THE STRUCTURE & EVOLUTION OF THE POLAR STRATOSPHERE & MESOSPHERE DURING IPY SPARC-IPY EARLY RESULTS

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The Mission

The objective of SPARC-IPY project, titled The Structure and Evolution of the Polar Stratosphere and Mesosphere and Links to the Troposphere during IPY (IPY Activity No. 217), is to document the dynamics, chemistry and microphysical processes within the polar vortices during IPY, with a focus on the stratosphere-troposphere and stratosphere-mesosphere coupling. To achieve this goal the SPARC-IPY project is facilitating analysis of available research and operational satellite data while encouraging work on data assimilation and inter comparison of assimilated data sets. Deliverables of this project for the IPY period consists of a well-organized data set of polar observations as well as analysis products from two Canadian assimilation systems (GEM-BACH and CMAM-DAS) and major operational centers (ECMWF, Met Office, NCEP, and GMAO), which are being archived at the SPARC Data Center. Here we present the evolution of polar vortex as observed by the Microwave Limb Sounder (MLS) on board the Aura satellite in boreal winters 2005 to 2008 and analysis of sudden stratospheric warming (SSW) during the IPY period are discussed.

MLS Observations

In figure 1 significant interannual variability can be seen in tracer fields:

CO

- There is an apparent descent from the lower mesosphere into the upper stratospheric vortex.
- In 2006, the high CO abruptly decreases to almost nothing in early January, when the prolonged major warming starts. Also enhanced descent is seen after the upper stratosphere starts to recover from the SSW.
- In 2007 reduction occurs later and less abruptly. In February more pronounced descent is seen, suggesting a strong upper stratospheric vortex -- this is still before the major SSW in late February.
- The original decrease is latest in 2008, with CO consequently descending to lower altitudes -- the vortex did not recover after the late major SSW.

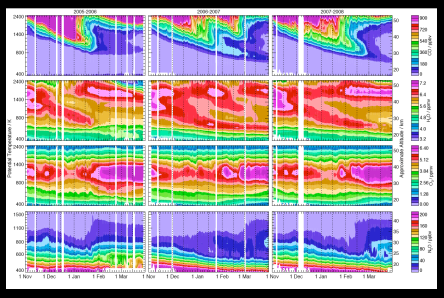


Figure 1 - Vortex averaged Volume Mixing Ratio of MLS long-lived tracers for winter/spring 2005-2006, 2006-2007, and 2007-2008. From top to bottom CO, H2O, O3, and N2O VMRs from November through March.

N2O

- N2O shows variability in descent clearly in the lower to middle stratosphere.
- In 2005-2006, the descent signature is relatively weak even in November to January, and the increase indicates the strong mixing as the vortex breaks down during the SSW. As the vortex in the lower stratosphere never recovered, thus no return of the signature of confined descent was seen.
- In 2006-2007 and 2007-2008, a signature of strong descent is seen December-March in the lower stratosphere. In both years, increase in mixing is seen in the mid-stratosphere in conjunction with late February SSWs.

H2O & O3

- The H2O morphology is complicated, but generally shows behavior consistent with that of CO in the upper stratosphere and N2O in the lower stratosphere.
- O3 shows substantial decreases in the lower stratosphere during February-March 2007 and 2008, consistent with chemical loss in the cold conditions, in contrast to 2006, when the SSW caused lower stratospheric temperature to rise above those at which O3 loss is expected.

Plot removed due to IP right of ACE team

Figure 2 - The plots show lower stratospheric O3 from ACE (left) and MLS (right) mapped in EqL /time at 490K potential temperature.

MLS & ACE Comparison

- Both ACE and MLS show substantial O3 loss in 2006-2007 and 2007-2008 cold winters.
- MLS and ACE signatures appear consistent, and show larger observed decreases in lower stratospheric O3 in 2006-2007 and 2007-2008 than in 2004-2005 (a year with arguably record O3 loss).
- The observed O3 loss is the result of the interaction of dynamical and chemical processes that need to be analyzed.

Pan-Arctic Study

- Pan-Arctic Study of the Stratospheric and Mesospheric Circulation is a coordinated aeronomical study to extend our understanding of upper atmospheric circulation and features and its interaction with the lower atmosphere.
- The Pan-Arctic observational network consists of
  - Arctic Lidar Observatory for Middle Atmosphere Research, Andoya, Norway (69°N, 16°E).
  - Polar Environment Atmospheric Research Laboratory, Eureka, Nunavut, Canada (80°N, 86°W).
  - Poker Flat Research Range, Chatanika, Alaska, USA (65° N, 147° W).
  - Sondrestrom Upper Atmospheric Research Facility, Kangerlussuaq, Greenland (67°N, 51°W).
  - Leibniz Institute of Atmospheric Physics, Kühlungsborn, Germany (54°N ,12°E).
- More on Pan-Arctic Study can be found at: http://research.iarc.uaf.edu/IPY-CTSM/

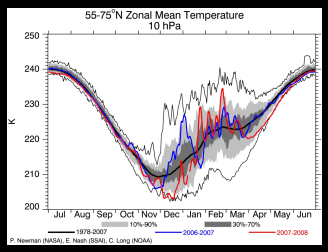


Figure 3 - NCEP analysis of the temperatures in the 55°-75° latitude band at 10 hPa (~30 km). Four warming events in late winter/early spring 2008 can be seen.

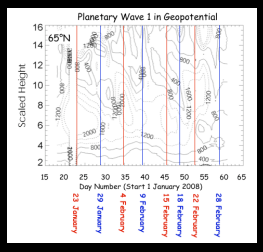
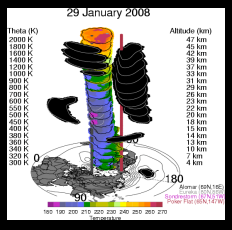


Figure 4 - Wave amplitudes at 65°N. Analysis of wave 1 components in SABER geo-potential measurements shows four periods with a maximum wave amplitude.



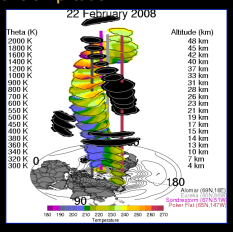
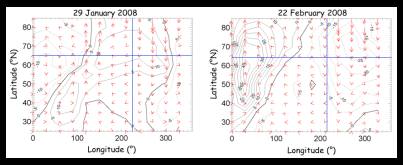


Figure 5 - Comparison of the vortex and anticyclones on January 29, 2008 (quiet day) and February 22, 2008 (active day).



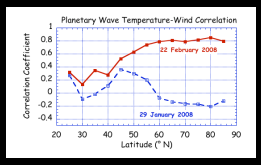


Figure 6 - Using the SABER geopotentials and temperatures we determine the wave 1-5 meridional heat fluxes based on gradient winds at ~ 30 km height.

Pan-Arctic Study Summary

- The IPY study is aimed at better understanding the middle atmospheric circulation with the help of an Arctic network of lidar measurements, satellite measurements, and meteorological soundings and analysis.
- Lidar temperature measurements during 2008 winter shows variations associated with planetary wave activity.

SPARC-IPY Participants

University of Reading, UK; NOAA Aeronomy Laboratory, USA; University of Alaska, USA; Environment Canada, Canada; Stony Brook University, USA; Dalhousie University, Canada; Clemson University, USA; Institute of Atmospheric Physics, Germany; FCEN UBA CONICET, Argentina; University of Colorado, USA; National Institute for Information and Communications, Japan; SRI International, USA; University of Toronto, Canada; York University, Canada.

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