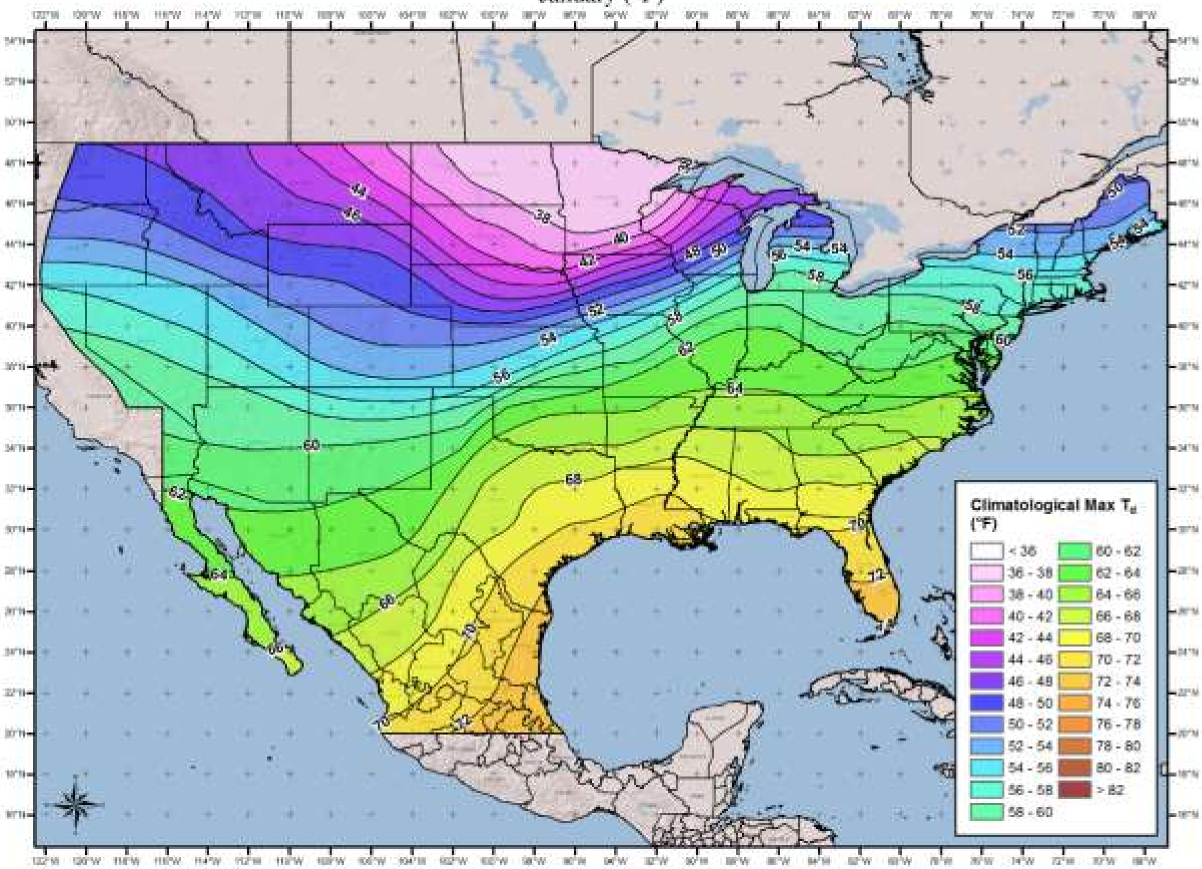
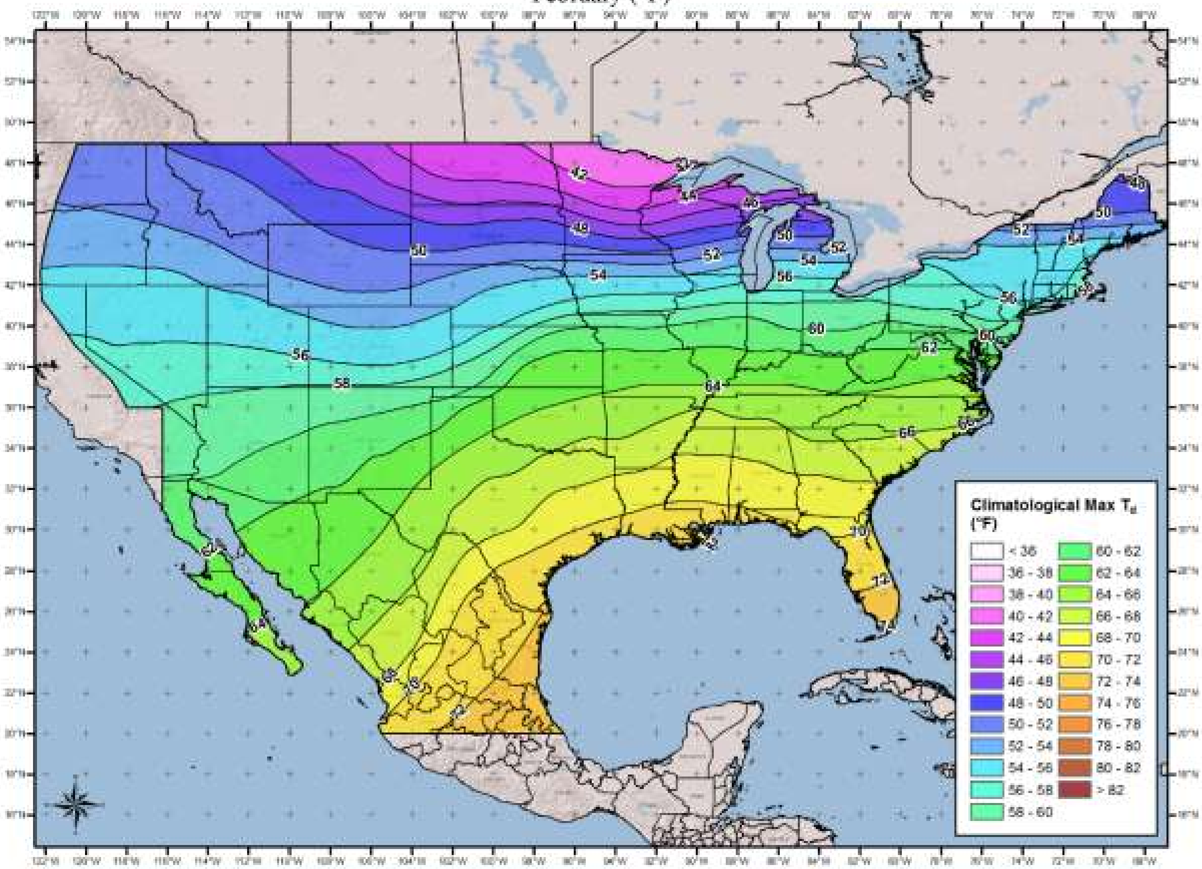
Appendix A
100-year Return Frequency Maximum Average Dew Point Climatology Maps

6-hour 100-year Dew Point Climatology Maps

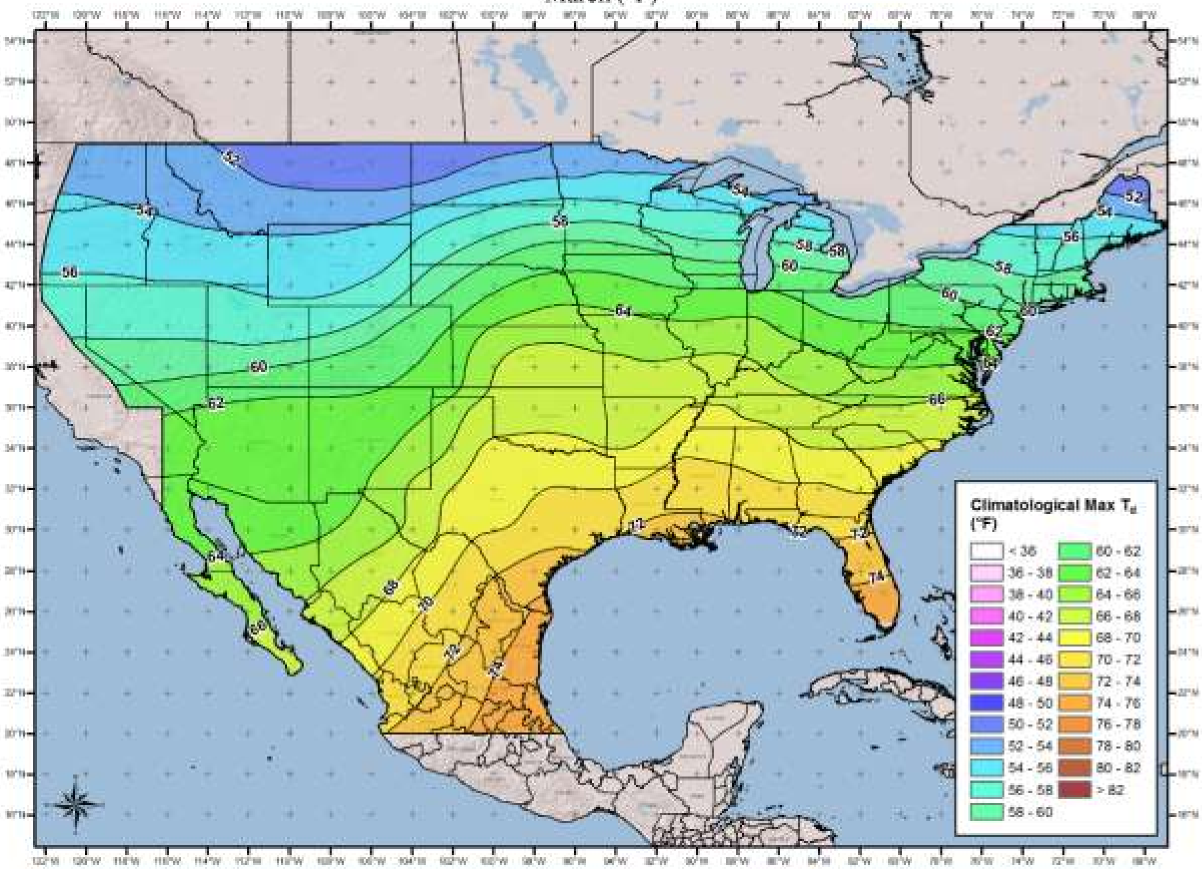
100-year Return Frequency 6-hour Maximum Dew Point Climatology
January (°F)



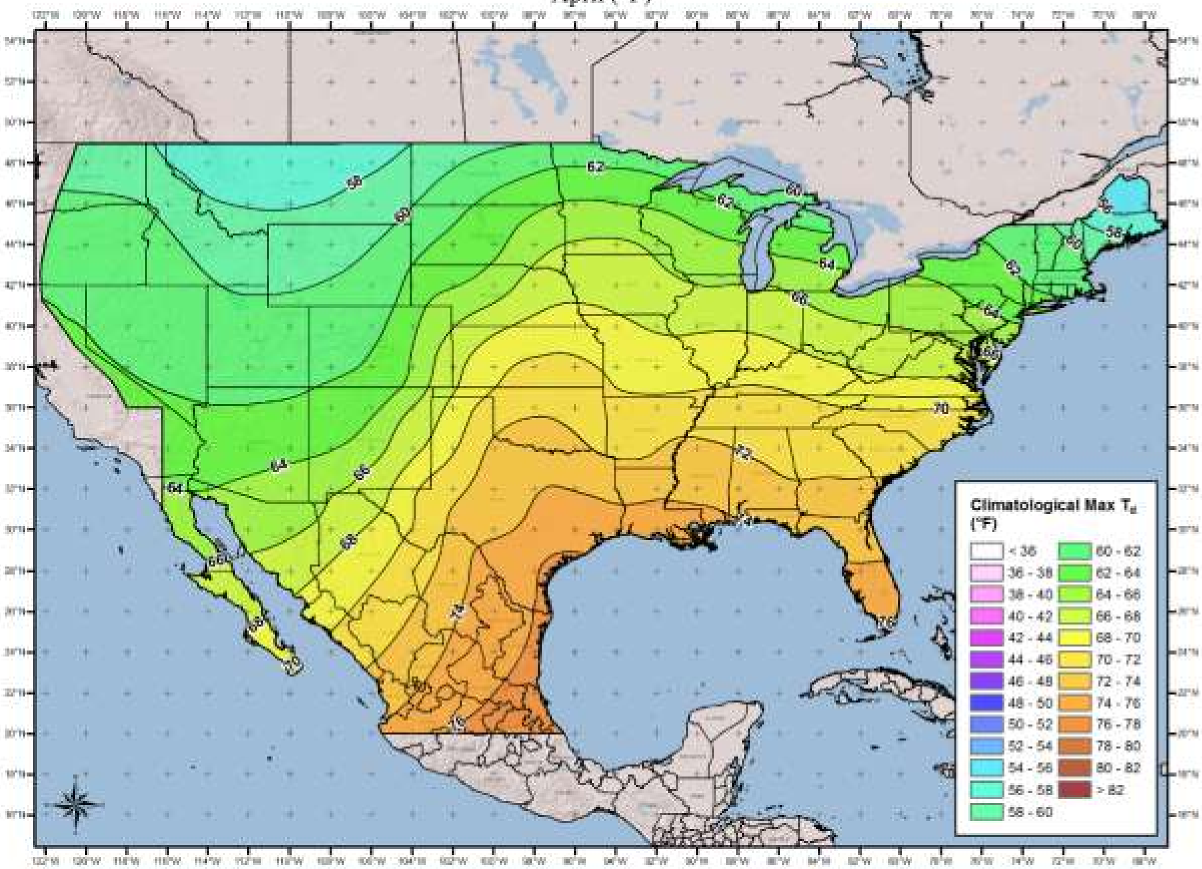
100-year Return Frequency 6-hour Maximum Dew Point Climatology
February (°F)



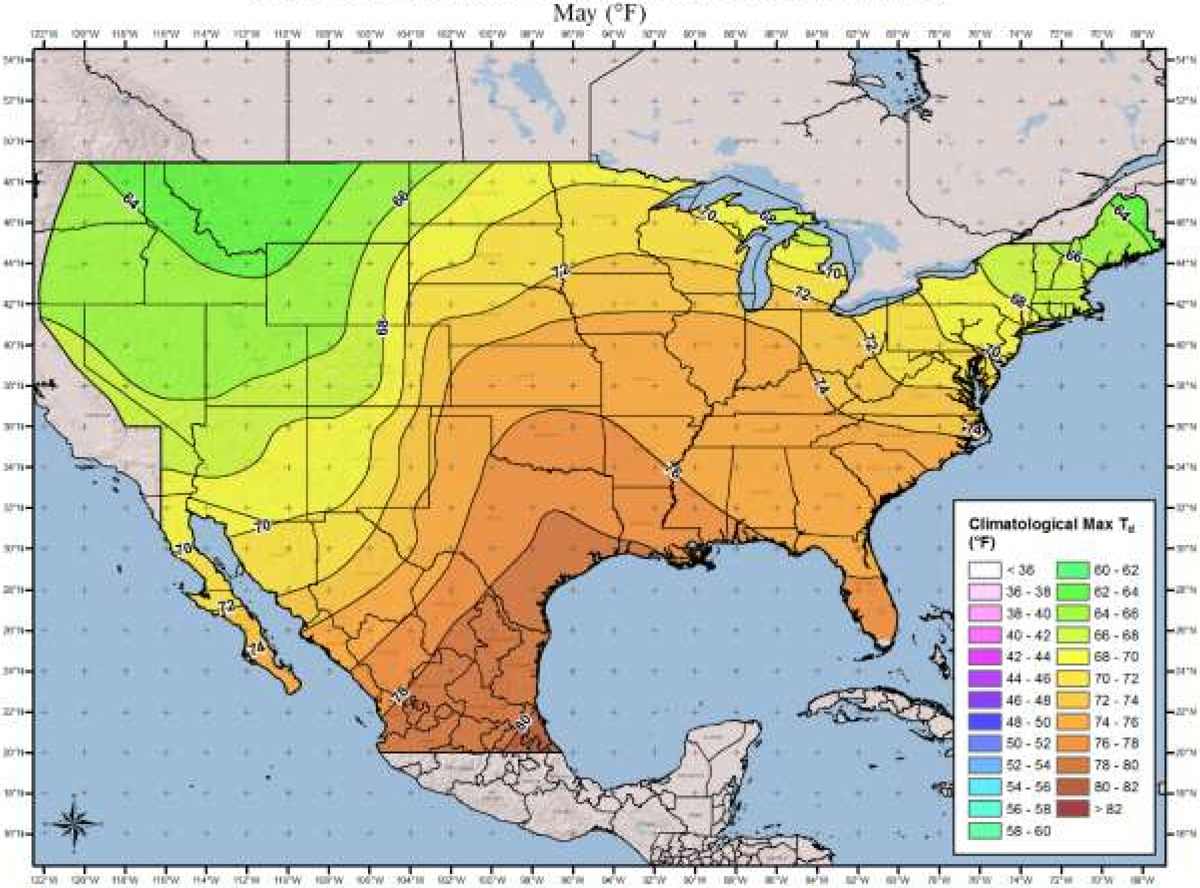
100-year Return Frequency 6-hour Maximum Dew Point Climatology
March (°F)



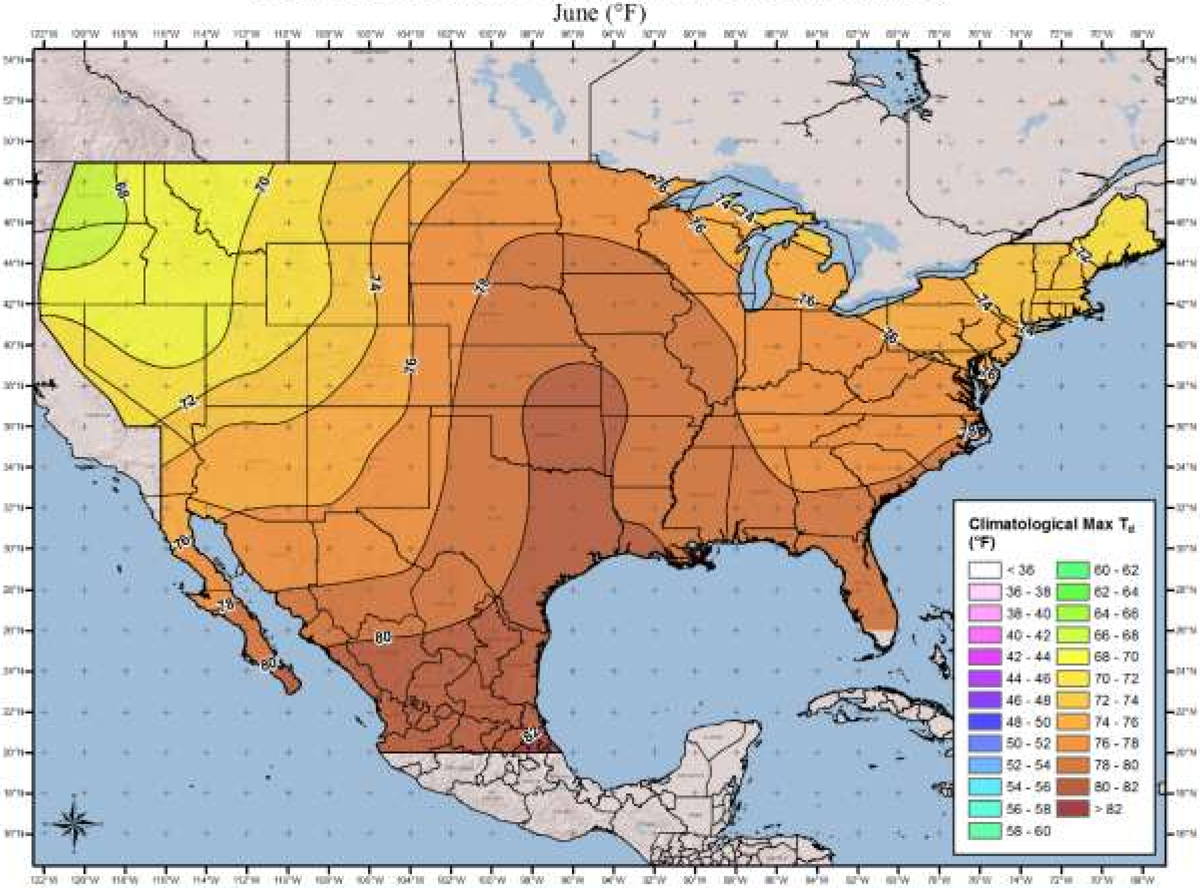
100-year Return Frequency 6-hour Maximum Dew Point Climatology
April (°F)



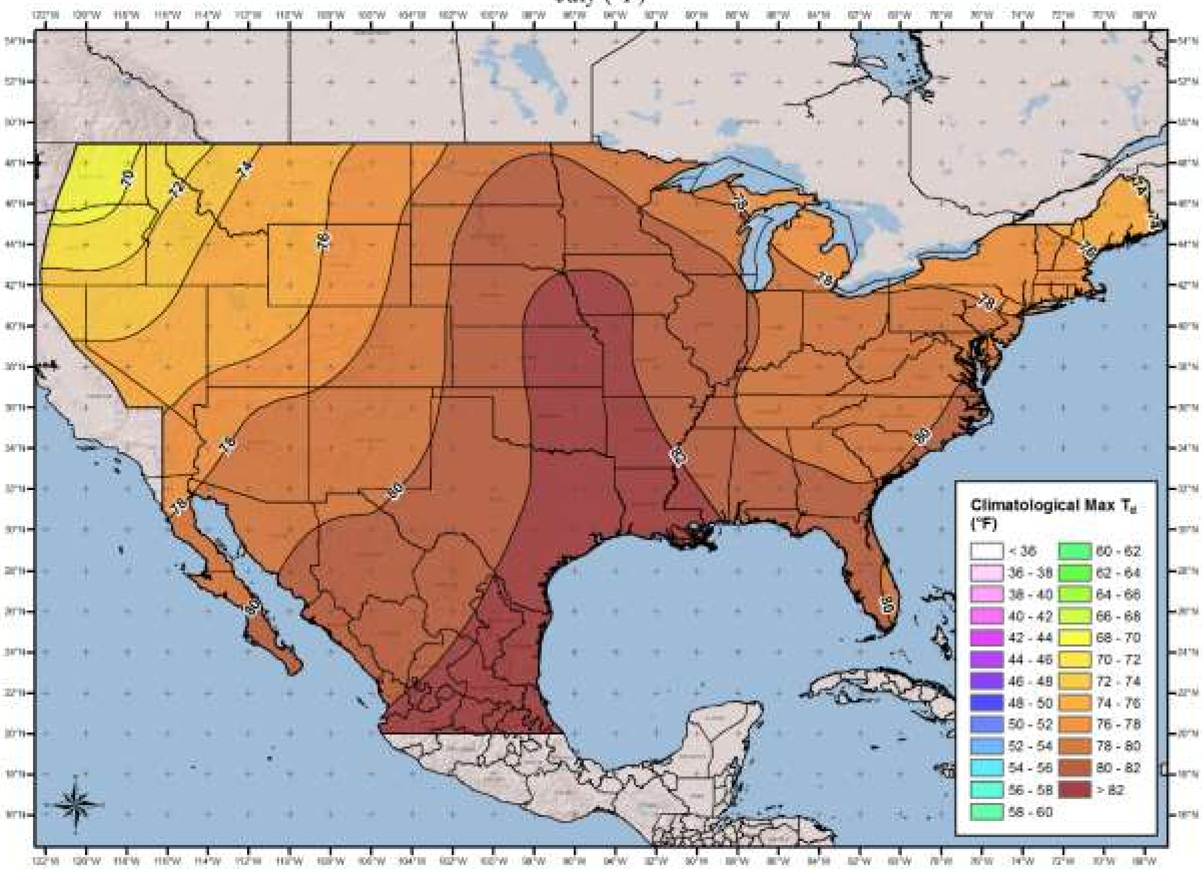
100-year Return Frequency 6-hour Maximum Dew Point Climatology
May (°F)



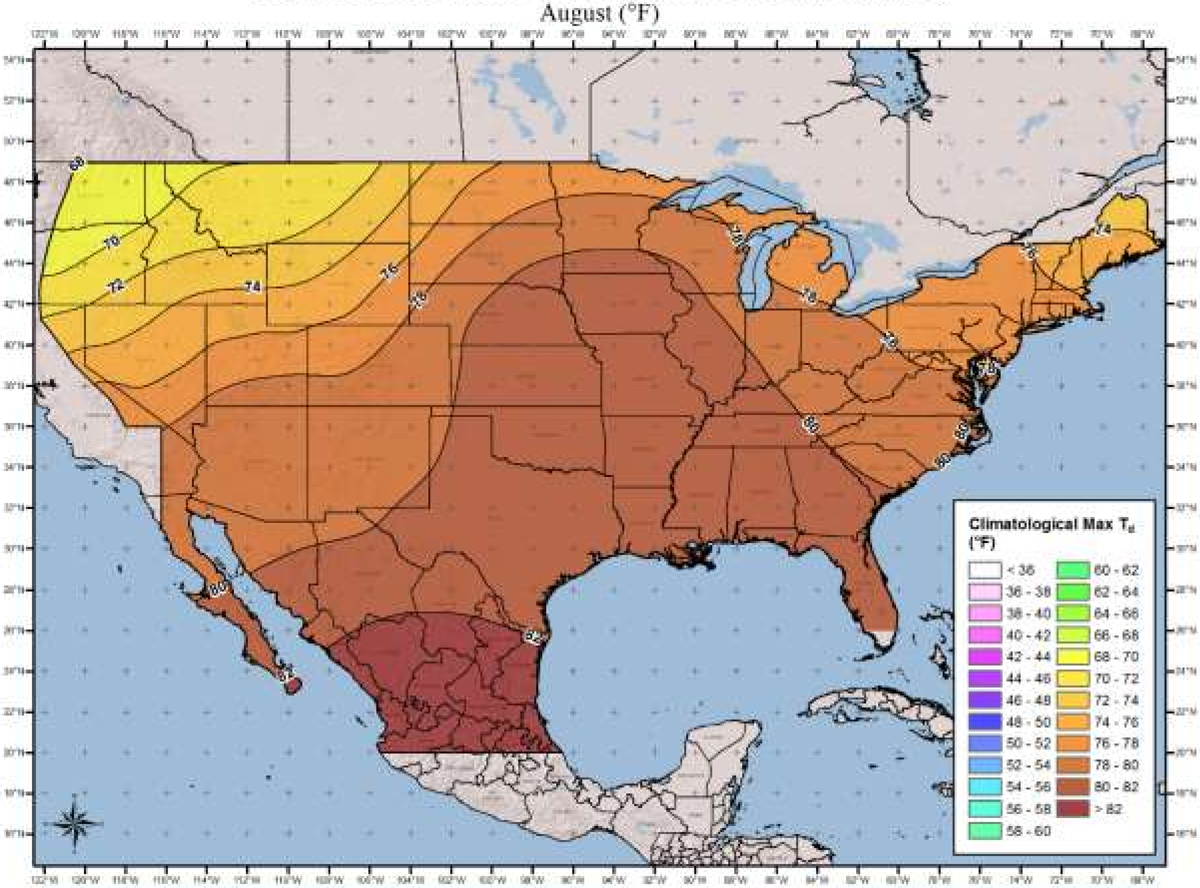
100-year Return Frequency 6-hour Maximum Dew Point Climatology
June (°F)



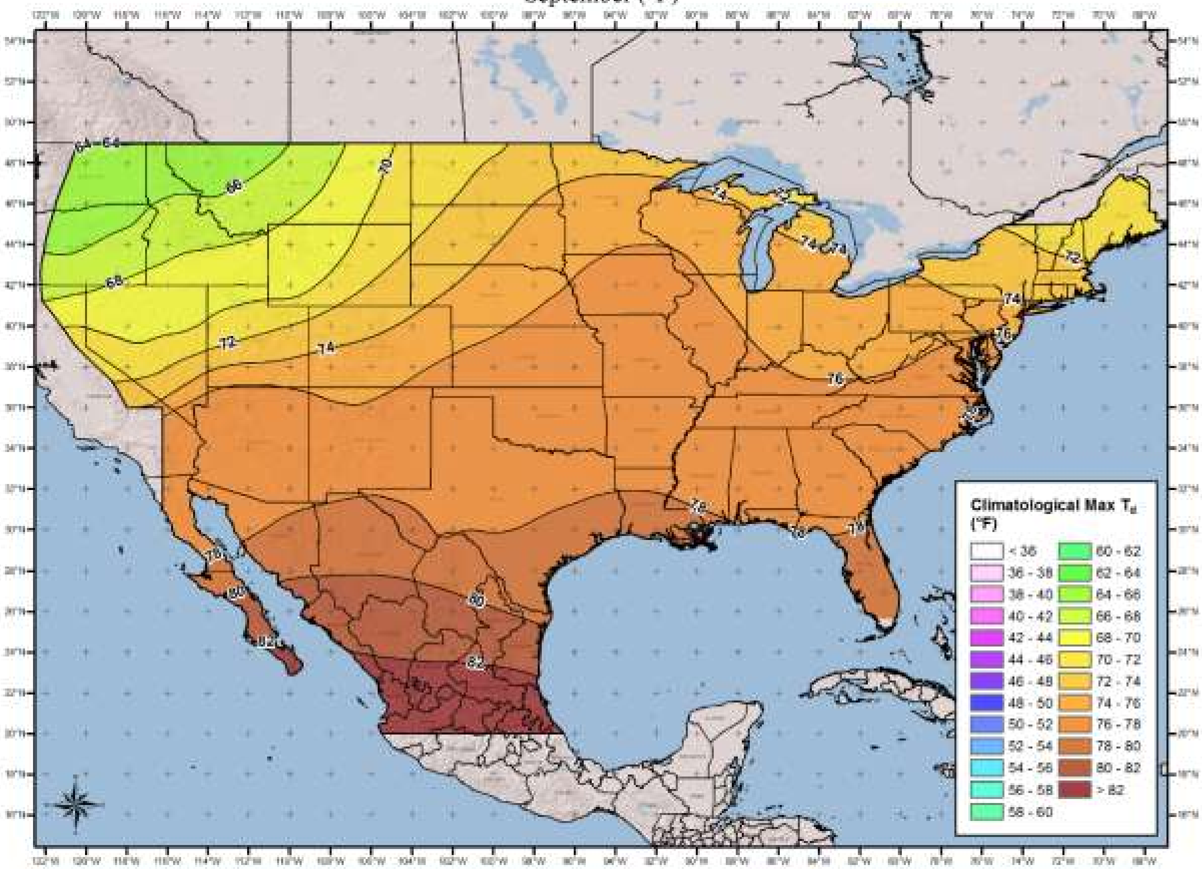
100-year Return Frequency 6-hour Maximum Dew Point Climatology
July (°F)



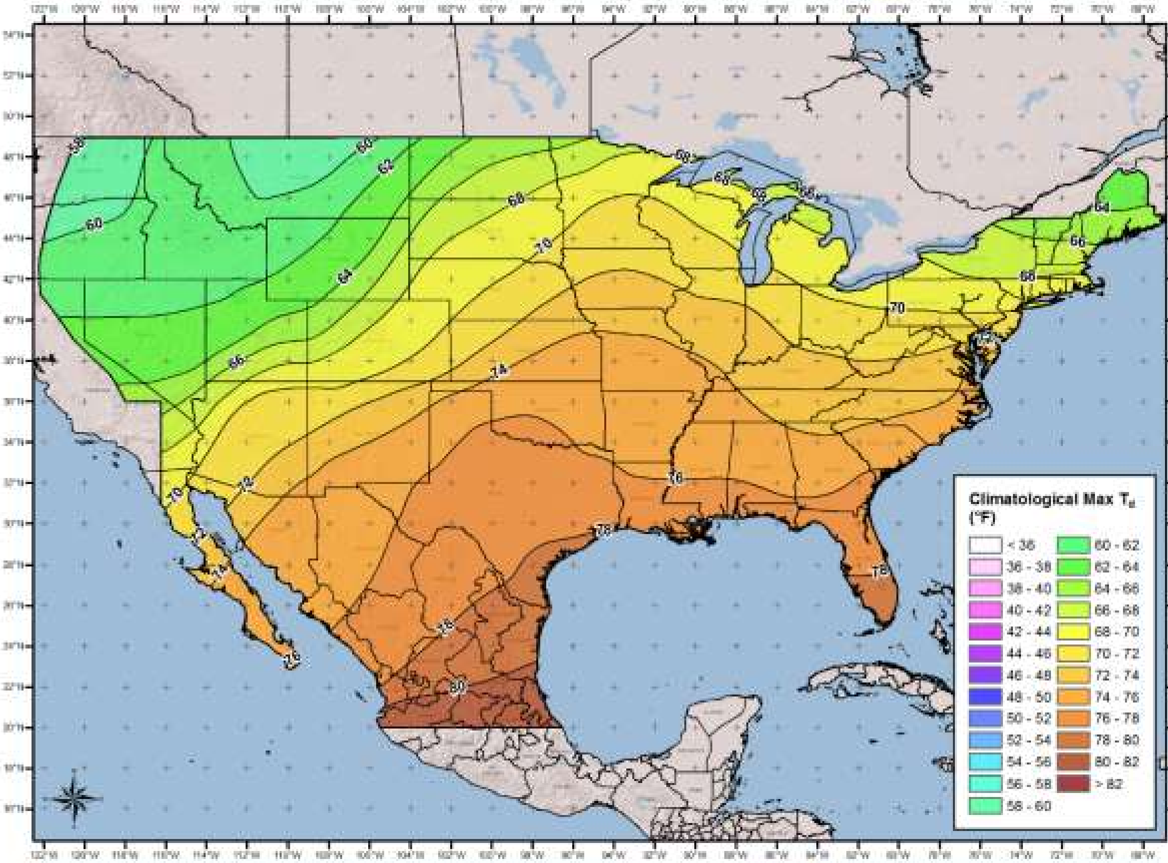
100-year Return Frequency 6-hour Maximum Dew Point Climatology
August (°F)



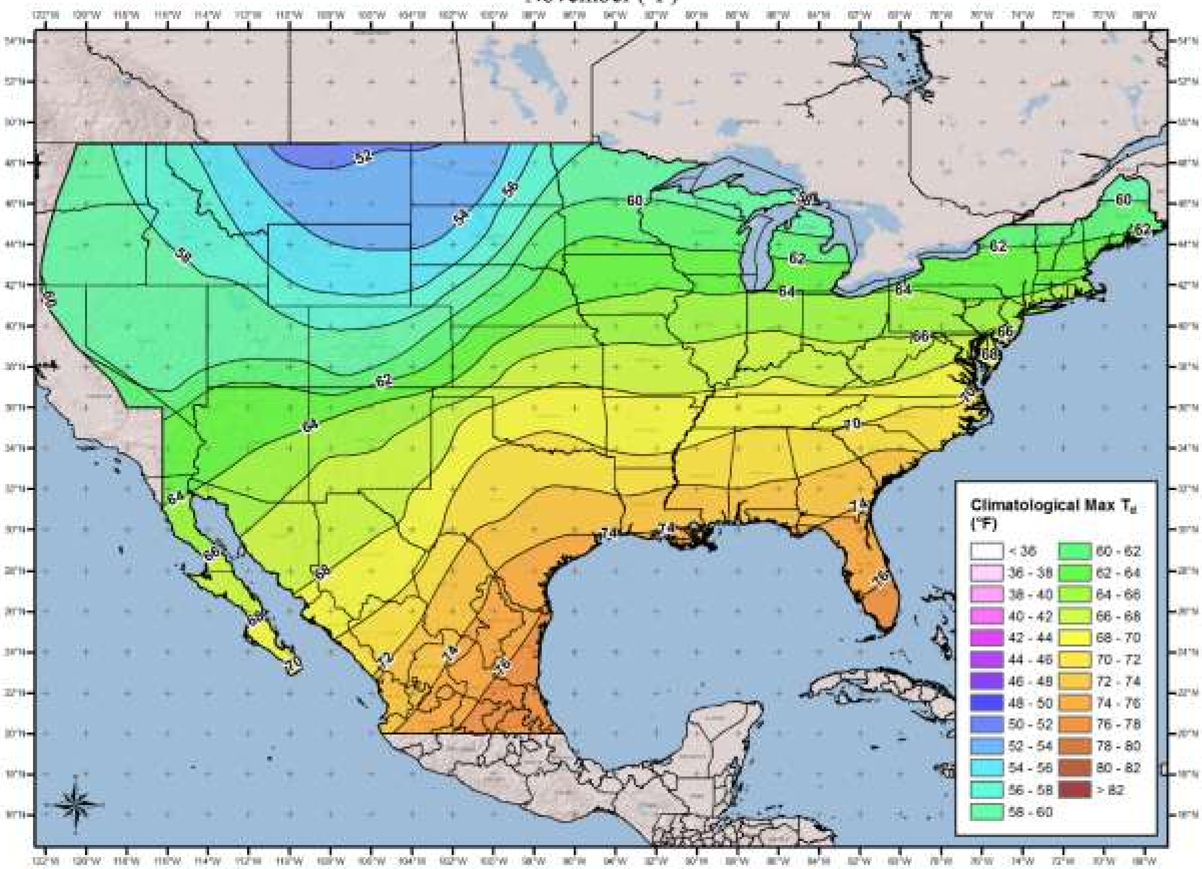
100-year Return Frequency 6-hour Maximum Dew Point Climatology
September (°F)



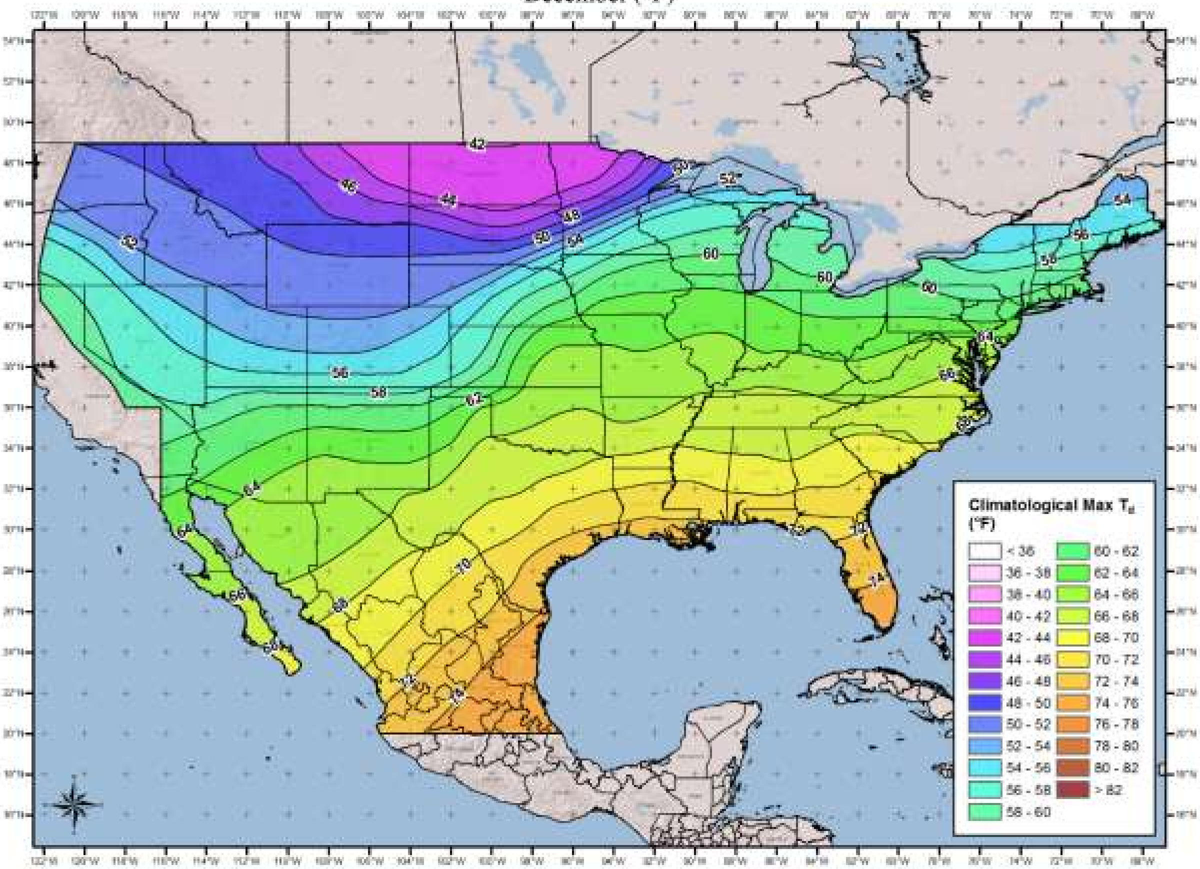
100-year Return Frequency 6-hour Maximum Dew Point Climatology
October (°F)



100-year Return Frequency 6-hour Maximum Dew Point Climatology
November (°F)

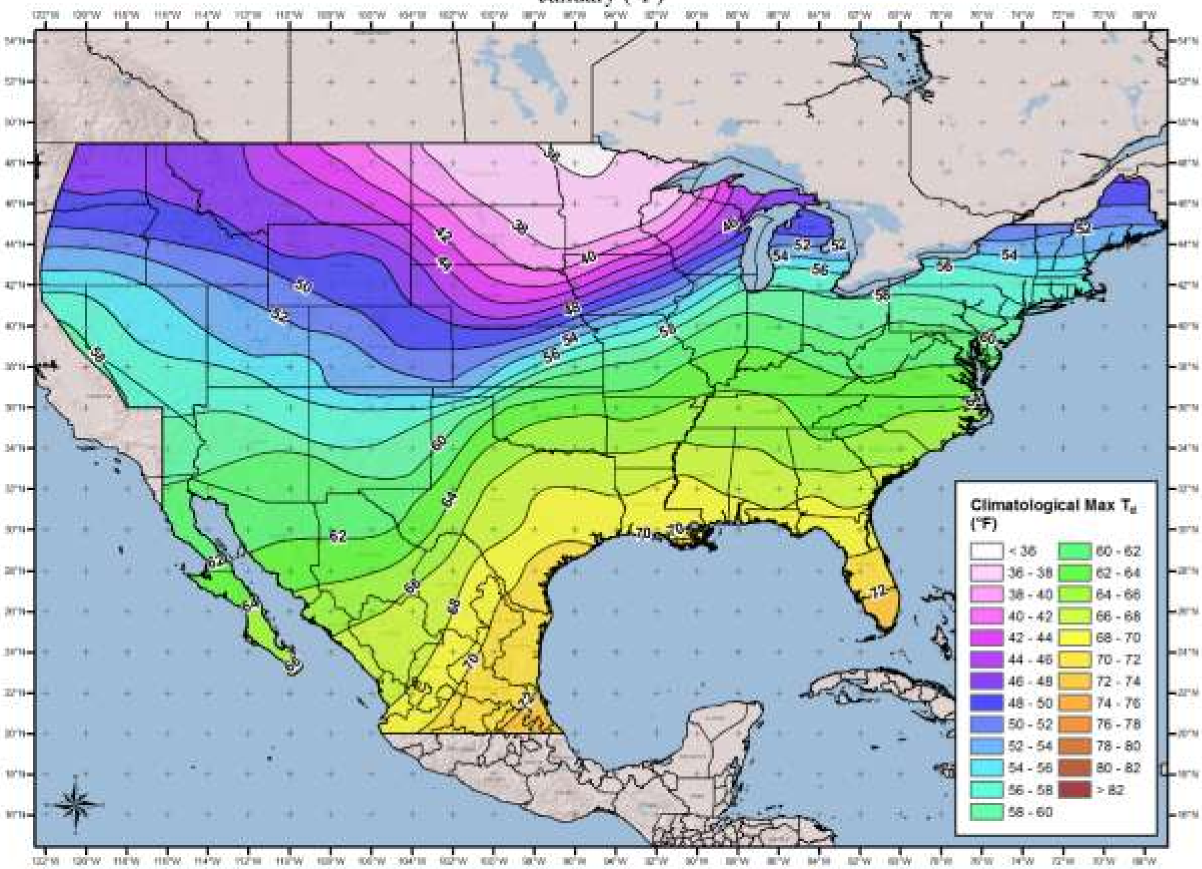


100-year Return Frequency 6-hour Maximum Dew Point Climatology
December (°F)

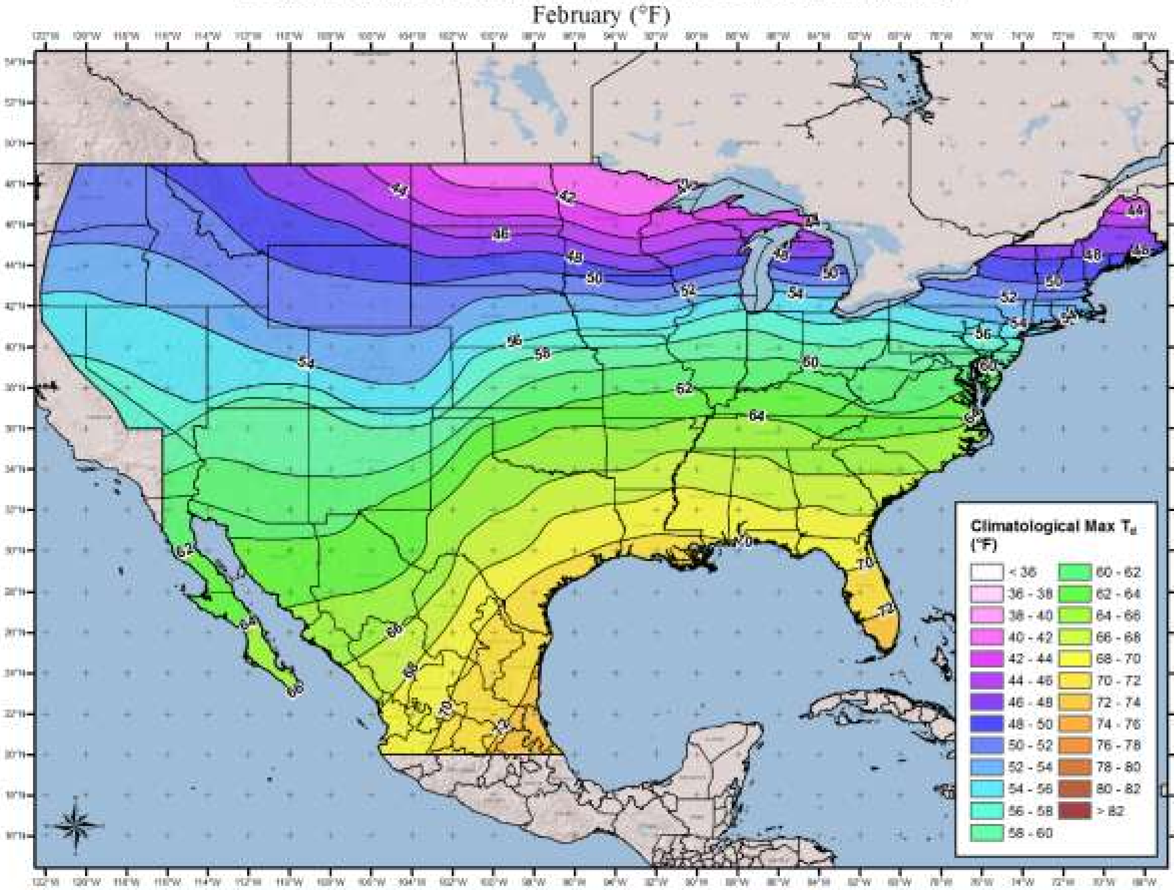


12-hour 100-year Dew Point Climatology Maps

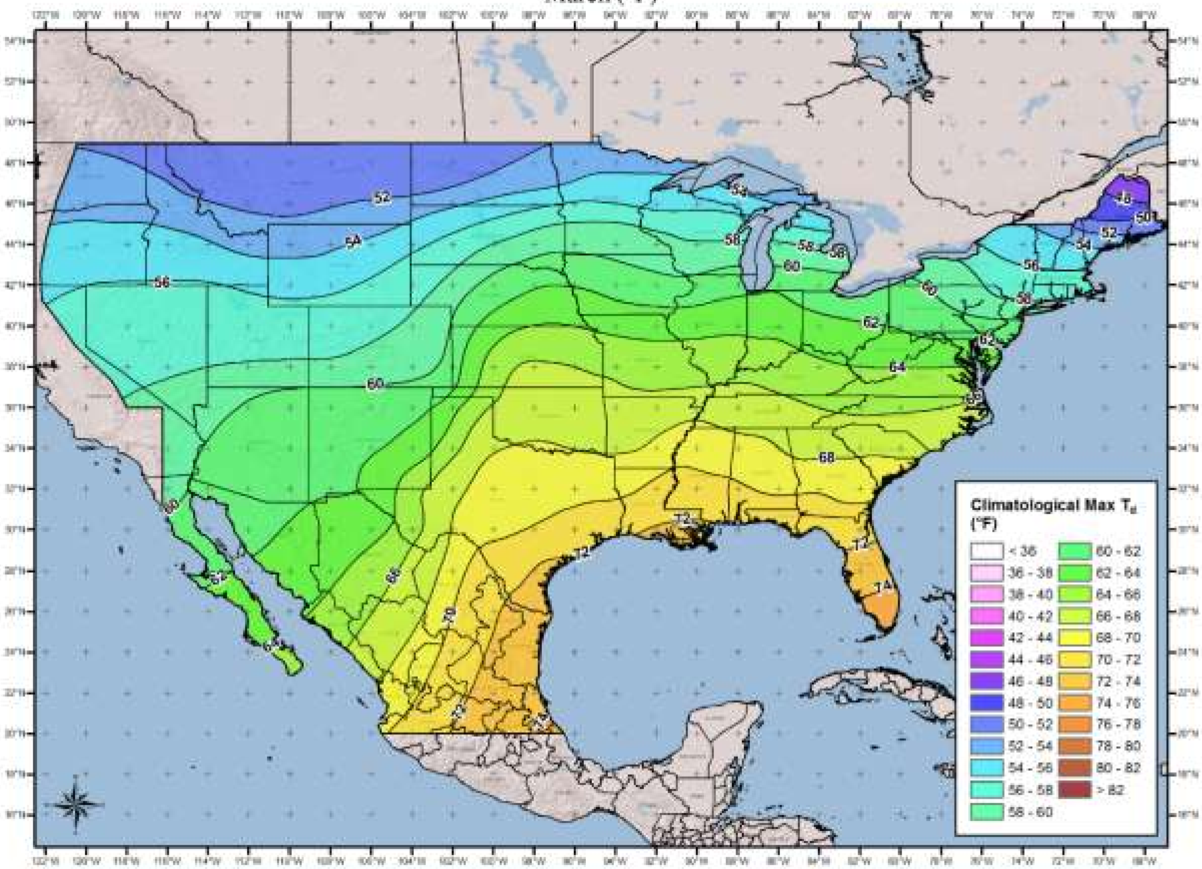
100-year Return Frequency 12-hour Maximum Dew Point Climatology
January (°F)



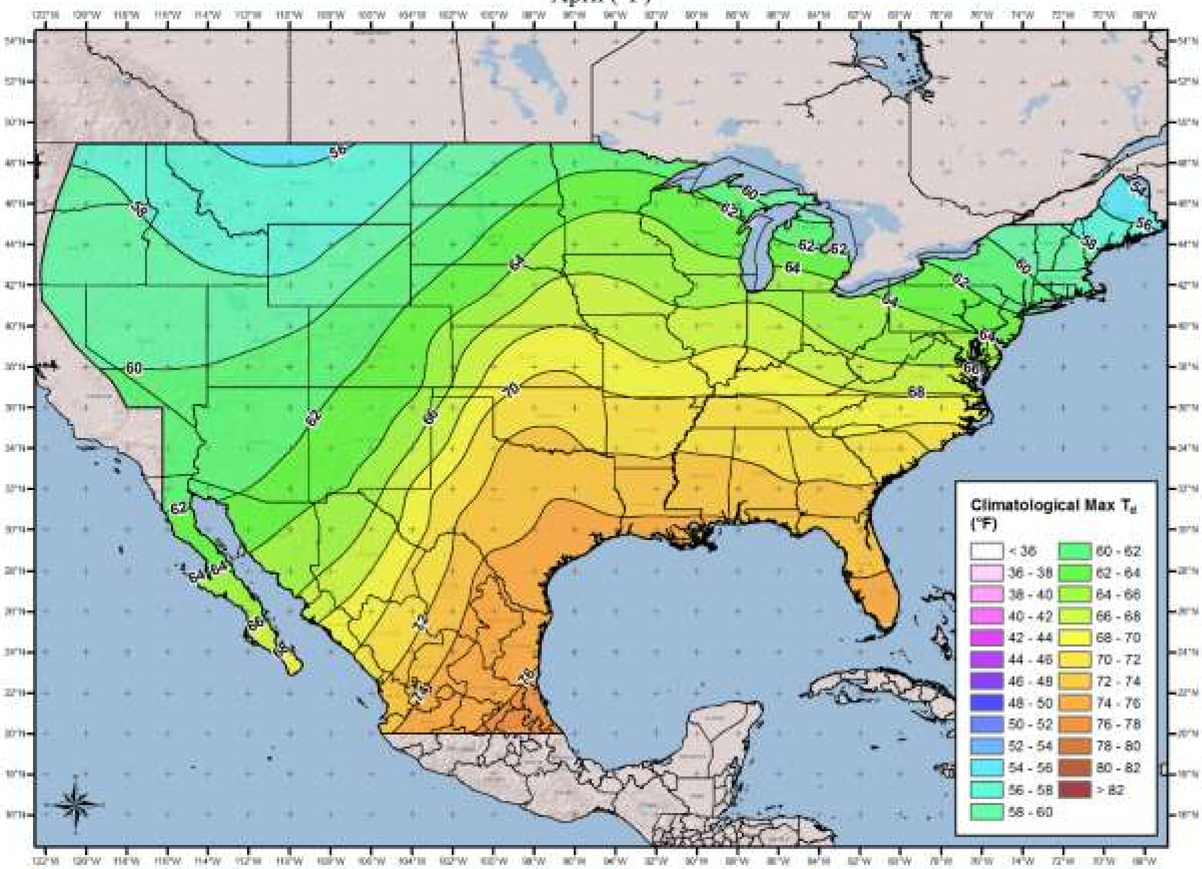
100-year Return Frequency 12-hour Maximum Dew Point Climatology
February (°F)



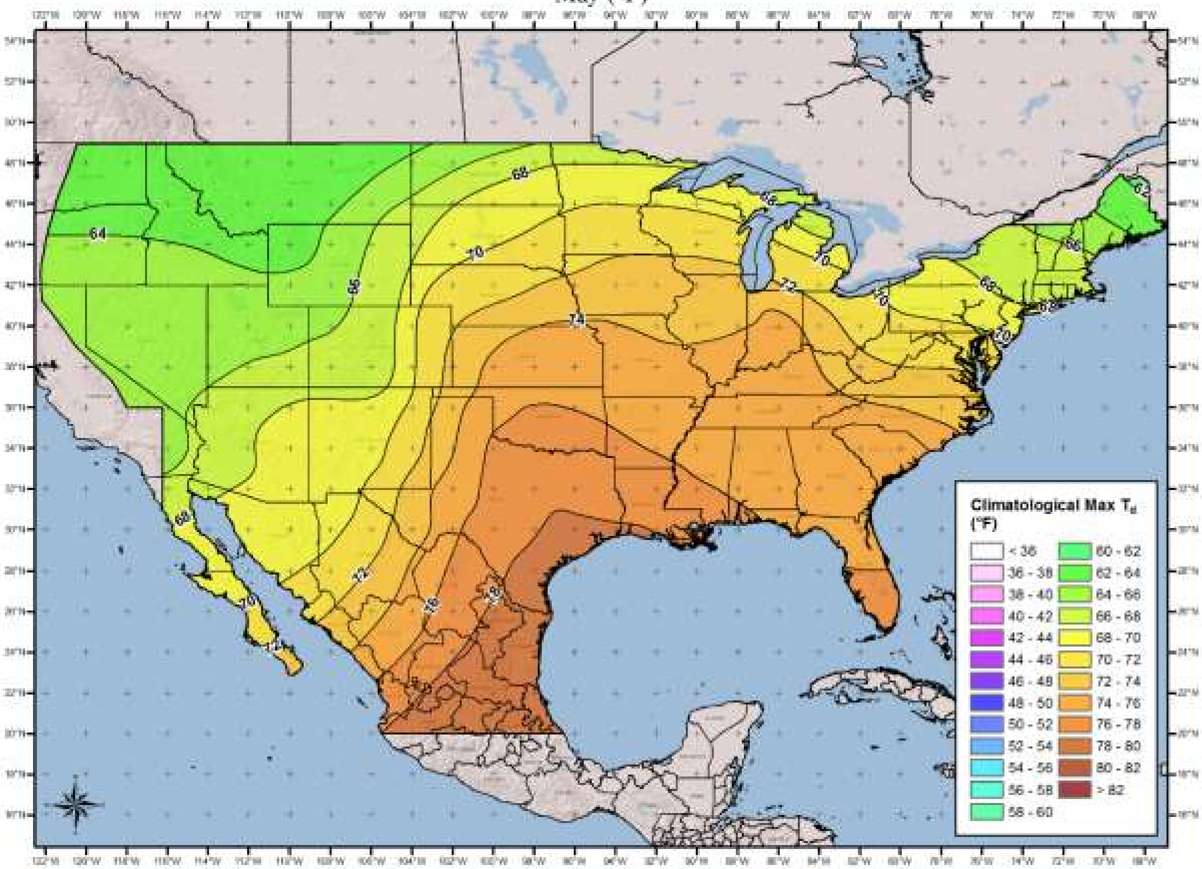
100-year Return Frequency 12-hour Maximum Dew Point Climatology
March (°F)



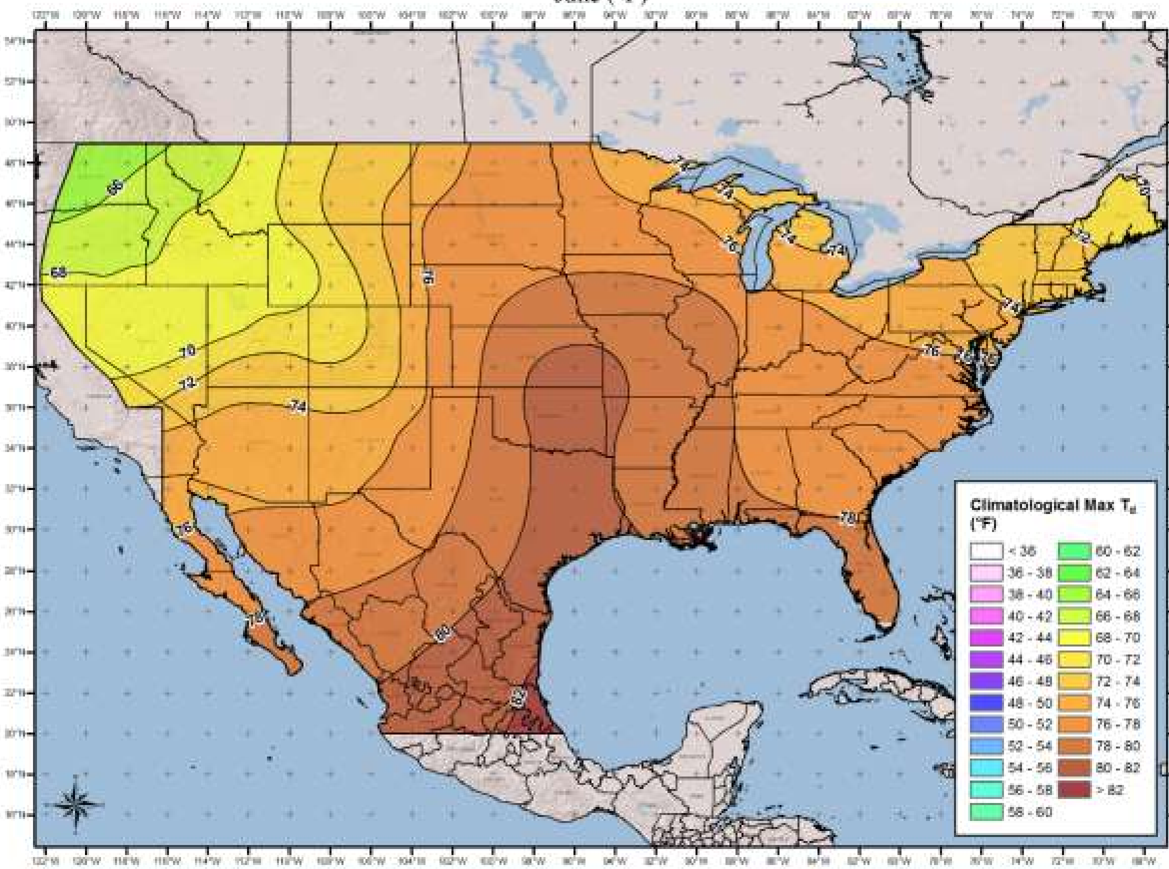
100-year Return Frequency 12-hour Maximum Dew Point Climatology
April (°F)



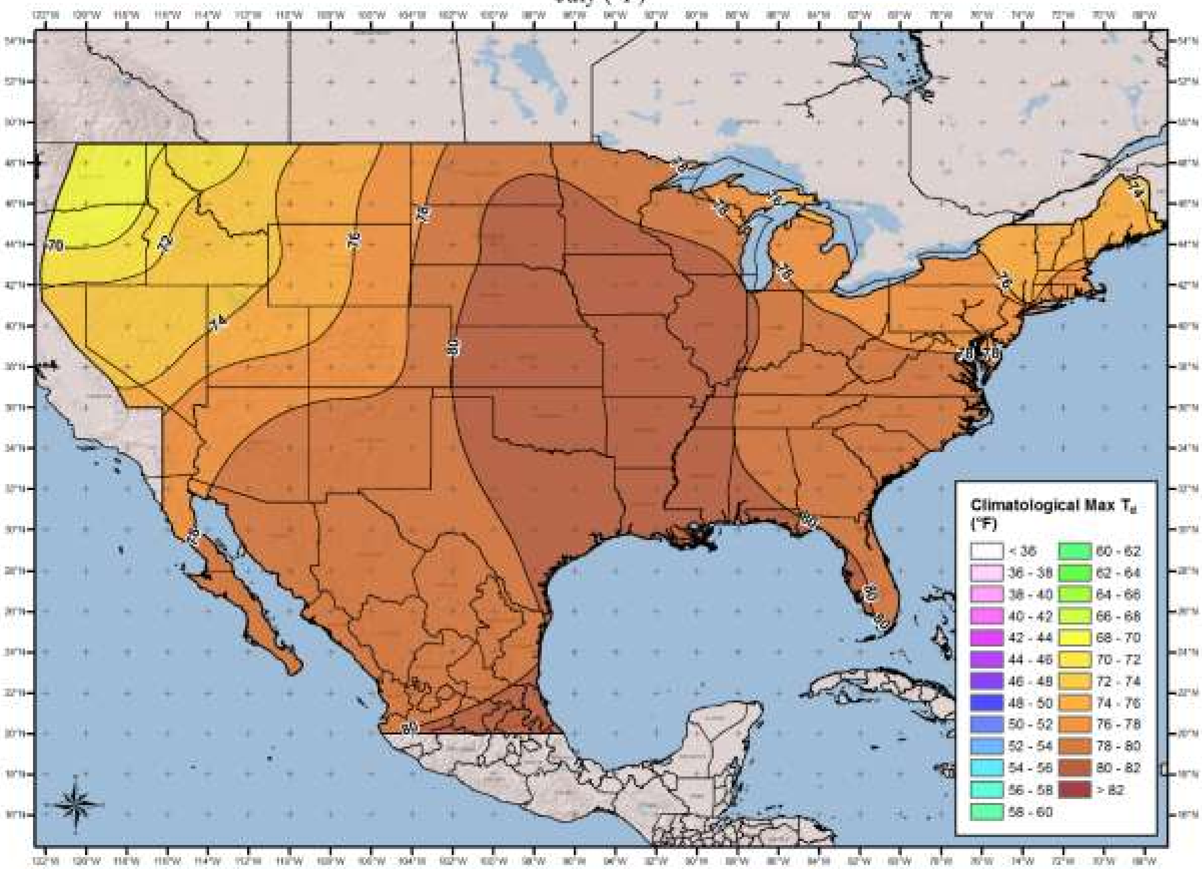
100-year Return Frequency 12-hour Maximum Dew Point Climatology
May (°F)



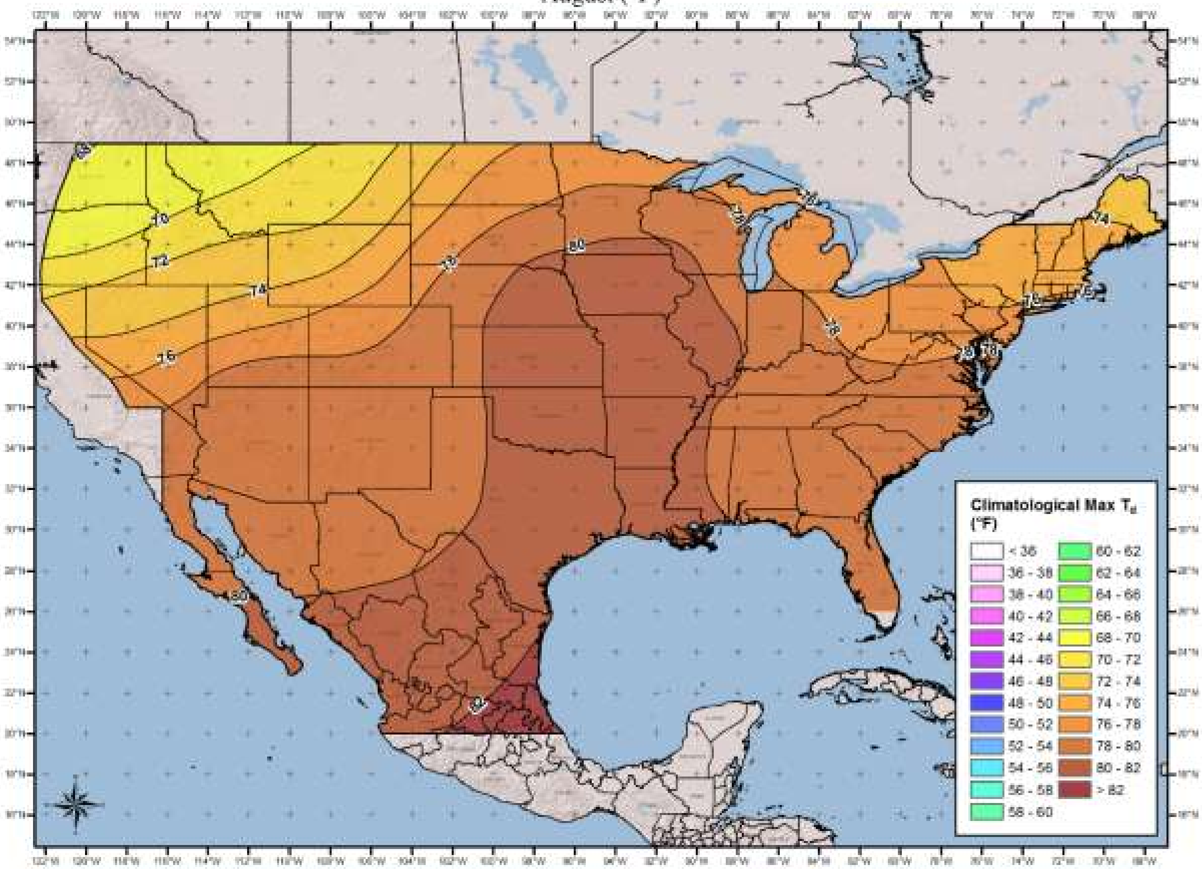
100-year Return Frequency 12-hour Maximum Dew Point Climatology
June (°F)



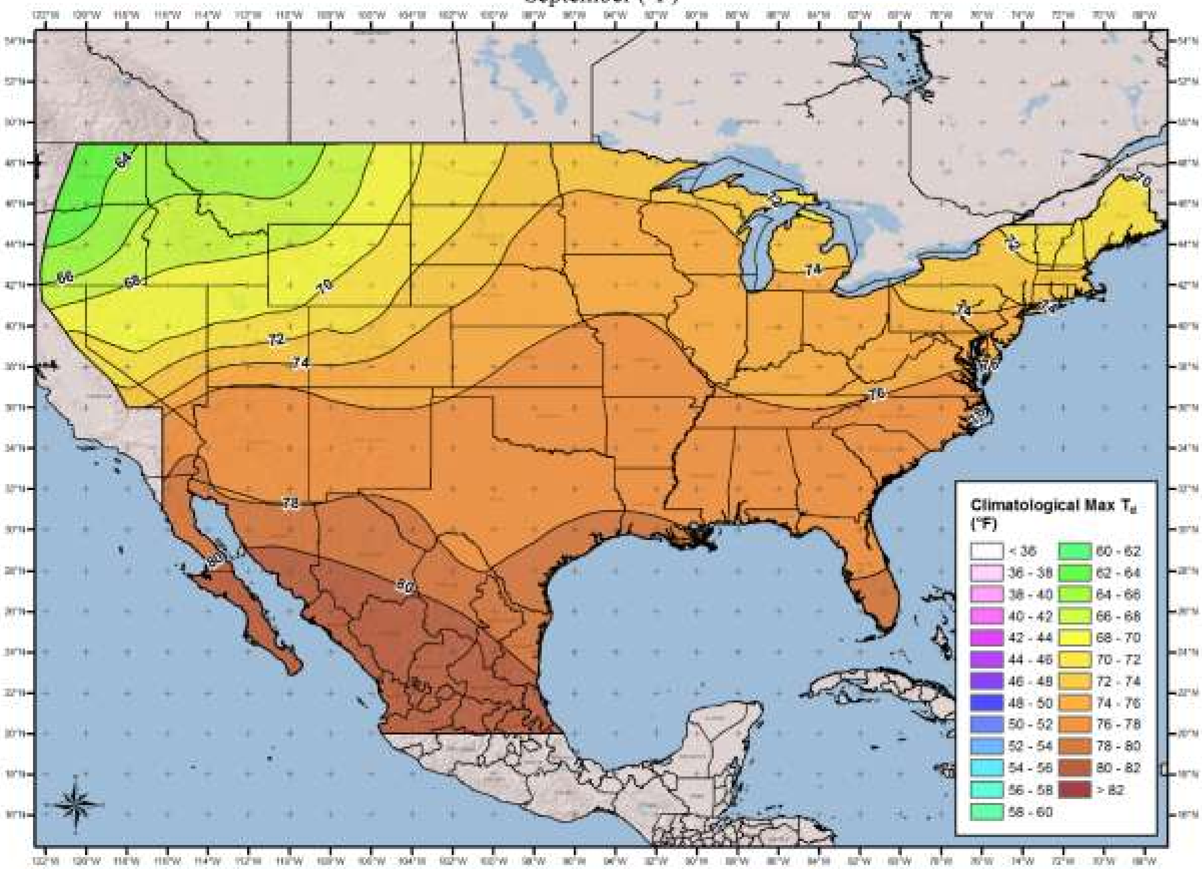
100-year Return Frequency 12-hour Maximum Dew Point Climatology
July (°F)



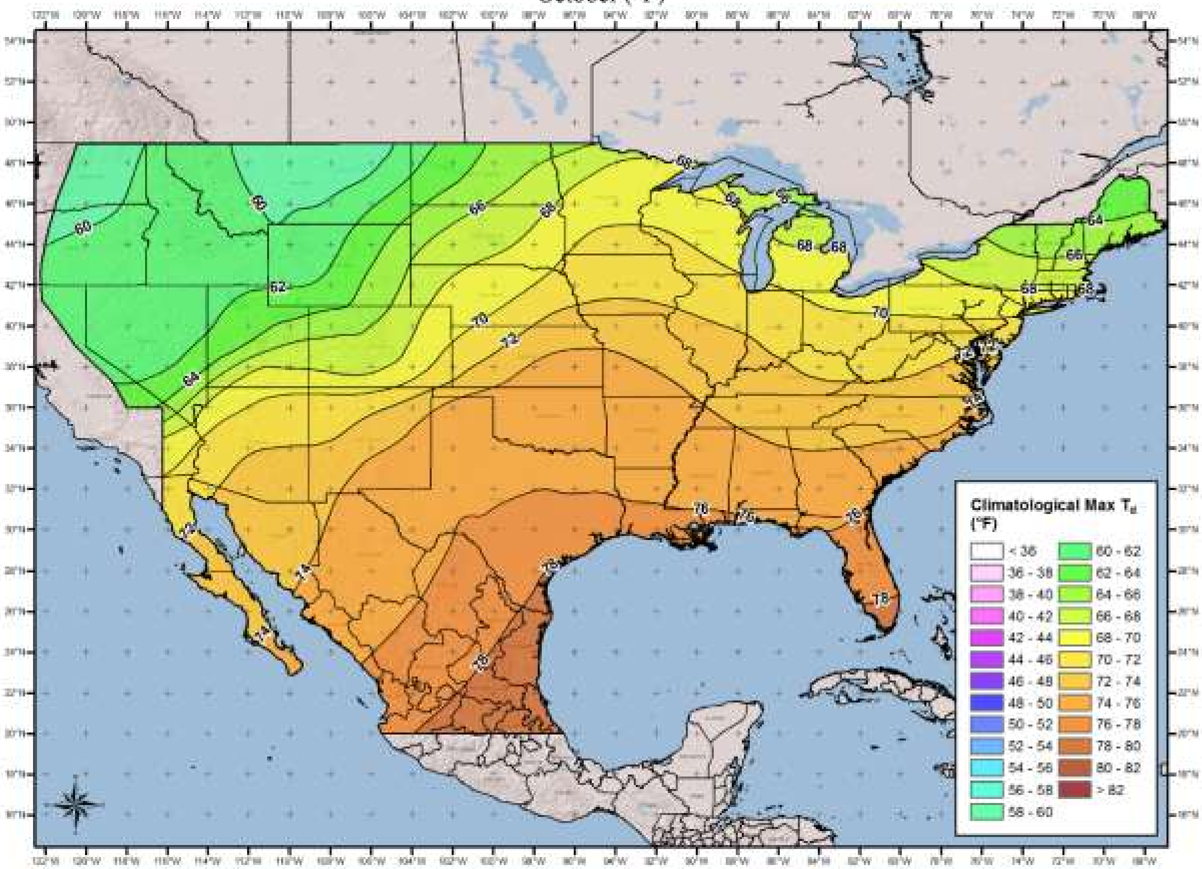
100-year Return Frequency 12-hour Maximum Dew Point Climatology
August (°F)



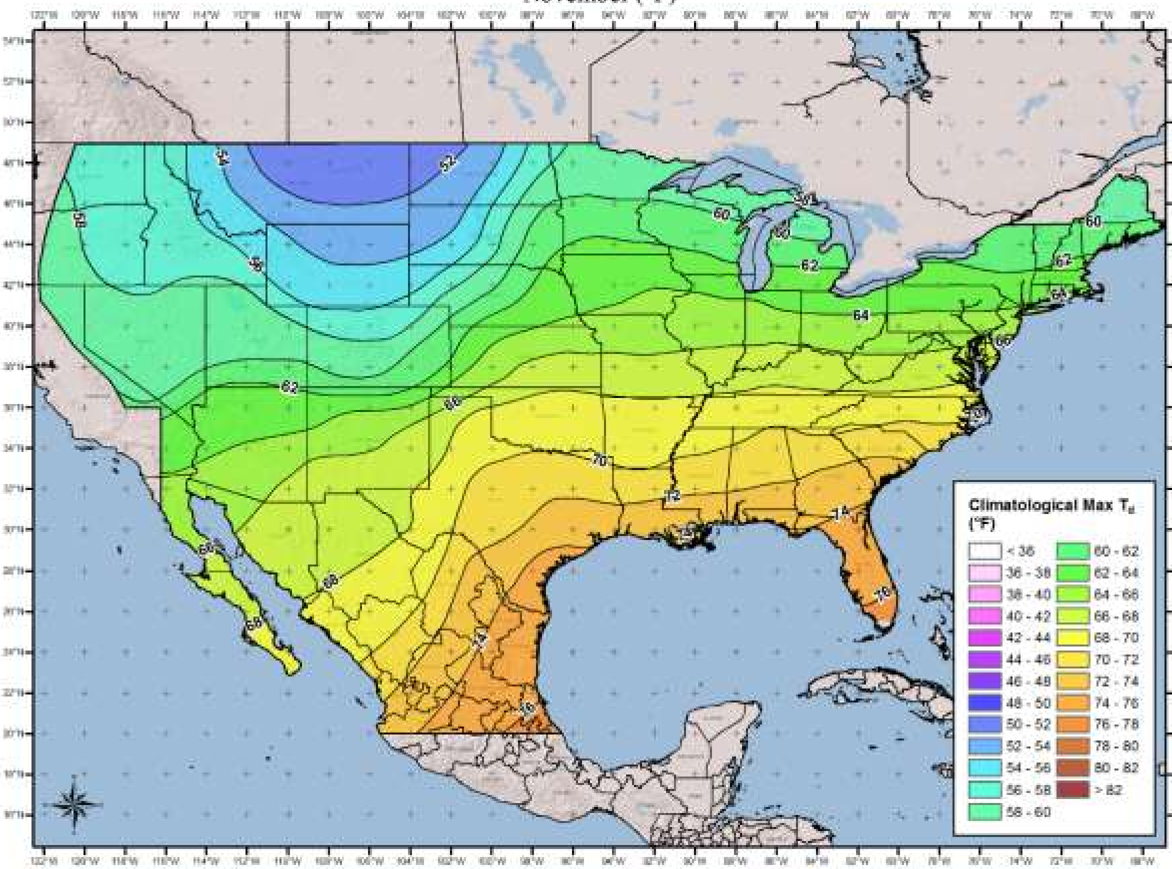
100-year Return Frequency 12-hour Maximum Dew Point Climatology
September (°F)



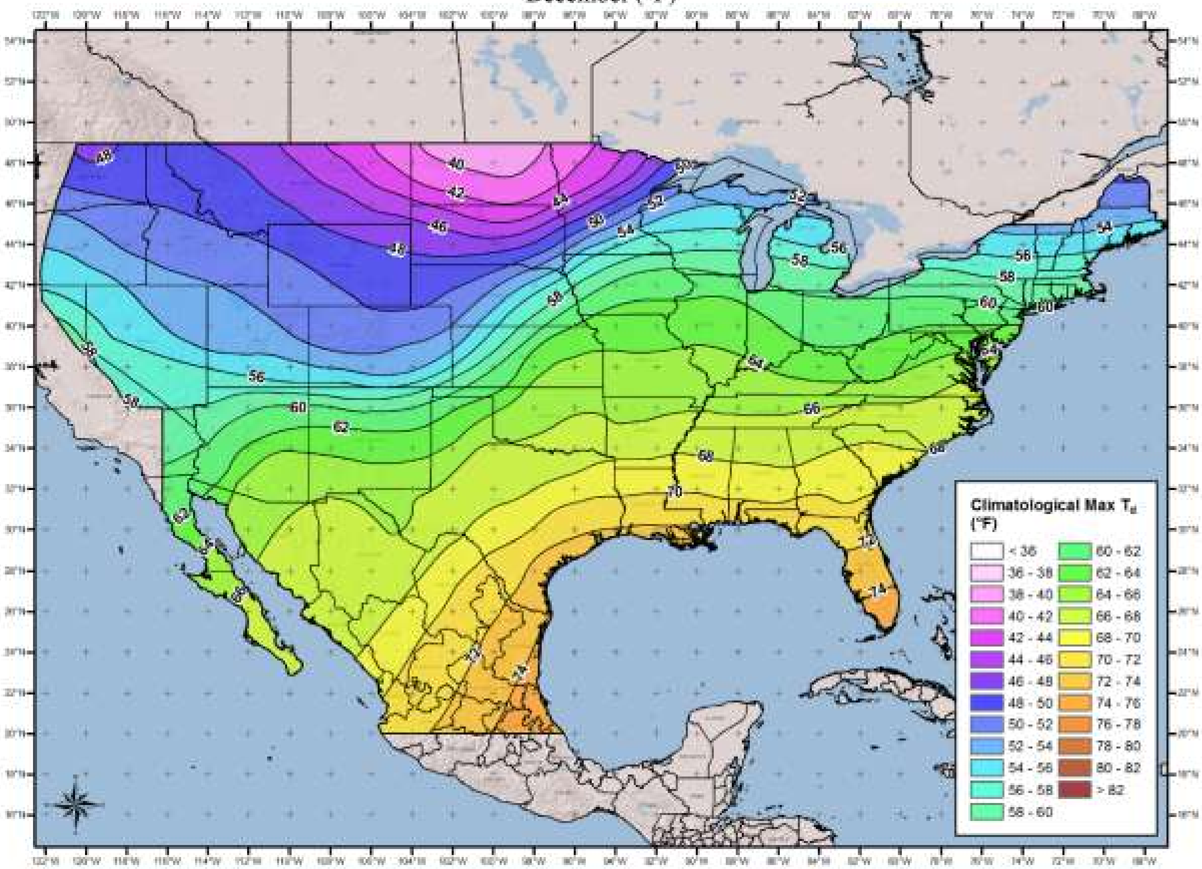
100-year Return Frequency 12-hour Maximum Dew Point Climatology
October (°F)



100-year Return Frequency 12-hour Maximum Dew Point Climatology
November (°F)

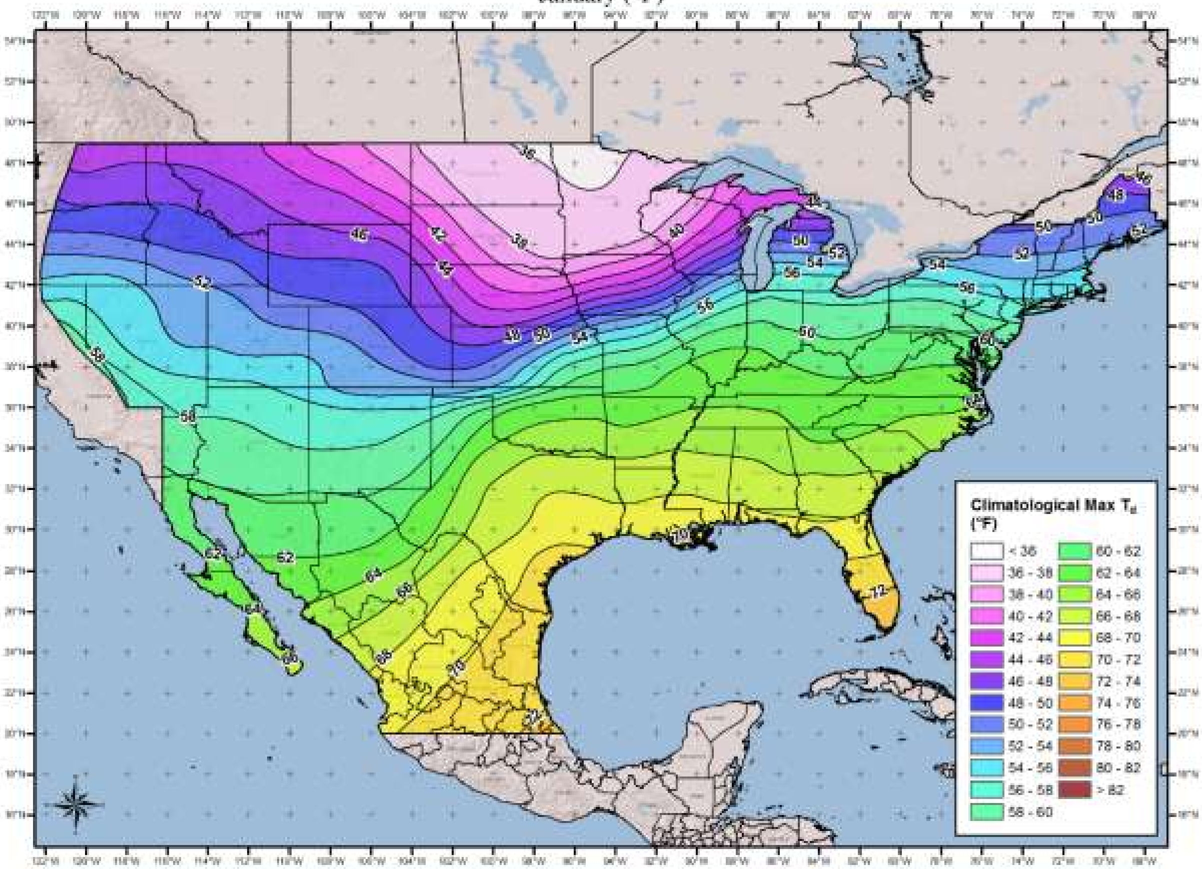


100-year Return Frequency 12-hour Maximum Dew Point Climatology
December (°F)

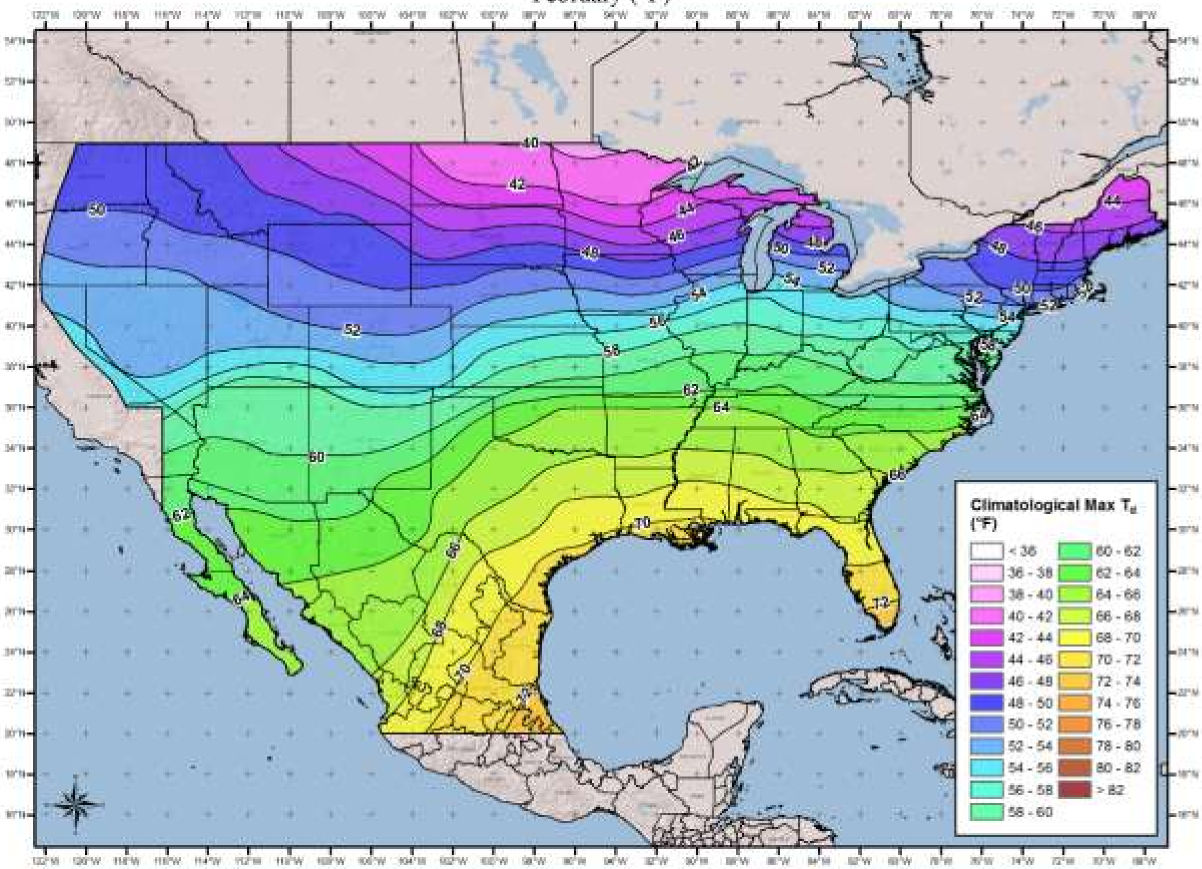


24-hour 100-year Dew Point Climatology Maps

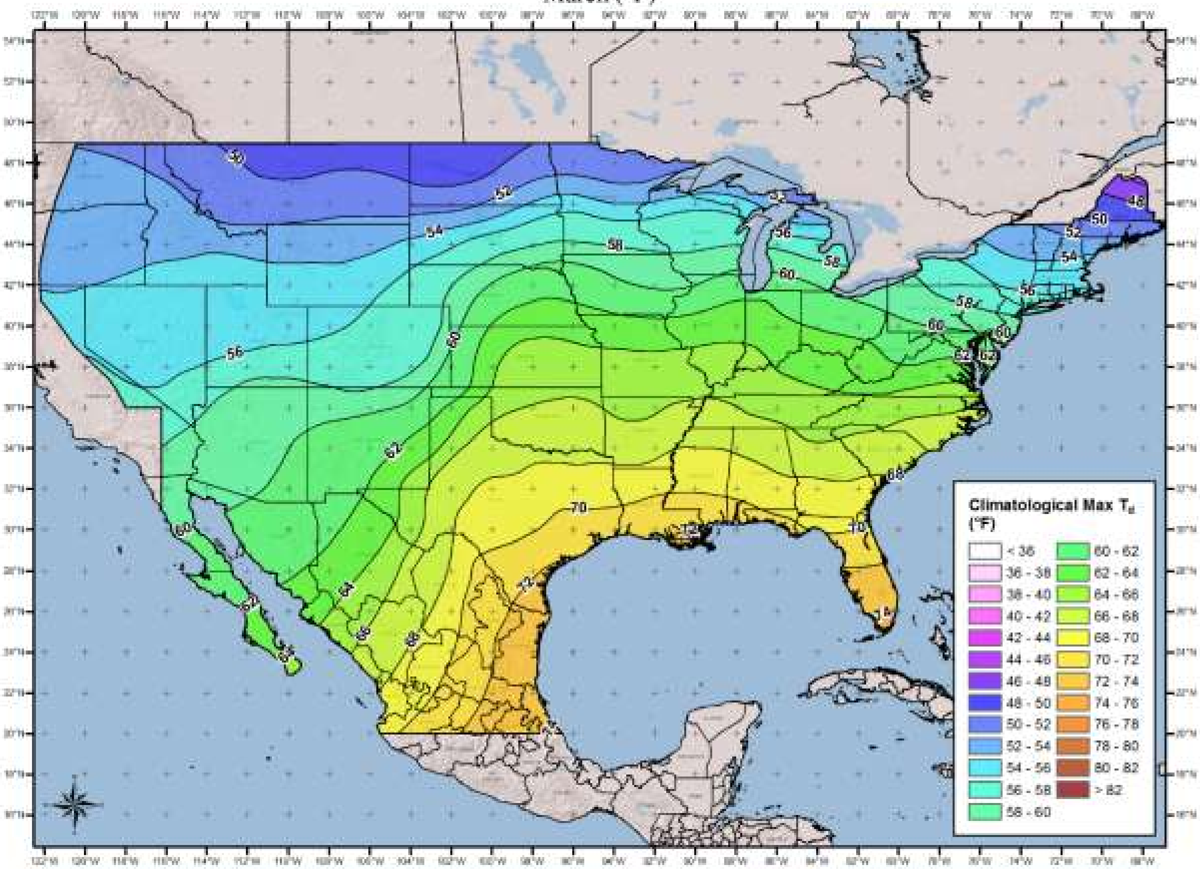
100-year Return Frequency 24-hour Maximum Dew Point Climatology
January (°F)



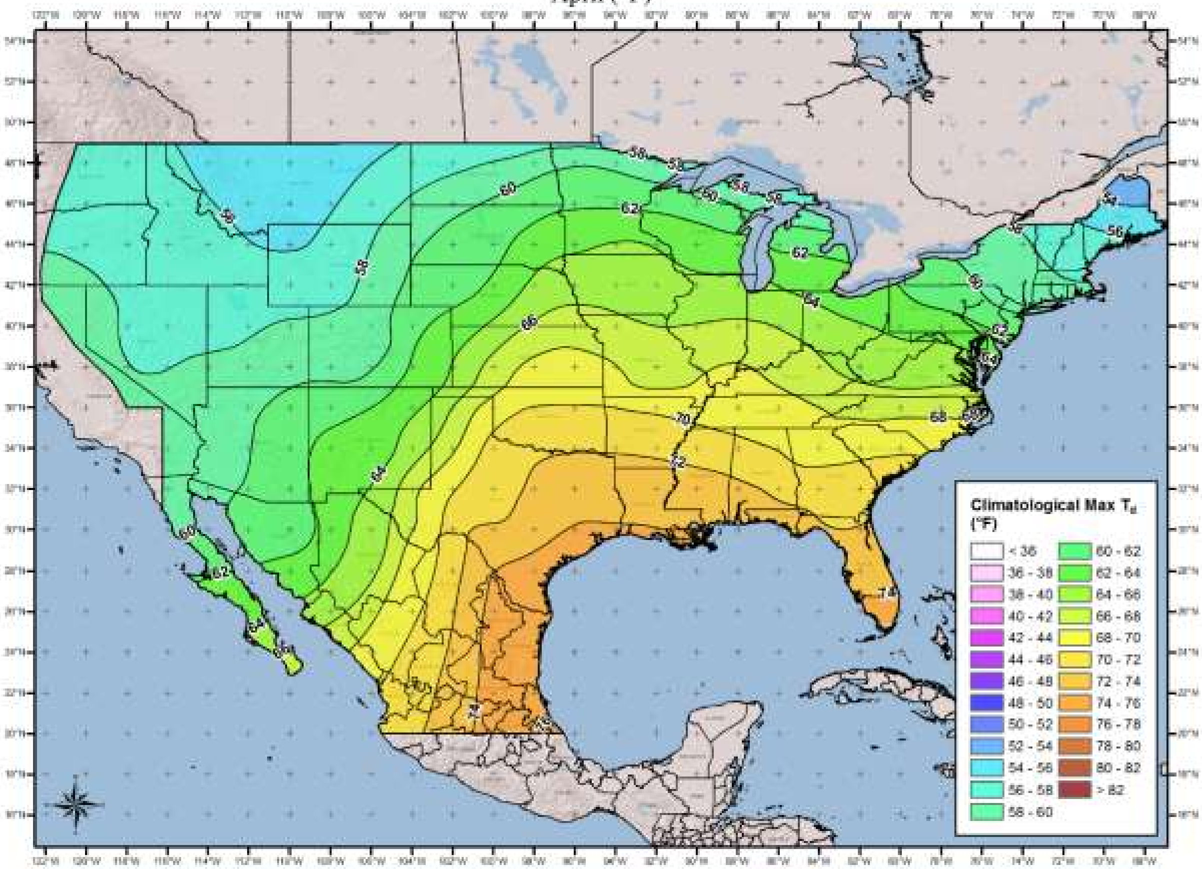
100-year Return Frequency 24-hour Maximum Dew Point Climatology
February (°F)



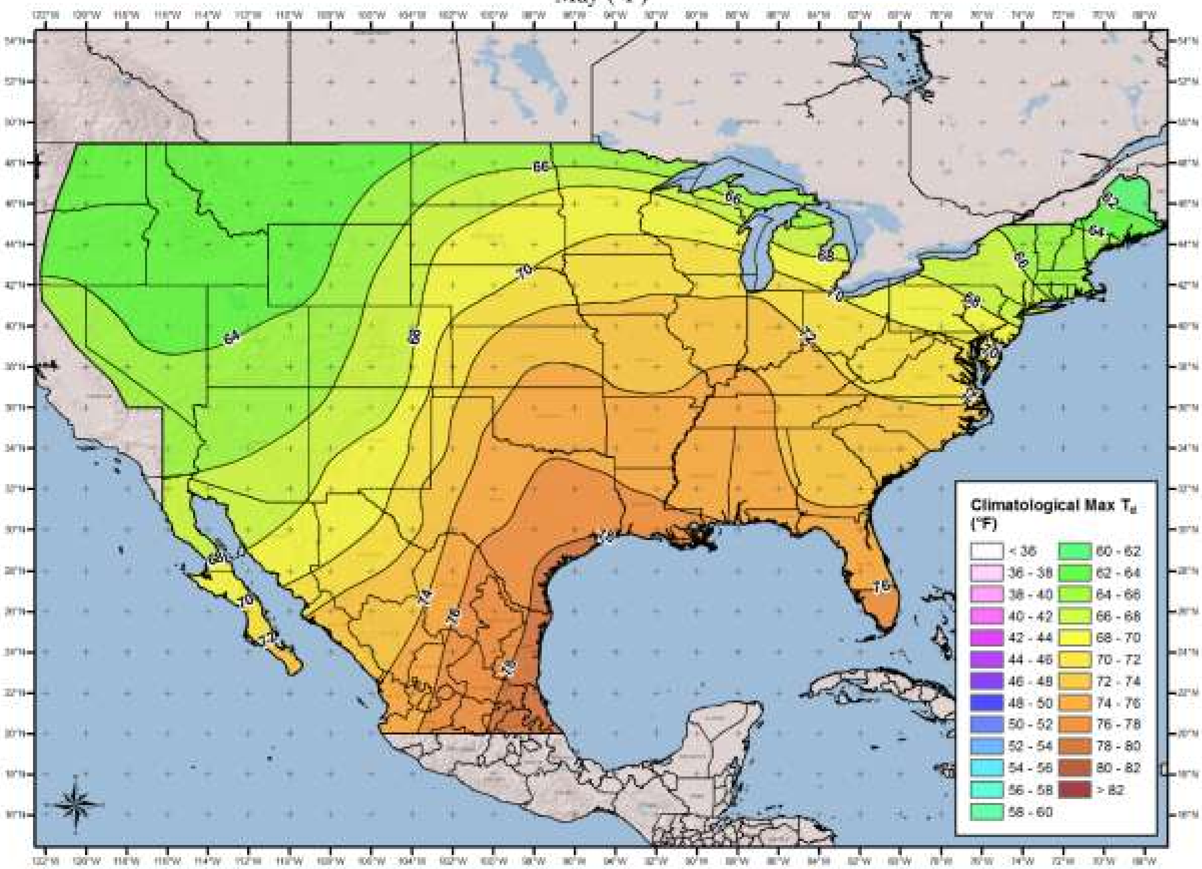
100-year Return Frequency 24-hour Maximum Dew Point Climatology
March (°F)



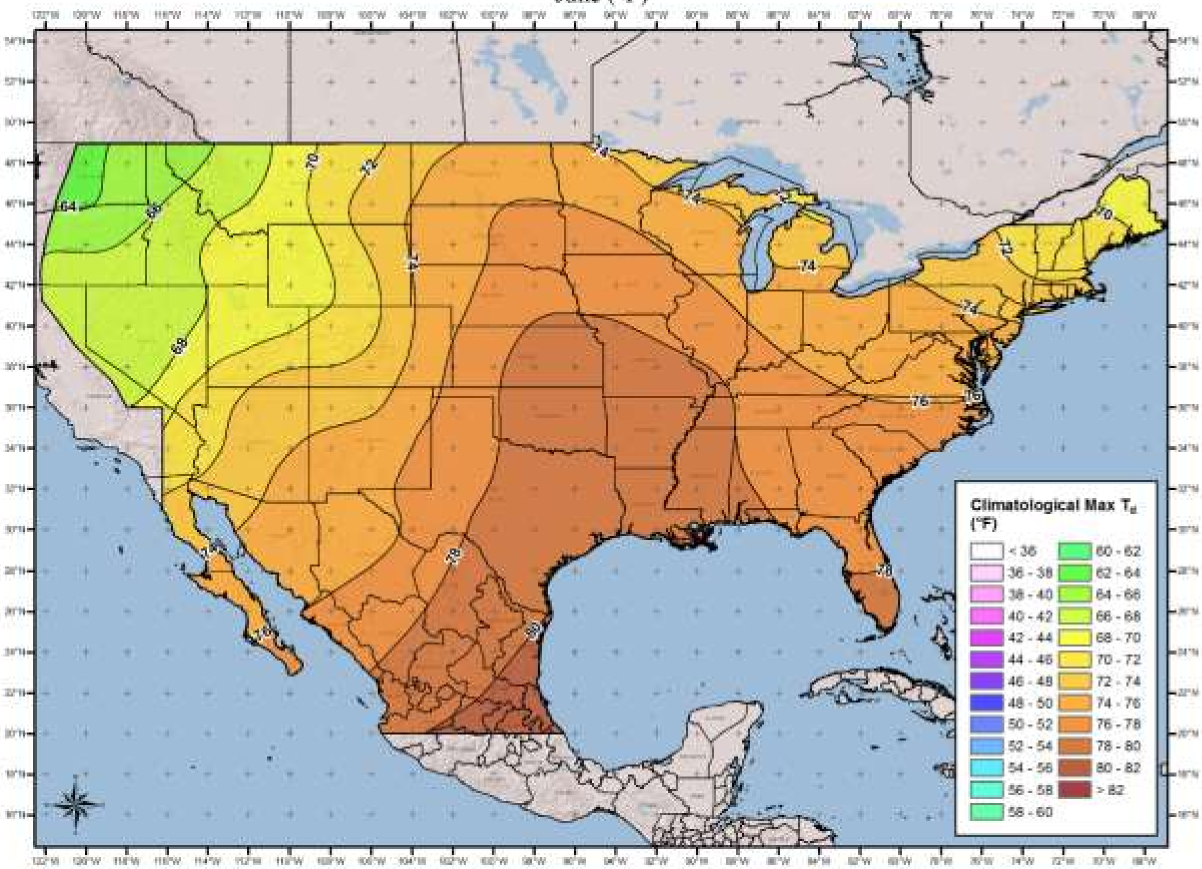
100-year Return Frequency 24-hour Maximum Dew Point Climatology
April (°F)



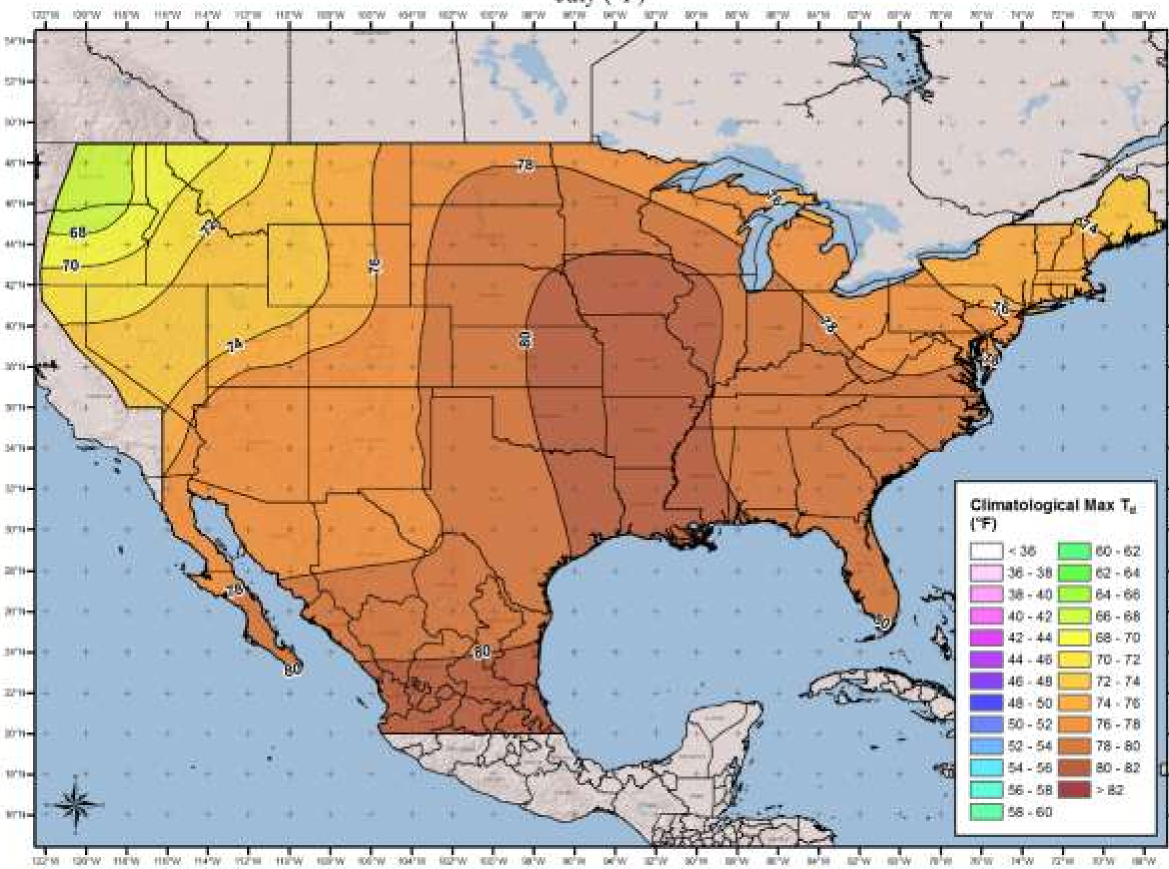
100-year Return Frequency 24-hour Maximum Dew Point Climatology
May (°F)



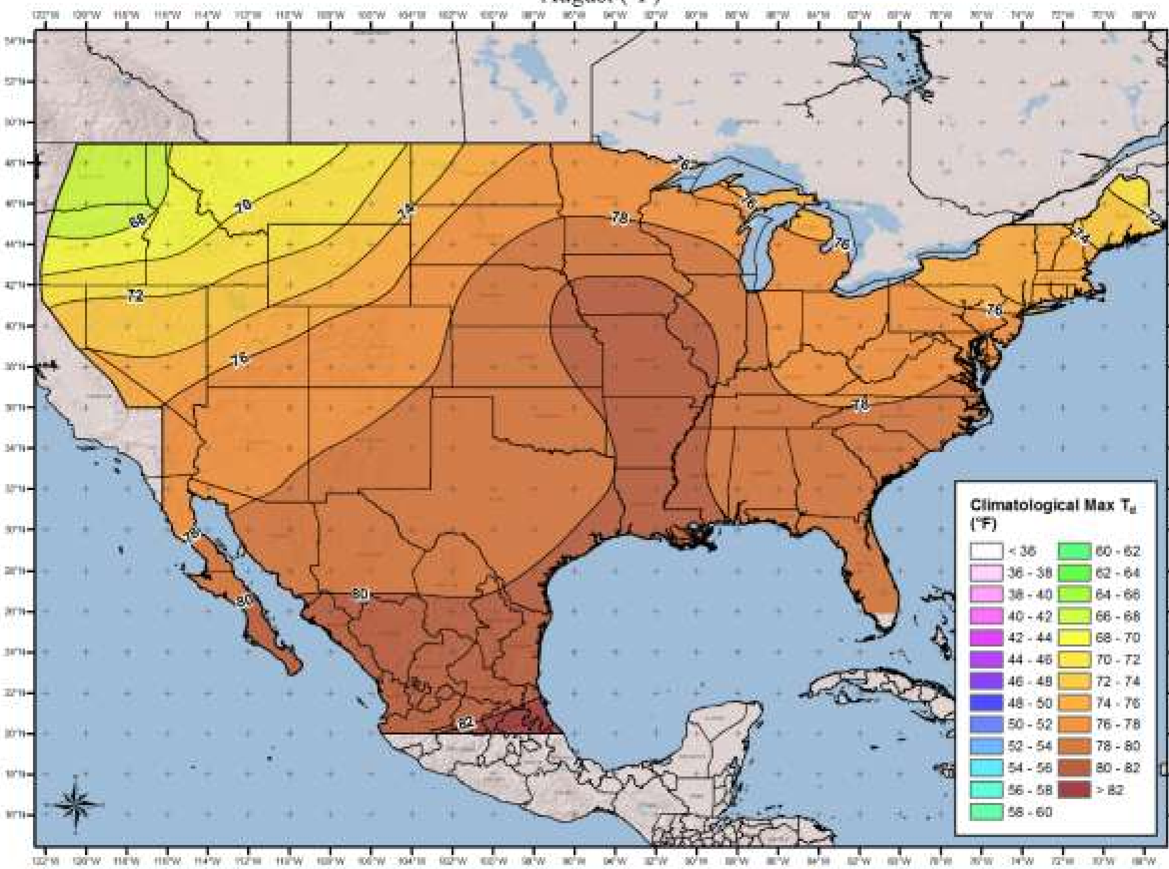
100-year Return Frequency 24-hour Maximum Dew Point Climatology
June (°F)



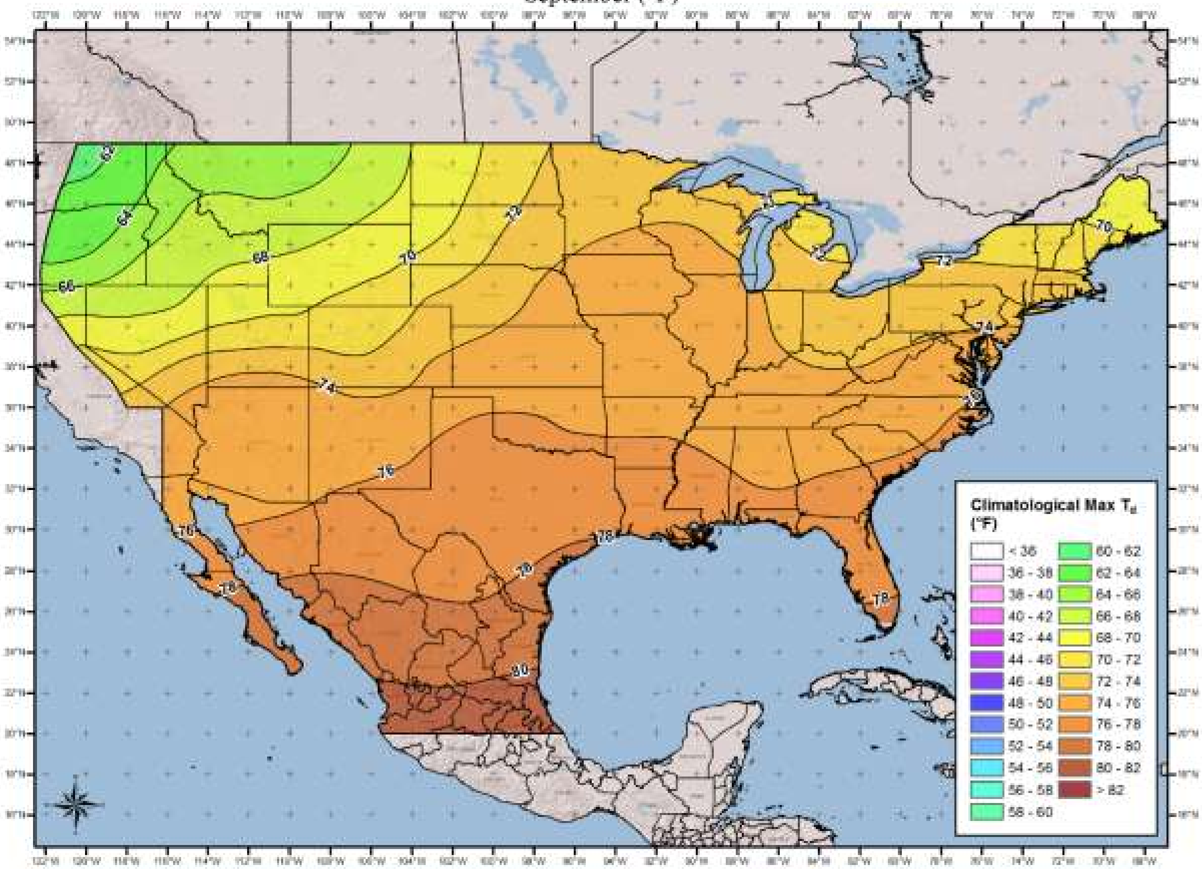
100-year Return Frequency 24-hour Maximum Dew Point Climatology
July (°F)



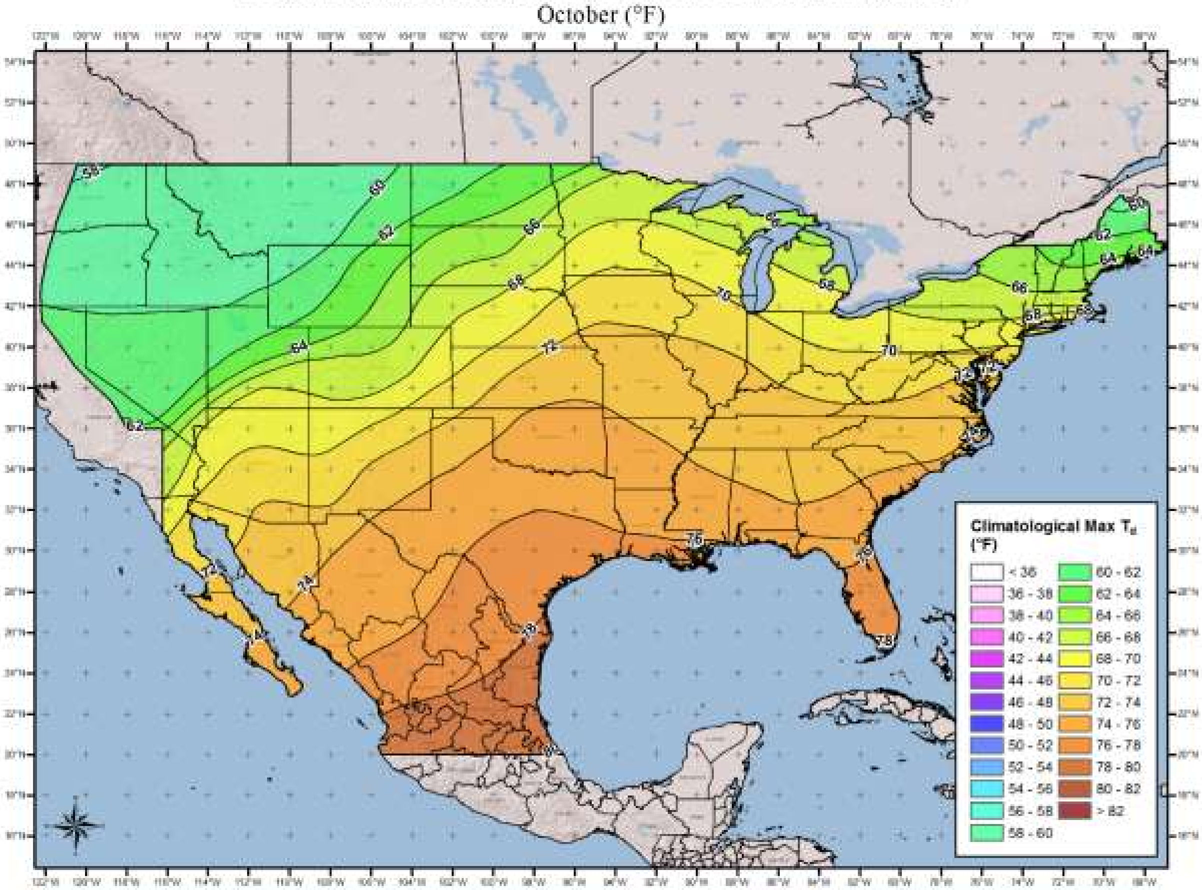
100-year Return Frequency 24-hour Maximum Dew Point Climatology
August (°F)



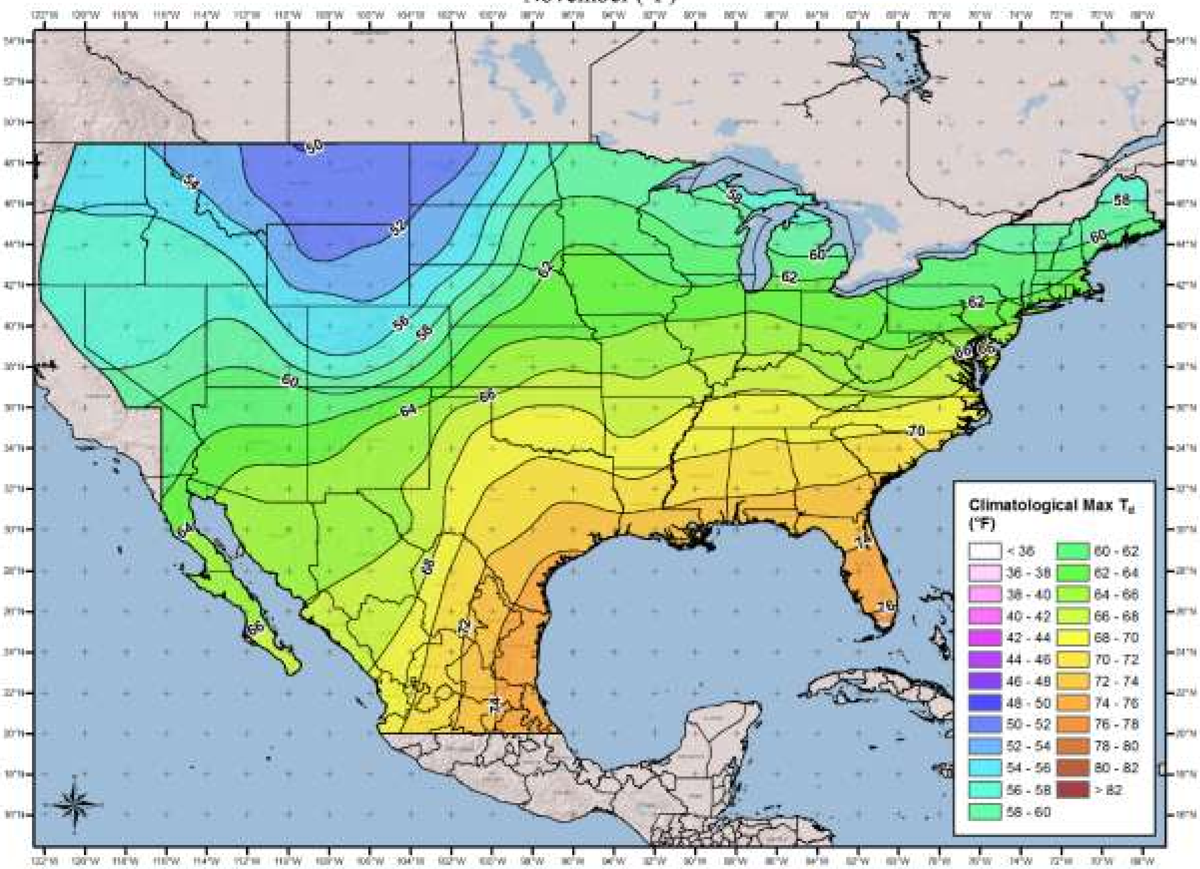
100-year Return Frequency 24-hour Maximum Dew Point Climatology
September (°F)



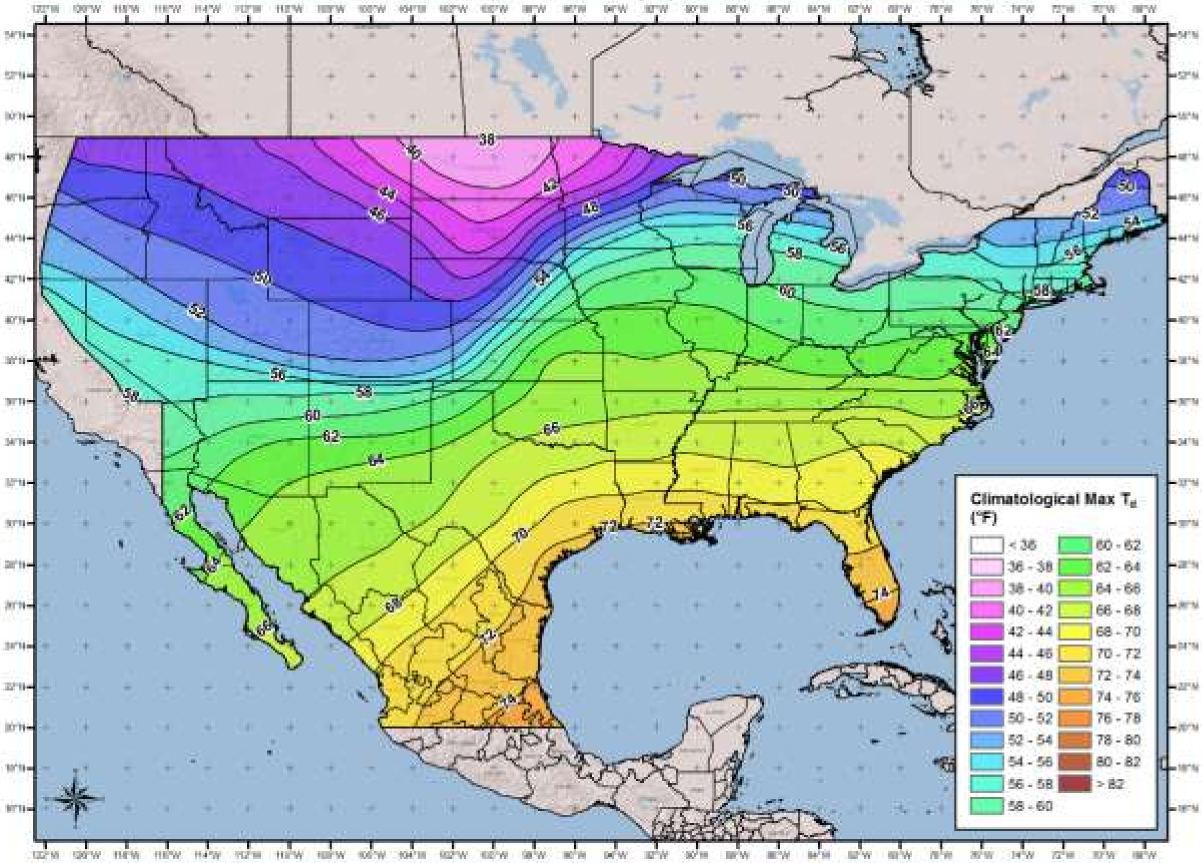
100-year Return Frequency 24-hour Maximum Dew Point Climatology
October (°F)



100-year Return Frequency 24-hour Maximum Dew Point Climatology
November (°F)



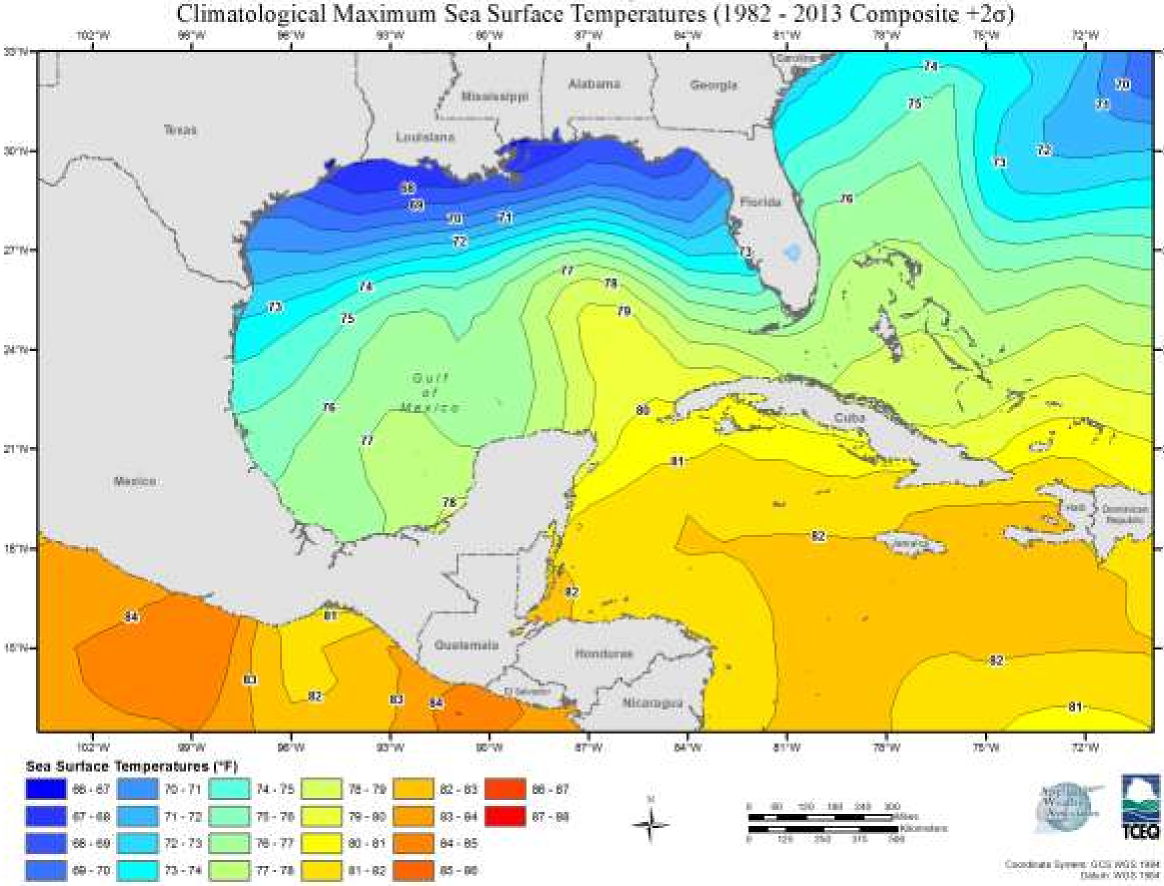
100-year Return Frequency 24-hour Maximum Dew Point Climatology
December (°F)



Appendix B
2-Sigma Sea Surface Maximum Climatology Maps

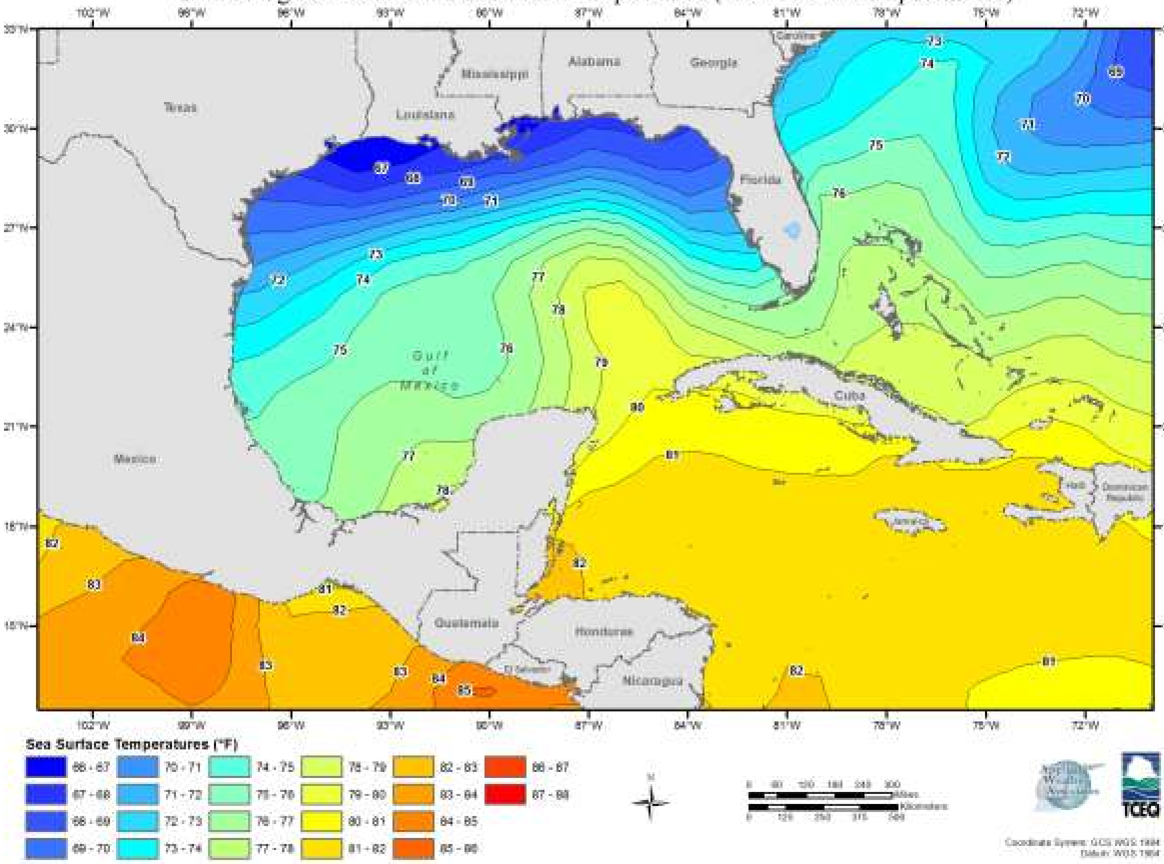
January

Climatological Maximum Sea Surface Temperatures (1982 - 2013 Composite +2σ)



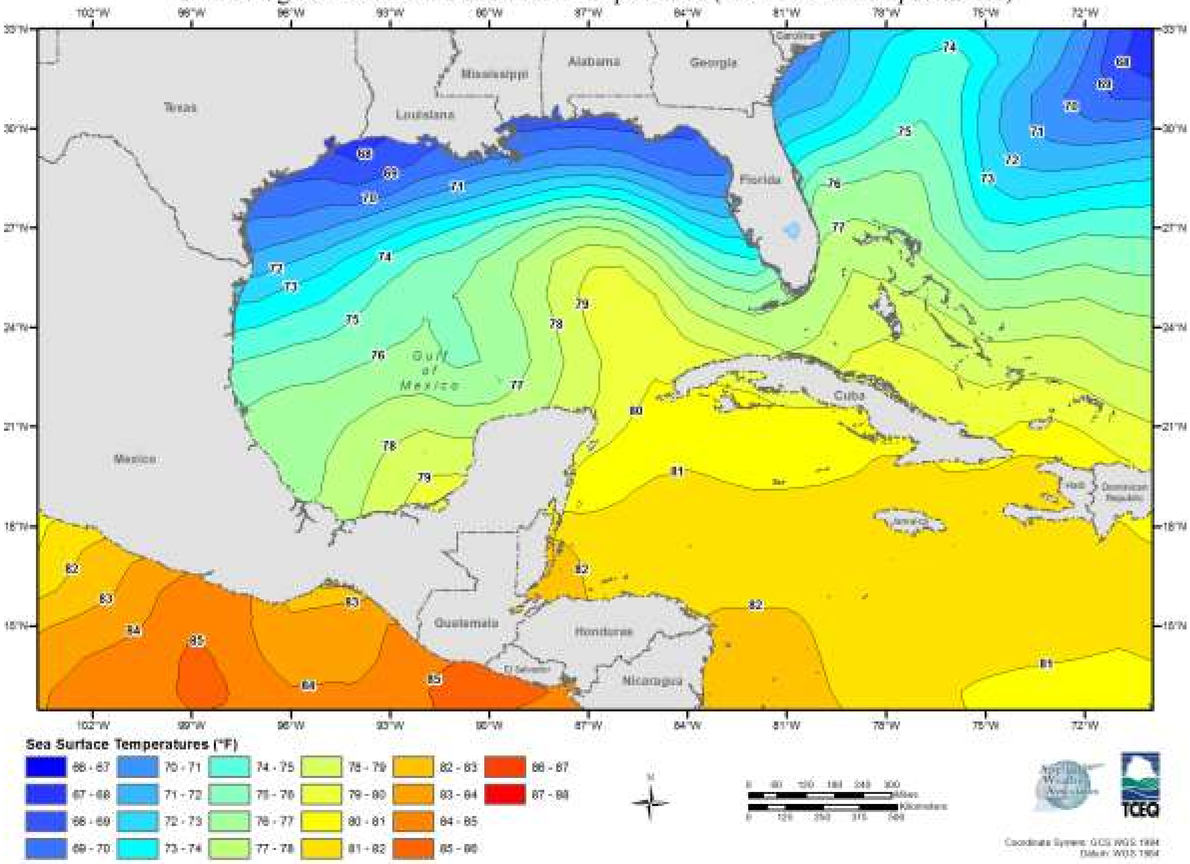
February

Climatological Maximum Sea Surface Temperatures (1982 - 2013 Composite +2σ)

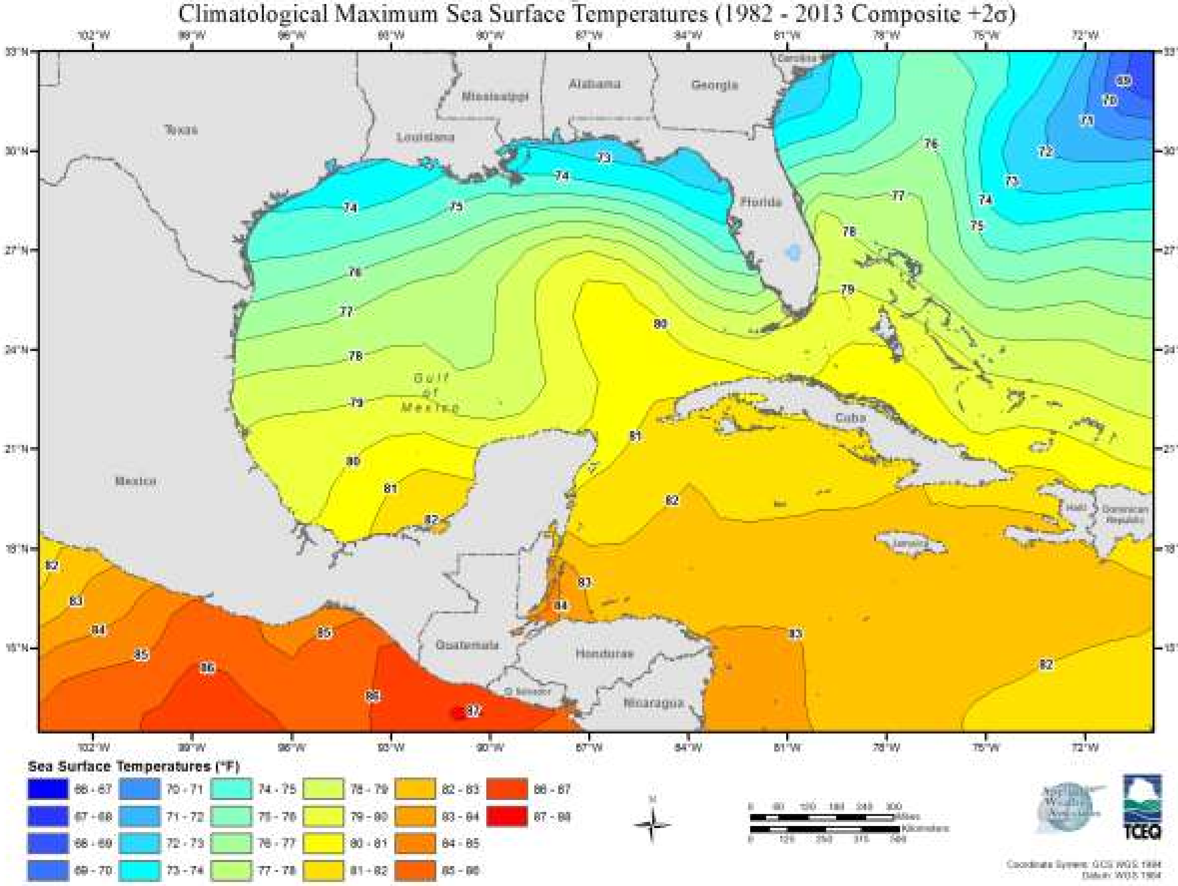


March

Climatological Maximum Sea Surface Temperatures (1982 - 2013 Composite +2σ)

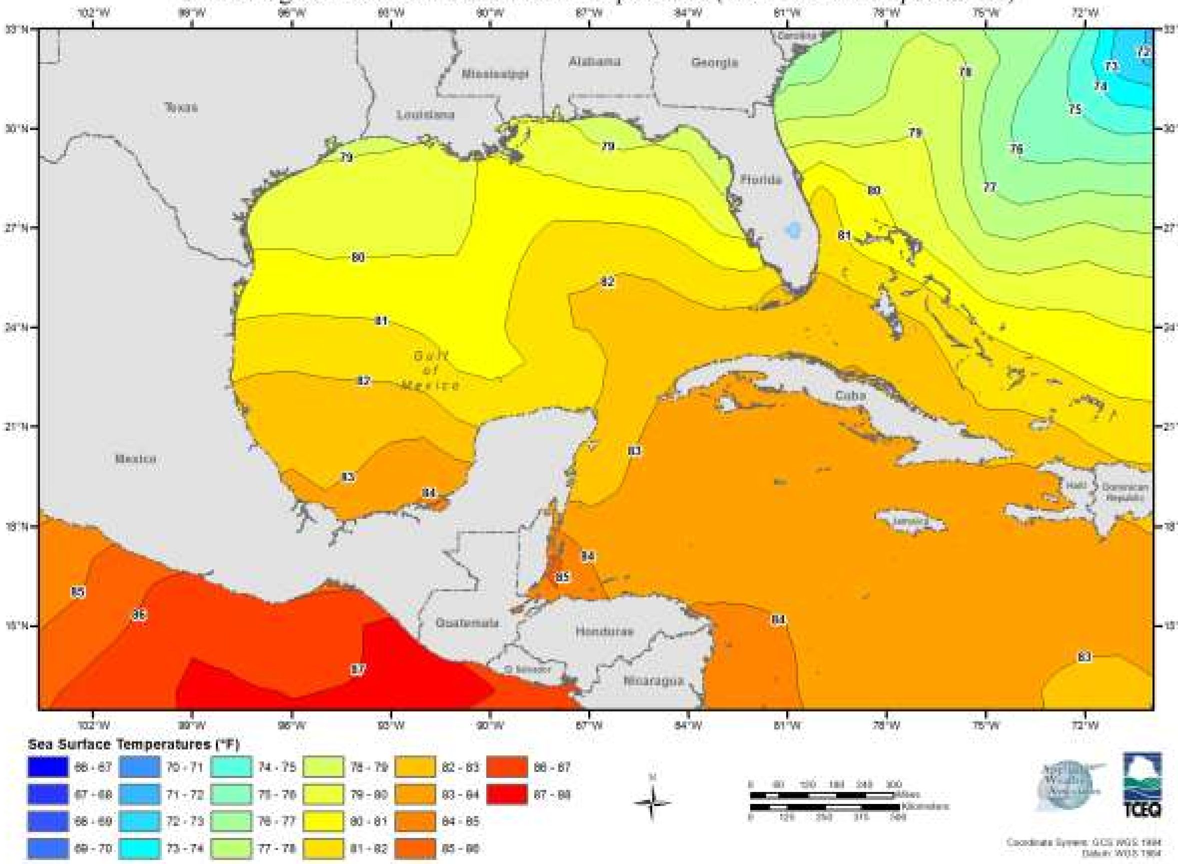


April
Climatological Maximum Sea Surface Temperatures (1982 - 2013 Composite +2σ)



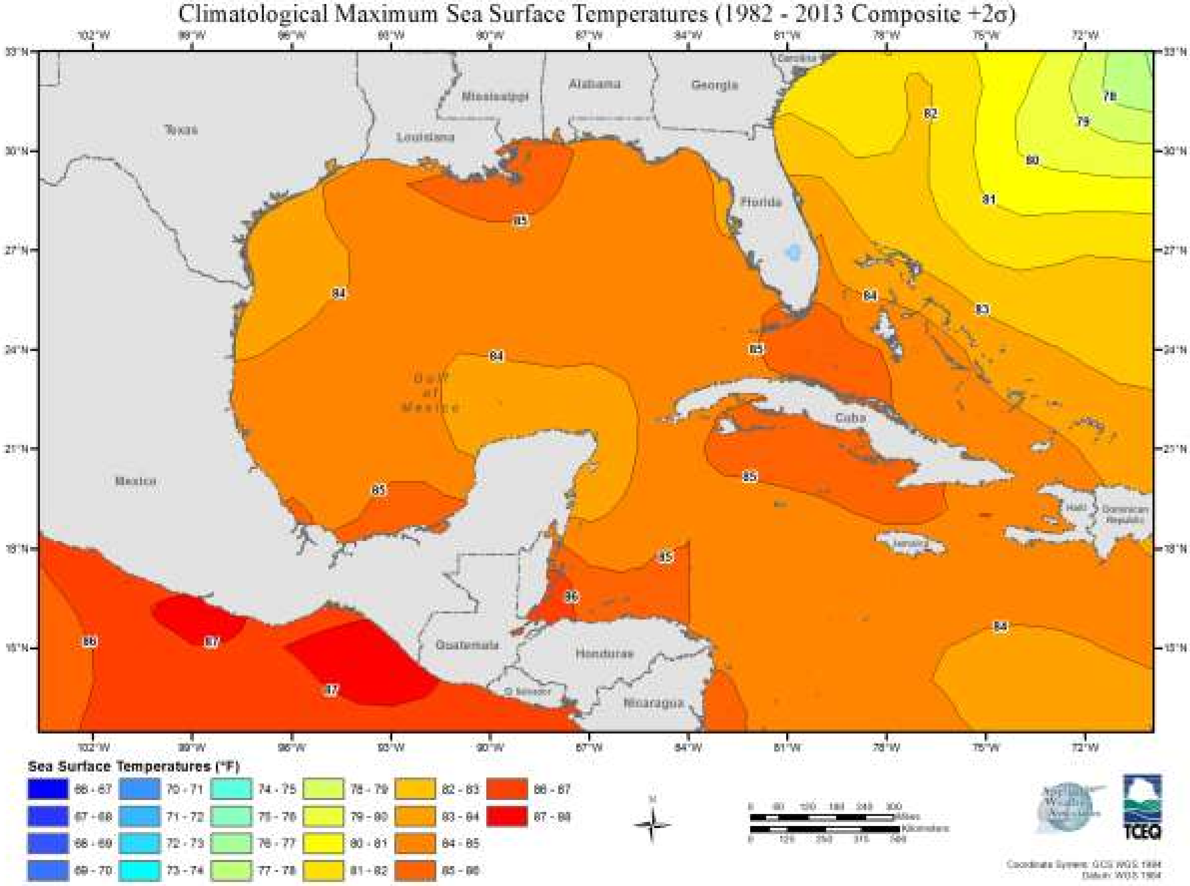
May

Climatological Maximum Sea Surface Temperatures (1982 - 2013 Composite +2σ)



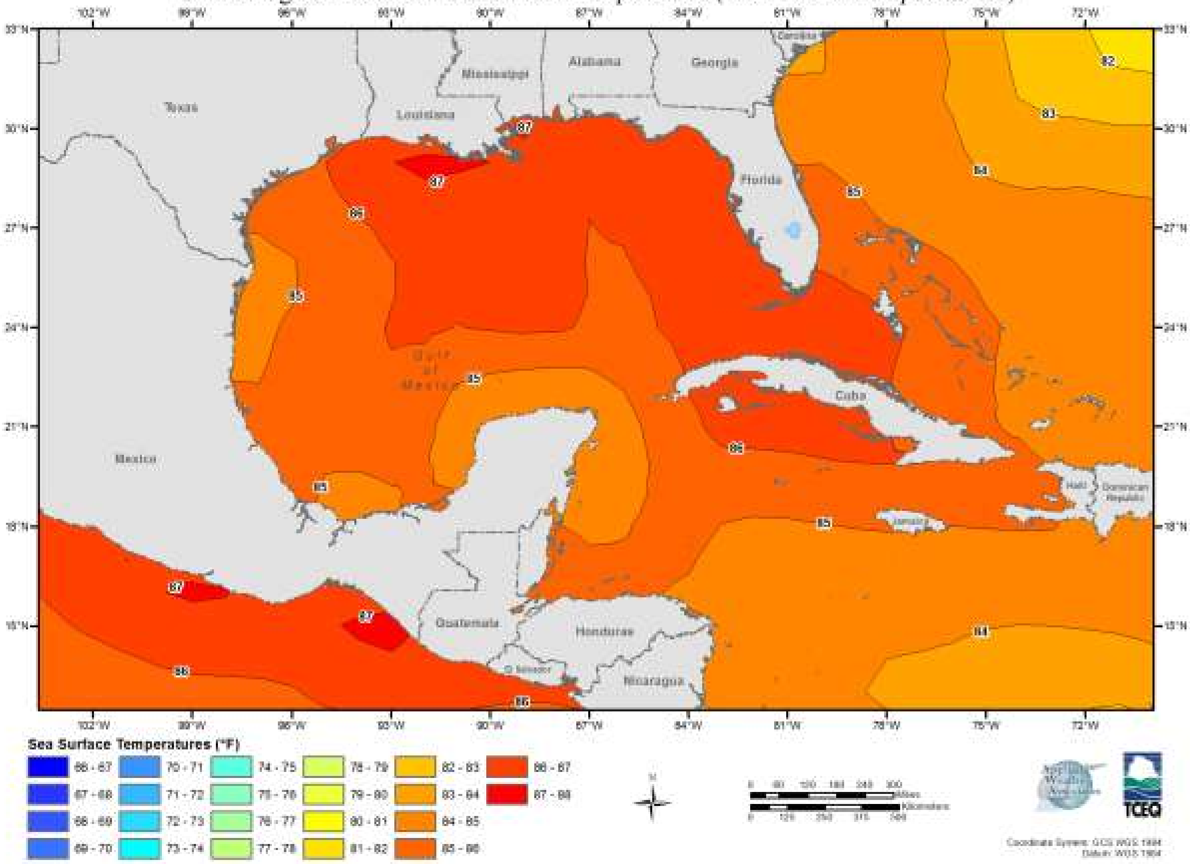
June

Climatological Maximum Sea Surface Temperatures (1982 - 2013 Composite +2σ)



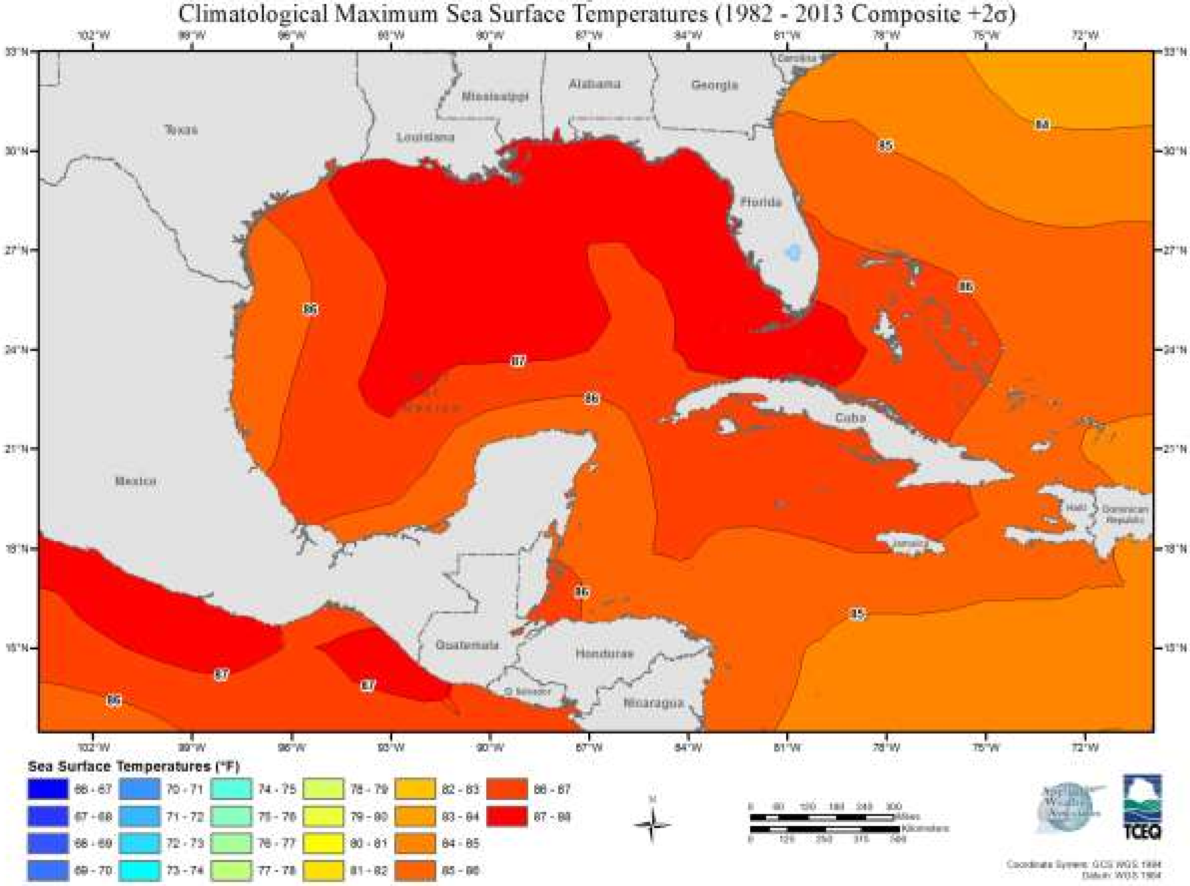
July

Climatological Maximum Sea Surface Temperatures (1982 - 2013 Composite +2σ)



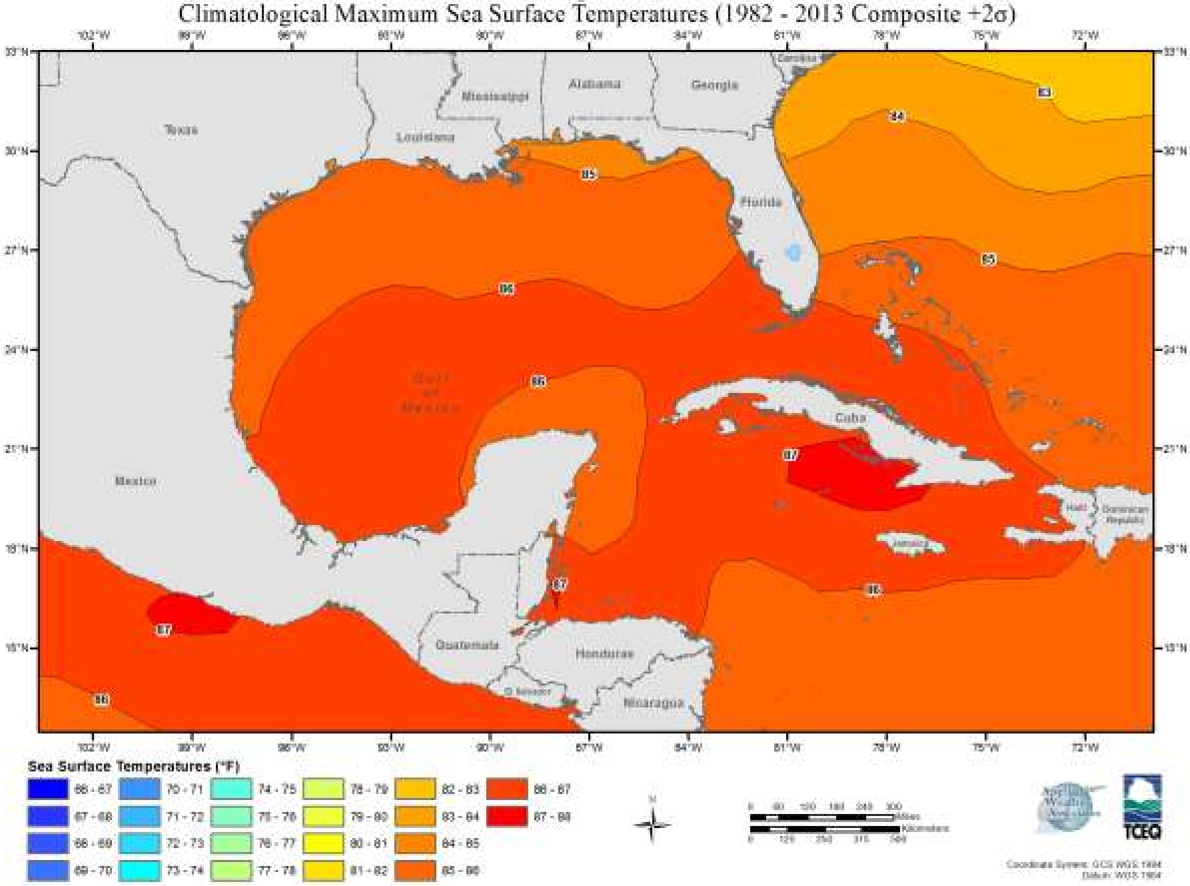
August

Climatological Maximum Sea Surface Temperatures (1982 - 2013 Composite +2σ)



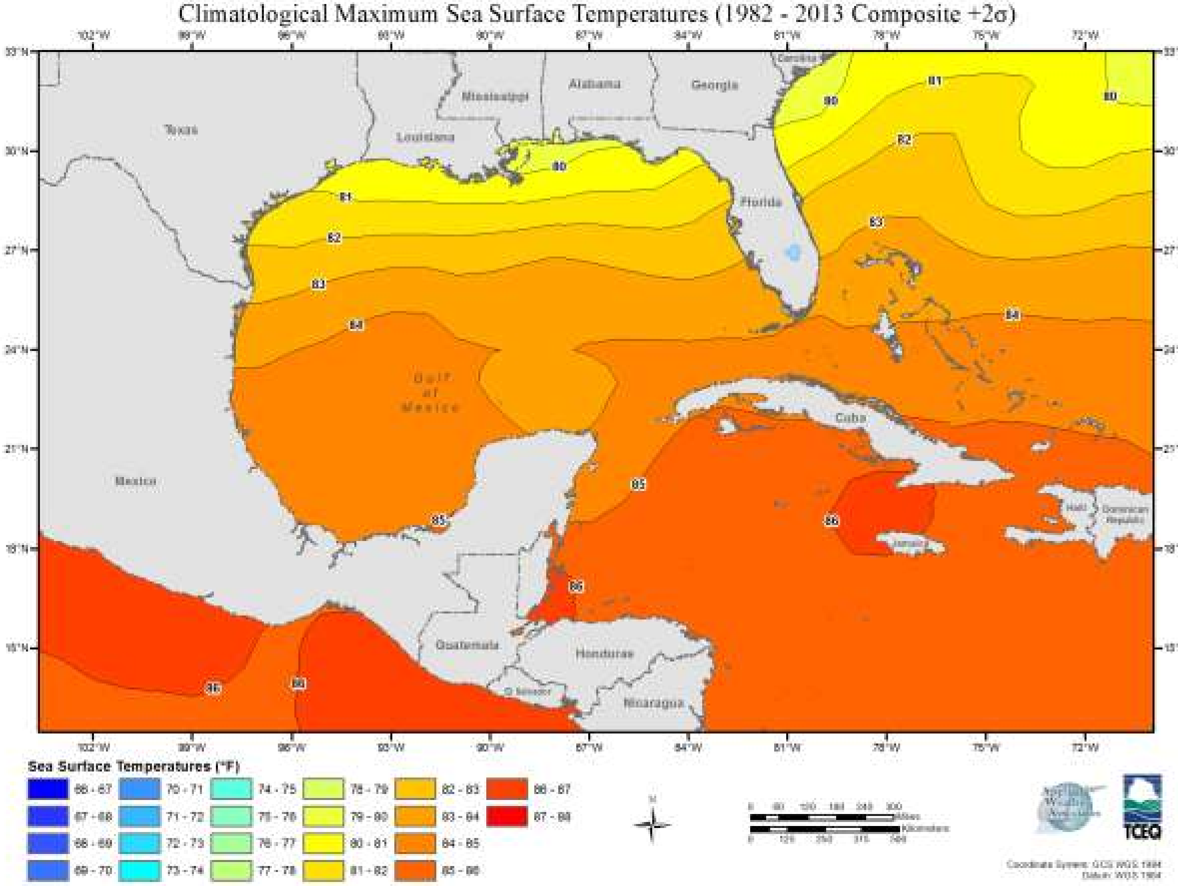
September

Climatological Maximum Sea Surface Temperatures (1982 - 2013 Composite +2σ)



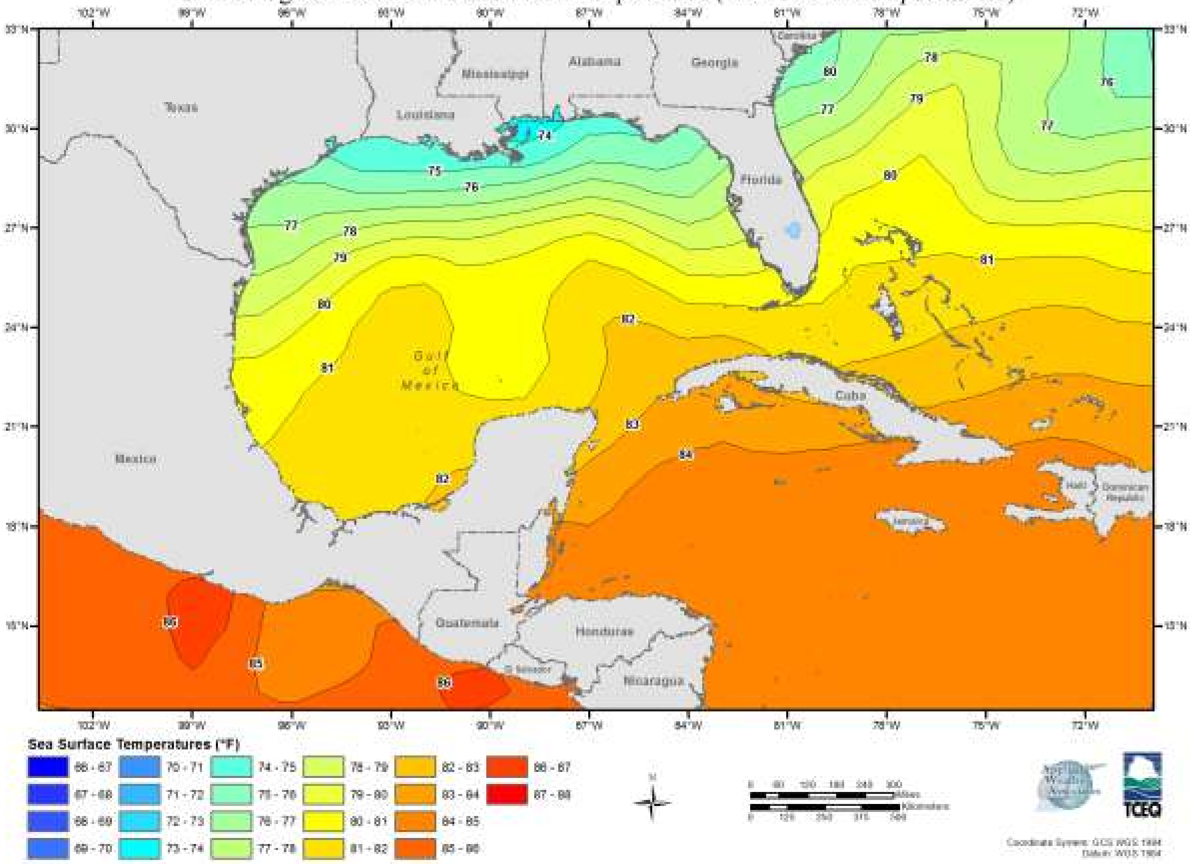
October

Climatological Maximum Sea Surface Temperatures (1982 - 2013 Composite +2σ)



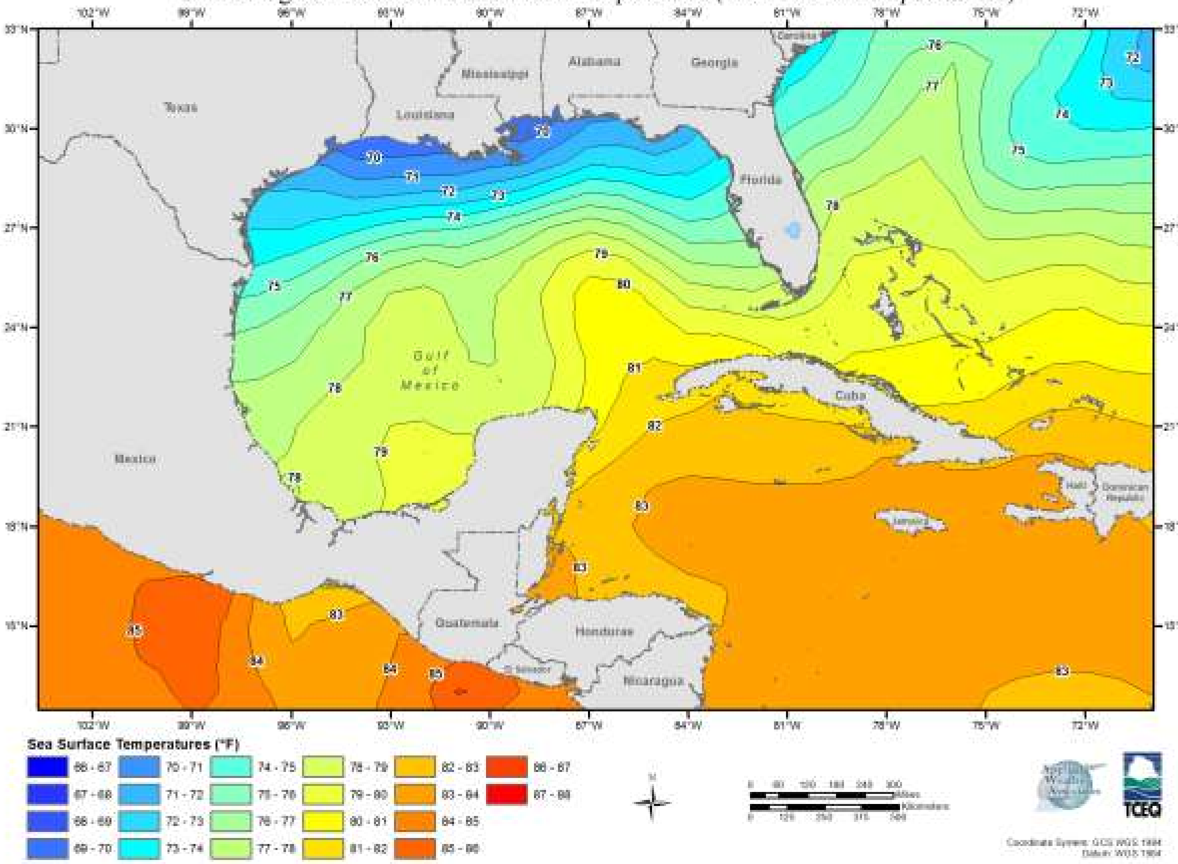
November

Climatological Maximum Sea Surface Temperatures (1982 - 2013 Composite +2σ)



December

Climatological Maximum Sea Surface Temperatures (1982 - 2013 Composite +2σ)



Appendix C
Precipitation Frequency Development Background[1] and Final Maps

[1] AWA would like to acknowledge the work performed by Metstat, Inc., providing significant support in the development of the updated precipitation frequency climatology described here.

Table of Contents

OVERVIEW

This document describes the methodology and results of an all-season regional rainfall frequency analysis for the 6- and 24-hour durations across the state of Texas and adjacent Probable Maximum Precipitation (PMP) domain. The purpose of this project was to produce 06- and 24-hour 2-, 5-, 10-, 25-, 50-, 100-, 200-, 500- and 1000-year Average Recurrence Interval (ARI) precipitation estimate maps/grids for Texas. The motivation of this project was to produce updated 100-year rainfall frequency estimates to optimize the transposition and maximization of storms for a PMP study, especially in orographically influenced areas where the Proportionality Constant and resulting Orographic Transposition Factor will be utilized. Metstat, Inc provided significant assistance in the development of the updated precipitation frequency climatology.

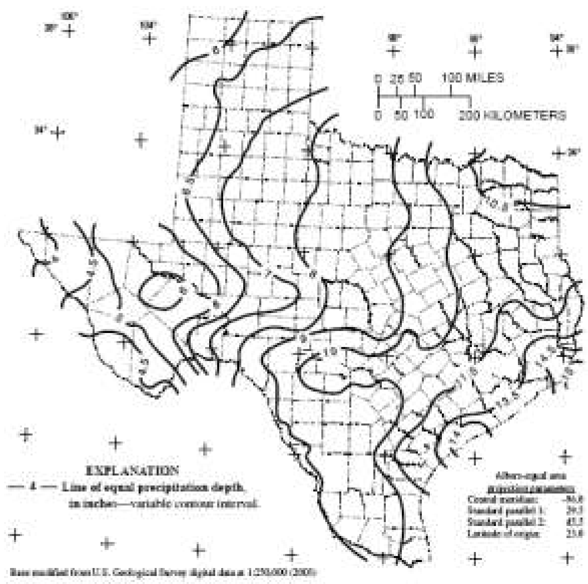


Figure 1. Isopluvials of 100-year 24-hour precipitation in tenths of an inch from Asquith and Roussell (2004).

This project provides an update of the 6- and 24-hour estimates contained in *Update Atlas of Depth-Duration Frequency of Precipitation Annual Maxima for Texas* (Asquith and Roussell, 2004) which supersedes Technical Paper 40 (Hershfield, 1961). The 100-year 24-hour isohyets from Asquith and Roussell (2004) are shown in Figure 1, which was based on precipitation data collected through 1994, while this project includes precipitation data collected through 2014. This represents 20 years of additional data. Table 1 also shows the station counts between the two projects. Both projects used data from the National Weather Service, but this analysis also incorporated data from the United States Geological Survey (USGS), National Resources Conservation Service (NRCS), Texas Water Development Board (TWDB), Remote Automatic Weather Stations (RAWS), and data in Mexico. The USGS data were included to supplement the data density for the 6-hour duration (and not the 24-hour) where an increase in station density was more necessary. The number of hourly stations used in the Asquith study for the 24-hour duration may include hourly stations co-located with daily stations which are removed in the count of stations for this analysis, therefore the hourly station count for Asquith's 24-hour duration is approximated.

Table 1. Numbers of stations used in this analysis and in the previous study (Asquith, 1998).

Duration	Recording Increment	Asquith (1998)	This Analysis
6-hour	Hourly	274	493
24-hour	Hourly	~274	249
	Daily	865	1082

In recent years, several statistical and spatial interpolation advancements have been developed to increase the reliability of the results, particularly across complex terrain. This project approach closely follows procedures and conventions used by NOAA's National Weather Service Hydrometeorological Design Studies Center in developing NOAA Atlas 14, thereby instilling consistency between this analysis and NOAA Atlas 14 (Bonnin et al. 2004, 2006a, 2006b; Perica et al. 2009a, 2009b, 2011).

The regional frequency analysis approached utilizes L-moments, which decreases the uncertainty of rainfall frequency estimates for rarer events and dampens the influence of outlier precipitation amounts from extreme storms. Meanwhile and similar to NOAA Atlas 14, a climatologically-aided spatial interpolation approach was used to distribute the at-site rainfall frequency estimates across Texas, thereby accounting for micro-climates, orographics and other terrain driven spatial patterns of rainfall. Each of these important project elements are discussed in detail below.

Given the purpose of this project was to produce 6- and 24-hour rainfall grids for use in a PMP project for Texas, a few customary components of a standard rainfall frequency project were not included in this project. Those include:

- Areal reduction factors (ARFs) – ARFs are used to convert point rainfall frequency values into areal rainfall frequency estimates. Since this conversion results in lower rainfall frequency estimates, the term "reduction" is part of the terminology. ARFs are recognized as an important component in applying and utilizing rainfall frequency estimates; however, the development of ARFs was beyond the scope of this project.

- Temporal distributions –Together with rainfall frequency estimates, temporal distributions of precipitation are used to compute a "design storm." To compute temporal distributions, it is necessary to distribute the rainfall for the critical storm duration into hourly values for purposes of hydrologic modeling. Refer to the Hydrologic and Hydraulic Guidelines for Dams in Texas (Texas Commission on Environmental Quality, 2007) and Summary of Dimensionless Texas Hyetographs and Distribution of Storm Depth (Asquith et al., 2005) for additional information regarding temporal distributions in Texas. Temporal variations of the PMP rainfall will be determined as part of the PMP development using the actual storm data and after discussions with the hydrologists, engineers, and other end users of this data.

- Seasonality – Given the date of occurrence of each annual maximum at each station, monthly and seasonal histograms (as shown in Figure 4) of extreme rainfall can be summarized. Seasonality statistics can be helpful for ascertaining the likelihood of when extreme events occur throughout the year. Although seasonality was considered for purposes of dividing the stations into homogenous regions, a comprehensive summary of the results was not prepared.

- Other durations – Given the 6-and 24-hour durations were the critical durations for purposes of storm transposition and maximization for the PMP project, other durations where not considered in this project.

PROJECT AREA

Although Texas is the area of interest, the project analysis area included roughly 1 degree or 69 miles (111 km) buffer beyond the Texas watersheds to provide adequate data along the border regions and include basins extending beyond the Texas state-line. Accordingly, the project area included portions of Arkansas, Colorado, Louisiana, New Mexico, Oklahoma, and Mexico. The project area was defined by five longitude/latitude boxes (purple boxes in Figure 2) to provide adequate coverage without including extraneous stations. From west to east, the southwest corner to northeast corner of the boxes are: (1) 25.1°N, 108.9°W to 34.5°N, 105.4°W; (2) 25.1°N, 105.4°W to 37.9°N, 103.8°W; (3) 23.9°N, 103.8°W to 37.9°N, 99.0°W; (4) 24.7°N, 99.0°W to 35.5°N, 96.1°W; (5) 27.6°N, 96.1°W to 35.0°N, 92.4°W.

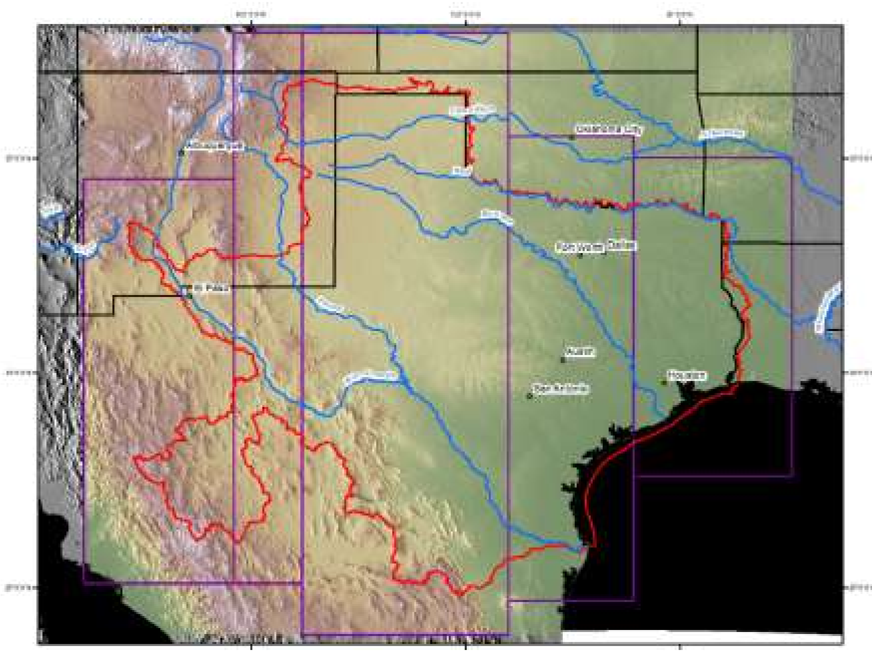


Figure 2. Texas terrain and precipitation frequency project area (purple boxes).

METEOROLOGY AND CLIMATOLOGY OF PROJECT AREA

Mean annual precipitation (MAP) was used to characterize the general climate and meteorology of Texas. Gridded MAP from PRISM (Parameter-elevation Regressions on Independent Slopes Model) developed by Oregon State University (Daly et al., 1997 and 2002) for the United States and from the United States Department of Agriculture (USDA) for North America (USDA Forest Service/RMRS/Moscow Forestry Sciences Laboratory; http://forest.moscowfsl.wsu.edu/climate/current/) were used in this project. The PRISM MAP grid represents a 30-year climatological mean for the period 1961-1990 and the USDA grid represents the period 1961-1990. The PRISM grids are at a spatial resolution of ~800 meters and the USDA grids were 1 kilometer. The PRISM grid covering the United States and the USDA grid covering Mexico were merged to create a seamless coverage (Figure 3). Discontinuities at the borders of the grids were minimal to nonexistent, therefore no spatial smoothing was necessary. The 800 meter resolution was adopted as the spatial resolution of this project's final grids.

In general, mean annual precipitation gradually increases across the state from west to east. Elevation steadily decreases from mountains in the west to the coast in the east. Temperatures vary from cooler in the north to warmer in the south. Snowfall is only observed in the north and western parts of the state (and considered insignificant to hydrologic applications, therefore inherently not included in this analysis). Winter may deliver snow to the north and western regions of Texas, ice to the northeast and central regions, and usually rain elsewhere. Coastal influence creates more humid and mild climates in the east.

The Gulf of Mexico is the primary moisture-source of rainfall-producing storms across Texas. Warm air from Mexico can create a capping inversion over the humid air from the Gulf, however a frontal system or dry-line can disrupt this and allow for severe convection (thunderstorms) to occur in central and southern Texas. Most severe weather (including tornadoes and hail) occurs in the spring due to the interaction between the moist air from the Gulf and the cooler, drier air from the west. Other air mass sources include the arctic which delivers cold, dry air along the Rocky Mountains into northern Texas. Lastly, tropical cyclones can deliver a year's worth of total rainfall to some areas but are inconsistent from year to year; these primarily originate from the Gulf but occasionally storms cross over into Texas from the Pacific Ocean.

May is generally the wettest month of the year across Texas as a whole. In summer, (June-August) floods are most common from Mesoscale Convective Complexes (MCCs), stalled fronts and/or tropical systems. In fact, western sections of Texas receive most of their rain from afternoon thunderstorms. However, high temperatures during the summer can lead to increased evaporation which can lead to drought conditions. During the fall, more cold fronts from the north traverse Texas. Fall is also when tropical systems can impact the area from the Gulf which can sometimes make September the wettest month of the year across eastern and southern sections of Texas.

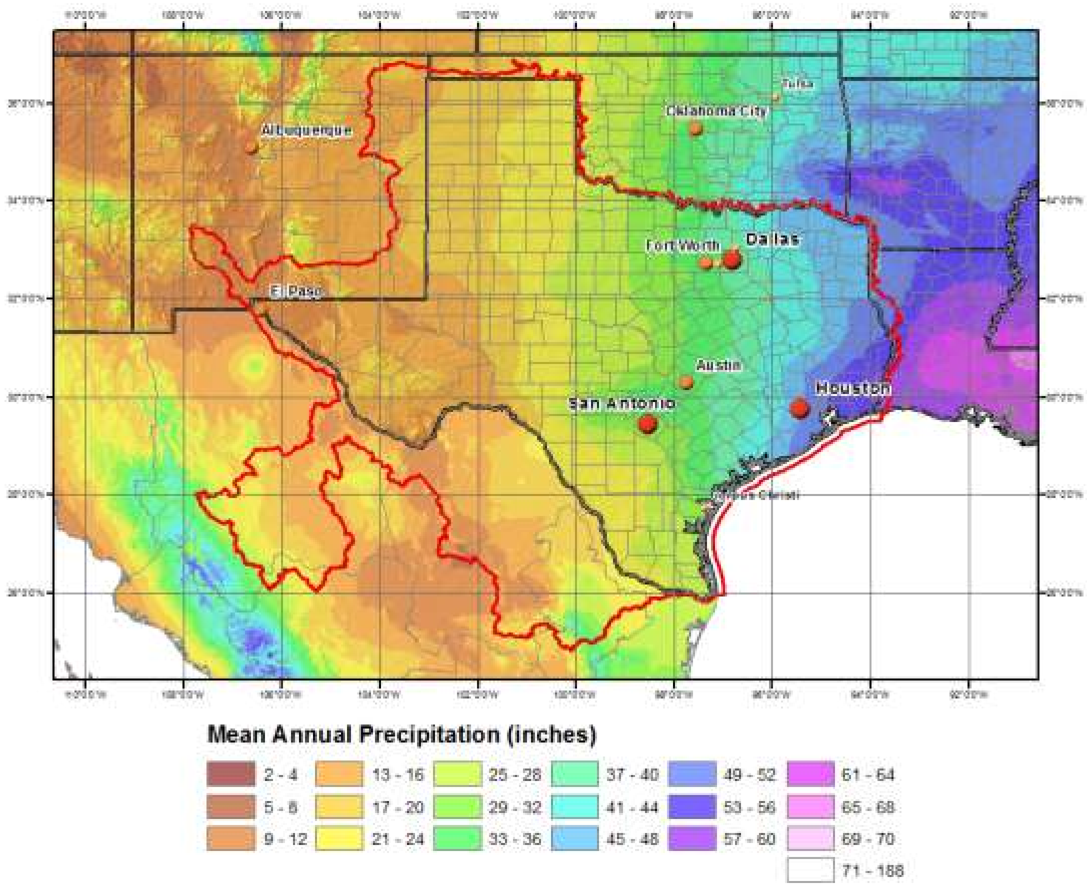


Figure 3. Mean (1961-1990) Annual Precipitation for Texas and adjacent portions of nearby states (Daly, 1994) and Mexico (USDA Forest Service/RMRS/Moscow Forestry Sciences Laboratory; http://forest.moscowfsl.wsu.edu/climate/current/).

DATA SOURCES

The primary source of daily rainfall gauge data for the 24-hour analysis was the National Weather Service (NWS) Cooperative Observer Program's (COOP) station data obtained from National Oceanic and Atmospheric Administration's (NOAA) National Climatic Data Center (NCDC) which has been operating since the late 1800s. The COOP data are collected and recorded daily. For the 6- and 24-hour analysis, we primarily utilized hourly reporting data from NCDC's Hourly Precipitation Data set.

Although data from NOAA represented the primary data sources, additional sources provided data as listed in Table 2 and Table 3. The tables also show the number of stations collected and used after screening. Station screening is discussed in the next section but the primary reason for omitting a station was that it did not meet the minimum number of data years (i.e., each station must have at least15 years of data to be used). The average data length of stations used in the 24-hour analysis was 50 years (ranging from 15 to 123 years); the average data length of stations used in the 6-hour analysis was 43 years (ranging from 15 to 72 years).

Table 2. List of data sources and number of stations collected and used (after screening) for the 6-hour rainfall frequency analysis.

Data set name	Data set source	Number of stations collected	Number of useable stations
NCDC TD-3240 (U.S. Hourly Precipitation Data)	National Climatic Data Center (NCDC)	599	406
Mexico Surface Data	National Weather Service (personal communication)	10	4
Soil Climate Automated Network (SCAN)	Natural Resources Conservation Service (NRCS)	8	0
United States Geological Survey (USGS)	United States Geological Survey (USGS)	613	65
Remote Automatic Weather Stations (RAWS)	National Interagency Fire Center, Western Region Climate Center	63	18
Total		**1,293**	**493**

Table 3. List of data sources and number of stations collected and used (after screening) for the 24-hour rainfall frequency analysis.

Data set name	Data set source	Formatted reporting interval	Number of stations collected	Number of useable stations
DSI-3200 (U.S. Cooperative Summary of the Day Data); DSI-3206 (U.S. Cooperative Summary of the Day Data - Pre-1948)	National Climatic Data Center (NCDC)	1-Day	1,816	1,019
Global Historical Climatology Network (GHCN)	National Climatic Data Center (NCDC)	1-Day	68	21

19th Century Forts and Voluntary Observers Database	Midwestern Regional Climate Center	1-Day	52	18
Soil Climate Automated Network (SCAN)	Natural Resources Conservation Service (NRCS)	1-Day	8	1
Snow Telemetry (SNOTEL)	Natural Resources Conservation Service (NRCS)	1-Day	9	5
Texas Water Development Board	Texas Water Development Board	1-Day	53	18
NCDC DSI-3240 (U.S. Hourly Precipitation Data)	National Climatic Data Center (NCDC)	1-Hour	608	249
Total			**2,614**	**1,331**

DATA SCREENING AND QUALITY CONTROL

Annual Maximum Series Extraction

Consistent with the Hosking and Wallis regional frequency analysis approach, the annual maximum series (AMS) was used as the statistical basis for computing the rainfall frequency estimates for a variety of annual exceedance probabilities (AEPs). However, rainfall frequency estimates can be obtained by analyzing an AMS or partial duration series (PDS); the PDS is also commonly referred to as the "peaks over threshold" method and provide estimates for average recurrence intervals (ARIs) whereas the AMS is the greatest rainfall amount for each 12-month period for a specified duration for each year in a station's period of record. For this project, we utilized the calendar year, January 1st through December 31st as the 12 month period from which to extract the 6- and 24-hour AMS. Consistent with NOAA Atlas 14 and most published precipitation frequency projects, this project is based on precipitation which includes rain and snow water equivalent. However, in the Texas project area it was assumed that all maximum 6- and 24-hour observations represented rainfall events and no systematic screening of observations was made to ensure rainfall-only. Even so, the majority (88%) of all 89,488 annual maxima in the 24-hour analysis occurred in non-winter months (March through November).

AMS inherently excludes heavy rainfall events that occur in the same year, regardless of whether they exceed maximum events of other years. PDS however, includes all amounts for a specified duration at a given station above a pre-defined threshold regardless of year; a PDS can include more than one event from any particular year. A PDS- and AMS-based analysis will result in slightly different rainfall frequency magnitudes, especially for average recurrence intervals less than about 15 years, otherwise the differences are negligible. These differences may be important depending on the application, and since the PDS can potentially include more than one event in any particular year, the results from a PDS-based analysis are regarded as more suitable for designs based on more frequent events. In order to be consistent with NOAA Atlas 14 and the regional frequency analysis procedure outlined by Hosking and Wallis, this project computed rainfall frequency estimates based on AMS data, but then converted the results to PDS-based estimates using Langbein's formula shown in Equation 1 (Langbein, 1949). Langbein's formula transforms PDS-based average recurrence intervals (ARIs) to annual exceedance probabilities (AEPs):

Equation 1. Langbein's formula. $$AEP = 1 - \exp\left(-\frac{1}{ARI}\right)$$

Applying this equation provided the conversion factors shown in Table 4 for converting the AEP values into ARI values.

Table 4. AEP to ARI conversion factors.

Frequency	AEP to ARI Conversion Factor
1-year	1.5820
2-year	1.2707
5-year	1.1033
10-year	1.0508
20-year	1.0252
50-year	1.0100
100-year	1.0050
200-year	1.0025
500-year	1.0010
1000-year	1.0005

One-day annual maximum values were extracted from the daily database, while 6- and 24-hour annual maximum values were extracted from the hourly database. Each annual maximum was accompanied by the associated date and the percent of complete data for the corresponding year. Accumulated rainfall data were evenly distributed among the days/hours that represented the accumulation period before an annual maximum (AM) was extracted. An annual maximum was accepted from an accumulation if the accumulation period was less than two times the duration in question. For instance, a 1-day annual maximum could only be drawn from a 2-day accumulation, nothing longer.

The minimum period of record needed for a station to be included in the statistical computations of rainfall frequency estimates was 15 years. In general, an at-site frequency analysis can only accurately estimate rainfall frequency estimates at recurrence intervals equal to two times the period of record. However, the regional L-moment frequency analysis approach used in this project allows the data from a number of stations (region) to be pooled together, thereby extending reliable recurrence intervals out well beyond twice the period of record of any given station. However, the representativeness of rainfall frequency estimates is also strongly tied to the accuracy of the mean annual maximum (MAM) since the MAM is used as a scaling factor (discussed later). Errors associated with an unrepresentative mean will propagate throughout the rainfall frequency estimates. Therefore, the mean must be representative of the climatology of extreme events and not of a particularly wet or dry period at a location. The average period-of-record for the 6- and 24-hour stations used in this project were 43 and 50 years, respectively.

AMS Quality Control

Each annual maximum (AM) was evaluated rather than imposing global thresholds and automatically keeping or omitting high AM values. For instance, if the AM was verified and ranked among the highest in the period of record, then it was accepted regardless of how much data was missing during the given year. Thorough quality control of the AMS data was conducted via evaluation of the annual maximum time series and other screening plots at each station using LRAP (L-Moment Regional Analysis Program - MGS Software, LLC, 2011). See Figure 4.

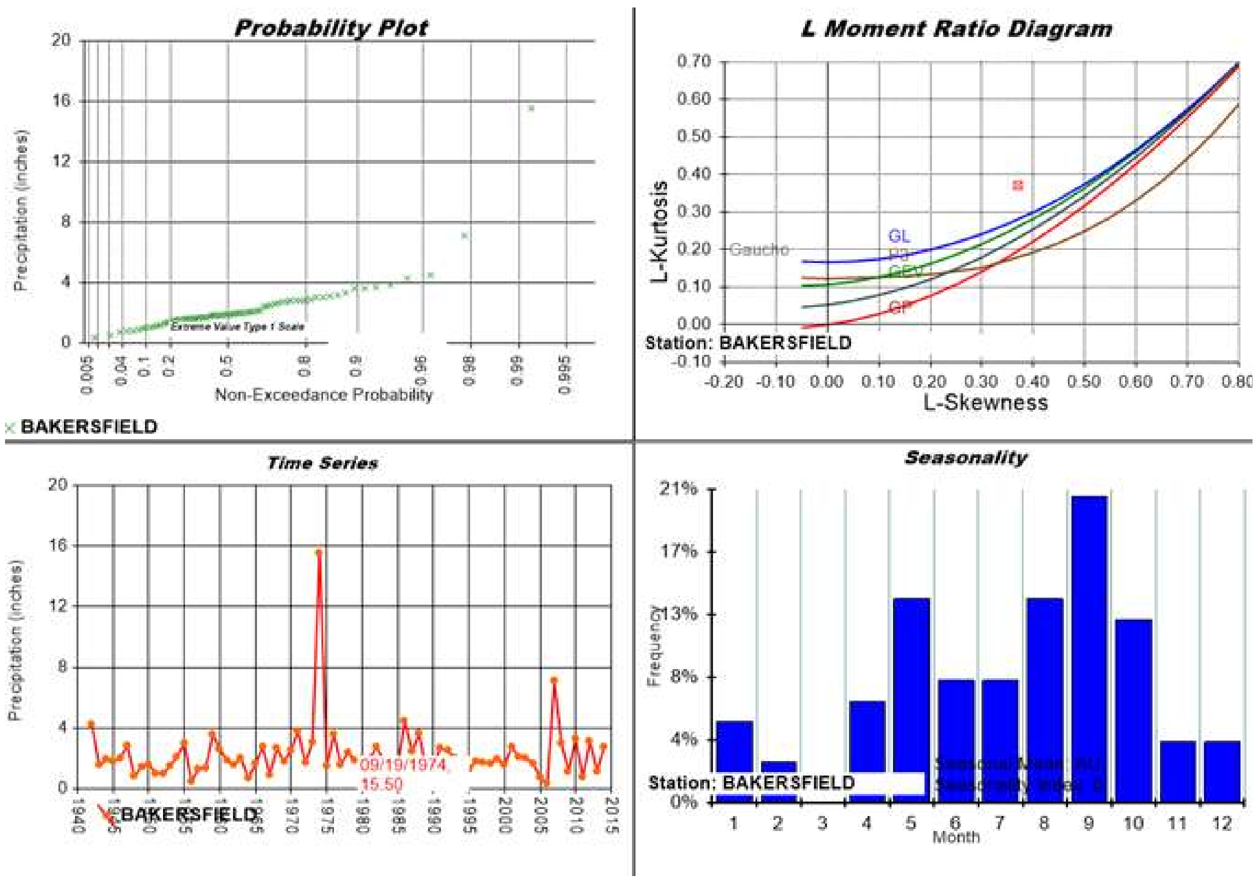


Figure 4. Sample station screening plots used for quality control of annual maximum time series data. This example is for Bakersfield, Texas.

Since exceedingly high and low AM values can greatly affect the distribution of annual maxima, questionable AM values were carefully investigated and either validated, corrected or removed from the series. Low outliers were often associated with years that had a significant percent of missing and/or accumulated data and hence presumed unreliable. Criteria were applied to remove suspiciously low AM values from the AMS. After ranking the AM values at a station, if an AM was among the lowest 5% of ranked values and had less than 50% of data in the year, it was automatically rejected. Also, if a year had less than 33% complete data and the AM was in the lowest 20% of ranked values, the AM was also automatically rejected. Other low AM values were evaluated on a case by case basis.

Meanwhile, high AM outliers were more carefully evaluated against concurrent observations taken at nearby stations (Figure 5) and/or evaluation of the publications available via NCDC's Image and Publications System (http://www.ncdc.noaa.gov/IPS/), which provides on-line access to scanned copies of COOP observation forms and other publications. See example in Figure 6. Additionally, other available on-line products were used as appropriate to help validate high observations, particularly for more recent events (e.g., the Advanced Hydrologic Prediction Service's archived precipitation maps, http://water.weather.gov/precip/). Depending on the outcome of the investigation, values were retained, corrected, eliminated or replaced with the next highest/validated AM value.

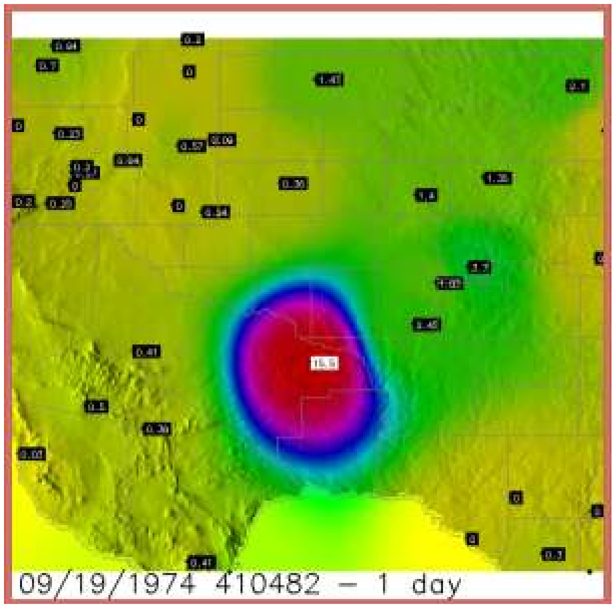
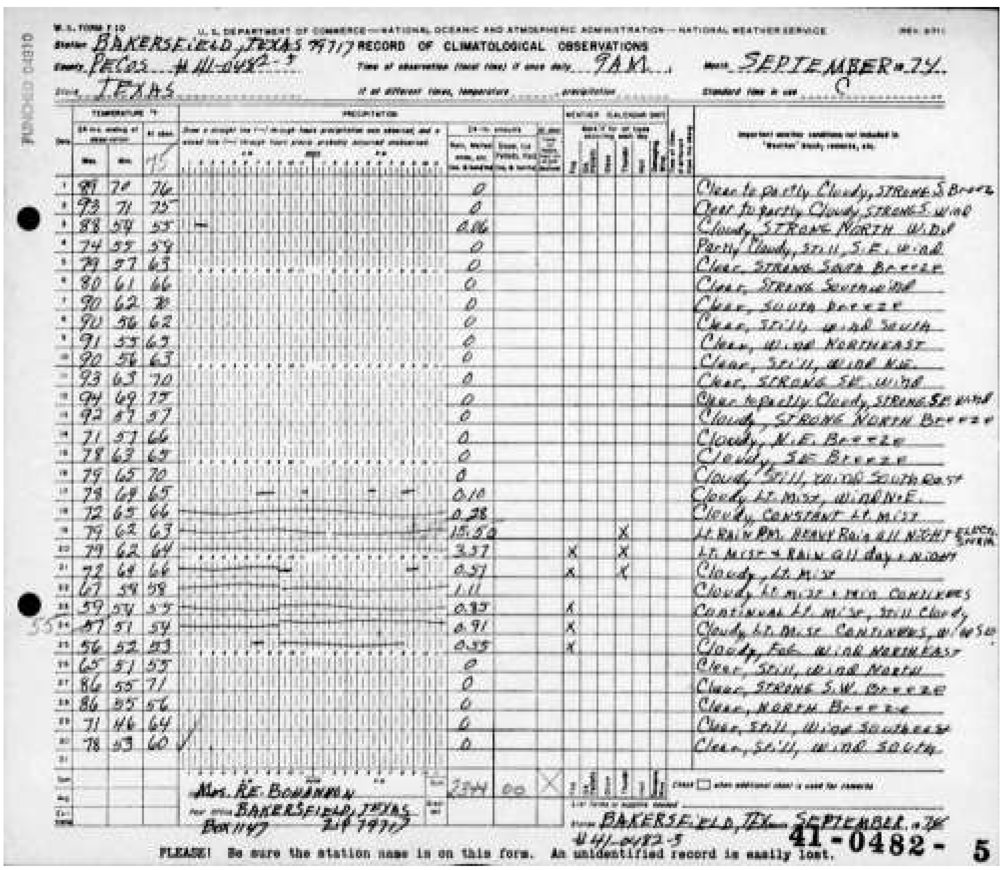


Figure 5. Sample spatial plot for evaluating rainfall at nearby stations for 2-day event ending 09/19/1974 at Bakersfield, Texas.



W.S. FORM F-10 U.S. DEPARTMENT OF COMMERCE—NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION—NATIONAL WEATHER SERVICE

RECORD OF CLIMATOLOGICAL OBSERVATIONS

Station BAKERSFIELD, TEXAS 79717
County PECOS # 41-0482-5
State TEXAS
Time of observation (local time) if once daily 9 AM
Month SEPTEMBER 74
Standard time in use C

Day	Temp. Max.	Temp. Min.	At obsn.	Rain, melted snow, etc. (in.)	Weather	Important weather conditions not included in "Weather" block, remarks, etc.
1	91	70	76	0		Clear to partly Cloudy, STRONG S. Breeze
2	93	71	75	0		Clear to partly Cloudy, STRONG S. wind
3	88	54	55	0.06		Cloudy, STRONG NORTH Wind
4	74	55	59	0		Partly Cloudy, Still, S.E. wind
5	79	57	63	0		Clear, STRONG South Breeze
6	80	61	66	0		Clear, STRONG South wind
7	90	62	70	0		Clear, South Breeze
8	90	56	62	0		Clear, Still, wind South
9	91	55	63	0		Clear, wind NORTHEAST
10	90	56	63	0		Clear, Still, wind N.E.
11	93	63	70	0		Clear, STRONG SE. wind
12	94	69	75	0		Clear to partly Cloudy, STRONG SE wind
13	92	57	57	0		Cloudy, STRONG NORTH Breeze
14	71	57	66	0		Cloudy, N.E. Breeze
15	78	63	65	0		Cloudy, SE Breeze
16	79	65	70	0		Cloudy, Still, wind South east
17	78	64	65	0.10		Cloudy Lt. mist, wind N.E.
18	72	65	66	0.28		Cloudy, CONSTANT Lt. mist
19	79	62	63	15.50	X	Lt. Rain PM. HEAVY Rain all NIGHT Elect. Storm
20	79	62	64	3.57	X X	Lt. mist & Rain all day & night
21	72	64	66	0.57	X X	Cloudy, Lt. mist
22	67	54	58	1.11		Cloudy Lt. mist & rain continues
23	59	54	55	0.85	X	Continual Lt. mist, Still Cloudy
24	57	51	54	0.91	X	Cloudy Lt. mist Continues, wind S
25	56	52	53	0.35	X	Cloudy, Fog wind NORTHEAST
26	65	51	55	0		Clear, Still, wind North
27	86	55	71	0		Clear, STRONG S.W. Breeze
28	86	55	56	0		Clear, NORTH Breeze
29	71	46	64	0		Clear, Still, wind Southeast
30	78	53	60	0		Clear, Still, wind South
31						
Sum				2344		

Mrs. R.E. Bohannon
For office BAKERSFIELD, TEXAS
Box 1147 Zip 79717

Station BAKERSFIELD, TEX. SEPTEMBER 74
41-0482-5

41-0482- 5

PLEASE! Be sure the station name is on this form. An unidentified record is easily lost.

Figure 6. Sample COOP observation form from NCDC's on-line Image and Publications System (IPS) for Bakersfield, Texas (September 1974).

Hourly surface data for Mexico required careful scrutiny given the data records were short and less complete and the data itself less reliable and difficult to quality control. Some data were reported in 6-hour increments, which required disaggregation into 1-hour amounts for appropriate annual maximum values to be extracted. There were limited resources for quality controlling these data, however given that they were the only hourly point data available in Mexico, the data were screened as best as possible and retained in the analysis. Low AM values were removed on a case by case data to retain enough data to be included in the analysis. For these reasons, the final 6-hour results may be less reliable across Mexico, but represent a reasonable estimation.

Co-located Stations

For the 24-hour duration, some locations had both a daily and an hourly-reporting station. In these cases, the data were individually inspected to determine which station statistics should be used since only one station statistics can exist at the same location. In general, the daily station was retained since they are more reliable during extreme events and generally had longer periods of record. However, occasionally the hourly counterpart had a longer, more reliable record and was thus retained.

AMS Adjustment Factors

The majority of data used in the project came from daily-reporting stations, which represent readings taken once-a-day at a fixed time (constrained). It is likely many of the constrained AM observations did not capture the true maximum unconstrained 24-hour rainfall amount. Therefore, it was necessary to adjust the constrained AM observations to represent an estimated unconstrained observation. A number of previous western U.S. studies have already evaluated the difference between 24-hour and 1-day observations, so it was justified to adopt the widely accepted adjustment factor 1.13 (Weiss, 1964; MGS Software, 2011). Therefore, each 1-day AM value was multiplied by 1.13 to provide a reliable estimate of a 24-hour, unconstrained observation before being used in the L-Moment statistical computations. No adjustment was necessary for converting between a constrained 6-hour period to an unconstrained 360-minute period.

METHODOLOGY

REGIONAL ANALYSIS

Estimation of extreme rainfall values at rare frequencies is often difficult because extreme events are by definition rare and data records are often relatively short. A regional L-moments frequency analysis reduces the uncertainty of this problem by "trading space for time." Rainfall data from several stations can be used in estimating frequencies at any location. L-moments, a relatively recent development within statistics, are described in detail in the Regional Frequency Analysis book by Hosking and Wallis (Hosking and Wallis, 1997). The L-moment Regional Frequency Analysis method has demonstrated skill in producing robust and reliable rainfall frequency results in numerous frequency studies worldwide (Schaefer et al., 2002 and 2006; Asquith, 1998), including NOAA Atlas 14 (Bonnin et al., 2004; Perica et al., 2013a, 2013b) which adjoin this project to the east, north and west.

Consistent with previous studies, it was decided to initially divide Texas into several large general Climatic Regions based on mean annual precipitation and topography and on existing NWS climate regions. These general regions were then sub-divided into sub-regions that meet the homogeneity criteria necessary for the regional L-moments frequency analysis.

A homogeneous sub-region, in the context of a regional analysis, implies the probability distribution of extreme events and their resulting frequency curves are identical. Although regional statistics describe the probability distribution, each at-site mean annual maximum is used as a scaling factor, thereby allowing spatial variability in the rainfall frequency estimates to occur within the sub-region.

Given the theory of regional frequency analysis is already well described by Hosking and Wallis, it will not be repeated here in the same level of detail. For this project, the majority of numerical and statistical calculations were carried out in LRAP, which is specifically designed to conduct regional L-moment frequency analyses. LRAP is based on the process described by Hosking and Wallis, which is the same approach used to update precipitation frequency estimates across adjacent states in NOAA Atlas 14. Using LRAP helped to instill consistency in the overall project with NOAA Atlas 14. The authors of LRAP were available and helpful throughout this project.

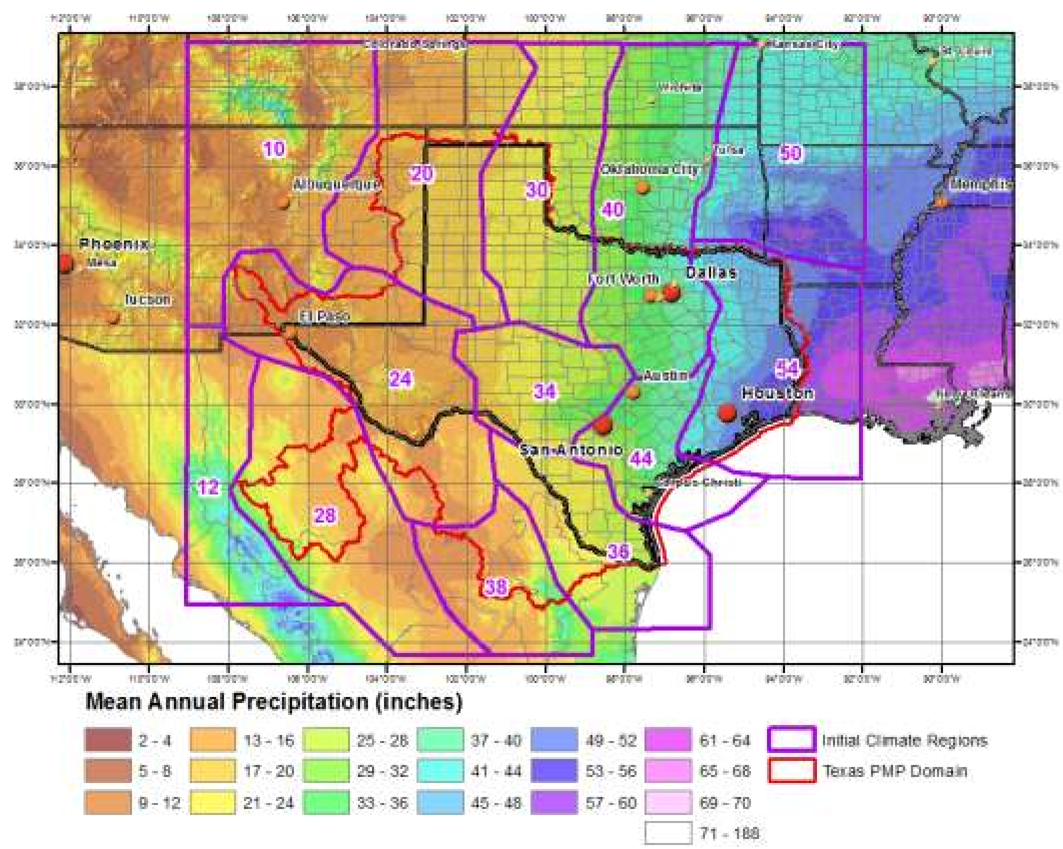
FORMATION OF GENERAL CLIMATE REGIONS

The overarching goal was to create homogeneous regions for computing regional statistics that will be used to compute the rainfall frequency estimates. Instead of trying to define these smaller regions at the onset, it was decided to create large, generalized climate regions that can then be sub-divided into homogeneous regions. This approach is consistent with the co-called "super-region approach" first used in Washington (Schaefer et al., 2002). Given the emphasis on rainfall, the general climate regions could be considered general rainfall regions.

Definition and delineation of the general climate regions meant evaluating the topographic, climatic and meteorological characteristics of the state. As part of this process, we considered information from the NCDC climate divisions (Figure 7), the Climatic Atlas of Texas (Larkin and Bomar, 1983), NCDC's Climate Atlas of the United States (Plantico et al., 2000), and previous frequency studies (Asquith, 1998).

Based on meteorological, climatological, topographical similarities, coupled with information from the various resources, thirteen general climatic regions were identified (see Figure 8). Mean annual precipitation (MAP), shown in Figure 8, provided the most influence on the regional boundaries of the general climate regions. The MAP over the United States was based on the period 1961-1990, a 30-year climate period mapped by PRISM, to be consistent with the MAP grid for Mexico available through the United States Department of Agriculture (USDA) for North America (USDA Forest Service/RMRS/Moscow Forestry Sciences Laboratory; http://forest.moscowfsl.wsu.edu/climate/current/). Topography, together with gradients and magnitude of MAP, provided an objective means for delineating the regional boundaries. The regions, which are indicated by a sequential number scheme beginning in the west and traversing roughly north to south are described in Table 5.

Figure 7. Climate divisions from the National Weather Service, NCDC. (Figure is found in multiple sources; this



version produced by Texas Water Development Board shown here for reference.)

Figure 8. Delineation of generalized Climate Regions in the Texas PMP domain.

Table 5. Description of generalized Climate Regions.

Region number	Description	Corresponding NWS region
10	Semiarid mountains and highlands of New Mexico and southwestern Colorado; outside of the Texas watershed in U.S.	
12	Sierra Madre Occidental mountains of western Mexico; closes to the Pacific moisture source; outside of Texas watershed	
20	Semiarid high plains of eastern New Mexico, southeastern Colorado and western Texas Panhandle; only region in Texas with significant snow (15-30" annually); MAP ranges from 10-20"; wettest months – April-May	High Plains
24	Arid Guadalupe mountains in west Texas and Sierra Madre Oriental mountains of eastern Mexico. MAP ranges from 1-15"; highest mountains in Texas, which can have snow; wettest months - summer	Trans Pecos
28	The Central Mexican Plateau (Mexican Altiplano) between Sierra Madre Oriental and Sierra Madre Occidental mountains in Mexico. MAP ranges from 10-38"; part of Texas watershed	N/A
30	Eastern Texas and Oklahoma panhandle regions of flat terrain with influence from continental air; transitioning to a more humid environment; MAP ranges from 20-30"; light snow and ice can/do occur; severe thunderstorms common	Low Rolling Plains
34	Flat Edwards Plateau region of central Texas; uniform distribution of seasonal rainfall; little snow; MAP ranges from 15-35"; temperatures among the hottest in state in summer	Edwards Plateau
36	Transition between semiarid and sub-tropical climates in southwestern Texas; MAP ranges 20-30"; low humidity in winter but some during summer from Gulf; wettest months - April-May; dry-line thunderstorms common in the summer	Southern and Lower Valley
38	Transition between Central Mexican Plateau (Mexican Altiplano) and Sierra Madre Oriental mountains in Mexico;	N/A

Region number	Description	Corresponding NWS region
	includes more rugged terrain; 4-24” MAP	
40	Temperate sections of central Kansas, Oklahoma and Texas; MAP ranges 30-45”; light snow and ice can/do occur	North Central
44	Sub-tropical areas of south-central Texas; prone to tropical storms; MAP ranges 25-45”; wettest months April-May	South Central
50	Boston Mountains of Arkansas and Oklahoma, plus Ozark Plateau of Missouri; Outside Texas watershed; some orographic influences; MAP ranges from 40-70”	N/A
54	Humid sub-tropical portions of far-eastern Texas; highest MAP in Texas ranging from 45-65”; strong coastal and tropical cyclone influence	East Texas

FORMATION OF HOMOGENEOUS L-MOMENT SUB-REGIONS

It was necessary to further refine the generalized climatic regions into sub-regions in order for the sites to meet the homogeneity criteria and better reflect local differences in extreme rainfall. Definition and delineation of homogeneous sub-regions meant evaluating the topographic, climatic and meteorological characteristics as recommended by Hosking and Wallis (1997).

A homogenous sub-region is one where all sites within the region can be described by one probability distribution. The common probability distribution parameters within a homogenous region provide a magnitude-frequency curve, known as a regional growth curve/factor (see Figure 9). Using the at-site mean as a scaling factor, the probability distribution and its parameters are used to compute the rainfall frequency estimates. The at-site means allow the rainfall frequency estimates to vary spatially and magnitudinally within a region. This approach is often referred to as the “index flood” approach to regional frequency analysis, first proposed by Dalrymple (1960) but put into practice by Hosking and Wallis (1997). In order for this approach to result in reliable, robust rainfall frequency estimates, the sites within a sub-region must meet the homogeneity criteria.

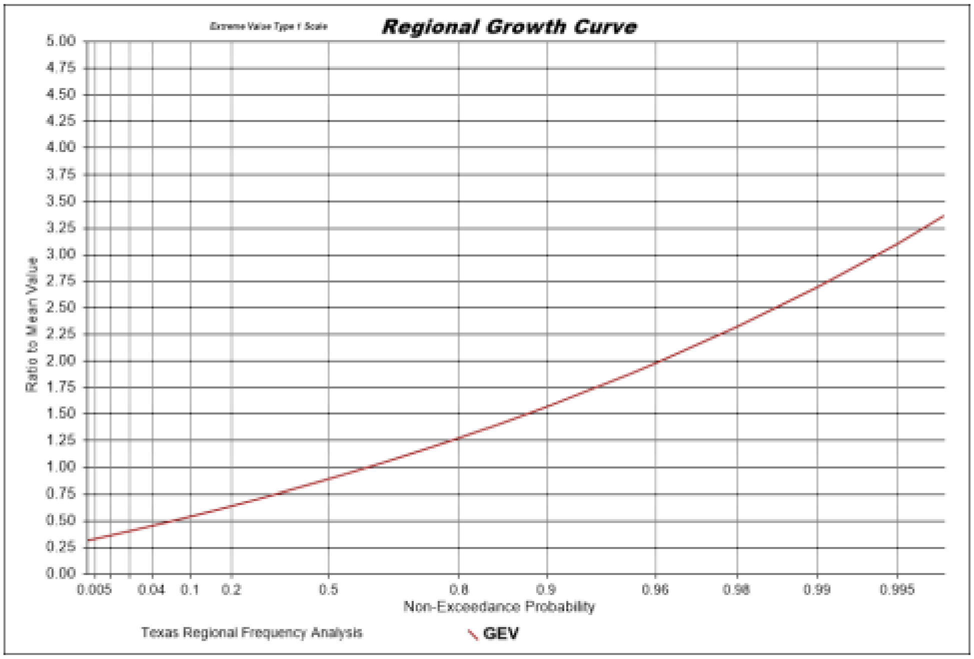
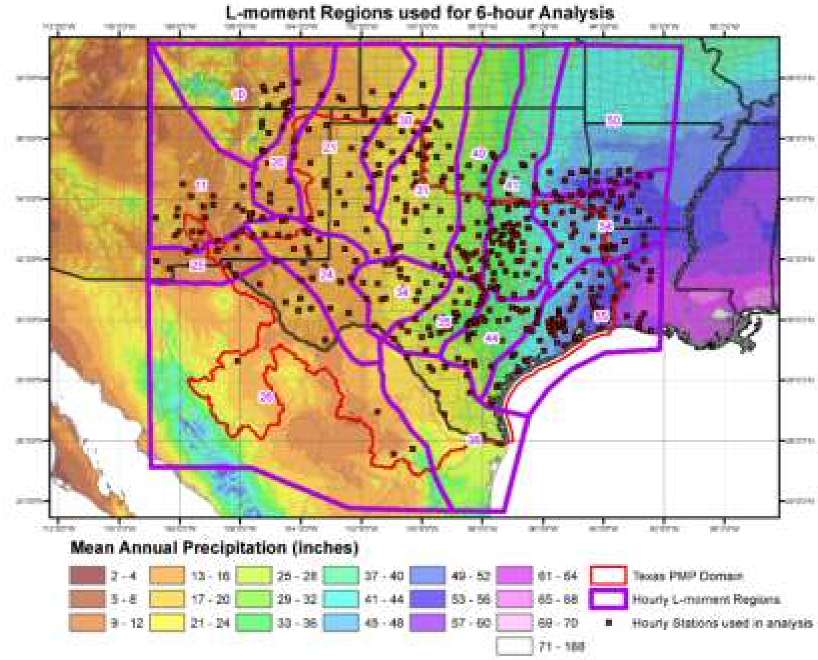


Figure 9. Sample regional growth curve for 24-hour region 34.

Definition of Sub-regions

Using the general climate regions as a starting point, sub-regions were created based on similarities in mean annual precipitation, mean annual maximum 24-hour rainfall, seasonality and orographics. Creation of sub-regions used many of the same datasets used to create the general climate regions, but in a more detailed manner. In some cases, the boundaries of the original general climate regions were adjusted in order to satisfy the homogeneity criteria. It was important to establish enough sub-regions to capture the variability of extreme rainfall events, yet avoid introducing statistically-based variability in otherwise meteorologically similar regions. Uncertainty in the final rainfall frequency estimates decreases with an increasing sample (region) size, so a balance between a region size and spatial variability in the statistics was made in defining the final regions. Although not necessary, all of the final 6-hour and 24-hour sub-regions were geographically contiguous. Given the number of 6-hour stations is considerably smaller than the 24-hour sample size, it was necessary to group several of the 24-hour regions together in order to attain enough stations within a 6-hour region to extrapolate reliable results and reduce uncertainty. Figure 10 shows the final 18 homogenous L-moment regions for the 6-hour analysis. Figure 11 shows the final 25 homogenous L-moment regions for the 24-hour analysis.



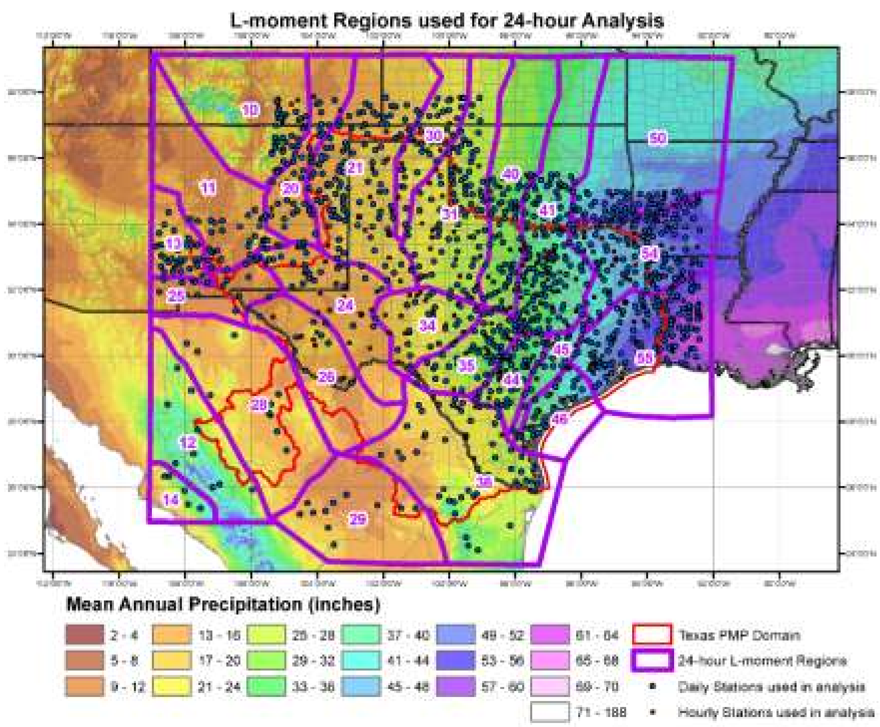


Figure 10. 6-hour homogeneous L-moment regions and station locations.

Figure 11. 24-hour homogeneous L-moment regions and station locations.

AMS Stationarity and Serial Independence Tests

The statistical methods used to compute rainfall frequency in this project were based on the requirement that the AMS within a sub-region were serially independent (random) and had no significant trends throughout the period of record. To test for this, LRAP subjected the AMS at each station to a pass-fail test for both stationarity and serial independence.

The test for serial independence was conducted by computing a serial correlation coefficient for the AMS at each station. A global weighted-average serial correlation coefficient was also computed, where the weights were based on the record length of each station. A standard t-test was conducted to examine if the global serial correlation coefficient (Rho) was significantly different from zero, the null hypothesis. Depending on if the correlation coefficient was significantly different, LRAP issued a pass or fail designation to each station.

The stationarity test was also conducted on every station. For each station, the observed annual maximum for each year was divided (normalized) by the mean AMS value for the period of record. The resulting dimensionless values representing the rainfall maximum at each station were regressed against the year of occurrence minus 2000. A standard linear regression was computed from the time series. The slope (Beta) of the regression line for each station was computed for measuring the trend. A perfectly stationary sample would have a slope of zero, meanwhile a slope significantly different than zero would have indicated a trend in the AMS. A standard t-test was used to determine if the slope was statistically significant at each station; depending on the results, LRAP issued a pass or fail designation to each station.

A weighted-average serial correlation coefficient (Rho) and slope (Beta) was computed for each homogenous sub-region and provide an objective indication of independence and stationarity. Presented in Table 10 and Table 11 are the test summary statistics for each of the sub-regions. The tests concluded the AMS could be confidently used as the basis for the regional L-moment frequency analysis in this project.

Table 10. Summary of 6-hour stationarity and serial independence tests.

Sub-region Number (Fig. 10)	Number of stations	Station years	Serial correlation (Rho)	Stationarity slope (Beta)
10	15	553	-0.033	-0.0017
11	23	1093	0.039	0.0013
20	10	554	-0.007	-0.0020
21	27	1504	-0.005	-0.0014
24	23	1015	-0.006	-0.0006
25	10	507	0.049	0.0029
26	11	398	0.026	-0.0002
30	15	676	0.005	0.0021
31	37	1726	-0.036	0.0009
34	21	975	-0.023	0.0001
35	28	1045	-0.020	-0.0030
36	13	553	-0.033	-0.0012
40	26	1151	-0.022	0.0000
41	62	3000	-0.014	0.0002
44	31	1169	0.012	-0.0007
50	19	917	0.093	0.0000
54	53	2334	0.003	-0.0003

55	69	2207	-0.029	0.0006

Table 11. Summary of 24-hour stationarity and serial independence tests.

Sub-region Number (Fig. 11)	Number of stations	Station years	Serial correlation (Rho)	Stationarity slope (Beta)
10	43	2190	-0.029	-0.0007
11	32	2133	0.043	0.0017
12	9	408	0.033	0.0003
13	33	1874	-0.002	0.0011
14	5	246	-0.022	-0.0034
20	43	2163	0.026	-0.0011
21	118	6396	-0.024	-0.0010
24	42	2182	-0.021	0.0000
25	19	1495	0.193	0.0034
26	20	887	0.048	0.0035
28	10	515	-0.041	0.0022
29	11	502	0.069	-0.0007
30	42	2146	-0.033	0.0003
31	99	5482	-0.052	0.0010
34	40	1523	-0.044	0.0034
35	62	2372	-0.021	-0.0025
36	56	2212	-0.030	0.0010
40	64	3743	0.006	0.0010
41	147	7203	-0.035	0.0006
44	53	1779	-0.068	-0.0000
45	27	1252	-0.001	-0.0017
46	30	1019	-0.026	-0.0039
50	53	2921	0.036	0.0001
54	143	7713	0.001	0.0003
55	130	5573	-0.015	-0.0008

Cross-Correlation

One of the strengths of a regional analysis is the concept of "trading time for space" where by the collective information from a group of stations improves the reliability of the rainfall frequency estimates for all stations. The degree of improvement, however, depends on the sample size of the sub-region and the assumption that individual AMs extracted at different stations are independent of one and other. If the AM are independent or have low-cross-correlation within a homogenous sub-region, then the equivalent independent record length for the sub-region is nearly equal to the actual record length of the regional dataset, thereby affording a higher degree of confidence in the rainfall frequency estimates.

To assess the degree of cross-correlation, a plot showing the decay of cross-correlation with distance between stations was constructed (in LRAP) for each homogenous sub-region. The plot also provides a LOWESS fit line (Helsel and Hirsch, 1992) to assist in qualitatively assessing the level of cross-correlation; see example in Figure 12. Although the LOWESS line often indicated a tendency for inter-station correlation to increase with decreasing inter-station distance, the large amount of scatter in the data deemed the relationship to be poor. Evaluation of LOEWSS lines for all sub-regions lead to the conclusion that cross-correlation between stations was not statistically significant. Therefore, it was assumed that the impact of potential station dependence on the rainfall frequency estimates would be negligible. Additionally, studies have shown that the impact of cross-correlated station data on rainfall frequency estimates is minimal (e.g., Hosking and Wallis, 1997; Bonnin et al., 2004, 2006a).

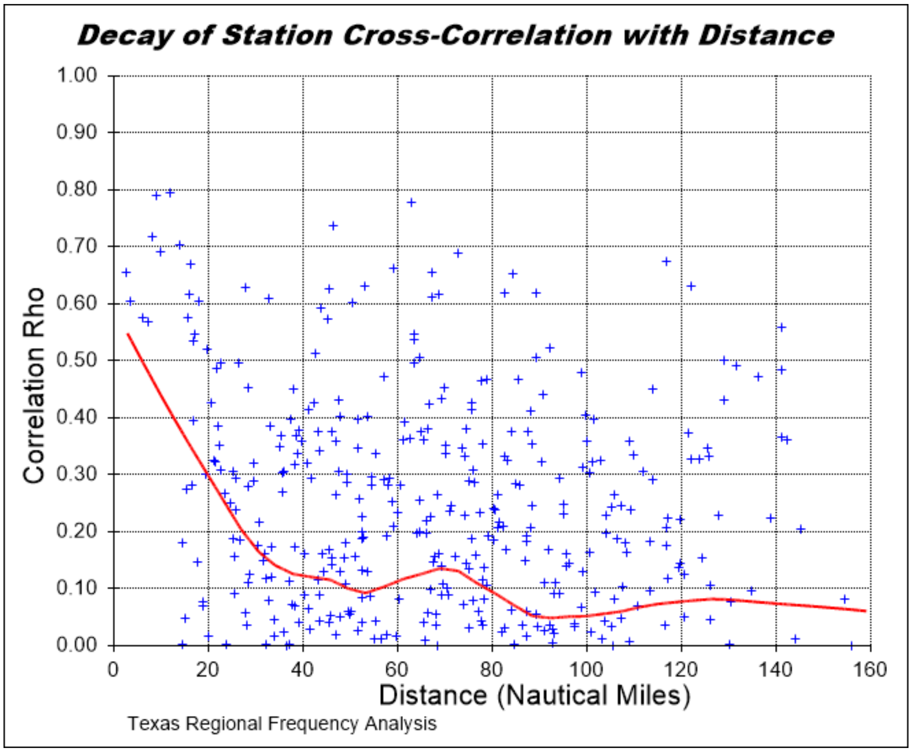


Figure 12. Plot of decay of cross-correlation with distance and LOWESS fit (red line) for 24-hour L-moment region 34. Distance refers to the distance between paired stations.

Heterogeneity Test

Hosking and Wallis (1997) developed heterogeneity measures to help indicate the level of heterogeneity or homogeneity in the L-moment ratios for a group of stations representing a sub-region. The statistics H1 and H2 denote the relative variability of observed L-Cv and L-Skewness respectively for stations within a sub-region. The H1 and H2 measures compare the observed variability to that which is expected from a large sample drawn from a homogeneous region based on the Kappa distribution. For purposes of rainfall annual maximums, Hosking and Wallis recommend regions with H1 and H2 values less than 2.00 may be considered acceptably homogeneous and H1 values greater than 3.00 would suggest heterogeneity and redefinition of the region be considered. All of the sub-regions defined in this project passed the homogeneity criteria.

Goodness-of-fit Test

Once a region was acceptably homogeneous, a goodness-of-fit test was used to determine which probability distribution fit the regional data the best. LRAP tests seven different probability distributions, which include:

- Generalized Logistic (GLO)
- Generalized Extreme Value (GEV)
- Generalized Normal (GNO)
- Gaucho
- Generalized Pareto (GP)
- Person 3 (P3)
- Kappa distribution (KAP)

The goodness-of-fit measure developed by Hosking and Wallis is discussed in detail in their book; we accepted the pass or fail designation LRAP provided, which was based on a 95 percent confidence test. Figure 13 illustrates the goodness-of-fit results for region 34.

Most of the homogenous sub-regions across Texas favored a GEV distribution in both the 24-hour and 6-hour data. Given that the GEV distribution is typically used to describe extreme rainfall, passed for all sub-regions, and was the choice of distribution used in NOAA Atlas 14 and for the 1-day duration in Asquith (1998), it was decided GEV would be used for all sub-regions and durations. Given the GLO distribution was used in the Asquith (1998) study for hourly durations, it was carefully considered for the 6-hour duration in this project. However, GLO passed the goodness-of-fit test for only 3 of the 18 regions for the 6-hour data in this study. Therefore, the use of a single distribution (GEV) across the entire project area and for both durations (6- and 24-hour) was used to eliminate potential edge effects between sub-regions with differing distributions, particularly at rarer recurrence intervals.

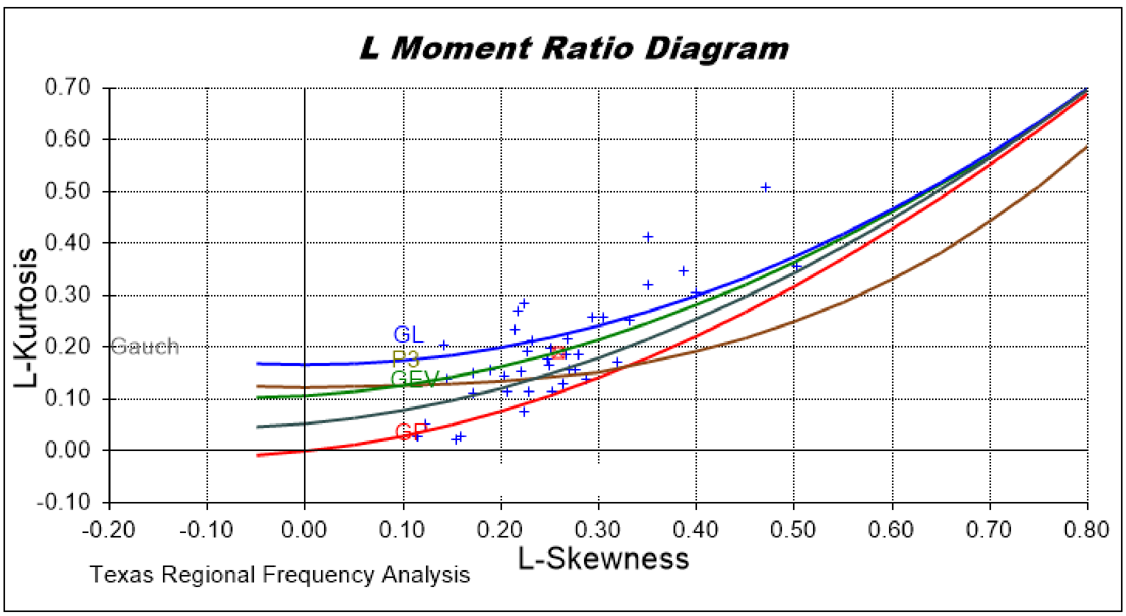


Figure 13. The goodness-of-fit test can be illustrated by plotting the regional L-Skewness and L-Kurtosis and identifying the probability distributions that best fits. The mean data point is shown as the red square. The above example is for 24-hour region 34

Discordancy Test

Even among homogeneous regions, some stations were considered grossly inconsistent from the region as a whole. Such stations were identified using a test which resulted in a discordancy measure. The discordancy measure provided an important indicator of stations that should be moved to a different region and/or contained an error in their AMS. However, by nature of the L-moment approach an erroneous individual annual maximum at this stage in the analysis will have a limited negative impact on the results. In general, a station was considered discordant if the discordancy measure was greater than 3. Hosking and Wallis (1997) provide details of this test, which was automatically computed for all stations in LRAP. Occasionally, stations would be flagged as discordant as a result of their relatively short period of record. In areas where these stations were spatially relevant and their mean annual maxima was consistent, these stations were retained since the L-moment approach appropriately (down) weights these short-period-of-record stations in the regional statistics.

Summary

In summary, the methodology used for creating sub-regions, testing for homogeneity, evaluating goodness-of-fit and computing rainfall frequency estimates followed this general procedure:

1. Create "super-regions" that define general climate regions.
2. Sub-divide the general climate regions into sub-regions with similar mean annual precipitation, mean annual maximum rainfall, seasonality and orographics.
3. Using LRAP, run L-moment analysis on stations in proposed sub-regions.
4. Evaluate L-moment heterogeneity measures H1 and H2 to see if they are <3.00. If not, return to Step 1.
5. Evaluate discordancy measures at all stations within proposed region. Resolve or move all discordant (>3) stations to adjacent regions, if possible.
6. Once the region is acceptably homogeneous, evaluate goodness-of-fit measures for each distribution. For all suitable distributions, a dimensionless regional growth factor (RGF) is computed by LRAP.
7. Utilizing the individual mean annual maximum at each station coupled with the RGF, rainfall frequency estimates are computed at each station.

Results of the final heterogeneity tests, along with regional L-moment statistics for the 6-hour and 24-hour durations are shown in Table 12 and 13, respectively.

Table 12. 6-hour heterogeneity tests and regional average L-moment ratio summary statistics.

Sub-region (Fig. 10)	Number of stations	Average data years	H1 value	H2 value	L-CV	L-Skew	L-Kurtosis
10	15	36.9	-1.04	-0.63	0.2307	0.2610	0.2011
11	23	47.5	1.79	1.08	0.2244	0.2157	0.1783
20	10	55.4	-0.07	0.68	0.2393	0.2183	0.1668
21	27	55.7	0.49	-0.01	0.2317	0.2078	0.1600
24	23	44.1	0.01	0.19	0.2577	0.1859	0.1521
25	10	50.7	2.87	1.51	0.2494	0.1851	0.1353
26*	11	36.2	2.92	1.15	0.2447	0.2250	0.2040
30	15	45.1	2.66	0.67	0.2413	0.2186	0.1605
31	37	46.6	0.80	0.27	0.2173	0.2234	0.1826
34	21	46.4	0.89	0.06	0.2308	0.2215	0.1835
35	28	37.3	-0.77	-1.92	0.2447	0.2765	0.2028
36	13	42.5	0.89	-0.27	0.2464	0.2044	0.1648
40	26	44.3	-1.18	-2.42	0.2181	0.2229	0.1776

Sub-region (Fig. 10)	Number of stations	Average data years	H1 value	H2 value	L-CV	L-Skew	L-Kurtosis
41	62	48.4	-1.01	-0.62	0.2047	0.2236	0.1737
44	31	37.7	2.12	1.13	0.2328	0.2273	0.1787
50	19	48.3	1.59	1.75	0.1772	0.1849	0.1645
54	53	44.0	1.13	1.46	0.1873	0.1943	0.1551
55	69	32.0	1.09	0.86	0.2238	0.2345	0.1735

Table 13. 24-hour heterogeneity tests and regional average L-moment ratio summary statistics.

Sub-region (Fig. 11)	Number of stations	Average data years	H1 value	H2 value	L-CV	L-Skew	L-Kurtosis
10	43	50.9	0.56	-0.71	0.2102	0.2323	0.1862
11	32	66.7	1.72	1.06	0.2222	0.2311	0.1873
12	9	45.3	0.55	1.28	0.1844	0.2208	0.1889
13	33	56.8	0.61	-1.61	0.2024	0.1926	0.1704
14	5	49.2	0.30	-0.83	0.2079	0.2655	0.1969
20	43	50.3	1.67	0.19	0.2338	0.2178	0.1656
21	118	54.2	-0.04	-0.10	0.2254	0.2345	0.1712
24	42	52.0	0.91	0.25	0.2612	0.2379	0.1937
25	19	78.7	2.14	1.83	0.2304	0.2370	0.1791
26	20	44.3	0.97	-1.27	0.2133	0.1758	0.1717
28	10	51.5	2.93	1.51	0.2271	0.1834	0.1553
29	11	45.6	1.33	0.89	0.2224	0.1618	0.1679
30	42	51.1	-0.56	-1.12	0.2088	0.2117	0.1773
31	99	55.4	0.54	0.01	0.2149	0.2271	0.1808
34	40	38.1	0.05	-1.68	0.2398	0.2511	0.1834
35	62	38.3	-1.05	-1.02	0.2512	0.2733	0.1974
36	56	39.5	1.53	0.39	0.2617	0.2550	0.1844
40	64	58.5	-0.63	-1.50	0.2088	0.2461	0.1829
41	147	49.0	-1.27	0.85	0.2078	0.2278	0.1706
44	53	33.6	-0.09	-0.85	0.2453	0.2790	0.2124
45	27	46.4	-0.35	0.55	0.2324	0.2744	0.2083
46	30	34.0	-1.47	-1.10	0.2460	0.2327	0.1643
50	53	55.1	-0.93	-0.49	0.1900	0.2301	0.1827
54	143	53.9	-0.24	0.59	0.1936	0.2287	0.1777
55	130	42.9	1.92	-0.65	0.2305	0.2688	0.1932

SPATIAL INTERPOLATION OF THE MEANS

Methodology

The mean annual maximum (MAM) values at stations serve as scaling factors to generate station-specific rainfall frequency estimates using regional growth factors (RGFs). Therefore, it was necessary to spatially distribute the mean annual maximum in order to derive spatially continuous rainfall frequency estimates. Interpolation of the MAMs is the first critical step of the entire interpolation process, which is shown as a flow chart in Figure 14.

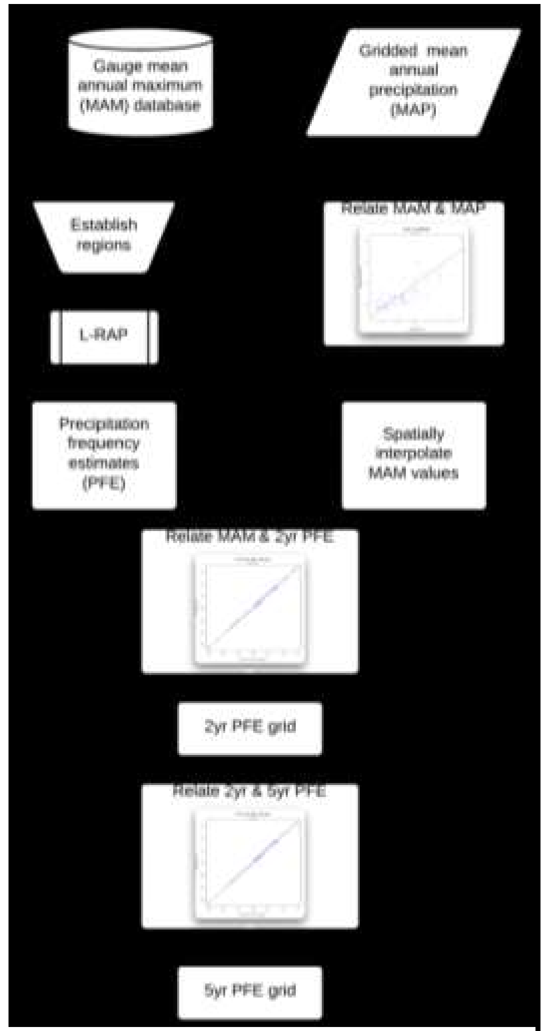


Figure 14. Generalized flow chart depicting the spatial interpolation procedure.

The 6- and 24-hour MAM values at stations were spatially interpolated to a uniform grid using a hybrid statistical geographic approach. The pre-existing PRISM and USDA grid of mean annual precipitation (MAP) was used for interpolation of the 24-hour MAMs to a grid. The 24-hour MAM grid was subsequently used as the predictor grid for the 6-hour MAM grid. Given the PRISM grids are based on a much denser station dataset, they inherently capture important spatial variations of rainfall that the smaller MAM dataset may not. The use of mean annual precipitation grids/maps to help interpolate MAMs is a procedure used in previous projects, including NOAA Atlas 2 (Miller et al., 1973), NOAA Atlas 14, and across the Pacific Northwest (Schaefer et al., 1997, 2002, 2006, 2008).

A 2nd order polynomial function was used to relate the square-root of MAP and 24-hour MAMs (Figure 15a). Then, the final 24-hour MAM grid, instead of MAP, was used as the predictor variable/grid for deriving the 6-hour MAM grid (Figure 15b). The least-square fit 2nd order polynomial functions from the MAP to 24-hour MAM and 24-hour MAM to 6-hour MAM scatter plots described the variability across the entire project area as a whole reasonably well (r^2 = 0.88 and 0.92, respectively). Then an improved MAM was computed for each station based on the MAM computed from the 2nd order polynomial and the observed/calculated MAM. Equation 2 shows the calculation where *wt* is the data year weighting factor defined as the number of data years at that station divided by the maximum number of data years from all stations in the project area (123 years for 24-hour data; 90 years for 6-hour data).

Equation 2. Calculation of MAM$_{improved}$.

$$MAM_{improved} = [MAM_{station} \times wt] + [MAM_{computed} \times (1 - wt)]$$

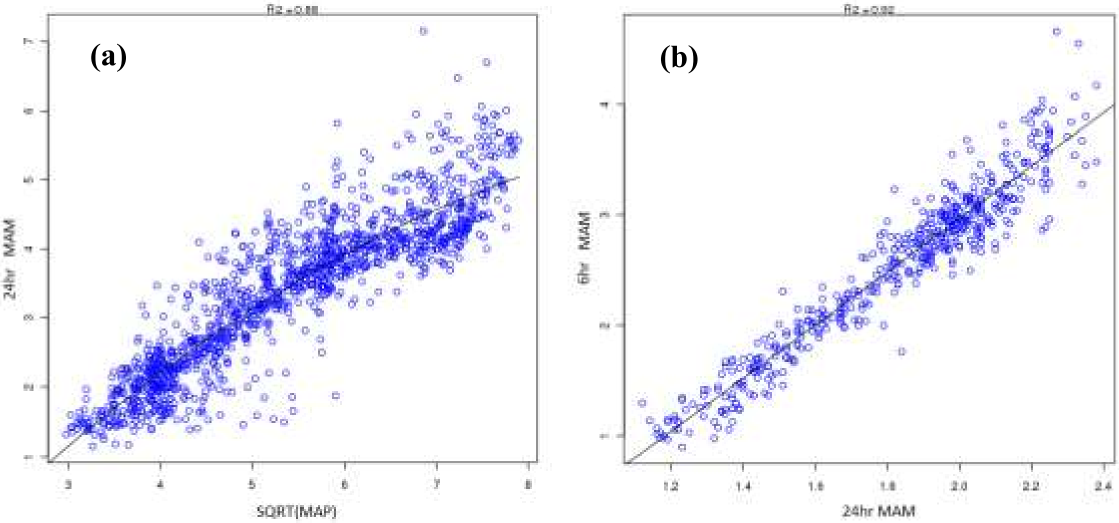


Figure 15. Scatter plots and 2nd order polynomial function relating (a) 24-hour MAM (inches) and the square root of MAP and (b) 6-hour MAM (inches) and 24-hour MAM (inches) across the project area.

Even given a high-quality annual maximum dataset, certain issues inherently cause unnatural sampling variability. For example, a short period of record station may have sampled a time period with a higher occurrence of extreme storms, thereby elevating its MAM over what a longer period of record would have suggested. Leveraging the improved MAM allowed the process to objectively reduce some of the sampling variability and instill a higher degree of consistency and confidence in the results.

Specifically, the weighting algorithm allowed the improved MAM for stations with a short period of record to be based more on the polynomial relationship than the observed MAM and vice versa. The improved MAMs helped to eliminate station-driven inconsistencies (i.e., "bulls eyes") in the spatial patterns associated with sampling variability. The difference between the $MAM_{improved}$ and the observed MAM ($MAM_{station}$) were generally very small;

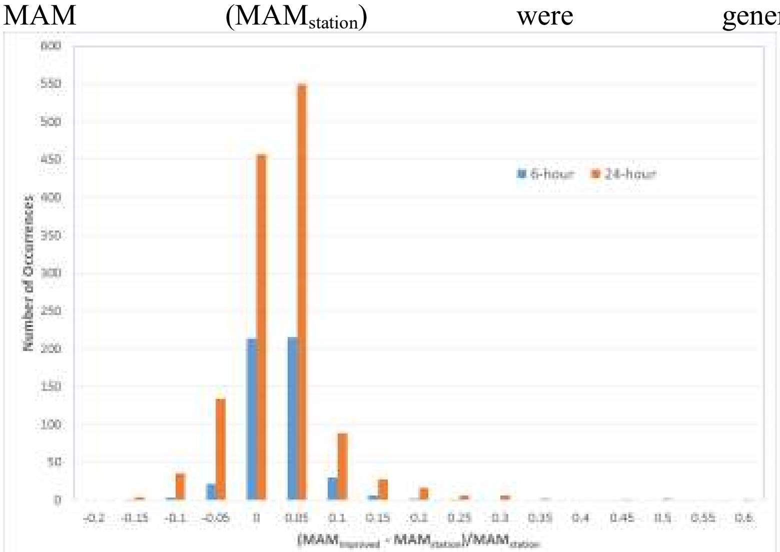


Figure 16 depicts a histogram of the differences. There were twelve stations where differences were greater than +/- 0.25; these were checked and generally due to short records. When not due to short records, the station was found to be located near a station with a much longer record, among complex terrain and/or near the boundary of the project domain. We are confident that the $MAM_{improved}$ is more representative of true climate than the at-station MAM. To attain consistency throughout the process, the relative differences between the individual $MAM_{station}$ and $MAM_{improved}$ at each station were propagated through the rainfall frequency estimates.

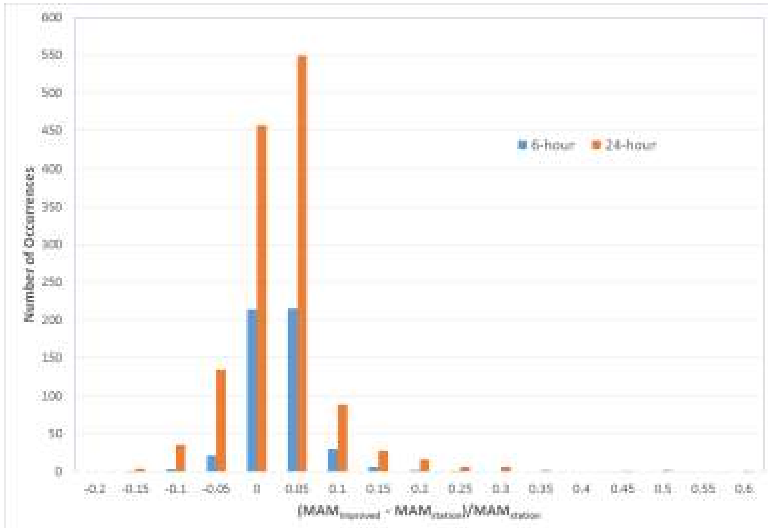


Figure 16. Histogram of differences between $MAM_{improved}$ vs. $MAM_{station}$ as a percent of $MAM_{station}$.

At-site variations (residuals) from the MAP-MAM relationship were subsequently computed, normalized (by the square-root of MAP) and interpolated to a grid using a traditional IDW interpolation algorithm. A final grids of 6- and 24-hour MAM were computed by adding the residual grid to the initial grid of MAM, thereby forcing the improved MAMs at station locations to be equal to the corresponding grid cell value.

Although internal inconsistencies between the 6- and 24-hour MAM grids are unlikely, it was ensured that the resulting 6-hour MAM gridcell values were less than the 24-hour MAM gridcell values.

Lastly, some minor manual edits to MAMs were applied to improve the spatial interpolation results to be more consistent with expectations. Table 14 lists edits made to the MAMs of existing stations. These stations required edits due to relatively short records when it was considered beneficial to retain the station for the analysis rather than simply omitting it. Additionally, Table 15 shows the MAMs added at so-called "pseudo-station" locations to anchor the spatial interpolation. These were added primarily along the coast where a lack of stations led to edge effects that impacted the interpolation; one hourly pseudo-station was added in Mexico where data were sparse. In one area, southeast coastal Texas, it was determined that the interpolation was improved by increasing the weight of the observed MAM ($MAM_{station}$) used in Equation 2. The observed MAMs were more representative and consistent with longer records nearby than the MAM computed using the global relationship with MAP. The additional weighting was achieved by artificially increasing the data years at six selected stations. Finally, at one particular station, Agua Nueva (410081), where a high outlier (21.02") was unduly affecting the MAM and subsequent spatial interpolation due to a short period of record, the value was substituted with a pseudo-value (13.65") obtained using trimmed L-moments to achieve equivalent L-moments for the station (Asquith, personal communication). The MAM for this station was then re-calculated and used in the interpolation process.

Table 14. Stations where the MAM values were nudged to achieve improved spatial interpolation results.

Station name	Latitude	Longitude	Duration	MAM (inches)	Revised MAM (inches)

Wimberley 1 NW (419815)	30.0008	-98.0664	24-hr	5.33	4.60
Lockhart 2 SW (415285)	29.8569	-97.6958	24-hr	5.24	4.50
Kingsbury (414805)	29.6867	-97.7644	24-hr	4.81	4.10
Speaks 2 (418519)	29.2750	-96.6878	24-hr	5.46	5.30
Gordon 1SW (413639)	32.5408	-98.3814	24-hr	4.24	3.50
Morgan Mill (416060)	32.3842	-98.1703	24-hr	4.63	3.60
Aransas (837152A)	28.3044	-96.8233	6-hr	3.97	3.75

Table 15. Locations where MAMs were entered to anchor spatial interpolation.

Station name	Latitude	Longitude	Duration	MAM (inches)
Pseudo 1 daily	28.992	-95.202	24-hr	5.00
Pseudo 2 daily	29.826	-96.155	24-hr	4.00
Pseudo 3 daily	28.831	-95.720	24-hr	5.00
Pseudo 4 daily	26.338	-97.447	24-hr	4.00
Pseudo 1 hourly	28.846	-95.705	6-hr	3.70
Pseudo 2 hourly	30.289	-101.087	6-hr	2.55
Pseudo 3 hourly	31.132	-106.350	6-hr	1.70

The resulting high-resolution (30 x 30-seconds, approximately 800m^2 or 660 feet^2) MAM grids, shown in Figures 17 and 18 then served as the basis for spatially interpolating rainfall frequency estimates at different recurrence intervals. The spatial interpolation approach used is similar to NOAA's Cascade, Residual Add-Back (CRAB) spatial interpolation procedure discussed in the next section.

Cross-validation

A jack-knife cross-validation technique was used to evaluate the performance of the mean annual maximum interpolation. The jackknife cross-validation involved deleting random stations from the data set one at a time, making a spatially interpolated prediction (at its location) in its absence, then adding it back in and making a prediction. Twenty-five percent (25%) of the stations were randomly selected for the validation. Most of the largest validation differences occurred near the outer boundary of the study area were the interpolation apparently suffered edge effects or in areas of low station density. Final summary statistics presented in Table 16 suggest the interpolation error is minimal. The overall (mean) bias was very low (<1 percent) and the mean absolute error (MAE) less than 1 percent for both the 6- and 24-hour interpolation of the MAM.

Table 16. Jack-knife cross-validation error statistics of MAM spatial interpolation.

Statistic	**Number of stations omitted**	**Bias**	**Mean Absolute Error**
6-hour mean annual maximum	117	0.01%	0.033% (0.08 inches)
24-hour mean annual maximum	326	0.00%	0.026% (0.08 inches)

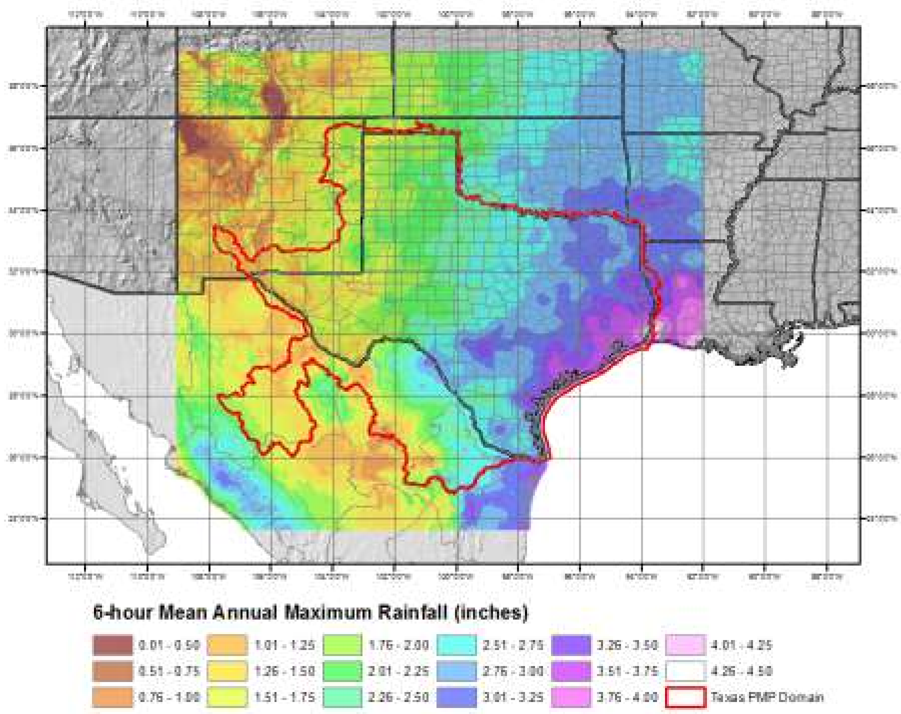


Figure 17. Final 6-hour MAM rainfall map.

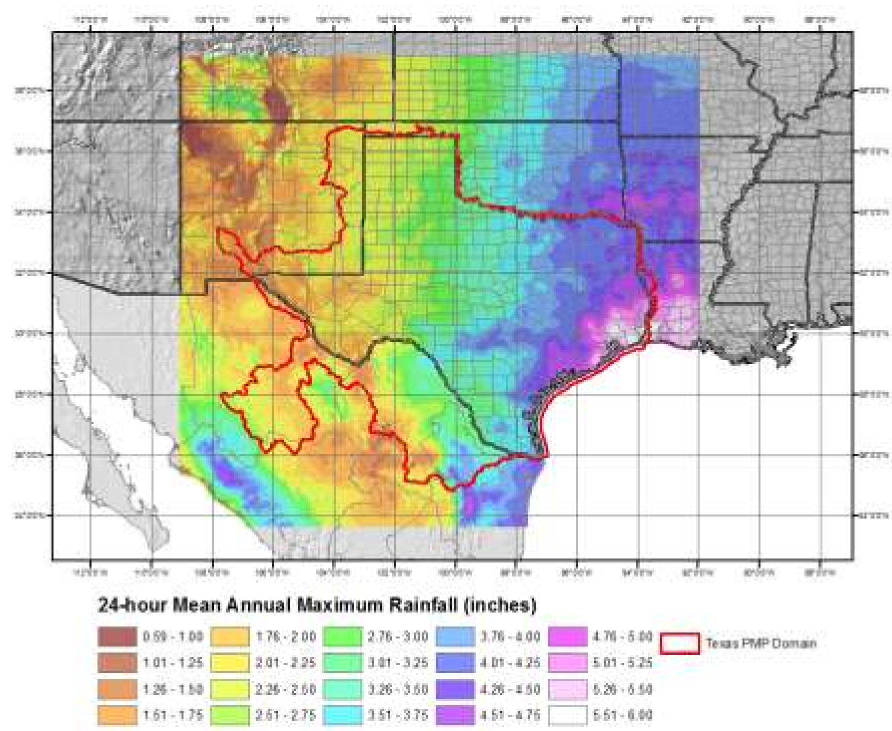


Figure 18. Final 24-hour MAM rainfall map.

SPATIAL INTERPOLATION OF THE RAINFALL FREQUENCY ESTIMATES

Methodology

A spatial interpolation technique similar to NOAA's Cascade, Residual Add-Back (CRAB) procedure (Bonnin et al., 2004, 2006) was used to convert the MAM grids into grids of rainfall frequency estimates for frequencies of 2-years to 1,000-years. The generalized process is shown in Figure 14. The technique leverages the inherently strong linear relationship that exists between MAM and rainfall frequency estimates. Figure 19 shows an example of the relationship between the 24-hour MAM and 2-year 24-hour rainfall frequency estimates for Texas. The R^2 value of 1.0, implying a perfect relationship, was common for all relationships. Since this equation was calculated using all stations in the project area, the slope coefficient can be thought of as an average domain-wide ratio between the MAM and the 2-year 24-hour estimates for 24-hour duration, also known as a regional growth factor. The same logic and R^2 values hold for the 6-hour duration as well.

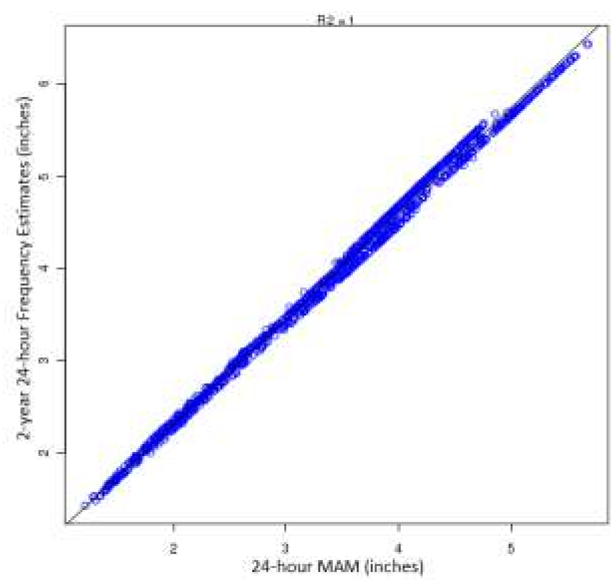


Figure 19. 24-hour MAM versus 2-year 24-hour rainfall frequency estimates for Texas.

For both the 6- and 24-hour durations, the process began by regressing the gridded MAM values and the 2-year rainfall frequency estimates at all station locations. As a result of spatial smoothing during the MAM interpolation process, slight differences between the gridded MAM and observed MAMs sometimes occurred at station locations. To ensure consistency, differences in the MAMs were used to adjust the rainfall frequency estimates accordingly. In other words, if the gridded MAM was 2 percent higher than the observed MAM at a station, the suite (2-year through 1,000-year) of rainfall frequency estimates were increased 2 percent at the station.

Residuals were then computed for each station to quantify the difference between the at-station rainfall frequency estimate and the initial (liner equation) estimate. The residuals were normalized by the

MAM and spatially interpolated to a grid using a conventional inverse-distance-weighting (IDW) algorithm. The IDW interpolation method was used because by definition it is an exact interpolator and therefore remains faithful to the data at station locations. The normalized residuals were highly auto-correlated, so the IDW carried a good deal of skill in capturing the spatial patterns.

The normalized residual grid was then multiplied by the MAM grid to obtain a spatially interpolated grid of actual residuals for the entire project area. The spatially interpolated grid of actual residuals was added back to the initial grid of 2-year estimates to create a final grid of 2-year rainfall frequency estimates.

In subsequent iterations, the 2-year rainfall frequency estimates became the predictor grid/variable for the 5-year estimates, the 5-year for the 10-year, and so on. The end result was a suite of rainfall frequency grids/maps for 2-year through 1,000-year average recurrence intervals per duration.

Comparison to Depth-Duration Frequency of Rainfall for Texas (Asquith and Roussel, 2004) and to NOAA Atlas 14 (Perica et. al, 2013; Bonnin et al., 2004)

Differences between 100-year rainfall frequency estimates from this project and those published in Asquith (1998) and subsequently contoured in Asquith and Roussel (2004) were carefully considered. The spatial patterns of the 100-year estimates between the current project and Asquith's agreed remarkably well; the Board of Consultants reviewed and approved the differences. Figures 20 and 21 show the new 6- and 24-hour 100-year, respectively, overlain with the contours from Asquith and Roussel (2004) using the same contoured intervals. Several points were also randomly selected across the state to get a detailed point comparison in several different climate areas (Table 17a). The 100-year 24-hour and 100-year 6-hour values were estimated from the contour maps of in the Asquith study and pulled from the grids of the current study. Differences were generally small and due to one or more of the following:

- Variations due to the georeferencing and digitization of the Asquith contoured maps;
- Higher spatial interpolation resolution in this project, hence better definition among complex terrain;
- Increased number of stations (see Table 1);
- Longer (~20 years more) period of record at stations;
- Distribution selected for 6-hour duration (GEV versus GLO).

Additionally, comparisons with NOAA Atlas 14 are provided. NOAA Atlas 14 does not cover Texas, but a comparison along the borders with Alabama (Volume 9), Oklahoma (Volume 8) and New Mexico (Volume 1) provided the means of making objective comparisons. Stations along the border where the projects overlapped were selected for comparison (Table 17b). Current estimates are very near the mean estimates provided in NOAA Atlas 14 and well within the confidence limits they provide.

The pattern and magnitudes of the new rainfall frequency estimates are similar across much of Texas to the previous studies. Differences were generally less than +/- 10% but could be as great as 15% and 20% in a few areas between Asquith's and NOAA Atlas 14, respectively. Most of the differences occurred in topographically complex terrain and along the coast where Asquith and Roussel lacked the spatial resolution and/or station data to capture the spatial detail.

Table 17a. Point estimates comparing previous study (Asquith and Roussel, 2004).

Location	Latitude	Longitude	Asquith & Roussel (2004)		Current Project	
			6-hour	24-hour	6-hour	24-hour
North Central	35.424	-101.639	5.00	6.55	5.20	6.38
West	30.414	-103.786	3.50	5.10	4.32	5.21

South	26.322	-97.649	7.50	10.00	6.87	9.58
East Coast	29.904	-94.377	10.45	14.40	9.01	14.52
Northeast	33.361	-96.372	6.55	10.05	7.15	10.31
Central	31.434	-98.854	6.00	8.40	6.55	6.74

Table 17b. Point estimates comparing previous NOAA Atlas 14 study.

			NOAA Atlas 14 (2004, 2013)		Current Project	
Location	**Latitude**	**Longitude**	**6-hour**	**24-hour**	**6-hour**	**24-hour**
Orogrande, NM (296435)	32.379	-106.091	3.11 (2.70-3.48)	3.64 (3.14-4.19)	3.27	4.15
Shattuck 1NW, OK (348101)	36.289	-99.893	5.26 (4.04-6.74)	6.64 (5.16-8.38)	5.41	7.03
Vinton, LA (169375)	30.192	-93.581	10.10 (7.56-14.0)	15.70 (11.8-21.4)	10.47	14.80

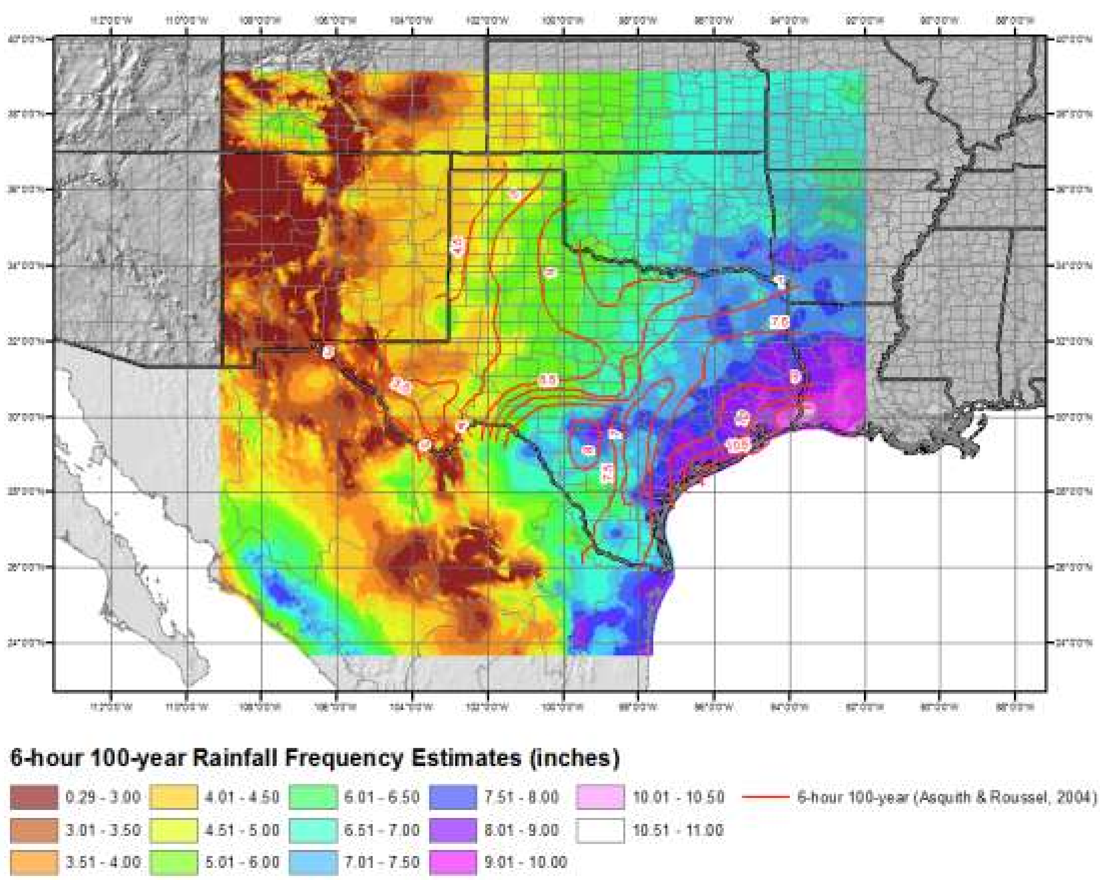


Figure 20. 100-year 6-hour map of current results and contours from the previous study (Asquith and Roussel, 2004) showing consistency in spatial patterns.

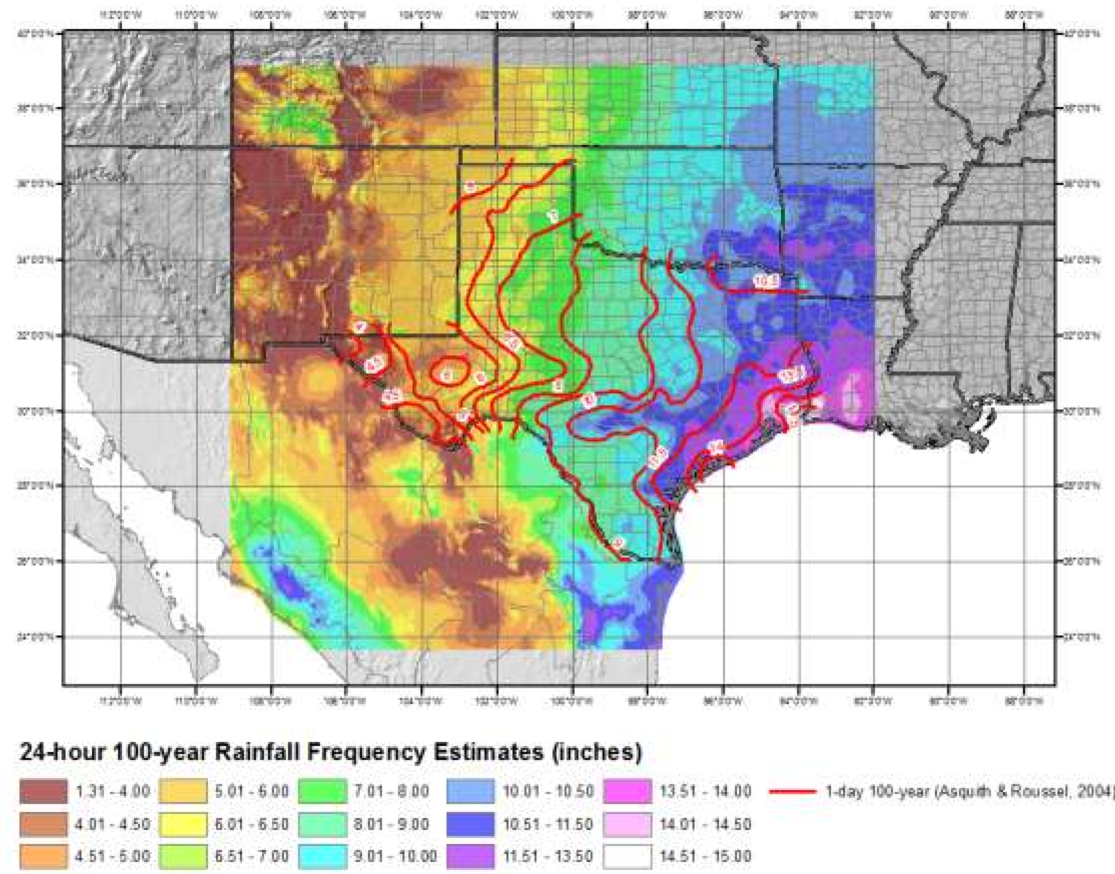


Figure 21. 100-year 24-hour map of current results and contours from the previous study (Asquith and Roussel, 2004) showing consistency in spatial patterns.

Peer-Review

The rainfall frequency estimates were peer reviewed by the project's Board of Consultants including the author of the previous study (William Asquith) and the State Climatologist of Texas (John Nielsen-Gammon). Careful consideration was given to reviewer comments and when possible and appropriate, changes were made to accommodate reviewer suggestions and/or concerns.

Deliverables

The final deliverables of this project are contained in the appendix of this report, as well as a digital ASCII grid files. The primary deliverable is the suite of all-season rainfall frequency GIS grids. The final grids/maps were clipped to the Texas PMP domain, plus a small buffer was added to ensure complete coverage along the borders and across watershed boundaries extending beyond Texas.

REFERENCES

Asquith, William H., 1998: *Depth-Duration Frequency of Precipitation for Texas*. Water-Resources Investigations Report 98–4044, in cooperation with the Texas Department of Transportation and the U.S. Department of the Interior, U.S. Geological Survey, Austin, TX. http://pubs.usgs.gov/wri/wri98-4044/pdf/98-4044.pdf

Asquith, W. H. and M. C. Roussell, 2004: *Atlas of Depth-Duration Frequency of Precipitation Annual Maxima for Texas*, Scientific Investigations Report 2004–5041, in cooperation with the Texas Department of Transportation and the U.S. Department of the Interior, U.S. Geological Survey, Austin, TX. (TxDOT 5-1301-01-1) http://pubs.usgs.gov/sir/2004/5041/pdf/sir2004-5041.pdf

Asquith, W. H., M. C. Roussel, D. B. Thompson, T. G. Cleveland, and X. Fang, 2005. *Summary of Dimensionless Texas Hyetographs and Distribution of Storm Depth,* Developed for Texas Department of Transportation Research Project 0-4194, U.S. Geological Survey, Austin, TX. (TxDOT 0-4194-4)

Bonnin, G., D. Martin, B. Lin, T. Parzybok, M. Yekta, and D. Riley, 2004: NOAA *Atlas 14 Volume 1, Precipitation-Frequency Atlas of the United States, Semiarid Southwest*. NOAA, National Weather Service, Silver Spring, MD.

Bonnin, G., D. Martin, B. Lin, T. Parzybok, M. Yekta, and D. Riley, 2006a: *NOAA Atlas 14 Volume 2, Precipitation-Frequency Atlas of the United States, Delaware, District of Columbia, Illinois, Indiana, Kentucky, Maryland, New Jersey, North Carolina, Ohio, Pennsylvania, South Carolina, Tennessee, Virginia, West Virginia*. NOAA, National Weather Service, Silver Spring, MD.

Bonnin, G., D. Martin, B. Lin, T. Parzybok, M. Yekta, and D. Riley, 2006b: *NOAA Atlas 14 Volume 3, Precipitation-Frequency Atlas of the United States, Puerto Rico and the U.S. Virgin Islands*. NOAA, National Weather Service, Silver Spring, MD.

Dalrymple, D., 1960: *Flood Frequency Analysis*. USGS Water Supply Paper 1543-A.

Daly, C., G. Taylor, and W. Gibson, 1997: *The PRISM Approach to Mapping Precipitation and Temperature.* 10th Conf. on Applied Climatology, American Meteorology Society, 10-12, Reno, Nevada. http://www.ocs.orst.edu/pub/prism/docs/appclim97-prismapproach-daly.pdf

Daly, C., R.P. Neilson, and D.L. Phillips, 1994: *A Statistical-Topographic Model for Mapping Climatological Precipitation over Mountainous Terrain*. Journal Applied. Meteorology, 33, 140-158.

Daly, C., W.P. Gibson, G.H. Taylor, G.L. Johnson, and P. Pasteris, 2002: *A knowledge-based approach to the statistical mapping of climate*. Climate Research, 23, 99-113.

Helsel, D.R. and Hirsch, 1992: *Statistical methods in water resources*. New York, Elsevier, Studies in Environmental Science 49, 522 pp.

Hershfield, D.M., 1961: *Rainfall frequency atlas of the United States for durations from 30 minutes to 24 hours and return periods from 1 to 100 years*. Weather Bureau Technical Paper No. 40, U.S. Weather Bureau, Washington, D.C., 115 pp.

Hosking, J.R.M. and J.R. Wallis, 1997: *Regional frequency analysis, an approach based on L-moments*. Cambridge University Press, 224 pp.

Langbein, W.B., 1949: *Annual Floods and the Partial Duration Flood Series*. Transaction American Geophysical Union, Vol. 30, pp. 879-881.

Larkin, T., J. and G. W. Bomar, 1983: *Climatic Atlas of Texas*. Texas Department of Water Resources, Austin, Texas.

MGS Software, LLC, 2011: L-moments Regional Analysis Program (LRAP) Users Manual.
Miller, J.F., R.H. Frederick and R.S. Tracey, 1973: *NOAA Atlas 2, Precipitation: Frequency Atlas of the Western United States*. U.S. Dept. of Commerce, NOAA, National Weather Service, Washington DC.

Perica, S. D. Martin, S. Pavlovic, I. Roy, M. St. Laurent, C., Trypaluk, D. Unruh, M. Yekta, G. Bonnin, 2013b: *NOAA Atlas 14 Volume 9, Precipitation-Frequency Atlas of the United States, Southeastern States (Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi)*. NOAA, National Weather Service, Silver Spring, MD.

Perica, S. D. Martin, S. Pavlovic, I. Roy, M. St. Laurent, C., Trypaluk, D. Unruh, M. Yekta, G. Bonnin, 2013a: *NOAA Atlas 14 Volume 8, Precipitation-Frequency Atlas of the United States, Midwestern States (Colorado, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Oklahoma, South Dakota, Wisconsin)*. NOAA, National Weather Service, Silver Spring, MD.

Perica, S., S. Dietz, S. Heim, L. Hiner, K., Maitaria, D. Martin, S. Pavlovic, I. Roy, C., Trypaluk, D. Unruh, F. Yan, M. Yekta, T. Zhao, G. Bonnin, D. Brewer, L. Chen, T. Parzybok, J. Yarchoan, 2011: *NOAA Atlas 14 Volume 6, Precipitation-Frequency Atlas of the United States, California*. NOAA, National Weather Service, Silver Spring, MD.

Perica, S., B. Lin, D. Martin, F. Yan, D. Brewer, C. Trypaluk, M. Yekta, L. Hiner, S. Heim, S. Dietz, T. Parzybok, L.-C. Chen, K. Maitaria, R. Chen, I. Roy, D. Unruh, T. Zhao, J. Yarchoan, G. Bonnin, 2009b: *NOAA Atlas 14 Volume 5, Precipitation-Frequency Atlas of the United States, Selected Pacific Islands.* NOAA, National Weather Service, Silver Spring, MD.

Perica, S., D. Martin, B. Lin, T. Parzybok, D. Riley, M. Yekta, L. Hiner, L.-C. Chen, D. Brewer, F. Yan, K. Maitaria, C. Trypaluk, G. Bonnin, 2009a: *NOAA Atlas 14 Volume 4, Precipitation-Frequency Atlas of the United States, Hawaiian Islands*. NOAA, National Weather Service, Silver Spring, MD.

Plantico, M.S., L.A. Goss, C. Daly, and G. Taylor. 2000: *A new U.S. climate atlas*. In: Proc., 12th AMS Conf. on Applied Climatology, American Meteorological Society, May 8-11, 247-248, Asheville, North Carolina.

Schaefer, M.G., B.L. Barker, G.H. Taylor and J.R. Wallis, 2002: *Regional Precipitation-Frequency Analysis and Spatial Mapping of Precipitation for 24-Hour and 2-Hour Durations in Western Washington*. Publication prepared for Washington State Department of Transportation, Report WARD 544.1, MGS Engineering Consultants.

Schaefer, M.G., B.L. Barker, G.H. Taylor and J.R. Wallis, 2006: *Regional Precipitation-Frequency Analysis and Spatial Mapping of Precipitation for 24-Hour and 2-Hour Durations in Eastern Washington*. Publication prepared for Washington State Department of Transportation, MGS Engineering Consultants.

Schaefer, M.G., B.L. Barker, G.H. Taylor and J.R. Wallis, 2008: *Regional Precipitation-Frequency Analysis and Spatial Mapping of Precipitation For Oregon*. Publication prepared for Oregon Department of Transportation and Federal Highway Administration, MGS Engineering Consultants.

Schaefer, M.G., 1997: *Magnitude-Frequency Characteristics of Precipitation Annual Maximum In Southern British Columbia*, MGS Engineering Consultants, Inc., prepared for BChyrdo Power Supply and Engineering.

Texas Commission on Environmental Quality, 2007: *Hydrologic and Hydraulic Guidelines for Dams in Texas*, https://www.tceq.texas.gov/publications/gi/gi-364.html/at_download/file.

Weiss, L.L., 1964: *Ratio of True to Fixed Interval Maximum Rainfall*. Journal Hydraulics, ASCE, Vol. 90, No. 1, pp. 77-82.

Station Catalogs

The station catalog listing includes the station identification (ID) number, station name, state, latitude (decimal degrees), longitude (decimal degrees), type of gauge (HR, hourly or DY, daily), source of data, data years, mean (1961-1990) annual precipitation (MAP) from PRISM, L-moment region number, and the mean annual maximum (MAM) amount. Stations are listed in alphabetical order according to the station name. The 6-hour listing is shown in Table A-6 and the 24-hour in Table A-8.

Table A-6. Station catalog of hourly gauges used in the 6-hour rainfall frequency analysis for Texas.

Station ID	Station name	State	Lat.	Long.	Source	Data years	PRISM MAP (inches)	L-mom. Region	MAM (inches)
410016	ABILENE RGNL AP	TX	32.4106	-99.6822	NCDC	71	25.3	31	2.30
410050	ADAMSVILLE	TX	31.2833	-98.1500	NCDC	23	29.9	40	2.30
290199	ALAMOGORDO	NM	32.9183	-105.9467	NCDC	38	12.8	25	1.13
160098	ALEXANDRIA	LA	31.3206	-92.4611	NCDC	41	59.5	55	3.74
410174	ALPINE	TX	30.3764	-103.6600	NCDC	35	16.6	26	1.62
340188	ALTUS 7 NE	OK	34.7167	-99.2667	NCDC	23	28.4	31	2.00
340179	ALTUS IRIG RSCH STN	OK	34.5903	-99.3344	NCDC	39	27.9	31	2.46
030130	ALUM FORK	AR	34.7961	-92.8417	NCDC	64	55.6	50	3.02
410206	ALVORD 3 N	TX	33.3867	-97.7164	NCDC	65	35.5	41	2.46
030136	ALY	AR	34.8000	-93.4667	NCDC	34	54.3	50	2.81
410211	AMARILLO WSO AP	TX	35.1300	-101.4300	NCDC	71	22.5	30	2.14
410248	ANDREWS	TX	32.3483	-102.5517	NCDC	68	14.4	24	1.70
290407	ANGEL FIRE 1S	NM	36.3950	-105.2853	NCDC	17	22.9	10	1.06
290417	ANIMAS 3 ESE	NM	31.9378	-108.7686	NCDC	41	12.1	25	1.03
410262	ANNA	TX	33.3500	-96.5167	NCDC	50	41.6	41	2.83
340242	ANTHON 6 W	OK	35.7500	-99.1000	NCDC	26	29.2	31	2.19
340256	ANTLERS	OK	34.2208	-95.6150	NCDC	50	47.7	50	3.22
030178	ANTOINE	AR	34.0292	-93.4211	NCDC	59	53.7	54	3.17
837152A	ARANSAS	TX	28.3044	-96.8233	RAWS	16	37.9	55	3.97
340292	ARDMORE	OK	34.1714	-97.1294	NCDC	48	37.6	41	2.68
030220	ARKADELPHIA 2 N	AR	34.1433	-93.0589	NCDC	63	53.1	54	3.15
290600	ARTESIA 6S	NM	32.7547	-104.3836	NCDC	64	12.3	24	1.50
410380	ASHERTON	TX	28.4333	-99.7500	NCDC	19	20.4	36	3.23
8208000	ATASCOSA RV AT WHITS	TX	28.6222	-98.2814	USGS	22	26.8	44	2.92
290640	AUGUSTINE 2E	NM	34.0750	-107.6211	NCDC	63	12.9	11	0.98
410428	AUSTIN CAMP MABRY	TX	30.3211	-97.7600	NCDC	70	33.5	44	2.90
8040000	B. A. STEINHAGEN LK	TX	30.7955	-94.1802	USGS	23	56.2	55	2.86
3265958	BALCONES	TX	30.5661	-98.0389	RAWS	15	32.5	35	3.02
410509	BANKERSMITH	TX	30.1411	-98.8200	NCDC	71	31.6	35	3.05
410518	BARDWELL DAM	TX	32.2631	-96.6369	NCDC	47	38.8	41	2.89
8072500	BARKER RES NR	TX	29.7700	-95.6472	USGS	23	48.9	55	3.34

Station ID	Station name	State	Lat.	Long.	Source	Data years	PRISM MAP (inches)	L-mom. Region	MAM (inches)
	ADDICK								
410569	BAY CITY WTR WKS	TX	28.9797	-95.9750	NCDC	69	47.9	55	3.29
290818	BEAVERHEAD R/S	NM	33.4286	-108.1000	NCDC	62	16.5	11	1.13
410639	BEEVILLE 5 NE	TX	28.4575	-97.7061	NCDC	59	30.8	44	3.01
410665	BELTON DAM	TX	31.1000	-97.4833	NCDC	41	35.7	41	2.99
410690	BENAVIDES 2	TX	27.5969	-98.4161	NCDC	71	21.2	36	2.58
410691	BENBROOK DAM	TX	32.6475	-97.4439	NCDC	62	35.4	41	2.62
340670	BENGAL 2 NNW	OK	34.8547	-95.0697	NCDC	59	48.8	50	3.31
160761	BERNICE 2 S	LA	32.7833	-92.6667	NCDC	18	56.1	54	3.29
410738	BERTRAM 3 ENE	TX	30.7603	-98.0164	NCDC	44	32.8	35	2.85
160786	BETHANY	LA	32.3833	-94.0500	NCDC	28	52.4	54	2.92
140802	BIG BOW 4 WSW	KS	37.5514	-101.6344	NCDC	52	17.0	21	1.80
410779	BIG LAKE 2	TX	31.2000	-101.4625	NCDC	69	17.3	34	2.14
410784	BIG SPRING FLD STN	TX	32.2683	-101.4858	NCDC	72	19.5	21	2.10
030764	BLAKELY MTN DAM	AR	34.5697	-93.1947	NCDC	62	54.5	50	3.17
8171300	BLANCO RV NR KYLE	TX	29.9794	-97.9100	USGS	20	34.6	44	3.35
340908	BOISE CITY 2 E	OK	36.7236	-102.4803	NCDC	62	17.6	21	1.83
410917	BON WIER	TX	30.7333	-93.6500	NCDC	35	58.2	55	3.60
410926	BONITA 4NW	TX	33.8472	-97.6528	NCDC	72	35.9	41	2.66
291120	BONITO DAM	NM	33.4486	-105.6847	NCDC	64	24.0	11	1.60
291138	BOSQUE DEL APACHE	NM	33.8044	-106.8908	NCDC	20	9.2	11	0.97
411013	BRACKETTVILLE 22 N	TX	29.6081	-100.4744	NCDC	16	23.4	35	2.69
411017	BRADY	TX	31.1444	-99.3492	NCDC	71	27.0	34	2.42
8370A0D	BRAZORIA NWR	TX	29.1464	-95.3031	RAWS	21	52.2	55	3.54
8091000	BRAZOS RV NR GLEN RO	TX	32.2590	-97.7025	USGS	18	33.7	41	2.62
8111500	BRAZOS RV NR HEMPSTE	TX	30.1291	-96.1877	USGS	15	43.2	44	3.16
8088000	BRAZOS RV NR SOUTH B	TX	33.0243	-98.6440	USGS	15	31.1	40	2.56
411057	BRICE 2 S	TX	34.6833	-100.9000	NCDC	42	23.2	31	2.00
411068	BRIGGS	TX	30.8833	-97.9333	NCDC	59	32.9	35	2.90
030900	BRIGGSVILLE	AR	34.9458	-93.4636	NCDC	26	51.2	50	2.83
411081	BRITTON	TX	32.5500	-97.0667	NCDC	28	37.6	41	2.59
341168	BROKEN BOW DAM	OK	34.1333	-94.7000	NCDC	34	53.0	54	3.03
411136	BROWNSVILLE INTL AP	TX	25.9142	-97.4231	NCDC	70	27.2	36	3.17
411185	BUENAVISTA 2 NNW	TX	31.2500	-102.6667	NCDC	22	11.9	24	1.38
8073600	BUFFALO BAYOU AT W B	TX	29.7622	-95.5577	USGS	23	50.1	55	3.83
8072300	BUFFALO BAYOU NR KAT	TX	29.7433	-95.8069	USGS	22	47.1	55	3.53
411246	BURLESON	TX	32.5067	-97.3442	NCDC	29	36.7	41	3.01
291286	CABALLO DAM	NM	32.8967	-107.3092	NCDC	63	10.9	11	1.06
3288936	CADDO	TX	33.7408	-95.9222	RAWS	15	45.4	54	3.05

Station ID	Station name	State	Lat.	Long.	Source	Data years	PRISM MAP (inches)	L-mom. Region	MAM (inches)
031140	CALION L&D	AR	33.3111	-92.4850	NCDC	62	53.0	54	2.97
031152	CAMDEN 1	AR	33.5900	-92.8236	NCDC	63	53.4	54	3.15
7227500	CANADIAN RV NR AMARI	TX	35.4703	-101.8796	USGS	19	19.7	30	2.02
341437	CANEY 1 E	OK	34.2300	-96.1950	NCDC	61	44.0	50	3.05
411429	CANYON DAM	TX	29.8706	-98.1967	NCDC	34	35.7	44	3.25
411431	CANYON DAM #1	TX	29.8617	-98.2919	NCDC	40	34.5	44	2.94
411433	CANYON DAM #3	TX	29.9464	-98.3969	NCDC	42	34.6	35	3.14
411434	CANYON DAM #4	TX	29.9111	-98.3714	NCDC	50	33.8	44	2.98
411436	CANYON DAM #6	TX	29.9469	-98.3011	NCDC	48	35.1	44	2.95
411438	CANYON DAM #7	TX	29.9167	-98.2167	NCDC	33	35.6	44	2.94
411435	CANYON DAM 5	TX	29.9167	-98.3500	NCDC	26	33.9	44	3.13
8167700	CANYON LK NR NEW BRA	TX	29.8688	-98.1989	USGS	16	35.7	44	2.56
291440	CAPITAN	NM	33.5311	-105.5947	NCDC	35	17.3	11	1.25
291445	CAPROCK	NM	33.3433	-103.6783	NCDC	29	15.9	21	1.53
325B241	CAPROCK	NM	32.9272	-103.8569	RAWS	25	15.1	24	1.64
291469	CARLSBAD	NM	32.3478	-104.2225	NCDC	61	13.3	24	1.71
291515	CARRIZOZO 1SW	NM	33.6308	-105.8964	NCDC	62	13.1	11	1.13
411492	CARTA VALLEY	TX	29.7908	-100.6742	NCDC	32	22.5	35	2.83
341544	CARTER TWR	OK	34.2661	-94.7753	NCDC	61	53.1	50	3.04
411528	CATARINA	TX	28.3392	-99.6328	NCDC	42	19.5	36	2.60
161601	CATFISH POINT	LA	29.8667	-92.8500	NCDC	16	59.0	55	3.84
411646	CHANNING	TX	35.6869	-102.3342	NCDC	71	18.2	21	1.83
411671	CHEAPSIDE	TX	29.3103	-97.3469	NCDC	70	35.8	44	3.12
411680	CHEROKEE	TX	30.9833	-98.7167	NCDC	30	29.2	35	2.69
341750	CHICKASHA EXP STATIO	OK	35.0489	-97.9158	NCDC	53	34.7	40	2.63
762250S	CHIHUAHUA CHIH	MX	28.6330	-106.0830	MEXICO	15	0.0	26	1.13
411698	CHILDRESS MUNI AP	TX	34.4272	-100.2831	NCDC	70	24.4	31	1.99
8206900	CHOKE CANYON RES NR	TX	28.4839	-98.2458	USGS	17	26.0	44	2.82
325B376	CHUPADERA	NM	33.7731	-106.0986	RAWS	25	13.4	11	1.06
291840	CIRCLE F RCH	NM	33.9000	-105.0000	NCDC	42	12.8	20	1.36
411773	CLARKSVILLE 1W	TX	33.6100	-95.0217	NCDC	63	48.4	54	2.95
291887	CLAYTON MUNI ARPK AP	NM	36.4486	-103.1539	NCDC	59	15.7	21	1.78
291939	CLOVIS	NM	34.4239	-103.2008	NCDC	59	18.2	21	1.79
291963	CLOVIS 13 N	NM	34.5989	-103.2161	NCDC	63	18.3	21	1.82
8074150	COLE CK AT DEIHL RD	TX	29.8513	-95.4880	USGS	27	50.8	55	3.41
411903	COLORADO CITY	TX	32.3978	-100.8594	NCDC	16	20.7	31	2.11
8161000	COLORADO RV AT COLUM	TX	29.7064	-96.5369	USGS	17	43.3	44	3.21
8159500	COLORADO RV AT SMITH	TX	30.0127	-97.1619	USGS	15	37.8	44	2.96

Station ID	Station name	State	Lat.	Long.	Source	Data years	PRISM MAP (inches)	L-mom. Region	MAM (inches)
8162000	COLORADO RV AT WHART	TX	29.3091	-96.1039	USGS	17	46.8	55	3.47
292024	COLUMBUS	NM	31.8297	-107.6389	NCDC	63	9.8	25	1.18
411920	COMFORT 2	TX	29.9617	-98.8942	NCDC	21	33.6	35	2.86
411921	COMMERCE 4SW	TX	33.1997	-95.9283	NCDC	60	43.3	54	3.08
292030	CONCHAS DAM	NM	35.4072	-104.1906	NCDC	63	15.4	21	1.62
411956	CONROE	TX	30.3303	-95.4831	NCDC	63	48.7	55	3.62
8842246	CONROE	TX	30.2361	-95.4831	RAWS	15	48.9	55	3.82
412015	CORPUS CHRISTI AP	TX	27.7742	-97.5122	NCDC	64	31.4	55	3.59
412024	CORYELL CITY	TX	31.5500	-97.6167	NCDC	44	34.7	41	2.71
412048	COTULLA LA SALLE CO	TX	28.4567	-99.2183	NCDC	53	23.5	36	2.68
412082	CRANE	TX	31.3875	-102.3553	NCDC	62	14.0	24	1.88
412086	CRANFILLS GAP	TX	31.7708	-97.8281	NCDC	70	33.8	41	2.78
412096	CRESSON 3NW	TX	32.5561	-97.6697	NCDC	66	35.3	41	2.66
412131	CROSS PLAINS #2	TX	32.1267	-99.1606	NCDC	71	28.8	31	2.56
292207	CROSSROADS 2	NM	33.5133	-103.3403	NCDC	33	15.6	21	1.71
052040	CUCHARAS DAM	CO	37.7500	-104.6000	NCDC	38	16.2	10	1.45
412206	CYPRESS	TX	30.0211	-95.7069	NCDC	19	46.9	55	3.48
8068700	CYPRESS CK AT SHARP	TX	29.9211	-95.8402	USGS	22	46.2	55	3.15
031814	DAISY	AR	34.2500	-93.7333	NCDC	27	55.7	54	3.36
412242	DAL-FTW WSCMO AP	TX	32.8978	-97.0189	NCDC	64	37.4	41	2.52
412244	DALLAS FAA AP	TX	32.8519	-96.8556	NCDC	68	38.2	41	2.84
031952	DE QUEEN DAM	AR	34.1003	-94.3725	NCDC	35	53.6	54	2.81
412360	DEL RIO AP	TX	29.3772	-100.9275	NCDC	63	19.8	35	2.80
292436	DEMING	NM	32.2531	-107.7531	NCDC	50	10.7	25	1.02
412394	DENISON DAM	TX	33.8167	-96.5667	NCDC	58	41.2	41	2.94
412404	DENTON 2 SE	TX	33.1989	-97.1050	NCDC	65	38.5	41	2.71
8053500	DENTON CK NR JUSTIN	TX	33.1190	-97.2906	USGS	20	37.8	41	2.46
412415	DEPORT 4 NW	TX	33.5639	-95.3742	NCDC	56	46.8	54	3.04
032020	DIERKS DAM	AR	34.1475	-94.0889	NCDC	31	54.0	54	3.14
292510	DILIA	NM	35.1842	-105.0569	NCDC	63	15.5	20	1.30
412462	DIME BOX	TX	30.3606	-96.8456	NCDC	31	37.8	44	2.85
142164	DODGE CITY RGNL AP	KS	37.7686	-99.9678	NCDC	63	21.9	30	2.00
412621	DUMONT	TX	33.8094	-100.5169	NCDC	40	23.8	31	2.15
342654	DUNCAN AP	OK	34.4831	-97.9578	NCDC	63	36.3	40	2.65
325B41F	DUNKEN	NM	32.8247	-105.1825	RAWS	25	16.2	24	1.46
292665	DURAN	NM	34.4692	-105.3975	NCDC	63	14.6	20	1.37
8070000	E FK SAN JACINTO RV	TX	30.3366	-95.1041	USGS	24	54.1	55	2.89
412676	EAGLE LAKE RESCH CTR	TX	29.6211	-96.3661	NCDC	70	43.9	55	3.10
292700	EAGLE NEST	NM	36.5575	-105.2628	NCDC	63	17.2	10	0.98

Station ID	Station name	State	Lat.	Long.	Source	Data years	PRISM MAP (inches)	L-mom. Region	MAM (inches)
412679	EAGLE PASS 3N	TX	28.7567	-100.4789	NCDC	68	20.0	36	2.94
412715	EASTLAND	TX	32.3989	-98.8175	NCDC	45	28.7	40	2.52
412744	EDEN 2	TX	31.2167	-99.8500	NCDC	46	25.1	34	2.37
327CA1D	EIGHT MILE DRAW	NM	33.6506	-104.3214	RAWS	29	13.4	20	1.81
412797	EL PASO AP	TX	31.8111	-106.3758	NCDC	70	9.6	25	1.14
412811	ELDORADO 1 N	TX	30.8833	-100.6000	NCDC	50	21.7	34	2.12
412815	ELDORADO 12N	TX	31.0369	-100.5911	NCDC	16	21.7	34	2.42
342849	ELK CITY 4 W	OK	35.3925	-99.5064	NCDC	33	28.7	31	2.61
142432	ELKHART	KS	37.0058	-101.8867	NCDC	61	18.1	21	1.81
142560	ENGLEWOOD 1 NW	KS	37.0458	-99.9964	NCDC	61	22.7	30	2.08
343002	EVA	OK	36.7975	-101.9075	NCDC	63	17.9	21	1.66
413005	EVANT 1SSW	TX	31.4625	-98.1619	NCDC	67	31.2	40	2.57
413033	FABENS	TX	31.5000	-106.1500	NCDC	25	8.2	25	1.30
032489	FERNDALE 6 E	AR	34.7594	-92.4553	NCDC	30	52.0	54	2.69
413133	FERRIS	TX	32.5336	-96.6606	NCDC	63	38.9	41	2.94
413156	FISCHERS STORE	TX	29.9756	-98.2647	NCDC	16	35.4	44	2.78
413171	FLAT	TX	31.3089	-97.6306	NCDC	57	34.0	41	2.99
293225	FLORIDA	NM	32.4333	-107.4833	NCDC	45	11.4	11	1.35
032544	FOREMAN	AR	33.7164	-94.3814	NCDC	60	48.8	54	3.19
343304	FORT SUPPLY 3SE	OK	36.5442	-99.5350	NCDC	64	24.6	31	2.20
413329	FREDERICKSBURG	TX	30.2392	-98.9089	NCDC	35	30.8	35	2.89
8195000	FRIO RV AT CONCAN T	TX	29.4886	-99.7048	USGS	19	28.9	35	2.83
413370	FRISCO	TX	33.1519	-96.8122	NCDC	43	39.9	41	2.95
293265	FT BAYARD	NM	32.7939	-108.1517	NCDC	41	17.4	11	1.34
343281	FT COBB	OK	35.1036	-98.4428	NCDC	54	31.3	40	2.75
413270	FT MCKAVETT 7 N	TX	30.9303	-100.1125	NCDC	50	24.4	34	2.19
413278	FT STOCKTON 35 SSW	TX	30.3833	-103.0333	NCDC	29	14.9	24	1.94
413284	FT WORTH MEACHAM FLD	TX	32.8192	-97.3614	NCDC	64	36.2	41	2.61
413285	FT WORTH WSFO	TX	32.8339	-97.2975	NCDC	52	36.6	41	2.62
343407	GAGE AP	OK	36.2967	-99.7689	NCDC	17	22.5	31	2.23
413410	GAGEBY 3 WNW	TX	35.6306	-100.3917	NCDC	67	24.6	31	2.21
413415	GAINESVILLE	TX	33.6358	-97.1444	NCDC	70	38.4	41	2.68
413430	GALVESTON	TX	29.3333	-94.7717	NCDC	59	45.6	55	3.64
413446	GARDEN CITY 16 E	TX	31.8333	-101.2000	NCDC	24	19.7	34	1.89
032810	GILLHAM DAM	AR	34.2056	-94.2464	NCDC	34	54.4	54	3.55
413546	GILMER 4 WNW	TX	32.7464	-95.0497	NCDC	62	46.6	54	3.13
343628	GOODWELL RSCH STN	OK	36.5914	-101.6181	NCDC	65	17.9	21	1.71
413642	GORDONVILLE	TX	33.7969	-96.8569	NCDC	65	39.7	41	2.71
413646	GORMAN 2 NNE	TX	32.2422	-98.6631	NCDC	48	30.7	40	2.78
413686	GRANGER DAM	TX	30.7000	-97.3497	NCDC	32	34.7	41	2.75

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413691	GRAPEVINE DAM	TX	32.9506	-97.0553	NCDC	63	37.6	41	2.60
8076000	GREENS BAYOU NR HOUS	TX	29.9183	-95.3069	USGS	16	51.8	55	3.75
413771	GROESBECK 2	TX	31.5253	-96.5306	NCDC	33	41.6	41	3.12
8165500	GUADALUPE RV AT HUNT	TX	30.0699	-99.3217	USGS	19	30.3	35	2.72
8176500	GUADALUPE RV AT VICT	TX	28.7930	-97.0130	USGS	19	39.0	55	3.81
3243D7A	HACHITA VALLEY	NM	31.7019	-108.3417	RAWS	30	11.4	25	1.33
344010	HEAVENER EXP FARM	OK	34.9167	-94.6000	NCDC	20	50.0	50	2.86
344052	HENNEPIN 5 N	OK	34.5828	-97.3464	NCDC	63	38.2	41	3.02
414098	HEREFORD	TX	34.8172	-102.4003	NCDC	67	20.0	21	1.78
414137	HICO	TX	31.9844	-98.0311	NCDC	32	34.7	40	2.78
294009	HILLSBORO	NM	32.9236	-107.5628	NCDC	62	13.4	11	1.22
414191	HINDES	TX	28.7167	-98.8000	NCDC	59	25.8	44	3.12
344204	HOBART MUNI AP	OK	34.9894	-99.0525	NCDC	64	29.6	31	2.69
294089	HONDO 1SE	NM	33.3803	-105.2544	NCDC	64	14.7	11	1.56
414257	HONEY GROVE	TX	33.5881	-95.9039	NCDC	64	45.7	54	3.02
294112	HOPE	NM	32.8111	-104.7336	NCDC	41	14.1	24	1.64
033428	HOPE 3 NE	AR	33.7089	-93.5561	NCDC	17	53.3	54	2.93
414278	HORDS CREEK DAM	TX	31.8456	-99.5606	NCDC	41	26.9	31	2.67
414309	HOUSTON ADDICKS	TX	29.7689	-95.6439	NCDC	64	48.9	55	3.47
414311	HOUSTON ALIEF	TX	29.7147	-95.5947	NCDC	64	49.8	55	3.48
414300	HOUSTON BUSH INTL AP	TX	29.9800	-95.3600	NCDC	42	51.1	55	3.77
414307	HOUSTON HOBBY AP	TX	29.6381	-95.2819	NCDC	18	53.3	55	3.55
414329	HOUSTON SATSUMA	TX	29.9333	-95.6333	NCDC	50	46.8	55	3.44
414305	HOUSTON WB CITY	TX	29.7667	-95.3667	NCDC	31	51.5	55	3.23
344384	HUGO	OK	34.0211	-95.5381	NCDC	52	47.1	54	3.07
344386	HUGO DAM	OK	34.0000	-95.4000	NCDC	29	47.9	54	2.74
414375	HUNT 10 W	TX	30.0628	-99.5050	NCDC	71	28.4	35	2.68
414425	IMPERIAL	TX	31.2667	-102.7000	NCDC	30	12.0	24	1.63
414440	INDIAN GAP	TX	31.6667	-98.4167	NCDC	32	30.3	40	2.38
414476	IREDELL	TX	31.9803	-97.8608	NCDC	48	34.5	41	2.74
414517	JACKSBORO	TX	33.2231	-98.1608	NCDC	71	33.0	40	2.42
414570	JAYTON	TX	33.2544	-100.5725	NCDC	71	23.4	31	2.29
414577	JEFFERSON	TX	32.7681	-94.3561	NCDC	35	49.6	54	2.87
164700	JENNINGS	LA	30.2003	-92.6642	NCDC	34	60.6	55	3.89
414591	JEWETT	TX	31.3500	-96.1500	NCDC	49	40.1	41	2.87
294426	JORNADA EXP RANGE	NM	32.6169	-106.7411	NCDC	63	10.4	11	1.15
414670	JUNCTION 4SSW	TX	30.4453	-99.8044	NCDC	69	23.8	34	2.31
414679	JUSTIN	TX	33.0806	-97.2967	NCDC	58	37.8	41	2.99
164816	KEITHVILLE	LA	32.3550	-93.8619	NCDC	26	52.4	54	3.08

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414792	KILLEEN 3 S	TX	31.0719	-97.7306	NCDC	25	33.9	41	2.58
054538	KIM 15 NNE	CO	37.4536	-103.3219	NCDC	64	16.1	20	1.69
344865	KINGSTON 5 SSE	OK	33.9300	-96.6961	NCDC	47	42.0	41	2.93
414866	KOPPERL 5 NNE	TX	32.1347	-97.4786	NCDC	69	35.0	41	2.67
414878	KOUNTZE	TX	30.3750	-94.2994	NCDC	40	58.8	55	3.94
414880	KRESS	TX	34.3708	-101.7483	NCDC	72	20.4	21	1.95
8077740	LA MARQUE LEVEE PUMP	TX	29.3458	-94.9633	USGS	18	52.3	55	2.96
414920	LA PRYOR	TX	28.9836	-99.8678	NCDC	68	22.4	35	2.84
165065	LAKE ARTHUR 10 SW	LA	30.0031	-92.7808	NCDC	22	59.3	55	3.67
414972	LAKE BRIDGEPORT DAM	TX	33.2250	-97.8317	NCDC	66	35.0	40	2.47
165078	LAKE CHARLES AP	LA	30.1247	-93.2283	NCDC	49	60.2	55	4.07
414974	LAKE COLORADO CITY	TX	32.3333	-100.9167	NCDC	37	20.5	31	2.07
414975	LAKE CROCKETT	TX	33.7411	-95.9217	NCDC	64	45.4	54	2.80
344978	LAKE OVERHOLSER	OK	35.4878	-97.6644	NCDC	59	35.3	40	2.75
8103800	LAMPASAS RV NR KEMPN	TX	31.0793	-98.0167	USGS	20	31.9	40	2.74
8072760	LANGHAM CK AT W LITT	TX	29.8672	-95.6466	USGS	22	47.6	55	3.91
415048	LANGTRY	TX	29.7931	-101.5603	NCDC	67	14.5	34	2.14
415060	LAREDO 2	TX	27.5683	-99.4917	NCDC	28	19.5	36	2.73
294850	LAS VEGAS 2 NW	NM	35.6167	-105.2667	NCDC	27	17.9	10	1.59
294862	LAS VEGAS WWTP	NM	35.5678	-105.2131	NCDC	28	17.6	10	1.48
415094	LAVON DAM	TX	33.0353	-96.4861	NCDC	62	40.5	41	2.89
415113	LEAKEY	TX	29.7392	-99.7611	NCDC	66	30.0	35	3.29
165266	LEESVILLE	LA	31.1417	-93.2397	NCDC	46	59.5	55	3.29
345108	LEHIGH 4 SW	OK	34.4339	-96.2717	NCDC	62	43.2	50	3.21
8099100	LEON RV NR DE LEON	TX	32.1738	-98.5331	USGS	18	32.2	40	2.38
034185	LEWISVILLE	AR	33.3614	-93.5678	NCDC	37	52.7	54	2.86
415192	LEWISVILLE DAM	TX	33.0694	-97.0094	NCDC	61	37.8	41	2.80
415193	LEXINGTON	TX	30.4064	-97.0136	NCDC	72	36.1	44	2.94
415247	LIPSCOMB	TX	36.2358	-100.2675	NCDC	65	22.3	30	1.97
8106500	LITTLE RV NR CAMERON	TX	30.8352	-96.9467	USGS	16	35.0	41	3.06
8067118	LK CHARLOTTE NR ANAH	TX	29.8674	-94.7149	USGS	22	57.1	55	3.28
165527	LOGANSPORT 4 ENE	LA	31.9833	-93.9500	NCDC	39	52.3	54	3.30
415303	LOMA ALTA	TX	28.1569	-98.5142	NCDC	21	22.7	36	2.52
415303	LOMA ALTA	TX	28.1569	-98.5142	NCDC	21	22.7	36	2.87
415312	LONDON 3N	TX	30.7131	-99.5681	NCDC	69	26.4	34	2.38
8066200	LONG KING CK AT LIVI	TX	30.7163	-94.9588	USGS	15	51.3	55	3.62
415348	LONGVIEW 11 SE	TX	32.3467	-94.6533	NCDC	36	48.5	54	2.77
415358	LORAINE	TX	32.4167	-100.7167	NCDC	44	21.6	31	2.16

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415398	LOVELADY	TX	31.1333	-95.4500	NCDC	47	45.7	54	3.38
415410	LUBBOCK 9 N	TX	33.6897	-101.8219	NCDC	70	19.4	21	2.06
415411	LUBBOCK INTL AP	TX	33.6656	-101.8231	NCDC	61	19.4	21	2.01
415463	MABANK 4 SW	TX	32.3317	-96.1506	NCDC	71	41.0	41	3.17
345463	MACKIE 4 NNW	OK	35.7481	-99.8178	NCDC	51	25.7	31	2.24
034548	MAGNOLIA	AR	33.2506	-93.2336	NCDC	60	52.4	54	3.35
295370	MALJAMAR	NM	32.8567	-103.7625	NCDC	62	15.0	24	1.62
415528	MALONE 3ENE	TX	31.9442	-96.8464	NCDC	29	37.9	41	2.91
415596	MARFA 3W	TX	30.3125	-104.0722	NCDC	65	15.2	26	1.58
165935	MARTIN FIRE TWR	LA	32.0775	-93.2167	NCDC	27	56.6	55	3.06
415656	MATADOR NO 2	TX	34.0114	-100.8319	NCDC	70	23.8	31	2.02
345648	MAYFIELD	OK	35.3392	-99.8769	NCDC	60	25.7	31	2.62
415695	MAYPEARL	TX	32.3167	-97.0167	NCDC	51	37.4	41	2.86
415770	MC LEAN	TX	35.2358	-100.6067	NCDC	68	26.3	31	2.27
345664	MCALESTER RGNL AP	OK	34.8822	-95.7831	NCDC	29	43.7	50	2.69
7301200	MCCLELLAN CK NR MCLE	TX	35.3292	-100.6093	USGS	15	25.0	31	2.08
837184C	MCFADDIN	TX	29.7072	-94.1211	RAWS	15	59.0	55	3.48
8178880	MEDINA RV AT BANDERA	TX	29.7238	-99.0700	USGS	18	32.5	35	3.68
034756	MENA	AR	34.5731	-94.2494	NCDC	63	59.7	50	3.12
8128400	MIDDLE CONCHO RV ABV	TX	31.4274	-100.7112	USGS	18	21.1	34	2.05
415890	MIDLAND INTL AP	TX	31.9431	-102.1906	NCDC	67	14.4	24	1.80
415897	MIDLOTHIAN	TX	32.4842	-96.9942	NCDC	36	37.6	41	3.06
8111700	MILL CK NR BELLVILLE	TX	29.8811	-96.2052	USGS	15	43.7	55	3.46
034839	MILLWOOD DAM	AR	33.6772	-93.9903	NCDC	46	51.1	54	3.06
295754	MIMBRES RS	NM	32.9325	-108.0142	NCDC	56	19.3	11	1.30
166244	MINDEN	LA	32.6053	-93.2947	NCDC	47	54.6	54	2.89
415957	MINERAL WELLS 1 SSW	TX	32.7864	-98.1183	NCDC	59	32.8	40	2.61
295800	MOGOLLON	NM	33.3833	-108.7833	NCDC	26	27.4	11	1.39
415996	MOLINE	TX	31.3933	-98.3081	NCDC	67	30.7	40	2.73
763420S	MONCLOVA INTL	MX	26.9560	-101.4700	MEXI CO	15	0.0	26	1.38
763930S	MONTERREY NL	MX	25.7330	-100.3000	MEXI CO	16	0.0	26	1.76
166324	MONTGOMERY	LA	31.6667	-92.9000	NCDC	21	57.8	55	3.94
8077650	MOSES LK-GALVESTON B	TX	29.4475	-94.9202	USGS	24	55.3	55	4.66
8049580	MOUNTAIN CK NR VENUS	TX	32.4910	-97.1231	USGS	18	36.8	41	2.69
034988	MT IDA 3 SE	AR	34.5408	-93.5878	NCDC	60	56.4	50	2.96
416104	MT LOCKE	TX	30.7053	-104.0233	NCDC	62	19.8	26	1.72
416108	MT PLEASANT	TX	33.1689	-95.0056	NCDC	68	47.0	54	2.94
055819	MULE SHOE LODGE 1 SS	CO	37.5833	-105.1833	NCDC	38	20.5	10	1.24

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416136	MULESHOE 2	TX	34.2208	-102.7367	NCDC	71	18.5	21	1.57
416177	NACOGDOCHES	TX	31.6164	-94.6431	NCDC	56	51.5	55	3.46
296043	NARROWS	NM	33.3833	-107.1667	NCDC	21	7.3	11	1.07
035110	NARROWS DAM	AR	34.1453	-93.7139	NCDC	61	56.5	54	3.24
035112	NASHVILLE	AR	33.9303	-93.8514	NCDC	59	53.7	54	3.27
166582	NATCHITOCHES	LA	31.7722	-93.0956	NCDC	39	55.7	55	3.55
416210	NAVARRO MILLS DAM	TX	31.9611	-96.6881	NCDC	49	38.3	41	3.07
8041000	NECHES RV AT EVADALE	TX	30.3558	-94.0932	USGS	20	57.7	55	3.57
8033000	NECHES RV NR DIBOLL	TX	31.1330	-94.8099	USGS	20	51.9	55	2.95
8033500	NECHES RV NR ROCKLAN	TX	31.0250	-94.3994	USGS	20	54.1	55	3.41
416270	NEW BOSTON	TX	33.4547	-94.4089	NCDC	36	48.8	54	2.94
416335	NEW SUMMERFIELD 2W	TX	31.9750	-95.1375	NCDC	49	47.0	54	2.73
035200	NIMROD DAM	AR	34.9553	-93.1594	NCDC	63	53.8	50	2.67
346328	NINNEKAH	OK	34.9500	-97.9333	NCDC	20	34.3	40	2.86
296138	NOGAL LAKE 1 S	NM	33.5167	-105.6833	NCDC	23	22.1	11	1.37
8194000	NUECES RV AT COTULLA	TX	28.4264	-99.2400	USGS	25	23.4	36	2.81
8190000	NUECES RV AT LAGUNA	TX	29.4286	-99.9973	USGS	24	25.2	35	2.67
416504	O DONNELL	TX	32.9711	-101.8247	NCDC	71	19.7	21	2.03
296275	OCATE 2 NW	NM	36.1839	-105.0608	NCDC	50	19.9	10	1.46
3284F71	ODEN	AR	34.6242	-93.8061	RAWS	16	56.0	50	2.90
346638	OKEMAH	OK	35.4253	-96.3033	NCDC	60	43.3	41	2.72
346661	OKLAHOMA CITY WILL R	OK	35.3889	-97.6006	NCDC	64	36.3	40	2.83
416615	OLD 8 CAMP 6666	TX	33.5639	-100.1853	NCDC	20	25.0	31	2.31
8158700	ONION CK NR DRIFTWOO	TX	30.0830	-98.0078	USGS	21	35.6	44	3.08
346740	OPTIMA LAKE	OK	36.6500	-101.1333	NCDC	21	19.3	30	2.14
296435	OROGRANDE	NM	32.3789	-106.0911	NCDC	63	11.9	25	1.26
416734	OZONA	TX	30.7044	-101.2022	NCDC	17	19.4	34	2.35
416736	OZONA 8 WSW	TX	30.6819	-101.3375	NCDC	52	19.4	34	2.24
325B671	PADUCA	NM	32.1797	-103.7217	RAWS	25	13.3	24	1.70
416757	PALESTINE 2 NE	TX	31.7831	-95.6039	NCDC	70	46.4	54	3.15
8091500	PALUXY RV AT GLEN RO	TX	32.2315	-97.7773	USGS	18	34.7	41	2.56
416776	PAMPA 2	TX	35.5544	-100.9736	NCDC	71	22.4	30	1.96
8068400	PANTHER BR AT GOSLIN	TX	30.1922	-95.4838	USGS	16	49.0	55	3.33
8068450	PANTHER BR NR SPRING	TX	30.1344	-95.4777	USGS	16	49.1	55	3.61
416792	PANTHER JUNCTION	TX	29.3272	-103.2061	NCDC	57	13.6	26	1.59
346859	PAOLI 2 W	OK	34.8231	-97.2850	NCDC	64	38.4	41	2.80
296619	PASAMONTE	NM	36.2994	-103.7408	NCDC	17	16.5	21	1.84
296659	PEARL	NM	32.6500	-103.3833	NCDC	48	14.7	24	2.15

Station ID	Station name	State	Lat.	Long.	Source	Data years	PRISM MAP (inches)	L-mom. Region	MAM (inches)
8143600	PECAN BAYOU NR MULLI	TX	31.5174	-98.7406	USGS	15	29.6	40	2.80
167174	PECAN ISLAND	LA	29.6500	-92.4333	NCDC	18	61.1	55	4.55
416893	PECOS 8W	TX	31.3783	-103.6331	NCDC	46	11.7	24	1.42
8152900	PEDERNALES RV NR FRE	TX	30.2205	-98.8698	USGS	15	30.9	35	3.01
324BE69	PELONA MOUNTAIN	NM	33.6939	-108.0617	RAWS	29	17.7	11	1.24
416935	PEP	TX	33.8153	-102.5578	NCDC	51	18.6	21	2.04
296812	PIETOWN 19NE	NM	34.4931	-107.8883	NCDC	23	14.4	11	1.08
347080	PINE CREEK DAM	OK	34.1167	-95.0833	NCDC	32	50.7	54	3.05
8041700	PINE ISLAND BAYOU NR	TX	30.1061	-94.3346	USGS	18	58.3	55	3.45
417060	PITCHFORK RCH	TX	33.5992	-100.5319	NCDC	37	23.8	31	1.98
417066	PITTSBURG 5 SSE	TX	32.9258	-94.9397	NCDC	58	45.5	54	2.91
167344	PLAIN DEALING 4 W	LA	32.9078	-93.7981	NCDC	18	50.8	54	3.20
417074	PLAINS	TX	33.1869	-102.8281	NCDC	66	17.6	21	1.96
763900S	PLAN DE GUADALUPE IN	MX	25.5490	-100.9290	MEXICO	15	0.0	26	1.67
417116	PLEMONS	TX	35.7667	-101.3333	NCDC	18	20.7	30	1.80
417140	POINT COMFORT	TX	28.6575	-96.5553	NCDC	54	42.8	55	3.86
167424	POLLOCK 6 NNW	LA	31.6000	-92.4333	NCDC	15	59.9	55	3.93
417174	PORT ARTHUR AP	TX	29.9506	-94.0206	NCDC	62	59.6	55	4.17
417213	POST OAK SCHOOL	TX	30.2667	-96.7167	NCDC	17	39.3	44	3.08
7297910	PR DOG TWN FK RED RV	TX	34.8376	-101.4141	USGS	20	21.5	30	2.31
7299540	PR DOG TWN FK RED RV	TX	34.5692	-100.1940	USGS	20	25.1	31	2.28
417243	PRAIRIE MTN	TX	30.5836	-98.8997	NCDC	66	29.4	35	2.50
035908	PRESCOTT 2 NNW	AR	33.8203	-93.3878	NCDC	61	53.8	54	2.93
417300	PROCTOR RSVR	TX	31.9633	-98.4942	NCDC	37	32.1	40	2.80
297094	PROGRESSO	NM	34.4208	-105.8914	NCDC	64	14.4	11	1.28
297254	RAMON 8 SW	NM	34.1508	-105.0044	NCDC	41	13.3	20	1.42
417422	RANDOLPH AFB	TX	29.5439	-98.2736	NCDC	68	32.1	44	2.98
347412	RANGE	OK	36.5447	-101.0842	NCDC	60	20.0	30	2.05
417431	RANKIN	TX	31.2286	-101.9461	NCDC	57	16.2	34	2.03
297279	RATON FLTR PLT	NM	36.9194	-104.4325	NCDC	44	18.2	10	1.46
297283	RATON WB AP	NM	36.7500	-104.5000	NCDC	19	16.8	10	1.67
036016	RAVANA	AR	33.0667	-94.0333	NCDC	22	50.2	54	3.25
417481	RED BLUFF DAM	TX	31.8950	-103.9183	NCDC	51	11.4	24	1.69
167738	RED RIVER RSCH STN	LA	32.4219	-93.6381	NCDC	43	51.8	54	3.30
417497	RED ROCK	TX	29.9667	-97.4500	NCDC	32	35.1	44	3.03
417499	RED SPRINGS 3 N	TX	33.6100	-99.3831	NCDC	65	27.6	31	2.44
036102	REMMEL DAM	AR	34.4333	-92.9000	NCDC	18	53.4	54	3.19
417556	RENO	TX	32.9536	-97.5739	NCDC	55	35.9	41	2.83
417594	RICHMOND	TX	29.5839	-95.7553	NCDC	58	48.6	55	3.10

Station ID	Station name	State	Lat.	Long.	Source	Data years	PRISM MAP (inches)	L-mom. Region	MAM (inches)
297423	RIENHARDT RCH	NM	33.7528	-107.2094	NCDC	59	10.0	11	1.13
417608	RIESEL	TX	31.4833	-96.8833	NCDC	29	37.3	41	2.89
347660	RIVERSIDE 4 W	OK	36.7889	-100.4183	NCDC	61	21.4	30	2.03
167924	ROBSON	LA	32.3556	-93.6425	NCDC	18	52.0	54	2.99
167932	ROCKEFELLER WL REFUG	LA	29.7286	-92.8181	NCDC	24	60.4	55	3.71
417700	ROCKLAND 2 NW	TX	31.0167	-94.4000	NCDC	35	54.1	55	3.15
417706	ROCKSPRINGS 1S	TX	30.0039	-100.2067	NCDC	58	25.1	35	2.51
347705	ROFF 2 WNW	OK	34.6403	-96.8783	NCDC	63	40.4	41	2.75
347714	ROLL	OK	35.7833	-99.7167	NCDC	22	26.2	31	2.05
297610	ROSWELL IND AP	NM	33.3075	-104.5083	NCDC	38	13.1	24	1.71
297638	ROY	NM	35.9422	-104.2014	NCDC	63	16.4	20	1.55
297649	RUIDOSO	NM	33.3589	-105.6653	NCDC	61	22.5	11	1.37
168067	RUSTON LA TECH	LA	32.5014	-92.6547	NCDC	41	55.5	54	2.74
7311782	S WICHITA RV AT LOW	TX	33.6220	-100.2090	USGS	19	25.0	31	2.61
8099300	SABANA RV NR DE LEON	TX	32.1140	-98.6056	USGS	19	31.6	40	2.50
297736	SACRAMENTO #2	NM	32.7906	-105.5606	NCDC	62	25.3	24	1.58
417936	SAM RAYBURN DAM	TX	31.0619	-94.1011	NCDC	40	56.1	55	3.30
417943	SAN ANGELO MATHIS F	TX	31.3517	-100.4950	NCDC	62	21.9	34	2.11
417945	SAN ANTONIO INTL AP	TX	29.5333	-98.4700	NCDC	70	32.8	44	3.27
418653	SAN ANTONIO STINSON	TX	29.3386	-98.4722	NCDC	30	30.7	44	3.03
417951	SAN AUGUSTINE	TX	31.5069	-94.1072	NCDC	17	53.9	55	3.14
8206700	SAN MIGUEL CK NR TIL	TX	28.5875	-98.5459	USGS	24	25.7	44	2.48
418023	SANDERSON 5 NNW	TX	30.2156	-102.4164	NCDC	56	14.3	24	1.96
8152000	SANDY CK NR KINGSLAN	TX	30.5577	-98.4723	USGS	15	29.7	35	2.74
837197B	SANTA ANA NWR	TX	26.0786	-98.1572	RAWS	16	22.1	36	3.15
418047	SANTA ANNA	TX	31.7428	-99.3106	NCDC	68	27.9	31	2.37
418081	SARITA 7 E	TX	27.2169	-97.6956	NCDC	62	28.1	55	3.03
8201500	SECO CK AT MILLER RH	TX	29.5733	-99.4031	USGS	21	31.5	35	3.55
348101	SHATTUCK 1NW	OK	36.2892	-99.8933	NCDC	58	23.4	31	2.23
057572	SHEEP MTN	CO	37.7150	-105.2353	NCDC	23	13.9	10	0.90
418252	SHEFFIELD	TX	30.6886	-101.8272	NCDC	65	15.5	34	1.91
418265	SHEPHERD 2 SE	TX	30.4833	-95.0000	NCDC	25	52.7	55	3.73
168440	SHREVEPORT AP	LA	32.4472	-93.8244	NCDC	57	51.8	54	3.22
418305	SIERRA BLANCA 2 E	TX	31.1831	-105.3542	NCDC	42	10.8	26	1.29
418335	SIMMS 4 WNW	TX	33.3667	-94.5667	NCDC	30	50.9	54	2.89
8075500	SIMS BAYOU AT HOUSTO	TX	29.6744	-95.2894	USGS	25	52.8	55	3.97
348290	SNOMAC 2 NE	OK	35.1000	-96.6167	NCDC	33	41.7	41	2.75
298387	SOCORRO	NM	34.0828	-106.8831	NCDC	62	9.3	11	1.15
418446	SOMERVILLE DAM	TX	30.3367	-96.5403	NCDC	54	39.4	44	2.96

Station ID	Station name	State	Lat.	Long.	Source	Data years	PRISM MAP (inches)	L-mom. Region	MAM (inches)
418451	SONORA VALIANT RCH	TX	30.6500	-100.2000	NCDC	18	24.3	34	2.15
FA63443	SOUTHERN ROUGH	TX	30.5447	-94.3461	RAWS	16	57.9	55	3.68
418531	SPICEWOOD	TX	30.4828	-98.1597	NCDC	42	31.6	35	2.76
418544	SPRING BRANCH 2SE	TX	29.8656	-98.3819	NCDC	46	33.3	44	2.95
298501	SPRINGER	NM	36.3628	-104.5850	NCDC	63	16.2	20	1.43
057866	SPRINGFIELD 7 WSW	CO	37.3694	-102.7428	NCDC	31	16.5	21	1.91
057867	SPRINGFIELD 8 S	CO	37.2833	-102.6167	NCDC	24	15.0	21	2.01
418563	SPRINGTOWN 4 S	TX	32.9086	-97.6786	NCDC	32	35.5	41	2.84
418583	STAMFORD 1	TX	32.9403	-99.8036	NCDC	68	26.3	31	2.21
298535	STATE UNIV	NM	32.2822	-106.7597	NCDC	64	9.9	25	1.03
418623	STEPHENVILLE 1N	TX	32.2450	-98.1956	NCDC	42	32.1	40	2.58
418625	STEPHENVILLE 7 WSW	TX	32.1667	-98.3167	NCDC	28	34.8	40	2.96
418630	STERLING CITY	TX	31.8347	-100.9828	NCDC	31	19.7	34	1.89
418631	STERLING CITY 8 NE	TX	31.9186	-100.8786	NCDC	27	20.8	34	2.27
418646	STILLHOUSE HOLLOW DA	TX	31.0372	-97.5283	NCDC	45	35.5	41	3.01
418647	STINNETT	TX	35.8333	-101.4500	NCDC	32	20.4	30	2.11
147922	SUBLETTE 7WSW	KS	37.4414	-100.9792	NCDC	53	18.9	21	1.67
418743	SULPHUR SPRINGS	TX	33.1481	-95.6269	NCDC	67	45.5	54	3.09
298596	SUMNER LAKE	NM	34.6033	-104.3811	NCDC	63	14.2	20	1.60
418761	SUNRAY 4 SW	TX	35.9667	-101.8667	NCDC	36	17.2	21	1.94
418778	SWAN 4 NW	TX	32.4561	-95.4231	NCDC	50	45.1	54	3.14
7301410	SWEETWATER CK NR KEL	TX	35.4731	-100.1210	USGS	27	24.2	31	2.31
418845	TARPLEY	TX	29.6675	-99.2883	NCDC	70	33.5	35	3.22
418859	TATUM	TX	32.3000	-94.5167	NCDC	36	49.2	54	2.96
8064700	TEHUACANA CK NR STRE	TX	31.8485	-96.2900	USGS	20	41.4	41	2.91
058220	TERCIO 4 NW	CO	37.0708	-105.0572	NCDC	63	21.4	10	1.23
418942	TEXARKANA	TX	33.4367	-94.0772	NCDC	41	50.6	54	3.15
FA61E13	THE BOWL	TX	31.9250	-104.8253	RAWS	29	25.4	26	2.04
418996	THOMPSONS 3 WSW	TX	29.4822	-95.6314	NCDC	49	49.0	55	3.28
419037	TINNIN RCH	TX	31.3167	-103.9833	NCDC	28	12.2	24	1.42
058429	TRINIDAD	CO	37.1786	-104.4869	NCDC	39	15.8	10	1.20
058434	TRINIDAD AP	CO	37.2622	-104.3378	NCDC	18	14.1	10	1.18
058436	TRINIDAD LAKE	CO	37.1503	-104.5567	NCDC	23	17.6	10	1.25
8057000	TRINITY RV AT DALLAS	TX	32.7749	-96.8220	USGS	19	38.0	41	3.01
419163	TRUSCOTT 3 W	TX	33.7572	-99.8617	NCDC	67	25.9	31	2.35
299156	TUCUMCARI 4 NE	NM	35.2006	-103.6867	NCDC	62	17.0	21	1.63
349023	TUSKAHOMA	OK	34.6147	-95.2803	NCDC	65	51.0	50	3.02
299265	TWO RIVERS RSVR	NM	33.2833	-104.6167	NCDC	20	13.2	24	1.69
8167347	UNM TRIB HONEY CK SI	TX	29.8553	-98.4848	USGS	15	34.2	35	2.92

Station ID	Station name	State	Lat.	Long.	Source	Data years	PRISM MAP (inches)	L-mom. Region	MAM (inches)
8167350	UNM TRIB HONEY CK SI	TX	29.8504	-98.4729	USGS	15	34.2	35	2.98
8167353	UNM TRIB HONEY CK SI	TX	29.8562	-98.4801	USGS	15	34.1	35	2.82
419270	VALENTINE	TX	30.5908	-104.4914	NCDC	47	13.3	26	1.46
419364	VICTORIA ASOS	TX	28.8614	-96.9303	NCDC	57	40.5	55	3.66
8041500	VILLAGE CK NR KOUNTZ	TX	30.3980	-94.2635	USGS	20	58.5	55	3.29
8049500	W FK TRINITY RV AT G	TX	32.7625	-96.9944	USGS	19	37.3	41	2.79
419417	WACO DAM	TX	31.6003	-97.2169	NCDC	45	35.5	41	2.92
419419	WACO RGNL AP	TX	31.6189	-97.2283	NCDC	70	35.5	41	2.72
037488	WALDRON	AR	34.8992	-94.1942	NCDC	62	50.5	50	2.77
058781	WALSENBURG 1 NW	CO	37.6303	-104.7956	NCDC	63	17.9	10	1.25
419491	WASHINGTON SP	TX	30.3236	-96.1594	NCDC	55	41.8	44	3.10
299569	WASTE ISOLTN PILOT P	NM	32.3778	-103.7986	NCDC	25	13.4	24	1.52
419499	WATER VALLEY	TX	31.6725	-100.7283	NCDC	54	21.9	34	2.16
419527	WAYSIDE	TX	34.7933	-101.5483	NCDC	61	21.0	30	1.69
419532	WEATHERFORD	TX	32.7483	-97.7700	NCDC	63	35.1	41	2.70
419565	WELLINGTON	TX	34.8422	-100.2103	NCDC	54	24.1	31	2.32
419588	WESLACO	TX	26.1781	-97.9708	NCDC	55	23.5	36	2.76
419665	WHEELOCK	TX	30.9003	-96.3953	NCDC	65	39.5	41	3.12
058997	WHITE ROCK	CO	37.8672	-104.1139	NCDC	63	13.0	20	1.24
299686	WHITE SANDS NATL MON	NM	32.7817	-106.1747	NCDC	63	9.8	25	1.00
419715	WHITNEY DAM	TX	31.8611	-97.3750	NCDC	60	35.3	41	2.73
419729	WICHITA FALLS MUNI A	TX	33.9786	-98.4928	NCDC	71	29.6	40	2.49
349629	WICHITA MTN WR	OK	34.7325	-98.7125	NCDC	63	33.7	40	2.55
419772	WILLIAM HARRIS RSVR	TX	29.2500	-95.5500	NCDC	15	54.1	55	4.04
419815	WIMBERLEY 1 NW	TX	30.0008	-98.0664	NCDC	22	36.7	44	3.00
419817	WINCHELL	TX	31.4661	-99.1711	NCDC	43	28.1	34	2.53
037950	WING	AR	34.9500	-93.4667	NCDC	38	51.6	50	2.79
419830	WINK FAA AP	TX	31.7800	-103.2017	NCDC	60	12.4	24	1.62
169803	WINNFIELD 3 N	LA	31.9622	-92.6561	NCDC	52	59.3	55	3.51
349724	WISTER 3 S	OK	34.9417	-94.7039	NCDC	22	47.7	50	2.50
349748	WOLF 4 N	OK	35.1419	-96.6758	NCDC	31	41.5	41	2.97
7235000	WOLF CK AT LIPSCOMB	TX	36.2387	-100.2757	USGS	19	22.2	30	2.04
419858	WOLF CREEK DAM	TX	36.2333	-100.6667	NCDC	34	21.5	30	1.93
419893	WOODSON	TX	33.0178	-99.0539	NCDC	70	28.2	31	2.44
8841A57	WOODVILLE	TX	30.7500	-94.4000	RAWS	15	55.5	55	3.39
349762	WOODWARD FLD STN	OK	36.4167	-99.4000	NCDC	31	25.3	31	2.05
419976	ZAPATA 1 S	TX	26.8706	-99.2536	NCDC	64	18.5	36	2.65

Table A-8. Station catalog of gauges used in the 24-hour precipitation frequency analysis for Texas. (A source of "MEXICO" indicates the station is from the GHCN database and located in Mexico.)

Station ID	Station name	State	Lat.	Long.	Gauge type	Source	Data years	PRISM MAP (inches)	L-mom. Region	MAM (inches)
290022	ABBOTT 1 SE	NM	36.3028	-104.2497	DY	NCDC	98	15.7	20	2.00
410012	ABERNATHY	TX	33.8400	-101.8581	DY	NCDC	71	20.3	21	2.46
410016	ABILENE RGNL AP	TX	32.4106	-99.6822	HR	NCDC	71	25.3	31	3.03
410025	ACKER RCH	TX	28.1569	-98.5142	DY	NCDC	26	22.7	36	4.03
410034	ACKERLY 4SE	TX	32.5097	-101.6747	DY	NCDC	60	18.6	21	2.98
410040	ACTON RCH	TX	30.3519	-101.2519	DY	NCDC	23	20.6	34	3.88
340017	ADA	OK	34.7864	-96.6850	DY	NCDC	104	41.1	41	3.98
2015	ADAMS RANCH 1	NM	34.2500	-105.4200	DY	SCAN	17	15.5	20	1.46
290119	ADOBE RCH	NM	33.5667	-107.9000	DY	NCDC	40	14.9	13	1.45
290125	AFTON 6 NE	NM	32.1167	-106.8667	DY	NCDC	55	9.4	25	1.56
410081	AGUA NUEVA	TX	26.9000	-98.6000	DY	NCDC	31	21.3	36	4.24
050102	AGUILAR	CO	37.4011	-104.6547	DY	NCDC	24	19.5	10	1.94
050105	AGUILAR 18WSW	CO	37.3169	-104.9503	DY	NCDC	16	22.6	10	1.88
290199	ALAMOGORDO	NM	32.9183	-105.9467	DY	NCDC	89	12.5	25	1.43
290200	ALAMOGORDO 1	NM	32.8667	-105.9333	DY	NCDC	45	13.8	25	1.67
290205	ALAMOGORDO DAM	NM	34.6000	-104.3833	DY	NCDC	67	14.2	20	1.97
410120	ALBANY	TX	32.7294	-99.3017	DY	NCDC	114	27.3	31	3.38
290214	ALBERT	NM	35.9333	-103.8667	DY	NCDC	22	16.0	21	2.35
410129	ALEDO 4 SE	TX	32.6444	-97.5617	DY	NCDC	41	35.5	41	3.72
290268	ALEMAN RCH	NM	32.9308	-106.9328	DY	NCDC	52	10.9	11	1.48
160098	ALEXANDRIA	LA	31.3206	-92.4611	DY	NCDC	122	59.5	55	4.86
160103	ALEXANDRIA 5 SSE	LA	31.2489	-92.4489	DY	NCDC	23	59.6	55	4.31
410145	ALICE INTL AP	TX	27.7411	-98.0247	DY	NCDC	98	25.8	45	4.25
M100005	ALLENDE	MX	28.3300	-100.8300	DY	MEXICO	45	0.0	36	3.47
410174	ALPINE	TX	30.3764	-103.6600	DY	NCDC	89	16.7	26	2.00
410190	ALTO 5 SW	TX	31.6094	-95.1342	DY	NCDC	66	47.5	54	3.94
340184	ALTUS DAM	OK	34.8847	-99.2964	DY	NCDC	70	29.4	31	3.19
340179	ALTUS IRIG RSCH STN	OK	34.5903	-99.3344	DY	NCDC	91	27.9	31	3.21
030130	ALUM FORK	AR	34.7961	-92.8417	DY	NCDC	78	55.7	50	4.46
410202	ALVARADO 4NE	TX	32.4644	-97.1831	DY	NCDC	49	36.9	41	4.10
410204	ALVIN	TX	29.3653	-95.2336	DY	NCDC	107	52.2	55	5.14
410206	ALVORD 3 N	TX	33.3867	-97.7164	HR	NCDC	66	35.5	41	3.33
030136	ALY	AR	34.8000	-93.4667	HR	NCDC	34	54.3	50	3.82
410211	AMARILLO WSO AP	TX	35.1300	-101.4300	DY	NCDC	63	22.5	30	2.62
340200	AMBER	OK	35.1600	-97.8764	DY	NCDC	25	33.6	40	3.07
290377	AMISTAD 5 SSW	NM	35.8742	-103.1819	DY	NCDC	82	15.9	21	2.05
410225	AMISTAD DAM	TX	29.4608	-101.0286	DY	NCDC	51	18.9	35	3.47
030150	AMITY 1N	AR	34.2808	-93.4614	DY	NCDC	103	57.5	54	4.44

Station ID	Station name	State	Lat.	Long.	Gauge type	Source	Data years	PRISM MAP (inches)	L-mom. Region	MAM (inches)
340224	ANADARKO 3 E	OK	35.0619	-98.1989	DY	NCDC	76	32.0	40	3.65
410235	ANAHUAC	TX	29.7878	-94.6342	DY	NCDC	100	56.9	55	5.37
290394	ANCHO	NM	33.9333	-105.7500	DY	NCDC	62	16.2	11	1.51
410244	ANDERSON	TX	30.4833	-95.9833	DY	NCDC	59	44.2	55	4.46
410246	ANDICE 2 SW	TX	30.7569	-97.8619	DY	NCDC	47	33.7	35	3.71
410248	ANDREWS	TX	32.3483	-102.5517	DY	NCDC	51	14.4	24	2.42
290407	ANGEL FIRE 1S	NM	36.3950	-105.2853	DY	NCDC	16	22.8	10	1.53
410257	ANGLETON 2 W	TX	29.1572	-95.4592	DY	NCDC	100	54.1	55	5.81
290417	ANIMAS 3 ESE	NM	31.9378	-108.7686	DY	NCDC	92	12.0	25	1.54
410262	ANNA	TX	33.3500	-96.5167	DY	NCDC	51	41.6	41	3.88
410268	ANSON 3ESE	TX	32.7489	-99.8528	DY	NCDC	62	26.2	31	3.19
410271	ANTELOPE	TX	33.4406	-98.3708	DY	NCDC	77	31.7	40	3.41
340242	ANTHON 6 W	OK	35.7500	-99.1000	HR	NCDC	26	29.2	31	2.79
160253	ANTIOCH FIRE TWR	LA	32.8833	-93.0000	DY	NCDC	35	57.3	54	4.43
340256	ANTLERS	OK	34.2208	-95.6150	DY	NCDC	91	47.7	50	4.14
030178	ANTOINE	AR	34.0292	-93.4211	DY	NCDC	74	53.7	54	4.43
340260	APACHE	OK	34.8958	-98.3594	DY	NCDC	91	33.5	40	3.56
05M07S	APISHAPA	CO	37.3167	-105.0667	DY	SNOTEL	34	29.0	10	1.93
030188	APLIN 1 W	AR	34.9667	-93.0000	DY	NCDC	31	52.6	50	4.09
410297	AQUILLA 1 SSE	TX	31.8411	-97.2114	DY	NCDC	23	35.5	41	3.99
410302	ARANSAS PASS 2	TX	27.9167	-97.1333	DY	NCDC	29	34.8	46	5.18
410437	ARANSAS WILDLIFE REF	TX	28.2667	-96.8000	DY	NCDC	74	38.2	46	5.40
160277	ARCADIA	LA	32.5511	-92.9186	DY	NCDC	53	57.0	54	4.42
290525	ARCH	NM	34.1128	-103.1667	DY	NCDC	35	17.3	21	2.11
410313	ARCHER CITY	TX	33.5881	-98.6381	DY	NCDC	71	30.2	40	3.61
340292	ARDMORE	OK	34.1714	-97.1294	DY	NCDC	112	37.6	41	3.78
340296	ARDMORE FAA AP	OK	34.3000	-97.0167	DY	NCDC	22	38.9	41	4.07
030220	ARKADELPHIA 2 N	AR	34.1433	-93.0589	DY	NCDC	118	53.1	54	4.29
410337	ARLINGTON	TX	32.7394	-97.1278	DY	NCDC	71	37.9	41	3.86
410342	ARMSTRONG	TX	26.9333	-97.8000	DY	NCDC	34	25.9	36	3.53
340332	ARNETT 3NE	OK	36.1669	-99.7214	DY	NCDC	90	25.3	31	2.80
290600	ARTESIA 6S	NM	32.7547	-104.3836	DY	NCDC	105	12.3	24	2.01
410367	ARTHUR CITY	TX	33.8756	-95.5022	DY	NCDC	77	47.0	54	3.79
030286	ASHDOWN 4 SSE	AR	33.6194	-94.0994	DY	NCDC	67	50.7	54	4.33
410380	ASHERTON	TX	28.4333	-99.7500	HR	NCDC	19	20.4	36	3.89
140365	ASHLAND	KS	37.1942	-99.7633	DY	NCDC	115	23.4	30	2.69
160349	ASHLAND	LA	32.1633	-93.1331	DY	NCDC	64	55.9	55	4.21
340364	ASHLAND	OK	34.7833	-96.0667	DY	NCDC	27	44.8	50	4.16
410394	ASPERMONT	TX	33.1525	-100.2333	DY	NCDC	103	23.9	31	2.91
030300	ATHENS	AR	34.3253	-93.9811	DY	NCDC	58	60.8	50	4.82

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410404	ATHENS	TX	32.1633	-95.8300	DY	NCDC	69	42.7	41	4.18
410408	ATLANTA	TX	33.1244	-94.1661	DY	NCDC	65	49.7	54	4.11
340391	ATOKA	OK	34.3983	-96.1400	DY	NCDC	55	43.2	50	4.12
340394	ATOKA DAM	OK	34.4500	-96.0667	DY	NCDC	37	43.0	50	3.87
290640	AUGUSTINE 2E	NM	34.0750	-107.6211	DY	NCDC	87	12.9	11	1.36
290646	AURORA	NM	36.2667	-105.0500	DY	NCDC	52	22.5	10	1.94
410420	AUSTIN	TX	30.2833	-97.7333	DY	NCDC	36	33.7	44	3.89
410428	AUSTIN CAMP MABRY	TX	30.3211	-97.7600	DY	NCDC	81	33.5	44	3.79
410430	AUSTIN DAM	TX	30.3000	-97.7833	DY	NCDC	18	33.4	44	3.44
410432	AUSTIN MONTOPOLIS BR	TX	30.2500	-97.6833	DY	NCDC	59	34.1	44	4.54
410436	AUSTWELL	TX	28.3711	-96.8364	DY	NCDC	52	37.6	46	4.75
410440	AVALON	TX	32.2067	-96.7958	DY	NCDC	38	38.0	41	4.22
M200008	BACHINIVA		28.8000	-107.2500	DY	MEXICO	53	0.0	28	1.70
M300025	BADIRAGUATO		25.3700	-107.5500	DY	MEXICO	72	0.0	14	4.62
410478	BAIRD	TX	32.4000	-99.4000	DY	NCDC	31	27.0	31	3.66
410482	BAKERSFIELD	TX	30.8878	-102.3044	DY	NCDC	71	14.4	24	2.63
410493	BALLINGER 2 NW	TX	31.7414	-99.9764	DY	NCDC	112	24.1	34	3.18
410498	BALMORHEA	TX	30.9844	-103.7403	DY	NCDC	87	13.3	26	1.98
M400025	BAMICORI		26.3500	-108.4800	DY	MEXICO	19	0.0	14	3.97
410509	BANKERSMITH	TX	30.1411	-98.8200	HR	NCDC	72	31.6	35	3.97
410518	BARDWELL DAM	TX	32.2631	-96.6369	DY	NCDC	50	38.8	41	4.07
410560	BATESVILLE	TX	28.9567	-99.6228	DY	NCDC	36	23.5	35	3.38
M500008	BATOPILAS		27.0200	-107.7500	DY	MEXICO	53	0.0	12	2.66
340567	BATTIEST	OK	34.3850	-94.8981	DY	NCDC	30	55.2	50	4.33
410569	BAY CITY WTR WKS	TX	28.9797	-95.9750	DY	NCDC	81	47.9	46	4.62
410586	BAYTOWN	TX	29.7917	-95.0436	DY	NCDC	58	55.8	55	5.71
290806	BEAR CREEK RCH	NM	32.9500	-108.4167	DY	NCDC	19	17.7	13	1.76
340584	BEAR MTN TWR	OK	34.1394	-94.9519	DY	NCDC	50	51.8	50	4.50
410611	BEAUMONT CITY	TX	30.0969	-94.0997	DY	NCDC	113	60.0	55	5.49
410613	BEAUMONT RSCH CTR	TX	30.0689	-94.2928	DY	NCDC	52	58.3	55	5.91
340593	BEAVER	OK	36.8125	-100.5308	DY	NCDC	98	21.1	30	2.56
160617	BEAVER FIRE TWR	LA	30.7925	-92.4953	DY	NCDC	42	62.8	55	5.44
290818	BEAVERHEAD R/S	NM	33.4286	-108.1000	DY	NCDC	68	16.5	13	1.63
410635	BEDIAS	TX	30.7833	-95.9500	DY	NCDC	43	44.7	45	3.98
410639	BEEVILLE 5 NE	TX	28.4575	-97.7061	DY	NCDC	109	30.8	45	4.22
290858	BELL RANCH	NM	35.5297	-104.0936	DY	NCDC	105	14.6	21	2.11
140676	BELLEFONT 3S	KS	37.8264	-99.6542	DY	NCDC	42	22.6	30	2.57
410655	BELLVILLE 6 NNE	TX	30.0317	-96.2167	DY	NCDC	30	42.2	45	3.79
410665	BELTON DAM	TX	31.1000	-97.4833	DY	NCDC	40	35.7	41	3.90
410690	BENAVIDES 2	TX	27.5969	-98.4161	HR	NCDC	71	21.2	36	3.28

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410691	BENBROOK DAM	TX	32.6475	-97.4439	DY	NCDC	66	35.4	41	3.44
340670	BENGAL 2 NNW	OK	34.8547	-95.0697	HR	NCDC	58	48.8	50	4.27
410708	BENJAMIN 15 W	TX	33.5392	-100.0208	DY	NCDC	25	24.9	31	3.40
410704	BENJAMIN 4 SSE	TX	33.5333	-99.7667	DY	NCDC	36	25.3	31	2.92
030582	BENTON	AR	34.5675	-92.6006	DY	NCDC	85	52.9	54	4.34
160761	BERNICE 2 S	LA	32.7833	-92.6667	HR	NCDC	19	56.1	54	4.20
410738	BERTRAM 3 ENE	TX	30.7603	-98.0164	DY	NCDC	47	32.8	35	3.95
160800	BIENVILLE 3 NE	LA	32.3744	-92.9433	DY	NCDC	42	59.2	54	4.96
410764	BIG BEND RCH SP	TX	29.4372	-103.9583	DY	NCDC	18	12.5	26	1.99
140802	BIG BOW 4 WSW	KS	37.5514	-101.6344	DY	NCDC	87	17.0	21	2.30
030664	BIG FORK 1 SSE	AR	34.4692	-93.9567	DY	NCDC	63	63.3	50	4.89
410779	BIG LAKE 2	TX	31.2000	-101.4625	HR	NCDC	69	17.3	34	2.65
410784	BIG SPRING FLD STN	TX	32.2683	-101.4858	HR	NCDC	72	19.5	21	2.67
410787	BIG WELLS 2W	TX	28.5731	-99.6044	DY	NCDC	78	21.7	36	3.52
290983	BINGHAM 2 NE	NM	33.9114	-106.3494	DY	NCDC	69	11.9	11	1.44
410805	BISHOP	TX	27.5844	-97.8033	DY	NCDC	36	29.8	46	3.80
030724	BISMARCK 2 SE	AR	34.2872	-93.1444	DY	NCDC	49	52.5	54	5.17
290992	BITTER LAKES WR	NM	33.4594	-104.4042	DY	NCDC	64	12.8	20	2.27
291000	BLACK LAKE	NM	36.3119	-105.2692	DY	NCDC	96	24.0	10	1.60
030764	BLAKELY MTN DAM	AR	34.5697	-93.1947	HR	NCDC	62	54.5	50	4.55
340830	BLANCHARD 2 SSW	OK	35.1183	-97.6700	DY	NCDC	60	36.2	40	3.64
410832	BLANCO	TX	30.1058	-98.4286	DY	NCDC	119	34.3	35	3.97
410839	BLANKET	TX	31.8167	-98.7833	DY	NCDC	18	30.9	40	3.29
410852	BLEWETT 5 NW	TX	29.2333	-100.1000	DY	NCDC	45	23.6	35	3.54
050784	BLOOM	CO	37.6833	-103.9500	DY	NCDC	21	14.4	20	2.14
410866	BLUE	TX	30.4000	-97.1500	DY	NCDC	22	35.6	44	3.58
030800	BLUFF CITY 3 SW	AR	33.6919	-93.1622	DY	NCDC	66	51.4	54	4.43
160920	BODCAU FIRE TWR	LA	32.7000	-93.5167	DY	NCDC	28	54.7	54	4.08
410902	BOERNE	TX	29.7978	-98.7347	DY	NCDC	122	36.5	35	4.25
030814	BOGG SPRINGS	AR	34.3267	-94.4122	DY	NCDC	20	56.8	50	4.21
340908	BOISE CITY 2 E	OK	36.7236	-102.4803	DY	NCDC	89	17.6	21	2.23
340917	BOKCHITO	OK	34.0158	-96.1342	DY	NCDC	17	44.0	54	4.25
410917	BON WIER	TX	30.7333	-93.6500	DY	NCDC	74	58.2	55	4.97
410923	BONHAM 3NNE	TX	33.6397	-96.1678	DY	NCDC	108	45.6	54	4.45
410926	BONITA 4NW	TX	33.8472	-97.6528	HR	NCDC	72	35.8	41	3.60
291120	BONITO DAM	NM	33.4486	-105.6847	HR	NCDC	64	25.2	11	2.06
030820	BONNERDALE 4 SW	AR	34.3667	-93.4231	DY	NCDC	48	56.4	54	4.79
410944	BOOKER	TX	36.4533	-100.5394	DY	NCDC	79	21.4	30	2.55
410950	BOQUILLAS RS	TX	29.1853	-102.9622	DY	NCDC	54	10.0	26	1.55
410955	BORGER	TX	35.6500	-101.4000	DY	NCDC	17	21.5	30	2.49

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410958	BORGER	TX	35.6364	-101.4542	DY	NCDC	66	21.4	30	2.51
291138	BOSQUE DEL APACHE	NM	33.8044	-106.8908	DY	NCDC	118	9.2	11	1.43
340980	BOSWELL 1 S	OK	34.0211	-95.8722	DY	NCDC	55	45.2	54	4.16
030848	BOUGHTON	AR	33.8667	-93.3333	DY	NCDC	47	53.3	54	4.18
410984	BOWIE	TX	33.5511	-97.8472	DY	NCDC	89	35.0	40	3.65
410991	BOXELDER 3 NNE	TX	33.5164	-94.8608	DY	NCDC	52	50.0	54	4.23
161232	BOYCE 3 WNW	LA	31.3944	-92.7164	DY	NCDC	39	59.4	55	5.00
161235	BOYCE 7 SW	LA	31.3025	-92.7300	DY	NCDC	18	60.1	55	5.47
410996	BOYD	TX	33.0800	-97.5639	DY	NCDC	51	36.9	41	4.20
411000	BOYS RANCH	TX	35.5303	-102.2564	DY	NCDC	38	19.0	21	2.41
411007	BRACKETTVILLE	TX	29.3067	-100.4186	DY	NCDC	107	22.9	35	3.69
411013	BRACKETTVILLE 22 N	TX	29.6081	-100.4744	DY	NCDC	32	23.3	35	3.42
411017	BRADY	TX	31.1444	-99.3492	DY	NCDC	83	27.0	34	3.15
411026	BRANDON	TX	32.0508	-96.9661	DY	NCDC	21	38.2	41	3.99
050898	BRANSON	CO	37.0167	-103.8833	DY	NCDC	35	16.8	20	2.01
291153	BRANTLEY DAM	NM	32.5158	-104.3828	DY	NCDC	24	12.7	24	1.92
68	BRAUNIG LAKE	TX	29.2500	-98.3833	DY	TWDB	22	30.0	44	4.32
411033	BRAVO	TX	35.6200	-103.0072	DY	NCDC	74	17.7	21	2.44
411034	BRAZORIA	TX	29.0500	-95.5667	DY	NCDC	35	51.8	55	4.77
411035	BRAZOS	TX	32.6489	-98.1336	DY	NCDC	72	32.4	40	3.71
411042	BRECKENRIDGE	TX	32.7500	-98.9017	DY	NCDC	90	28.0	40	3.27
411045	BREMOND	TX	31.1589	-96.6825	DY	NCDC	52	38.8	41	3.93
411048	BRENHAM	TX	30.1589	-96.3972	DY	NCDC	113	43.1	45	4.33
411063	BRIDGEPORT	TX	33.2064	-97.7761	DY	NCDC	102	35.2	40	3.59
411068	BRIGGS	TX	30.8833	-97.9333	HR	NCDC	59	32.9	35	3.48
030900	BRIGGSVILLE	AR	34.9458	-93.4636	HR	NCDC	27	51.3	50	4.16
411073	BRIGHTON	TX	27.6500	-97.3000	DY	NCDC	26	30.6	46	3.90
411081	BRITTON	TX	32.5500	-97.0667	HR	NCDC	28	37.5	41	3.32
411089	BROADDUS	TX	31.3050	-94.2703	DY	NCDC	37	53.1	55	4.83
291223	BROADVIEW	NM	34.8333	-103.2000	DY	NCDC	25	18.2	21	2.12
291225	BROADVIEW 5 S	NM	34.7333	-103.2167	DY	NCDC	16	18.3	21	2.90
341162	BROKEN BOW 1 N	OK	34.0497	-94.7381	DY	NCDC	76	51.5	54	4.60
341168	BROKEN BOW DAM	OK	34.1333	-94.7000	DY	NCDC	34	53.0	54	4.77
411094	BRONSON	TX	31.3500	-94.0167	DY	NCDC	50	55.2	55	4.51
411128	BROWNFIELD #2	TX	33.1908	-102.2681	DY	NCDC	100	19.7	21	2.66
411133	BROWNSVILLE	TX	25.9008	-97.5039	DY	NCDC	39	27.3	36	4.31
411136	BROWNSVILLE INTL AP	TX	25.9142	-97.4231	DY	NCDC	89	27.2	36	4.37
411138	BROWNWOOD 2ENE	TX	31.7383	-98.9456	DY	NCDC	111	29.9	40	3.50
10	BUCHANAN DAM	TX	30.7333	-98.4333	DY	TWDB	40	28.7	35	3.22
291252	BUCKHORN	NM	33.0394	-108.7142	DY	NCDC	64	15.8	13	1.82

Station ID	Station name	State	Lat.	Long.	Gauge type	Source	Data years	PRISM MAP (inches)	L-mom. Region	MAM (inches)
141104	BUCKLIN	KS	37.5433	-99.6383	DY	NCDC	96	24.1	30	2.71
411185	BUENAVISTA 2 NNW	TX	31.2500	-102.6667	DY	NCDC	23	11.9	24	1.96
291269	BUEYEROS 4 NW	NM	36.0167	-103.7333	DY	NCDC	39	15.9	21	2.20
411188	BUFFALO	TX	31.4667	-96.0500	DY	NCDC	48	42.6	41	4.16
341243	BUFFALO 2 SSW	OK	36.8003	-99.6403	DY	NCDC	95	23.9	31	2.84
411203	BULER 4 NNW	TX	36.1833	-100.8333	DY	NCDC	33	21.2	30	2.22
411215	BULVERDE	TX	29.7447	-98.4517	DY	NCDC	73	33.9	44	4.32
411224	BUNKER HILL	TX	36.1500	-102.9333	DY	NCDC	48	15.0	21	2.16
411239	BURKETT	TX	31.9917	-99.2203	DY	NCDC	65	28.5	31	3.60
411246	BURLESON	TX	32.5067	-97.3442	DY	NCDC	71	36.7	41	3.97
411250	BURNET	TX	30.7411	-98.2361	DY	NCDC	114	30.6	35	3.67
411267	BUSHLAND 1 WSW	TX	35.1867	-102.0797	DY	NCDC	18	19.7	21	2.43
291286	CABALLO DAM	NM	32.8967	-107.3092	DY	NCDC	76	10.9	11	1.50
M700019	CADEREYTA	MX	25.6000	-100.0000	DY	MEXICO	34	0.0	36	3.99
411314	CALDWELL	TX	30.5322	-96.7022	DY	NCDC	49	38.6	45	4.19
031140	CALION L&D	AR	33.3111	-92.4850	HR	NCDC	62	52.9	54	4.18
411334	CALLAN	TX	31.0500	-99.7167	DY	NCDC	18	27.5	34	3.14
411337	CALLIHAM	TX	28.4958	-98.3953	DY	NCDC	36	25.4	44	3.93
341391	CALVIN	OK	34.9642	-96.2492	DY	NCDC	104	41.4	41	4.01
341396	CAMARGO	OK	36.0167	-99.2833	DY	NCDC	52	26.8	31	2.91
291309	CAMBRAY	NM	32.2333	-107.3333	DY	NCDC	40	10.8	13	1.37
031152	CAMDEN 1	AR	33.5900	-92.8236	DY	NCDC	122	53.4	54	4.22
161425	CAMERON	LA	29.7500	-93.3333	DY	NCDC	23	59.3	55	5.64
291332	CAMERON	NM	34.9039	-103.4428	DY	NCDC	59	19.3	21	2.26
411348	CAMERON	TX	30.8458	-96.9700	DY	NCDC	101	35.0	41	3.86
161446	CAMP POLK	LA	31.0667	-93.2000	DY	NCDC	21	60.5	55	5.56
411398	CAMP WOOD	TX	29.6797	-100.0175	DY	NCDC	60	27.6	35	3.70
291345	CAMPANA	NM	35.5167	-103.8500	DY	NCDC	20	16.2	21	2.11
051268	CAMPO 7 S	CO	37.0158	-102.5550	DY	NCDC	60	16.6	21	2.20
411412	CANADIAN	TX	35.9092	-100.3883	DY	NCDC	92	23.1	30	2.64
411416	CANDELARIA	TX	30.1383	-104.6822	DY	NCDC	69	12.8	26	1.76
291423	CANTON	NM	34.2753	-104.1636	DY	NCDC	63	15.0	20	2.26
411425	CANTON 5 W	TX	32.5669	-95.9578	DY	NCDC	52	43.6	41	4.18
411430	CANYON	TX	34.9806	-101.9264	DY	NCDC	92	19.9	21	2.74
411429	CANYON DAM	TX	29.8706	-98.1967	DY	NCDC	53	35.7	44	4.19
411433	CANYON DAM #3	TX	29.9464	-98.3969	HR	NCDC	42	34.5	35	3.86
411434	CANYON DAM #4	TX	29.9111	-98.3714	HR	NCDC	50	33.7	44	3.69
411436	CANYON DAM #6	TX	29.9469	-98.3011	HR	NCDC	48	34.9	44	3.77
411438	CANYON DAM #7	TX	29.9167	-98.2167	HR	NCDC	32	35.5	44	3.46
411435	CANYON DAM 5	TX	29.9167	-98.3500	HR	NCDC	27	33.9	44	3.59

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M800010	CAON FERNANDEZ		25.2800	-103.7500	DY	MEXICO	40	0.0	29	1.64
291440	CAPITAN	NM	33.5311	-105.5947	DY	NCDC	94	17.8	11	1.77
291445	CAPROCK	NM	33.3433	-103.6783	HR	NCDC	29	15.9	21	1.94
291452	CAPULIN 6 SSE	NM	36.6667	-103.9500	DY	NCDC	40	17.1	20	2.00
291469	CARLSBAD	NM	32.3478	-104.2225	DY	NCDC	112	13.4	24	2.25
291480	CARLSBAD CAVERNS	NM	32.1783	-104.4433	DY	NCDC	77	14.2	24	2.44
341499	CARNASAW TWR	OK	34.1442	-94.6378	DY	NCDC	51	53.2	54	4.74
341504	CARNEGIE 5 NE	OK	35.1756	-98.5794	DY	NCDC	79	31.6	40	3.47
411481	CARR RCH	TX	30.1667	-99.1167	DY	NCDC	42	30.7	35	3.68
411486	CARRIZO SPRINGS 3W	TX	28.4897	-99.8739	DY	NCDC	81	19.8	36	3.44
291515	CARRIZOZO 1SW	NM	33.6308	-105.8964	DY	NCDC	103	13.1	11	1.47
411490	CARROLLTON	TX	32.9850	-96.9258	DY	NCDC	78	38.8	41	3.95
291532	CARSON SEEP NEAR	NM	32.1000	-104.7667	DY	NCDC	30	22.0	24	2.67
411492	CARTA VALLEY	TX	29.7908	-100.6742	DY	NCDC	48	22.5	35	3.83
341544	CARTER TWR	OK	34.2661	-94.7753	DY	NCDC	68	53.0	50	4.67
411500	CARTHAGE	TX	32.1614	-94.3397	DY	NCDC	63	51.0	54	4.40
411511	CASE RCH 3 S	TX	31.6333	-101.0333	DY	NCDC	36	20.4	34	2.71
411521	CASTELL	TX	30.7000	-98.9667	DY	NCDC	27	28.2	35	3.24
411524	CASTOLON	TX	29.1344	-103.5150	DY	NCDC	38	10.2	26	1.65
411528	CATARINA	TX	28.3392	-99.6328	DY	NCDC	41	19.5	36	3.44
291475	CAVERN CITY AIRPORT	NM	32.3375	-104.2633	DY	NCDC	58	13.6	24	2.15
M900019	CDE FLORES	MX	25.9500	-100.1700	DY	MEXICO	46	0.0	36	4.05
411573	CELINA	TX	33.3167	-96.8000	DY	NCDC	37	40.2	41	3.73
411578	CENTER	TX	31.8075	-94.1642	DY	NCDC	74	53.2	55	4.49
411580	CENTER CITY	TX	31.4683	-98.4106	DY	NCDC	50	30.2	40	3.31
411596	CENTERVILLE	TX	31.2581	-95.9744	DY	NCDC	77	42.8	41	3.99
291653	CHACON	NM	36.1667	-105.3833	DY	NCDC	72	28.1	10	1.59
291656	CHACON 2 S	NM	36.1211	-105.3756	DY	NCDC	23	22.8	10	1.68
411625	CHALK MTN	TX	32.1561	-97.9369	DY	NCDC	51	33.3	41	3.56
411646	CHANNING	TX	35.6869	-102.3342	HR	NCDC	71	18.2	21	2.24
411651	CHAPMAN RCH	TX	27.5892	-97.4547	DY	NCDC	43	30.1	46	4.54
411663	CHARLOTTE 5 NNW	TX	28.9275	-98.7494	DY	NCDC	51	27.1	44	3.61
341706	CHATTANOOGA 3 NE	OK	34.4497	-98.6222	DY	NCDC	109	31.0	40	3.44
411671	CHEAPSIDE	TX	29.3103	-97.3469	HR	NCDC	70	35.8	45	3.85
411680	CHEROKEE	TX	30.9833	-98.7167	HR	NCDC	30	29.2	35	3.42
341738	CHEYENNE	OK	35.6000	-99.6833	DY	NCDC	66	26.9	31	3.17
341745	CHICKASAW NRA	OK	34.5019	-96.9717	DY	NCDC	96	40.6	41	4.01
341750	CHICKASHA EXP STATIO	OK	35.0489	-97.9158	DY	NCDC	113	34.7	40	3.53
411698	CHILDRESS MUNI AP	TX	34.4272	-100.2831	DY	NCDC	101	24.4	31	2.82

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411701	CHILLICOTHE	TX	34.2500	-99.5167	DY	NCDC	71	27.7	31	3.03
411711	CHIRENO	TX	31.5036	-94.3531	DY	NCDC	24	54.8	55	4.92
411715	CHISOS BASIN	TX	29.2703	-103.3003	DY	NCDC	69	18.6	26	2.27
M110025	CHOIX		26.7330	-108.2830	DY	MEXICO	29	0.0	12	2.69
411720	CHOKE CANYON DAM	TX	28.4675	-98.2525	DY	NCDC	32	25.9	44	3.25
411735	CHRISTOVAL	TX	31.2000	-100.4833	DY	NCDC	17	22.9	34	3.08
411741	CIBOLO CREEK	TX	29.0167	-97.9333	DY	NCDC	37	29.6	44	4.20
141522	CIMARRON	KS	37.8131	-100.3456	DY	NCDC	102	21.8	30	2.72
291813	CIMARRON 4 SW	NM	36.4661	-104.9456	DY	NCDC	106	18.3	10	1.90
291840	CIRCLE F RCH	NM	33.9000	-105.0000	DY	NCDC	52	12.8	20	1.88
M120008	CIUDAD DELICIAS		28.2000	-105.4300	DY	MEXICO	64	0.0	28	1.69
M130008	CIUDAD GUERRERO		28.5200	-108.5200	DY	MEXICO	79	0.0	12	1.88
M140008	CIUDAD JIMENEZ		27.1300	-104.9300	DY	MEXICO	56	0.0	28	1.70
411761	CLARENDON	TX	34.9325	-100.8903	DY	NCDC	103	23.4	31	3.12
411773	CLARKSVILLE 1W	TX	33.6100	-95.0217	HR	NCDC	63	48.3	54	4.04
411772	CLARKSVILLE 2NE	TX	33.6164	-95.0717	DY	NCDC	106	48.2	54	3.98
411778	CLAUDE	TX	35.1100	-101.3619	DY	NCDC	94	22.6	30	2.69
341858	CLAYTON 14 WNW	OK	34.6606	-95.5828	DY	NCDC	30	49.5	50	4.05
291881	CLAYTON 9 SSE	NM	36.3333	-103.1000	DY	NCDC	34	16.3	21	2.28
291887	CLAYTON MUNI ARPK AP	NM	36.4486	-103.1539	DY	NCDC	100	15.8	21	2.18
411800	CLEBURNE	TX	32.3139	-97.4064	DY	NCDC	105	37.5	41	4.00
411810	CLEVELAND	TX	30.3636	-95.0839	DY	NCDC	61	54.1	55	5.19
411889	CLG STN EASTERWD AP	TX	30.5892	-96.3647	DY	NCDC	58	41.0	45	4.16
291901	CLIFF	NM	32.9833	-108.6333	DY	NCDC	37	14.5	13	1.81
291910	CLIFF 11 SE	NM	32.8331	-108.5036	DY	NCDC	68	15.8	13	1.57
411823	CLIFTON 10 E	TX	31.8000	-97.4333	DY	NCDC	65	35.5	41	3.80
411838	CLODINE	TX	29.7067	-95.6878	DY	NCDC	62	49.0	55	5.09
341927	CLOUD CHIEF 2 SE	OK	35.2333	-98.8167	DY	NCDC	75	30.3	40	3.12
291931	CLOUDCROFT	NM	32.9544	-105.7353	DY	NCDC	107	30.5	25	2.12
341936	CLOUDY TWR	OK	34.3833	-95.2500	DY	NCDC	29	53.8	50	4.37
291939	CLOVIS	NM	34.4239	-103.2008	DY	NCDC	98	18.2	21	2.49
291963	CLOVIS 13 N	NM	34.5989	-103.2161	DY	NCDC	66	18.3	21	2.20
341954	COALGATE 1 WNW	OK	34.5500	-96.2333	DY	NCDC	48	43.6	50	4.57
411870	COLDSPRING 5 SSW	TX	30.5333	-95.1500	DY	NCDC	48	51.4	55	4.67
141704	COLDWATER	KS	37.2706	-99.3272	DY	NCDC	113	25.8	31	2.90
411874	COLDWATER	TX	36.4000	-102.5667	DY	NCDC	40	16.0	21	1.99
342011	COLEMAN	OK	34.2742	-96.4139	DY	NCDC	15	42.7	41	4.56
411875	COLEMAN	TX	31.8211	-99.4200	DY	NCDC	120	28.1	31	3.42
161941	COLFAX	LA	31.5183	-92.7142	DY	NCDC	47	58.9	55	5.09

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411888	COLLEGE STN 6 SW	TX	30.5333	-96.4167	DY	NCDC	66	41.2	45	4.03
342039	COLONY	OK	35.3500	-98.6756	DY	NCDC	30	32.1	40	3.80
411903	COLORADO CITY	TX	32.3978	-100.8594	DY	NCDC	80	20.7	31	2.96
292024	COLUMBUS	NM	31.8297	-107.6389	DY	NCDC	101	9.8	25	1.52
411911	COLUMBUS	TX	29.6989	-96.5731	DY	NCDC	75	43.2	45	4.37
342054	COMANCHE	OK	34.3622	-97.9736	DY	NCDC	63	36.4	40	3.79
411914	COMANCHE	TX	31.8983	-98.6033	DY	NCDC	96	31.5	40	3.44
411920	COMFORT 2	TX	29.9617	-98.8942	DY	NCDC	26	33.6	35	4.27
411921	COMMERCE 4SW	TX	33.1997	-95.9283	HR	NCDC	60	43.3	54	4.27
411925	COMSTOCK	TX	29.6833	-101.1833	DY	NCDC	23	17.5	34	3.02
292030	CONCHAS DAM	NM	35.4072	-104.1906	DY	NCDC	78	15.4	21	2.03
411934	CONCHO PK IVIE RSVR	TX	31.5514	-99.7081	DY	NCDC	17	25.8	34	3.20
M150005	CONCORDIA		25.7800	-103.1200	DY	MEXICO	34	0.0	29	1.60
411946	CONLEN	TX	36.2353	-102.2406	DY	NCDC	74	16.9	21	2.24
411956	CONROE	TX	30.3303	-95.4831	DY	NCDC	97	48.7	55	5.07
162023	CONVERSE	LA	31.7500	-93.7000	DY	NCDC	40	52.6	55	3.98
411970	COOPER	TX	33.3694	-95.7069	DY	NCDC	68	45.3	54	4.01
411974	COPE RCH	TX	31.5333	-101.2842	DY	NCDC	65	18.7	34	2.64
411984	COPPERAS COVE	TX	31.1167	-97.9000	DY	NCDC	63	33.0	41	3.64
411990	COPPERAS COVE 5 NW	TX	31.1603	-97.9564	DY	NCDC	31	32.5	41	3.67
342125	CORDELL	OK	35.2836	-98.9819	DY	NCDC	74	30.3	31	3.20
412012	CORNUDAS SVC STN	TX	31.7800	-105.4700	DY	NCDC	51	9.9	25	1.68
292093	CORONA	NM	34.2500	-105.5833	DY	NCDC	68	17.7	20	1.61
292095	CORONA 10SW	NM	34.1492	-105.6975	DY	NCDC	22	15.3	11	1.66
412015	CORPUS CHRISTI AP	TX	27.7742	-97.5122	HR	NCDC	65	31.3	46	4.65
412011	CORPUS CHRISTI NWS	TX	27.7792	-97.5056	DY	NCDC	15	31.4	46	4.18
412017	CORRIGAN 1 ENE	TX	31.0033	-94.8161	DY	NCDC	19	53.9	55	5.07
412019	CORSICANA	TX	32.1078	-96.4747	DY	NCDC	25	39.6	41	3.84
412024	CORYELL CITY	TX	31.5500	-97.6167	HR	NCDC	44	34.6	41	3.46
162121	COTTON VALLEY 5 NNW	LA	32.8869	-93.4569	DY	NCDC	65	53.2	54	4.13
412040	COTTONWOOD	TX	30.1606	-99.1356	DY	NCDC	21	30.6	35	3.64
412048	COTULLA LA SALLE CO	TX	28.4567	-99.2183	HR	NCDC	53	23.5	36	3.18
162144	COUSHATTA GRAND BAYO	LA	32.0075	-93.2694	DY	NCDC	32	55.4	55	5.03
031666	COVE	AR	34.4314	-94.4175	DY	NCDC	69	56.8	50	4.54
342196	COX CITY 2 NE	OK	34.7422	-97.7039	DY	NCDC	31	37.7	41	4.15
412082	CRANE	TX	31.3875	-102.3553	HR	NCDC	62	14.0	24	2.14
412086	CRANFILLS GAP	TX	31.7708	-97.8281	HR	NCDC	70	33.8	41	3.53
M160008	CREEL		27.7500	-107.6300	DY	MEXICO	39	0.0	12	2.20
412096	CRESSON 3NW	TX	32.5561	-97.6697	HR	NCDC	66	35.3	41	3.40

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412114	CROCKETT	TX	31.3072	-95.4508	DY	NCDC	20	46.5	54	4.54
412121	CROSBYTON	TX	33.6517	-101.2450	DY	NCDC	30	23.4	31	2.80
412125	CROSS	TX	28.5978	-98.5547	DY	NCDC	18	25.7	44	3.67
412131	CROSS PLAINS #2	TX	32.1267	-99.1606	HR	NCDC	71	28.8	31	3.27
292207	CROSSROADS 2	NM	33.5133	-103.3403	DY	NCDC	70	15.6	21	2.34
412142	CROWELL	TX	33.9883	-99.7283	DY	NCDC	19	27.4	31	3.38
412160	CRYSTAL CITY	TX	28.6794	-99.8311	DY	NCDC	21	20.3	36	3.07
031750	CRYSTAL VALLEY	AR	34.6886	-92.4500	DY	NCDC	71	53.2	54	4.51
M170005	CUATRO CIENEGAS		26.9800	-102.0700	DY	MEXICO	54	0.0	36	1.97
052040	CUCHARAS DAM	CO	37.7500	-104.6000	HR	NCDC	38	16.2	10	1.62
M180010	CUENCAME		24.7800	-103.6700	DY	MEXICO	41	0.0	29	2.06
05M03S	CULEBRA #2	CO	37.2000	-105.1833	DY	SNOTEL	34	32.8	10	1.86
412206	CYPRESS	TX	30.0211	-95.7069	DY	NCDC	24	46.8	55	5.07
412218	DACUS	TX	30.4364	-95.7919	DY	NCDC	19	45.9	55	5.03
412225	DAINGERFIELD 9 S	TX	32.9203	-94.7225	DY	NCDC	25	46.7	54	3.90
031814	DAISY	AR	34.2500	-93.7333	DY	NCDC	27	55.7	54	4.69
342354	DAISY 4 ENE	OK	34.5433	-95.6764	DY	NCDC	62	49.8	50	4.47
412242	DAL-FTW WSCMO AP	TX	32.8978	-97.0189	HR	NCDC	65	37.4	41	3.37
412244	DALLAS FAA AP	TX	32.8519	-96.8556	HR	NCDC	69	38.1	41	3.76
412266	DANEVANG 1 W	TX	29.0567	-96.2319	DY	NCDC	25	46.1	46	4.85
292362	DANLEY RCH	NM	33.8000	-108.3333	DY	NCDC	26	12.2	13	1.17
412282	DARROUZETT	TX	36.4453	-100.3264	DY	NCDC	20	22.7	30	2.87
292367	DATIL	NM	34.1500	-107.8500	DY	NCDC	38	14.2	11	1.50
412295	DAVILLA 2N	TX	30.8014	-97.2689	DY	NCDC	25	35.3	41	4.38
292384	DAWSON	NM	36.6667	-104.7833	DY	NCDC	53	16.6	10	2.11
031952	DE QUEEN DAM	AR	34.1003	-94.3725	HR	NCDC	35	53.6	54	4.07
162361	DE QUINCY	LA	30.4347	-93.4692	DY	NCDC	53	60.9	55	5.36
162367	DE RIDDER	LA	30.8428	-93.2869	DY	NCDC	96	61.2	55	5.06
412334	DECATUR	TX	33.2733	-97.5769	DY	NCDC	21	38.4	41	3.89
412352	DEKALB	TX	33.5139	-94.6164	DY	NCDC	18	50.6	54	4.21
412360	DEL RIO AP	TX	29.3772	-100.9275	HR	NCDC	63	19.7	35	3.44
052178	DELHI	CO	37.6333	-104.0167	DY	NCDC	27	14.0	20	1.96
292436	DEMING	NM	32.2531	-107.7531	DY	NCDC	108	10.7	25	1.31
292440	DEMING FAA AP	NM	32.2500	-107.7000	DY	NCDC	21	10.6	25	1.15
412394	DENISON DAM	TX	33.8167	-96.5667	HR	NCDC	58	41.2	41	4.04
412404	DENTON 2 SE	TX	33.1989	-97.1050	HR	NCDC	66	38.4	41	3.67
412415	DEPORT 4 NW	TX	33.5639	-95.3742	HR	NCDC	56	46.8	54	4.06
031948	DEQUEEN	AR	34.0464	-94.3481	DY	NCDC	82	53.5	54	4.35
412417	DERBY 1 S	TX	28.7519	-99.1347	DY	NCDC	16	25.1	44	3.31
292453	DES MOINES	NM	36.7500	-103.8333	DY	NCDC	79	18.6	20	2.05

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412430	DEVINE	TX	29.1500	-98.9000	DY	NCDC	19	28.3	35	3.80
412436	DEWEYVILLE 5 S	TX	30.2333	-93.7333	DY	NCDC	33	56.7	55	6.29
032015	DIERKS	AR	34.1267	-94.0172	DY	NCDC	55	53.5	54	4.63
292510	DILIA	NM	35.1842	-105.0569	DY	NCDC	73	15.5	20	1.81
412458	DILLEY	TX	28.6806	-99.1833	DY	NCDC	64	25.9	44	3.68
412462	DIME BOX	TX	30.3606	-96.8456	HR	NCDC	31	37.8	45	3.77
412464	DIMMITT 2 N	TX	34.5858	-102.3119	DY	NCDC	21	20.8	21	2.51
142164	DODGE CITY RGNL AP	KS	37.7686	-99.9678	DY	NCDC	62	21.9	30	2.50
142158	DODGE CITY RIVER	KS	37.7447	-100.0328	DY	NCDC	35	21.8	30	2.30
162525	DODSON 6 ENE	LA	32.1000	-92.5833	DY	NCDC	35	58.9	55	4.48
052312	DOHERTY RCH	CO	37.3833	-103.8833	DY	NCDC	41	13.5	20	1.82
M190008	DOLORES		26.0000	-107.1800	DY	MEXICO	33	0.0	12	2.50
412585	DRIPPING SPRINGS 6 E	TX	30.2133	-97.9822	DY	NCDC	21	35.1	44	4.09
412598	DUBLIN 2SE	TX	32.0628	-98.3047	DY	NCDC	20	35.7	40	4.19
412617	DUMAS	TX	35.8733	-101.9728	DY	NCDC	21	16.8	21	2.51
412621	DUMONT	TX	33.8094	-100.5169	HR	NCDC	40	23.8	31	2.79
342660	DUNCAN	OK	34.5011	-97.9592	DY	NCDC	76	36.3	40	3.56
342668	DUNCAN 10 W	OK	34.4933	-98.1419	DY	NCDC	63	34.5	40	3.63
342654	DUNCAN AP	OK	34.4831	-97.9578	HR	NCDC	63	36.3	40	3.53
412633	DUNDEE 6 NNW	TX	33.8158	-98.9317	DY	NCDC	20	26.9	31	3.13
292665	DURAN	NM	34.4692	-105.3975	HR	NCDC	63	14.7	20	1.59
342678	DURANT	OK	34.0003	-96.3686	DY	NCDC	111	43.7	41	4.15
292677	DUVAL POTASH MINE	NM	32.5333	-103.9000	DY	NCDC	19	13.4	24	2.66
66	EAGLE LAKE	TX	29.6333	-96.3833	DY	TWDB	23	43.8	46	4.42
412676	EAGLE LAKE RESCH CTR	TX	29.6211	-96.3661	HR	NCDC	68	44.0	46	4.03
292700	EAGLE NEST	NM	36.5575	-105.2628	DY	NCDC	86	17.1	10	1.39
412679	EAGLE PASS 3N	TX	28.7567	-100.4789	HR	NCDC	68	19.9	36	3.39
412715	EASTLAND	TX	32.3989	-98.8175	HR	NCDC	45	28.7	40	3.17
412744	EDEN 2	TX	31.2167	-99.8500	HR	NCDC	46	25.1	34	2.91
412770	EDNA 7 NW	TX	29.0622	-96.7714	DY	NCDC	20	43.5	46	4.72
M210028	EL BARRETAL	MX	24.1000	-99.1300	DY	MEXICO	52	0.0	36	3.91
M220019	EL CUCHILLO		25.7300	-99.2500	DY	MEXICO	47	0.0	36	3.80
032300	EL DORADO GOODWIN FL	AR	33.2208	-92.8142	DY	NCDC	106	53.5	54	4.03
M230025	EL FUERTE		26.3300	-108.6200	DY	MEXICO	44	0.0	14	3.35
412824	EL INDIO	TX	28.5161	-100.3133	DY	NCDC	21	20.1	36	3.51
412797	EL PASO AP	TX	31.8111	-106.3758	DY	NCDC	18	9.6	25	1.42
342818	EL RENO 2 W	OK	32.5333	-98.0000	DY	NCDC	86	32.8	40	3.46
342836	ELDORADO	OK	34.4667	-99.6500	DY	NCDC	44	27.0	31	2.97
412811	ELDORADO 1 N	TX	30.8833	-100.6000	HR	NCDC	50	21.8	34	2.73

Station ID	Station name	State	Lat.	Long.	Gauge type	Source	Data years	PRISM MAP (inches)	L-mom. Region	MAM (inches)
292848	ELEPHANT BUTTE DAM	NM	33.1461	-107.1844	DY	NCDC	88	10.2	11	1.46
412820	ELGIN	TX	30.3494	-97.3683	DY	NCDC	21	34.5	44	3.90
292854	ELIDA	NM	33.9403	-103.6572	DY	NCDC	97	16.1	21	2.26
162800	ELIZABETH	LA	30.8500	-92.7833	DY	NCDC	78	61.9	55	5.36
292860	ELIZABETHTOWN	NM	36.6167	-105.2833	DY	NCDC	44	19.2	10	1.41
292865	ELK	NM	32.9161	-105.3381	DY	NCDC	68	17.8	24	2.00
342849	ELK CITY 4 W	OK	35.3925	-99.5064	DY	NCDC	85	28.7	31	3.41
142432	ELKHART	KS	37.0058	-101.8867	DY	NCDC	109	18.1	21	2.48
292871	ELKINS	NM	33.7000	-104.0667	DY	NCDC	38	14.8	20	2.28
162812	ELMER 2 SW	LA	31.1042	-92.7050	DY	NCDC	22	61.4	55	5.64
342872	ELMORE CITY 3 SW	OK	34.6100	-97.4222	DY	NCDC	30	38.2	41	4.00
412906	ENCINAL	TX	28.0239	-99.3508	DY	NCDC	23	20.1	36	3.32
292940	ENDEE 5 SSE	NM	35.0667	-103.0667	DY	NCDC	19	17.9	21	2.04
292945	ENGLE	NM	33.1833	-107.0333	DY	NCDC	44	11.0	11	1.48
142560	ENGLEWOOD 1 NW	KS	37.0458	-99.9964	HR	NCDC	61	22.7	30	2.50
342944	ERICK	OK	35.2164	-99.8628	DY	NCDC	99	26.4	31	3.05
162981	EUNICE	LA	30.4917	-92.4303	DY	NCDC	62	59.7	55	5.47
343002	EVA	OK	36.7975	-101.9075	HR	NCDC	63	17.9	21	1.98
413005	EVANT 1SSW	TX	31.4625	-98.1619	HR	NCDC	67	31.2	40	3.22
052803	EVERSOLL RCH	CO	37.0333	-102.0667	DY	NCDC	23	17.3	21	2.24
413060	FALCON DAM	TX	26.5581	-99.1372	DY	NCDC	21	19.7	36	3.52
413063	FALFURRIAS	TX	27.1394	-98.1200	DY	NCDC	22	24.0	36	3.86
413065	FALLS CITY 7 WSW	TX	28.9614	-98.1103	DY	NCDC	21	28.0	44	3.16
343065	FANSHAWE	OK	34.9511	-94.9081	DY	NCDC	72	51.5	50	4.14
343070	FARGO	OK	36.3744	-99.6264	DY	NCDC	70	24.1	31	2.92
163079	FARMERVILLE	LA	32.7750	-92.4075	DY	NCDC	73	56.0	54	4.27
343083	FARRIS 3 WNW	OK	34.2667	-95.9167	DY	NCDC	55	46.3	50	4.16
293157	FAYWOOD	NM	32.6319	-107.8639	DY	NCDC	67	14.4	13	1.64
413112	FEDOR	TX	30.3167	-97.0381	DY	NCDC	20	36.0	45	4.43
032489	FERNDALE 6 E	AR	34.7594	-92.4553	HR	NCDC	31	51.9	54	4.25
413133	FERRIS	TX	32.5336	-96.6606	HR	NCDC	63	38.9	41	3.86
413156	FISCHERS STORE	TX	29.9756	-98.2647	DY	NCDC	73	35.4	44	3.97
343182	FLASHMAN TWR	OK	34.4833	-95.0000	DY	NCDC	42	55.1	50	4.58
413171	FLAT	TX	31.3089	-97.6306	HR	NCDC	57	34.0	41	3.72
413183	FLATONIA	TX	29.6778	-97.1111	DY	NCDC	21	37.9	45	4.17
413199	FLORENCE	TX	30.8392	-97.7925	DY	NCDC	18	33.8	41	4.68
293225	FLORIDA	NM	32.4333	-107.4833	DY	NCDC	59	11.3	13	1.67
293231	FLOYD	NM	34.2167	-103.5500	DY	NCDC	31	16.5	21	2.02
413214	FLOYDADA	TX	33.9869	-101.3361	DY	NCDC	21	21.5	30	2.48
413215	FLOYDADA 9 SE	TX	33.8761	-101.2464	DY	NCDC	21	21.4	31	3.07

Station ID	Station name	State	Lat.	Long.	Gauge type	Source	Data years	PRISM MAP (inches)	L-mom. Region	MAM (inches)
293237	FLYING H	NM	33.0000	-105.1000	DY	NCDC	50	15.9	24	2.23
413225	FOLLETT	TX	36.4328	-100.1369	DY	NCDC	16	23.3	30	2.41
293242	FOLSOM	NM	36.8667	-103.9167	DY	NCDC	18	17.3	20	2.54
032540	FORDYCE	AR	33.8167	-92.4167	DY	NCDC	78	54.6	54	4.30
032544	FOREMAN	AR	33.7164	-94.3814	HR	NCDC	60	48.8	54	4.37
032556	FORESTER 4 WNW	AR	34.7833	-93.8833	DY	NCDC	16	52.5	50	3.69
413261	FORT CONCHO	TX	31.4667	-100.4333	DY	NCDC	18	21.9	34	2.65
343304	FORT SUPPLY 3SE	OK	36.5442	-99.5350	DY	NCDC	69	24.6	31	2.70
142855	FOWLER 3 NNE	KS	37.4167	-100.1833	DY	NCDC	41	21.0	30	2.77
413299	FOWLERTON	TX	28.4689	-98.8167	DY	NCDC	19	24.3	36	4.23
413321	FRANKLIN	TX	31.0328	-96.4889	DY	NCDC	19	38.6	41	3.98
343353	FREDERICK	OK	34.3864	-99.0122	DY	NCDC	105	29.5	31	3.12
413329	FREDERICKSBURG	TX	30.2392	-98.9089	HR	NCDC	35	30.8	35	3.61
343358	FREEDOM	OK	36.7647	-99.1128	DY	NCDC	67	26.8	31	3.16
413341	FREER 4N	TX	27.9361	-98.6169	DY	NCDC	18	23.9	36	3.74
413368	FRIONA	TX	34.6400	-102.7231	DY	NCDC	21	20.0	21	2.28
413370	FRISCO	TX	33.1519	-96.8122	HR	NCDC	43	39.8	41	3.83
293265	FT BAYARD	NM	32.7939	-108.1517	DY	NCDC	113	17.4	13	1.70
343281	FT COBB	OK	35.1036	-98.4428	HR	NCDC	54	31.3	40	3.44
413262	FT DAVIS	TX	30.6033	-103.8861	DY	NCDC	19	17.3	26	1.62
413265	FT GRIFFIN	TX	32.9264	-99.2350	DY	NCDC	27	29.1	31	3.97
413266	FT HANCOCK 8SSE	TX	31.1853	-105.7414	DY	NCDC	17	8.8	26	1.32
413257	FT MCKAVETT	TX	30.8275	-100.1103	DY	NCDC	20	24.2	34	3.07
413270	FT MCKAVETT 7 N	TX	30.9303	-100.1125	HR	NCDC	50	24.4	34	2.95
293288	FT STANTON	NM	33.5000	-105.5167	DY	NCDC	74	15.9	11	1.66
413280	FT STOCKTON	TX	30.9072	-102.9153	DY	NCDC	35	12.9	24	2.37
413278	FT STOCKTON 35 SSW	TX	30.3833	-103.0333	HR	NCDC	29	14.8	24	2.28
293294	FT SUMNER	NM	34.4667	-104.2319	DY	NCDC	92	15.1	20	2.33
293296	FT SUMNER 5 S	NM	34.3942	-104.2503	DY	NCDC	67	14.9	20	2.43
293300	FT UNION	NM	35.9000	-105.0333	DY	NCDC	60	18.1	10	2.19
413284	FT WORTH MEACHAM FLD	TX	32.8192	-97.3614	HR	NCDC	64	36.1	41	3.41
413285	FT WORTH WSFO	TX	32.8339	-97.2975	HR	NCDC	53	36.6	41	3.44
032670	FULTON	AR	33.6128	-93.8136	DY	NCDC	94	52.2	54	4.17
293368	GAGE	NM	32.2261	-108.0867	DY	NCDC	102	11.2	25	1.52
343407	GAGE AP	OK	36.2967	-99.7689	DY	NCDC	65	22.5	31	2.79
413410	GAGEBY 3 WNW	TX	35.6306	-100.3917	HR	NCDC	68	24.6	31	2.68
413411	GAIL	TX	32.7744	-101.4539	DY	NCDC	19	19.2	21	2.37
413415	GAINESVILLE	TX	33.6358	-97.1444	HR	NCDC	71	38.3	41	3.62
413420	GAINESVILLE 5 ENE	TX	33.6461	-97.0592	DY	NCDC	21	39.5	41	4.32
M250008	GALEANA		30.1200	-107.6300	DY	MEXICO	41	0.0	28	1.74

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293408	GALLINAS RS	NM	34.1500	-105.6500	DY	NCDC	38	14.7	11	1.65
413430	GALVESTON	TX	29.3333	-94.7717	HR	NCDC	58	45.5	55	4.83
413446	GARDEN CITY 16 E	TX	31.8333	-101.2000	HR	NCDC	24	19.6	34	2.26
053222	GARDNER	CO	37.7667	-105.1833	DY	NCDC	32	14.1	10	1.37
343489	GATE	OK	36.8500	-100.0569	DY	NCDC	56	22.6	30	2.69
413485	GATESVILLE 4 SSE	TX	31.3822	-97.7217	DY	NCDC	18	33.5	41	4.65
M260019	GENERAL BRAVO		25.8000	-99.1800	DY	MEXICO	36	0.0	36	3.99
M270005	GENERAL CEPEDA	MX	25.3700	-101.4700	DY	MEXICO	37	0.0	29	1.95
413507	GEORGETOWN LAKE	TX	30.6836	-97.7172	HR	NCDC	30	35.7	41	4.05
413525	GIDDINGS 5E	TX	30.1872	-96.8594	DY	NCDC	20	38.0	45	4.06
293530	GILA HOT SPRINGS	NM	33.1953	-108.2078	DY	NCDC	55	16.4	13	1.53
032810	GILLHAM DAM	AR	34.2056	-94.2464	HR	NCDC	35	54.3	54	5.03
413546	GILMER 4 WNW	TX	32.7464	-95.0497	HR	NCDC	62	46.6	54	4.15
032842	GLENWOOD	AR	34.3217	-93.5617	DY	NCDC	78	57.2	54	4.86
293575	GLENWOOD	NM	33.3217	-108.8794	DY	NCDC	74	18.1	13	1.65
163657	GLOSTER 1 W	LA	32.2000	-93.8333	DY	NCDC	35	52.2	54	3.98
413605	GOLD	TX	30.3481	-98.6861	DY	NCDC	21	32.3	35	3.96
413614	GOLDTHWAITE 1 WSW	TX	31.4406	-98.5906	DY	NCDC	21	30.2	40	3.38
413618	GOLIAD	TX	28.6617	-97.3850	DY	NCDC	20	34.4	46	4.54
413622	GONZALES 1N	TX	29.5339	-97.4500	DY	NCDC	21	35.4	45	4.15
343628	GOODWELL RSCH STN	OK	36.5914	-101.6181	DY	NCDC	94	17.9	21	2.28
413639	GORDON 1SW	TX	32.5408	-98.3814	DY	NCDC	17	32.2	40	4.24
413642	GORDONVILLE	TX	33.7969	-96.8569	HR	NCDC	65	39.7	41	3.74
413646	GORMAN 2 NNE	TX	32.2422	-98.6631	HR	NCDC	48	30.7	40	3.47
163741	GORUM FIRE TWR	LA	31.4358	-92.8828	DY	NCDC	51	59.0	55	4.71
343688	GRADY 2 E	OK	34.0225	-97.6342	DY	NCDC	23	35.2	41	3.45
293649	GRAN QUIVIRA NATL MO	NM	34.2594	-106.0931	DY	NCDC	85	16.7	11	1.71
163794	GRAND CANE FIRE TWR	LA	32.1333	-93.8000	DY	NCDC	46	52.3	54	3.99
163798	GRAND CHENIER	LA	29.7667	-92.9500	DY	NCDC	27	60.4	55	5.15
343709	GRANDFIELD 4 NW	OK	34.2833	-98.7333	DY	NCDC	52	30.4	40	3.66
413685	GRANGER	TX	30.7206	-97.4489	DY	NCDC	19	35.3	41	3.74
413686	GRANGER DAM	TX	30.7000	-97.3497	HR	NCDC	32	34.7	41	3.41
032908	GRANNIS	AR	34.2500	-94.3333	DY	NCDC	37	55.7	54	4.82
413691	GRAPEVINE DAM	TX	32.9506	-97.0553	HR	NCDC	62	37.6	41	3.60
032922	GRAVELLY 1 ESE	AR	34.8758	-93.6761	DY	NCDC	75	53.2	50	4.05
143239	GREENSBURG	KS	37.6019	-99.3000	DY	NCDC	108	24.8	31	2.75
413734	GREENVILLE KGVL RADI	TX	33.1675	-96.1014	DY	NCDC	21	43.7	41	3.90
413734	GREENVILLE KGVL RADI	TX	33.1675	-96.1014	DY	NCDC	21	43.8	41	3.90
163877	GREENWOOD FIRE TWR	LA	32.4175	-94.0003	DY	NCDC	37	53.4	54	4.93

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293706	GRENVILLE	NM	36.5939	-103.6192	DY	NCDC	75	17.0	21	2.15
413771	GROESBECK 2	TX	31.5253	-96.5306	HR	NCDC	33	41.6	41	4.04
413787	GRUVER	TX	36.2631	-101.4050	DY	NCDC	21	20.2	30	2.60
M290008	GUADALUPE Y CALVO		26.1000	-106.9700	DY	MEXICO	46	0.0	12	3.23
M310010	GUANACEVI		25.9300	-105.9700	DY	MEXICO	68	0.0	12	1.85
163930	GUEYDAN 5 S	LA	29.9500	-92.5167	DY	NCDC	34	60.4	55	5.69
033074	GURDON	AR	33.9167	-93.1333	DY	NCDC	39	52.8	54	4.29
413828	GUTHRIE	TX	33.6267	-100.3369	DY	NCDC	20	25.0	31	2.86
343835	GUYMON	OK	36.7028	-101.4781	DY	NCDC	38	18.4	21	2.44
293775	HACHITA	NM	31.9222	-108.3200	DY	NCDC	99	11.9	25	1.61
163979	HACKBERRY 8 SSW	LA	29.8889	-93.4031	DY	NCDC	72	59.3	55	5.47
413846	HAGANSPORT	TX	33.3361	-95.2486	DY	NCDC	15	46.4	54	4.40
293792	HAGERMAN	NM	33.1167	-104.3333	DY	NCDC	32	14.2	24	2.07
413877	HALLSVILLE 1 W	TX	32.5117	-94.5892	DY	NCDC	17	49.2	54	3.74
343871	HAMMON 3 SSW	OK	35.5850	-99.3953	DY	NCDC	74	28.9	31	3.12
164050	HANNA 4 SSE	LA	31.9158	-93.3183	DY	NCDC	54	54.5	55	3.99
343902	HARDESTY	OK	36.6167	-101.1833	DY	NCDC	17	19.5	30	2.78
413941	HARLETON	TX	32.6758	-94.5675	DY	NCDC	19	47.5	54	4.52
413943	HARLINGEN	TX	26.2028	-97.6728	DY	NCDC	21	25.7	36	3.85
413954	HARPER 1W	TX	30.3011	-99.2681	DY	NCDC	19	29.0	35	4.18
413972	HART	TX	34.3653	-102.0903	DY	NCDC	21	18.6	21	2.32
413981	HARTLEY 4 ESE	TX	35.8653	-102.3317	DY	NCDC	27	16.9	21	2.58
413992	HASKELL	TX	33.1578	-99.7456	DY	NCDC	28	26.1	31	2.98
293849	HASSELL	NM	34.7167	-104.0167	DY	NCDC	31	16.3	21	1.95
293855	HATCH	NM	32.6775	-107.1958	DY	NCDC	87	10.5	11	1.43
414020	HAWKINS	TX	32.5783	-95.2042	DY	NCDC	17	43.3	54	3.98
164131	HAYNESVILLE	LA	32.9683	-93.1297	DY	NCDC	52	54.0	54	3.93
343998	HEADRICK	OK	34.6300	-98.1406	DY	NCDC	22	35.2	40	3.32
344001	HEALDTON 3 E	OK	34.2331	-97.4203	DY	NCDC	99	37.1	41	3.58
344008	HEAVENER 2 N	OK	34.9128	-94.5997	DY	NCDC	59	50.1	50	4.03
414058	HEBBRONVILLE	TX	27.3194	-98.6775	DY	NCDC	21	21.7	36	3.63
344017	HEE MTN TWR	OK	34.3333	-94.6500	DY	NCDC	45	54.3	50	4.61
414080	HEMPSTEAD	TX	30.1000	-96.0833	DY	NCDC	42	44.3	55	4.29
414080	HEMPSTEAD 8 WNW	TX	30.1000	-96.0833	DY	NCDC	42	43.1	45	4.29
414081	HENDERSON	TX	32.1822	-94.7967	DY	NCDC	21	48.9	54	4.41
344052	HENNEPIN 5 N	OK	34.5828	-97.3464	HR	NCDC	64	38.1	41	3.99
414098	HEREFORD	TX	34.8172	-102.4003	HR	NCDC	65	20.0	21	2.26
293946	HERMANAS	NM	31.8500	-107.9833	DY	NCDC	45	11.7	25	1.58
414137	HICO	TX	31.9844	-98.0311	HR	NCDC	31	34.7	40	3.57
M320028	HIDALGO	MX	24.2500	-99.4300	DY	MEXICO	50	0.0	36	4.93

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414140	HIGGINS	TX	36.1161	-100.0239	DY	NCDC	17	24.3	31	3.20
294009	HILLSBORO	NM	32.9236	-107.5628	DY	NCDC	102	13.3	13	1.74
414182	HILLSBORO	TX	32.0161	-97.1094	DY	NCDC	21	37.5	41	4.05
414191	HINDES	TX	28.7167	-98.8000	HR	NCDC	59	25.8	44	3.77
164260	HINESTON 4 NNE	LA	31.1833	-92.7500	DY	NCDC	25	60.3	55	4.58
344204	HOBART MUNI AP	OK	34.9894	-99.0525	DY	NCDC	94	29.6	31	3.20
294026	HOBBS	NM	32.7264	-103.1314	DY	NCDC	92	15.4	24	2.66
294030	HOBBS 13W	NM	32.7125	-103.3539	DY	NCDC	17	15.0	24	2.59
164288	HODGES GARDENS	LA	31.3747	-93.3911	DY	NCDC	62	56.3	55	4.70
344235	HOLDENVILLE 2SSE	OK	35.0567	-96.3861	DY	NCDC	110	41.2	41	3.98
344249	HOLLIS 5E	OK	34.6808	-99.8136	DY	NCDC	89	25.5	31	3.14
164355	HOMER 1N	LA	32.8100	-93.0625	DY	NCDC	62	56.2	54	4.26
414254	HONDO	TX	29.3372	-99.1386	DY	NCDC	20	28.6	35	4.38
294089	HONDO 1SE	NM	33.3803	-105.2544	HR	NCDC	64	14.7	11	1.91
414257	HONEY GROVE	TX	33.5881	-95.9039	HR	NCDC	64	45.7	54	4.25
344298	HOOKER	OK	36.8589	-101.2172	DY	NCDC	97	18.2	21	2.40
294106	HOOSIER RCH	NM	35.8667	-104.1667	DY	NCDC	39	16.5	21	2.44
294112	HOPE	NM	32.8111	-104.7336	DY	NCDC	69	14.2	24	2.26
033428	HOPE 3 NE	AR	33.7089	-93.5561	DY	NCDC	104	53.3	54	4.31
033438	HOPPER	AR	34.3608	-93.6817	DY	NCDC	65	57.2	50	4.00
033442	HORATIO	AR	33.9350	-94.3586	DY	NCDC	60	53.8	54	4.66
164398	HOSSTON	LA	32.8867	-93.8733	DY	NCDC	74	50.1	54	3.87
033466	HOT SPRINGS 1 NNE	AR	34.5144	-93.0522	DY	NCDC	118	54.9	54	4.43
294175	HOUSE	NM	34.6344	-103.8903	DY	NCDC	73	15.0	21	2.27
414309	HOUSTON ADDICKS	TX	29.7689	-95.6439	HR	NCDC	64	48.9	55	4.67
414311	HOUSTON ALIEF	TX	29.7147	-95.5947	HR	NCDC	64	49.7	55	4.55
414300	HOUSTON BUSH INTL AP	TX	29.9800	-95.3600	HR	NCDC	42	51.0	55	5.05
414315	HOUSTON DEER PARK	TX	29.7283	-95.1306	DY	NCDC	17	54.5	55	5.68
414321	HOUSTON HEIGHTS	TX	29.7914	-95.4261	DY	NCDC	17	51.3	55	7.15
414307	HOUSTON HOBBY AP	TX	29.6381	-95.2819	HR	NCDC	19	53.4	55	5.02
414327	HOUSTON NORTH HOUSTO	TX	29.8733	-95.5275	DY	NCDC	21	49.8	55	5.95
414333	HOUSTON NWSO	TX	29.4717	-95.0833	DY	NCDC	21	57.6	55	5.93
414329	HOUSTON SATSUMA	TX	29.9333	-95.6333	HR	NCDC	50	46.9	55	4.55
414305	HOUSTON WB CITY	TX	29.7667	-95.3667	HR	NCDC	31	51.5	55	4.51
414326	HOUSTON-PORT	TX	29.7300	-95.2736	DY	NCDC	19	52.3	55	5.43
414325	HOUSTON-WESTBURY	TX	29.6600	-95.4711	DY	NCDC	16	51.4	55	5.14
414348	HUDSPETH RIVER RANCH	TX	29.9881	-101.1786	DY	NCDC	21	19.8	34	3.34
344384	HUGO	OK	34.0211	-95.5381	DY	NCDC	86	47.1	54	4.32
344386	HUGO DAM	OK	34.0000	-95.4000	HR	NCDC	29	47.8	54	3.94

Station ID	Station name	State	Lat.	Long.	Gauge type	Source	Data years	PRISM MAP (inches)	L-mom. Region	MAM (inches)
143855	HUGOTON	KS	37.1644	-101.3397	DY	NCDC	111	18.8	21	2.33
414363	HUMBLE PUMP STN 5 WN	TX	30.3606	-100.3056	DY	NCDC	21	22.2	34	3.06
414375	HUNT 10 W	TX	30.0628	-99.5050	HR	NCDC	36	28.4	35	3.94
414382	HUNTSVILLE	TX	30.7064	-95.5419	DY	NCDC	65	48.3	55	4.52
414402	HYE	TX	30.2533	-98.5711	DY	NCDC	68	32.5	35	4.10
344451	IDABEL	OK	33.9336	-94.8278	DY	NCDC	94	51.5	54	4.23
414425	IMPERIAL	TX	31.2667	-102.7000	HR	NCDC	30	12.0	24	1.90
414440	INDIAN GAP	TX	31.6667	-98.4167	HR	NCDC	32	30.3	40	3.22
16	INGRAM	TX	30.1500	-99.3500	DY	TWDB	22	30.1	35	3.59
294306	IONE	NM	35.7500	-103.3000	DY	NCDC	49	16.2	21	2.54
414476	IREDELL	TX	31.9803	-97.8608	HR	NCDC	49	34.4	41	3.49
144008	IRENE	KS	37.8333	-101.9333	DY	NCDC	24	17.2	21	2.18
414503	ITASCA	TX	32.1667	-97.1500	DY	NCDC	29	38.5	41	3.74
414517	JACKSBORO	TX	33.2231	-98.1608	HR	NCDC	72	33.0	40	3.24
414525	JACKSONVILLE	TX	31.9622	-95.2736	DY	NCDC	34	46.9	54	4.44
M330025	JAINA		25.9000	-108.0200	DY	MEXICO	53	0.0	14	3.90
294346	JAL	NM	32.1103	-103.1872	DY	NCDC	81	12.9	24	2.27
414556	JARRELL	TX	30.8472	-97.5994	DY	NCDC	21	35.3	41	4.43
414563	JASPER	TX	30.9153	-94.0097	DY	NCDC	20	56.3	55	5.58
414570	JAYTON	TX	33.2544	-100.5725	HR	NCDC	71	23.4	31	2.88
414575	JEDDO 3S	TX	29.7664	-97.3164	DY	NCDC	27	36.5	44	4.45
414577	JEFFERSON	TX	32.7681	-94.3561	HR	NCDC	35	49.6	54	3.87
164700	JENNINGS	LA	30.2003	-92.6642	DY	NCDC	117	60.6	55	5.37
033704	JESSIEVILLE	AR	34.7522	-93.0256	DY	NCDC	62	55.8	50	4.38
414591	JEWETT	TX	31.3500	-96.1500	HR	NCDC	50	40.0	41	3.81
294375	JEWETT WORK CTR	NM	33.9833	-108.6333	DY	NCDC	44	16.6	13	1.41
414597	JOE POOL LAKE	TX	32.6406	-96.9747	DY	NCDC	21	37.9	41	4.53
144114	JOHNSON	KS	37.5669	-101.7508	DY	NCDC	20	17.3	21	2.26
414605	JOHNSON CITY	TX	30.2836	-98.4172	DY	NCDC	21	32.8	35	4.15
164732	JONESBORO 4 ENE	LA	32.2550	-92.6544	DY	NCDC	43	57.3	55	4.56
294426	JORNADA EXP RANGE	NM	32.6169	-106.7411	DY	NCDC	100	10.4	11	1.40
414670	JUNCTION 4SSW	TX	30.4453	-99.8044	HR	NCDC	69	23.7	34	2.92
414679	JUSTIN	TX	33.0806	-97.2967	HR	NCDC	58	37.8	41	3.90
164816	KEITHVILLE	LA	32.3550	-93.8619	DY	NCDC	75	52.4	54	4.25
294461	KELLY RCH	NM	34.0311	-107.1250	DY	NCDC	68	15.3	11	1.99
414757	KENDALIA	TX	29.9658	-98.5117	DY	NCDC	19	35.2	35	4.40
414770	KENT 8SE	TX	31.0169	-104.1103	DY	NCDC	19	14.0	26	1.73
344766	KENTON	OK	36.9031	-102.9650	DY	NCDC	97	17.2	21	2.25
414782	KERRVILLE 3 NNE	TX	30.0744	-99.1086	DY	NCDC	21	31.9	35	3.60
344820	KIAMICHI TWR	OK	34.6333	-94.8167	DY	NCDC	29	63.5	50	4.66

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414792	KILLEEN 3 S	TX	31.0719	-97.7306	HR	NCDC	25	33.8	41	3.09
054538	KIM 15 NNE	CO	37.4536	-103.3219	HR	NCDC	64	16.1	20	2.09
164884	KINDER 3 W	LA	30.5000	-92.9000	DY	NCDC	44	61.9	55	5.58
414805	KINGSBURY	TX	29.6867	-97.7644	DY	NCDC	18	33.8	44	4.81
344865	KINGSTON 5 SSE	OK	33.9300	-96.6961	DY	NCDC	61	42.0	41	4.20
294506	KINGSTON RS	NM	32.9167	-107.6833	DY	NCDC	37	16.9	13	1.88
414810	KINGSVILLE	TX	27.5236	-97.8617	DY	NCDC	19	29.0	46	4.24
144363	KISMET NEAR	KS	37.3333	-100.8833	DY	NCDC	39	19.3	21	2.38
414841	KNAPP 2 SW	TX	32.6258	-101.1503	DY	NCDC	17	21.6	21	2.87
414848	KNICKERBOCKER	TX	31.2667	-100.6333	DY	NCDC	28	22.0	34	2.92
344915	KONAWA	OK	34.9614	-96.7500	DY	NCDC	73	41.2	41	4.21
414866	KOPPERL 5 NNE	TX	32.1347	-97.4786	HR	NCDC	69	35.0	41	3.45
164931	KORAN	LA	32.4178	-93.4669	DY	NCDC	67	52.4	54	4.09
414878	KOUNTZE	TX	30.3750	-94.2994	DY	NCDC	21	58.8	55	5.46
414878	KOUNTZE	TX	30.3750	-94.2994	HR	NCDC	40	58.8	55	5.27
414880	KRESS	TX	34.3708	-101.7483	HR	NCDC	72	20.4	21	2.47
414903	LA GRANGE	TX	29.9172	-96.8753	DY	NCDC	21	39.9	45	4.19
054726	LA JUNTA 20 S	CO	37.7511	-103.4775	DY	NCDC	59	15.0	20	1.76
414920	LA PRYOR	TX	28.9836	-99.8678	HR	NCDC	68	22.3	35	3.42
054870	LA VETA PASS	CO	37.4667	-105.1667	DY	NCDC	45	24.3	10	2.30
294722	LAGUNITA	NM	34.6000	-104.7167	DY	NCDC	20	13.7	20	2.22
414950	LAJITAS	TX	29.2694	-103.7575	DY	NCDC	21	10.4	26	1.66
414967	LAKE ALAN HENRY	TX	33.0642	-101.0489	DY	NCDC	21	21.0	31	2.57
294728	LAKE ALICE NEAR	NM	36.9500	-104.3833	DY	NCDC	33	22.1	10	2.11
165065	LAKE ARTHUR 10 SW	LA	30.0031	-92.7808	DY	NCDC	95	59.3	55	5.68
294736	LAKE AVALON	NM	32.4833	-104.2500	DY	NCDC	65	13.8	24	2.12
414972	LAKE BRIDGEPORT DAM	TX	33.2250	-97.8317	HR	NCDC	66	35.0	40	3.27
165074	LAKE CHARLES 2 N	LA	30.2544	-93.2186	DY	NCDC	76	61.5	55	5.33
165078	LAKE CHARLES AP	LA	30.1247	-93.2283	HR	NCDC	49	60.2	55	5.64
414974	LAKE COLORADO CITY	TX	32.3333	-100.9167	HR	NCDC	37	20.5	31	2.64
414975	LAKE CROCKETT	TX	33.7411	-95.9217	HR	NCDC	65	45.4	54	4.13
70	LAKE FORK	TX	32.8167	-95.5333	DY	TWDB	21	44.0	54	4.19
414976	LAKE FORK RSVR	TX	32.8242	-95.5275	DY	NCDC	21	44.0	54	4.01
72	LAKE GRANBURY	TX	32.4167	-97.7500	DY	TWDB	20	35.0	41	3.72
57	LAKE J.B. THOMAS	TX	32.5833	-101.1333	DY	TWDB	21	21.5	21	2.81
414982	LAKE KEMP	TX	33.7542	-99.1442	HR	NCDC	37	25.9	31	2.90
71	LAKE LIMESTONE	TX	31.5333	-96.5333	DY	TWDB	23	41.6	41	4.23
67	LAKE LIVINGSTON	TX	30.6333	-95.0100	DY	TWDB	24	51.5	55	4.88
294742	LAKE MALOYA	NM	36.9825	-104.3753	DY	NCDC	72	23.2	10	2.36

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034010	LAKE MAUMELLE	AR	34.8511	-92.4889	DY	NCDC	55	48.8	54	4.08
294747	LAKE MC MILLAN	NM	32.6000	-104.3333	DY	NCDC	27	12.8	24	2.27
344978	LAKE OVERHOLSER	OK	35.4878	-97.6644	HR	NCDC	60	35.3	40	3.76
21	LAKE TAWAKONI	TX	32.8500	-95.8833	DY	TWDB	22	43.4	41	4.27
414980	LAKE TAWAKONI	TX	32.8522	-95.8864	DY	NCDC	21	43.4	41	3.88
22	LAKE TRAVIS	TX	30.4000	-97.8833	DY	TWDB	21	30.9	44	4.48
415013	LAMESA 1 SSE	TX	32.7228	-101.9456	DY	NCDC	19	18.8	21	2.25
415018	LAMPASAS	TX	31.0717	-98.1847	DY	NCDC	25	31.7	35	2.95
294786	LANEY RCH	NM	32.7333	-107.6500	DY	NCDC	72	16.8	13	1.75
034060	LANGLEY	AR	34.2647	-93.8153	DY	NCDC	63	56.0	54	4.98
415048	LANGTRY	TX	29.7931	-101.5603	HR	NCDC	67	14.5	34	2.71
415056	LAREDO	TX	27.5036	-99.5117	DY	NCDC	65	19.4	36	3.47
415060	LAREDO 2	TX	27.5683	-99.4917	DY	NCDC	21	19.5	36	3.37
415060	LAREDO 2	TX	27.5683	-99.4917	HR	NCDC	29	19.5	36	3.15
M350008	LAS BURRAS		28.5300	-105.4200	DY	MEXICO	49	0.0	28	1.64
294850	LAS VEGAS 2 NW	NM	35.6167	-105.2667	DY	NCDC	88	18.1	10	1.98
294858	LAS VEGAS EXP PLOT	NM	35.5833	-105.1833	DY	NCDC	28	17.7	10	2.05
294856	LAS VEGAS MUNI AP	NM	35.6522	-105.1472	DY	NCDC	64	17.5	10	1.84
294862	LAS VEGAS WWTP	NM	35.5678	-105.2131	DY	NCDC	28	17.6	10	1.93
415089	LAURELES RANCH	TX	27.5833	-97.9667	DY	NCDC	20	27.5	45	3.27
345045	LAVERNE	OK	36.6992	-99.8967	DY	NCDC	70	23.1	30	2.52
415094	LAVON DAM	TX	33.0353	-96.4861	HR	NCDC	62	40.5	41	3.79
415097	LAWN	TX	32.1414	-99.7528	DY	NCDC	17	25.6	31	3.19
345063	LAWTON	OK	34.6094	-98.4575	DY	NCDC	103	32.9	40	3.64
345068	LAWTON 2N	OK	34.6500	-98.4000	DY	NCDC	49	33.2	40	3.55
415113	LEAKEY	TX	29.7392	-99.7611	HR	NCDC	67	30.0	35	4.00
345090	LEEDEY	OK	35.8781	-99.3433	DY	NCDC	73	27.5	31	3.18
165266	LEESVILLE	LA	31.1417	-93.2397	DY	NCDC	91	59.5	55	4.78
165287	LEESVILLE 6 SSW	LA	31.0517	-93.2789	DY	NCDC	27	60.3	55	5.77
345108	LEHIGH 4 SW	OK	34.4339	-96.2717	HR	NCDC	62	43.2	50	4.39
415158	LENORAH	TX	32.3081	-101.8775	DY	NCDC	19	17.4	21	2.37
034134	LEOLA	AR	34.1742	-92.5947	DY	NCDC	65	54.0	54	4.58
M360010	LERDO-IN-DURANGO		25.5330	-103.5170	DY	MEXICO	47	0.0	29	1.83
415183	LEVELLAND	TX	33.5869	-102.3828	DY	NCDC	21	19.8	21	2.32
294936	LEVY	NM	36.0833	-104.6833	DY	NCDC	50	18.9	20	2.11
034185	LEWISVILLE	AR	33.3614	-93.5678	HR	NCDC	38	52.6	54	4.07
415192	LEWISVILLE DAM	TX	33.0694	-97.0094	HR	NCDC	61	37.8	41	3.67
415193	LEXINGTON	TX	30.4064	-97.0136	HR	NCDC	72	36.0	45	3.74
144695	LIBERAL	KS	37.0222	-100.9294	DY	NCDC	110	19.5	30	2.57
415196	LIBERTY	TX	30.0592	-94.7950	DY	NCDC	18	60.2	55	6.47

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165365	LIBERTY HILL	LA	32.3167	-92.9167	DY	NCDC	25	59.0	54	4.25
415229	LINDEN	TX	33.0161	-94.3675	DY	NCDC	23	51.1	54	4.41
345216	LINDSAY 2 W	OK	34.8261	-97.6386	DY	NCDC	70	36.8	41	3.79
415243	LIPAN 4NW	TX	32.5683	-98.0819	DY	NCDC	19	32.6	40	3.80
415247	LIPSCOMB	TX	36.2358	-100.2675	HR	NCDC	64	22.2	30	2.44
415258	LITTLE ELM	TX	33.1667	-96.9333	HR	NCDC	21	38.0	41	3.20
415265	LITTLEFIELD	TX	33.9150	-102.3275	DY	NCDC	21	18.8	21	2.42
415271	LIVINGSTON 2 NNE	TX	30.7394	-94.9256	DY	NCDC	21	51.4	55	5.64
415272	LLANO	TX	30.7425	-98.6542	DY	NCDC	29	27.4	35	2.92
415276	LLANO 18S	TX	30.5014	-98.7453	DY	NCDC	15	30.7	35	3.49
415285	LOCKHART 2 SW	TX	29.8569	-97.6958	DY	NCDC	18	34.3	44	5.24
345247	LOCO	OK	34.3281	-97.6794	DY	NCDC	27	35.7	41	3.89
165522	LOGANSPORT	LA	31.9672	-94.0003	DY	NCDC	111	52.3	54	4.54
415312	LONDON 3N	TX	30.7131	-99.5681	HR	NCDC	69	26.3	34	3.09
295073	LONG CANYON	NM	37.0000	-103.6500	DY	NCDC	19	16.7	20	2.54
415341	LONGVIEW	TX	32.4725	-94.7172	DY	NCDC	21	47.8	54	4.26
415348	LONGVIEW 11 SE	TX	32.3467	-94.6533	HR	NCDC	36	48.5	54	3.61
165584	LONGVILLE	LA	30.6000	-93.2333	DY	NCDC	45	59.3	55	5.39
345329	LOOKEBA 1 N	OK	35.3736	-98.3775	DY	NCDC	69	32.7	40	3.69
595	LOOKOUT MOUNTAIN	NM	33.3600	-107.8300	DY	SNOTEL	34	20.3	13	1.66
415358	LORAINE	TX	32.4167	-100.7167	HR	NCDC	43	21.5	31	2.71
295079	LORDSBURG 4 SE	NM	32.3097	-108.6533	DY	NCDC	120	11.5	25	1.50
415369	LOS ANGELES 4 WSW	TX	28.4478	-99.0656	DY	NCDC	16	23.9	36	3.49
M370019	LOS HERRERAS		25.9000	-99.4200	DY	MEXICO	42	0.0	36	4.04
M380019	LOS RAMONES		25.7000	-99.6300	DY	MEXICO	40	0.0	36	4.41
415398	LOVELADY	TX	31.1333	-95.4500	HR	NCDC	47	45.7	54	4.28
295199	LOVING	NM	32.2833	-104.0833	DY	NCDC	32	13.0	24	2.00
295204	LOVINGTON 2 WNW	NM	32.9667	-103.3833	DY	NCDC	46	16.2	21	2.28
165630	LSU DEAN LEE RSCH ST	LA	31.1783	-92.4108	DY	NCDC	39	59.7	55	5.55
415410	LUBBOCK 9 N	TX	33.6897	-101.8219	DY	NCDC	56	19.4	21	2.66
415410	LUBBOCK 9 N	TX	33.6897	-101.8219	HR	NCDC	69	19.4	21	2.70
415411	LUBBOCK INTL AP	TX	33.6656	-101.8231	HR	NCDC	62	19.4	21	2.68
415427	LUFKIN #2	TX	31.3383	-94.7261	DY	NCDC	17	49.7	55	4.57
415415	LUFKIN 11 NW	TX	31.4286	-94.8997	DY	NCDC	21	48.8	55	4.85
415424	LUFKIN ANGELINA CO A	TX	31.2361	-94.7544	HR	NCDC	21	49.5	55	4.23
415429	LULING	TX	29.6753	-97.6564	DY	NCDC	21	34.2	44	4.11
415429	LULING	TX	29.6753	-97.6564	HR	NCDC	22	34.2	44	3.92
415430	LULING 12 NE	TX	29.8403	-97.5672	DY	NCDC	18	34.8	44	4.58
415435	LUMBERTON	TX	30.2503	-94.1786	DY	NCDC	20	59.6	55	5.62

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415463	MABANK 4 SW	TX	32.3317	-96.1506	HR	NCDC	70	41.0	41	4.06
345463	MACKIE 4 NNW	OK	35.7481	-99.8178	HR	NCDC	51	25.7	31	2.73
345468	MADILL	OK	34.0919	-96.7708	DY	NCDC	76	41.9	41	4.13
415477	MADISONVILLE	TX	30.9392	-95.9203	DY	NCDC	21	44.4	45	4.04
295353	MAGDALENA	NM	34.1167	-107.2333	DY	NCDC	86	12.1	11	1.43
034548	MAGNOLIA	AR	33.2506	-93.2336	HR	NCDC	60	52.4	54	4.35
295370	MALJAMAR	NM	32.8567	-103.7625	HR	NCDC	62	15.0	24	2.04
415528	MALONE 3ENE	TX	31.9442	-96.8464	HR	NCDC	29	37.9	41	3.69
034562	MALVERN	AR	34.3658	-92.8144	DY	NCDC	66	54.4	54	4.30
345509	MANGUM	OK	34.8911	-99.5017	DY	NCDC	90	28.1	31	3.18
165874	MANSFIELD	LA	32.0236	-93.6881	DY	NCDC	58	52.2	54	4.35
165892	MANY	LA	31.5769	-93.4817	DY	NCDC	62	53.7	55	4.59
165896	MANY 9 WSW	LA	31.5119	-93.6200	DY	NCDC	26	52.3	55	4.87
415580	MARBLE FALLS	TX	30.5667	-98.2833	DY	NCDC	39	30.9	35	3.54
415596	MARFA 3W	TX	30.3125	-104.0722	HR	NCDC	38	15.1	26	1.98
415591	MARFA CHARCO M R	TX	30.4833	-104.1167	HR	NCDC	27	18.5	26	1.83
345563	MARIETTA 5SW	OK	33.8761	-97.1642	DY	NCDC	72	38.7	41	3.90
415611	MARLIN 3 NE	TX	31.3339	-96.8572	DY	NCDC	17	37.1	41	3.88
345581	MARLOW 1 WSW	OK	34.6456	-97.9778	DY	NCDC	114	36.9	40	3.78
415618	MARSHALL	TX	32.5403	-94.3508	DY	NCDC	23	49.7	54	4.21
165935	MARTIN FIRE TWR	LA	32.0775	-93.2167	HR	NCDC	27	56.6	55	3.87
415650	MASON	TX	30.7400	-99.2239	DY	NCDC	21	27.4	35	3.71
415656	MATADOR NO 2	TX	34.0114	-100.8319	HR	NCDC	70	23.8	31	2.73
415667	MAUD	TX	33.3331	-94.3431	DY	NCDC	25	49.5	54	4.70
295490	MAXWELL 3 NW	NM	36.5697	-104.5867	DY	NCDC	92	14.8	10	1.97
345648	MAYFIELD	OK	35.3392	-99.8769	HR	NCDC	59	25.8	31	3.12
295502	MAYHILL RS	NM	32.9167	-105.4667	DY	NCDC	60	22.2	24	2.06
415695	MAYPEARL	TX	32.3167	-97.0167	HR	NCDC	51	37.3	41	3.61
295532	MC CAULEY RCH	NM	33.3500	-107.9500	DY	NCDC	15	24.5	13	1.54
415770	MC LEAN	TX	35.2358	-100.6067	HR	NCDC	68	26.3	31	2.88
345662	MCALESTER 4 W	OK	34.9500	-95.8333	DY	NCDC	55	43.8	50	4.03
345664	MCALESTER RGNL AP	OK	34.8822	-95.7831	DY	NCDC	51	43.7	50	4.10
415707	MCCAMEY	TX	31.1333	-102.2217	DY	NCDC	18	13.6	34	3.04
295516	MCCARTY RCH	NM	35.6022	-103.3644	DY	NCDC	45	15.8	21	2.40
345688	MCCOMB	OK	35.1500	-97.0167	DY	NCDC	19	38.7	41	3.27
415721	MCCOOK	TX	26.5650	-98.1236	DY	NCDC	21	22.5	36	3.83
345713	MCGEE CREEK DAM	OK	34.3094	-95.8672	DY	NCDC	33	46.8	50	4.01
415757	MCGREGOR	TX	31.4350	-97.4011	DY	NCDC	20	35.6	41	4.01
145171	MEADE	KS	37.2850	-100.3450	DY	NCDC	66	21.2	30	2.44
415742	MEDINA 1NE	TX	29.8097	-99.2503	DY	NCDC	17	34.0	35	4.23

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345779	MEEKER 1 SSE	OK	35.4833	-96.9000	DY	NCDC	115	38.8	41	4.02
295617	MELROSE	NM	34.4278	-103.6250	DY	NCDC	105	17.1	21	2.21
415821	MEMPHIS	TX	34.7261	-100.5372	DY	NCDC	21	22.8	31	2.77
034756	MENA	AR	34.5731	-94.2494	DY	NCDC	123	59.5	50	4.44
415822	MENARD	TX	30.9144	-99.7958	DY	NCDC	23	24.4	34	3.11
M410008	MEOQUI		28.2700	-105.4800	DY	MEXICO	47	0.0	28	1.67
415836	MERCEDES 6 SSE	TX	26.0619	-97.8997	DY	NCDC	20	24.0	36	4.25
415845	MERIDIAN	TX	31.9300	-97.6608	DY	NCDC	15	35.1	41	3.81
166142	MERMENTAU	LA	30.1900	-92.5906	DY	NCDC	45	60.5	55	6.01
M420008	MESA DEL HURACAN		29.6300	-108.2300	DY	MEXICO	35	0.0	12	2.20
295691	MIAMI	NM	36.3500	-104.7667	DY	NCDC	51	17.8	10	1.98
415891	MIDLAND 4 ENE	TX	32.0186	-102.0258	DY	NCDC	59	14.4	24	2.40
415890	MIDLAND INTL AP	TX	31.9431	-102.1906	HR	NCDC	67	14.4	24	2.23
415897	MIDLOTHIAN	TX	32.4842	-96.9942	HR	NCDC	36	37.5	41	4.20
415904	MIDWAY 4 NE	TX	31.0706	-95.7150	DY	NCDC	18	44.0	54	4.02
166202	MILAM TEXAS 8 E	LA	31.4667	-93.7333	DY	NCDC	15	53.3	55	4.16
295725	MILLS	NM	36.0667	-104.2000	DY	NCDC	21	16.8	20	1.95
034839	MILLWOOD DAM	AR	33.6772	-93.9903	HR	NCDC	46	51.1	54	4.16
295754	MIMBRES RS	NM	32.9325	-108.0142	DY	NCDC	94	19.4	13	1.82
166244	MINDEN	LA	32.6053	-93.2947	DY	NCDC	122	54.6	54	4.20
415954	MINEOLA	TX	32.6350	-95.4822	DY	NCDC	17	43.8	54	3.98
415957	MINERAL WELLS 1 SSW	TX	32.7864	-98.1183	HR	NCDC	59	32.8	40	3.47
415958	MINERAL WELLS AP	TX	32.7817	-98.0603	DY	NCDC	17	32.8	40	3.16
145371	MINNEOLA	KS	37.4500	-100.0167	DY	NCDC	48	22.4	30	2.34
166271	MITTIE 2 SE	LA	30.7000	-92.8833	DY	NCDC	32	60.4	55	5.49
M430025	MOCORITO		25.4800	-107.9200	DY	MEXICO	58	0.0	14	4.17
295800	MOGOLLON	NM	33.3833	-108.7833	HR	NCDC	26	27.8	13	1.80
415996	MOLINE	TX	31.3933	-98.3081	HR	NCDC	67	30.7	40	3.49
M440005	MONCLOVA	MX	26.8830	-101.4330	DY	MEXICO	58	0.0	36	2.22
M450019	MONTEMORELOS	MX	25.2000	-99.8300	DY	MEXICO	48	0.0	36	4.09
M460076	MONTERREY CITY	MX	25.7330	-100.3000	DY	MEXICO	34	0.0	36	3.82
145421	MONTEZUMA	KS	37.5975	-100.4444	DY	NCDC	19	20.5	30	2.57
166324	MONTGOMERY	LA	31.6667	-92.9000	HR	NCDC	21	57.8	55	5.00
416024	MONTGOMERY	TX	30.3908	-95.6969	DY	NCDC	21	46.5	55	5.66
416019	MONTELL	TX	29.5333	-100.0167	DY	NCDC	33	25.2	35	4.07
295874	MONTOYA 10 SE	NM	35.0000	-103.9333	DY	NCDC	40	16.2	21	2.02
166364	MOORINGSPORT 1 N	LA	32.7050	-93.9608	DY	NCDC	40	50.1	54	3.98
346035	MORAVIA 2 NNE	OK	35.1464	-99.4956	DY	NCDC	71	28.4	31	3.27
416060	MORGAN MILL	TX	32.3842	-98.1703	DY	NCDC	21	31.4	40	4.63
295931	MOSQUERO 1	NM	35.7833	-103.9667	DY	NCDC	28	16.8	21	2.26

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295937	MOSQUERO 1 NE	NM	35.8022	-103.9439	DY	NCDC	89	16.9	21	2.24
166431	MOSS BLUFF	LA	30.2944	-93.2078	DY	NCDC	26	61.6	55	5.93
034988	MT IDA 3 SE	AR	34.5408	-93.5878	DY	NCDC	96	56.7	50	4.29
416104	MT LOCKE	TX	30.7053	-104.0233	HR	NCDC	63	19.8	26	2.08
416108	MT PLEASANT	TX	33.1689	-95.0056	HR	NCDC	68	47.0	54	3.84
416119	MT VERNON	TX	33.1953	-95.2233	DY	NCDC	21	46.8	54	4.07
295960	MTN PARK	NM	32.9547	-105.8242	DY	NCDC	99	21.6	25	1.86
416130	MUENSTER	TX	33.6564	-97.3769	DY	NCDC	28	37.9	41	3.68
055819	MULE SHOE LODGE 1 SS	CO	37.5833	-105.1833	HR	NCDC	38	20.6	10	1.52
416135	MULESHOE #1	TX	34.2192	-102.7328	DY	NCDC	25	18.5	21	2.26
416136	MULESHOE 2	TX	34.2208	-102.7367	HR	NCDC	71	18.5	21	1.97
416137	MULESHOE NTL WR	TX	33.9544	-102.7783	DY	NCDC	21	17.4	21	2.45
035079	MURFREESBORO 1 W	AR	34.0783	-93.7019	DY	NCDC	42	55.7	54	4.94
346139	MUTUAL	OK	36.2278	-99.1700	DY	NCDC	95	26.4	31	3.23
26	NACOGDOCHES	TX	31.6167	-94.6500	DY	TWDB	17	51.5	55	4.92
416177	NACOGDOCHES	TX	31.6164	-94.6431	HR	NCDC	56	51.5	55	4.45
035110	NARROWS DAM	AR	34.1453	-93.7139	HR	NCDC	62	56.5	54	4.50
035112	NASHVILLE	AR	33.9303	-93.8514	DY	NCDC	76	53.6	54	4.63
166582	NATCHITOCHES	LA	31.7722	-93.0956	DY	NCDC	92	55.6	55	4.59
166584	NATCHITOCHES #2	LA	31.8142	-93.0856	DY	NCDC	58	55.6	55	4.38
416210	NAVARRO MILLS DAM	TX	31.9611	-96.6881	HR	NCDC	49	38.3	41	4.13
M470010	NAZAS		25.2300	-104.1200	DY	MEXICO	33	0.0	29	1.80
416265	NEUVILLE	TX	31.6503	-94.1519	DY	NCDC	20	53.7	55	4.93
416270	NEW BOSTON	TX	33.4547	-94.4089	HR	NCDC	36	48.9	54	4.15
416276	NEW BRAUNFELS	TX	29.7192	-98.1189	DY	NCDC	28	34.7	44	4.20
416280	NEW CANEY 2 E	TX	30.1375	-95.1783	DY	NCDC	17	52.5	55	5.45
416335	NEW SUMMERFIELD 2W	TX	31.9750	-95.1375	HR	NCDC	49	47.0	54	3.62
416346	NEW ULM	TX	29.8833	-96.4833	DY	NCDC	20	42.2	45	4.35
035174	NEWHOPE 3 E	AR	34.2333	-93.8333	DY	NCDC	42	55.7	54	4.48
035177	NEWHOPE 6 S	AR	34.1469	-93.8936	DY	NCDC	67	53.7	54	4.67
296115	NEWKIRK	NM	35.0700	-104.2575	DY	NCDC	81	15.7	21	2.27
035200	NIMROD DAM	AR	34.9553	-93.1594	DY	NCDC	73	53.8	50	4.11
416368	NIXON	TX	29.2692	-97.7575	DY	NCDC	18	32.8	44	3.73
296138	NOGAL LAKE 1 S	NM	33.5167	-105.6833	HR	NCDC	23	22.1	11	1.64
346386	NORMAN 3SSE	OK	35.1811	-97.4378	DY	NCDC	111	37.6	41	3.80
665	NORTH COSTILLA	NM	36.9900	-105.2600	DY	SNOTEL	35	29.1	10	1.50
055990	NORTH LAKE	CO	37.2167	-105.0500	DY	NCDC	70	23.2	10	1.64
416448	NORTHINGTON RCH	TX	29.8642	-98.6581	DY	NCDC	18	36.8	35	3.94
416477	NOTLA 3 SE	TX	36.1014	-100.5894	DY	NCDC	26	20.9	30	2.68

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M480008	NUEVA CASAS GRANDES		30.3670	-107.9500	DY	MEXICO	65	0.0	28	1.69
416504	O DONNELL	TX	32.9711	-101.8247	HR	NCDC	72	19.7	21	2.54
81	O.H. IVIE	TX	31.5000	-99.6681	DY	TWDB	16	26.0	34	3.33
166836	OAKDALE	LA	30.8214	-92.6697	DY	NCDC	62	61.9	55	5.65
416496	OAKWOOD	TX	31.5914	-95.8442	DY	NCDC	16	43.2	54	3.38
296258	OBAR	NM	35.5500	-103.2000	DY	NCDC	42	17.4	21	2.38
166938	OBERLIN FIRE TWR	LA	30.6036	-92.7739	DY	NCDC	63	62.0	55	5.57
296275	OCATE 2 NW	NM	36.1839	-105.0608	DY	NCDC	55	19.9	10	1.92
296281	OCHOA	NM	32.1664	-103.4250	DY	NCDC	71	12.7	24	2.03
035358	ODEN 1 SE	AR	34.6008	-93.7667	DY	NCDC	87	55.9	50	4.39
145920	OFFERLE 5 S	KS	37.8167	-99.5611	DY	NCDC	39	23.2	30	3.03
M510008	OJO CALIENTE		27.7000	-105.2200	DY	MEXICO	48	0.0	28	2.08
296332	OJO RICO RCH	NM	36.0167	-104.4667	DY	NCDC	15	17.9	20	2.55
035376	OKAY	AR	33.7667	-93.9167	DY	NCDC	71	51.2	54	4.18
346638	OKEMAH	OK	35.4253	-96.3033	DY	NCDC	101	43.3	41	3.98
346663	OKLAHOMA CITY EAST	OK	35.4667	-97.4667	DY	NCDC	39	36.0	40	3.36
346656	OKLAHOMA CITY PENN A	OK	35.4833	-97.5333	DY	NCDC	27	36.0	40	3.34
346661	OKLAHOMA CITY WILL R	OK	35.3889	-97.6006	HR	NCDC	64	36.3	40	3.69
166968	OLD TOWN BAY	LA	30.2869	-93.1444	DY	NCDC	27	61.5	55	5.06
416636	OLNEY	TX	33.3733	-98.7664	DY	NCDC	16	30.1	40	3.75
416644	OLTON	TX	34.1797	-102.1356	DY	NCDC	18	18.8	21	2.32
296412	OPTIMO	NM	35.9000	-104.7167	DY	NCDC	20	19.2	20	2.48
416664	ORANGE	TX	30.0858	-93.7417	DY	NCDC	22	60.2	55	5.86
416680	ORANGE 9 N	TX	30.2264	-93.7394	DY	NCDC	20	61.5	55	5.88
296435	OROGRANDE	NM	32.3789	-106.0911	DY	NCDC	103	11.9	25	1.65
296443	OSCURO #2	NM	33.4833	-106.0500	DY	NCDC	19	12.9	11	1.18
035498	OWENSVILLE 3E	AR	34.6133	-92.7742	DY	NCDC	61	54.4	54	4.42
77	OZONA	TX	30.7500	-101.2167	DY	TWDB	23	19.4	34	2.70
416734	OZONA	TX	30.7044	-101.2022	DY	NCDC	16	19.4	34	2.42
416736	OZONA 8 WSW	TX	30.6819	-101.3375	HR	NCDC	52	19.4	34	2.68
416740	PADUCAH	TX	34.0067	-100.2989	DY	NCDC	20	24.8	31	2.59
416745	PADUCAH 10S	TX	33.8758	-100.3831	DY	NCDC	17	24.3	31	3.23
416742	PADUCAH 15 S	TX	33.8083	-100.2981	DY	NCDC	21	24.5	31	2.88
416750	PALACIOS MUNI AP	TX	28.7247	-96.2536	DY	NCDC	17	44.6	46	5.50
M520005	PALESTINA		29.1500	-100.9800	DY	MEXICO	36	0.0	35	4.10
416757	PALESTINE 2 NE	TX	31.7831	-95.6039	HR	NCDC	71	46.4	54	4.18
416766	PALO PINTO	TX	32.7664	-98.3083	DY	NCDC	19	33.6	40	3.47
296540	PALO VERDE (1)	NM	35.9667	-104.1833	DY	NCDC	37	16.4	20	2.06
416776	PAMPA 2	TX	35.5544	-100.9736	DY	NCDC	21	22.4	30	2.46

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416780	PANDALE 1 N	TX	30.1719	-101.5564	DY	NCDC	17	17.8	34	3.27
416785	PANHANDLE	TX	35.4139	-101.3417	DY	NCDC	20	22.2	30	2.36
416792	PANTHER JUNCTION	TX	29.3272	-103.2061	HR	NCDC	57	13.8	26	1.82
346859	PAOLI 2 W	OK	34.8231	-97.2850	HR	NCDC	60	38.3	41	3.70
416794	PARIS	TX	33.6744	-95.5586	DY	NCDC	21	46.8	54	3.94
035591	PARKS	AR	34.8186	-93.9606	DY	NCDC	53	51.0	50	4.36
296572	PARKS SPRING RCH	NM	35.2667	-104.9333	DY	NCDC	39	15.4	20	2.12
M530005	PARRAS	MX	25.4500	-102.1700	DY	MEXICO	24	0.0	29	1.84
296619	PASAMONTE	NM	36.2994	-103.7408	DY	NCDC	105	16.5	21	2.04
296630	PASTURA 6 SSE	NM	34.7000	-104.9167	DY	NCDC	47	14.2	20	1.83
346926	PAULS VALLEY 4 WSW	OK	34.7253	-97.2814	DY	NCDC	111	38.3	41	3.74
296659	PEARL	NM	32.6500	-103.3833	DY	NCDC	81	14.7	24	2.53
416879	PEARSALL	TX	28.8894	-99.0897	DY	NCDC	20	25.7	44	3.13
167174	PECAN ISLAND	LA	29.6500	-92.4333	HR	NCDC	18	61.1	55	5.95
416893	PECOS 8W	TX	31.3783	-103.6331	HR	NCDC	45	11.7	24	1.73
296728	PENNINGTON	NM	36.3167	-103.5833	DY	NCDC	35	17.2	21	2.43
416935	PEP	TX	33.8153	-102.5578	HR	NCDC	49	18.6	21	2.52
416950	PERRYTON	TX	36.3897	-100.8239	DY	NCDC	21	21.4	30	2.60
416953	PERRYTON 11 WNW	TX	36.4408	-100.9961	DY	NCDC	24	20.4	30	2.47
296797	PHILMONT RCH	NM	36.6167	-105.0500	DY	NCDC	19	17.7	10	1.60
296804	PICACHO	NM	33.3503	-105.1400	DY	NCDC	62	14.3	11	2.10
417017	PIDCOKE	TX	31.2789	-97.8883	DY	NCDC	20	33.1	41	2.82
417020	PIERCE 1 E	TX	29.2369	-96.1994	DY	NCDC	21	46.3	46	4.83
347080	PINE CREEK DAM	OK	34.1167	-95.0833	HR	NCDC	32	50.7	50	4.25
035760	PINE RIDGE	AR	34.5831	-93.9011	DY	NCDC	90	56.4	50	4.34
417040	PINELAND	TX	31.2447	-93.9658	DY	NCDC	21	54.8	55	5.22
035770	PINEY GROVE	AR	34.1728	-93.2050	DY	NCDC	37	54.0	54	4.44
296854	PINOS ALTOS	NM	32.8667	-108.2167	DY	NCDC	62	24.8	13	1.99
417060	PITCHFORK RCH	TX	33.5992	-100.5319	HR	NCDC	36	23.8	31	2.77
417066	PITTSBURG 5 SSE	TX	32.9258	-94.9397	DY	NCDC	19	45.5	54	4.19
417066	PITTSBURG 5 SSE	TX	32.9258	-94.9397	HR	NCDC	56	45.5	54	3.86
167344	PLAIN DEALING 4 W	LA	32.9078	-93.7981	DY	NCDC	117	50.8	54	4.22
146427	PLAINS	KS	37.2667	-100.6000	DY	NCDC	64	20.0	30	2.55
417079	PLAINVIEW	TX	34.1892	-101.7022	DY	NCDC	21	19.7	21	2.47
417111	PLEASANTON	TX	28.9606	-98.4772	DY	NCDC	20	29.1	44	3.58
417140	POINT COMFORT	TX	28.6575	-96.5553	HR	NCDC	54	42.9	46	4.88
167424	POLLOCK 6 NNW	LA	31.6000	-92.4333	HR	NCDC	15	59.9	55	4.95
167421	POLLOCK FOREST NURSE	LA	31.5000	-92.4667	DY	NCDC	31	60.5	55	4.90
347214	PONTOTOC	OK	34.4997	-96.6275	DY	NCDC	71	41.0	41	3.90
82	PORT ARANSAS	TX	27.8358	-97.0522	DY	TWDB	16	35.6	46	5.27

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417170	PORT ARANSAS	TX	27.8364	-97.0531	DY	NCDC	21	35.6	46	5.82
417174	PORT ARTHUR AP	TX	29.9506	-94.0206	HR	NCDC	61	59.6	55	6.07
79	PORT ISABEL	TX	26.1667	-97.5000	DY	TWDB	16	26.2	36	4.36
417179	PORT ISABEL	TX	26.0942	-97.3094	DY	NCDC	21	27.0	36	3.98
417184	PORT MANSFIELD	TX	26.5578	-97.4264	DY	NCDC	21	24.7	36	4.08
297008	PORTALES	NM	34.1742	-103.3519	DY	NCDC	105	17.0	21	2.34
297014	PORTALES 7 WNW	NM	34.2333	-103.4333	DY	NCDC	27	17.4	21	2.52
297026	PORTER 2 E	NM	35.2333	-103.2833	DY	NCDC	59	17.8	21	2.08
417206	POST	TX	33.1986	-101.3744	DY	NCDC	21	21.7	31	2.90
417213	POST OAK SCHOOL	TX	30.2667	-96.7167	HR	NCDC	17	39.3	45	3.68
417232	PRADE RCH	TX	29.9161	-99.7747	DY	NCDC	21	29.4	35	4.24
347264	PRAGUE 2W	OK	35.4875	-96.7203	DY	NCDC	71	40.4	41	3.98
417243	PRAIRIE MTN	TX	30.5836	-98.8997	HR	NCDC	63	29.4	35	3.26
297054	PRAIRIEVIEW	NM	33.1167	-103.2000	DY	NCDC	38	16.4	21	2.30
M540005	PRESA CARRANZA	MX	27.5500	-100.7500	DY	MEXICO	21	0.0	36	2.67
035908	PRESCOTT 2 NNW	AR	33.8203	-93.3878	DY	NCDC	123	53.9	54	4.13
417264	PRESIDIO 2	TX	29.5600	-104.3728	DY	NCDC	80	9.7	26	1.62
417300	PROCTOR RSVR	TX	31.9633	-98.4942	HR	NCDC	37	32.1	40	3.39
M550005	PROGRESO	MX	27.0800	-101.0000	DY	MEXICO	44	0.0	36	3.18
297094	PROGRESSO	NM	34.4208	-105.8914	DY	NCDC	83	14.4	11	1.65
347327	PURCELL	OK	35.0325	-97.3733	DY	NCDC	81	40.1	41	3.90
417327	PUTNAM	TX	31.3664	-99.1925	DY	NCDC	21	27.7	34	3.50
417336	QUANAH 2 SW	TX	34.2761	-99.7578	DY	NCDC	18	27.1	31	3.31
297180	QUEMADO	NM	34.3447	-108.4922	DY	NCDC	84	12.0	13	1.25
417365	QUITMAN 2	TX	32.8050	-95.4353	DY	NCDC	15	44.0	54	3.38
297226	RAGLAND 3 SSW	NM	34.7800	-103.7489	DY	NCDC	80	17.5	21	2.34
417388	RAINBOW	TX	32.2619	-97.7064	DY	NCDC	33	33.7	41	3.87
297254	RAMON 8 SW	NM	34.1508	-105.0044	DY	NCDC	52	13.4	20	1.84
347403	RANDLETT 8 E	OK	34.1736	-98.3186	DY	NCDC	49	31.2	40	3.38
417422	RANDOLPH AFB	TX	29.5439	-98.2736	HR	NCDC	67	32.1	44	3.75
347412	RANGE	OK	36.5447	-101.0842	HR	NCDC	61	19.9	30	2.35
347435	RANKIN	OK	35.5167	-99.9167	DY	NCDC	16	25.6	31	2.71
417431	RANKIN	TX	31.2286	-101.9461	HR	NCDC	56	16.1	34	2.41
297279	RATON FLTR PLT	NM	36.9194	-104.4325	DY	NCDC	117	18.2	10	2.01
297280	RATON KRTN RADIO	NM	36.8864	-104.4428	DY	NCDC	35	16.5	10	1.75
036016	RAVANA	AR	33.0667	-94.0333	HR	NCDC	22	50.2	54	4.23
417458	RAYMONDVILLE	TX	26.4819	-97.8097	DY	NCDC	21	25.4	36	3.72
417481	RED BLUFF DAM	TX	31.8950	-103.9183	HR	NCDC	50	11.4	24	1.99
167738	RED RIVER RSCH STN	LA	32.4219	-93.6381	DY	NCDC	49	51.8	54	4.28
417497	RED ROCK	TX	29.9667	-97.4500	HR	NCDC	33	35.1	44	3.80

Station ID	Station name	State	Lat.	Long.	Gauge type	Source	Data years	PRISM MAP (inches)	L-mom. Region	MAM (inches)
417499	RED SPRINGS 3 N	TX	33.6100	-99.3831	HR	NCDC	60	27.6	31	3.22
297340	REDROCK 1 NNE	NM	32.7044	-108.7269	DY	NCDC	100	13.7	13	1.66
417533	REFUGIO 2 NW	TX	28.3294	-97.2947	DY	NCDC	18	36.8	46	5.02
417530	REFUGIO 3 SW	TX	28.2939	-97.3297	DY	NCDC	21	36.5	46	4.62
347534	REGNIER	OK	36.9425	-102.6314	DY	NCDC	58	16.5	21	2.19
417556	RENO	TX	32.9536	-97.5739	HR	NCDC	50	35.9	41	3.61
297386	RESERVE RS	NM	33.7158	-108.7769	DY	NCDC	101	16.8	13	1.59
347565	RETROP	OK	35.1589	-99.3658	DY	NCDC	34	28.5	31	3.45
347579	REYDON 2SSE	OK	35.6256	-99.9106	DY	NCDC	65	24.9	31	2.94
417588	RICHARDSON	TX	32.9964	-96.7428	DY	NCDC	16	40.2	41	3.77
146808	RICHFIELD 1 NE	KS	37.2811	-101.7719	DY	NCDC	102	17.2	21	2.31
146813	RICHFIELD 10 WSW	KS	37.2294	-101.9511	DY	NCDC	74	16.9	21	2.32
417593	RICHLAND SPRINGS	TX	31.2700	-98.9486	DY	NCDC	16	27.7	35	3.58
417594	RICHMOND	TX	29.5839	-95.7553	HR	NCDC	58	48.5	55	4.24
297423	RIENHARDT RCH	NM	33.7528	-107.2094	DY	NCDC	60	10.1	11	1.49
417608	RIESEL	TX	31.4833	-96.8833	HR	NCDC	29	37.3	41	3.77
417622	RIO GRANDE CITY	TX	26.3769	-98.8117	DY	NCDC	68	19.5	36	3.32
417628	RIOMEDINA	TX	29.4403	-98.8806	DY	NCDC	20	29.9	35	4.20
347660	RIVERSIDE 4 W	OK	36.7889	-100.4183	HR	NCDC	61	21.3	30	2.34
417659	ROANOKE	TX	33.0050	-97.2331	DY	NCDC	27	38.2	41	4.16
167905	ROBELINE	LA	31.6833	-93.3000	DY	NCDC	62	55.0	55	4.24
417669	ROBERT LEE	TX	31.9008	-100.5025	DY	NCDC	19	22.6	34	3.03
167924	ROBSON	LA	32.3556	-93.6425	DY	NCDC	51	52.0	54	4.39
417677	ROBSTOWN	TX	27.7894	-97.6619	DY	NCDC	21	30.5	46	4.39
167932	ROCKEFELLER WL REFUG	LA	29.7286	-92.8181	DY	NCDC	49	60.5	55	5.49
417700	ROCKLAND 2 NW	TX	31.0167	-94.4000	HR	NCDC	35	54.1	55	4.47
417704	ROCKPORT	TX	28.0286	-97.0567	DY	NCDC	20	33.6	46	5.05
417706	ROCKSPRINGS 1S	TX	30.0039	-100.2067	DY	NCDC	16	25.1	35	3.22
417717	ROCKSPRINGS 26SSW	TX	29.6883	-100.4217	DY	NCDC	19	24.0	35	3.73
417707	ROCKWALL	TX	32.9331	-96.4647	DY	NCDC	21	40.0	41	4.41
M560010	RODEO		25.1800	-104.5300	DY	MEXICO	70	0.0	29	1.86
347705	ROFF 2 WNW	OK	34.6403	-96.8783	HR	NCDC	63	40.4	41	3.74
347727	ROOSEVELT	OK	34.8511	-99.0208	DY	NCDC	63	29.9	31	3.53
417743	ROSCOE	TX	32.4481	-100.5264	DY	NCDC	21	21.4	31	2.96
417744	ROSEBUD	TX	31.0736	-96.9789	DY	NCDC	20	35.7	41	3.94
168046	ROSEPINE RSCH STN	LA	30.9461	-93.2789	DY	NCDC	36	60.2	55	4.52
417773	ROSSER	TX	32.4611	-96.4494	DY	NCDC	27	39.3	41	4.21
297604	ROSWELL	NM	33.3167	-104.4333	DY	NCDC	26	13.1	24	2.25
297610	ROSWELL IND AP	NM	33.3075	-104.5083	DY	NCDC	38	13.1	24	2.18
297609	ROSWELL MUNI AP	NM	33.4000	-104.5333	DY	NCDC	73	13.2	24	1.95

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417782	ROTAN	TX	32.8556	-100.4611	DY	NCDC	21	23.6	31	3.09
417791	ROUND ROCK 3 NE	TX	30.5414	-97.6350	DY	NCDC	21	35.3	44	4.44
297638	ROY	NM	35.9422	-104.2014	DY	NCDC	100	16.4	20	2.03
297649	RUIDOSO	NM	33.3589	-105.6653	DY	NCDC	63	22.5	11	1.97
417836	RUNGE	TX	28.8297	-97.7133	DY	NCDC	23	30.6	45	3.66
417841	RUSK	TX	31.8086	-95.1428	DY	NCDC	21	48.8	54	4.52
168067	RUSTON LA TECH	LA	32.5014	-92.6547	DY	NCDC	120	55.6	54	4.33
M570005	S BUENAVENTURA	MX	27.0700	-101.5500	DY	MEXICO	23	0.0	36	1.94
M580005	SABINAS		27.8700	-101.2800	DY	MEXICO	55	0.0	36	3.15
297736	SACRAMENTO #2	NM	32.7906	-105.5606	HR	NCDC	63	25.7	24	2.10
168094	SAILES FIRE TWR	LA	32.3589	-93.1428	DY	NCDC	37	55.1	54	4.31
M590019	SALINILLAS		27.4500	-100.1200	DY	MEXICO	46	0.0	36	3.26
M610005	SALTILLO	MX	25.3670	-101.0170	DY	MEXICO	66	0.0	29	1.82
417936	SAM RAYBURN DAM	TX	31.0619	-94.1011	HR	NCDC	40	56.0	55	4.78
M620008	SAMALAYUCA		31.3500	-106.4800	DY	MEXICO	50	0.0	25	1.59
417943	SAN ANGELO MATHIS F	TX	31.3517	-100.4950	HR	NCDC	62	21.9	34	2.71
417950	SAN ANTONIO - COOP	TX	29.4500	-98.4667	DY	NCDC	18	31.6	44	3.91
417947	SAN ANTONIO 8NNE	TX	29.5253	-98.4539	DY	NCDC	18	32.8	44	4.90
417945	SAN ANTONIO INTL AP	TX	29.5333	-98.4700	HR	NCDC	69	32.8	44	4.12
417948	SAN ANTONIO NURSERY	TX	29.3000	-98.4667	DY	NCDC	38	30.5	44	3.07
418653	SAN ANTONIO STINSON	TX	29.3386	-98.4722	HR	NCDC	30	30.6	44	3.69
418169	SAN ANTONIO/SEAWORLD	TX	29.4508	-98.7028	DY	NCDC	18	31.2	44	3.32
417951	SAN AUGUSTINE	TX	31.5069	-94.1072	DY	NCDC	20	53.9	55	4.46
417951	SAN AUGUSTINE	TX	31.5069	-94.1072	HR	NCDC	17	53.9	55	3.77
M630028	SAN FERNANDO		24.8500	-98.1500	DY	MEXICO	61	0.0	36	4.04
297867	SAN JON	NM	35.1086	-103.3283	DY	NCDC	103	18.1	21	2.18
M640019	SAN JUAN	MX	25.5500	-99.8500	DY	MEXICO	33	0.0	36	3.80
M650010	SAN MARCOS		24.2700	-103.5000	DY	MEXICO	57	0.0	29	1.87
417994	SAN SABA 7 NW	TX	31.2842	-98.7589	DY	NCDC	15	28.9	35	3.59
297987	SANCHEZ	NM	35.6167	-104.4333	DY	NCDC	20	16.6	20	2.05
418023	SANDERSON 5 NNW	TX	30.2156	-102.4164	HR	NCDC	54	14.2	24	2.53
418047	SANTA ANNA	TX	31.7428	-99.3106	HR	NCDC	64	27.9	31	3.22
298107	SANTA ROSA	NM	34.9358	-104.6806	DY	NCDC	96	14.6	20	1.97
418081	SARITA 7 E	TX	27.2169	-97.6956	HR	NCDC	58	28.1	46	3.96
347952	SAYRE	OK	35.3061	-99.6275	DY	NCDC	79	27.2	31	3.07
418126	SCHULENBURG	TX	29.6825	-96.8564	DY	NCDC	39	39.0	45	5.11
418139	SCOTLAND	TX	33.6633	-98.4700	DY	NCDC	18	30.9	40	3.92
348016	SEDAN	OK	34.9692	-98.7603	DY	NCDC	17	30.8	40	4.06
298187	SEDAN 7 NW	NM	36.2000	-103.2167	DY	NCDC	49	16.7	21	2.27

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418187	SEGUIN 1 SSW	TX	29.5519	-97.9697	DY	NCDC	21	33.4	44	4.00
348042	SEMINOLE	OK	35.2317	-96.6531	DY	NCDC	82	41.8	41	4.07
418201	SEMINOLE	TX	32.7136	-102.6597	DY	NCDC	26	17.7	24	2.52
418221	SEYMOUR	TX	33.5969	-99.2694	DY	NCDC	16	28.2	31	3.47
418236	SHAMROCK 2	TX	35.2150	-100.2503	DY	NCDC	21	25.0	31	3.22
348101	SHATTUCK 1NW	OK	36.2892	-99.8933	HR	NCDC	57	23.4	31	2.81
348110	SHAWNEE	OK	35.3544	-96.9203	DY	NCDC	113	39.3	41	3.92
057572	SHEEP MTN	CO	37.7150	-105.2353	DY	NCDC	27	13.6	10	1.51
418252	SHEFFIELD	TX	30.6886	-101.8272	HR	NCDC	64	15.5	34	2.37
418265	SHEPHERD 2 SE	TX	30.4833	-95.0000	HR	NCDC	25	52.8	55	5.63
418274	SHERMAN	TX	33.7033	-96.6419	DY	NCDC	21	42.0	41	4.08
168440	SHREVEPORT AP	LA	32.4472	-93.8244	DY	NCDC	81	51.8	54	4.34
168436	SHREVEPORT DWTN	LA	32.5158	-93.7447	DY	NCDC	37	51.0	54	4.72
418305	SIERRA BLANCA 2 E	TX	31.1831	-105.3542	HR	NCDC	39	10.9	26	1.55
348197	SIGNAL MTN TWR	OK	34.3167	-95.0500	DY	NCDC	24	53.2	50	4.66
755	SIGNAL PEAK	NM	32.9200	-108.1500	DY	SNOTEL	34	30.2	13	2.19
168489	SIKES 2 E	LA	32.0833	-92.4667	DY	NCDC	17	57.9	55	4.17
418311	SILSBEE 4 N	TX	30.3703	-94.2019	DY	NCDC	20	58.2	55	5.21
298324	SILVER CITY	NM	32.7833	-108.2667	DY	NCDC	55	19.2	13	1.79
757	SILVER CREEK DIVIDE	NM	33.3700	-108.7100	DY	SNOTEL	34	33.0	13	2.38
418326	SILVER VALLEY	TX	31.9669	-99.5544	DY	NCDC	21	26.9	31	3.68
418323	SILVERTON	TX	34.4658	-101.3064	DY	NCDC	31	22.3	30	2.25
418335	SIMMS 4 WNW	TX	33.3667	-94.5667	HR	NCDC	30	51.0	54	3.65
168513	SIMPSON	LA	31.2667	-93.0000	DY	NCDC	23	57.9	55	4.91
168519	SINGER	LA	30.6500	-93.4167	DY	NCDC	21	60.0	55	5.35
418358	SISTERDALE	TX	29.9767	-98.7300	DY	NCDC	26	35.4	35	4.26
348285	SMITHVILLE	OK	34.4678	-94.6428	DY	NCDC	83	54.8	50	4.68
418415	SMITHVILLE	TX	30.0156	-97.1539	DY	NCDC	20	37.8	44	3.99
348290	SNOMAC 2 NE	OK	35.1000	-96.6167	HR	NCDC	33	41.7	41	3.53
418433	SNYDER	TX	32.7100	-100.9111	DY	NCDC	20	21.9	31	3.33
348299	SNYDER 1 N	OK	34.6867	-98.9483	DY	NCDC	76	30.1	31	3.38
348305	SOBOL TWR	OK	34.1333	-95.2333	DY	NCDC	38	50.2	50	4.84
298387	SOCORRO	NM	34.0828	-106.8831	DY	NCDC	117	9.3	11	1.49
418446	SOMERVILLE DAM	TX	30.3367	-96.5403	HR	NCDC	71	39.5	45	3.88
33	SONORA	TX	30.2667	-100.5667	DY	TWDB	20	22.7	34	3.28
036768	SPARKMAN	AR	33.9153	-92.8267	DY	NCDC	74	53.7	54	4.15
418519	SPEAKS 2	TX	29.2750	-96.6878	DY	NCDC	21	44.5	46	5.46
168669	SPEARSVILLE FIRE TWR	LA	32.9006	-92.5714	DY	NCDC	55	56.0	54	4.05
M660010	SPEDRO DEL G		25.5200	-104.3000	DY	MEXICO	53	0.0	29	1.46
348407	SPENCERVILLE 1 E	OK	34.1500	-95.3500	DY	NCDC	16	49.7	50	4.52

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418531	SPICEWOOD	TX	30.4828	-98.1597	HR	NCDC	39	31.7	35	3.44
418544	SPRING BRANCH 2SE	TX	29.8656	-98.3819	HR	NCDC	47	33.3	44	3.77
298501	SPRINGER	NM	36.3628	-104.5850	DY	NCDC	114	16.2	20	1.90
057862	SPRINGFIELD	CO	37.4000	-102.6167	DY	NCDC	72	16.3	21	2.31
057866	SPRINGFIELD 7 WSW	CO	37.3694	-102.7428	DY	NCDC	45	16.6	21	2.18
168683	SPRINGHILL	LA	32.9922	-93.4419	DY	NCDC	37	52.6	54	4.10
418563	SPRINGTOWN 4 S	TX	32.9086	-97.6786	HR	NCDC	29	35.5	41	3.93
297741	ST VRAIN	NM	34.4167	-103.5000	DY	NCDC	34	17.3	21	2.17
418583	STAMFORD 1	TX	32.9403	-99.8036	HR	NCDC	68	26.3	31	2.90
290131	STATE UNIV	NM	32.2833	-106.7500	DY	NCDC	116	9.9	25	1.40
348479	STELLA	OK	35.3197	-97.2117	DY	NCDC	21	38.8	41	3.72
418623	STEPHENVILLE 1N	TX	32.2450	-98.1956	DY	NCDC	21	32.2	40	3.63
418625	STEPHENVILLE 7 WSW	TX	32.1667	-98.3167	HR	NCDC	28	34.9	40	3.67
418630	STERLING CITY	TX	31.8347	-100.9828	HR	NCDC	29	19.7	34	2.56
418631	STERLING CITY 8 NE	TX	31.9186	-100.8786	HR	NCDC	27	20.8	34	2.63
418646	STILLHOUSE HOLLOW DA	TX	31.0372	-97.5283	HR	NCDC	44	35.4	41	3.76
418647	STINNETT	TX	35.8333	-101.4500	HR	NCDC	32	20.4	30	2.58
418658	STOCKDALE 4 N	TX	29.2878	-97.9669	DY	NCDC	20	30.9	44	3.69
057992	STONINGTON	CO	37.2931	-102.1864	DY	NCDC	56	17.1	21	2.44
418692	STRATFORD	TX	36.3372	-102.0753	DY	NCDC	36	17.2	21	2.14
418696	STRAWN 8 NNE	TX	32.6592	-98.4678	DY	NCDC	21	30.1	40	3.50
147922	SUBLETTE 7WSW	KS	37.4414	-100.9792	DY	NCDC	96	18.8	21	2.37
418728	SUGAR LAND	TX	29.6183	-95.6358	DY	NCDC	68	49.3	55	5.02
168828	SUGARTOWN	LA	30.8500	-93.0167	DY	NCDC	58	60.8	55	4.99
168831	SULPHUR	LA	30.2383	-93.3447	DY	NCDC	41	61.8	55	5.79
418743	SULPHUR SPRINGS	TX	33.1481	-95.6269	HR	NCDC	65	45.5	54	4.16
418761	SUNRAY 4 SW	TX	35.9667	-101.8667	HR	NCDC	36	17.2	21	2.32
348627	SUPPLY 1 E	OK	36.5667	-99.5500	DY	NCDC	57	24.5	31	2.72
418778	SWAN 4 NW	TX	32.4561	-95.4231	HR	NCDC	51	45.1	54	4.01
348652	SWEETWATER	OK	35.4219	-99.9053	DY	NCDC	25	24.8	31	3.04
418845	TARPLEY	TX	29.6675	-99.2883	HR	NCDC	67	33.5	35	4.06
298713	TATUM	NM	33.2422	-103.3611	DY	NCDC	91	16.3	21	2.34
418859	TATUM	TX	32.3000	-94.5167	HR	NCDC	36	49.2	54	3.78
037038	TAYLOR	AR	33.0986	-93.4647	DY	NCDC	54	52.1	54	3.81
418861	TAYLOR	TX	30.5700	-97.4092	DY	NCDC	74	34.5	44	3.98
418863	TAYLOR RCH	TX	30.9731	-98.9433	DY	NCDC	17	28.9	35	3.36
418877	TEAGUE RCH	TX	30.4322	-98.8103	DY	NCDC	21	31.8	35	3.54
348751	TECUMSEH 4 S	OK	35.1992	-96.9408	DY	NCDC	22	38.4	41	3.80
418897	TELEGRAPH	TX	30.3289	-99.9067	DY	NCDC	16	24.3	35	3.43
M670008	TEMOSACHIC		28.9500	-107.8170	DY	MEXICO	26	0.0	12	1.84

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418910	TEMPLE	TX	31.0781	-97.3183	DY	NCDC	17	36.4	41	3.94
058220	TERCIO 4 NW	CO	37.0708	-105.0572	HR	NCDC	62	21.7	10	1.53
418929	TERRELL	TX	32.7336	-96.3225	DY	NCDC	22	41.1	41	4.06
037048	TEXARKANA WEBB FLD	AR	33.4536	-94.0075	DY	NCDC	109	50.7	54	3.84
298793	TEXICO NEAR	NM	34.3000	-103.0833	DY	NCDC	18	17.8	21	2.50
298819	THOMPSON CANYON RCH	NM	32.5428	-108.6369	DY	NCDC	54	13.7	13	1.49
418996	THOMPSONS 3 WSW	TX	29.4822	-95.6314	HR	NCDC	47	49.0	55	4.25
419001	THORNDALE	TX	30.6167	-97.2000	DY	NCDC	21	35.4	44	3.97
419004	THORNTON 1SSE	TX	31.3917	-96.5656	DY	NCDC	25	39.6	41	4.51
298838	THREE RIVERS	NM	33.3167	-106.0833	DY	NCDC	23	12.1	11	1.30
419007	THREE RIVERS 8 NE	TX	28.5817	-98.1444	DY	NCDC	21	26.1	44	4.07
419016	THROCKMORTON 7NE	TX	33.2936	-99.1006	DY	NCDC	15	27.5	31	3.20
419031	TILDEN 4 SSE	TX	28.4114	-98.5294	DY	NCDC	17	22.6	36	4.22
058290	TIMPAS 13 SW	CO	37.6667	-103.9167	DY	NCDC	16	14.6	20	1.90
419037	TINNIN RCH	TX	31.3167	-103.9833	HR	NCDC	28	12.2	24	1.59
348879	TIPTON 4 S	OK	34.4333	-99.1333	DY	NCDC	47	28.5	31	2.95
348884	TISHOMINGO NATL WR	OK	34.1925	-96.6439	DY	NCDC	112	42.0	41	4.00
934	TOLBY	NM	36.4700	-105.1900	DY	SNOTEL	17	27.4	10	1.54
419076	TOMBALL	TX	30.1003	-95.6114	DY	NCDC	25	47.9	55	5.59
419088	TORNILLO 2 SSE	TX	31.4028	-106.0581	DY	NCDC	18	8.8	26	1.35
419099	TOW	TX	30.8797	-98.4728	DY	NCDC	21	28.6	35	3.25
419125	TRENTON	TX	33.4253	-96.3394	DY	NCDC	22	43.0	54	4.15
348951	TRIBBEY 1 N	OK	35.1333	-97.0500	DY	NCDC	24	38.9	41	4.15
05M08S	TRINCHERA	CO	37.3500	-105.2167	DY	SNOTEL	24	28.5	10	1.46
058429	TRINIDAD	CO	37.1786	-104.4869	DY	NCDC	109	15.8	10	1.84
058434	TRINIDAD AP	CO	37.2622	-104.3378	DY	NCDC	63	14.1	10	1.52
058436	TRINIDAD LAKE	CO	37.1503	-104.5567	DY	NCDC	26	17.6	10	1.75
058431	TRINIDAD RIVER	CO	37.1833	-104.5167	DY	NCDC	16	15.6	10	1.63
148245	TROUSDALE 1 NE	KS	37.8236	-99.0781	DY	NCDC	98	26.2	31	2.76
419153	TROY	TX	31.2061	-97.2956	DY	NCDC	23	36.2	41	4.40
058468	TROY 1 SE	CO	37.1333	-103.3000	DY	NCDC	47	16.4	21	2.22
299125	TRUJILLO	NM	35.5333	-104.7000	DY	NCDC	31	18.0	20	2.13
419163	TRUSCOTT 3 W	TX	33.7572	-99.8617	HR	NCDC	62	25.9	31	3.15
299128	TRUTH OR CONSEQUENCE	NM	33.1406	-107.2314	DY	NCDC	34	10.6	11	1.64
299129	TRUTH OR CONSEQUENCE	NM	33.2333	-107.2667	DY	NCDC	31	9.7	11	1.40
299148	TUCUMCARI	NM	35.1667	-103.7000	DY	NCDC	48	17.0	21	2.29
299156	TUCUMCARI 4 NE	NM	35.2006	-103.6867	DY	NCDC	110	17.0	21	2.14
299153	TUCUMCARI FAA AP	NM	35.1833	-103.6000	DY	NCDC	28	16.6	21	2.05
299165	TULAROSA	NM	33.0719	-106.0417	DY	NCDC	99	11.4	11	1.44

Station ID	Station name	State	Lat.	Long.	Gauge type	Source	Data years	PRISM MAP (inches)	L-mom. Region	MAM (inches)
419175	TULIA	TX	34.5392	-101.7672	DY	NCDC	21	21.4	21	2.70
419191	TURKEY	TX	34.3956	-100.8972	DY	NCDC	22	23.5	31	3.42
349017	TURPIN 4 SSE	OK	36.8136	-100.8636	DY	NCDC	32	18.5	30	2.86
349023	TUSKAHOMA	OK	34.6147	-95.2803	DY	NCDC	95	51.4	50	4.11
058510	TWO BUTTES	CO	37.5667	-102.4000	DY	NCDC	66	16.1	21	2.21
058516	TWO BUTTES RSVR	CO	37.6500	-102.5333	DY	NCDC	16	16.0	21	2.32
299265	TWO RIVERS RSVR	NM	33.2833	-104.6167	HR	NCDC	20	13.3	24	2.13
419207	TYLER	TX	32.3067	-95.2969	DY	NCDC	21	45.8	54	4.14
299199	TYRONE	NM	32.6333	-108.3333	DY	NCDC	17	17.9	13	1.39
148287	ULYSSES 3NE	KS	37.5983	-101.2908	DY	NCDC	116	17.5	21	2.26
419224	UMBARGER	TX	34.9578	-102.1044	DY	NCDC	21	19.0	21	2.64
349086	UNION CITY 3 SE	OK	35.3672	-97.8872	DY	NCDC	100	35.3	40	3.72
299284	UTE DAM	NM	35.3600	-103.4433	DY	NCDC	78	16.2	21	2.00
058574	UTLEYVILLE	CO	37.2667	-103.0333	DY	NCDC	37	16.7	21	2.03
419260	UTOPIA	TX	29.5889	-99.5181	DY	NCDC	20	31.5	35	4.00
419270	VALENTINE	TX	30.5908	-104.4914	HR	NCDC	46	13.2	26	1.80
419275	VALENTINE 10 WSW	TX	30.5525	-104.6467	DY	NCDC	19	13.7	26	1.77
299304	VALLEY	NM	36.9667	-103.3667	DY	NCDC	17	16.3	21	2.46
419282	VALLEY MILLS	TX	31.6606	-97.4661	DY	NCDC	16	35.4	41	4.18
349118	VALLIANT 3 W	OK	33.9981	-95.1433	DY	NCDC	78	50.6	54	4.27
299330	VALMORA	NM	35.8167	-104.9244	DY	NCDC	93	16.6	10	2.01
419312	VANDERPOOL 10 N	TX	29.8119	-99.5689	DY	NCDC	19	31.6	35	3.84
299382	VARIADERO	NM	35.3833	-104.4833	DY	NCDC	39	15.5	20	1.94
299405	VAUGHN	NM	34.6000	-105.2000	DY	NCDC	67	12.9	20	1.72
419330	VEGA 2NW	TX	35.2775	-102.4633	DY	NCDC	73	18.6	21	2.33
349172	VICI	OK	36.1508	-99.3003	DY	NCDC	56	27.5	31	3.09
419364	VICTORIA ASOS	TX	28.8614	-96.9303	HR	NCDC	56	40.4	46	4.92
419365	VICTORIA CP&L	TX	28.7875	-97.0106	DY	NCDC	37	38.8	46	4.59
M680008	VILLA AHUMADA		30.6170	-106.5170	DY	MEXICO	58	0.0	28	1.66
M690008	VILLA DE ALDAMA		28.8300	-105.1800	DY	MEXICO	34	0.0	28	2.10
M710005	VILLA JUAREZ	MX	27.6200	-100.7200	DY	MEXICO	39	0.0	36	2.79
M720028	VILLAGRAN	MX	24.4800	-99.4800	DY	MEXICO	56	0.0	36	4.86
299496	VILLANUEVA	NM	35.2667	-105.3572	DY	NCDC	65	15.6	20	1.57
349212	VINSON	OK	34.9003	-99.8614	DY	NCDC	69	26.3	31	3.26
169375	VINTON	LA	30.1922	-93.5811	DY	NCDC	35	61.7	55	6.69
169392	VIVIAN	LA	32.9033	-93.9819	DY	NCDC	73	49.8	54	4.23
419421	WACO	TX	31.5333	-97.0667	DY	NCDC	43	35.8	41	3.69
419417	WACO DAM	TX	31.6003	-97.2169	HR	NCDC	44	35.5	41	3.42
419419	WACO RGNL AP	TX	31.6189	-97.2283	HR	NCDC	69	35.5	41	3.49
037488	WALDRON	AR	34.8992	-94.1942	DY	NCDC	91	50.8	50	4.05

Station ID	Station name	State	Lat.	Long.	Gauge type	Source	Data years	PRISM MAP (inches)	L-mom. Region	MAM (inches)
058781	WALSENBURG 1 NW	CO	37.6303	-104.7956	HR	NCDC	64	18.2	10	1.70
058793	WALSH 1 W	CO	37.3822	-102.2986	DY	NCDC	43	18.6	21	2.39
349278	WALTERS	OK	34.3603	-98.3006	DY	NCDC	93	33.2	40	3.77
419491	WASHINGTON SP	TX	30.3236	-96.1594	HR	NCDC	55	41.8	45	4.04
037592	WASHITA	AR	34.6508	-93.5350	DY	NCDC	87	50.9	50	4.19
419499	WATER VALLEY	TX	31.6725	-100.7283	HR	NCDC	52	21.9	34	2.71
419501	WATER VALLEY 11 NNE	TX	31.8136	-100.6286	DY	NCDC	21	22.6	34	3.23
419504	WATSON	TX	30.9328	-98.0197	DY	NCDC	21	32.0	35	4.00
349400	WAURIKA 1ENE MESONET	OK	34.1678	-97.9881	DY	NCDC	105	33.7	40	3.50
419522	WAXAHACHIE	TX	32.4281	-96.8422	DY	NCDC	17	39.0	41	4.19
419527	WAYSIDE	TX	34.7933	-101.5483	HR	NCDC	56	21.0	30	2.17
419532	WEATHERFORD	TX	32.7483	-97.7700	HR	NCDC	63	35.1	41	3.56
419559	WELDER WILDLIFE FNDN	TX	28.1136	-97.4178	DY	NCDC	21	35.1	46	4.70
419565	WELLINGTON	TX	34.8422	-100.2103	HR	NCDC	53	24.1	31	3.00
419588	WESLACO	TX	26.1781	-97.9708	DY	NCDC	53	23.5	36	3.88
419593	WEST	TX	31.8106	-97.0939	DY	NCDC	19	35.7	41	4.49
349571	WETUMKA 3 NE	OK	35.2614	-96.2081	DY	NCDC	55	44.4	41	4.07
349575	WEWOKA	OK	35.1467	-96.4964	DY	NCDC	75	42.2	41	3.86
419655	WHARTON	TX	29.3178	-96.0847	DY	NCDC	21	46.8	46	5.04
419662	WHEELER	TX	35.4375	-100.2753	DY	NCDC	19	22.4	31	3.38
419665	WHEELOCK	TX	30.9003	-96.3953	HR	NCDC	63	39.4	41	4.12
05M14S	WHISKEY CK	CO	37.2000	-105.1167	DY	SNOTEL	33	34.5	10	2.00
037812	WHITE CLIFFS	AR	33.8000	-94.0667	DY	NCDC	56	51.2	54	3.78
058997	WHITE ROCK	CO	37.8672	-104.1139	HR	NCDC	62	13.0	20	1.47
299686	WHITE SANDS NATL MON	NM	32.7817	-106.1747	DY	NCDC	74	9.8	25	1.38
299691	WHITE SIGNAL	NM	32.5561	-108.3653	DY	NCDC	59	17.0	13	1.68
299697	WHITE TAIL	NM	33.2333	-105.5500	DY	NCDC	39	24.4	24	1.93
299720	WHITEWATER	NM	32.5578	-108.1264	DY	NCDC	55	14.8	13	1.46
419715	WHITNEY DAM	TX	31.8611	-97.3750	HR	NCDC	58	35.3	41	3.65
419717	WHITSETT	TX	28.6611	-98.2564	DY	NCDC	21	26.9	44	4.52
419729	WICHITA FALLS MUNI A	TX	33.9786	-98.4928	HR	NCDC	70	29.5	40	3.38
349629	WICHITA MTN WR	OK	34.7325	-98.7125	DY	NCDC	109	33.5	40	3.62
349634	WILBURTON 9 ENE	OK	34.9611	-95.1711	DY	NCDC	67	50.6	50	4.04
419754	WILDWOOD	TX	30.5164	-94.4383	DY	NCDC	21	57.7	55	5.37
349668	WILLOW	OK	35.0522	-99.5125	DY	NCDC	32	29.3	31	3.59
419800	WILLS POINT	TX	32.7017	-96.0150	DY	NCDC	21	43.2	41	3.77
148914	WILMORE 16SE	KS	37.1317	-99.0558	DY	NCDC	29	26.0	31	3.04
419815	WIMBERLEY 1 NW	TX	30.0008	-98.0664	DY	NCDC	21	36.7	44	5.33
419817	WINCHELL	TX	31.4661	-99.1711	HR	NCDC	41	28.1	34	3.13

Station ID	Station name	State	Lat.	Long.	Gauge type	Source	Data years	PRISM MAP (inches)	L-mom. Region	MAM (inches)
037950	WING	AR	34.9500	-93.4667	HR	NCDC	38	51.7	50	3.99
419830	WINK FAA AP	TX	31.7800	-103.2017	HR	NCDC	61	12.4	24	1.97
169803	WINNFIELD 3 N	LA	31.9622	-92.6561	DY	NCDC	56	59.3	55	5.33
419836	WINNSBORO 6 SW	TX	32.8847	-95.3342	DY	NCDC	19	43.3	54	4.13
169809	WINONA FIRE TWR	LA	32.0294	-92.6553	DY	NCDC	40	60.2	55	4.79
299806	WINSTON	NM	33.3497	-107.6492	DY	NCDC	65	13.2	13	1.59
419847	WINTERS 1 NNE	TX	31.9678	-99.9586	DY	NCDC	21	24.3	31	3.28
50	WIRTZ DAM	TX	30.5500	-98.3333	DY	TWDB	16	30.8	35	4.08
349724	WISTER 3 S	OK	34.9417	-94.7039	DY	NCDC	43	47.7	50	3.95
349748	WOLF 4 N	OK	35.1419	-96.6758	HR	NCDC	31	41.5	41	4.08
419858	WOLF CREEK DAM	TX	36.2333	-100.6667	HR	NCDC	34	21.4	30	2.58
419859	WOLFE CITY	TX	33.3675	-96.0675	DY	NCDC	18	44.7	54	4.24
419893	WOODSON	TX	33.0178	-99.0539	HR	NCDC	69	28.2	31	3.18
419898	WOODVILLE	TX	30.7678	-94.4117	DY	NCDC	18	55.4	55	5.58
349760	WOODWARD	OK	36.4408	-99.3817	DY	NCDC	105	25.2	31	2.99
349762	WOODWARD FLD STN	OK	36.4167	-99.4000	DY	NCDC	35	25.3	31	2.64
169865	WOODWORTH 2 SE	LA	31.1167	-92.4667	DY	NCDC	58	60.3	55	5.57
419916	WRIGHT PATMAN DM & L	TX	33.3042	-94.1728	HR	NCDC	46	49.8	54	3.72
299840	YATES 6S	NM	36.0500	-103.8667	DY	NCDC	30	16.3	21	1.95
299851	YESO 2 S	NM	34.4031	-104.6128	DY	NCDC	71	13.1	20	1.96
299857	YESO OVERTON RCH	NM	34.3167	-104.7333	DY	NCDC	16	13.4	20	1.81
419953	YORKTOWN	TX	28.9825	-97.5181	DY	NCDC	27	33.3	45	4.11
419962	YOUNGSPORT	TX	30.9597	-97.7183	DY	NCDC	21	33.3	41	4.05
349841	YUBA 2 W	OK	33.8167	-96.2333	DY	NCDC	28	44.1	54	3.89
419976	ZAPATA 1 S	TX	26.8706	-99.2536	HR	NCDC	62	18.5	36	3.14
M730005	ZARAGOZA	MX	28.5000	-100.9200	DY	MEXICO	35	0.0	36	3.33
349985	ZOE 1 S	OK	34.7500	-94.6333	DY	NCDC	37	51.9	50	3.95
169980	ZWOLLE 2 NW	LA	31.6664	-93.6664	DY	NCDC	25	52.6	55	5.09

Select Definitions

Some of these definitions have been adapted from the NOAA Atlas 14 documentation.

ANNUAL EXCEEDANCE PROBABILITY (AEP) – The probability associated with exceeding a given amount in any given year once or more than once; the inverse of AEP provides a measure of the average time between years (and not events) in which a particular value is exceeded at least once; the term is associated with analysis of annual maximum series.

ANNUAL MAXIMUM SERIES (AMS) – Time series of the largest precipitation amounts in a continuous 12-month period (calendar or water year) for a specified duration at a given station.

AT-SITE – The term used to distinguish the analyses/data at a specific station/site from the regional analyses/data.

AVERAGE RECURRENCE INTERVAL (ARI; a.k.a. RETURN PERIOD, AVERAGE RETURN PERIOD) – Average time between cases of a particular precipitation magnitude for a specified duration and at a given location; the term is associated with the analysis of partial duration series. However, ARI is frequently calculated as the inverse of AEP for the annual maximum series; in this case it represents the average period between years in which a given precipitation magnitude is exceeded at least once.

CASCADE, RESIDUAL ADD-BACK (CRAB) –A spatial interpolation procedure for deriving grids of precipitation frequency estimates from grids of mean annual maximum and point precipitation frequency estimates for a given duration developed by NOAA. A similar approach was used in this project.

DATA YEARS – See RECORD LENGTH.

DISTRIBUTION FUNCTION (CUMULATIVE DISTRIBUTION FUNCTION) – Mathematical description that completely describes frequency distribution of a random variable, here precipitation. distribution functions commonly used to describe precipitation data include 3-parameter distributions such as Generalized Extreme Value (GEV), Generalized Normal, Generalized Pareto, Generalized Logistic and Pearson type III, the 4-parameter Kappa distribution, and the 5-parameter Wakeby distribution.

ESRI ASCII GRID – Grid format with a 6-line header, which provides location and size of the grid and precedes the actual grid data. The grid is written as a series of rows, which contain one ASCII integer or floating point value per column in the grid. The first element of the grid corresponds to the upper-left corner of the grid. This format was developed by Environmental Systems Research Institute (ESRI).

FEDERAL GEOGRAPHIC DATA COMMITTEE (FGDC) COMPLIANT METADATA – A document that describes the content, quality, condition, and other characteristics of data and follows the guidelines set forth by the FGDC; metadata is "data about data."

FREQUENCY – General term for specifying the average recurrence interval or annual exceedance probability associated with specific precipitation magnitude for a given duration.

FREQUENCY ANALYSIS – Process of derivation of a mathematical model that represents the relationship between precipitation magnitudes and their frequencies.

PRECIPITATION (RAINFALL) FREQUENCY ESTIMATE – Precipitation (rainfall) magnitude associated with specific average recurrence interval or annual exceedance probability for a given duration.

L-MOMENTS – L-moments are summary statistics for probability distributions and data samples. They are analogous to ordinary moments, providing measures of location, dispersion, skewness, kurtosis, and other aspects of the shape of probability distributions or data samples, but are computed from linear combinations of the ordered data values (hence the prefix L).

MEAN ANNUAL MAXIMUM (MAM) – The mean of the Annual Maximum Series (AMS) for a specific duration.

MEAN ANNUAL PRECIPITATION (MAP) – The average precipitation for a year (usually calendar) based on the whole period of record or for a selected period (usually 30 year period such as 1981-2010).

PARTIAL DURATION SERIES (PDS) – Time series that includes all precipitation amounts for a specified duration at a given station above a pre-defined threshold regardless of year; it can include more than one event in any particular year.

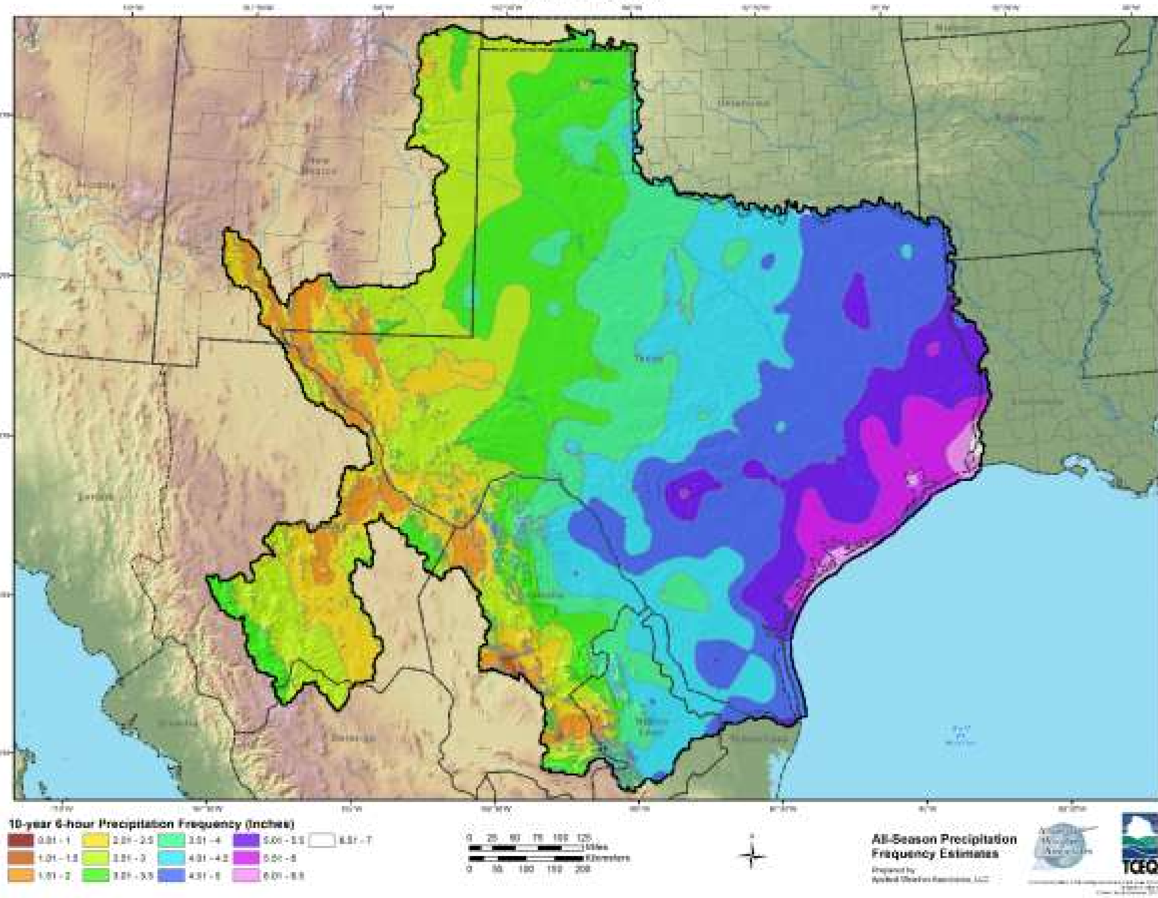
PARAMETER-ELEVATION REGRESSIONS ON INDEPENDENT SLOPES MODEL (PRISM) –Hybrid statistical-geographic approach to mapping climate data developed by Oregon State University's PRISM Climate Group.

RECORD LENGTH – Number of years in which enough precipitation data existed to extract meaningful and usable annual maximum in a station's period of record (or data years).

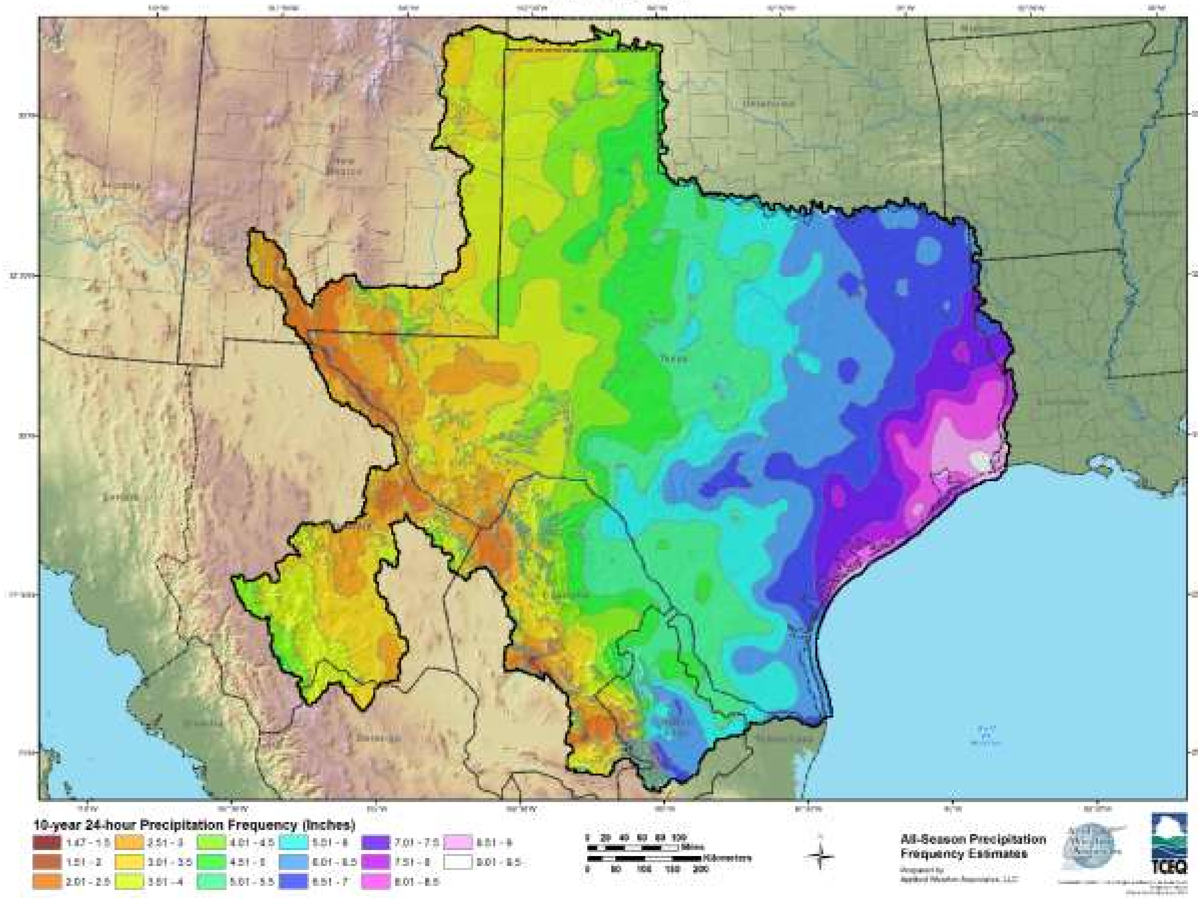
REGIONAL GROWH CURVE/FACTOR – A magnitude-frequency curve that is applicable to all sites within a homogeneous region. The regional growth factor, times the mean, provides a precipitation frequency estimate.

STATION – An instrumented location with precipitation measurements and perhaps other meteorological variables. The term station, gauge, and site are often used interchangeably.

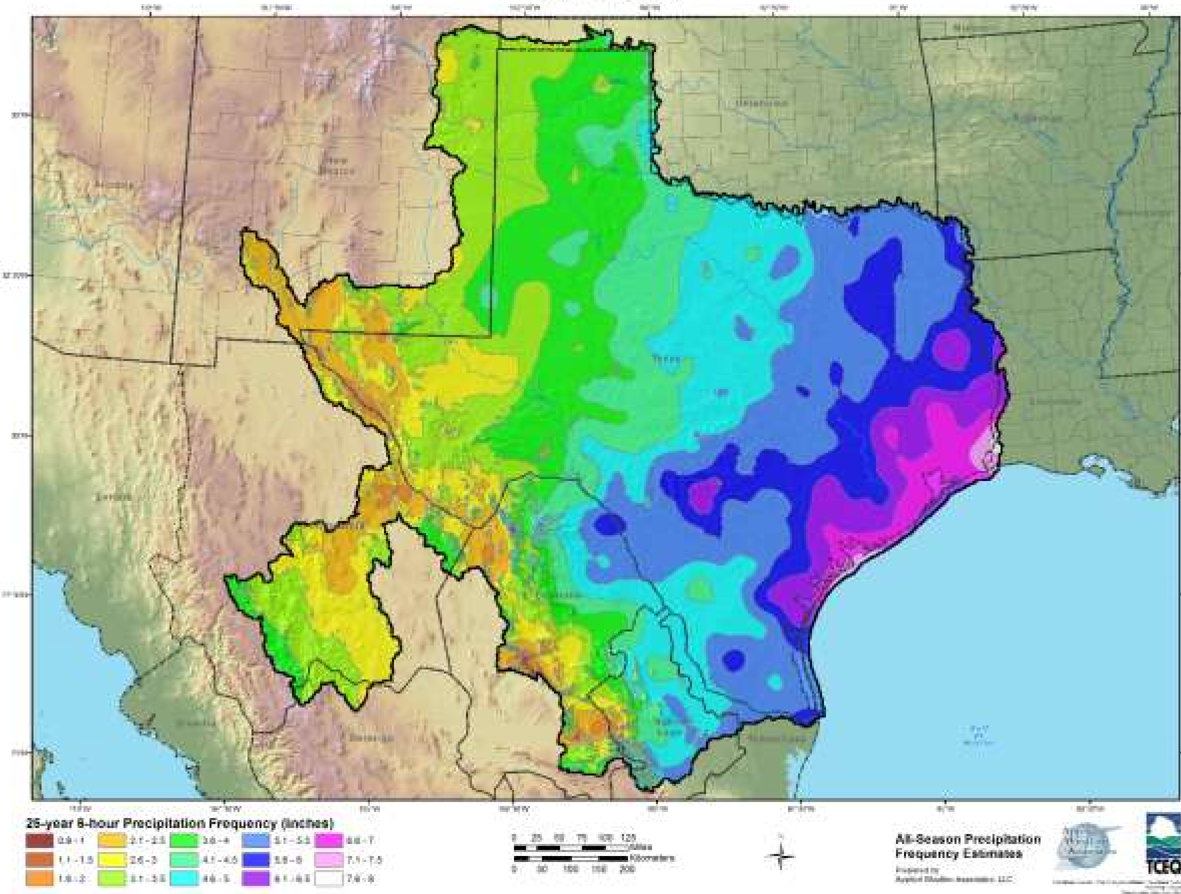
6 hour Precipitation Frequency Estimates - 10 year Recurrence Interval
Texas PMP Study



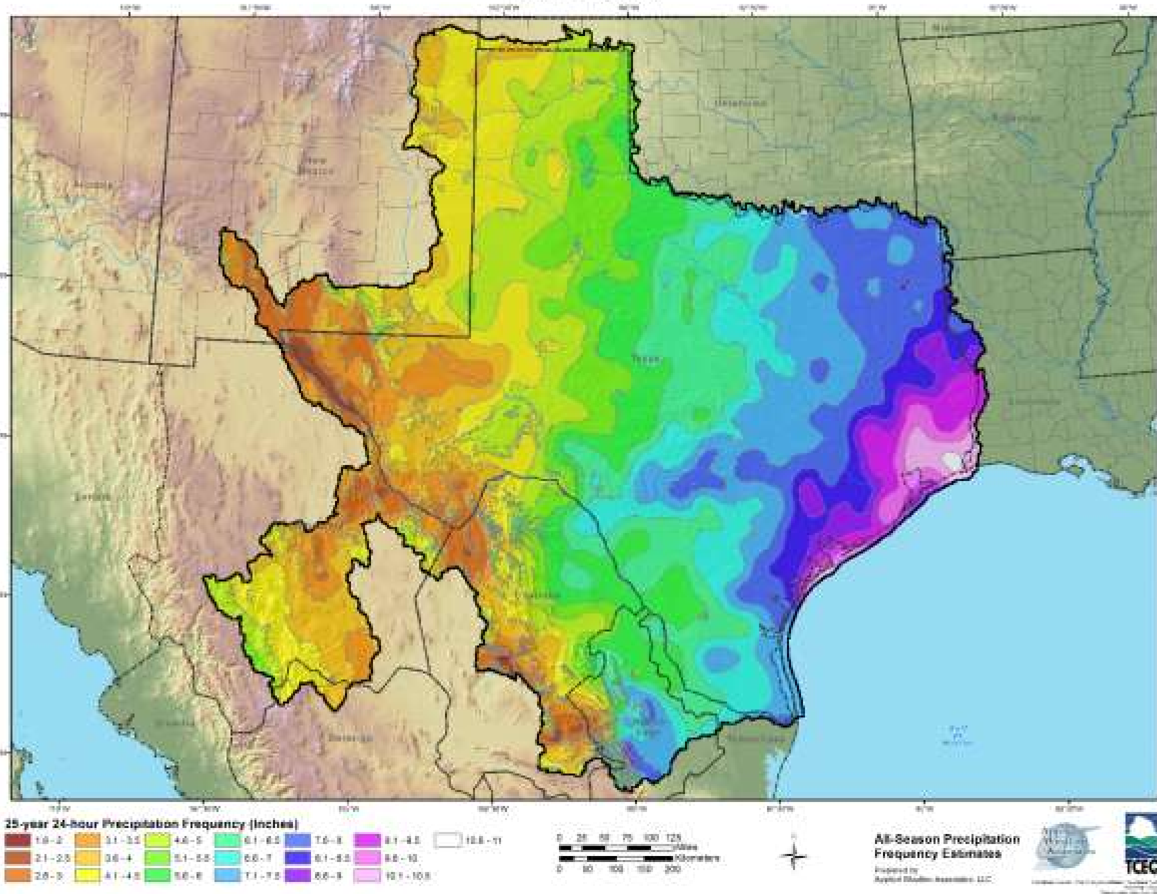
24 hour Precipitation Frequency Estimates - 10 year Recurrence Interval
Texas PMP Study



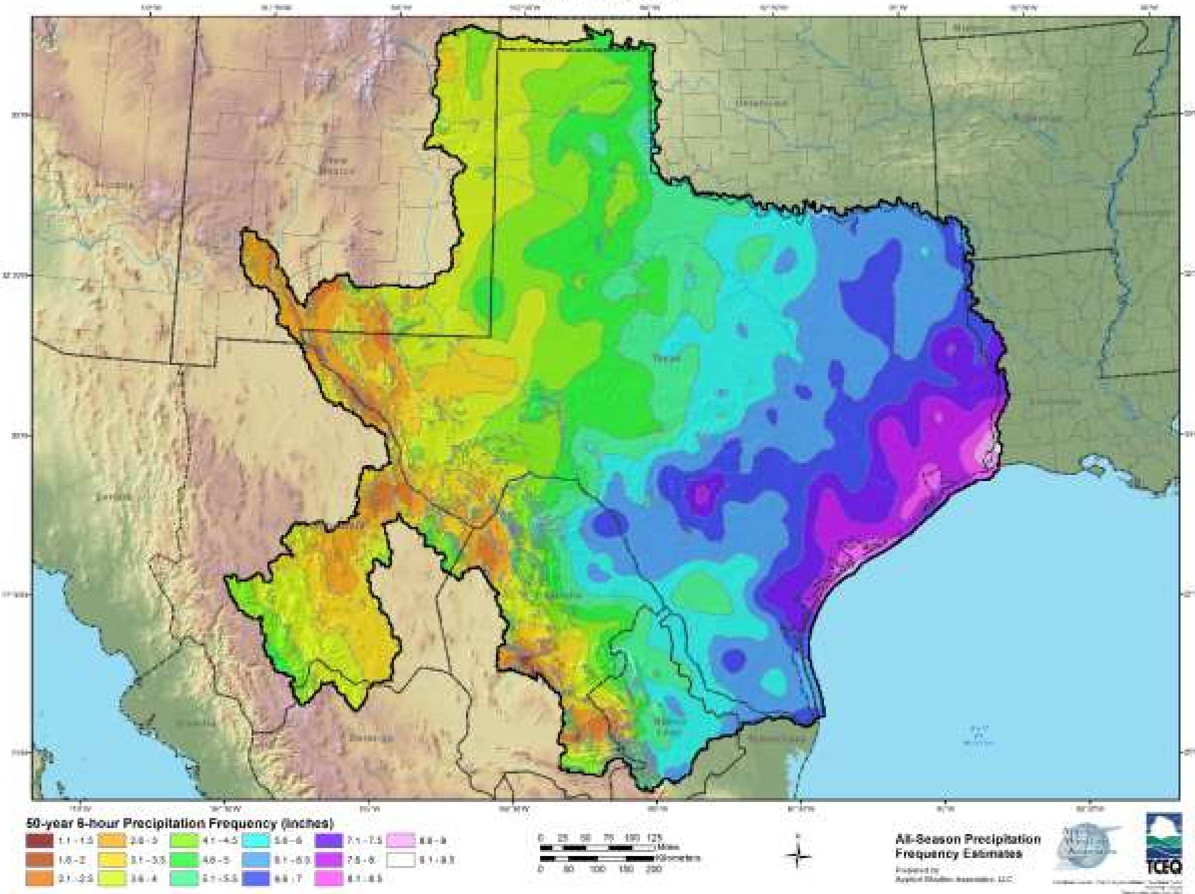
6 hour Precipitation Frequency Estimates - 25 year Recurrence Interval
Texas PMP Study



24 hour Precipitation Frequency Estimates - 25 year Recurrence Interval
Texas PMP Study



6 hour Precipitation Frequency Estimates - 50 year Recurrence Interval
Texas PMP Study



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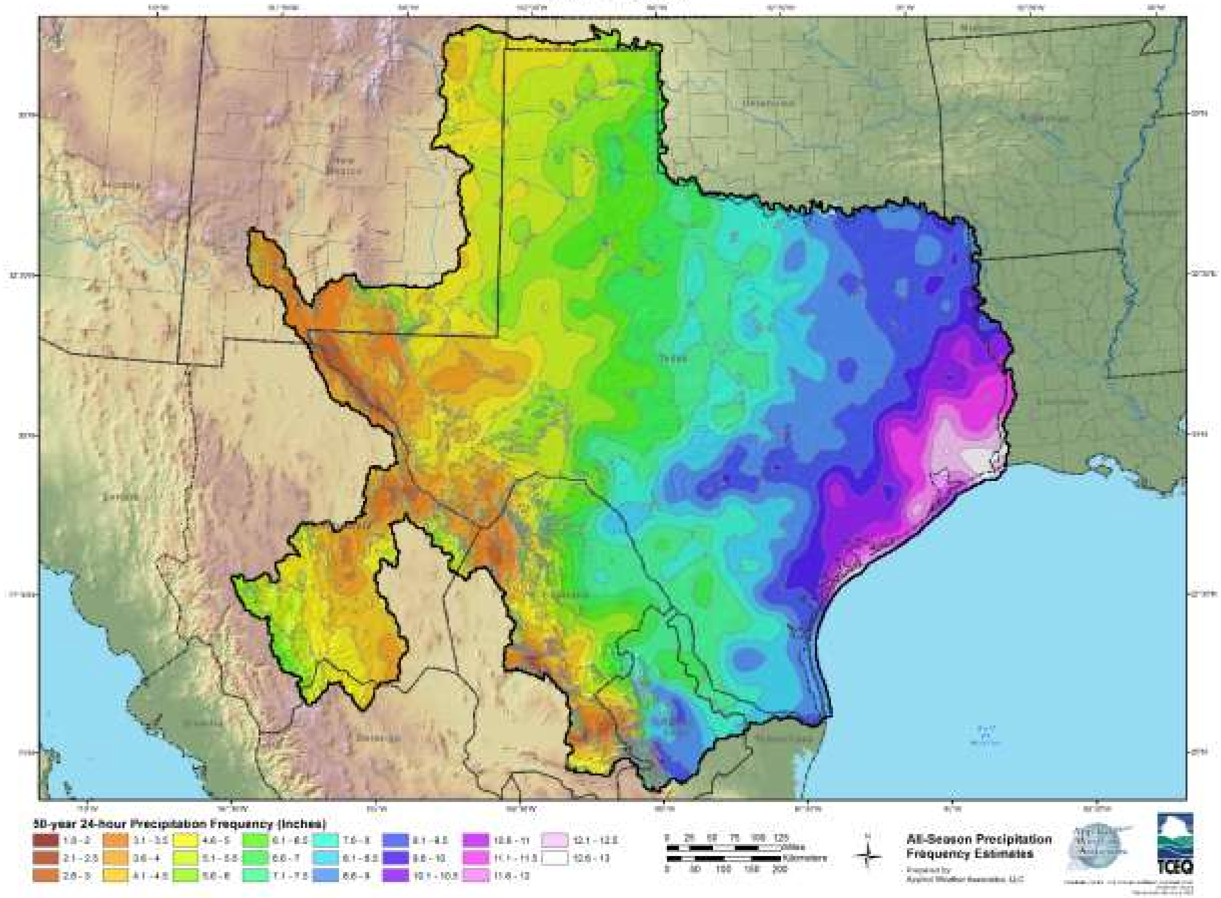
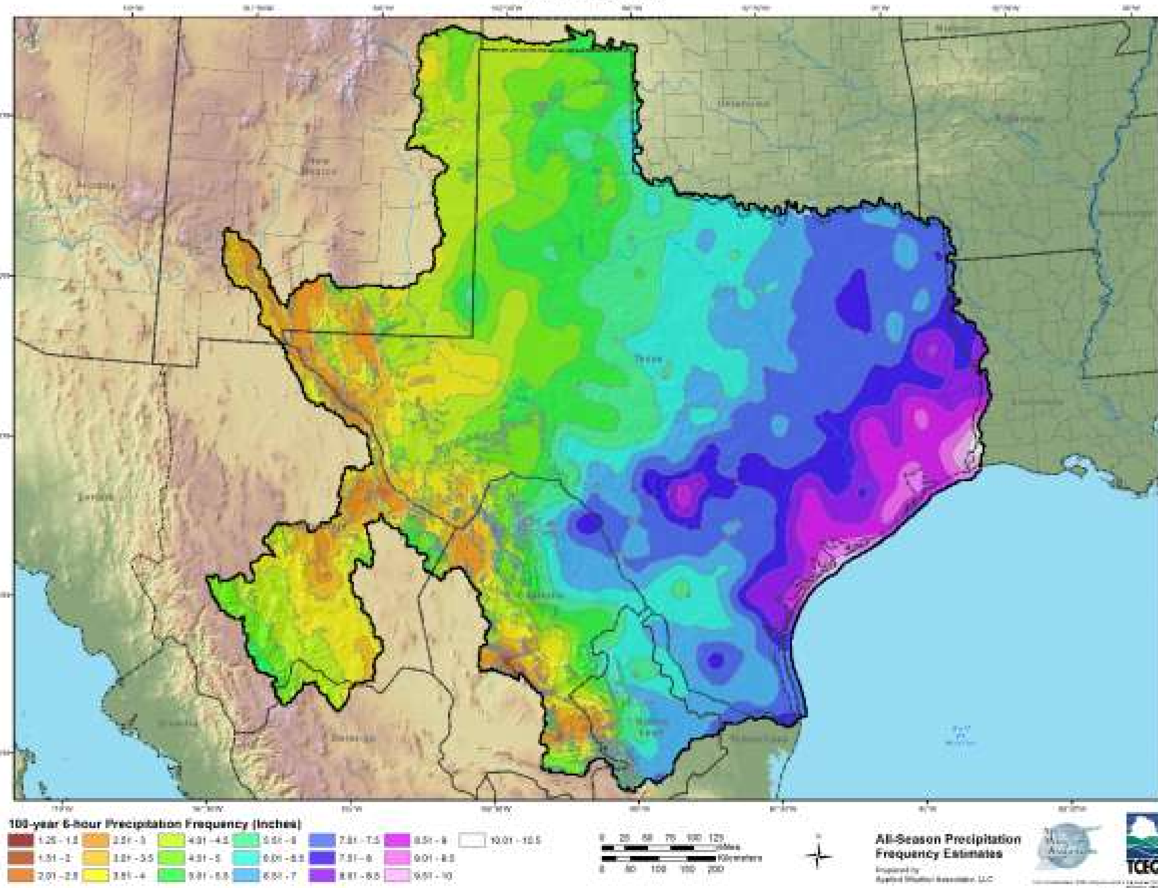
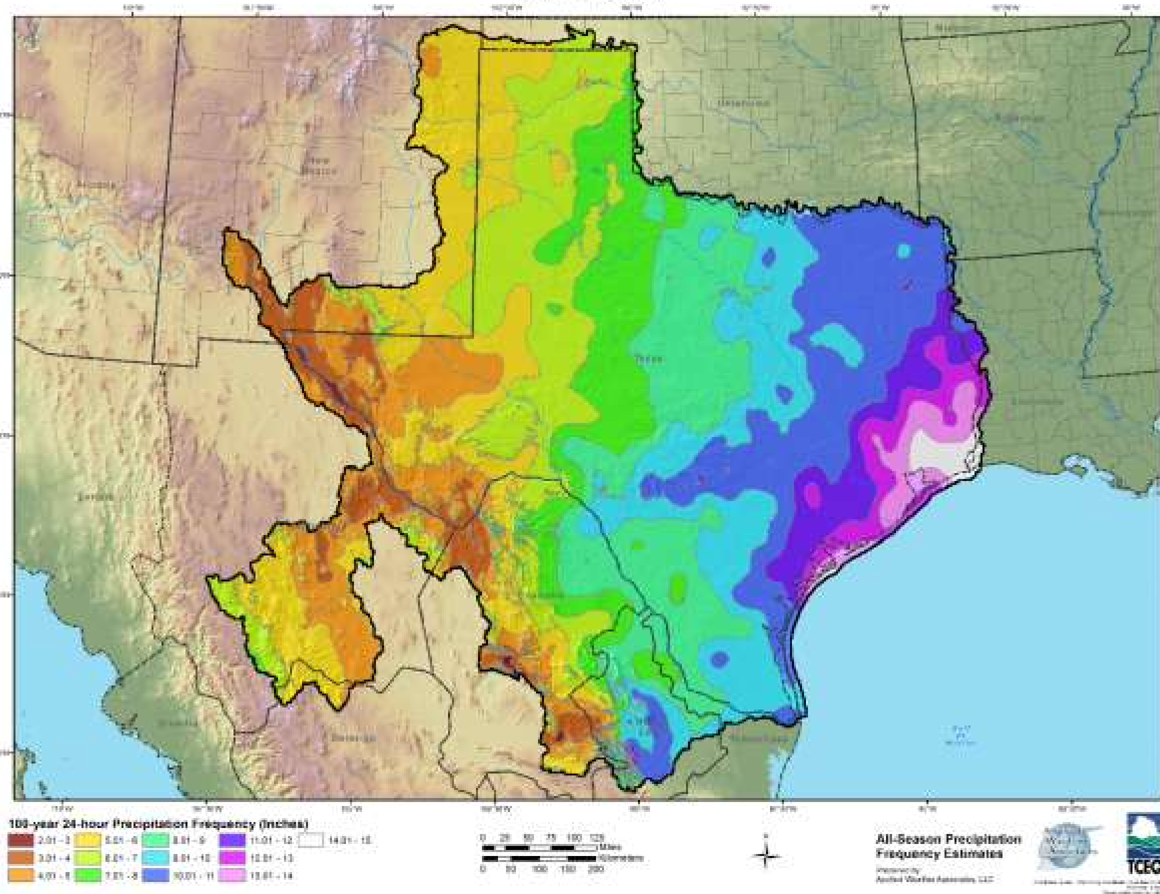
Texas PMP Study



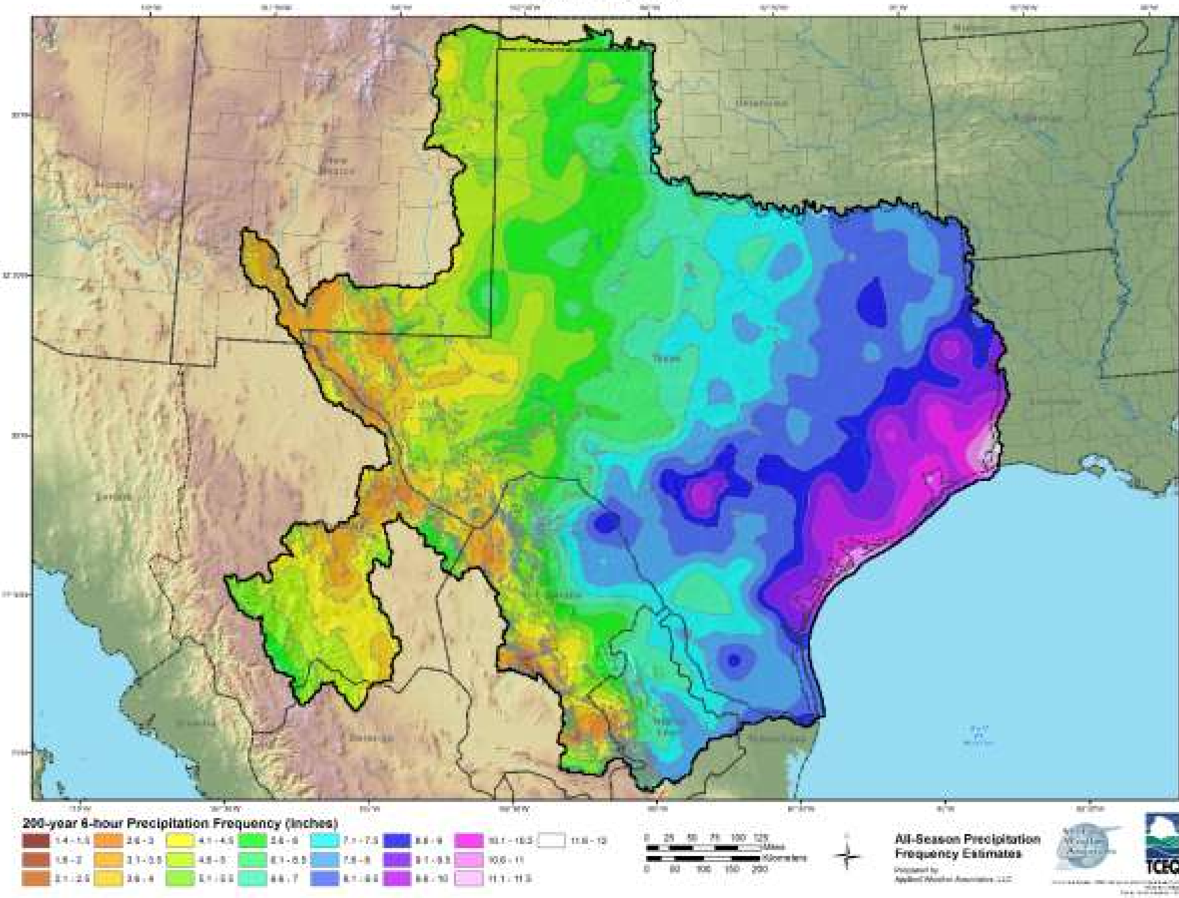
6 hour Precipitation Frequency Estimates - 100 year Recurrence Interval
Texas PMP Study



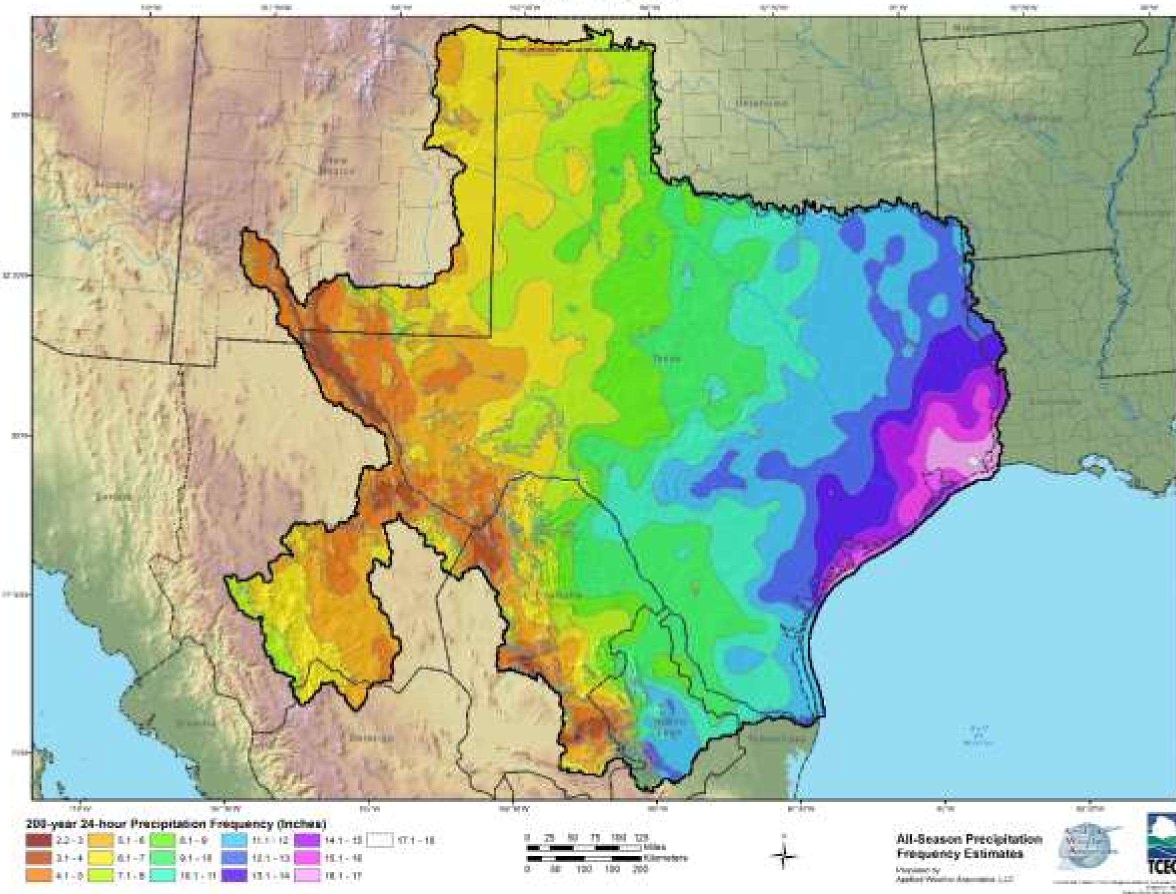
24 hour Precipitation Frequency Estimates - 100 year Recurrence Interval
Texas PMP Study



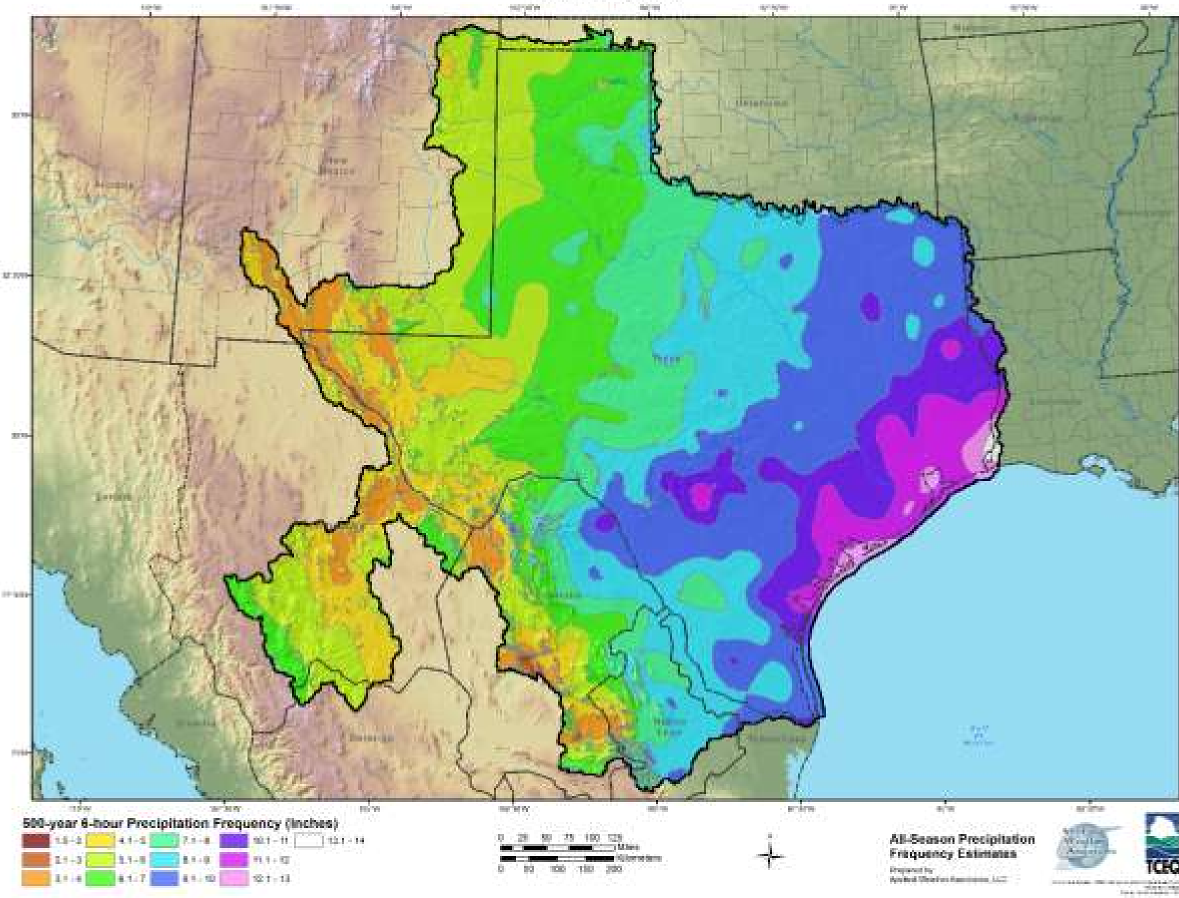
6 hour Precipitation Frequency Estimates - 200 year Recurrence Interval
Texas PMP Study



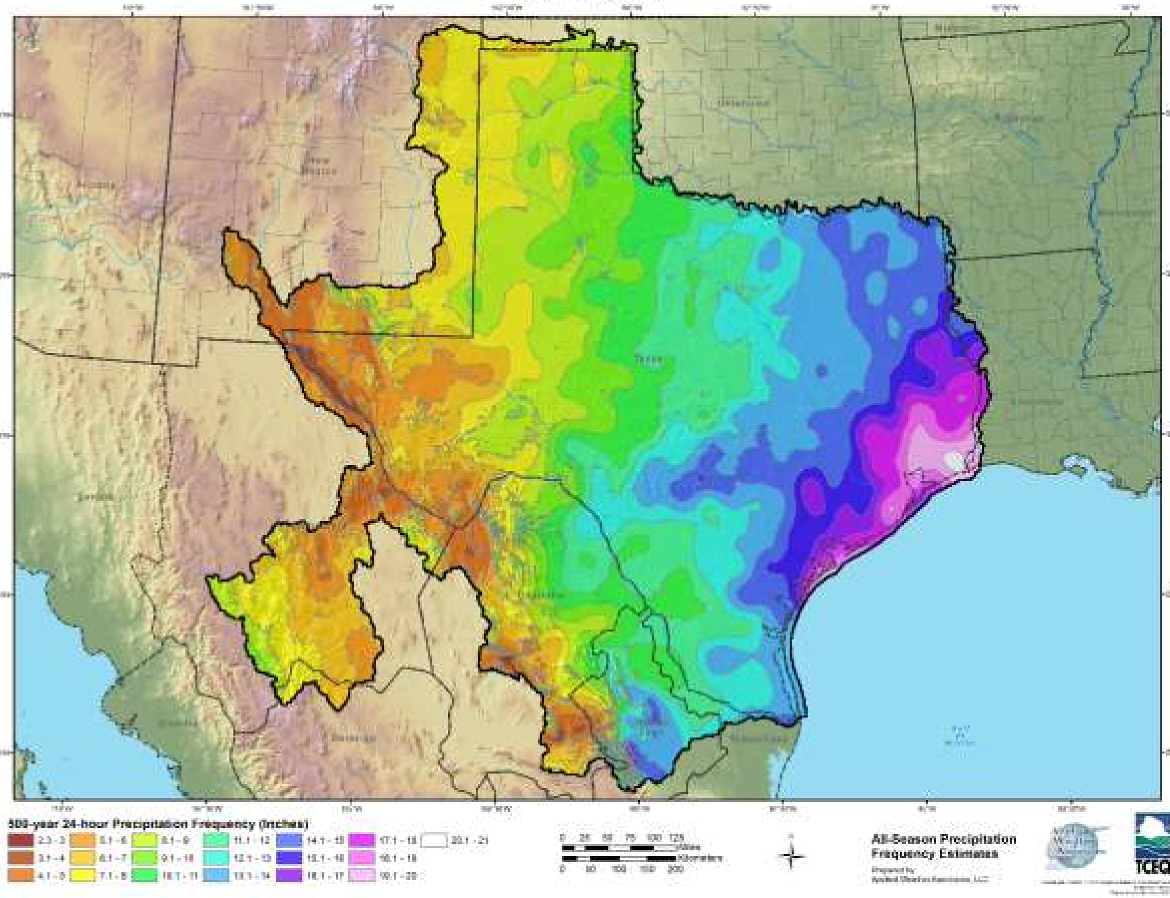
24 hour Precipitation Frequency Estimates - 200 year Recurrence Interval
Texas PMP Study



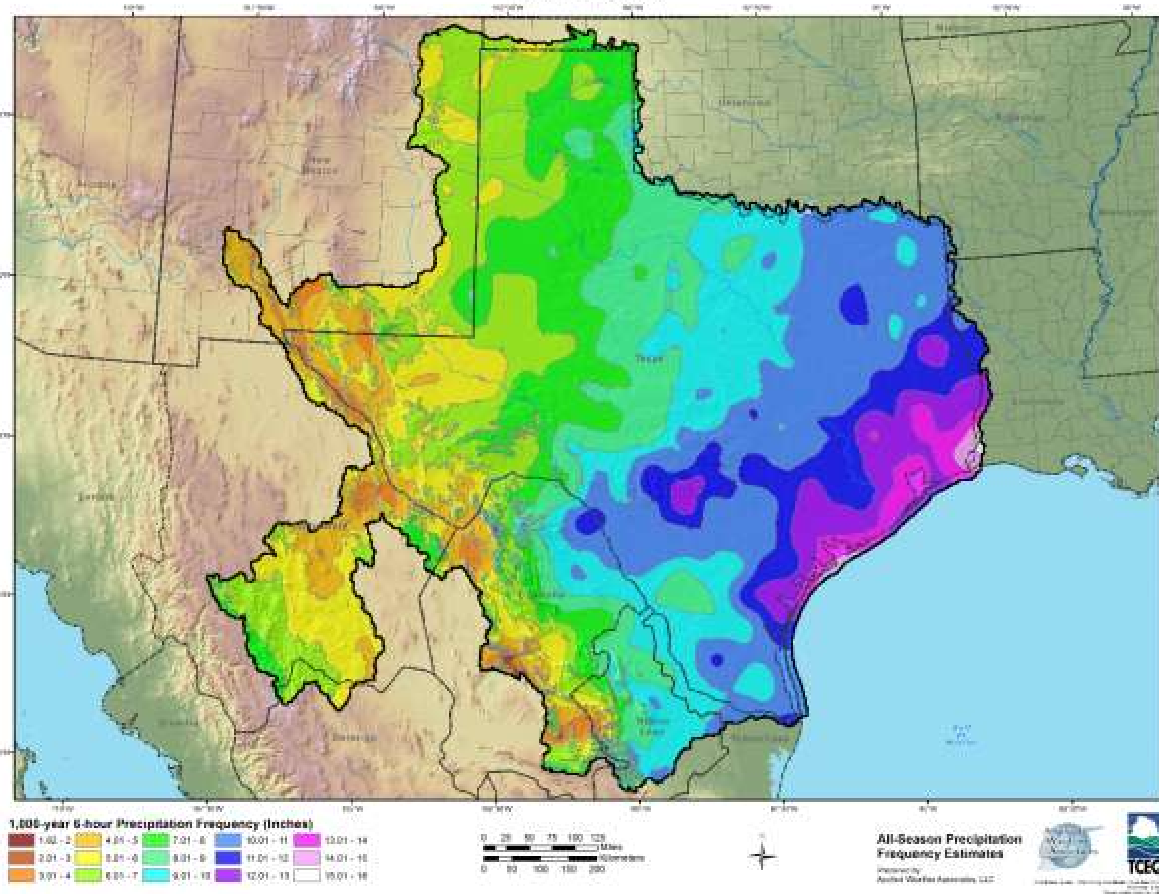
6 hour Precipitation Frequency Estimates - 500 year Recurrence Interval
Texas PMP Study



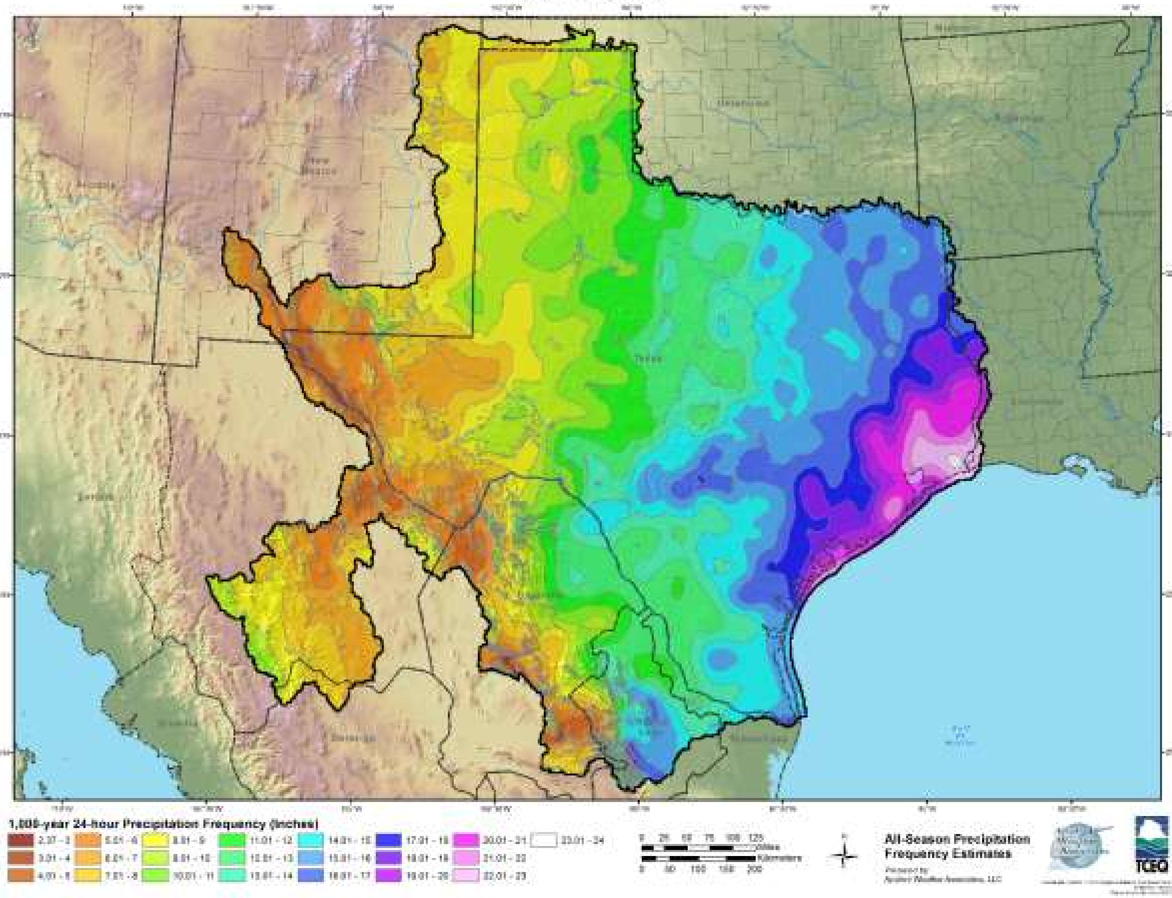
24 hour Precipitation Frequency Estimates - 500 year Recurrence Interval
Texas PMP Study



6 hour Precipitation Frequency Estimates - 1,000 year Recurrence Interval
Texas PMP Study

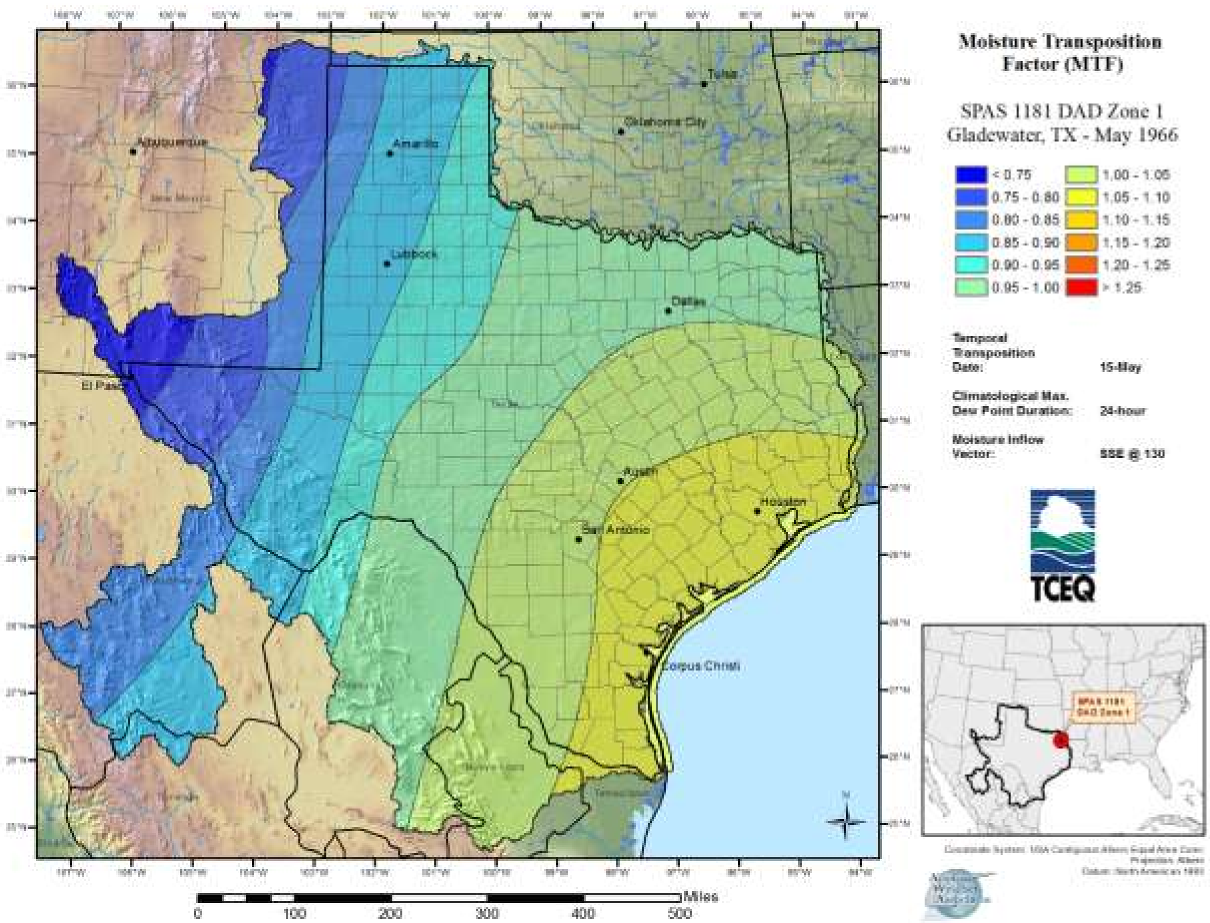


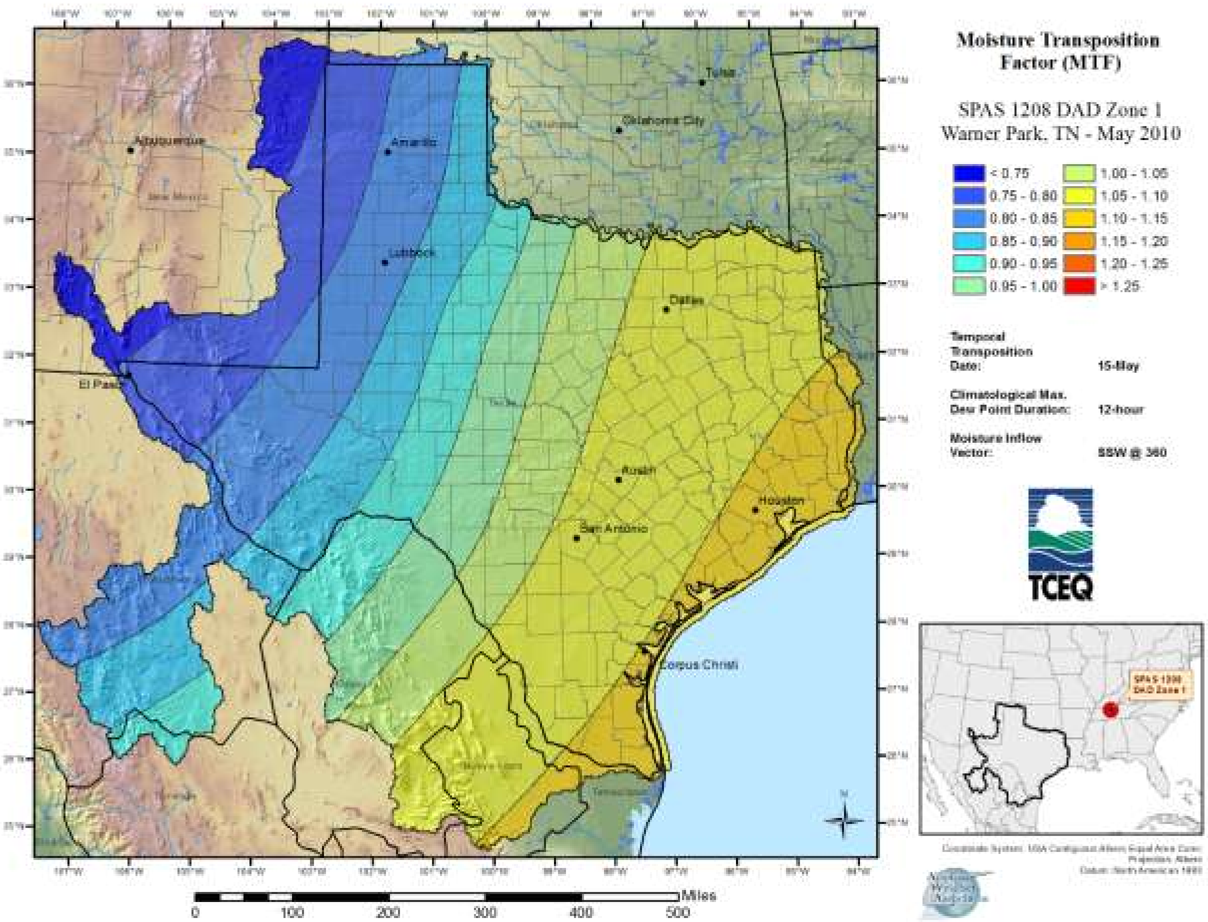
24 hour Precipitation Frequency Estimates - 1,000 year Recurrence Interval
Texas PMP Study

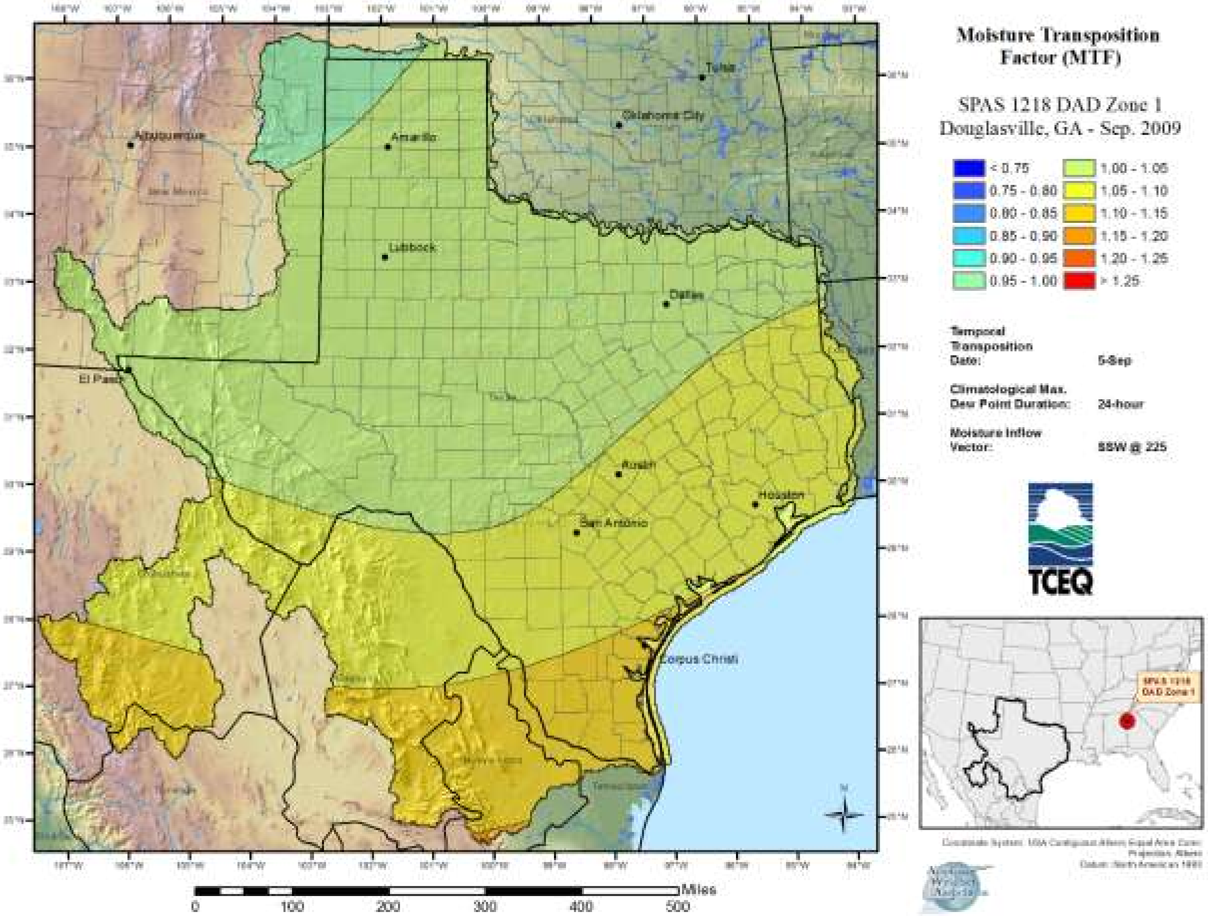


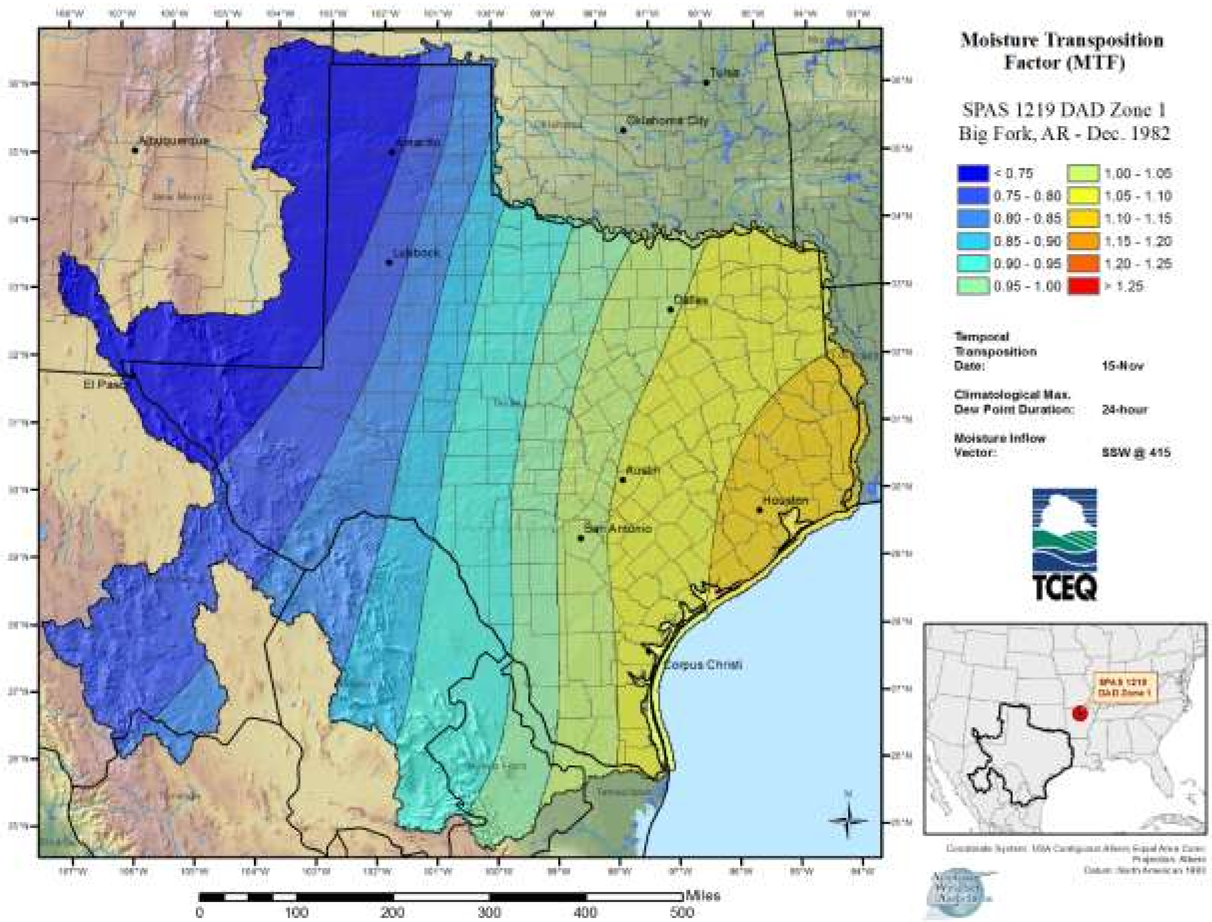
Appendix D
Moisture Transposition Factor (MTF) Maps

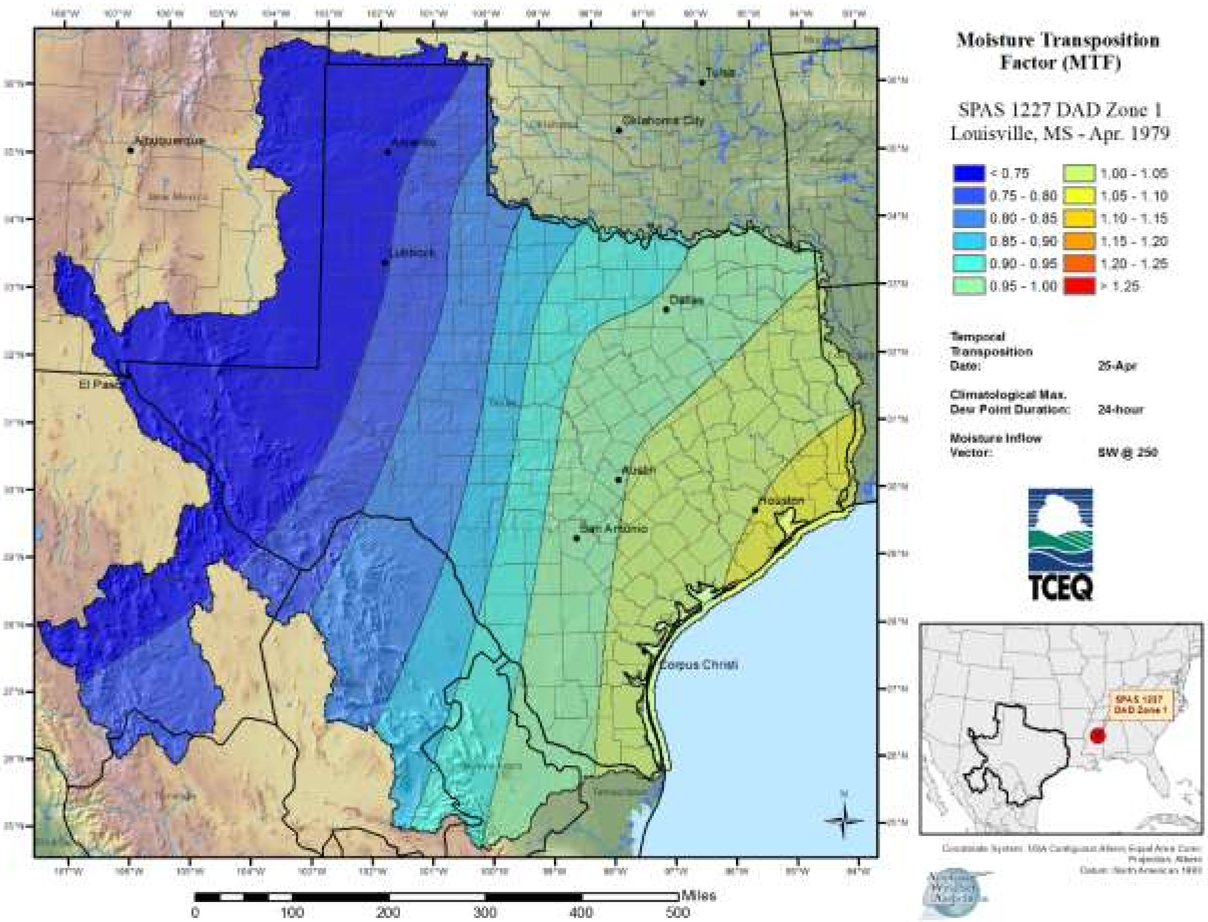
General Storms


Moisture Transposition Factor (MTF)
SPAS 1181 DAD Zone 1
Gladewater, TX - May 1966
< 0.75
0.75 - 0.80
0.80 - 0.85
0.85 - 0.90
0.90 - 0.95
0.95 - 1.00
1.00 - 1.05
1.05 - 1.10
1.10 - 1.15
1.15 - 1.20
1.20 - 1.25
> 1.25
Temporal Transposition Date: 15-May
Climatological Max. Dew Point Duration: 24-hour
Moisture Inflow Vector: SSE @ 130
TCEQ
SPAS 1181 DAD Zone 1
Tulsa
Oklahoma City
Albuquerque
Amarillo
Lubbock
Dallas
El Paso
Austin
Houston
San Antonio
Corpus Christi
Miles
0 100 200 300 400 500

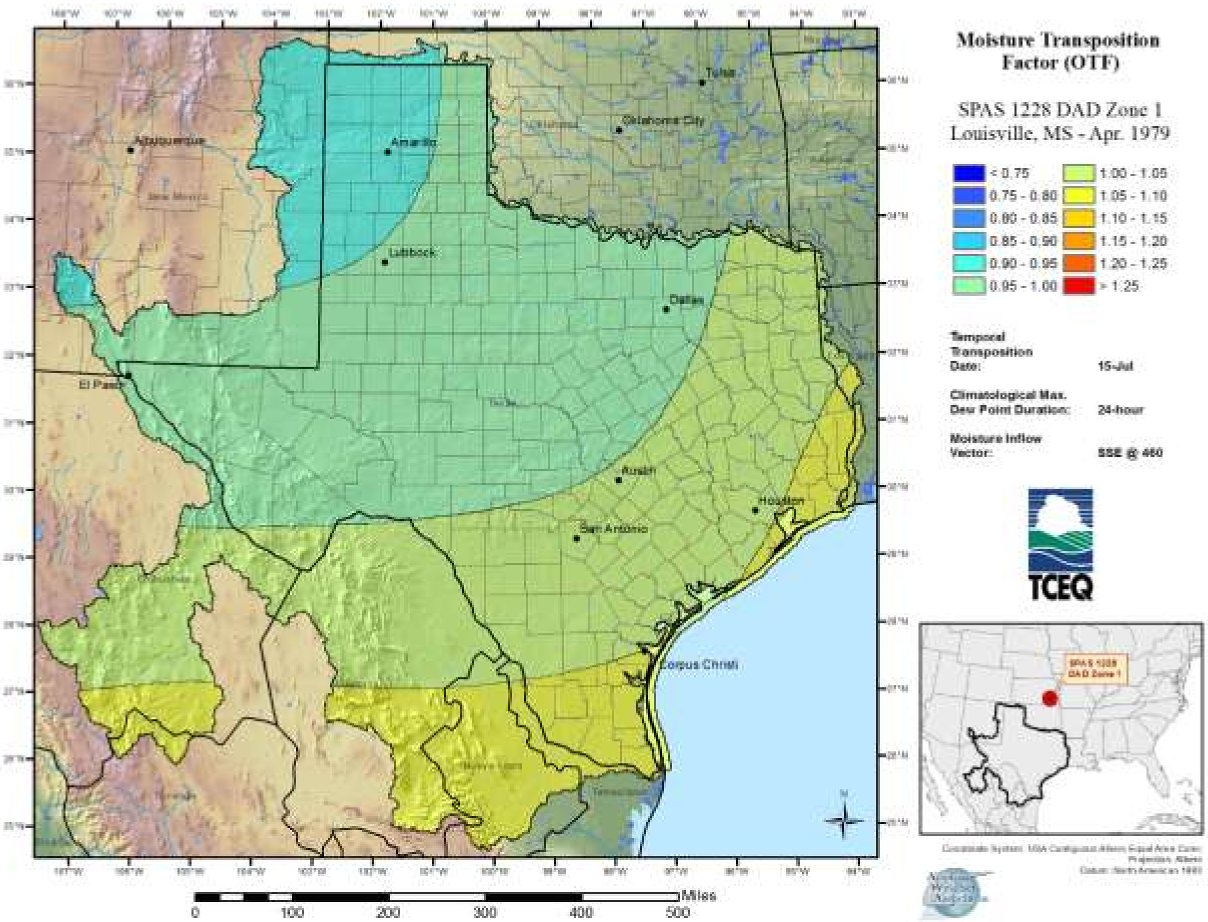

Moisture Transposition Factor (MTF)
SPAS 1208 DAD Zone 1
Warner Park, TN - May 2010
< 0.75
0.75 - 0.80
0.80 - 0.85
0.85 - 0.90
0.90 - 0.95
0.95 - 1.00
1.00 - 1.05
1.05 - 1.10
1.10 - 1.15
1.15 - 1.20
1.20 - 1.25
> 1.25
Temporal Transposition Date: 15-May
Climatological Max. Dew Point Duration: 12-hour
Moisture Inflow Vector: SSW @ 360
TCEQ
Tulsa
Oklahoma City
Albuquerque
Amarillo
Lubbock
Dallas
El Paso
Austin
Houston
San Antonio
Corpus Christi
Miles
0
100
200
300
400
500


Moisture Transposition Factor (MTF)
SPAS 1218 DAD Zone 1
Douglasville, GA - Sep. 2009
< 0.75
0.75 - 0.80
0.80 - 0.85
0.85 - 0.90
0.90 - 0.95
0.95 - 1.00
1.00 - 1.05
1.05 - 1.10
1.10 - 1.15
1.15 - 1.20
1.20 - 1.25
> 1.25
Temporal Transposition Date: 5-Sep
Climatological Max. Dew Point Duration: 24-hour
Moisture Inflow Vector: SSW @ 225
TCEQ
Tulsa
Oklahoma City
Albuquerque
Amarillo
Lubbock
Dallas
El Paso
Austin
Houston
San Antonio
Corpus Christi
SPAS 1218 DAD Zone 1
Miles
0
100
200
300
400
500

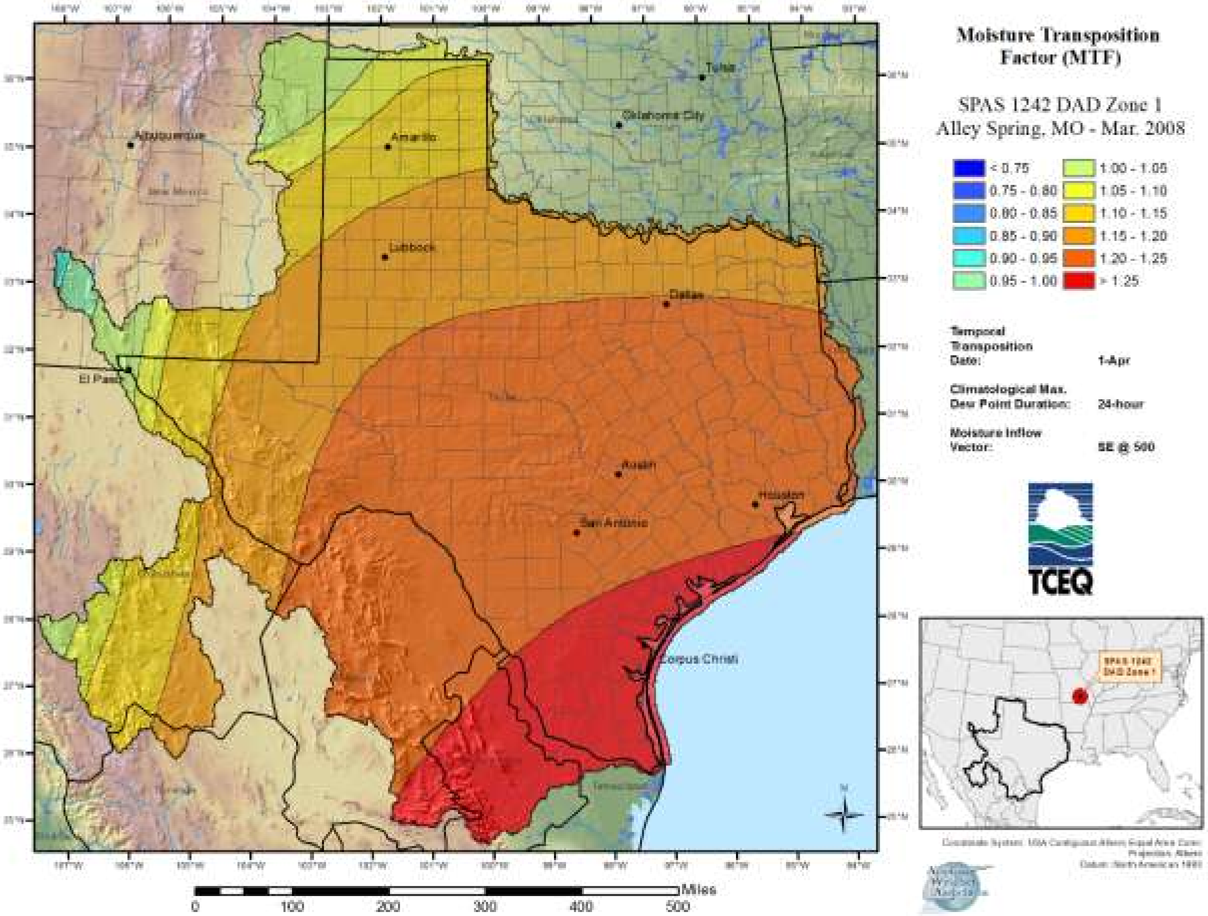

Moisture Transposition Factor (MTF)
SPAS 1219 DAD Zone 1
Big Fork, AR - Dec. 1982
< 0.75
0.75 - 0.80
0.80 - 0.85
0.85 - 0.90
0.90 - 0.95
0.95 - 1.00
1.00 - 1.05
1.05 - 1.10
1.10 - 1.15
1.15 - 1.20
1.20 - 1.25
> 1.25
Temporal Transposition Date: 15-Nov
Climatological Max. Dew Point Duration: 24-hour
Moisture Inflow Vector: SSW @ 415
TCEQ
Tulsa
Oklahoma City
Albuquerque
Amarillo
Lubbock
Dallas
El Paso
Austin
Houston
San Antonio
Corpus Christi
Miles
0
100
200
300
400
500

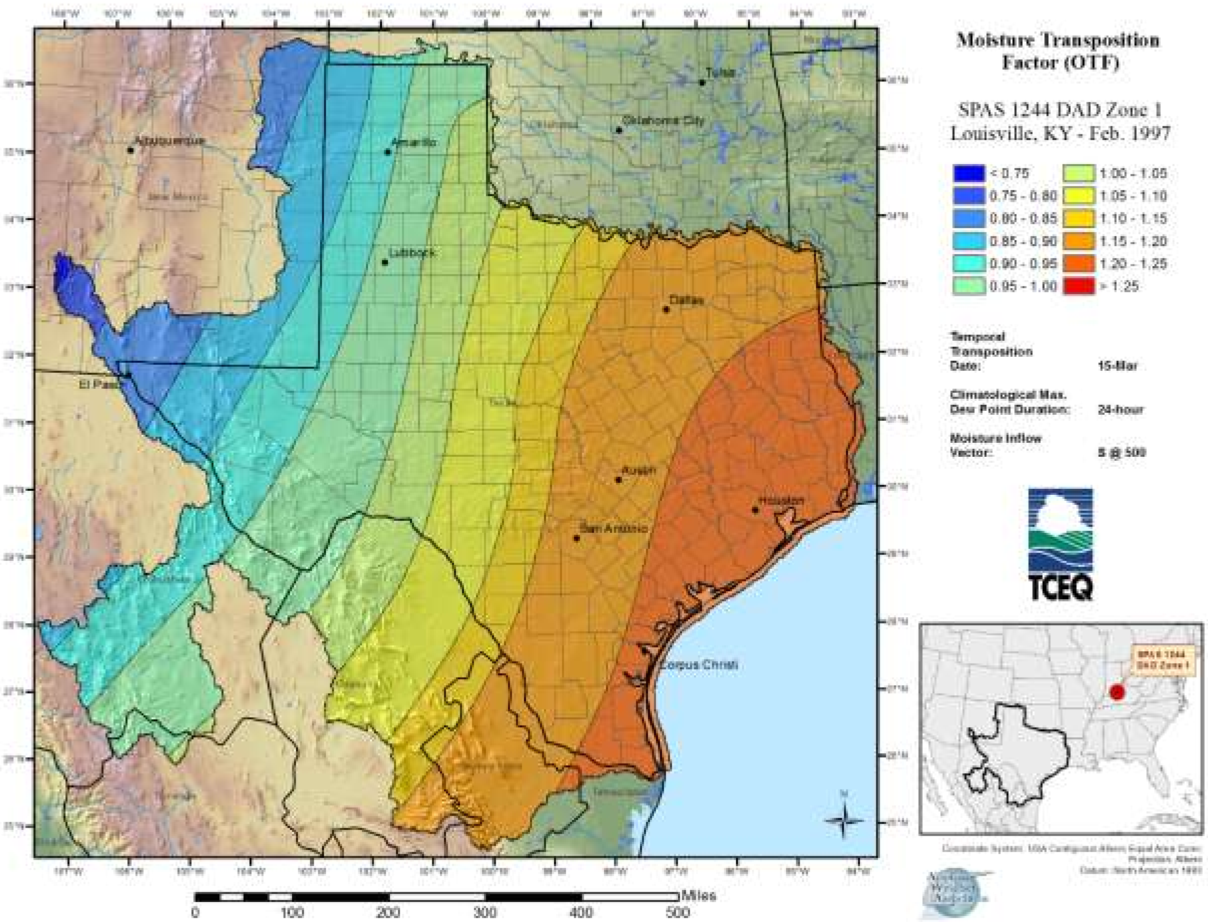


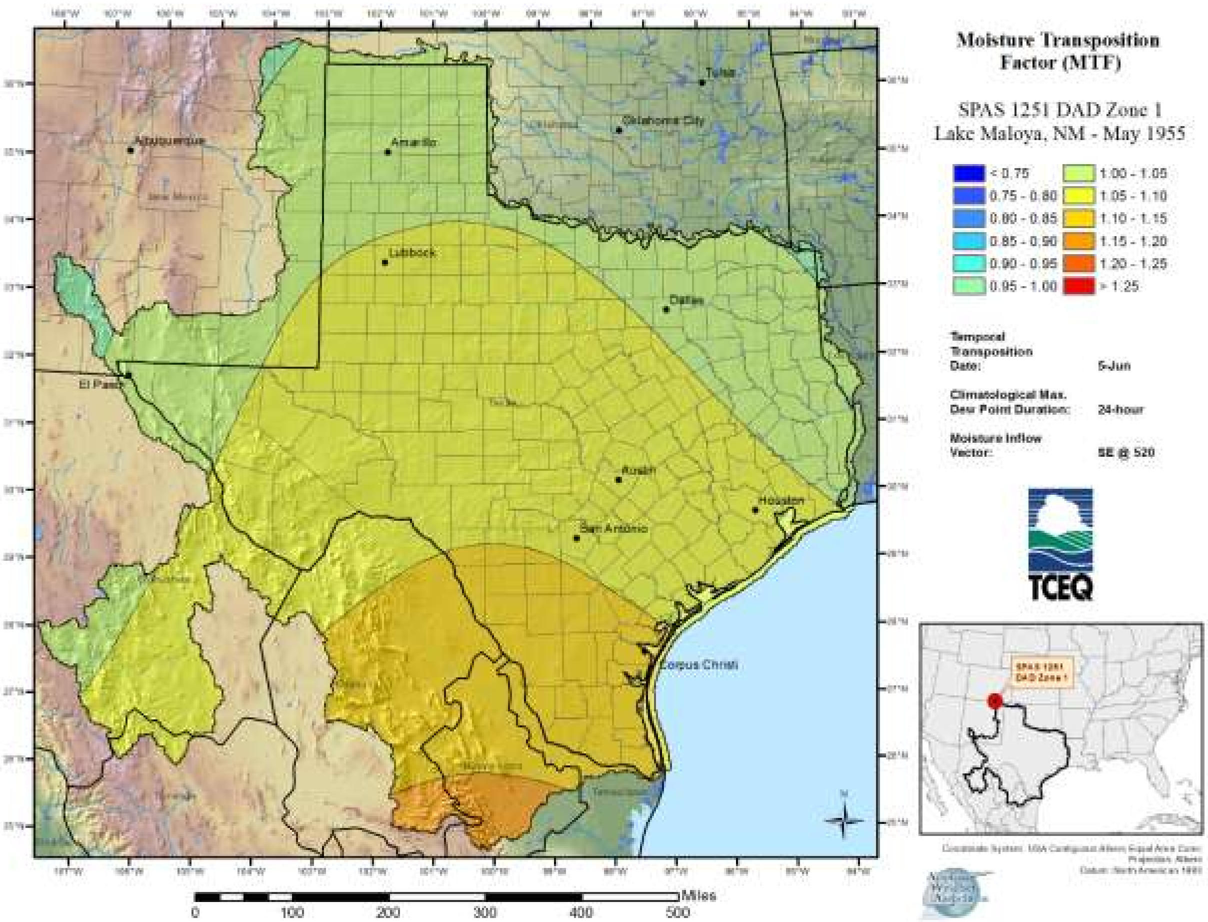
Moisture Transposition Factor (MTF)
SPAS 1227 DAD Zone 1
Louisville, MS - Apr. 1979
< 0.75
0.75 - 0.80
0.80 - 0.85
0.85 - 0.90
0.90 - 0.95
0.95 - 1.00
1.00 - 1.05
1.05 - 1.10
1.10 - 1.15
1.15 - 1.20
1.20 - 1.25
> 1.25
Temporal Transposition Date: 25-Apr
Climatological Max. Dew Point Duration: 24-hour
Moisture Inflow Vector: SW @ 250
TCEQ
SPAS 1227 DAD Zone 1
Tulsa
Oklahoma City
Albuquerque
Amarillo
Lubbock
Dallas
El Paso
Austin
Houston
San Antonio
Corpus Christi
N
Miles
0
100
200
300
400
500



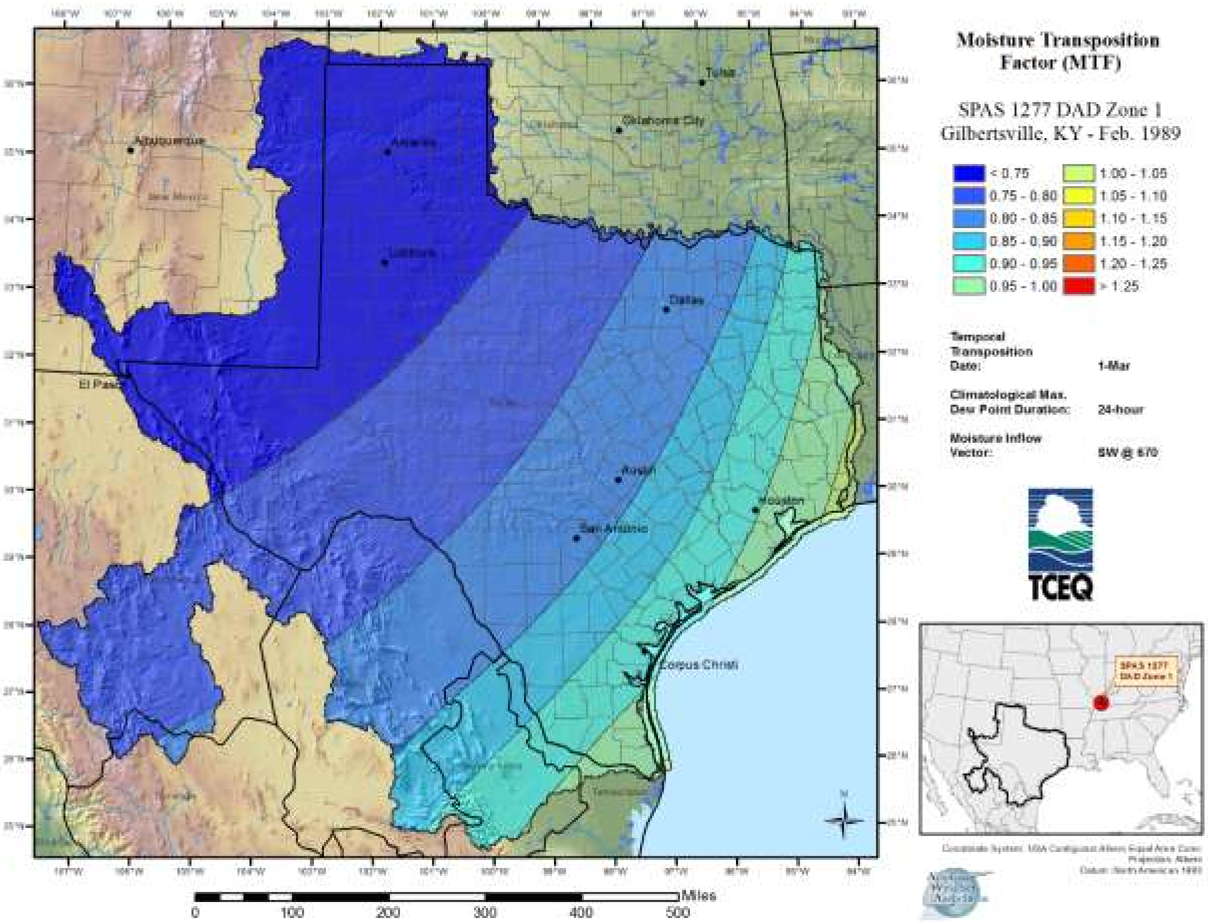
Moisture Transposition Factor (OTF)
SPAS 1228 DAD Zone 1
Louisville, MS - Apr. 1979
< 0.75
0.75 - 0.80
0.80 - 0.85
0.85 - 0.90
0.90 - 0.95
0.95 - 1.00
1.00 - 1.05
1.05 - 1.10
1.10 - 1.15
1.15 - 1.20
1.20 - 1.25
> 1.25
Temporal Transposition Date: 15-Jul
Climatological Max. Dew Point Duration: 24-hour
Moisture Inflow Vector: SSE @ 460
TCEQ
SPAS 1228 DAD Zone 1
Tulsa
Oklahoma City
Albuquerque
Amarillo
Lubbock
Dallas
El Paso
Austin
Houston
San Antonio
Corpus Christi
Miles
0
100
200
300
400
500


Moisture Transposition
Factor (MTF)
SPAS 1242 DAD Zone 1
Alley Spring, MO - Mar. 2008
< 0.75
0.75 - 0.80
0.80 - 0.85
0.85 - 0.90
0.90 - 0.95
0.95 - 1.00
1.00 - 1.05
1.05 - 1.10
1.10 - 1.15
1.15 - 1.20
1.20 - 1.25
> 1.25
Temporal
Transposition
Date:
1-Apr
Climatological Max.
Dew Point Duration:
24-hour
Moisture Inflow
Vector:
SE @ 500
TCEQ
Tulsa
Oklahoma City
Albuquerque
Amarillo
Lubbock
Dallas
El Paso
Austin
Houston
San Antonio
Corpus Christi
Miles
0
100
200
300
400
500

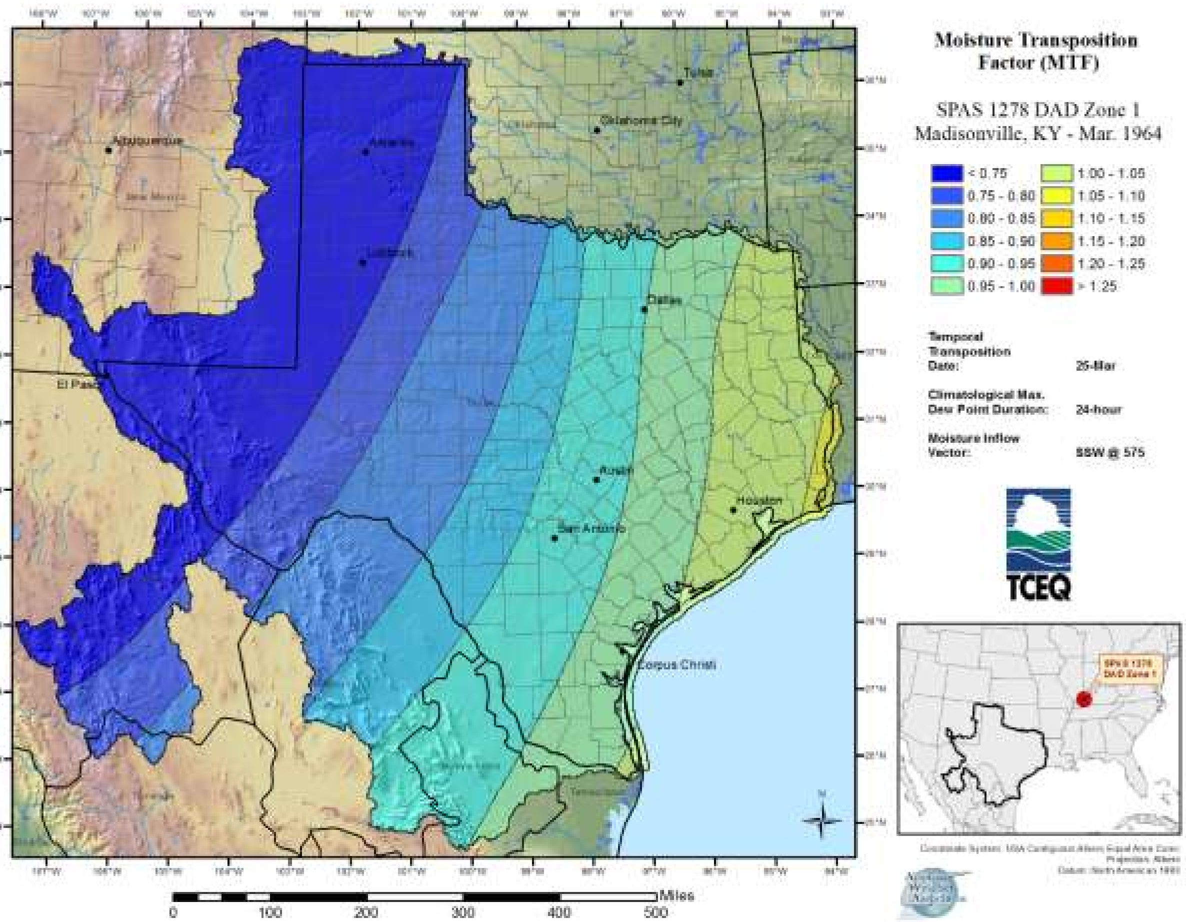

Moisture Transposition Factor (OTF)
SPAS 1244 DAD Zone 1
Louisville, KY - Feb. 1997
< 0.75
0.75 - 0.80
0.80 - 0.85
0.85 - 0.90
0.90 - 0.95
0.95 - 1.00
1.00 - 1.05
1.05 - 1.10
1.10 - 1.15
1.15 - 1.20
1.20 - 1.25
> 1.25
Temporal Transposition Date: 15-Mar
Climatological Max. Dew Point Duration: 24-hour
Moisture Inflow Vector: S @ 500
TCEQ
Tulsa
Oklahoma City
Albuquerque
Amarillo
Lubbock
Dallas
El Paso
Austin
Houston
San Antonio
Corpus Christi
Miles
0
100
200
300
400
500

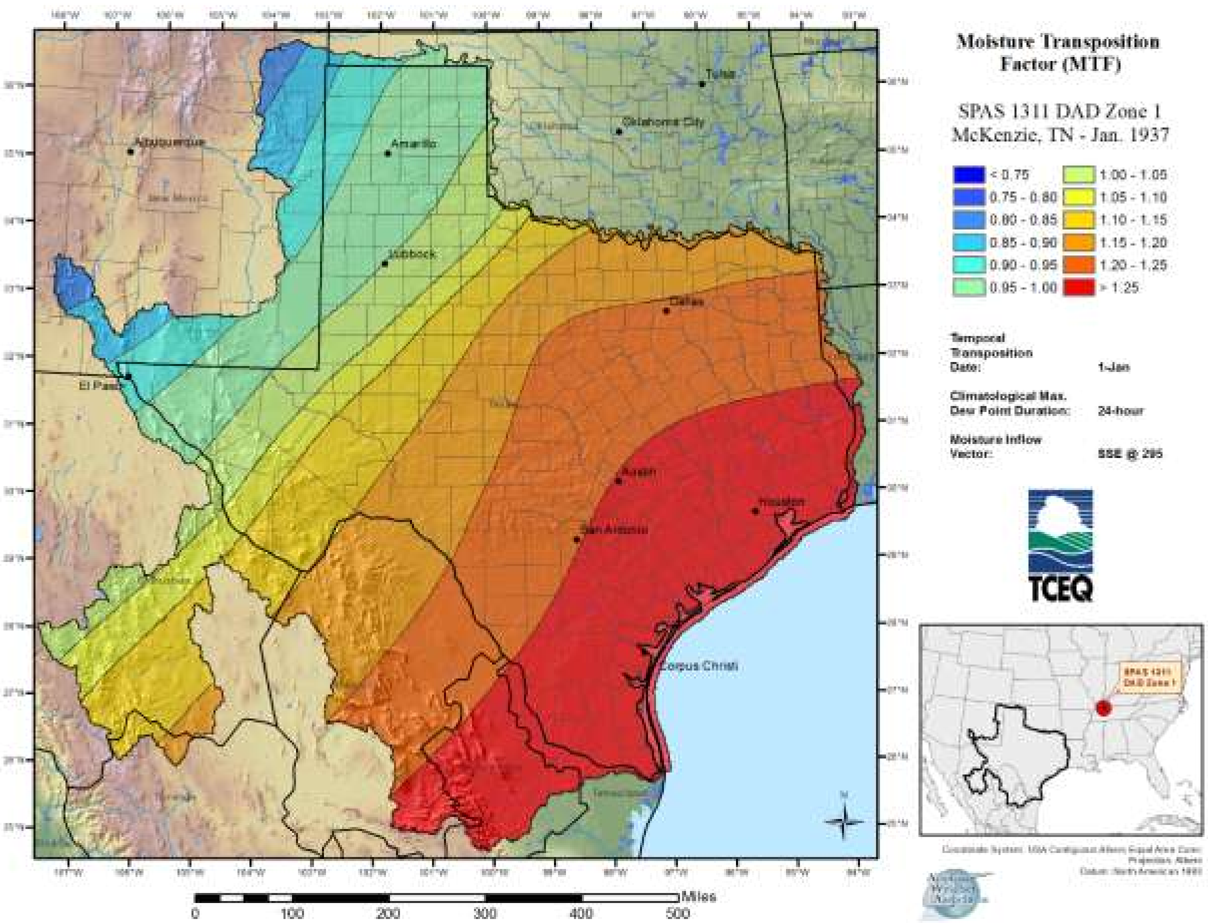


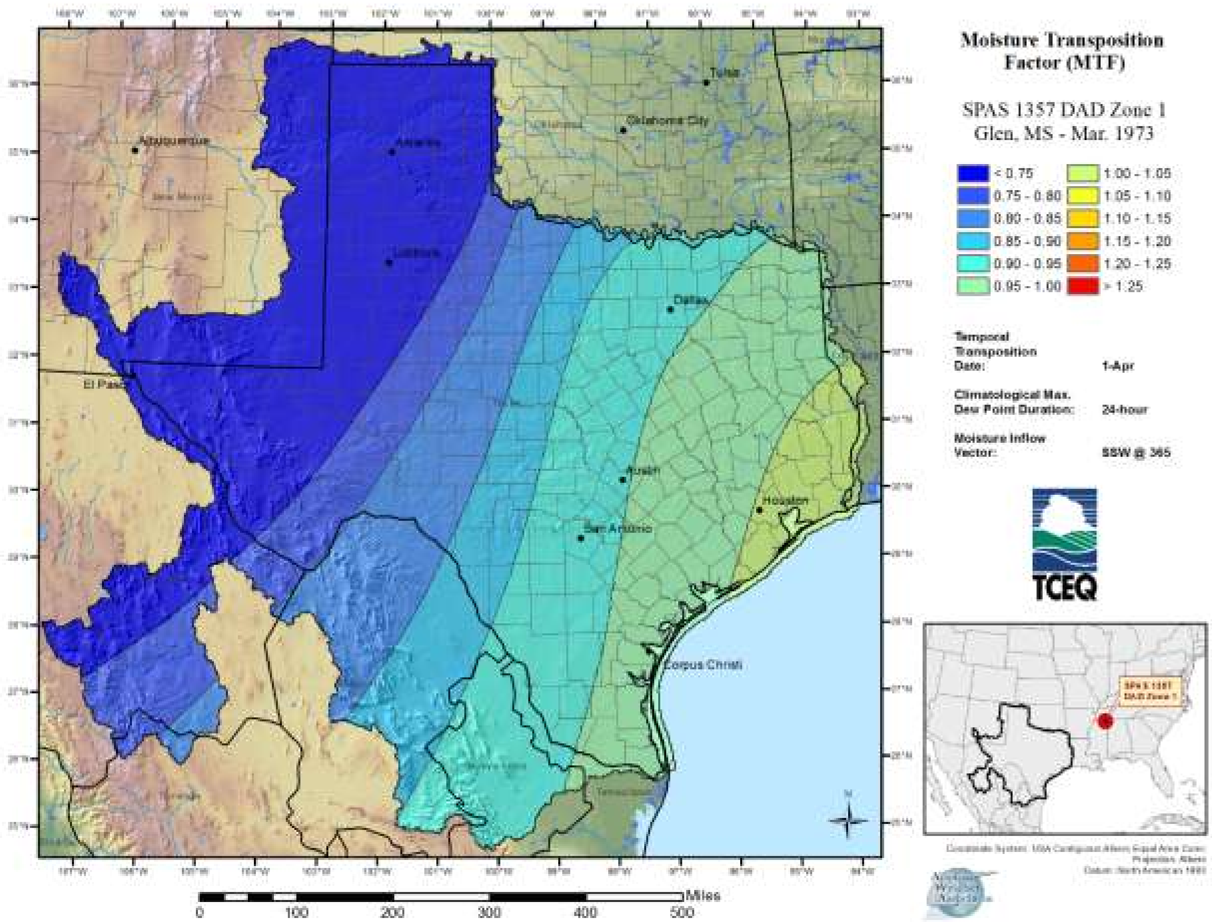
Moisture Transposition
Factor (MTF)
SPAS 1251 DAD Zone 1
Lake Maloya, NM - May 1955
< 0.75
0.75 - 0.80
0.80 - 0.85
0.85 - 0.90
0.90 - 0.95
0.95 - 1.00
1.00 - 1.05
1.05 - 1.10
1.10 - 1.15
1.15 - 1.20
1.20 - 1.25
> 1.25
Temporal Transposition Date: 5-Jun
Climatological Max. Dew Point Duration: 24-hour
Moisture Inflow Vector: SE @ 520
TCEQ
SPAS 1251
DAD Zone 1
Tulsa
Oklahoma City
Albuquerque
Amarillo
Lubbock
Dallas
El Paso
Austin
Houston
San Antonio
Corpus Christi
Miles
0
100
200
300
400
500

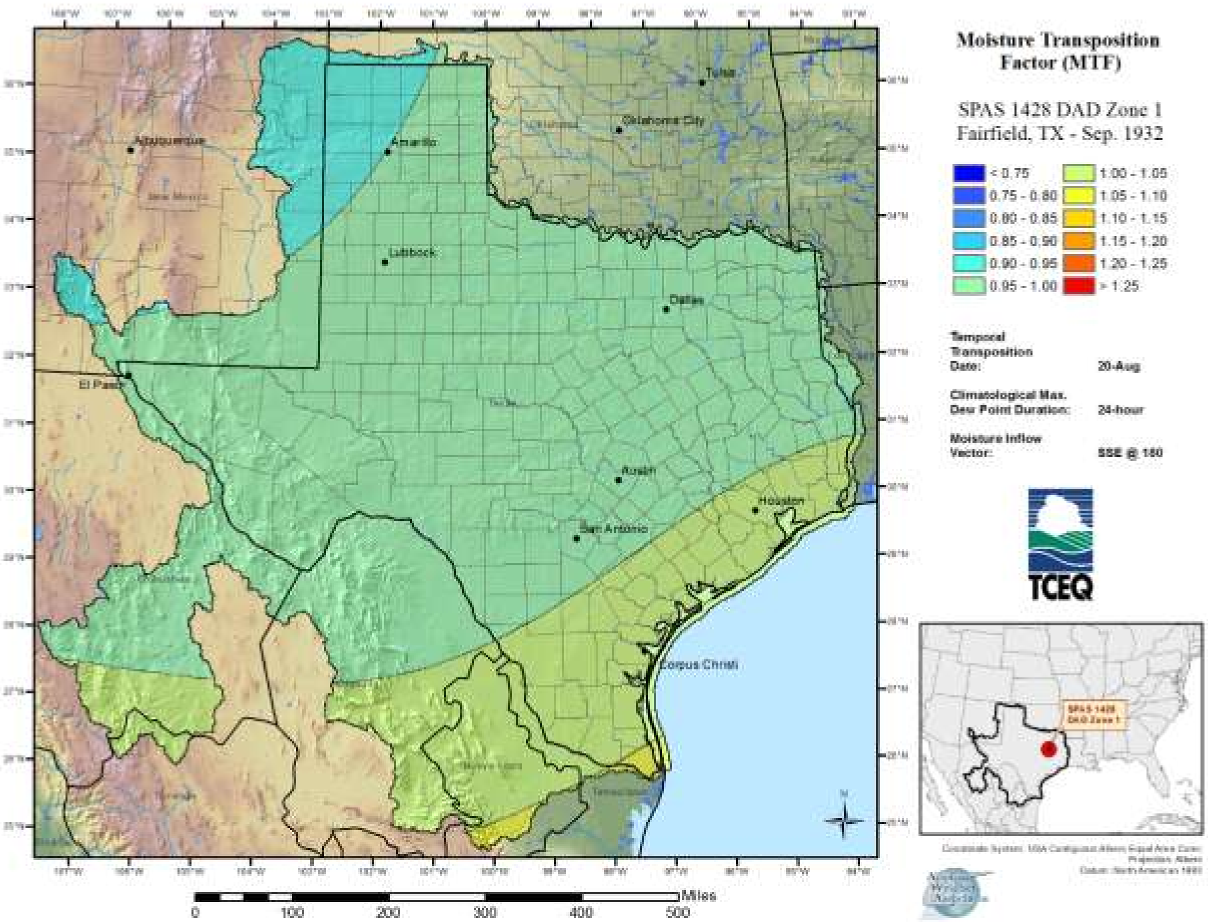


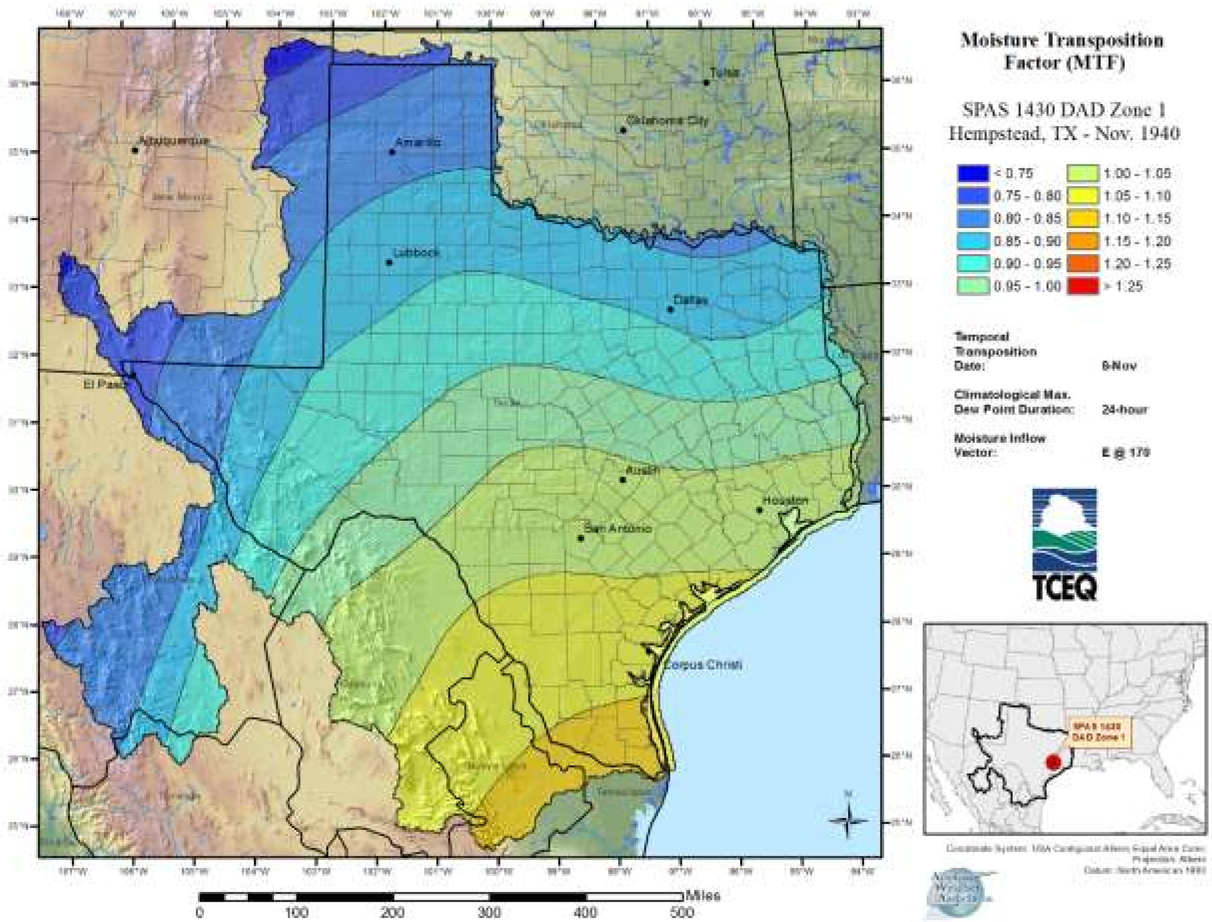
Moisture Transposition Factor (MTF)
SPAS 1277 DAD Zone 1
Gilbertsville, KY - Feb. 1989
< 0.75
0.75 - 0.80
0.80 - 0.85
0.85 - 0.90
0.90 - 0.95
0.95 - 1.00
1.00 - 1.05
1.05 - 1.10
1.10 - 1.15
1.15 - 1.20
1.20 - 1.25
> 1.25
Temporal Transposition Date: 1-Mar
Climatological Max. Dew Point Duration: 24-hour
Moisture Inflow Vector: SW @ 670
TCEQ
SPAS 1277 DAD Zone 1
Tulsa
Oklahoma City
Albuquerque
Amarillo
Lubbock
Dallas
El Paso
Austin
Houston
San Antonio
Corpus Christi
Miles
0
100
200
300
400
500

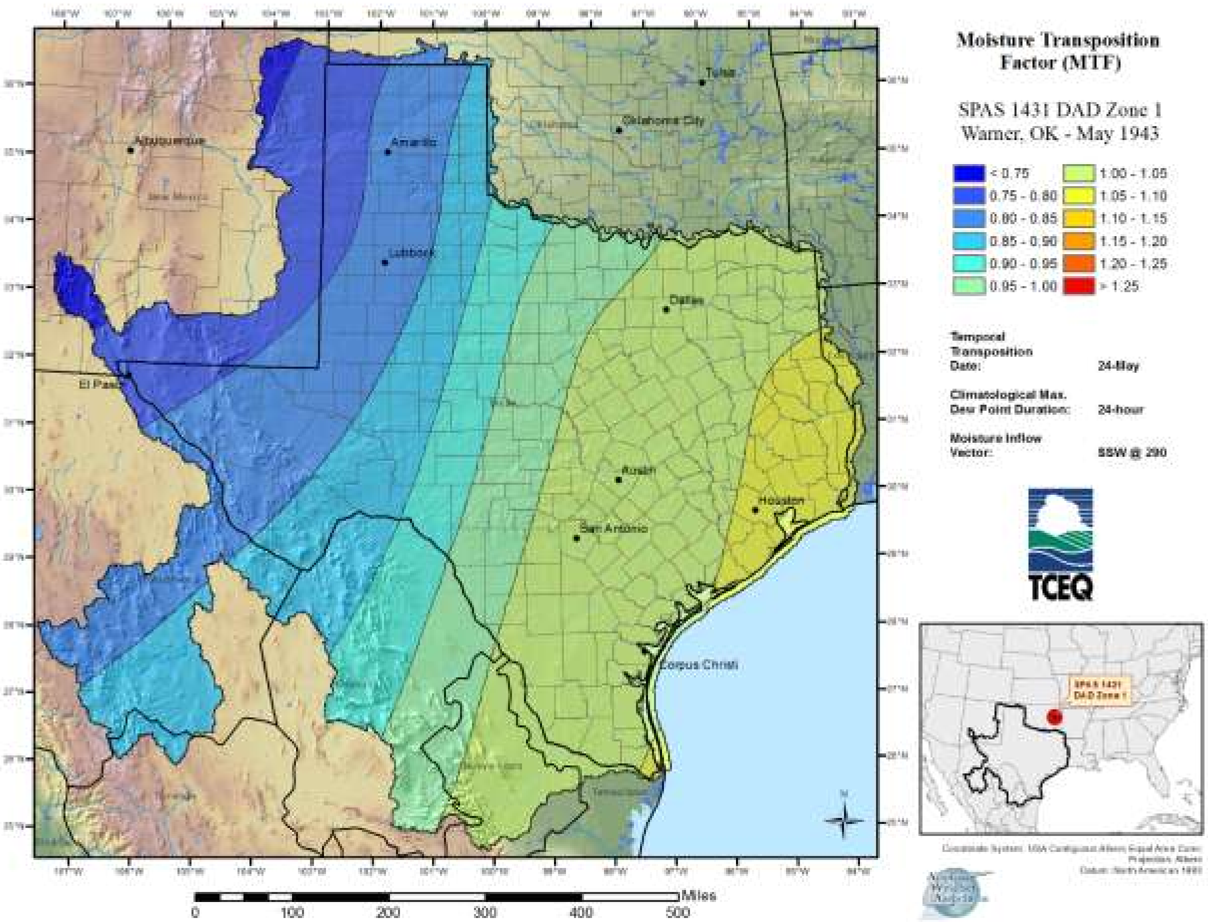

Moisture Transposition Factor (MTF)
SPAS 1278 DAD Zone 1
Madisonville, KY - Mar. 1964
< 0.75
0.75 - 0.80
0.80 - 0.85
0.85 - 0.90
0.90 - 0.95
0.95 - 1.00
1.00 - 1.05
1.05 - 1.10
1.10 - 1.15
1.15 - 1.20
1.20 - 1.25
> 1.25
Temporal Transposition Date: 25-Mar
Climatological Max. Dew Point Duration: 24-hour
Moisture Inflow Vector: SSW @ 575
TCEQ
Tulsa
Oklahoma City
Albuquerque
Amarillo
Lubbock
Dallas
El Paso
Austin
Houston
San Antonio
Corpus Christi
Miles
0
100
200
300
400
500

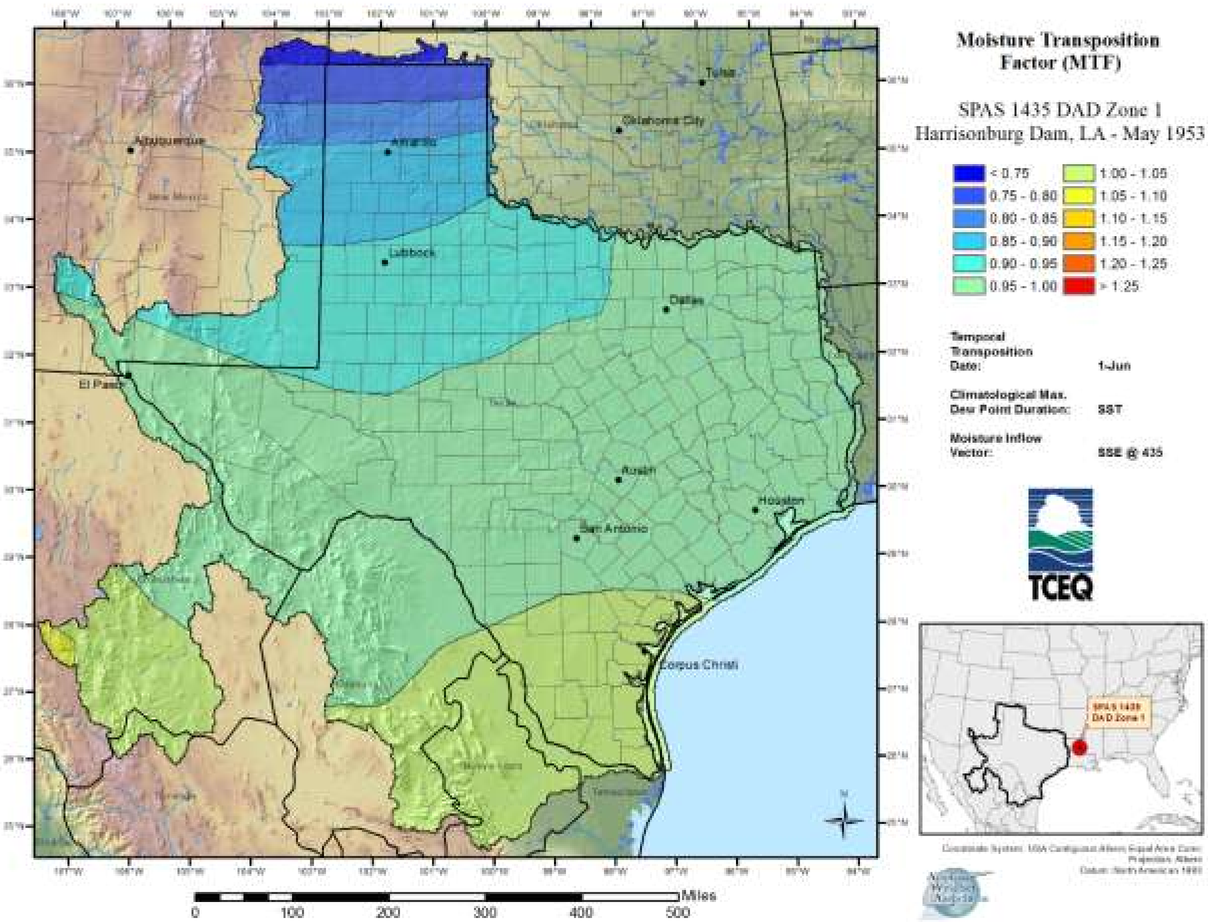

Moisture Transposition Factor (MTF)
SPAS 1311 DAD Zone 1
McKenzie, TN - Jan. 1937
< 0.75
0.75 - 0.80
0.80 - 0.85
0.85 - 0.90
0.90 - 0.95
0.95 - 1.00
1.00 - 1.05
1.05 - 1.10
1.10 - 1.15
1.15 - 1.20
1.20 - 1.25
> 1.25
Temporal Transposition Date: 1-Jan
Climatological Max. Dew Point Duration: 24-hour
Moisture Inflow Vector: SSE @ 295
TCEQ
Tulsa
Oklahoma City
Albuquerque
Amarillo
Lubbock
Dallas
El Paso
Austin
Houston
San Antonio
Corpus Christi
SPAS 1311 DAD Zone 1
Miles
0 100 200 300 400 500

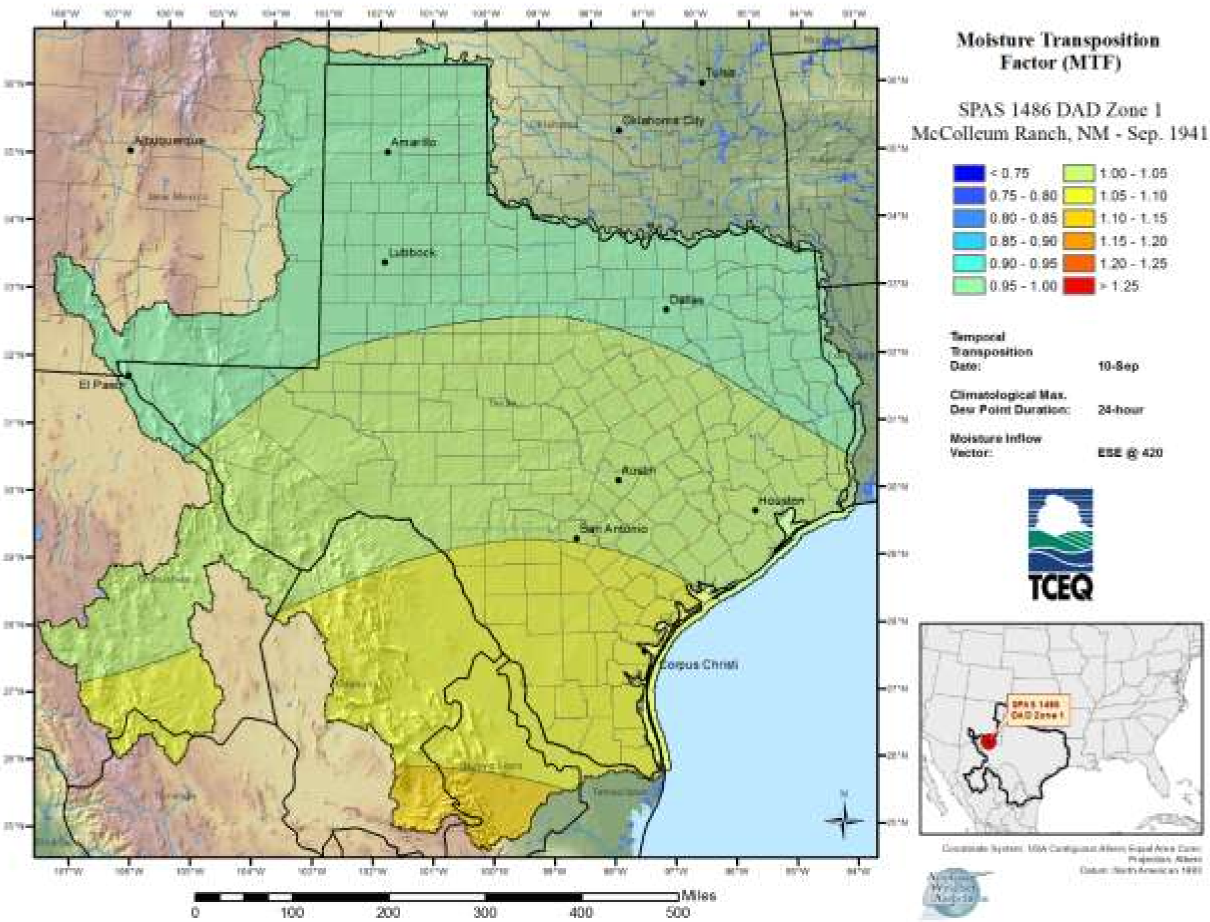

Moisture Transposition Factor (MTF)
SPAS 1357 DAD Zone 1
Glen, MS - Mar. 1973
< 0.75
0.75 - 0.80
0.80 - 0.85
0.85 - 0.90
0.90 - 0.95
0.95 - 1.00
1.00 - 1.05
1.05 - 1.10
1.10 - 1.15
1.15 - 1.20
1.20 - 1.25
> 1.25
Temporal Transposition Date: 1-Apr
Climatological Max. Dew Point Duration: 24-hour
Moisture Inflow Vector: SSW @ 365
TCEQ
Tulsa
Oklahoma City
Albuquerque
Amarillo
Lubbock
Dallas
El Paso
Austin
Houston
San Antonio
Corpus Christi
Miles
0
100
200
300
400
500

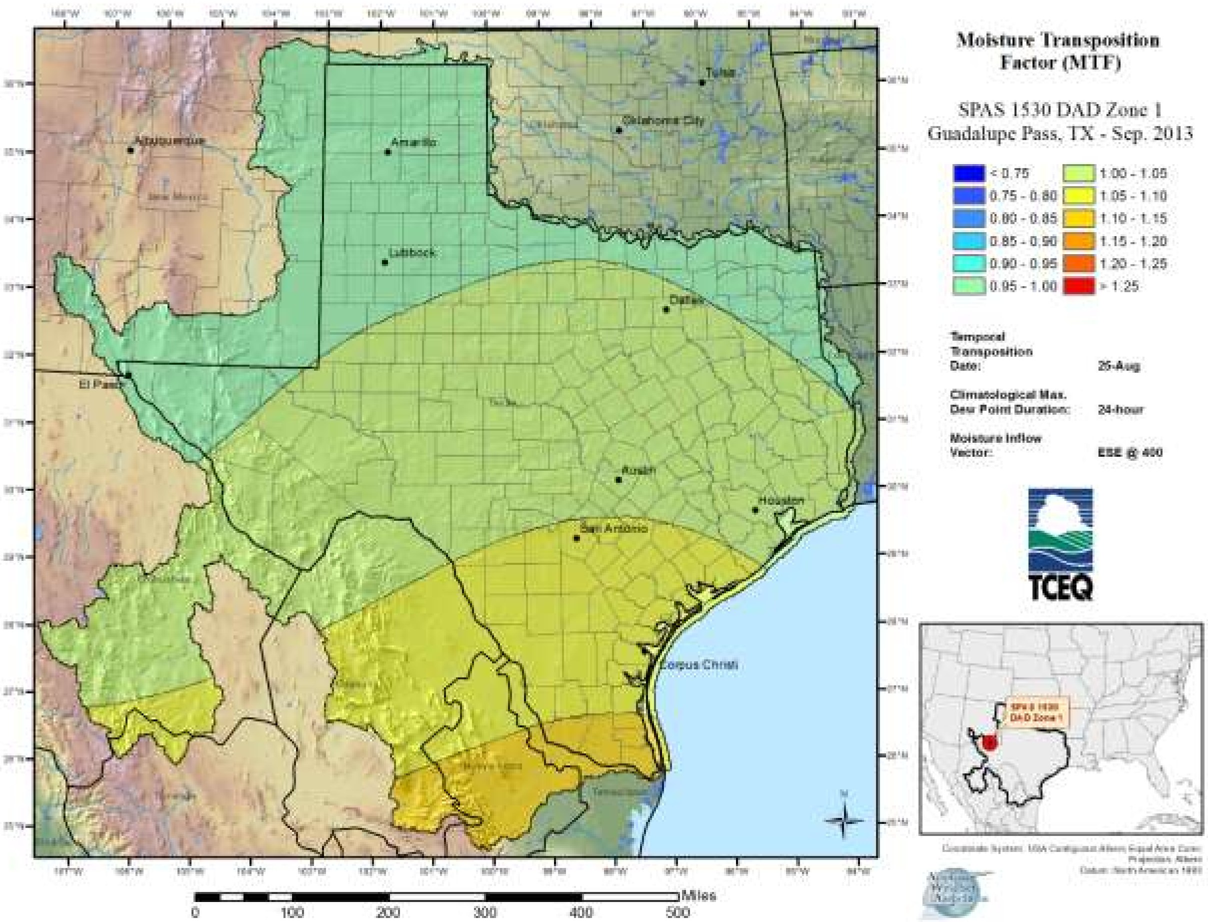

Moisture Transposition Factor (MTF)
SPAS 1428 DAD Zone 1
Fairfield, TX - Sep. 1932
< 0.75
0.75 - 0.80
0.80 - 0.85
0.85 - 0.90
0.90 - 0.95
0.95 - 1.00
1.00 - 1.05
1.05 - 1.10
1.10 - 1.15
1.15 - 1.20
1.20 - 1.25
> 1.25
Temporal Transposition Date: 20-Aug
Climatological Max. Dew Point Duration: 24-hour
Moisture Inflow Vector: SSE @ 180
TCEQ
Tulsa
Oklahoma City
Albuquerque
Amarillo
Lubbock
Dallas
El Paso
Austin
Houston
San Antonio
Corpus Christi
Miles
0
100
200
300
400
500

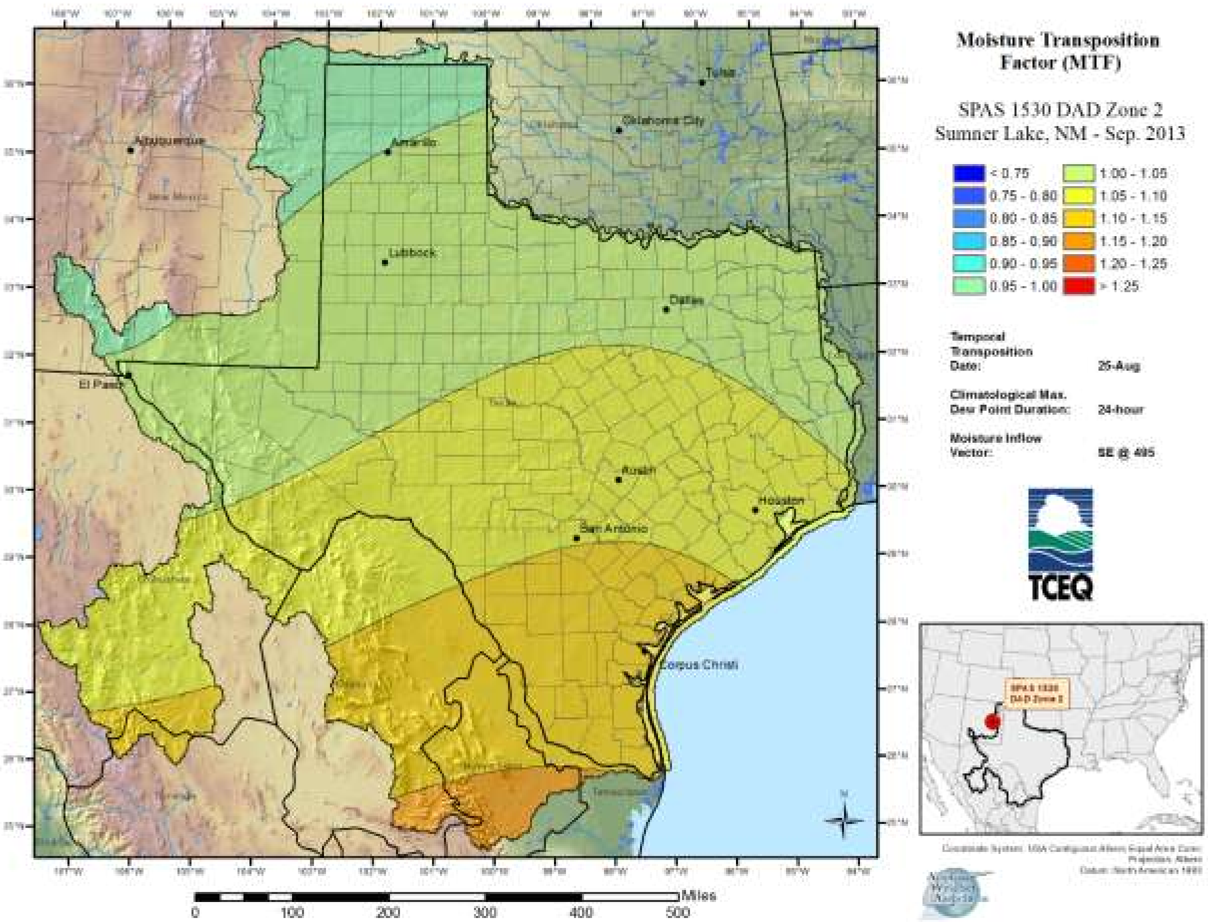

Moisture Transposition
Factor (MTF)
SPAS 1430 DAD Zone 1
Hempstead, TX - Nov. 1940
< 0.75
0.75 - 0.80
0.80 - 0.85
0.85 - 0.90
0.90 - 0.95
0.95 - 1.00
1.00 - 1.05
1.05 - 1.10
1.10 - 1.15
1.15 - 1.20
1.20 - 1.25
> 1.25
Temporal Transposition Date: 9-Nov
Climatological Max. Dew Point Duration: 24-hour
Moisture Inflow Vector: E @ 170
TCEQ
Tulsa
Oklahoma City
Albuquerque
Amarillo
Lubbock
Dallas
El Paso
Austin
Houston
San Antonio
Corpus Christi
Miles
0
100
200
300
400
500


Moisture Transposition Factor (MTF)
SPAS 1431 DAD Zone 1
Warner, OK - May 1943
< 0.75
0.75 - 0.80
0.80 - 0.85
0.85 - 0.90
0.90 - 0.95
0.95 - 1.00
1.00 - 1.05
1.05 - 1.10
1.10 - 1.15
1.15 - 1.20
1.20 - 1.25
> 1.25
Temporal Transposition Date: 24-May
Climatological Max. Dew Point Duration: 24-hour
Moisture Inflow Vector: SSW @ 290
TCEQ
Tulsa
Oklahoma City
Albuquerque
Amarillo
Lubbock
Dallas
El Paso
Austin
Houston
San Antonio
Corpus Christi
Miles
0
100
200
300
400
500

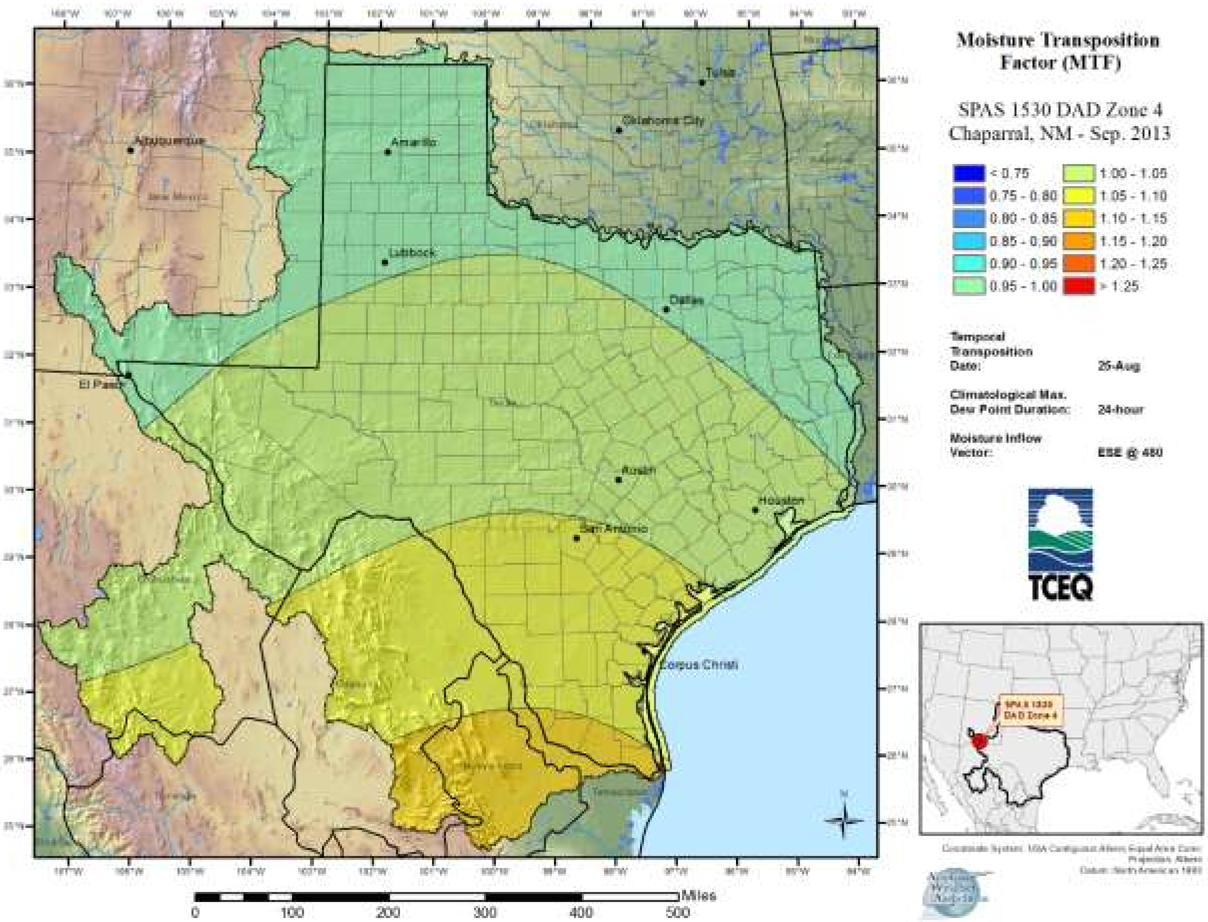

Moisture Transposition Factor (MTF)
SPAS 1435 DAD Zone 1
Harrisonburg Dam, LA - May 1953
< 0.75
0.75 - 0.80
0.80 - 0.85
0.85 - 0.90
0.90 - 0.95
0.95 - 1.00
1.00 - 1.05
1.05 - 1.10
1.10 - 1.15
1.15 - 1.20
1.20 - 1.25
> 1.25
Temporal Transposition Date: 1-Jun
Climatological Max. Dew Point Duration: SST
Moisture Inflow Vector: SSE @ 435
TCEQ
Tulsa
Oklahoma City
Albuquerque
Amarillo
Lubbock
Dallas
El Paso
Austin
Houston
San Antonio
Corpus Christi
Miles
0
100
200
300
400
500
SPAS 1435 DAD Zone 1

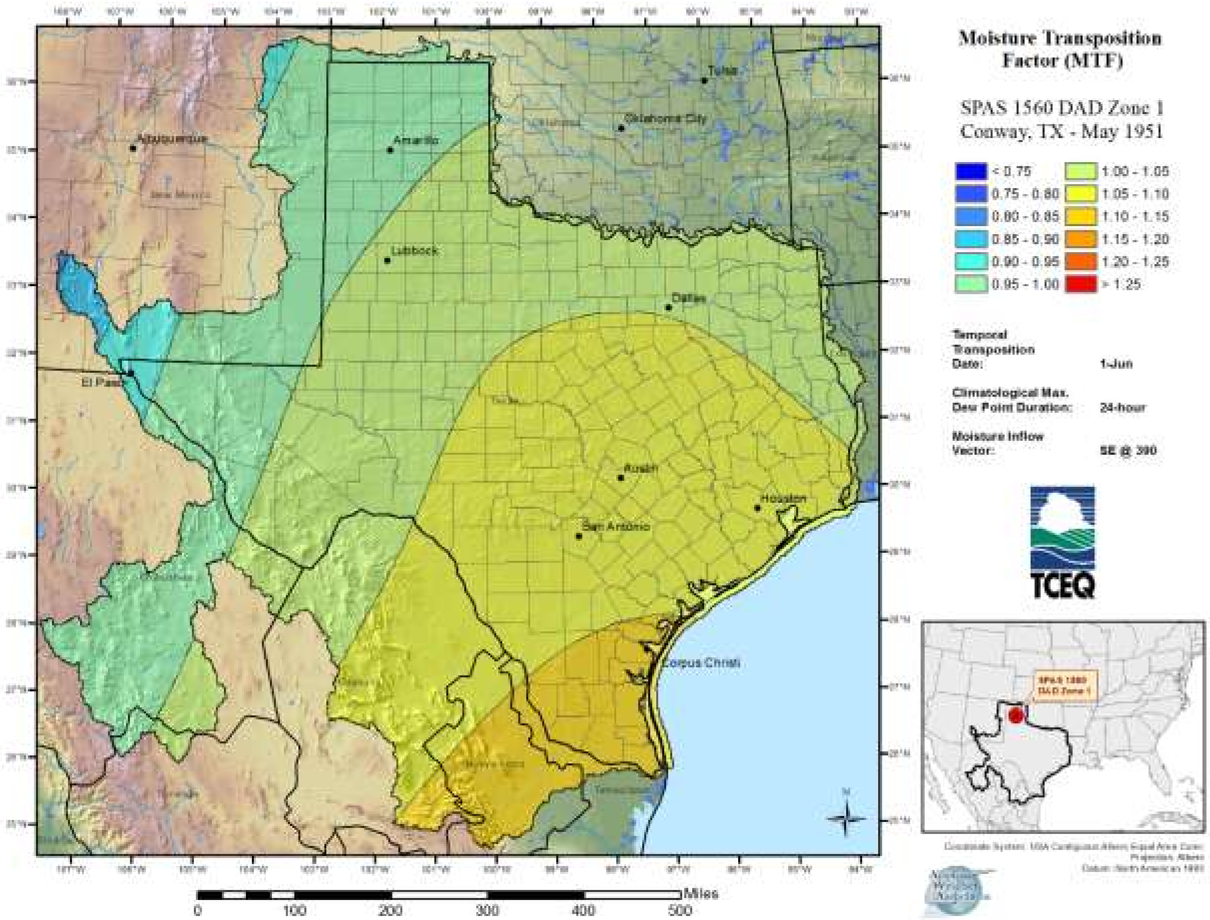

Moisture Transposition
Factor (MTF)
SPAS 1486 DAD Zone 1
McColleum Ranch, NM - Sep. 1941
< 0.75
0.75 - 0.80
0.80 - 0.85
0.85 - 0.90
0.90 - 0.95
0.95 - 1.00
1.00 - 1.05
1.05 - 1.10
1.10 - 1.15
1.15 - 1.20
1.20 - 1.25
> 1.25
Temporal Transposition Date: 10-Sep
Climatological Max. Dew Point Duration: 24-hour
Moisture Inflow Vector: ESE @ 420
TCEQ
Tulsa
Oklahoma City
Albuquerque
Amarillo
Lubbock
Dallas
El Paso
Austin
Houston
San Antonio
Corpus Christi
SPAS 1486 DAD Zone 1
Miles
0
100
200
300
400
500

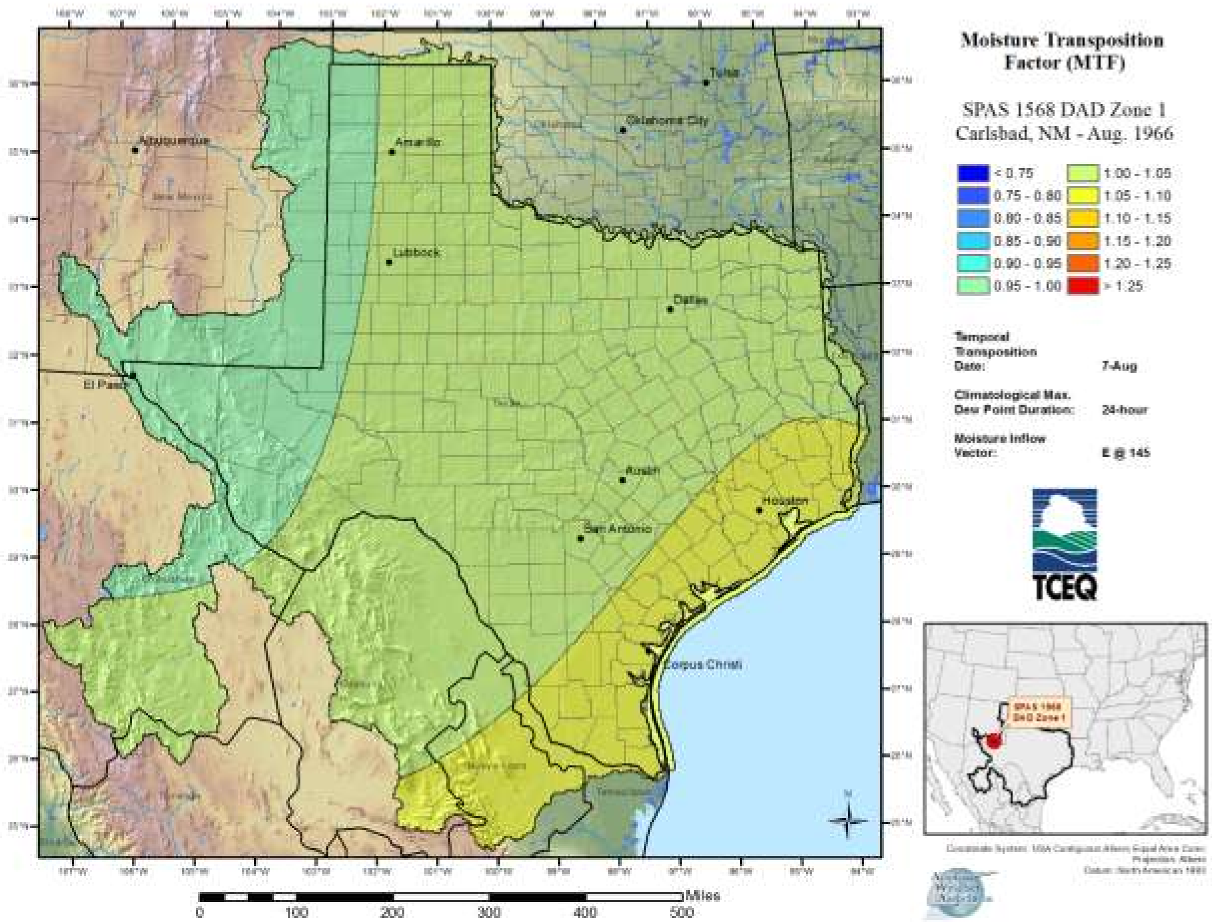

Moisture Transposition Factor (MTF)
SPAS 1530 DAD Zone 1
Guadalupe Pass, TX - Sep. 2013
< 0.75
0.75 - 0.80
0.80 - 0.85
0.85 - 0.90
0.90 - 0.95
0.95 - 1.00
1.00 - 1.05
1.05 - 1.10
1.10 - 1.15
1.15 - 1.20
1.20 - 1.25
> 1.25
Temporal Transposition Date: 25-Aug
Climatological Max. Dew Point Duration: 24-hour
Moisture Inflow Vector: ESE @ 400
TCEQ
Tulsa
Oklahoma City
Albuquerque
Amarillo
Lubbock
Dallas
El Paso
Austin
Houston
San Antonio
Corpus Christi
Miles
0
100
200
300
400
500

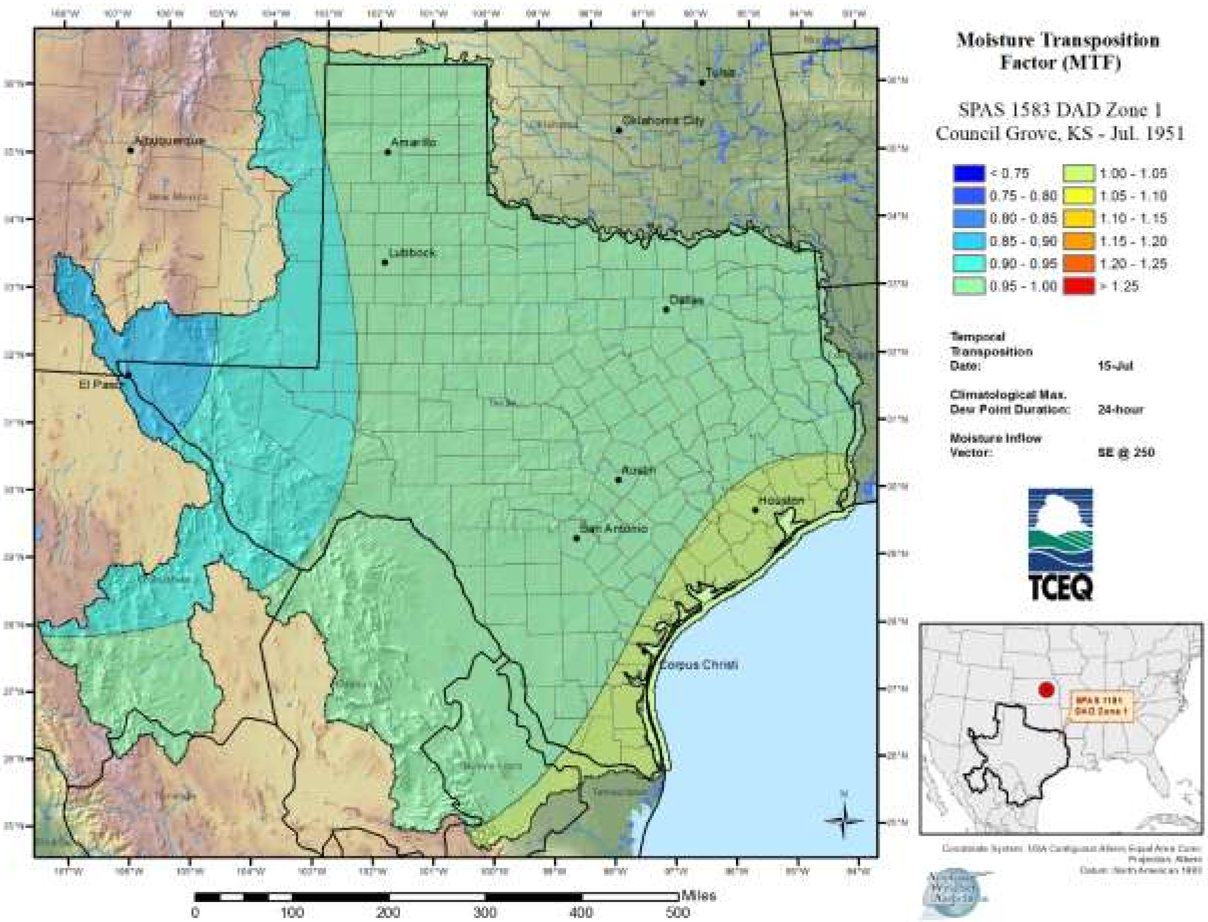


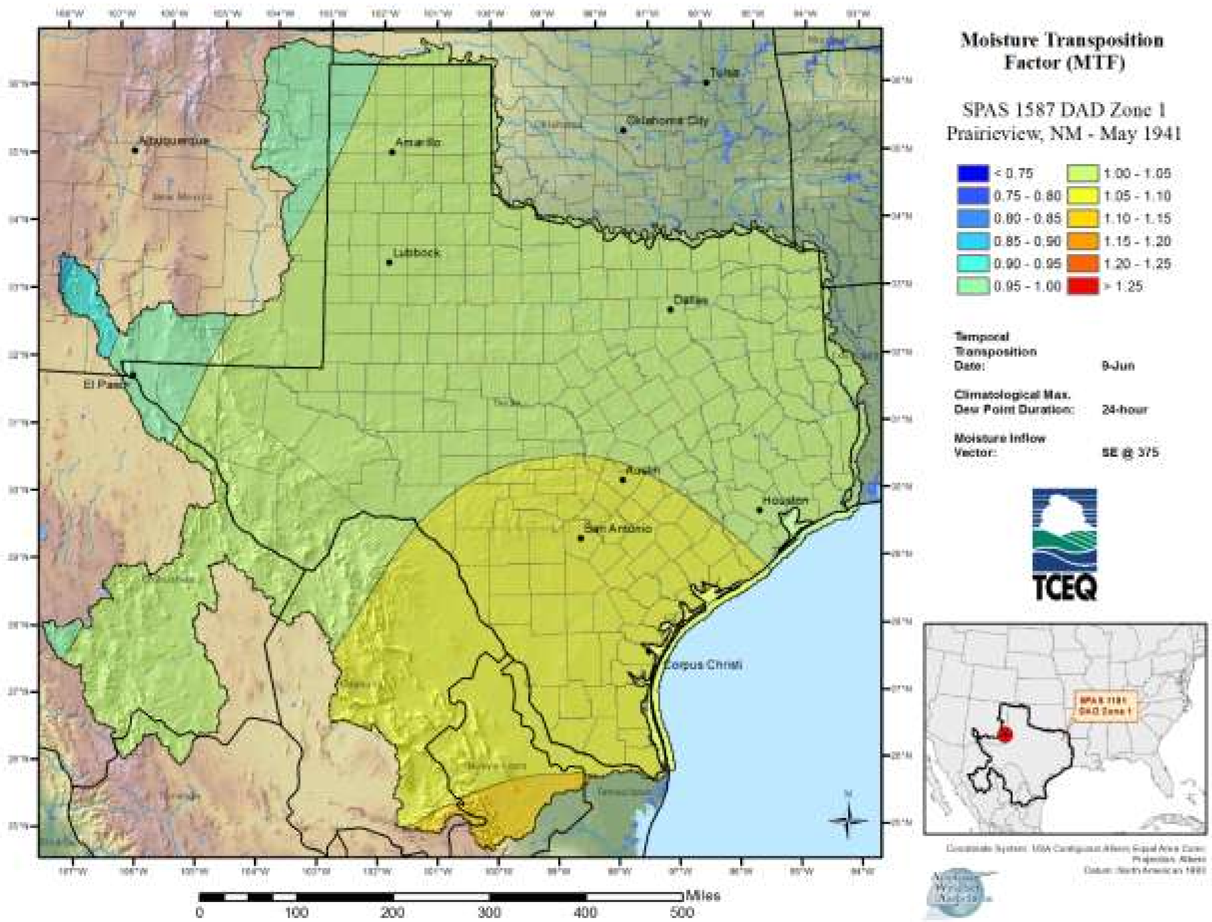
Moisture Transposition Factor (MTF)
SPAS 1530 DAD Zone 2
Sumner Lake, NM - Sep. 2013
< 0.75
0.75 - 0.80
0.80 - 0.85
0.85 - 0.90
0.90 - 0.95
0.95 - 1.00
1.00 - 1.05
1.05 - 1.10
1.10 - 1.15
1.15 - 1.20
1.20 - 1.25
> 1.25
Temporal Transposition Date: 25-Aug
Climatological Max. Dew Point Duration: 24-hour
Moisture Inflow Vector: SE @ 495
TCEQ
Tulsa
Oklahoma City
Albuquerque
Amarillo
Lubbock
Dallas
El Paso
Austin
Houston
San Antonio
Corpus Christi
Miles
0
100
200
300
400
500

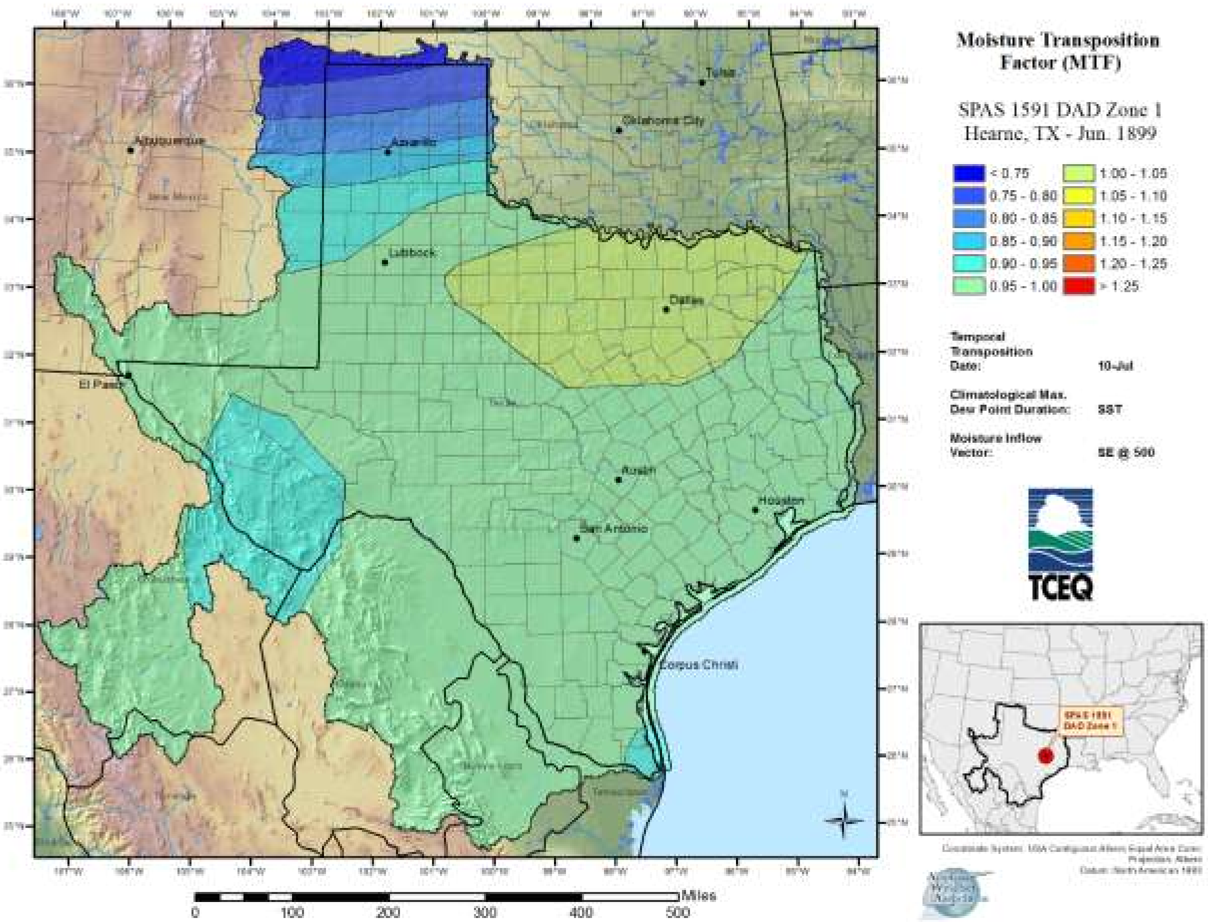

Moisture Transposition Factor (MTF)
SPAS 1530 DAD Zone 4
Chaparral, NM - Sep. 2013
< 0.75
0.75 - 0.80
0.80 - 0.85
0.85 - 0.90
0.90 - 0.95
0.95 - 1.00
1.00 - 1.05
1.05 - 1.10
1.10 - 1.15
1.15 - 1.20
1.20 - 1.25
> 1.25
Temporal Transposition Date: 25-Aug
Climatological Max. Dew Point Duration: 24-hour
Moisture Inflow Vector: ESE @ 480
TCEQ
Albuquerque
Amarillo
Lubbock
Tulsa
Oklahoma City
Dallas
El Paso
Austin
Houston
San Antonio
Corpus Christi
Miles
0
100
200
300
400
500

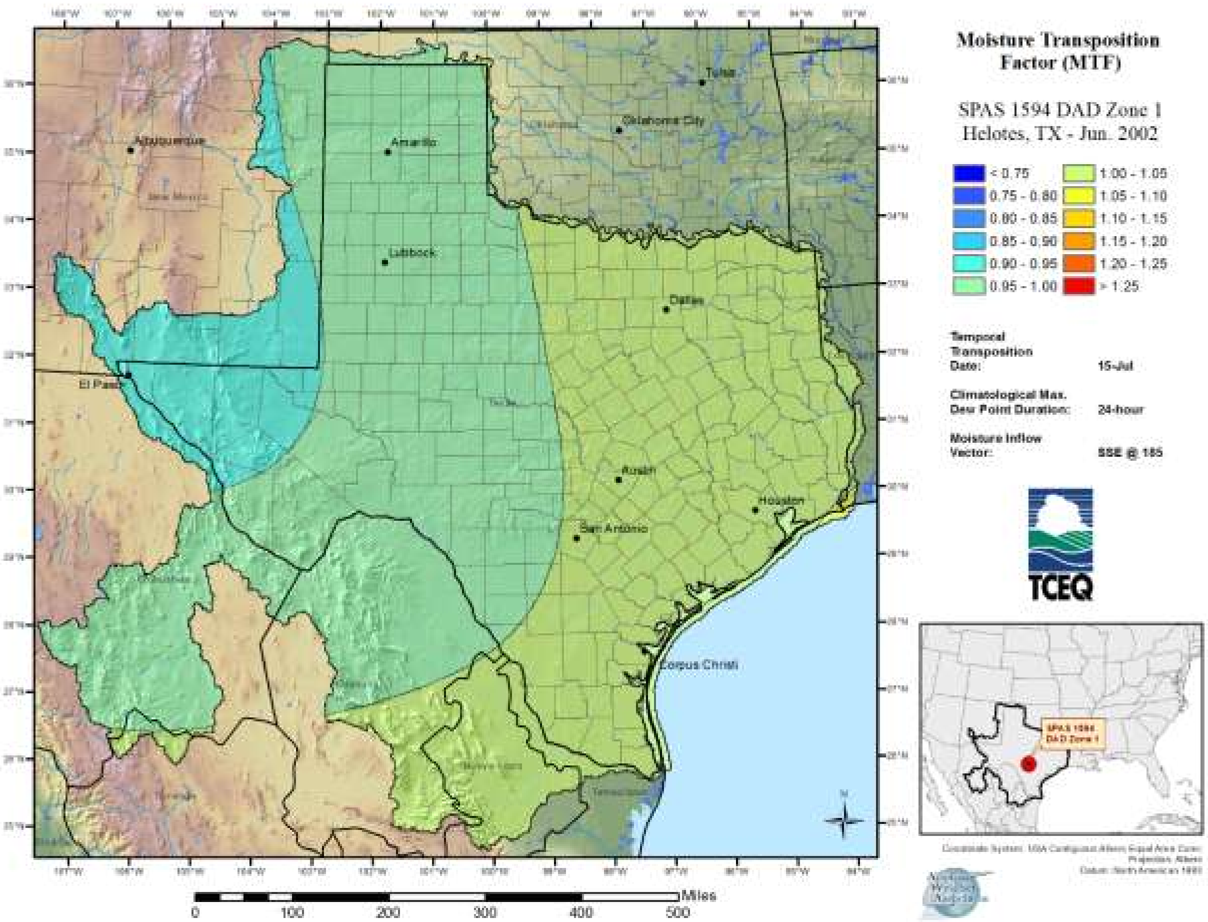

Moisture Transposition Factor (MTF)
SPAS 1560 DAD Zone 1
Conway, TX - May 1951
< 0.75
0.75 - 0.80
0.80 - 0.85
0.85 - 0.90
0.90 - 0.95
0.95 - 1.00
1.00 - 1.05
1.05 - 1.10
1.10 - 1.15
1.15 - 1.20
1.20 - 1.25
> 1.25
Temporal Transposition Date: 1-Jun
Climatological Max. Dew Point Duration: 24-hour
Moisture Inflow Vector: SE @ 390
TCEQ
Tulsa
Oklahoma City
Albuquerque
Amarillo
Lubbock
Dallas
El Paso
Austin
Houston
San Antonio
Corpus Christi
Miles
0
100
200
300
400
500

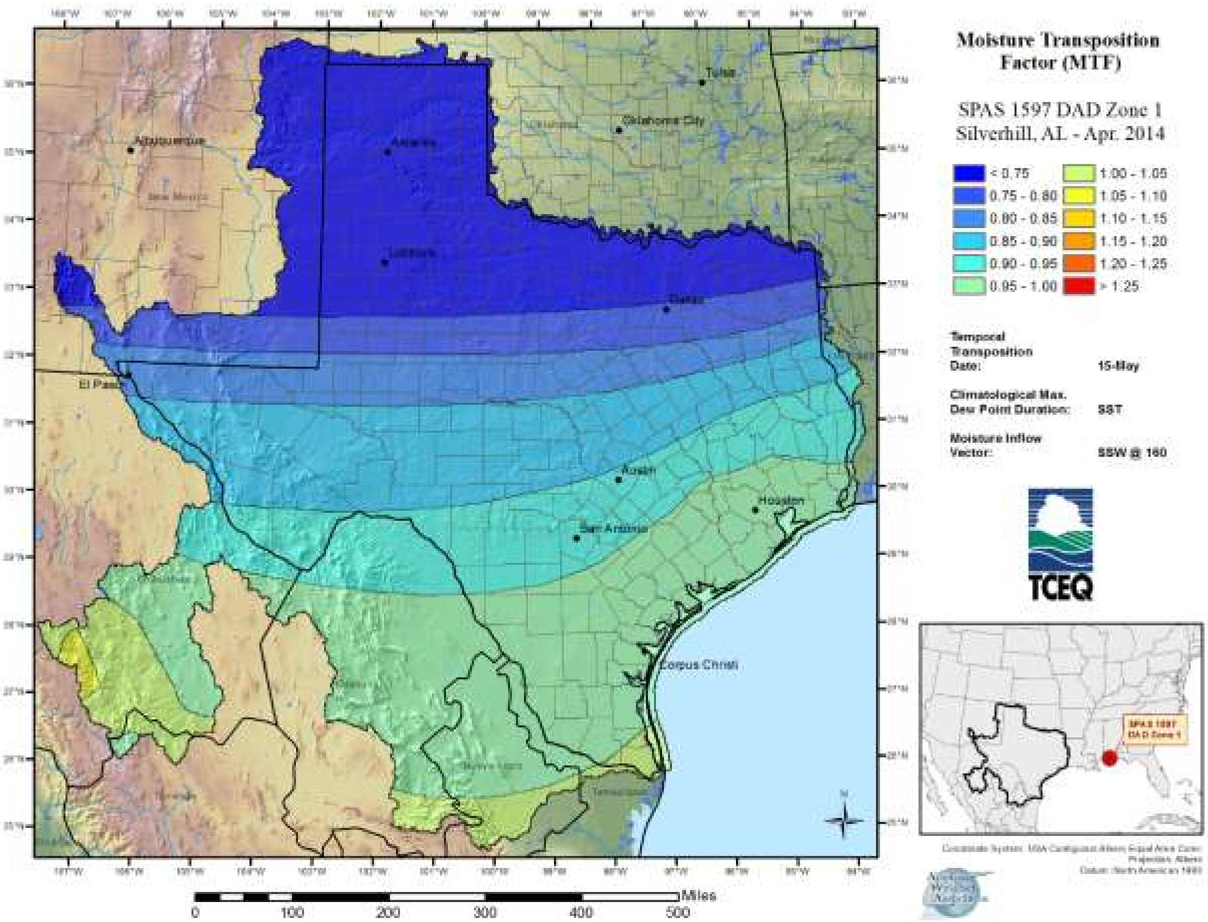

Moisture Transposition Factor (MTF)
SPAS 1568 DAD Zone 1
Carlsbad, NM - Aug. 1966
< 0.75
0.75 - 0.80
0.80 - 0.85
0.85 - 0.90
0.90 - 0.95
0.95 - 1.00
1.00 - 1.05
1.05 - 1.10
1.10 - 1.15
1.15 - 1.20
1.20 - 1.25
> 1.25
Temporal Transposition Date: 7-Aug
Climatological Max. Dew Point Duration: 24-hour
Moisture Inflow Vector: E @ 145
TCEQ
Tulsa
Oklahoma City
Albuquerque
Amarillo
Lubbock
Dallas
El Paso
Austin
Houston
San Antonio
Corpus Christi
SPAS 1568 DAD Zone 1
Miles
0
100
200
300
400
500


Moisture Transposition Factor (MTF)
SPAS 1583 DAD Zone 1
Council Grove, KS - Jul. 1951
< 0.75
0.75 - 0.80
0.80 - 0.85
0.85 - 0.90
0.90 - 0.95
0.95 - 1.00
1.00 - 1.05
1.05 - 1.10
1.10 - 1.15
1.15 - 1.20
1.20 - 1.25
> 1.25
Temporal Transposition Date: 15-Jul
Climatological Max. Dew Point Duration: 24-hour
Moisture Inflow Vector: SE @ 250
TCEQ
Tulsa
Oklahoma City
Albuquerque
Amarillo
Lubbock
Dallas
El Paso
Austin
Houston
San Antonio
Corpus Christi
Miles
0
100
200
300
400
500

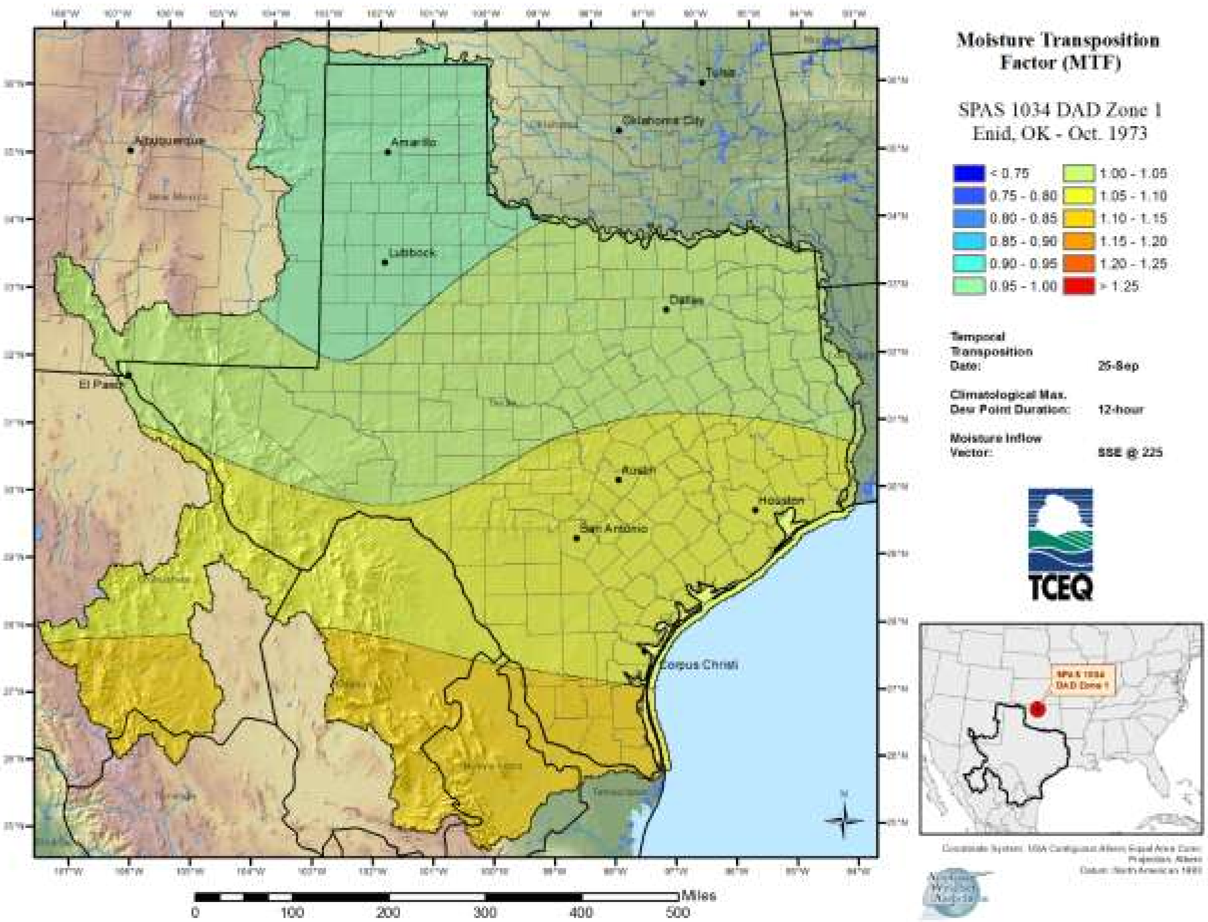

Moisture Transposition Factor (MTF)
SPAS 1587 DAD Zone 1
Prairieview, NM - May 1941
< 0.75
0.75 - 0.80
0.80 - 0.85
0.85 - 0.90
0.90 - 0.95
0.95 - 1.00
1.00 - 1.05
1.05 - 1.10
1.10 - 1.15
1.15 - 1.20
1.20 - 1.25
> 1.25
Temporal Transposition Date: 9-Jun
Climatological Max. Dew Point Duration: 24-hour
Moisture Inflow Vector: SE @ 375
TCEQ
Tulsa
Oklahoma City
Albuquerque
Amarillo
Lubbock
Dallas
El Paso
Austin
Houston
San Antonio
Corpus Christi
Miles
0
100
200
300
400
500

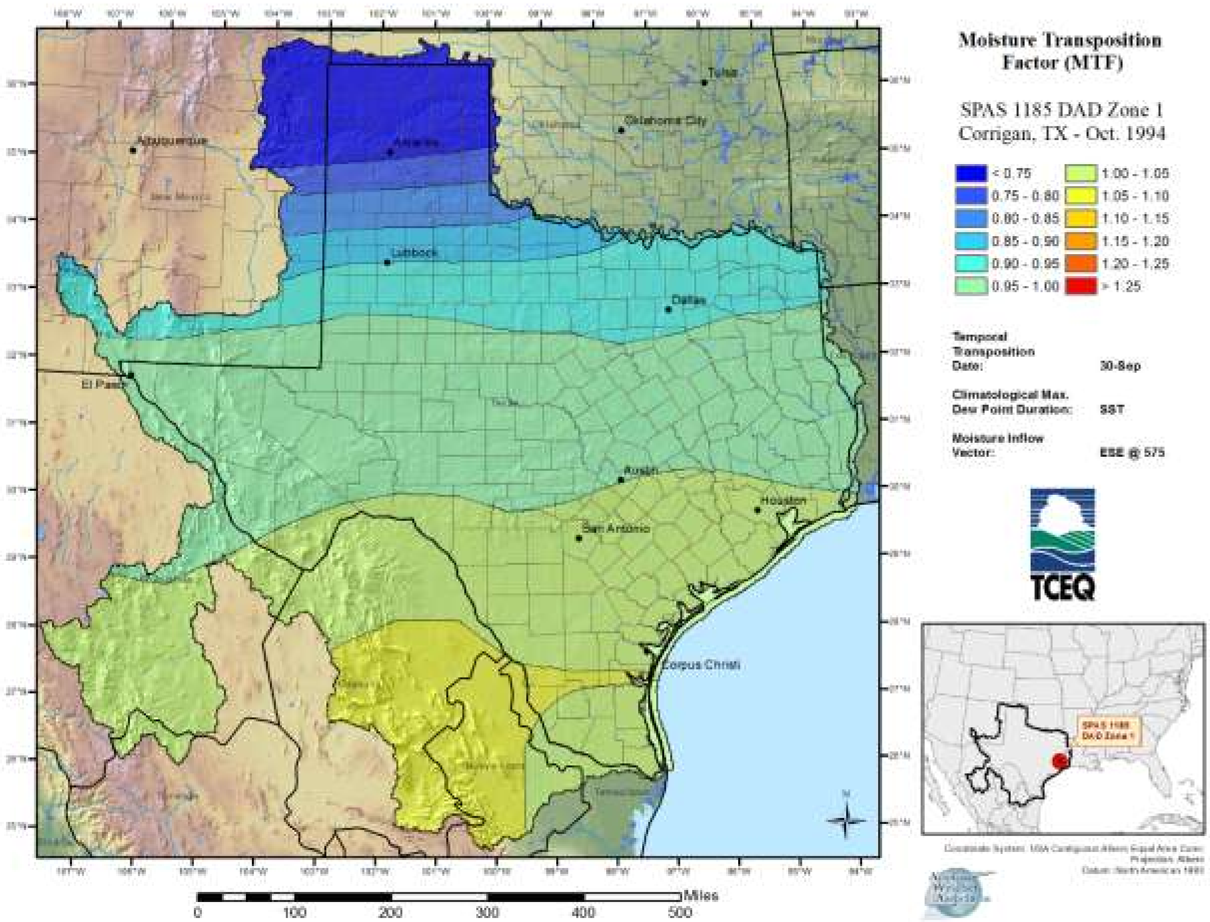

Moisture Transposition Factor (MTF)
SPAS 1591 DAD Zone 1
Hearne, TX - Jun. 1899
< 0.75
0.75 - 0.80
0.80 - 0.85
0.85 - 0.90
0.90 - 0.95
0.95 - 1.00
1.00 - 1.05
1.05 - 1.10
1.10 - 1.15
1.15 - 1.20
1.20 - 1.25
> 1.25
Temporal Transposition Date: 10-Jul
Climatological Max. Dew Point Duration: SST
Moisture Inflow Vector: SE @ 500
TCEQ
Tulsa
Oklahoma City
Albuquerque
Amarillo
Lubbock
Dallas
El Paso
Austin
Houston
San Antonio
Corpus Christi
SPAS 1591 DAD Zone 1
Miles
0
100
200
300
400
500

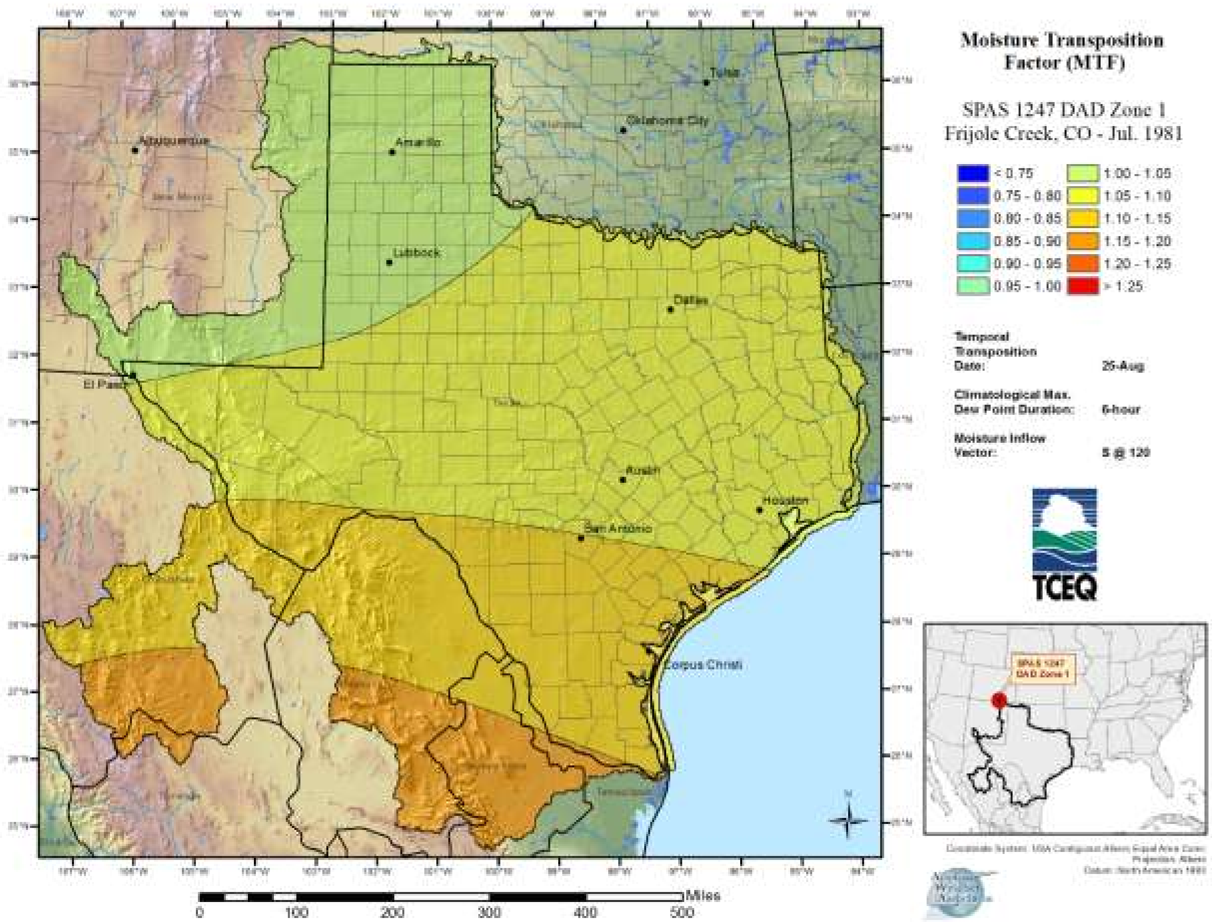

Moisture Transposition Factor (MTF)
SPAS 1594 DAD Zone 1
Helotes, TX - Jun. 2002
< 0.75
0.75 - 0.80
0.80 - 0.85
0.85 - 0.90
0.90 - 0.95
0.95 - 1.00
1.00 - 1.05
1.05 - 1.10
1.10 - 1.15
1.15 - 1.20
1.20 - 1.25
> 1.25
Temporal Transposition Date: 15-Jul
Climatological Max. Dew Point Duration: 24-hour
Moisture Inflow Vector: SSE @ 185
TCEQ
Tulsa
Oklahoma City
Albuquerque
Amarillo
Lubbock
Dallas
El Paso
Austin
Houston
San Antonio
Corpus Christi
SPAS 1594 DAD Zone 1
Miles
0
100
200
300
400
500


Moisture Transposition Factor (MTF)
SPAS 1597 DAD Zone 1
Silverhill, AL - Apr. 2014
< 0.75
0.75 - 0.80
0.80 - 0.85
0.85 - 0.90
0.90 - 0.95
0.95 - 1.00
1.00 - 1.05
1.05 - 1.10
1.10 - 1.15
1.15 - 1.20
1.20 - 1.25
> 1.25
Temporal Transposition Date: 15-May
Climatological Max. Dew Point Duration: SST
Moisture Inflow Vector: SSW @ 160
TCEQ
Tulsa
Oklahoma City
Albuquerque
Amarillo
Lubbock
Dallas
El Paso
Austin
Houston
San Antonio
Corpus Christi
Miles
0
100
200
300
400
500

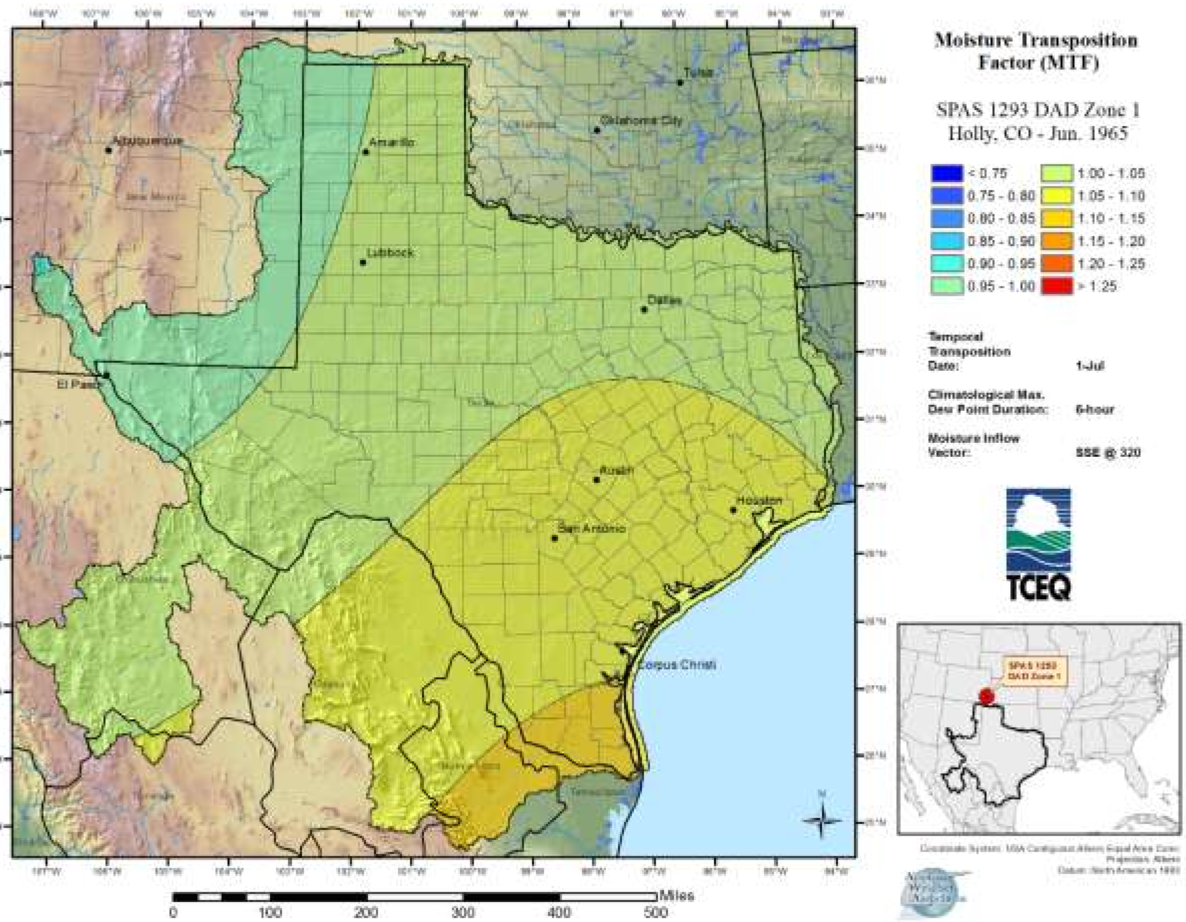
Local Storms


Moisture Transposition Factor (MTF)
SPAS 1034 DAD Zone 1
Enid, OK - Oct. 1973
< 0.75
0.75 - 0.80
0.80 - 0.85
0.85 - 0.90
0.90 - 0.95
0.95 - 1.00
1.00 - 1.05
1.05 - 1.10
1.10 - 1.15
1.15 - 1.20
1.20 - 1.25
> 1.25
Temporal Transposition Date: 25-Sep
Climatological Max. Dew Point Duration: 12-hour
Moisture Inflow Vector: SSE @ 225
TCEQ
Tulsa
Oklahoma City
Albuquerque
Amarillo
Lubbock
Dallas
El Paso
Austin
Houston
San Antonio
Corpus Christi
SPAS 1034 DAD Zone 1
Miles
0
100
200
300
400
500

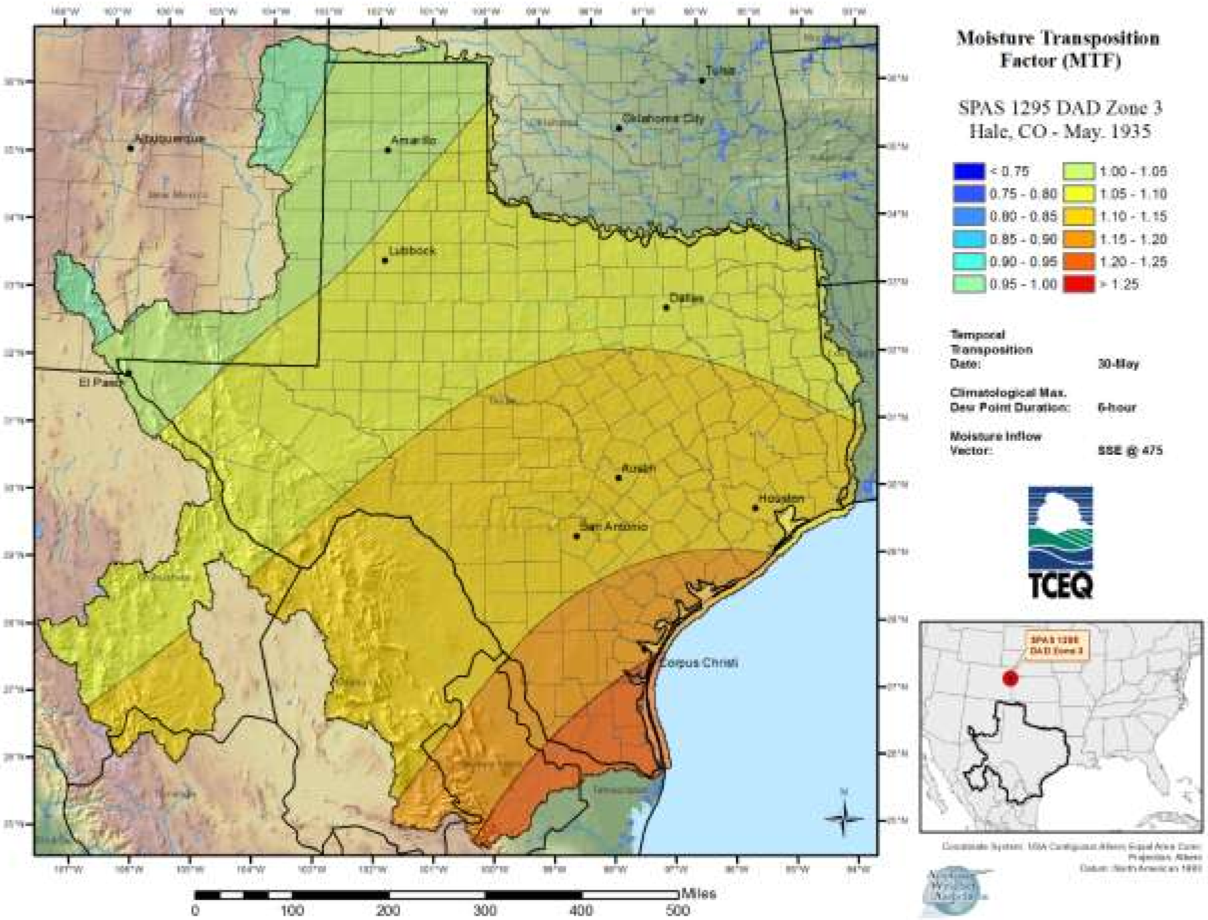

Moisture Transposition Factor (MTF)
SPAS 1185 DAD Zone 1
Corrigan, TX - Oct. 1994
< 0.75
0.75 - 0.80
0.80 - 0.85
0.85 - 0.90
0.90 - 0.95
0.95 - 1.00
1.00 - 1.05
1.05 - 1.10
1.10 - 1.15
1.15 - 1.20
1.20 - 1.25
> 1.25
Temporal Transposition Date: 30-Sep
Climatological Max. Dew Point Duration: SST
Moisture Inflow Vector: ESE @ 575
TCEQ
Tulsa
Oklahoma City
Albuquerque
Amarillo
Lubbock
Dallas
El Paso
Austin
Houston
San Antonio
Corpus Christi
Miles
0
100
200
300
400
500

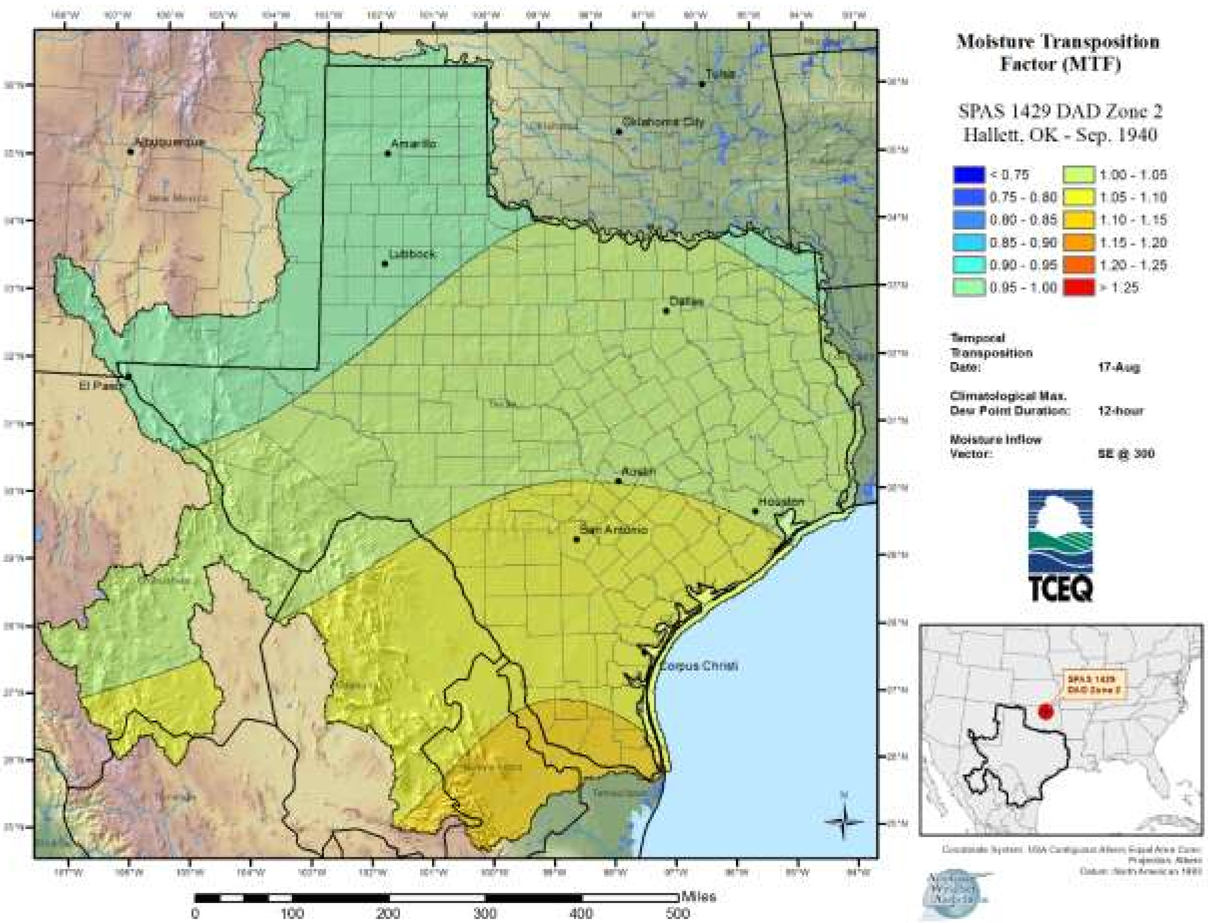


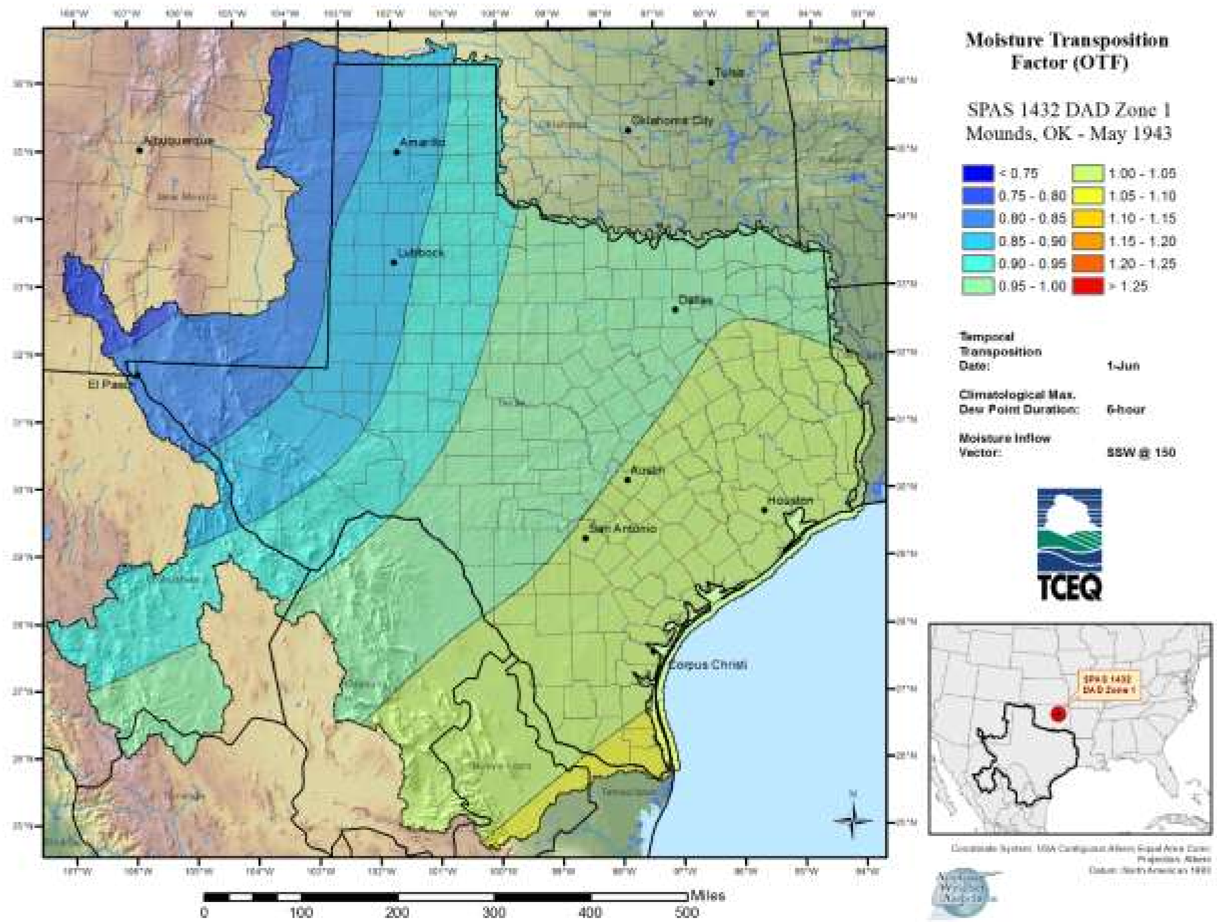
Moisture Transposition Factor (MTF)
SPAS 1247 DAD Zone 1
Frijole Creek, CO - Jul. 1981
< 0.75
0.75 - 0.80
0.80 - 0.85
0.85 - 0.90
0.90 - 0.95
0.95 - 1.00
1.00 - 1.05
1.05 - 1.10
1.10 - 1.15
1.15 - 1.20
1.20 - 1.25
> 1.25
Temporal Transposition Date: 25-Aug
Climatological Max. Dew Point Duration: 6-hour
Moisture Inflow Vector: S @ 120
TCEQ
Tulsa
Oklahoma City
Albuquerque
Amarillo
Lubbock
Dallas
El Paso
Austin
Houston
San Antonio
Corpus Christi
Miles
0
100
200
300
400
500

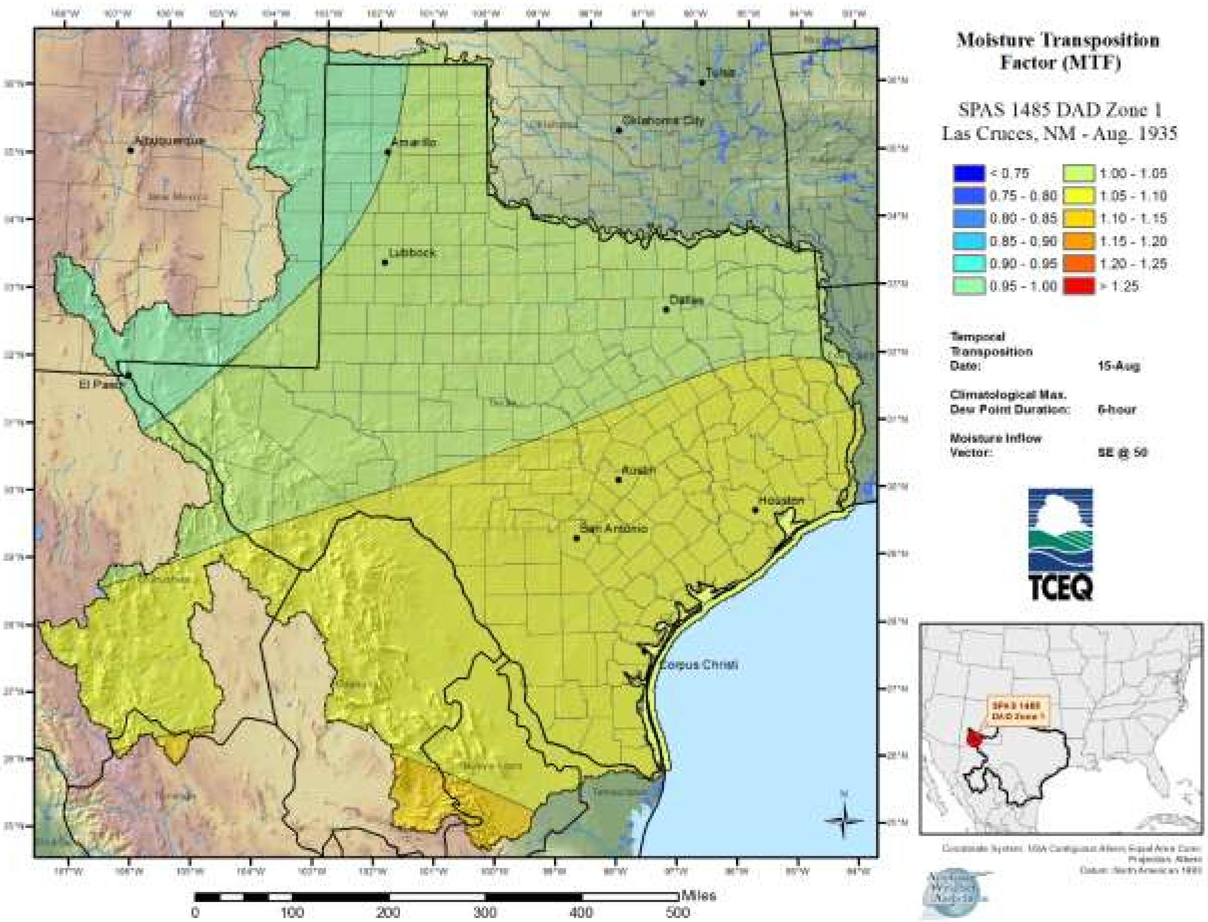


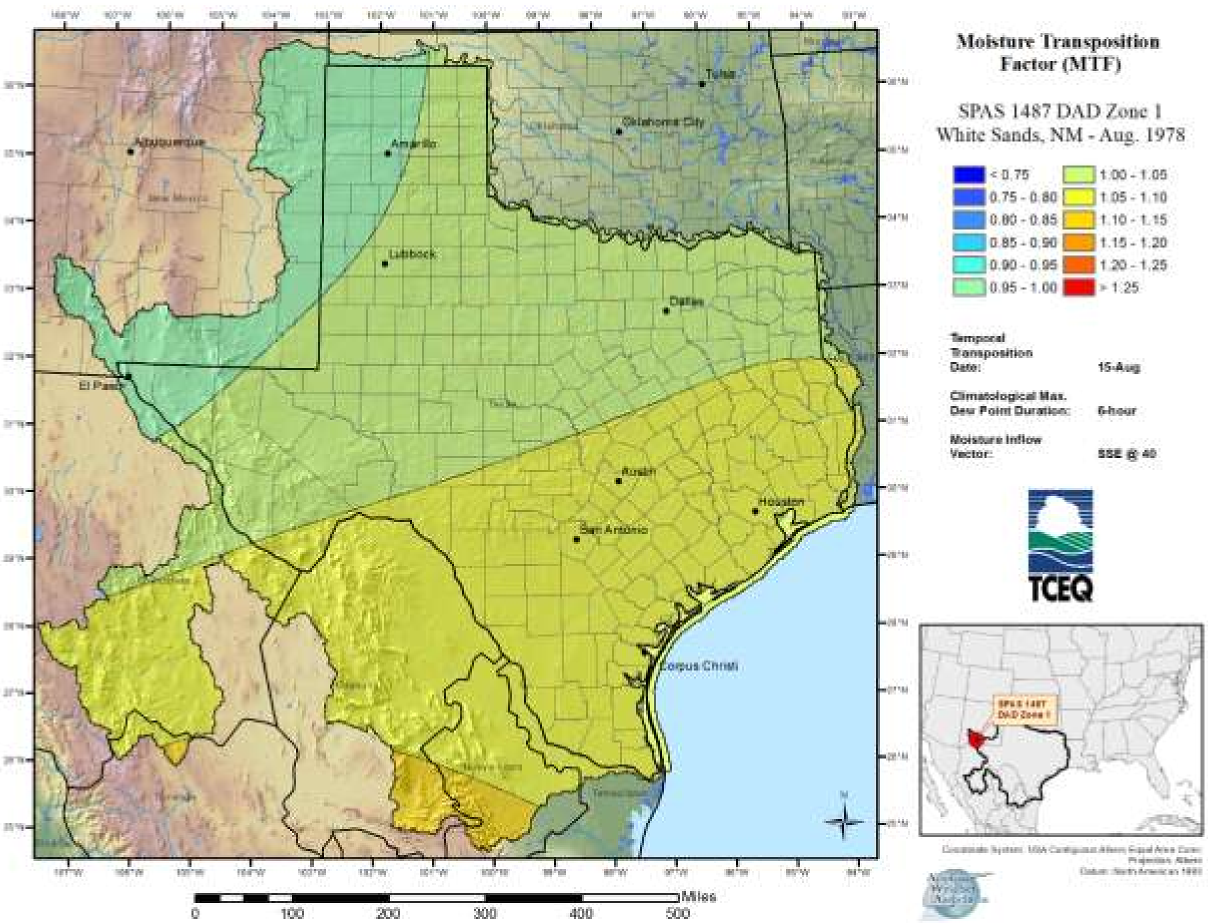
Moisture Transposition Factor (MTF)
SPAS 1293 DAD Zone 1
Holly, CO - Jun. 1965
< 0.75
0.75 - 0.80
0.80 - 0.85
0.85 - 0.90
0.90 - 0.95
0.95 - 1.00
1.00 - 1.05
1.05 - 1.10
1.10 - 1.15
1.15 - 1.20
1.20 - 1.25
> 1.25
Temporal Transposition Date: 1-Jul
Climatological Max. Dew Point Duration: 6-hour
Moisture Inflow Vector: SSE @ 320
TCEQ
SPAS 1293 DAD Zone 1
Tulsa
Oklahoma City
Albuquerque
Amarillo
Lubbock
Dallas
El Paso
Austin
Houston
San Antonio
Corpus Christi
Miles
0
100
200
300
400
500

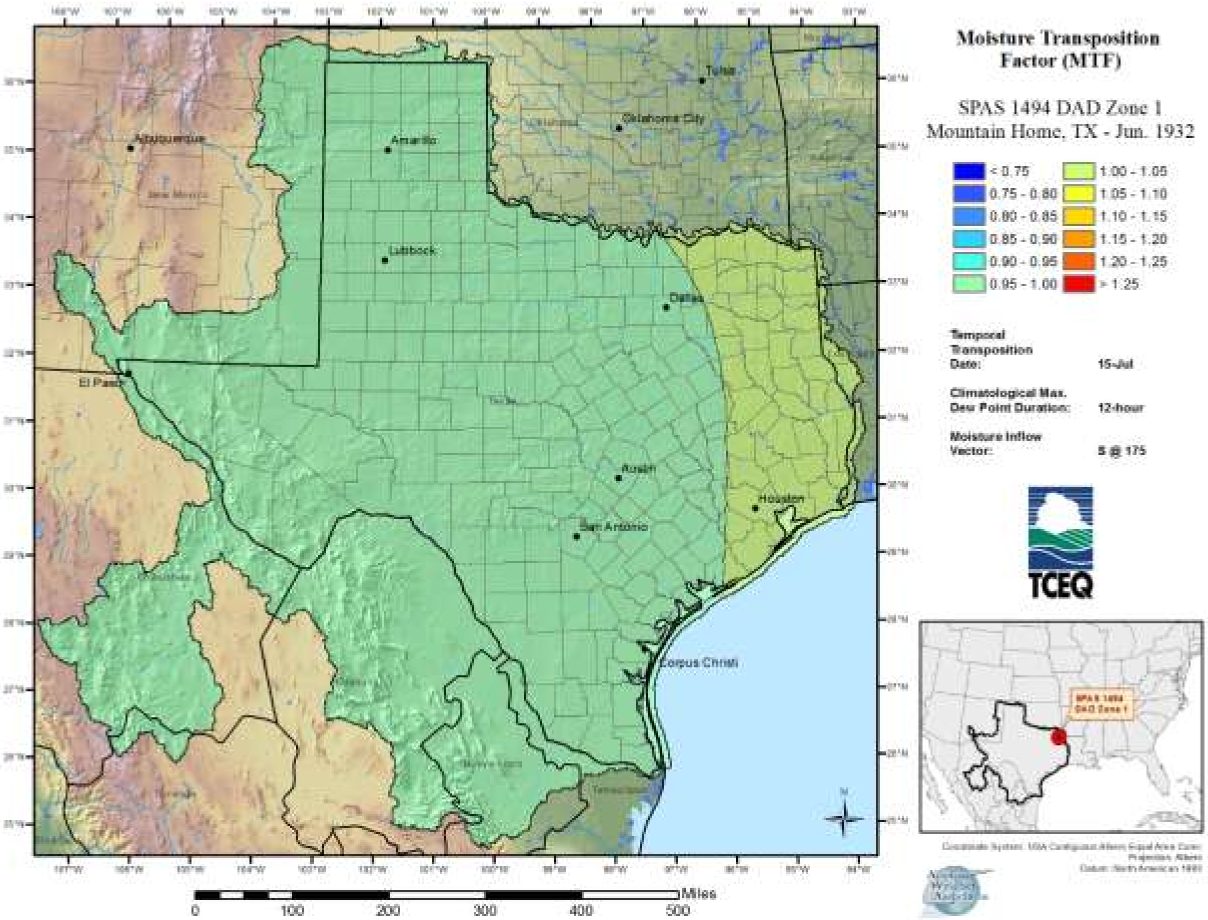

Moisture Transposition Factor (MTF)
SPAS 1295 DAD Zone 3
Hale, CO - May. 1935
< 0.75
0.75 - 0.80
0.80 - 0.85
0.85 - 0.90
0.90 - 0.95
0.95 - 1.00
1.00 - 1.05
1.05 - 1.10
1.10 - 1.15
1.15 - 1.20
1.20 - 1.25
> 1.25
Temporal Transposition Date: 30-May
Climatological Max. Dew Point Duration: 6-hour
Moisture Inflow Vector: SSE @ 475
TCEQ
Tulsa
Oklahoma City
Albuquerque
Amarillo
Lubbock
Dallas
El Paso
Austin
Houston
San Antonio
Corpus Christi
Miles
0
100
200
300
400
500

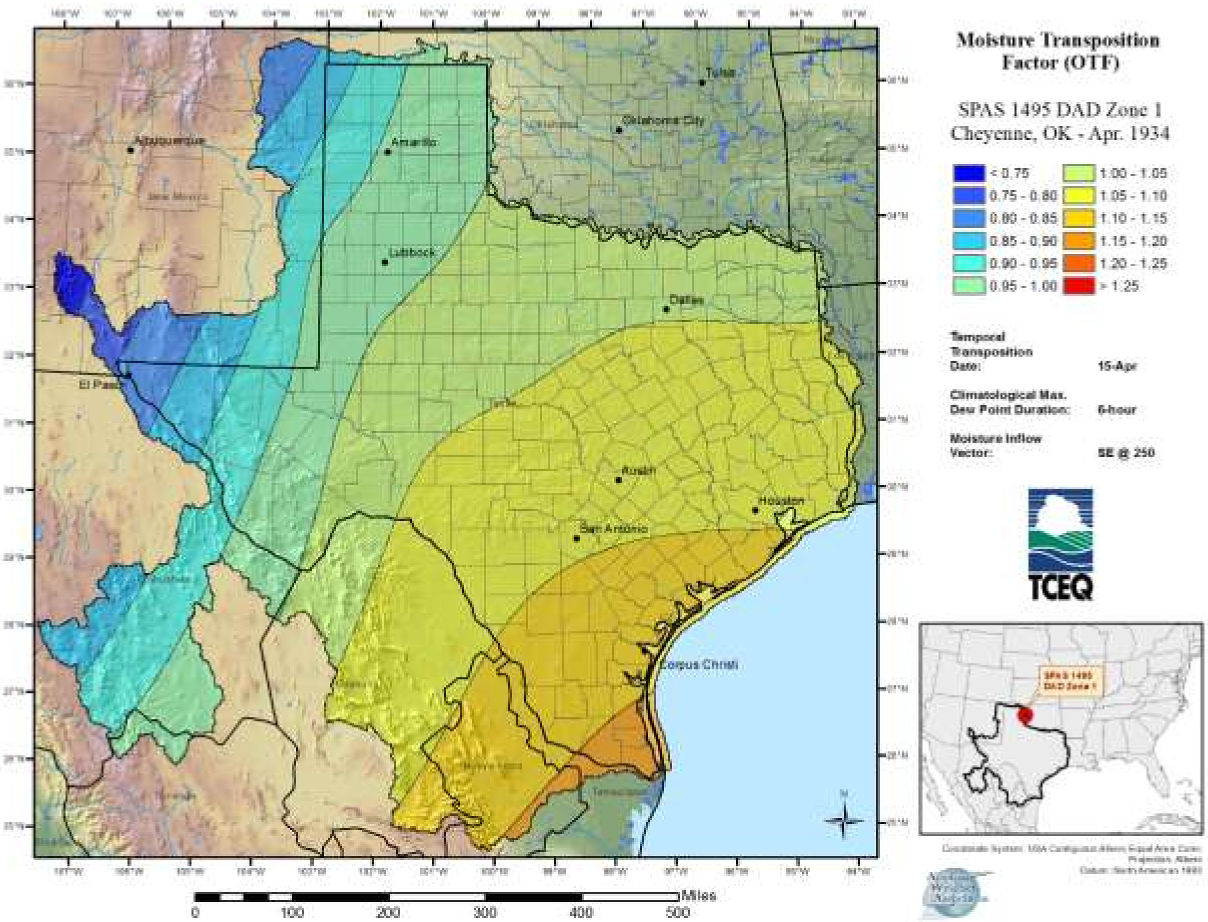

Moisture Transposition Factor (MTF)
SPAS 1429 DAD Zone 2
Hallett, OK - Sep. 1940
< 0.75
0.75 - 0.80
0.80 - 0.85
0.85 - 0.90
0.90 - 0.95
0.95 - 1.00
1.00 - 1.05
1.05 - 1.10
1.10 - 1.15
1.15 - 1.20
1.20 - 1.25
> 1.25
Temporal Transposition Date: 17-Aug
Climatological Max. Dew Point Duration: 12-hour
Moisture Inflow Vector: SE @ 300
TCEQ
Tulsa
Oklahoma City
Albuquerque
Amarillo
Lubbock
Dallas
El Paso
Austin
Houston
San Antonio
Corpus Christi
Miles
0
100
200
300
400
500


Moisture Transposition Factor (OTF)
SPAS 1432 DAD Zone 1
Mounds, OK - May 1943
< 0.75
0.75 - 0.80
0.80 - 0.85
0.85 - 0.90
0.90 - 0.95
0.95 - 1.00
1.00 - 1.05
1.05 - 1.10
1.10 - 1.15
1.15 - 1.20
1.20 - 1.25
> 1.25
Temporal Transposition Date: 1-Jun
Climatological Max. Dew Point Duration: 6-hour
Moisture Inflow Vector: SSW @ 150
Tulsa
Oklahoma City
Albuquerque
Amarillo
Lubbock
Dallas
El Paso
Austin
Houston
San Antonio
Corpus Christi
Miles
0
100
200
300
400
500
SPAS 1432 DAD Zone 1

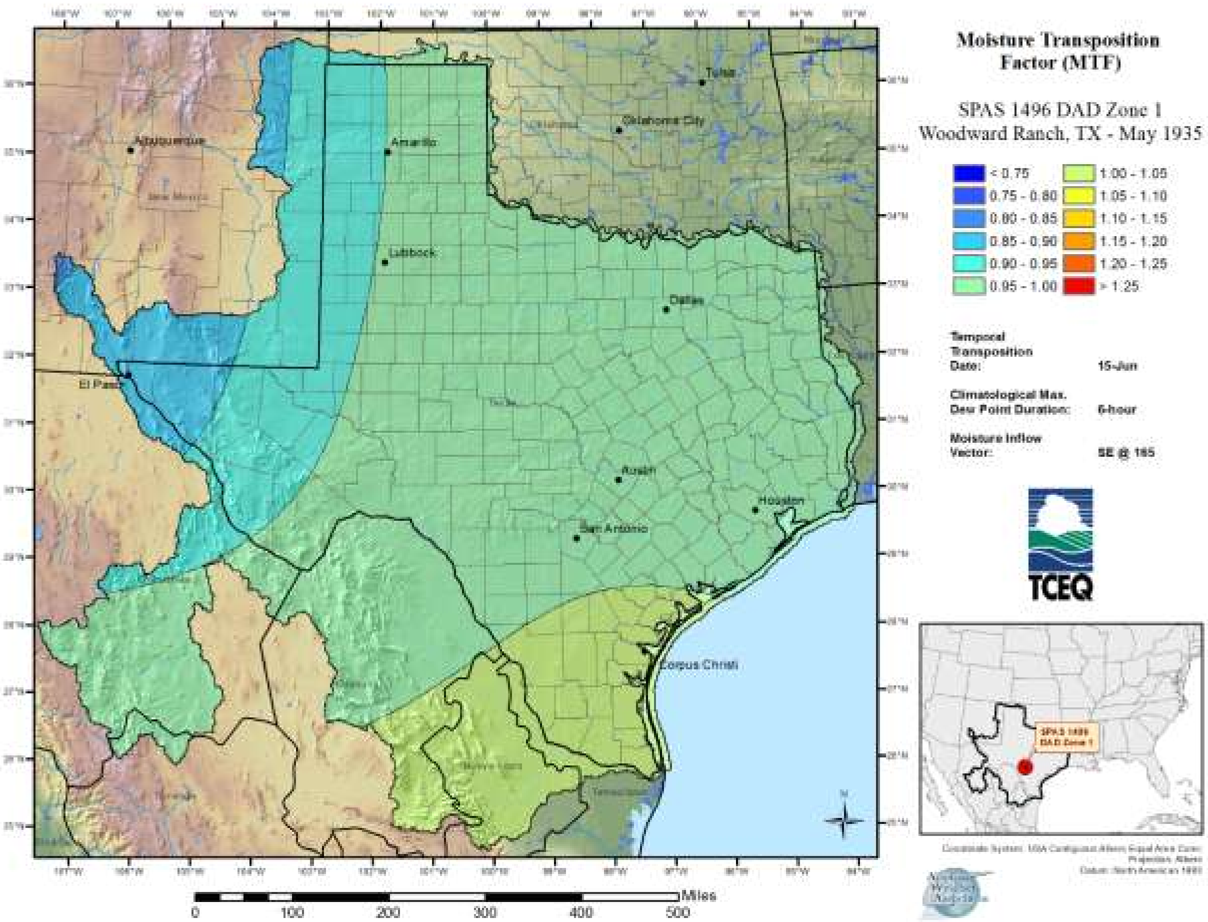

Moisture Transposition Factor (MTF)
SPAS 1485 DAD Zone 1
Las Cruces, NM - Aug. 1935
< 0.75
0.75 - 0.80
0.80 - 0.85
0.85 - 0.90
0.90 - 0.95
0.95 - 1.00
1.00 - 1.05
1.05 - 1.10
1.10 - 1.15
1.15 - 1.20
1.20 - 1.25
> 1.25
Temporal Transposition Date: 15-Aug
Climatological Max. Dew Point Duration: 6-hour
Moisture Inflow Vector: SE @ 50
TCEQ
Tulsa
Oklahoma City
Albuquerque
Amarillo
Lubbock
Dallas
El Paso
Austin
Houston
San Antonio
Corpus Christi
SPAS 1485 DAD Zone 1
Miles
0
100
200
300
400
500


Moisture Transposition
Factor (MTF)
SPAS 1487 DAD Zone 1
White Sands, NM - Aug. 1978
< 0.75
0.75 - 0.80
0.80 - 0.85
0.85 - 0.90
0.90 - 0.95
0.95 - 1.00
1.00 - 1.05
1.05 - 1.10
1.10 - 1.15
1.15 - 1.20
1.20 - 1.25
> 1.25
Temporal Transposition Date: 15-Aug
Climatological Max. Dew Point Duration: 6-hour
Moisture Inflow Vector: SSE @ 40
TCEQ
Tulsa
Oklahoma City
Albuquerque
Amarillo
Lubbock
Dallas
El Paso
Austin
Houston
San Antonio
Corpus Christi
SPAS 1487
DAD Zone 1
Miles
0
100
200
300
400
500

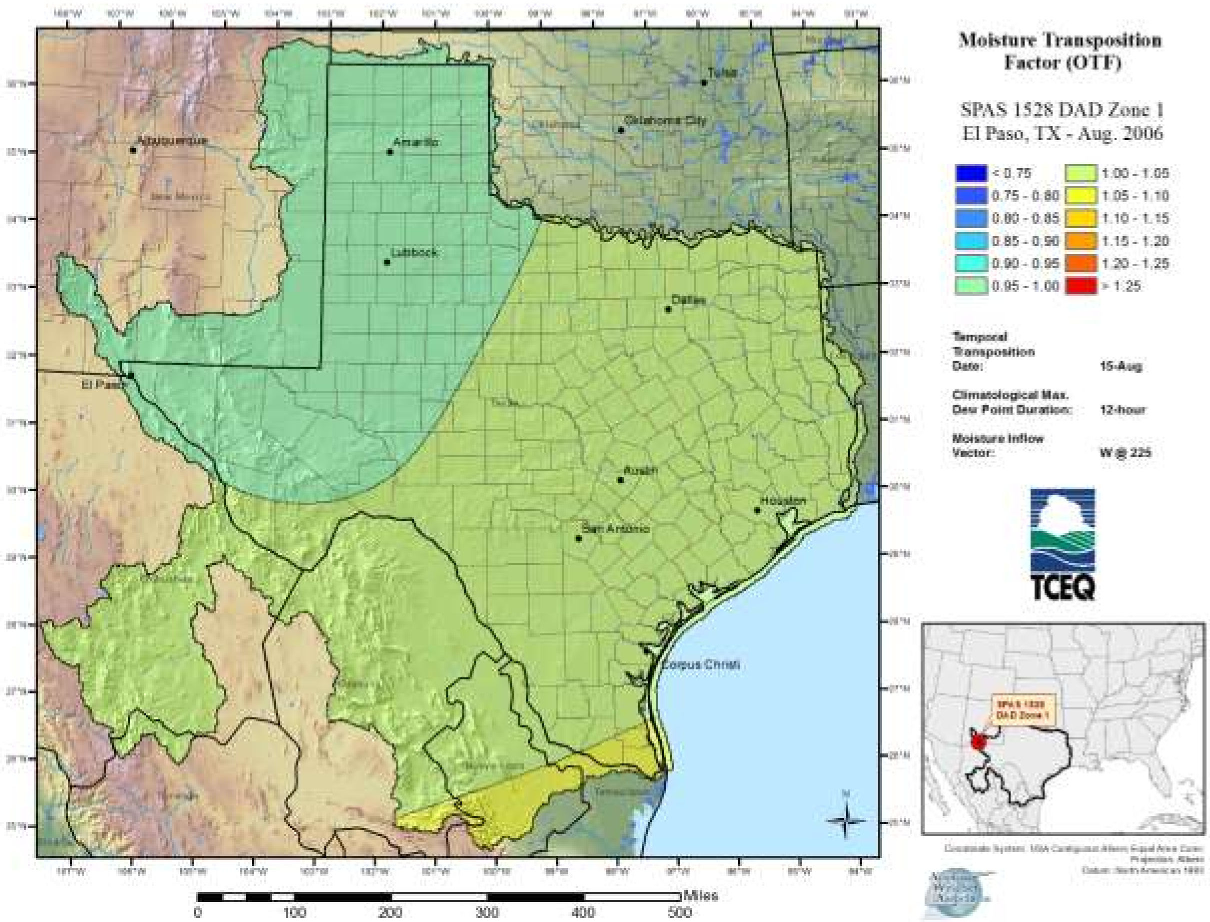

Moisture Transposition Factor (MTF)
SPAS 1494 DAD Zone 1
Mountain Home, TX - Jun. 1932
< 0.75
0.75 - 0.80
0.80 - 0.85
0.85 - 0.90
0.90 - 0.95
0.95 - 1.00
1.00 - 1.05
1.05 - 1.10
1.10 - 1.15
1.15 - 1.20
1.20 - 1.25
> 1.25
Temporal Transposition Date: 15-Jul
Climatological Max. Dew Point Duration: 12-hour
Moisture Inflow Vector: S @ 175
TCEQ
Tulsa
Oklahoma City
Albuquerque
Amarillo
Lubbock
Dallas
El Paso
Austin
Houston
San Antonio
Corpus Christi
Miles
0
100
200
300
400
500

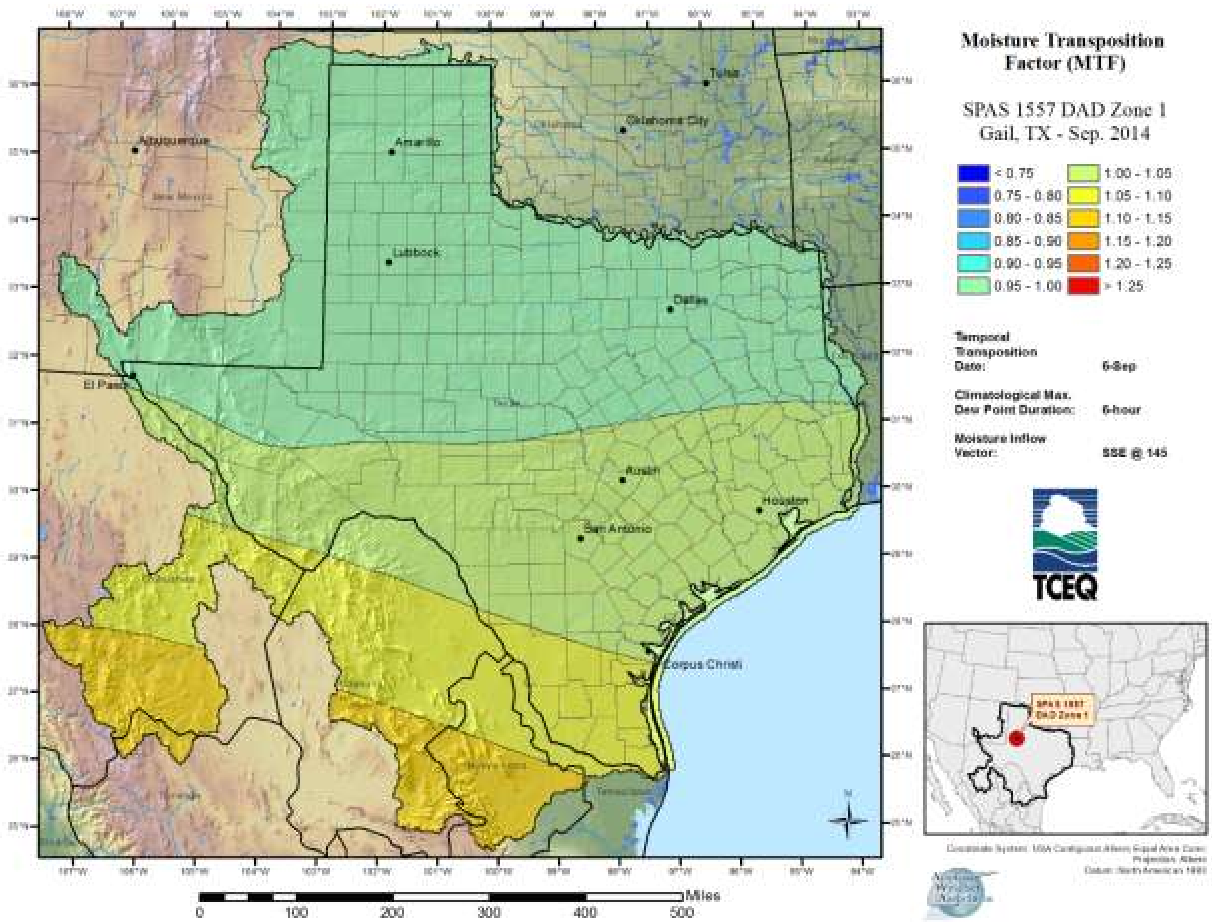


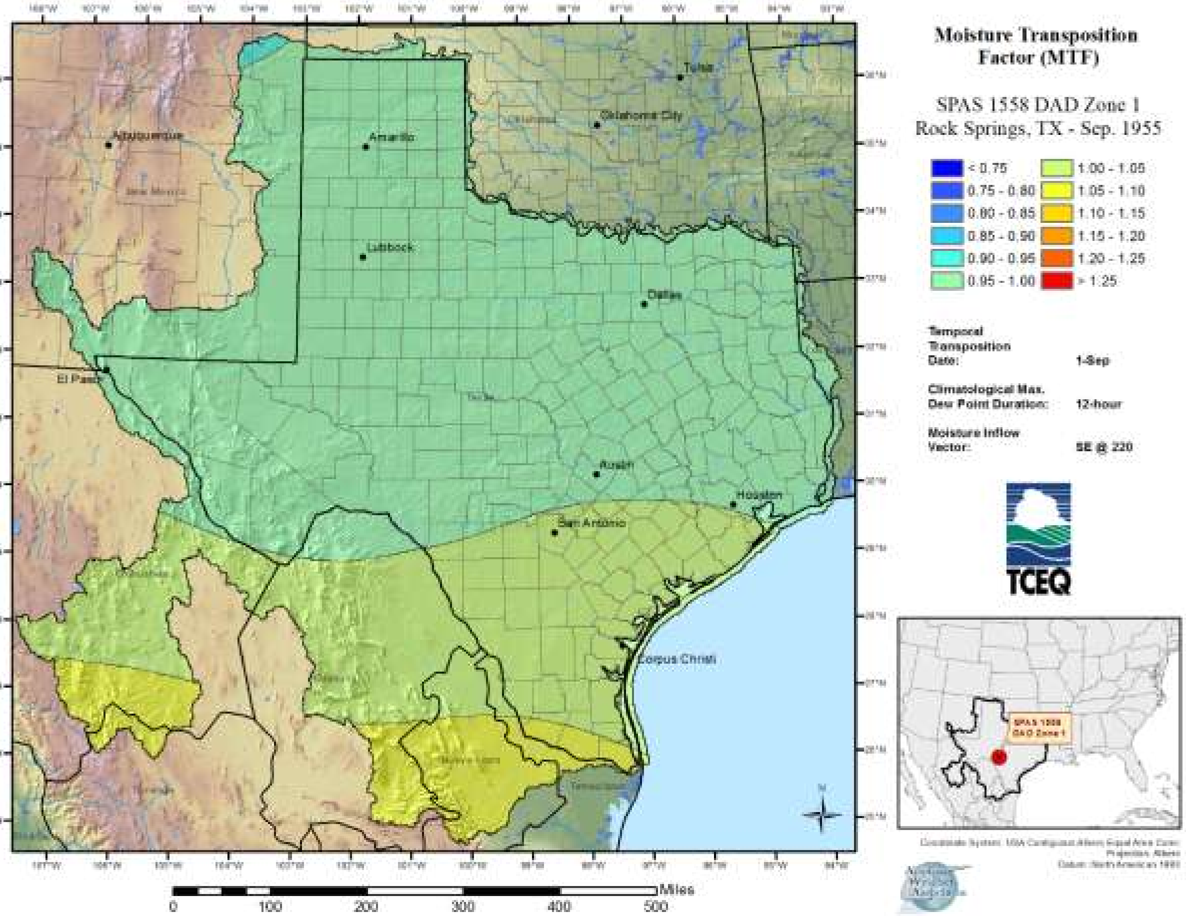
Moisture Transposition Factor (OTF)
SPAS 1495 DAD Zone 1
Cheyenne, OK - Apr. 1934
< 0.75
0.75 - 0.80
0.80 - 0.85
0.85 - 0.90
0.90 - 0.95
0.95 - 1.00
1.00 - 1.05
1.05 - 1.10
1.10 - 1.15
1.15 - 1.20
1.20 - 1.25
> 1.25
Temporal Transposition Date: 15-Apr
Climatological Max. Dew Point Duration: 6-hour
Moisture Inflow Vector: SE @ 250
TCEQ
Tulsa
Oklahoma City
Albuquerque
Amarillo
Lubbock
Dallas
El Paso
Austin
Houston
San Antonio
Corpus Christi
Miles
0
100
200
300
400
500

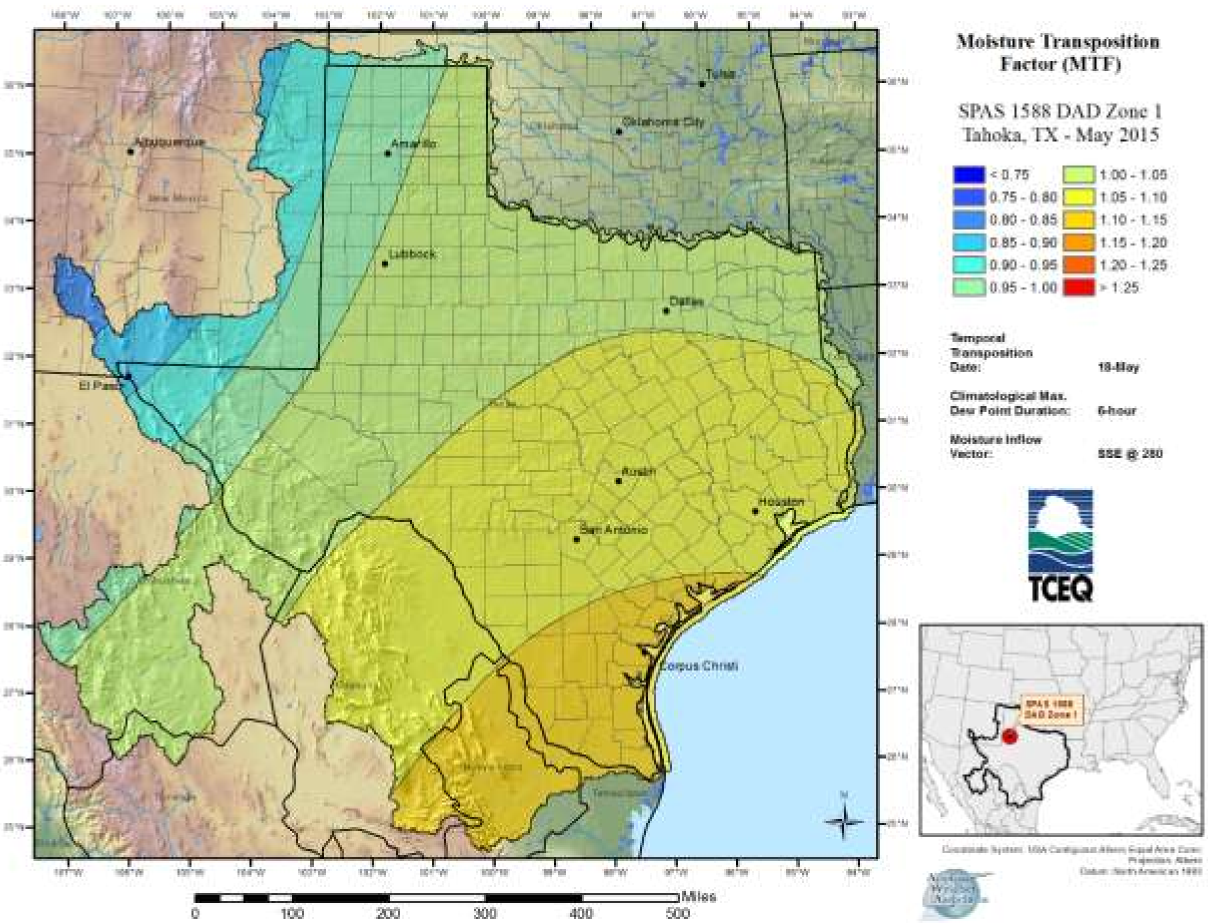


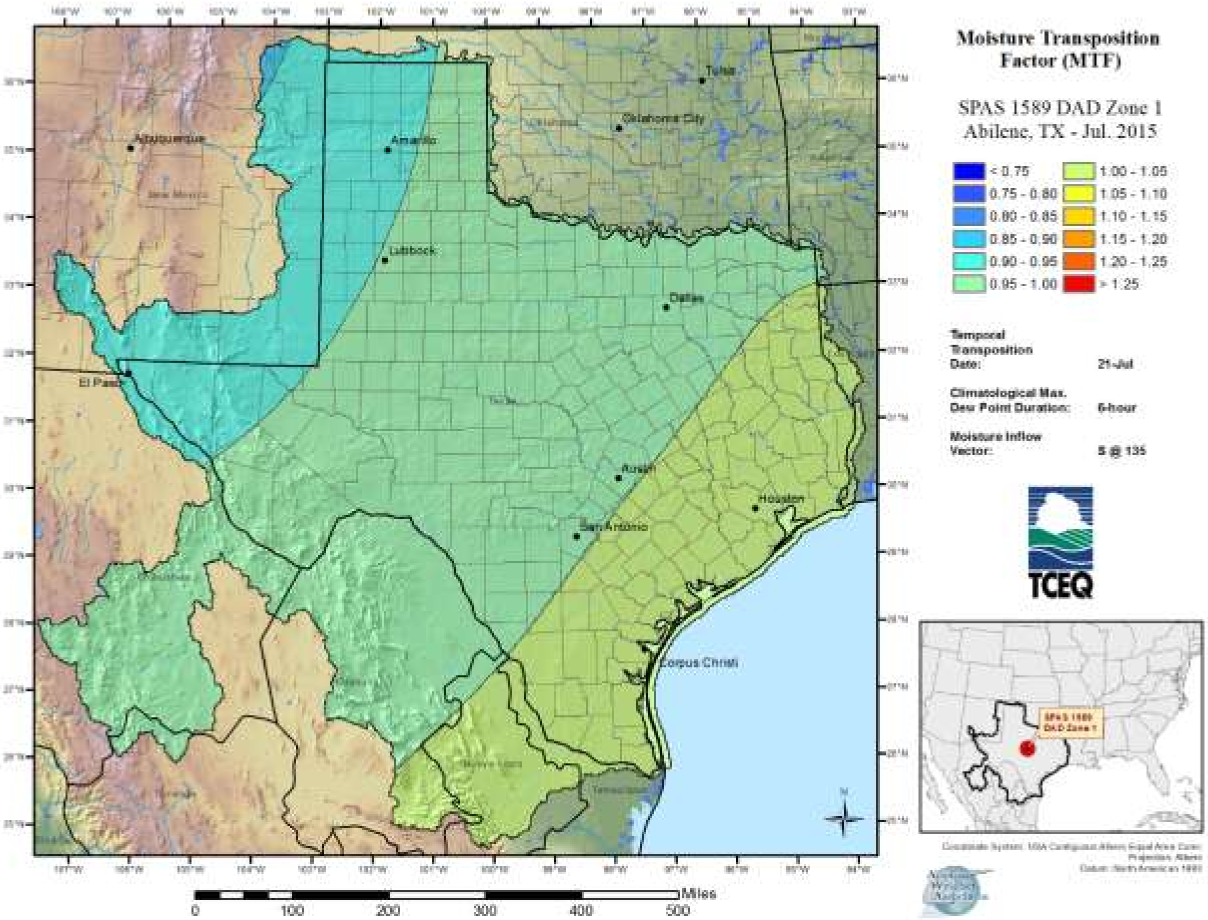
Moisture Transposition Factor (MTF)
SPAS 1496 DAD Zone 1
Woodward Ranch, TX - May 1935
< 0.75
0.75 - 0.80
0.80 - 0.85
0.85 - 0.90
0.90 - 0.95
0.95 - 1.00
1.00 - 1.05
1.05 - 1.10
1.10 - 1.15
1.15 - 1.20
1.20 - 1.25
> 1.25
Temporal Transposition Date: 15-Jun
Climatological Max. Dew Point Duration: 6-hour
Moisture Inflow Vector: SE @ 165
TCEQ
Tulsa
Oklahoma City
Albuquerque
Amarillo
Lubbock
Dallas
El Paso
Austin
Houston
San Antonio
Corpus Christi
SPAS 1496 DAD Zone 1
Miles
0
100
200
300
400
500


Moisture Transposition
Factor (OTF)
SPAS 1528 DAD Zone 1
El Paso, TX - Aug. 2006
< 0.75
0.75 - 0.80
0.80 - 0.85
0.85 - 0.90
0.90 - 0.95
0.95 - 1.00
1.00 - 1.05
1.05 - 1.10
1.10 - 1.15
1.15 - 1.20
1.20 - 1.25
> 1.25
Temporal Transposition Date: 15-Aug
Climatological Max. Dew Point Duration: 12-hour
Moisture Inflow Vector: W @ 225
TCEQ
Tulsa
Oklahoma City
Albuquerque
Amarillo
Lubbock
Dallas
El Paso
Austin
Houston
San Antonio
Corpus Christi
Miles
0
100
200
300
400
500

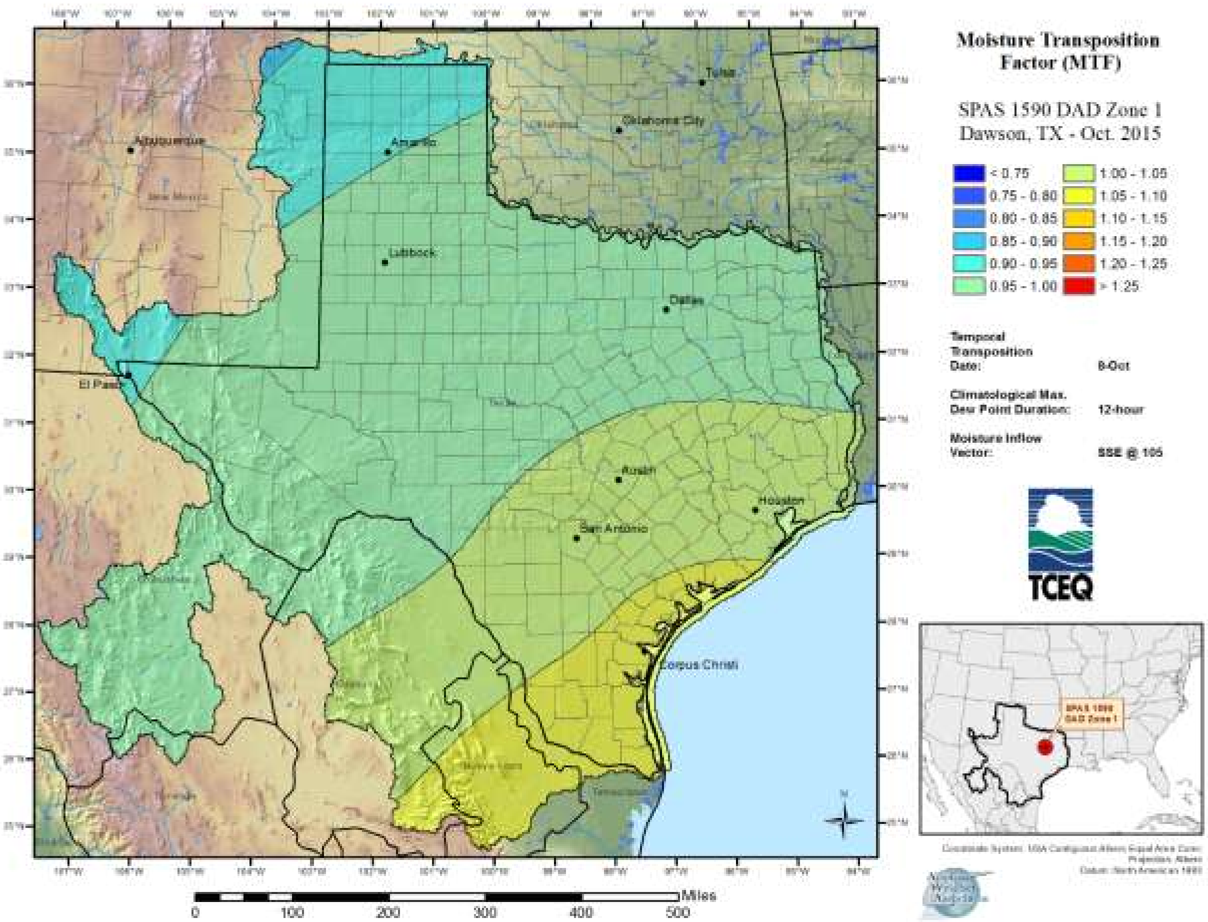

Moisture Transposition Factor (MTF)
SPAS 1557 DAD Zone 1
Gail, TX - Sep. 2014
< 0.75
0.75 - 0.80
0.80 - 0.85
0.85 - 0.90
0.90 - 0.95
0.95 - 1.00
1.00 - 1.05
1.05 - 1.10
1.10 - 1.15
1.15 - 1.20
1.20 - 1.25
> 1.25
Temporal Transposition Date: 6-Sep
Climatological Max. Dew Point Duration: 6-hour
Moisture Inflow Vector: SSE @ 145
TCEQ
Tulsa
Oklahoma City
Amarillo
Albuquerque
Lubbock
Dallas
El Paso
Austin
Houston
San Antonio
Corpus Christi
SPAS 1557 DAD Zone 1
Miles
0
100
200
300
400
500


Moisture Transposition Factor (MTF)
SPAS 1558 DAD Zone 1
Rock Springs, TX - Sep. 1955
< 0.75
0.75 - 0.80
0.80 - 0.85
0.85 - 0.90
0.90 - 0.95
0.95 - 1.00
1.00 - 1.05
1.05 - 1.10
1.10 - 1.15
1.15 - 1.20
1.20 - 1.25
> 1.25
Temporal Transposition Date: 1-Sep
Climatological Max. Dew Point Duration: 12-hour
Moisture Inflow Vector: SE @ 220
TCEQ
Tulsa
Oklahoma City
Albuquerque
Amarillo
Lubbock
Dallas
El Paso
Austin
Houston
San Antonio
Corpus Christi
Miles
0
100
200
300
400
500

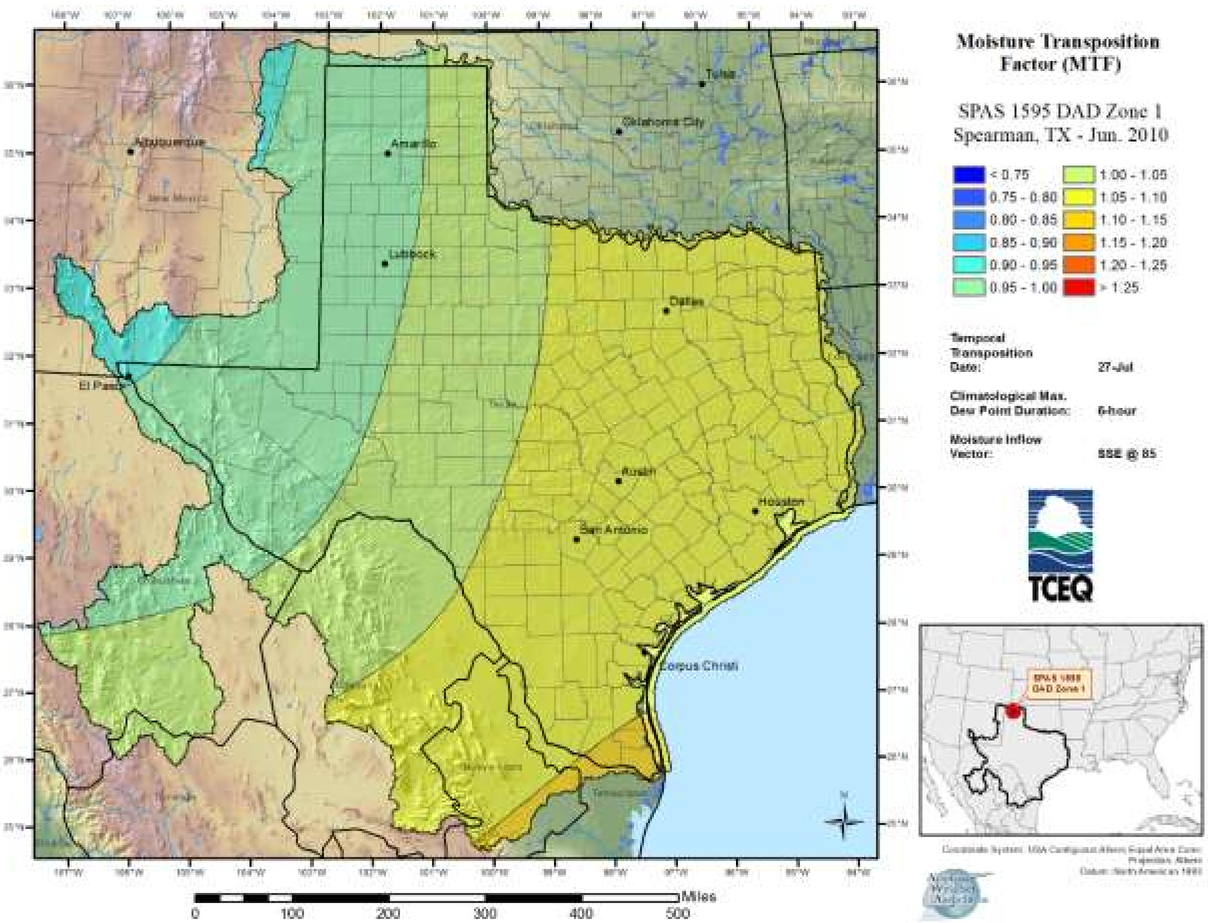

Moisture Transposition Factor (MTF)
SPAS 1588 DAD Zone 1
Tahoka, TX - May 2015
< 0.75
0.75 - 0.80
0.80 - 0.85
0.85 - 0.90
0.90 - 0.95
0.95 - 1.00
1.00 - 1.05
1.05 - 1.10
1.10 - 1.15
1.15 - 1.20
1.20 - 1.25
> 1.25
Temporal Transposition Date: 18-May
Climatological Max. Dew Point Duration: 6-hour
Moisture Inflow Vector: SSE @ 280
TCEQ
Tulsa
Oklahoma City
Albuquerque
Amarillo
Lubbock
Dallas
El Paso
Austin
Houston
San Antonio
Corpus Christi
SPAS 1588 DAD Zone 1
Miles
0
100
200
300
400
500



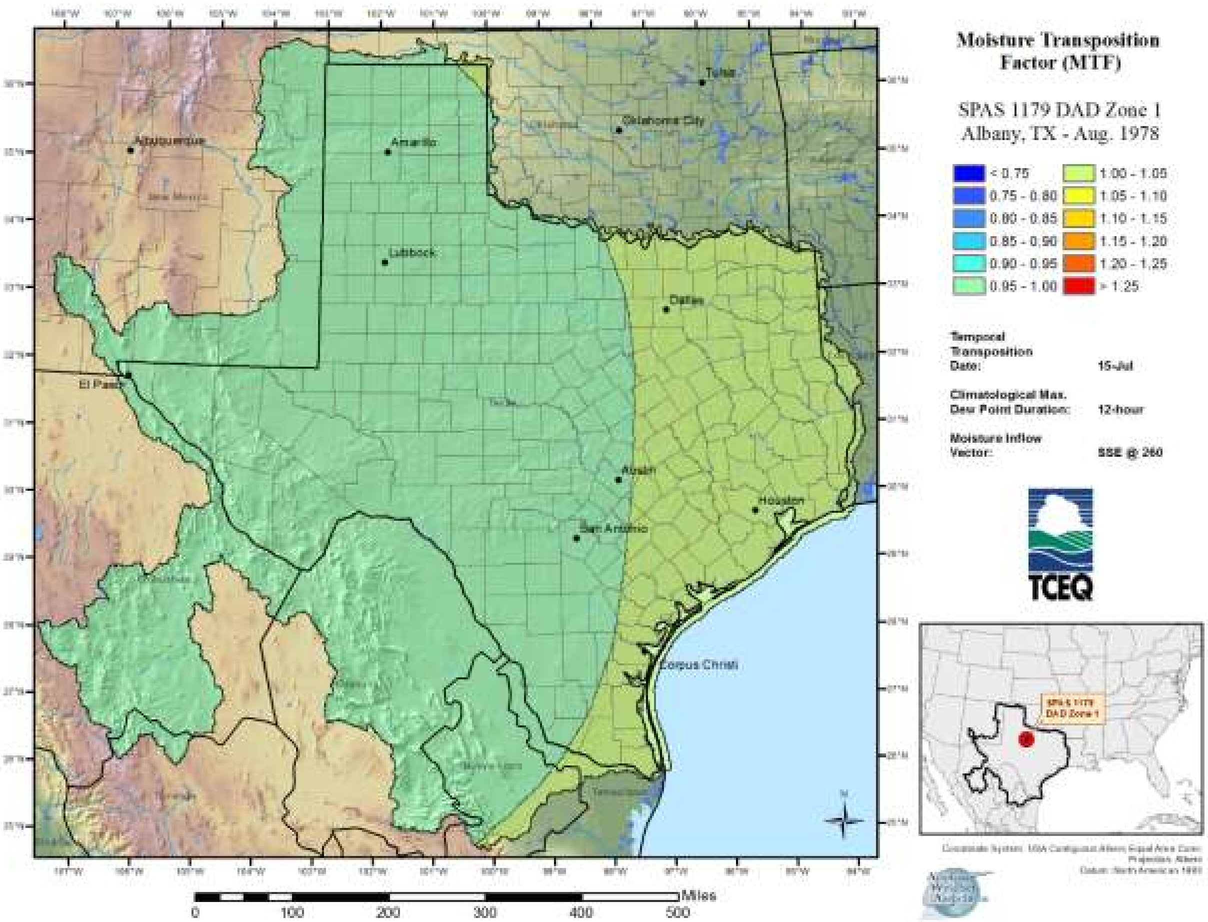
Moisture Transposition Factor (MTF)
SPAS 1589 DAD Zone 1
Abilene, TX - Jul. 2015
< 0.75
0.75 - 0.80
0.80 - 0.85
0.85 - 0.90
0.90 - 0.95
0.95 - 1.00
1.00 - 1.05
1.05 - 1.10
1.10 - 1.15
1.15 - 1.20
1.20 - 1.25
> 1.25
Temporal Transposition Date: 21-Jul
Climatological Max. Dew Point Duration: 6-hour
Moisture Inflow Vector: S @ 135
TCEQ
Tulsa
Oklahoma City
Albuquerque
Amarillo
Lubbock
Dallas
El Paso
Austin
Houston
San Antonio
Corpus Christi
SPAS 1589 DAD Zone 1
Miles
0
100
200
300
400
500

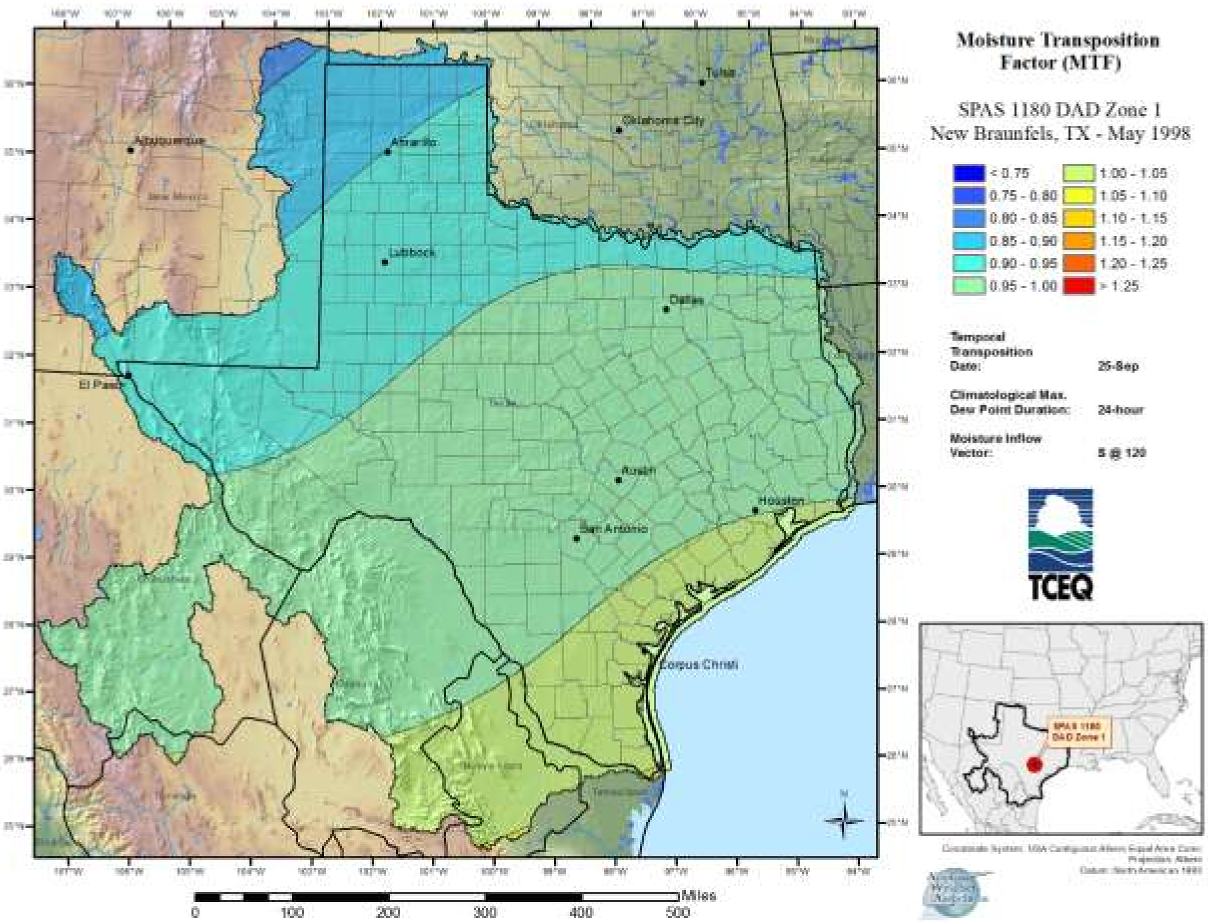


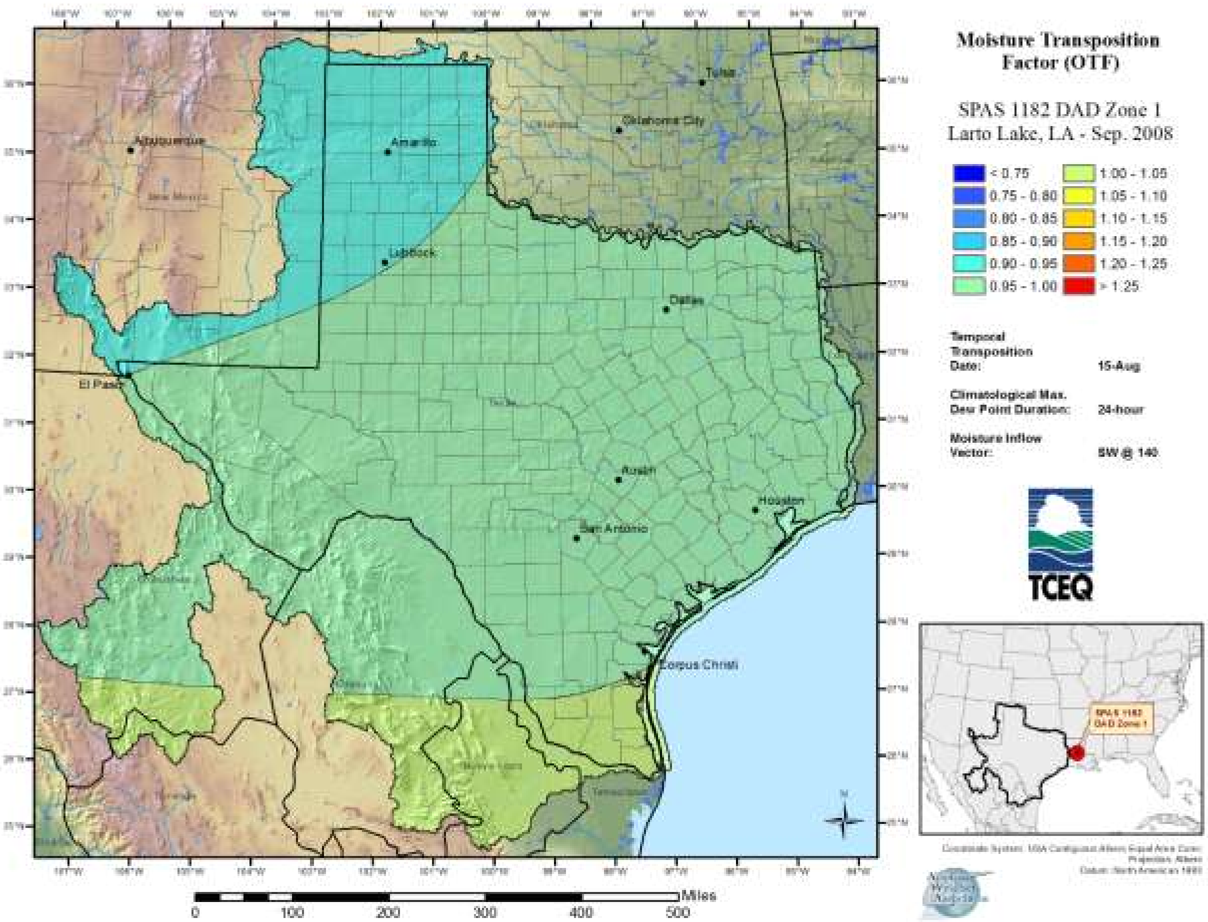
Moisture Transposition Factor (MTF)
SPAS 1590 DAD Zone 1
Dawson, TX - Oct. 2015
< 0.75
0.75 - 0.80
0.80 - 0.85
0.85 - 0.90
0.90 - 0.95
0.95 - 1.00
1.00 - 1.05
1.05 - 1.10
1.10 - 1.15
1.15 - 1.20
1.20 - 1.25
> 1.25
Temporal Transposition Date: 8-Oct
Climatological Max. Dew Point Duration: 12-hour
Moisture Inflow Vector: SSE @ 105
TCEQ
SPAS 1590 DAD Zone 1
Tulsa
Oklahoma City
Albuquerque
Amarillo
Lubbock
Dallas
El Paso
Austin
Houston
San Antonio
Corpus Christi
Miles
0
100
200
300
400
500


Moisture Transposition Factor (MTF)
SPAS 1595 DAD Zone 1
Spearman, TX - Jun. 2010
< 0.75
0.75 - 0.80
0.80 - 0.85
0.85 - 0.90
0.90 - 0.95
0.95 - 1.00
1.00 - 1.05
1.05 - 1.10
1.10 - 1.15
1.15 - 1.20
1.20 - 1.25
> 1.25
Temporal Transposition Date: 27-Jul
Climatological Max. Dew Point Duration: 6-hour
Moisture Inflow Vector: SSE @ 85
Tulsa
Oklahoma City
Albuquerque
Amarillo
Lubbock
Dallas
El Paso
Austin
Houston
San Antonio
Corpus Christi
Miles
0
100
200
300
400
500

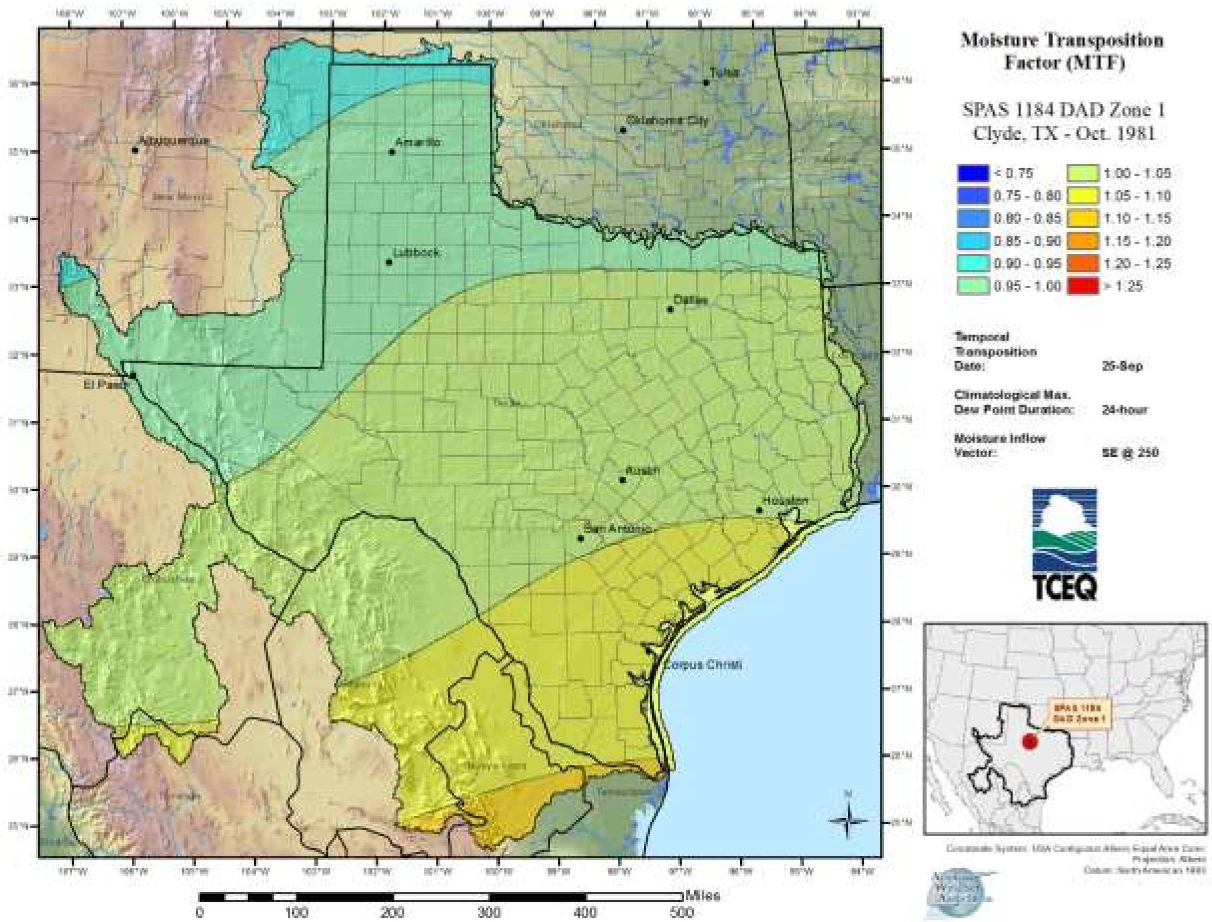
Tropical Storms

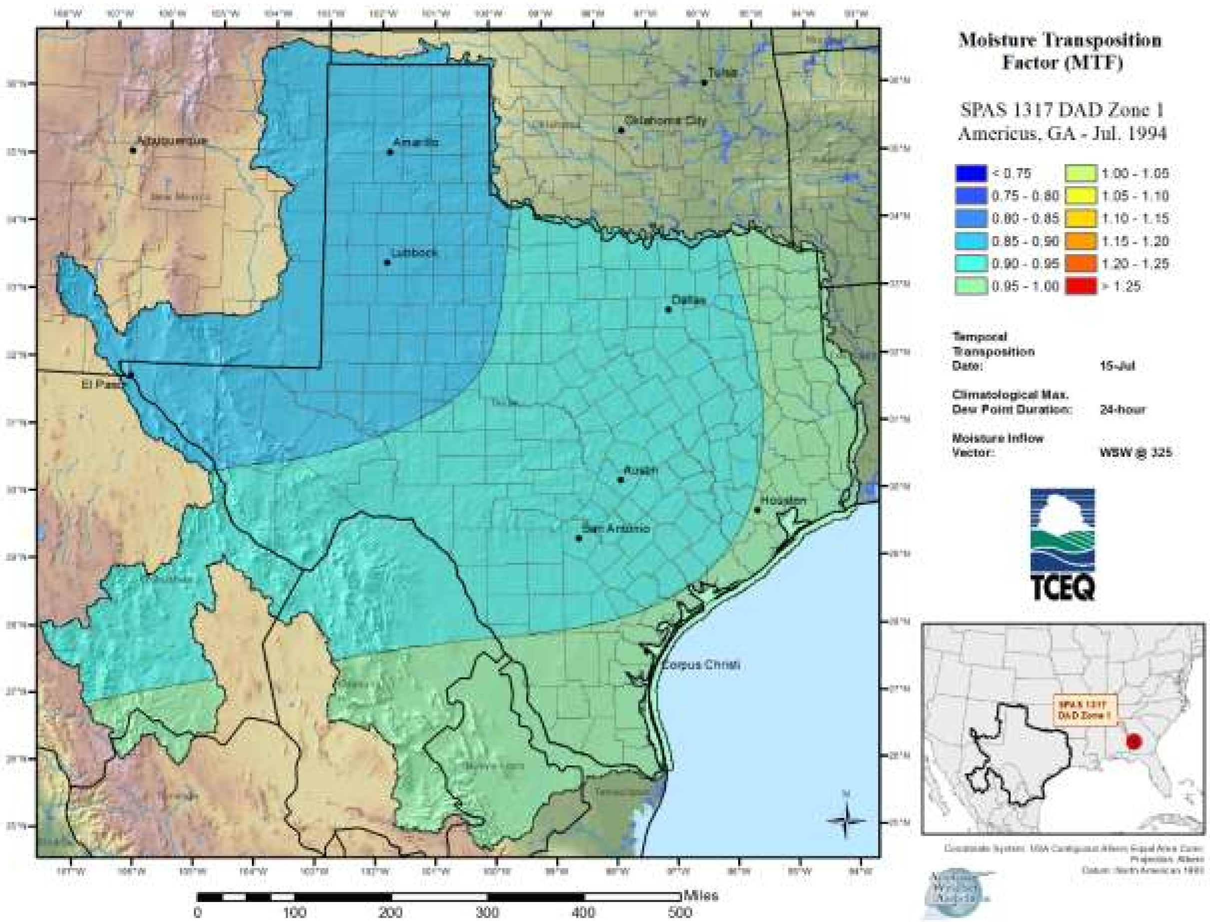

Moisture Transposition Factor (MTF)
SPAS 1179 DAD Zone 1
Albany, TX - Aug. 1978
< 0.75
0.75 - 0.80
0.80 - 0.85
0.85 - 0.90
0.90 - 0.95
0.95 - 1.00
1.00 - 1.05
1.05 - 1.10
1.10 - 1.15
1.15 - 1.20
1.20 - 1.25
> 1.25
Temporal Transposition Date: 15-Jul
Climatological Max. Dew Point Duration: 12-hour
Moisture Inflow Vector: SSE @ 260
TCEQ
Tulsa
Oklahoma City
Albuquerque
Amarillo
Lubbock
Dallas
El Paso
Austin
Houston
San Antonio
Corpus Christi
Miles
0
100
200
300
400
500

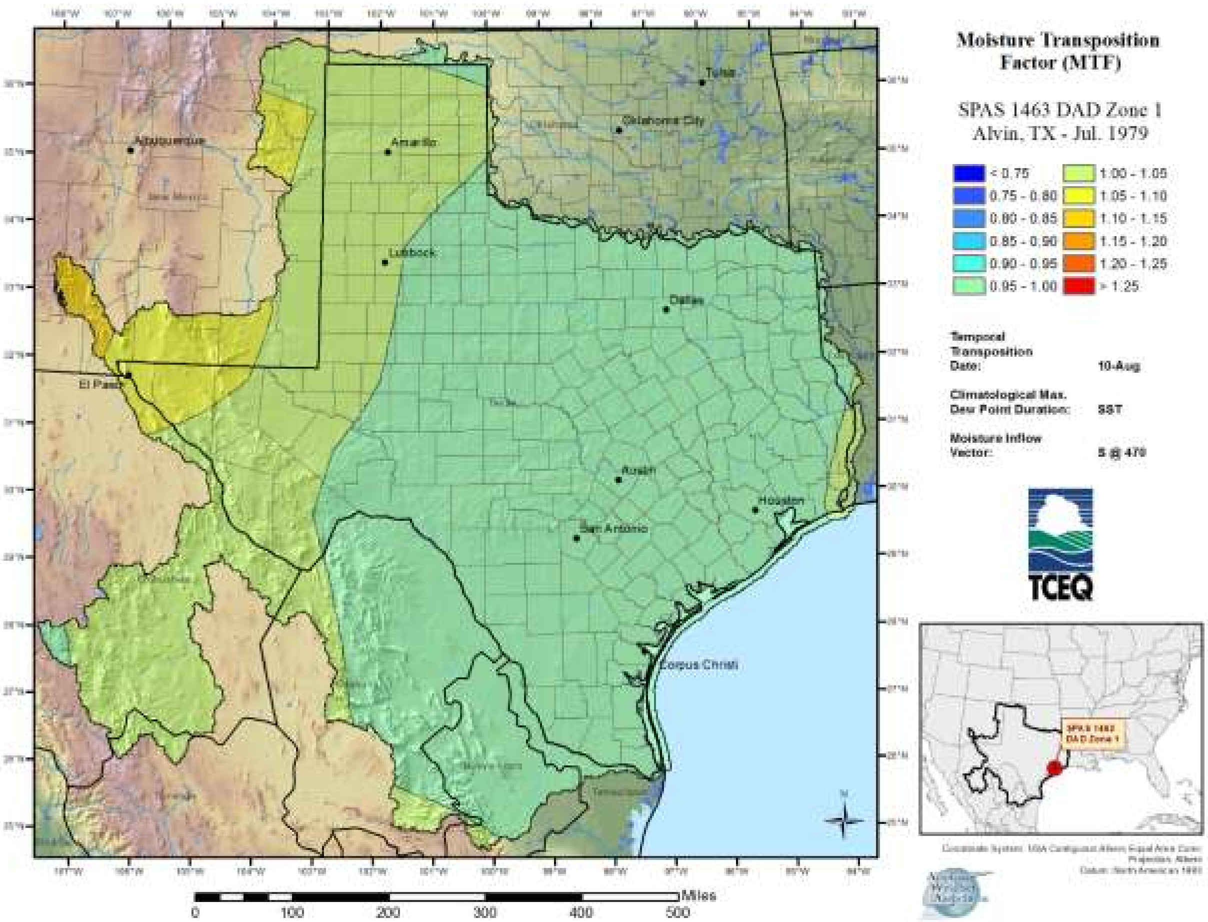

Moisture Transposition
Factor (MTF)
SPAS 1180 DAD Zone 1
New Braunfels, TX - May 1998
< 0.75
0.75 - 0.80
0.80 - 0.85
0.85 - 0.90
0.90 - 0.95
0.95 - 1.00
1.00 - 1.05
1.05 - 1.10
1.10 - 1.15
1.15 - 1.20
1.20 - 1.25
> 1.25
Temporal Transposition Date: 25-Sep
Climatological Max. Dew Point Duration: 24-hour
Moisture Inflow Vector: S @ 120
TCEQ
SPAS 1180
DAD Zone 1
Tulsa
Oklahoma City
Albuquerque
Amarillo
Lubbock
Dallas
El Paso
Austin
Houston
San Antonio
Corpus Christi
Miles
0
100
200
300
400
500

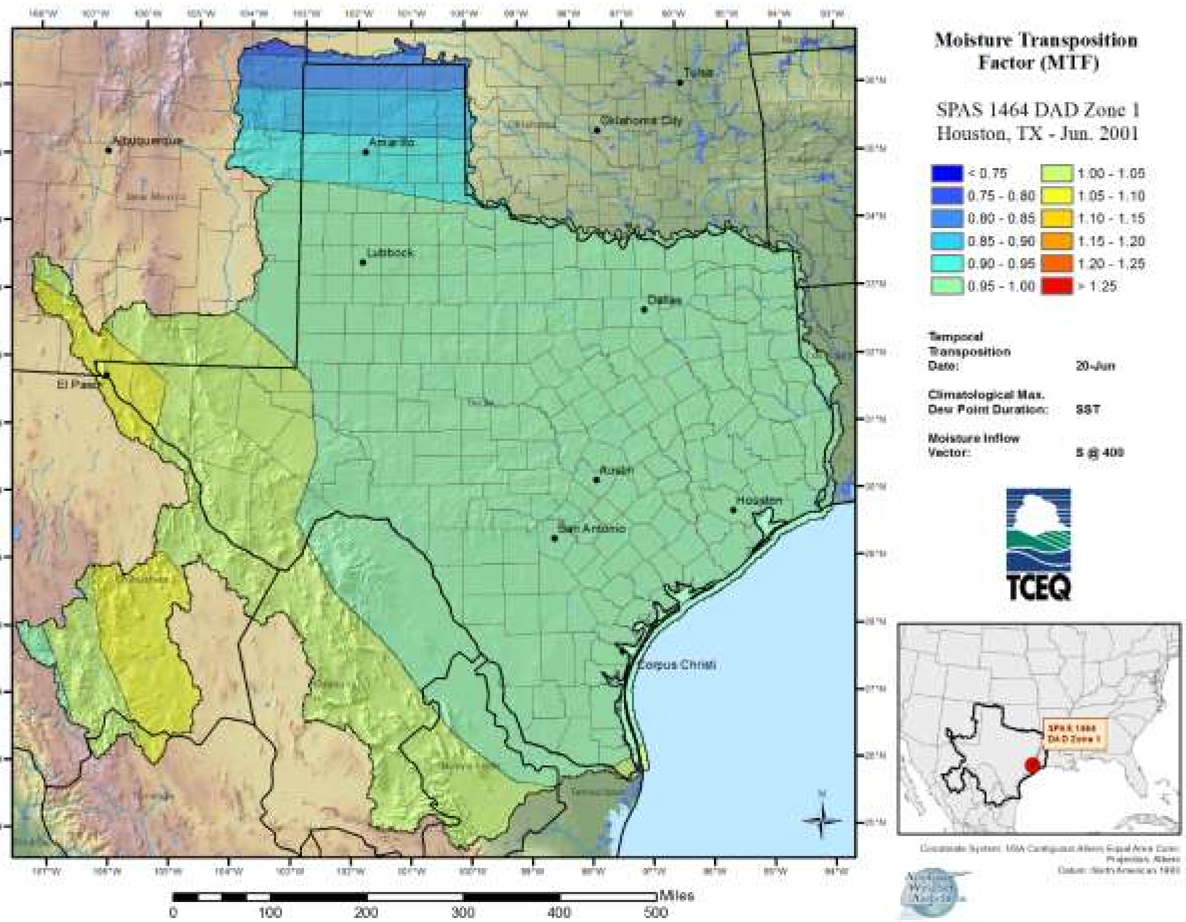


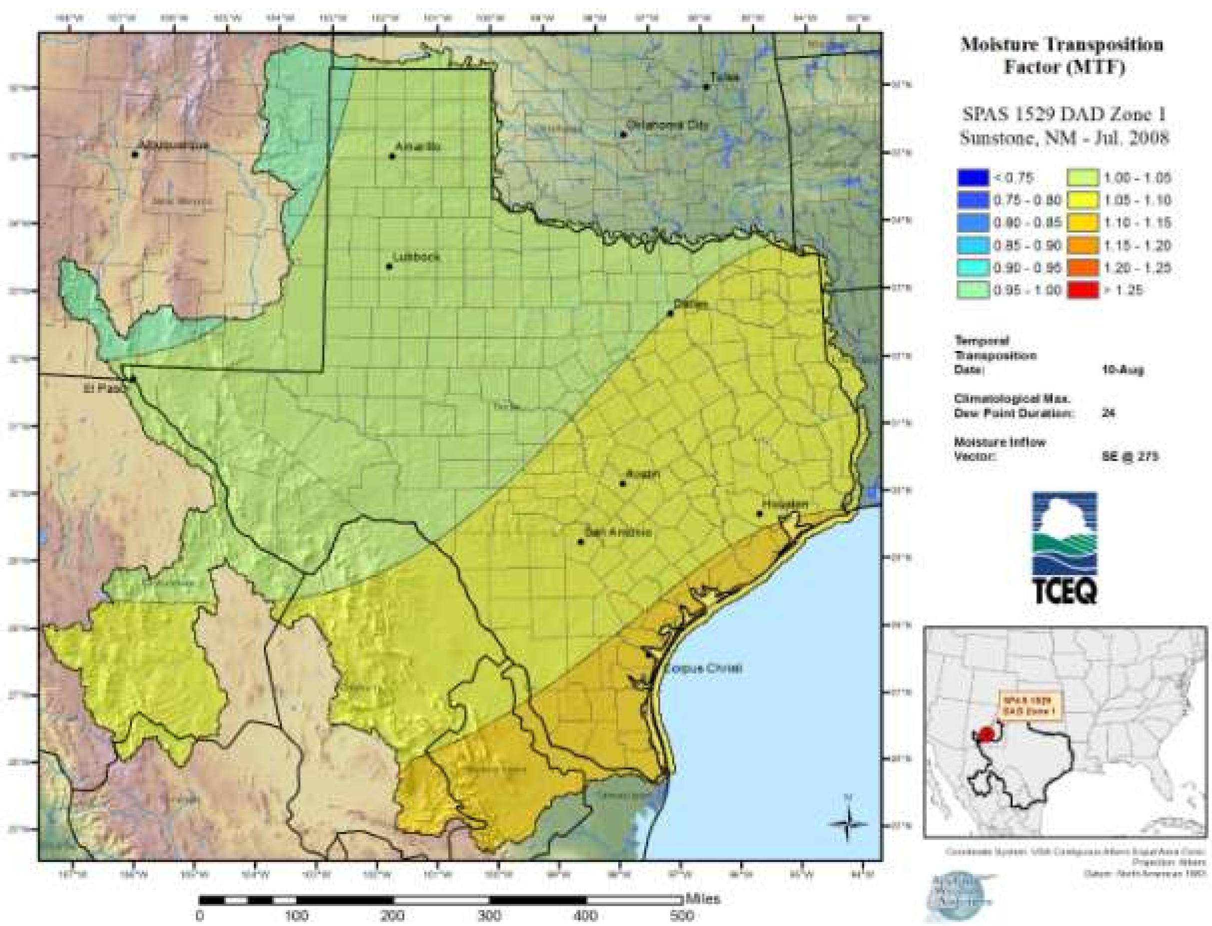
Moisture Transposition Factor (OTF)
SPAS 1182 DAD Zone 1
Larto Lake, LA - Sep. 2008
< 0.75
0.75 - 0.80
0.80 - 0.85
0.85 - 0.90
0.90 - 0.95
0.95 - 1.00
1.00 - 1.05
1.05 - 1.10
1.10 - 1.15
1.15 - 1.20
1.20 - 1.25
> 1.25
Temporal Transposition Date: 15-Aug
Climatological Max. Dew Point Duration: 24-hour
Moisture Inflow Vector: SW @ 140
TCEQ
Tulsa
Oklahoma City
Albuquerque
Amarillo
Lubbock
Dallas
El Paso
Austin
Houston
San Antonio
Corpus Christi
SPAS 1182 DAD Zone 1
Miles
0
100
200
300
400
500

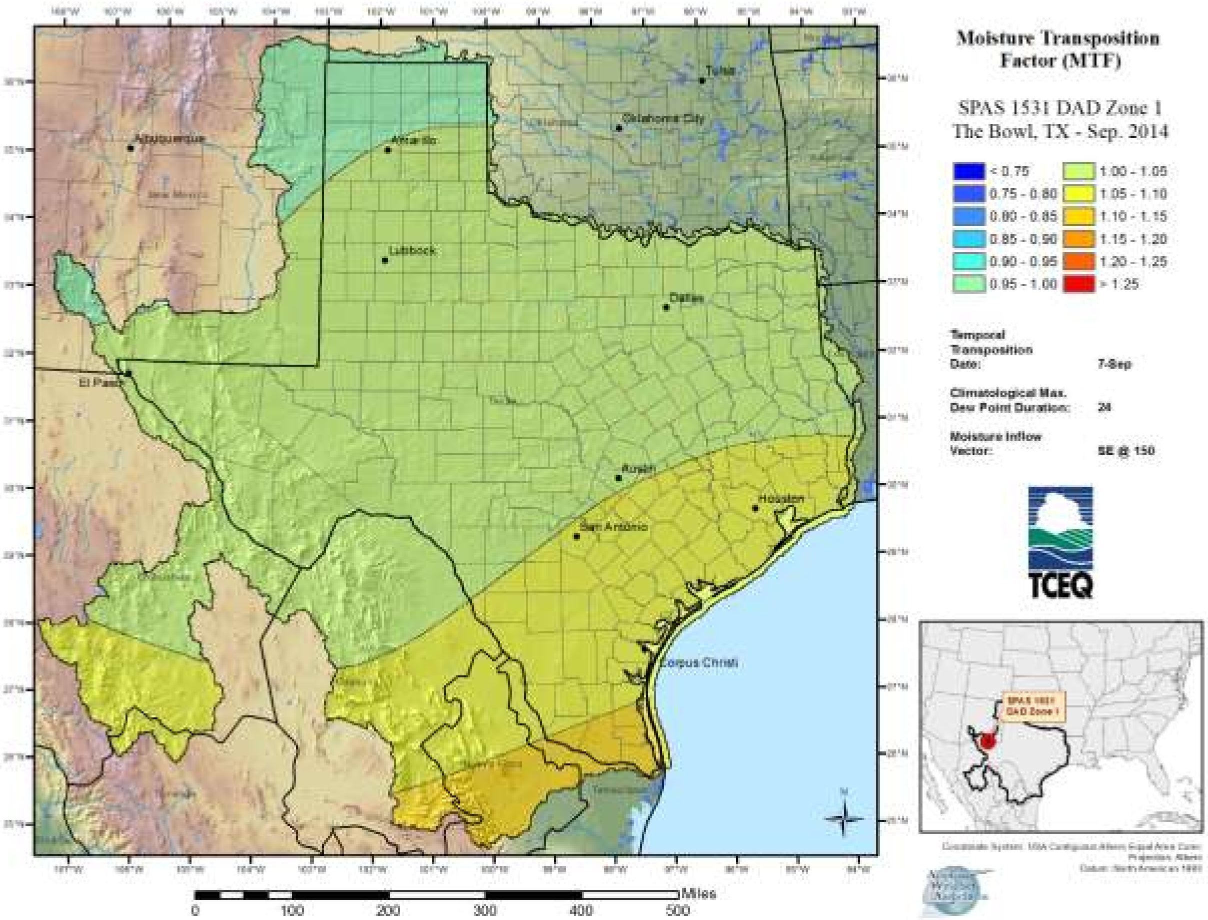

Moisture Transposition Factor (MTF)
SPAS 1184 DAD Zone 1
Clyde, TX - Oct. 1981
< 0.75
0.75 - 0.80
0.80 - 0.85
0.85 - 0.90
0.90 - 0.95
0.95 - 1.00
1.00 - 1.05
1.05 - 1.10
1.10 - 1.15
1.15 - 1.20
1.20 - 1.25
> 1.25
Temporal Transposition Date: 25-Sep
Climatological Max. Dew Point Duration: 24-hour
Moisture Inflow Vector: SE @ 250
TCEQ
Tulsa
Oklahoma City
Albuquerque
Amarillo
Lubbock
Dallas
El Paso
Austin
Houston
San Antonio
Corpus Christi
Miles
0
100
200
300
400
500

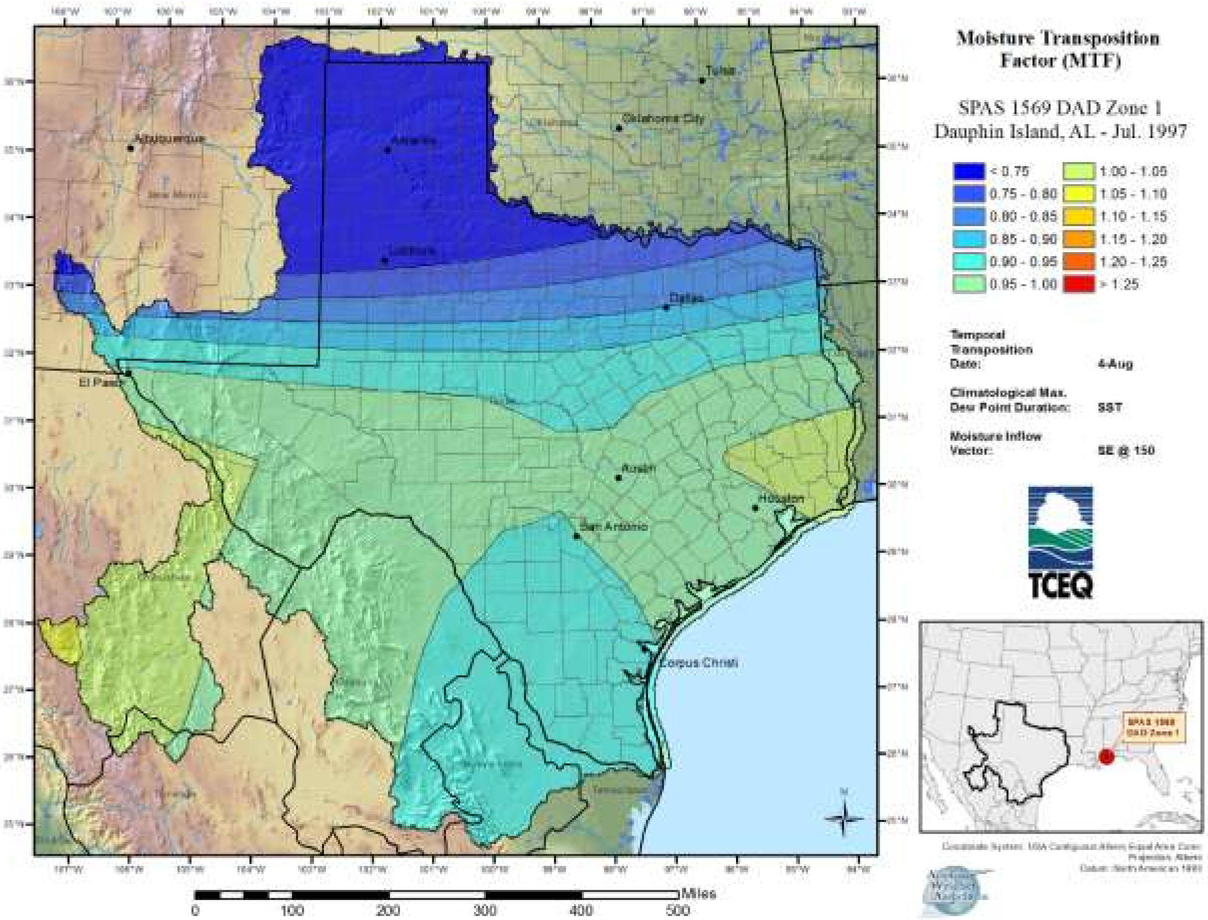

Moisture Transposition Factor (MTF)
SPAS 1317 DAD Zone 1
Americus, GA - Jul. 1994
< 0.75
0.75 - 0.80
0.80 - 0.85
0.85 - 0.90
0.90 - 0.95
0.95 - 1.00
1.00 - 1.05
1.05 - 1.10
1.10 - 1.15
1.15 - 1.20
1.20 - 1.25
> 1.25
Temporal Transposition Date: 15-Jul
Climatological Max. Dew Point Duration: 24-hour
Moisture Inflow Vector: WSW @ 325
TCEQ
Tulsa
Oklahoma City
Albuquerque
Amarillo
Lubbock
Dallas
El Paso
Austin
Houston
San Antonio
Corpus Christi
Miles
0
100
200
300
400
500

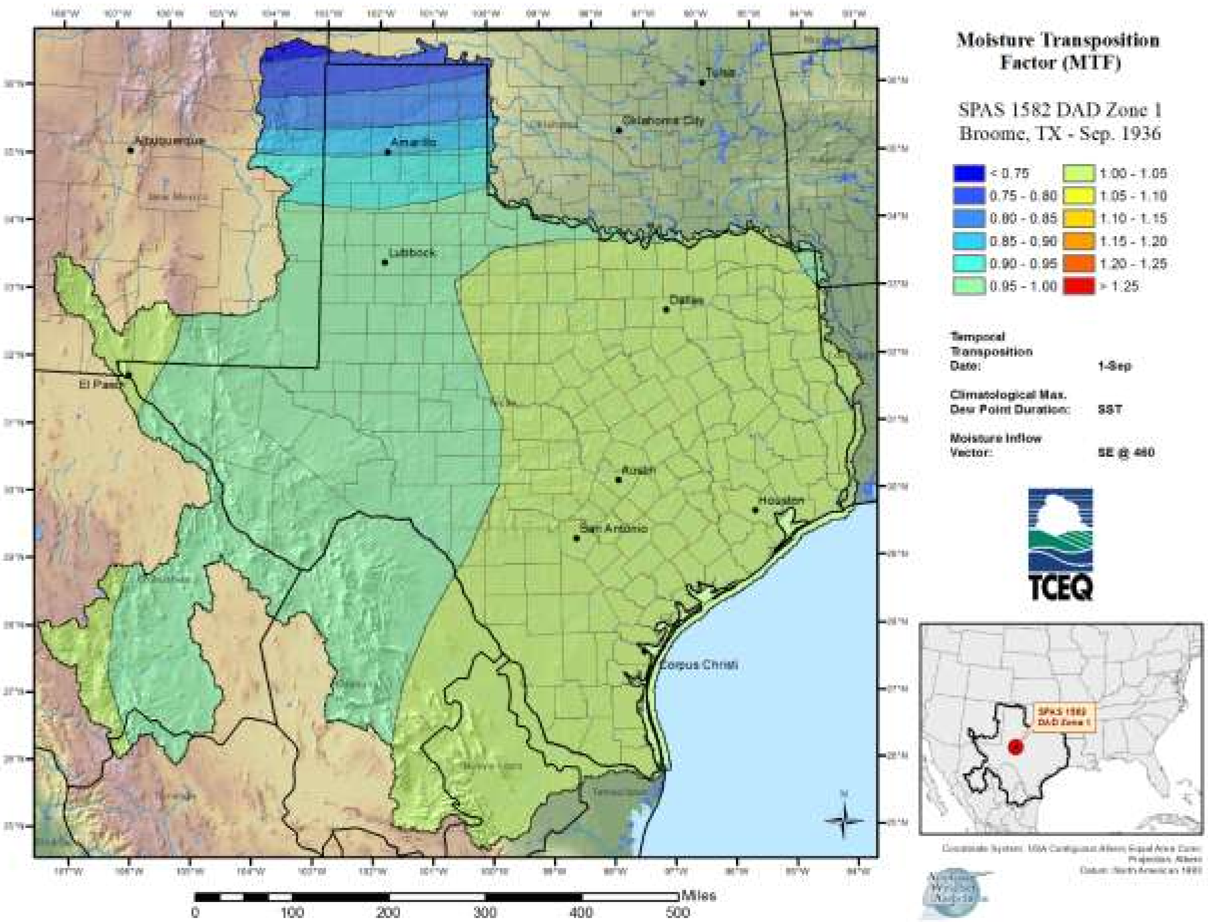

Moisture Transposition Factor (MTF)
SPAS 1463 DAD Zone 1
Alvin, TX - Jul. 1979
< 0.75
0.75 - 0.80
0.80 - 0.85
0.85 - 0.90
0.90 - 0.95
0.95 - 1.00
1.00 - 1.05
1.05 - 1.10
1.10 - 1.15
1.15 - 1.20
1.20 - 1.25
> 1.25
Temporal Transposition Date: 10-Aug
Climatological Max. Dew Point Duration: SST
Moisture Inflow Vector: S @ 470
TCEQ
Tulsa
Oklahoma City
Albuquerque
Amarillo
Lubbock
Dallas
El Paso
Austin
Houston
San Antonio
Corpus Christi
Miles
0
100
200
300
400
500

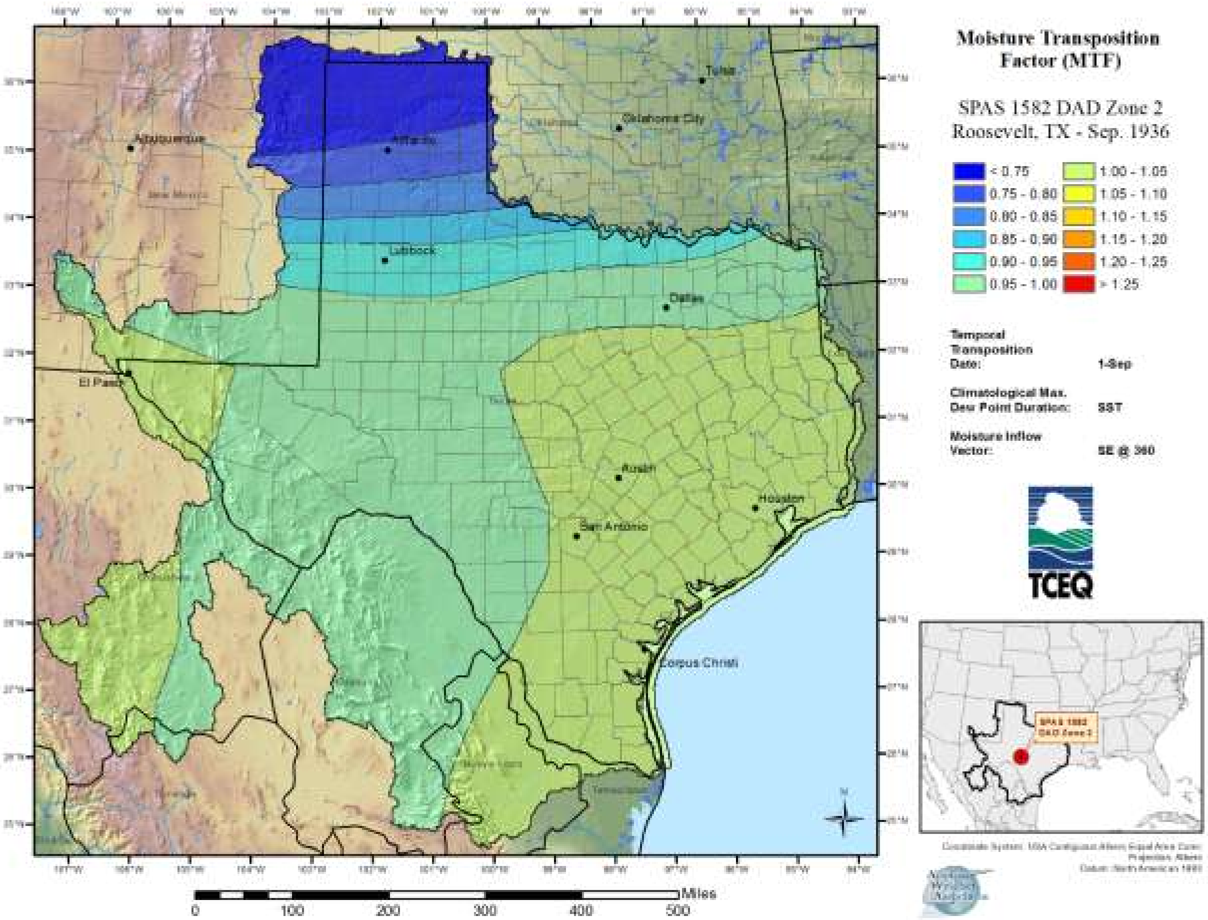

Moisture Transposition Factor (MTF)
SPAS 1464 DAD Zone 1
Houston, TX - Jun. 2001
< 0.75
0.75 - 0.80
0.80 - 0.85
0.85 - 0.90
0.90 - 0.95
0.95 - 1.00
1.00 - 1.05
1.05 - 1.10
1.10 - 1.15
1.15 - 1.20
1.20 - 1.25
> 1.25
Temporal Transposition Date: 20-Jun
Climatological Max. Dew Point Duration: SST
Moisture Inflow Vector: S @ 400
TCEQ
SPAS 1464 DAD Zone 1
Tulsa
Oklahoma City
Albuquerque
Amarillo
Lubbock
Dallas
El Paso
Austin
Houston
San Antonio
Corpus Christi
Miles
0
100
200
300
400
500

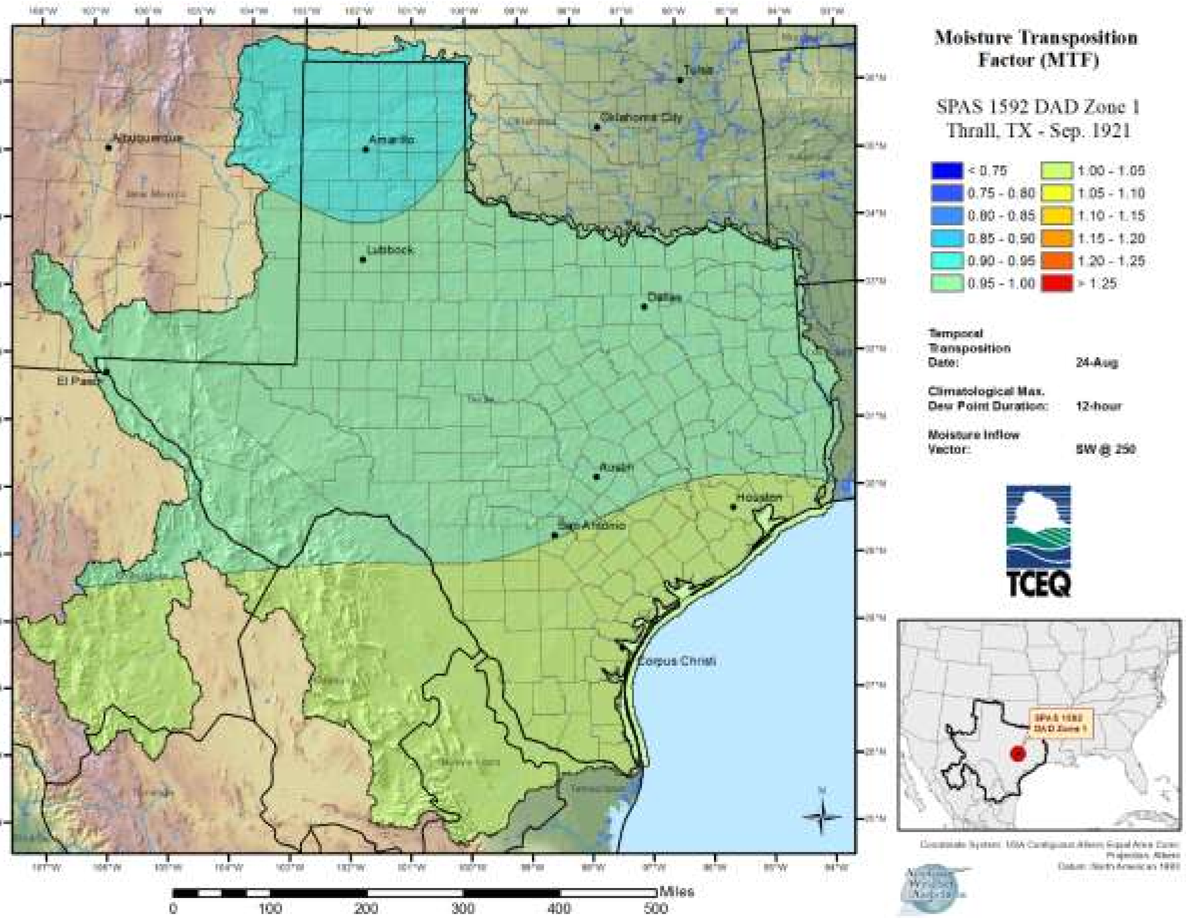

Moisture Transposition Factor (MTF)
SPAS 1529 DAD Zone 1
Sunstone, NM - Jul. 2008
< 0.75
0.75 - 0.80
0.80 - 0.85
0.85 - 0.90
0.90 - 0.95
0.95 - 1.00
1.00 - 1.05
1.05 - 1.10
1.10 - 1.15
1.15 - 1.20
1.20 - 1.25
> 1.25
Temporal Transposition Date: 10-Aug
Climatological Max. Dew Point Duration: 24
Moisture Inflow Vector: SE @ 275
TCEQ
Tulsa
Oklahoma City
Albuquerque
Amarillo
Lubbock
Dallas
El Paso
Austin
Houston
San Antonio
Corpus Christi
Miles
0
100
200
300
400
500

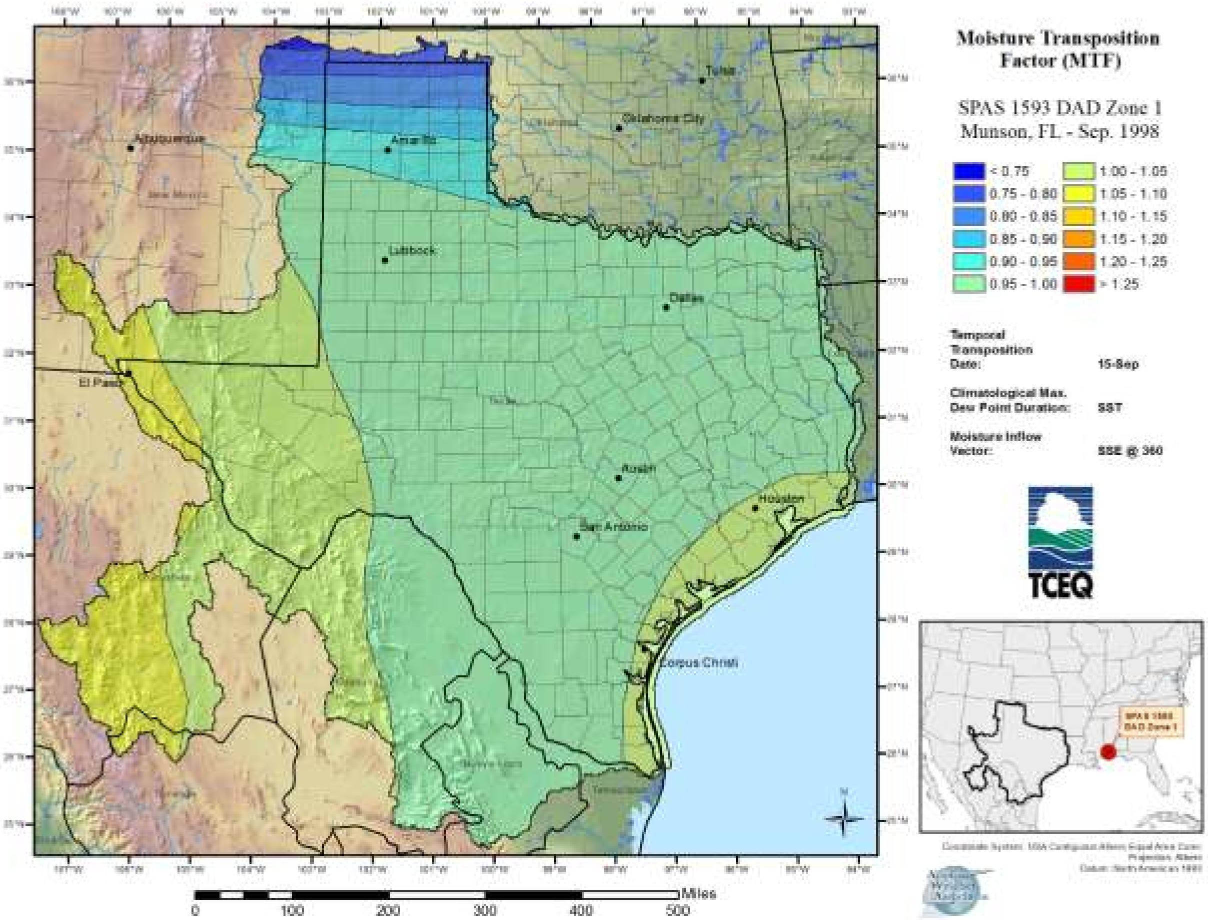

Moisture Transposition Factor (MTF)
SPAS 1531 DAD Zone 1
The Bowl, TX - Sep. 2014
< 0.75
0.75 - 0.80
0.80 - 0.85
0.85 - 0.90
0.90 - 0.95
0.95 - 1.00
1.00 - 1.05
1.05 - 1.10
1.10 - 1.15
1.15 - 1.20
1.20 - 1.25
> 1.25
Temporal Transposition Date: 7-Sep
Climatological Max. Dew Point Duration: 24
Moisture Inflow Vector: SE @ 150
TCEQ
Tulsa
Oklahoma City
Albuquerque
Amarillo
Lubbock
Dallas
El Paso
Austin
Houston
San Antonio
Corpus Christi
SPAS 1531 DAD Zone 1
Miles
0
100
200
300
400
500


Moisture Transposition
Factor (MTF)
SPAS 1569 DAD Zone 1
Dauphin Island, AL - Jul. 1997
< 0.75
0.75 - 0.80
0.80 - 0.85
0.85 - 0.90
0.90 - 0.95
0.95 - 1.00
1.00 - 1.05
1.05 - 1.10
1.10 - 1.15
1.15 - 1.20
1.20 - 1.25
> 1.25
Temporal Transposition Date: 4-Aug
Climatological Max. Dew Point Duration: SST
Moisture Inflow Vector: SE @ 150
TCEQ
SPAS 1569 DAD Zone 1
Tulsa
Oklahoma City
Albuquerque
Amarillo
Lubbock
Dallas
El Paso
Austin
Houston
San Antonio
Corpus Christi
Miles
0
100
200
300
400
500

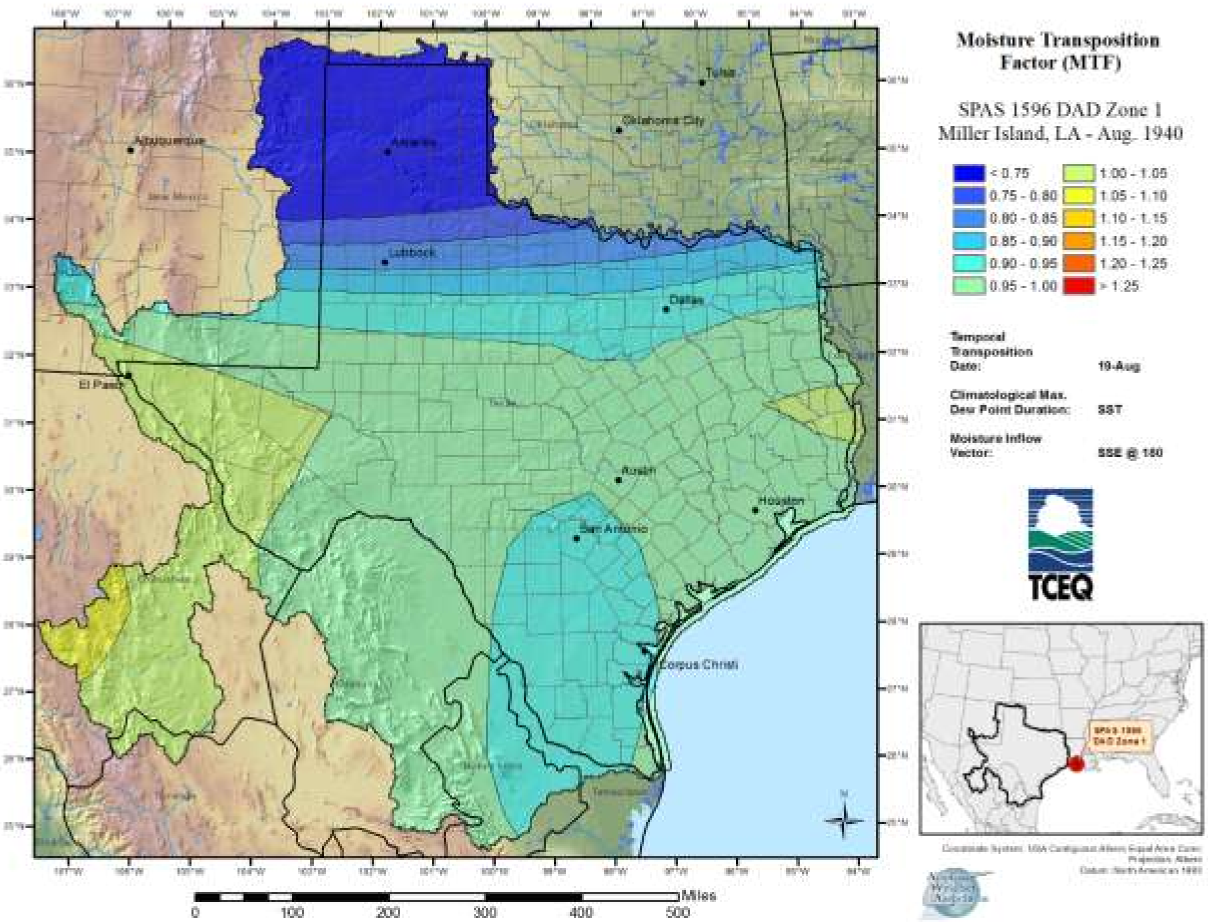

Moisture Transposition Factor (MTF)
SPAS 1582 DAD Zone 1
Broome, TX - Sep. 1936
< 0.75
0.75 - 0.80
0.80 - 0.85
0.85 - 0.90
0.90 - 0.95
0.95 - 1.00
1.00 - 1.05
1.05 - 1.10
1.10 - 1.15
1.15 - 1.20
1.20 - 1.25
> 1.25
Temporal Transposition Date: 1-Sep
Climatological Max. Dew Point Duration: SST
Moisture Inflow Vector: SE @ 460
TCEQ
SPAS 1582 DAD Zone 1
Tulsa
Oklahoma City
Albuquerque
Amarillo
Lubbock
Dallas
El Paso
Austin
Houston
San Antonio
Corpus Christi
N
Miles
0
100
200
300
400
500

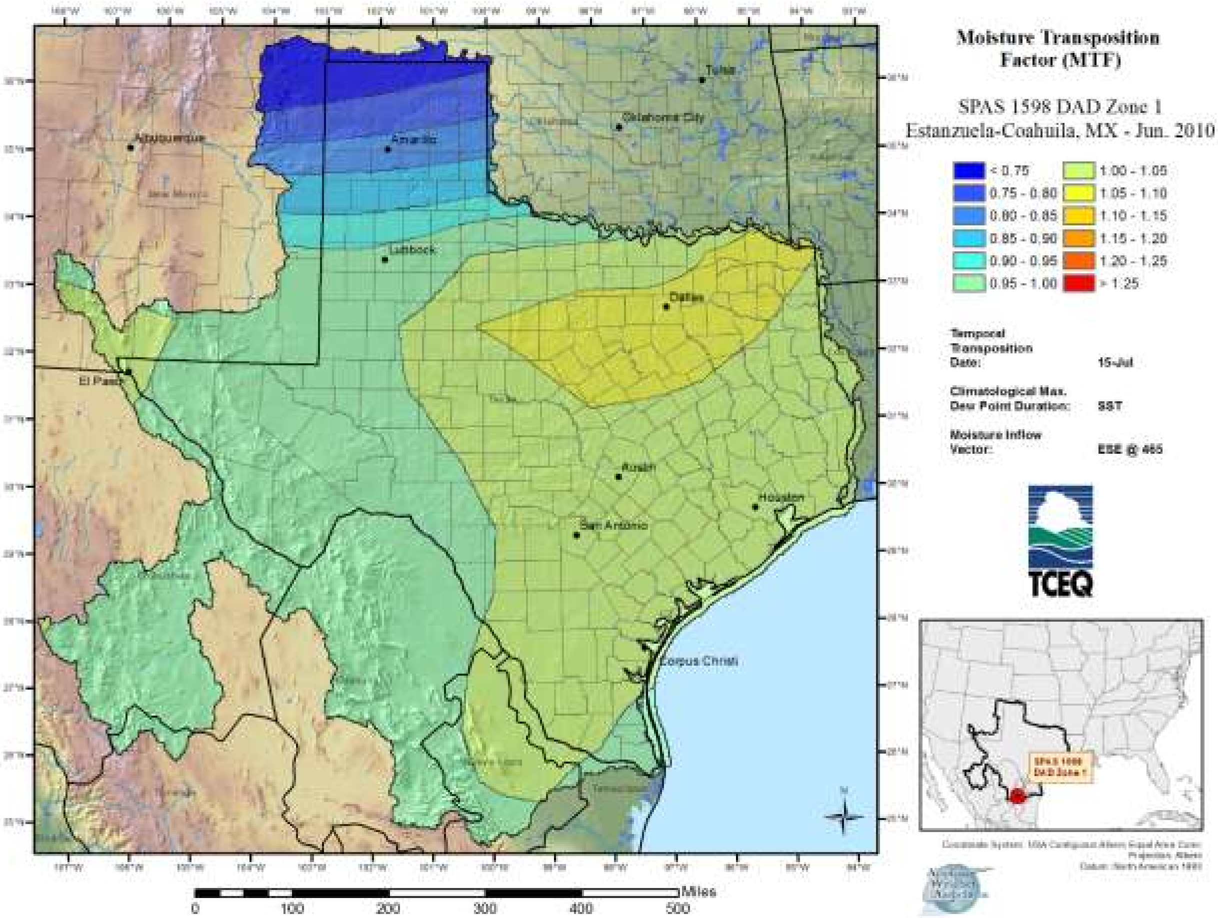

Moisture Transposition Factor (MTF)
SPAS 1582 DAD Zone 2
Roosevelt, TX - Sep. 1936
< 0.75
0.75 - 0.80
0.80 - 0.85
0.85 - 0.90
0.90 - 0.95
0.95 - 1.00
1.00 - 1.05
1.05 - 1.10
1.10 - 1.15
1.15 - 1.20
1.20 - 1.25
> 1.25
Temporal Transposition Date: 1-Sep
Climatological Max. Dew Point Duration: SST
Moisture Inflow Vector: SE @ 360
TCEQ
SPAS 1582 DAD Zone 2
Tulsa
Oklahoma City
Albuquerque
Amarillo
Lubbock
Dallas
El Paso
Austin
Houston
San Antonio
Corpus Christi
Miles
0
100
200
300
400
500

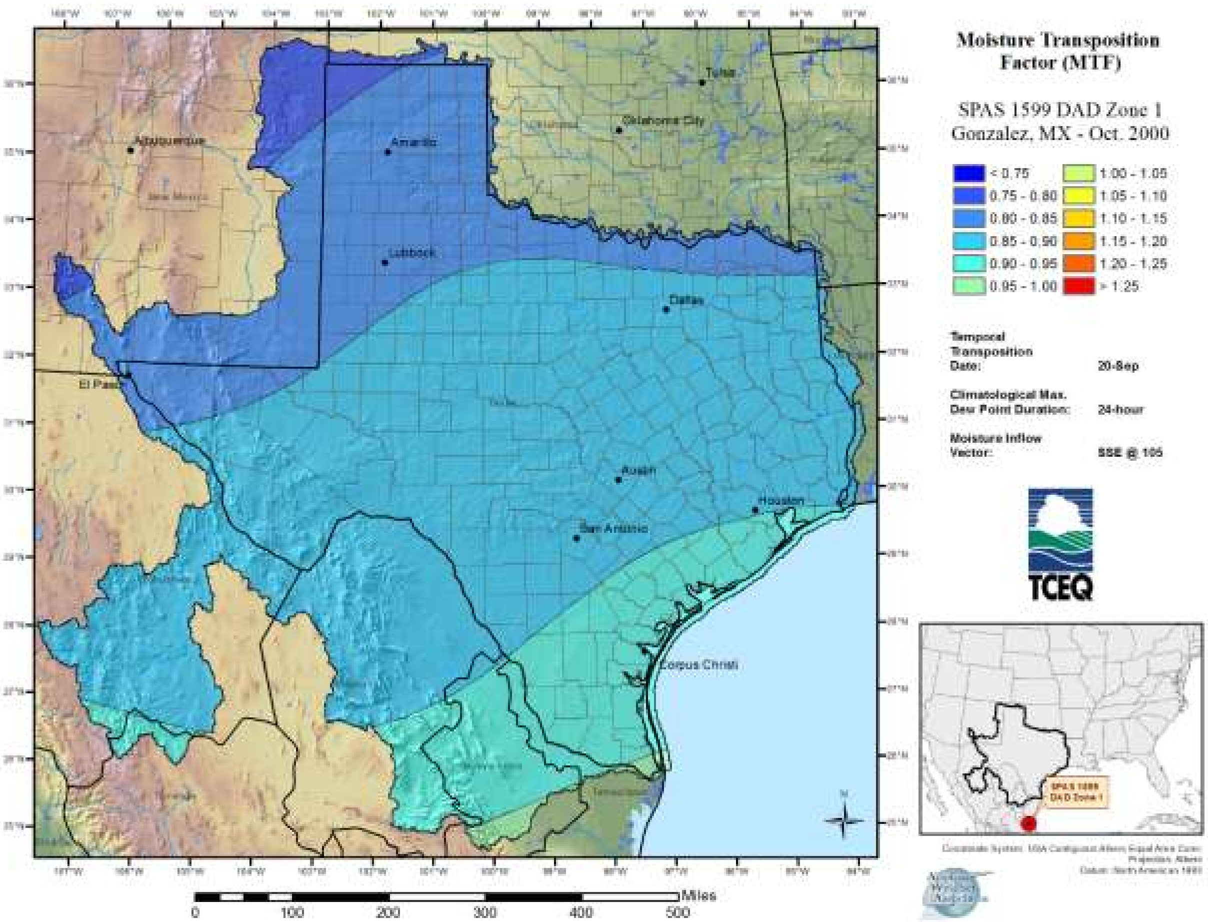

Moisture Transposition
Factor (MTF)
SPAS 1592 DAD Zone 1
Thrall, TX - Sep. 1921
< 0.75
0.75 - 0.80
0.80 - 0.85
0.85 - 0.90
0.90 - 0.95
0.95 - 1.00
1.00 - 1.05
1.05 - 1.10
1.10 - 1.15
1.15 - 1.20
1.20 - 1.25
> 1.25
Temporal Transposition Date: 24-Aug
Climatological Max. Dew Point Duration: 12-hour
Moisture Inflow Vector: SW @ 250
TCEQ
SPAS 1592 DAD Zone 1
Tulsa
Oklahoma City
Albuquerque
Amarillo
Lubbock
Dallas
El Paso
Austin
Houston
San Antonio
Corpus Christi
Miles
0
100
200
300
400
500

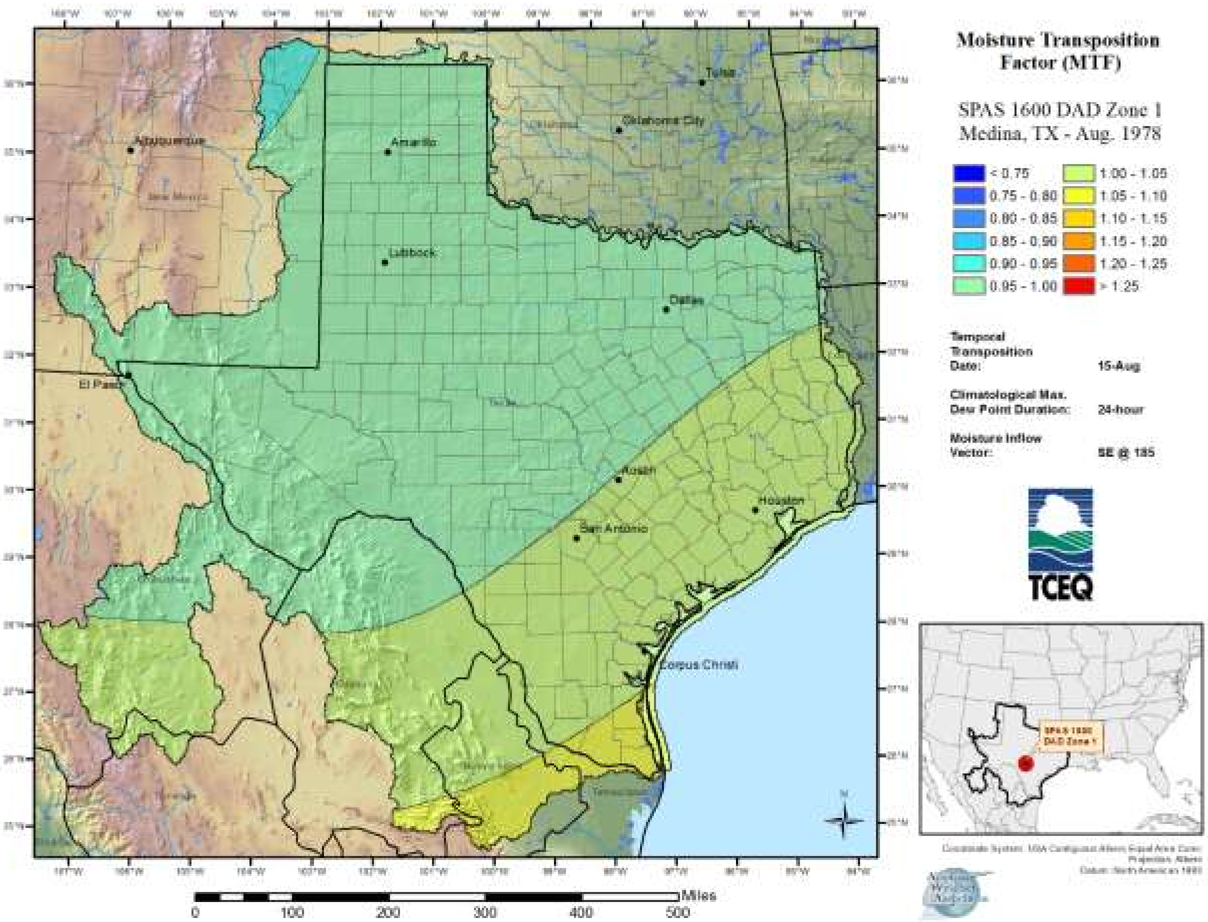


Moisture Transposition Factor (MTF)
SPAS 1593 DAD Zone 1
Munson, FL - Sep. 1998
< 0.75
0.75 - 0.80
0.80 - 0.85
0.85 - 0.90
0.90 - 0.95
0.95 - 1.00
1.00 - 1.05
1.05 - 1.10
1.10 - 1.15
1.15 - 1.20
1.20 - 1.25
> 1.25
Temporal Transposition Date: 15-Sep
Climatological Max. Dew Point Duration: SST
Moisture Inflow Vector: SSE @ 360
TCEQ
Tulsa
Oklahoma City
Albuquerque
Amarillo
Lubbock
Dallas
El Paso
Austin
Houston
San Antonio
Corpus Christi
SPAS 1593 DAD Zone 1
Miles
0
100
200
300
400
500

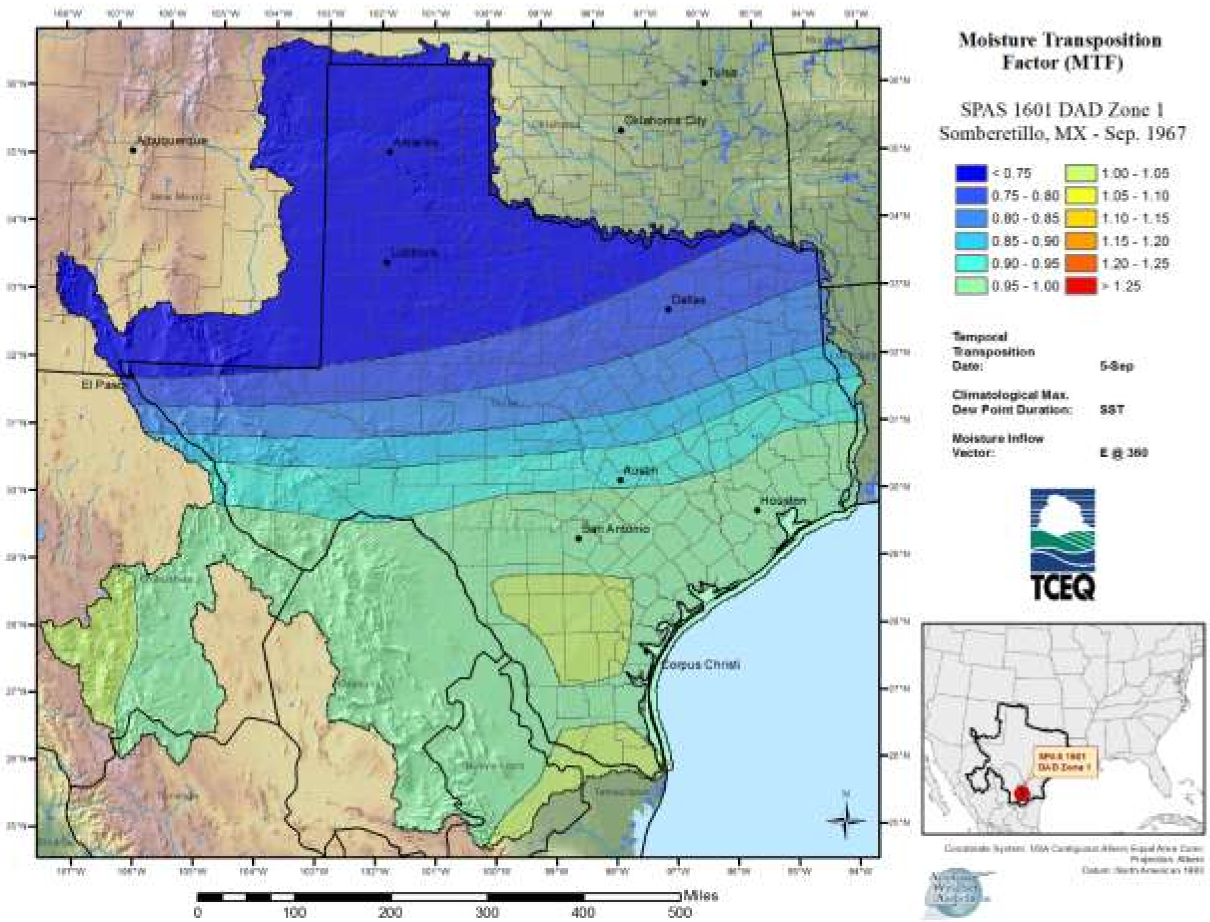

Moisture Transposition
Factor (MTF)
SPAS 1596 DAD Zone 1
Miller Island, LA - Aug. 1940
< 0.75
0.75 - 0.80
0.80 - 0.85
0.85 - 0.90
0.90 - 0.95
0.95 - 1.00
1.00 - 1.05
1.05 - 1.10
1.10 - 1.15
1.15 - 1.20
1.20 - 1.25
> 1.25
Temporal Transposition Date: 19-Aug
Climatological Max. Dew Point Duration: SST
Moisture Inflow Vector: SSE @ 180
TCEQ
Tulsa
Oklahoma City
Albuquerque
Amarillo
Lubbock
Dallas
El Paso
Austin
Houston
San Antonio
Corpus Christi
Miles
0
100
200
300
400
500

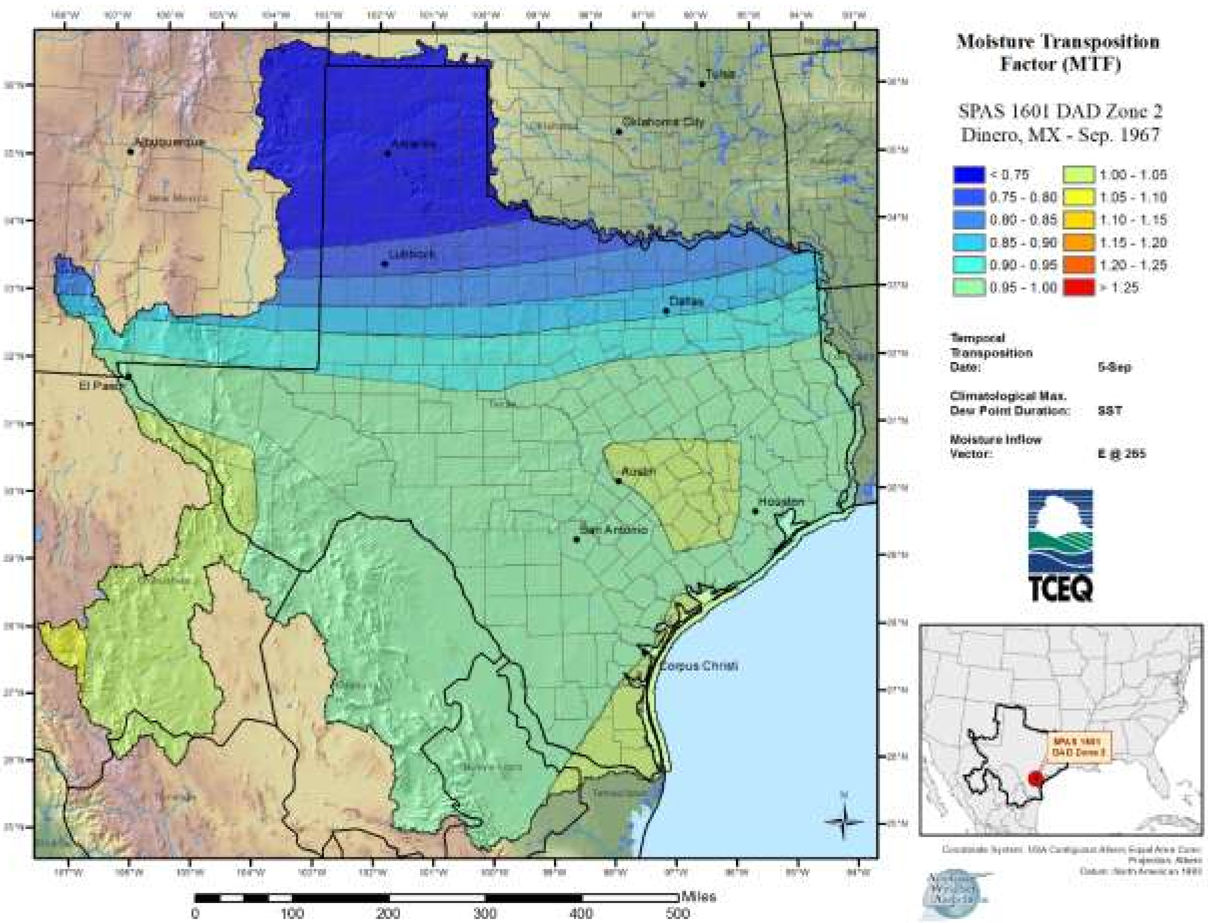

Moisture Transposition
Factor (MTF)
SPAS 1598 DAD Zone 1
Estanzuela-Coahuila, MX - Jun. 2010
< 0.75
0.75 - 0.80
0.80 - 0.85
0.85 - 0.90
0.90 - 0.95
0.95 - 1.00
1.00 - 1.05
1.05 - 1.10
1.10 - 1.15
1.15 - 1.20
1.20 - 1.25
> 1.25
Temporal Transposition Date: 15-Jul
Climatological Max. Dew Point Duration: SST
Moisture Inflow Vector: ESE @ 465
TCEQ
Tulsa
Oklahoma City
Albuquerque
Amarillo
Lubbock
Dallas
El Paso
Austin
Houston
San Antonio
Corpus Christi
SPAS 1598 DAD Zone 1
Miles
0
100
200
300
400
500


Moisture Transposition Factor (MTF)
SPAS 1599 DAD Zone 1
Gonzalez, MX - Oct. 2000
< 0.75
0.75 - 0.80
0.80 - 0.85
0.85 - 0.90
0.90 - 0.95
0.95 - 1.00
1.00 - 1.05
1.05 - 1.10
1.10 - 1.15
1.15 - 1.20
1.20 - 1.25
> 1.25
Temporal Transposition Date: 20-Sep
Climatological Max. Dew Point Duration: 24-hour
Moisture Inflow Vector: SSE @ 105
TCEQ
Tulsa
Oklahoma City
Amarillo
Albuquerque
Lubbock
Dallas
El Paso
Austin
Houston
San Antonio
Corpus Christi
Miles
0
100
200
300
400
500

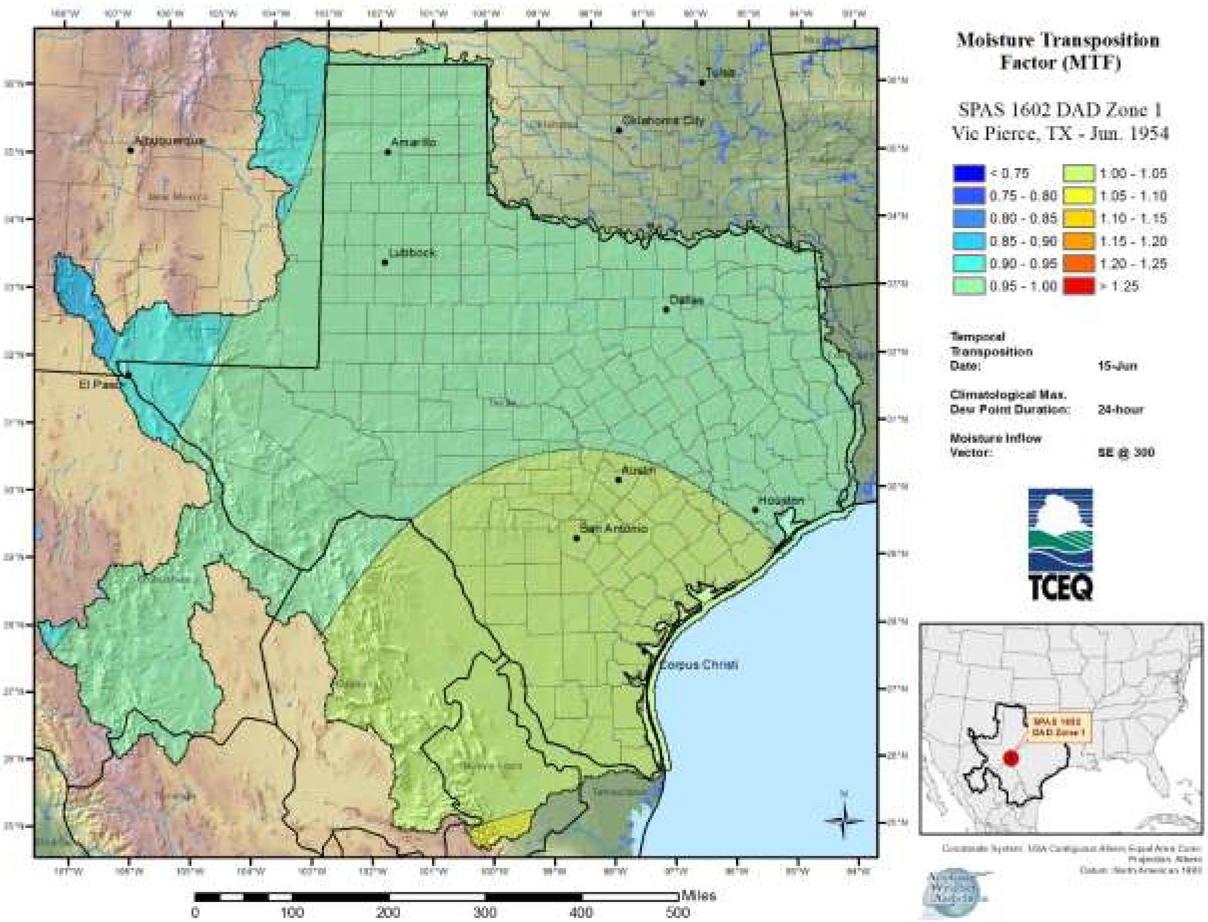


Moisture Transposition Factor (MTF)
SPAS 1600 DAD Zone 1
Medina, TX - Aug. 1978
< 0.75
0.75 - 0.80
0.80 - 0.85
0.85 - 0.90
0.90 - 0.95
0.95 - 1.00
1.00 - 1.05
1.05 - 1.10
1.10 - 1.15
1.15 - 1.20
1.20 - 1.25
> 1.25
Temporal Transposition Date: 15-Aug
Climatological Max. Dew Point Duration: 24-hour
Moisture Inflow Vector: SE @ 185
TCEQ
Tulsa
Oklahoma City
Albuquerque
Amarillo
Lubbock
Dallas
El Paso
Austin
Houston
San Antonio
Corpus Christi
SPAS 1600 DAD Zone 1
Miles
0
100
200
300
400
500


Moisture Transposition Factor (MTF)
SPAS 1601 DAD Zone 1
Somberetillo, MX - Sep. 1967
< 0.75
0.75 - 0.80
0.80 - 0.85
0.85 - 0.90
0.90 - 0.95
0.95 - 1.00
1.00 - 1.05
1.05 - 1.10
1.10 - 1.15
1.15 - 1.20
1.20 - 1.25
> 1.25
Temporal Transposition Date: 5-Sep
Climatological Max. Dew Point Duration: SST
Moisture Inflow Vector: E @ 360
TCEQ
SPAS 1601 DAD Zone 1
Tulsa
Oklahoma City
Albuquerque
Amarillo
Lubbock
Dallas
El Paso
Austin
Houston
San Antonio
Corpus Christi
Miles
0
100
200
300
400
500



Moisture Transposition Factor (MTF)
SPAS 1601 DAD Zone 2
Dinero, MX - Sep. 1967
< 0.75
0.75 - 0.80
0.80 - 0.85
0.85 - 0.90
0.90 - 0.95
0.95 - 1.00
1.00 - 1.05
1.05 - 1.10
1.10 - 1.15
1.15 - 1.20
1.20 - 1.25
> 1.25
Temporal Transposition Date: 5-Sep
Climatological Max. Dew Point Duration: SST
Moisture Inflow Vector: E @ 265
TCEQ
Tulsa
Oklahoma City
Albuquerque
Amarillo
Lubbock
Dallas
El Paso
Austin
Houston
San Antonio
Corpus Christi
Miles
0
100
200
300
400
500



Moisture Transposition Factor (MTF)
SPAS 1602 DAD Zone 1
Vic Pierce, TX - Jun. 1954
< 0.75
0.75 - 0.80
0.80 - 0.85
0.85 - 0.90
0.90 - 0.95
0.95 - 1.00
1.00 - 1.05
1.05 - 1.10
1.10 - 1.15
1.15 - 1.20
1.20 - 1.25
> 1.25
Temporal Transposition Date: 15-Jun
Climatological Max. Dew Point Duration: 24-hour
Moisture Inflow Vector: SE @ 300
TCEQ
SPAS 1602 DAD Zone 1
Tulsa
Oklahoma City
Albuquerque
Amarillo
Lubbock
Dallas
El Paso
Austin
Houston
San Antonio
Corpus Christi
Miles
0
100
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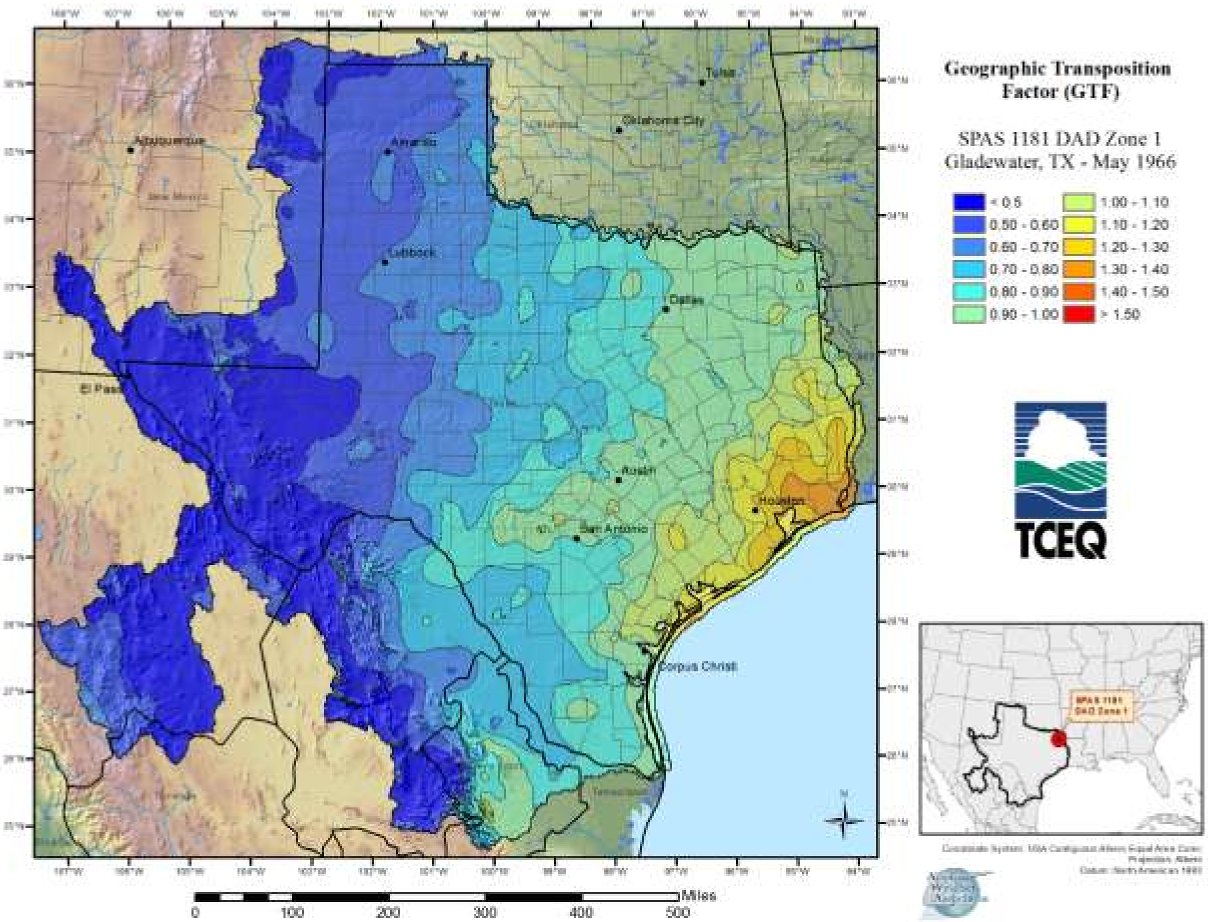
Appendix E
Geographic Transposition Factor (GTF) Maps

General Storms


Geographic Transposition Factor (GTF)
SPAS 1181 DAD Zone 1
Gladewater, TX - May 1966
< 0.5
0.50 - 0.60
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0.70 - 0.80
0.80 - 0.90
0.90 - 1.00
1.00 - 1.10
1.10 - 1.20
1.20 - 1.30
1.30 - 1.40
1.40 - 1.50
> 1.50
TCEQ
Tulsa
Oklahoma City
Albuquerque
Amarillo
Lubbock
Dallas
El Paso
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Houston
San Antonio
Corpus Christi
SPAS 1181
DAD Zone 1
Miles
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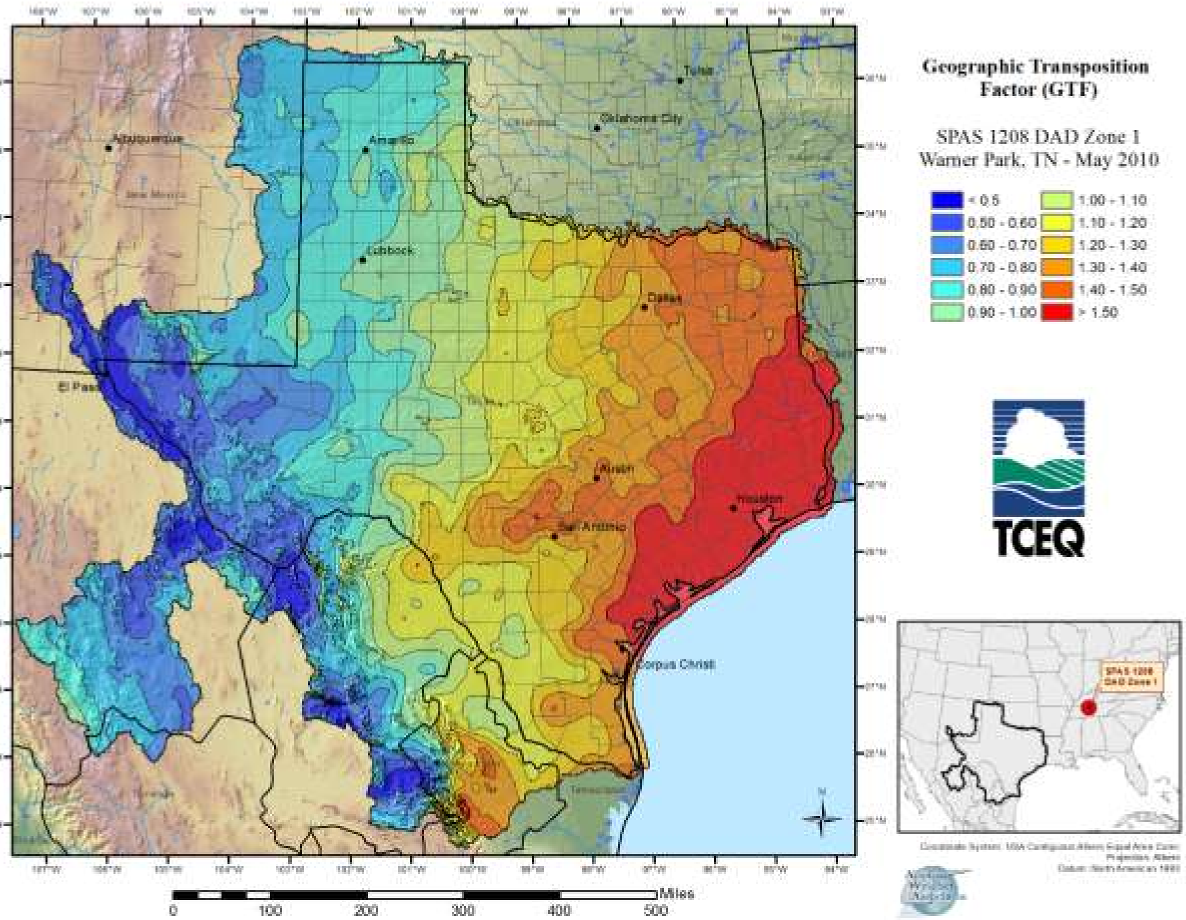
Geographic Transposition Factor (GTF)
SPAS 1208 DAD Zone 1
Warner Park, TN - May 2010
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0.90 - 1.00
1.00 - 1.10
1.10 - 1.20
1.20 - 1.30
1.30 - 1.40
1.40 - 1.50
> 1.50
TCEQ
Tulsa
Oklahoma City
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Amarillo
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Dallas
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San Antonio
Corpus Christi
SPAS 1208 DAD Zone 1
Miles
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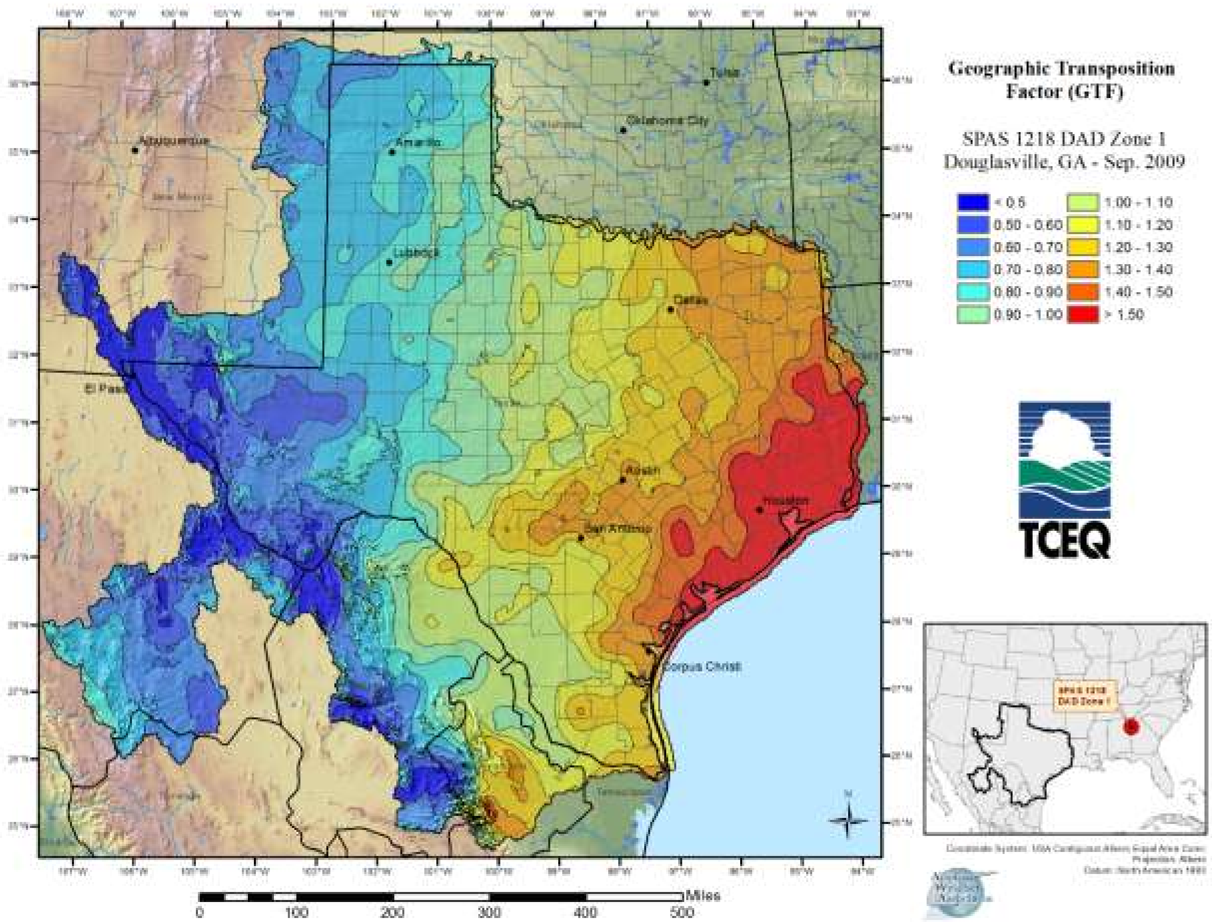

Geographic Transposition Factor (GTF)
SPAS 1218 DAD Zone 1
Douglasville, GA - Sep. 2009
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0.90 - 1.00
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1.10 - 1.20
1.20 - 1.30
1.30 - 1.40
1.40 - 1.50
> 1.50
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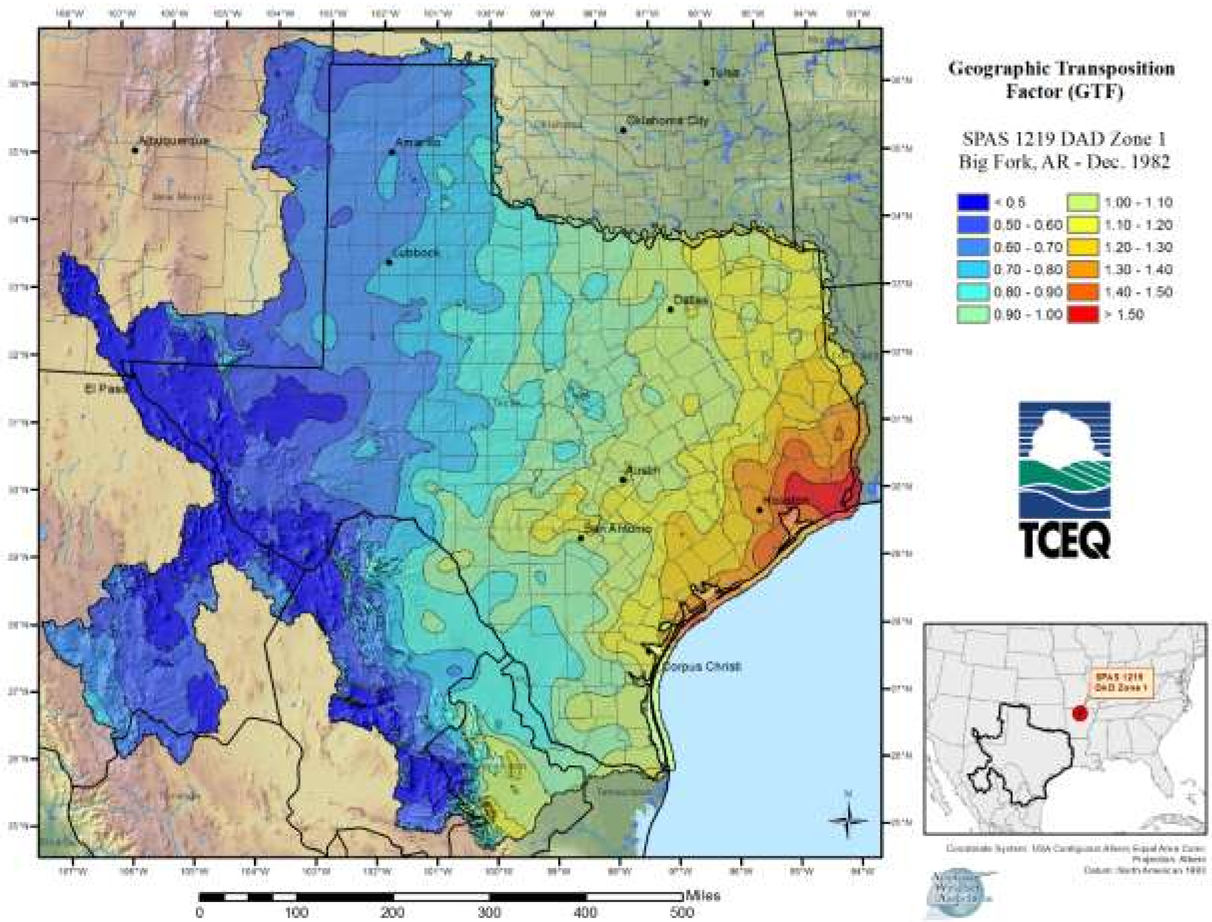
Geographic Transposition Factor (GTF)
SPAS 1219 DAD Zone 1
Big Fork, AR - Dec. 1982
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0.90 - 1.00
1.00 - 1.10
1.10 - 1.20
1.20 - 1.30
1.30 - 1.40
1.40 - 1.50
> 1.50
TCEQ
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SPAS 1219 DAD Zone 1
Miles
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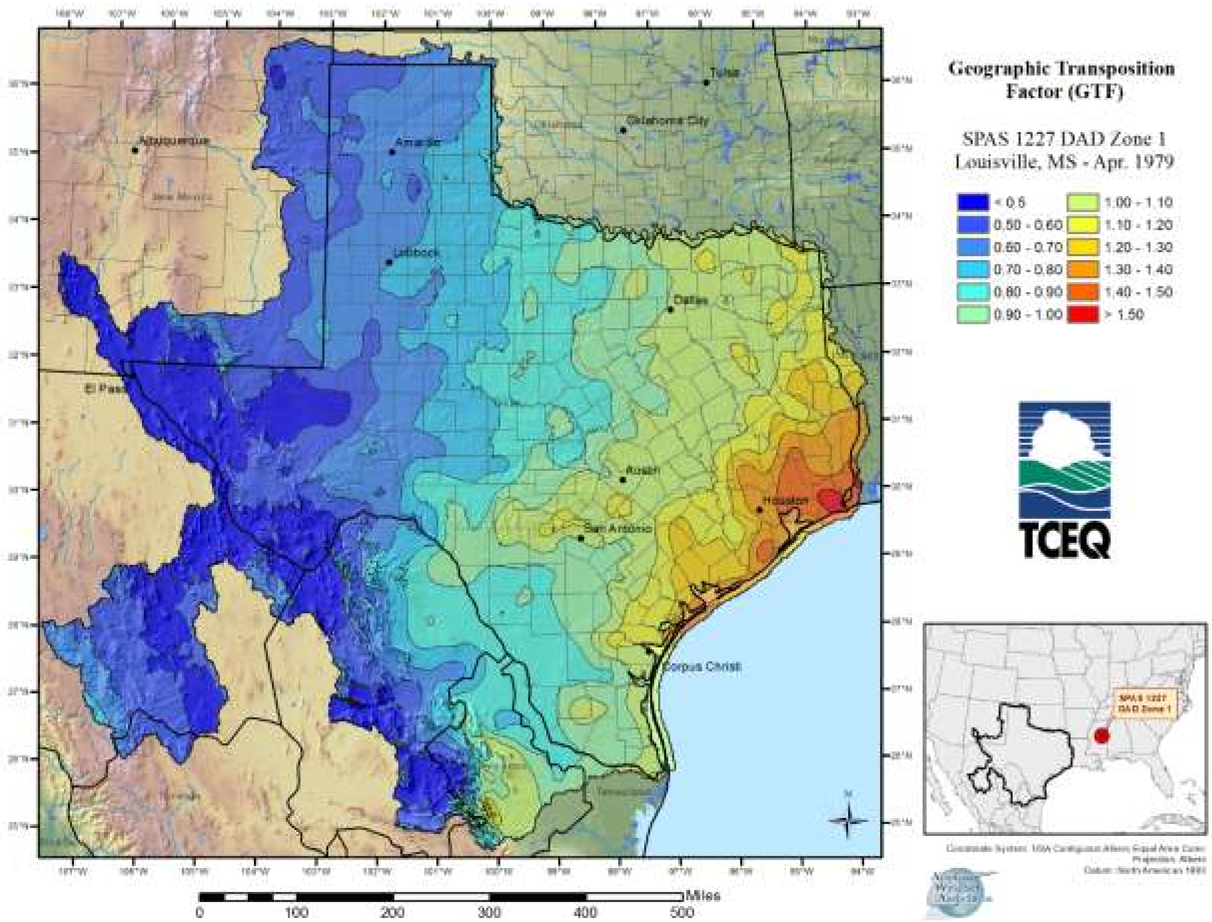
Geographic Transposition Factor (GTF)
SPAS 1227 DAD Zone 1
Louisville, MS - Apr. 1979
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0.80 - 0.90
0.90 - 1.00
1.00 - 1.10
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1.20 - 1.30
1.30 - 1.40
1.40 - 1.50
> 1.50
TCEQ
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Amarillo
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Corpus Christi
SPAS 1227
DAD Zone 1
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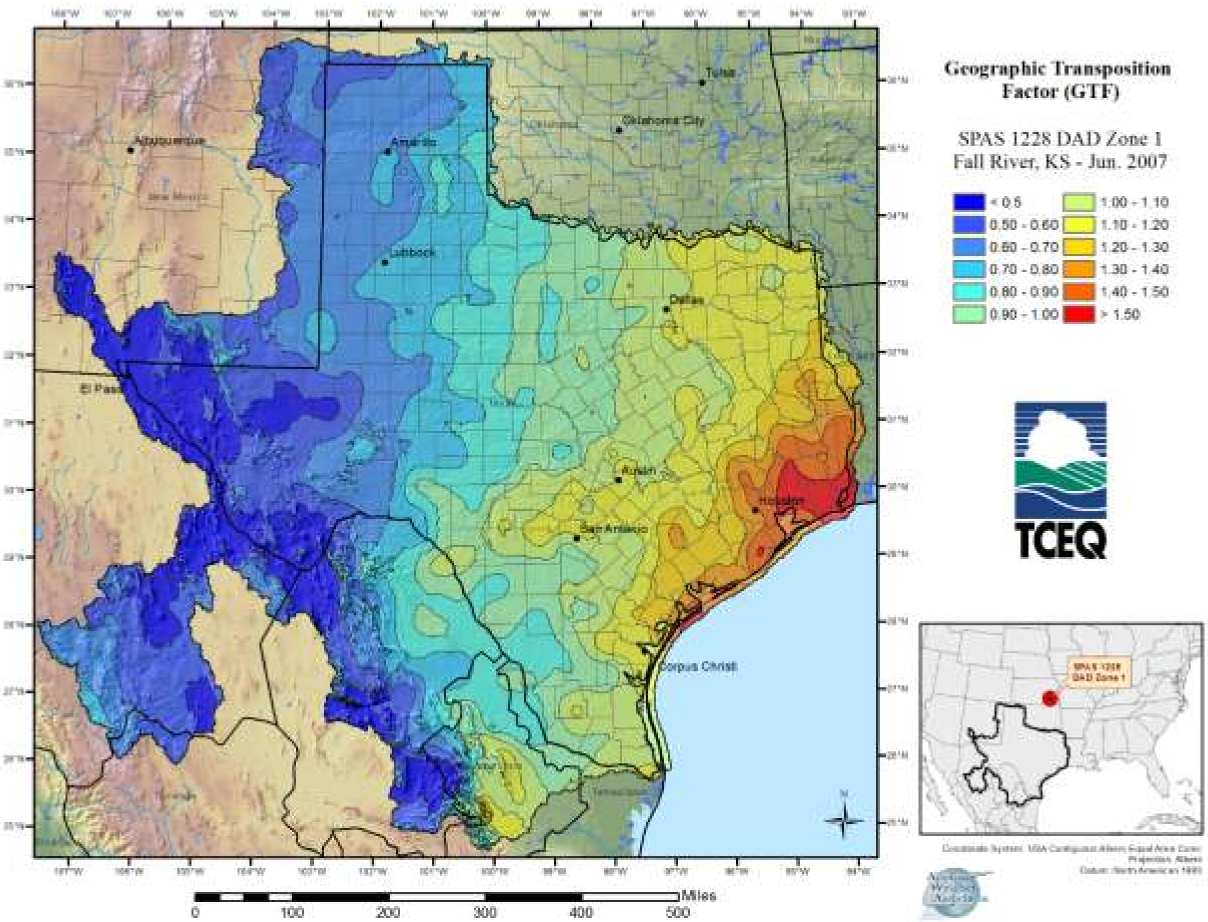
Geographic Transposition Factor (GTF)
SPAS 1228 DAD Zone 1
Fall River, KS - Jun. 2007
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0.70 - 0.80
0.80 - 0.90
0.90 - 1.00
1.00 - 1.10
1.10 - 1.20
1.20 - 1.30
1.30 - 1.40
1.40 - 1.50
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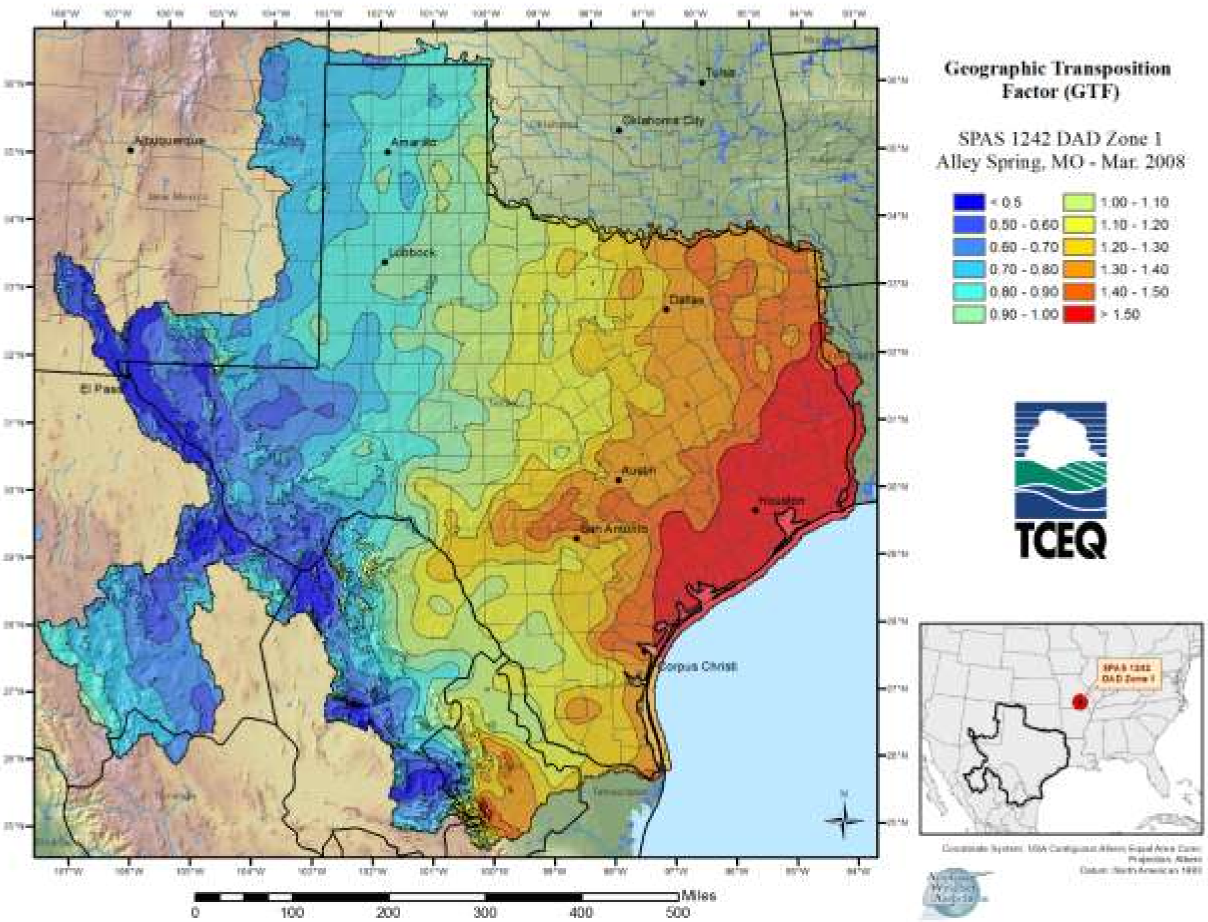
Geographic Transposition Factor (GTF)
SPAS 1242 DAD Zone 1
Alley Spring, MO - Mar. 2008
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0.80 - 0.90
0.90 - 1.00
1.00 - 1.10
1.10 - 1.20
1.20 - 1.30
1.30 - 1.40
1.40 - 1.50
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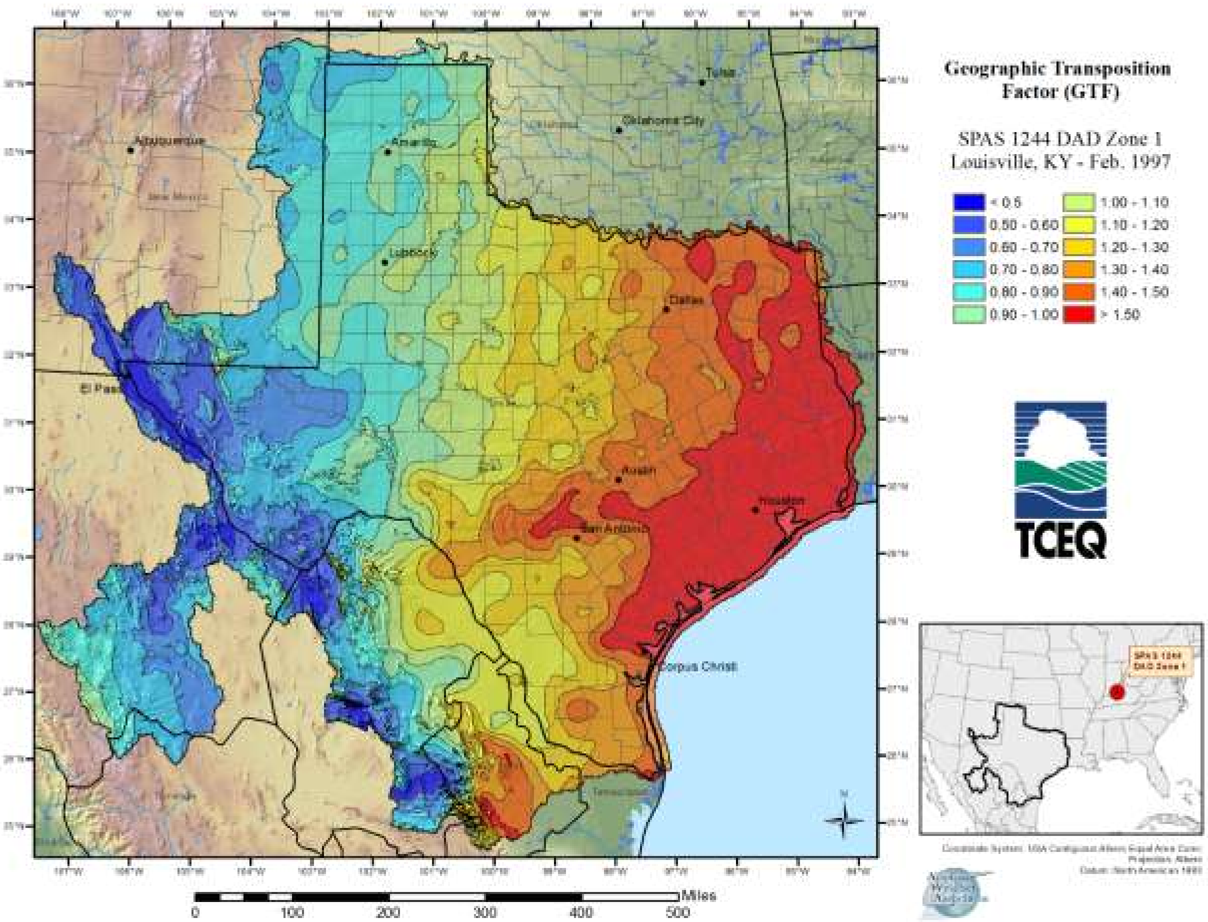
Geographic Transposition Factor (GTF)
SPAS 1244 DAD Zone 1
Louisville, KY - Feb. 1997
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0.90 - 1.00
1.00 - 1.10
1.10 - 1.20
1.20 - 1.30
1.30 - 1.40
1.40 - 1.50
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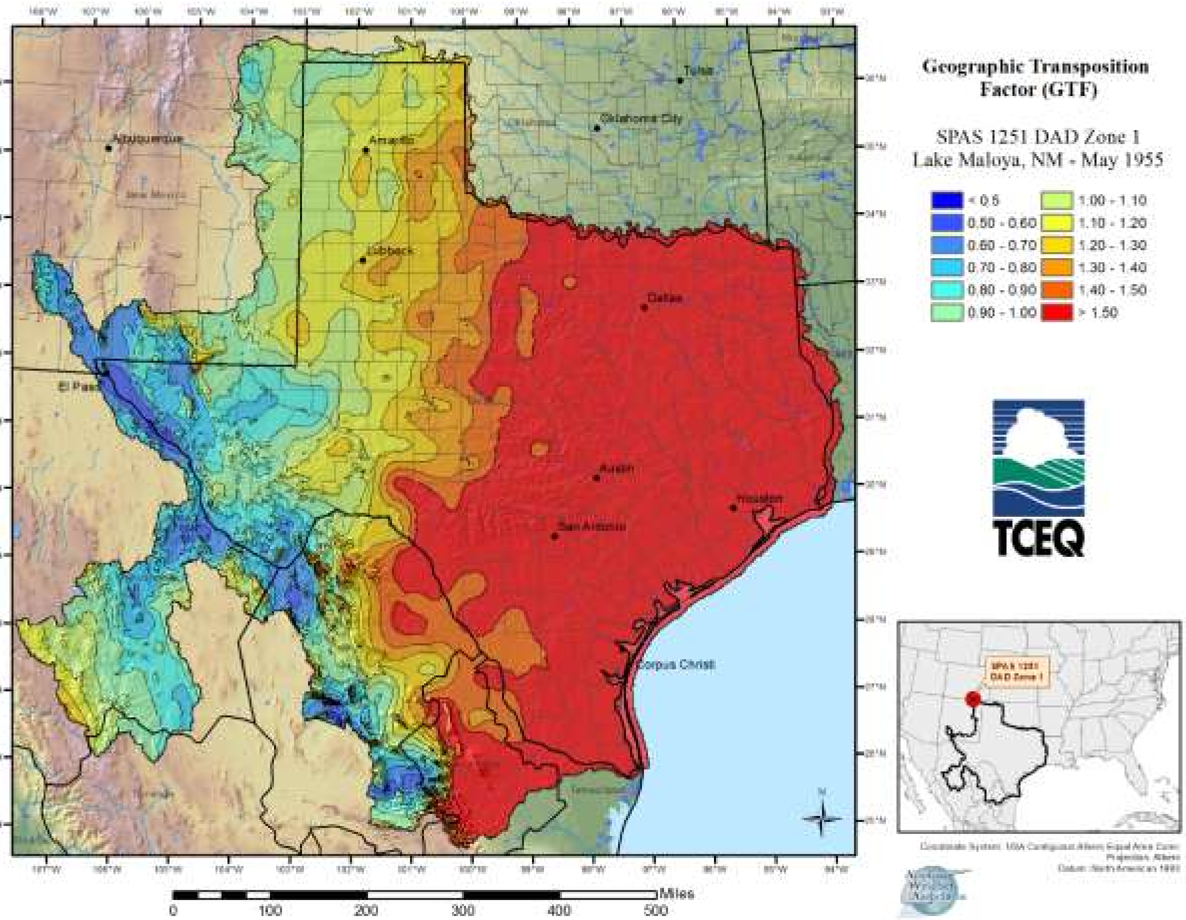

Geographic Transposition Factor (GTF)
SPAS 1251 DAD Zone 1
Lake Maloya, NM - May 1955
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0.90 - 1.00
1.00 - 1.10
1.10 - 1.20
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1.40 - 1.50
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SPAS 1251 DAD Zone 1
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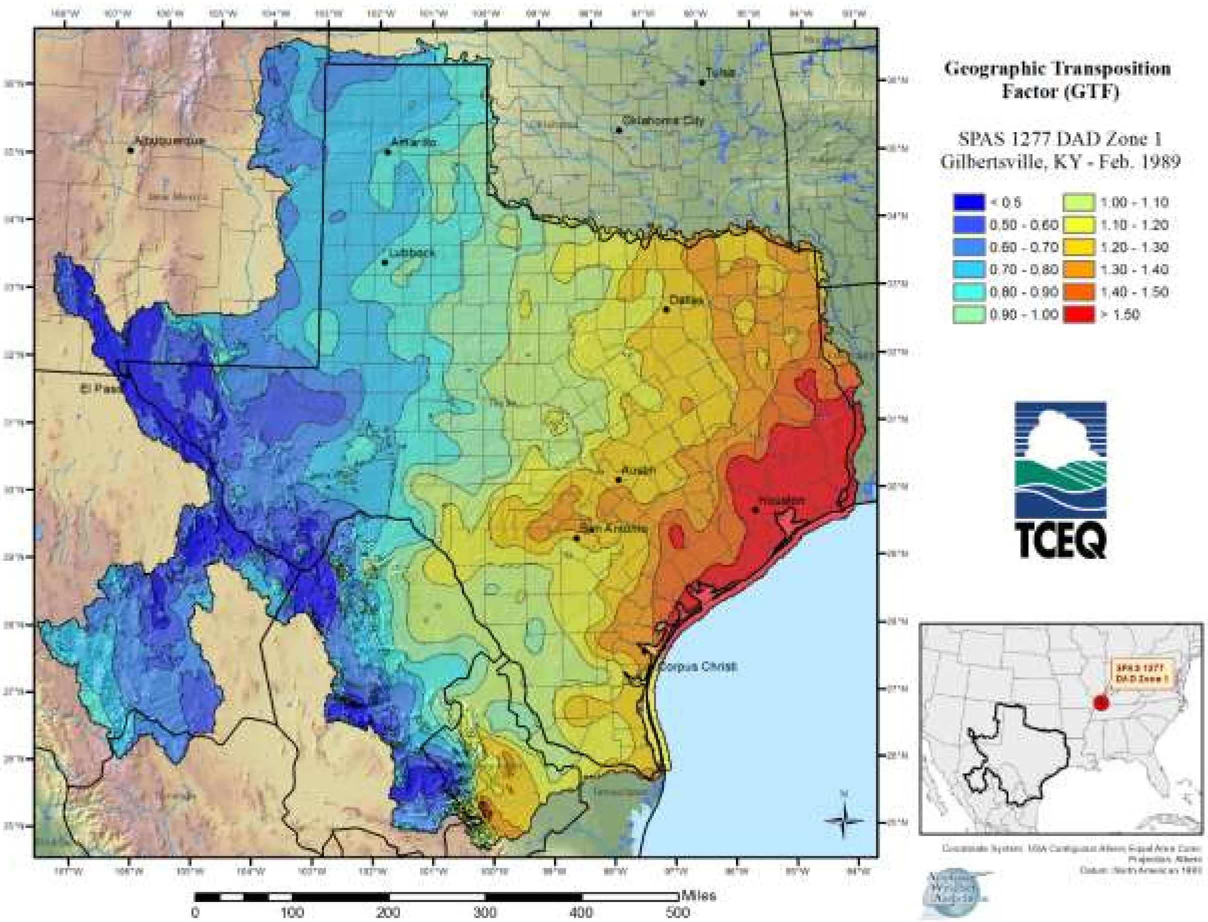
Geographic Transposition Factor (GTF)
SPAS 1277 DAD Zone 1
Gilbertsville, KY - Feb. 1989
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0.90 - 1.00
1.00 - 1.10
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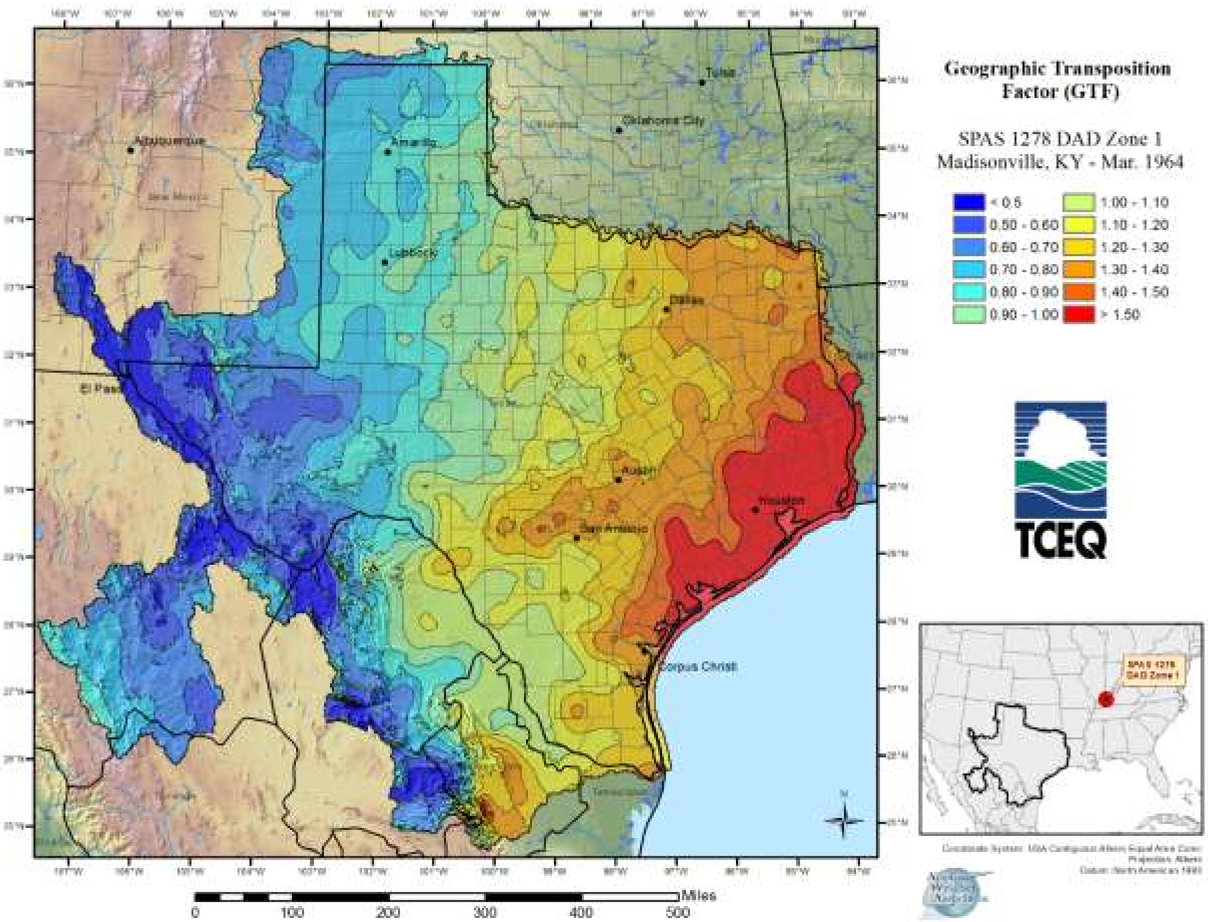

Geographic Transposition Factor (GTF)
SPAS 1278 DAD Zone 1
Madisonville, KY - Mar. 1964
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0.70 - 0.80
0.80 - 0.90
0.90 - 1.00
1.00 - 1.10
1.10 - 1.20
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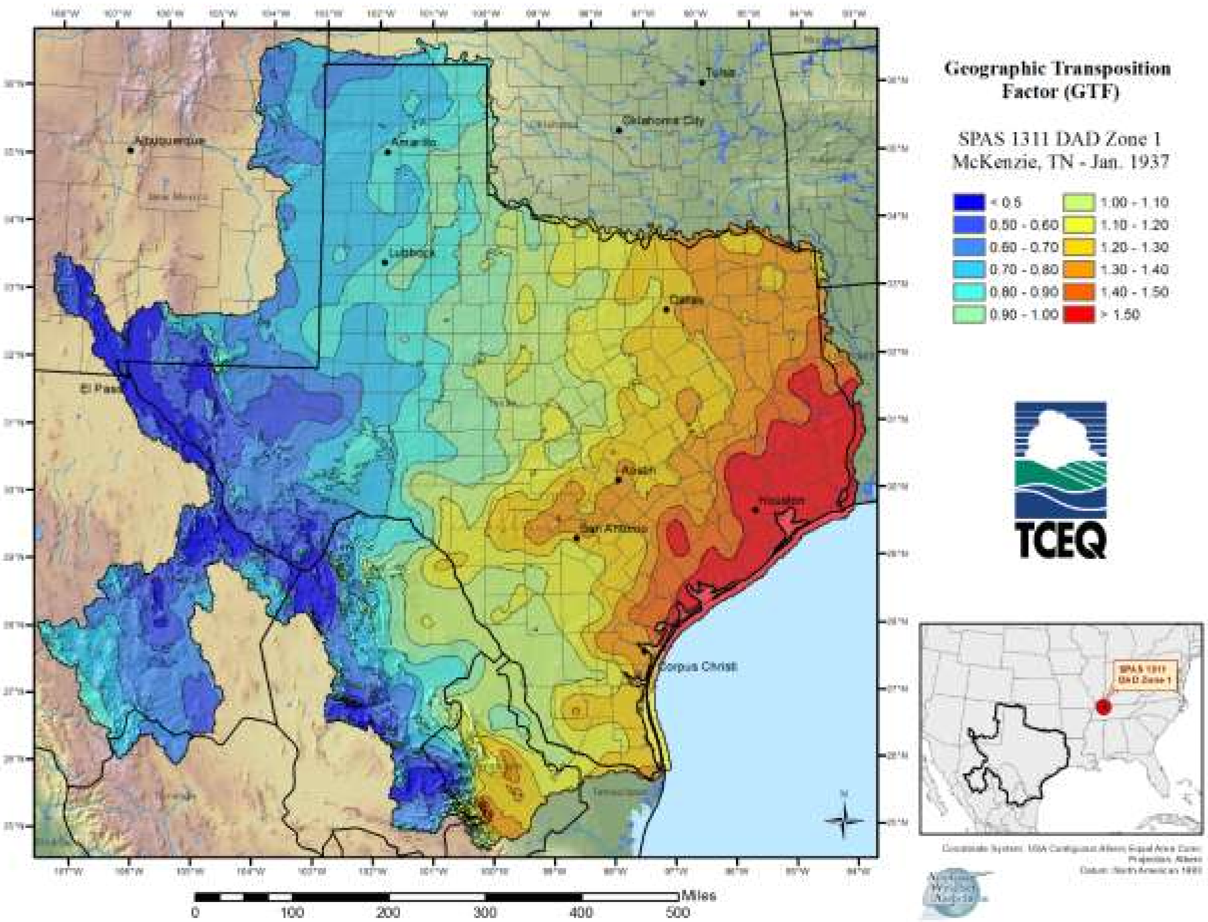
Geographic Transposition Factor (GTF)
SPAS 1311 DAD Zone 1
McKenzie, TN - Jan. 1937
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SPAS 1311 DAD Zone 1
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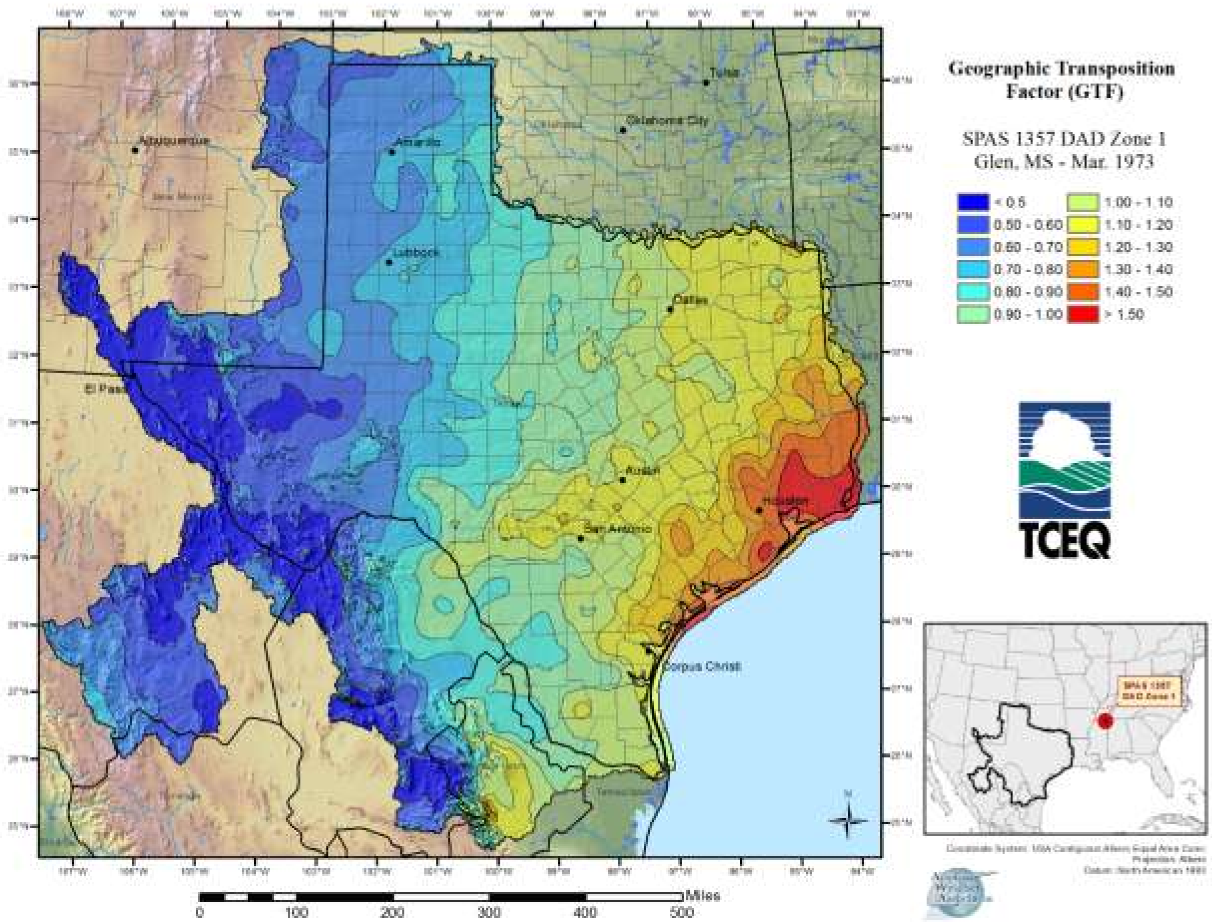
Geographic Transposition Factor (GTF)
SPAS 1357 DAD Zone 1
Glen, MS - Mar. 1973
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SPAS 1357 DAD Zone 1
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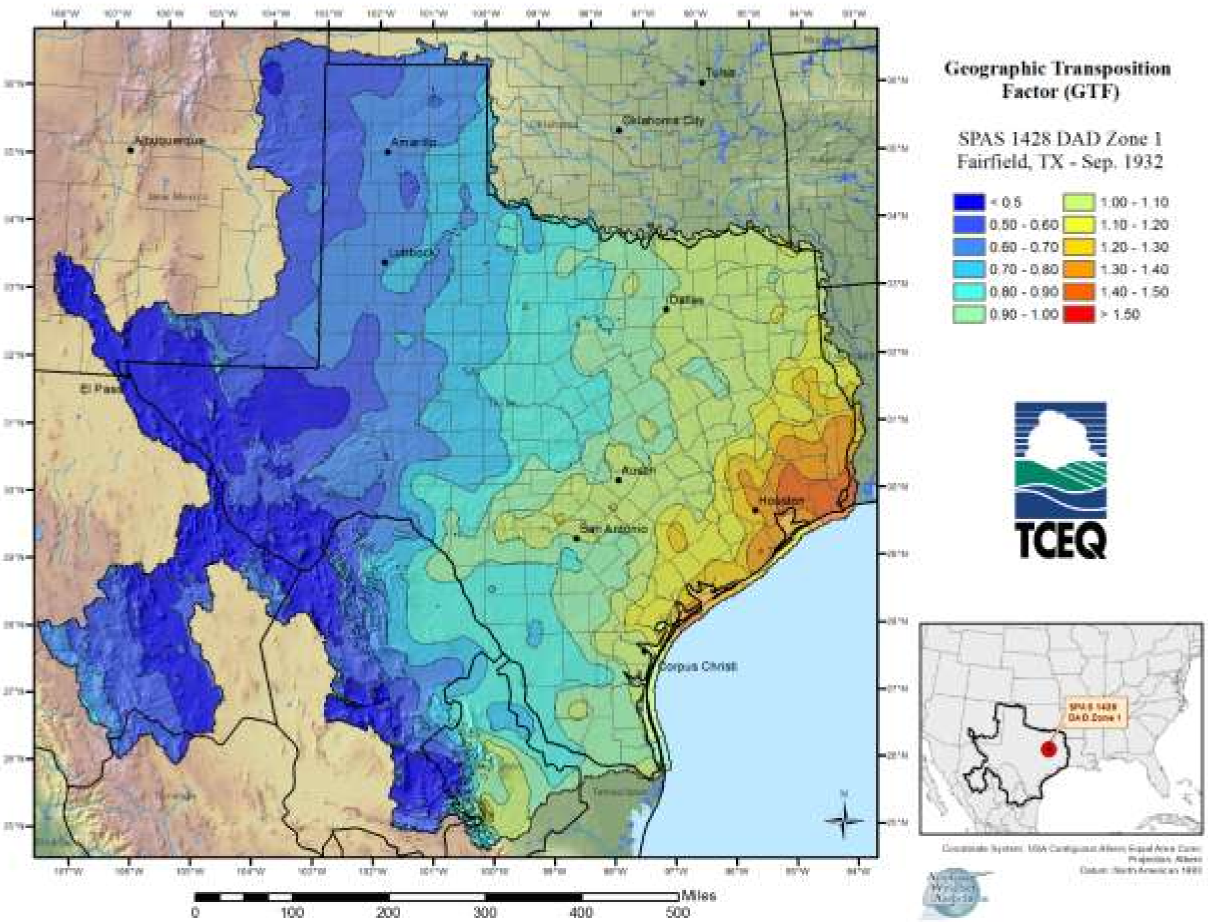
Geographic Transposition Factor (GTF)
SPAS 1428 DAD Zone 1
Fairfield, TX - Sep. 1932
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1.40 - 1.50
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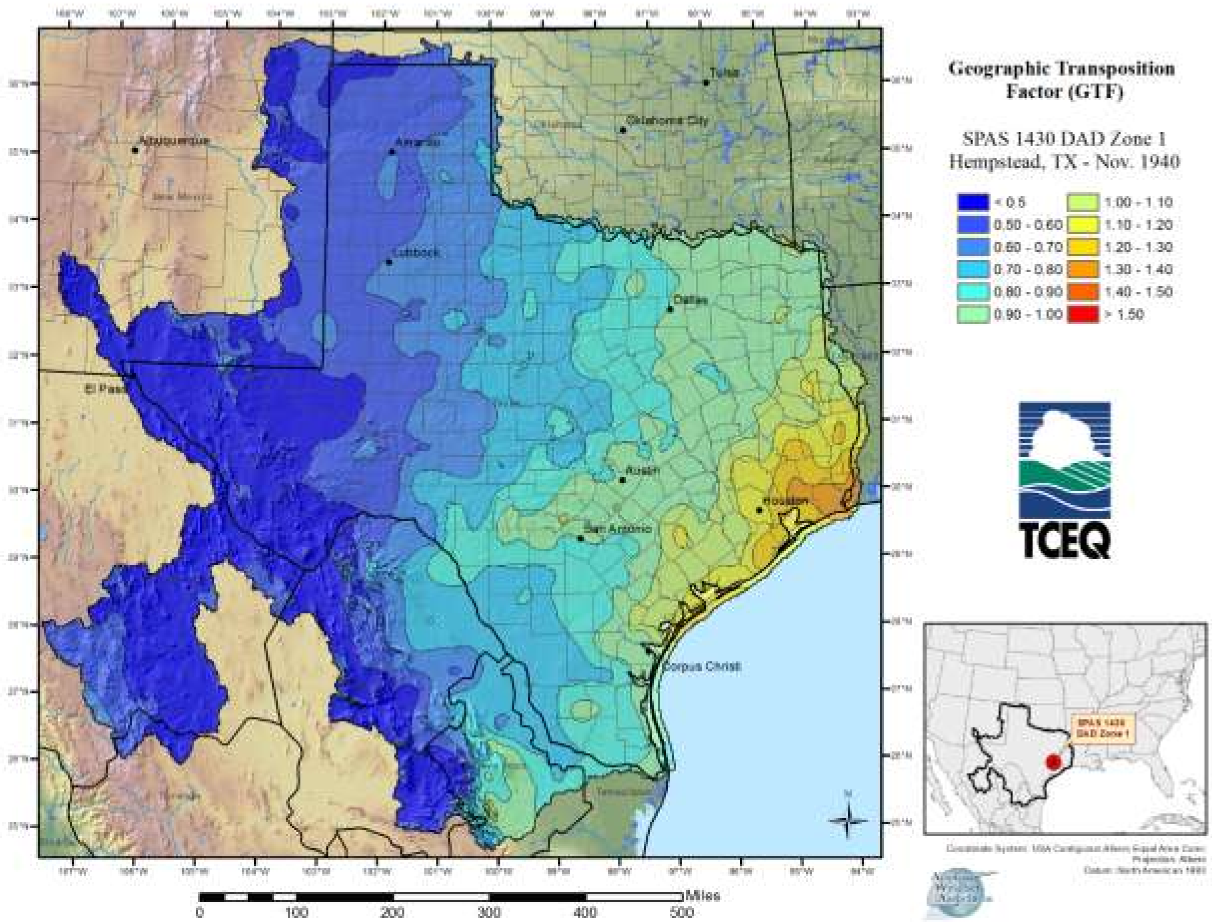
Geographic Transposition Factor (GTF)
SPAS 1430 DAD Zone 1
Hempstead, TX - Nov. 1940
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0.90 - 1.00
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1.40 - 1.50
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SPAS 1430 DAD Zone 1
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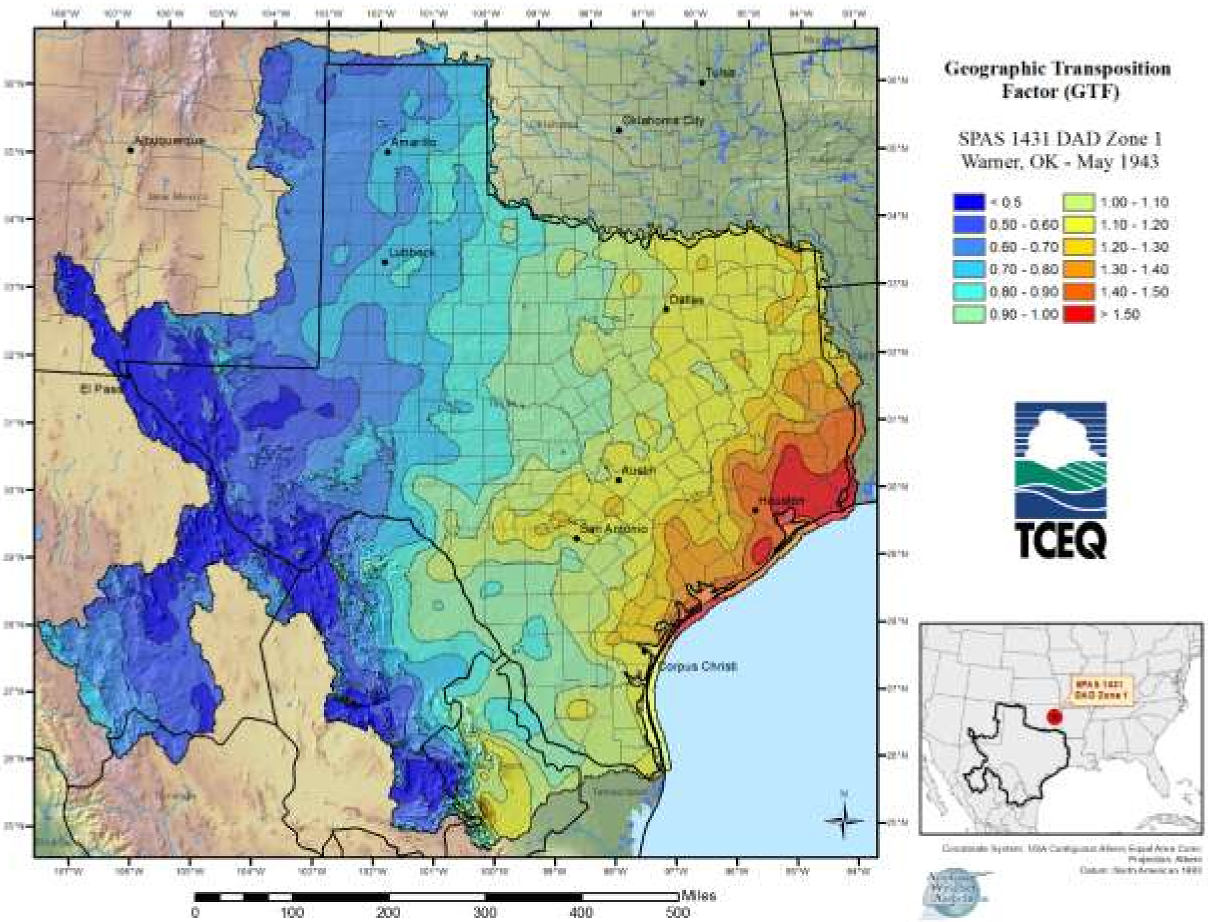
Geographic Transposition Factor (GTF)
SPAS 1431 DAD Zone 1
Warner, OK - May 1943
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0.80 - 0.90
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1.00 - 1.10
1.10 - 1.20
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1.40 - 1.50
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TCEQ
Tulsa
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SPAS 1431 DAD Zone 1
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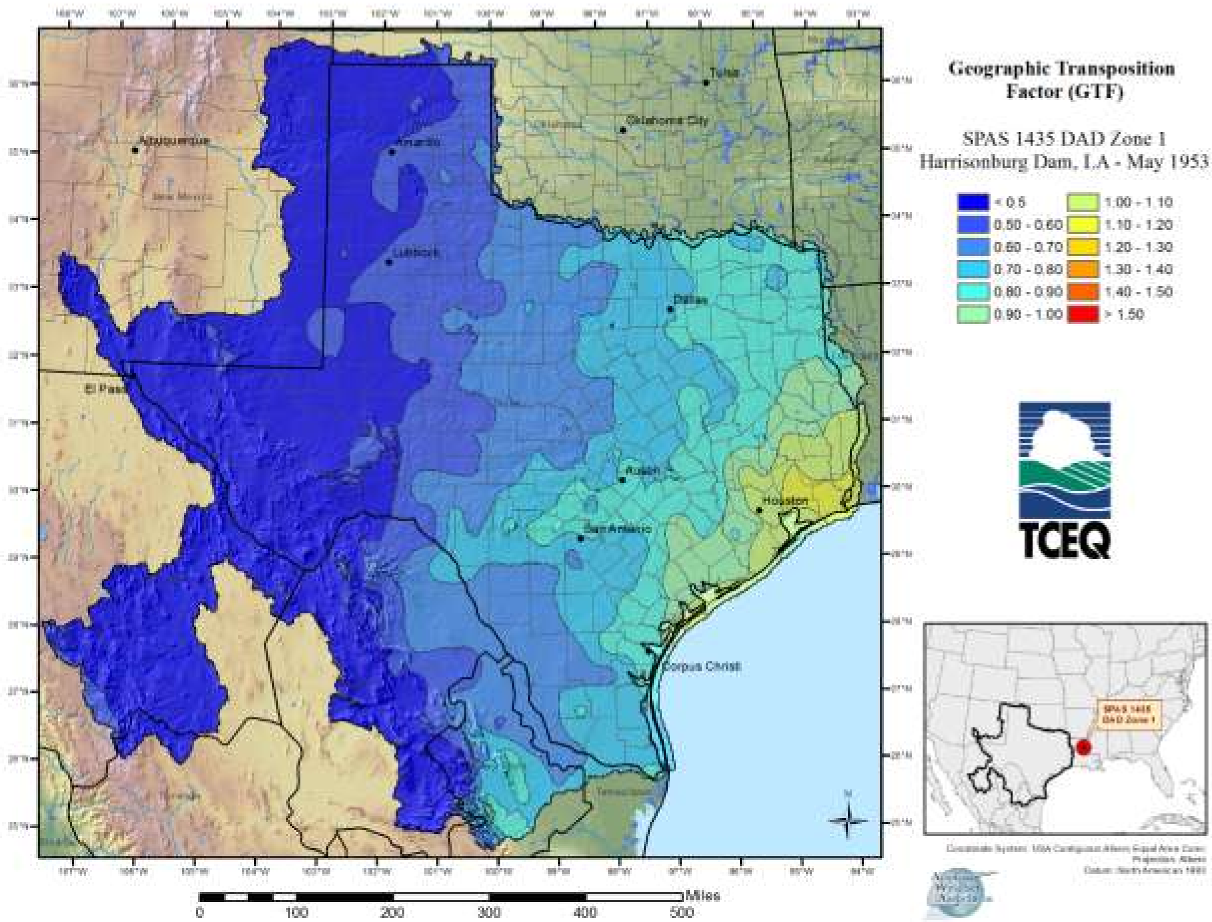
Geographic Transposition Factor (GTF)
SPAS 1435 DAD Zone 1
Harrisonburg Dam, LA - May 1953
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0.90 - 1.00
1.00 - 1.10
1.10 - 1.20
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1.40 - 1.50
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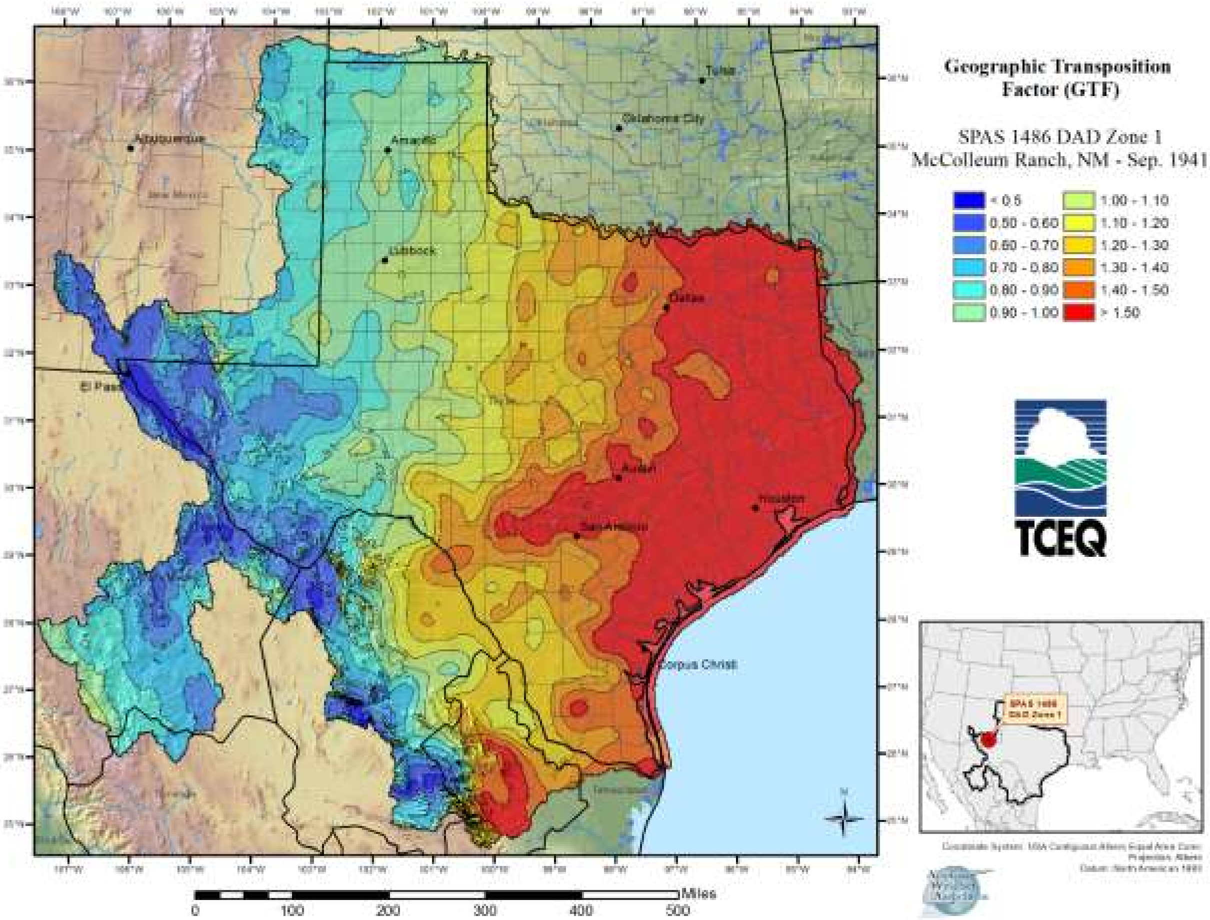
Geographic Transposition Factor (GTF)
SPAS 1486 DAD Zone 1
McColleum Ranch, NM - Sep. 1941
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1.00 - 1.10
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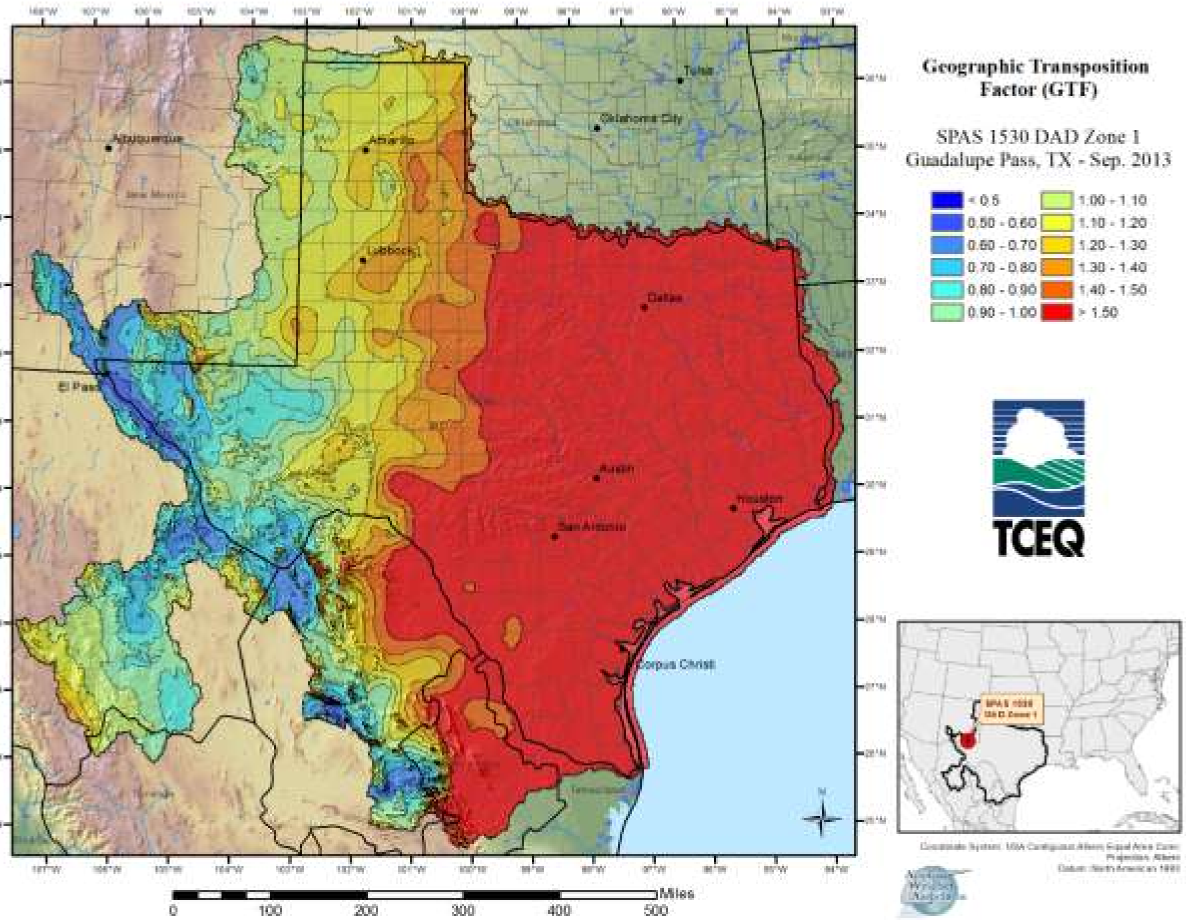
Geographic Transposition Factor (GTF)
SPAS 1530 DAD Zone 1
Guadalupe Pass, TX - Sep. 2013
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0.90 - 1.00
1.00 - 1.10
1.10 - 1.20
1.20 - 1.30
1.30 - 1.40
1.40 - 1.50
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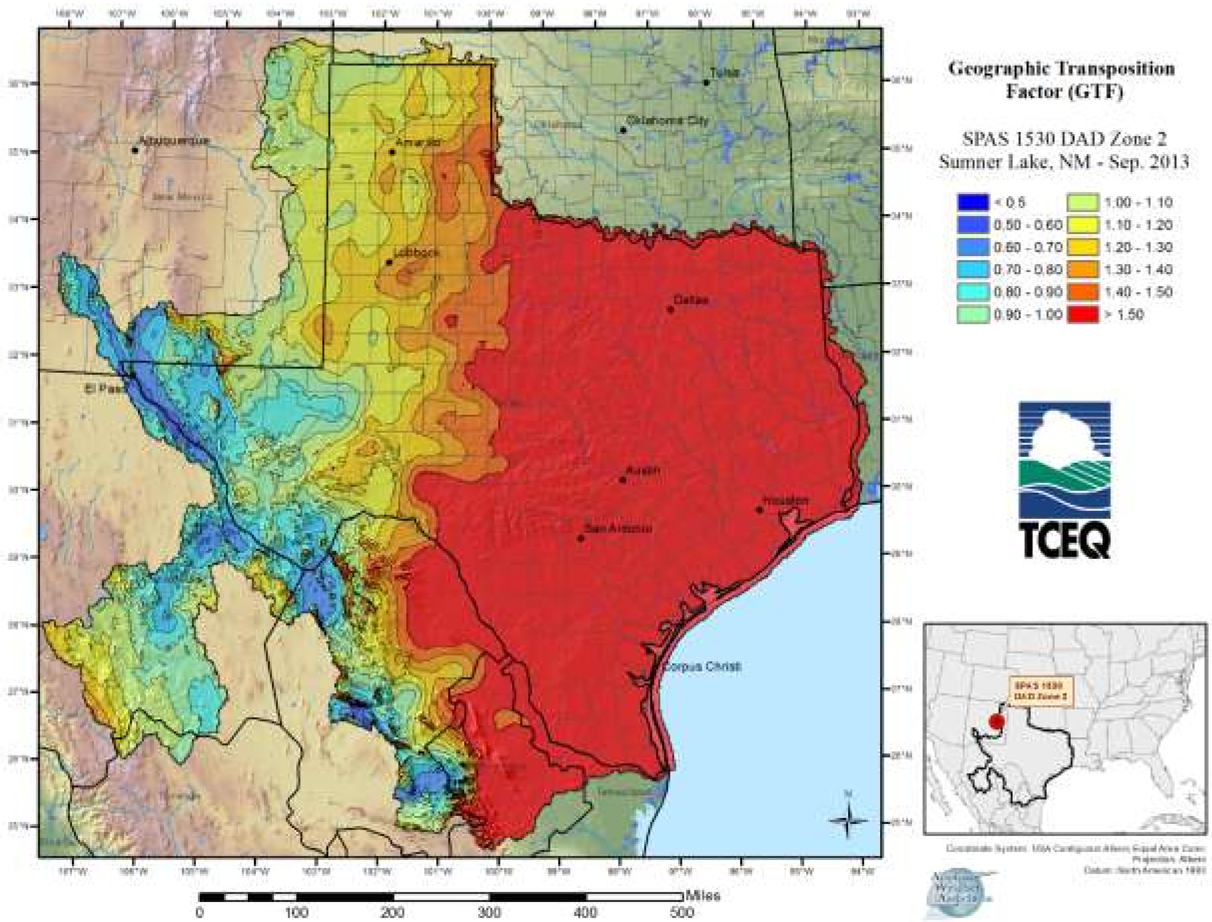
Geographic Transposition Factor (GTF)
SPAS 1530 DAD Zone 2
Sumner Lake, NM - Sep. 2013
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0.70 - 0.80
0.80 - 0.90
0.90 - 1.00
1.00 - 1.10
1.10 - 1.20
1.20 - 1.30
1.30 - 1.40
1.40 - 1.50
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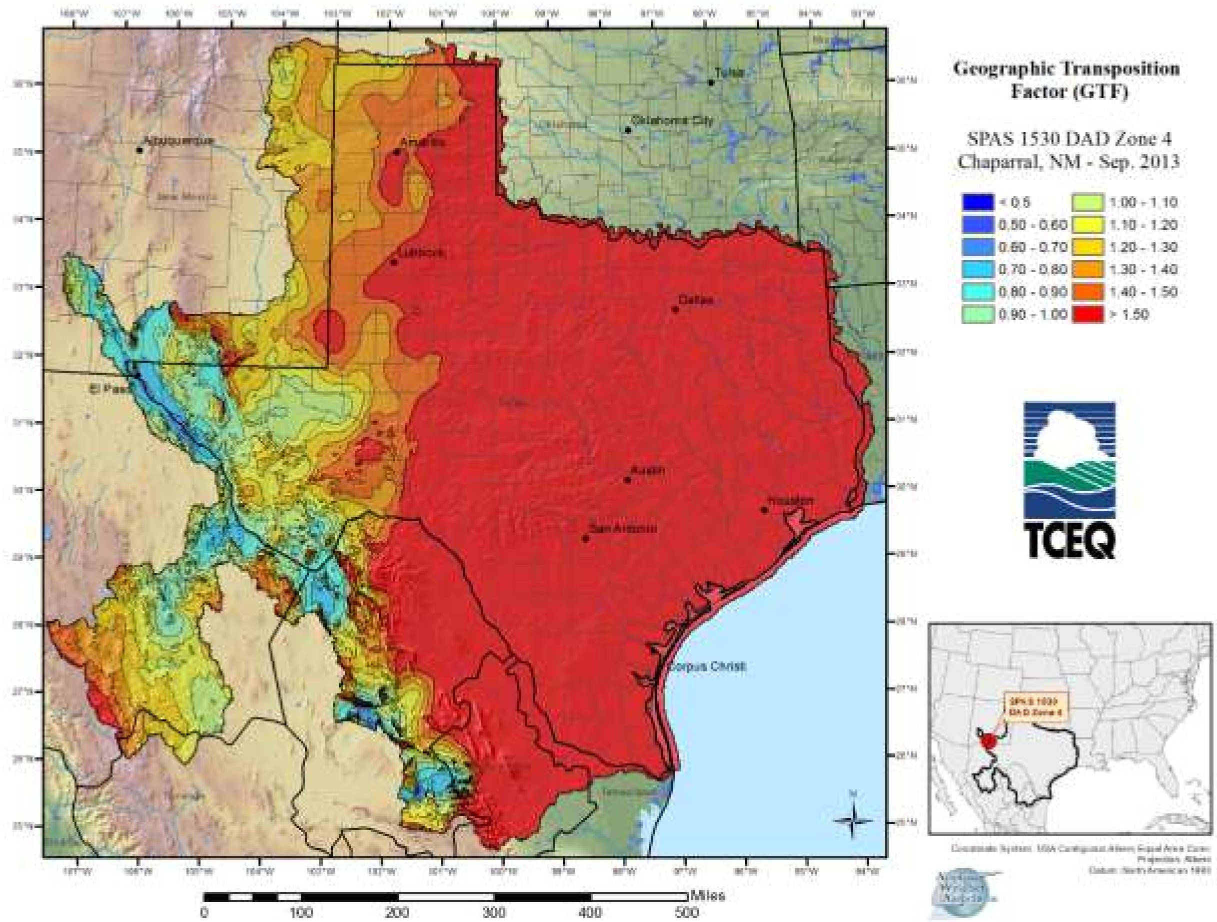
Geographic Transposition Factor (GTF)
SPAS 1530 DAD Zone 4
Chaparral, NM - Sep. 2013
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0.70 - 0.80
0.80 - 0.90
0.90 - 1.00
1.00 - 1.10
1.10 - 1.20
1.20 - 1.30
1.30 - 1.40
1.40 - 1.50
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TCEQ
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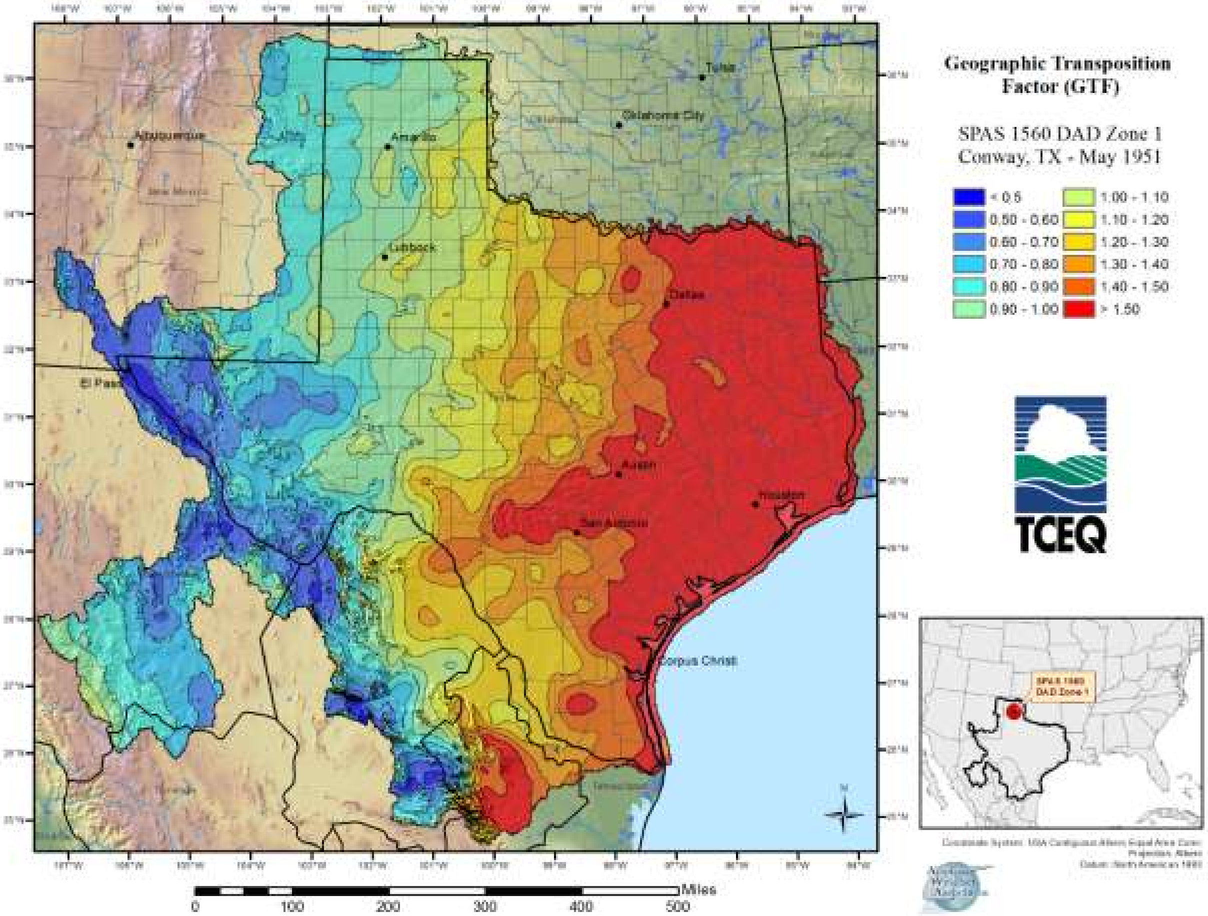

Geographic Transposition Factor (GTF)
SPAS 1560 DAD Zone 1
Conway, TX - May 1951
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0.80 - 0.90
0.90 - 1.00
1.00 - 1.10
1.10 - 1.20
1.20 - 1.30
1.30 - 1.40
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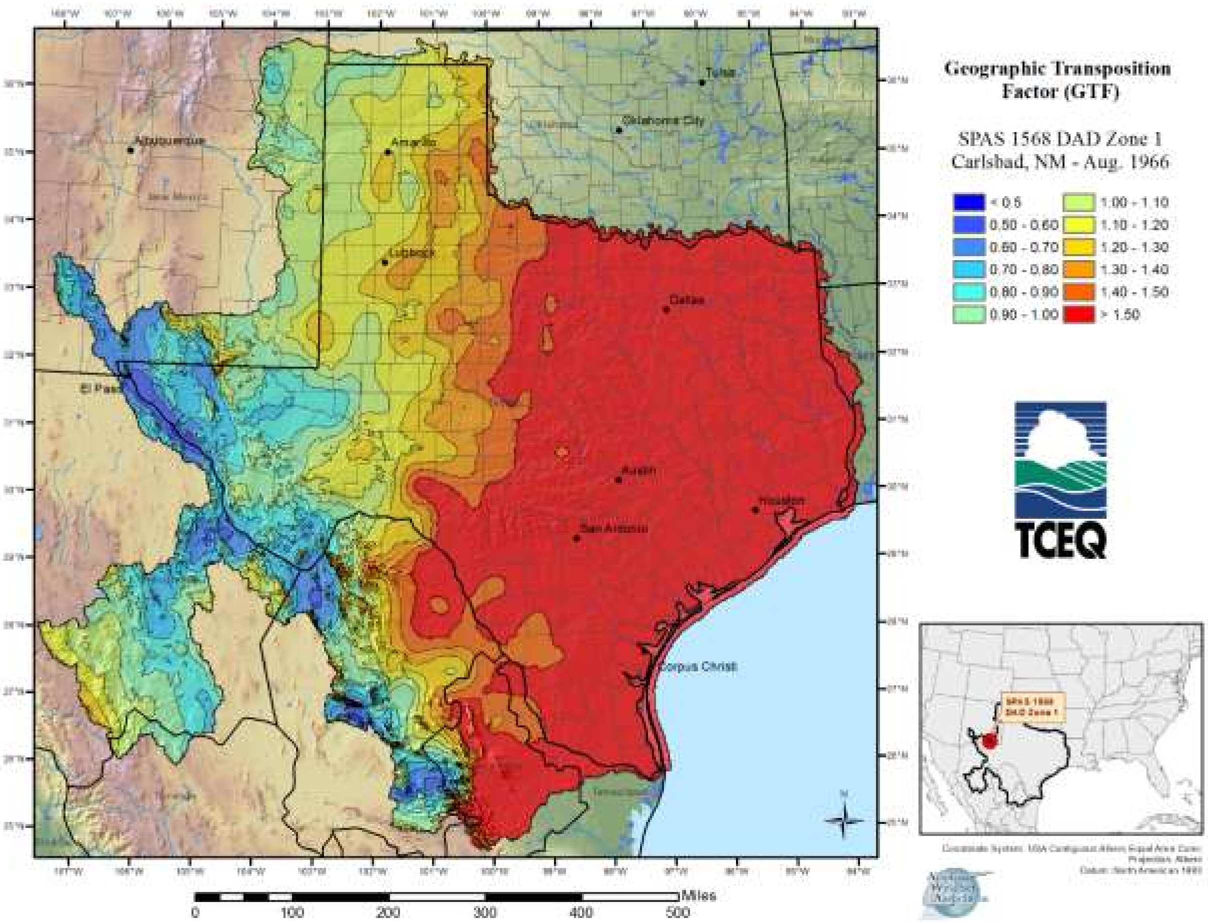

Geographic Transposition Factor (GTF)
SPAS 1568 DAD Zone 1
Carlsbad, NM - Aug. 1966
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0.70 - 0.80
0.80 - 0.90
0.90 - 1.00
1.00 - 1.10
1.10 - 1.20
1.20 - 1.30
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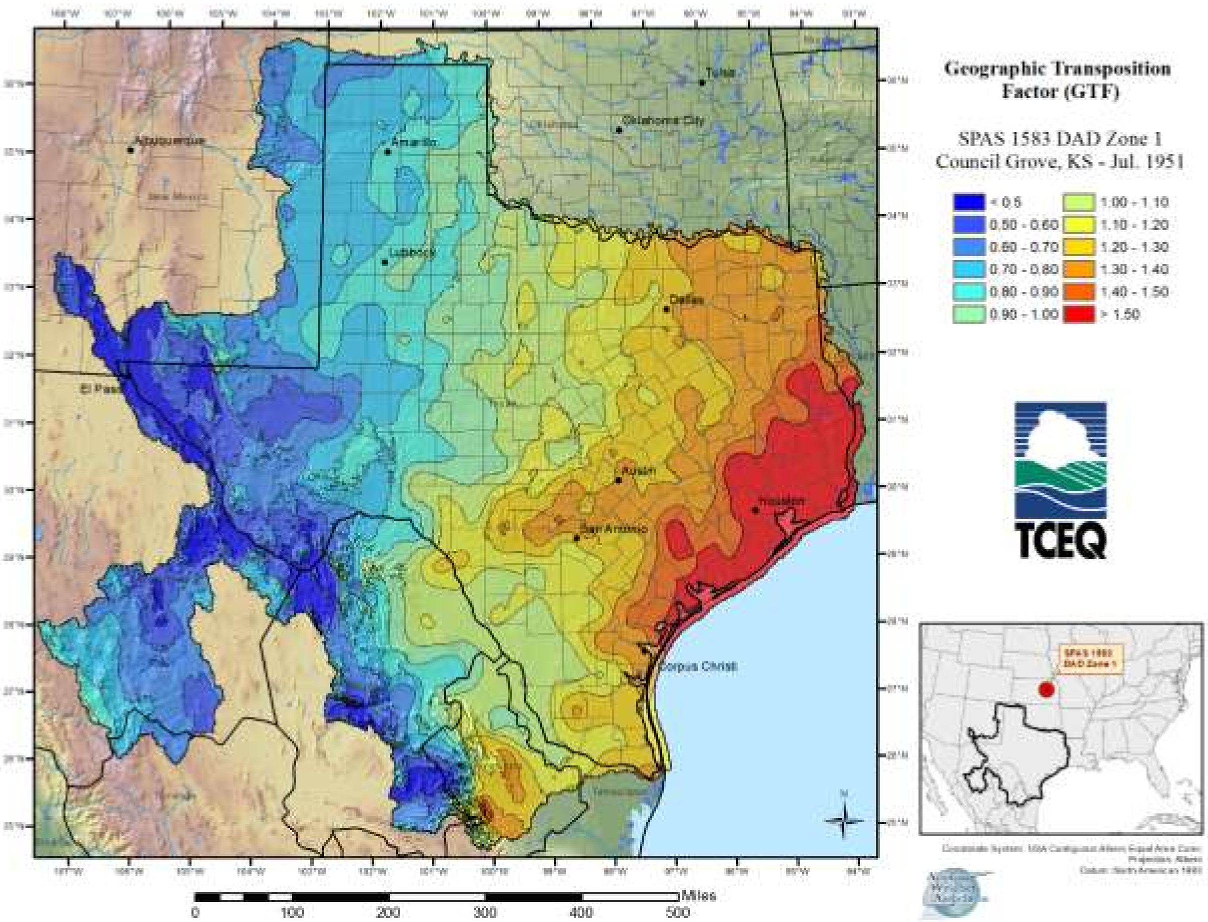
Geographic Transposition Factor (GTF)
SPAS 1583 DAD Zone 1
Council Grove, KS - Jul. 1951
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1.00 - 1.10
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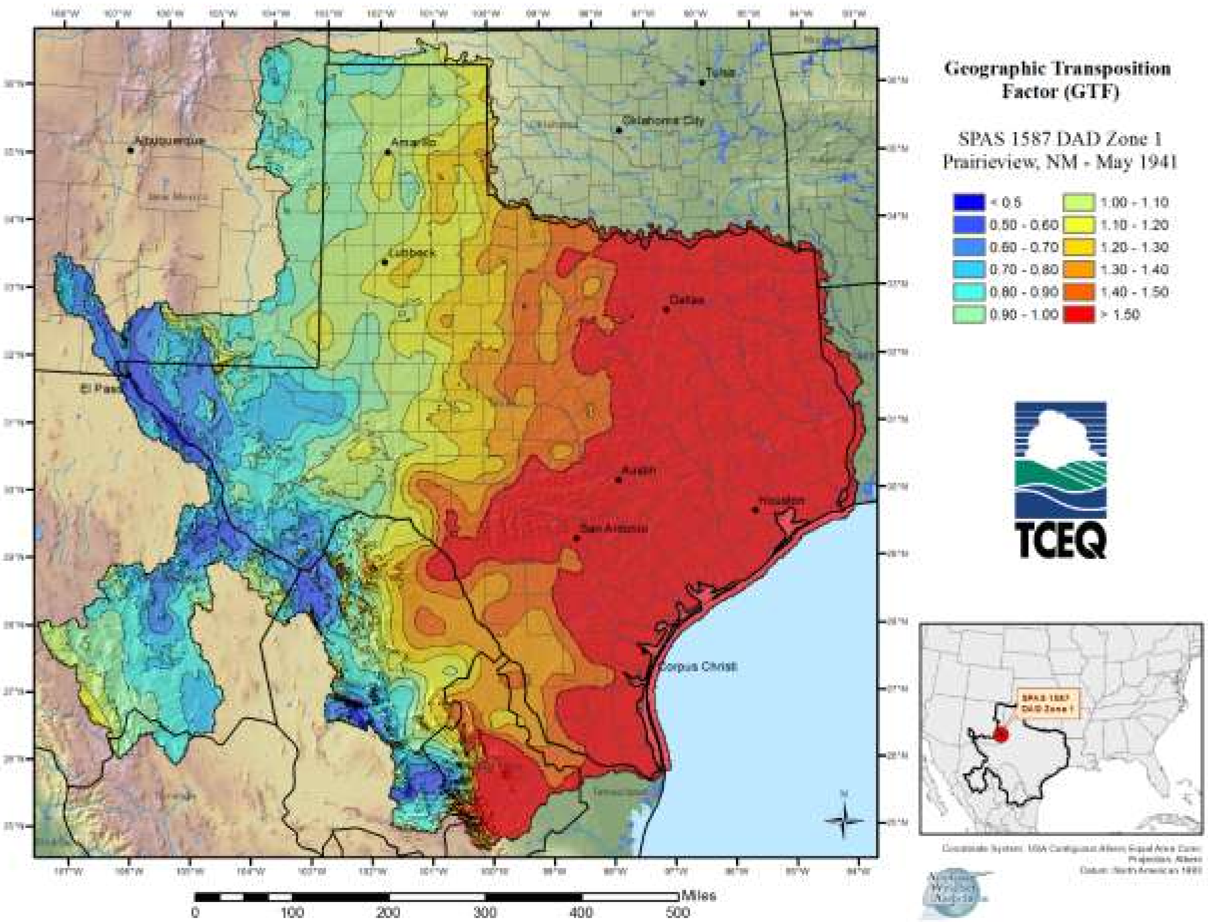
Geographic Transposition Factor (GTF)
SPAS 1587 DAD Zone 1
Prairieview, NM - May 1941
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0.80 - 0.90
0.90 - 1.00
1.00 - 1.10
1.10 - 1.20
1.20 - 1.30
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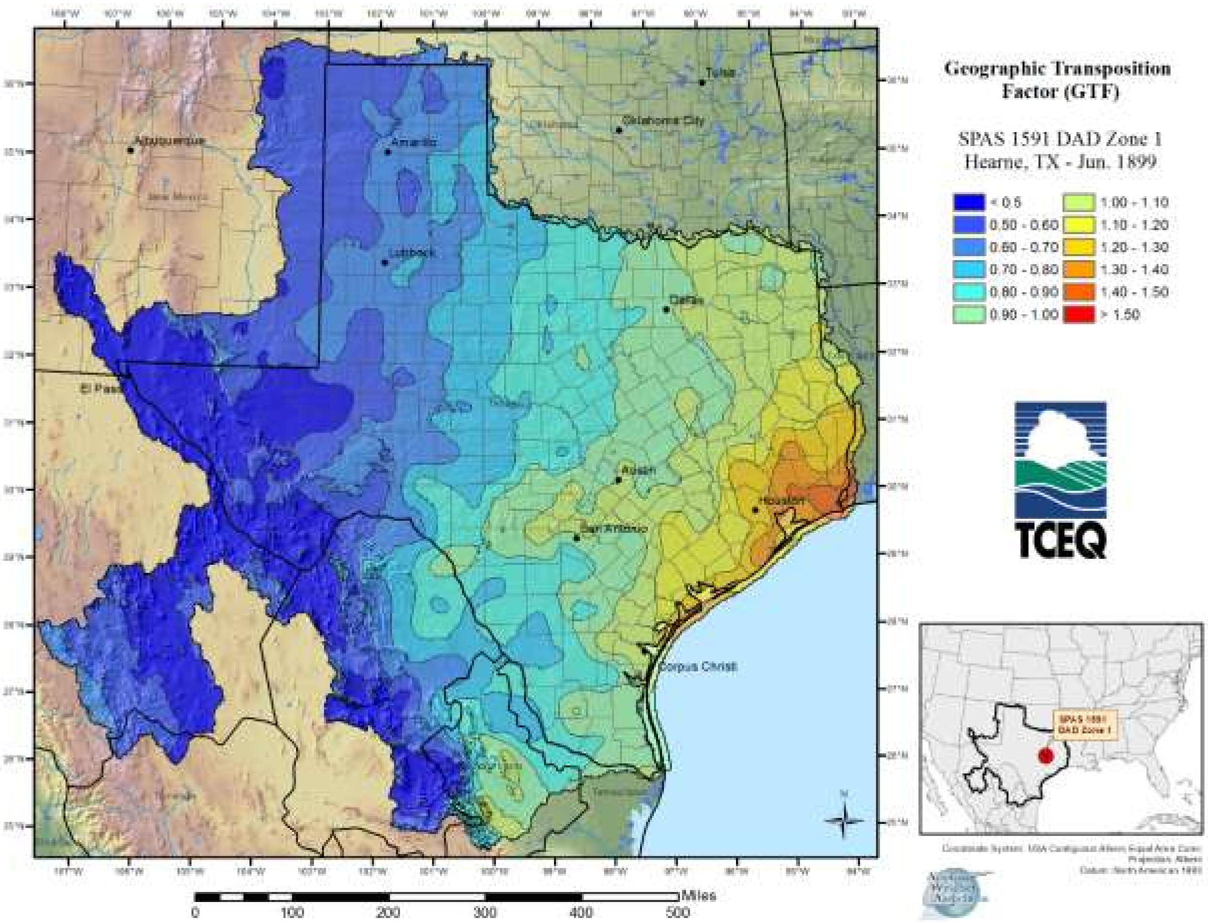
SPAS 1587
DAD Zone 1


Geographic Transposition Factor (GTF)
SPAS 1591 DAD Zone 1
Hearne, TX - Jun. 1899
< 0.5
0.50 - 0.60
0.60 - 0.70
0.70 - 0.80
0.80 - 0.90
0.90 - 1.00
1.00 - 1.10
1.10 - 1.20
1.20 - 1.30
1.30 - 1.40
1.40 - 1.50
> 1.50
TCEQ
SPAS 1591
DAD Zone 1
Tulsa
Oklahoma City
Albuquerque
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Houston
San Antonio
Corpus Christi
Miles
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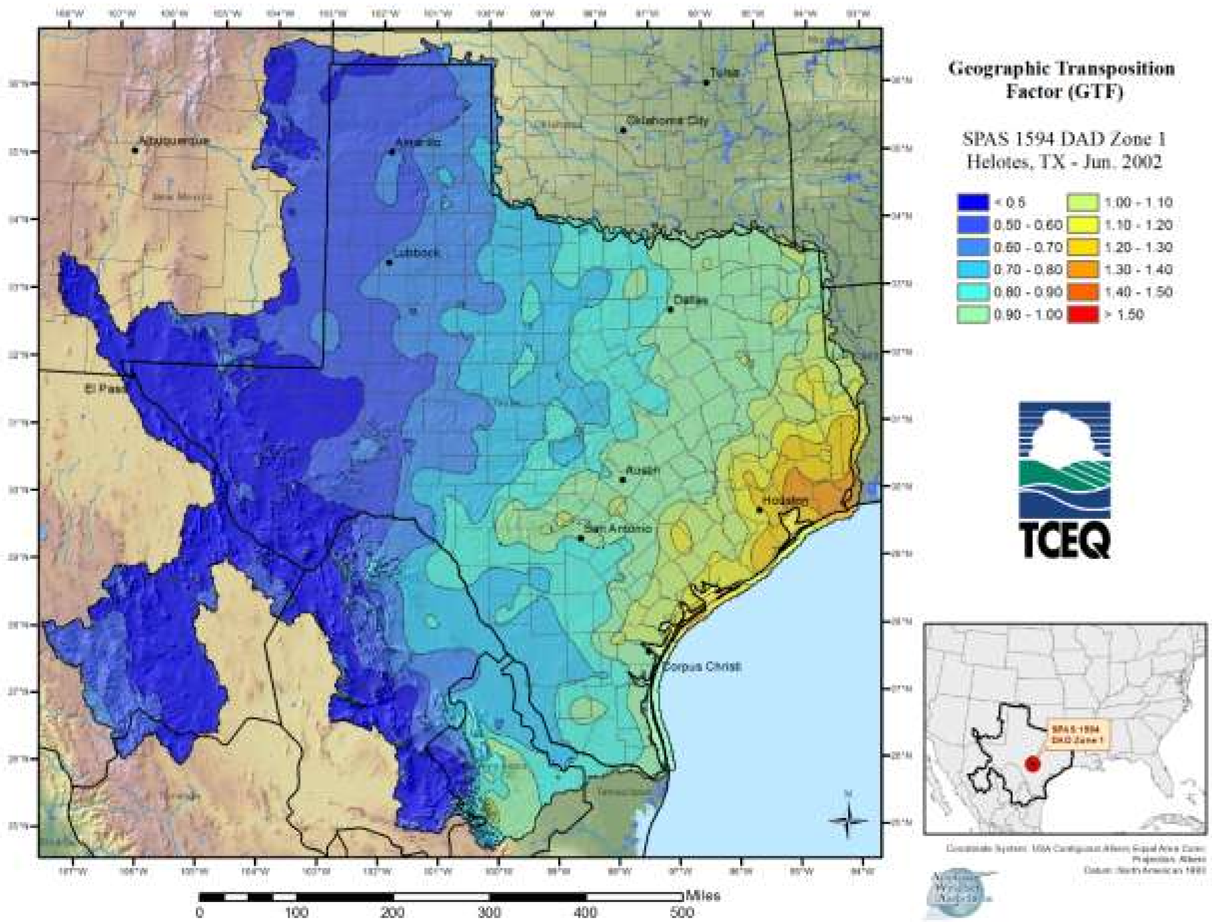
Geographic Transposition Factor (GTF)
SPAS 1594 DAD Zone 1
Helotes, TX - Jun. 2002
< 0.5
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0.90 - 1.00
1.00 - 1.10
1.10 - 1.20
1.20 - 1.30
1.30 - 1.40
1.40 - 1.50
> 1.50
TCEQ
Tulsa
Oklahoma City
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Miles
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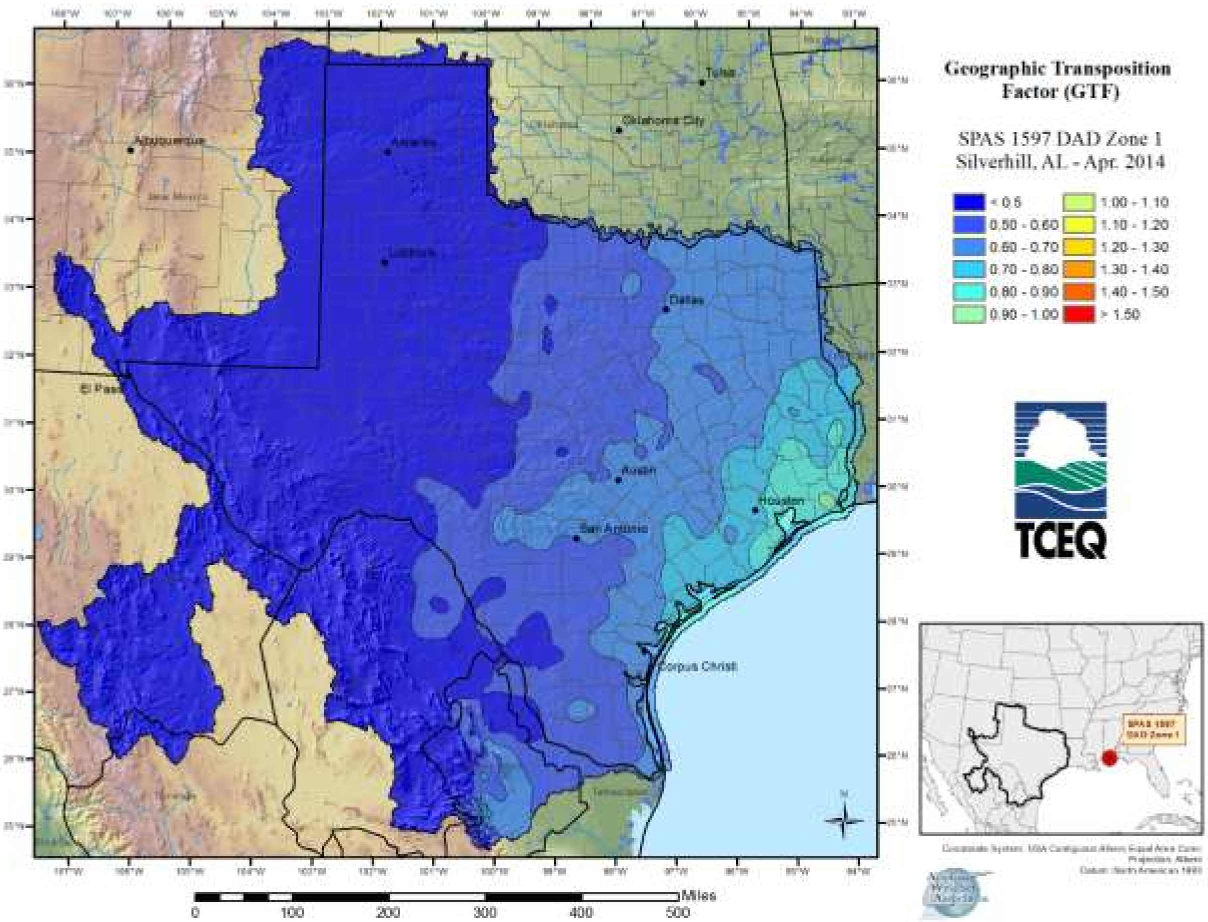

Geographic Transposition Factor (GTF)
SPAS 1597 DAD Zone 1
Silverhill, AL - Apr. 2014
< 0.5
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0.70 - 0.80
0.80 - 0.90
0.90 - 1.00
1.00 - 1.10
1.10 - 1.20
1.20 - 1.30
1.30 - 1.40
1.40 - 1.50
> 1.50
TCEQ
Tulsa
Oklahoma City
Albuquerque
Amarillo
Lubbock
Dallas
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Miles
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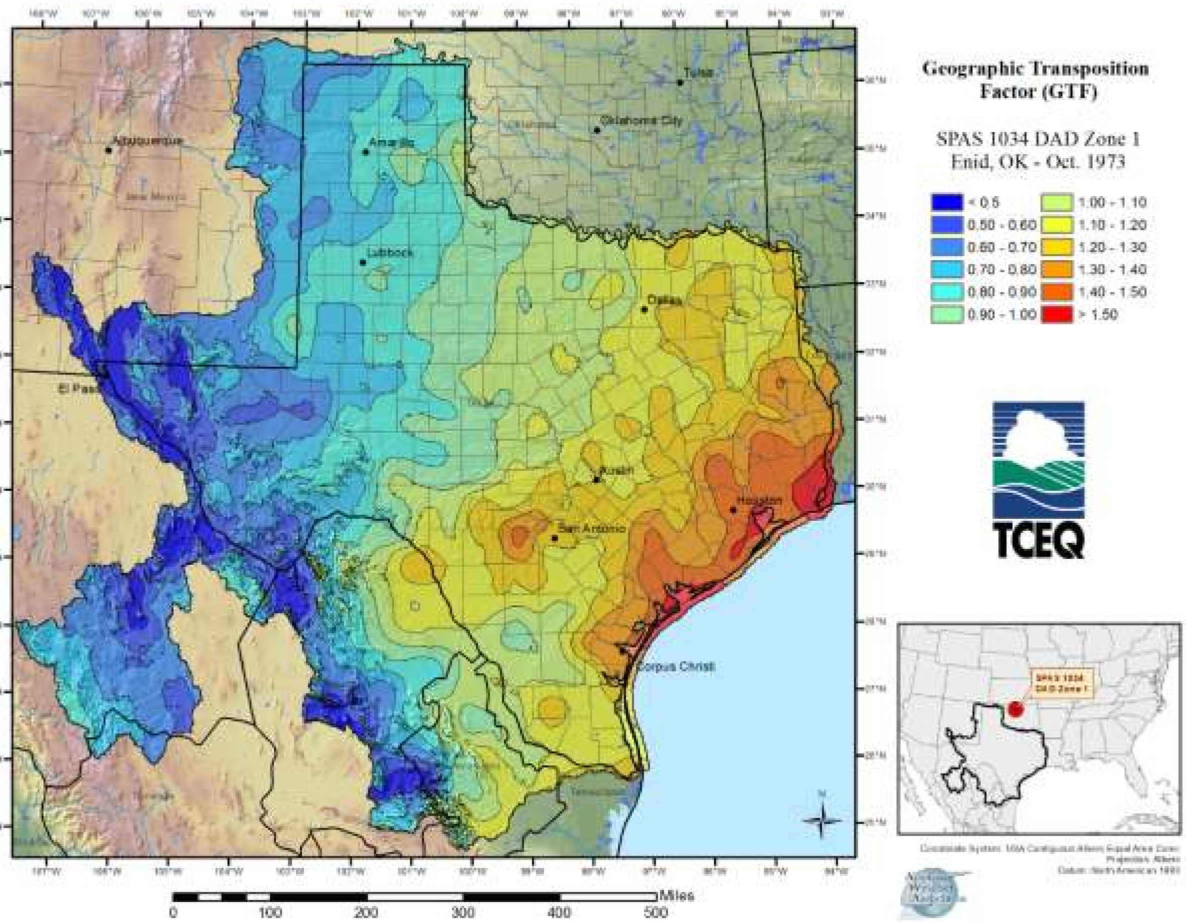
SPAS 1597
DAD Zone 1

Local Storms



Geographic Transposition Factor (GTF)
SPAS 1034 DAD Zone 1
Enid, OK - Oct. 1973
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0.70 - 0.80
0.80 - 0.90
0.90 - 1.00
1.00 - 1.10
1.10 - 1.20
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1.30 - 1.40
1.40 - 1.50
> 1.50
TCEQ
Tulsa
Oklahoma City
Albuquerque
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Miles
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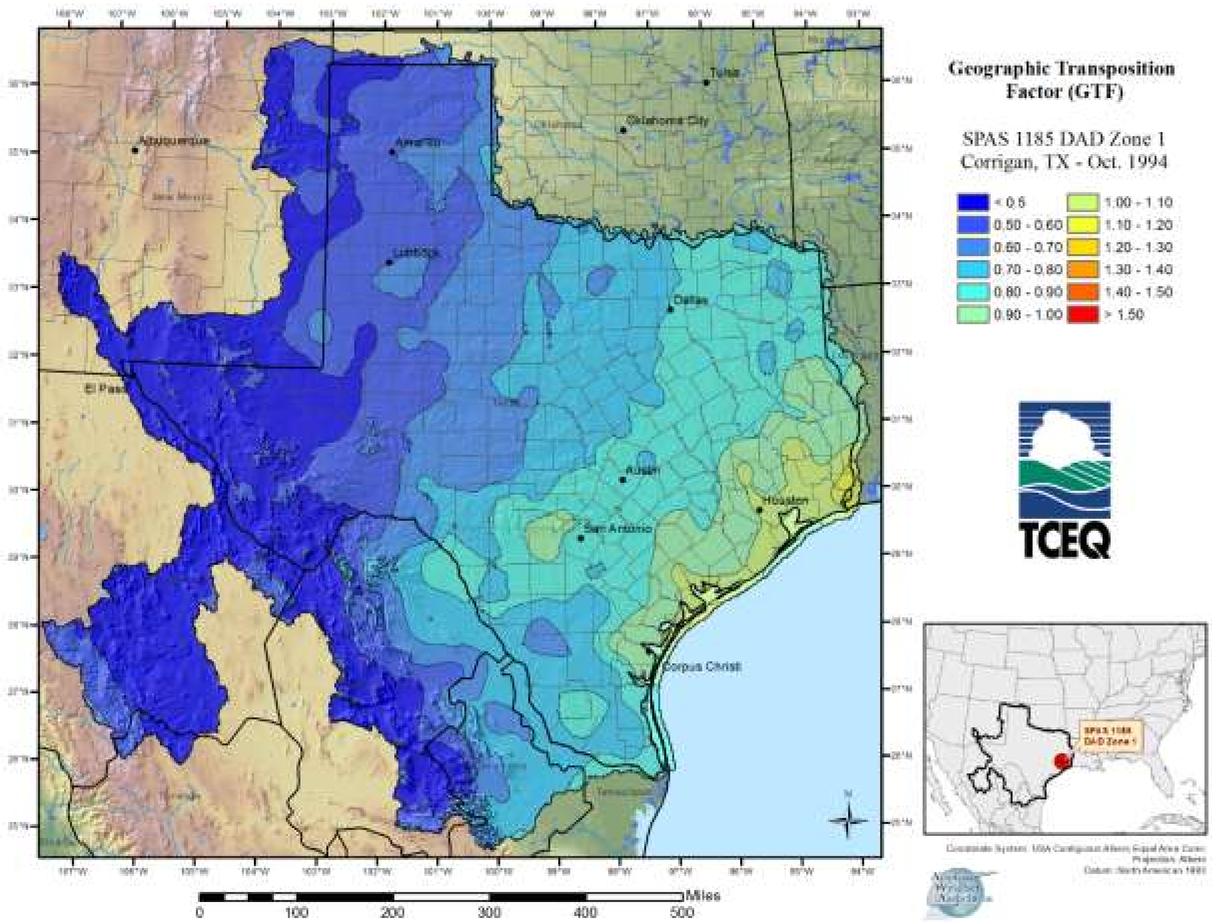
Geographic Transposition Factor (GTF)
SPAS 1185 DAD Zone 1
Corrigan, TX - Oct. 1994
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0.80 - 0.90
0.90 - 1.00
1.00 - 1.10
1.10 - 1.20
1.20 - 1.30
1.30 - 1.40
1.40 - 1.50
> 1.50
TCEQ
Tulsa
Oklahoma City
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Austin
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San Antonio
Corpus Christi
Miles
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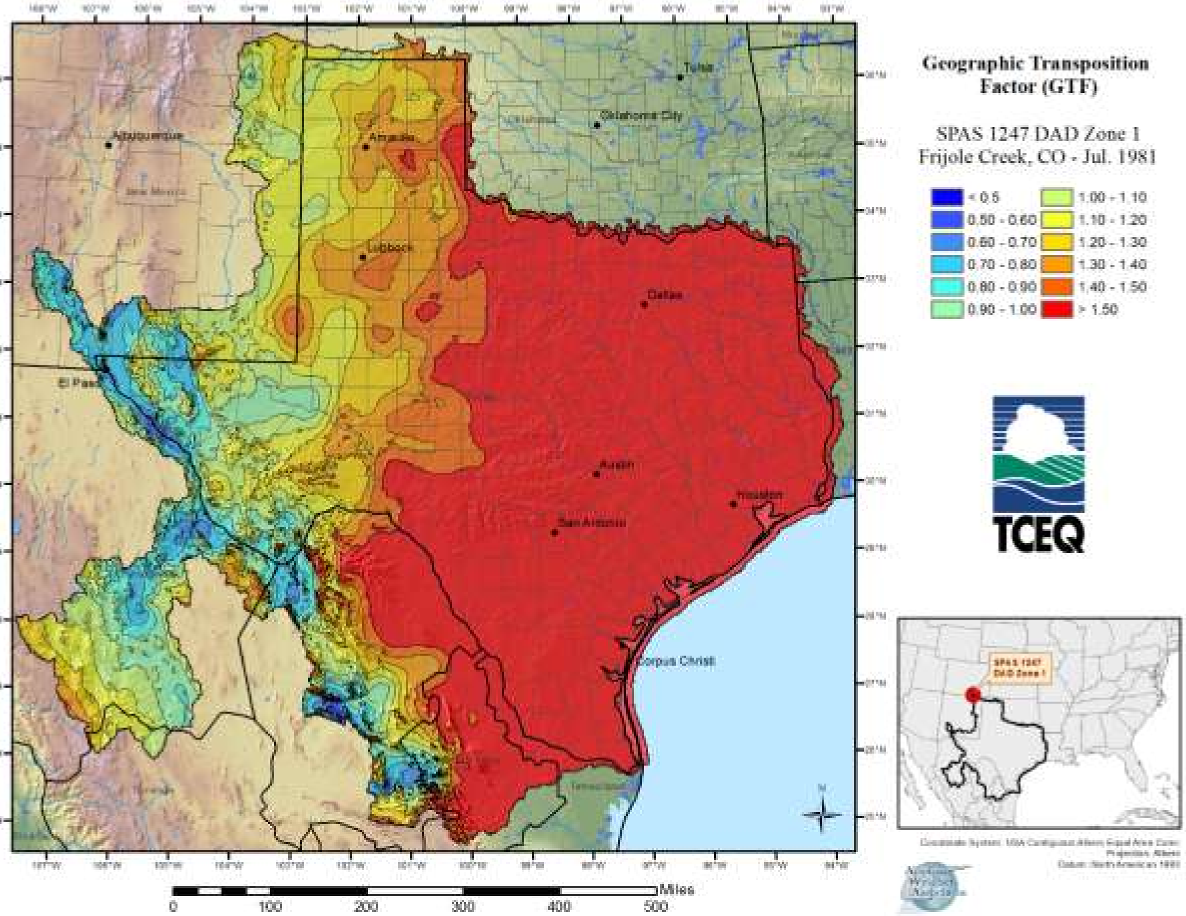
Geographic Transposition Factor (GTF)
SPAS 1247 DAD Zone 1
Frijole Creek, CO - Jul. 1981
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0.60 - 0.70
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0.80 - 0.90
0.90 - 1.00
1.00 - 1.10
1.10 - 1.20
1.20 - 1.30
1.30 - 1.40
1.40 - 1.50
> 1.50
Tulsa
Oklahoma City
Albuquerque
Amarillo
Lubbock
Dallas
El Paso
Austin
Houston
San Antonio
Corpus Christi
SPAS 1247 DAD Zone 1
Miles
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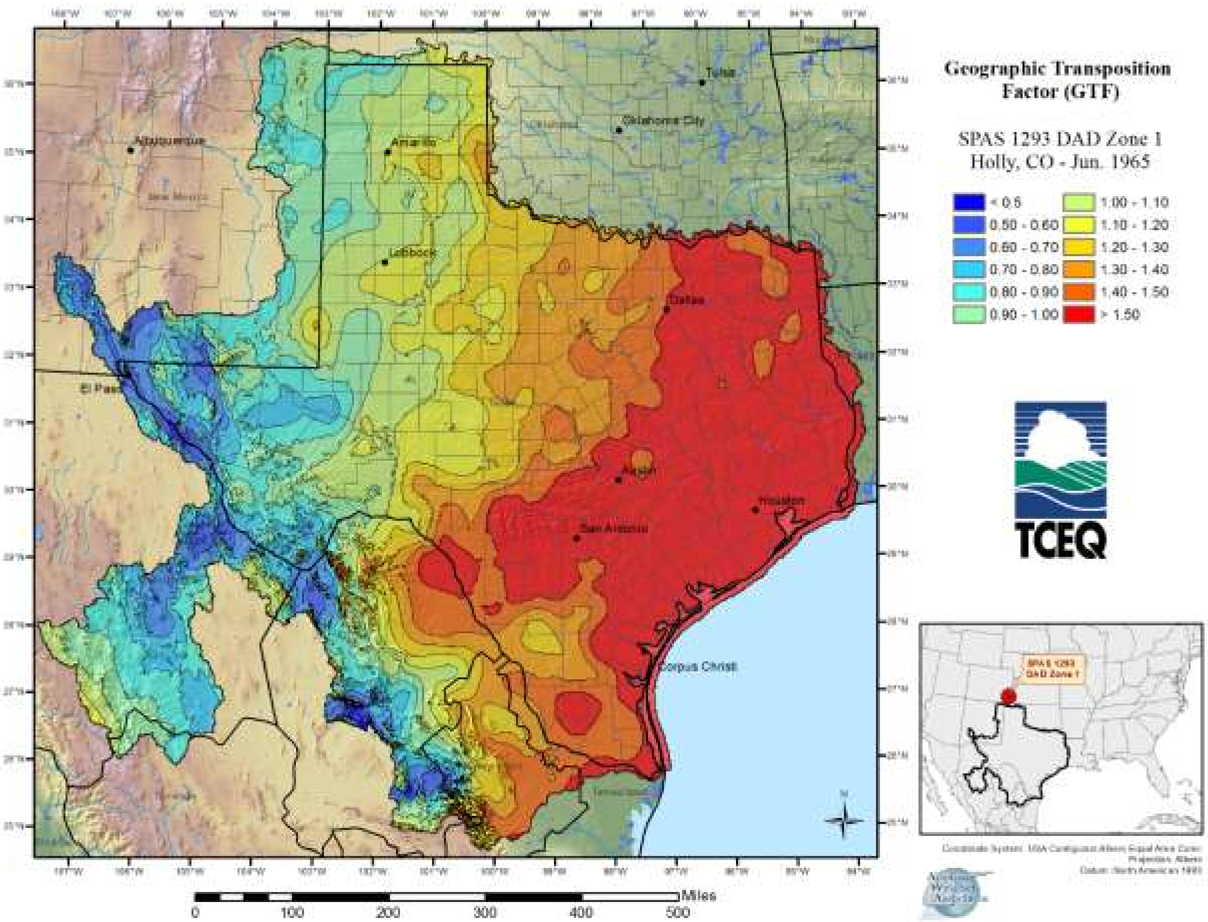
Geographic Transposition Factor (GTF)
SPAS 1293 DAD Zone 1
Holly, CO - Jun. 1965
< 0.5
0.50 - 0.60
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0.70 - 0.80
0.80 - 0.90
0.90 - 1.00
1.00 - 1.10
1.10 - 1.20
1.20 - 1.30
1.30 - 1.40
1.40 - 1.50
> 1.50
TCEQ
Tulsa
Oklahoma City
Albuquerque
Amarillo
Lubbock
Dallas
El Paso
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Houston
San Antonio
Corpus Christi
SPAS 1293
DAD Zone 1
Miles
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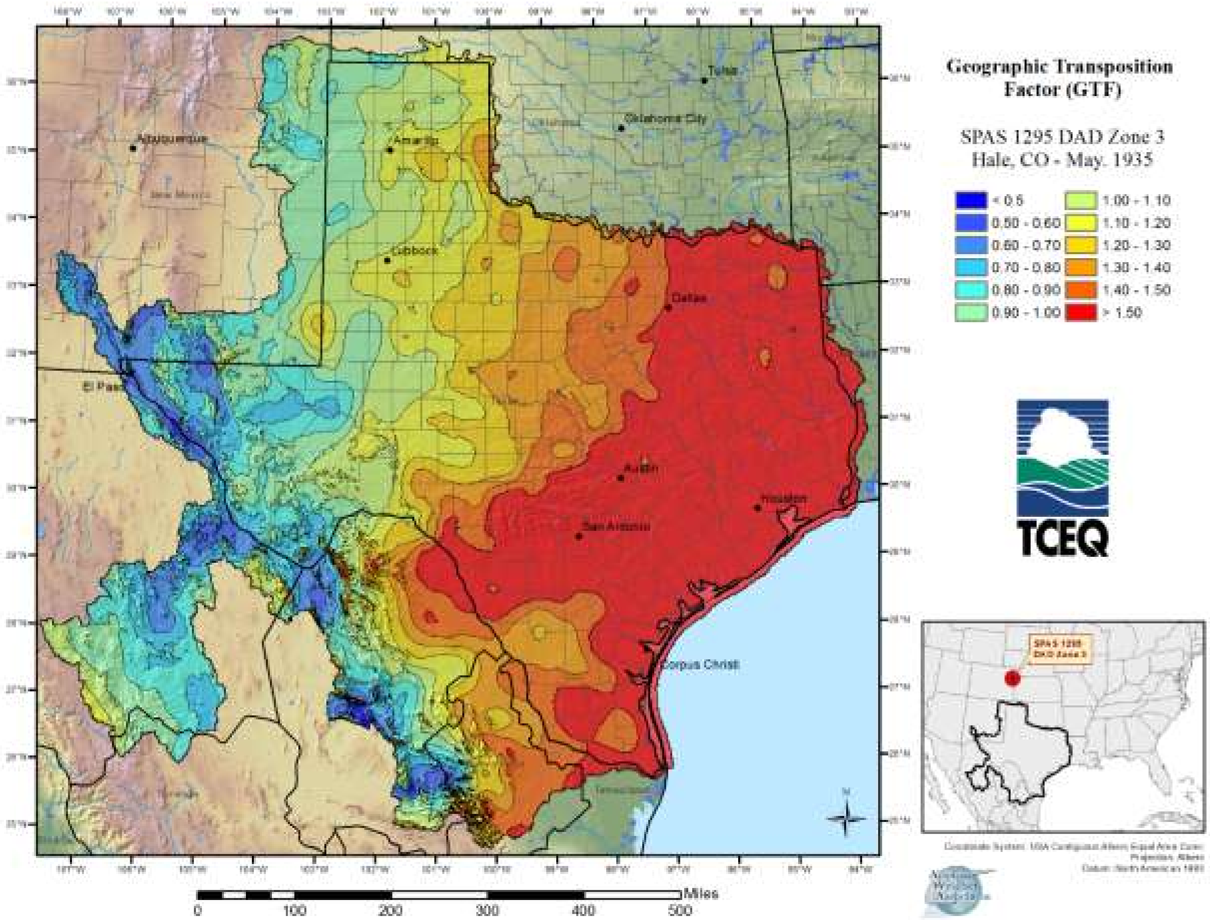

Geographic Transposition Factor (GTF)
SPAS 1295 DAD Zone 3
Hale, CO - May. 1935
< 0.5
0.50 - 0.60
0.60 - 0.70
0.70 - 0.80
0.80 - 0.90
0.90 - 1.00
1.00 - 1.10
1.10 - 1.20
1.20 - 1.30
1.30 - 1.40
1.40 - 1.50
> 1.50
TCEQ
Tulsa
Oklahoma City
Albuquerque
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Dallas
El Paso
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Houston
San Antonio
Corpus Christi
Miles
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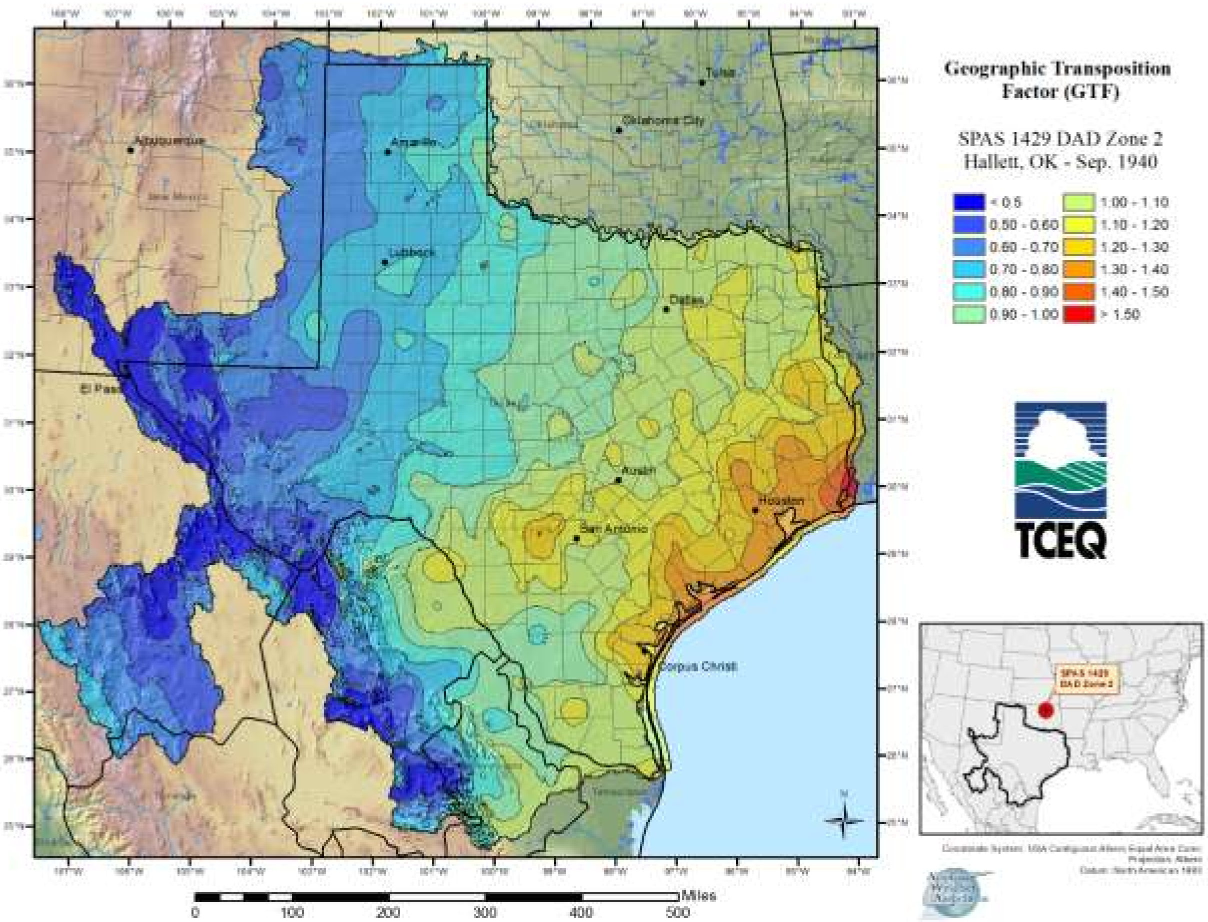
Geographic Transposition Factor (GTF)
SPAS 1429 DAD Zone 2
Hallett, OK - Sep. 1940
< 0.5
0.50 - 0.60
0.60 - 0.70
0.70 - 0.80
0.80 - 0.90
0.90 - 1.00
1.00 - 1.10
1.10 - 1.20
1.20 - 1.30
1.30 - 1.40
1.40 - 1.50
> 1.50
Tulsa
Oklahoma City
Albuquerque
Amarillo
Lubbock
Dallas
El Paso
Austin
Houston
San Antonio
Corpus Christi
Miles
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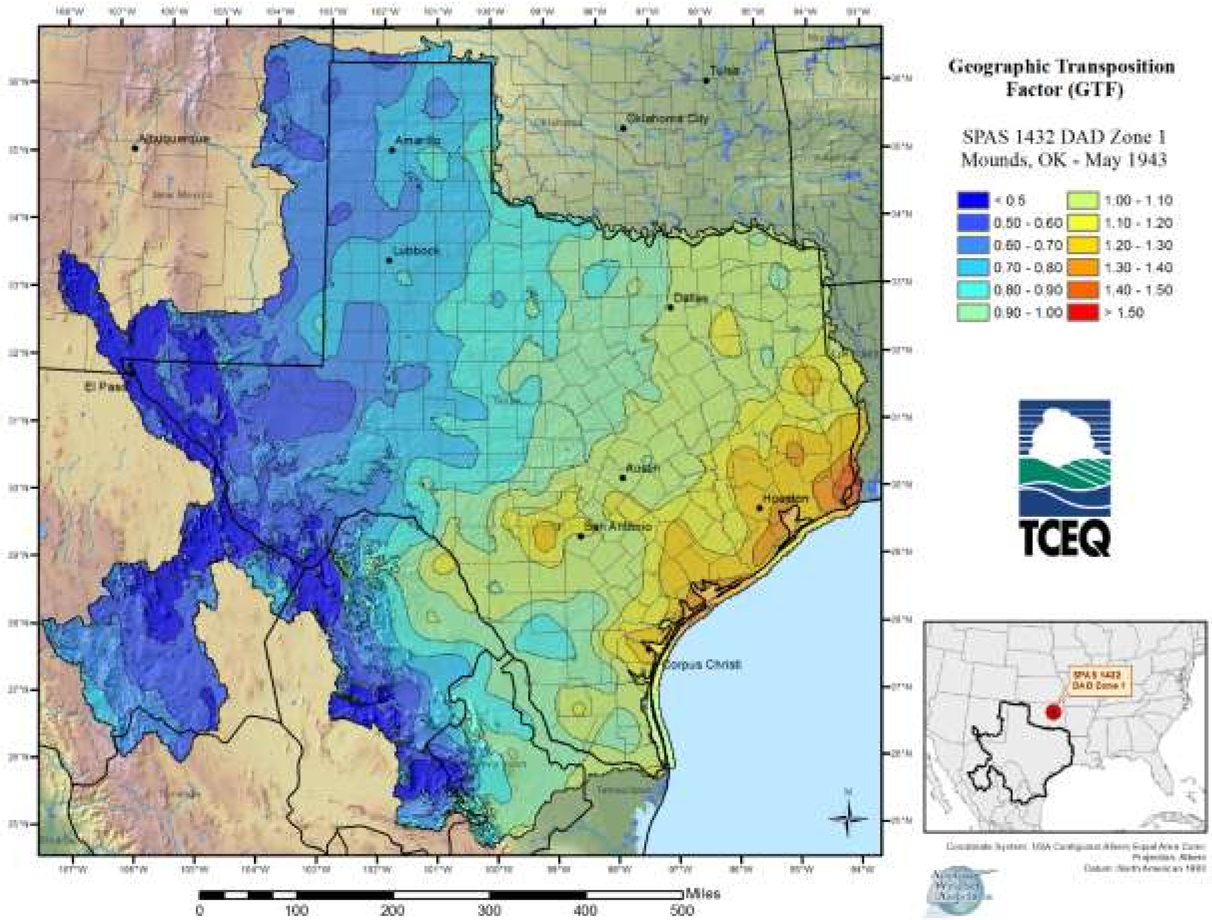
400
500
SPAS 1429 DAD Zone 2


Geographic Transposition Factor (GTF)
SPAS 1432 DAD Zone 1
Mounds, OK - May 1943
< 0.5
0.50 - 0.60
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0.70 - 0.80
0.80 - 0.90
0.90 - 1.00
1.00 - 1.10
1.10 - 1.20
1.20 - 1.30
1.30 - 1.40
1.40 - 1.50
> 1.50
Tulsa
Oklahoma City
Albuquerque
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Lubbock
Dallas
El Paso
Austin
Houston
San Antonio
Corpus Christi
TCEQ
Miles
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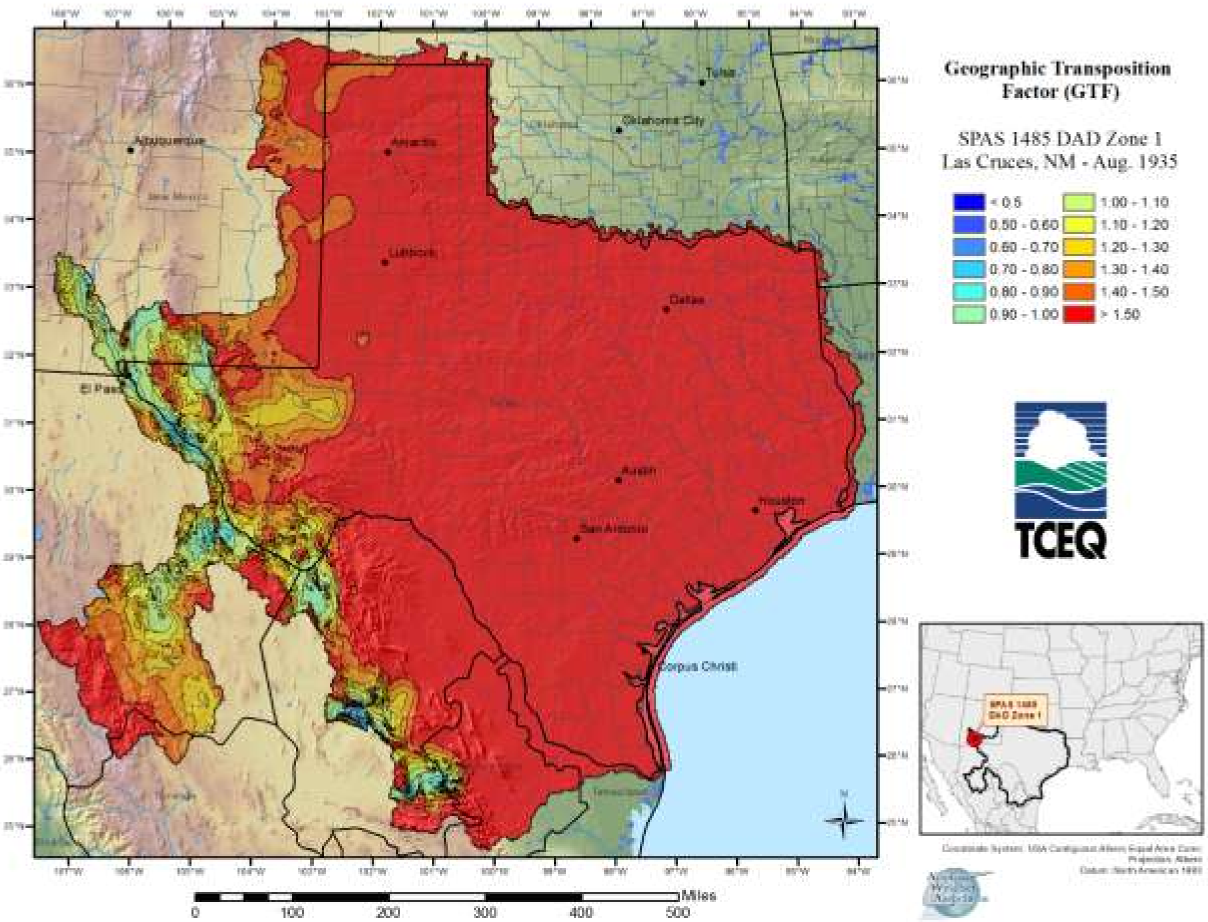
Geographic Transposition Factor (GTF)
SPAS 1485 DAD Zone 1
Las Cruces, NM - Aug. 1935
< 0.5
0.50 - 0.60
0.60 - 0.70
0.70 - 0.80
0.80 - 0.90
0.90 - 1.00
1.00 - 1.10
1.10 - 1.20
1.20 - 1.30
1.30 - 1.40
1.40 - 1.50
> 1.50
Tulsa
Oklahoma City
Albuquerque
Amarillo
Lubbock
Dallas
El Paso
Austin
Houston
San Antonio
Corpus Christi
TCEQ
SPAS 1485
DAD Zone 1
Miles
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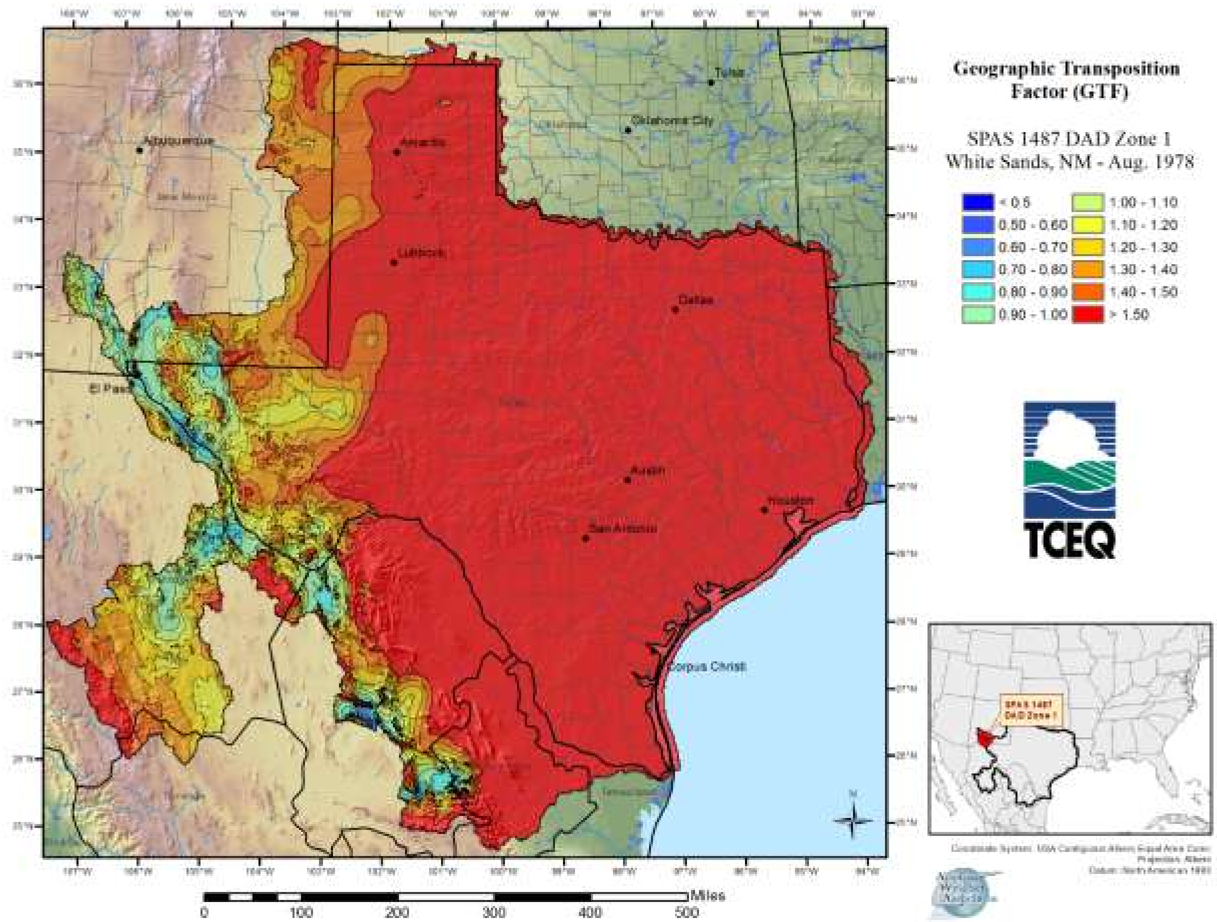
Geographic Transposition
Factor (GTF)
SPAS 1487 DAD Zone 1
White Sands, NM - Aug. 1978
< 0.5
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0.70 - 0.80
0.80 - 0.90
0.90 - 1.00
1.00 - 1.10
1.10 - 1.20
1.20 - 1.30
1.30 - 1.40
1.40 - 1.50
> 1.50
Tulsa
Oklahoma City
Albuquerque
Amarillo
Lubbock
Dallas
El Paso
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Houston
San Antonio
Corpus Christi
Miles
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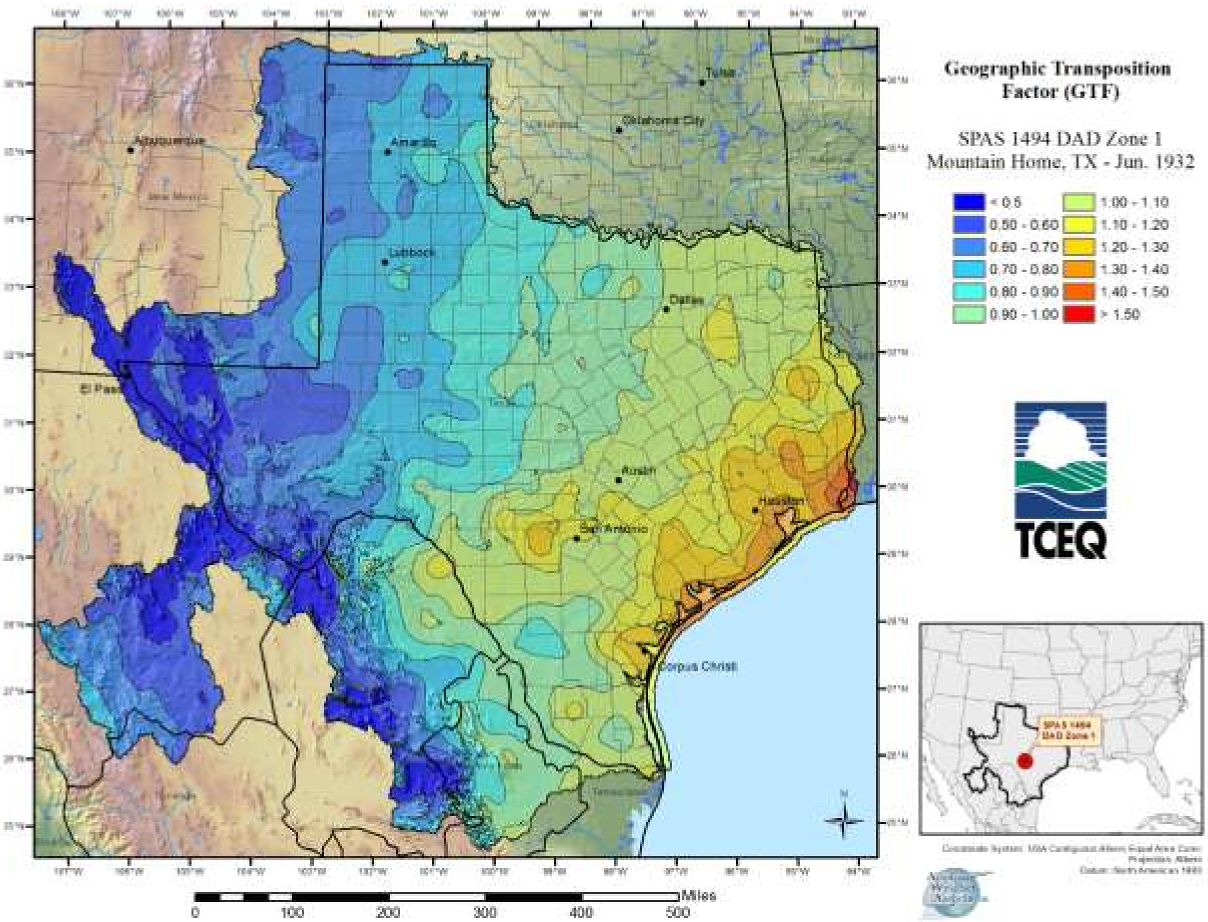
Geographic Transposition Factor (GTF)
SPAS 1494 DAD Zone 1
Mountain Home, TX - Jun. 1932
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0.70 - 0.80
0.80 - 0.90
0.90 - 1.00
1.00 - 1.10
1.10 - 1.20
1.20 - 1.30
1.30 - 1.40
1.40 - 1.50
> 1.50
TCEQ
Tulsa
Oklahoma City
Albuquerque
Amarillo
Lubbock
Dallas
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Corpus Christi
SPAS 1494
DAD Zone 1
Miles
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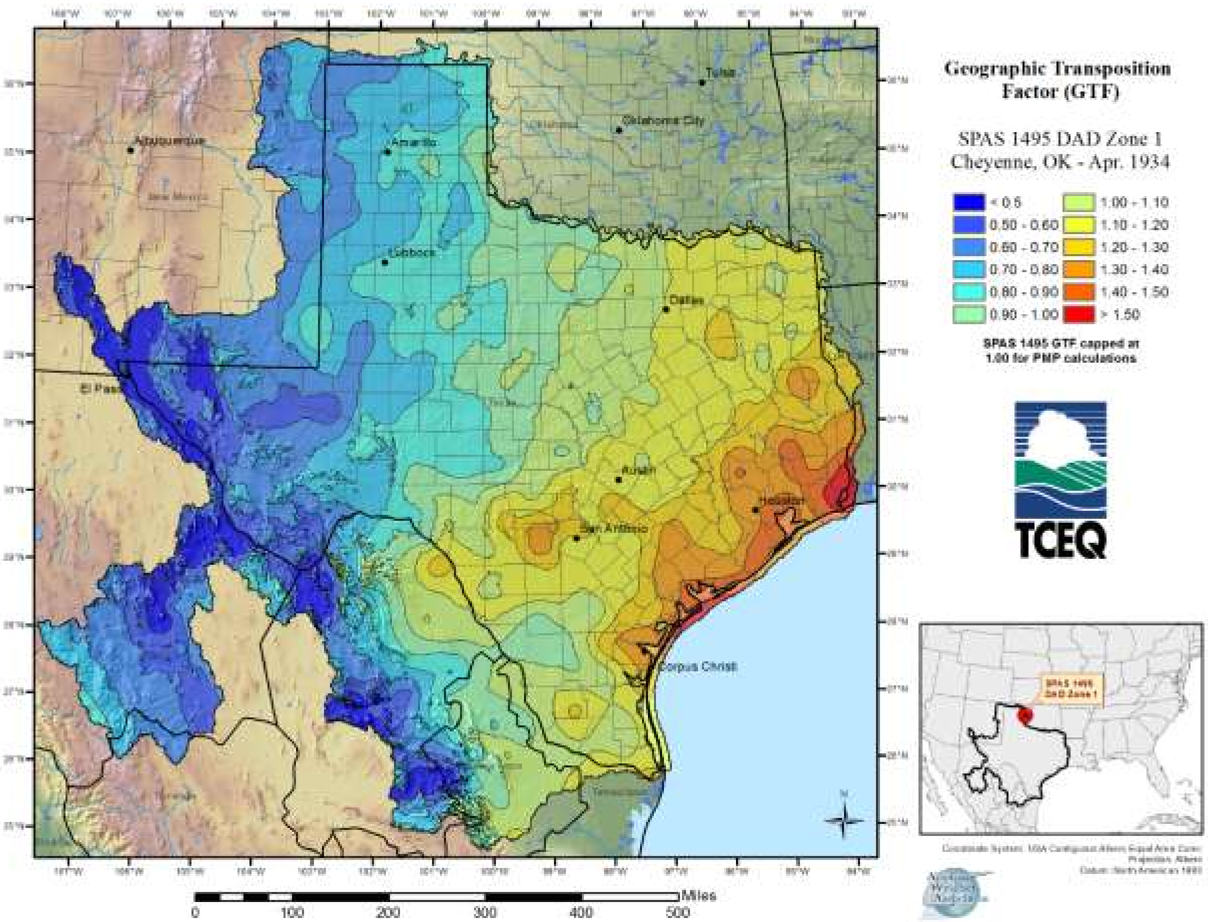

Geographic Transposition Factor (GTF)
SPAS 1495 DAD Zone 1
Cheyenne, OK - Apr. 1934
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0.80 - 0.90
0.90 - 1.00
1.00 - 1.10
1.10 - 1.20
1.20 - 1.30
1.30 - 1.40
1.40 - 1.50
> 1.50
SPAS 1495 GTF capped at 1.00 for PMP calculations
TCEQ
Tulsa
Oklahoma City
Albuquerque
Amarillo
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Dallas
El Paso
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Houston
San Antonio
Corpus Christi
Miles
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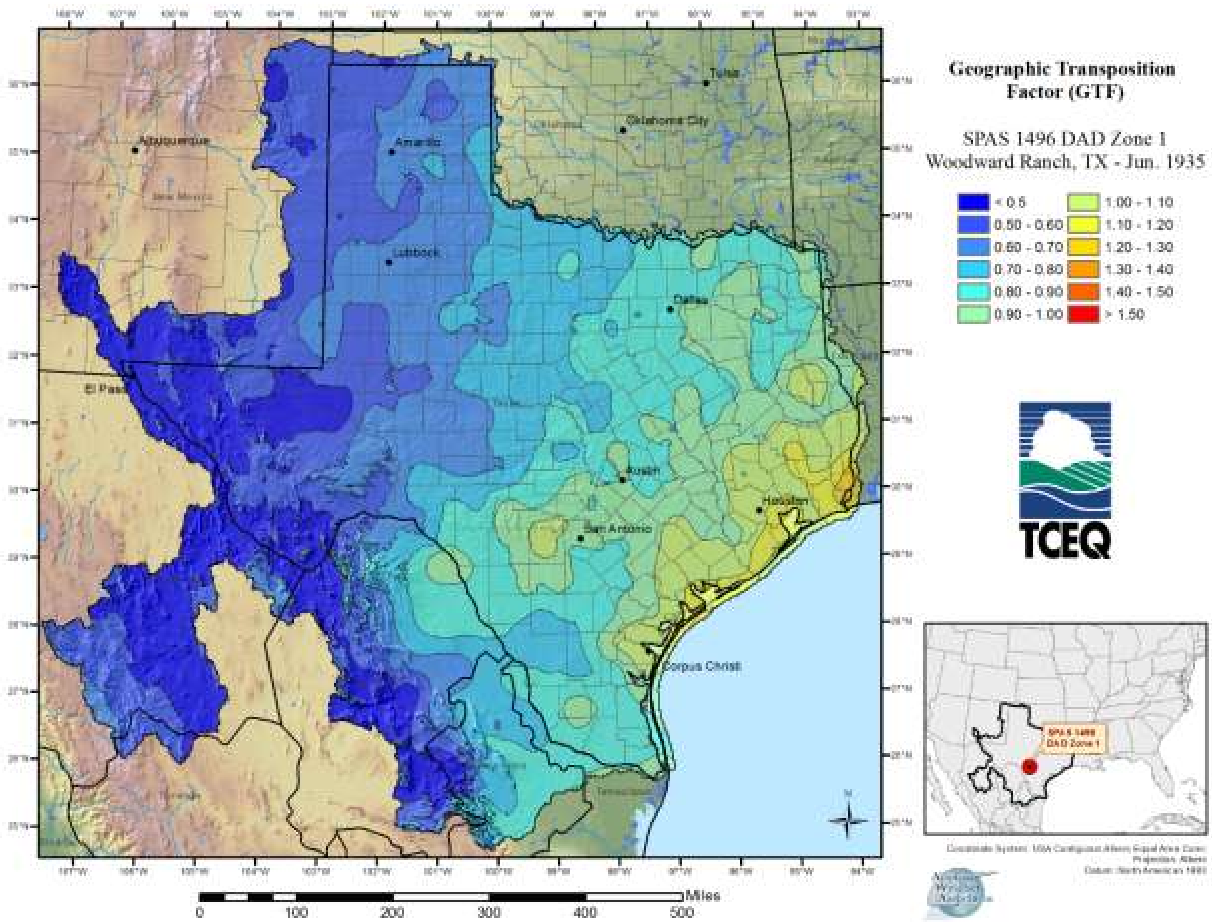
Geographic Transposition
Factor (GTF)
SPAS 1496 DAD Zone 1
Woodward Ranch, TX - Jun. 1935
< 0.5
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0.70 - 0.80
0.80 - 0.90
0.90 - 1.00
1.00 - 1.10
1.10 - 1.20
1.20 - 1.30
1.30 - 1.40
1.40 - 1.50
> 1.50
TCEQ
Tulsa
Oklahoma City
Albuquerque
Amarillo
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Austin
Houston
San Antonio
Corpus Christi
Miles
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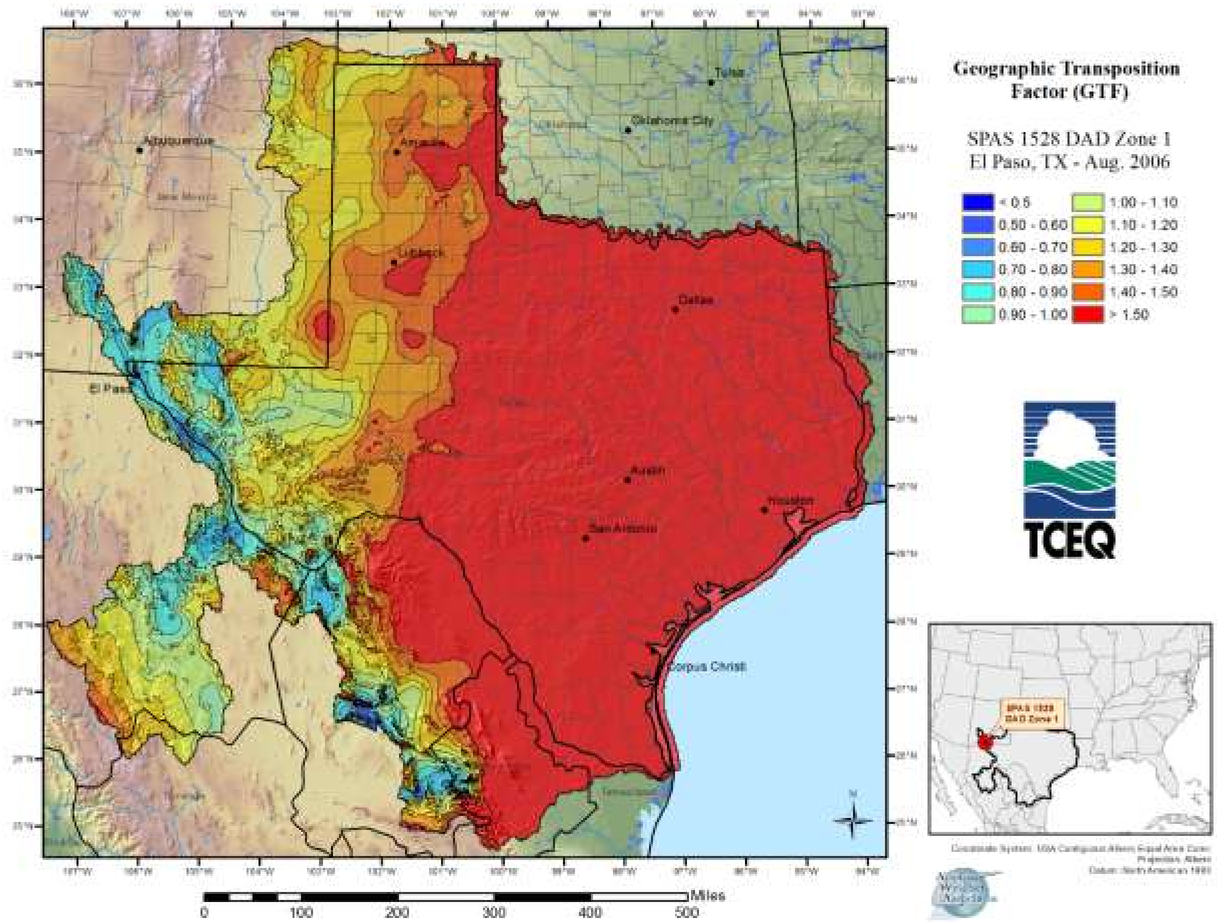

Geographic Transposition Factor (GTF)
SPAS 1528 DAD Zone 1
El Paso, TX - Aug. 2006
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0.70 - 0.80
0.80 - 0.90
0.90 - 1.00
1.00 - 1.10
1.10 - 1.20
1.20 - 1.30
1.30 - 1.40
1.40 - 1.50
> 1.50
TCEQ
Tulsa
Oklahoma City
Albuquerque
Amarillo
Lubbock
Dallas
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San Antonio
Corpus Christi
SPAS 1528
DAD Zone 1
Miles
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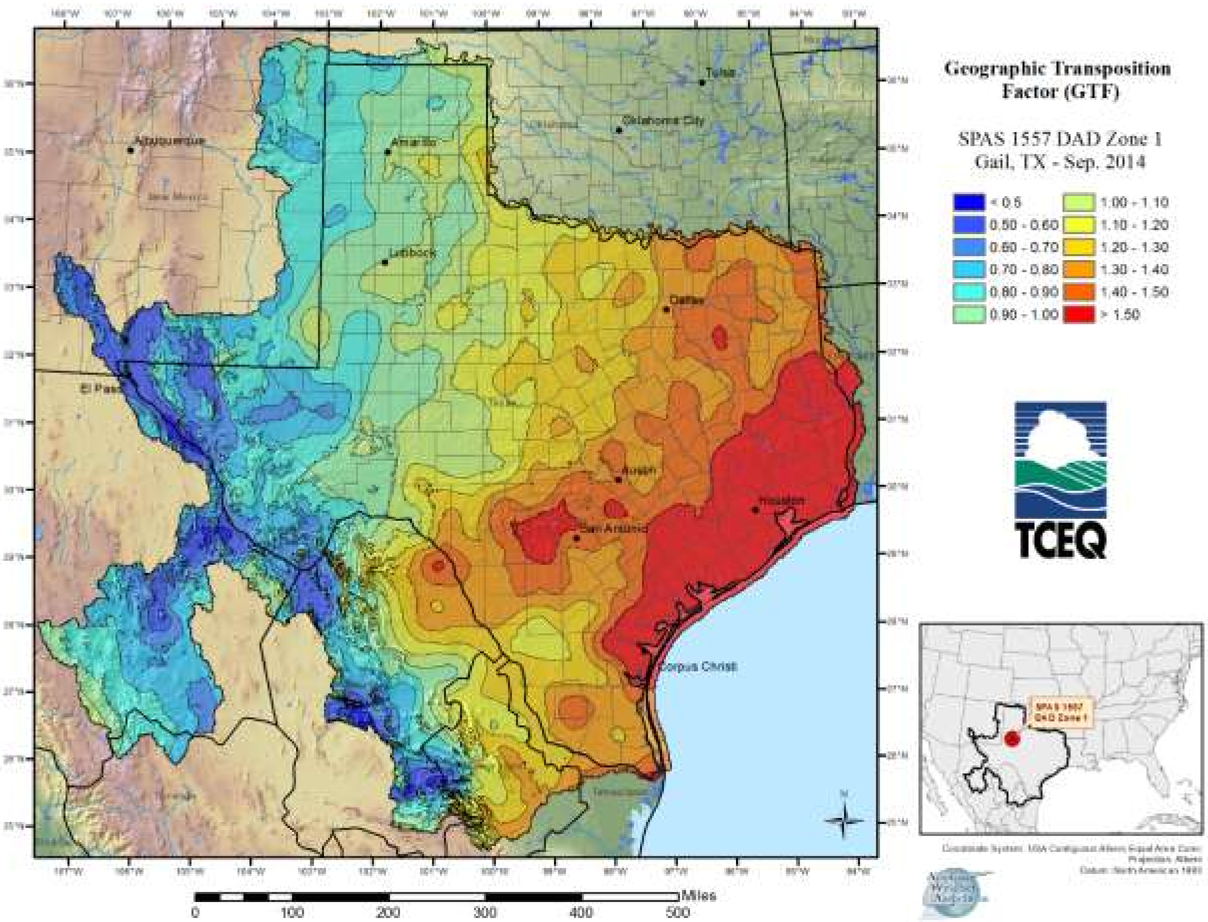
Geographic Transposition Factor (GTF)
SPAS 1557 DAD Zone 1
Gail, TX - Sep. 2014
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0.80 - 0.90
0.90 - 1.00
1.00 - 1.10
1.10 - 1.20
1.20 - 1.30
1.30 - 1.40
1.40 - 1.50
> 1.50
Tulsa
Oklahoma City
Albuquerque
Amarillo
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San Antonio
Corpus Christi
TCEQ
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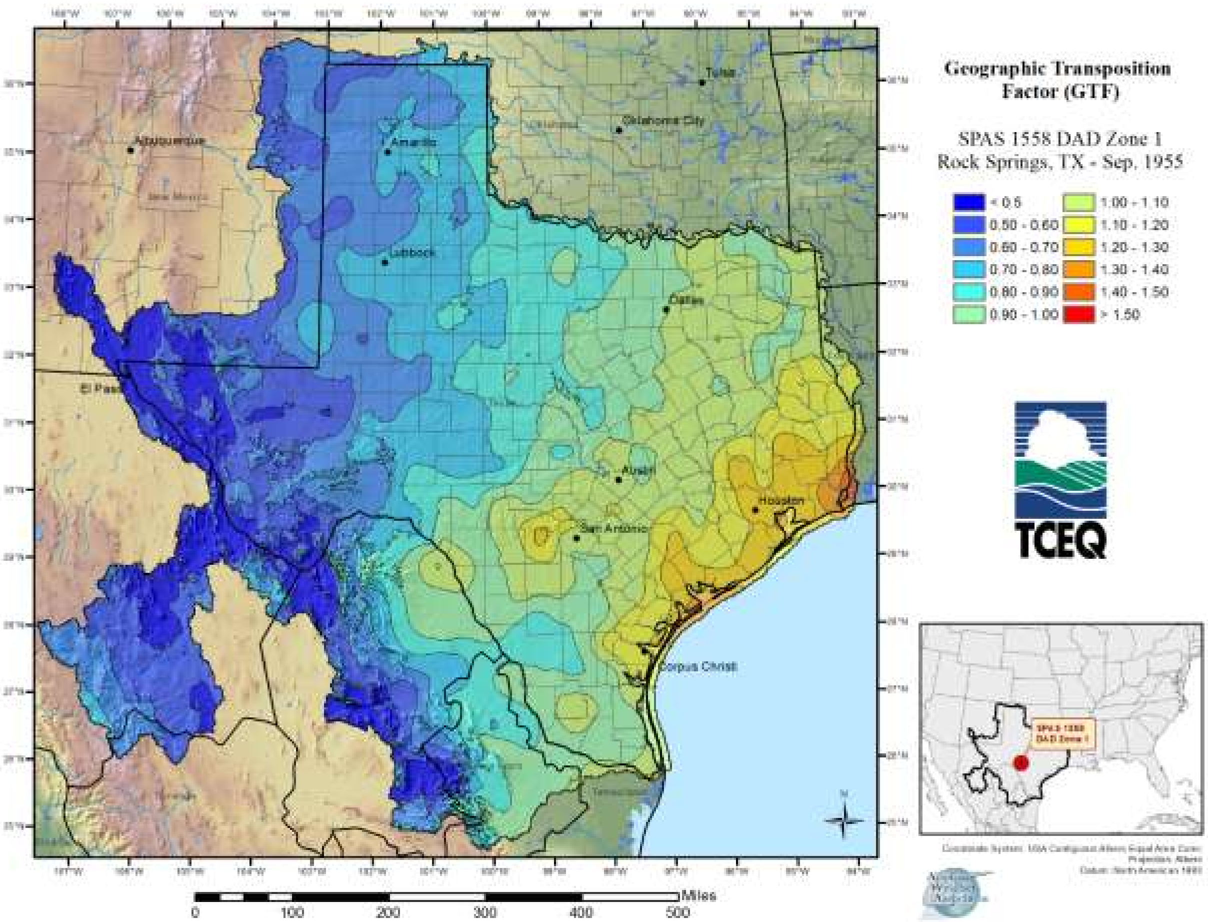
Geographic Transposition Factor (GTF)
SPAS 1558 DAD Zone 1
Rock Springs, TX - Sep. 1955
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0.90 - 1.00
1.00 - 1.10
1.10 - 1.20
1.20 - 1.30
1.30 - 1.40
1.40 - 1.50
> 1.50
Tulsa
Oklahoma City
Albuquerque
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Corpus Christi
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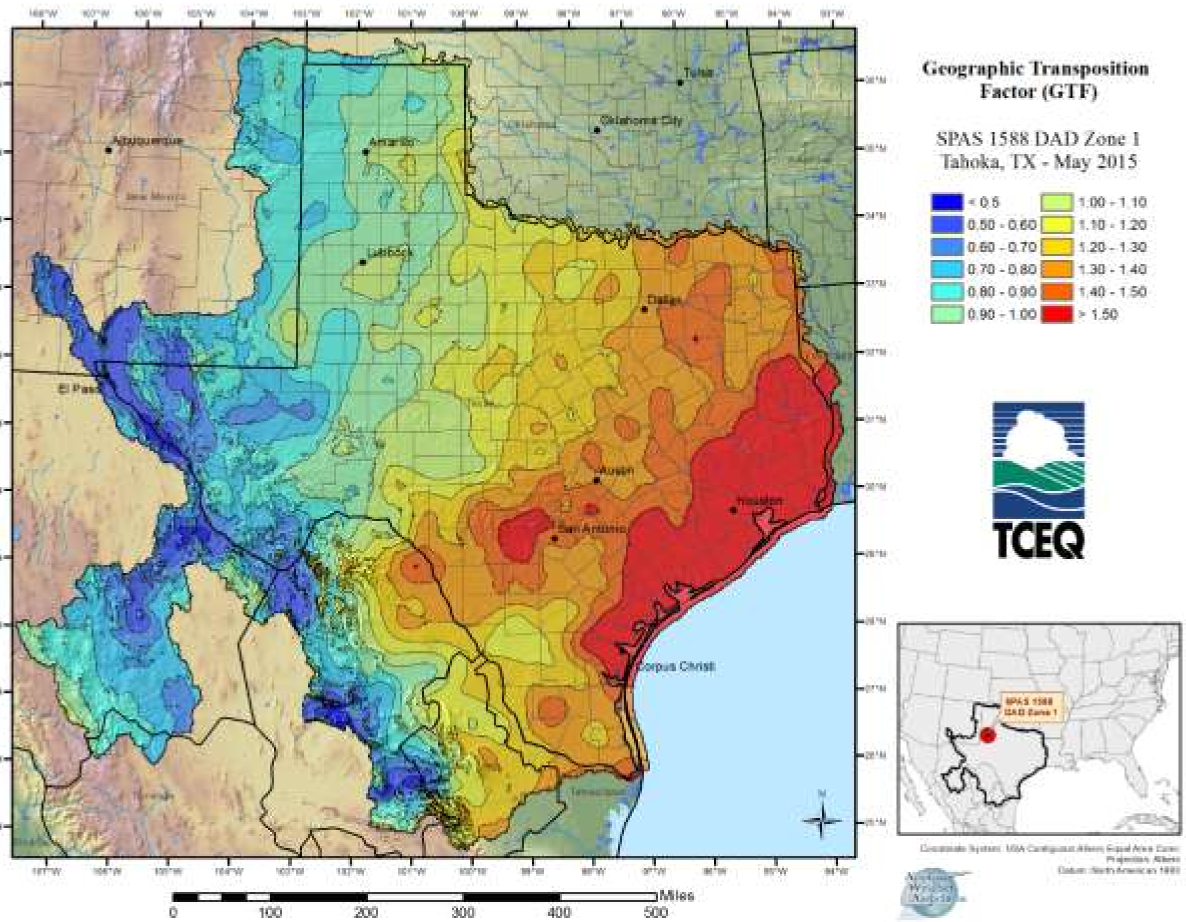
Geographic Transposition Factor (GTF)
SPAS 1588 DAD Zone 1
Tahoka, TX - May 2015
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0.70 - 0.80
0.80 - 0.90
0.90 - 1.00
1.00 - 1.10
1.10 - 1.20
1.20 - 1.30
1.30 - 1.40
1.40 - 1.50
> 1.50
TCEQ
Tulsa
Oklahoma City
Albuquerque
Amarillo
Lubbock
Dallas
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San Antonio
Corpus Christi
SPAS 1588
DAD Zone 1
Miles
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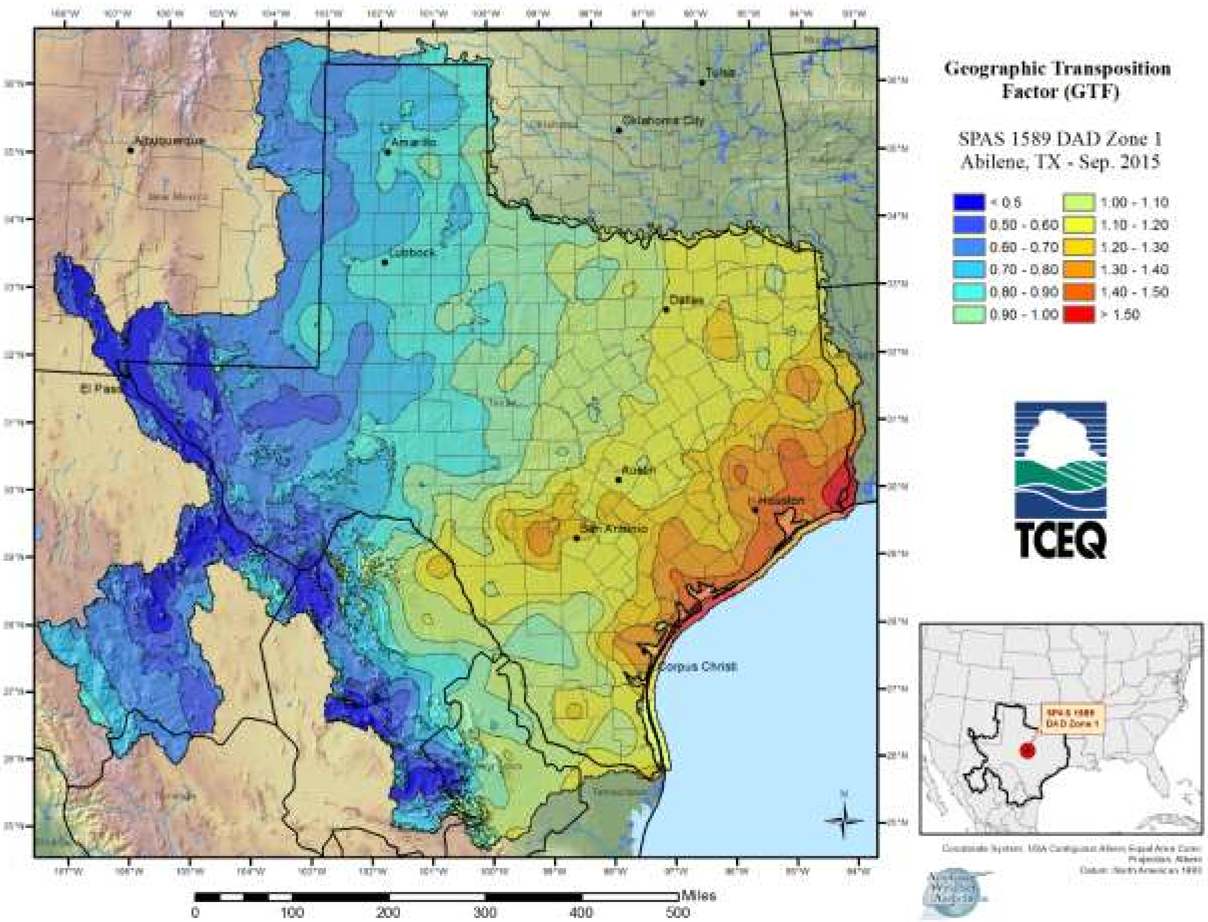
Geographic Transposition Factor (GTF)
SPAS 1589 DAD Zone 1
Abilene, TX - Sep. 2015
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0.80 - 0.90
0.90 - 1.00
1.00 - 1.10
1.10 - 1.20
1.20 - 1.30
1.30 - 1.40
1.40 - 1.50
> 1.50
TCEQ
Tulsa
Oklahoma City
Albuquerque
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San Antonio
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Miles
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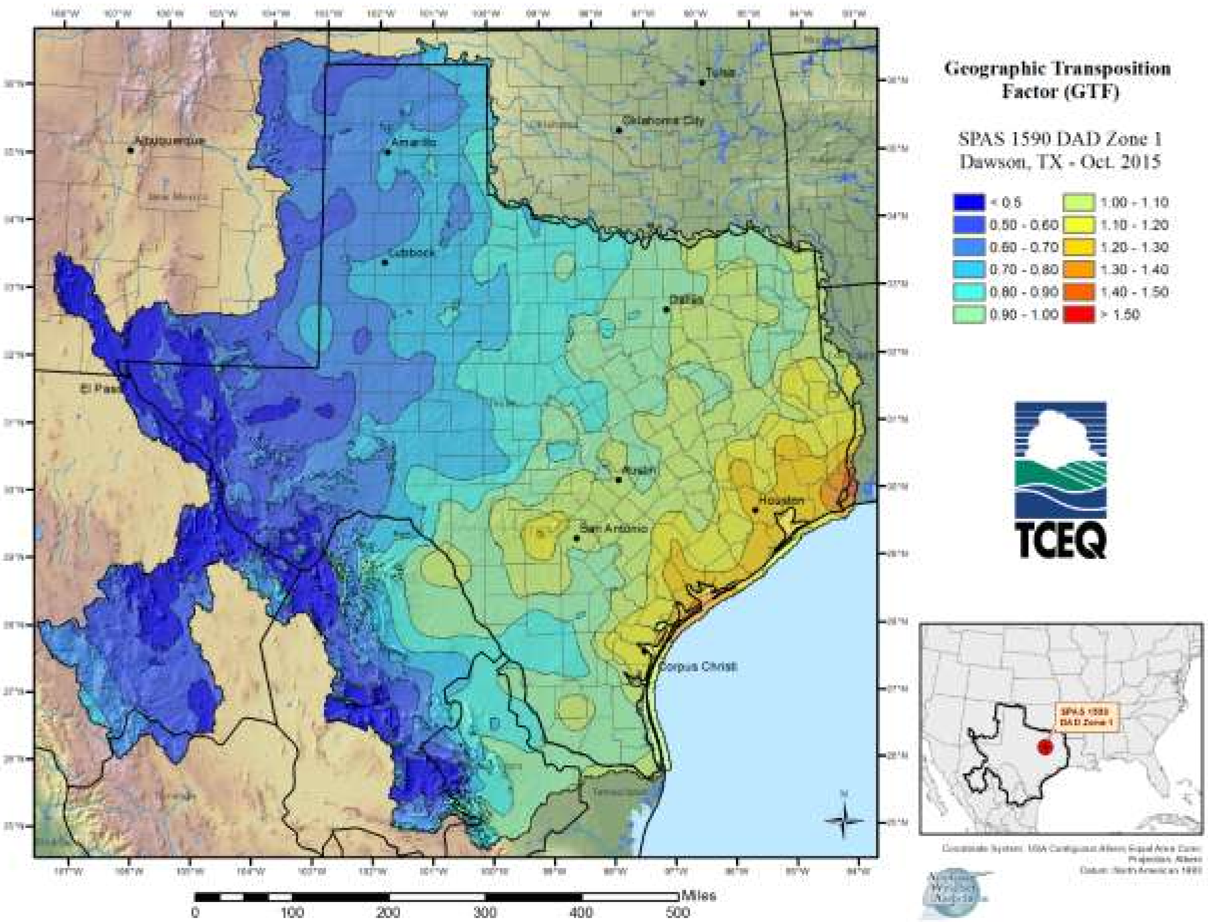
Geographic Transposition Factor (GTF)
SPAS 1590 DAD Zone 1
Dawson, TX - Oct. 2015
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0.90 - 1.00
1.00 - 1.10
1.10 - 1.20
1.20 - 1.30
1.30 - 1.40
1.40 - 1.50
> 1.50
Tulsa
Oklahoma City
Albuquerque
Amarillo
Lubbock
Dallas
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San Antonio
Corpus Christi
SPAS 1590 DAD Zone 1
Miles
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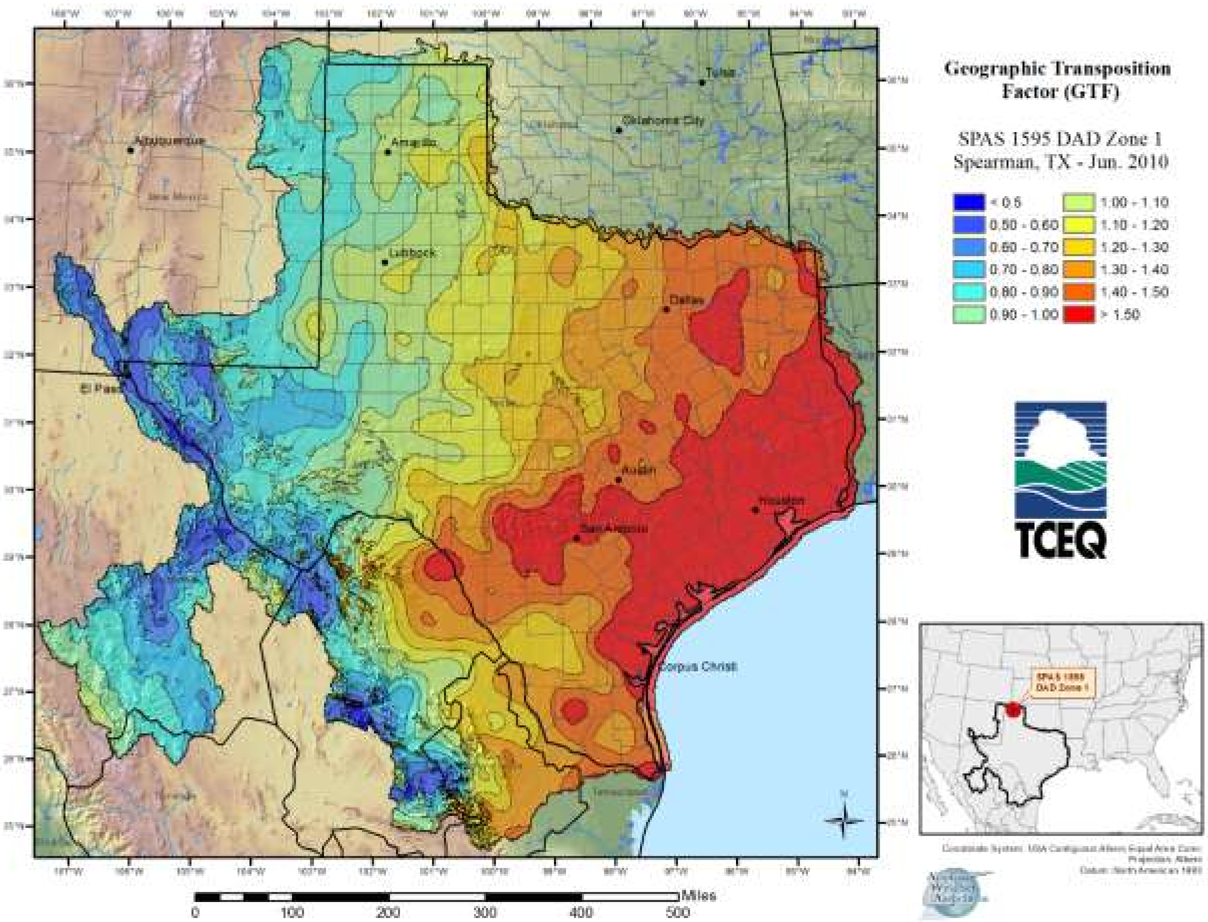
Geographic Transposition Factor (GTF)
SPAS 1595 DAD Zone 1
Spearman, TX - Jun. 2010
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0.80 - 0.90
0.90 - 1.00
1.00 - 1.10
1.10 - 1.20
1.20 - 1.30
1.30 - 1.40
1.40 - 1.50
> 1.50
Tulsa
Oklahoma City
Albuquerque
Amarillo
Lubbock
Dallas
El Paso
Austin
Houston
San Antonio
Corpus Christi
TCEQ
SPAS 1595 DAD Zone 1
Miles
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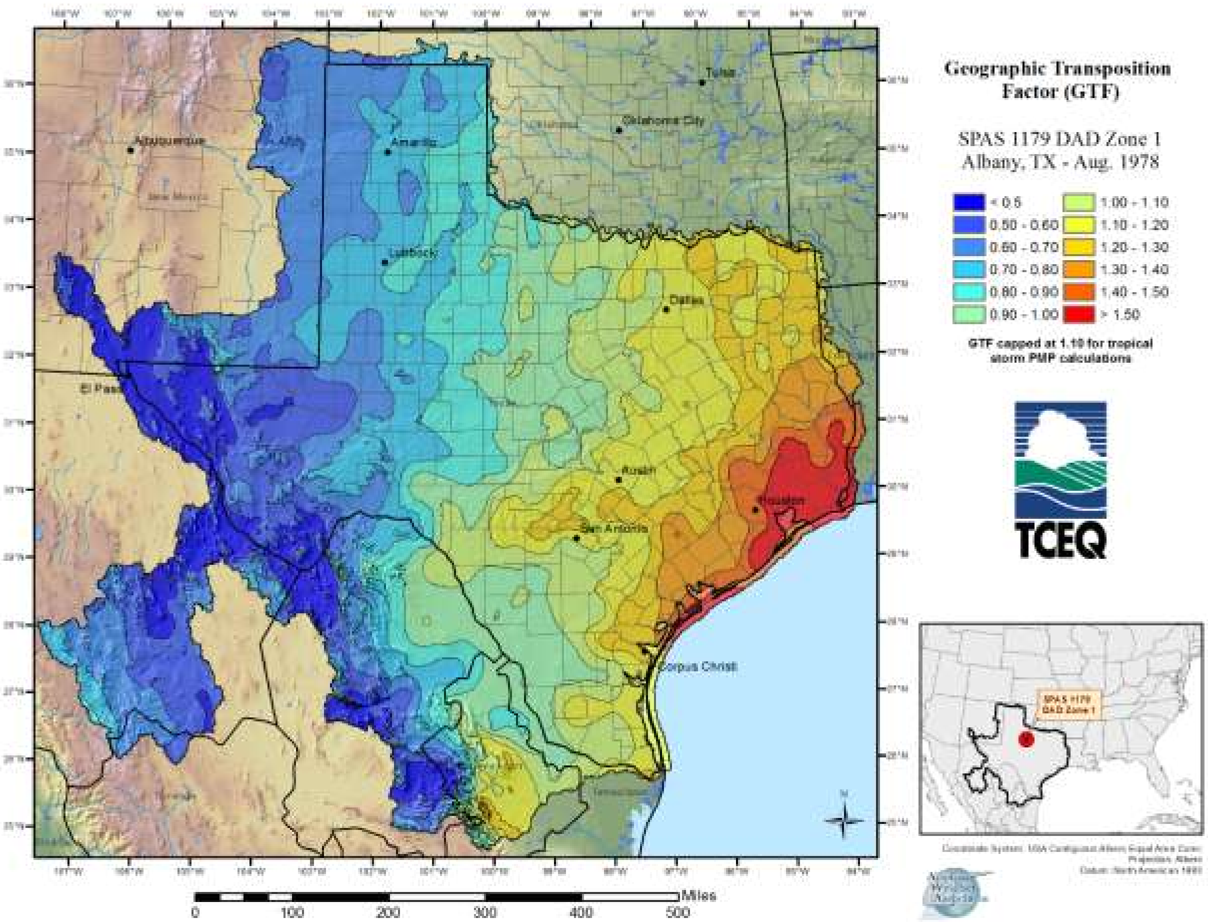
Tropical Storms


Geographic Transposition Factor (GTF)
SPAS 1179 DAD Zone 1
Albany, TX - Aug. 1978
< 0.5
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0.80 - 0.90
0.90 - 1.00
1.00 - 1.10
1.10 - 1.20
1.20 - 1.30
1.30 - 1.40
1.40 - 1.50
> 1.50
GTF capped at 1.10 for tropical storm PMP calculations
Tulsa
Oklahoma City
Albuquerque
Amarillo
Lubbock
Dallas
El Paso
Austin
Houston
San Antonio
Corpus Christi
SPAS 1179 DAD Zone 1
Miles
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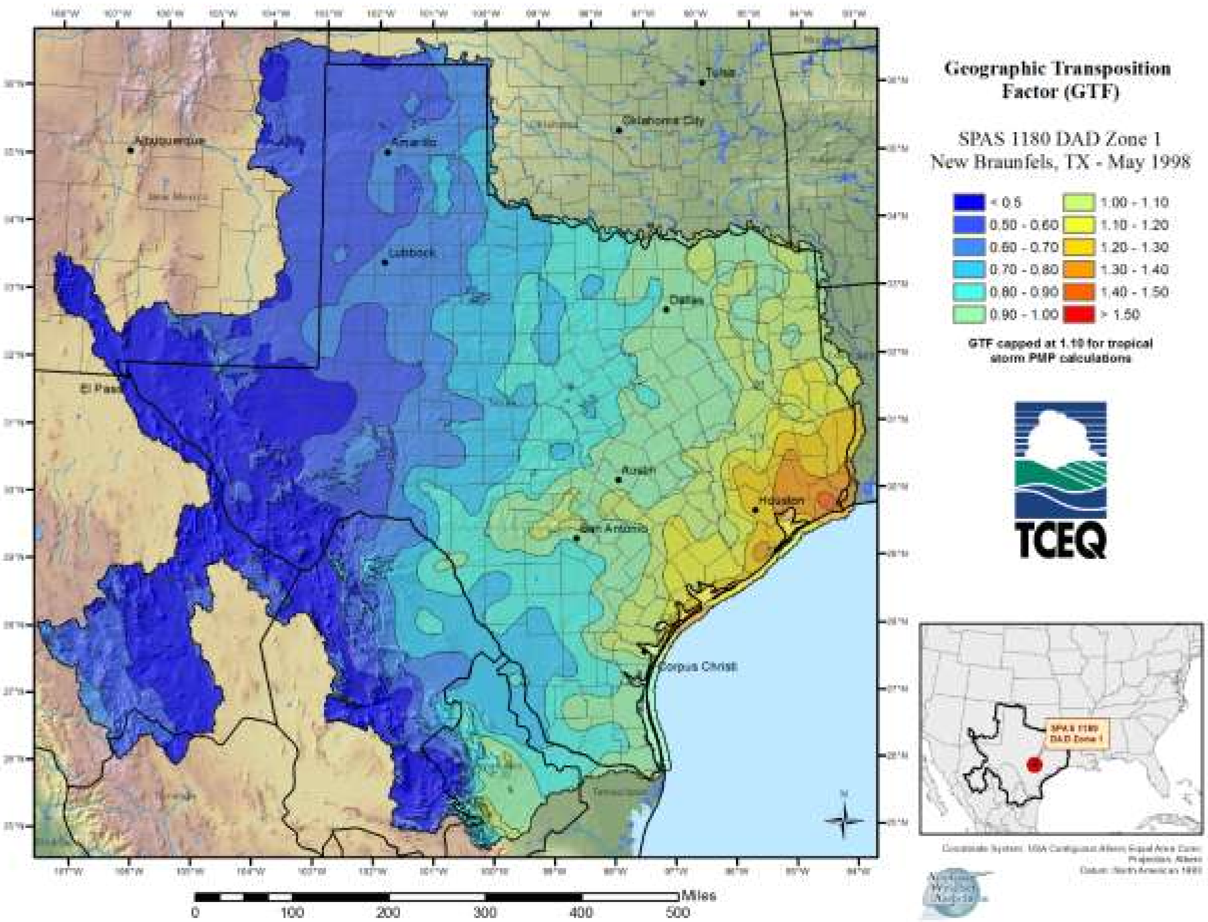
Geographic Transposition Factor (GTF)
SPAS 1180 DAD Zone 1
New Braunfels, TX - May 1998
< 0.5
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0.70 - 0.80
0.80 - 0.90
0.90 - 1.00
1.00 - 1.10
1.10 - 1.20
1.20 - 1.30
1.30 - 1.40
1.40 - 1.50
> 1.50
GTF capped at 1.10 for tropical storm PMP calculations
Tulsa
Oklahoma City
Albuquerque
Amarillo
Lubbock
Dallas
El Paso
Austin
Houston
San Antonio
Corpus Christi
Miles
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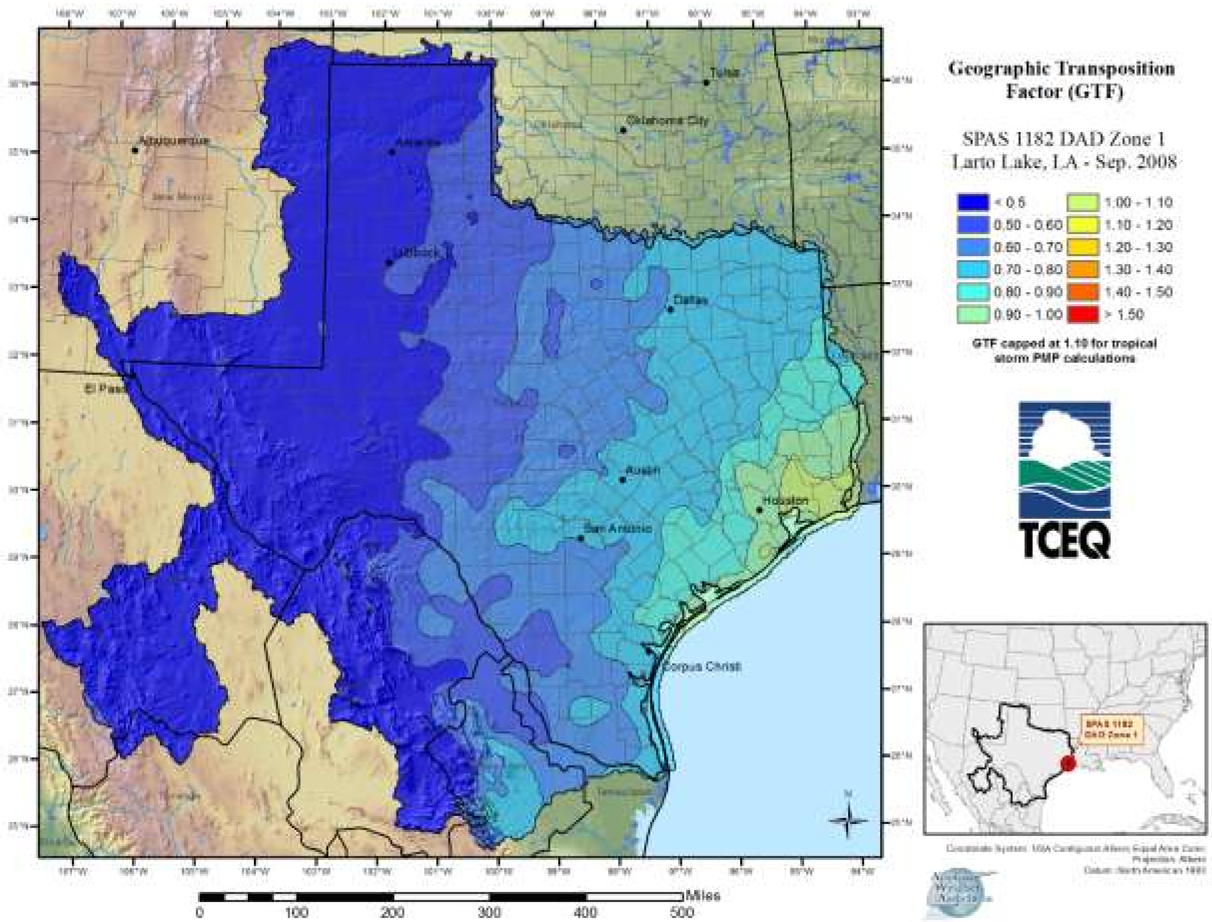
Geographic Transposition Factor (GTF)
SPAS 1182 DAD Zone 1
Larto Lake, LA - Sep. 2008
< 0.5
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0.80 - 0.90
0.90 - 1.00
1.00 - 1.10
1.10 - 1.20
1.20 - 1.30
1.30 - 1.40
1.40 - 1.50
> 1.50
GTF capped at 1.10 for tropical storm PMP calculations
TCEQ
Tulsa
Oklahoma City
Albuquerque
Amarillo
Lubbock
Dallas
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Houston
San Antonio
Corpus Christi
SPAS 1182 DAD Zone 1
Miles
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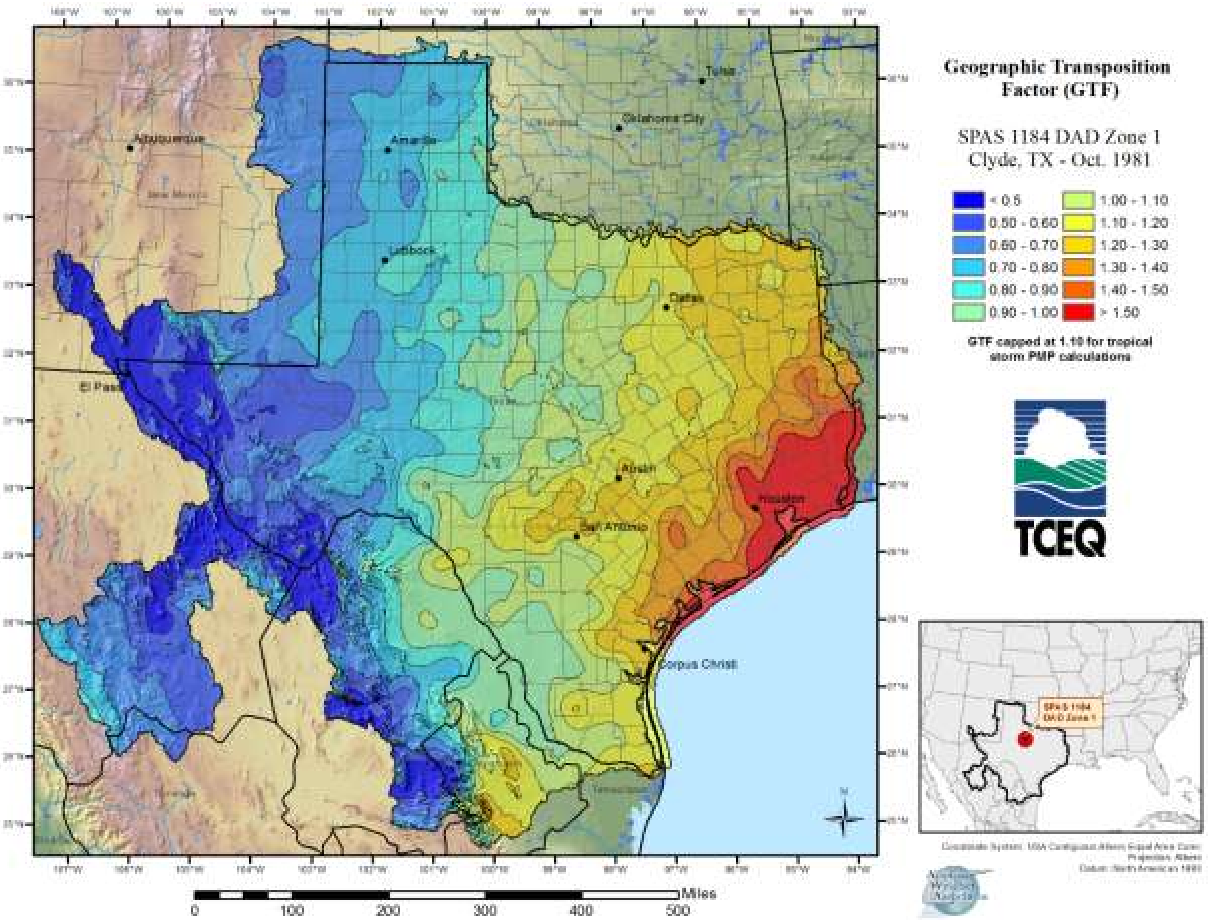
Geographic Transposition Factor (GTF)
SPAS 1184 DAD Zone 1
Clyde, TX - Oct. 1981
< 0.5
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0.70 - 0.80
0.80 - 0.90
0.90 - 1.00
1.00 - 1.10
1.10 - 1.20
1.20 - 1.30
1.30 - 1.40
1.40 - 1.50
> 1.50
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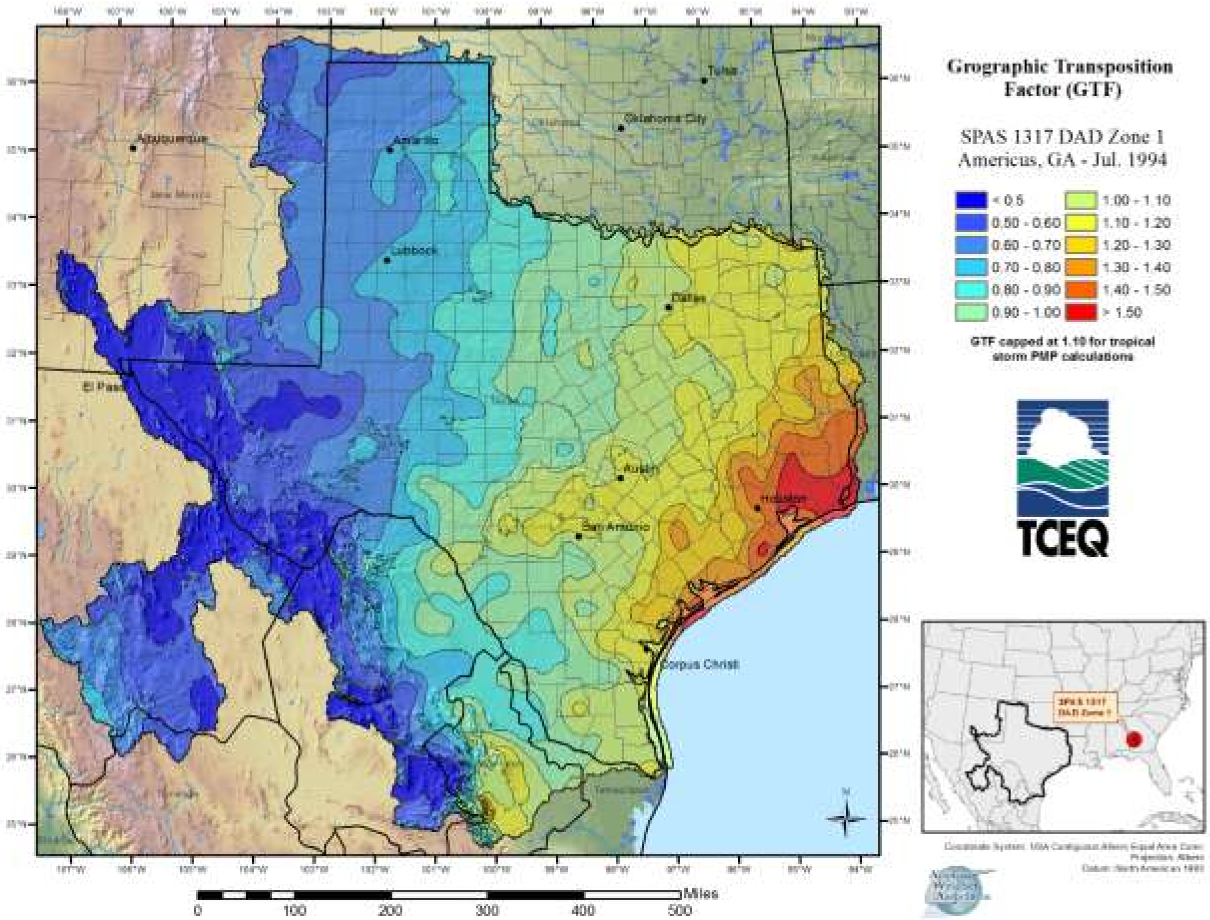

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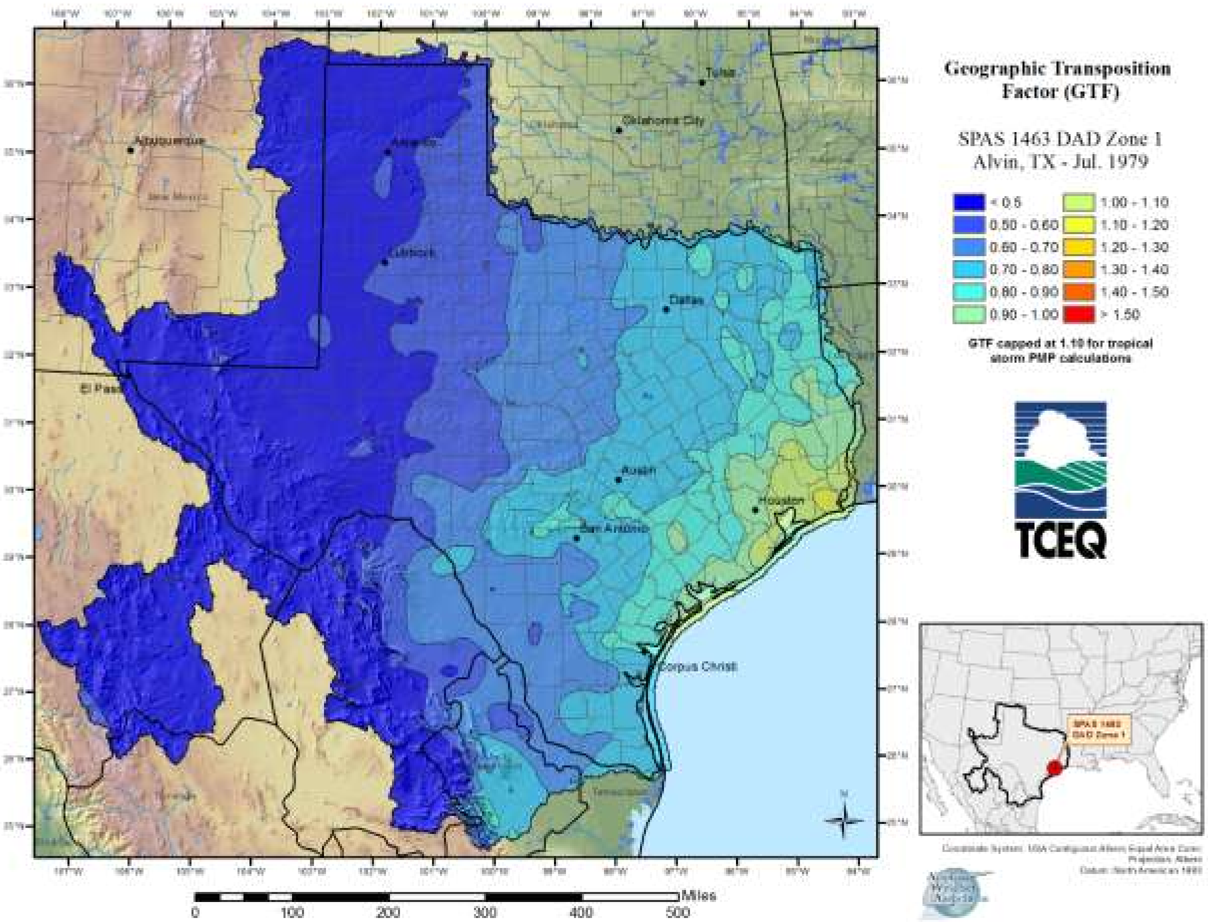
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0.70 - 0.80
0.80 - 0.90
0.90 - 1.00
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GTF capped at 1.10 for tropical storm PMP calculations
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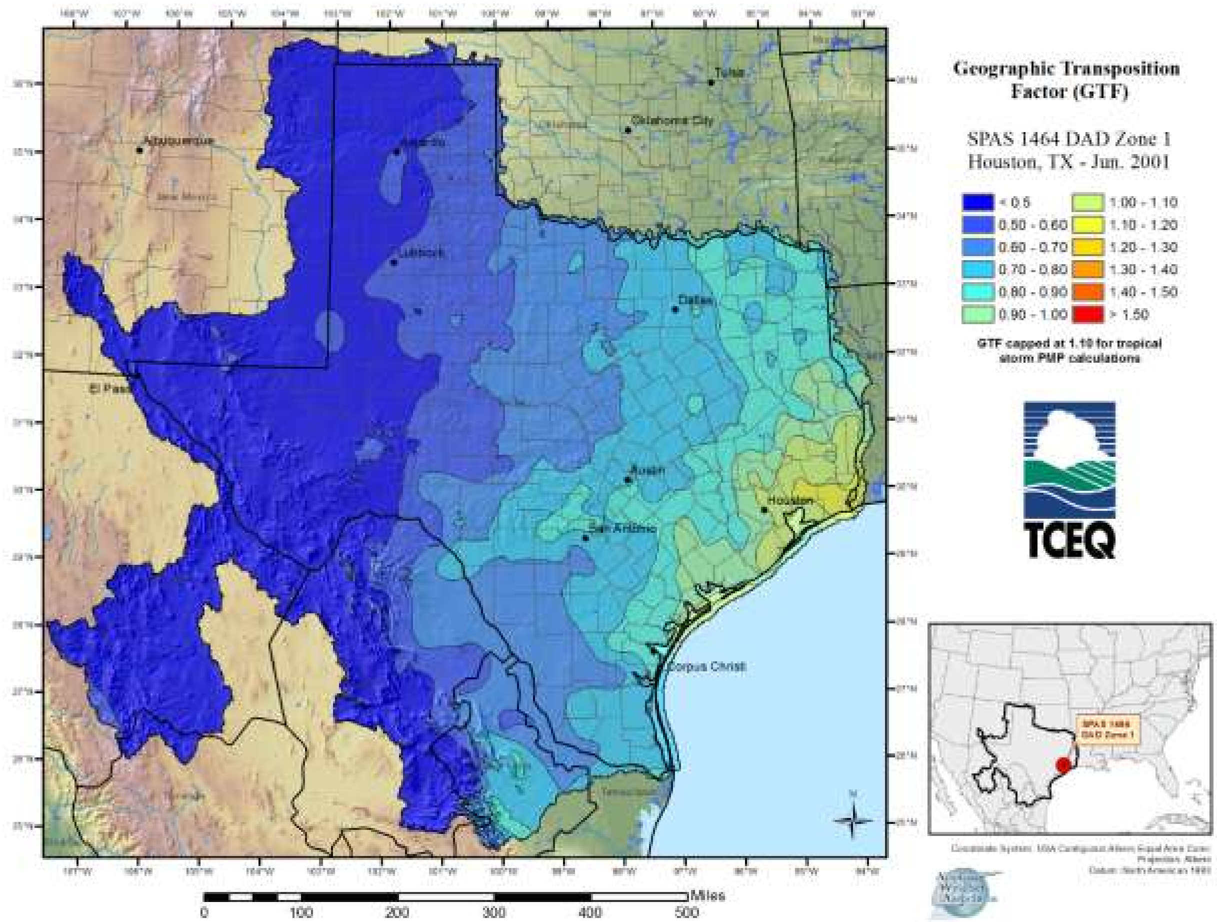
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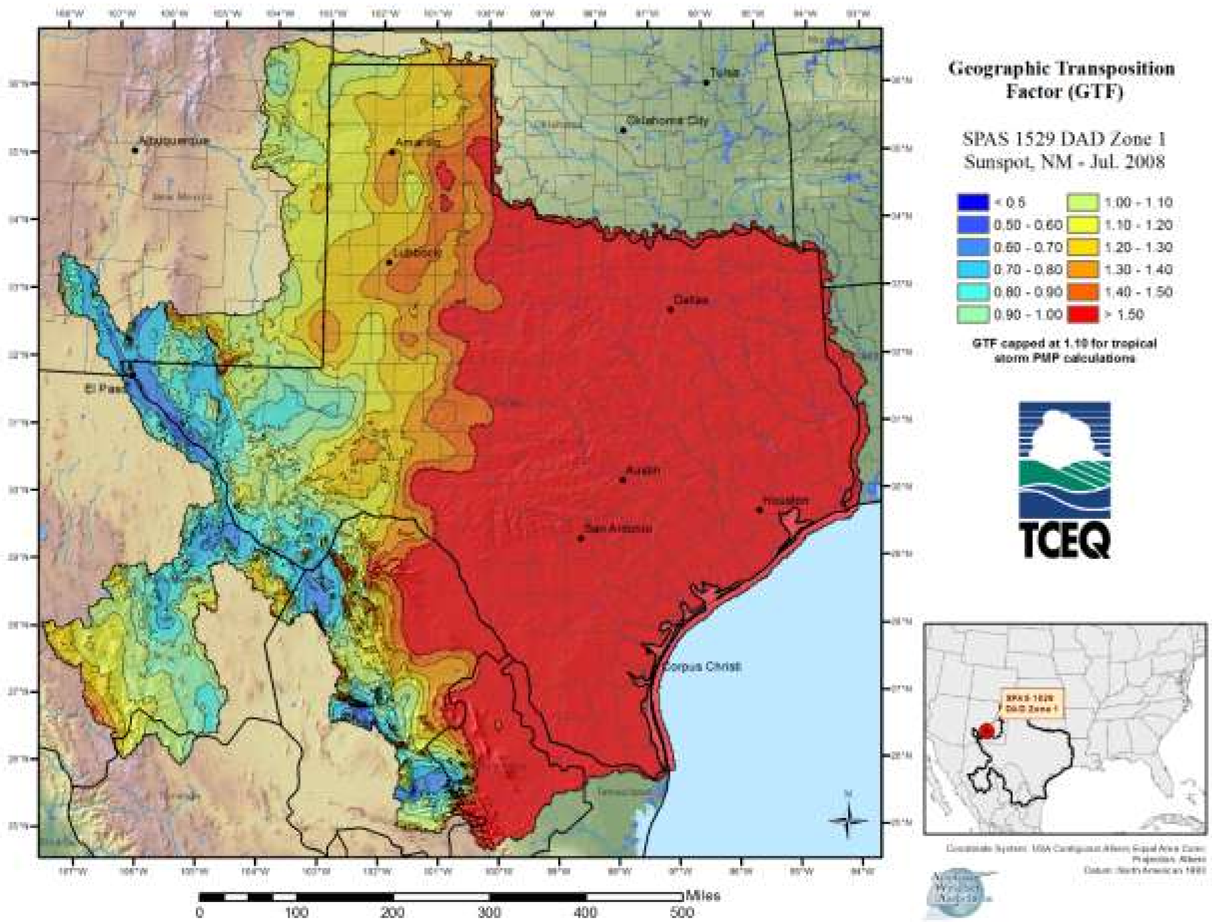
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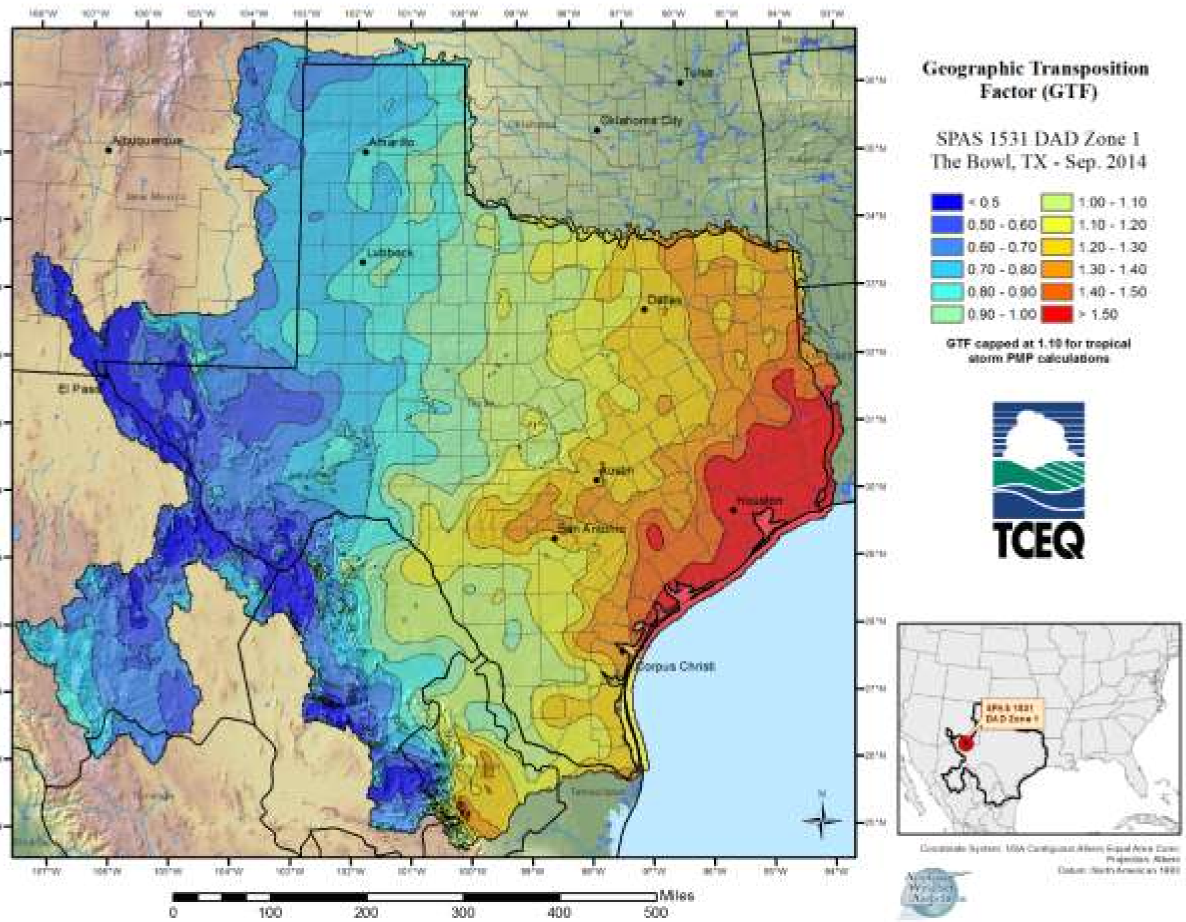
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0.80 - 0.90
0.90 - 1.00
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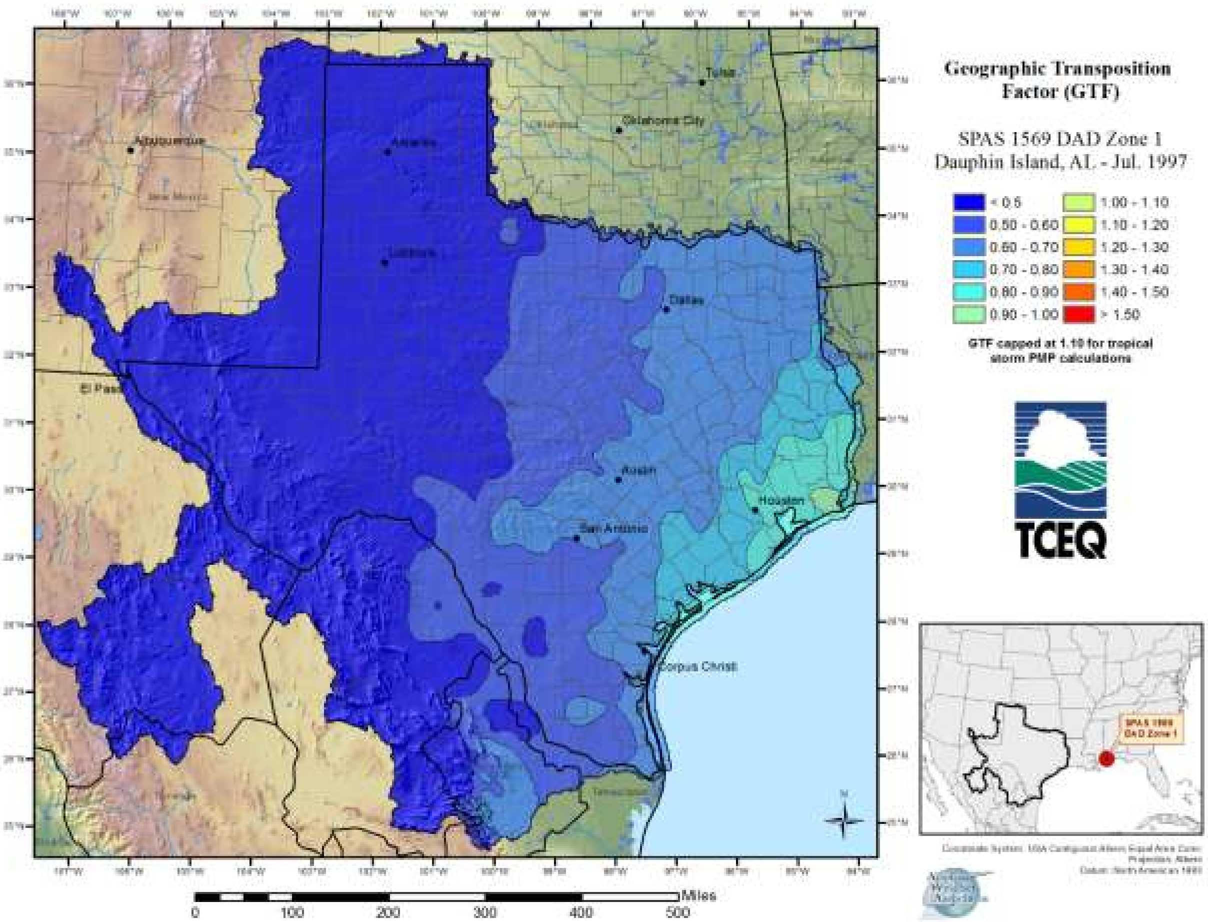
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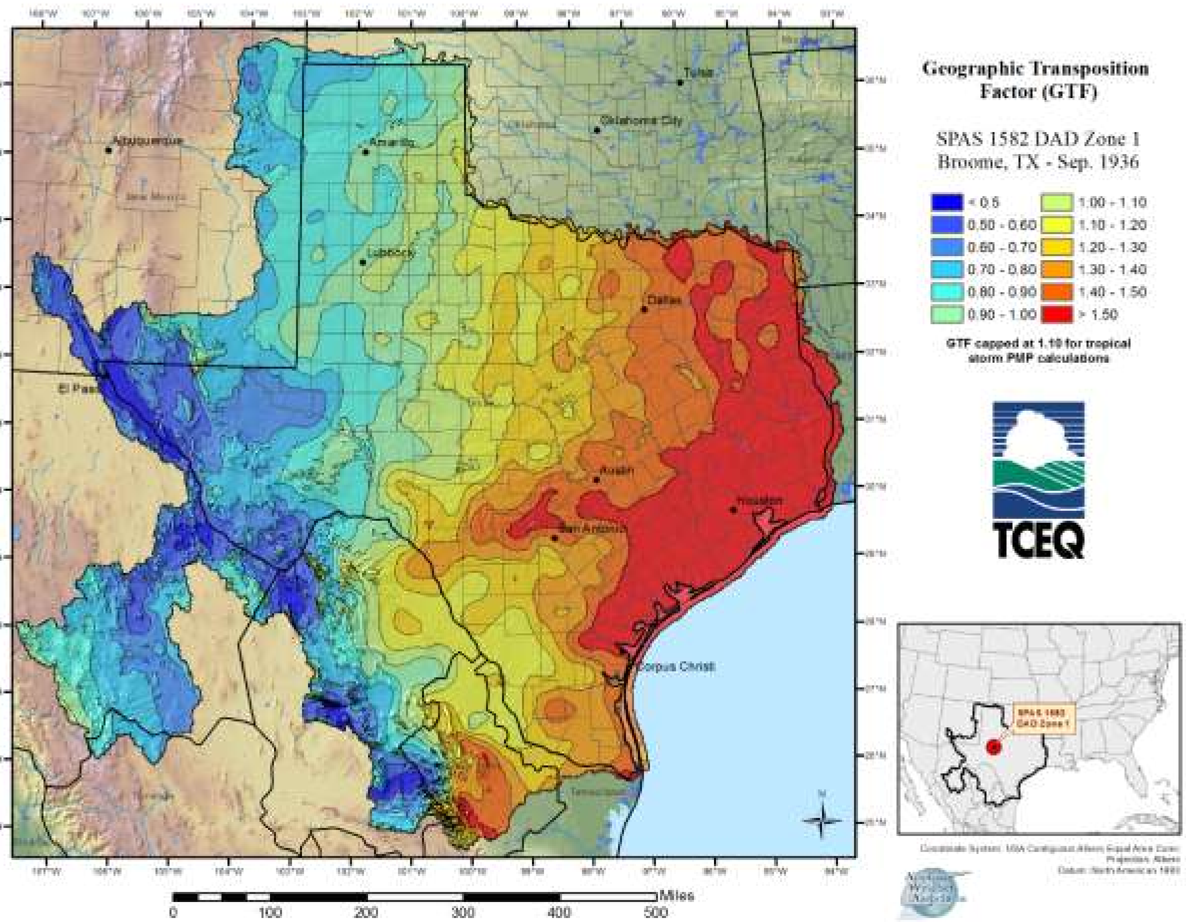

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0.80 - 0.90
0.90 - 1.00
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GTF capped at 1.10 for tropical storm PMP calculations
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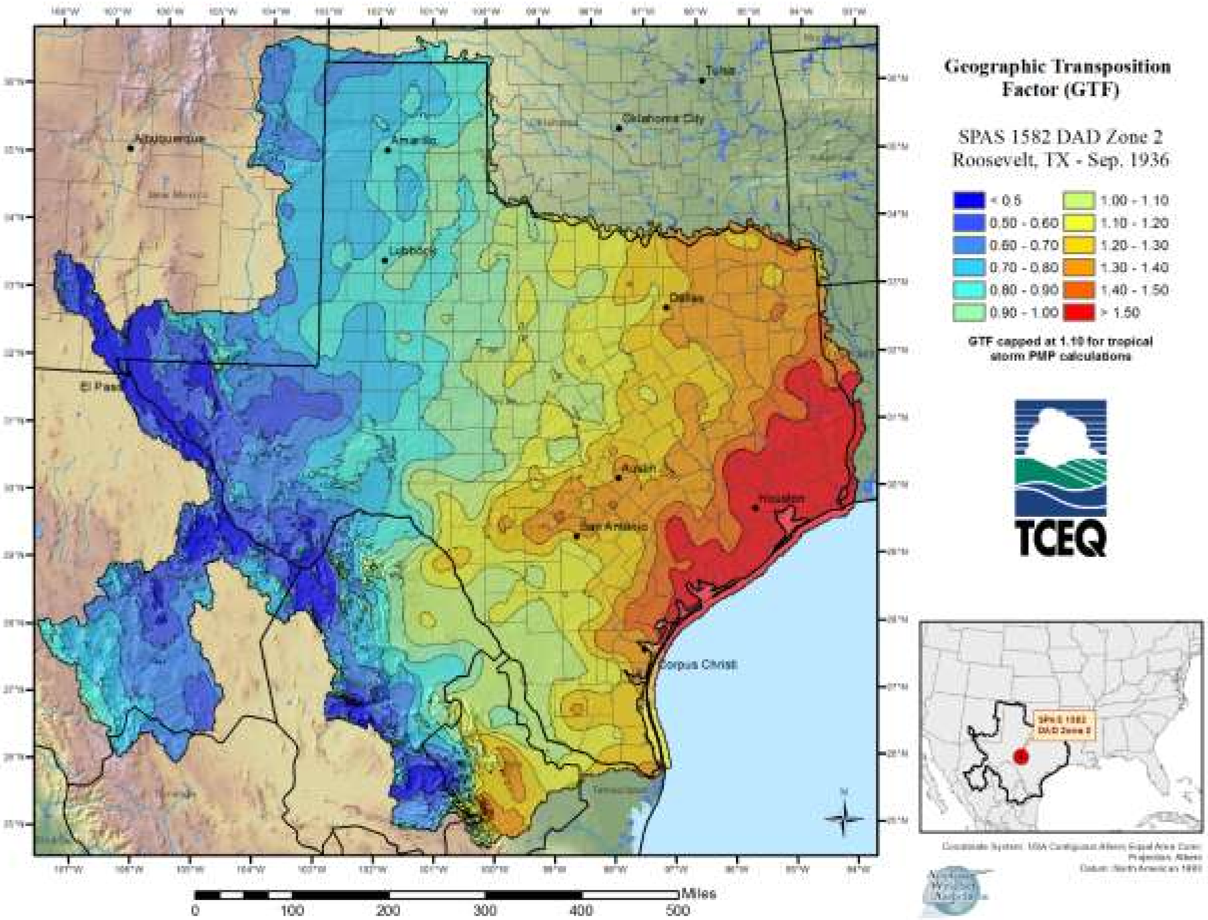
Geographic Transposition Factor (GTF)
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Roosevelt, TX - Sep. 1936
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GTF capped at 1.10 for tropical storm PMP calculations
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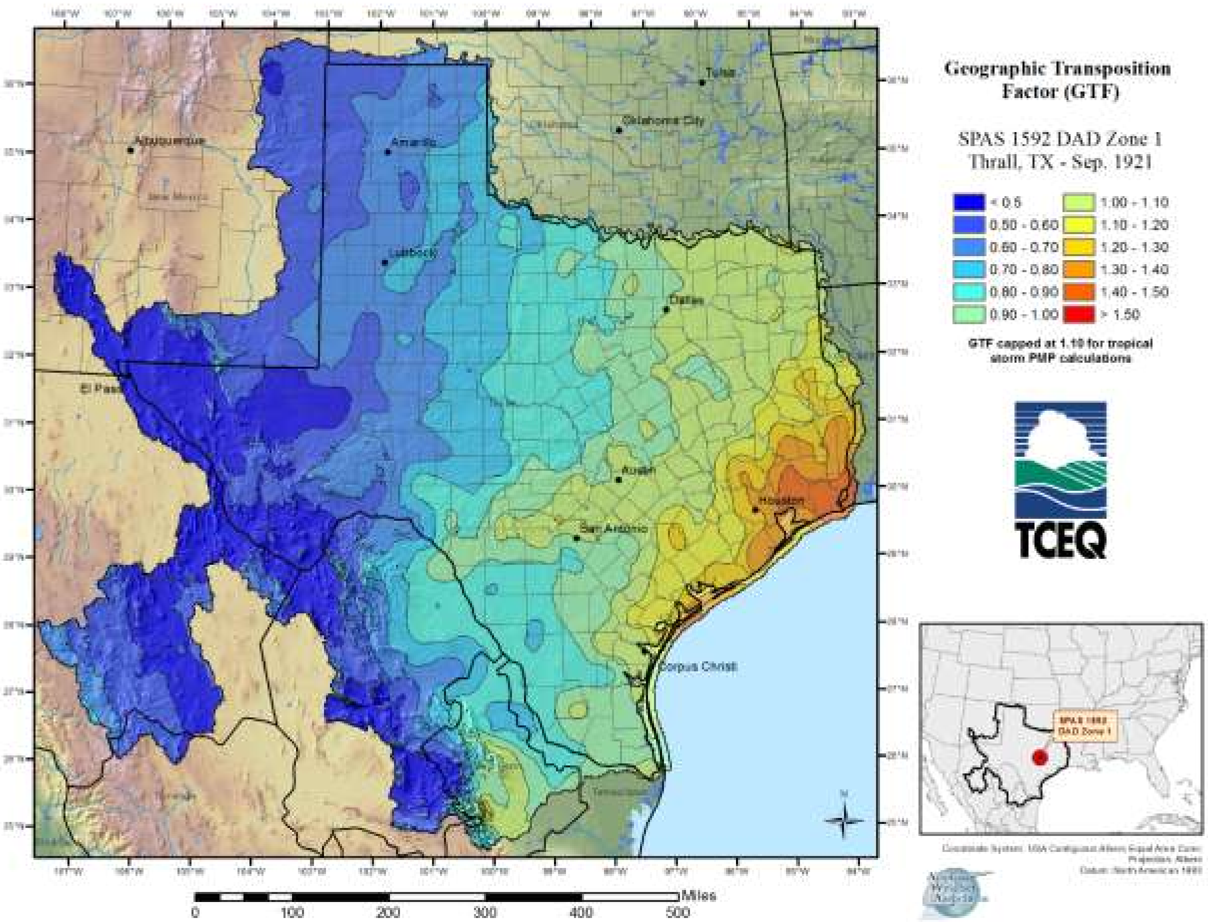

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SPAS 1592 DAD Zone 1
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0.70 - 0.80
0.80 - 0.90
0.90 - 1.00
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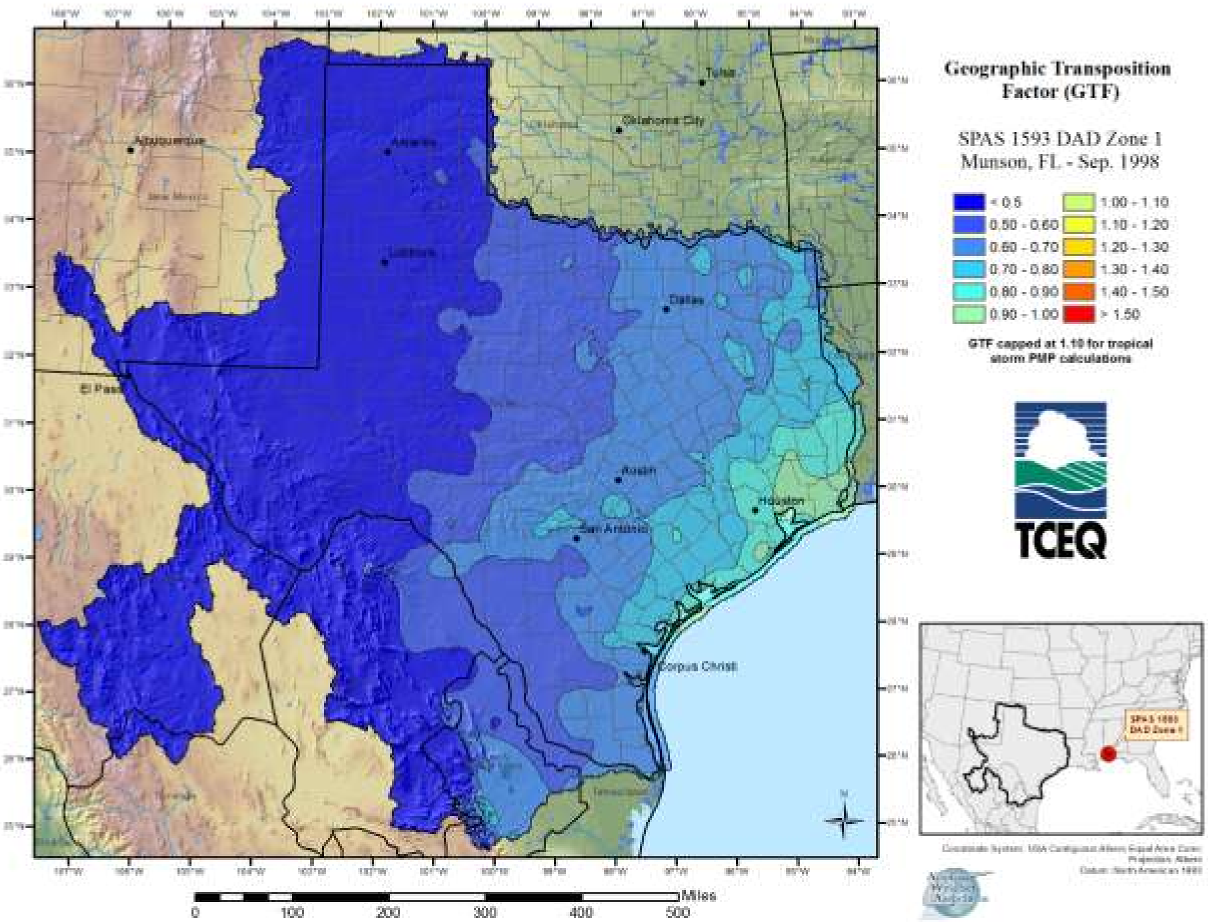
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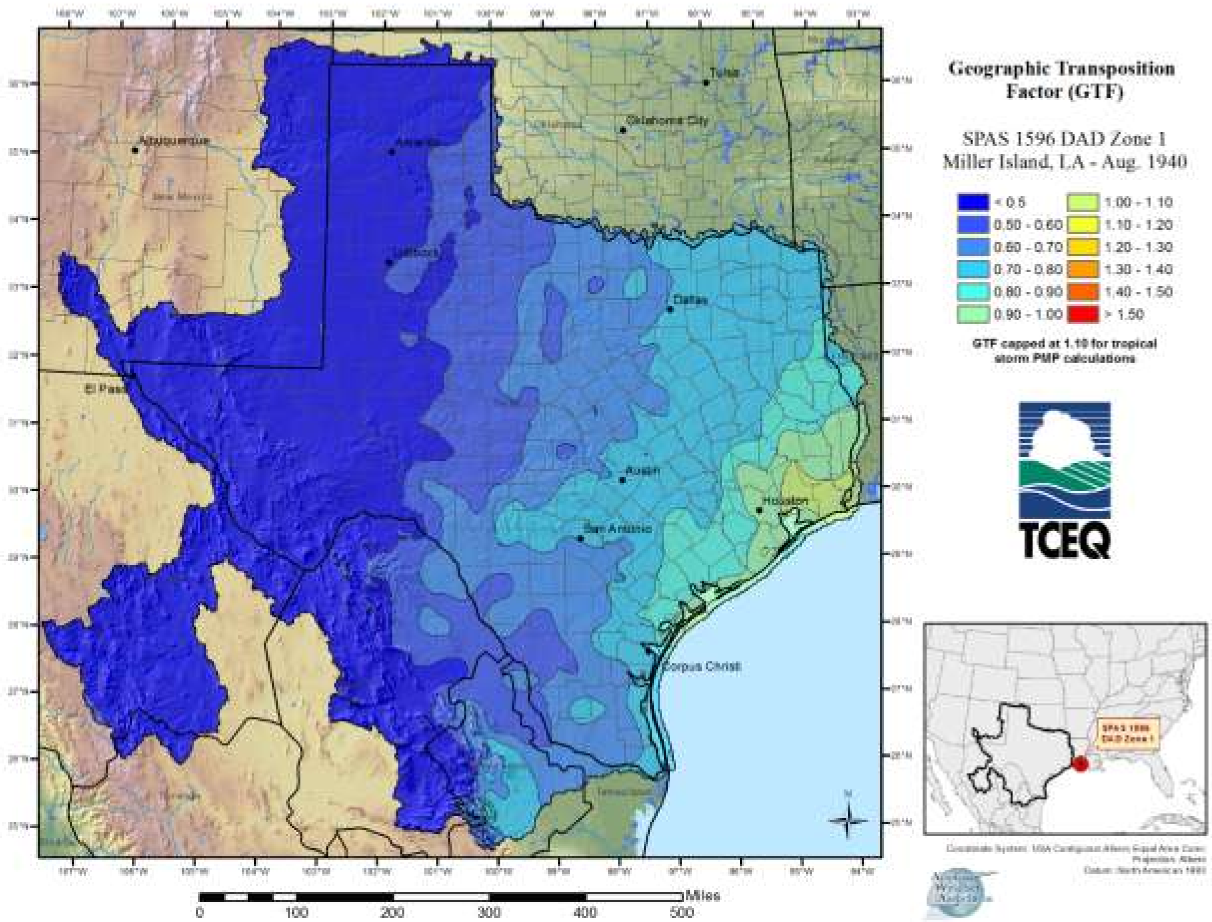

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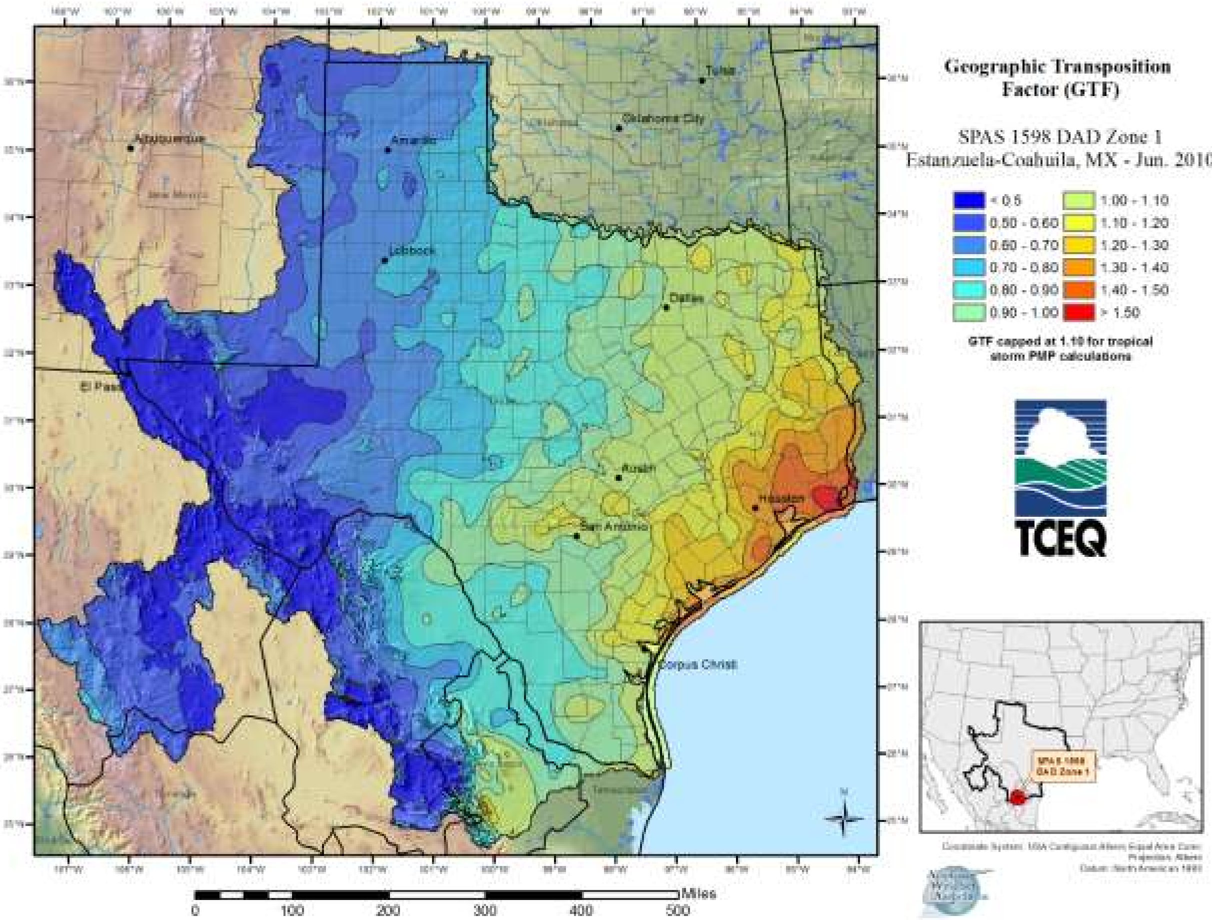
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0.70 - 0.80
0.80 - 0.90
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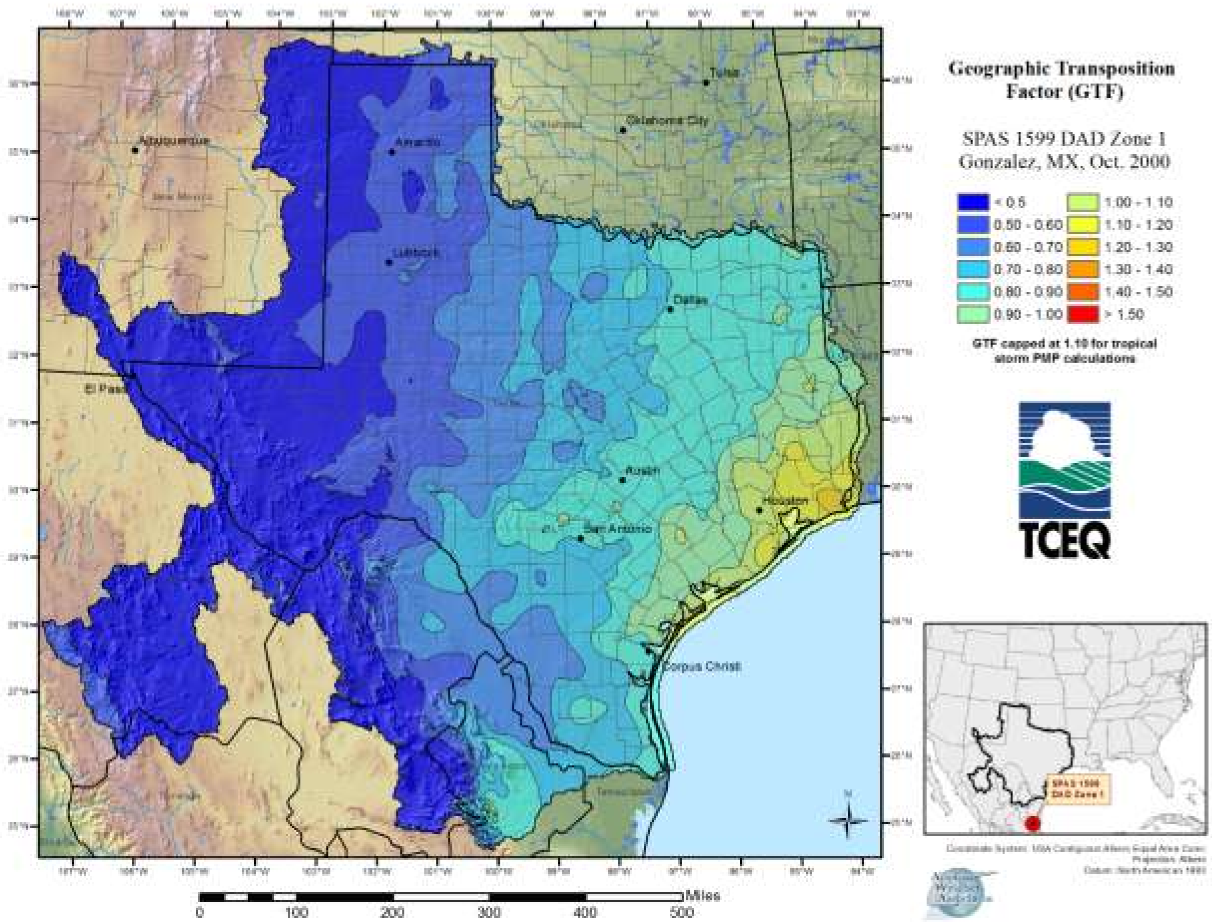

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GTF capped at 1.10 for tropical storm PMP calculations
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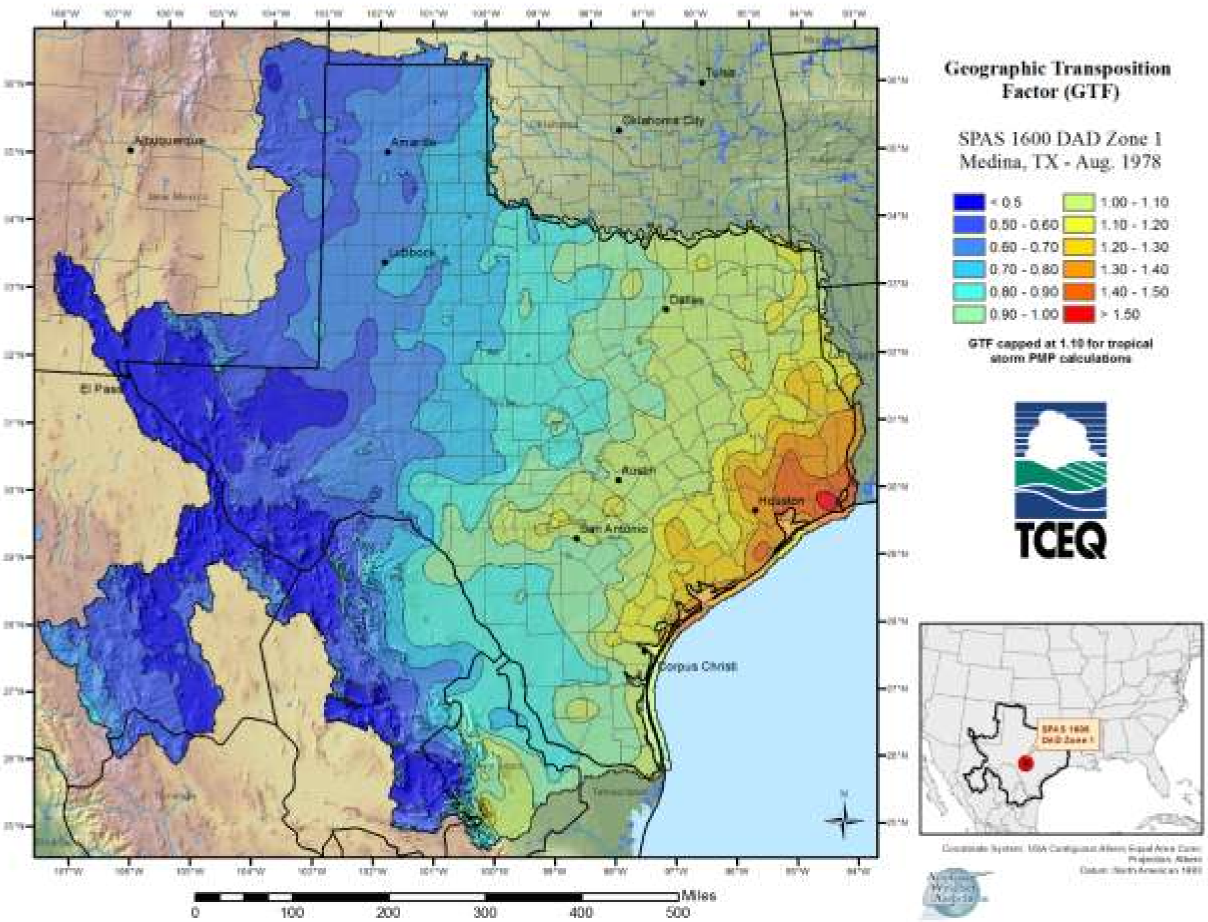

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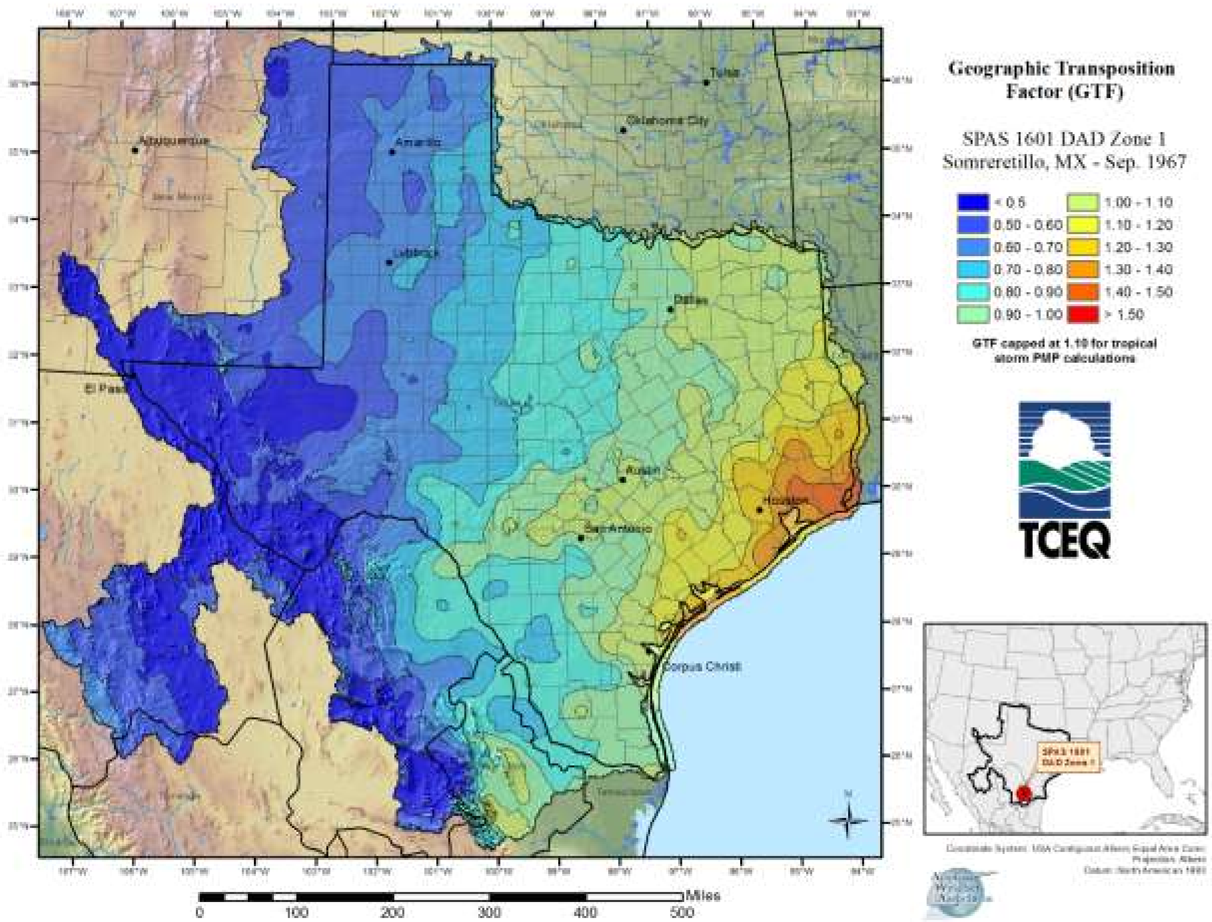

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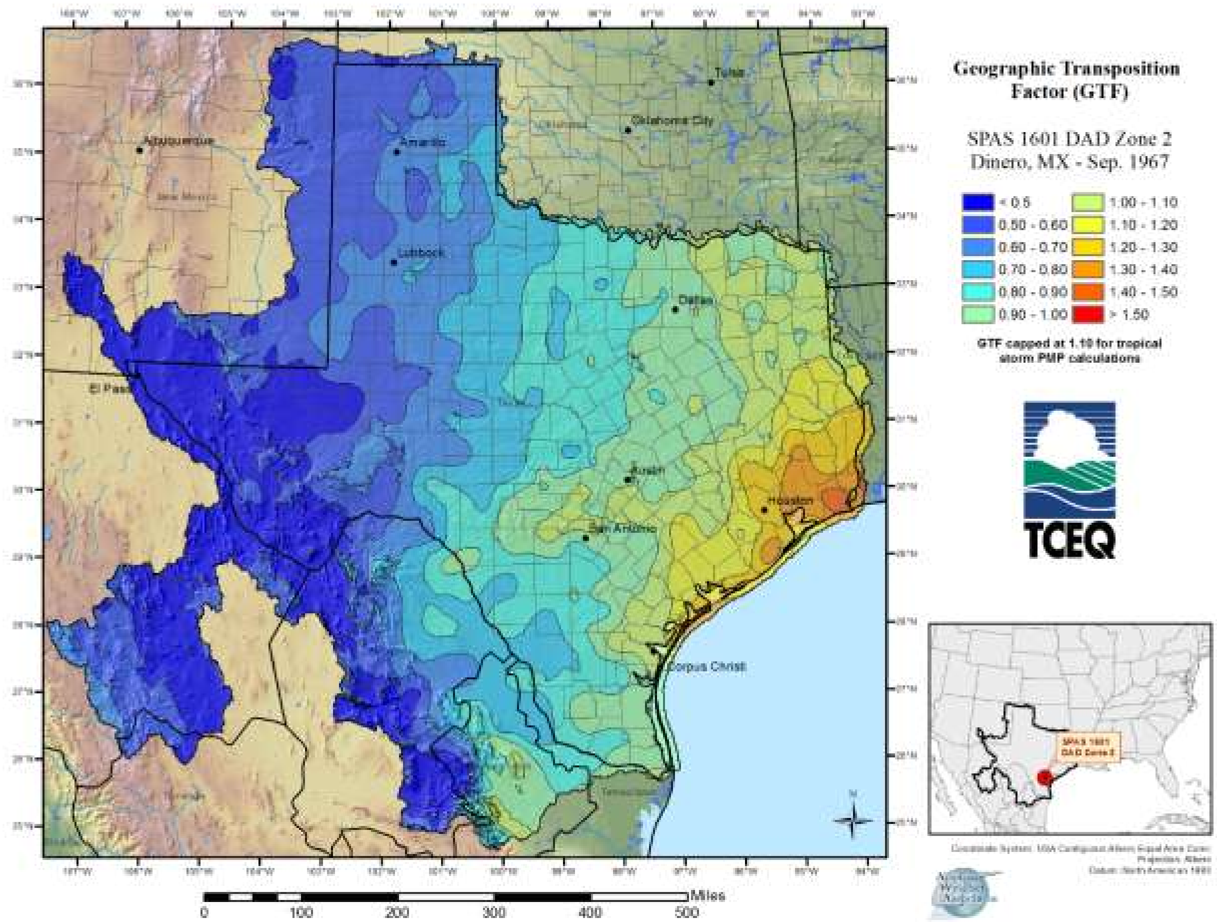
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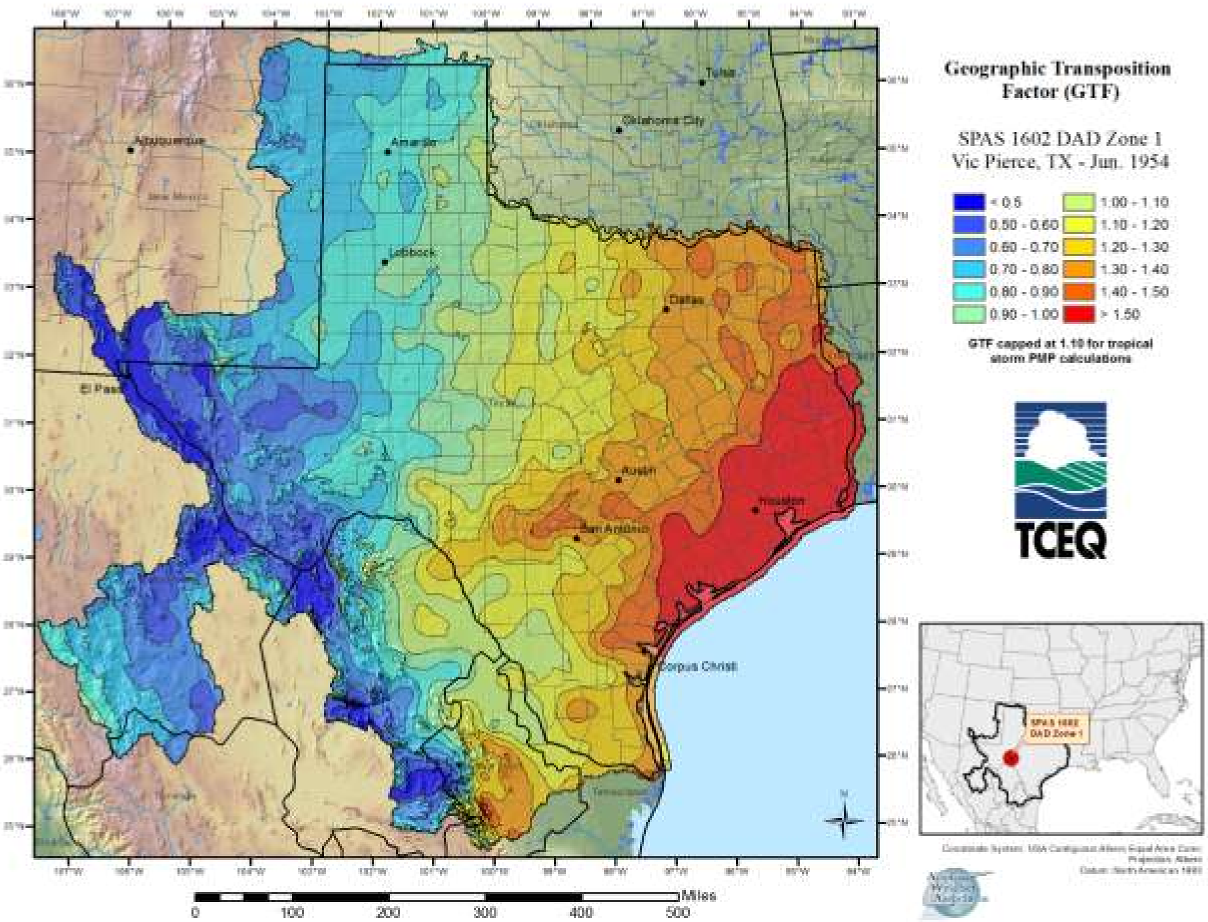
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Vic Pierce, TX - Jun. 1954
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GTF capped at 1.10 for tropical storm PMP calculations
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Appendix F
PMP Short Storm List Storm Data (Separate Binding)

Appendix G
Storm Precipitation Analysis System (SPAS) Description

Introduction

The Storm Precipitation Analysis System (SPAS) is grounded on years of scientific research with a demonstrated reliability in hundreds of post-storm precipitation analyses. It has evolved into a trusted hydrometeorological tool that provides accurate precipitation data at a high spatial and temporal resolution for use in a variety of sensitive hydrologic applications (Faulkner et al., 2004, Tomlinson et al., 2003-2012). Applied Weather Associates, LLC and METSTAT, Inc. initially developed SPAS in 2002 for use in producing Depth-Area-Duration values for Probable Maximum Precipitation (PMP) analyses. SPAS utilizes precipitation gauge data, basemaps and radar data (when available) to produce gridded precipitation at time intervals as short as 5 minutes, at spatial scales as fine as 1 km^2 and in a variety of customizable formats. To date (March 2015 SPAS has been used to analyze over 500 storm centers across all types of terrain, among highly varied meteorological settings and some occurring over 100-years ago.

SPAS output has many applications including, but not limited to: hydrologic model calibration/validation, flood event reconstruction, storm water runoff analysis, forensic cases and PMP studies. Detailed SPAS-computed precipitation data allow hydrologists to accurately model runoff from basins, particularly when the precipitation is unevenly distributed over the drainage basin or when rain gauge data are limited or not available. The increased spatial and temporal accuracy of precipitation estimates has eliminated the need for commonly made assumptions about precipitation characteristics (such as uniform precipitation over a watershed), thereby greatly improving the precision and reliability of hydrologic analyses.

To instill consistency in SPAS analyses, many of the core methods have remained consistent from the beginning. However, SPAS is constantly evolving and improving through new scientific advancements and as new data and improvements are incorporated. This write-up describes the current inner-workings of SPAS, but the reader should realize SPAS can be customized on a case-by-case basis to account for special circumstances; these adaptations are documented and included in the deliverables. The over-arching goal of SPAS is to combine the strengths of rain gauge data and radar data (when available) to provide sound, reliable and accurate spatial precipitation data.

Hourly precipitation observations are generally limited to a small number of locations, with many basins lacking observational precipitation data entirely. However, Next Generation Radar (NEXRAD) data provide valuable spatial and temporal information over data-sparse basins, which have historically lacked reliability for determining precipitation rates and reliable quantitative precipitation estimates (QPE). The improved reliability in SPAS is made possible by hourly calibration of the NEXRAD radar-precipitation relationship, combined with local hourly bias adjustments to force consistency between the final result and “ground truth” precipitation measurements. If NEXRAD radar data are available (generally for storm events since the mid-1990s), precipitation accumulation at temporal scales as frequent as 5-minutes can be analyzed. If no NEXRAD data are available, then precipitation data are analyzed in hourly increments. A summary of the general SPAS processes is shown in flow chart in Figure G.1.

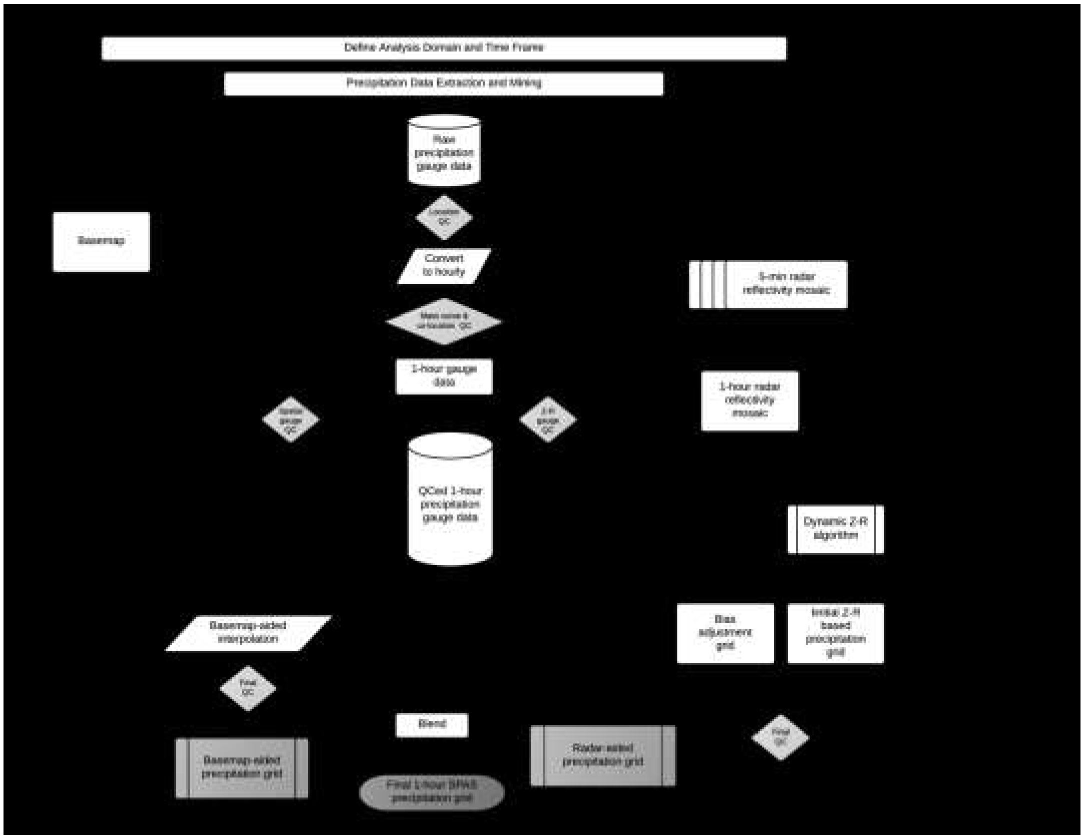


Figure G.1: SPAS flow chart

Setup

Prior to a SPAS analysis, careful definition of the storm analysis domain and time frame to be analyzed is established. Several considerations are made to ensure the domain (longitude-latitude box) and time frame are sufficient for the given application.

SPAS Analysis Domain

For PMP applications it is important to establish an analysis domain that completely encompasses a storm center, meanwhile hydrologic modeling applications are more concerned about a specific basin, watershed or catchment. If radar data are available, then it is also important to establish an area large enough to encompass enough stations (minimum of ~30) to adequately derive reliable radar-precipitation intensity relationships (discussed later). The domain is defined by evaluating existing documentation on the storm as well as plotting and evaluating initial precipitation gauge data on a map. The analysis domain is defined to include as many hourly recording gauges as possible given their importance in timing. The domain must include enough of a buffer to accurately model the nested domain of interest. The domain is defined as a longitude-latitude (upper left and lower right corner) rectangular region.

SPAS Analysis Time Frame

Ideally, the analysis time frame, also referred to as the Storm Precipitation Period (SPP), will extend from a dry period through the target wet period then back into another dry period. This is to ensure that total storm precipitation amounts can be confidently associated with the storm in question and not contaminated by adjacent wet periods. If this is not possible, a reasonable time

period is selected that is bounded by relatively lighter precipitation. The time frame of the hourly data must be sufficient to capture the full range of daily gauge observational periods for the daily observations to be disaggregated into estimated incremental hourly values (discussed later). For example, if a daily gauge takes observations at 8:00 AM, then the hourly data must be available from 8:00 AM the day prior. Given the configuration of SPAS, the minimum SPP is 72 hours and aligns midnight to midnight.
The core precipitation period (CPP) is a sub-set of the SPP and represents the time period with the most precipitation and the greatest number of reporting gauges. The CPP represents the time period of interest and where our confidence in the results is highest.

Data

The foundation of a SPAS analysis is the "ground truth" precipitation measurements. In fact, the level of effort involved in "data mining" and quality control represent over half of the total level of effort needed to conduct a complete storm analysis. SPAS operates with three primary data sets: precipitation gauge data, a basemap and, if available, radar data. Table G.1 conveys the variety of precipitation gauges usable by SPAS. For each gauge, the following elements are gathered, entered and archived into SPAS database:

- Station ID
- Station name
- Station type (H=hourly, D=Daily, S=Supplemental, etc.)
- Longitude in decimal degrees
- Latitude in decimal degrees
- Elevation in feet above MSL
- Observed precipitation
- Observation times
- Source
- If unofficial, the measurement equipment and/or method is also noted.

Based on the SPP and analysis domain, hourly and daily precipitation gauge data are extracted from our in-house database as well as the Meteorological Assimilation Data Ingest System (MADIS). Our in-house database contains data dating back to the late 1800s, while the MADIS system (described below) contains archived data back to 2002.

Hourly Precipitation Data

Our hourly precipitation database is largely comprised of data from NCDC TD-3240, but also precipitation data from other mesonets and meteorological networks (e.g. ALERT, Flood Control Districts, etc.) that we have collected and archived as part of previous studies. Meanwhile, MADIS provides data from a large number of networks across the U.S., including NOAA's HADS (Hydrometeorological Automated Data System), numerous mesonets, the Citizen Weather Observers Program (CWOP), departments of transportation, etc. (see http://madis.noaa.gov/mesonet_providers.html for a list of providers). Although our automatic data extraction is fast, cost-effective and efficient, it never captures all of the available precipitation data for a storm event. For this reason, a thorough "data mining" effort is undertaken to acquire all available data from sources such as U.S. Geological Survey (USGS), Remote Automated Weather Stations (RAWS), Community Collaborative Rain, Hail & Snow

Network (CoCoRaHS), National Atmospheric Deposition Program (NADP), Clean Air Status and Trends Network (CASTNET), local observer networks, Climate Reference Network (CRN), Global Summary of the Day (GSD) and Soil Climate Analysis Network (SCAN). Unofficial hourly precipitation data are gathered to give guidance on either timing or magnitude in areas otherwise void of precipitation data. The WeatherUnderground and MesoWest, two of the largest weather databases on the Internet, contain a large proportion of official data, but also includes data from unofficial gauges.

Table G.1: Different precipitation gauge types used by SPAS

Precipitation Gauge Type	Description
Hourly	Hourly gauges with complete, or nearly complete, incremental hourly precipitation data.
Hourly estimated	Hourly gauges with some estimated hourly values, but otherwise reliable.
Hourly pseudo	Hourly gauges with reliable temporal precipitation data, but the magnitude is questionable in relation to co-located daily or supplemental gauge.
Daily	Daily gauge with complete data and known observation times.
Daily estimated	Daily gauges with some or all estimated data.
Supplemental	Gauges with unknown or irregular observation times, but reliable total storm precipitation data. (E.g. public reports, storms reports, “Bucket surveys”, etc.)
Supplemental estimated	Gauges with estimated total storm precipitation values based on other information (e.g. newspaper articles, stream flow discharge, inferences from nearby gauges, pre-existing total storm isohyetal maps, etc.)

Daily Precipitation Data

Our daily database is largely based on NCDC’s TD-3206 (pre-1948) and TD-3200 (1948 through present) as well as SNOTEL data from NRCS. Since the late 1990s, the CoCoRaHS network of more than 15,000 observers in the U.S. has become a very important daily precipitation source. Other daily data are gathered from similar, but smaller gauge networks, for instance the High Spatial Density Precipitation Network in Minnesota.

As part of the daily data extraction process, the time of observation accompanies each measured precipitation value. Accurate observation times are necessary for SPAS to disaggregate the daily precipitation into estimated incremental values (discussed later). Knowing the observation time also allows SPAS to maintain precipitation amounts within given time bounds, thereby retaining known precipitation intensities. Given the importance of observation times, efforts are taken to insure the observation times are accurate. Hardcopy reports of “Climatological Data,” scanned observational forms (available on-line from the NCDC) and/or gauge metadata forms have proven to be valuable and accurate resources for validating observation times. Furthermore, erroneous observation times are identified in the mass-curve quality-control procedure (discussed later) and can be corrected at that point in the process.

Supplemental Precipitation Gauge Data

For gauges with unknown or irregular observation times, the gauge is considered a “supplemental” gauge. A supplemental gauge can either be added to the storm database with a storm total and the associated SPP as the temporal bounds or as a gauge with the known, but irregular observation times and associated precipitation amounts. For instance, if all that is known is 3 inches fell between 0800-0900, then that information can be entered. Gauges or reports with nothing more than a storm total are often abundant, but to use them, it is important the precipitation is only from the storm period in question. Therefore, it is ideal to have the analysis time frame bounded by dry periods.

Perhaps the most important source of data, if available, is from "bucket surveys," which provide comprehensive lists of precipitation measurements collected during a post-storm field exercise. Although some bucket survey amounts are not from conventional precipitation gauges, they provide important information, especially in areas lacking data. Particularly for PMP-storm analysis applications, it is customary to accept extreme, but valid non-standard precipitation values (such as bottles and other open containers that catch rainfall) to capture the highest precipitation values.

Basemap

"Basemaps" are independent grids of spatially distributed weather or climate variables that are used to govern the spatial patterns of the hourly precipitation. The basemap also governs the spatial resolution of the final SPAS grids, unless radar data are available/used to govern the spatial resolution. Note that a base map is not required as the hourly precipitation patterns can be based on station characteristics and an inverse distance weighting technique (discussed later). Basemaps in complex terrain are often based on the PRISM mean monthly precipitation (Figure G.2a) or Hydrometeorological Design Studies Center precipitation frequency grids (Figure G.2b) given they resolve orographic enhancement areas and micro-climates at a spatial resolution of 30-seconds (about 800 m). Basemaps of this nature in flat terrain are not as effective given the small terrain forced precipitation gradients. Therefore, basemaps for SPAS analyses in flat terrain are often developed from pre-existing (hand-drawn) isohyetal patterns (Figure G.2c), composite radar imagery or a blend of both.

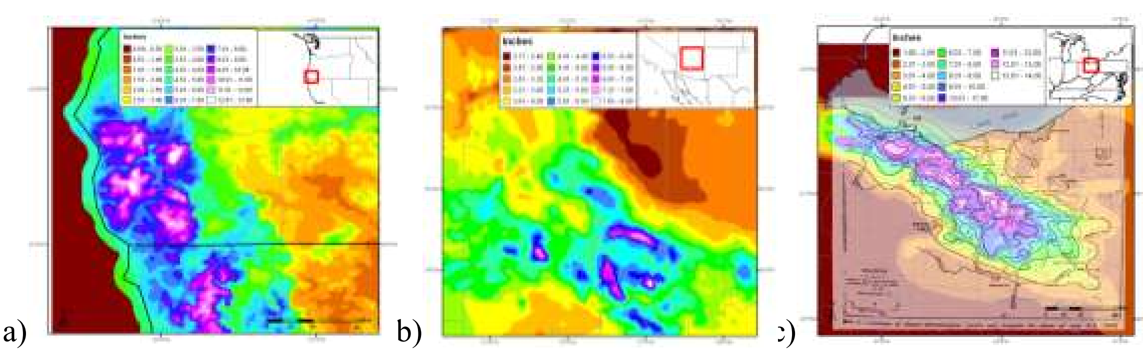


Figure G.2: Sample SPAS "basemaps:" (a) A pre-existing (USGS) isohyetal pattern across flat terrain (SPAS #1209), (b) PRISM mean monthly (October) precipitation (SPAS #1192) and (c) A 100-year 24-hour precipitation grid from NOAA Atlas 14 (SPAS #1138)

Radar Data

For storms occurring since approximately the mid-1990s, weather radar data are available to supplement the SPAS analysis. A fundamental requirement for high quality radar-estimated precipitation is a high quality radar mosaic, which is a seamless collection of concurrent weather radar data from individual radar sites, however in some cases a single radar is sufficient (i.e. for a small area size storm event such as a thunderstorm). Weather radar data have been in use by meteorologists since the 1960s to estimate precipitation depths, but it was not until the early 1990s that new, more accurate NEXRAD Doppler radar (WSR88D) was placed into service across the United States. Currently, efforts are underway to convert the WSR88D radars to dual polarization (DualPol) radar. Today, NEXRAD radar coverage of the contiguous United States is comprised of 159 operational sites and there are 30 in Canada. Each U.S. radar covers an approximate 285 mile (460 km) radial extent while Canadian radars have approximately 256 km (138 nautical miles) radial extent over which their radar can detect precipitation (see Figure G.3). The primary vendor of NEXRAD weather radar data for SPAS is Weather Decision Technologies, Inc. (WDT), who accesses, mosaics, archives and quality-controls NEXRAD radar data from NOAA and Environment Canada. SPAS utilizes Level II NEXRAD radar reflectivity data in units of dBZ, available every 5-minutes in the U.S. and 10-minutes in Canada.

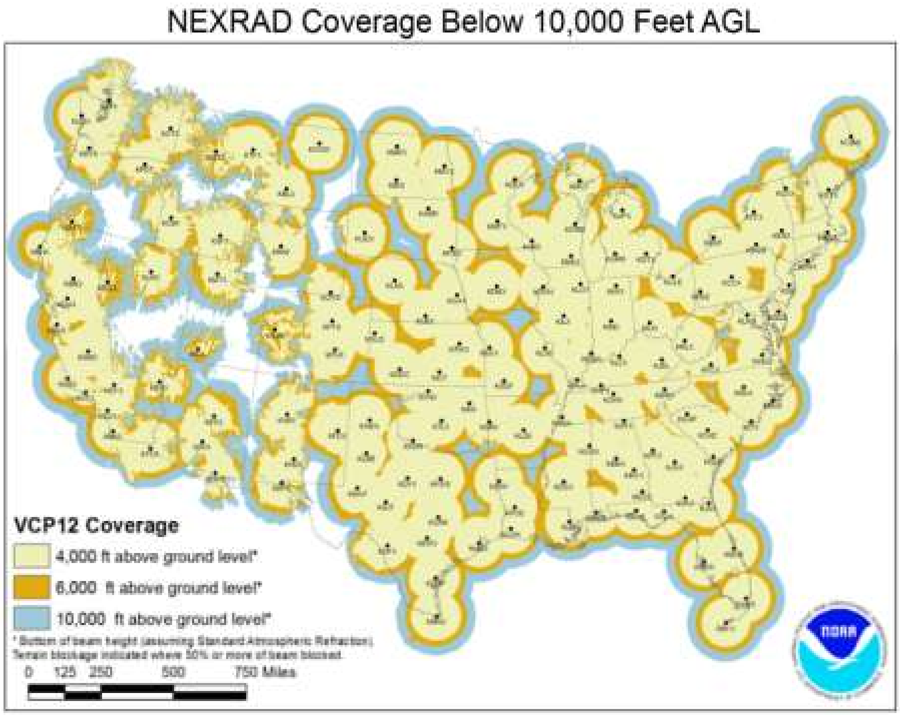


Figure G.3: U.S. radar locations and their radial extents of coverage below 10,000 feet above ground level (AGL). Each U.S. radar covers an approximate 285 mile radial extent over which the radar can detect precipitation.

The WDT and National Severe Storms Lab (NSSL) Radar Data Quality Control Algorithm (RDQC) removes non-precipitation artifacts from base Level–II radar data and remaps the data from polar coordinates to a Cartesian (latitude/longitude) grid. Non-precipitation artifacts include ground clutter, bright banding, sea clutter, anomalous propagation, sun strobes, clear air returns, chaff, biological targets, and electronic interference and hardware test patterns. The RDQC algorithm uses sophisticated data processing and a Quality Control Neural Network (QCNN) to delineate the precipitation echoes caused by radar artifacts (Lakshmanan and Valente 2004). Beam blockages due to terrain are mitigated by using 30 meter DEM data to compute and then discard data from a radar beam that clears the ground by less than 50 meters and incurs more than 50% power blockage. A clear-air echo removal scheme is applied to radars in clear-air mode when there is no precipitation reported from observation gauges within the vicinity of the radar. In areas of radar coverage overlap, a distance weighting scheme is applied to assign reflectivity to each grid cell, for multiple vertical levels. This scheme is applied to data from the nearest radar that is unblocked by terrain.

Once data from individual radars have passed through the RDQC, they are merged to create a seamless mosaic for the United States and southern Canada as shown in Figure G.4. A multi-sensor quality control can be applied by post-processing the mosaic to remove any remaining "false echoes." This technique uses observations of infra-red cloud top temperatures by GOES satellite and surface temperature to create a precipitation/no-precipitation mask. Figure G.4(b) shows the impact of WDT's quality control measures. Upon completing all QC, WDT converts the radar data from its native polar coordinate projection (1 degree x 1.0 km) into a longitude-latitude Cartesian grid (based on the WGS84 datum), at a spatial resolution of $\sim 1/3^{rd} mi^2$ for processing in SPAS.

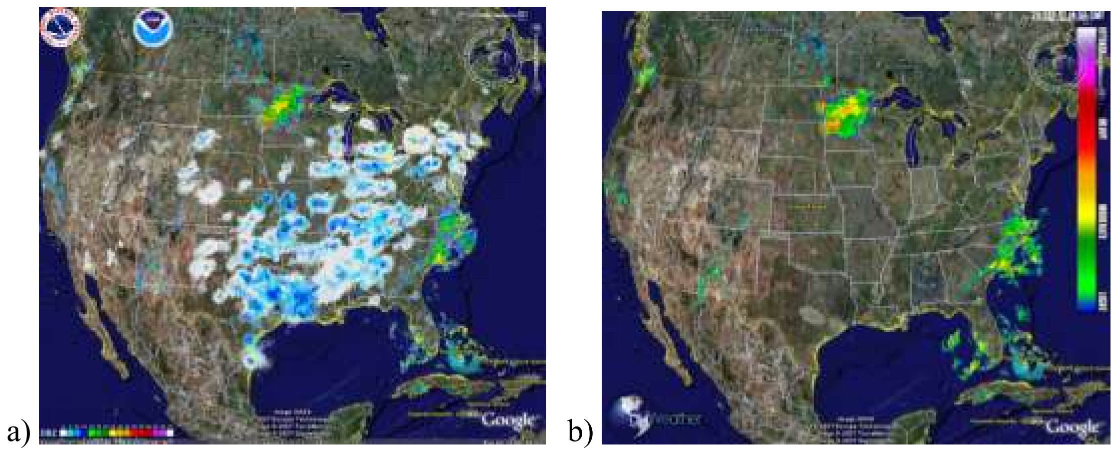


Figure G.4: (a) Level-II radar mosaic of CONUS radar with no quality control, (b) WDT quality controlled Level-II radar mosaic

SPAS conducts further QC on the radar mosaic by infilling areas contaminated by beam blockages. Beam blocked areas are objectively determined by evaluating total storm reflectivity grid which naturally amplifies areas of the SPAS analysis domain suffering from beam blockage as shown in Figure G.5.

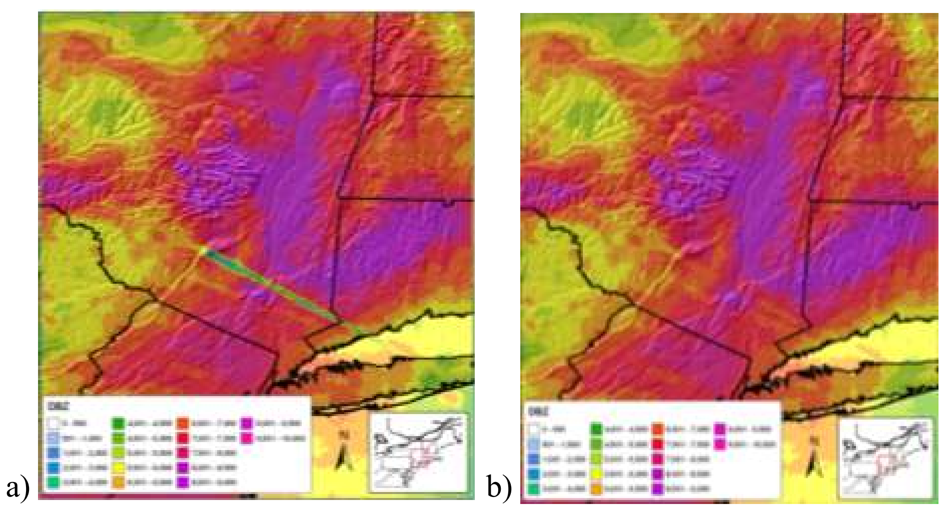


Figure G.5: Illustration of SPAS-beam blockage infilling where (a) is raw, blocked radar and (b) is filled for a 42-hour storm event

Methodology

Daily and Supplemental Precipitation to Hourly

To obtain one hour temporal resolutions and utilize all gauge data, it is necessary to disaggregate daily and supplemental precipitation observations into estimated hourly amounts. This process has traditionally been accomplished by distributing (temporally) the precipitation at each daily/supplemental gauge in accordance to a single nearby hourly gauge (Thiessen polygon approach). However, this may introduce biases and not correctly represent hourly precipitation at daily/supplemental gauges situated in-between hourly gauges. Instead, SPAS uses a spatial approach by which the estimated hourly precipitation at each daily and supplemental gauge is governed by a distance weighted algorithm of all nearby true hourly gauges.

To disaggregate (i.e. distribute) daily/supplemental gauge data into estimate hourly values, the true hourly gauge data are first evaluated and quality controlled using synoptic maps, nearby gauges, orographic effects, gauge history and other documentation on the storm. Any problems with the hourly data are resolved, and when possible/necessary accumulated hourly values are distributed. If an hourly value is missing, the analyst can choose to either estimate it or leave it missing for SPAS to estimate later based on nearby hourly gauges. At this point in the process, pseudo (hourly) gauges can be added to represent precipitation timing in topographically complex locations, areas with limited/no hourly data or to capture localized convention. Hourly Pseudo stations add additional detail on the timing of rainfall, either from COOP forms, radar reflectivity timing, and/or bucket survey reports with time increments. Hourly Pseudo stations are used only for the timing surrounding daily and supplemental stations and not for the magnitude. The limitations of Hourly Pseudo stations is that they are based on surrogate information, the quality of the information can be highly questionable (based on source) thus the importance of the station QC procedures are extremely important. To adequately capture the temporal variations of the precipitation, a pseudo hourly gauge is sometimes necessary. A pseudo gauge is created by distributing the precipitation at a co-located daily gauge or by creating a completely new pseudo gauge from other information such as inferences from COOP observation forms, METAR visibility data (if hourly precipitation are not already available), lightning data, satellite data, or radar data. Often radar data are the best/only choice for creating pseudo hourly gauges, but this is done cautiously given the potential differences (over-shooting of the radar beam equating to erroneous precipitation) between radar data and precipitation. In any case, the pseudo hourly gauge is flagged so SPAS only uses it for timing and not magnitude. Care is taken to ensure hourly pseudo gauges represent justifiably important physical and meteorological characteristics before being incorporated into the SPAS database. Although pseudo gauges provide a very important role, their use is kept to a minimum. The importance of insuring the reliability of every hourly gauge cannot be over emphasized. All of the final hourly gauge data, including pseudos, are included in the hourly SPAS precipitation database.

Using the hourly SPAS precipitation database, each hourly precipitation value is converted into a percentage that represents the incremental hourly precipitation divided by the total SPP precipitation. The GIS-ready x-y-z file is constructed for each hour and it includes the latitude (x), longitude(y) and the percent of precipitation (z) for a particular hour. Using the GRASS GIS, an inverse-distance-weighting squared (IDW) interpolation technique is applied to each of the hourly files. The result is a continuous grid with percentage values for the entire analysis domain, keeping the grid cells on which the hourly gauge resides faithful to the observed/actual percentage. Since the percentages typically have a high degree of spatial autocorrelation, the spatial interpolation has skill in determining the percentages between gauges, especially since the percentages are somewhat independent of the precipitation magnitude. The end result is a GIS grid for each hour that represents the percentage of the SPP precipitation that fell during that hour.

After the hourly percentage grids are generated and QC'd for the entire SPP, a program is executed that converts the daily/supplemental gauge data into incremental hourly data. The timing at each of the daily/supplemental gauges is based on (1) the daily/supplemental gauge observation time, (2) daily/supplemental precipitation amount and (3) the series of interpolated hourly percentages extracted from grids (described above).

This procedure is detailed in Figure G.6 below. In this example, a supplemental gauge reported 1.40" of precipitation during the storm event and is located equal distance from the three surrounding hourly recording gauges. The procedure steps are:

Step 1. For each hour, extract the percent of SPP from the hourly gauge-based percentage at the location of the daily/supplemental gauge. In this example, assume these values are the average of all the hourly gauges.

Step 2. Multiply the individual hourly percentages by the total storm precipitation at the daily/supplemental gauge to arrive at estimated hourly precipitation at the daily/supplemental gauge. To make the daily/supplemental accumulated precipitation data faithful to the daily/supplemental observations, it is sometimes necessary to adjust the hourly percentages so they add up to 100% and account for 100% of the daily observed precipitation.

	Hour						
Precipitation	**1**	**2**	**3**	**4**	**5**	**6**	**Total**
Hourly station 1	0.02	0.12	0.42	0.50	0.10	0.00	1.16
Hourly station 2	0.01	0.15	0.48	0.62	0.05	0.01	1.32
Hourly station 3	0.00	0.18	0.38	0.55	0.20	0.05	1.36
	Hour						
Percent of total storm precip.	**1**	**2**	**3**	**4**	**5**	**6**	**Total**
Hourly station 1	2%	10%	36%	43%	9%	0%	100%
Hourly station 2	1%	11%	36%	47%	4%	1%	100%
Hourly station 3	0%	13%	28%	40%	15%	4%	100%
Average	*1%*	*12%*	*34%*	*44%*	*9%*	*1%*	*100%*
Storm total precipitation at daily gauge				1.40			
	Hour						
Precipitation (estimated)	**1**	**2**	**3**	**4**	**5**	**6**	**Total**
Daily station	0.01	0.16	0.47	0.61	0.13	0.02	1.40

Figure G.6: Example of disaggregation of daily precipitation into estimated hourly precipitation based on three (3) surrounding hourly recording gauges

In cases where the hourly grids do not indicate any precipitation falling during the daily/supplemental gauge observational period, yet the daily/supplemental gauge reported precipitation, the daily/supplemental total precipitation is evenly distributed throughout the hours that make up the observational period; although this does not happen very often, this solution is consistent with NWS procedures. However, the SPAS analyst is notified of these cases in a comprehensive log file, and in most cases they are resolvable, sometimes with a pseudo hourly gauge.

Gauge Quality Control

Exhaustive quality control measures are taken throughout the SPAS analysis. Below are a few of the most significant QC measures taken.

Mass Curve Check

A mass curve-based QC-methodology is used to ensure the timing of precipitation at all gauges is consistent with nearby gauges. SPAS groups each gauge with the nearest four gauges (regardless of type) into a single file. These files are subsequently used in software for graphing and evaluation. Unusual characteristics in the mass curve are investigated and the gauge data corrected, if possible and warranted. See Figure G.7 for an example.

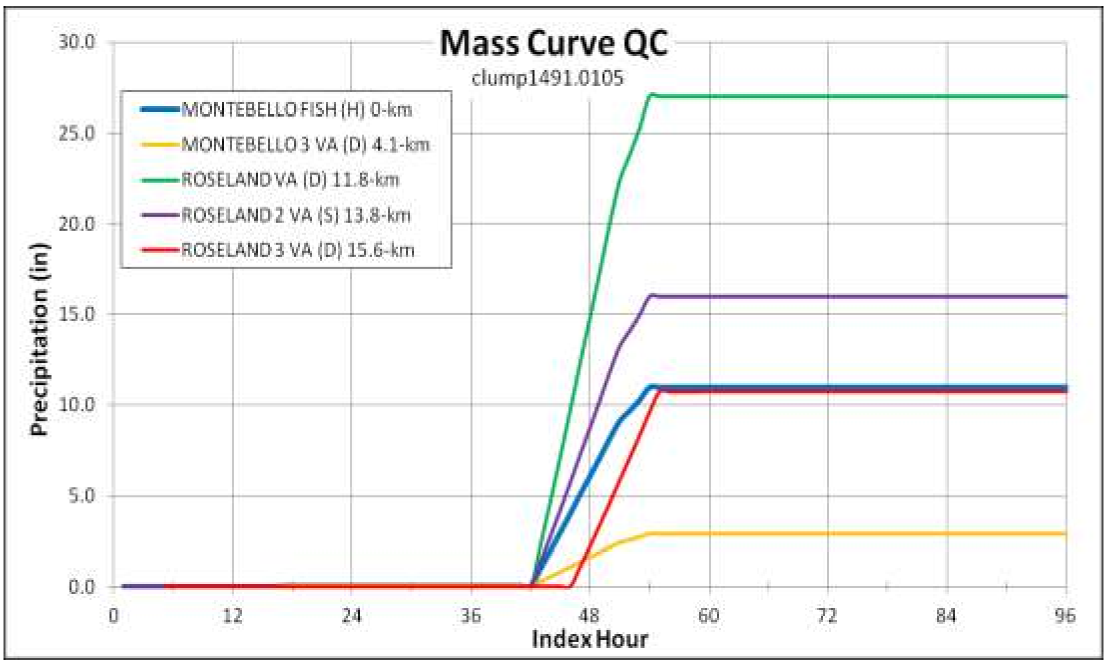


Figure G.7: Sample mass curve plot depicting a precipitation gauge with an erroneous observation time (red line). X-axis is the SPAS index hour and the y-axis is inches. The statistics in the upper left denote gauge type, and distance from target gauge (in km). In this example, the daily gauge (red line) was found to have an observation error/shift of 6-hours.

Gauge Mis-location Check

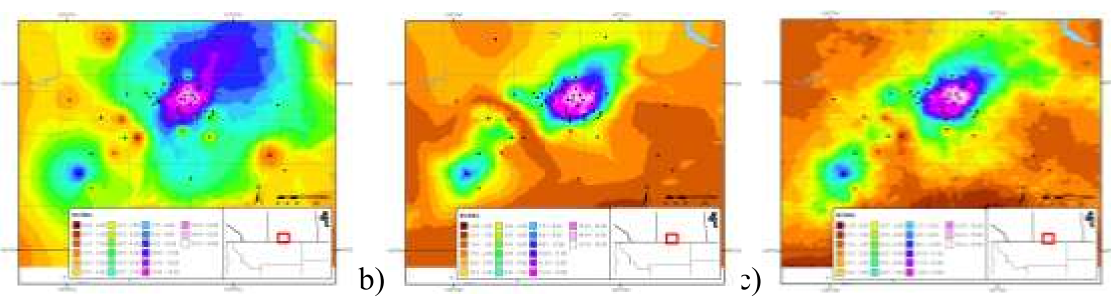
Although the gauge elevation is not explicitly used in SPAS, it is however used as a means of QC'ing gauge location. Gauge elevations are compared to a high-resolution 15-second DEM to identify gauges with large differences, which may indicate erroneous longitude and/or latitude values.

Co-located Gauge QC

Care is also taken to establish the most accurate precipitation depths at all co-located gauges. In general, where a co-located gauge pair exists, the highest precipitation is accepted (if deemed accurate). If the hourly gauge reports higher precipitation, then the co-located daily (or supplemental) is removed from the analysis since it would not add anything to the analysis. Often daily (or supplemental) gauges report greater precipitation than a co-located hourly station since hourly tipping bucket gauges tend to suffer from gauge under-catch, particularly during extreme events, due to loss of precipitation during tips. In these cases the daily/supplemental is retained for the magnitude and the hourly used as a pseudo hourly gauge for timing. Large discrepancies between any co-located gauges are investigated and resolved since SPAS can only utilize a single gauge magnitude at each co-located site.

Spatial Interpolation

At this point the QC'd observed hourly and disaggregated daily/supplemental hourly precipitation data are spatially interpolated into hourly precipitation grids. SPAS has three options for conducting the hourly precipitation interpolation, depending on the terrain and availability of radar data, thereby allowing SPAS to be optimized for any particular storm type or location. Figure G.8 depicts the results of each spatial interpolation methodology based on the same precipitation gauge data.



a) b) c)

Figure G.8: Depictions of total storm precipitation based on the three SPAS interpolation methodologies for a storm (SPAS #1177, Vanguard, Canada) across flat terrain: (a) no basemap, (b) basemap-aided and (c) radar

Basic Approach

The basic approach interpolates the hourly precipitation point values to a grid using an inverse distance weighting squared GIS algorithm. This is sometimes the best choice for convective storms over flat terrain when radar data are not available, yet high gauge density instills reliable precipitation patterns. This approach is rarely used.

Basemap Approach

Another option includes use of a basemap, also known as a climatologically-aided interpolation (Hunter 2005). As noted before, the spatial patterns of the basemap govern the interpolation between points of hourly precipitation estimates, while the actual hourly precipitation values govern the magnitude. This approach to interpolating point data across complex terrain is widely used. In fact, it was used extensively by the NWS during their storm analysis era from the 1940s through the 1970s (USACE 1973, Hansen et al., 1988, Corrigan et al., 1999).

In application, the hourly precipitation gauge values are first normalized by the corresponding grid cell value of the basemap before being interpolated. The normalization allows information and knowledge from the basemap to be transferred to the spatial distribution of the hourly precipitation. Using an IDW squared algorithm, the normalized hourly precipitation values are interpolated to a grid. The resulting grid is then multiplied by the basemap grid to produce the hourly precipitation grid. This is repeated each hour of the storm.

Radar Approach

The coupling of SPAS with NEXRAD provides the most accurate method of spatially and temporally distributing precipitation. To increase the accuracy of the results however, quality-controlled precipitation observations are used for calibrating the radar reflectivity to rain rate relationship (Z-R relationship) each hour instead of assuming a default Z-R relationship. Also, spatial variability in the Z-R relationship is accounted for through local bias corrections (described later). The radar approach involves several steps, each briefly described below. The radar approach cannot operate alone – either the basic or basemap approach must be completed before radar data can be incorporated. The SPAS general code is where the daily and supplemental station are timed to hourly data. Therefore, to get the correct timing of daily and supplemental stations, SPAS general needs to be run. The timed hourly data are used as input into SPAS-NEXRAD to derive the dynamic ZR relationship each hour.

Basemaps are only used to aid in the spatial interpolation. In regards to SPAS-NEXRAD, a basemap is used to interpolate the radar residuals (bias adjustments).

Z-R Relationship

SPAS derives high quality precipitation estimates by relating quality controlled level–II NEXRAD radar reflectivity radar data with quality-controlled precipitation gauge data to calibrate the Z-R (radar reflectivity, Z, and precipitation, R) relationship. Optimizing the Z-R relationship is essential for capturing temporal changes in the Z-R. Most current radar-derived precipitation techniques rely on a constant relationship between radar reflectivity and precipitation rate for a given storm type (e.g. tropical, convective), vertical structure of reflectivity and/or reflectivity magnitudes. This non-linear relationship is described by the Z-R equation below:

$$Z = A\ R^{b} \qquad (1)$$

Where Z is the radar reflectivity (measured in units of dBZ), R is the precipitation (precipitation) rate (millimeters per hour), A is the “multiplicative coefficient” and b is the “power coefficient”. Both A and b are directly related to the rain drop size distribution (DSD) and rain drop number distribution (DND) within a cloud (Martner and Dubovskiy 2005). The variability in the results of Z versus R is a direct result of differing DSD, DND and air mass characteristics (Dickens 2003). The DSD and DND are determined by complex interactions of microphysical processes that fluctuate regionally, seasonally, daily, hourly, and even within the same cloud. For these reasons, SPAS calculates an optimized Z-R relationship across the analysis domain each hour, based on observed precipitation rates and radar reflectivity (see Figure G.9).

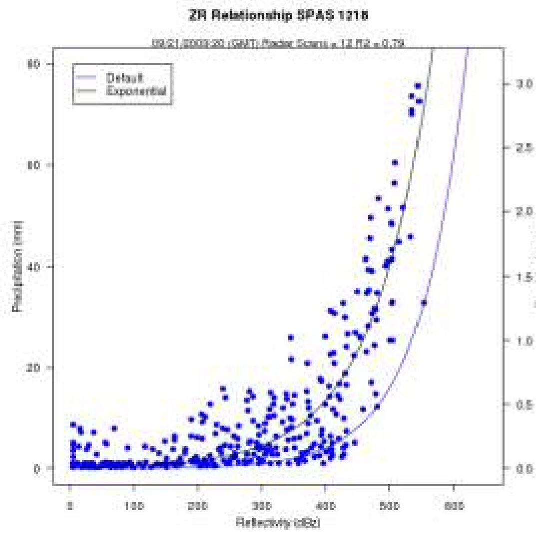


Figure G.9: Example SPAS (denoted as "Exponential") vs. default Z-R relationship (SPAS #1218, Georgia September 2009)

The National Weather Service (NWS) utilizes different default Z-R algorithms, depending on the type of precipitation event, to estimate precipitation from NEXRAD radar reflectivity data across the United States (see Figure G.10) (Baeck and Smith 1998 and Hunter 1999). A default Z-R relationship of Z = 300R1.4 is the primary algorithm used throughout the continental U.S. However, it is widely known that this, compared to unadjusted radar-aided estimates of precipitation, suffers from deficiencies that may lead to significant over or under-estimation of precipitation.

RELATIONSHIP	Optimum for:	Also recommended for:
Marshall-Palmer ($z=200R^{1.6}$)	General stratiform precipitation	
East-Cool Stratiform ($z=130R^{2.0}$)	Winter stratiform precipitation - east of continental divide	Orographic rain - East
West-Cool Stratiform ($z=75R^{2.0}$)	Winter stratiform precipitation - west of continental divide	Orographic rain - West
WSR-88D Convective ($z=300R^{1.4}$)	Summer deep convection	Other non-tropical convection
Rosenfeld Tropical ($z=250R^{1.2}$)	Tropical convective systems	

Figure G.10: Commonly used Z-R algorithms used by the NWS

Instead of adopting a standard Z-R, SPAS utilizes a least squares fit procedure for optimizing the Z-R relationship each hour of the SPP. The process begins by determining if sufficient (minimum 12) observed hourly precipitation and radar data pairs are available to compute a reliable Z-R. If insufficient (<12) gauge pairs are available, then SPAS adopts the previous hour Z-R relationship, if available, or applies a user-defined default Z-R algorithm. If sufficient data are available, the one hour sum of NEXRAD reflectivity (Z) is related to the 1-hour precipitation at each gauge. A least-squares-fit exponential function using the data points is computed. The resulting best-fit, one hour-based Z-R is subjected to several tests to determine if the Z-R relationship and its resulting precipitation rates are within a certain tolerance based on the R-squared fit measure and difference between the derived and default Z-R precipitation results. Experience has shown the actual Z-R versus the default Z-R can be significantly different (Figure G.11). These Z-R relationships vary by storm type and location. A standard output of all SPAS analyses utilizing NEXRAD includes a file with each hour's adjusted Z-R relationship as calculated through the SPAS program.

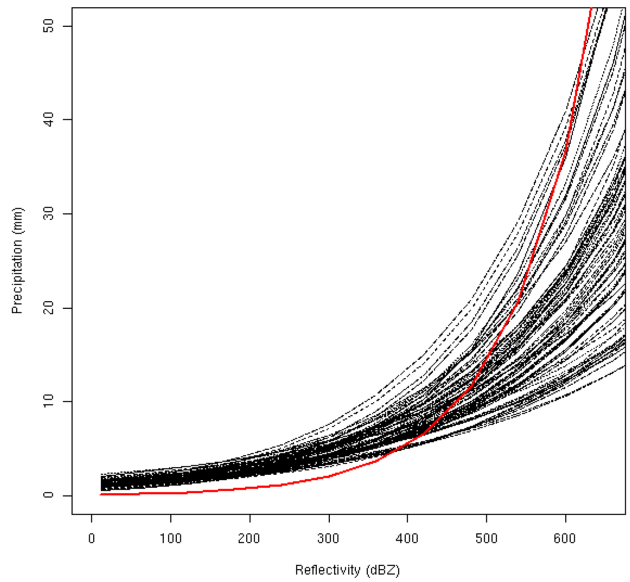


Figure G.11: Comparison of the SPAS optimized hourly Z-R relationships (black lines) versus a default Z=75R2.0 Z-R relationship (red line) for a period of 99 hours for a storm over southern California.

Radar-aided Hourly Precipitation Grids

Once a mathematically optimized hourly Z-R relationship is determined, it is applied to the total hourly Z grid to compute an initial precipitation rate (inches/hour) at each grid cell. To account for spatial differences in the Z-R relationship, SPAS computes residuals, the difference between the initial precipitation analysis (via the Z-R equation) and the actual "ground truth" precipitation (observed – initial analysis), at each gauge. The point residuals, also referred to as local biases, are normalized and interpolated to a residual grid using an inverse distance squared weighting algorithm. A radar-based hourly precipitation grid is created by adding the residual grid to the initial grid; this allows precipitation at the grid cells for which gauges are "on" to be true and faithful to the gauge measurement. The pre-final radar-aided precipitation grid is subject to some final, visual QC checks to ensure the precipitation patterns are consistent with the terrain; these checks are particularly important in areas of complex terrain where even QC'd radar data can be unreliable. The next incremental improvement with SPAS program will come as the NEXRAD radar sites are upgraded to dual-polarimetric capability.

Radar- and Basemap-Aided Hourly Precipitation Grids

At this stage of the radar approach, a radar- and basemap-aided hourly precipitation grid exists for each hour. At locations with precipitation gauges, the grids are equal, however elsewhere the grids can vary for a number of reasons. For instance, the basemap-aided hourly precipitation grid may depict heavy precipitation in an area of complex terrain, blocked by the radar, whereas the radar-aided hourly precipitation grid may suggest little, if any, precipitation fell in the same area. Similarly, the radar-aided hourly precipitation grid may depict an area of heavy precipitation in flat terrain that the basemap-approach missed since the area of heavy precipitation occurred in an area without gauges. SPAS uses an algorithm to compute the hourly precipitation at each pixel given the two results. Areas that are completely blocked from a radar signal are accounted for with the basemap-aided results (discussed earlier). Precipitation in areas with orographically effective terrain and reliable radar data are governed by a blend of the basemap- and radar-aided precipitation. Elsewhere, the radar-aided precipitation is used exclusively. This blended approach has proven effective for resolving precipitation in complex terrain, yet retaining accurate radar-aided precipitation across areas where radar data are reliable. Figure G.12 illustrates the evolution of final precipitation from radar reflectivity in an area of complex terrain in southern California.

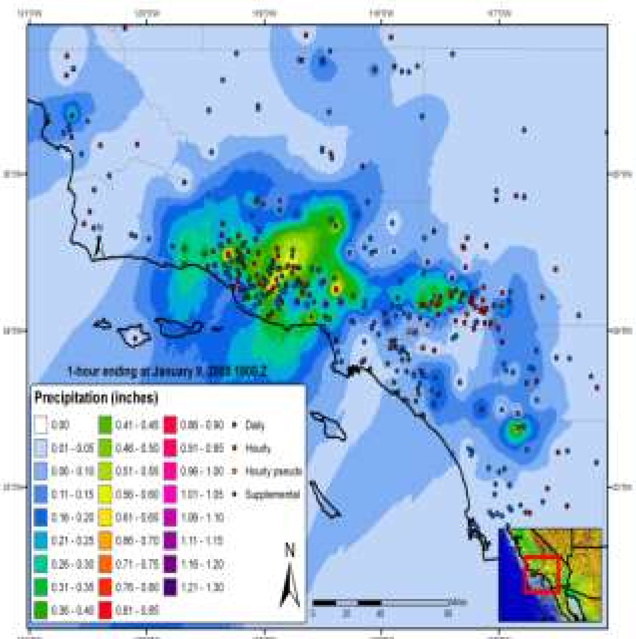


Figure G.12a: Map depicting 1-hour of precipitation utilizing inverse distance weighting of gauge precipitation for a January 2005 storm in southern California, USA

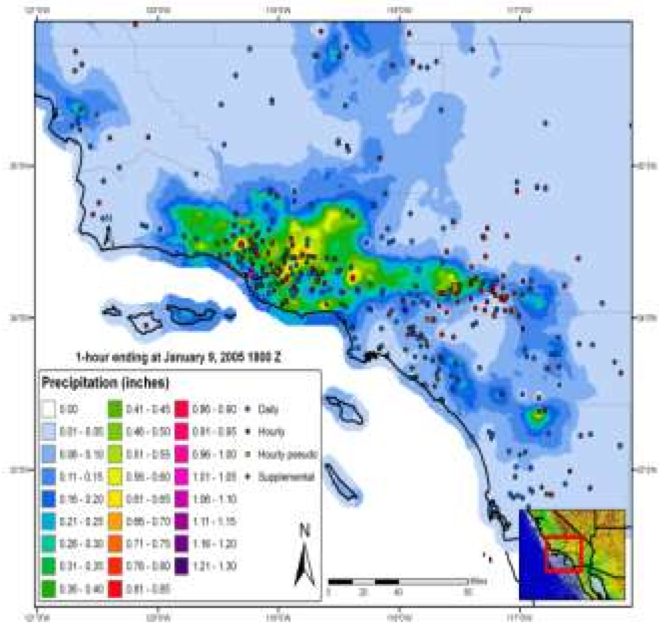


Figure G.12b: Map depicting 1-hour of precipitation utilizing gauge data together with a climatologically-aided interpolation scheme for a January 2005 storm in southern California, USA

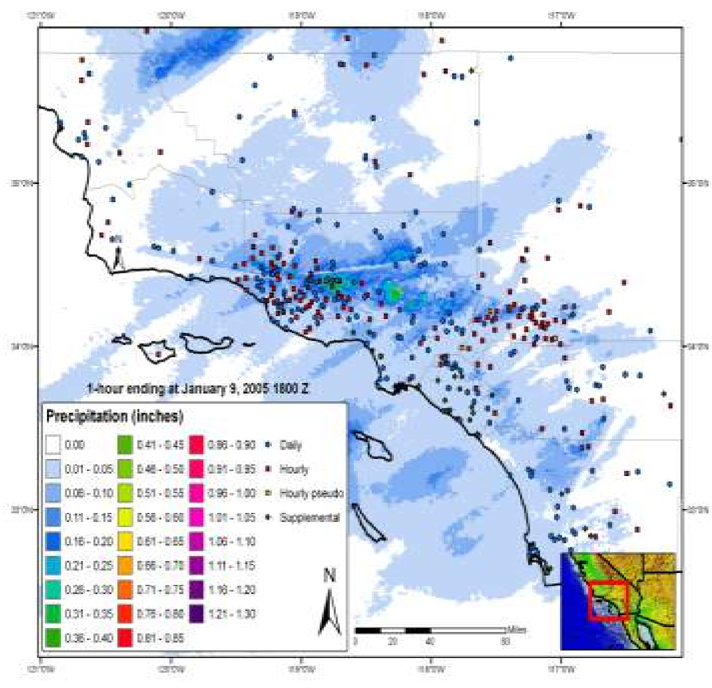


Figure G.12c: Map depicting 1-hour of precipitation utilizing default Z-R radar-estimated interpolation (no gauge correction) for a January 2005 storm in southern California, USA

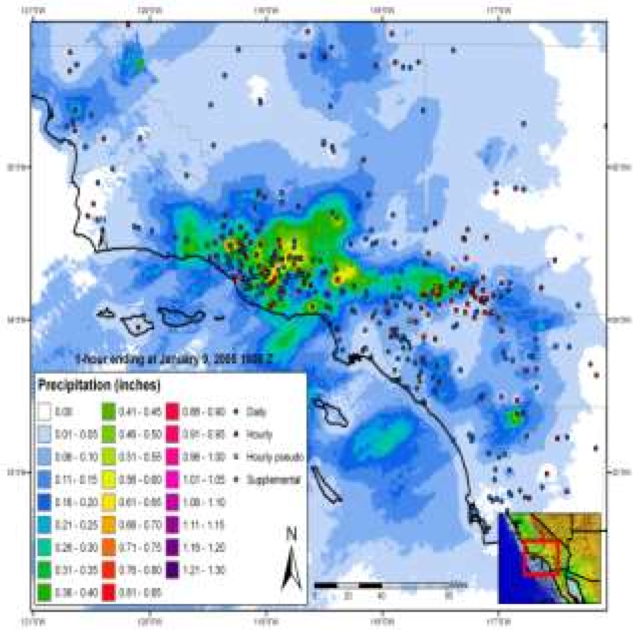


Figure G.12d: Map depicting 1-hour of precipitation utilizing SPAS precipitation for a January 2005 storm in southern California, USA

SPAS versus Gauge Precipitation

Performance measures are computed and evaluated each hour to detect errors and inconsistencies in the analysis. The measures include: hourly Z-R coefficients, observed hourly maximum precipitation, maximum gridded precipitation, hourly bias, hourly mean absolute error (MAE), root mean square error (RMSE), and hourly coefficient of determination (r^2).

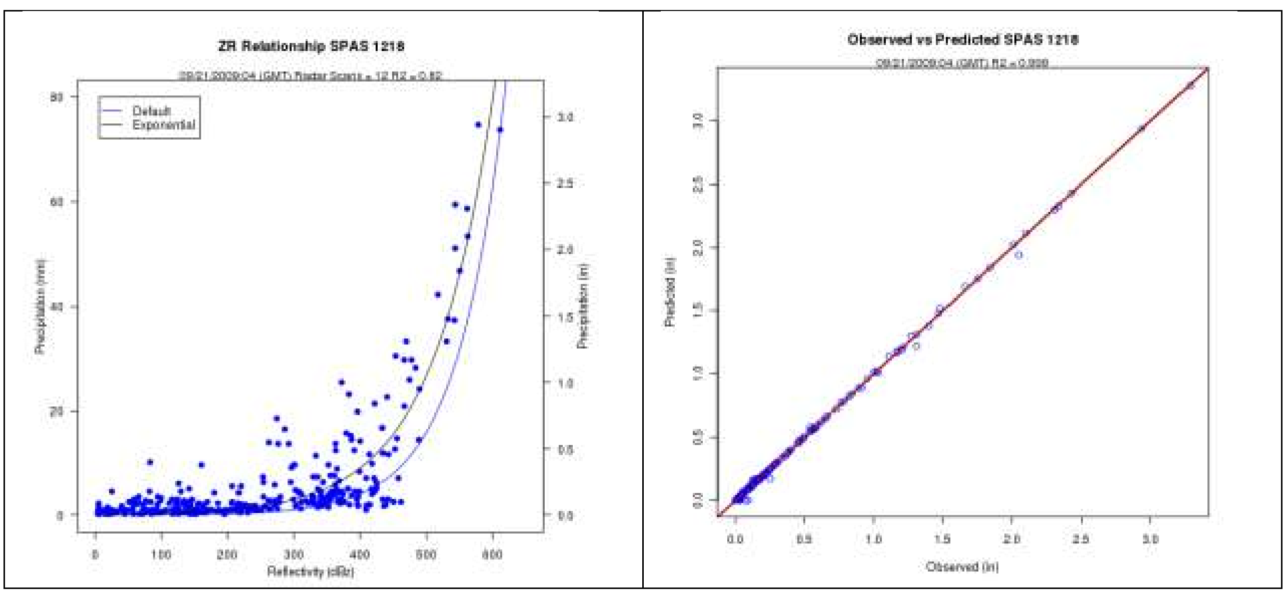


Figure G.13: Z-R plot (a), where the blue line is the SPAS derived Z-R and the black line is the default Z-R, and the (b) associated observed versus SPAS scatter plot at gauge locations.

Comparing SPAS-calculated precipitation (R_{spas}) to observed point precipitation depths at the gauge locations provides an objective measure of the consistency, accuracy and bias. Generally speaking SPAS is usually within 5% of the observed precipitation (see Figure G.13). Less-than-perfect correlations between SPAS precipitation depths and observed precipitation at gauged locations could be the result of any number of issues, including:

- **Point versus area:** A rain gauge observation represents a much smaller area than the area sampled by the radar. The area that the radar is sampling is approximately 1 km^2, whereas a standard rain gauge has an opening 8 inches in diameter, hence it only samples approximately $8.0x10^{-9}$ km^2. Furthermore, the radar data represent an average reflectivity (Z) over the grid cell, when in fact the reflectivity can vary across the 1 km^2 grid cell. Therefore, comparing a grid cell radar derived precipitation value to a gauge (point) precipitation depth measured may vary.
- **Precipitation gauge under-catch:** Although we consider gauge data "ground truth," we recognize gauges themselves suffer from inaccuracies. Precipitation gauges, shielded and unshielded, inherently underestimate total precipitation due to local airflow, wind under-catch, wetting, and evaporation. The wind under-catch errors are usually around 5% but can be as large as 40% in high winds (Guo et al., 2001, Duchon and Essenberg 2001, Ciach 2003, Tokay et al., 2010). Tipping buckets miss a small amount of precipitation during each tip of the bucket due to the bucket travel and tip time. As precipitation intensities increase, the volumetric loss of precipitation due to tipping tends to increase. Smaller tipping buckets can have higher volumetric losses due to higher tip frequencies, but on the other hand capture higher precision timing.
- **Radar Calibration:** NEXRAD radars calibrate reflectivity every volume scan, using an internally generated test. The test determines changes in internal variables such as beam power and path loss of the receiver signal processor since the last off-line calibration. If this value becomes large, it is likely that there is a radar calibration error that will translate into less reliable precipitation estimates. The calibration test is supposed to maintain a reflectivity precision of 1 dBZ. A 1 dBZ error can result in an error of up to 17% in R_{spas} using the default Z-R relationship $Z=300R^{1.4}$. Higher calibration errors will result in higher R_{spas} errors. However, by performing correlations each hour, the calibration issue is minimized in SPAS.
- **Attenuation:** Attenuation is the reduction in power of the radar beams' energy as it travels from the antenna to the target and back. It is caused by the absorption and the scattering of power from the beam by precipitation. Attenuation can result in errors in Z as large as 1 dBZ especially when the radar beam is sampling a large area of heavy precipitation. In some cases, storm precipitation is so intense (>12 inches/hour) that individual storm cells become "opaque" and the radar beam is totally attenuated. Armed with sufficient gauge data however, SPAS will overcome attenuation issues.
- **Range effects:** The curvature of Earth and radar beam refraction result in the radar beam becoming more elevated above the surface with increasing range. With the increased elevation of the radar beam comes a decrease in Z values due to the radar beam not sampling the main precipitation portion of the cloud (i.e. "over topping" the precipitation and/or cloud altogether). Additionally, as the radar beam gets further from the radar, it naturally samples a larger and larger area, therefore amplifying point versus area differences (described above).
- **Radar Beam Occultation/Ground Clutter:** Radar occultation (beam blockage) results when the radar beam's energy intersects terrain features as depicted in Figure G.14. The result is an increase in radar reflectivity values that can result in higher than normal precipitation estimates. The WDT processing algorithms account for these issues, but SPAS uses GIS spatial interpolation functions to infill areas suffering from poor or no radar coverage.
- **Anomalous Propagation (AP):** AP is false reflectivity echoes produced by unusual rates of refraction in the atmosphere. WDT algorithms remove most of the AP and false echoes,

however in extreme cases the air near the ground may be so cold and dense that a radar beam that starts out moving upward is bent all the way down to the ground. This produces erroneously strong echoes at large distances from the radar. Again, equipped with sufficient gauge data, the SPAS bias corrections will overcome AP issues.

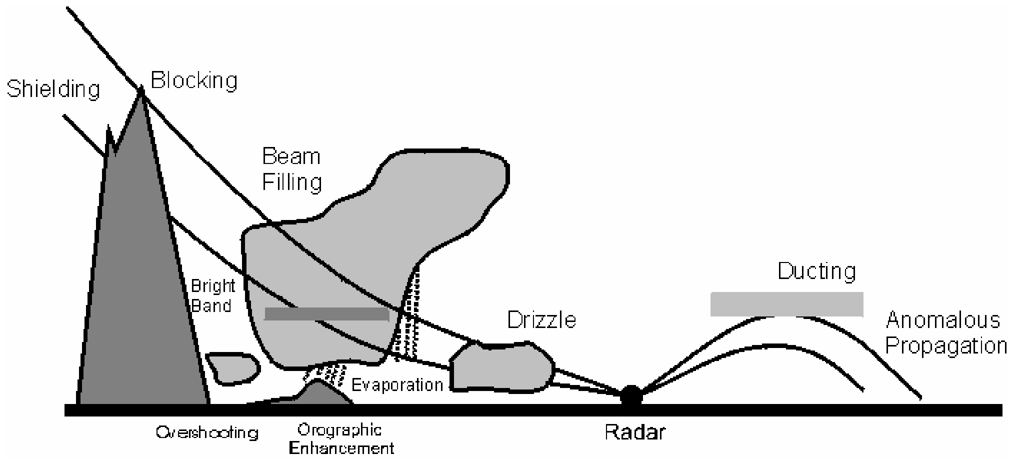


Figure G.14: Depiction of radar artifacts. (Source: Wikipedia)

SPAS is designed to overcome many of these short-comings by carefully using radar data for defining the spatial patterns and relative magnitudes of precipitation, but allowing measured precipitation values ("ground truth") at gauges to govern the magnitude. When absolutely necessary, the observed precipitation values at gauges are nudged up (or down) to force SPAS results to be consistent with observed gauge values. Nudging gauge precipitation values helps to promote better consistency between the gauge value and the grid-cell value, even though these two values sometimes should not be the same since they are sampling different area sizes. For reasons discussed in the "SPAS versus Gauge Precipitation" section, the gauge value and grid-cell value can vary. Plus, SPAS is designed to toss observed individual hourly values that are grossly inconsistent with radar data, hence driving a difference between the gauge and grid-cell. In general, when the gauge and grid-cell value differ by more than 15% and/or 0.50 inches, and the gauge data have been validated, then it is justified to artificially increase or decrease slightly the observed gauge value to "force" SPAS to derive a grid-cell value equal to the observed value. Sometimes simply shifting the gauge location to an adjacent grid-cell resolves the problems. Regardless, a large gauge versus grid-cell difference is a "red flag" and sometimes the result of an erroneous gauge value or a mis-located gauge, but in some cases the difference can only be resolved by altering the precipitation value.

Before results are finalized, a precipitation intensity check is conducted to ensure the spatial patterns and magnitudes of the maximum storm intensities at 1-, 6-, 12-, etc. hours are consistent with surrounding gauges and published reports. Any erroneous data are corrected and SPAS re-run. Considering all of the QA/QC checks in SPAS, it typically requires 5-15 basemap SPAS runs and, if radar data are available, another 5-15 radar-aided runs, to arrive at the final output.

Test Cases

To check the accuracy of the DAD software, three test cases were evaluated.

"Pyramidville" Storm

The first test was that of a theoretical storm with a pyramid shaped isohyetal pattern. This case was called the Pyramidville storm. It contained 361 hourly stations, each occupying a single grid-cell. The configuration of the Pyramidville storm (see Figure G.15) allowed for uncomplicated and accurate calculation of the analytical DA truth independent of the DAD software. The main motivation of this case was to verify that the DAD software was properly computing the area sizes and average depths.

1. Storm center: 39°N 104°W
2. Duration: 10-hours
3. Maximum grid-cell precipitation: 1.00"
4. Grid-cell resolution: 0.06 sq.-miles (361 total cells)
5. Total storm size: 23.11 sq-miles
6. Distribution of precipitation:

    Hour 1: Storm drops 0.10" at center (area 0.06 mi^2)

    Hour 2: Storm drops 0.10" over center grid-cell AND over one cell width around hour 1 center

    Hours 3-10:

    1. Storm drops 0.10" per hour at previously wet area, plus one cell width around previously wet area
    2. Area analyzed at every 0.10"
    3. Analysis resolution: 15-sec (~.25 mi^2)

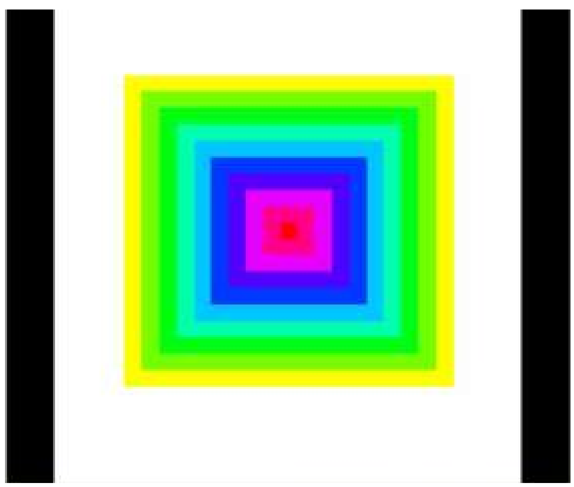


Figure G.15: "Pyramidville" Total precipitation. Center = 1.00", Outside edge = 0.10"

The analytical truth was calculated independent of the DAD software, and then compared to the DAD output. The DAD software results were equal to the truth, thus demonstrating that the DA estimates were properly calculated (Figure G.16).

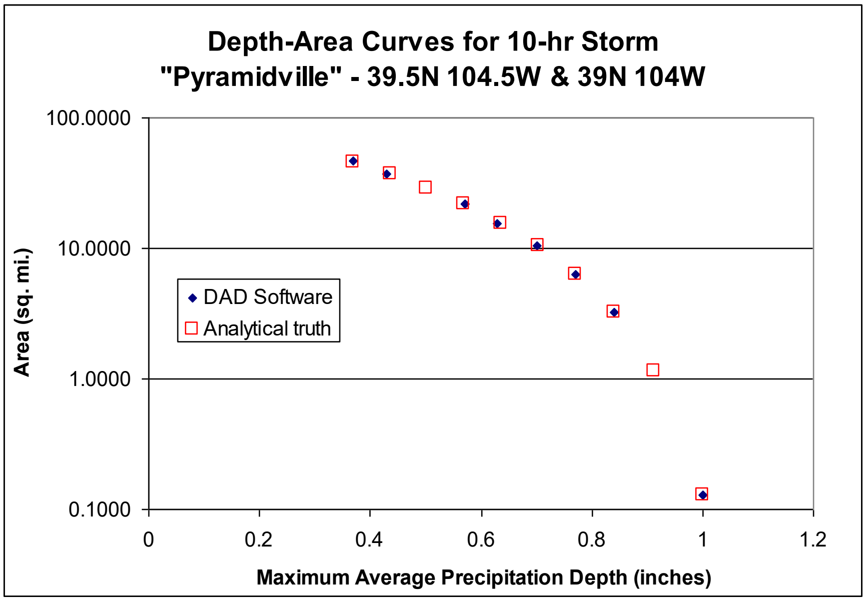


Figure G.16: 10-hour DA results for "Pyramidville"; truth vs. output from DAD software

The Pyramidville storm was then changed such that the mass curve and spatial interpolation methods would be stressed. Test cases included:

- Two-centers, each center with 361 hourly stations
- A single center with 36 hourly stations, 0 daily stations
- A single center with 3 hourly stations and 33 daily stations

As expected, results began shifting from the 'truth,' but minimally and within the expected uncertainty.

Ritter, Iowa Storm, June 7, 1953

Ritter, Iowa was chosen as a test case for a number of reasons. The NWS had completed a storm analysis, with available DAD values for comparison. The storm occurred over relatively flat terrain, so orographics were not an issue. An extensive "bucket survey" provided a great number of additional observations from this event. Of the hundreds of additional reports, about 30 of the most accurate reports were included in the DAD analysis. The DAD software results are very similar to the NWS DAD values (Table G.2).

Table G.2: The percent difference [(AWA-NWS)/NWS] between the AWA DA results and those published by the NWS for the 1953 Ritter, Iowa storm.

% Difference

	Duration (hours)				
Area (sq.mi.)		6	12	24	total
10		-15%	-7%	2%	2%
100		-7%	-6%	1%	1%
200		2%	0%	9%	9%
1000		-6%	-7%	4%	4%
5000		-13%	-8%	2%	2%
10000		-14%	-6%	0%	0%

Westfield, Massachusetts Storm, August 8, 1955
Westfield, Massachusetts was also chosen as a test case for a number of reasons. It is a probable maximum precipitation (PMP) driver for the northeastern United States. Also, the Westfield storm was analyzed by the NWS and the DAD values are available for comparison. Although this case proved to be more challenging than any of the others, the final results are very similar to those published by the NWS (Table G.3).

Table G.3: The percent difference [(AWA-NWS)/NWS] between the AWA DA results and those published by the NWS for the 1955 Westfield, Massachusetts storm

% Difference

	Duration (hours)							
Area (sq. mi.)		6	12	24	36	48	60	total
10		2%	3%	0%	1%	-1%	0%	2%
100		-5%	2%	4%	-2%	-6%	-4%	-3%
200		-6%	1%	1%	-4%	-7%	-5%	-5%
1000		-4%	-2%	1%	-6%	-7%	-6%	-3%
5000		3%	2%	-3%	-3%	-5%	-5%	0%
10000		4%	9%	-5%	-4%	-7%	-5%	1%
20000		7%	12%	-6%	-3%	-4%	-3%	3%

The primary components of SPAS are: storm search, data extraction, quality control (QC), conversion of daily precipitation data into estimated hourly data, hourly and total storm precipitation grids/maps and a complete storm-centered DAD analysis.

Output
Armed with accurate, high-resolution precipitation grids, a variety of customized output can be created (see Figures G.17A-D). Among the most useful outputs are sub-hourly precipitation grids for input into hydrologic models. Sub-hourly (i.e. 5-minute) precipitation grids are created by applying the appropriate optimized hourly Z-R (scaled down to be applicable for instantaneous Z) to each of the individual 5-minute radar scans; 5-minutes is often the native scan rate of the radar in the US. Once the scaled Z-R is applied to each radar scan, the resulting precipitation is summed up. The proportion of each 5-minute precipitation to the total 1-hour radar-aided precipitation is calculated. Each 5-minute proportion (%) is then applied to the quality controlled, bias corrected 1-hour total precipitation (created above) to arrive at the final 5 minute precipitation for each scan. This technique ensures the sum of 5-minute precipitation equals that of the quality controlled, bias corrected 1-hour total precipitation derived initially. Depth-area-duration (DAD) tables/plots, shown in Figure G.17d, are computed using a highly-computational extension to SPAS. DADs provide an objective three dimensional (magnitude, area size, and duration) perspective of a storms' precipitation. SPAS DADs are computed using the procedures outlined by the NWS Technical Paper 1 (1946).

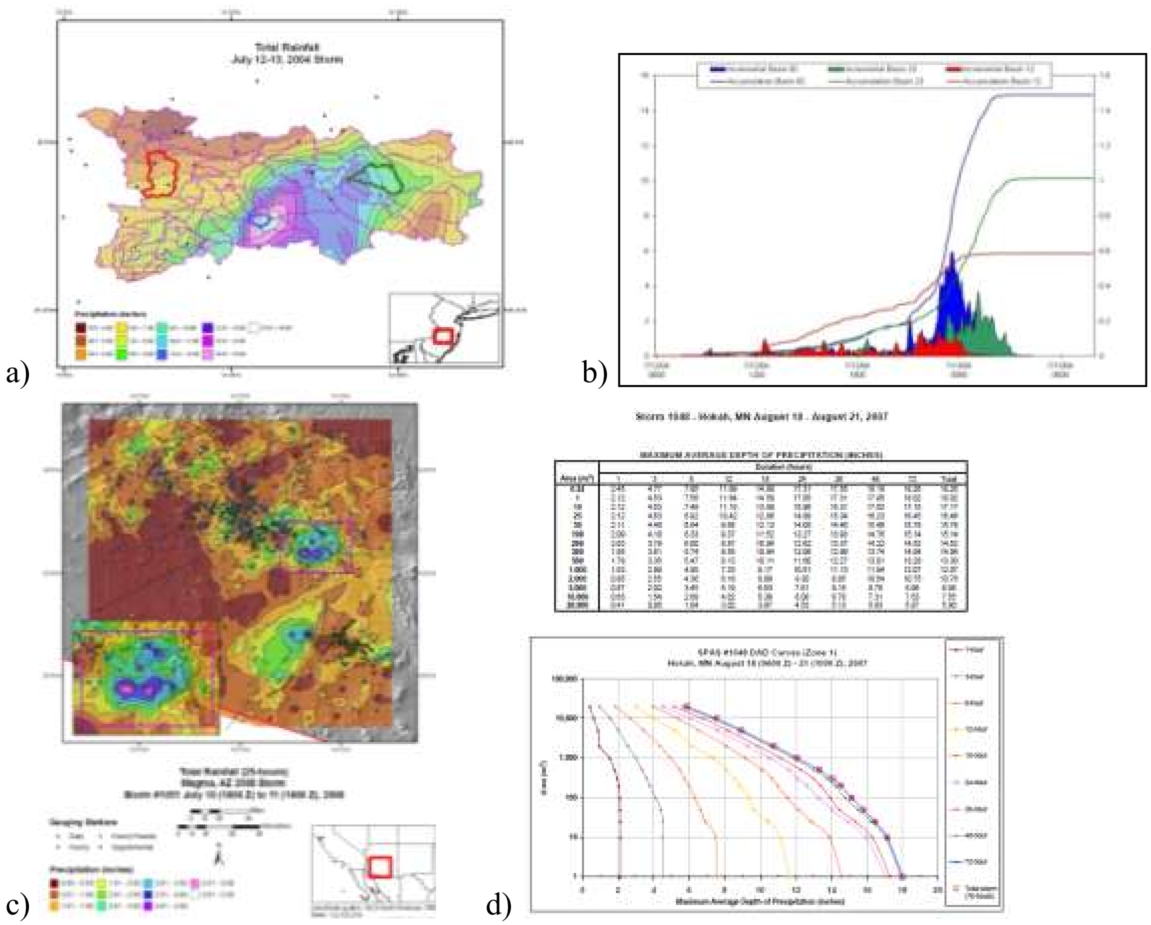


Figure G.17: Various examples of SPAS output, including (a) total storm map and its associated (b) basin average precipitation time series, (c) total storm precipitation map, (d) depth-area-duration (DAD) table and plot

Summary

Grounded on years of scientific research with a demonstrated reliability in post-storm analyses, SPAS is a hydro-meteorological tool that provides accurate precipitation analyses for a variety of applications. SPAS has the ability to compute precise and accurate results by using sophisticated timing algorithms, basemaps, a variety of precipitation data and most importantly NEXRAD weather radar data (if available). The approach taken by SPAS relies on hourly, daily and supplemental precipitation gauge observations to provide quantification of the precipitation amounts while relying on basemaps and NEXRAD data (if available) to provide the spatial distribution of precipitation between precipitation gauge sites. By determining the most appropriate coefficients for the Z-R equation on an hourly basis, the approach anchors the precipitation amounts to accepted precipitation gauge data while using the NEXRAD data to distribute precipitation between precipitation gauges for each hour of the storm. Hourly Z-R coefficient computations address changes in the cloud microphysics and storm characteristics as the storm evolves. Areas suffering from limited or no radar coverage are estimated using the spatial patterns and magnitudes of the independently created basemap precipitation grids. Although largely automated, SPAS is flexible enough to allow hydro-meteorologists to make important adjustments and adapt to any storm situation.

References

Baeck M.L., Smith J.A., 1998: "Precipitation Estimation by the WSR-88D for Heavy Precipitation Events", *Weather and Forecasting*: Vol. 13, No. 2, pp. 416–436.

Ciach, G.J., 2003: Local Random Errors in Tipping-Bucket Rain Gauge Measurements. *J. Atmos. Oceanic Technol.*, **20**, 752–759.

Corps of Engineers, U.S. Army, 1945-1973: Storm Rainfall in the United States, Depth-Area-Duration Data. Office of Chief of Engineers, Washington, D.C.

Corrigan, P., Fenn, D.D., Kluck, D.R., and J.L. Vogel, 1999: Probable Maximum Precipitation Estimates for California. *Hydrometeorological Report No. 59*, U.S. National Weather Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, Silver Spring, MD, 392 pp.

Dickens, J., 2003: "On the Retrieval of Drop Size Distribution by Vertically Pointing Radar", American Meteorological Society 32nd Radar Meteorology Conference, Albuquerque, NM, October 2005.

Duchon, C.E., and G.R. Essenberg, 2001: Comparative Precipitation Observations from Pit and Above Ground Rain Gauges with and without Wind Shields, *Water Resources Research,* Vol. 37, N. 12, 3253-3263.

Faulkner, E., T. Hampton, R.M. Rudolph, and Tomlinson, E.M., 2004: Technological Updates for PMP and PMF – Can They Provide Value for Dam Safety Improvements? Association of State Dam Safety Officials Annual Conference, Phoenix, Arizona, September 26-30, 2004.

Guo, J. C. Y., Urbonas, B., and Stewart, K., 2001: Rain Catch under Wind and Vegetal Effects. ASCE, *Journal of Hydrologic Engineering*, Vol. 6, No. 1.

Hansen, E.M., Fenn, D.D., Schreiner, L.C., Stodt, R.W., and J.F., Miller, 1988: Probable Maximum Precipitation Estimates, United States between the Continental Divide and the 103rd Meridian, *Hydrometeorological Report Number 55A*, National weather Service, National Oceanic and Atmospheric Association, U.S. Dept of Commerce, Silver Spring, MD, 242 pp.

Hunter, R.D. and R.K. Meentemeyer, 2005: Climatologically Aided Mapping of Daily Precipitation and Temperature, *Journal of Applied Meteorology*, October 2005, Vol. 44, pp. 1501-1510.

Hunter, S.M., 1999: Determining WSR-88D Precipitation Algorithm Performance Using The Stage III Precipitation Processing System, Next Generation Weather Radar Program, WSR-88D Operational Support Facility, Norman, OK.

Lakshmanan, V. and M. Valente, 2004: Quality control of radar reflectivity data using satellite data and surface observations, 20th Int'l Conf. on Inter. Inf. Proc. Sys. (IIPS) for Meteor., Ocean., and Hydr., Amer. Meteor. Soc., Seattle, CD-ROM, 12.2.

Martner, B.E, and V. Dubovskiy, 2005: Z-R Relations from Raindrop Disdrometers: Sensitivity To Regression Methods And DSD Data Refinements, 32nd Radar Meteorology Conference, Albuquerque, NM, October, 2005

Tokay, A., P.G. Bashor, and V.L. McDowell, 2010: Comparison of Rain Gauge Measurements in the Mid-Atlantic Region. *J. Hydrometeor.*, **11**, 553-565.

Tomlinson, E.M., W.D. Kappel, T.W. Parzybok, B. Rappolt, 2006: Use of NEXRAD Weather Radar Data with the Storm Precipitation Analysis System (SPAS) to Provide High Spatial

Resolution Hourly Precipitation Analyses for Runoff Model Calibration and Validation, ASDSO Annual Conference, Boston, MA.

Tomlinson, E.M., and T.W. Parzybok, 2004: Storm Precipitation Analysis System (SPAS), proceedings of Association of Dam Safety Officials Annual Conference, Technical Session II, Phoenix, Arizona.

Tomlinson, E.M., R.A. Williams, and T.W. Parzybok, September 2003: Site-Specific Probable Maximum Precipitation (PMP) Study for the Great Sacandaga Lake / Stewarts Bridge Drainage Basin, Prepared for Reliant Energy Corporation, Liverpool, New York.

Tomlinson, E.M., R.A. Williams, and T.W. Parzybok, September 2003: Site-Specific Probable Maximum Precipitation (PMP) Study for the Cherry Creek Drainage Basin, Prepared for the Colorado Water Conservation Board, Denver, CO.

Tomlinson, E.M., Kappel W.D., Parzybok, T.W., Hultstrand, D., Muhlestein, G., and B. Rappolt, May 2008: Site-Specific Probable Maximum Precipitation (PMP) Study for the Wanahoo Drainage Basin, Prepared for Olsson Associates, Omaha, Nebraska.

Tomlinson, E.M., Kappel W.D., Parzybok, T.W., Hultstrand, D., Muhlestein, G., and B. Rappolt, June 2008: Site-Specific Probable Maximum Precipitation (PMP) Study for the Blenheim Gilboa Drainage Basin, Prepared for New York Power Authority, White Plains, NY.

Tomlinson, E.M., Kappel W.D., and T.W. Parzybok, February 2008: Site-Specific Probable Maximum Precipitation (PMP) Study for the Magma FRS Drainage Basin, Prepared for AMEC, Tucson, Arizona.

Tomlinson, E.M., Kappel W.D., Parzybok, T.W., Hultstrand, D., Muhlestein, G., and P. Sutter, December 2008: Statewide Probable Maximum Precipitation (PMP) Study for the state of Nebraska, Prepared for Nebraska Dam Safety, Omaha, Nebraska.

Tomlinson, E.M., Kappel, W.D., and Tye W. Parzybok, July 2009: Site-Specific Probable Maximum Precipitation (PMP) Study for the Scoggins Dam Drainage Basin, Oregon.

Tomlinson, E.M., Kappel, W.D., and Tye W. Parzybok, February 2009: Site-Specific Probable Maximum Precipitation (PMP) Study for the Tuxedo Lake Drainage Basin, New York.

Tomlinson, E.M., Kappel, W.D., and Tye W. Parzybok, February 2010: Site-Specific Probable Maximum Precipitation (PMP) Study for the Magma FRS Drainage Basin, Arizona.

Tomlinson, E.M., Kappel W.D., Parzybok, T.W., Hultstrand, D.M., Muhlestein, G.A., March 2011: Site-Specific Probable Maximum Precipitation Study for the Tarrant Regional Water District, Prepared for Tarrant Regional Water District, Fort Worth, Texas.

Tomlinson, E.M., Kappel, W.D., Hultstrand, D.M., Muhlestein, G.A., and T. W. Parzybok, November 2011: Site-Specific Probable Maximum Precipitation (PMP) Study for the Lewis River basin, Washington State.

Tomlinson, E.M., Kappel, W.D., Hultstrand, D.M., Muhlestein, G.A., and T. W. Parzybok, December 2011: Site-Specific Probable Maximum Precipitation (PMP) Study for the Brassua Dam basin, Maine.

U.S. Weather Bureau, 1946: Manual for Depth-Area-Duration analysis of storm precipitation. *Cooperative Studies Technical Paper No. 1*, U.S. Department of Commerce, Weather Bureau, Washington, D.C., 73pp.

Appendix H
TCEQ Gridded PMP Tool Python Script

```
''' ---------------------------------------------------------------------------
Name: TCEQ Gridded PMP Tool Python Script
Script Version: 1.6
Python Version: 2.7
ArcGIS Version: ArcGIS Desktop 10.3
Author: Applied Weather Associates
Usage:  The tool is designed to be executed within an the ArcMap environment with an
open MXD session.
Description:
    This tool calculates PMP depths for a given drainage basin for the
specified durations.  PMP point values are calculated (in inches) for each
grid point (spaced at 90 arc-second intervals) over the project domain. The
points are converted to gridded PMP datasets for each duration.
See TCEQ Texas Statewide PMP Study for more information.
---------------------------------------------------------------------------'''
###########################################################################
## import Python modules
import sys
import arcpy
from arcpy import env
import arcpy.analysis as an
import arcpy.management as dm
import arcpy.conversion as con
import numpy as np
env.overwriteOutput = True                                                 # Set
overwrite option
env.addOutputsToMap = False
###########################################################################
## get input parameters
basin = arcpy.GetParameter(0)                                                    # get
AOI Basin Shapefile
home = arcpy.GetParameterAsText(1)                                               # get
location of 'PMP' Project Folder
outLocation = arcpy.GetParameterAsText(2)
locDurations = arcpy.GetParameter(3)                                             # get
local storm durations (string)
genDurations = arcpy.GetParameter(4)                                             # get
general storm durations (string)
tropDurations = arcpy.GetParameter(5)                                            # get
tropical storm durations (string)
weightedAve = arcpy.GetParameter(8)                                      # get option
to apply weighted average (boolean)
outputTable = arcpy.GetParameter(9)                                      # get file
path for basin average summary table
dadGDB = home + "\\Input\\DAD_Tables.gdb"                                        #
location of DAD tables
adjFactGDB = home + "\\Input\\Storm_Adj_Factors.gdb"                             #
location of feature datasets containing total adjustment factors
arcpy.AddMessage("\nDAD Tables geodatabase path:  " + dadGDB)
arcpy.AddMessage("Storm Adjustment Factor geodatabase path:  " + adjFactGDB)
mxd = arcpy.mapping.MapDocument("CURRENT")
df = arcpy.mapping.ListDataFrames(mxd)[0]
basAveTables = []                                                                #
global list of Basin Average Summary tables
def pmpAnalysis(aoiBasin, stormType, durList):
    ###########################################################################
    ## Create PMP Point Feature Class from points within AOI basin and add fields
    def createPMPfc():
        arcpy.AddMessage("\nCreating feature class: 'PMP_Points' in Scratch.gdb...")
        dm.MakeFeatureLayer(home + "\\Input\Non_Storm_Data.gdb\\Vector_Grid",
"vgLayer")                 # make a feature layer of vector grid cells
        dm.SelectLayerByLocation("vgLayer", "INTERSECT", aoiBasin)
# select the vector grid cells that intersect the aoiBasin polygon
```

```
        dm.MakeFeatureLayer(home + "\\Input\Non_Storm_Data.gdb\\Grid_Points",
"gpLayer")                   # make a feature layer of grid points
        dm.SelectLayerByLocation("gpLayer", "HAVE_THEIR_CENTER_IN", "vgLayer")
# select the grid points within the vector grid selection
        con.FeatureClassToFeatureClass("gpLayer", env.scratchGDB, "PMP_Points")
# save feature layer as "PMP_Points" feature class
        arcpy.AddMessage("(" + str(dm.GetCount("gpLayer")) + " grid points will be
analyzed)\n")

        # Add PMP Fields
        for dur in durList:
            arcpy.AddMessage("\t...adding field: PMP_" + str(dur))
            dm.AddField(env.scratchGDB + "\\PMP_Points", "PMP_" + dur, "DOUBLE")
        # Add STORM Fields (this string values identifies the driving storm by SPAS
ID number)
        for dur in durList:
            arcpy.AddMessage("\t...adding field: STORM_" + str(dur))
            dm.AddField(env.scratchGDB + "\\PMP_Points", "STORM_" + dur, "TEXT", "",
"", 16)

        return
    ###########################################################################
    ##  Define getAOIarea() function:
    ##  getAOIarea() calculates the area of AOI (basin outline) input shapefile/
    ##  featureclass.  The basin outline shapefile must be projected.  The area
    ##  is sqaure miles, converted from the basin layers projected units (feet
    ##  or meters).  The aoiBasin feature class should only have a single feature
    ##  (the basin outline).  If there are multiple features, the area will be stored
    ##  for the final feature only.
    def getAOIarea():
        sr = arcpy.Describe(aoiBasin).SpatialReference
# Determine aoiBasin spatial reference system
        srname = sr.name
        srtype = sr.type
        srunitname = sr.linearUnitName
# Units
        arcpy.AddMessage("\nAOI basin spatial reference:  " + srname + "\nUnit type:
" + srunitname + "\nSpatial reference type: " + srtype)

        aoiArea = 0.0
        rows = arcpy.SearchCursor(aoiBasin)
        for row in rows:
            feat = row.getValue("Shape")
            aoiArea += feat.area
        if srtype == 'Geographic':                                  # Must have a
surface projection.  If one doesn't exist it projects a temporary file and uses that.
                arcpy.AddMessage("\n***The basin shapefile's spatial reference
'Geographic' is not supported.  Projecting temporary shapefile for AOI.***")
                arcpy.Project_management(aoiBasin,env.scratchGDB +
"\\TempBasin",102039)     #Projects AOI Basin (102039 =
USA_Contiguous_Albers_Equal_Area_Conic_USGS_version)
                TempBasin = env.scratchGDB + "\\TempBasin"
# Path to temporary basin created in scratch geodatabase
                sr = arcpy.Describe(TempBasin).SpatialReference
# Determine Spatial Reference of temporary basin
                aoiArea = 0.0
                rows = arcpy.SearchCursor(TempBasin)
       # Assign area size in square meters
                for row in rows:
                    feat = row.getValue("Shape")
                    aoiArea += feat.area
                aoiArea = aoiArea * 0.000000386102
# Converts square meters to square miles
        elif srtype == 'Projected':
```

```
            if srunitname == "Meter":
                aoiArea = aoiArea * 0.000000386102
# Converts square meters to square miles
            elif srunitname == "Foot" or "Foot_US":
                aoiArea = aoiArea * 0.00000003587
# Converts square feet to square miles
            else:
                arcpy.AddMessage("\nThe basin shapefile's unit type '" + srunitname +
"' is not supported.")
                sys.exit("Invalid linear units")
# Units must be meters or feet

        aoiArea = round(aoiArea, 3)
        arcpy.AddMessage("\nArea of interest: " + str(aoiArea) + " square miles.")

        if arcpy.GetParameter(6) == False:
            aoiArea = arcpy.GetParameter(7)
# Enable a constant area size
        aoiArea = round(aoiArea, 1)
        arcpy.AddMessage("\n***Area used for PMP analysis: " + str(aoiArea) + "
sqmi***")
        return aoiArea
    ###########################################################################
    ##  Define dadLookup() function:
    ##  The dadLookup() function determines the DAD value for the current storm
    ##  and duration according to the basin area size.  The DAD depth is interpolated
    ##  linearly between the two nearest areal values within the DAD table.
    def dadLookup(stormLayer, duration, area):                  # dadLookup() accepts
the current storm layer name (string), the current duration (string), and AOI area
size (float)
        #arcpy.AddMessage("\t\tfunction dadLookup() called.")
        durField = "H_" + duration                                  # defines the name of
the duration field (eg., "H_06" for 6-hour)
        dadTable = dadGDB + "\\" + stormLayer
        rows = arcpy.SearchCursor(dadTable)

        try:
            row = rows.next()                                           # Sets DAD area
x1 to the value in the first row of the DAD table.
            x1 = row.AREASQMI
            y1 = row.getValue(durField)
            xFlag = "FALSE"                                             # xFlag will
remain false for basins that are larger than the largest DAD area.
        except RuntimeError:                                            # return if
duration does not exist in DAD table
            return

        row = rows.next()
        i = 0
        while row:                                                      # iterates
through the DAD table - assiging the bounding values directly above and below the
basin area size
            i += 1
            if row.AREASQMI < area:
                x1 = row.AREASQMI
                y1 = row.getValue(durField)
            else:
                xFlag = "TRUE"                                          # xFlag is
switched to "TRUE" indicating area is within DAD range
                x2 = row.AREASQMI
                y2 = row.getValue(durField)
                break

            row = rows.next()
```

```
        del row, rows, i
        if xFlag == "FALSE":
            x2 = area                                           # If x2 is equal to
the basin area, this means that the largest DAD area is smaller than the basin and
the resulting DAD value must be extrapolated.
            arcpy.AddMessage("\t\tThe basin area size: " + str(area) + " sqmi is
greater than the largest DAD area: " + str(x1) + " sqmi.\n\t\tDAD value is estimated
by extrapolation.")
            y = x1 / x2 * y1                                    # y (the DAD depth)
is estimated by extrapolating the DAD area to the basin area size.
            return y                                            # The extrapolated
DAD depth (in inches) is returned.
        # arcpy.AddMessage("\nArea = " + str(area) + "\nx1 = " + str(x1) + "\nx2 = "
+ str(x2) + "\ny1 = " + str(y1) + "\ny2 = " + str(y2))
        x = area                                                # If the basin area
size is within the DAD table area range, the DAD depth is interpolated
        deltax = x2 - x1                                        # to determine the
DAD value (y) at area (x) based on next lower (x1) and next higher (x2) areas.
        deltay = y2 - y1
        diffx = x - x1
        y = y1 + diffx * deltay / deltax
        if x < x1:
            arcpy.AddMessage("\t\tThe basin area size: " + str(area) + " sqmi is less
than the smallest DAD table area: " + str(x1) + " sqmi.\n\t\tDAD value is estimated
by extrapolation.")

        return y                                                # The interpolated
DAD depth (in inches) is returned.
    ###########################################################################
    ##  Define updatePMP() function:
    ##  This function updates the 'PMP_XX_' and 'STORM_XX' fields of the PMP_Points
    ##  feature class with the largest value from all analyzed storms stored in the
    ##  pmpValues list.
    def updatePMP(pmpValues, stormID, duration):
# Accepts four arguments: pmpValues - largest adjusted rainfall for current duration
(float list); stormID - driver storm ID for each PMP value (text list); and duration
(string)
        pmpfield = "PMP_" + duration
        stormfield = "STORM_" + duration
        gridRows = arcpy.UpdateCursor(env.scratchGDB + "\\PMP_Points")
# iterates through PMP_Points rows
        i = 0
        for row in gridRows:
            row.setValue(pmpfield, pmpValues[i])
# Sets the PMP field value equal to the Max Adj. Rainfall value (if larger than
existing value).
            row.setValue(stormfield, stormID[i])
# Sets the storm ID field to indicate the driving storm event
            gridRows.updateRow(row)
            i += 1
        del row, gridRows, pmpfield, stormfield
        arcpy.AddMessage("\n\t" + duration + "-hour PMP values update complete. \n")
        return

    ###########################################################################
    ##  The outputPMP() function produces raster GRID files for each of the PMP
durations.
    ##  Aslo, a space-delimited PMP_Distribition.txt file is created in the
'Text_Output' folder.
    def outputPMP(type, area, outPath):
       desc = arcpy.Describe(basin)
       basinName = desc.baseName
       pmpPoints = env.scratchGDB + "\\PMP_Points"                          #
Location of 'PMP_Points' feature class which will provide data for output
```

```
        outType = type[:1]
        outArea = str(int(round(area,0))) + "sqmi"
        outGDB = "PMP_"+ basinName + "_" + outArea +".gdb"
        if not arcpy.Exists(outPath + "\\" + outGDB):                          #
Check to see if PMP_XXXXX.gdb already exists
            arcpy.AddMessage("\nCreating output geodatabase '" + outGDB + "'")
            dm.CreateFileGDB(outPath, outGDB)
        arcpy.AddMessage("\nCopying PMP_Points feature class to " + outGDB + "...")
        con.FeatureClassToFeatureClass(pmpPoints, outPath + "\\" + outGDB, type +
"_PMP_Points_" + basinName + "_" + outArea)
        pointFC = outPath + "\\" + outGDB + "\\" + type + "_PMP_Points_" + basinName
+ "_" + outArea
        addLayerMXD(pointFC)

        arcpy.AddMessage("\nBeginning PMP Raster Creation...")
        for dur in durList:                                                    #
This code creates a raster GRID from the current PMP point layer
            durField = "PMP_" + dur
            outLoc = outPath + outGDB +"\\" + outType + "_" + dur + "_" + basinName +
"_" + outArea
            arcpy.AddMessage("\n\tInput Path: " + pmpPoints)
            arcpy.AddMessage("\tOutput raster path: " + outLoc)
            arcpy.AddMessage("\tField name: " + durField)
            con.FeatureToRaster(pmpPoints, durField, outLoc, "0.025")
            arcpy.AddMessage("\tOutput raster created...")
        del durField, outLoc, dur
        arcpy.AddMessage("\nPMP Raster Creation complete.")
        arcpy.AddMessage("\nCreating Basin Summary Table...")
        tableName = type + "_PMP_Basin_Average" + "_" + outArea
        tablePath = outPath + "\\" + outGDB + "\\" + tableName
        dm.CreateTable(outPath + "\\" + outGDB, tableName)          # Create blank
table
        cursor = arcpy.da.InsertCursor(tablePath, "*")              # Create Insert
cursor and add a blank row to the table
        cursor.insertRow([0])
        del cursor

        dm.AddField(tablePath, "STORM_TYPE", "TEXT", "", "", 10, "Storm Type")
# Create "Storm Type" field
        dm.CalculateField(tablePath, "STORM_TYPE", "'" + type + "'", "PYTHON_9.3")
# populate storm type field
        i = 0
        for field in arcpy.ListFields(pmpPoints, "PMP_*"):          # Add fields for
each PMP duration and calculate the basin average
            fieldName = field.name
            fieldAve = basinAve(basin, fieldName)                   # Calls the
basinAve() function - returns the average (weighted or not)
            dm.AddField(tablePath, fieldName, "DOUBLE", "", 2)       # Add duration
field
            dm.CalculateField(tablePath, fieldName, fieldAve)       # Assigns the
basin average
            dur = durList[i]                                        # following lines
add alias field names to basin average table
            if dur[0] == "0":
                dur = dur[1:]
            fieldAlias = dur + "-hour PMP"
            dm.AlterField(tablePath, fieldName, "#", fieldAlias)
            i += 1
        arcpy.AddMessage("\nSummary table complete.")
        basAveTables.append(tablePath)

        return
    ###########################################################################
```

```
    ##  The basin() returns the basin average PMP value for a given duration field.
    ##  If the option for a weighted average is checked in the tool parameter the
script
    ##  will weight the grid point values based on proportion of area inside the
basin.
    def basinAve(aoiBasin, pmpField):
        pmpPoints = env.scratchGDB + "\\PMP_Points"
# Path of 'PMP_Points' scratch feature class
        if weightedAve:
            arcpy.AddMessage("\tCalculating basin average for " + pmpField +
"(weighted)...")
            vectorGridClip = env.scratchGDB + "\\VectorGridClip"
# Path of 'PMP_Points' scratch feature class

            dm.MakeFeatureLayer(home + "\\Input\Non_Storm_Data.gdb\\Vector_Grid",
"vgLayer")                # make a feature layer of vector grid cells
            dm.SelectLayerByLocation("vgLayer", "INTERSECT", aoiBasin)
# select the vector grid cells that intersect the aoiBasin polygon
            an.Clip("vgLayer", aoiBasin, vectorGridClip)
# clips aoi vector grid to basin
            dm.AddField(pmpPoints, "WEIGHT", "DOUBLE")
# adds 'WEIGHT' field to PMP_Points scratch feature class
            dm.MakeFeatureLayer(vectorGridClip, "vgClipLayer")
# make a feature layer of basin clipped vector grid cells
            dm.MakeFeatureLayer(pmpPoints, "pmpPointsLayer")
# make a feature layer of PMP_Points feature class
            dm.AddJoin("pmpPointsLayer", "ID", "vgClipLayer", "ID")
# joins PMP_Points and vectorGridBasin tables
            dm.CalculateField("pmpPointsLayer", "WEIGHT",
"!vectorGridClip.Shape_Area!", "PYTHON_9.3")      # Calculates basin area proportion
to use as weight for each grid cell.
            dm.RemoveJoin("pmpPointsLayer", "vectorGridClip")
            na = arcpy.da.TableToNumPyArray(pmpPoints,(pmpField, 'WEIGHT'))
# Assign pmpPoints values and weights to Numpy array (na)
            wgtAve = np.average(na[pmpField], weights=na['WEIGHT'])
# Calculate weighted average with Numpy average
            del na
            return round(wgtAve, 2)

        else:
            arcpy.AddMessage("\tCalculating basin average for " + pmpField + "(not
weighted)...")
            na = arcpy.da.TableToNumPyArray(pmpPoints, pmpField)
# Assign pmpPoints values to Numpy array (na)
            fieldAve = np.average(na[pmpField])
# Calculates aritmetic mean
            del na
            return round(fieldAve, 2)

    ###########################################################################
    ##  This portion of the code iterates through each storm feature class in the
    ##  'Storm_Adj_Factors' geodatabase (evaluating the feature class only within
    ##  the Local, Tropical, or general feature dataset).  For each duration,
    ##  at each grid point within the aoi basin, the transpositionality is
    ##  confirmed.  Then the DAD precip depth is retrieved and applied to the
    ##  total adjustement factor to yield the total adjusted rainfall.  This
    ##  value is then sent to the updatePMP() function to update the 'PMP_Points'
    ##  feature class.
##~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~##

    desc = arcpy.Describe(basin)
# Check to ensure AOI input shape is a Polygon. If not - exit.
    basinShape = desc.shapeType
```

```
    if desc.shapeType == "Polygon":
        arcpy.AddMessage("\nBasin shape type: " + desc.shapeType)
    else:
        arcpy.AddMessage("\nBasin shape type: " + desc.shapeType)
        arcpy.AddMessage("\nError: Input shapefile must be a polygon!\n")
        sys.exit()

    createPMPfc()
# Call the createPMPfc() function to create the PMP_Points feature class.
    env.workspace = adjFactGDB
# the workspace environment is set to the 'Storm_Adj_Factors' file geodatabase
    aoiSQMI = round(getAOIarea(),2)
# Calls the getAOIarea() function to assign area of AOI shapefile to 'aoiSQMI'

    for dur in durList:
        stormList = arcpy.ListFeatureClasses("", "Point", stormType)
# List all the total adjustment factor feature classes within the storm type feature
dataset.

arcpy.AddMessage("\n*********************************************************\nEv
aluating " + dur + "-hour duration...")
        pmpList = []
        driverList = []
        gridRows = arcpy.SearchCursor(env.scratchGDB + "\\PMP_Points")
        try:
            for row in gridRows:
                pmpList.append(0.0)
# creates pmpList of empty float values for each grid point to store final PMP values
                driverList.append("STORM")
# creates driverList of empty text values for each grid point to store final Driver
Storm IDs
            del row, gridRows
        except UnboundLocalError:
            arcpy.AddMessage("\n***Error: No data present within basin/AOI
area.***\n")
            sys.exit()
        for storm in stormList:
            arcpy.AddMessage("\n\tEvaluating storm: " + storm + "...")
            dm.MakeFeatureLayer(storm, "stormLayer")
# creates a feature layer for the current storm
            dm.SelectLayerByLocation("stormLayer", "HAVE_THEIR_CENTER_IN", "vgLayer")
# examines only the grid points that lie within the AOI
            gridRows = arcpy.SearchCursor("stormLayer")
            pmpField = "PMP_" + dur
            i = 0
            try:
                dadPrecip = round(dadLookup(storm, dur, aoiSQMI),3)
                arcpy.AddMessage("\t\t" + dur + "-hour DAD value:  " + str(dadPrecip)
+ chr(34))
            except TypeError:
# In no duration exists in the DAD table - move to the next storm
                arcpy.AddMessage("\t***Duration '" + str(dur) + "-hour' is not
present for " + str(storm) + ".***\n")
                continue
            arcpy.AddMessage("\t\tComparing " + storm + " adjusted rainfall values
against current driver values...\n")
            for row in gridRows:
                if row.TRANS == 1:                                          #
Only continue if grid point is transpositionable ('1' is transpostionable, '0' is
not).
                    try:                                                      # get
total adj. factor if duration exists
                        adjRain = round(dadPrecip * row.TAF,1)
                        if adjRain > pmpList[i]:
```

```
                            pmpList[i] = adjRain
                            driverList[i] = storm
                    except RuntimeError:
                        arcpy.AddMessage("\t\t   *Warning*  Total Adjusted Raifnall
value falied to set for row " + str(row.CNT))
                        break
                    del adjRain
                i += 1
            del row
        del storm, stormList, gridRows, dadPrecip
        updatePMP(pmpList, driverList, dur)             # calls function to update
"PMP Points" feature class
    del dur, pmpList

    arcpy.AddMessage("\n'PMP_Points' Feature Class 'PMP_XX' fields update complete
for all '" + stormType + "' storms.")

    outputPMP(stormType, aoiSQMI, outputPath)               # calls outputPMP()
function

    del aoiSQMI
    return
##~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~##
def outputBasAveTable():
    arcpy.AddMessage("\nCreating basin average summary table.\n")
    tableList = basAveTables
    for table in tableList:
        arcpy.AddMessage("\t\t...Table: " + table)
    dm.Merge(basAveTables, outputTable)
    addLayerMXD(outputTable)
    return
##~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~##
def addLayerMXD(addFC):
    desc = arcpy.Describe(addFC)
    layerName = desc.name
    arcpy.AddMessage("\nAdding " + layerName + " to current MXD...")
    if desc.dataType == "FeatureClass":
        dm.MakeFeatureLayer(addFC, layerName)
        layer = arcpy.mapping.Layer(layerName)
        arcpy.mapping.AddLayer(df, layer)
        arcpy.AddMessage("\n" + layerName + " added to " + mxd.filePath)
    elif desc.dataType == "Table" or "ArcInfoTable":
        layer = arcpy.mapping.TableView(desc.catalogPath)
        arcpy.mapping.AddTableView(df, layer)
        arcpy.AddMessage("\n" + layerName + " added to " + mxd.filePath)
    del desc, layerName, layer
    return
##~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~##

if locDurations:
    type = "Local"
    durations = locDurations
    dm.CreateFolder(outLocation, type)
    outputPath = outLocation + "\\Local\\"
    arcpy.AddMessage("\nRunning PMP analysis for storm type: " + type)
    pmpAnalysis(basin, type, durations)          # Calls the pmpAnalysis() function
to calculate the local storm PMP
    arcpy.AddMessage("\nLocal storm analysis
complete...\n*********************************************************************
*******************************")
if genDurations:
```

```
    type = "General"
    durations = genDurations
    dm.CreateFolder(outLocation, type)
    outputPath = outLocation + "\\General\\"
    arcpy.AddMessage("\nRunning PMP analysis for storm type: " + type)
    pmpAnalysis(basin, type, durations)          # Calls the pmpAnalysis() function
to calculate the general storm PMP
    arcpy.AddMessage("\nGeneral Winter storm analysis
complete...\n************************************************************************
*********************************")
if tropDurations:
    type = "Tropical"
    durations = tropDurations
    dm.CreateFolder(outLocation, type)
    outputPath = outLocation + "\\Tropical\\"
    arcpy.AddMessage("\nRunning PMP analysis for storm type: " + type)
    pmpAnalysis(basin, type, durations)          # Calls the pmpAnalysis() function
to calculate the tropical storm PMP
    arcpy.AddMessage("\nTropical storm analysis
complete...\n************************************************************************
*********************************")
if arcpy.Describe(outputTable).name:
    arcpy.AddMessage("\nVariable outputTable exists ")
    outputBasAveTable()
arcpy.RefreshTOC()
arcpy.RefreshActiveView()
mxd.save()
del mxd, df
```

Appendix I

PMP Version Log: Changes to Storm Database and Transposition Limits

Version 0.90:

General

- SPAS 1180_1 - Hybrid no longer used for General PMP (now Tropical)
- SPAS 1208_1 - Limit western extent to 500' (instead of -97.5°)
- SPAS 1242_1 - Limit western extent to 1200' (instead of -99°)
- SPAS 1494_1 - Hybrid no longer used for General PMP
- SPAS 1558_1 - Hybrid no longer used for General PMP
- SPAS 1590_1 - Hybrid no longer used for General PMP
- SPAS 1591_1 - Add Zone 2 & 3
- SPAS 1592_1 - Hybrid no longer used for General PMP
- SPAS 1530_4 - No elevation constrain on Zone 2
- SPAS 1568_1 - Change to only -1,000' constraint (no constraint on +elev)
- SPAS 1602_1 - Hybrid no longer used for General PMP (now Tropical)

Local

- SPAS 1247_1 - Limit to Zone 10 only (with existing constraints
- SPAS 1295_3 - Correct to 35°N. Limit to above 3,900' (instead of 2,500)
- SPAS 1432_1 - Add zones 3,4, and 5 (with +/- 1,000' constraint)
- SPAS 1494_1 - No elevation constrain on Zone 2
- SPAS 1495_1 - Constrain elev to +1000/-500'
- SPAS 1496_1 - Local storm added
- SPAS 1568_1 - Change to only -1,000' constraint (no constraint on +elev)
- SPAS 1592_1 - Add Zone 2, 12 (with +/-1000' constraint). Add all of Zone 4

Tropical

- SPAS 1180_1 - Hybrid added to Tropical PMP
- SPAS 1598_1 - Tropical storm added
- SPAS 1599_1 - Tropical storm added
- SPAS 1600_1 - Tropical storm added
- SPAS 1601_1 - Tropical storm added
- SPAS 1601_2 - Tropical storm added
- SPAS 1602_1 - Hybrid added to Tropical PMP

Version 0.90a (investigative):

- Combine tropical and general PMP

Version 0.90b (investigative):

- Run general PMP without SPAS 1582

Version 0.91 (applied to changes in v.90):

General

- SPAS 1180_1 - West to 1,200' (instead of 500')
- SPAS 1218_1 - West to 1,200', no longitude constraint
- SPAS 1242_1 - Zones 4, 8, 9 < 1,200' and < 1.50 GTF
- SPAS 1486_1 - Add all of Zones 1 & 2 (no lat. constraint)
- SPAS 1530_1 - Add all of Zones 1 & 2 (no lat. constraint)
- SPAS 1560_1 - Add Zone 7 (with +/- 1000' constraint)
- SPAS 1582_1 - Only use <+1,000' constraint (no >-1,000'), no Zone 9

Local

- SPAS 1432_1 - Add all of Zone 4, Zone 2 (with +/- 1000' constraint)
- SPAS 1495_1 - Add all of Zones 7, 10, 11; Zones 4, 8, 9, 12 (> -500' elev)
- SPAS 1592_1 - Add Zone 2 < 3,500'

- SPAS 1560_1_loc - Add Zone 7 (with +/- 1000' constraint)
- SPAS 1602_1_loc - Add Zone 1, 6, 7, 11, 10 (GTF > 0.5); Zones 2, 4, 8, 12 (> 2,000')

Tropical
- SPAS 1179_1 - Add all of Zone 9 where GTF > 1.50
- SPAS 1184_1 - Remove elevation constraint
- SPAS 1463_1 - Add Zones 2 and 3 (with + 1,000' constraint)
- SPAS 1600_1 - All of Zones 1, 2, 3, 4, 6 (no elev. constraint)
- SPAS 1601_2 - Add Zone 9 < 31°N
- SPAS 1602_1 - Add Zone 1, 6, 7, 11, 10 (GTF > 0.5); Zones 2, 4, 8, 12 (> 2,000')

Version 0.95 (applied to changes in v.91):

General
- SPAS 1242_1 - All of 4, 8, 12
- SPAS 1431_1 - Add 7 and 11, Allow up to 3,000' elevation
- SPAS 1530_1 - Add >-1000' elev. constraint
- SPAS 1560_1 - All of Zone 7
- SPAS 1582_1 - Now a tropical storm
- SPAS 1591_1 - Allow up to 3,000' elevation
-

Local
- SPAS 1495_1 - Change elev. constraint to +/- 1000' (from -500')
- SPAS 1496_1 - Add 8, 9, 12 and +/- 1,000' elev. constraint
- SPAS 1560_1_loc - All of Zone 7

Tropical
- SPAS 1179_1 - Add Zones 4 and 9 with (+/- elev. constraint, no OTF constraint)
- SPAS 1184_1 - Add Zone 4 (+/- 1,000')
- SPAS 1463_1 - Add Zones 4 & 9 (with +/-1,000' constraint)
- SPAS 1582_1 - Now a tropical storm
- SPAS 1592_1 - Now a hybrid local/tropical storm
- SPAS 1600_1 - Add >-1000' constraint to 2,3, and 4
- SPAS 1601_1 - Add Zone 5

Version 0.95a (investigative):

- SPAS 1495_1 - Removed

Version 0.95b (investigative):

- SPAS 1495_1 - Changed storm rep. Td to 68° (IPMF 1.35)

Version 0.96 (applied to changes in v.95):

General
- SPAS 1242_1 - Add Zone 5
- SPAS 1530_1 - > 1,200 (instead of elev-3,000); add 4, 8, 12; All of 4, 8, 12

Local
- SPAS 1495_1 - No changes – needs investigation.
- SPAS 1602_1_loc - > 1,500

Tropical
- SPAS 1602_1 - > 1,500

Version 0.97 (applied to changes in v.96):

General

- SPAS 1242_1 - Add Zone 9
- SPAS 1530_1 - Remove 4, 8, 12; Add all of Zones 1 & 6; Add Zones 7, 10 (>-1000) west of Pecos River.

Local

- SPAS 1295_3 - Constrain to north of Canadian River and west of Palo Verde drainage boundary (apply manual constraints – see image)
- SPAS 1495_1 - Changed storm rep. Td to 68° (IPMF 1.35)
- SPAS 1602_1_loc - Remove GTF constraint

Tropical

- SPAS 1602_1 - Add Zone 2 +/- 1000'
- All storms - Cap GTF at 1.10

Version 0.98a (investigative):

General

- SPAS 1208_1 - All zones < 3,000'
- SPAS 1218_1 - All zones < 3,000'
- SPAS 1242_1 - All zones < 3,000'

Local

- SPAS 1495_1 - Zones 4, 7, 8, 9, 10 11, 12 < Storm Elevation (1,930')

Tropical

- SPAS 1602_1 - All of zones 2, 3, 4. Zones 7, 8, 11, 12 where GTF <0.90
- SPAS 1592_1 - Zones 2, 3, 4, 5, 8, 9, 12 < 3,500'

Version 0.98b (investigative):

Local

- SPAS 1495_1 - Add Zone 9 and add a 1.00 GTF cap.
- SPAS 1602_1_loc - Remove Zones 10 (N of 33°), 11, and 12
- SPAS 1592_1_loc - Zones 2, 3, 4, 5, 8, 9, 12 < 3,500'

Tropical

- SPAS 1602_1 - Remove Zones 10 (N of 33°), 11, and 12. Add GTF cap of 1.00
- SPAS 1592_1 - Zones 2, 3, 4, 5, 8, 9, 12 < 3,500'

Version 0.99 (applied to changes in v.98b) Draft PMP:

General

- SPAS 1208_1 - All zones < 3,000'
- SPAS 1218_1 - All zones < 3,000'
- SPAS 1242_1 - All zones < 3,000'

Local

- Hybrid Local/Tropical storms GTF capped at 1.10 (1180, 1592, 1602)

Tropical

- SPAS 1602_1 - Move to all Zones

Version 0.99b (investigative):

Tropical

- Removed SPAS 1602_1

Version 1.0 (final PMP):

- An update to the SPAS code was made and applied to all DAD tables used for this study (68 DAD tables) to more accurately represent the rainfall accumulations of each storm

All DAD Tables

- The DAD tables were recalculated using maximum values for standard area sizes

Appendix J
HMR Storm Separation Method (SSM)

Applied Weather Associates, LLC (AWA) has reviewed the Storm Separation Method (SSM) as described in detail in HMR 55A and its application in HMR 57 and HMR 59. The SSM is used in hydrometeorological analysis to arrive at an approximation of the non-orographic component of precipitation from storms centered in orographic areas. The SSM was originally developed for HMR 55A (1988) as a standardized procedure to isolate and quantify orographic from non orographic factors in record setting storms (HMR 59, Section 5.4). HMRs 57 and 59 refer to HMR 55A for details of the development of the SSM. The application of the SSM is described in HMR 57 and HMR 59 with some examples of the maps developed for each publication provided in various figures in Chapter 7 of HMR 57 and Chapter 6 of HMR 59. An attempt was made to acquire copies of the actual maps and data used in the computation of PMP for these publications. AWA visited the Hydrometeorology Design Studies Center (HDSC) December 8-10, 2008 to review archives of maps and working papers for HMRs 55A, 57 and 59. No maps or working papers are available for the SSM applications in those documents. Therefore, the review of the SSM is based entirely on information in HMRs 55A, 57 and 59.

Introduction

The initial review discussion describes the procedure presented in HMR 55A in detail. Maps from HMR 57 were digitized and computations completed based on the discussions in HMR 57. Results from these computations are compared with the HMR 57 PMP maps. Maps in HMR 59 were also digitized but not all maps for the SSM were available. Results from the limited information available are discussed.

The following discussion is extracted from the information provided in HMR 55A for the determination of Free Atmospheric Forced Precipitation (FAFP). The information is condensed to present major discussions. The complete text is available in Sections 6 and 7 of HMR 55A.

HMR 55A Section 6. APPROACHES

1.1 Introduction

HMR 55A states that estimation of PMP in orographic regions is difficult and storm data are limited. This is the result of a low population density that restricts the number of regular observing stations and also limits the effectiveness of supplementary precipitation surveys. In addition, the complicating effects of terrain on storm structure and precipitation must be considered. In HMR 55A, several procedures were investigated, but primary reliance was placed on a procedure that separates the effect of orography from the dynamic effects of the storm.

6.4 Storm Separation Method

It was necessary to find a procedure which would enable the precipitation potential for this diverse terrain to be analyzed in a consistent fashion. The precipitation that results from atmospheric forces (convergence precipitation) involved in the major storms in the region is defined. Convergence precipitation amounts were determined for the 24-hr 10-mi^2 precipitation amounts for all major storms in the region. These rainfall values were moisture maximized and transposed to locations where similar storms have occurred. The moisture maximized, transposed values were then analyzed to develop a generalized map of convergence PMP throughout the region.

Values of convergence rainfall were increased for orographic effects that occur over the region. The orographic intensification factor is developed from the 100-yr 24-hr precipitation-frequency amounts of NOAA Atlas 2. Since the dynamic strength of a storm varies from the most intense 1-, 2-, 3-, or 6-hr period through the end of the storm, it is not appropriate to apply the same orographic intensification factor throughout the entire storm. To vary this intensification factor, a storm intensity factor was developed. The storm intensification factor reduced the effect of the orographic factor during the most intense rainfall period of the maximum 24 hours of the storm.

After determining the 24-hr 10-mi^2 PMP, 6-/24- and 72-/24-hr ratio maps were used to develop PMP values for these two other index durations for the 10-mi^2 area. Finally, a 1-hr 10-mi^2 PMP map was developed using a 1-/6-hr ratio map. These four maps provide the key estimates of general-storm PMP for the region.

6.5 Depth-Area Relations

The technique discussed in sections 6.3 and 6.4 provide 10-mi^2, or point, estimates of general-storm PMP for four index durations. Depth-area relations were developed utilizing data from the important storms of record in and near the study region to permit estimates for larger areas. These relations provide percentages to estimate PMP for areas as large as 5,000 mi^2. Different depth-area relations are required for disparate regions. Differences also exist between orographic and non-orographic portions of the study region. These differences resulted in a set of depth-area relations.

HMR 55A Section 7. STORM SEPARATION METHOD (SSM)

7.1 Introduction

It was considered necessary to find a property of observed major storm precipitation events that is only minimally affected by terrain so transposition of observed precipitation amounts would not be limited to places where the terrain characteristics are the same as those at the place where the storm occurred. The name given to this idealized property is "free atmospheric forced precipitation" (FAFP) which has been called “convergence only" precipitation in publications such as HMR No. 49. The definition of FAFP is the precipitation not caused by orographic forcing; i.e. it is precipitation caused by the dynamic, thermodynamic, and microphysical processes of the atmosphere. It is all the precipitation from a storm occurring in an area where terrain influence or forcing is negligible, termed a non-orographic area. In areas classified as orographic, it is that part of the total precipitation which remains when amounts attributable to orographic forcing have been removed. Factors involved in the production of FAFP are:

1. Convergence at middle and low tropospheric levels and often, divergence at high levels
2. Buoyancy arising from heating and instability
3. Forcing mesoscale systems, i.e., pseudo fronts, squall lines, bubble highs, etc.
4. Storm structure, especially at the thunderstorm scale involving the interaction of precipitation unloading with the storm sustaining updraft
5. Lastly, condensation efficiency involving the role of hydroscopic nuclei and the heights of the condensation and freezing levels.

It is emphasized that FAFP is an idealized property of precipitation since no experiment has yet been devised to identify in nature which raindrops were formed by orographic forcing and which by atmospheric forcing.

7.2 Glossary of Terms (partial list)

A_o: See P_a. It is the term for the effectiveness of orographic forcing used in module 3.

Bi: It is the term representing the "triggering effects" of orography. It is used in module 2. Bi is a number between 0 and 1.0 representing the degree of FAFP implied by the relative positioning of the 1st through i-th isohyetal maxima with those terrain features (steepest slopes, prominences, converging upslope valleys) generally thought to induce or "stimulate" precipitation. A high positive correlation between terrain features and isohyetal maxima yields a low value for Bi.

BFAC: 0.95 (RCAT). It represents an upper limit for FAFP in modules 2 and 5. See also the definition for PX.

DADRF: The depth-area-duration reduction factor is the ratio of two average depths of precipitation. DADRF: RCAT/MXVATS

DADFX: DADFX = (HIFX)(DADRF).
It is used in module 2 to represent the largest amount of non-orographic precipitation caused by the same atmospheric mechanism that produced MXVATS.

F_i: See PCTHIFX: The largest isohyetal value in the non-orographic part of the storm. The same atmospheric forces (storm mechanism) must be the cause of precipitation over the areas covered by the isohyet used to determine HIFX and MXVATS.

Im: That part of RCAT attributed solely to atmospheric processes and having the dimension of depth. Since it is postulated that FAFP cannot be directly observed in an orographic area, some finite portion of it was caused by forcing other than free atmospheric. The FAFP component of the total depth must always be derived by making one or more assumptions about how the precipitation was caused. The subscript "m" identifies the single assumption or set of assumptions used to derive the amount designated by I. For example, a subscript of 2 will refer to the assumptions used in module 2.

LOFACA: LOFACA is the lowest isohyetal value at which it first becomes clear to the analyst that the topography is influencing the distribution of precipitation depths. Confirmation of this influence is assumed to occur when good correlation is observed between the LOFACA isohyet and one or more elevation contours in the orographic part of the storm. The significance of LOFACA is that precipitation depths at and below this value are assumed to have been produced solely by atmospheric forces without any additional precipitation resulting from topographic effects; i.e., they represent the "minimum level of FAFP for the storm.

LOFAC: $$\text{LOFAC} = \text{LOFACA} + \frac{\text{AI}}{2}\left(\text{PB}^{\frac{(\text{AI})}{2}} - 1\right).$$

It is a refinement to LOFACA based on the concept that AI may prejudice the assigning of a minimum level of FAFF.

MXVATS: The average depth of precipitation for the total storm duration for the smallest area size analyzed, provided that it is not larger than 100 sq mi.

OSL: Orographic Separation Line is a line which separates the region into two distinct regions. In one region, the non-orographic, it is assumed no more than a 5 percent change (in either increasing or decreasing the precipitation amount for any storm or series of storms) results from terrain effect. In contrast, the other region is one where the influence of terrain on the precipitation process is significant. An upper limit of 95 percent and a lower limit of no less than 5 percent is allowed. The line may exist anywhere from a few to 20 miles upwind (where the wind direction is that which is judged to prevail in typical record setting storms.

P_a (and A_a) is a ratio in which the effectiveness of an actual storm in producing precipitation is compared with a conceptualized storm of "perfect" effectiveness.

The SSM was developed because four distinct sets of precipitation were available for record-setting storms.

1. Reported Total storm precipitation, used in Module 1
2. Isohyet and depth-area-duration analyses of total storm precipitation, including Part I and Part II Summaries, used in Module 2
3. Meteorological data and analyses, used in Module 3
4. Topographic charts, used in all modules

It is noted that clearly the SSM depends on the validity of the input information.

The mechanics of the procedure used to arrive at FAFP are accomplished by completing the tasks symbolically represented in a MAIN FLOWCHART for the SSM along with its associated SSM MODULE FLOWCHARTS.

The validity of the techniques in the SSM depends on the validity of the concepts upon which they are based.

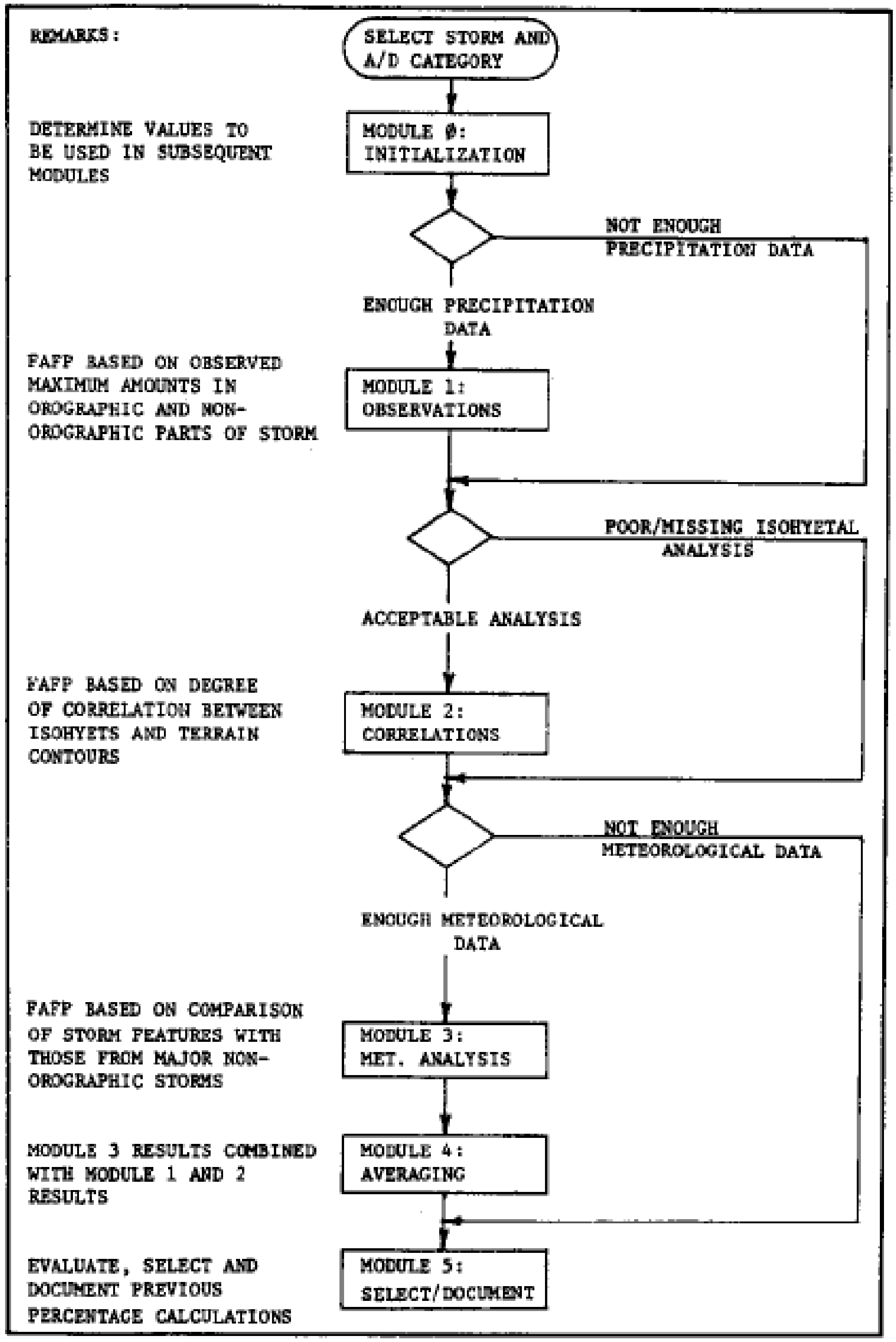


Figure 7.2.—Main flowchart for SSM.

SSM Modules from HMR 55A

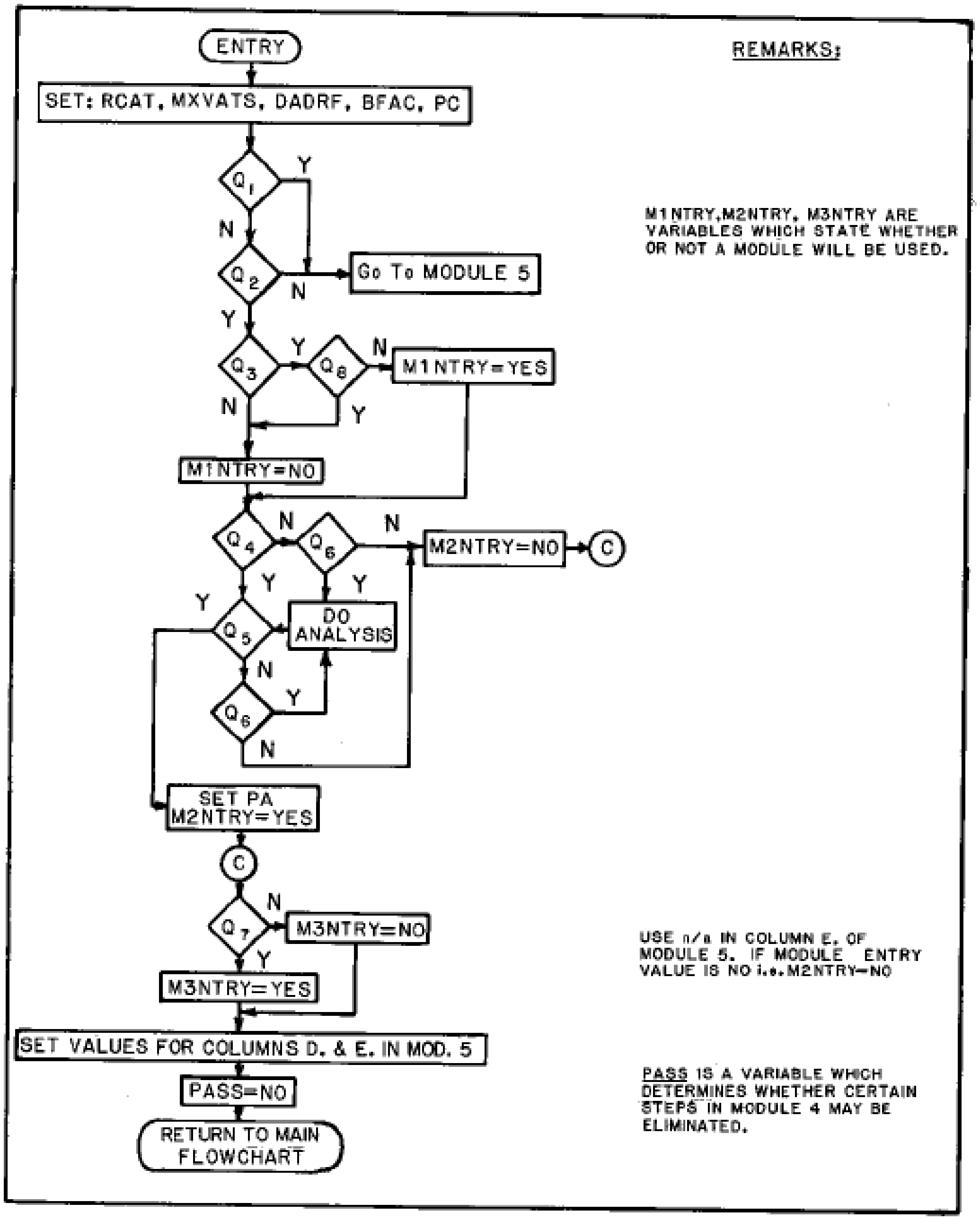


Figure 7.3.--Flowchart for module 0, SSM.

7.4.1.1 Module 0.

Module 0 is used to decide if there is adequate data available. A decision is made by the analyst if there are no data available, if the data are judged to be adequate or if the data are judged to be highly adequate. Values range from 1 for the lowest level to 9 for the highest level. The analyst assigns the value that is considered most applicable. Questions that are asked include the following:

1. Is the isohyetal analysis reliable?
2. Is there adequate data in non orographic areas to select a reliable value for non orographic precipitation?
3. Is the highest observed precipitation in the non orographic part of the storm equal to zero?
4. Are the data adequate to determine a ratio of the effectiveness of the actual storm in producing precipitation to a conceptual storm of "perfect" effectiveness?

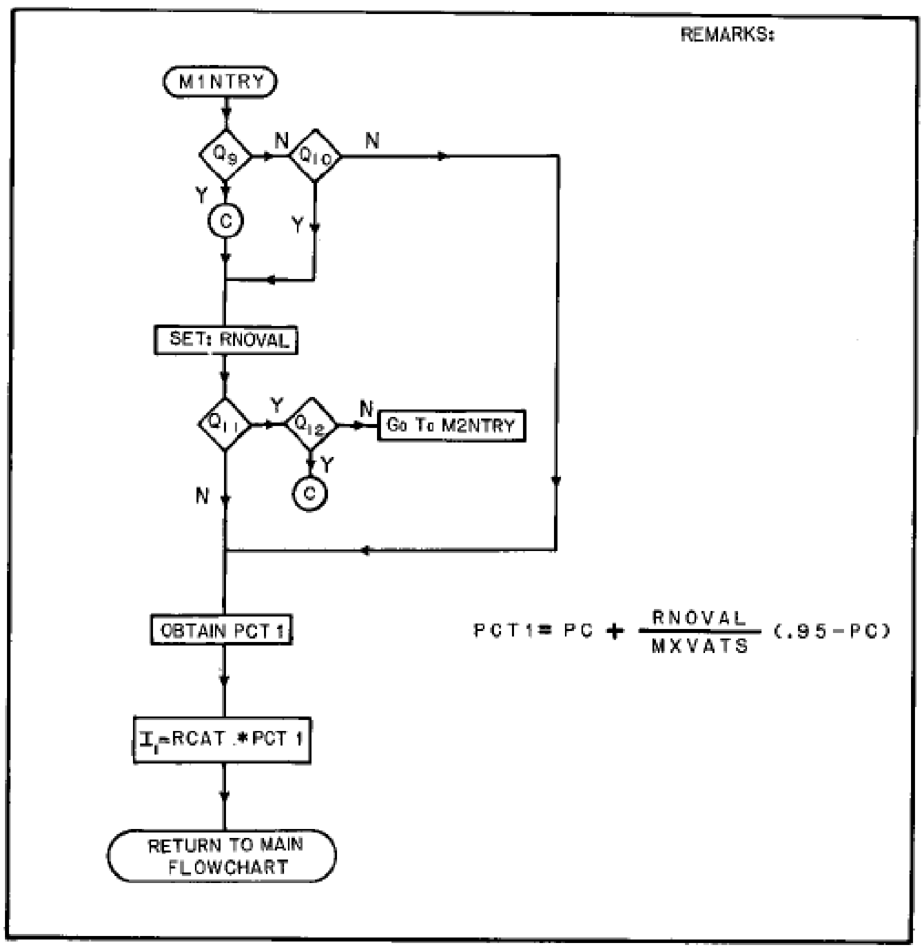


Figure 7.4.--Flowchart for module 1, SSM.

7.4.1.2 Module 1.

An analytical judgment must be made concerning the storm mechanism that resulted in the maximum precipitation over orographic regions and over non orographic regions. Questions asked include the following:

1. Is a review of the data needed?
2. Is the precipitation in the non orographic region equal to the precipitation in the orographic region?

The reliability of the result of this module depends on the density of good precipitation observations on the date the storm occurred.

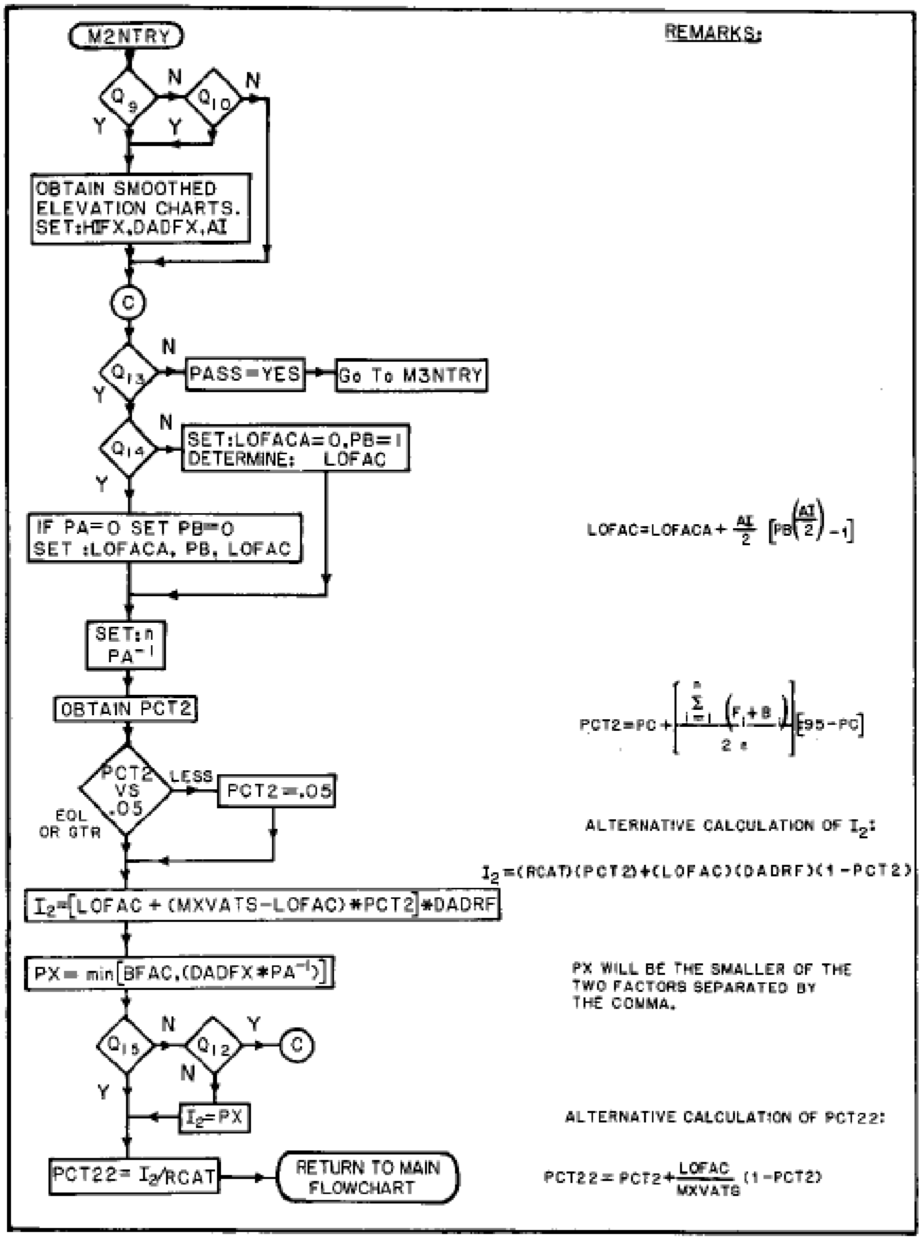
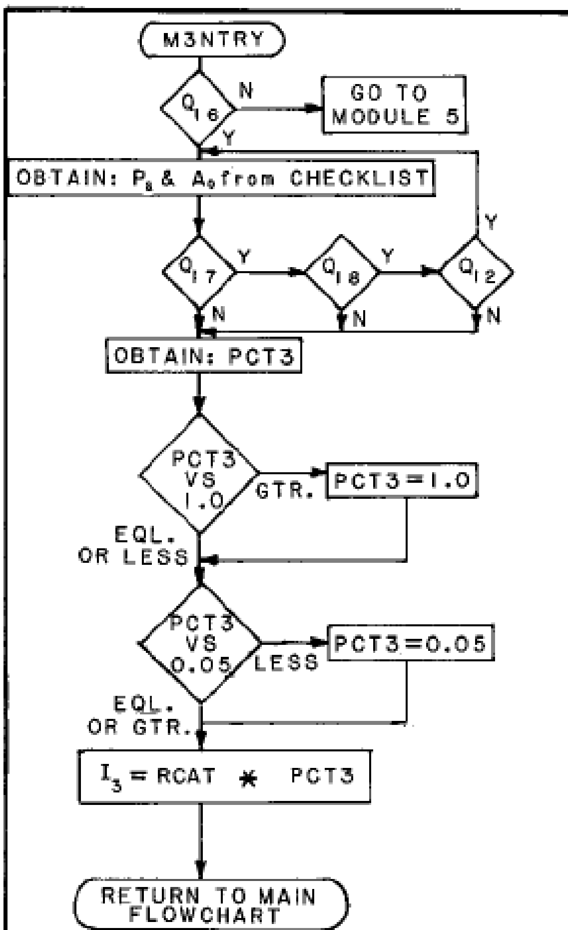


Figure 7.5.--Flowchart for module 2, SSM.

7.4.1.2 Module 2.

In this module, the average depth of precipitation is conceived of a column of water comprised of top and bottom sections. The limit to the top of the bottom section is set by the lowest isohyetal value at which it first becomes clear to the analyst that the topography is influencing the distribution of precipitation depths. The bottom section is conceived to contain only a minimum level of FAFP. The top section contains precipitation that results from orographic forcing or perhaps additional atmospheric forcing. A complex set of judgment questions are asked to evaluate each section. As in module 1, an analytical judgment must be made. Some of questions asked are as follows:

1. Is a review of the data needed?
2. Can it be determined which isohyetal maxima controls the average depth?
3. Is there a good correlation between some isohyet and the elevation contours in the orographic part of the storm?
4. Is the average depth of precipitation that is FAFP less than or equal to the smaller of either the upper limit for FAFP in module 2 or the largest amount of non orographic precipitation caused by the same atmospheric mechanism that produced the average depth of precipitation for the total storm duration for the smallest area size analyzed, provided that it is no larger than 100 square miles?



REMARKS

$$PCT3 = PC + \frac{P_a}{P_a + A_o}(.95 - PC)$$

LEGEND

PVA = Positive Vorticity Advection
MCC = Mesoscale Convective Complex
LEWP = Line Echo Wave Pattern

P_a CHECKLIST

Cat. Data	Parameter	A (√)	B .05-.95	C 1-3	D B*C
Surface	Iso.Ptn. Fronts Waves Sq.Ln. Other				
Upper Air	PVA/SW Cutoff Blocking JetStm Other				
Rawinsonde	Stability Shear Other				
Satellite	Diver. Merger MCC Other				
Radar	LEWP Merger Others				
Other					
Duration (%)				X	X
Totals =					
P_a = Total D/Total C =					

A_o CHECKLIST

Parameter	A Phys. Val.	B 0-±.95	C 1-3	D B*C
Inflow Direct				
Inflow Speed				
Gradient of Elevation				
Stability				
Other				
Duration (%)		X	X	X
Totals =				
A_o = Total D/Total C =				

Figure 7.6.—Flowchart for module 3, SSM.

7.4.1.2 Module 3.

This module uses meteorological and terrain information to evaluate an appropriate level of FAFP. This is accomplished through evaluation of the ratio in which the effectiveness of an actual storm in producing precipitation is compared with a conceptualized storm of "perfect" effectiveness. In such a conceptual model, features known by experience to be highly correlated with positive vertical motions, or an efficient storm structure, would be numerous and exist at an optimum (not always the largest or strongest) intensity level. The presence of one or more features that infer positive vertical motion, or which may contribute toward an efficient storm structure are identified. Then take as a basis for comparison an idealized storm which contains the same features or phenomena and indicate by selecting a number between 0.05 and 0.95, the degree to which the effectiveness of the selected actual storm features/phenomena approaches the effectiveness of the same features/phenomena in the idealized storm. If the quality and quantity of the information permits, the degree of convective-scale forcing may be distinguished from forcing due to larger scale mechanisms. Features may be assigned a weighted value in relationship to others. Meteorological data categories, for which there is not sufficient information from a particular storm, are disregarded in the ratio calculations.

The effectiveness of orographic forcing effects is determined. A vertical displacement parameter is determined using the component of the wind perpendicular to terrain slopes and the slope. The effectiveness is then compared with an idealized value representing 100 percent effectiveness. A stability effectiveness is assigned and combined with the vertical displacement parameter to determine a combined effect. The “model” in module 3 follows the concept that FAFP is directly proportional to the effectiveness of atmospheric forcing and inversely proportional to the effectiveness of the orographic forcing mechanisms.

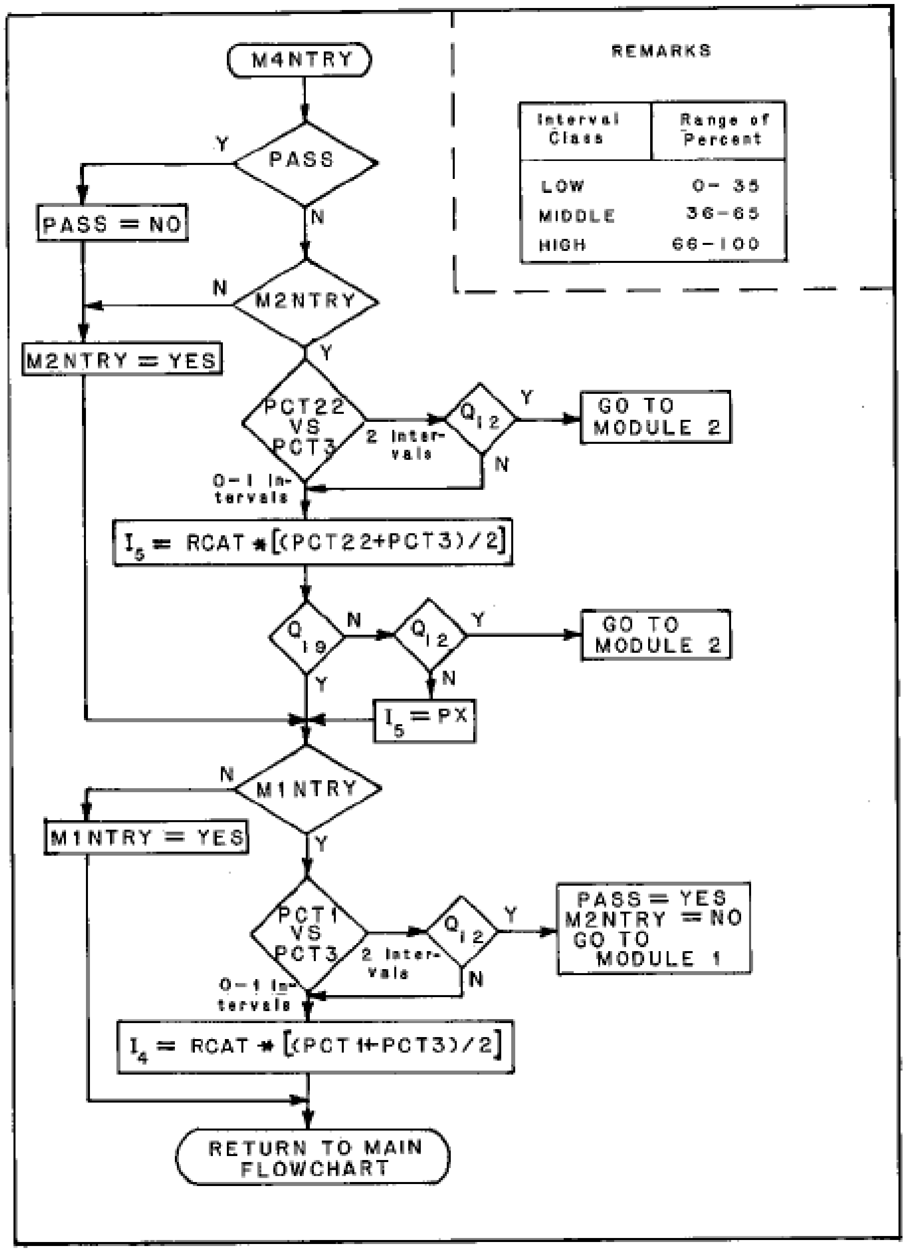


Figure 7.7.—Flowchart for module 4, SSM.

7.4.1.5 Module 4.

A basic assumption underlying the use of module 4 is that better results can be obtained by combining information; i.e., averaging the percentages obtained from the isohyetal analysis with the meteorological analysis and those obtained from analysis of the precipitation observations with the meteorological analysis. Better estimates are produced by averaging when there is little difference in the expressed preference for any one of the techniques or sources of information and, also, when the calculated percentage of FAFP from each of the modules exhibits wide differences.

Little is to be gained from use of the averaging technique over estimates produced by one of the individual analyses of modules 1, 2, or 3 when:

1. There are large differences in the expressed preference for the techniques of one module
2. The sources of information for one of the individual modules is definitely superior
3. The calculated percentages among the modules are in close agreement

DOCUMENTATION AND INDEX SELECTION

STORM ID/DATE, REMARKS:

EVALUATION SCALE: COL.D 0-9; COL.E 1-9 MODULES 1-3: COL.F: IS THE SUM OF COLS. D&E. COL.D: HOW ADEQUATE IS THE INPUT INFORMATION FOR THE REQUIREMENTS SET BY MODULE'S TECHNIQUE. COL.E: HOW LIKELY IT IS THAT THIS TECHNIQUE WILL ESTIMATE THE CORRECT INDEX VALUE BASED ON ITS ASSUMPTIONS? FOR MODULE 4 SEE SELECTION RULE. OVERALL RULE: SELECT INDEX VALUE WITH LARGEST COL. F SCORE. LARGEST SUBSCRIPT BREAKS TIES.

MODULE	PARAMETER	VALUE			REMARKS	D	E	F
ø	CATEGORY							
	RCAT							
	BFAC							
	MXVATS							
	DADRF							
	PA							
	PC							
1	RNOVAL							
	PCT1							
	I_1							
2	AI							
	LOFACA							
	PB							
	LOFAC							
	HIFX							
	DADFX							
	PA^{-1}							
	PX							
	$\sum^{n} (F_i+B_i)$							
	PCT2							
	I_2							
	PCT22							
3	COLUMN	A	B	C				
	INFLOW DIR.							
	INFLOW SPD.							
	GRAD. ELEV.							
	W_o							
	STABILITY							
	A_o							
	SURFACE							
	UPPER AIR							
	RAOB							
	SATELLITE							
	RADAR							
	P_a							
	PCT3							
	I_3							
4	(PCT22 + PCT3)/2							
	I_5							
	(PCT1 + PCT3)/2				RETURN TO MAIN FLOWCHART			
	I_4							

Figure 7.8.--Documentation form for SSM, module 5.

7.4.1.6 Module 5.

Module 5 is used for documentation. Values from the other modules are entered into the module 5 sheet. Assigning values involves subjectivity which must be the case because the "correct" value cannot be known and, hence, there is no way to know which of the various techniques used produces "correct" results most frequently. After a storm has been evaluated in each of the modules, all information is available to assign a value to the question "How likely is it that this technique will estimate the correct value based on the assumptions?" If confidence is high, assign a value of either 7, 8 or 9. If confidence is lower, assign a lower number. The scheme is designed to permit selection of one of the module results when there is a strong preference of one of them. The analyst must make a decision as to which module is to be preferred.

The final value selected for FAFP is determined by the largest value in module 5.

AWA Discussion on HMR 55A Modules

After reviewing the information provided above from Sections 6 and 7 of HMR 55A, several observations and conclusions have been made.

1. The procedures presented in HMR 55A are very detailed and following the procedures is at best very difficult since many of the parameters used are not standard meteorological parameters and their physical meaning is rarely intuitive.
2. The definition of terms in most cases includes other terms unique to this procedure and the relationship among parameters, even when a mathematical formula is provided, is not obvious when trying to associate physical characteristics to the combinations of parameters.
3. The formulas provided appear to have been subjectively derived with no obvious physical parameter associations connected through physical meteorological processes. In some cases, the process can be completed but other than a number to plug into a module, there is no meaning to the numbers that can be associated with the physical processes associated with extreme precipitation.
4. There are numerous places in the procedures where subjective evaluations are quantified with some explicit number where the number is no more than the opinion of the analyst. Then that number is used later in the procedure. In the final module, one of the critical inputs is, in the opinion of the analyst, how likely is it that the technique will estimate the correct value based on the assumptions? Examples of subjective decisions are as follows:
    1) Bi is the "triggering effect" of orography. It is a number between 0.0 and 1.0 representing the degree of FAFP implied by the relative positioning of isohyetal maxima lines with terrain features.
    2) Im is that part of the average depth of precipitation solely attributed to atmospheric processes
    3) LOFACA is the lowest isohyetal value where it first becomes clear to the analyst that topography is influencing the distribution of rainfall depths.
    4) P_a and A_a are ratios in which the effectiveness of an actual storm in producing precipitation is compared with a conceptual storm of "perfect" effectiveness. This is a very interesting subjective decision since if the analyst knew the effectiveness of the conceptual storm of "perfect" effectiveness, then one of the major unknowns in PMP determination is no longer an unknown.

5) The statement is made that the validity of the techniques in the SSM depends on the validity of the concepts upon which they are based. Since the concepts involve many subjective judgments, the SSM procedure is only as valid as those subjective judgments. Unfortunately the validity of those judgments vary from analyst to analyst with no way of objectively evaluating their reliability.
6) Module 4 makes seemingly contradicting statements.
   A basic assumption underlying the use of module 4 is that *better results can be obtained by combining information*; i.e., averaging the percentages obtained from the isohyetal analysis with the meteorological analysis and those obtained from analysis of the precipitation observations with the meteorological analysis. *Better estimates are produced by averaging when there is little difference* in the expressed preference for any one of the techniques or sources of information and, *also,* when the calculated percentage of FAFP from each of the modules exhibits *wide differences*. *Little is to be gained from use of the averaging technique* over estimates produced by one of the individual analyses of modules 1, 2, or 3 when:
      There are *large differences* in the expressed preference for the techniques of one module
      The sources of information for one of the individual modules is definitely superior
      The calculated percentages among the modules are *in close agreement*

The following discussion is extracted from the information provided in HMR 55A for the determination of the orographic factor. The information is condensed to present major discussions. The complete text is available in Section 9 of HMR 55A.

HMR 55A Section 9.2 Orographic Factor, T/C

Maps of 100-yr 24-hr precipitation from NOAA Atlas 2 were used to form a ratio of total 100-yr to convergence component 100-yr rainfall, T/C, and it was assumed that this ratio related to a ratio of similar parameters for PMP. The ratio of T/C can be used as a representative index of orographic effects.

The availability of the 100-yr 24-hr maps provides only part of the needed ratio, the total rainfall or numerator in the fraction, and it remains to determine how to obtain the convergence component, C. The rationale followed was that isopleths of the convergence component would exhibit a smooth, gradually varying geographic pattern. The gradients and general geographic variation would be somewhat similar to the FAFP component. HMR 51 has smooth PMP lines east of the 105th meridian and is assumed to be convergence only PMP, so NOAA Atlas 2 isopluvials for this region are also assumed to be convergence only.

The approach taken to determine C is to look at the 100-yr precipitation analysis for zones of least topographic effect. These zones would be tied together in some form of smooth analysis. A rough pattern of smooth contours was sketched. This provides a map of C. Using NOAA Atlas 2 and the map of C, T/C can be computed.

HMR 55A Section 9.3 Storm Intensity Factor, M

A storm intensity factor adjustment, M, was developed to relate the amount of precipitation that could be expected during the most intense precipitation period to the total amount of precipitation for a period. M varies with storm type.

The 6-hr interval was determined as the duration of the most intense precipitation period with the base period being the 24-hr duration. The storm intensity factor was defined as the ratio of rainfall in the maximum 6-hr period to the rainfall in the basic 24-hr period. M is obtained by dividing the FAFP for 6 hours by the FAFP for 24 hours.

By combining the results of the FAFP, T/C and M evaluations, then PMP can be computed using the FAFP and an orographic influence parameter, K. K is a function of the orographic factor, T/C. PMP is represented as the sum of two parts representing the core period and the remaining period. Through some mathematical combinations,
$PMP = (FAFP)\ (K) = (FAFP)(M^2\ (1\text{-}T/C) + T/C)$

AWA Discussion on HMR 55A Section 9

After reviewing the information provided above from Section 9 of HMR 55A, several observations and conclusions have been made.

1. NOAA Atlas 2 is based on statistical analyses of precipitation data observed within the NOAA Atlas 2 domain. Although NOAA Atlas 2 is being updated for various regions in the United States, it is the current return frequency analysis for this region and is based on evaluation of rainfall data, and hence has a basis for being objectively derived from rainfall observations.
2. C is the 100-year 24-hour convergence only component of rainfall. It is assumed that for regions where there is least orographic influence, NOAA Atlas 2 values approximate C. For regions where there is significant orographic influences, C is subjectively estimated since there are no observational data that provide only the convergence component of observed rainfall. Hence, C much like FAFP, is derived using very limited data and subjective analyses over regions where orographic influences are significant.
3. The M factor also has subjective decisions incorporated into its determination. The duration of the core rainfall period seems to be subjectively derived. For locations where a core period cannot be identified, M = 0.

4. For storms without large core precipitation periods, i.e. where M is small or 0, PMP is primarily dependent on FAFP, T and C. While T has basis for being objectively derived, FAFP and C are largely subjective determined. Hence PMP values computed using the SSM provide highly subjective PMP values.

HMR 57 SSM Application

Section 6 Storm Separation Method

The technique for developing FAFP used in HMR 55A is complex and involves the analyst tracking through a set of modules in which knowledge of observed conditions and experience are used to arrive at estimates of FAFP. The estimates are in turn weighted, based on the analyst's judgment of the amount and quality of overall information to obtain a result.

The SSM has undergone minor refinements since its development in HMR 55A. A decision about the level of FAFP for a storm may have to accommodate a fair amount of uncertainty. The questions asked in the SSM modules are formulated in such a way that analysts with different levels of experience could estimate different amounts of FAFP. Under such circumstances a consensus among analysts often leads to the best FAFP estimate for a storm, but the consensus process is not a necessary part of the SSM.

The SSM technique was considered most appropriate for the present study (HMR 57). The technique was applied directly according to original guidance, subject to modifications. A discussion is provided in HMR 57 with the comment that the discussion covers specific changes in details that may be beyond the casual reader's interest. Module 2 was not used to analyze any of the storms but the other modules were used to determine FAFP.

A map of C was constructed using regions of relative minima in the 100-year return frequency map. This was used together with the 100-year return frequency map to compute T/C. For some locations, the T/C maps were subjectively adjusted. The M-Factor for western Washington was determined to be zero so the K factors became T/C.

AWA Discussion on HMR 57 SSM Application

After reviewing the information provided above from Sections 6, 7 and 8 of HMR 57, several observations and conclusions have been made.

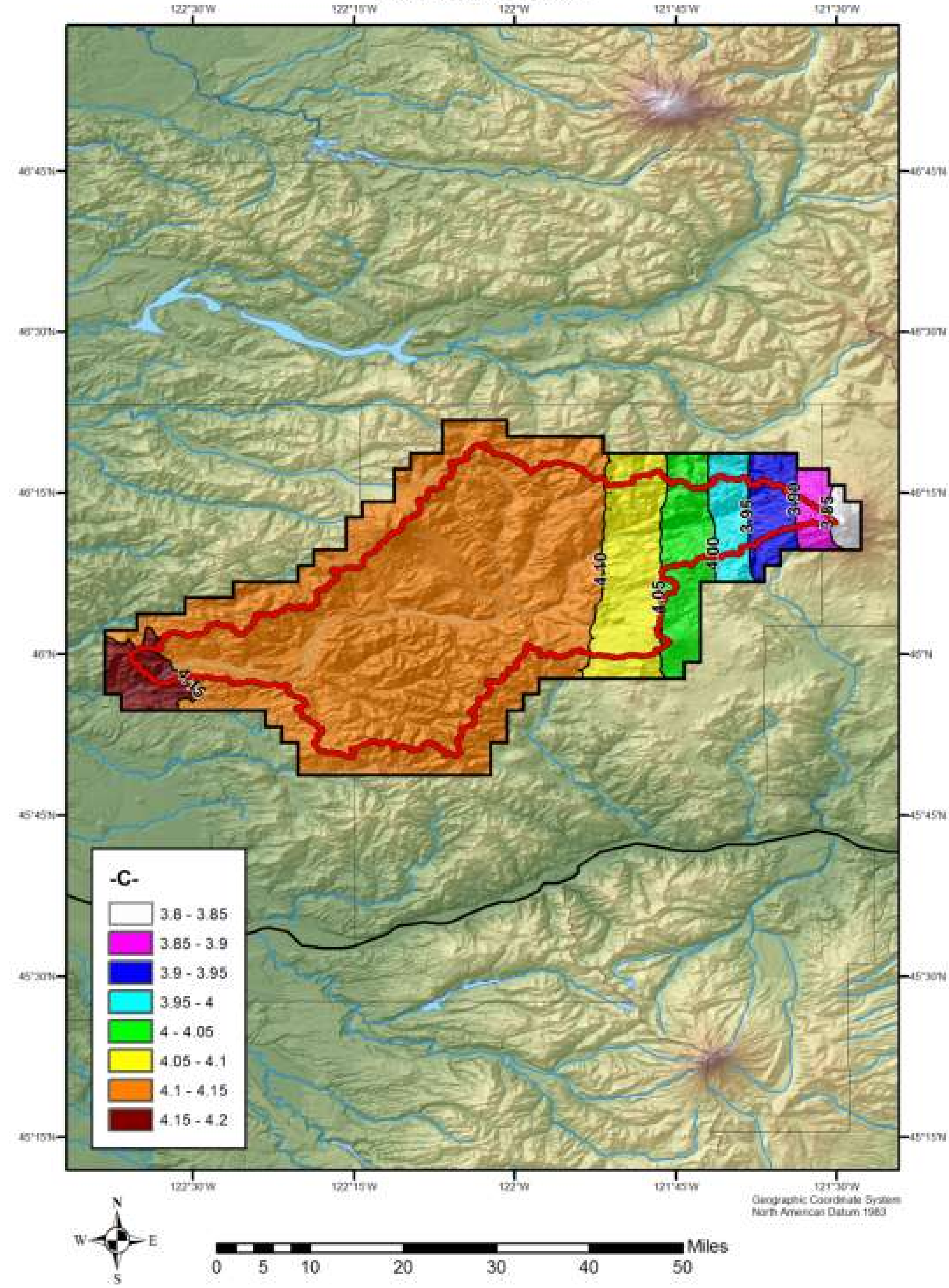
1. The discussion in Section 6 emphasizes that the SSM is complex, involves tracking through a set of modules in which knowledge of observed conditions and experience are used to arrive at estimates of FAFP, estimates are based on the analyst's judgment, and that there is a fair amount of uncertainty indicating that the authors of HMR 57 recognized major issues with the SSM. However, it was applied directly according to the original guidance in HMR 57.

2. The T/C maps were adjusted subjectively with no documentation on what adjustments were made or why.

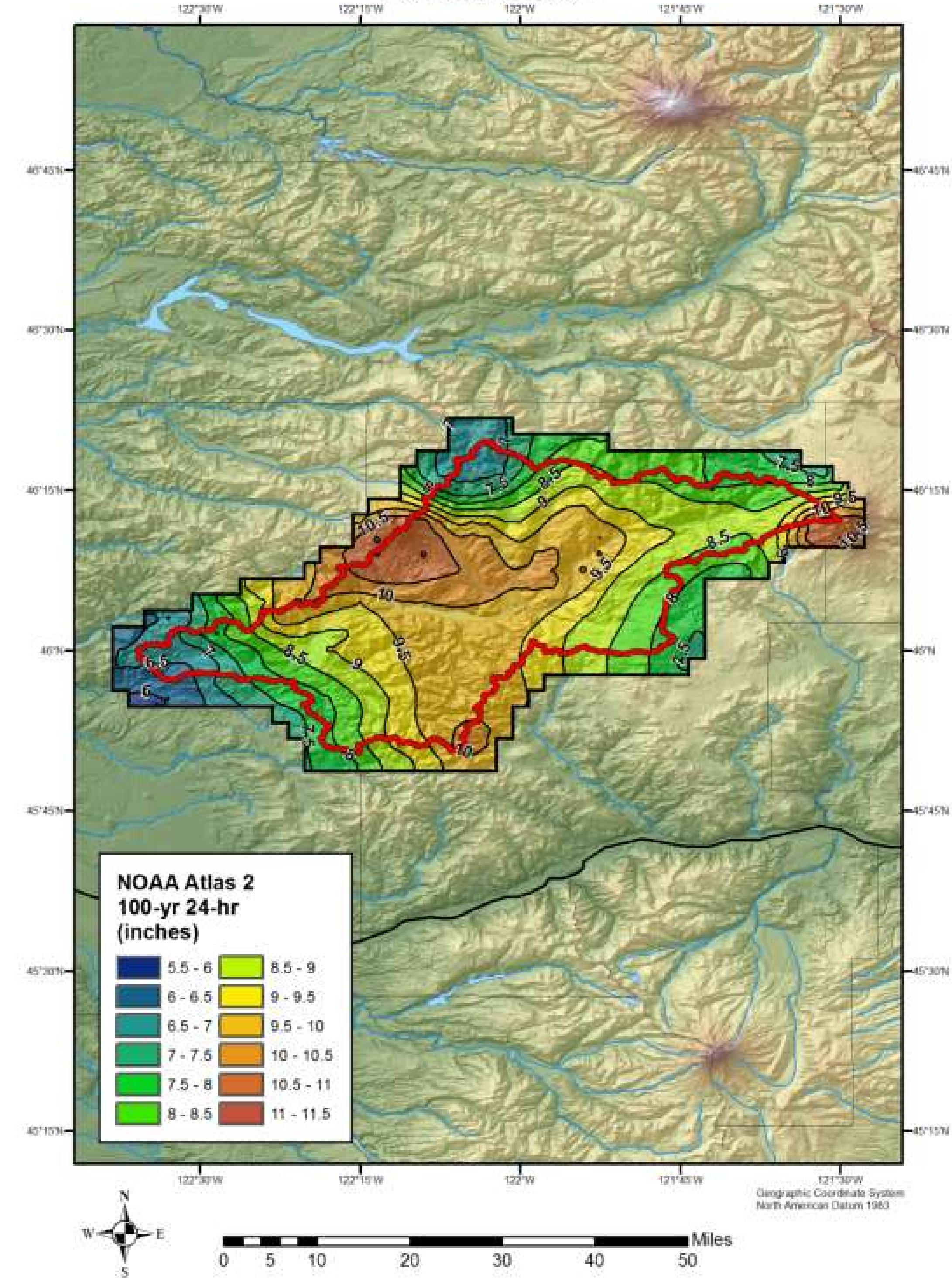
As discussed earlier, the maps used for FAFP, C and M for computation of PMP in HMR 57 are not available from the HSDC. However, low resolution example maps are published in HMR 57 for these parameters that cover western Washington. Figure 8.1 shows the C map, Figure 8.2 shows the T/C map, Figure 8.3 shows the M factor map and Figure 8.4 shows the orographic factor K map for the Lewis River basin in southern Cascades of Washington state. These maps were digitized in GIS for analysis. Using the formulas in HMR 57 Chapter 8, maps were produced from the digitized figure maps to compare with the maps shown in HMR 57. The Lewis River drainage basin in southern Washington was the domain used for the comparisons.

NOAA Atlas 2 provides the map for the 100-year 24-hour T values. Using the map of C from HMR 57 Figure 8.1, a map of T/C was computed. Since HMR 57 Figure 8.3 shows that M=0 for the Lewis River Basin, K=T/C. The computed T/C map was compared with HMR 57 Figure 8.4 (HMR 57 K). The NOAA Atlas 2 map, the HMR 57 maps for C and K, and the computed maps for K are shown below. The HMR 57 K map was compared with the computed K map and a percentage difference map is shown.

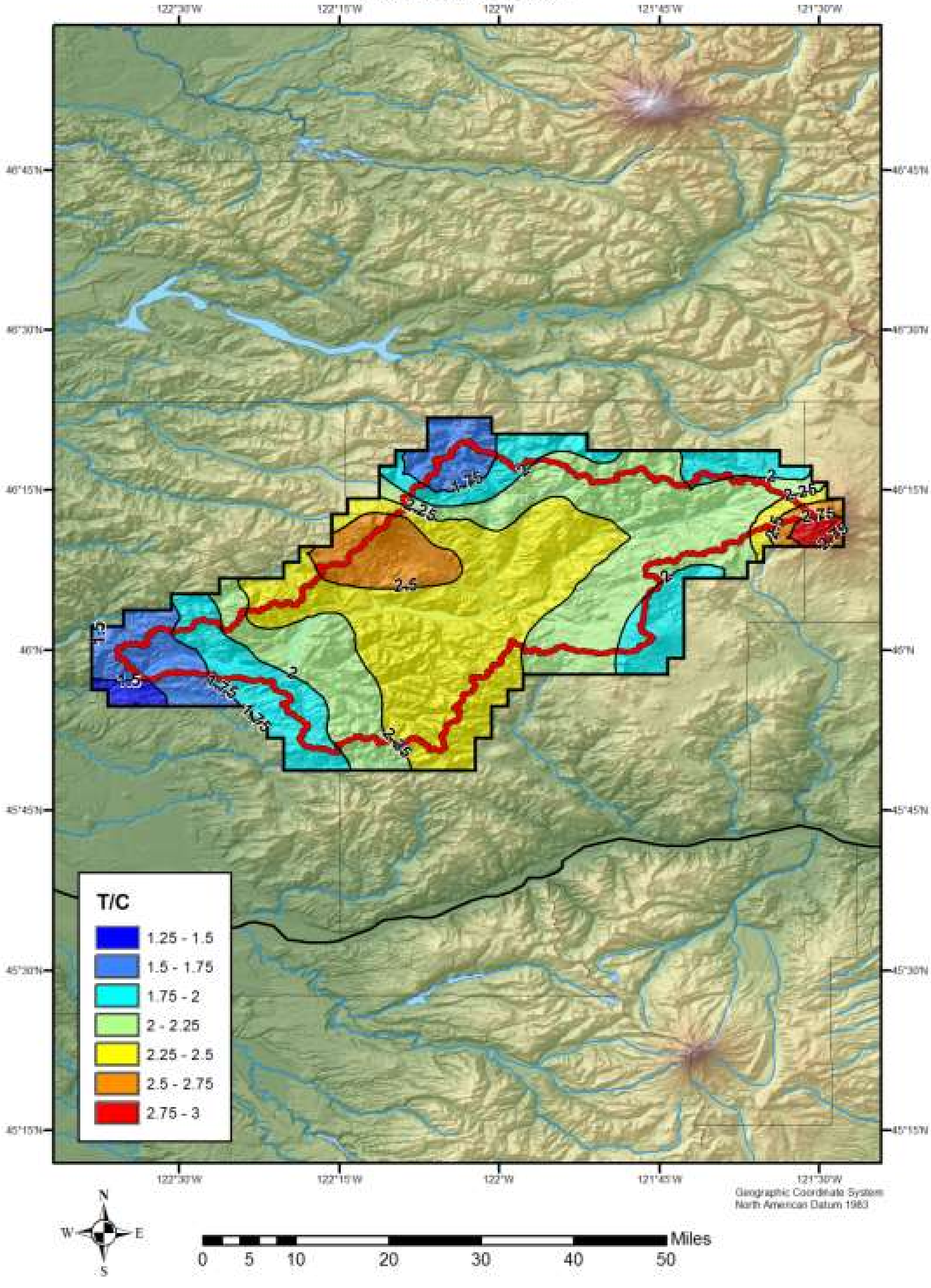
HMR-57 C (from fig 8.1)
Lewis River Basin

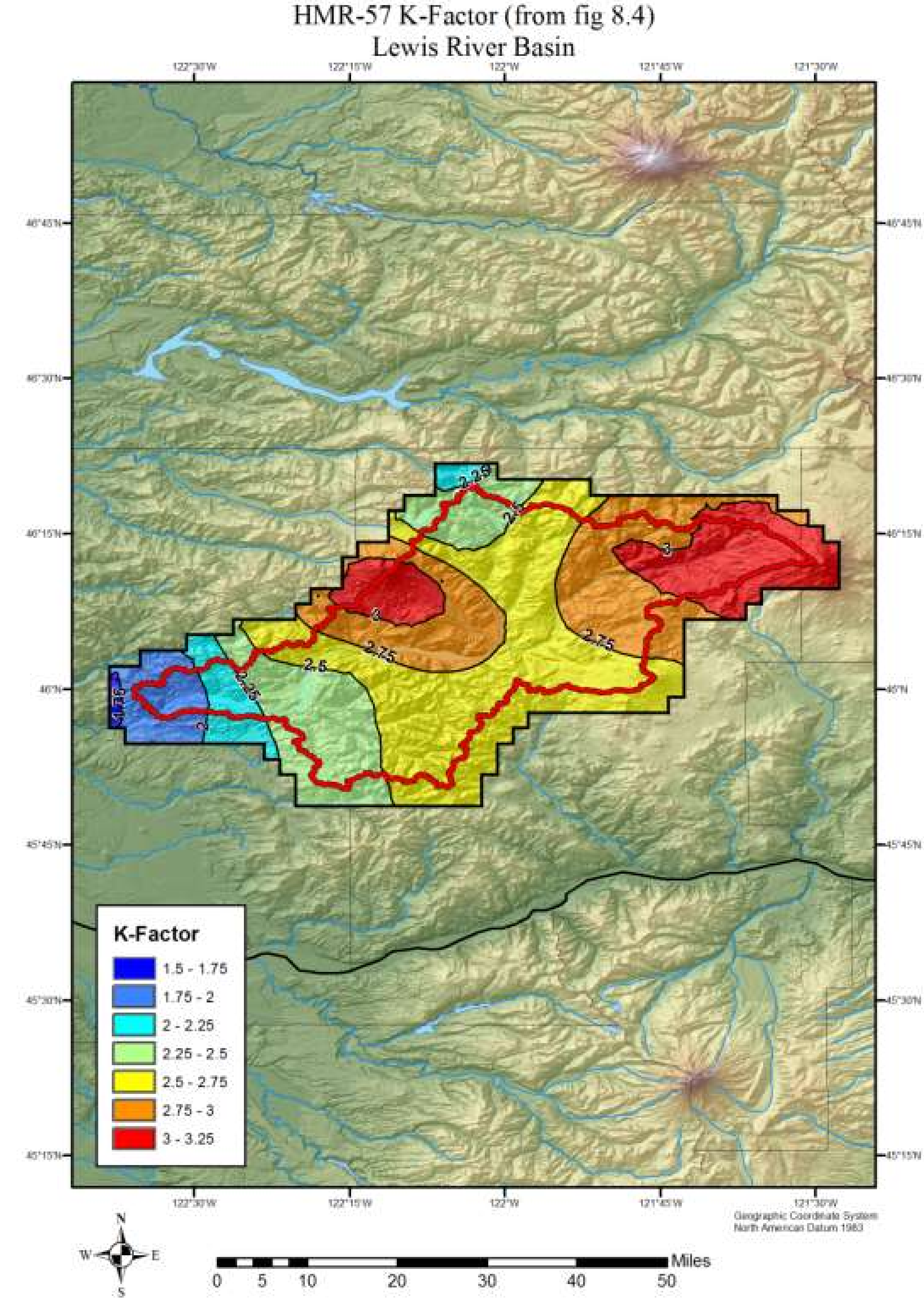


NOAA Atlas 2 100-year 24-hour Precipitation
Lewis River Basin



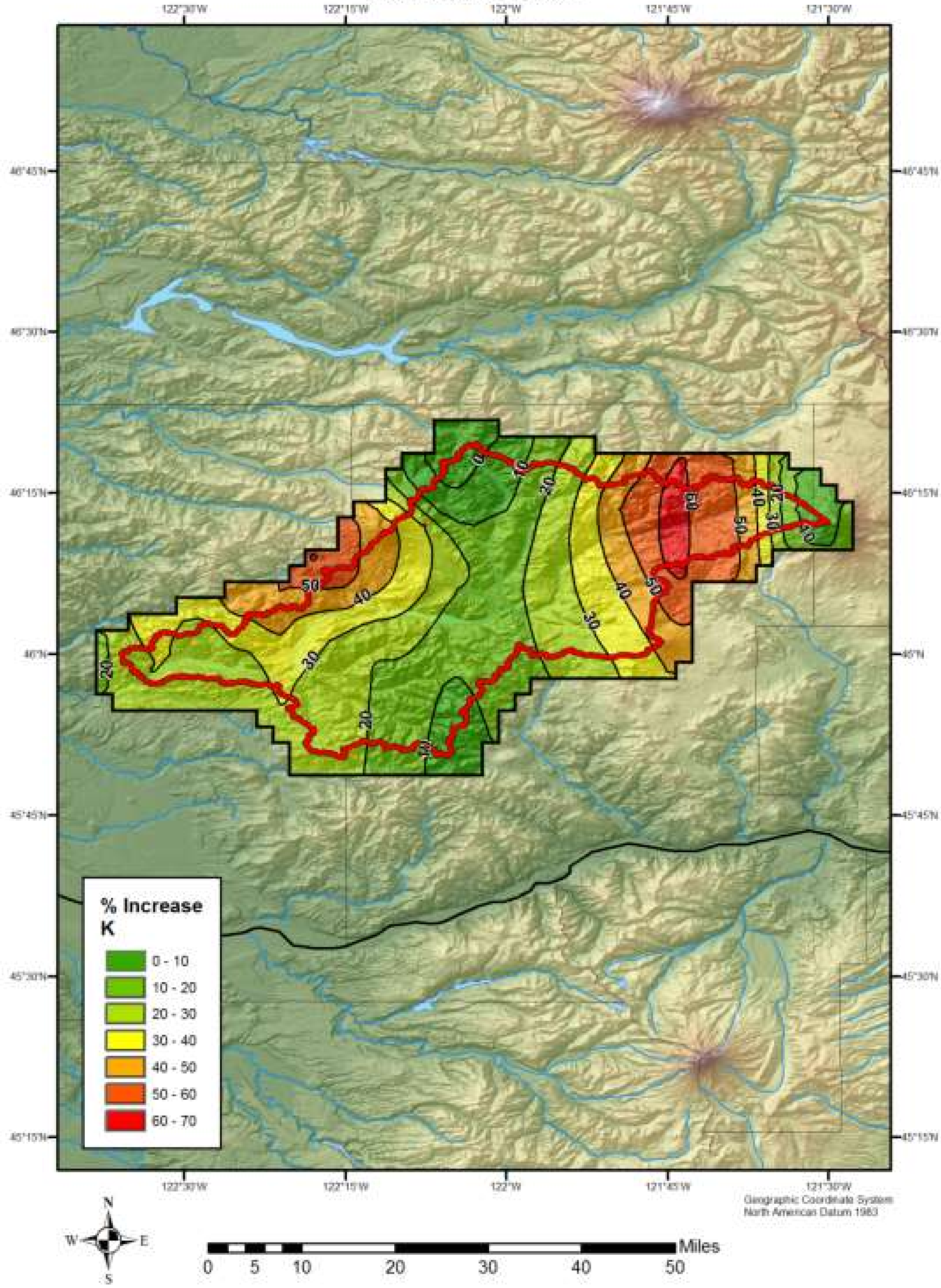
T/C - (NOAA Atlas 2 100-year 24-hour Precipitation ÷ HMR 57 C)
Lewis River Basin





HMR-57 K-Factor (from fig 8.4)
Lewis River Basin
122°30'W
122°15'W
122°W
121°45'W
121°30'W
46°45'N
46°30'N
46°15'N
46°N
45°45'N
45°30'N
45°15'N
2.25
2.5
3
2.75
2
K-Factor
1.5 - 1.75
1.75 - 2
2 - 2.25
2.25 - 2.5
2.5 - 2.75
2.75 - 3
3 - 3.25
Geographic Coordinate System
North American Datum 1983
N
W
E
S
Miles
0
5
10
20
30
40
50

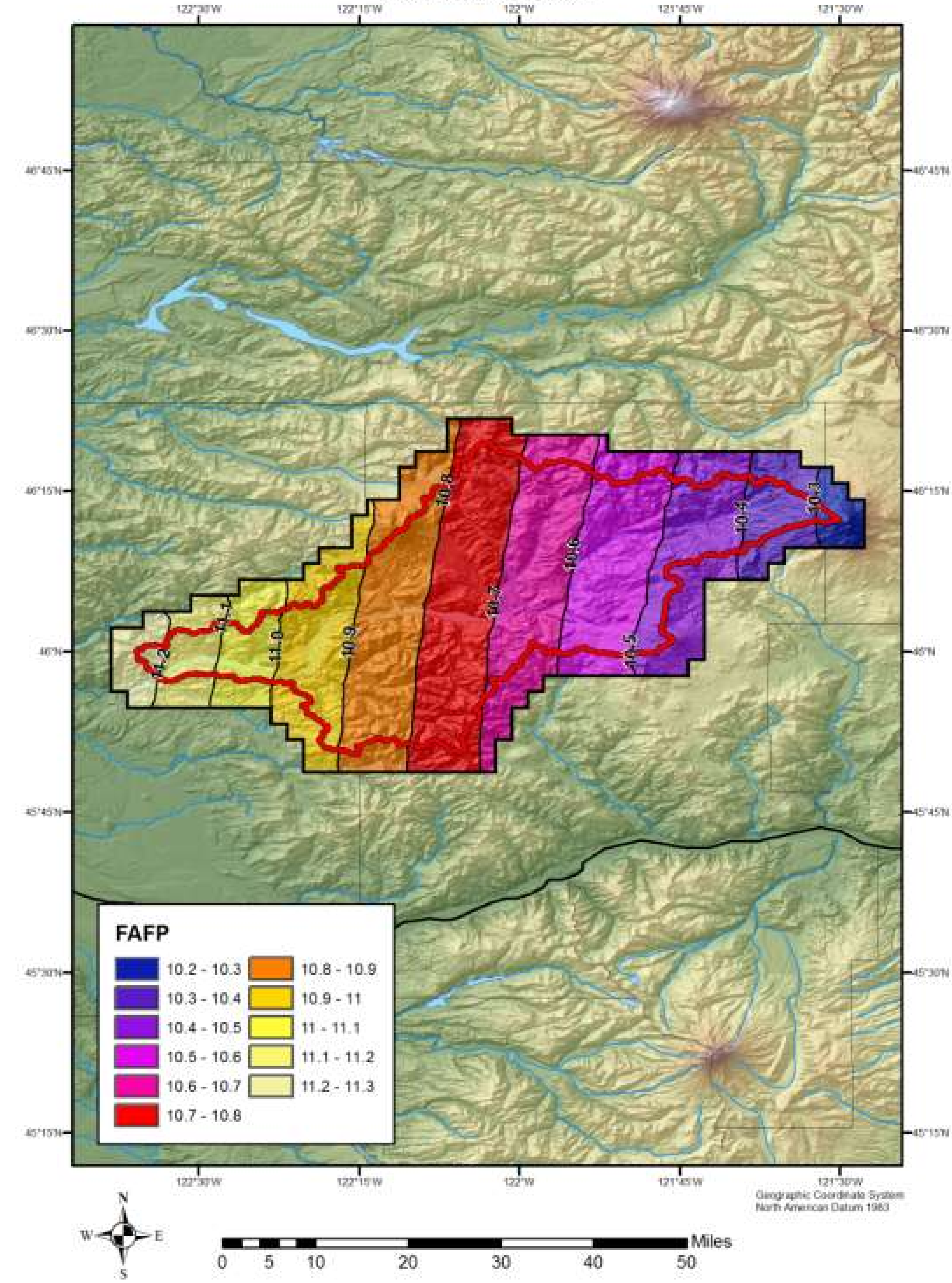
Percent Increase of HMR 57 K Values from T/C Values
Lewis River Basin



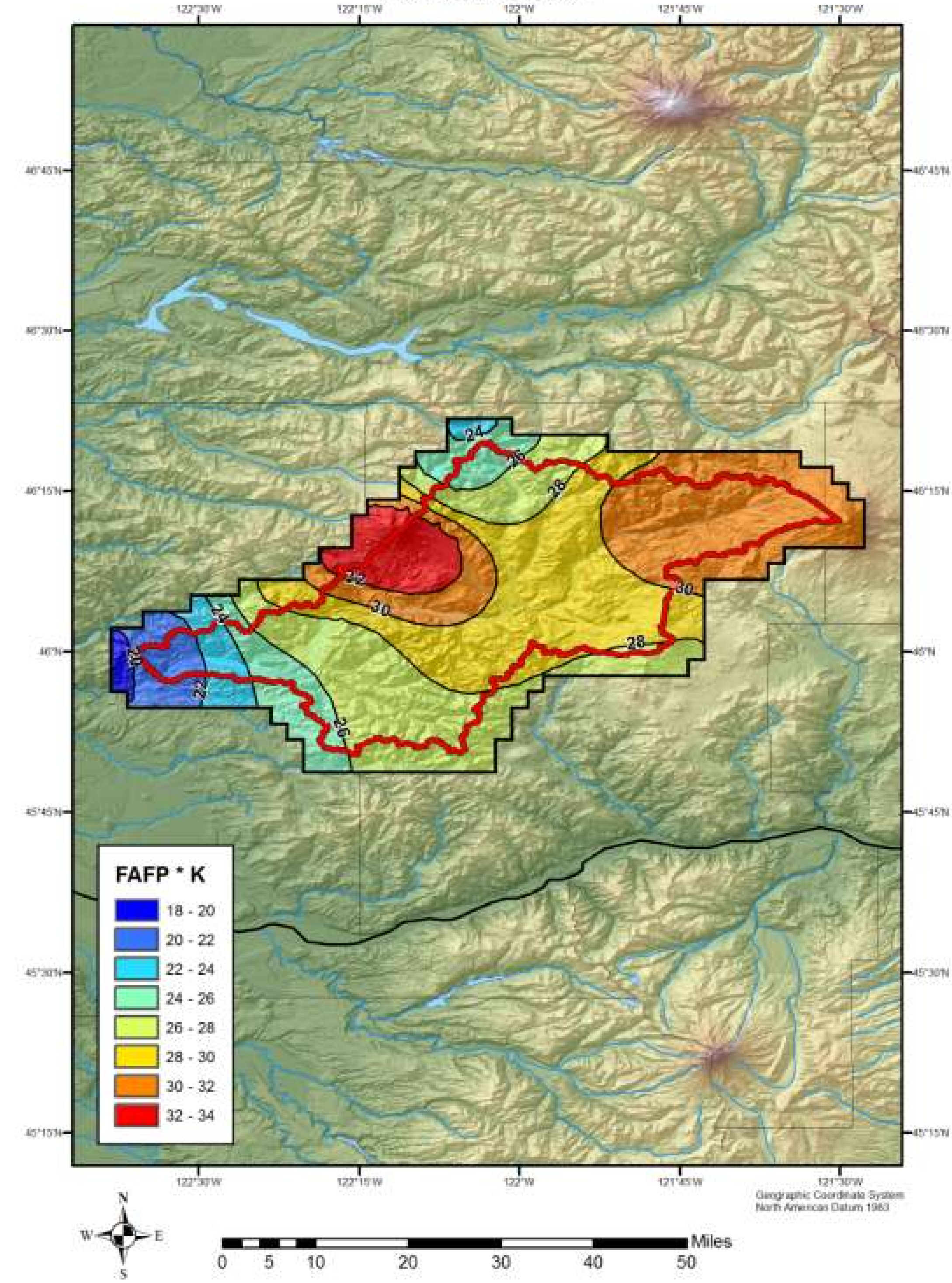
The comparison between the computed K map and the HMR 57 K map shows significant differences. Overall the computed K values are significantly smaller than the K values from HMR 57. The differences range from about 10% to over 60% with the HMR 57 values being consistently larger.

Having values for FAFP from HMR 57 Figure 7.2 and values for K from Figure 8.4, a map of PMP can be constructed using PMP = (FAFP) (K). Figures showing these values are show below along with HMR 24-hour 10-mi^2 PMP values.

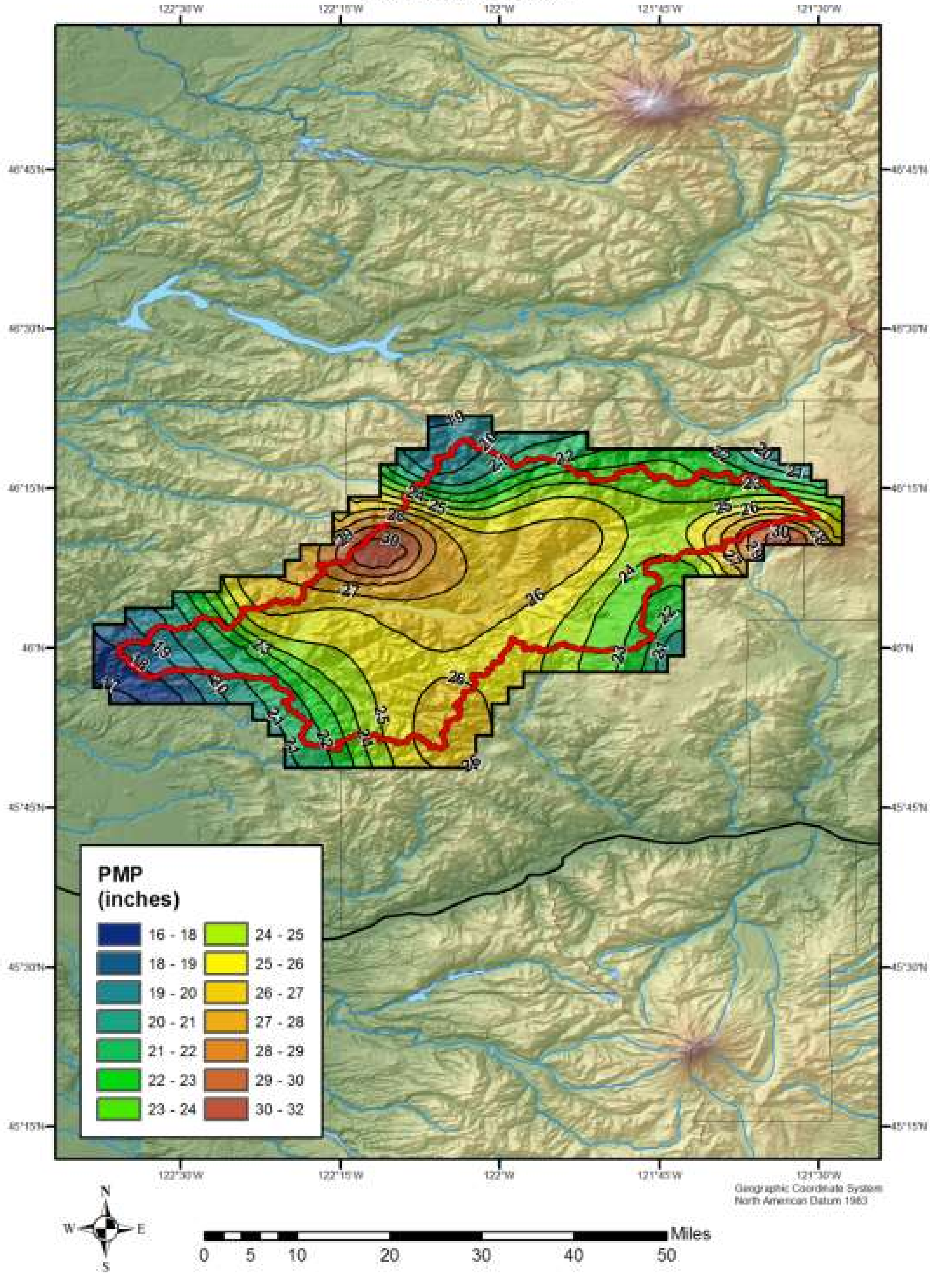
HMR-57 FAFP (from fig 7.2)
Lewis River Basin



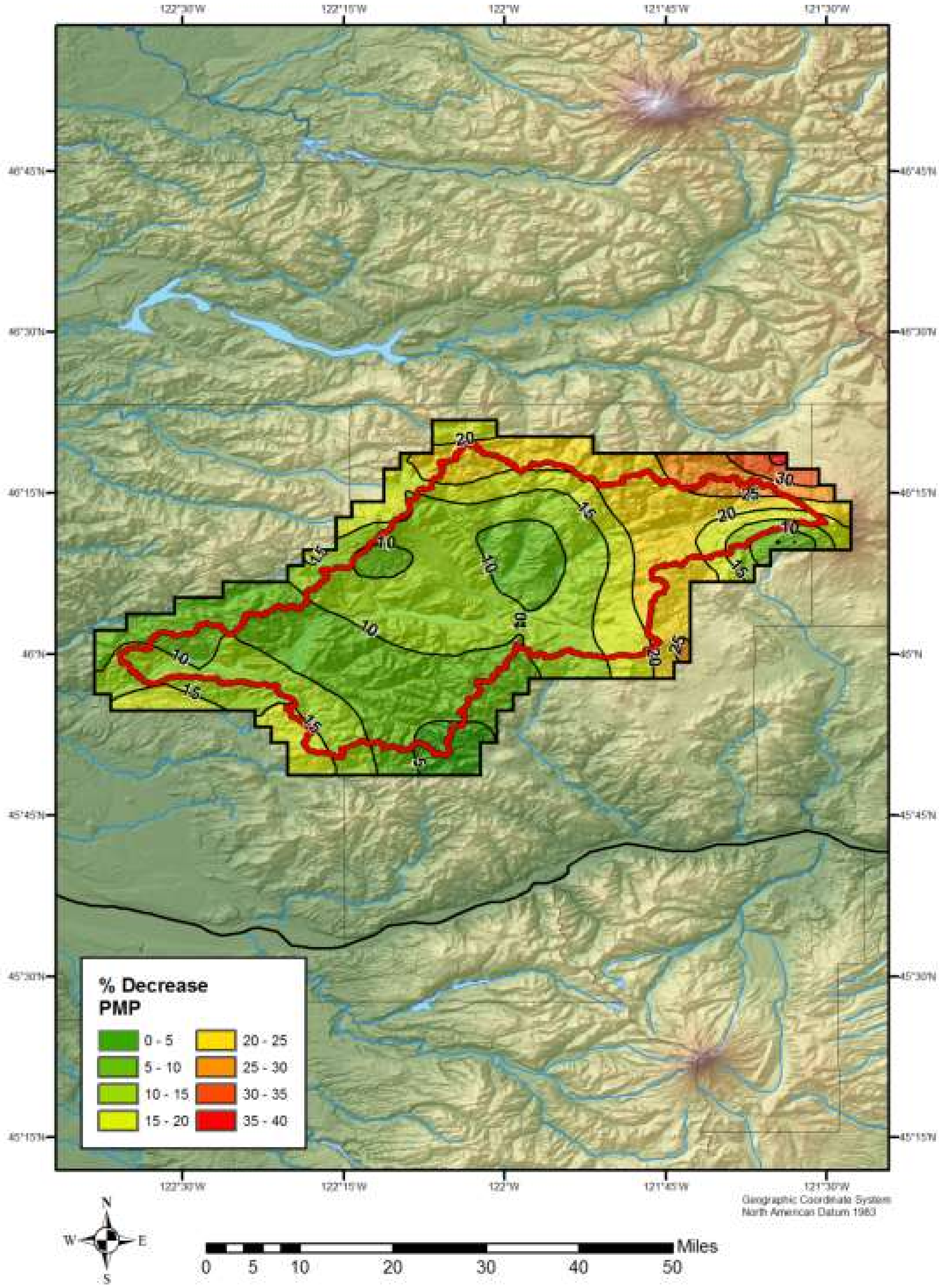
[HMR 57 FAFP] * [HMR 57 K]
Lewis River Basin



HMR-57 24-hour PMP
Lewis River Basin



Percent Decrease in HMR 57 24-hr PMP Values from HMR 57 (FAFP * K) Values
Lewis River Basin



The comparison between the computed PMP map and the HMR 57 PMP map also shows significant differences. Overall the computed PMP values are larger than the PMP values from

HMR 57. The differences range from about 7% to over 25% with the HMR 57 values being consistently smaller.

The reasons for these differences are not known. It appears that after the highly subjective SSM procedure is followed, significant changes are manually made to the SSM maps and to the resulting maps of PMP produced using the SSM maps. The conclusion is made that for the Lewis River drainage basin domain, the SSM maps published in HMR 57 cannot be objectively duplicated and using the HMR 57 maps of SSM parameters, the HMR 57 PMP values cannot be objective duplicated.

HMR 59 SSM Application

A similar exercise was completed in the HMR 59 domain in and around the Piru Creek region and the Piru Creek drainage basin in southern California was used as the domain to compare computed maps with HMR 59 maps. Again none of the HMR 59 maps used to compute PMP was available from HDSC. Example low resolution maps for T/C (Figure 6.4), M-factor (Figure 6.5), and the K factor (Figure 6.6) for southern California are included in HMR 59. Unfortunately, the example map for FAFP (Figure 6.3) was for northern California and no example map of C is included in HMR 59. Therefore comparisons of computed maps with HMR 59 maps are limited.

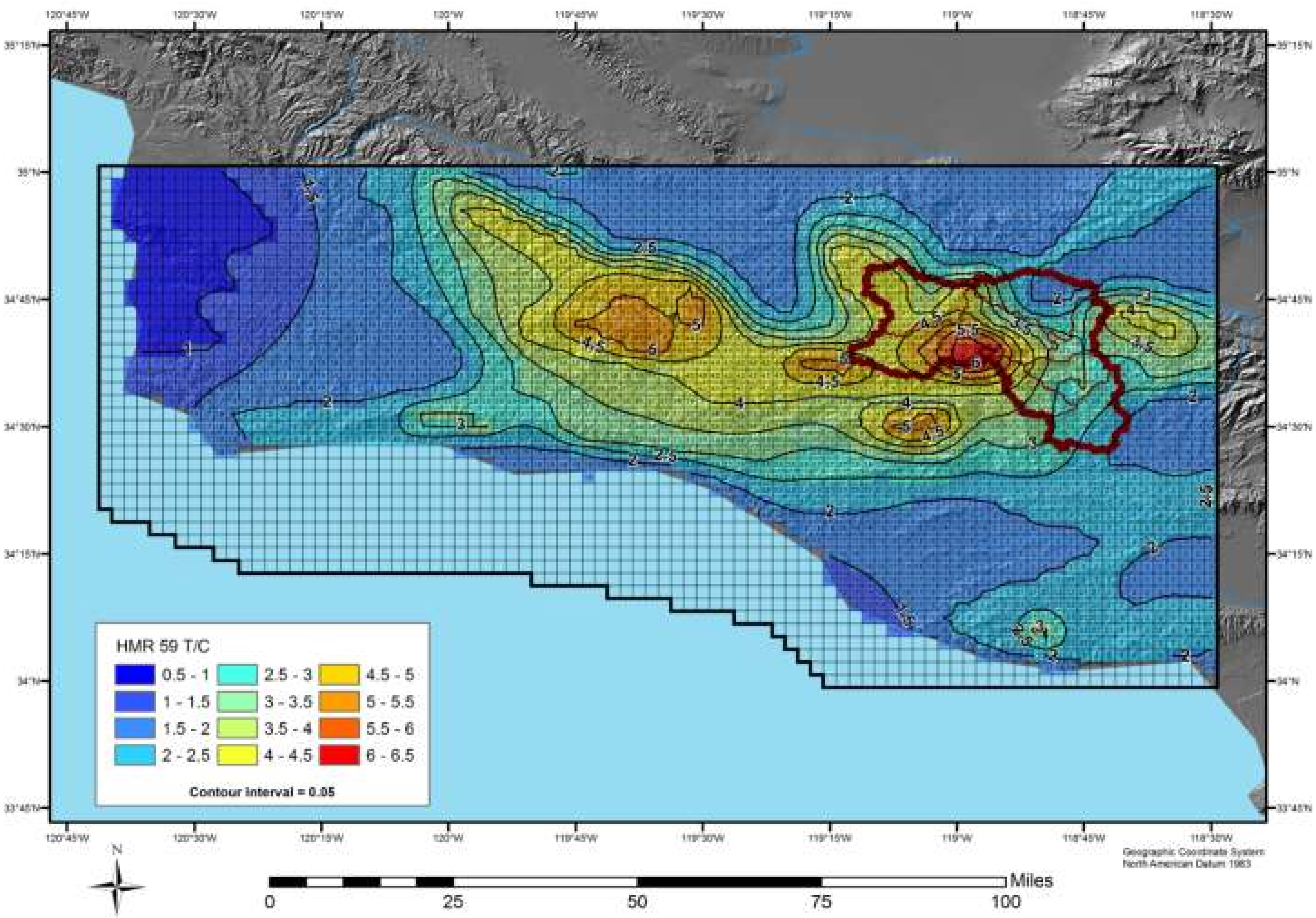
Using the example maps in HMR 59, maps for C and FAFP can be constructed. Unfortunately by constructing these maps, independent comparisons with HMR 59 maps is not possible. Figure 6.4 provides a map of T/C. By inverting the values on this map, a map of C/T was produced. That map is then multiplied by the NOAA Atlas 2 map (T) to produce a map of C. The M-factors for the Piru Creek drainage basin can be determined from Figure 6.5 and of course the PMP values for the Piru Creek domain are available from the HMR 59 PMP maps. Using Equation 6-5 from HMR 59,

$$K = M^2 (1 - (T/C)) + T/C$$

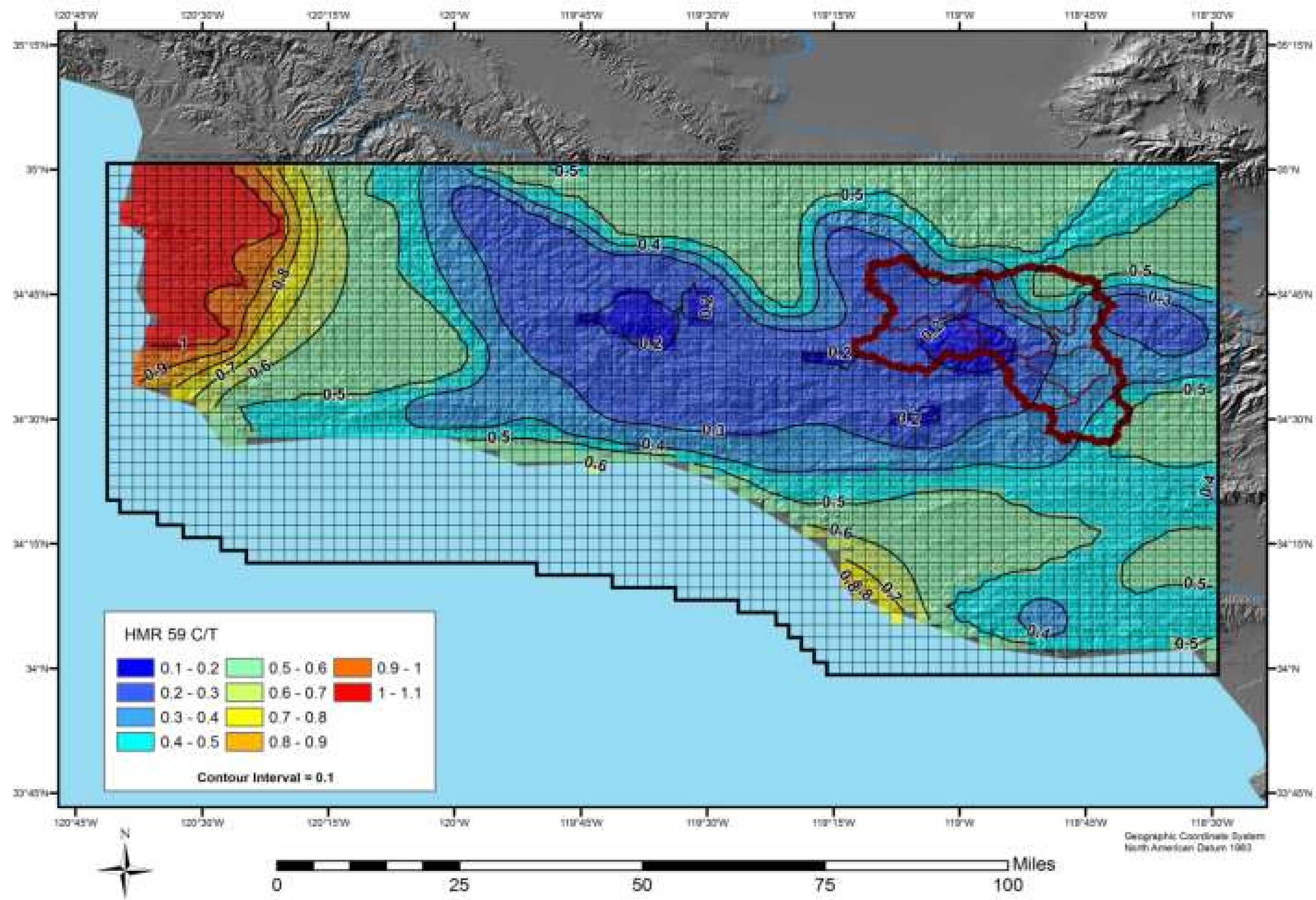
a computed map of K can be constructed.

HMR 59 maps and computed maps are shown below:

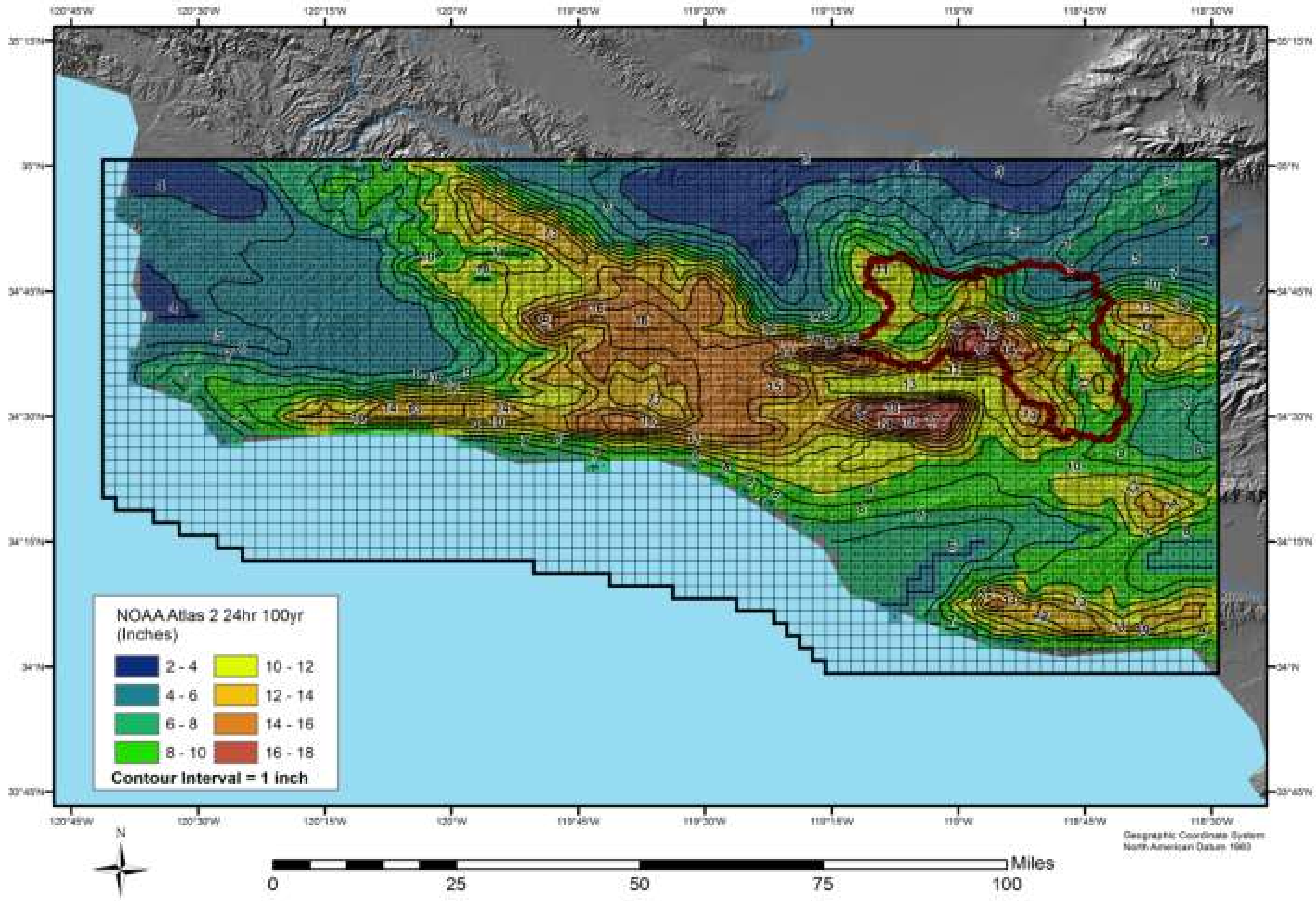
HMR 59 T/C


HMR 59 T/C
0.5 - 1
1 - 1.5
1.5 - 2
2 - 2.5
2.5 - 3
3 - 3.5
3.5 - 4
4 - 4.5
4.5 - 5
5 - 5.5
5.5 - 6
6 - 6.5
Contour Interval = 0.05
Geographic Coordinate System
North American Datum 1983
Miles
0
25
50
75
100

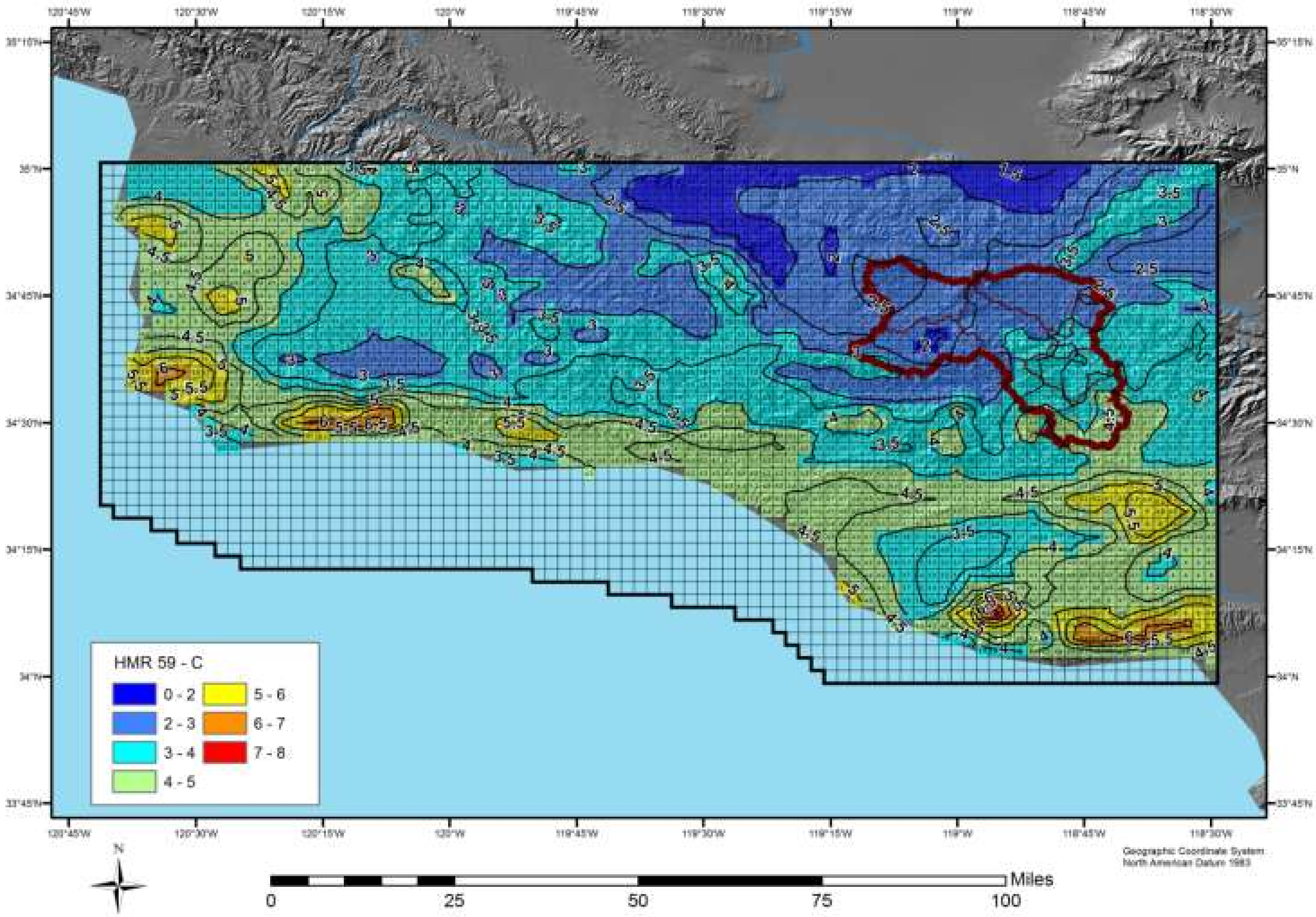
HMR 59 C/T


HMR 59 C/T
0.1 - 0.2
0.2 - 0.3
0.3 - 0.4
0.4 - 0.5
0.5 - 0.6
0.6 - 0.7
0.7 - 0.8
0.8 - 0.9
0.9 - 1
1 - 1.1
Contour Interval = 0.1
Miles
0
25
50
75
100
N

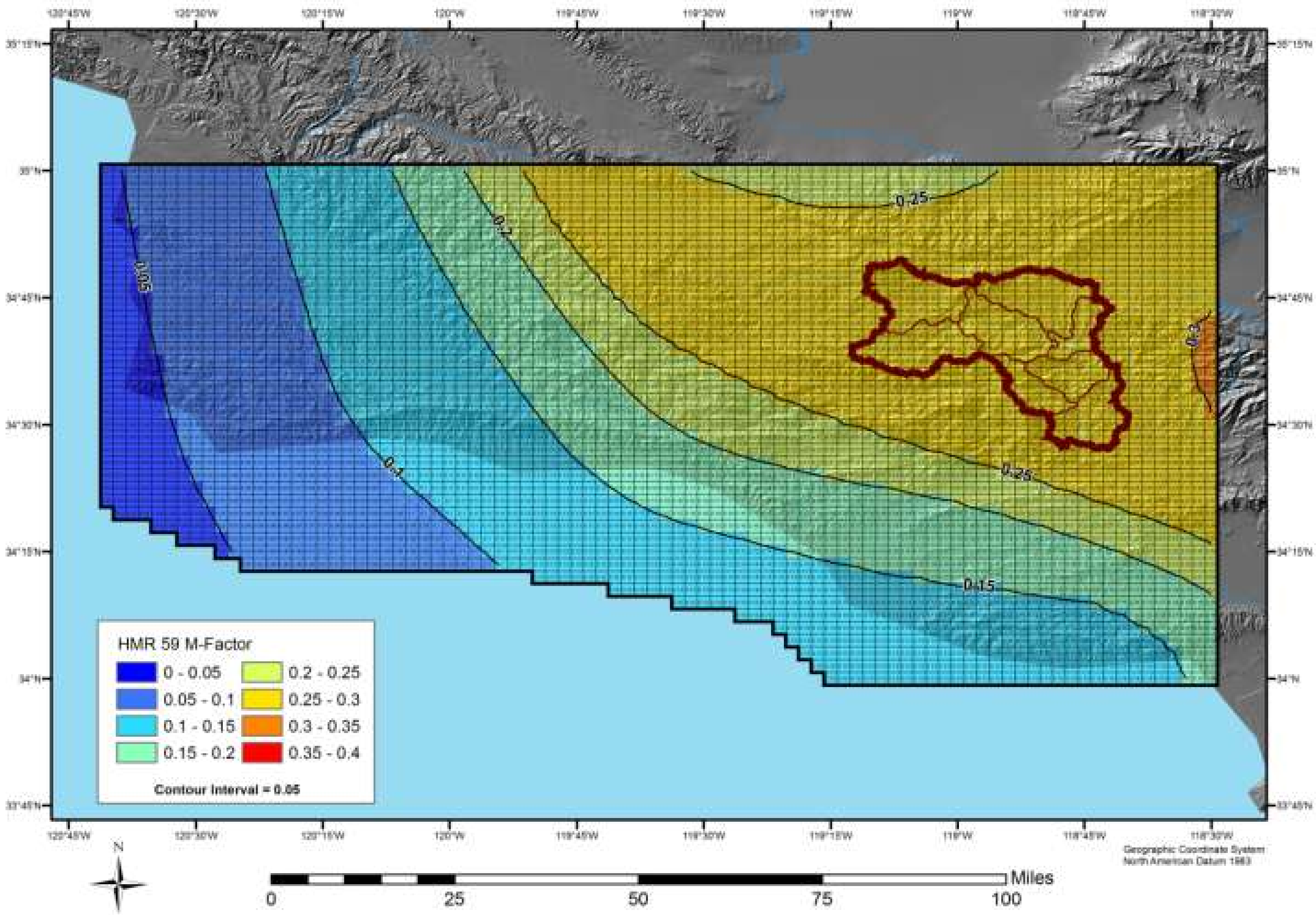
NOAA Atlas 2 - 24-hour 100-year Precipitation Frequency Estimates



HMR 59 100-year Convergence Component "C"

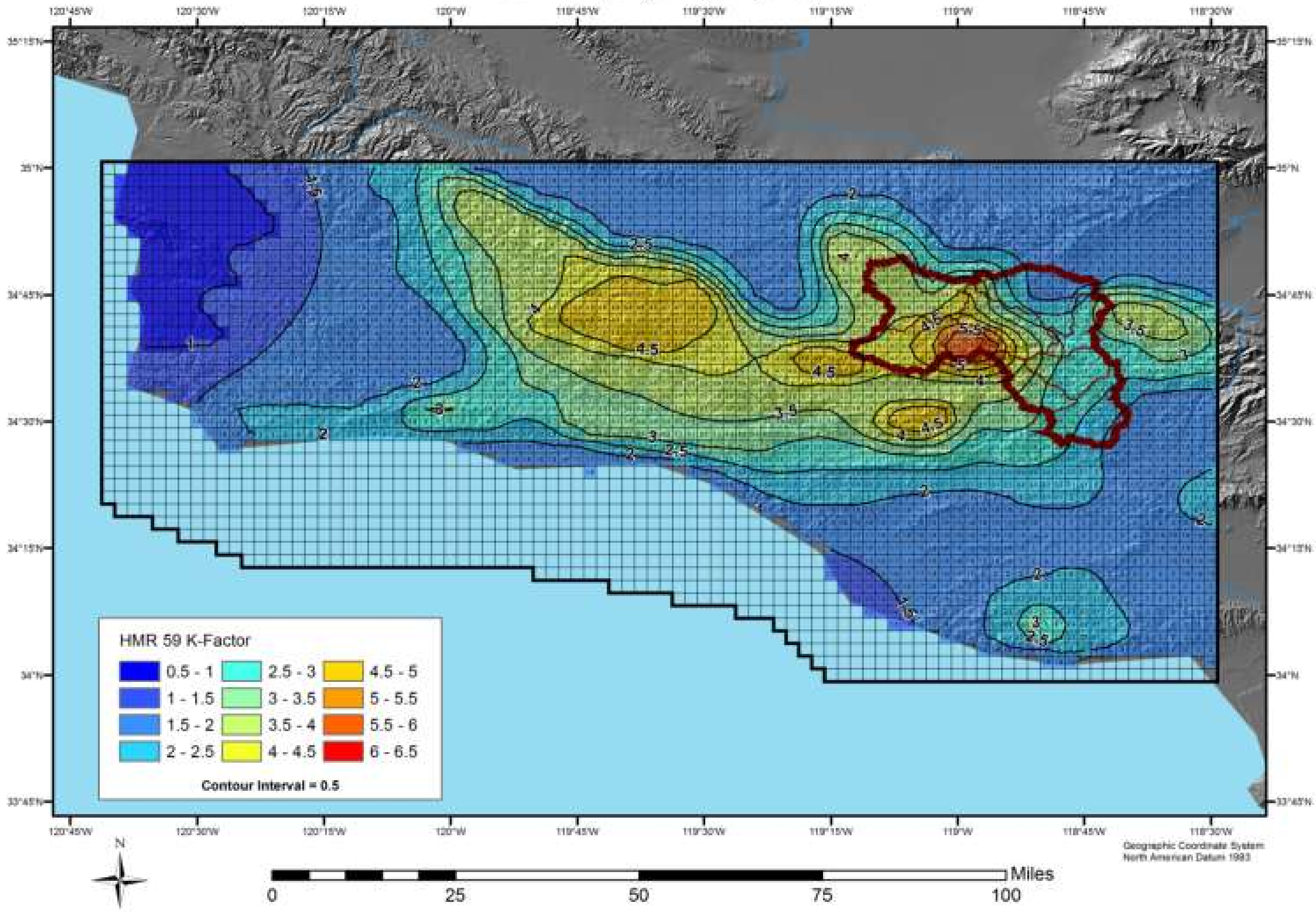


HMR 59 M-Factor

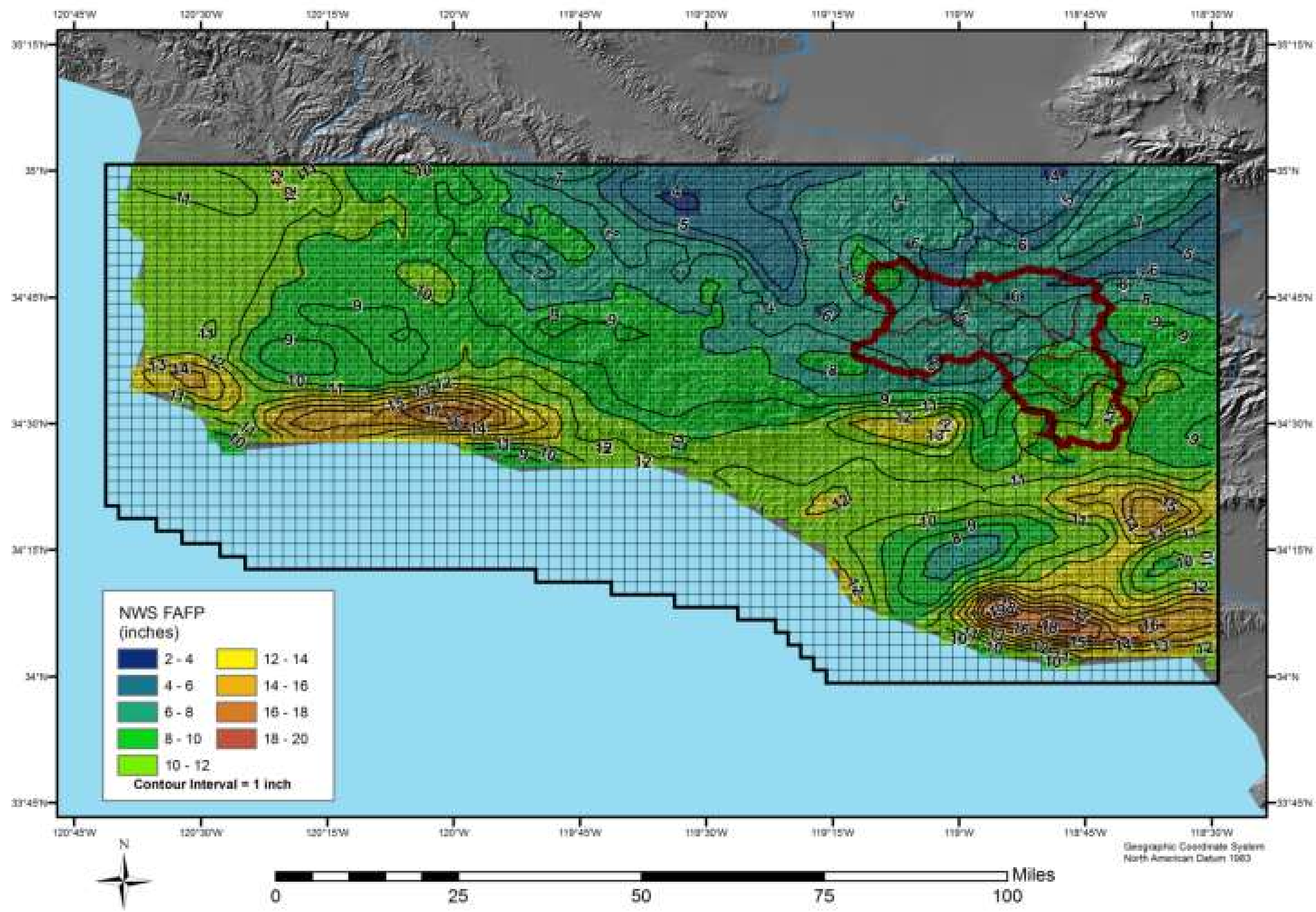


AWA Produced K-Factor

$K = M^2 (1- (T/C)) + (T/C)$



NWS FAFP = PMP ÷ K



There are several significant observations from these maps. The 100-year C map has been constructed using the HMR 59 T/C map and the NOAA Atlas 2 map for T. Since this map is the 100-year rainfall produced from storm dynamics without any influence from underlying terrain, the gradients of rainfall should be relatively smooth. The C map from HMR 57 shown previously shows a relatively smooth analysis. The constructed C map from the HMR 59 data shows areas of large gradients, especially for coastal regions. Since this map is subjectively constructed in the SSM procedure, the large gradient areas were manually introduced into the analysis for unknown reasons.

A similar observation is made for the constructed FAFP map. FAFP is the rainfall produced by a storm from atmospheric dynamics without the influence of the underlying topography. The FAFP map from HMR 57 shown previously shows a relatively smooth analysis. The large rainfall gradient areas in the FAFP map (HMR 59 Figure 6.3-see below) indicate that subjective adjustments were made to the FAFP map which introduced artificial gradients from the coast through the Central Valley and into the Sierra Nevada.

The K factor map in HMR 59 was compared to the computed K factor map using values for M, C and T from HMR 59 and from NOAA Atlas 2. The comparison resulted in good agreement for the region surrounding the Piru Creek drainage basin.

An interesting region to look at is the relatively non-orographic region between Lompoc and Santa Maria, approximately 120.5W and 34.75N. Both the HMR 59 K factor map and the computed K factor map identify values of M to be approximately 0 and K to be approximately 1. Hence for this area PMP is approximately equal to FAFP.

According to the discussions related to the SSM, the FAFP map is constructed using storm data for regions where K is approximately equal to 1, i.e. regions where orographic influences are at a minimum. This region seems appropriate for K to be approximately 1. The FAFP values in this region are between 11 inches and 12 inches, consistent with the HMR 59 PMP values of approximately 12 inches. However, the largest maximized storm rainfall from storms analyzed for the Piru Creek site-specific PMP study for this region is 4.5 inches from the January 1943 storm. It is not obvious how the largest maximized storm rainfall was increased from 4.5 inches to 11.5 inches resulting significantly larger FAFP values than those from maximized storm rainfall values. It can only be assumed that use of the various subject producers and decisions was applied. These subjective changes drastically affect the final PMP values developed for HMR 59 and of course or not reproducible.

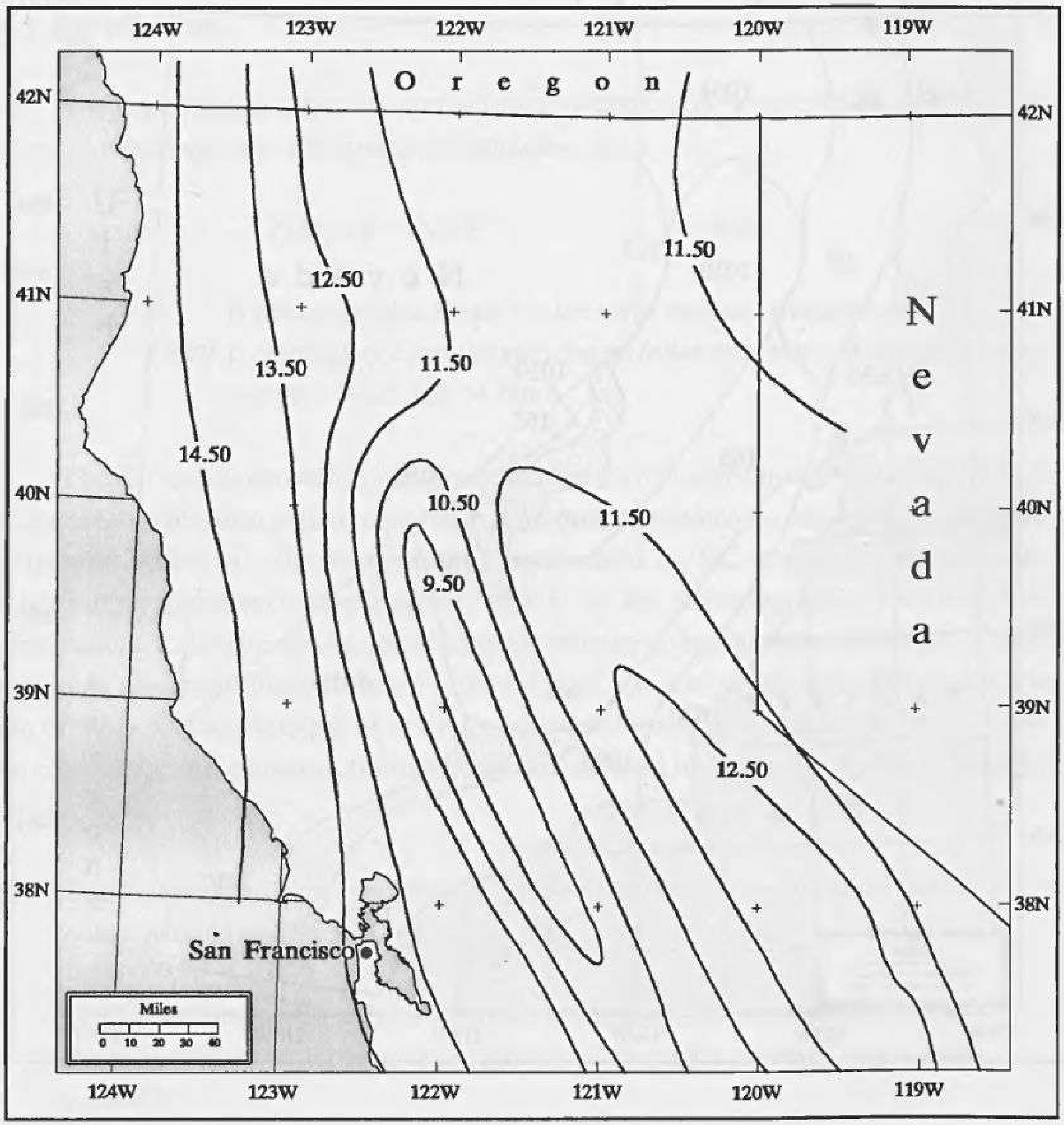


Figure 6.3. *Non-orographic PMP (FAFP) at 1000 mb (inches of rainfall).*

HMR 59 Figure 6.3 FAFP map for northern California

Summary

Discussions on the development of the SSM from HMR 55A have been provided which show the subjectivity associated with the SSM, especially with the development of FAFP and C in the computations. Example maps from HMR 57 and HMR 59 have been compared with computed maps using information in the HMRs. Significant differences between the HMR maps and the computed maps have been shown for HMR 57 in the K factor maps and the PMP maps. For HMR 59, example maps were not available for all parameters so independent comparisons could not be made. However, the FAFP values for the region where K is approximately equal to one shows that the FAFP values for that region are significantly larger than available storm data indicate. Additionally there are large rainfall gradient areas in the HMR 59 FAFP and C maps that are not generally expected and do not show up in the HMR 57 FAFP and C maps. Because of this, serious questions are raised as to the validity of the treatment of orographic influence on rainfall in HMRs 55A, 57, and 59 and the resulting PMP values. Specifically, any values for PMP given in those documents in areas that are orographically influenced should at the very least be re-evaluated to verify their accuracy.

Appendix K
Supplemental Electronic Data

- PMP Tool and database
- Final Report Documents
- Dew Point Maps
- Sea Surface Temperature Maps
- Moisture Transposition Factor Maps
- Geographic Transposition Factor Maps
- Total Adjustment Factor spreadsheets

Appendix L
Board of Consultants Final Report