1. Characterizing the Atmospheric Boundary Layer During DISCOVER-AQ

Executive Summary

DISCOVER-AQ (Deriving Information on Surface Conditions from Column and Vertically Resolved Observations Relevant to Air Quality) is a National Aeronautics and Space Administration (NASA) Earth Venture program-funded mission that consists of field studies in several locations across the United States, with an overall objective to improve the use of satellites to monitor near-surface air quality, and in turn, to help scientists make better air quality forecasts, more accurately determine pollution sources, and develop successful strategies to reduce pollution and improve public health. The DISCOVER-AQ Houston field study took place in September 2013. During this study, detailed meteorological and air quality observations were taken throughout the Houston area by instruments on the ground, on aircraft, on payloads of balloons (both tethered and free-released), and in Earth orbit. Instrumentation operated during the field campaign included seven radar wind profilers (RWPs) and three ozonesonde sites in and around Houston, Texas. Measurements were taken to provide data to characterize the atmospheric boundary layer conditions during DISCOVER-AQ to support the analysis of chemical data and future air quality modeling by the Texas Commission on Environmental Quality (TCEQ).

This report provides a basis for understanding key meteorological processes that were observed during the 2013 DISCOVER-AQ campaign in the Houston area. Meteorological and air quality data from standard surface monitors, RWPs, ozonesondes, weather satellites and radar, and air parcel trajectory models were analyzed by meteorologists at Sonoma Technology, Inc. (STI) and Gary Morris, PhD (St. Edwards University) to characterize atmospheric boundary layer conditions and relate those findings to observed air quality during the DISCOVER-AQ campaign, as well as on some days with high ozone levels that occurred following the campaign. This analysis stands alone but can also assist other researchers with the interpretation of measurements collected during DISCOVER-AQ and provide context for the results derived from data collected during DISCOVER-AQ. A summary of key findings from this analysis is provided below.

- Two general meteorological regimes were identified during the DISCOVER-AQ period: (1) deep onshore flow with lower ozone concentrations, and (2) weak large-scale flow and complex local flows with higher ozone concentrations.
- In agreement with previous analyses, the highest ozone concentrations occurred during periods of weak large-scale flow, typically following the passage of a surface cold front. Two days with such events were identified during the time period analyzed in this report: September 25 and October 8, 2013.
- On high-ozone days, mixing heights were typically low (at or below 500 m) at coastal and inland locations during the early- to mid-morning hours, before increasing rapidly to near

2000 m inland during the late-morning and early-afternoon hours while remaining steady at the coast. In contrast, mixing heights on low-ozone days showed less diurnal and spatial variation.

- Surface ozone concentrations were more spatially and diurnally variable on high-ozone days compared to low-ozone days, due to the presence of complex, local flow patterns.
- During both meteorological regimes identified (deep onshore flow with long transport distances or weak offshore/shore-parallel flow with short transport distances), ozone concentrations were typically highest on the downwind side of Houston, illustrating the important impact of local pollution emissions on regional air quality.

Section 1.1 contains a description of the data sets, instrumentation, and methods used for this analysis. Section 1.2 contains a detailed description of the atmospheric boundary layer on DISCOVER-AQ flight days and days with high ozone levels in the Houston, Texas, area between August 28 and October 9, 2013. Figures accompanying the daily boundary layer analyses are in Section 1.3. The comparison of boundary layer conditions during DISCOVER-AQ to those observed during the TexAQS-II study is found in Section 2.1, and a comparison of general meteorological conditions and ozone profiles observed in DISCOVER-AQ to the September 10-yr averages is found in Section 2.2.

1.1 Data Sets, Instrumentation, and Methods

Several data sets were used to assess large-scale aloft and large-scale surface weather patterns, local meteorological conditions, transport and surface winds, mixing, cloud cover, and surface ozone patterns. The data sets and their uses are described in Table 1.

Table 1. Data sets and their uses for boundary layer characterization analysis.

Data Set	Data Usage
Surface and 500 mb weather maps	Characterizing large-scale meteorological patterns and identifying areas of general rising and sinking motion
Satellite and radar imagery	Assessing impacts of cloud cover and precipitation on ozone formation
Surface meteorological data	Analyzing local-scale meteorological patterns and development and motion of diurnal land/sea breezes
Radar wind profiler data	Assessing spatial and temporal structure of boundary layer winds and mixing heights
Air parcel trajectories	Identifying pollution source regions and transport distances
Surface ozone data	Characterizing regional ozone patterns in relation to local winds and transport