11 years of water vapour observations by Odin/SMR: Overview and future plans

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and many data contributors

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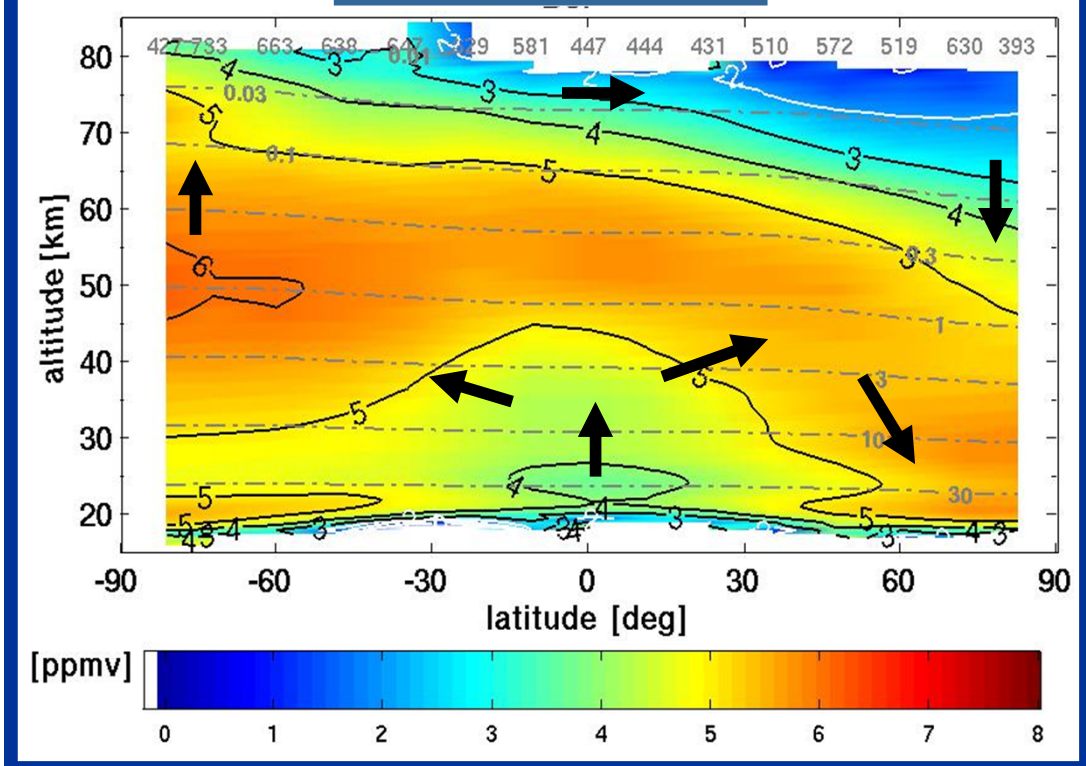
Stratospheric water vapour

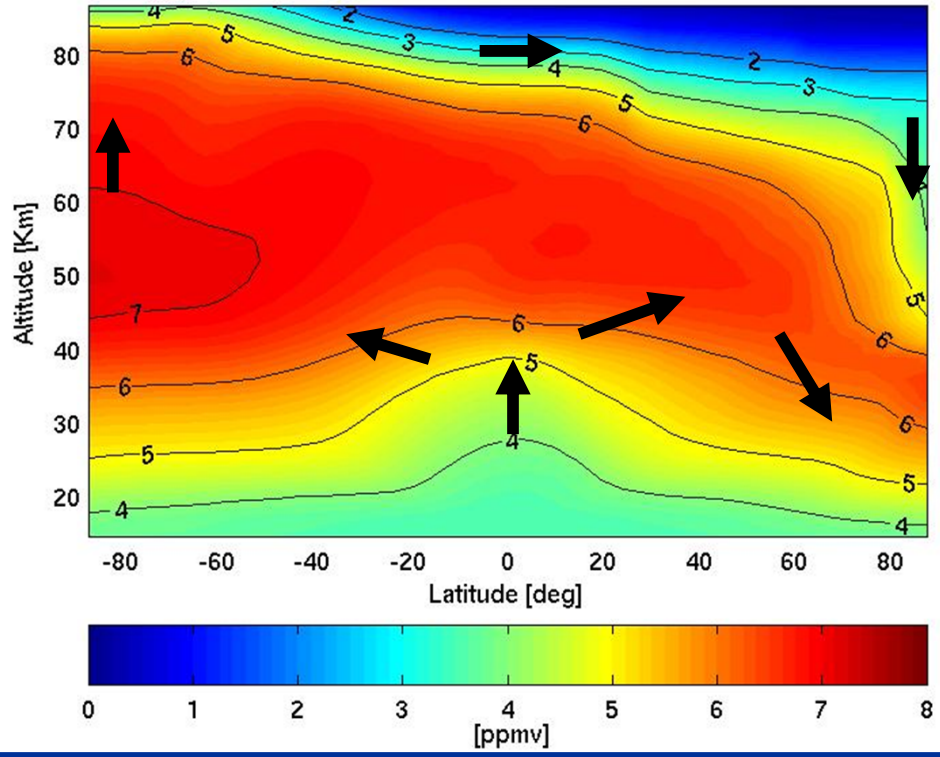
Stratospheric water vapour – zonal mean

Zonal mean of water vapour $H_2{}^{16}O$ (2001-2006)

Odin/SMR - DJF



2d model - DJF



Sources of stratospheric water vapour: transport through TTL; methane oxidation

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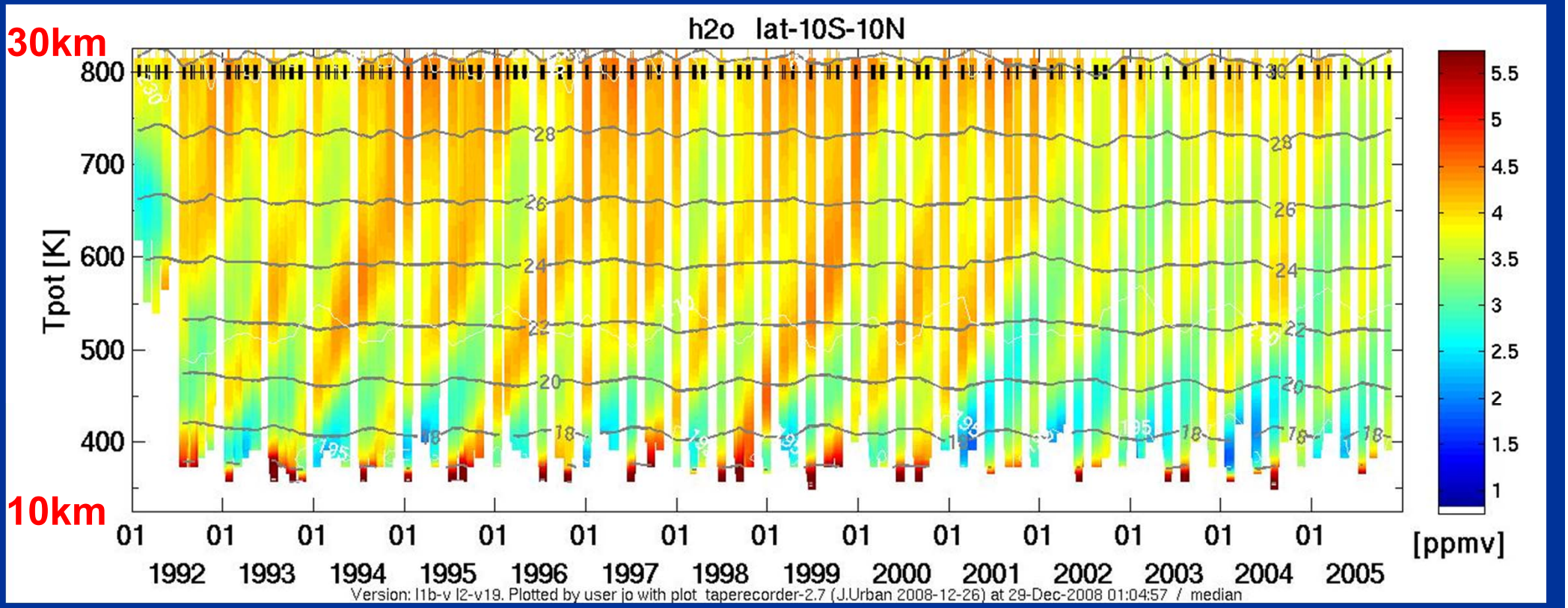
2d-model from Ridal & Siskind – calculations C. Sanchez

HALOE water vapour: tropical tape-recorder

Infrared solar occultation technique

Operation on UARS satellite 1991-2005



based on daily zonal means, smoothed over 15 days - HALOE v19 data

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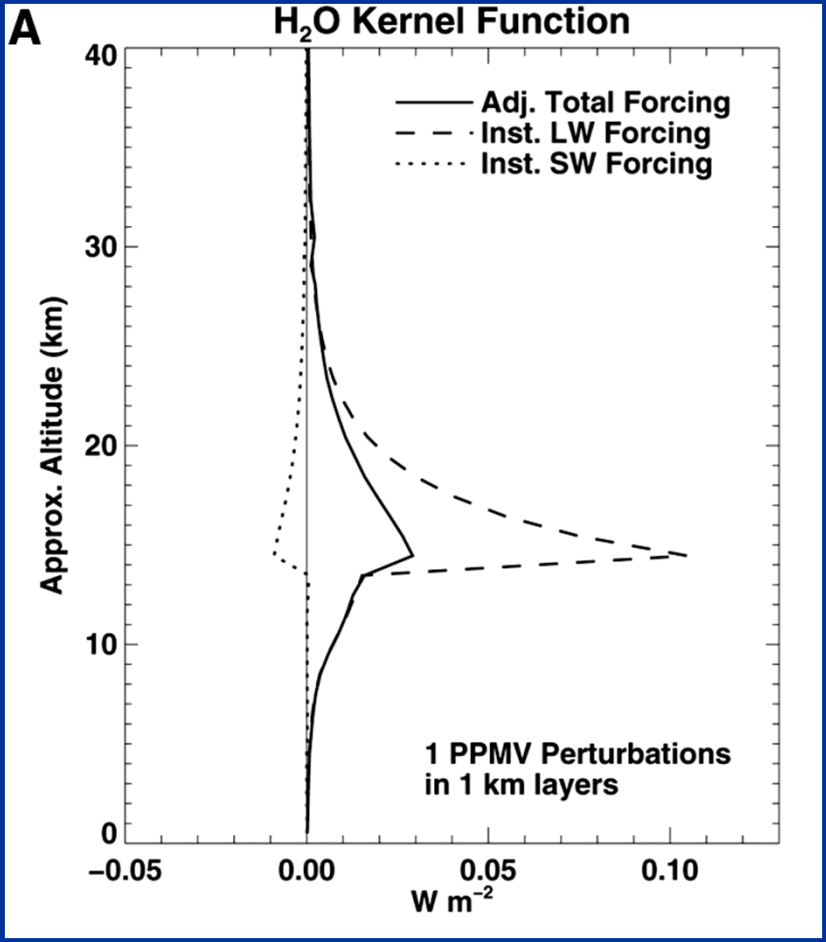
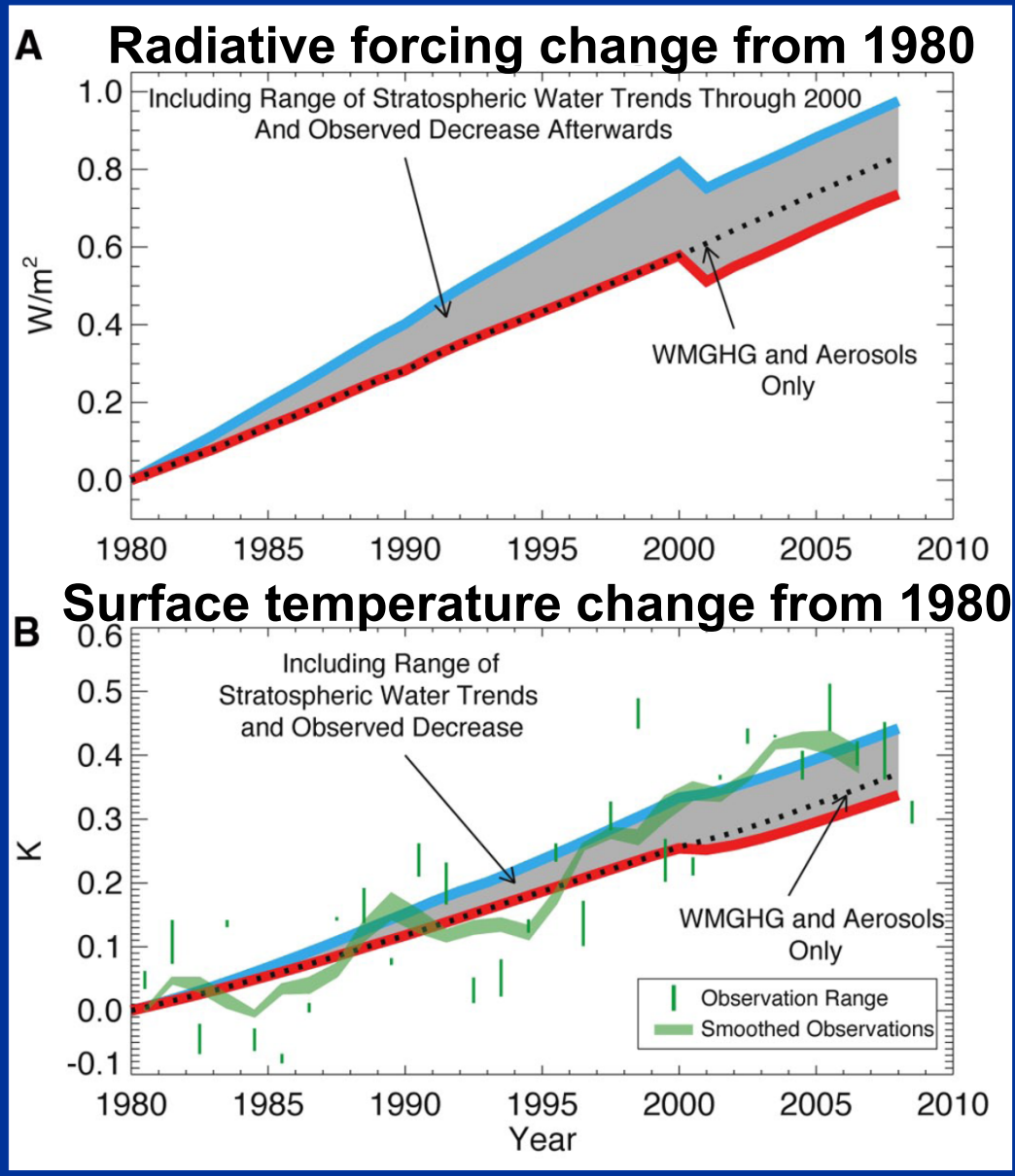
Motivation:

Do changes of ±0.5 ppmv H_2O matter?

Contributions of stratospheric water vapour to decadal changes in the rate of global warming

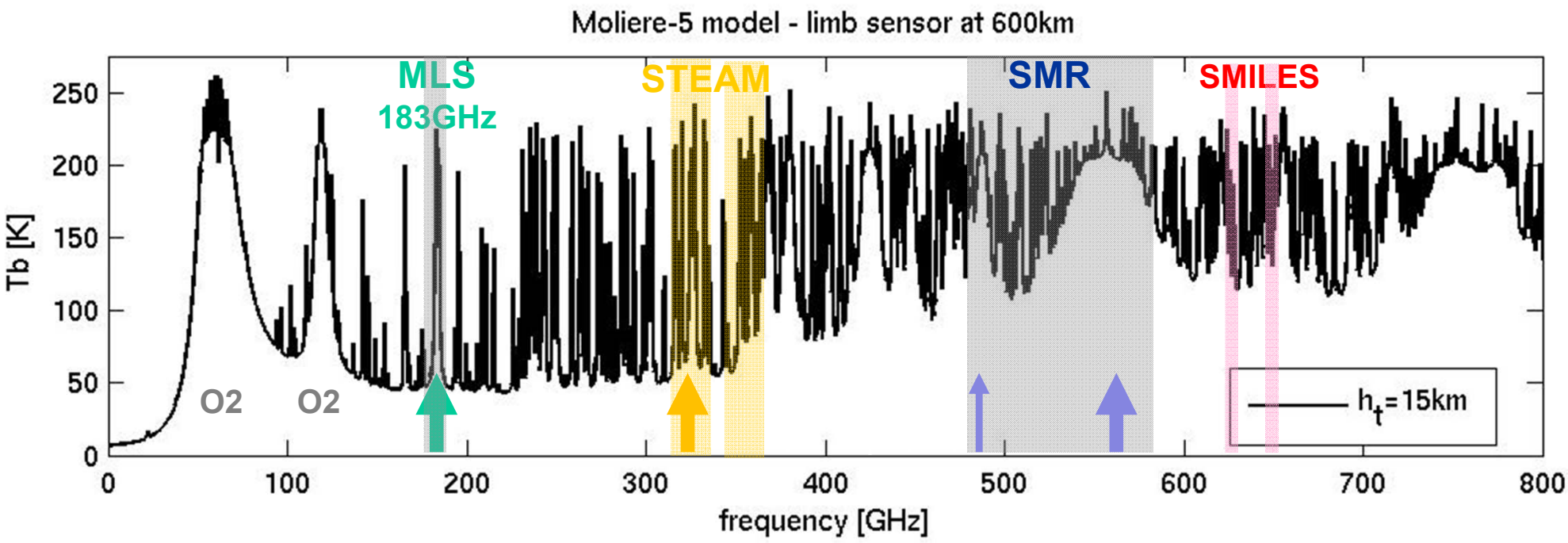




[Solomon & Rosenlof, Science 2010]

Odin observations

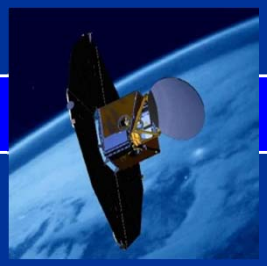
Microwave limb sounding: major water lines



1991

UARS/MLS 183GHz
MAS/ATLAS (Space Shuttle)

2001

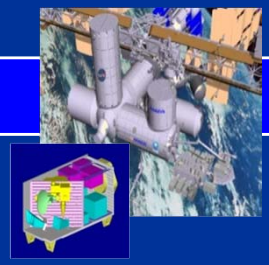


Odin/SMR
489+557GHz

2004

Aura/MLS
183GHz

2009



JEM/SMILES

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Odin/SMR spectral range

H2O, HDO, H2O-18, O3, O3-18 490GHz

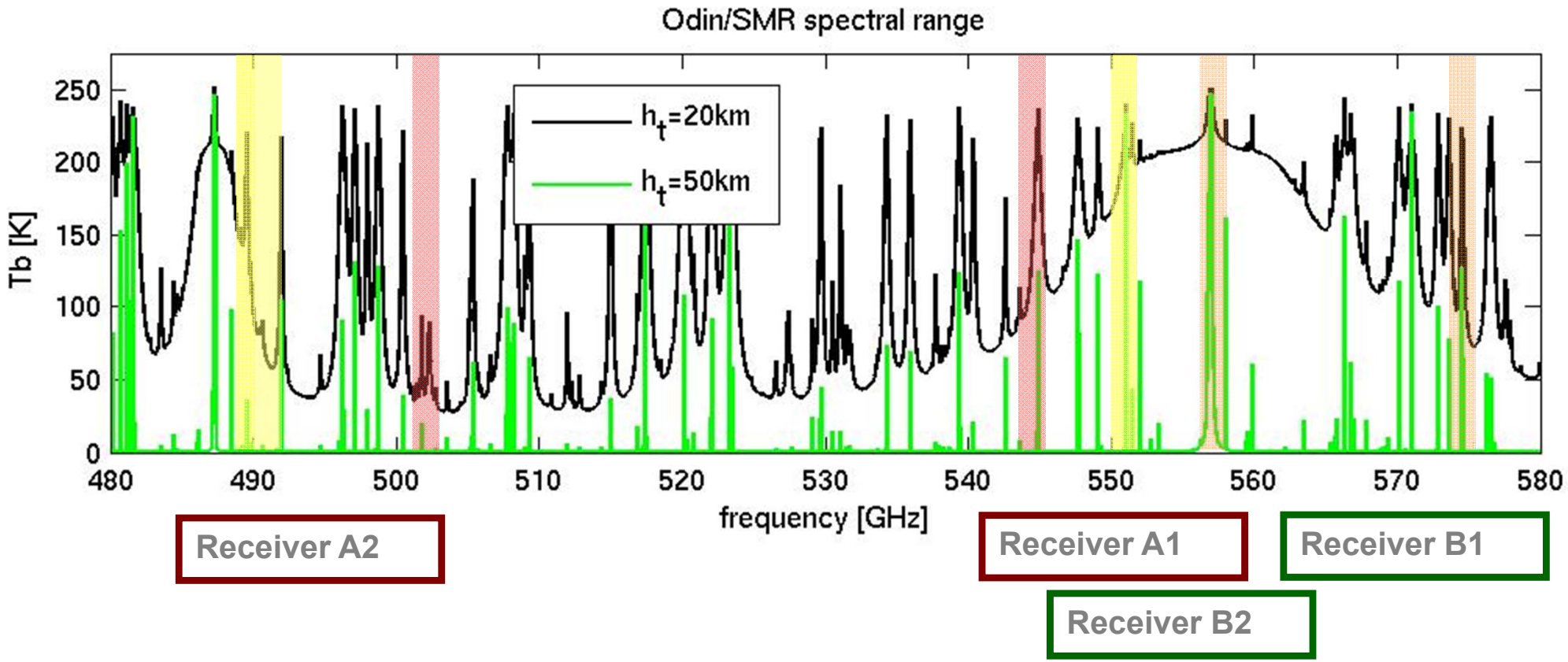
ClO, O3, N2O, UTH, IWP 501GHz

H2O-17, O3, NO 551GHz

O3, HNO3, H2O, UTH, IWP, T 544GHz

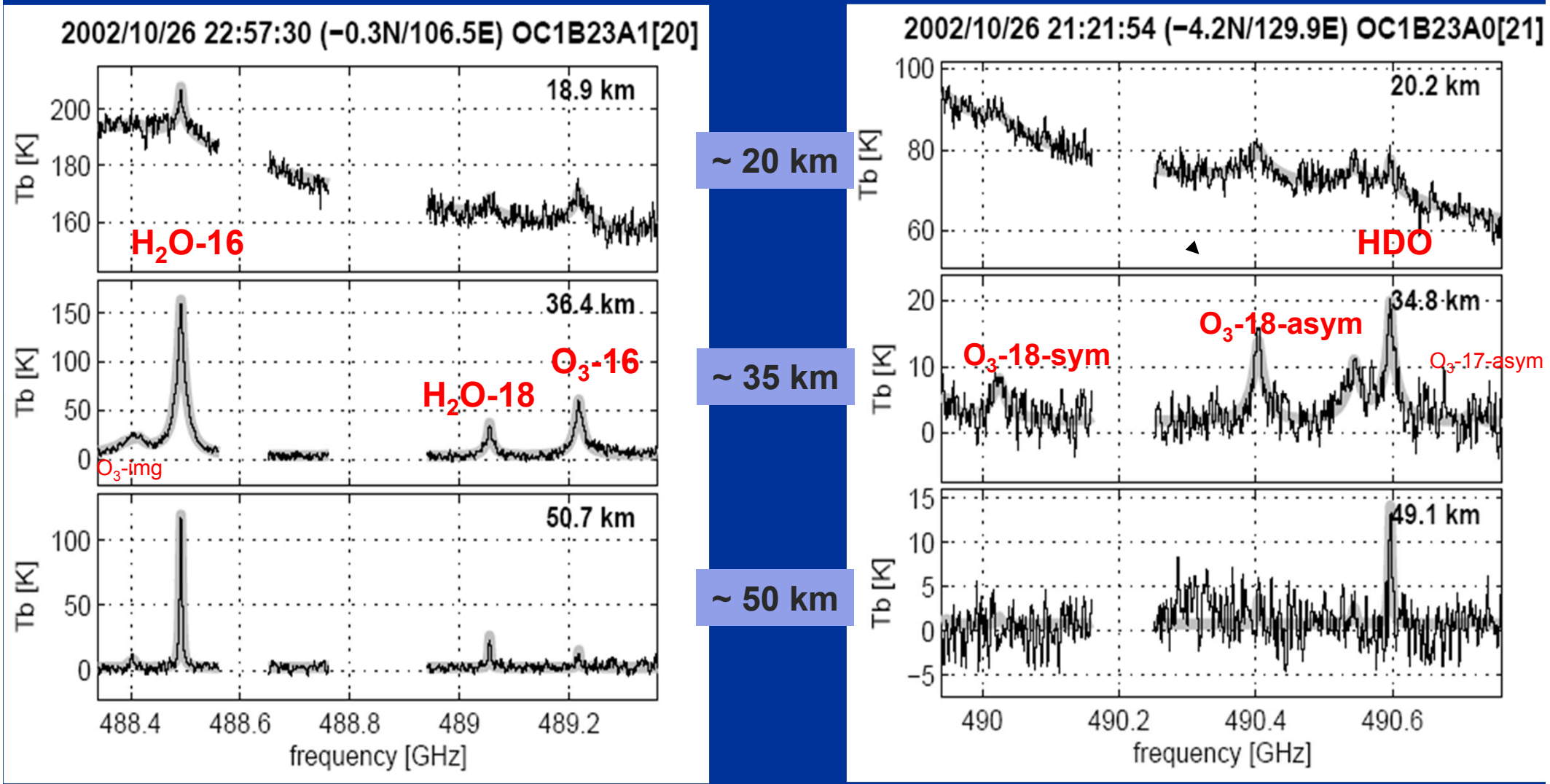
H2O, O3, T 557GHz

CO, O3, T 576GHz



Odin/SMR Water Isotope Mode: H_2O, HDO, H_2O-18

488.9 GHz band — **tropics - 2002-10-26** — **490.4 GHz band**



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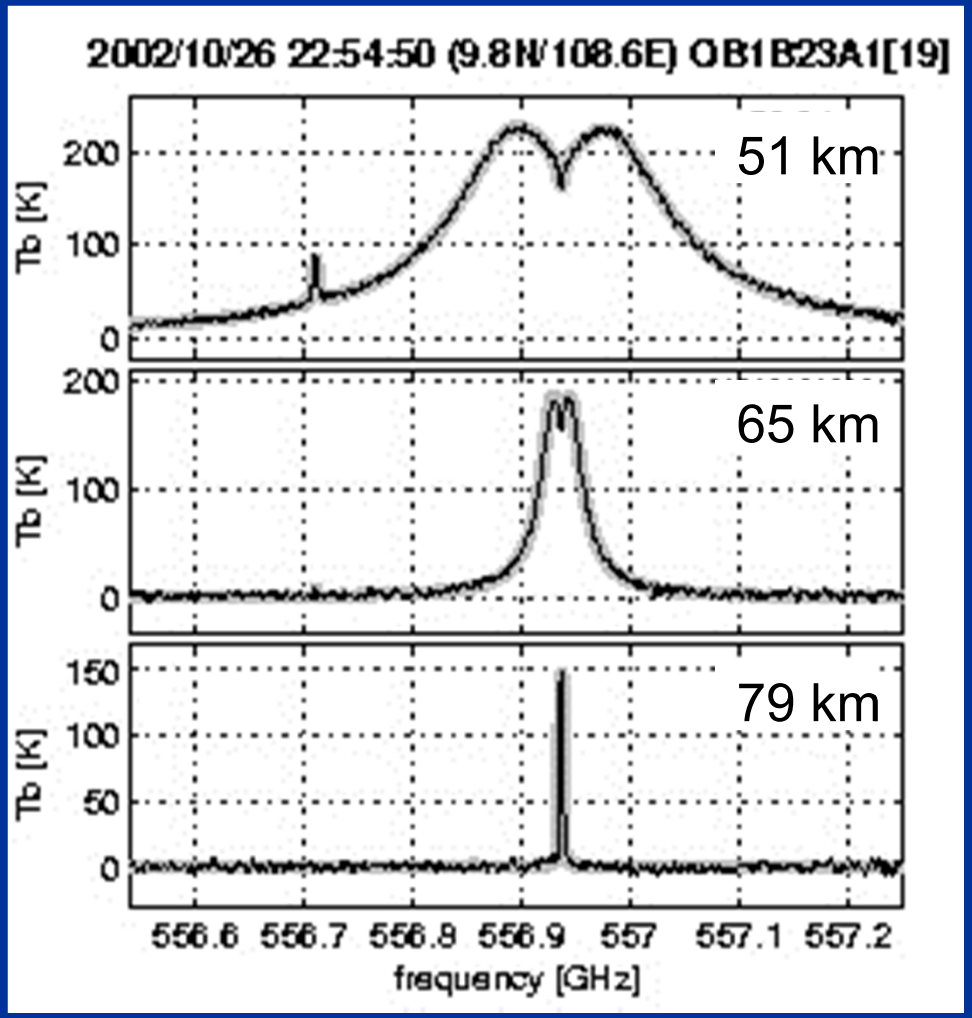
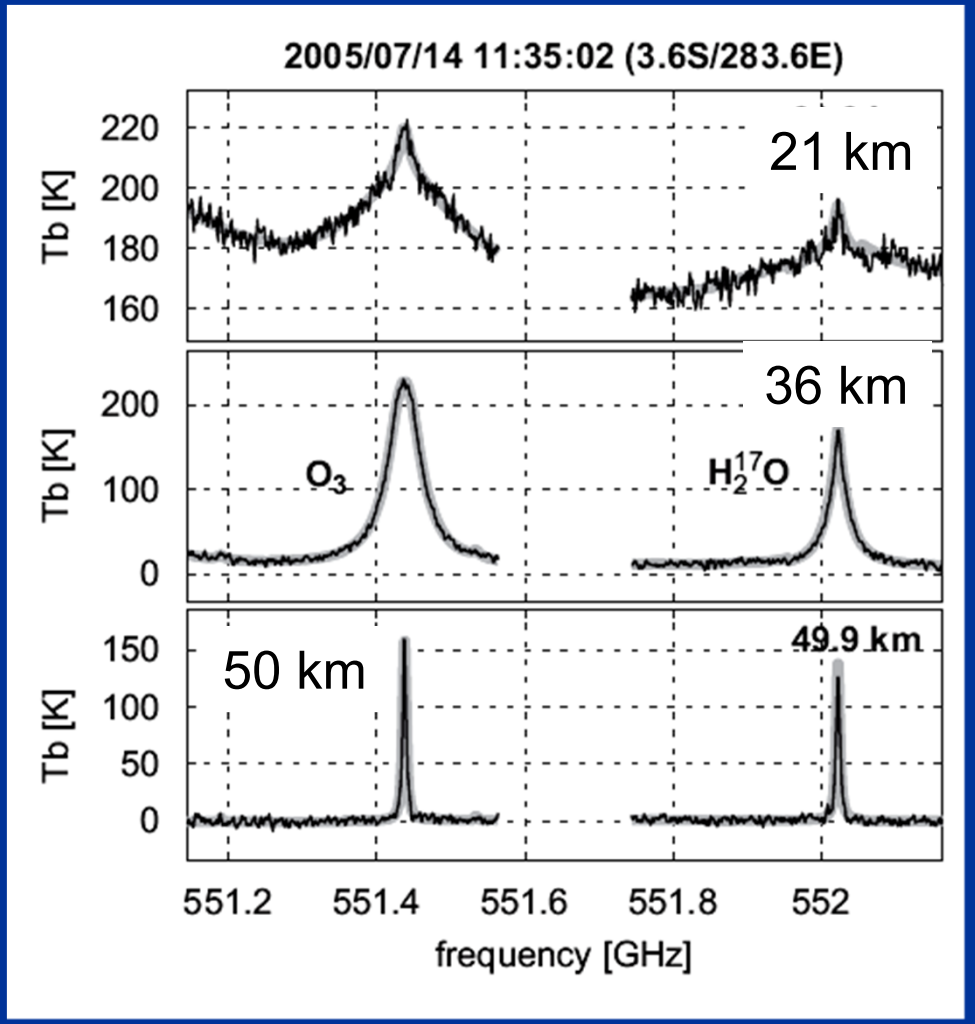
Odin/SMR water vapour

H_2O @ 557.0 GHz



H_2O-17 @ 551.7 GHz



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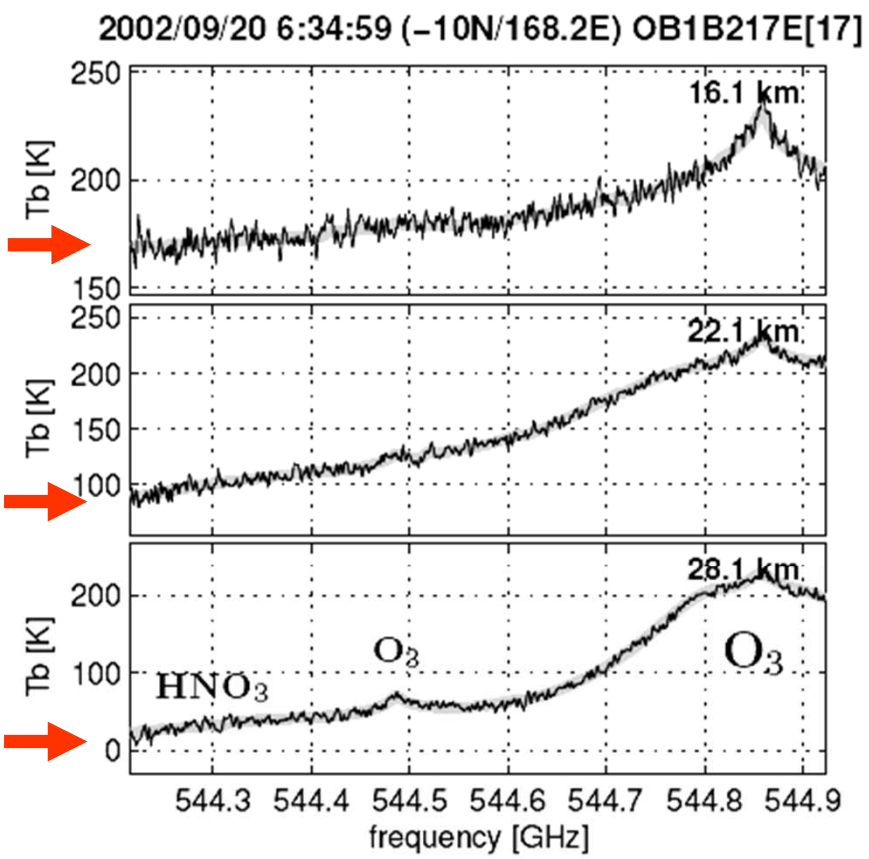
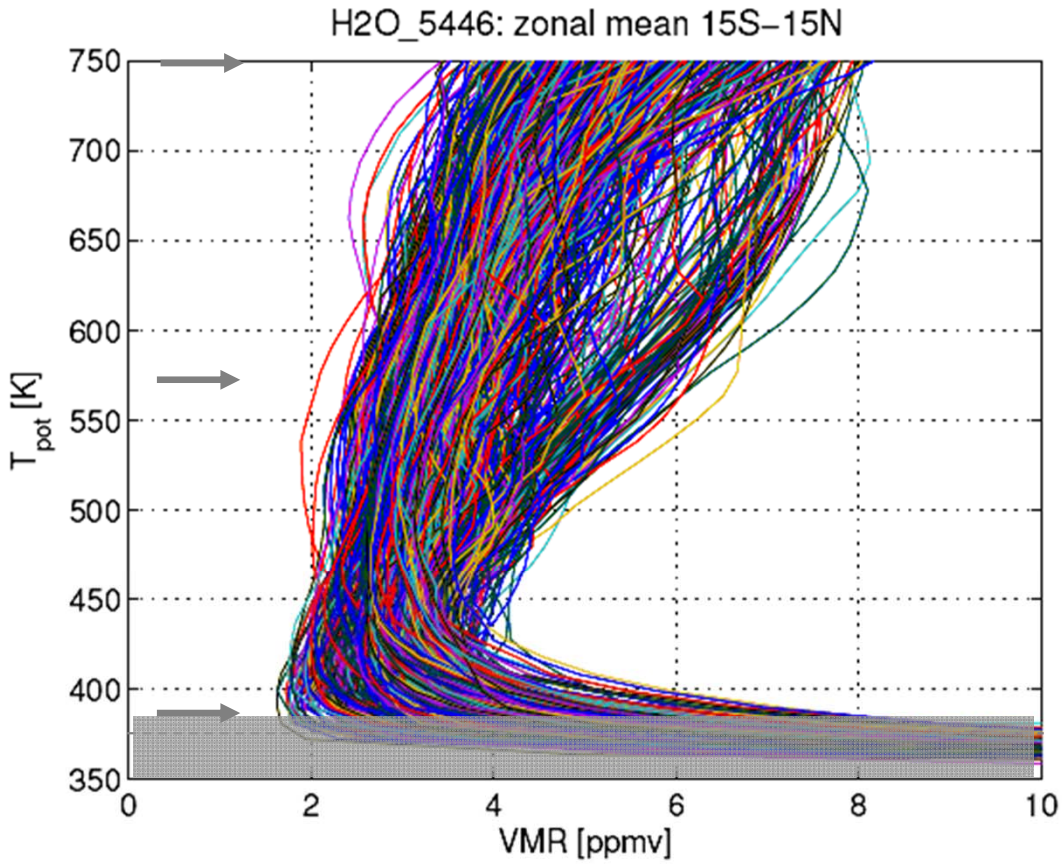
Odin/SMR 544.6 GHz water vapour

Lower stratospheric water vapour retrieved from H2O continuum





tropics: altitude range ~16-25km

H_2O satellite data

Stratospheric water vapour data sets

- SAGE II	(v6.2)	1984-2005	*
- HALOE	(v19.0)	1991-2005	*
- POAM III	(v4.0)	1998-2005	*

- SMR	(v2.1)	2001-present	*
- SABER		2002-present	
- MIPAS *, SCIAMACHY, GOMOS		2002-2012	
- ACE	(v2.2)	2003-present	*
- MLS	(v3.3)	2004-present	*

- Boulder CFH	(revised)	1980-present	*

H2O zonal mean intercomparison

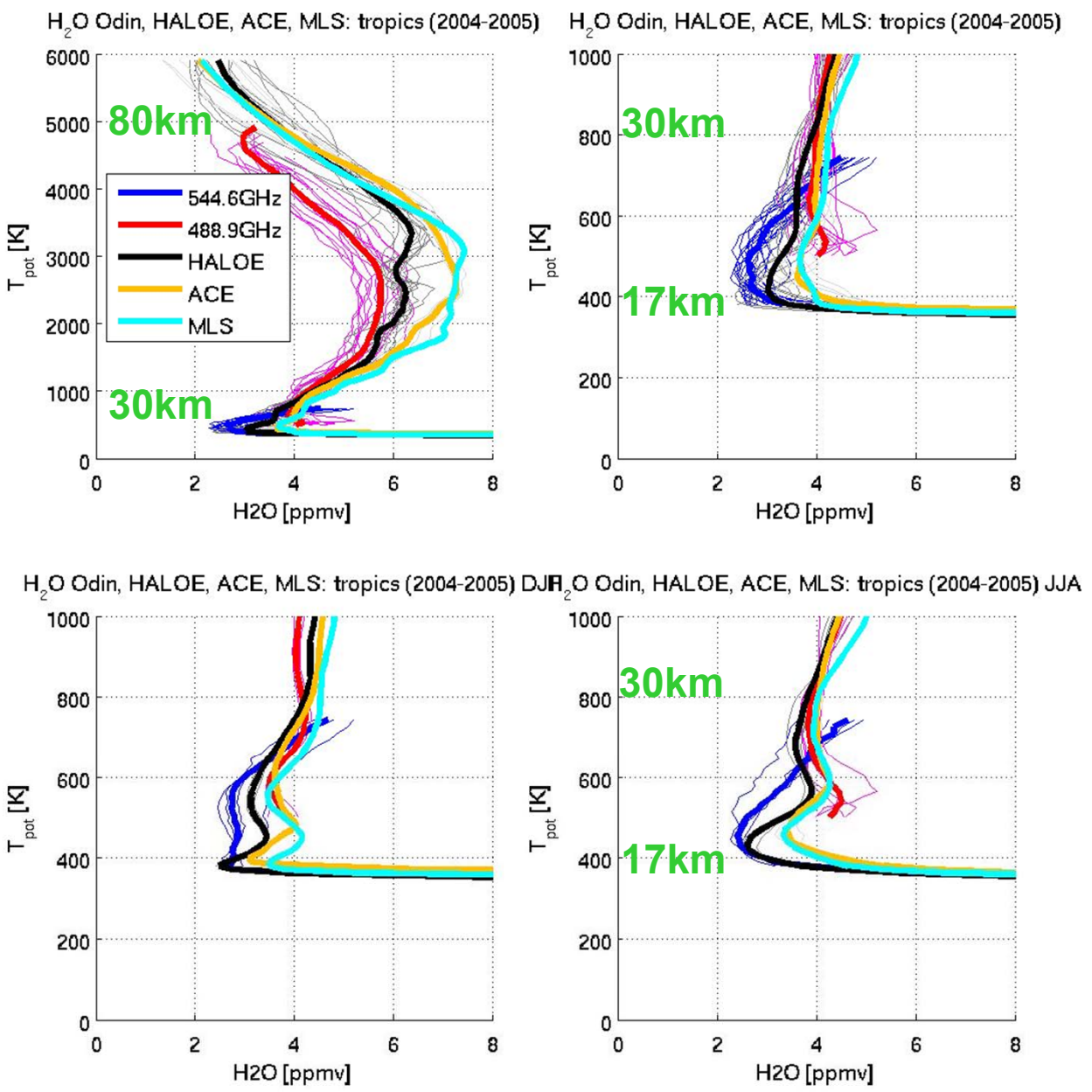
tropics 2004-2005

stratosphere and mesosphere

lower stratosphere

DJF

JJA



H2O evolution / mid-latitudes

Boulder balloon time-series / 17-22km

middle latitudes

Boulder
40N / 105 W

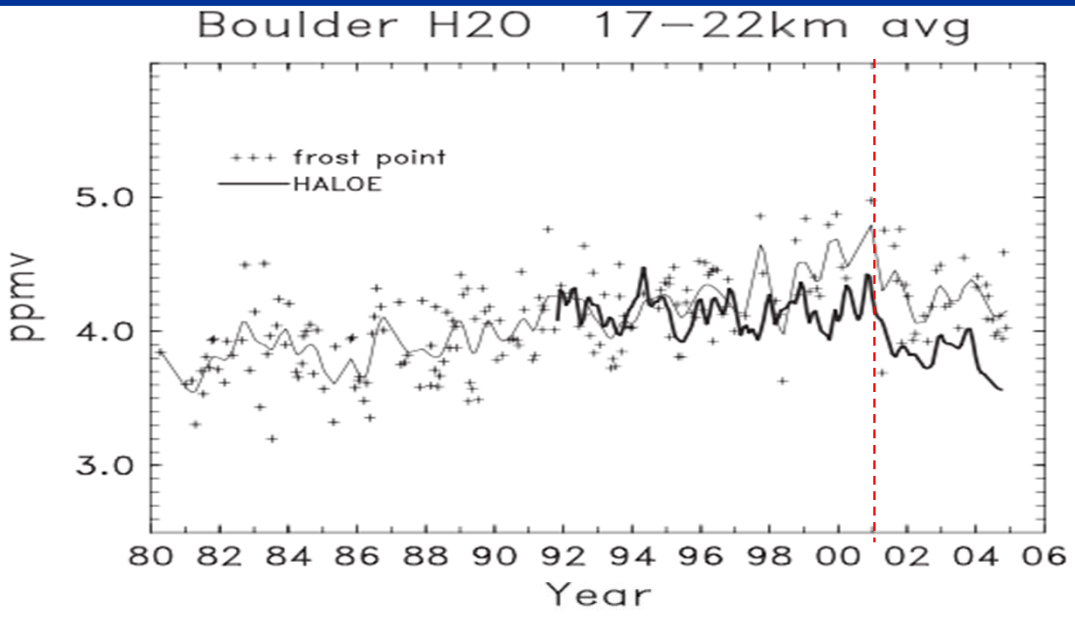


Figure 5-4. Evolution of stratospheric water vapor mixing ratio (in ppmv, averaged over 17-22 km) at Boulder, Colorado (40°N, 105°W), derived from balloonborne frost point hygrometer measurements covering 1980-2005. The thin line shows a smooth fit through the data points, using a running Gaussian window with a half-width of three months. The heavy line shows HALOE satellite water vapor data during 1992-2005 for the same altitude region, using measurements near Boulder (over latitudes 35°N-45°N, and longitudes 80°W-130°W). Note the difference between the two datasets after about 1997. Updated from Randel et al., 2004a.

from [Randel et al, 2004]

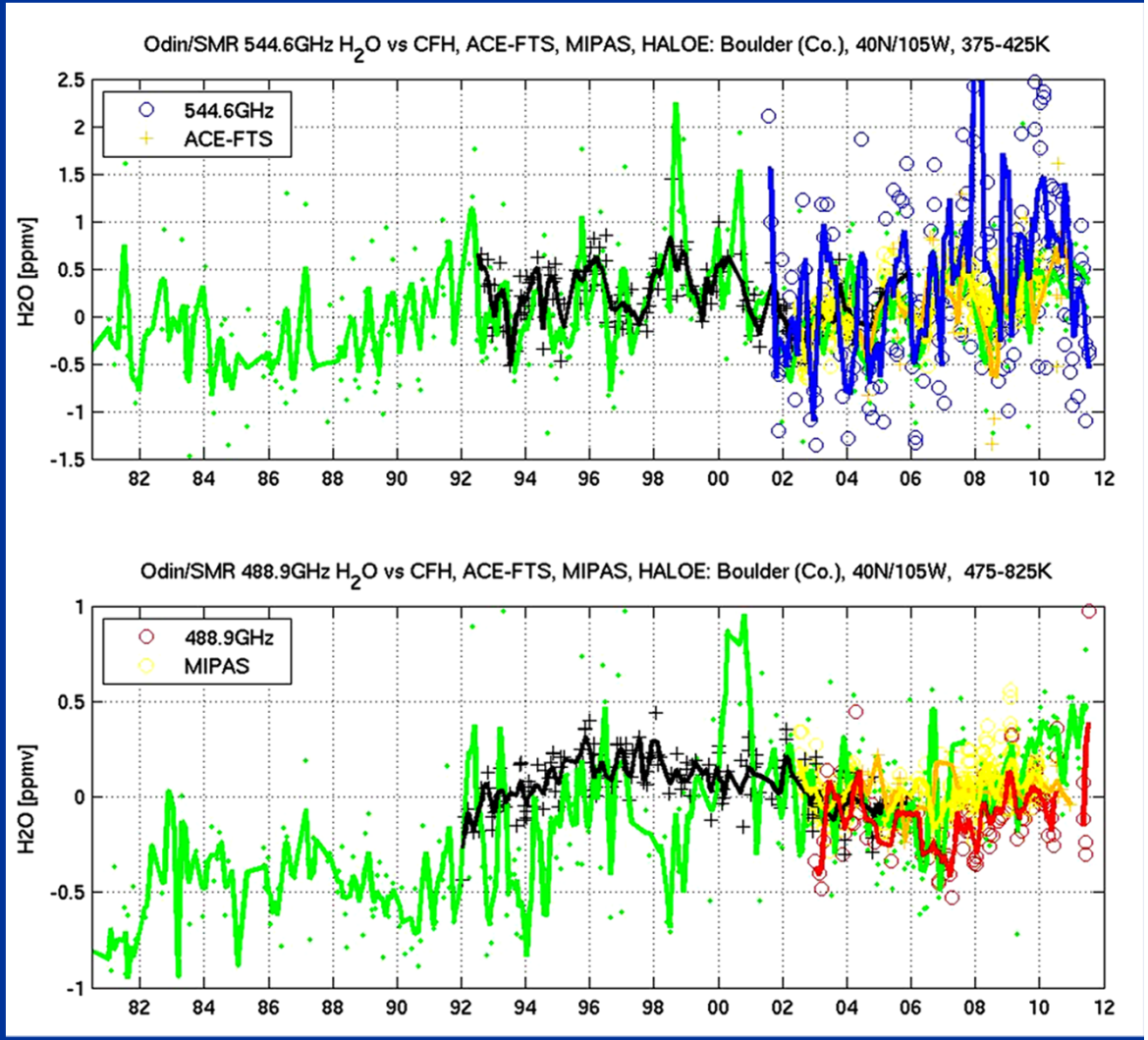
Evolution of mid-latitude water vapour: Boulder, Colorado, de-seasonalized

1980-2011

H2O 375-425K
(~16-18km)

HALOE
Odin 544.6GHz
ACE
Odin 488.9GHz
CFH
MIPAS

H2O 475-825K
(~20-30km)



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H2O evolution / tropics

Evolution of water vapour in the tropics

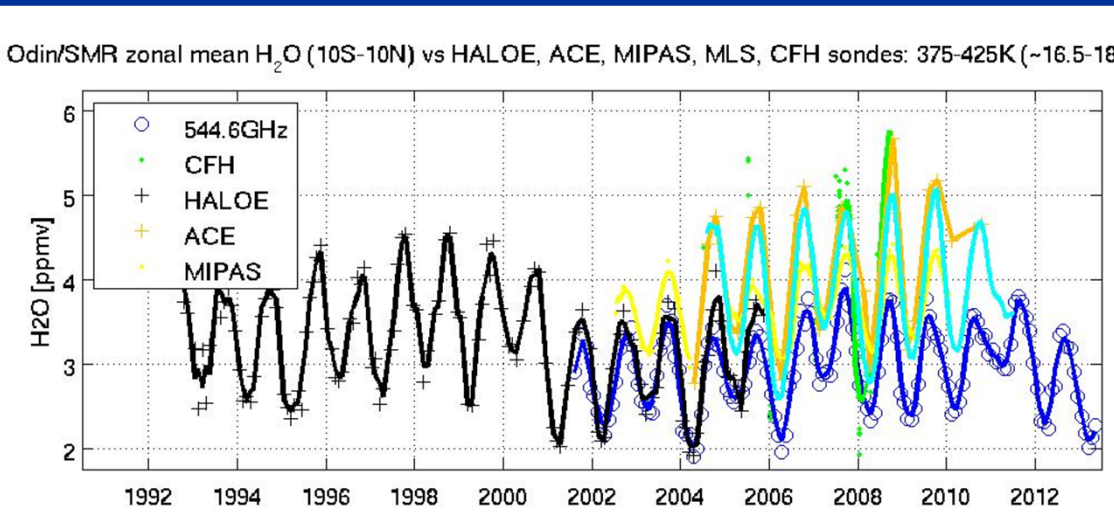
1992-2013

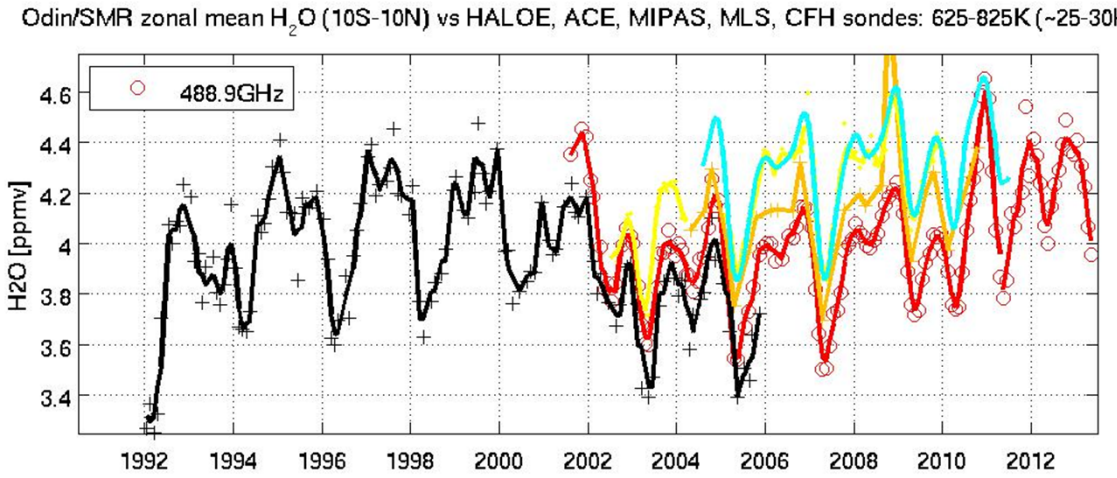
zonal mean

H2O 375-425K (~16.5-18.5km)

HALOE
Odin 544.6GHz
ACE
Odin 488.9GHz
CFH
MIPAS
MLS

H2O 625-825K (~25-30km)





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Evolution of water vapour in the tropics, de-seasonalized

TTL minimum temperature

1992-2013

zonal mean

H2O 375-425K (~16.5-18.5km)

HALOE
Odin 544.6GHz
ACE
Odin 488.9GHz
CFH
MIPAS
MLS

H2O 625-825K (~25-30km)

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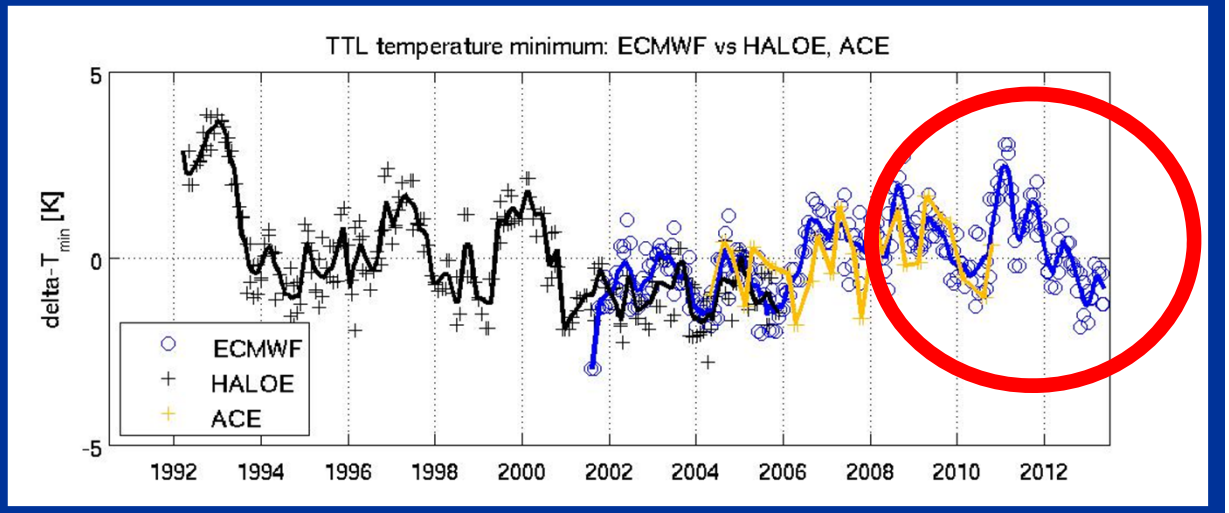
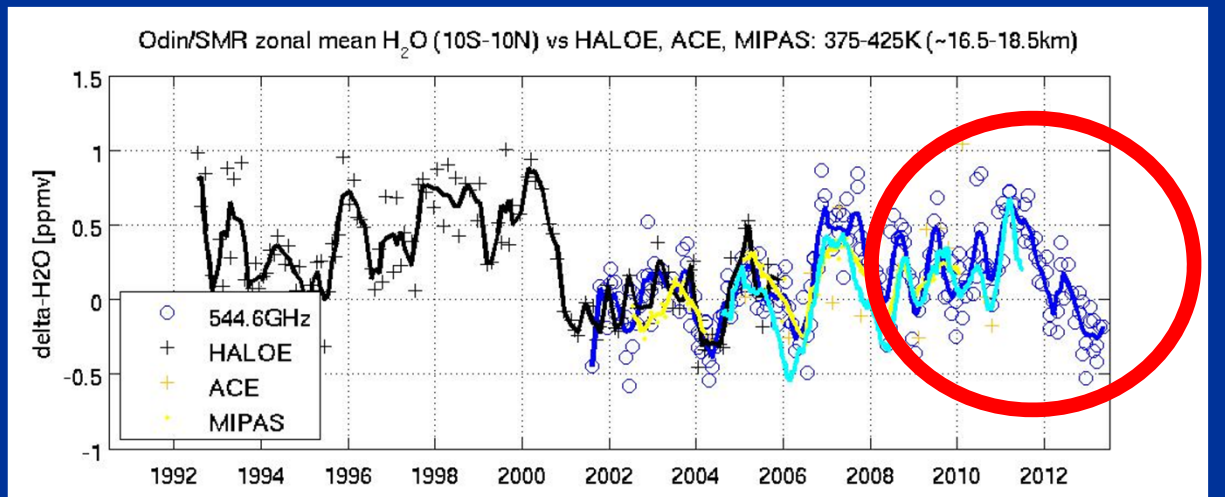
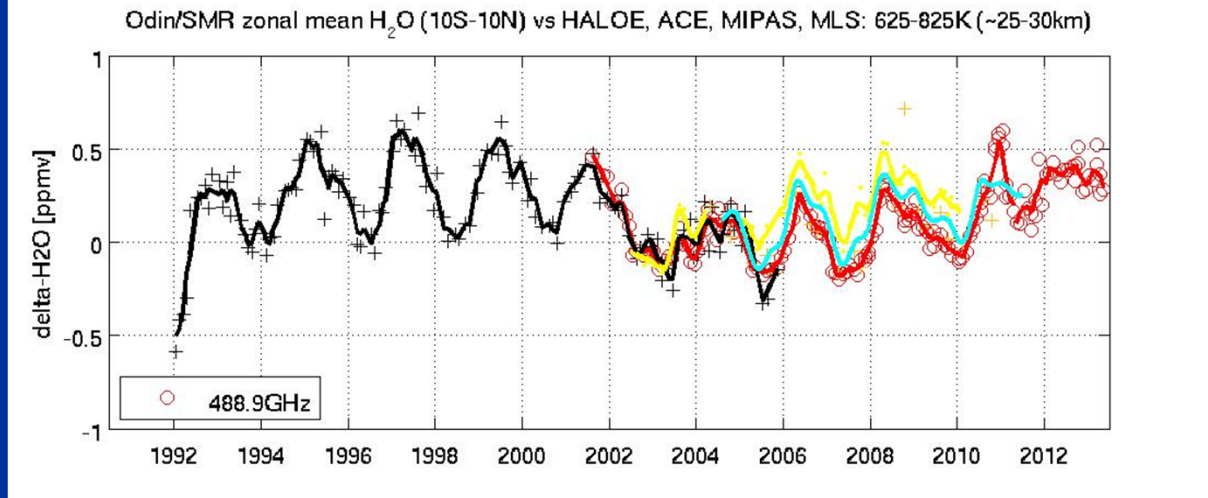
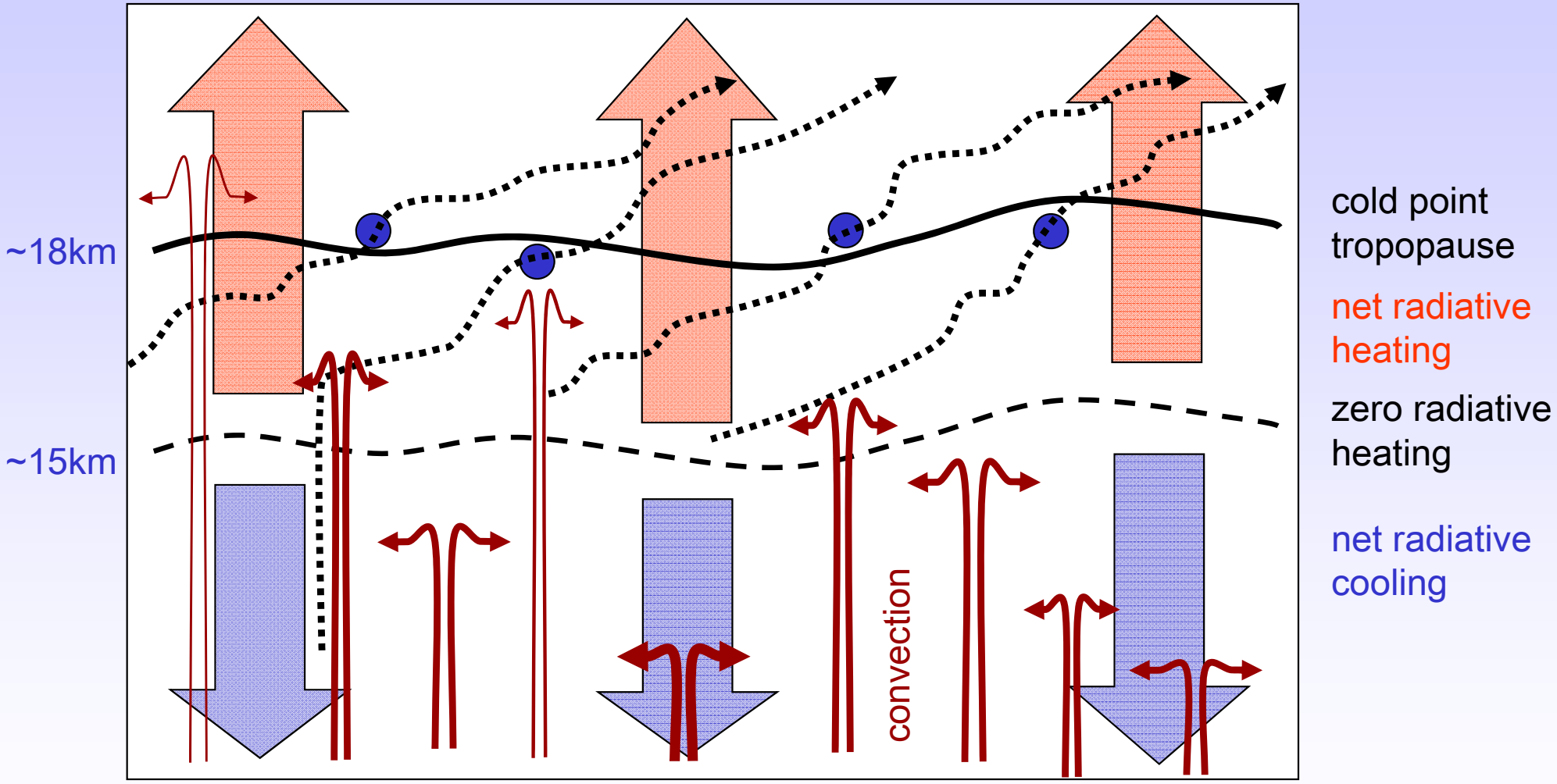






Transport in TTL and TLS

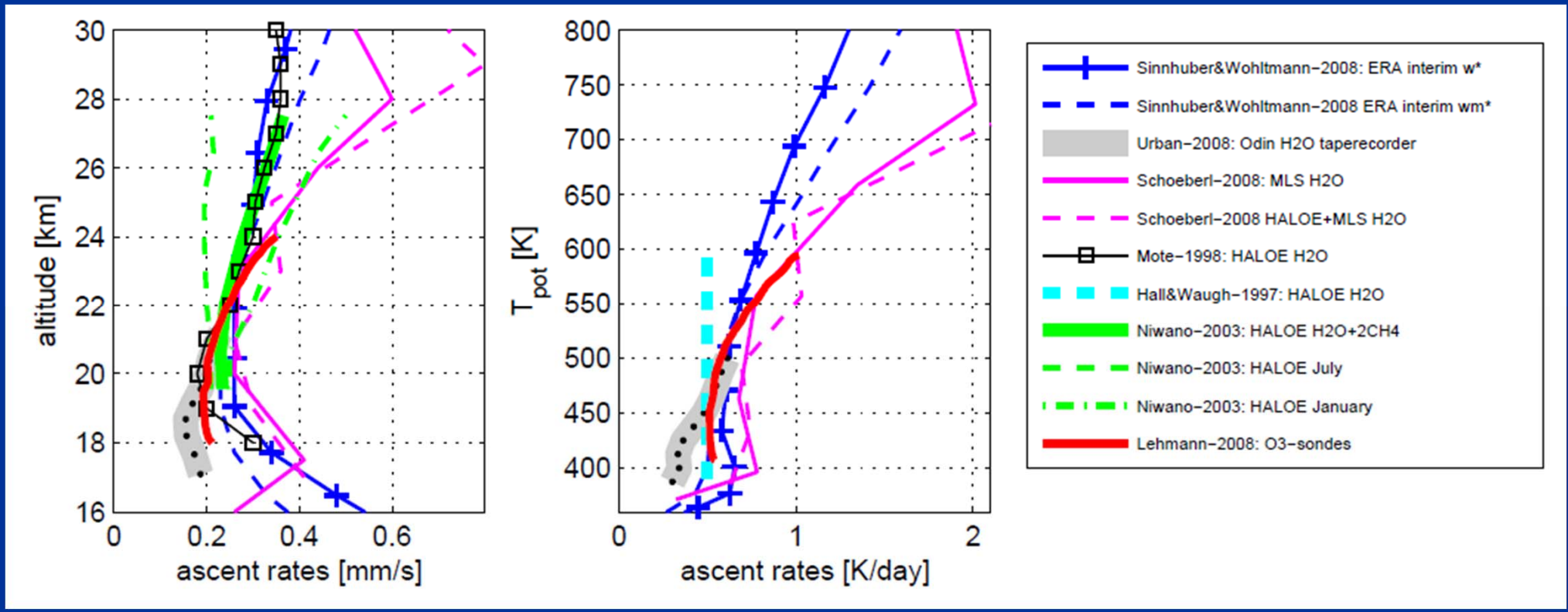
Lagrangian Cold Points (LCP)



Slide: M. Rex

Tropical ascent rates

from tape-recorder (HALOE, MLS, Odin), O3-sondes and heating rate calculations (ECMWF)



0.4-0.7 K/day ≈ 10-20 K/month

0.2-0.3 mm/s ≈ 0.5-0.8 km/month

1 mm/s ≈ 86 m/day ≈ 2.6 km/month

Correlation of tropical water vapour and TTL temperature

375-425K **425-475K** **475-625K**

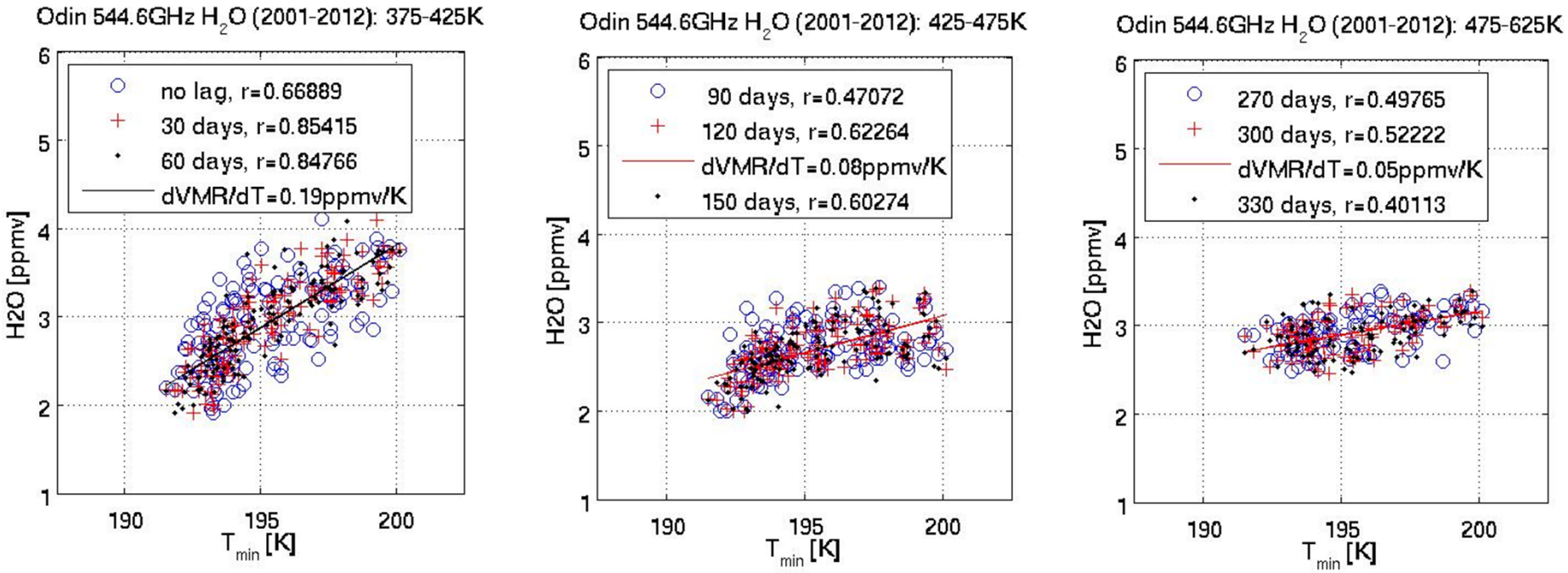
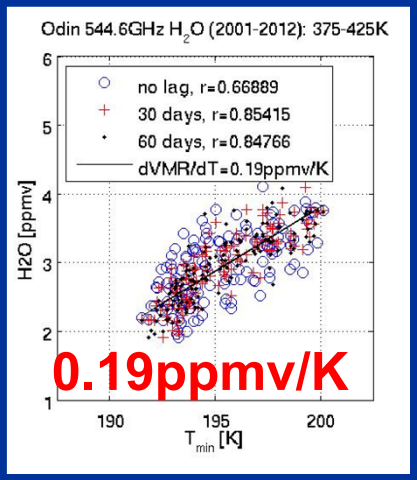
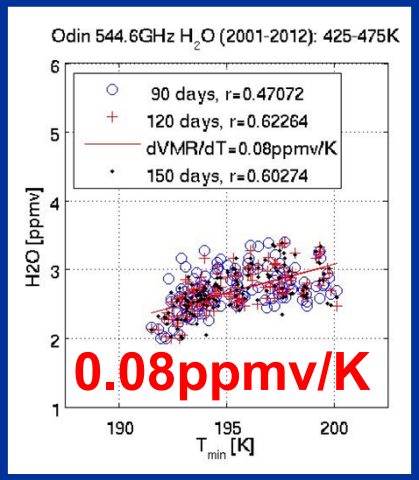
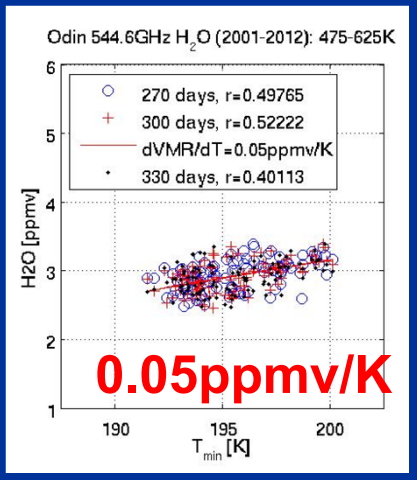
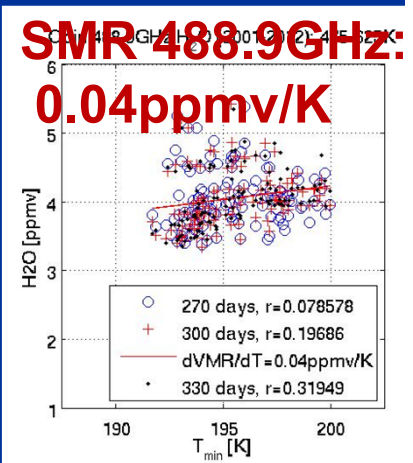
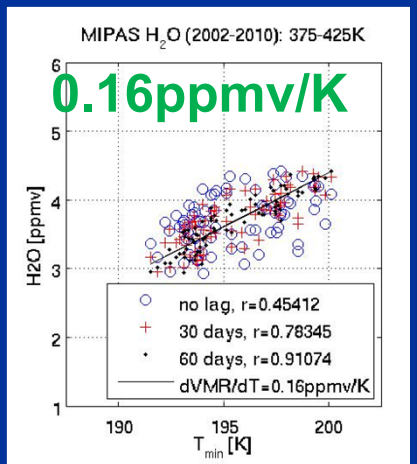
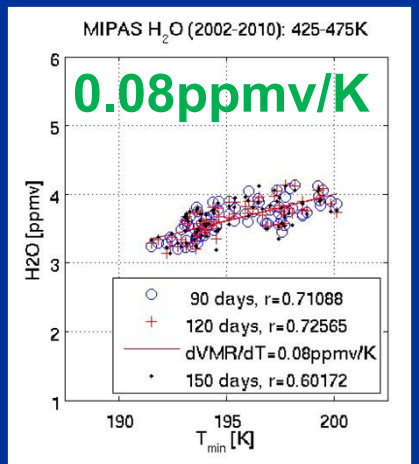
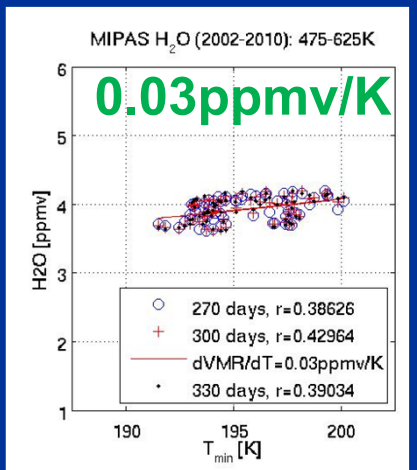
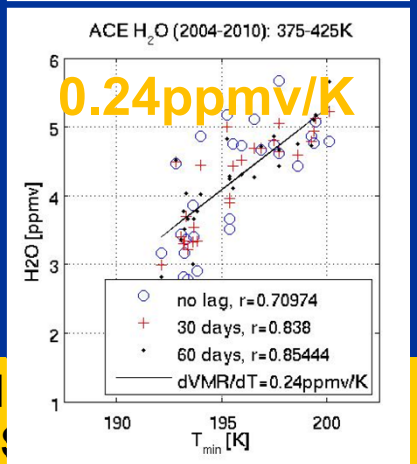
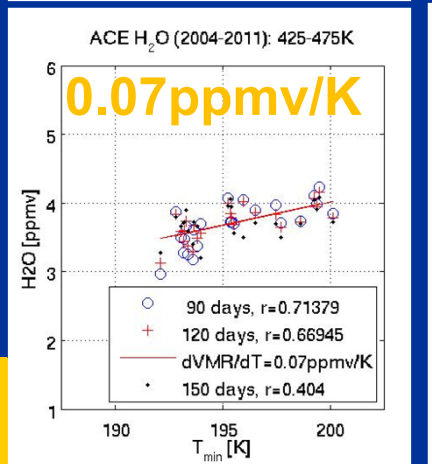
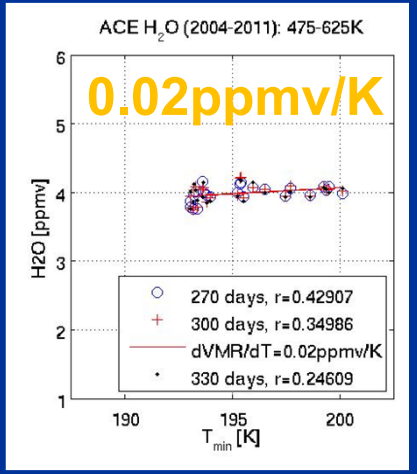


Figure 5. Correlation of Odin/SMR monthly zonal mean water vapour in the tropical (10°S-10°N) tropopause and lower stratosphere region with the minimum (monthly zonal mean) tropopause temperature (from ECMWF analyses). Left: 375-425 K (~16.5-18.5 km). Middle: 425-475 K (~18.5-20.5 km). Right: 475-625 K (~20.5-25 km). Data are from the Odin/SMR 544.6 GHz band. The plots show original (not deseasonalized) monthly zonal mean data. Correlation coefficients are indicated for different time lags between the minimum temperature occurrence in the tropopause region and the Odin water measurements to account for the effect of slowly rising air in the tropics.

60days: 0.19ppmv/K **120days: 0.08ppmv/K** **300days: 0.05ppmv/K**

Correlation of tropical water vapour and TTL temperature

	375-425K	425-475K	475-625K	475-625K
SMR 544.6GHz:	 0.19ppmv/K	 0.08ppmv/K	 0.05ppmv/K	
MIPAS:				
ACE-FTS:				

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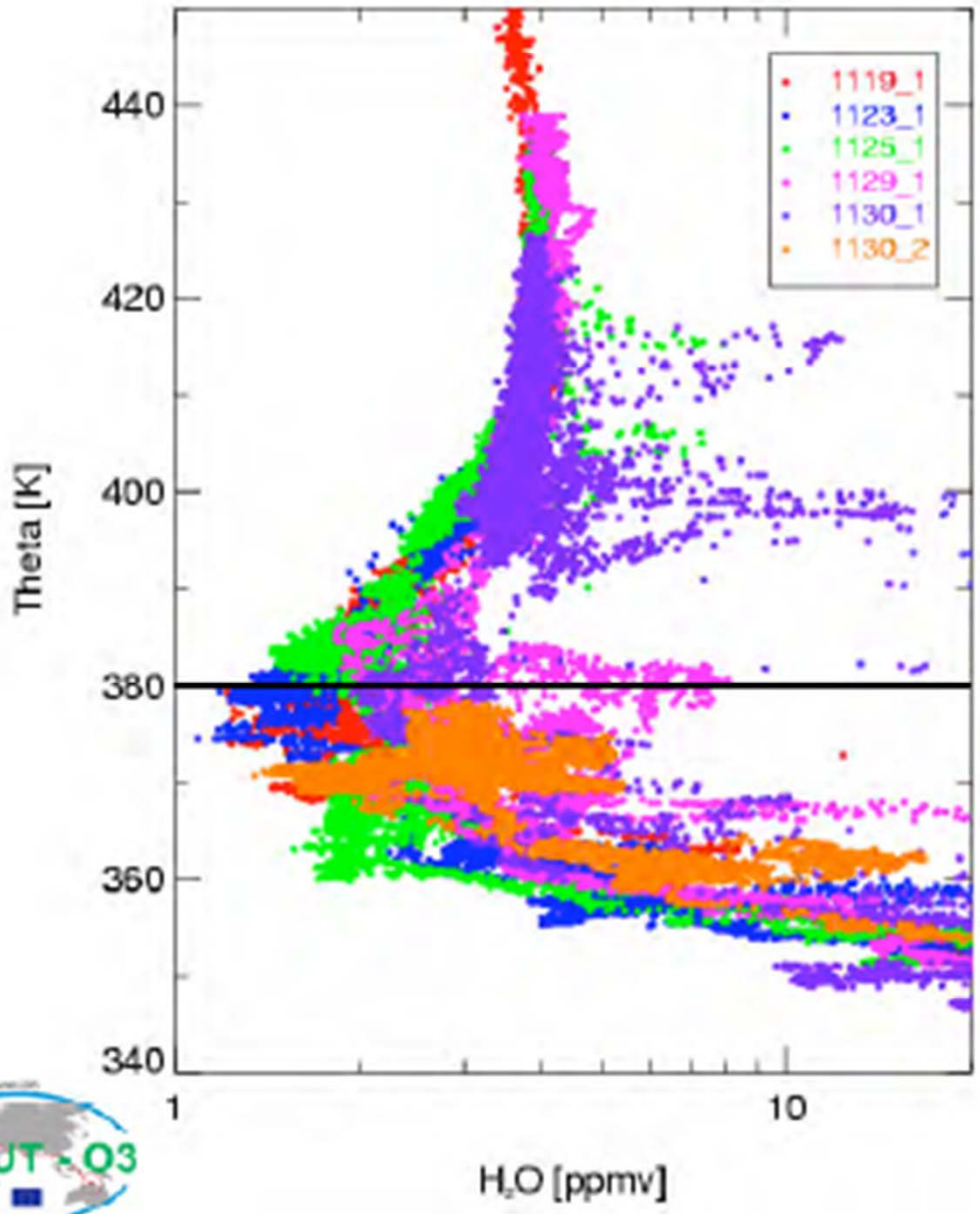
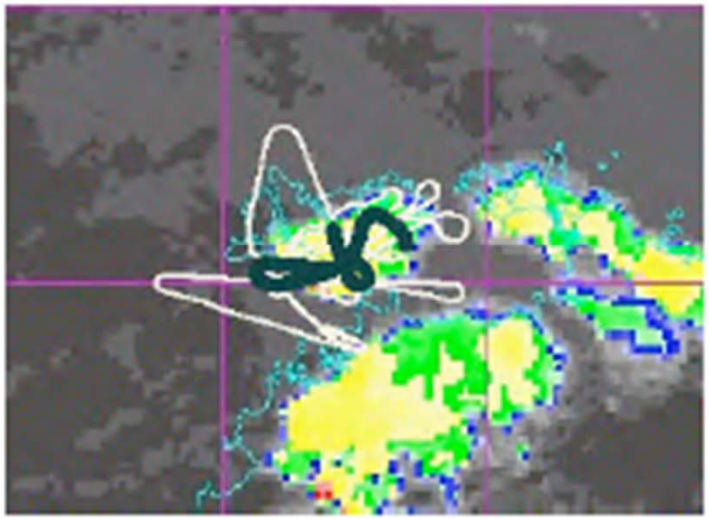
Impact of convection on H_2O: the shooting gun



flights close to convection



SCOUT - O3

JÜLICH

Slide: C. Schiller

H2O evolution
upper stratosphere / mesosphere

Evolution of water vapour in the tropics, de-seasonalized

H2O 825-1400K
~30-40km

1992-2013

zonal mean

H2O 1400-2100K
~40-50km

HALOE
Odin 557.0GHz
ACE
Odin 488.9GHz
CFH
MIPAS
MLS

H2O 2100-2800K
~50-60km

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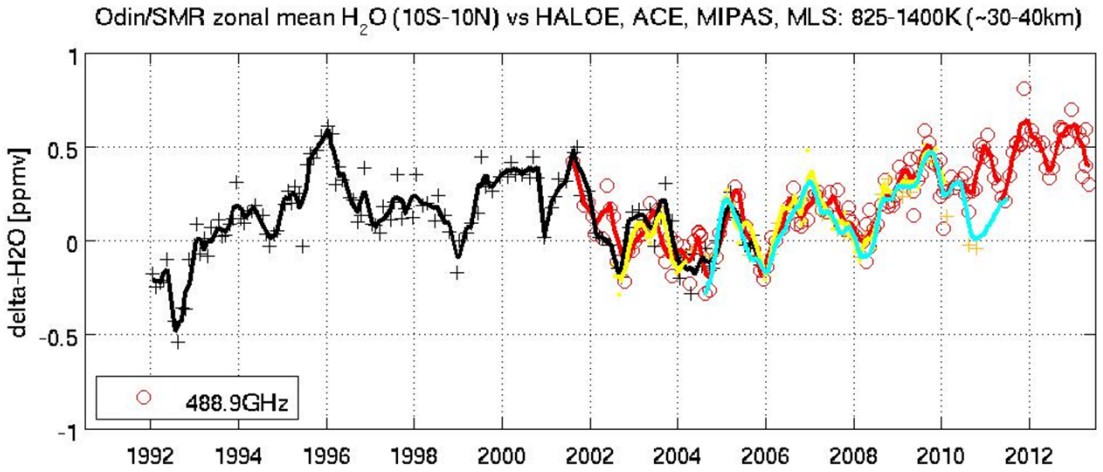
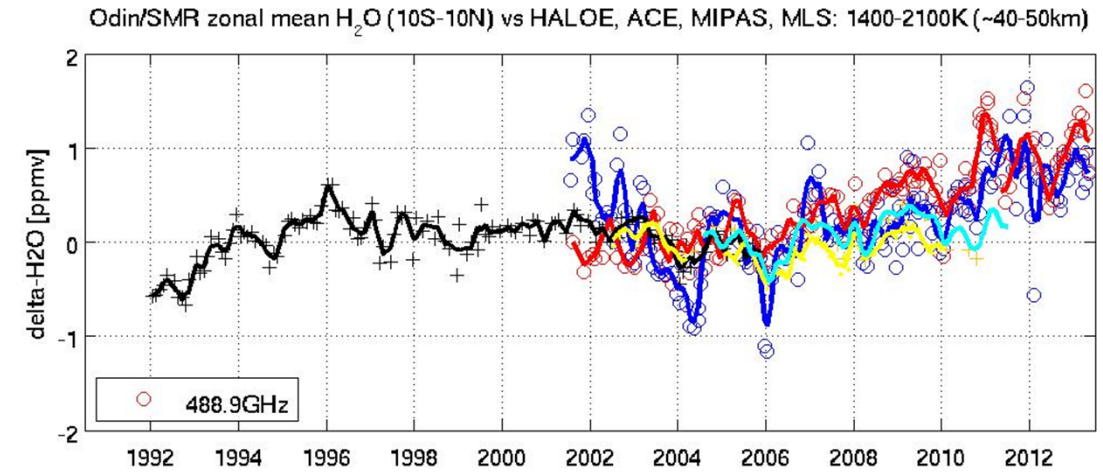
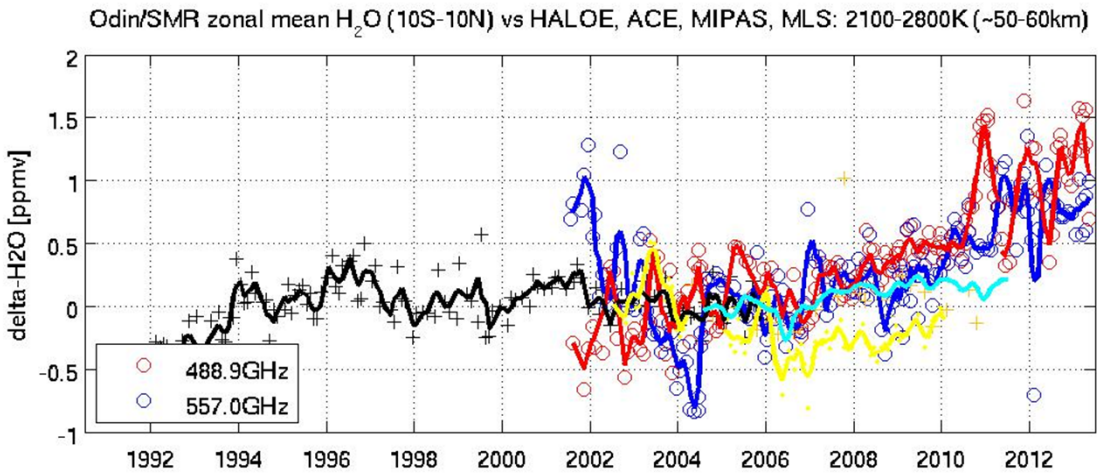
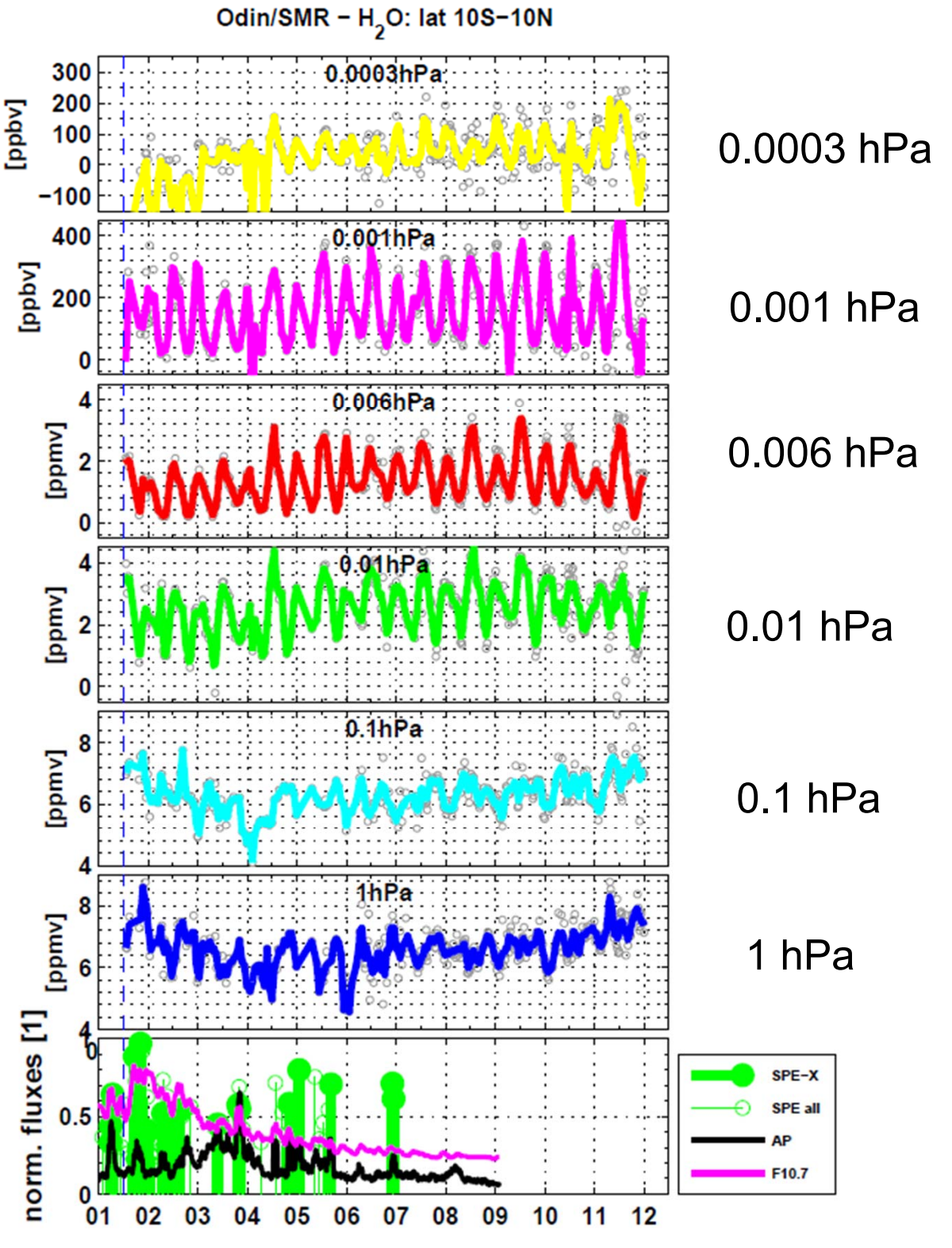






Odin/SMR mesospheric water mode

tropics 10S-10N



Water isotopologues

Equivalent latitude time-series @ 960K

~32km

Odin/SMR
water isotopologues

Chalmers-v2.1 data

H2O-16

H2O-18

H2O-17

HDO

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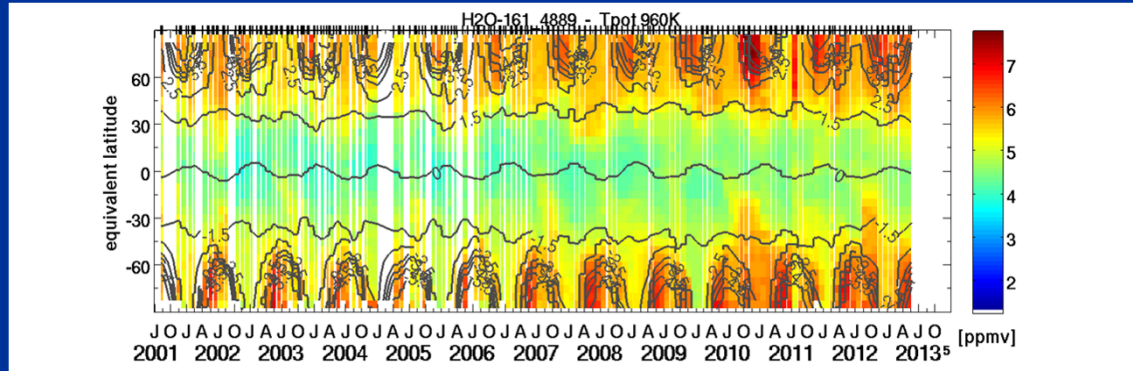
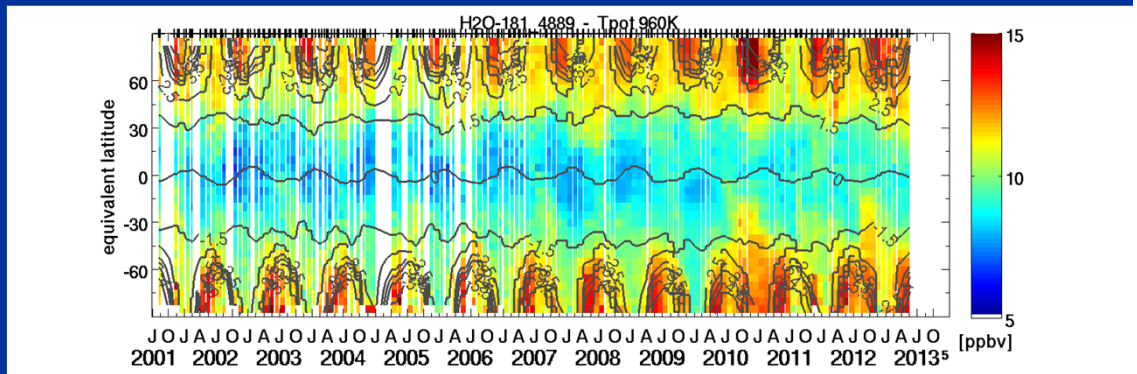
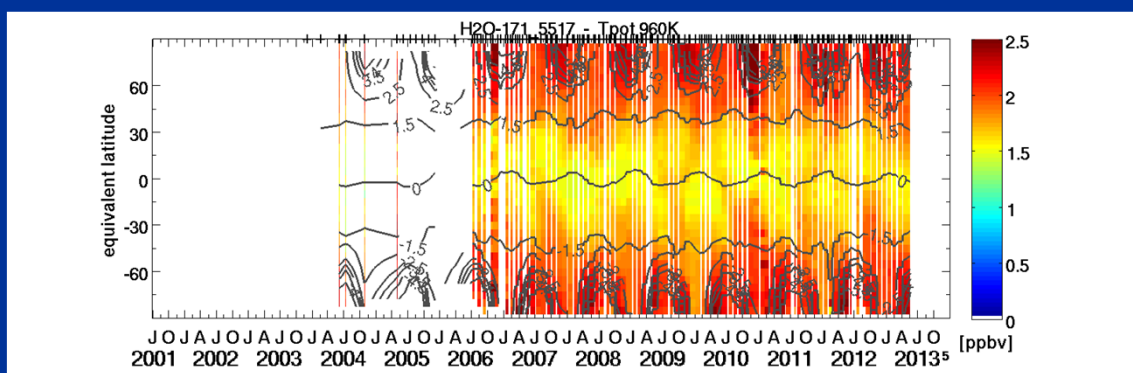
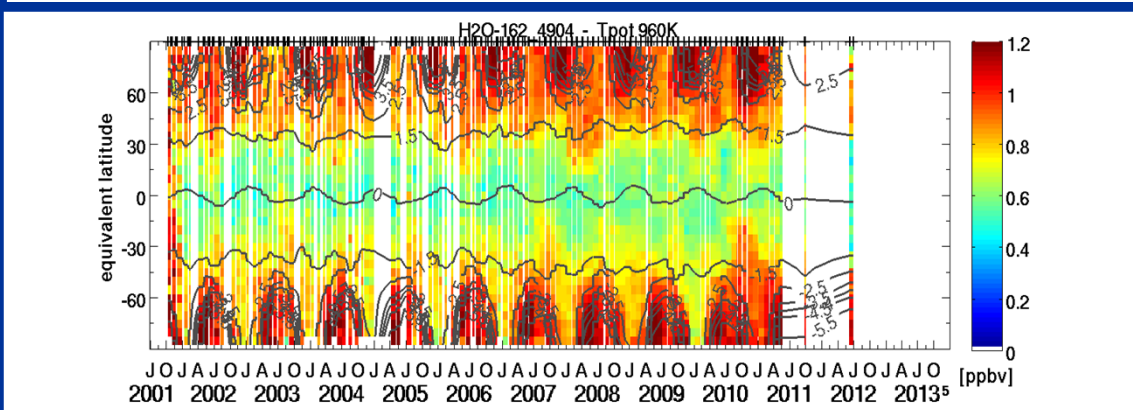


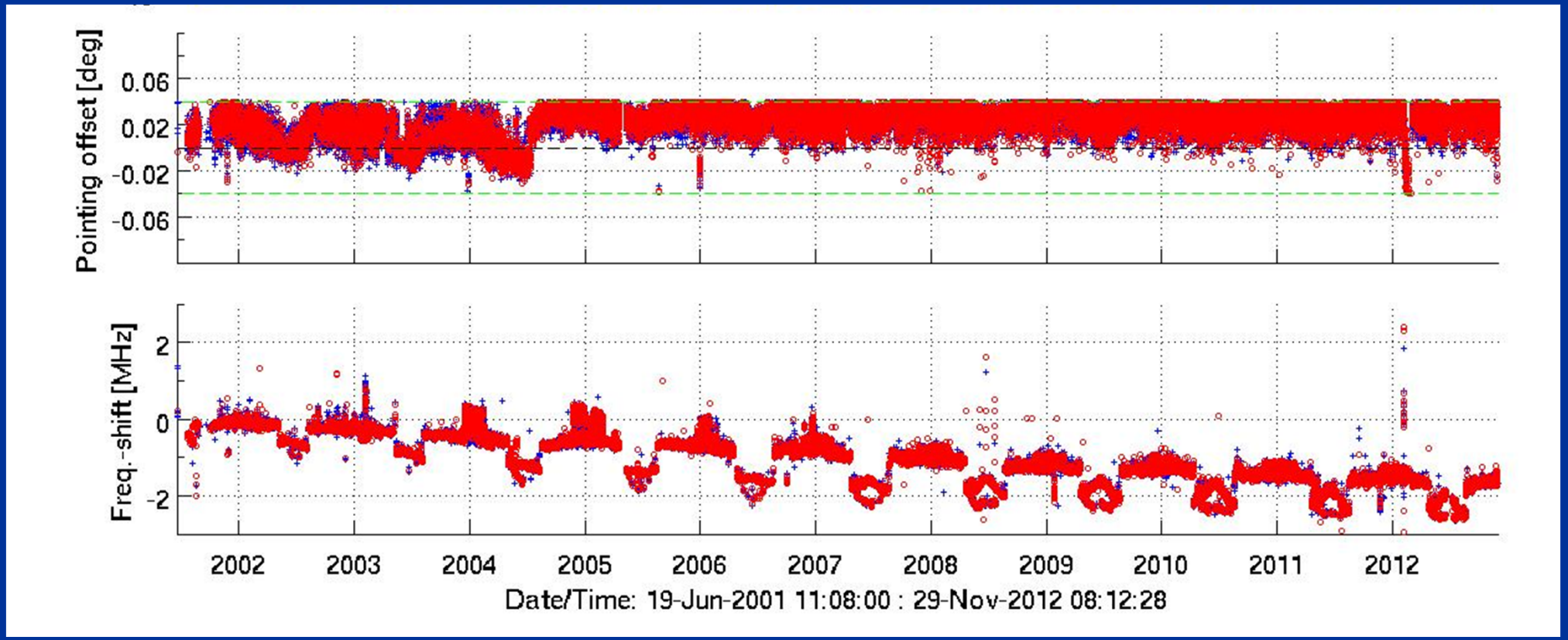






Odin/SMR reprocessing plans

SMR I2 diagnostics – SM_AC1e (544.6GHz)



Stratosphere-Troposphere Exchange And climate Monitor

STEAM

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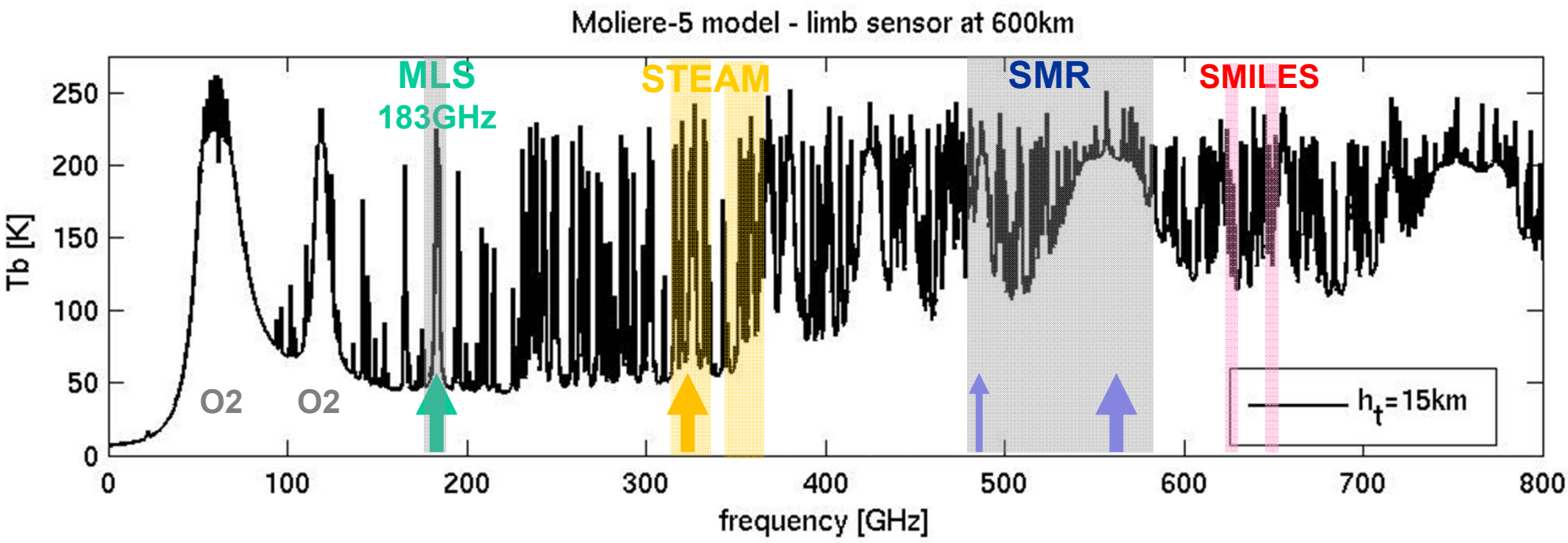
Earth and Space Sciences

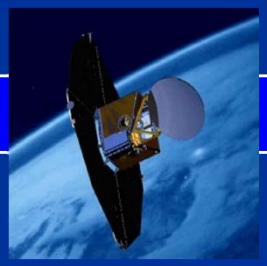
Microwave limb sounding: major water lines



1991

UARS/MLS 183GHz
MAS/ATLAS (Space Shuttle)

2001

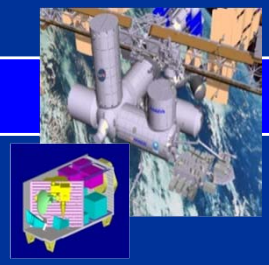


Odin/SMR
489+557GHz

2004

Aura/MLS
183GHz

2009



JEM/SMILES

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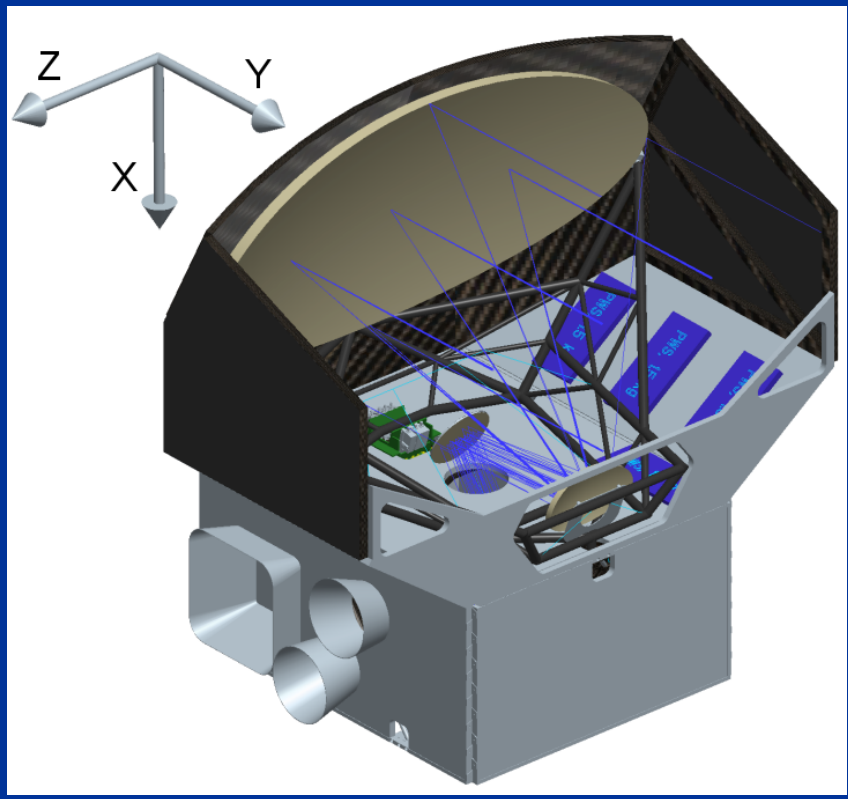
STEAM – Stratosphere-Troposphere Exchange And climate Monitor

STEAM-R / PREMIER

- Optimized 12GHz (DSB) UT/LS channel:
  lsb 324.0-336.0 GHz, usb 343.25-355.25 GHz
  H2O, HDO, O3, CO, HCN,
  N2O, HNO3, CH3CN, CH3Cl, ClO,
  temperature
- Sun-synchronous orbit
  (820 km as MetOp),
- 14 simultaneous limb views 5-28 km
  1.5 - 2 km vertical / ≤ 50 km horizontal sampling
- Auto-correlators: 12 GHz / 25 MHz
- Options: dsb, 2sb



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STEAM – Stratosphere-Troposphere Exchange And climate Monitor

STEAM-R

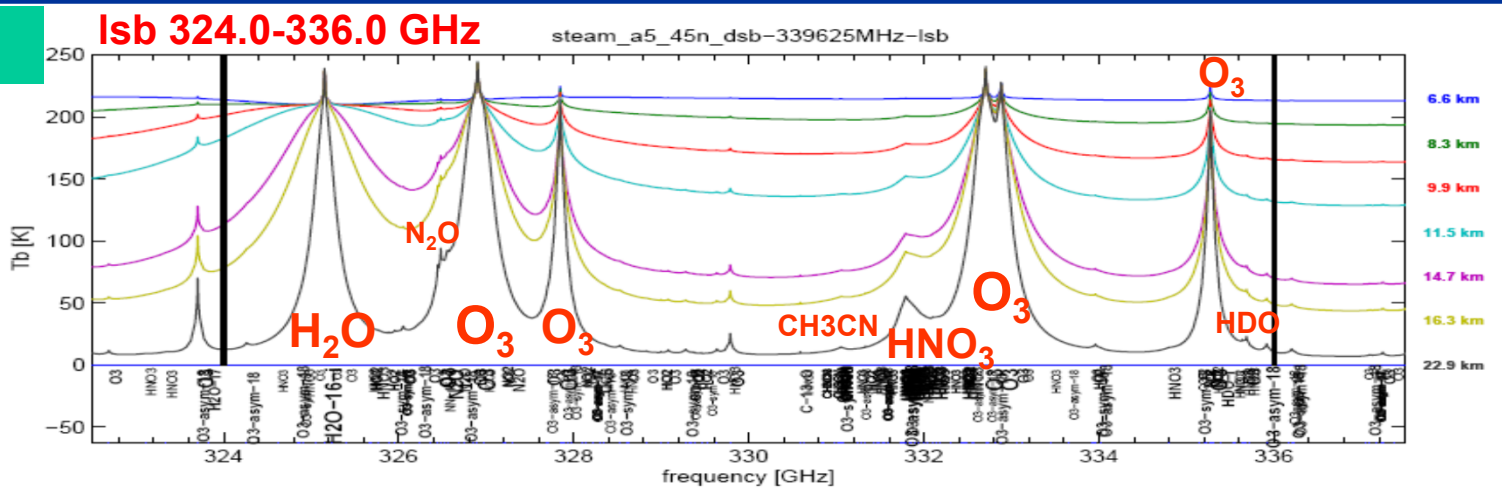
UT/LS band

a5

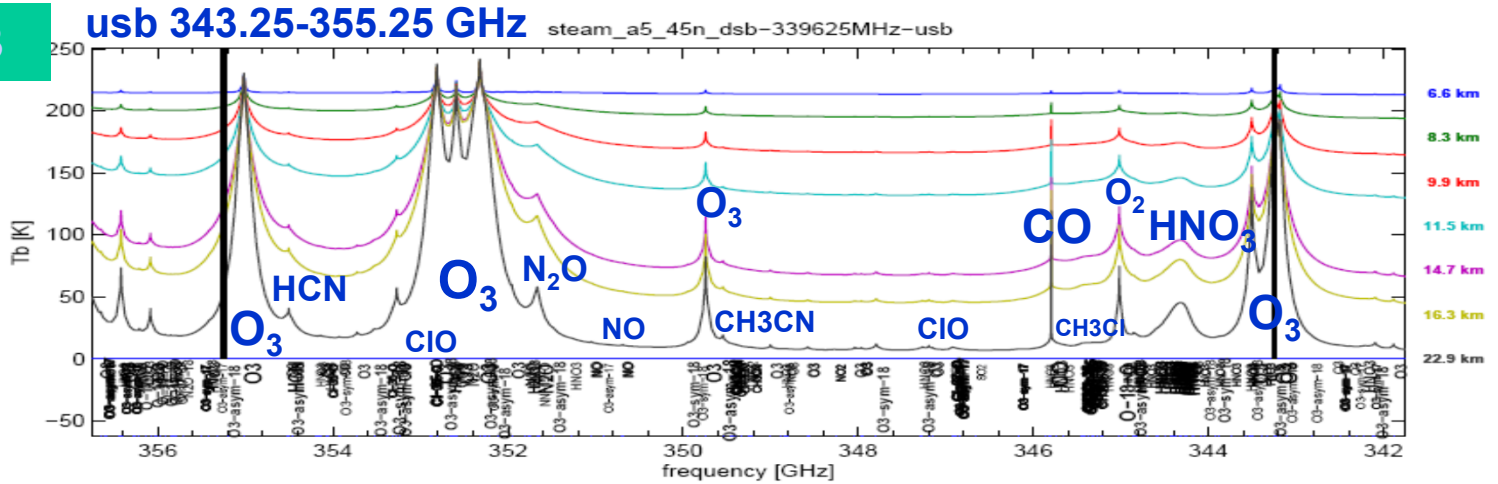
12 GHz DSB

lo 339.625 GHz

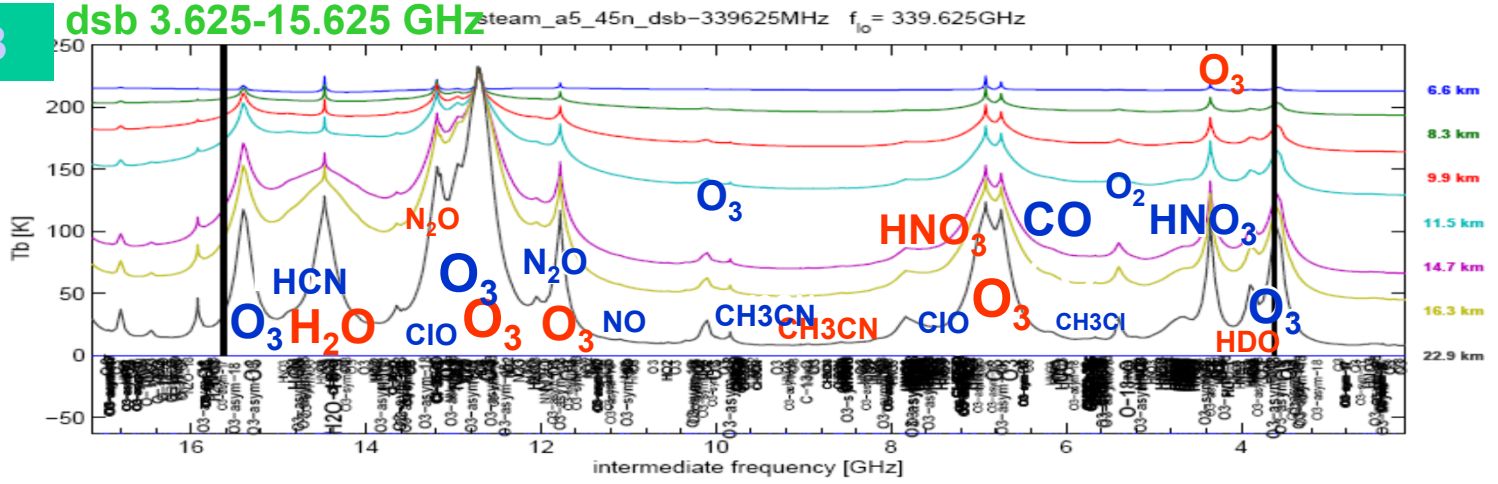
LSB



USB



DSB



H2O, HDO,
O3, **CO**, **HCN**,
N2O, **HNO3**,
CH3Cl, ClO

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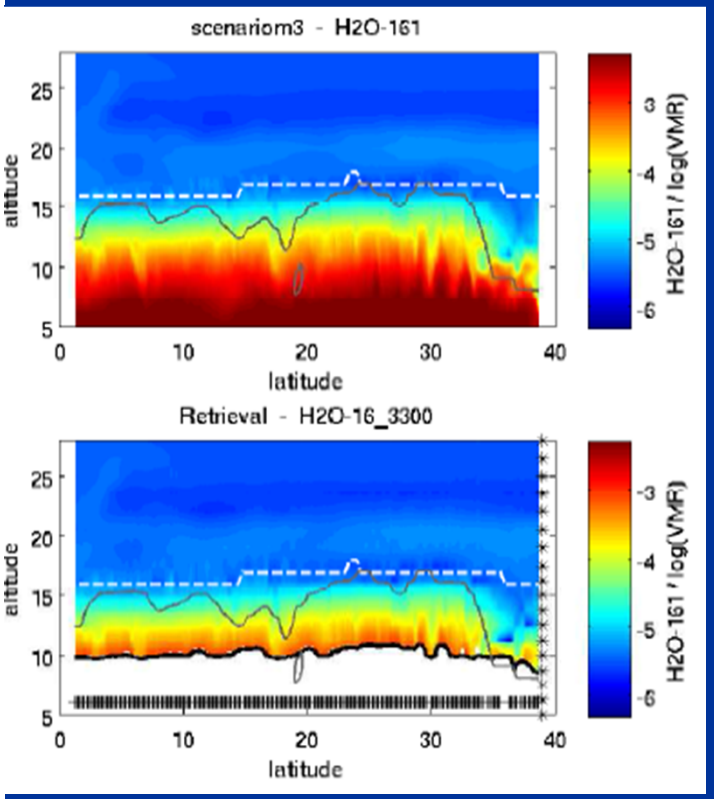
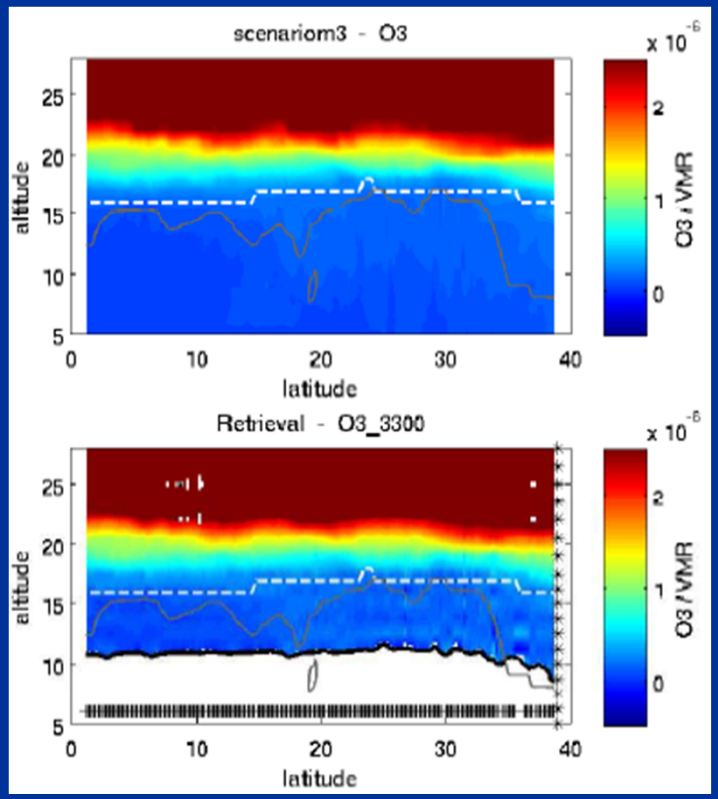
Scenario M3, Monsoon core:

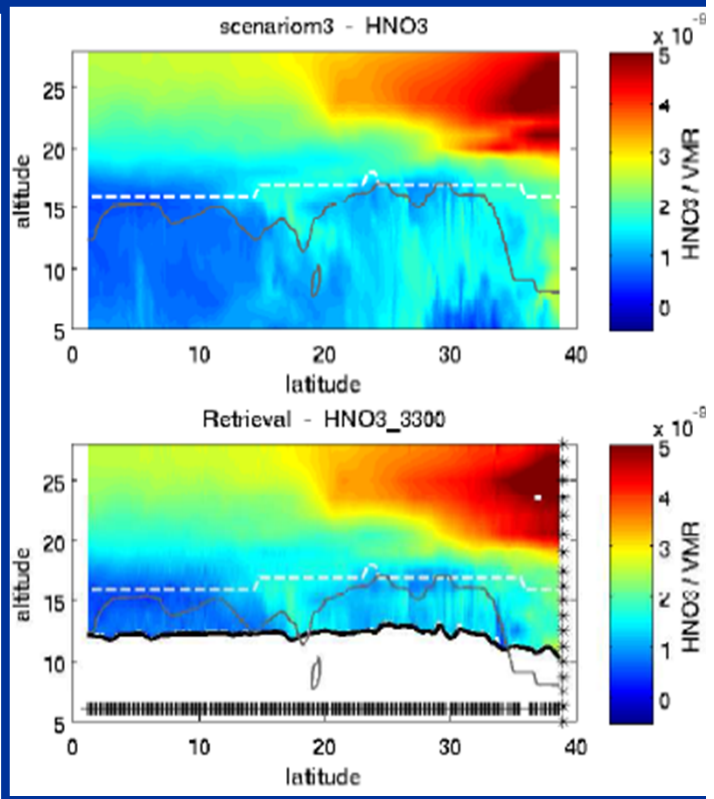
H2O



O3



HNO3



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Summary

- **Odin/SMR** measures water vapour isotopologues in several different bands:
  - H2O-16: 488.9, 544.6, 557.0 GHz
  - H2O-17: 551.7 GHz
  - H2O-18: 488.9 GHz
  - HDO: 490.4 GHz
- **STEAM-R** designed to observe H2O in the UT/LS region with unprecedented horizontal/vertical sampling and resolution
- **Water evolution update**: Decrease observed by Odin in 2012-2013 above tropical tropopause. Evolution to be monitored!


Thank you!
Photo: K. Sagi, Göteborg 2010-12-24