



# A High-Resolution Time-of-Flight Aerosol Mass Spectrometer Study on Size Resolved Aerosol Composition at the Peak of Whistler Mountain during INTEX-B



Qi Zhang<sup>1</sup> (qz@asrc.cestm.albany.edu), Yele Sun<sup>1</sup>, Richard Leaitch<sup>2</sup>, Anne Marie Macdonald<sup>2</sup>, Kathy Hayden<sup>2</sup>, Shao-Meng Li<sup>2</sup>, John Liggit<sup>2</sup>, Aaron van Donkelaar<sup>3</sup>, Randall Martin<sup>3</sup>, Douglas Worsnop<sup>4</sup>, and Mike Cubison<sup>5</sup>

<sup>1</sup>Atmospheric Sciences Research Center (ASRC), State University of New York, Albany, NY <sup>2</sup>Environment Canada <sup>3</sup>Dalhousie University <sup>4</sup>Aerodyne Research <sup>5</sup>University of Colorado-Boulder

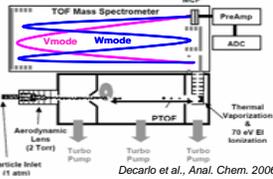
## Introduction

A high mass resolution time-of-flight aerosol mass spectrometer (HR-ToF-AMS) was deployed at the summit of the Whistler Mountain from April 20- May 17, 2006 as part of the NASA INTEX-B, the Canadian component. A main objective of this study is to quantify the implications of Asian pollution on North American air quality and climate.



Submicron aerosols were characterized *in situ* for their chemical compositions and size distributions at a time resolution of 5 min. During this study, the HR-ToF-AMS alternated between two configurations of the ion optics: the high mass resolution mode that offers a mass resolution of ~ 5000 and the lower resolution mode which reaches detection limits of ~ 5 - 20 ng m<sup>-3</sup> for NO<sub>3</sub><sup>-</sup>, SO<sub>4</sub><sup>2-</sup>, Cl<sup>-</sup>, organics, and NH<sub>4</sub><sup>+</sup>. These two modes are referred to as "W" and "V", respectively, according to the shape of the ion flight path (see the schematics below).

### Aerodyne HR-ToF-AMS schematic



The W-mode operation better distinguishes ion fragments that have the same integer *m/z* value but are slightly different in exact mass due to different elemental composition. The V-mode operation better quantifies aerosol composition and size distribution. In addition, a water-based particle concentrator was operated intermittently to enhance aerosol signal by 5-7 folds. This has significantly improved the S/N of the AMS measurements, and thus allowed better aerosol characterization in a clean atmospheric environment like the Whistler summit.

The concentrations, compositions, mass spectra, and size distributions of submicron aerosols at the Whistler summit were determined from this dataset. These results offer insights into the origins of aerosols and will be valuable additions to other measurements within the context of INTEX-B.

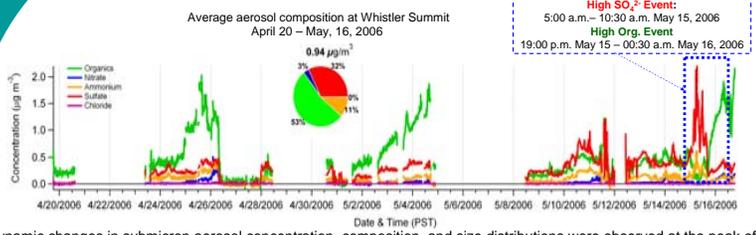
## Acknowledgements

We thank Jose Luis Jimenez (CU Boulder) for lending us the particle concentrator, Donna Sueper (CU Boulder), James Allan (U. Manchester), and Edward Dunlea (CU Boulder) for the SQUIRREL data analysis software.

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## Results and Discussions

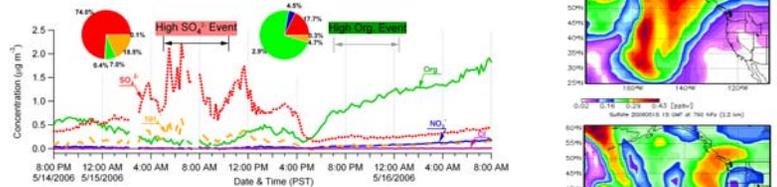
### Submicron aerosol composition at Mt. Whistler Summit



Dynamic changes in submicron aerosol concentration, composition, and size distributions were observed at the peak of Mt. Whistler during this study (see above for the time traces). On average, organics account for > 50% of the total submicron non-refractory aerosol mass, followed by sulfate. We sampled a few sulfate episodes in May 2006.

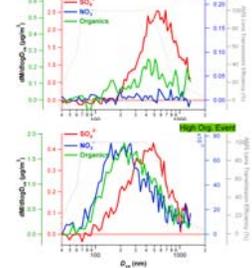
The most prominent SO<sub>4</sub><sup>2-</sup> episode happened in May 15 (see below figure to the left for a close up of this time period), sustained for more than 0.5 day, and quickly dissipated at ~ 4:00pm associated with a simultaneous increase of the organic aerosol concentrations.

### SO<sub>4</sub><sup>2-</sup> to Organic Transition on May 15<sup>th</sup>, 2006



A global model of oxidant-aerosol chemistry (GEOS-Chem) shows an aged sulfate plume being transported in the middle troposphere (~ 400 hPa) on the 14<sup>th</sup>, subsiding to the elevation of Whistler summit (~ 800 hPa) on the 15<sup>th</sup>, and dissipating by the 16<sup>th</sup> (see figures on the right)

### HR-ToF-AMS Size Dist.

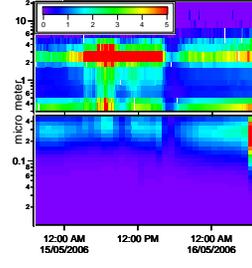


According to chemically resolved size distributions by the AMS (see the figures on the left):

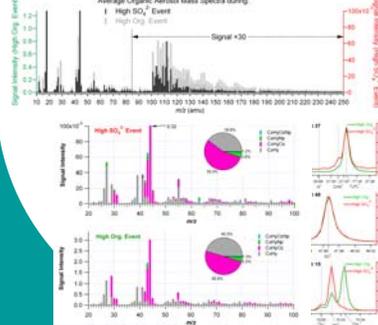
- During the high SO<sub>4</sub><sup>2-</sup> event, aerosols appeared to be larger in size, internally mixed, primarily composed of SO<sub>4</sub><sup>2-</sup> & NH<sub>4</sub><sup>+</sup>, more aged,
- During the high org. event, aerosols composed of organic and nitrate were externally mixed with the sulfate aerosols.

Size distributions of aerosol number concentration (see figure on the right) indicate a persistent coarse mode during these two events, yet much enhanced during the sulfate episode.

### Particle Number Distribution



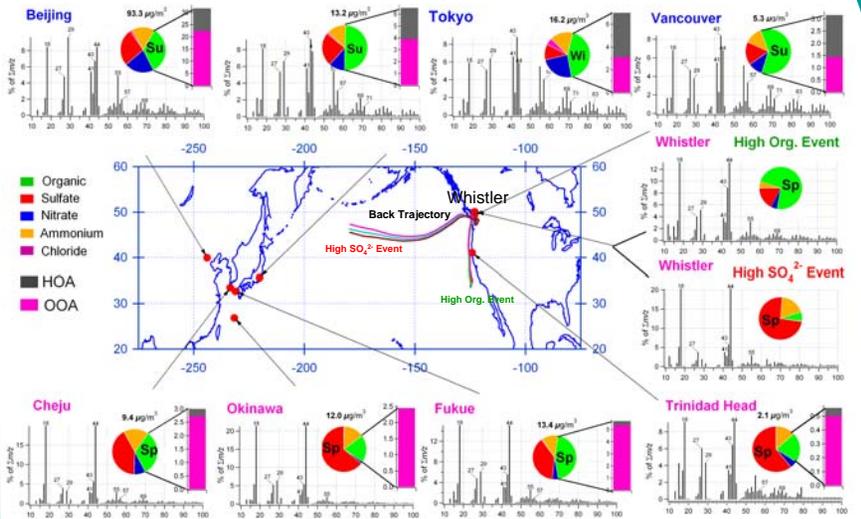
### HR-ToF-AMS mass spectra



Mass spectra analysis reveal considerable differences in organic aerosol composition between these two periods. Organic aerosols from the high Org. period are less oxidized and contain relatively higher fraction of larger *m/z*'s, an indication of consisting of more higher molecular weight organic compounds. The high resolution mass spectra also suggest significant structure difference in organic species.

### Investigate aerosol origins during the high SO<sub>4</sub><sup>2-</sup> and high Org. events

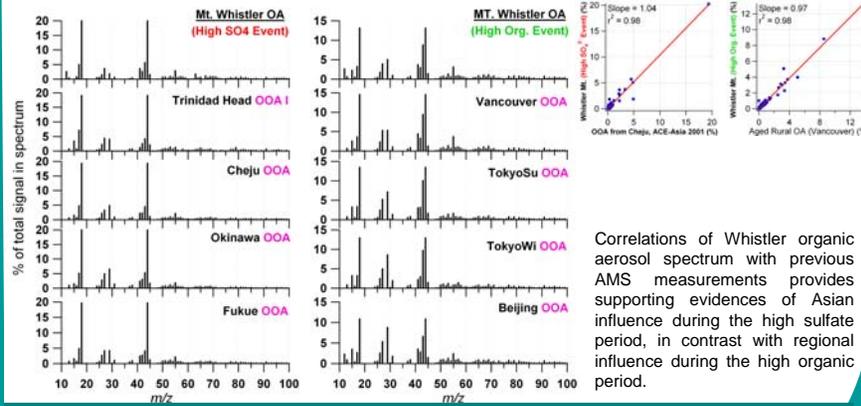
Compared below are the average mass spectra of organic aerosol, the chemical composition of non-refractory submicron aerosol species, and the distributions of HOA (hydrocarbon-like organic aerosol) and OOA (oxygenated organic aerosol) in eastern Asia and western North America. All these data were from Aerodyne AMS.



### Quadrupole AMS data provided by:

Beijing - Junying Sun et al., Chinese Academy of Meteorological Sciences, Beijing, China  
Tokyo - Nobuyuki Takegawa et al., Tokyo U. Japan  
Fukue and Okinawa - Akinori Takami et al., National Institute for Environmental Studies, Japan  
Cheju (ACE-ASIA), Trinidad Head (ITCT) & Vancouver - James Allan et al. U. Manchester, UK

HOA and OOA were determined by analyzing the AMS organic aerosol mass spectra using a multiple component data analysis technique. According to previous studies, HOA is linked to primary combustion emissions (mainly from fossil fuel and lubricating oil) and other primary sources such as meat cooking. OOA is likely linked to secondary OA (SOA) although may also contain contributions from biomass burning aerosols (Zhang et al., 2005 & 2007).



Correlations of Whistler organic aerosol spectrum with previous AMS measurements provides supporting evidences of Asian influence during the high sulfate period, in contrast with regional influence during the high organic period.

## References

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Zhang, Q., J.L. Jimenez, M.R. Canagaratna, J.D. Allan, et al., Oxygenated Species Dominate Organic Aerosols in Anthropogenically-Influenced Northern Hemisphere Mid-Latitudes, Geophys. Res. Lett. (in preparation), 2007.