Work Order No. 582-22-31152-027
Contract No. 582-19-90500
Tracking No. 2022-33
Task 5.2

Prepared for:

Texas Commission on Environmental Quality
12100 Park 35 Circle MC 164
Austin, TX 78753

Prepared by:

Ramboll US Consulting, Inc.
7250 Redwood Blvd., Suite 105
Novato, California 94945

June 1, 2022

MEGAN Training
Final Report

PREPARED UNDER A CONTRACT FROM THE
TEXAS COMMISSION ON ENVIRONMENTAL QUALITY

The preparation of this document was financed through a contract from the State of Texas through the Texas Commission on Environmental Quality.
The content, findings, opinions and conclusions are the work of the author(s) and do not necessarily represent findings, opinions or conclusions of the TCEQ.

RAMBOLL

MEGAN Training
Final Report

Ramboll
7250 Redwood Boulevard
Suite 105
Novato, CA 94945
USA

T +1 415 899 0700
https://ramboll.com

Contents

EXECUTIVE SUMMARY

Isoprene and other biogenic volatile organic compounds (BVOCs) strongly influence air quality in Texas and can dominate the total VOC emission inventory for some Texas locations. The Model of Emissions of Gases and Aerosols from Nature (MEGAN) is one of the two most widely used biogenic emissions models to quantify emissions of isoprene and other BVOCs. MEGAN is designed for both regional-scale and hemispheric modeling with global coverage and includes Texas-specific emission factors and vegetation characteristics data.

This project provided training to TCEQ staff on using current version of MEGAN (v3.2) to generate biogenic emissions input for air quality modeling, such as ozone SIP and Hemispheric CAMx. The training included a general introduction webinar and a virtual hands-on training on MEGAN modeling. Twenty TCEQ staff attended the introduction webinar and customized hands-on training was provided to selected TCEQ staff. The webinar and hands-on training session were recorded for future reference.

1 INTRODUCTION

Isoprene and other biogenic volatile organic compounds (BVOCs) strongly influence air quality in Texas and can dominate the total VOC emission inventory for some Texas locations. The Model of Emissions of Gases and Aerosols from Nature (MEGAN)[1] is one of the two most widely used biogenic emissions models to quantify emissions of isoprene and other BVOCs. MEGAN is designed for both hemispheric and regional-scale modeling and provides global coverage. In contrast, the other model, the Biogenic Emission Inventory System (BEIS), which was recently used in TCEQ ozone and regional haze State Implementation Plan (SIP) modeling, is geographically limited to North American domains. Another advantage of MEGAN over BEIS is that it simplifies the process of updating and improving data on vegetation cover and emissions.

1.1 Project Objectives

The propose of this project is to provide training to TCEQ staff on using the most recent version of the MEGAN model (MEGANv3.2) to generate biogenic emissions input for air quality modeling, such as ozone SIP and Hemispheric CAMx.

[1] https://bai.ess.uci.edu/megan

2 TRAINING ACTIVITY SUMMARY

Ramboll provided training via a general introduction webinar and a virtual hands-on training on MEGAN modeling to develop biogenic emissions input for air quality modeling. Twenty TCEQ staff attended the training webinar. The training agenda, PowerPoint presentation, electronic files for the hands-on training, and step-by-step instructions for the practice run were provided to the TCEQ Project Manager before the training. The training was scheduled such that the webinar was delivered in the morning and hands-on practice on the TCEQ's Air Modeling and Data Analysis (AMDA) Linux system in the afternoon session.

The training webinar, which was open to the Air Modeling and Data Analysis (AMDA) section, covered basic scientific concepts related to biogenic emissions including key environmental drivers, functionalities of the MEGAN model, and an overview of run scripts. We also showed key differences between two widely used biogenic emission models, BEIS and MEGAN, focusing on input landcover data, usability, canopy environmental model and other important differences. The current version of MEGAN, MEGAN3.2, is updated from MEGAN3.1 to include improved characterization of vegetation type for Texas urban areas by conducting urban tree surveys and combining these survey results with aerial imagery to produce fine spatial resolution vegetation maps that includes the relative abundance of high BVOC-emitting trees. MEGAN3.2 contains emission factors and vegetation characteristics data from literature and recent Texas Air Quality Research Program (AQRP) Project 18-005 (Guenther et al. 2019) and Project 20-007 (Shah et al., 2021).

Selected TCEQ staff were then trained on MEGAN3.2 processing including installation and compilation of source code. We provided virtual assistance while participants practiced running MEGAN on their own. The hands-on training included instructions to process landcover and other input data for a user-defined domain, running Python-based emission factor processor (EFP) to generate landscape average emission factors and running main MEGAN code that calculates emissions and performs chemical mechanism mapping. Each TCEQ staff was assigned a working folder on TCEQ computers that contains necessary training files. The webinar and hands-on training session were recorded so the TCEQ staff can refer to it whenever they need to. There were some questions from TCEQ staff during and after the training which are summarized below.

1. **Does MEGAN consider variation in crop growing season?**
   In the MEGAN soil NO module, the subroutine "GROWSEASON" determines days in the growing season which are used to adjust fertilizer application. The growing season varies with latitude, e.g., if latitude is within 23N to 23S then the growing season is year-long, but the season gets shorter for higher latitudes.

2. **What is the use of an intermediate file "PFILE" created by the MET2MGN processor?**
   The intermediate file "PFILE" stores variables used to calculate accumulated precipitation and used to adjust soil NO emissions for the old Yienger and Levy 1995 approach (known as YL95).

3. **In the MEGVEA processing, there is an option for applying bidirectional exchange LAI response. Can you please explain this option and what kind of impact would be from it?**
   For some VOC species, there is bi-directional exchange between vegetation surface and atmosphere, i.e., vegetation can absorb and emit those species. This option applies adjustments to ethanol and acetaldehyde resulting in lower emissions.

4. **I couldn't match the inputs, e.g., ecotypes, growth form, canopy type, you shared with inputs available on MEGAN website (**(https://bai.ess.uci.edu/megan/data-and-code**). Are they just named differently?**
   Dr. Alex Guenther, who maintains MEGAN portal, replied to this question as follows:

"The MEGAN portal has not been updated since more than a year ago. Around the time we finished the Texas projects last summer, we started to have some difficulty with the portal because Google Drive made some changes in the way it worked. I had a student looking into alternatives, including using Github for the code, but it didn't end up going anywhere (the disadvantage of unpaid labor). The Google Drive seems to be OK now, so I'll go ahead and update the existing website and portal with the latest files."

5. Please provide sample calculation for domain offsets.

1) If you have run WRFCAMx processor, you can obtain domain offsets from message files as shown below:

```
CAMx Lambert/grid identical to WRF Lambert/grid
       I,J offsets:         6         6
```

You can use these I/J offsets in the PREPMEGAN input file for specifying domain but remember to account for buffer cells.

2) If you don't have WRFCAMx message files or MCIP namelist file, there are a couple of steps involved to calculate domain offsets:

   a. You will need to use GIS software to convert WRF lat/long at grid origin (X0, Y0) to PGM model origin (x0, y0) in terms of LCP coordinates.

   b. Once you LCP x/y coordinates for WRF (X0, Y0) and PGM domain (x0, y0), you can calculate the offsets as follows:
   x-offset = (x0-X0)/dx
   y-offset = (y0-Y0)/dy
   where dx and dy are grid spacing

3 SUMMARY AND RECOMMENDATIONS FOR FUTURE WORK

Biogenic emissions strongly influence air quality in Texas and can dominate the total VOC emissions for some Texas locations. Biogenic emissions need to be accounted for in atmospheric chemical transport models (CTM) as they are widespread and ubiquitous contributors to background air chemistry. In this project, Ramboll provided training to TCEQ staff on using the most recent version of MEGAN model to create biogenic emissions input for air quality modeling.

The training was conducted in two parts:

- Introduction webinar provided an overview of basic science concepts, functionalities, and run scripts. The webinar was open to the AMDA section. The introduction webinar provided was well-received by audiences with different knowledge background as indicated by the feedbacks shared by the TCEQ project manager.
- Customized hands-on training to selected TCEQ staff.

3.1 Recommendations for future work

The TCEQ staff may benefit from additional training and careful evaluation of biogenic emissions:

- Training on GIS processing to create vegetation cover data for MEGAN (growth forms, ecotypes, LAI etc.) when new data become available.
- Evaluate biogenic emission estimates from BEIS and MEGAN using satellite, aircraft, and/or ground measurements via CAMx modeling and considering the influence of chemical mechanism in the modeling

4 REFERENCES

Guenther, A., Shah, T., Huang, L. (2019). Next steps for improving Texas biogenic VOC and NO emission estimates. (AQRP Project 18-005).

Shah, T., Huang, L., Parker, L., Shi, Y., Emery, C., Yarwood, G., and Guenther, A. (2021). Texas Urban Vegetation BVOC Emission Source Inventory. (AQRP Project 20-007)