Atmospheric processes in the UTLS as seen by MIPAS

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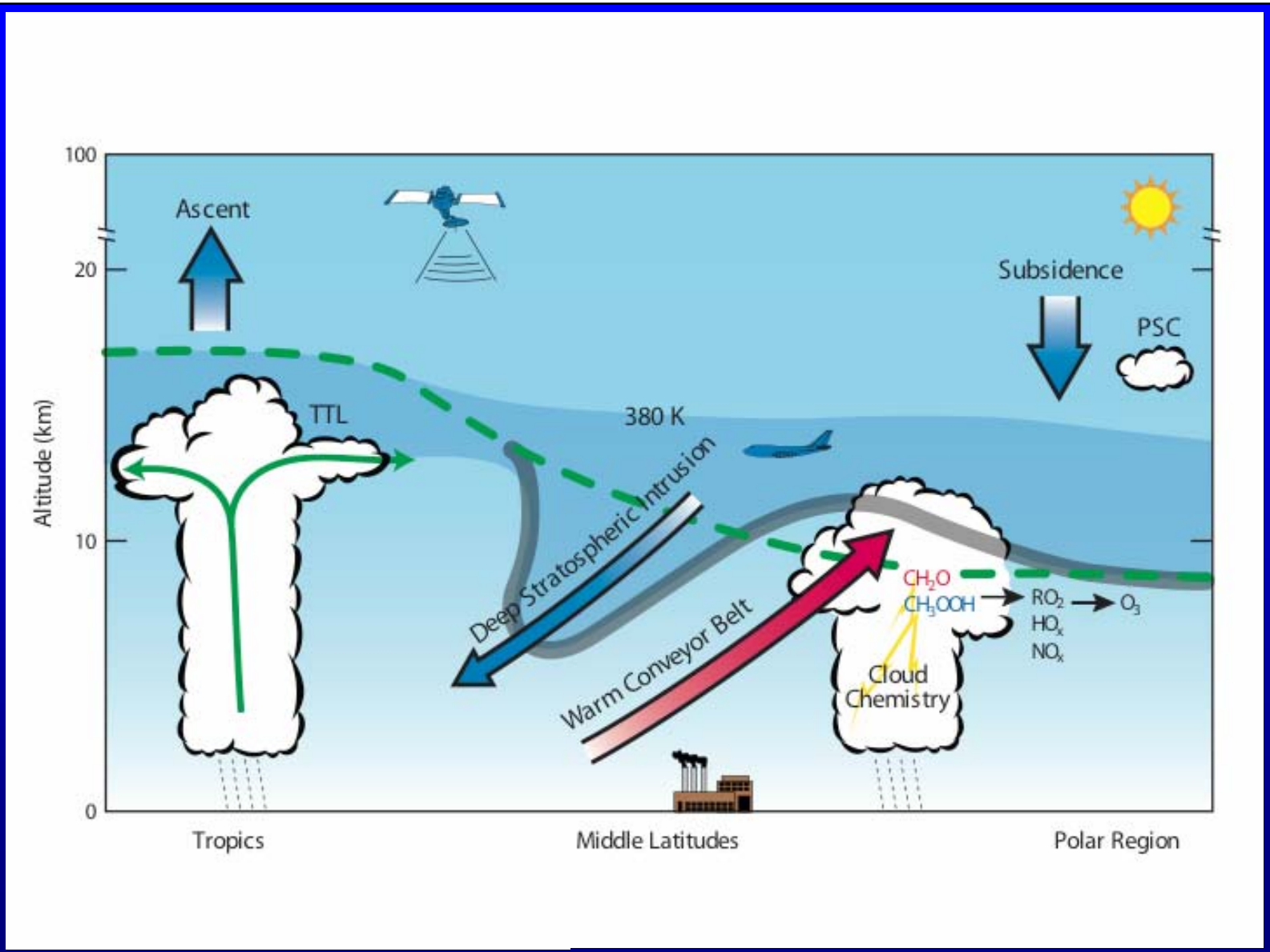
Outline

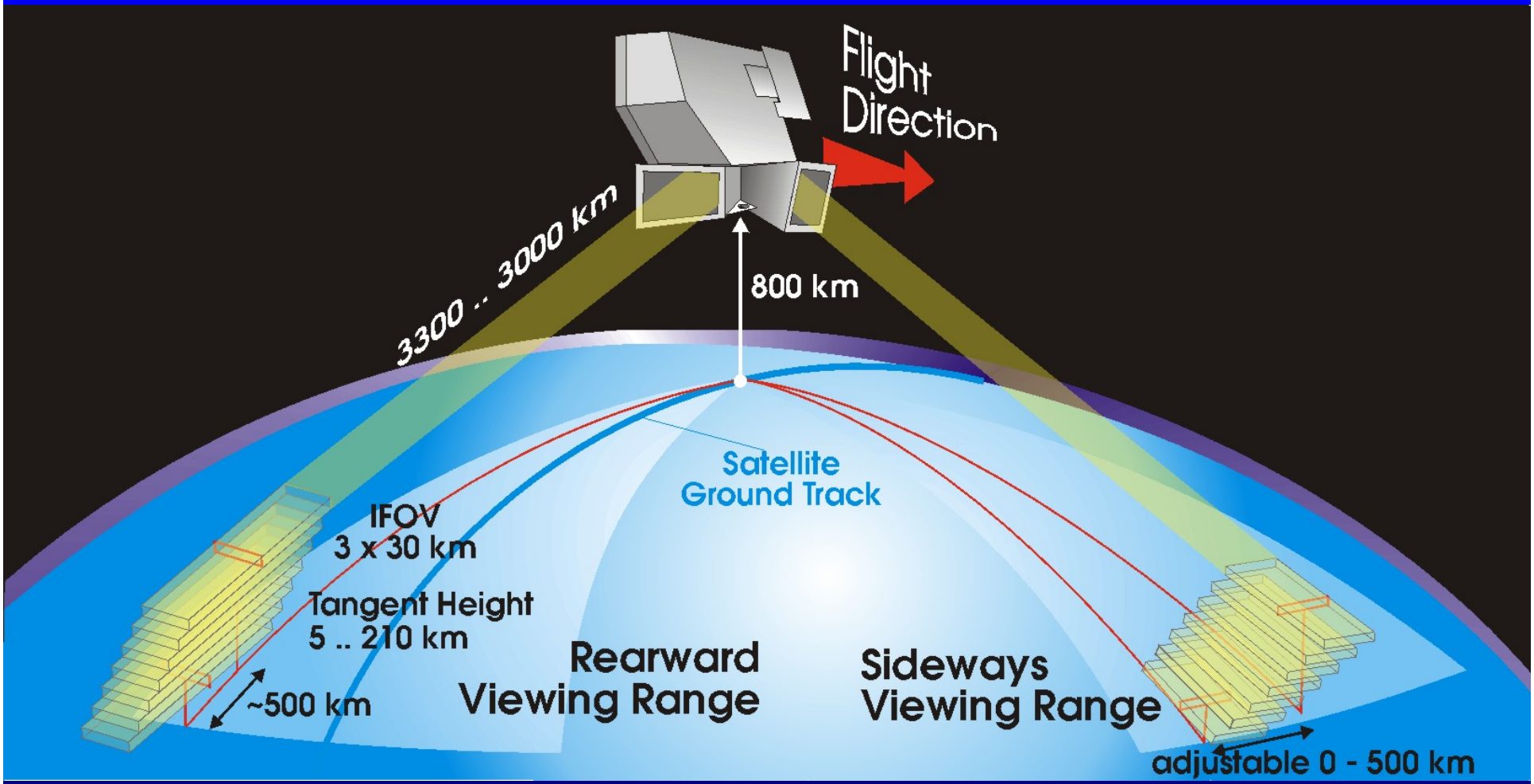
- Scientific questions at UTLS
- MIPAS observations and retrieved species
- Results – coupling between troposphere and stratosphere
  - SF_6 as a tracer for vertical transport
  - Transport of water vapour through the tropical troposphere
  - CO as a tracer for TST
  - Identification of deep intrusion by MIPAS S6 mode
- Results – upper troposphere
  - Biomass burning and industrial pollution
  - GHGs in the troposphere
  - Cirrus clouds

Scientific questions at UTLS



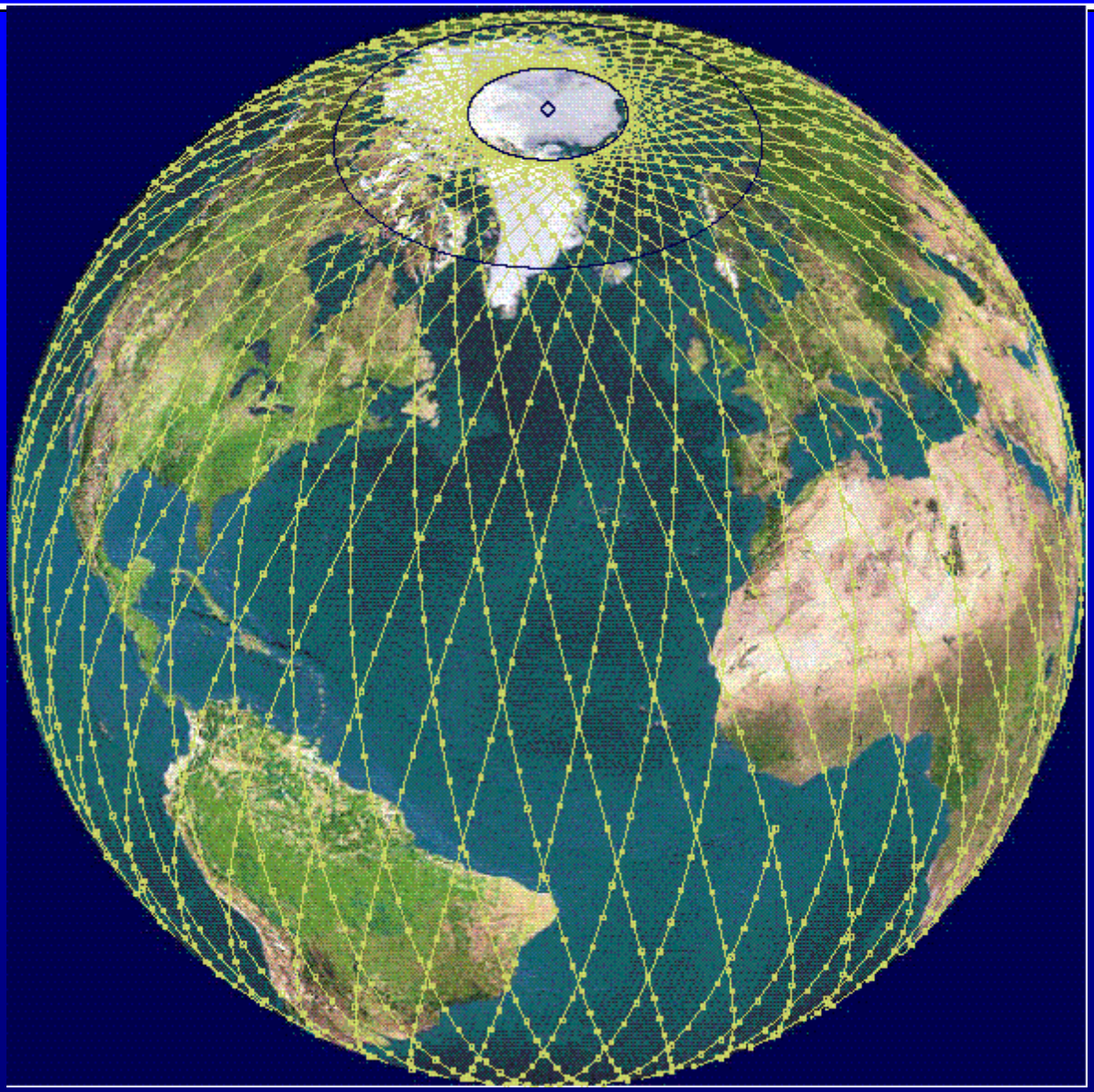
From G. Brasseur, SPARC mtg 2004

MIPAS Observation Geometry

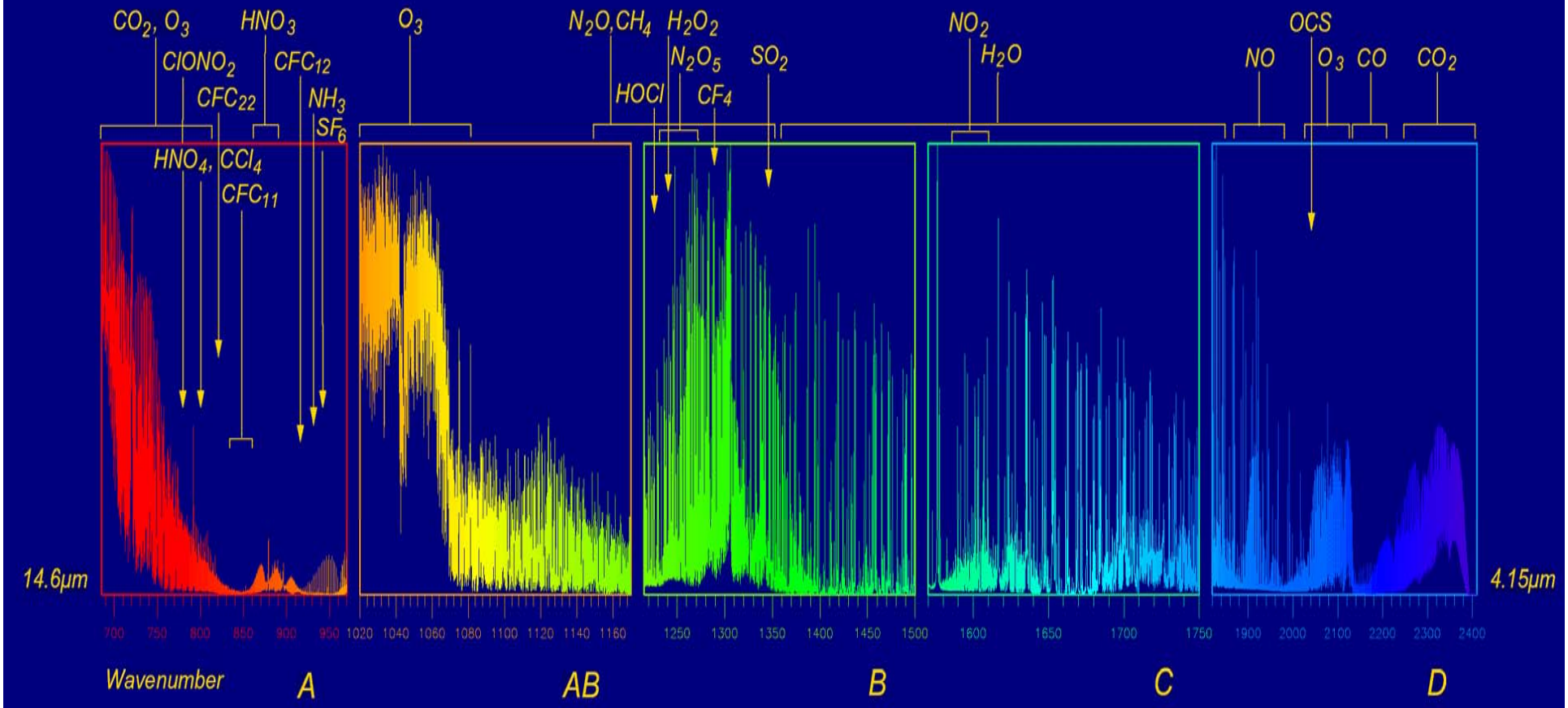


Spectral high resolution mode (Sep2002 – Mar2004) only

MIPAS Global Coverage



MIPAS Spectral Coverage



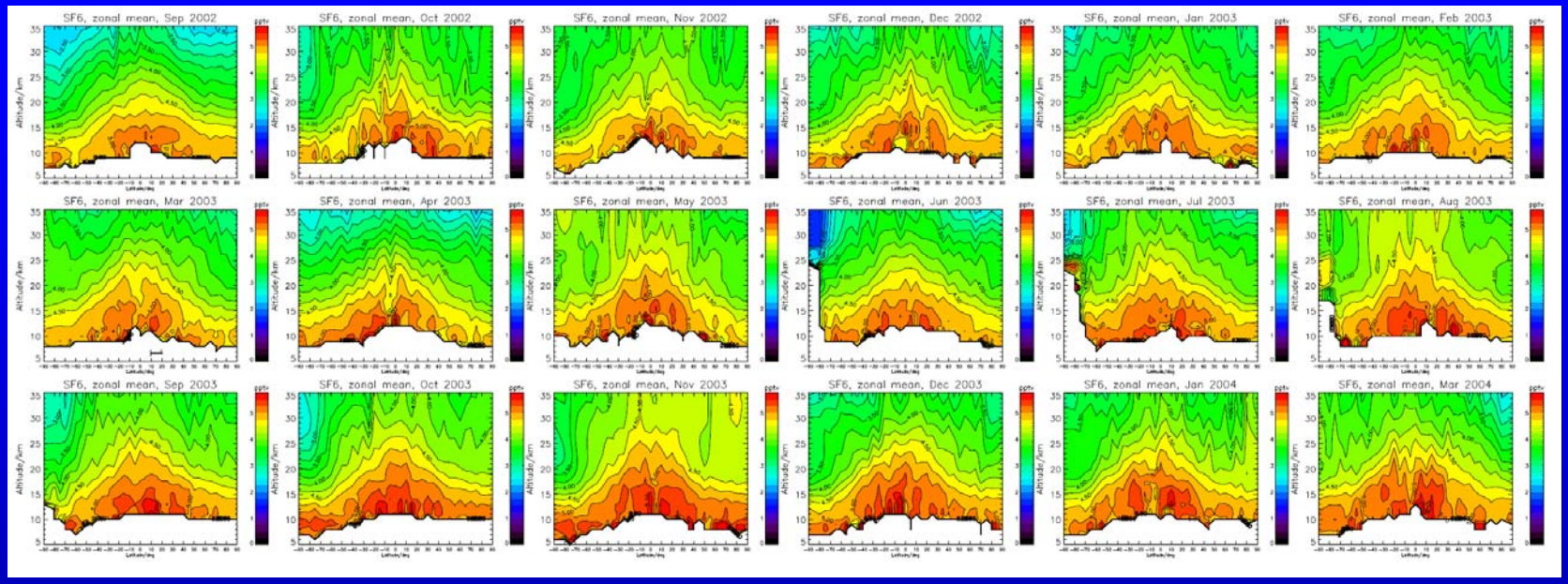
Species retrieved in the UTLS

- ✓ H_2O, HDO, $H_2{}^{18}O$
- ✓ CFC-11, CFC-12, HCFC-22
- ✓ CH_4, N_2O
- ✓ CO
- ✓ SF_6
- ✓ C_2H_6, C_2H_2
- ✓ O_3
- ✓ HNO_3
- ✓ HO_2NO_2
- ✓ PAN
- ✓ Cirrus clouds

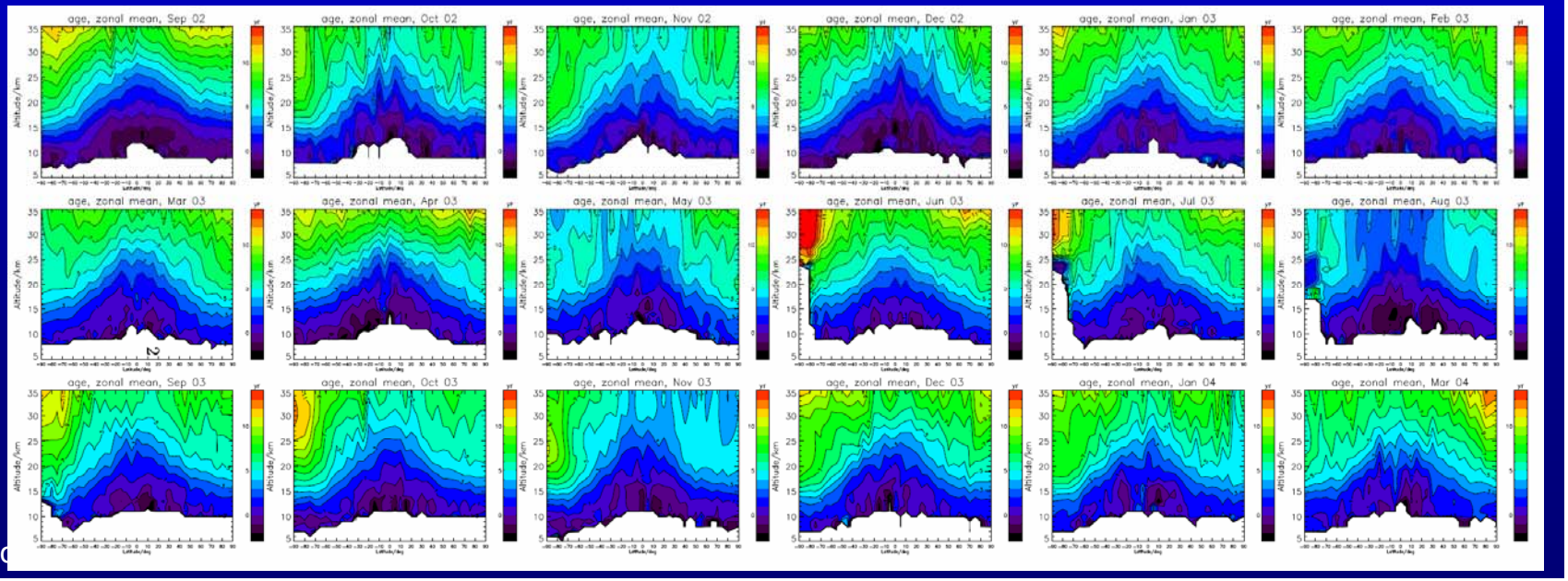
⇨ All data shown in this talk from scientific L-2 processing at IMK Karlsruhe / IAA Granada

SF_6 as a tracer for vertical transport

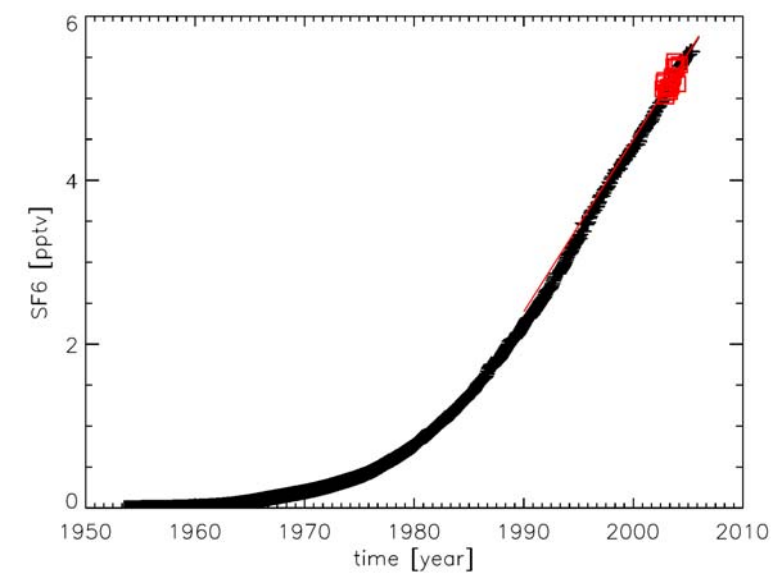
SF_6 monthly zonal means

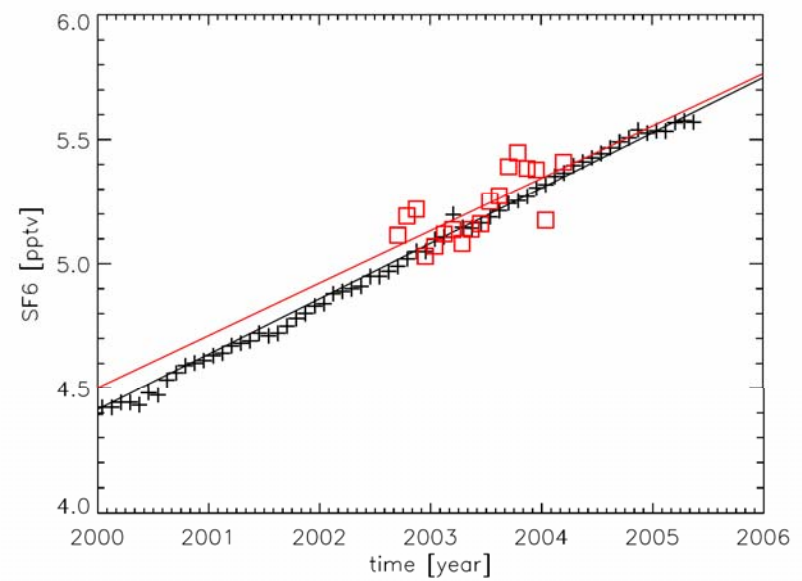


Mean age of strato-spheric air



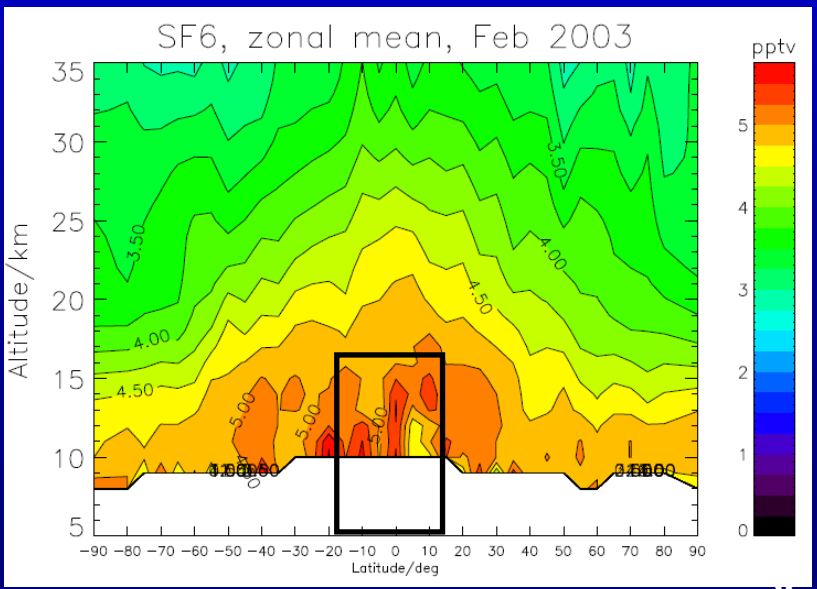
SF_6 as tracer for vertical transport





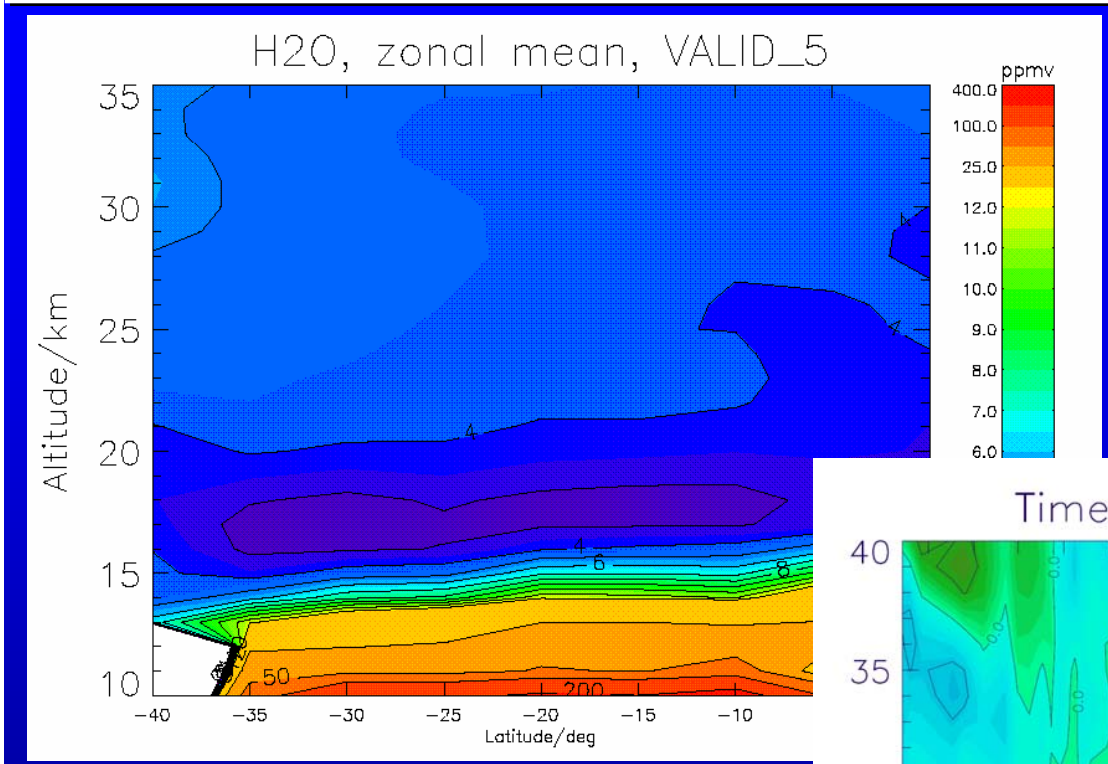
Regression line through Engel&Bönisch data set since 1990:
SF_6 [pptv] = 0.222 pptv/yr (t - 1990) + 2.190 pptv

Trend MIPAS: 0.211 pptv/yr
Mean value 1Jul 2003 MIPAS: 5.24 pptv
Mean value 1Jul 2003 E&B: 5.19 pptv

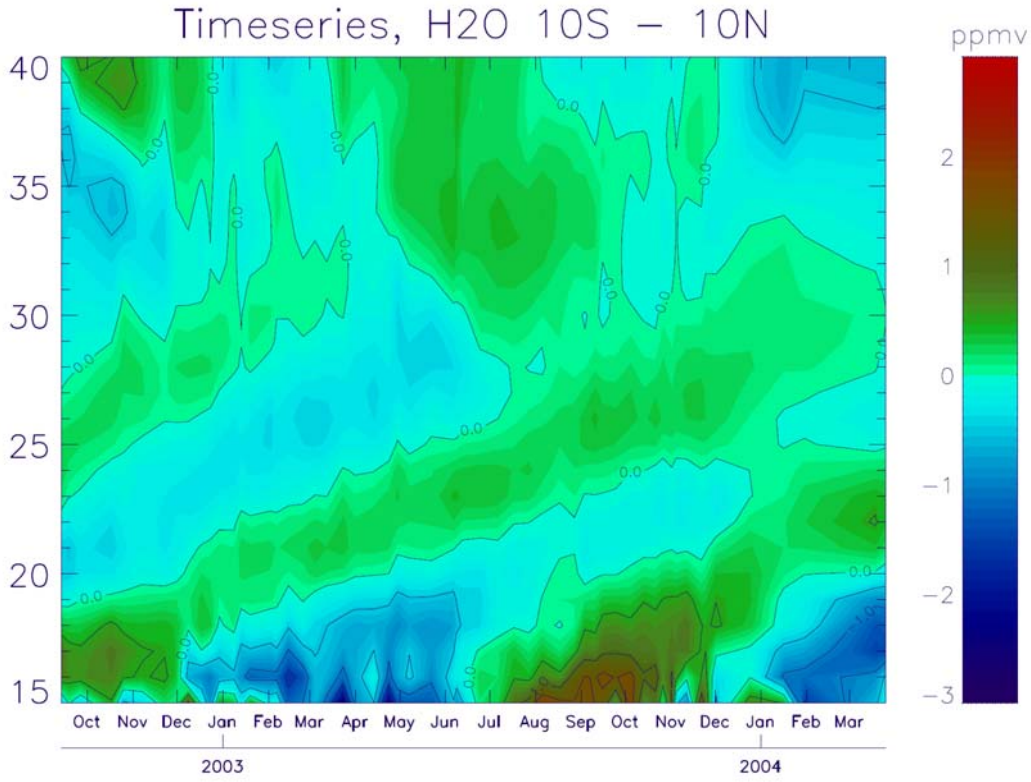


See also Poster by G. Stiller et al.

Transport of water vapour through the tropical troposphere



Zonal mean distribution of water vapour during Feb/Mar 2004 over S-America (TROCCINOX 2004)



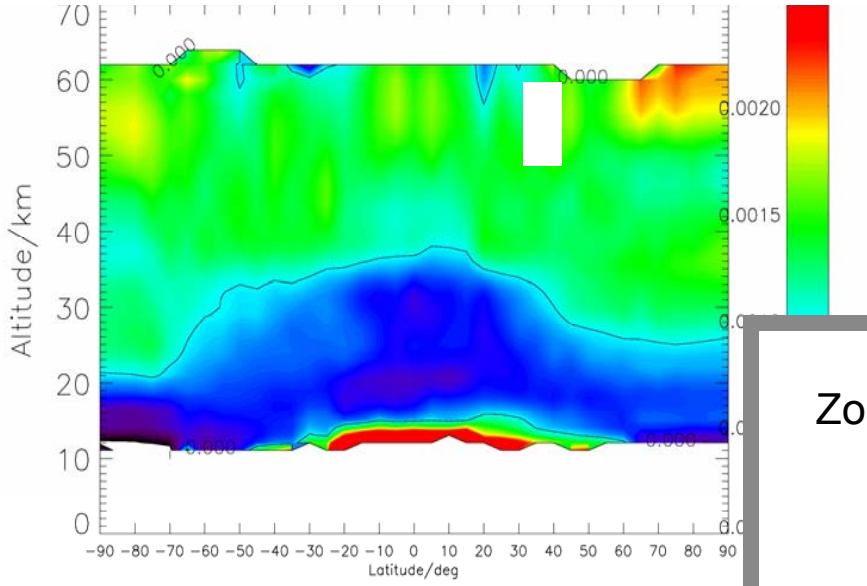
"Tape recorder":

- Imprint of tropopause temperatures
- Inter-annual variability

More details: contact Mathias Milz

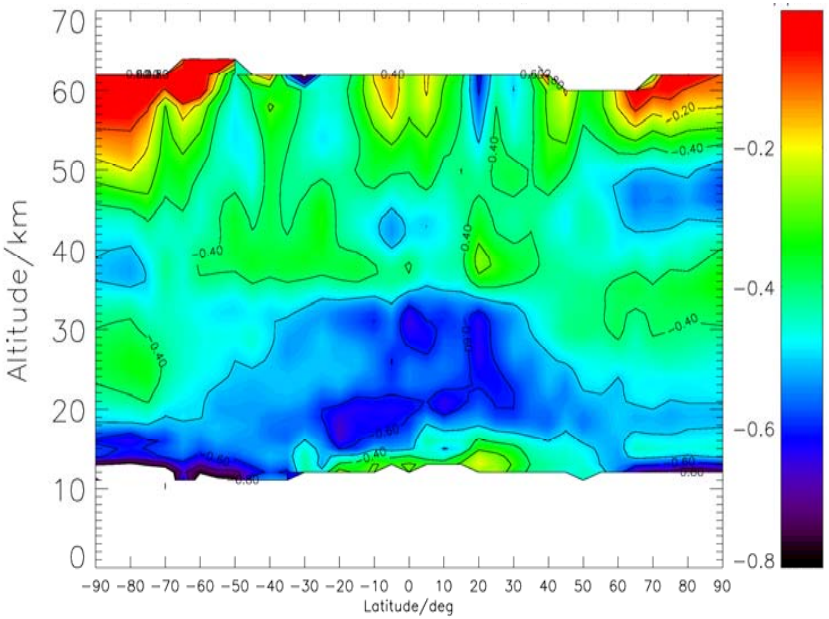
HDO retrievals

Zonal Mean HDO, 18 Sep 2002, 14 orbits ppmv



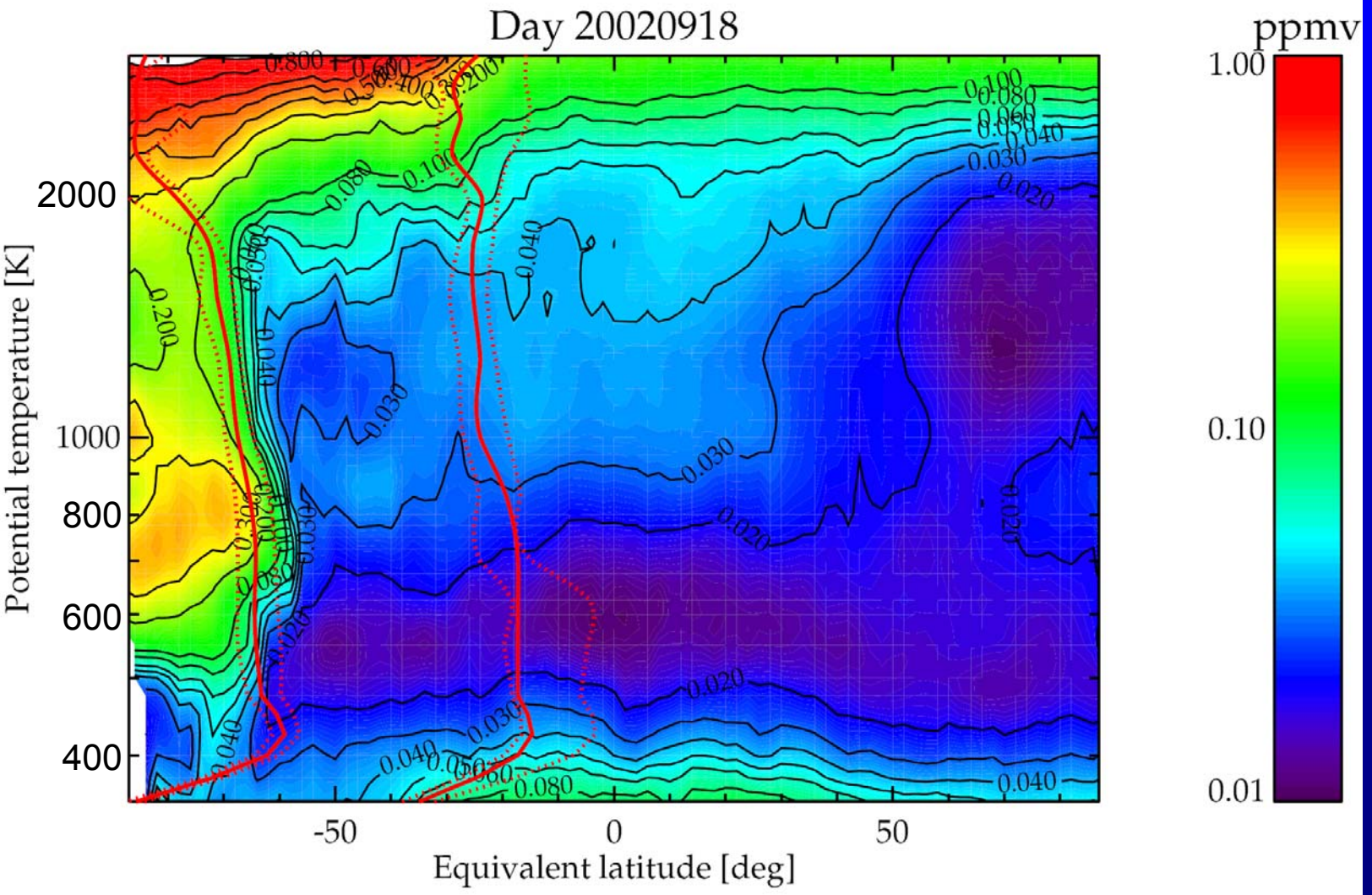
HDO/H2O ratio (expressed as δD = permil depletion relative to standard conditions)is sensitive phase change processes

Zonal Mean δD, Sep 18th 2002, 14 orbits



δD is used to study the processes relevant to dehydration (condensation, convective overshooting …) when water passes the tropical tropopause

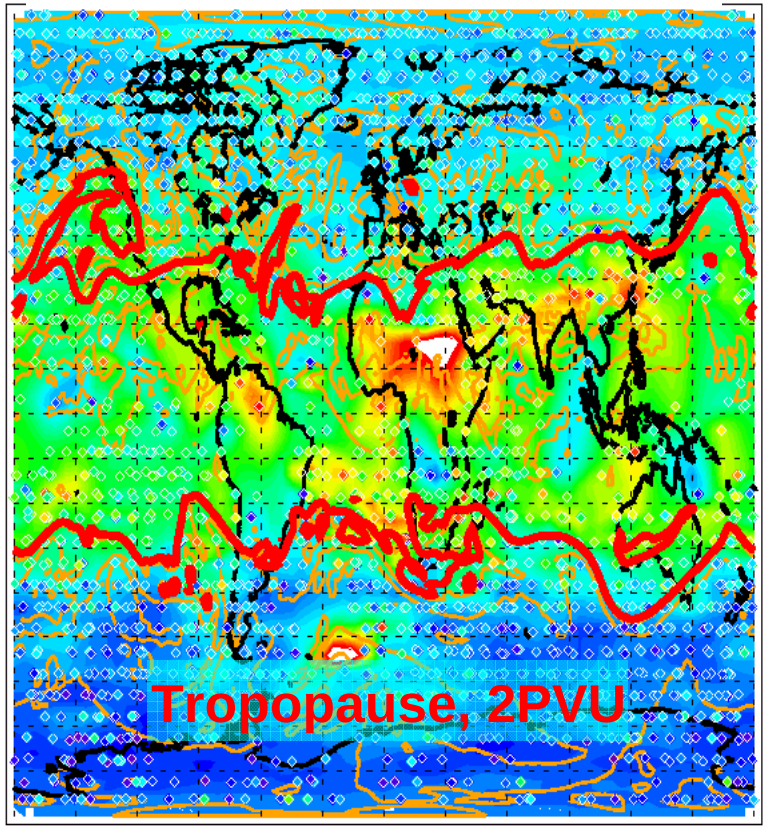
CO as a tracer for troposphere to stratosphere transport



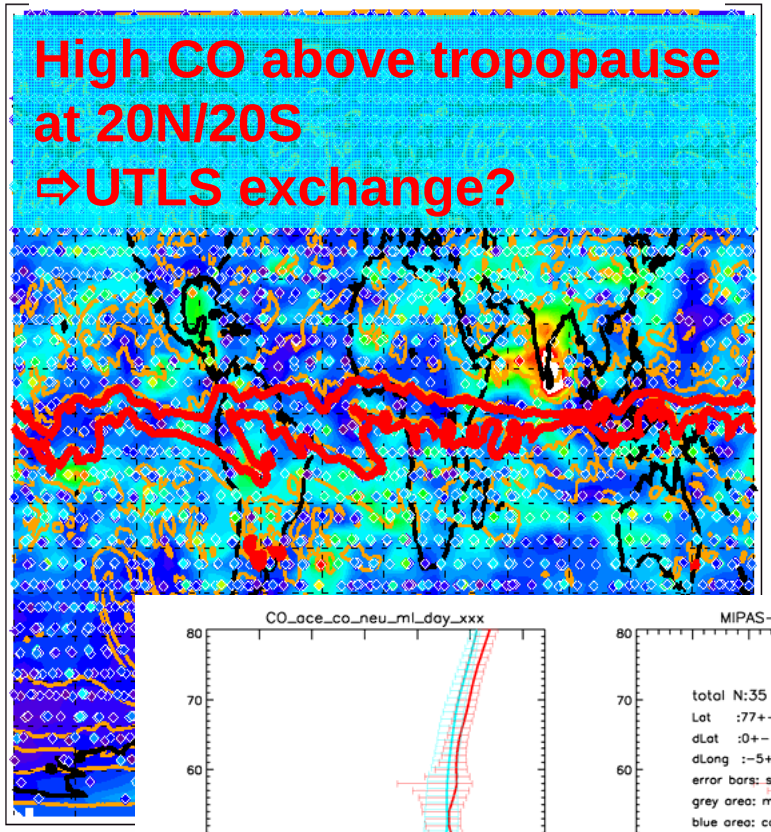
For more details on CO, see poster by B. Funke et al.

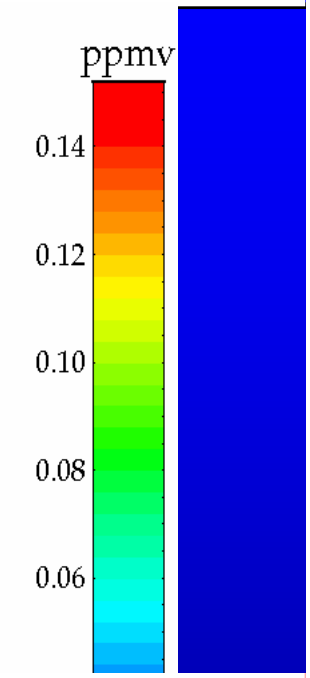
CO as a tracer for troposphere to stratosphere transport

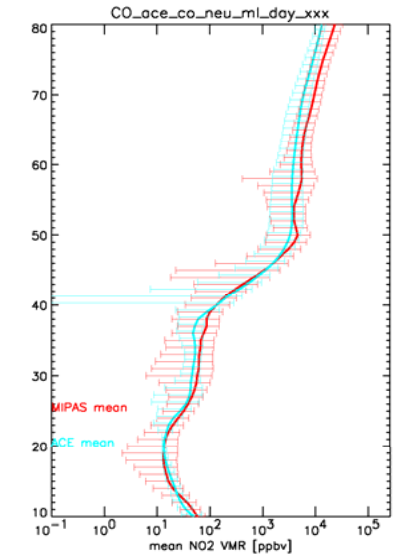
350 K; 10-14 km

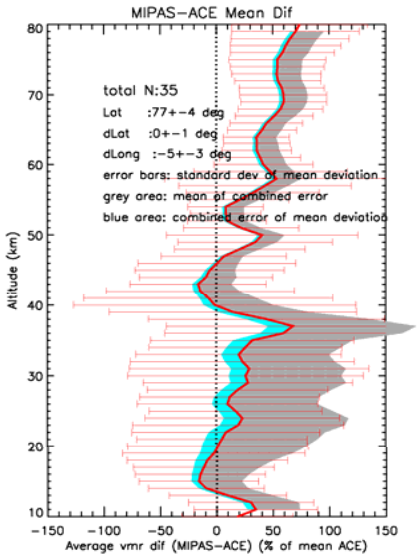


400 K; 13-18 km









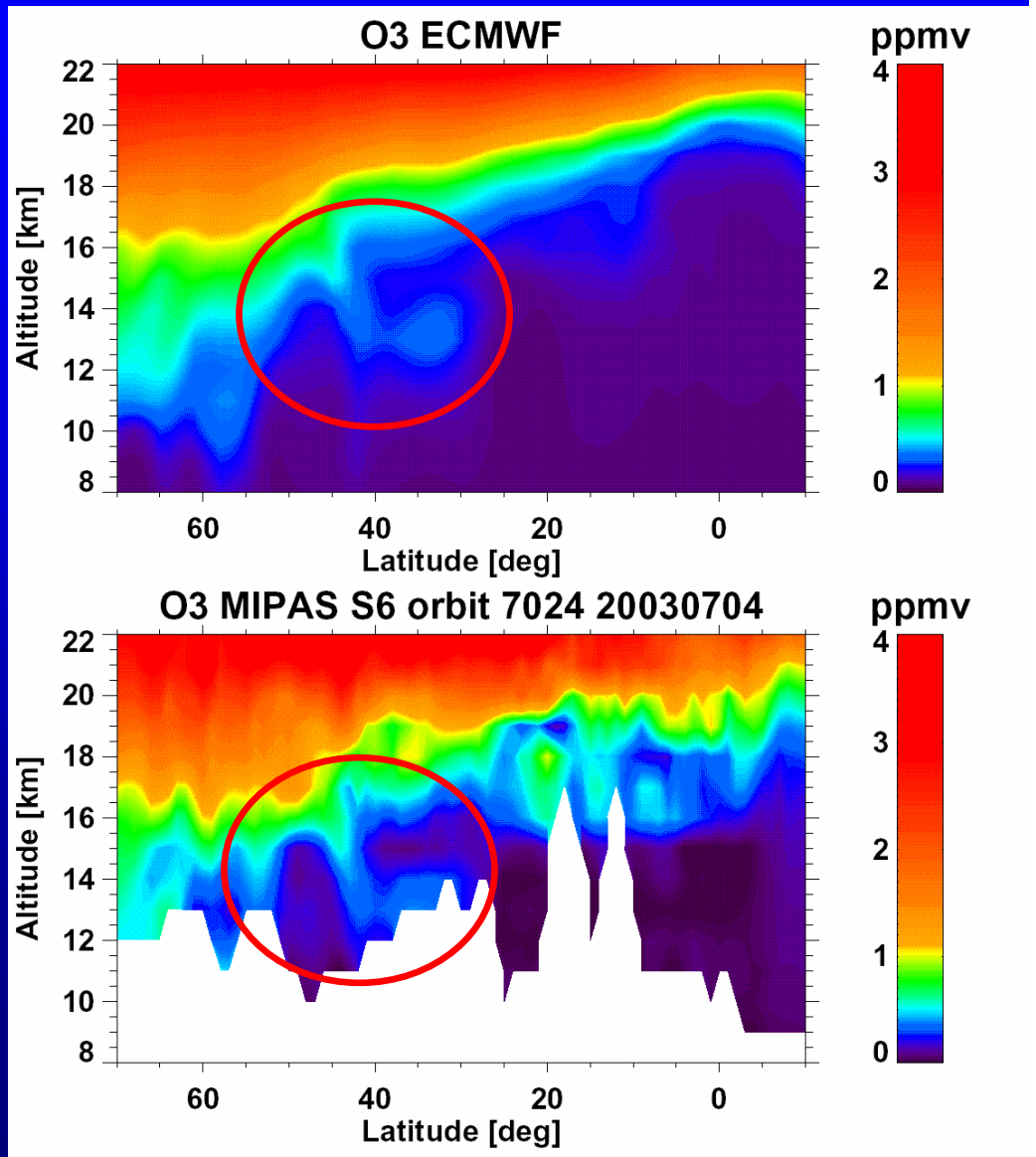
Comparison to ACE-FTS
Mean differences Feb/Mar 2004

Deep intrusion obs. by MIPAS S6 mode

S6 Mode:
Spectral resolution: 0.1 cm^{-1}
Horizontal distance between two scans : ca. 150 km
Vertical sampling (lat. dep.): 2(6) to 20 (24) km every 2 km, 24 (28) km, 31 (35) km
Attainable vertical resolution: 2 - 3 km
Attainable horizontal resolution: 110 - 140 km

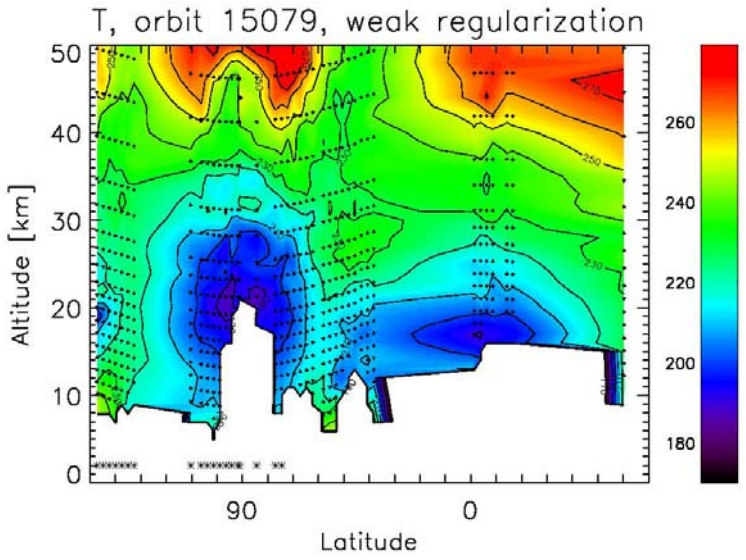
2D tomographic retrieval approach, sequential estimation (Steck et al., 2005)

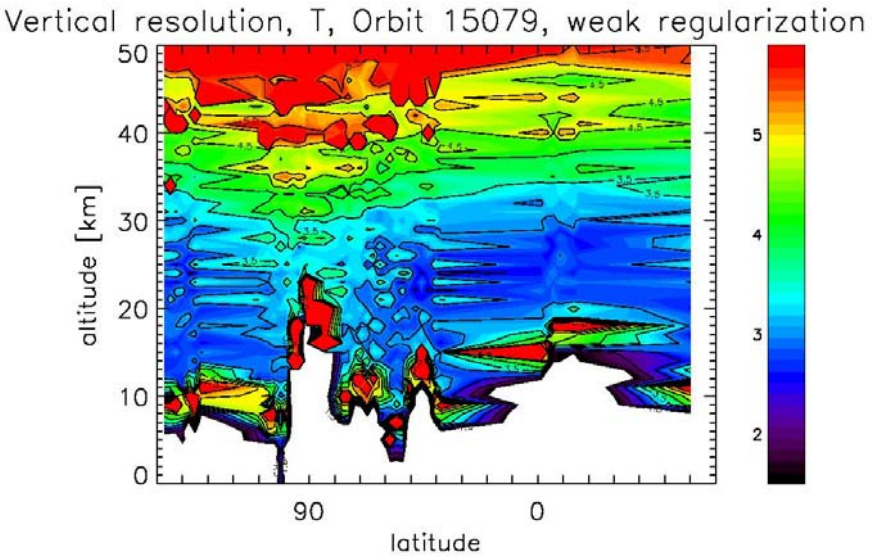
See also Poster 33 by T.Steck et al.



Retrievals from red. resolution mode UTLS1/2

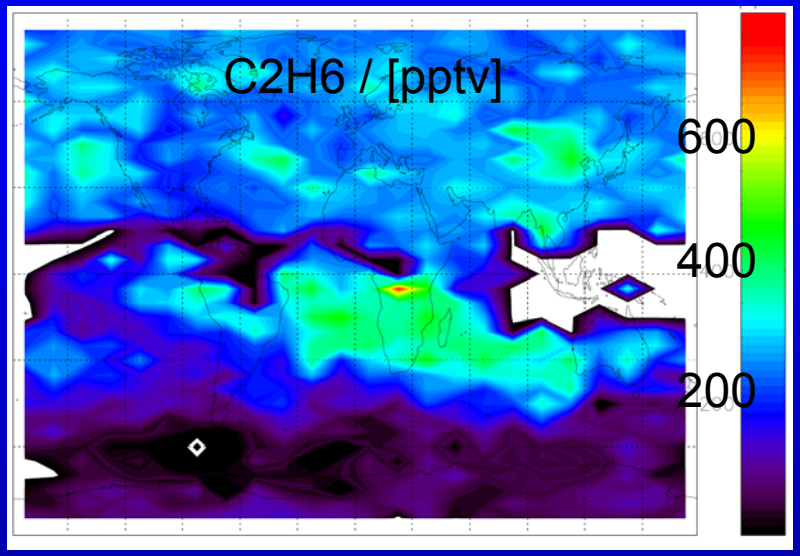
Tangent altitude spacing:
- Lowest 10 tangent altitudes: approx. 1.5 km
- Tangent altitudes 11 to 13: approx. 2 km
- Lowest tangent altitude: floating
- Measurements every 42 s
- (approx. 280 km between measurements)
- Improved vertical resolution: ~ 2.5 to 3 km for T

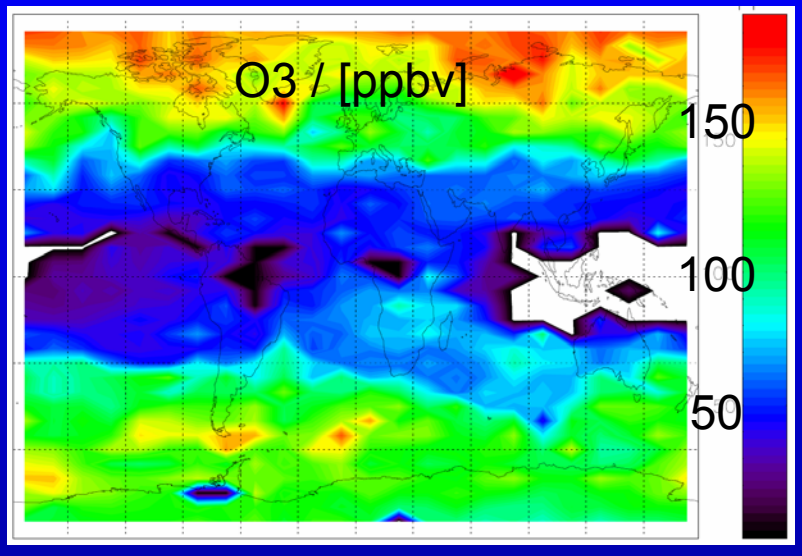


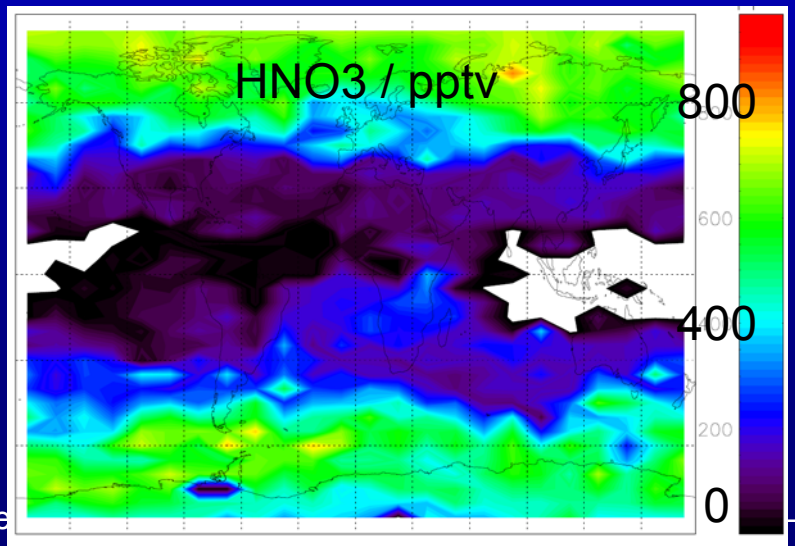


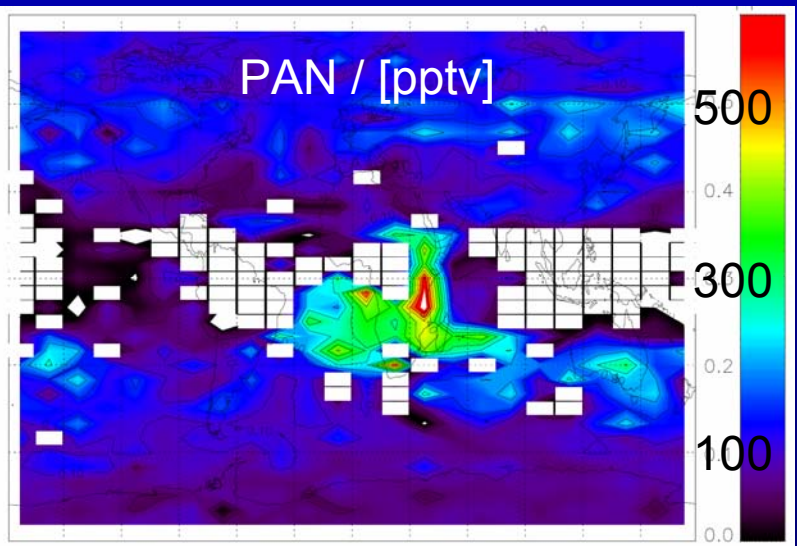
Biomass burning observed by MIPAS

MIPAS observations of C_2H_6, O_3, HNO_3, and PAN at 275 hPa, 21 Oct – 14 Nov 2003

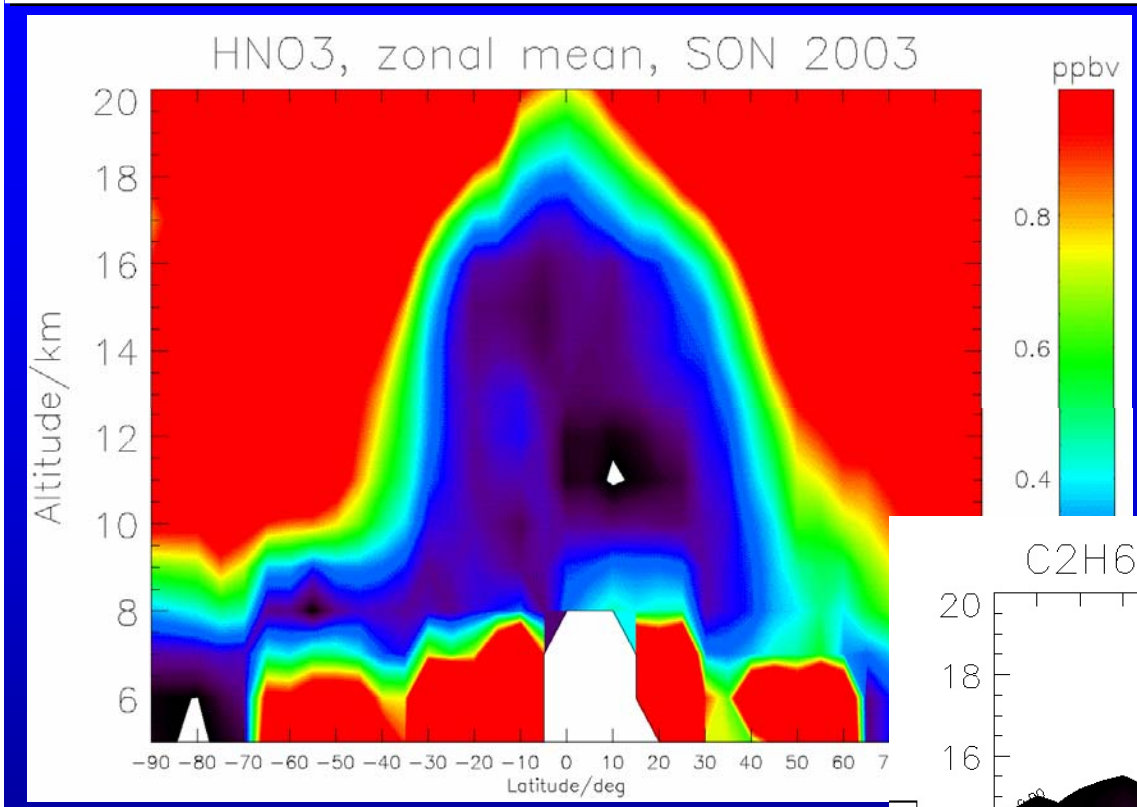




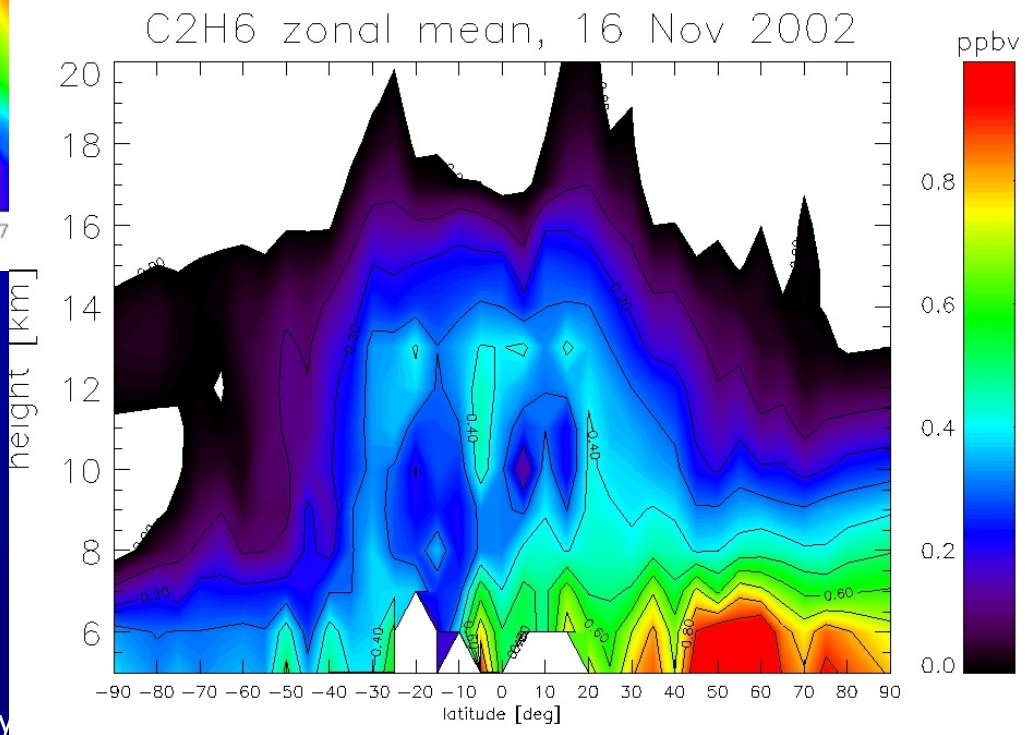




Biomass burning observed by MIPAS

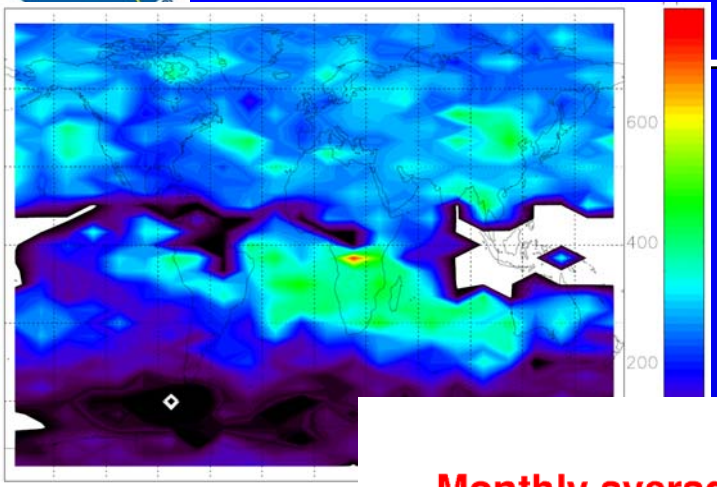


Zonal mean distribution HNO_3, Sep/Oct/Nov 2003

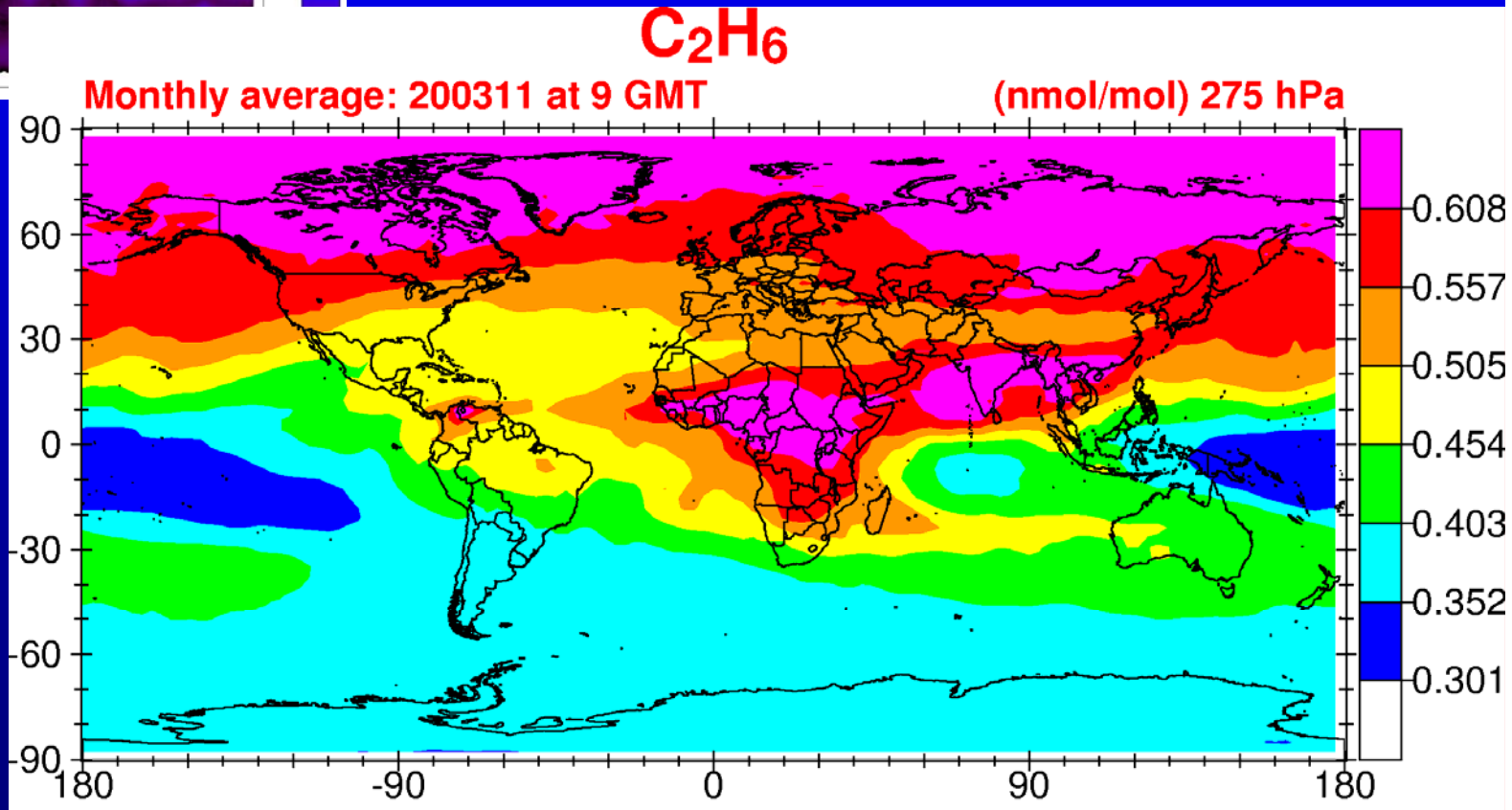


Zonal mean distribution C_2H_6, 16 Nov 2003

Biomass burning observed by MIPAS



MATCH-MPIC model run, M. Lawrence et al., 2005

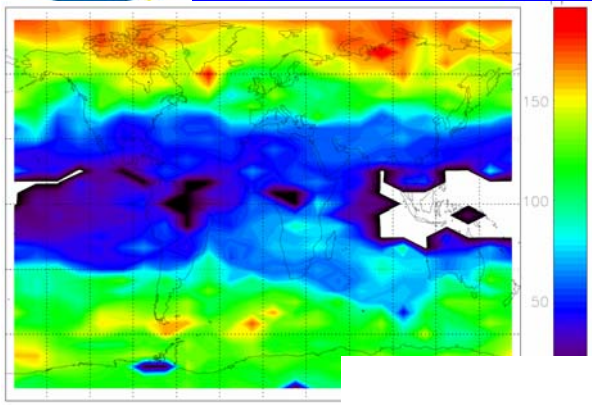


Based on Output from the MATCH-MPIC Chemical Weather Forecast and Analysis Run

Contact: Mark Lawrence, Max Planck Institute for Chemistry, Mainz, Germany

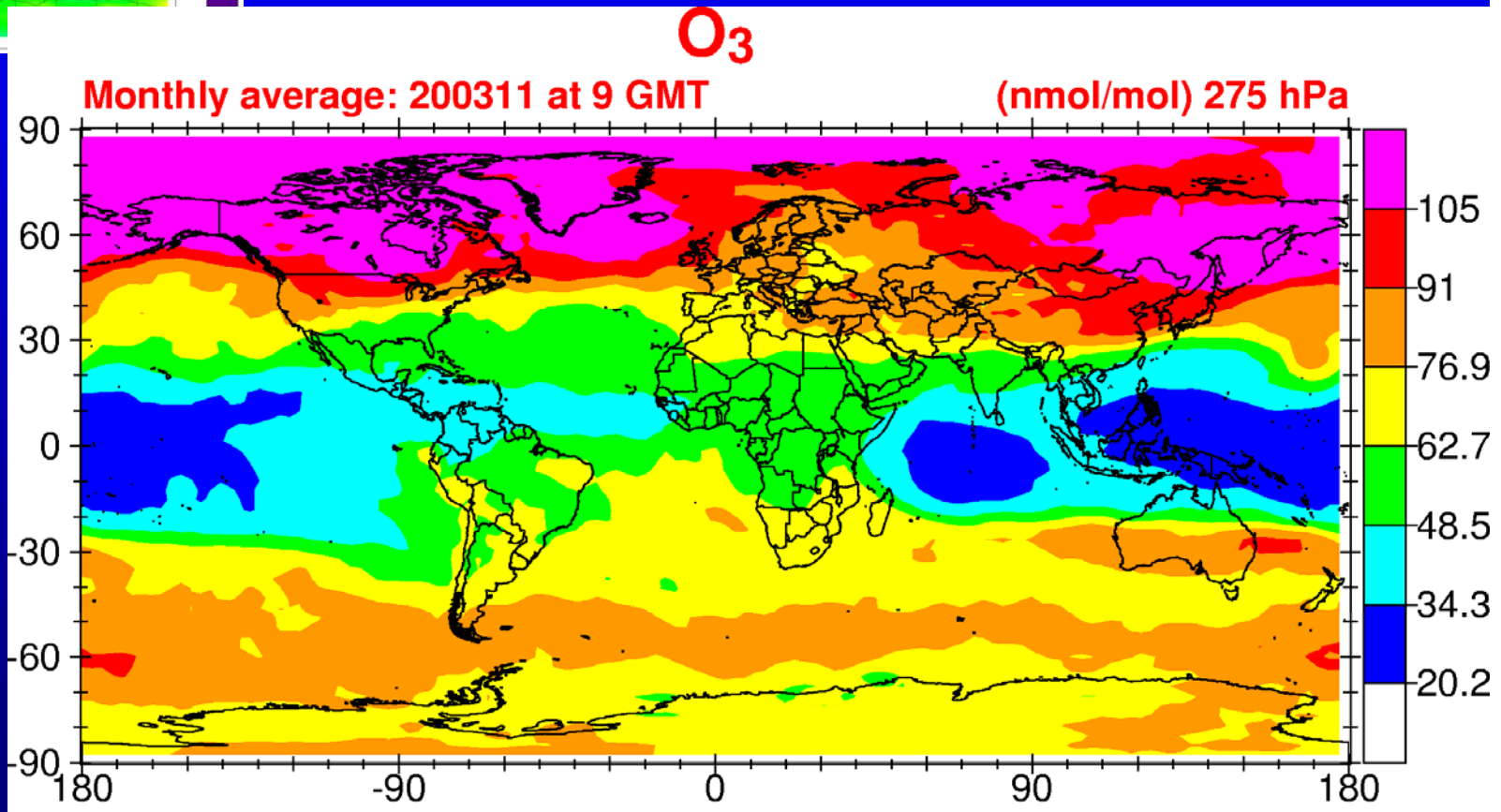
Atmospheric Science Co

Biomass burning observed by MIPAS



MIPAS O_3, 275 hPa

MATCH-MPIC O3, M. Lawrence et al., 2005



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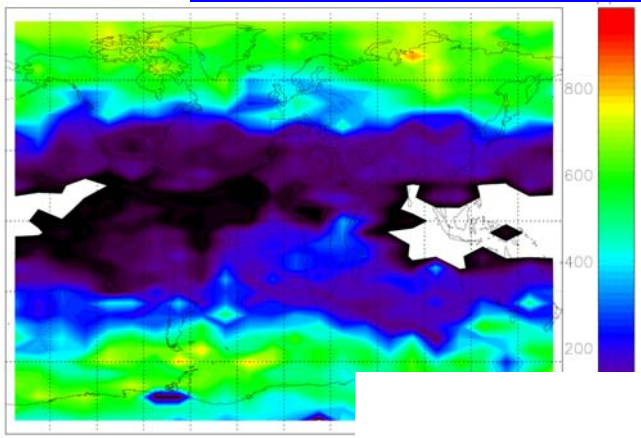
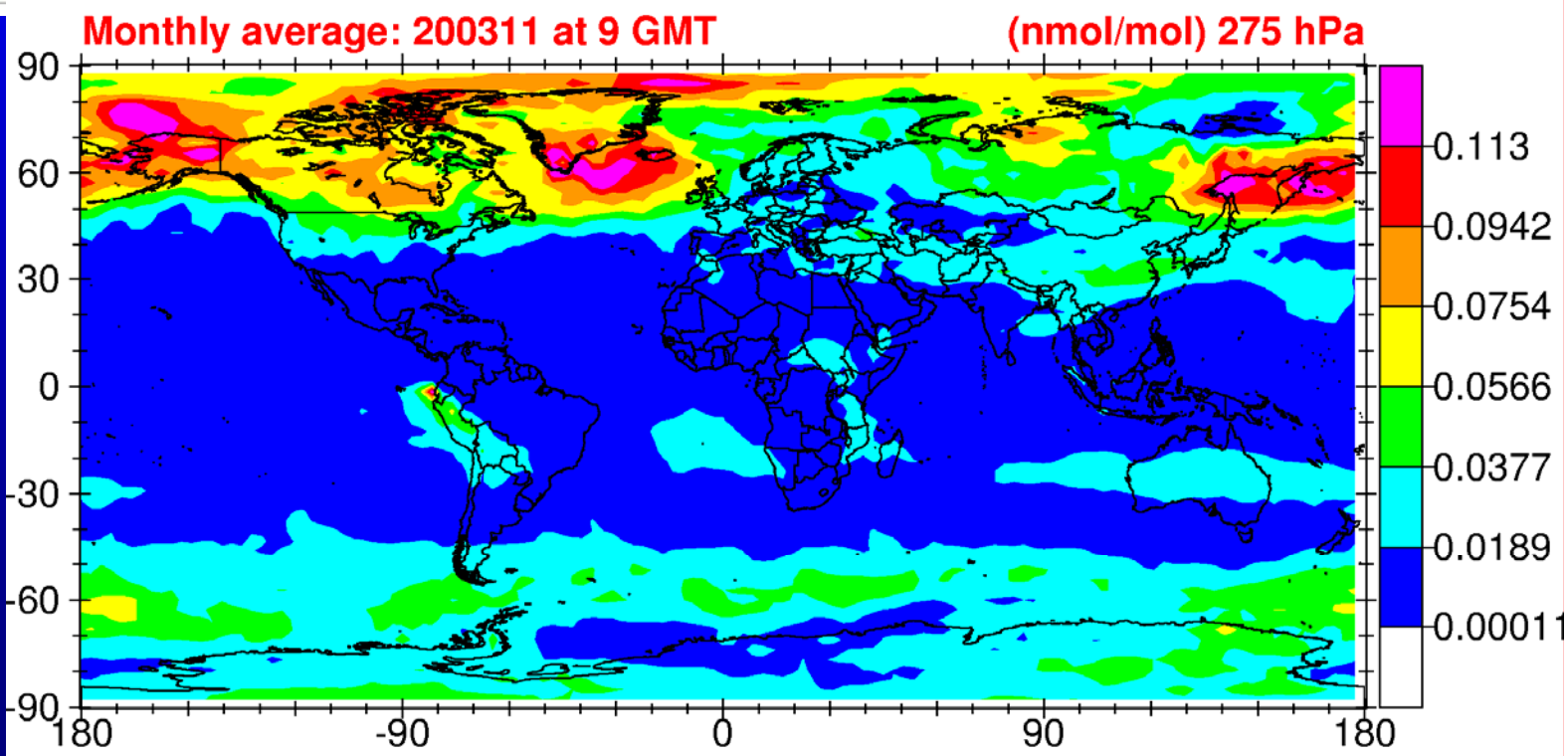
Biomass burning observed by MIPAS



MIPAS HNO_3, 275 hPa
Appr. 300 pptv

MATCH-MPIC HNO_3, M. Lawrence et al., 2005
Appr. 30 pptv!



Based on Output from the MATCH-MPIC Chemical Weather Forecast and Analysis Run
Contact: Mark Lawrence, Max Planck Institute for Chemistry, Mainz, Germany

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Biomass burning observed by MIPAS

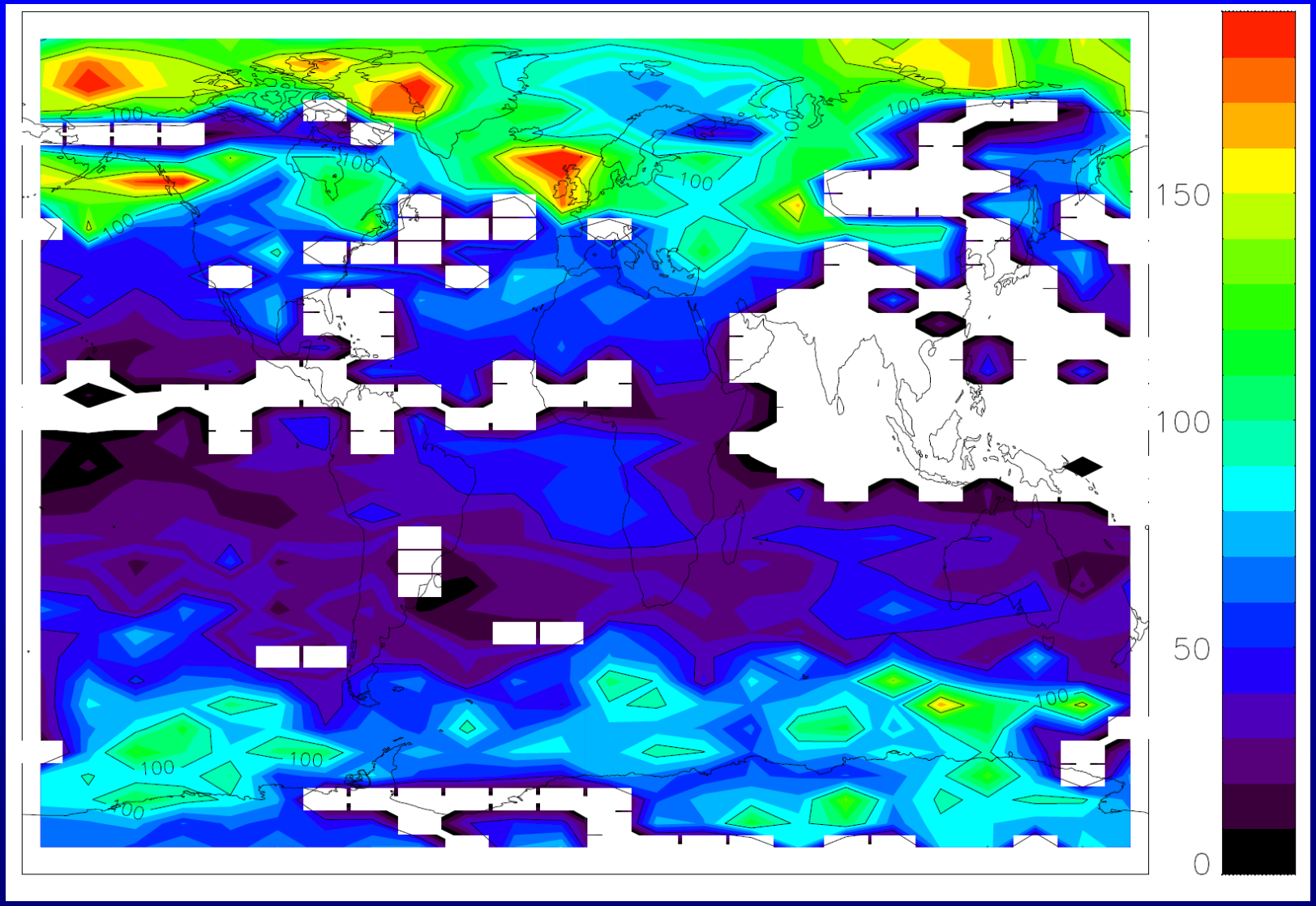
Check also posters:

Retrieval of PAN in the UTLS from MIPAS
by N. Glatthor et al.

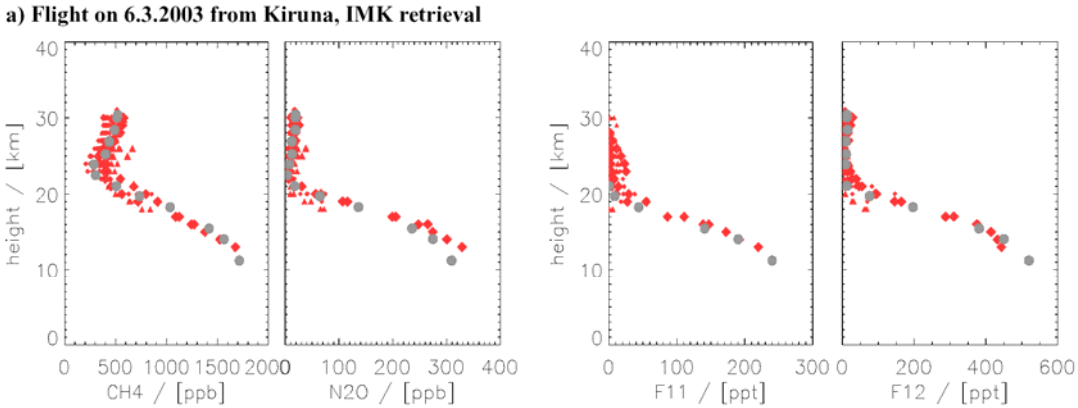
Southern hemispheric biomass burning as seen by MIPAS
by T. von Clarmann et al.

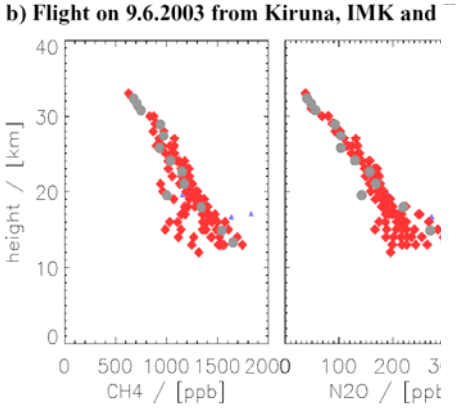
Long range transport of polluted air

O_3 @ 8 km altitude, 21 – 28 July 2003 ppbv



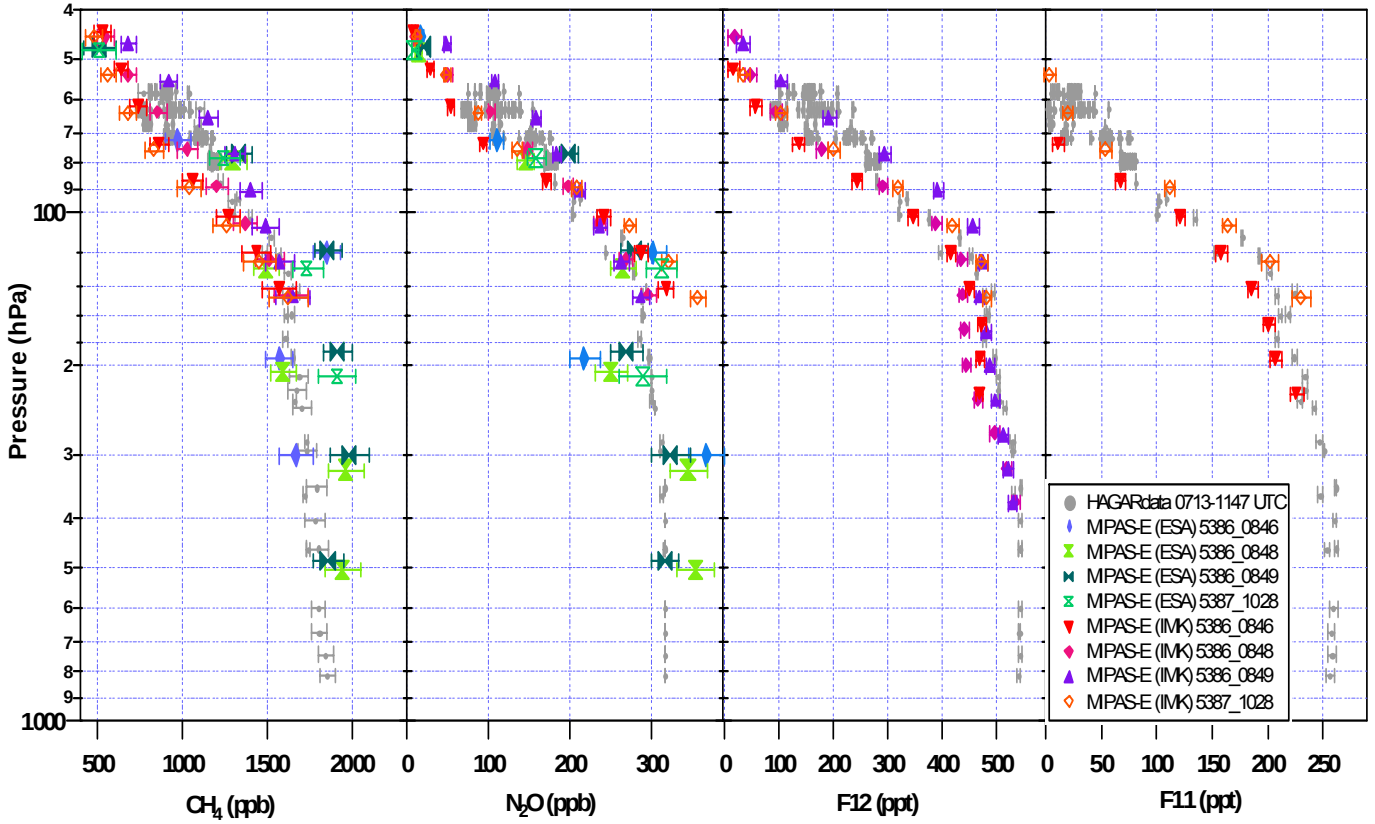
GHGs in the troposphere





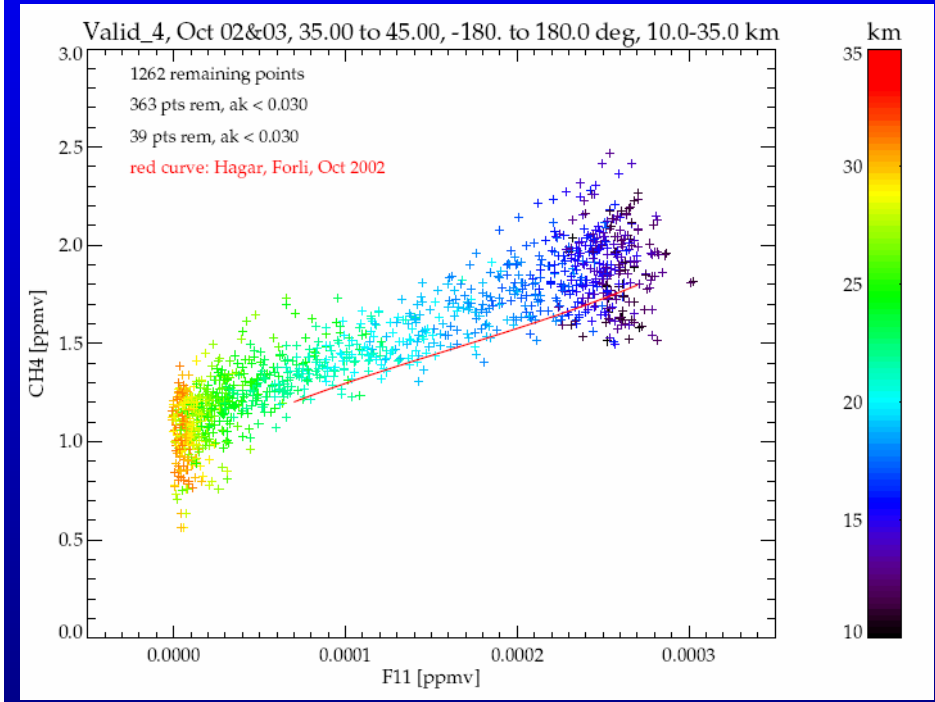
Comparison to BONBON, co-locations from forward/ backward trajectory calculations
J. Baehr et al., 2004

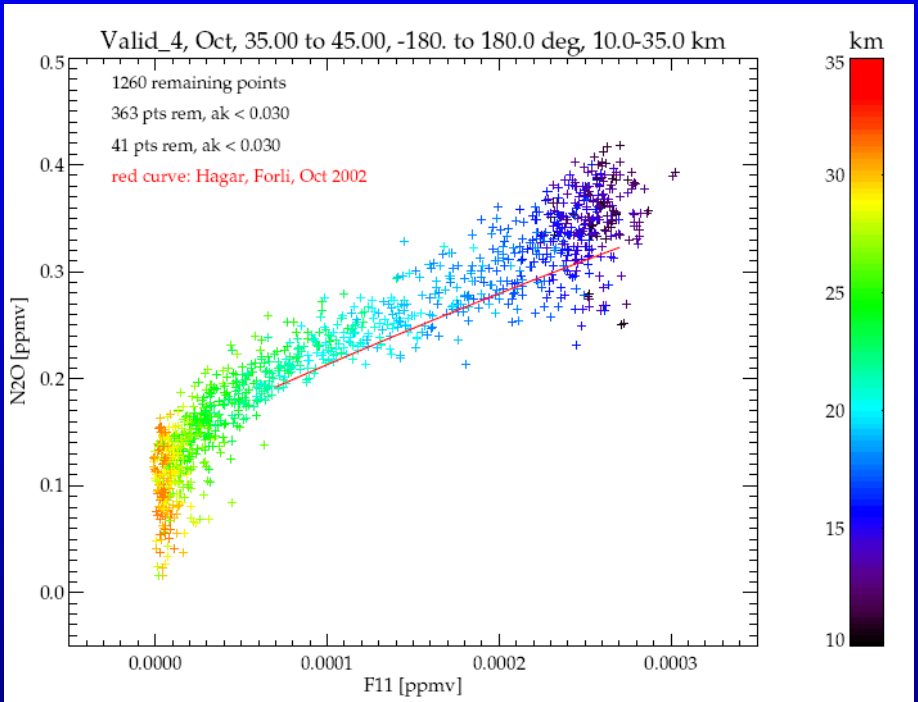
Comparison to HAGAR, Kiruna 12 March 2003



CH4 and N2O from re-processed L1B data: Correlation to CFC-11

October 2002/2003 Northern Mid-Latitudes

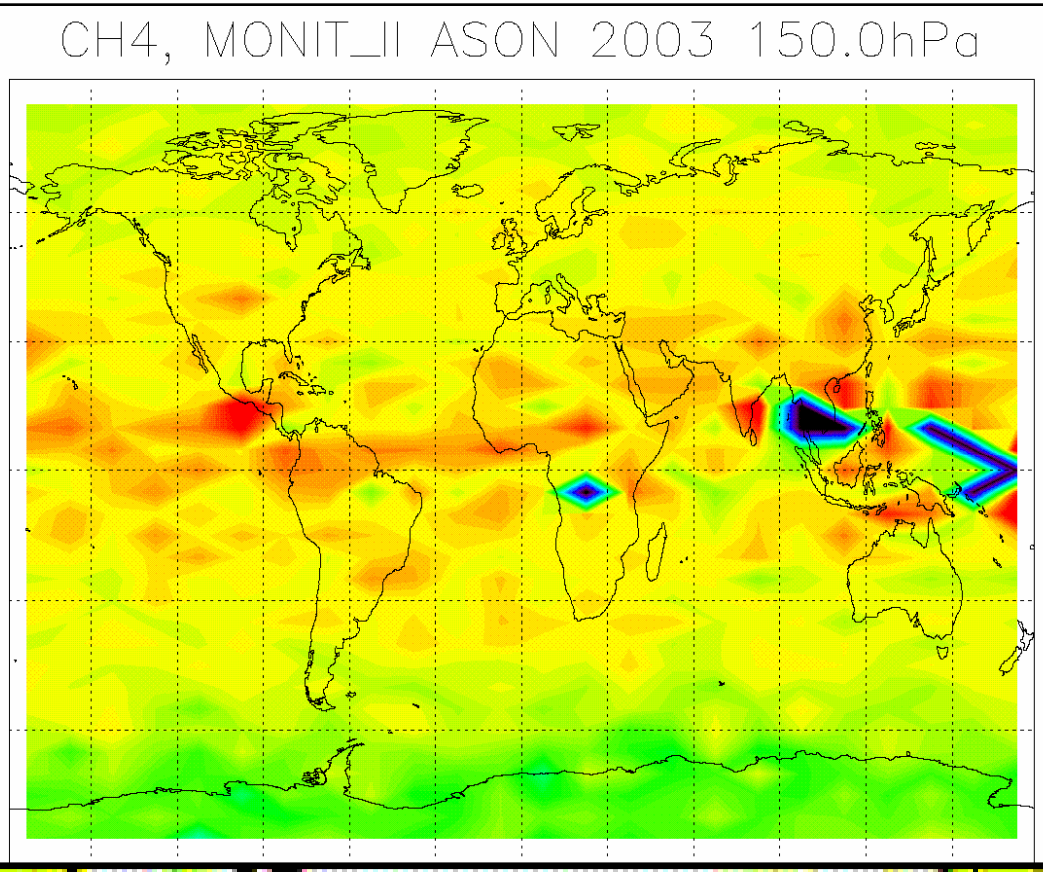


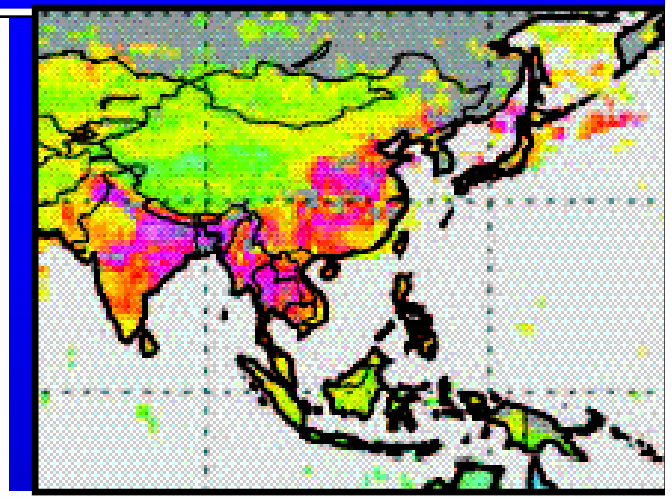


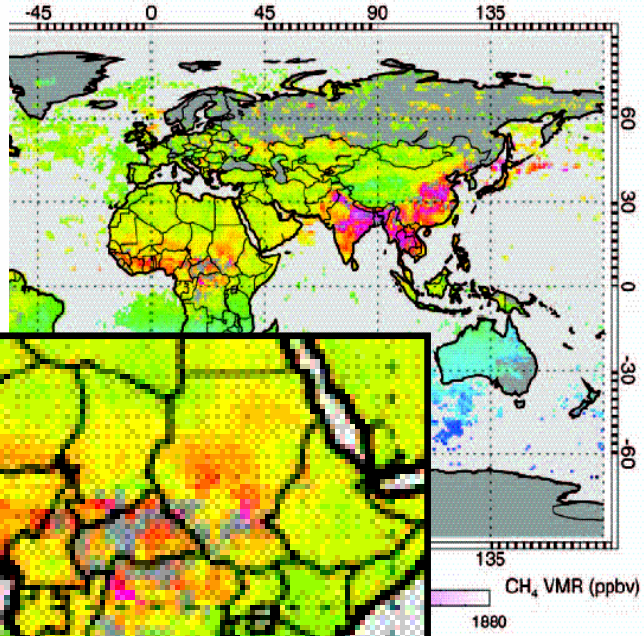
CH4: High bias ~ 200 ppbv

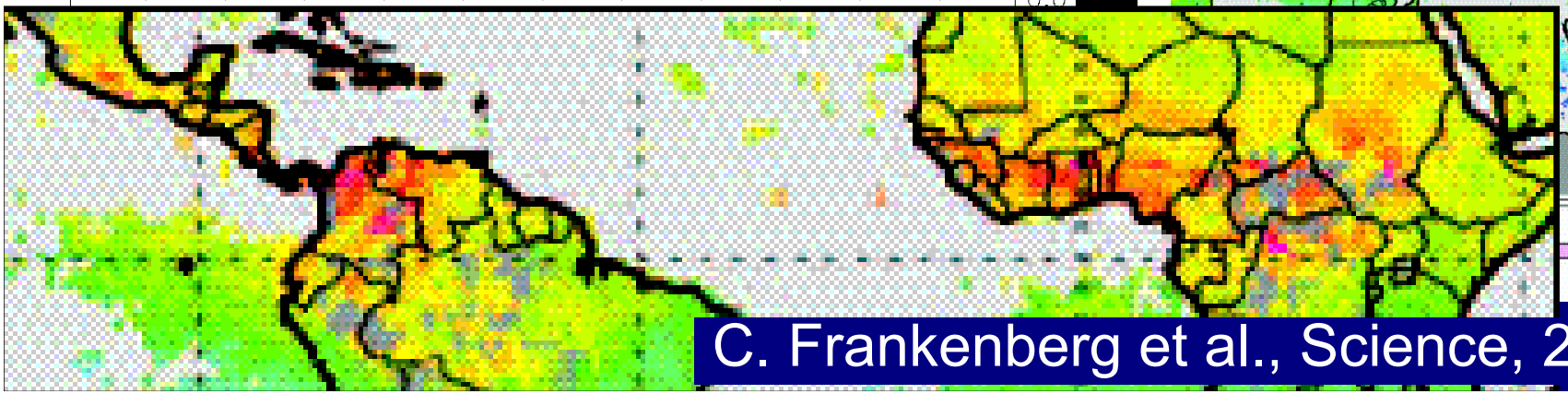
N2O: High bias ~ 23 ppbv

Comparing MIPAS and SCIAMACHY: CH4 Global trop. distribution





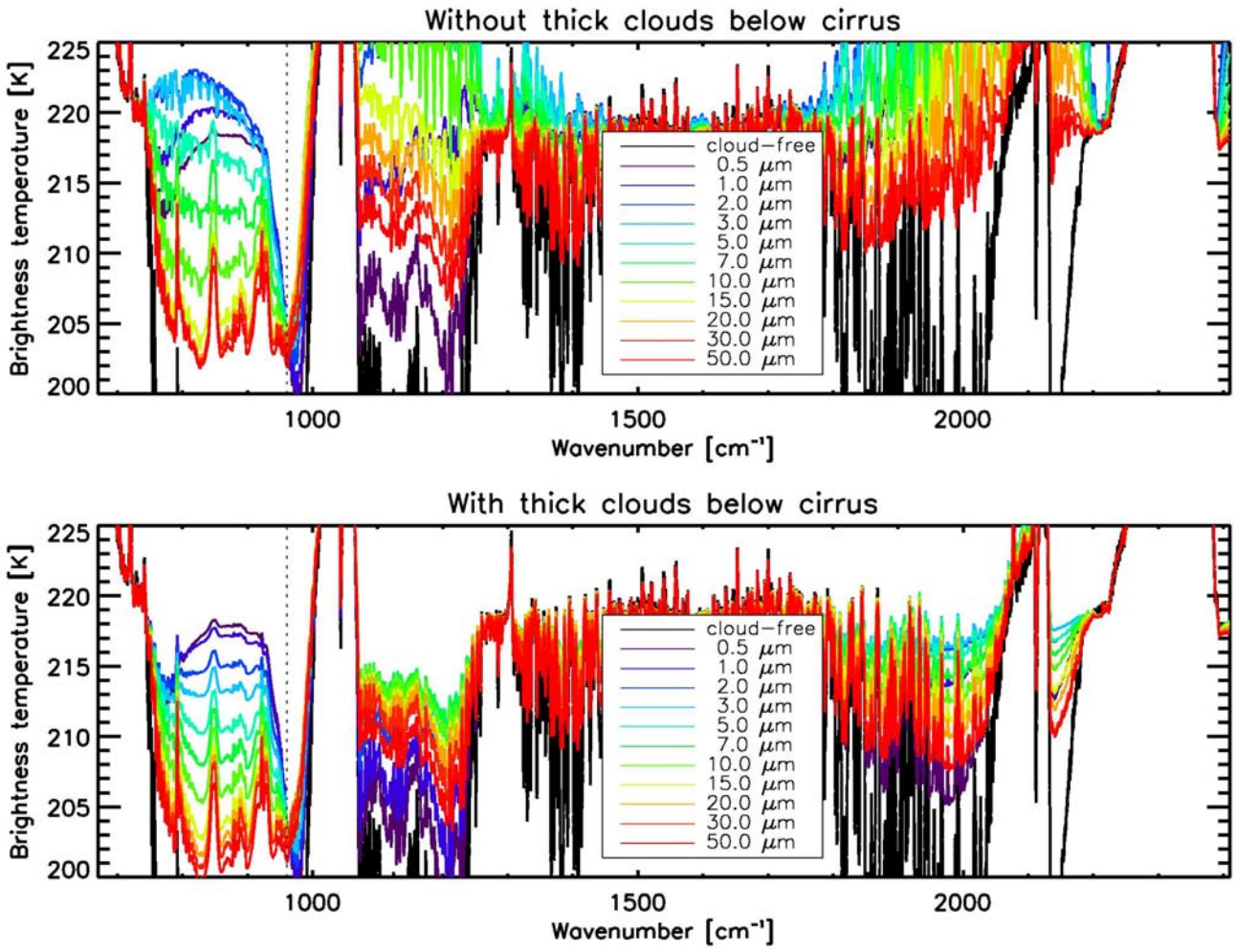




C. Frankenberg et al., Science, 2005

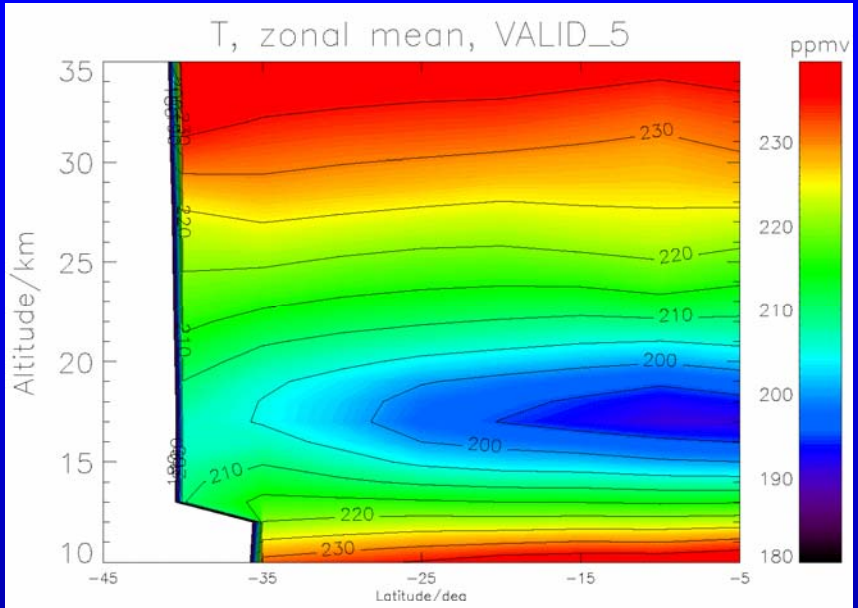
Cirrus clouds

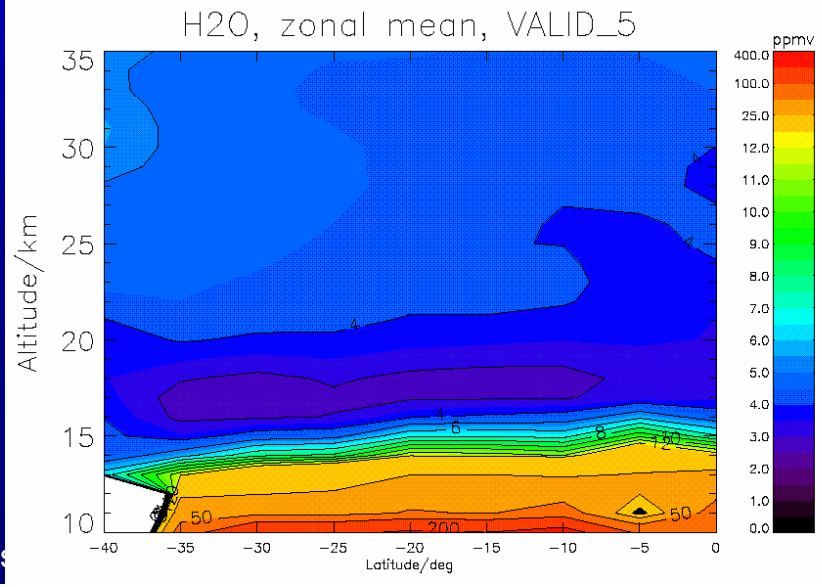
Simulation of different sizes of ice particles

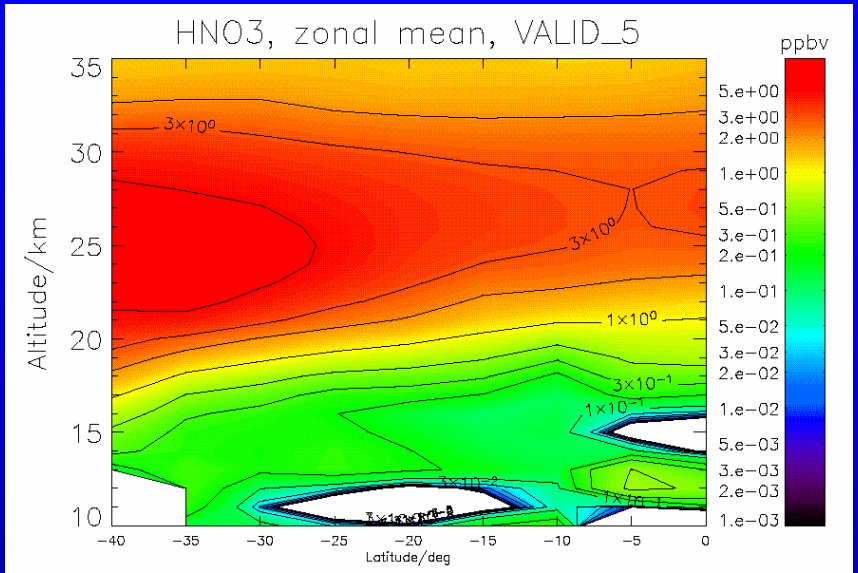


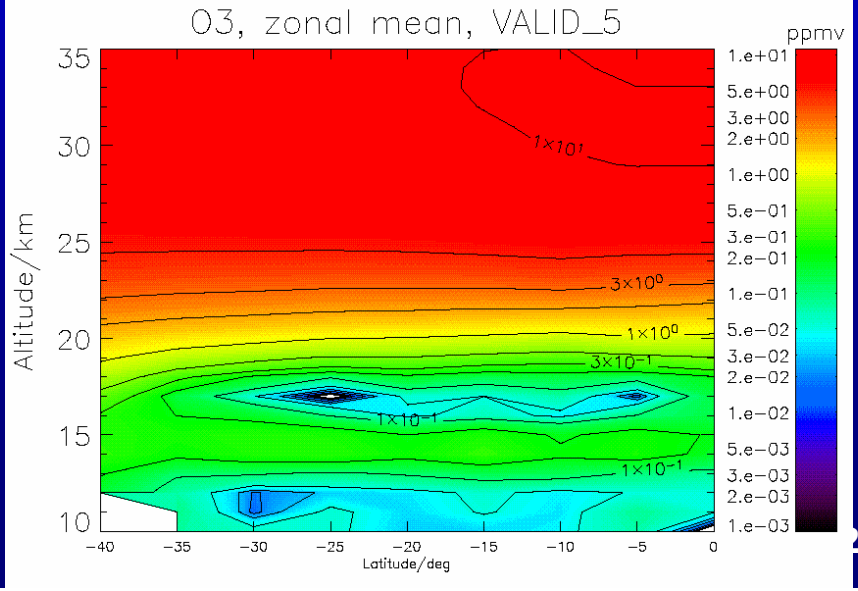
Cirrus clouds: HNO3 uptake

TROCCINOX/HIBISCUS 2004 campaign









Conclusions

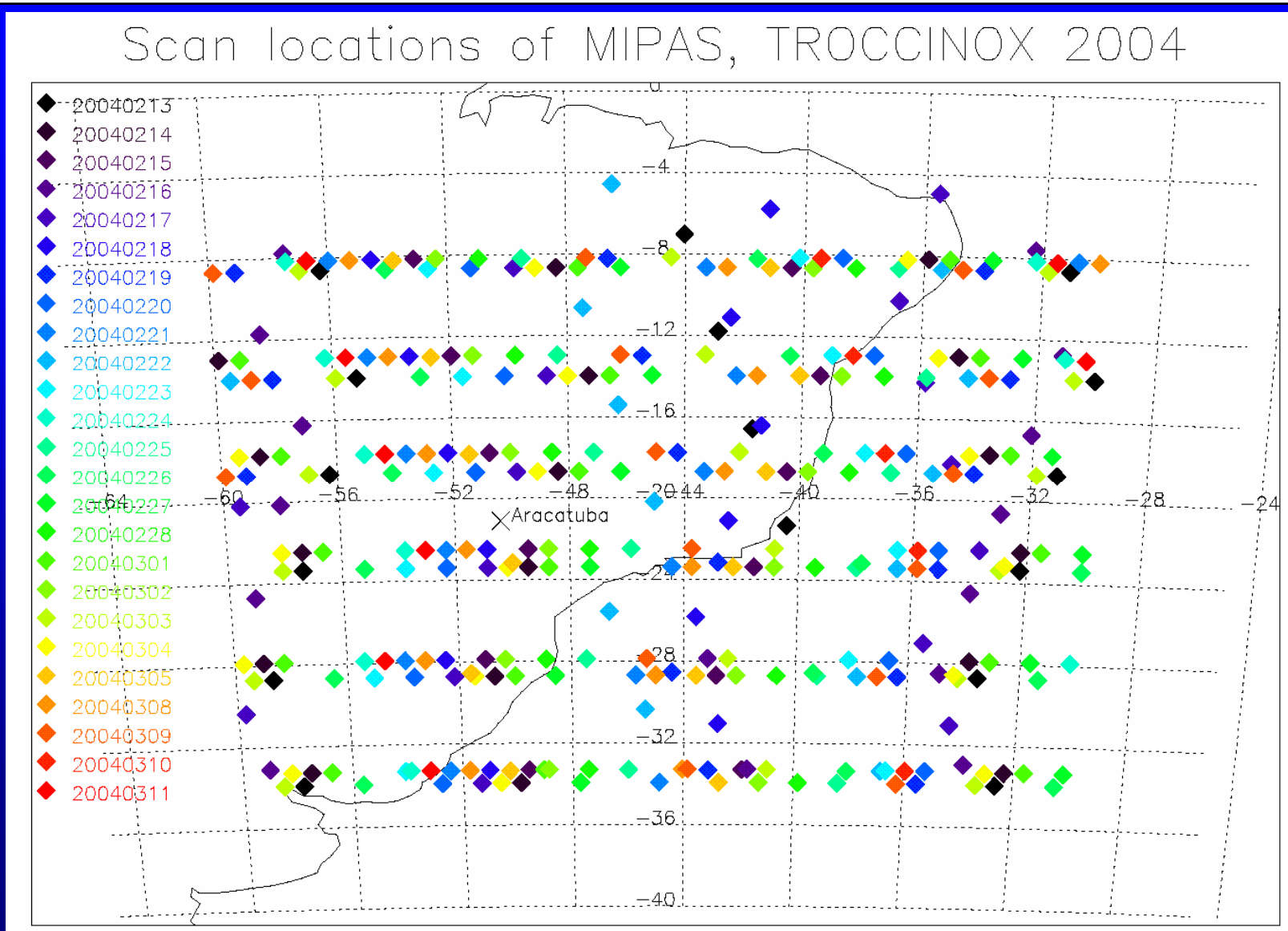
- ✓ MIPAS provides a wealth of information on the UTLS with vertical resolution of 4 to 6 km
- ✓ Tropospheric SF_6 is observed to increase by 0.221 pptv/yr well in consistency to in-situ measurements
- ✓ Water vapour and isotopologues allow to study transport mechanisms of water through the tropical tropopause
- ✓ CO can be retrieved down to the upper troposphere and provides a tracer for industrial/biomass burning pollution and for troposphere-to-stratosphere exchange
- ✓ High spatial resolution modes of MIPAS allow to resolve STE events like tropopause folds
- ✓ Biomass burning has been observed (C_2H_6, O_3, HNO_3, PAN) and has been traced back to S-American rainforest and S-African savanna burning

Conclusions / cntd.

- ✓ Model calculations compare well to MIPAS biomass burning observations except HNO_3
- ✓ PAN and O_3 show episodes of N-hemisphere industrial pollution
- ✓ GHGs in the troposphere can be retrieved with vertical resolution of appr. 4 km
- ✓ CH_4 distribution from MIPAS confirms SCIAMACHY observations of increased CH_4 above rainforests
- ✓ Microphysical properties of cirrus clouds can be retrieved from MIPAS spectra
- ✓ HNO_3 uptake into cirrus clouds will be studied

Additional material

Tropical tracers: TROCCINOX



Tropical tracers: TROCCINOX