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Background & Goals
We have used daily ozonesonde from Intensive Ozone Network Study experiments in 2004, 2006, 2008 [Thompson et al., 2007, 2011] to study the interaction of ozone and dynamical variability through Laminar Identification (LID) analysis combined with meteorological fields and to evaluate satellite derived tropospheric ozone column amounts [Doughty et al., 2011]. DISCOVER-AQ (Deriving Information on Surface Conditions from Column and Vertically Resolved Observations Relevant to Air Quality) in Maryland during July 2011 included 25 ozonesonde launches near Washington, DC, at the Howard University Beltsville Research Facility (“BV”), and 39 launches at Edgewood, Maryland (“EW”). We examined these soundings in detail to answer specific questions:

-- How do boundary layer (BL) heights and ozone amounts compare to sondes at Beltsville?
-- How do boundary layer (BL) heights and ozone amounts compare at the two locations?
-- What do LID budgets and P-3 aircraft spirals say about influences on ozone at BV and EW?
-- How do 2011 BV influences compare to 2006-2010?

Ozone Data
Figure 1 displays ozone mixing ratio (in ppb) from soundings taken during DISCOVER-AQ over Beltsville (upper) and Edgewood (lower), MD. Tropopause in white is an ozonopause; boundary layer height (BLH) is given by *.

Results: Satellite Comparisons & Profile Variability

Figure 2 (above) comparisons of the OMI/MLS TTOR product are closer to the sondes at Beltsville than at Edgewood. Mean of ozone (below, Figure 3) at the two sites indicates the sonde ozone being much greater than TTOR could arise from higher BL ozone at Edgewood (compare Stauffer et al. 2012) on bay breeze impacts at EW.

Results: DISCOVER-AQ LID Budgets, Beltsville LID, 2006-2011

In Figure 5 we see that O3 profiles and fast on the NASA P-3 agree quite well; note the P-3 samples to 3.5 km over EW and only 1.5 km over BV (black and gray traces in lower left panel of each set of four (upper panels = 2 July; lower 4 panels = 14 July 2011). On 2 July the sondes (profiles of O3, RH, FT) display locally elevated O3 in dry layers; this signifies stratospheric air (RW, pink bands, in Figure 4, both sites). However, a bay breeze circulation pattern (Stauffer et al., 2012) causes an increase in BL O3 over EW - to 120 ppbv; this does not develop at BV.

The lowest ozone amounts in total column occurred with cleaner conditions (CO, NOy) on 14 July.

Results: Meteorological Variations in 2006-2011

Figure 6. In Figure 6, 500mb geopotential height anomalies for 2006-2011 help identify potential meteorological causes of tropospheric ozone budget variability (as in Table). The years 2008 and 2009 display the lowest 500mb heights, likely from a more active wave pattern. Consequently, as the Table indicates, the highest average RW amounts show up for those summers at BV.

Conclusions

• Profound variation in meteorological influences on ozone profiles as observed in soundings during DISCOVER-AQ is manifested in (1) differences between two Maryland sites only 70 km apart; (2) in Laminar (LID) budgets at each site; (3) in rapid day-to-day changes. The challenge implied for satellite tropospheric ozone retrievals is significant.
• Aircraft profiles of CO, NOy and water vapor measurements of the soundings aid considerable information for interpretation of ozone variability.
• The 2006-2011 Baltimore ozone profile record reflects year-to-year meteorological variations that are corroborated by geopotential height fields, cloud cover, moisture, etc.

Literature Cited


Acknowledgments

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Figure 3.

Figure 4. In Figure 4 LID budgets for 2011 over Edgewood are displayed (upper frame). The LID budgets are based on assigning segments within each profile to BL, Gravity Wave (GW) and Rossby Wave (RW) by the techniques of Pierce and Grant [1998] and Thompson et al. [2007, 2011, 2013]. Compared to the Beltsville DISCOVER-AQ budgets (right frame, 2011 values on right) there is more Gravity Wave (GW, light blue) influenced ozone as a fraction of the total tropospheric ozone over Edgewood (left). This means more vertical mixing and possibly convection. Note that surface ozone values tend to be higher at EW than BL but the BL column is less at EW because BL height is ~25% lower at EW than over BV. The Table compares GW, RW influences over BV from 2006-2011.

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