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	02/07/2017
REPORTING PERIOD	**From:** 01/01/2017 **To:** 01/31/2017	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: Three methods of selecting 15% highest ozone days have been compared.

Task 2: Not started.

Task 3: The second case study of the impact of Central American fires on HGB ozone was selected and the GEOS-Chem simulation was conducted.

Task 4: Not started.

Preliminary Analysis

Task 1

Since the count of exceedance days in Houston has been decreasing during 2000-2015, using an absolute threshold (e.g. 70 ppbv) may miss the influence of some relatively high ozone days during the latter years of the research period. We employed a relative standard to select high ozone days by picking the **15% highest ozone days**. The are three methods to select the 15% highest ozone days were:

15% by month: the 15% highest ozone days in each calendar month (Apr-Oct) over the 16-year study period (2000-2015), corresponding to a total of 72 days per month;

15% by year: the 15% highest ozone days in each year, corresponding to a total of 32 days per year;

15% in a single month: the 15% highest ozone days in each single month, corresponding to a total of 4 days per month.

These selection methods were applied to the MDA8 ozone and background ozone data. We also plotted the results of **all data** (all days over the 16-year period, 2000-2015) for the convenience of comparing the differences among the three methods.

Figure 1 shows the time series of ozone mixing ratio averaged over the top 15% groups. For annual series, the correlation coefficients of the MDA8 ozone between all data and 15% by month, 15% by year, and 15% in a single month are 0.6365, 0.8959, and 0.9344 respectively, and the corresponding correlation coefficients of background ozone are 0.5085, 0.8436, and 0.8581 respectively. Ozone mixing ratios from the different ways of selecting the top 15% groups all display a decreasing trend from 2000 to 2015. Compared to 15% in a single month, 15% by year always shows a higher mixing ratio since it selects highest ozone days in each year excluding the relatively high ozone days in nonpeak months. Compared to the other two methods, 15% by month shows relatively lower values in the first few years but relatively higher values in the last few years because it discounts the decreasing trend of ozone mixing ratio.

For monthly series (bottom panels), the correlation coefficients of the MDA8 ozone between all data and 15% by month, 15% by year and 15% in a single month are 0.7699, 0.1240, and 0.8817 respectively, and the corresponding correlation coefficients for background ozone are 0.7927, -0.1859, and 0.9020 respectively. Compared to 15% in a single month, the 15% by month always shows higher mixing ratios since it selects highest ozone days over the whole 16-year period. The 15% by year does not show a distinct trough in July because it selects only the highest ozone values in July that can make to the top 15% category of each year.

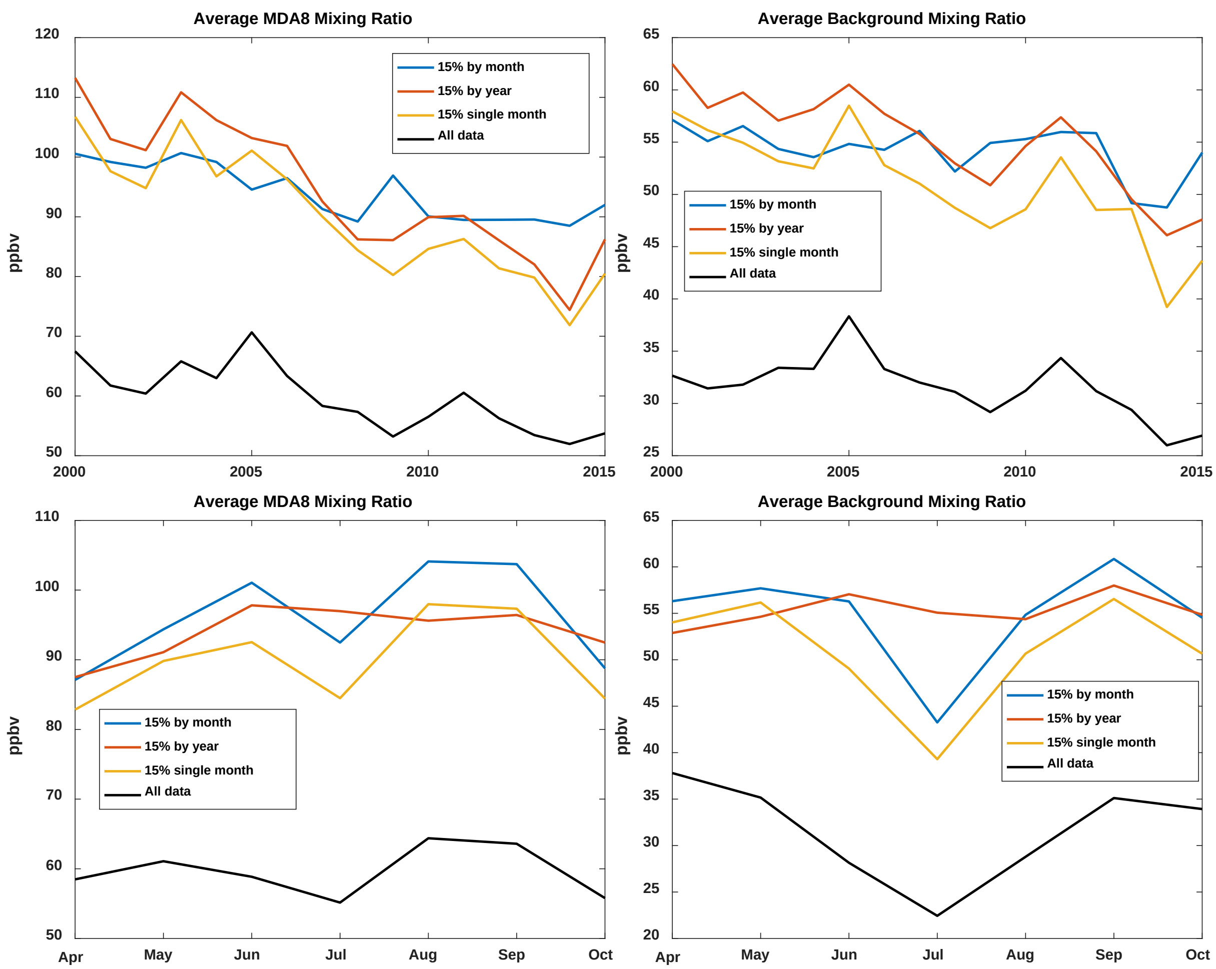

Figure 1. Yearly (upper row) and monthly (lower row) time series of average MDA8 (left column) and background (right column) ozone mixing ratios.

Figure 2 shows the boxplots of ozone mixing ratio. Maximum of MDA8 ozone are all 144 ppbv. Minimum of MDA8 ozone of all data, 15% by month, 15% by year, and 15% in a single month were 80, 48, 41, and 61 ppbv respectively. Maximum of background ozone were all 81 ppbv. The minimum background ozone values of all the data, 15% by month, 15% by year, and 15% in a single month were 1, 33, 40, and 20 ppbv respectively. The range of the MDA8 ozone of all data, 15% by month, 15% by year, and 15% in a single month were 129, 69, 78, and 94 ppbv respectively while the ranges of background ozone were 80, 48, 41, and 61 ppbv respectively. It may indicate that interannual MDA8 ozone variation was greater than monthly variation, while monthly background variation was greater than interannual variation.

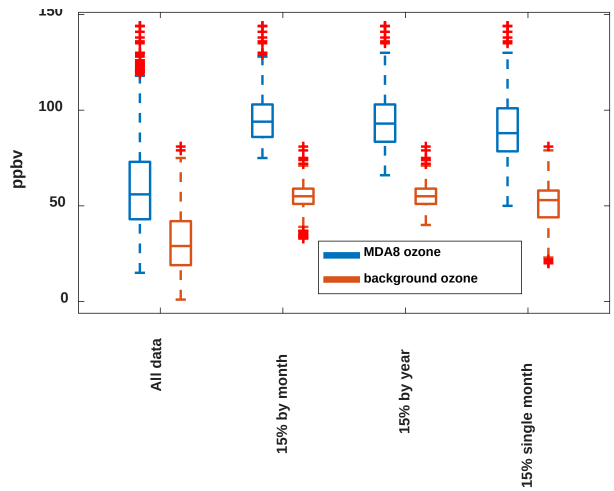

Figure 2. Boxplot of MDA8 (blue boxes) and Background (red boxes) ozone mixing ratios.

Figure 3 shows the probability curves of ozone mixing ratio. All three methods have similar right shoulders for both MDA8 and background mixing ratios. The 15% in a single month showed clearly higher left shoulders for both MDA8 and background curves compared to the other two methods. The 15% by year showed a litter higher left shoulder for MDA8 mixing ratio while it showed a slight lower left shoulder for background mixing ratio. This is consistent with the inference pointed out above.

To study the effect of peak ozone years (e.g. 2005 and 2011) on skewness, the curves without 2005 and 2011 were plotted as '--' and '·-' respectively in Figure 3. The skewness is mainly affected by the lowest and highest values. The average mixing ratio in 2005 was highest during the whole research period. The curves moved to the left a little after 2005 was removed. Though the average mixing ratio in 2011 showed as a peak, it was still on the average level for the whole research period. Thus, it showed the more significant effect on skewness during 2008-2015 than 2000-2015. Overall the effects of removing a certain year data were much less than selecting the high ozone day with different methods.

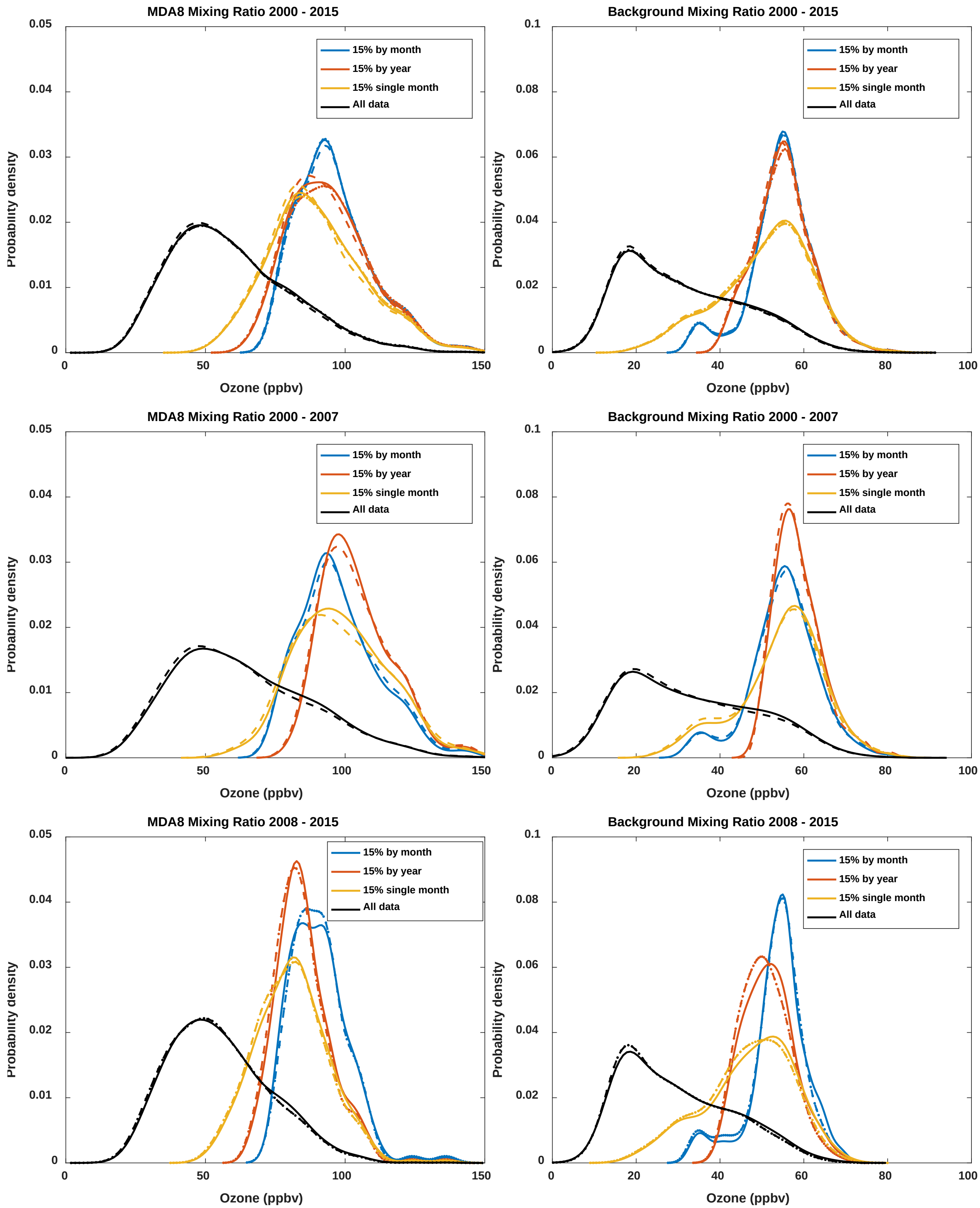

Figure 3. Probability density curves (solid lines) of MDA8 (left) and background (right) ozone mixing ratio. Dashed lines show the data without 2005 data, and dot-dashed lines show the data without 2011.

Figure 4 shows the annual time series of percentages of weather event days during high ozone days. For heatwaves percentages during both high MDA8 and background ozone days were zero in 2001, 2002, 2003, 2004, 2007, 2008, 2010, 2014, and 2015 since few or no heatwaves occurred. In 2000 both the count of heatwaves and mean ozone mixing ratio were above averages. Most of the heatwaves happened in 2011, and heatwaves were associated with more than 20% of the high ozone days in that year.

Stagnation (bottom panels of Figure 4) has a stronger and more consistent association with high ozone days than heatwaves. The variations of overlapping percentages generally followed the time series of stagnation counts. Differences among the three methods were greatest in 2013 - 2015 for MDA8 ozone, 2014 and 2015 for background ozone. Notice that the 15% by month showed much higher percentage of overlapping with stagnation than the other two methods in some years during 2009-2015. This is because the 15% by month method selected less ozone days in the second half of the research period because of the decreasing trend of ozone.

The reason why the three methods showed great differences is because ozone mixing ratio showed both interannual and monthly variations. The method of selecting 15% in a single month may be a more "stable" approach than the other two methods because it has the same sample size every month (4).

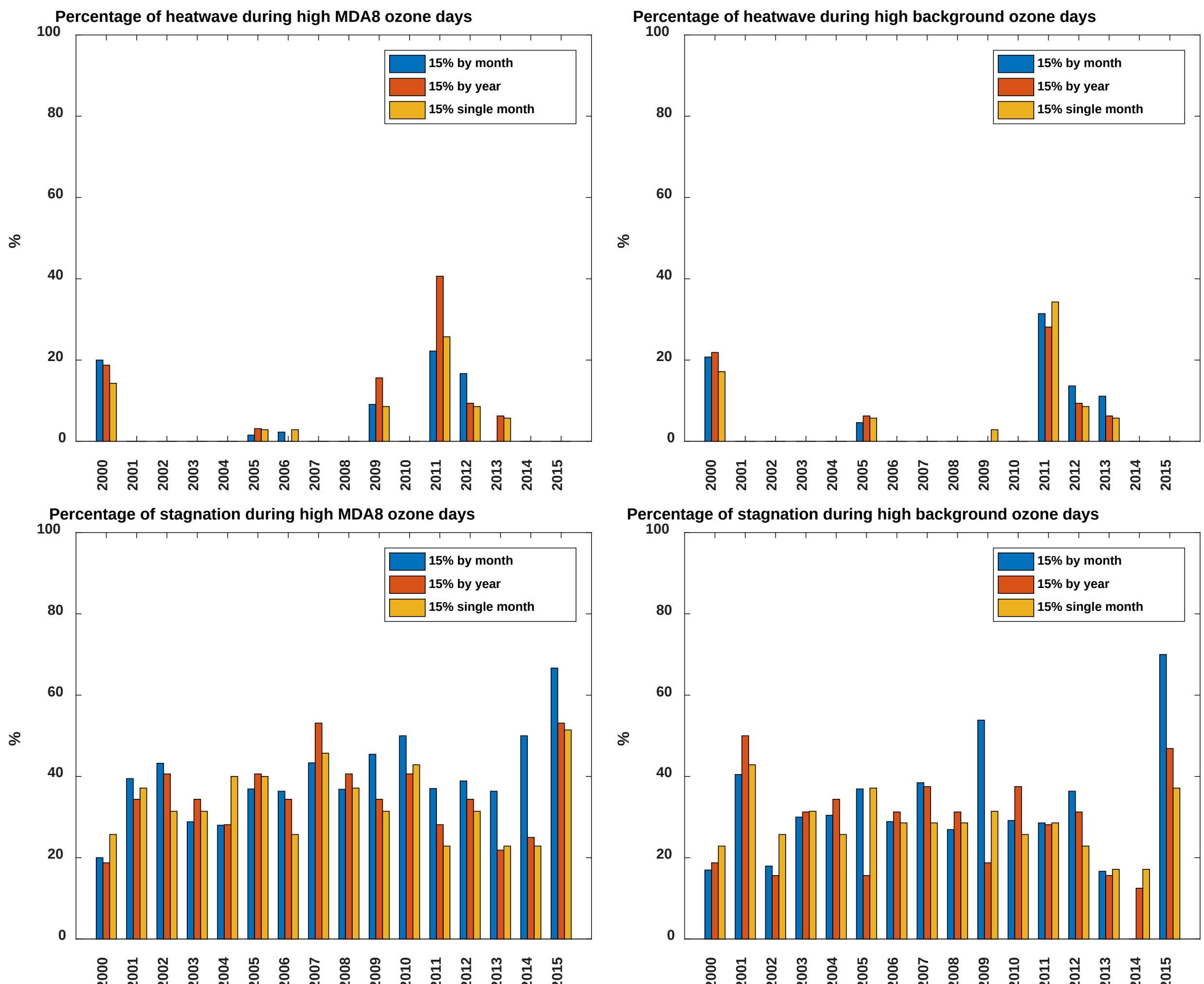

Figure 4. Annual time series of percentages of weather event days (upper row: heatwaves, lower row: stagnation) during high MDA8 (left column) and background ozone (right column) days.

Figure 5 shows the monthly time series of the percentages of weather event days during high ozone days. For heatwaves (upper panels), the percentage in June, August, and September were high since both mixing ratio and count of heatwaves were high. Note that heatwaves were frequent only in a few days (c.f. Figure 4 upper panels), so the seasonality shown here reflects that of those years with heatwaves.

For stagnation (lower panel), the variations of percentages also generally followed the time series of stagnation counts like the annual plots. Both percentage and count curves showed a "W" shape. Monthly differences among three methods were not as significant as interannual plots. The 15% in a single month has more "stable" results than the other two methods.

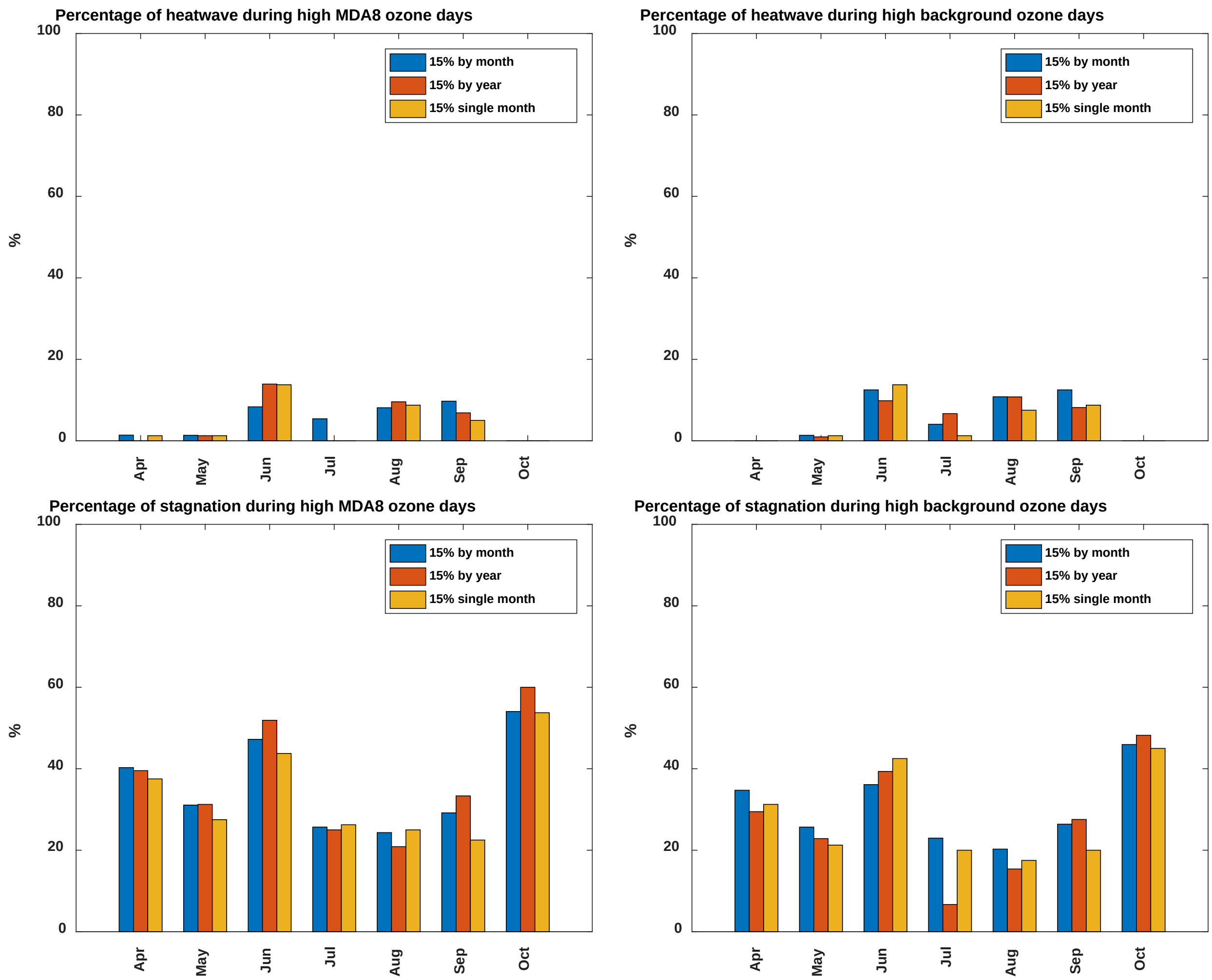

Figure 5. Monthly time series of percentages of weather event days (upper row: heat wave, lower row: stagnation) during high MDA8 (left column) and background ozone (right column) days

In summary, the differences among three methods are more significant on interannual series than monthly series. The15% in a single month is the most "stable" method to select the highest ozone days. It showed highest correlation coefficient on average ozone mixing ratio with all the data set, with a moderate range and standard deviation on overlapping percentages with weather events. But the 15% in a single month method missed some high ozone days during the heatwave years (e.g. 2011). In that case, using a fixed threshod (e.g. 70 ppbv) may be better in capturing all the high ozone days in 2011.

Task 3:

The fire case of April 2011 has been analyzed by using GEOS-Chem model simulation with the resolution of $0.5^o \times 0.667^o$ outlined in our previous report. In this report we discuss the model simulation of another case (May 2008) which was reported in Saide et al. (2016). Figure 6 shows observed daily ozone compared with model simulation with and without Central American fires in May 2008. The model-simulated period includes May 6 to May 14, which was around the fire event of May 10^{th} 2008 reported by Saide et al. (2016). The model captured some ozone variability in the time period (comparing the black line and blue line in Figure 6) but had a low bias probably due to the coarse resolution, The differences in the model simulations with and without Central American fires (blue line and black dashed line in Figure 6) range between 2 and 20 ppbv, with higher values on 9-11 May. This indicates the Central American fires could have contributed around 2-20 ppbv to HGB ozone during the fire-impact days from May 6 to May 14 2008.

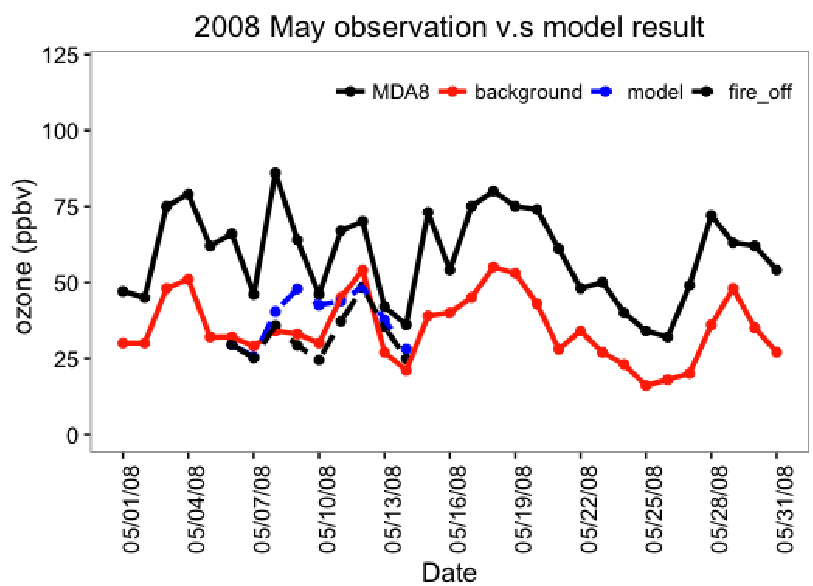

Figure 6. Daily observed MDA8 ozone (black line) and background ozone (red line) compared with model simulated surface ozone with (blue dashed line) and without (black dashed line) Central American fires in May 2008.

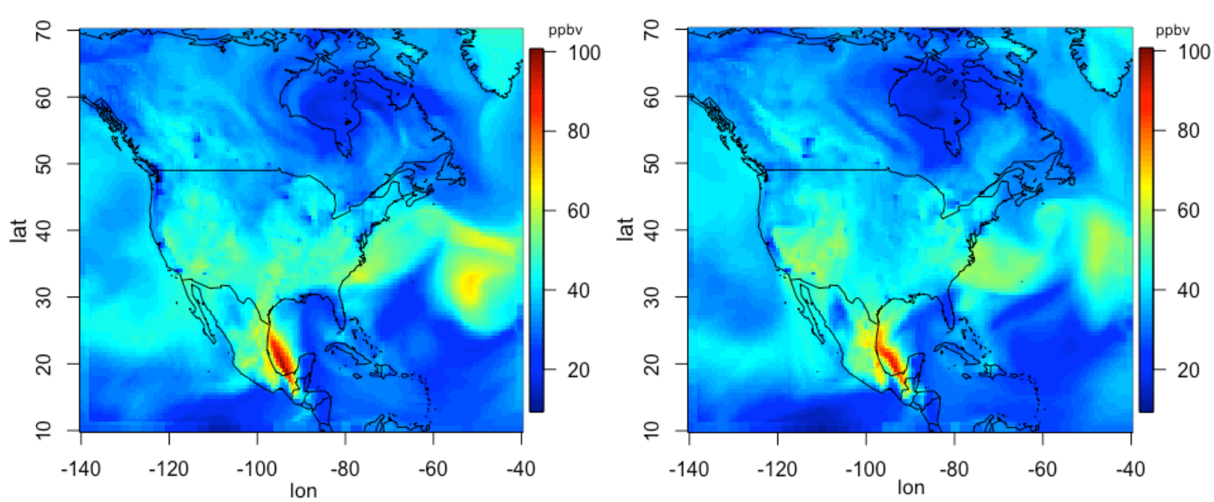

Figure 7. The simulated surface ozone on May 10 (left) and May 11(right) 2008.

Figure 7 shows the spatial distribution of simulated surface ozone from May 10 to 11 2008, which has been reported in Saide et al. (2016). The plume from Central America can be clearly seen shown in our simulations of the two days. The magnitude of ozone enhancement in the plume is different between the two days because fire emissions were different due to different burning area (Figure 8). The burning area peaked on May 9 and then decreased on May 11, which is consistent with changes of our simulated surface ozone (Figure 6). The positive bias on May 9 and 10 suggests the background ozone over the HGB may be affected not only by burning area in Central America but also by other factors which are not well-considered in model (*e.g.*, plume chemistry). The sensitivity simulation was conducted by turning off the biomass burning emissions over Central America. Figure 9 shows the differences of surface ozone mixing ratios with and without Central American fires (with fires simulation minus without fires) by turning off fires in the selected region in the model on May 10 and 11 2008. The plumes in two different days show different patterns, which may be caused by different meteorological conditions. In the HGB area, the contribution of fires on ozone is around 20 ppbv on May 10 and around 6 ppbv on May 11 according to our model results.

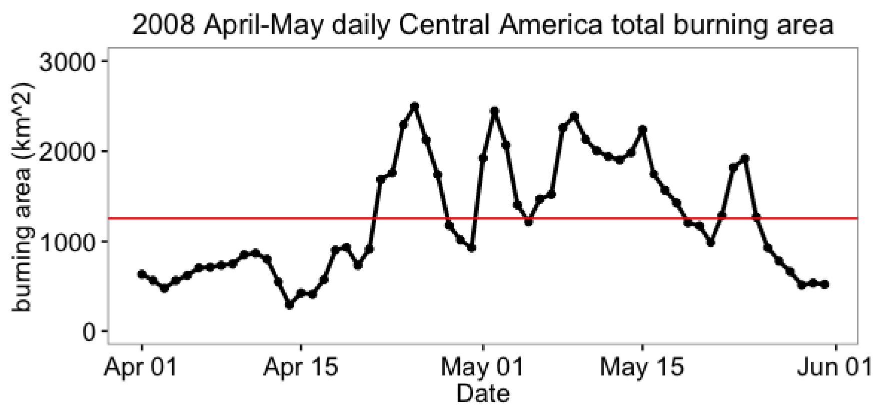

Figure 8. Time series of total burning area in Central America from April to May in 2008. The red line indicates the mean burning area in the time period.

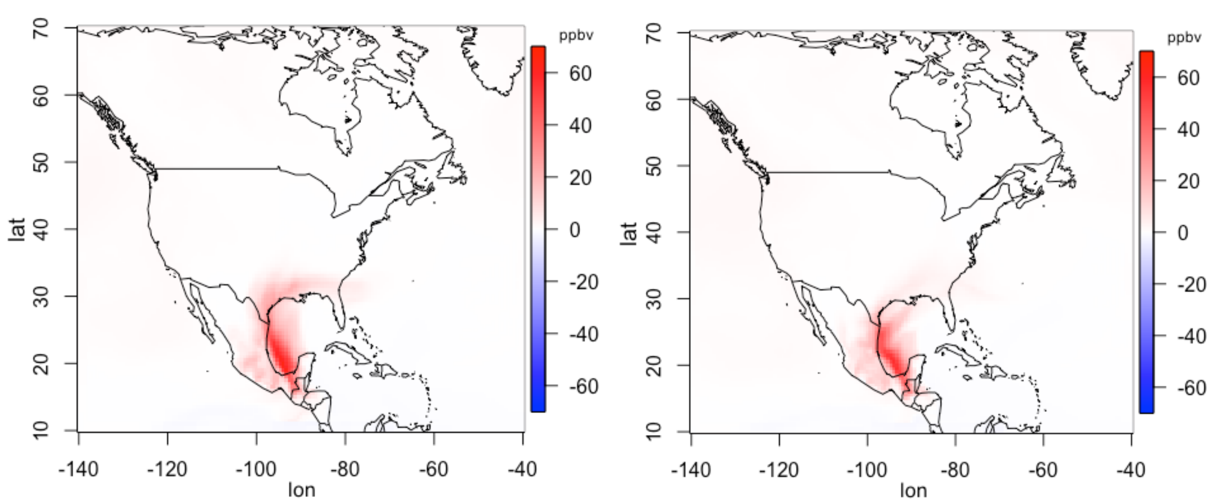

Figure 9. The differences of surface ozone mixing ratios with and without Central American fires on May 10 (left) and 11 (right).

Data Collected
None this period.

Identify Problems or Issues Encountered and Proposed Solutions or Adjustments
None this period.

Goals and Anticipated Issues for the Succeeding Reporting Period
Task 1: Relationship between high ozone days and weather events will be further analyzed.

Task 3: The upper 25% of background ozone in fire-impact days will be picked and analyzed. More case studies will be simulated and model discrepancies will be improved.

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

References

Saide, P. E., Thompson, G., Eidhammer, T., Silva, A. M., Pierce, R. B., & Carmichael, G. R. (2016). Assessment of biomass burning smoke influence on environmental conditions for multiyear tornado outbreaks by combining aerosol-aware microphysics and fire emission constraints. Journal of Geophysical Research: Atmospheres, 121(17).