

Scope of Work For

Project # 19-025

Apportioning the Sources of Ozone Production during the San Antonio Field Study

Prepared for

Air Quality Research Program (AQRP)

The University of Texas at Austin

By

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Aerodyne Research, Inc.

October 5th, 2018

Version #3

QA Requirements: Audits of Data Quality: 10% Required

Report of QA Findings: Required in Final Report

NOTE: The workplan package consists of three independent documents: Scope of Work, Quality Assurance Project Plan (QAPP), and budget and justification. Please deliver each document (as well as all subsequent documents submitted to AQRP) in Microsoft Word format.

Approvals

This Scope of Work was approved electronically on **October 15, 2018** by Elena McDonald-Buller, The University of Texas at Austin

Elena McDonald-Buller
Project Manager, Texas Air Quality Research Program

This Scope of Work was approved electronically on **October 15, 2018** by Bright Dornblaser, Texas Commission on Environmental Quality

Bright Dornblaser
Project Liaison, Texas Commission on Environmental Quality

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1.0 Abstract

Ozone high up in the stratosphere is protective against UV rays, but when it is present at ground-level, it is a pollutant that can cause shortness of breath and other respiratory health problems. With new federal ozone standards in effect, it is more important than ever to understand the causes of ozone in and around San Antonio.

Ozone is formed when volatile organic hydrocarbons (VOCs) react with the nitrogen oxides (NO_x, the primary component in smog). A wide variety of VOCs are present in the air around cities such as San Antonio; they stem from sources as varied as vehicle exhaust, oil and gas extraction, and trees and vegetation. This project aims to discover which sources contribute to the formation of ground-level ozone in and around San Antonio, and in what quantities.

Raw data from the 2017 San Antonio Field Study (SAFS) will be examined closely and analyzed in full to identify characteristic sets of VOCs associated with different source types. Computer modeling of air transport will help identify the broad geographic areas where the measured air originated. An ozone formation computer model, in which individual source categories can be turned on, off, or varied, will be used to understand how each source type contributes to ozone formation in and around San Antonio.

2.0 Background

The Environmental Protection Agency (EPA) designates ozone as a criteria pollutant. The EPA has designated Bexar County, which includes the city of San Antonio, in nonattainment for federal ozone standards. Ozone is formed in a complicated series of reactions of volatile organic compounds (VOCs) with nitrogen oxides (NO_x). Mitigation strategies require an understanding of not only of the fundamental chemical regime (“VOC limited” vs “NO_x limited”) but also of the source types or industry sectors whose emissions have the greatest impact on ozone formation.

Aerodyne Research, Inc. will conduct analysis of field data collected during the 2017 San Antonio Field Study (SAFS) in order to understand and apportion ozone formation in the studied area. As a core participant in SAFS, Aerodyne collected, submitted and analyzed field data for ozone, NO_x, trace gases, and mass-spectrometer-based measurements of VOCs and semi-VOCs (SVOCs), oxygenated VOCs (OVOCs) and particulate matter (PM). Here, we propose to mine the gigabytes worth of mass data via high-resolution analysis.

Reprocessing of the dataset with high-resolution methods will identify previously unreported chemical species, while improving detection limits on existing results. With high-resolution data in hand, we will then continue down three core analysis pathways that directly address the 2018-2019 priority research areas of the Texas Air Quality Research Program (AQRP).

- Priority A: “How much do the different source categories contribute to the peak concentrations [of ozone] observed?” and “Can contributing source categories be identified and quantified from measurement data alone”?
- Priority B: “Collaborate and share data with other SAFS participants”)

- Priority C: “How much do upwind source categories contribute [to ozone formation in San Antonio]”

Photochemical box modeling will use VOC inputs to constrain and understand the formation of ozone. Positive Matrix Factorization (PMF) is a mathematical technique that groups species with similar sources together, based on their time series. PMF will be used to identify characteristic source categories, or “factors”, in the data. For example, we may find sets of VOCs from evaporative condensate emissions vs sets of VOCs from trees (Priority A), and will look to identify other specific industry sectors. HYSPLIT footprint analysis will draw borders on a map indicating where the sampled air mass likely originated (Priority C). This source region information will inform and complement the analysis and interpretation of individual groups of compounds from the PMF analysis. Finally, these groups will be fed back into the box model, varying their contributions as needed to constrain ozone formation in the San Antonio area (Priority A). Together, this research will allow for a sector-based apportionment of OH reactivity in the SAFS area.

3.0 Objectives

The project has the following objectives:

- Perform high-resolution fitting of the mass-spectrometer-acquired data from the San Antonio Field Study (SAFS).
- Constrain the formation of ozone using photochemical box modeling and input data from SAFS.
- Identify the source regions of measured air masses using HYSPLIT footprint analysis.
- Identify sets of chemical species that vary together using Positive Matrix Factorization (PMF).
- Interpret these covarying species into characteristic source categories (e.g. evaporative condensate emissions vs isoprene and other tree emissions).
- Perform a sector-based apportionment of OH reactivity in the SAFS area using the photochemical box model run with varying contributions of the identified source categories.

Throughout, we will communicate and share preliminary results with other SAFS participants. Most notably, this project couples strongly with **AQRP Project 18-040: Analysis of Ozone Production Data from the San Antonio Field Study** by Dr. Ezra Wood at Drexel University in Philadelphia, and with a separately funded study by Dr. James Flynn at the University of Houston, Texas.

These specific project objectives directly address the 2018-2019 priority research areas of the Texas Air Quality Research Program (AQRP).

- “How much do the different source categories contribute to the peak concentrations [of ozone] observed?” and “Can contributing source categories be identified and quantified from measurement data alone”?
- “Collaborate and share data with other SAFS participants”)
- “How much do upwind source categories contribute [to ozone formation in San Antonio?]”

4.0 Task Descriptions

4.1 High-resolution Analysis of Mass Spectrometer Datasets

In this task, we will identify the large number of peaks in the high-resolution mass spectrometry datasets from the SAFS. The result will be time series of analytes (both absolute calibrated and relative intensity) that can be shared with other SAFS researchers (Priority B).

Recent developments in high-resolution time-of-flight mass-spectrometry (HR-ToF-MS) have made possible the direct detection of gas-phase atmospheric organic compounds in real time. Three HR-ToF-MS instruments were deployed during the SAFS: a proton transfer reaction ToF (PTR-ToF), an iodide ion ToF (I⁻CIMS, for short) and a gas-chromatography ToF (GC-TOF). The majority of PTR-ToF signals comprise primary VOC emissions such as benzene or isoprene, and some lightly oxidized products of atmospheric photochemistry such as acetone or butanone. The I⁻CIMS, on the other hand, detected many highly oxygenated organic nitrates and hydroperoxides that are produced from the photochemical oxidation of VOCs. The GC-ToF quantitated hydrocarbon species: alkanes, aromatics, cycloalkanes and biogenic (e.g. isoprene), while measuring response from oxygenated and halogenated organic carbon species as well. Each of the PTR-ToF, I⁻CIMS and GC-ToF detected hundreds to thousands of mass spectral signals in varying quantities at all SAFS measurement sites with little overlap between instruments in identified elemental formulas.

Many of the most abundant mass spectral signals are well-defined and easily identified. For example, at mass-to-charge (m/Q) 59, the PTR-ToF observes only protonated acetone ($C_3H_6OH^+$). Many such common PTR-ToF and I⁻CIMS signals have been previously identified in peer-reviewed literature (e.g. Koss et al.¹ and Lee et al.², respectively), and have already been applied to the SAFS peak lists.

However, smaller signals often have several possible elemental formulas that may not be separated at the mass-resolving power of the instrument. Figure 1 shows an example of an average mass spectrum m/Q 247. At least 7 peaks can be observed in the mass spectrum. Each of the peaks can be fit to one of several possible elemental formulas, depending on the probable atomic constituents.

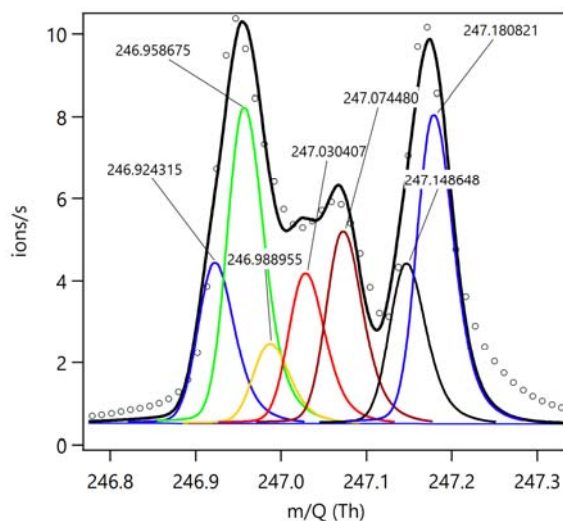


Figure 1. an averaged mass spectrum from the I-CIMS at the San Antonio measurement site during the SAFS. This example is relevant to all mass-spectral methods deployed at the SAFS.

Published peak lists have only recently begun identifying oxidation products of VOCs in oil and gas regions,³ and so the identified peaks in this task may reveal additional potentially novel molecular tracers of specific emission sources. High-resolution fitting can also allow for lower limits of detection for previously-reported species, through the separation of unit-resolved signal to the constituent ion responses. This, in turn, may allow for reduced uncertainties in the reported mixing ratios for the various species we have already reported.

Results of the high-resolution fitting procedure are required for subsequent tasks, notably the positive matrix factorization (PMF) task, Task 3. However, preliminary high-resolution fits that include individual peaks but without a final chemical assignment are already useful for the first stages of PMF. Indeed the initial PMF results can feed back into Task 1, helping with peak identification.

Task 1 Deliverables:

- Time series of all high-resolution fits (in order of preference: absolute calibrated data in ppb when available; estimated calibration factor based on chemical identification;⁴ relative intensities.)
- Data description including calibration factor or scaling factor applied.

4.2 0-D Photochemical Box Modeling

The purpose of this task will be to use the VOC data to constrain a detailed photochemical box model such as the master chemical mechanism (MCM). The results of this modeling will allow the synthesized OH reactivity ($k[\text{OH}]$) to be apportioned among the different VOC emissions categories input (Priority A). The end product of this sub task will be at a minimum, a time series of total OH reactivity that will be shared with other SAFS scientists (Priority B).

We will employ the Dynamically Simple Model for Atmospheric Chemical Complexity (DSMACC) package that uses the Master Chemical Mechanism (MCM) to model complex photochemistry. The MCM is a large, community-developed, near-explicit sequence of chemical reactions that govern the tropospheric oxidation of emitted VOCs (anthropogenic and biogenic). It tracks primary emissions and partial oxidation products that are not commonly quantified. The compounds measured analytically during the field campaign with known calibration factors will be constrained in the DSMACC with the reactive intermediate species allowed to run to photo-stationary state. The ensemble of species will be used to calculate OH reactivity. An example of such an OH reactivity apportionment is depicted in Figure 2.⁵ Mao *et al.* compare the chemical type (e.g. alkanes vs alkenes) responsible for OH reactivity in very different cities, and finds, for example, that alkenes are much more important in Houston than in NYC.

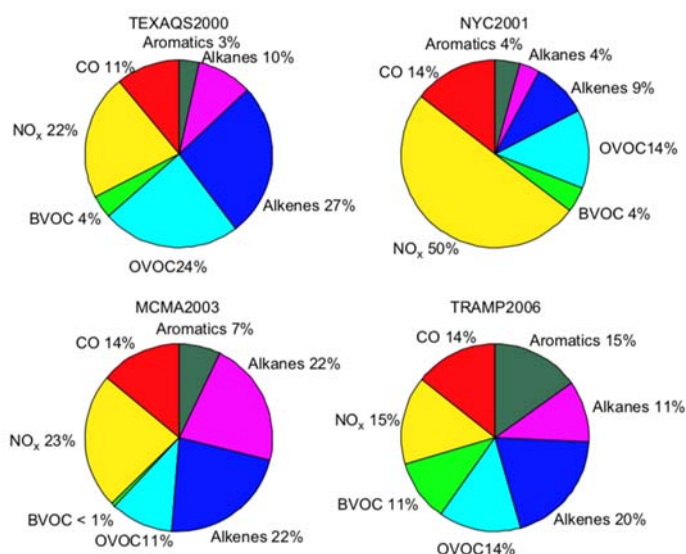


Figure 2. Contributions of different atmospheric constituents to OH reactivity in Houston (TEXAQS2000), New York City (NYC2001), Mexico City (MCMA2003) and Houston (TRAMP2006). Figure taken from Mao *et al.*⁵

In this task, rather than the evaluating $k[\text{OH}]$ by chemical class, we will use VOC emission fingerprints by source type. Initially, the source types will be constructed based both on literature analysis of different emissions profiles (e.g. unburned gasoline, dry natural gas., biogenic isoprene and terpenes), allowing for a sector-based apportionment of OH reactivity. In later stages, the model will be used with the source types calculated via PMF (see Task 3),

Interpretation of this $k[\text{OH}]$ apportionment will be facilitated by the footprint calculations undertaken in Task 4. The footprints, which identify a source region for the sampled airmass, can help identify contributions of local versus transported emissions, for example. Comparison of these box model results will also be done to the ozone production rate measurement and the analysis performed by Drexel University (Priority B). Ultimately, these apportionments of

OH reactivity will inform predictions of high-ozone periods outside the time period of the field intensive and could reveal gaps in ozone prediction models for the San Antonio region.

Task 2 Deliverables:

- Time series of total OH reactivity
- Analysis results to be included in Monthly Technical Reports and Final Report

4.3 Positive Matrix Factorization (PMF)

The purpose of this task is to use the high-resolution mass spectral VOC and OVOC datasets generated in Task 1 to classify the measured VOCs and OVOCs according to their different sources. In order to do so, we use Positive Matrix Factorization (PMF) analysis,⁶ a multivariate analysis technique which allows for the deconvolution of measured mass spectra into distinct groups of ions with similar source regions and/or photochemical processes. The result of this task will be combined with the results the air mass footprint data product (Task 4) to evaluate these techniques and to identify regional emission source factors (Priority A).

Previous work^{7,8} has shown that PMF can be effectively used to classify the wide range of gas phase species present in complex ambient environments. Yan et al., for example, analyzed CIMS measurements of highly oxidized gas phase organic molecules measured in Hyytiälä, Finland, using PMF to separate gas phase species from local and transported pollution sources as well as from different photochemical processing conditions.⁸ More recently, Massoli et al. applied PMF to ToF-CIMS data from a biogenically influenced field site, distinguishing between species from isoprene and terpene sources versus those formed under different oxidation regimes (ozonolysis, NO₃ radical oxidation and high NO_x OH photochemistry).⁹ In this analysis, the high-resolution spectra were particularly useful for identifying and distinguishing between species produced from chemistry involving high NO_x and/or NO₃ radical conditions.

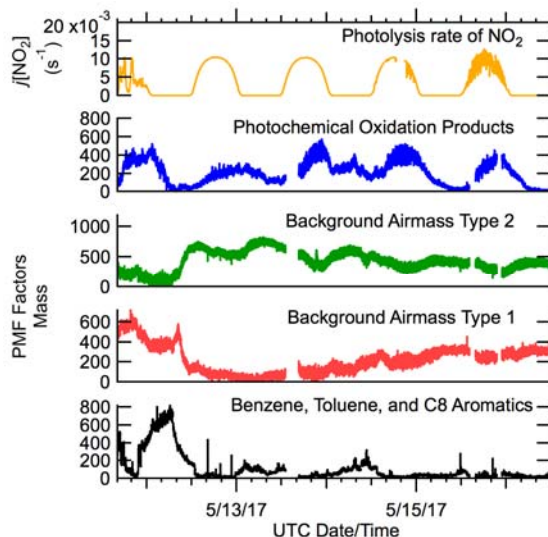


Figure 3. Time series of PMF factors obtained from a preliminary PMF analysis of the unit mass resolution PTR-ToF data measured during SAFS 2017. The calculated photolysis rate of NO_2 is shown for comparison.

Figure 3 shows the results from a preliminary PMF analysis of the unit-mass resolution spectra collected with the PTR-ToF during SAFS 2017. The time trends of the four extracted PMF factors are shown and the factors are identified according to the different signature ions that are present in the corresponding factor mass spectra. The PMF factor time trends indicate a clear shift in the gas phase composition of the airmasses sampled before and after 5/13/2017 (UTC). Based on the mass spectra (not shown), it is also clear that one of the PMF factors (black trace, Figure 3) corresponds to aromatic gas phase species. On the other hand, the blue trace in Figure 3, corresponds to species such as isoprene and isoprene oxidation products (MEK/MVK) as well as oxidation products of aromatics and cycloalkanes observed in oil and gas-production regions.³ It varies diurnally, as can be seen with a comparison with the photolysis rate of NO_2 (yellow). Koss et al. have shown that many of the ions observed in oil and gas-production regions have potential isobaric and isomeric interferences from other sources when analyzed with unit-mass resolution.³ Thus, while this preliminary data analysis already shows promising results, PMF analysis of the high-resolution spectra is needed for better separation of sources observed in the SAFS dataset.

In the proposed work, PMF analysis will be performed separately on the high-resolution PTR-ToF and the high-resolution I-CIMS datasets. This analysis will be used to identify the key sources of variability for the high-resolution ions observed in each of the datasets. A PMF analysis of the combined PTR-ToF and I-CIMS dataset will also be explored since it would have the potential for providing better separation and identification of sources/processes that cannot be resolved with either dataset alone.

The GC-ToF dataset contains both chromatographic information (retention times) and mass data (fragmentation of the eluting compounds) for each air sample (~3 per hour). The application of PMF to this dataset is an area of active research, and we will pursue two different

approaches as part of this task. First, PMF can be run on a single chromatogram (one sample, all retention times) to identify additional quantifiable compounds based on co-variation of multiple fragmentation masses. Second, PMF can be run on a portion of a chromatogram for timeseries (many samples, one retention time window), showing which newly identified species have similar time trends (and potentially similar sources) as those from the other instruments.

It is useful to note that a key advantage of the PMF technique for this analysis is that it does not require *a-priori* information and is thus ideal for identifying new and unknown sources in complex environments. This also means that even preliminary high-resolution fit results without chemically identified species can be usefully analyzed. Correlations of the PMF factors with all the other co-located measurements such as O₃, NO_x, and VOCs will be exploited in order to interpret the PMF factors. Identification of the PMF factors will be also based on comparisons with factor mass spectra observed in previous studies. This includes the database of CIMS spectra compiled from previous and on-going experiments at ARI that involve laboratory photooxidation of various precursors in a potential aerosol mass (PAM) oxidation flow reactor.¹⁰

Task 3 Deliverables:

- PMF analysis results to be included in Monthly Technical and Final Report.

4.4 Back-trajectory footprint analysis

The purpose of this task will be to produce back-trajectory sample footprints. These will be shared with SAFS researchers (Priority B). Comparing the calculated footprint at a given measurement time will allow for a better interpretation of which source categories are influencing the sampled air (Priority C), and ultimately how these categories contribute to ozone formation (Priority A).

Previous studies have looked at the impact of sources “upwind” and “downwind.” For example, Schade et al. show clear differences in hydrocarbon concentrations depending on wind direction.¹¹ This task takes a wind direction analysis even further, looking instead at a specific “footprint”, or source region.

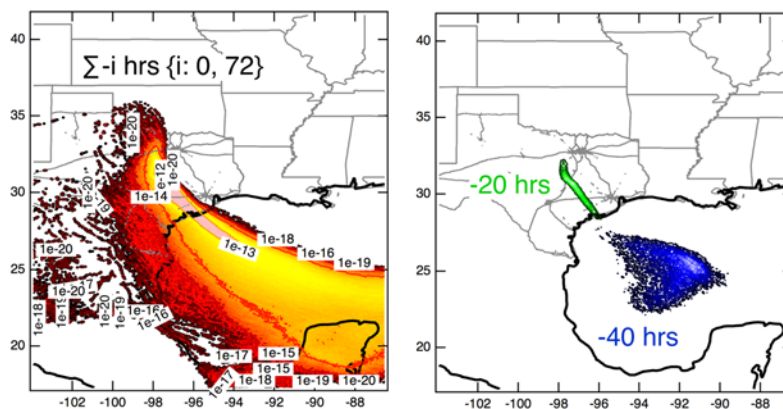


Figure 4. Development of the “footprint” for 2017/05/21 08:00. The top panel shows two HYSPLIT runs at minus 20 and minus 40 hours (green field and blue field, respectively). The bottom panel shows the result of geographically summing each of the HYSPLIT runs for the prior 72 hours.

A sample footprint using the NOAA HYSPLIT¹²⁻¹⁴ model is shown in Figure 4. This simulation was for an air mass sampled at the University of Texas, San Antonio (UTSA) SAFS site. The 72-hour footprint (bottom panel) is constructed by summing the contributions of individual particle release model runs at the sampling site, run backwards in time (-20 and -40 hours shown in top panel). The footprint depicts the most likely source of the air particles that were sampled. In this example, it is clear that the Yucatan peninsula in Mexico is an important contributor to the sampled air all the way at UTSA, and, indeed, this model run coincides with measurements indicative of biomass burning from the agricultural areas in the Yucatan.

Evident from this example, footprint analysis provides a detailed understanding of potential source regions. Unlike a simple wind rose analysis, it will also help with understanding results showing complex mixtures of species, for example, combinations of oxidized compounds transported from far away, with fresher, more volatile compounds from nearby sources. This will be particularly crucial when interpreting factors that are generated as part of PMF analysis. The chemical components of the factors may suggest a source category, and a footprint analysis will add more evidence to this assignment.

Task 4 Deliverables:

- Footprint analysis results to be included in Monthly Technical Reports and Final Report

4.5 Project Reporting and Presentation

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.

Dr. Yacovitch will lead the project reporting activities with assistance from team members (there are no formal project collaborators). Dr. Yacovitch (or her 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.**** Final project data and associated metadata will be prepared and submitted to the AQRP archive.

Deliverables:

- A work plan that includes the scope of proposed work (this document), the budget with justifications, and a Quality Assurance Project Plan.
- An abstract (at project initiation)
- Monthly Technical reports, Monthly Financial Reports and Quarterly Reports
- Draft Final Report (30 days before end of project) and Final Report
- Attendance and Presentation at AQRP workshop (~30 days before end of project)
- Submissions of project data and associated metadata
- Submissions of presentations and manuscripts

Schedule: The schedule for Task 4.5 Deliverables is shown in 7.0.

5.0 Project Participants and Responsibilities

Project roles and responsibilities for scientists at ARI and subcontractor are described in this section.

Dr. Tara Yacovitch will serve as PI for this project. She will be supported by Drs. Herndon, Krechmer, Canagaratna, Roscioli, Lerner, Claflin and Mr. Daube. Dr. Berk Knighton, who also participated in the field study that collected this project's data, will serve again as a consultant here. Personnel roles are listed below.

- **Dr. Tara I. Yacovitch** will serve as Principal Investigator for this project. She will manage the overall project's scientific goals and will ensure timely submission of all required reports and deliverables. Additionally, she will assist with high-resolution fitting efforts and PMF analysis.
- **Dr. Scott C. Herndon** will perform HYSPLIT footprint calculations. He will lead the effort to perform photochemical box modeling.
- **Dr. Manjula Canagaratna** will provide training and instruction for performing PMF analysis. This will include PMF on single-instrument data as well as combined data from

multiple SAFS instruments. She will provide technical oversight of the PMF analysis effort and any conclusions stemming from it.

- **Dr. Jordan Krechmer** will perform high-resolution fitting of CIMS data. He will provide training and instruction to other team members in their high-resolution fit efforts.
- **Dr. J. Rob Roscioli** will perform high-resolution fitting of mass-spectrometer data and assist with PMF analysis.
- **Dr. Brian Lerner** will lead the efforts to do high-resolution fitting and PMF analysis of GC-TOF data.
- **Dr. Megan Clafin** will assist Dr. Lerner in analysis of GC-TOF data.
- **Mr. Connor Daube** will perform HYSPLIT footprint calculations and assist Dr. Herndon in these and other analysis efforts.
- **Dr. W. Berk Knighton** will assist with high-resolution analysis of PTR-ToF data. He will work on the identification of individual species and classes of species using the results of the high-resolution fits and PMF analysis. He will oversee efforts to assign uncertainties and response factors to PTR species.
- **Dr. Ed Fortner** will assist with high-resolution fitting.

6.0 Timeline

High-resolution analysis will be undertaken first, Fall 2018. OD box modeling (to understand ozone formation) and PMF Analysis (to understand source categories) will begin in Fall/Winter 2018, using preliminary results of the high-resolution analysis. First results will feed back into Task 1 to improve the chemical identification of species and to suggest improvements to the high-resolution analysis. Footprint analysis will begin in early 2019, in order to pinpoint emission source areas. Final report draft preparation will begin in the summer of 2019. Time has been allocated during this report preparation phase to re-run the OD box model, PMF and footprint analyses as necessary with updated results. Throughout, collaboration with other SAFS study participants will be undertaken. The anticipated work schedule is charted below.

Task	Description	Year 18				Year 19										
		Month 7	8	9	10	11	12	1	2	3	4	5	6	7	8	
Task 1	High Res. Analysis			x	x	x	x									
Task 2	OD Box Modeling					x	x	x	x					x	x	
Task 3	PMF Analysis					x	x	x	x	x	x	x	x	x	x	
Task 4	Footprint Analysis								x	x	x	x				
Reporting	Final Report Preparation													x	x	x

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: Friday, August 31, 2018

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
Aug2018 Quarterly Report	June, July, August 2018	Friday, August 31, 2018
Nov2018 Quarterly Report	September, October, November 2018	Friday, November 30, 2018
Feb2019 Quarterly Report	December 2018, January & February 2019	Thursday, February 28, 2019
May2019 Quarterly Report	March, April, May 2019	Friday, May 31, 2019
Aug2019 Quarterly Report	June, July, August 2019	Friday, August 30, 2019
Nov2019 Quarterly Report	September, October, November 2019	Friday, November 29, 2019

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
Aug2018 MTR	Project Start - August 31, 2018	Monday, September 10, 2018
Sep2018 MTR	September 1 - 30, 2018	Monday, October 8, 2018
Oct2018 MTR	October 1 - 31, 2018	Thursday, November 8, 2018

Nov2018 MTR	November 1 - 30 2018	Monday, December 10, 2018
Dec2018 MTR	December 1 - 31, 2018	Tuesday, January 8, 2019
Jan2019 MTR	January 1 - 31, 2019	Friday, February 8, 2019
Feb2019 MTR	February 1 - 28, 2019	Friday, March 8, 2019
Mar2019 MTR	March 1 - 31, 2019	Monday, April 8, 2019
Apr2019 MTR	April 1 - 28, 2019	Wednesday, May 8, 2019
May2019 MTR	May 1 - 31, 2019	Monday, June 10, 2019
Jun2019 MTR	June 1 - 30, 2019	Monday, July 8, 2019
Jul2019 MTR	July 1 - 31, 2019	Thursday, August 8, 2019

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

FSR Due Dates:

Report	Period Covered	Due Date
Aug2018 FSR	Project Start - August 31	Monday, September 17, 2018
Sep2018 FSR	September 1 - 30, 2018	Monday, October 15, 2018
Oct2018 FSR	October 1 - 31, 2018	Thursday, November 15, 2018
Nov2018 FSR	November 1 - 30 2018	Monday, December 17, 2018
Dec2018 FSR	December 1 - 31, 2018	Tuesday, January 18, 2019
Jan2019 FSR	January 1 - 31, 2019	Friday, February 15, 2019
Feb2019 FSR	February 1 - 28, 2019	Friday, March 15, 2019
Mar2019 FSR	March 1 - 31, 2019	Monday, April 15, 2019
Apr2019 FSR	April 1 - 28, 2019	Wednesday, May 15, 2019
May2019 FSR	May 1 - 31, 2019	Monday, June 17, 2019
Jun2019 FSR	June 1 - 30, 2019	Monday, July 15, 2019
Jul2019 FSR	July 1 - 31, 2019	Thursday, August 15, 2019
Aug2019 FSR	August 1 - 31, 2019	Monday, September 16, 2019
FINAL FSR	Final FSR	Tuesday, October 15, 2019

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: Thursday, August 1, 2019

Final Report: A Final Report incorporating comments from the AQR 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: Tuesday, September 3, 2019

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 30, 2019). 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 2019.

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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