The Michelson Interferometer for Passive Atmospheric Sounding (MIPAS)

Question 6: What are the GHG and chemical agent sensing capabilities of hyperspectral satellite sensors?

Thomas von Clarmann

With contributions from: E. Eckert, B. Funke, M. Garcia-Comas, N. Glatthor, U. Grabowski, M. Grutter, F. Haenel, M. Höpfner, S. Kellmann, M. Kiefer, A. Laeng, A. Linden, M. López-Puertas, S. Lossow, J. Orphal, J. Plieninger, T. Schieferdecker, G.P. Stiller, S. Versick, and A. Wiegele

MIPAS

Infrared: → many species are observable

High spectral resolution → minor species are detectable

Limb:→good altitude resolution

→ good sensitivity to minor species

Emission:→global coverage;

→ day and night measurements

Polar orbit → global coverage

There exist several MIPAS data processors, operated by different institutions (e.g. ESA, Oxford University, Bologna University, IFAC etc). Differences are:

- The retrieval scheme;
- the radiative transfer forward model;
- the scope (near-real-time analysis vs. scientific analysis).

Examples shown in this talk are based on data generated with the IMK/IAA scientific data processor (Karlsruhe/Granada).

MIPAS observes the upper troposphere, the stratosphere, the mesosphere, and the lower thermosphere

SME; energetic particles:
O_3, HNO_3, NO_2, N_2O, N_2O_5, $ClONO_2$, NO, ClO, HOCl, H_2O, CO, CH_4, H_2O_2

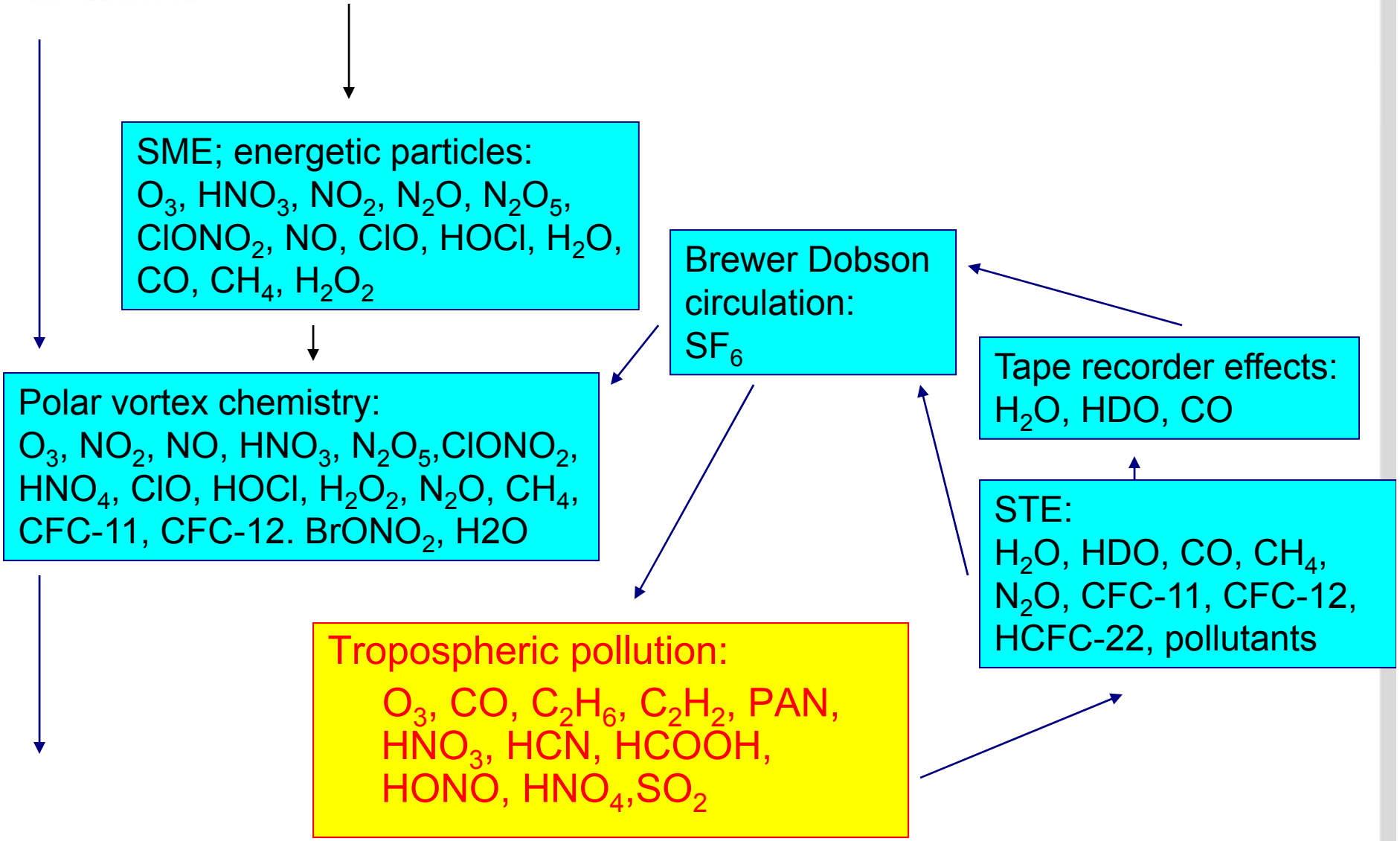
Polar vortex chemistry:
O_3, NO_2, NO, HNO_3, N_2O_5,$ClONO_2$, HNO_4, ClO, HOCl, H_2O_2, N_2O, CH_4, CFC-11, CFC-12, $BrONO_2$, H2O

Brewer Dobson circulation:
SF_6, CFC-11, CFC-12

Tape recorder effects:
H_2O, HDO, CO

STE:
H_2O, HDO, CO, CH_4, N_2O, CFC-11, CFC-12, HCFC-22, pollutants

Tropospheric pollution:
O_3, CO, C_2H_6, C_2H_2, PAN, HNO_3, HCN, HCOOH, HONO, HNO_4,SO_2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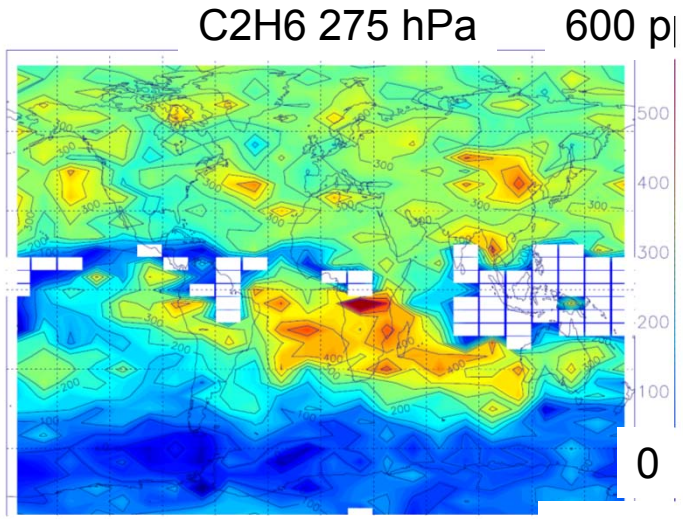
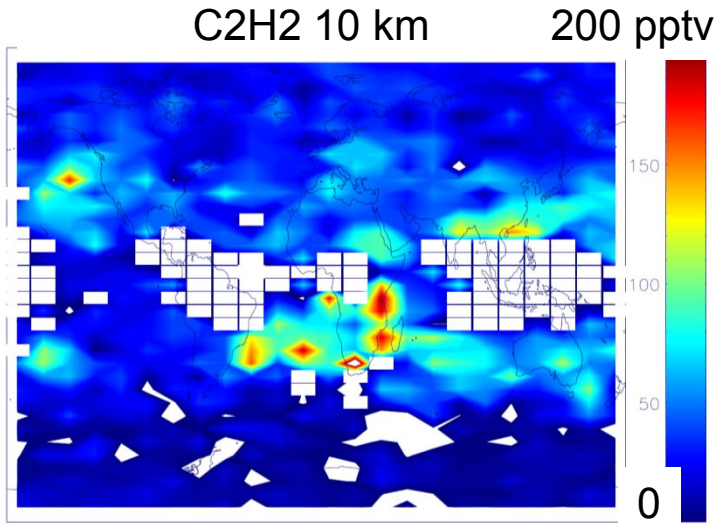
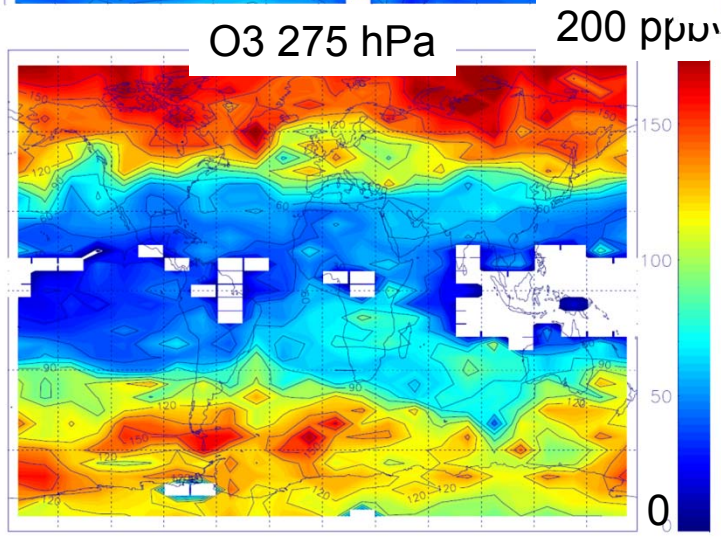
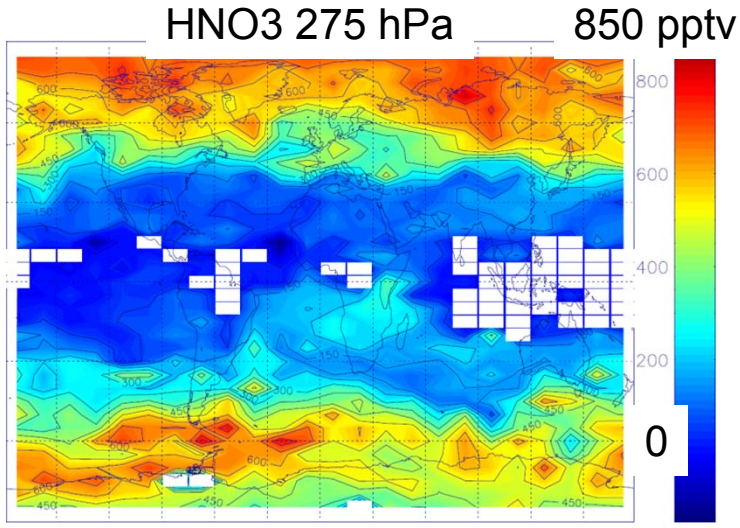
Tropospheric Pollution

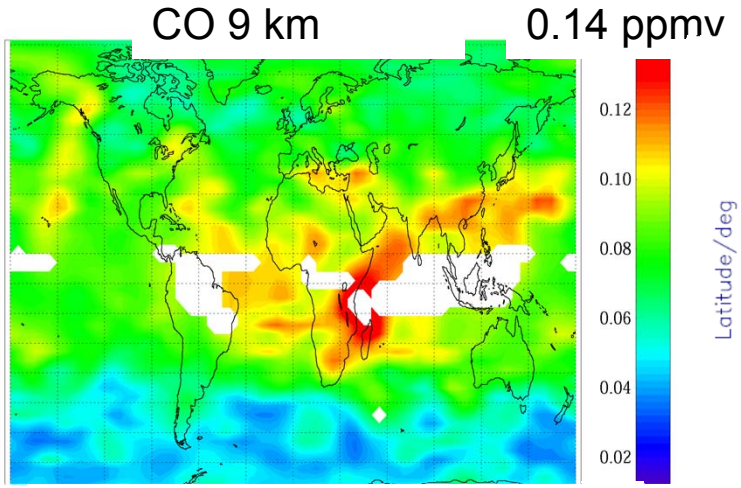


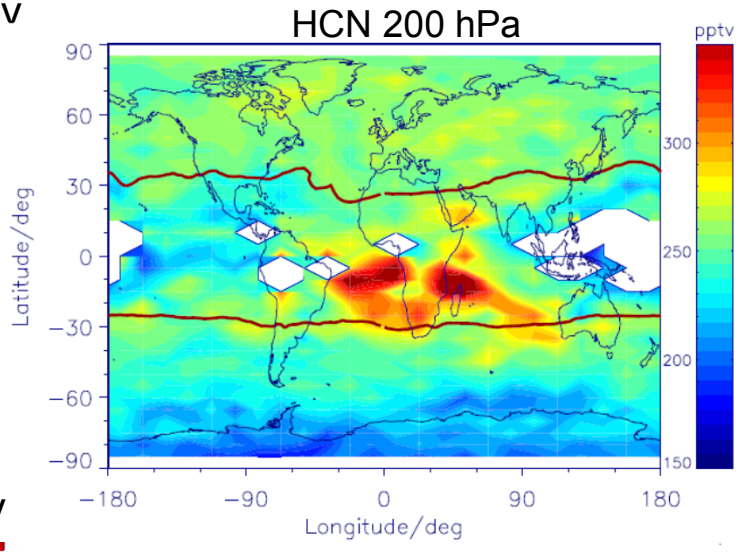


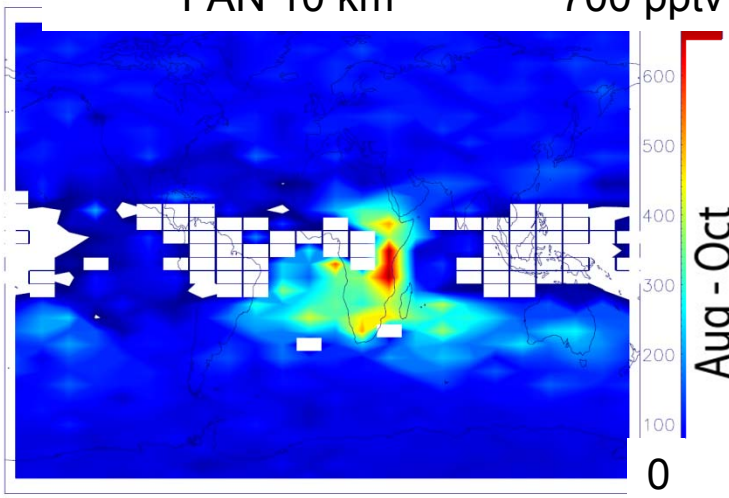


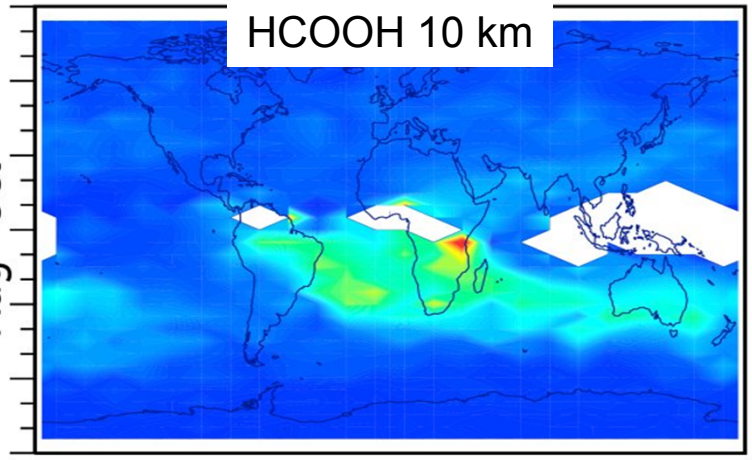


von Clarmann et al. 2007; Gatthor et al, 2009









Funke et al. 2009
Grutter et al. 2010
Glatthor et al. 2009
Glatthor et al. 2007

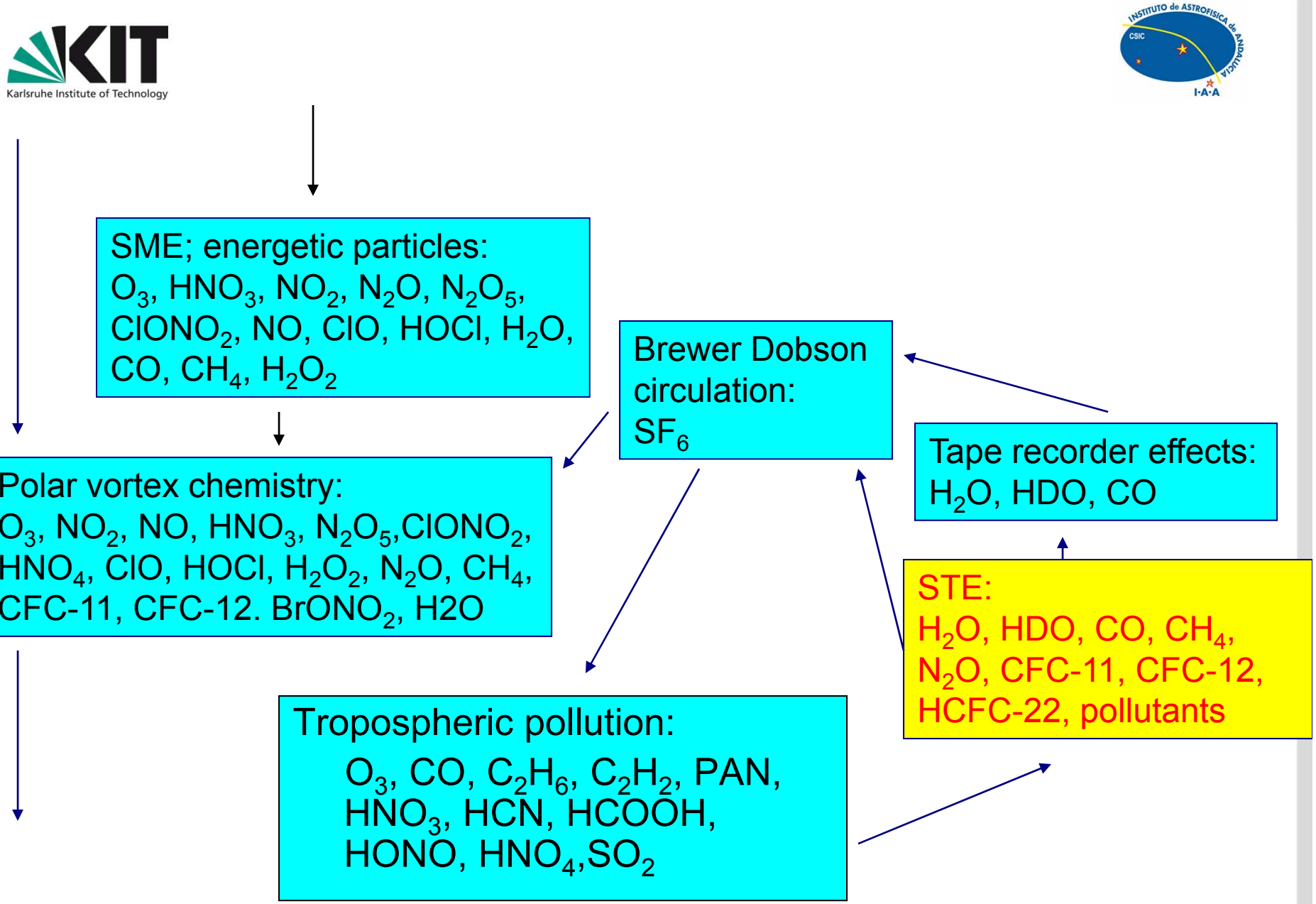
Tropospheric pollution

Gases analyzed at IMK/IAA:

- O_3
- CO
- C_2H_6
- C_2H_2
- PAN
- HNO_3
- HCN
- HCOOH
- HONO
- HNO_4
- SO_2
- C_3H_6O

Related questions:

- Sources
- Transport
- Lifetimes
- Impact on ozone budget
- Are these gases transported into the stratosphere?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Tropospheric pollution:
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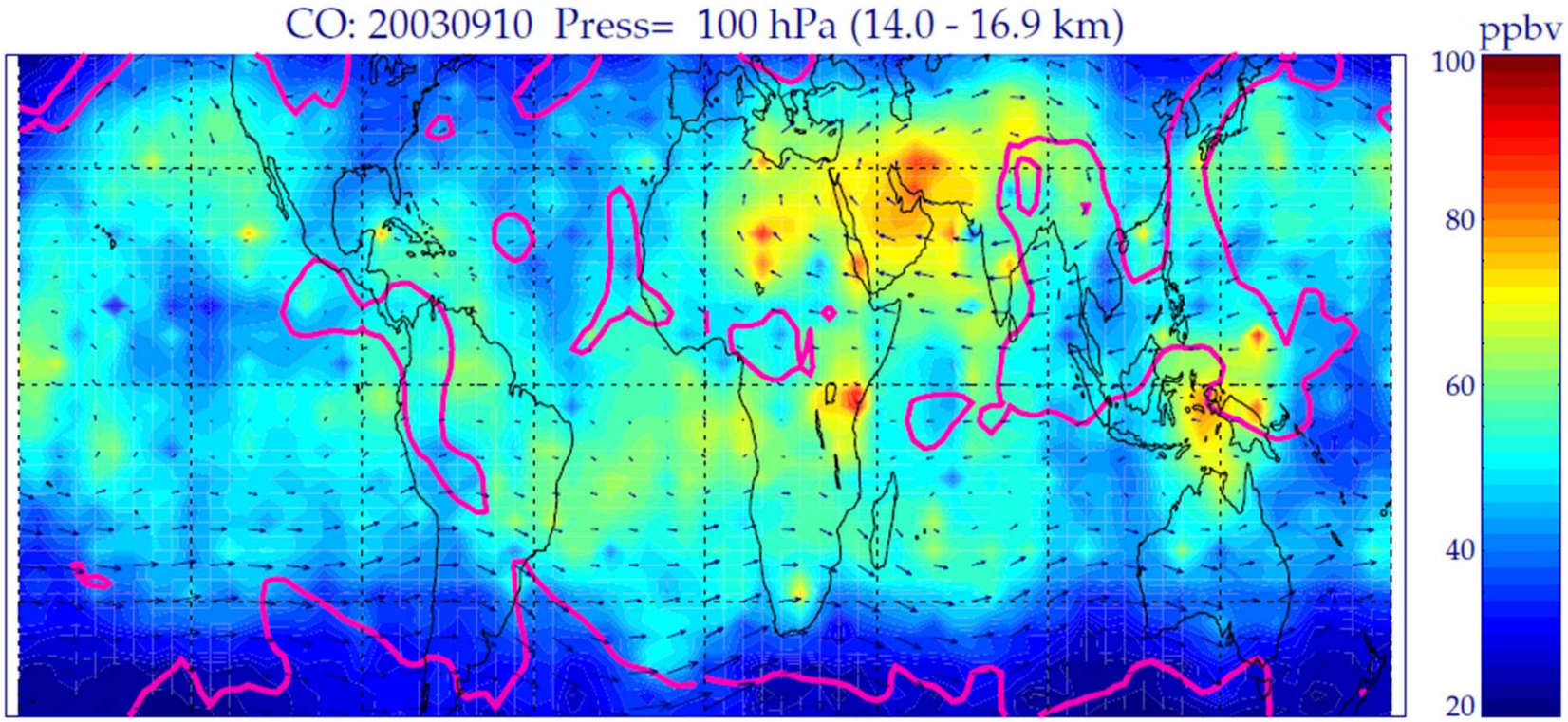
STE Processes: MIPAS CO



Funke et al., 2009

STE Processes: MIPAS H_2O and O_3

Kunze et al. 2010

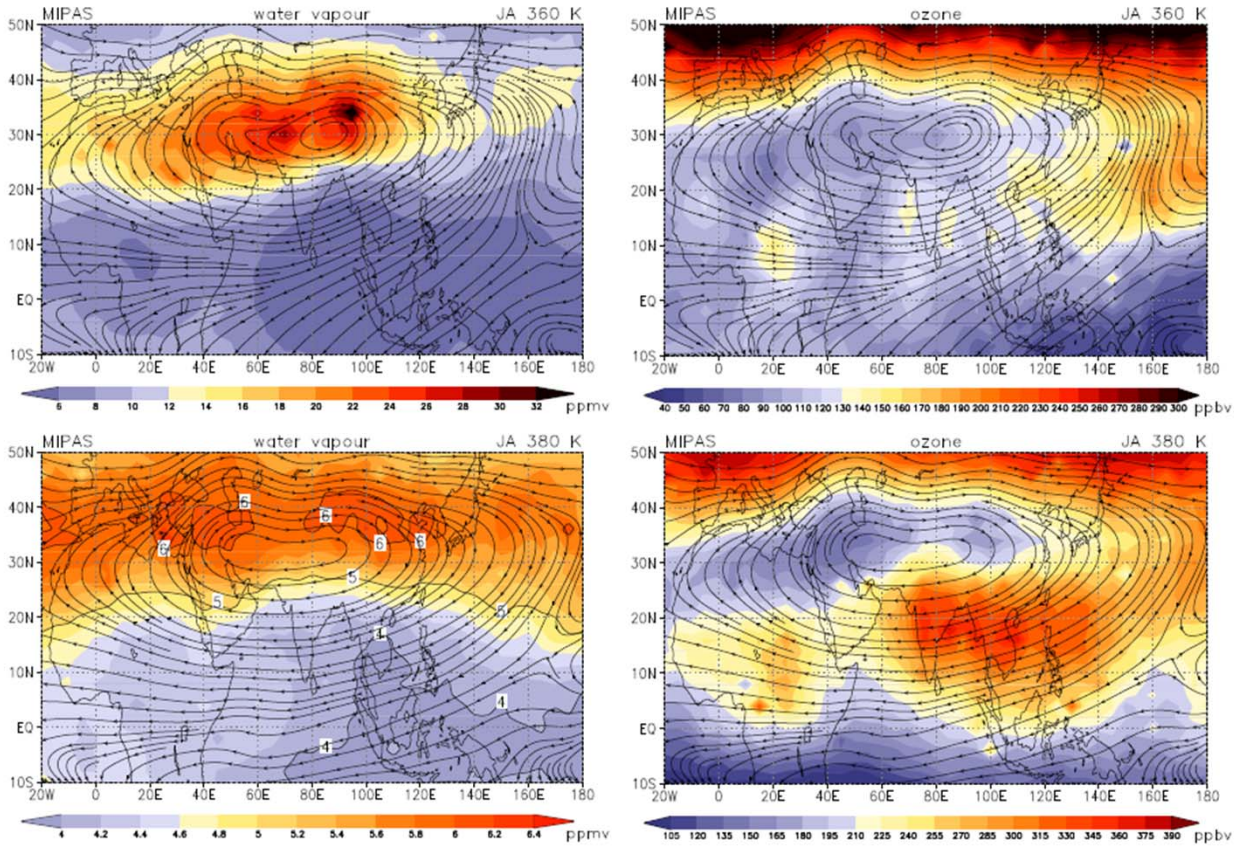


FIG. 5. MIPAS data (4 years) for July/August at 360 K (top) and 380 K (bottom) for a region 10°S – 50°N; 20°W – 180°; left: water vapour in ppmv, shaded with an interval of 2 (0.2) ppmv; right: ozone in ppbv, shaded with an interval of 10 (15) ppbv at 360 (380) K respectively. Overlaid as stream lines are the horizontal wind components of ECMWF analyses.

STE Processes

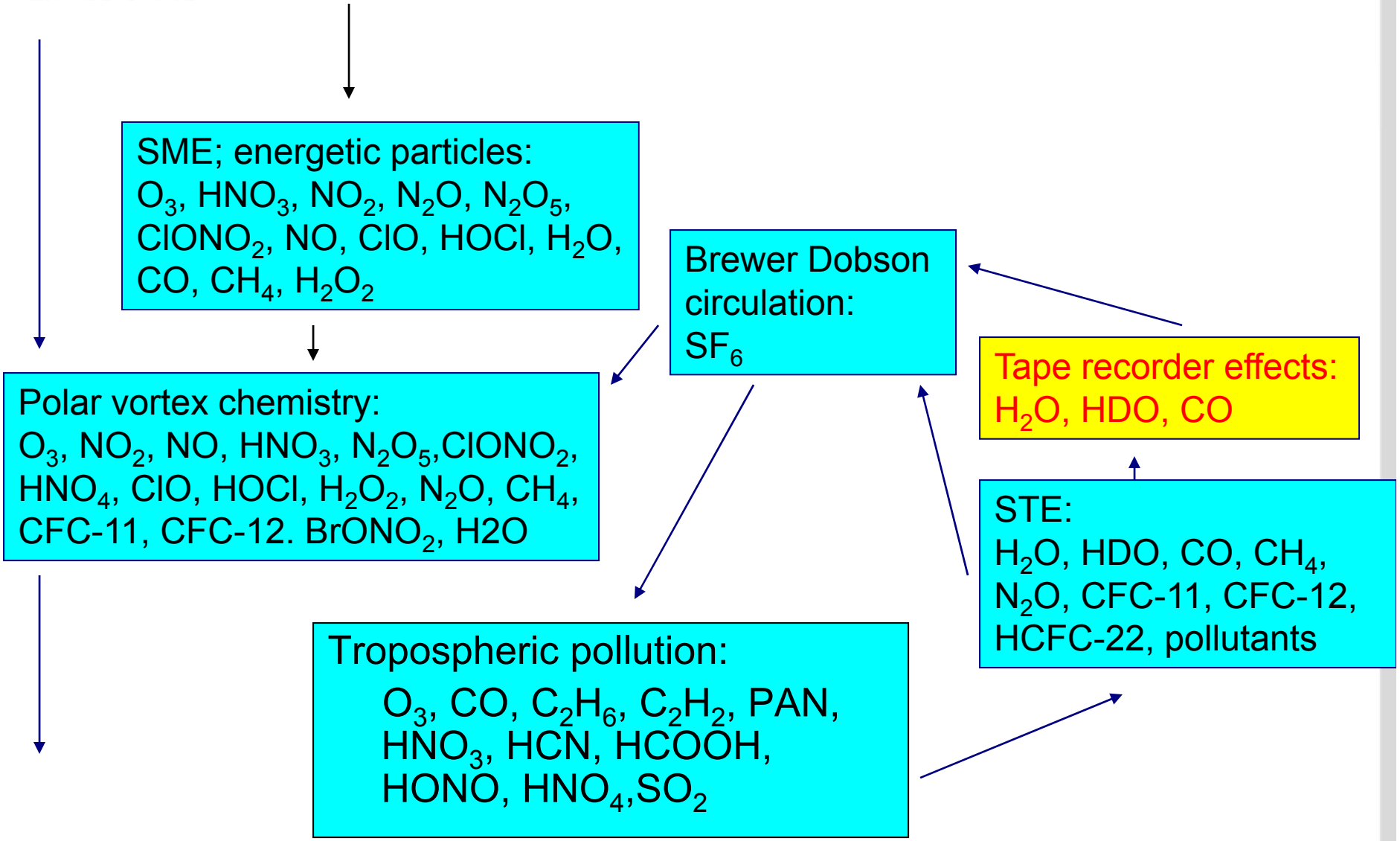
Gases Analyzed at IMK/IAA:

- H2O
- HDO
- CO
- CH4
- N2O
- CFC-11
- CFC-12
- Pollutants (previous viewgraph)

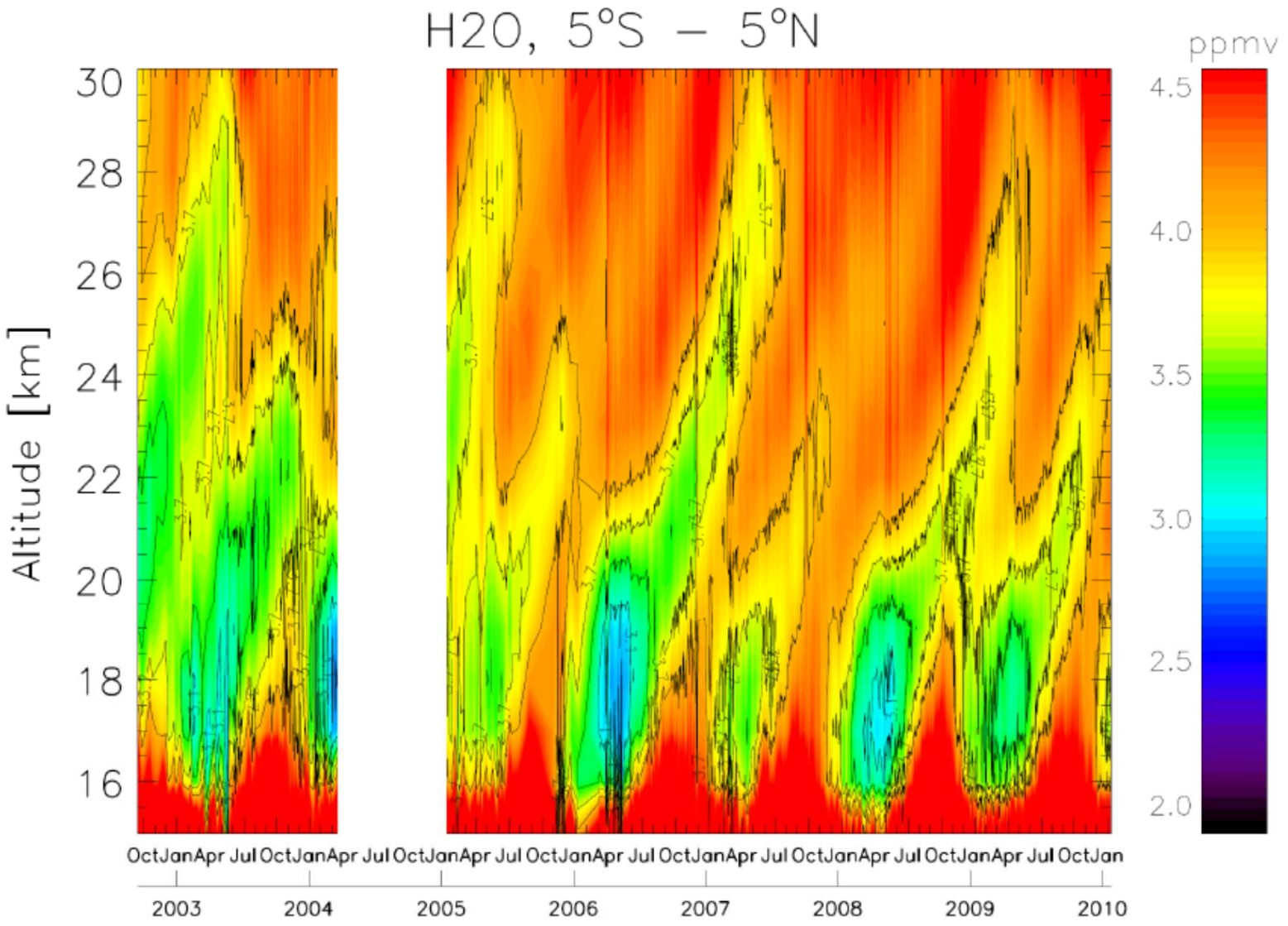
Related questions:

- Asian monsoon anticyclone
- Extratropical UTLS
- Transport through TTL
- H2O entry into stratosphere

MIPAS observes the Stratosphere



Tropical tape recorder: H_2O



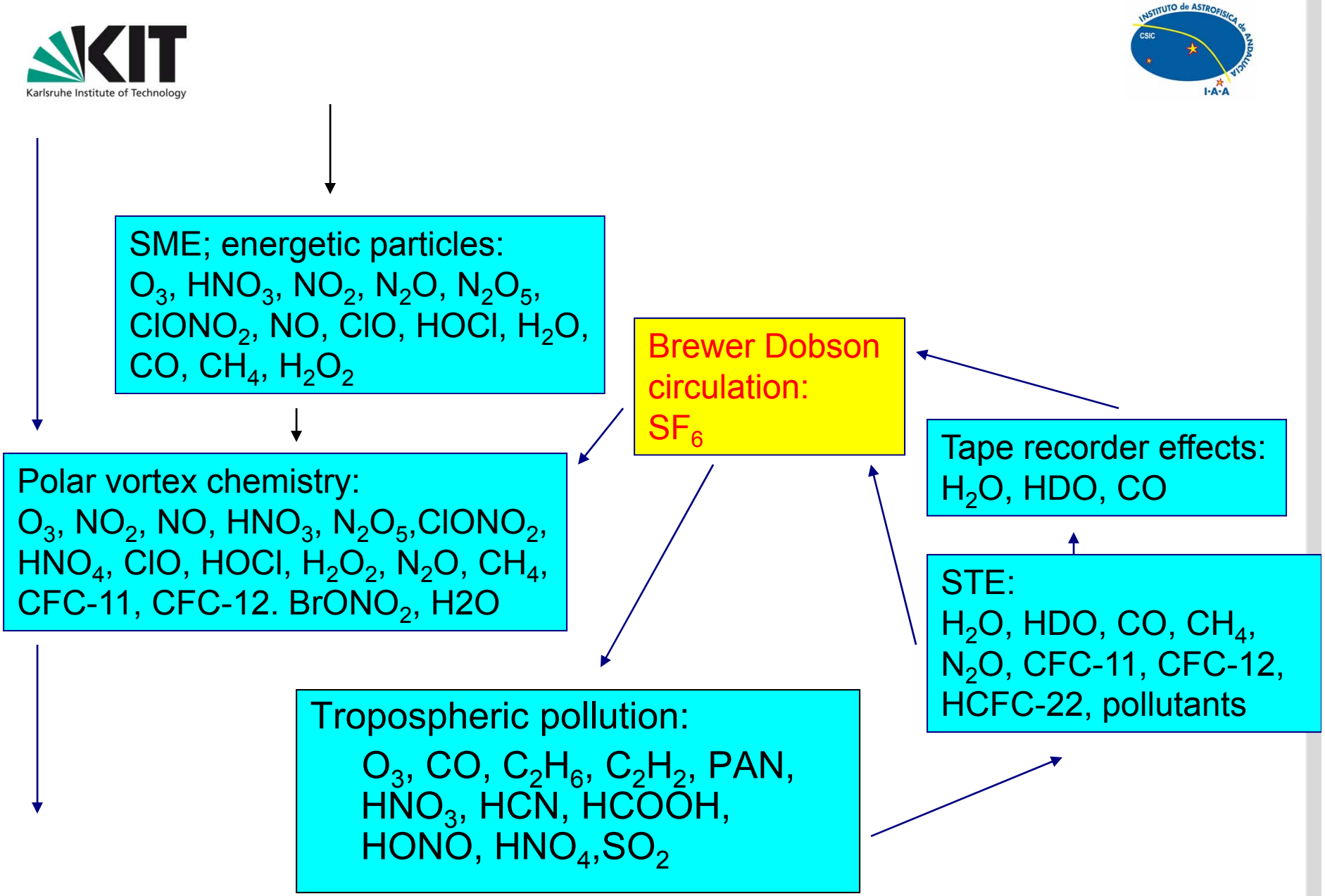
Tropical tape recorder

Relevant Gases:

- H_2O
- HDO
- CO

Science Questions:

- QBO – inter-annual differences
- Variation in upward velocity
- Regional head of tape recorder at 375 K
- Long-term trends (combined time series HALOE – MIPAS-HR – MIPAS-RR
- Role of phase transitions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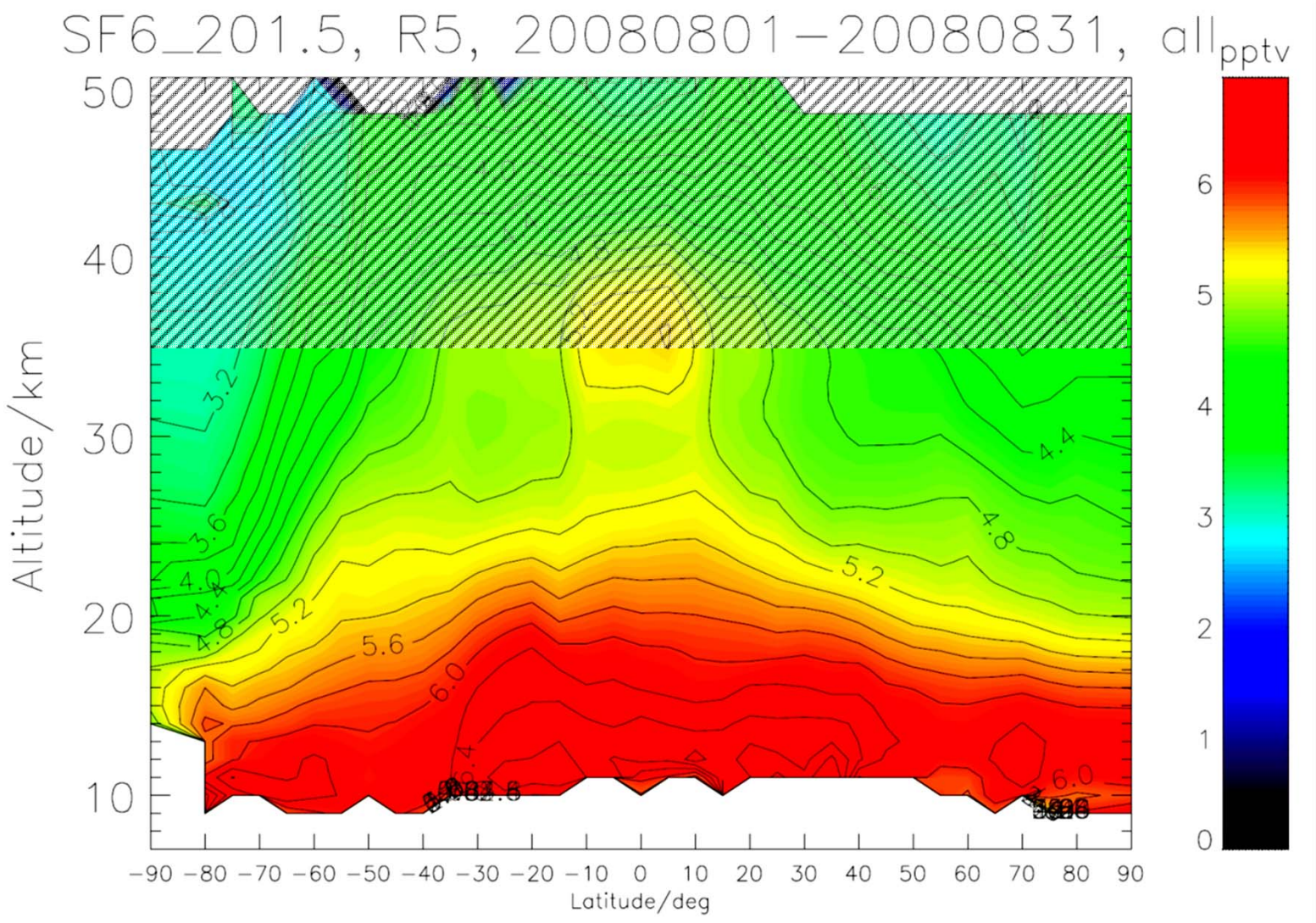

SF6_201.5, R5, 20080801–20080831, all pptv
Altitude/km
50
40
30
20
10
3.2
3.6
4.0
4.4
4.8
5.2
5.6
6.0
6.4
−90 −80 −70 −60 −50 −40 −30 −20 −10 0 10 20 30 40 50 60 70 80 90
Latitude/deg
6
5
4
3
2
1
0

Age of air and Brewer-Dobson-Circulation

Gases processed at IMK/IAA:

SF_6

CFC-11

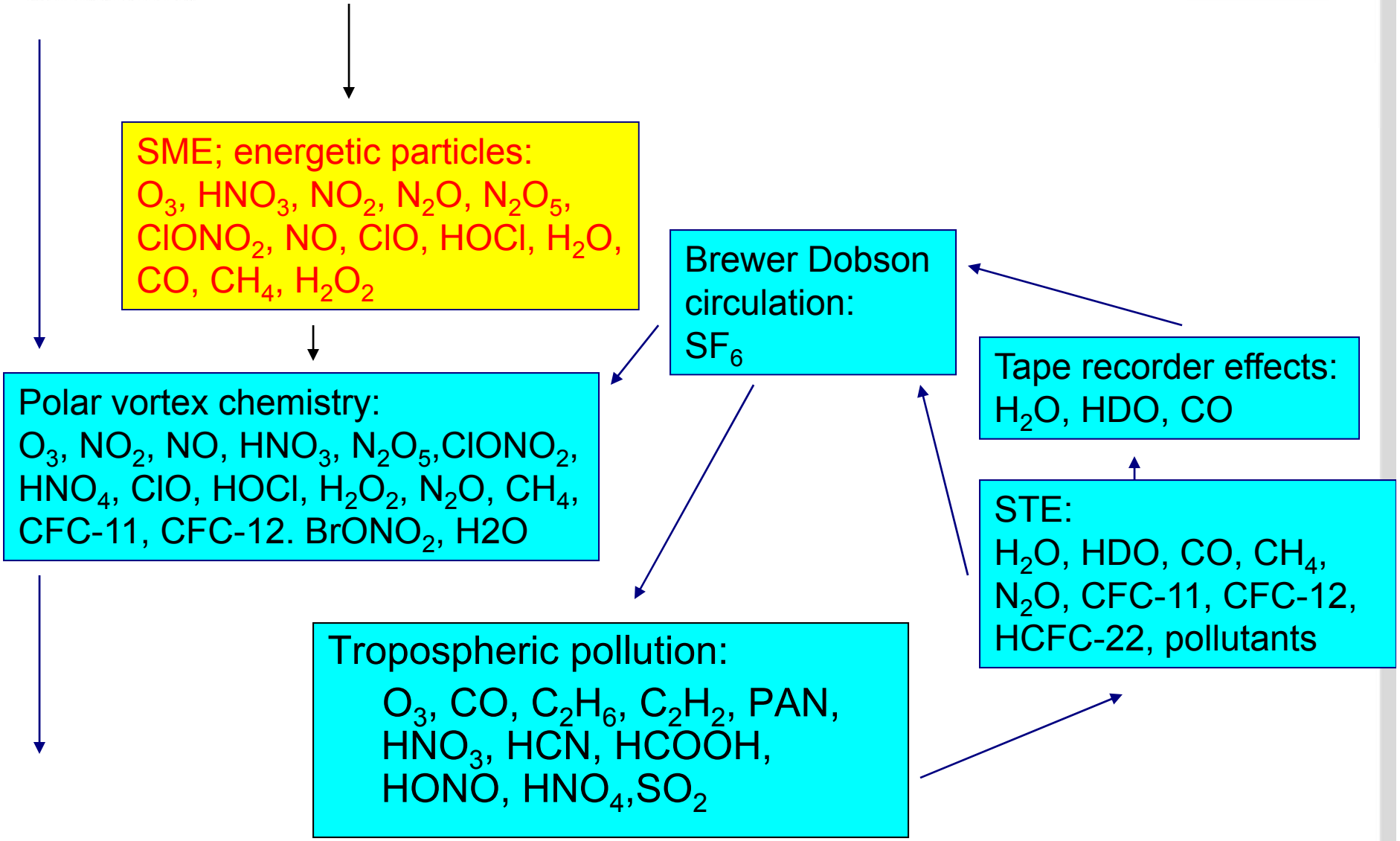
CFC-12

CH_4

N_2O

Related questions:

- Short term (inter-annual and multiyear) variability of age of air
- Detection of mixing barriers
- Long term changes of Brewer-Dobson circulation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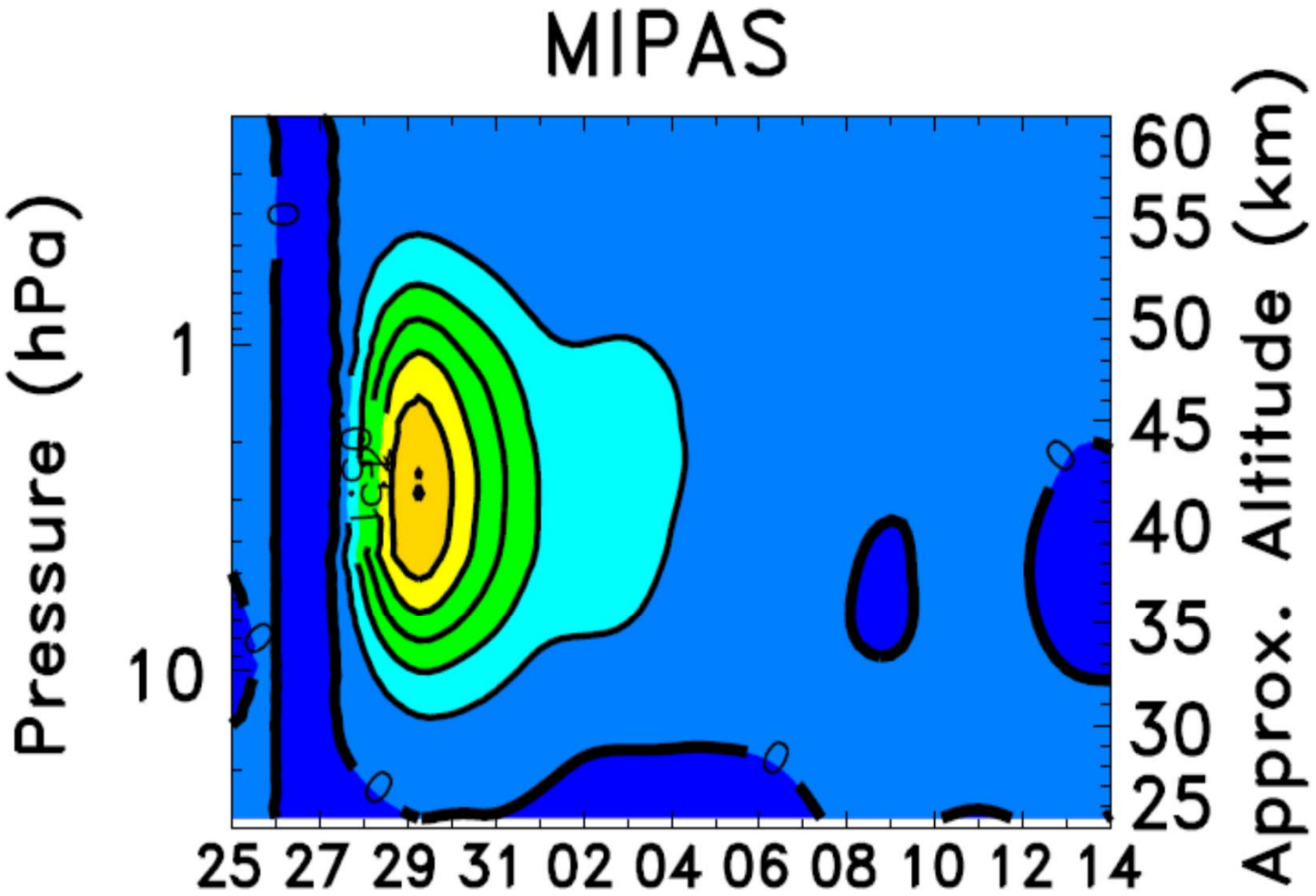
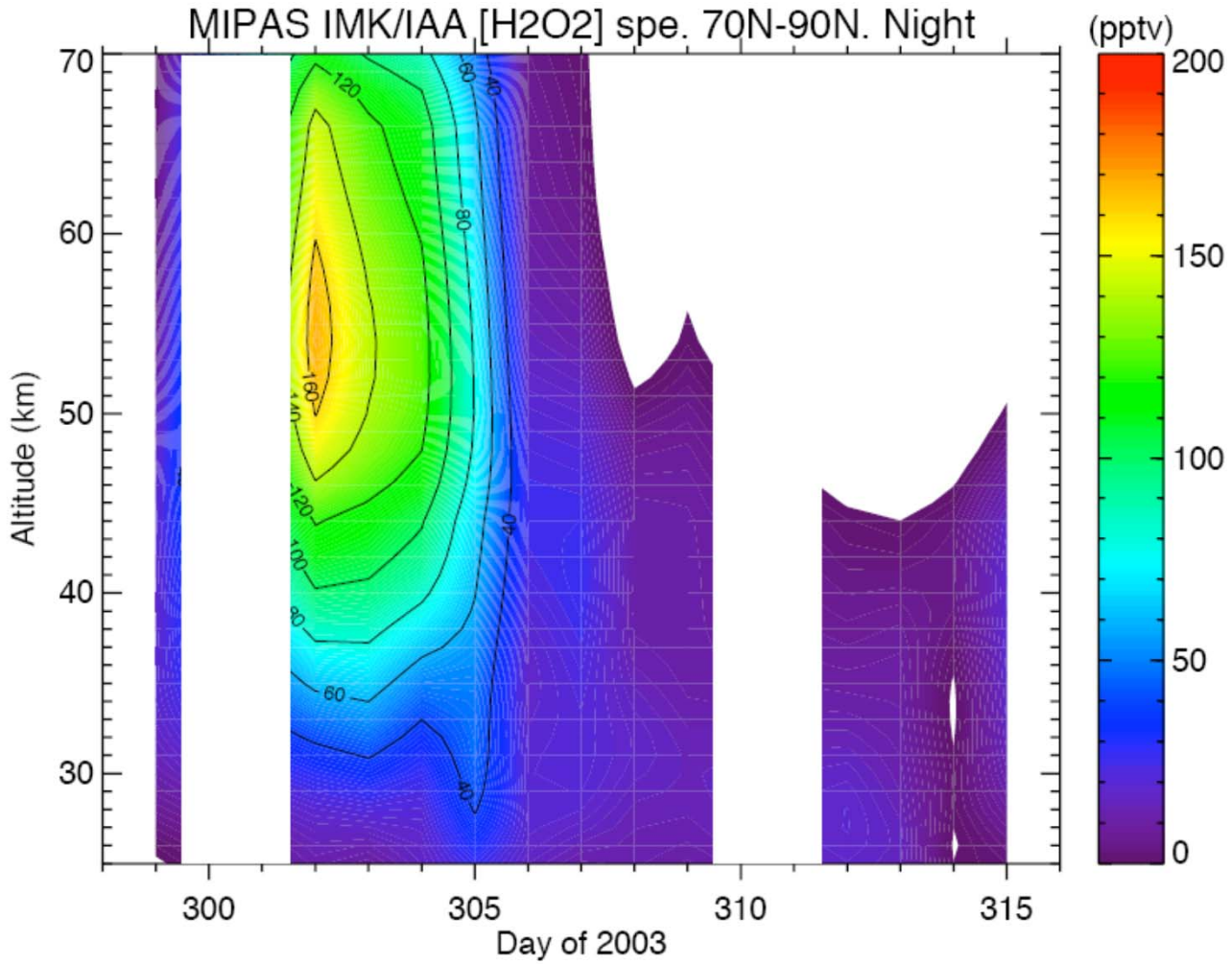
SPE fall 2003: ΔHOCl (night)



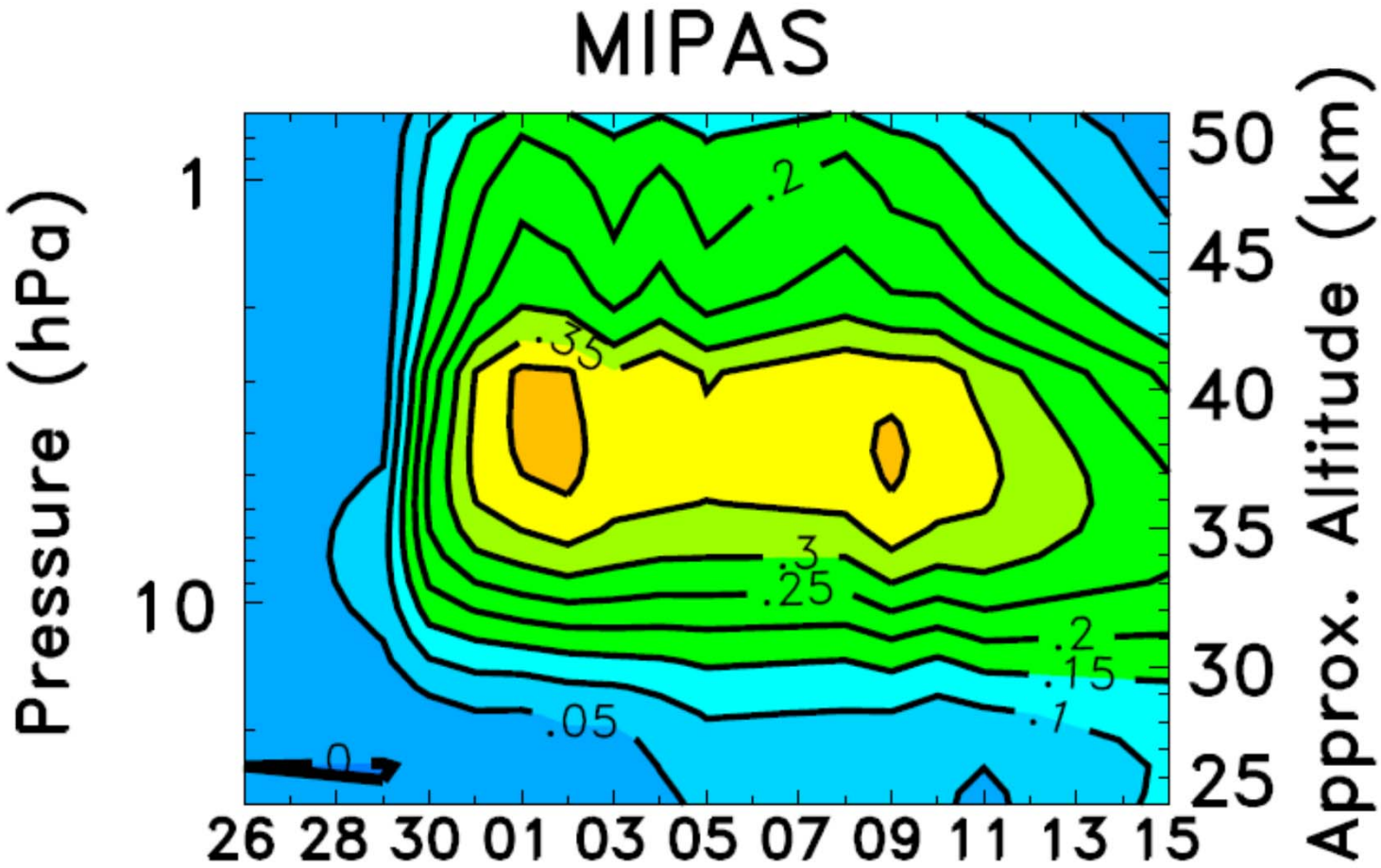
von Clarmann et al., 2005; Jackman et al., 2008

Nighttime H_2O_2 after SPE 2003



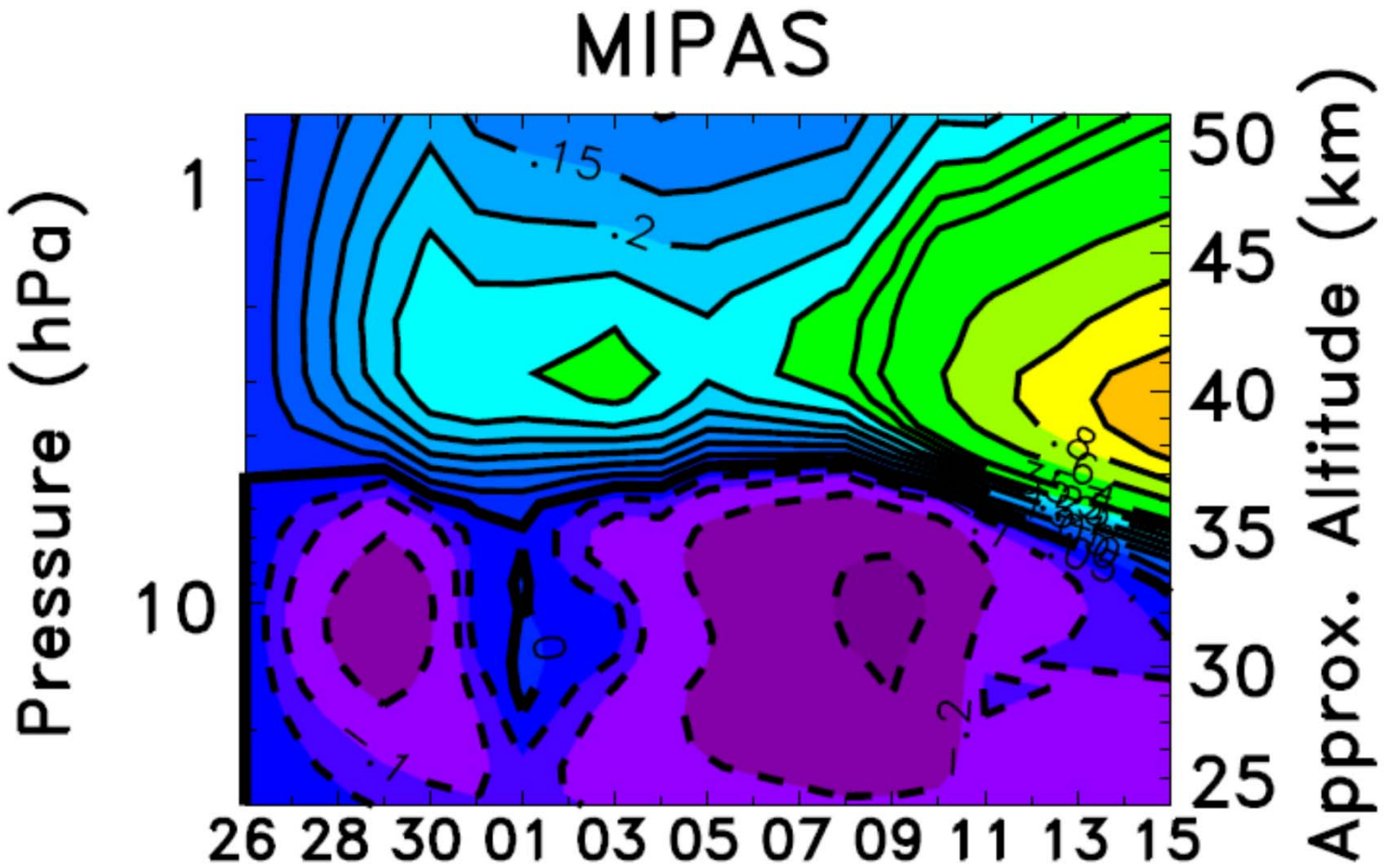
Ph.D. thesis S. Versick 2010

SPE fall 2003: $\Delta ClONO_2$ (night)



López-Puertas et al., 2005; von Clarmann et al., 2005, Jackman et al. 2008

SPE Fall 2003: ΔN_2O_5 (night)



López-Puertas et al., 2005; Jackman et al., 2008

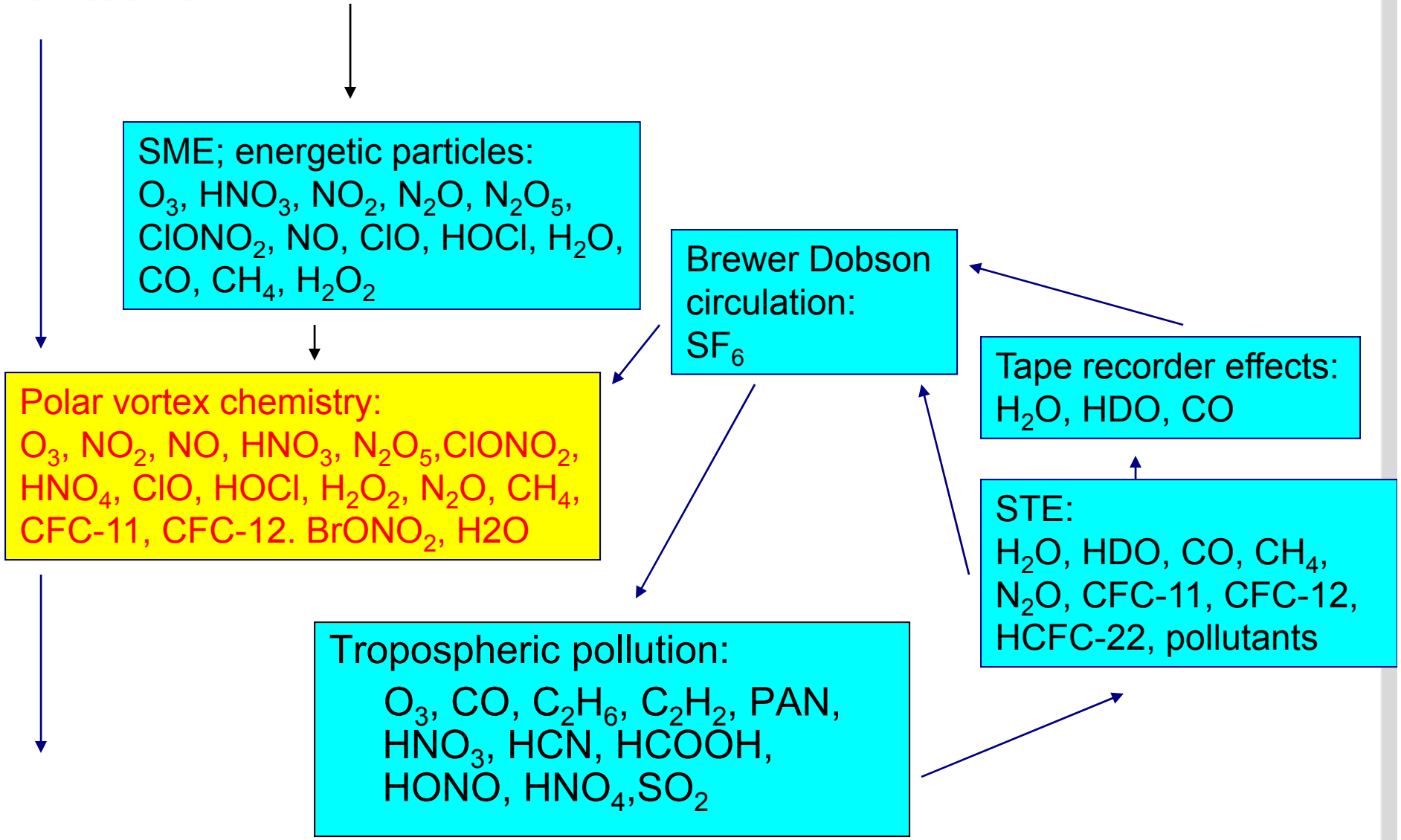
Response of the atmosphere to energetic particle precipitation observed by MIPAS:

Gases analysed by IMK/IAA:

- O_3
- HNO_3
- NO_2
- N_2O
- N_2O_5
- $ClONO_2$
- ClO
- HOCl
- H_2O
- CO and CH_4 (subsidence tracers)

Related questions:

- Quantification of Ion chemistry;
- Validation of postulated reaction paths;
- In situ production or subsidence?
- Long-term or short-term perturbation?
- Impact on ozone chemistry;
- Impact on climate.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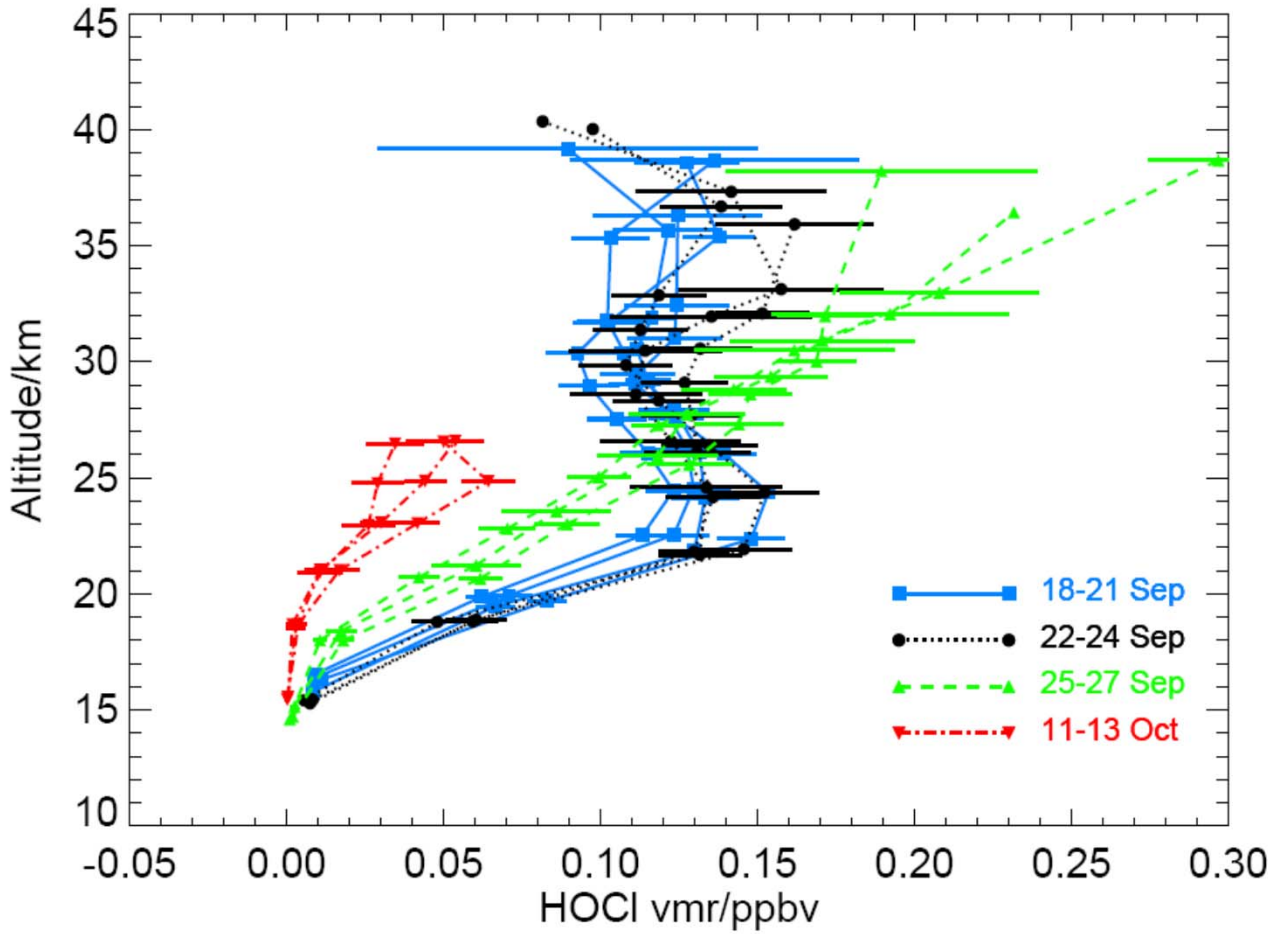
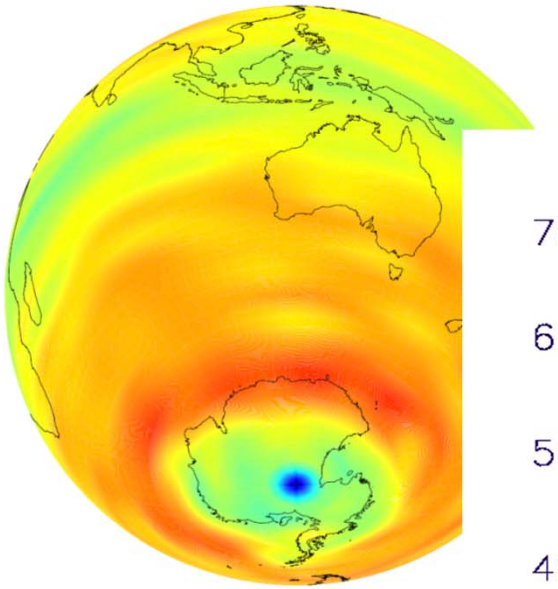
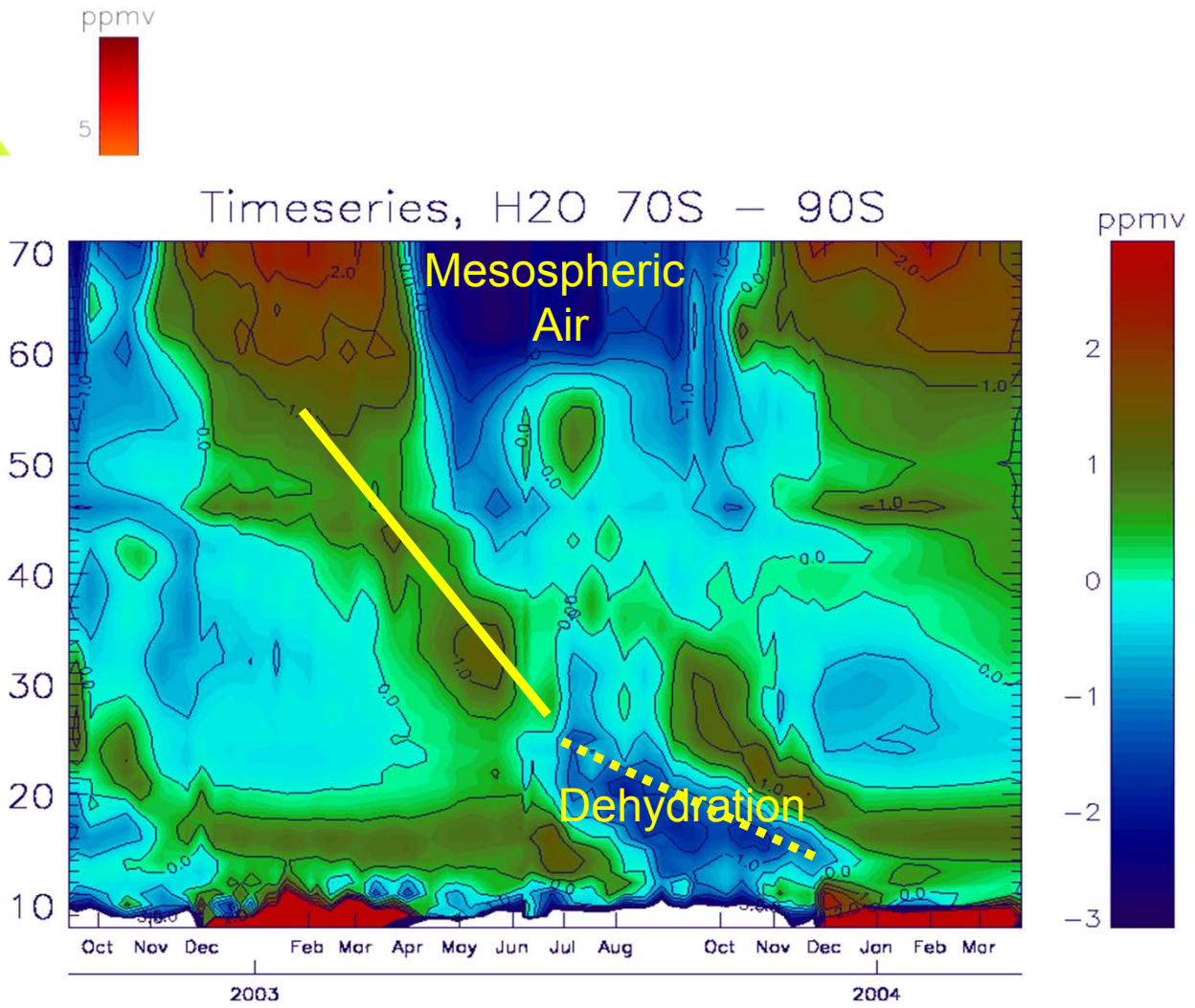
Polar vortex chemistry: HOCl



Dehydration of the polar vortex





Milz et al.
unpublished data

Mar 2004

Polar Vortex Chemistry

Gases analysed by IMK/IAA:

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- NO_2
- N_2O
- N_2O_5
- NO
- $ClONO_2$
- ClO
- HOCl
- H_2O_2
- H_2O
- CO, N_2O, CH_4, CFC-11, CFC-12 (subsidence tracers)
- $BrONO_2$ (!)

Related Questions:

- PSC formation and heterogeneous processes
- Halogen chemistry
- HO_x chemistry
- Nitrogen chemistry
- Impact of mesospheric air

IMK/IAA MIPAS data are available to registered users:

http://www.imk-asf.kit.edu/english/308.php

or just type “IMK MIPAS data access” in your search engine

ESA MIPAS data (much less species, simpler processing, earlier availability) are available to registered users at:

http://envisat.esa.int/instruments/mipas


Be careful: whatever you do in the stratosphere, MIPAS will stand up as witness.
THANK YOU!