Transport of Asian Biomass Burning Emissions to the Arctic-Climatological Considerations

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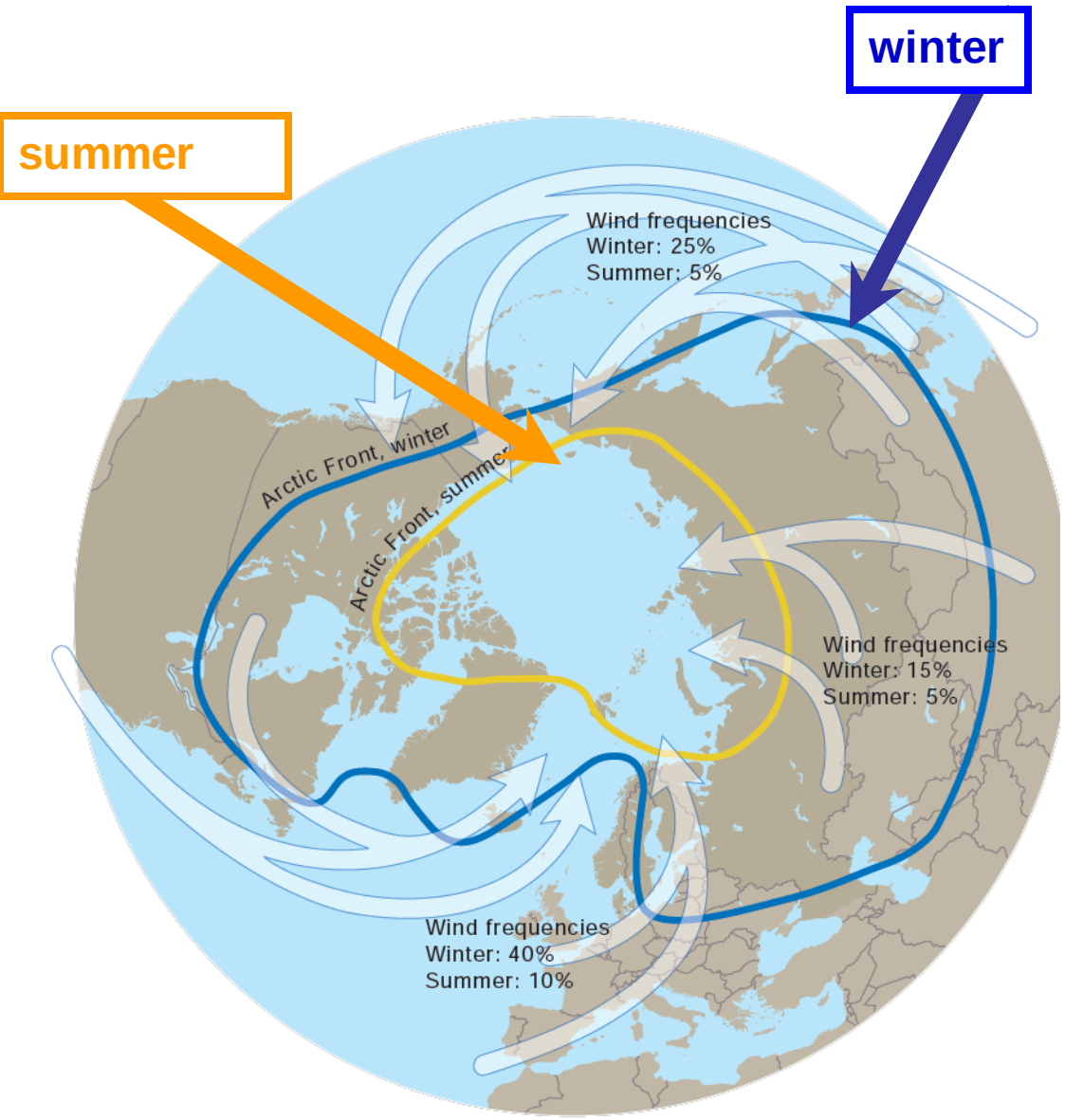
The Arctic does not always have pristine air !

Picture courtesy: Ann-Christine Engvall

Mean Position of Arctic Front



Winter/Early Spring

- The Arctic Front, which forms a barrier to transport, extends to lower latitudes.

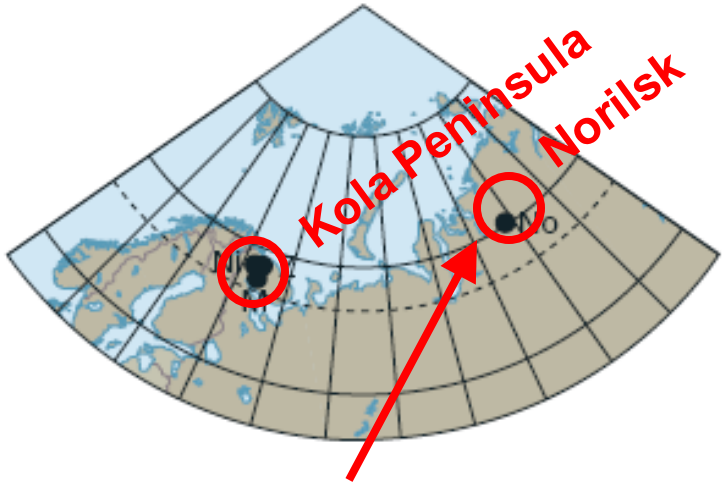
Pollution sources interior to Arctic front can travel ~ horiz. to the pole

- The barrier can be penetrated by air masses from lower latitudes that undergo surface cooling enroute.

Sources of Pollutants Within the Arctic

Stationary Sources

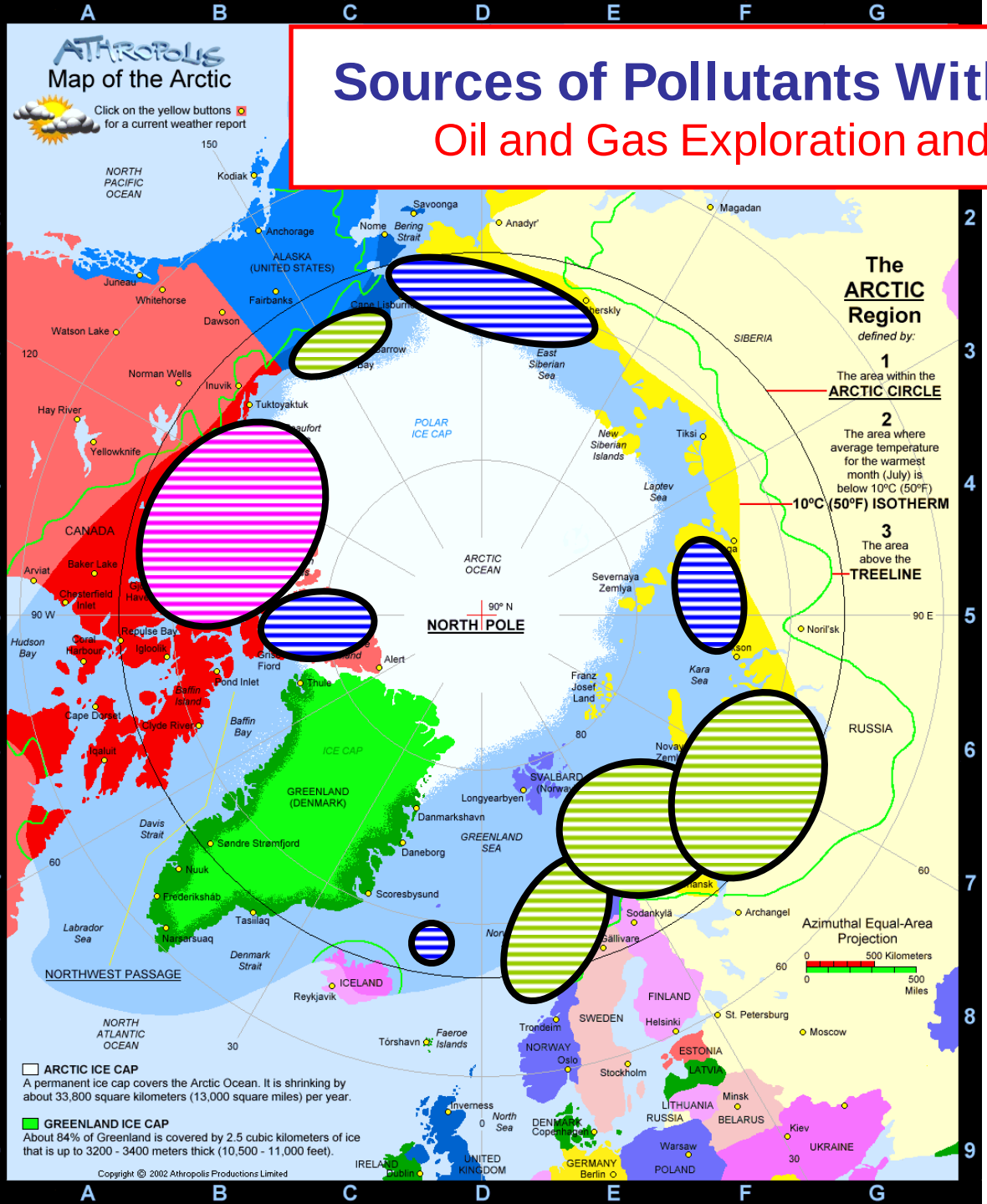
The major emissions of SO_2 within the Arctic come from industrial activities, primarily non-ferrous metal smelters, in the northern territories of the Russian Federation



Smelter complex at Norilsk
Western Siberia

Sources of Pollutants Within the Arctic

Oil and Gas Exploration and Production



Main areas of oil and gas production in the Arctic today

Extensive oil and gas exploration occurring today

Extensive petroleum reserves

The Arctic is estimated to contain at least 25% of the world's undiscovered petroleum resources.

The use of oil and gas resources in the Arctic is expected to increase as the ice-free season increases and ice cover decreases.

2008-9 Was International Polar Year

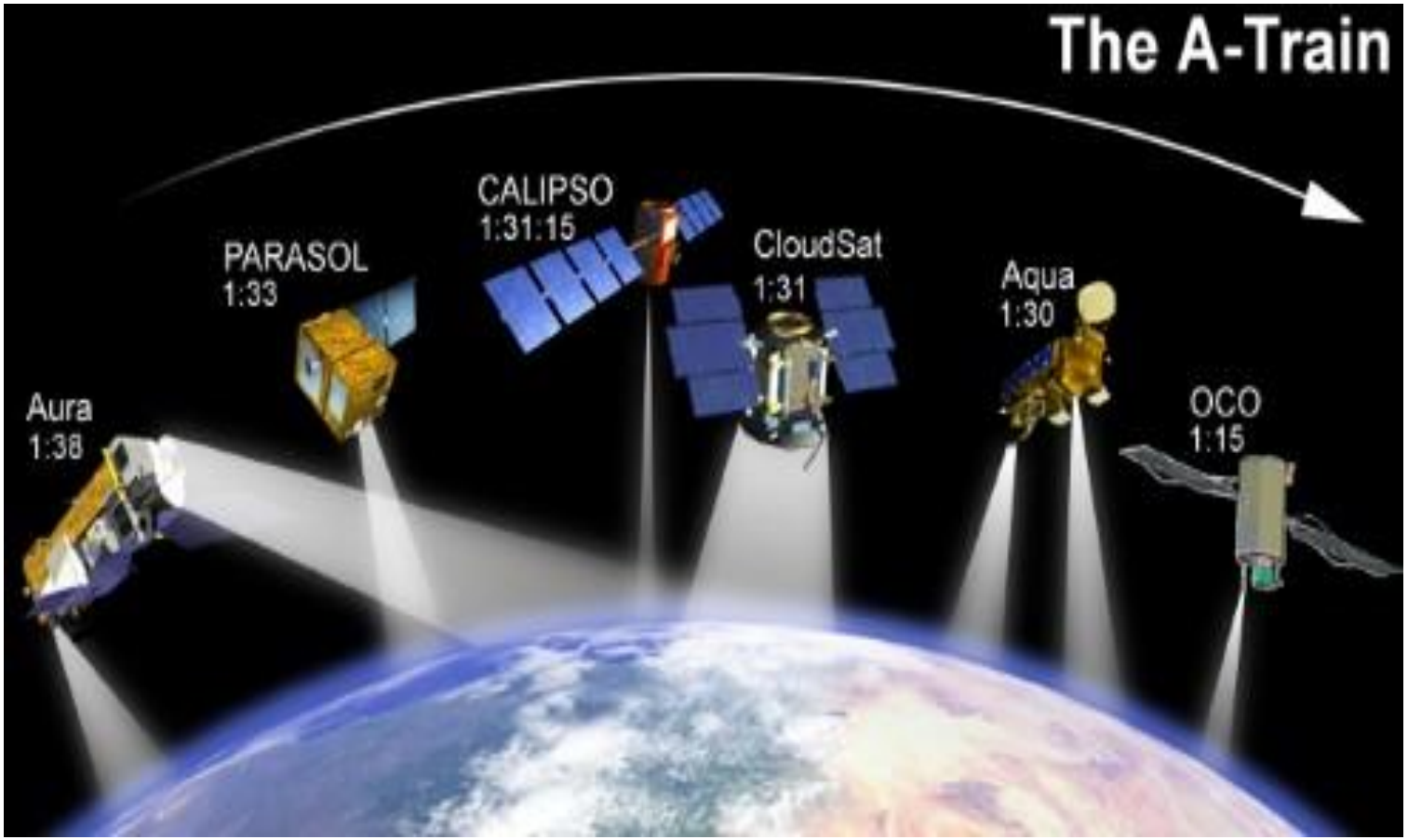
- The U.S. sponsored the ARCTAS field project through NASA and NOAA
- Other countries had their own field programs or special research projects

Objectives of ARCTAS

Study the **role of long-range poleward transport of aerosols and trace gases to the Arctic**

- What is the role of boreal forest fires for aerosols in the Arctic troposphere? What is the impact of pyro-convection on aerosol and trace gas levels in the Arctic stratosphere?
- How does the deposition of soot ("Black Carbon") on snow / ice affect the albedo? What are the effects on radiation transfer in the atmosphere?
- How do the aerosols interact with Arctic clouds?
- What is the role of halogen atom chemistry in the Arctic boundary layer and free troposphere?
- How well do satellite retrievals of the concentrations of various chemical species work in the Arctic environment?

Satellite Coverage



"The A-Train." Listed under each satellite's name is its equator crossing time.

DC-8
21 instruments

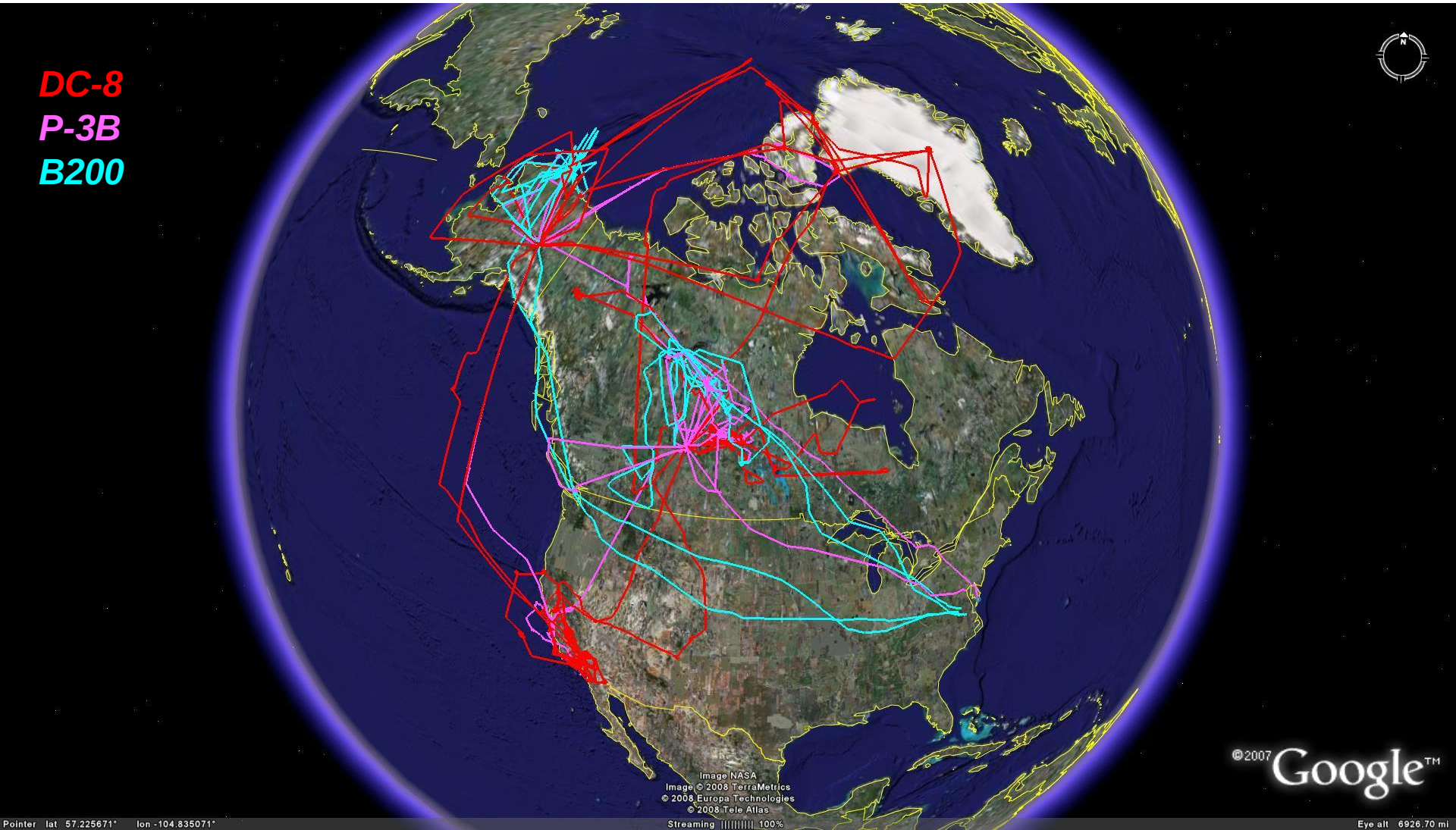
P-3
9 Instruments

B-200

Satellite Teams
Model Forecasting
Ozonesonde network with Environment Canada

Our “Stomping Ground”

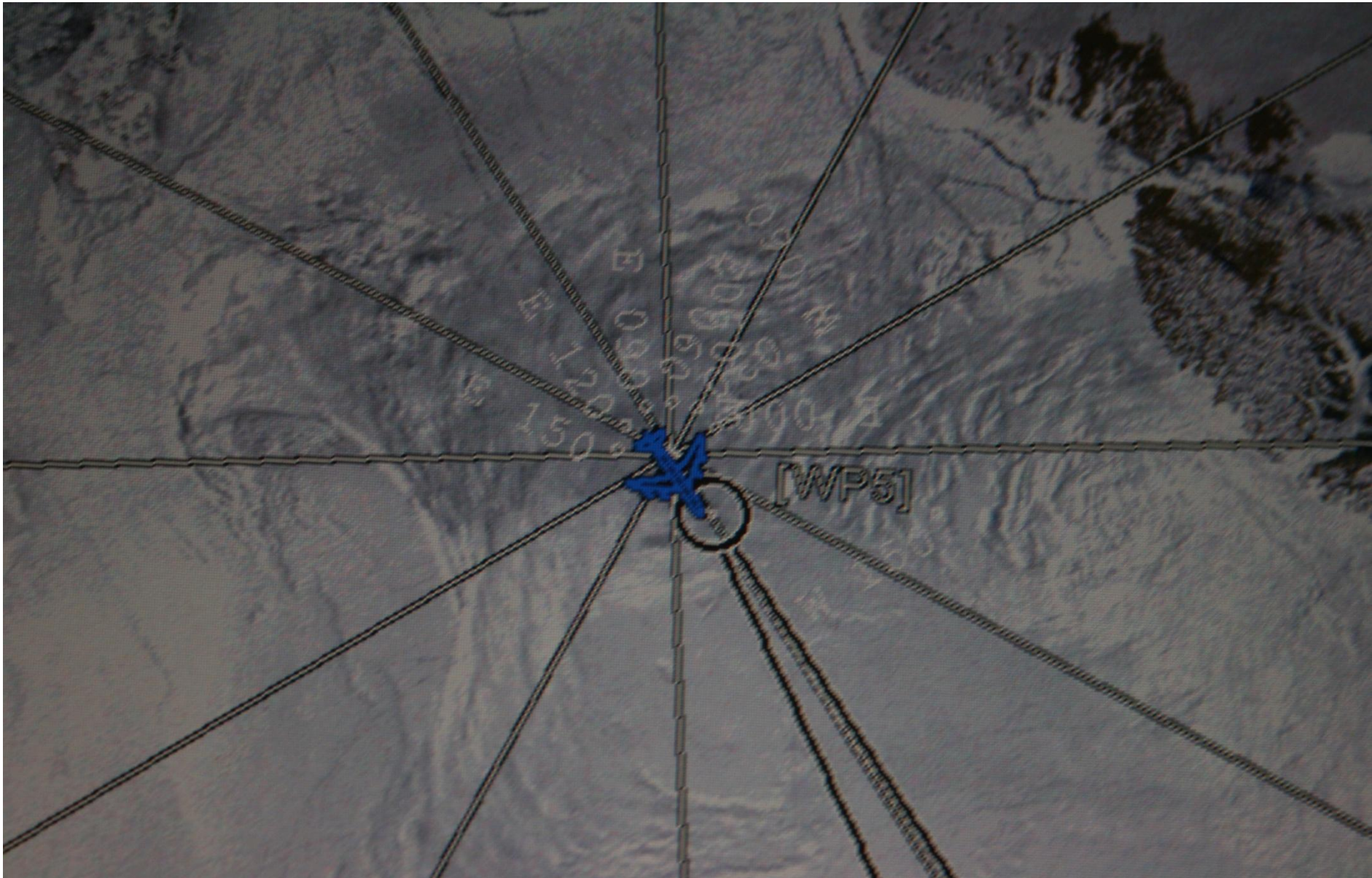
	DC-8 (185 flight hours)	P-3B (158 flight hours)	B-200 (150 flight hours)
Spring (1-20 April)	9 sorties	8 sorties	27 sorties
California (18-24 July)	4 sorties	1 sortie	
Summer (26 Jun-13 July)	9 sorties	12 Sorties	21 Sorties



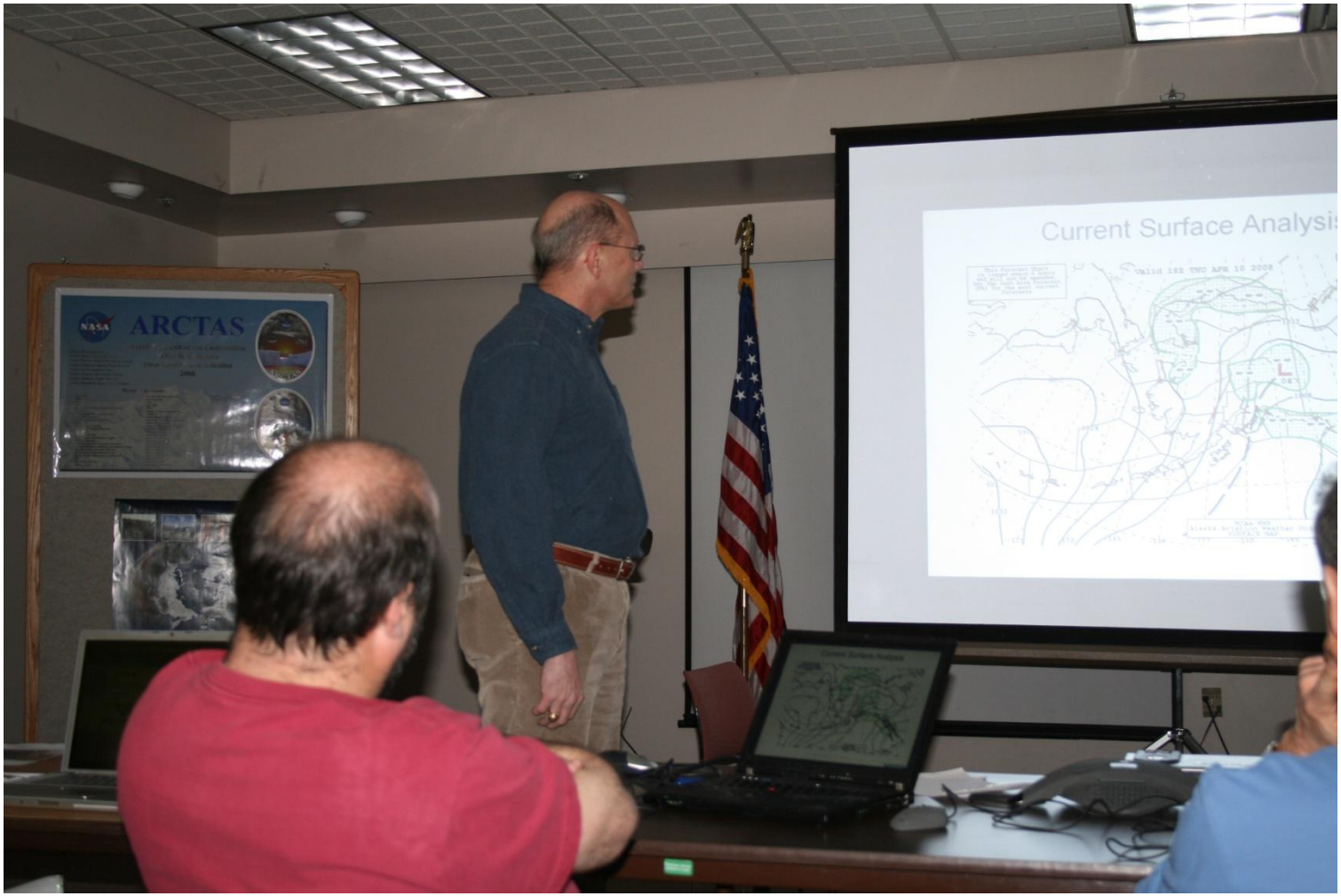
Thule, Greenland is not Green during Winter

Prudhoe Bay Area

At the North Pole



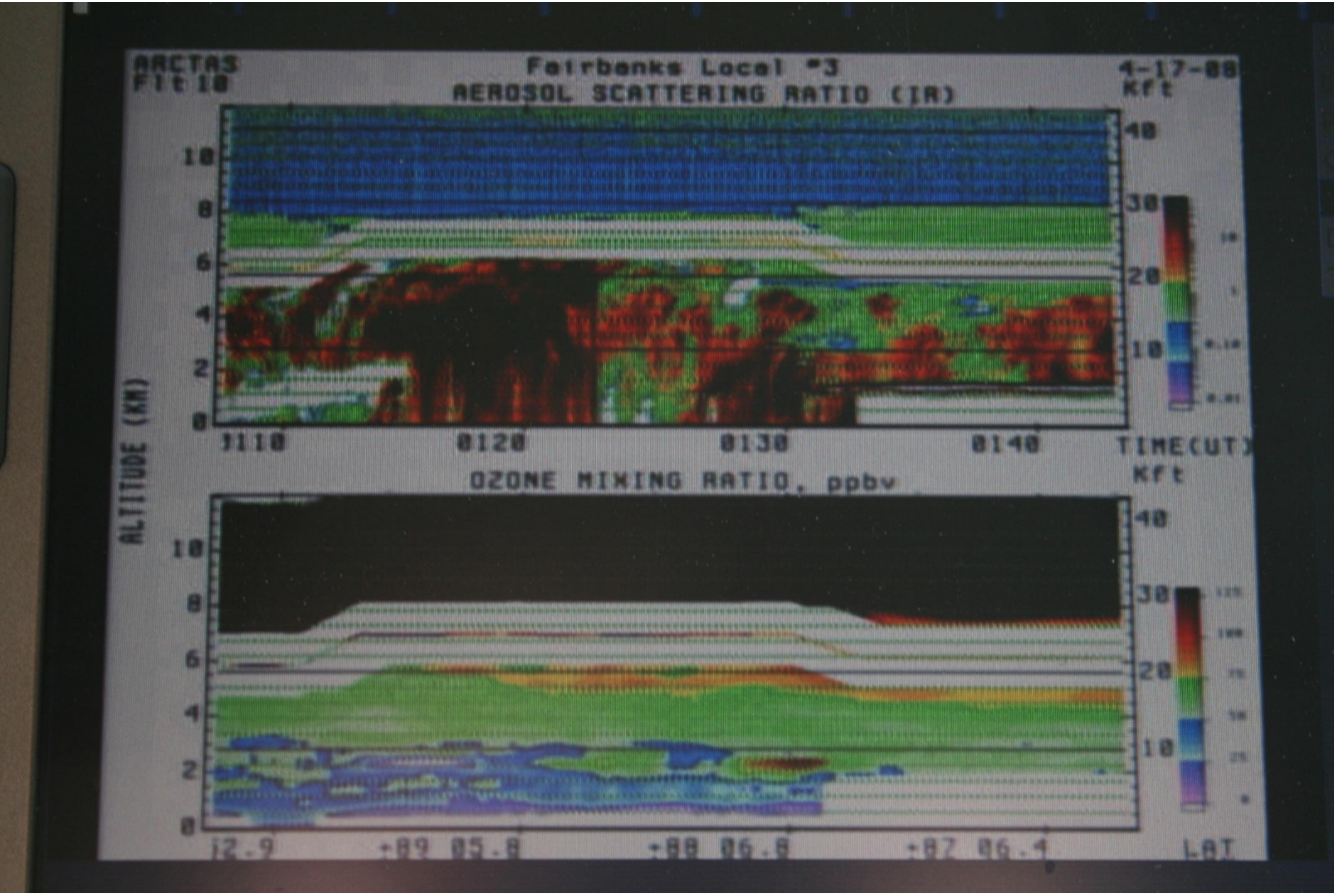
During Field Phase
Weather Briefings-Flight Planning



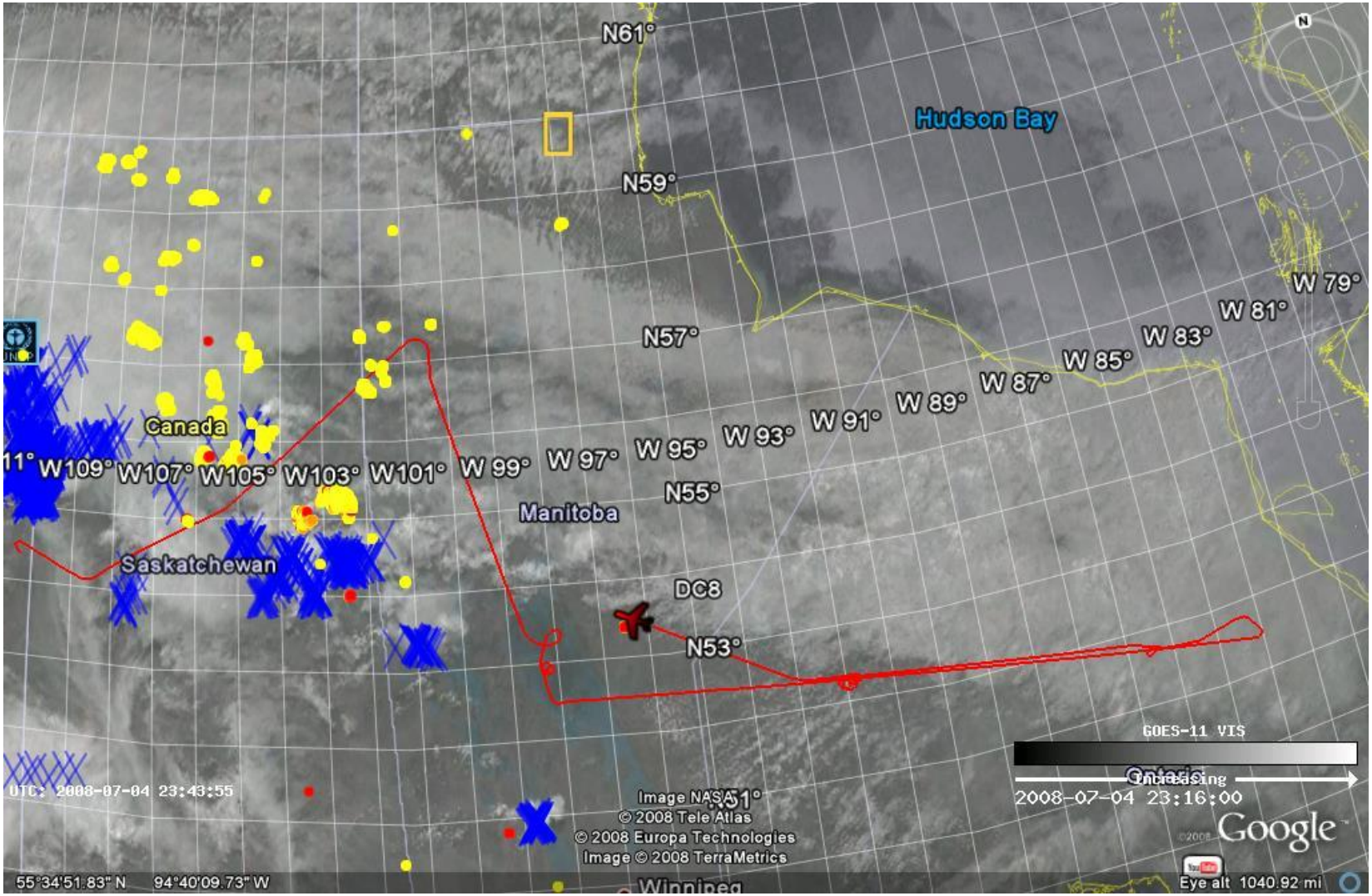
I flew on the DC-8 and supported the other two NASA aircraft


TRIPP-LITE
TRIPP-LITE
MOXA

Be on the lookout for pollution plumes and weather


ARCTAS
Fit 18
Fairbanks Local #3
4-17-08
AEROSOL SCATTERING RATIO (IR)
Kft
40
30
20
10
0
2
4
6
8
10
ALTITUDE (KM)
0110
0120
0130
0140
TIME(UT)
OZONE MIXING RATIO, ppbv
Kft
40
30
20
10
0
2
4
6
8
10
12.9
+89 05.8
+88 06.8
+87 06.4
LAT

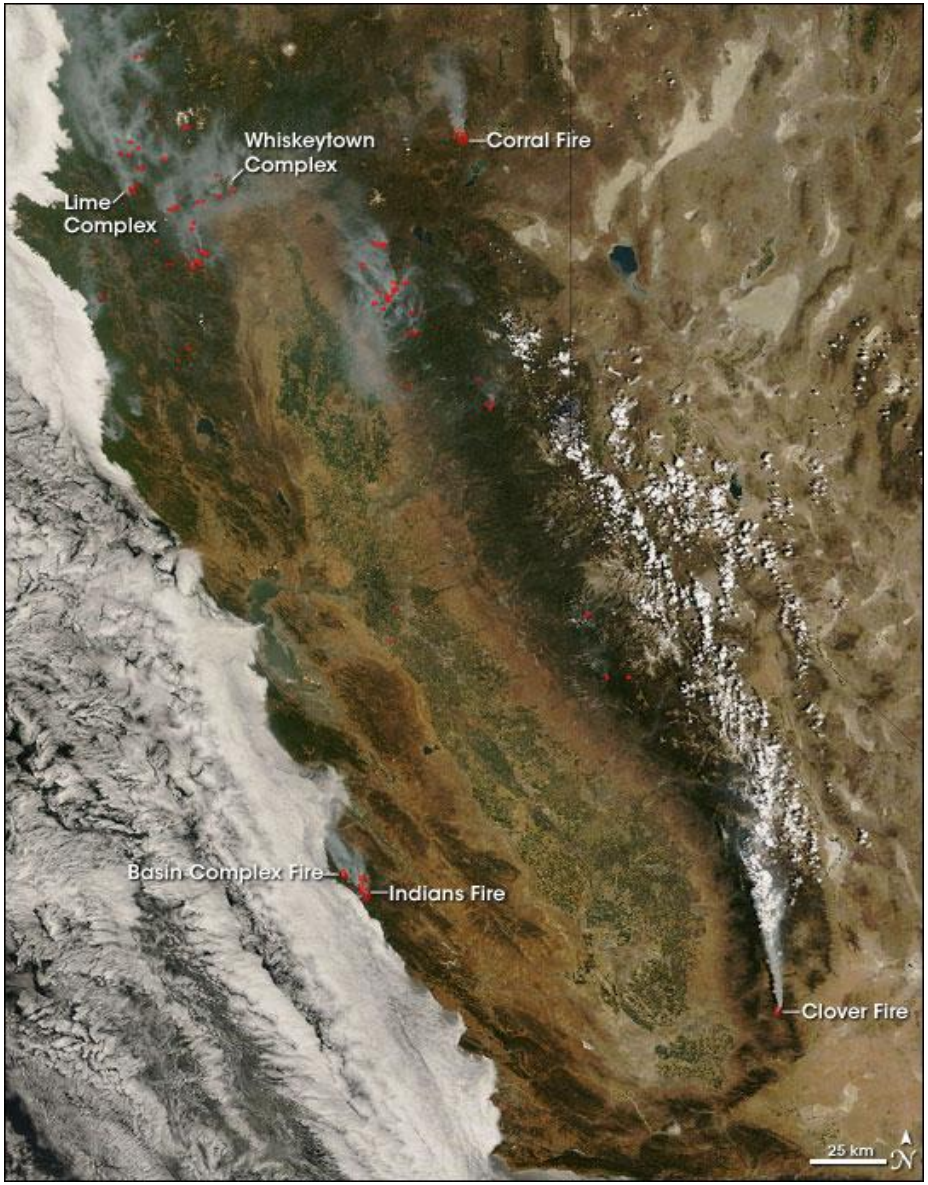
Avoiding Lightning



2008 Was Atypical

- An extreme amount of biomass burning over Asia, western Canada, and California
- Due to much warmer, drier conditions
- Biomass burning chemical signature overwhelmed the anthropogenic signal

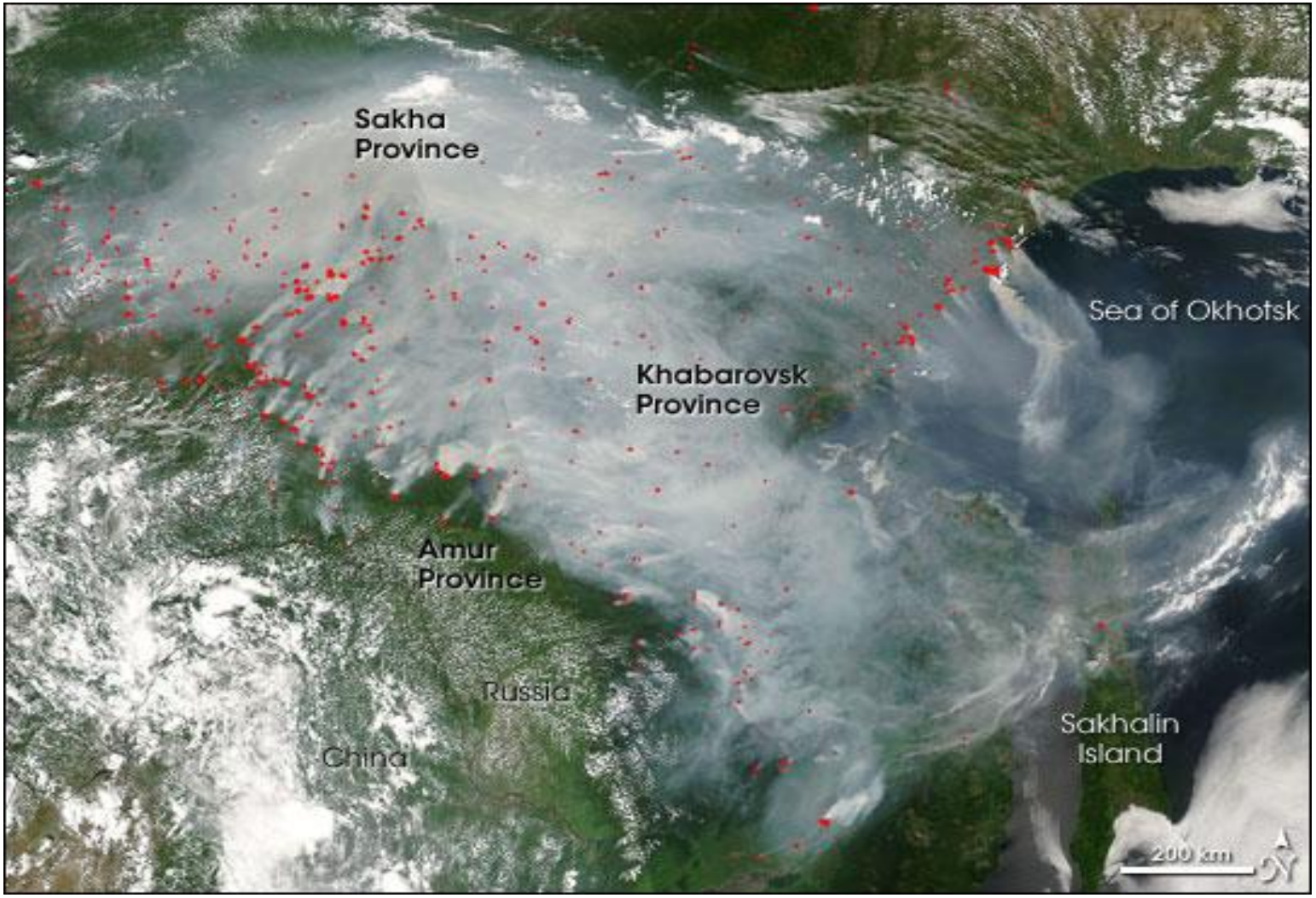
California—June 29--MODIS



Wildfires in California


Boreal Forest Fires

Southeast Russia—June 30--MODIS



We Sampled Fires in Saskatchewan

FSU Research

Climatological Studies

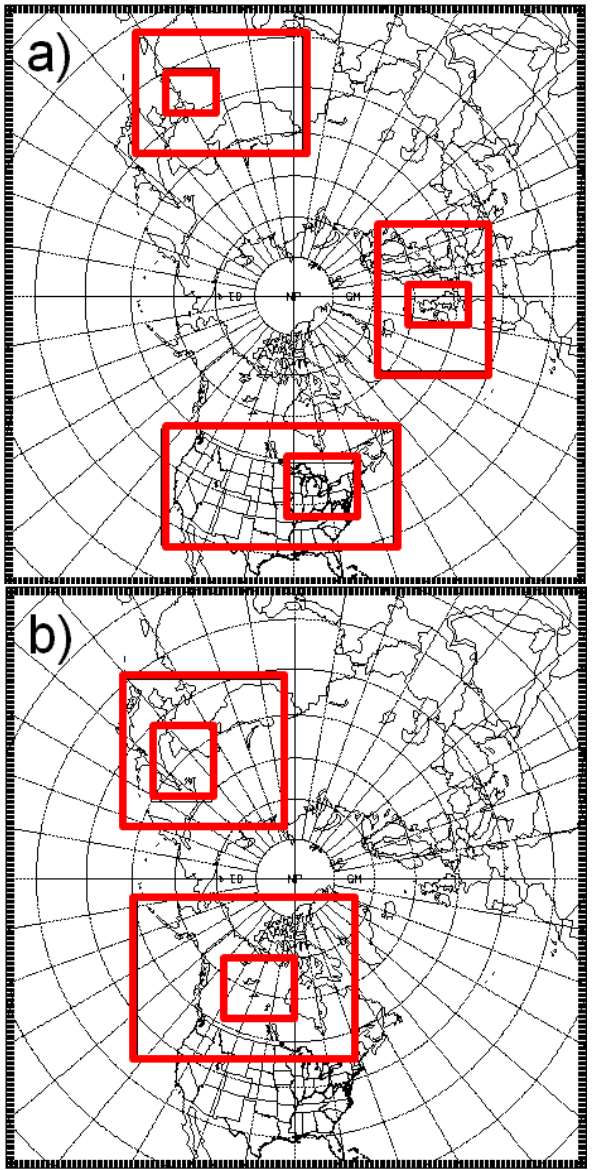
Detailed Case Studies of Anthropogenic Transport (traditional haze)

Detailed Case Studies of Biomass Emissions

After the Mission Research

Weather Research &
Forecasting Model (WRF)
Nested grids— 45, 15, 5 km
50 Vertical levels

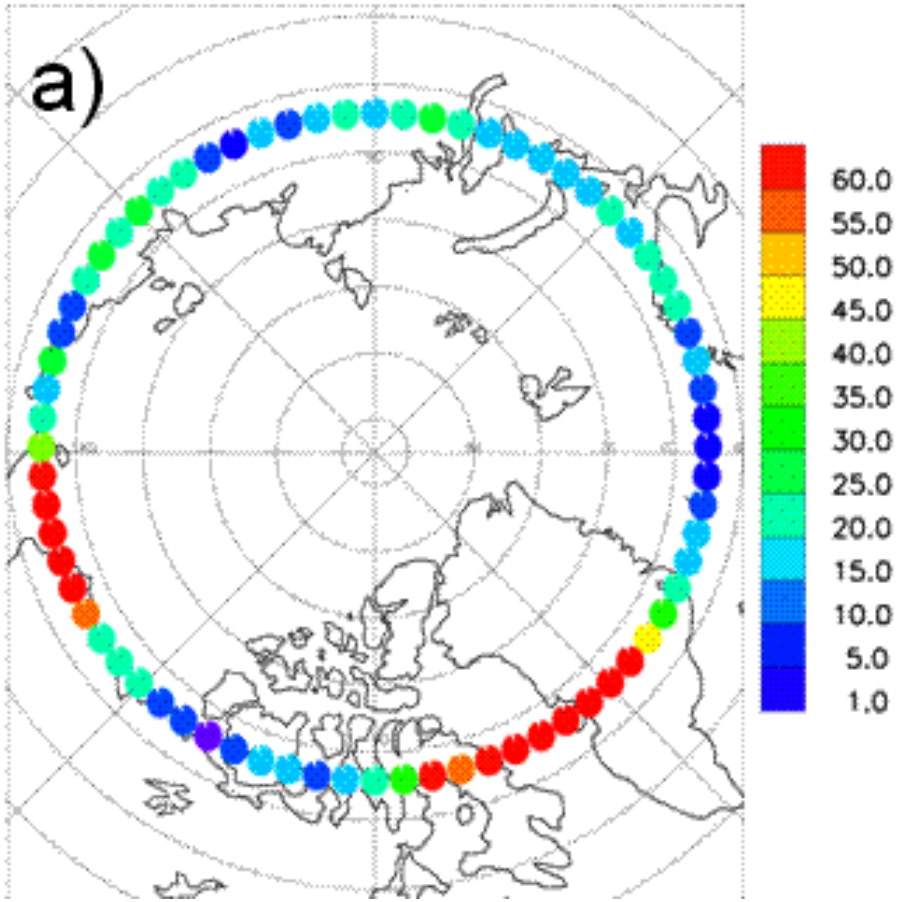
Trajectories
Flexpart runs—Lagrangian
particle dispersion model



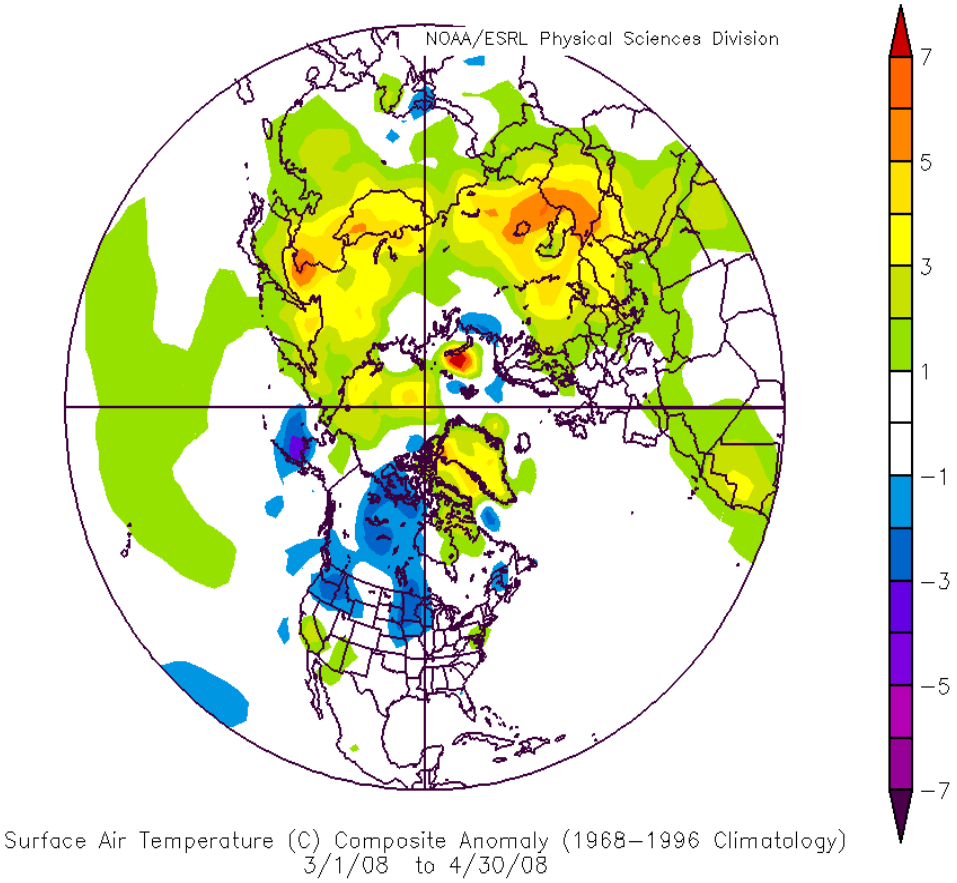
Spring

Summer

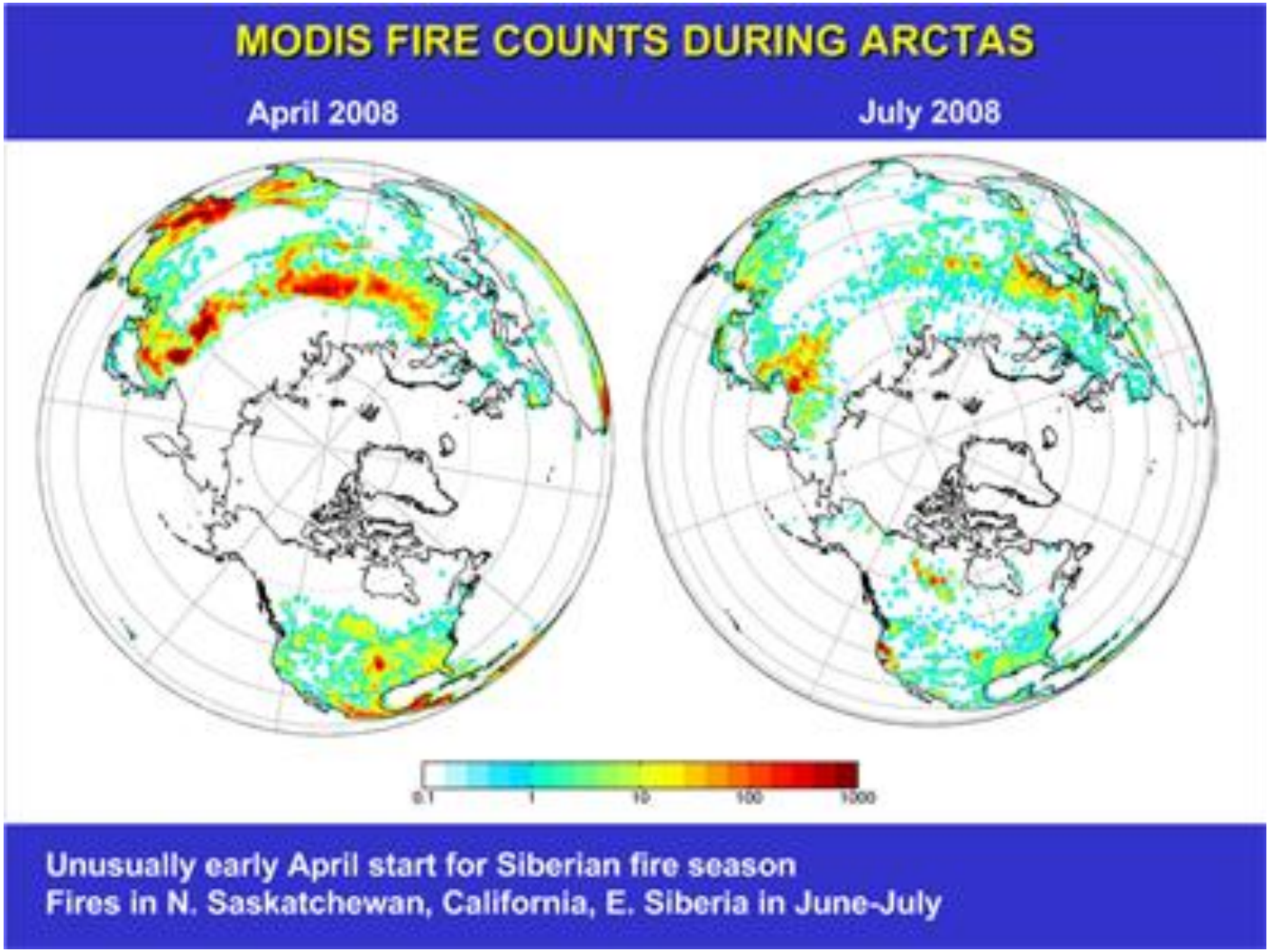
Where does air enter the Arctic (70 N)



Surface temperature anomaly (ºC) for March-April 2008

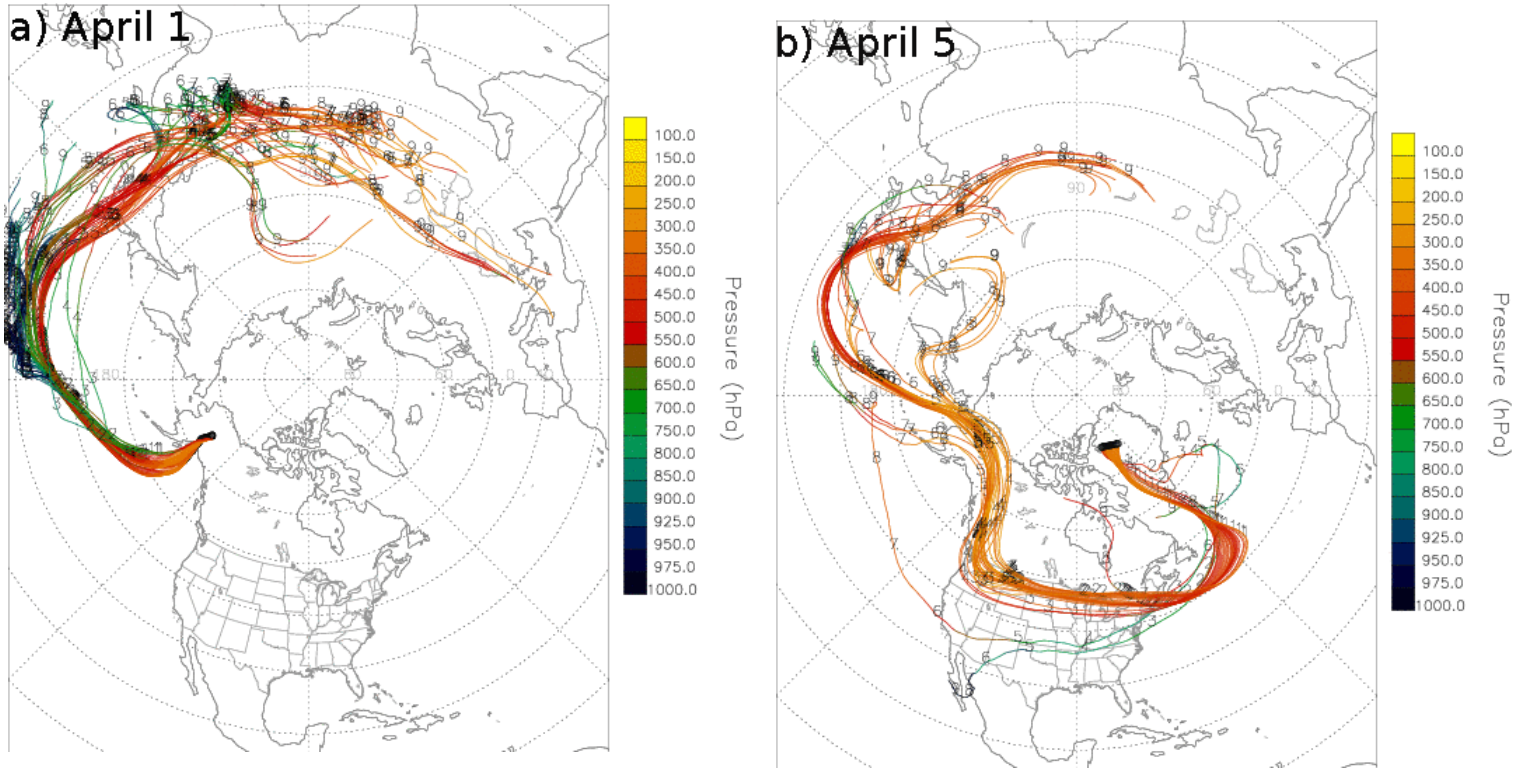


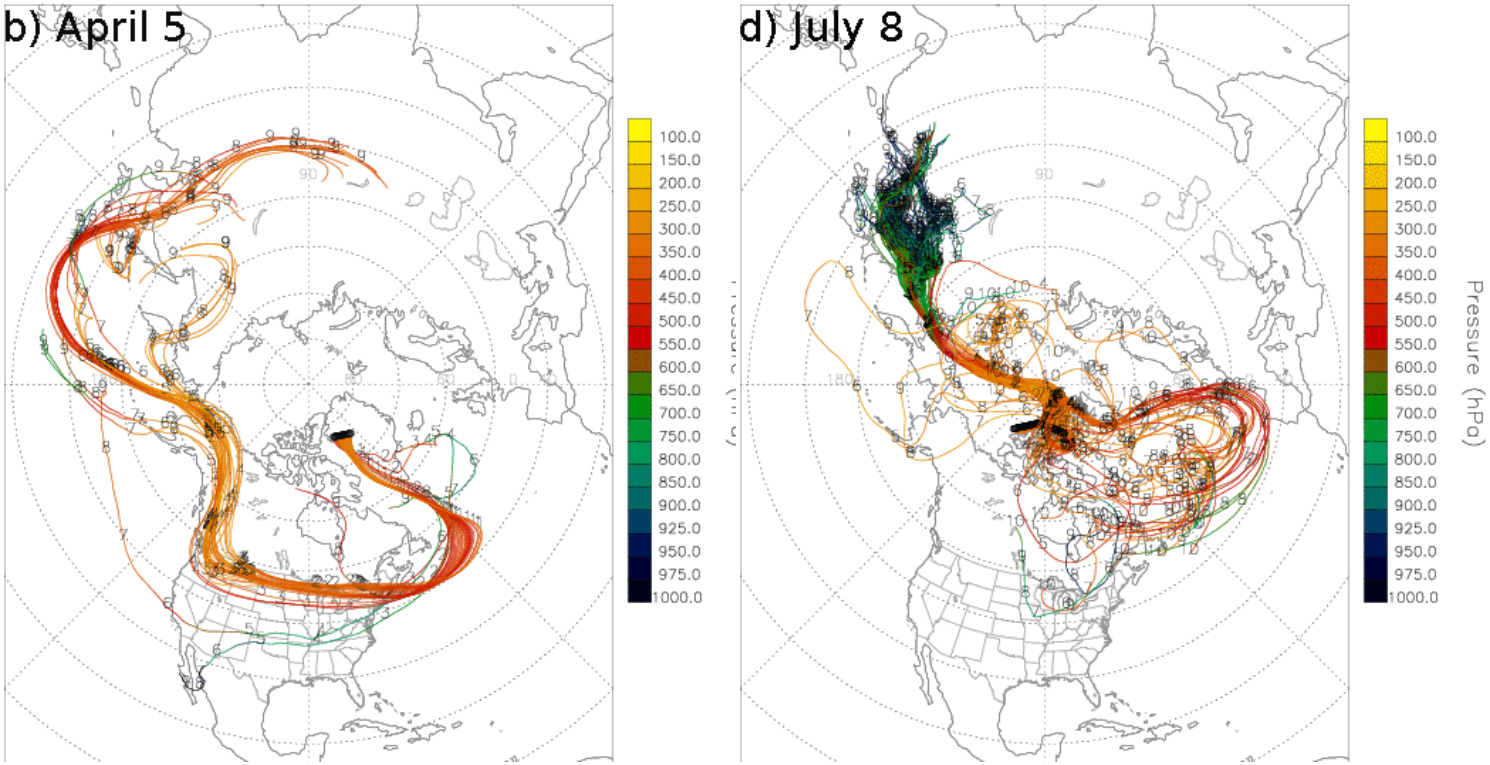
Satellite-derived Fire Counts



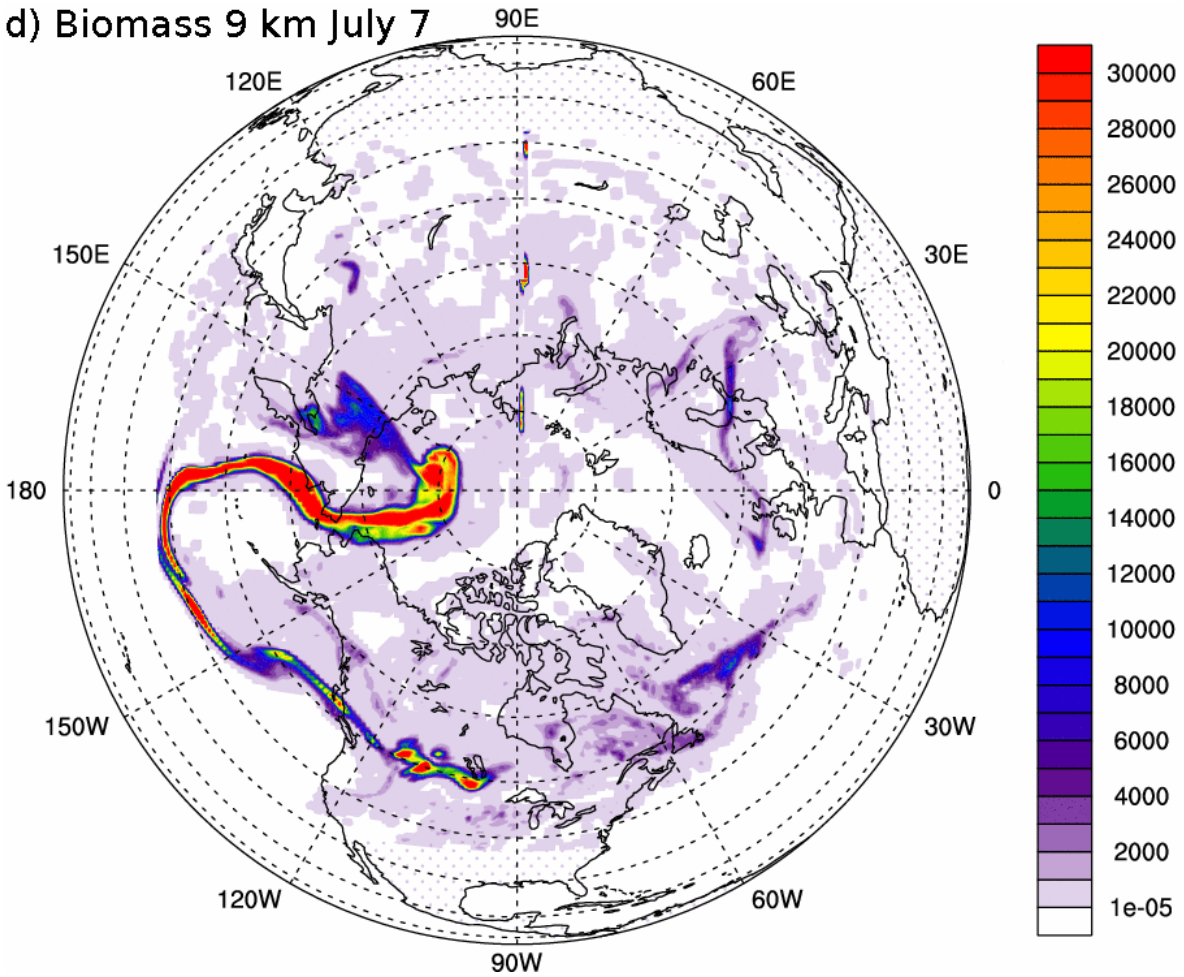
Courtesy of Louisa Emmons-NCAR

10 day back trajectories from DC-8 locations

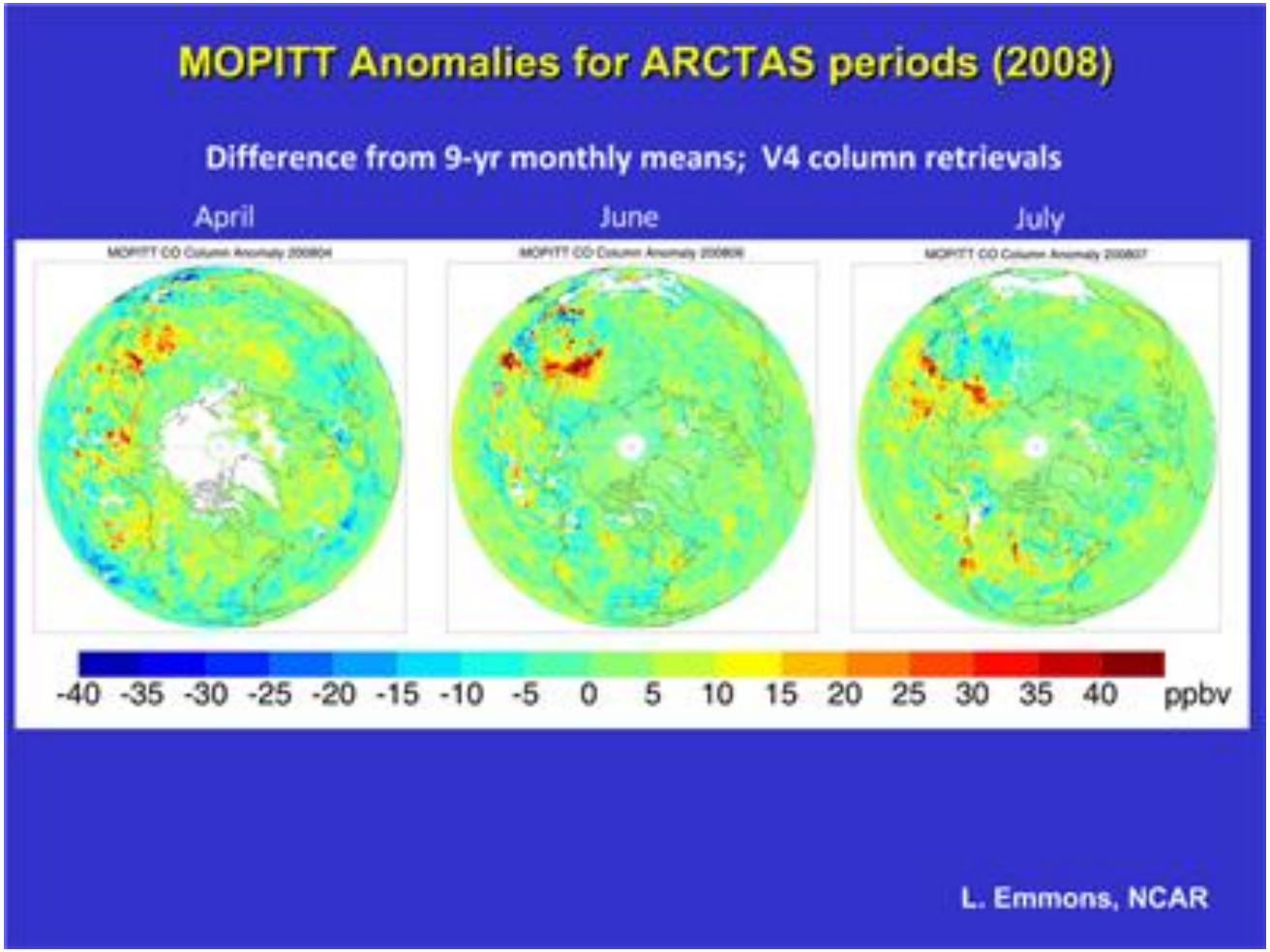



b) April 5
d) July 8
100.0
150.0
200.0
250.0
300.0
350.0
400.0
450.0
500.0
550.0
600.0
650.0
700.0
750.0
800.0
850.0
900.0
925.0
950.0
975.0
1000.0
Pressure (hPa)

Particle Dispersion Model



Transport leads to CO Anomalies



Conclusions

- Excessively warm temperatures in Asia during 2008
- Anomalously large fire counts in Asia
- Biomass pollutants transported to Arctic (and elsewhere)
- Similar situation happened in 2010
- Should we expect more of this in the future ?