The Role of Sea Ice and Snow in the Deposition of Mercury in Northern Alaska

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Mercury enters the Arctic ecosystem through a complex series of reactions that are strongest at the coastal zone

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How?

1) A series of reactions involving sunlight, halogens (salts) & ozone convert gaseous mercury to a reactive form of mercury

The ocean and sea ice are potential sources of halogens

Vertical mixing and vapor condensation at sea ice leads

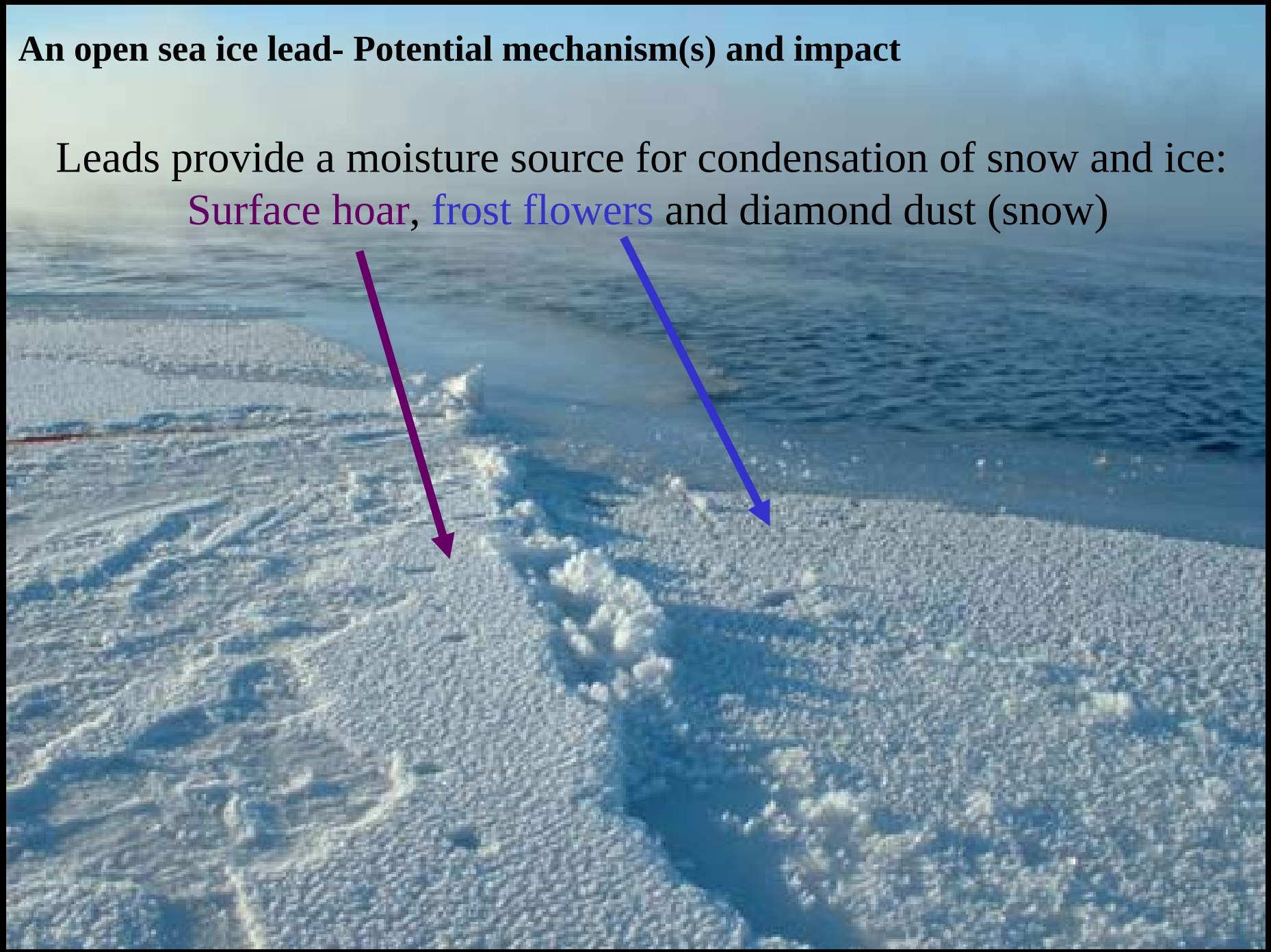
2) The reactive form of mercury ends up in the snow pack but the mechanism for deposition is largely unknown

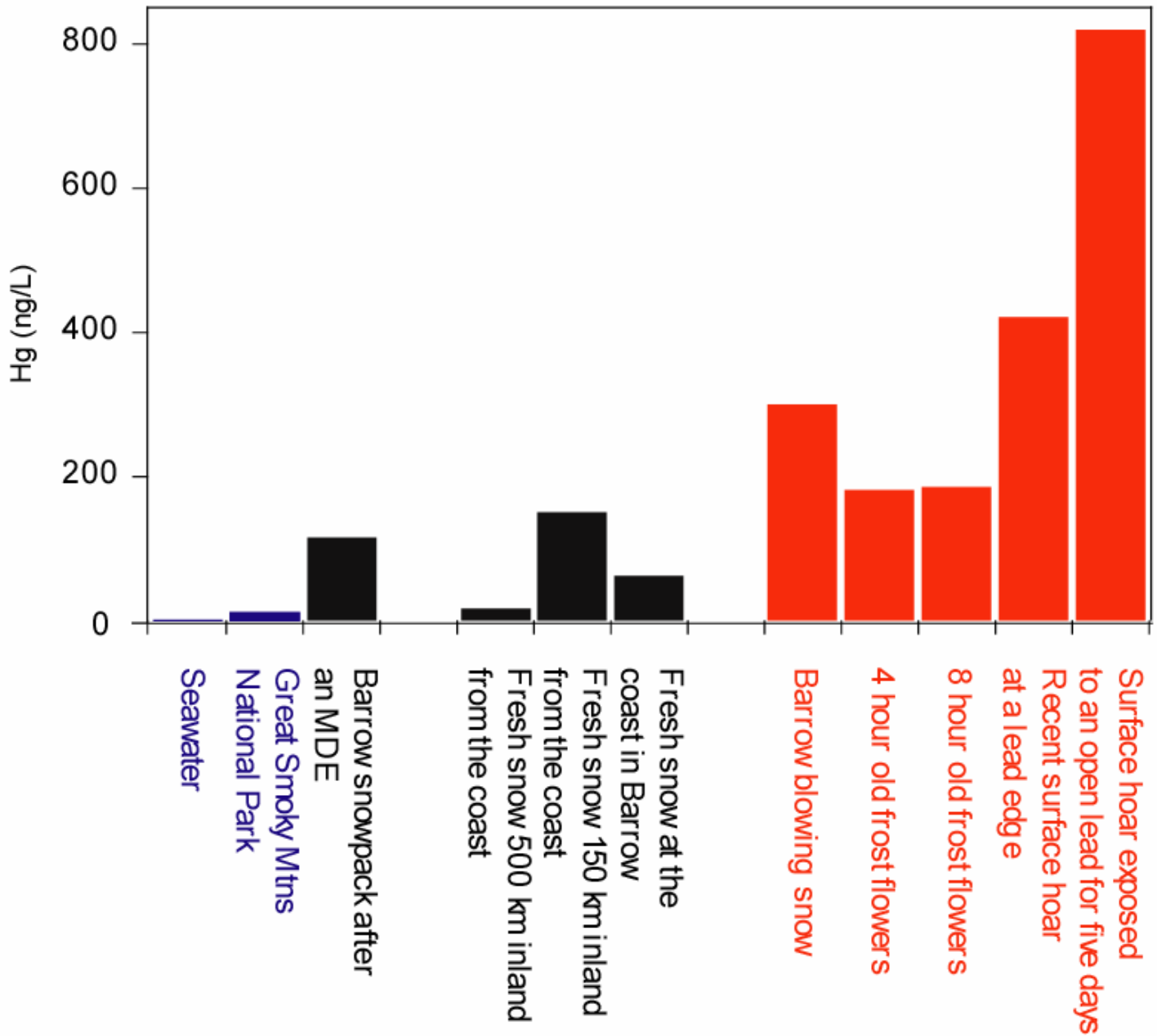
Research questions:

- What are the deposition mechanisms?
- What is the fate of the mercury in the snow during and after melt?

An open sea ice lead- Potential mechanism(s) and impact

Leads provide a moisture source for condensation of snow and ice:
Surface hoar, frost flowers and diamond dust (snow)





Enhanced mercury deposition near sea ice leads

Tracking the deposition of mercury into the Arctic during spring

Project work in 2004-2005:

- Measured mercury and halogens in snow and ice near open sea ice leads
- Measured gaseous mercury, reactive mercury and ozone in air
- Measured halogens in air near the coast and inland
- Measured mercury and halogens in snow melt and surface waters
- Cored tundra and lake sediments to gain a time series of concentrations on land

Examples of snow and ice sample collections

Frost flowers
on newly formed sea ice

Condensation from air
above an open lead

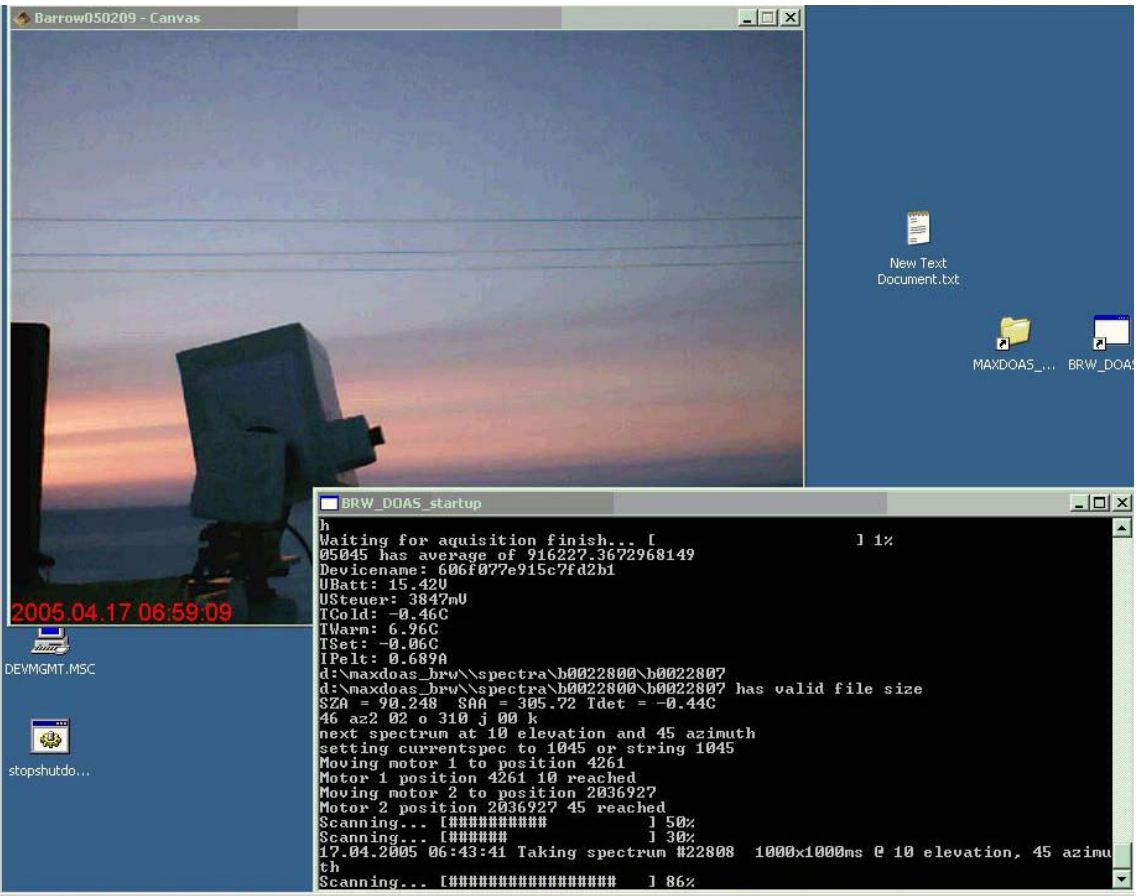
Examples of snow and ice sample collections

Examples of snow and ice sample collections

Riming on wings of an Aerosonde robotic aerial vehicle

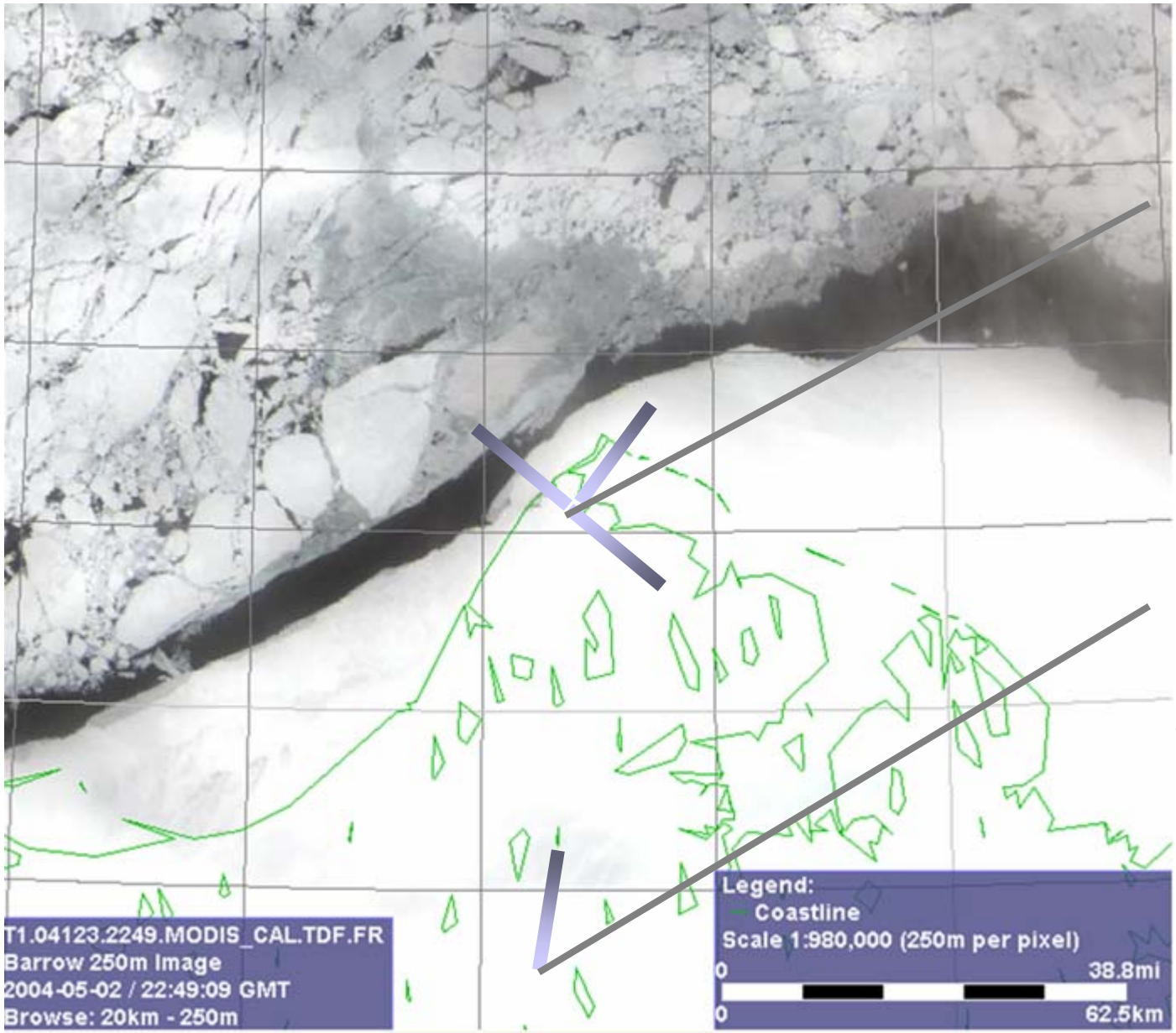
Photos by Ryan Vu, Aerosonde.com

Multiple Axis (MAX) DOAS



- Measure scattered skylight spectra at various elevation angles.
- Fitting spectra gives the slant column density of BrO along the path
- Differences between elevation angles allow inversion to a vertical profile

Multi-axis differential optical absorption spectroscopy (MAX-DOAS)



Barrow:
2-D system
(vertical profiles
along three
azimuths)

Atqasuk:
1-D system
measuring
vertical profiles
100km south of
Barrow

Ongoing hypotheses

1) Leads are where intense condensation (and perhaps scavenging) occurs.
Typical precipitation in Michigan, Florida, New England 3-10 parts per trillion
Typical mercury in snow during an Arctic deposition event ~50 parts per trillion
Surface hoar near leads ~1000 parts per trillion
Frost flowers, vapor condensation near leads 150-500 parts per trillion

2) Highest Hg concentrations are related to pristine crystals not subjected to postdepositional processes. Crystals formed from vapor phase are notably high.
(Riming, hoar crystals, frost flowers)

3) Complex interplay of Condensation, Remission, Impaction and Sublimation controls Hg concentration in snow and ice.
A better understanding of these crystal forming events is necessary before we can relate deposition to atmospheric chemistry observations.

4) The spatial availability of halogen and mercury chemistry in the lower atmosphere are a key component in this system