METEOROLOGICAL OVERVIEW OF ARCTAS

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Florida State University

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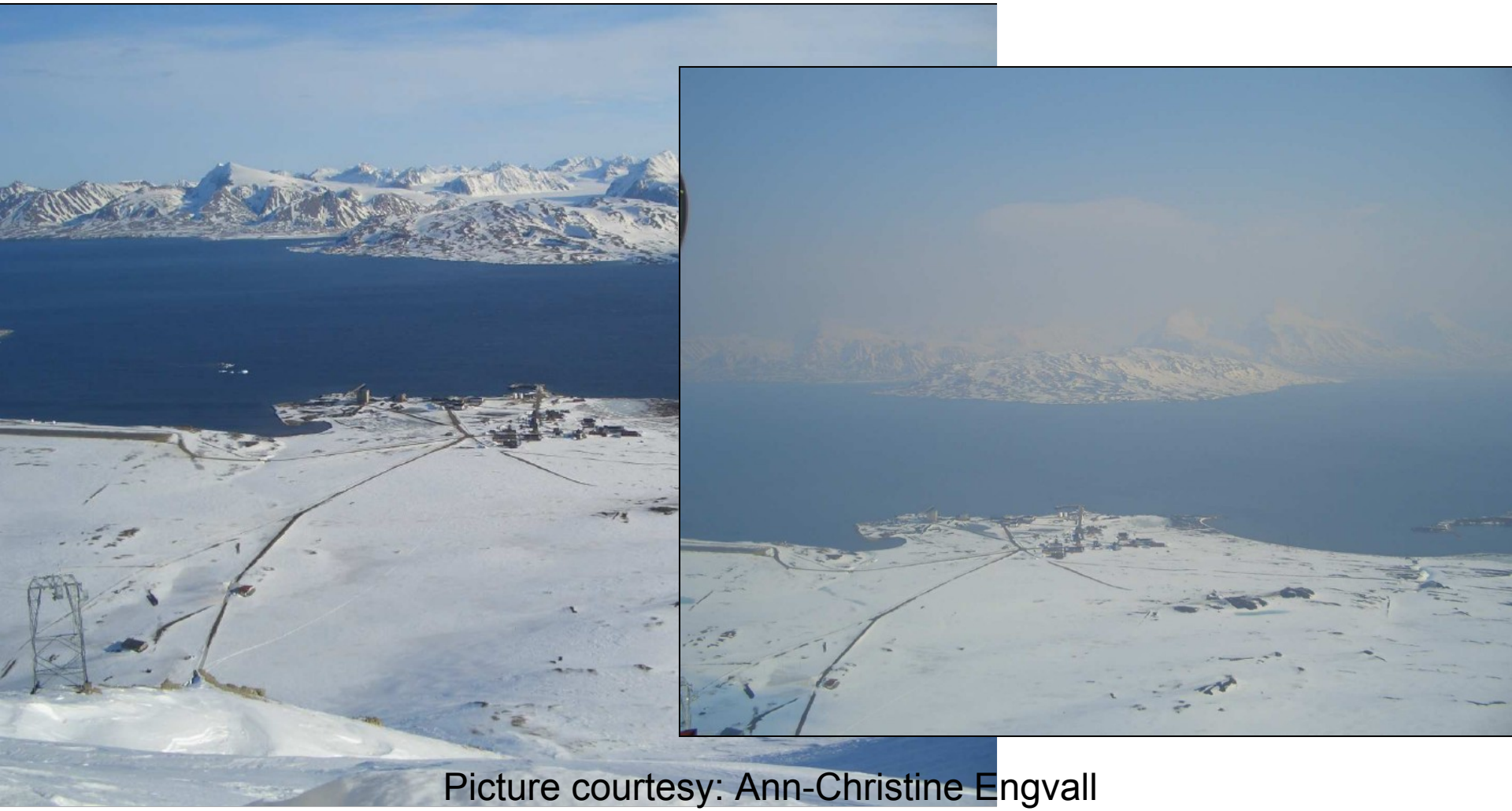
Extreme Arctic Haze

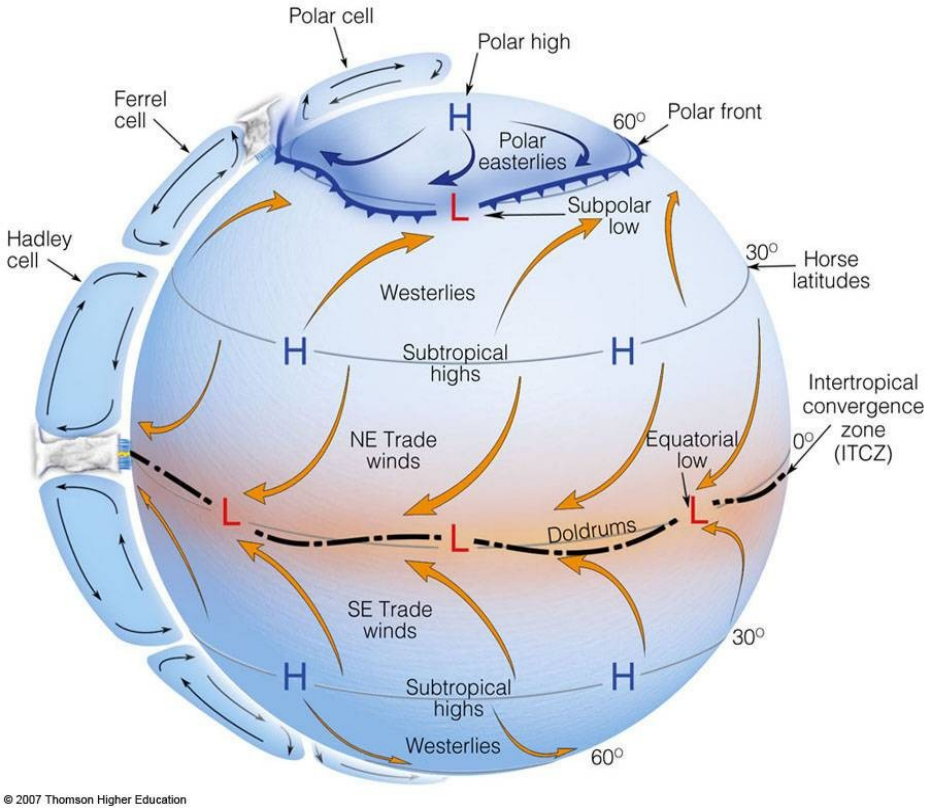
This and weaker events are what ARCTAS is about !

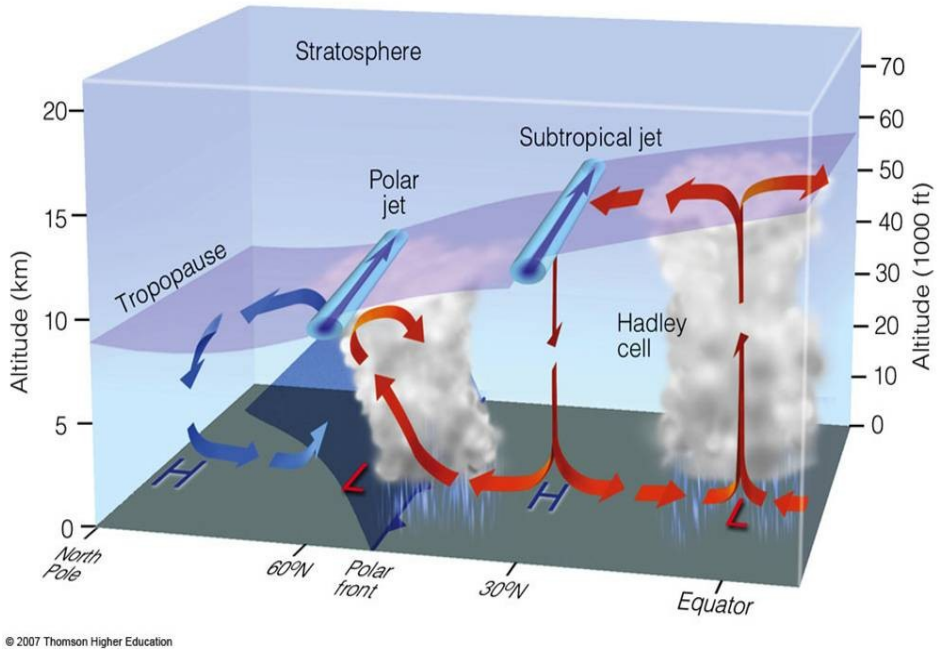


Picture courtesy: Ann-Christine Engvall

Our “Stomping Ground”

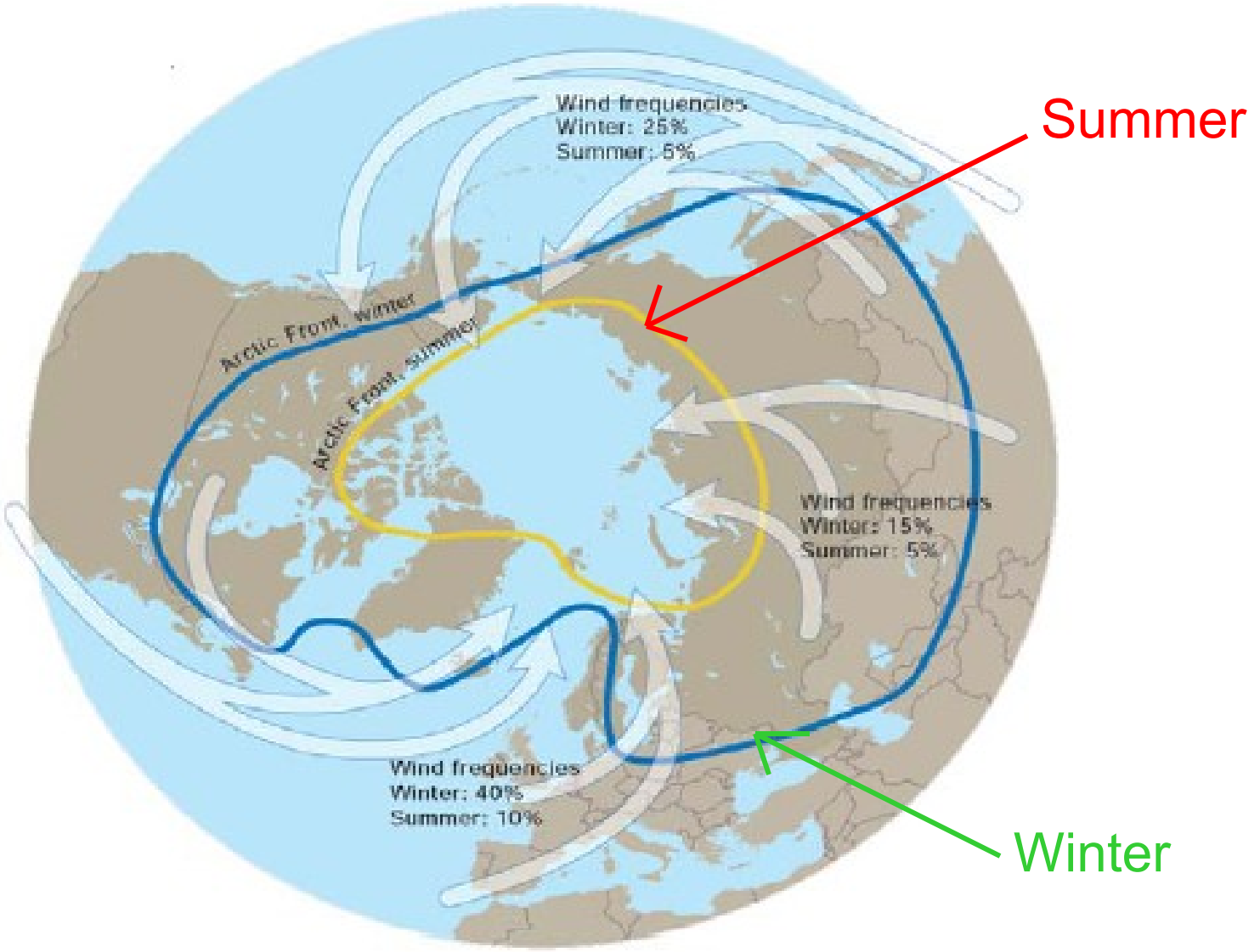
General Circulation Concepts



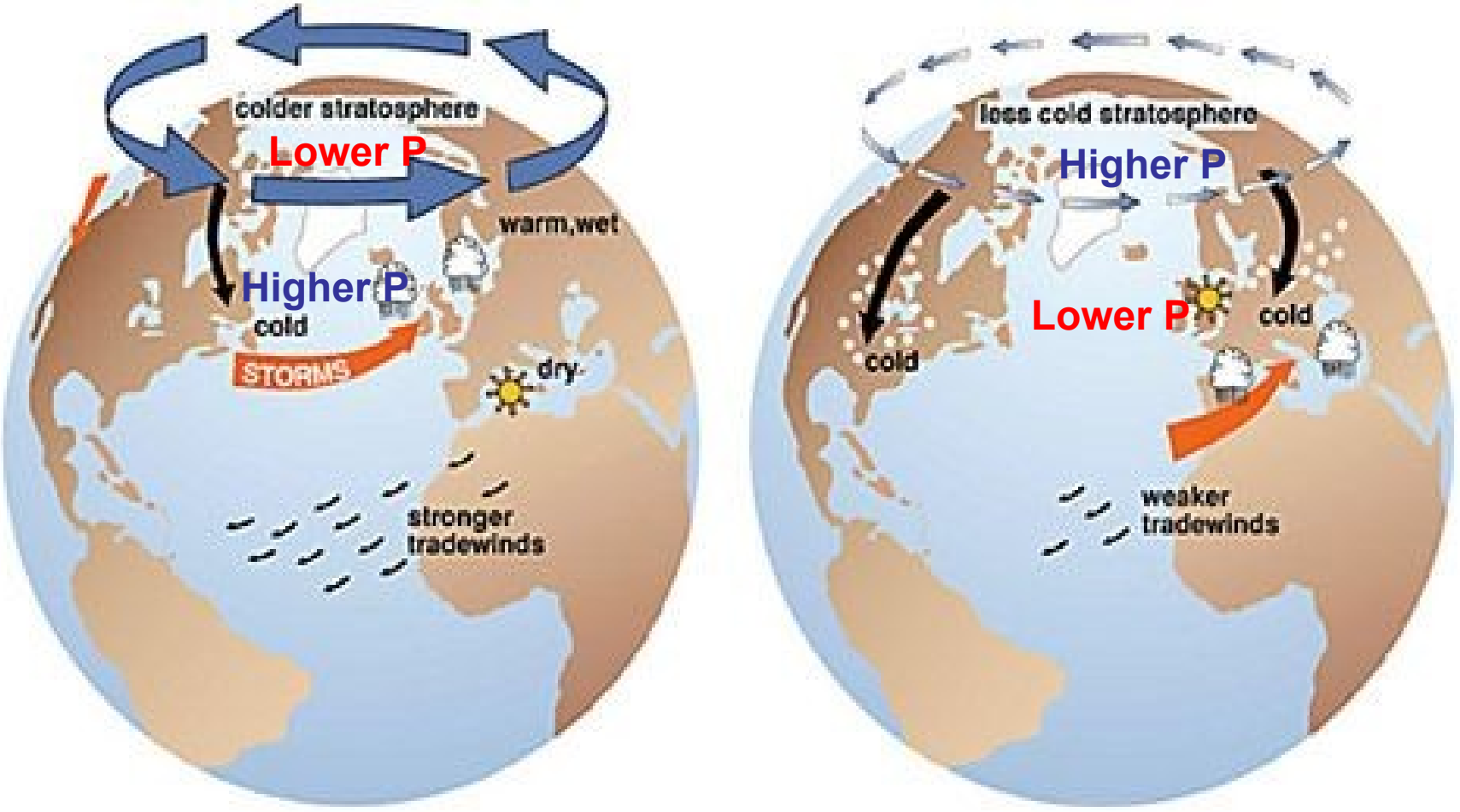


Situation more complicated—Arctic Front

The Arctic Front



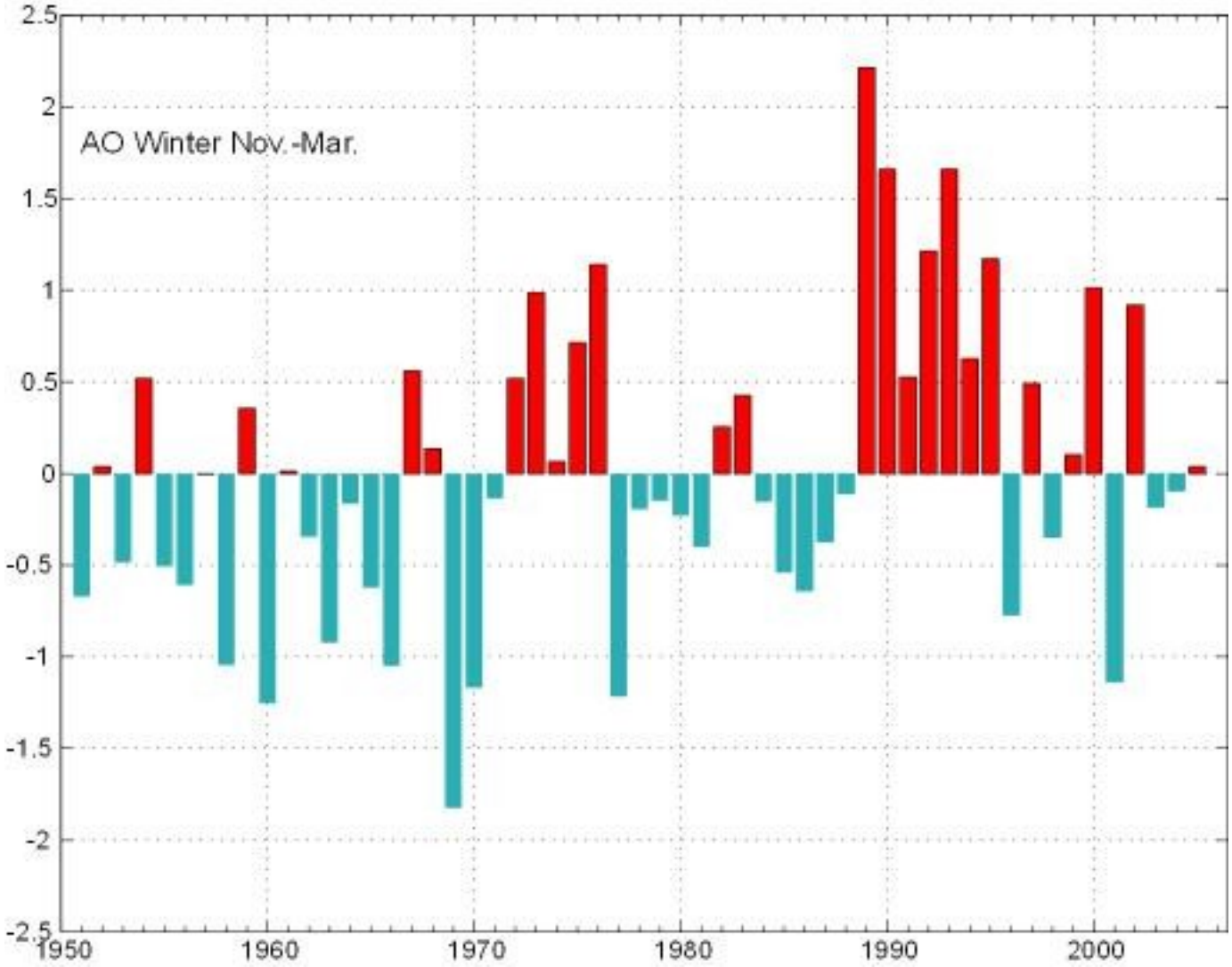
Arctic Oscillation



Positive Phase **Negative Phase**

Closely related to North Atlantic Oscillation

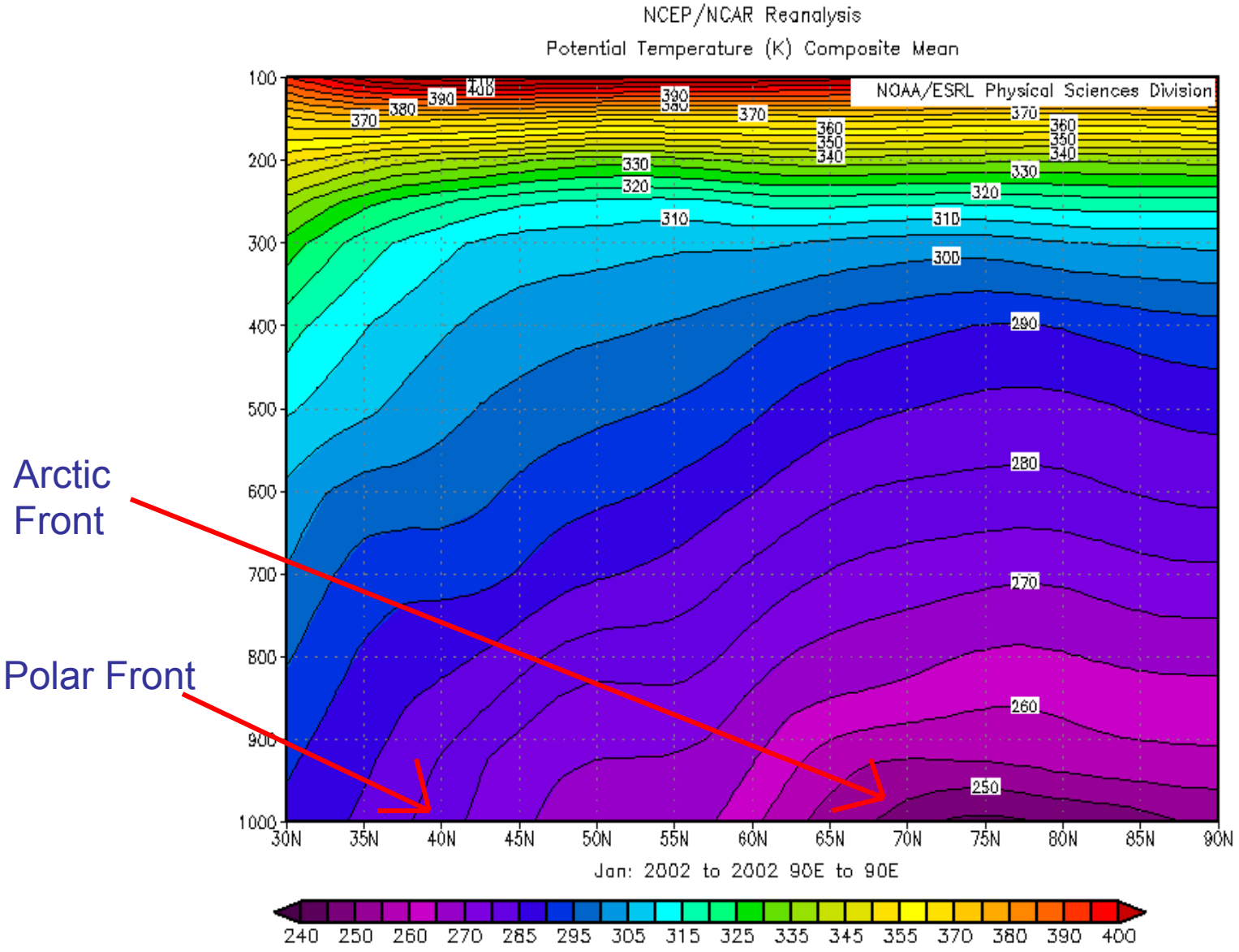
Time Series of Arctic Oscillation 1950-2006



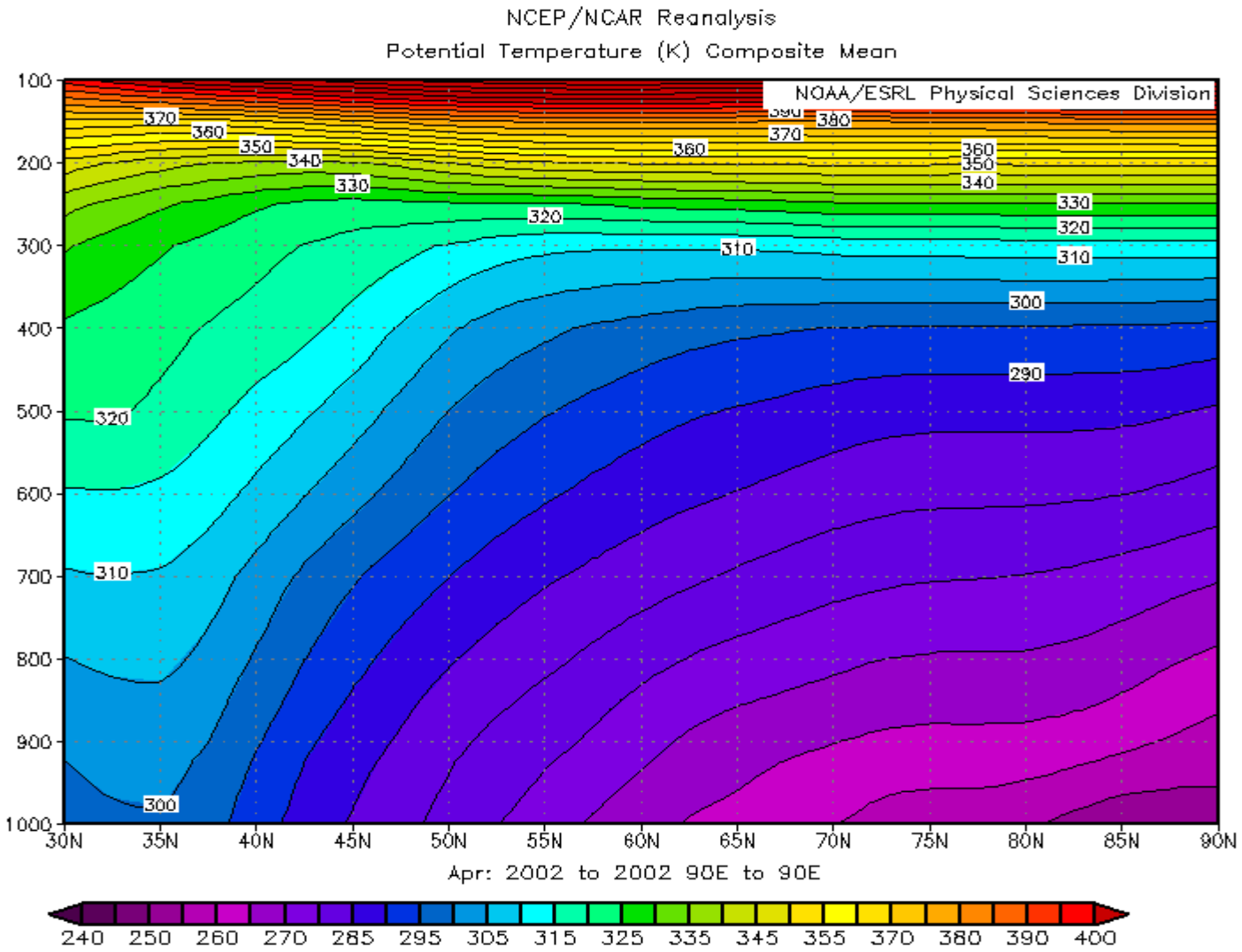
Potential Temperature (θ)

- The temperature that a parcel of air would have if brought dry adiabatically to a pressure of 1000 mb
- Parcels conserve θ as long as no heat is added or subtracted, i.e, an adiabatic process

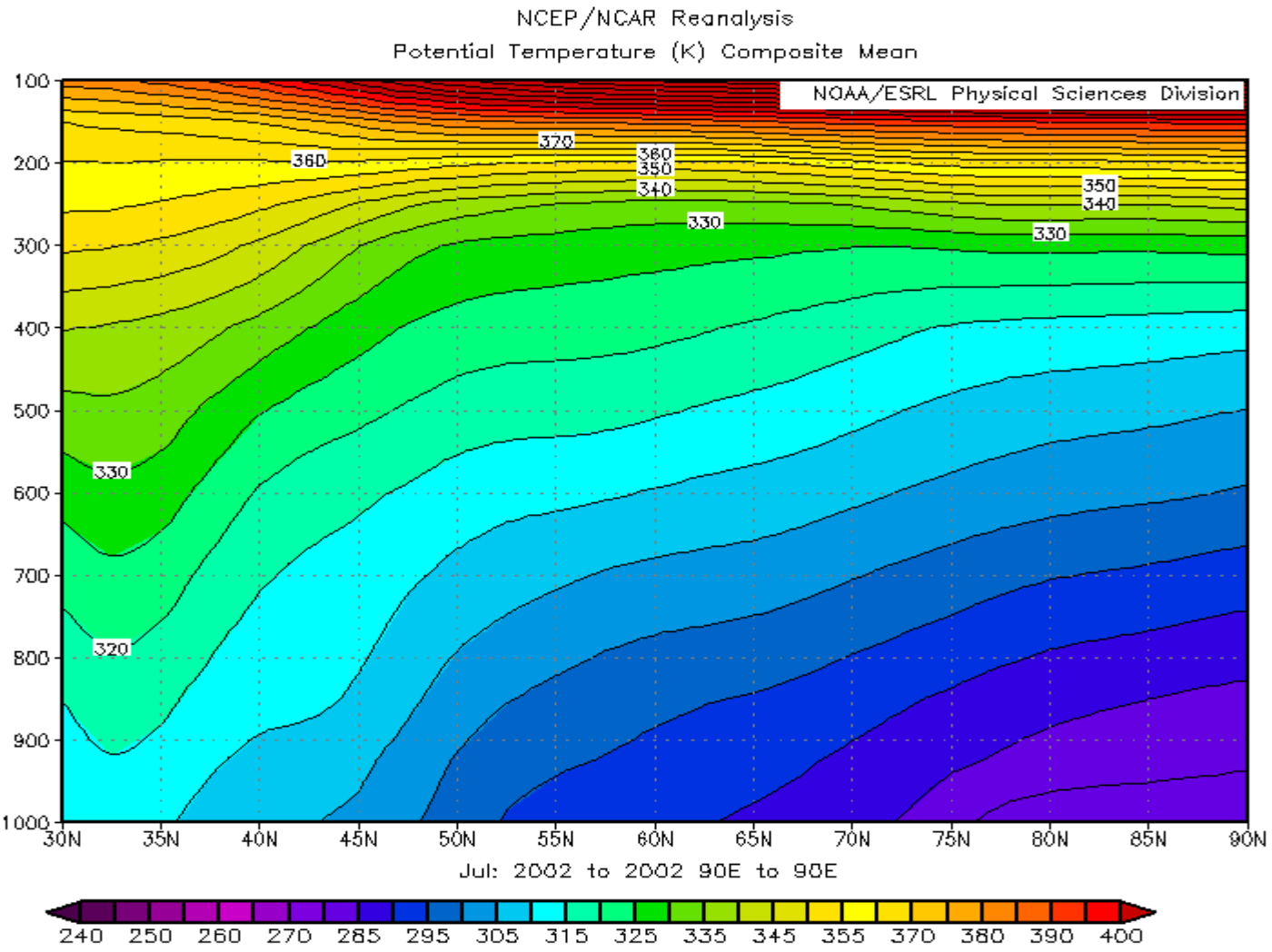
Cross Section of θ at 90° W--January



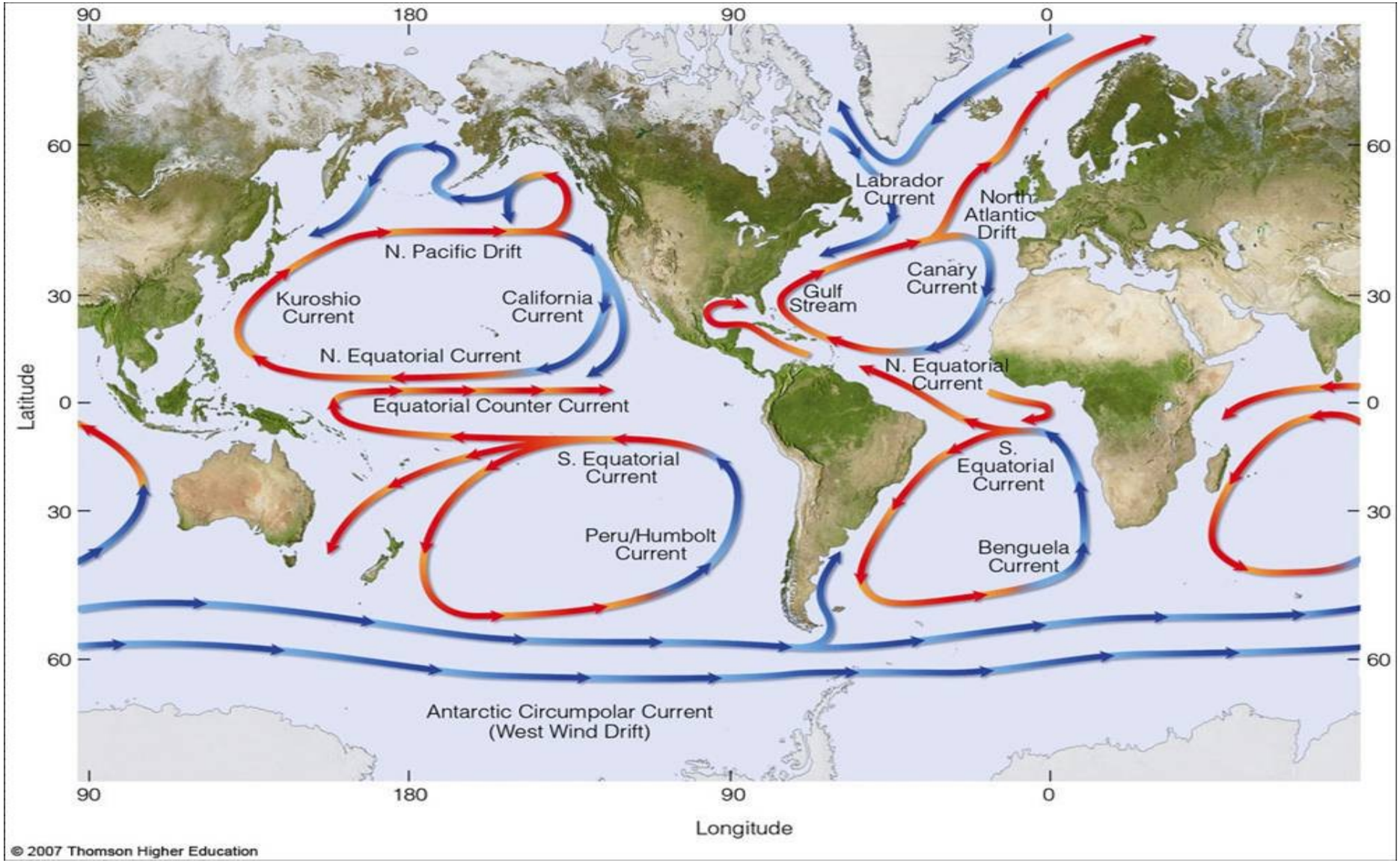
Cross Section of θ at 90°W--April



Cross Section of θ at 90°W--July

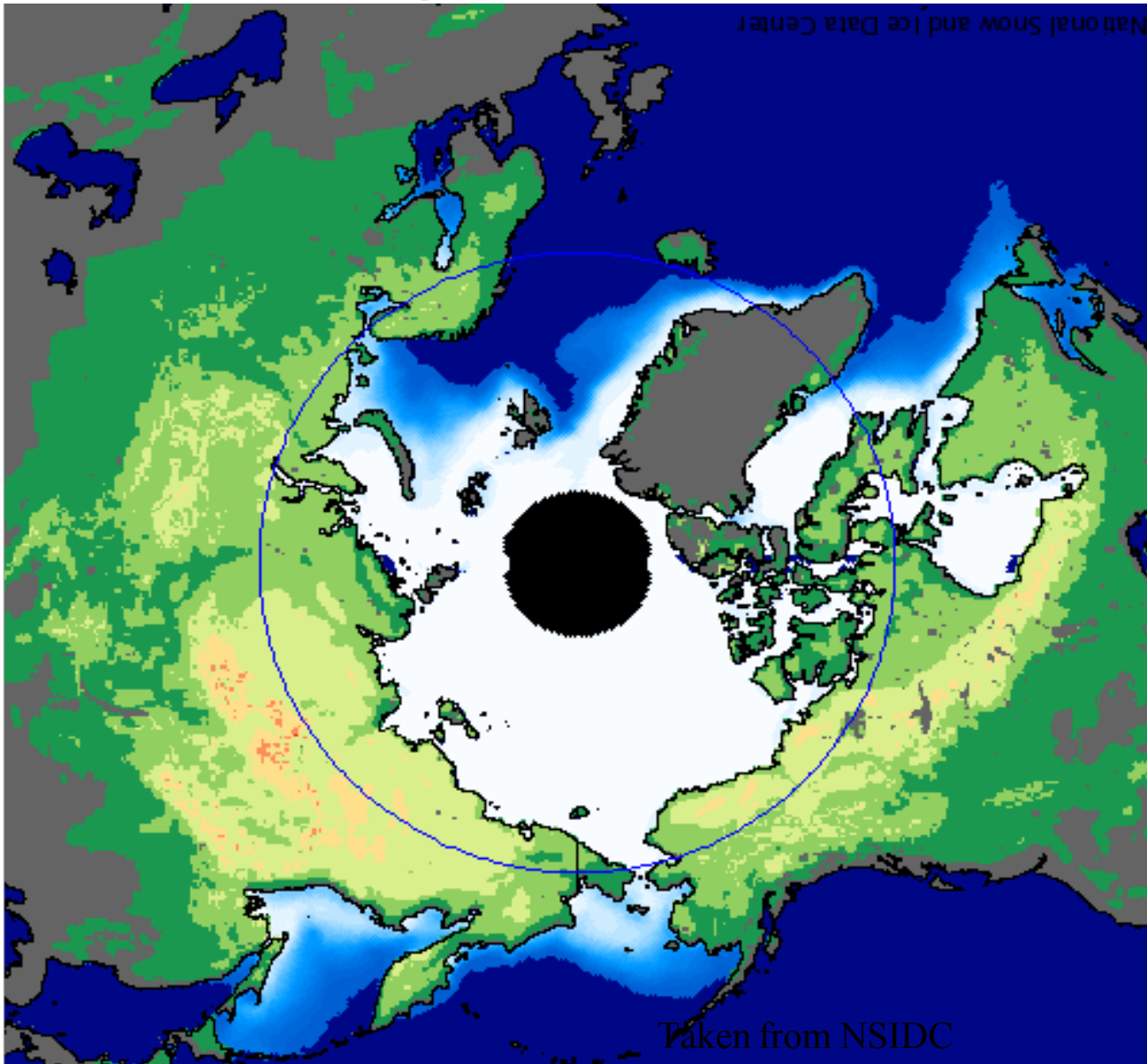


Ocean Currents



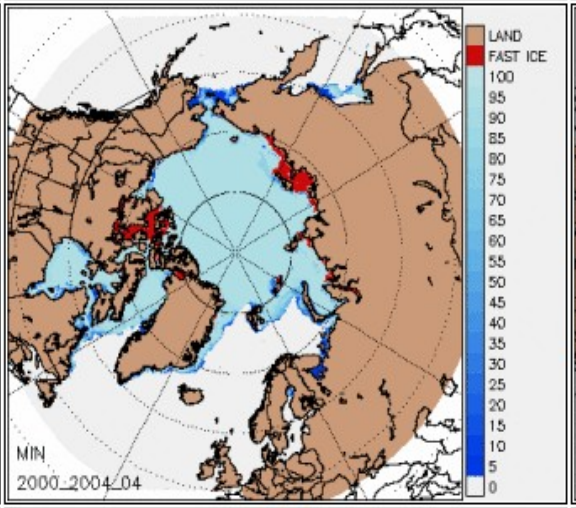
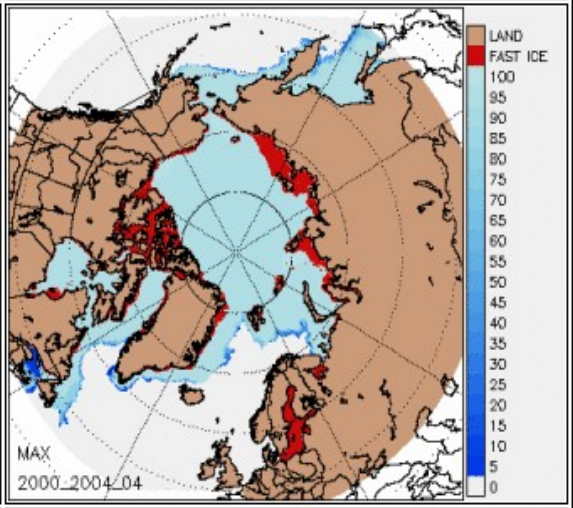
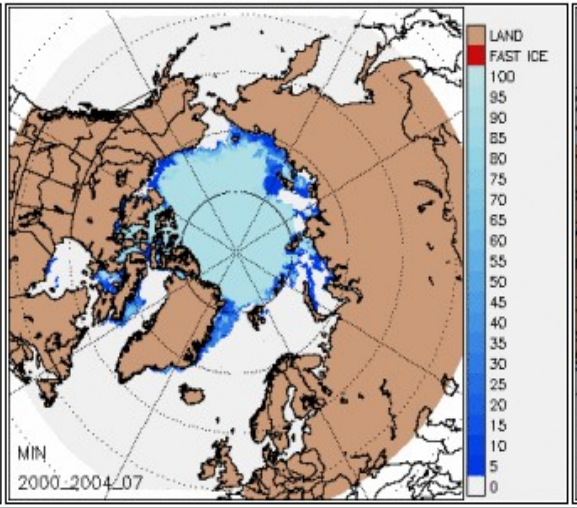
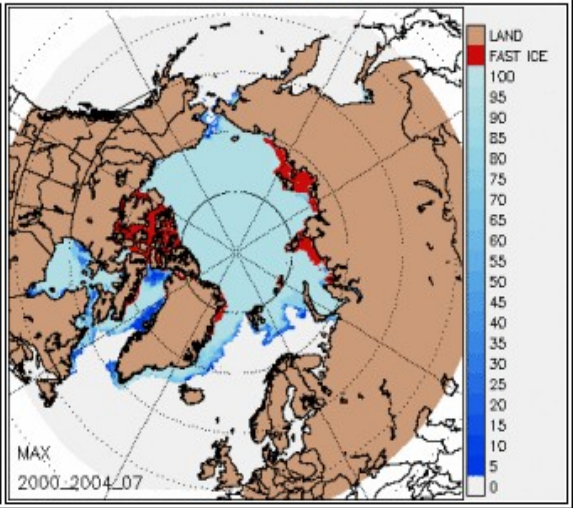
Historical Mean April Sea Ice Extent and Snow Water Equivalent

- Max ice in February
- Starts retreat April
- Min ice September



Taken from NSIDC

NSIDC April-July Maximum/ Minimum Sea Ice Extents, 2000-2004

	Minimum	Maximum
Climo years: 2000-2004 Month: Apr		
Climo years: 2000-2004 Month: Jul		

Vertical Structure of Atmosphere

Arctic atmosphere tends to be **very** stable:

- Cooled from below via negative radiation balance
- Strong surface based temperature inversions
- Positive surface radiation balances are often spent thawing snow/ice
- Mixing heights/boundary layer heights are low
- Weak mixing
- Tropopause is low (can go below 500 mb)
- Summer convection in interior - small scale by lower 48 standards

Synoptic Aspects & Extremes

Synoptic Aspects

- Arctic regions usually removed from areas of strong steering (e.g., mid-latitude jet)
- Systems do not always move through as quickly
- Systems can get trapped by topography and stall
- Ice edge can form a baroclinic zone for local storm development

Arctic sees extremes

- For example - late Jan 2007 at FAI - warmest 850 mb temp ever for the entire Oct - May period (+12 C)
- Then - coldest Feb 15 - Mar 15 (2007) in 100 years.
- Climatologies - can only provide rough guidance

Operational Considerations

Geosynchronous Satellite Support Poor

- Angle is too great
- Polar orbiters - high repeat rate but images not lined up

Met. Forecast Models have Difficulty

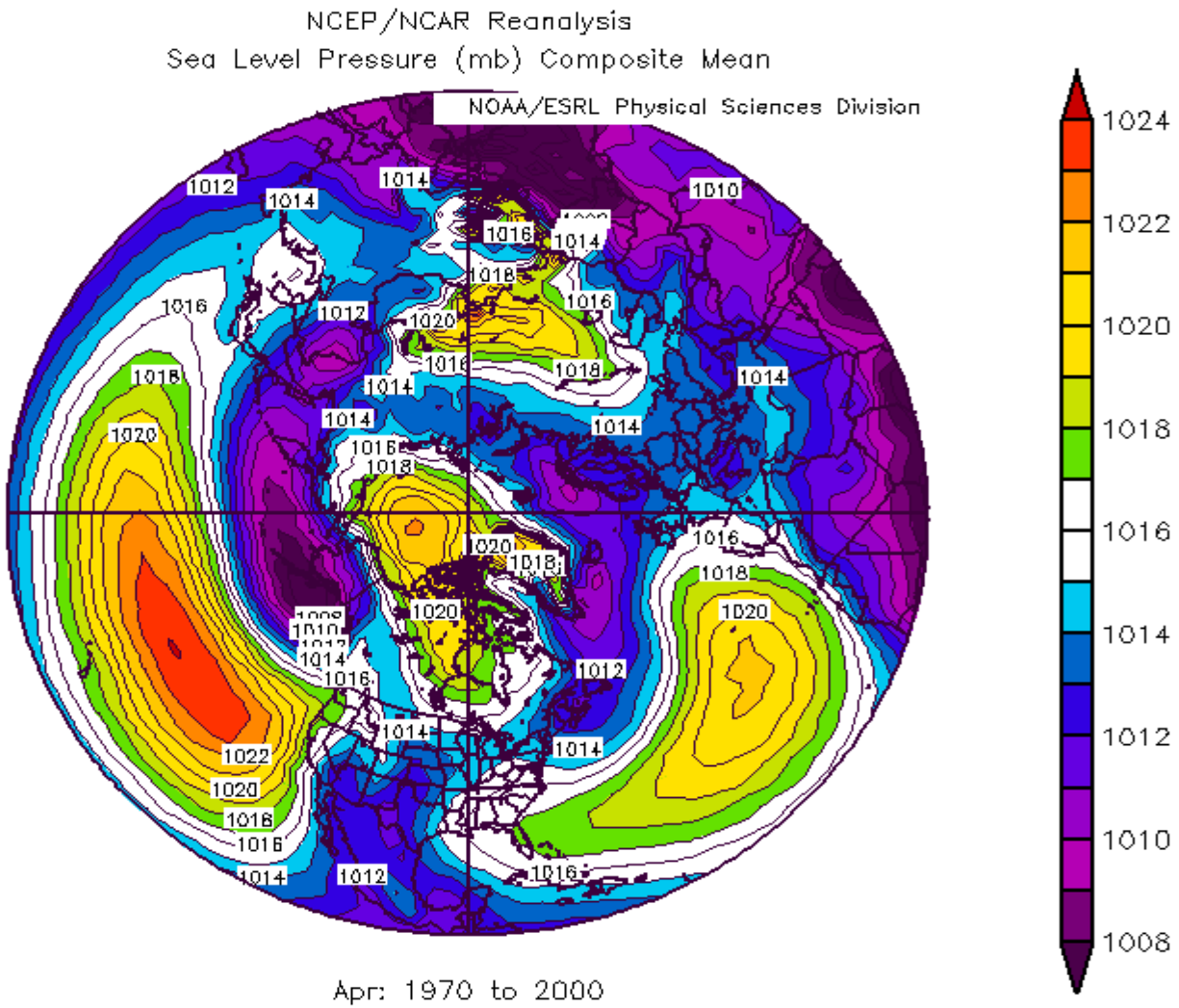
- Forecast models depend on observational data for constraint - very little in situ observed data available
- Problem in Bering/Chukchi Sea storm forecasting
- Strong surface inversions difficult for models
- Moisture contents low - get localized, small amounts of precipitation that the models cannot capture
- Local cloudiness also difficult, especially where sea ice is involved

ARCTAS-SPRING

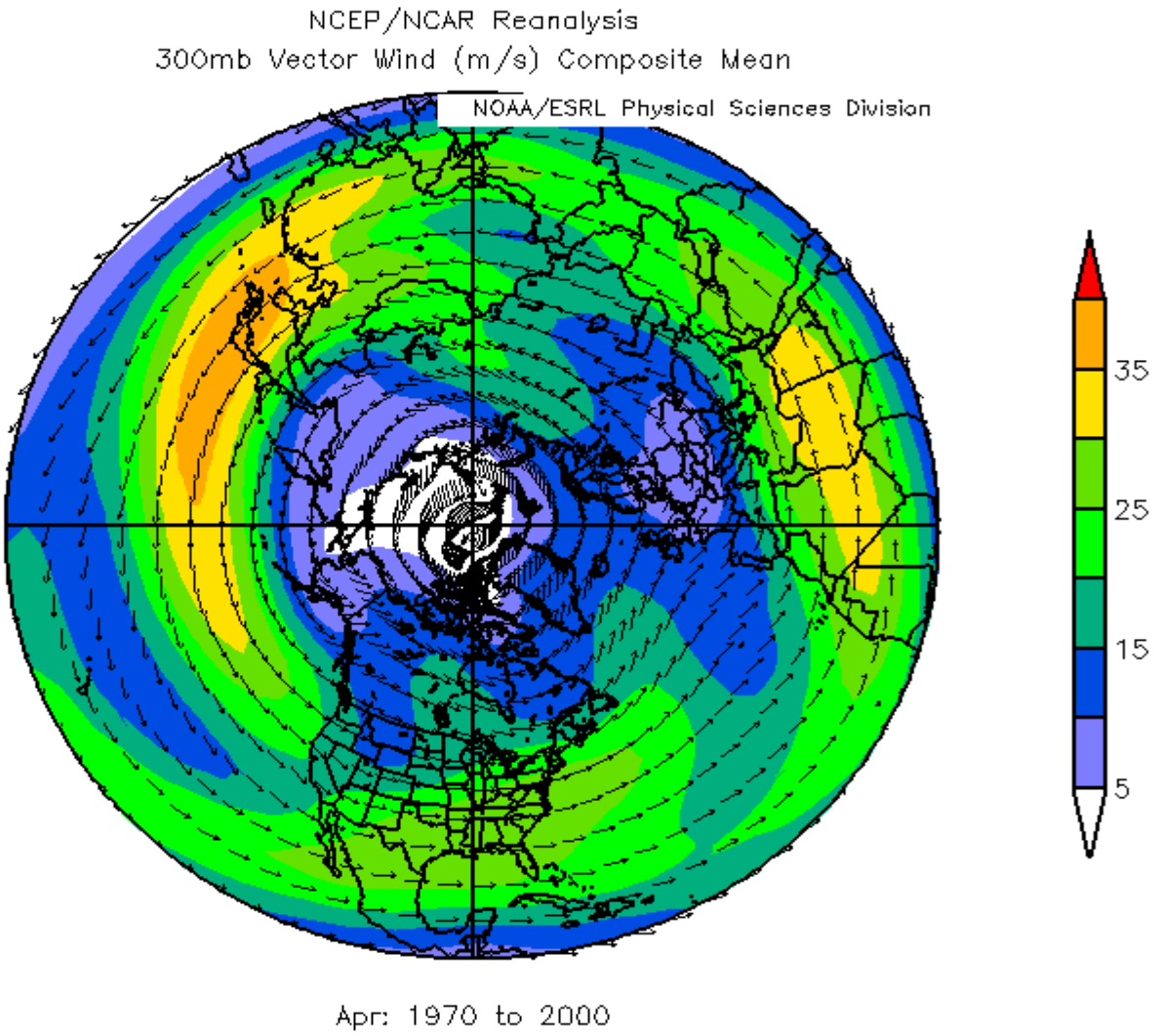
Weather on the Ground--April

	Avg Max (deg F)	Avg Min (deg F)	Avg Precip (inches)
Cold Lake	49.1	27.5	0.43
Thule	10.0	-7.0	0.20
Fairbanks	43.6	19.8	0.21
Barrow	6.3	-7.3	0.12

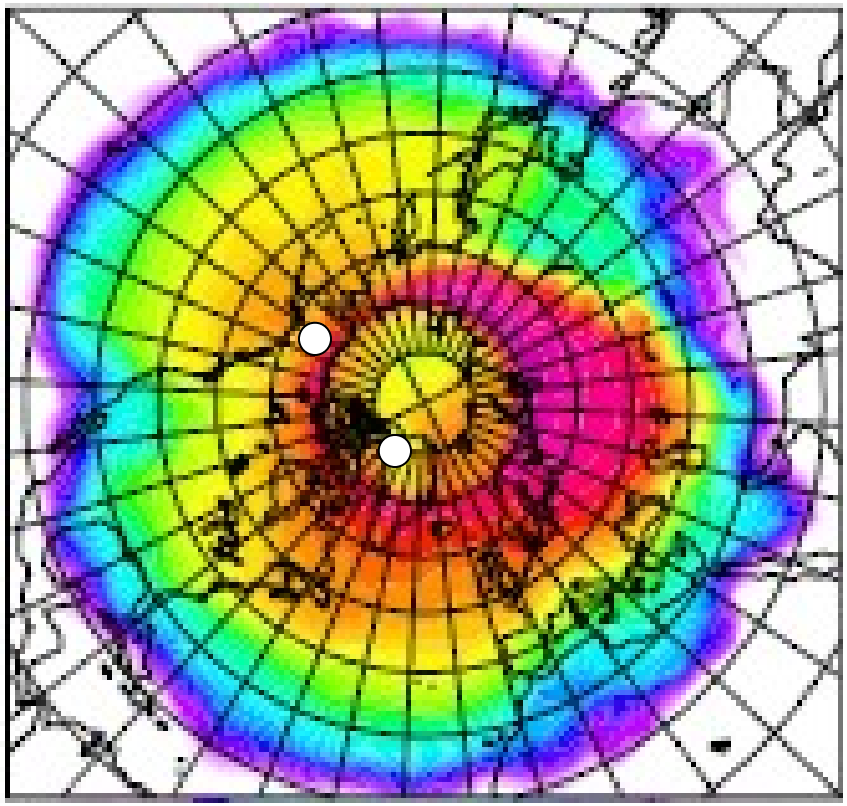
April Mean Sea Level Pressure



April Mean 300 mb Winds



Preferred Pathway to Arctic--Winter



Eurasian route preferred

Stohl, JGR, 2006

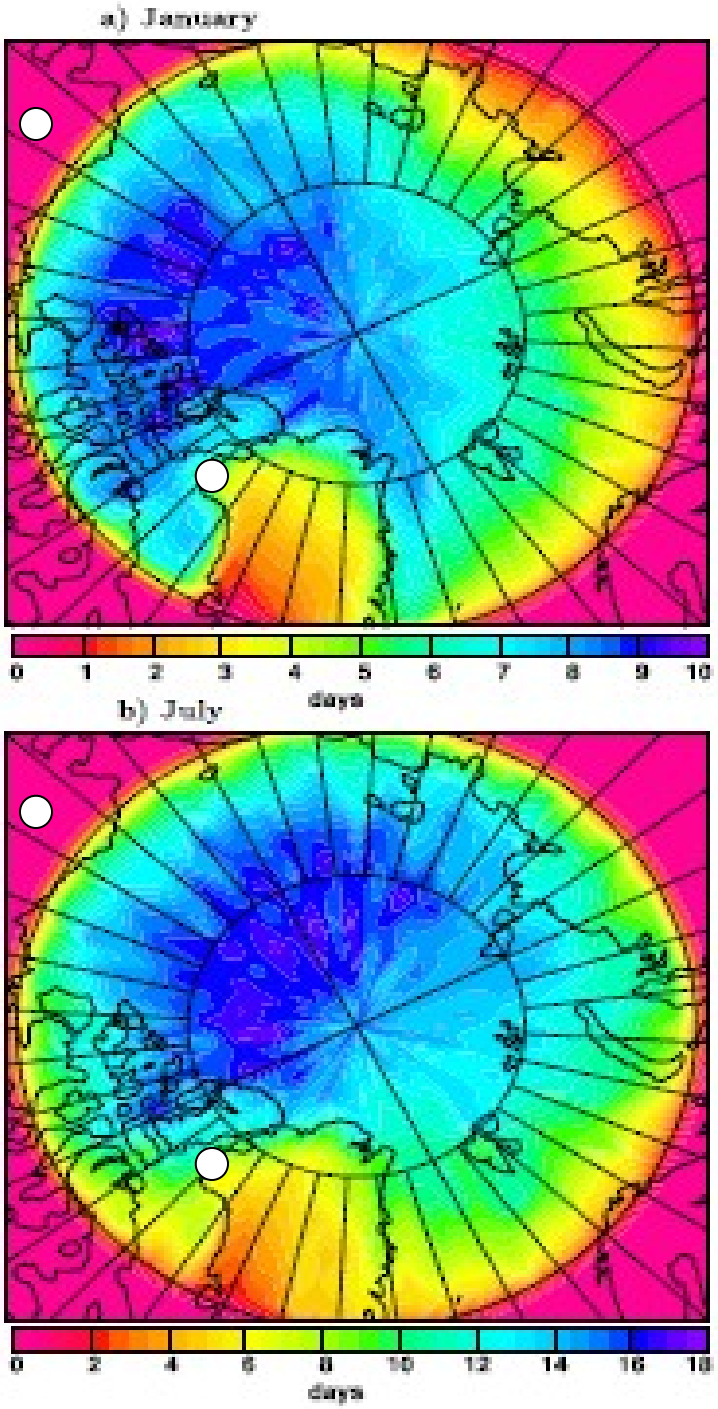
Transport

January

Number of continuous days that lowest 100 m of atmosphere has spent in the Arctic

Pretty Stagnant

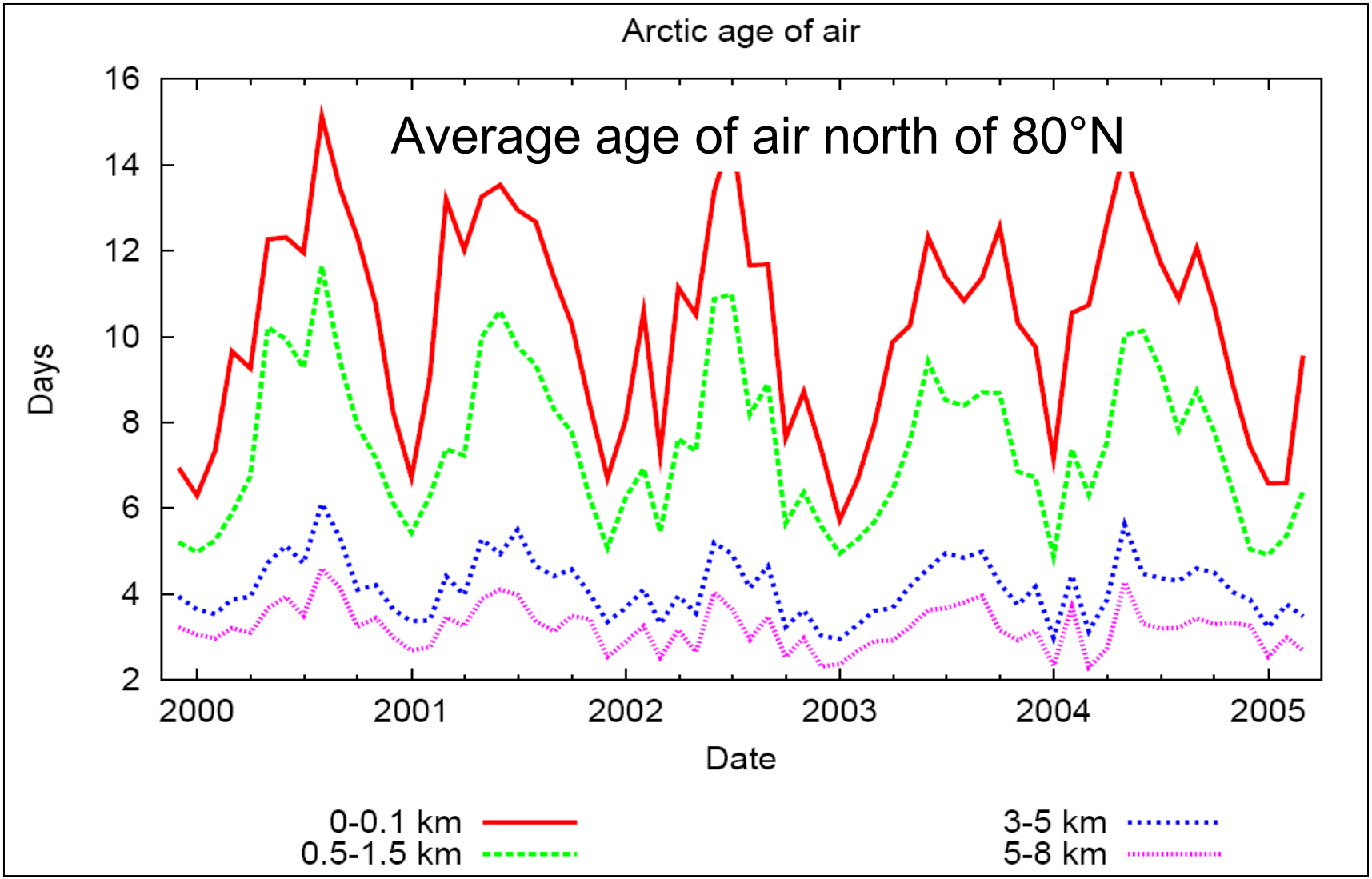
July



High topo. In Green-land

Stohl, JGR, 2006

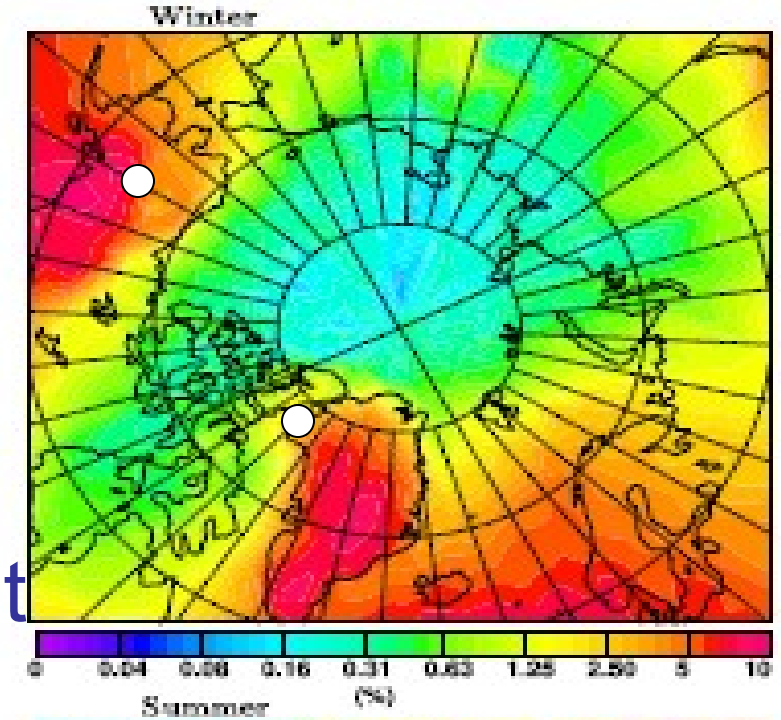
Shorter Arctic Ages Aloft



Stohl, JGR, 2006

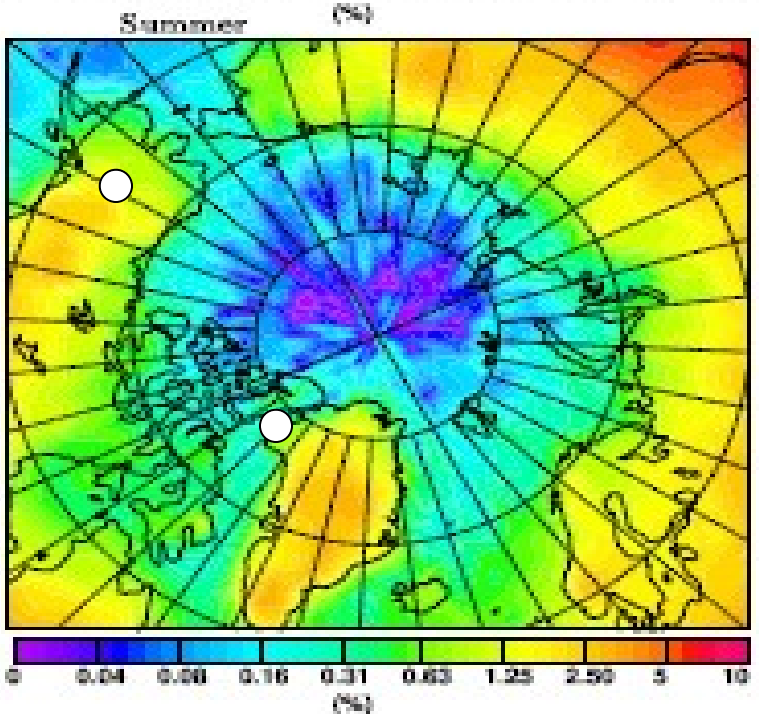
Stratospheric Contribution?

Winter



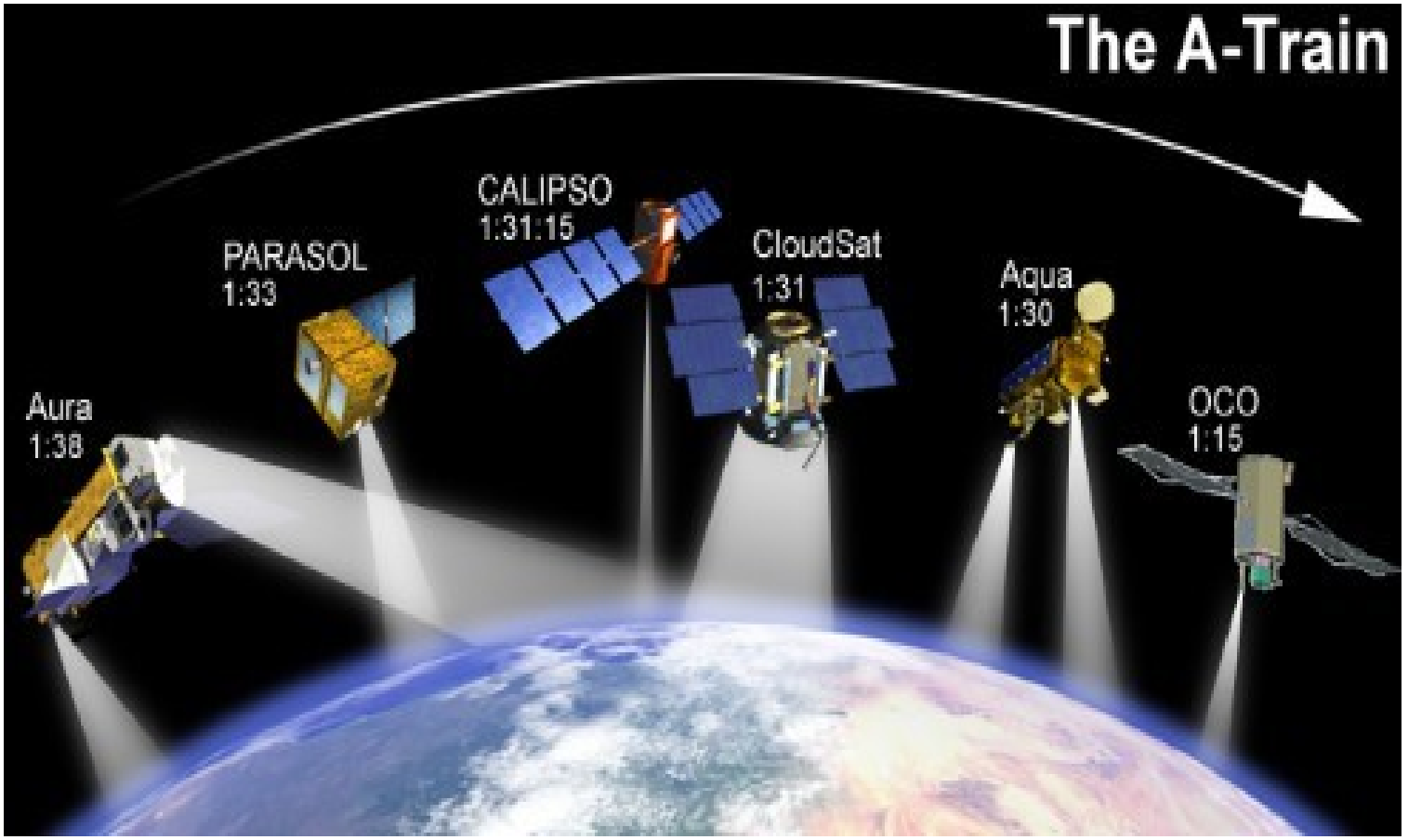
Probability that air in lowest 500 m had a stratospheric origin within the previous 10 days

Summer



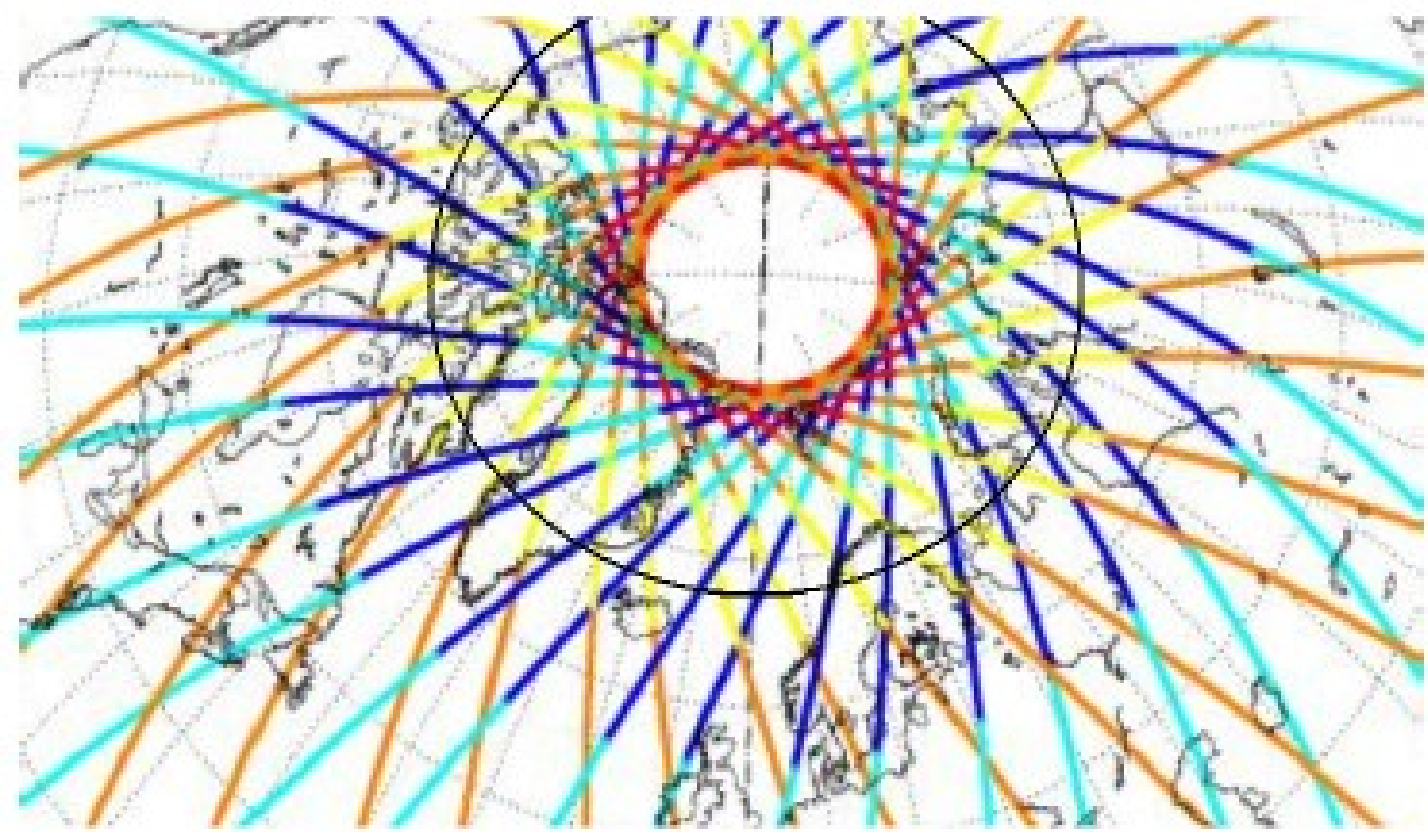
Stohl, JGR 2006

Satellite Inter-comparisons



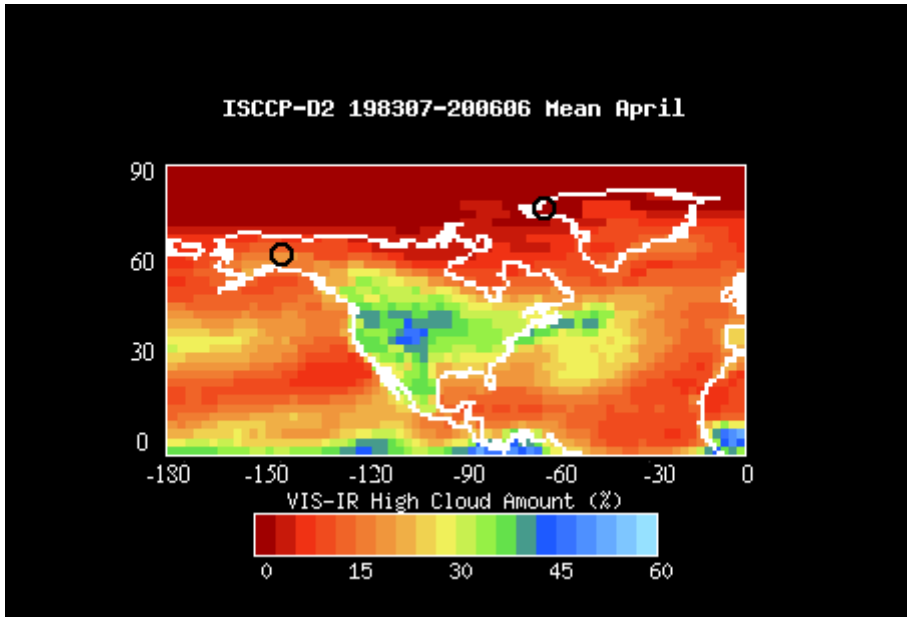
"The A-Train." Listed under each satellite's name is its equator crossing time.

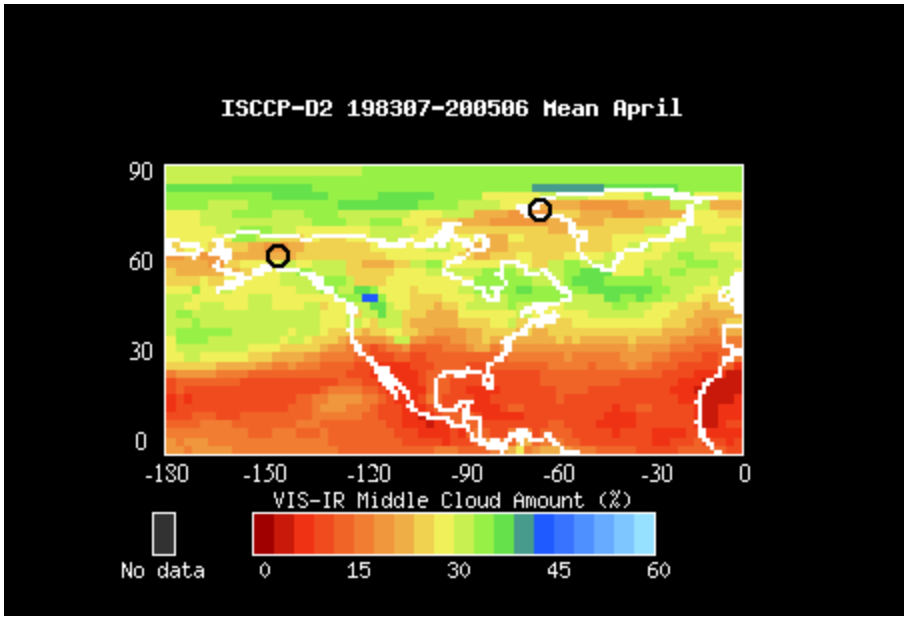
Many Overpasses Each Day

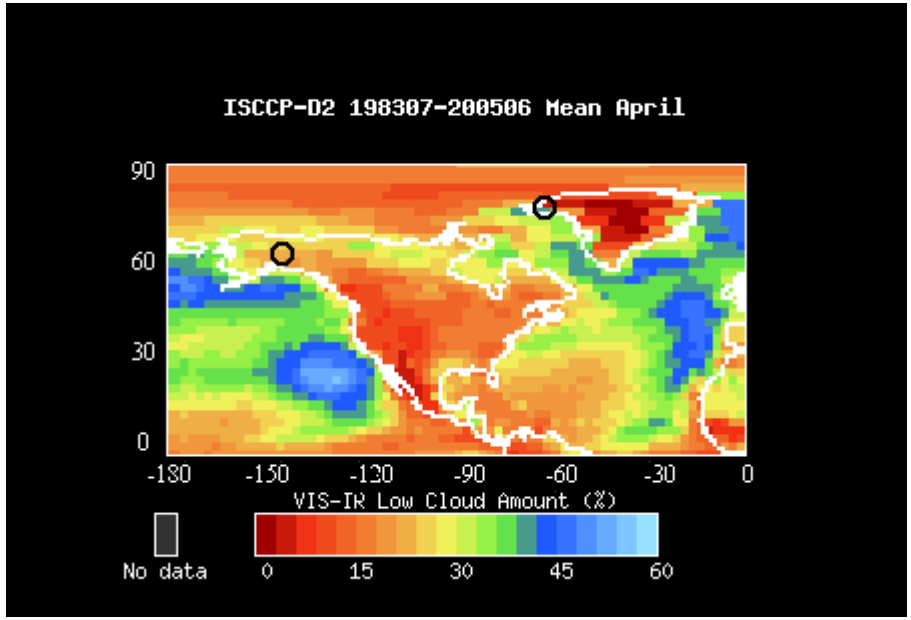


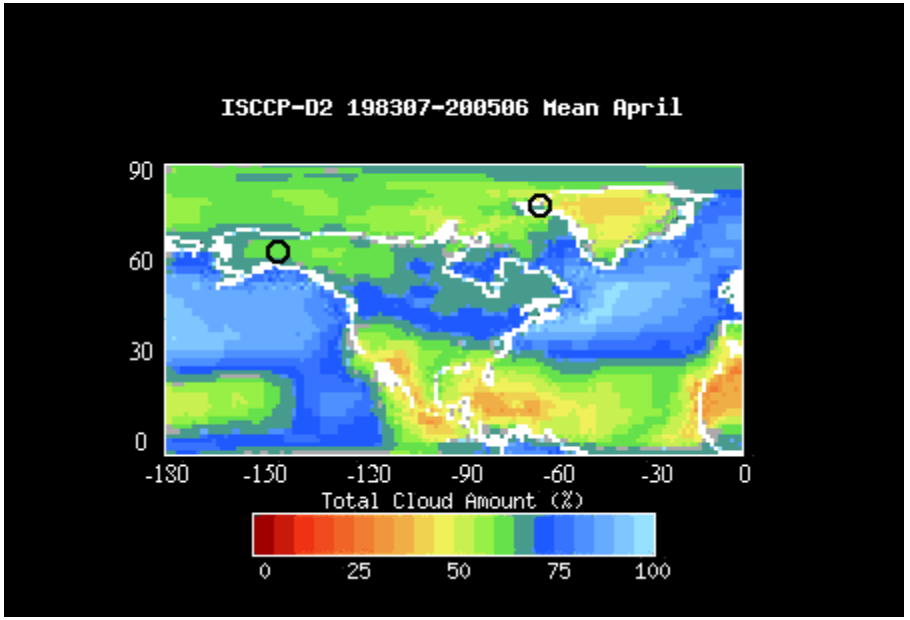
CALIPSO ORBIT OVER 2 DAYS (M. Capderou/Ixion)

April Cloud Cover







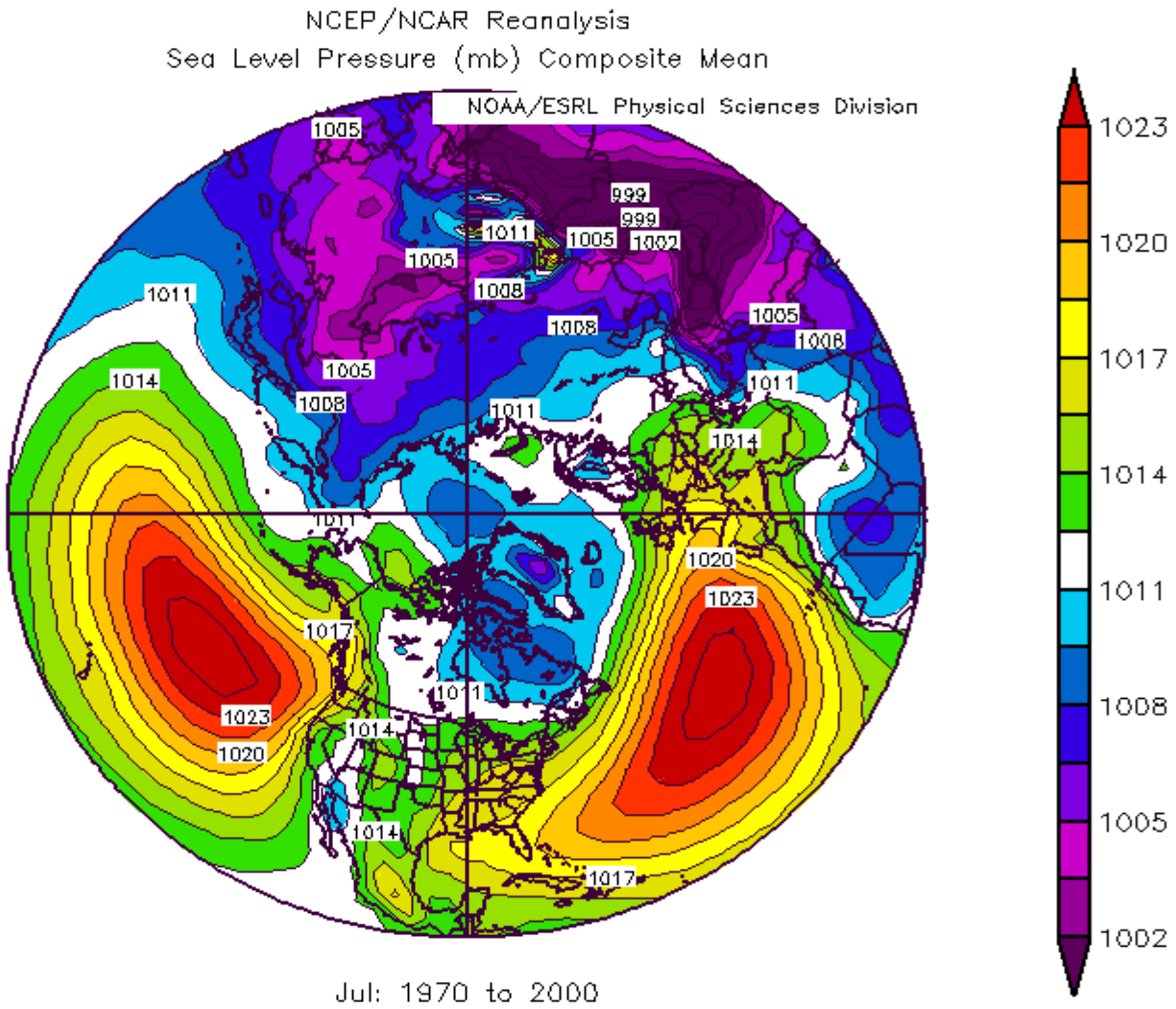


ARCTAS-SUMMER

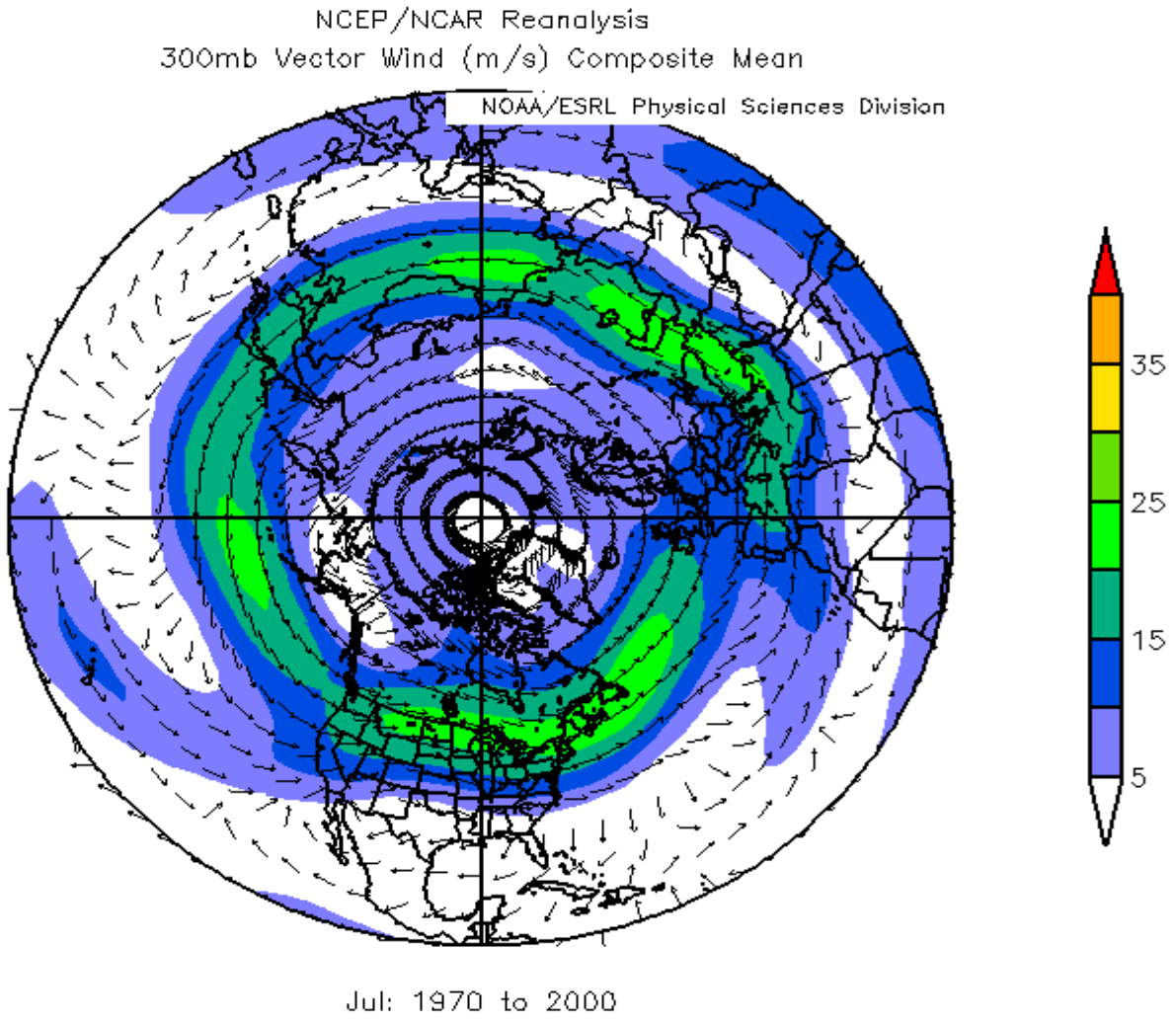
Weather on the Ground--July

	Avg Max (deg F)	Avg Min (deg F)	Avg Precip (inches)
Cold Lake	73.2	51.6	3.31
Thule	46.0	38.0	0.70
Fairbanks	73.0	51.9	1.73
Barrow	46.5	34.3	0.87

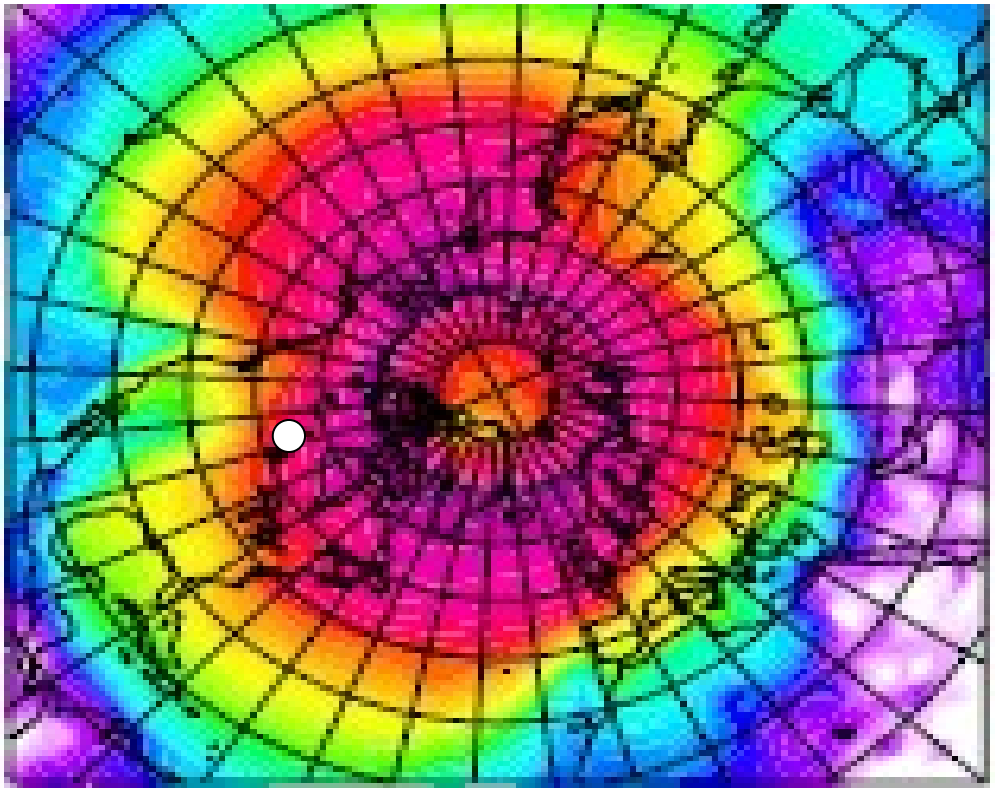
July Sea Level Pressure



July Mean 300 mb Winds



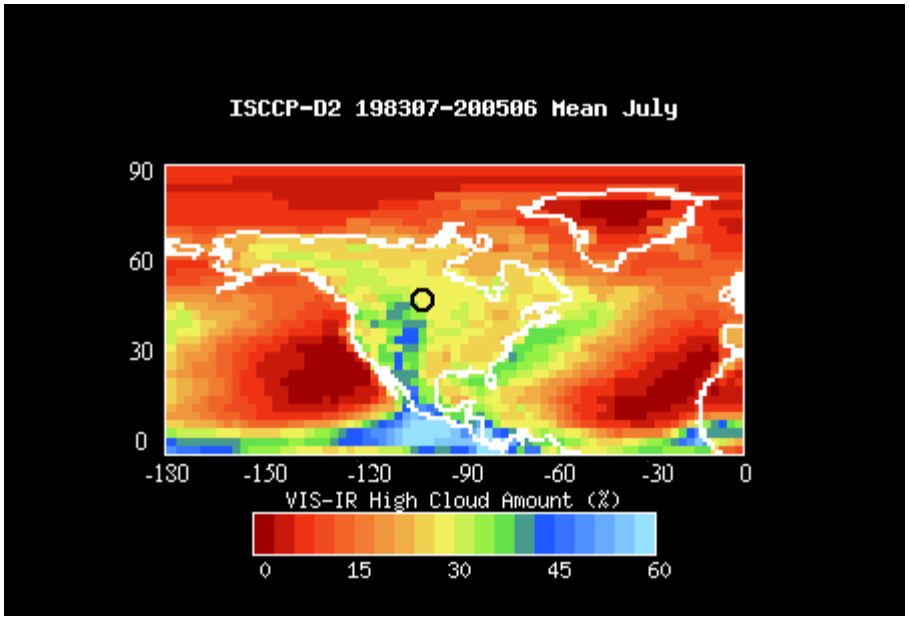
Preferred Path to Arctic--Summer

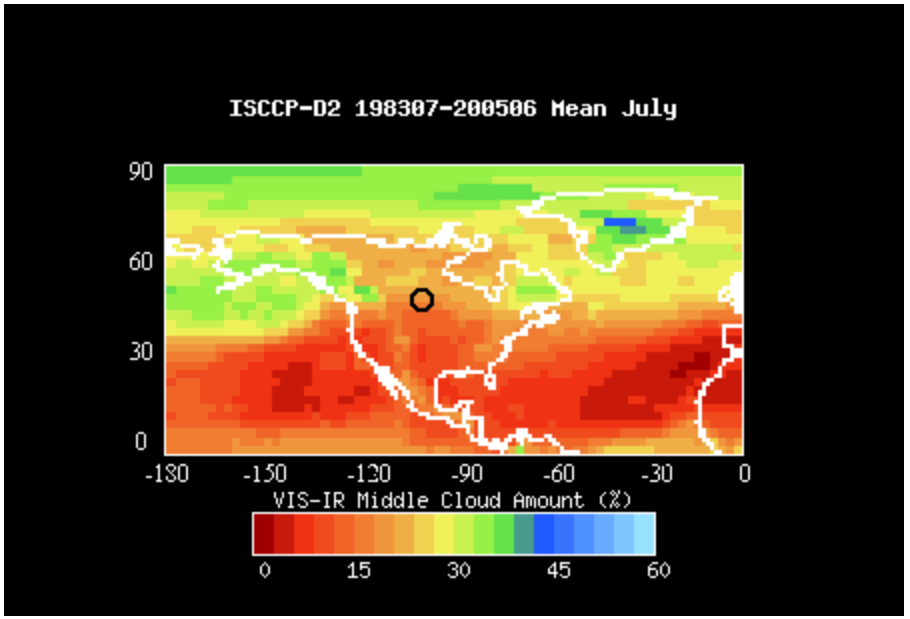


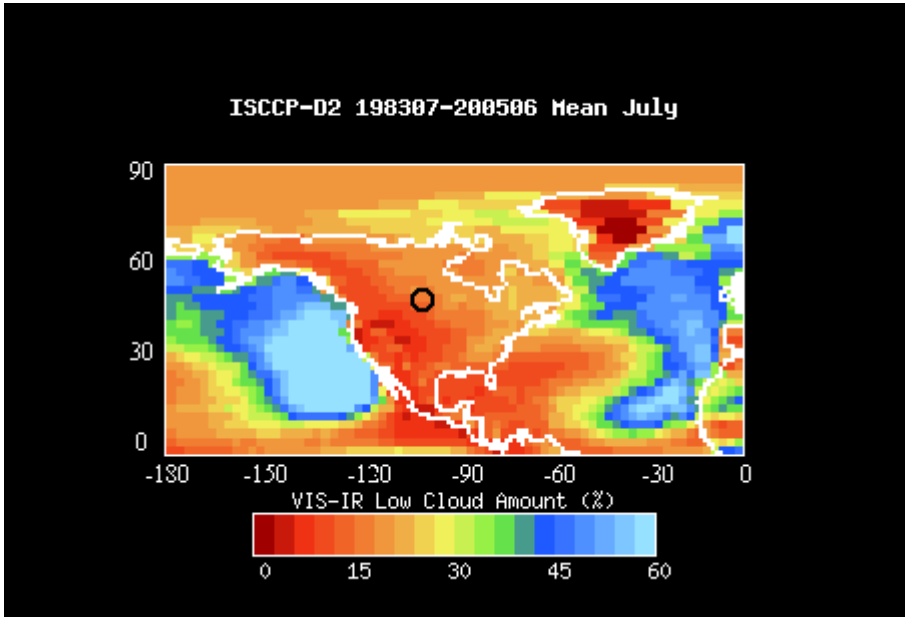
- Preferred paths over oceans
- Weakening of Aleutian and Icelandic lows
- Monsoonal low over Asia

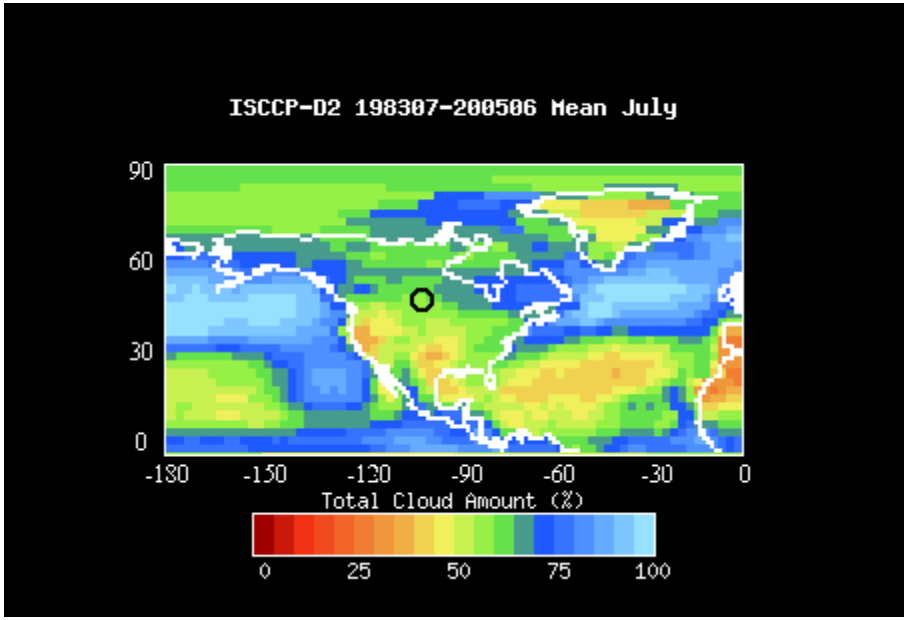
Stohl, JGR, 2006

July Cloud Cover



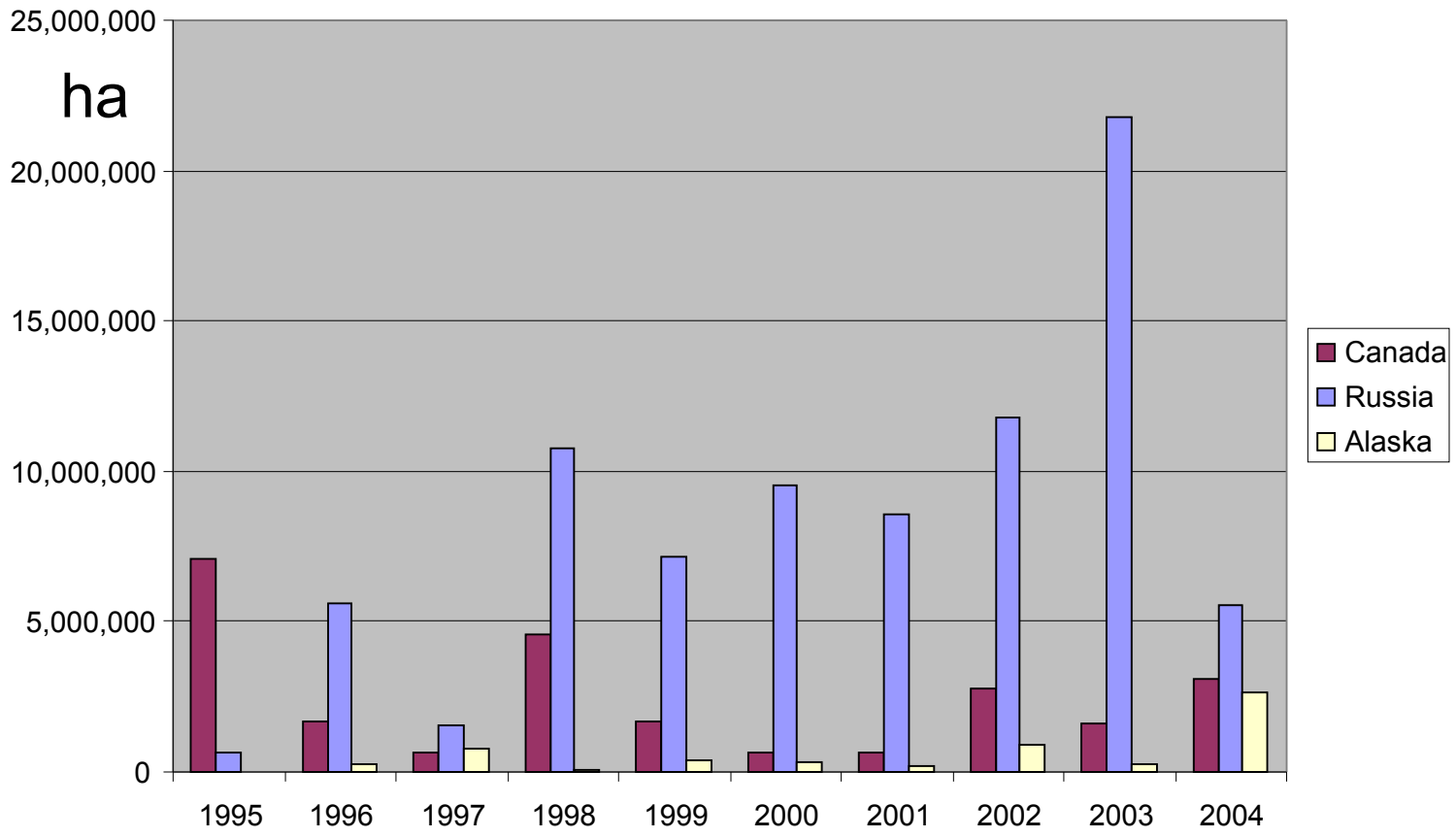




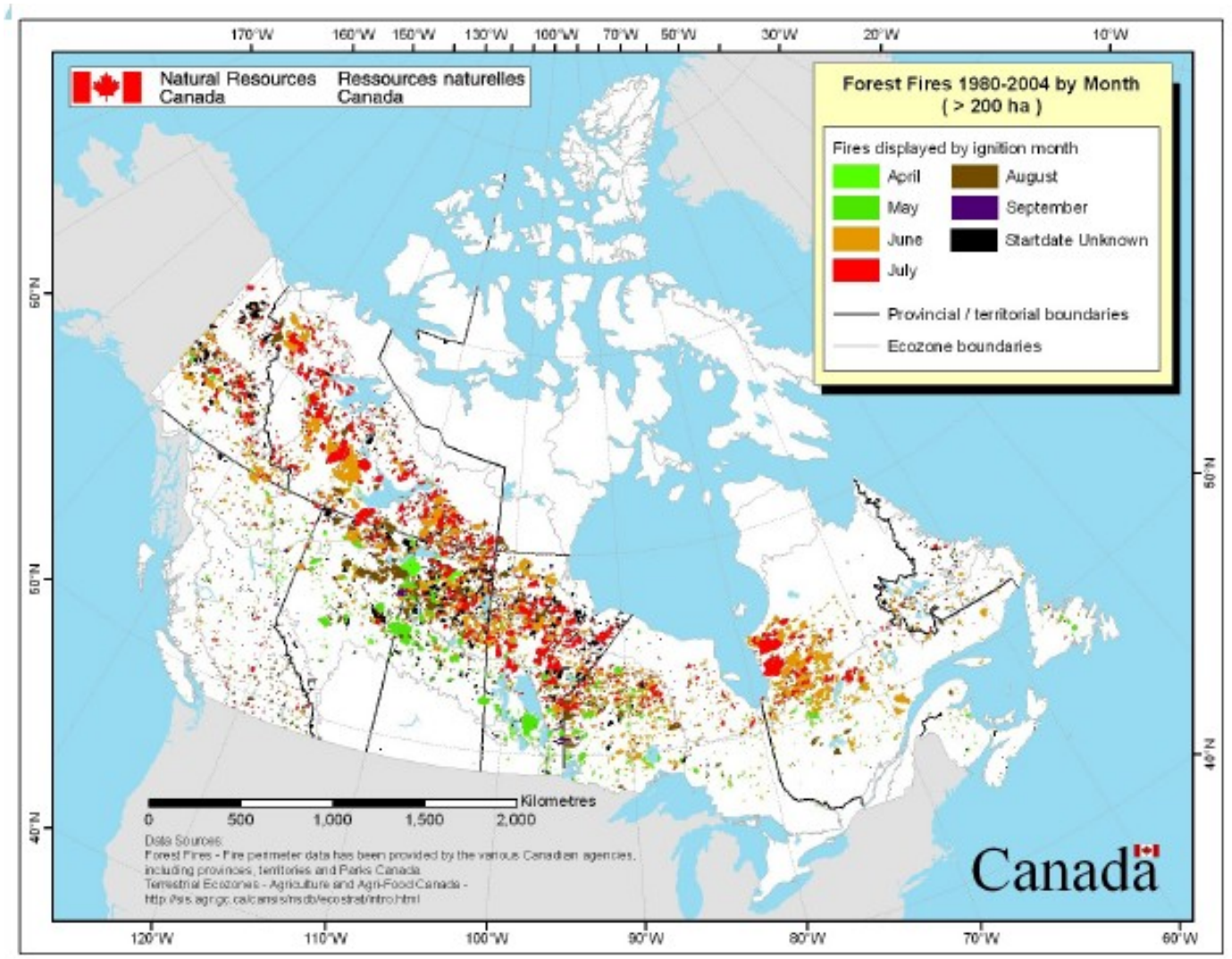


Boreal Forest Fires

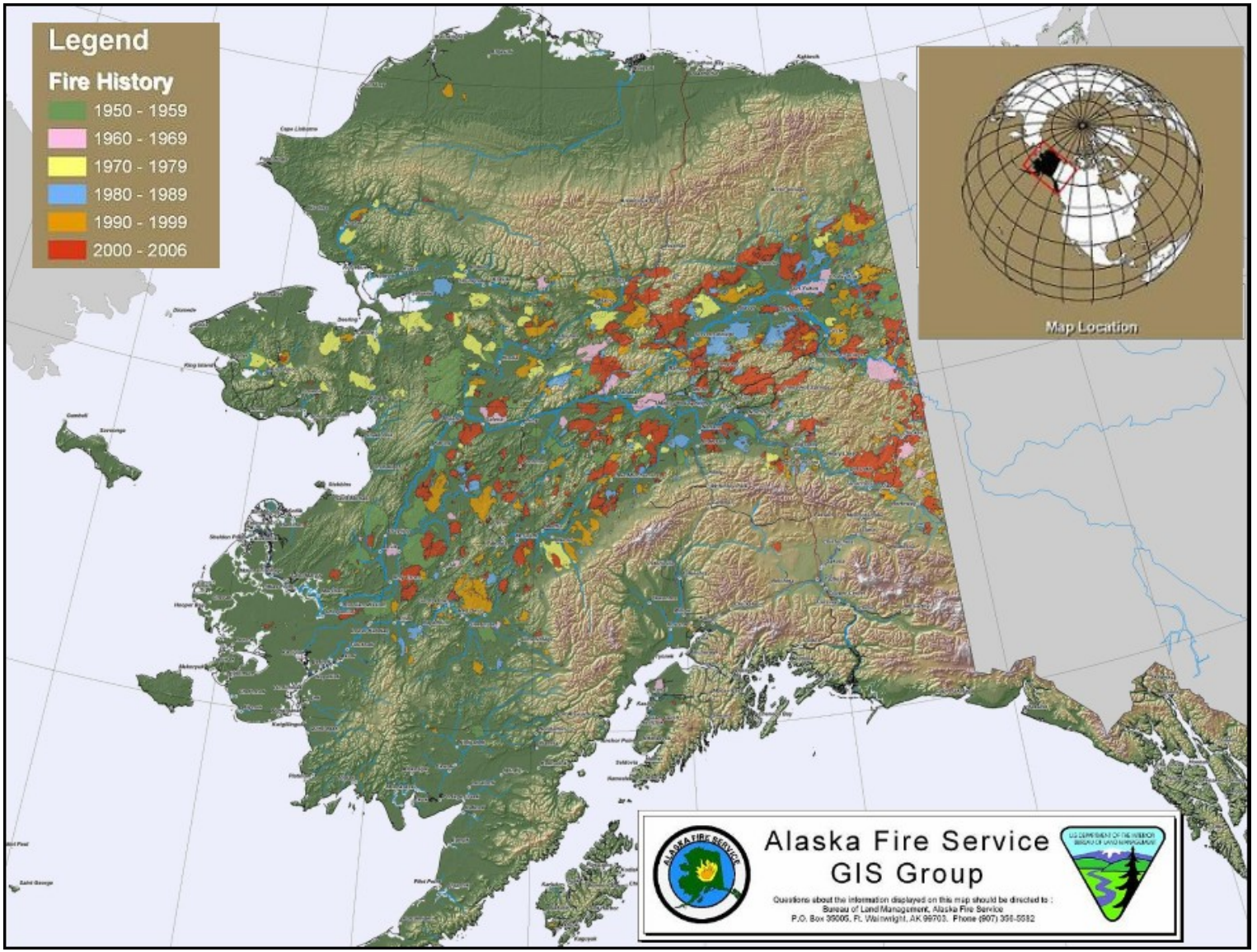
Annual Areas Burned



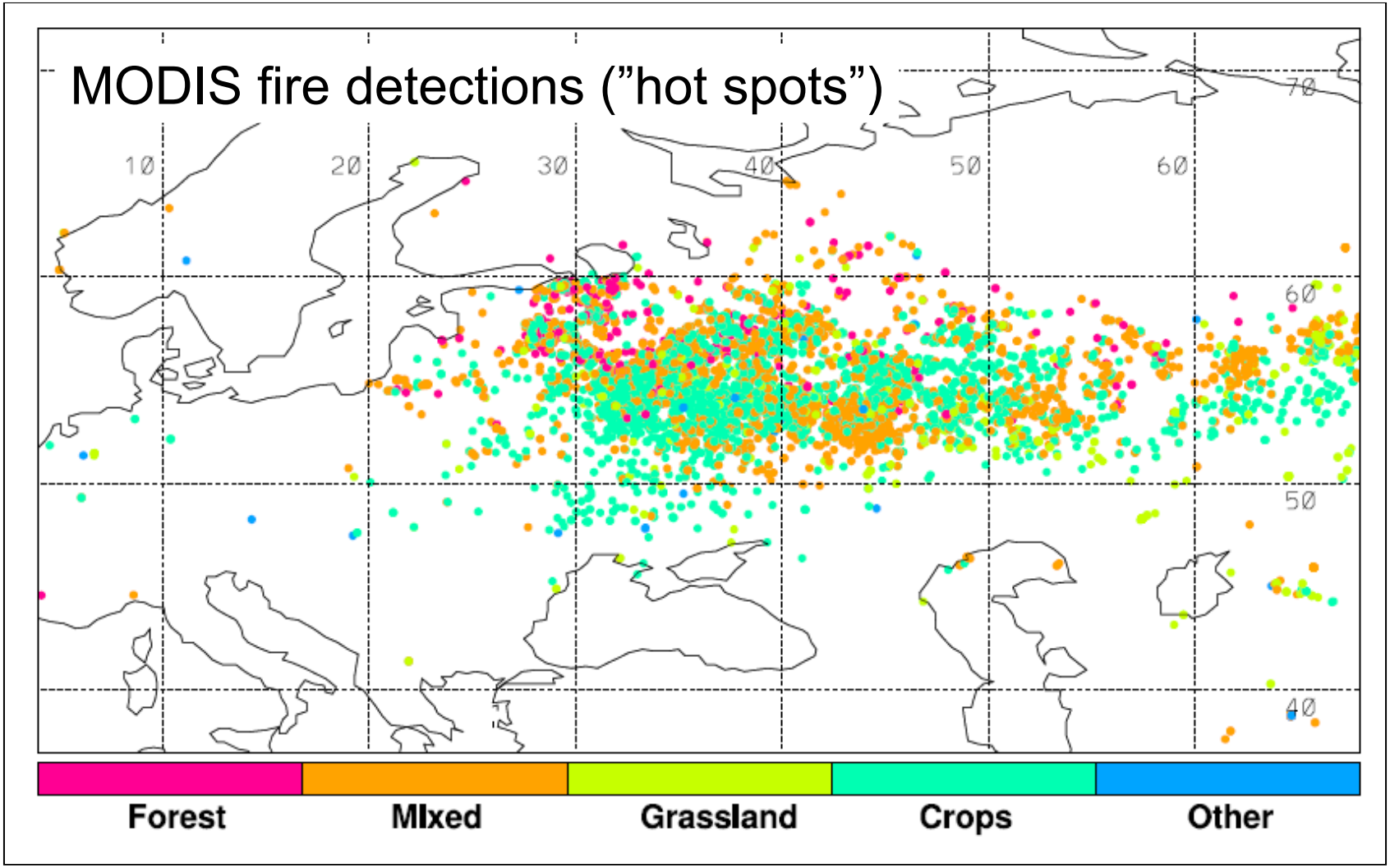
Canadian Fires by Month (1980-2004)



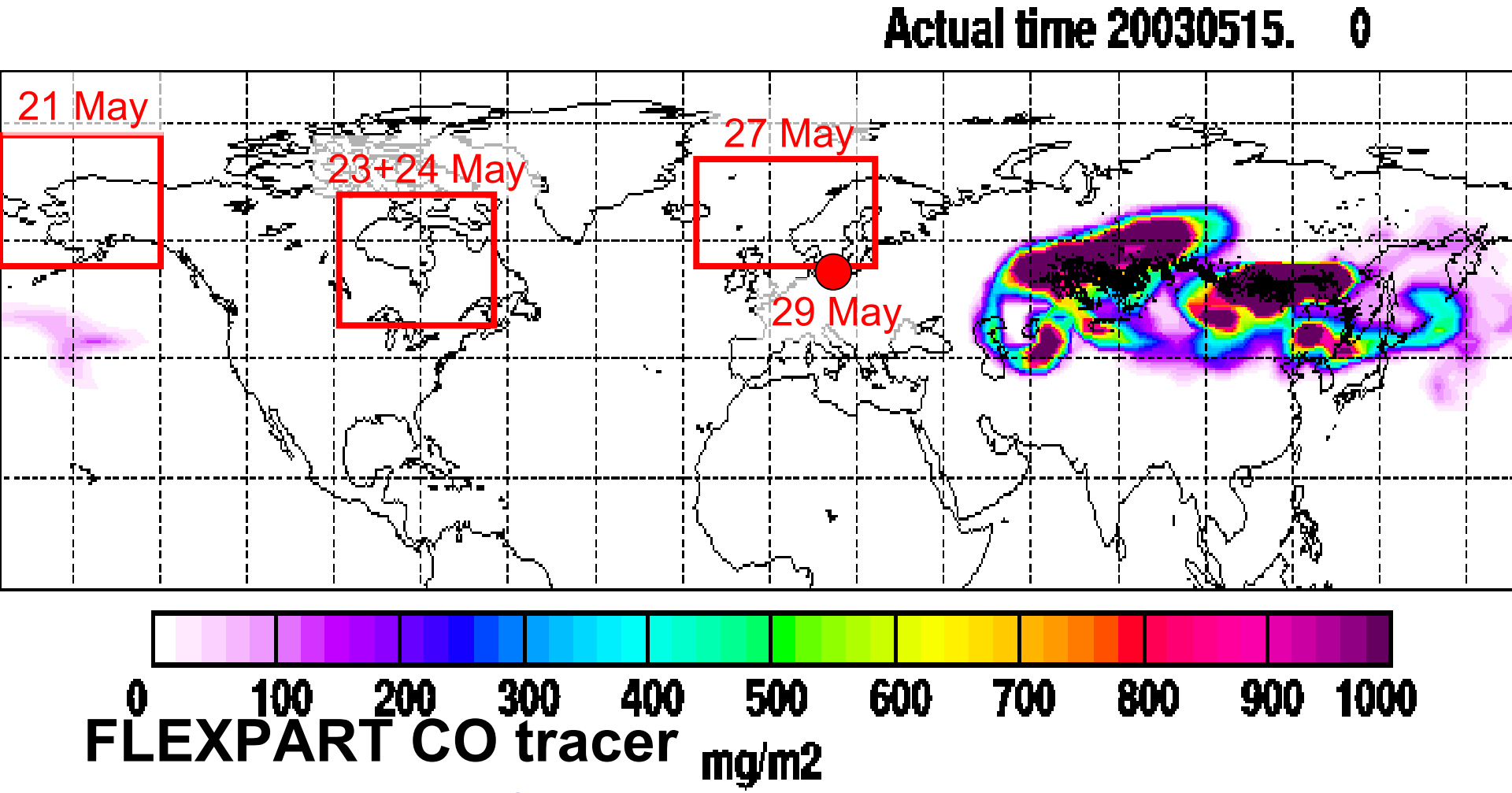
Alaskan Fires 1950-2006



Fires in Eastern Europe
April / May 2006



Around the World in 17 Days—Forest Fire Smoke from Russia

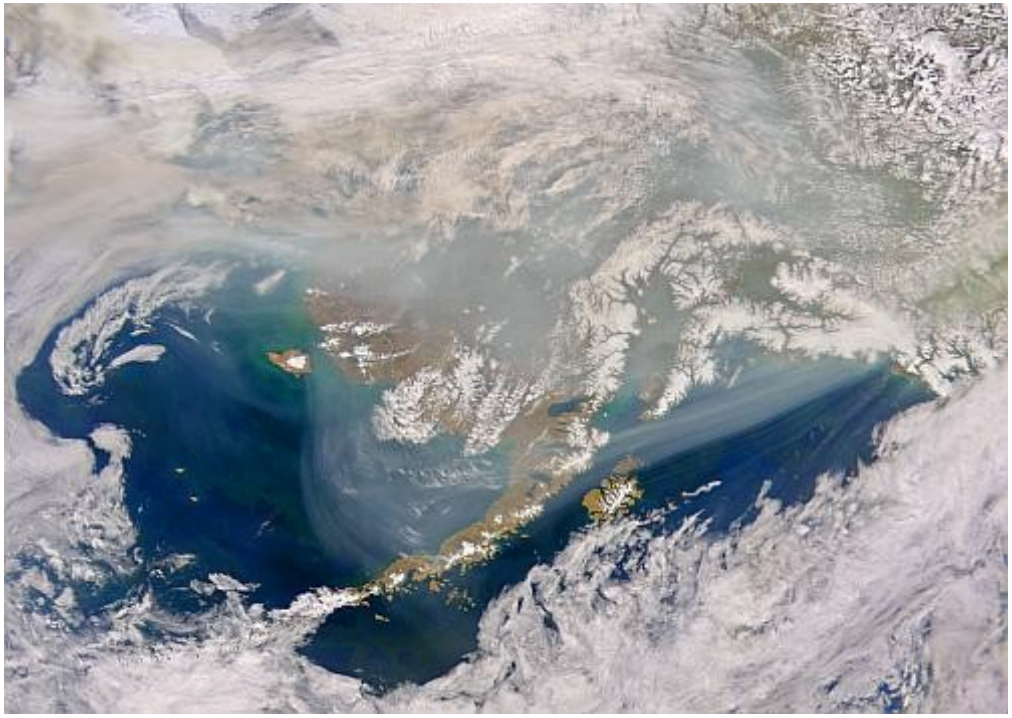


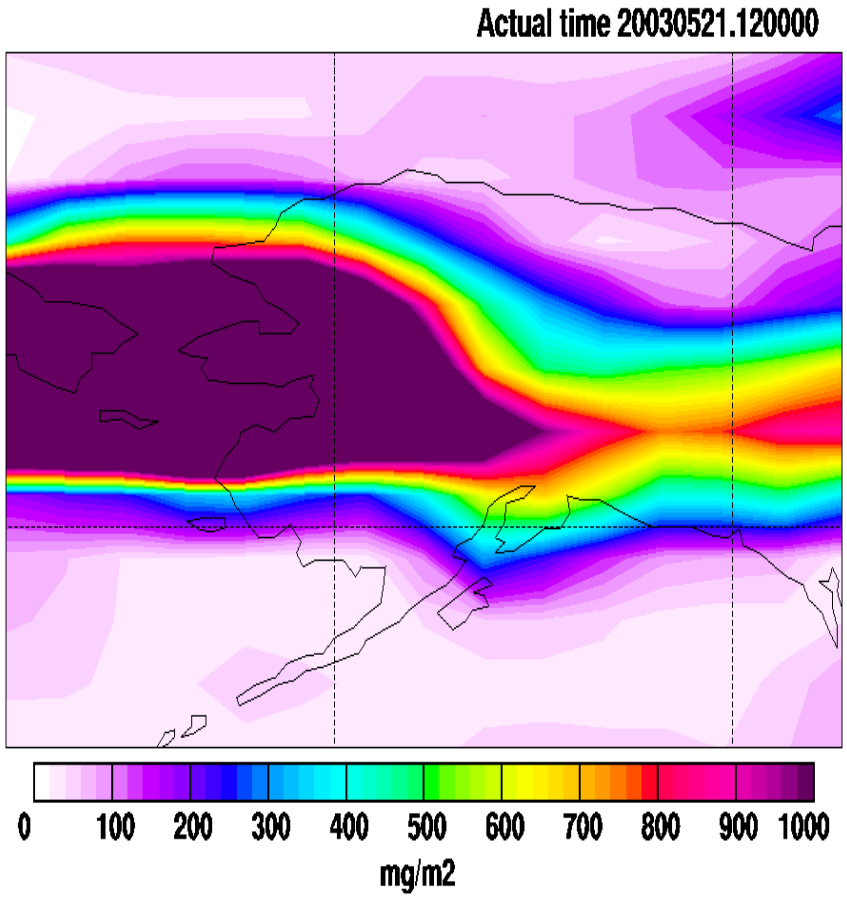
Damoah et al. (2004): ACP **4**, 1311-1321

Day 8--21 May--Alaska

FLEXPART Tracer

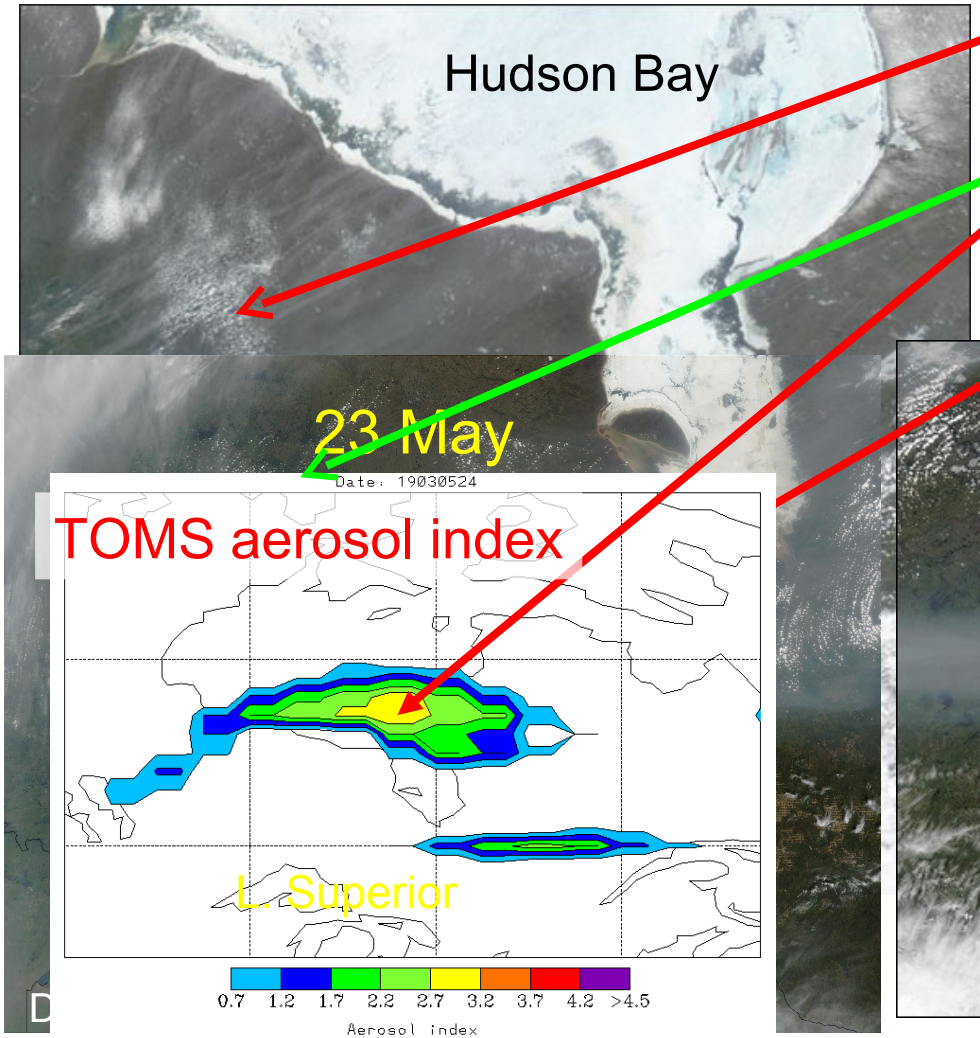
SeaWiFS Image

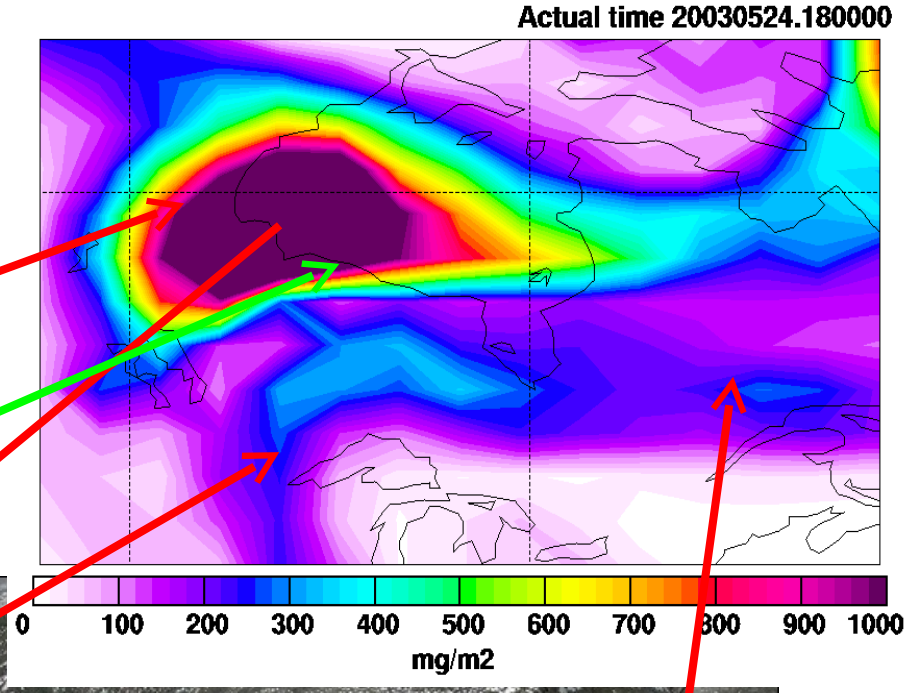


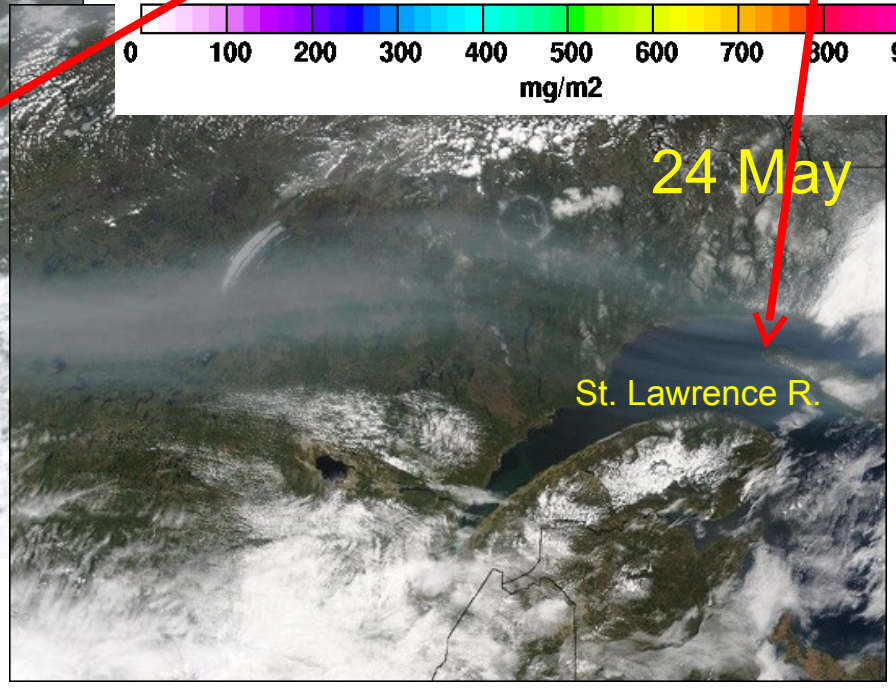


Day 11-12---23-24 May---Canada

MODIS Image

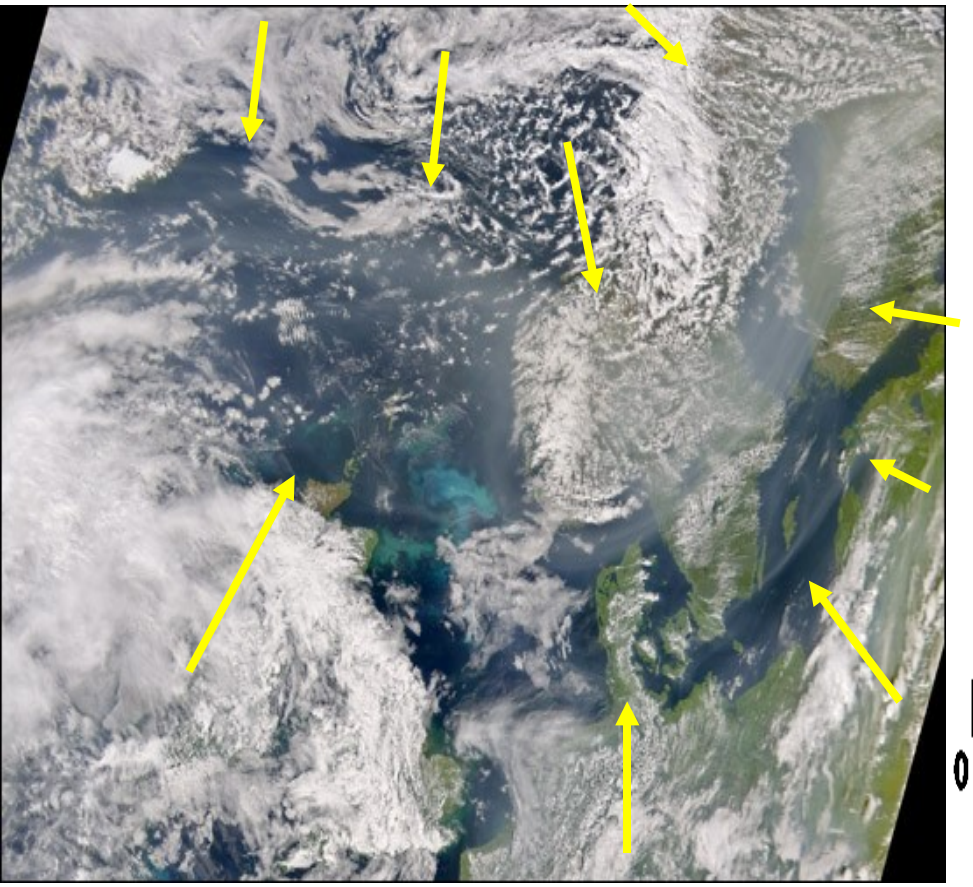




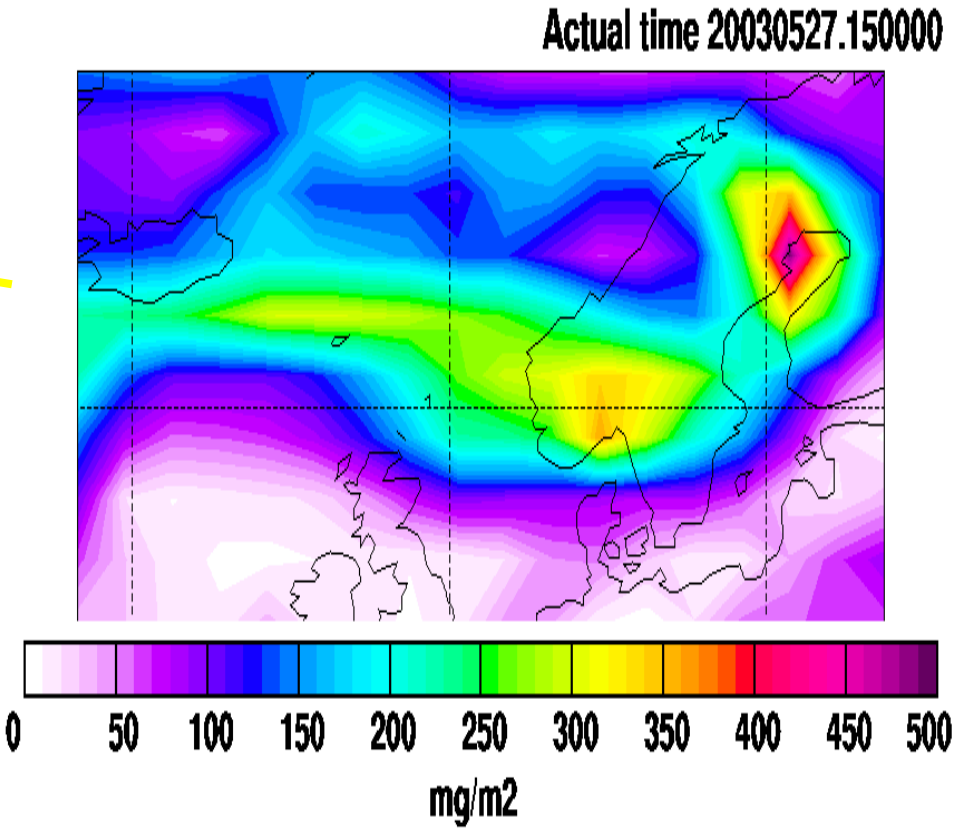


Day 14--27 May---Scandinavia

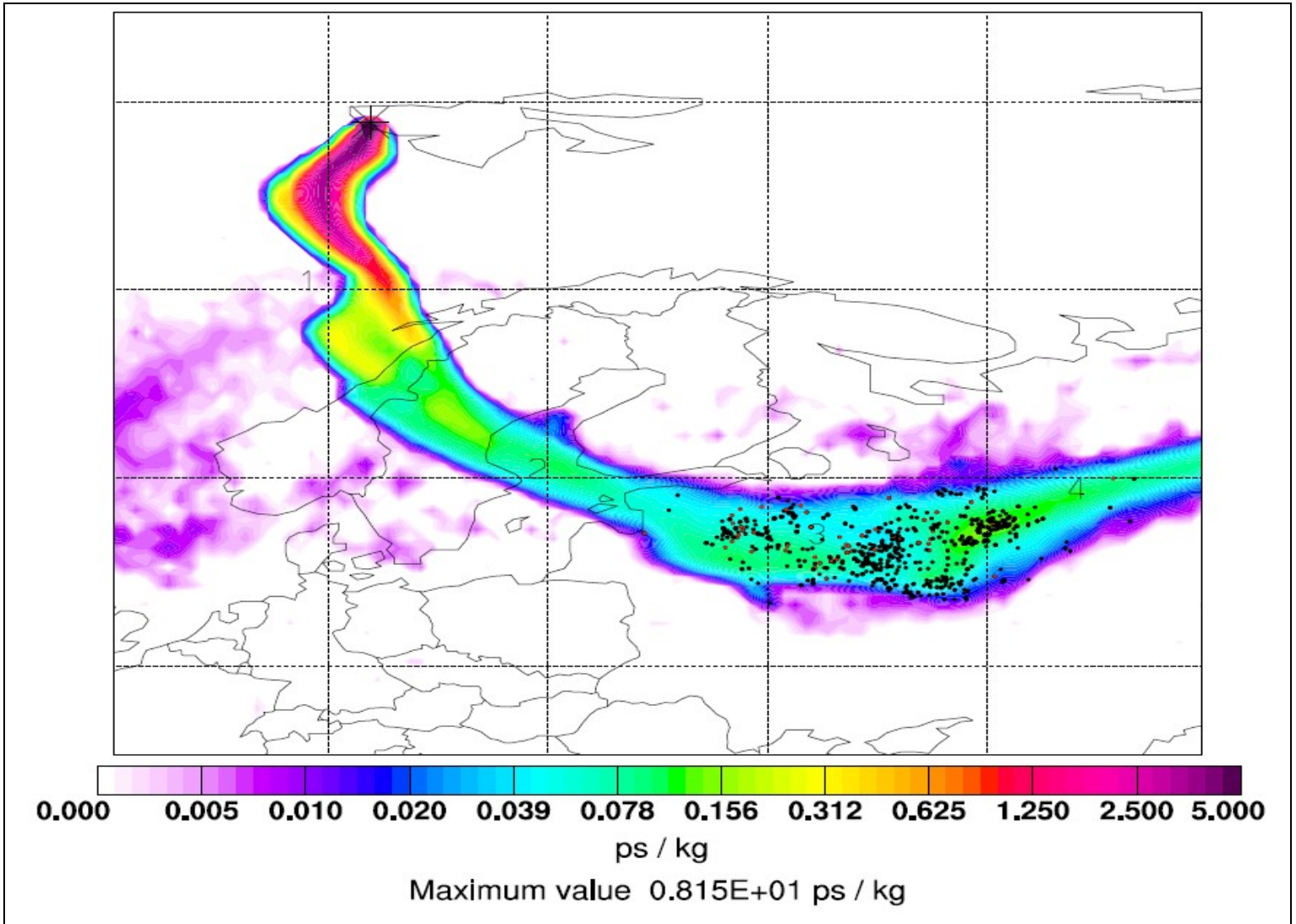
SeaWiFS Image



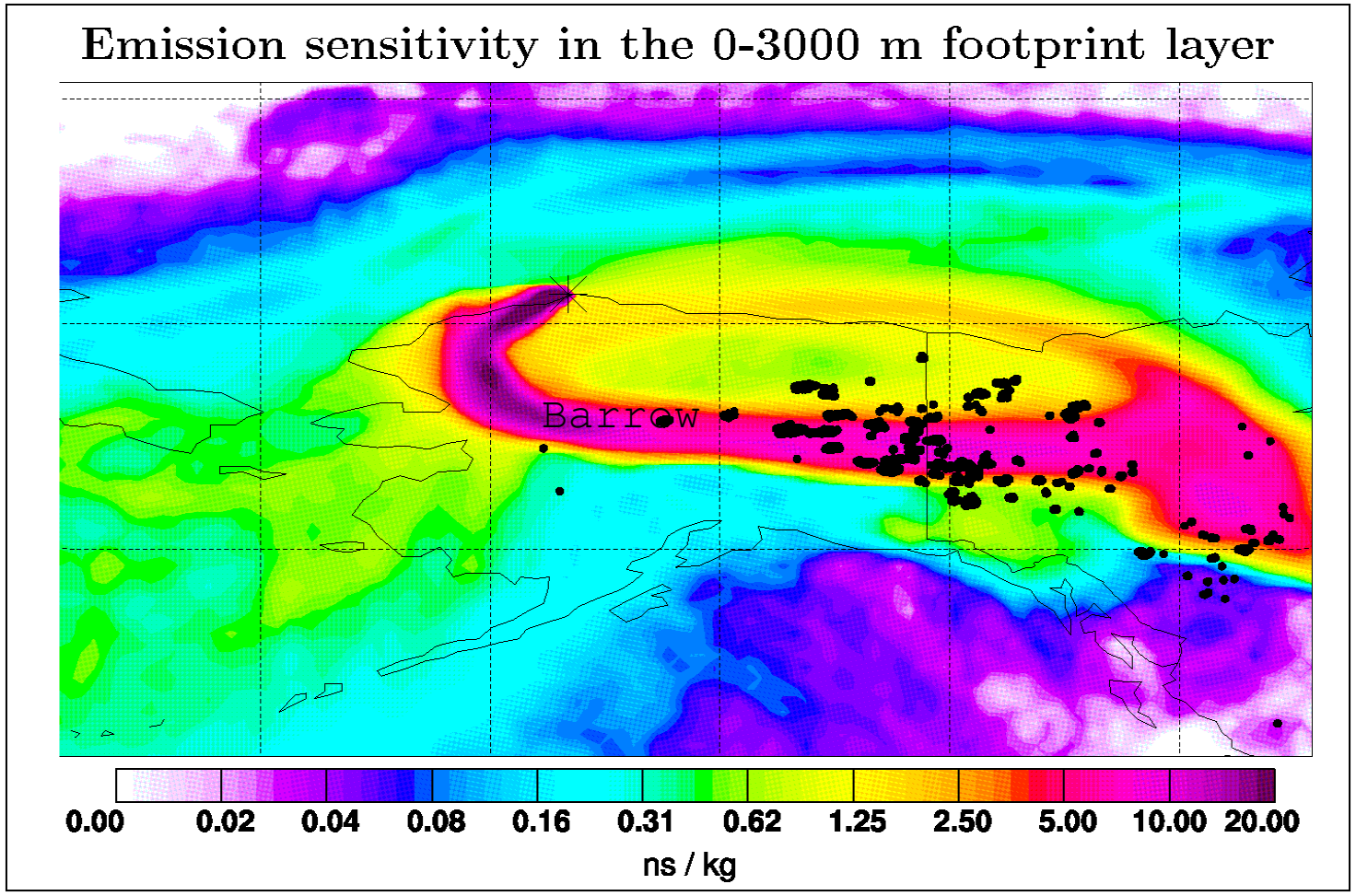
FLEXPART Tracer



Transport of Biomass Burning Emissions to the European Arctic



Backward Simulation from Barrow

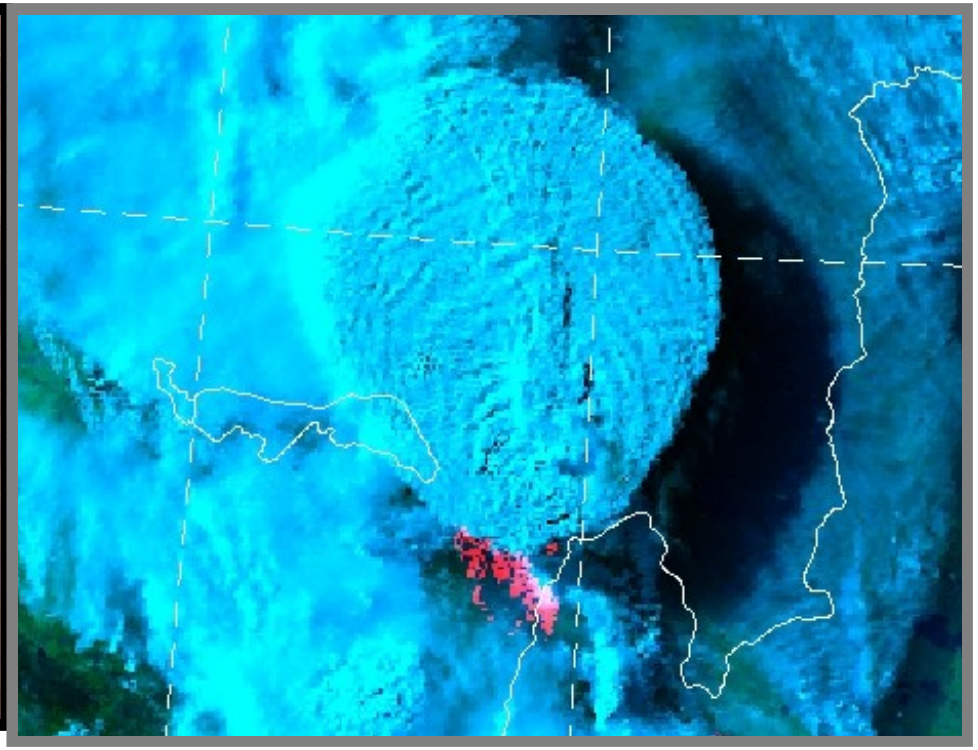


Pyro-Cumulonimbus

Mike Fromm

The Chisholm (Alberta) PyroCb

28 May 2001



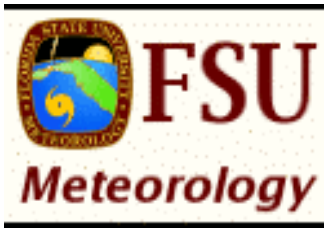
Mike Fromm

ARCTAS Will Be An Exciting Experiment !!

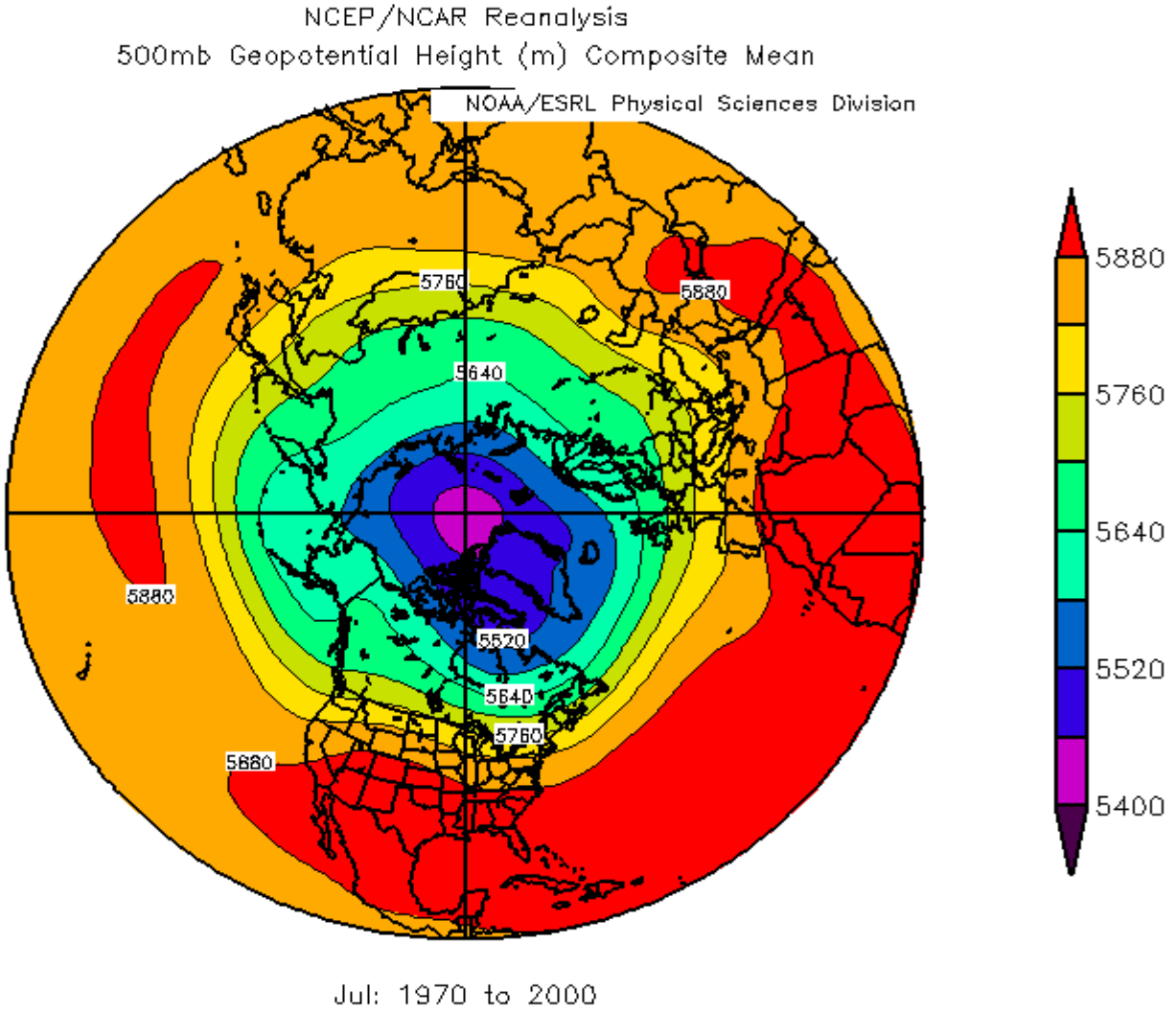
Our Hero !

The End

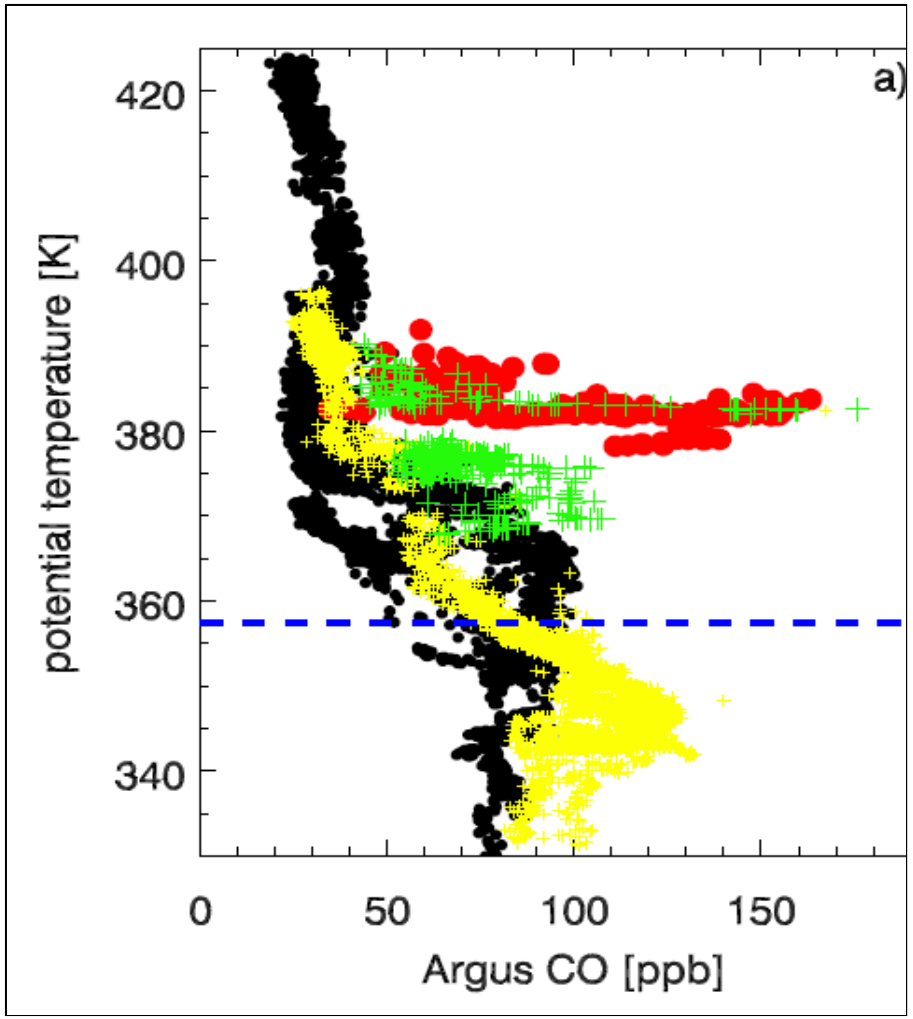
Questions ?



July Mean 500 mb Heights



Boreal Forest Fires Pollute the Stratosphere



Enhanced CO at 15.4 km, 1.3 km above trop

Tropopause

Yellow/black are background air

First in-situ measurements—2 flight days

Jost, Drdla, Stohl et al., *GRL* **31**, L11101, 2004.