Source attribution of ozone in Southeast Texas before and after the Deepwater Horizon accident using satellite, sonde, surface monitor, and air mass trajectory data

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Abstract

Since the summer of 2004, over 300 ozonesondes have been launched from Rice University (29.7° N, 95.4° W) or the University of Houston (29.7° N, 95.3° W) each < 5 km from downtown Houston. The Texas Commission on Environmental Quality (TCEQ) maintains a large database of hourly surface ozone observations in Southeast Texas. In this study, we identify the contributions to surface ozone pollution levels from natural and anthropogenic sources, both local and remote in nature. This source identification is performed two ways: 1) through an analysis of ozonesonde data, including ozone concentrations, wind speed and direction, and relative humidity data; and 2) through an analysis that combines trajectory calculations with surface monitor data. We also examine regional changes in Ozone Monitoring Instrument (OMI) measurements of nitrogen dioxide and formaldehyde from 2004 to 2010. In particular, we compare the 2010 sonde, surface monitor, and satellite data after the Deepwater Horizon accident (20 April 2010) with data from previous years to determine the impact, if any, of the large source of hydrocarbons in the Gulf of Mexico on air quality in Southeast Texas.

OMI Satellite Observations

N2O4 April – June

Figure 1. OMI Tropospheric Column NO2 for the Gulf Coast of the USA in 2009 (left) and 2010 (right). The satellite data indicate no significant differences before and after the Deepwater Horizon accident.

HCHO April – June

Figure 2. Same as Figure 1 but for HCHO, which seems generally elevated by 50 – 100% throughout the Gulf in 2010 compared to the same period in 2009.

TCEQ Surface O3 Observations

NO2 April – June

Figure 3. Histogram of daily 1-hr O3 maxima from 54 CAMS sites in the Houston-Galveston-Brazoria County (HGB) non-attainment region. Summer data are for August & September 2004 – 2009 with 2010 data separated out. Spring data are for April & May 2005 – 2009 with 2010 separated out. The Summer 2010 data do not appear to be significantly different from previous years. The 2010 data show somewhat higher frequencies at both low and high O3 concentrations.

HCHO April – June

Figure 4. O3, RH, and Theta profiles (left) can be helpful in defining the boundary layer (BL, shaded gray) and distinguishing local from remote, and natural from anthropogenic O3. We subtracted the max O3 in the BL from the max O3 at all levels in that layer. For those regions: New Mexico, Oklahoma, Kansas, and Missouri (top); and Georgia, South Carolina, and Florida (bottom). The max O3 in the BL and FT are plotted as a function of season (center), with the monthly mean (12 months) for May – Sept. (right). The O3 values shown is relative to the current EPA 8-hr O3 standard. O3 in air near the BL frequently exceeds the EPA Limit, especially in May – Sept. Finally, the difference between top and bottom O3 is also plotted as a function of season (right). The color coded data in the right-hand figure identify different transport regimes: UT/LS air with O3 > 75 ppb, UT/LS air with O3 < 75 ppb, and transported pollution with O3 > 75 ppb. In March and April, FT O3 > BL O3, suggesting transport is more important. In Aug. and Sept., BL O3 > FT O3, suggesting local production is more important. All error bars are 1σ.

Table 1. We compare the max O3 in the 1-km layer above the BL (see Figure 4) with the EPA 8-hr O3 standard for the 282 afternoon Houston sonde profiles. The table lists the fraction that exceed the standard: the top row is for all soundings; the 2nd row is only those that also exceed the max O3; the 3rd row is for those with a min RH in that layer < 10%; and for which the max O3 is 10% higher; the 4th row is for those with a max FT O3 > 75 ppb; and the 5th row is for those with a min RH in that layer < 10% and for which the max FT O3 is 20% higher.

Table 2 (right). The analysis of Fig. 8 is repeated at all the CAMS sites in the HGB region, and a comparison is performed two ways: 1) through an analysis of sonde data, including ozone concentrations, wind speed and direction, and relative humidity data, and 2) through an analysis that combines trajectory calculations with surface monitor data. We compare daily 1-hr O3 maxima on days of influence with daily O3 maxima on background days to diagnose the influence of these various source regions on Houston O3.

Conclusions

• OMI satellite data, TCEQ surface monitors in Houston, and Houston ozonesondes show no conclusive evidence of air quality impacts from the Deepwater Horizon accident.

• Ozone data show higher O3 from the South (Spring) and East (Summer) in 2010 than previous years, as indicated by 10% higher O3 compared to 2009.

• Transported FT O3 > EPA O3 standard is found on 16% of ozonesonde profiles. This rate increases to 44% once during September.

• Trajectory studies suggest continental transport of BL air results in +20 – 30 ppb O3 in Houston.