Chemical and Physical Properties of Aerosols in Regional Background and Free Tropospheric Air Masses in the Western U.S.

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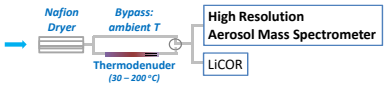
Introduction

- Atmospheric aerosols affect the Earth's radiative budget directly and indirectly.
- Aerosols are mostly produced and concentrated in the planetary boundary layer (BL), but can be transported into the free troposphere (FT), where they are subjected to fewer removal processes and therefore have longer lifetime and climate effects.
- Understanding the sources, evolution, and physicochemical properties of aerosols in regional background air masses and in the FT is crucial for constraining the climate impacts of aerosols on a global scale.
- High-altitude mountaintop observatories provide the opportunity to study aerosol properties in remote areas, especially the FT, without the added expense and difficulty of making airborne measurements.

Methodology

- The Mt. Bachelor Observatory (MBO; 2763 m a.s.l.) is a regional background site in the western US.
- The location allows for FT air masses to be sampled during the night and air coming from the BL during daytime.
- Real-time aerosol measurements were conducted at MBO during the Biomass Burning Observation Period (BBOP) in July 25 – August 25, 2013.

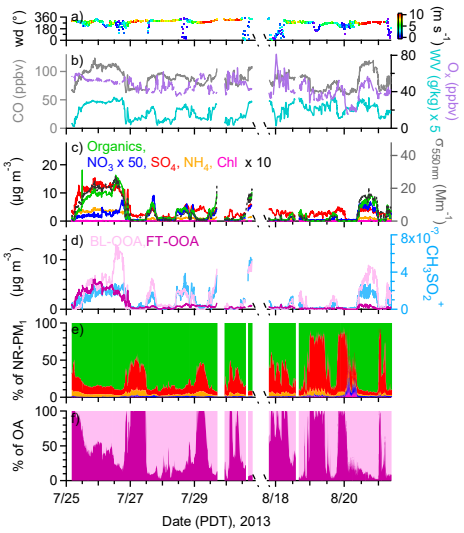


Measurements of submicron aerosols optical properties, trace gases, and meteorological parameters

Results

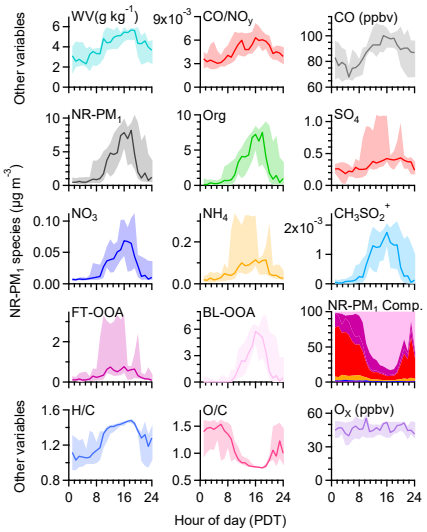
Aerosol concentration and composition at MBO during periods representing regional background and free tropospheric conditions

a. Temporal trends



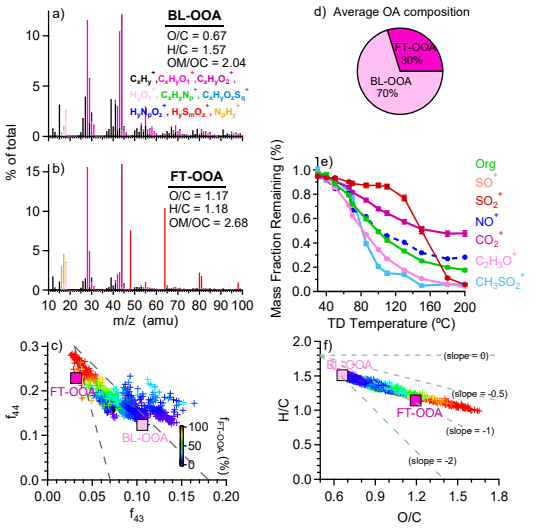
- Water vapor (WV) mixing ratio is a tracer for FT and BL air
- Aerosol concentration and composition differ significantly between FT and BL air masses.

b. Diurnal variations



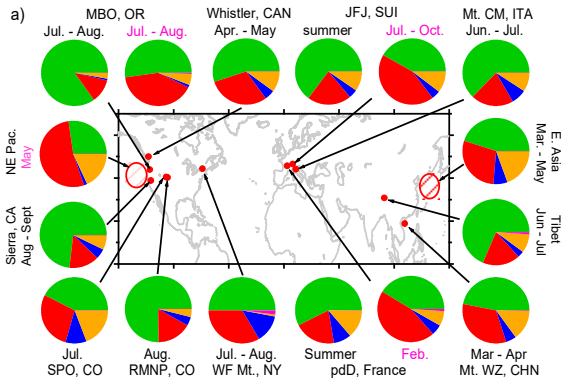
- Major aerosol components and primary gaseous pollutants show clear diurnal cycles driven by the BL.

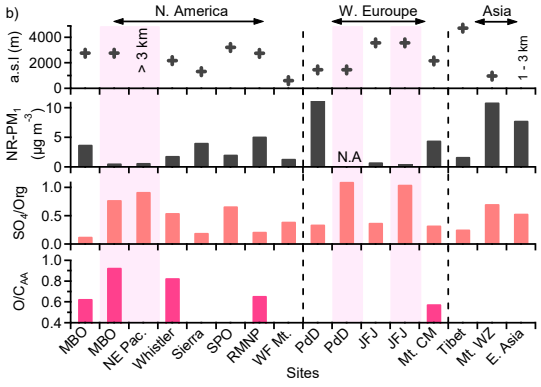
c. Composition and volatility of organic aerosol (OA)



- Positive Matrix Factorization analysis of HR-AMS data identified two oxygenated OA (OOA) factors: BL-OOA and FT-OOA.
- BL-OOA and FT-OOA have different compositions and volatilities

Global observations of aerosol composition in the regional background air masses at high-altitude





MBO:	Mt. Bachelor Observatory, OR, USA
NE Pac.:	Northeast Pacific
Whistler :	Whistler mountain, Canada
Sierra:	Sierra Nevada, USA
SPO:	Storm Peak Observatory, USA
RMNP:	Rocky Mountains National Park, USA
WF Mt.:	Whiteface Mountain, USA
PdD:	Puy-de-Dome, France
JFJ:	Jungfraujoch, Swizerland
Mt. CM:	Mt. Cimone, Itaty
Tibet:	Tibet, China
Mt. WZ:	Mt. Wuzhi, China
E. Asia :	East Asia

- A summary of measurements of regional background aerosols at multiple high-altitude sites and aircraft. Pink labels in (a) and shades in (b) indicate FT air and the rest represent mixed BL and FT air.
- Compared to aerosols in mixed air masses, FT aerosols have much lower aerosol concentrations with substantially higher mass fractions of sulfate and sulfate-to-organic ratios.

Conclusions

Chemical and physical properties of aerosols in regional background and free tropospheric air masses in the western US were studied in summer 2013 at MBO:

- Low aerosol loading (average NR-PM_1 = 3.75 μg m^{-3}) was observed.
- Main aerosol components showed clear diurnal variations driven by boundary layer dynamics with higher concentrations occurring during daytime and lower concentrations at night.
- Aerosols in the free troposphere tended to be more acidic and contained a higher mass fraction of ammonium sulfate (up to 90% of NR-PM_1 mass) compared to air masses from the boundary layer.
- Organic aerosol was highly oxidized (O/C = 0.84) and dominated aerosol composition (85% of NR-PM_1 mass):
  - BL-OOA (O/C = 0.67; 70% of OA mass) representing biogenically-influenced SOA formed in the BL
  - FT-OOA (O/C = 1.17) representing highly oxidized low-volatility organics in the FT.

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