The Arctic polar troposphere, stratosphere and mesosphere during IPY

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Outline

• Motivation: Explore vertical coupling between the Arctic troposphere, stratosphere, and mesosphere during IPY 2007-2008 and 2008-2009
• IPY Web Page
• Current conditions and meteorological forecasts to coordinate lidar measurements
• Met Office and GEOS-5 meteorological analyses
• Pan-Arctic lidar temperature profiles
• Definition of the stratospheric polar vortex and anticyclones
• IPY 2007-2008 & 2008-2009 Arctic troposphere, stratosphere and mesosphere
• North American cold-air outbreaks, stratospheric warming events, and mesospheric gravity waves
Briefing of middle atmosphere conditions primarily in support of lidar observers at ALOMAR, Andoya, Norway; PEARL, Eureka, Nunavut; PFRR, Chatanika, Alaska; and SUARF, Kangerlussuaq, Greenland.

1. Complete information on status of Arctic middle atmosphere at http://research.iarc.uaf.edu/IPY-CTSM/


3. Stratospheric circulation diagnostics and weather briefings
**Arctic Vortex and anticyclone definition**

Q is negative where rotation dominates shear. Vortex/anticyclone edges are defined as the outermost SF contour where the area integral of $Q < 0$. Define at each altitude (10-70 km). Compare vortex edge with MLS CO.
Stratospheric vortex vs. MLS CO
• IPY motive: Interpret single-site temperature profiles based air masses sampled.

• Example: Interpretation of Poker Flat temperature profile on 5 October 2002.
Stream function analysis that identifies the stratospheric vortex and the anticyclones (e.g. Aleutian High).

Lidars sample different air masses
The Arctic Winter 2007 - 2008
November 27-29, 2007
LIDAR vs. GEOS-5 temperature

Agreement btw analyses and lidars. PF in the anticyclone, Greenland in the vortex.
The Arctic Stratosphere in 2007-2008

NCEP analysis of the temperatures at the North Pole at 10 hPa (~30 km).

Four warming events in late winter/early spring 2008.
The Vortex and Anticyclones on Active Days

Met Office analyses up to 50 km
PF samples the Aleutian High between 20 and 70 km (GEOS-5). Temperature profile is consistent (low stratopause, cold mesosphere)
Temperature profiles in the anticyclone
The View from Kangerlussuaq, Greenland

Temperature profiles in the vortex core and at the edge.
The View from Andoya, Norway

Isothermal atmosphere during February warming.
The View from Kühlungsborn, Germany

Density profiles have been provided at 30 minute resolution. These data show downward phase progressions associated with upward propagating gravity waves.

Gravity wave activity varies significantly between polar sites.
From the middle atmosphere to the surface…

Cold Air Outbreaks over North America.
Cold-Air Outbreak in late January 2008

20080128

20080129

20080130

Courtesy of Donavan Wheeler
Cold-Air Outbreaks over North America

2007-2008

2008-2009

Superimpose Arctic vortex edge to explore vertical coupling
3-D Animation
20 - 27 February
2008
Major Stratospheric Warming Feb 2008

Analysis using GEOS reanalysis that extends upward to 72 km from Meteorological Office analyses at 47 km and provides 6 h rather than 24 h estimates of atmosphere.

Movie shows final week in February at 6 h resolution.
Conditions thus far in the Arctic
2008 - 2009
November 2008 Lidar Measurements

Anticyclones merged a week later
Robust Aleutian High and vigorous planetary wave breaking between 50 and 70 km. Upper tropospheric jet shows ridging over North Pacific under the anticyclone.
Geopotential Height 20081209

30 hPa

500 hPa

20 km

5 km

NOAA-15 AMSU 30-hPa HEIGHT ANALYSIS
Northern Hemisphere

ECMWF analysis for 127.9 DEC 08
• To increase the lead time to alert lidar operations, NCEP forecasts are posted to the web page.
• Forecasts are monitored and “weather briefings” are sent encouraging measurements on active days.
Temperature forecasts

20081212

50 km

20081214

30 km

20081216
Geopotential height forecasts

50 km

30 km
Summary

- IPY Web Page http://research.iarc.uaf.edu/IPY-CTSM/
- IPY 2007-2008 & 2008-2009 Arctic troposphere, stratosphere and mesosphere
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Thank you!
Mesospheric vortex vs. MLS CO and H₂O

60 km
SABER vs. GEOS USLM winds

• Contamination of vortex edge by the SAO similar to in the UTLS by the subtropical jet. Is this feature accurately represented here?
• Should the vortex “close off” above the separated polar stratopause instead of bulge out to low latitudes? Probably.
Agreement between GEOS and SABER Ubar deteriorates with altitude
GEOS-4 4-yr Average Annual Cycle

New Poleward-most Jet algorithm

Lower Mesosphere
Upper Stratopause

Subtropical Mesospheric Jet & Stratopause

Polar Night Jet & Cold Vortex

Similar results in SABER and WACCM

RWB descends from Aug to Oct
“Double jet” in USLM

Should the vortex edge follow the jet axis toward the pole?
Arctic Cross-Polar section of “Double Jet”
(not zonal mean)

20050119

SABER

GEOS-4

Lower and Cooler Polar Stratopause

Strongest Jet=grey
Poleward-most Jet=black