Tropospheric Ozone Satellite Retrievals in the Pacific Northwest
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**Background:**

Tropospheric ozone is difficult to retrieve from satellites because of the abundance of ozone in the stratosphere. Tropospheric ozone has become a significant environmental issue and can be exacerbated by UT/LS folding and long-range transport events. Ozone can be moved from the stratosphere to the troposphere by upper tropospheric meteorological events. The Ozone Monitoring Instrument (OMI) and the Atmospheric Infrared Sounder (AIRS) are two instruments that are used to retrieve ozone from space. In this project, we looked at a folding event in late June 2008 and a long-range transport event in early July 2008. Both events caused elevated ozone that was detected at the Mt. Bachelor Observatory in Oregon (Ambrose et al., 2011).

**Methods:**

**Aura/OMI:** The Aura is a NASA spacecraft flown in a sun-synchronous polar orbit at 705 km altitude with a 98.2° inclination to provide near-global daily coverage with a 1:30 p.m., equatorial crossing time. OMI is a Dutch-Finnish instrument that measures backscattered sunlight in the 270-500 nm wavelength range. OMI provides products for ozone and ozone related chemistry such as NO₂, SO₂, and HCHO.

—Jerry Ziemke’s Research Product (Ziemke et al., 2006)

Uses the Microwave Limb Sounder (MLS) on board the Aura spacecraft to derive the stratospheric over-burden.

—Xiong Liu’s Research Product (Liu et al., 2010)

Does not use MLS and differs from Ziemke in the respect that you get a profile of ozone rather than a single tropospheric ozone column. Represents a better algorithm as cross-track dependent biases and striped pixels are removed.

**AIRS:** The Aura is a NASA spacecraft with similar orbit parameters to Aura. AIRS was designed to provide high-quality temperature and moisture profiles as well as trace gases sensitive to the IR wavelength region such as carbon monoxide, methane, and ozone (Maddy et al., 2008).

**Ozonesonde Data:** A lightweight, balloon-borne instrument interfaced to a meteorological radiosonde to derive ozone profiles. As the balloon package ascends through the atmosphere, the ozonesonde telemeters to a ground receiving station information on ozone and standard meteorological quantities. The balloon will ascend to 35km before it bursts.

**Ozone Surface Measurements (Mt. Bachelor & Boise, ID):** The Mt. Bachelor Observatory (MBO) is located at the summit of Mt. Bachelor in central Oregon (Ambrose et al., 2011). Ozone, CO, and water vapor measurements are used to identify sources of large ozone enhancements. MBO is uniquely positioned for characterizing the composition of clean air in the free troposphere near the U.S. west coast as well as perturbations from regional and distant sources (Ambrose et al., 2011). Boise is an elevated urban site approximately 12 hours downwind of MBO.

**Results:**

From the analysis we find that satellite retrievals of tropospheric ozone can help identify pollution sources. The AIRS CO and ozone retrievals (Figure 1) clearly show a long-range transport event (from Asian emissions) in July 2008. Carbon monoxide did not increase in the June 2008 event. However, a stationary column of ozone (Figure 2) was retrieved for several days in the Gulf of Alaska, which could be the location of the folding event detected at Mt. Bachelor.

Tropospheric column ozone measurements from the two OMI researchers also successfully retrieved the transport event (Figure 3). Liu and Ziemke correlate well (Table 1) but there are significant differences in tropospheric ozone columns. In general, the AIRS and OMI (Liu) profiles agree in the lower troposphere (between 1000 and 500mb). However, satellites have very little sensitivity to ozone in the lower troposphere. In contrast, the AIRS retrievals typically show stratospheric ozone influence at ~250 mb while OMI (Liu) profiles typically show stratospheric ozone influence higher in the atmosphere. Liu’s derivation of ozone results in a more realistic ozone profile than AIRS near the tropopause (Figure 4) when compared to the ozone sondes.

Finally, simultaneous measurements of carbon monoxide and ozone at elevated sites (Figure 5) are the most definitive way to differentiate between transport and folding events.

**Conclusions:**

Throughout this project, we have analyzed several sources of data that showed enhanced ozone amounts in the Pacific Northwest. Our sources have showed increased ozone but normal CO during the June 20-27, 2008 event. We attribute this to a UT/LS folding event. We have also seen an increase in both ozone and CO during the July 7-8, 2008 event which is attributed to a long-range transport event from Asian emissions. We conclude that it is possible to use both surface measurements and satellite retrievals together to help identify particulars of ozone pollution events not driven by local emissions. This is important for air-quality managers that need to differentiate “exceptional events” from local pollution events.

**References:**


