Scope of Work For

Project 16-011

A Next Generation Modelling System for Estimating Texas Biogenic VOC Emissions

Prepared for

Air Quality Research Program (AQRP)

The University of Texas at Austin

By

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QA Requirements: Audits of Data Quality: 10% Required
Report of QA Findings: Required in Final Report

Approvals

This Scope of Work was approved electronically on 9/7/2016 by Dr. Elena McDonald-Buller, The University of Texas at Austin

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Project Manager, Texas Air Quality Research Program

This Scope of Work was recommended electronically on 9/19/2016 by Mr. Doug Boyer, Texas Commission on Environmental Quality

Mr. Doug Boyer
Project Liaison, Texas Commission on Environmental Quality

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1.0 Abstract

This document provides the work plan for the Texas Air Quality Research Program (AQRP) Project 16-011, "A Next Generation Modelling System for Estimating Texas Biogenic VOC Emissions". The project Co-Principal Investigators (Co-PIs) are Dr. Greg Yarwood and Dr. Susan Kemball-Cook of Ramboll Environ and Dr. Alex Guenther. The AQRP project manager is Dr. Elena McDonald-Buller at the University of Texas, Austin. The project liaison for the Texas Commission on Environmental Quality (TCEQ) is Mr. Doug Boyer.

The overall goal of this project is to improve numerical model predictions of regional ozone and aerosol distributions in Texas by reducing uncertainties associated with quantitative estimates of biogenic volatile organic compound (BVOC) emissions from Texas and the surrounding region. Although there have been significant advancements in the procedures used to simulate BVOC emissions, there are still major uncertainties that affect the reliability of Texas air quality simulations. This includes significant gaps in our understanding of BVOC emissions and their implementation in numerical models including 1) isoprene emission factors, 2) missing compounds, and 3) and unrepresented processes including canopy heterogeneity and stress induced emissions. For example, Texas AQRP project 14-016 (Yarwood et al., 2015) reported direct aircraft measurements of isoprene fluxes that were lower than the MEGAN predictions and Texas AQRP project 14-030 (Ying et al., 2015) summarized near surface isoprene concentrations that were higher than those predicted using MEGAN emissions with a chemistry and transport model. We propose to reconcile these and other observations by developing new emission factors and incorporating missing BVOC compounds and unrepresented BVOC emission processes into the Model of Emissions of Gases and Aerosols from Nature (MEGAN, Guenther et al., 2012) framework. To accomplish this, we will develop a transparent and comprehensive approach to assigning isoprene and monoterpene emission factors and will update MEGAN to include additional BVOC and processes including stress induced emissions and canopy heterogeneity. We expect the explicit representation of canopy heterogeneity and other processes will eliminate any significant difference between MEGAN isoprene emission estimates and aircraft flux measurements.

The primary output of the proposed research will be a flexible, transparent and more accurate approach for estimating BVOC emissions. The proposed work aims to reduce BVOC emission uncertainties and develop an improved version of a model for estimating emissions of isoprene, monoterpenes and other significant BVOC from Texas. Outcomes will include improved BVOC emission estimates and a better understanding of the current inconsistencies in various BVOC observations and model simulations. The overall benefit of this project will be more accurate VOC emission estimates for the Texas air quality simulations that are critical for scientific understanding and the development of regulatory control strategies that will enhance efforts to improve and maintain clean air.

2.0 Background

Emissions of reactive gases from the earth's surface drive the production of ozone and aerosol and other atmospheric constituents relevant for regional air quality. Emissions of some compounds, including BVOCs, are highly variable and can vary more than an order of magnitude over spatial scales of a few kilometers and time scales of less than a day. This makes estimation of these emissions especially challenging and yet accurate quantification and simulation of these fluxes is a necessary step towards developing air pollution control strategies and for attributing observed atmospheric composition changes to their causes.

3.0 Objectives

The project aims to reduce BVOC emission uncertainties associated with the absolute magnitude of the emissions and the response of the emissions to changes in plant stress (e.g., water and heat stress) and to improve the ability of biogenic emission estimation tools to better predict emissions of monoterpenes and responses to short- and long-term drought stress. This project will incorporate biogenic emission findings from previous Texas projects into a version of a biogenic model appropriate for Texas air quality applications. This will be accomplished by synthesizing results from previous Texas AQRP projects and other studies into a new version of MEGAN, a biogenic emissions model used for predicting BVOC emissions in Texas and other regions.

Our specific objectives include:

1. Develop a database system that provides a transparent approach for estimating BVOC emission factors.
2. Synthesize available isoprene and monoterpenes emission and concentration observations for Texas and surrounding regions, reconcile any discrepancies, and calculate Texas isoprene and monoterpene emission factor best estimates and ranges.
3. Develop a next generation BVOC emission model, MEGAN3, that includes missing compounds and unrepresented processes including stress induced (drought, extreme temperature and air pollution) emissions and canopy heterogeneity.
4. Investigate MEGAN3 model sensitivity and evaluate model emission and ambient concentration estimates using surface and aircraft observations and a photochemical model.

4.0 Task Descriptions

Task 1: Development and application of a transparent approach for estimating BVOC emission factor distributions (Alex Guenther and Ramboll Environ)

Most biogenic VOC emission models assume that emission rates are the product of an emission factor and an emission activity factor, similar to the approach used for most anthropogenic emission estimates. BVOC emissions research has focused on the identification and quantification of processes controlling variations in emission activity, which is not surprising since most studies have been conducted with the intent to publish in the scientific literature and studies focused on emission factors may be considered more mundane and difficult to publish. Yet it is clear that uncertainties in emission factors make an important contribution and may even dominate the total uncertainty in BVOC emission rate estimates (Arneth et al. 2011, Guenther 2013). The task of synthesizing relevant observations and compiling emission factors is challenging, due to the diverse measurement approaches and the immense biological and chemical diversity of BVOC, and up to now has been accomplished through a relatively opaque process. Initial attempts to adopt a more systematic approach, e.g., Benjamin et al. 1996, led to unsatisfactory results due to the limited number of measurements and because of unrepresentative measurements. We propose to revisit the methods used for assigning BVOC emission factors and develop a community BVOC emission factor database using the system outlined in Figure 1. This will be a transparent approach that will enable users to determine the basis of each emission factor and will facilitate updates to emission factors. The approach will enable different weighting of existing observations to account for some observations being more relevant and representative than others. We will use open source software and code to develop a database system that will be freely available to the regulatory and scientific community. The database system and associated input and output data will be freely available and archived in the UCAR community data portal (http://cdp.ucar.edu/acd/megan/). Data will need to be prepared in a predefined format for submission to the database. We will provide templates with examples on the community data portal. Our ultimate vision is for the expert and user communities to contribute to this community database, including both observations and weighting factors, to improve the future accuracy of emission factors that will be available to all users.

The BVOC emission factor database system shown in Figure 1 will consist of data tables, queries to process the data, and input/output modules for formatting the data. The four data tables include: an emission measurement database, an ecoregion chemotype composition database to characterize the chemotypes associated with specific growth forms (e.g. tree, shrubs, herbaceous) in each ecoregion, a growth form distribution database and an ecoregion distribution database.

Task 1 Deliverables:

Community BVOC emission factor database archived in the UCAR community data portal and documentation of database including templates with examples showing how to prepare data for submission to the database in a predefined format.

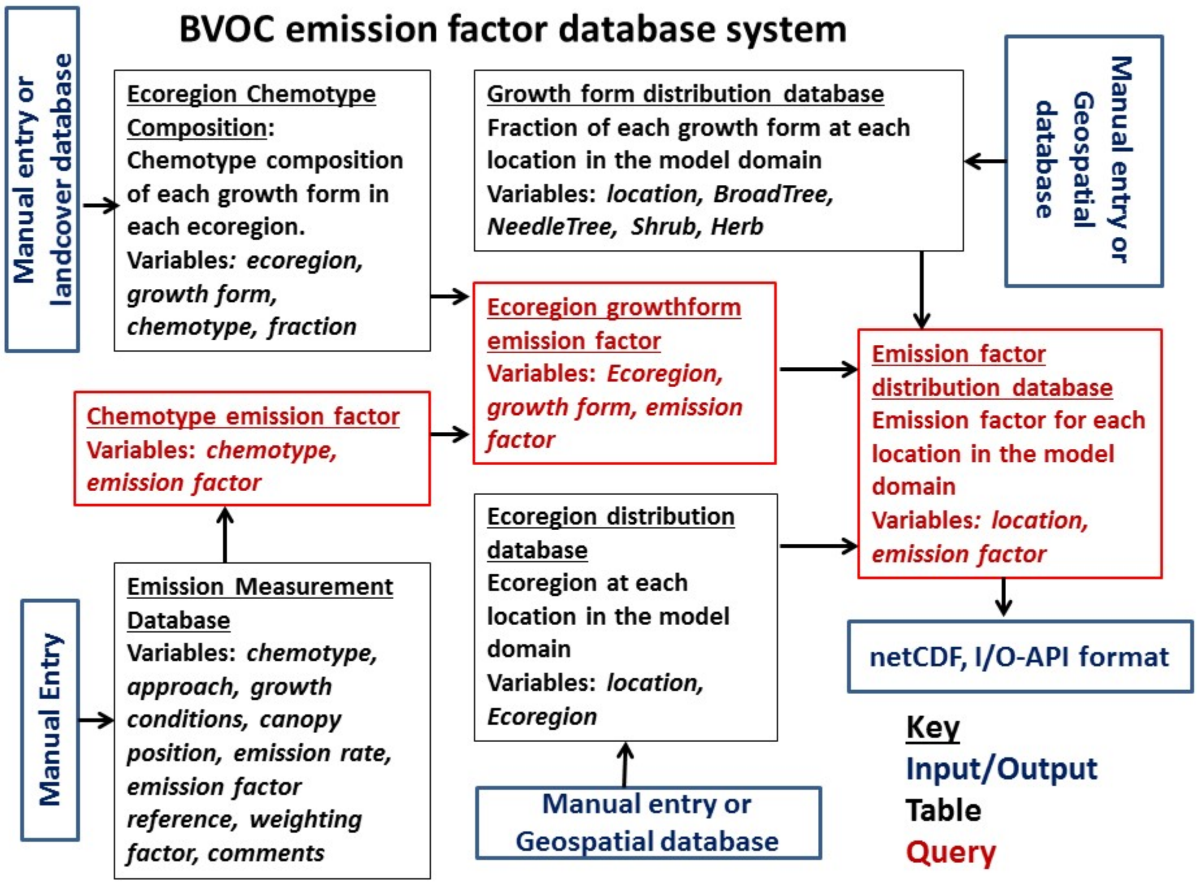

Figure 1. Schematic approach of proposed transparent BVOC emission factor database that can be easily updated.

Task 2: Synthesize, reconcile and calculate isoprene and monoterpene (terpenoid) emission factors for Texas and the surrounding region (Alex Guenther)

Most plant species do not emit substantial amounts of isoprene but those that do emit at such high levels that isoprene is the dominant BVOC emission in many landscapes including many parts of Texas (Guenther et al., 2006). Monoterpene emission capacity is more wide spread but there is still considerable variation. Low and high emitters can occur within the same plant families or genera making the characterization of emission factor distributions a challenging task. However, since trees are the major source of terpenoid emissions from most ecosystems, the task is simplified in regions such as Texas where there are relatively few tree genera that dominate the contribution to the total terpenoid emission. We will examine the observations available for assigning terpenoid emission factors and identify any inconsistencies in those observations. We will also assess the importance of each plant genera/species and ecoregion in Texas and determine whether there are any major gaps in knowledge of terpenoid emission from specific types of Texas vegetation.

Subtask 2.1: Synthesize Texas isoprene and monoterpene emissions data

All available and relevant isoprene and monoterpene observations for Texas and the surrounding region will be compiled into the database system developed for Task 1. This will include leaf, branch, canopy (tower), landscape (aircraft) flux measurements as well as surface, aircraft and satellite data that are suitable for inverse modelling of emission estimates. A weighting factor will be assigned to the emission factor estimated from each set of observations based on the number of measurements, the measurement approach (i.e., direct measurements will be weighted more heavily than indirect measurements) and the ancillary data used to relate the emission rates to an emission factor.

We will compare results from different measurement approaches (e.g., enclosure, aircraft, tower fluxes) as well as compare within a measurement type. For example, we will assess all available observations from emission enclosure studies of individual plants. Geron et al. (2001) have shown that much of the reported variability among isoprene-emitting broadleaf tree species (e.g., Quercus, Liquidambar, Nyssa, Populus, Salix, and Robinia species) can be attributed to weather, plant physiology and the location of a leaf within the canopy rather than genetics. One implication of this finding is that the observations reported from many earlier studies, where these factors were not considered, are highly uncertain for the purpose of assigning emission factors. We will also conduct a detailed examination of the approaches used to convert leaf and branch level emissions to canopy scale emission factors. The various canopy models that can be used for this can generate results that differ by more than 35% (Guenther et al. 2006).

Subtask 2.2: Reconcile Texas terpenoid observations from various studies and approaches

We will investigate the causes for any discrepancies in the various approaches highlighted by the emission factor database compiled for subtask 2.1. This includes bias in estimates of light and temperature (Guenther et al. 2012), inconsistencies in canopy environment models (Guenther et al. 2006), unrepresentative samples (Guenther et al. 1994), and other factors (Arneth et al. 2011). We will consider both differences in emission factors reported for similar techniques as well as differences in emission factors determined from measurements on various scales (tower, aircraft) including observations described in Texas AQRP project 14-016 (Yarwood et al., 2015). We will also investigate the findings from Texas AQRP project 14-30 (Ying et al., 2015) that the “MEGAN model with its own isoprene emission factor (EF) field severely over-predicts observed isoprene concentrations from Automated gas chromatograph (Auto-GC) instruments throughout the continental United States”.

Subtask 2.3: Calculate terpenoid emission factors for Texas and surrounding region

We will apply the emission factor database system developed for Task 1 with the data synthesized for subtasks 2.1 and 2.2 to generate improved isoprene and monoterpene emission factors for Texas vegetation and ecoregion types. In addition to a best estimate of emission factors, we will be able to provide a range with a lower and upper bound. The recommended emission factor and range determined for specific vegetation types will be compared with those currently used in BVOC emission models, including BEIS and MEGAN, and we will review the procedures used for assigning these factors in the current versions of BVOC models.

Task 2 Deliverables: New isoprene and monoterpene emission factors and ranges for Texas vegetation and ecoregion types developed within the database system.

Task 3: Development of MEGAN3 (Alex Guenther and Ramboll Environ)

BVOC emission estimates progressed from a simple calculation based on a single measurement (Went 1960) to compilations of enclosure measurements and regional landcover and weather data in the early 1980s (Zimmerman 1979; Winer 1982). The first EPA biogenic emission model, the Biogenic Emissions Inventory System (BEIS, Pierce and Waldruff, 1991) was adapted from the Lamb et al. (1987) approach developed for acid rain model simulations. The second version of the model (BEIS2), released in the mid-1990s, predicted dramatically higher (about a factor of five) estimates of isoprene emissions (Pierce et al. 1998) and differed in other aspects including leaf level emission algorithms, biomass densities, and landcover distributions. BEIS3 was developed in 2001 and designed for use with the Sparse Matrix Operational Kernel Emissions (SMOKE) emissions system for the Community Multiscale Air Quality (CMAQ). BEISv3.6.1 is the latest version and has two main updates: the use of leaf temperature instead of ambient temperature and a new landcover database (Biogenic Emissions Landuse Database, version 4; BELD4).

The Model of Emission of Gases and Aerosols from Nature (MEGAN), initially developed as a collaborative effort between USEPA and the NSF sponsored National Center for Atmospheric Research (NCAR), was based on BEIS3 but is more flexible and is widely used for scientific and regulatory studies. The most recent update (MEGAN2.1) was released in 2011 and included additional compounds, source types, and emission processes (Guenther et al. 2012). We propose to develop and release an updated version, MEGAN3, that will include the updates and enhancements illustrated in Figure 2 and described below. The code and input files will be freely available and archived in the UCAR community data portal (http://cdp.ucar.edu/acd/megan/).

Subtask 3.1 BVOC emission response to stress

Recent studies have shown that both extreme weather (drought, winds, temperature) and air pollution can substantially modify BVOC emission rates but there have been no attempts to include this process in BVOC emission models. Kaser et al. (2013) concluded that a severe storm caused a 40% increase in monthly total monoterpene emissions from a western U.S. pine plantation. A large increase in whole canopy emissions of total monoterpenes and methyl salicylate was also observed when a U.S. walnut plantation was exposed to temperature extremes (Karl et al. 2008). BVOC emissions induced by ozone and other air pollution stress were estimated to increase total BVOC emissions in the Beijing region by about 65% (Ghirardo et al. 2016). Ozone reactions with diterpenes on leaf surfaces have recently been suggested as an important unaccounted source of BVOC emissions into the atmosphere (Jud et al. 2016). We will create a framework in MEGAN3 to include BVOC emissions induced by extreme weather and air pollution stress. We will synthesize recent observations characterizing BVOC emission response to extreme weather and pollution events to develop an initial approach for incorporating stress induced emissions into BVOC emission models.

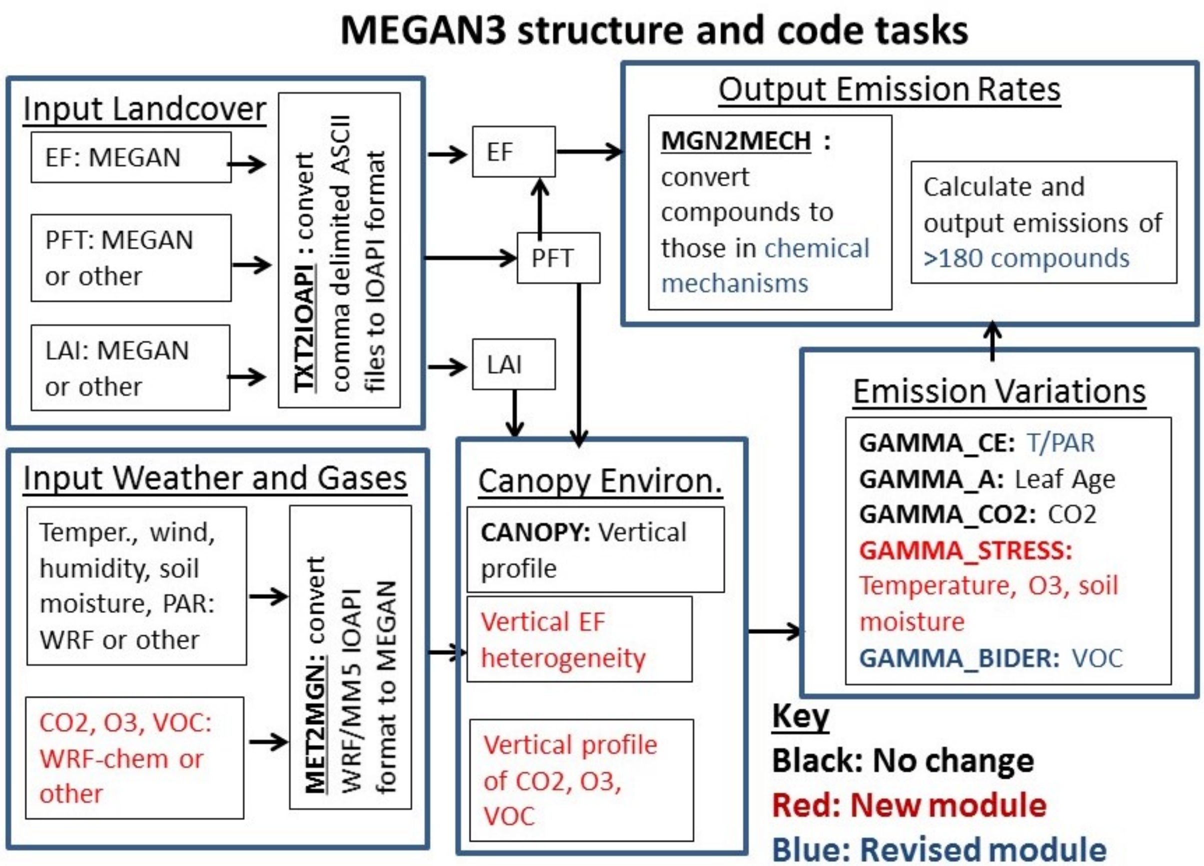

Figure 2. Schematic of MEGAN3 code structure indicating new and revised modules as well as modules that remain unchanged from MEGAN2.1.

Subtask 3.2 Canopy environment and structural heterogeneity

While some BVOC emission models assume that vegetation canopies act as a "big leaf", it has been shown that explicit simulation of canopy environment, especially solar radiation distributions on sun and shade leaves at different canopy depths, can have a substantial impact on predicted emissions, mainly for light dependent compounds such as isoprene. We will improve the procedures used in MEGAN to estimate the vertical canopy environment profile and the associated influence on emissions. This will include modifying the current approach which assumes a uniform vertical distribution of emission factors within the canopy environment. Bryan et al. (2015) have shown that using a realistic (heterogeneous) tree species profile changed predicted isoprene emissions by 34% in a Michigan forest. A preliminary examination of forestry statistics for Texas and the surrounding region suggests that isoprene emitters in the mixed forests of this region tend to be in the understory, with relatively little light for producing isoprene, which means that assuming a constant canopy vertical emission factor distribution could greatly overestimate isoprene emissions. We will use tree canopy height distribution data from the US Forestry Inventory and Analysis (FIA) statistics database to partition tree species into the upper and lower canopy and determine the vertical distribution of isoprene emission factors for specific ecosystems. In contrast to the approach used in BEIS and MEGAN2.1, the MEGAN3 approach will calculate the emissions at each canopy level as the product of the emission factor and emission activity at each level.

Subtask 3.3 Revise emission categories and include additional compounds.

Recent studies have revealed additional BVOC (e.g., 3-pentanone, 1-penten-3-ol, methyl vinyl ketone, carbon tetrachloride, benzothiazole) that are emitted from vegetation in significant amounts but are not included in the list of 146 VOC species included in MEGANv2.1. These compounds will be included in MEGAN3 and the existing 18 categories (which include some individual VOC such as isoprene and alpha-pinene as well as some groups of compounds) will be revised. In addition, MEGAN3 will account for the existence of undetected BVOC that have been inferred based on discrepancies between calculated and observed loss rates of oxidants, “missing OH reactivity” (e.g., Di Carlo et al. 2004, Nolscher et al. 2016), and associated with unidentified BVOC. Enclosure emission measurement studies of missing OH reactivity (e.g., Kim et al. 2011) will be used to assign values to the MEGAN3 “missing BVOC” emission category. While there will be some additional BVOC emission categories created for MEGAN3, there will also be a merging of some categories so that the total number of categories in MEGAN3 is expected to be about the same as with MEGAN2.1. Compounds will be grouped by their production/emission pathways, so that their emission response can be simulated by a common emission activity algorithm, and by their atmospheric impacts (e.g., OH reactivity, ozone production potential, SOA yields).

Subtask 3.4 PFT dependent emission traits

The use of variable emission traits (i.e. different parameters) allows MEGAN to account for differences among plant types. Presently, the only emission trait that can be specified in MEGAN is the emission factor. Other traits (e.g., temperature response parameters, light dependent fraction) are constant for all plants even though it is well known that there is considerable variation. For example, a-pinene emissions from tropical forest trees are almost entirely light dependent while only a small part of the a-pinene emission from temperate forest trees is light dependent. MEGANv2.1 uses a constant value (=0.6) for the light dependent fraction of a-pinene emission from all trees. We will implement an approach in MEGAN3 that will enable representation of the variation of parameters, such as light dependent fraction of a-pinene, in order to more realistically represent these important emission traits.

Subtask 3.5 Update existing parameters

Results from recent studies and recommendations from the MEGAN user community will be synthesized and used as the basis for updating the existing MEGAN parameters. This will include parameters in the emission algorithms, the canopy environment model, and the chemical species to chemical mechanisms mapping scheme. Any changes will be documented and the reason for the change will be described and justified.

Subtask 3.6 Clarify existing code

Several aspects of the MEGAN2.1 code will be clarified in order to minimize confusion and potential errors. Examples include 1) modifying the code to use same Plant Functional Type (PFT) naming convention as that used in the Community Land Model (CLM). The MEGAN2.1 PFT designations for "Needleleaf Evergreen Boreal Tree" and "Needleleaf Deciduous Boreal Tree" are different than those used by CLM, 2) replace “isoil” with “ifsoil” in the MEGAN soil NOx code, and 3) remove the code referring to the Palmer Drought Index which is no longer used in MEGAN. The last issue was pointed out in the final report of the Texas AQRP project 14-030 (Ying et al., 2015).

Subtask 3.7 Update MEGAN documentation and users guide

The updates to the MEGAN code and emission factor preprocessor proposed for this project will be accompanied by relevant updates to the existing MEGAN documentation and users guide.

<u>Task 3 Deliverables</u>: MEGAN3 biogenic emissions model code and updated documentation and user’s guide.

Task 4: MEGAN evaluation and sensitivity study (Ramboll Environ)

The objective of Task 4 is to investigate MEGAN3 model sensitivity and evaluate model emission and ambient concentration estimates using surface and aircraft observations. We will carry out emissions sensitivity modeling in support of the Task 2 isoprene emission factor database development and the Task 3 MEGAN3 development. We will select a small number of best estimate and/or sensitivity test MEGAN3 emission inventories for comparison against aircraft flux data from the 2013 Southeast Atmosphere Study (SAS) and evaluate them using a photochemical model. The purpose of the evaluation is to constrain the MEGAN3 emissions using the SAS aircraft flux and concentration data together with the photochemical model.

The Comprehensive Air quality Model with Extensions (CAMx; Ramboll Environ, 2016) version 6.30 with IEEE compile flag will be used to model fluxes and atmospheric concentrations of BVOCs. The AQRP Project 14-016 2013 modeling platform will be used. The modeling domain and time period encompass nearly all of the overland flight tracks of the NCAR C-130 and NOAA P-3 aircraft. A detailed description of the aircraft data and the CAMx modeling platform are available in Yarwood et al. (2015). For the selected MEGAN3 emission inventories, we will compare modeled and measured BVOC fluxes and concentrations along the aircraft flight tracks.

Task 4 Deliverables: All MEGAN inputs and modeling files and all CAMx modeling files and evaluation of MEGAN and CAMx model results against ambient data.

Task 5: Project Management (Ramboll Environ), Reporting and Presentation (Alex Guenther and Ramboll Environ)

As specified in Section 7.0 "Deliverables" of this Scope of Work, AQRP requires the regular and timely submission of monthly technical, monthly financial status and quarterly reports as well as an abstract at project initiation and, near the end of the project, submission of the draft final and final reports. Additionally, at least one member of the project team will attend and present at the AQRP data workshop. For each reporting deliverable, one report per project will be submitted (collaborators will not submit separate reports), with the exception of the Financial Status Reports (FSRs). The lead PI (or their designee) will electronically submit each report to both the AQRP and TCEQ liaisons and will follow the State of Texas accessibility requirements as set forth by the Texas State Department of Information Resources. The report templates and accessibility guidelines found on the AQRP website at http://aqrp.ceer.utexas.edu/ will be followed. ****Draft copies of any planned presentations (such as at technical conferences) or manuscripts to be submitted for publication resulting from this project will be provided to both the AQRP and TCEQ liaisons per the Publication/Publicity Guidelines included in Attachment G of the subaward.**** Finally, our team will prepare and submit our final project data and associated metadata to the AQRP archive.

Task 5 Deliverables: Abstract, monthly technical reports, monthly financial status reports, quarterly reports, draft final report, final report, attendance and presentation at AQRP data workshop, submissions of presentations and manuscripts, project data and associated metadata

The schedule for Task 5 deliverables is shown in Section 7.

5.0 Project Participants and Responsibilities

This project is being conducted by Ramboll Environ and Alex Guenther under a grant from the Texas Air Quality Research Program. The project Co-Principal Investigators (PIs) are Dr. Greg Yarwood and Dr. Sue Kemball-Cook of Ramboll Environ and Dr. Alex Guenther. The Co-PIs will assume overall responsibility for the research and associated quality assurance. Dr. Guenther will lead the development of the BVOC emission factor database system and will calculate terpenoid emission factors for Texas and surrounding regions. Dr. Guenther will also direct the development of MEGAN3. Dr. Kemball-Cook will oversee the Ramboll Environ effort in development of the BVOC database and MEGAN3 and the evaluation of the new inventories using a regional photochemical model. She will be responsible for project management and reporting. Dr. Yarwood will provide technical guidance and oversight. All Principal Investigators will contribute to the final report.

The project will be overseen by AQRP Project Manager Dr. Elena McDonald-Buller and TCEQ Project Liaison Mr. Doug Boyer. The personnel working on this project and their specific responsibilities are listed in the Table below.

Participant	Project Responsibility
Dr. Greg Yarwood (Ramboll Environ)	Co-Principal Investigator: Project oversight; responsible for providing technical guidance and review of reports and presentations
Dr. Susan Kemball-Cook (Ramboll Environ)	Co-Principal Investigator: Project oversight, management and reporting; responsible for Ramboll Environ effort in development of the BVOC database and MEGAN3 and the evaluation of MEGAN3 inventories using a regional photochemical model.
Dr. Alex Guenther	Co-Principal Investigator: Lead researcher; responsible for development of the BVOC emission factor database system, calculation of terpenoid emission factors for Texas and surrounding regions, direction of the development of MEGAN3, and contributions to final report
Mr. Tejas Shah (Ramboll Environ)	Project Manager, Ramboll Environ: responsible for development of emission factor database and update of MEGAN3 code.
Ms. Michele Jimenez (Ramboll Environ)	Develop emission factor database
Dr. Ling Huang (Ramboll Environ)	Develop MEGAN3 model code
Mr. Jeremiah Johnson (Ramboll Environ)	Conduct MEGAN3 and CAMx modeling and perform model evaluation

6.0 Timeline

The project schedule by task is presented below with associated deliverables. The project start date is assumed to be September 1, 2016. Technical work will not begin until final funding authorization by TCEQ and AQRP. The entire project will be completed by August 31, 2017.

Figure 3. Schedule of project activities.

Task	Task Name	Task Manager	Duration	2016					2017										
				8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11
				AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV
Task 1	Develop Community BVOC EF Database System	AG/TS	4 mo		■	■	■	■											
Task 2	Terpenoid EFs for Texas and Surrounding Region																		
Task 2.1	Synthesize TX emissions data	AG	4 mo		■	■	■	■											
Task 2.2	Reconcile TX terpenoid emissions data	AG	4 mo			■	■	■	■										
Task 2.3	Calculate TX terpenoid EFs	AG	1 mo							■									
Task 3	Development of MEGAN3																		
Task 3.1	BVOC Emission Response to Stress	AG/TS	6 mo					■	■	■	■	■	■						
Task 3.2	Canopy Environment and Structural Heterogeneity	AG/TS	6 mo			■	■	■	■	■	■								
Task 3.3	Revise Emission Categories/Add New Compounds	AG/TS	3 mo								■	■	■						
Task 3.4	PFT Dependent Emission Traits	AG/TS	3 mo							■	■	■							
Task 3.5	Update Existing Parameters	AG/TS	2 mo						■	■									
Task 3.6	Clarify Existing Code	AG/TS	1 mo					■											
Task 3.7	Update MEGAN Documentation and User's Guide	AG/TS	2 mo											■	■				
Task 4	MEGAN3 Evaluation and Sensitivity Study	JJ/TS/SKC	3 mo									■	■	■					
Task 5	Project Management																		
Task 5.1	Contract, Work Plan, QAPP, Abstract	SKC	2 wk	■															
Task 5.2	Draft and Final Report	AG/SKC/TS/GY	2 mo											■	■ Draft	■ Final			
Task 5.3	AQRP Meeting Presentation	AG/SKC/TS/GY	3 wk												■	■			
Task 5.4	Compile and Submit Deliverables	SKC	1 wk														■		
Task 5.5	Monthly Technical Reports	SKC/TS	1 day		■	■	■	■	■	■	■	■	■	■	■	■	■		
Task 5.6	Financial Status Reports	SKC	1 day		■	■	■	■	■	■	■	■	■	■	■	■	■	■	
Task 5.7	Quarterly Reports	SKC/TS	1 day	■			■			■			■			■	■	■	■

7.0 Deliverables

AQRP requires certain reports to be submitted on a timely basis and at regular intervals. A description of the specific reports to be submitted and their due dates are outlined below. One report per project will be submitted (collaborators will not submit separate reports), with the exception of the Financial Status Reports (FSRs). The lead PI will submit the reports, unless that responsibility is otherwise delegated with the approval of the Project Manager. All reports will be written in third person and will follow the State of Texas accessibility requirements as set forth by the Texas State Department of Information Resources. Report templates and accessibility guidelines found on the AQRP website at http://aqrp.ceer.utexas.edu/ will be followed.

Abstract: At the beginning of the project, an Abstract will be submitted to the Project Manager for use on the AQRP website. The Abstract will provide a brief description of the planned project activities, and will be written for a non-technical audience.

Abstract Due Date: Wednesday, August 31, 2016

Quarterly Reports: Each Quarterly Report will provide a summary of the project status for each reporting period. It will be submitted to the Project Manager as a Microsoft Word file. It will not exceed 2 pages and will be text only. No cover page is required. This document will be inserted into an AQRP compiled report to the TCEQ.

Quarterly Report Due Dates:

Report	Period Covered	Due Date
Aug2016 Quarterly Report	June, July, August 2016	Wednesday, August 31, 2016
Nov2016 Quarterly Report	September, October, November 2016	Wednesday, November 30, 2016
Feb2017 Quarterly Report	December 2016, January & February 2017	Tuesday, February 28, 2017
May2017 Quarterly Report	March, April, May 2017	Friday, May 31, 2017
Aug2017 Quarterly Report	June, July, August 2017	Thursday, August 31, 2017
Nov2017 Quarterly Report	September, October, November 2017	Thursday, November 30, 2017

Monthly Technical Reports (MTRs): Technical Reports will be submitted monthly to the Project Manager and TCEQ Liaison in Microsoft Word format using the AQRP FY16-17 MTR Template found on the AQRP website.

MTR Due Dates:

Report	Period Covered	Due Date
Sep2016 MTR	September 1 - 30, 2016	Monday, October 10, 2016
Oct2016 MTR	October 1 - 31, 2016	Tuesday, November 8, 2016
Nov2016 MTR	November 1 - 30 2016	Thursday, December 8, 2016
Dec2016 MTR	December 1 - 31, 2016	Monday, January 9, 2017
Jan2017 MTR	January 1 - 31, 2017	Wednesday, February 8, 2017
Feb2017 MTR	February 1 - 28, 2017	Wednesday, March 8, 2017
Mar2017 MTR	March 1 - 31, 2017	Monday, April 10, 2017
Apr2017 MTR	April 1 - 28, 2017	Monday, May 8, 2017
May2017 MTR	May 1 - 31, 2017	Thursday, June 8, 2017
Jun2017 MTR	June 1 - 30, 2017	Monday, July 10, 2017
Jul2017 MTR	July 1 - 31, 2017	Tuesday, August 8, 2017

Financial Status Reports (FSRs): Financial Status Reports will be submitted monthly to the AQRP Grant Manager (Maria Stanzione) by each institution on the project using the AQRP FY16-17 FSR Template found on the AQRP website.

FSR Due Dates:

Report	Period Covered	Due Date
Sep2016 FSR	September 1 - 30, 2016	Monday, October 17, 2016
Oct2016 FSR	October 1 - 31, 2016	Tuesday, November 15, 2016
Nov2016 FSR	November 1 - 30 2016	Thursday, December 15, 2016
Dec2016 FSR	December 1 - 31, 2016	Tuesday, January 17, 2017
Jan2017 FSR	January 1 - 31, 2017	Wednesday, February 15, 2017
Feb2017 FSR	February 1 - 28, 2017	Wednesday, March 15, 2017
Mar2017 FSR	March 1 - 31, 2017	Monday, April 17, 2017
Apr2017 FSR	April 1 - 28, 2017	Monday, May 15, 2017
May2017 FSR	May 1 - 31, 2017	Thursday, June 15, 2017
Jun2017 FSR	June 1 - 30, 2017	Monday, July 17, 2017
Jul2017 FSR	July 1 - 31, 2017	Tuesday, August 15, 2017
Aug2017 FSR	August 1 - 31, 2017	Friday, September 15, 2017
FINAL FSR	Final FSR	Monday, October 16, 2017

Draft Final Report: A Draft Final Report will be submitted to the Project Manager and the TCEQ Liaison. It will include an Executive Summary. It will be written in third person and will follow the State of Texas accessibility requirements as set forth by the Texas State Department of Information Resources. It will also include a report of the QA findings.

Draft Final Report Due Date: Tuesday, August 1, 2017

Final Report: A Final Report incorporating comments from the AQRP and TCEQ review of the Draft Final Report will be submitted to the Project Manager and the TCEQ Liaison. It will be written in third person and will follow the State of Texas accessibility requirements as set forth by the Texas State Department of Information Resources.

Final Report Due Date: Thursday, August 31, 2017

Project Data: All project data including but not limited to QA/QC measurement data, metadata, databases, modeling inputs and outputs, etc., will be submitted to the AQRP Project Manager within 30 days of project completion (September 29, 2017). The data will be submitted in a format that will allow AQRP or TCEQ or other outside parties to utilize the information. It will also include a report of the QA findings.

AQRP Workshop: A representative from the project will present at the AQRP Workshop in the first half of August 2017.

Presentations and Publications/Posters: All data and other information developed under this project which is included in **published papers, symposia, presentations, press releases, websites and/or other publications** shall be submitted to the AQRP Project Manager and the TCEQ Liaison per the Publication/Publicity Guidelines included in Attachment G of the Subaward.

8.0 References

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