Executive Summary

The Bermuda High is a key driver of large-scale circulation patterns in Southeastern Texas in summer (Davis et al., 1997). There are two mechanistic linkages between the Bermuda High (BH) and surface ozone in the Houston-Galveston-Brazoria (HGB) region: first, the western extension of the BH defines the strength of the southerly low-level jet (LLJ) that brings marine air with lower ozone background from the Gulf of Mexico (Higgins et al. 1997); second, the high pressure system allows for clear skies and high temperature conditions that are favorable for local production of ozone (O_3). This project investigates the complex effects of the BH and the related meteorological conditions on surface O_3 variations in the HGB region by analyzing the more than decade-long observational record of maximum daily 8 h average (MDA8) surface ozone and meteorology from June to September. The indicators of the BH location and strength developed/refined in this project are the longitude index of the BH western edge (BH-Lon), and two BH intensity related indices (BHI1 and BHI2). The BH indicators are proved to have significant utility in explaining the year-to-year variability in monthly mean HGB MDA8 ozone for June, July, August, and September during 1998-2013. Other indicators of large-scale meteorological conditions, including Palmer Drought Severity Index (PDSI), Arctic oscillation (AO), and HGB mean temperatures, are found to be of lesser utility than the BH indicators, but still show significant correlations with HGB ozone variability in some months. Through stepwise regression based on the Akaike Information Criterion (AIC), these meteorological predictors are employed to develop the multiple linear regression (MLR) model which reproduces more than 50% of interannual variability of the monthly mean MDA8 ozone over the HGB from June to September.

The observation-derived statistical relationships between the HGB ozone and BH are then used to develop an empirical scheme to correct for the known high bias of the GEOS-Chem chemical transport model when simulating summertime ozone along the Gulf Coast (Li et al.,

2002; Fiore et al., 2002; Reidmiller et al., 2009; Zhang et al., 2011; McDonald-Buller, 2011). A set of multiple-year simulations of HGB ozone is conducted using the GEOS-Chem model. A moderate to strong correlation is identified between the BH-Lon and the model bias for June and July, which supports the hypothesis that the model bias is caused in part by the insufficient representation of the dynamic linkage between BH and ozone inflow to HGB. The following provides a summary of major findings:

1. The MLR model we developed captures 58% - 72% of interannual variance during 1998-2013 of the monthly mean MDA8 ozone over the HGB from June to September, indicating the significant role of large-scale meteorology on ozone variability for this region. The Bermuda High variability is the most important meteorological driver of ozone variability for each month.
2. The cross-validation (CV) and hindcast analyses suggest that the MLR models have good skills in predicting interannual (1995-2013) variations of the monthly-mean MDA8 ozone over the HGB from June to September, with CV R^2 higher than 0.45 for each month.
3. The relationships between the BH-Lon and HGB ozone are valuable observational constraints that can be used to correct the high bias in simulated ozone. After the correction, the mean model bias for June and July, months with the largest model bias, shows a 70-75% decrease and the correlation coefficient between the observed and simulated ozone also improves.