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**	06/08/2017
REPORTING PERIOD	**From:** 05/01/2017 **To:** 05/31/2017	**REPORT #**	8

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: Case studies were conducted based on cold front position data from the Weather Prediction Center (WPC) Surface Analysis Archive to identify effects of cold fronts on the HGB ozone.

Task 2: None this period.

Task 3: Passive tracers were implemented in the GEOS-Chem model nested version to track air mass origins from 2000 to 2015. Quantification of fire impacts during 2000 to 2015 in the nested model was conducted and compared to results using the back trajectory method.

Task 4: None this period.

Preliminary Analysis

Task 1:

In previous reports we conducted analyses of cyclone data to determine the effects of cold fronts on HGB ozone. The difficulty in this is that relationship between the HGB ozone and cyclone days is unclear since cold frontal positions could not be directly located by cyclone center tracks. For this period, we employed a new data set, the Weather Prediction Center (WPC) Surface Analysis Archive (http://www.wpc.ncep.noaa.gov), which directly marked cold front positions.

The WPC Surface Analysis is part of the National Weather Service (NWS) Unified Surface Analysis and a collaborative effort with the Ocean Prediction Center (OPC) and the National Hurricane Center (NHC). It is a manual analysis of surface fronts and pressure over North America and adjacent oceans at three-hour intervals from 2003 to present. They utilize a variety of weather data in addition to observations of surface weather conditions, such as upper air observations, global satellite imagery, Doppler radar, and model mass fields to ensure that the product is meteorologically consistent and of the highest quality. Figure 1 shows a sample of weather map of the WPC surface analysis valid for 04/04/2014 at 12 UTC when a cold front crossed the HGB.

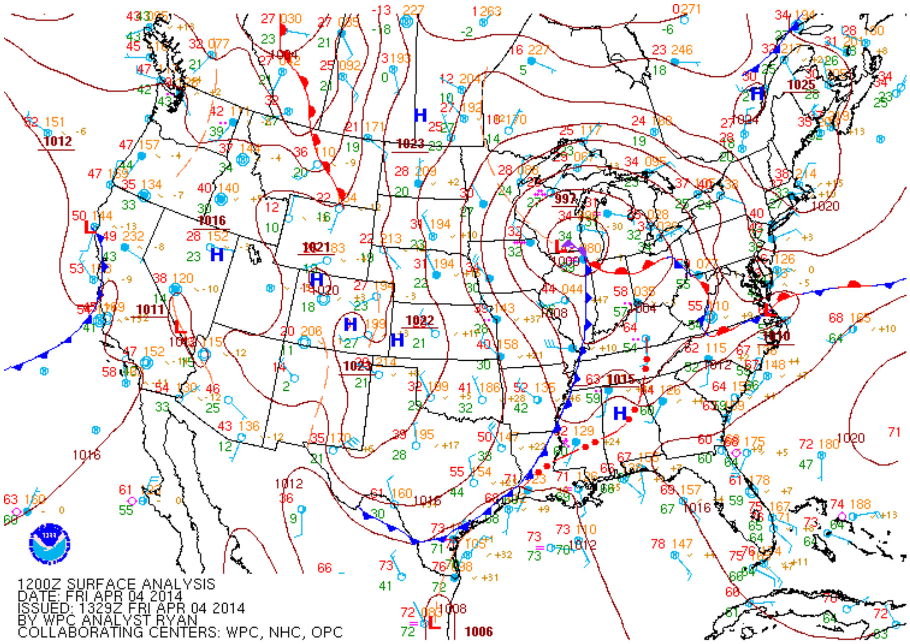

Figure 1. Weather map sample of the WPC surface analysis valid for 04/04/2014 at 12 UTC.

To better understand the data set, we conducted case studies of April 2014 since cold front has a higher frequency in the HGB in spring and different responses of the HGB ozone on cold fronts were found in April 2014. Figure 2 shows the time series of MDA8 and background ozone in the HGB in April 2014. Sampled days marked as "•" during which the cold front lines crossed the HGB at least in one three-hour frame.

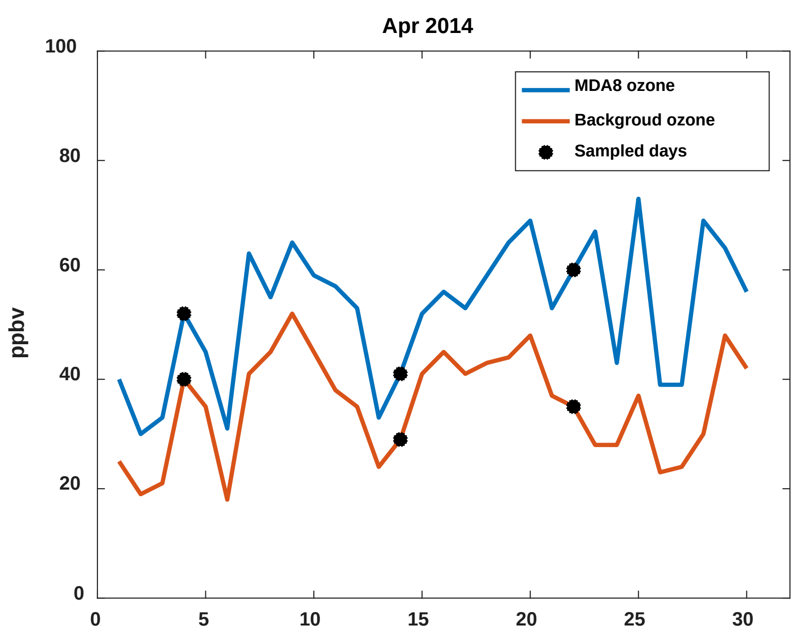

Figure 2. Time series of MDA8 and background ozone in the HGB in April 2014.

Figure 3 shows the cold front positions on sampled says (April 4, 14, and 22, 2014). To better understand how cold fronts moved, we zoomed in the weather map to the Texas area and marked the HGB as a red rectangle. Then we merged 8 frames in one day into single plots and marked cold front locations in distinct colors for each time.

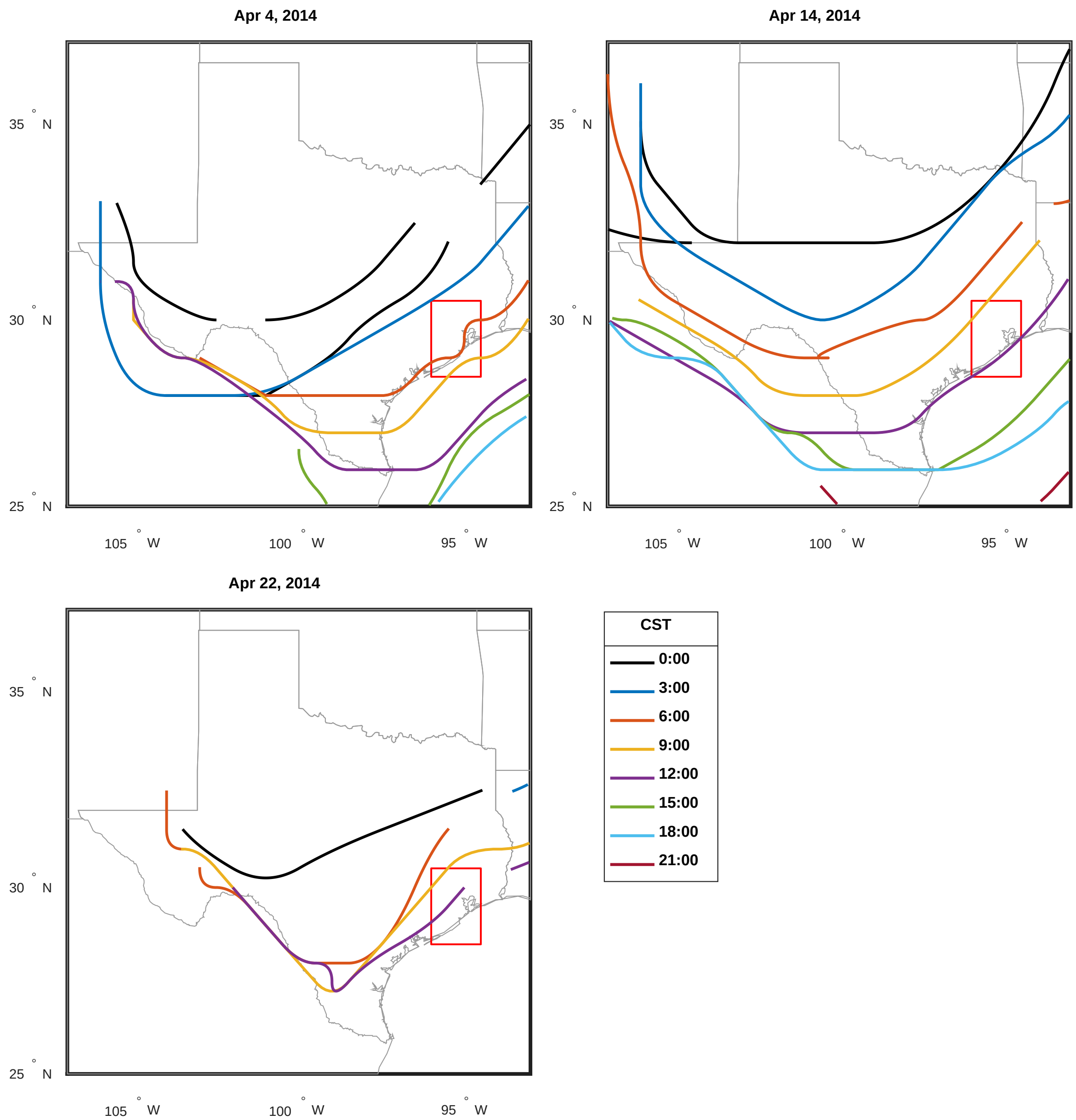

Figure 3. Cold front positions on April 4 (a), 14 (b), and 22 (c), 2014.

On April 4, both MDA8 and background ozone were higher than previous and the following days. The cold front approached the HGB from the northeast and reached the boundary of the HGB around 3 AM CST then left the HGB land area around 6 AM CST. Since this cold front pass happened in the early morning, warming processes occurred in morning and afternoon that may have raised the MDA8 and background ozone.

On April 14, 2014, both MDA8 and background ozone were higher than the previous day and lower than the next day. The cold front approached the HGB from the northeast and reached the boundary of the HGB around 9 AM CST then left the HGB land area around 12 PM CST. Since this cold front pass happened from morning to noon, the warming processes that happened in afternoon may raise the MDA8 and background ozone but it was not as significant as it was on April 4.

On April 22 MDA8 ozone was higher than the previous day and lower than the next day while background ozone was lower than the previous day and higher than the next day. The cold front approached the HGB from the northeast and reached the boundary of the HGB around 6 AM CST. It reached the center of the HGB around 12 PM CST then disappeared. The reason why MDA8 and background ozone shows opposite trend around April 22, 2014, may be because it brought "cleaner" air to the background site and pushed the ozone precursors to the center of the HGB area.

In summary, the Weather Prediction Center (WPC) Surface Analysis Archive may help to understand cold front effects on the HGB ozone by directly marking cold front locations. A cold front may have confounding effects on HGB ozone by pushing contaminated air masses from the northeast and causing low temperatures which leads to low ozone production rates at the same time. The final effect of each cold front on the HGB may differ from when it reached the HGB, how long it stayed, whether it penetrated the HGB, and so on. More case studies are needed in following time periods to identify and quantify effects of the above factors.

<u>Task 3</u>:

In a previous report we showed the passive tracer simulation using GEOS-Chem for April 2011 and May 2008. In order to identify the southern fires impact days and the clean Gulf days and quantify their impacts, we ran the passive tracer simulation in nested version using MERRA2 reanalysis meteorology with finer resolution 0.5°×0.625° for April and May of 2000 to 2015. The classification is based on CI values from passive tracer simulations. CI is the sum of the northern tracers (including Texas and the U.S. tracer) minus the sum of the southern tracers (including the Gulf, Mexico and RCA tracer). The south impact day is the day with negative CI value and the clean-Gulf day is defined when the standardized Gulf tracer is positive and all other tracers are negative.

Figure 4 shows the boxplot of HGB background ozone combing April and May 2000-2015 in each group for the two methods. Overall, there is no significant difference between these two methods, indicating the consistency of these two methods. Table 1 illustrates the quantified southern fire impact of the two methods. If the clean-Gulf is taken as a reference, the southern impact contributes 3.7ppbv and 5.7 ppbv on HGB background ozone during 2000 to 2015 April and May according to passive tracer and back trajectory methods respectively.

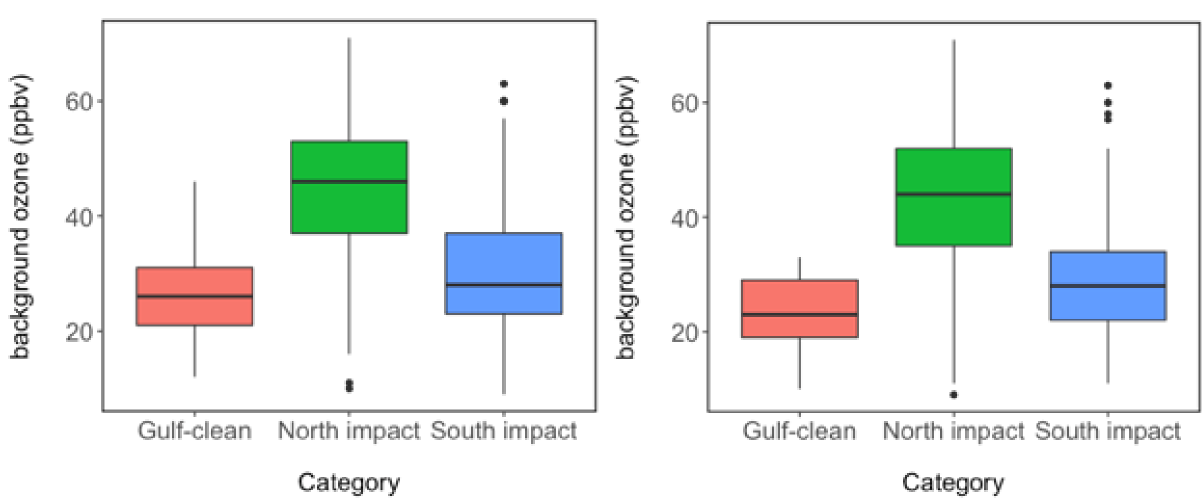

Figure 4. Boxplot of HGB background ozone combing April and May 2000-2015 in each group for passive tracer method (left) and back trajectory method (right).

Table 1. The average background ozone and its standard deviation of the southern fire group, clean-Gulf group, and the quantified impact (southern fire-clean gulf) of the two methods during 2000 to 2015.

	Passive tracer method	Back trajectory
Southern impact	30.25 ± 10.16	29.09 ± 9.13
Clean-gulf	26.57 ± 7.00	23.43 ± 6.13
Δ O_3 (Southern-clean gulf)	3.68 ± 3.16	5.66 ± 3.00

In order to investigate the cause of the differences of the two methods, we separate the impact from the two months. Figure 5 shows the boxplot of HGB background ozone for April and May 2000-2015 in each group for the two methods. Passive tracer-sampled Gulf-clean background ozone is larger the Passive tracer-sampled ones for April, resulting in smaller Δ O_3 (Southern-clean Gulf) of passive tracer methods in April. Table 2 illustrates the quantified southern fire impact of the two methods for the two months. The southern fire impact contributes 2.4 ppbv and 8.0ppbv on HGB background ozone during 2000 to 2015 April according to passive tracer and back trajectory methods respectively. For May, the southern fire impact contributes 4.3 ppbv and 4.2 ppbv on HGB background ozone according to passive tracer and back trajectory methods respectively. The inconsistency of quantified Δ O_3 in April results from higher background ozone in the clean-Gulf group sampled by passive tracer method.

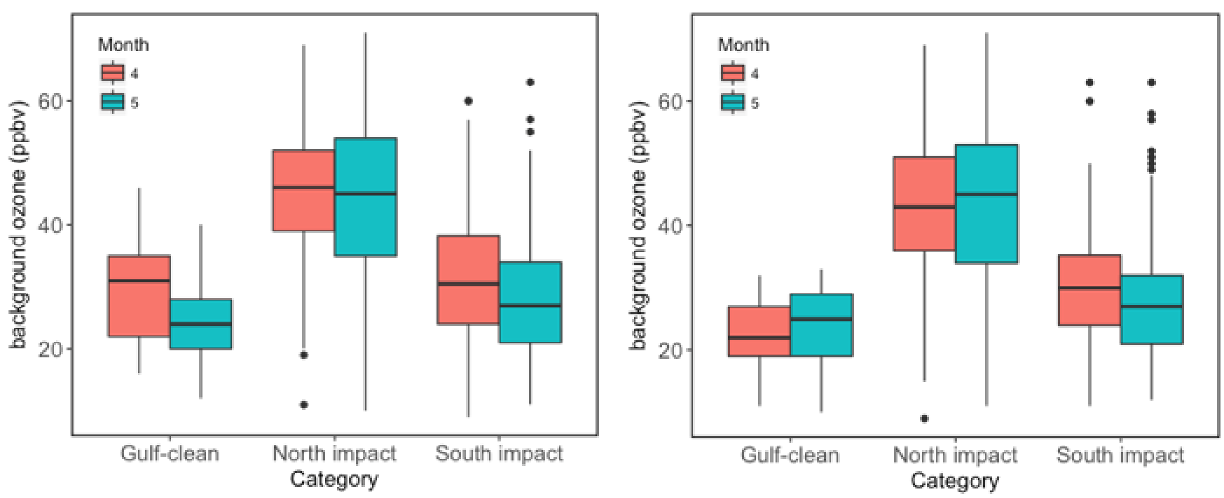

Figure 5. Boxplot of HGB background ozone in April and May 2000-2015 in each group for passive tracer method (left) and back trajectory method (right).

Table 2. The average background ozone and its standard deviation of the southern fire group, clean-Gulf group, and the quantified impact (southern fire-clean gulf) of the two methods during 2000 to 2015 April and May.

	Passive tracer method (April)	Back trajectory (April)	Passive tracer method (May)	Back trajectory (May)
Southern impact	31.94 ± 10.15	30.59 ± 8.92	28.52 ± 9.90	27.90 ± 9.13
Clean-gulf	29.58 ± 7.70	22.59 ± 5.82	24.24 ± 5.42	23.71 ± 6.27

Δ O_3 (Southern-clean gulf)	2.36 ± 2.45	8.00 ± 3.1	4.28 ± 3.48	4.19 ± 2.86

In summary, the passive tracer method agrees well with the back trajectory method for quantifying the southern fire impact. Based on categorization using the CI, we estimated from observations that the Central American fires resulted in a 2.4 ppbv and 4.3 ppbv increase of background ozone at HGB during 2000 to 2015 for April and May respectively. The corresponding enhancement back trajectory method is 8.0 ppbv and 4.2 ppbv, respectively.

Data Collected
The Weather Prediction Center (WPC) Surface Analysis Archive (http://www.wpc.ncep.noaa.gov).

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

Goals and Anticipated Issues for the Succeeding Reporting Period
Task 1: More case studies will be conducted to investigate effects of parameters of cold fronts on the HGB ozone.

Task 3: Investigation of interannual variability of southern fire impact during 2000 to 2015 April and May and quantifying the impact from satellite observation.

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

Title: Impacts of Central American Fires on Ozone Air Quality in Texas
Conference: The 8th International GEOS-Chem Meeting (IGC8)

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