

Polar Mesospheric Descent and Stratopause Jumps following Mid-Winter Sudden Stratospheric Warmings as observed in Odin/SMR Water Vapor and Temperature

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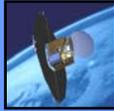
INTRODUCTION. Downward transport of minor constituents from the polar mesosphere can significantly alter the stratospheric chemical composition. Produced by background low-energy auroral electrons and particle precipitation (EPP) in the mesosphere/thermosphere, descending nitrogen oxides (NO_x) is a significant source for NO_x in the winter polar stratosphere, where they drive an important catalytic cycle of ozone destruction when sunlight returns [e.g. *Randall et al.*, 2006]. Following prolonged descent motion within the winter polar vortex, dry air masses (of mesospheric origin) rich with long-lived carbon monoxide (CO) or methane (CH₄) can be found readily in the lower stratosphere [*Huret et al.*, 2006; *Manney et al.*, 2009ab].

Here, we present evidence of polar mesospheric descent as part of the mesospheric temperature and H₂O wintertime evolution between 2001-2009, using the newly analyzed observations from the Odin satellite. Focus will be placed on the occurrence of stratopause "jumps", leading to the formation of an elevated stratopause near 0.01 hPa, and the subsequent fall of very dry mesospheric air into the stratosphere.

ODIN/SMR OBSERVATIONS (2001-2009)

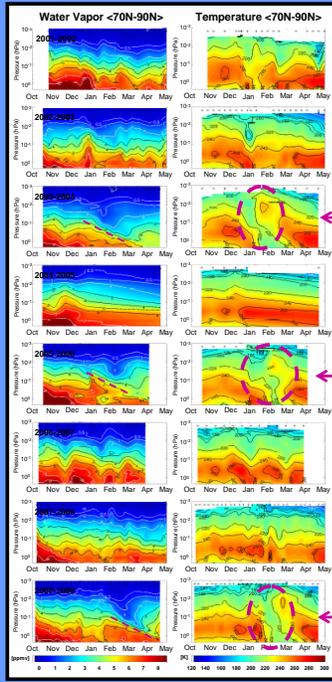
- Odin: Swedish-Canadian-French satellite
- SMR (Sub-Millimeter Radiometer) microwave instrument
- Sun-synchronous, polar orbit
- Nearly global coverage of the middle atmosphere
- Temperature (7-110 km) & H₂O (40-100 km) data:

- 4 days/month (July 2001 to April 2006)
- 7 days/month (April 2006 to April 2007)
- 10 days/month (after April 2007)



- Retrieved from the 556.9-GHz line, H₂O has a vertical resolution of ~3 km and precision of ~0.5-1.0 ppmv.

4 NH WINTERTIME OBSERVATIONS (2001-2009)



Stratopause jump + descent over 1-2 months

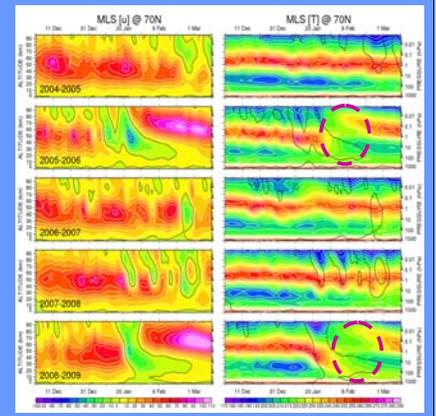
3 cases of stratopause jumps, followed by strong descent of dry air.

Minor warmings (e.g. 2002/03 or 2007/08) do not give rise to the stratopause jump

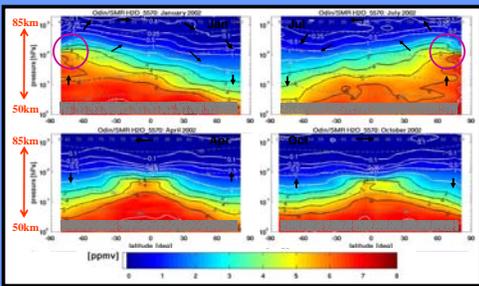
These 3 SSWs reached lower stratosphere (or below) and occurred mid-winter (January)

SUMMARY. Using newly analyzed mesospheric water vapor and temperature observations from the Sub-millimeter Radiometer instrument aboard the Odin research satellite over the period 2001-2009, we present evidence for an anomalously strong descent of dry mesospheric air from the lower mesosphere into the upper stratosphere in the winters of 2003/04, 2005/06 and 2008/09. In the three cases, the descent follows the recovery of the upper stratospheric polar vortex from a mid-winter sudden stratospheric warming. It is also accompanied by the rapid formation of an anomalously warm polar mesospheric layer, i. e. an elevated polar stratopause, near 75km, and its slower descent to pre-warming level (near 1 hPa) over 1.5-2 months.

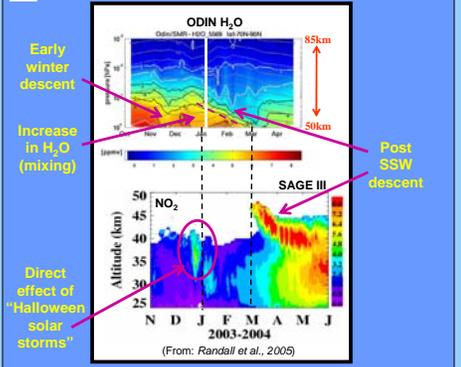
5 MLS OBSERVATIONS (2004-2009)



1 ODIN 2002 WATER VAPOR ANNUAL CYCLE



6 MESOSPHERIC WATER: WINTER 2003/04



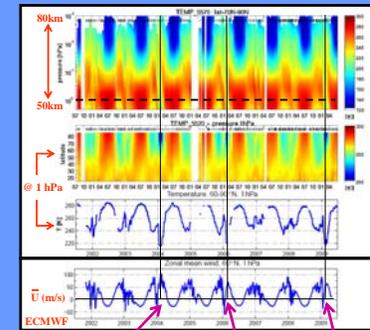
Early winter descent

Increase in H₂O (mixing)

Direct effect of "Halloween solar storms"

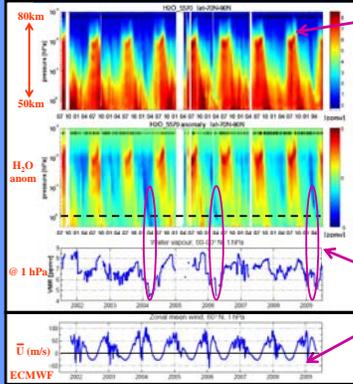
Post SSW descent

2 ODIN TEMPERATURE



Recovery of an intensely cold vortex after SSWs
SSW = Sudden Stratospheric Warming

3 ODIN WATER VAPOR



Annual cycle linked to pole-to-pole meridional circulation

Anomalous descent of dry air following SSWs

REFERENCES

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Orsolini, Y. J., et al., 2009: Descent from the polar mesosphere and stratopause jumps following mid-winter sudden stratospheric warmings, observed in Odin/SMR water vapor and temperature, *J. Geophys. Res.*, in review.