→ ATMOS 2015

Advances in Atmospheric Science and Applications

New MIPAS V7 products

Piera Raspollini on behalf of the

MIPAS Quality Working Group

8–12 June 2015 | University of Crete | Heraklion, Greece

European Space Agency

MIPAS Quality Working Group

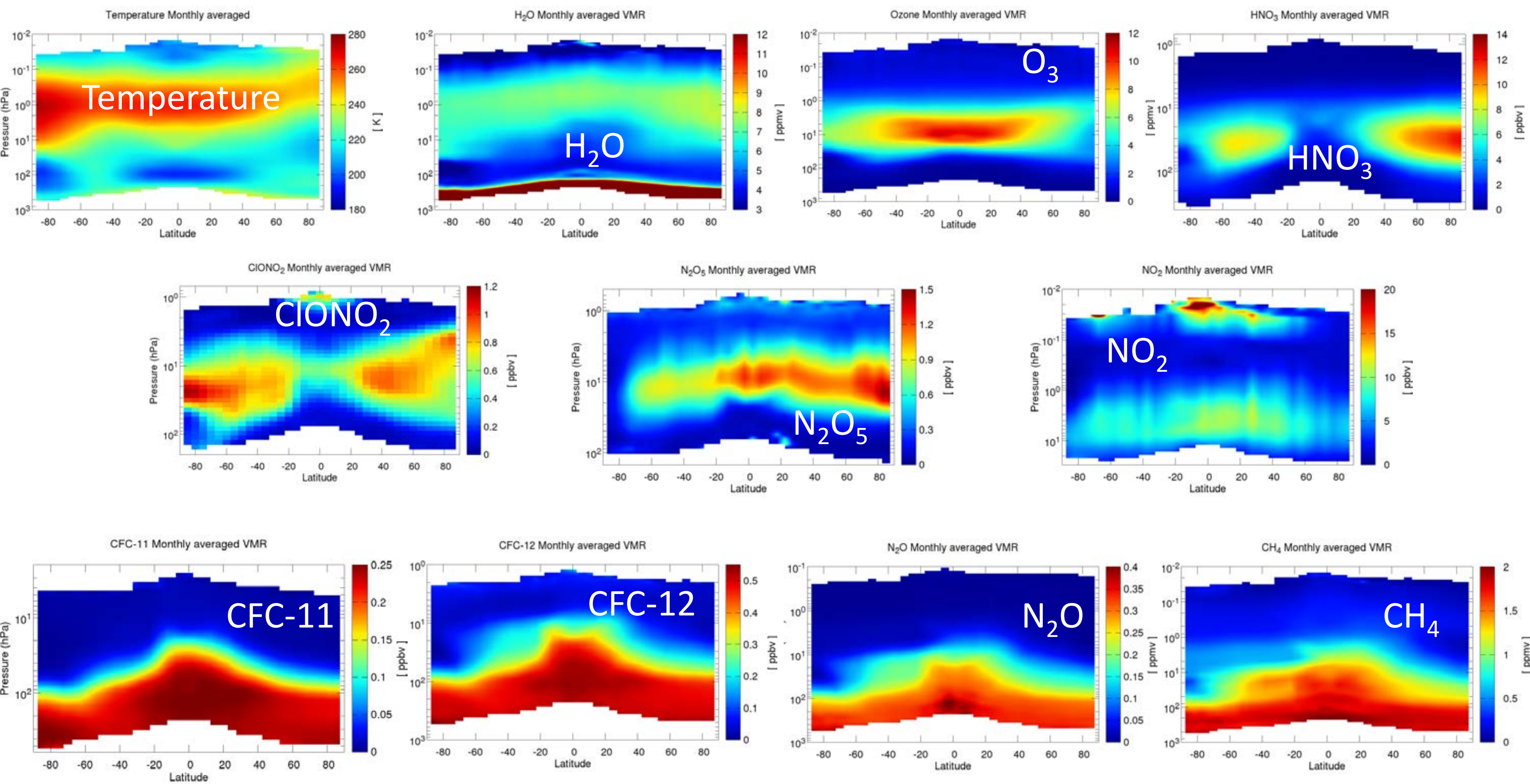
P. Raspollini, B. Carli, S. Ceccherini and F. Barbara
M. Carlotti and M. Ridolfi
B. M. Dinelli, E. Castelli and E. Papandrea
L. Sgheri
A. Dudhia
D. Moore and J. Remedios
J.-M. Flaud
M. López-Puertas
M. Bernau
M. Kiefer
G. Aubertin and G. Perron
M. Birk and G. Wagner
M. De Laurentis
A. Dehn

L2 group

L1 group

ESA L2 processor V6, with L1 V5 data (released data)

October 2007 monthly averages of the species retrieved by ML2PP V6



Raspollini et al., AMT, 2006

ESA processor V7 (next release)

Level 1

The new MIPAS **Level 1b** data set **version 7.11** was officially released on 22 May (https://earth.esa.int/web/guest/content/-/article/envisat-mipas-level-1b-dataset-processed-with-ipf-version-7-11-is-available).

Level 2

A subset of about 4000 orbits was used as diagnostic data set to analyse the impact of the new Level 1b data set and the new Level 2 algorithm. This analysis has lead to further adjustments of the Level 2 processor that will be considered in the full mission reprocessed data set.

The reprocessing of the new **Level 2 version 7.03** dataset is expected to be ready next July, to be followed by validation activity.

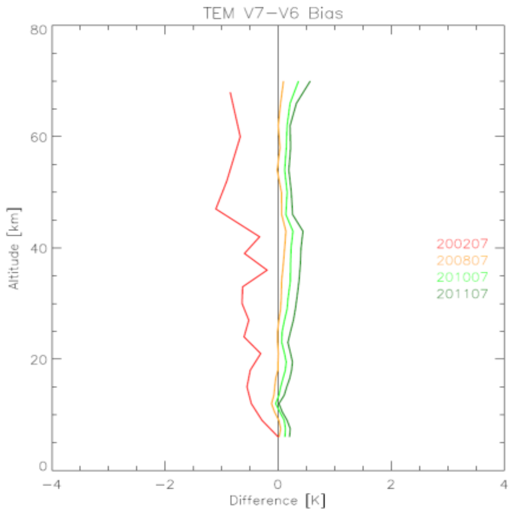
Significant improvements are contained in both L1 and L2 processors.

Improvements in V7 L1 processor: correction of time dependent calibration error

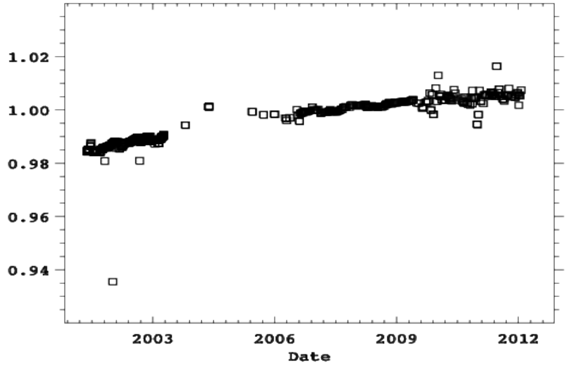
➢In some studies of trends performed with MIPAS L1 V5 data (Ceccherini et al., Opt. Express, 2011, Eckert et al., ACP, 2014) the uncertainties caused by the drift of the instrument gain was identified as the largest source of error.

➢MIPAS detectors of some spectral bands are affected by nonlinearities that change with time due to the aging of the instrument.

➢In-flight measurements have allowed nonlinearity characterization and correction in L1 V7 (Birk and Wagner, ESA TN, 2013; Kiefer et al., ACVE proc., 2013).



Difference in the monthly mean of temperature profile retrieved when using L1 V7 files and L1 V5 files in July in the years 2002, 2008, 1010, 2011



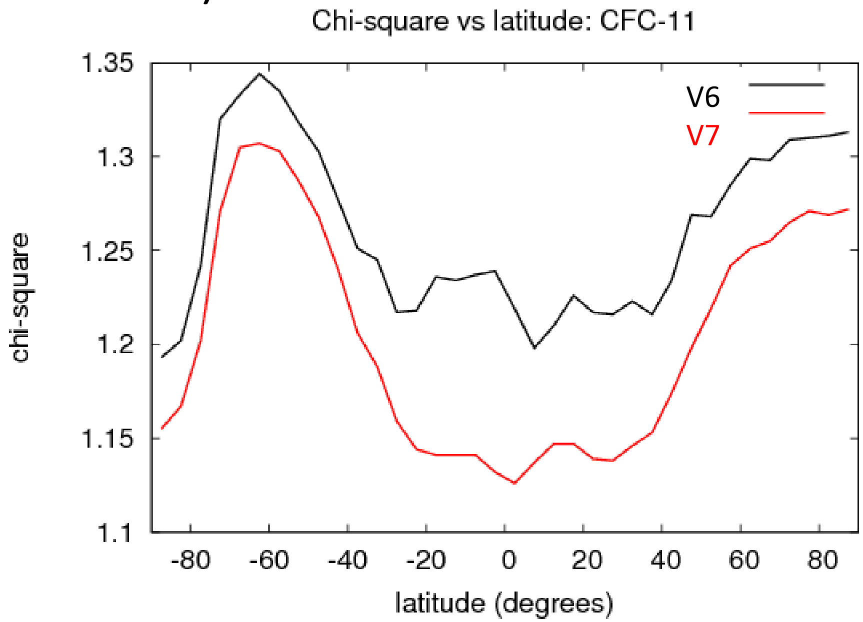
Ratio between mean L1 V7 and L1 V5 radiance for one band affected by non-linearities. The effect of the correction is a reduction of the radiance at the beginning of the mission and then a progressive increase of the ratio up to 1.01 at the end of the mission.

Improvements in V7 L2 processor

Significant improvements have been implemented also in the L2 processor:

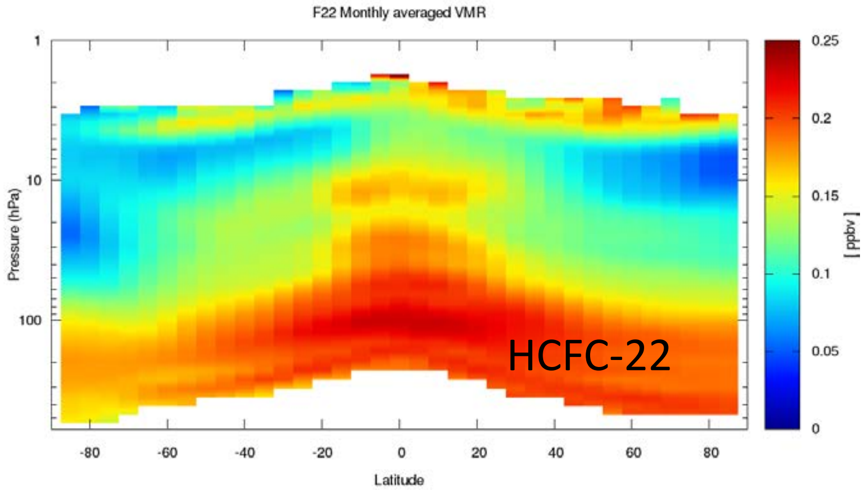
- different approach used for retrieving atmospheric continuum,
- a posteriori regularization with altitude dependent constraint,
- spectral windows used for the analysis of the first phase of the mission with larger information content.
- better approach for handling interfering species
- additional retrieved species (see next slide)

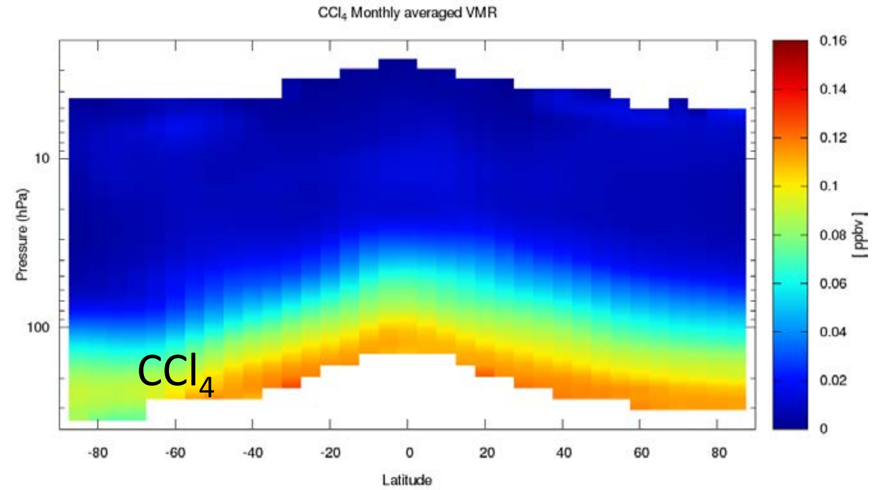
In general, the implemented improvements help in reducing the final χ^2, and the conditioning number of the matrix to be inverted.

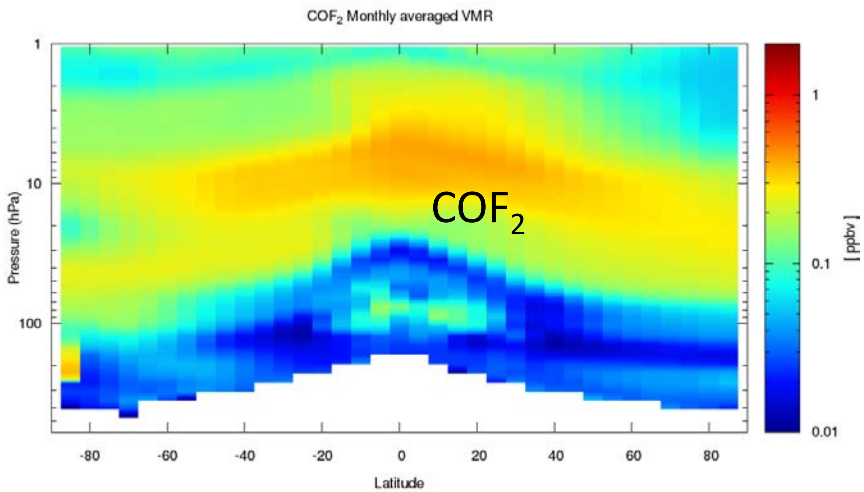


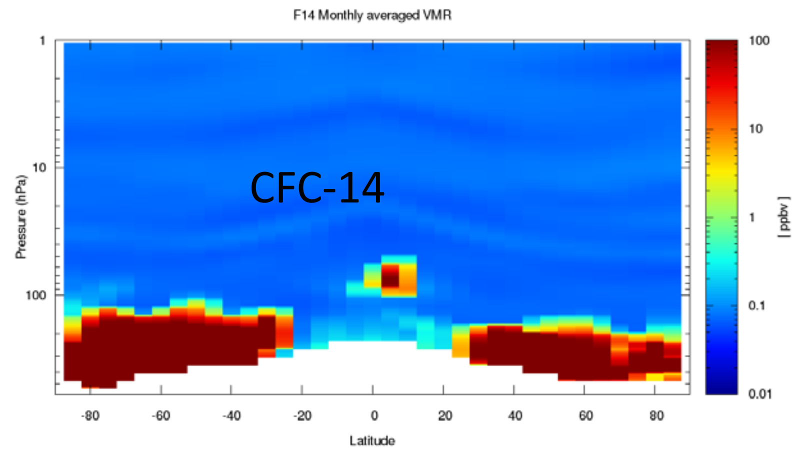
Improvements in V7 L2 processor

Retrieval of the following additional species: COF_2, CCl_4, CFC-14 , HCFC-22 and HCN.









Trend studies

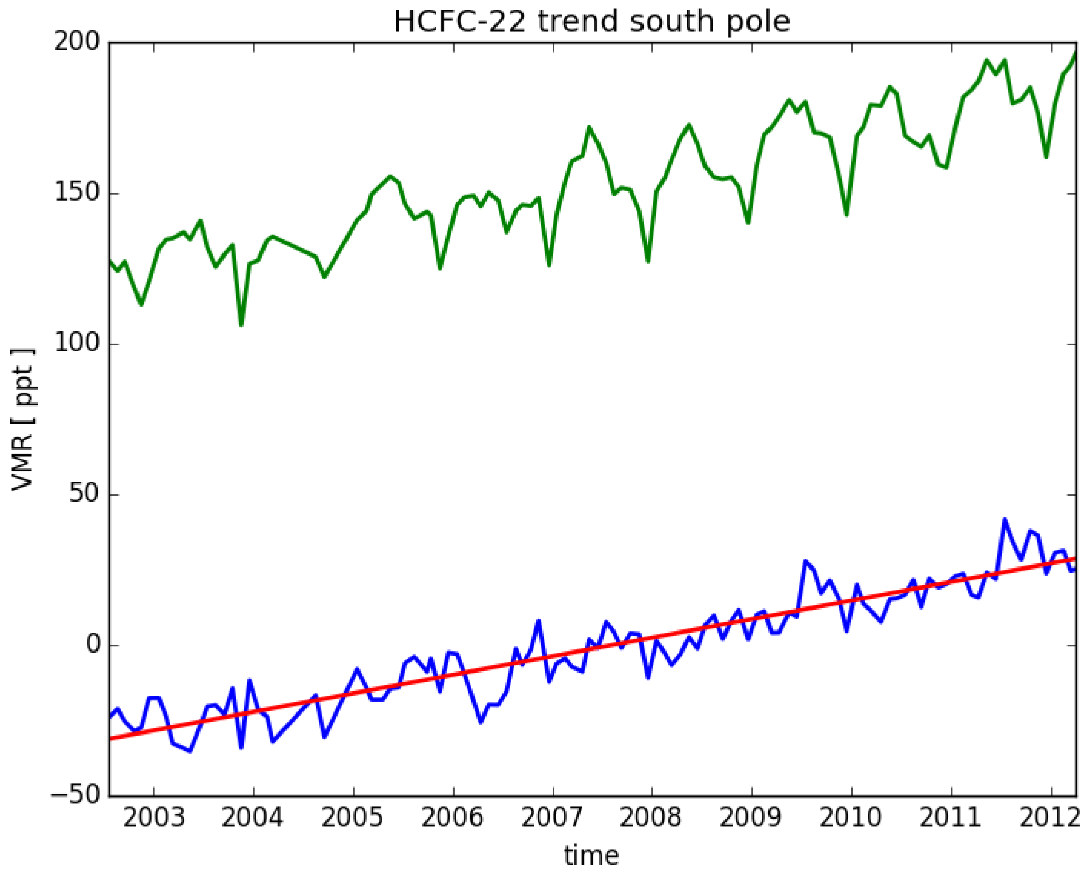
Some trend studies have already been made using the MIPAS data (Ceccherini et al., Opt. Express, 2011, Kelmann et al., ACP, 12, 2012, Eckert et al., ACP, 2014) with some empirical correction for the instrumental drift.

The non-linearity calibration made in the new data release will allow more accurate trend studies, about stratospheric temperature, water vapor, ozone, methane, nitrous oxide and Ozone Depleting Substances (ODS).

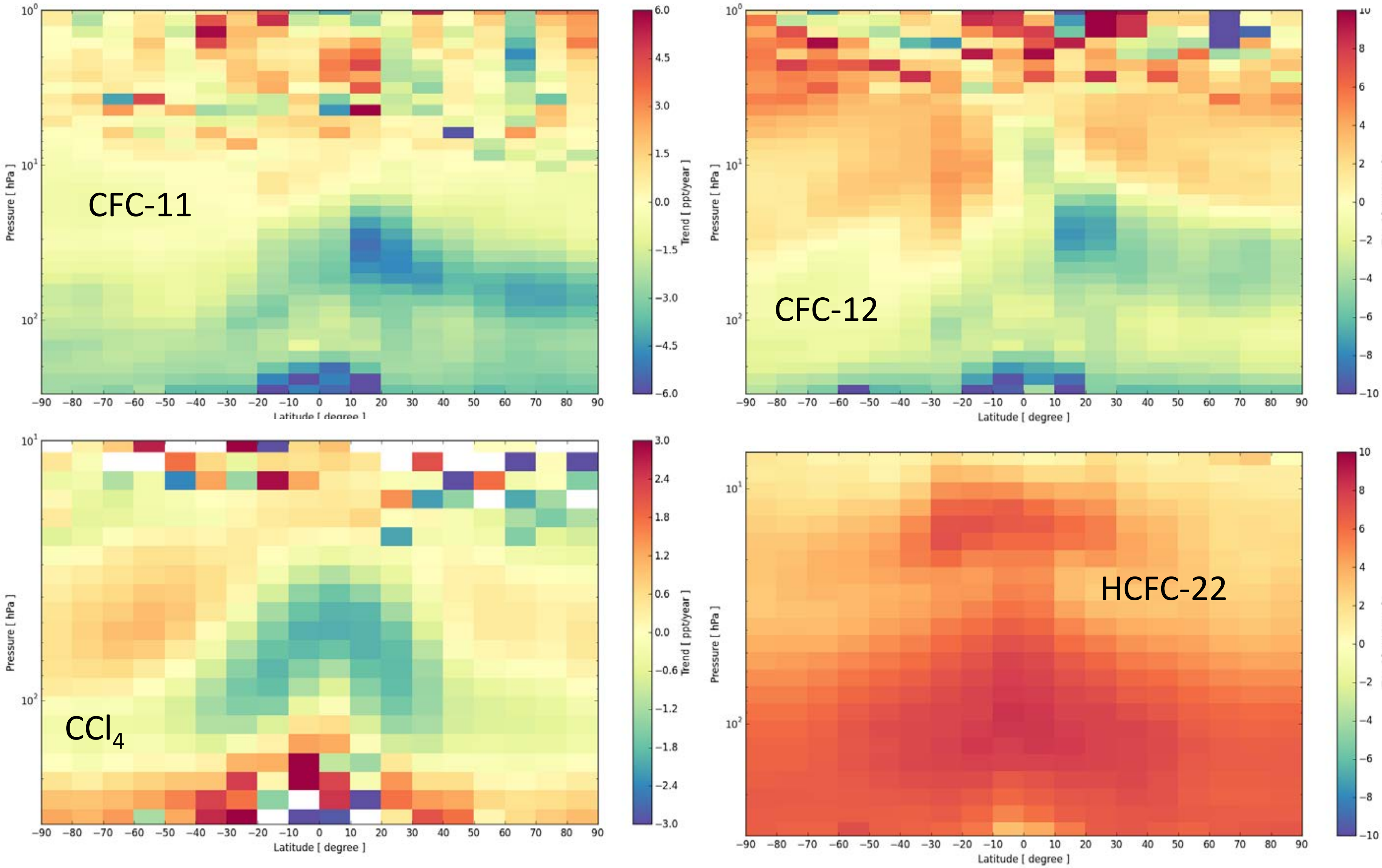
Using the diagnostic dataset V7 some preliminary results are shown about the trend of some Ozone Depleting Substances.

Methodology for trend estimation

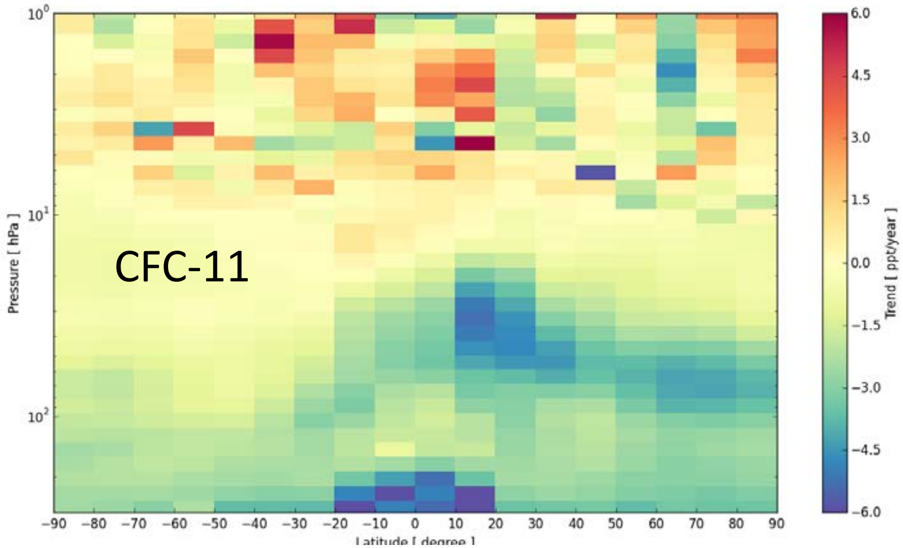
Monthly means (green curve) have been calculated for each species at each altitude for latitude bins of 10°.
The annual variability has been removed subtracting from the monthly means the average for each month of the year for all observed years.
The trend (red line) was obtained by linear fit of the resulting values (blue curve).

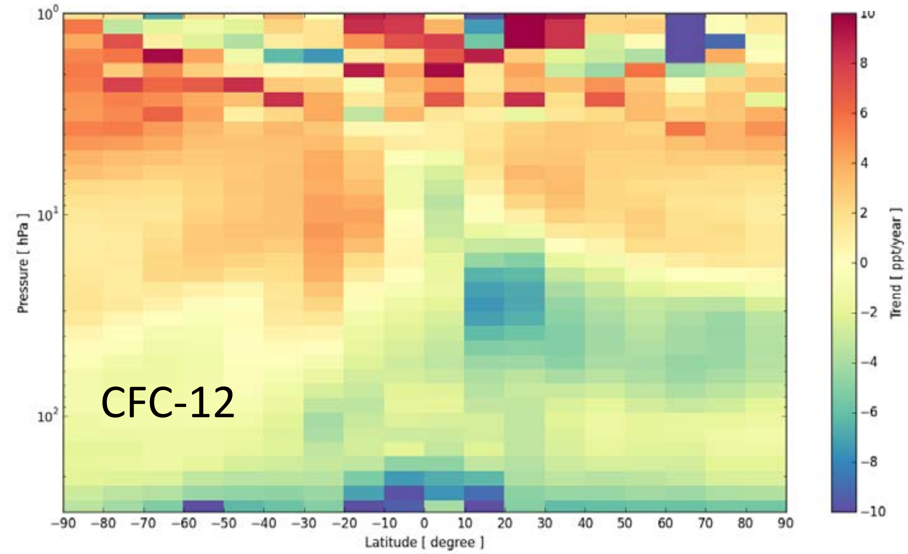


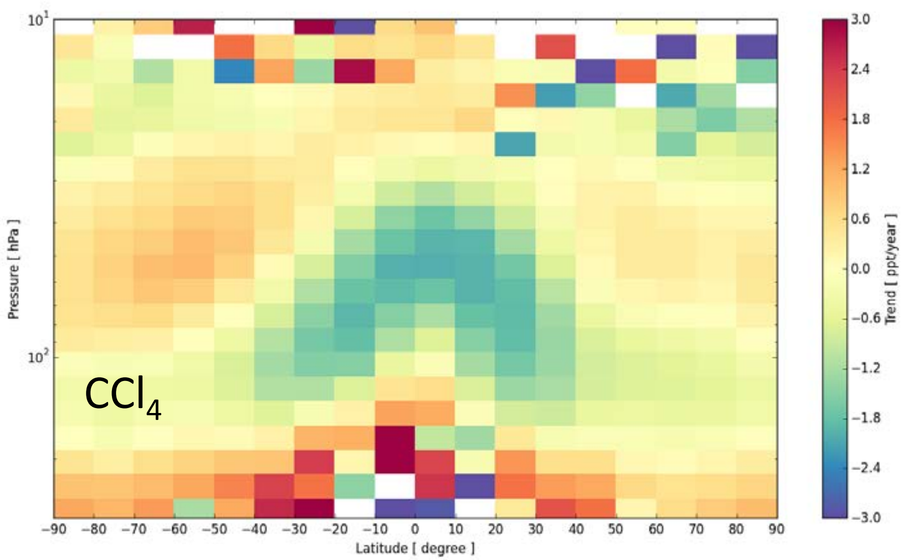
Annual trends of some ODSs as a function of latitude and altitude



Annual trends of CFCs as a function of latitude and altitude



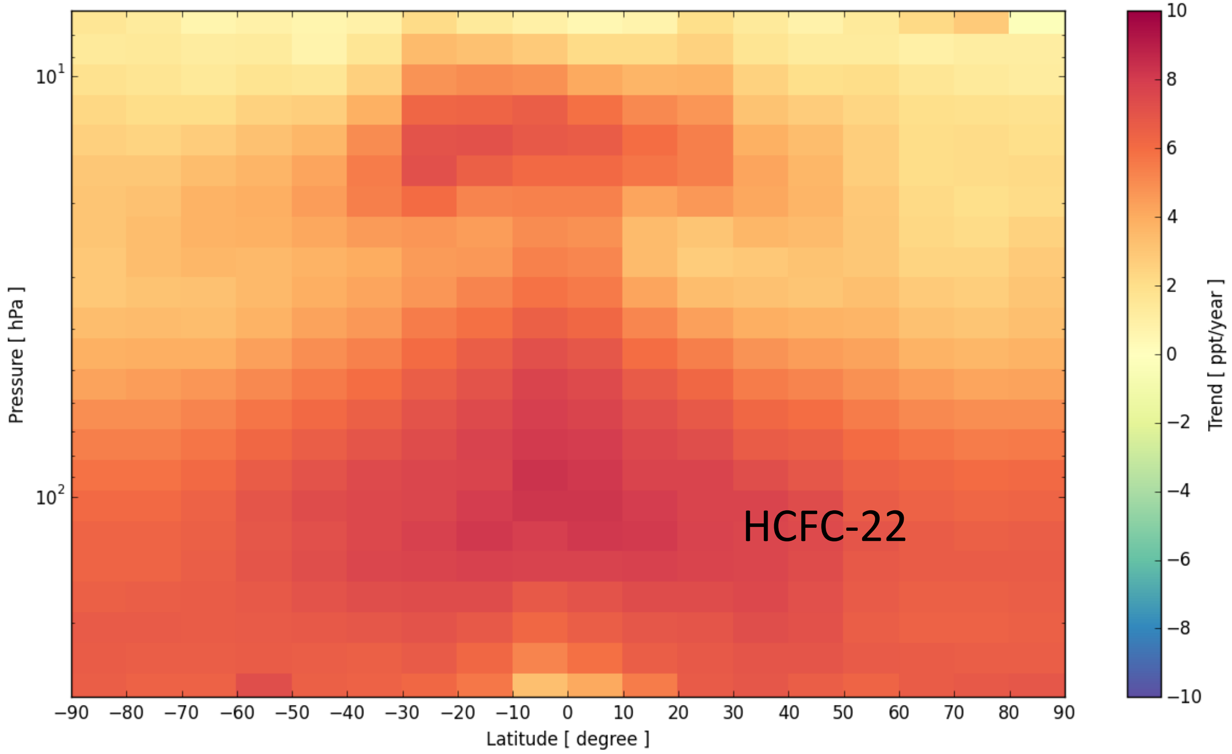




Rather similar latitude and altitude structure of the three species banned by Montreal protocol since 1987: negative trends in the UTLS with a peak in the tropics , some positive trends in stratospheric middle latitude, asymmetry between Northern and Southern Hemispheres.

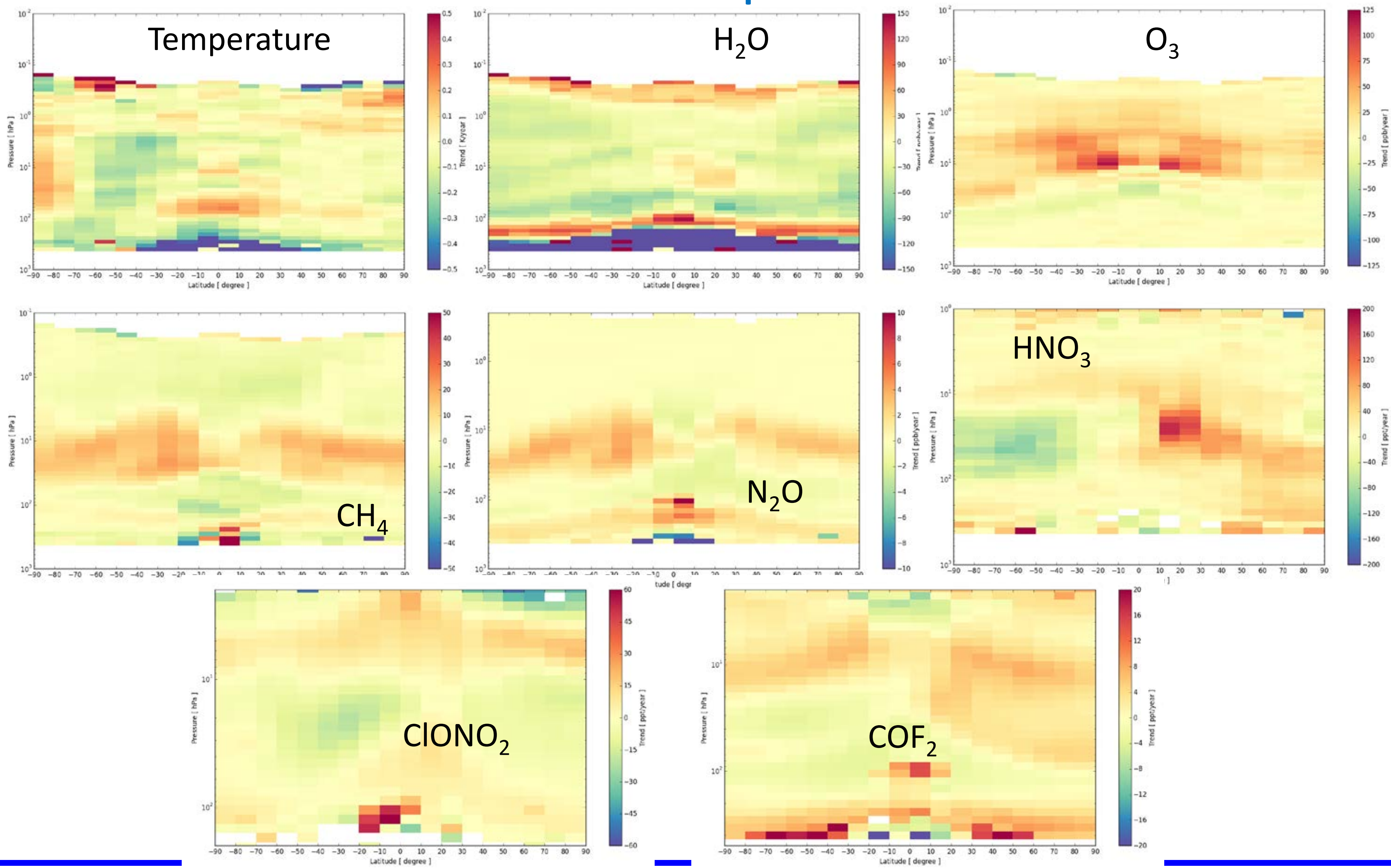
Annual trends of HCFC-22 as a function of latitude and altitude

HCFC-22 has been used as temporary substitute of CFCs for its lower flux of chlorine in the stratosphere (20 times smaller than CFC-12) due to its partial oxidation with hydroxyl radical (OH) in the troposphere. However, for its large stratospheric lifetime and its huge radiating forcing, the Montreal Protocol ratified for HCFC-22 emission a gradual reduction since 2004 up to complete banning in 2030 for developed countries and in 2040 for developing countries.



Positive trends are found at all latitudes and altitudes, larger in the tropics, where the air is the youngest. We observe a mushroom-shape of the trend centered at the equator.

Preliminary trends of other species



Summary

MIPAS ESA processor products V7 will be characterized by:

- reduced time dependent calibration error due to nonlinearities (which were better characterized in the new Level 1b algorithm),
- improved quality of the products using new microwindows with an increased information content,
- reduced χ^2,
- more retrieved species (COF2, HCFC-22, CFC-14, CCl4, HCN).

The new MIPAS products will allow the study of the trends with larger accuracy.

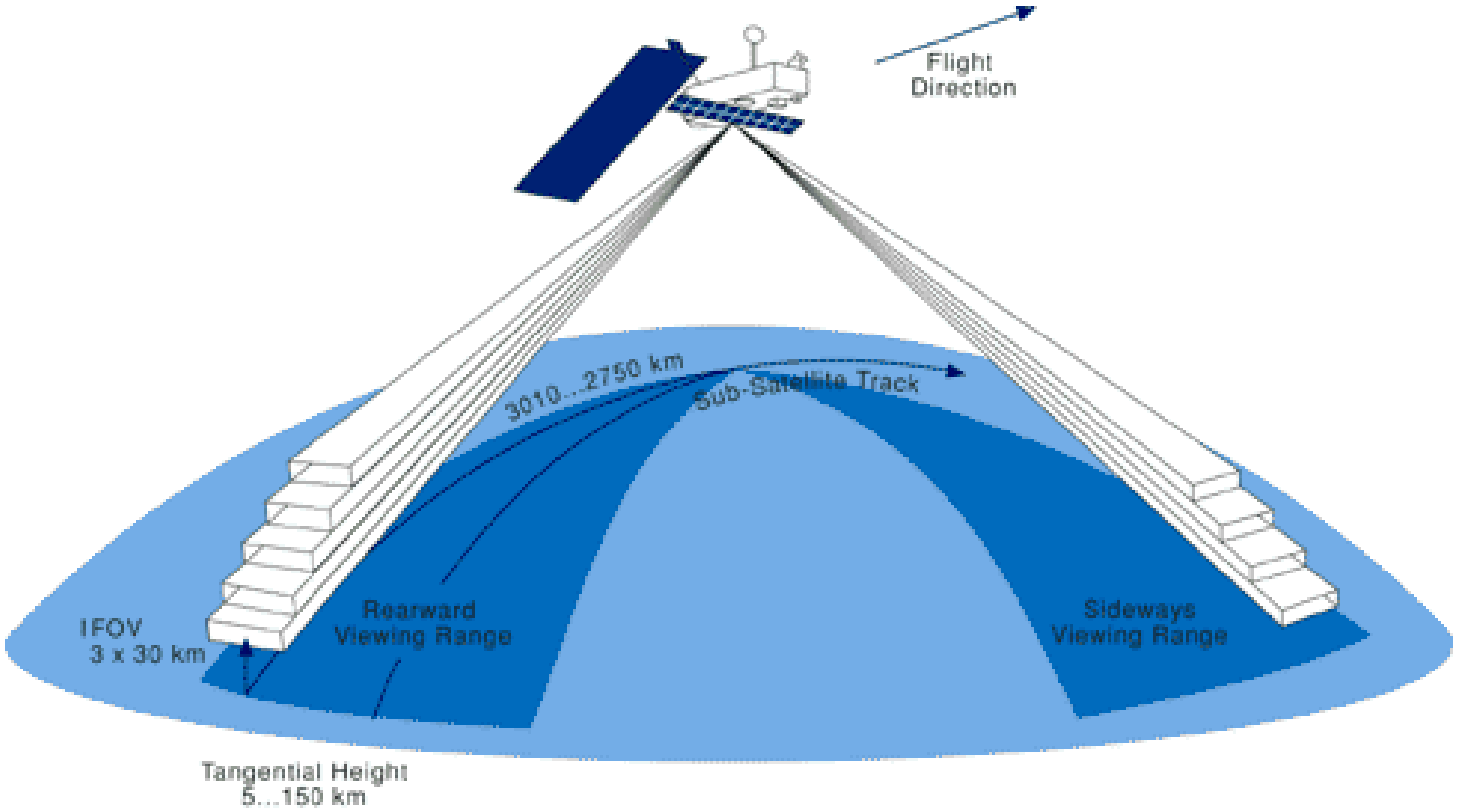
Preliminary results of latitude and altitude resolved stratospheric trends of CFC-11, CFC-12 and CCl_4 indicate negative trends in the UTLS, but positive trends in middle latitudes and asymmetry between Northern and Southern Hemispheres.

Large positive trends are found for HCFC-22 at all altitudes and latitudes.

Outlook

The MIPAS Quality Working Group is still working for further improving the quality of MIPAS products after V7 release.

The final full mission reanalysis of MIPAS data is expected in 2018.


Flight
Direction
3010...2750 km
Sub-Satellite Track
IFOV
3 x 30 km
Rearward
Viewing Range
Sideways
Viewing Range
Tangential Height
5...150 km

Thanks!

Backup slides

References

Birk, M. and Wagner, G., 'Radiometric impact of new nonlinearity analysis', Technical Note, 12.11.2013

Ceccherini, S., Carli, B. , Raspollini, P. and Ridolfi, M., Rigorous determination of stratospheric water vapor trends from MIPAS observations, Optics Express, Vol. **19**, Iss. S3, A340-A360 (2011)

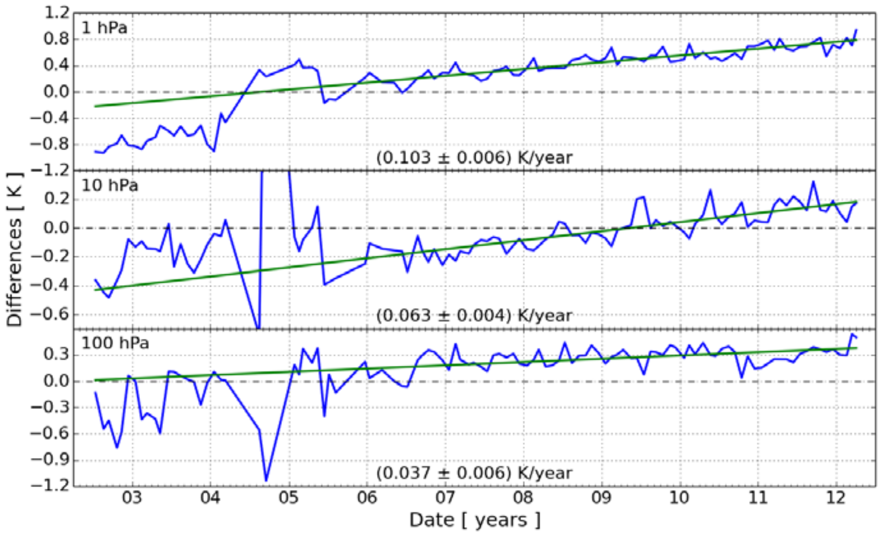
Eckert, E., von Clarmann, T., Kiefer, M., Stiller, G. P., Lossow, S., Glatthor, N., Degenstein, D. A., Froidevaux, L., Godin-Beekmann, S., Leblanc, T., McDermid, S., Pastel, M., Steinbrecht, W., Swart, D. P. J., Walker, K. A., and Bernath, P. F.: Drift-corrected trends and periodic variations in MIPAS IMK/IAA ozone measurements, Atmos. Chem. Phys., 14, 2571-2589, doi:10.5194/acp-14-2571-2014, 2014.

Kellmann, S., von Clarmann, T., Stiller, G. P., Eckert, E., Glatthor, N., Höpfner, M., Kiefer, M., Orphal, J., Funke, B., Grabowski, U., Linden, A., Dutton, G. S., and Elkins, J. W.: Global CFC-11 (CCl_3F) and CFC-12 (CCl_2F_2) measurements with the Michelson Interferometer for Passive Atmospheric Sounding (MIPAS): retrieval, climatologies and trends, Atmos. Chem. Phys., 12, 11857-11875, doi:10.5194/acp-12-11857-2012, 2012.

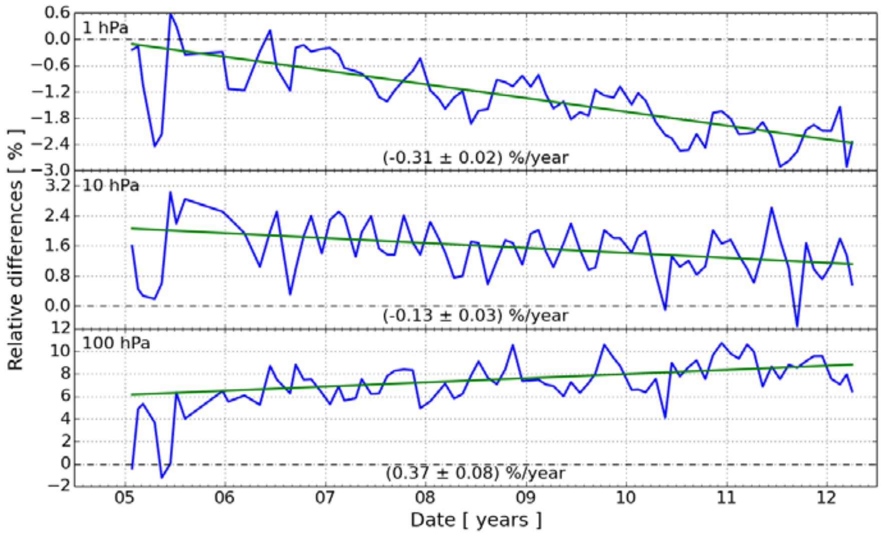
Raspollini, P., Carli, B., Carlotti, M., Ceccherini, S., Dehn, A., Dinelli, B. M., Dudhia, A., Flaud, J.-M., López-Puertas, M., Niro, F., Remedios, J. J., Ridolfi, M., Sembhi, H., Sgheri, L., and von Clarmann, T.: Ten years of MIPAS measurements with ESA Level 2 processor V6 – Part 1: Retrieval algorithm and diagnostics of the products, Atmos. Meas. Tech., 6, 2419-2439, doi:10.5194/amt-6-2419-2013, 2013.

Improvements in V7 L1 processor: correction of time dependent calibration error

The analysis of the differences between V7 and V6 profiles provides an indication of the error in V6 products due to unaccounted non-linearities. This error varies for the different species retrieval and for different altitudes.



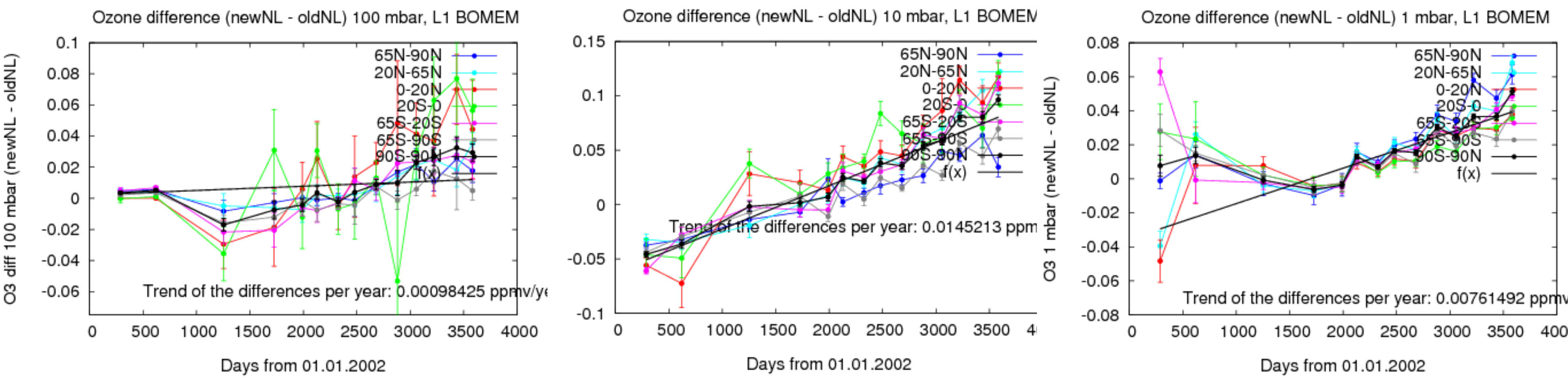
Temporal variation of V7 - V6 differences of **temperature** at different pressures.



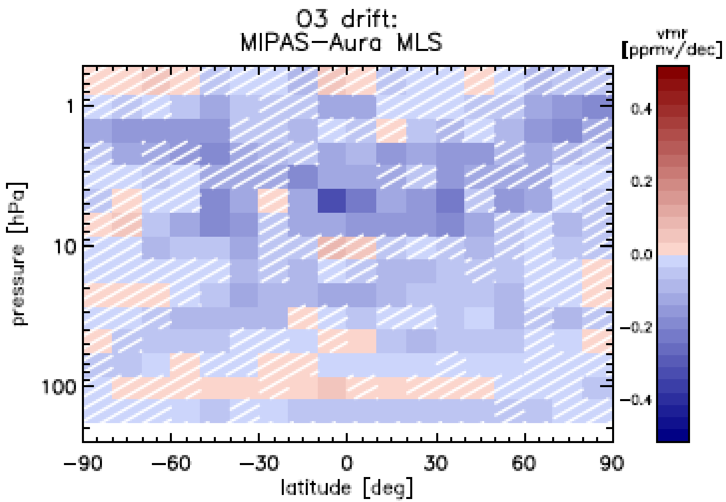
Temporal variation of V7 - V6 differences of **water vapor** at different pressures. Non-linearity correction impacts the species retrievals in two ways: a direct effect, due to changes in the radiance and an indirect effect, due to changes in temperature.

Improvements in V7 L1 processor: correction of time dependent calibration error

Temporal variation of V7 - V6 differences of **ozone**.



Comparison of altitude dependent V7 – V6 correction in O3 profiles wrt MIPAS IMK (with old version of L1) drift compared to AURA MLS



Maximum drift at 10 mbar, about 1.5 ppmv/decade

Eckert et al., 2014

Improvements in V7 L2 processor

New continuum retrieval approach

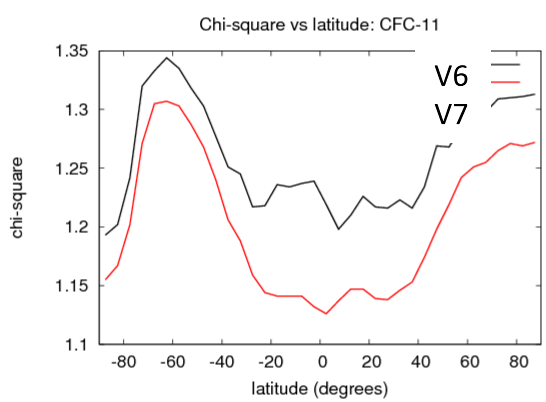
MW-dependent continuum profiles (including all the emission sources that are frequency independent within a microwindow) are fitted together with the unknown profile.

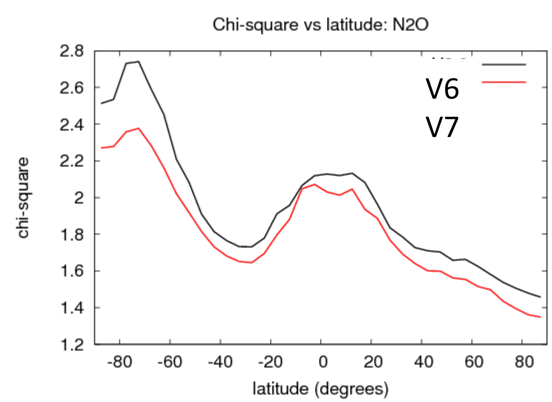
While in V6, for each layer i^{th}, the continuum cross-section k_i was retrieved, in V7 the transmission

$\xi i=exp(-k_i C)$ due to the continuum is retrieved. The sensitivity of the forward model to k_i vanishes for large enough values of k_i because of the exponential dependence, the new variables ξ_i are polynomially connected with the optical transparency of the layer due to the continuum, thus they are tightly linked to the measured spectra. The main effect of this improvement is that a better convergence towards the minimum of the χ^2 is reached .

Main effects of the new continuum approach

The new approach generally leads to a significant reduction of the conditioning number of the matrix to be inverted. This, together with the reduced non-linearity of the forward model with respect to the new continuum variables, allows to decrease by a factor of 10 the initial value of the Levenberg-Marquardt parameter for the new retrieval variables. Results are that the final χ^2 is reduced by about 3%, the number of iterations by about 15% and the number of degrees of freedom increased by 5% with respect to the previous approach.

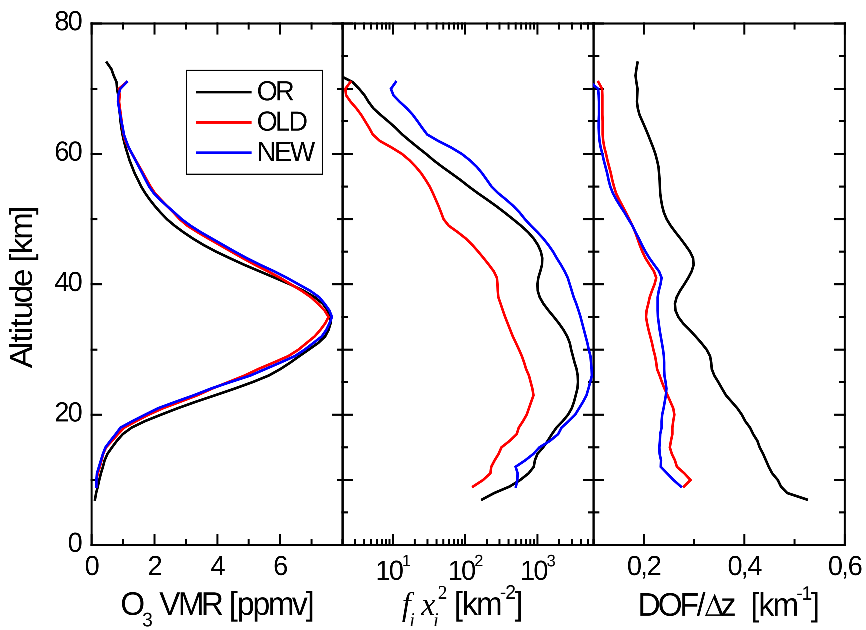


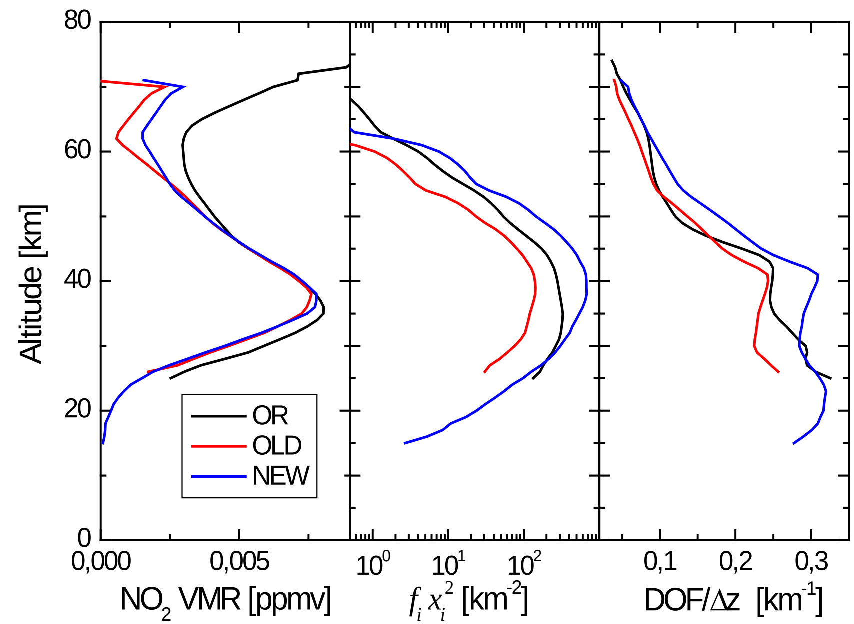


Improvements in V7 L2 processor

Improved microwindows for the first phase of the mission (2002-2004)

Upgraded microwindows for the analysis of the Full Resolution measurements are now used. The spectral intervals used by ML2PP V6 for the analysis of the Full Resolution measurements were selected with strong constraints for the computing time. A new selection was performed recently, the new microwindows being characterized by an improved information content.



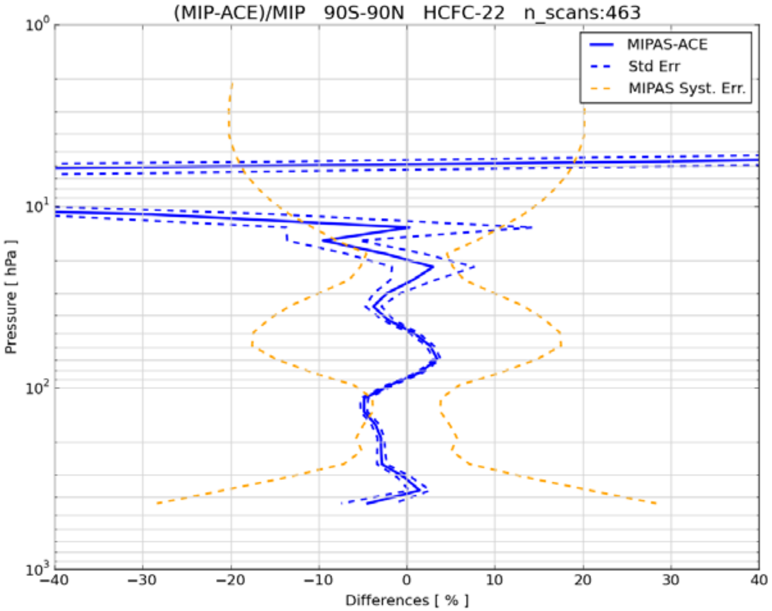


(Ceccherini et al., 2013)

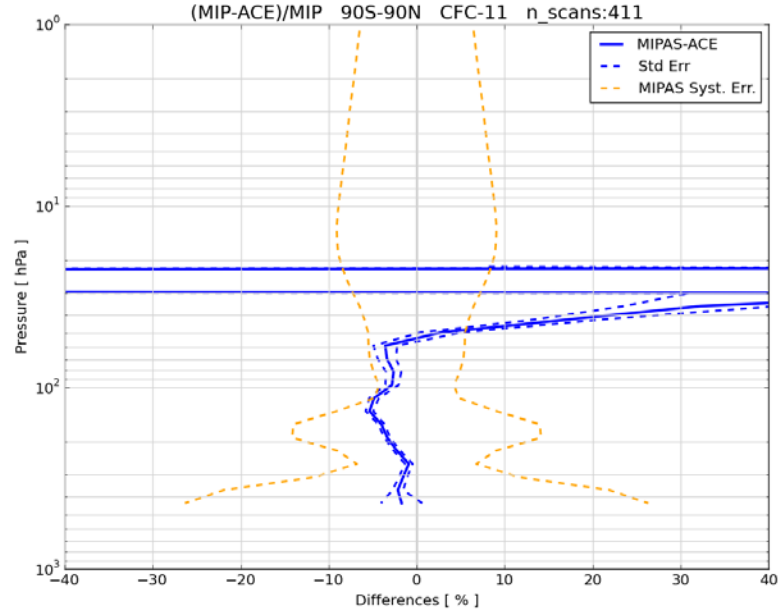
Validation of V7 products

MIPAS vs ACE-FTS

HCFC-22



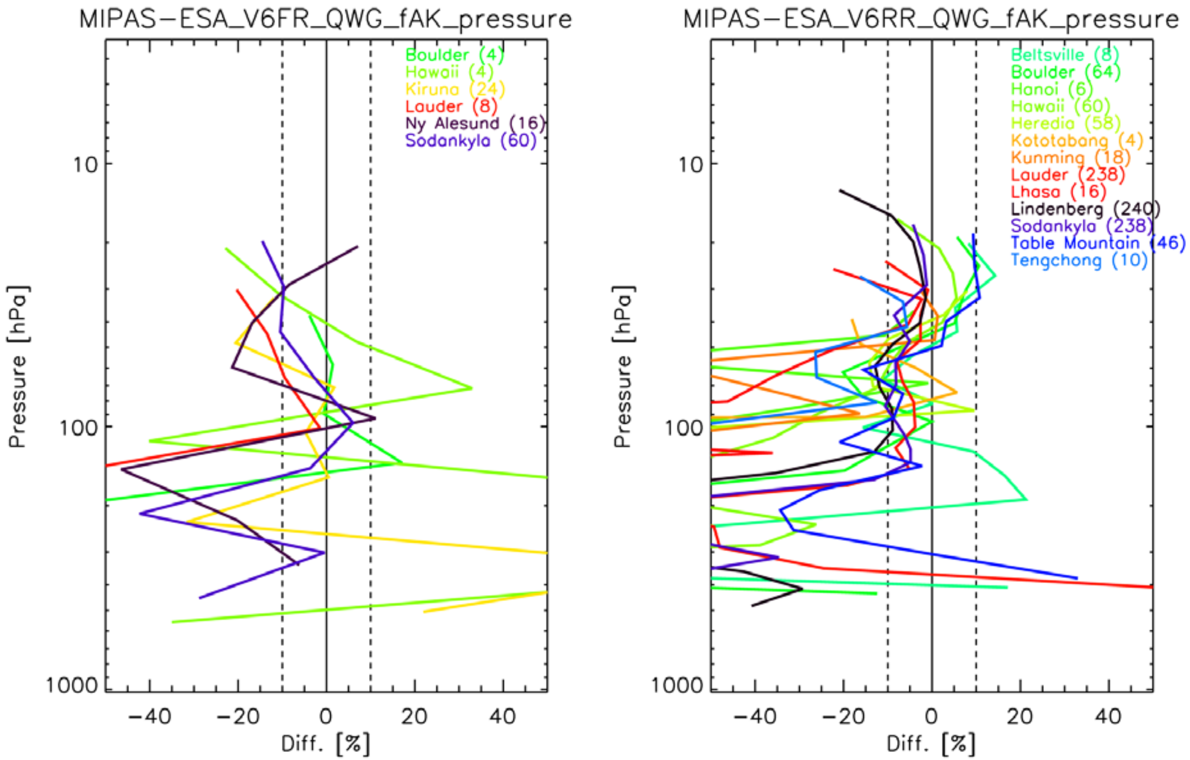
CFC-11



Differences smaller than 5% are obtained for HCFC-22 in the pressure range 400-20 hPa, for CFC-11 the difference is smaller than 5% only in the range 400-50 hPa, where the VMR is significantly different of 0.

Validation of V7 products

MIPAS V7 water vapor vs Frost Point Hygrometers (FPH) at different stations



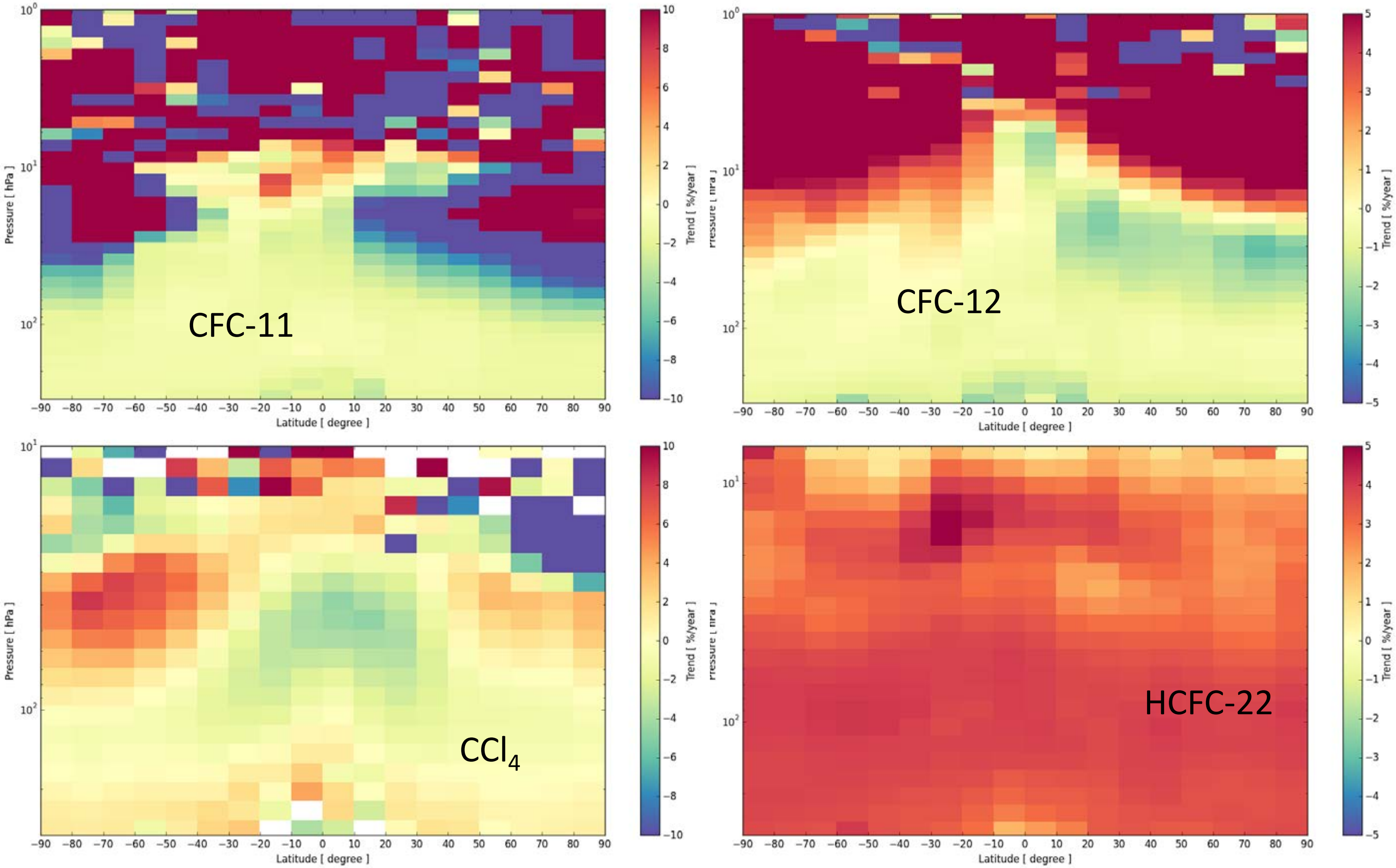
Courtesy of
M. Kiefer - IMK

A comparison between ML2PP V7 and ML2PP V6 H2O data with respect to FPH shows several improvements:

- Differences between FR and OR decreased
- V7 OR data are clearly smoother than V6
- Bias of V7 vs. FPH is reduced compared to V6

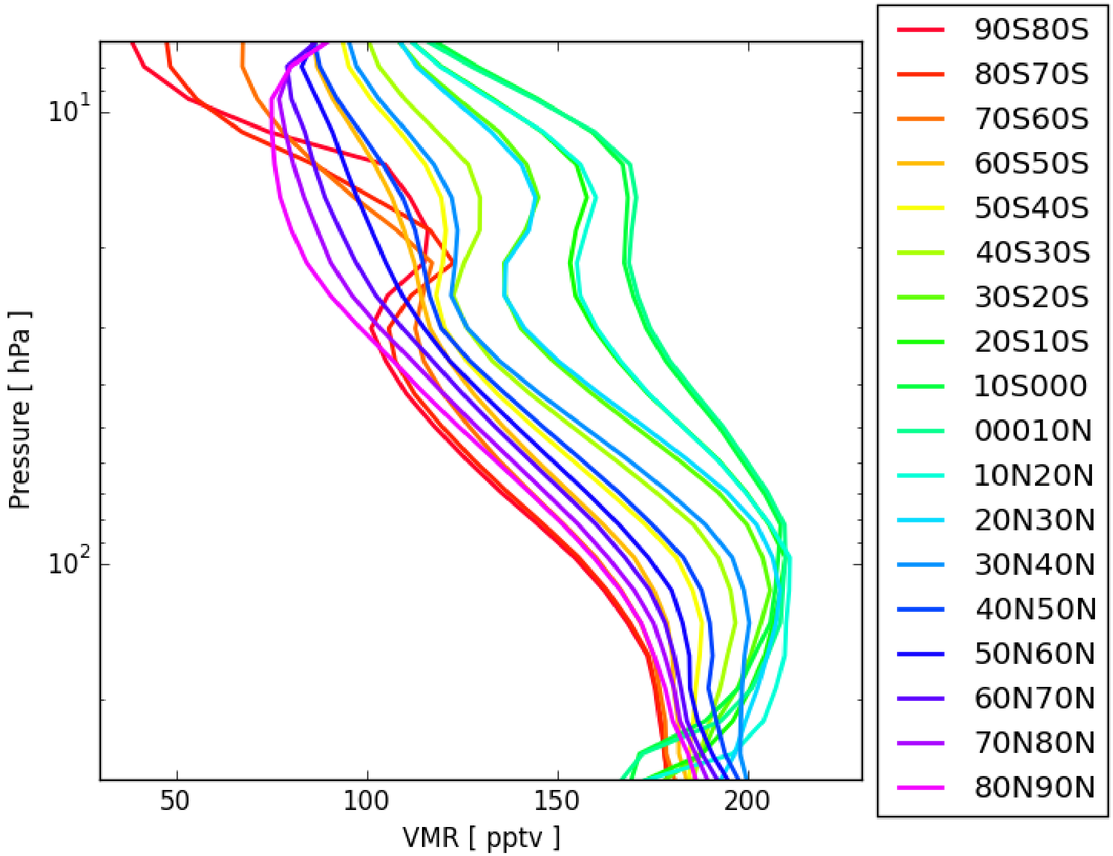
New MIPAS V7 products

Percent annual trends as a function of latitude and altitude

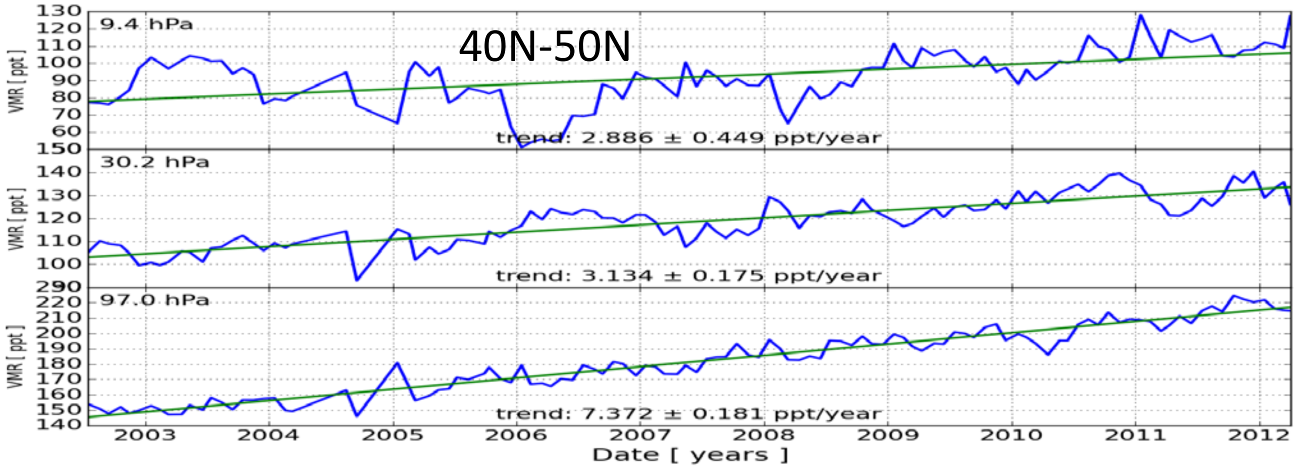


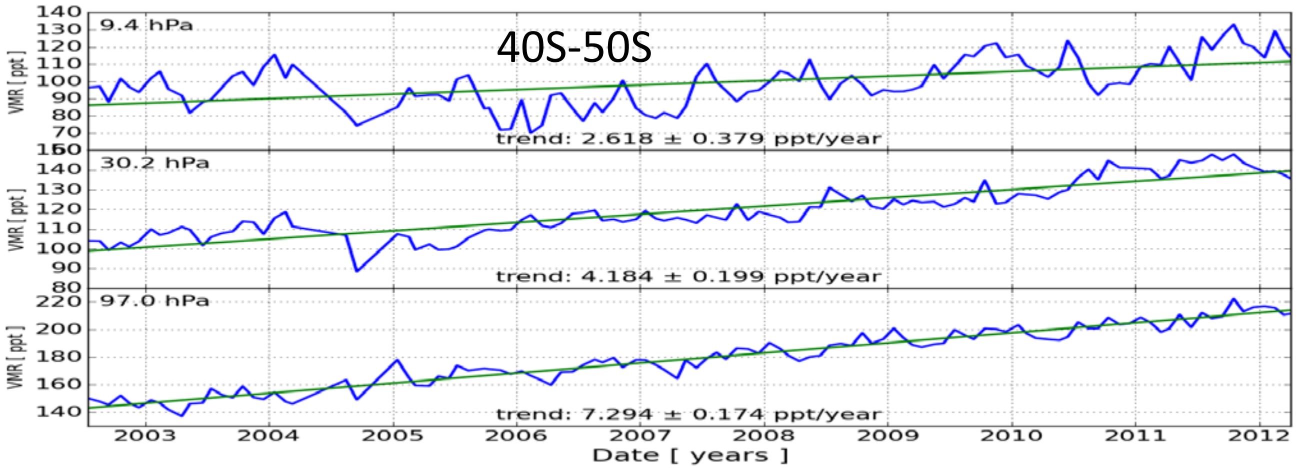
HCFC-22

Zonal means



HCFC-22: trends vs latitude and altitude





HCFC-22: trends vs latitude and altitude

HCFC-22 trend (ppt/year) vs latitude at 3 pressure levels