Source Attribution of Aerosol Size Distributions and Model Evaluation Using Whistler Mountain Measurements and GEOS-Chem-TOMAS Simulations

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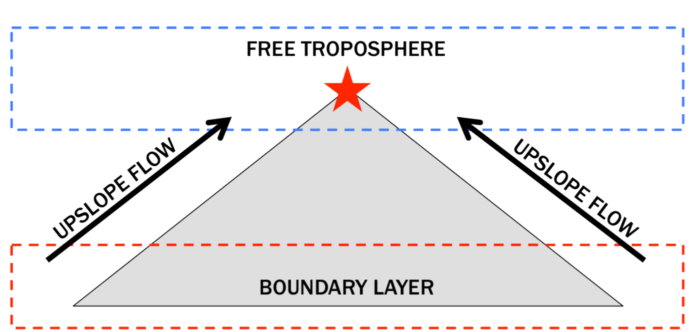
Summary

The peak of Whistler Mountain generally resides in the free troposphere, a largely uncharacterized layer of unmixed high elevation air, but frequently experiences a variety of aerosol source influences. By comparing measured and modeled size distributions, we seek to characterize contributions to Whistler aerosol from boundary layer upslope flow, long-range Asian transport, and local biomass burning. We find the following:

I. Temperature and relative humidity filters improve model-measurement correlation.
II. Asian transport enhances climate relevant particles but suppresses new particle formation during winter months. Biomass burning enhances both climate relevant particles and new particle formation during summer months.
III. Biogenic secondary organic aerosol is another major local aerosol source.

1. Motivation

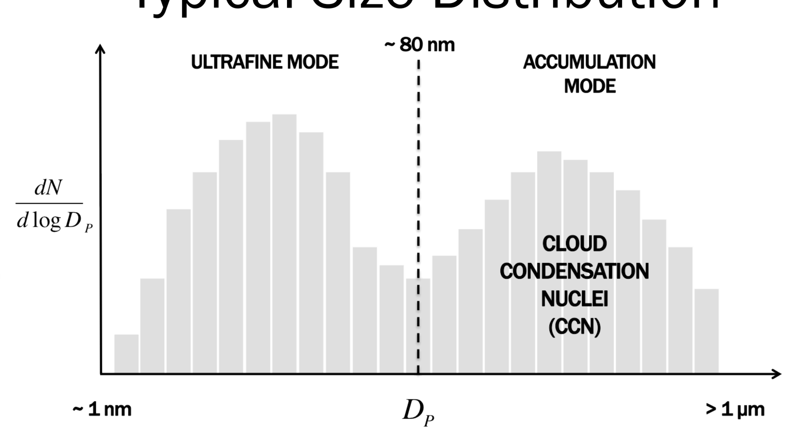
Boundary Layer Influence



Whistler peak (red star) generally resides in the free troposphere at 1.6 km above model ground level; however, upslope flow frequently brings boundary layer air. Local and long-range pollution also contribute to aerosol. We evaluate model representation of upslope flow and pollution.

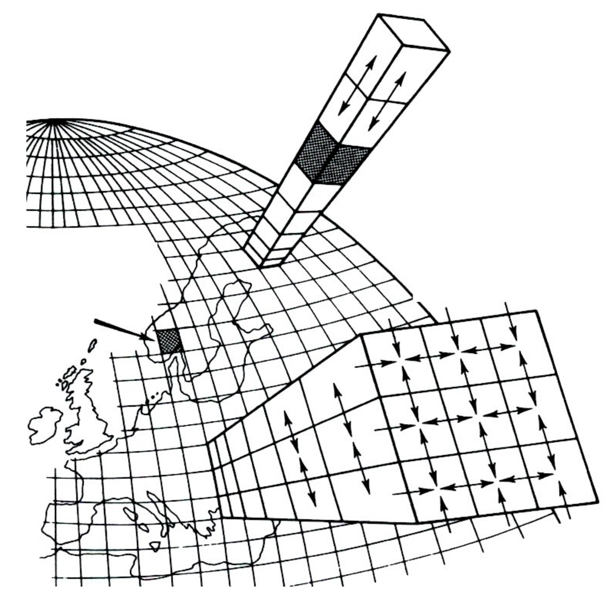
Typical Size Distribution

Specifically, we evaluate the modeled size distribution: the number of particles at various diameters. Particles larger than 80 nm may act as cloud condensation nuclei (CCN), surfaces on which cloud drops form; we are ultimately interested in the number of these climate relevant particles.



2. Model and Measurements

GEOS-Chem-TOMAS Model



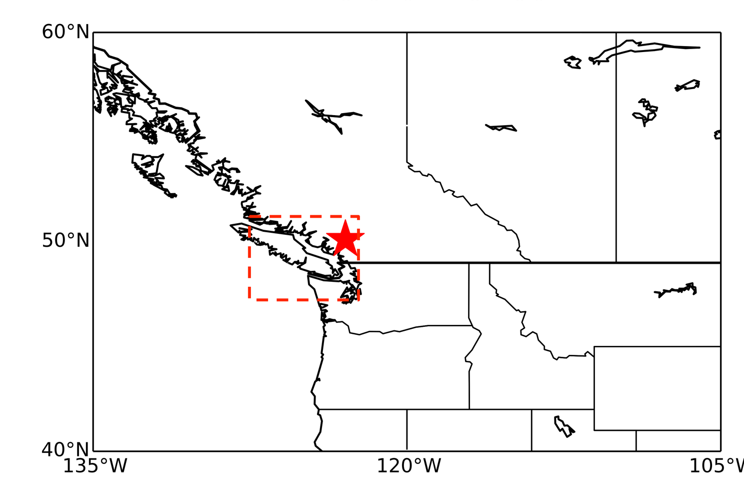
GEOS-Chem (http://geos-chem.org/) is a global chemical transport model with 47 vertical layers and 4°x 5° horizontal resolution.

TOMAS (TwO-Moment Aerosol Sectional) models aerosol microphysics within GEOS-Chem.

We perform 3 model runs: a base run, a run without Asian anthropogenic emissions, and a run without biomass burning.

Whistler Site

We compare model outputs to measurements taken at Whistler Mountain, BC, Canada (red star) from April 2010 to December 2011. Model grid box is resolved to 400 km x 400 km (red dashed box); elevation is averaged to 600 m above sea level. Whistler Mountain is resolved vertically but not horizontally.

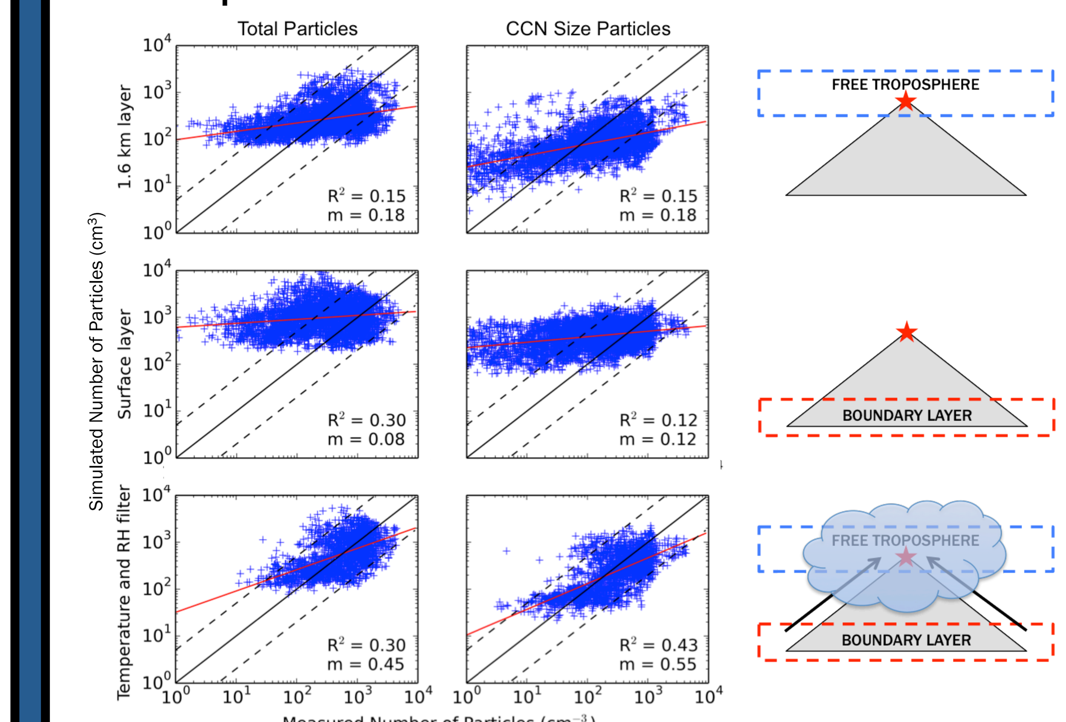


3. Objectives

I. Evaluate model representation of upslope flow.
II. Characterize known pollution source influences in model.
III. Investigate other pollution sources.

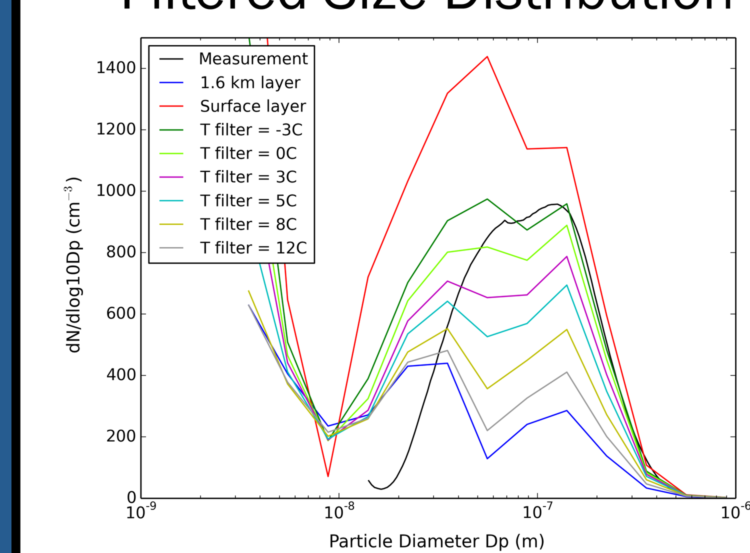
4. Improving Model-Measurement Correlation

Temperature and RH filter



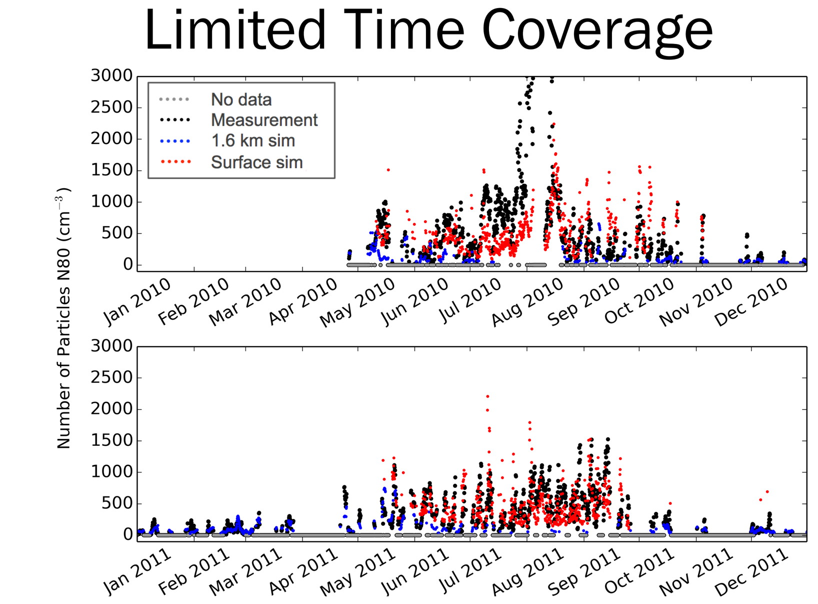
Simulation versus measurements for 1.6 km model layer (top), surface layer (middle), and filtered combination (bottom). For filter, surface layer is selected when measured temperature exceeds 3C, 1.6 km layer is selected otherwise, and points with > 90% relative humidity are removed to reduce in-cloud sampling. Regression line (red), ideal 1:1 line (solid black), and 1:5 and 5:1 lines (dashed black) are shown.

Filtered Size Distribution



Size distribution of measurements (black) and temperature-selected simulation layer combinations (colors). 3C filter (purple) improves distribution from unfiltered 1.6 km layer (blue).

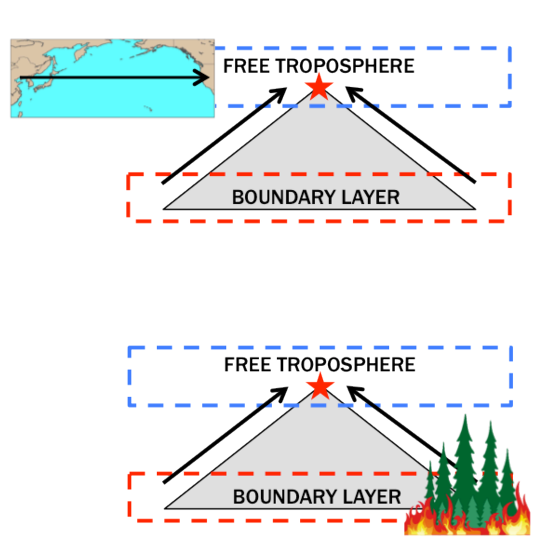
Limited Time Coverage



Time series of measured (black), simulated (red surface layer, blue 1.6 km layer), and missing (gray) CCN size particles. Relative humidity filter eliminates many fall, winter, and spring points.

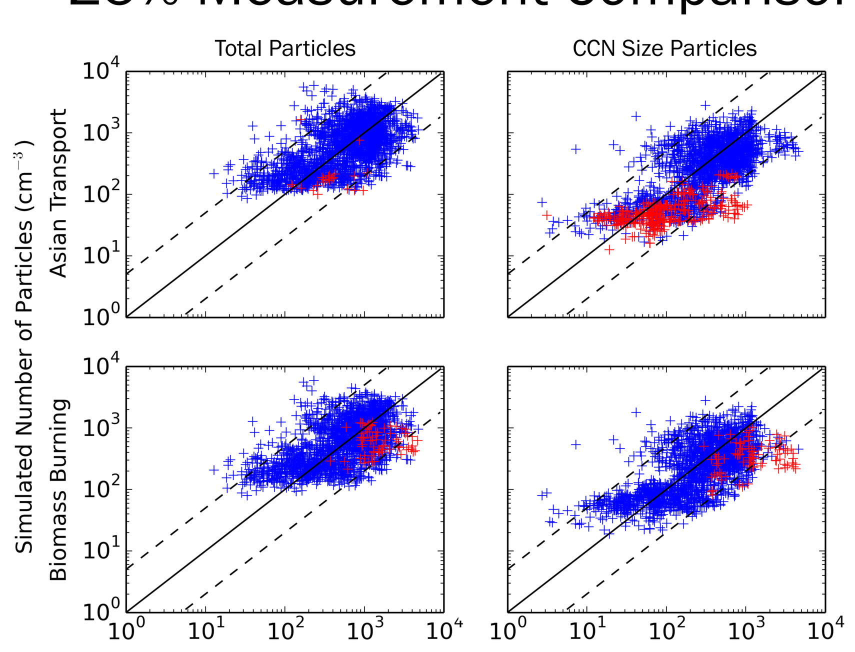
5. Asian Transport and Biomass Burning Contributions

Pollution Sources



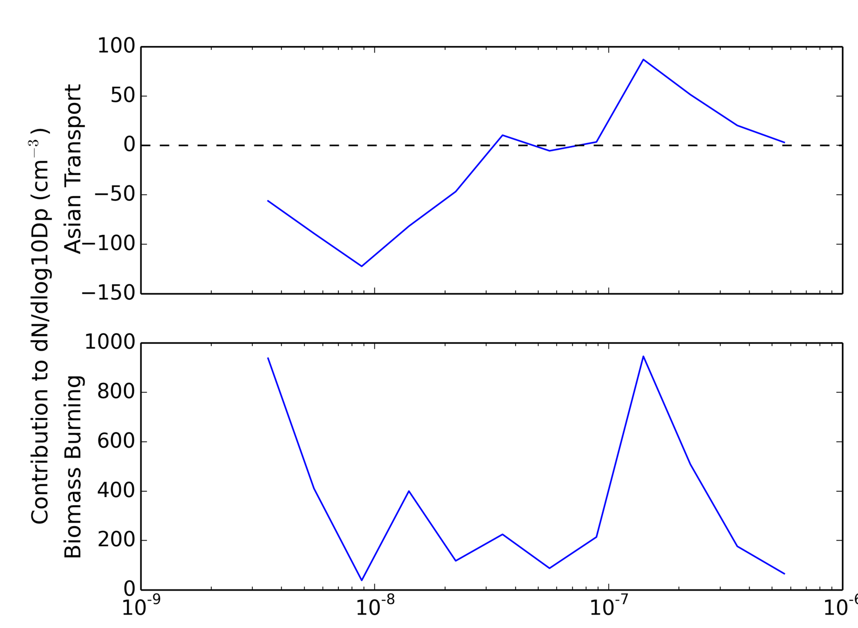
Whistler receives aerosol from long range Asian transport and local biomass burning.

>25% Measurement Comparison



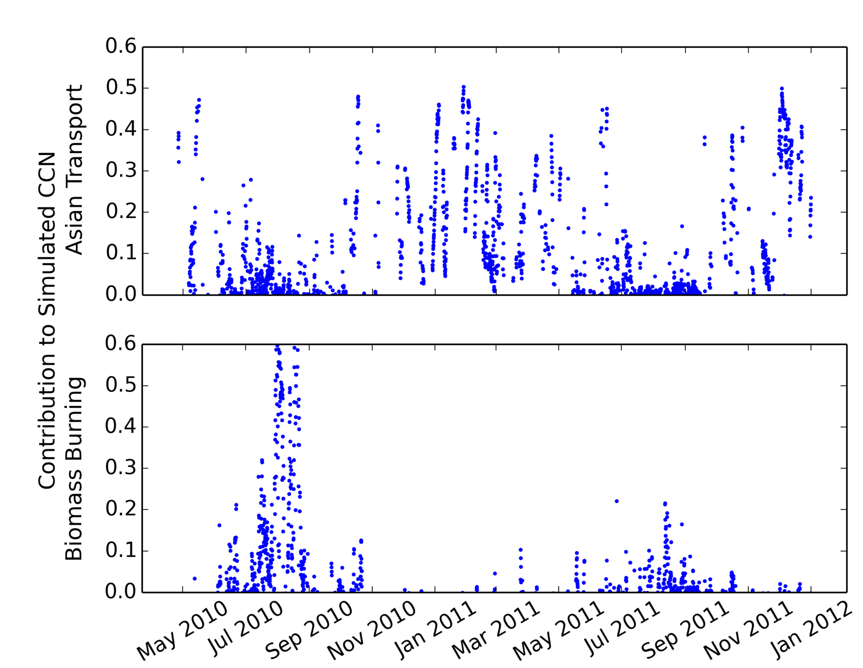
Base simulation versus measurements with high Asian transport (top) and high biomass burning (bottom) in red. Asian transport travels in clean free troposphere measurements. Biomass is carried in polluted boundary layer measurements.

>25% Size Distribution



Size distribution of averaged Asian transport (top) and biomass burning (bottom). Asian transport suppresses new particles < 40 nm and enhances CCN size particles > 100 nm. Biomass burning enhances both new particles < 10 nm and CCN size particles > 100 nm.

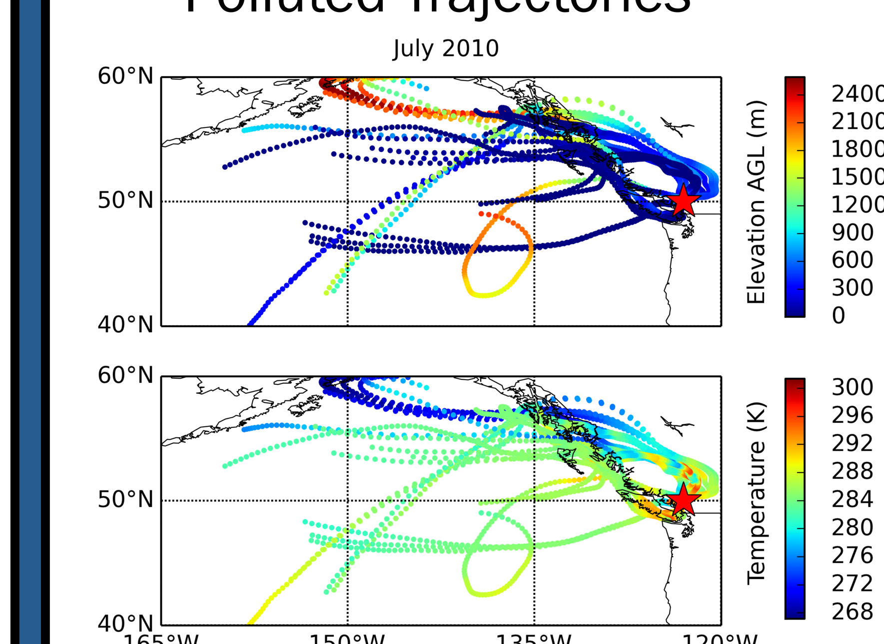
Pollution Time Profile



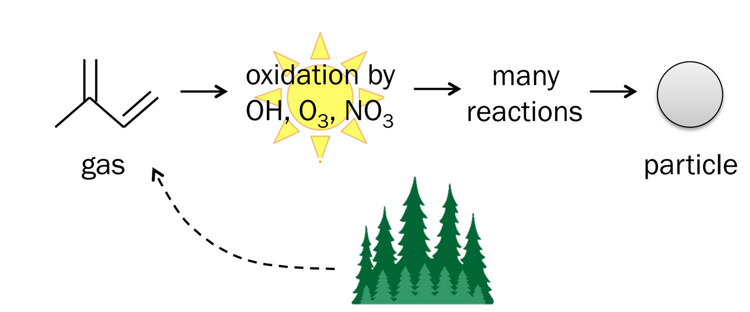
Time series of relative difference between base and No Asia (top) and between base and No Biomass (bottom) simulated CCN size particles. Asian transport peaks in cold months when 1.6 km layer is used. Biomass burning shows strong summer seasonality.

6. Other Pollution Sources

Polluted Trajectories



Back trajectories for air parcels with high CCN, low Asian transport, and low biomass burning. Paths through forested valleys with increasing temperature at low elevation suggest biogenic secondary organic aerosol formation.



Acknowledgements

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