AQRP Monthly Technical Report

PROJECT TITLE	High Background Ozone Events in the Houston-Galveston-Brazoria Area: Causes, Effects, and Case Studies of Central American Fires	**PROJECT #**	16-008
PROJECT PARTICIPANTS	University of Houston	**DATE SUBMITTED**	03/07/2017
REPORTING PERIOD	**From:** 02/01/2017 **To:** 02/27/2017	**REPORT #**	4

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 15th of the month following the reporting period shown above.

Detailed Accomplishments by Task

Task 1: None this period.

Task 2: We compared the ozone mixing ratio with and without weather events during high ozone days.

Task 3: Analysis of GEOS-Chem simulation of surface ozone for several cases.

Task 4: Not started.

Preliminary Analysis

Task 2

In the previous report, we discussed the three different ways to select top 15% high ozone days. We concluded that the 15% in a single month is the most “stable” method to select them. Thus, we will use this method to present top 15% high ozone days in the following reports.

We studied the effects of selected weather events on ozone mixing ratio of the whole data set. In this report, we will focus on the effects on high ozone. Figure 1 compares ozone mixing ratio with and without weather events during three kinds of high ozone days: top 15% MDA8 ozone, top 15% background ozone, and MDA8 ozone exceedances.

The medians of MDA8 ozone in heatwave days were 10 and 11.5 ppbv higher than no heatwave days in the top 15% MDA8 and top 15% background days respectively. For exceedance days, the medians of MDA8 and background ozone were 3.5 and 4 ppbv higher during heatwave days than no heatwave days respectively. Heatwave days had the same maximum, 144 ppbv, of MDA8 ozone as the no heatwave days, while they had higher minimums than no heatwave days. Heatwave days had lower maximums of background ozone than no heatwave days for all three kinds of high ozone days, and they had higher minimums with no heatwave days except for exceedance.

Stagnation days had the same medians as no stagnation days in terms of top 15% MDA8 and exceedance days, 88 and 91 ppbv respectively. The medians of background ozone in stagnation days were within +/- 2 ppbv of those in no stagnation days for the top 15% MDA8, top 15% MDA8 background, and exceedance days. Maximums of MDA8 and background ozone were 2~3 ppbv lower than no stagnation days. Minimums of MDA8 ozone with stagnation during top 15% MDA8 and background days were 8 and 10 ppbv higher than without stagnation. If neglect the single outlier, stagnation days and no stagnation days had same minimums of MDA8 ozone, 71 ppbv, in exceedance days. The minimums of background ozone in stagnation days were 1, 0, and 1 ppbv higher no stagnation days.

In summary, both heatwave and stagnation events tended to narrow the range of ozone mixing ratio during high ozone days compared to no-event days. Heatwave resulted in an increase of medians of high ozone days while stagnation affected mostly the lower distribution of ozone (e.g. below median).

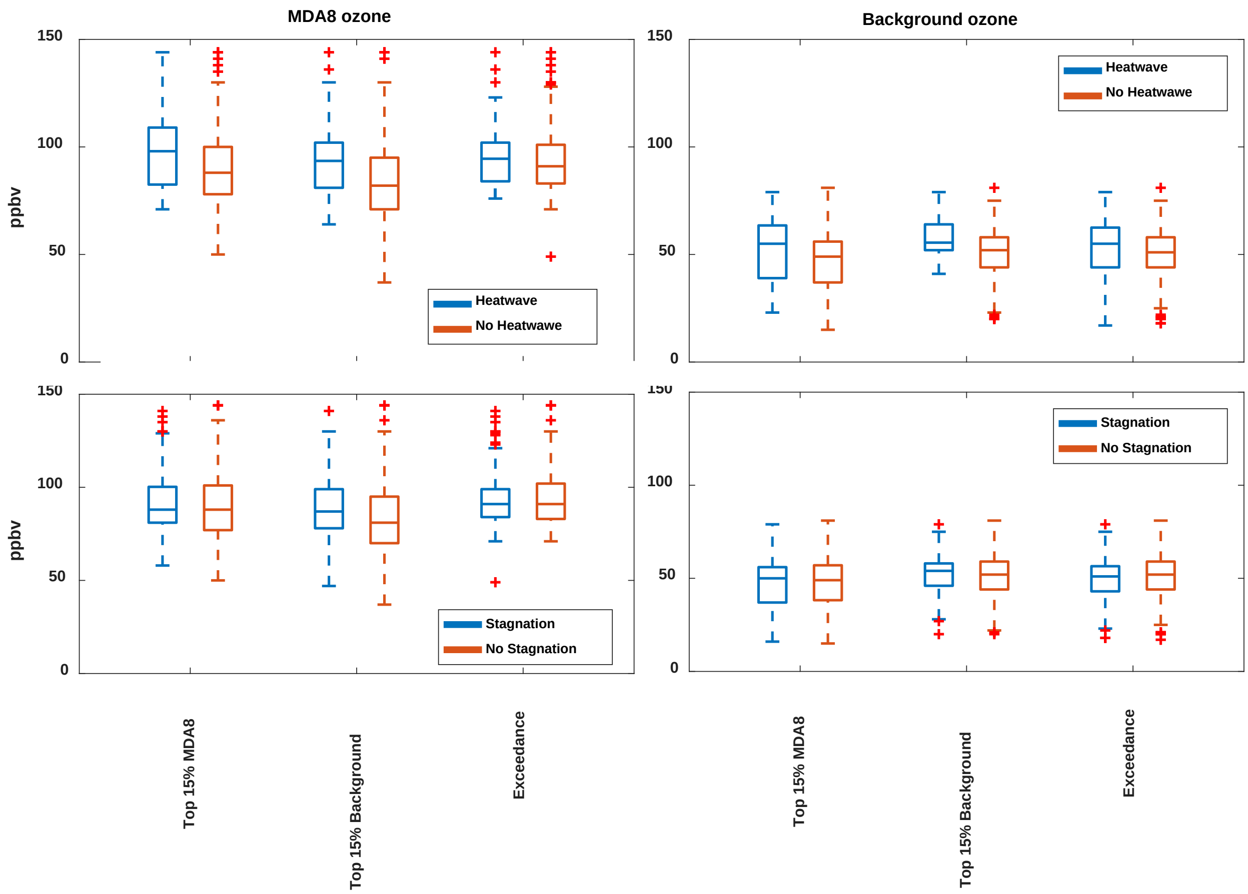

Figure 1. Boxplots of MDA8 (left) and Background (right) ozone mixing ratio with and without heatwave (upper row) and stagnation (lower row) during high ozone days.

Since most heatwaves happened in 2011, we just present time series of stagnation in the following figure. Figure 2 shows the time series of the median of MDA8 ozone with and without stagnation during the top 15% MDA8 and exceedance days. All four lines in Figure 2 showed decreasing trends during 2000 – 2015. Stagnation days tended to have higher median ozone after

2010 (except for the low ozone year of 2014). This indicates weather conditions play relatively a more important role in causing high ozone events when local emissions are reduced.

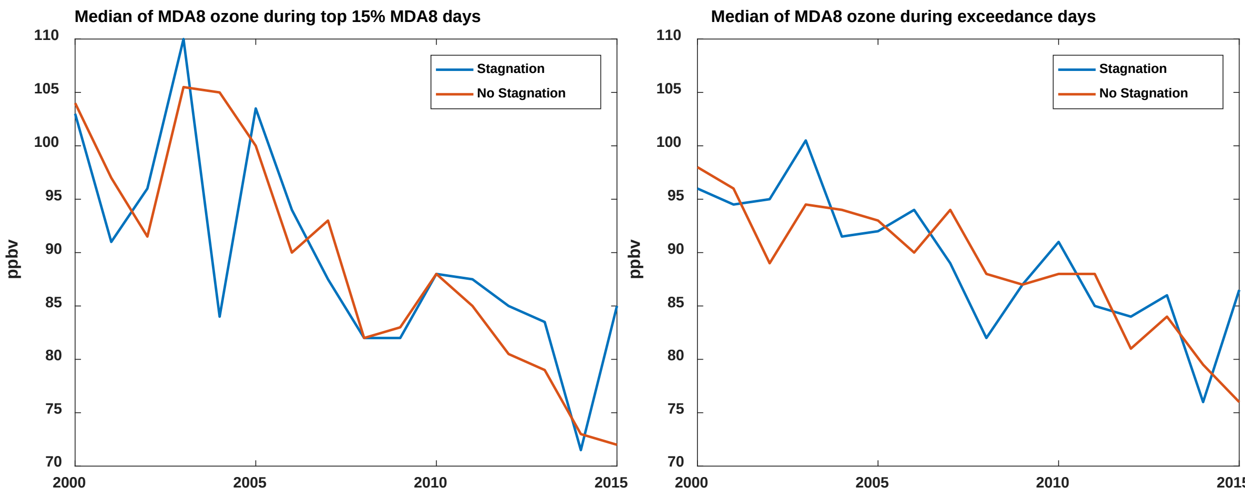

Figure 2. Time series of medians of MDA8 ozone with and without stagnation during the top 15% MDA8 (left) and exceedance days (right).

<u>Task 3</u>:

In previous reports, we used the peak MDA8 ozone and background ozone observations from Mr. Mark Estes (TCEQ). Since the peak MDA8 ozone is sensitive to local effects, the HGB-mean MDA8 ozone at all the surface sites should be a better metric to compare with predicted MDA8 ozone from grid-based models. Therefore, all the analysis/plots comparing model results and observations have been updated in terms of HGB-mean MDA8 ozone. The observational records of MDA8 ozone over HGB were obtained from the TCEQ website (https://www.tceq.texas.gov/cgi-bin/compliance/monops/8hr_monthly.pl).

Figure 3 shows the observed daily mean MDA8 ozone compared with model simulation with and without Central American fires in April 2011. Overall, the model captures the temporal patterns of MDA8 ozone but it has a positive mean bias around 6.98 ppbv, which is a common problem of current air quality models in simulating surface ozone along the Gulf Coast in absence of advanced halogen chemistry.

In order to remove the possible model bias and compare model results with observation, we calculated the daily anomalies in each time series by subtracting their mean values respectively. Figure 4 shows the anomaly of MDA8 ozone in April 2011. The correlation between observed and simulated MDA8 anomalies is 0.92, indicating good performance of the model in simulating the day-to-day variability of HGB-mean ozone relative to the monthly mean.

Since back trajectory has its uncertainties, the fire-impact days selected by back trajectory may not be the true fire-impact days. Hence, we picked fire-impact days based on back trajectory which also have positive Δozone in model results to evaluate model performance. Model simulated mean MDA8 is 48.05 ppbv while observational mean MDA8 is 37.38 ppbv, which shows that the model has a larger positive bias in simulating HGB ozone on the fire-impact days than that on non-impact days. This is because air masses on the fire-impact days were predominantly onshore maritime flows and these air masses tend to have the lowest ozone levels (when absent of fire influences) for which the model has the largest high bias. In the following work we will investigate the model bias in more detail and try different bias-removal methods so as to separate the model bias from the simulated fire impacts.

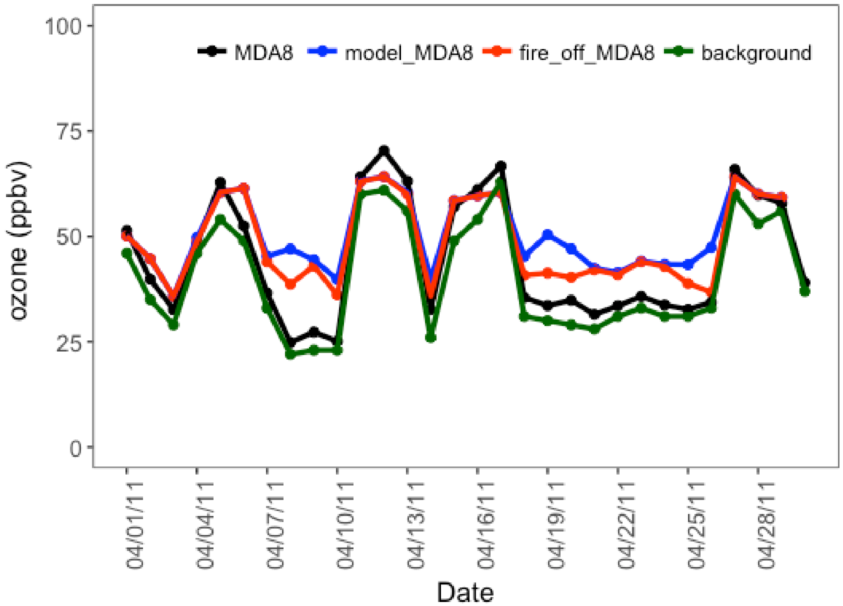

Figure 3. Daily observed MDA8 ozone (black line) and background ozone (green line) compared with model simulated surface ozone with (blue line) and without (black dashed line) Central American fires in April 2011.

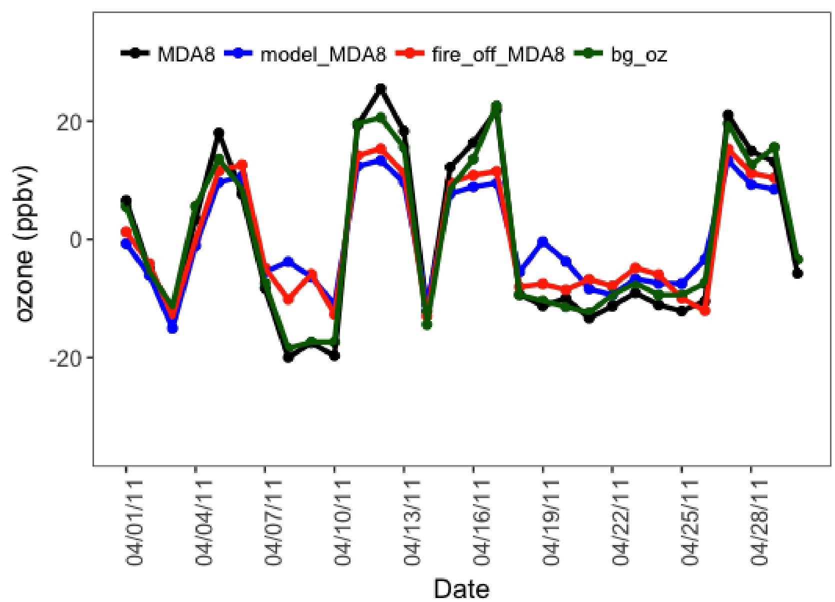

Figure 4. Daily anomalies of observed MDA8 ozone (black line) and background ozone (green line) for April 2011 compared with model MDA8 ozone with (blue line) and without (black dashed line) Central American fires.

Figure 5 and Figure 6 shows the same analysis as in Figure 3 and 4, respectively, but for the month of May 2008. The positive bias between observation and model MDA8 in May 2008 is around 15.6 ppbv, which is larger than the bias of April 2011. The simulated mean MDA8 is 53.41 ppbv on fire-impact days while the observational mean MDA8 is 36.56 ppbv, again showing a larger positive bias than non-impact days. The correlation between observed and modeled MDA8 ozone anomalies is 0.48 for May 2008.

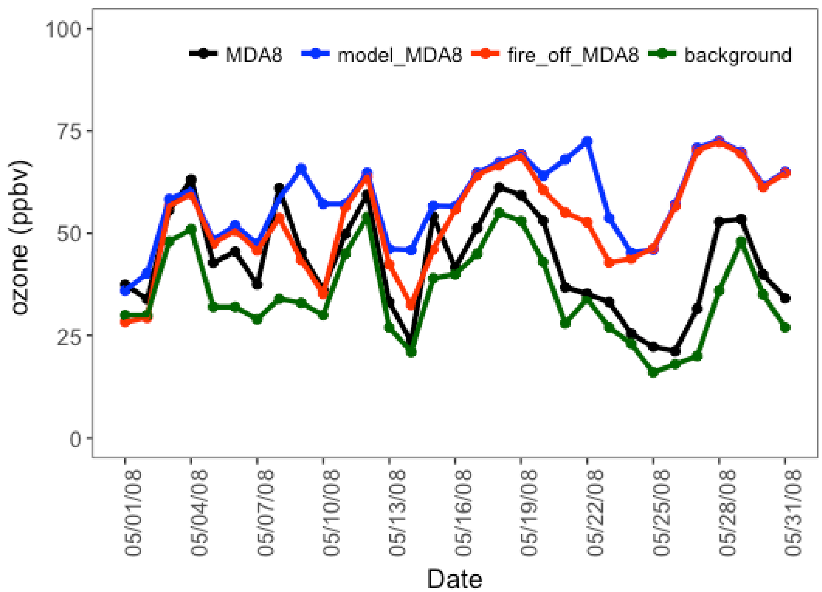

Figure 5. Daily observed MDA8 ozone (black line) and background ozone (green line) compared with model simulated surface ozone with (blue line) and without (black dashed line) Central American fires in May 2008.

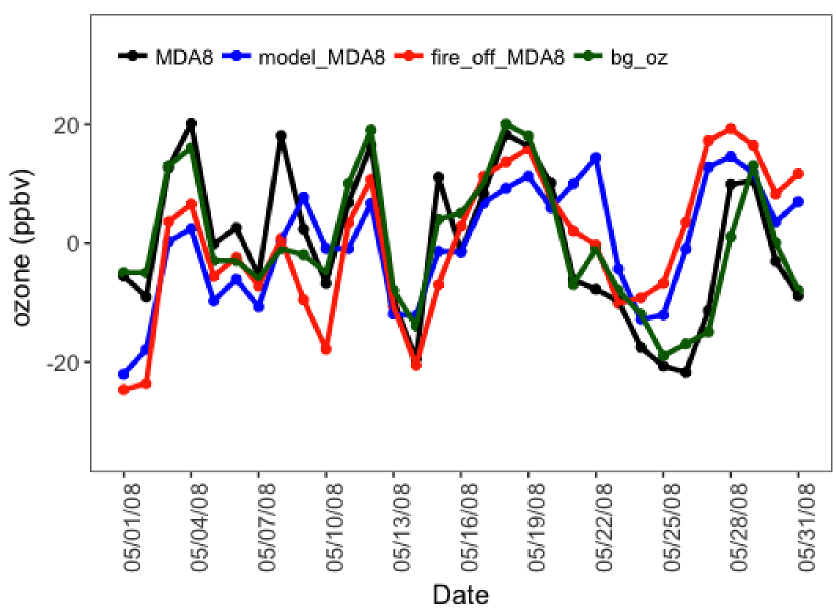

Figure 6. Daily anomalies of observed MDA8 ozone (black line) and background ozone (green line) for May 2008 compared with model MDA8 ozone with (blue line) and without (black dashed line) Central American fires.

Figure 7 summarizes the model simulated Δozone for the fire impacts days during April 2011 and May 2008. In the model world it suggests that Central American fires led to 5-11 ppbv enhancement of HGB mean MDA8 ozone in the two sample months. However, as noted above the model has intrinsic difficulties in simulating the baseline ozone levels of maritime air masses. However, we do not expect such deficiencies to significant affect the simulated Δozone for the fire impacts because they are caused by completely different mechanisms. But more in-depth analysis of the model bias is warranted and will be a focus of our subsequent analysis. In addition, uncertainties in fire emissions and plume chemistry will lead to errors in model predicted ozone enhancements by Central American fires. We will investigate these issues in the subsequent analysis.

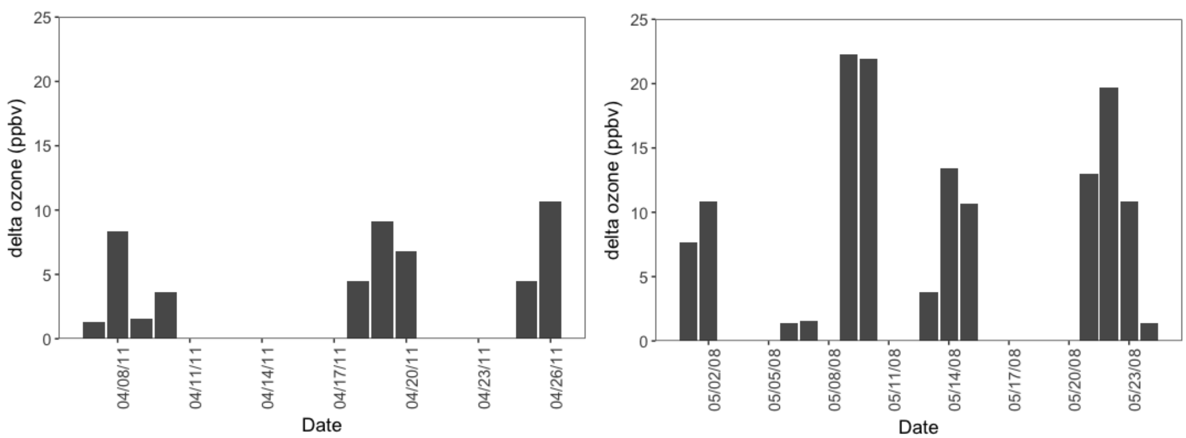

Figure 7. Simulated Δozone for the fire impacts days during April 2011(left) and May 2008 (right).

Data Collected

MDA8 ozone observation in May 2008 and April 2011 from TCEQ website (https://www.tceq.texas.gov/cgi-bin/compliance/monops/8hr_monthly.pl).

Identify Problems or Issues Encountered and Proposed Solutions or Adjustments

None this period.

Goals and Anticipated Issues for the Succeeding Reporting Period

<u>Task 2</u>: We will continue investigating the effect of weather event on high ozone days.

<u>Task 3</u>: Model improvements and bias analysis. Simulation of another month with fire impacts.

<u>Task 4</u>: How many days of ozone exceedances in the HGB area can be avoided during the past 16 years (2000-2015) if background ozone concentrations had been 10% lower during the days of exceedances?

Detailed Analysis of the Progress of the Task Order to Date
Progress on the project is ongoing.

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 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

Submitted to AQRP by

Principal Investigators: Yuxuan Wang and Robert Talbot