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**	08/08/2017
REPORTING PERIOD	**From:** 07/01/2017 **To:** 07/31/2017	**REPORT #**	10

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: None this period.

Task 3: We updated the selection of the days with strong influences of Central American fires based on the GEOS-Chem passive tracer simulation and analyzed CO and AOD enhancements at HGB from satellite retrievals during those days.

Task 4: Contribution of background ozone to MDA8 ozone and exceedance over the HGB area have been investigated.

Preliminary Analysis

Task 3:

Previous report showed the selection of upper southern days and upper Gulf days by passive tracer simulation in the GEOS-Chem model. In this report we updated the selection by the results from passive tracer simulation and also burned area estimated from the Fire INventory from NCAR version 1.0 (FINNv1): (1) Simulated Mexico tracer at HGB exceeding 85-percentile of all days combined; and (2) Burned area over Central America exceeds 70-percentile. These days were all selected on the basis of under favorable transport of pollutant from fires and also large emissions from source regions so that they represent the extreme cases which were influenced by Central American fires. Clean-Gulf days are also defined by the criteria below: (1) simulated Gulf tracer at HGB exceeding the 85-percentile of all days combined; and (2) Burned area of Central America lower than 70-percentile. The selection with burned area added is to constrain emissions since emission is not considered in the passive tracer simulation. The time period starts from 2002 instead of 2000 is because burned area estimated by FINN is only available from 2002.

Figure 1 shows the mean HGB background ozone for April and May from 2002 to 2015 categorized by the proportion of Mexico tracer and burned area. Compared to the clean-Gulf group, the Central America group has mean background ozone enhancement of 8.8±1.6 ppbv. The enhancement is higher than we quantified by back trajectory because the more extreme fire-impact days with favorable transport and large emission were selected by the passive tracer method.

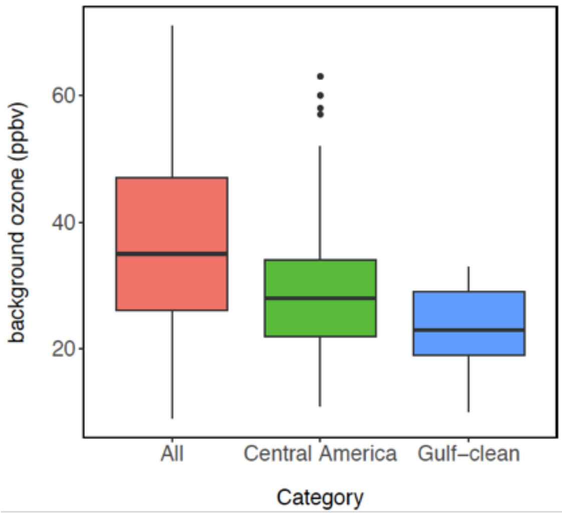

Figure 1. HGB background ozone grouped by air mass origins identified by passive tracers and burned area for Apr-May from 2002 to 2015.

To confirm whether the updated selection is better, satellite observations of carbon monoxide (CO) and aerosol optical depth (AOD) were sampled and compared. CO is an important tracer of biomass burning and has longer lifetime (around 1-2 months) compared to other fire-emitted tracer gases, so it is widely used to track the transport of fire plumes. We sampled the CO retrievals from Measurements of Pollution in the Troposphere (MOPITT) Version 7(V7) product for fire-impact days and clean-Gulf days selected by updated criteria of the 2002-2015 period. Figure 2 presents the total column of MOPITT CO for fire-impact days, clean-Gulf days, and the differences between them. For the fire-impact days, the MOPITT CO column shows fire plumes transporting CO emissions from Central America to the US, leading to enhancements of CO by 9.2% at HGB compared to the upper Gulf days. In contrast, during the clean-Gulf days, CO emissions from Central America stayed closer to their source region and the emission was much smaller than during fire-impact days. MOPITT CO observations thus provide independent evidence to support the selection of fire-impact days and demonstrate the pollutant enhancements along the U.S. Gulf coast (including HGB) due to those fires.

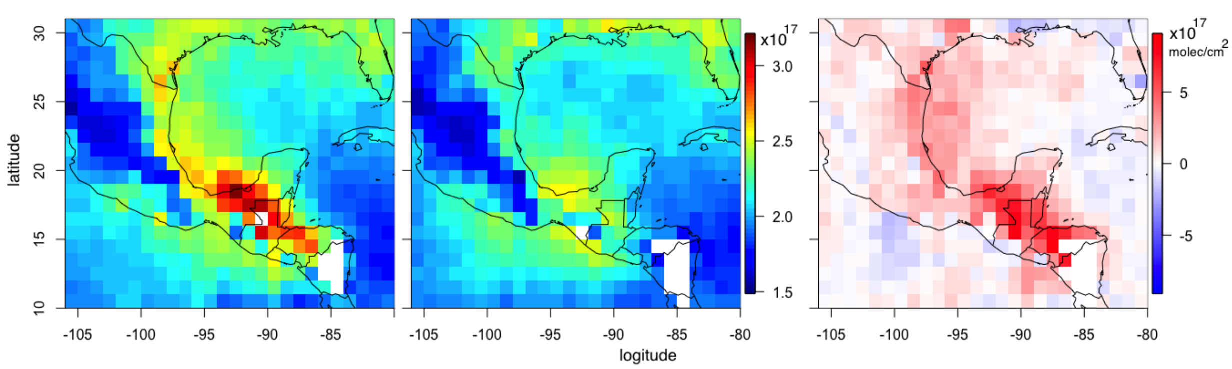

Figure 2. MOPITT CO total column observations for fire-impact days (left), clean-Gulf days (middle), and the difference between fire-impact days and clean-Gulf days (right). The sampling period is for April and May from 2002 to 2015.

The AOD products from Moderate Resolution Imaging Spectroradiometer (MODIS) on NASA's Terra satellite were employed. MODIS AOD measures aerosol optical depth globally on a daily basis. In most cases, aerosol concentrations rise when fires exist, so AOD is also an indicator for transportation of fire emissions. Figure 3 presents the MODIS AOD observations of fire-impact days, clean-Gulf days and the difference between the two for April and May from 2002 to 2015. Strong evidence of the fire plume transporting to southern U.S. is also found in the AOD observations during fire-impact days, which is also shown in the measurements of MOPITT CO. The enhancement of AOD over HGB regions is around 0.04, which is increased by 19% compared to clean-Gulf.

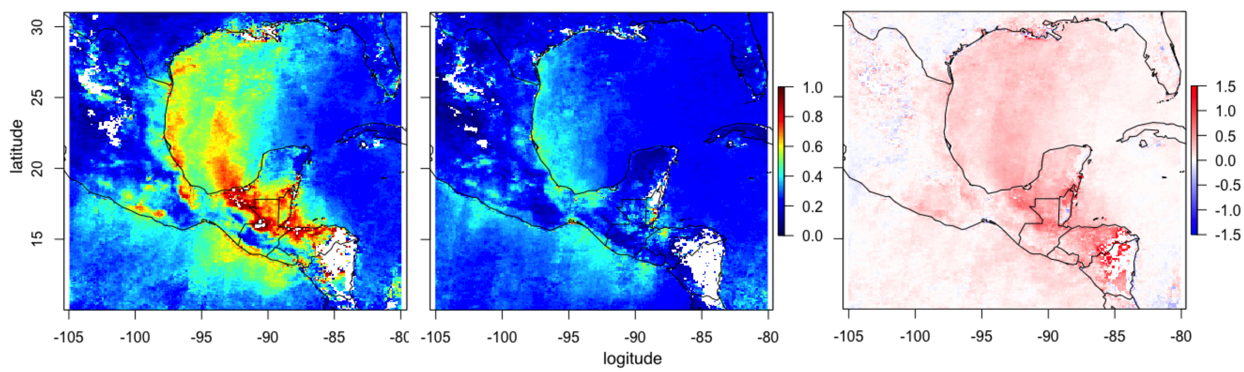

Figure 3. Vertical profile of MOPITT CO (day time only; average along 97.5°W-85°W) in upper southern days (left), upper gulf days (middle) and the difference between the upper southern days and upper gulf days (right).

In summary, we used the differences between the Mexico tracer and the clean Gulf tracer from the GEOS-Chem model plus burned area estimated by FINN to separately identify the days with enhanced fire influences to HGB. The selection of fire-impact days and their transport patterns were verified by both MOPITT CO and MODIS AOD observations which are independent from the model simulations.

Task 4:

To quantify the contribution of background ozone to MDA8 ozone over the HGB area, the contribution is defined as follows:

Contribution (%) = (Background ozone) / (Peak MDA8 ozone)*100%.

Figure 4 presents the background ozone and mean background ozone during corresponding event days. The sequence of events is ranked by the median of contribution rates. Medians of contribution rates of background ozone during all data, post front, cold front, exceedance, stagnation, top 15% peak MDA8 ozone, and thunderstorm days are 53.66%, 60.56%, 58.33%, 55.91%, 54.82%, 53.85%, 50.00% respectively. Post front days show highest background contribution since northwesterly winds brought contaminated air masses to the HGB area. Northwesterly wind on cold front days also brought contaminated air mass but relatively low daily mean temperature might inhibit background ozone growth during cold front days. Both cold front and post front days have a higher background contribution than exceedance days even though mean background ozone is lower than on exceedance days. Stagnation days show similar background contribution with exceedance and top 15% peak ozone days. Thunderstorm is the only meteorological event that shows a lower contribution median than the entire data set.

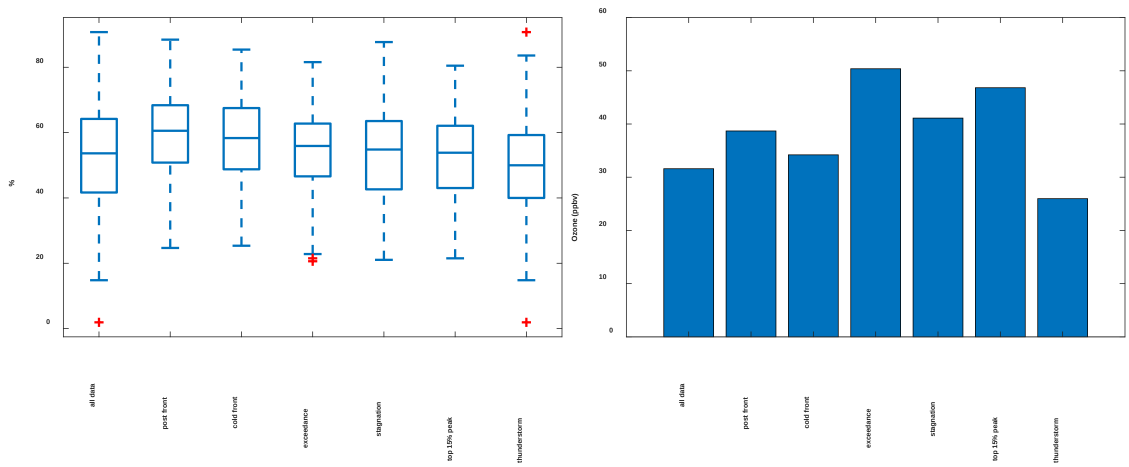

Figure 4. Contribution of background ozone (left) and mean background ozone (right) during event days.

To quantify the contribution of background ozone to exceedance over the HGB area, background ozone for all 28 CAMS sites is assumed to equal to daily background ozone over HGB area. Local ozone for each site is defined as follows:

Local ozone = MDA8 ozone – background ozone.

Adjusted MDA8 ozone for each site is calculated as follows:

Adjusted MDA8 ozone = r1 * Background ozone + r2 * Local ozone.

Where r1 is the ratio of adjusted background ozone level, r2 is the ratio of adjusted local ozone level. R1 and r2 on levels of 100%, 90%, 80%, 70% have been tested in this study. Adjusted exceedance days over HGB area were calculated by the same definition of ozone exceedance days: the days when at least two surface monitors in HGB exceeded 70 ppbv..

Figure 5 shows counts of exceedance days with adjusted background ozone and local ozone. Total counts of exceedance days in 16-year period in ozone season (April - October) with 100%, 90%, 80%, 70% background are 615, 486, 345, and 234 days respectively while counts are 615, 538, 458, and 366 with 100%, 90%, 80%, 70% local ozone respectively. It means about 62% exceedance days could be avoided when removing 30% background ozone while only 40% exceedance days could be avoided when removing the same percent local ozone. It suggests important roles of background in exceedances. Average annual counts of exceedance days with 100%, 90%, 80%, 70% background are 38.44, 30.38, 21.56, and 14.63 days respectively while counts are 38.44, 33.63, 28.63, and 22.88 day with 100%, 90%, 80%, 70% local ozone respectively. Monthly panels show similar results. During 16-year period average monthly counts of exceedance days with 100%, 90%, 80%, 70% background ozone are 87.86, 69.43, 49.29, and 33.42 respectively while counts of exceedance days with 100%, 90%, 80%, 70% local ozone were 87.86, 76.86, 65.43, and 52.29 respectively.

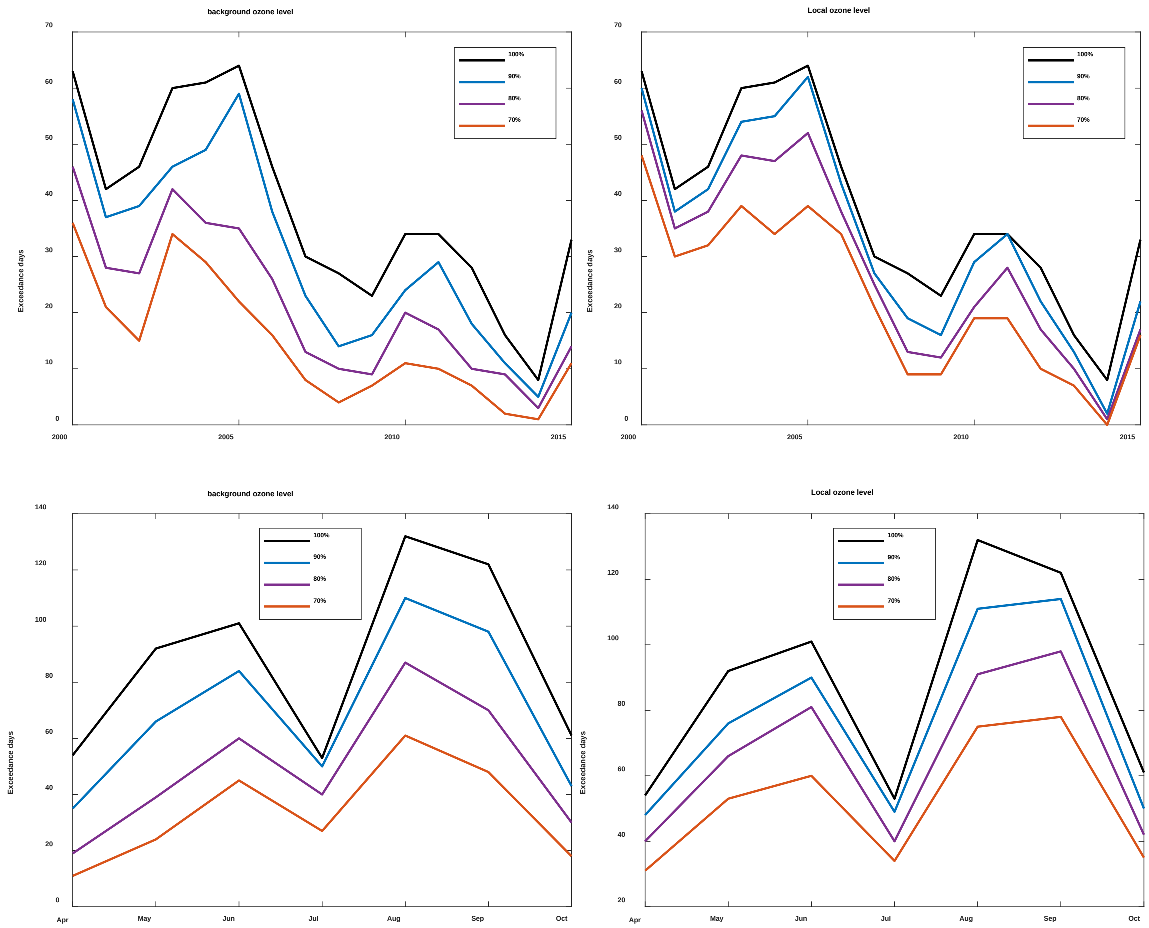

Figure 5. Count of exceedance days with adjusted background ozone (left column) and local ozone (right column).

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

<u>Task 3</u>: Analysis of interannual variability of the ozone enhancement at HGB.

<u>Task 4</u>: Seasonal contribution of background ozone will be studied.

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