Tropospheric ozone over North America from assimilation of Aura OMI and MLS

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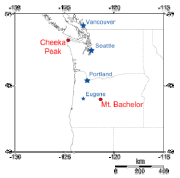
Abstract

Tropospheric ozone obtained by assimilation of Aura OMI and MLS ozone data into a global general circulation model (GCM) (Stajner et al, 2008) is compared with independent observations over North America during years 2005 and 2006. Mt. Bachelor Observatory, on an isolated volcanic peak in Oregon at about 2.7 km above the sea level, provides a multi-year time series of hourly observations of ozone and other chemical constituents (Weiss-Penzias et al, 2004). Assimilated ozone has 3-hourly resolution and captures many features of the Mt. Bachelor ozone time series, especially variability due to transport in winter and spring. INTEX-B Ozonesonde Network Study 2006 (IONS-06) provides ozone profiles throughout North America between March and September 2006 (Thompson et al, 2008). Assimilated Aura ozone reproduces major features of IONS-06 profiles in the upper troposphere and lower stratosphere (UT/LS): the high ozone variability during spring months and the transition towards lower ozone variability in the summer. Mt. Bachelor and IONS-06 data are used synergistically with assimilated Aura ozone to determine likely origin of air masses of enhanced ozone in several case studies.

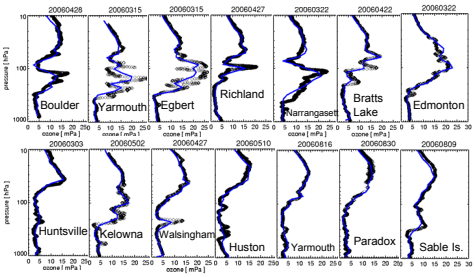
Mt. Bachelor observatory in on an isolated volcanic peak ~2.7 km above sea level in Oregon



A model grid cell is 1 deg. latitude by 1.25 deg longitude, approximately represented by the area of the map above

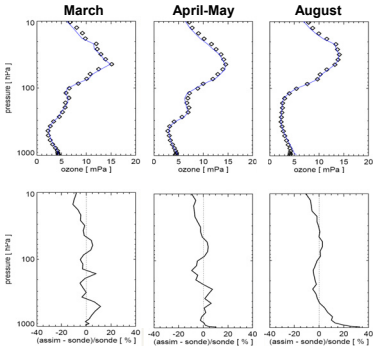
Aura assimilation compared with IONS-06

Examples of UT/LS variability



Ozone variability in the UT/LS seen in IONS-06 profiles (black) is typically well reproduced in the Aura assimilation (blue).

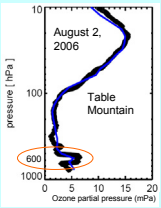
Statistical comparisons



Mean profiles from IONS-06 (black) and Aura assimilation (blue).

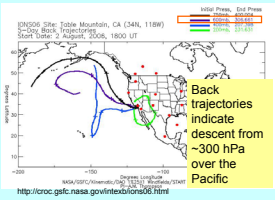
Relative mean difference between IONS-06 and Aura assimilation.

Case study: High ozone at Table Mountain on August 2, 2006

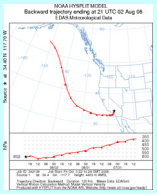


Sonde profile (black) shows elevated ozone near 600 hPa. Low humidity was measured. This combination indicates stratospheric origin.

Assimilation of Aura OMI and MLS ozone data (blue; plotted using surface pressure from the sonde profile) reproduces this feature, but with smaller magnitude.



Back trajectories indicate descent from ~300 hPa over the Pacific

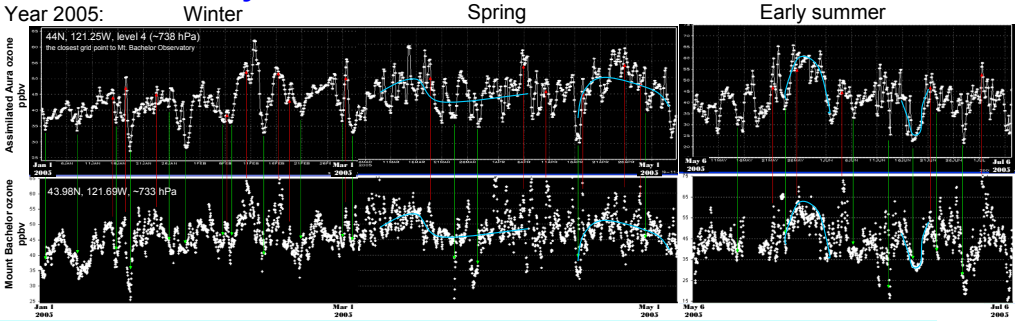


Ozone enhancement on August 2 that is captured in the assimilation is relatively broad horizontally.

A narrower enhancement on August 17 is not captured in the assimilation, likely due to the model resolution.

Ozone variability: Aura assimilation vs. Mt. Bachelor

Year 2005: Winter Spring Early summer

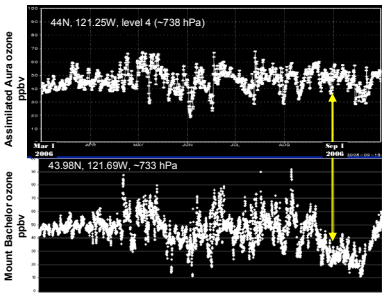


Consistent features visible in both Aura assimilation and Mt. Bachelor time series are marked:

- elevated ozone
- low ozone
- coherent change over several days

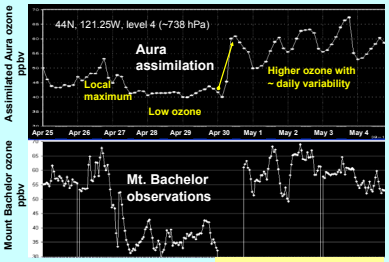
The resolution of the Aura assimilation is 1° latitude × 1.25° longitude at 55 levels between the surface and 0.01 hPa. Ozone is archived with 3-hourly frequency.

Year 2006

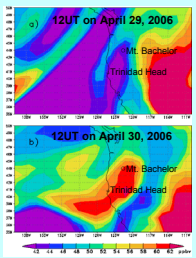


A decrease in ozone from August to September at Mt. Bachelor is not reproduced in the Aura assimilation

Case study: Ozone increase at Mt. Bachelor on April 30, 2006



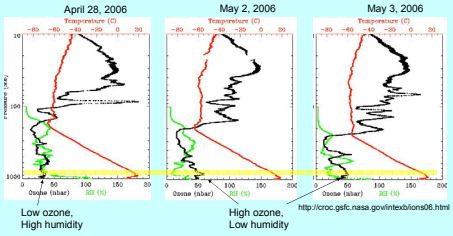
Transition from low to high ozone on April 30 is well represented in the Aura assimilation (vertical lines are due to missing data at Mt. Bachelor)



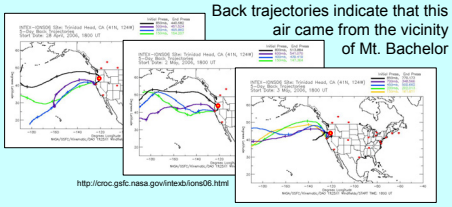
Low and high ozone features at Mt. Bachelor are several grid points wide. The transition is consistent at neighboring grid points.

Model level 4 is shown ~850 hPa when surface pressure is 1000 hPa, ~738 hPa in the grid cell containing Mt. Bachelor

IONS-06 ozone profiles at Trinidad Head



Transition near 800 hPa at Trinidad Head: from low ozone on April 28 to higher ozone on May 2 and 3.



Back trajectories indicate that this air came from the vicinity of Mt. Bachelor

Consistent transitions are seen in the Aura assimilation, Mt. Bachelor and IONS-06 data around April 30, 2006.

Summary

- Assimilation of Aura OMI and MLS ozone reproduces the high variability in the UT/LS that is seen in the IONS-06 sondes in the spring and the reduced variability in the summer.
- Ozone enhancement near 600 hPa at Table Mt. on Aug 2, 2006 is captured in the Aura assimilation, but with smaller magnitude. Low moisture and back trajectories indicate stratospheric origin.
- Ozone variability features at Mt. Bachelor Observatory are reproduced better in the Aura assimilation from winter to early summer than in the fall.
- Consistent ozone increase is seen around April 30, 2006 in the Aura assimilation, Mt. Bachelor, and IONS-06 Trinidad Head data.
- Plans: continue case studies, focus on stratospheric influence on tropospheric ozone, evaluate impact of newer versions of OMI and MLS retrievals.

References:

Thompson et al. (2008), Tropospheric ozone sources and wave activity over Mexico City and Houston during MILAGRO/ Intercontinental Transport Experiment (INTEX-B) Ozonesonde Network Study, 2006 (IONS-06) , Atmos. Chem. Phys., 8, 5113-5125.

Stajner et al. (2008), Assimilated ozone from EOS-Aura: Evaluation of the tropopause region and tropospheric columns, J. Geophys. Res., 113, D16S32, doi:10.1029/2007JD008863.

Weiss-Penzias et al. (2006), Observations of Asian air pollution in the free troposphere at Mount Bachelor Observatory during the spring of 2004, J. Geophys. Res., 111, D10304, doi:10.1029/2005JD006522.

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