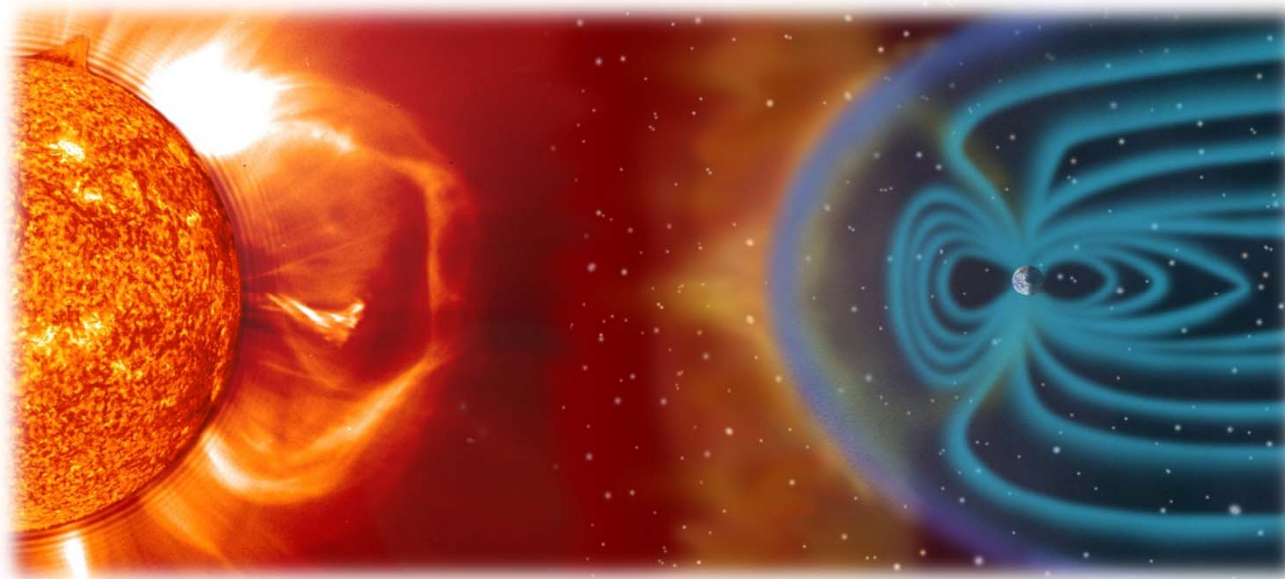


Energetic Particle Precipitation Indirect Effects as seen by Odin / SMR



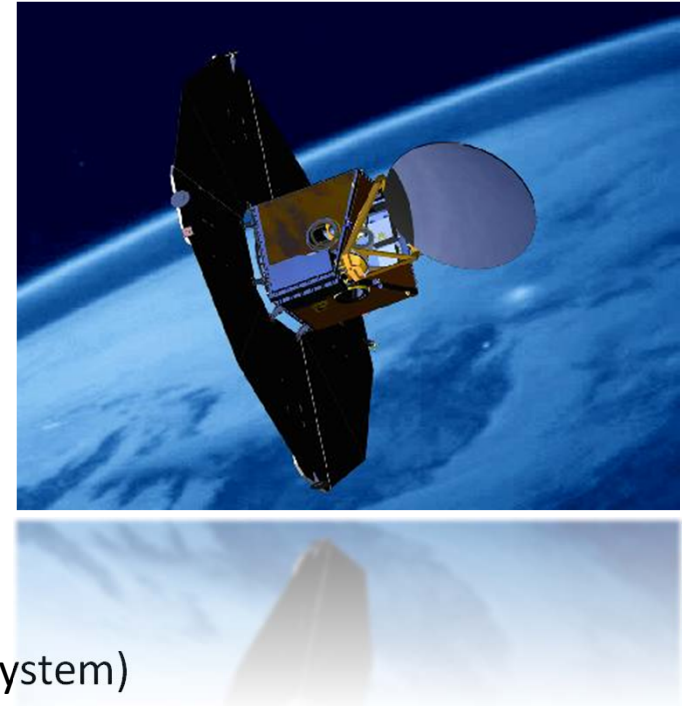
NASA

Kristell Pérot, Joachim Urban, Donal Murtagh
Chalmers University of Technology
Department of Earth and Space Sciences
Göteborg, Sweden

CHALMERS

Odin / SMR

- **Odin:** Swedish-led satellite, in cooperation with Canada, Finland and France.
- Launched in **February 2001**.
- Sun-synchronous polar orbit,
6 am / 6 pm equator crossing.
- 50% astronomy, 50% aeronomy
100% aeronomy and ESA third party mission since 2007.
- 2 instruments:
OSIRIS (the Optical Spectrograph and Infra-Red Imaging System)
SMR (Sub-Millimetre Radiometer): Limb emission sounder in aeronomy mode,
trace gases measurements in the middle atmosphere.

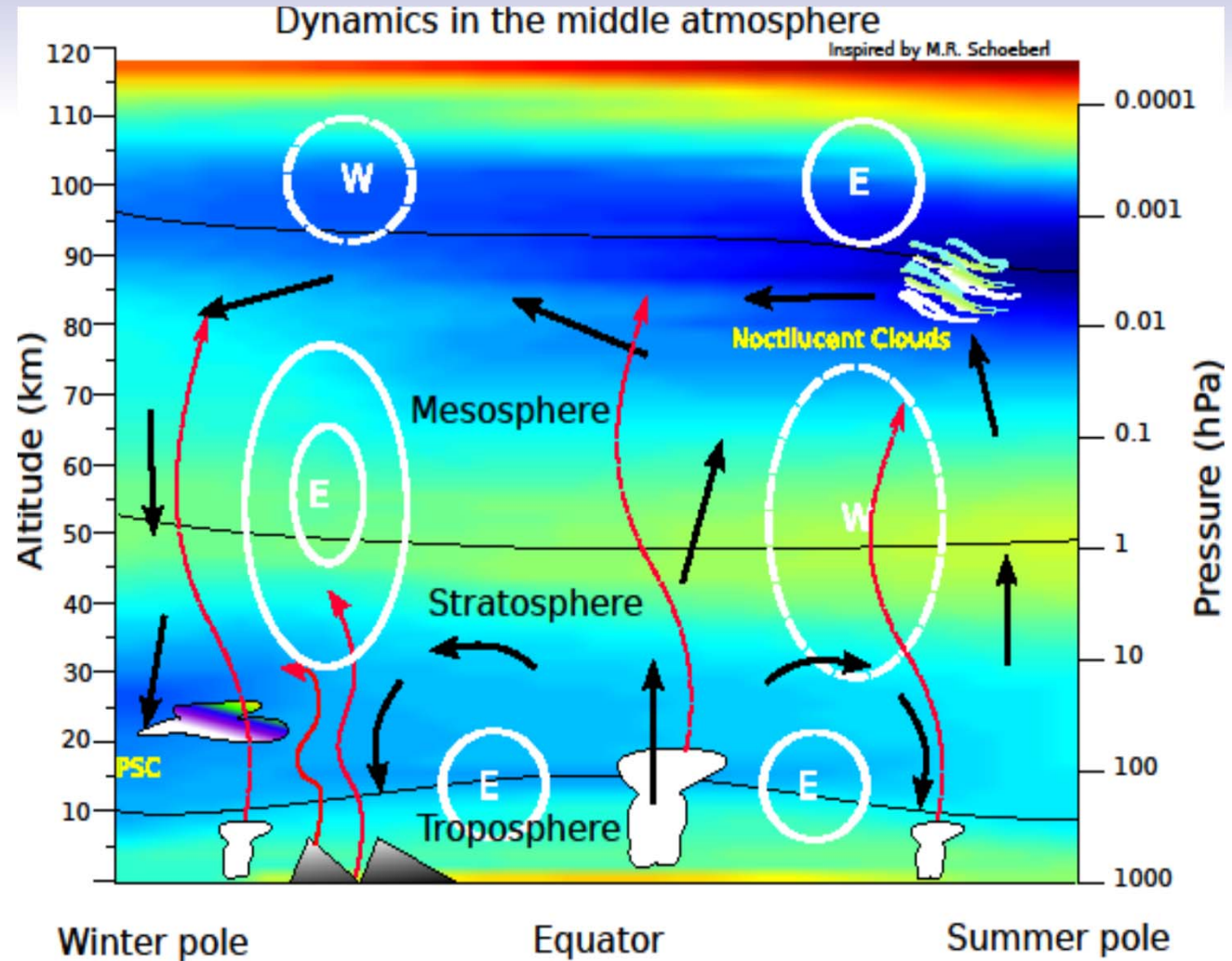


The middle atmosphere

Region of intense interactions between radiative, chemical and dynamical processes.

Poles: Access regions for **particle precipitation**.

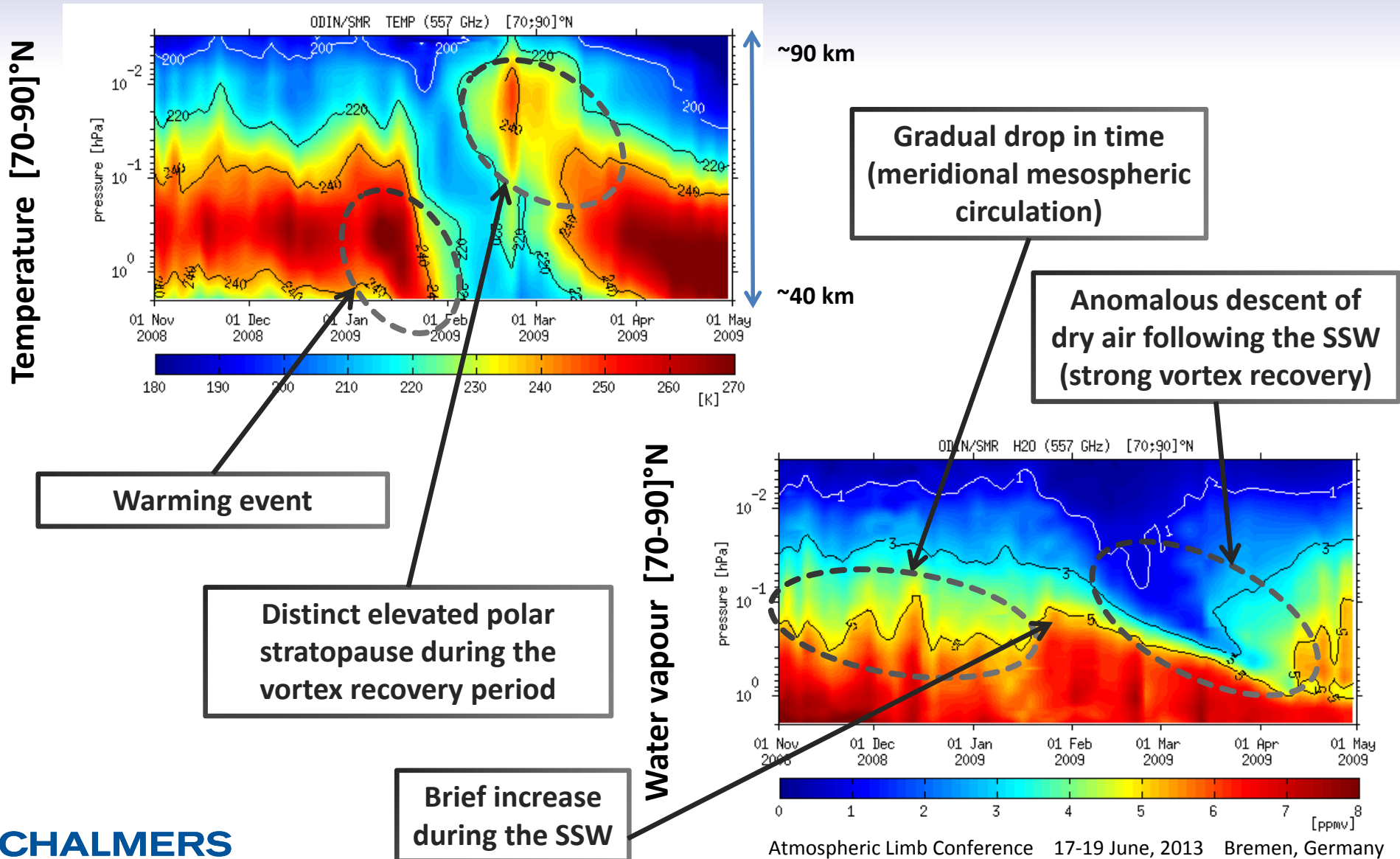
Winter: polar vortex
→ **Downward transport** of chemical species, especially if the winter is characterized by a **SSW event**.



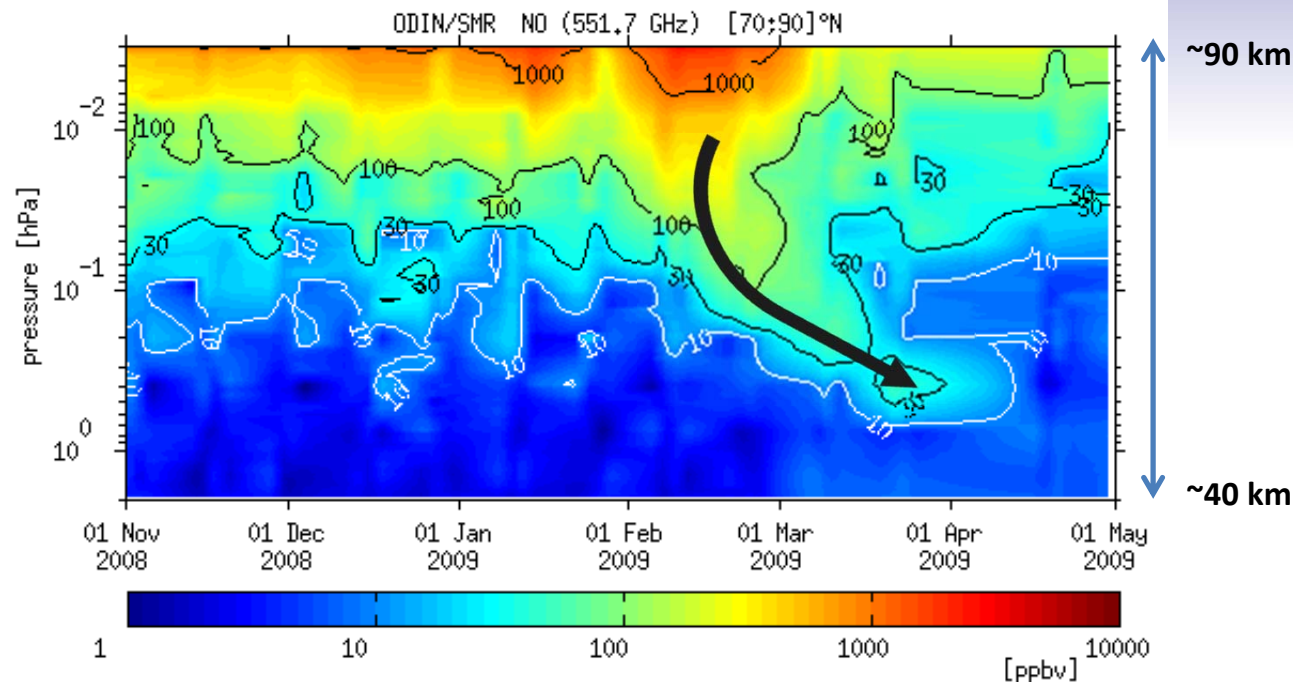
This work by Ole Martin Christensen is licensed under a Creative Commons Attribution 3.0 Unported License.

Well-known Sudden Stratospheric Warming in 2009

Typical evolution of T and H₂O during a SSW event



EPP indirect effects



Electron precipitation
in the polar LTUM
→ Ionisation
→ **NO production**

Strong descent event
following SSW
→ **Downward**
transport of NO_x:
Can affect the
O₃ balance
= EPP indirect effect

Important **solar-terrestrial coupling mechanism**
that must be understood and correctly modelled.

- Can influence middle atmospheric composition on relatively long time scales.
- Large variability (dynamical modulations), making its modelling challenging.

HEPPA - MMI

High Energy Particle
Precipitation in the Atmosphere
– Model-Measurement
Intercomparison

International working group led
by Bernd Funke (IAA, Spain)

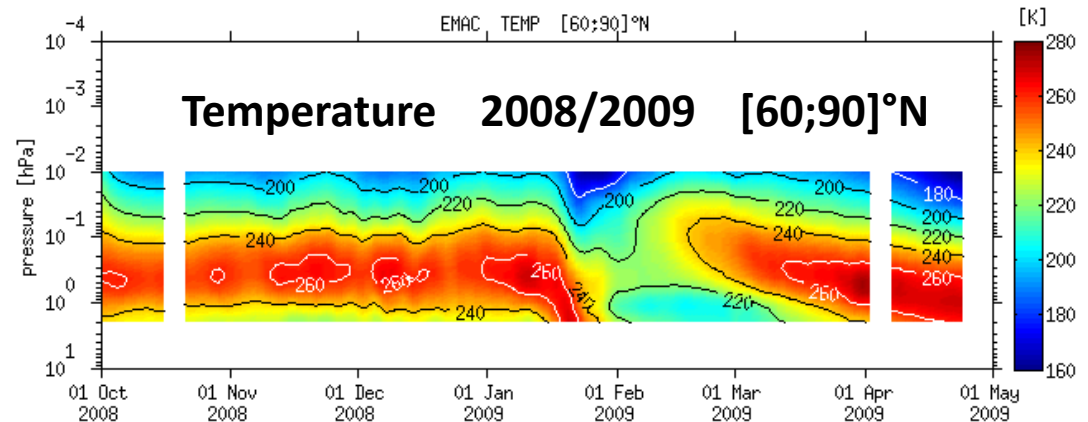
Focused on the
2008/2009 NH polar winter

5 models & 7 instruments
involved

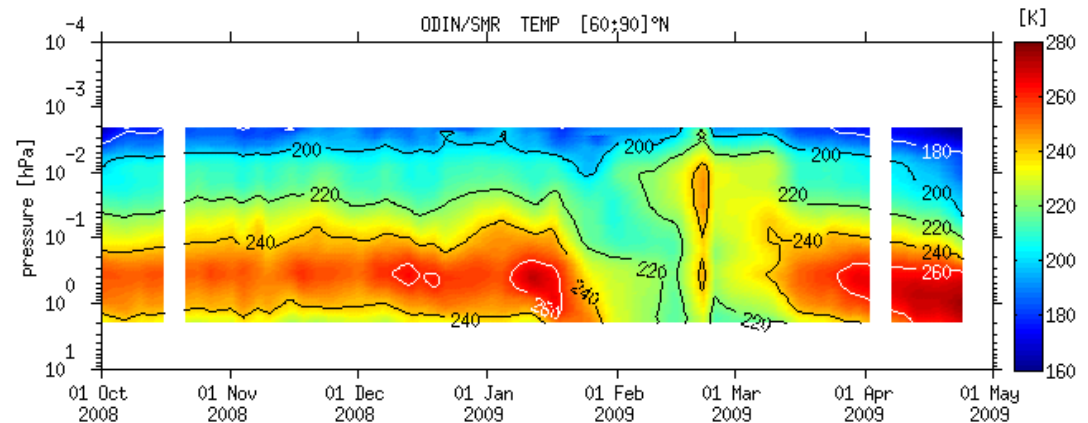
Goals:

- to get a better understanding of EPP-induced middle atmospheric changes.
- to assess the ability of current models to reproduce those phenomena.

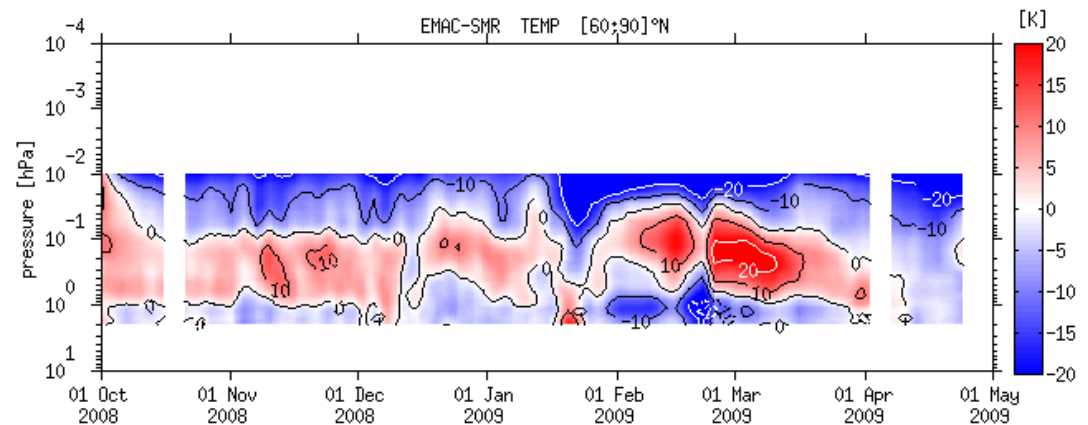
EMAC model



Odin/SMR

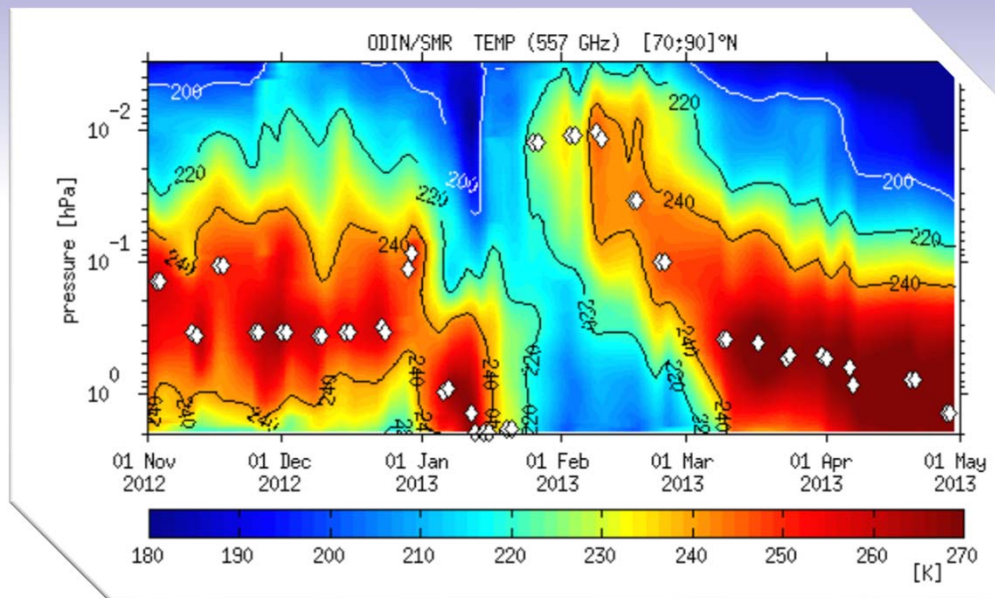


EMAC-SMR



Arctic winter 2012/2013

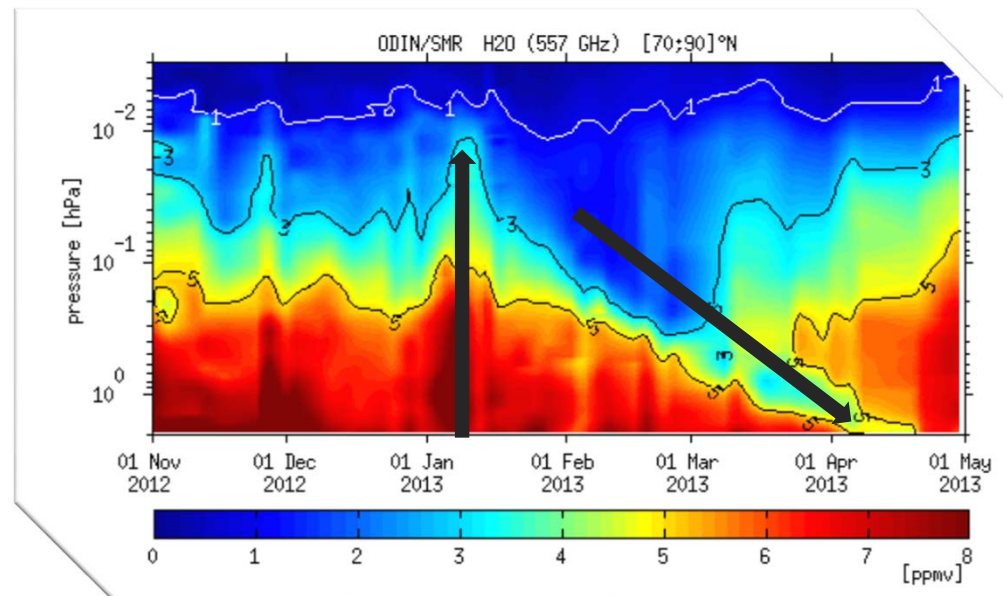
Temperature [70-90]°N



Formation of an **elevated stratopause** at an altitude of ~75 km observed by Odin / SMR in late January / February 2013

- Upward motion in early January
- Particularly **strong descent of mesospheric dry air** into the stratosphere

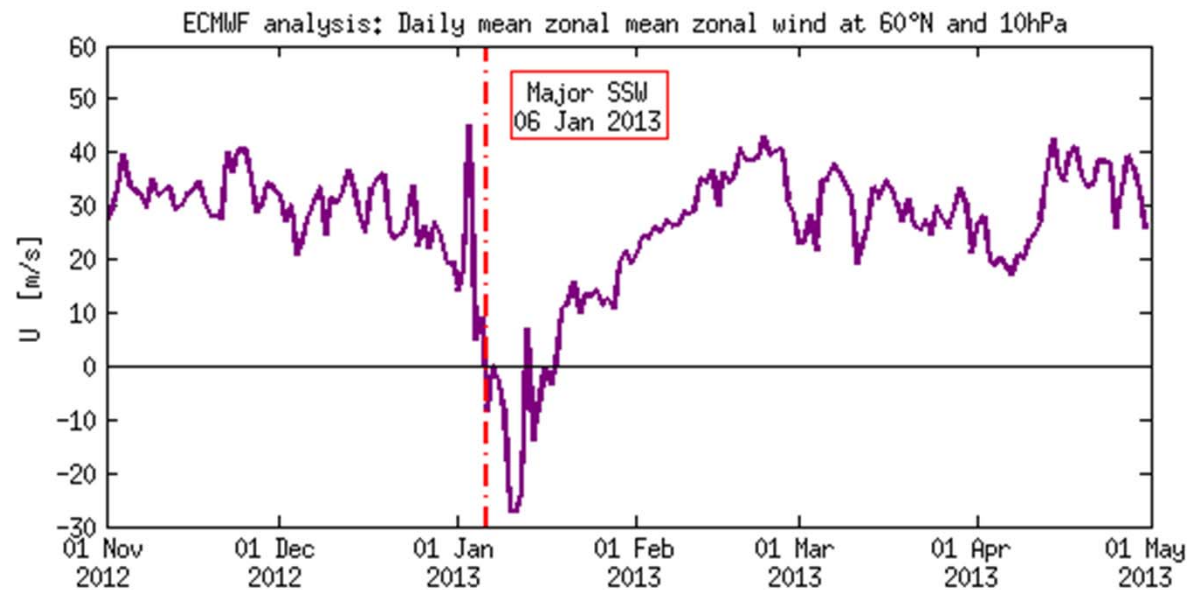
Water vapour [70-90]°N



Major midwinter warming in January 2013

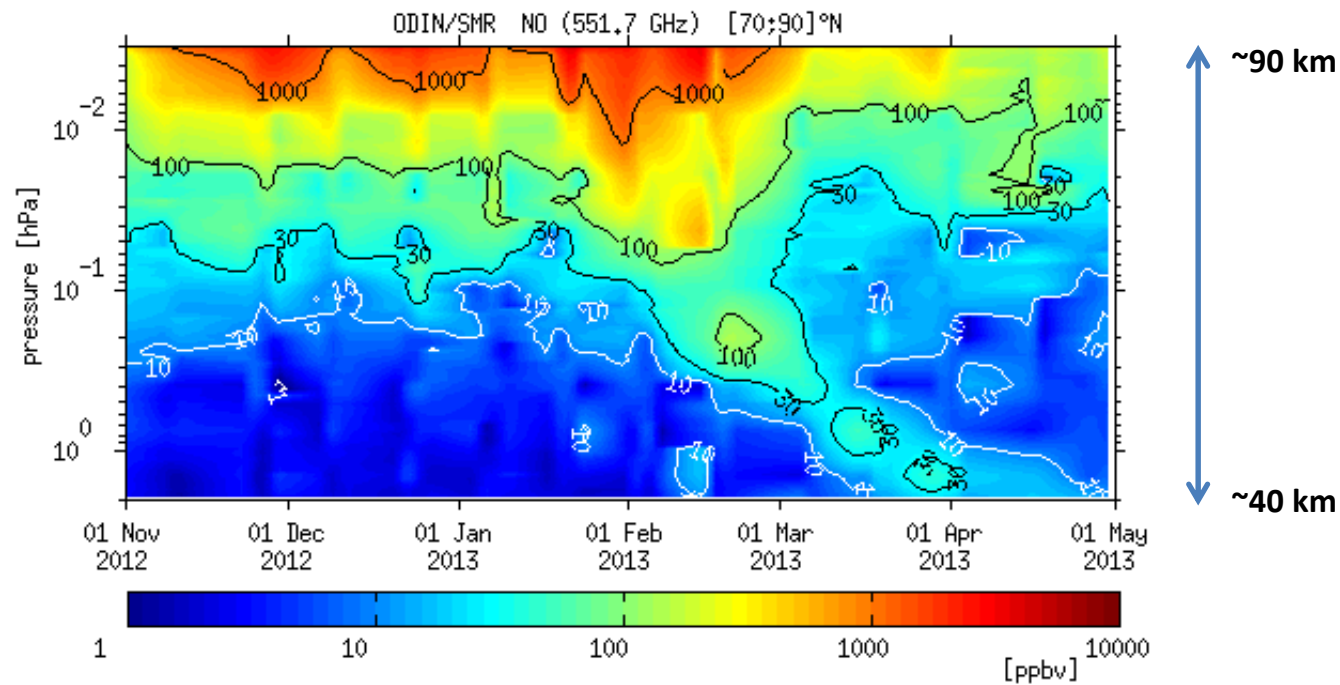
WMO definition
(Charlton and Polvani, 2007)

1. Reversal of the zonal mean **zonal winds** at **60°N** and **10hPa** (~30km):
Become **easterly** during winter (Nov-Mar)
2. Reversal of the poleward zonal mean **temperature gradient** from **60°N** to **90°N**,
at **10hPa**: $\Delta T > 0$



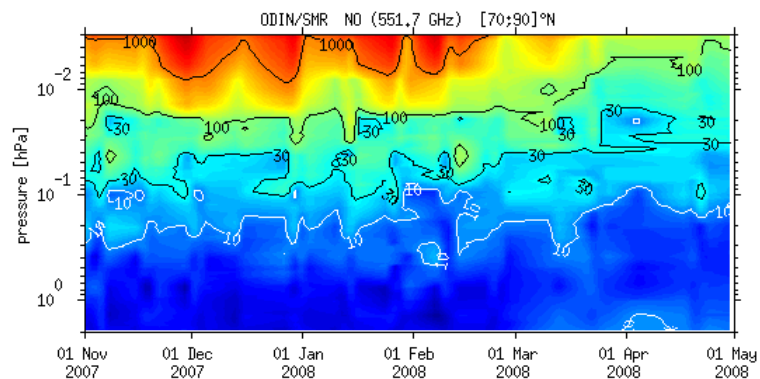
NO descent in the arctic stratosphere in early 2013

→ **NO produced by energetic particle precipitation**
in the upper mesosphere / lower thermosphere
able to reach the stratosphere during the months following the SSW event:

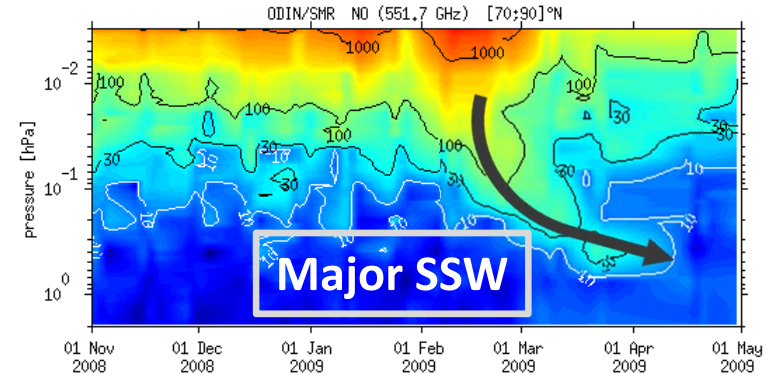


Odin / SMR NO measurements (551.7 GHz) [70-90]°N

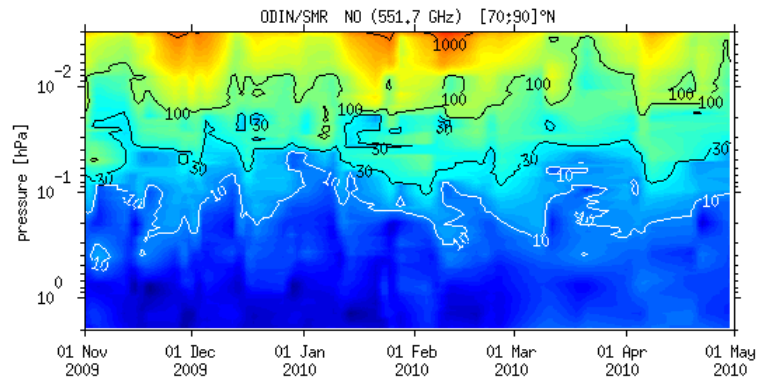
2007-2008



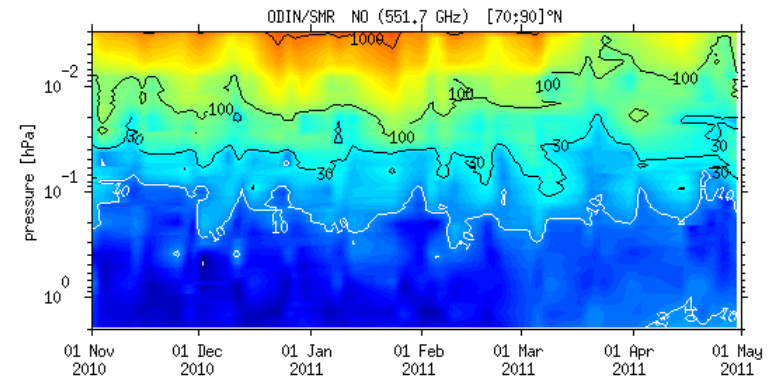
2008-2009



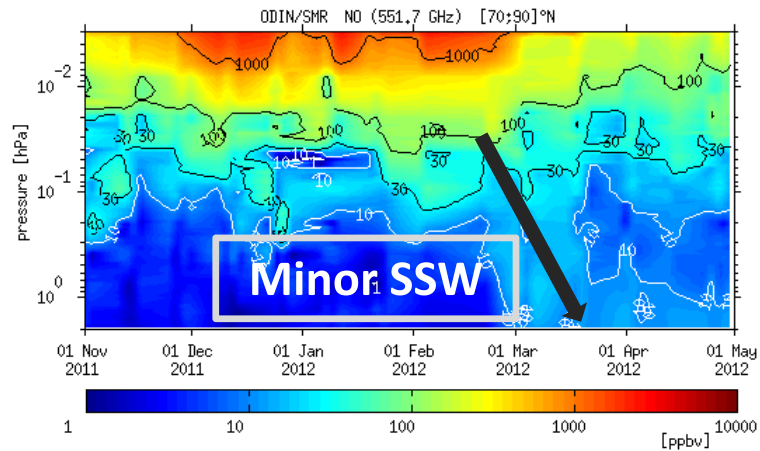
2009-2010



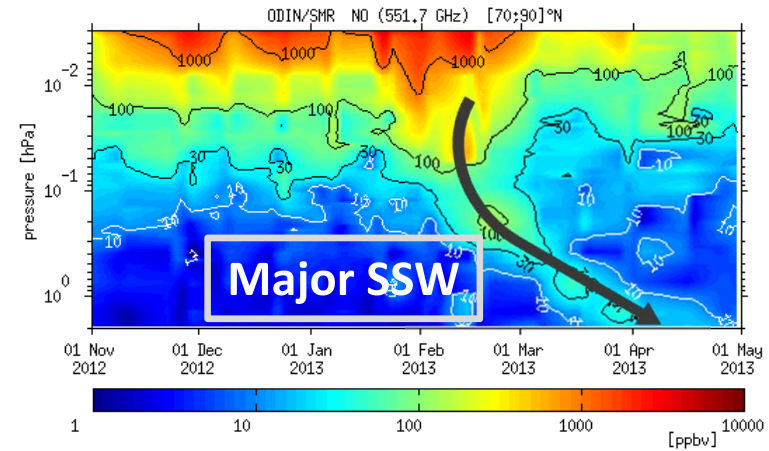
2010-2011



2011-2012

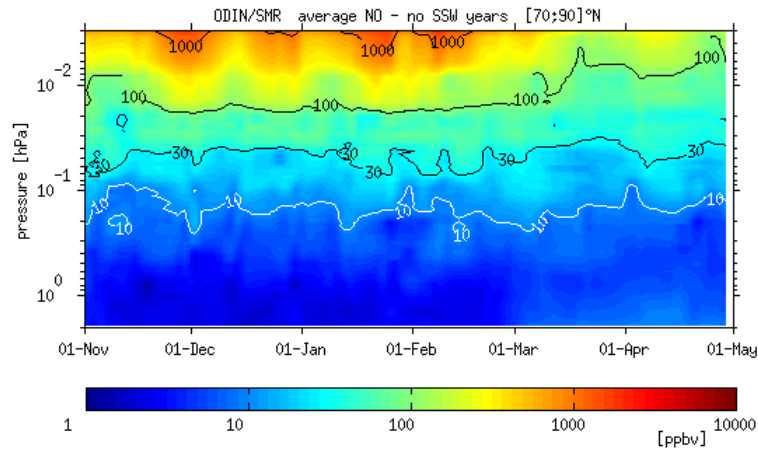


2012-2013

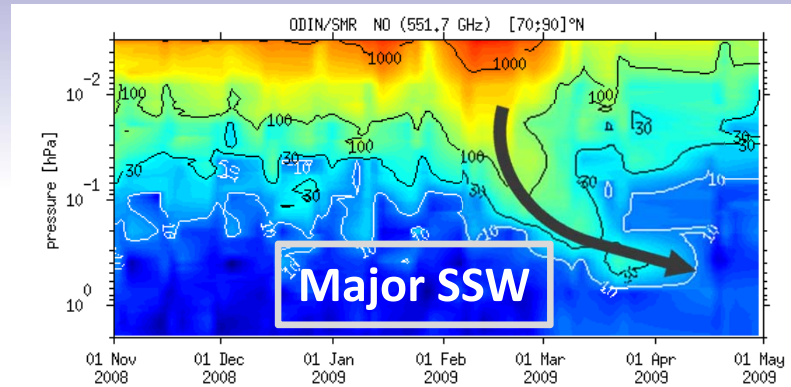


Odin / SMR NO measurements (551.7 GHz) [70-90]°N

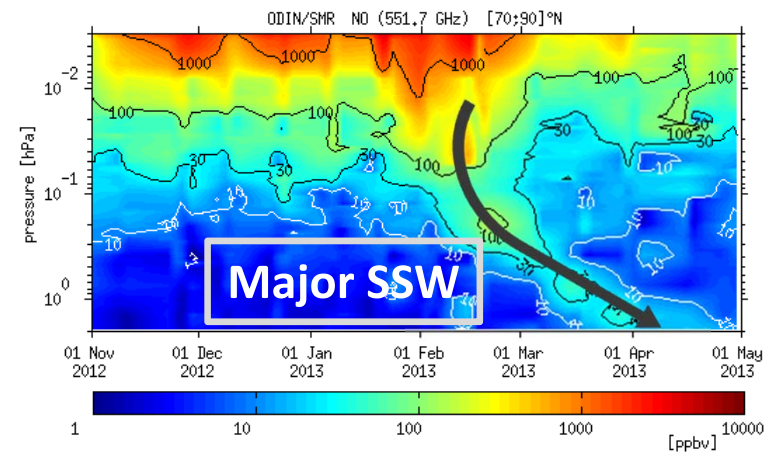
Average NO observed in
2007-2008, 2009-2010 and 2010-2011:
3 “standard” winters,
without any particular dynamical event



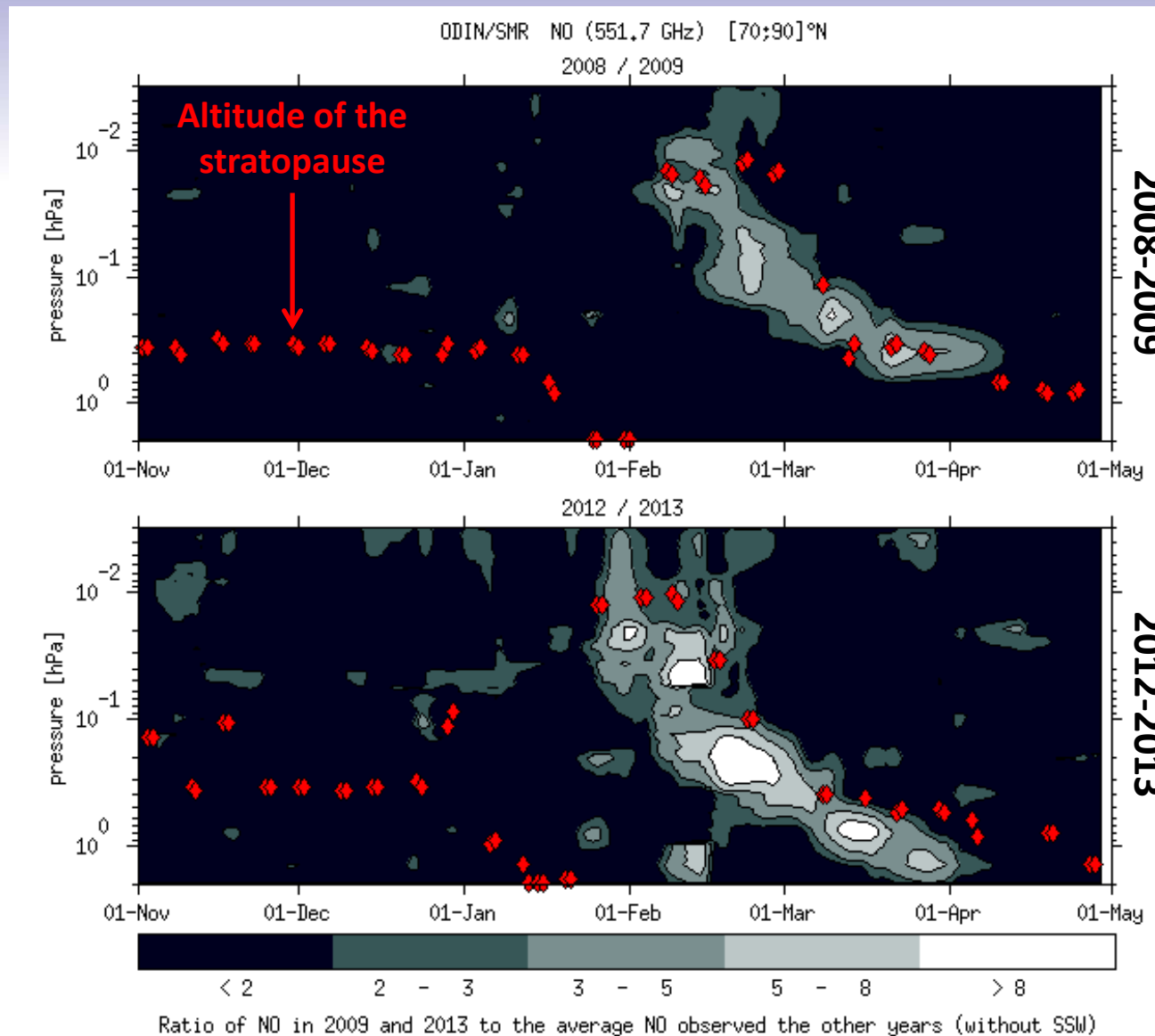
2008-2009



2012-2013



Relative NO enhancements



2013:

- Larger enhancements than in 2009 (up to 20 times more NO in the stratosphere than normal)

- Onset \equiv formation of the elevated stratopause.

- The tongue of EPP-NO extends **lower in altitude**

- Higher potential to influence the middle atmospheric composition

Summary

Odin / SMR →

- **Rich data sets** for studying the effects of high energetic particle precipitation on the middle atmospheric composition
- Involved in **HEPPA** - Model-Measurement Intercomparison project
- Particularly strong and persistent SSW event in **January 2013**:
Interesting case to study EPP indirect effects :
Dynamics?
Impact on stratospheric ozone?
Relationship with solar activity?
etc.

Thank you for your attention!

