Scope of Work

Project #22-008

Modeling analysis of TRACER-AQ and over-water measurements to improve prediction of on-land and offshore ozone

Prepared for

Air Quality Research Program (AQRP)
The University of Texas at Austin

By

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August 15, 2022
Version #1

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 **DATE** 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 09/07/2022 by Barry Exum, Texas Commission on Environmental Quality

Barry Exum
Project Liaison, Texas Commission on Environmental Quality

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1.0 Abstract

The Tracking Aerosol Convection ExpeRiment-Air Quality (TRACER-AQ) study, including the Galveston Offshore Ozone Observations (GO3) field campaign, provided unprecedentedly rich observations of ozone air pollution covering both offshore and onshore locations that are needed to validate current air quality models. During the TRACER-AQ period (July – October 2021), there were six multi-day ozone episodes, resulting in over 20 days during which at least one land-based site or ship-based measurement with Maximum Daily 8-hour Average (MDA8) ozone concentrations exceeded the current National Ambient Air Quality Standard (NAAQS) of 70 ppbv. The project team's preliminary analysis of TRACER-AQ observations has revealed definitive gaps in the Weather Research and Forecasting (WRF) model and WRF-driven photochemical models in replicating the observations. This AQRP project will address these issues via continued efforts of model-observation comparisons and photochemical model intercomparisons using three models driven by the same high-resolution WRF meteorology and emissions (CAMx, WRF-GC, and WRF-Chem). The activities are designed to focus on the following primary science questions:

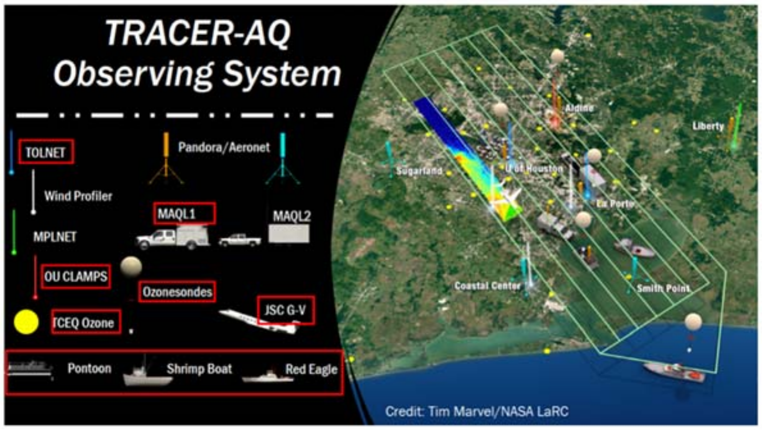
1. Which configurations and simulation settings of WRF most accurately replicate the extensive meteorological data collected as part of TRACER-AQ?
2. How well do coupled mesoscale meteorological and photochemical grid modeling of coastal/maritime boundary layers replicate observations?
3. How well do photochemical grid models predict over-water concentrations and formation rates of ozone?
4. What are the spatial distributions of ozone and ozone precursors during TRACER-AQ on days with on-land monitors recording exceedances of the NAAQS and how well does the photochemical model predict such distributions?
5. Which emission source categories affect ozone formation over Galveston Bay and the Gulf of Mexico?

The project specifically targets the AQRP Priority Research Area FY2022-2023: *TRACER-AQ and over-water measurements*. The project will lead to improvements in meteorological and photochemical models to better simulate on-land and offshore ozone in the Houston-Galveston-Brazoria (HGB). The model intercomparison will characterize the strengths and weaknesses of the regulatory model, CAMx, in the context of other air quality models. The modeling interpretation of TRACER-AQ observations will better understand offshore O_3 formation and transport and their effects on high ozone episodes on land that directly relate to ozone exceedances.

2.0 Introduction

In the urban coastal environment of the Houston-Galveston-Brazoria (HGB), ozone pollution can be driven by diverse mechanisms that influence ozone development. Due in part to different regional background ozone, high O_3 events in the HGB are most associated with continental outflow, while the lowest O_3 levels are from onshore winds (Berlin et al., 2013; Wang et al., 2016; Li et al., 2020). When a sea breeze recirculation occurs, ozone concentrations initially over the ocean can be recirculated throughout the coast and further inland leading to high ozone levels (Banta et al., 2005; Rappenglück et al., 2008; Caicedo et al., 2019). While photochemical models occasionally predict elevated ozone concentrations offshore, there is limited confidence in model predictions because the offshore environment of the HGB has been historically under-monitored until recently.

The Tracking Aerosol Convection ExpeRiment-Air Quality (TRACER-AQ) study, including the Galveston Offshore Ozone Observations (GO3) field campaign, was carried out during July – October 2021. TRACER-AQ has a wide range of measurement platforms covering both offshore and onshore locations (Figure 1), including ozonesondes, boats, ground-based ozone lidars, mobile labs, stationary sites, and aircraft remote sensing. During the TRACER-AQ period, there were six multi-day ozone episodes, resulting in over 20 days during which at least one on-land monitor or ship-based measurement with Maximum Daily 8-hour Average (MDA8) ozone concentrations exceeded the current National Ambient Air Quality Standard (NAAQS) of 70 ppbv. Therefore, TRACER-AQ provided unprecedentedly rich observations of ozone air pollution that are needed to validate current air quality models.



Credit: Tim Marvel/NASA LaRC

Figure 1. Schematic summary of the observing systems in the TRACER-AQ campaign. Red squares show the observations to be used in the project.

The project team actively participated in the TRACER-AQ study and led the sampling of offshore ozone and meteorology using ships and ozonesondes. Funded by the TCEQ, the team has conducted a preliminary evaluation of the Weather Research and Forecasting (WRF) model and Comprehensive Air Quality Model with Extensions (CAMx), TCEQ's regulatory photochemical model, against the 2021 offshore monitoring data. Observation-model comparisons revealed definitive gaps in the WRF model (details in Section 4.1) and improving them will go beyond the scope of funded TCEQ projects. Furthermore, we found intriguing differences in modeled land-water ozone gradients between CAMx and another air quality model, WRF-driven GEOS-Chem (WRF-GC), despite both being driven by the same WRF outputs (details in Section 4.2). Inter-model comparisons using the TRACER-AQ data provide a valuable avenue to triangulate model-observation disagreements between different processes, e.g., chemical versus meteorological. The model intercomparison is not within the scope of the currently funded project.

Therefore, this AQRP project aims to continue our efforts of using TRACER-AQ observations, particularly offshore monitoring data, to evaluate and improve meteorological and photochemical models. The project will compare three different photochemical models that are driven by the same WRF outputs. The model intercomparison will characterize the strengths and weaknesses of the regulatory model, CAMx, in the context of other air quality models. Finally, this project will identify model settings that best represent the TRACER-AQ observations and use the models to identify the sources and influences of high ozone over Galveston Bay and the Gulf of Mexico.

3.0 Science Questions

Using TRACER-AQ data to evaluate/compare multiple models (or multiple model settings in the case of WRF), the project is designed to focus on the following primary science questions:

1. Which configurations and simulation settings of WRF most accurately replicate the extensive meteorological data collected as part of TRACER-AQ?
2. How well do coupled mesoscale meteorological and photochemical grid modeling of coastal/maritime boundary layers replicate observations?
3. How well do photochemical grid models predict over-water concentrations and formation rates of ozone?
4. What are the spatial distributions of ozone and ozone precursors during TRACER-AQ on days with on-land monitors recording exceedances of the NAAQS and how well does the photochemical model predict such distributions?
5. Which emission source categories affect ozone formation over Galveston Bay and the Gulf of Mexico?

4.0 Data and Models

4.1 Data

Synchronized observations from onshore monitoring stations, mobile measurements, boats, and airborne remote sensing during TRACER-AQ will be used to validate the modeled meteorological conditions and air quality simulations. Figure 1 (red rectangles) lists the measurements to be used. All data are available from the TRACER-AQ website (https://www-air.larc.nasa.gov/missions/tracer-aq/). The project team has worked with most of these datasets during preliminary modeling analysis. Based on TRACER-AQ observations, our preliminary work identified six ozone episodes which will be model case studies. The episode days are July 26-28, August 25, September 6-11, September 17-19, September 23-26, and October 6-9, 2021. Each day had at least one on-land monitor or ship-based measurement with MDA8 ozone exceeding the NAAQS of 70 ppbv. Figure 2 shows O_3 measurements by different platforms during the Sep 6-11 episode where the monitoring data revealed substantial ozone variability that will be valuable to evaluate models.

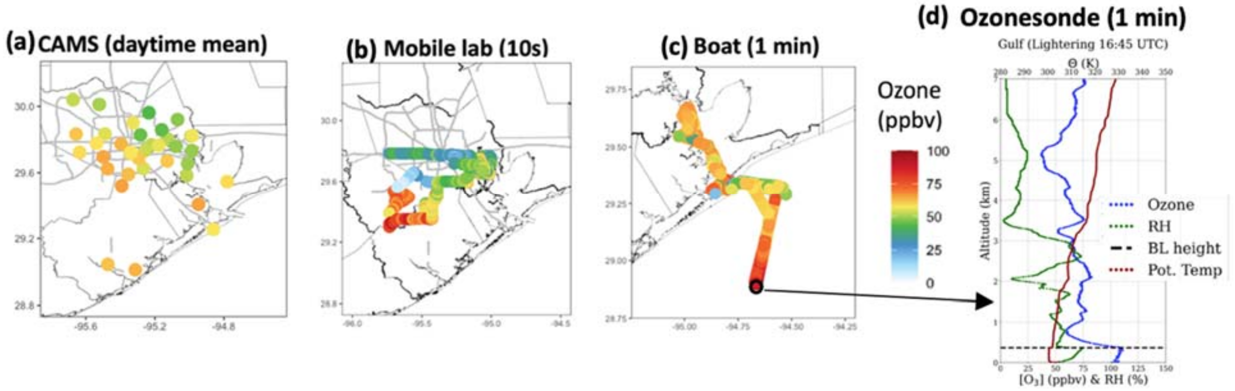


Figure 2. Mean O_3 observations during 6-11 Sep 2021 from on-land monitors (a), mobile lab (b), boats (c), and ozonesonde (d). The black circle in (c) shows the location of ozonesonde in (d).

4.2 WRF

The meteorological model to be evaluated is WRF, the leading mesoscale weather prediction model commonly used to drive air quality models including the regulatory photochemical model, CAMx. WRF v3.9.1.1 will be used, the same version as used in the current TCEQ project. The current project set up three nested domains with different horizontal resolutions (Figure 3) that cover the contiguous United States, Southeast Texas, and the Houston-Galveston region, referred to as domains 1, 2, and 3, respectively, with the corresponding horizontal resolutions of 12 km × 12 km, 4 km × 4 km, and 1.33 km × 1.33 km. All domains have identical vertical resolutions with 50 hybrid sigma-eta vertical levels spanning from surface up to 10 hPa. Boundary conditions are generated every six hours from the outer domain to the inner domain, except for domain 1 which obtains boundary conditions from the global analysis (NCEP or ERA5).

WRF has different physics packages, comes with data assimilation options (e.g., nudging), and can be run continuously for an extended period (i.e, a month) or with regular re-initiation. The current project has carried out the testing of WRF physics options and identified needs for further work (details in Section 5, Task 1). The AQRP project will focus on observational nudging with offshore monitoring data and vertical profiling data (i.e., ozonesondes and CLAMPS) and re-initiation frequencies, to be described in Task 1 of Section 5.

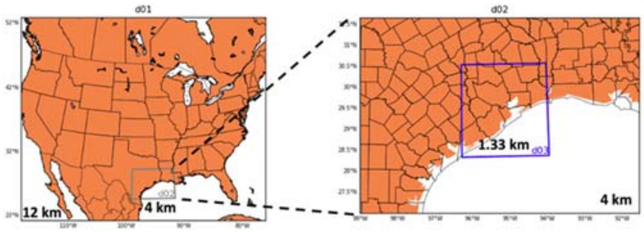


Figure 3. WRF nested model domains and horizontal resolutions.

4.3. Photochemical Models

Photochemical models to be evaluated are CAMx, WRF-GC, and WRF-Chem, all using WRF meteorology to drive photochemistry and transport. CAMx is the regulatory photochemical model used by the TCEQ and uses Carbon bond 6 Revision 5 (CB6r5) chemical mechanism in State Implementation Plan (SIP) modeling with no aerosol chemistry. WRF-GC (Feng et al., 2021; Lin et al., 2020) has the most updated full Ox-NOx-VOC-halogen-aerosol chemistry from the global GEOS-Chem model v12.7.2. Note the GEOS-Chem global model provides chemical initial and boundary chemical conditions to CAMx. WRF-Chem is a coupled meteorology-chemistry model that is widely used to simulate regional air quality and chemistry-weather interactions. It uses MOZART gas-phase chemistry coupled with the MOSAIC sectional aerosol model (Zaveri et al. 2008). This chemistry option does not include halogen chemistry.

5.0 Task Descriptions

The project includes six tasks, as shown in **Table 2**. Task 1 is Grant Activity Description (GAD). Task 2 covers monthly progress reports. Tasks 3, 4, and 5 are reports on specific scientific questions shown in detail below. Task 6 is draft final and final reports.

Task 3. Meteorological model evaluation and improvement

The current project already conducted six WRF experiments to compare different boundary and initial conditions, physics options, and data assimilation options, as shown in Figure 4. [Base] is the baseline configuration that represents our initial guess of the best model configurations; it uses NCEP as boundary conditions, MYNN as PBL scheme (Nakanishi and Niino, 2009), and 2M as microphysics scheme and has no observational nudging. Keeping other options the same as [Base], [WSM6] replaces 2M with the WSM6 microphysics scheme, [YSU] and [ACM2] replace MYNN with YSU and ACM2 PBL scheme respectively, [ERA5] replaces NCEP with ERA5 reanalysis as boundary and initial conditions. [Nudged] is the same as [Base] but adds observational nudging using on-land meteorological observations.

Regardless of model configurations, the WRF model has a persistent high bias in surface wind speeds (Figure 4), and the high bias is larger over the waters than on land. This is indicative of horizontal dispersion and mixing being too fast in the model, with possible implications for vertical mixing yet to be identified. Observational nudging with on-land observations only ([Nudged]) has the best performance in all meteorological parameters evaluated.

An interesting finding from our preliminary work is that land-only nudging was able to significantly reduce wind speed high bias over the waters, by more than 50% during some high-ozone episodes (Figure 4). We thus deduce that observational nudging using offshore monitoring data will lead to further improvement of the model. Additionally, vertical nudging is needed to better capture vertical profiles. Ozonesondes and CLAMPS (the Collaborative Lower Atmospheric Mobile Profiling System) provide vertically resolved meteorological data (c.f. Figure 2d) and nudging them should be able to improve the model above the surface. These nudging options including boats, ozonesondes, and CLAMPS observations are not in the standard nudging package of WRF; they are not within the scope of our existing projects either. We will carry them out in the AQRP project. To ingest boats and ozonesonde observations, one challenge is to interpolate these high-frequency (1-min interval) and fast-moving data spatially and temporally to match with the coarser spatial and slower temporal resolution of WRF. While CLAMPS observations are fixed in location (at La Porte), it is high-frequency remote-sensing measurements with much finer vertical resolutions than WRF and thus proper interpolation schemes need to be developed to ingest CLAMPS in nudging. In the project we will carry out different spatiotemporal interpolation schemes and test them to ensure physically-sound nudging results.

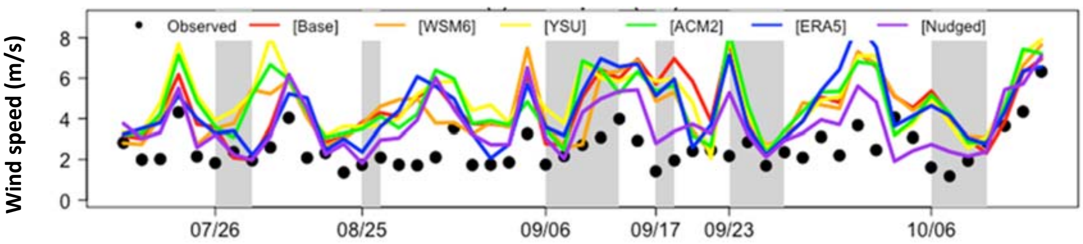


Figure 4. Offshore wind speeds between boat observations (black circles) and WRF simulations with different configurations (colored lines). Grey shading indicates ozone episode days.

Our existing work also uncovered an issue with a continuous simulation of WRF (i.e., free-running mode with only the outer-most boundary conditions forced by global analysis products every 3-6 hours), which is the setting used to drive CAMx. Even with nudging, the model bias of certain meteorological parameters and ozone shows an increasing trend with the simulation time. Figure 5 shows this issue for temperature and ozone at a CAMS site. To prevent the growing model bias, regular re-initiation may be needed for month-long simulations, where all nested domains of WRF are re-initiated with new boundary and initial conditions from external reanalysis meteorological fields. For example, Abdi-Oskoue et al. (2020) shows WRF performed better in capturing the lake breeze when re-initiating the model every 30 hours using the 3 km

High-Resolution Rapid Refresh [HRRR] meteorology analysis (Blaylock et al., 2017) for initial and boundary conditions without nudging. We will test this configuration in WRF and compare the outcome with the nudging options described above.

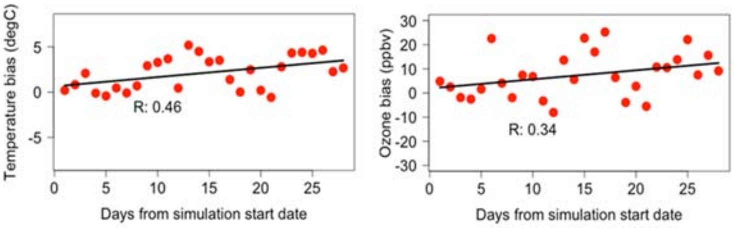


Figure 5. Temperature (left) and ozone (right) biases in WRF-GC at Baytown Garth site as a function of days from the simulation start date (Sep 1, 2021). The black line is the trend with correlation coefficient (R).

Boundary layer dynamics plays an important role in the diffusion, accumulation, and deposition of chemicals. The marine boundary layer (MBL) has different features than the planetary boundary layer on land. Shipp-based ceilometer measurement from the 2021 offshore monitoring provided, for the first time, MBL observations which can constrain WRF model configuration and settings. Figure 6 shows a preliminary comparison between boat ceilometer-derived MBL and WRF-predicted MBL. Regardless of configurations, WRF overestimates afternoon MBL on most days, consistent with the model overestimation of surface wind speeds. This suggests the model's vertical mixing scheme needs further investigation. Nighttime MBL comparison between the boat ceilometer and model is pending further validation as the ceilometer data have different layers based on aerosol backscatter profiles and it is not always straightforward which layer(s) should be compared to the model MBL. We will re-evaluate the simulated MBL over the waters as well as the PBL on land after implementing new observational nudging and re-initiation as described above.

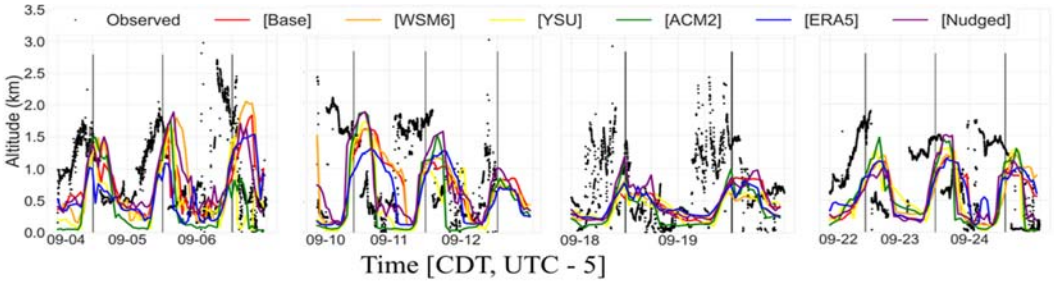


Figure 6. Marine boundary layer (MBL) height comparisons: MBL derived from pontoon boat-based ceilometer is shown as black dots, color lines denote WRF-predicted MBL with different configurations as in Table 2, and vertical black lines denote noon local time.

Deliverables: Monthly reports and a technical report describing the new nudging method, re-initiation approaches, and their effects on simulated MBL and PBL.

Schedule: The schedule for Task 3 Deliverables is shown in Section 7.

Task 4. Photochemical model evaluation and model inter-comparison
A comparative evaluation of multiple photochemical models against TRACER-AQ observations will provide tremendous insights into the validity of photochemical model configurations and results. Such inter-comparison will help identify the strengths and shortcomings of the many components in the complex meteorological-photochemical modeling system used for SIP and can provide “weight of evidence” information for SIP results. Therefore, in Task 2, we will evaluate and compare three photochemical models (CAMx, WRF-GC, and WRF-Chem). While CAMx and WRF-GC were used in separately funded TCEQ projects, the model intercomparison analysis is *not* in past and currently funded projects nor is the WRF-Chem model.

Table 1. Comparison of chemical processes in CAMx, WRF-GC, and WRF-Chem.

Process	**CAMx**	**WRF-GC**	**WRF-Chem**
Chemical Mechanism	CB6r5 (gas-phase chemistry only)	Ox-NOx-VOC-halogen-aerosol chemistry from GEOS-Chem	MOZART gas-phase chemistry coupled with MOSAIC aerosol chemistry
Biogenic Emissions	BEIS	MEGAN	MEGAN
O3 deposition velocity over the water	Constant	Variable, depending on reaction with sea-surface iodide.	Constant
Halogen chemistry	On	On	Off

The same WRF configurations/outputs based on the best WRF setting derived from Task 1 will be used to drive three photochemical models. Anthropogenic emissions of primary air pollutants will be taken from the 2019 SIP emissions released by the TCEQ, the most recent inventory available. Considering the importance of NOx for ozone and availability of observational constraints, we will run a sensitivity simulation in which NO_x emissions from all sources are scaled from 2019 to 2021 level with a scaling factor derived from 2019 and 2021 TROPOMI NO_2 vertical column densities. By using the same meteorology and anthropogenic emissions, we make sure the three photochemical models differ mainly in (1) chemical processes (e.g., chemical mechanisms, deposition), (2) natural emissions, and (3) how chemical processes are coupled with meteorology. All three models calculate biogenic emissions such as BVOCs online according to model meteorology. WRF-GC and WRF-Chem use MEGAN, whereas CAMx uses BEIS (Biogenic Emission Inventory System). On (3), CAMx uses offline WRF outputs, whereas WRF-GC and WRF-Chem simulate meteorology and chemistry synchronously at run time. Table 1 lists the model differences.

From our exploratory investigation, we found significant differences in predicted O_3 between CAMx and WRF-GC when the two models used the same WRF meteorology ([Nudged]), anthropogenic emissions, and similar spatial resolutions (1 km x 1 km for WRF-GC and 1.33 x 1.33 km for CAMx). Figure 7 shows an example of CAMx and WRF-GC results at an urban site and a coastal site where the differences in predicted O_3 can reach 10 – 15 ppbv. We verified that the model differences were not caused by different initial conditions. CAMx appears to predict lower O_3 at coastal locations but higher O_3 in urban locations compared to WRF-GC, hence producing a larger land-water ozone gradient. Compared to the observed land-water gradient of ~20 ppbv (c.f. Figure 2), the model-to-model differences are large and warrant investigation.

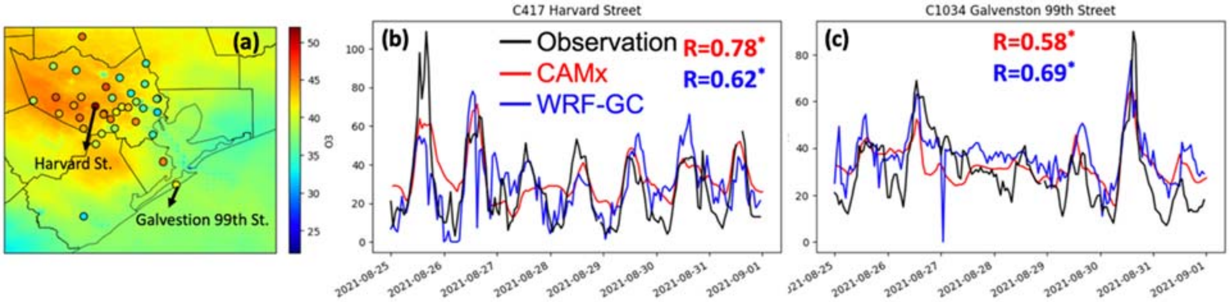


Figure 7. (a) CAMx-predicted surface O_3 distribution (1.33 km x 1.33 km resolution) during the last week of August 2021overlaid with on-land observations (filled circles). (b-c) Time-series of observed (black line) and simulated hourly ozone by CAMx (red) and WRF-GC (blue) at an urban site (C417 Harvard Street) (b) and a coastal site (C1034 Galveston 99th Street) (c). Correlation coefficient (R) between observed and predicted ozone time series is listed in red for CAMx and blue for WRF-GC.

We will probe the following model processes to understand the model differences:

(1) Chemistry mechanism and biogenic emissions. We will output in situ ozone production and loss rates from each model during episode and non-episode days and examine the differences. We anticipate on-land ozone production rate to depend on the level of BVOC emissions in the model and thus we will analyze the association between differences in predicted O_3 production/loss and isoprene emissions. Ozone production and loss rates will be further decomposed onto different reaction pathways to probe the differences in chemical mechanisms. Since CAMx does not activate aerosol chemistry in the SIP setting while the other models do, we will test if aerosol effects on ozone via affecting radicals and photolysis rate play a role in causing the model-by-model differences in ozone.

(2) O_3 dry deposition velocity over the waters. Photochemical models typically have an essentially uniform deposition velocity of ~0.05cm s^{-1} to seawater, which is significantly higher

than observation (Pound et al., 2020). WRF-GC includes the representation of the oceanic deposition of ozone based on its reaction with sea-surface iodide by Pound et al. (2020). The updated scheme halves the mean deposition velocity to water, likely resulting in higher O_3 near coastal locations in WRF-GC than CAMx. We will further investigate the effect of over-water dry deposition parameters and assumptions on offshore ozone predictions using the same models.

(3) Reactive halogen chemistry. Reactive halogen species are known to destroy ozone through catalytic cycles and can therefore have a significant impact on offshore ozone. Halogen chemistry is represented to different extents in CAMx and WRF-GC, with none in WRF-Chem (Table 2). We will examine how halogen concentrations on the waters differ between CAMx and WRF-GC and how this affects over-water ozone simulation across the two models.

(4) Air pollution feedback on meteorology. Although the work focuses on meteorology's effect on air quality, WRF-Chem can simulate two-way interactions between chemistry and meteorology. We will test the effects on simulated ozone when turning on the aerosol feedback onto meteorology in WRF-Chem.

Deliverables: Monthly reports and a technical report describing the individual model's comparison against TRACER-AQ data, inter-model differences and reasons for these differences, and the effects of investigated processes on model differences on land and over water.

Schedule: The schedule for Task 4 Deliverables is shown in Section 7.

Task 5. Sources of offshore high ozone

The 2021 offshore monitoring data confirmed that high O_3 does occur over water and can be associated with weak synoptic forcing and local recirculation events as well as after frontal passages under northerly flow (c.f. Figure 2c). Under such conditions, on-land ozone monitors also registered high concentrations (c.f. Figure 2a and 2b). It is not clear, based on observations alone, to what extent high ozone over land and the water are interrelated and what emission sources are responsible for high ozone over the water. How much ozone is it due to precursor emissions emitted in situ over the water (e.g., shipping emissions)? How much is due to precursor emissions exported from the land (e.g., Houston urban emissions)? To address these questions, we will carry out *soft* emission perturbation experiments in each of the three photochemical models, in which anthropogenic emissions over the land and the water are increased separately by 10% to preserve the ozone chemical regimes. By tracing the propagating effects of these added anthropogenic emissions, we will be able to identify how precursor emissions from the land affect *in situ* ozone formation over the waters and vice versa.

In addition to in situ ozone production, the fact that northerly flow brings higher ozone over the waters suggests regional background ozone should be an important factor for observed ozone variability over the waters. We will use the models to investigate the differences between background ozone during episode days and clean days by turning off anthropogenic emissions in Texas, a standard modeling approach to estimate regional background ozone. The resulting changes in vertical profiles of ozone will provide clues as to horizontal and vertical transport pathways of background ozone during days when high ozone was observed over the waters versus days of low ozone.

These source-identification model experiments will be carried out separately in each of the three photochemical models on selected ozone episodes. We expect to find similarities and differences between each model's identification of major source regions/categories responsible for high ozone over the water and estimates of their respective contributions. The range of between-model differences will bracket the uncertainty levels on the sources of over-water high ozone.

Deliverables: Monthly reports and a technical report describing model sensitivity experiments, results on high ozone sources, background ozone estimates, and inter-model differences.

Schedule: The schedule for Task 5 Deliverables is shown in Section 7.

6.0 Organization and Responsibilities

Yuxuan Wang (PI), Department of Earth and Atmospheric Sciences, University of Houston.

- Coordinates the operations of the project and is the primary contact person.
- Leads reporting requirements (GAD, QAPP, monthly reports, draft, and final reports)
- Works with UH and Saint Edward's University postdoctoral researcher and graduate students to perform the planned modeling analysis.

James Flynn (co-PI), Department of Earth and Atmospheric Sciences, University of Houston.

- Assists with reporting requirements (GAD, QAPP, draft, and final reports)
- Advises UH graduate students and postdocs to perform an observational evaluation of model outputs

Paul Walter (Co-PI), Department of Mathematics, Saint Edward's University.

- Assists with reporting requirements (GAD, QAPP, draft, and final reports)
- Advises UH graduate students and postdocs to analyze ozonesonde data and other data collected in 2021

7.0 Project Schedule

The schedule for this project is listed below in Table 2.

Table 2. Schedule of Project Schedule.

Deliverable	**Deliverable Date**
Grant Activity Description (GAD) (Task 1) **Deliverable 1.1:** TCEQ approved GAD **Deliverable 1.2:** TCEQ approved QAPP	**(1.1):** September 1, 2022 **(1.2):** September 1, 2022
Progress Reports (Task 2) **Deliverable 2.1:** Monthly Progress Reports	**(2.1):** Monthly by the 15th of the subsequent month
Meteorological Model Evaluation and Improvement (Task 3) **Deliverable 3.1:** Meteorological Model Evaluation and Improvement Report	**(3.1):** January 1, 2023
Photochemical Model Evaluation and Model Intercomparison (Task 4) **Deliverable 4.1:** Photochemical Model Evaluation and Model Intercomparison Report	**(4.1):** May 1, 2023
Investigation of Elevated Offshore Ozone's Sources (Task 5) **Deliverable 5.1:** 2021 Elevated Offshore Ozone Sources Report **Deliverable 5.2:** Meteorological and Photochemical Modeling Files	**(5.1):** July 1, 2023 **(5.2):** July 1, 2023
Draft Final and Final Reports (Task 6) **Deliverable 6.1:** Draft Final Report **Deliverable 6.2:** Final Report	**(6.1):** August 1, 2023 **(6.2):** August 31, 2023

8.0 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 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: Ten (10) business day after notice of intent to fund

Quarterly Reports: The Quarterly Report will provide a summary of the project status for each reporting period. It will be submitted to the Project Manager as a Word doc file. It will not exceed 3 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
Quarterly Report #1	August, September, October 2022	October 31, 2022
Quarterly Report #2	November, December 2022, January 2023	January 31, 2023
Quarterly Report #3	February, March, April 2023	April 30, 2023
Quarterly Report #4	May, June, July 2023	July 31, 2023

Monthly Technical Reports (MTRs): Technical Reports will be submitted monthly to the Project Manager and TCEQ Liaison as a Word doc using the AQRP Template.

Monthly Technical Report Due Dates:

Report	Period Covered	Due Date
Technical Report #1	Project Start - August 31, 2022	September 10, 2022
Technical Report #2	September 1 - 30, 2022	October 10, 2022
Technical Report #3	October 1 - 31, 2022	November 10, 2022
Technical Report #4	November 1 - 30, 2022	December 10, 2022
Technical Report #5	December 1 - 31, 2022	January 10, 2023
Technical Report #6	January 1 - 31, 2023	February 10, 2023
Technical Report #7	February 1 - 28, 2023	March 10, 2023
Technical Report #8	March 1 - 31, 2023	April 10, 2023
Technical Report #9	April 1 - 30, 2023	May 10, 2023
Technical Report #10	May 1 - 31, 2023	June 10, 2023
Technical Report #11	June 1 - 30, 2023	July 10, 2023
Technical Report #12	July 1 - 31, 2023	August 10, 2023

Financial Status Reports (FSRs): Financial Status Reports will be submitted monthly to the AQRP Grant Manager (RoseAnna Goewey) by each institution on the project using the AQRP FSR Template.

FSR Due Dates:

Report	Period Covered	Due Date
FSR #1	Project Start - August 31, 2022	September 15, 2022
FSR #2	September 1 - 30, 2022	October 15, 2022
FSR #3	October 1 - 31, 2022	November 15, 2022
FSR #4	November 1 - 30, 2022	December 15, 2022
FSR #5	December 1 - 31, 2022	January 15, 2023
FSR #6	January 1 - 31, 2023	February 15, 2023
FSR #7	February 1 - 28, 2023	March 15, 2023
FSR #8	March 1 - 31, 2023	April 15, 2023
FSR #9	April 1 - 30, 2023	May 15, 2023
FSR #10	May 1 - 31, 2023	June 15, 2023
FSR #11	June 1 - 30, 2023	July 15, 2023
FSR #12	July 1 - 31, 2023	August 15, 2023
FSR #13	August 1 -31, 2023	September 15, 2023
FSR #14	Final FSR	October 15, 2023

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.
Draft Final Report Due Date: August 1, 2023

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: August 31, 2023

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

AQRP Workshop: A representative from the project will present at the AQRP Workshop in the first half of August 2023.

9.0 References

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