AQRP Monthly Technical Report

PROJECT TITLE	Galveston Offshore Ozone Observations (GO3)	**PROJECT #**	20-004
PROJECT PARTICIPANTS	James Flynn (UH) Yuxuan Wang (UH) Paul Walter (St. Edward's University) Gary Morris (St. Edward's University)	**DATE SUBMITTED**	7/9/2021
REPORTING PERIOD	**From:** June 1, 2021 **To:** June 30, 2021	**REPORT #**	12

A Financial Status Report (FSR) and Invoice will be submitted separately from each of the Project Participants reflecting charges for this Reporting Period. I understand that the FSR and Invoice are due to the AQRP by the 14th of the month following the reporting period shown above.

Detailed Accomplishments by Task for reporting period

- Launched the pontoon boat out of Clear Lake Boat Ramp on 6/9/21 at 10:00AM with the intention of taking a route crossing the Houston Ship Channel via the South Boat Crossing and then loop around Trinity Bay and back to the dock in Clear Lake. However, when we arrived at the exit of Clear Lake to the Bay it was discovered to be closed for construction on the overhead Kemah Bridge. The day was spent testing fuel consumption to estimate range and economy by making passers around Clear Lake at different levels of RPM. Data was recorded and plotted. Participants, James Flynn (UH), Paul Walters (St. Edward's), Michael Comas (UH), and Travis Griggs (UH).
- On 7/10/21, the pontoon boat was launched from the Sylvan Beach Boat ramp in La Porte, Texas. Sylvan Beach Boat ramp has good access to the Bay and nice ramp/docks. The Bay was slightly choppy at launch (8:30AM) but made speeds of approximately 15mph from the ramp to the ship channel. Crossing it was not an issue outbound with no nearby boat traffic. When entering Trinity Bay, the wind speeds began to pick up along with the swells. The pontoon was initially anchored at 29.58534N, 94.85750W to attempt the balloon launch. With the higher wind speeds and swells rocking the boat it was difficult to fill and it ended up coming loose of the nozzle. On the second attempt, we changed our positioning and were able to successfully launch the balloon at 29.59748N, 94.95947W. The boat drifted 1–1.5 miles from first anchoring to raising anchor after tracking the successful balloon launch. We went back to La Porte to resupply on Helium and attempt an afternoon launch, however the bay conditions began to deteriorate on the way back. Large vessel traffic in the Houston ship channel was more active and we had to make a few loops in 5-mile cut to wait for a clear opportunity to pass. We arrived back at La Porte at approximately 1:15PM. The latest National Weather Service (NWS) marine forecast put the conditions 'near a small craft advisory' status and we were beginning to see white caps form on the bay, so we decided not to return for the afternoon launch. Fuel consumed on this outing was approximately 11 gallons, or roughly 2/3 of

the available fuel if following the typical “rule of thirds” (1/3 of a tank to go out, 1/3 to return, and 1/3 for emergency reserves. Participants: Jimmy Flynn (UH), Paul Walters (St. Edward’s), Michael Comas (UH), Travis Griggs (UH)

- Purchased a fully rugged and waterproof Panasonic Toughbook laptop to allow monitoring of the instrumentation in the equipment case without having to work inside the box.
- Replaced the original 24-gallon fuel tank with a 40-gallon fuel tank plus fuel selector valve to allow the connection of an auxiliary 6-gallon reserve fuel tank that is carried in the vented bow seating of the pontoon. A 5-gallon safety fuel can is also carried on board, providing a total of 51 gallons of fuel.
- A smaller, quieter generator was installed on the pontoon to improve crew communication, reduce fatigue, and allow for better communication with the FAA.
- On 6/23/21, the pontoon boat was launched out of Clear Lake Boat Ramp at 10:50AM with a plan to make a loop around the ship channel in a counterclockwise orientation. Scattered showers developed west and north of the Bay (Baytown/Crosby) and we encountered light showers on the approach to the Kemah Bridge and exit to the Bay. The southern leg of the journey was initially mostly smooth. The narrow part of the route, near San Leon, was noticeably choppier. During this portion a wave came over the bow and knocked the ‘play pen’ portion of the front pontoon loose. Due to the development of nearby scattered showers and busier than expected ship traffic in the channel, we decided to take a more conservative route and not make the full loop in the Bay. Instead, we made a loop along the Texas City Dike and back around to our approach path towards Clear Lake. With the wind at our backs, the return was smooth and we made a pace of 12 to 15 mph. There was a large tanker ship headed inbound with a distinctly yellow exhaust plume, noticed by all the crew at approximately 2:30PM near the Clear Lake entry channel. After entering into Clear Lake, we secured a slip at the Portofino Marina. Using the Toughbook laptop on this trip greatly increased the comfort level and prevented the participants from getting seasick. Total estimated distance for the trip was approximately 40 miles and we burned roughly 20 gallons. With the larger tank and reserve fuel, we estimate that under normal conditions we can safely execute 60-mile routes in the future. Participants: Travis Griggs (UH), Jimmy Flynn (UH), Alexandra Ulinski (UH)
- The sample flow rate on the two boat sampling packages was reduced to about 0.85 liters per minute to prepare for installation of the GSP photocells.
- On June 30 2021, we relocated the pontoon to a single boat slip at the Portofino Marina to allow better access. On this date, we also added a shore power system to the boat in order to keep the starting battery charged as well as to keep the instrumentation operating. Initially only the ceilometer and weather station will be operating while we design a system to allow the ozone (O_3) instrument and air conditioner to run safely while unattended.
- Paul Walter trained UH students on preparing and launching ozonesondes over the course of a few days.

Data Collected

One ozonesonde was launched at approximately 10:30AM CDT (15:30Z or UTC) on 10 June 2021. The vertical profiles of ozone, relative humidity, and potential temperature are shown in Figure 1. Data from the surface to 0.76 km above mean sea level (AMSL) was removed. The ozonesonde was turned on too close to the launch time and this led to the ozone measurement still reaching equilibrium during the initial 0.75 km of the ascent.

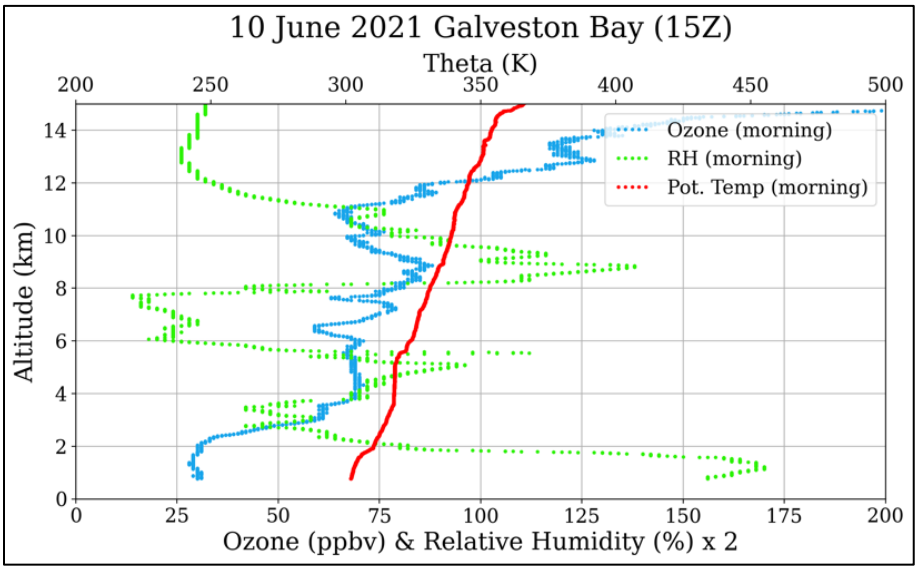

Figure 1: Tropospheric profiles of ozone (light blue), relative humidity (green), and potential temperature (red) from a morning ozonesonde flight on 10 June 2021 launched from the pontoon boat in Trinity Bay.

The figures 2–5 below are from the June 23, 2021 outing described in the section above. What's noticeable in the spatial plot showing the boat speed are the slow speeds required in the Clear Lake channel which extends into Galveston Bay and the slow forward speed southbound past San Leon. This is the choppy area described above where the boat was moving south into northbound waves which were compounded by ship wakes and the relative narrowing of the distance from the main channel to the land. The northbound trip was much smoother when moving with the direction of the waves. Future southbound legs to the southern portion of the Bay may be conducted east of the main channel in an attempt to find smoother waters. Other areas of the bay were quite smooth, especially on the north side of the Texas City Dike.

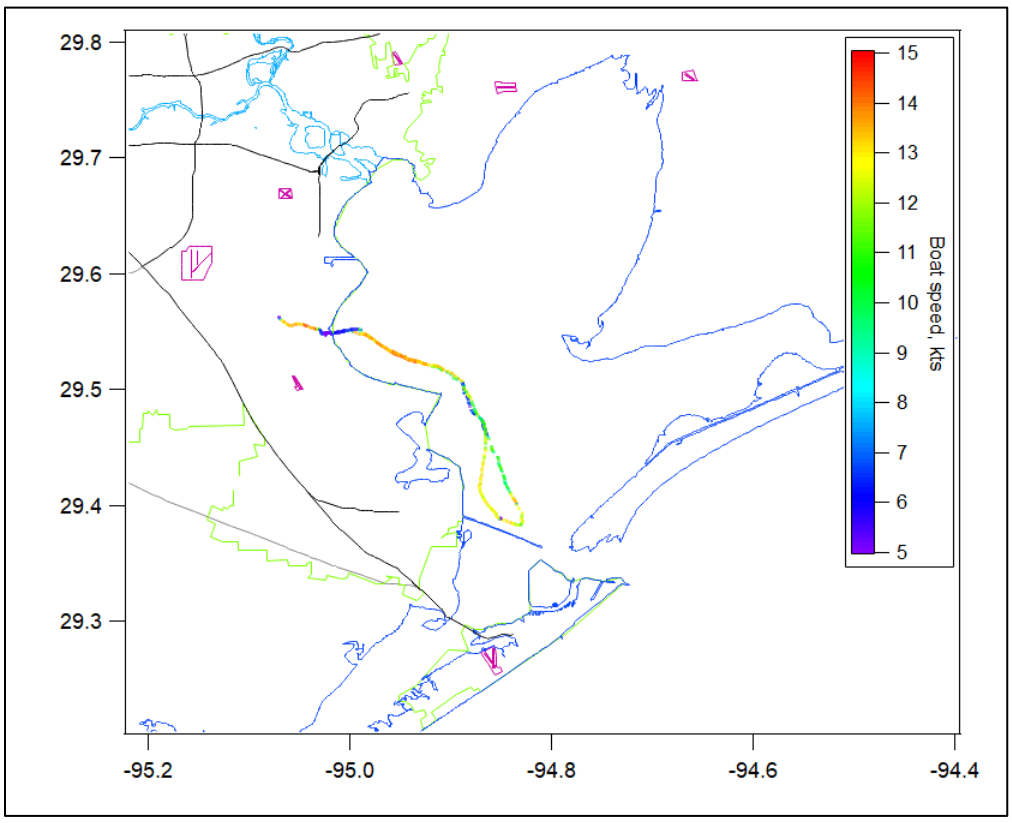

Figure 2: Spatial plot showing boat speed for 6/23/2021.

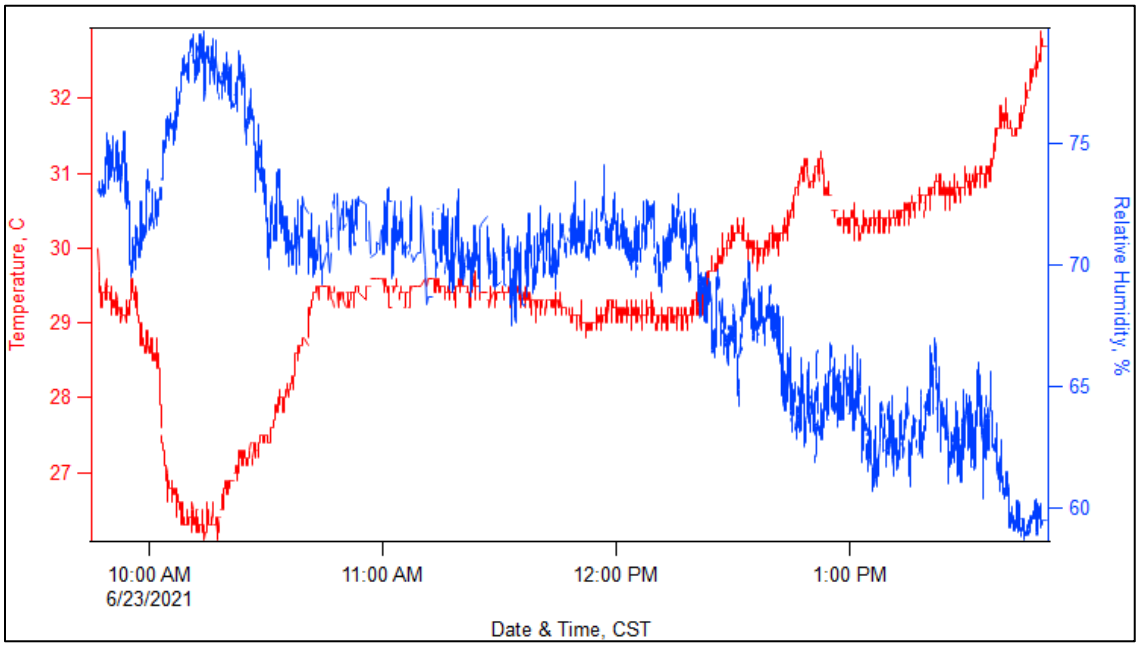

Figure 3: Time series showing temperature and relative humidity during the 6/23/2021 measurements. The drop in temperature and increase in RH were due to a light rain shower.

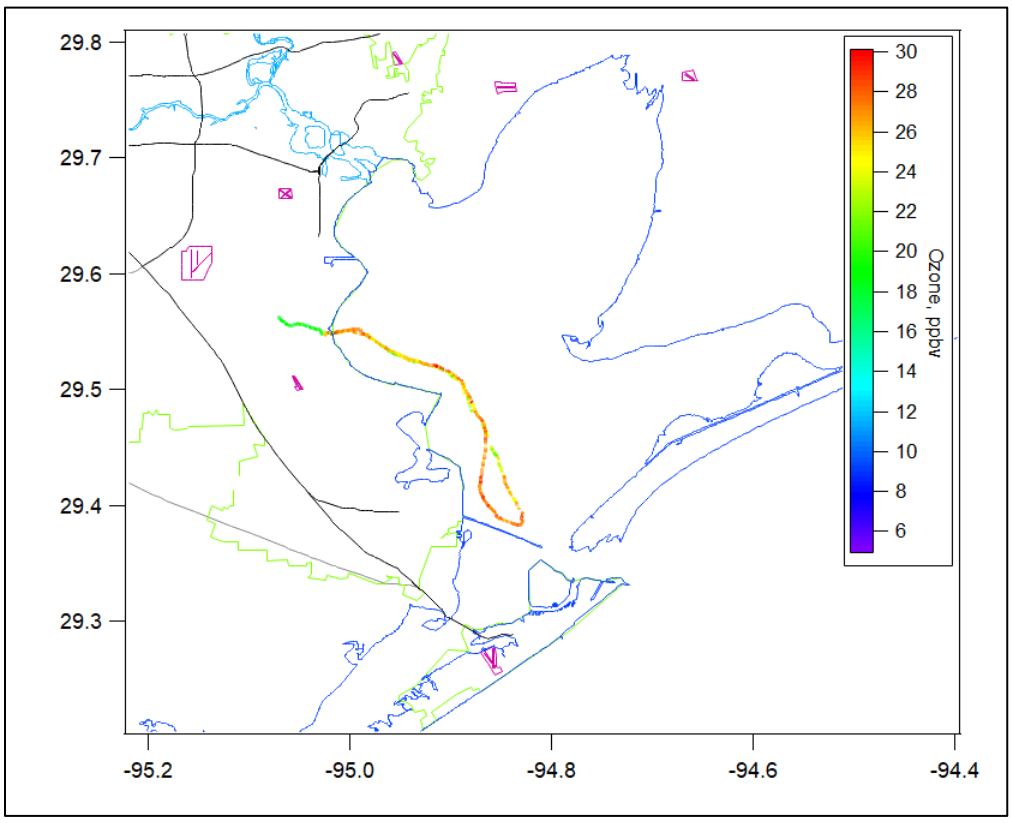

Figure 4: Ozone spatial plot of the pontoon route.

Of potential interest is the lower O_3 in the vicinity of the main channel. While the relative magnitude of the change is not large, we will look for this feature in future measurement outings.

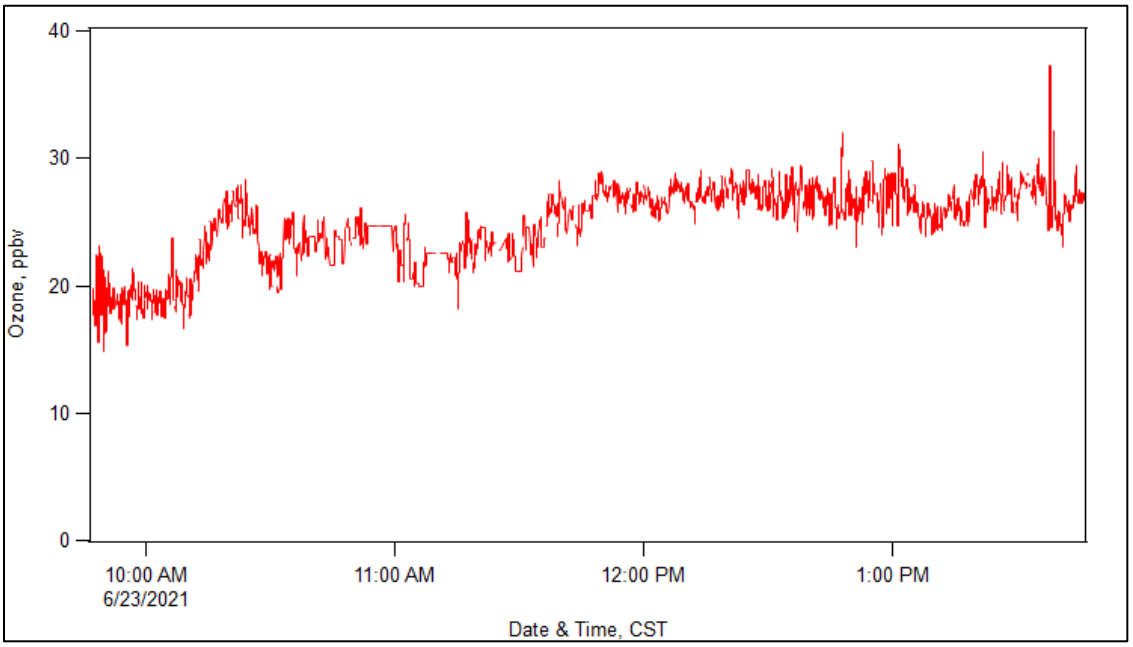

Figure 5: Time series of ozone data from the 6/23/2021 outing.

Note that computer workload caused several minutes of stalled data collection just before and after 11:00 CST. The project team is investigating why the computer stalled as during this time so that improvements can be made.

Preliminary Analysis

- Validated the WRF-GC model with TCEQ CAMS observations in April 2021 (Figure 6). While the model captures daily variability, it overestimates ozone in general (R= 0.7, NMB= 30%, RMSE= 15.9 ppbv in Figure 7).
- The model has certain ability to predict the water-land transition in meteorology and ozone. On average, the waters have slightly higher ozone than land. April mean ozone over the Gulf, the Bay and Urban Houston are 49.9, 50.8 and 49.5 ppbv respectively (Figure 8). But this is not an everyday phenomenon. For example, when the wind brought high ozone to the northern Gulf and the Bay (1–2 April), ozone gradient goes down from the Gulf > the Bay > Urban Houston in Figure 9. Later when onshore clean air came (6–7 April), ozone gradient can be reversed from the Gulf < the Bay < Urban Houston.
- We will further divide the Houston urban region into two sub regions (shipping channel with high NO_X and lower ozone and the downwind northwest with higher ozone) to examine the effect of shipping emission on ozone.
- We will move to simulate the campaign periods covering July and August 2021 soon, once meteorological inputs are ready to be downloaded.

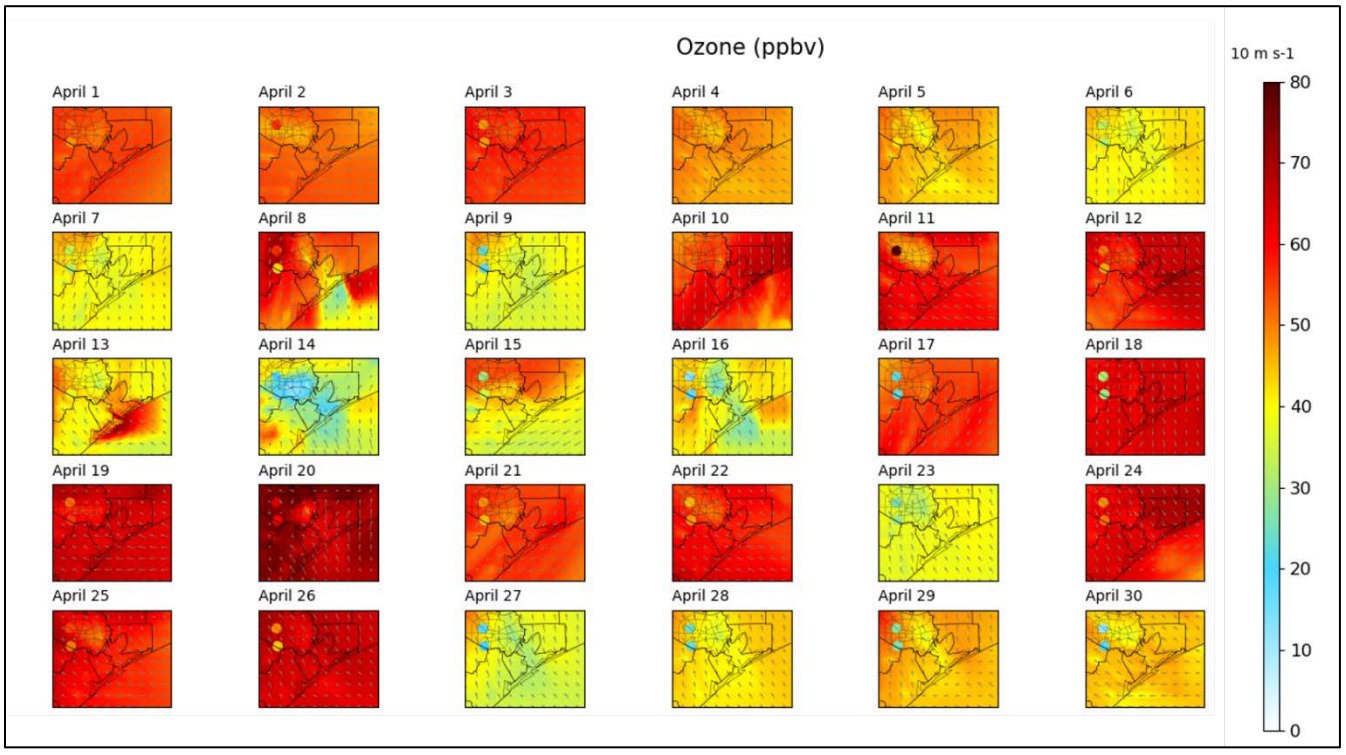

Figure 6: Day-to-day comparison of WRF-GC and TCEQ CAMS ozone in April 2021.

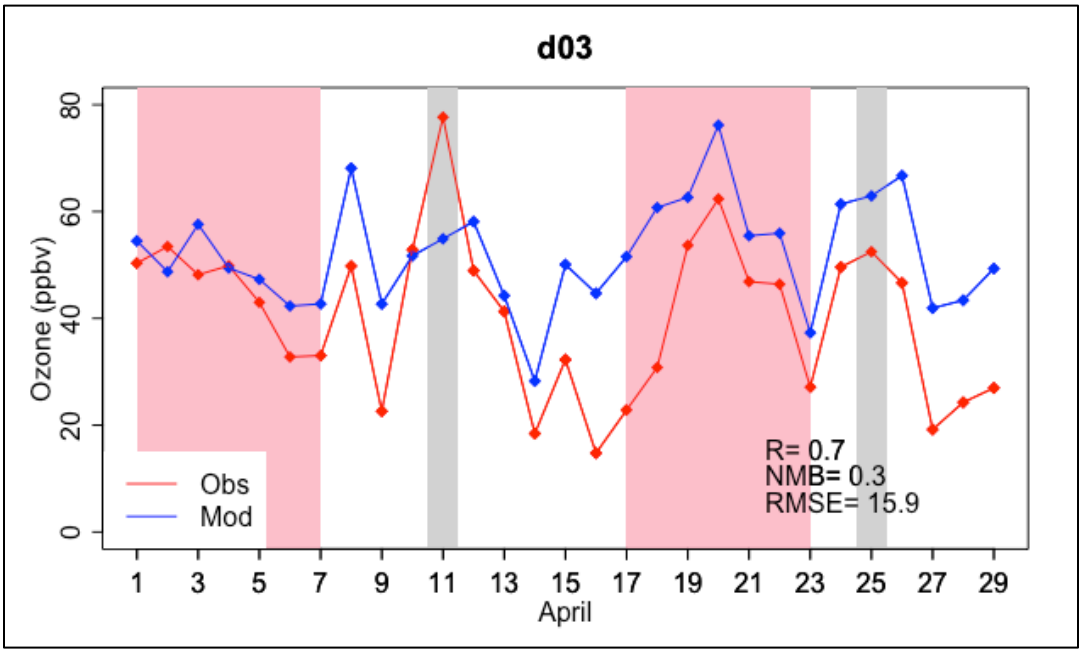

Figure 7: Time series of WRF-GC and TCEQ CAMS ozone in April 2021.

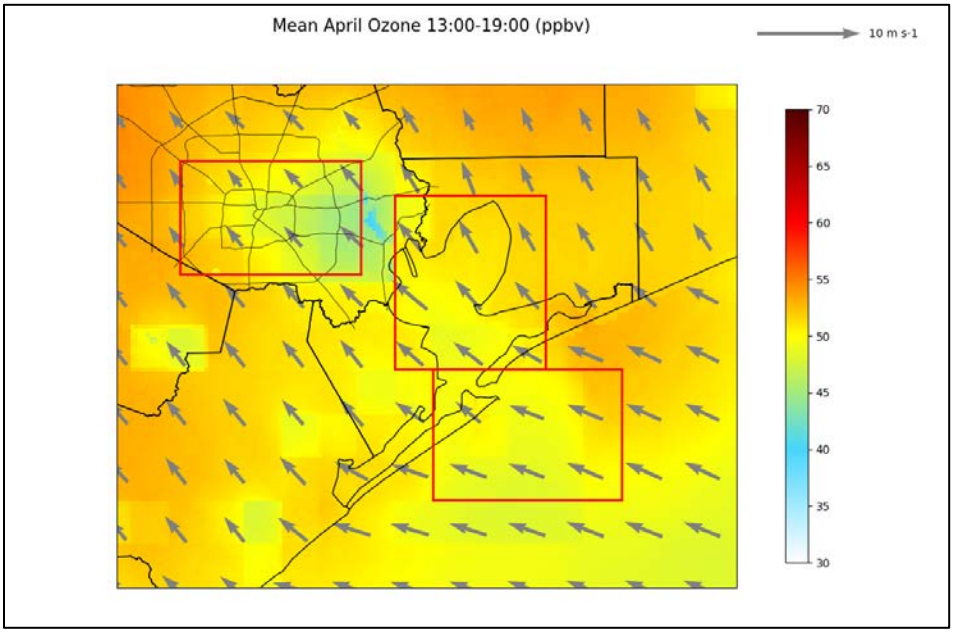

Figure 8: April 2021 monthly mean ozone. Red boxes denote for urban Houston, Galveston Bay, and the Gulf respectively.

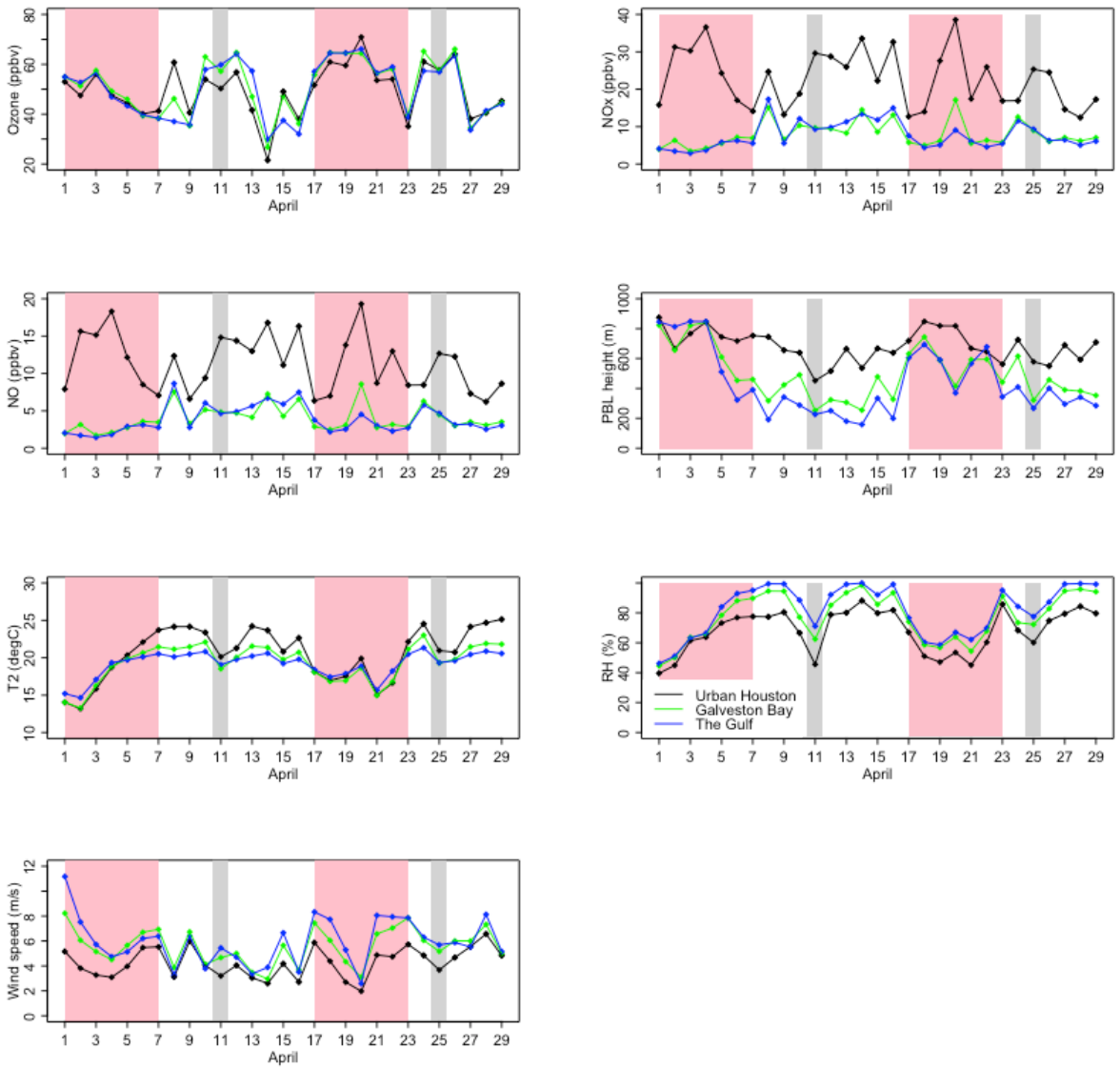

Figure 9: Time series of chemical species and meteorological variables of urban Houston (black), Galveston Bay (green), and the Gulf (blue).

Identify Any Problems or Issues Encountered and Proposed Solutions or Adjustments

- Install and uninstall the GSPs that came back from Air Quality Design (AQD).
  - The GSP was installed but failed soon after a system restart. Ozone readings indicated a potential burn from the LEDs. Second LED was unable to communicate with the computer. Both GSPs were sent back to AQD for repairs and revisions.
  - **Note: Depending on the timeline for receiving the repaired and revised GSPs, the science team may opt to deploy the small sampling packages on the commercial boats without the GSP photocells and focus on ozone, meteorology, and boundary layer heights. In the event that the GSPs are returned in working order and are determined to be viable, the team will attempt field installations on the commercial boats. Upgrades to the pontoon boat sampling**

package for NO_2 will be easier as the dedicated instrument can be prepared in the lab and installed in the case.

- The boat ramp in Clear Lake we had chosen had unexpected construction closing our access to the Bay. We will look for an alternate location.
- The ozonesonde flight from the pontoon boat on 6/10/21 had a few challenges that will lead to future improvements. The initial flight laptop was not working effectively prior to launch and a backup was used. Wind and wave conditions made filling and handling the balloon difficult. The first balloon that was filled slipped off the nozzle and was lost. We will use a wider nozzle on the filling hose that will help make that less likely to occur. We discovered that wind speeds and swells made it difficult to control the balloon. Should have cleared the front deck to allow for more maneuverability when filling the balloon. A net system to restrain the balloon when filling may be useful. The AirMar Sensor caused the data acquisition computer to crash. Putting the power to the AirMar would allow you to reset it remotely. Troubleshooting in the instrument case can cause motion sickness, especially in choppy conditions.
- The channel crossing near Texas City/Galveston was busy with ship traffic. The three crossings in the Middle/North side of the Bay would be better to use to access Trinity Bay.

Goals and Anticipated Issues for the Succeeding Reporting Period

- Deploy small sampling packages on the two commercial boats.
- Deploy the pontoon boat more regularly, weather permitting, and begin routine ozonesonde launches

Detailed Analysis of the Progress of the Task Order to Date

COVID related delays in receiving the nitrogen dioxide (NO_2) photolysis cells (GSPs) delayed the decision to deploy the instrumentation on the commercial boats. Repeated delays in delivery and subsequent operational issues with the operation of the GSPs resulted in returning them to AQD for repair and revision. The PI team is approaching the point at which we may proceed and deploy the instrumentation to begin collection of ozone, meteorology, and boundary layer height data in the event that the GSP manufacturer continues to be unable to deliver a working product in a timely manner. In the event that the GSPs can be received and tested, we may consider a field installation of the GSPs onto the commercial boats in order to attempt to measure NO_2. The PI team is still confident that the data collected on the commercial boats and pontoon boat will allow for the completion of this project.

Do you have any publications related to this project currently under development? If so, please provide a working title, and the journals you plan to submit to.

☐Yes ☒ No

Do you have any publications related to this project currently under review by a journal? If so, what is the working title and the journal name? Have you sent a copy of the article to your AQRP Project Manager and your TCEQ Liaison?

☐ **Yes** ☒ **No**

Do you have any bibliographic publications (ie: publications that cite the project) related to this project that have been published? If so, please list the reference information. List all items for the lifetime of the project.

☐ **Yes** ☒ **No**

Do you have any presentations related to this project currently under development? If so, please provide working title, and the conference you plan to present it (this does not include presentations for the AQRP Workshop).

☐ **Yes** ☒ **No**

Do you have any presentations related to this project that have been published? If so, please list reference information. List all items for the lifetime of the project.

☐ **Yes** ☒ **No**

Have any personnel changes occurred that were not listed in the original proposal? If so, please include a detailed description of the personnel change(s) below.

☐ **Yes** ☒ **No**

Are any delays expected in the progress of the research? If so, please include a detailed description of the potential delay below.

☒ **Yes** ☐ **No**

The AQRP and TCEQ have requested the deployment to be delayed into CY2021.

Describe any possible concerns/issues (technical or non-technical) that AQRP should be made aware of.

☐ **Yes** ☒ **No**

Are you anticipating using all the available funds allocated to this project by the end date? If not, why and approximately what is the amount to be returned?

☒ **Yes** ☐ **No**

Acronyms/Abbreviations:

AMSL: above mean sea level
AQD: Air quality Design
CST: Central Standard Time
CDT: Central Daylight Time
FAA: Federal Aviation Administration
NO_2: Nitrogen Dioxide
NMB= Normalized Mean Bias
NWS: National Weather Service
O_3: Ozone
O_x: Nitrogen Dioxide plus Ozone
ppbv: Parts per billion by volume
R: Correlation coefficient
RMSE= Root Mean Square Error
RPM: Revolutions per minute
UTC: Universal Time Coordinated

Submitted to AQRP by

James Flynn