Aerosols

Catherine F. Cahill
Geophysical Institute and Department of Chemistry
University of Alaska Fairbanks

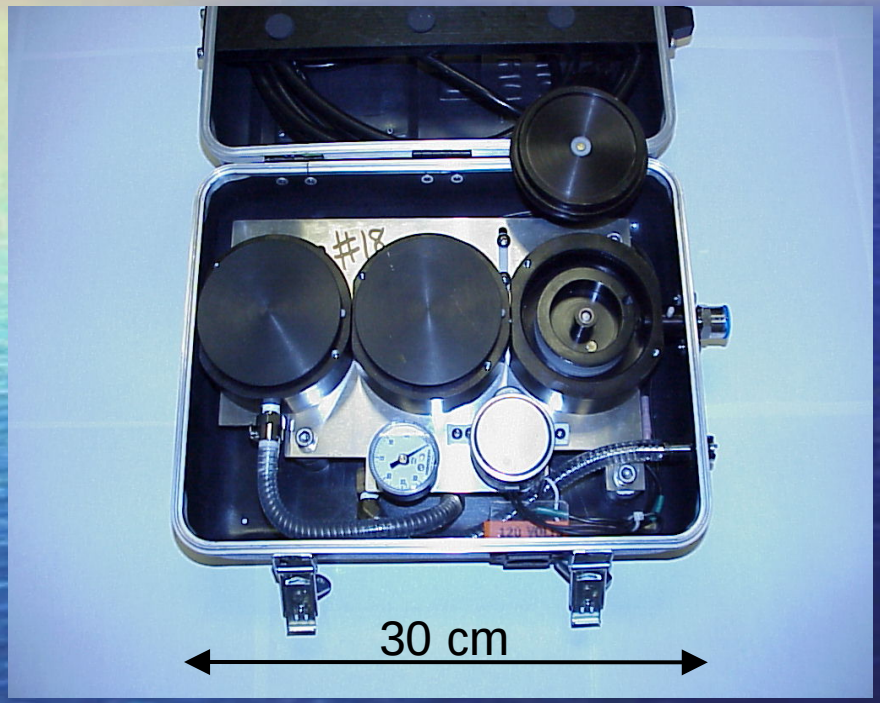
Aerosols during RUSALCA

- Sampling method
- Analysis methods
- Results and interpretation
- Comparison with other studies
- Conclusions
- Future work

Sampling Method

- The aerosol sampler was a 3-stage DRUM aerosol impactor with a 2.5 μm cut-point cyclone inlet
- The three size cuts of the sampler are:
  - 2.5 to 1.15 μm
  - 1.15 to 0.34 μm
  - 0.34 to 0.1 μm
- Continuous sampling with 3.6 hour resolution from August 6 to 24, 2004

Aerosol Sampler



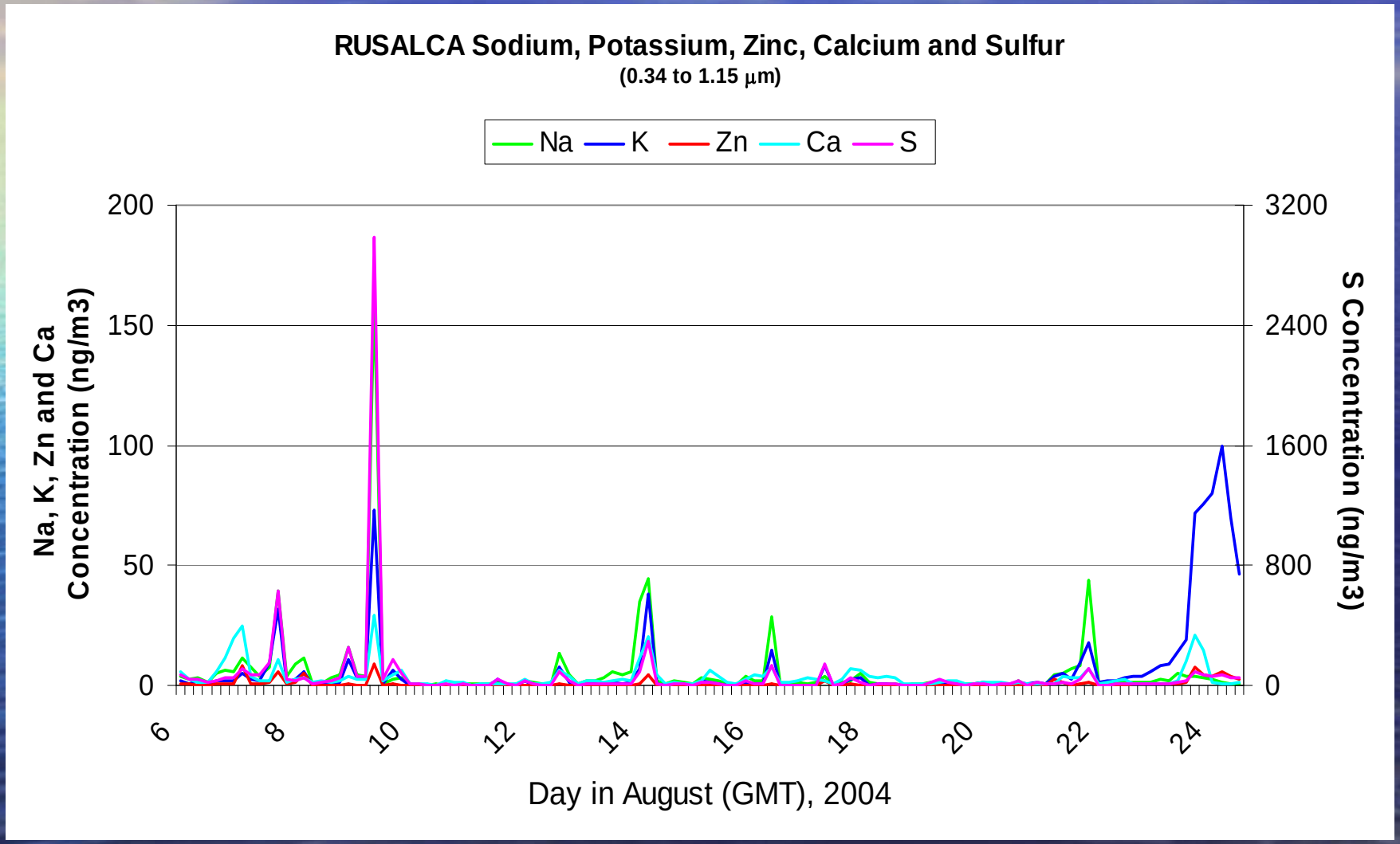
3-stage DRUM aerosol impactor

The DRUM on the Professor Khromov.

Analysis Methods

- Elemental concentrations by Synchrotron X-ray Fluorescence
  - Lawrence Berkeley National Laboratory Advanced Light Source
  - 42 elements between sodium and lead
- Mass concentration by β-gauge

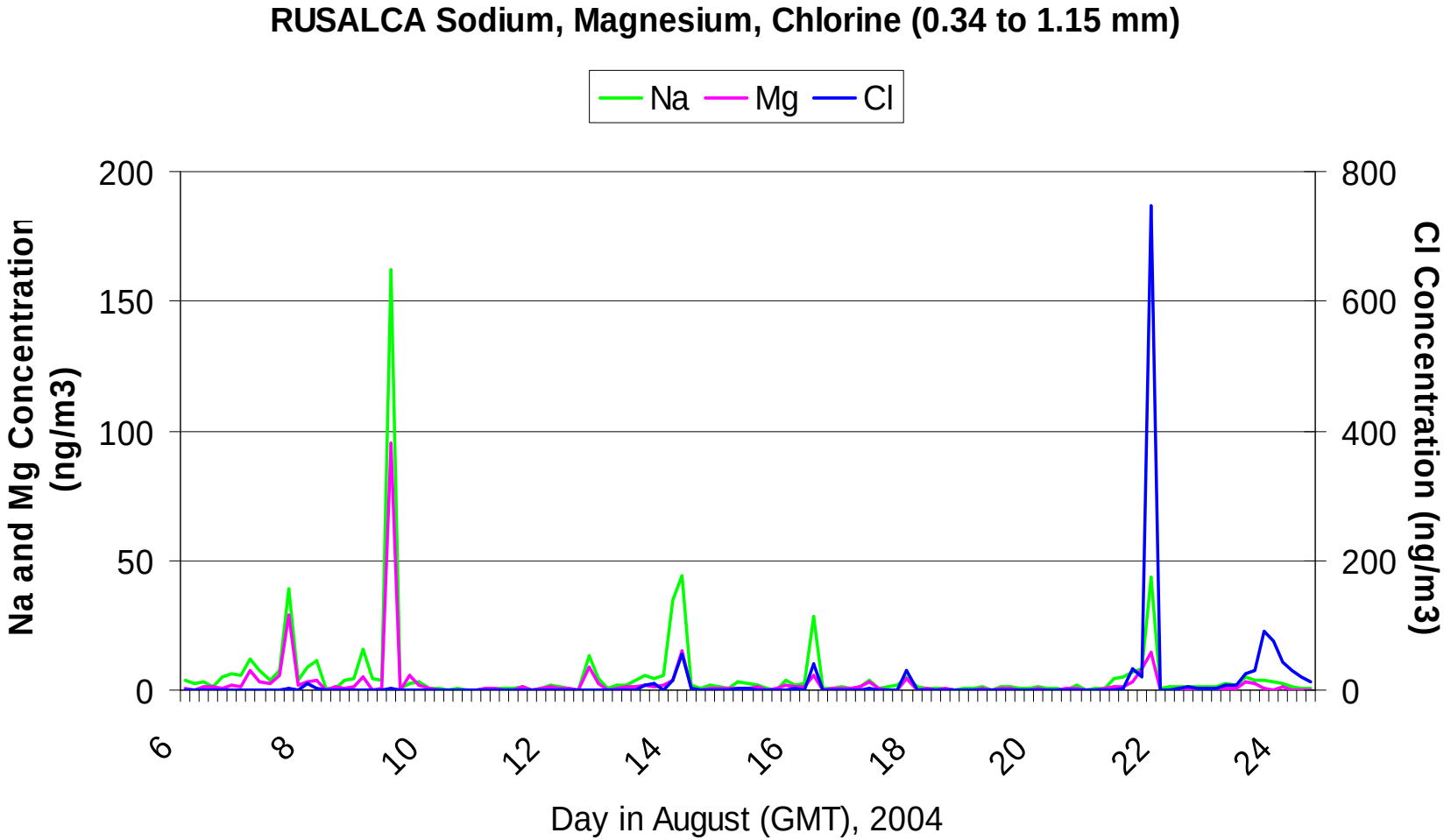
Representative Elements



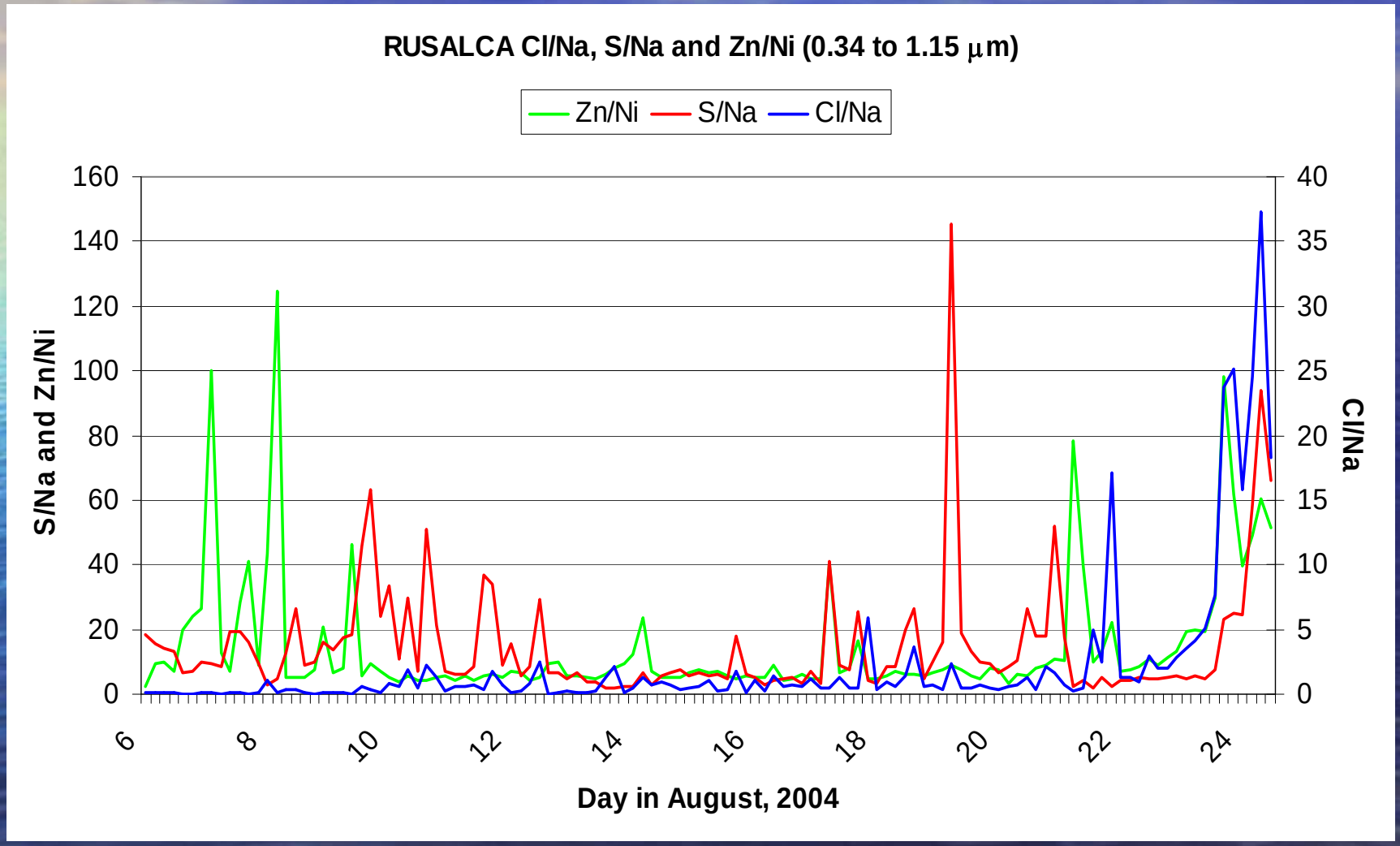
Representative Elements (cont.)

- Very clean
- The periods in Nome are the dirtiest
- Influence of different sources is very episodic
- Sulfur has the highest concentrations

Sea Salt

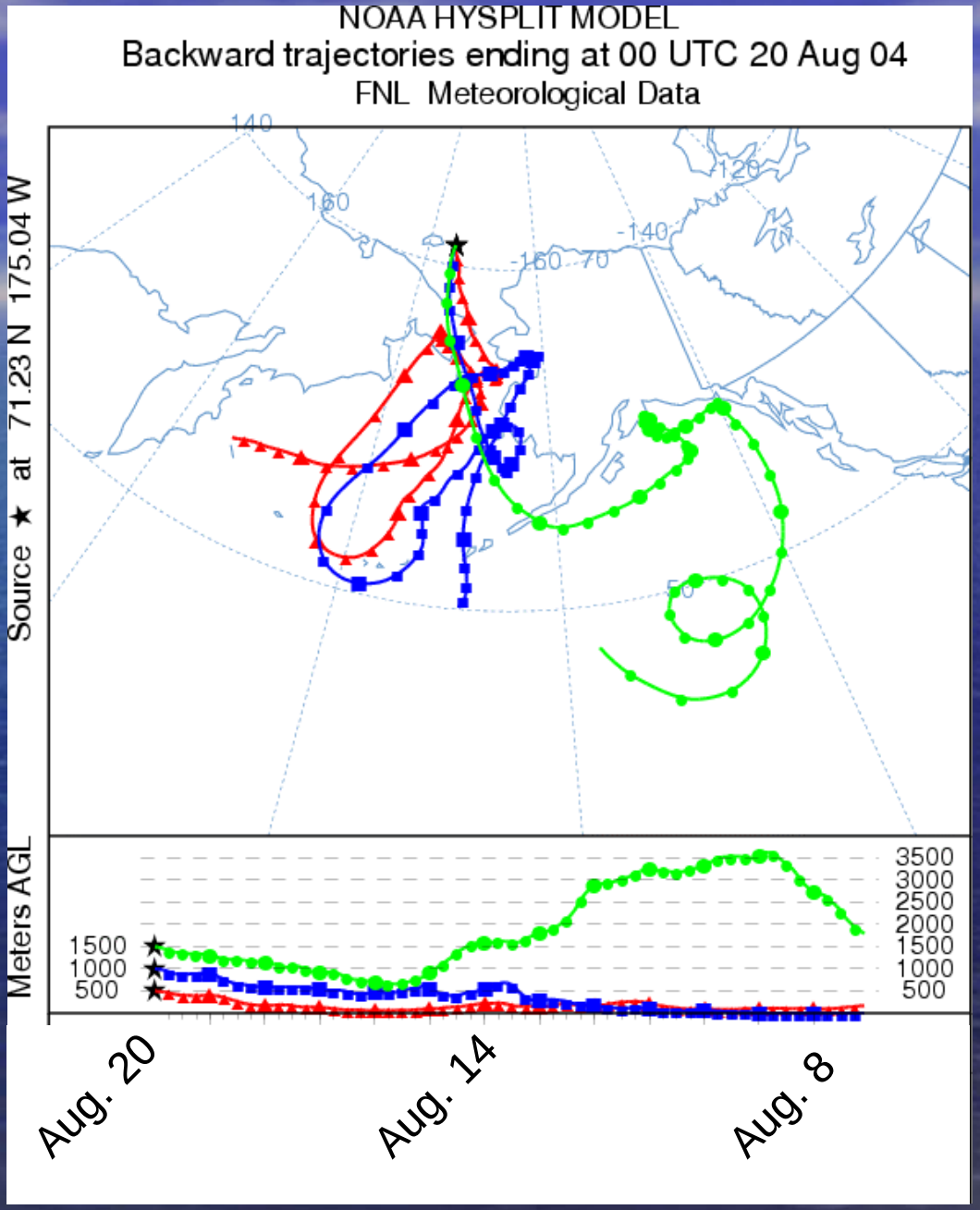

RUSALCA Sodium, Magnesium, Chlorine (0.34 to 1.15 mm)
Na
Mg
Cl
Na and Mg Concentration (ng/m3)
Cl Concentration (ng/m3)
200
150
100
50
0
800
600
400
200
0
6
8
10
12
14
16
18
20
22
24
Day in August (GMT), 2004

Sea Salt

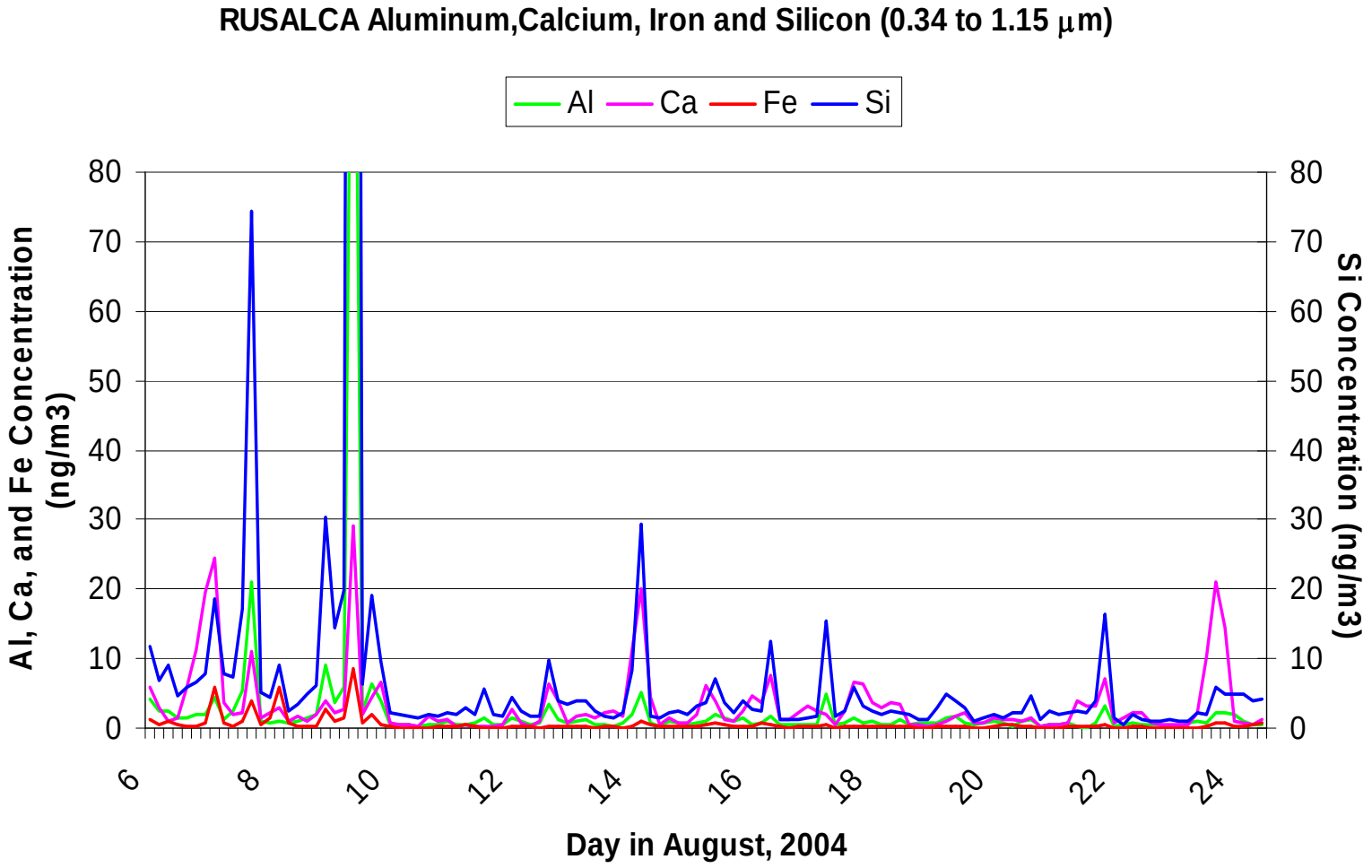

RUSALCA Cl/Na, S/Na and Zn/Ni (0.34 to 1.15 μm)
Zn/Ni
S/Na
Cl/Na
S/Na and Zn/Ni
Cl/Na
Day in August, 2004
0
20
40
60
80
100
120
140
160
0
5
10
15
20
25
30
35
40
6
8
10
12
14
16
18
20
22
24

Sea Salt

Meteorological backwards-trajectories are oceanic when sea salt is the dominant aerosol type.



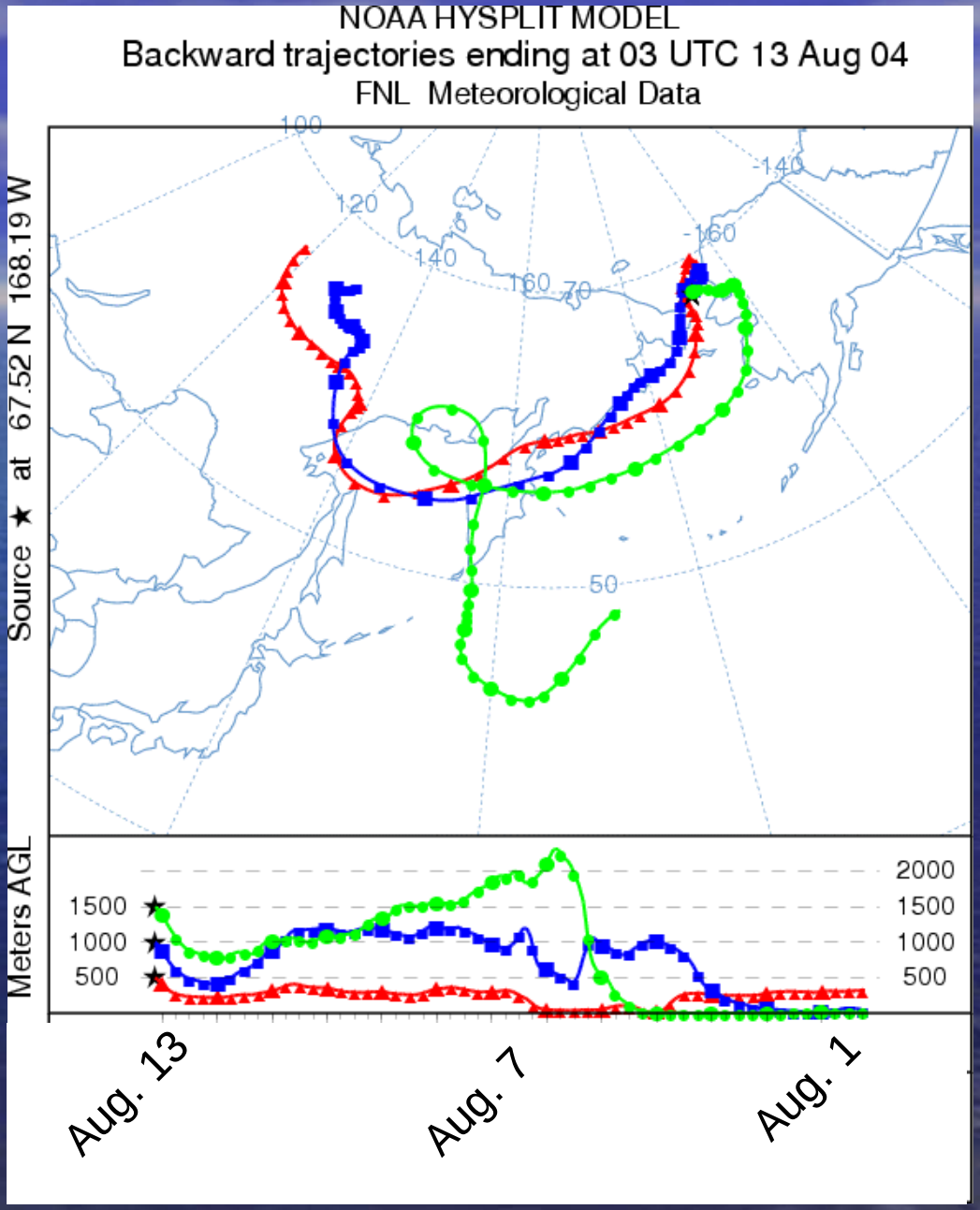
Soil


RUSALCA Aluminum,Calcium, Iron and Silicon (0.34 to 1.15 μm)
Al
Ca
Fe
Si
Al, Ca, and Fe Concentration (ng/m3)
Si Concentration (ng/m3)
0
10
20
30
40
50
60
70
80
6
8
10
12
14
16
18
20
22
24
Day in August, 2004

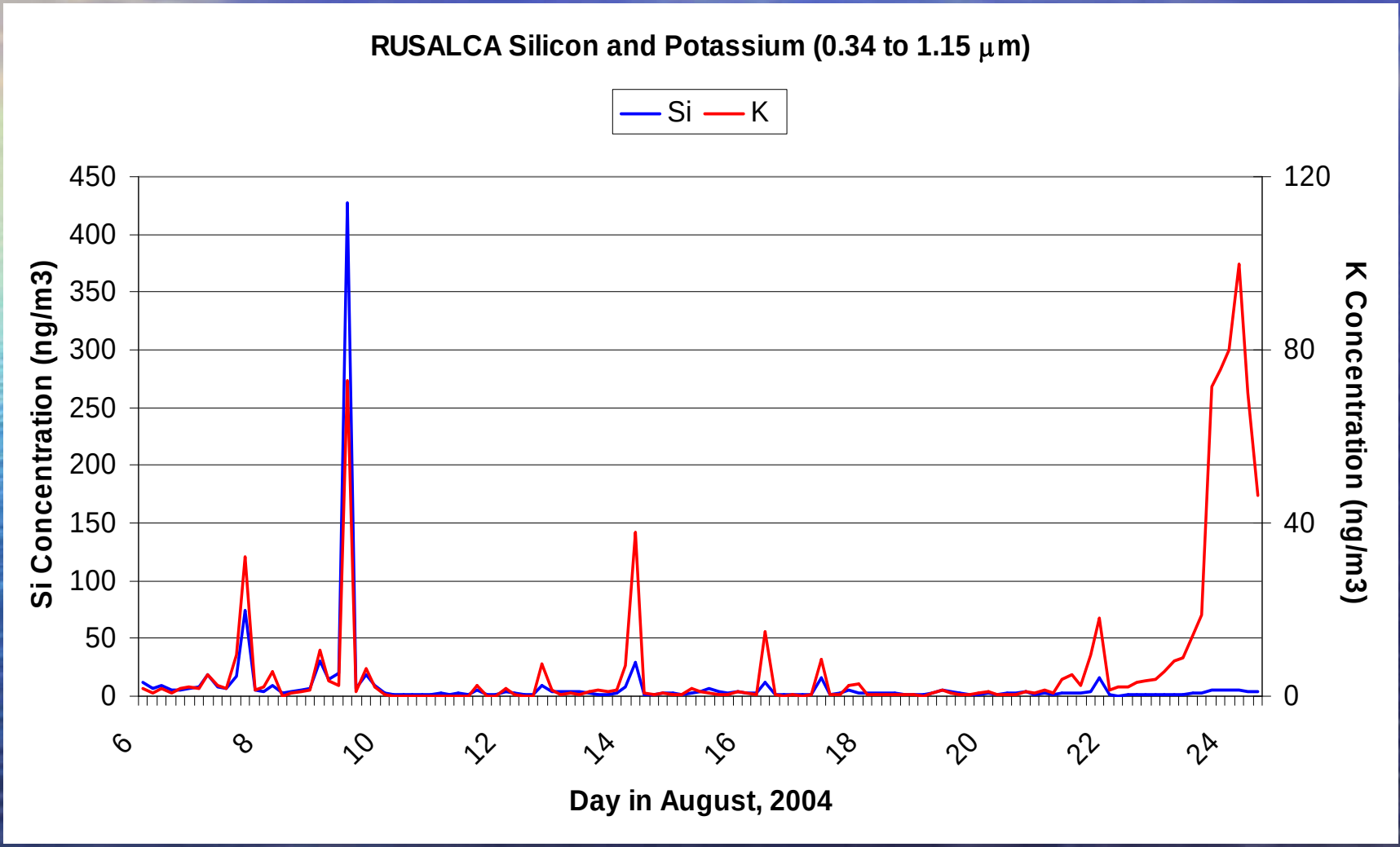
Volcano

The soil elements observed on August 13th appear to be associated with volcanic activity at Sheveluch on the northern Kamchatka peninsula.

We did not see any Gobi or Taklimakan dust during this cruise.

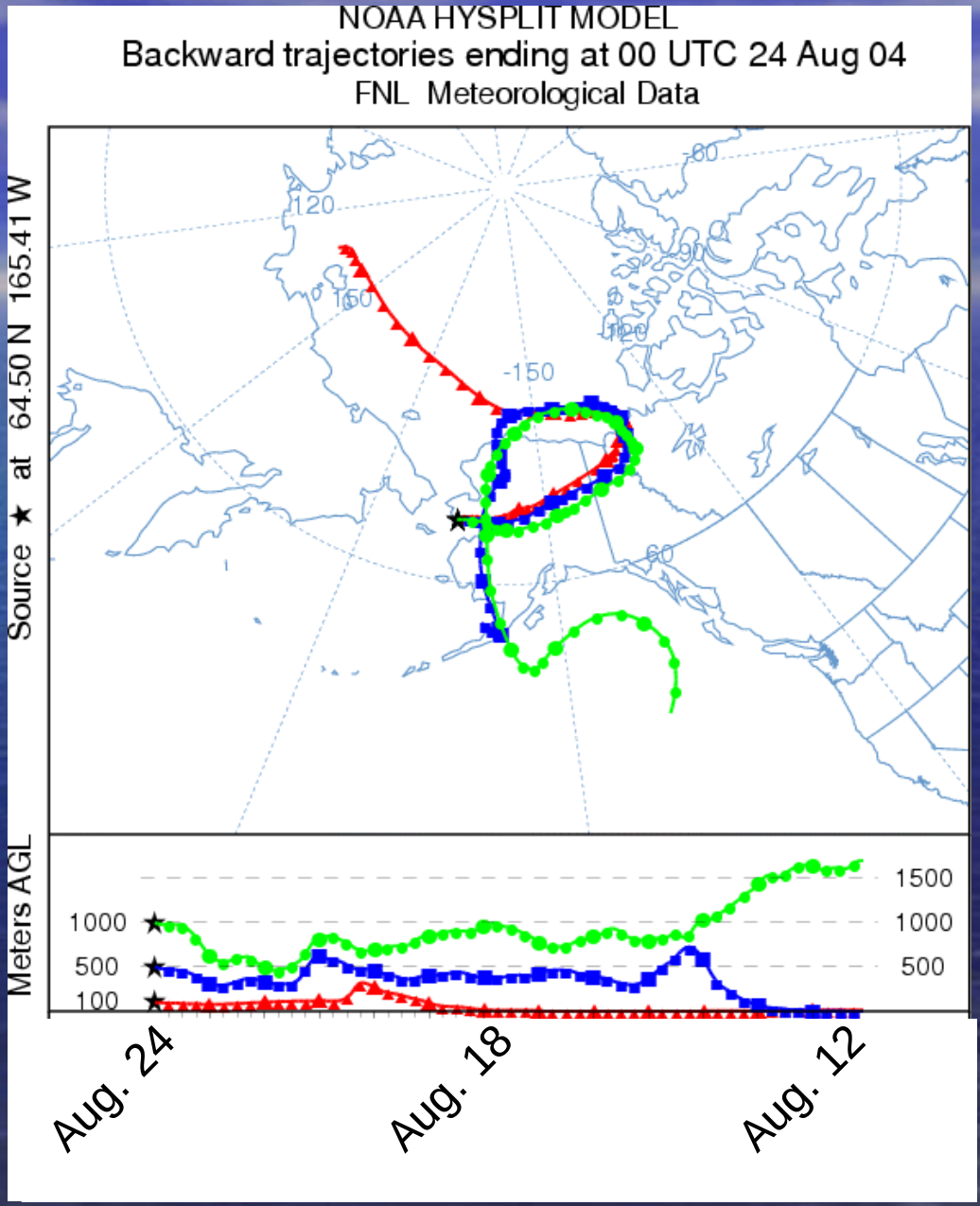


Smoke


RUSALCA Silicon and Potassium (0.34 to 1.15 μm)
Si
K
Si Concentration (ng/m3)
K Concentration (ng/m3)
450
400
350
300
250
200
150
100
50
0
120
80
40
0
6
8
10
12
14
16
18
20
22
24
Day in August, 2004

Smoke

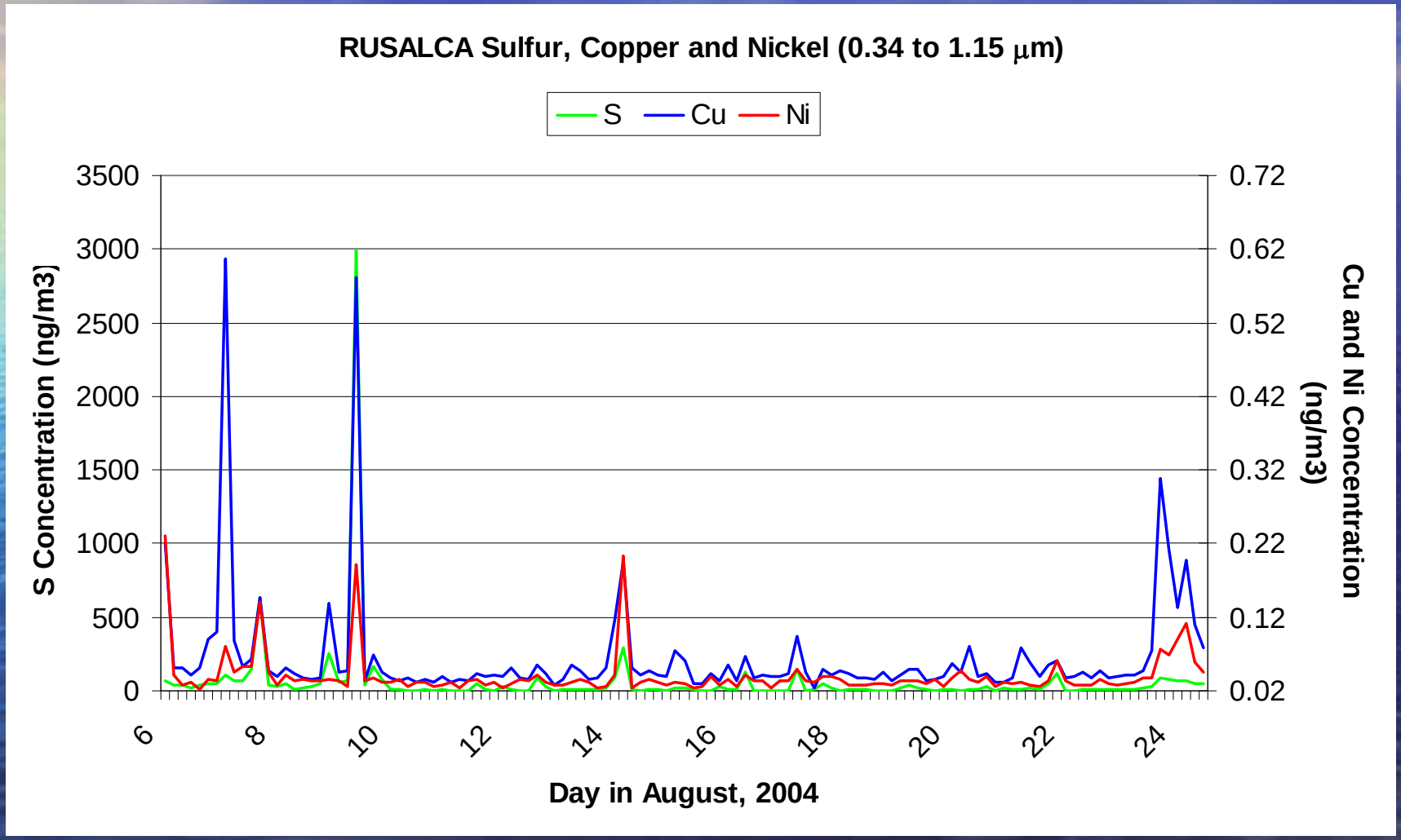
The high potassium concentrations in and near Nome at the end of the cruise were due to the high concentrations of wildfire smoke from fires in Interior Alaska reaching the ship.



Wildfire Smoke

- Wildfires in sub-Arctic and Arctic Alaska and Siberia produce smoke
- Occurs in summer
- Characterized by soluble potassium and organic and elemental carbon
- This is a natural phenomenon, but recent studies suggest that the frequency of fires in high-latitudes is increasing due to climate change.

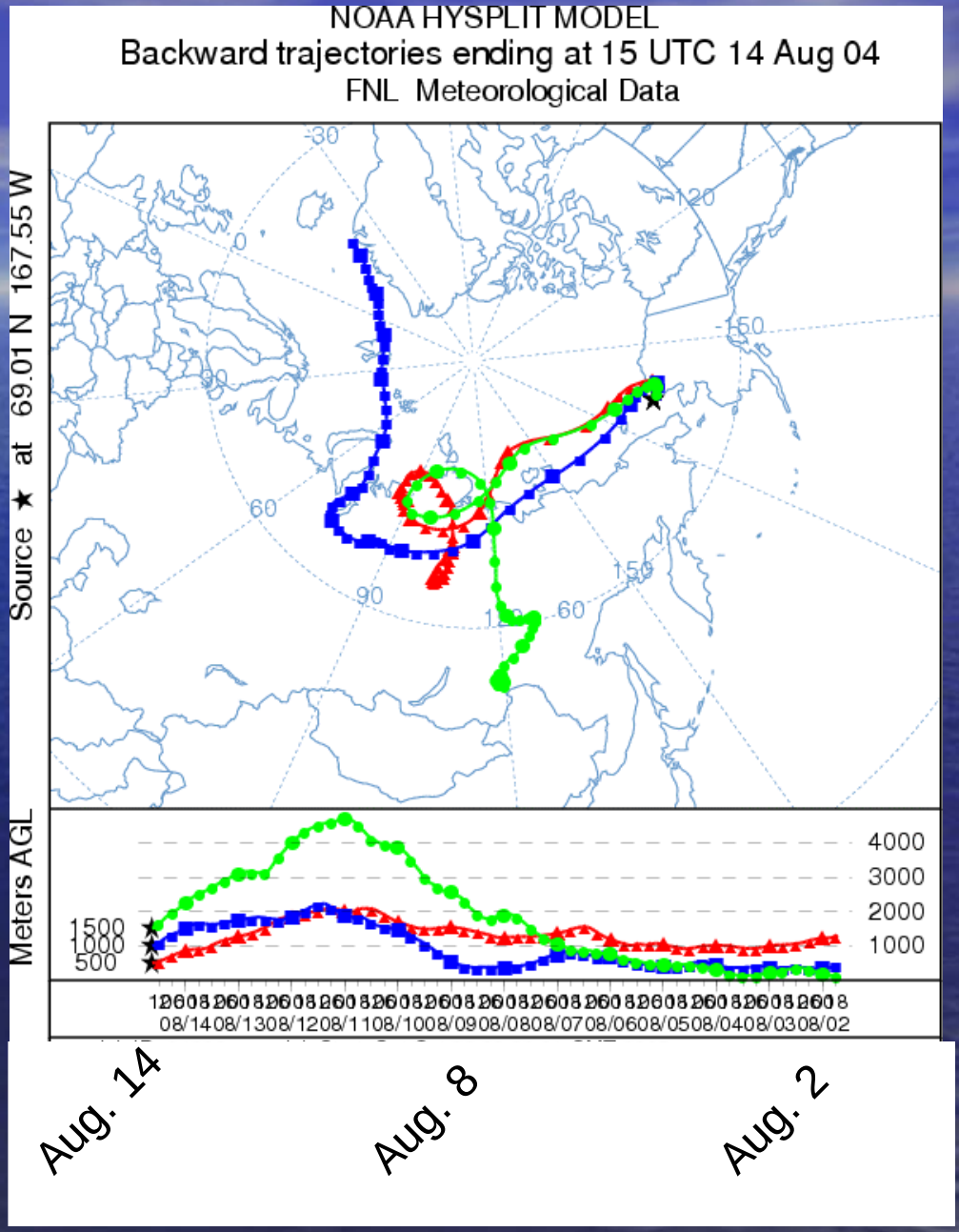
Anthropogenic



Anthropogenic

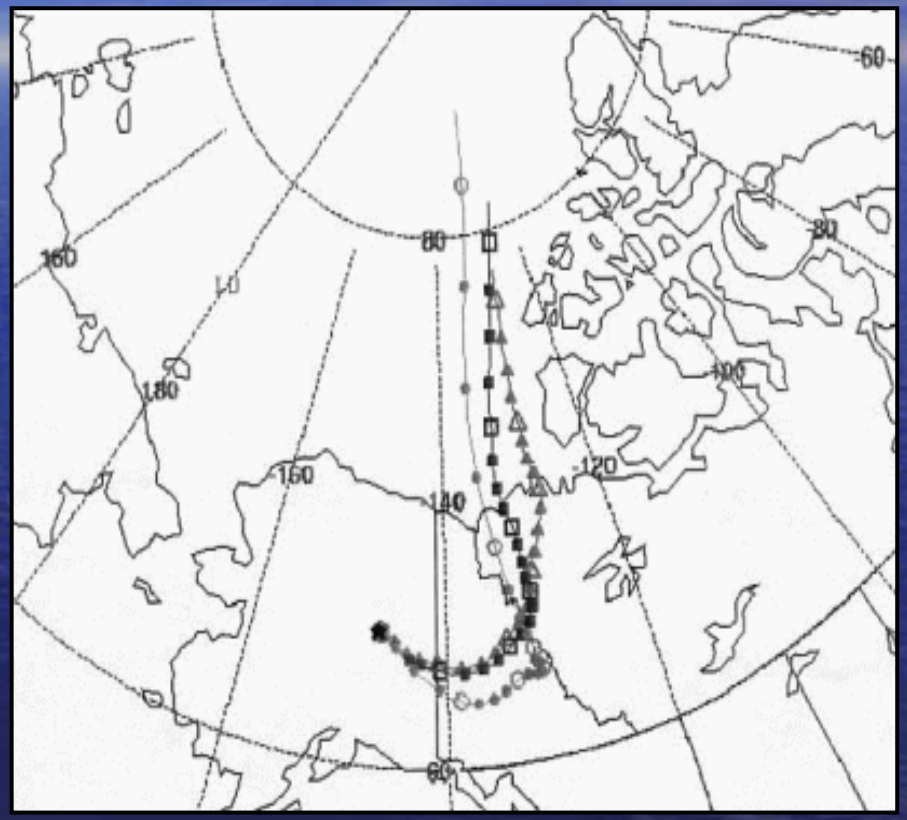
The trajectories during the middle of the cruise associated with high concentrations of metals and other anthropogenic components accumulate these components in industrial regions in northern Russia, such as Norilsk.

The high levels of these compounds in Nome is a result of diesel generators and other fossil fuel burning equipment in port and on the ship.



Arctic Haze

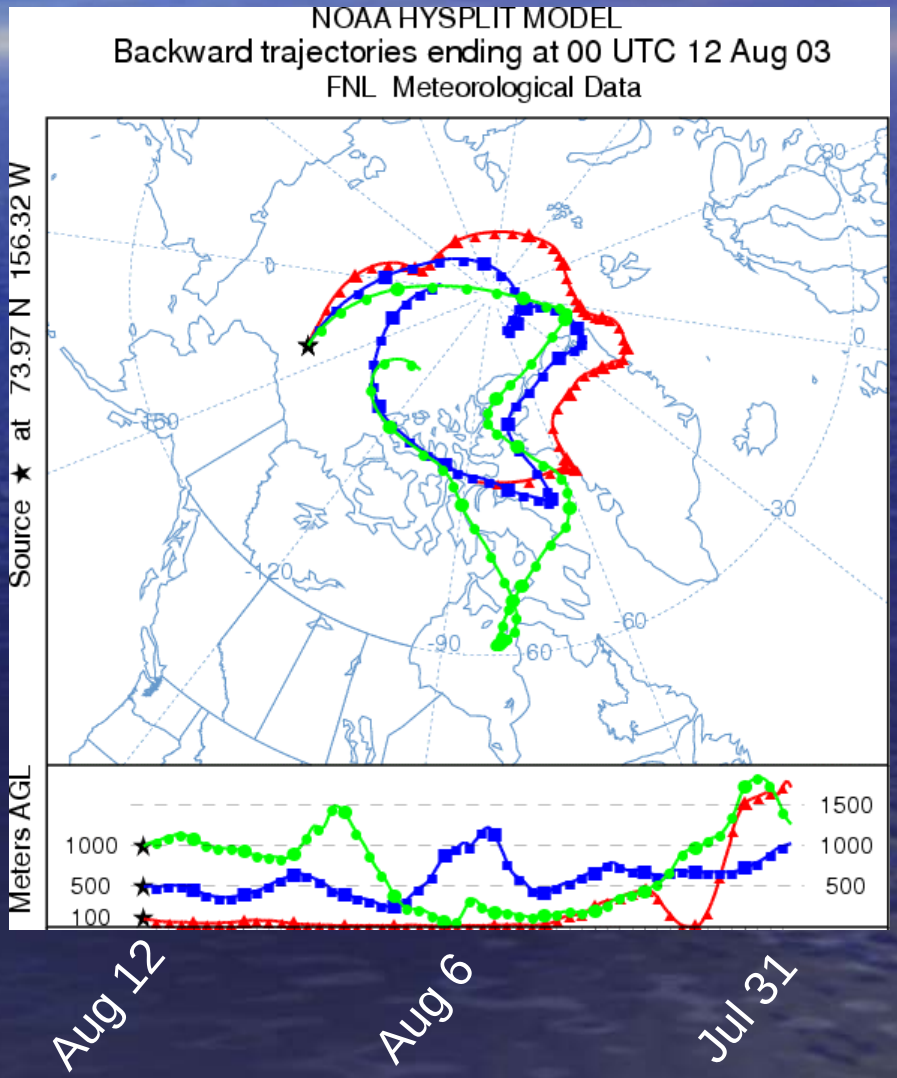
- Air enters Alaska from the Arctic
- Classically, a wintertime transport
- Characterized by layers of sulfate, metals, polycyclic aromatic hydrocarbons and light absorbing carbon aerosols from industry in Northern Europe and Russia



HYSPLIT4 meteorological backwards trajectory for an Arctic Haze event observed at Poker Flat Research Range in Alaska.

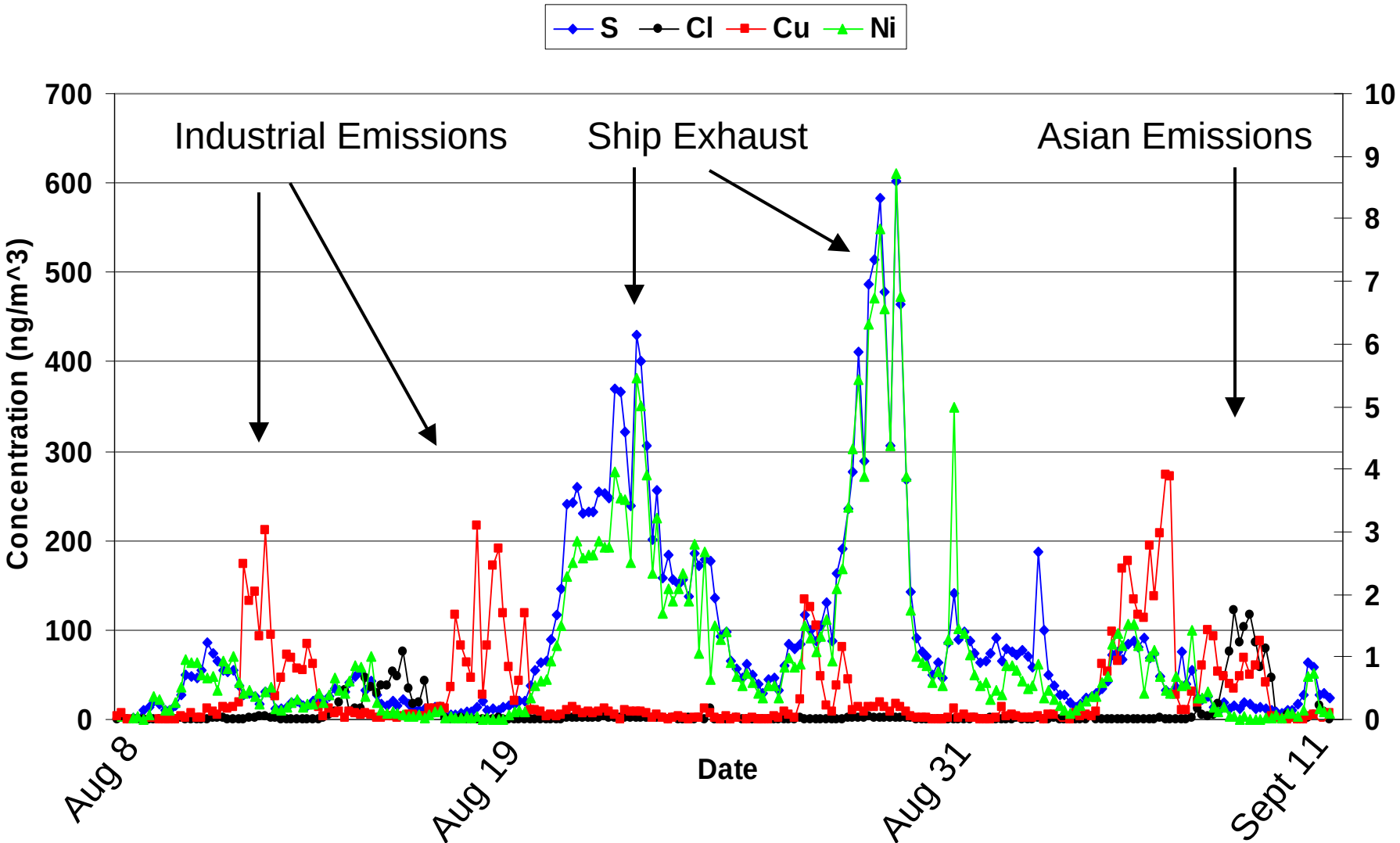
Summertime Arctic Haze

- Around-the-pole transport like wintertime Arctic Haze
- Different aerosol composition and concentrations due to photochemistry, aqueous phase chemistry and different removal mechanisms

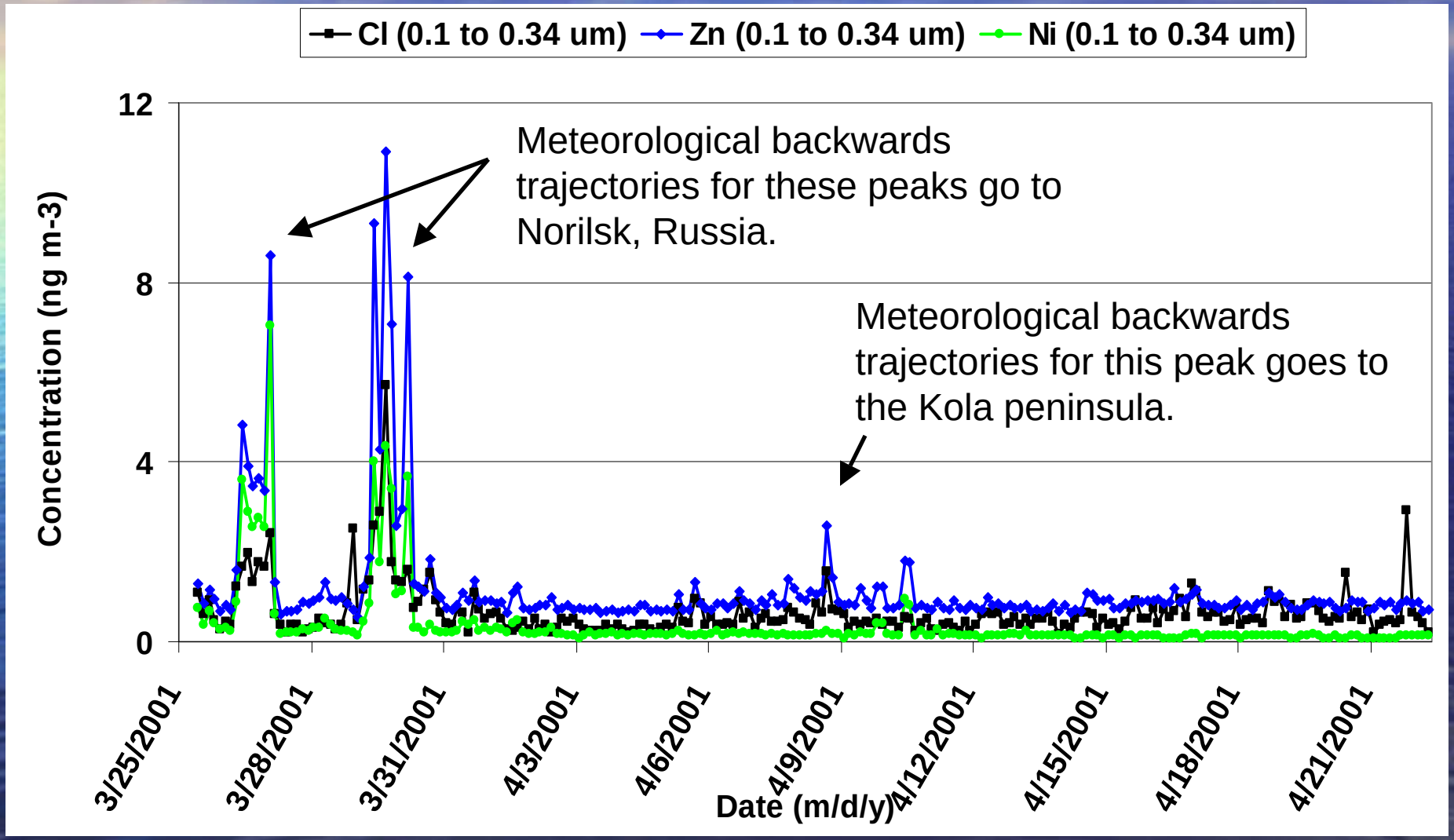


0.34-1.15 μm S, Cl, Cu and Ni during a Chinese Research Cruise (CHINARE II) to the Chukchi and Beaufort Seas and Arctic Ocean in 2003

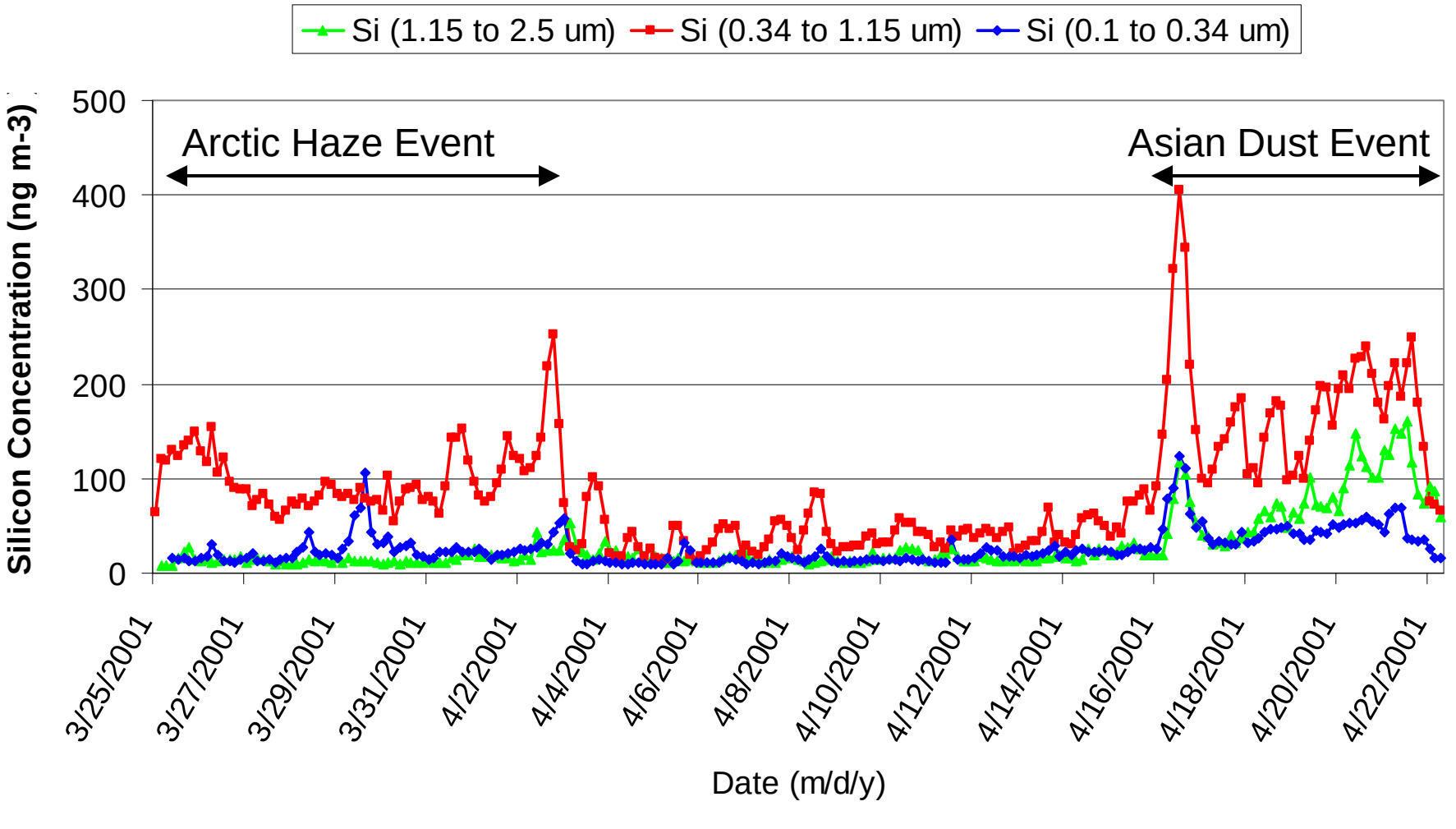
(Cu and Ni are plotted on the secondary axis)



0.1-0.34 μm Cl, Zn and Ni at the Poker Flat Research Range (Spring 2001)

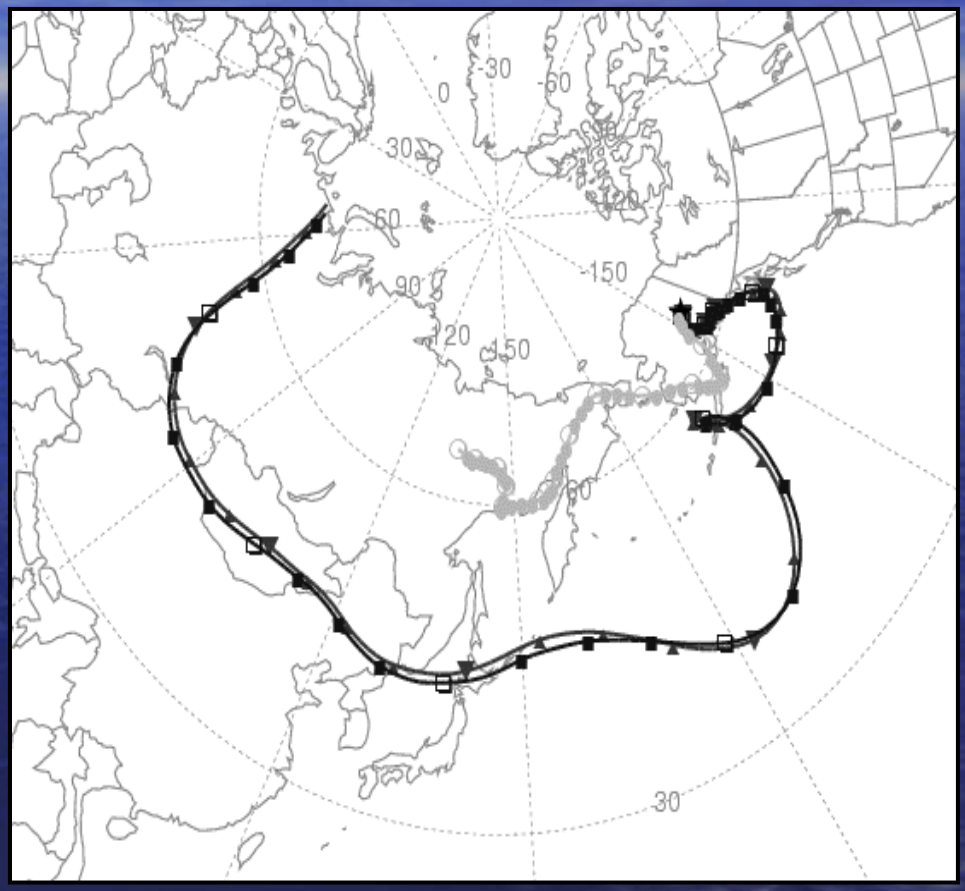


Examples of Arctic Haze and Asian Dust Reaching Interior Alaska (Poker Flat Research Range)



Asian Emissions

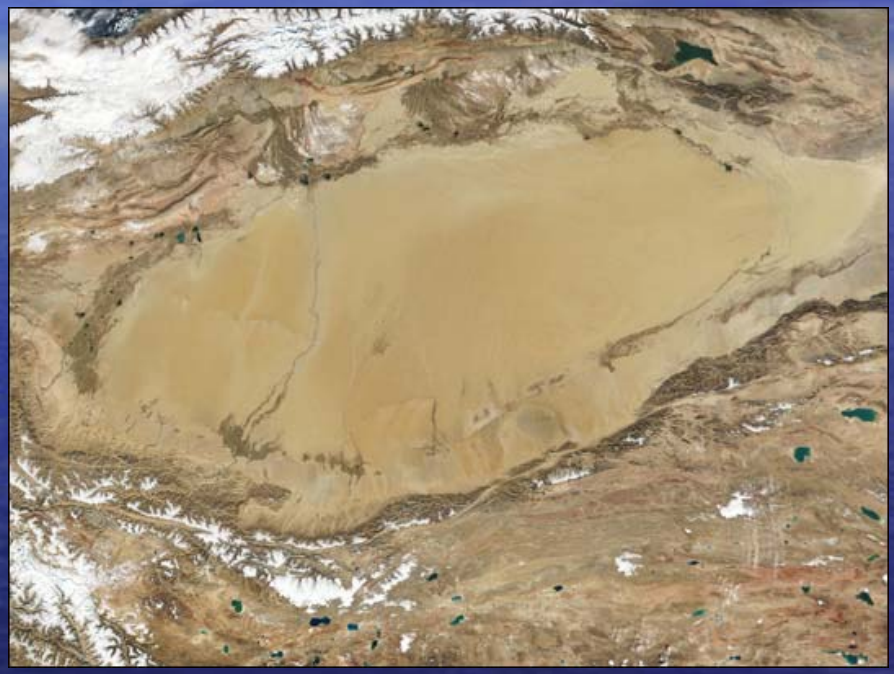
- Each spring emissions from Asia enter the Arctic.
- The typical transport path crosses the North Pacific Ocean and enters the Arctic from the southwest.
- These events are observed in Barrow, Alaska, and over the Arctic Ocean.



HYSPLIT4 meteorological backwards trajectory for an Asian event observed at Poker Flat Research Range in Alaska.

Asian Emissions

- The Asian emissions are characterized by soil elements from the Gobi and Taklimakan Deserts.
- The emissions include metals, sulfur and other compounds from industrial sources along the transport path.

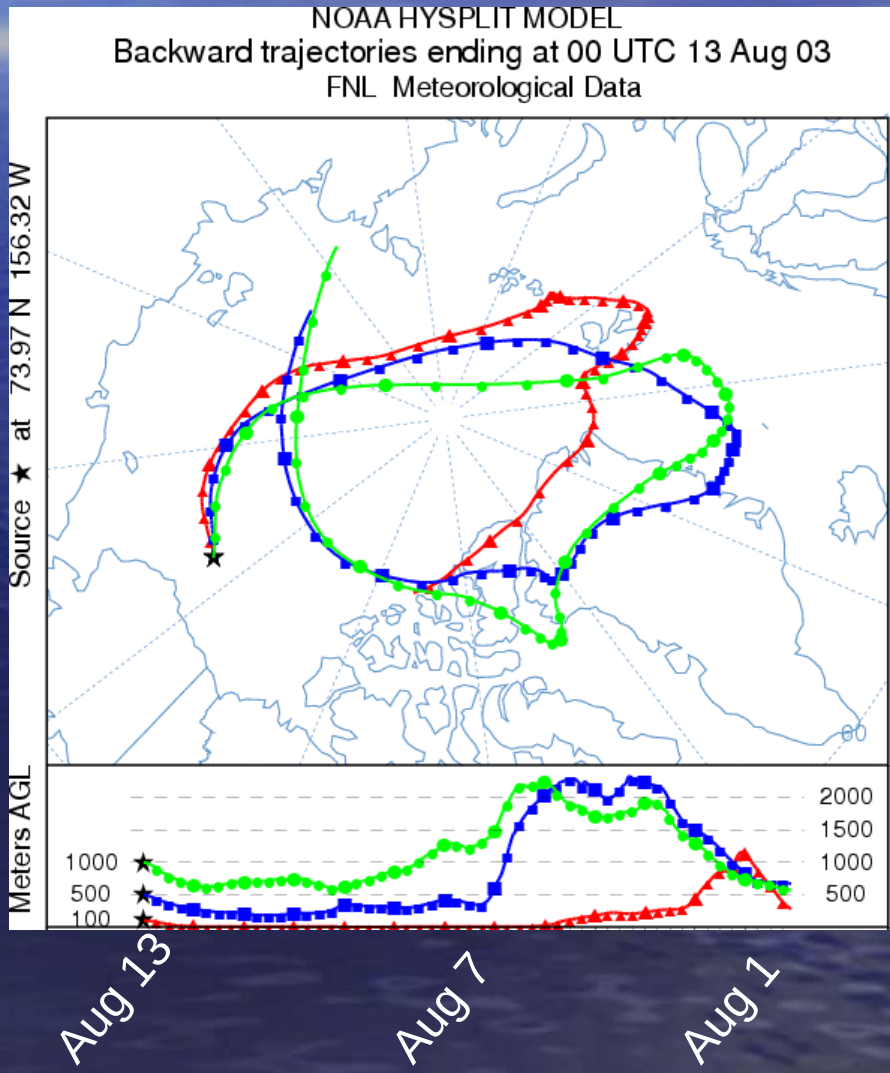


The Taklimakan Desert, China

Image courtesy of Jacques Descloitres, MODIS Land Rapid Response Team at NASA GSFC

Difficulty in Determining Sources of Contaminants in Arctic

- Contaminants, once they reach the Arctic, remain in the Arctic air mass for a long time and travel long distances.
- So, unless there is a very specific and consistent signature for a source, the best way to identify the sources of the contaminants in the Arctic is to characterize them as they enter the Arctic.



Summary

- The results from RUSALCA show that the aerosols over the Bering and Chukchi Seas are:
  - Present in low concentrations (<1 μg m^{-3})
  - Predominantly sea salt
  - Influenced by strong, episodic aerosol plumes from sources both natural and anthropogenic
- These results are consistent with results from other cruises and ground-based experiments

Summary

The implications from these results are:

- The deposition of pollutants and nutrients in the Arctic in summer will depend on where the pollutant plumes cross the Arctic and will not be spatially or temporally homogeneous
- The primary aerosols causing summertime direct aerosol radiative forcing effects are contained in transient plumes
- There is enough sulfate available in many of the aerosol plumes to cause cloud nucleation and indirect aerosol radiative forcing effects

Future Work

- Perform calculations using the RUSALCA data to estimate aerosol deposition and radiative impacts in the Arctic
- Collect additional aerosol samples during future cruises to try to establish an aerosol baseline and observe any aerosol trends over the Bering and Chukchi Seas
- Establish additional ground-based sites around the Arctic to quantify the high temporal and spatial variability of the aerosol plumes observed during RUSALCA and other experiments