AQRP Monthly Technical Report

PROJECT TITLE	Impact of large-scale circulation patterns on surface ozone concentrations in Houston-Galveston-Brazoria (HGB)	PROJECT #	14-010
PROJECT PARTICIPANTS	Texas A&M University at Galveston	DATE SUBMITTED	5/8/2014
REPORTING PERIOD	**From:** April 1, 2015 **To:** April 30, 2015	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 *(Include all Task actions conducted during the reporting month.)*
Task 1: We analyzed the interannual variations of monthly mean ozone and the west edge longitude of BH (BH-Lon) by adjusting the definition of BH-Lon for August and September (Figure 2). We also analyzed the impacts of drought on the interannual variations of monthly mean HGB ozone for August and September (Figure 3-6).

In previous reports, ozone data time series were detrended by subtracting a best-fit straight line. However, the change of ozone precursor emissions over HGB may not be linear, which makes the linear trend assumption for ozone questionable. From this report on, we detrended the raw ozone data time series by subtracting the 3-year moving average.

Task 2: We applied a multiple linear regression (MLR) model to construct the statistical relationship between HGB ozone and the two indices (BH-Lon and drought index) (Figure 6).

Task 3: The set up of GEOS-Chem on the supercomputer of TAMU (ada) was finished.

Preliminary Analysis

In the former analysis, we found a significant increasing trend in summer-mean BH-Lon from 1998 to 2013 (Fig 1a). One study by the University of Houston group (Liu et al., poster presented at the UT Air Quality Symposium) suggested an increasing trend of southerly wind frequency over HGB in the past ten years. To test if there exists any association between BH-Lon and southerly winds, we analyzed the long-term trends of BH-Lon and the strength of surface southerly winds over HGB for summer season as a whole (Fig 1a) and by individual month (June, July and August). Figure 1b-d shows the variations of monthly BH-Lon and surface southerly wind speed from 1998 to 2013. Although monthly BH-Lon shows an increasing trend, it is not significant. The time series of surface southerly wind speeds over HGB do not show significant increasing or decreasing trends for the three months. Note that our analysis is based on NCEP reanalysis data, while Liu et al. used local winds measured at surface sites.

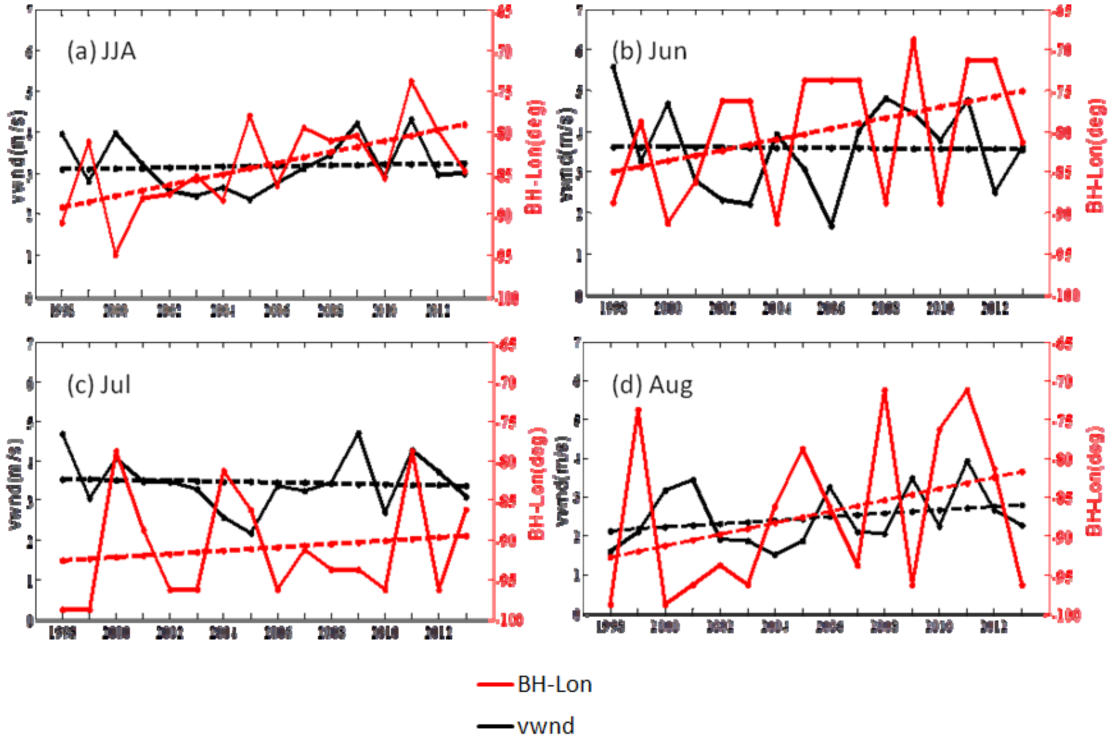
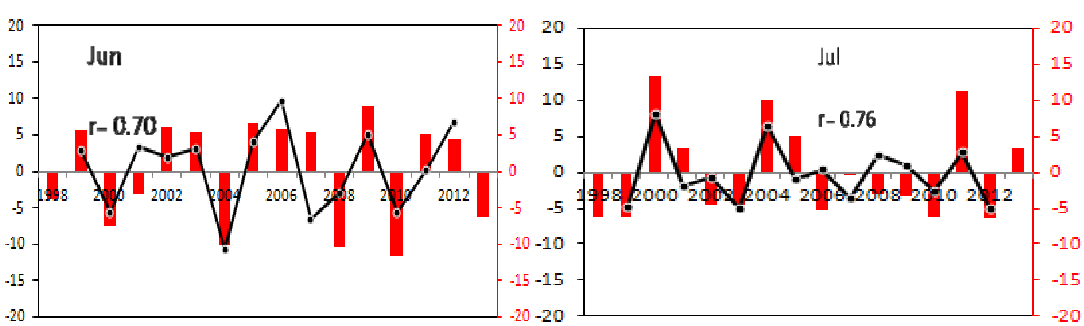


Figure 1. Time series of BH-Lon and surface southerly wind speed over HGB region.

In the prior analysis, we used the 1560-gpm isoline to define the BH-Lon for the whole study period. Since the Bermuda High is much weaker in August and September than in June and July, we tried other isolines to adjust the definition of BH-Lon for August and September. We got the best results (in terms of correlation with HGB ozone) when we use the 1556-gpm isoline to define BH-Lon for August and the 1536-gpm isoline for September. Figure 2 shows the detrended HGB ozone and BH-Lon for June, July, August and September respectively. Note that the BH-Lon for Jun and July is defined using the 1560-gpm, while that for Aug and Sep is defined using the 1556- and 1536-gpm respectively. In the strong-BH months (June and July), the interannual variations of ozone is well captured by BH-Lon. However, in the weaker-BH months (August and September), the correlation is not as good. There may be also other indicators influencing HGB ozone in those weaker-BH months. For example, we can see the regression residual of ozone in September 2011 is quite large, and 2011 happened to be a drought year. Thus, we speculate that drought maybe an indicator to explain some high ozone events in August and September.



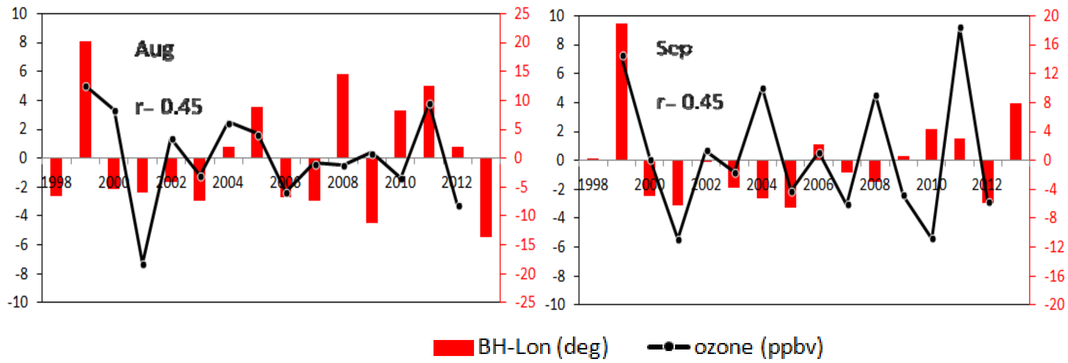


Figure 2. The interannual variations of the detrended monthly mean surface ozone and BH-Lon for June, July, August and September.

Figure 3 shows the association between Palmer Drought Severity Index (PDSI) and detrended HGB ozone for August and September. Negative drought index represent drought conditions. High ozone in August 2011 and September 2011, which cannot be well explained by BH-Lon, corresponds with negative drought index (severe drought).

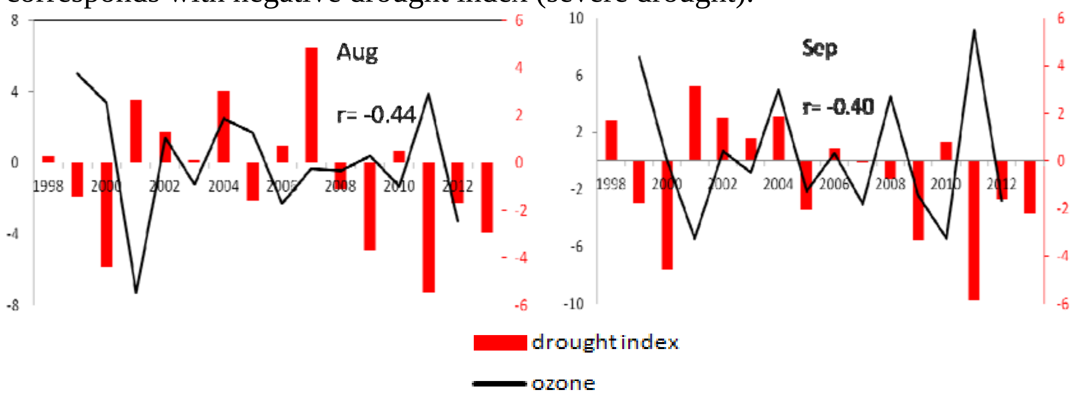


Figure 3. The interannual variations of the detrended monthly mean surface ozone and drought index for August and September.

To find out the mechanisms of drought influencing HGB ozone, we divided the sites over HGB region into rural sites and urban sites. We made a first-order, simple assumption that the mean ozone over rural sites represents the background ozone. In the subsequent analysis, we will use more carefully-analyzed background ozone values provided by TCEQ to refine this analysis. Figure 4 displays the locations of the sites over HGB region, and the sites outside the red boundary are able to measure background ozone. Figure 5 shows the distribution of specific and relative ozone change between 2011(drought year) and normal years. The ozone concentration over urban sites shows a higher increase than rural sites in 2011 (Table 1). This indicates that drought influences ozone concentration over urban area by enhancing its photochemical formation. Since emissions near the rural sites are expected to be less than those over urban sites, the response of ozone to drought is weaker at the rural sites.

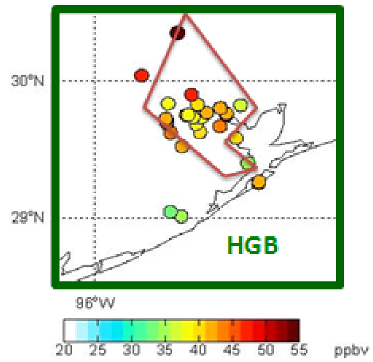


Figure 4. The locations of the sites over HGB region.

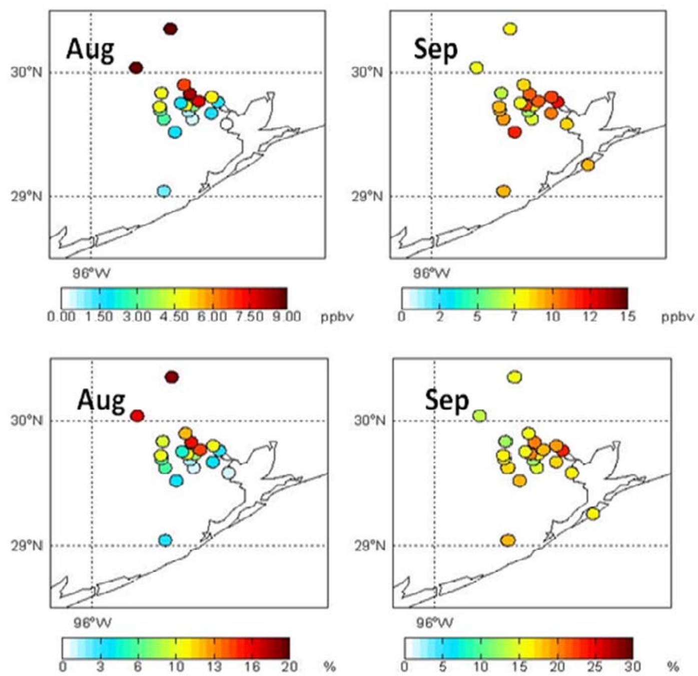


Figure 5. Spatial distribution of ozone change due to drought (2011 minus 2010-2012 mean). The top panel shows absolute changes and the bottom panel for relative ozone change .

Table 1. Specific and relative change of rural mean and urban mean ozone between 2011 and 2010-2012 mean (2011 minus 2010-2012 mean)

	Absolute change (ppbv)		Relative change (%)	
	rural mean	urban mean	rural mean	urban mean
August	2.3	4.5	4.5	9.3
September	9.3	9.2	16.7	16.9

Figure 6 shows the interannual variations of detrended urban ozone and drought index for August and September. Compared with Figure 3, the higher correlations shown in Figure 6 indicates that drought index is better correlated with urban ozone than total ozone, supporting our aforementioned hypothesis.

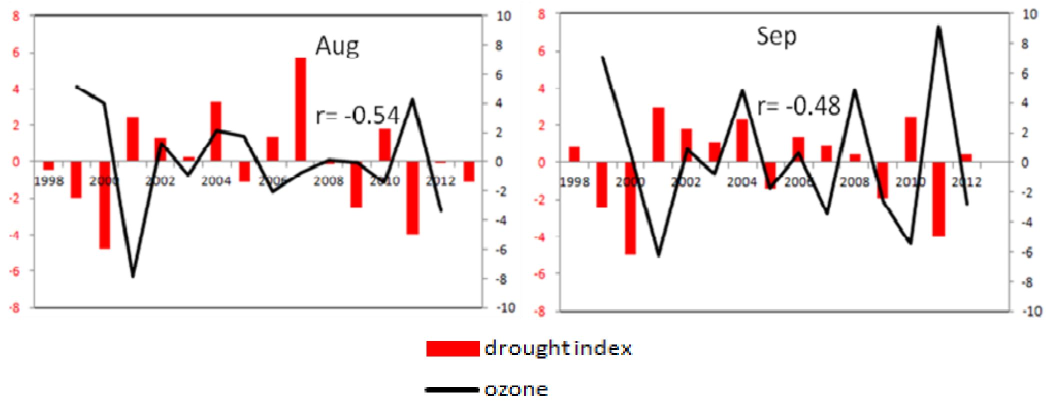


Figure 6. The interannual variations of the detrended monthly urban ozone and drought index for August and September.

Finally, we applied a multiple linear regression (MLR) model to construct the statistical relationship between HGB ozone and the two indices (BH-Lon and drought index) for August and September. Since we found no relations between total ozone and drought index when the drought index is larger than 0 (meaning no drought; data not shown), we only used negative drought index in the MLR. Figure 7 shows the results of MLR. The regression results of the drought years (e.g. 2000 and 2011) show improvements after we include drought index into MLR, with a ~30% increase in the overall correlation coefficient compared to that between ozone and BH-Lon alone.

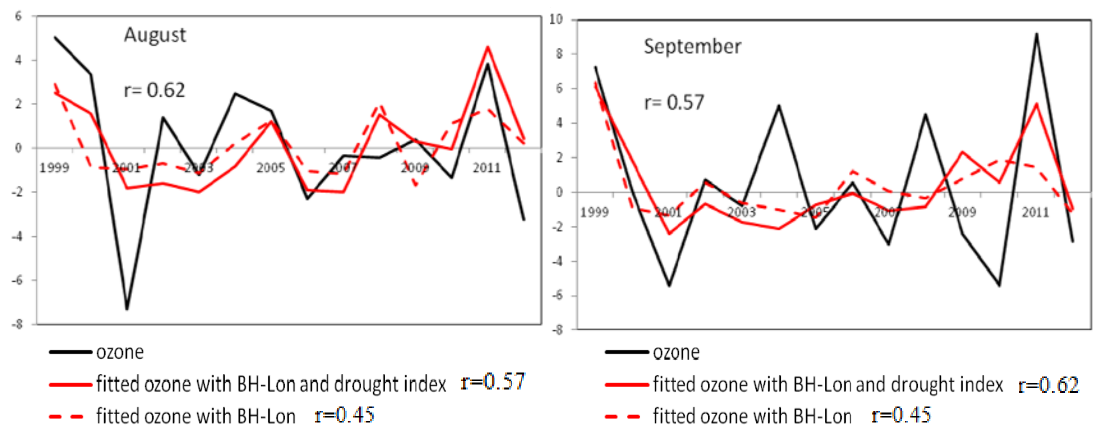


Figure 7. The interannual variations of the detrended ozone and fitted ozone with the indices.

Data Collected

We collected Palmer Drought Severity Index (PDSI) for HGB on NOAA website. It is a meteorological drought index developed in 1965 by Wayne Palmer to measure the departure of the moisture supply. The PDSI is calculated based on precipitation and temperature data, as well as the local Available Water Content (AWC) of the soil. From the inputs, all the basic terms of the water balance equation can be determined, including evapotranspiration, soil recharge, runoff, and moisture loss from the surface layer.

Identify Problems or Issues Encountered and Proposed Solutions or Adjustments

None this period.

Goals and Anticipated Issues for the Succeeding Reporting Period

There are still some extremely high and low ozone months that cannot be explained by BH-Lon or drought index. We plan to look for other large-scale patterns that are related to the activities of frontals to explain the high ozone events.

We will use background ozone data provided by TCEQ to analyze the statistical relationship between BH-Lon and background ozone. The TCEQ background ozone data will be further applied as a measure to separate continental and marine influences on ozone over HGB.

We will start the simulations of surface ozone using GEOS-Chem.

Detailed Analysis of the Progress of the Task Order to Date*(Discuss the Task Order schedule, progress being made toward goals of the Work Plan, explanation for any delays in completing tasks and/or project goals. Provide justification for any milestones completed more than one (1) month later than projected.)*

Progress on the project is ongoing.

Submitted to AQRP by:

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