Long Range Transport of Aerosols into the Canadian High Arctic

T. Kuhn, A. Bacak, R. Damoah and J. J. Sloan

EGU 2011 AS 3.5
Vienna, Austria
4 April 2011

Waterloo Centre for Atmospheric Sciences

University of Waterloo

Location

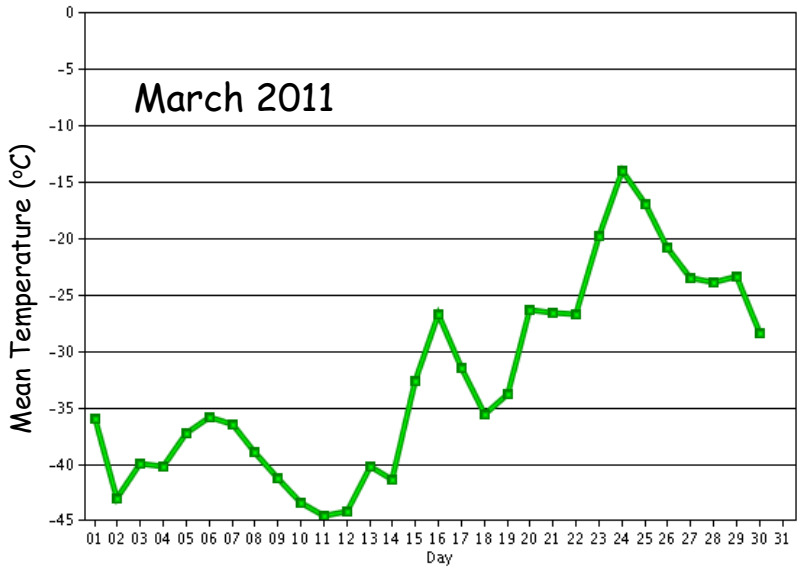
- Polar Environment Atmospheric Research Laboratory (PEARL)
  - 80° N; 86° W in Nunavut, Canada.
  - 610m above sea level, in the free troposphere

Waterloo Centre for Atmospheric Sciences

University of Waterloo

Measurements

- Aerosol Mass Spectrometer (Aerodyne Inc.)
- Cold, dry conditions require good thermal control of sample inlet

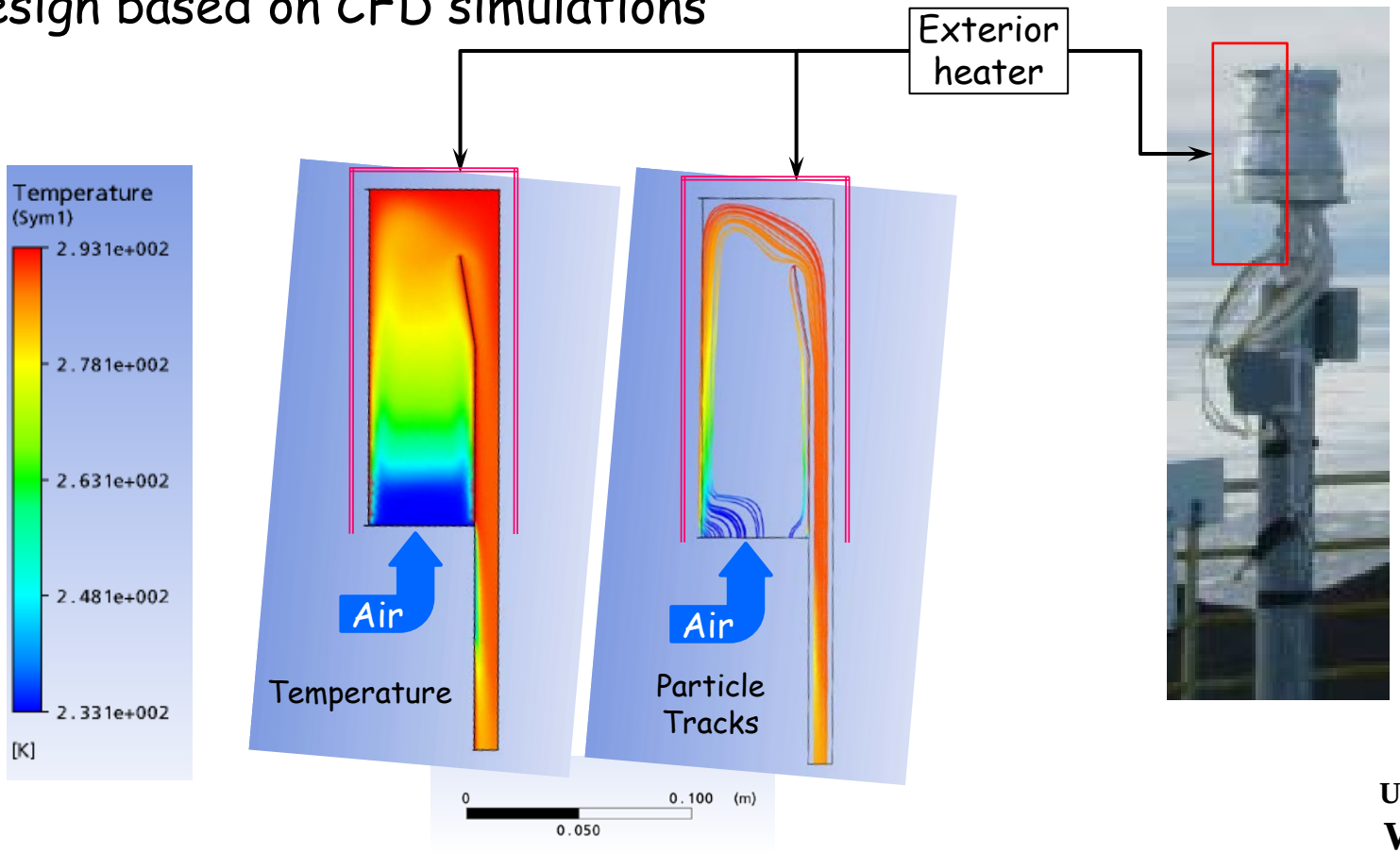


Waterloo Centre for Atmospheric Sciences

University of Waterloo

Heated Sample Inlet

- Sample inlet must melt ice crystals, evaporate water, raise temperature to 20°
- Design based on CFD simulations



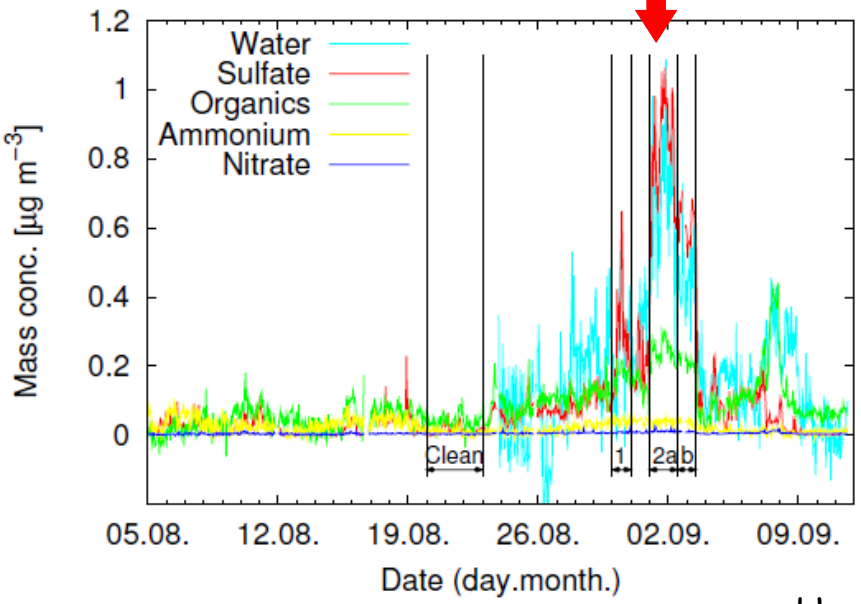
Inlet Cross Section

Waterloo Centre for Atmospheric Sciences

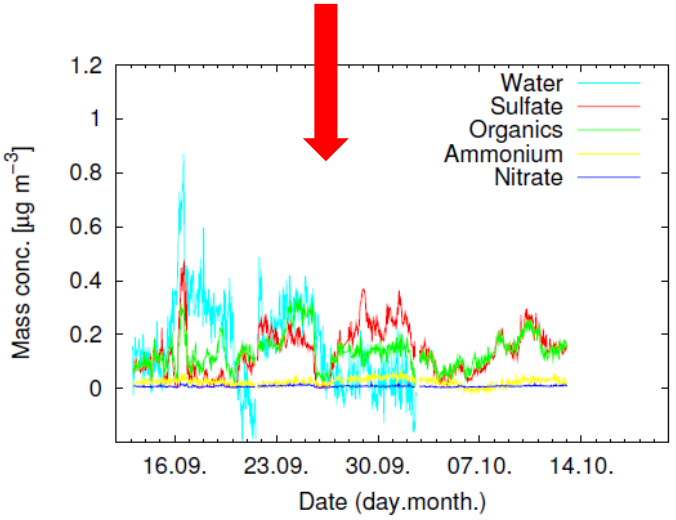
University of Waterloo

Example of H_2SO_4 Aerosol Episode

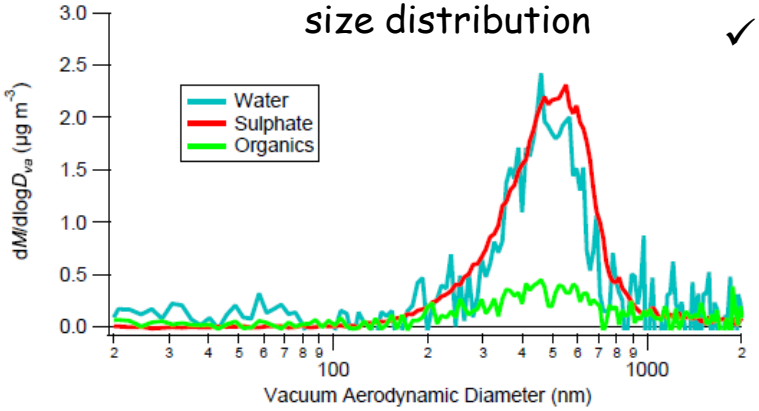
Water and sulfate signals are correlated …



(Normally they are uncorrelated)



… and have the same size distribution



Conclusions

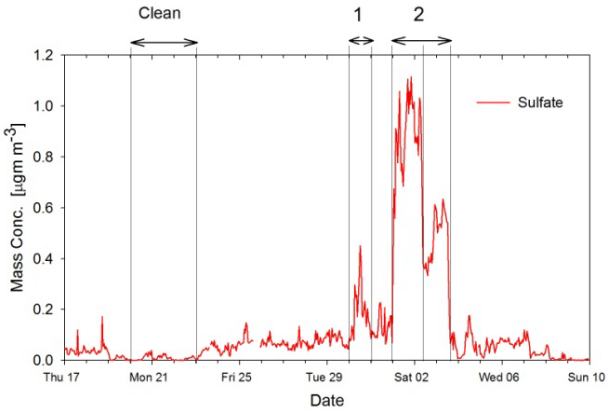
- ✓ Aerosols are H_2SO_4
- ✓ Anthropogenic (very short duration)

Waterloo Centre for Atmospheric Sciences

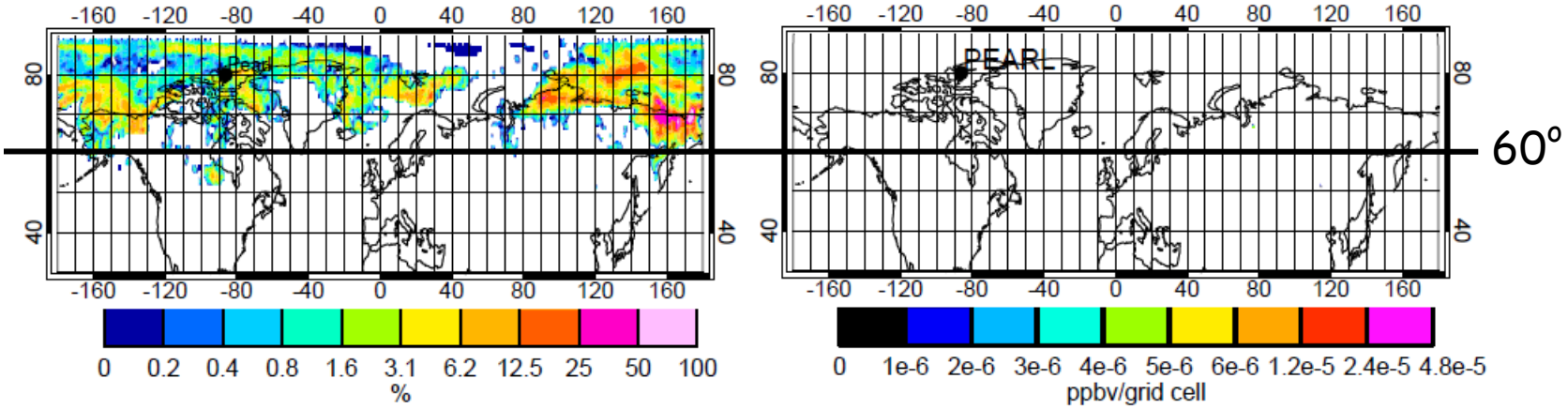
University of Waterloo

Lagrangian Analysis (FLEXPART)

- Backward simulations
  - Footprints: particle residence times in volumes 1°x1°x500m deep evaluated every 3 hours; summed for 20 days
- Sulfate source identification
  - ✓ Convolution of footprints with SO_2 emissions (EDGAR v3.2)
  - ✓ $SO_2 \rightarrow SO_4^=$ oxidation in a few days



"Clean" Period



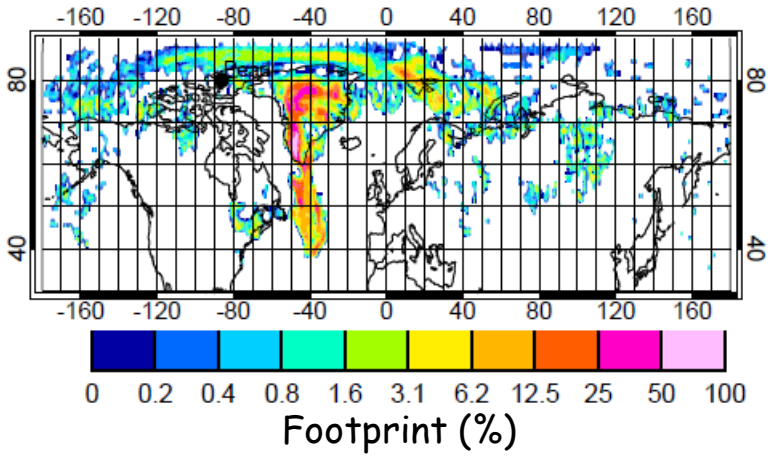
Footprint

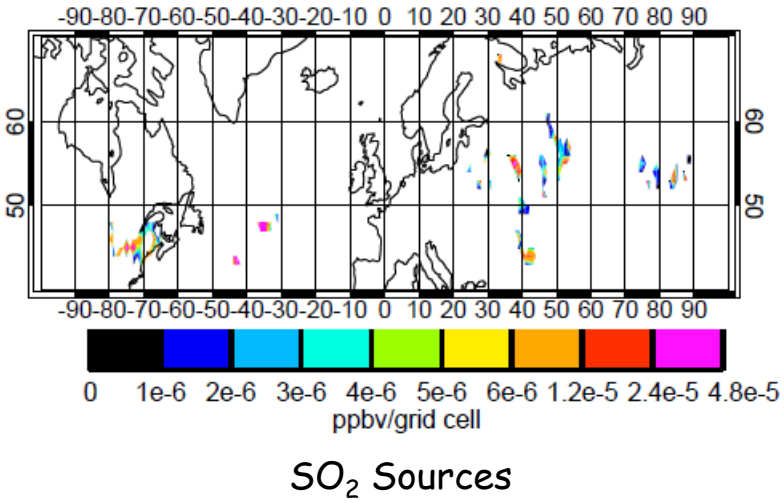
SO_2 Sources

Waterloo Centre for Atmospheric Sciences

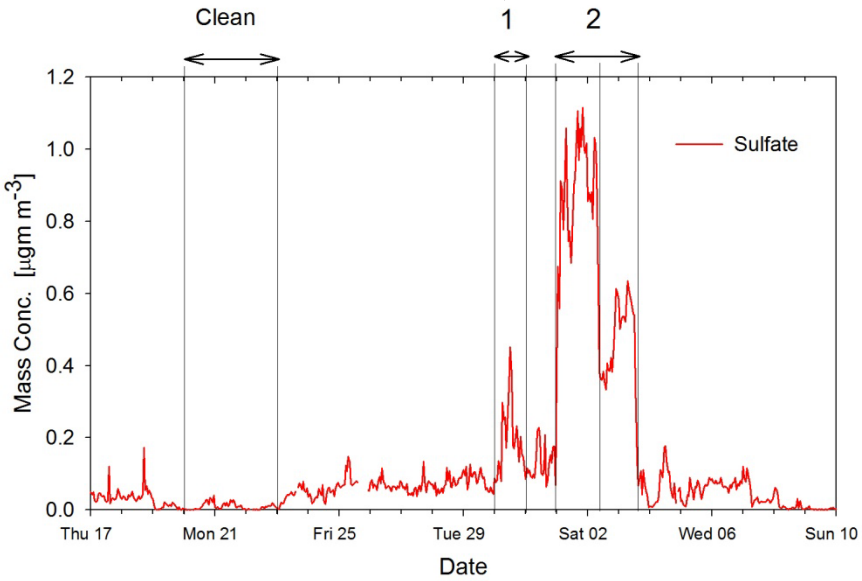
University of Waterloo

H_2SO_4 Episode 1; 30-31 August





SO_2 Sources

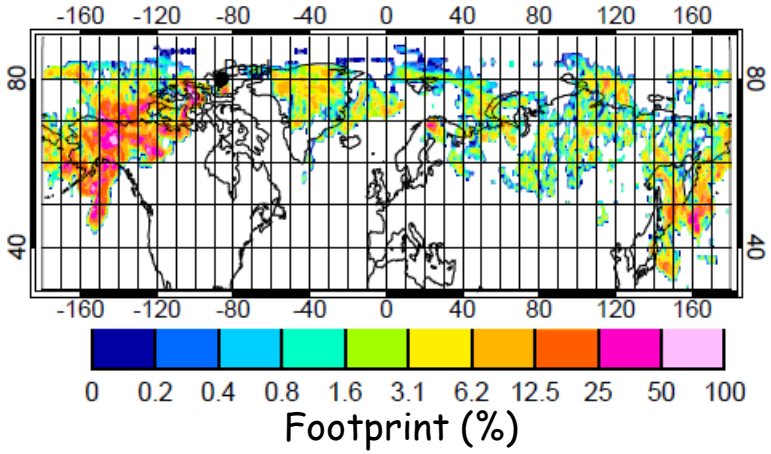


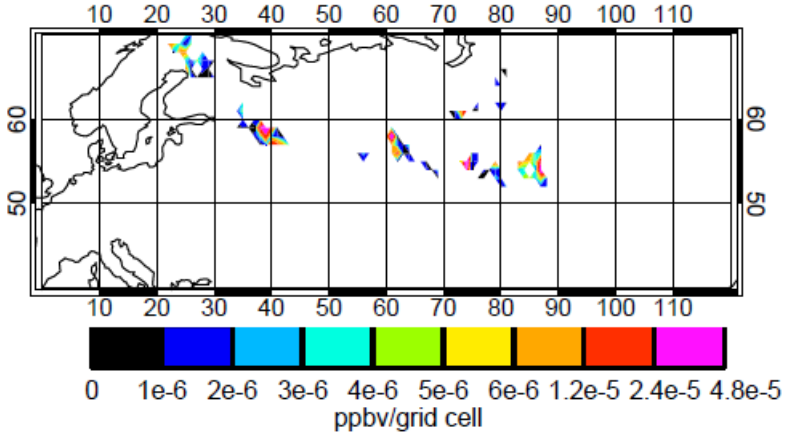
- Sources in Europe, Asia and North America
  - all below 60°
  - note ship emissions

Waterloo Centre for Atmospheric Sciences

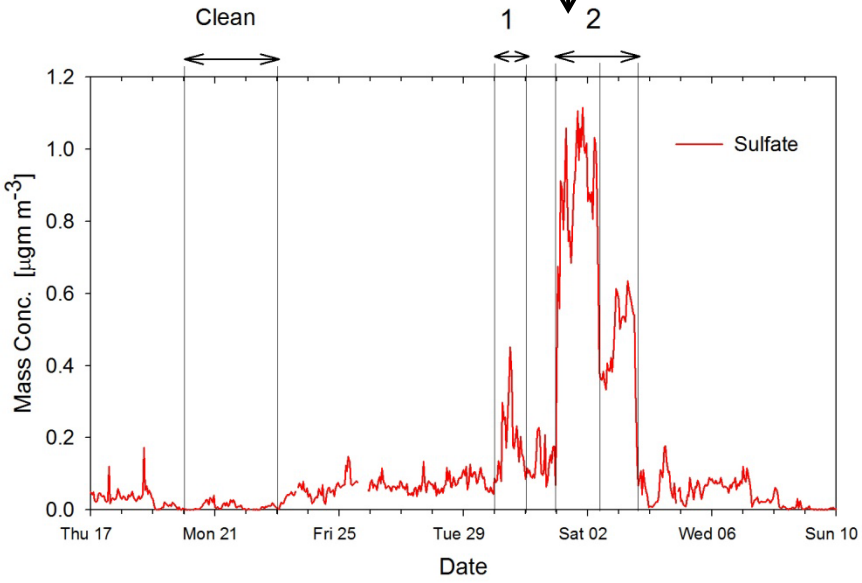
University of Waterloo

H_2SO_4 Episode 2a; 1-2 September





SO_2 Sources

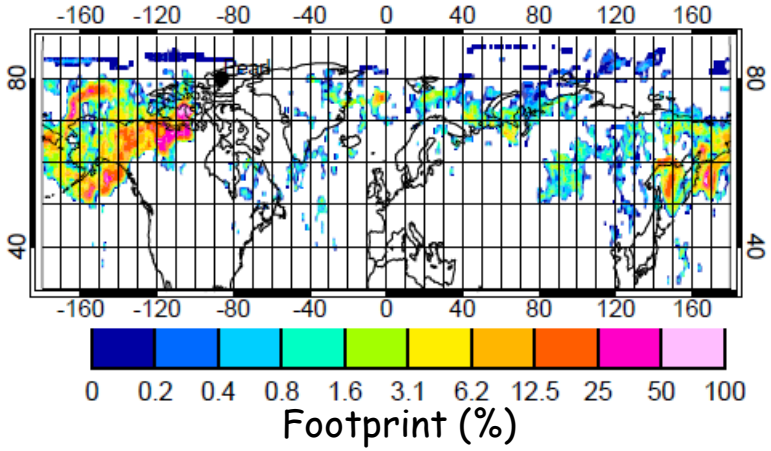


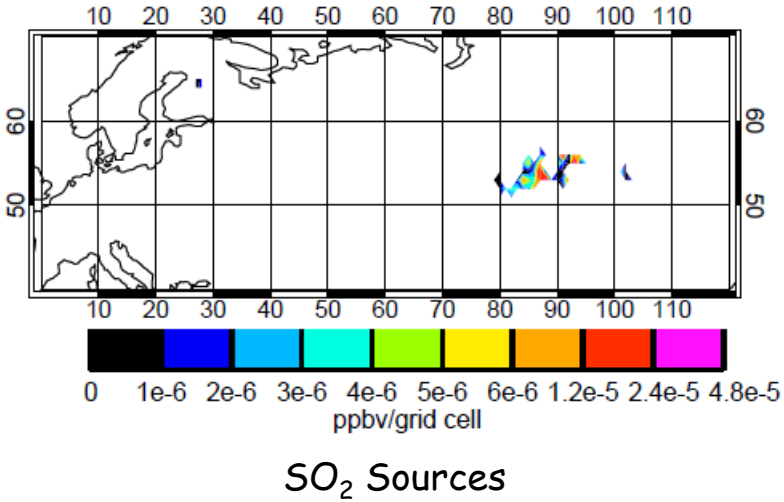
- Sources in Scandinavia and Siberia
  - most are below 60°

Waterloo Centre for Atmospheric Sciences

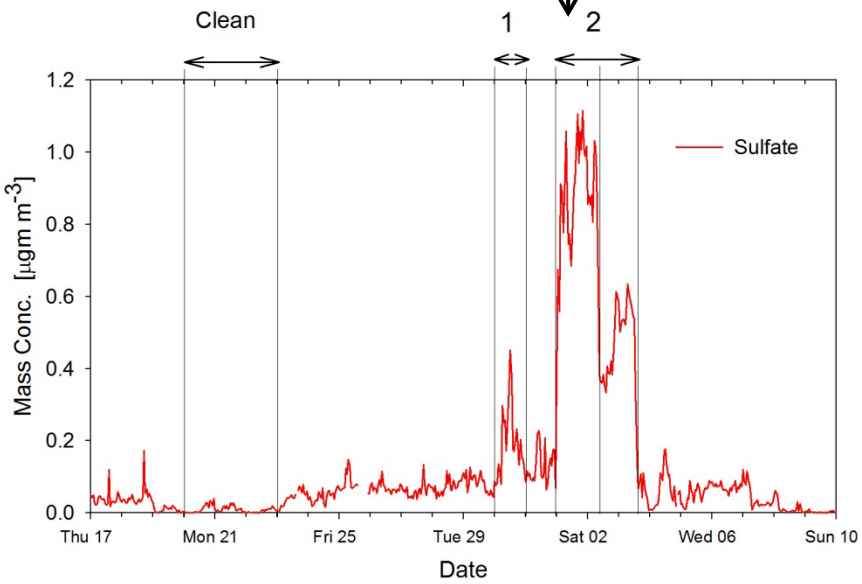
University of Waterloo

H_2SO_4 Episode 2b; 3-4 September





SO_2 Sources



- Sources in Siberia, below 60°

Waterloo Centre for Atmospheric Sciences

University of Waterloo

Locations of Largest Sources

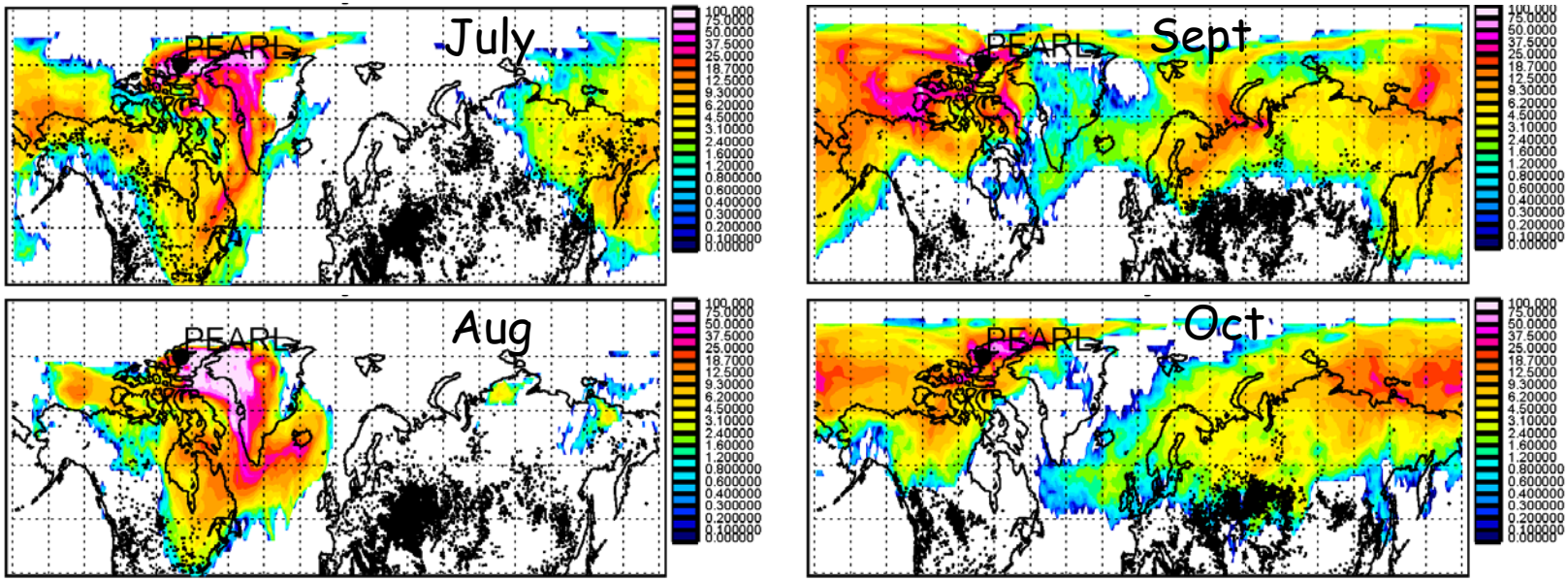
Location	Population Centre / Activity
(1)	
55N; 37 E	Moscow / Heavy industry
52N; 76E	Pavlodar (Kazakstan) / Oil refining, Thermal power generation
54-58N; 48-54E	Tatarstan / Oil production
53N, 87E	Novokuznetsk / Coal production
46-48N, 79-81W	Timmins, Val d'Or, Sudbury (Canada) / Mining
45N; 73W	Montreal (Canada) / Oil refining
40-50N; 30-50W	Europe-North America shipping routes
43-45N, 40-44E	Stavropol / Oil and gas production
(2a)	
61N, 73E	Surgut / Oil and Gas production
59N, 38E	Cherepovets / Steel manufacturing
56-58N, 60-61E	Yekaterinburg-Sverdlovsk / Coal, Refining, Thermal power generation
55N, 73.4E	Omsk / Oil refining
53N, 87E	Novokuznetsk / Thermal electric generation
(2b)	
56N, 91E	Achinsk / Heavy industry, Oil refining, Cement
56N, 93E	Krasnoyarsk / Aluminum, Rubber
54N, 87E	Novokuznetsk / Coal, Metals, Power
49N, 84E	Zyryanovsk / Mining

Waterloo Centre for Atmospheric Sciences

University of Waterloo

Climatology (Preliminary)

- Monthly Average Footprints (2007)
  - Summer: transport is mainly from North America
  - Autumn: more circumpolar transport



Waterloo Centre for Atmospheric Sciences

University of Waterloo

Acknowledgements

- Financial Support:
  - Canadian Network for the Detection of Atmospheric Change
  - Canadian Space Agency

Waterloo Centre for Atmospheric Sciences

University of Waterloo