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MIPAS observations of the Asian monsoon anticyclone: Focus on water vapor, tracers, and pollutants

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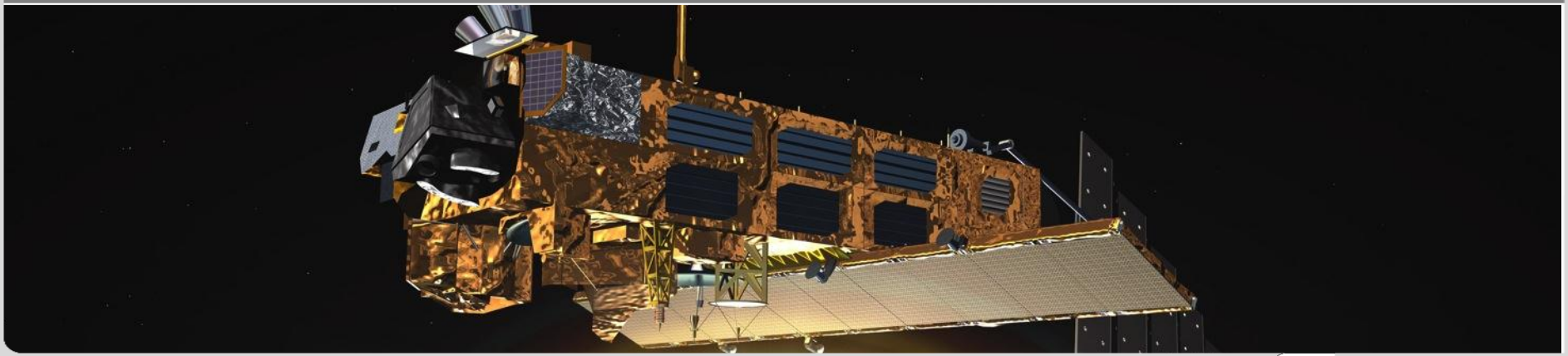
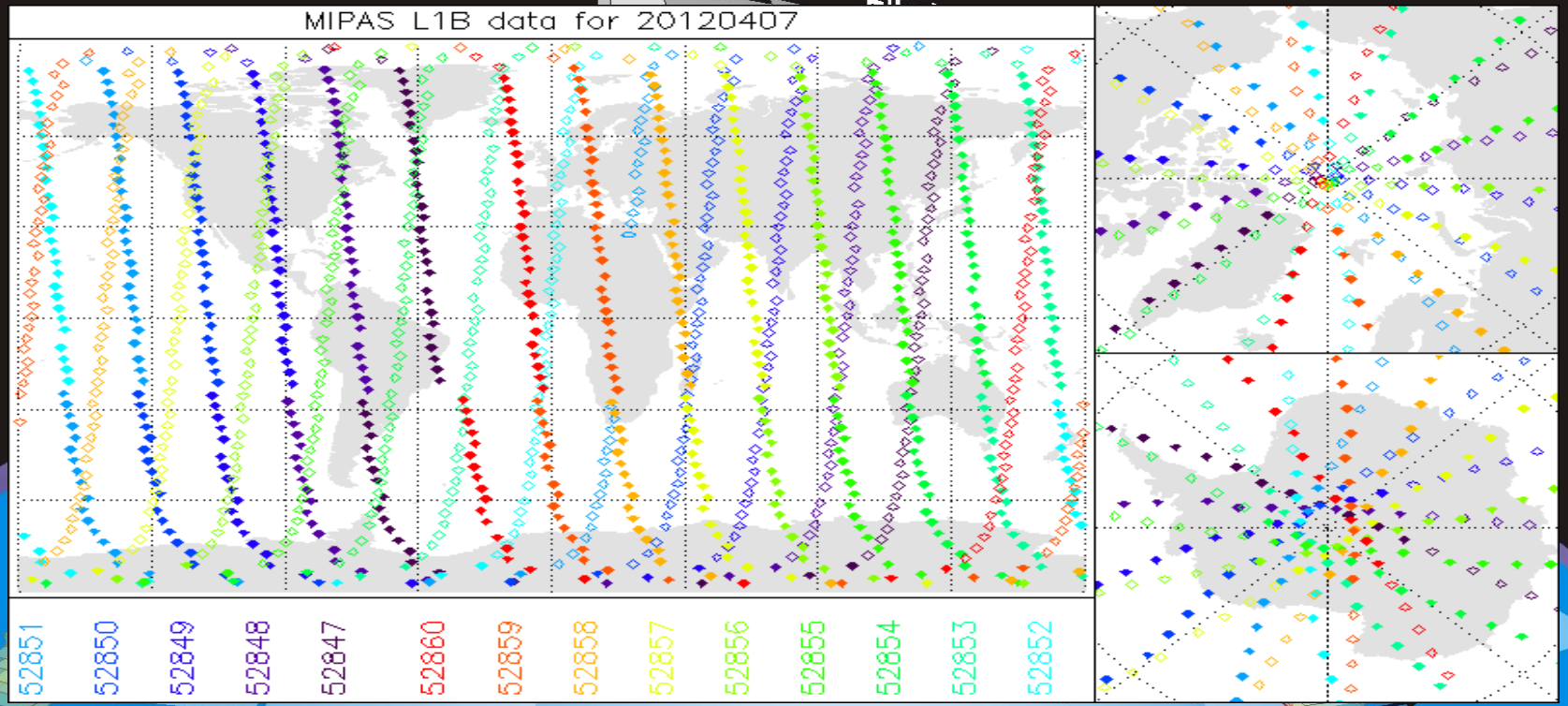


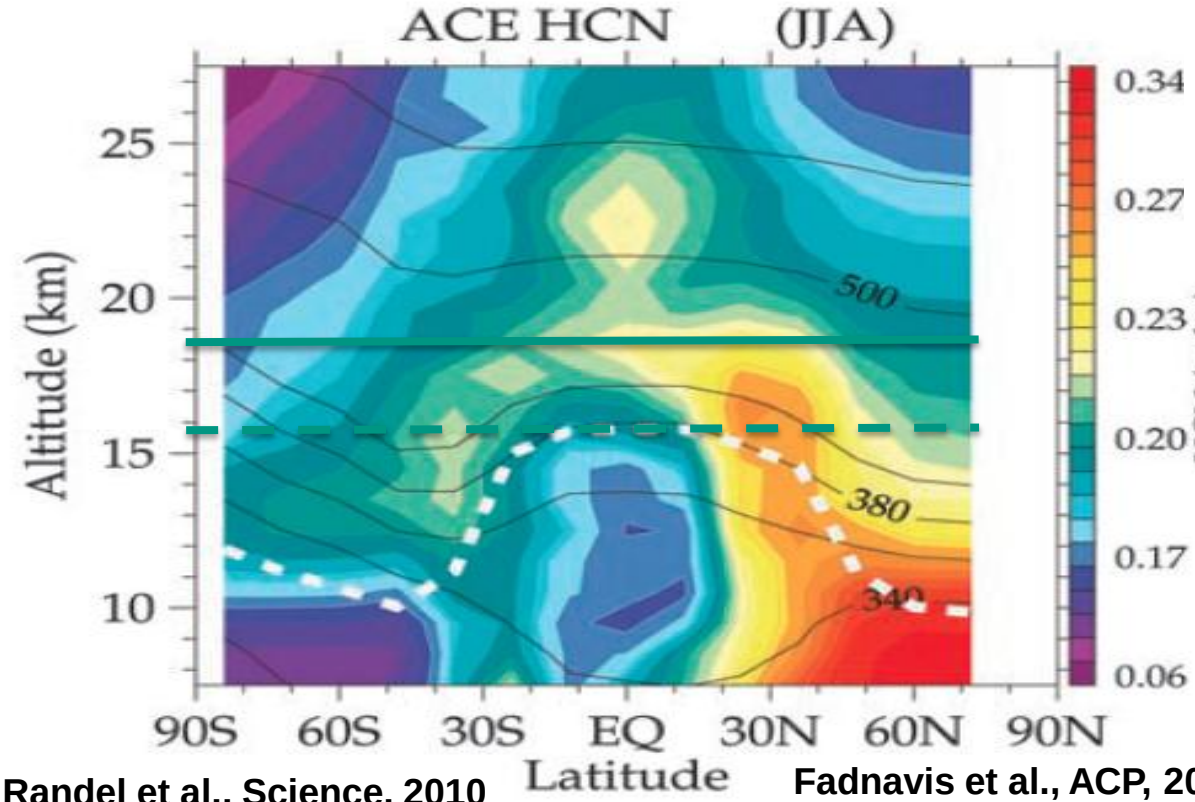
MIPAS overview

- FTIR limb … visat from July 2002 to A…
- Altitude c… 2 km
- More thar… clouds and temperatu… 000 before 2005)
- Full data … rsion 5) available, see http://… IPAS data IMK“
- Trace spe… O3, C2H2, C2H6, CO, HCN…
- Several re… species ➔ the 100 000 …

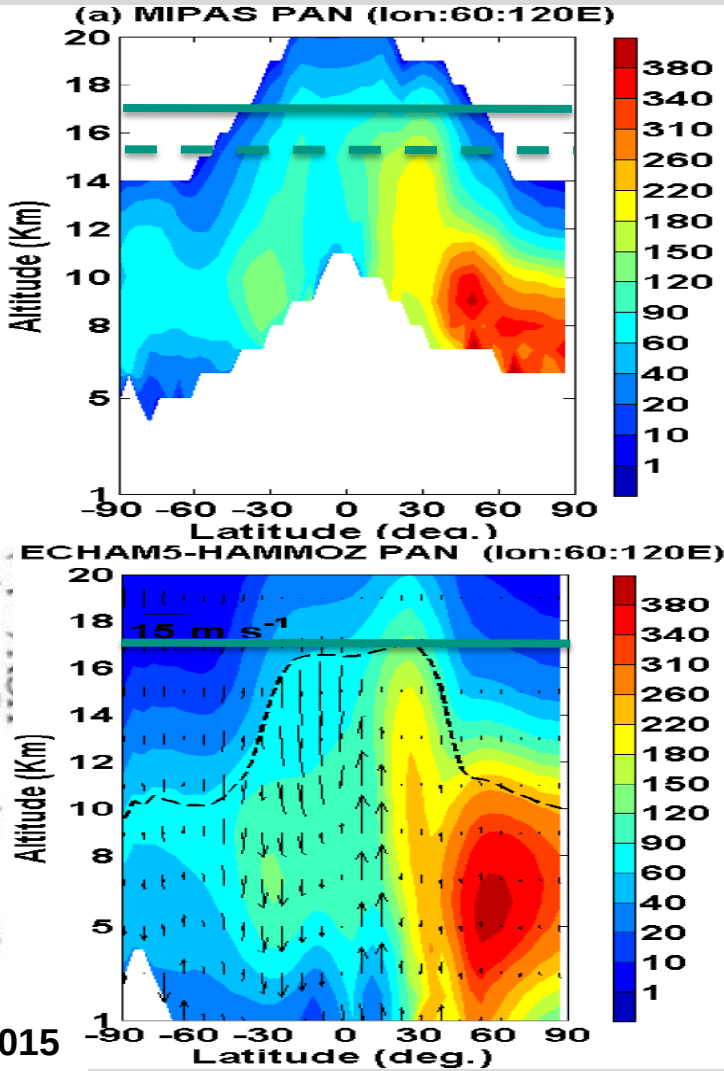
MIPAS overview



Is the Asian monsoon system a relevant pathway for direct trop-strat transport?

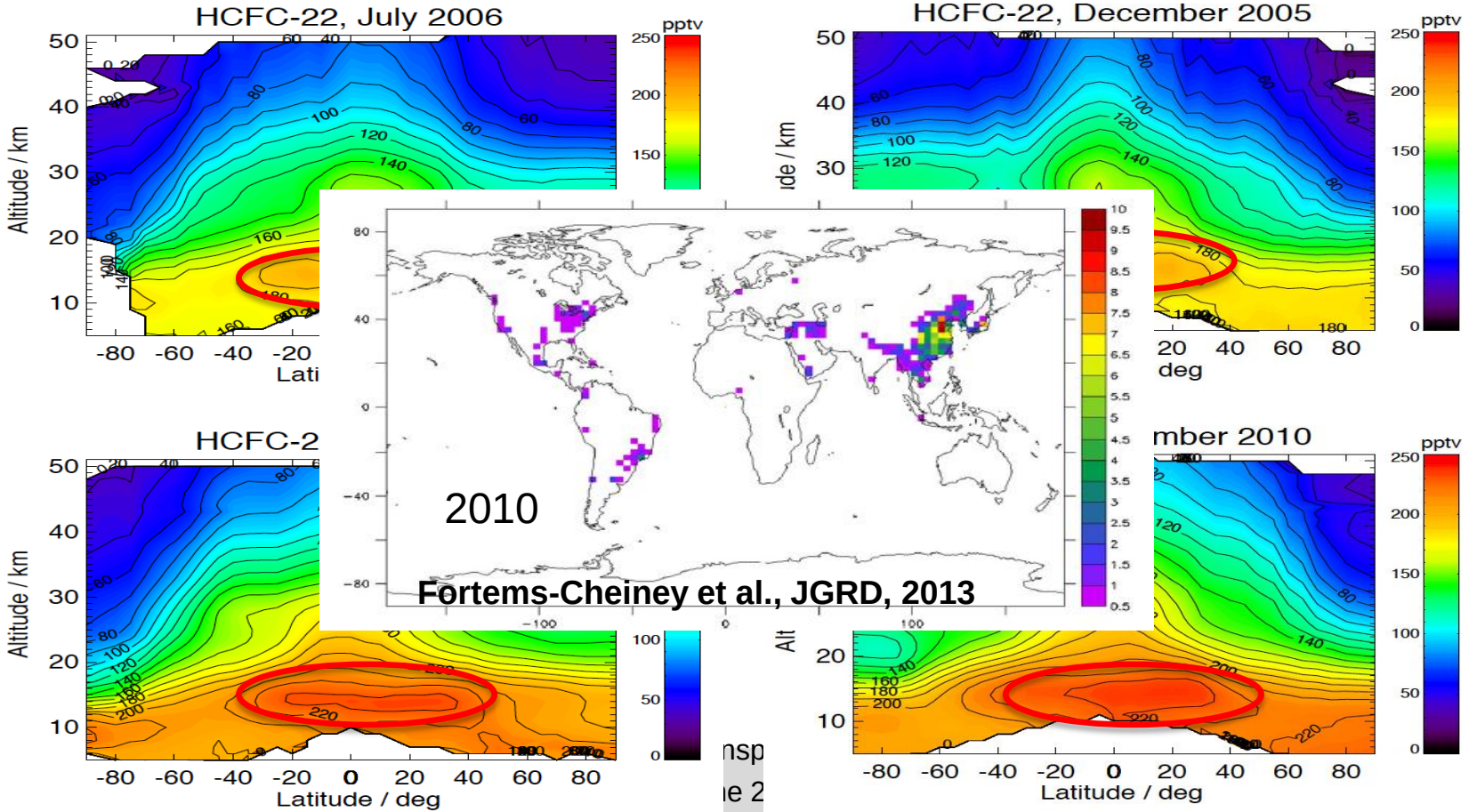


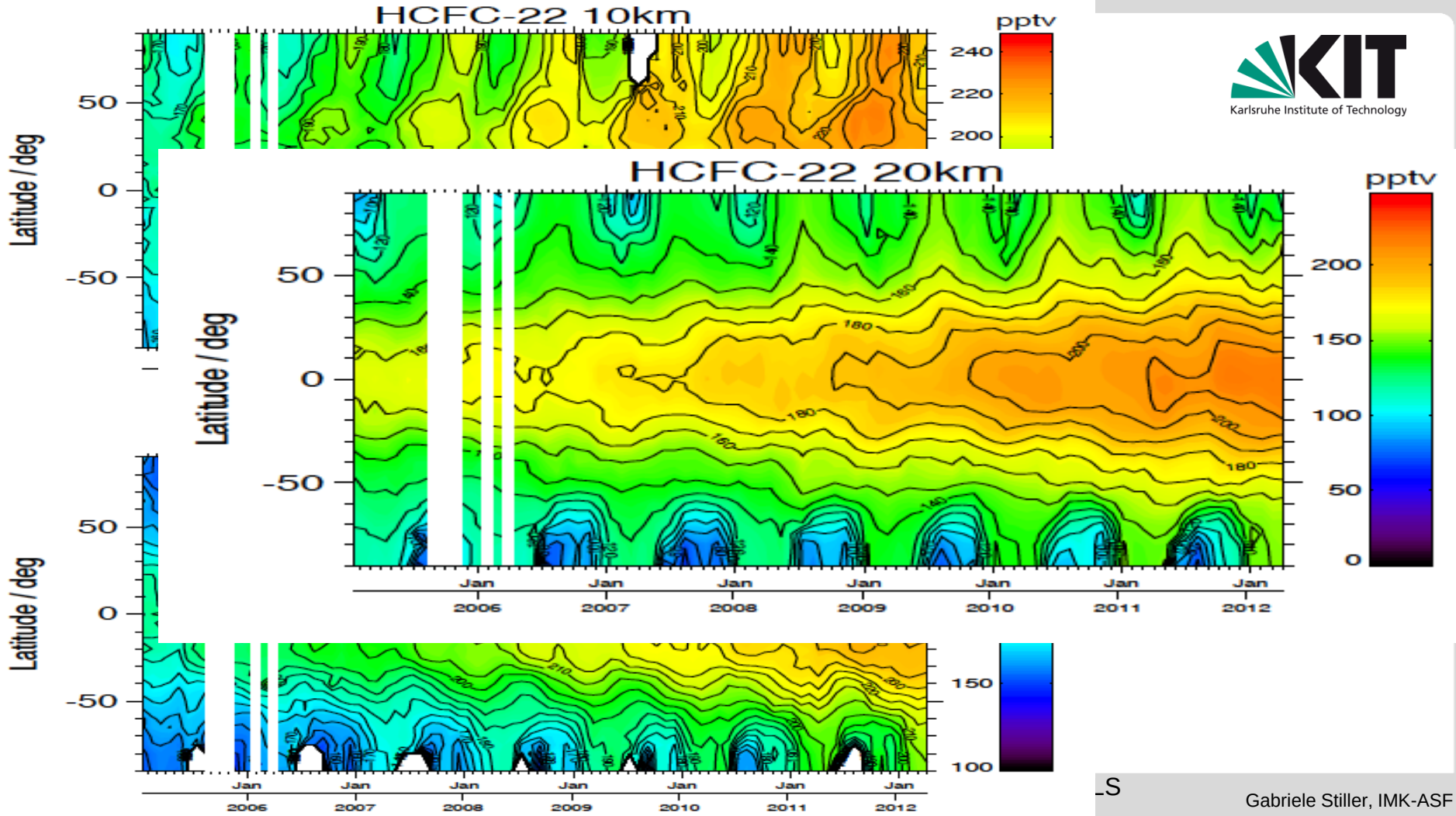
Randel et al., Science, 2010



Fadnavis et al., ACP, 2015

Transport of Asian emissions by the Asian summer monsoon





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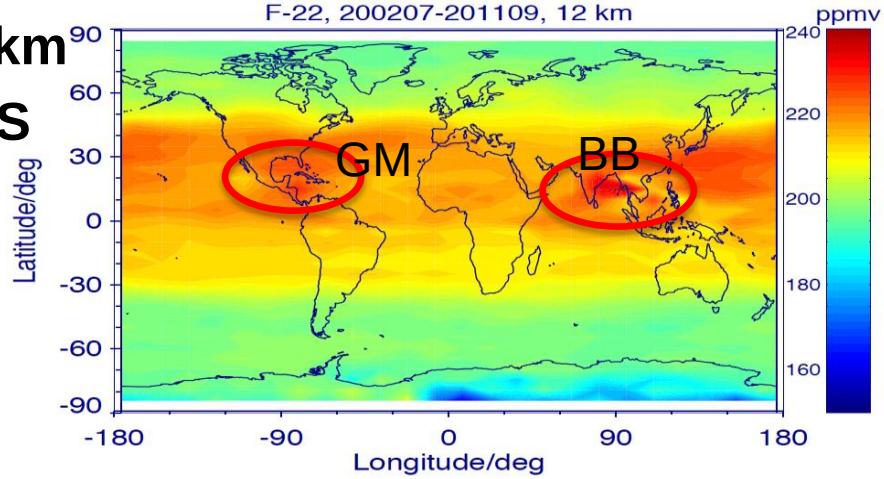
LS

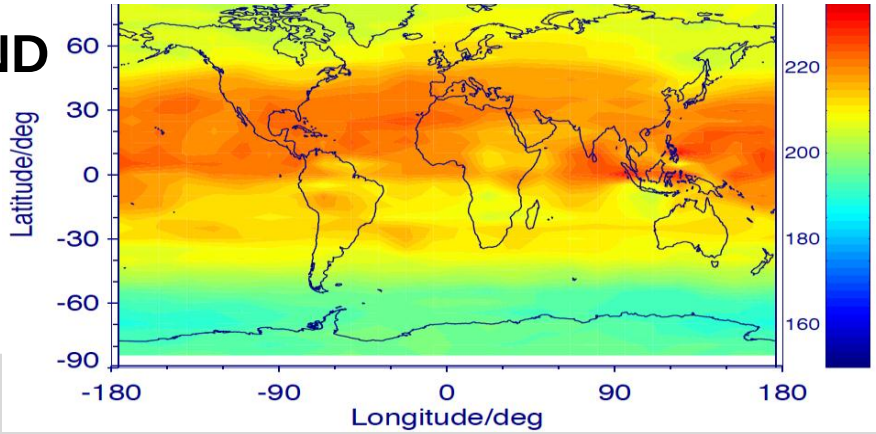
Global maps: 12 and 16 km, JAS and OND

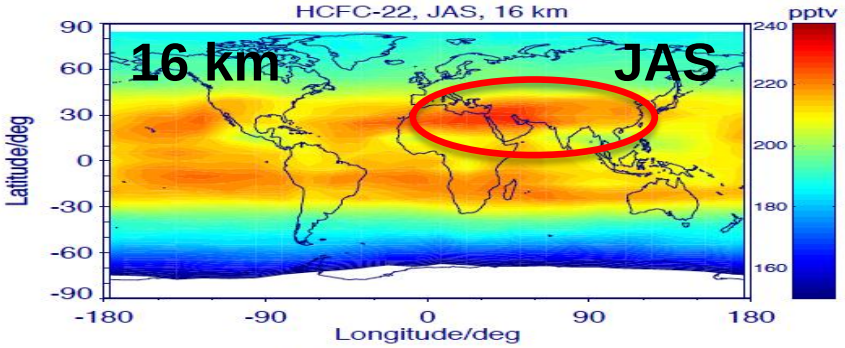
12 km

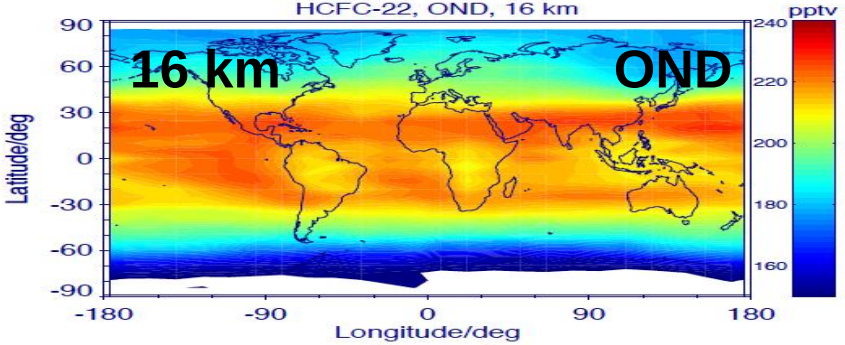
JAS

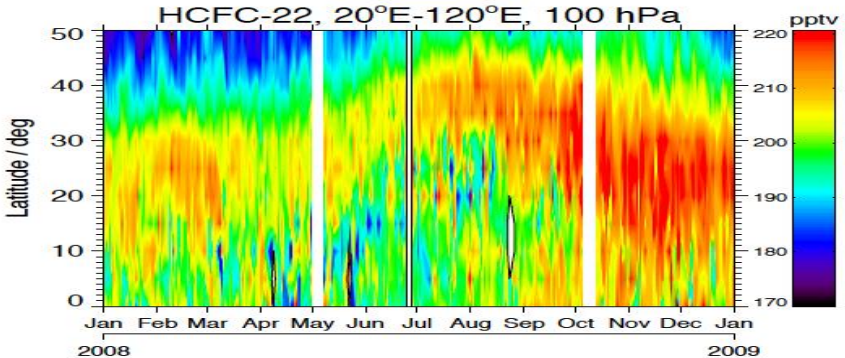


OND



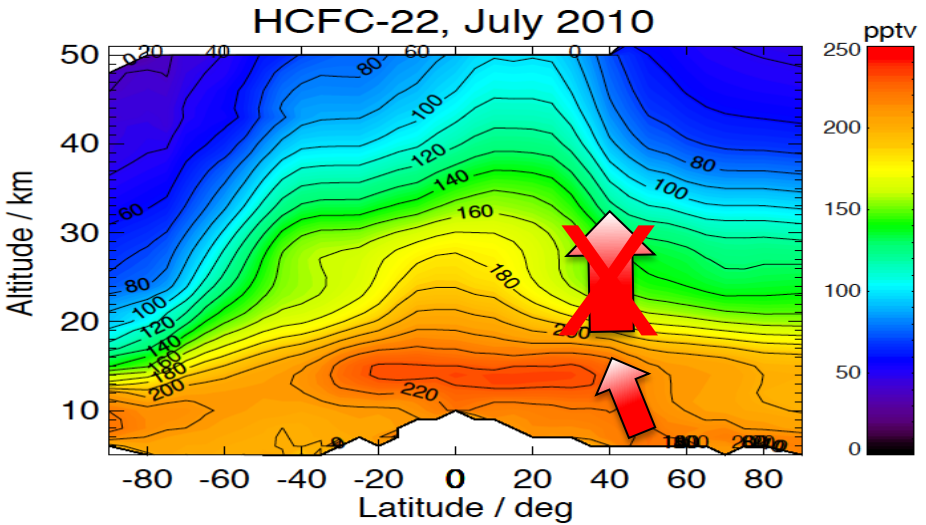


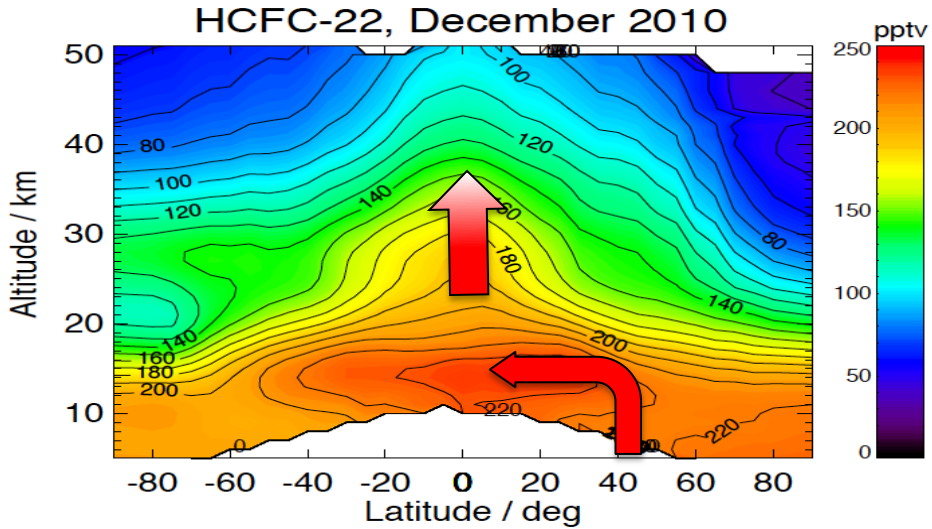




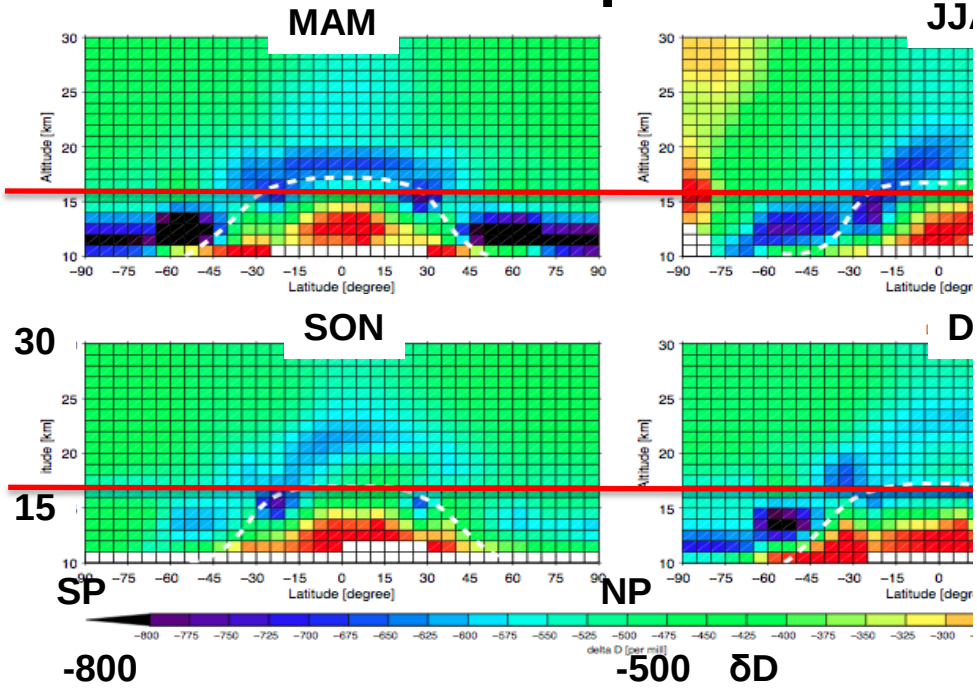
Transport of Asian emissions by the Asian summer monsoon

- HCFC-22 abundances of > 240 pptv are higher than observed at any ground-based station
- East-Asian emissions are uplifted in the monsoon convective systems and trapped within the AMA during summer
- They are distributed **below the tropopause** over the entire tropics
- They are uplifted in the tropical pripe to the stratosphere
- No significant direct TSE from the AMA in the subtropics

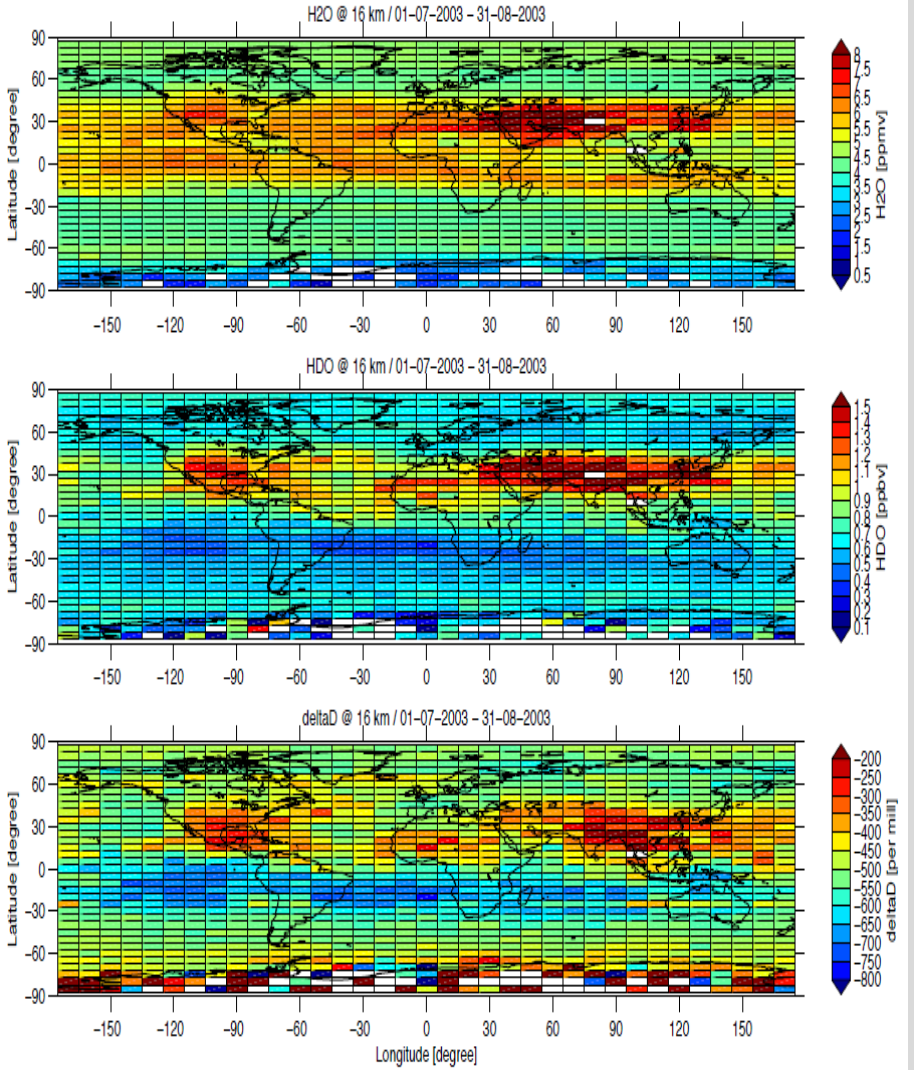




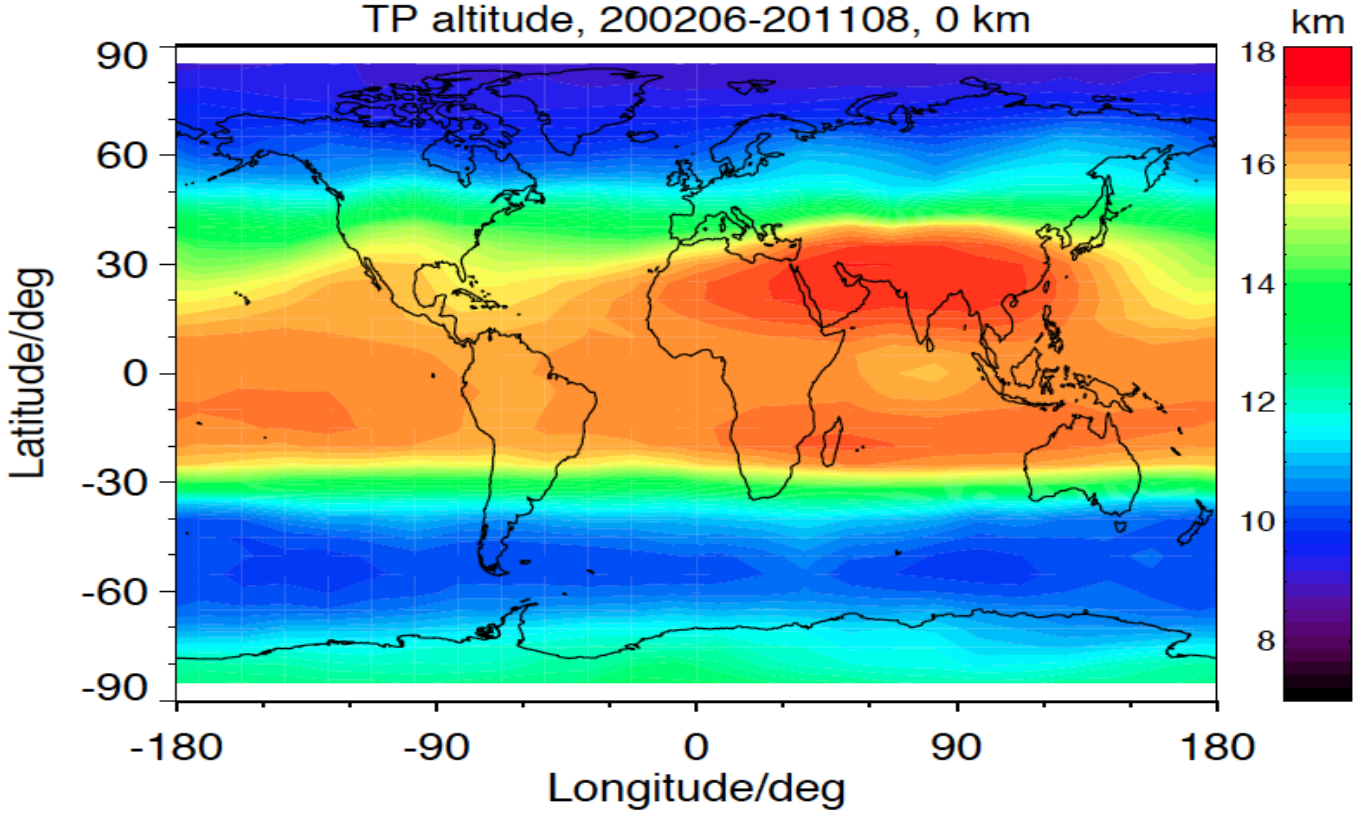
Transport of water vapor throug
ctnd.: monsoon impact



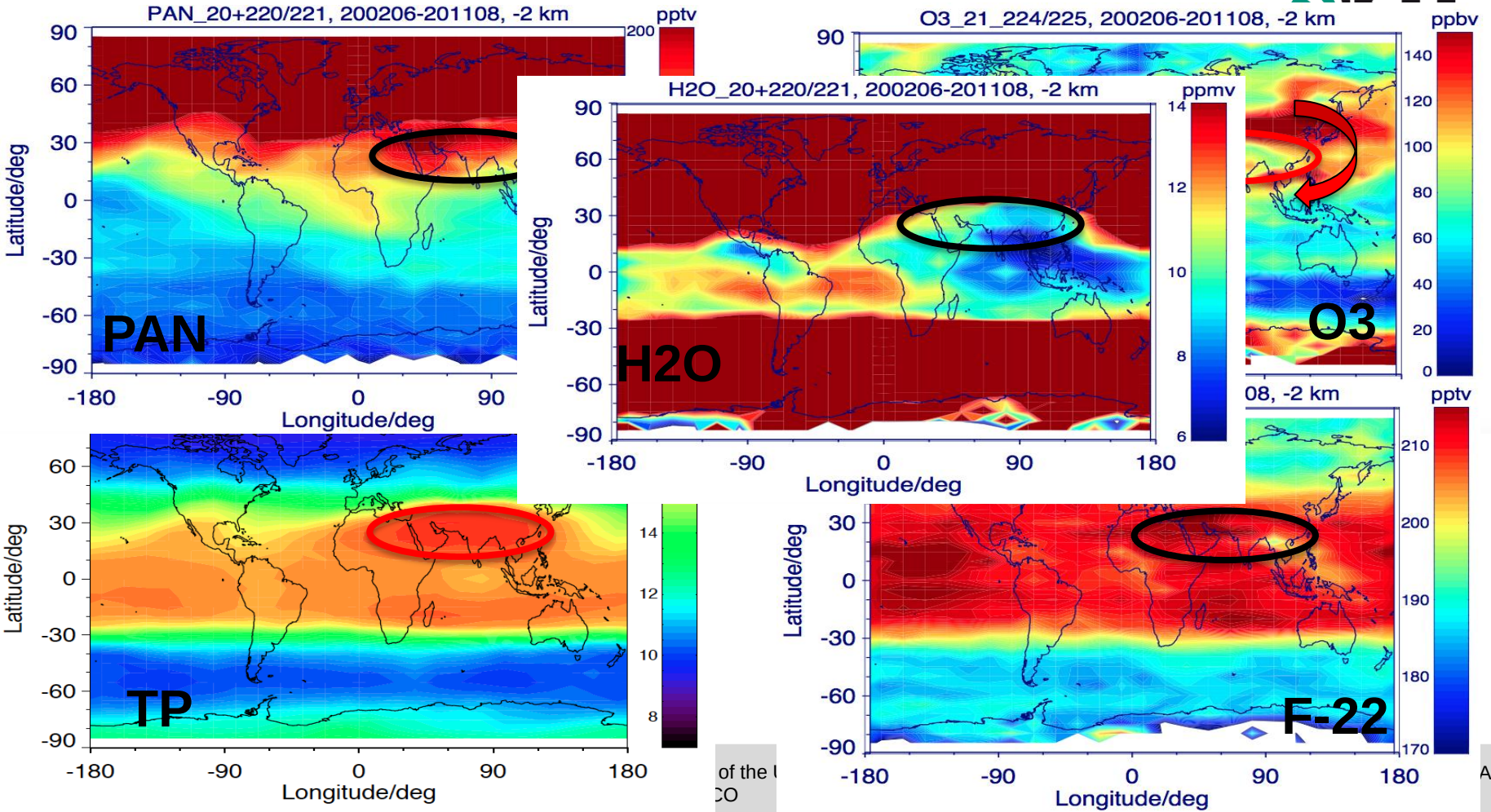
Lossow et al, in preparation



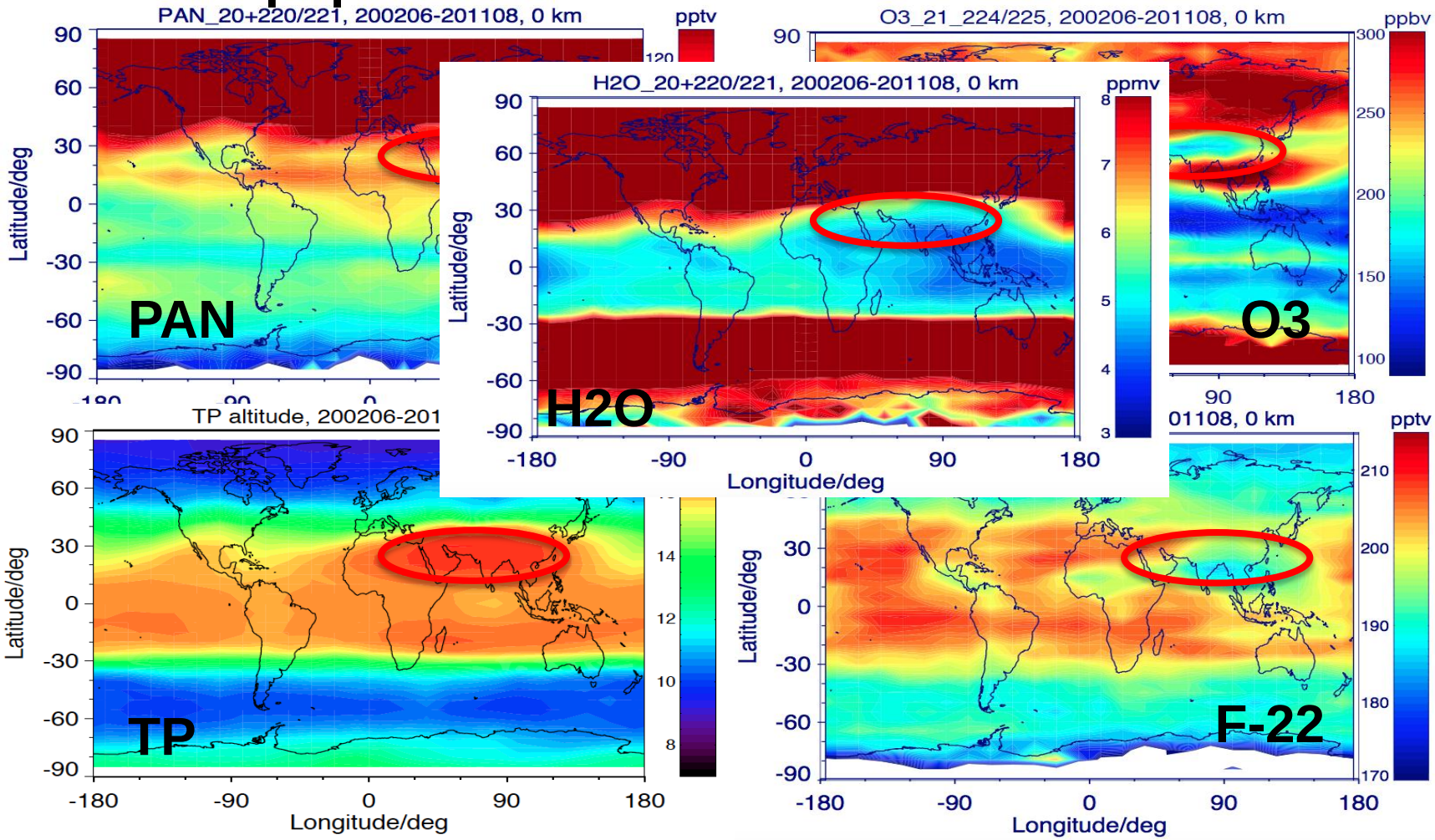
Tropopause height for JJA (from MIPAS temperature profiles)



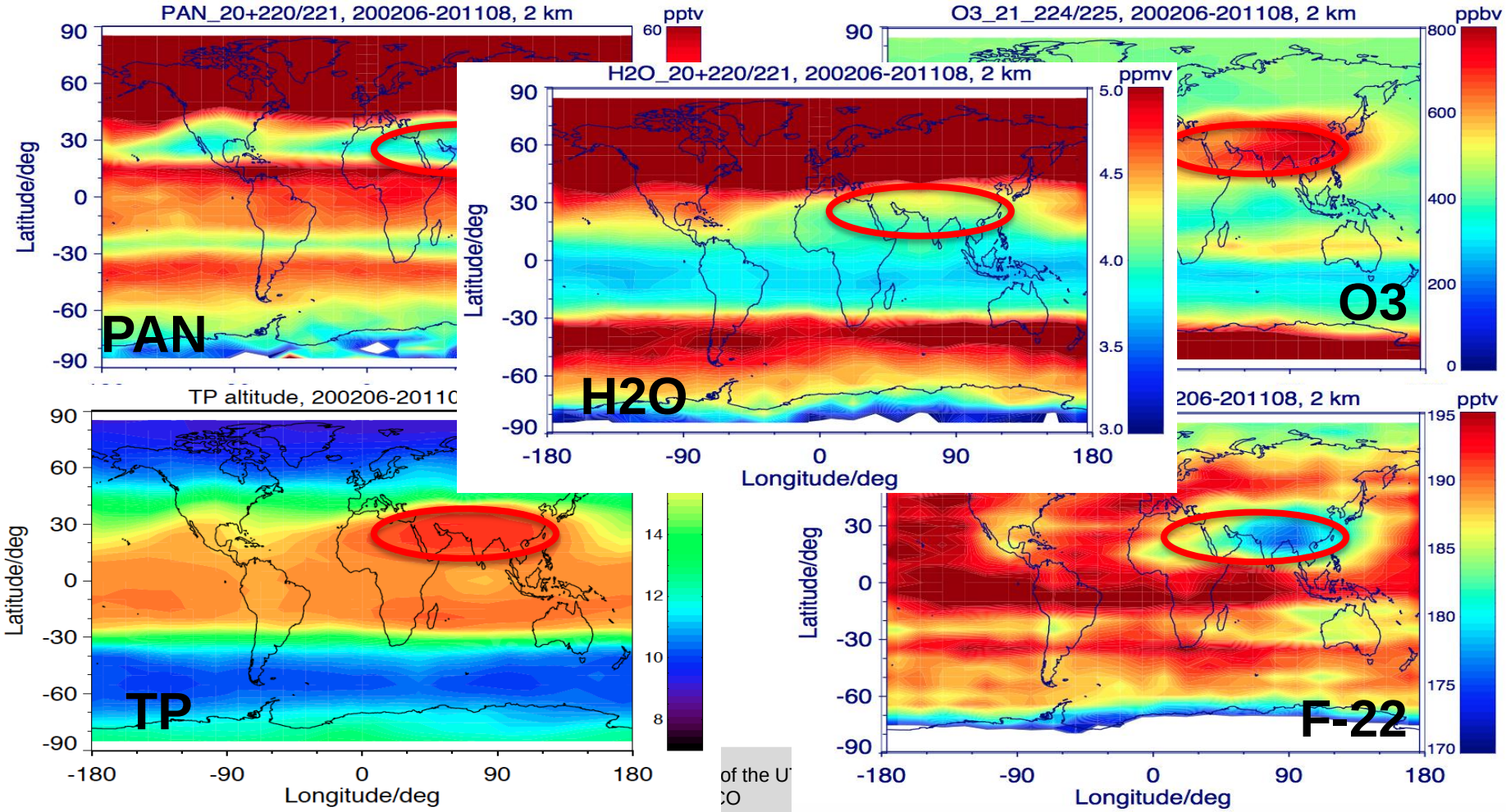
2 km below the tropopause



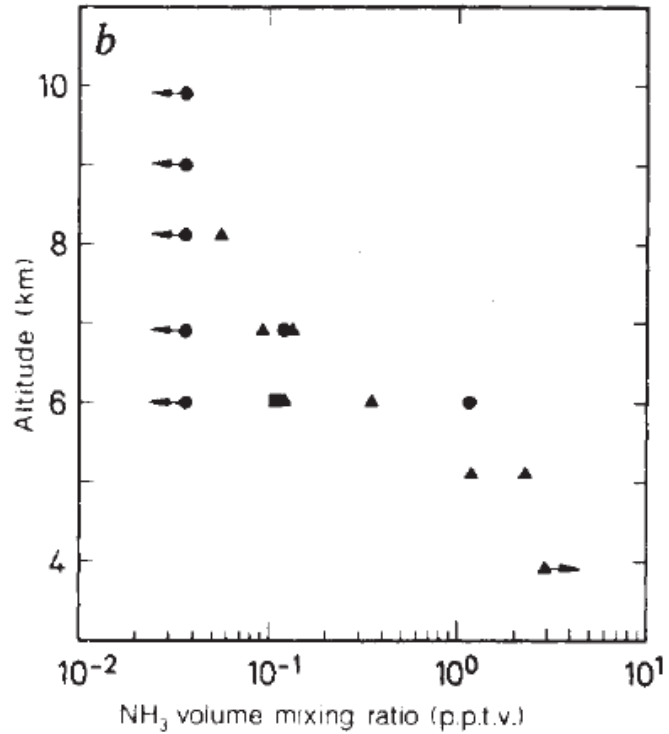
At the tropopause



2 km above the tropopause

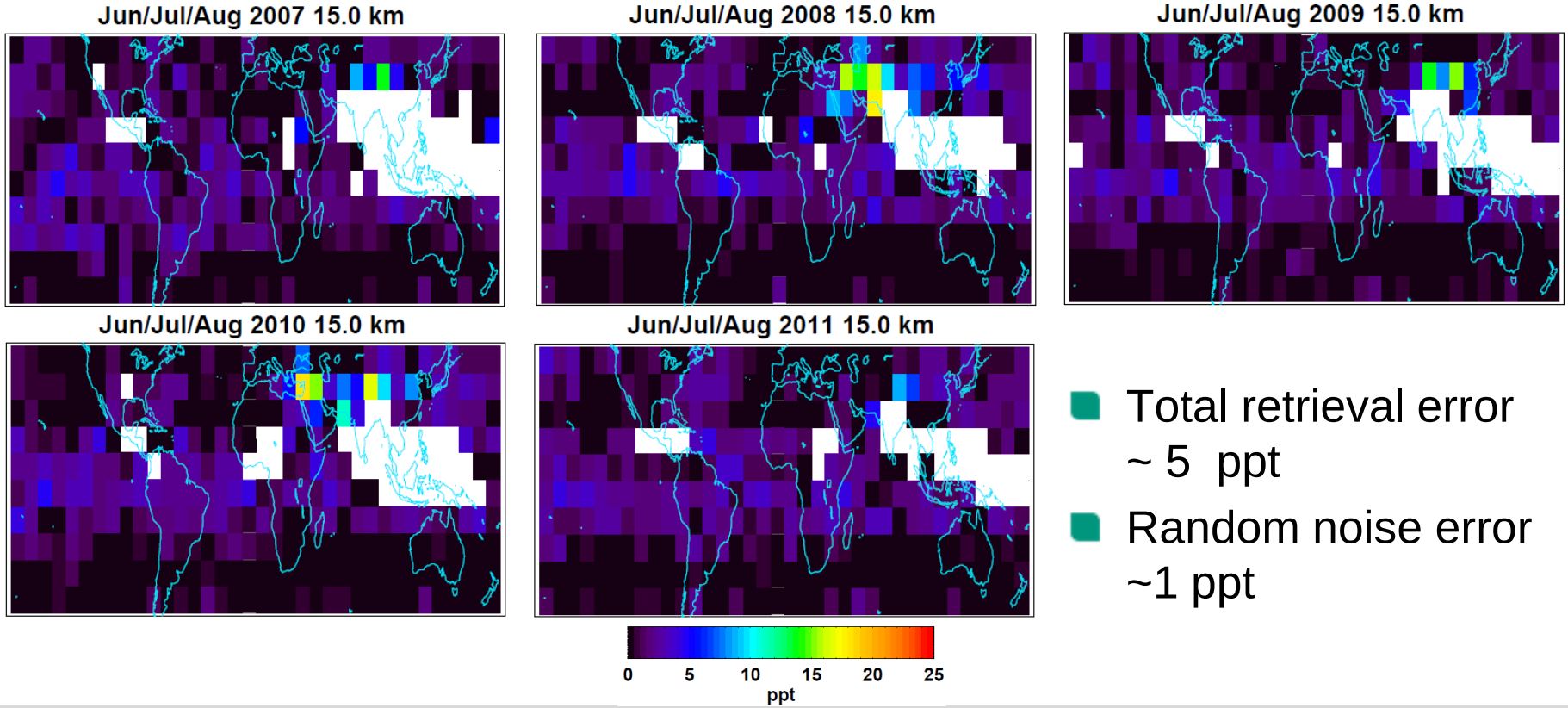


Ammonia (NH_3) in the UTLS?



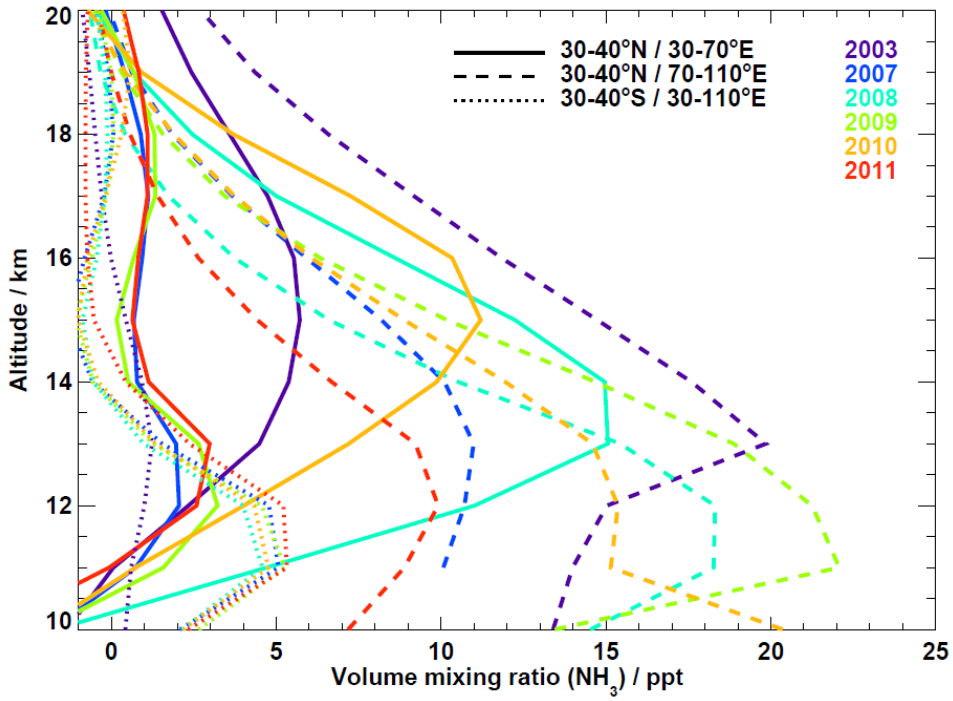
- Only measurements of ammonia in the UT by Ziereis and Arnold, Nature, 1986
- NH_3 volume mixing ratios clearly below 0.1 ppt in the UT

NH_3 distribution 50N/S: Jun/Jul/Aug 2005-2011



- Total retrieval error ~ 5 ppt
- Random noise error ~1 ppt

NH_3 profile comparisons



- NH3 maximum larger and at lower altitudes in the eastern part of the monsoon area - - - -
- Much more variable and peaking at higher altitudes in the western part ------
- Maximum in southern hemisphere indicates detection limit of ~5 ppt ....

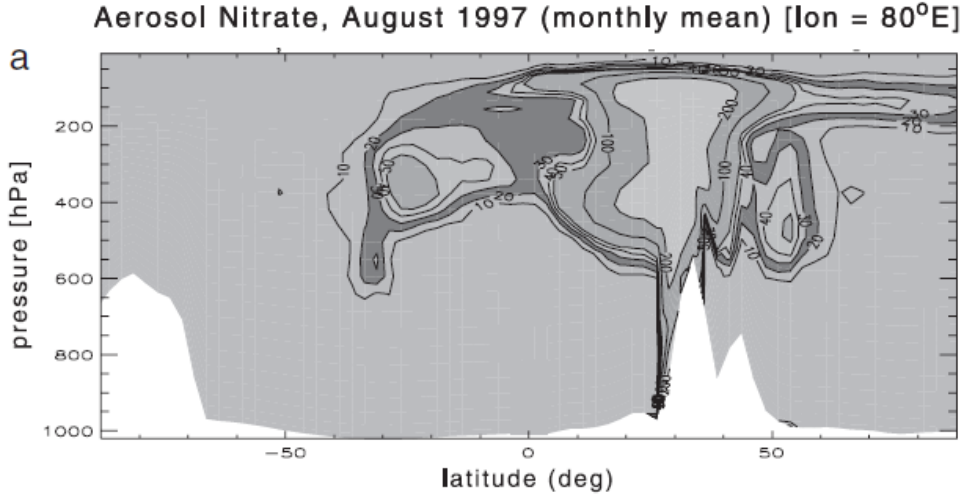
NH3 and the ATAL?

Metzger et al., 2002

Gas/aerosol partitioning

2. Global modeling results

[24] Figures 4a and 4b illustrate that ammonium nitrate aerosol may be formed and transported to the free troposphere, even in summer. Remarkably, concentrations can reach up to 200 pptv at 200 hPa over the convective region south of the Himalaya (Figure 4a, top). The only possibility to form nitrate in our model is through aerosol neutralization by ammonia. In Europe during summer there is not



Europe, which actually originates from southern Asia. The explanation is that in northern India ammonia is emitted at relatively high altitudes. During the Indian summer strong monsoon convection is associated with upper tropospheric dry easterlies, while substantial amounts of ammonia are convectively transported above the boundary layer. The convective clouds through which the ammonia is transported are hardly acidic so that the ammonia is only partly dissolved and removed by precipitation. Once transported to the upper troposphere surplus ammonia neutralizes nitric acid that is present in higher amounts than sulfuric acid. As a result, an extended plume of ammonium nitrate is predicted to exist in the upper troposphere. Hence surface emitted ammonia from northern India forms ammonium nitrate that can be efficiently transported in the subtropical jet stream toward Africa and even to southern Europe near the tropopause.

Summary and conclusions

- MIPAS provides many species for the study of the Asian (and American) monsoon UTLS
- HCFC-22 is a good tracer for Indian/Chinese pollution because of its unique sources in East Asia.
- HCFC-22 forms a maximum layer in the tropics below the tropopause, indicating transport from the Asian monsoon UT into the TTL and upward in the tropical pipe.
- Analysis of species at the tropopause: vertical transport through the AMA tropopause rather weak if any; even subsidence above the AMA?
- Strange behaviour of H2O at the AMA tropopause, more linked to the West Pacific.
- New product: NH3, enhanced in AMA (for some years); link to ammonium nitrate aerosol and ATAL.

Thank you!