Odin climatology of NO_x in the stratosphere

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Overview

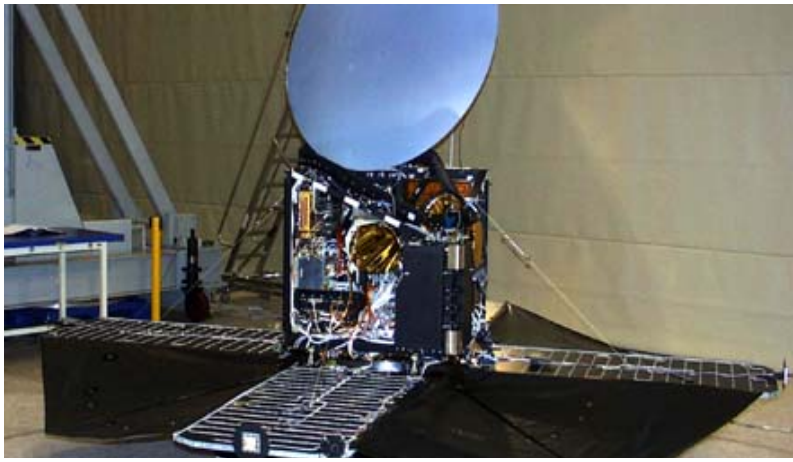
- NO_x : active nitrogen species [nitric oxide(NO)+NO_2 (nitrogen dioxide)]
- largest contributor to ozone destruction in the middle stratosphere.

- Sources of NO_x in the stratosphere and lower mesosphere:
  1- Photo-dissociation of N_2O (tropical troposphere)
  2- $N_2O + O(^1D) \rightarrow NO + NO$
  3- Downward transport of NO_x generated by highly energetic particle precipitation from the lower thermosphere-upper mesosphere in the winter polar upper stratosphere.

- Sinks of NO_x :
  1- Photo-dissociation of NO and NO_2
  2- Reaction with ozone, halogens and atomic oxygen

The Odin satellite

Odin - Swedish led **mini-satellite,**
cooperation with Canada, Finland, France.
Launched in February 2001.



Limb-sounding in aeronomy mode,

Polar sun-synchronous orbit:
6am/6pm equator crossing,
near global daily coverage.

SMR (*Sub-Millimetre Radiometer*)

OSIRIS (*Optical Spectrograph and InfraRed Imaging System*)

Odin NO and NO_2 data

- SMR NO data: 30-70km and 80-110km

Global measurements of NO in the middle atmosphere by the Odin satellite (~ one observation day per month from October 2003 to April 2007 and on a nearly weekly basis thereafter).

- OSIRIS NO_2 data: 10-45km

Global measurements in the upper troposphere and stratosphere (one observation every other day from October 2003 to April 2007 and on a every day basis thereafter.)

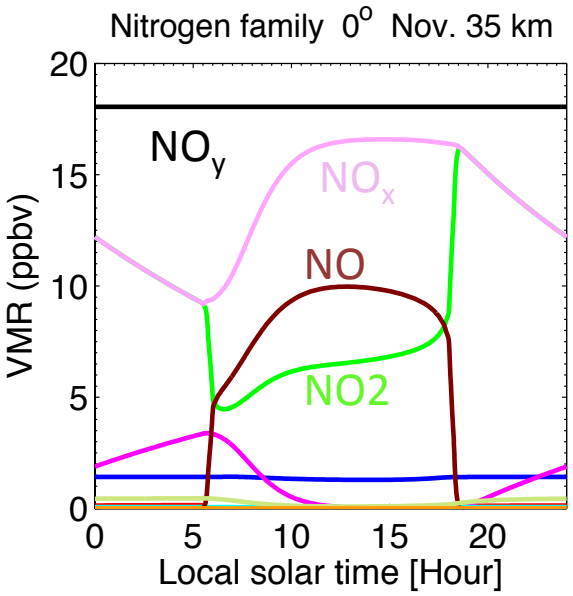
- S. Brohede have done NO_2 and NO_y climatology using NO_2 , HNO_3 from Odin and NO, $ClONO_2$ and other nitrogen species from model simulations (PRATMO, REPROBUS).

Motivation

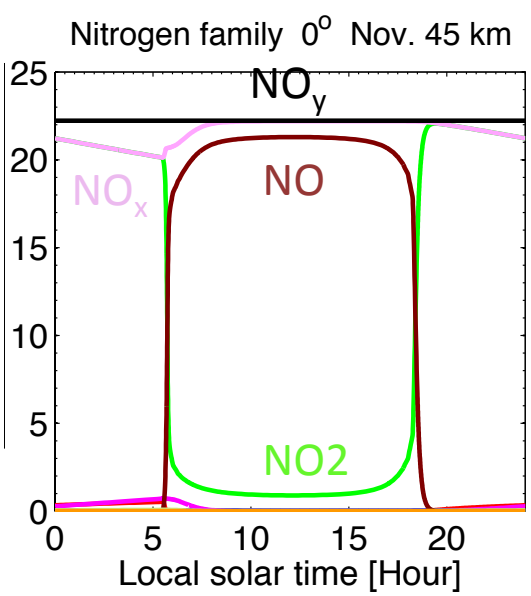
- Long-term measurements provide the possibility of trend studies.
- Odin measures at certain local time around sunrise/sunset. (the equator descending/ascending nodes, ~ 6am/pm). The Odin data can not be directly compared with similar instruments (MLS and MIPAS)
- Correction of the short-lived species measured by Odin using a photochemical model.
- This presentation gives an overview of the NO_x (NO and NO2) climatology and scaling factors calculated by a photochemical model.

The nitrogen partitioning in the tropics in the stratosphere and lower mesosphere

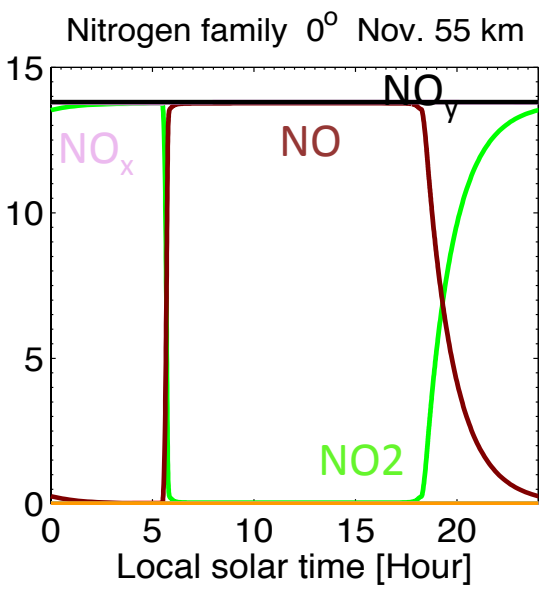
35 km



45 km



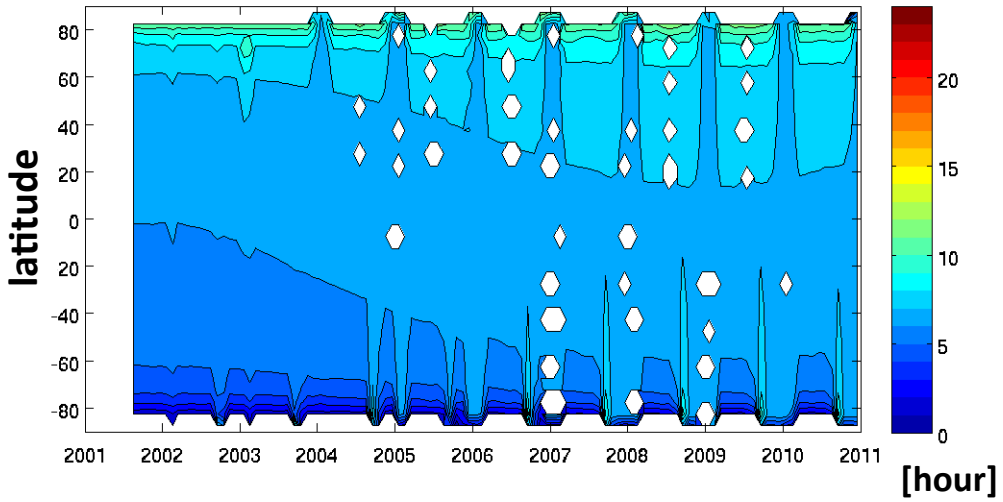
55 km



NO$_x$ comprises the major part of NO$_y$ in the upper stratosphere-lower mesosphere.

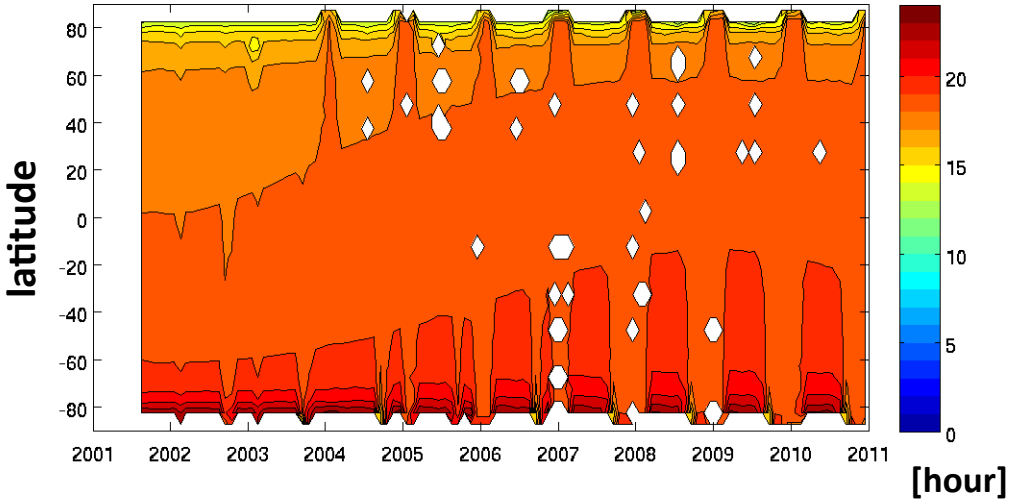
Odin / local solar time

LST - am - ascending node



6.00 → 7.00

LST - pm - descending node



18.00 → 19.00

Methodology

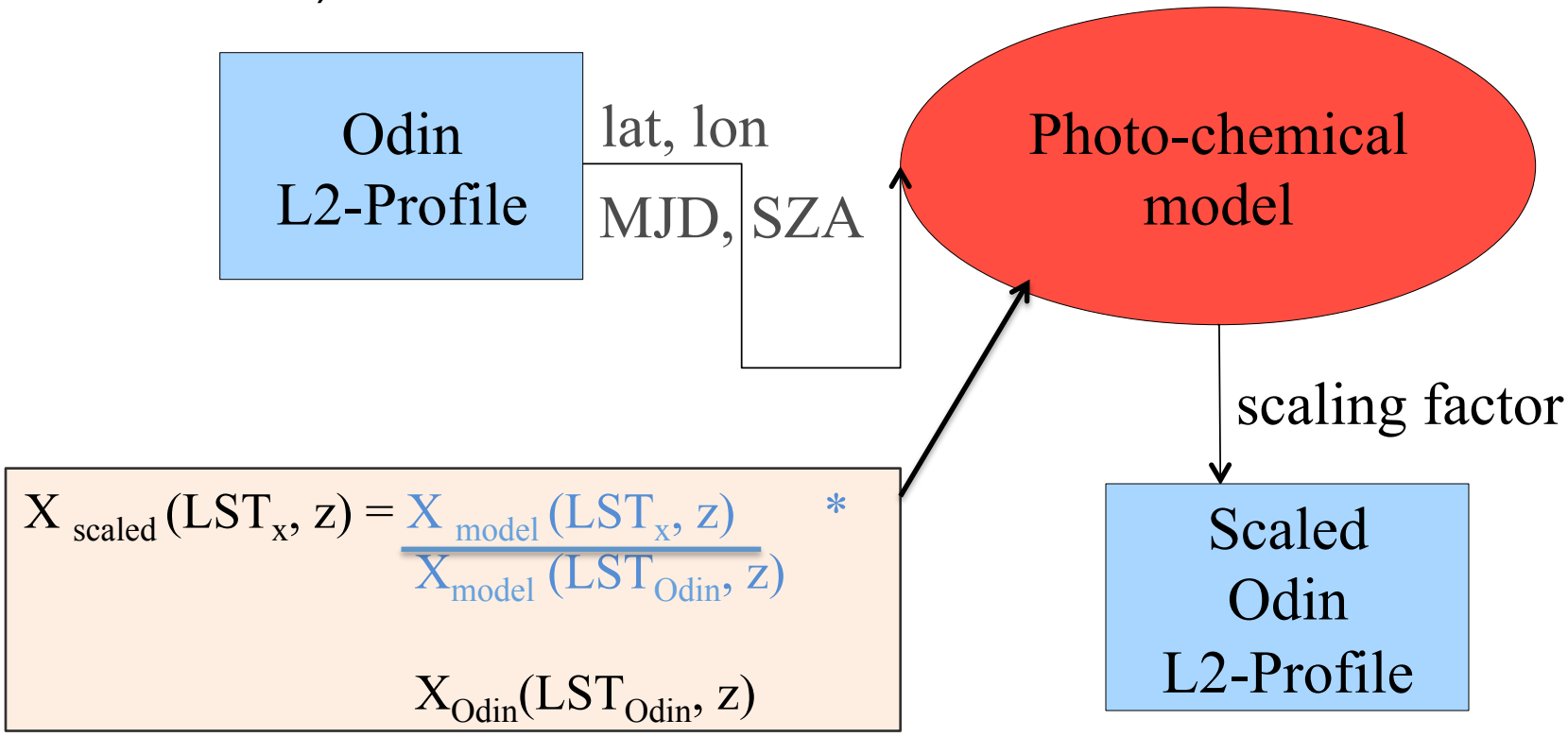
1. Data is splited to am and pm climatologies.

2. Selection of the proper reference time (10 am/10 pm ascending time for MIPAS)

3. Correction methods for SZA dependence of species concentrations
   - Scaling with help of model (precalculated look-up tables to save time/effort)

Scaling factor

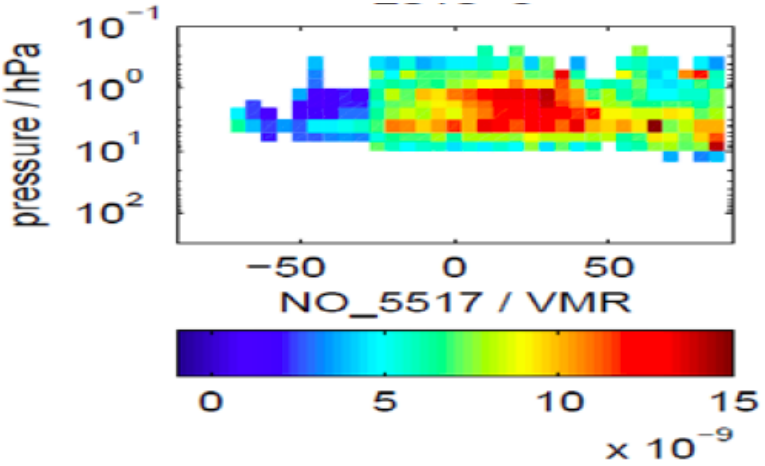
- Scale all the profiles to a reference LST/SZA.
- The photochemical model (MISU_1d model) has been previousely validated for short-lived species ClO, HO_2 and HOCl (khosravi et al., ACPD2012)



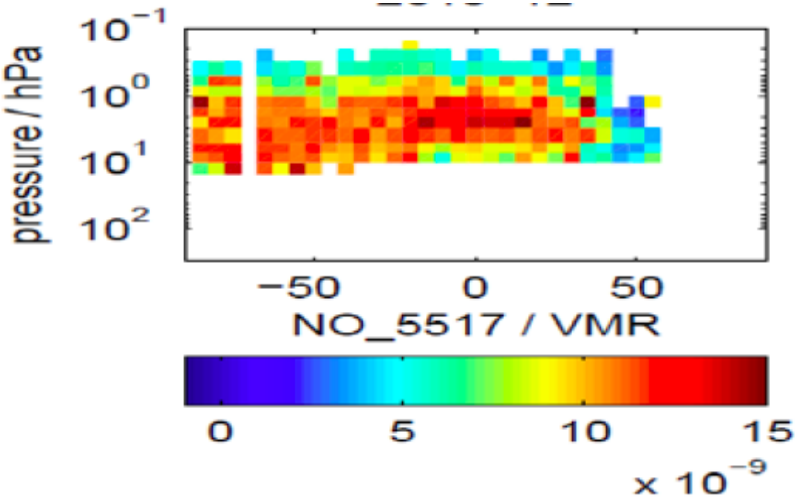
SMR NO climatology (unscaled)

am

June 2010



December 2010



pm

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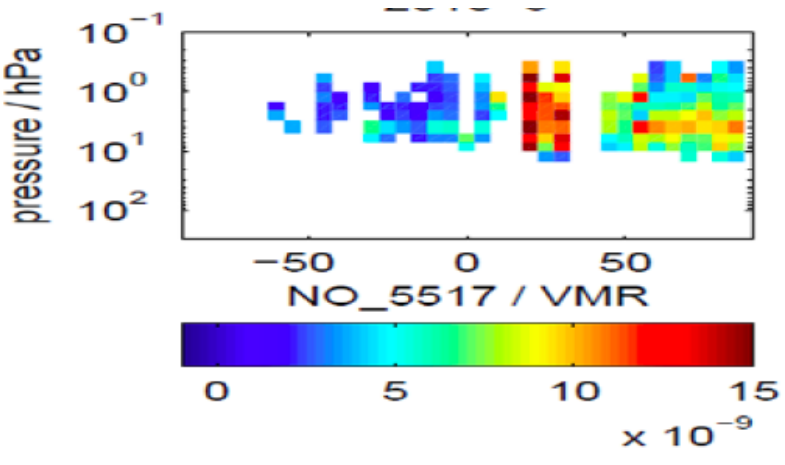

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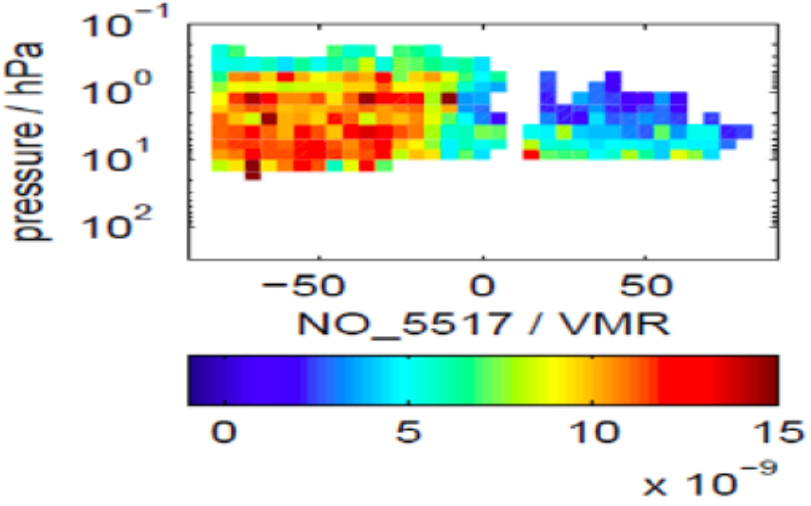
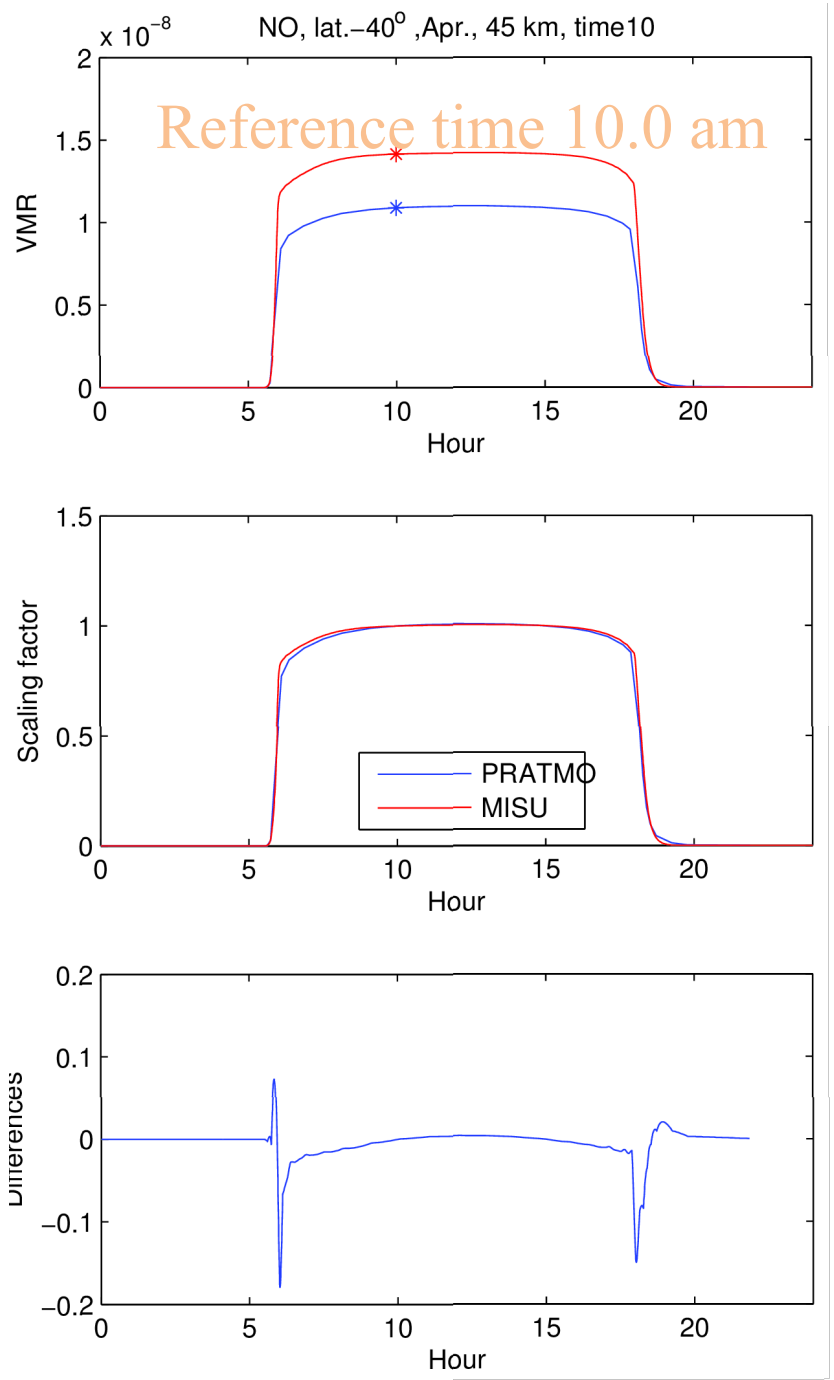
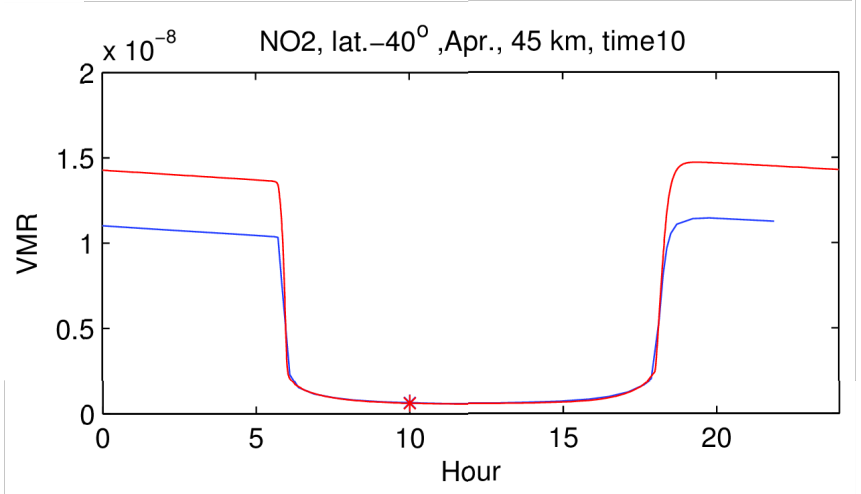
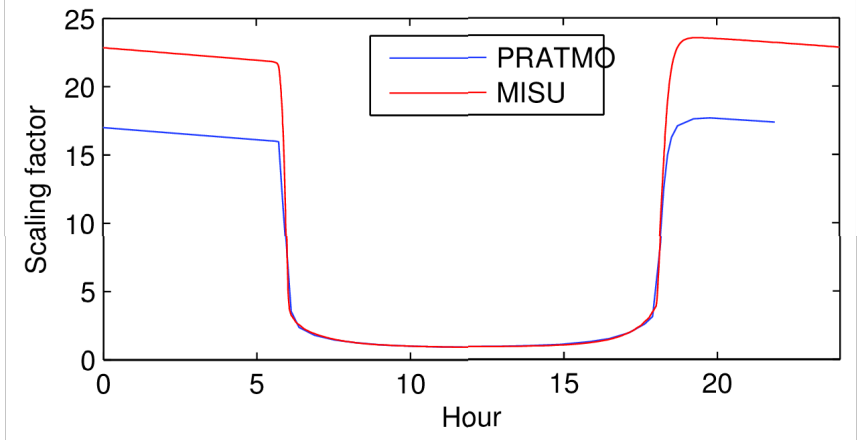


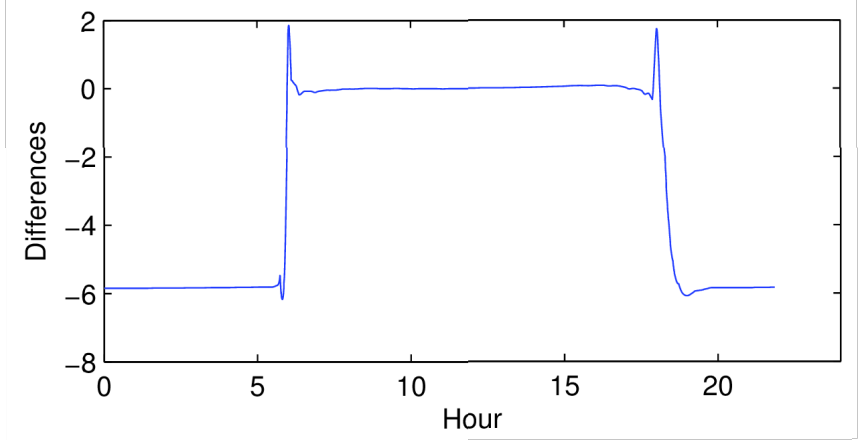


Comparisons of NO scaling factors calculated by MISU-1d (A. Jonsson) and PRATMO (S. Brohede, C. McLinden) models

- The smallest differences between the scaling factors from MISU and PRATMO is at night and day time (in contrast with sunrise/sunset).
- Latitudes 60 N to 60 S, about 25 – 55 km all seasons.
- The largest difference of 10-20% are found around sunrise and sunset.







Comparisons of NO_2 scaling factors calculated by MISU and PRATMO models

- The smallest differences between the scaling factors from MISU and PRATMO are during daytime.
- Latitudes 60 N to 60 S, about 25 – 55 km all seasons.
- The largest difference of 60% are found at nighttime and sunrise and sunset.
- Scaling to 10 pm as the reference time decreases the difference between the scaling factors given by the models (differences are about 20% during sunrise/sunset).

Summary

- The direct inter-comparison of climatologies of diurnally active species (NO and NO_2) is impossible using sun-synchronous measurements.

- The photochemical models can be used to scaled the data to a specific (reference) solar time /SZA.

- The model validated for NO and NO_2 and SMR data will scale to 10 am (ascending node for MIPAS) to be validated by MIPAS observations.

- The scaling factors calculated by MISU and PRATMO for NO agree better at reference time of 10 am and for NO_2 at reference time of 10 pm due to the higher mixing ratios.

Outlook

- Quality assessment
  - Validity range and limitations?
  - Internal consistency am/pm, inter-comparisons?
  - Comparison of the SMR climatologies with external satellite data sets

- The model will be validated for NO and NO_2 and SMR data will scale to 10 am/pm (ascending/descending node for MIPAS) to be compared to MIPAS observations.

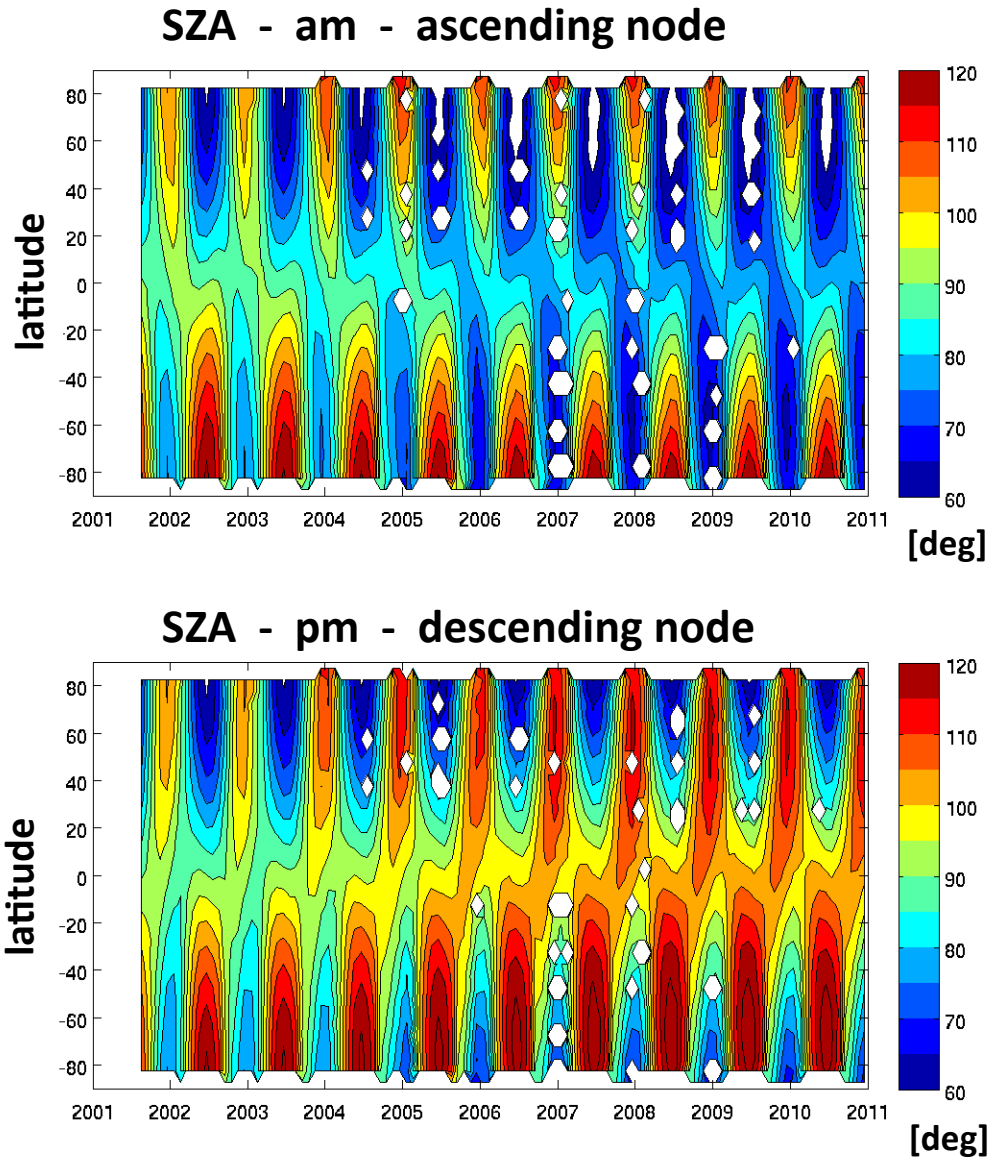
- Climatologies of stratospheric short-lived species species (SPARC/SPIN project).

- Possibility to be extended to NOy climatology if SMR HNO_3 is included.

Short-lived species observed by Odin

- **Sub-Millimeter Radiometer (SMR):**
  - ClO 15-60km
  - HO_2 (Oct-2003 to Oct-2004) 30-60km
  - NO (from Oct 2003) 30-70km and 80-110km
  - HNO_3 20-40km
- **Optical Spectrograph and InfraRed Imager (OSIRIS): uv-vis**
  - NO_2 10-45km
  - BrO

Odin / solar zenith angle



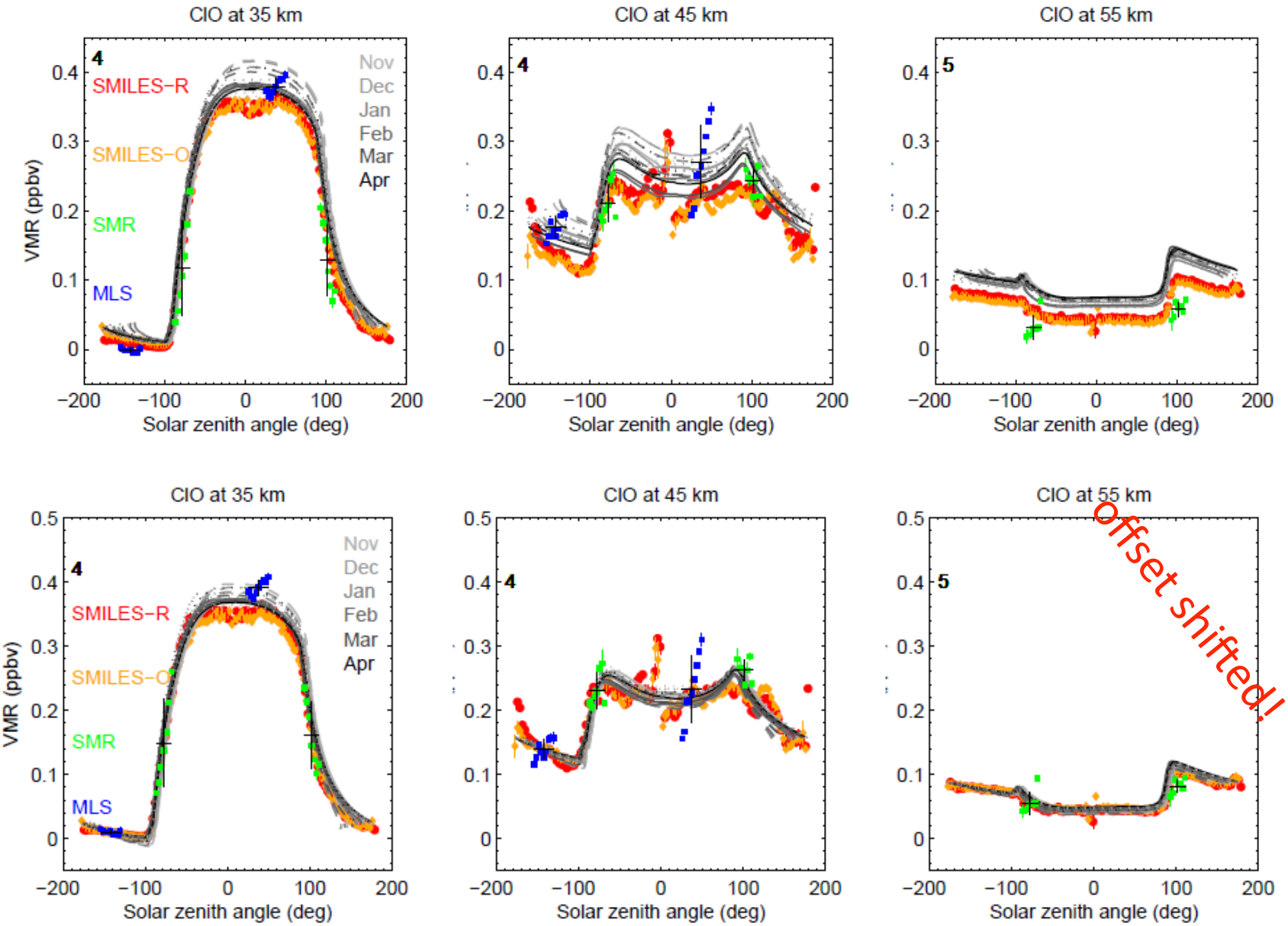
Data set inter-comparison: ClO and HO_2

tropics 20S-20N; Oct 2009 - April 2010

Assessment: ClO from SMR, MLS, SMILES, 1d model

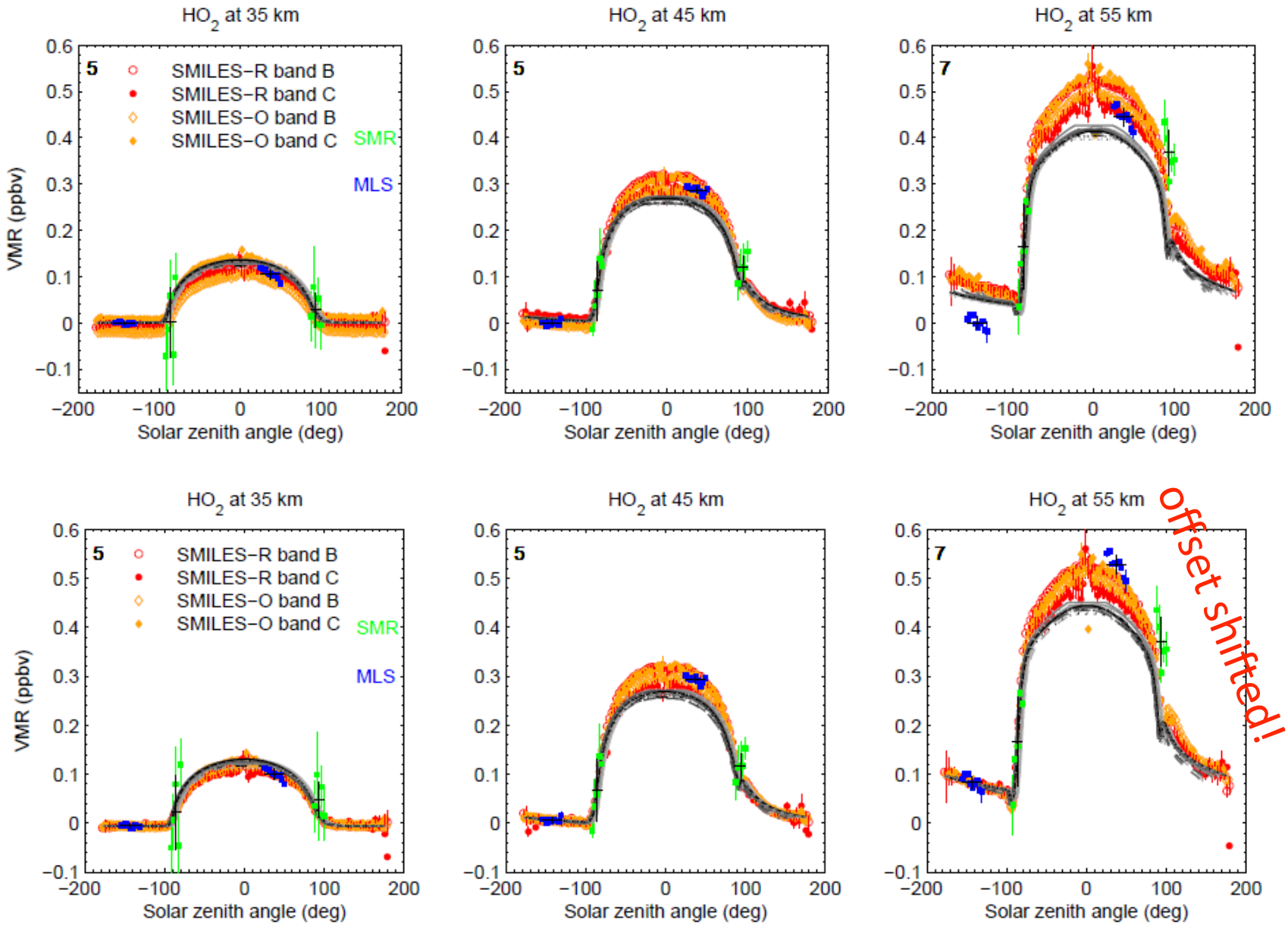
[Khosravi et al., ACPD 2012]

tropics Nov 2009 to Apr 2010

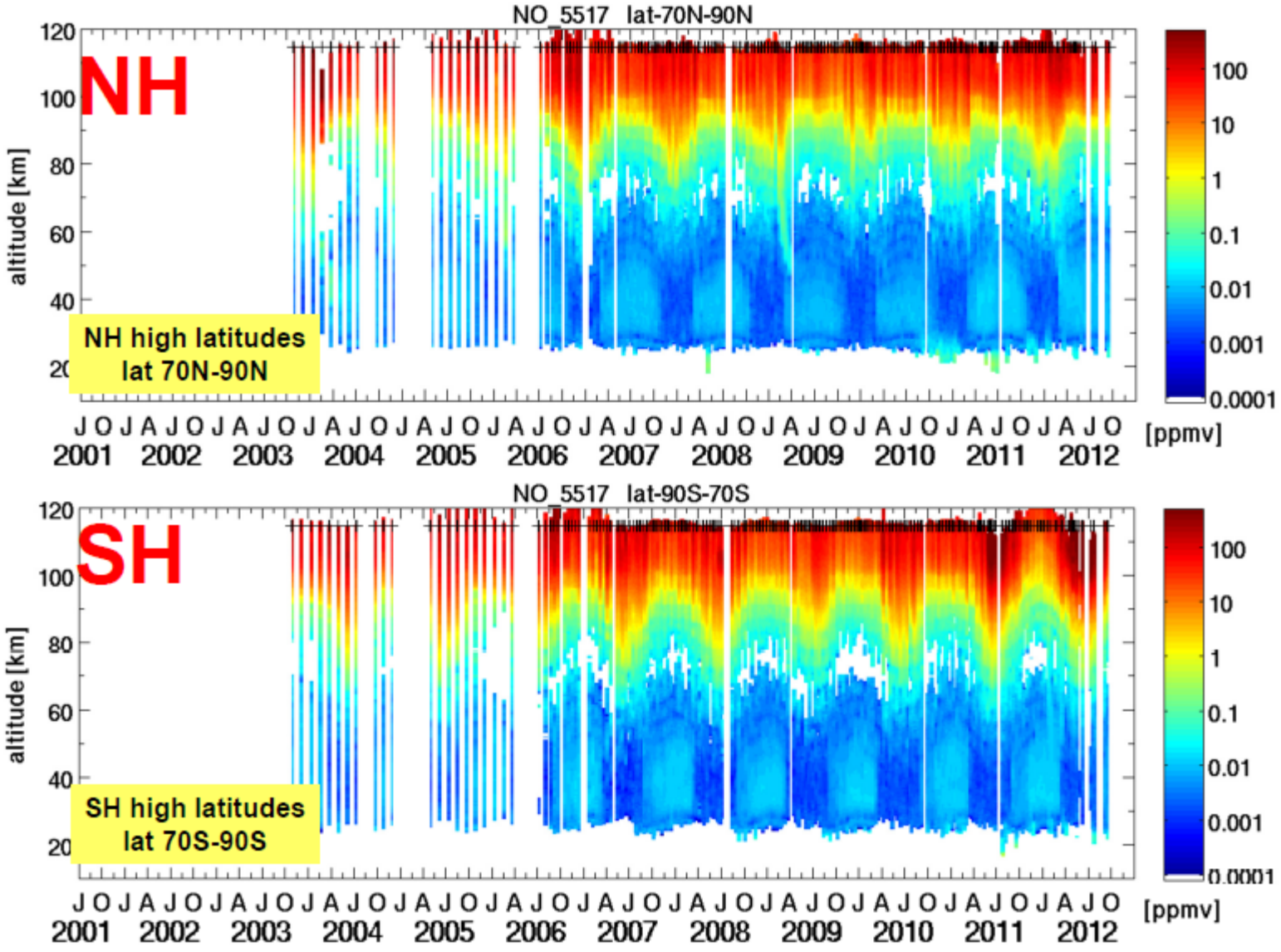


Assessment: HO_2 from SMR, MLS, SMILES, 1d model

Khosravi et al., ACPD 2012] **tropics Nov 2009 to Apr 2010**



Nitric oxide (NO) at high latitudes



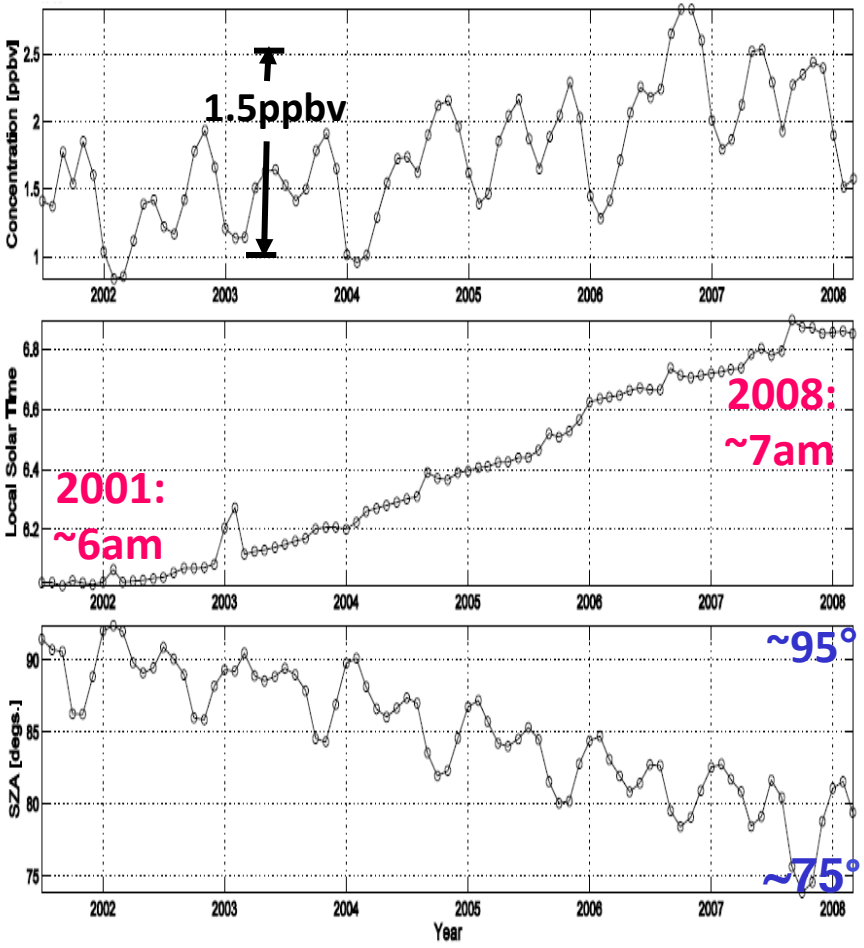
Example:

ClO

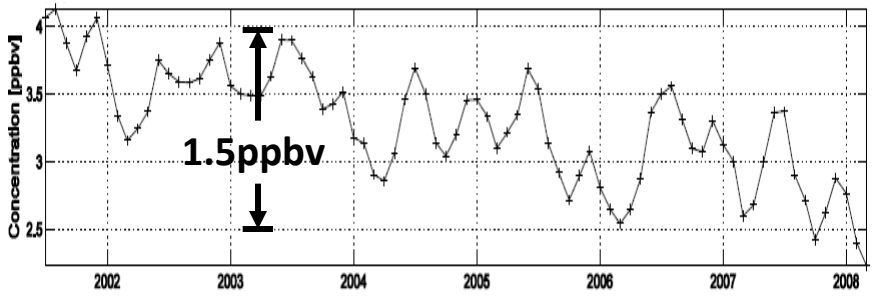
in tropical middle stratosphere

Effect of drifting Odin orbit on local time, SZA, and ClO: 2001-2008

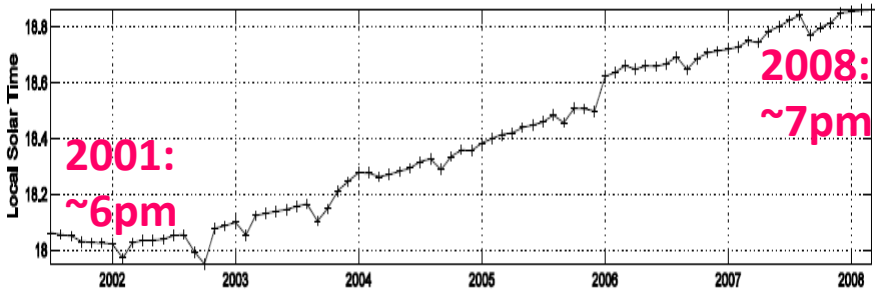
Eq: 20S-20N - 35-45km



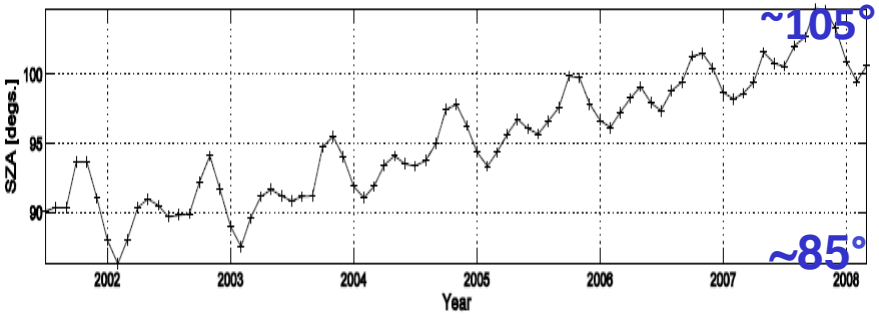
ClO



LST



SZA



from Jones et al., Ph.D., Chalmers 2009

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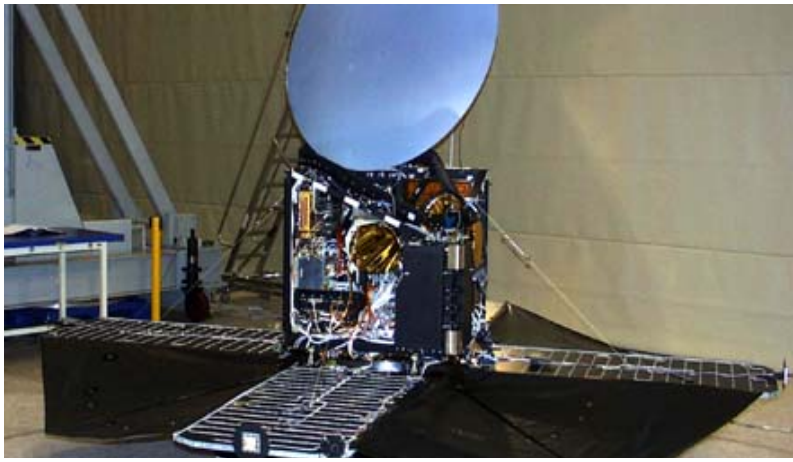

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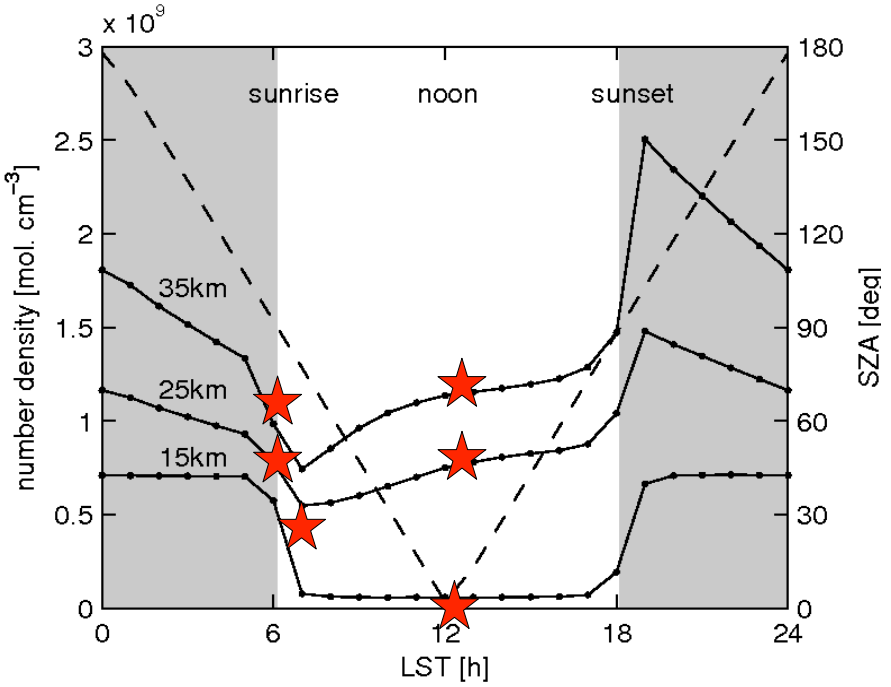
NO (from Oct 2003) 30-70km and 80-110km

OSIRIS (*Optical Spectrograph and InfraRed Imaging System*)

NO_2 10-45km

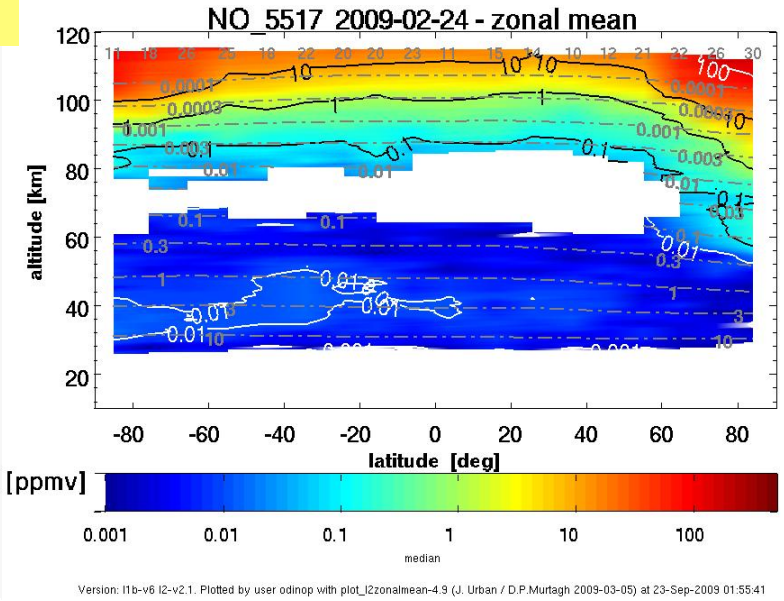
Diurnally Scaled Climatologies

- Scale ALL profiles to LST=12 or SZA=90^{o} to match solar occulations (but what to do with polar day regions then?)
- This cannot be performed on climatological means due to non-linearities.

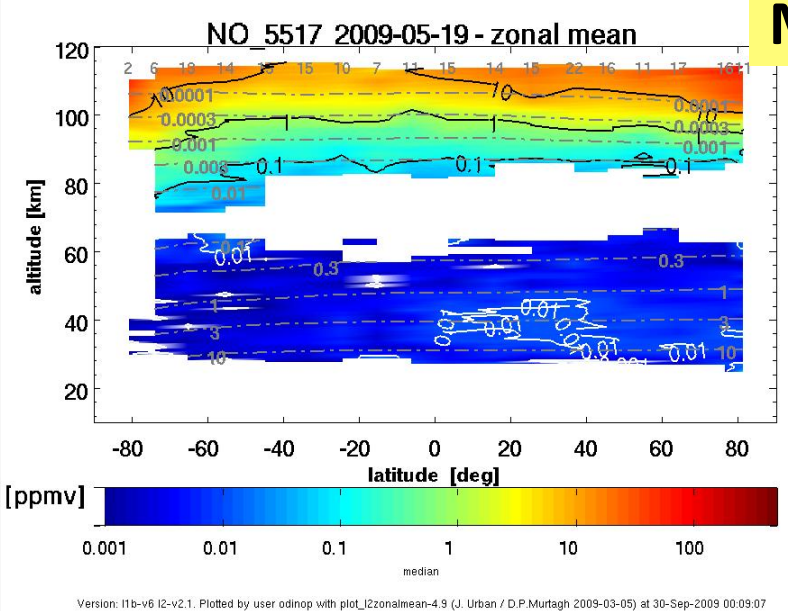


NO zonal mean distribution (2009)

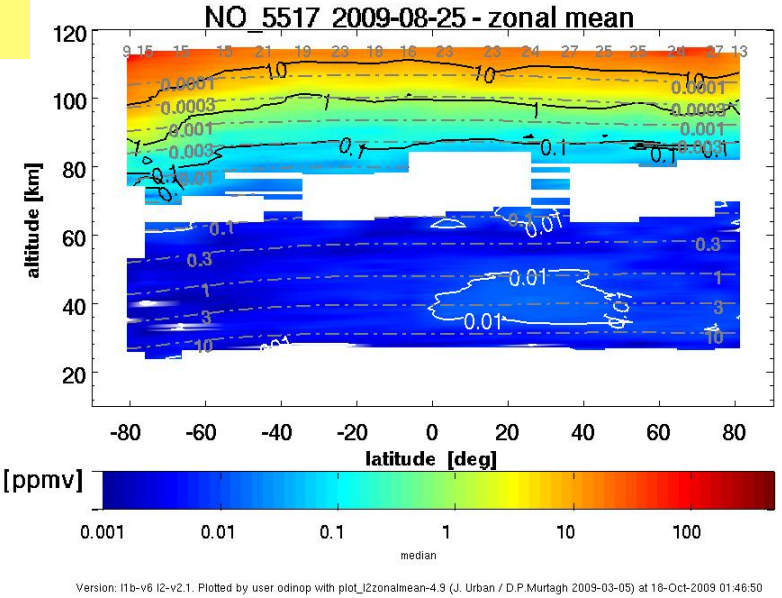
Feb



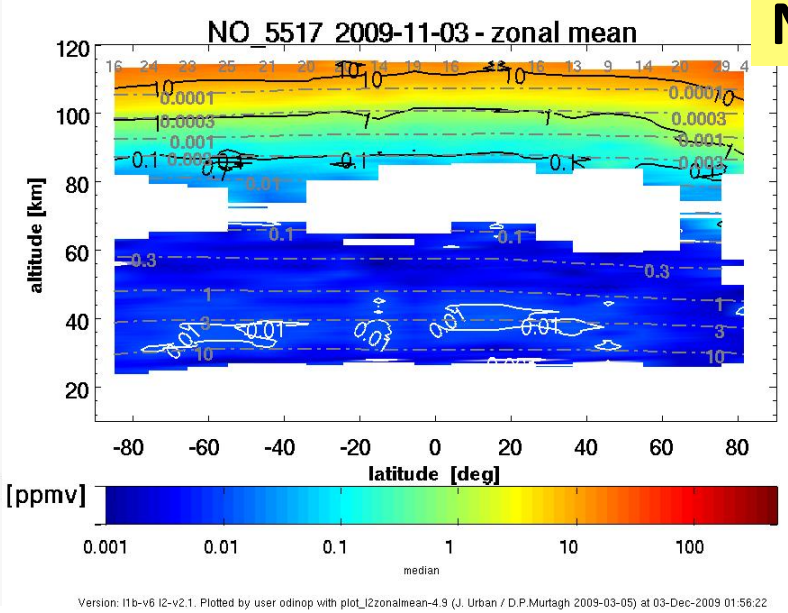
May



Aug



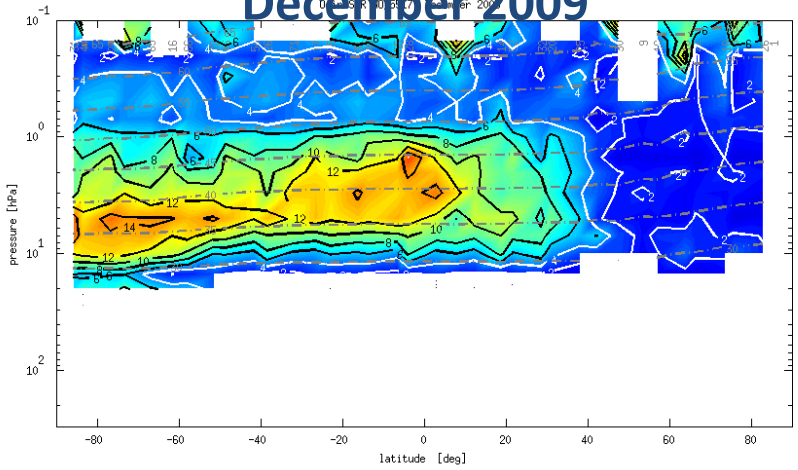
Nov



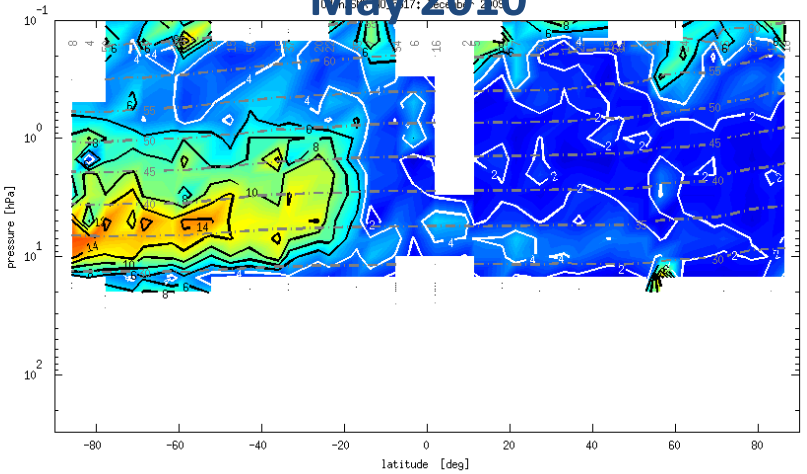
Odin NO climatology (unscaled)

am **pm**

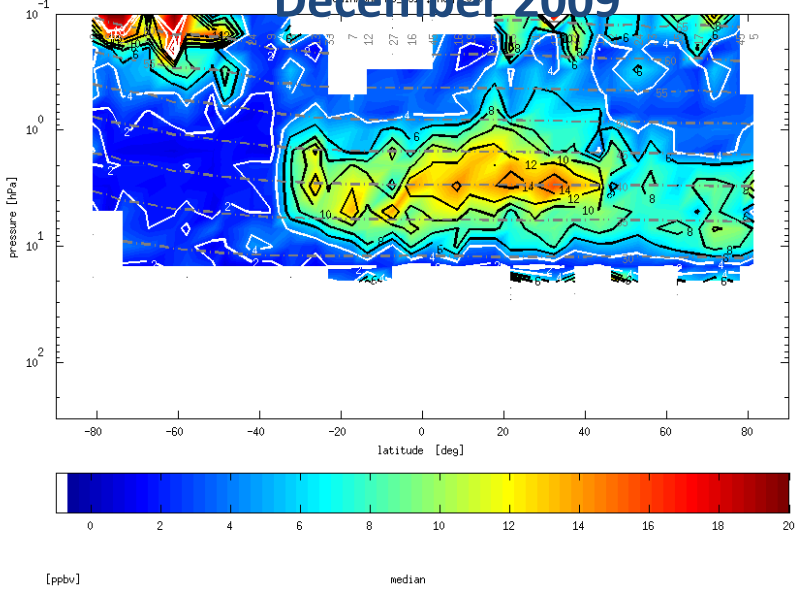
December 2009



May 2010



December 2009



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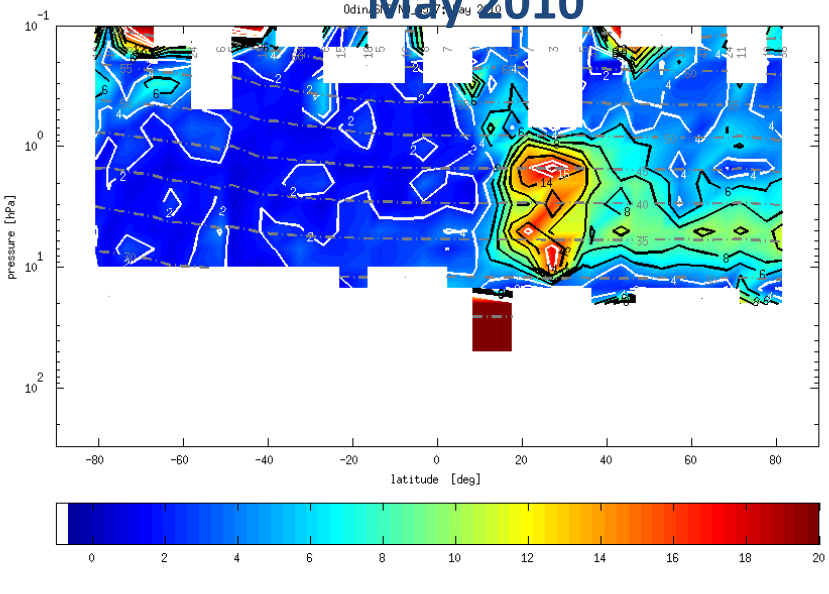
May 2010



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