Upper tropospheric and stratospheric trends of greenhouse gases as derived from MIPAS observations

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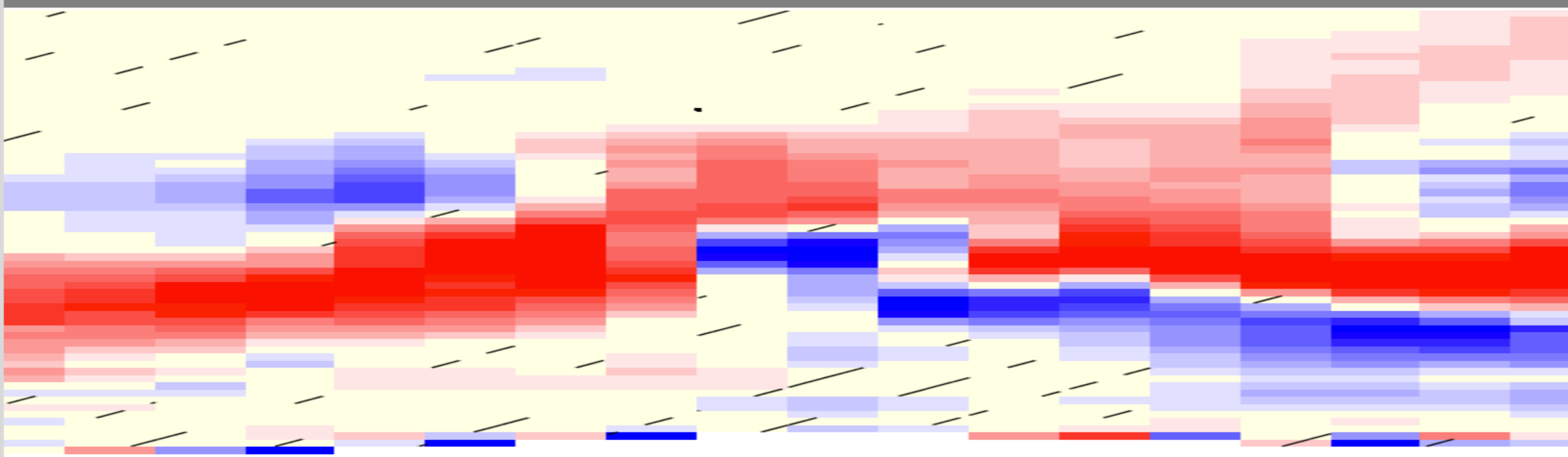
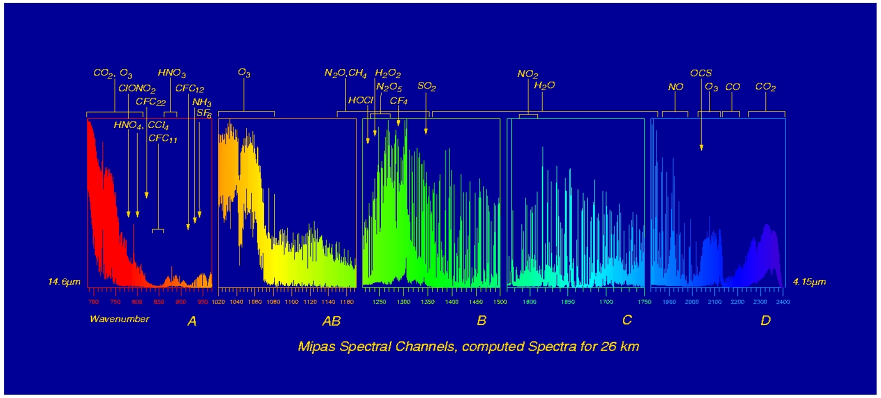


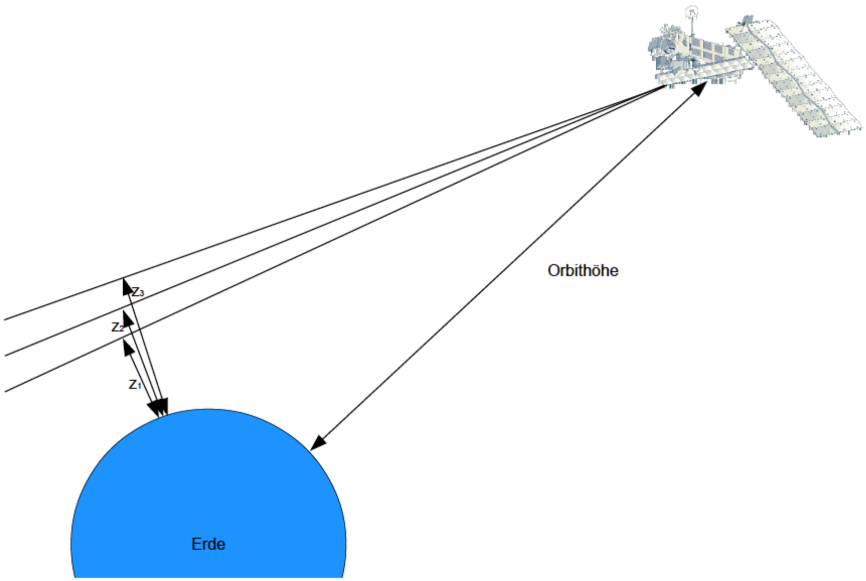
Outline

- MIPAS-observed trends of GHGs: CH_4, N_2O, SF_6, CFC-11, CFC-12, HCFC-22, CCl_4, O_3, H_2O, ...
- How to explain the hemispheric asymmetry
- New method to derive trends of stratospheric entry values
- Results for CH_4
- Conclusions

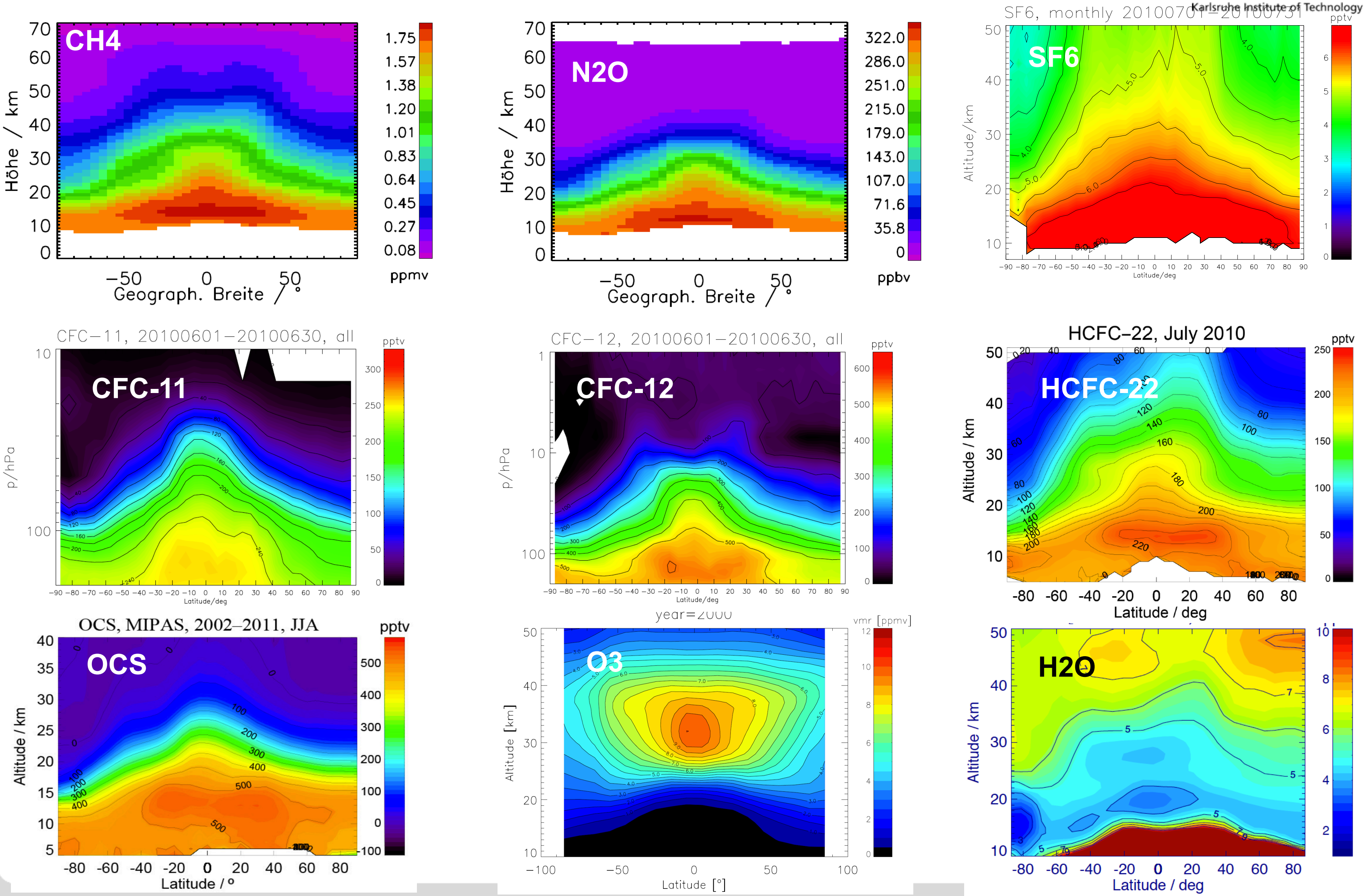
MIPAS observations of GHGs

- MIPAS was a limb sounder able to detect a wide range of species from the UT to the mesosphere
- Active from July 2002 to April 2012
- At IMK, we have derived 10-years data records of global distributions of ~30 species and isotopologues
- Among them are the greenhouse gases CH4, N2O, SF6, CFC-11, CFC-12, HCFC-22, SF6, O3, H2O, CCl4, …
- CO2 cannot be measured in the middle atmosphere below 70 km.
- Due to the limb sounding geometry, the sensitivity to low-abundant species is high.
- The lowest observation altitude is cloud top or ~ 6km, whatever is higher.



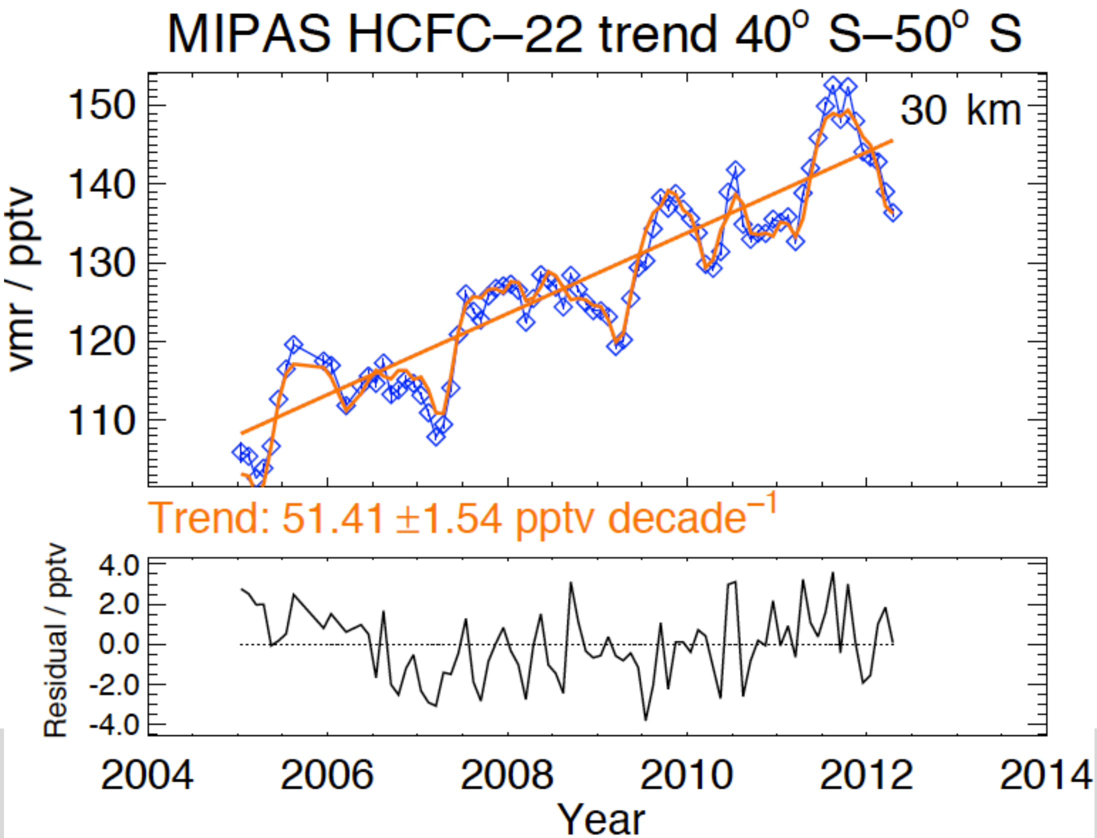


Distributions of GHGs

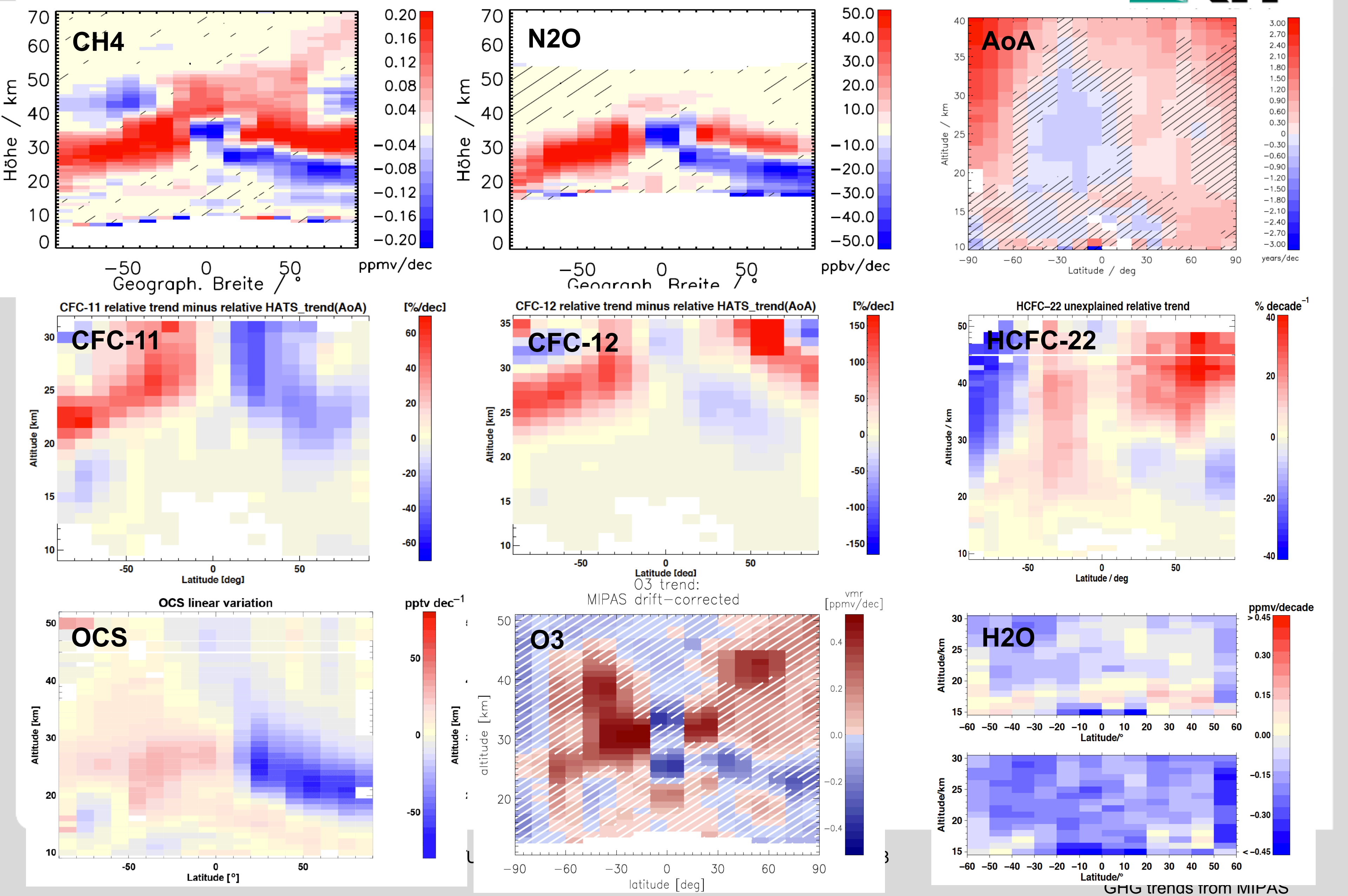


Determination of trends

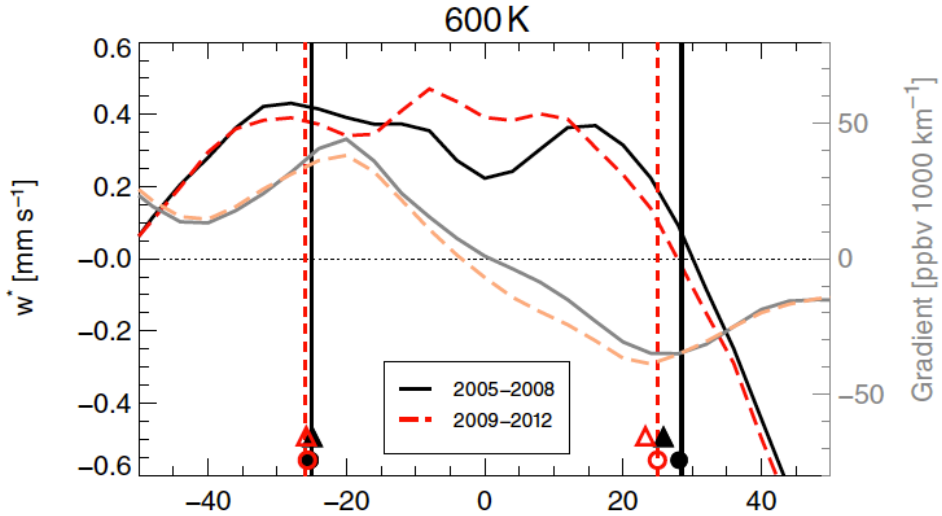
- Multivariate linear regression of the time series of monthly zonal means of volume mixing ratios in a latitude/altitude bin (typically 10 deg, 1 km)
- Parameters to be fitted: seasonal variation (sin/cos) and higher harmonics, 2 QBO terms, ENSO proxy, solar cycle proxy (F10.7 radio flux), linear term, offset
- The linear term is interpreted as the trend over time
- Example:

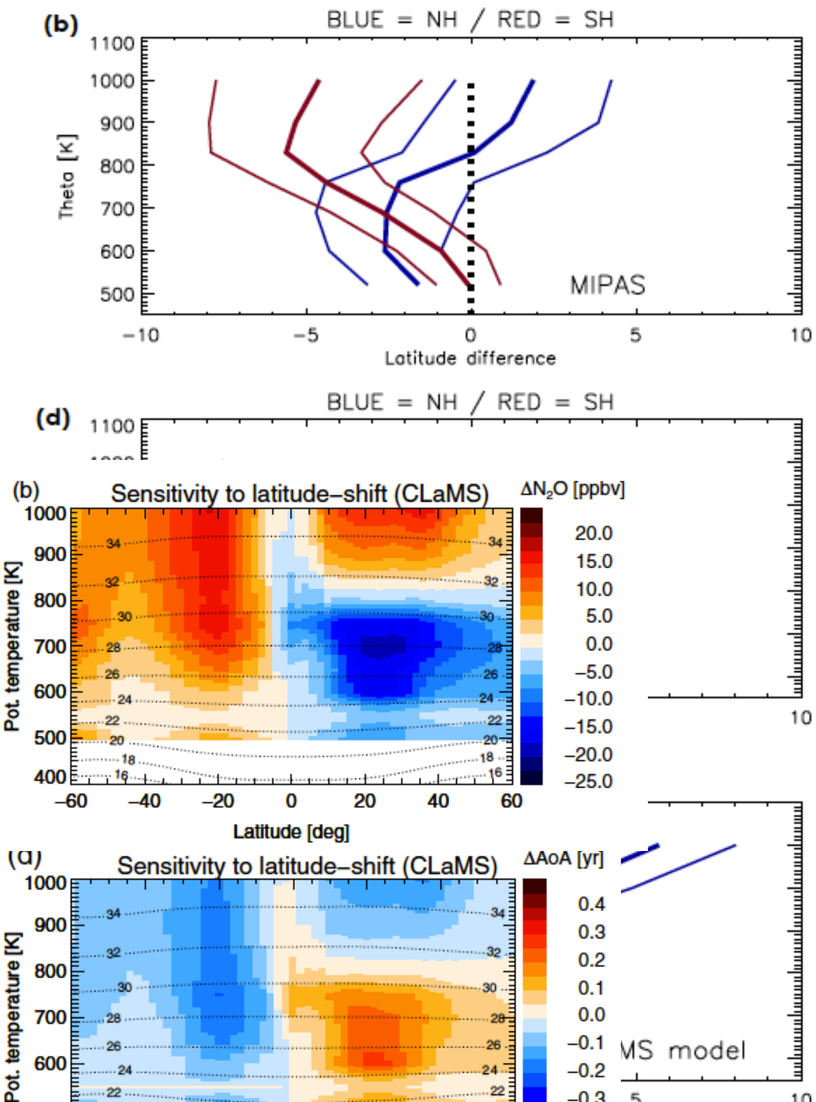


Linear decadal trends of GHGs from MIPAS, 2002 - 2012



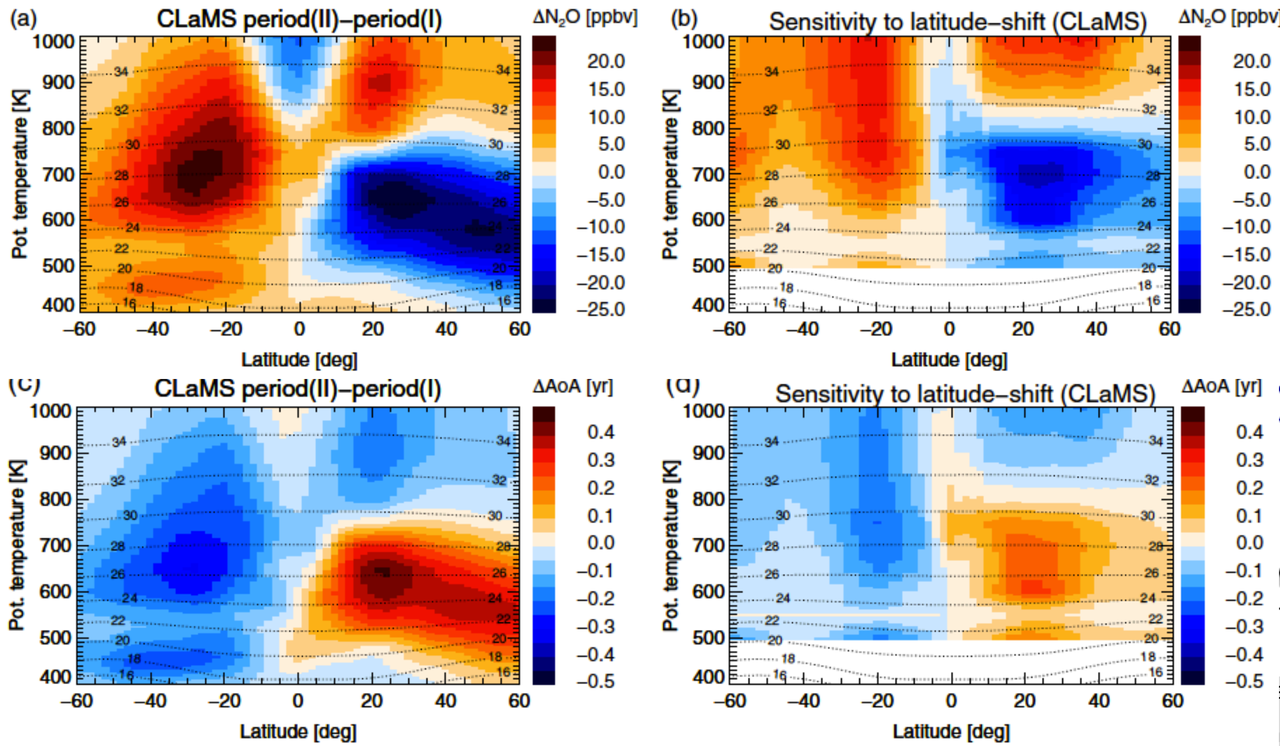
Shift of circulation pattern explains asymmetry





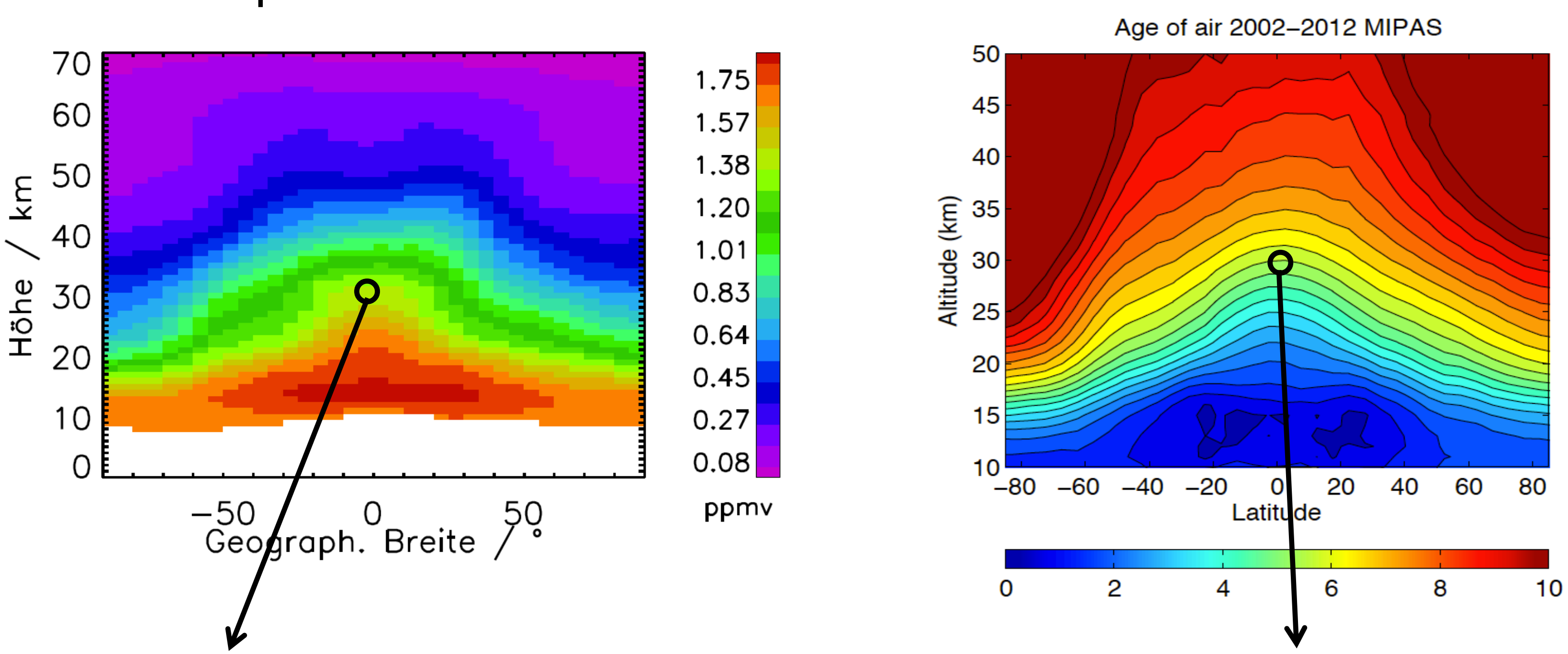
N2O

AoA



How to determine trends in stratospheric entry values?

- Inhomogeneous stratospheric trends make it difficult to determine trends in the stratosphere
- Determine stratospheric entry values with the help of measured age of air
- Sort data according to the entry date of the air mass into the stratosphere

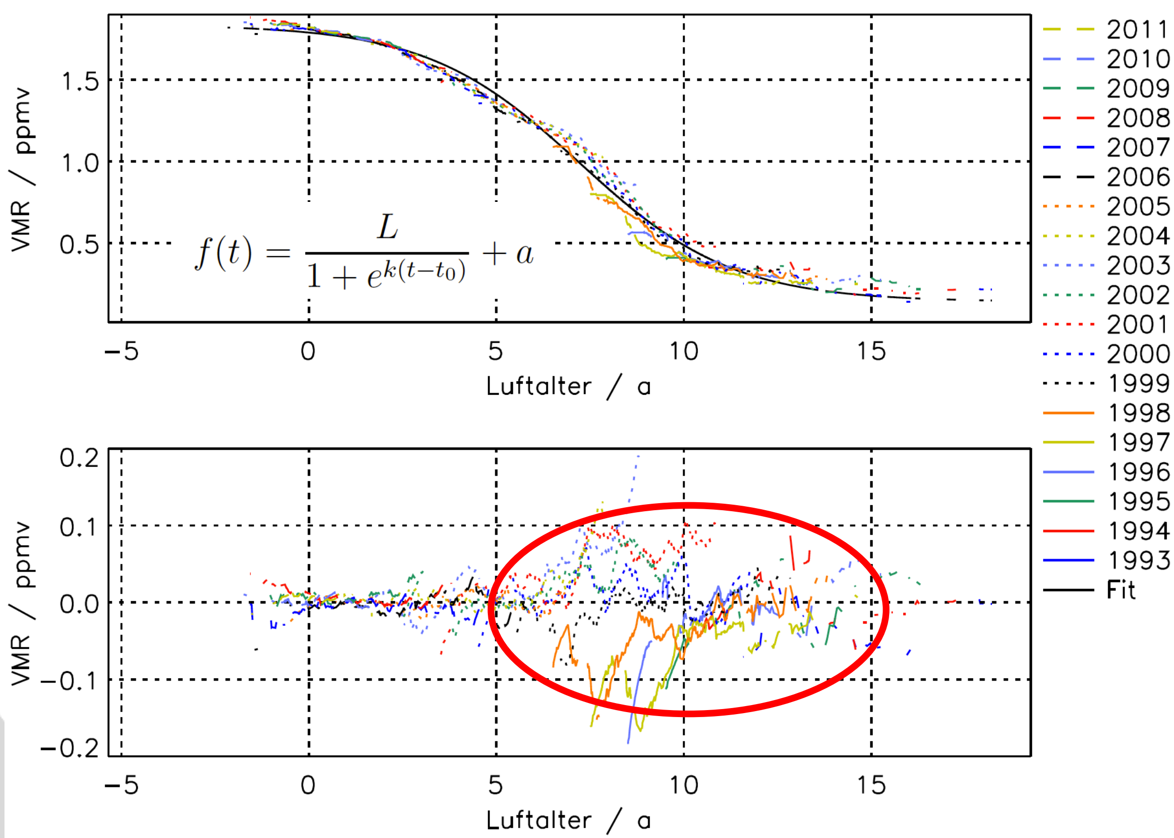


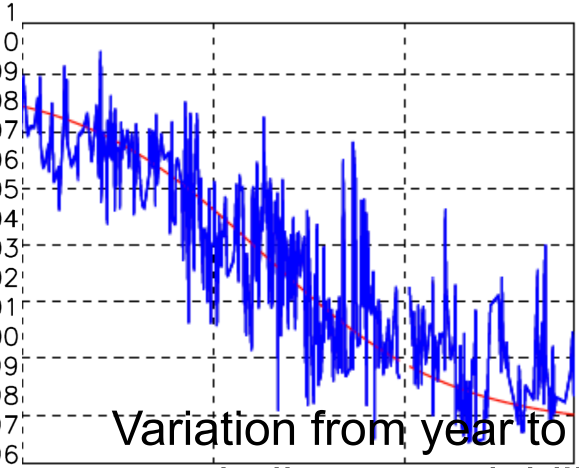
[CH4(lat,alt,t)] => [CH4(t_entry, age)] with t_entry = t – age(t,lat,alt)

How to determine trends in stratospheric entry values cntd.?

- For each entry date, the dependence of the abundance on age of air follows a logistic function
- Extrapolation to age = 0 provides abundance at the entry point for that entry date
- The parameters of the logistic function provide the stratospheric life time

Entry in June

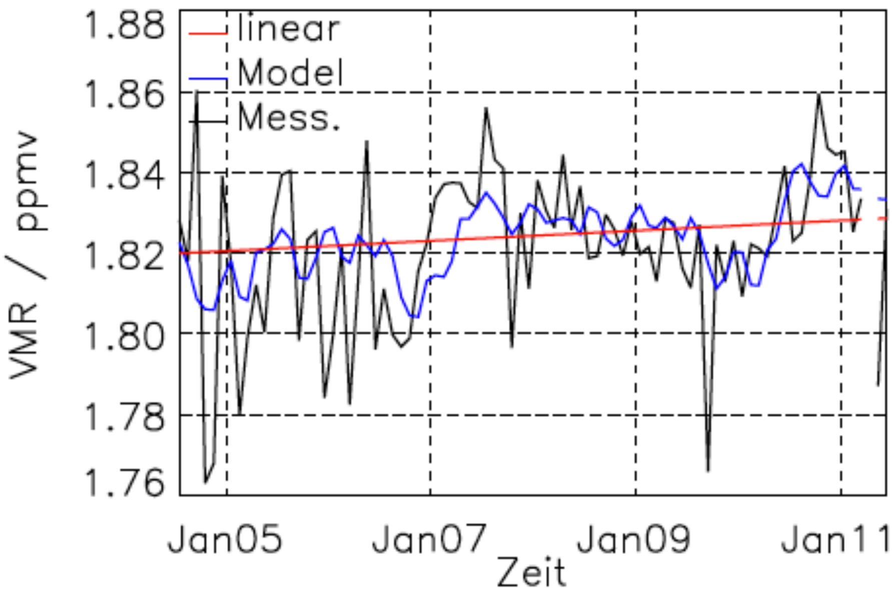




Variation from year to year indicates variability of the BDC (different pathways in the atmosphere)

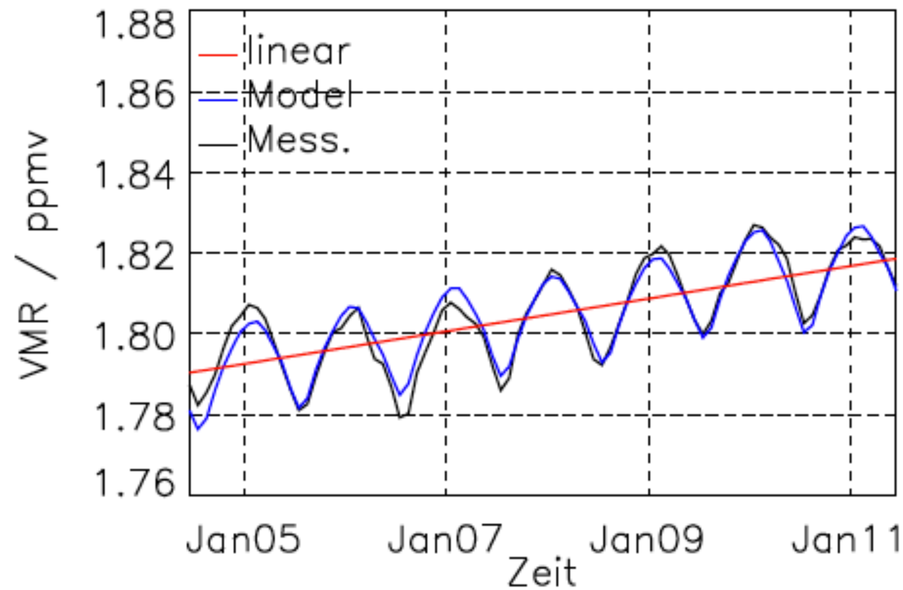
Results for CH4 (example): 2005 - 2011

CH4 increase at stratospheric entry point from MIPAS



Linear trend:
0.013 ± 0.012 ppmv/decade

CH4 increase at surface from Global Cooperative Air Sampling Network (GCASN) measurements



Linear trend:
0.040 ± 0.0028 ppmv/decade

The stratospheric increase of CH4 is lower than the tropospheric one. This is significant despite large uncertainties (and high bias) of MIPAS data.

Summary and conclusions

- MIPAS provided global distributions of a large number of GHGs in the upper troposphere and stratosphere over 10 years (2002 to 2012): CH_4, N_2O, CFC-11, CFC-12, HCFC-22, SF_6, CO, CCl_4, OCS, O_3, H_2O, …
- The trends of all the species are inhomogeneous over altitude and latitude, and all show a pronounced hemispheric asymmetry.
- The asymmetry can be explained by a shift of the circulation pattern in the stratosphere to the South.
- The trend assessment is complicated by the large inhomogeneity.
- We have presented a method to derive the trend at the entry point to the stratosphere.
- For the example of CH_4, this trend is significantly weaker than the trend at the surface.
- This hints towards a change of methane oxidation processes in the troposphere, compensating partly the increasing emissions.

Thank you!