Low latitude seasonal variability of the mesosphere as observed by MIPAS

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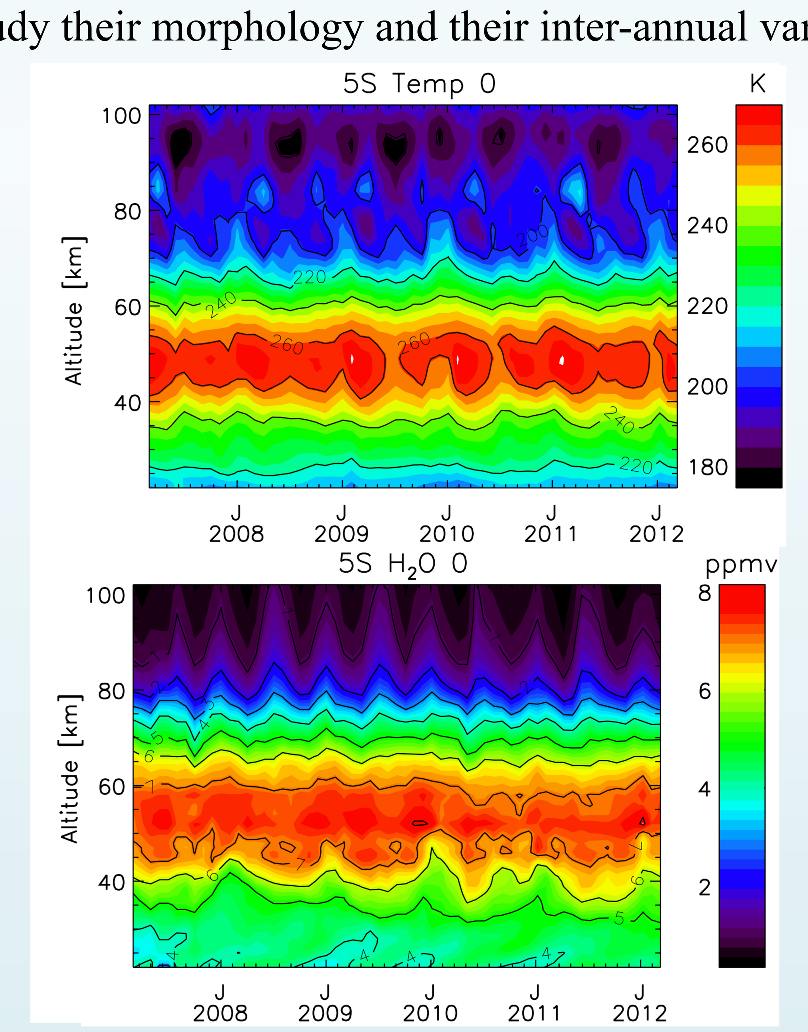
Introduction

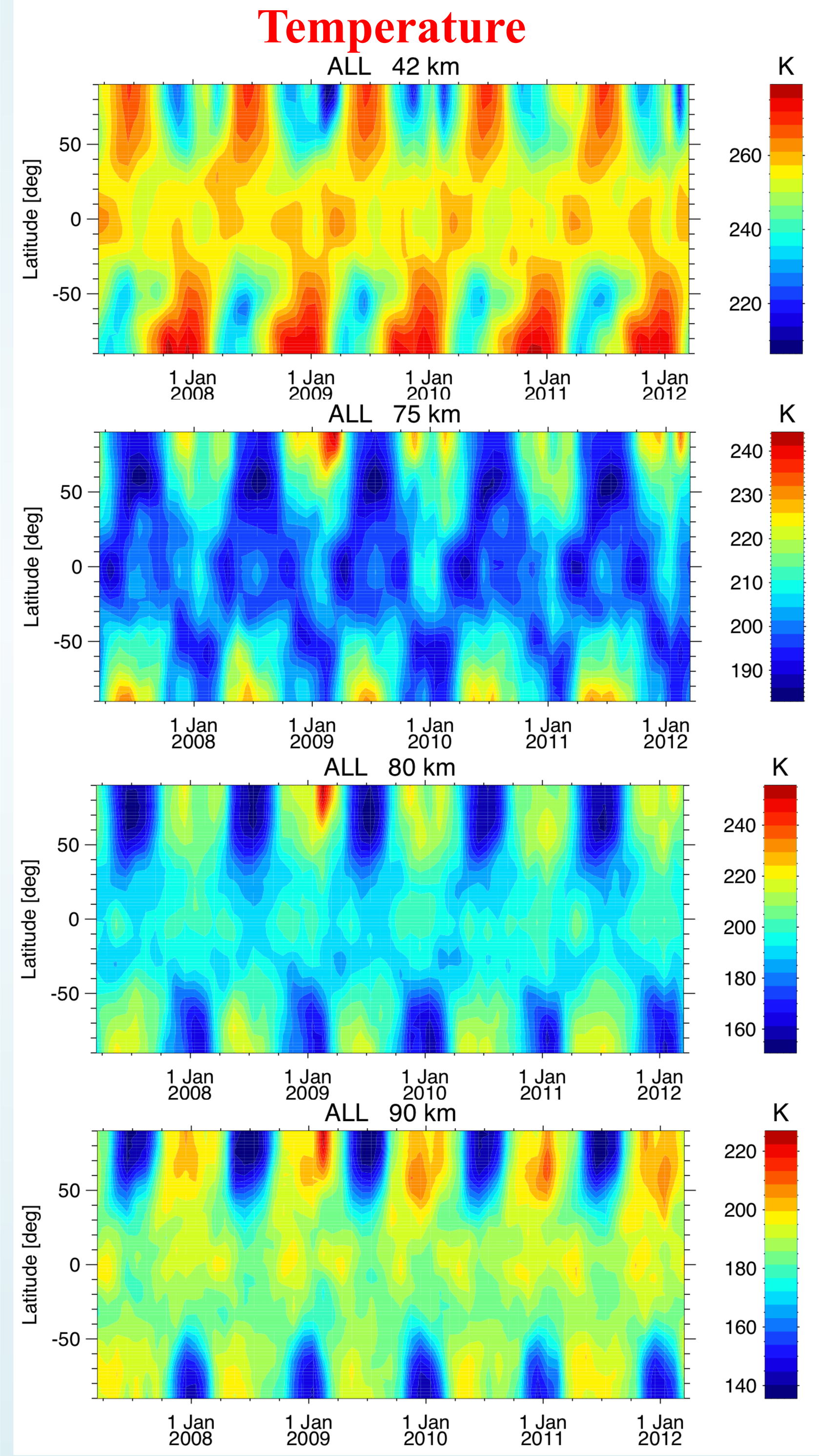
The intra-annual variability of the MLT near the equator is dominated by a strong semiannual oscillation (MSAO), plausibly originated by a differential filtering of the vertically propagating GWs by the stratospheric semi-annually oscillating wind. The MSAO effects are printed on T_k and abundances, accompanying the mean flow changes.
We derive T_k, H_2O and CO from MIPAS spectra using the IMK/IAA processor, which includes the GRANADA algorithm, and is able to deal with NLTE emissions, important for accurate retrievals in the MLT.
We analyze MIPAS T_k and H_2O time series from the stratosphere to the upper mesosphere at low latitudes (see below examples for 5°S) and derive seasonal oscillations to study their morphology and their inter-annual variability.



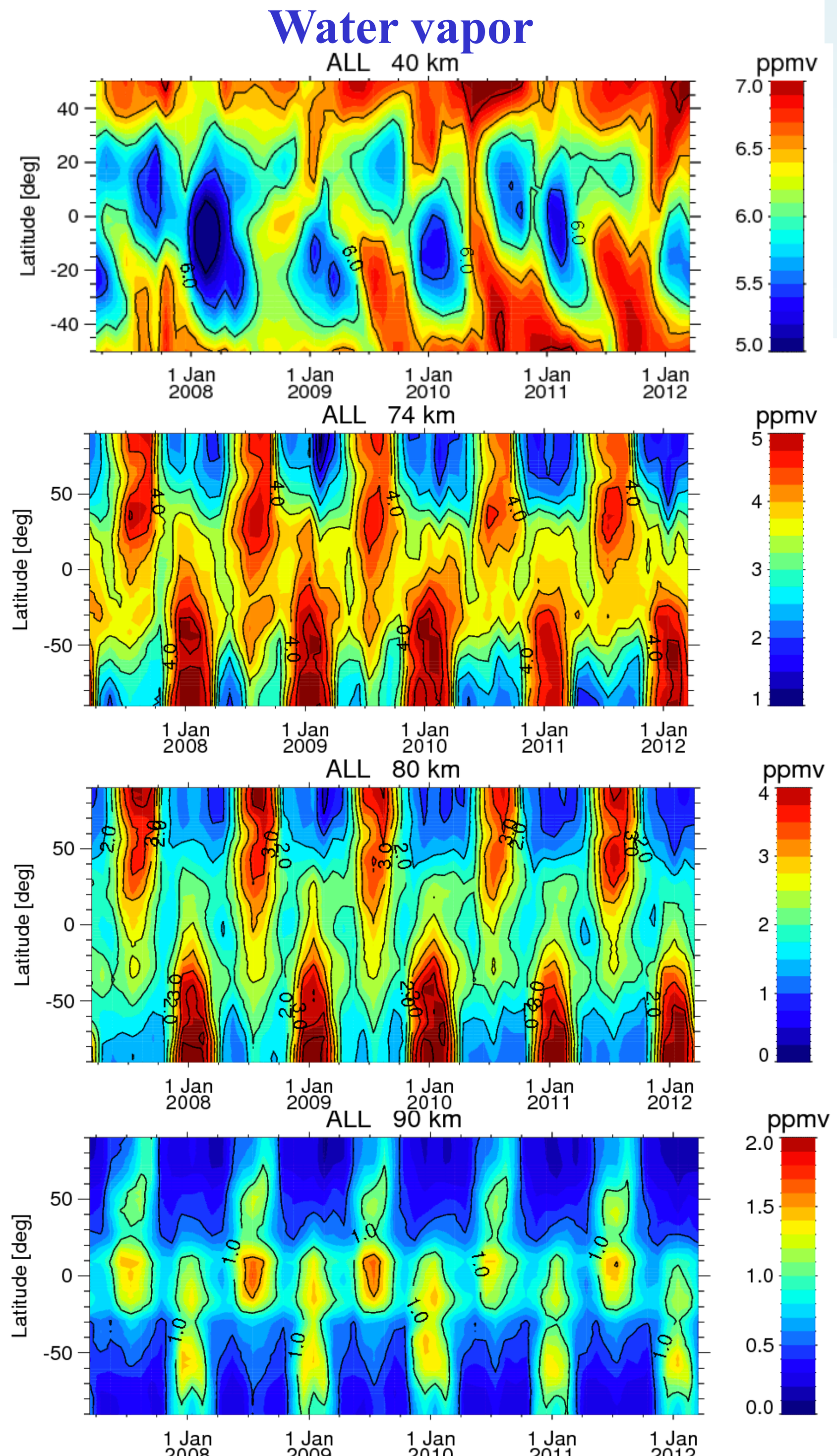
Dataset and method

We use temperature (v521), water vapor (v522) and carbon monoxide (v520) retrieved from MIPAS MA measurements from 2007 to 2012, all derived considering non-LTE effects. We constructed zonal mean time series (averages over 10° latitude boxes) for which we performed a harmonic analysis (decomposition for periods of 365, 182.5, 122, 91, 73 and 61 days) for each year in order to detect inter-annual variations. Below are the time series of zonal means for selected altitudes (where semiannual component is strong).

Temperature

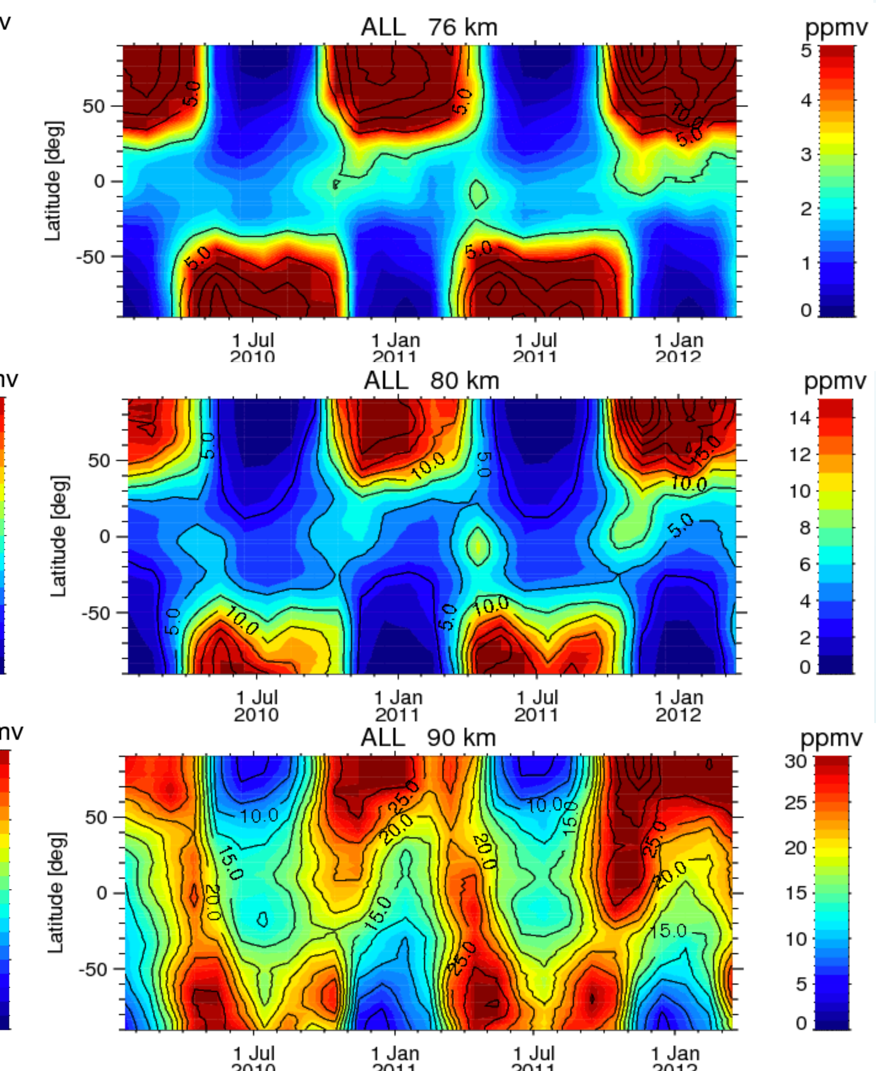


Water vapor



- The isolated oscillations at the equator show that the origin is not meridional advection but dominated by vertical motions
- The semiannual oscillations often show strong seasonal assymetry

Carbon monoxide



Harmonic decomposition of the T_k and H_2O zonal mean time series: MIPAS and WACCM annual and semi-annual components

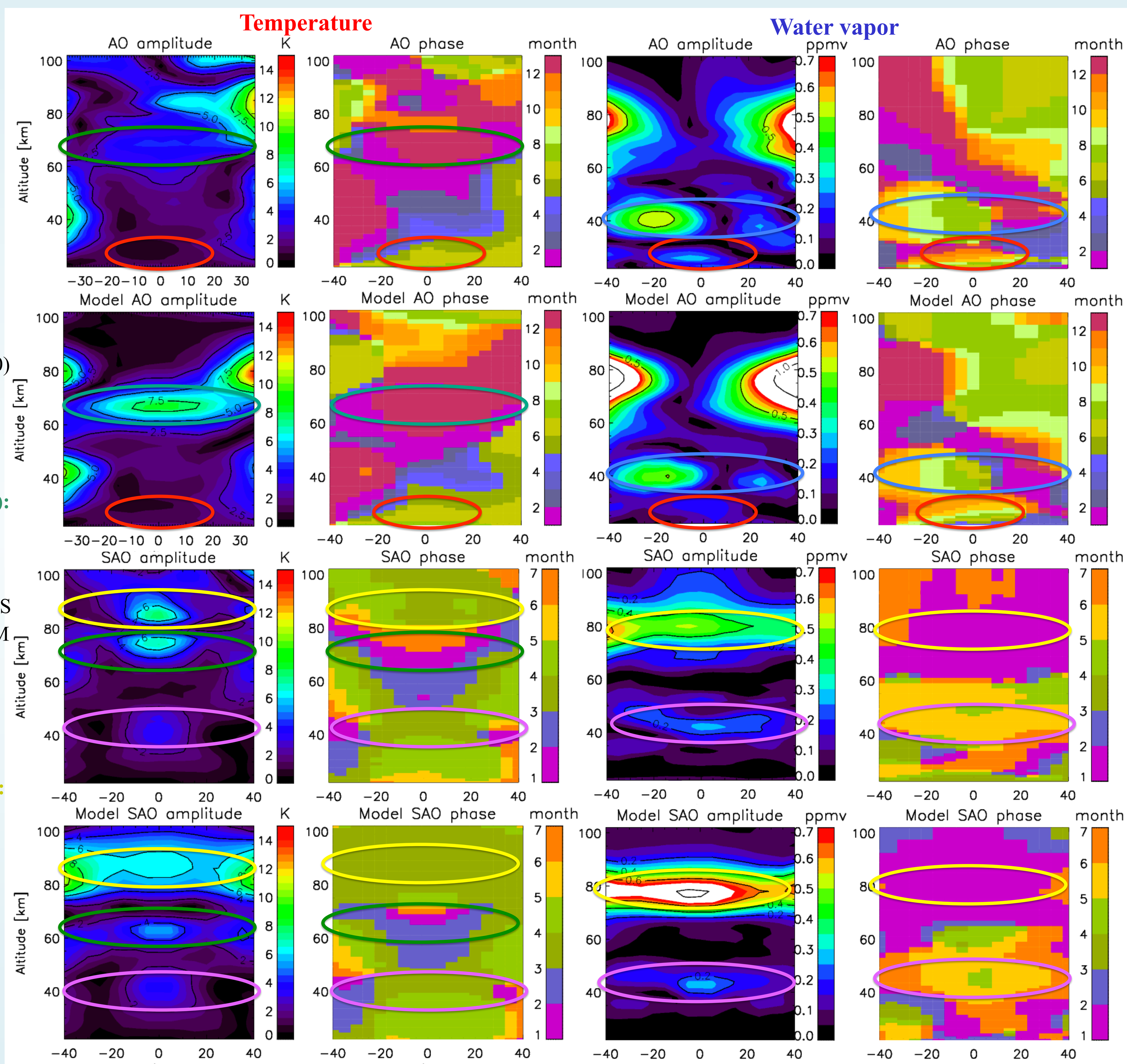
TEMPERATURE

Equatorial lower stratosphere annual oscillation:
(above tropical tropopause)
- Amplitude = 1-2K@22km
- Phase in May-June (weaker B-D)
- Similar location, amplitude and phase in WACCM

Stratospheric SAO (SSAO):
- Amplitude = 4K@40km
- Phase in March/April + Sept (w*<0)
- Hemispherically symmetric
- Very well modeled in WACCM

Middle mesospheric SAO (MSAO):
- Amplitude = 6K @75km
- Phase in Jan + July (u_z<0)
  - in phase with SSAO
- Stronger and 10km higher in MIPAS
- It shows more as an AO in WACCM
- Hemispherically symmetric
- Change of phase with z (change of sign in zonal wind shear u_z)

Upper Mesospheric SAO (MSAO):
- Amplitude = 6K @85km
- Confined to latitudes < 20°
- Phase in March + Sept (u_z>0)
  - in phase with SSAO
  - out of phase with lower MSAO



WATER VAPOR

Equatorial lower stratosphere tape recorder:
- In phase with T_k oscillation (tropopause T_k is the H_2O trap)
- Larger in MIPAS than WACCM due to deeper H_2O minimum (WACCM tropopause too warm)
- Change of phase with z:
  May @22km ➔ Dec @30km
- B-D circulation slower in WACCM
- Change of regime @30km

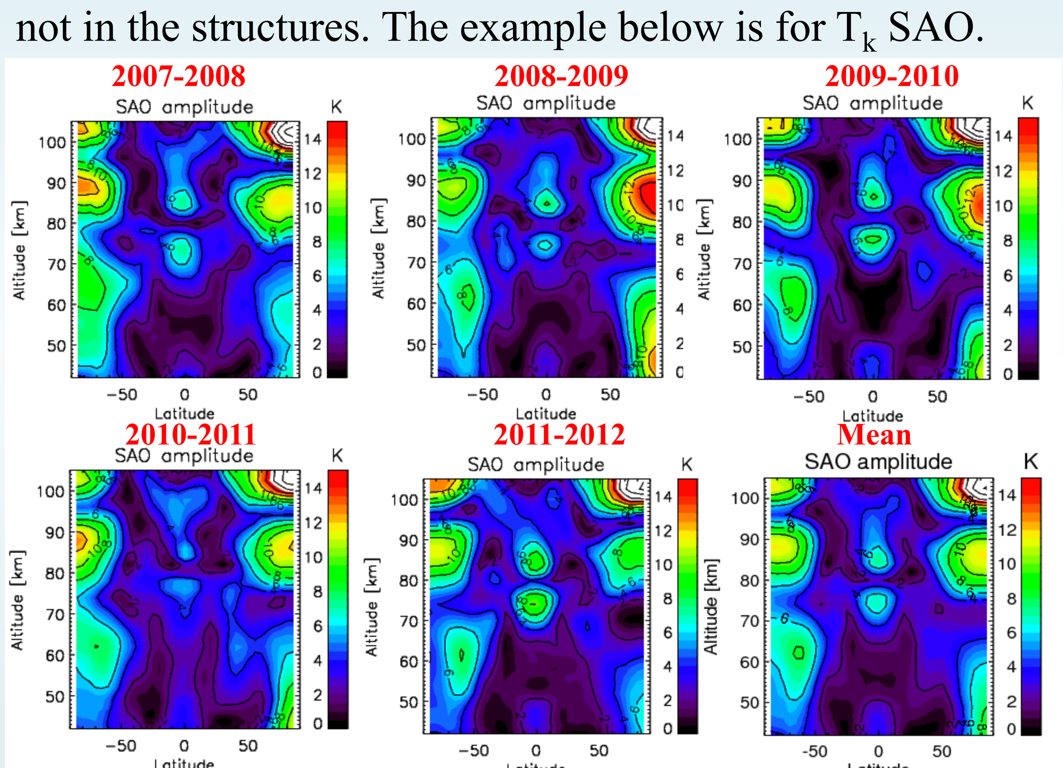
Tropical upper stratosphere Annual component:
- Stronger and 4km higher in SH
- NH/SH out of phase
- Responding to off-equator variability of B-D
- Phase:
  NH- slight change with z
  SH- change with lat
- Regime stops @50km, $[H2O]_z = 0$

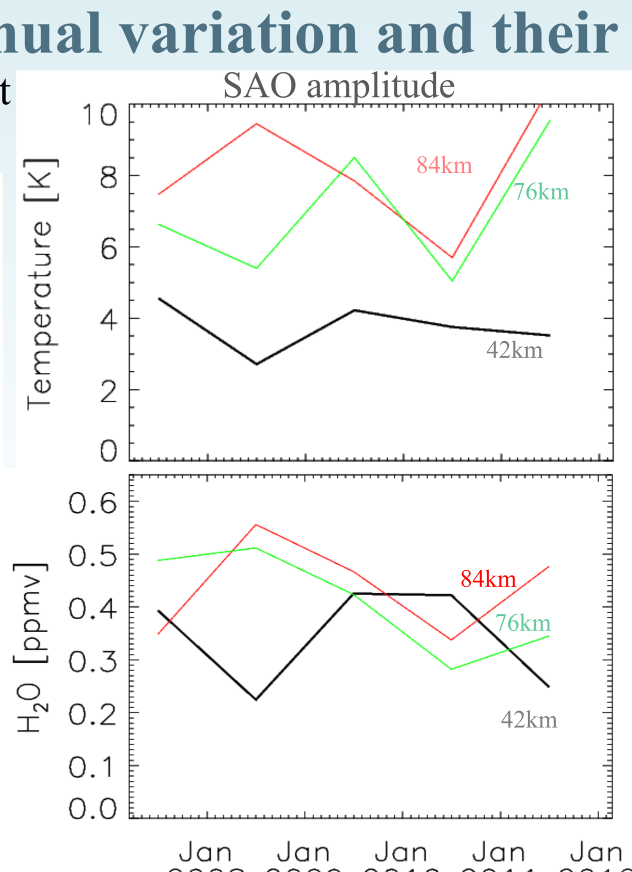
Stratospheric SAO (SSAO):
- Amplitude = 0.3 ppmv @40km
- Phase in April/May + Sept (w*<0)
- Hemispherically symmetric
- Well modeled in WACCM
- Change of regime @65km

Mesospheric SAO:
- Amplitude = 0.6 ppmv @80km (WACCM 30% larger)
- Phase in Jan + July (w*>0)
  - Effect of meridional advection
  - out of phase with SSAO
- No change of phase with z (shown in HALOE, ODIN; effect of vertical resolution?)

SSAO and MSAO inter-annual variation and their correlation

There is a year to year variation in the SAOs magnitudes but not in the structures. The example below is for T_k SAO.





The strong correlation between H_2O and T_k SAOs and MSAOs proves their same origin: change in the residual circulation. However, there is no strong correlation between stratospheric and mesospheric SAOs. Thus, the MSAO variation in the mean flow most likely feeded by an additionaly dynamical effects or interactions above 80km.

Summary

Highlights from MIPAS oscillations from 2007 to 2012:

Stratosphere:
- Tape recorder slightly faster and drier than WACCM
- Oscillations at equator consistent with w*
- WACCM and MIPAS AO and SAO in excellent agreement

Mesosphere:
- H_2O MSAO signature at the equatorial mesosphere 30% smaller than WACCM
- T_k middle-MSAO stronger and higher than WACCM
- No detection of distinct H_2O MSAO maximum @ 75 km
- Upper MSAO seasonally asymmetric in T_k and H_2O

- Half month lag between H_2O and T_k SAOs and MSAOs
- No strong correlation between SAO and MSAO strengths