Abstract

Since October 2004 the Ozone Monitoring Instrument (OMI) and Microwave Limb Sounder (MLS) onboard the Aura satellite have provided over 11 years of continuous tropospheric ozone measurements. These OMI/MLS measurements have been used in many studies to evaluate dynamical and photochemical effects caused by ENSO, the Madden-Julian Oscillation (MJO) and shorter timescales, as well as long-term trends and the effects of deep convection on tropospheric ozone. Given that the OMI and MLS instruments have now existed for well beyond their expected lifetimes, our goal is to continue their long record of tropospheric ozone using recent Ozone Mapping Profile Suite (OMPS) measurements. The OMPS onboard the Suomi National Polar-orbiting Partnership (NPP) satellite was launched on October 28, 2011 and is comprised of three instruments: the nadir mapper, the limb profiler, and the limb profiler. Our study combines total column ozone from the OMPS nadir mapper with stratospheric column ozone from the OMPS limb profiler to measure tropospheric ozone residual.

The time period for the OMPS measurements is March 2013 – present. For the OMPS limb profiler retrievals, the OMPS v2 algorithm from Goddard is tested against the University of Saskatchewan (Usask) Algorithm. The retrieved ozone profiles from each of these algorithms are evaluated with ozone profiles from both ozone sondes and the Aura Microwave Limb Sounder (MLS). Effects on derived OMPS tropospheric ozone caused by the 2015-2016 El Nino event are highlighted. This recent El Nino produced anomalies in tropospheric ozone throughout the tropical Pacific involving increases of ~10 DU over Indonesia and decreases ~5-10 DU in the eastern Pacific. These changes in ozone due to El Nino were predominantly dynamically induced, caused by the eastward shift in sea-surface temperature and convection from the western to the eastern Pacific.

Trends in Tropospheric Ozone

The 2015-2016 El Nino

OMPS Tropospheric Ozone Anomalies during the 2015-2016 El Nino Event

Measuring Ozone in Thick Clouds

Ozone ENSO Index (OEI)

Madden-Julian Oscillation (MJO)

And Shorter Timescales

Comparison between daily time series of OMI/MLS ozone dipole index (ODI, red solid curve) and OEI derived from the OMI chemical transport model (dotted blue curve). Also plotted is the OEI 3.4 Index (black curve). The OEI is a generalization of the OEI by using daily rather than monthly averages. The OEI is important for monitoring MJO events and as a diagnostic tool on all time scales for models that simulate tropospheric ozone.

The 2015-2016 El Nino event (Figure 3), the OMPS tropospheric ozone shows nearly identical anomalies patterns as OMI/MLS. These ozone anomalies include large increases over the western Pacific (via reduced convection + Indonesia biomass burning), large decreases over the eastern Pacific (caused by enhanced convection), and regional increases over Brazil (caused largely by dry conditions and large-scale biomass burning induced by the El Niño event).

Summary

- Tropospheric ozone from OMI/MLS during the Aura record has increased measurably, especially from India to China. These global patterns of decadal increase trends are very similar to OMI NO2.
- ENSO events have a large influence on the variability of tropospheric ozone. El Nino events (such as the recent 2015-2016 El Nino) coincide with an eastward shift in convection across the dateline that dynamically increases ozone in the western Pacific and decreases ozone in the eastern Pacific.
- El Niño also induces exceptionally dry conditions and uncontrolled biomass burning over both Indonesia and Brazil as did happen during the intense 2015–2016 El Nino event.
- The MJO and shorter time scale variability in tropospheric ozone exceeds total variability generated by ENSO in the tropics. It is shown that the GMI CTM well reproduces all time scales including MJO and shorter periods.
- Cloud ozone measured from OMI/MLS (October 2004 – present) is a useful data product for characterizing the properties of ozone in deep convective clouds.
- The Usask-2D algorithm has been applied to the OMPS LP ozone retrieval and indicates an improvement from the current OMPS v2 algorithm.