TEXAS COMMISSION ON ENVIRONMENTAL QUALITY

Houston 2012 $PM_{2.5}$ Exceptional Events Demonstration

For $PM_{2.5}$ Exceptional Events at the Houston Clinton Monitoring Site

8/30/2013

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Introduction

Exceptional events are unusual or naturally occurring events that affect air quality and are not reasonably controllable or preventable. An event may also be caused by human activity that is unlikely to recur at a particular location. Under Section 319 of the Federal Clean Air Act (FCAA), states are responsible for identifying air quality monitoring data affected by an exceptional event and requesting the United States Environmental Protection Agency (EPA) to exclude the data from consideration when determining whether an area is in attainment or nonattainment of a National Ambient Air Quality Standard (NAAQS). EPA has promulgated an exceptional event rule, 40 Code of Federal Regulations (CFR) § 50.14, and guidance to implement the requirements of the FCAA regarding exceptional events. States are required to identify air quality monitoring data potentially affected by exceptional events by "flagging" the data submitted into the EPA air quality system (AQS) database. If EPA concurs with this demonstration, the flagged data will not be eligible for consideration when making attainment or nonattainment determinations.

This document discusses the Texas Commission on Environmental Quality's (TCEQ) proposed exceptional event flags for particulate matter of 2.5 micrometers or less in aerodynamic diameter ($PM_{2.5}$) data collected at the Houston Clinton site on July 2, July 27, and July 28, 2012. This document will be posted on the main TCEQ web page beginning on August 30, 2013, for a 30-day public comment period. All comments received will be submitted to EPA for consideration. With this demonstration, the TCEQ is providing detailed evidence to support concurrence by the EPA for the $PM_{2.5}$ exceptional event flags shown in Appendix A. These proposed exceptional event flags for 2012 are for daily measurements from the Federal Reference Method (FRM) $PM_{2.5}$ monitor at the Houston Clinton site. A map identifying the Houston area $PM_{2.5}$ sites, including the Houston Clinton site, is shown in Figure 1 and a map of regional $PM_{2.5}$ transport sites used in the analyses is shown in Figure 2 along with the Houston Clinton site for reference.

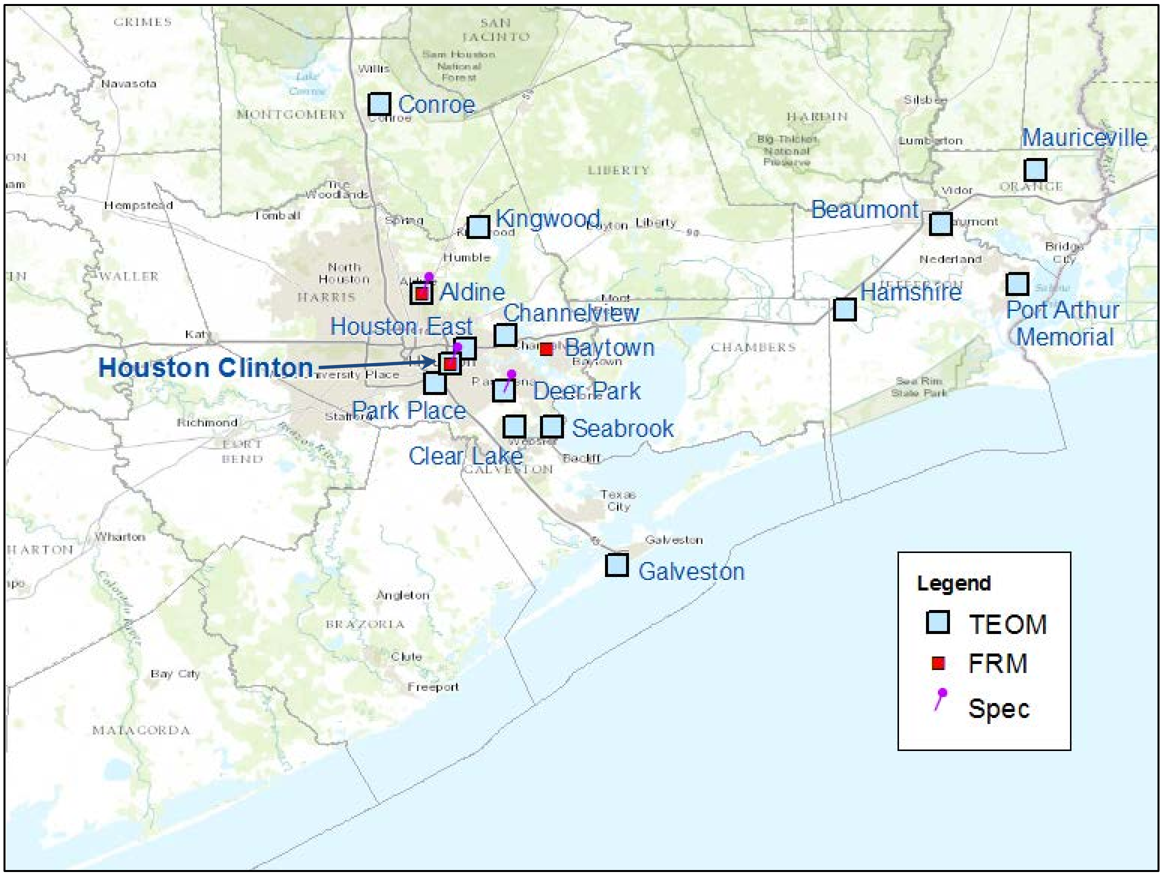


Figure 1. Map of active Houston area $PM_{2.5}$ monitoring sites in 2012, including the Houston Clinton FRM site as well as other area FRM sites, continuous $PM_{2.5}$ sites (TEOM), and speciated $PM_{2.5}$ sites (Spec).

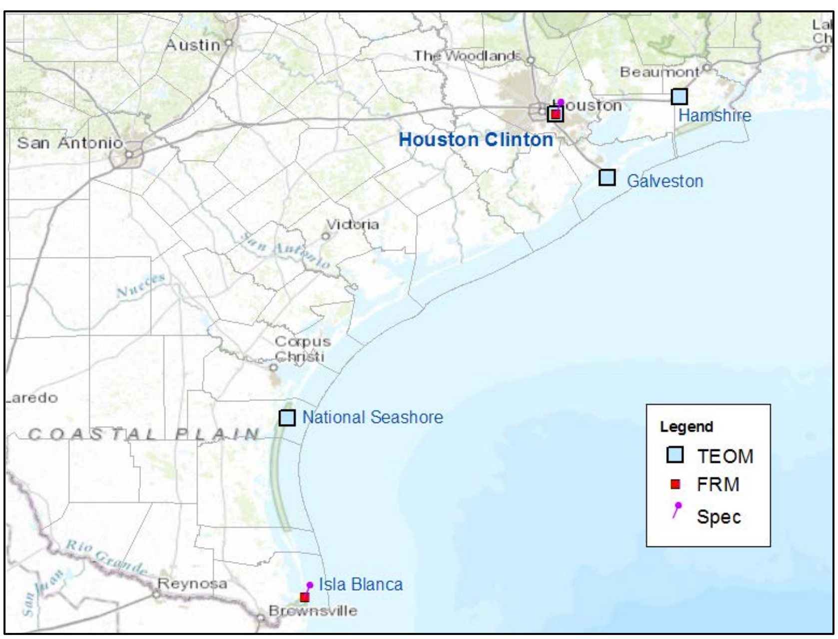


Figure 2. Map of regional $PM_{2.5}$ transport sites in 2012 and the Houston Clinton FRM site.

Exceptional Event Definition and Criteria

An exceptional event is defined in 40 CFR Part 50.1(j) as "[1] an event that affects air quality, [2] is not reasonably controllable or preventable, [3] is an event caused by human activity that is unlikely to recur at a particular location or a natural event, and [4] is determined by the [EPA] Administrator in accordance with 40 CFR 50.14 to be an exceptional event". Furthermore, 40 CFR 50.14(c)(3)(iv) states that the demonstration to justify data exclusion shall also provide evidence that "[5] there is a clear causal relationship between the measurement under consideration and the event that is claimed to have affected the air quality in the area; [6] the event is associated with a measured concentration in excess of normal historical fluctuations, including background; and [7] there would have been no exceedance or violation but for the event". These seven requirements must all be satisfied for data to be excluded from regulatory decisions as an exceptional event. Requirements 1 through 3 and 5 through 7 will be addressed individually in this demonstration document.

Mitigation of exceptional events is also required by 40 CFR 51.930, which reads:

> *A State requesting to exclude air quality data due to exceptional events must take appropriate and reasonable actions to protect public health from exceedances or violations of the national ambient air quality standards. At a minimum, the State must:*
>
> *(1) provide for prompt public notification whenever air quality concentrations exceed or are expected to exceed an applicable ambient air quality standard;*
>
> *(2) provide for public education concerning actions that individuals may take to reduce exposures to unhealthy levels of air quality during and following an exceptional event; and*
>
> *(3) provide for the implementation of appropriate measures to protect public health from exceedances or violations of ambient air quality standards caused by exceptional events.*

These requirements will be addressed in the "Mitigation of Exceptional Events" section.

Summary of Approach

The TCEQ used several methods for developing a demonstration that indicates the high $PM_{2.5}$ measurements in question qualify as exceptional events. $PM_{2.5}$ concentrations from three Houston FRM monitors were evaluated for a period of over 10 years to adequately establish historical trends in the data. In addition, the TCEQ evaluated $PM_{2.5}$ speciation data from these monitors to identify African dust contributions. Satellite imagery from the National Oceanic and Atmospheric Administration (NOAA) (NOAA, 2013), along with aerosol modeling provided by the Naval Research Laboratory (NRL) was used to track the African dust across the Atlantic Ocean, Caribbean Sea, and Gulf of Mexico. The TCEQ also analyzed Houston area $PM_{2.5}$ data to estimate contribution from long-range transport (incoming background levels) and local sources during the events as well as to estimate the baseline incoming background levels without the transport event for use in the "but for" analyses. Finally, the TCEQ reviewed NOAA $PM_{2.5}$ dispersion modeling output for the proposed exceptional event days as a basis to indicate that daily $PM_{2.5}$ concentrations would not have exceeded the level of the annual NAAQS "but for" the event.

Summary of Findings

The information provided in this demonstration document supports the conclusion that the high $PM_{2.5}$ measurements at Houston Clinton on July 2, July 27, and July 28, 2012, qualify as exceptional events. The measured $PM_{2.5}$ concentrations on these days were not reasonably preventable, were clearly due to African dust events, were in excess of normal historical fluctuations, and would not have occurred but for the African dust events. The TCEQ requests EPA's concurrence on these exceptional events and to have these days removed from consideration when making attainment or nonattainment determinations for the annual $PM_{2.5}$ NAAQS.

Data and Analysis Methods

Data and Imagery Used

For the analyses presented in this document, the TCEQ utilized an extensive set of monitoring data, satellite imagery, and air trajectory information. As detailed in Table 1, the monitoring data include FRM non-continuous $PM_{2.5}$ daily measurements, non-continuous $PM_{2.5}$ acceptable speciated daily measurements, and continuous $PM_{2.5}$ acceptable hourly and daily measurements (used for daily reporting of the EPA Air Quality Index [AQI]), as well as hourly and daily wind measurements.

All of the monitoring data used in this demonstration document are available in EPA's AQS database (EPA1, 2013) and meet EPA quality assurance requirements and guidelines. The satellite imagery used in this document are from NOAA and the imagery shown in the appendices were received and processed by the TCEQ and routinely displayed on the TCEQ web site for 24 hours (TCEQ, 2013). The air parcel trajectories were produced using the NOAA Applied Research Laboratory (ARL) Hybrid Single Particle Lagrangian Integrated Trajectory (HYSPLIT) model available on the ARL HYSPLIT web page (http://ready.arl.noaa.gov/HYSPLIT.php) (NOAA ARL, 2013).

Table 1. $PM_{2.5}$ monitors with data used for analyses.

Site Name	AQS Site Identifier	AQS Parameter Identifier	AQS POC Identifier	$PM_{2.5}$ Monitor Type
Isla Blanca Park	480612004	88101	1	FRM non-continuous
Isla Blanca Park	480612004	88502	5	Acceptable non-continuous speciated
Galveston	481671034	88101	1	FRM non-continuous
Galveston	481671034	88502	3	Acceptable continuous
Aldine	482010024	88101	5	FRM non-continuous
Aldine	482010024	88502	5	Acceptable non-continuous speciated
Aldine	482010024	88502	3	Acceptable continuous
Channelview	482010026	88502	3	Acceptable continuous
Baytown	482010058	88101	1	FRM non-continuous
Park Place	482010416	88502	3	Acceptable continuous
Clear Lake	482010572	88502	3	Acceptable continuous
Houston East	482011034	88502	3	Acceptable continuous
Clinton	482011035	88101	1	FRM non-continuous
Clinton	482011035	88101	2	FRM non-continuous
Clinton	482011035	88502	5	Acceptable non-continuous speciated
Clinton	482011035	88502	3	Acceptable continuous
Deer Park	482011039	88502	3	Acceptable continuous
Deer Park	482011039	88502	5	Acceptable non-continuous speciated
Kingwood	482011042	88502	3	Acceptable continuous
Seabrook	482011050	88502	3	Acceptable continuous
Port Arthur	482450021	88502	3	Acceptable continuous
Hamshire	482450022	88502	3	Acceptable continuous
Beaumont	482451050	88502	3	Acceptable continuous
National Seashore	482730314	88502	3	Acceptable continuous
Conroe	483390078	88502	3	Acceptable continuous
Mauriceville	483611100	88502	3	Acceptable continuous

Note: POC stands for parameter occurrence code.

AQS stands for EPA’s air quality system database.

FRM stands for federal reference method.

Analysis Methods

Several methods were used to analyze the data to determine if the specific monitor values of concern qualify as exceptional events. These methods include time series plots to show trends and events, comparison to statistical percentiles to show relevance, examination of satellite imagery and aerosol models for evidence of dust clouds, and review of backward-in-time air trajectories for independent confirmation of transport path of the affected air. Also, daily averages of hourly $PM_{2.5}$ continuous data were compiled for comparison with non-continuous data.

The TCEQ also used Houston area $PM_{2.5}$ monitoring data to estimate the transport contribution for each proposed exceptional event day in order to demonstrate what ambient conditions would have been but for the event. The transport contribution was derived using either representative upwind daily measurements or the second lowest area daily measurement depending on each individual day's meteorological conditions.

The approach of using the second lowest area daily measurement to derive an initial estimate of transport contribution has previously been presented as a method for estimating the impact of transport on annual $PM_{2.5}$ (Lambeth, 2010). Choosing the second lowest area daily measurement rather than the lowest area daily measurement with a sufficient number of samples is more statistically robust, similar to using the 98th percentile rather than the maximum for the 24-hour $PM_{2.5}$ NAAQS. Other researchers have also noted problems in using the lowest area measurement to represent incoming background levels in the Houston area (Nielsen-Gammon, Tobin, McNeel, & Li, 2005). On days where the incoming background levels are more uniform, the lowest and second lowest measurements will be close. However, significant gradients in the incoming background levels can result in substantial differences between the lowest and second lowest measurements. In these instances, the lowest may not best represent the transport contribution at the site of interest. Given the size of the Houston metropolitan area, significant gradients in the incoming background levels are quite common and result from the passage of incoming smoke plumes, haze, and dust clouds. Detailed assessments of wind patterns and $PM_{2.5}$ measurements can sometimes provide a more representative assessment of the incoming background level than using the area second lowest measurement, especially when significant gradients are present.

The TCEQ used the estimated transport contribution detailed above and monitoring data from the Houston Clinton site to estimate the local contribution to the $PM_{2.5}$ measurement at Clinton. The local contribution was calculated by subtracting the transport contribution from the Houston Clinton measurement.

In addition to the second lowest area daily measurement approach, the TCEQ also identified August 13, 2012, a day without the influence of incoming African dust and with similar meteorological conditions to the proposed exceptional event days as a surrogate day. A comparison evaluation of $PM_{2.5}$ concentrations and meteorological conditions between the proposed exceptional event days and the surrogate day was conducted to estimate the overall impact of the African dust on the Houston area.

Houston $PM_{2.5}$ Trends and Sources

$PM_{2.5}$ Air Quality Trends

With the exception of the Houston Clinton site, $PM_{2.5}$ levels in the Houston area have shown a gradual overall decline since monitoring began in 1999. As shown in Figure 3, the Houston Clinton site measured a pronounced increase in $PM_{2.5}$ concentrations from 2002 to 2007 believed to be caused by localized sources in the immediate vicinity of the site. This increase has been followed by a sharp decline resulting from extensive voluntary source remediation efforts (Sullivan, Price, Sheedy, Lambeth, Savanich, & Tropp, 2013) that are described in the Local Source Contributions section below.

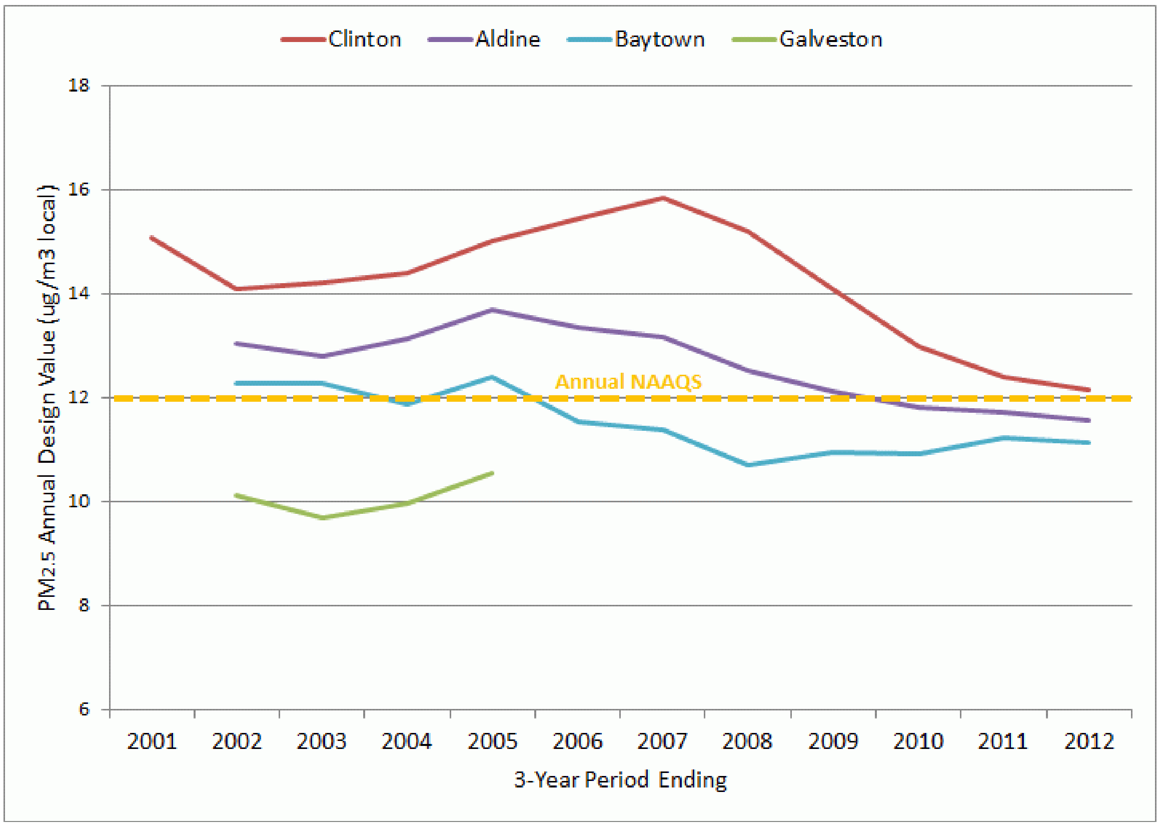


Figure 3. Houston $PM_{2.5}$ annual design value trends for long-term FRM monitoring sites including exceptional event days.

Historically, $PM_{2.5}$ levels in the Houston area have been greatly impacted by long-range transport from natural events outside of the area including wildfires; African dust; dust from large, intense regional dust storms in the West Texas-New Mexico-Northern Mexico area; and smoke from agricultural burning in Mexico and Central America. Long-range transport from other types of events also impact the Houston area, including controlled burns and haze and smoke accumulated from man-made emissions in the U.S. and Canada (also known as continental haze).

Elevations in Houston-area $PM_{2.5}$ concentrations due to transport events have historically followed a seasonal pattern. African dust impacts the Houston area every year, mainly in the summer, with typically three to six intense episodes that are characterized by high incoming background levels and lasting one to three days or more. Smoke from agricultural burning in Mexico affects the Houston area mainly from April to early June each year when the winds bring in air from eastern Mexico and Central America. Continental haze events are most common from May through October and often include high ozone background levels as well. All of these sources of $PM_{2.5}$ air pollution cannot be controlled locally and prior work indicates that these sources, along with the global background, account for about 75 to 90 percent of the annual $PM_{2.5}$ average at sites in the Houston area (Lambeth, 2010) as shown in Figure 4. A variety of urban and industrial local sources of $PM_{2.5}$ also contribute the remaining 10 to 25 percent of the annual means for 2010-2012.

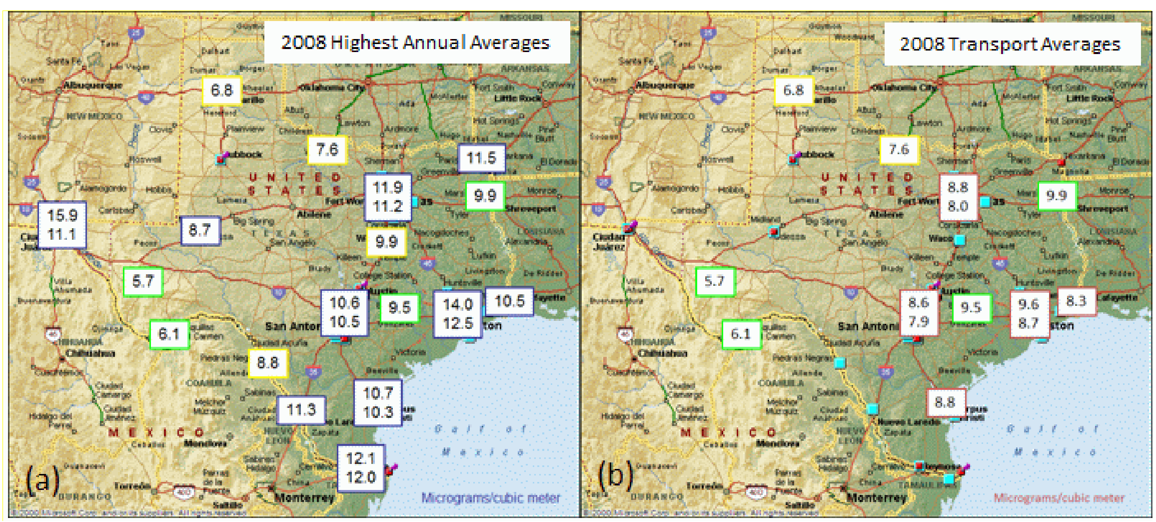


Figure 4. Texas annual average $PM_{2.5}$ concentrations, 2008. The green boxes indicate sites most representative of regional transport where local contributions should be minimal. The yellow boxes indicate sites where local contributions should be small. (a) Map showing the highest site annual averages by area, with the second highest shown in areas with more than one site. (b) Map showing the estimated annual average contribution from transport by area with the top average based on the second lowest area daily measurements for areas with more than one site. Areas where the number and placement of monitors were inadequate to determine local contribution were not included on this map (Lambeth, 2010).

Local Source Contributions

The Houston Clinton monitoring site, located near the west end of the Houston Ship Channel, was originally sited to measure impacts from industrial air pollution sources along the channel. When $PM_{2.5}$ concentrations began rising to near the level of the annual NAAQS in 2005 and 2006, voluntary control measures from some of the nearby industrial air pollution sources were pursued by the TCEQ and the City of Houston, in addition to traffic improvements to address emissions from nearby roads. Implemented control strategies included improving traffic flow through traffic barriers on the shoulder of Clinton Drive and traffic lights, adding vegetation along Clinton Drive, reducing locomotive emissions at the nearby port, replacing calcium sulfate from port roadways and work yards with fresh compacted soil topped by emulsified asphalt, paving of some parking areas, and implementing dust control measures at a nearby fluorspar unloading and storage facility. As a result of these activities, the estimated annual contribution from local $PM_{2.5}$ sources at Houston Clinton declined approximately 50 percent from approximately 6 $\mu g/m^3$ in 2006 to approximately 3 $\mu g/m^3$ in 2012 as shown in Figure 5. The estimated incoming background level contribution to the annual average declined by about 1 $\mu g/m^3$ from 2007 to 2012 as also shown in Figure 5. Analysis of the speciated $PM_{2.5}$ data at Houston Clinton indicated a 2 $\mu g/m^3$ decline in the soil component from 2006 to 2011 (Sullivan, Price, Sheedy, Lambeth, Savanich, & Tropp, 2013).

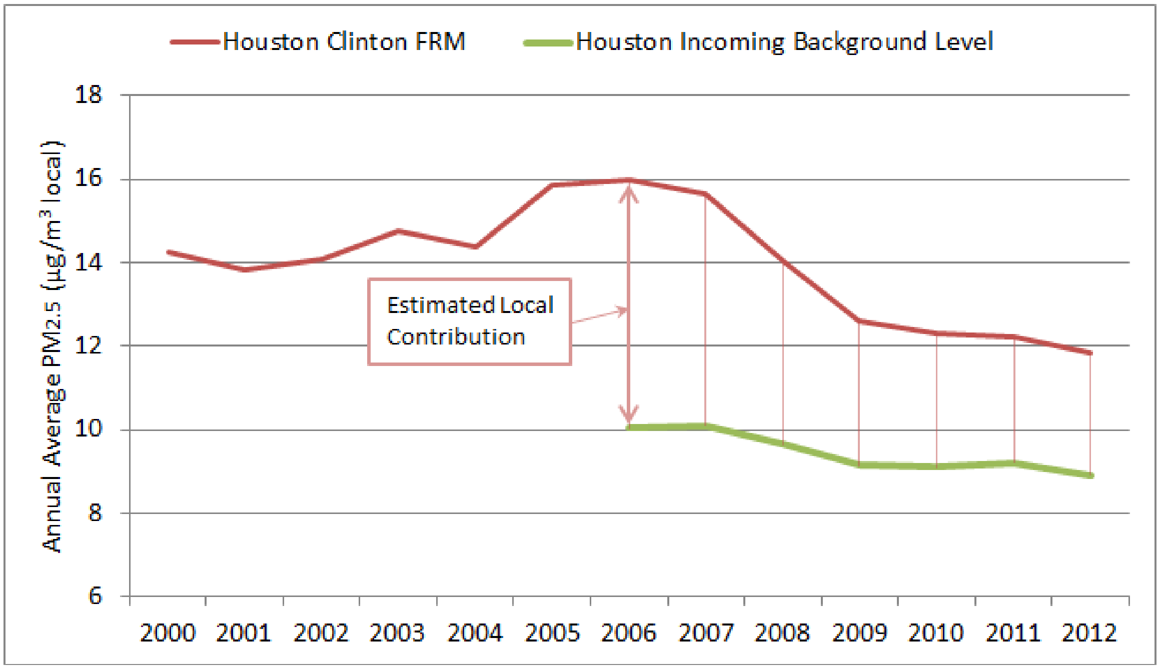


Figure 5. Houston Clinton FRM annual $PM_{2.5}$ concentrations, estimated Houston area incoming background level (transport contribution) based on the daily second lowest measurements, and estimated local contribution to $PM_{2.5}$ levels from 2000 – 2012 (for all days including proposed exceptional events).

Event Summaries

July 2, 2012

A large African dust cloud moved into the Houston area on July 1st and lingered through July 8th, causing elevated $PM_{2.5}$ concentrations on the proposed exceptional event day of July 2nd. As a result of African dust covering the eastern half of Texas, daily $PM_{2.5}$ AQI ratings in parts of Southeast Texas reached “Unhealthy for Sensitive Groups,” and “Moderate” levels were noted over much of the eastern half of the state, as illustrated in Figure 6. As further illustrated in Figures 7 and 8, widespread elevated $PM_{2.5}$ measurements along with moderate southeasterly winds across Southeast Texas on July 2nd support the influence of increased incoming background concentrations.

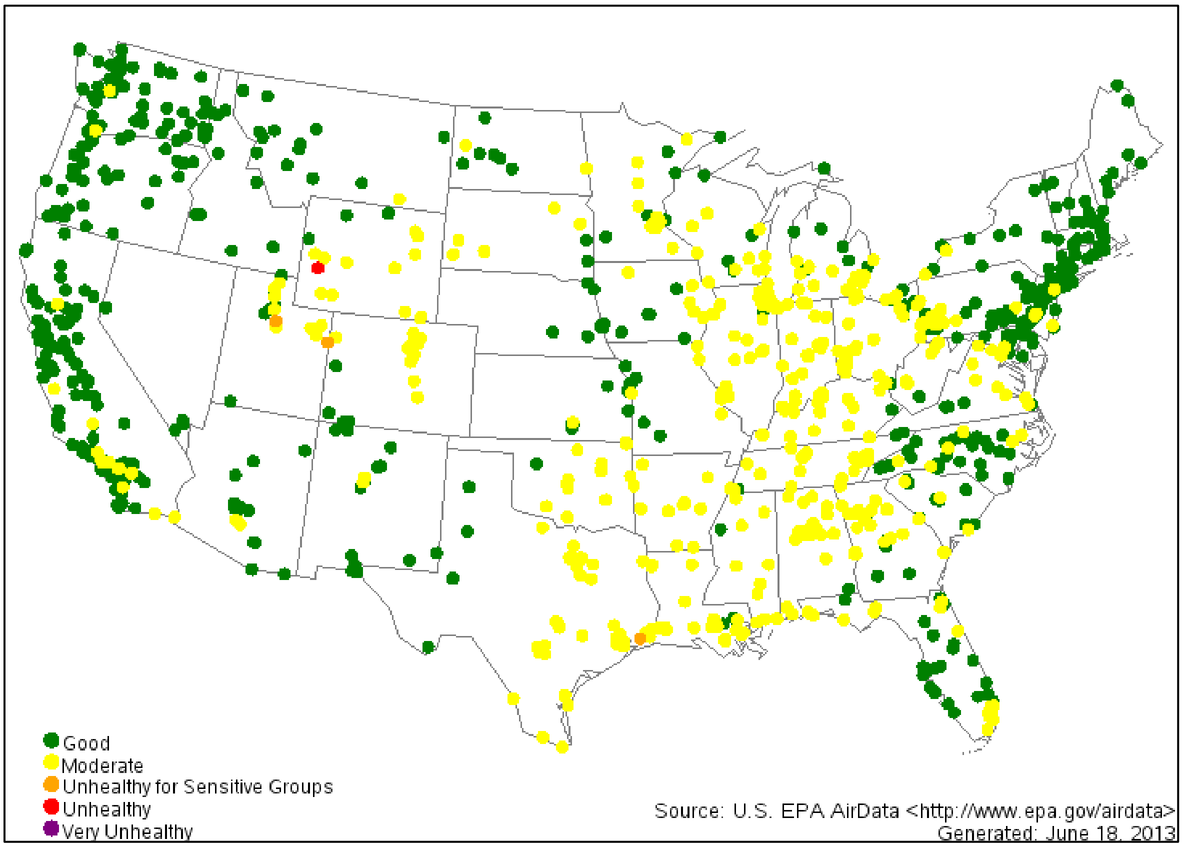


Figure 6. $PM_{2.5}$ AQI levels by site on July 2, 2012.

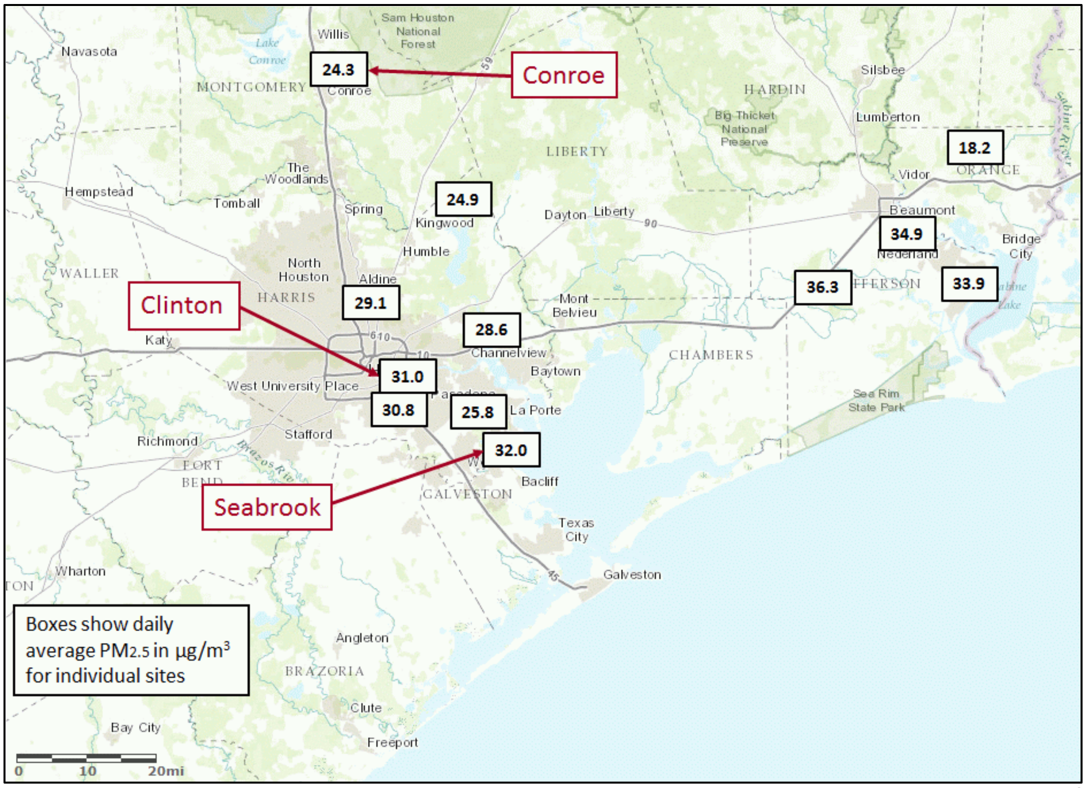


Figure 7. Map of Houston area daily average $PM_{2.5}$ measurements (µg/m^3) on July 2, 2012.

While concentrations measured inland were slightly lower than those measured closer to the coast, this difference can be attributed to the timing of the dust cloud first arriving along the coast before moving inland, where rolling 24-hour averages peaked during the noon July 2nd to noon July 3rd time period. Effects of this south to north gradient caused by transport timing are illustrated by comparing $PM_{2.5}$ concentrations at the Seabrook site to the Conroe site. On July 2nd, Seabrook measured 32.0 µg/m^3 whereas the inland Conroe site measured 24.3 µg/m^3.

Wind directions and speeds for July 2nd are depicted in Figure 8 using wind roses for selected monitoring locations in the region. The length of the bars on each wind rose indicates the frequency of winds occurring in the direction of the bar. The wind flow is along the bar toward the site. The wind roses show that winds were persistently from the southeast across the region at moderate speeds.

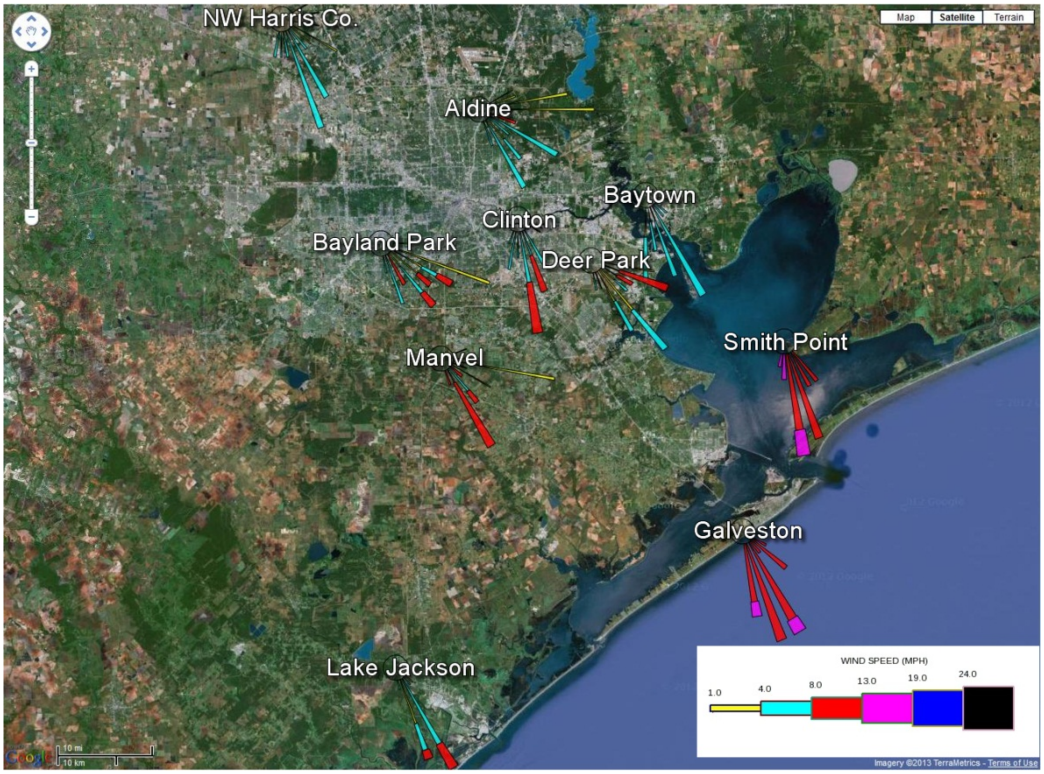


Figure 8. Houston-area wind rose plots for July 2, 2012.

$PM_{2.5}$ measurements at sites across the Houston area showed an increase in concentrations likely due to incoming transport of particulate matter beginning on July 1st, as illustrated in Figures 9 and 10. These $PM_{2.5}$ measurements along with a predominant southeasterly wind flow indicate that $PM_{2.5}$ levels coming onshore from the Gulf of Mexico were elevated. Continuous hourly $PM_{2.5}$ measurements from Houston sites during the time period of the event show an overall tight clustering of measurements as concentrations increase and decrease, providing strong evidence of a regional transport event affecting all sites, as illustrated in Figures 9 and 10. Figure 10 shows the impact of the main dust cloud as it first arrives along the coast, where coastal sites like Seabrook and Channelview are the first to show an increase in concentrations early on July 2nd. Later in the day, sites further inland begin to show evidence of the main dust cloud arriving as concentrations rapidly increase to levels comparable to the coastal sites, where they stay clustered through the rest of the event period. In these figures, hourly measurements from the Houston Clinton site, which are missing from June 30th to July 2nd when the continuous monitor was down, are plotted with a thicker line. Variations among the sites can be caused by gradients in the incoming background levels, impacts from local sources, and/or measurement uncertainties, all of which vary over time.

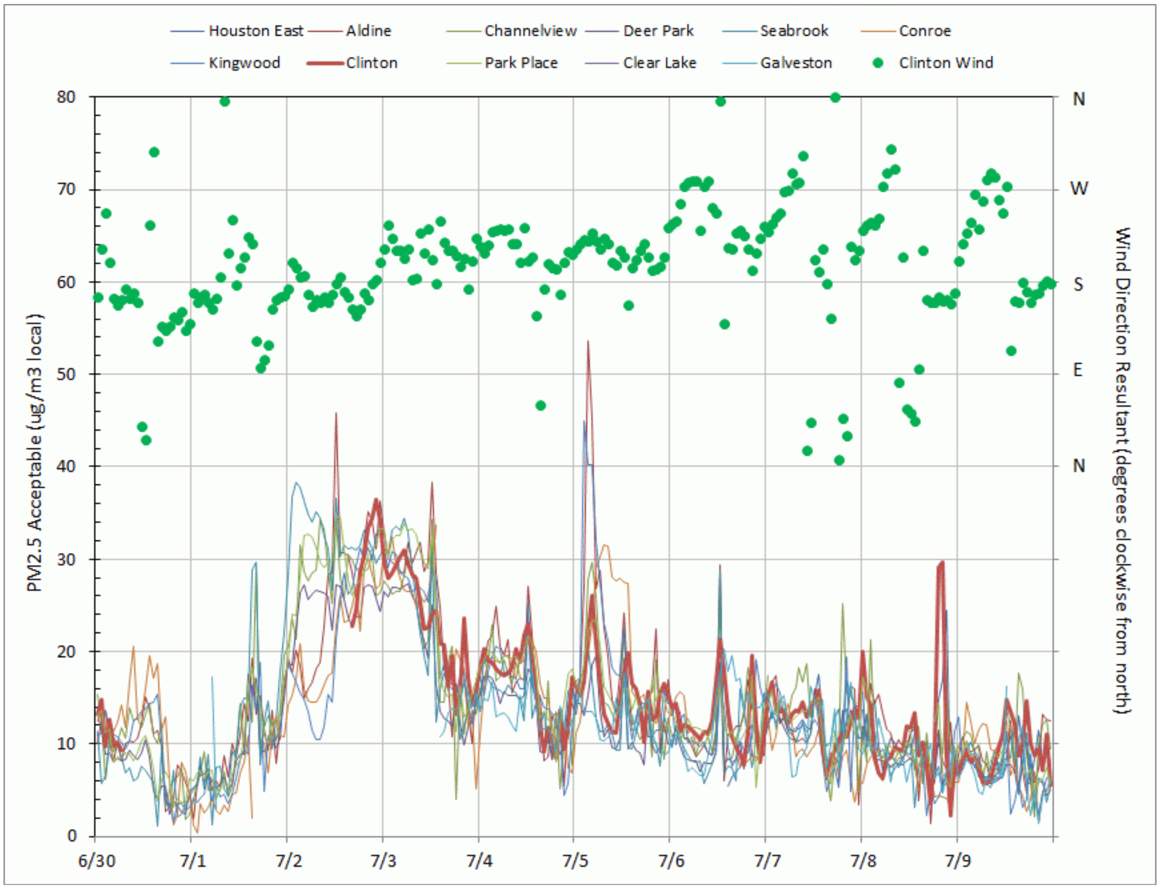


Figure 9. Houston hourly $PM_{2.5}$ concentrations by site for June 30 through July 9, 2012, with hourly wind direction at Clinton.

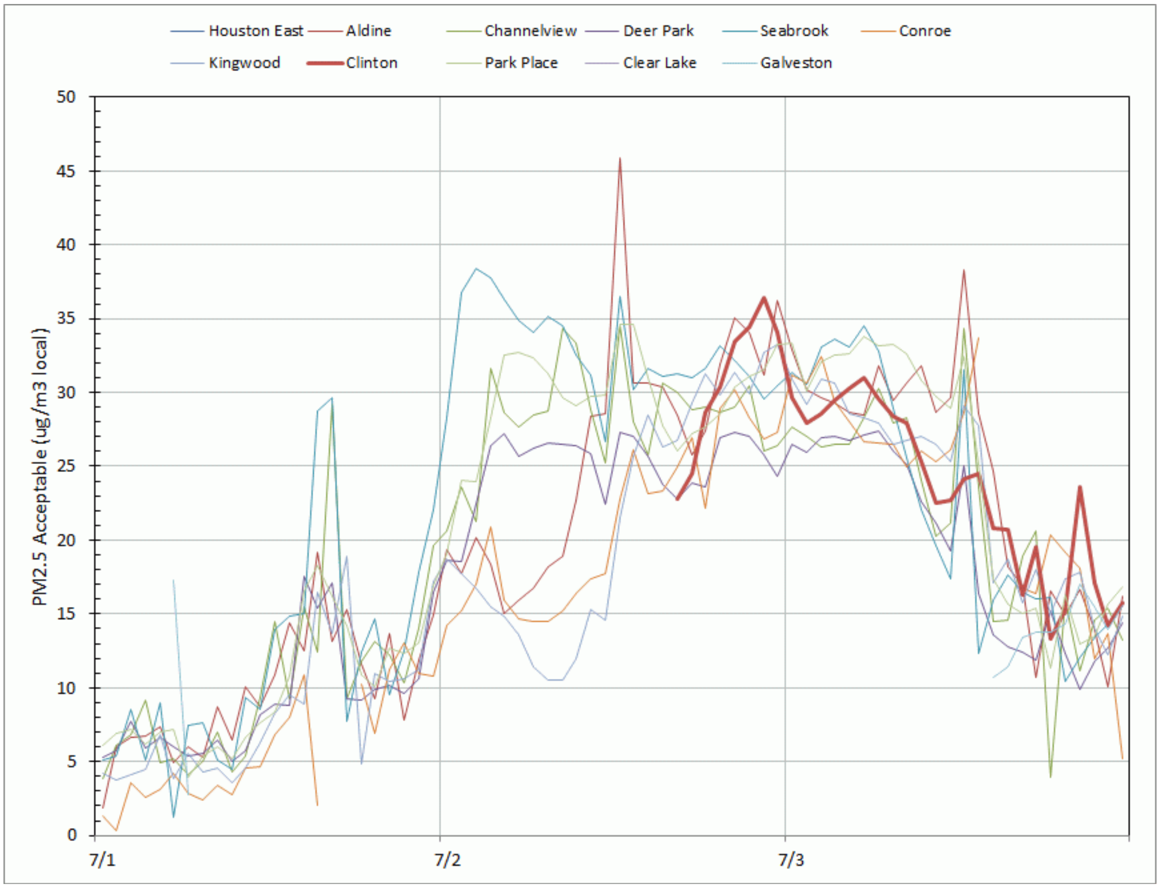


Figure 10. Houston hourly $PM_{2.5}$ concentrations by site for July 1 through 3, 2012.

July 27 and 28, 2012

A large African dust cloud moved through the Houston area in late July, causing elevated $PM_{2.5}$ concentrations on July 27th and 28th. As a result of African dust covering the eastern half of Texas, daily $PM_{2.5}$ AQI ratings over much of the eastern half of the state reached "Moderate," as illustrated in Figures 11 and 12. As further illustrated in Figures 13 and 15, widespread elevated $PM_{2.5}$ measurements along with moderate southerly winds across Southeast Texas on July 27th support the influence of increased incoming background concentrations. Figure 14 also shows widespread elevated $PM_{2.5}$ measurements across Southeast Texas on July 28th, and the somewhat variable winds at lighter speeds shown in Figure 16 indicate a brief stalling of the dust over Southeast Texas.

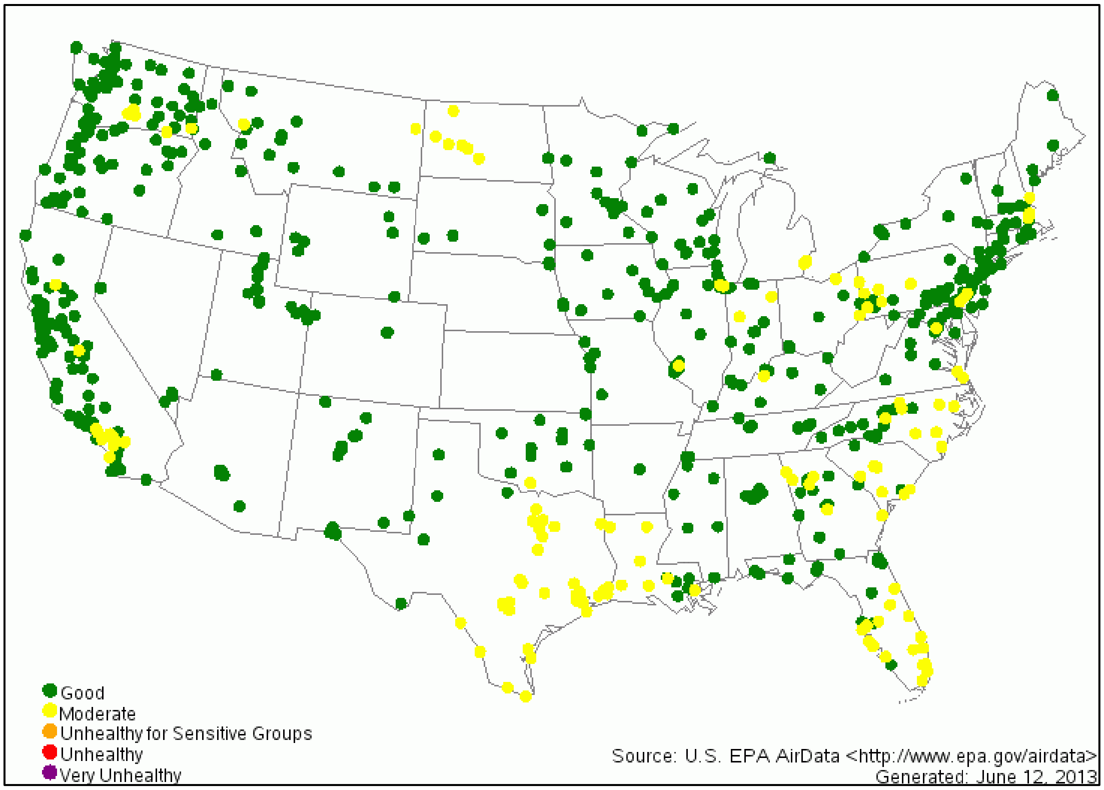


Figure 11. $PM_{2.5}$ AQI levels by site on July 27, 2012.

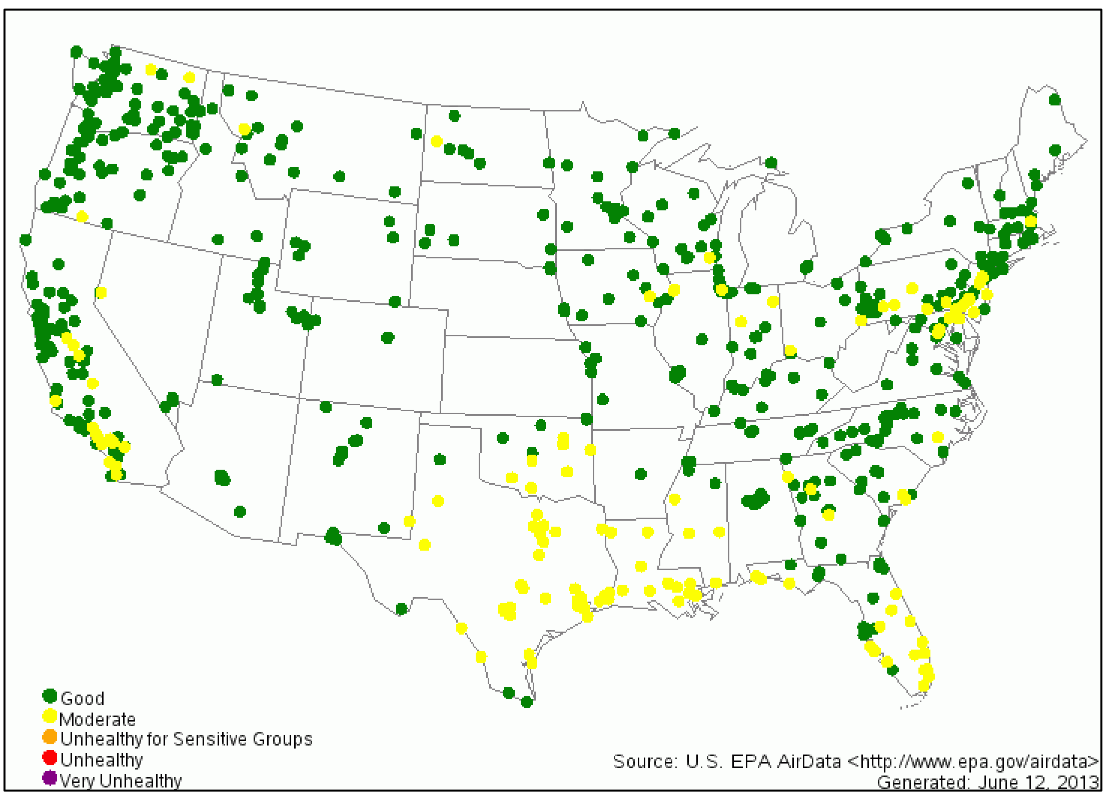


Figure 12. $PM_{2.5}$ AQI levels by site on July 28, 2012.

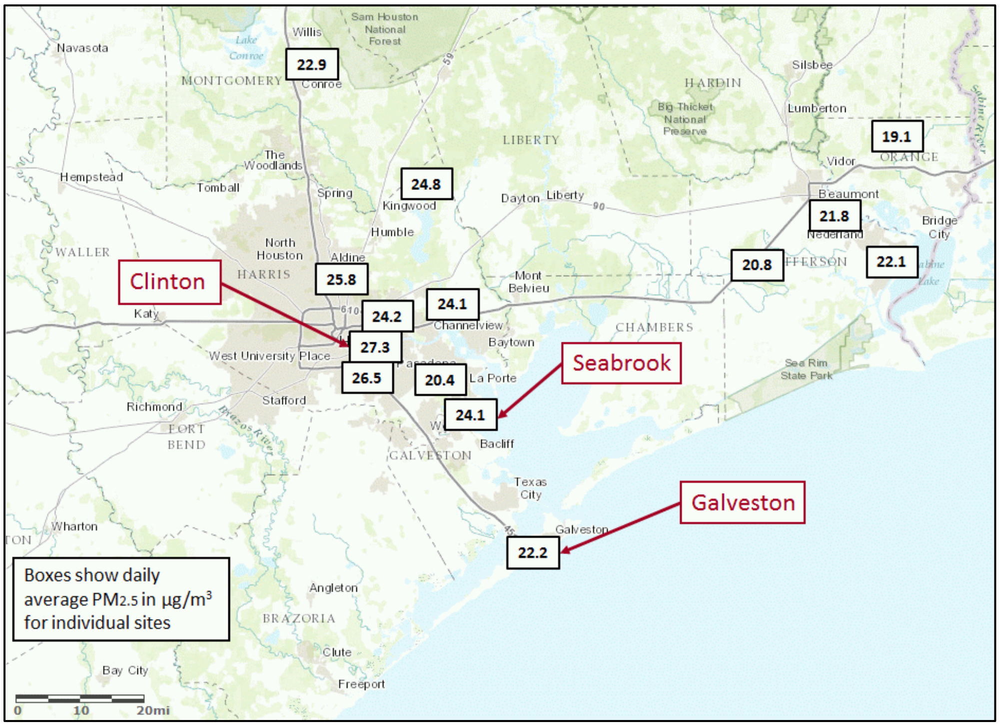


Figure 13. Map of Houston area daily average $PM_{2.5}$ measurements (µg/m^3) on July 27, 2012.

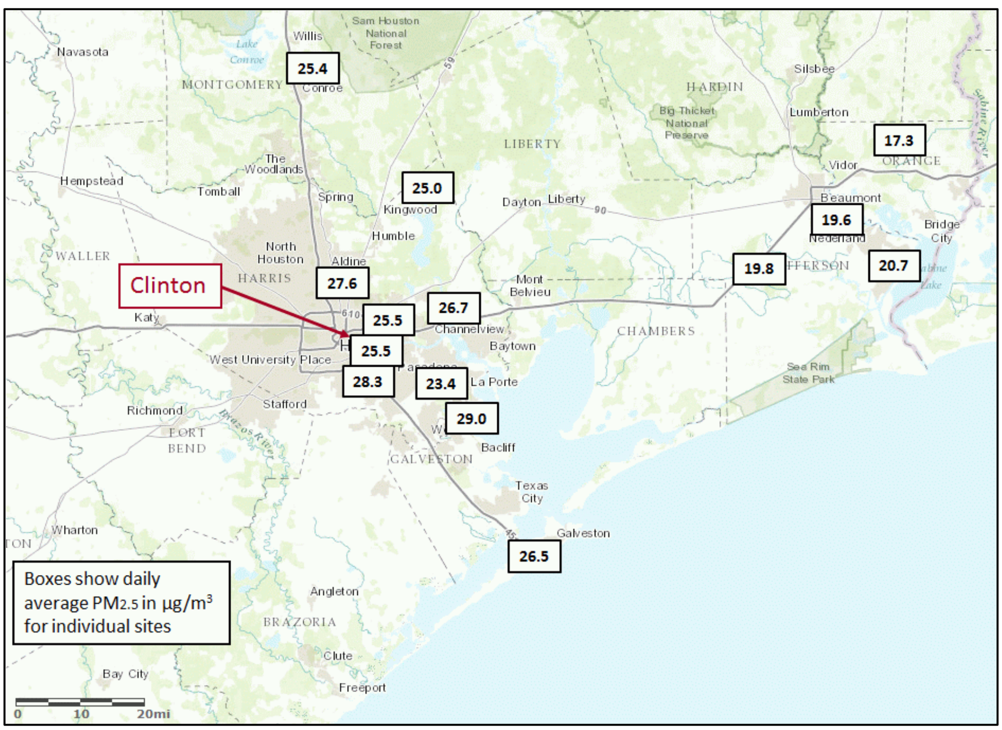


Figure 14. Map of Houston area daily average $PM_{2.5}$ measurements (µg/m^3) on July 28, 2012. Note that monitored concentrations were more uniform across the Houston area on this day.

On July 27th, the two upwind monitors at Galveston and Seabrook were used to evaluate incoming background levels, and indicate a range from about 22 to 24 µg/m^3 impacting the Houston area. Given the moderate speeds of the onshore wind flow on July 27th and the Galveston monitor's location on the coast with no upwind $PM_{2.5}$ sources of its own, the measured $PM_{2.5}$ concentration of 22.2 µg/m^3 at this site was used as a minimum estimate of the incoming background levels on this day. To address the impact of potential concentration gradients in the incoming background levels, the $PM_{2.5}$ measurement of 24.1 µg/m^3 at the upwind Seabrook site was included as a reasonable estimate of the upper limit in the range of incoming background levels on July 27th. On July 28th, the lighter and more variable nature of the winds resulted in a more even distribution of measured concentrations across the area. Thus the second lowest measurement was used as a reasonable estimate of incoming background concentrations for that day.

Wind directions and speeds for July 27th and 28th are depicted in Figures 15 and 16 using wind roses for selected monitoring locations in the region. The wind roses show that moderate winds were persistently from the south on July 27th and light and somewhat variable winds followed a general southwesterly flow on July 28th.

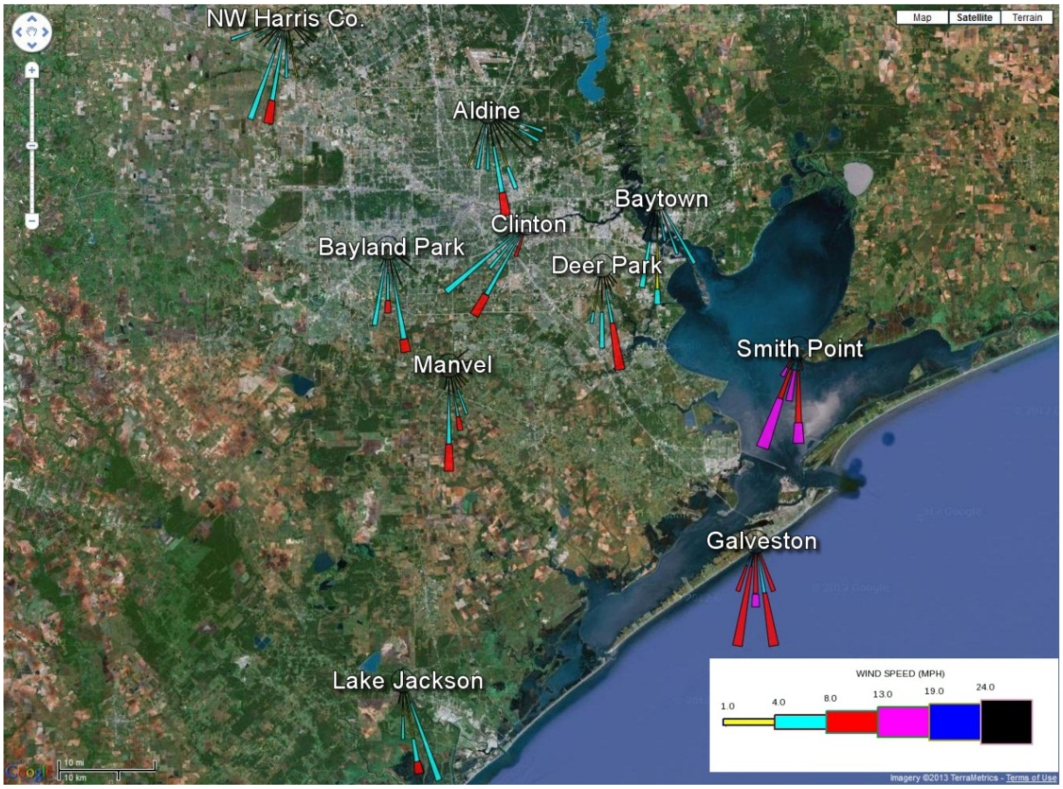


Figure 15. Houston-area wind rose plots for July 27, 2012.

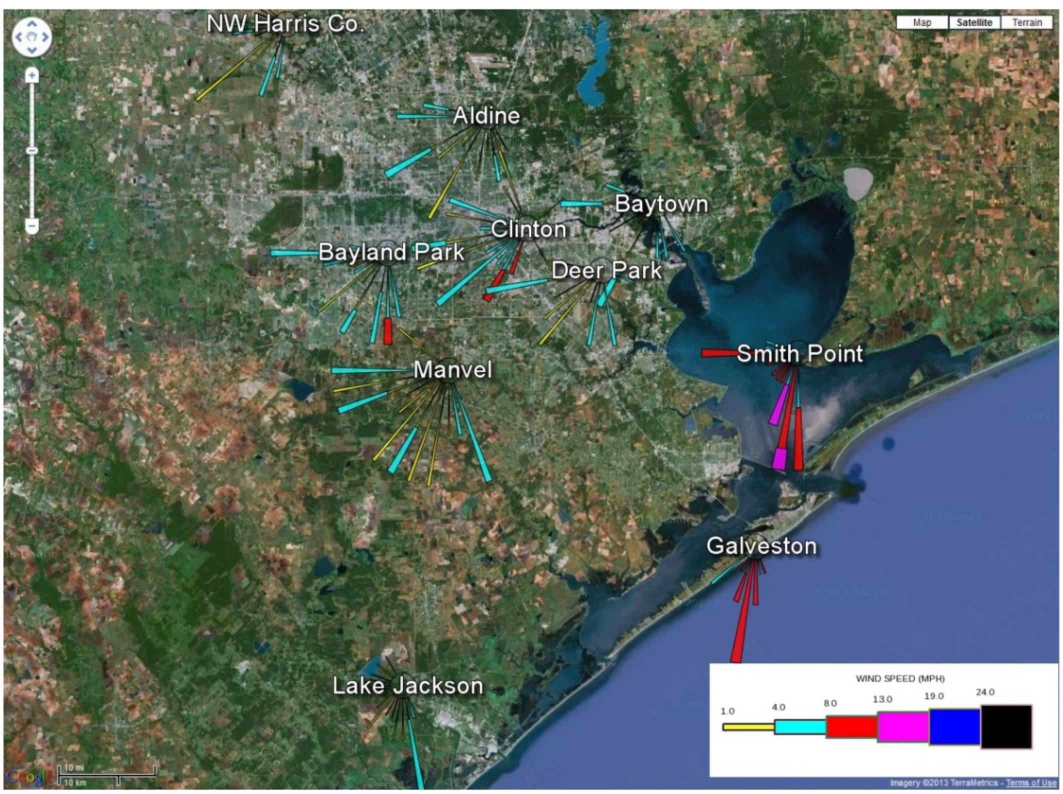


Figure 16. Houston-area wind rose plots for July 28, 2012.

$PM_{2.5}$ measurements at sites across the Houston area showed an increase in concentrations from incoming transport of particulate matter beginning on July 26th, as illustrated in Figures 17 and 18. These $PM_{2.5}$ measurements along with a predominant southerly wind flow indicate that the $PM_{2.5}$ levels coming onshore from the Gulf of Mexico were elevated. Continuous hourly $PM_{2.5}$ measurements from all Houston sites during the time period of the event show a tight clustering of measurements as concentrations increase and decrease, providing strong evidence of a regional transport event affecting all sites, as illustrated in Figures 17 and 18. In these figures, measurements from the Houston Clinton site are plotted with a thicker line. Variations among the sites can be caused by gradients in the incoming background levels, impacts from local sources, and/or measurement uncertainties, all of which vary over time.

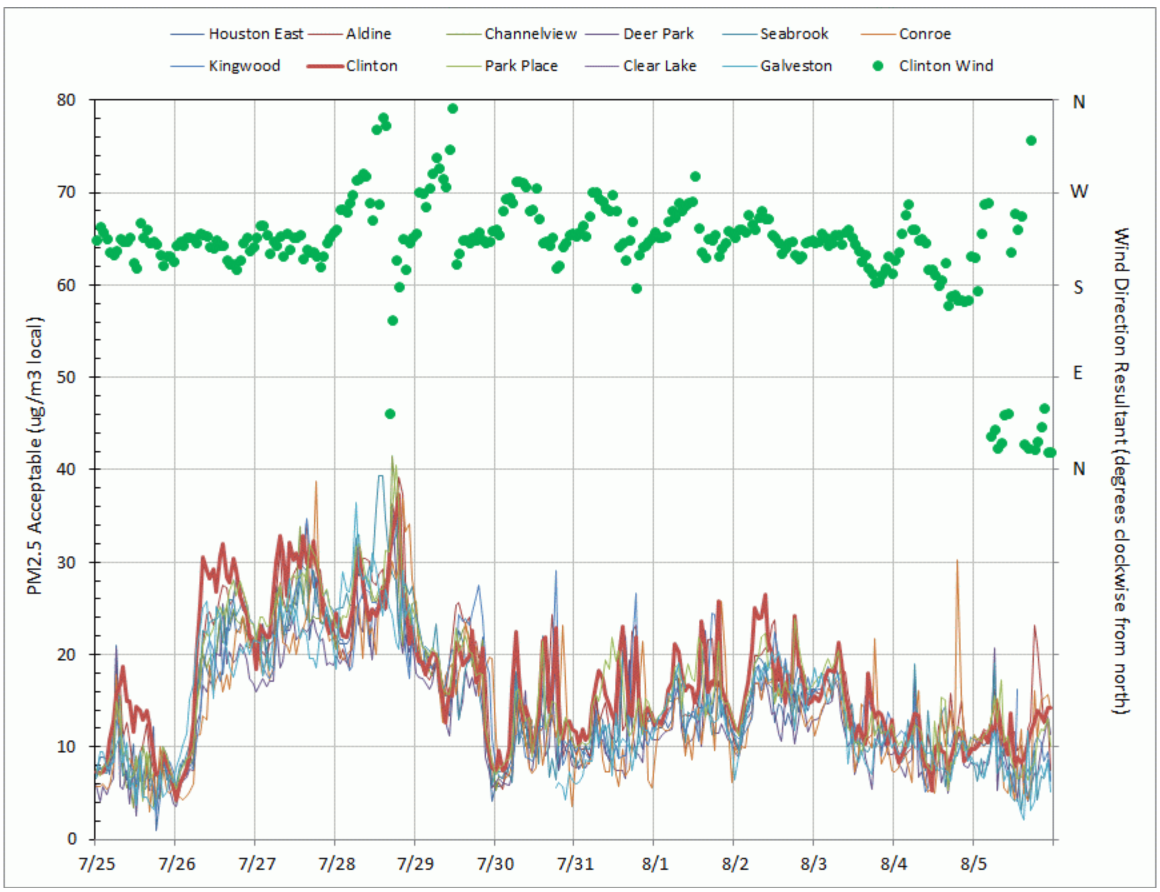


Figure 17. Houston hourly $PM_{2.5}$ concentrations by site for July 25 through August 5, 2012, with hourly wind direction at Clinton.

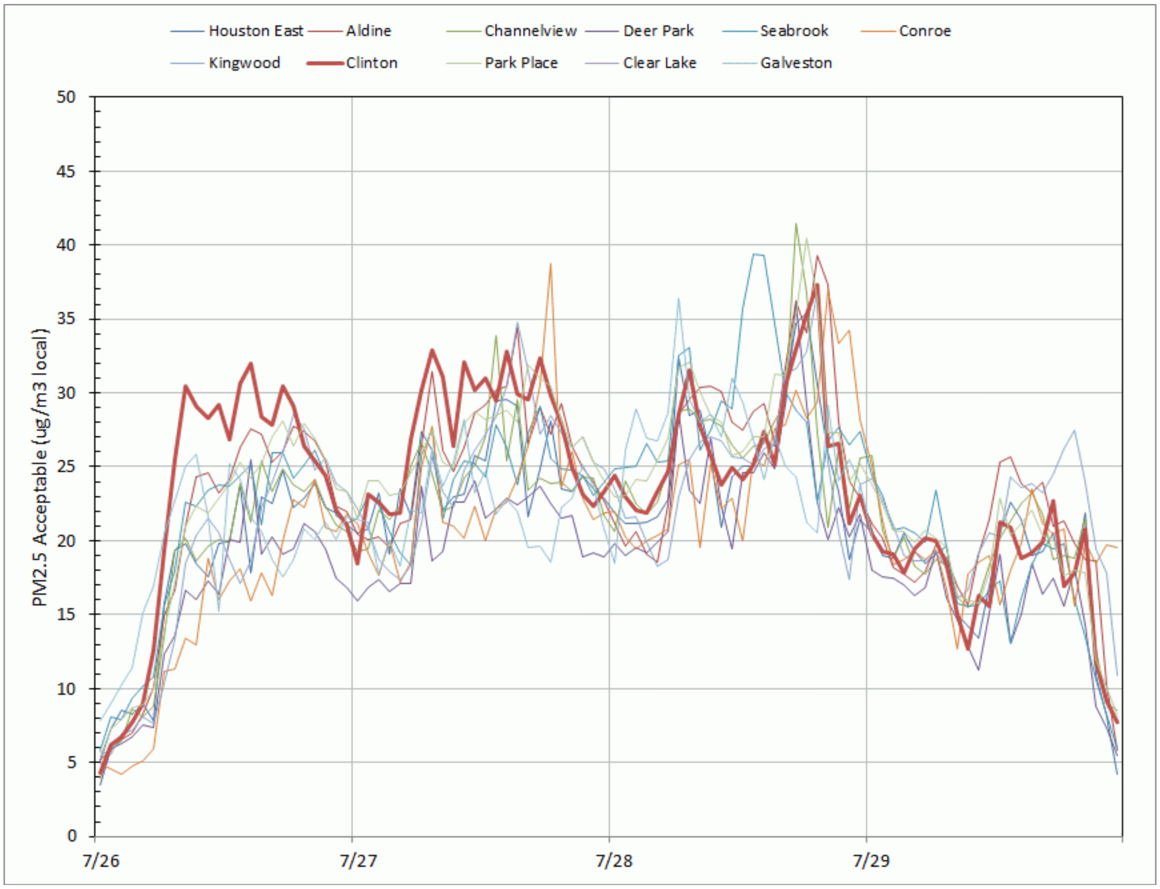


Figure 18. Houston hourly $PM_{2.5}$ concentrations by site for July 26 through 29, 2012.

Exceptional Events Demonstration

<u>Affects Air Quality</u>

All of the proposed exceptional event days for 2012 had measured concentrations over 25 µg/m^3, well above the annual $PM_{2.5}$ standard of 12.0 µg/m^3. These days were also above the 95th percentile of all FRM $PM_{2.5}$ measurements (20.6 µg/m^3) at the Houston Clinton site during the period from 2010 through 2012. Thus, these measurements were among the highest five percent of measurements over the three-year period ending with 2012 at the Houston Clinton FRM $PM_{2.5}$ monitor. The preamble to the Exceptional Event rule (72 *Federal Register* 13569) states:

> *For extremely high concentrations relative to historical values (e.g., concentrations greater than the 95th percentile), a lesser amount of documentation or evidence may be required to demonstrate that the event affected air quality.*

Figure 19 shows the 1,056 Houston Clinton FRM $PM_{2.5}$ valid daily measurements for the period from 2010 through 2012 and indicates the three proposed 2012 exceptional event days.

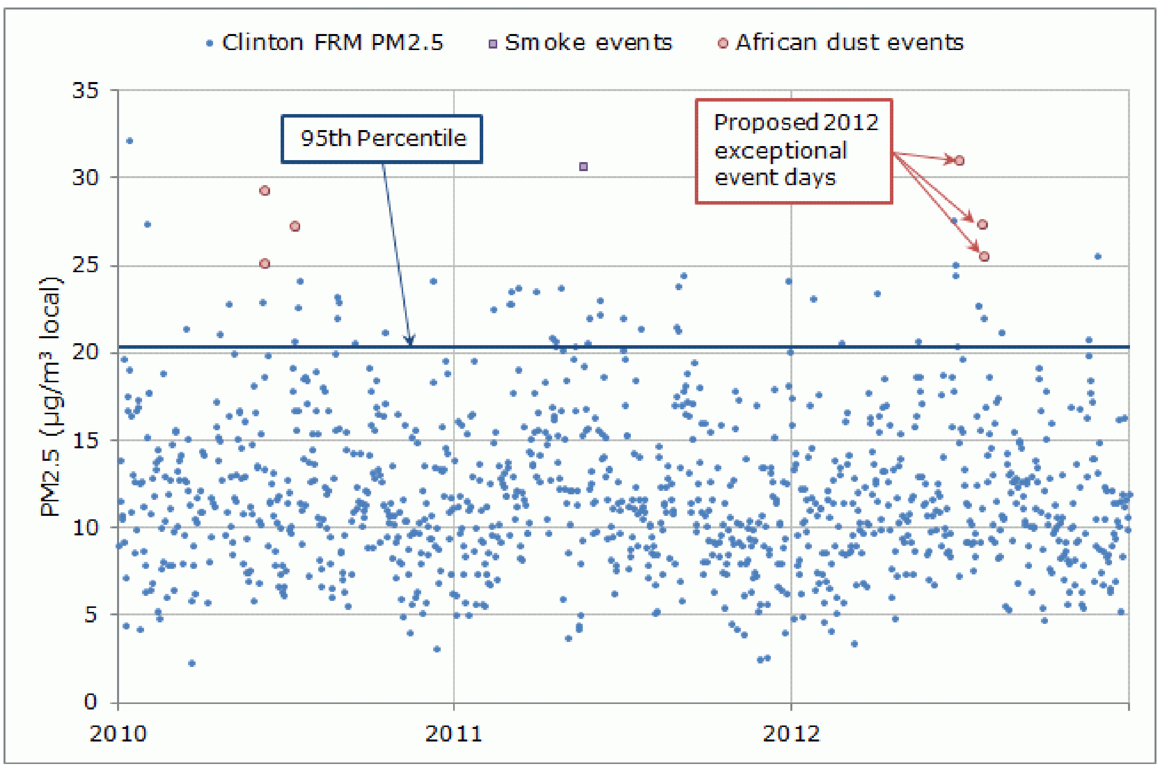


Figure 19. Houston Clinton FRM $PM_{2.5}$ daily measurements from 2010 through 2012, with symbols showing analyzed events from African dust and from smoke from agricultural burning in Mexico and Central America.

Not Reasonably Controllable or Preventable

All three of the proposed event days had incoming regional background levels greatly exceeding the levels of the annual NAAQS as indicated by the representative upwind daily measurements on July 2nd and 27th and the second lowest area daily measurement on July 28th. Local source controls could not affect these high incoming levels. Also, satellite imagery, aerosol models, and back trajectories show the transport of large amounts of fine particulate from uncontrollable sources outside of the United States and Texas associated with African dust as shown in Appendices B and C and discussed further below.

Natural Events

All three of the proposed exceptional event flags for 2012 are for African dust events, which are natural events. African dust impacts the Houston area every year, mainly in the summer. The three to six episodes per year are typically intense and characterized by high incoming background levels that last one to three days or more. Satellite imagery provides good visual evidence of African dust moving across the Atlantic Ocean, through the Caribbean, and into the Gulf of Mexico.

Monitoring data also provide evidence that the elevated $PM_{2.5}$ concentrations during these events were from natural sources. Silicon, aluminum, iron, and calcium are the most abundant soil components in African dust events (Goudie & Middleton, 2001) (Formenti et al., 2011). Silicon, aluminum, and iron show very clear high peaks in association with African dust events at Houston Clinton in the summer and much lower levels the remainder of the year, whereas calcium is dominated by contributions from local sources and does not show this trend. The implication is that silicon, aluminum, and iron from local sources are relatively low, as indicated by fall, winter, and spring (September through May) measurements, as compared to levels during African dust events (see Table 2). There is no evidence that would support the ability for local sources to contribute much higher concentrations of silicon, aluminum, and iron during very discrete time periods in the summer and not at any other time of year.

Table 2. Houston Clinton average daily $PM_{2.5}$ measurements and speciation measurements and calculations (µg/m^3) of routine every sixth day speciation sampling days from 2010 through 2012.

	$PM_{2.5}$	Soil	SAF	SI	AL	FE	CA
All Year	*12.4*	1.8	1.4	0.3	0.1	0.2	0.3
September through May	*12.1*	1.3	0.9	0.2	0.1	0.2	0.2
June through August	*13.2*	3.5	2.9	0.6	0.3	0.3	0.3
June through August, African dust days removed	11.7	2.0	1.5	0.3	0.1	0.2	0.3
June through August, African dust days only	*19.5*	9.7	8.7	2.0	0.9	0.7	0.5

Note: *Italics* indicate that a measurement is above the level of the annual $PM_{2.5}$ NAAQS.

Abbreviations:

$PM_{2.5}$ Clinton FRM $PM_{2.5}$ measurement

Soil IMPROVE calculation of soil component of speciation data

SAF Sum of silicon, aluminum, and iron components of Soil IMPROVE calculation

SI Silicon element measurement from speciation analysis

AL Aluminum element measurement from speciation analysis

FE Iron element measurement from speciation analysis

CA Calcium element measurement from speciation analysis

Figure 20 shows a seasonal pattern consistent with summer impacts from African dust for the silicon, aluminum, and iron portion (SAF) of the soil reconstruction formula used by the Interagency Monitoring of Protected Visual Environments (IMPROVE) $PM_{2.5}$ speciation monitoring program (Eldred, 2003). The individual speciated measurements for silicon (Figure 21), aluminum (Figure 22), and iron (Figure 23) all show the same seasonal patterns. The aluminum measurements show evidence of small local contributions that were highest in 2006 when the average aluminum concentration was 0.13 micrograms per cubic meter (µg/m^3) on 27 routine sample days, excluding routine samples collected during four African dust episodes with an aluminum average of 1.38 µg/m^3. The aluminum levels decreased steadily through 2007 and 2008 and have remained at this lower level from 2009 through 2012, outside of the much higher summer African dust events. In 2012, the average aluminum concentration was 0.06 µg/m^3 on 55 routine samples days, excluding routine samples collected during one West Texas dust and five African dust episodes with an aluminum average of 0.85 µg/m^3. The aluminum data also gauge the intensity and frequency of the African dust events each year and show considerable variability of both from year to year.

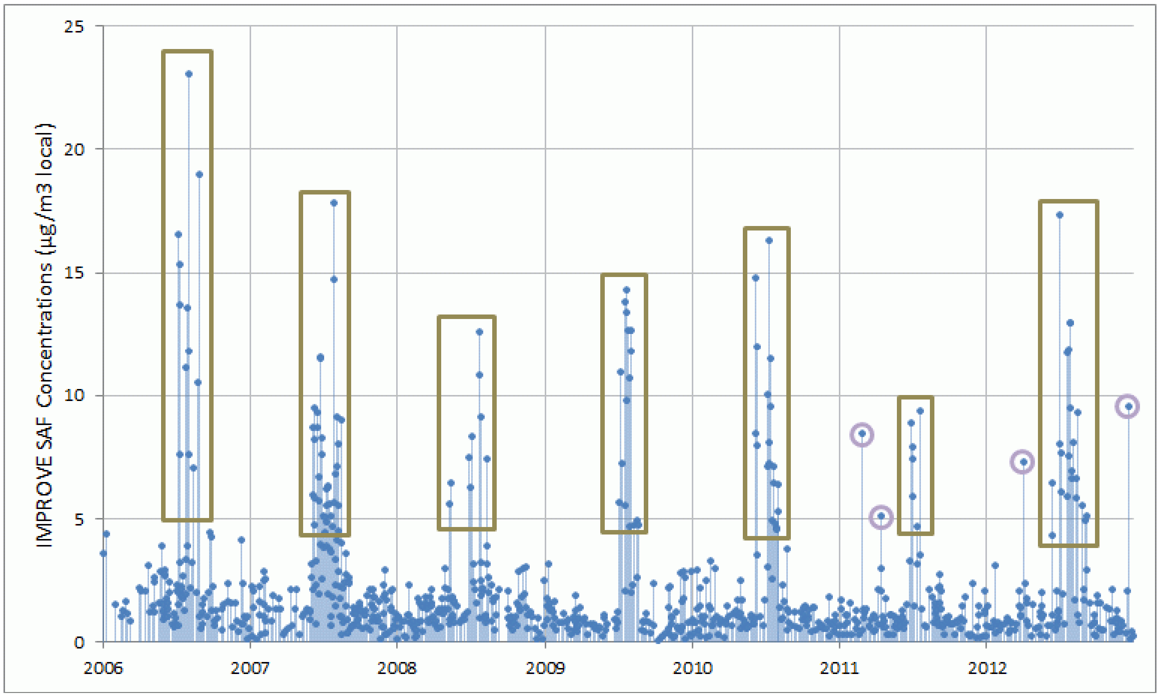


Figure 20. Houston Clinton IMPROVE calculated $PM_{2.5}$ soil component silicon plus aluminum plus iron (SI+AL+FE=SAF) concentrations using the IMPROVE soil reconstruction formula. These components of the reconstructed soil concentration show much higher levels during African dust events each summer. African dust events are shown in boxes and four transported dust events from West Texas dust storms in 2011 and 2012 are circled.

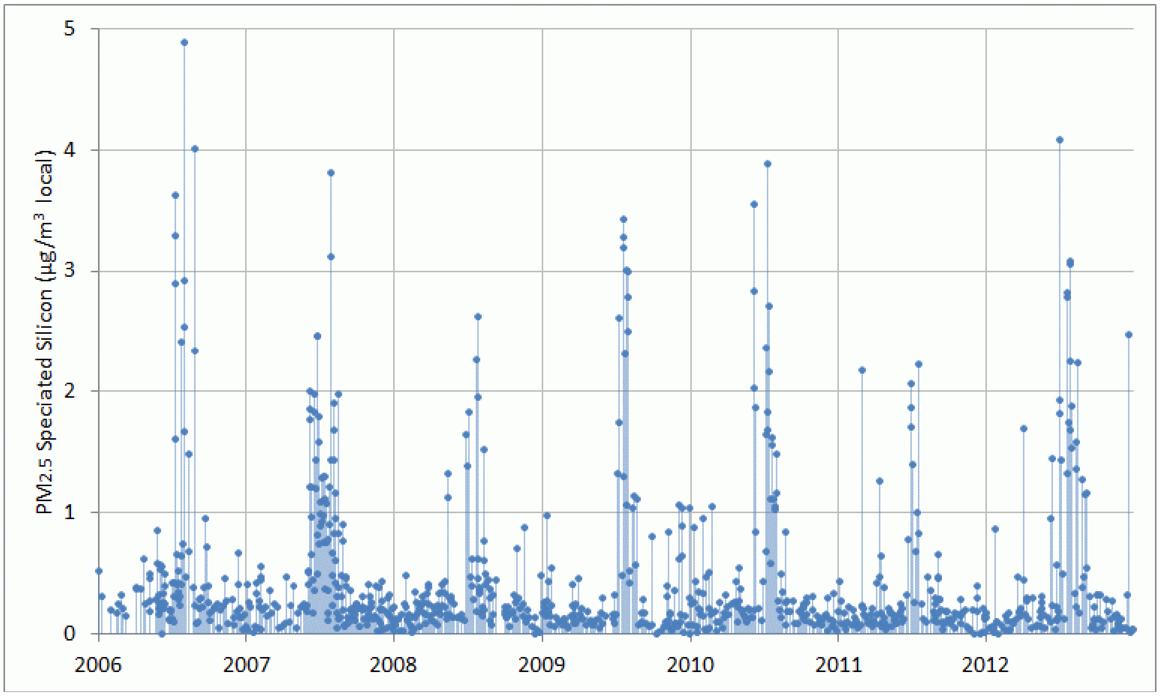


Figure 21. Houston Clinton speciated $PM_{2.5}$ silicon measurements showing much higher levels during African dust events each summer from 2006 through 2012.

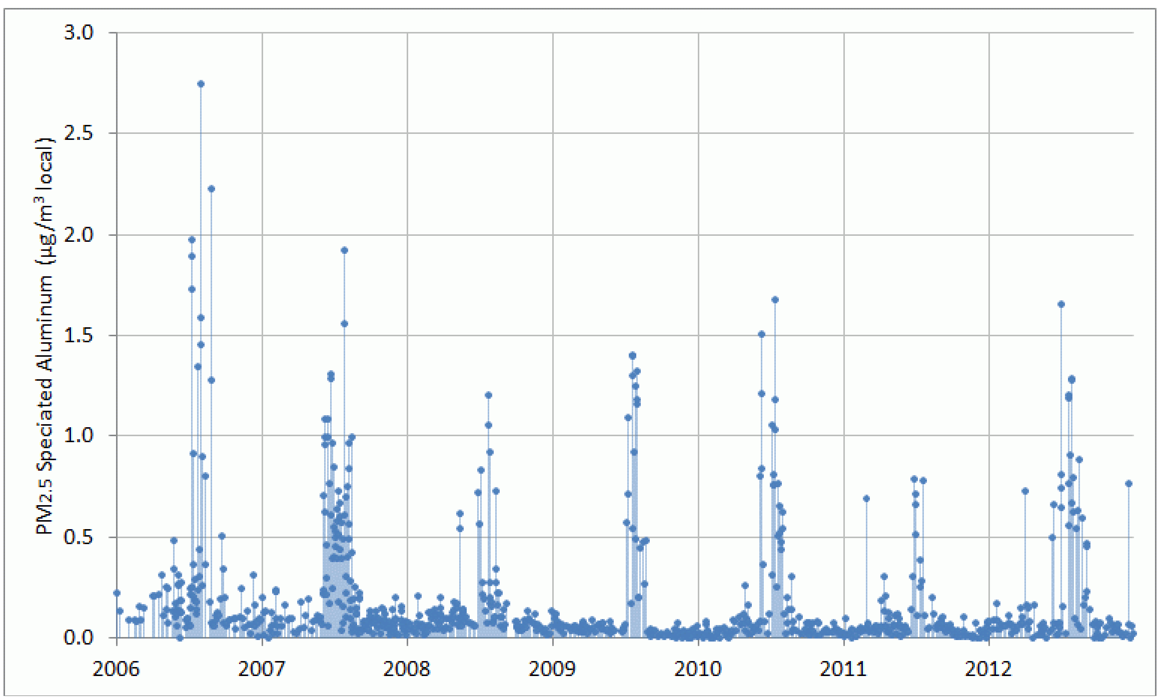


Figure 22. Houston Clinton speciated $PM_{2.5}$ aluminum measurements showing much higher levels during African dust events each summer from 2006 through 2012.

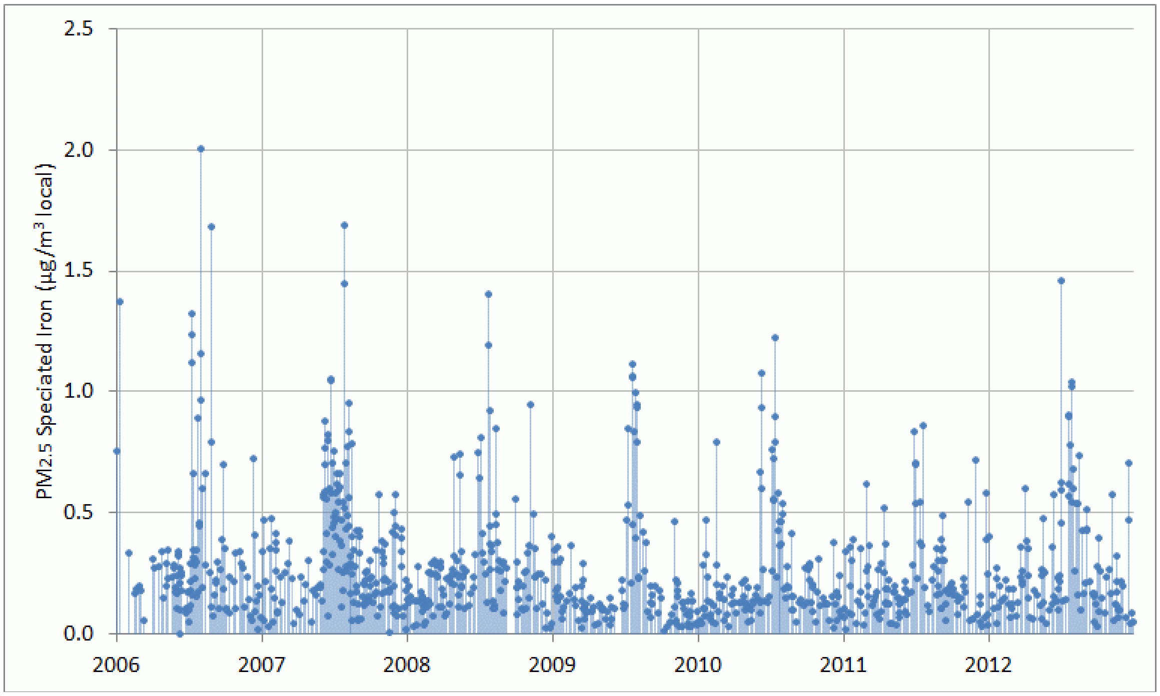


Figure 23. Houston Clinton speciated $PM_{2.5}$ iron measurements showing much higher levels during African dust events each summer from 2006 through 2012.

Although calcium is considered a part of African dust (Formenti et al., 2011), it is overwhelmed by contributions from local Houston area sources such that African dust events are difficult to distinguish in the speciated calcium measurements shown in Figure 24. Even though calcium measurements show a sharp decline in recent years due to voluntary remediation measures, local calcium is still largely obscuring calcium from 2006 through 2012 African dust events in the figure. The large difference in the pattern and trends seen in the calcium measurements versus the silicon, aluminum, and iron measurements offers further evidence that the high summer peaks in the data for silicon, aluminum, and iron are mostly from African dust and not local sources. The primary local source of the calcium is calcium sulfate (gypsum) used to cover roadways and parking areas frequented by large trucks in the port area (Sullivan, Price, Sheedy, Lambeth, Savanich, & Tropp, 2013).

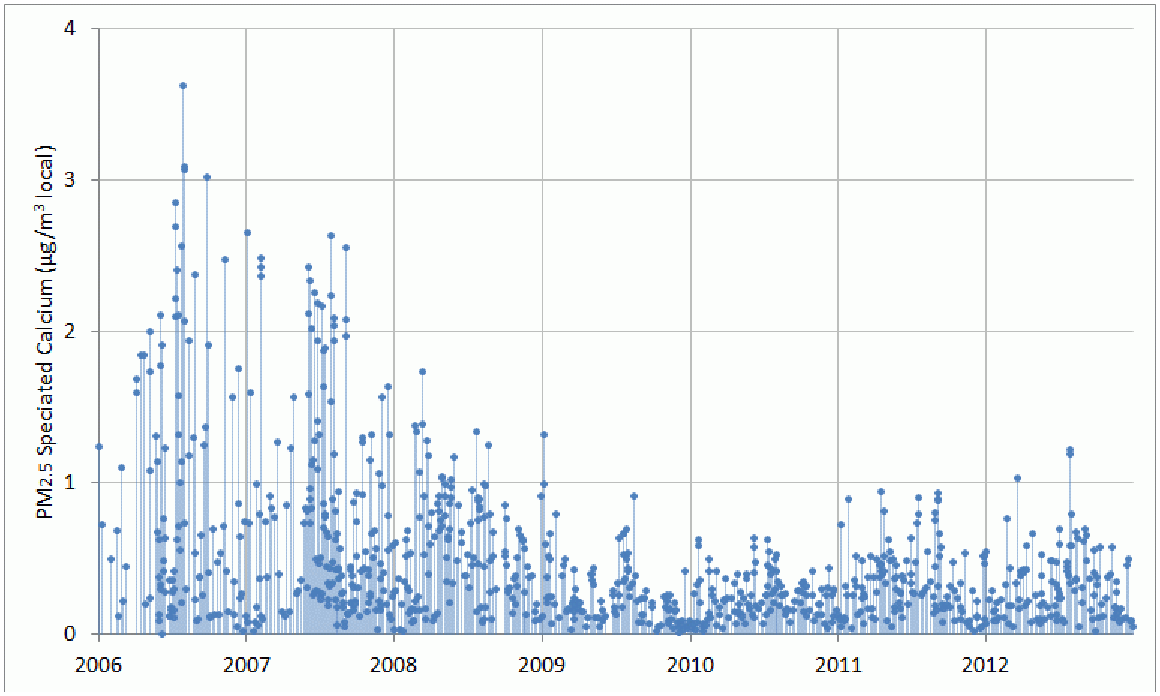


Figure 24. Houston Clinton speciated $PM_{2.5}$ calcium measurements showing dominance of local contributions and a decreasing trend from 2006 through 2012.

Figures 25 and 26 and Tables 3 and 4 compare the speciation data to Houston area daily $PM_{2.5}$ measurements during the exceptional event episodes and to 2010-2012 summer and non-summer speciation data averages, illustrating the significant contribution of African dust to the elevated particulate on the proposed days. As can be seen from the data presented in Tables 3 and 4, the speciated silicon, aluminum, and iron concentrations, as well as the SAF from the IMPROVE calculation, are orders of magnitude higher during African dust events than during either non-summer or summer periods with African dust days removed.

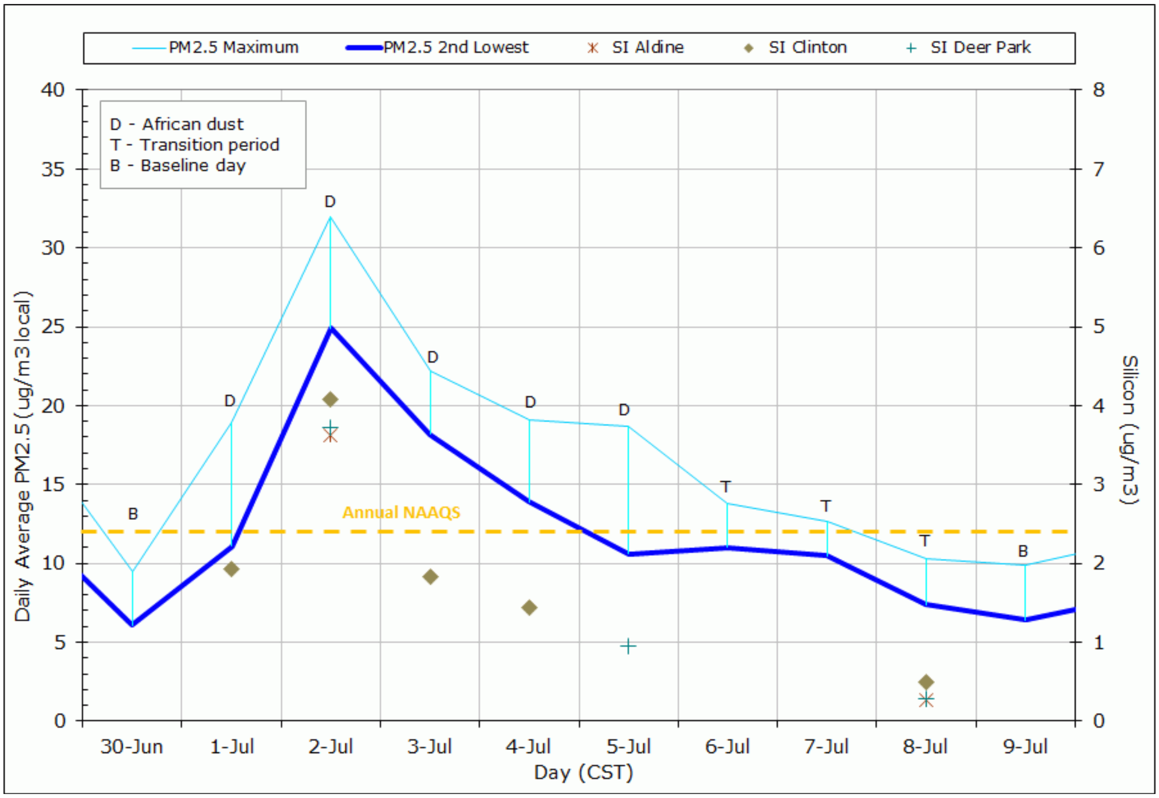


Figure 25. Houston area highest and second lowest daily average $PM_{2.5}$ concentrations with silicon (SI) concentrations at three speciation sites, June 30 through July 9, 2012.

Table 3. Houston Clinton daily $PM_{2.5}$ measurements and speciation measurements and calculations (µg/m^3) for June 30 through July 9, 2012.

Speciation Data	2010-2012 Jun-Aug*	2010-2012 Sep-May^	06/30/12	07/01/12	07/02/12	07/03/12	07/04/12	07/05/12	07/06/12	07/07/12	07/08/12	07/09/12
$PM_{2.5}$	11.7	*12.1*	7.3	*15.7*	*31.0*	*19.7*	*15.5*	*13.4*	*12.5*	11.5	9.2	9.2
Soil	2.0	1.3		8.6	*18.8*	8.8	6.6				2.1	
SAF	1.5	0.9		8.0	*17.4*	7.7	6.1				1.9	
SI	0.3	0.2		1.9	4.1	1.8	1.4				0.5	
AL	0.1	0.1		0.8	1.7	0.7	0.6				0.2	
FE	0.2	0.2		0.6	1.5	0.6	0.5				0.1	
CA	0.3	0.2		0.3	0.7	0.6	0.2				0.1	

Note: *Italics* indicate that a measurement is above the level of the annual $PM_{2.5}$ NAAQS and blank entries indicate no sample was scheduled, the monitor was not operational, or the measurement was not valid.

*Three-year summer average of the routine every sixth day speciation sampling days, with African dust days removed to illustrate typical concentrations of speciated parameters without the presence of African dust

^Three-year non-summer average of the routine every sixth day speciation sampling days (removal of African dust days was not necessary because these episodes normally only occur in the summer)

Abbreviations:

$PM_{2.5}$	Clinton FRM $PM_{2.5}$ measurement
Soil	IMPROVE calculation of soil component of speciation data
SAF	Sum of silicon, aluminum, and iron components of Soil IMPROVE calculation
SI	Silicon element measurement from speciation analysis
AL	Aluminum element measurement from speciation analysis
FE	Iron element measurement from speciation analysis
CA	Calcium element measurement from speciation analysis

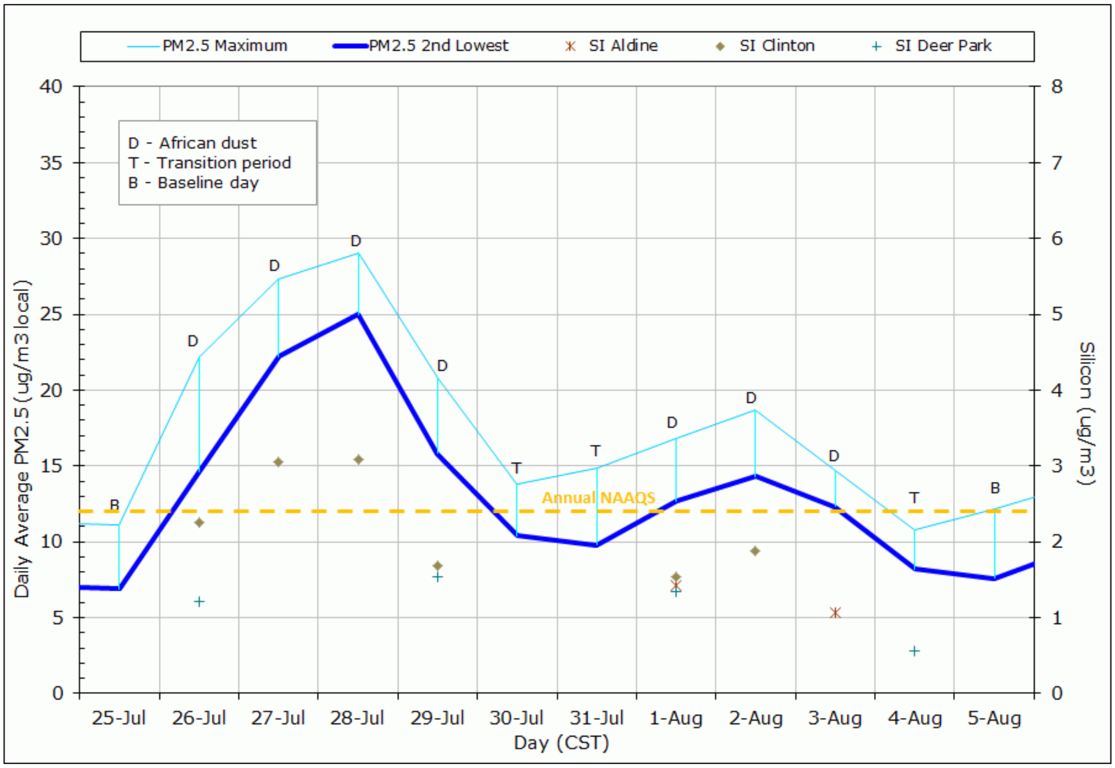


Figure 26. Houston area highest and second lowest daily average $PM_{2.5}$ with silicon (SI) concentrations at three speciation sites, July 25 through August 5, 2012.

Table 4. Houston Clinton daily $PM_{2.5}$ measurements and speciation measurements and calculations (µg/m^3) for July 25 through August 5, 2012.

Speciation Data	2010-2012 Jun-Aug*	2010-2012 Sep-May^	07/25/12	07/26/12	07/27/12	07/28/12	07/29/12	07/30/12	07/31/12	08/01/12	08/02/12	08/03/12	08/04/12	08/05/12
$PM_{2.5}$	11.7	*12.1*	11.1	*22.0*	*27.3*	*25.5*	*16.9*	*12.7*	*14.2*	*15.4*	*18.7*	*14.6*	9.4	10.2
Soil	2.0	1.3		11.6	*15.2*	*14.2*	7.6			7.7	9.5			
SAF	1.5	0.9		9.5	*13.0*	*13.0*	7.0			6.7	8.1			
SI	0.3	0.2		2.3	3.1	3.1	1.7			1.5	1.9			
AL	0.1	0.1		0.9	1.3	1.3	0.7			0.6	0.8			
FE	0.2	0.2		0.8	1.0	1.0	0.5			0.6	0.7			
CA	0.3	0.2		1.2	1.2	0.6	0.3			0.6	0.8			

Note: *Italics* indicate that a measurement is above the level of the annual $PM_{2.5}$ NAAQS and blank entries indicate no sample was scheduled, the monitor was not operational, or the measurement was not valid.

*Three-year summer average of the routine every sixth day speciation sampling days, with African dust days removed to illustrate typical concentrations of speciated parameters without the presence of African dust

^Three-year non-summer average of the routine every sixth day speciation sampling days (removal of African dust days was not necessary because these episodes normally only occur in the summer)

Abbreviations:

$PM_{2.5}$ Clinton FRM $PM_{2.5}$ measurement

Soil IMPROVE calculation of soil component of speciation data

SAF Sum of silicon, aluminum, and iron components of Soil IMPROVE calculation

SI Silicon element measurement from speciation analysis

AL Aluminum element measurement from speciation analysis

FE Iron element measurement from speciation analysis

CA Calcium element measurement from speciation analysis

Clear Causal Relationship

Numerous sources provide evidence that the elevated Houston Clinton $PM_{2.5}$ concentrations on July 2nd, 27th, and 28th were caused by African dust. The back trajectories, aerosol model output, and visible satellite imagery provided in Appendices B and C show a daily record of dust cloud locations back to Africa. Measured speciated $PM_{2.5}$ data show a very large contribution of soil species consistent with African dust on all three days as discussed in the Natural Events section above.

First, back trajectories provide confirmation of the path of the air originating in Africa. Produced using the NOAA ARL HYSPLIT model, the backward-in-time trajectories show model-predicted paths of air parcels. Figure 27, as well as the trajectories in Appendices B and C, clearly indicates that air arriving in the Houston area mid-day on each of the proposed exceptional event days originated from the west coast of Africa (NOAA ARL, 2013). These back trajectories, which are not allowed to run more than 312 hours backward in time, show good agreement with satellite tracking of the African dust, which further supports this relationship.

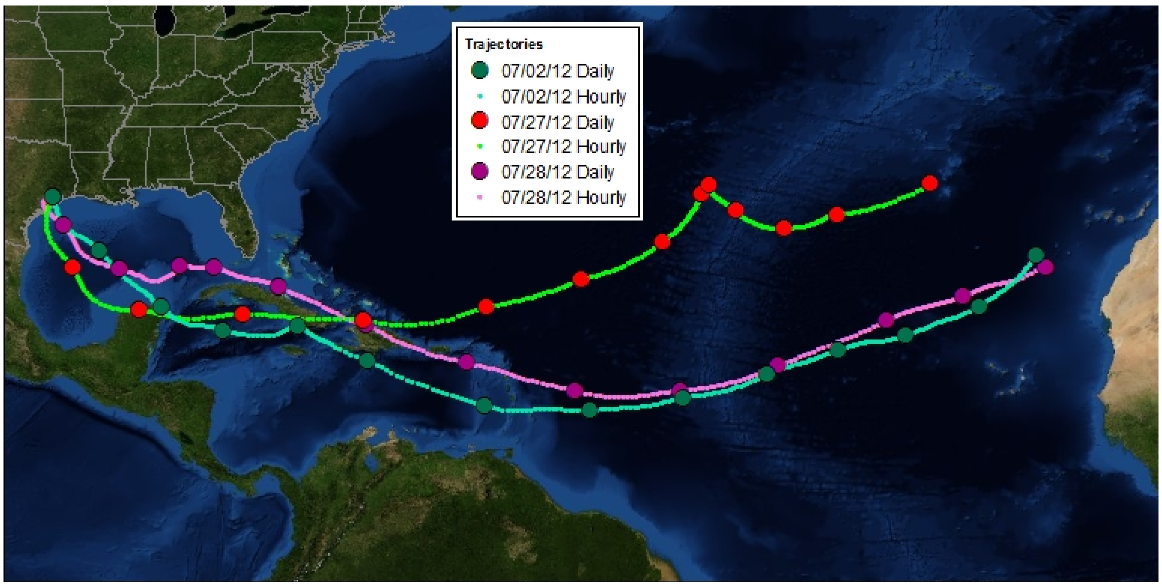


Figure 27. Plot of HYSPLIT model backward-in-time air parcel trajectories for each 2012 exceptional event day, for air arriving at noon Central Standard Time each day (NOAA ARL, 2013).

Second, the aerosol model outputs provided in Appendices B and C show dust clouds originating off the west coast of Africa being transported across the Atlantic Ocean, into the Gulf of Mexico, and finally into the Texas coast. Figure 28 shows an example of NRL aerosol model output for July 19, 2012, showing the dust cloud that arrived in the Houston area on July 27, 2012, as it was moving into the Lesser Antilles from the tropical Atlantic Ocean.

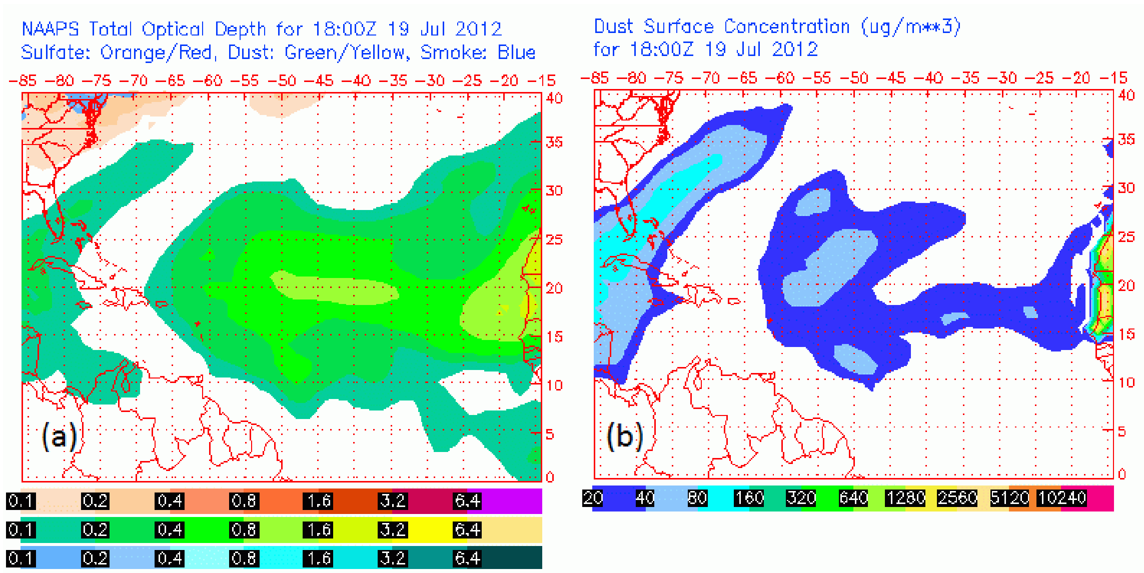


Figure 28. NRL aerosol model output showing aerosol optical depth (a) and dust surface concentration (b), for the dust cloud that arrived in Houston on July 27, 2012, as it was moving into the Lesser Antilles.

Third, the satellite imagery provided in Appendices B and C also show dust clouds originating off the west coast of Africa being transported across the Atlantic Ocean, into the Gulf of Mexico, and finally into the Texas coast. Sequences of satellite images provided in Appendix C indicate that the dust cloud depicted in Figure 28, marked “12” in the Appendix C satellite imagery, arrived in the Houston area on July 27 and 28, 2012. Figure 29 shows that same dust cloud as it approached the Lesser Antilles on July 19th with a trail of dust extending back to Africa behind it. The dust appears bluish-grayish in these images and clouds are bright white and blue. Cloud-free areas over the ocean are normally very dark blue in these natural color images when no dust or haze is present.

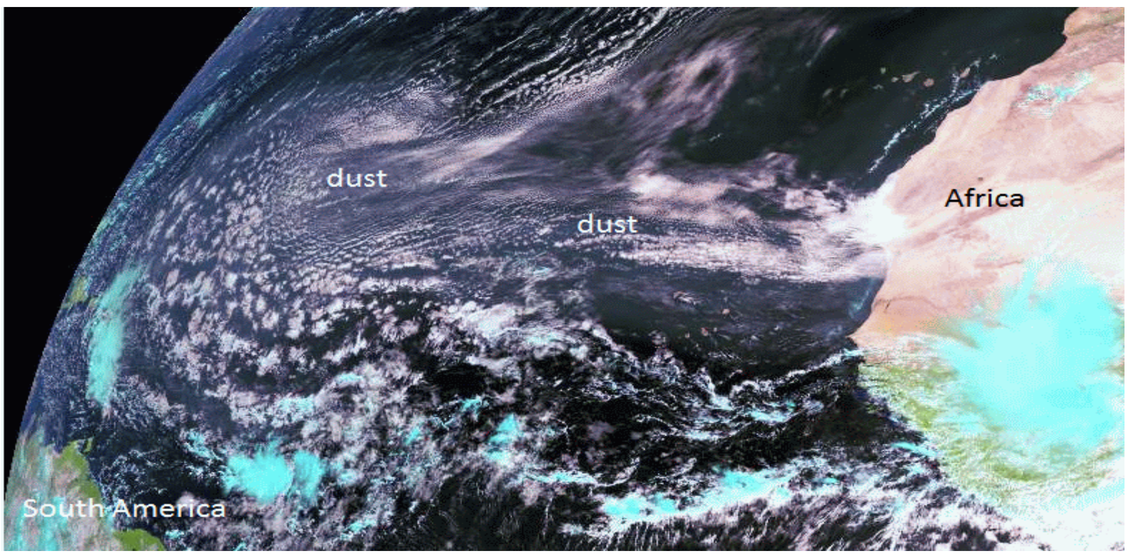


Figure 29. Meteosat natural color satellite image composite showing African dust approaching the Lesser Antilles and stretching across the Atlantic Ocean to Africa on July 19, 2012.

Finally, measured speciation data provide evidence that the elevated $PM_{2.5}$ concentrations were due to African dust. As discussed in the Natural Events section and illustrated in Figures 21 through 23, silicon, aluminum, and iron are excellent markers for African dust events in Southeast Texas because they remain low except during transported dust events. Using silicon as an example, levels were elevated by a factor of five to ten in the Houston area on the African dust event peaks marked with a "D" as compared to typical days without African dust before and after each event as shown in Figure 30.

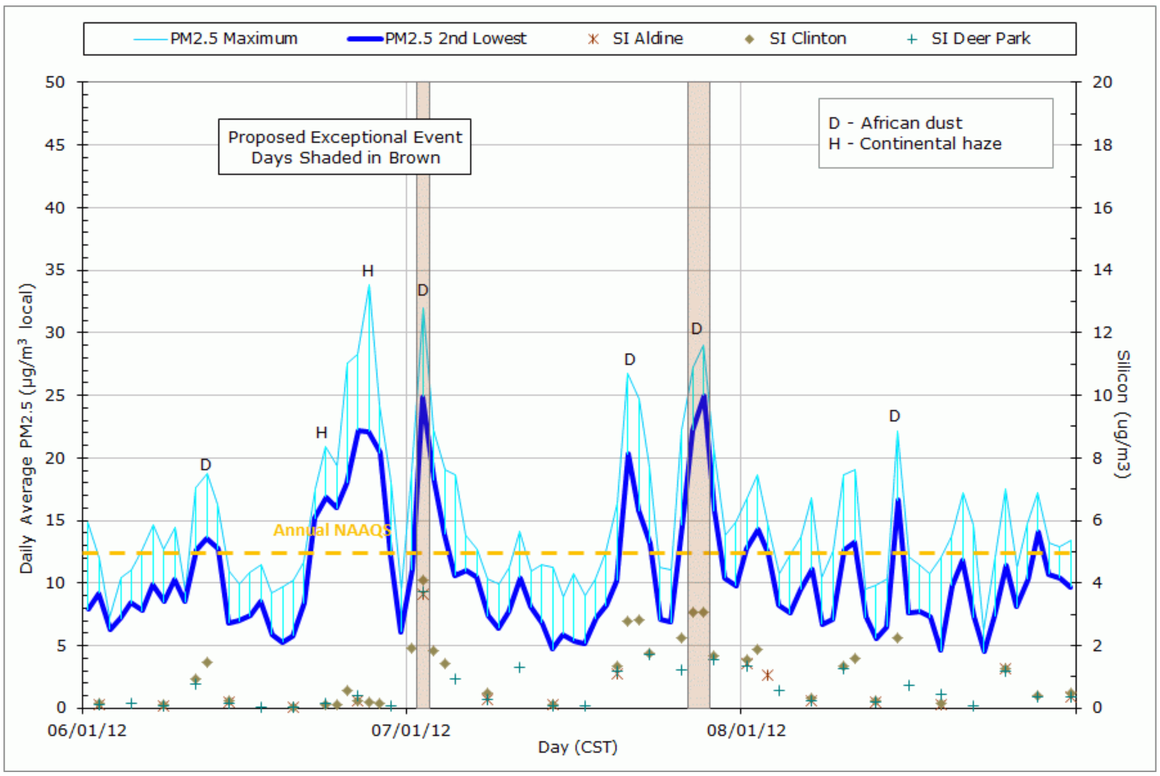


Figure 30. Houston area maximum and second lowest $PM_{2.5}$ levels each day (blue lines) based on both Federal Reference Method (FRM) and Tapered Element Oscillating Microbalance (TEOM) data, along with all available speciated silicon (SI) measurements (symbols) for the summer of 2012.

$PM_{2.5}$ levels were high at all Houston area sites on the proposed African dust exceptional event days, as were estimated incoming background levels as shown in Figures 25 and 26. Incoming background levels were estimated using either representative upwind daily measurements or the second lowest area daily measurement depending on each individual day's meteorological conditions. The estimated incoming $PM_{2.5}$ background levels were over 20 µg/m^3 and the SAF soil contribution alone was over 12 µg/m^3 on each of the proposed exceptional event days as shown in Figure 31. During all of the proposed African dust exceptional event days, the Houston Clinton $PM_{2.5}$ concentration and estimated incoming background levels were two to three times higher than levels in the intervening period.

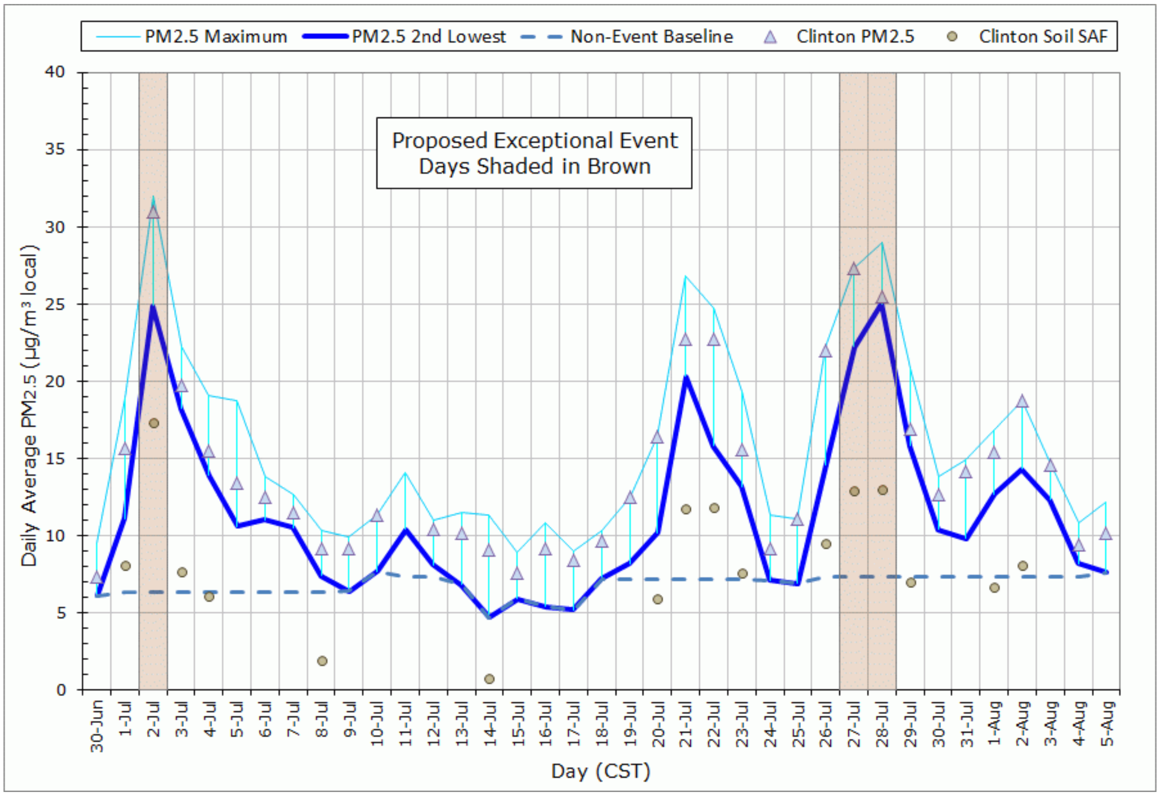


Figure 31. Houston area highest and second lowest daily average $PM_{2.5}$ levels with Clinton IMPROVE soil SAF, June 30 through August 5, 2012.

All together, the backward-in-time air trajectories, aerosol model output, satellite imagery, and speciated $PM_{2.5}$ data provide clear evidence that increased $PM_{2.5}$ concentrations at the Houston Clinton site on the proposed exceptional events were caused by these African dust events.

Event In Excess of Normal Historical Fluctuations

As mentioned in the Affects Air Quality section, $PM_{2.5}$ concentrations during the proposed exceptional event days were well above normal historical measurements. Statistics for the Houston Clinton FRM $PM_{2.5}$ monitor for 1,056 measurements over the three-year period from

2010 through 2012 show a 95th percentile concentration of 20.6 μg/m³. Figure 19 shows a comparison of the proposed exceptional event days to all Houston Clinton $PM_{2.5}$ measurements for 2010 through 2012.

The $PM_{2.5}$ concentrations on the proposed exceptional event days also represent the greatest incoming background levels for 2012, based on the Houston area second lowest daily measurements as shown in Figure 32. The Houston Clinton $PM_{2.5}$ concentration and estimated incoming background levels on July 2nd, 27th, and 28th were two to three times higher than levels in the intervening period.

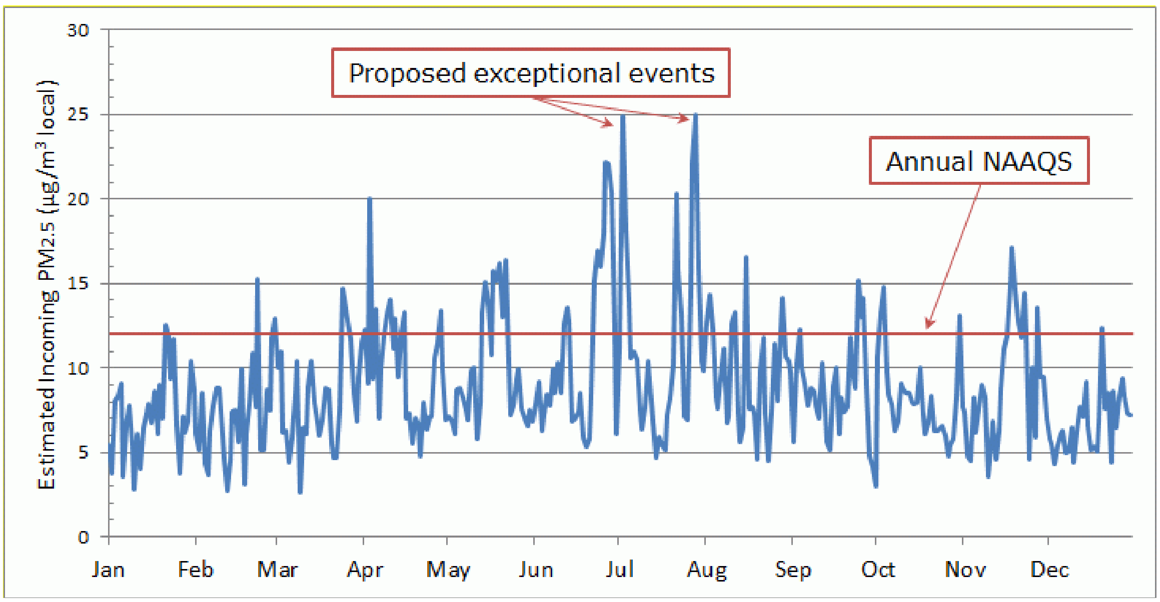


Figure 32. Houston area 2012 estimated incoming $PM_{2.5}$ background level based on using the area second lowest daily measurement as an initial screening strategy.

No Exceedance But For the Event

Title 40 CFR 50.14(c)(3)(iv)(D) states the demonstration to justify exceptional event designation shall provide evidence that “there would have been no exceedance or violation but for the event.” The TCEQ used mathematical, surrogate day, and modeling methods for estimating the daily $PM_{2.5}$ concentration at the Houston Clinton site but for the African dust events in July 2012.

Surrogate Day "But For" Analysis

The TCEQ identified August 13, 2012, as a day with similar meteorological conditions (referred to as a surrogate day) to the proposed exceptional event days. In order to determine the surrogate day, the TCEQ evaluated wind, temperature, precipitation, and solar radiation measurements collected at the Houston Clinton site as well as back trajectories to ensure similar local meteorological conditions and that the incoming air mass and $PM_{2.5}$ background concentrations originated off the west coast of Africa. Table 5 compares the key local meteorological parameters between the proposed exceptional event days and the surrogate day to illustrate the similar weather patterns present on all four days.

Table 5. Houston Clinton meteorological and $PM_{2.5}$ measurement comparison between the proposed exceptional event days and the August 13, 2012, surrogate day.

Houston Clinton Parameter (units)	07/02/2012	07/27/2012	07/28/2012	08/13/2012
Resultant Wind Direction (degrees)	170	218	244	231
Resultant Wind Speed (miles per hour)	7.0	6.2	3.1	6.7
Average Wind Speed (miles per hour)	7.5	6.7	4.9	7.3
Average Temperature (degrees Fahrenheit)	84.5	85.9	86.2	86.8
Total Precipitation (inches)	0.00	0.00	0.00	0.00
Sum of Hourly Average Solar Radiation measurements (langleys per minute)	9.2	9.3	9.0	7.8
$PM_{2.5}$ FRM 24-hour concentration ($\mu g/m^3$)	*31.0*	*27.3*	*25.5*	8.4

Note: *Italics* indicate that a measurement is above the level of the annual $PM_{2.5}$ NAAQS.

Abbreviations:

FRM Federal Reference Method non-continuous

Figure 33 provides a HYSPLIT back trajectory that shows the approximate path of air arriving in the Houston area at 1200 central standard time (CST) (or 1800 coordinated universal time [UTC]) at 500 meters, 1,000 meters, and 1,500 meters above ground level on the surrogate day and going backward in time 312 hours. As with the trajectories presented in Appendices B and C, the NOAA web site where the trajectories were produced does not allow them to run past 312 hours, so it is not possible to follow the air parcel all the way back into Africa. A comparison between this back trajectory and the back trajectories for the proposed exceptional events provided in Appendices B and C indicates that the incoming air mass followed a similar path from the west coast of Africa across the Atlantic before moving into the Gulf of Mexico and finally arriving along the Texas coast in the Houston area.

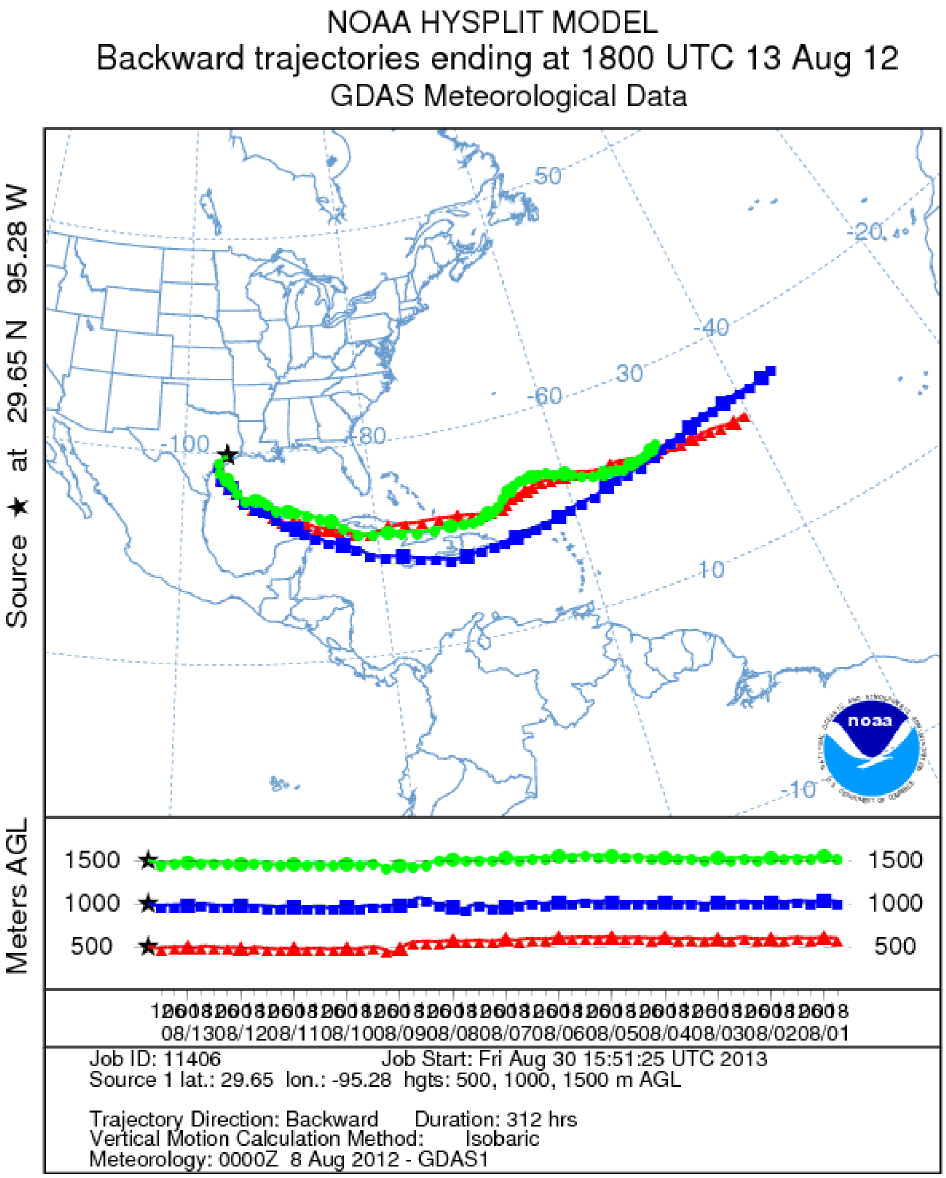


Figure 33. Backward-in-time air trajectory for August 13, 2012.

The peak 24-hour average $PM_{2.5}$ concentrations in the Houston area on July 2nd (32.0 μg/m^3), July 27th (27.3 μg/m^3), and July 28th (29.0 μg/m^3) were all about three times the peak 24-hour average concentration of 9.8 μg/m^3 on the August 13th surrogate day (see Tables 6 and 8). Given the similarity in key meteorological parameters between the four days, the presence of African dust on July 2nd, 27th, and 28th accounts for the difference in the measured $PM_{2.5}$ concentrations. This surrogate day analysis demonstrates that on a day with similar meteorological conditions but without African dust, there would have been no exceedance of the annual NAAQS on the proposed exceptional event days but for the African dust event.

Mathematical "But For" Analysis for July 2nd

The mathematical method for evaluation of the Clinton $PM_{2.5}$ concentration but for the event first required calculation of the baseline incoming background concentration without the influence of the African dust events.

Table 6 shows the Houston area daily average $PM_{2.5}$ measurements by site and Figure 34 illustrates the hourly $PM_{2.5}$ measurements at the Clinton site. $PM_{2.5}$ concentrations were elevated at all sites from July 1st through 4th in association with African dust prior to a transition period from July 5th through 8th when $PM_{2.5}$ levels slowly fell as the dust moved inland and dissipated. As shown in Figures 35 and 36, the Houston area second lowest $PM_{2.5}$ values indicate that incoming regional background levels were almost four times higher on July 2nd than the days before (June 30th) and after (July 9th) the African dust event. Consequently, June 30th was used to indicate the initial baseline incoming background level before the African dust event and July 9th was used to indicate the baseline incoming background level at the end of the event. The area second lowest daily measurements from June 30th (6.1 $\mu g/m^3$ measured at Deer Park) and July 9th (6.4 $\mu g/m^3$ measured at Deer Park and Kingwood) were averaged to estimate the baseline incoming background level during the intervening period at 6.3 $\mu g/m^3$.

Table 6. Houston area daily average $PM_{2.5}$ concentrations (µg/m^3) by site from June 30 through July 9, 2012, including the August 13, 2012, surrogate day.

Site Name	Type	06/30/12	07/01/12	07/02/12	07/03/12	07/04/12	07/05/12	07/06/12	07/07/12	07/08/12	07/09/12	08/13/12
Galveston	AC					*13.1*	11.3	*13.8*	10.9	7.5	9.9	6.8
Seabrook	AC	5.5	*18.9*	*32.0*	*18.2*	*14.4*	11.0	11.0	11.7	7.5	6.9	5.9
Deer Park	AS			*27.0*			11.4			7.1		5.6
Deer Park	AC	**6.1**	*13.2*	*25.8*	*16.9*	*13.9*	10.4	10.0		7.4	**6.4**	6.3
Baytown	FRM			*28.6*			10.6			7.7		7.3
Channel-view	AC	8.4	*14.9*	*28.6*	*19.2*	*16.3*	*12.9*	*12.3*	*12.7*	9.8	9.8	
Houston East	AC								11.9	10.1	8.6	7.6
Clinton	FRM	7.3	*15.7*	*31.0*	*19.7*	*15.5*	*13.4*	*12.5*	11.5	9.2	9.2	8.4
Clinton	AC				*20.5*	*16.4*	*14.0*	*12.9*	12.0	10.3	9.1	9.8
Park Place	AC	6.9	*14.8*	*30.8*	*21.3*	*17.4*	*14.2*	*12.3*	11.6	9.0	7.0	8.2
Aldine	FRM			*26.4*						8.5		5.8
Aldine	AC	7.9	*12.7*	*29.1*	*22.2*	*19.1*	*15.5*	*12.4*	11.2	9.1	9.3	6.2
Kingwood	AC	7.7	11.1	*24.9*	*20.3*	*18.6*	*14.9*	*12.1*	10.5	7.7	**6.4**	6.4
Conroe	AC	9.5	9.5	*24.3*	*20.1*	*16.3*	*18.7*	11.3	8.3	7.7	7.5	5.4

Note: *Italics* indicate that a measurement is above the level of the annual $PM_{2.5}$ NAAQS, **bold** indicates that the measurement was used in the calculation of the baseline incoming background levels as described in the preceding paragraph, and blank entries indicate no sample was scheduled, the monitor was not operational, or the measurement was not valid.

Abbreviations:

AC Acceptable continuous

AS Acceptable speciated non-continuous

FRM Federal Reference Method non-continuous

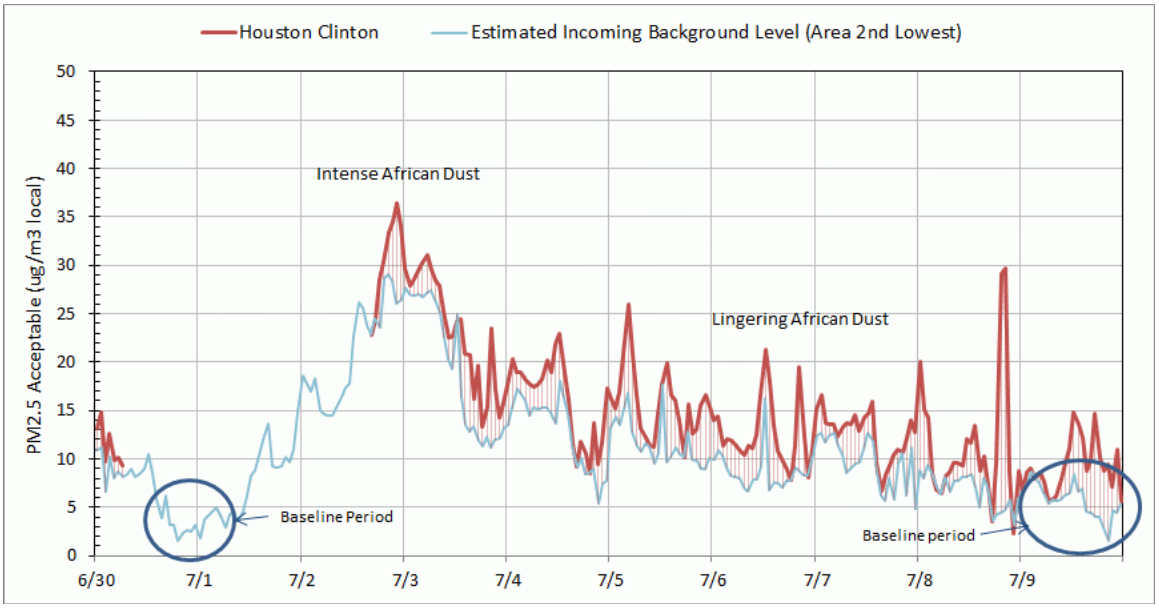


Figure 34. Houston Clinton hourly $PM_{2.5}$ measurements and the Houston area second lowest measurements from June 30 through July 9, 2012. Houston Clinton measurements were invalid from June 30 to July 2 while the continuous monitor was down.

Selection of these dates as being representative of the baseline incoming background is corroborated by evaluation of soil SAF data and $PM_{2.5}$ data from coastal sites. Figures 35 and 36 graphically show the high IMPROVE soil SAF calculated at the Clinton site corresponding with the increase in measured $PM_{2.5}$ during the proposed African dust event. Figure 36 also shows measurements from South Texas coastal sites National Seashore and Isla Blanca, which indicate an extreme increase in $PM_{2.5}$ concentrations on July 2nd, followed by a slow dissipation of the concentrations after July 3rd. The pattern of $PM_{2.5}$ concentrations from these coastal sites further corroborates the selection of the baseline days.

The choice of the second lowest $PM_{2.5}$ value for the baseline days is conservative for this event. On June 30th the wind direction was generally from the southeast as can be seen in Figure 9, and the lowest upwind concentration was 5.5 $\mu g/m^3$ at Seabrook while the area second lowest was 6.1 $\mu g/m^3$ at Deer Park. On July 9th the wind flow was from the south, and both the upwind Deer Park site and the downwind Kingwood sites measured area lowest and second lowest concentrations of 6.4 $\mu g/m^3$.

All area measurements were low on these days as can be seen in Figure 36 and Table 6. Because both the upwind site and the area second lowest site had such similar concentrations, there is a greater degree of confidence that the selection of the background concentration is both representative and statisticially appropriate. Furthermore, the use of the higher estimate of the baseline by selection of the area second lowest measurement increases the calculated "but for" concentration and is therefore more conservative than using measurements from the upwind site.

The second step in the mathematical "but for" calculation required estimating local contributions at the Clinton site. The local contribution for each day during the June 30th through July 9th time period was calculated by subtracting the Houston area second lowest measurement from the Clinton $PM_{2.5}$ measurement for that day, with the exception of July 2nd. While using the area second lowest measurement is an effective initial screening strategy to gauge incoming background levels, performing a detailed assessment of wind patterns and $PM_{2.5}$ measurements for an individual day can provide a more representative assessment of the incoming background level, especially when significant gradients are present. Because of a significant south-north gradient in the regional $PM_{2.5}$ background levels due to the arrival timing of the primary African dust cloud, the Houston area second lowest measurement was not used to indicate the incoming background level on July 2nd as discussed in the Event Summary section. Instead, the incoming background level affecting Clinton on July 2nd was estimated using the Deer Park measurement of 25.8 $\mu g/m^3$ due to its upwind location relative to Clinton with no upwind emission sources of its own.

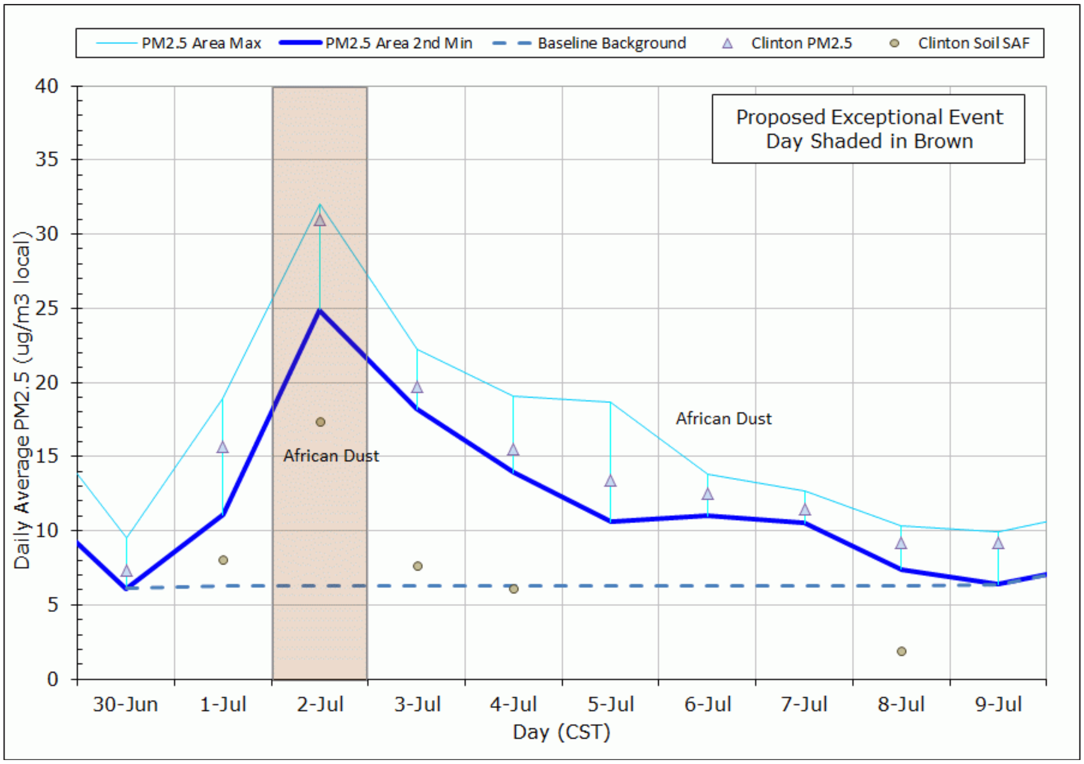


Figure 35. Houston area highest and second lowest daily average $PM_{2.5}$ with Clinton IMPROVE soil SAF, June 30 through July 9, 2012.

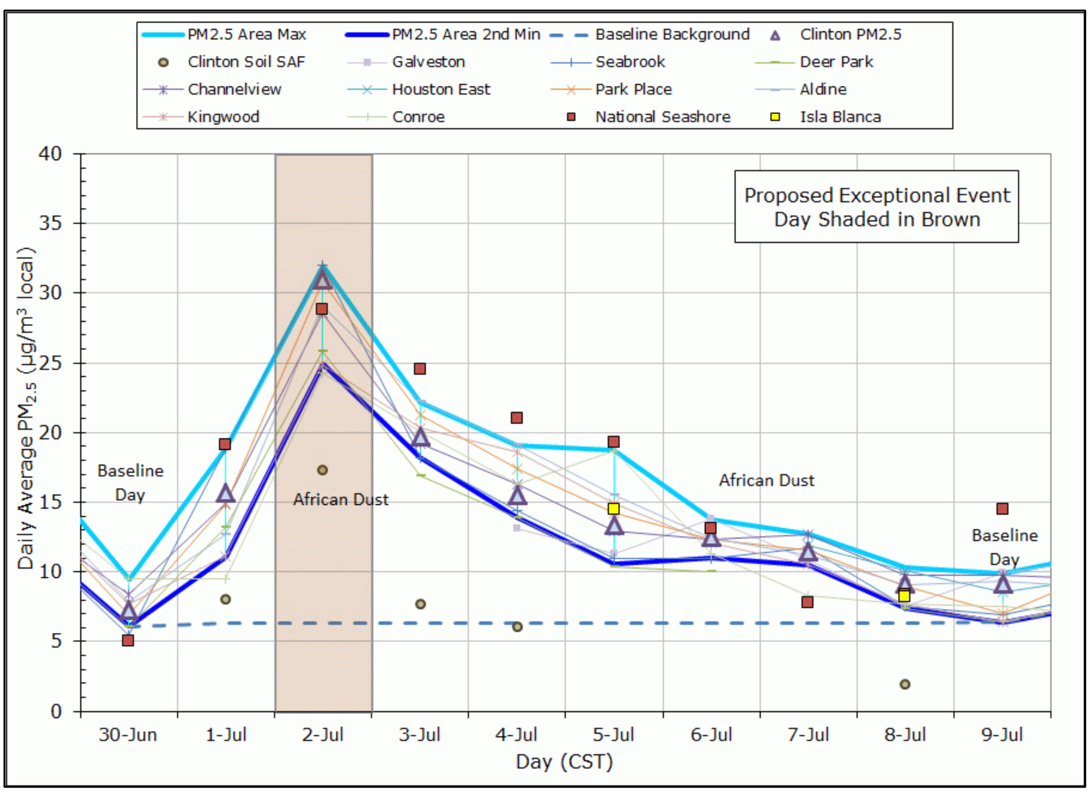


Figure 36. Houston area daily average $PM_{2.5}$ and Clinton IMPROVE soil SAF, June 30 through July 9, 2012, along with Isla Blanca and National Seashore.

The final step in mathematically calculating the Clinton "but for" $PM_{2.5}$ value was to add the calculated local contribution to the baseline incoming background estimates for each day of the event. Table 7 shows a summary of Houston area daily $PM_{2.5}$ measurements for June 30th through July 9th along with the Houston Clinton "but for" calculations. This analysis provides strong evidence that the daily average Clinton $PM_{2.5}$ concentration would not have exceeded the annual standard on the proposed exceptional event day of July 2nd without the occurrence of this African dust event.

Table 7. Summary of Houston area daily average $PM_{2.5}$ measurements ($\mu g/m^3$) for June 30th through July 9th showing the Houston Clinton concentrations but for the African dust event.

	06/30/12	07/01/12	07/02/12	07/03/12	07/04/12	07/05/12	07/06/12	07/07/12	07/08/12	07/09/12
Houston area maximum	9.5	*18.9*	*32.0*	*22.2*	*19.1*	*18.7*	*13.8*	*12.7*	10.3	9.9
Houston area second lowest *	6.1	11.1	*25.8*	*18.2*	*13.9*	10.6	11.0	10.5	7.4	6.4
Clinton FRM	7.3	*15.7*	*31.0*	*19.7*	*15.5*	*13.4*	*12.5*	11.5	9.2	9.2
$PM_{2.5}$ difference between Clinton and area second lowest (local contribution)	1.2	4.6	5.2	1.5	1.6	2.8	1.5	1.0	1.8	2.8
Baseline incoming background	6.1	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.4
But for Event Clinton concentration	7.3	10.9	11.5	7.8	7.9	9.1	7.8	7.3	8.1	9.2

Notes:

* Except for July 2nd where estimate from most representative upwind site was used.

Italics indicate that a measurement is above the level of the annual $PM_{2.5}$ NAAQS.

Mathematical "But For" Analysis for July 27th and 28th

Just as in the calculation of the July 2nd event, the mathematical method for evaluation of the Clinton $PM_{2.5}$ concentration but for the July 27th and 28th event first required calculation of the baseline incoming background concentration without the influence of the African dust.

Table 8 shows the Houston area daily average $PM_{2.5}$ measurements by site and Figure 37 illustrates the hourly $PM_{2.5}$ measurements at the Clinton site. $PM_{2.5}$ was elevated at all sites from July 26th through 29th in association with the primary African dust cloud, followed by a brief transition period on July 30th that preceded a second, weaker African dust cloud affecting the area from July 31st through August 4th. As shown in Figures 38 and 39, the Houston area second lowest $PM_{2.5}$ values indicate that incoming regional background levels were more than three times higher on July 27th and 28th than the days before (July 25th) and after (August 5th) the African dust event. Consequently, July 25th was used to indicate the initial baseline incoming background level before the African dust event and August 5th was used to indicate the baseline incoming background level at the end of the event. The area second lowest daily measurements from July 25th (6.9 $\mu g/m^3$ measured at Galveston) and August 5th (7.6 $\mu g/m^3$ measured at Seabrook) were averaged to estimate the baseline incoming background level for the intervening period at 7.3 $\mu g/m^3$.

Table 8. Houston area daily average $PM_{2.5}$ measurements ($\mu g/m^3$) by site from July 25 through August 5, 2012, including the August 13, 2012, surrogate day.

Site Name	Type	07/25/12	07/26/12	07/27/12	07/28/12	07/29/12	07/30/12	07/31/12	08/01/12	08/02/12	08/03/12	08/04/12	08/05/12	08/13/12
Galveston	AC	**6.9**	*18.8*	*22.2*	*26.5*			10.0	*14.1*	*16.0*	*12.3*	9.2	6.8	6.8
Seabrook	AC	7.3	*19.4*	*24.1*	*29.0*	*17.2*	10.4	11.6	*14.3*	*15.6*	*13.4*	9.7	**7.6**	5.9
Deer Park	AS		*14.0*			*15.8*			*12.7*			8.0		5.6
Deer Park	AC	6.3	*15.3*	*20.4*	*23.4*	*15.0*	9.8	9.7	*12.1*	*13.3*	11.3	8.2	8.6	6.3
Baytown	FRM		*15.7*			*17.9*			*14.1*			9.2		7.3
Channelview	AC	7.9	*17.7*	*24.1*	*26.7*	*18.4*								
Houston East	AC	8.2	*17.6*	*24.2*	*25.5*	*17.4*	11.5	*12.3*	*14.2*	*14.8*				7.6
Clinton	FRM	11.1	*22.0*	*27.3*	*25.5*	*16.9*	*12.7*	*14.2*	*15.4*	*18.7*	*14.6*	9.4	10.2	8.4
Clinton	AC	11.1	*22.2*	*27.2*	*26.5*	*17.5*	*13.8*	*14.9*	*16.8*	*18.3*	*14.7*	9.7	11.4	9.8
Park Place	AC	8.3	*19.7*	*26.5*	*28.3*	*18.5*	*12.2*	*14.5*	*16.1*	*17.2*	*14.1*	10.4	10.5	8.2
Aldine	FRM								*13.4*		*12.6*			5.8
Aldine	AC	9.1	*19.8*	*25.8*	*27.6*	*19.2*	11.8	*13.4*	*15.1*	*16.9*	*14.0*	10.8	*12.2*	6.2
Kingwood	AC	7.9	*17.7*	*24.8*	*25.0*	*20.8*	11.1	11.4	*14.6*	*16.3*	*14.3*	10.6	9.4	6.4
Conroe	AC	7.2	*14.6*	*22.9*	*25.4*	*19.0*	10.5	9.8	*13.0*	*14.3*	*12.7*	10.5	10.3	5.4

Note: *Italics* indicate that a measurement is above the level of the annual $PM_{2.5}$ NAAQS, **bold** indicates that the measurement was used in the calculation of the baseline incoming background levels as described in the preceding paragraph, and blank entries indicate no sample was scheduled, the monitor was not operational, or the measurement was not valid.

Abbreviations:

AC Acceptable continuous

AS Acceptable speciated non-continuous

FRM Federal Reference Method non-continuous

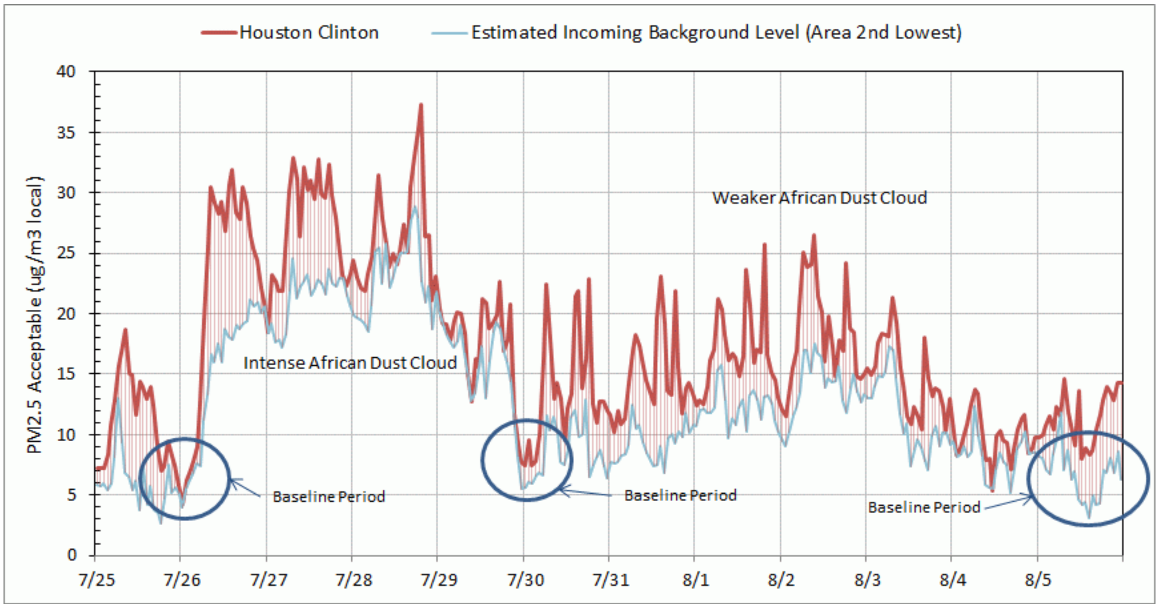


Figure 37. Houston Clinton hourly $PM_{2.5}$ measurements and the Houston area second lowest measurements from July 25 through August 5, 2012.

Selection of these dates as being representative of the baseline background is corroborated by evaluation of soil SAF data and $PM_{2.5}$ data from coastal sites. Figures 38 and 39 graphically show the high IMPROVE soil SAF calculated at the Clinton site corresponding with the increase in measured $PM_{2.5}$ concentrations during the proposed African dust event. Figure 39 also shows measurements from South Texas coastal sites National Seashore and Isla Blanca, which indicate an extreme increase in $PM_{2.5}$ concentrations on July 27th, followed by low, sustained $PM_{2.5}$ concentrations through August 4th. The pattern of $PM_{2.5}$ concentrations from these coastal sites further corroborates the selection of the baseline days.

The choice of the second lowest $PM_{2.5}$ value for the baseline days is conservative for this event. On July 25th the wind direction was generally from the southwest as can be seen in Figure 17, and the lowest concentration was 6.3 µg/m^3 at Deer Park while the area second lowest was 6.9 µg/m^3 at Galveston, which is upwind on this day. On August 5th the wind flow was somewhat variable, and the lowest concentration was 6.8 µg/m^3 at Galveston while the area second lowest was 7.6 µg/m^3 at Seabrook. These upwind sites either had lower or similar concentrations to the average of the second lowest site (7.3 ug/m^3). There is evidence that the estimated baseline incoming background level for this event of 7.3 ug/m^3 is significantly higher than what $PM_{2.5}$ measurements show under similar meteorological conditions when there is no contribution from African dust, as explained in the Surrogate Day “But For” Analysis section above. The lowest concentration measured on August 13th was 5.4 ug/m^3 at Conroe while the area second lowest was 5.6 ug/m^3 at Deer Park as shown in Table 8. Given the moderate south to southwesterly wind flow on this day comparable to July 27th, the measurement of 6.8 ug/m^3 at the upwind Galveston site is also a reasonable, but more conservative, estimate of the baseline incoming background level under these meteorological conditions. Thus, there is strong evidence that the estimated baseline incoming background levels used in the "but for" mathematical analysis of 7.3 ug/m^3 may be biased high by about 0.5 to 2.0 ug/m^3. A more detailed assessment of meteorological conditions and $PM_{2.5}$ measurements for August 13th is presented above in the Surrogate Day "But For" Analysis section.

All area measurements were low on these days as can be seen in Figure 39 and Table 8. Because both the area lowest and second lowest sites had such similar concentrations, there is a greater degree of confidence that the selection of the background concentration is both representative and statisticially appropriate. Furthermore, the use of the higher estimate of the baseline by selection of the area second lowest measurement increases the calculated "but for" concentration and is therefore more conservative than using measurements from the upwind site. Additionally, the assessment of incoming background levels for the surrogate day of August 13, 2012, confirms that using 7.3 ug/m^3 as the baseline incoming background level in the "but for" calculation for this event is indeed conservative.

The second step in the "but for" calculation required estimating local contributions at the Clinton site. The local contribution for each day during the July 25th through August 5th time period was calculated by subtracting the Houston area second lowest measurement from the Clinton $PM_{2.5}$ measurement for that day, with the exception of July 27th. While using the area second lowest measurement is an effective initial screening strategy to gauge incoming background levels, performing a detailed assessment of wind patterns and $PM_{2.5}$ measurements for an individual day can provide a more representative assessment of the incoming background level, especially when significant gradients are present. The $PM_{2.5}$ measurement of 22.2 µg/m^3 observed at Galveston on July 27th was the Houston area second lowest measurement for the day. As previously discussed in the Event Summary section for this event, the coastal location of the Galveston monitor combined with steady onshore wind flow indicates that this site would provide a reasonable estimate of the minimum incoming background levels on July 27th. Seabrook, the next upwind monitor with no major $PM_{2.5}$ sources of its own, was used as a reasonable estimate of the upper limit in the range of incoming background levels on July 27th in order to account for potential gradients in the incoming background levels. Thus, the incoming background level affecting Clinton on July 27th was estimated to be between 22.2 μg/m^3 and 24.1 μg/m^3 based on the upwind measurements at Galveston and Seabrook, respectively.

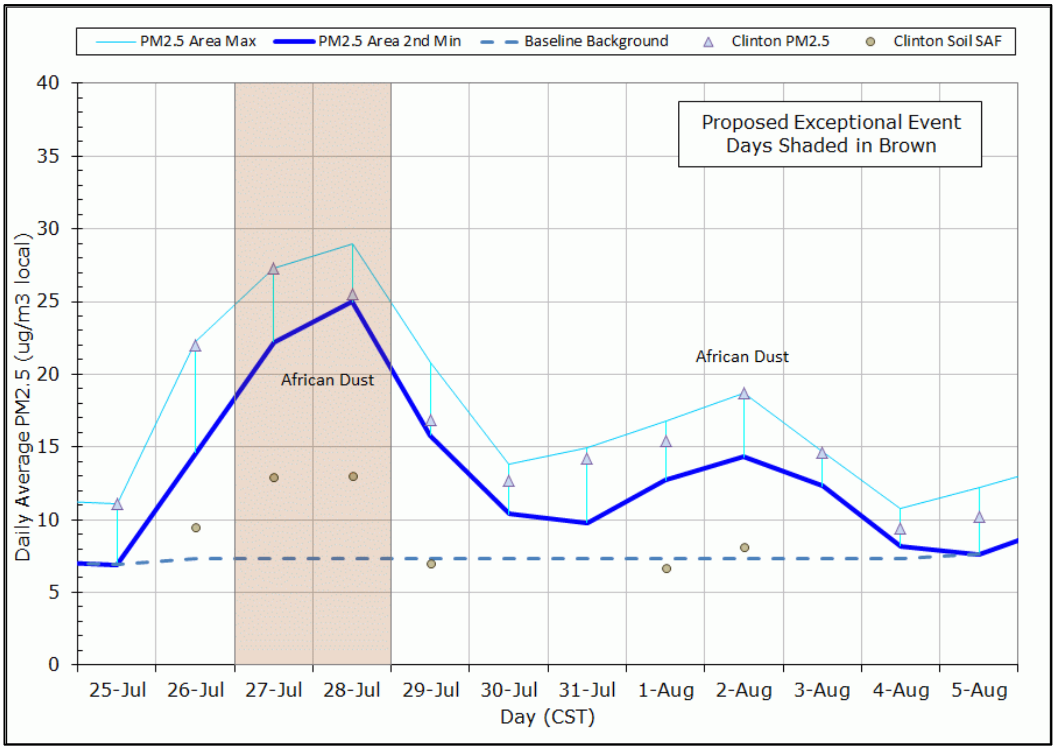


Figure 38. Houston area highest and second lowest daily average $PM_{2.5}$ with Clinton IMPROVE soil SAF, July 25 through August 5, 2012.

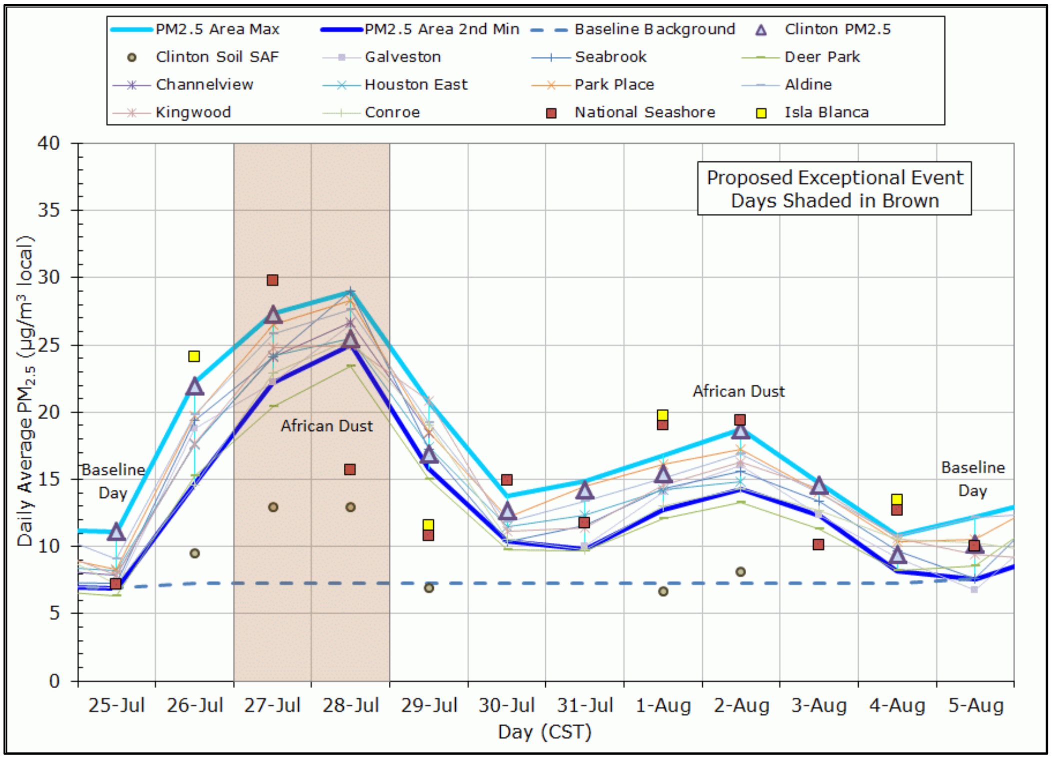


Figure 39. Houston area daily average $PM_{2.5}$ and Clinton IMPROVE soil SAF, July 25 through August 5, 2012, along with Isla Blanca and National Seashore.

The final step in mathematically calculating the Clinton “but for” $PM_{2.5}$ value was to add the calculated local contributions to the baseline incoming background estimates for each day of the event. Table 9 shows a summary of Houston daily $PM_{2.5}$ measurements for July 25th through August 5th along with the Houston Clinton “but for” calculations. Accounting for the fact that the baseline incoming background level for this event is biased high by at least 0.5 ug/m^3 (which is enough to bring the upper limit of the “but for event” Clinton concentration of 12.4 ug/m^3 below the annual standard of 12.0 ug/m^3) and perhaps up to 2.0 ug/m^3 as discussed previously, this analysis provides strong evidence that the daily average Clinton $PM_{2.5}$ concentration would not have exceeded the annual standard on the proposed exceptional event days of July 27th and 28th without the occurrence of this African dust event.

Table 9. Summary of Houston area daily average $PM_{2.5}$ measurements ($\mu g/m^3$) for July 25th through August 5th showing the Houston Clinton concentrations but for the African dust event.

	07/25/12	07/26/12	07/27/12	07/28/12	07/29/12	07/30/12	07/31/12	08/01/12	08/02/12	08/03/12	08/04/12	08/05/12
Houston area maximum	11.1	*22.2*	*27.3*	*29.0*	*20.8*	*13.8*	*14.9*	*16.8*	*18.7*	*14.7*	10.8	*12.2*
Houston area second lowest *	6.9	*14.6*	*22.2* to *24.1*	*25.0*	*15.8*	10.4	9.8	*12.7*	*14.3*	*12.3*	8.2	7.6
Clinton FRM	11.1	*22.0*	*27.3*	*25.5*	*16.9*	*12.7*	*14.2*	*15.4*	*18.7*	*14.6*	9.4	10.2
$PM_{2.5}$ difference between Clinton and area second lowest (local contribution)	4.2	7.4	3.2 to 5.1	0.5	1.1	2.3	4.4	2.7	4.4	2.3	1.2	2.6
Baseline incoming background	6.9	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.6
But for Event Clinton concentration	11.1	*14.7*	10.5 to *12.4*	7.8	8.4	9.6	11.7	10.0	11.7	9.6	8.5	10.2

Notes:

* Except for July 27th where a range of estimates from most representative upwind sites was used.

Italics indicate that a measurement is above the level of the annual $PM_{2.5}$ NAAQS.

Mathematical "But For" Analysis Conclusions for All Proposed Exceptional Event Days

Figures 40 and 41 show the estimated Clinton "but for" concentration (triangles) and the estimated baseline incoming background level (blue line) for the period including the three proposed exceptional events. The daily difference between these two estimates is the estimated local contribution to the $PM_{2.5}$ measurement at Houston Clinton (pink vertical line). This analysis provides strong evidence that the Houston Clinton estimated "but for" concentration would not have exceeded the annual NAAQS on the three proposed exceptional event days and therefore meets the "but for" requirement.

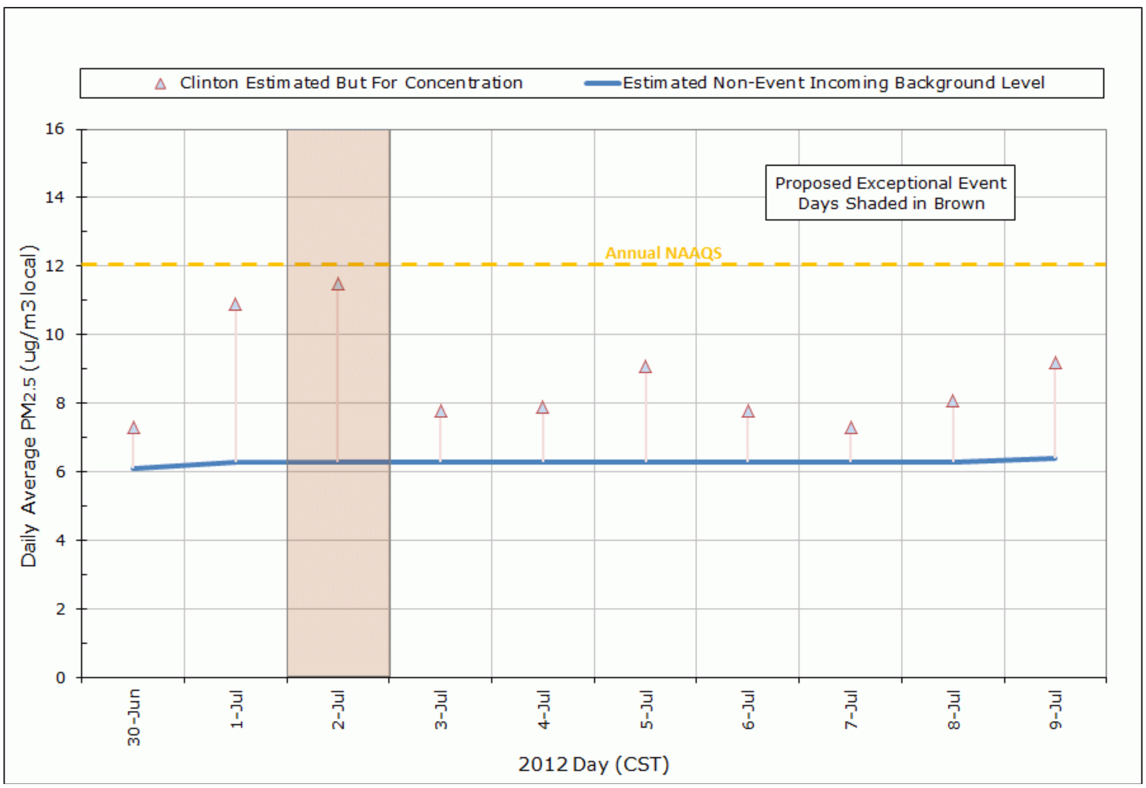


Figure 40. Houston Clinton daily estimated $PM_{2.5}$ but for event concentrations June 30 through July 9, 2012.

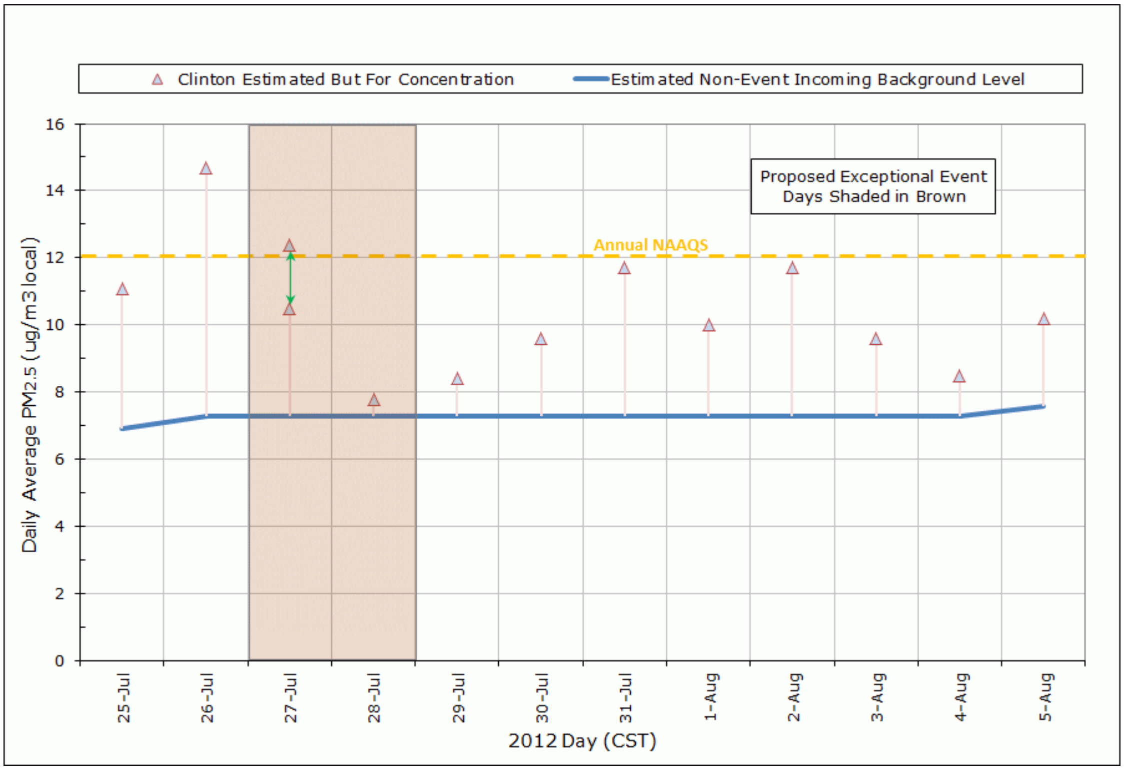


Figure 41. Houston Clinton daily estimated $PM_{2.5}$ but for event concentrations July 25 through August 5, 2012. The green segment between the two estimated but for concentrations on July 27 represents the difference in the estimated incoming background levels between Galveston and Seabrook on that day.

Community Multi-Scale Air Quality (CMAQ) Model "But For" Analysis

The final method used to evaluate the "but for" Clinton concentration on the exceptional event days was based on reviewing output from the real-time CMAQ modeling conducted by NOAA. NOAA has been testing a real-time version of the CMAQ model that would provide $PM_{2.5}$ forecasts for each day and the next day with the intent of eventually displaying the model output to the public. Since 2010 TCEQ staff have participated in the evaluation of this model and routinely monitor the model $PM_{2.5}$ forecasts. The CMAQ model relies on emissions input from annual emissions inventories and global baseline conditions at the model boundaries but it does not include intermittent sources like large fires or sources from outside the United States such as smoke from agricultural burning in Mexico and Central America or African dust. However, since it includes emissions from routine local sources, it is appropriate for predicting the local contribution of $PM_{2.5}$.

Figures 42 through 50 show the CMAQ model output of forecasted daily average $PM_{2.5}$ concentrations for days preceding, including, and following the three proposed exceptional event days. The model output shown in Figures 44, 48, and 49 indicate that without African dust (which is not included in the model) the $PM_{2.5}$ daily average would have been less than 10 µg/m^3 for all but a small portion of the Houston area, with the highest daily averages appearing in the 10 to 15 µg/m^3 range. TCEQ staff have reviewed the daily performance of this model for over two years and have observed that it has a consistent high bias on model-predicted high days as evidenced by the examples in Appendix D. Also, TCEQ staff reviewed reports of non-routine emission events from the State of Texas Environmental Electronic Reporting System and found no reports of significant particulate emissions reported on July 2nd, 27th, or 28th. Therefore this model estimates $PM_{2.5}$ concentrations very conservatively indicates that no exceedance of the annual NAAQS would have been measured on the proposed exceptional event days without the African dust events.

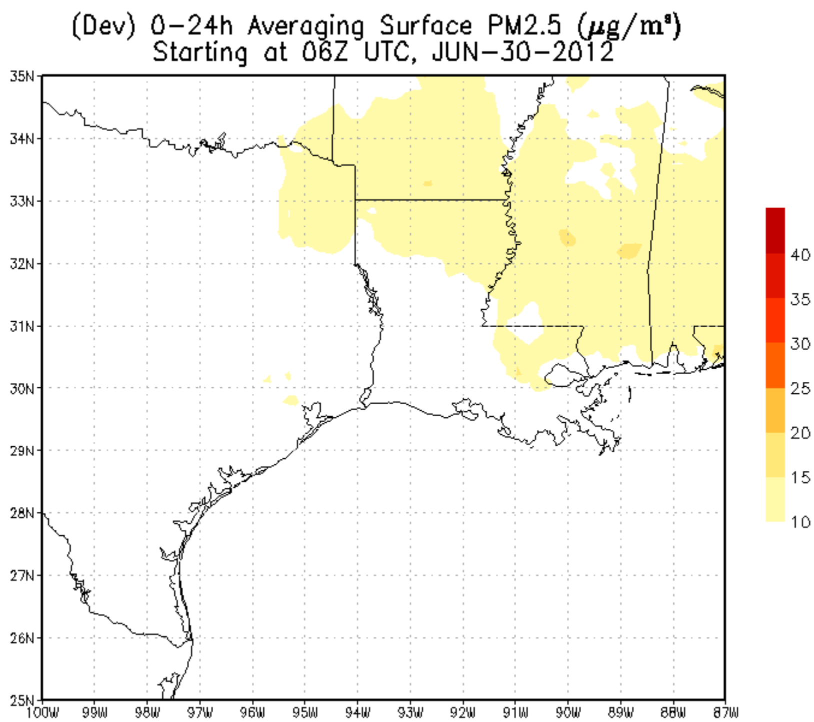


Figure 42. The CMAQ model output of daily $PM_{2.5}$ average concentrations for June 30, 2012 (24-hour period ending 0600 UTC July 1, 2012).

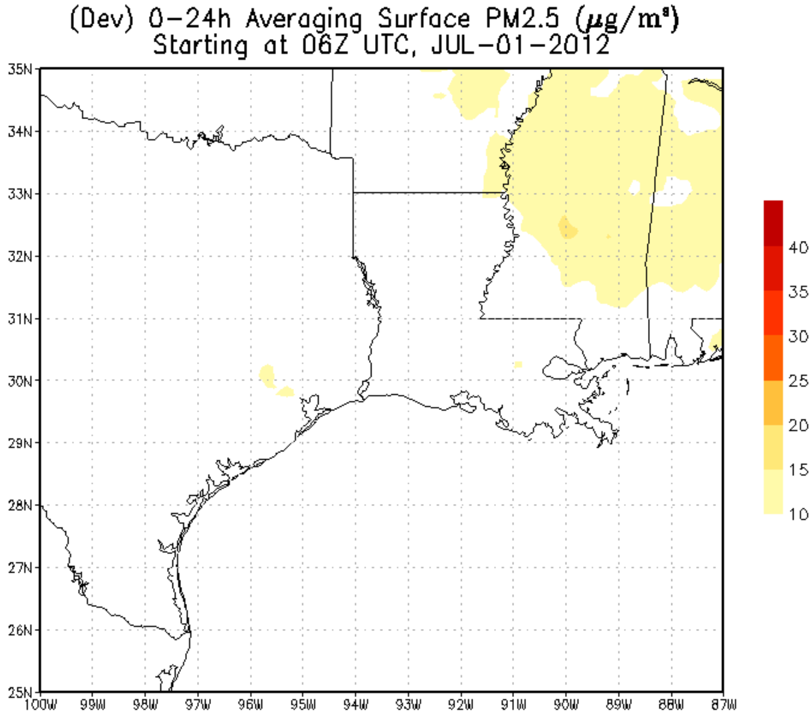


Figure 43. The CMAQ model output of daily $PM_{2.5}$ average concentrations for July 1, 2012 (24-hour period ending 0600 UTC July 2, 2012).

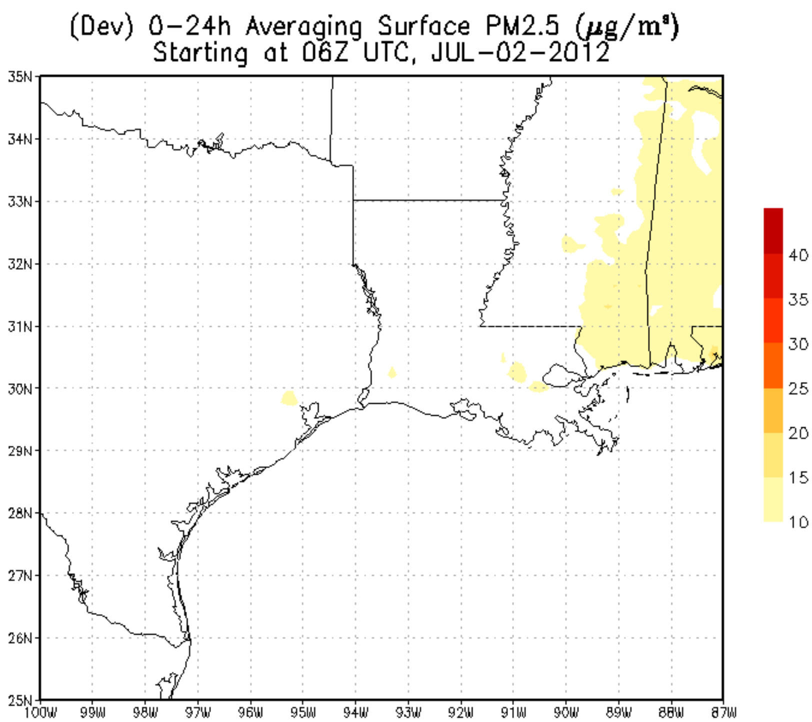


Figure 44. The CMAQ model output of daily $PM_{2.5}$ average concentrations for July 2, 2012 (24-hour period ending 0600 UTC July 3, 2012).

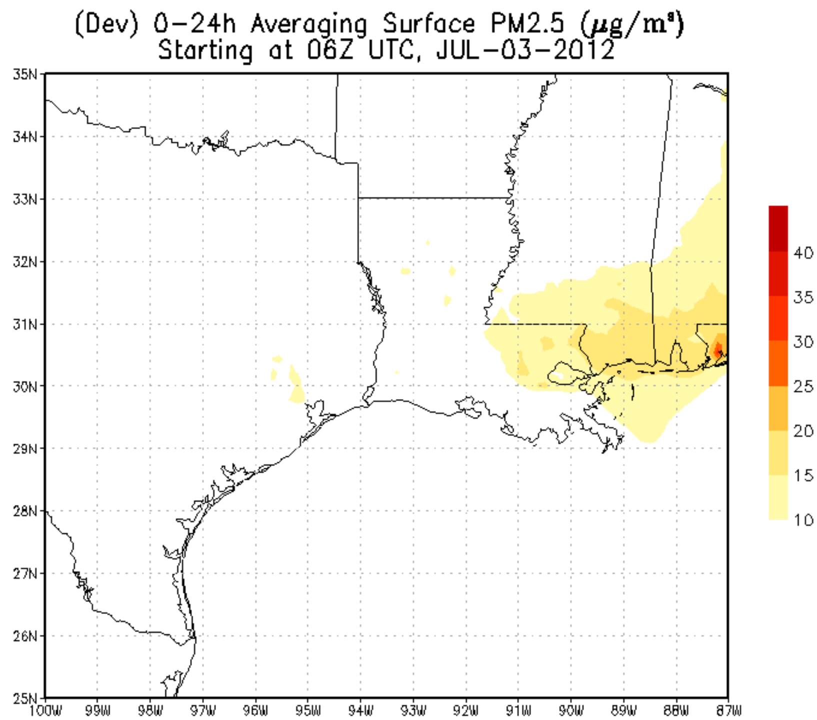


Figure 45. The CMAQ model output of daily $PM_{2.5}$ average concentrations for July 3, 2012 (24-hour period ending 0600 UTC July 4, 2012).

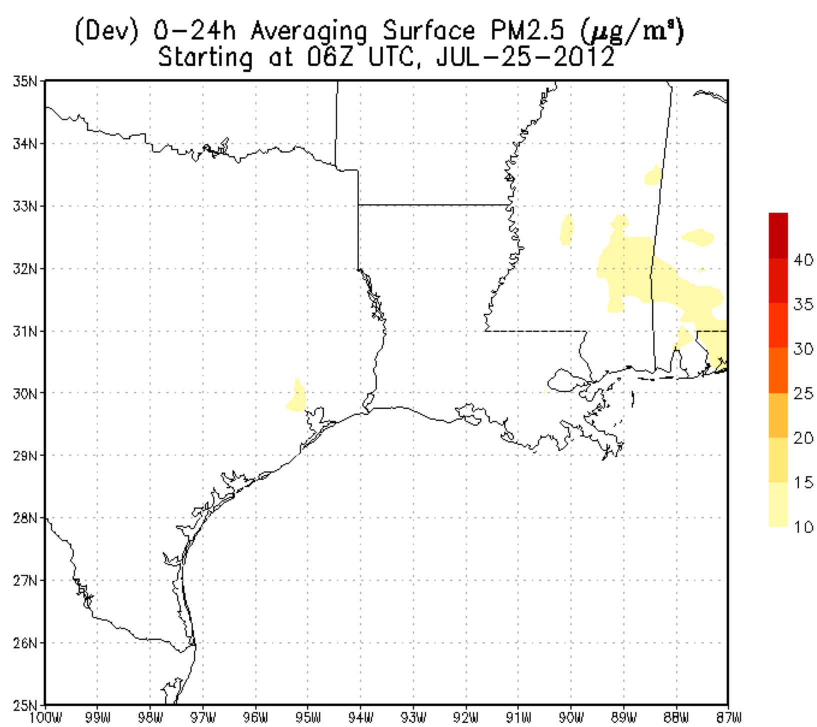


Figure 46. The CMAQ model output of daily $PM_{2.5}$ average concentrations for July 25, 2012 (24-hour period ending 0600 UTC July 26, 2012).

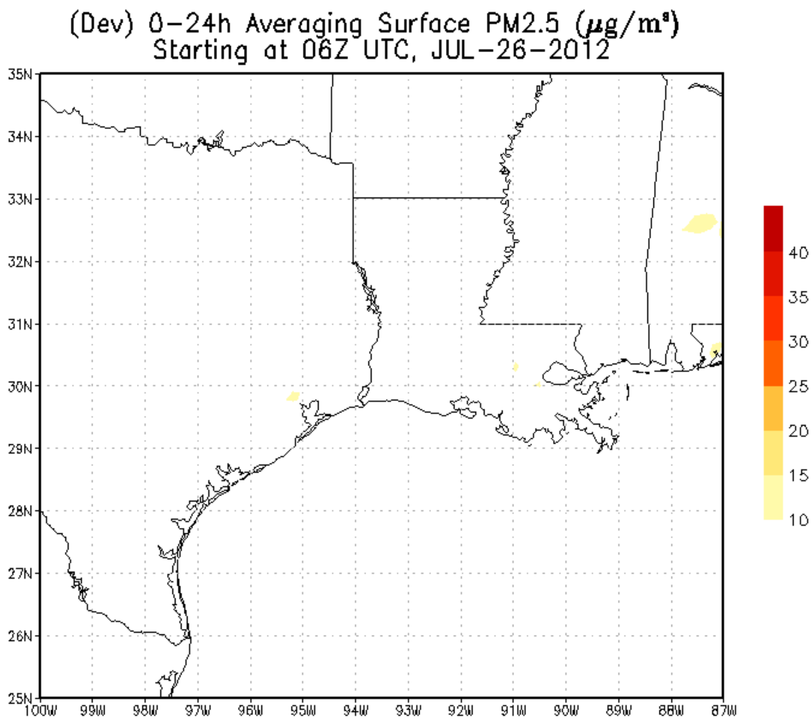


Figure 47. The CMAQ model output of daily $PM_{2.5}$ average concentrations for July 26, 2012 (24-hour period ending 0600 UTC July 27, 2012).

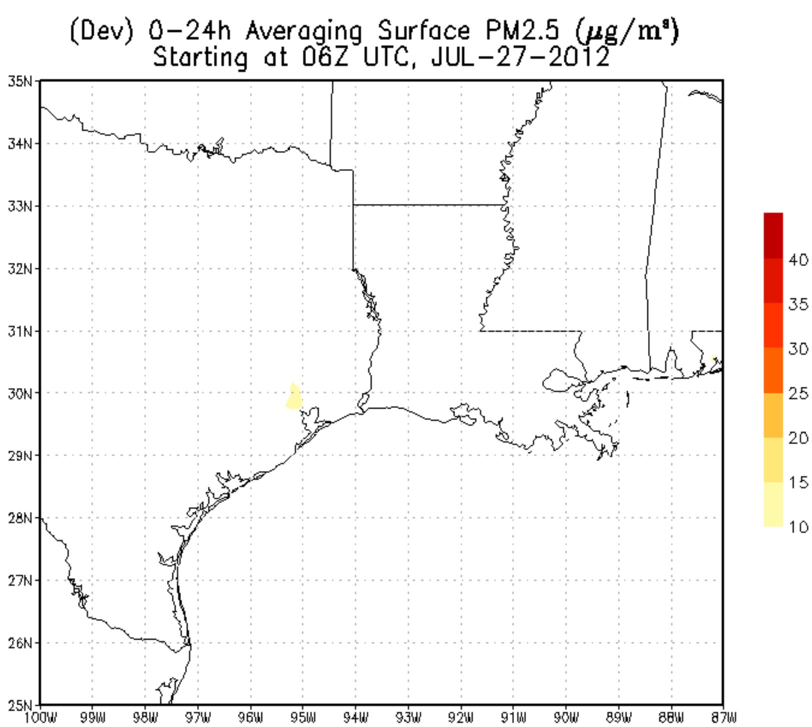


Figure 48. The CMAQ model output of daily $PM_{2.5}$ average concentrations for July 27, 2012 (24-hour period ending 0600 UTC July 28, 2012).

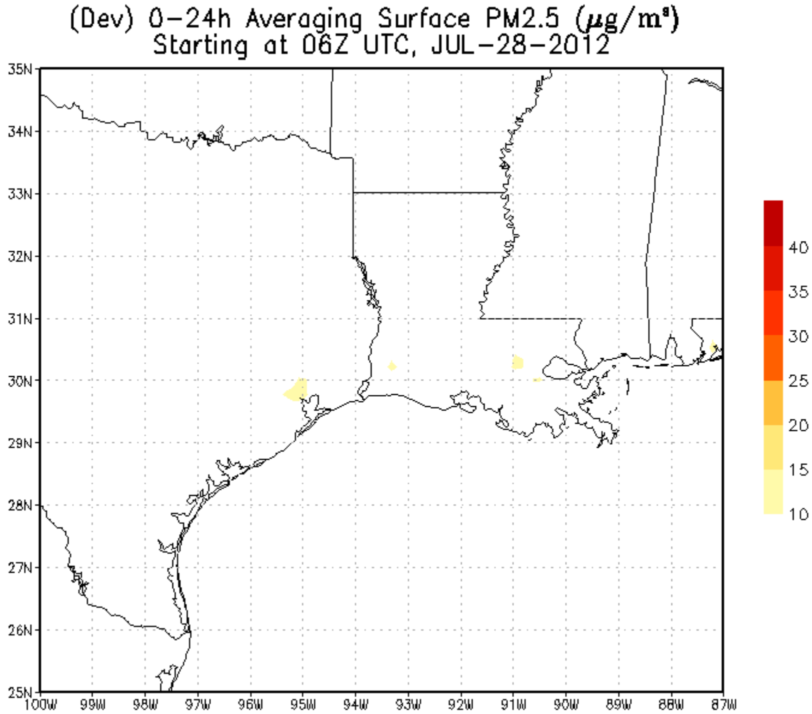


Figure 49. The CMAQ model output of daily $PM_{2.5}$ average concentrations for July 28, 2012 (24-hour period ending 0600 UTC July 29, 2012).

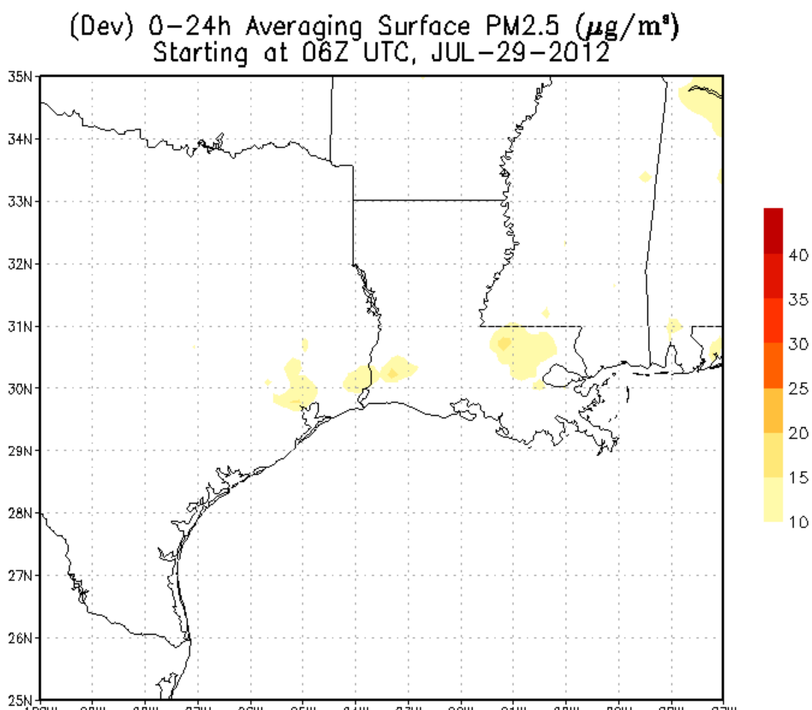


Figure 50. The CMAQ model output of daily $PM_{2.5}$ average concentrations for July 29, 2012 (24-hour period ending 0600 UTC July 30, 2012).

Mitigation of Exceptional Events

Title 40 CFR 51.930 requires that "a State requesting to exclude air quality data due to exceptional events must take appropriate and reasonable actions to protect public health from exceedances or violations of the national ambient air quality standards." Three specific requirements are described in this regulation and are addressed individually below. Examples of each of the web pages identified below can be found in Appendix E.

Prompt Public Notification

The first requirement is to "provide for prompt public notification whenever air quality concentrations exceed or are expected to exceed an applicable ambient air quality standard." The TCEQ provides ozone, $PM_{2.5}$, and PM_{10} AQI forecasts for the current day and the next three days for 14 areas in Texas including Houston. These forecasts are available to the public on the Today's Texas Air Quality Forecast web page of the TCEQ Web site (http://www.tceq.texas.gov/airquality/monops/forecast_today.html) and on the EPA AIRNOW Web site (http://airnow.gov/). Figures 51 and 52 show the Today's Texas Air Quality Forecast web pages as they appeared on the three exceptional event days.

The TCEQ also provides near real-time hourly $PM_{2.5}$ measurements from monitors across the state, including Houston, that are available to the public on the Current PM-2.5 Levels - Soot, Dust, and Smoke in Your Metro Area Web page of the TCEQ Web site (http://www.tceq.state.tx.us/cgi-bin/compliance/monops/texas_pm25.pl). Finally, the TCEQ publishes an AQI Report on the Air Quality Index Web page of the TCEQ Web site (http://www.tceq.state.tx.us/cgi-bin/compliance/monops/aqi_rpt.pl) that displays the latest and historical daily AQI measurements. These measures allow the public to assess forecast, current, and past $PM_{2.5}$ air quality levels.

July 2, 2012

Air Quality Index (AQI) Forecast	Air Quality Index Scale					
	Good	Moderate	Unhealthy Sensitive	Unhealthy	Very Unhealthy	Hazardous

Forecast Region (Click name for AIRNOW version)	Mon 07/02/12	Tue 07/03/12	Wed 07/04/12	Thu 07/05/12
Austin	PM2.5	PM2.5	Good	Good
Beaumont-Port Arthur	PM2.5	PM2.5	Good	Good
Brownsville-McAllen	PM2.5	PM2.5	Good	Good
Corpus Christi	PM2.5	PM2.5	Good	Good
Dallas-Fort Worth	PM2.5	PM2.5	Good	Good
El Paso	Good	Good	Good	Good
Houston	PM2.5	PM2.5	Good	Good
Laredo	PM2.5	PM2.5	Good	Good
Lubbock	Good	PM2.5	Good	Good
Midland-Odessa	Good	PM2.5	Good	Good
San Antonio	PM2.5	PM2.5	Good	Good
Tyler-Longview	PM2.5	PM2.5	Good	Good
Victoria	PM2.5	PM2.5	Good	Good
Waco-Killeen	PM2.5	PM2.5	Good	Good

Discussion

Monday 07/02/12
A large African dust cloud with "Moderate" fine particulate levels is rapidly spreading northward across the eastern half of the state this morning and should cover most of the eastern two-thirds of the state by this afternoon and evening. The dust may also spread into Northwest Texas this afternoon or evening. Elsewhere in West Texas, moderate winds and lower incoming background levels should help to keep air quality in the "Good" range.

Figure 51. Copy of the Today's Texas Air Quality Forecast web page that was posted on the proposed exceptional event day of July 2, 2012, showing African dust being forecast for much of the eastern two-thirds of the state.

July 27, 2012

Air Quality Index (AQI) Forecast

Air Quality Index Scale					
Good	Moderate	Unhealthy Sensitive	Unhealthy	Very Unhealthy	Hazardous

Forecast Region (Click name for AIRNOW version)	Fri 07/27/12	Sat 07/28/12	Sun 07/29/12	Mon 07/30/12
Austin	PM2.5	PM2.5	PM2.5	PM2.5
Beaumont-Port Arthur	PM2.5	PM2.5	Ozone	Ozone
Brownsville-McAllen	PM2.5	PM2.5	PM2.5	PM2.5
Corpus Christi	PM2.5	PM2.5	PM2.5	PM2.5
Dallas-Fort Worth	Ozone	Ozone	Ozone	Ozone
El Paso	Good	Good	Good	Ozone
Houston	PM2.5	Ozone	Ozone	Ozone
Laredo	PM2.5	PM2.5	PM2.5	PM2.5
Lubbock	Good	PM2.5	PM2.5	Good
Midland-Odessa	Good	PM2.5	PM2.5	Good
San Antonio	PM2.5	PM2.5	PM2.5	PM2.5
Tyler-Longview	PM2.5	Ozone	Ozone	Ozone
Victoria	PM2.5	PM2.5	PM2.5	PM2.5
Waco-Killeen	PM2.5	PM2.5	PM2.5	Good

Discussion

Friday 07/27/12
This morning, the African dust cloud is covering much of the eastern half of the state with "Moderate" levels of fine particulate, which should expand into far Northeast Texas in the afternoon. If background levels are high enough, winds should be light enough for ozone to reach "Moderate" levels on the north and northwest side of the Dallas-Fort Worth area, with highest concentrations in the afternoon and early evening. Elsewhere in the West Texas and the Panhandle, moderate winds, low incoming background levels, and heavy cloud cover should help to keep air quality in the "Good" range.

Saturday 07/28/12
A large African dust cloud with "Moderate" PM2.5 levels will expand to cover most of the state, excluding far West Texas and the far northern Panhandle. Winds may be light enough and background levels high enough for ozone to reach "Moderate" levels on the east and northeast side of the Houston area, on the north and northeast side of the Dallas-Fort Worth area, and in parts of Northeast Texas, with highest concentrations in the afternoon and early evening. Elsewhere in far West Texas, moderate winds, low incoming background levels, and heavy cloud cover with rain should help to keep air quality in the "Good" range.

Figure 52. Copy of the Today's Texas Air Quality Forecast web page that was posted on the proposed exceptional event days of July 27 and 28, 2012, showing African dust being forecast to cover much of the state.

Public Education

The second requirement is to "provide for public education concerning actions that individuals may take to reduce exposures to unhealthy levels of air quality during and following an exceptional event." Links to TCEQ and EPA Web pages describing recommended actions for individuals to reduce exposure to $PM_{2.5}$ whenever it is high (EPA2, 2013) are included on TCEQ web displays of forecast and measured AQI levels, including TCEQ's Air Pollution from Particulate Matter web page (http://www.tceq.texas.gov/airquality/sip/criteria-pollutants/sip-pm) and EPA's AQI - A Guide to Air Quality and Your Health web page (http://www.airnow.gov/index.cfm?action=aqibasics.aqi). EPA also provides similar links on the AIRNOW Web pages where TCEQ forecasts and current data are displayed.

The TCEQ also pursues outreach and educational opportunities in the Houston area through work with the Regional Air Quality Planning Committee (RAQPC) of the Houston-Galveston Area Council and through public informational meetings, including a recent meeting July 22, 2013, concerning the proposed $PM_{2.5}$ NAAQS designation for the Houston area. The RAQPC holds monthly meetings that are open to the public and these meetings are attended by TCEQ staff.

Implement Measures to Protect Public Health

The third requirement is to "provide for the implementation of appropriate measures to protect public health from exceedances or violations of ambient air quality standards caused by exceptional events." Since 2005, the TCEQ has pursued voluntary reduction efforts in the Houston Clinton vicinity that have greatly reduced local source impacts on $PM_{2.5}$ at the Houston Clinton site as discussed in more detail in the Local Source Contributions section above. As a result, the local $PM_{2.5}$ contributions at Houston Clinton have declined by as much as 50 percent from 2006 to 2012. The TCEQ will continue to seek efficient, timely, and effective voluntary control measures in the future as necessary.

Conclusion

The information provided in this document demonstrates that the proposed exceptional event flags for $PM_{2.5}$ data at the Houston Clinton site on July 2, July 27, and July 28, 2012, meet all of the requirements for exceptional events. Measured $PM_{2.5}$ concentrations on these days were well above the 95th percentile of 2010 through 2012 measurements and thus affected air quality in excess of normal historical fluctuations. The level of $PM_{2.5}$ transported into the Houston area on these days were heavily impacted by African dust, were not reasonably preventable, and were due to a natural event. As indicated by satellite imagery, back trajectories, aerosol modeling, and measurement statistics, African dust clearly caused exceedances of the annual $PM_{2.5}$ NAAQS on these days. Estimates of local contribution and incoming baseline background levels, as well as the CMAQ $PM_{2.5}$ model concentrations without the African dust, provide strong evidence that $PM_{2.5}$ on the proposed exceptional event days would not have exceeded the level of the annual NAAQS without the African dust events. The TCEQ therefore requests EPA's concurrence on these three exceptional event days and to have these days removed from consideration when making attainment or nonattainment determinations for the annual $PM_{2.5}$ NAAQS.

References

Eldred, B. (2003). *Evaluation of the Equation for Soil Composite.* IMPROVE Program.

EPA1. (2013). *Technology Transfer Network (TTN) Air Quality System (AQS)*. Retrieved 2013, from U.S. Environmentla Protection Agency: http://www.epa.gov/ttn/airs/airsaqs/

EPA2. (2013). *Air Quality Index (AQI) - A Guide to Air Quality and Your Health*. Retrieved 2013, from AIRNOW: http://www.airnow.gov/index.cfm?action=aqibasics.aqi

Formenti, P., Schutz, L., Balkanski, Y., Desboeufs, K., Ebert, M., Kandler, K., et al. (2011). Recent Progress in Understanding Physical and Chemical Properties of African and Asian Mineral Dust. *Atmospheric Chemistry and Physics*.

Goudie, A. S., & Middleton, N. (2001). Saharan Dust Storms: Nature and Consequences. *Earth-Science Reviews*, 179-204.

Lambeth, B. (2010). Assessing $PM_{2.5}$ Background Levels and Local Add-On. *2010 National Air Quality Conferences: Air Quality Forecasting, Mapping, and Monitoring, and Communicating Air Quality.* Raleigh, NC: U.S. EPA.

Nielsen-Gammon, J. W., Tobin, J., McNeel, A., & Li, G. (2005). *A Conceptual Model for Eight-Hour Ozone Exceedances in Houston, Texas Part I: Background Ozone Levels in Eastern Texas.* College Station, TX: Texas A&M University.

NOAA. (2013). *NOAA Satellites*. Retrieved 2013, from National Oceanic and Atmospheric Administration: http://www.noaa.gov/satellites.html

NOAA ARL. (2013). *HYSPLIT - Hybrid Single Particle Lagrangian Integrated Trajectory Model*. Retrieved 2013, from NOAA Air Resources Laboratory: http://www.arl.noaa.gov/HYSPLIT_info.php

Sullivan, D., Price, J., Sheedy, K., Lambeth, B., Savanich, K., & Tropp, R. (2013). Success in Reducing $PM_{2.5}$ in the Neighborhood North of the Houston Ship Channel - Voluntary Efforts Based on Field Study Results and Source Attribution. *Journal of the Air and Waste Management Association*.

TCEQ. (2013). *Texas Meteorological Satellite Images - GOES*. Retrieved 2013, from TCEQ: http://www.tceq.texas.gov/assets/public/compliance/monops/air/goes.html

TCEQ1. (2013). *Today's Texas Air Quality Forecast*. Retrieved 2013, from TCEQ: http://www.tceq.texas.gov/airquality/monops/forecast_today.html

TCEQ2. (2013). *Current PM-2.5 Levels - Soot, Dust, and Smoke in Your Metro Area*. Retrieved 2013, from TCEQ: http://www.tceq.state.tx.us/cgi-bin/compliance/monops/texas_pm25.pl

TCEQ3. (2013). *Air Quality Index*. Retrieved 2013, from TCEQ: http://www.tceq.state.tx.us/cgi-bin/compliance/monops/aqi_rpt.pl

Appendix A: Proposed 2012 Houston $PM_{2.5}$ Exceptional Event Flags

Table A-1. Proposed 2012 Houston $PM_{2.5}$ Exceptional Event Flags

Date	Site ID	Site Name	POC	$PM_{2.5}$	Flag	Description
07/02/12	482011035	Clinton C403	1	31.0	RA	African dust
07/27/12	482011035	Clinton C403	1	27.3	RA	African dust
07/28/12	482011035	Clinton C403	1	25.5	RA	African dust

Abbreviations:

Site ID - EPA site identification number

POC - EPA Parameter Occurrence Code

$PM_{2.5}$ - daily average concentration in micrograms per cubic meter local conditions

Appendix B: Source Analysis for July 2

Back Trajectory

Figures B-1 through B-3 provide HYSPLIT back trajectories that show the approximate path of air arriving in the Houston area at 1200 central standard time (CST) (or 1800 universal time coordinates [UTC]) at 500 meters, 1,000 meters, and 1,500 meters above ground level on the day indicated and going backward in time 312 hours. These trajectories indicate that the air arriving in Houston on July 2, 2012, came from Africa. The NOAA web site where the trajectories were produced does not allow them to run past 312 hours. So, it is not possible to follow the air parcel all the way back into Africa.

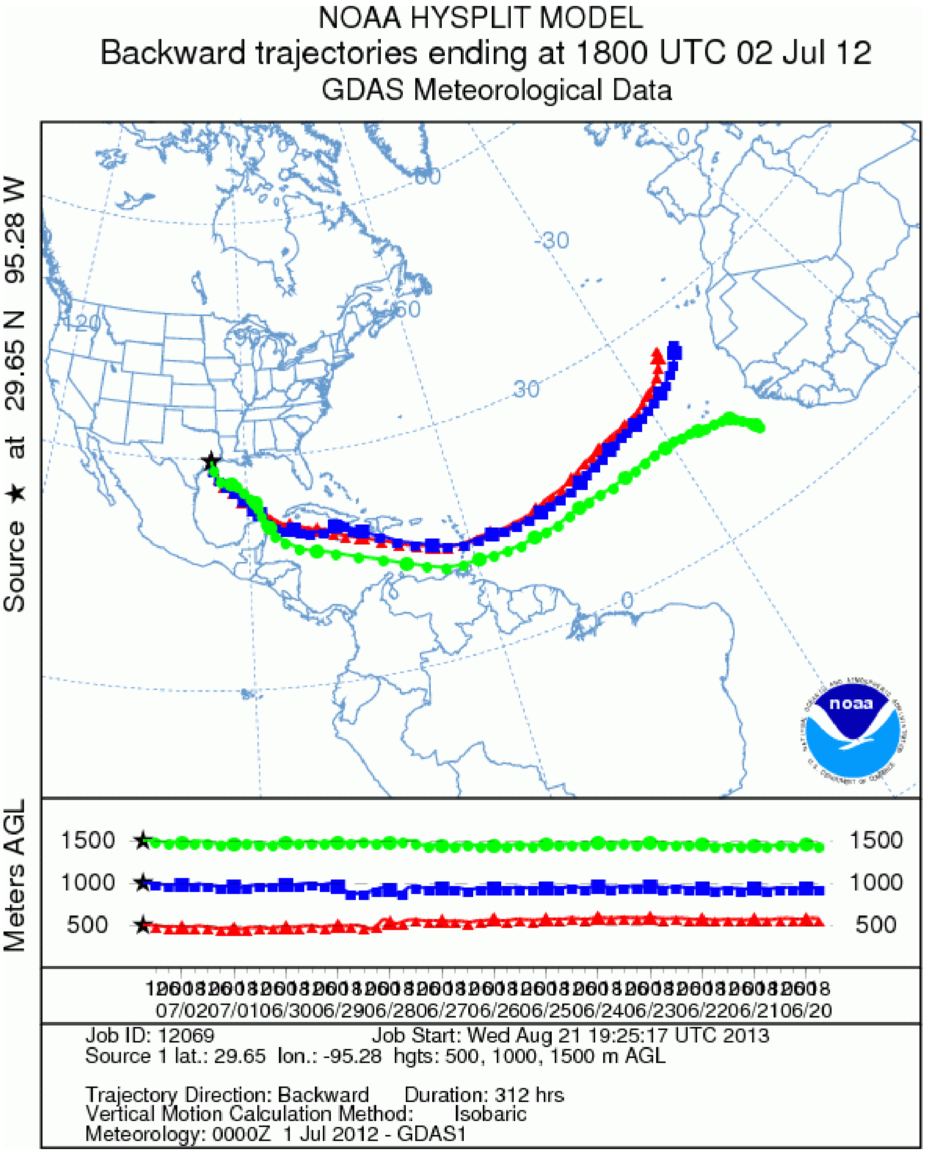


Figure B-1. Backward-in-time air trajectory for July 2, 2012.

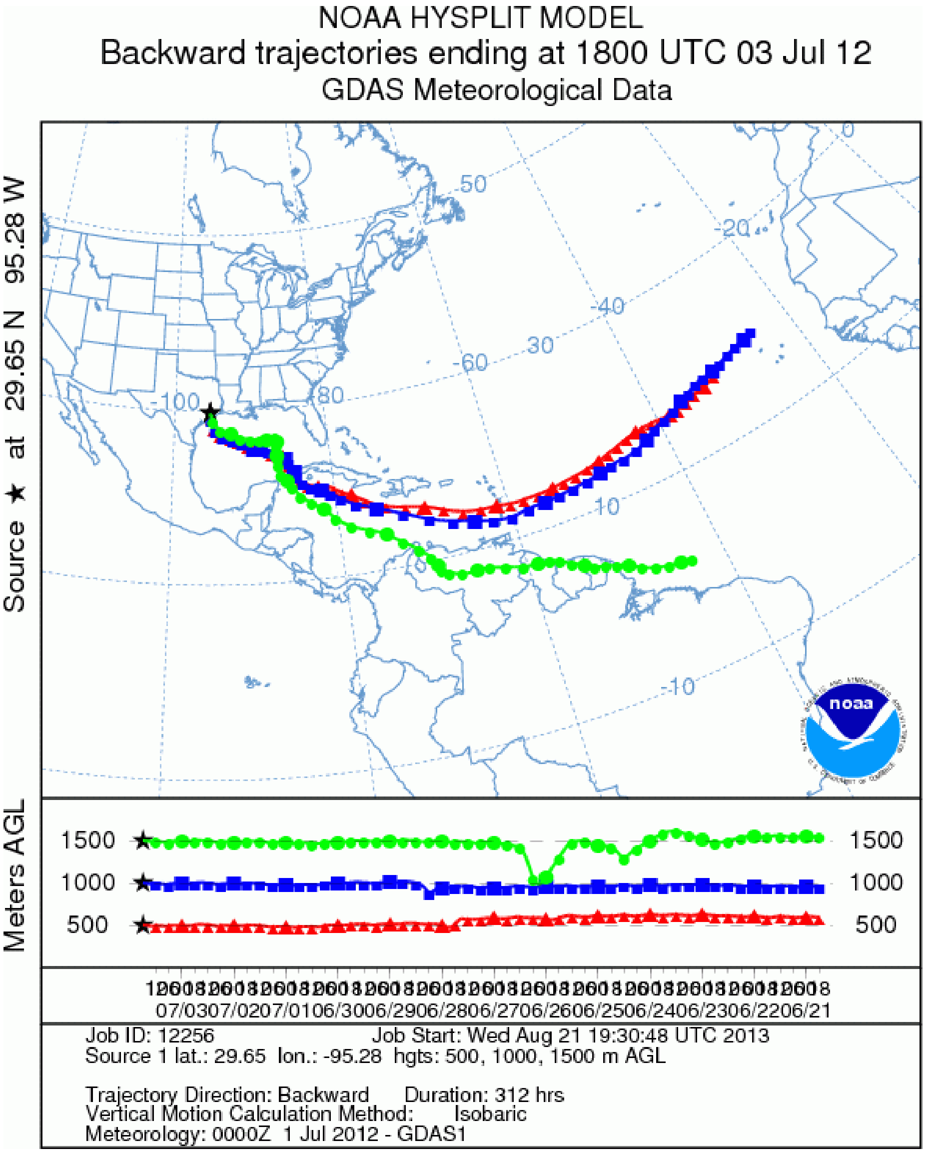


Figure B-2. Backward-in-time air trajectory for July 3, 2012.

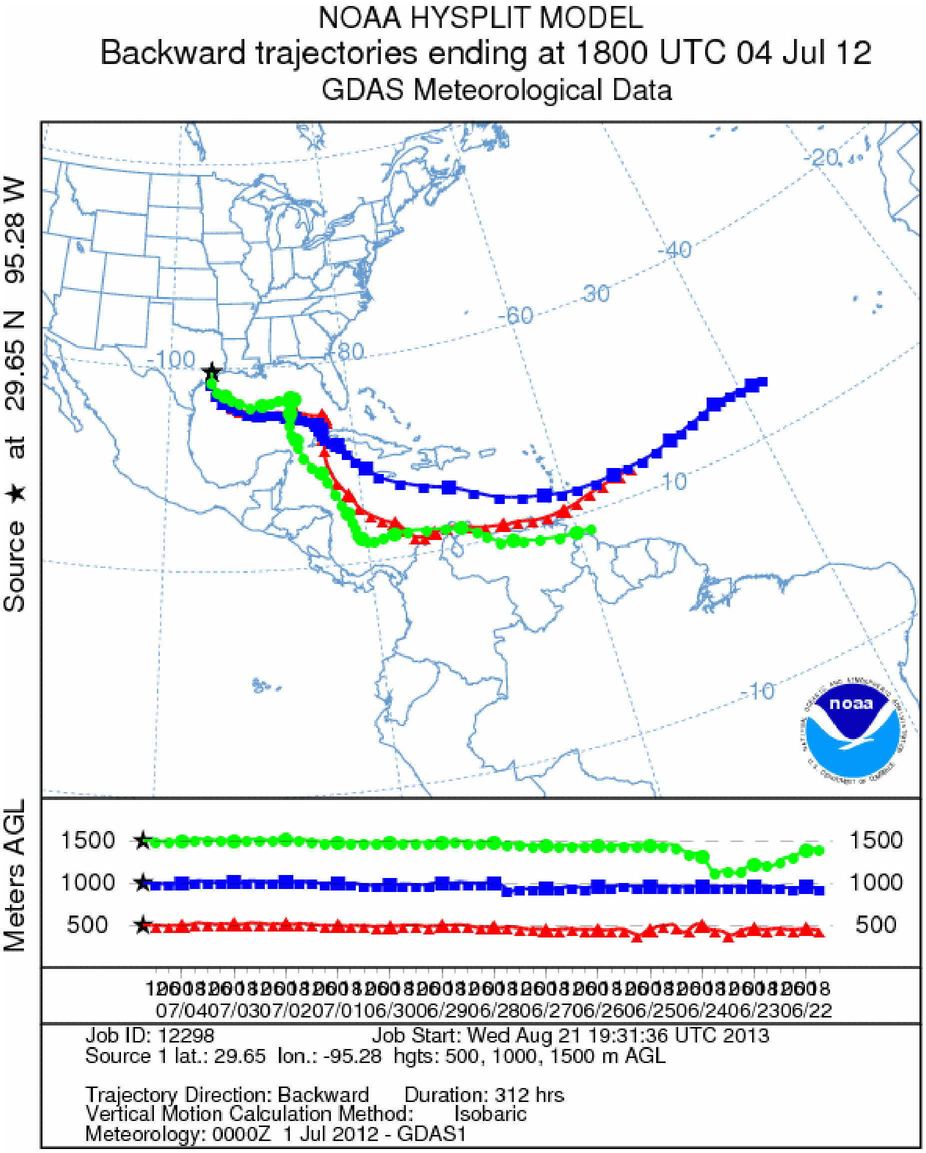


Figure B-3. Backward-in-time air trajectory for July 4, 2012.

Satellite Imagery

Figures B-4 through B-20 provide geostationary satellite images showing a large and intense African dust cloud move across the Atlantic, Caribbean Sea, and Gulf of Mexico. The image times are listed in UTC which is six hours ahead of CST. On these images, most clouds are bright white with sharp edges and ocean water is normally very dark away from clouds. Dust in the air makes the ocean look much brighter when present, giving it a milky appearance with soft indistinct edges to the dust cloud.

The satellite imagery shows a large and intense African dust cloud had emerged into the eastern Atlantic Ocean from the African coast by June 22, 2012. The dust cloud of interest is labeled number “6” in all of the satellite images. This dust cloud tracked across the Atlantic Ocean reaching the Lesser Antilles on June 26^{th} and began moving into the Gulf of Mexico on June 29^{th}. The dust cloud arrived in the Houston area on July 1^{st} and continued moving across the area through July 5^{th}.

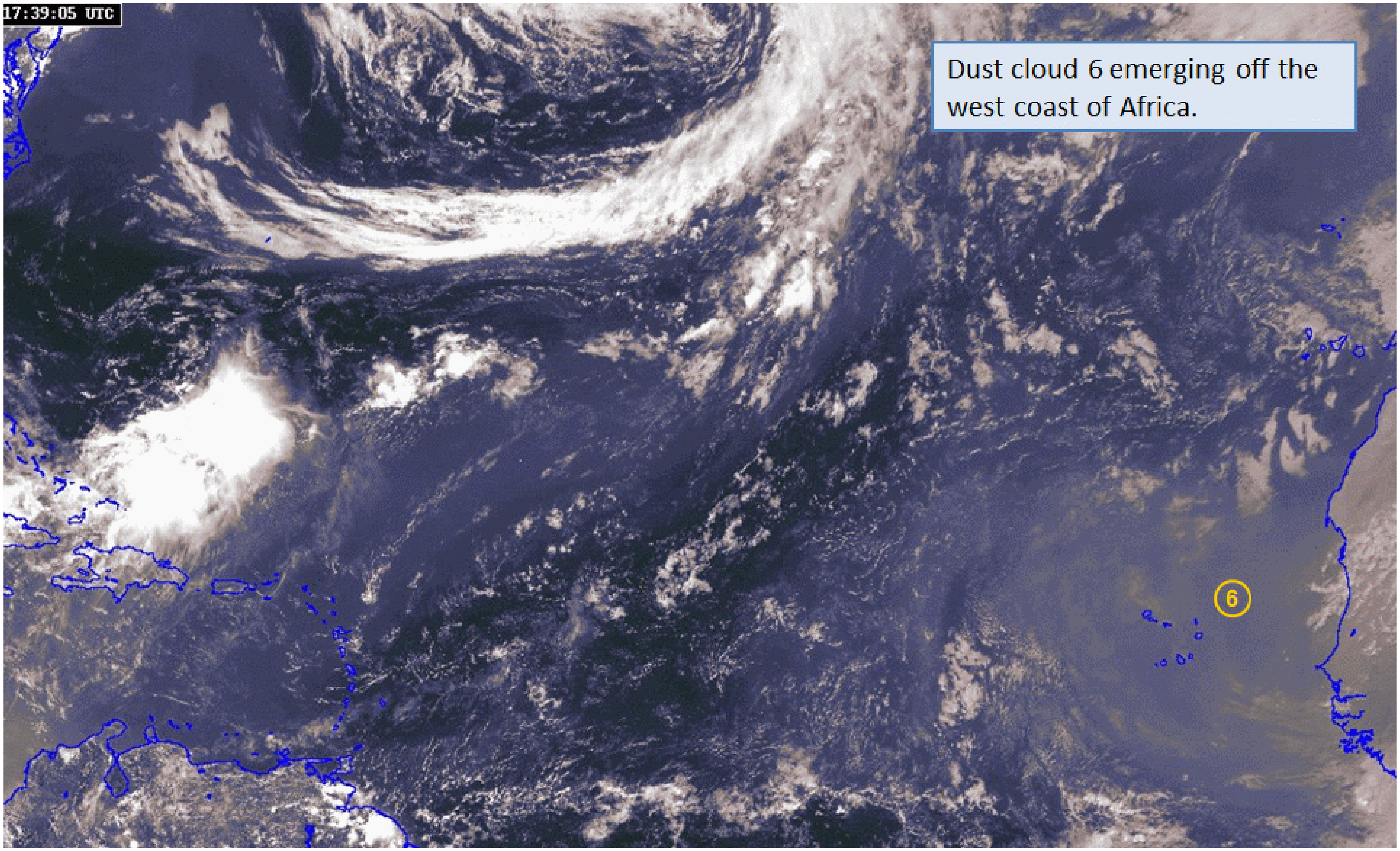


Figure B-4. Visible satellite image for 1739 UTC on June 22, 2012.

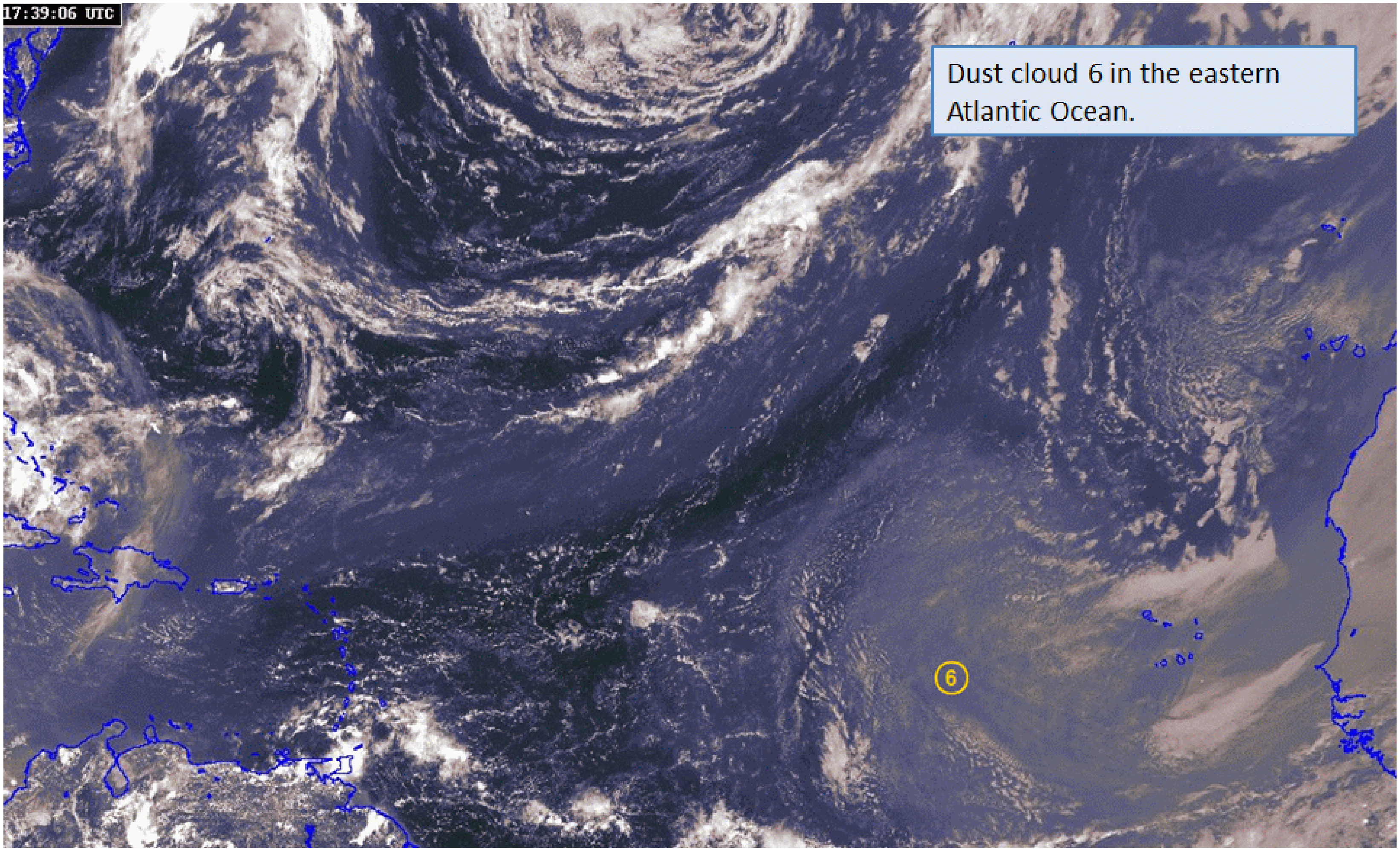


Figure B-5. Visible satellite image for 1739 UTC on June 23, 2012.

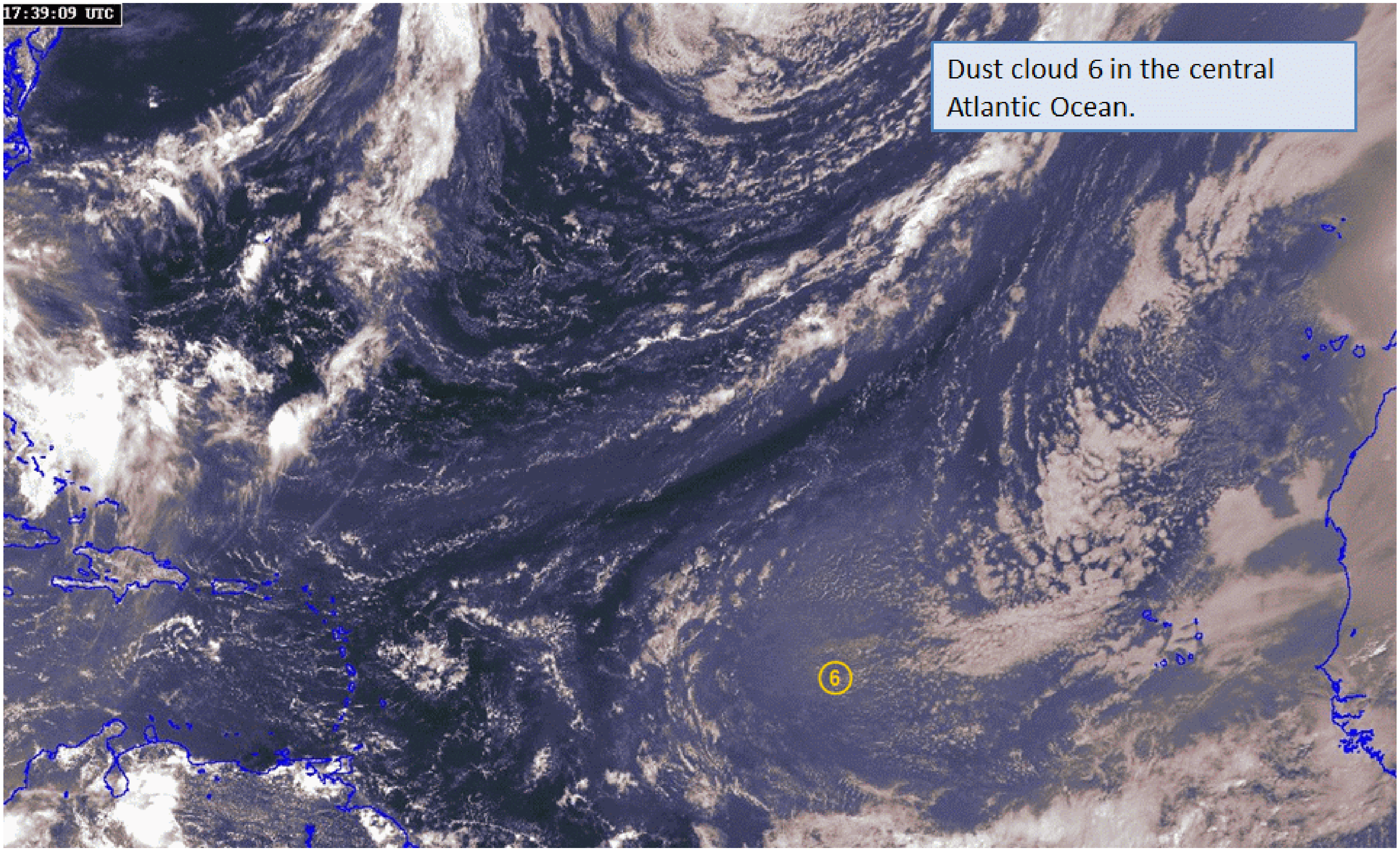


Figure B-6. Visible satellite image for 1739 UTC on June 24, 2012.

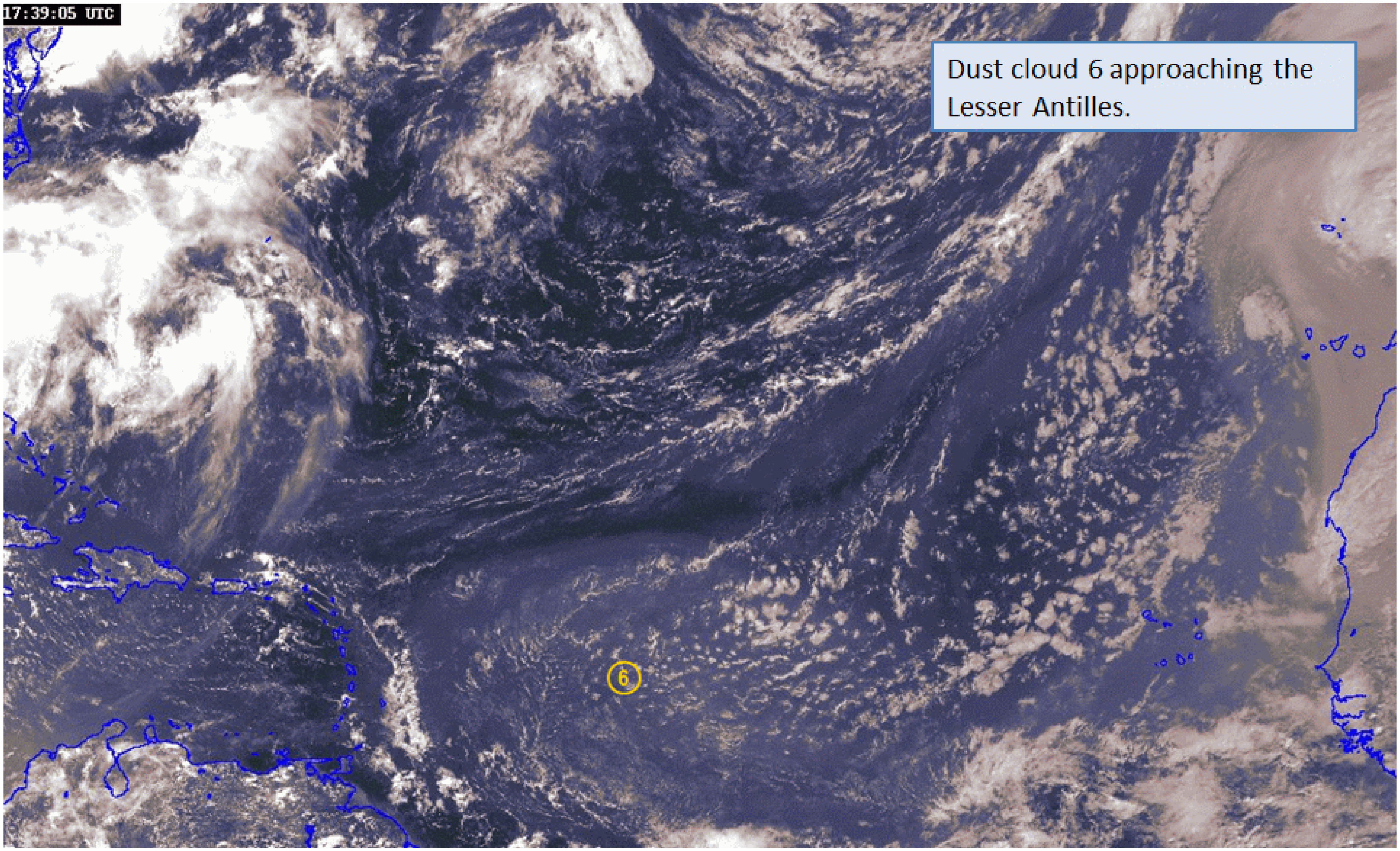


Figure B-7. Visible satellite image for 1739 UTC on June 25, 2012.

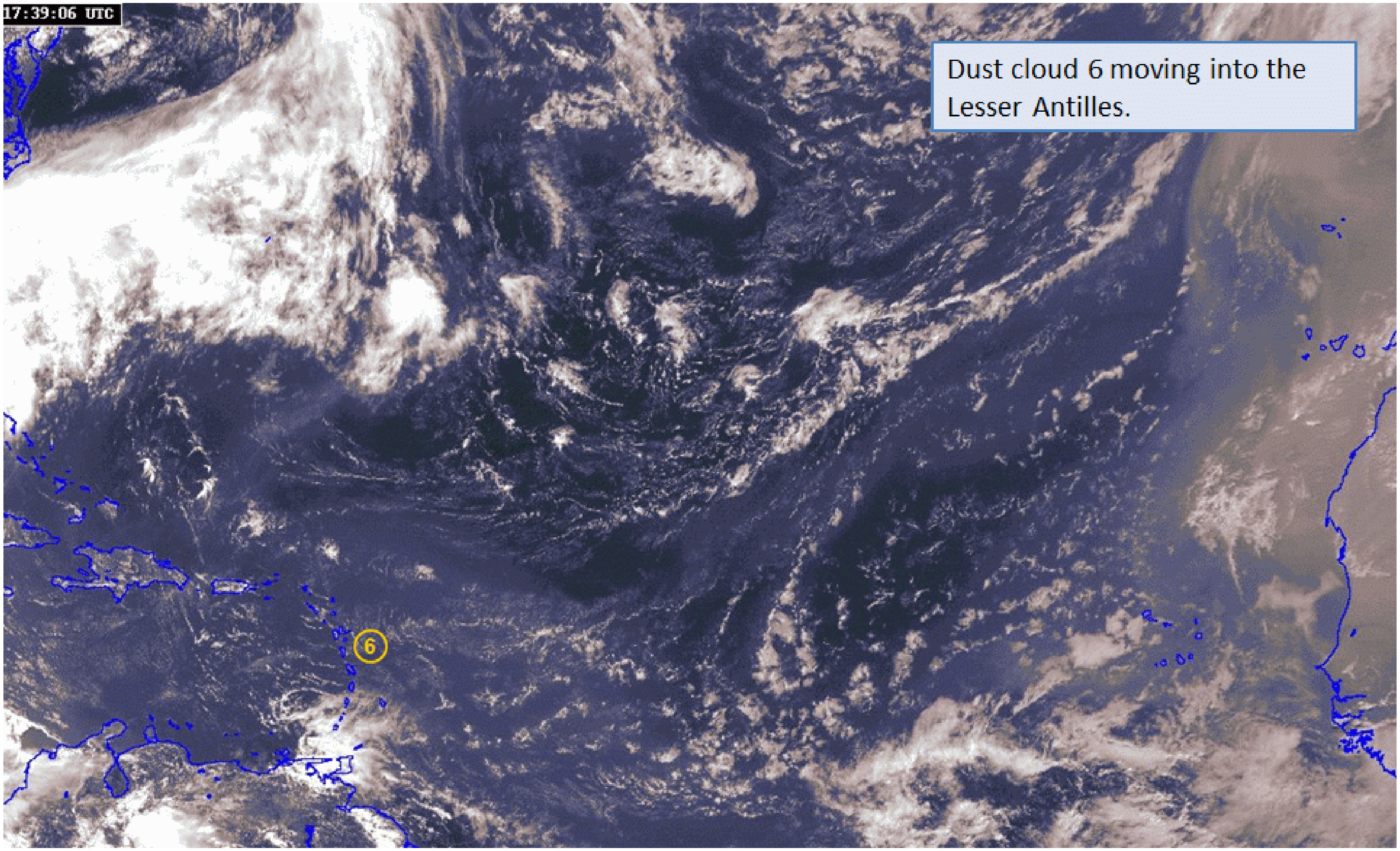


Figure B-8. Visible satellite image for 1739 UTC on June 26, 2012.

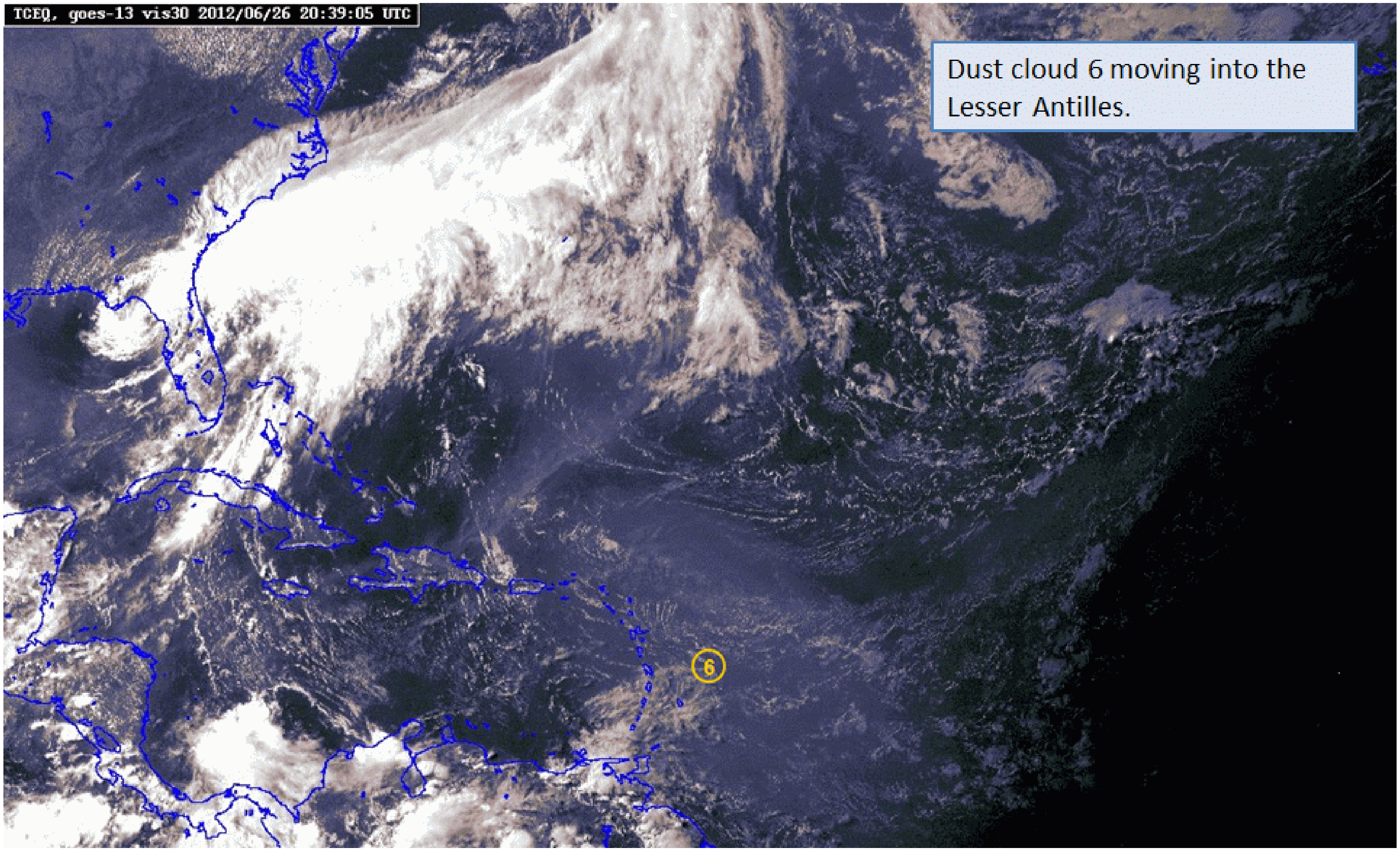


Figure B-9. Visible satellite image for 2039 UTC on June 26, 2012.

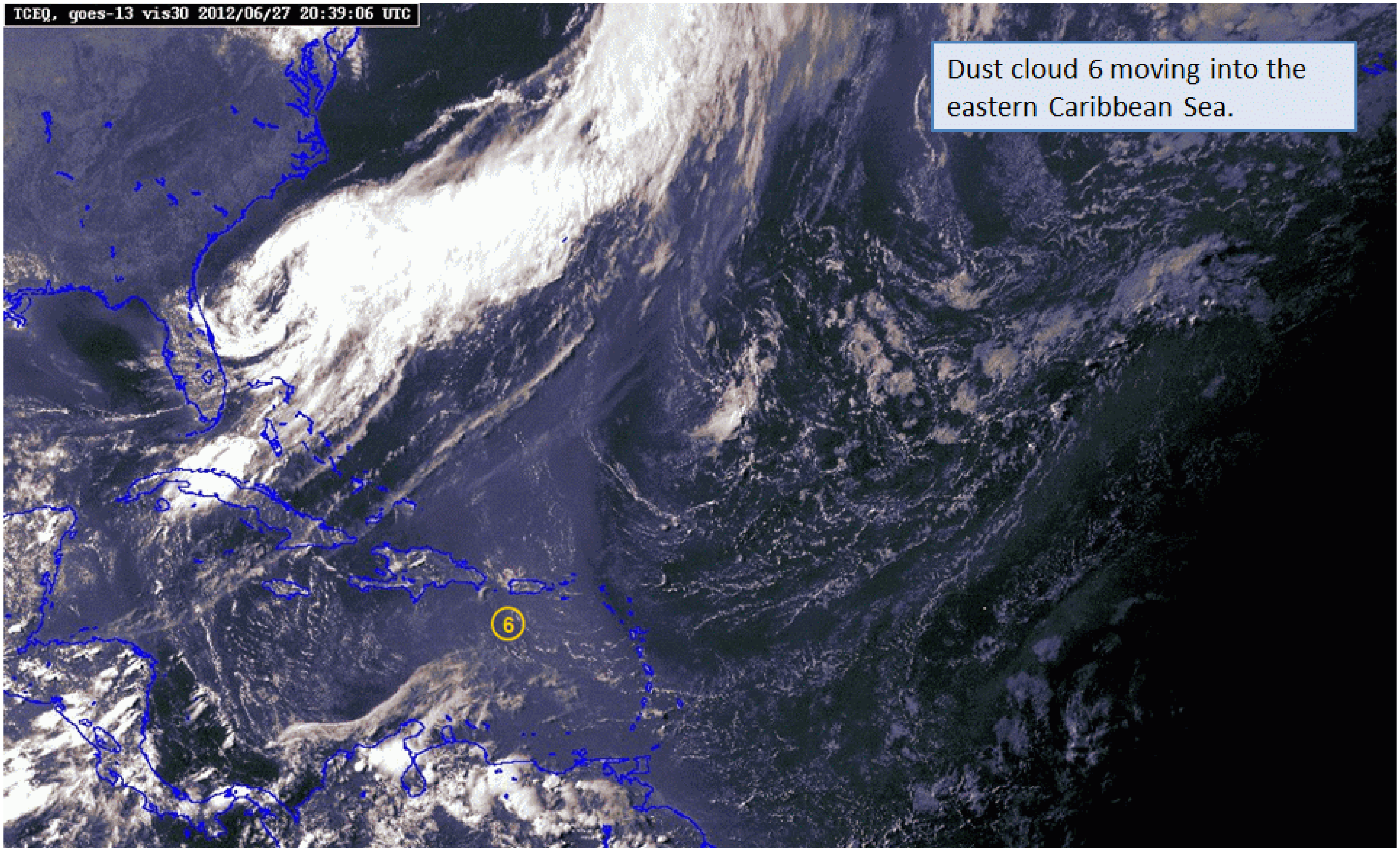


Figure B-10. Visible satellite image for 2039 UTC on June 27, 2012.

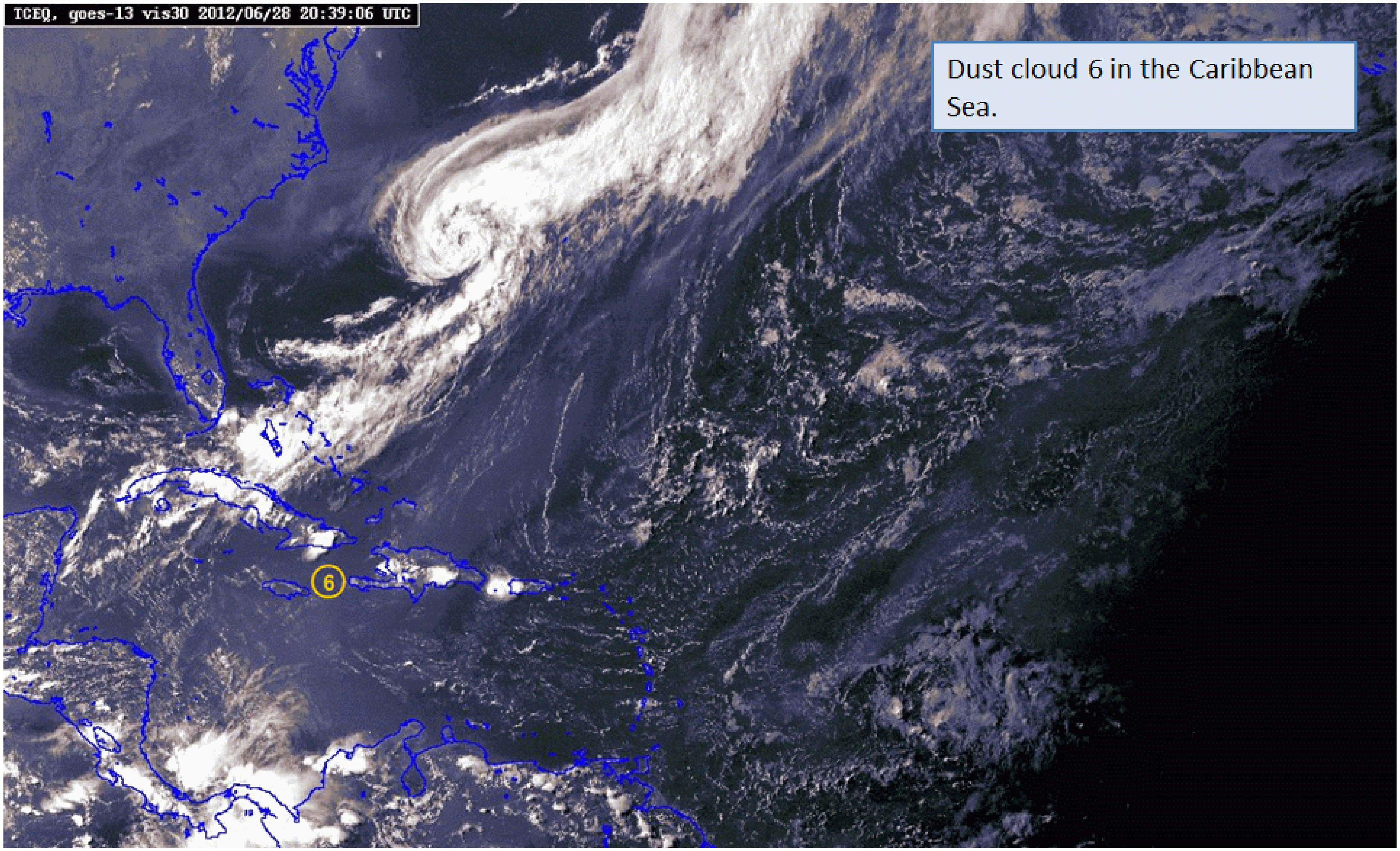


Figure B-11. Visible satellite image for 2039 UTC on June 28, 2012.

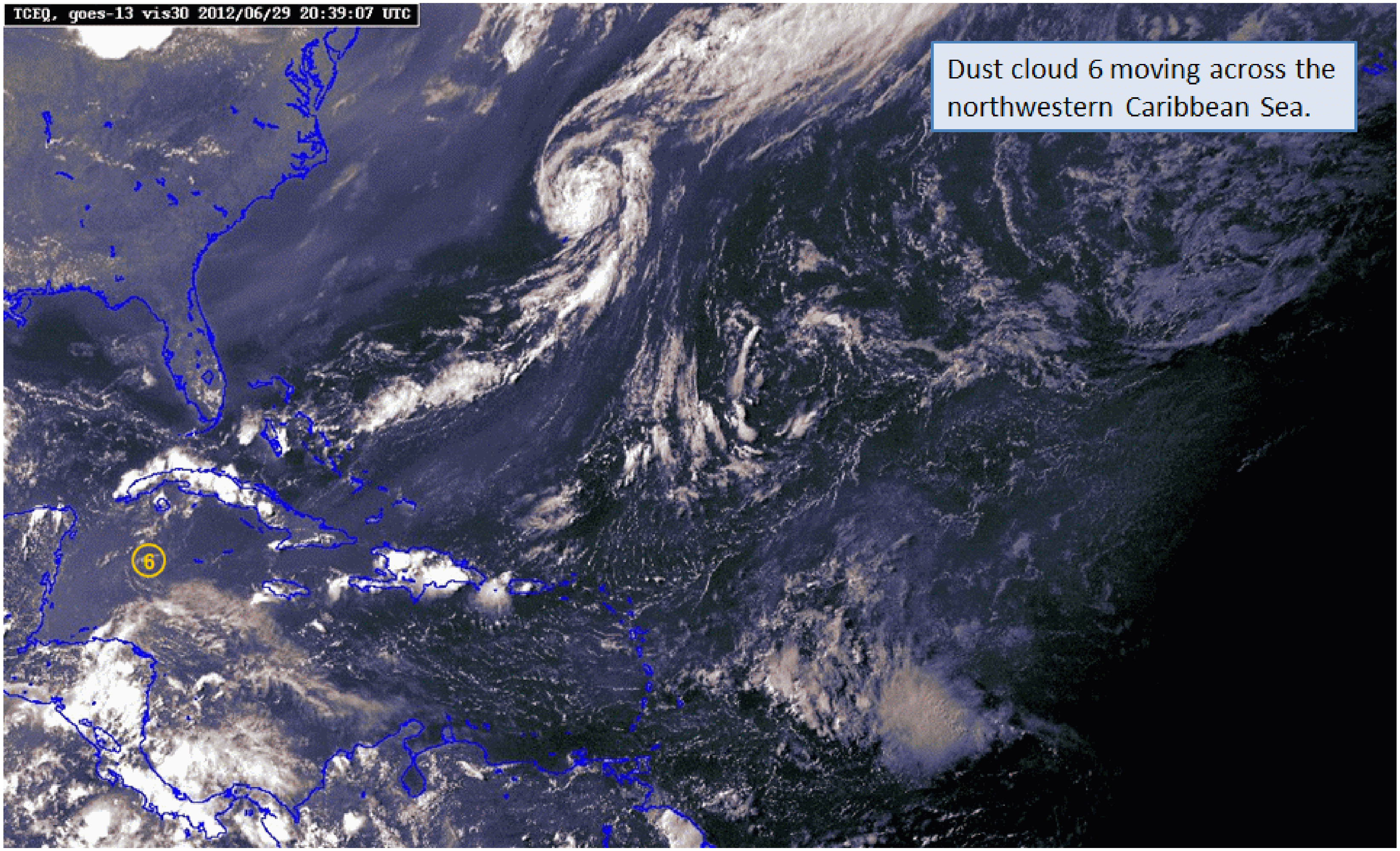


Figure B-12. Visible satellite image for 2039 UTC on June 29, 2012.

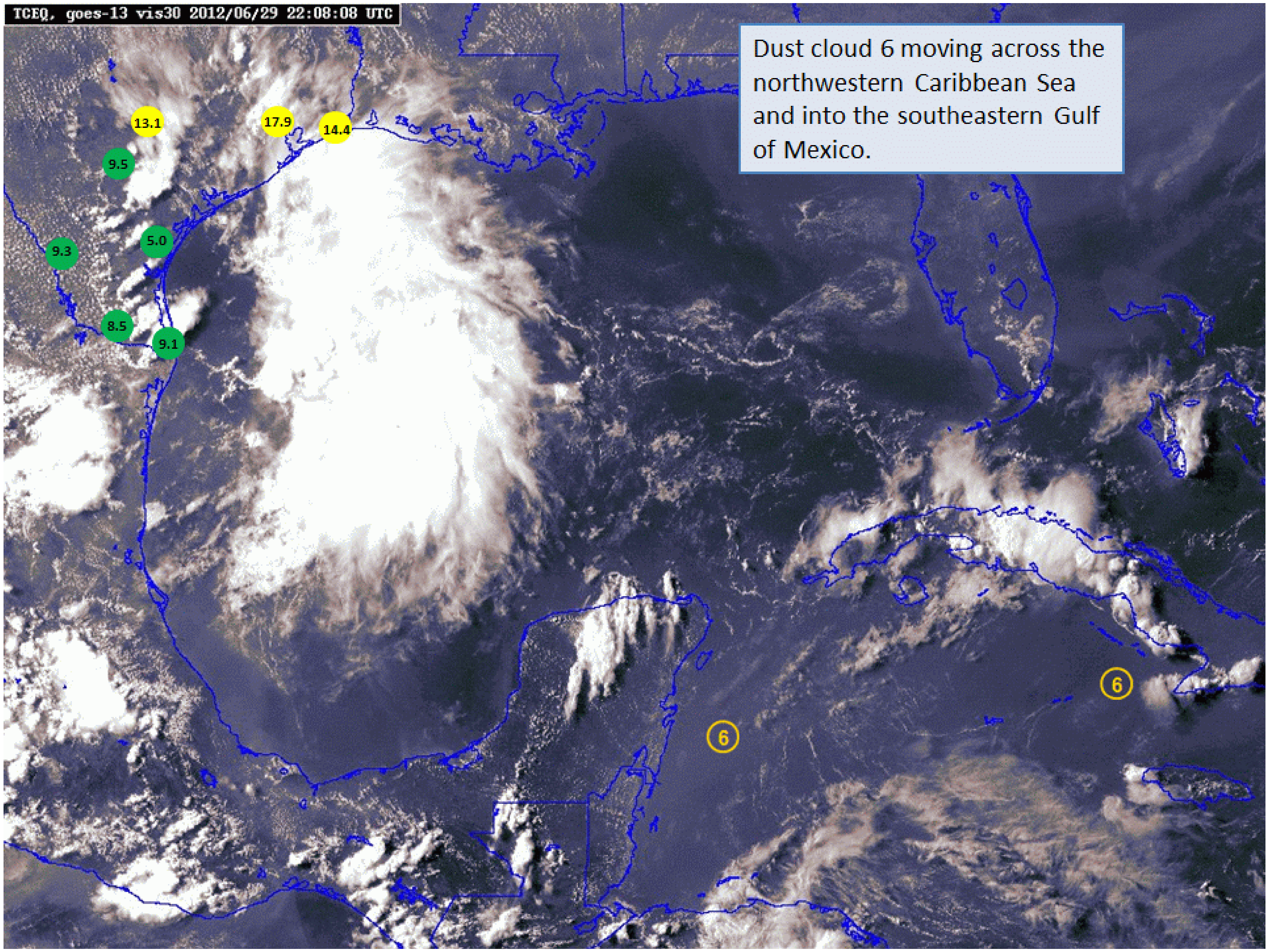


Figure B-13. Visible satellite image for 2208 UTC on June 29, 2012, including the highest area daily average $PM_{2.5}$ concentration ($\mu g/m^3$) for each area, which are indicated by a circle colored according to the EPA Air Quality Index.

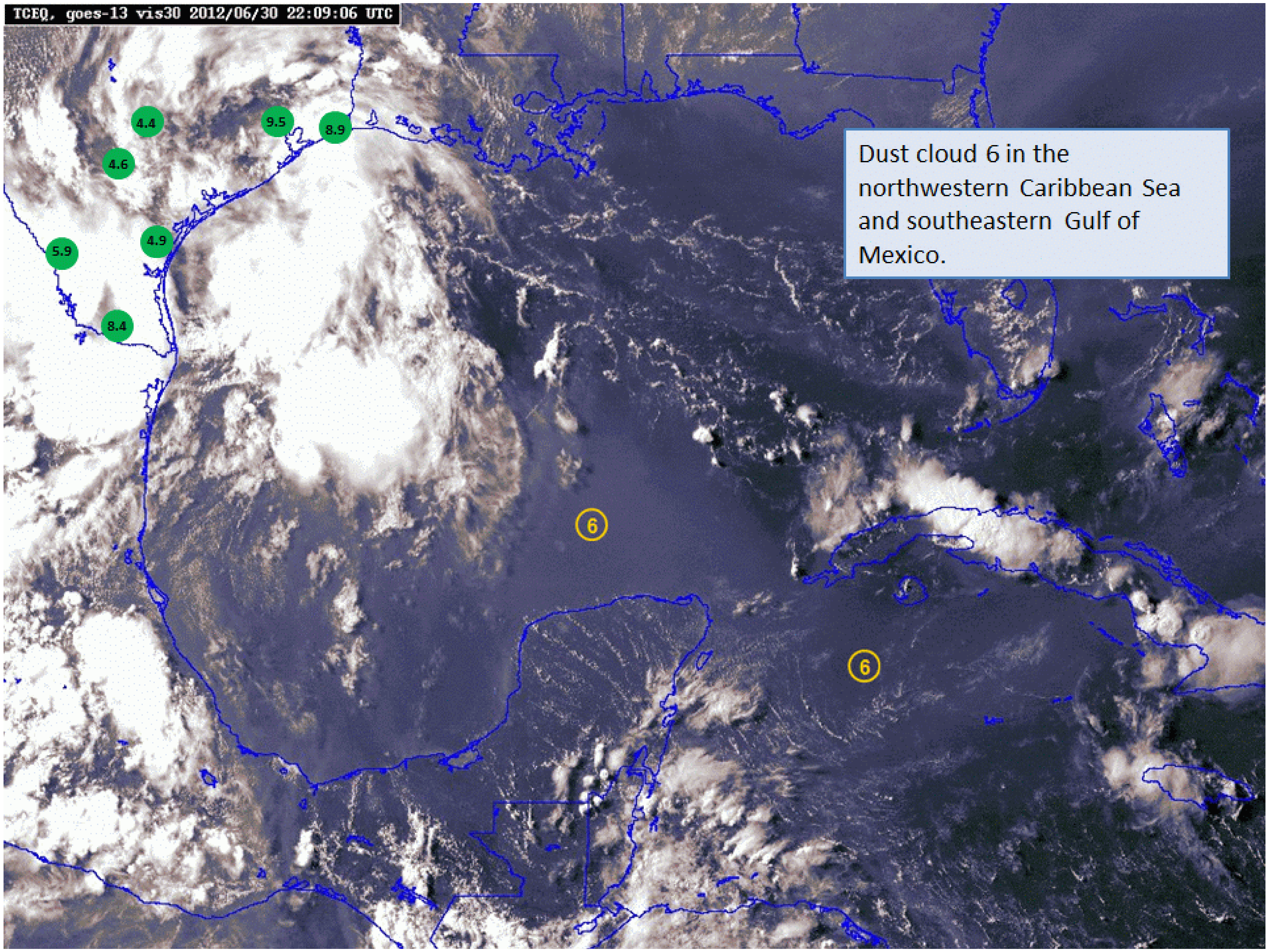


Figure B-14. Visible satellite image for 2209 UTC on June 30, 2012, including the highest area daily average $PM_{2.5}$ concentration ($\mu g/m^3$) for each area, which are indicated by a circle colored according to the EPA Air Quality Index.

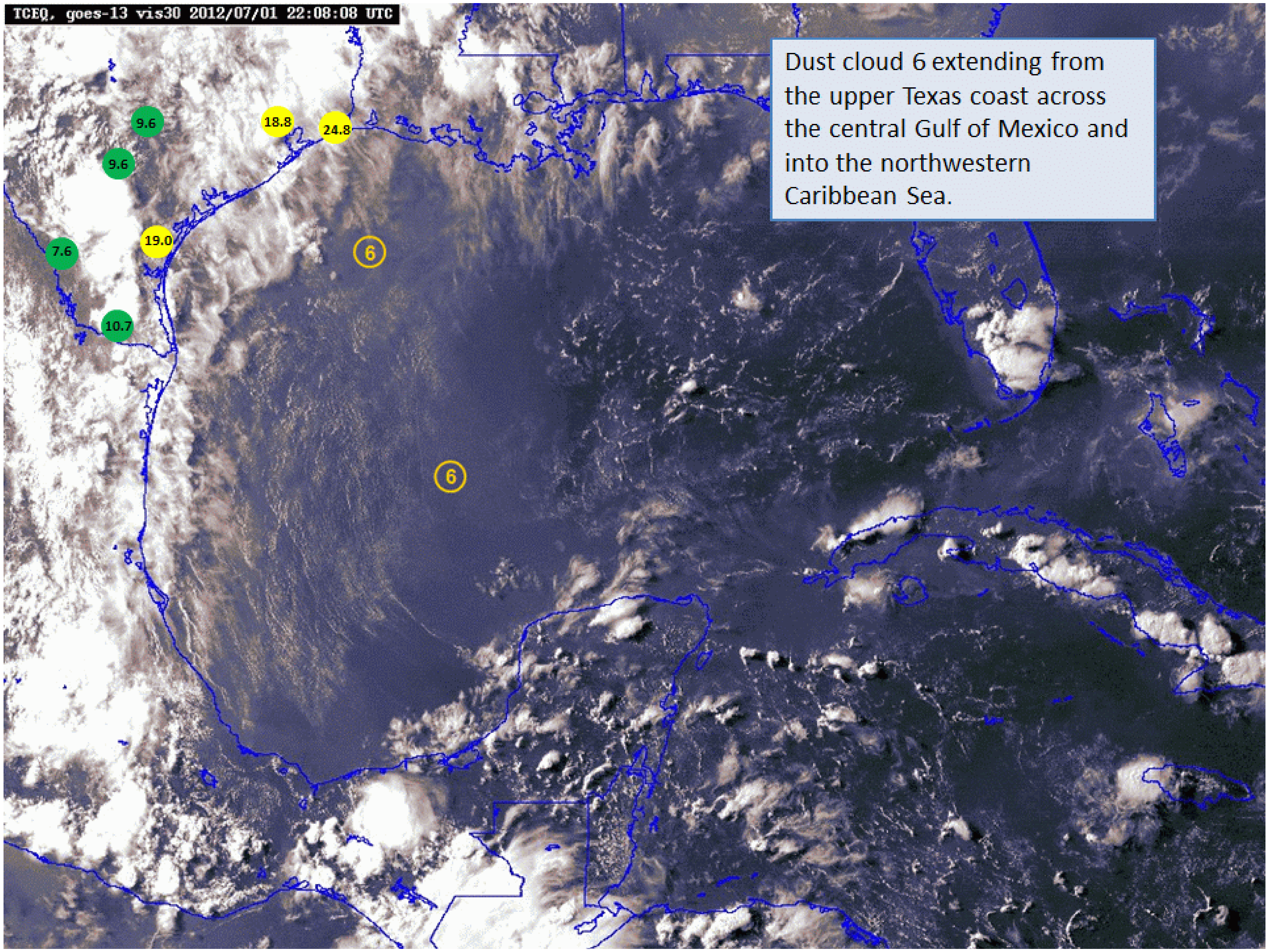


Figure B-15. Visible satellite image for 2208 UTC on July 1, 2012, including the highest area daily average $PM_{2.5}$ concentration ($\mu g/m^3$) for each area, which are indicated by a circle colored according to the EPA Air Quality Index.

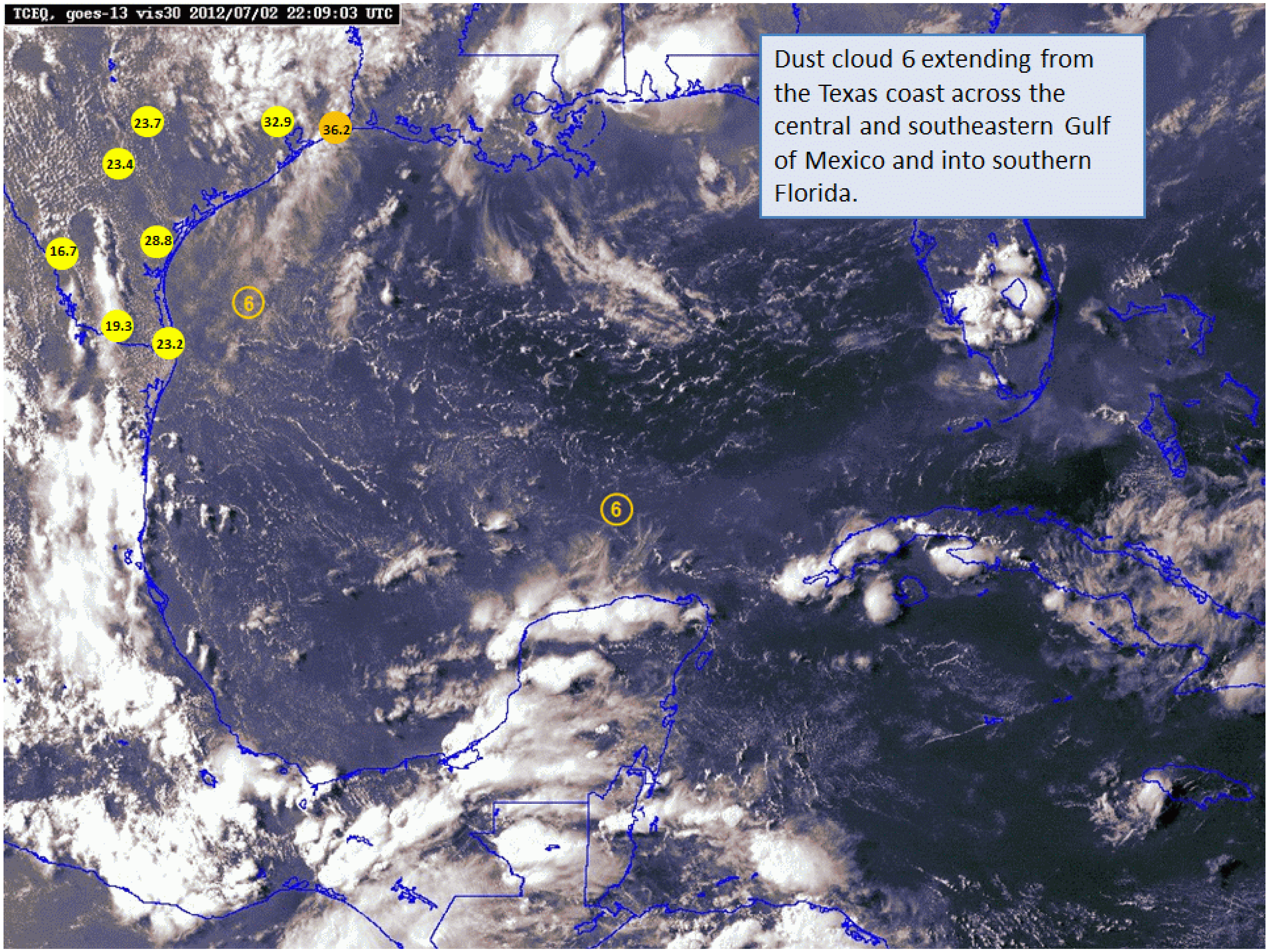


Figure B-16. Visible satellite image for 2209 UTC on July 2, 2012, including the highest area daily average $PM_{2.5}$ concentration ($\mu g/m^3$) for each area, which are indicated by a circle colored according to the EPA Air Quality Index.

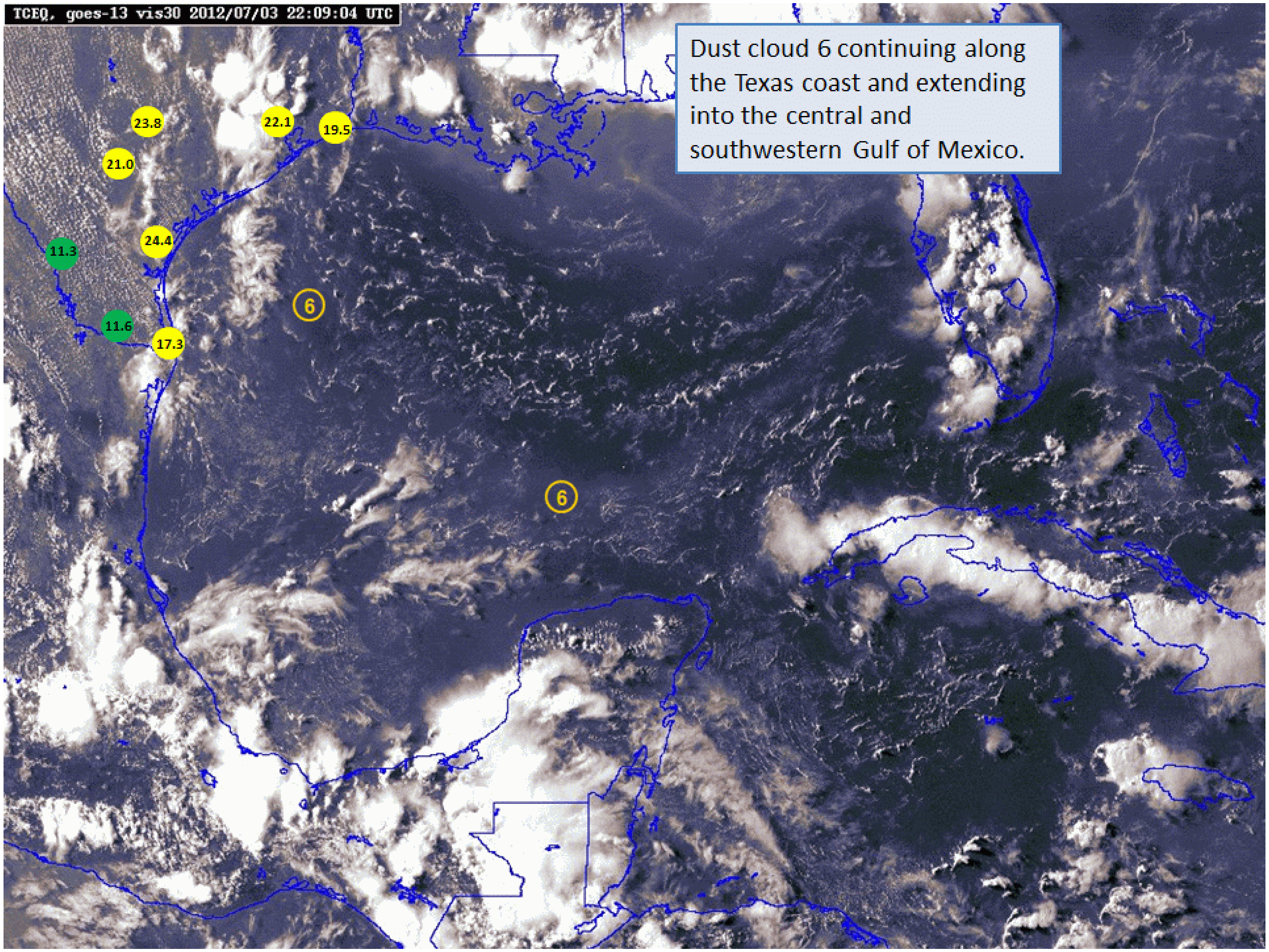


Figure B-17. Visible satellite image for 2209 UTC on July 3, 2012, including the highest area daily average $PM_{2.5}$ concentration ($\mu g/m^3$) for each area, which are indicated by a circle colored according to the EPA Air Quality Index.

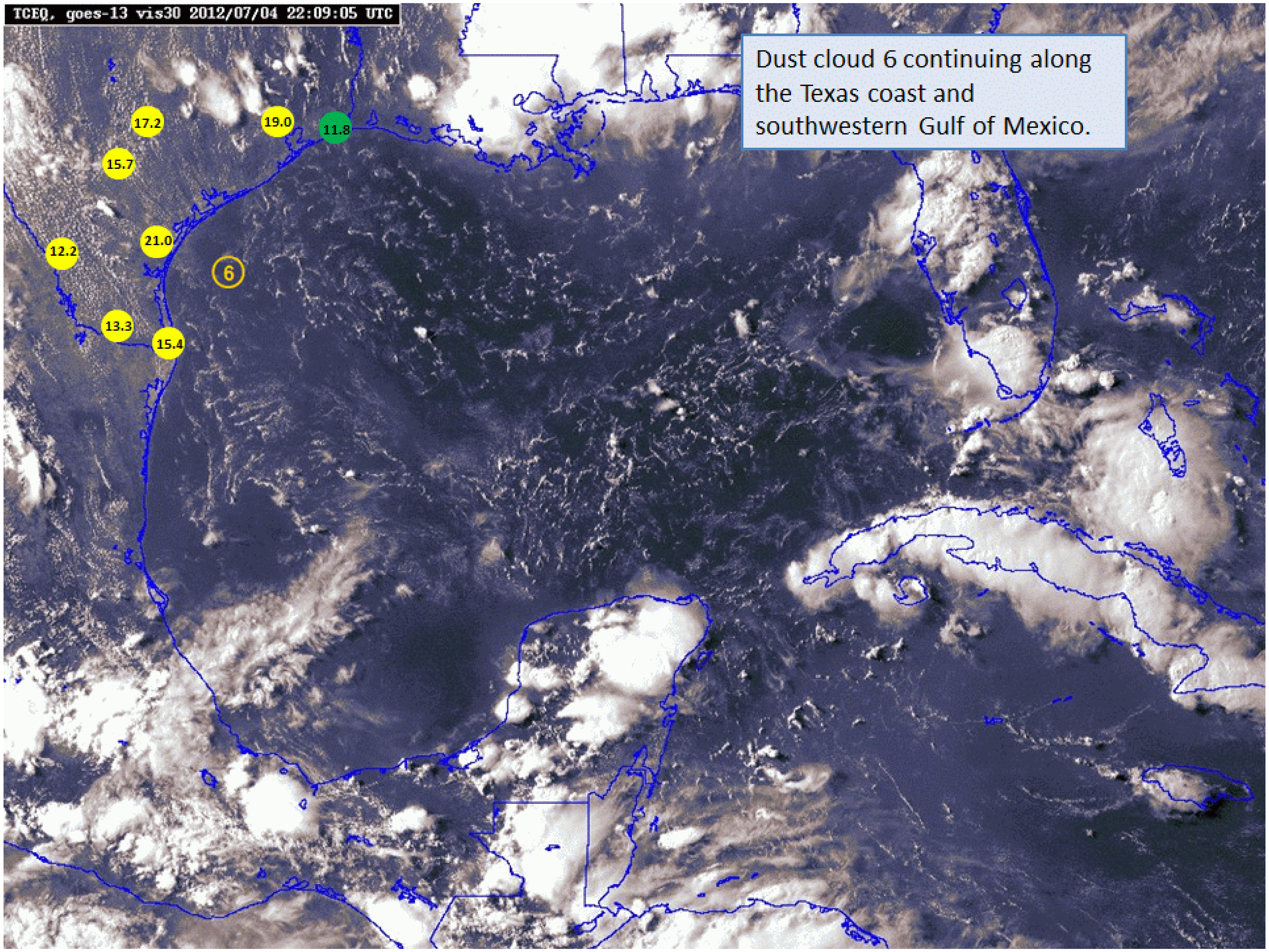


Figure B-18. Visible satellite image for 2209 UTC on July 4, 2012, including the highest area daily average $PM_{2.5}$ concentration (µg/m^3) for each area, which are indicated by a circle colored according to the EPA Air Quality Index.

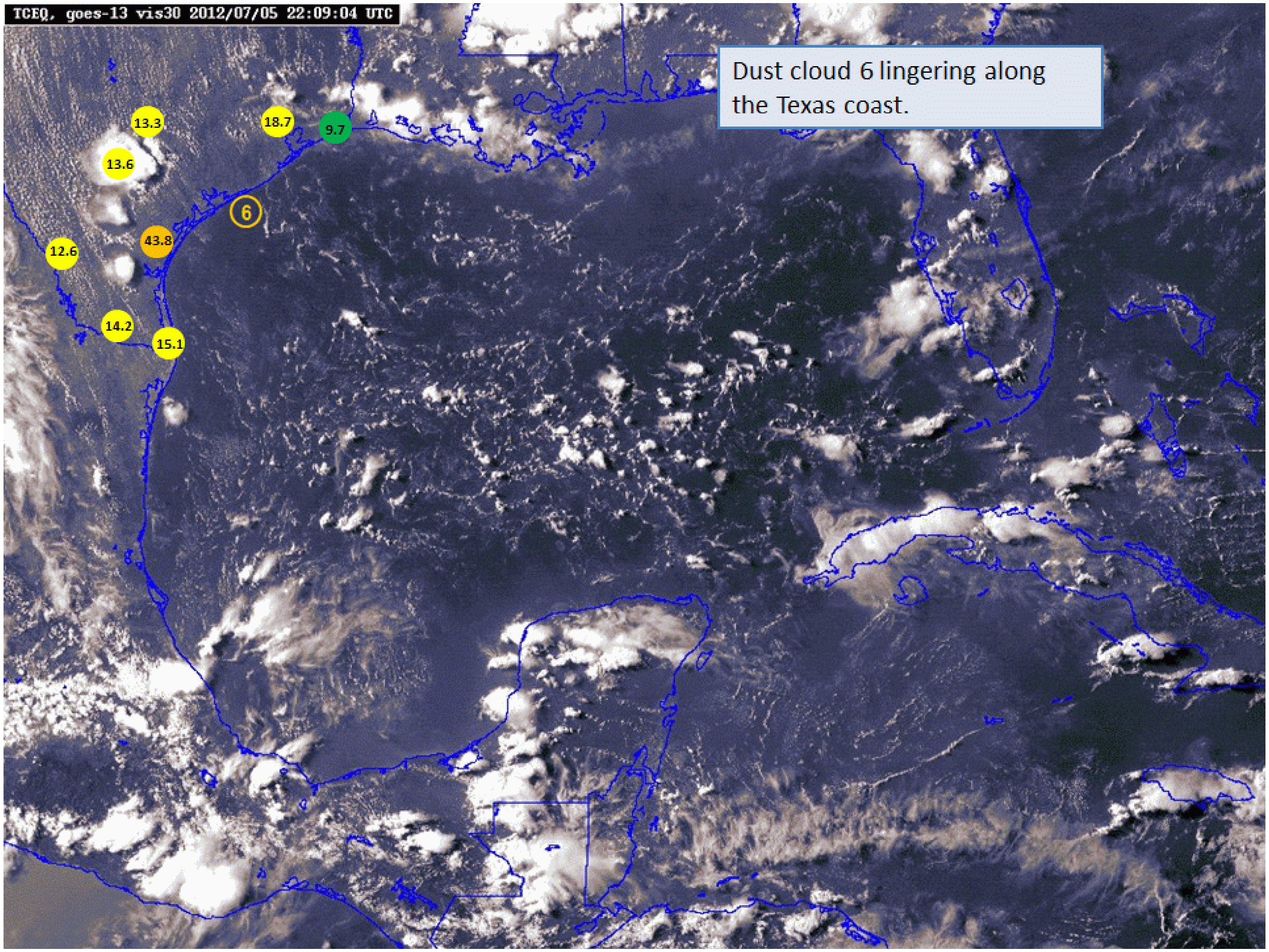


Figure B-19. Visible satellite image for 2209 UTC on July 5, 2012, including the highest area daily average $PM_{2.5}$ concentration (µg/m^3) for each area, which are indicated by a circle colored according to the EPA Air Quality Index.

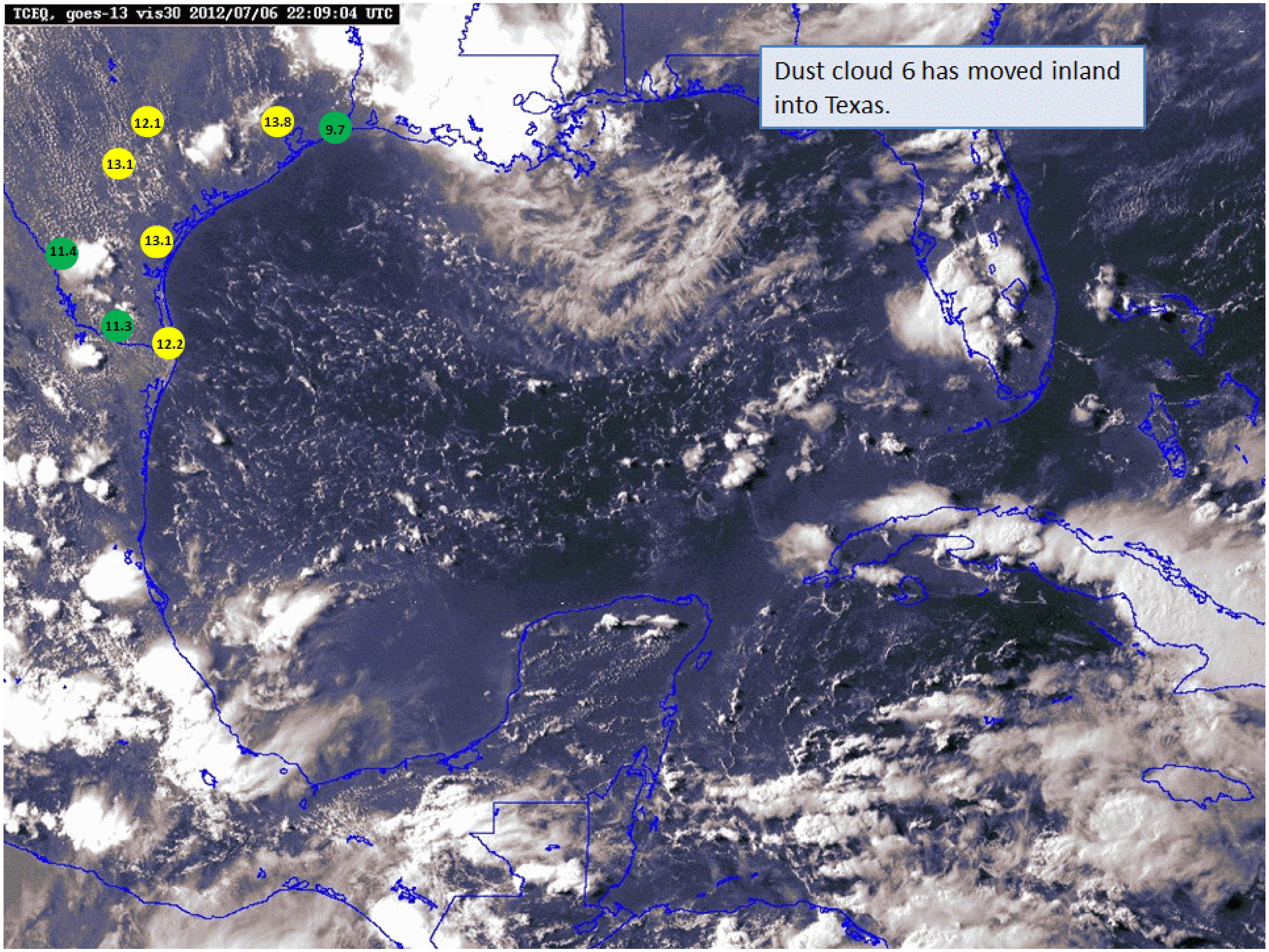


Figure B-20. Visible satellite image for 2209 UTC on July 6, 2012, including the highest area daily average $PM_{2.5}$ concentration (µg/m^3) for each area, which are indicated by a circle colored according to the EPA Air Quality Index.

Aerosol Analyses

Figures B-21 through B-34 provide aerosol analyses from the Naval Research Laboratory (NRL) showing the African dust cloud that arrived in the Houston area on July 2 as it progressed across the Atlantic, Caribbean Sea, and Gulf of Mexico. The satellite derived optical depth from dust is shown in shades of green and yellow in the upper left panel of each figure. The same numbering system used to identify dust clouds on the previous satellite imagery is used in these figures for comparison. These aerosol analyses corroborate well with the satellite imagery and back trajectories shown previously.

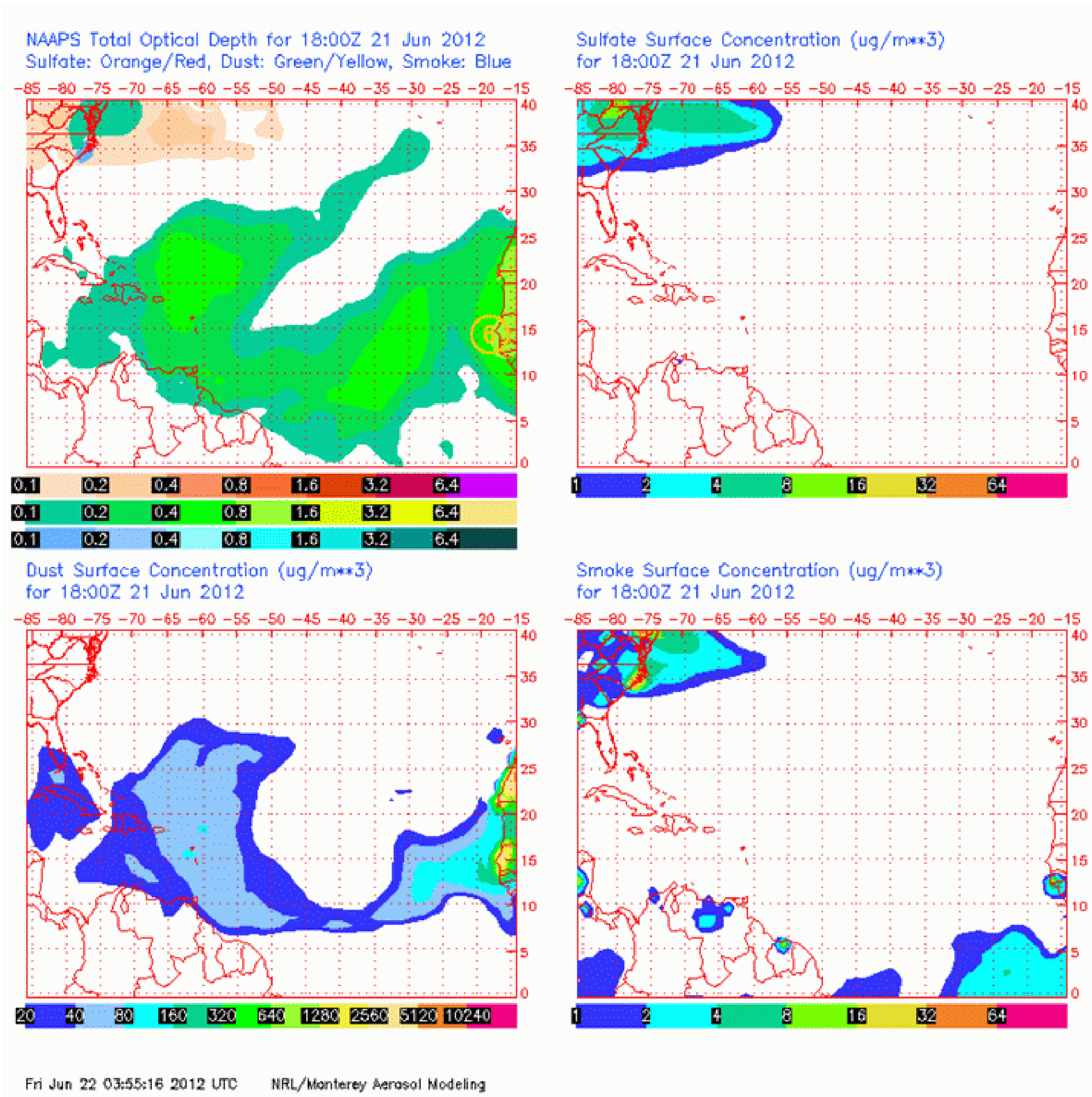


Figure B-21. NRL aerosol analysis for 1800 UTC on June 21, 2012, showing the African dust cloud emerging from the African coast.

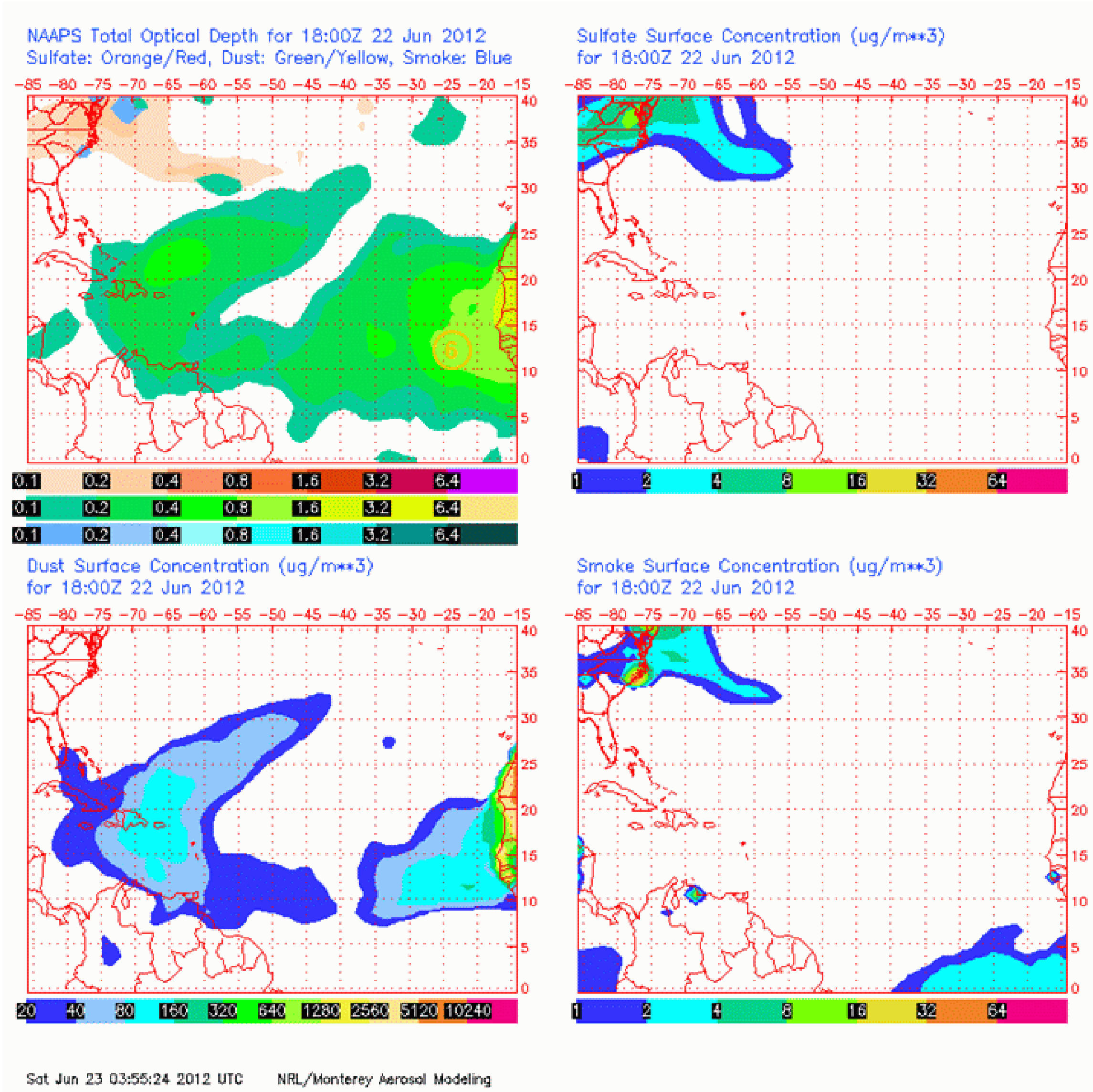


Figure B-22. NRL aerosol analysis for 1800 UTC on June 22, 2012, showing the African dust cloud moving into the eastern Atlantic Ocean.

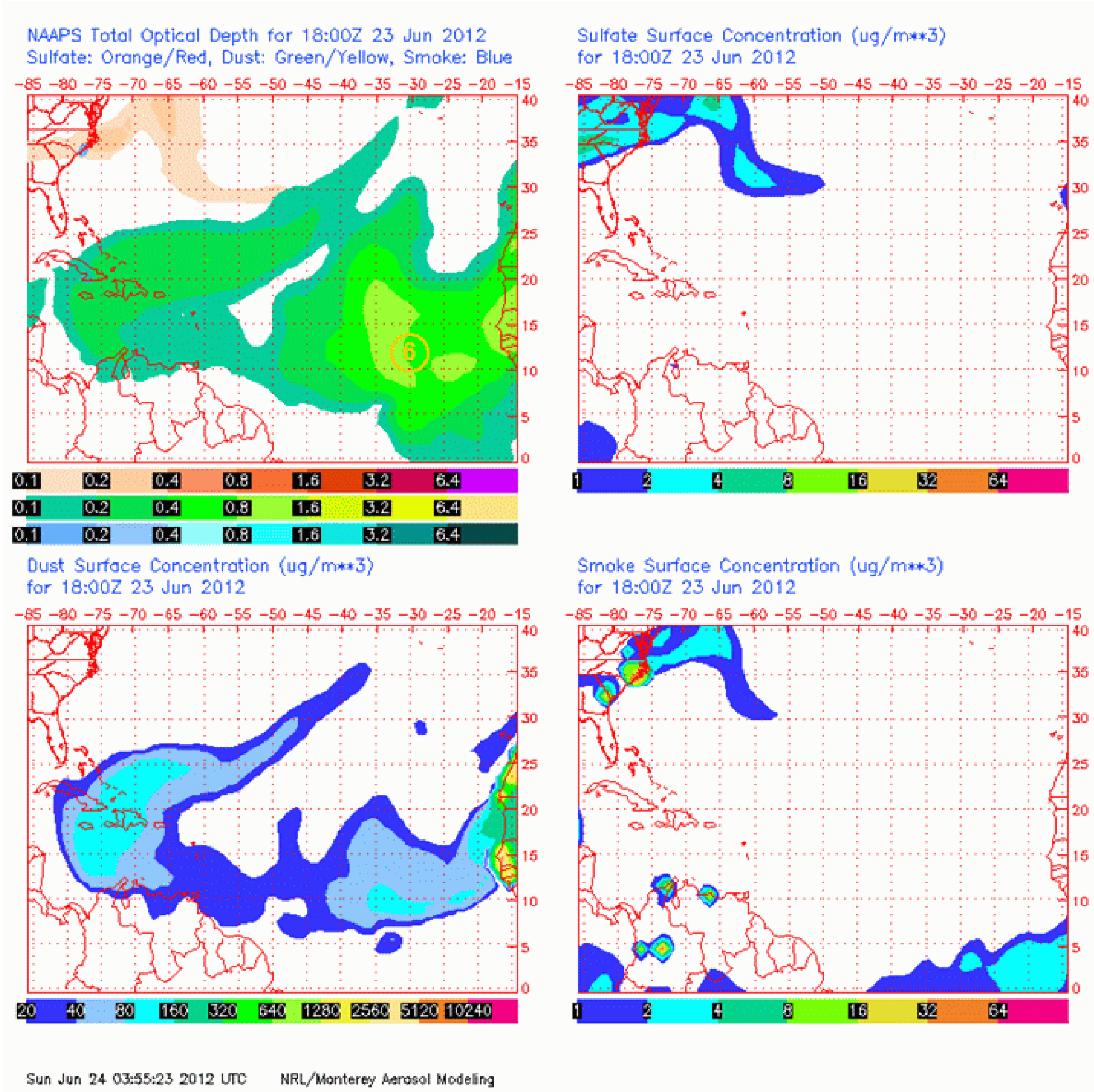


Figure B-23. NRL aerosol analysis for 1800 UTC on June 23, 2012, showing the African dust cloud moving into the eastern Atlantic Ocean.

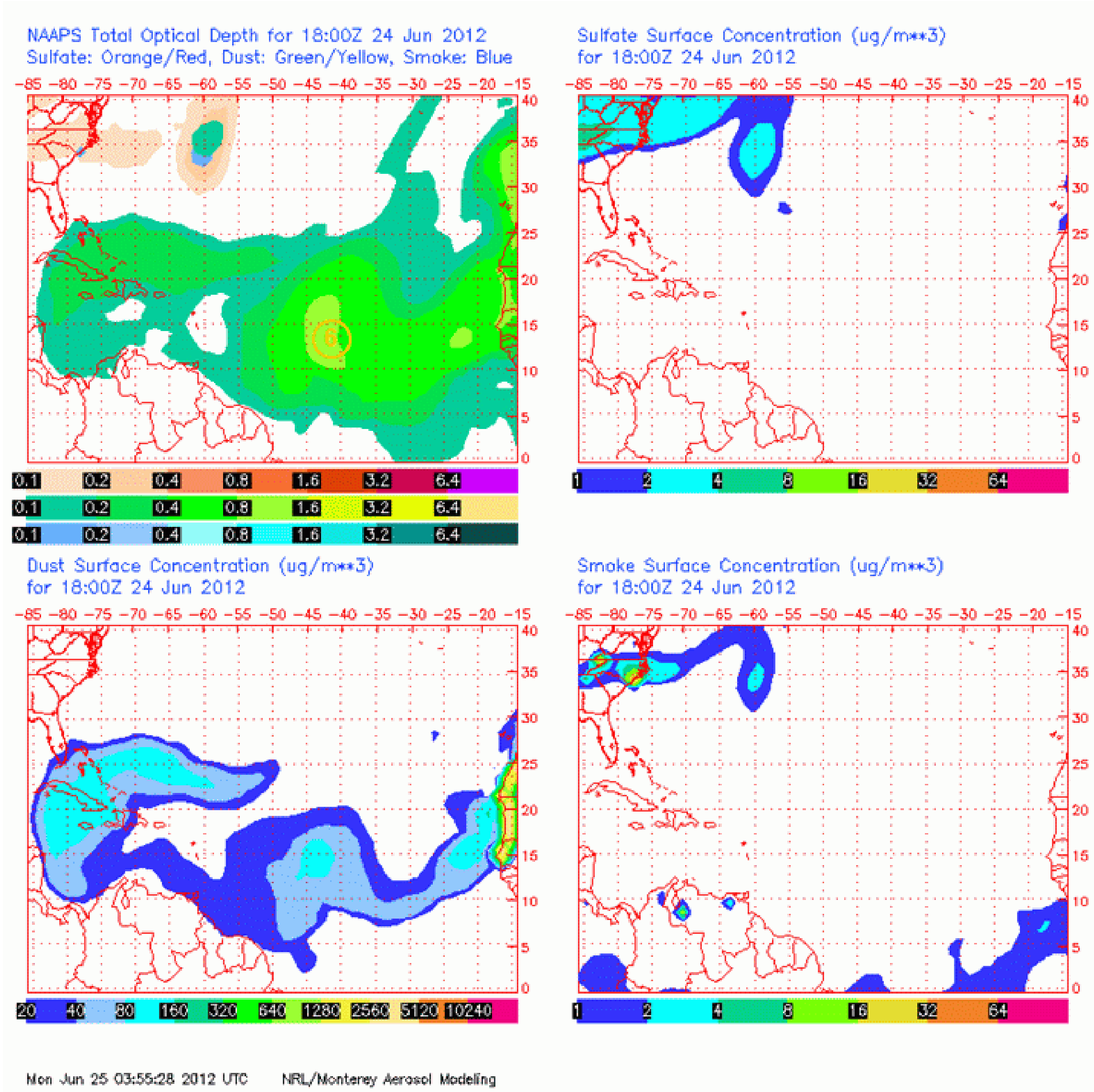


Figure B-24. NRL aerosol analysis for 1800 UTC on June 24, 2012, showing the African dust cloud moving into the central Atlantic Ocean.

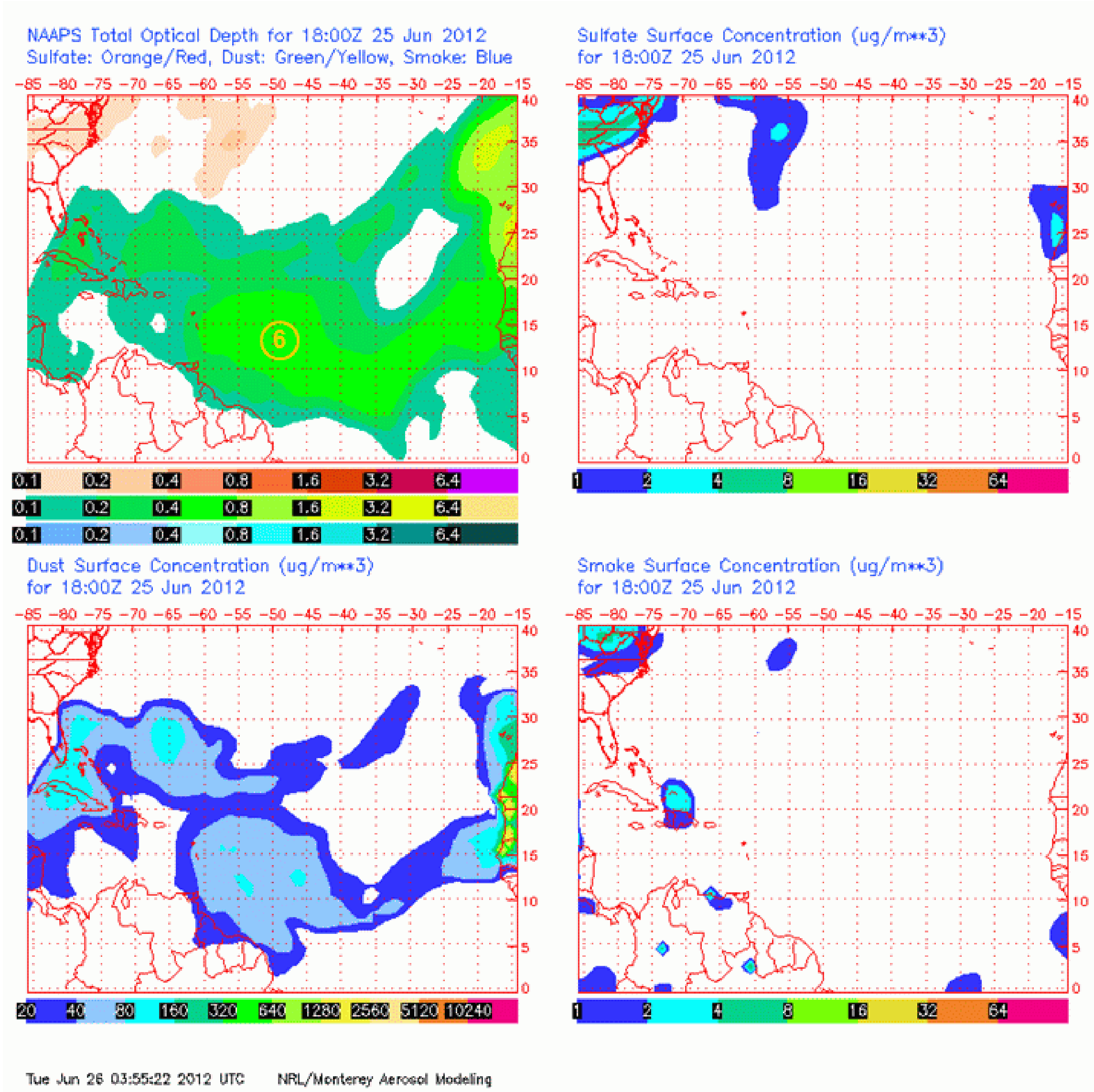


Figure B-25. NRL aerosol analysis for 1800 UTC on June 25, 2012, showing the African dust cloud approaching the Lesser Antilles.

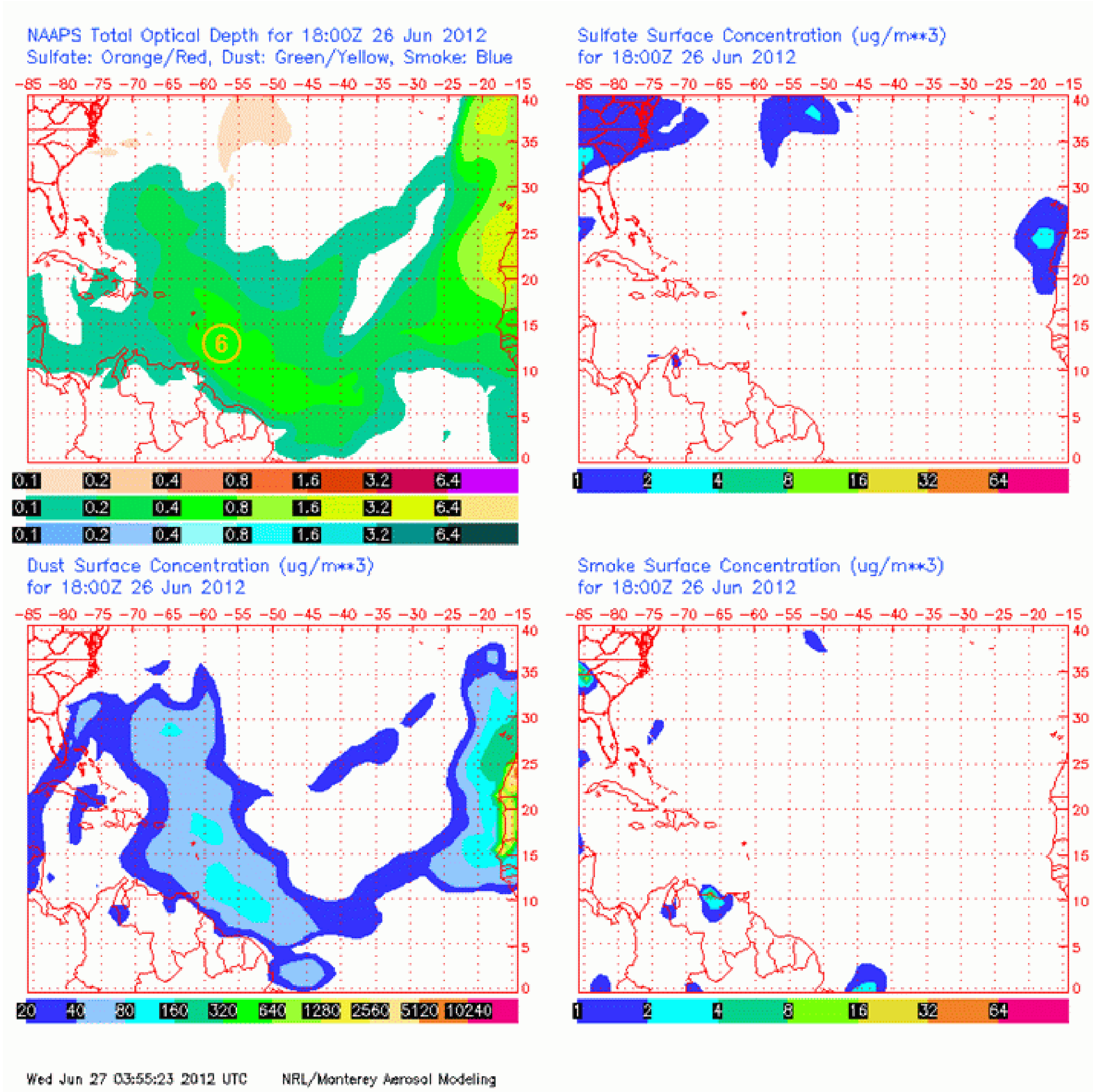


Figure B-26. NRL aerosol analysis for 1800 UTC on June 26, 2012, showing the African dust cloud moving into the Lesser Antilles.

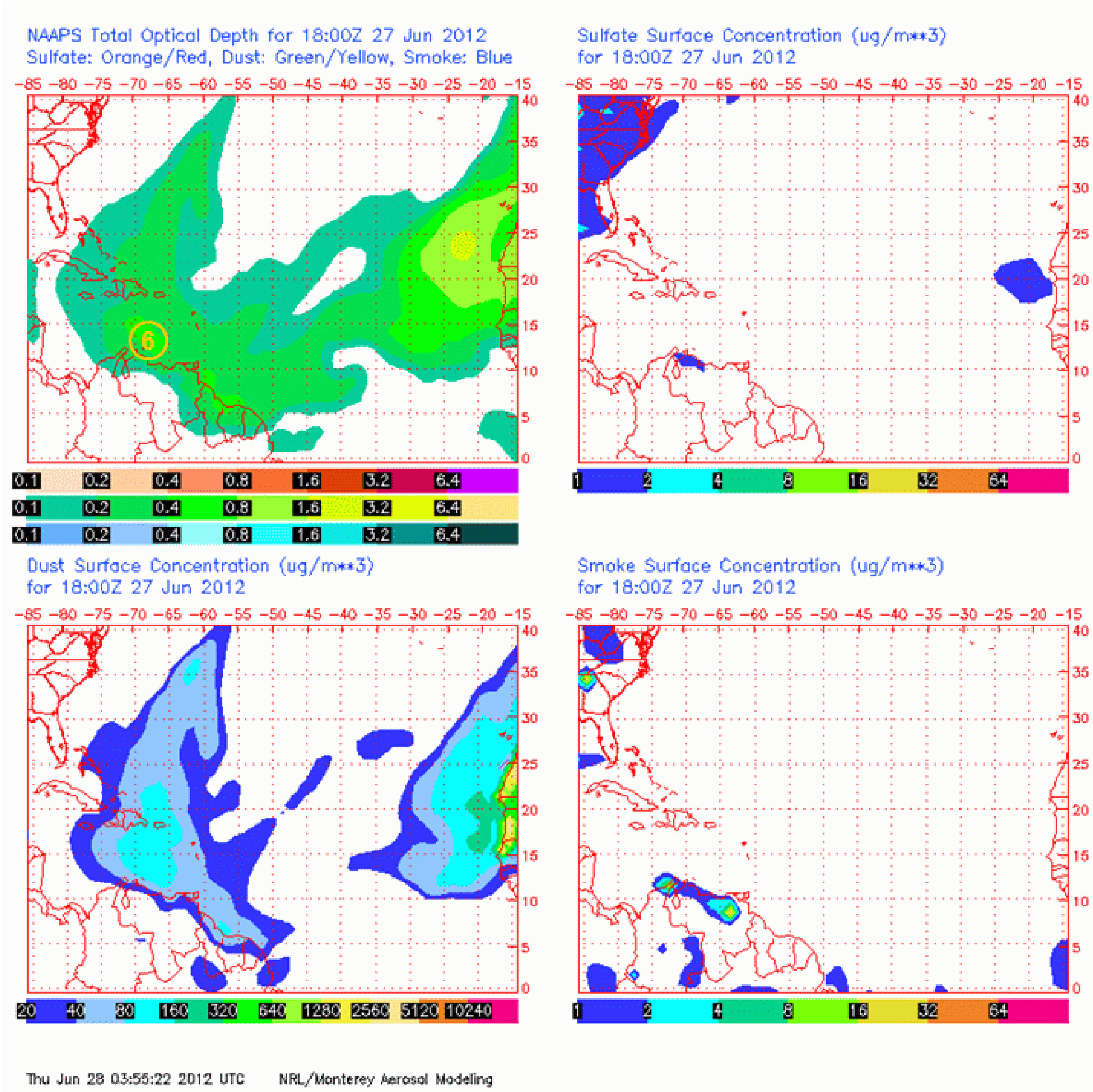


Figure B-27. NRL aerosol analysis for 1800 UTC on June 27, 2012, showing the African dust cloud moving into the eastern Caribbean Sea.

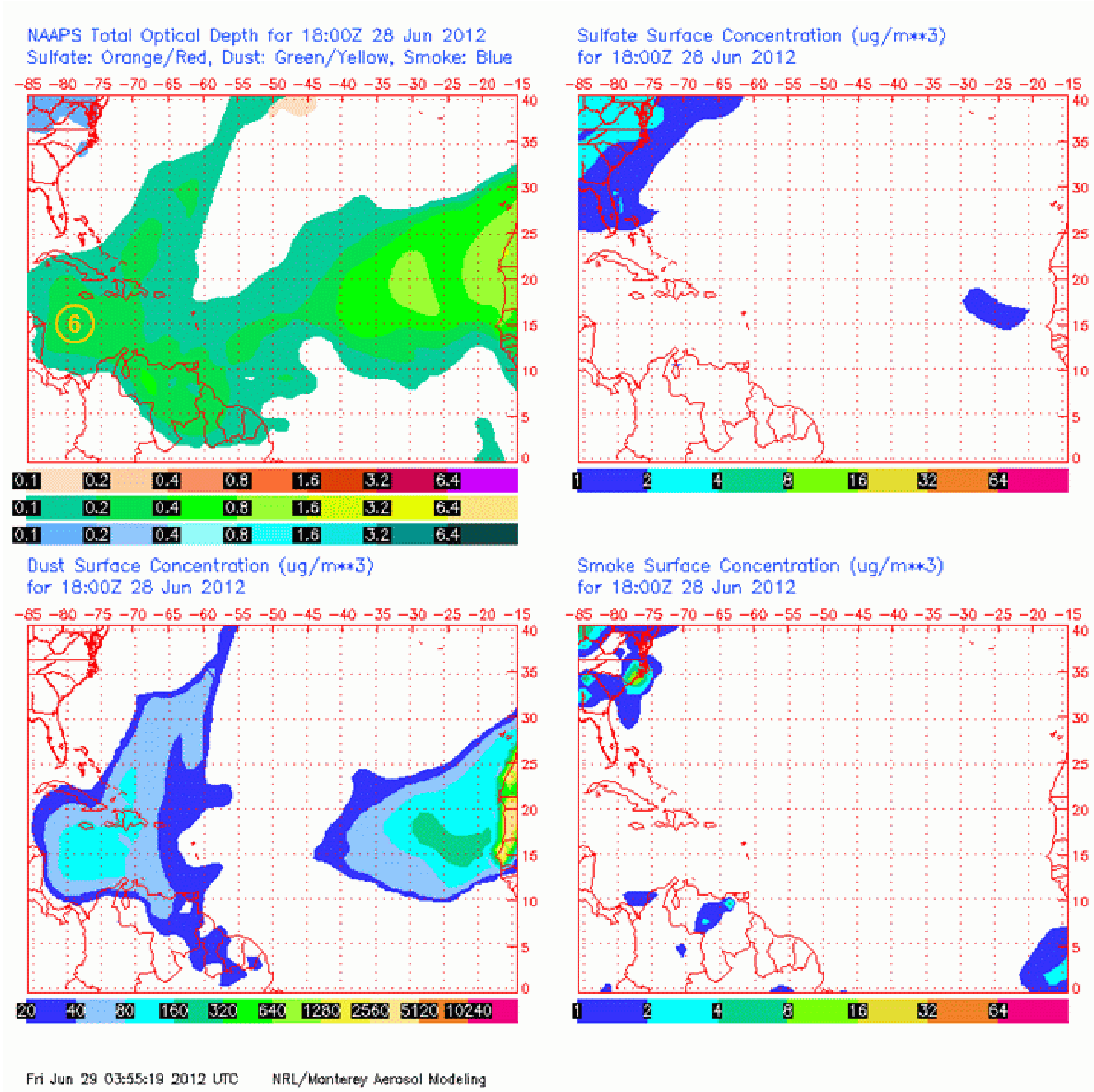


Figure B-28. NRL aerosol analysis for 1800 UTC on June 28, 2012, showing the African dust cloud in the Caribbean Sea.

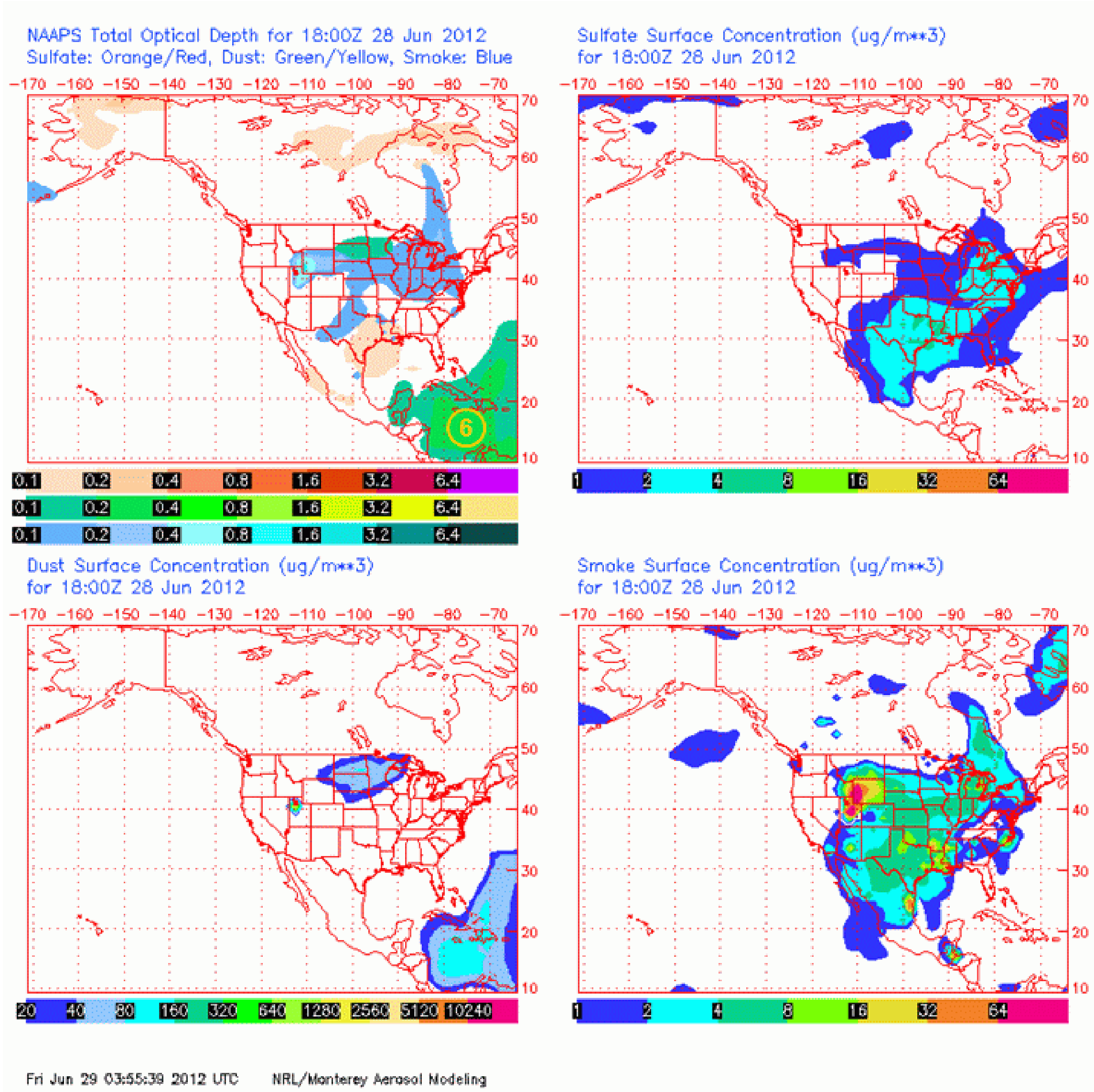


Figure B-29. NRL aerosol analysis for 1800 UTC on June 28, 2012, showing the African dust cloud in the Caribbean Sea.

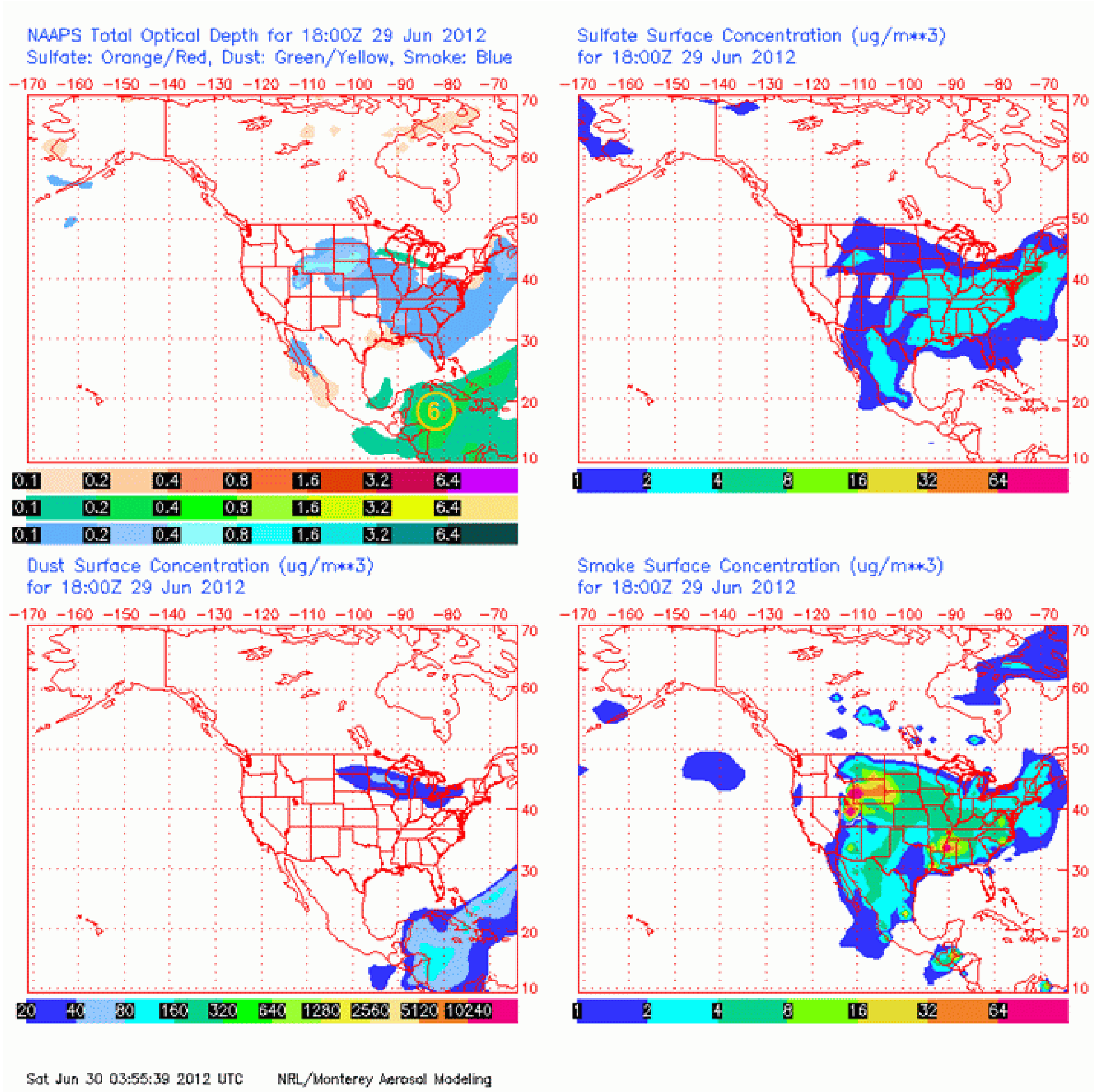


Figure B-30. NRL aerosol analysis for 1800 UTC on June 29, 2012, showing the African dust cloud in the Caribbean Sea.

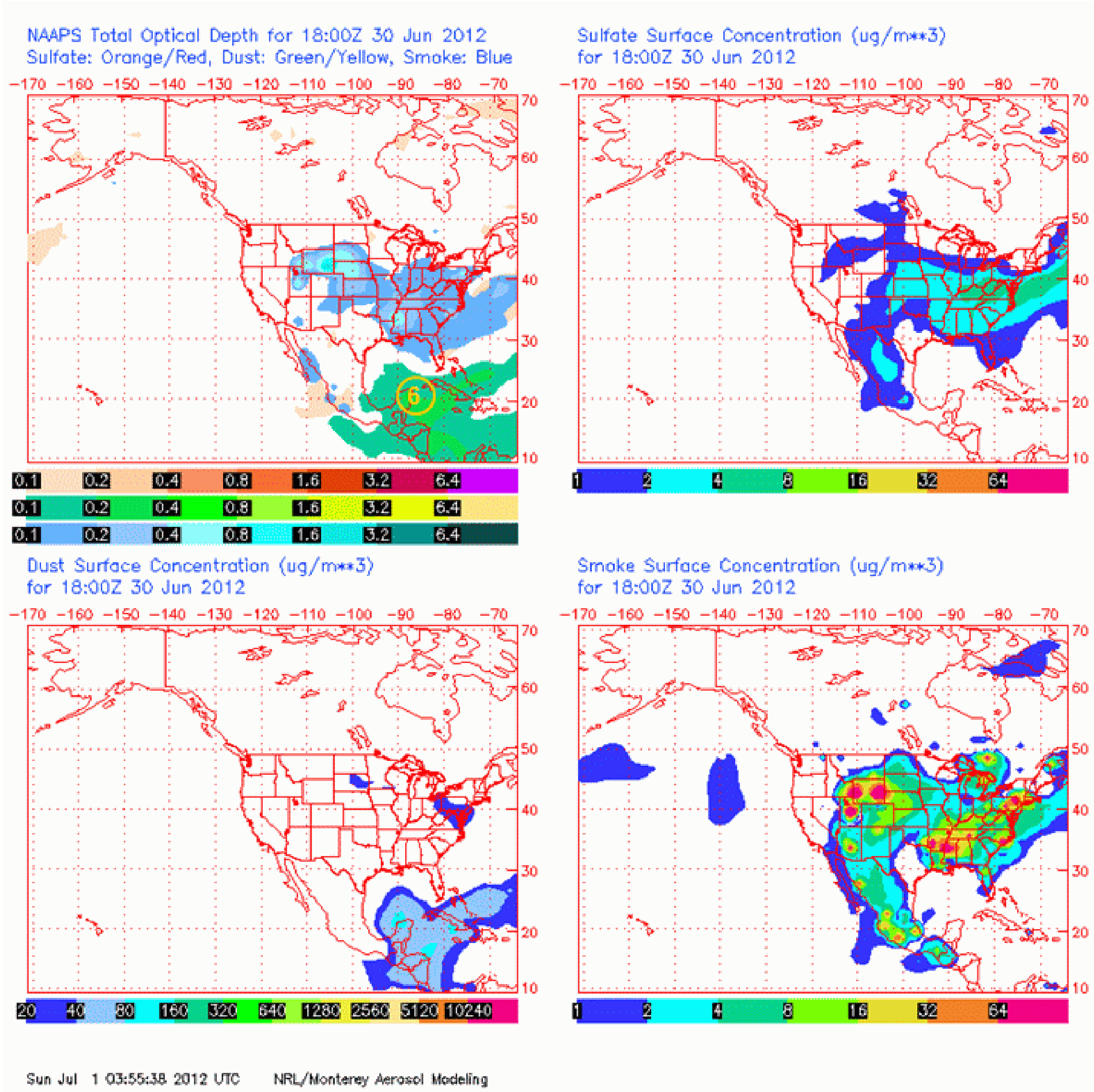


Figure B-31. NRL aerosol analysis for 1800 UTC on June 30, 2012, showing the African dust cloud in the Gulf of Mexico.

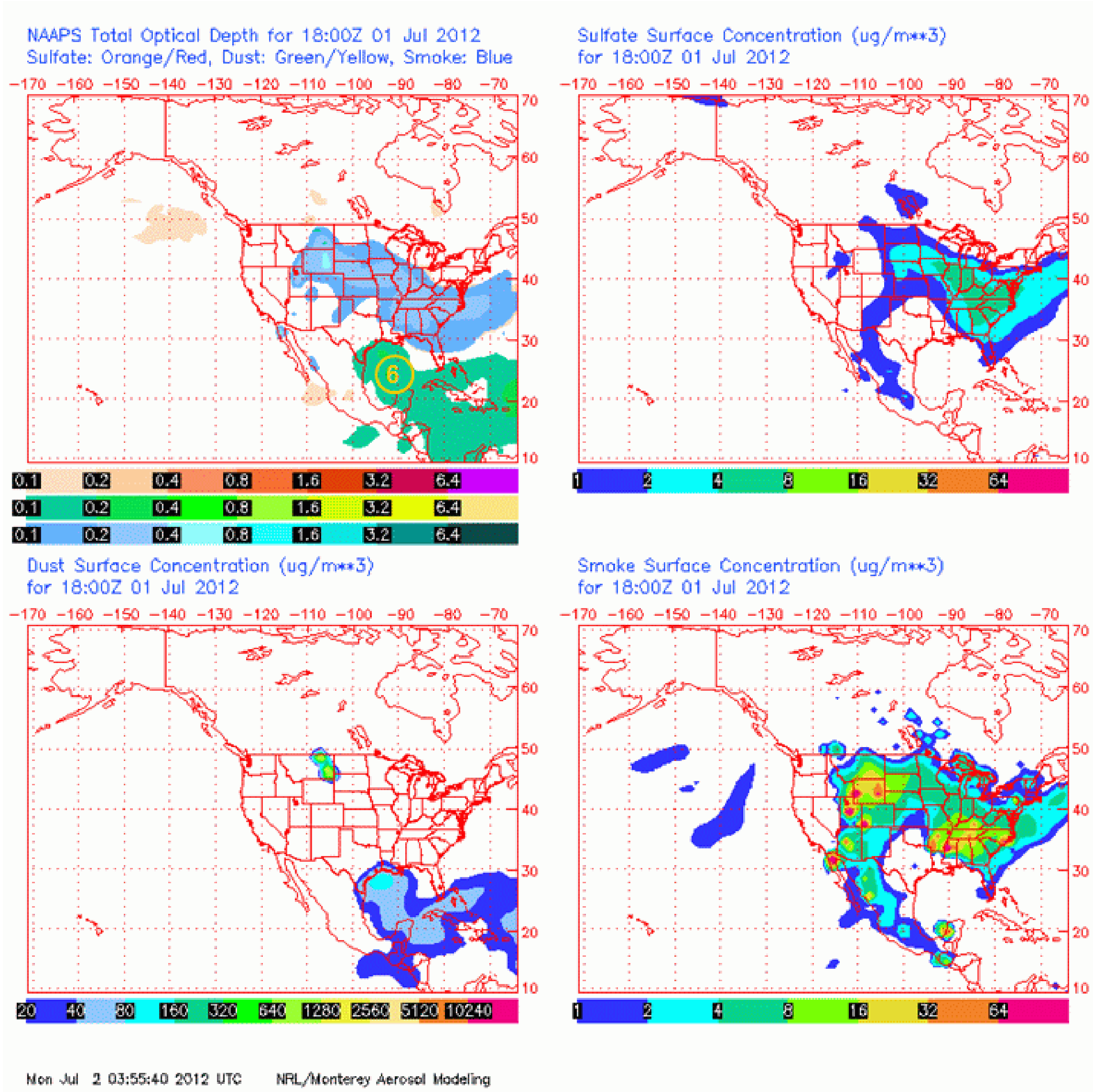


Figure B-32. NRL aerosol analysis for 1800 UTC on July 1, 2012, showing the African dust cloud in the Gulf of Mexico.

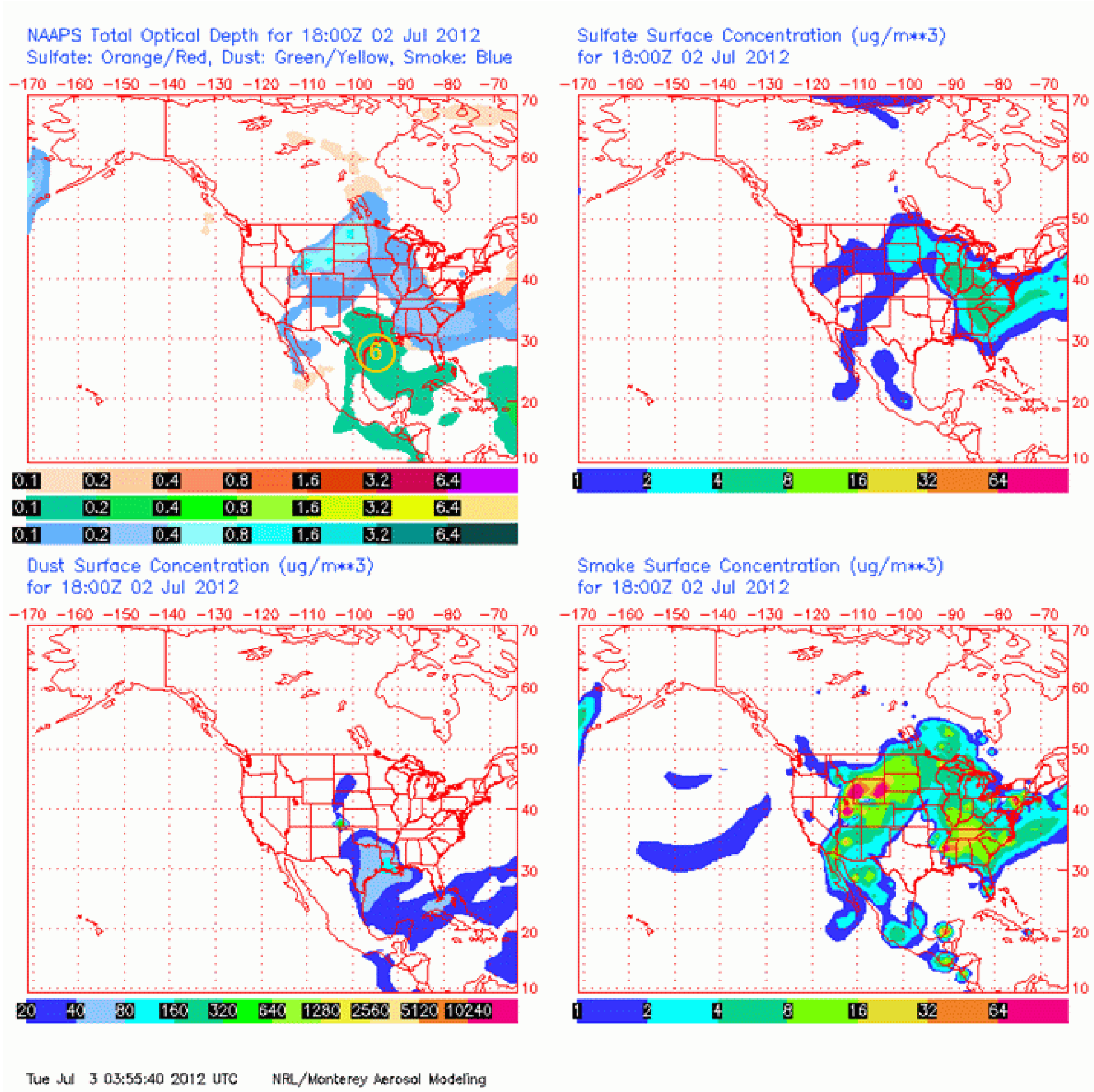


Figure B-33. NRL aerosol analysis for 1800 UTC on July 2, 2012, showing the African dust cloud in Texas extending into the Gulf of Mexico.

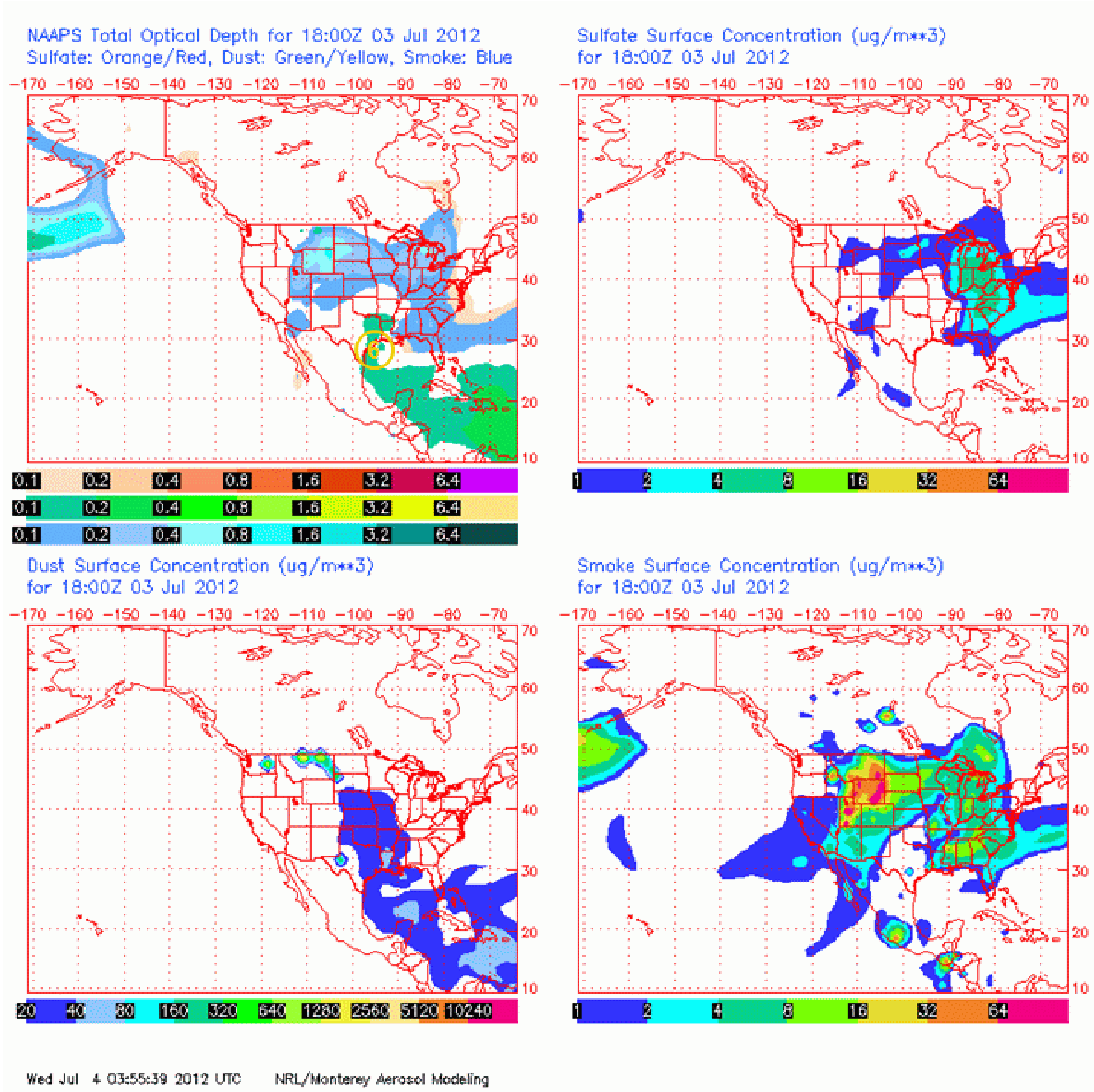


Figure B-34. NRL aerosol analysis for 1800 UTC on July 3, 2012, showing the African dust cloud in Texas extending into the Gulf of Mexico.

Appendix C: Source Analysis for July 27 and July 28

Back Trajectories

Figures C-1 through C-4 provide HYSPLIT back trajectories that show the approximate path of air arriving in the Houston area at 1200 central standard time (CST) (or 1800 universal time coordinates [UTC]) at 500 meters, 1,000 meters, and 1,500 meters above ground level on the day indicated and going backward in time 312 hours. These trajectories indicate that the air arriving in Houston on July 27 and July 28, 2012, came from Africa. The NOAA web site where the trajectories were produced does not allow them to run past 312 hours. So, it is not possible to follow the air parcel all the way back into Africa.

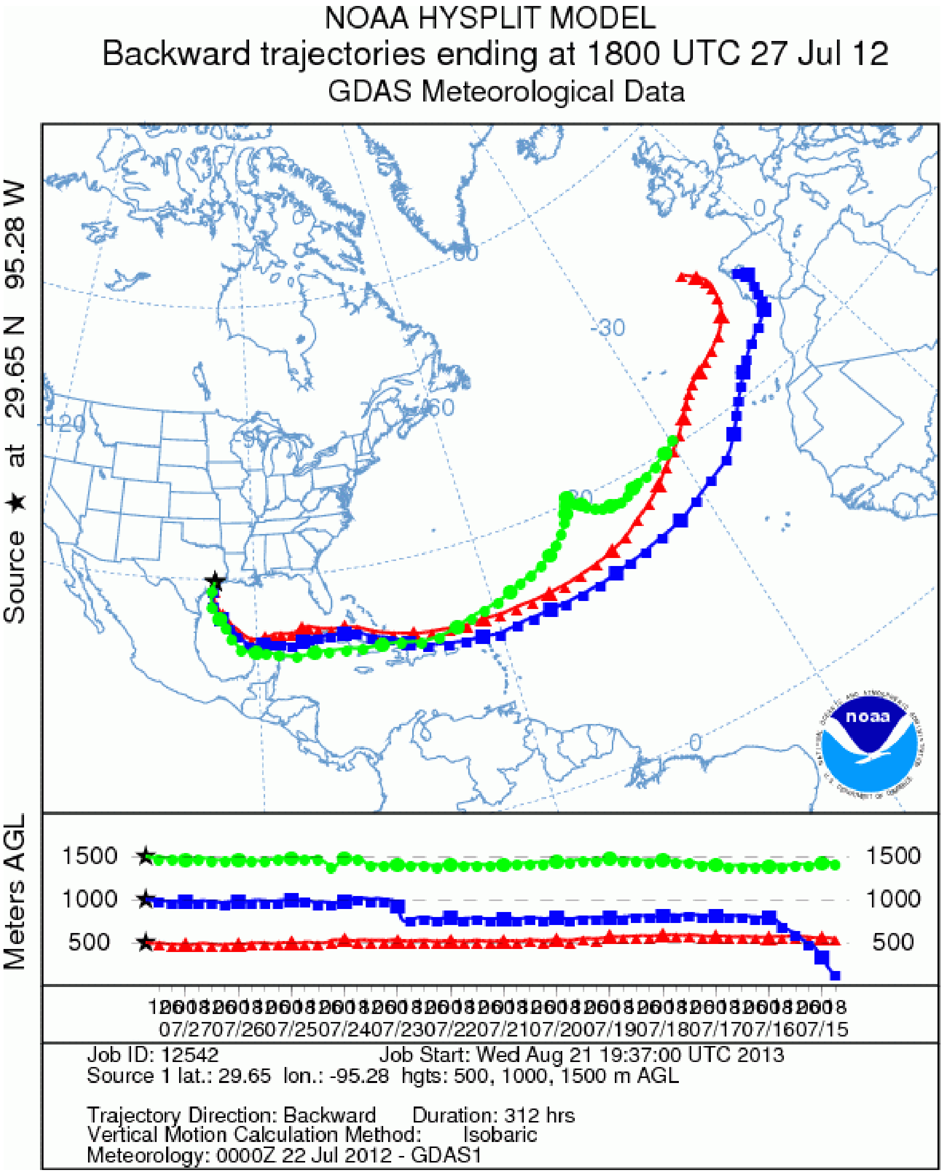


Figure C-1. Backward-in-time air trajectory for July 27, 2012.

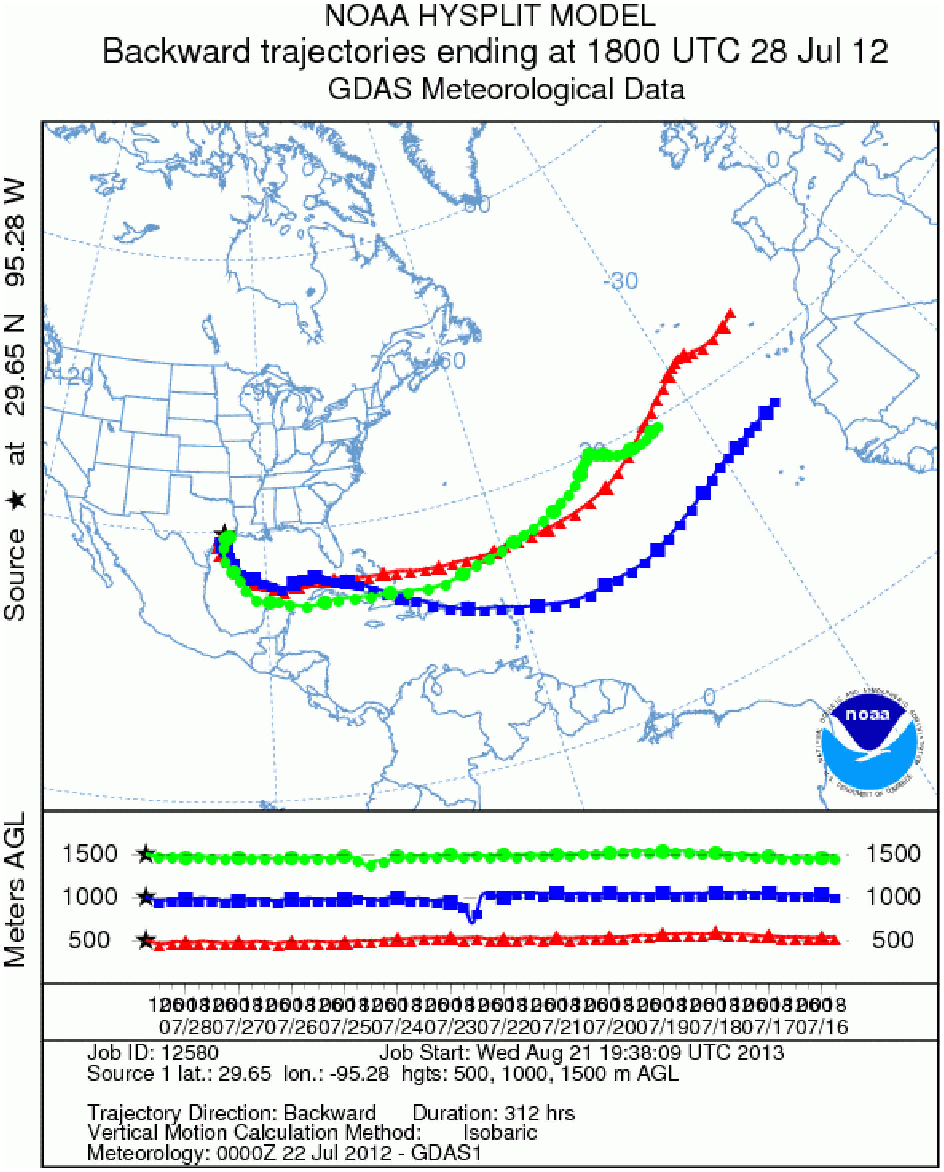


Figure C-2. Backward-in-time air trajectory for July 28, 2012.

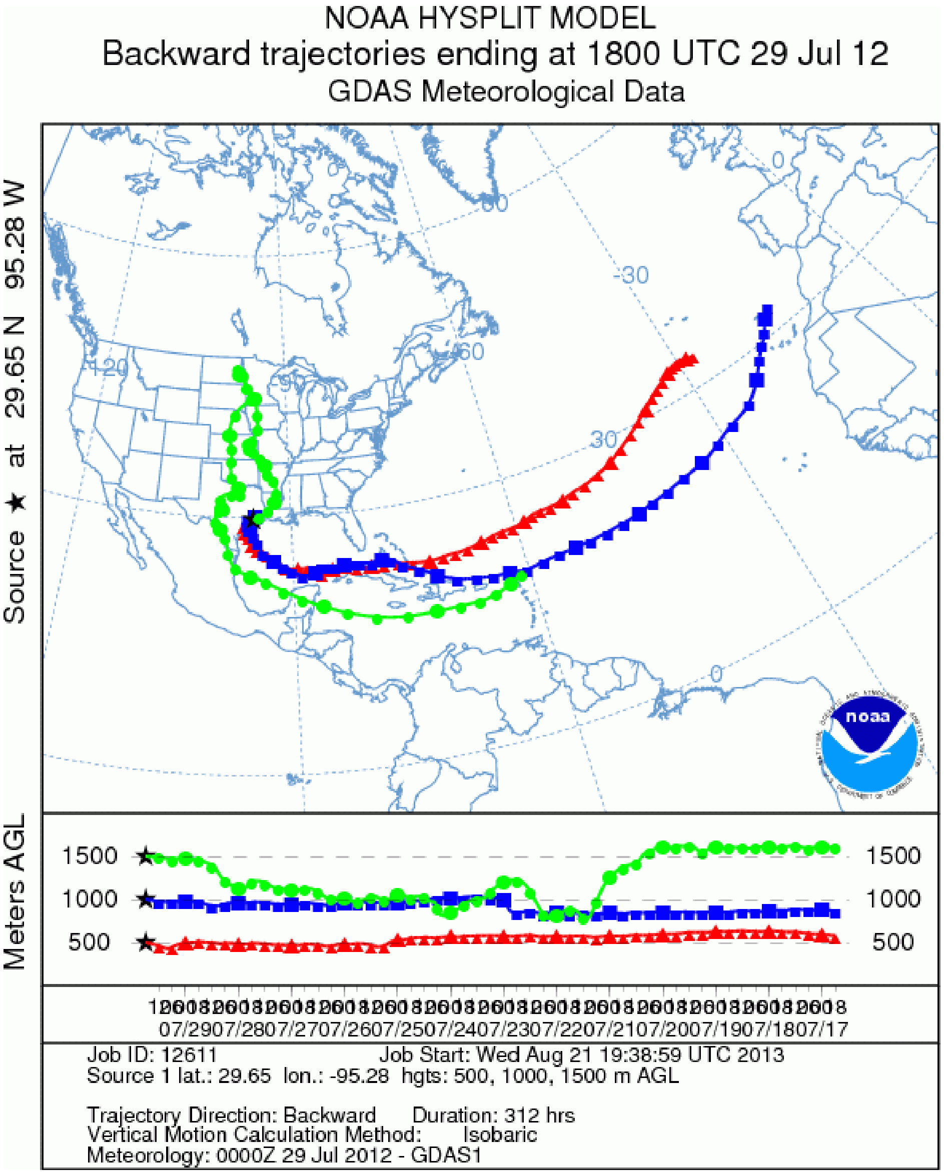


Figure C-3. Backward-in-time air trajectory for July 29, 2012.

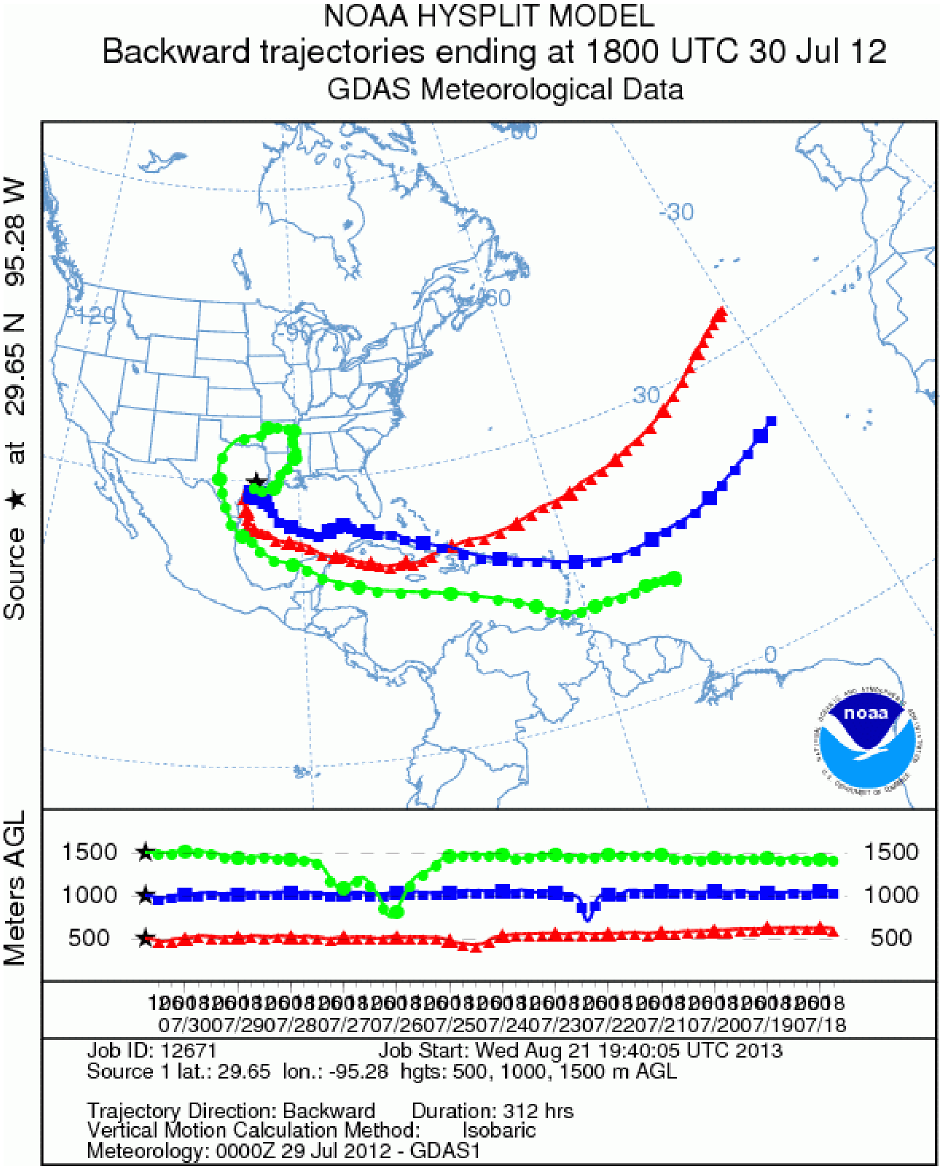


Figure C-4. Backward-in-time air trajectory for July 30, 2012.

Satellite Imagery

Figures C-5 through C-22 provide geostationary satellite images showing a large and intense African dust cloud move across the Atlantic, Caribbean Sea, and Gulf of Mexico. The image times are listed in Universal Time Coordinates (UTC) which is five hours ahead of Central Daylight Time. On these images, most clouds are bright white with sharp edges and ocean water is normally very dark away from clouds. Dust in the air makes the ocean look much brighter when present, giving it a milky appearance with soft indistinct edges to the dust cloud. The satellite imagery corroborates well with the back trajectories shown previously.

The satellite imagery shows a large and intense African dust cloud had emerged into the eastern Atlantic Ocean from the African coast by July 15, 2012. The dust cloud of interest is labeled number “12” in all of the satellite images. This dust cloud tracked across the Atlantic Ocean reaching the Lesser Antilles on July 19th and began moving north of the Caribbean Sea before the tail end rotated into the Caribbean and Gulf of Mexico by July 24th. The dust cloud arrived in the Houston area on July 26th and continued moving across the area through July 30th. The imagery also shows a weaker African dust cloud that would eventually reach the Texas coast on August 1st moving into the Gulf of Mexico on July 29th.

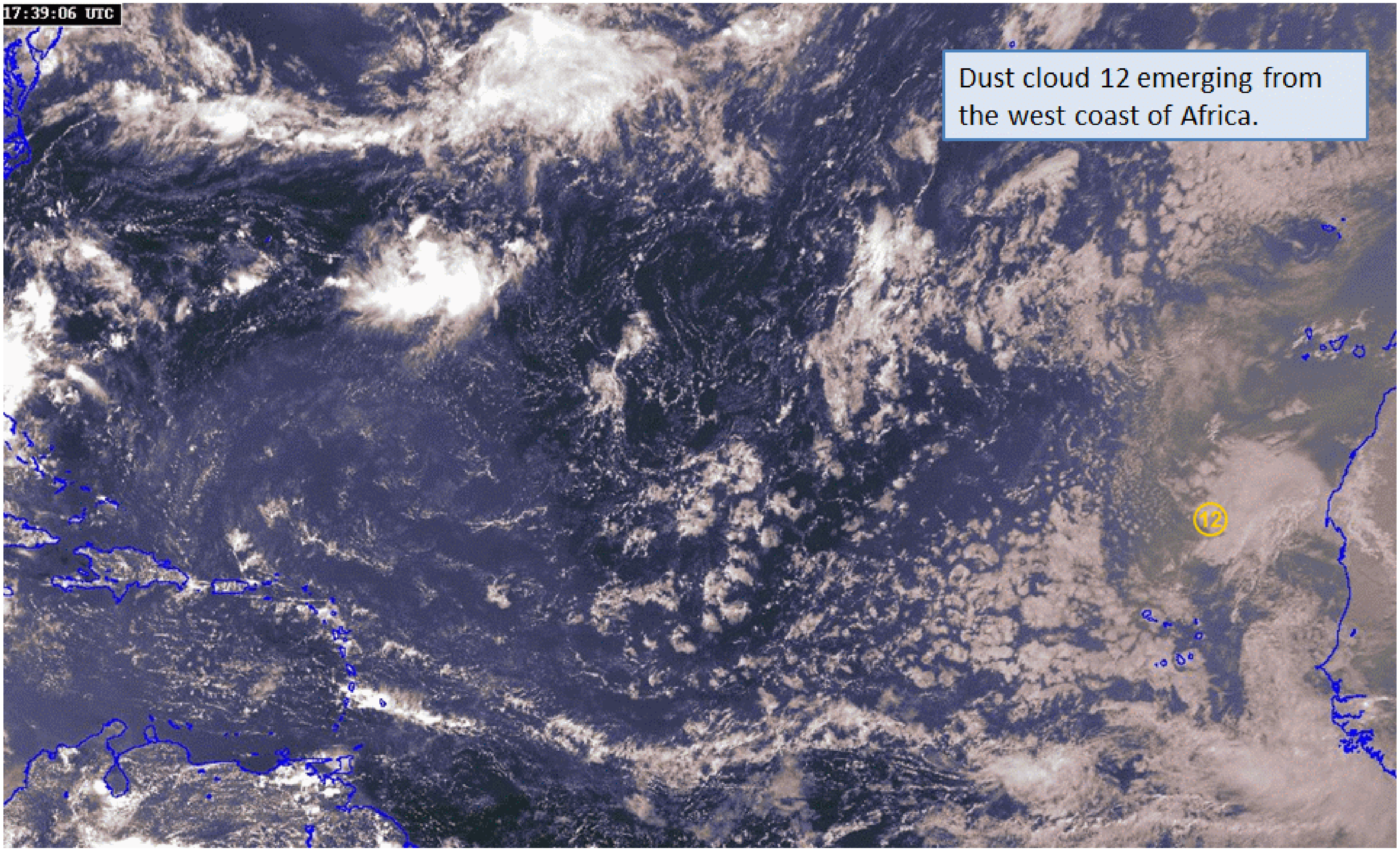


Figure C-5. Visible satellite image for 1739 UTC on July 15, 2012.

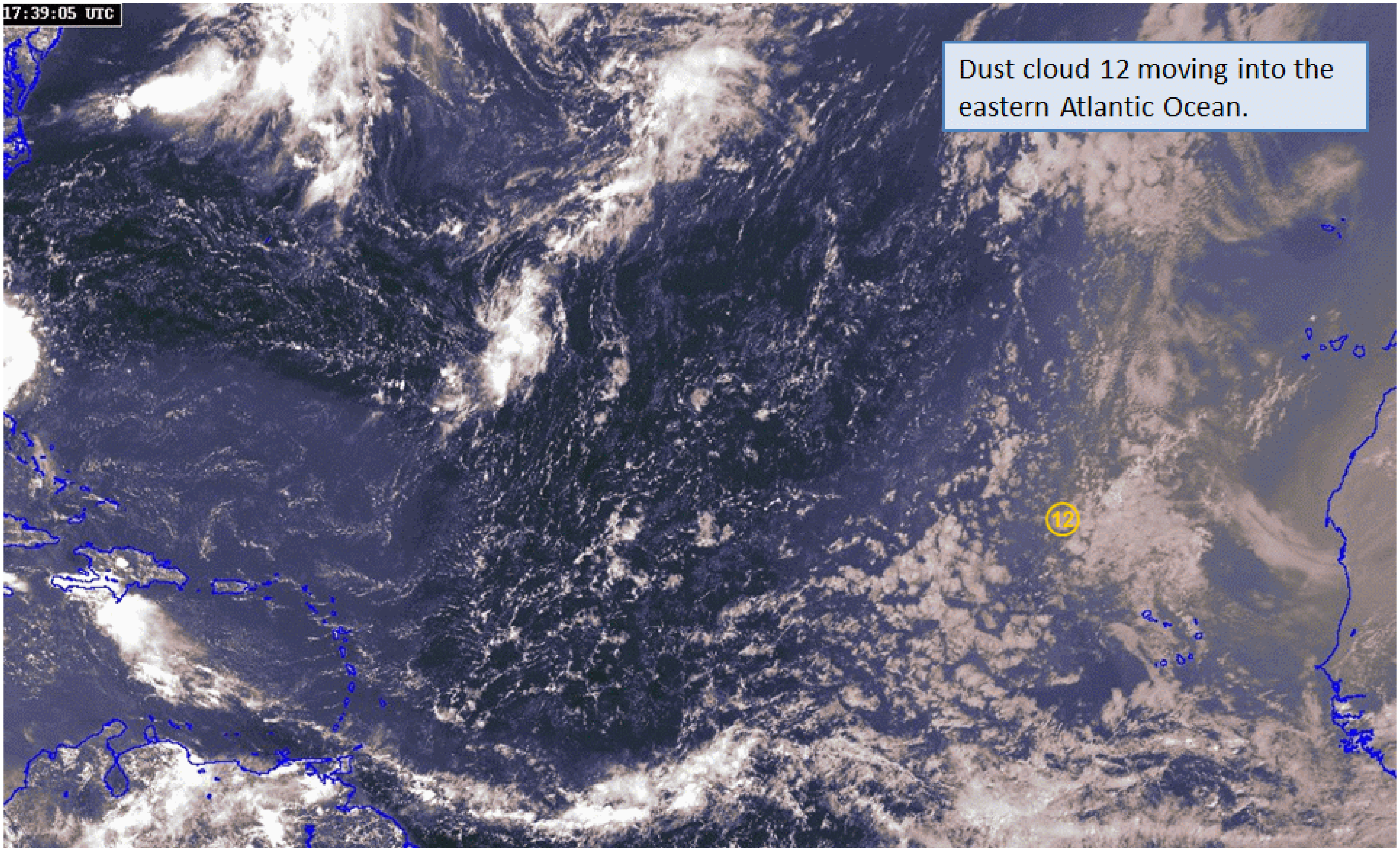


Figure C-6. Visible satellite image for 1739 UTC on July 16, 2012.

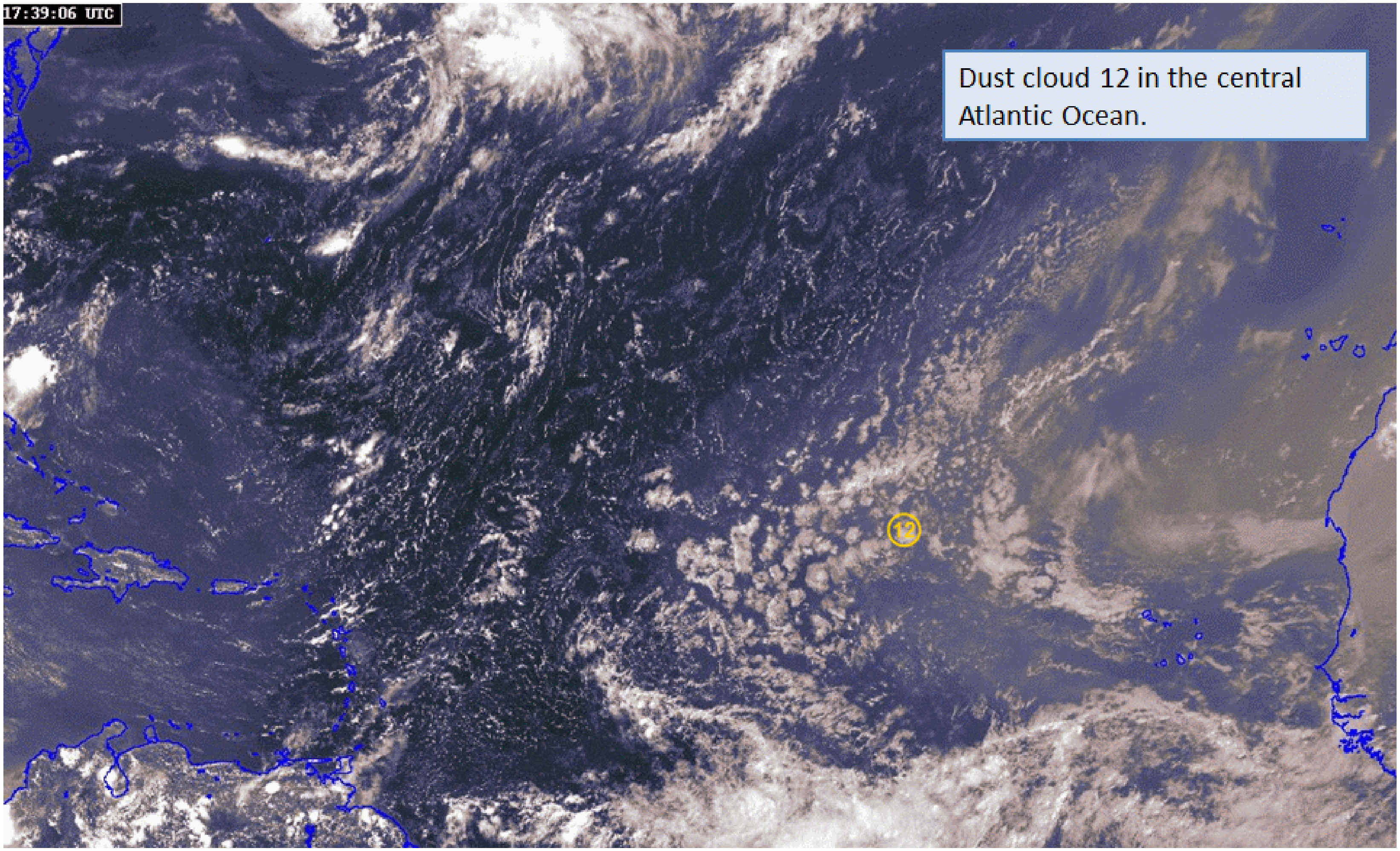


Figure C-7. Visible satellite image for 1739 UTC on July 17, 2012.

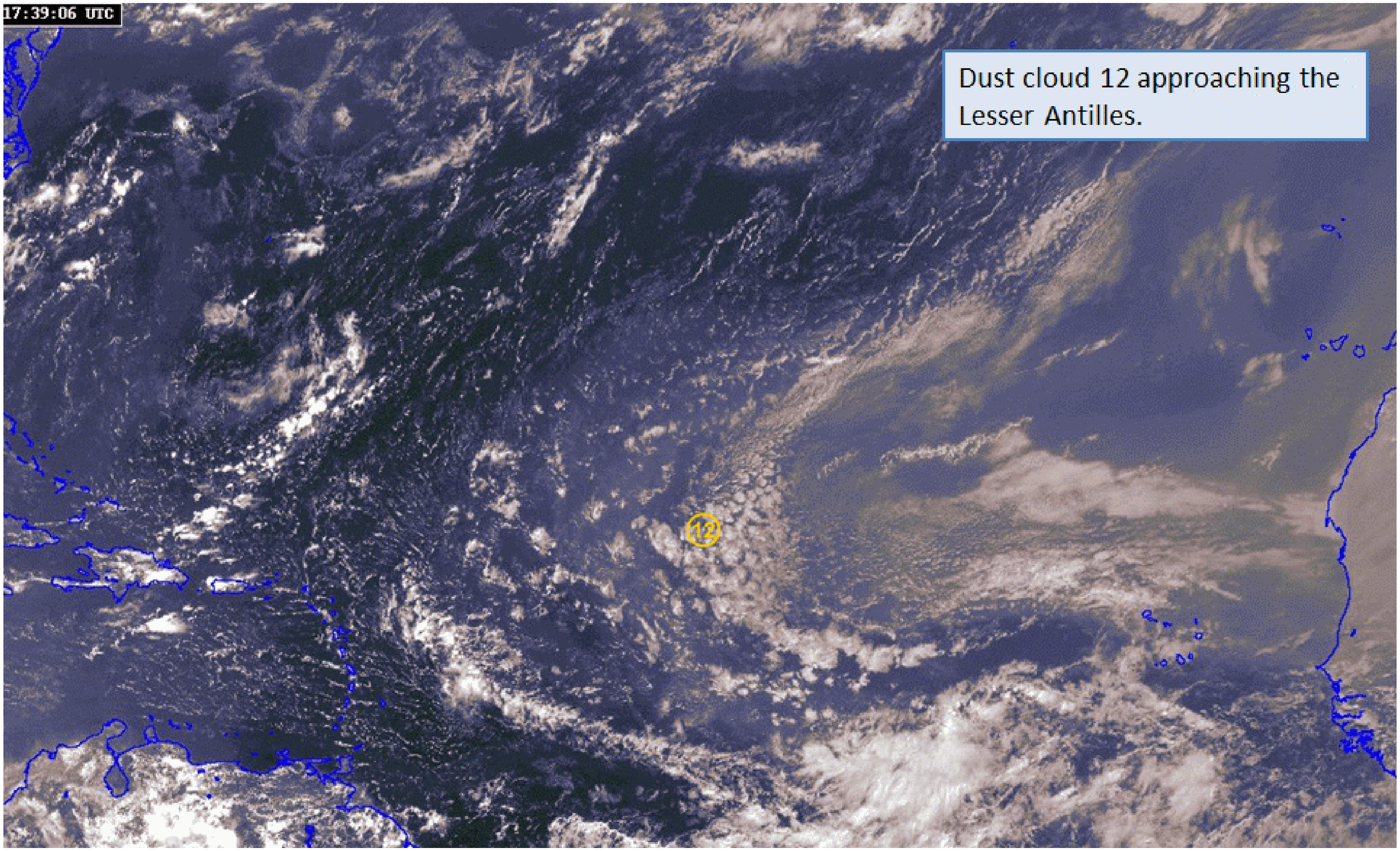


Figure C-8. Visible satellite image for 1739 UTC on July 18, 2012.

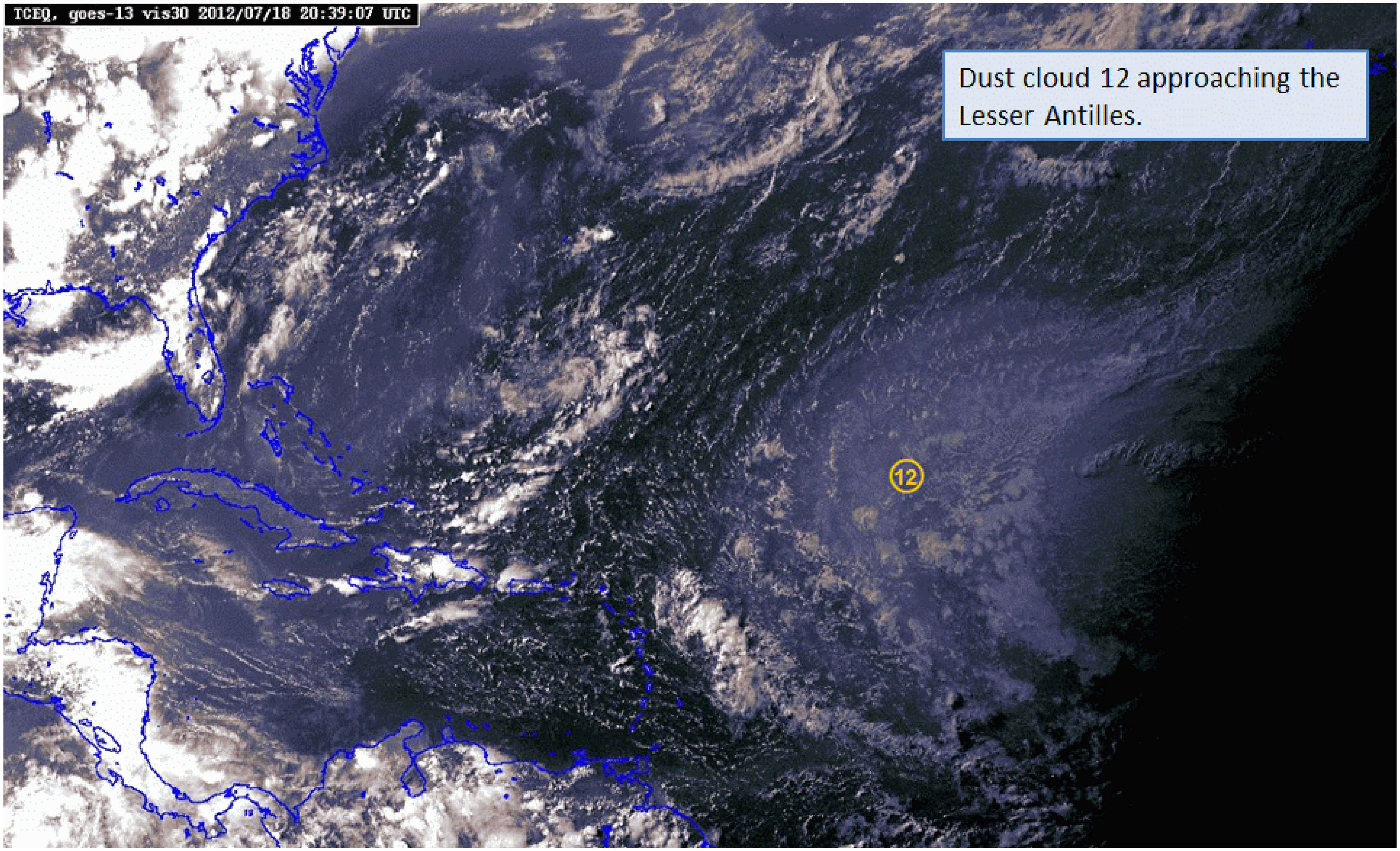


Figure C-9. Visible satellite image for 2039 UTC on July 18, 2012.

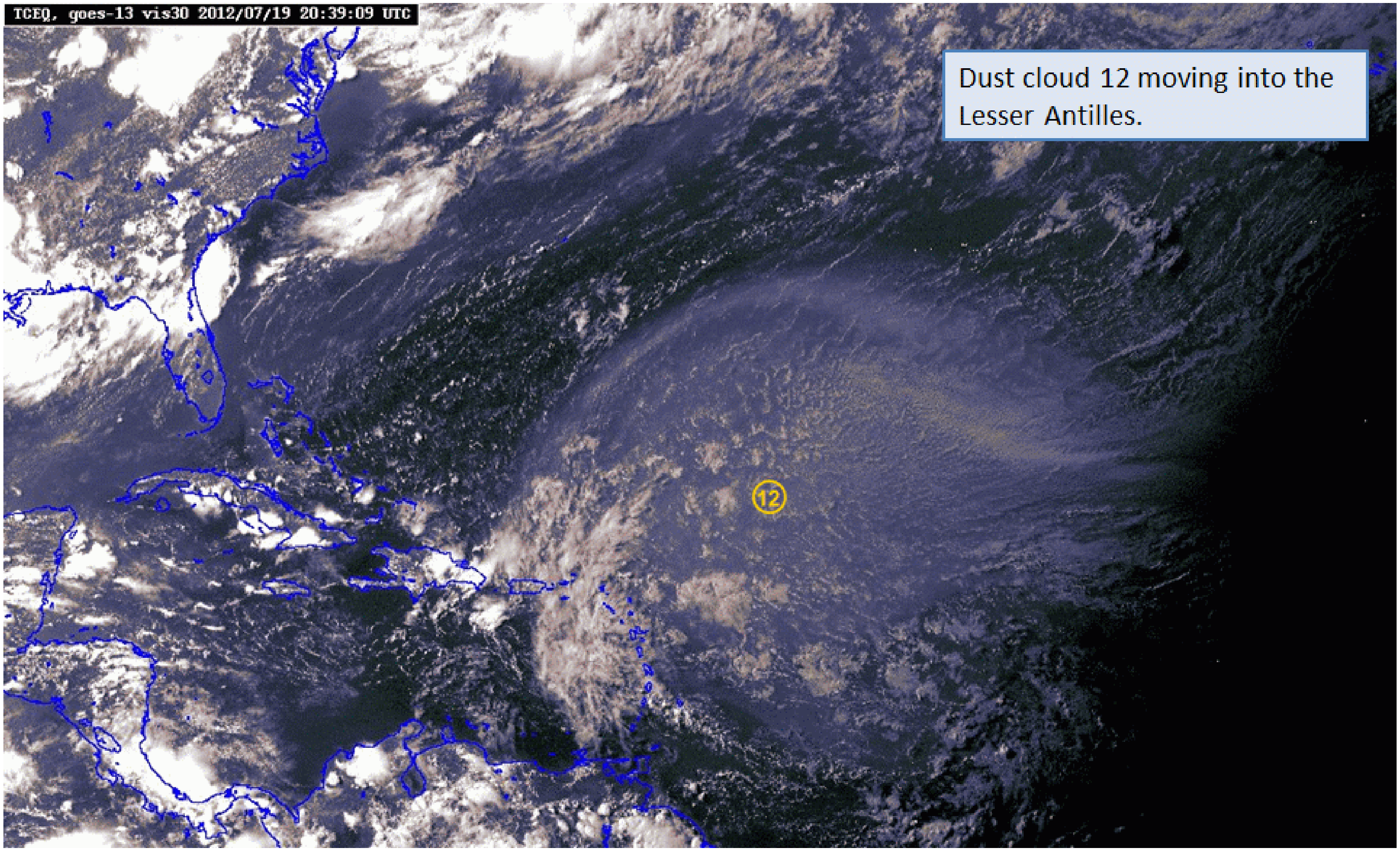


Figure C-10. Visible satellite image for 2039 UTC on July 19, 2012.

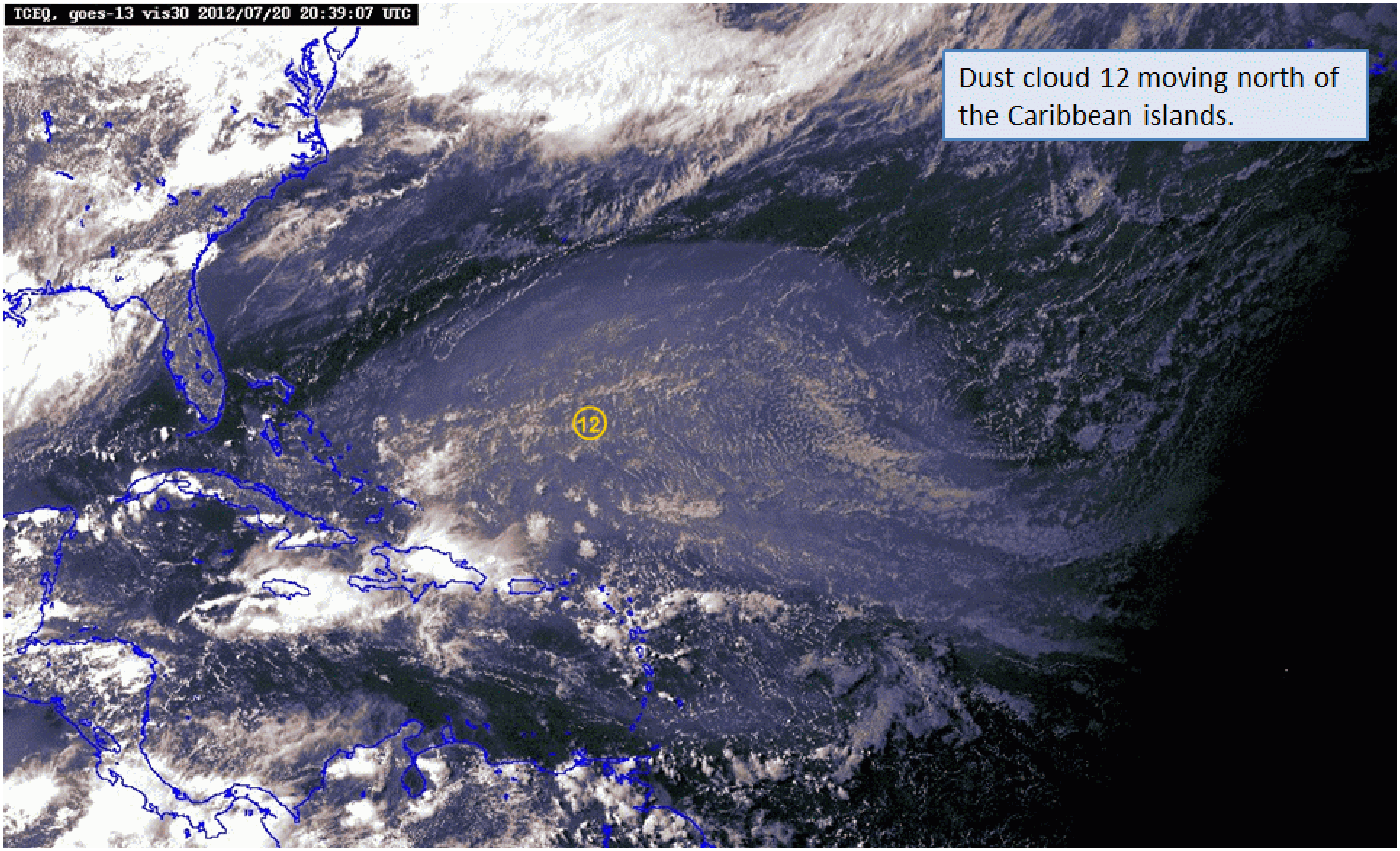


Figure C-11. Visible satellite image for 2039 UTC on July 20, 2012.

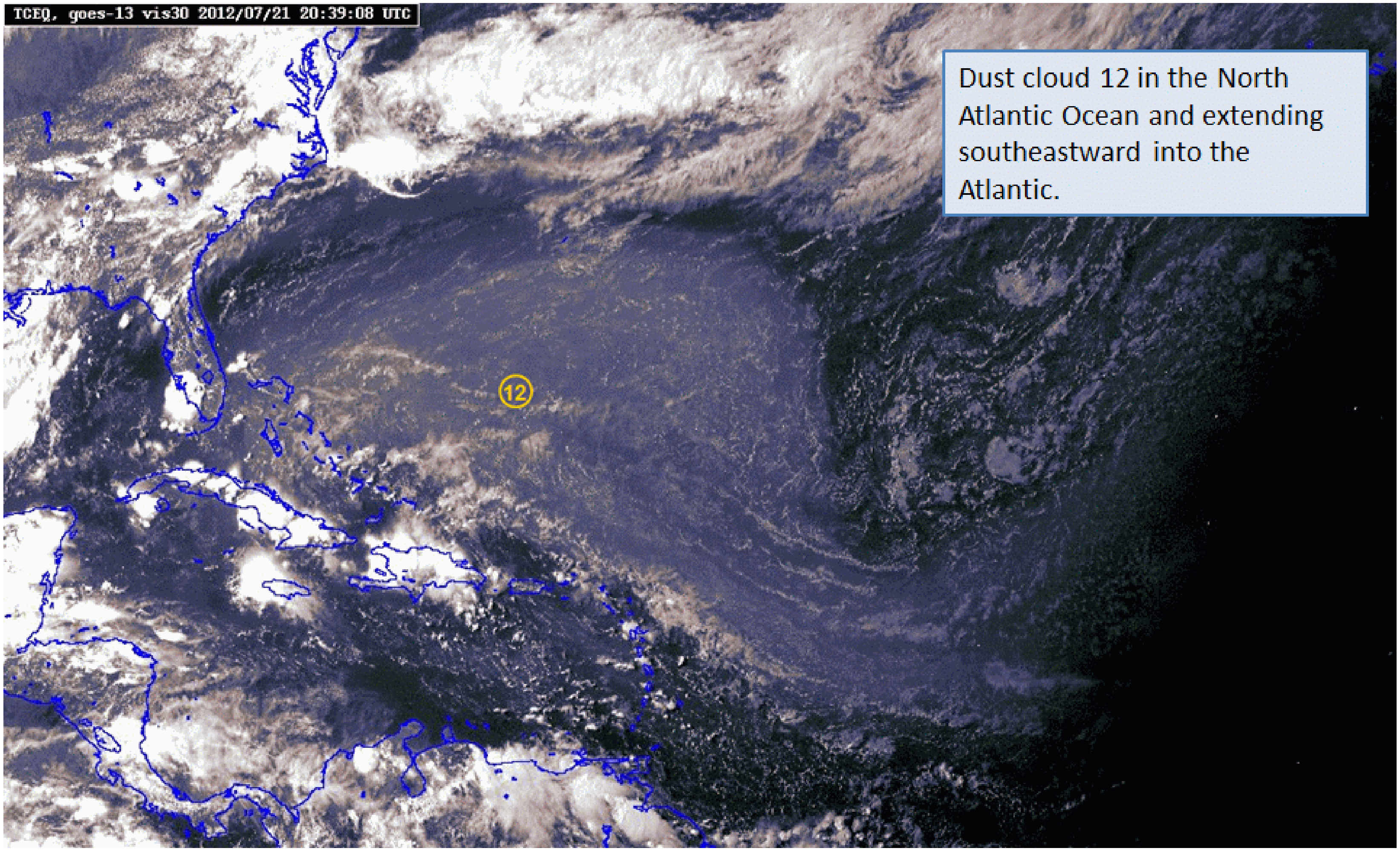


Figure C-12. Visible satellite image for 2039 UTC on July 21, 2012.

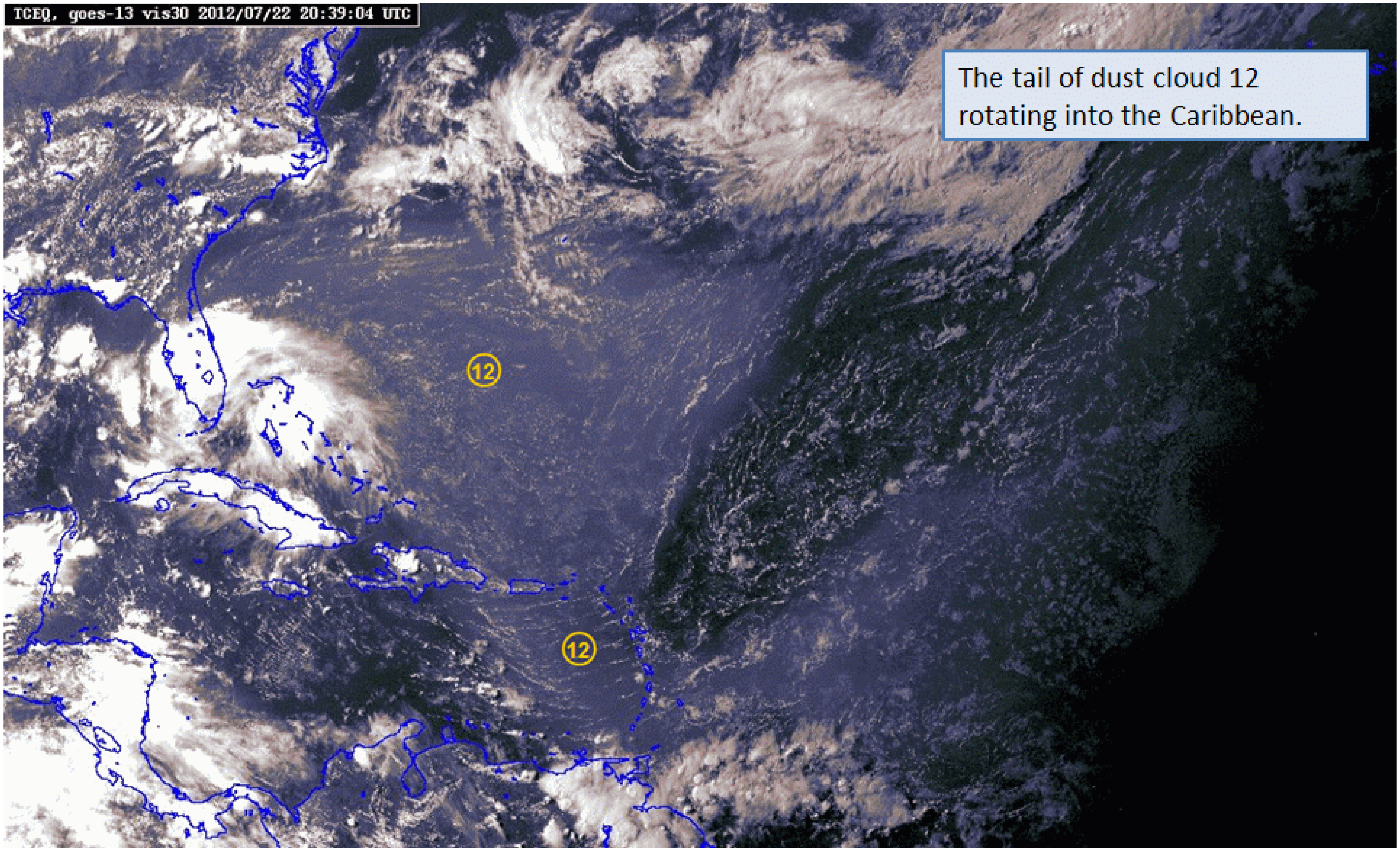


Figure C-13. Visible satellite image for 2039 UTC on July 22, 2012.

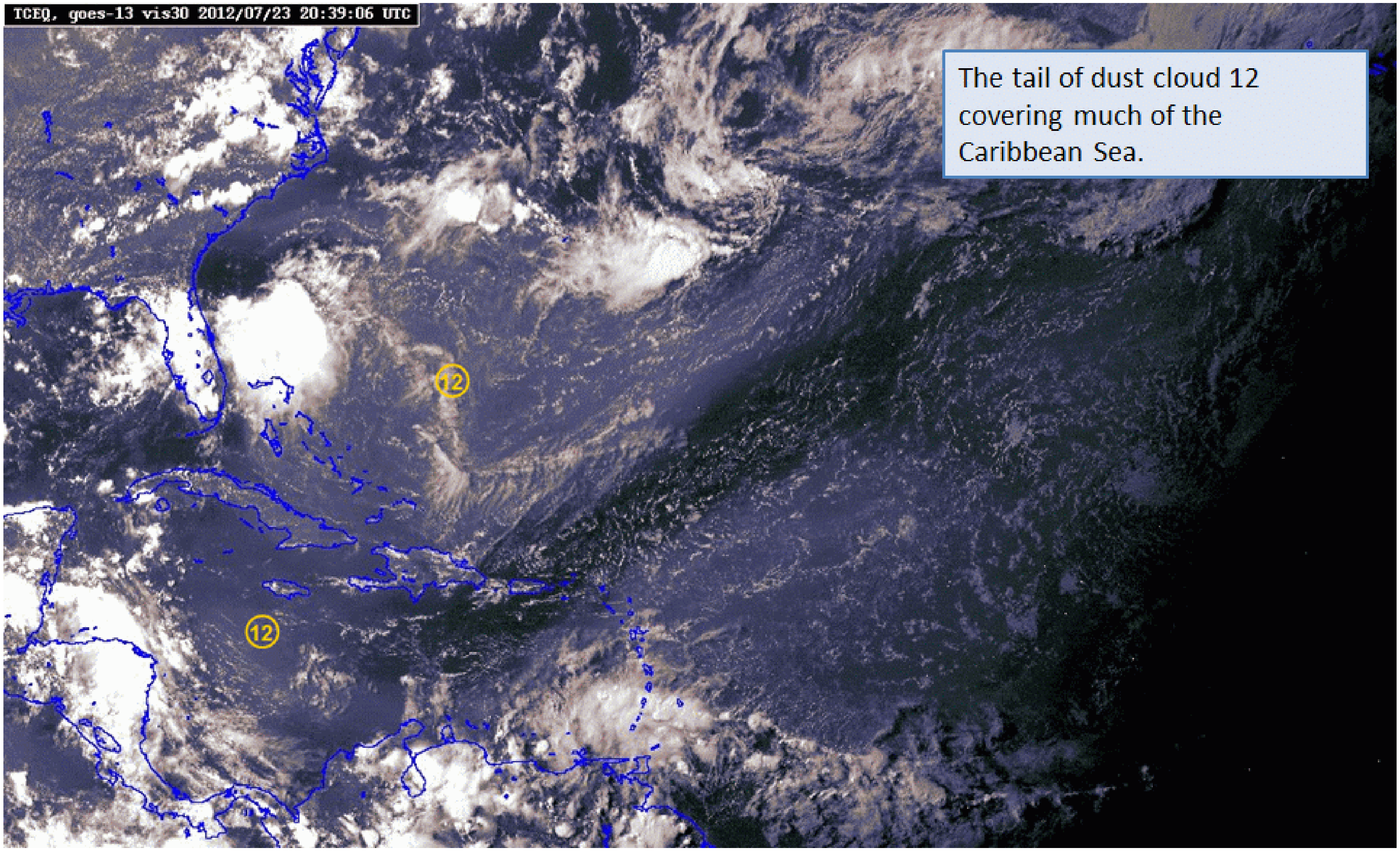


Figure C-14. Visible satellite image for 2039 UTC on July 23, 2012.

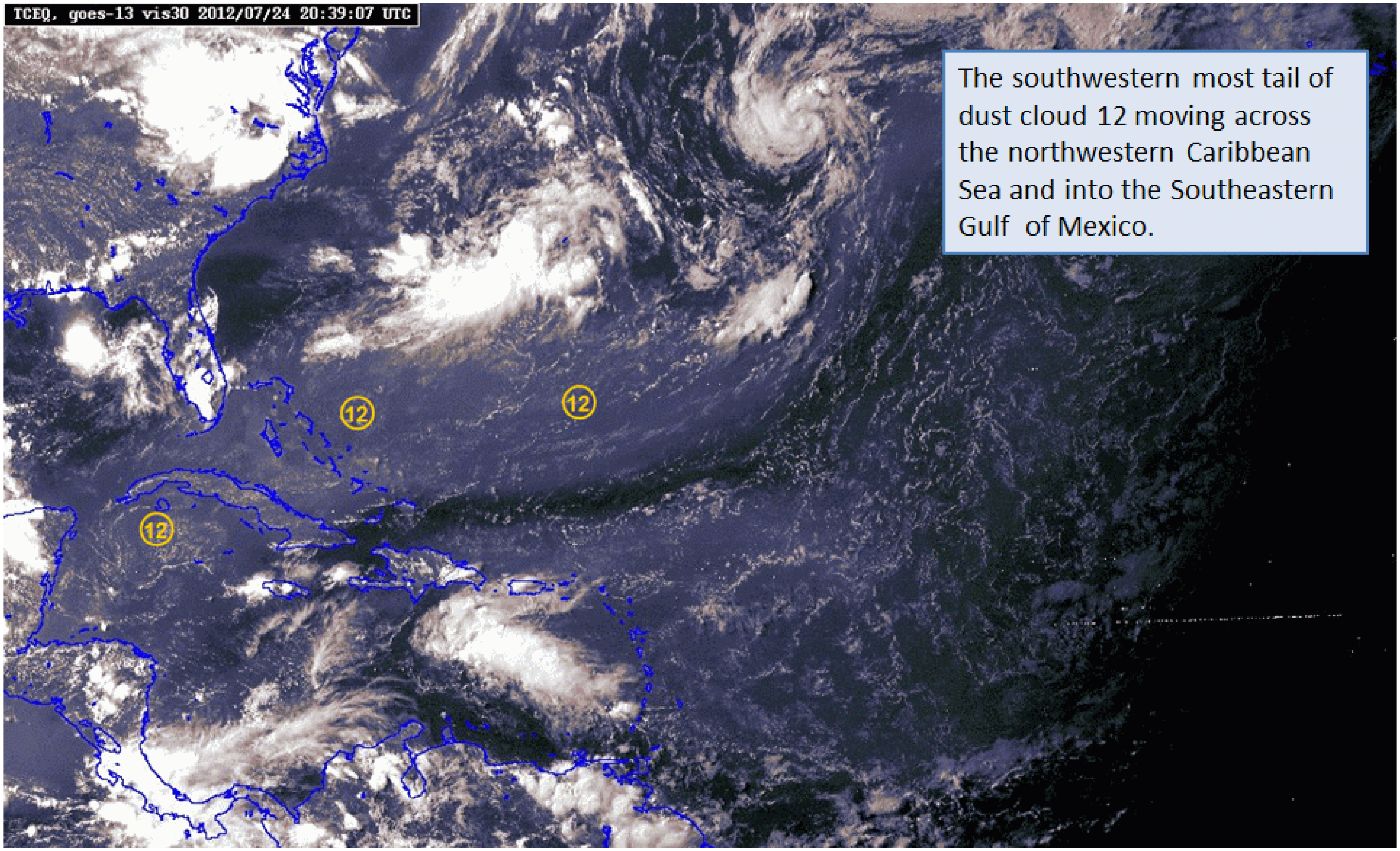


Figure C-15. Visible satellite image for 2039 UTC on July 24, 2012.

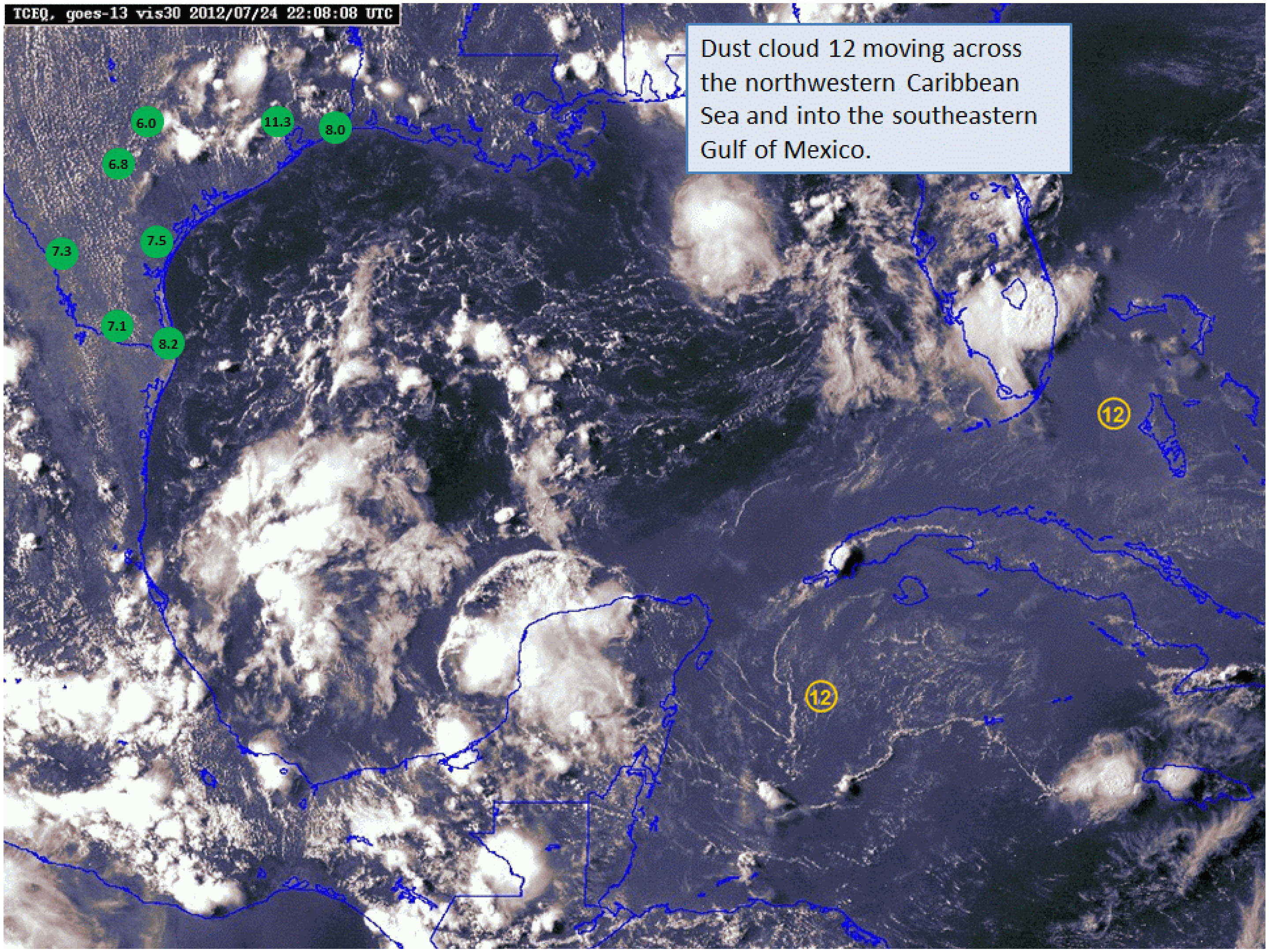


Figure C-16. Visible satellite image for 2208 UTC on July 24, 2012, including the highest area daily average $PM_{2.5}$ concentration ($\mu g/m^3$) for each area, which are indicated by a circle colored according to the EPA Air Quality Index.

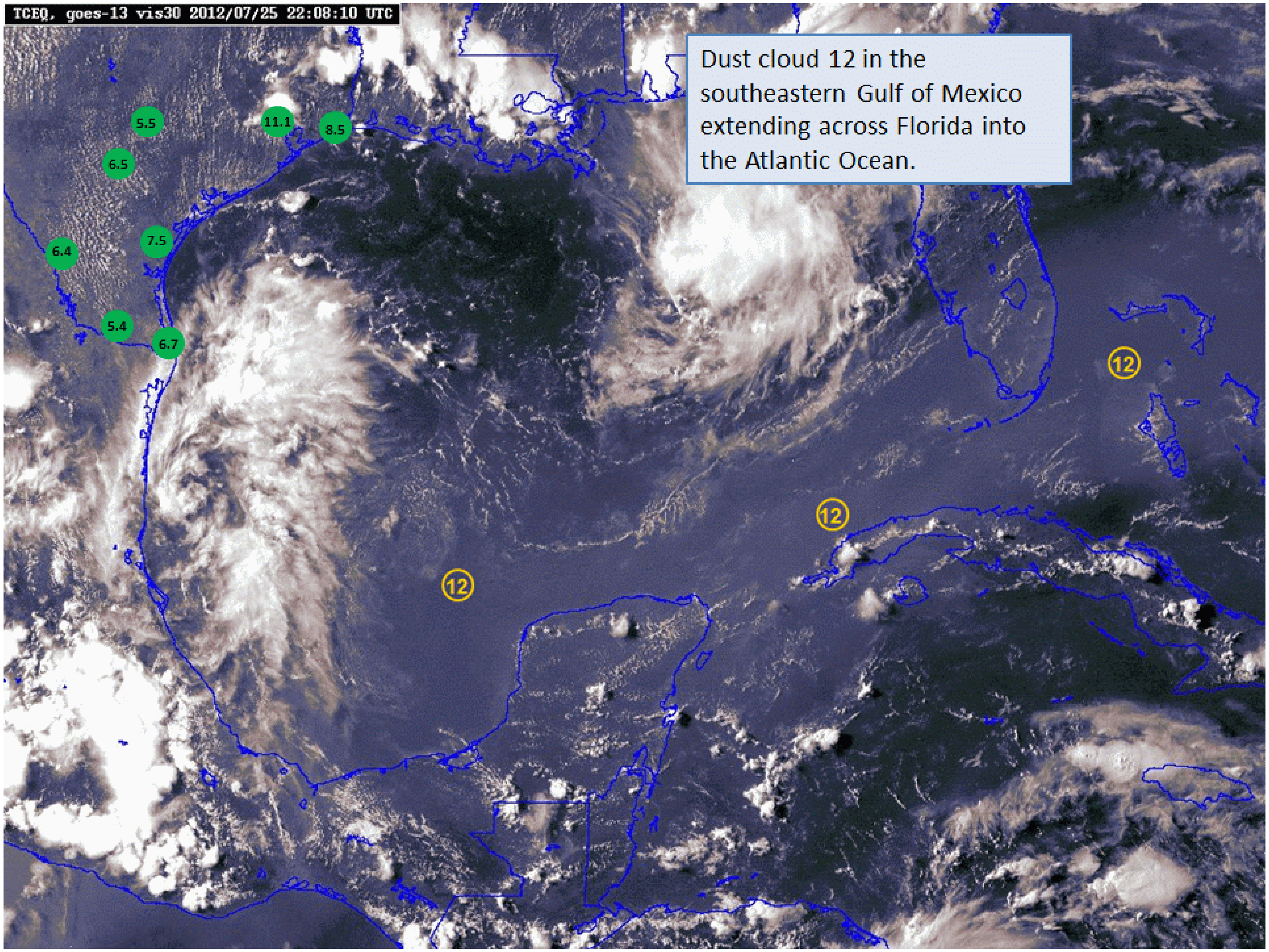


Figure C-17. Visible satellite image for 2208 UTC on July 25, 2012, including the highest area daily average $PM_{2.5}$ concentration ($\mu g/m^3$) for each area, which are indicated by a circle colored according to the EPA Air Quality Index.

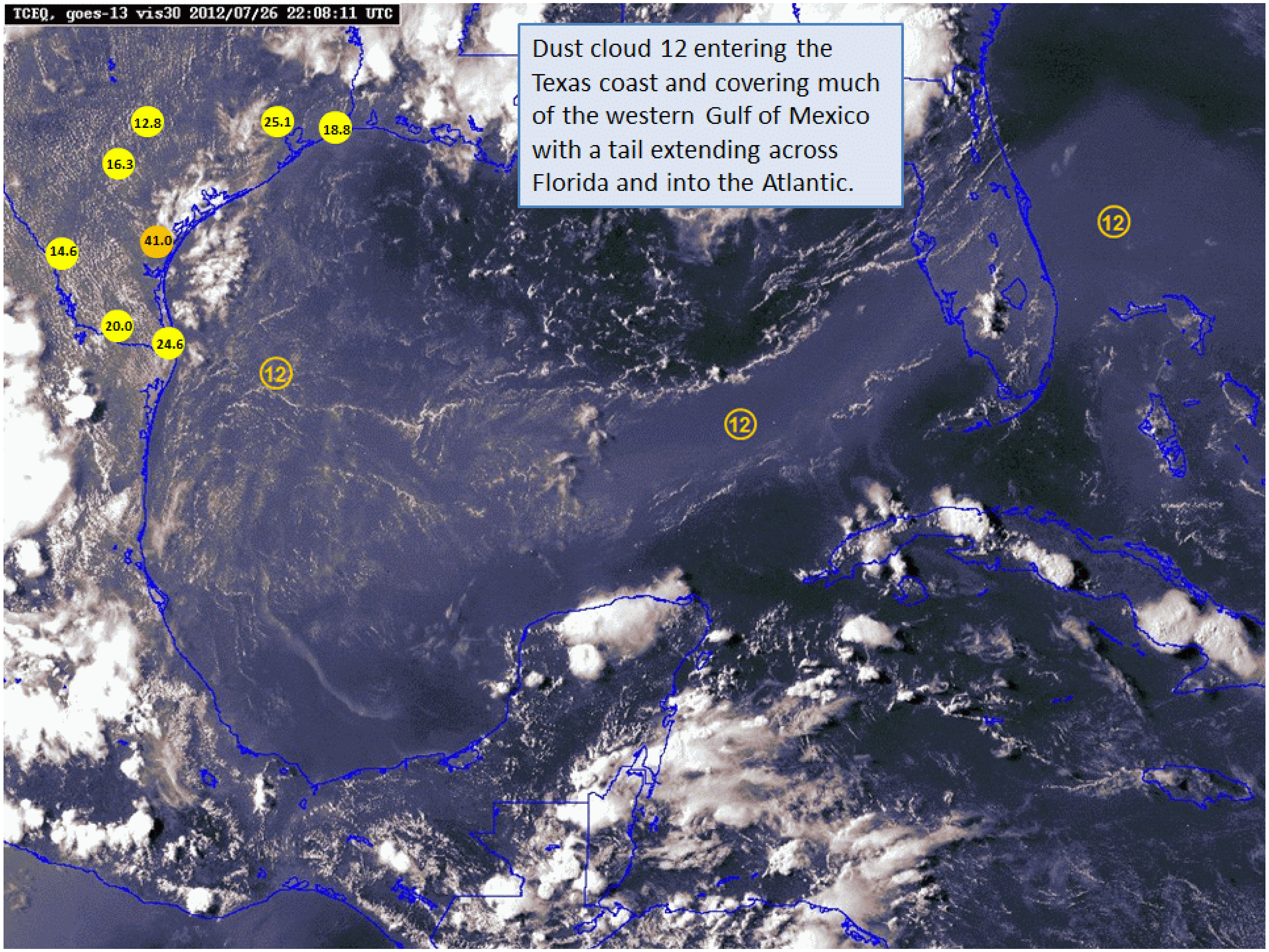


Figure C-18. Visible satellite image for 2208 UTC on July 26, 2012, including the highest area daily average $PM_{2.5}$ concentration ($\mu g/m^3$) for each area, which are indicated by a circle colored according to the EPA Air Quality Index.

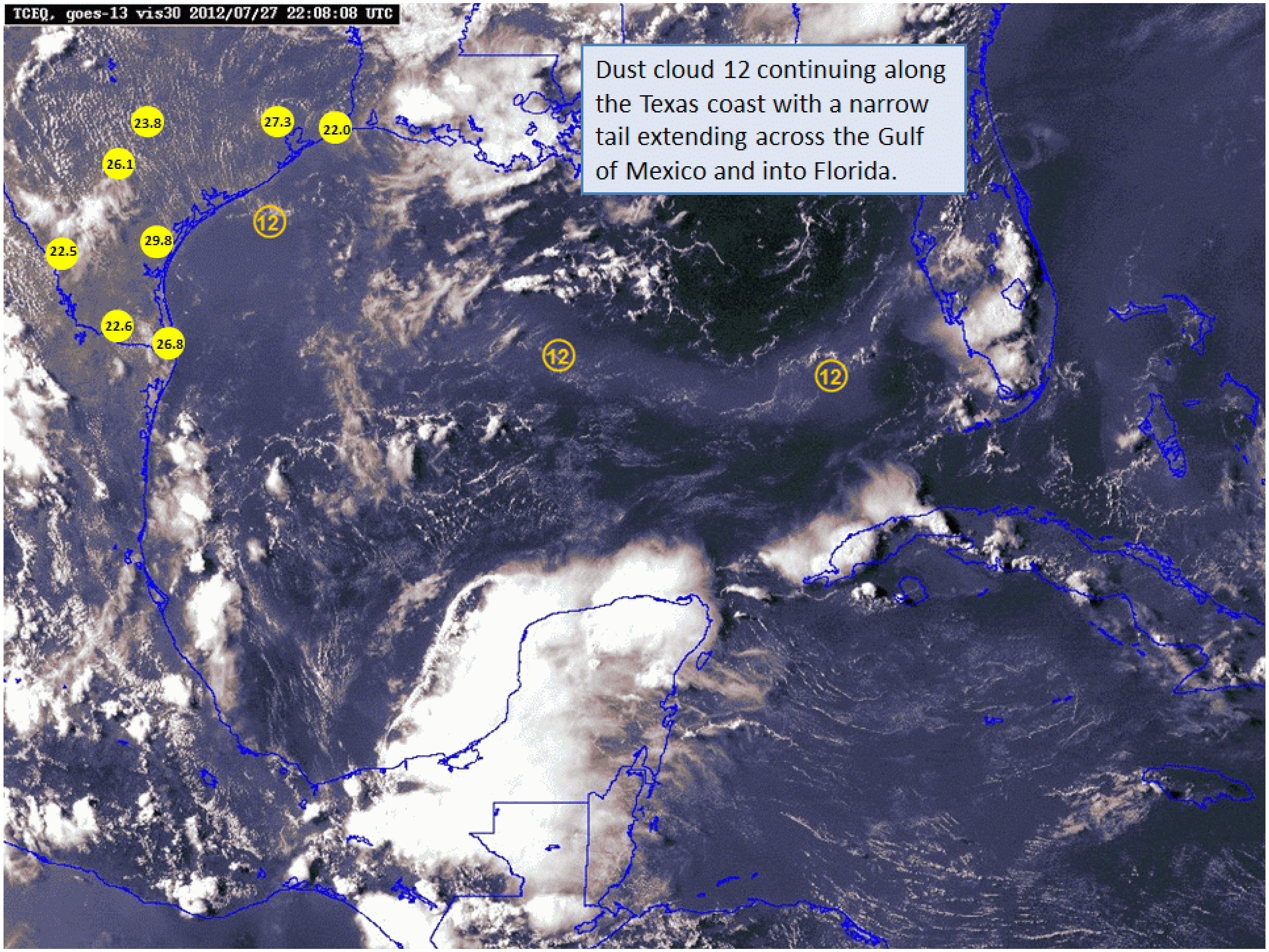


Figure C-19. Visible satellite image for 2208 UTC on July 27, 2012, including the highest area daily average $PM_{2.5}$ concentration ($\mu g/m^3$) for each area, which are indicated by a circle colored according to the EPA Air Quality Index.

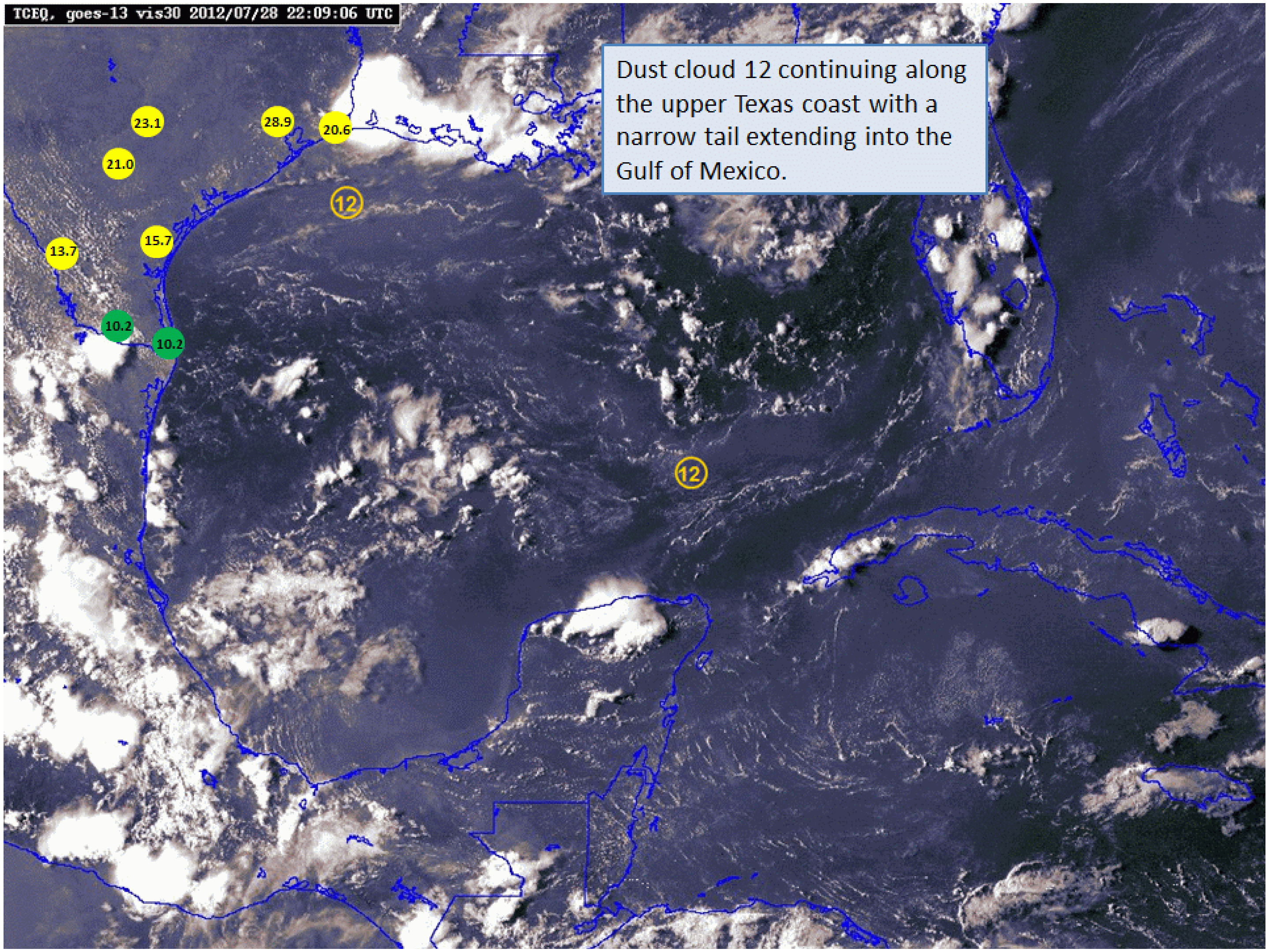


Figure C-20. Visible satellite image for 2209 UTC on July 28, 2012, including the highest area daily average $PM_{2.5}$ concentration ($\mu g/m^3$) for each area, which are indicated by a circle colored according to the EPA Air Quality Index.

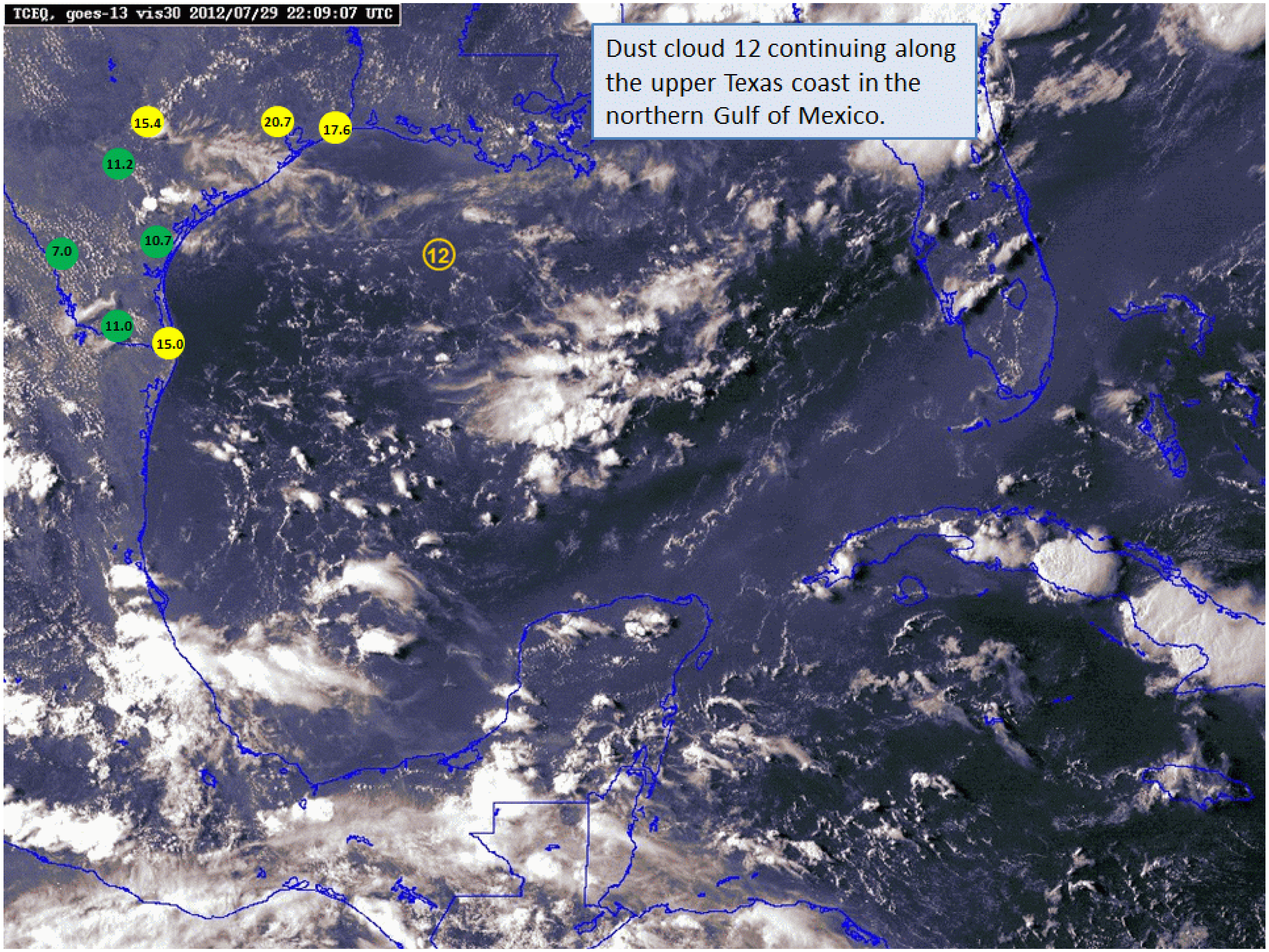


Figure C-21. Visible satellite image for 2209 UTC on July 29, 2012, including the highest area daily average $PM_{2.5}$ concentration ($\mu g/m^3$) for each area, which are indicated by a circle colored according to the EPA Air Quality Index.

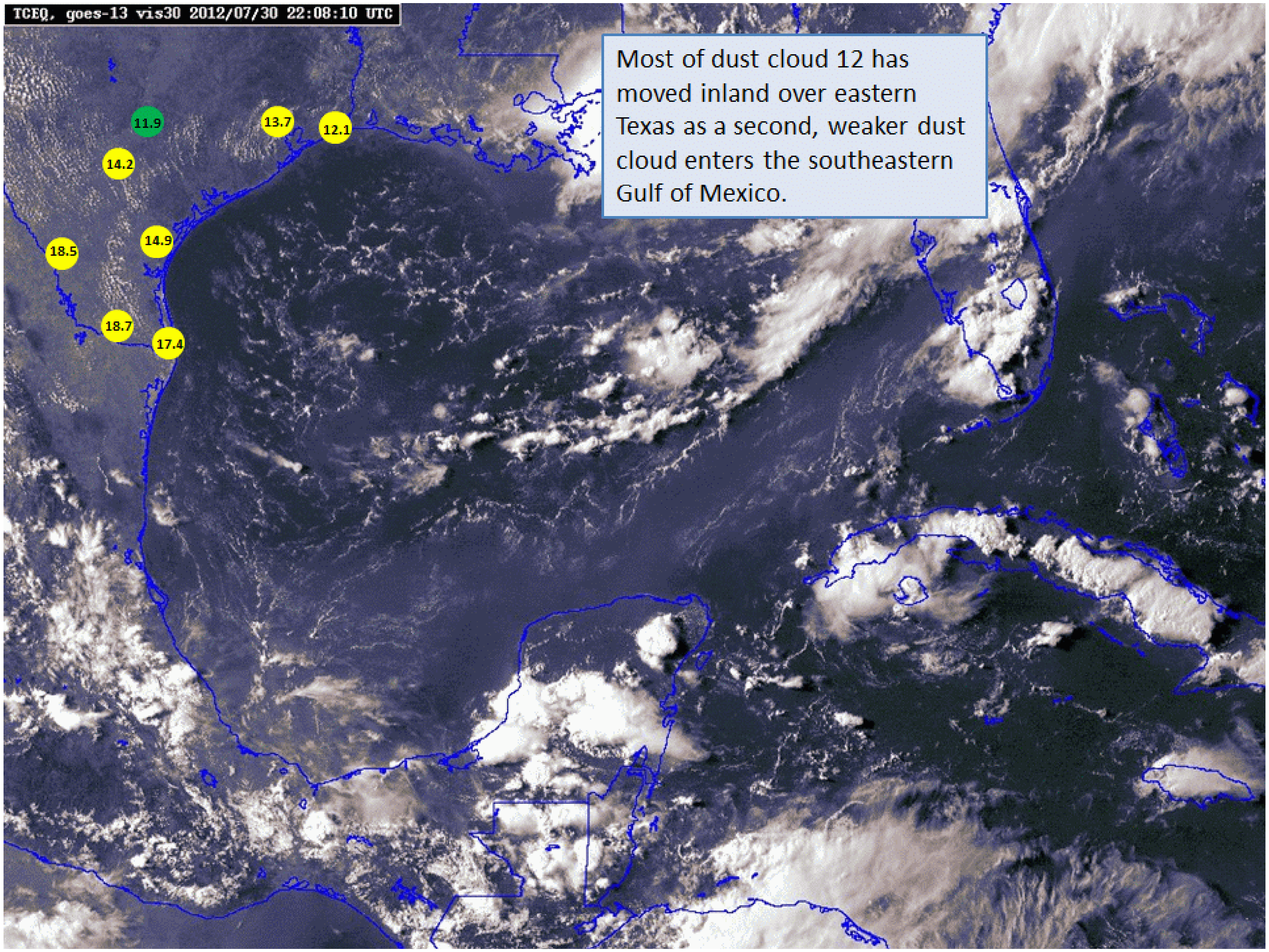


Figure C-22. Visible satellite image for 2208 UTC on July 30, 2012, including the highest area daily average $PM_{2.5}$ concentration ($\mu g/m^3$) for each area, which are indicated by a circle colored according to the EPA Air Quality Index.

Aerosol Analyses

Figures C-23 through C-36 provide aerosol analyses from the Naval Research Laboratory (NRL) showing the African dust cloud that arrived in the Houston area on July 27, 2012 as it progressed across the Atlantic, Caribbean Sea, and Gulf of Mexico. The satellite derived optical depth from dust is shown in shades of green and yellow in the upper left panel of each figure and the model derived surface dust concentration is shown in the lower left panel. Since this is a model, it cannot be expected to provide precise indications of dust but should show the general pattern. The same numbering system used to identify the dust cloud on the previous satellite imagery is used in these figures for comparison. These aerosol analyses corroborate well with the satellite imagery and back trajectories shown previously.

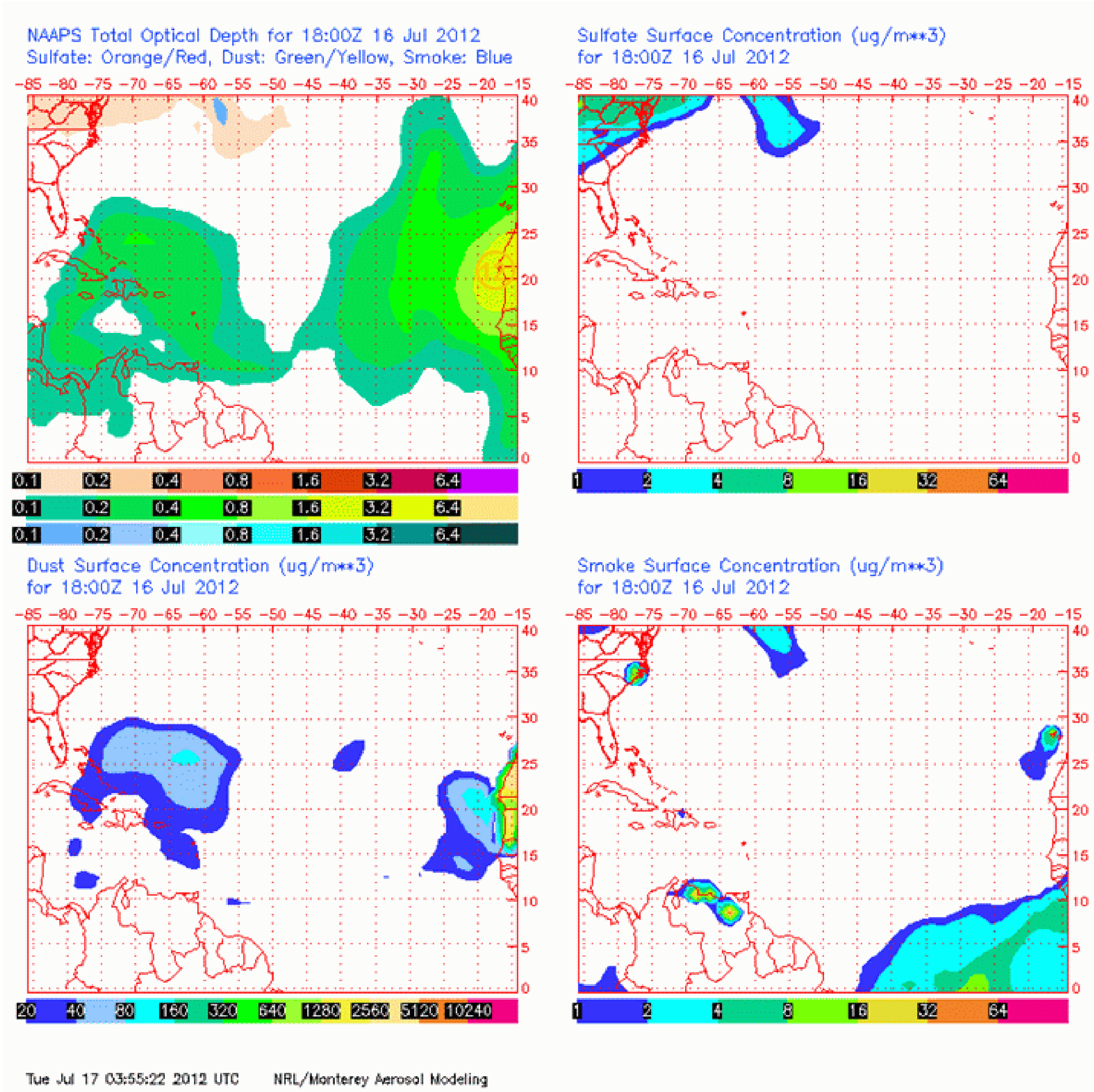


Figure C-23. NRL aerosol analysis for 1800 UTC on July 16, 2012, showing the African dust cloud emerging from the African coast.

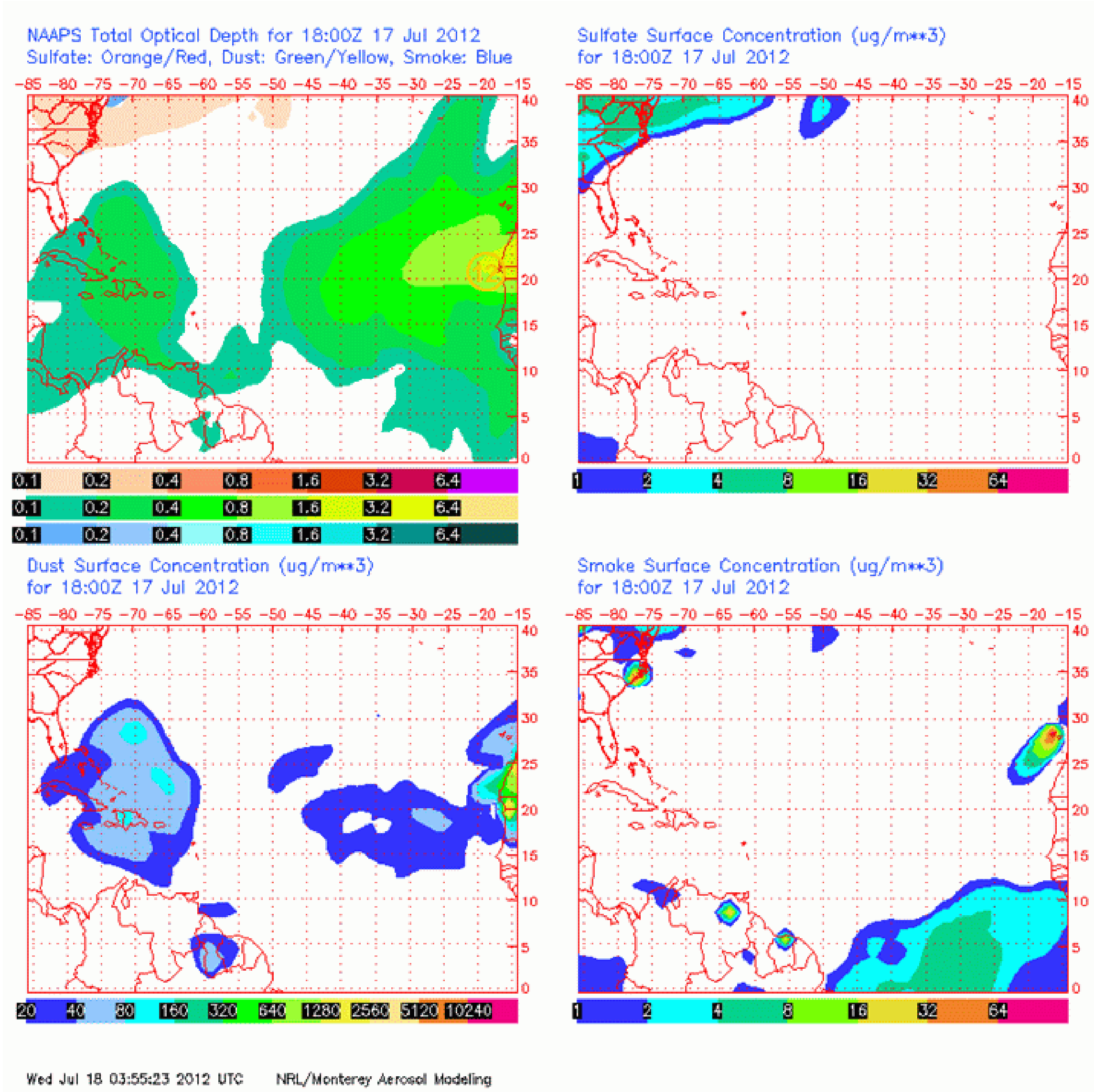


Figure C-24. NRL aerosol analysis for 1800 UTC on July 17, 2012, showing the African dust cloud moving into the eastern Atlantic Ocean.

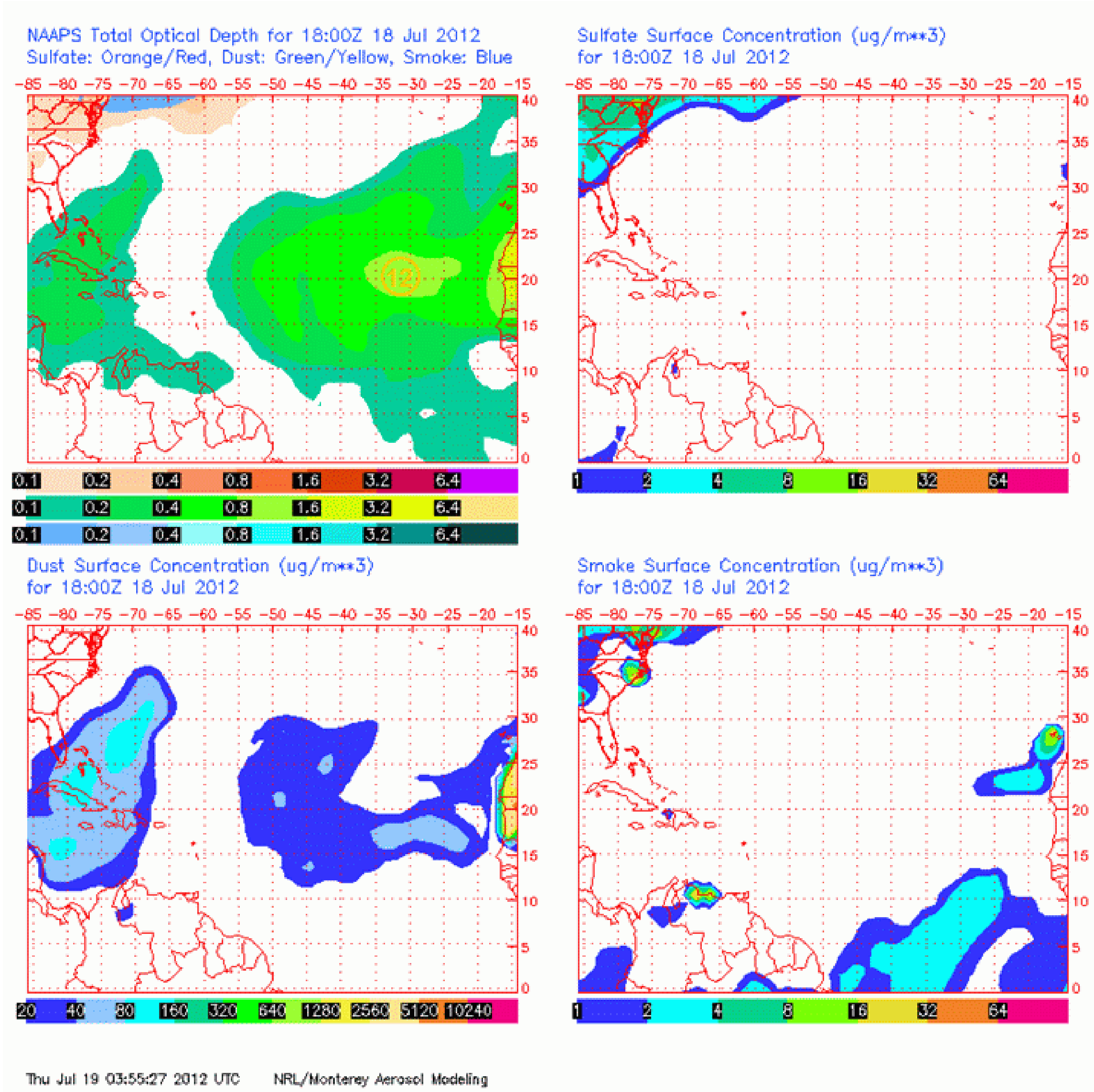


Figure C-25. NRL aerosol analysis for 1800 UTC on July 18, 2012, showing the African dust cloud moving into the eastern Atlantic Ocean.

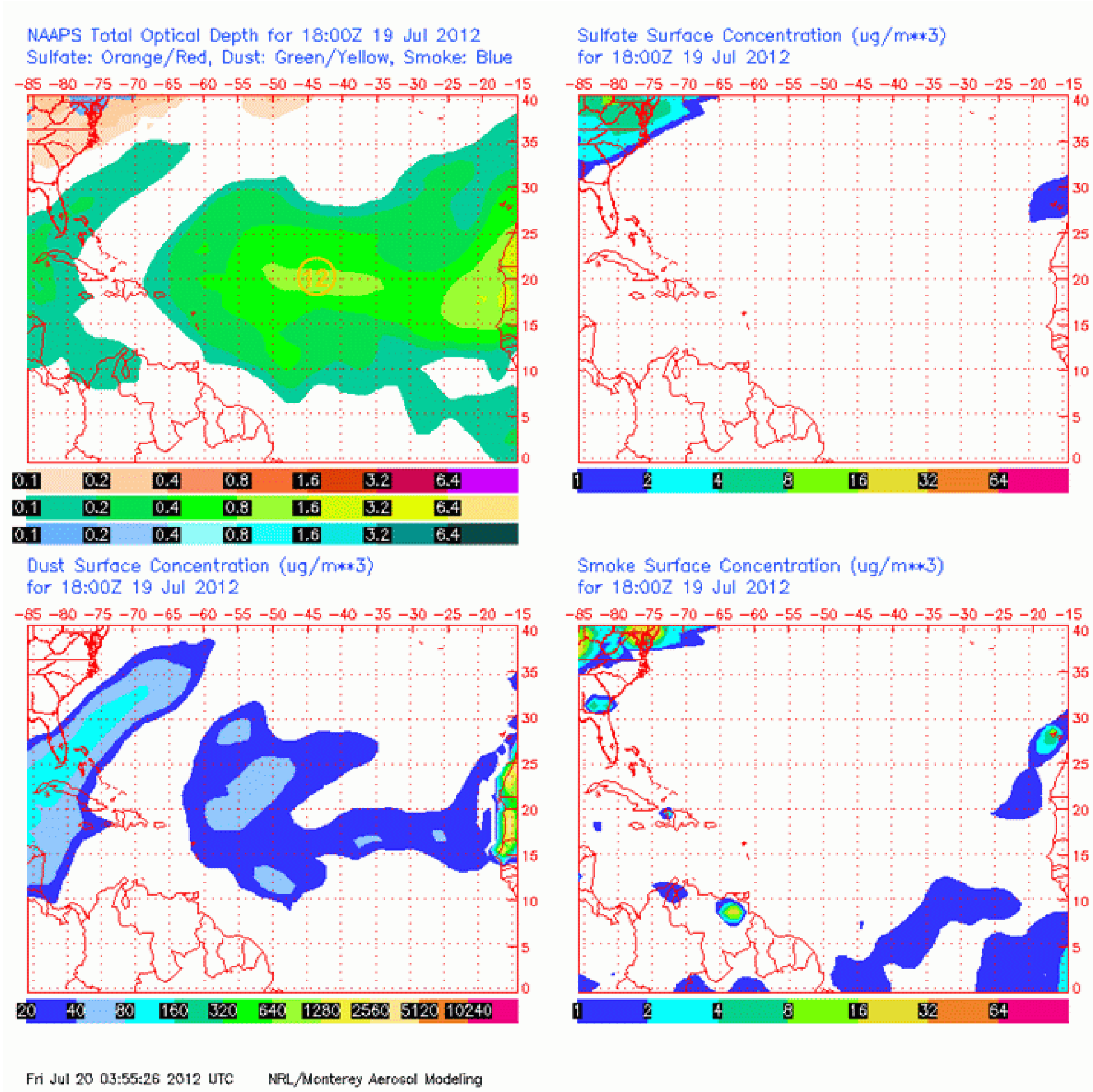


Figure C-26. NRL aerosol analysis for 1800 UTC on July 19, 2012, showing the African dust cloud moving into the central Atlantic Ocean.

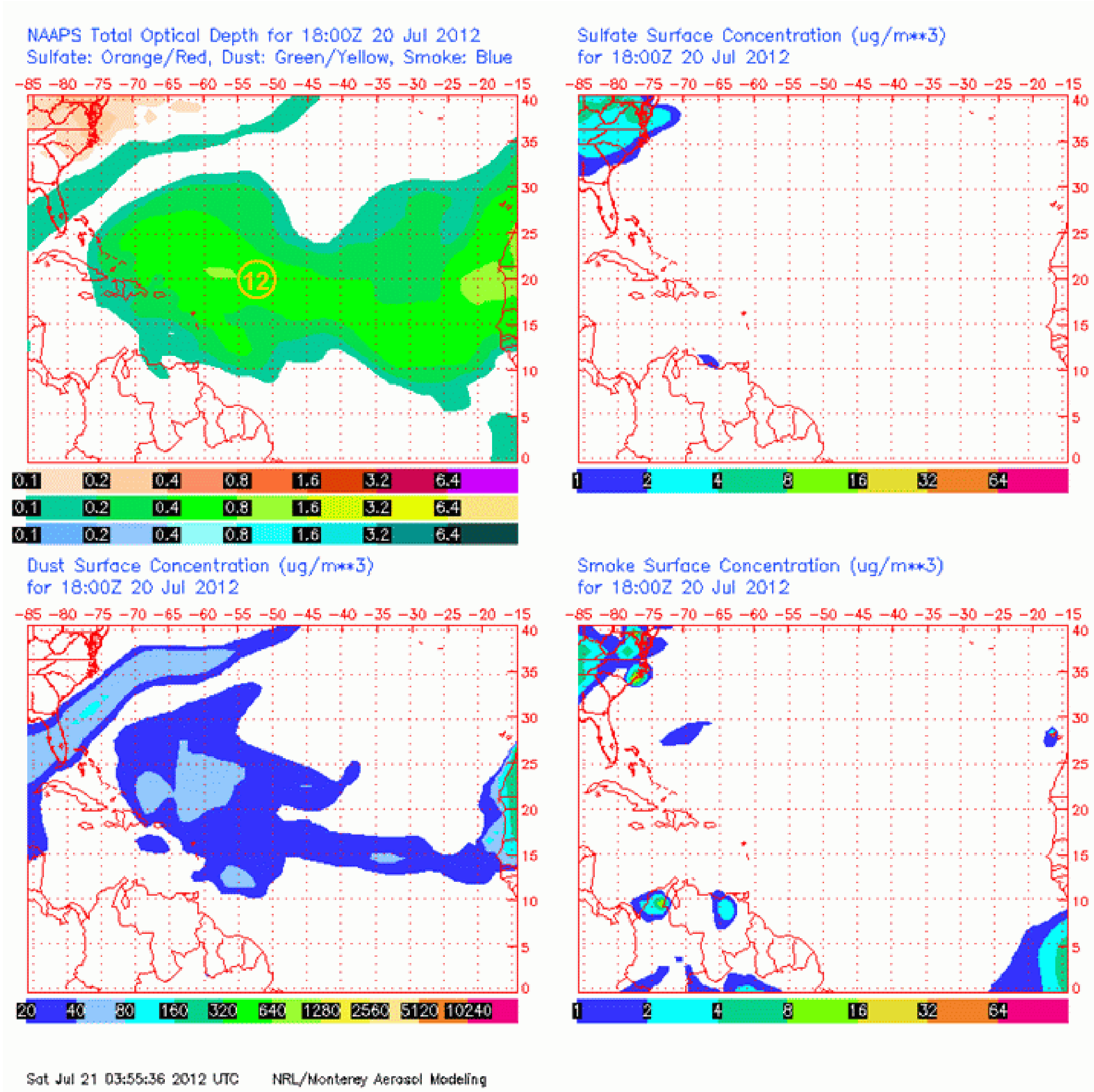


Figure C-27. NRL aerosol analysis for 1800 UTC on July 20, 2012, showing the African dust cloud approaching the Lesser Antilles.

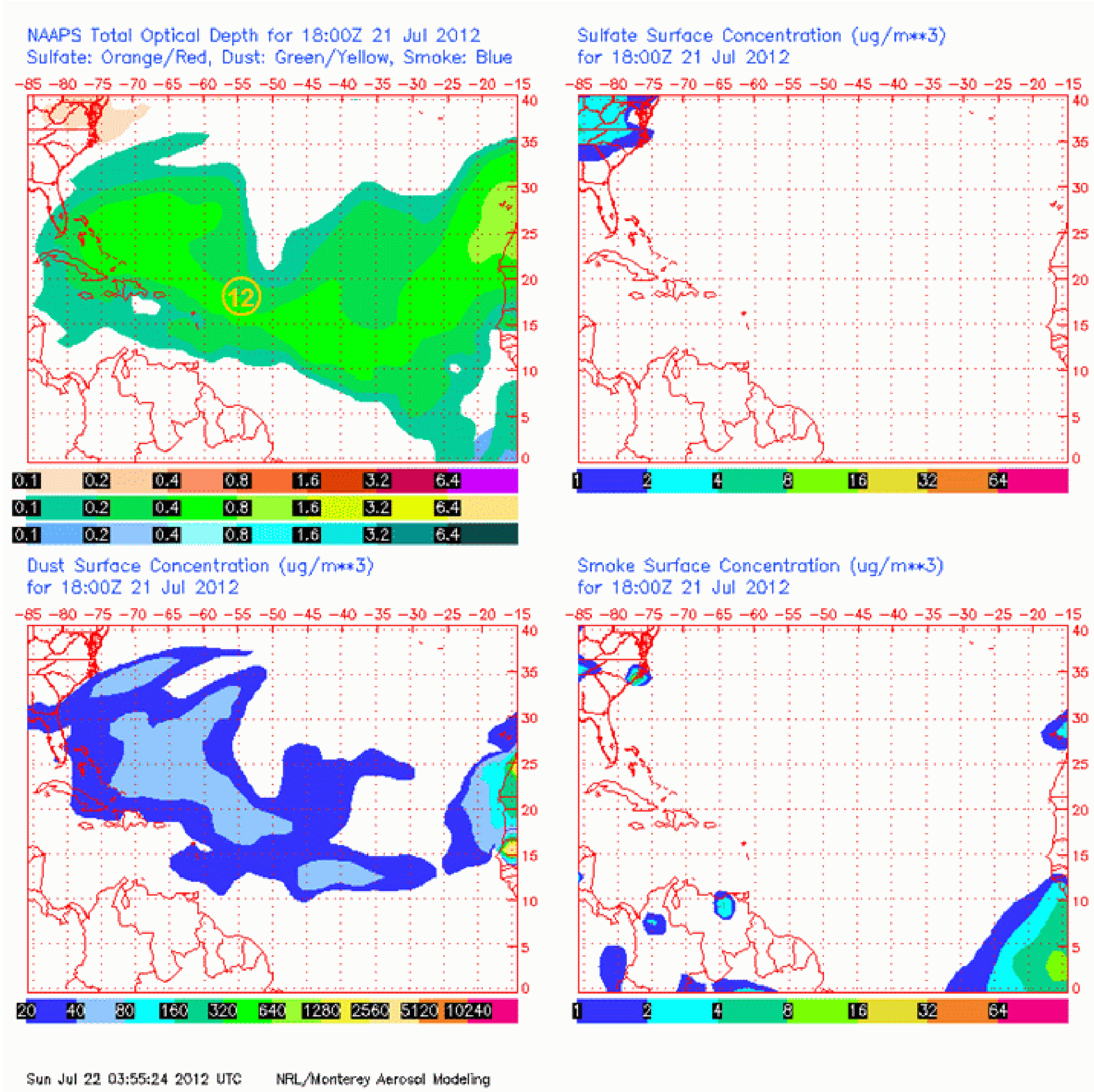


Figure C-28. NRL aerosol analysis for 1800 UTC on July 21, 2012, showing the African dust cloud moving north of the Caribbean islands.

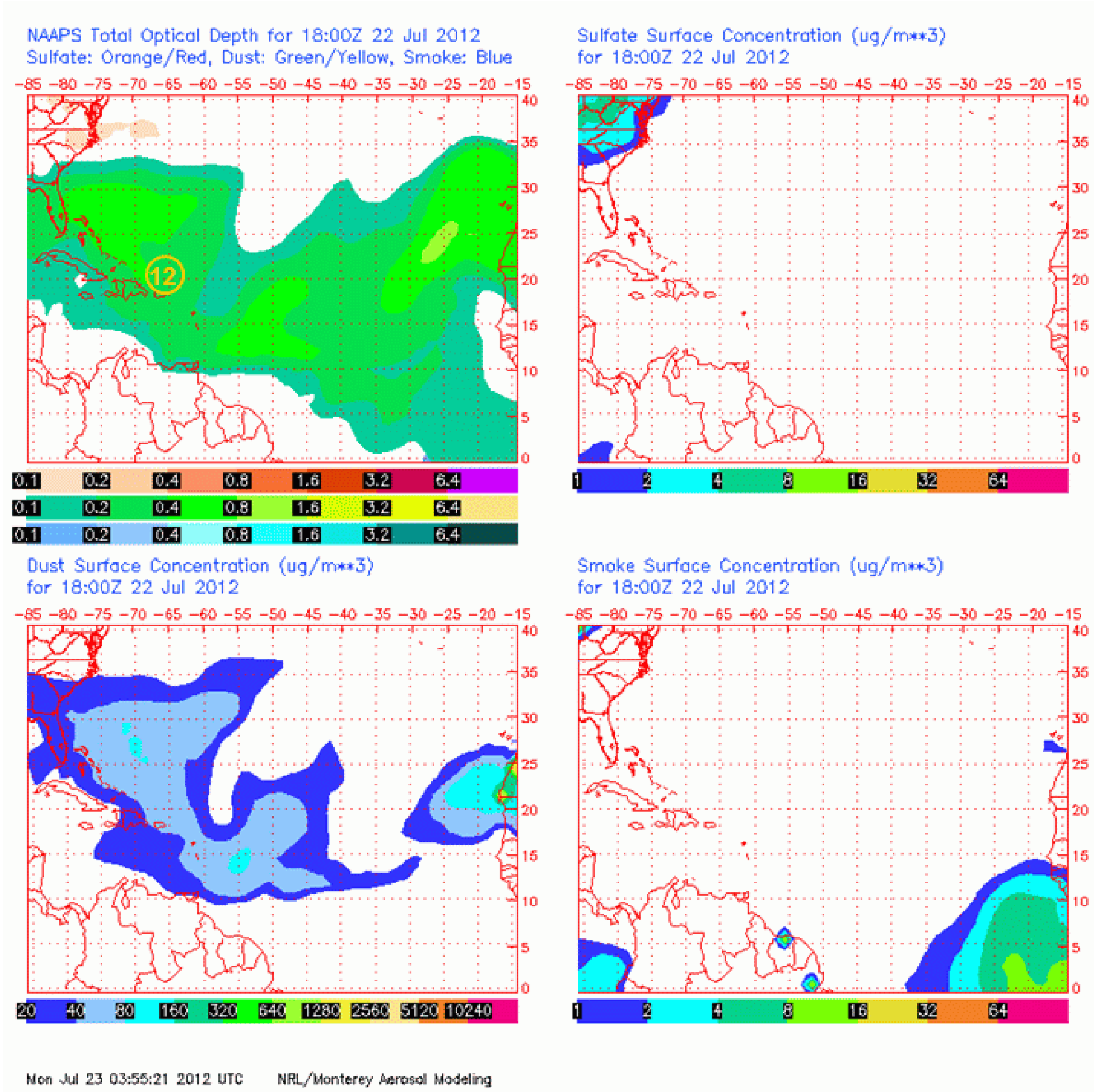


Figure C-29. NRL aerosol analysis for 1800 UTC on July 22, 2012, showing the African dust cloud moving north of the Caribbean islands with the tail end rotating into the Lesser Antilles.

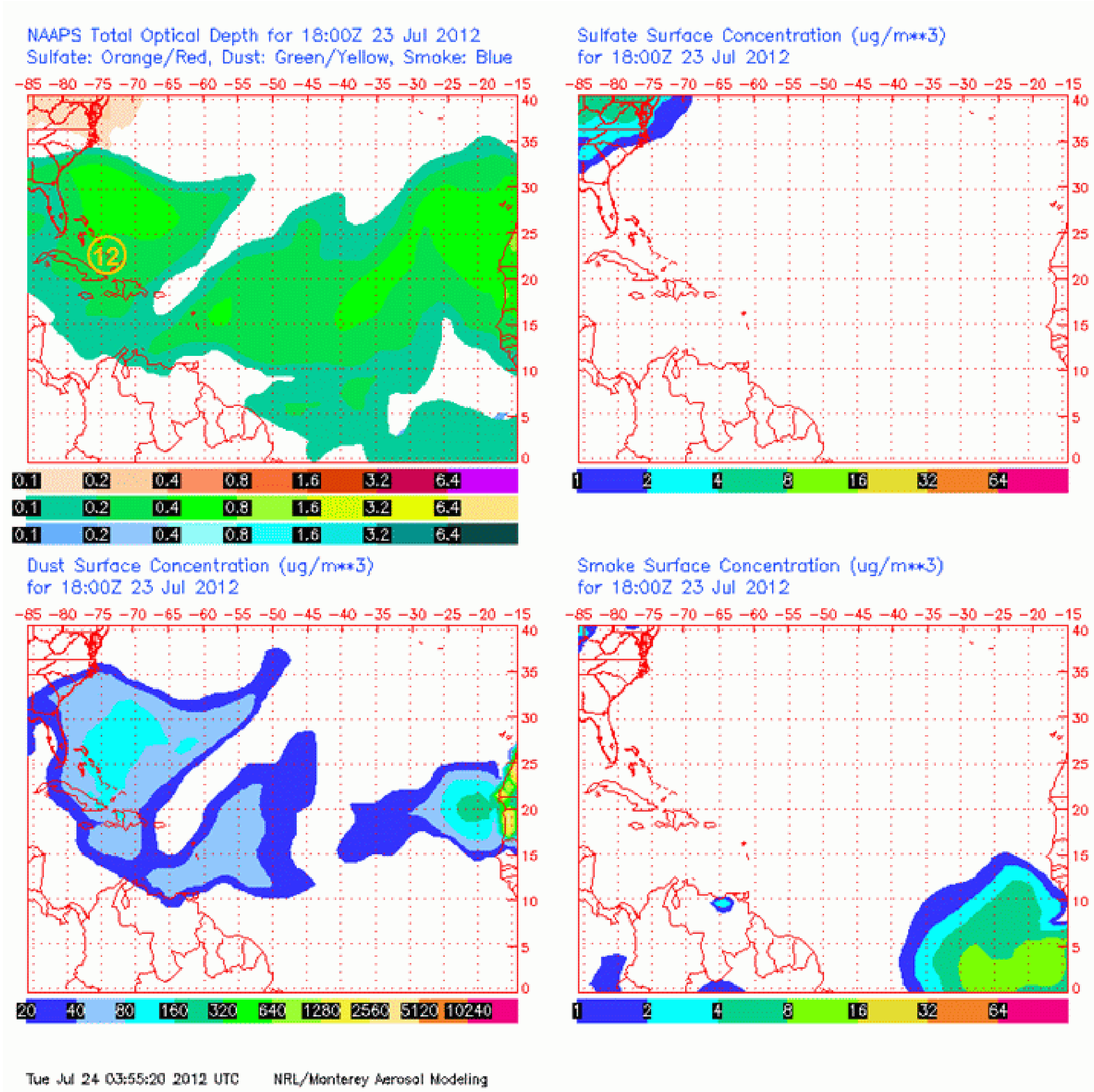


Figure C-30. NRL aerosol analysis for 1800 UTC on July 23, 2012, showing the tail of the African dust cloud moving into the eastern Caribbean Sea.

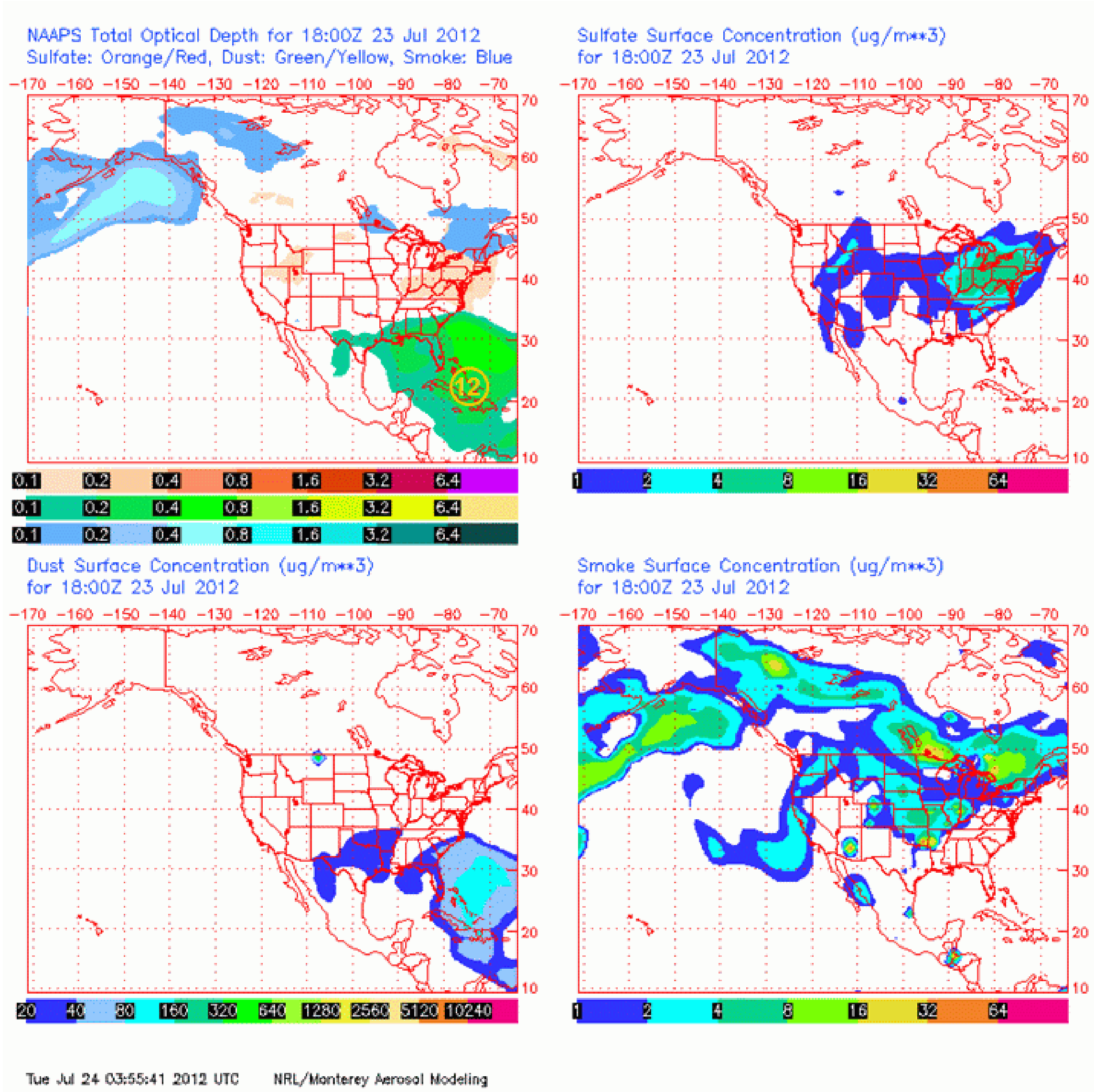


Figure C-31. NRL aerosol analysis for 1800 UTC on July 23, 2012, showing the tail of the African dust cloud moving into the eastern Caribbean Sea.

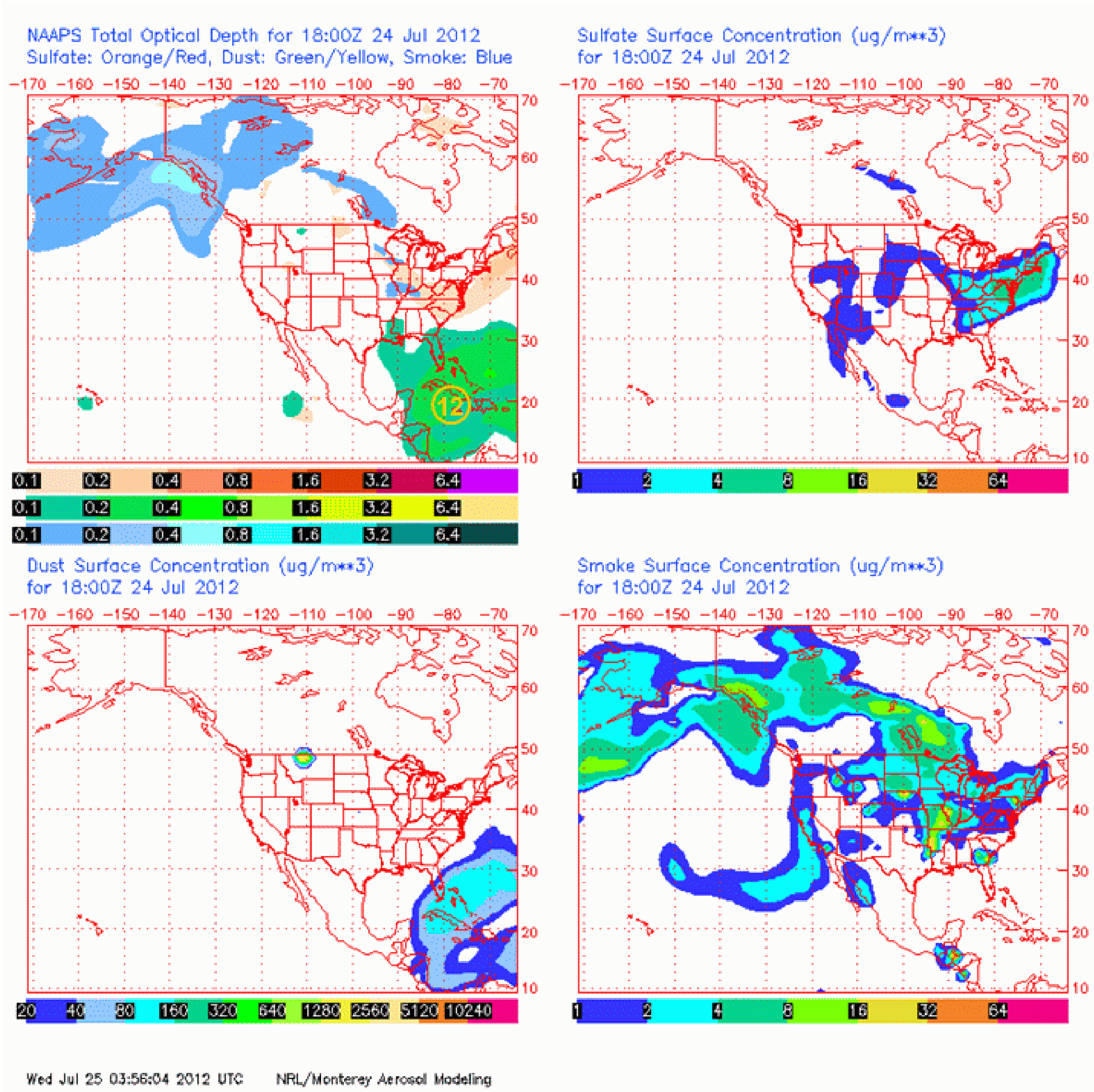


Figure C-32. NRL aerosol analysis for 1800 UTC on July 24, 2012, showing the African dust cloud in the Caribbean Sea and moving into the Gulf of Mexico.

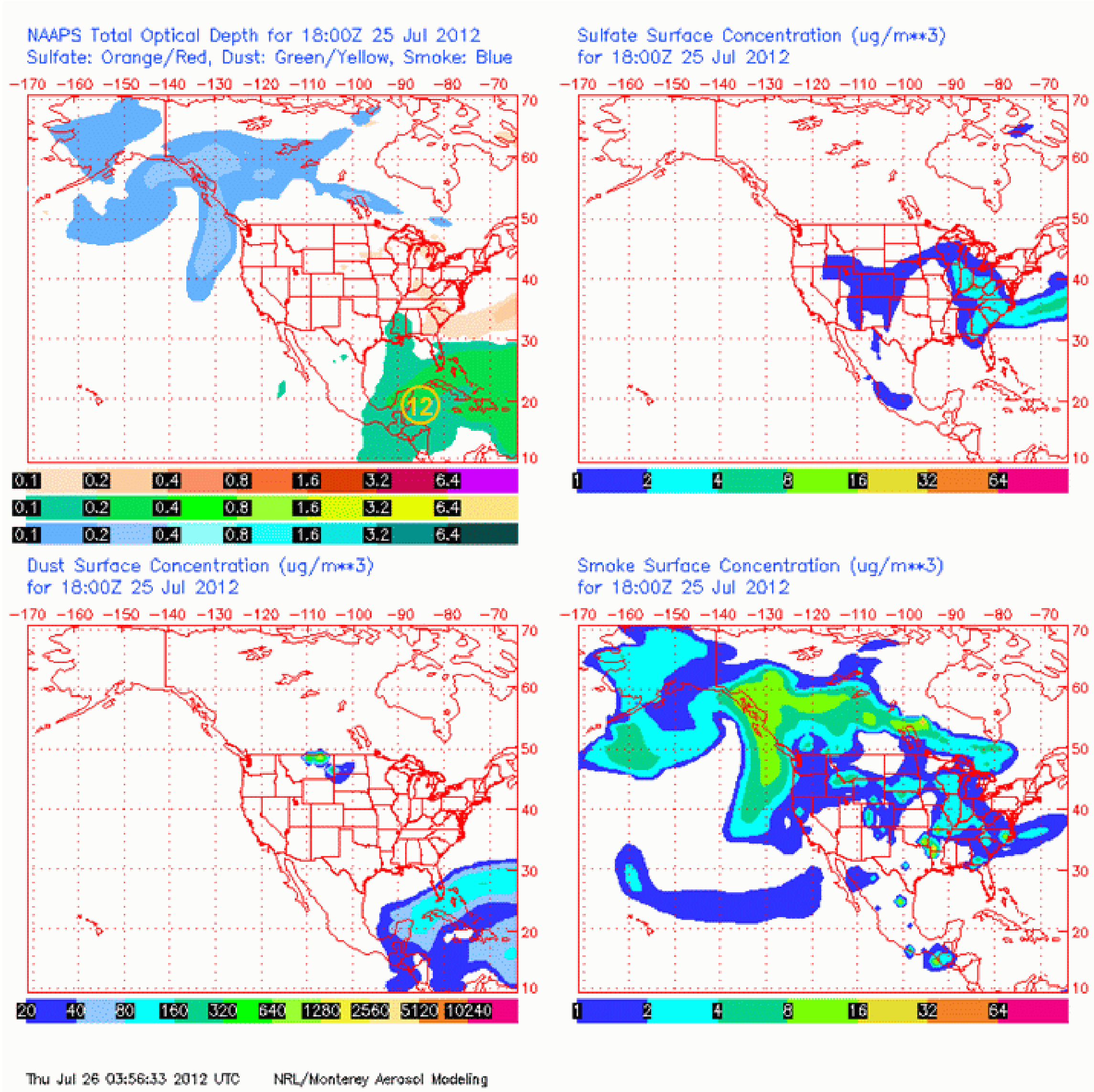


Figure C-33. NRL aerosol analysis for 1800 UTC on July 25, 2012, showing the African dust cloud in the southeastern Gulf of Mexico.

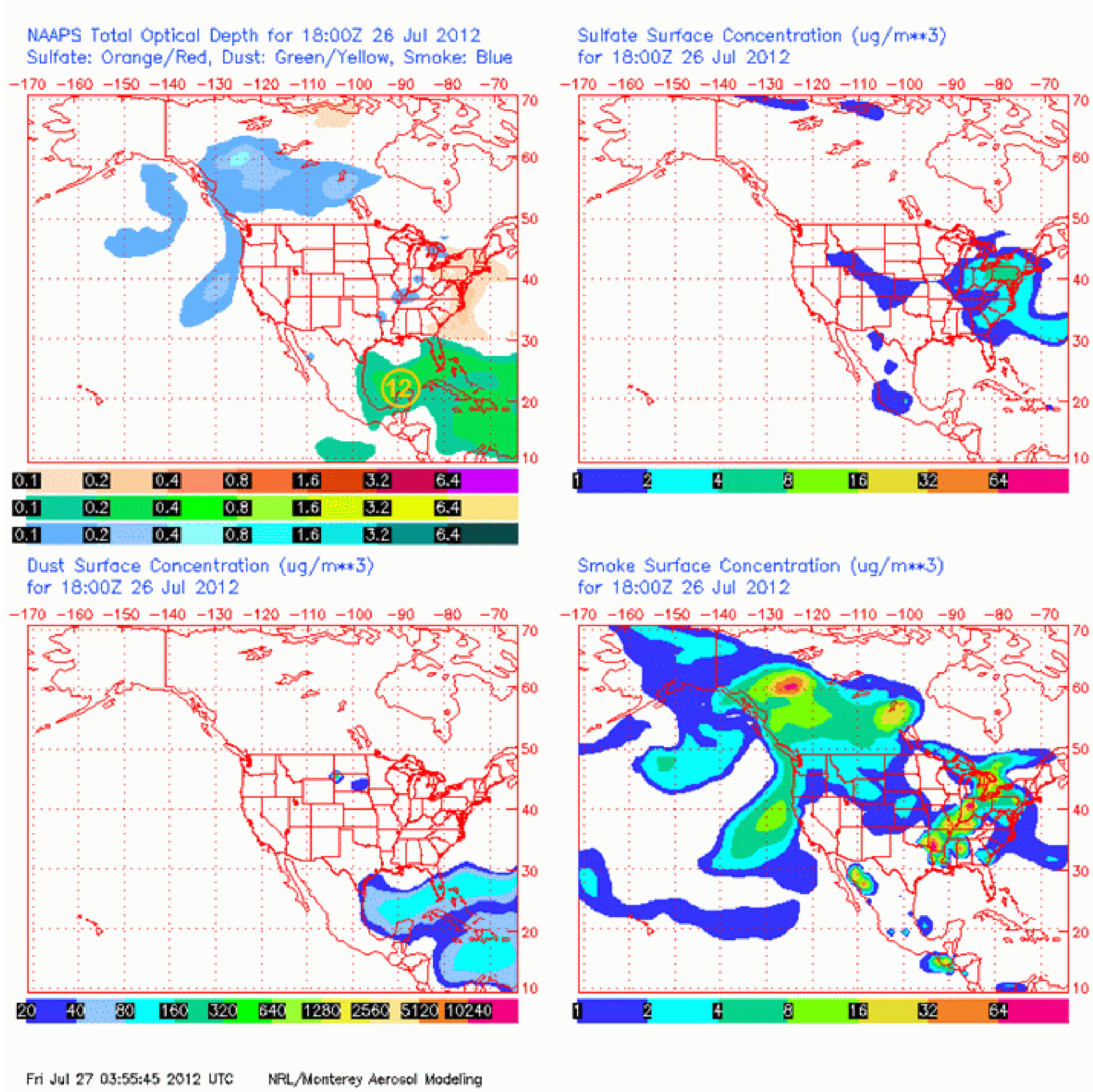


Figure C-34. NRL aerosol analysis for 1800 UTC on July 26, 2012, showing the African dust cloud reaching the lower Texas coast and extending into the Gulf of Mexico.

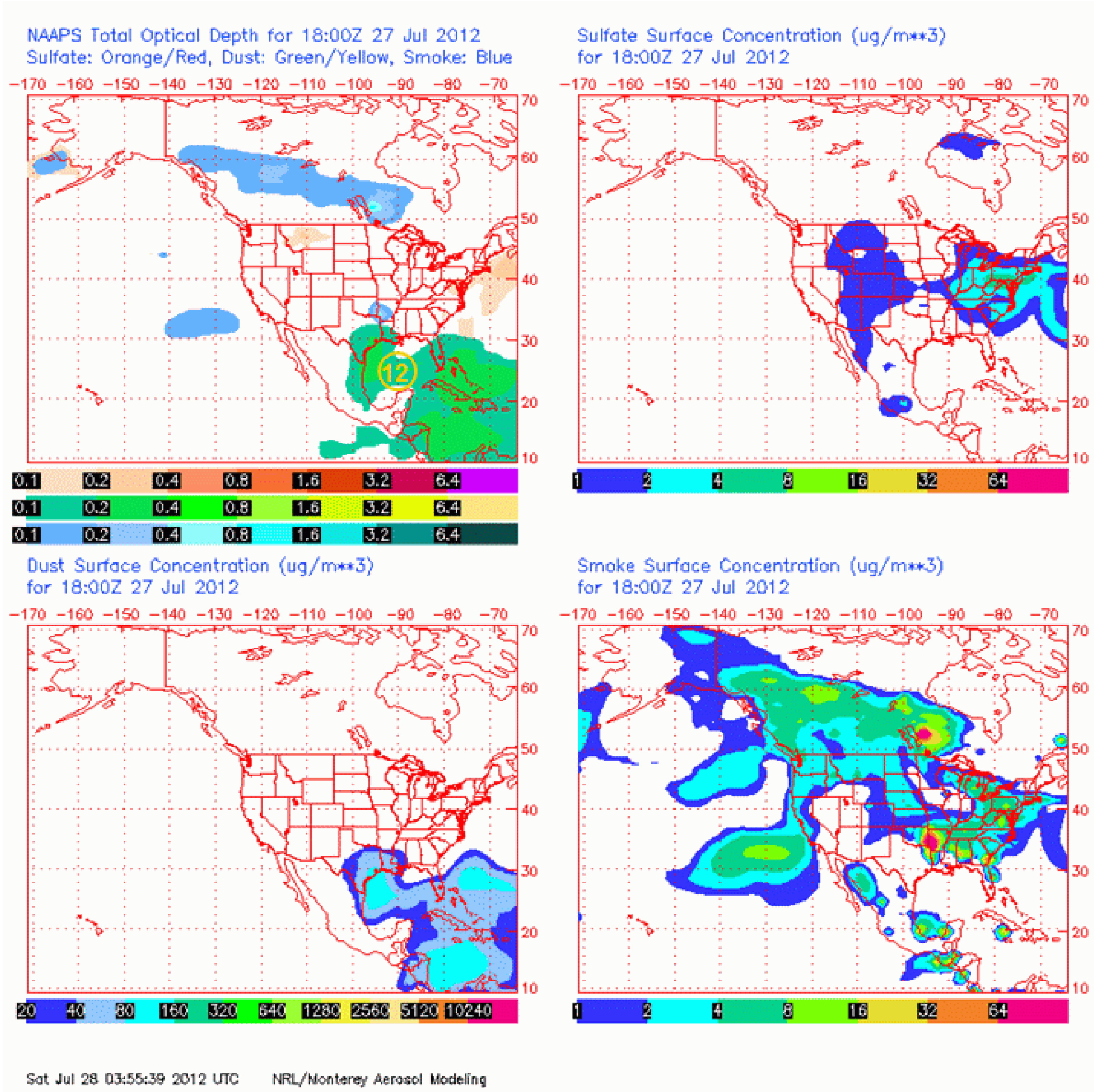


Figure C-35. NRL aerosol analysis for 1800 UTC on July 27, 2012, showing the African dust cloud in the Gulf of Mexico.

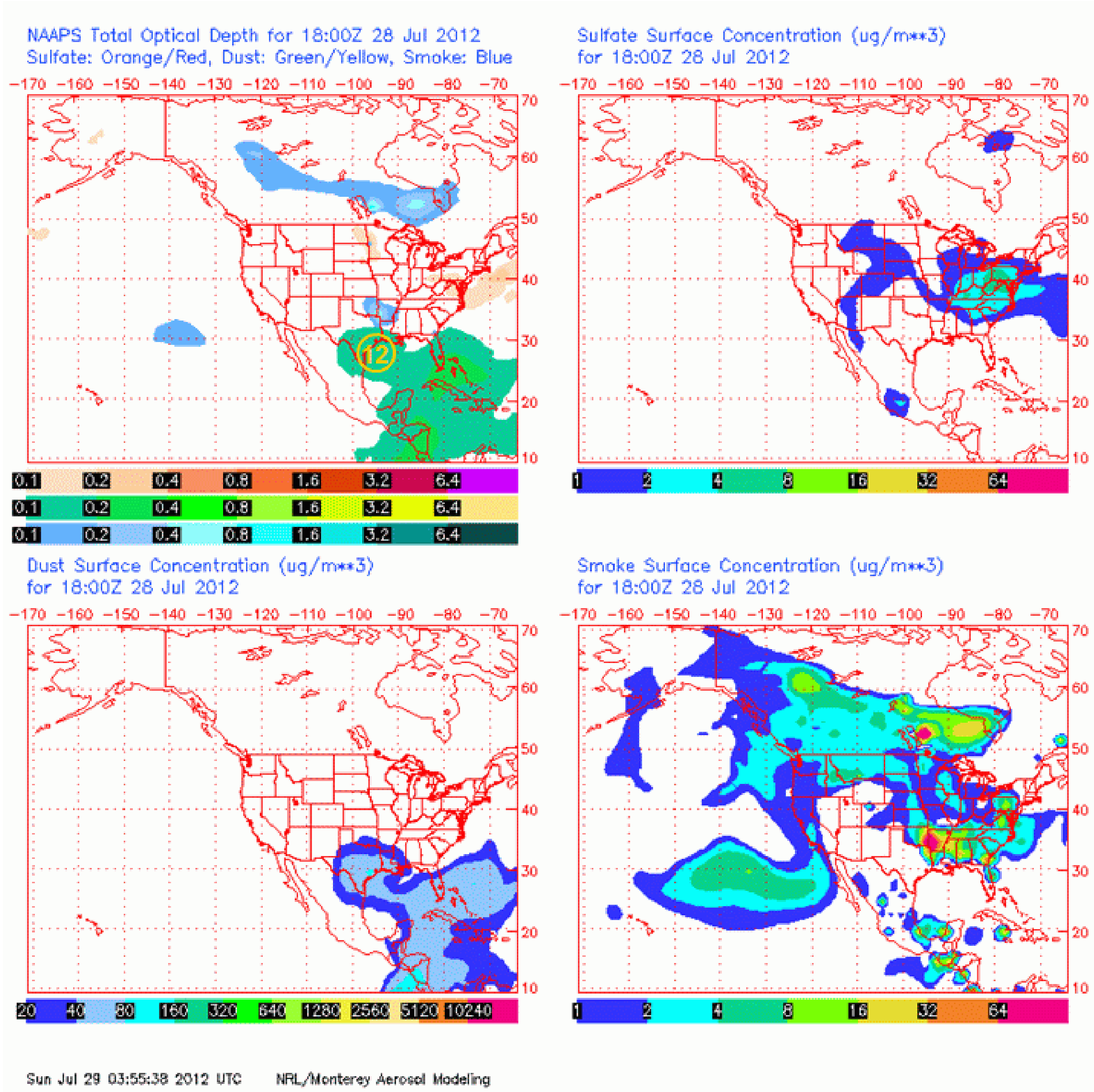


Figure C-36. NRL aerosol analysis for 1800 UTC on July 28, 2012, showing the African dust cloud in the Gulf of Mexico.

Appendix D: CMAQ Model Evaluation

Figures D-1 through D-4 show examples of cases where the Community Multi-Scale Air Quality (CMAQ) model indicated high $PM_{2.5}$ concentrations in the Houston area. The comparisons with actual concentrations show that the location of high particulate due to local emissions is generally correct, but there is strong evidence of a consistent high bias by about a factor of two on the high side. Thus, if routine local emissions were causing $PM_{2.5}$ to exceed the level of the annual NAAQS for a daily average, the model should indicate a concentration much higher than the annual NAAQS for that day. A check of the State of Texas Environmental Electronic Reporting System found no reports of unusual particulate related emissions events on July 2, 27, or 28, 2012. Therefore, the model predictions for July 2, 27, and 28, 2012, which do not show the daily average exceeding the level of the annual NAAQS in the Houston area, strongly indicates that no exceedance of the annual NAAQS would have been measured on the exceptional event days without the African dust events.

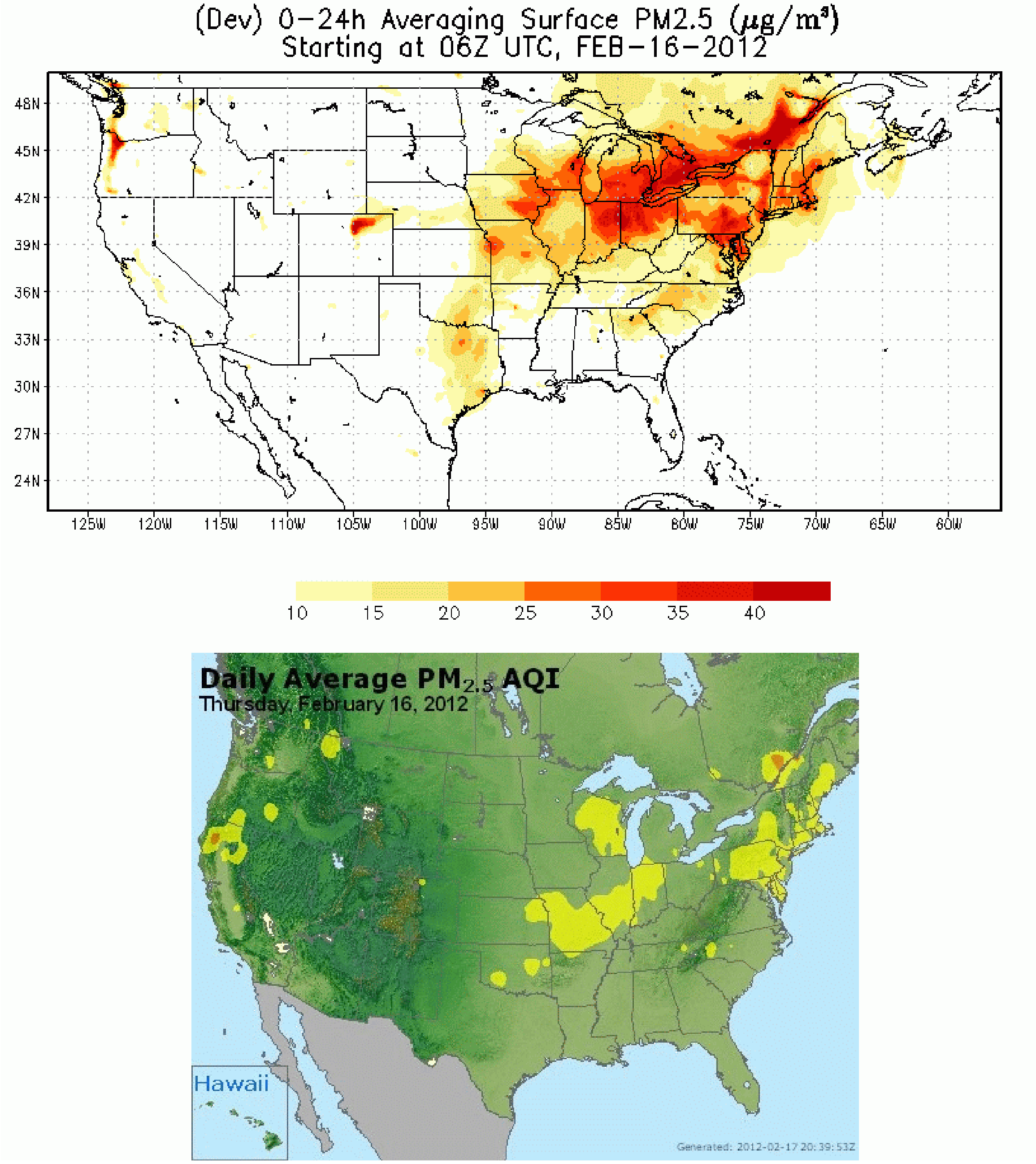
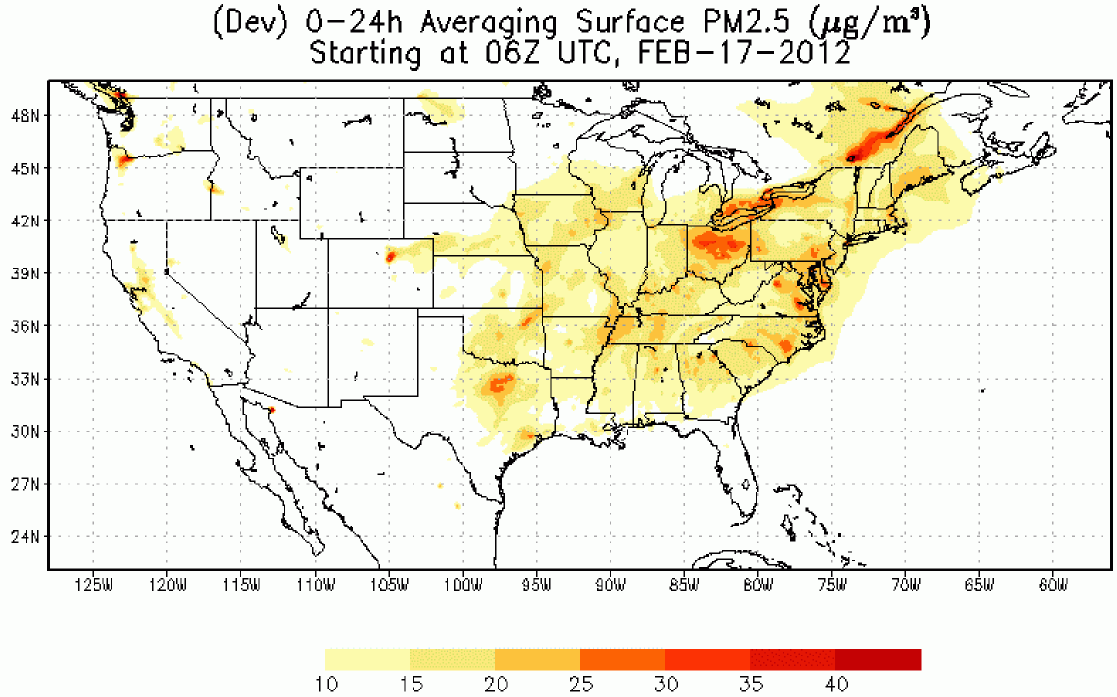


Figure D-1. Comparison of CMAQ model-predicted $PM_{2.5}$ concentrations versus actual measured AQI levels on February 16, 2012. The yellow areas on the AQI map indicate 2012 AQI Moderate $PM_{2.5}$ daily averages between 15.5 and 35.4 μg/m^3. The CMAQ model predicted concentrations above 25 μg/m^3 in Houston on this day, when actual measured AQI levels were Good.



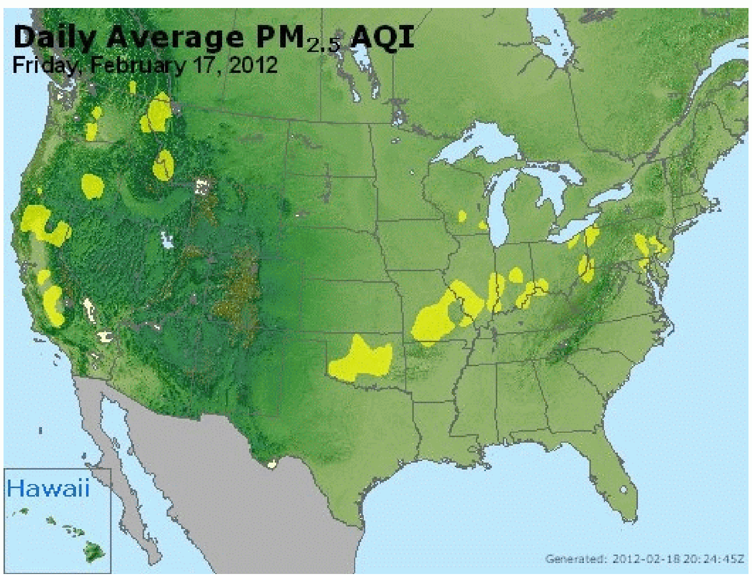


Figure D-2. Comparison of CMAQ model-predicted $PM_{2.5}$ concentrations versus actual measured AQI contours on February 17, 2012. The yellow areas on the AQI map indicate 2012 AQI Moderate $PM_{2.5}$ daily averages between 15.5 and 35.4 µg/m^3. The CMAQ model predicted concentrations above 25 µg/m^3 in Houston on this day, when actual measured AQI levels were Good.

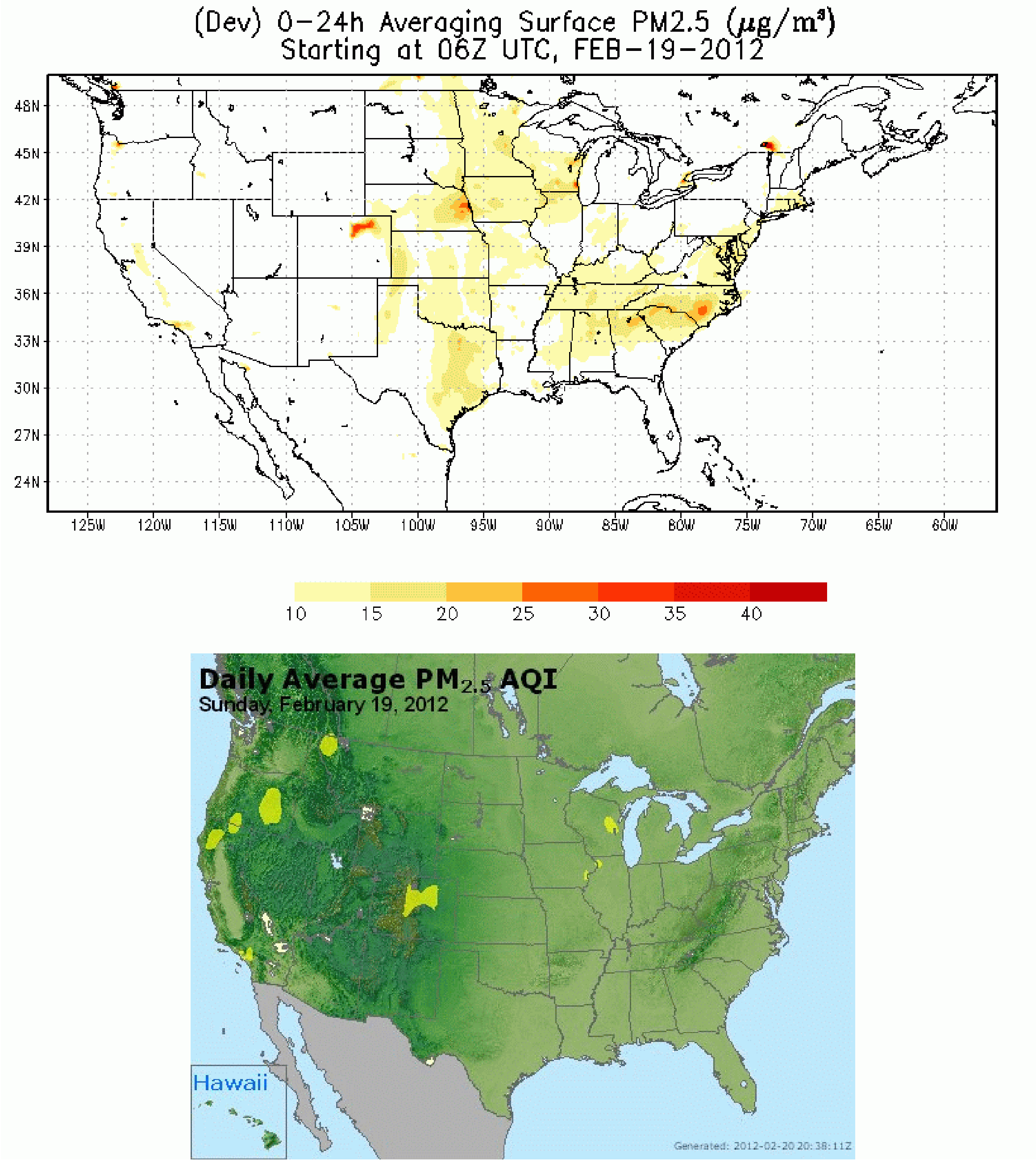


Figure D-3. Comparison of CMAQ model-predicted $PM_{2.5}$ concentrations versus actual measured AQI contours on February 19, 2012. The yellow areas on the AQI map indicate 2012 AQI Moderate $PM_{2.5}$ daily averages between 15.5 and 35.4 µg/m^3. The CMAQ model predicted widespread concentrations above 15 µg/m^3 in Houston on this day, when actual measured AQI levels were Good.

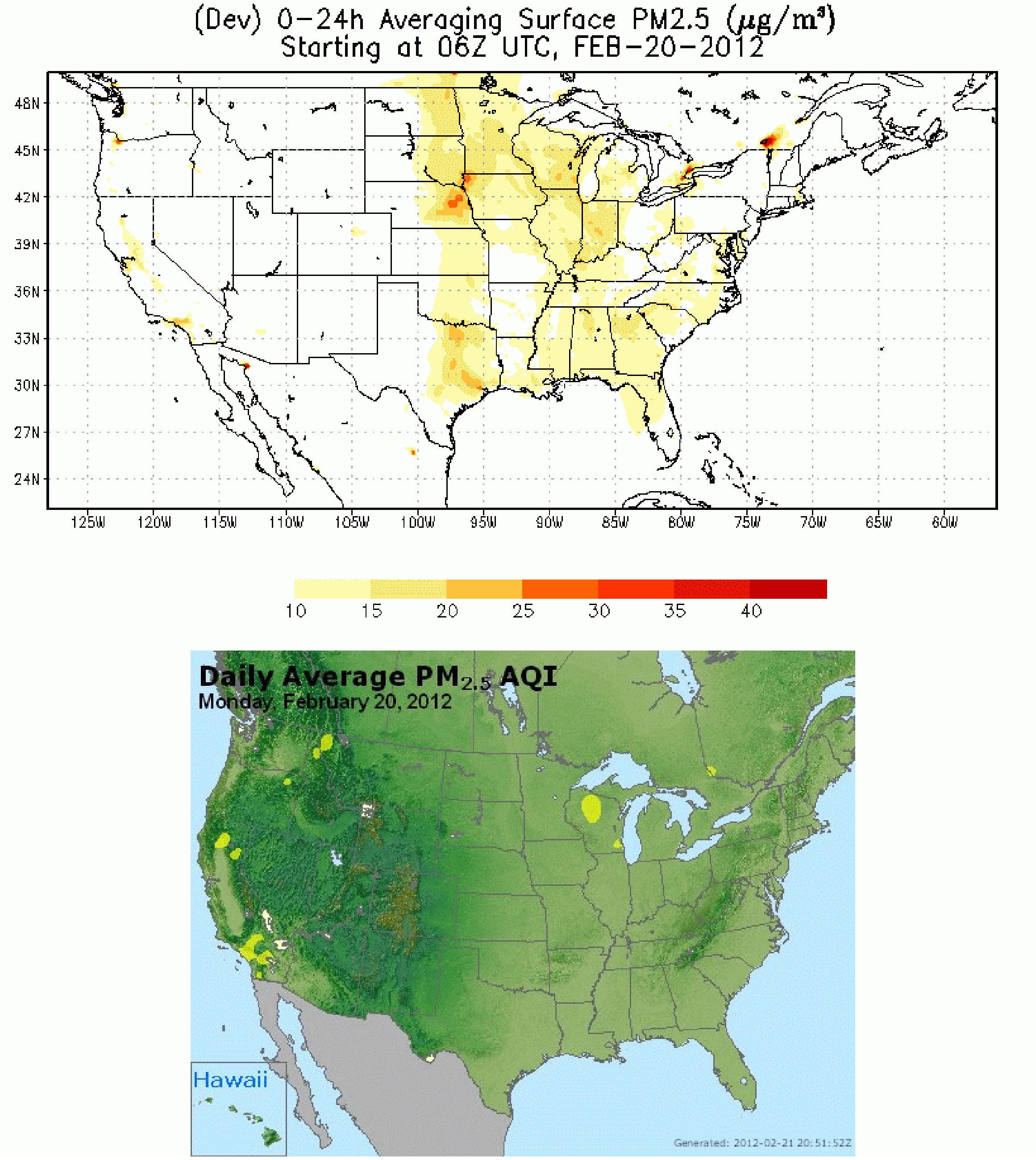


Figure D-4. Comparison of CMAQ model-predicted $PM_{2.5}$ concentrations versus actual measured AQI contours on February 20, 2012. The yellow areas on the AQI map indicate AQI 2012 Moderate $PM_{2.5}$ daily averages between 15.5 and 35.4 µg/m^3. The CMAQ model predicted concentrations above 25 µg/m^3 in Houston on this day, when actual measured AQI levels were Good.

Appendix E: Web Page Examples

Figures E-1 through E-6 show examples of web pages cited by links in the Mitigation of Exceptional Events section.

Today's Texas Air Quality Forecast

The latest forecast for air quality conditions in Texas' metropolitan areas.

August 23, 2013

Related Current Data

Air Quality Index (AQI) Report
Map of Current PM2.5 Levels
Map of Current Ozone Levels
Current Satellite Images
Real-Time Winds Aloft

Related Information

Ozone: The Facts
Texas Air Monitoring Data
EPA AIRNow Air Quality Forecasts Exit...
NOAA/EPA Ozone Model Forecasts Exit...
NRL Aerosol Model Forecasts Exit...

Air Quality Index (AQI) Forecast

Air Quality Index Scale

Good	Moderate	Unhealthy Sensitive	Unhealthy	Very Unhealthy	Hazardous

Forecast Region (Click name for AIRNOW version)	Fri 08/23/13	Sat 08/24/13	Sun 08/25/13	Mon 08/26/13
Austin	Good	Good	Good	Good
Beaumont-Port Arthur	Good	Good	Good	Good
Brownsville-McAllen	Good	Good	Good	Good
Corpus Christi	Good	Good	Good	Good
Dallas-Fort Worth	Ozone	Ozone	Ozone	Ozone
El Paso	Good	Good	Good	Good
Houston	Ozone	Good	Good	Good
Laredo	Good	Good	Good	Good
Lubbock	Good	Good	Good	Good
Midland-Odessa	Good	Good	Good	Good
San Antonio	Good	Good	Good	Good
Tyler-Longview	Ozone	Good	Good	Good
Victoria	Good	Good	Good	Good
Waco-Killeen	Good	Good	Good	Good

Discussion

Friday 8/23/13
Winds may be light enough and incoming background levels high enough for ozone to reach "Moderate" levels on the southwest and west side of the Houston area, on the northwest side of the Dallas-Fort Worth area, and in the Tyler-Longview area with highest concentrations this afternoon and into the early evening. Elsewhere in the state, moderate winds and lower incoming background levels should help to keep air quality in the "Good" range.

Saturday 8/24/13
Winds may be light enough and incoming background levels high enough for ozone to reach "Moderate" levels on the northwest side of the Dallas-Fort Worth area with highest concentrations in the afternoon and early evening. Elsewhere in the state, moderate winds and lower incoming background levels should help to keep air quality in the "Good" range.

Sunday 8/25/13 Outlook
Winds may be light enough and incoming background levels high enough for ozone to reach "Moderate" levels on the northwest side of the Dallas-Fort Worth area with highest concentrations in the afternoon and early evening. Elsewhere in the state, moderate winds and lower incoming background levels should help to keep air quality in the "Good" range.

Monday 8/26/13 Outlook
Winds may be light enough and incoming background levels high enough for ozone to reach "Moderate" levels on the northwest side of the Dallas-Fort Worth area with highest concentrations in the afternoon and early evening. Elsewhere in the state, moderate winds and lower incoming background levels should help to keep air quality in the "Good" range.

Tuesday 8/27/13 Extended Outlook
Winds may be light enough and incoming background levels high enough for ozone to reach "Moderate" levels on the north and northwest side of the Dallas-Fort Worth area with highest concentrations in the afternoon and early evening. Elsewhere in the state, moderate winds and lower incoming background levels should help to keep air quality in the "Good" range.

Figure E-1. Sample of the TCEQ Today's Texas Air Quality Forecast.

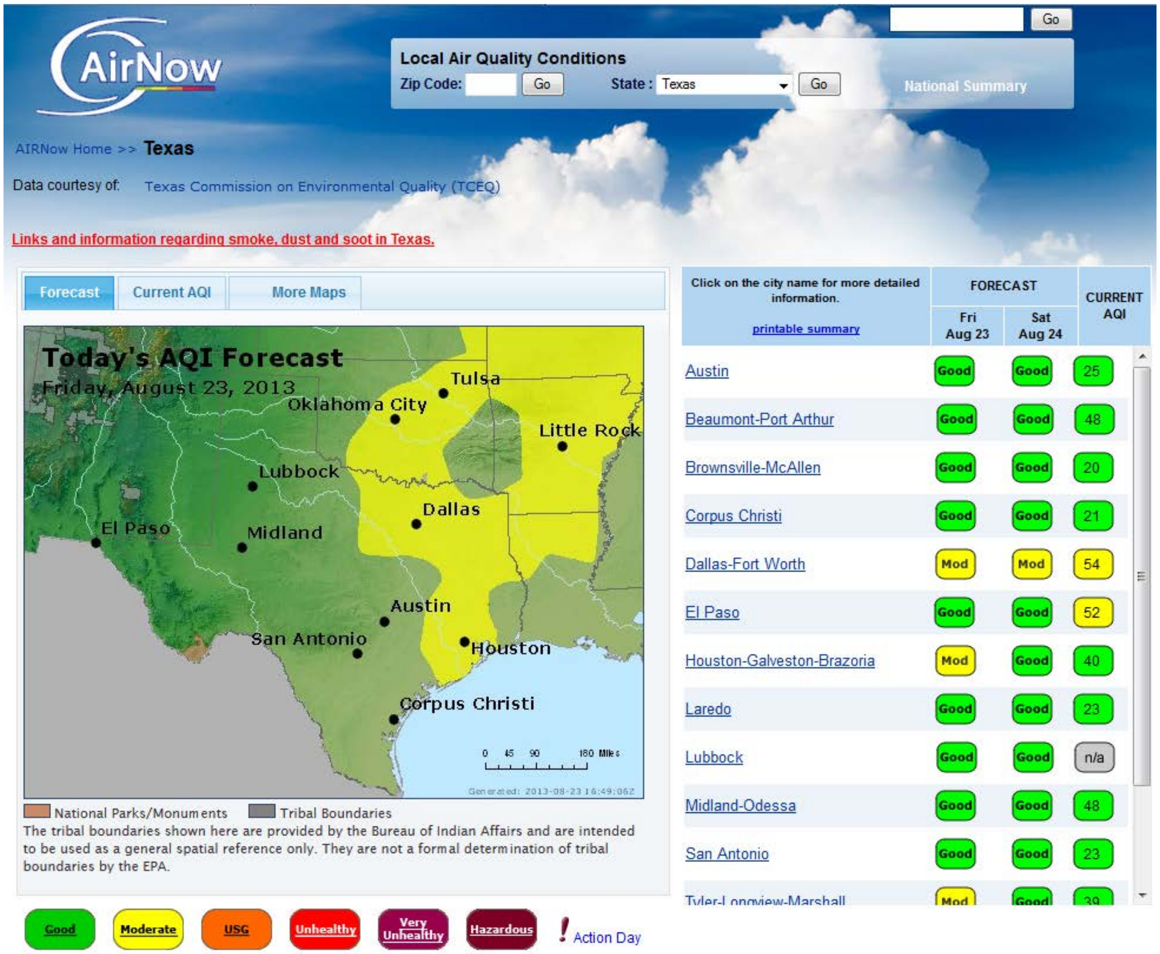
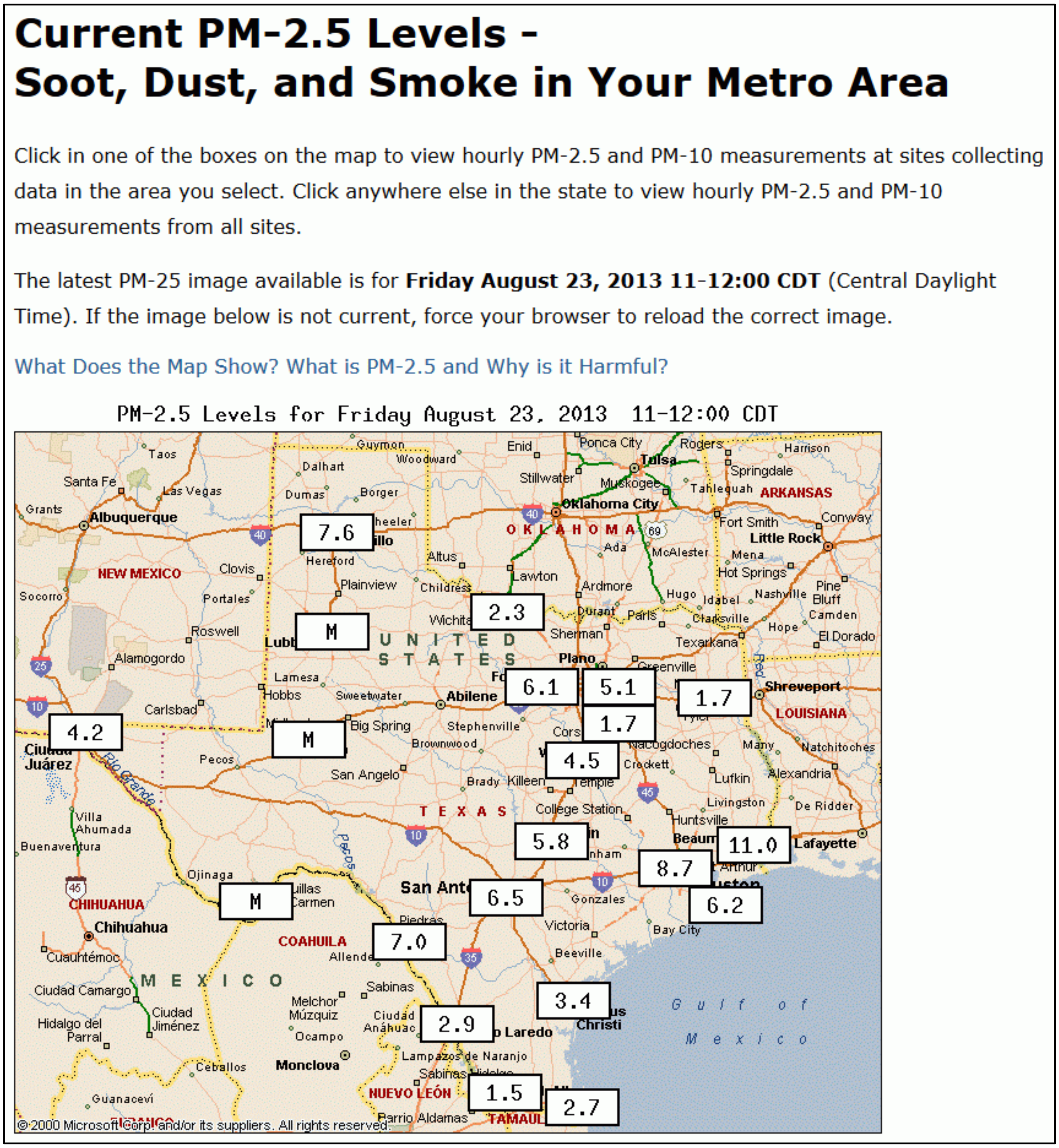


Figure E-2. Sample of the EPA AIRNOW web page.


Current PM-2.5 Levels -
Soot, Dust, and Smoke in Your Metro Area

Click in one of the boxes on the map to view hourly PM-2.5 and PM-10 measurements at sites collecting data in the area you select. Click anywhere else in the state to view hourly PM-2.5 and PM-10 measurements from all sites.

The latest PM-25 image available is for **Friday August 23, 2013 11-12:00 CDT** (Central Daylight Time). If the image below is not current, force your browser to reload the correct image.

What Does the Map Show? What is PM-2.5 and Why is it Harmful?

Figure E-3. Sample of the TCEQ map of current $PM_{2.5}$ levels.

Air Quality Index

AQI AIR QUALITY INDEX | Good | Moderate | Unhealthy for Sensitive Groups | Unhealthy | Very Unhealthy | Hazardous

How clean is the air in your metropolitan area? The U. S. Environmental Protection Agency (EPA) has provided a scale called the Air Quality Index (AQI) for rating air quality. This scale is based on the National Ambient Air Quality Standards (NAAQS) and is described in the Code of Federal Regulations, Part 58, Appendix G. This report is based on the AQI standards.

Interpreting the AQI

Reporting for August 23, 2013 as of 12:12 pm CDT August 23 2013 Select a Different Date

Metropolitan Area or Non-Metropolitan County	Air Quality	Critical Pollutant	Air Quality Index Rating															
			Ozone				Carbon Monoxide		Sulfur Dioxide		Nitrogen Dioxide		PM-10 (Std Cond)		PM-2.5 (Lcl Acpt)	
			1-Hour		8-Hour		8-Hour		1-Hour		1-Hour		24-Hour †		24-Hour †	
			AQI	ppb	AQI	ppb	AQI	ppm	AQI	ppb	AQI	ppb	AQI	µg/m³ (25° C)	AQI	µg/m³ LC
Amarillo -- Region 1																
Amarillo	Good	PM-2.5													36	8.6
Lubbock -- Region 2																
Lubbock [1]	††															§
Abilene -- Region 3																
Wichita Falls	Good	PM-2.5													35	8.4
Dallas-Fort Worth -- Region 4																
Dallas [1]	Moderate	PM-2.5	*	56	27	32	2	0.2	5	3	14	15			53	13.3
Fort Worth-Arlington	Good	PM-2.5	*	51	28	33	2	0.2			25	27			36	8.7
Navarro County [1]	Good	PM-2.5	*	39	19	23			6	4		§			30	7.1
Tyler-Longview-Marshall -- Region 5																
Longview-Marshall	Good	PM-2.5	*	52	19	23			1	1	11	12			34	8.3
Tyler	Good	Ozone	*	39	21	25					4	4				
El Paso-Juarez -- Region 6																
Brewster County	Good	Ozone	*	36	25	30									25	5.9
El Paso	Good	PM-2.5	*	43	27	32	5	0.4	1	1	22	23	20	21.2	31	7.4
Juarez [1]	Good	Ozone	*	28	17	20	3	0.3								
Odessa-Midland -- Region 7																
Odessa-Midland	Good	PM-2.5													38	9.2
Waco -- Region 9																
Killeen-Temple	Good	Ozone	*	35	14	16										
Waco	Good	PM-2.5	*	38	21	25	1	0.1	2	1	5	6			28	6.6
Beaumont-Port Arthur -- Region 10																
Beaumont-Port Arthur	Good	PM-2.5	*	46	17	20	2	0.1	3	2	16	17			46	11.1
Austin -- Region 11																
Austin-San Marcos [1]	Good	PM-2.5	*	43	17	20	1	0.1	2	1	12	13			19	4.5
Fayette County	Good	Ozone	*	32	14	16									14	3.4
Houston-Galveston-Brazoria -- Region 12																
Brazoria	Good	Ozone	*	40	14	16					13	14				
Galveston-Texas City	Good	Ozone	*	36	23	27			1	1	14	15			17	4.0
Houston [1]	Good	PM-2.5	*	48	14	16	4	0.3	6	4	22	24			33	8.0

Figure E-4. Sample of a portion of the TCEQ Air Quality Index Report.

Air Pollution from Particulate Matter

General information on particulate matter (PM), and TCEQ planning that addresses the PM National Ambient Air Quality Standards (NAAQS).

- Particulate Matter (PM): The Facts
- Latest air quality planning that addresses the PM NAAQS NEW
- Related Web pages and publications
- Get more information on the Texas SIP and contact the TCEQ

Particulate Matter (PM): The Facts

What is PM?

Particulate matter (PM) is a mix of small particles and liquid droplets. These particles can be made up of acids, organic chemicals, metal, dust, or soil. Particulates are different in several ways including size.

PM_{10} is sometimes referred to as coarse particles. They consist of particles that are less than 10 micrometers in diameter but greater than 2.5 micrometers in diameter.

$PM_{2.5}$ are fine particles and are the smallest particles that are regulated. They consist of particles that are 2.5 micrometers and smaller in diameter. By comparison, the average diameter of human hair is 70 micrometers.

The Federal Clean Air Act requires the United States Environmental Protection Agency (EPA) to set air quality standards, including those for PM, to protect both public health and the public welfare (e.g., visibility, crops, and vegetation).

What are the health effects of PM?

Particle size is directly related to its potential for causing health problems. Small particles less than 2.5 micrometers in diameter can be inhaled deeper into the lungs. Scientific studies have linked exposure to high concentrations of some types of PM with a variety of problems, including:

- irregular heartbeat;
- aggravated asthma;
- decreased lung function;
- increased respiratory symptoms, such as irritation of the airways, coughing or difficulty breathing;
- nonfatal heart attacks; and
- premature death in people with heart or lung disease.

These associations are much less certain at concentrations below the current standard set by the EPA for PM in ambient air.

How does PM affect the environment?

PM can contribute to haze, which reduces visibility. When PM is present in the air, it can absorb sunlight, and it can reflect sunlight. This reduces clarity in the air and can cause haze. Humid air can also combine with PM to further reduce visibility. PM from the air can deposit on water and soil harming ecosystems, soil, and crops. PM can stain and damage stone and other materials, including culturally important objects such as statues and monuments.

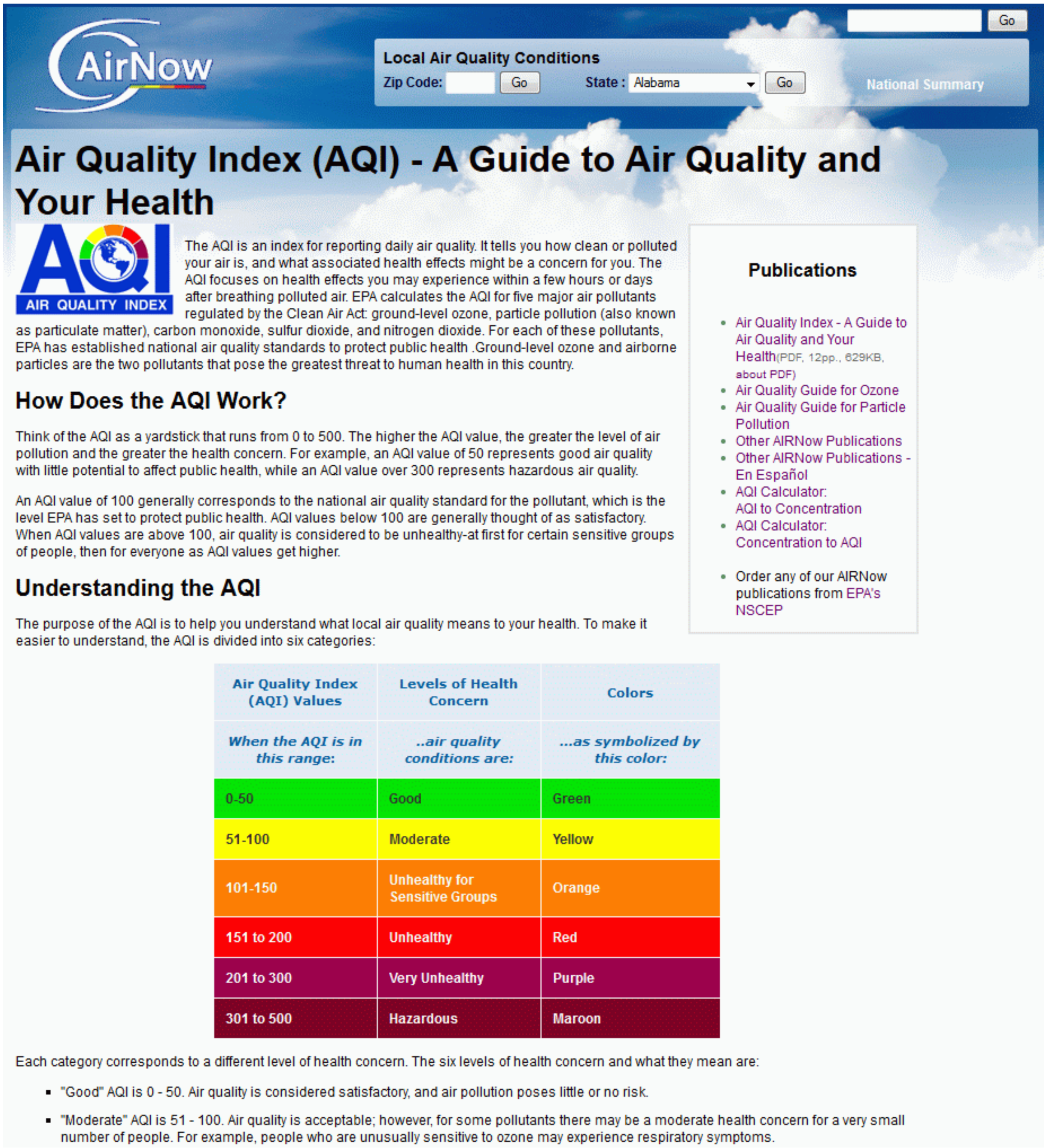
Where can I see daily PM levels in my area?

The TCEQ has multiple monitors that directly measure PM concentrations throughout the state. The TCEQ also offers air quality forecasts that include PM. The public can sign up for these to be delivered via e-mail using the Agency's GovDelivery system.

The EPA provides a web site that monitors and forecasts the quality of the air using a scale called the Air Quality Index (AQI). The AQI is based on the National Ambient Air Quality Standards (NAAQS) for the six criteria pollutants. The AQI is on a scale of 0 to 500, with 100 corresponding to the NAAQS set by the EPA. A higher AQI value means a larger level of air pollution and a greater potential health concern. These forecasts can be found on the EPA's Air Now Web page (http://airnow.gov/). Exit...

You can also sign up to receive e-mail alerts about PM through the EPA's EnviroFlash web site (http://www.enviroflash.info/). Exit...

Figure E-5. Sample of a portion of the TCEQ particulate matter web page.



AirNow

Local Air Quality Conditions

Zip Code: Go State : Alabama Go

National Summary

Air Quality Index (AQI) - A Guide to Air Quality and Your Health

AQI AIR QUALITY INDEX

The AQI is an index for reporting daily air quality. It tells you how clean or polluted your air is, and what associated health effects might be a concern for you. The AQI focuses on health effects you may experience within a few hours or days after breathing polluted air. EPA calculates the AQI for five major air pollutants regulated by the Clean Air Act: ground-level ozone, particle pollution (also known as particulate matter), carbon monoxide, sulfur dioxide, and nitrogen dioxide. For each of these pollutants, EPA has established national air quality standards to protect public health .Ground-level ozone and airborne particles are the two pollutants that pose the greatest threat to human health in this country.

How Does the AQI Work?

Think of the AQI as a yardstick that runs from 0 to 500. The higher the AQI value, the greater the level of air pollution and the greater the health concern. For example, an AQI value of 50 represents good air quality with little potential to affect public health, while an AQI value over 300 represents hazardous air quality.

An AQI value of 100 generally corresponds to the national air quality standard for the pollutant, which is the level EPA has set to protect public health. AQI values below 100 are generally thought of as satisfactory. When AQI values are above 100, air quality is considered to be unhealthy-at first for certain sensitive groups of people, then for everyone as AQI values get higher.

Understanding the AQI

The purpose of the AQI is to help you understand what local air quality means to your health. To make it easier to understand, the AQI is divided into six categories:

Air Quality Index (AQI) Values	Levels of Health Concern	Colors
When the AQI is in this range:	*..air quality conditions are:*	*...as symbolized by this color:*
0-50	Good	Green
51-100	Moderate	Yellow
101-150	Unhealthy for Sensitive Groups	Orange
151 to 200	Unhealthy	Red
201 to 300	Very Unhealthy	Purple
301 to 500	Hazardous	Maroon

Each category corresponds to a different level of health concern. The six levels of health concern and what they mean are:

- "Good" AQI is 0 - 50. Air quality is considered satisfactory, and air pollution poses little or no risk.
- "Moderate" AQI is 51 - 100. Air quality is acceptable; however, for some pollutants there may be a moderate health concern for a very small number of people. For example, people who are unusually sensitive to ozone may experience respiratory symptoms.

Publications

- Air Quality Index - A Guide to Air Quality and Your Health(PDF, 12pp., 629KB, about PDF)
- Air Quality Guide for Ozone
- Air Quality Guide for Particle Pollution
- Other AIRNow Publications
- Other AIRNow Publications - En Español
- AQI Calculator: AQI to Concentration
- AQI Calculator: Concentration to AQI

- Order any of our AIRNow publications from EPA's NSCEP

Figure E-6. Sample of a portion of the EPA Air Quality Index guide.