Pan-Arctic Study of the Coupled Tropospheric, Stratospheric and Mesospheric Circulation

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3: National Institute of Information and Communications Technology,
4: North West Research Associates

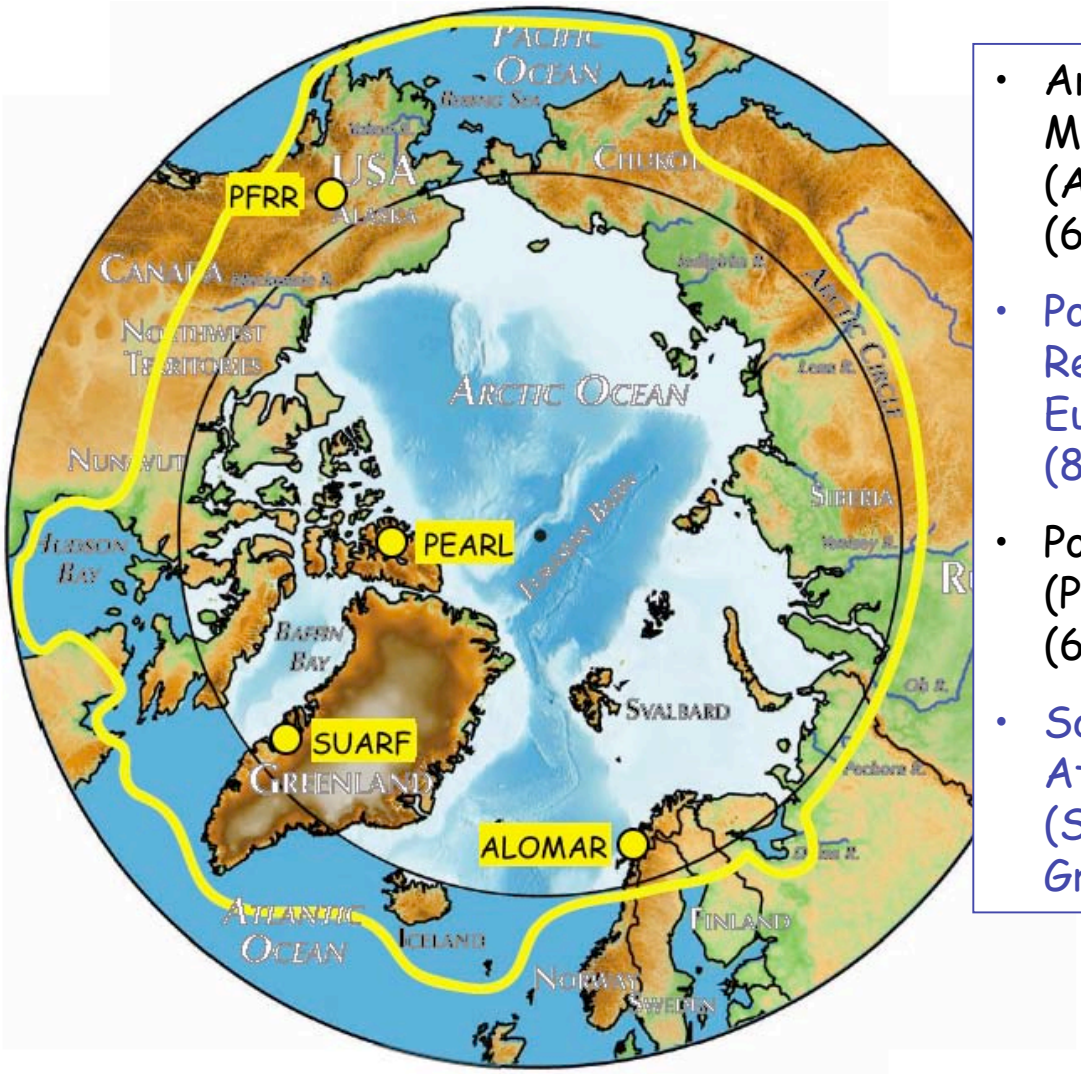
Scientific Goals

- To conduct an aeronomical study of the Arctic atmosphere that uses observations, modeling and theoretical interpretation to document 3-D structure and evolution of the Arctic vortex and anticyclones with emphasis on vortex-vortex interactions and stratospheric warming/mesospheric cooling events during IPY.
- To determine our ability to forecast weather events in the troposphere based on observations and analyses of the mesosphere and stratosphere.
- To study the coupling between anomalous stratospheric weather and tropospheric modes of variability during IPY.

Data and Measurements

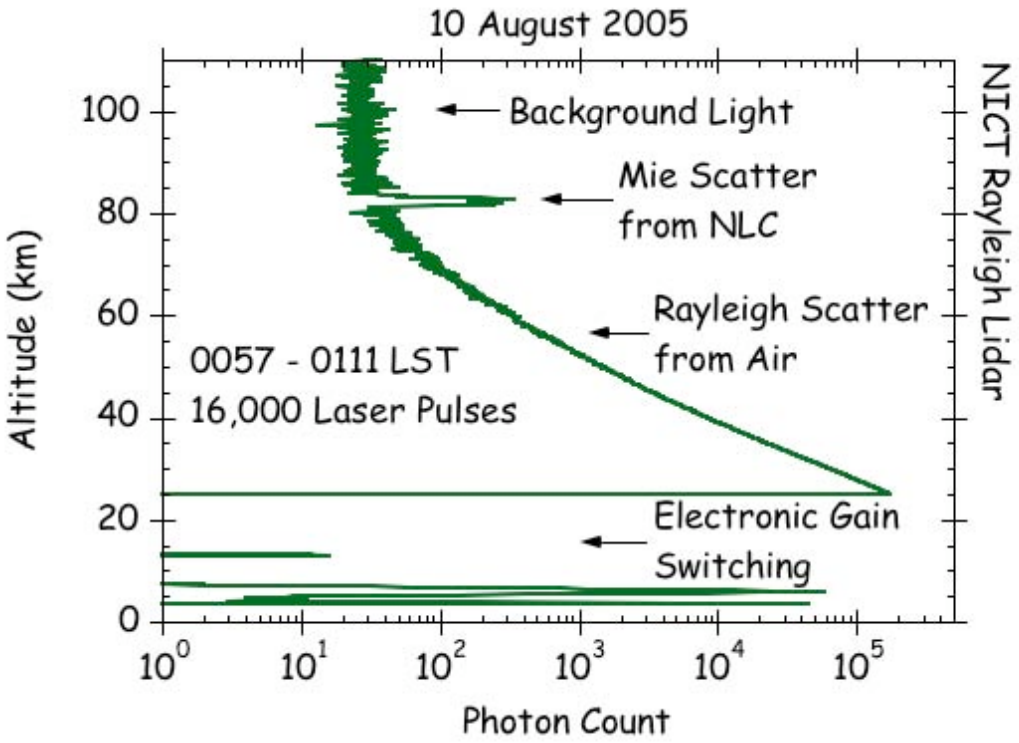
- High-resolution Rayleigh lidar temperature measurements (~ 1 km, 10's of minutes) of the stratosphere and mesosphere (~40-80 km).
- Meteorological analyses from national meteorological offices consisting of daily 3-D fields of temperature, geopotential height, and horizontal winds.
- Temperature, geopotential height, carbon monoxide (CO), and water vapor data from the EOS Microwave Limb Sounder (MLS) instrument (Aura), the Atmospheric Chemistry Experiment (ACE) instrument (SCISAT-1) the Sounding of the Atmosphere using Broadband Emission Radiometry (SABER) (TIMED).
- Focused on wintertime and springtime observations in 2007-2008 and 2008-2009.

Site Locations



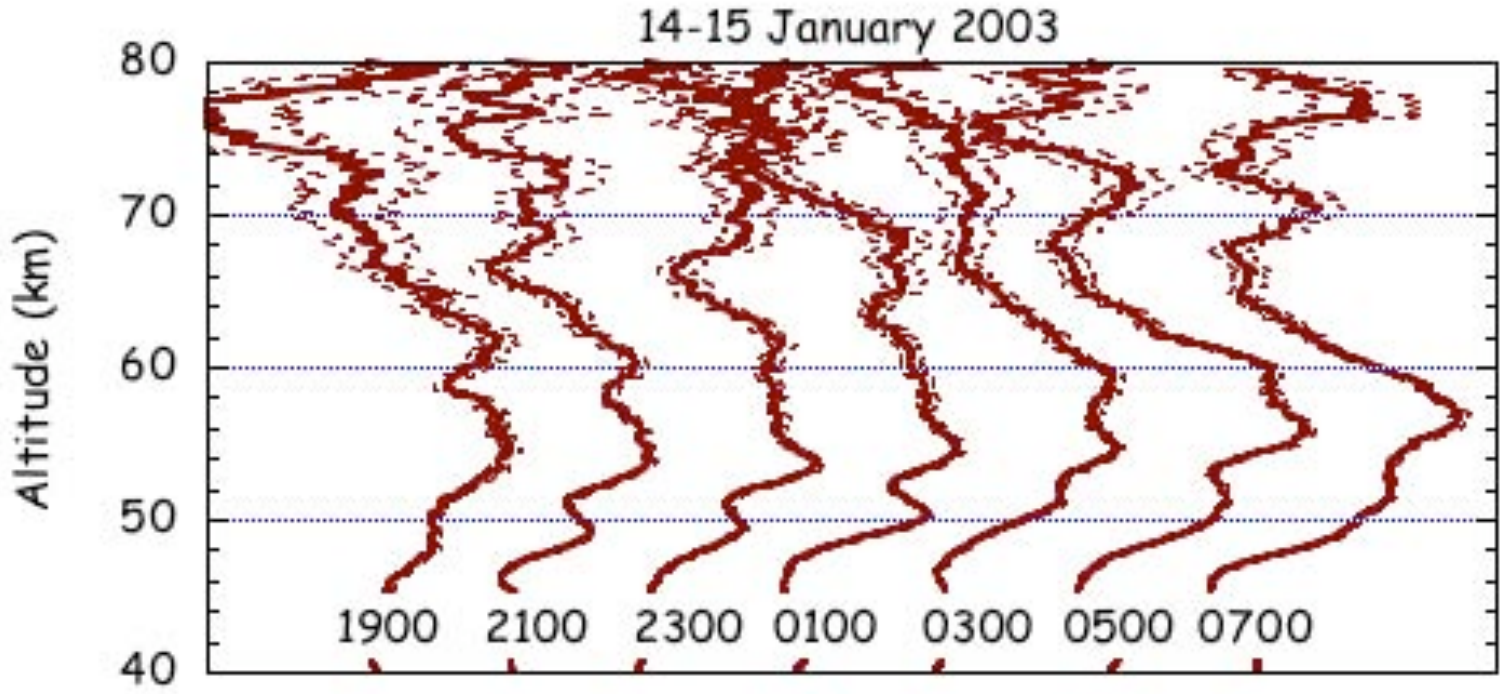
- Arctic Lidar Observatory for Middle Atmosphere Research (ALOMAR), Andoya, Norway (69° N, 16° E).
- Polar Environment Atmospheric Research Laboratory (PEARL), Eureka, Nunavut, Canada (80°N, 86°W).
- Poker Flat Research Range (PFRR), Chatanika, Alaska, USA (65° N, 147° W).
- Sondrestrom Upper Atmospheric Research Facility (SUARF), Kangerlussuaq, Greenland (67° N, 51° W).

Rayleigh Lidar Technique



Rayleigh lidar measures the echo from atmosphere and then employs hydrostatic equilibrium to determine temperature profile from Rayleigh scatter. An initial temperature estimate is used as a seed at the up most altitude.

Rayleigh Lidar Temperature Measurements



The lidar measurements yield sequences of temperature (and density) profiles for studies of waves and tides in the middle atmosphere. The resolution of the measurements can be adapted to optimize measurements at different altitudes.

Rayleigh Lidar Trends

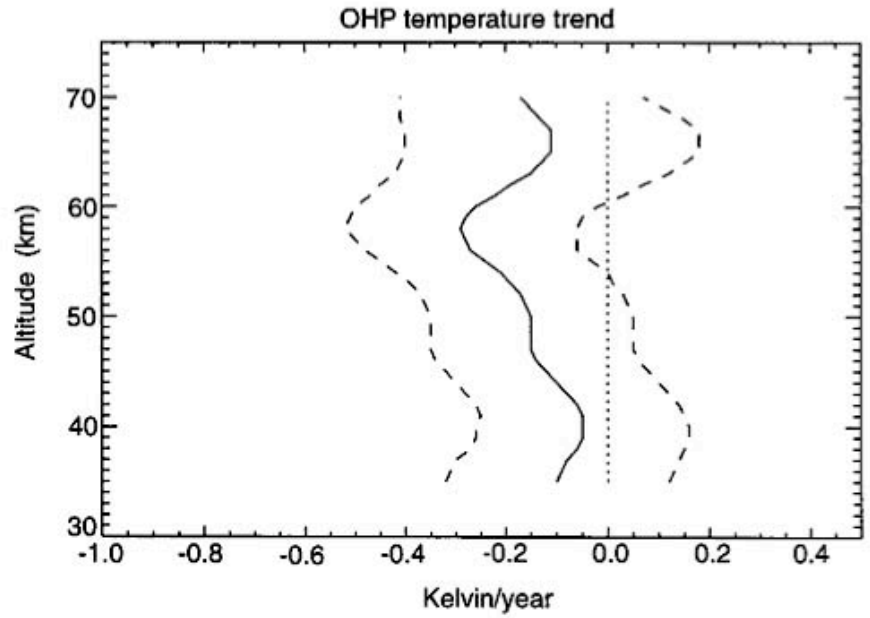


Figure 6. Trend (K/year) from the all-seasons lidar record at Haute Provence, France (44°N, 6°E), over the period 1979–1998. The solid curve denotes the estimated mean, while the dashed curves denote the 2-σ uncertainties. Updated from *Keckhut et al.* [1995].

Rayleigh lidar observations at Haute Provence indicate statistically significant long-term cooling of the middle atmosphere over 19 years.

STRATOSPHERIC TEMPERATURE TRENDS: OBSERVATIONS AND MODEL SIMULATIONS

V. Ramaswamy,[1] M.-L. Chanin,[2] J. Angell,[3] J. Barnett,[4] D. Gaffen,[3] M. Gelman,[5] P. Keckhut,[2] Y. Koshelkov,[2,6] K. Labitzke,[7] J.-J. R. Lin,[5] A. O'Neill,[8] J. Nash,[9] W. Randel,[10] R. Rood,[11] K. Shine,[8] M. Shiotani,[12] and R. Swinbank[9,13]

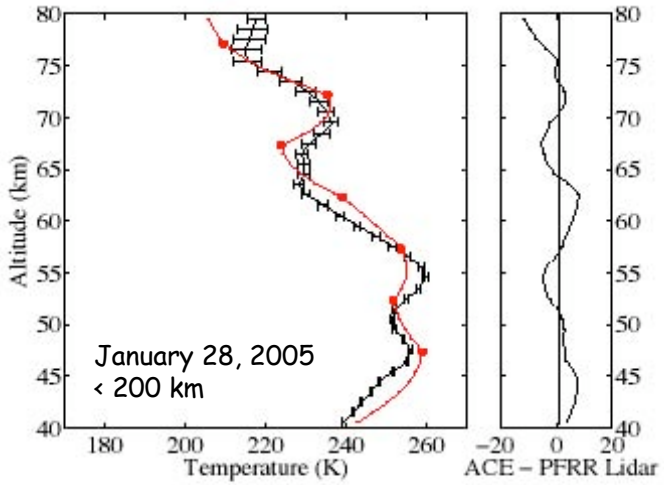
Rayleigh Lidar-Comparison with ACE

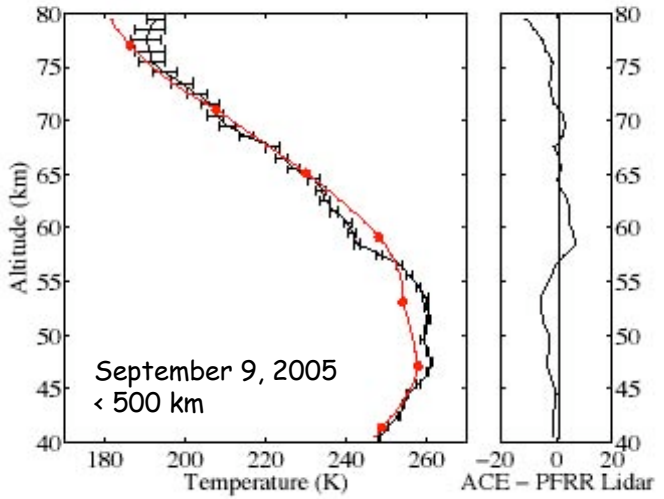
Atmos. Chem. Phys. Discuss., 7, 12463–12539, 2007
www.atmos-chem-phys-discuss.net/7/12463/2007/

Atmospheric Chemistry and Physics Discussions

Validation of the Atmospheric Chemistry Experiment (ACE) version 2.2 temperature using ground-based and space-borne measurements

R. J. Sica[1], M. R. M. Izawa[2], K. A. Walker[3,4], C. Boone[3], S. V. Petelina[5,6], P. S. Argall[1], P. Bernath[3,7], G. B. Burns[8], V. Catoire[9], R. L. Collins[10], W. H. Daffer[11], C. De Clercq[12], Z. Y. Fan[3], B. J. Firanski[13], W. J. R. French[8], P. Gerard[12], M. Gerding[14], J. Granville[12], J. L. Innis[8], P. Keckhut[15], T. Kerzenmacher[4], A. R. Klekociuk[8], E. Kyrö[16], J. C. Lambert[12], E. J. Llewellyn[5], G. L. Manney[17,18], I. S. McDermid[19], K. Mizutani[20], Y. Murayama[20], C. Piccolo[21], P. Raspollini[22], M. Ridolfi[23], C. Robert[9], W. Steinbrecht[24], K. B. Strawbridge[13], K. Strong[4], R. Stübi[25], and B. Thurairajah[10]

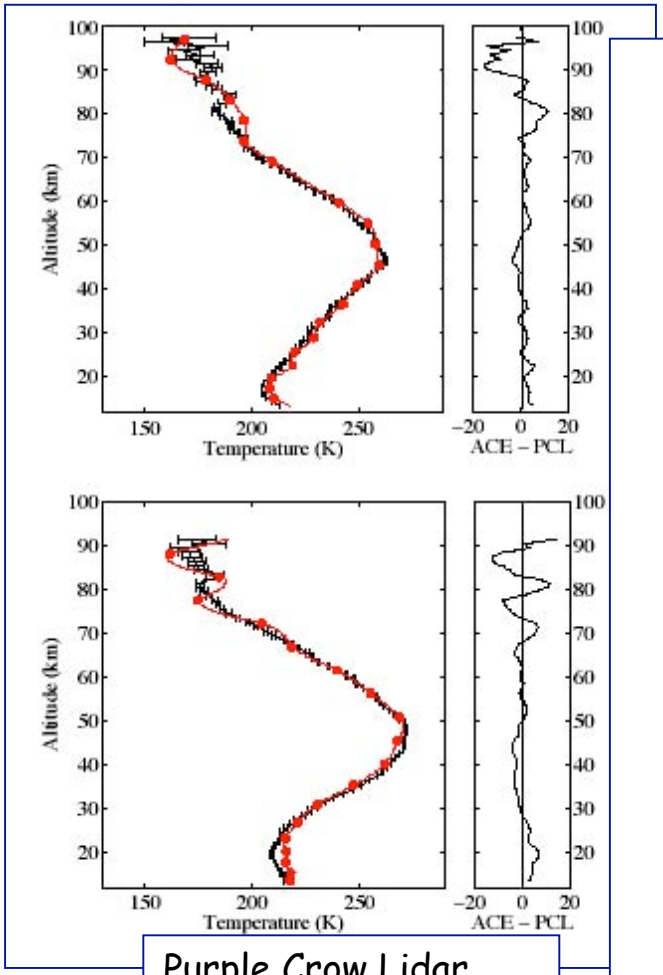




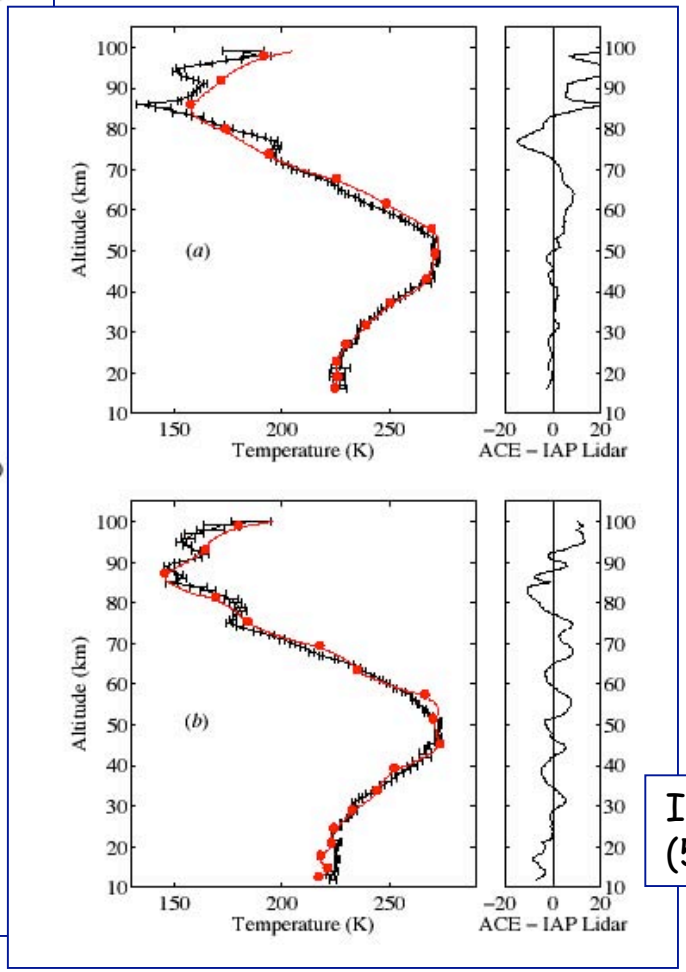
ACE-Lidar comparisons at NH high-latitude sites in early Fall/winter.

NICT Rayleigh Lidar (65.1°N, 147.5°W)

Rayleigh Lidar-Comparison with ACE



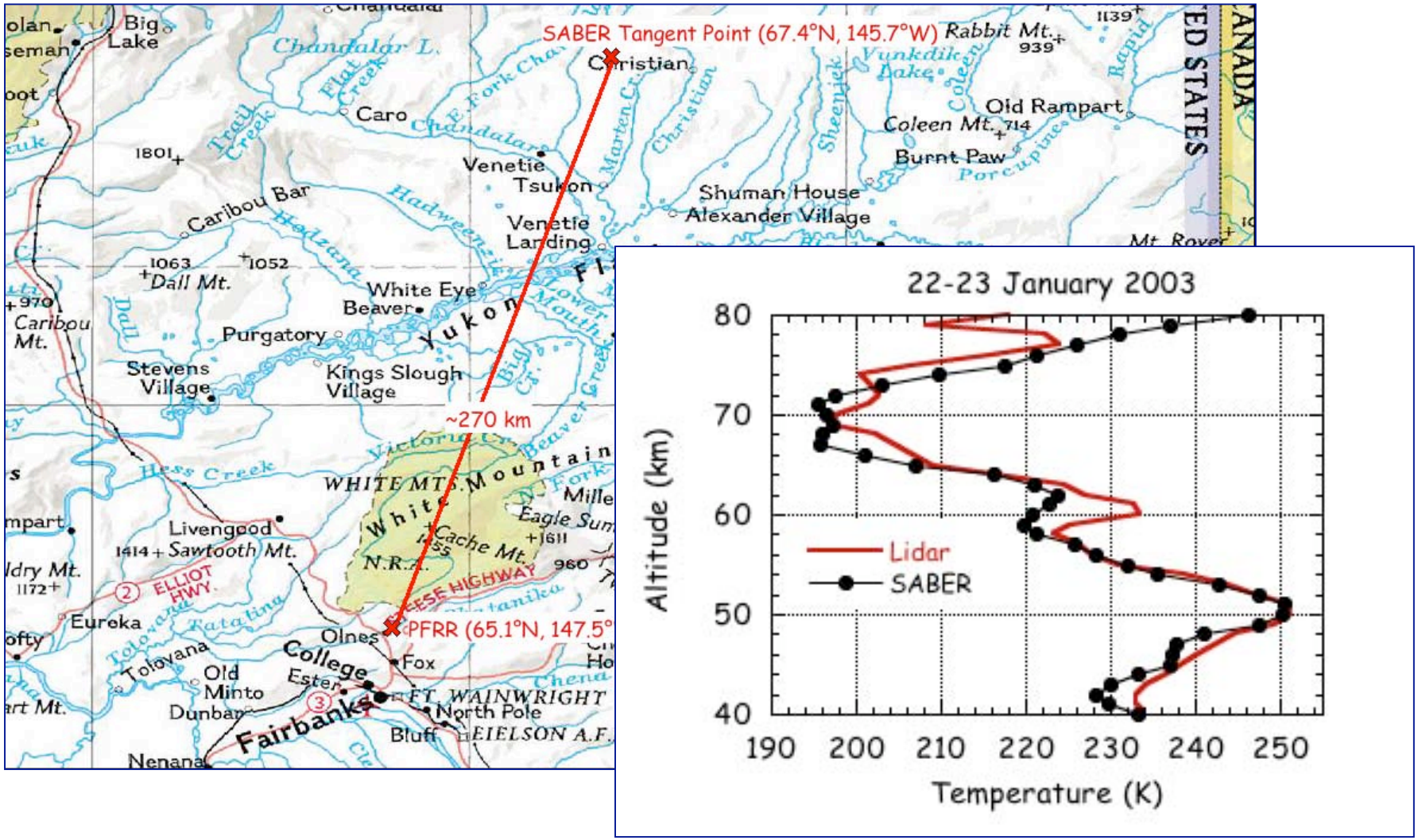
Purple Crow Lidar
(42.9°N, 81.4°W)



IAP Lidars
(51.4°N, 11.8°E)

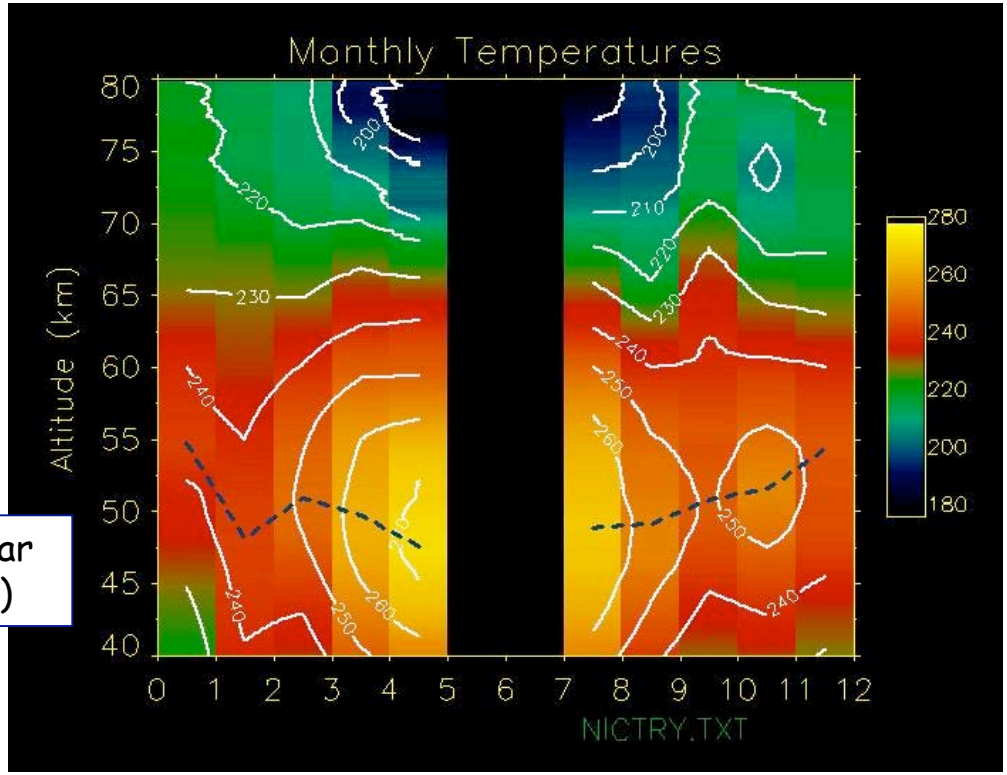
ACE-Lidar comparisons at NH mid-latitude sites in summer/early Fall.

Rayleigh Lidar-Comparison with SABER



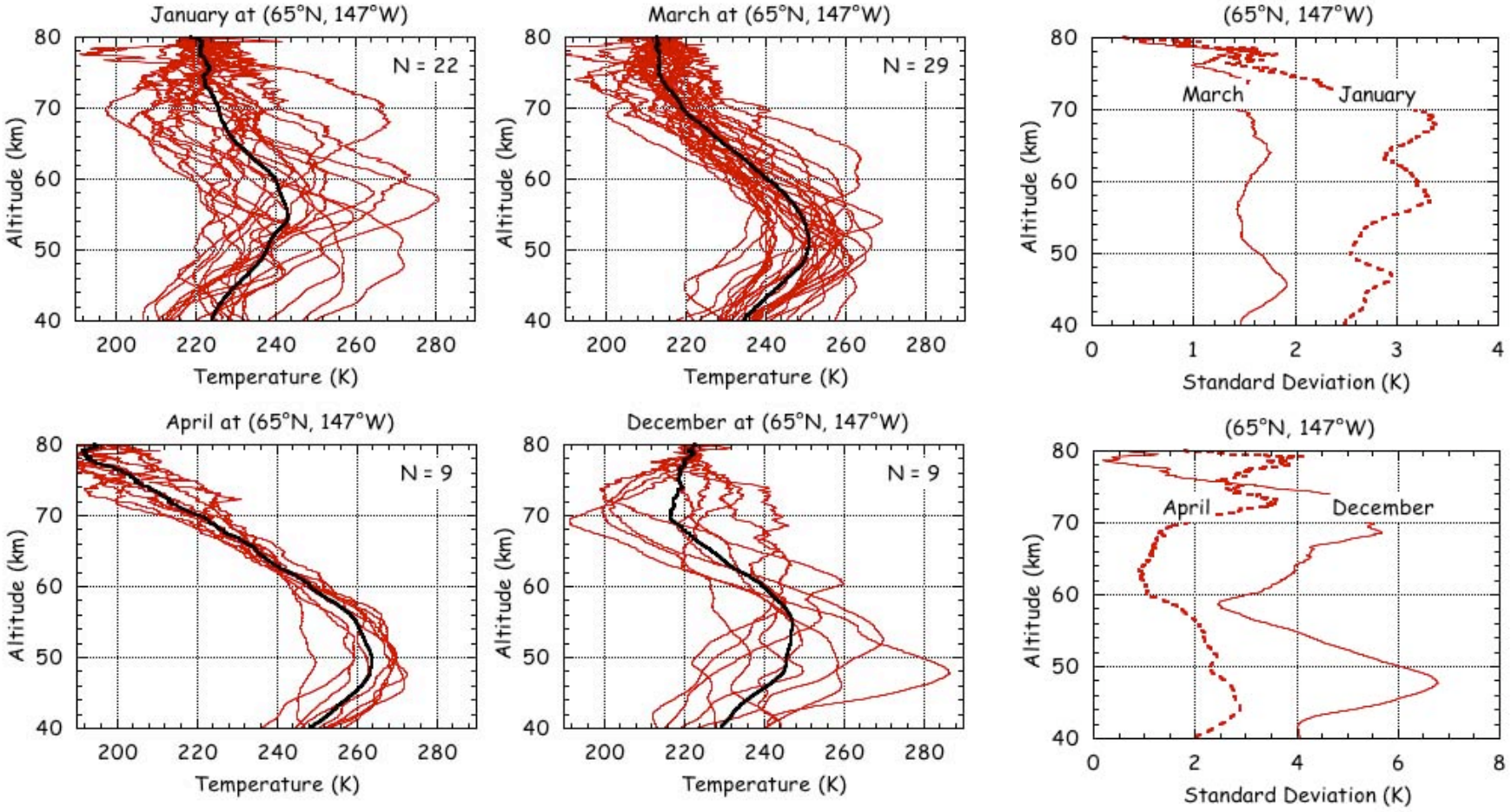
Monthly Temperatures in the Western Arctic

NICT Rayleigh Lidar
(65.1°N, 147.5°W)



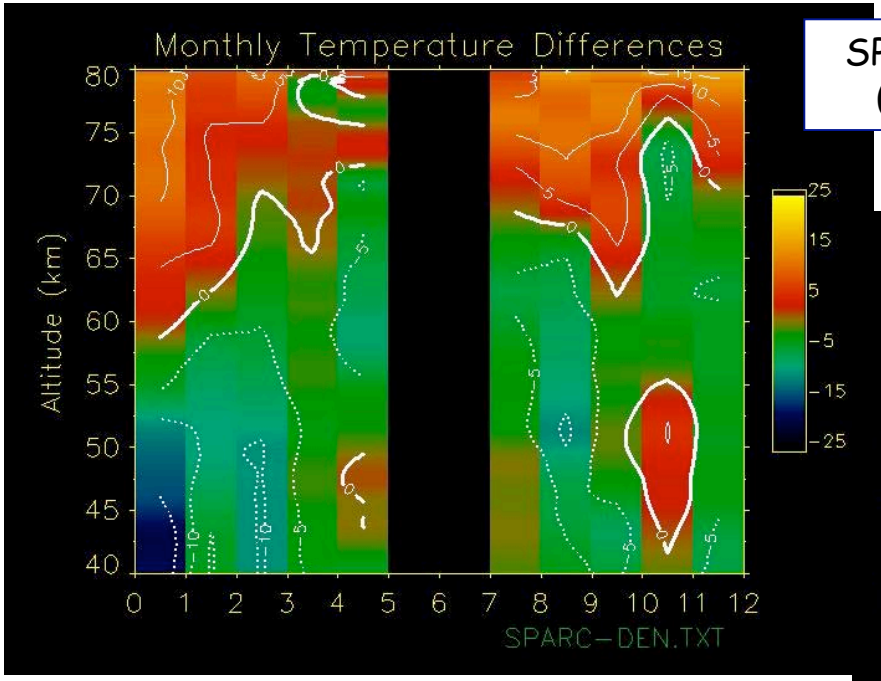
Rayleigh lidar observations of the upper stratosphere and mesosphere have been made in autumn, winter, and spring from November 1997 to April 2005. 116 individual nighttime measurements lasting between three and fifteen hours for a total of 904 hours of observations.The average observation period lasted 7.8 h.

Monthly Temperatures in the Western Arctic

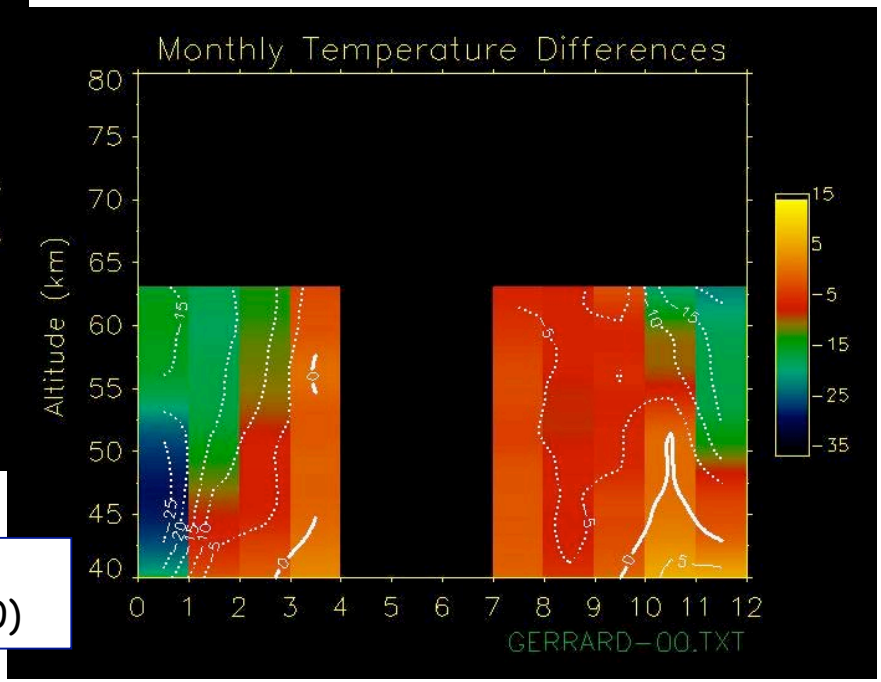


Wintertime variability in temperature profiles is much greater then other seasons.

Comparison with SPARC and other lidar sites



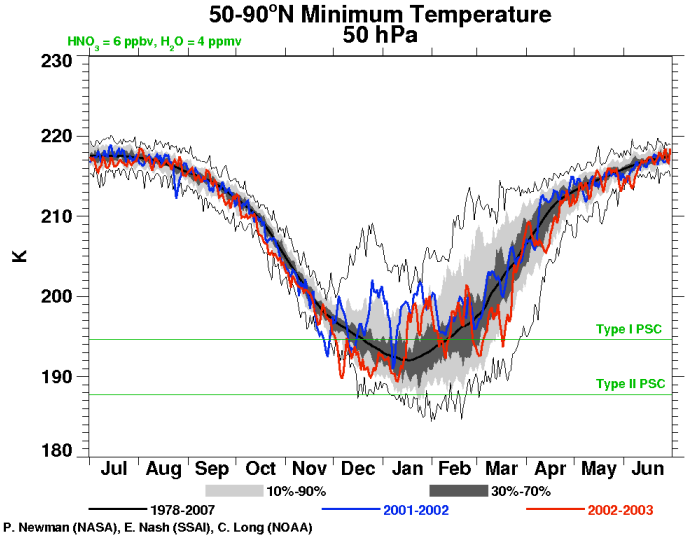
SPARC Reference Atlas
(Randel et al., 2004)

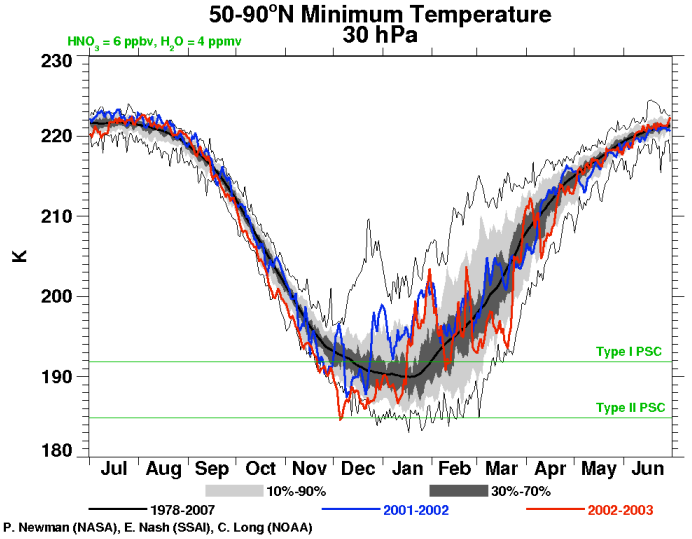


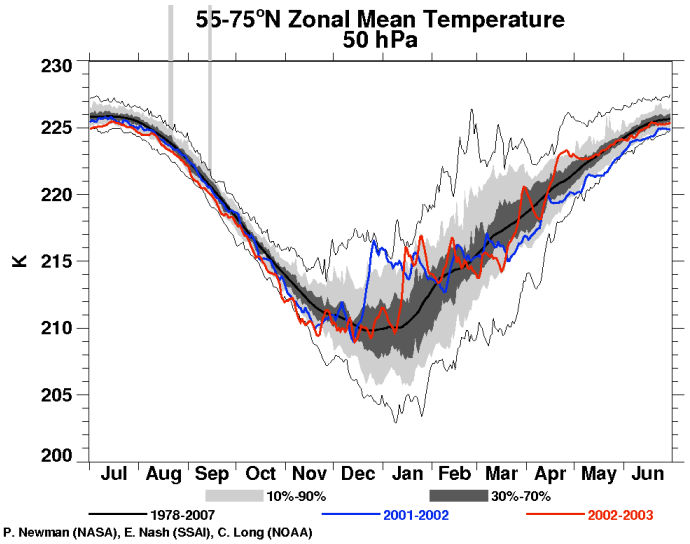
Lidar at SUARF
(Gerrard et al., 2000)

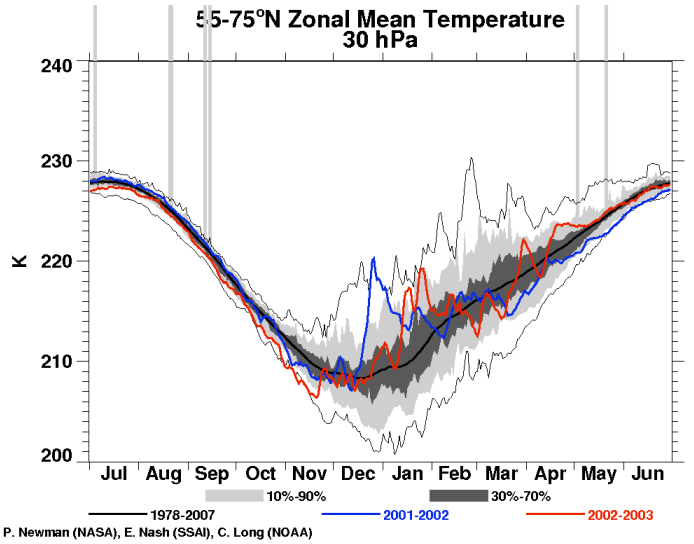
Upper stratosphere and lower mesosphere at PFRR is generally colder than measurements in eastern Arctic and SPARC zonal mean reference atlas.

Spring 2003 -A Prototype Study-NCEP



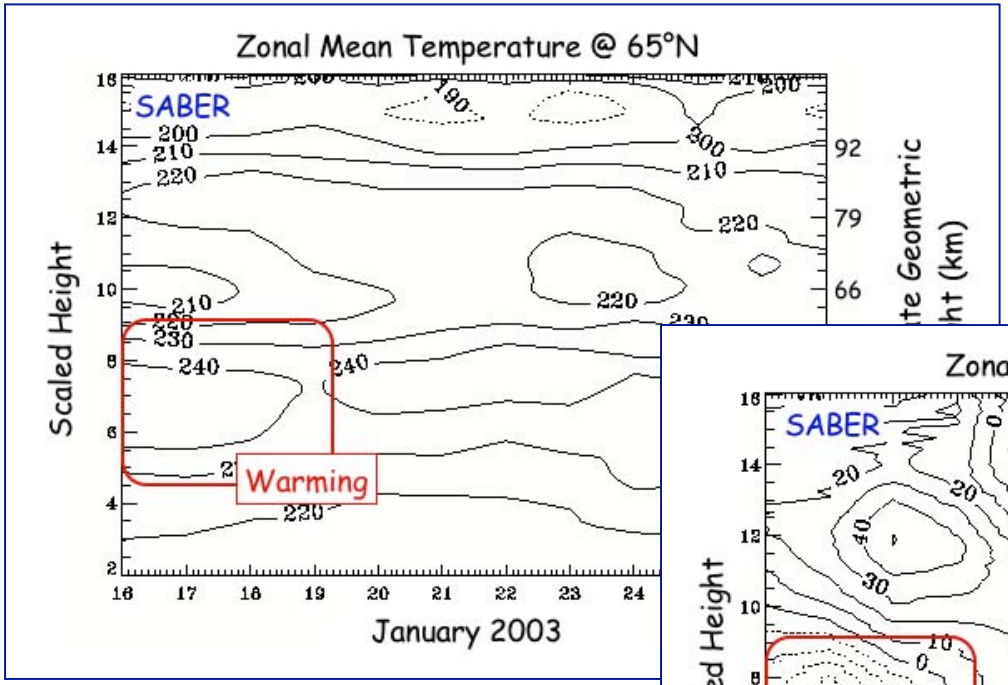


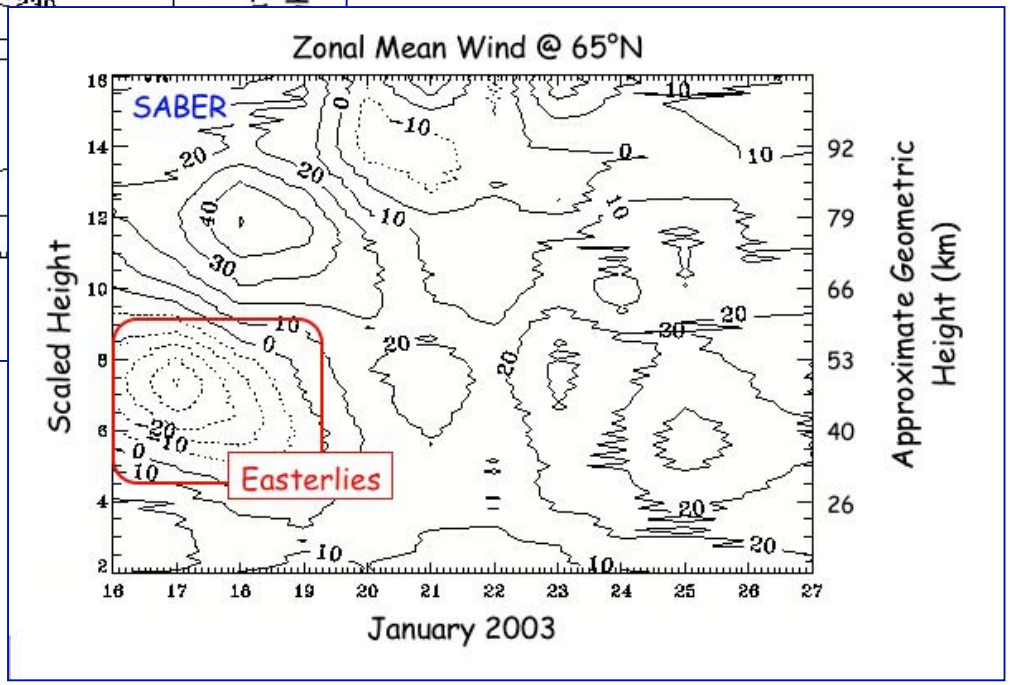




http://code613-3.gsfc.nasa.gov/Data_services/met/nmc_stats.html
NCEP Statistical and Climatological Analyses

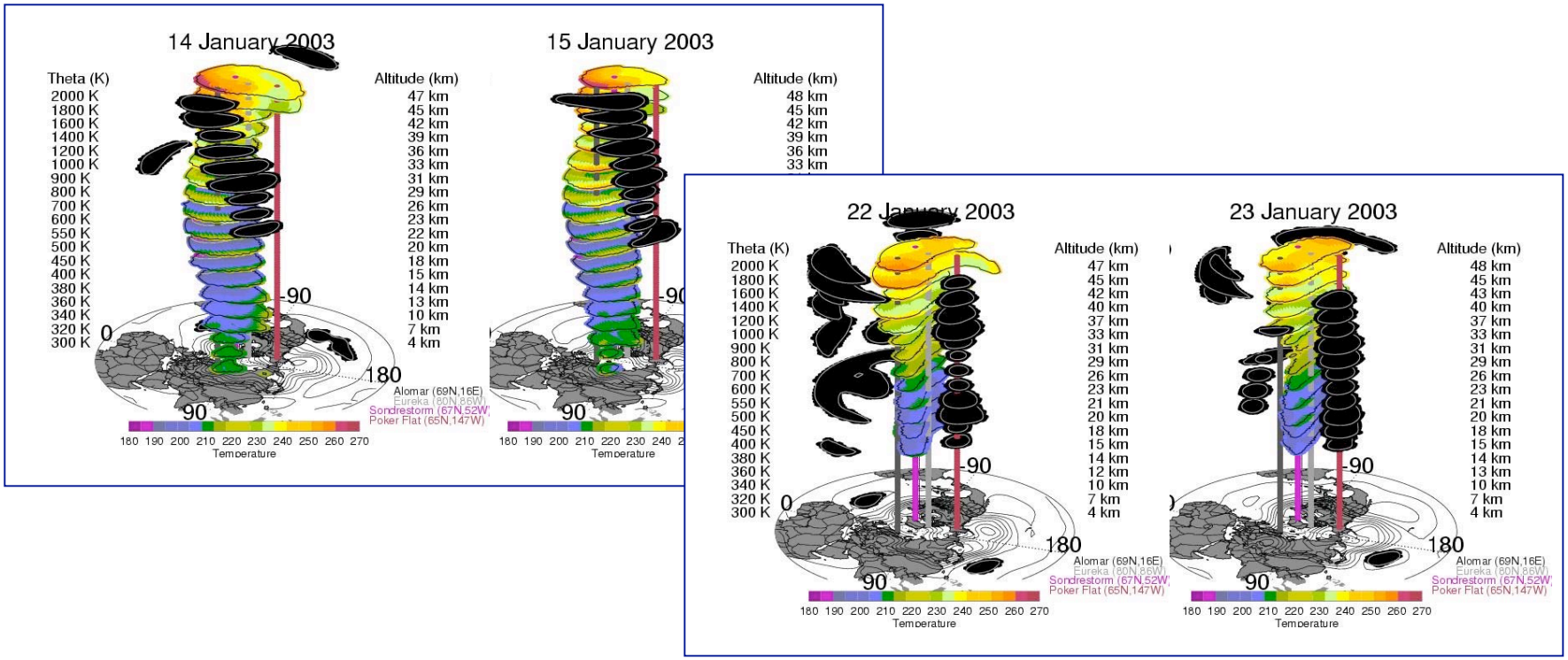
Spring 2003 -A Prototype Study-SABER





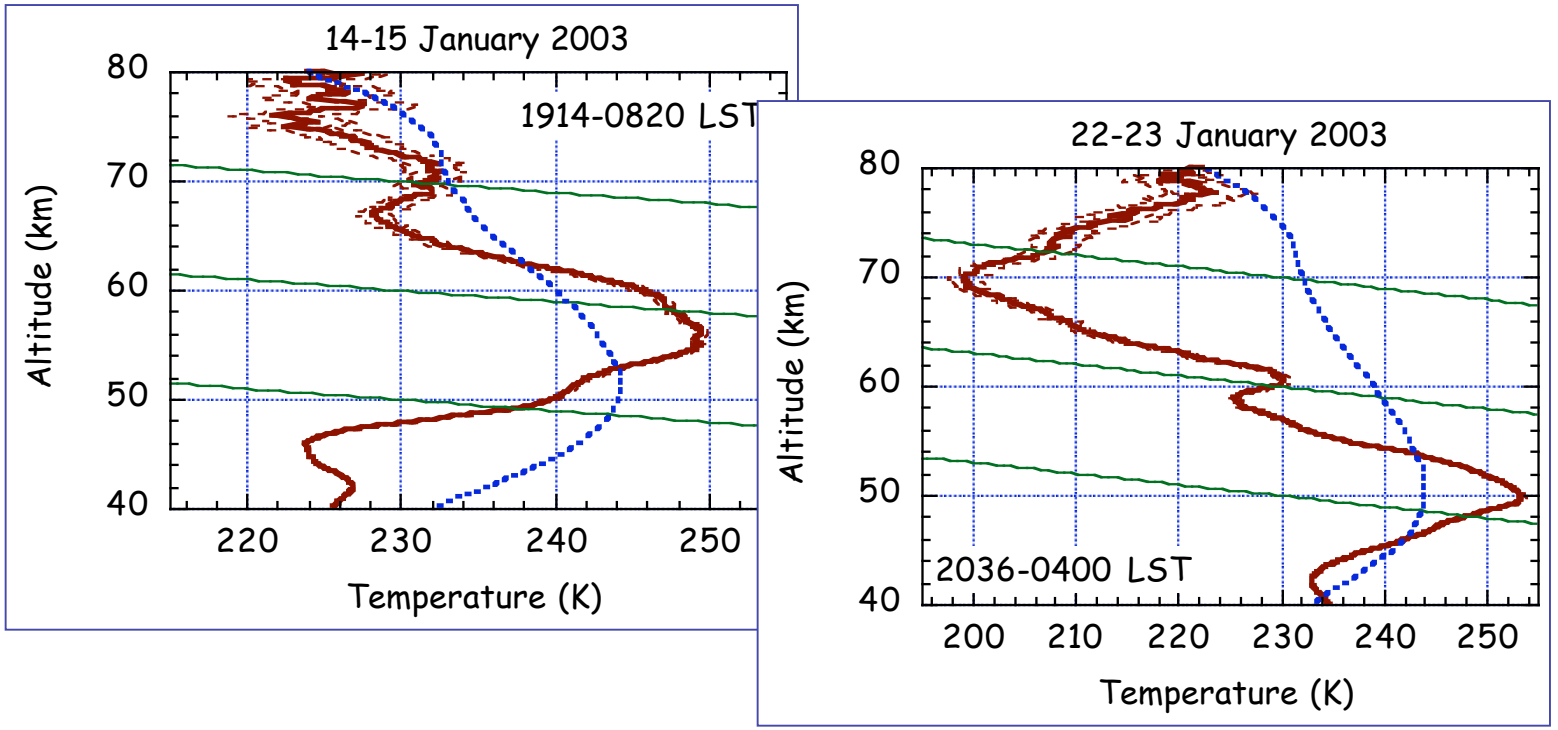
The SABER data reveals the stratospheric warming with reversal of zonal winds in the zonal mean.

Spring 2003 -A Prototype Study-Vortex



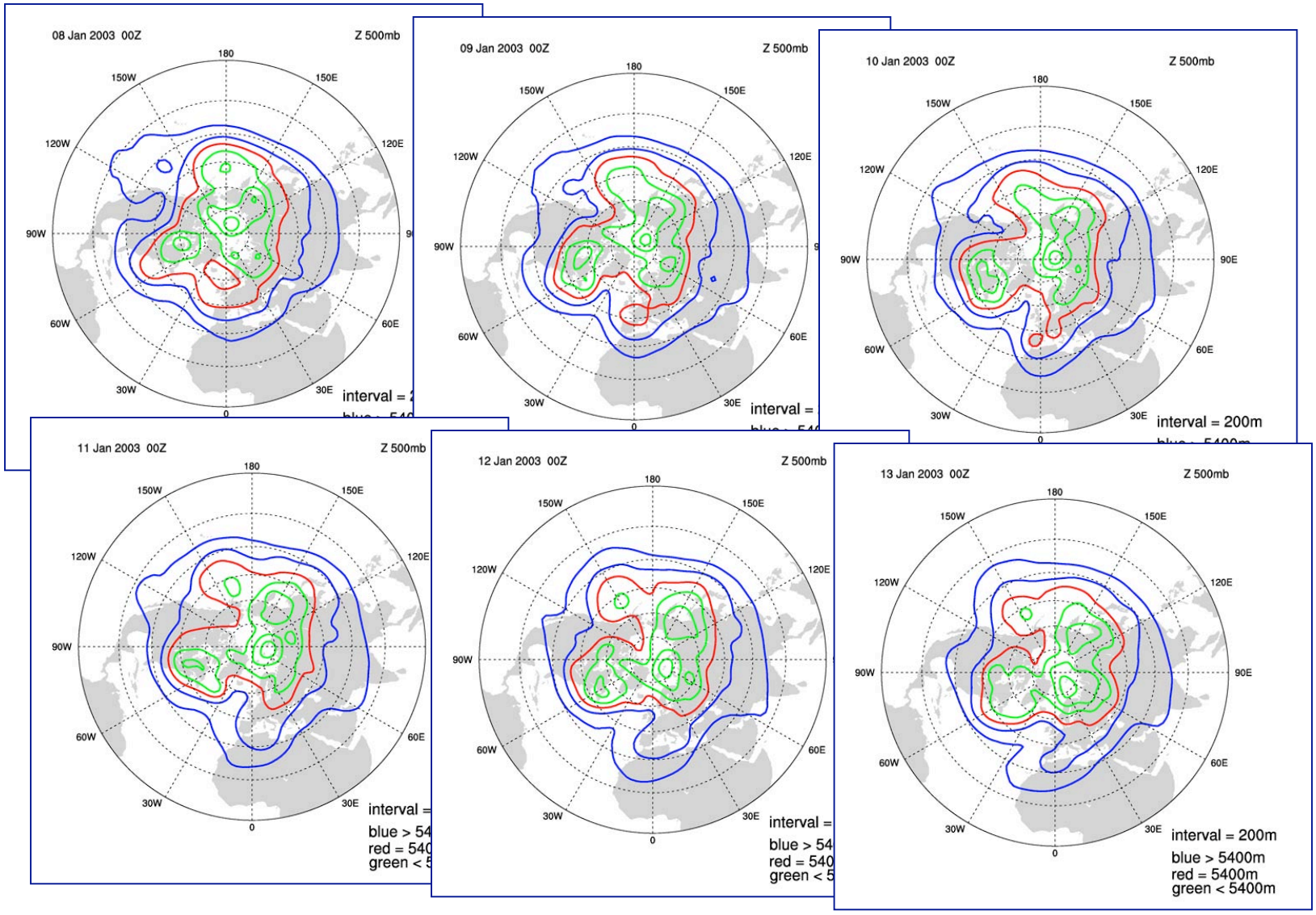
The stratospheric vortex and anticyclones show extensive interaction. The Aleutian High has a westward tilt with height during January 14th -15th and becomes more barotropic with height by the 22nd -23rd. It appears that by the 22nd-23rd there has been mixing between the air masses.

Spring 2003 -A Prototype Study-Lidar



Lidar temperature profiles show significant variability during this period. Average temperature profiles (red) show significant differences from MSIS (blue).

Spring 2003 -A Prototype Study-
500 hPa Geopotential Heights



Web Site

IPY-CTSM :: HOME

http://research.iarc.uaf.edu/IPY-CTSM/index.php

Getting Started Latest Headlines

Pan-Arctic Studies of the Coupled Tropospheric, Stratospheric and Mesospheric Circulation

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MEASUREMENTS

- mesosphere
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- troposphere

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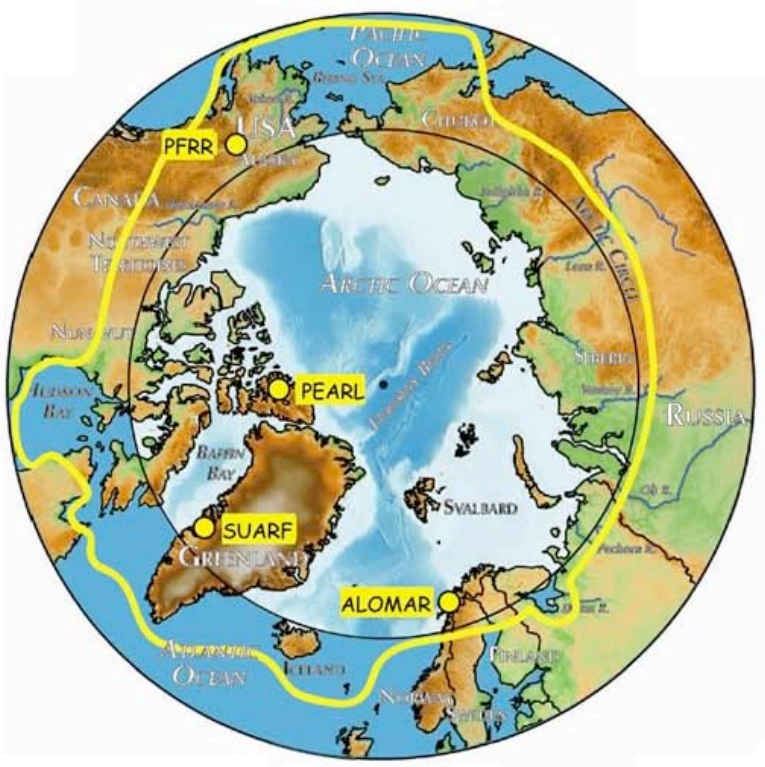
This National Science Foundation International Polar Year project is aimed at extending our understanding of upper atmospheric circulation and features and its interaction with the lower atmosphere. This largely observational study combines satellite measurements, lidar measurements, and meteorological soundings and analyses to study the troposphere, stratosphere, and mesosphere. This effort represents an international collaboration between investigators at six institutions in Canada, Germany, Japan and the United States.

The satellite observations yield global synoptic-scale temperature measurements of the mesosphere and upper stratosphere while the meteorological soundings and analyses provide global synoptic-scale measurements of the troposphere and lower stratosphere. An international network of four Rayleigh lidars:

- ALOMAR - Andoya, Norway (69°N, 16°E)
- PFRR - Chatanika, Alaska (65°N, 147°W)
- PEARL - Eureka, Nunavut (80°N, 86°W),
- SUARF - Kangarlussuaq, Greenland (67°N, 51°W)

provide a chain of high resolution temperature measurements from the eastern Arctic to the western Arctic.

The lidars will yield high-resolution measurements of the structure and circulation of the Arctic stratospheric vortex, the Aleutian anticyclone, the stratospheric surf-zone, planetary waves, tides, and gravity waves that are corroborated by the synoptic-scale satellite and meteorological observations.



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Done

Web Site - Tropo-Stratosphere

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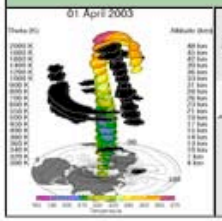
STRATOSPHERE/TROPOSPHERE

Stratosphere Analysis Charts

Select date: September 1 2002

Valid date range: **September 1, 2002** *to* **May 31, 2003**

The Arctic Vortex



Select date above

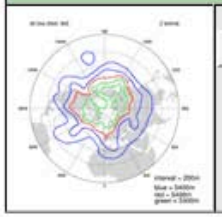
view plot | view animation

Troposphere Analysis Charts

Select date: January 10 2003

Valid date range: **January 1, 2002** *to* **December 31, 2003**

Height Analysis



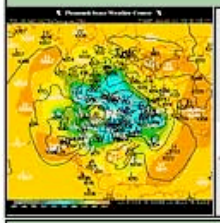
view plot | view animation

Troposphere Current Analysis Charts

Select date: May 17 2007

Valid date range: **May 17, 2007** *to* **August 29, 2007**

Sea Level Pressure



- ECMWF 500mb
- GFS 500mb

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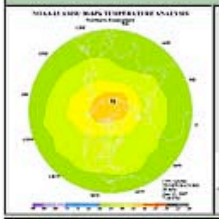
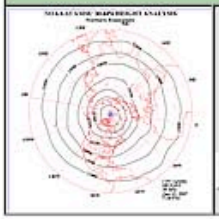
Temperature Analysis



- NOAA AMSU 30hPa
- NCEP GFS 30hPa
- NCEP GFS 50hPa

view plot | view animation

Height Analysis



- NOAA AMSU 30hPa
- NCEP GFS 30hPa
- NCEP GFS 50hPa

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Web Site - Mesosphere

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MESOSPHERE

2003

2003

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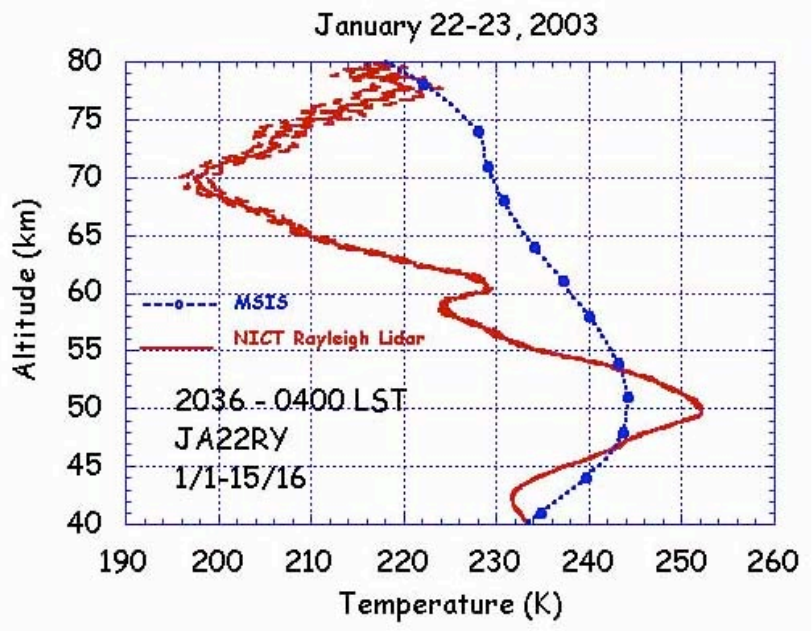
January 2003						
S	M	T	W	T	F	S
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30	31	

February 2003						
S	M	T	W	T	F	S
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	

March 2003						
S	M	T	W	T	F	S
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30	31					

April 2003						
S	M	T	W	T	F	S
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30			



Data Management

- Data will be archived with a web-based portal maintained by University of Alaska.
- University of Alaska and Colorado will create "virtual observatory".
- Host institutions will also make data available to community data bases (e.g. CEDAR).
- Interested in investigating role of integrated Arctic Observational Network (AON) virtual observatory and data base.

International Collaborators

- John Dragomir, National Weather Service, Fairbanks, USA (NWS)
- Peter Fox, National Center for Atmospheric Research, Boulder, USA (AON)
- Craig Heinselman , SRI International, Palo Alto, USA (SUARF)
- Franz-Josef Lübken, Institute of Atmospheric Physics, Külungsborn, Germany (ALOMAR)
- Kohei Mizutani, National Institute of information and Communications Technology, Tokyo, Japan (PFRR)
- Robert Sica, University of Western Ontario, London, Canada (PEARL)

Other Information

- Web-site http://research.iarc.uaf.edu/IPY-CTSM/
- This study is a component part of IPY-SPARC http://www.atmosp.physics.utoronto.ca/SPARC-IPY/ and IPY-IASOA http://www.iasoa.org/.
- Observational data set can provide data for WAACM studies (Han- Li Liu and Rolando Garcia).
- US Component funded by National Science Foundation - Office of Polar Programs
- Contact: Richard Collins - rlc@gi.alaska.edu.