Insights into Houston Air Quality from Rawinsonde and Ozonesonde Data

Ryan Perna, Sharon Zhong, Gary Morris, Bernhard Rappenglueck, Barry Letter, Renee Boudreaux, Craig Clements, Bridget Day, Ricky Fuller, Scott Hersey, Brad Morris, Monica Patil, and Leonardo Pedemonte

1Department of Geography, University of Houston, Houston, TX 77004
2Department of Geosciences, University of Houston, Houston, TX 77004
3Department of Physics & Astronomy, Valparaiso University, Valparaiso, IN 46383
4Department of Chemistry, California Institute of Technology, Pasadena, CA 91125
5Brown College, Rice University, Houston, TX 77005

Contact info:
Ryan Perna
Bernhard Rappenglueck
Gary Morris
Sharon Zhong


textured content

Introduction

Although the Gulf Coast is simple in topography, the boundary layer structure and wind circulation in the Gulf Coast region of southeastern Texas can be highly variable due to frequent presence of land/sea-breeze systems, the Gulf of Mexico, and the large scale atmospheric conditions. In order to understand these boundary layer phenomena, we carried out a suite of boundary layer measurements during the TEXAQS-II (Texas Air Quality Study – II) field campaign. These measurements included Rawinsonde and Ozonesonde soundings to obtain information of the atmospheric thermodynamic structure and wind over urban areas of Houston, along with information about the vertical distribution of ozone.

The rawinsonde data can be used to determine the height of the Planetary Boundary Layer (PBL), the strength and depth of the land/sea-breeze circulation, and the structure of the low level jet and strength of nocturnal inversions. The ozonesonde data can be used to complement the routine ground-based ozone measurements obtained during the TEXAQS-II period. The ozonesondes were launched at 12-hour intervals to capture the vertical structure of ozone episodes. Together, they help achieve a better understanding of air pollution problem in Houston and the region.

Site Location

The program began in August 2005 when rawinsondes were launched from the University of Houston (UH) coastal center in La Marque, TX (approx. 65 km south of Houston). The launch site was moved to the UH main campus in September 2005 after approval from the Federal Aviation Administration was obtained. This was done in order to gain further understanding of the urban boundary layer development. The main UH campus site (29.7421 N and 95.3395 W, 11 m above sea level) was chosen due to its central location approximately 5 km to the southeast of downtown Houston and thus it is the most representative site to characterize the structure and dynamics of the urban boundary layer in the Houston area.

Methods

For this study, the August-thru-September time frame was chosen since these months usually exhibit the highest frequency of “high ozone” days based on long-term ground-based ozone observations. A “high ozone” day was defined using the criteria specified by the U.S. Environmental Protection Agency (EPA) where the measured 8-hour average ozone mixing ratio within a cloud layer. Though ECC ozonesondes are known to exhibit a negative interference with SO2, it cannot be excluded that liquid phase SO2 chemistry may also have an impact on O3 chemistry. The winds in this cloud layer appear to the East which means they may include some increased SO2 coming from the ship channel industrial effects of Houston. This phenomenon was not observed in any other soundings or at any other sites in the region.

Figure 3. Ozonesonde package after launch, 10 PM

Figure 2. Ozonesonde package being launched by Ryan Perna (left) and Bridget McEvoy (right). Photo by Craig Clements.

Results

Potential temperature profiles for ozone episode days in August 2005

Figure 4a. Potential temperature profiles for ozone episode days in August 2005

Figure 4b. Potential temperature profiles for non-ozone episode days in August 2005

Figure 5. PBL development on a “Moderate” ozone day as defined by the TCEQ

Figure 6. PBL development on a “High” ozone day as defined by the TCEQ

Figure 7. September 2, 2006 morning profile with ozone mixing ratio (ppb), relative humidity (%), and potential temperature (K)

Figure 8. (Skew T of biased 2000 meters showing relatively small winds at 1000 m level, in region of ozone drop (5 AM image)

Figure 9. Morning ozone profile of 9-20-06

Figure 10. Afternoon ozone profile of 9-20-06

Conclusions

The profiles shown in this poster represent select examples of vertical ozone and rawinsonde data. These profiles offer an insight into the vertical differences of ozone vs. non-ozone days. It was found that the downward mixing of the early morning residual layer may have a significant effect on afternoon ozone levels. It was also found that cloud layers may have an impact on ozone concentration. Further analysis will be completed to determine the cause of this effect. Ozone concentration can also be affected by the vertical wind distribution, with easterly winds being especially important in bringing ozone precursors into the urban environment from the industrial region of Houston. Easterly wind directions can also be accompanied by higher continental background ozone levels.

Acknowledgements

This project was funded by the Texas Commission on Environmental Quality (TCEQ).