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**	07/10/2017
REPORTING PERIOD	**From:** 06/01/2017 **To:** 06/30/2017	**REPORT #**	9

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 conducted statistical analysis on cold front and its effects on the HGB ozone using newly acquired data from Weather Prediction Center (WPC) Surface Analysis Archive.

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

Task 4: None this period.

Preliminary Analysis

Task 2:

In the previous report, we conducted case studies of cold front days using the Weather Prediction Center (WPC) Surface Analysis Archive (http://www.wpc.ncep.noaa.gov), This archive data provides cold front positions every 3 hours. A cold front may have compounding effects on HGB ozone by bringing in contaminated air masses from the northeast while at the same time causing local temperatures to decrease which may lower ozone production rates. The net effect of each cold front on the HGB ozone may differ from each other and differ by various factors such as when it reached the HGB, how long it stayed, whether it penetrated the HGB, and so on.

To investigate the complex effects of cold fronts on the HGB ozone, we conducted statistical analysis on the characteristics of cold fronts reaching HGB and their associated effects on both daily MDA8 and background ozone. A cold front day was defined as the day during which a cold front line passed the HGB area during one or more 3-hour time frames. A post front day was defined as the day during which no cold front line passed the HGB area but the previous day was a cold front day. Figure 1 shows monthly and yearly time series of the count of cold front days at the

HGB. There are a total of 389 cold front days during April – October of 2003 – 2015. Seasonally, the occurrence peaks in April and October, reaching 4.69 and 5.07 days per month respectively. For yearly series, the average count of cold front day is 20.46 per year. It shows a slight increasing trend (+0.13 day per year) and large variations with a maximum of 26 days in 2009 and 2013 and a minimum of 13 days in 2010.

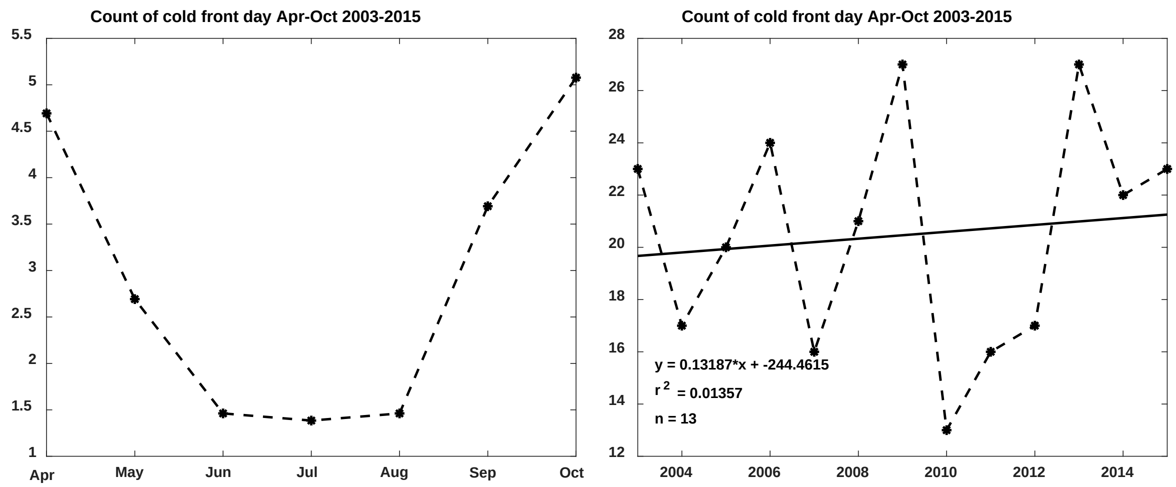

Figure 1. Time series of the count of the HGB cold front days.

Figure 2 shows the seasonal probability distribution of MDA8 ozone mixing ratio during cold front related days. For the whole study period, the mode of MDA8 ozone mixing ratio was 53, 66, and 42 ppbv for the cold front day, post front day and other days, respectively. MDA8 ozone during the post front days was clearly enhanced compared to the non-front days. This may be because the low temperature in cold front day had recovered while polluted air masses brought by the northerly flow during the preceding cold front day still sit over the HGB. Seasonally, the mode difference between cold front related days in summer appears to be much larger than the other two seasons, probably because of the low sample size of those days in summer. The post front days showed higher modes than other days in all seasons.

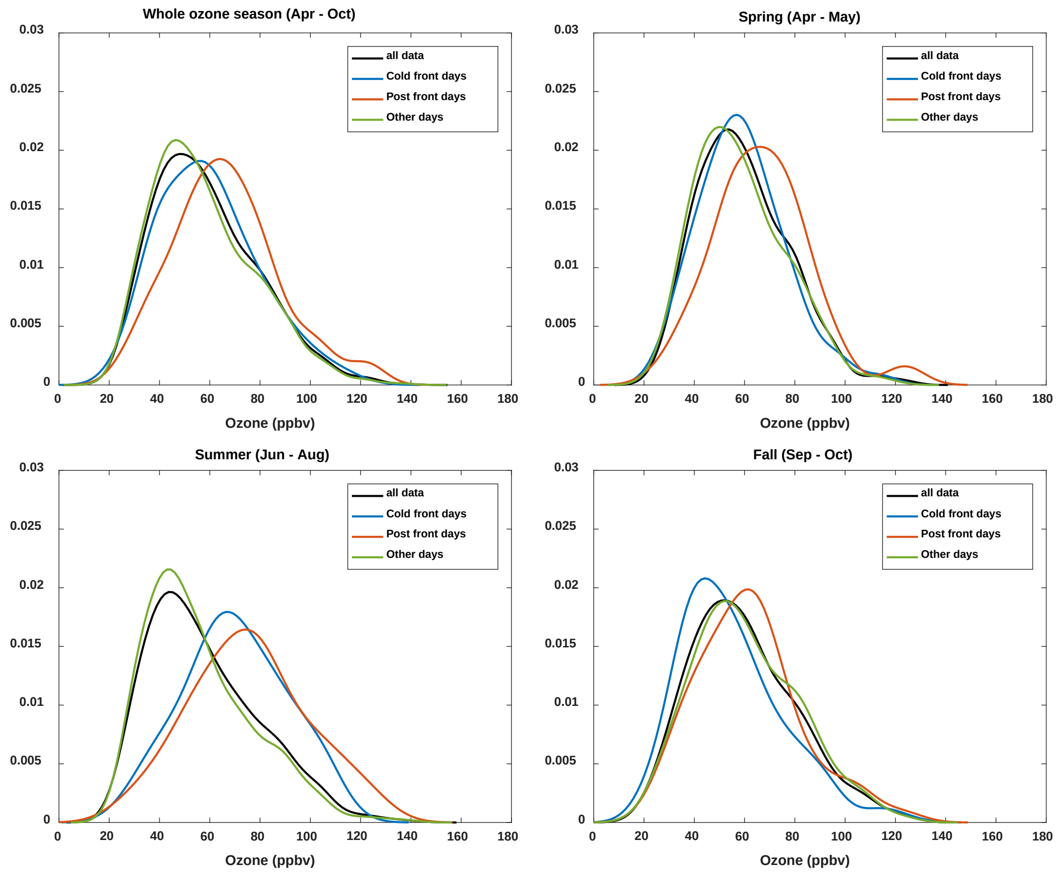

Figure 2. Probability density curves of seasonal MDA8 ozone mixing ratio during cold front related days.

Figure 3 shows the seasonal probability distribution of background ozone mixing ratio during cold front related days. For the whole study period, the modes of background ozone mixing ratio during the cold front day, post front day and other days were 40, 53, and 16 ppbv respectively. Background ozone shows the following same features as the MDA8 ozone. First, the mode of background ozone during post front days were the highest in all seasons, about 26, 15, and 7 ppbv higher than the other days during spring, summer, and fall, respectively. Second, the mode in cold front days is greater than that of the other days except in fall. Its mode is 12 ppbv higher than that in other days during spring and summer, but becomes 9 ppbv lower than other days during the fall. Third, the background ozone difference between other days and cold front related days appears to be largest in summer because of small sample size in this season.

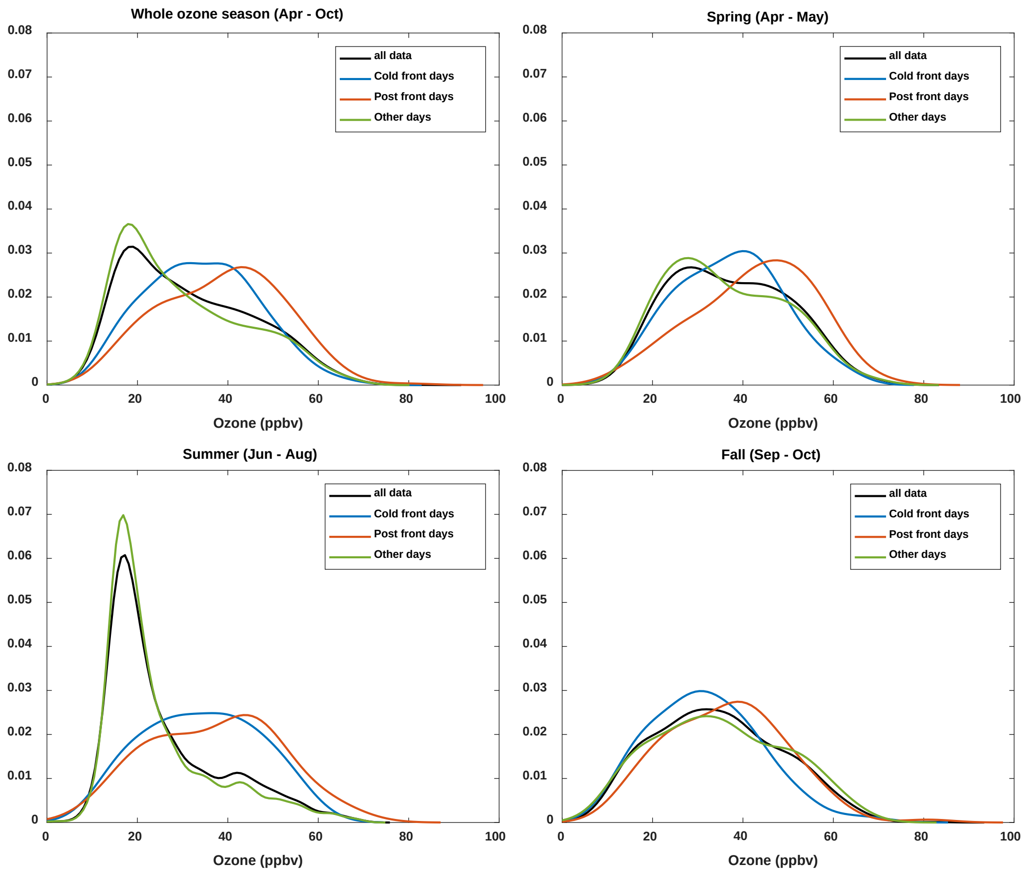

Figure 3. Probability density curves of seasonal Background ozone mixing ratio during cold front related days.

Table 1 compares the seasonal average MDA8 and background ozone and their standard deviations. Standard deviations show a slight variation in different event days and seasons where were 17.74 – 23.13 for MDA8 ozone and 11.39 – 14.28 for background ozone. For the whole research period, averages of MDA8 ozone mixing ratio during the cold front day, post front day and other days were 59.85, 66.44, and 57.64 ppbv respectively, and averages of background ozone in those three types of days were 34.21, 38.69, and 30.14 ppbv respectively. Features of averages are similar with the modes for both MDA8 and background ozone: 1) Averages in cold front days were greater than other days except in fall; 2) Averages in post front days were highest in all seasons; and 3) difference between other days and cold front related days was greatest in summer.

Table 1. The seasonal average MDA8 and background ozone and their standard deviations during non-cold front, cold front, and post front days 2003-2015.

		MDA8	Background
Other day	Overall	57.64 ± 20.38	30.14 ± 13.95
	Spring	58.26 ± 17.74	36.36 ± 12.71
	Summer	55.74 ± 21.14	24.47 ± 11.97
	Fall	60.81 ± 21.00	34.97 ± 14.28
Cold front day	Overall	59.85 ± 20.04	34.21 ± 12.03
	Spring	59.14 ± 17.15	37.01 ± 11.39
	Summer	70.19 ± 20.22	34.24 ± 12.38

	Fall	54.89 ± 20.42	31.64 ± 11.90
Post front day	Overall	66.44 ± 21.24	38.69 ± 13.29
	Spring	66.73 ± 19.06	42.54 ± 12.77
	Summer	75.38 ± 23.13	37.00 ± 13.67
	Fall	61.68 ± 20.73	36.22 ± 12.86

In summary, cold front day in the HGB area has a higher frequency in spring and fall than in summer. Cold front days tended to come with higher MDA8 and background ozone during spring and summer while showed slightly lower modes and averages in fall. Post front always tended to come with higher MDA8 and background ozone than cold front days and other days.

<u>Task 3</u>:

The previous report showed the passive tracer simulation in the nested-grid version of GEOS-Chem for April and May from 2000 to 2015. Using the southern tracers including the Gulf, Mexico, and rest of Central America (RCA) tracer, we can use the distribution of their mixing ratios simulated by the model to identify the days when the Gulf coast region received the strongest influences of Central American fires during the 16 years. We first selected the days which have upper 10% concentrations of the Gulf tracer, Mexico tracer, or RCA tracer over the Gulf coast region (the red box in Figure 4). Those days would indicate when the transport patterns were favorable to bring southern air masses to the Gulf coast cities, including HGB. Then the upper Mexico and upper RCA days are combined as the upper southern days.

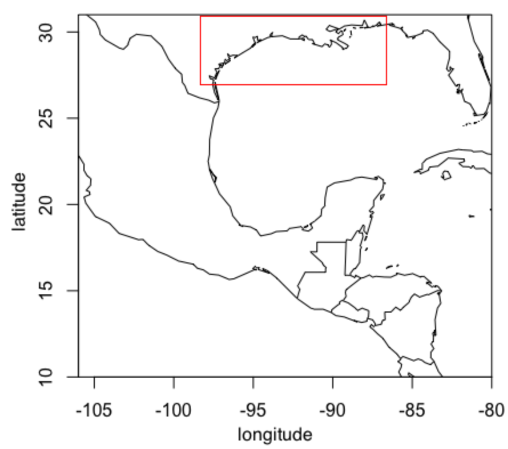

Figure 4. The Gulf coast domain (27.5^{o}N-31^{o}N; 97.5^{o}W-87^{o}W) used to select the days which have the top 10% of Gulf tracer, Mexico tracer and RCA tracer during 2000 to 2015.

For example, Figure 5 shows the surface mixing ratio of Mexico tracer averaged over the upper southern days and over the whole 16 years (Apr-May only) and the differences between those averages. During the upper southern days, the Mexico tracer is transported more preferably toward the US Gulf coast, and the plumes originated from Yucatan to HGB can be clearly identified in the difference plot. Figure 6 displays the mean vertical profile of Mexico tracer during the upper southern days and the whole 16 years and the difference. In the model world, the Mexico tracer can be transported up to the middle troposphere from the source, and such vertical transport is shifted more toward the north during the upper southern days, reaching to the US Gulf coast and southern US.

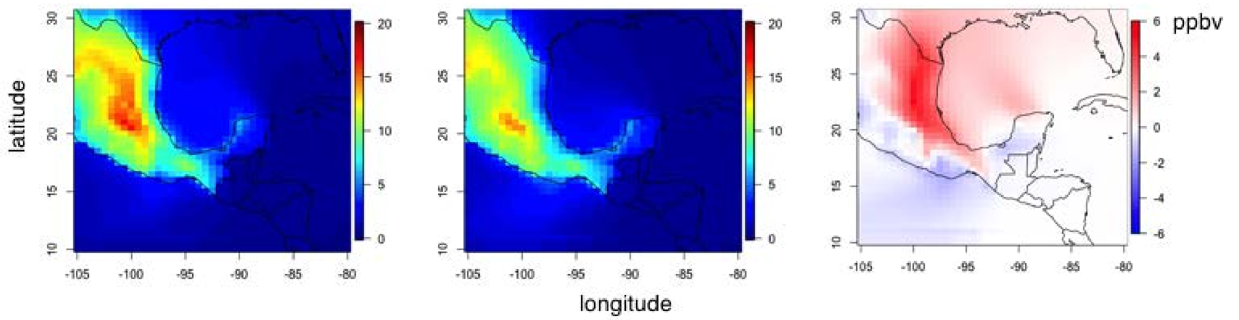

Figure 5. Surface map of Mexico tracer in upper southern days (left), climatological mean of 16 years (middle) and the difference between the upper days and climatological mean (right).

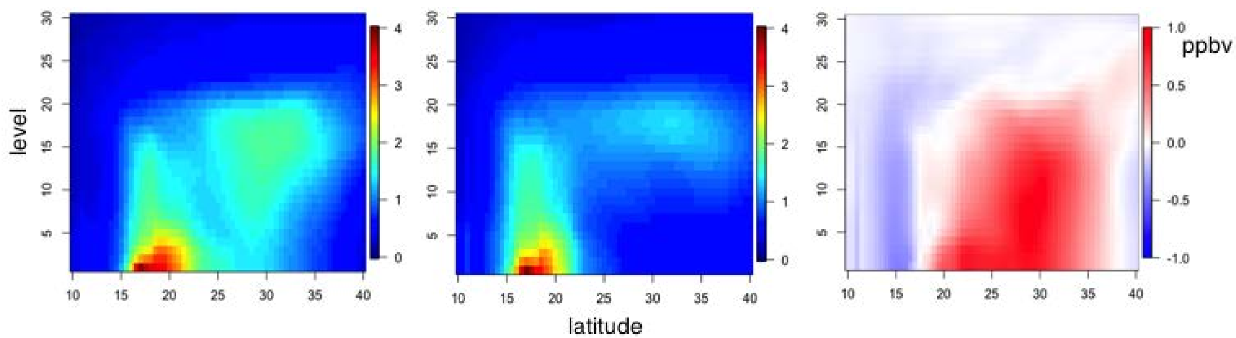

Figure 6. Vertical profile of Mexico tracer (average along 97.5°W-85°W) in upper southern days (left), climatological mean of 16 years (middle) and the difference between the upper days and climatological mean (right).

Carbon monoxide (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 all the upper southern days and upper Gulf days of the 2000-2015 period that we selected based on the GEOS-Chem simulation. Figure 7 presents the total column of MOPITT CO for the upper southern days, upper Gulf days, and the differences between them. For the upper southern days, the MOPITT CO column shows fire plumes transporting CO emission from Central America to the US, leading to enhancements of CO along the US Gulf coasts compared to the upper Gulf days. By contrast, during the upper gulf days, CO emissions from Central America stay closer to their source region and the prevailing transfer direction is toward the south and southwest, illustrated by the blue-colored plumes in the difference plot. MOPITT CO observations thus provide independent evidence to support the two different transport regimes of Central American fires identified by the GEOS-Chem model and demonstrate the pollutant enhancements along the US Gulf coast (including HGB) due to those fires.

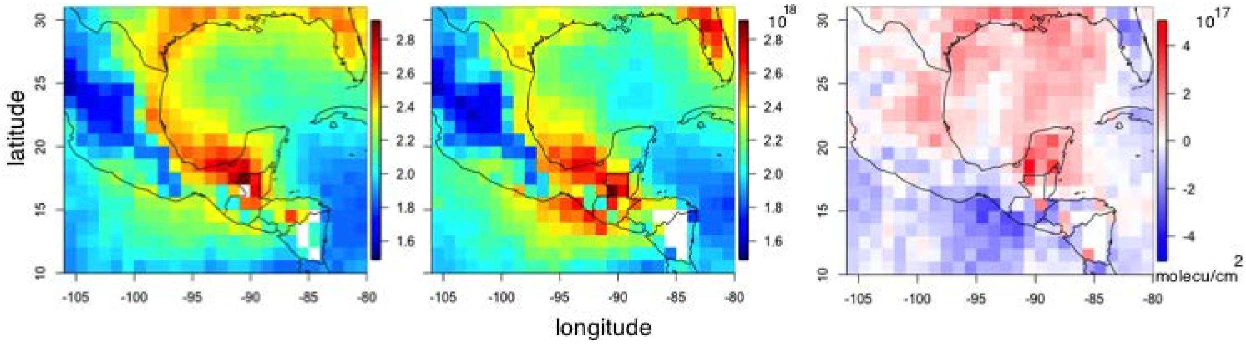

Figure 7. Total column of MOPITT CO measurement (day time only) during the upper southern days (left), upper Gulf days (middle) and the difference between them (right).

Figure 8 shows the vertical profiles of MOPITT CO during the upper southern days, upper Gulf days and the difference between them. These profiles are averages along 97.5°W-85°W, covering the zonal extent from source (Central America) to receptor (US Gulf coast). The difference plot clearly shows the CO enhancement above 800 hPa from 18°N to 30°N during the upper southern days, indicative of the transport of fire pollutant from Central America to the Gulf coast. The results are qualitatively consistent with the model simulated transport route of Mexico tracer in the upper southern days, providing further evidence to the influence of Central America fire plumes to the US.

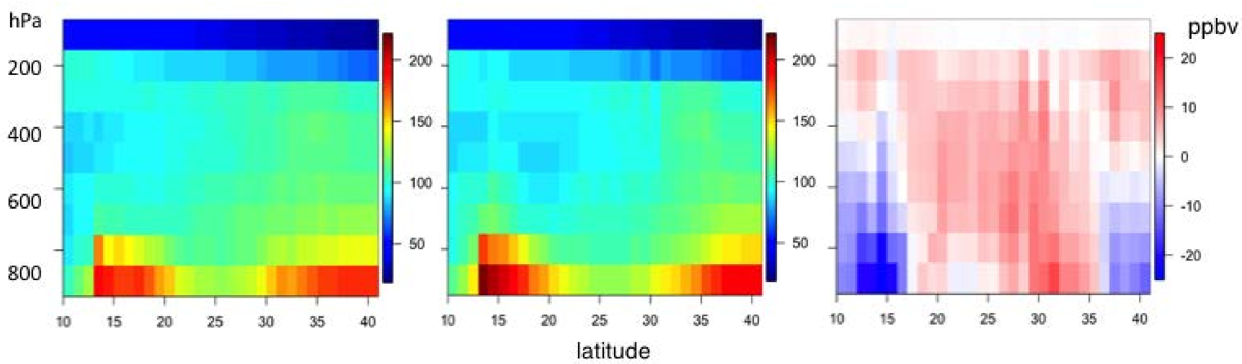

Figure 8. Vertical profile of MOPITT CO (day time only; average along 97.5°W-85°W) in upper southern days (left), upper gulf days (middle) and the difference between the upper southern days and upper gulf days (right).

In summary, we used the differences between the Central American tracer (Mexico plus RCA) and the clean Gulf tracer from the GEOS-Chem model to separately identify the days with enhanced fire influences on the US Gulf cost (i.e. the upper southern days) and those with predominantly clean maritime Gulf air masses (i.e. the upper Gulf days). The model suggests that Central American fire plumes have different transport patterns during the upper southern days and upper Gulf days. Those transport patterns, both horizontally and vertically, were verified by MOPITT CO observations that are independent from the model.

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 2: We will compare the effects of cold front and other weather events.

Task 3: Analysis of satellite measurements for other species (e.g. formaldehyde, NO_2 and AOD).

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