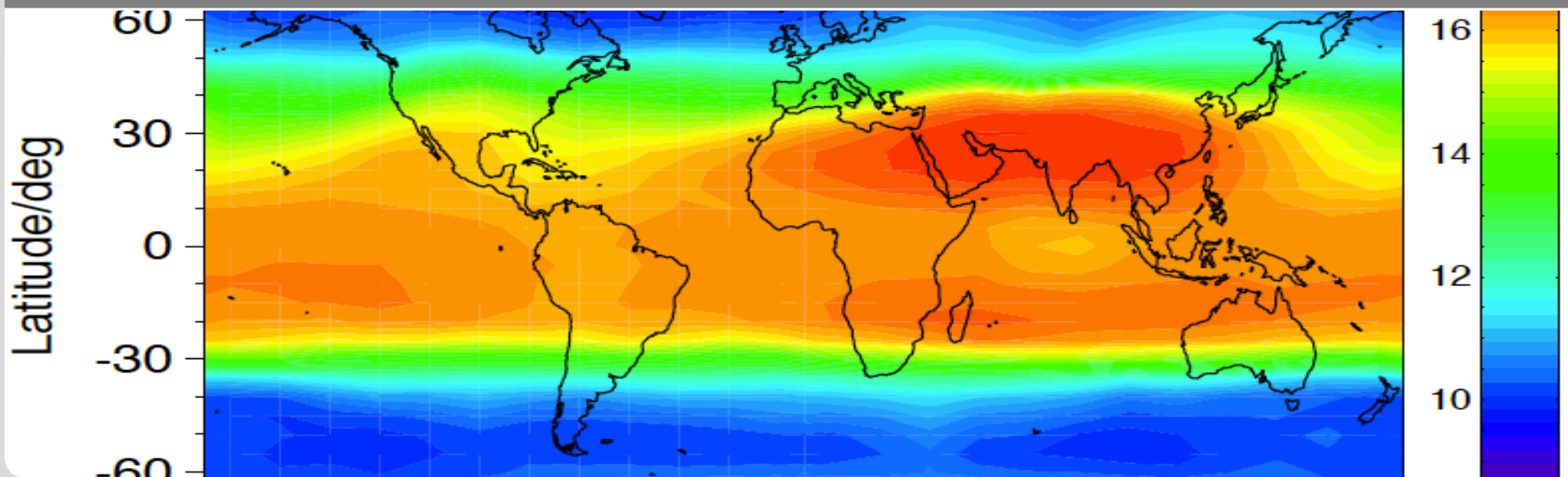


Tropopause-following analysis of water vapour and ΔD for the monsoon systems and the tropics

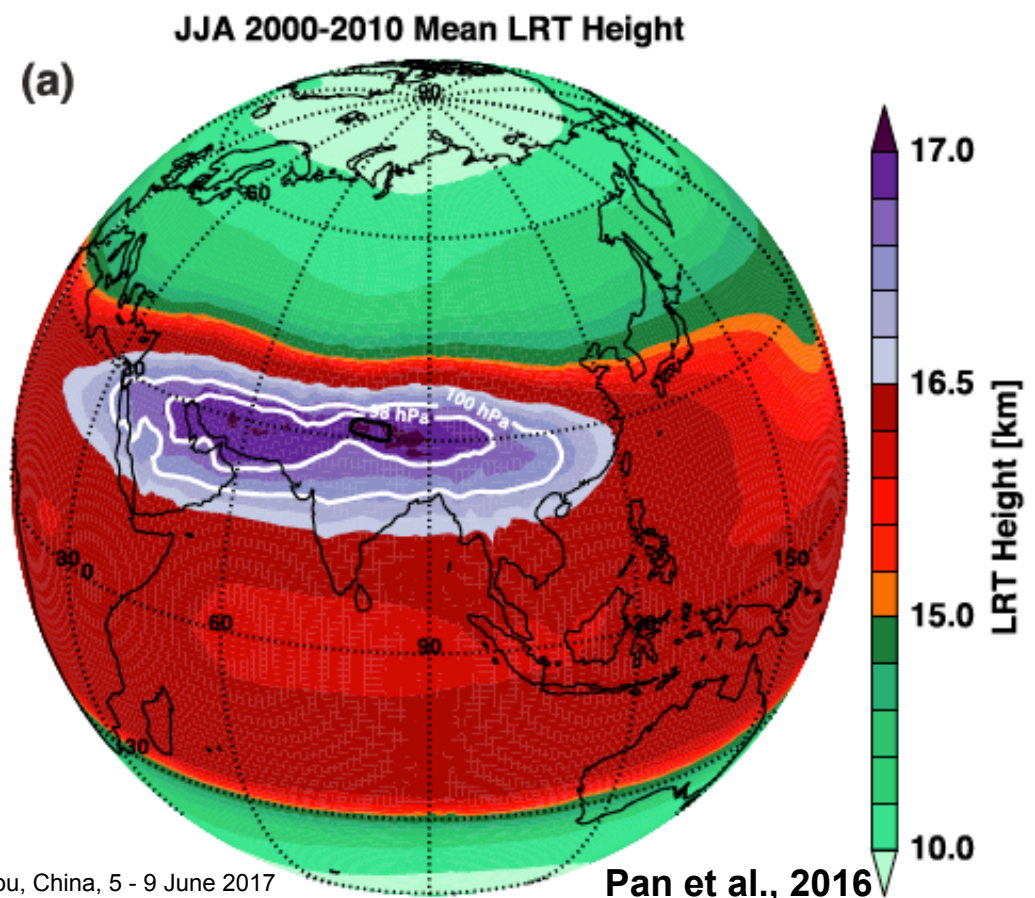
Gabriele Stiller, Norbert Glatthor, Stefan Lossow, and the MIPAS team at KIT

INSTITUTE OF METEOROLOGY AND CLIMATE RESEARCH, ATMOSPHERIC TRACE GASES AND REMOTE SENSING



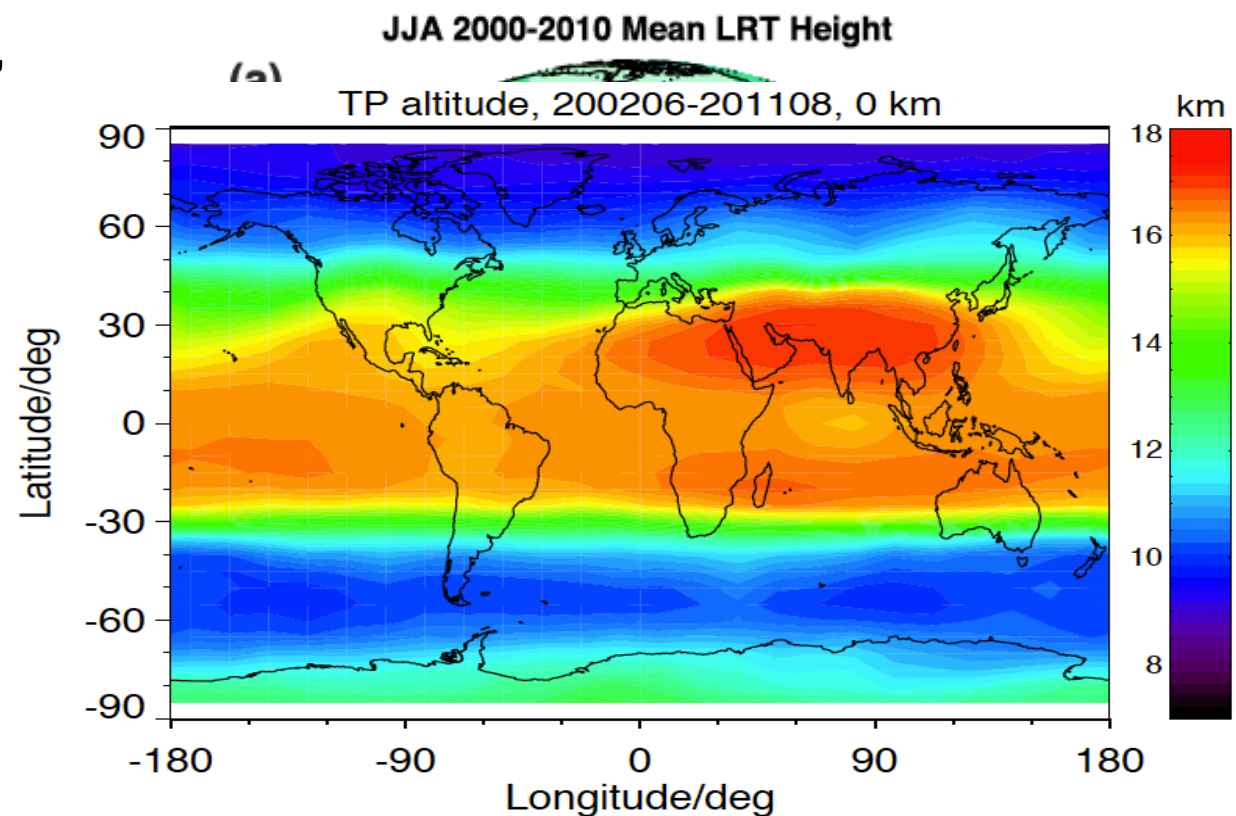
Motivation / open questions

- How is water vapour transported into the stratosphere?
- In particular: What role plays overshooting of convection?
- Are there systematic differences in relevance or frequency for monsoon systems and tropics, respectively?
- Tropopause altitude varies considerably, on altitude, pressure and potential temperature levels
- Therefore: analysis directly on tropopause surfaces
- Data base: MIPAS observations of temperature, water vapour and HDO for 2002 to 2012

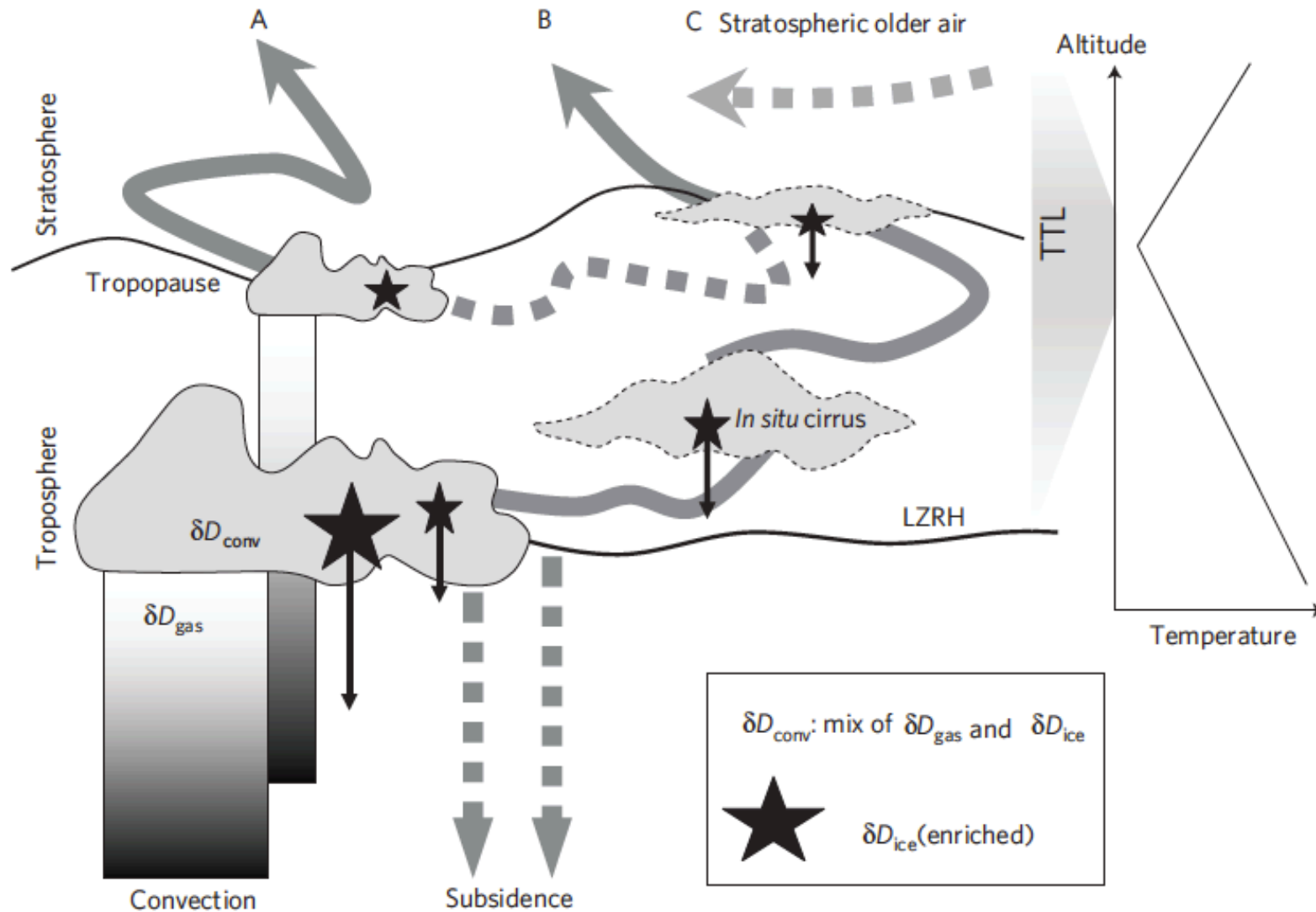


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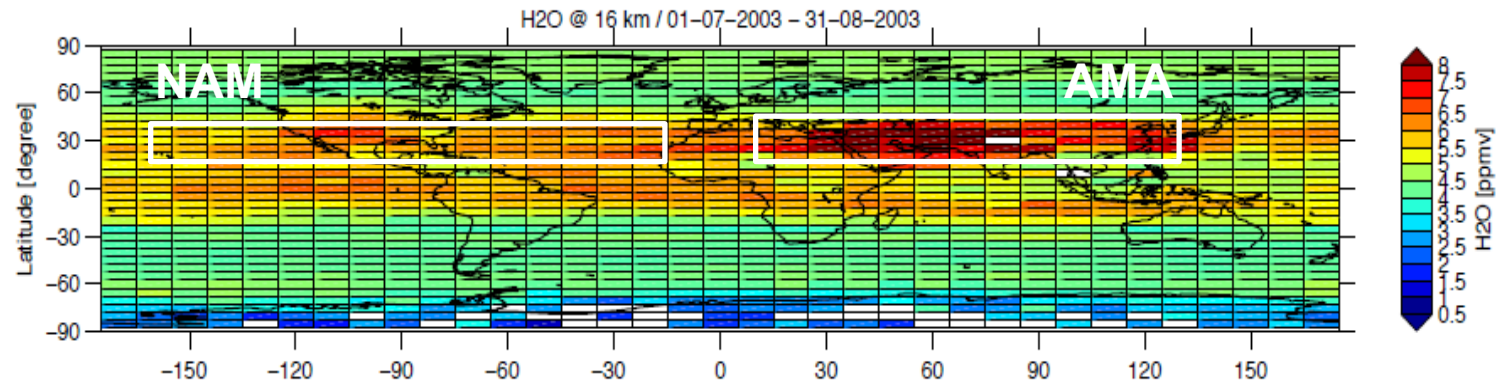


Processes leading to depletion and enrichment of heavy water (ΔD)

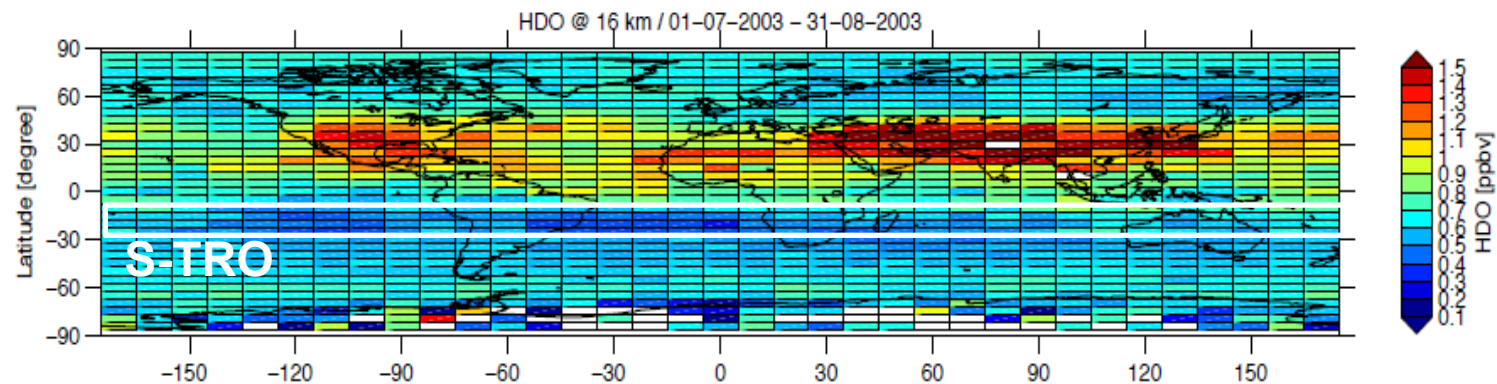


H₂O, HDO and ΔD at 16 km altitude, JA 2003

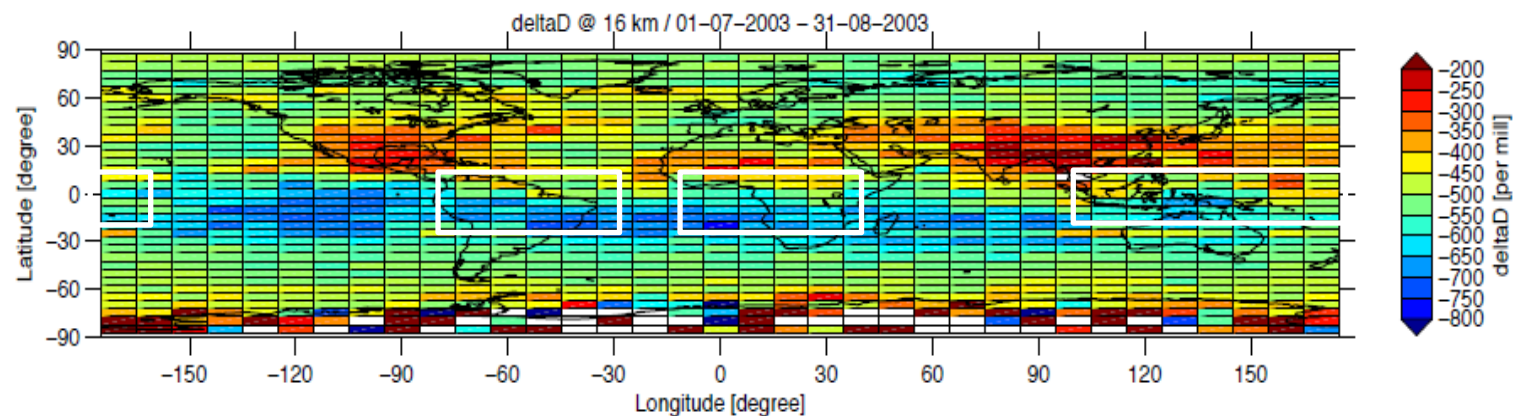
H₂O



HDO

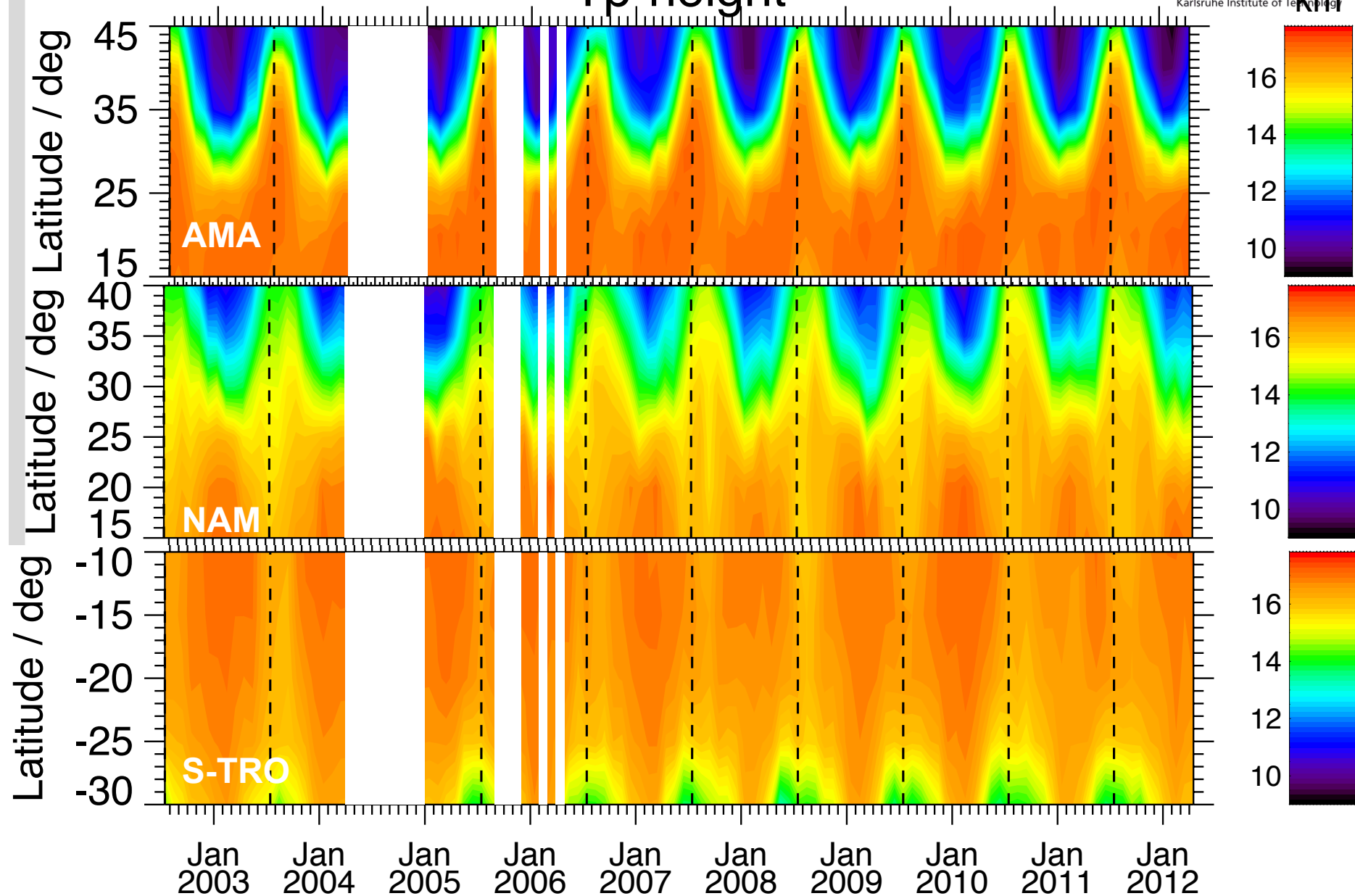


ΔD
@16 km

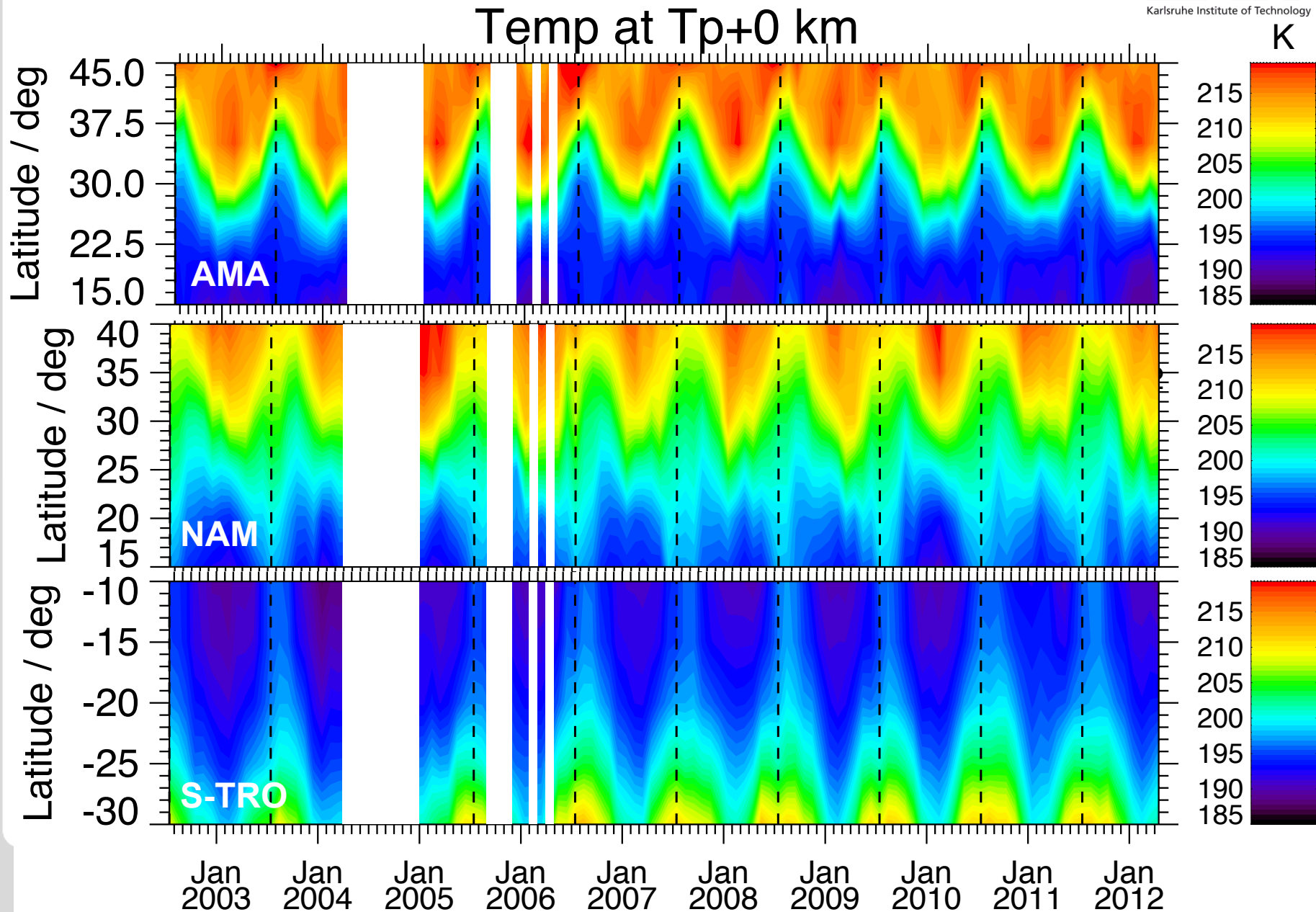


LR Tropopause altitudes from MIPAS

Tp-height



TP temperatures



General behavior of TP

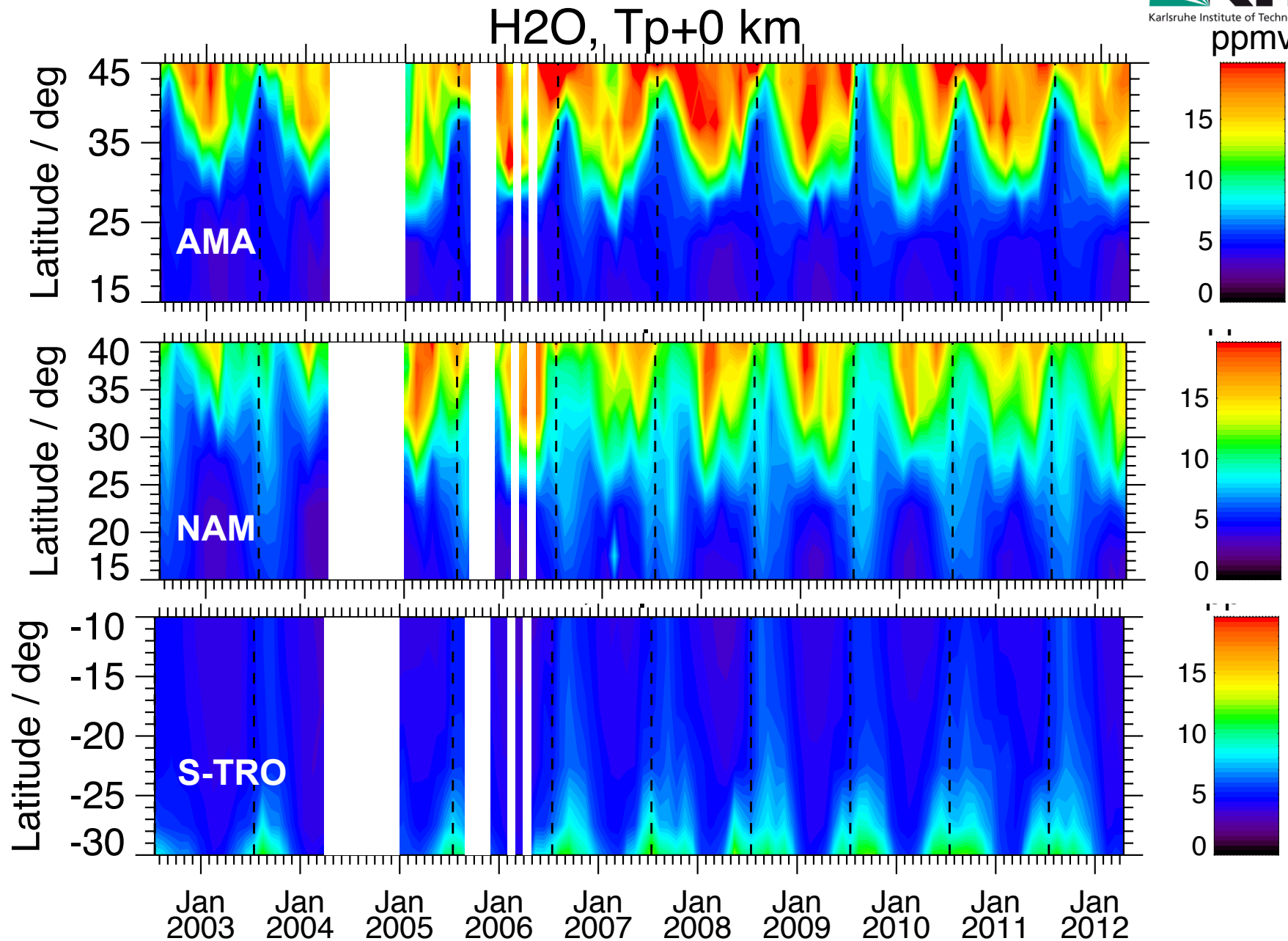
■ Altitude:

- S-TRO: TP highest during SH Summer (16-17 km), lowest around July (< 16 km)
- AMA: highest TP on absolute scale, 17-18 km; highest and the most North around 15 July
- NAM: lower than AMA (~15 km), phase and extension as AMA

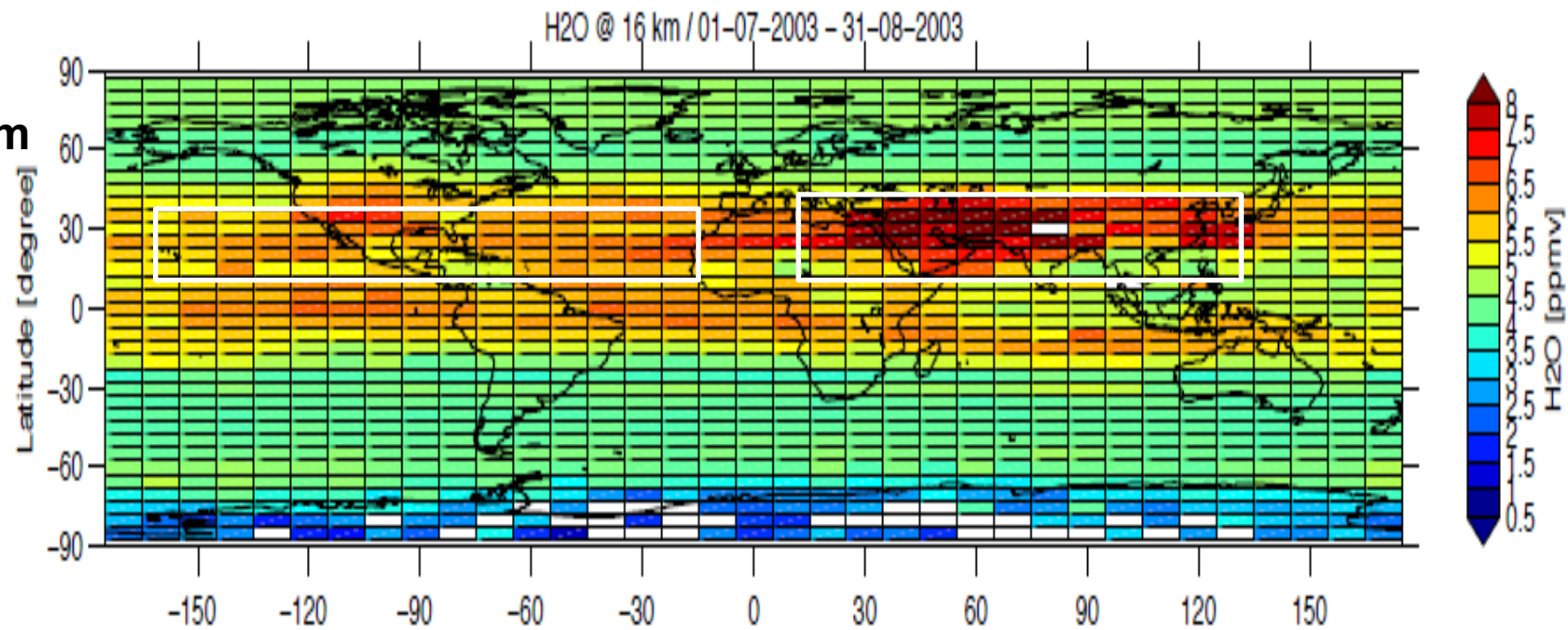
■ Temperature:

- S-TRO: T lowest during SH summer (<190 K), highest around July (~200K); → lowest WV above TP in SH summer; lowest WV absolute
- AMA: coldest and furthest North around July, T ~ 195 K; strong temperature contrast and meridional gradient between monsoon and extra-tropics; → low WV during monsoon season, but higher than tropics
- NAM: less cold than AMA (~200 – 205 K), less strong meridional gradient; → highest WV of all three regions expected

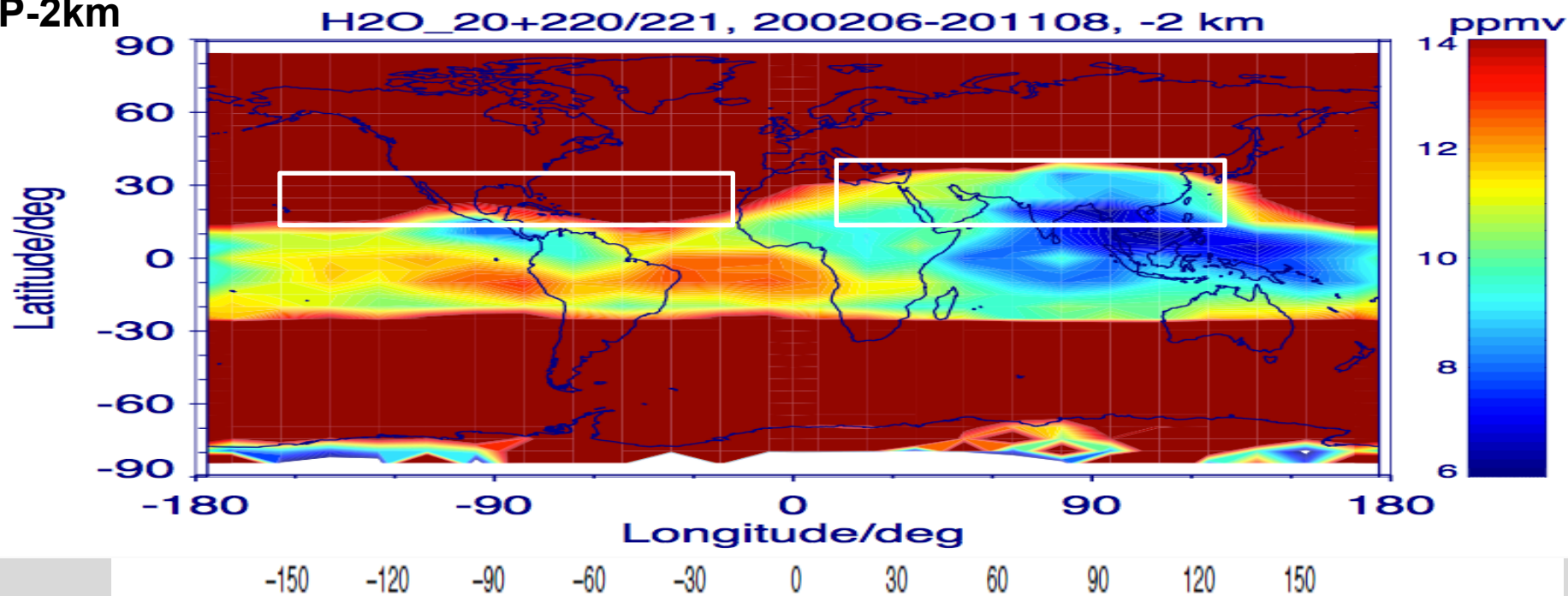
H2O for AMA, NAM and S-TROP at TP

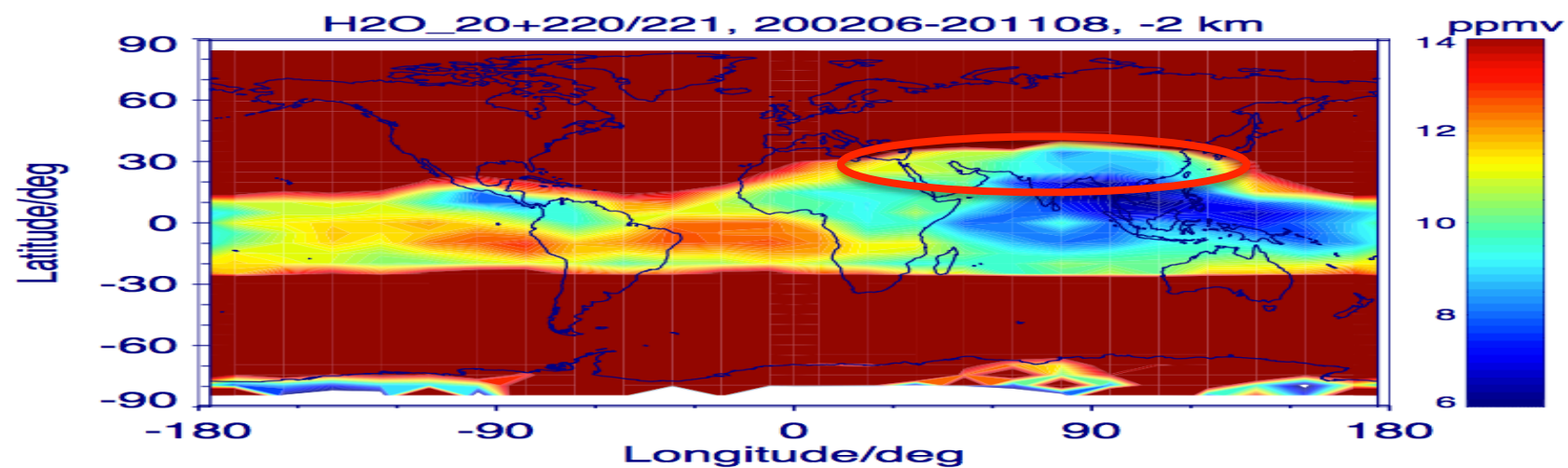


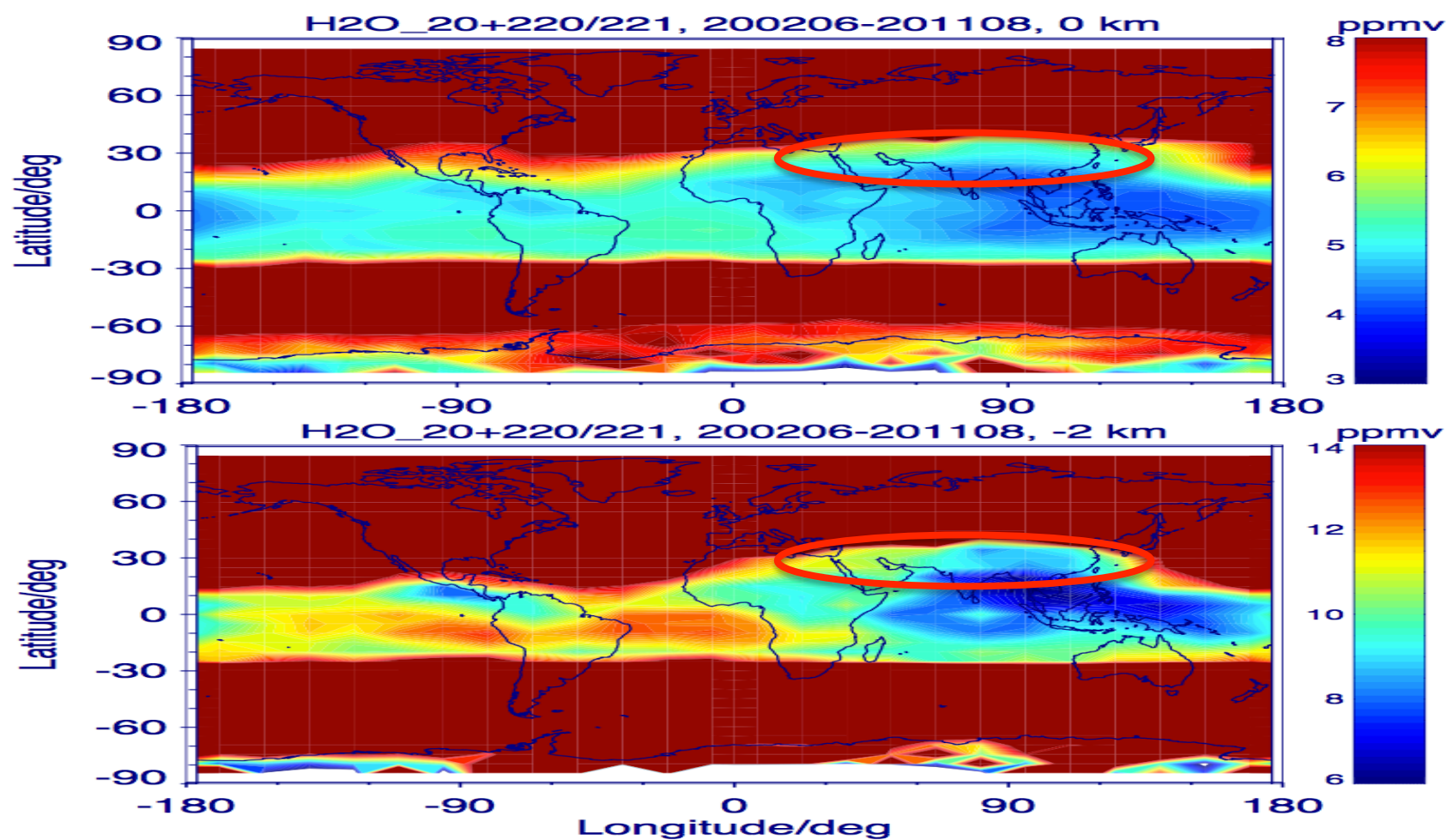
@ 16 km

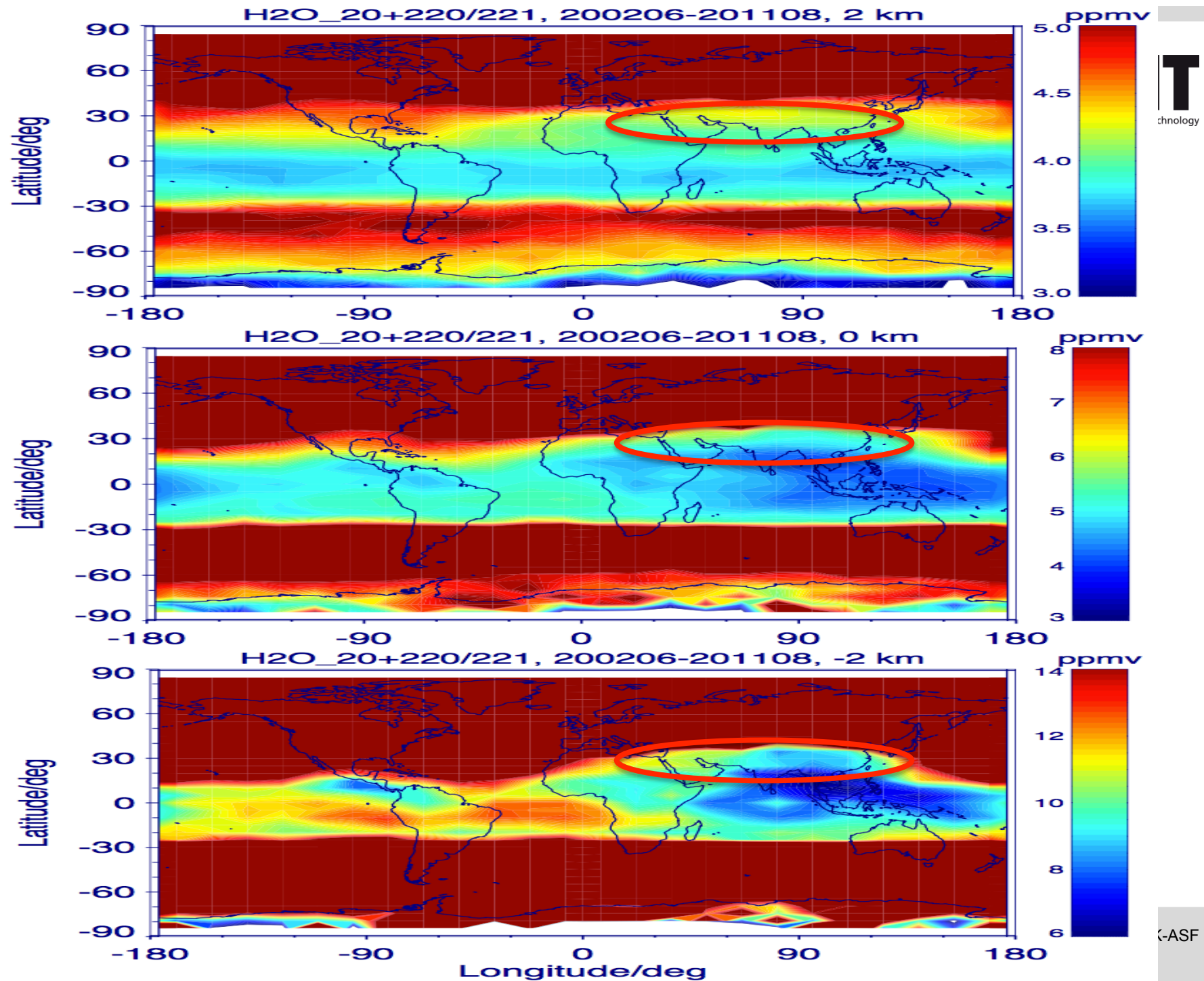


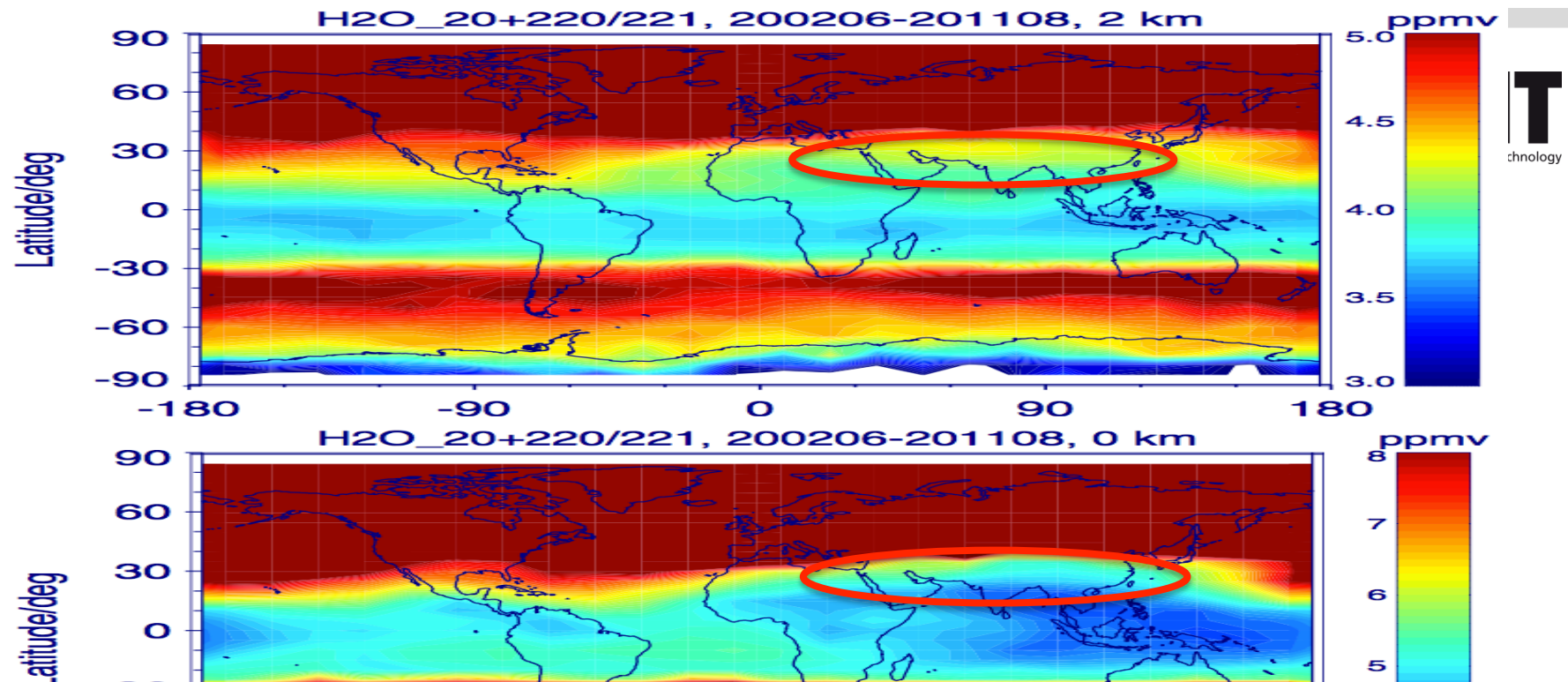
TP-2km



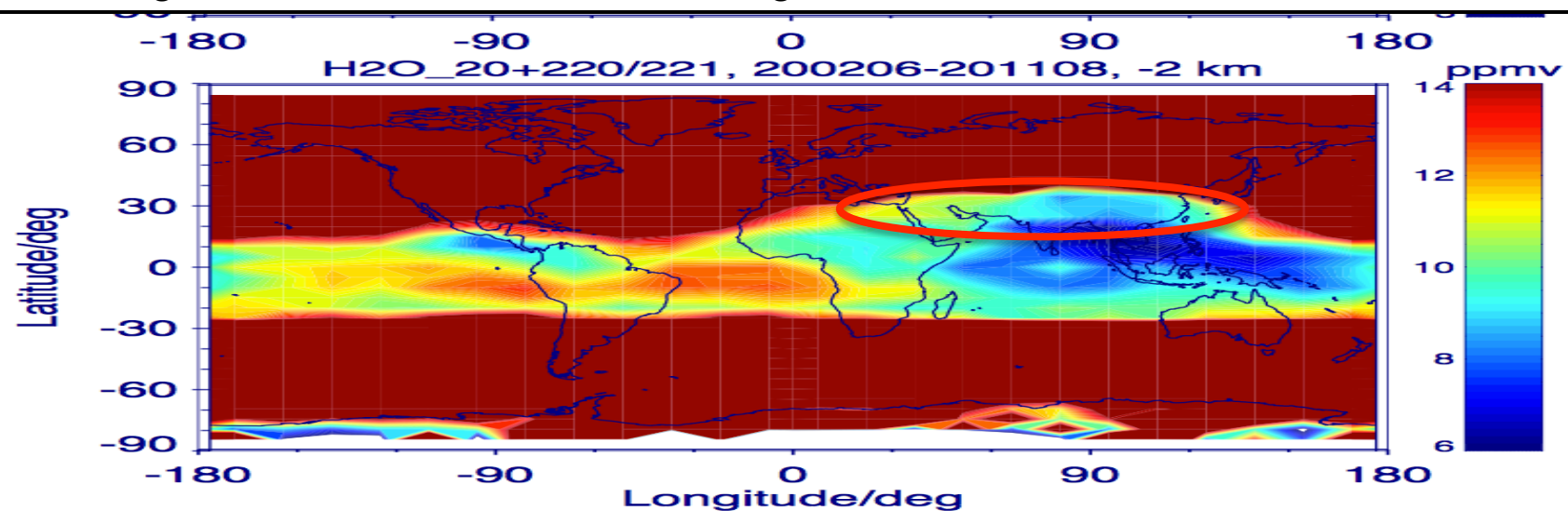


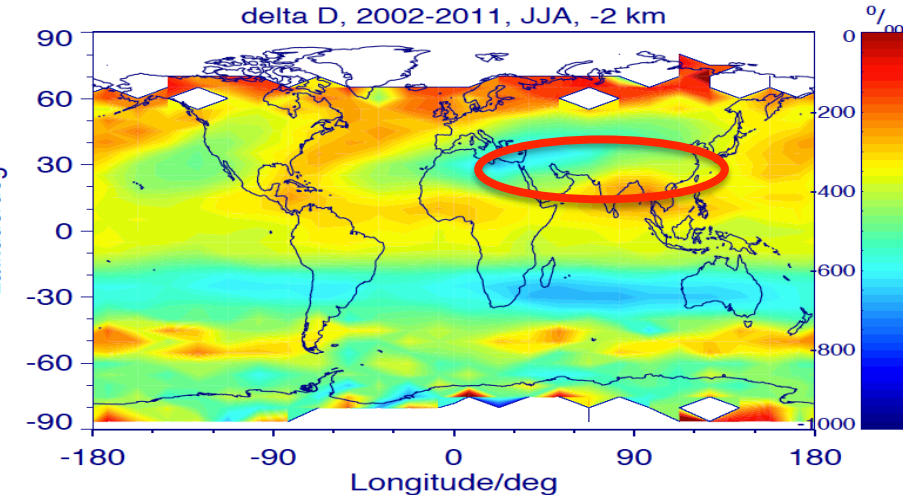
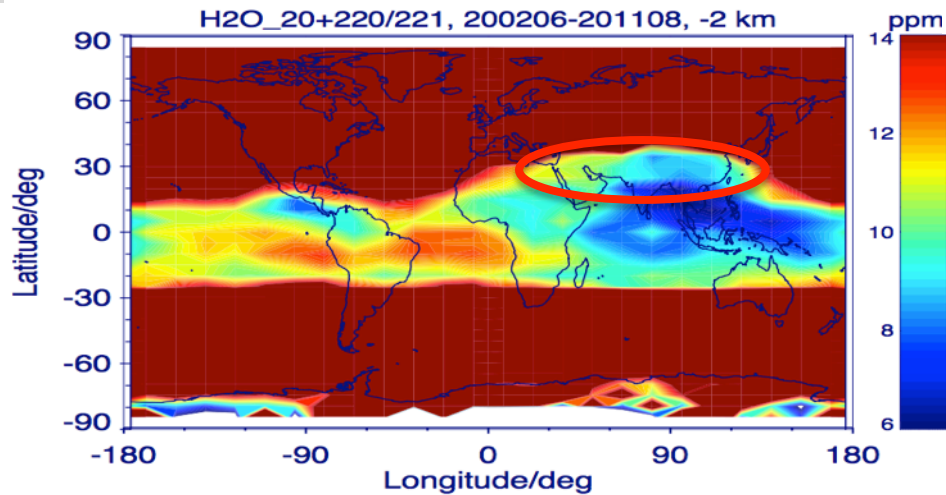
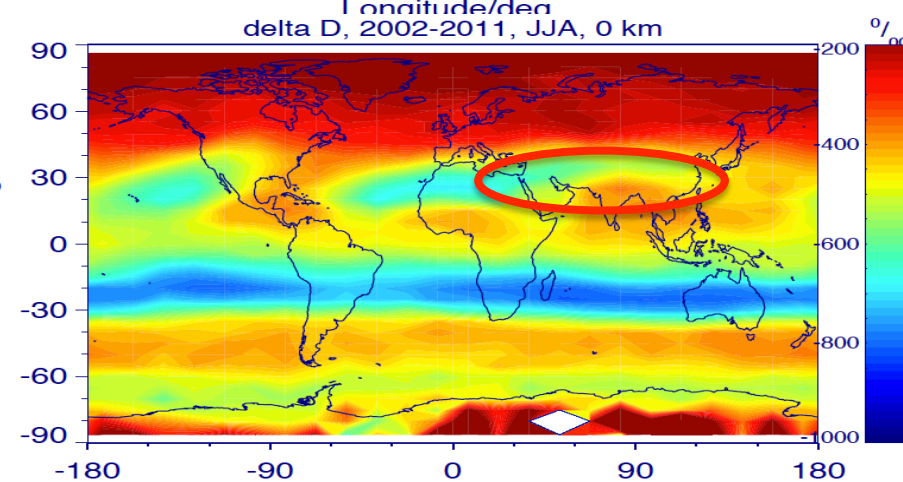
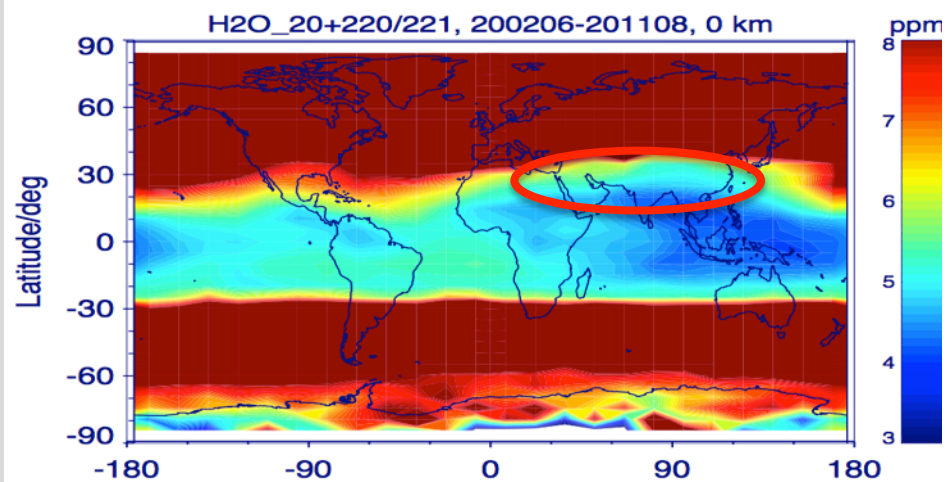
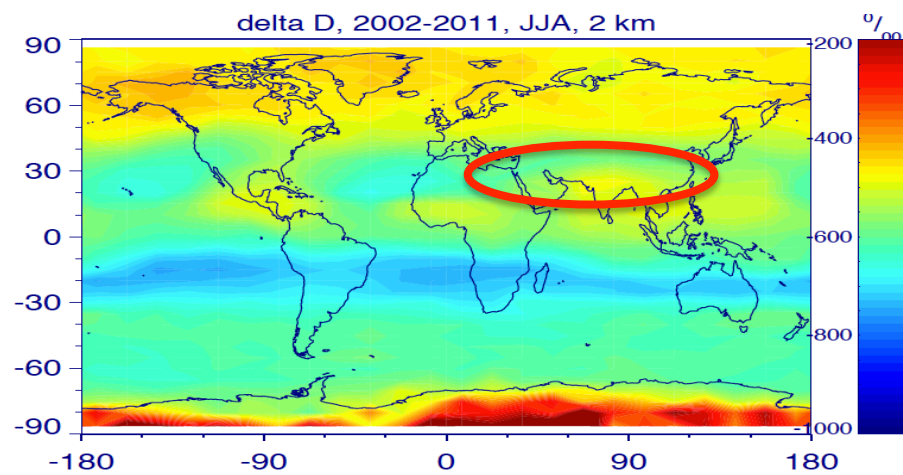
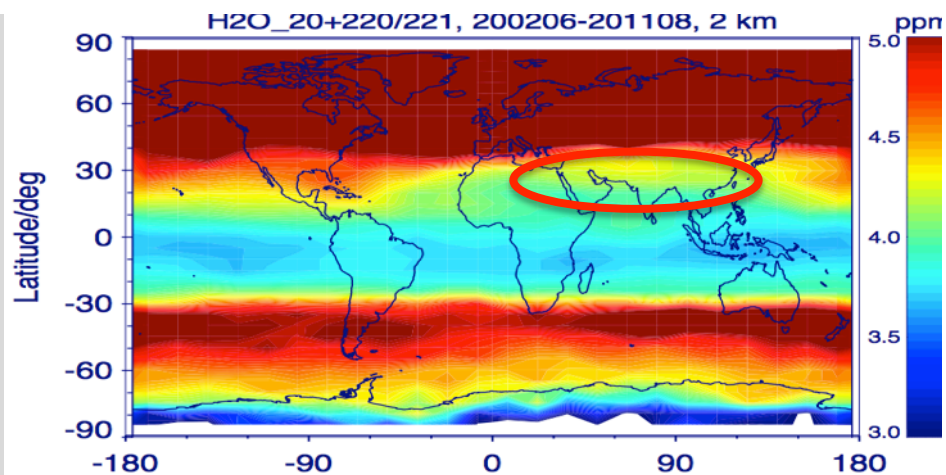


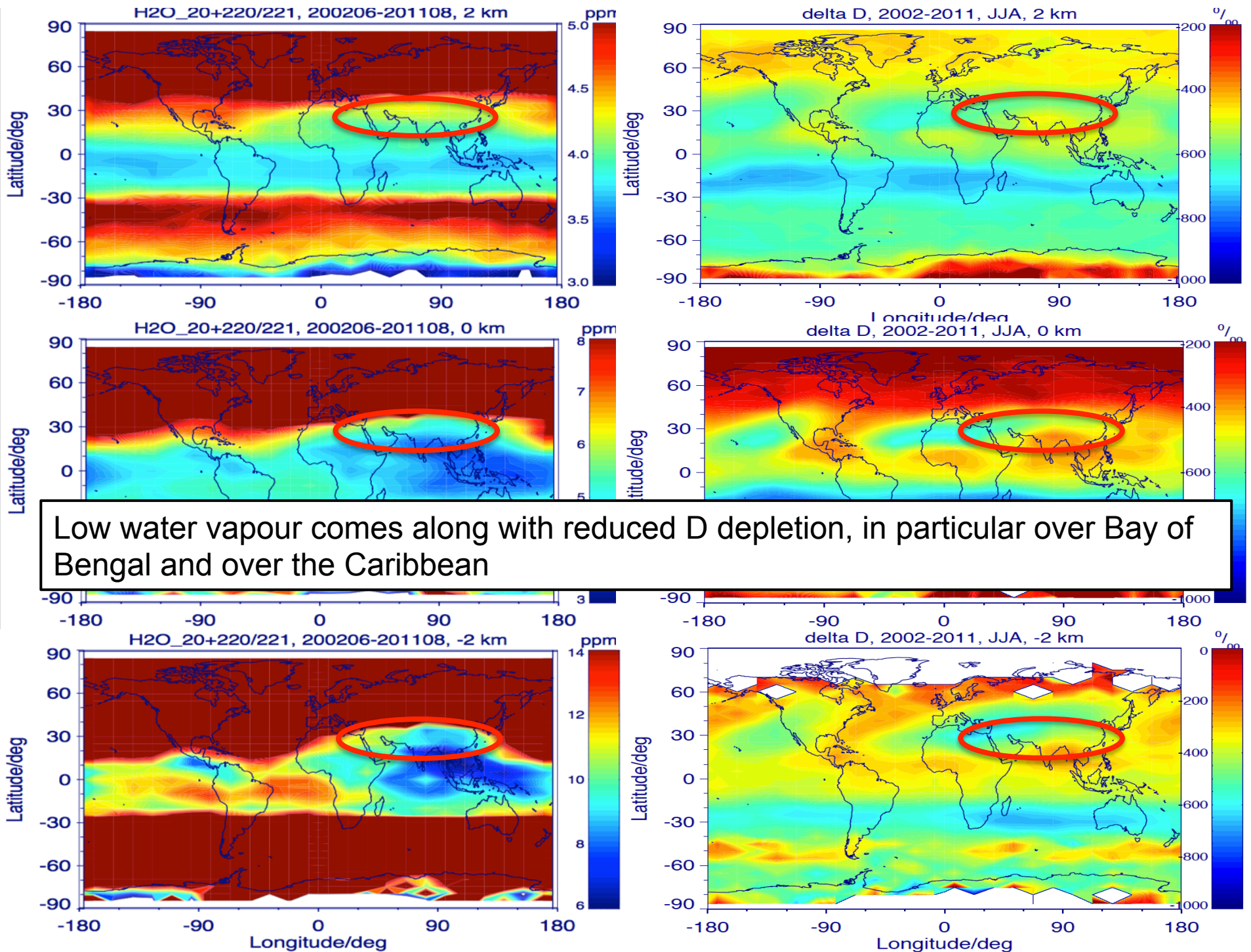




Pattern of low water vapor on TP surface seems to be linked to West Pacific low CPT region and not to the monsoon region

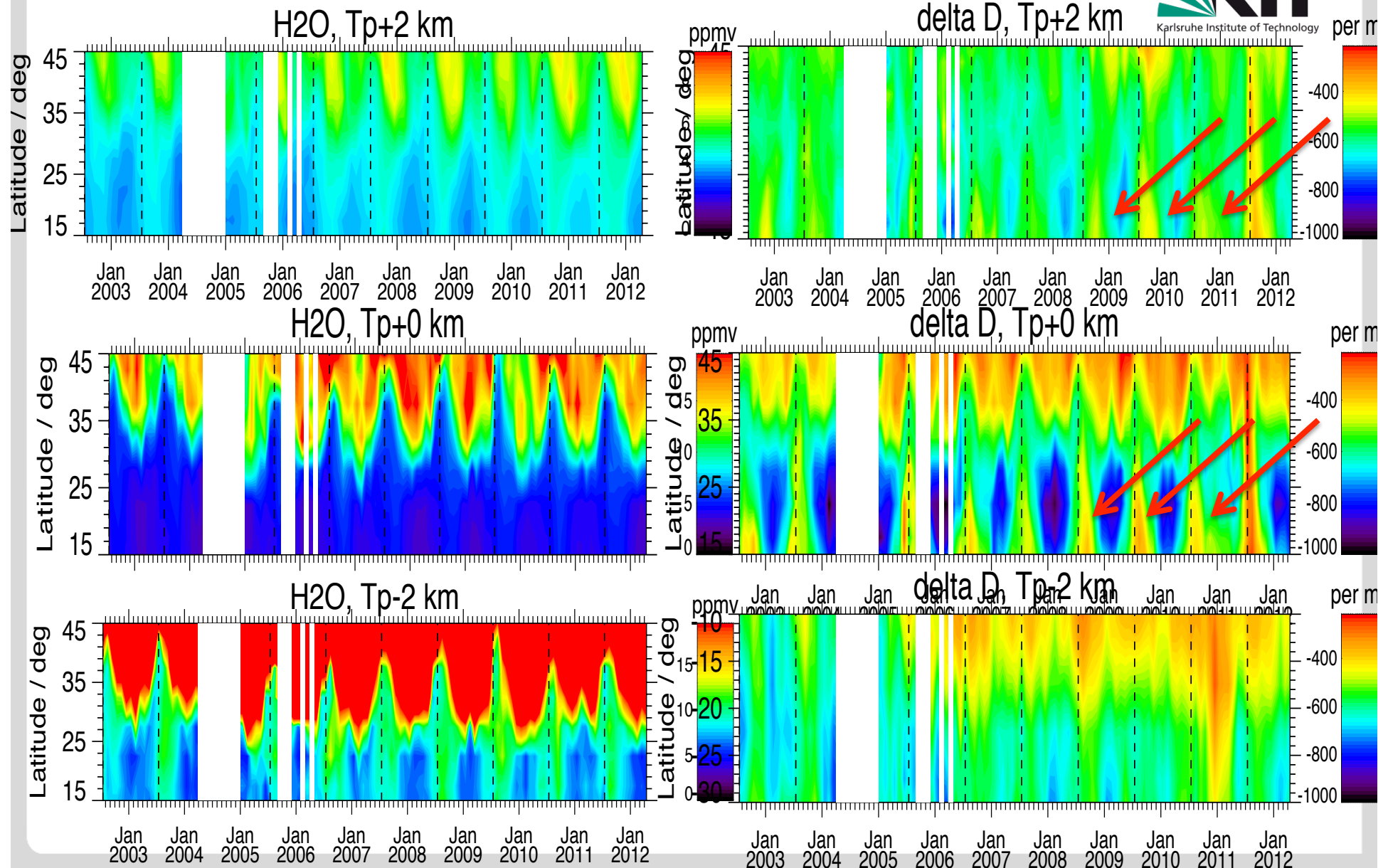


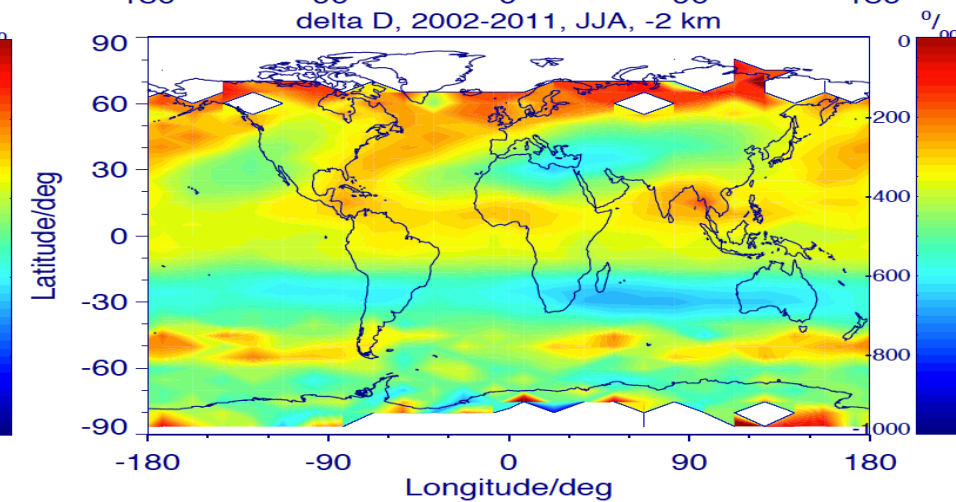
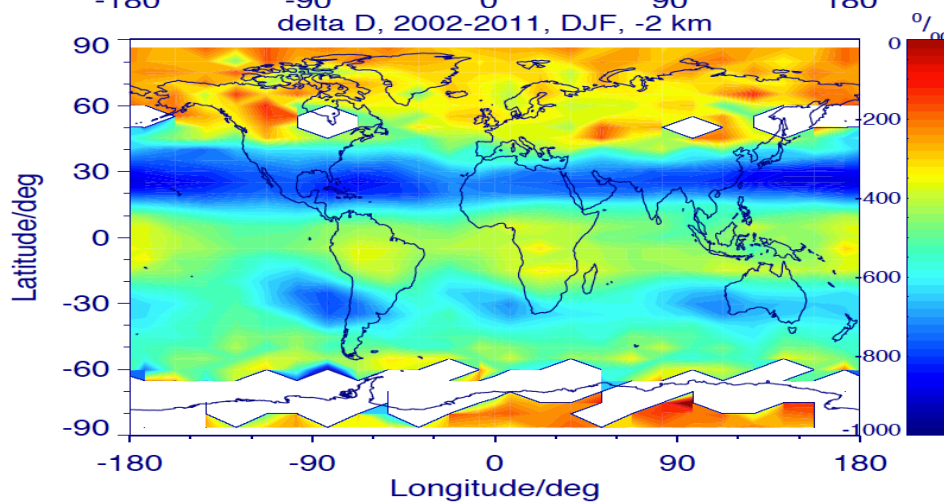
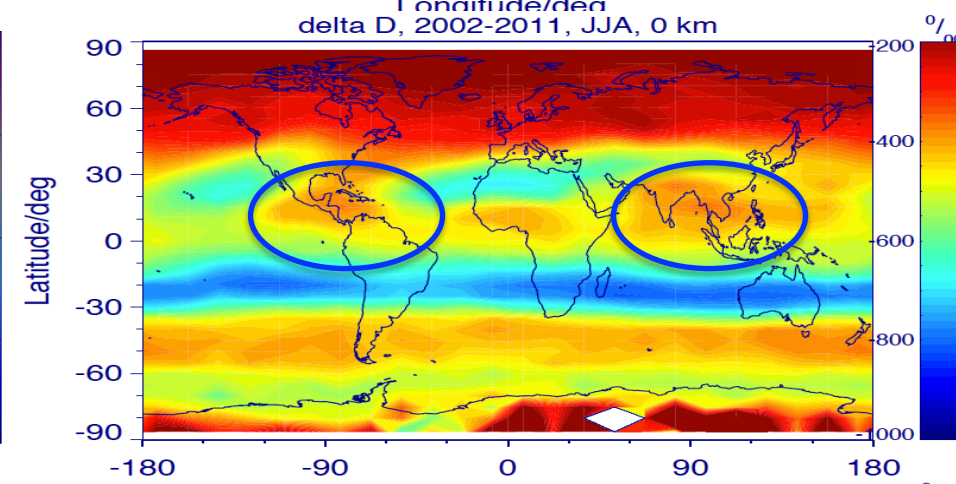
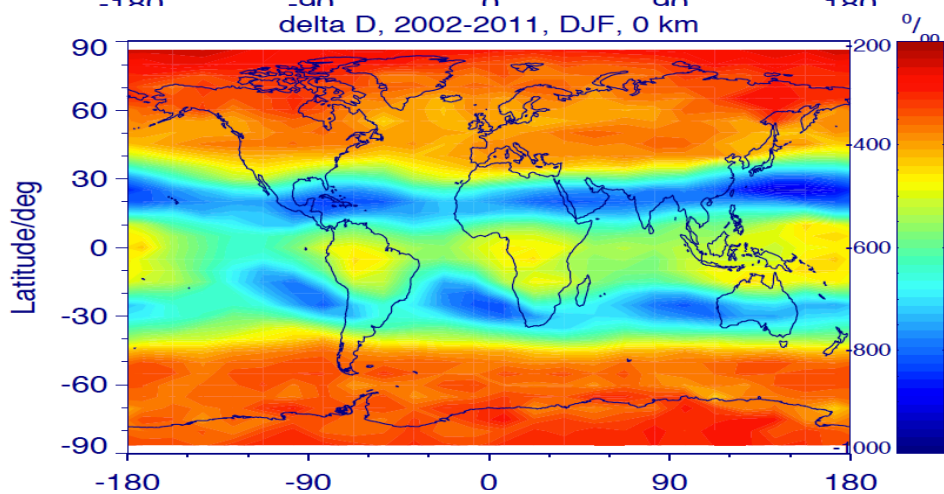
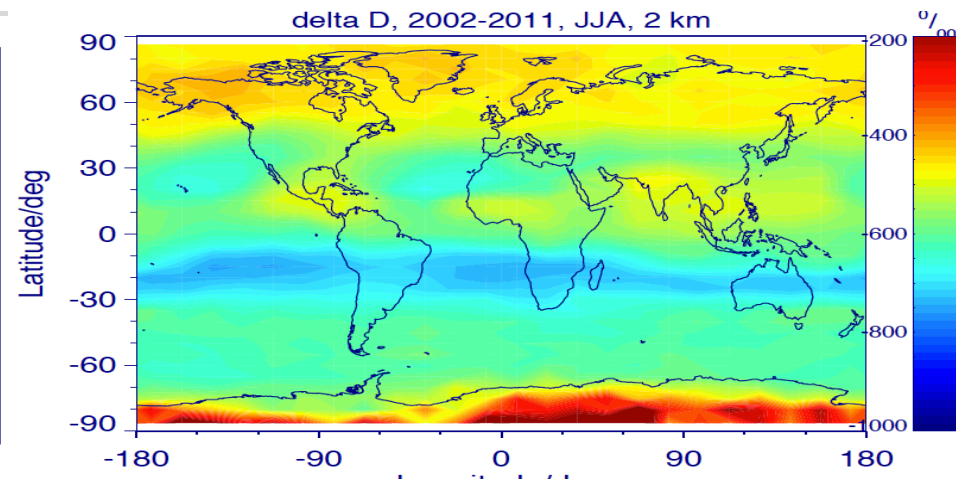
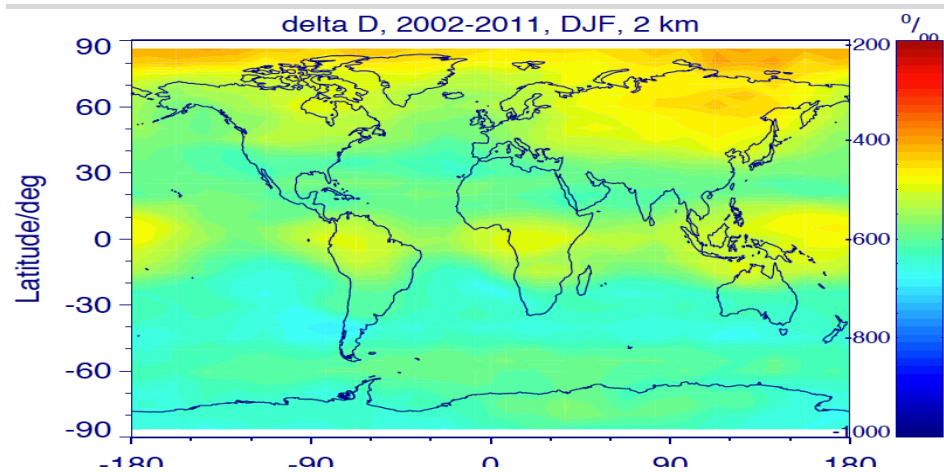




Low water vapour comes along with reduced D depletion, in particular over Bay of Bengal and over the Caribbean

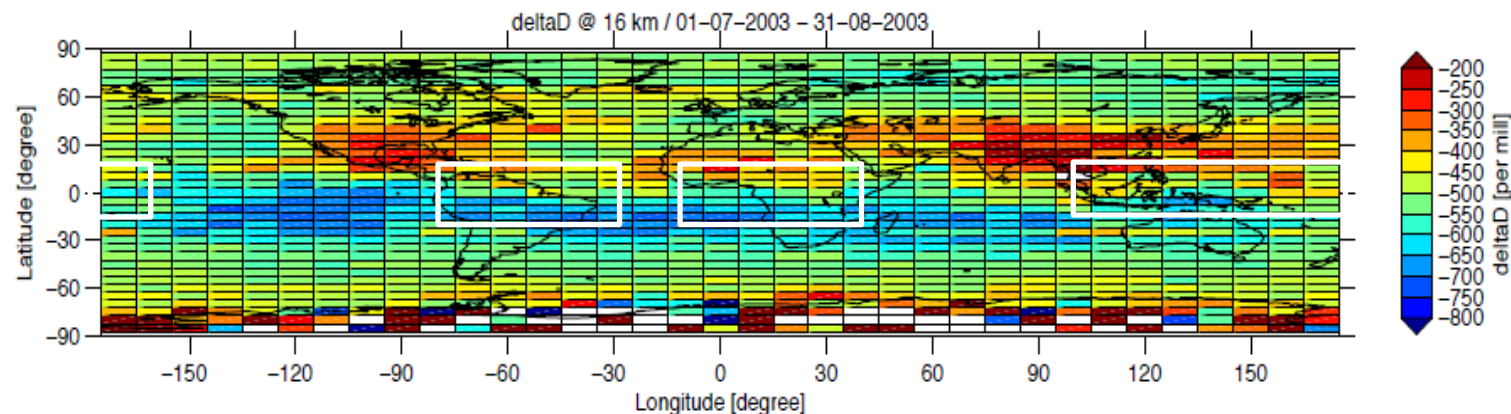
AMA, H₂O, delta D, TP-2, TP, TP +2



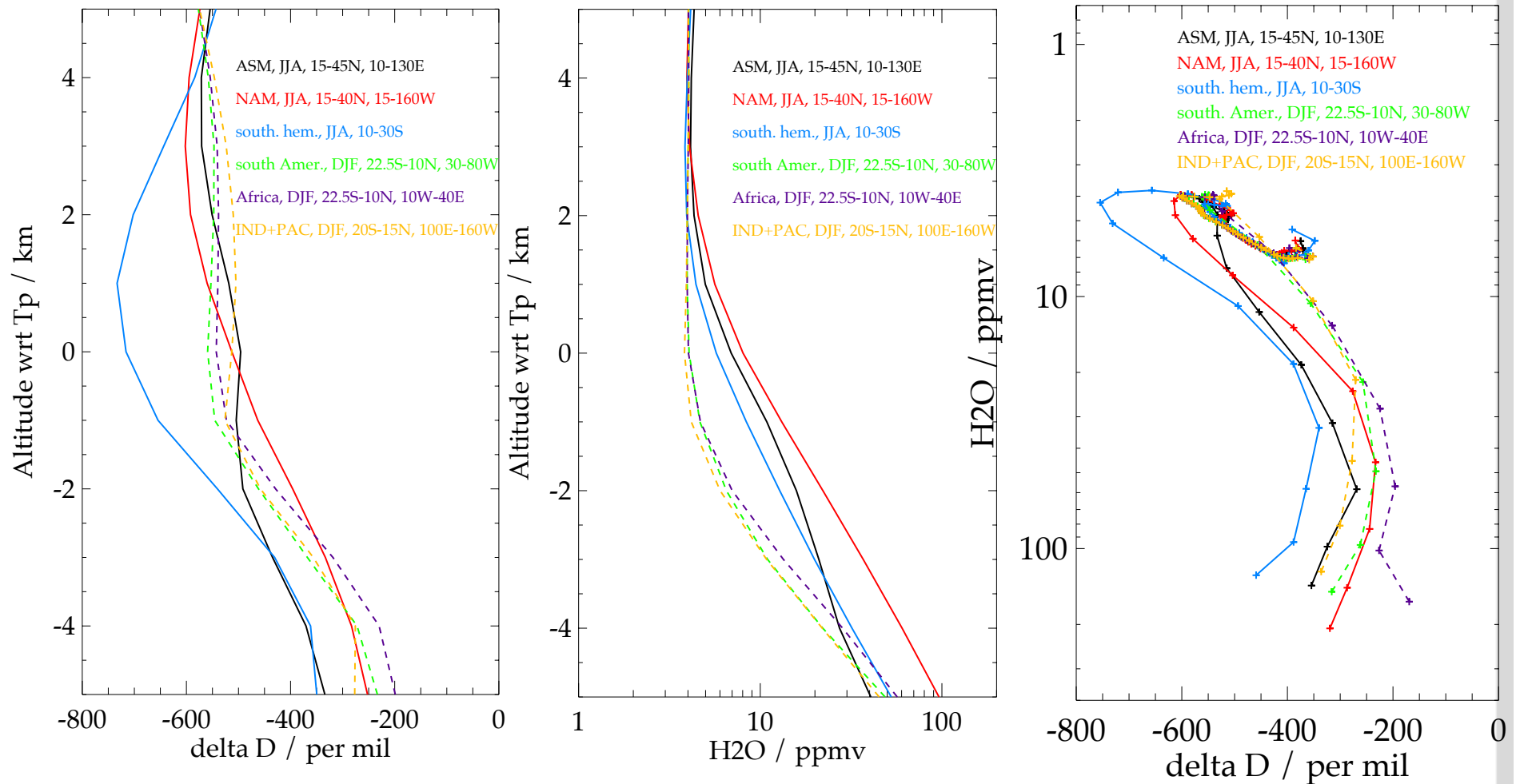


Summary so far

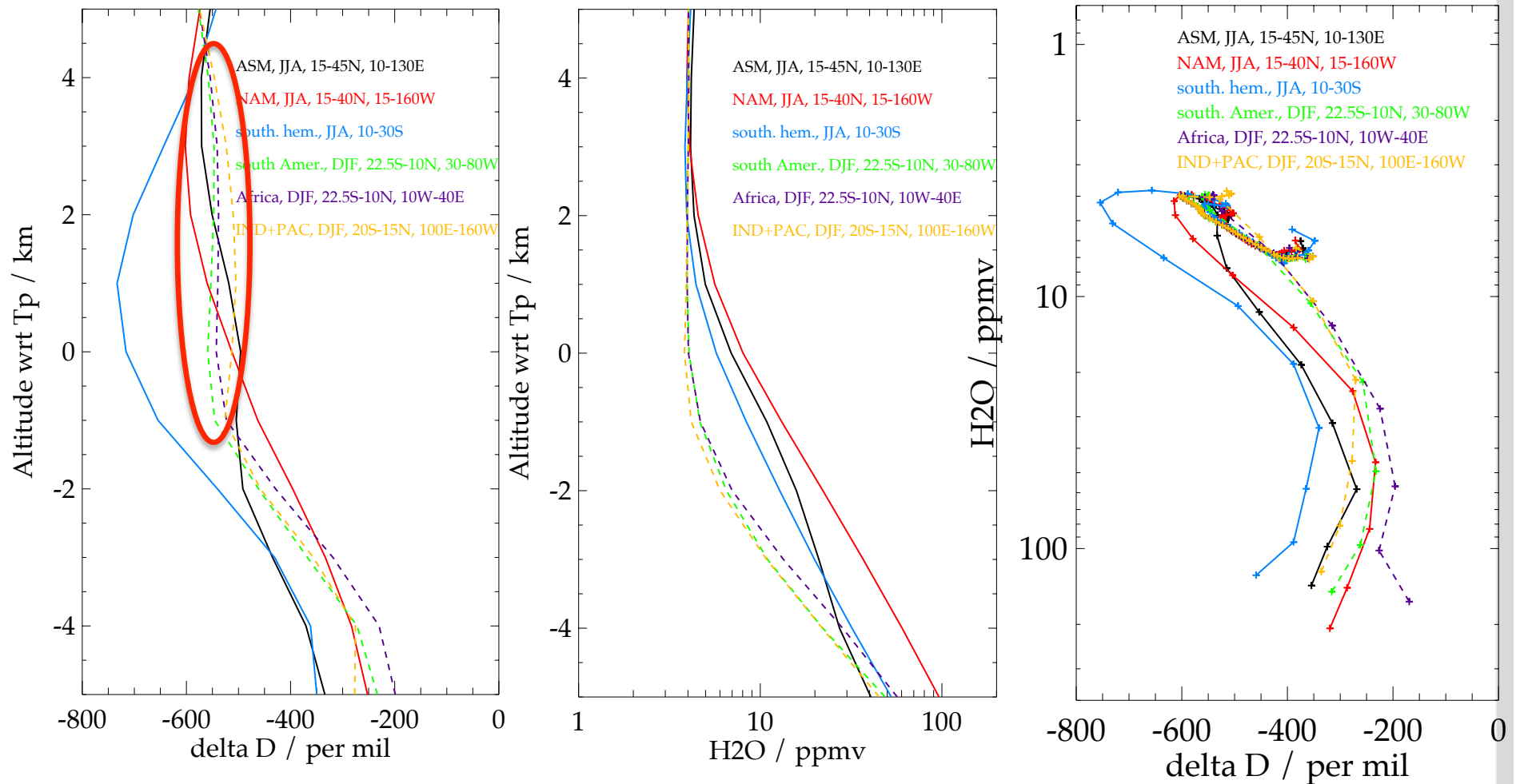
- ❑ Low water vapor just below and at monsoon tropopause
- ❑ Pattern of low water vapor on TP surface seems to be linked to West Pacific low CPT region and not to the monsoon region
- ❑ Low water vapour comes along with reduced D depletion, in particular over Bay of Bengal and over the Caribbean
- ❑ ΔD enhancements over Bay of Bengal and Caribbean seem not to travel further North in the central monsoon areas
- ❑ ΔD enhancements over Bay of Bengal and Caribbean seem to be unique features; no similar features exist in the SH during DJF => monsoon related
- ❑ Compare to convection areas over land:



Seasonal averages over selected regions

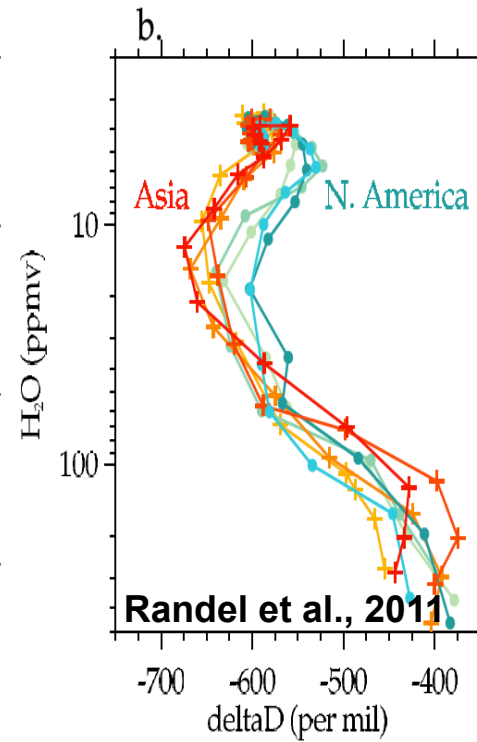
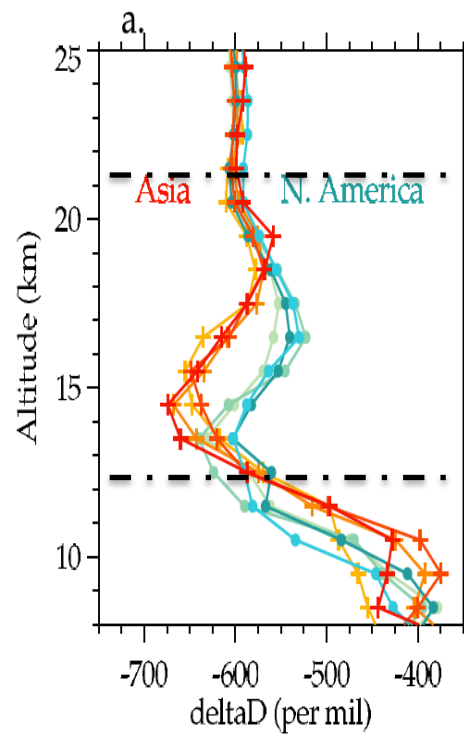
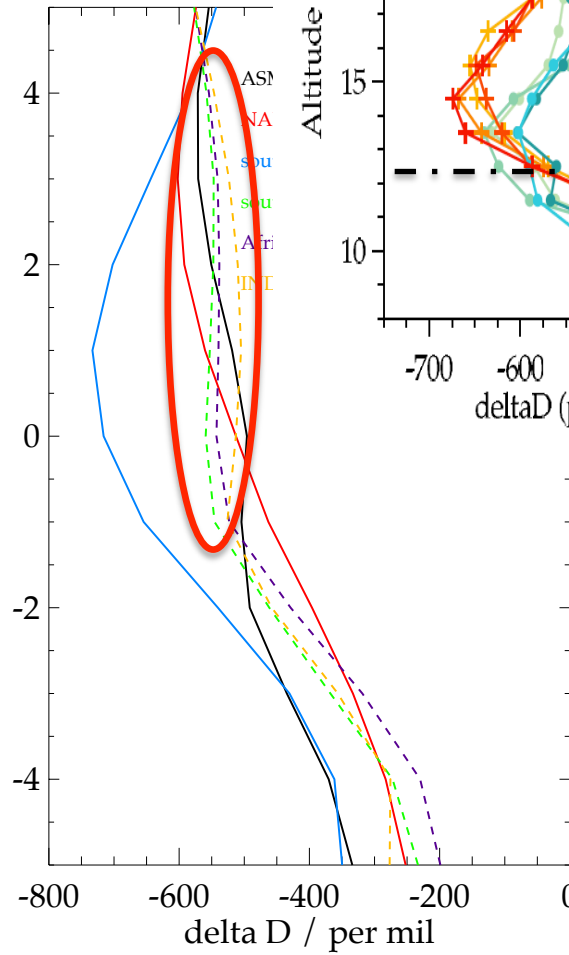


Seasonal averages over selected regions

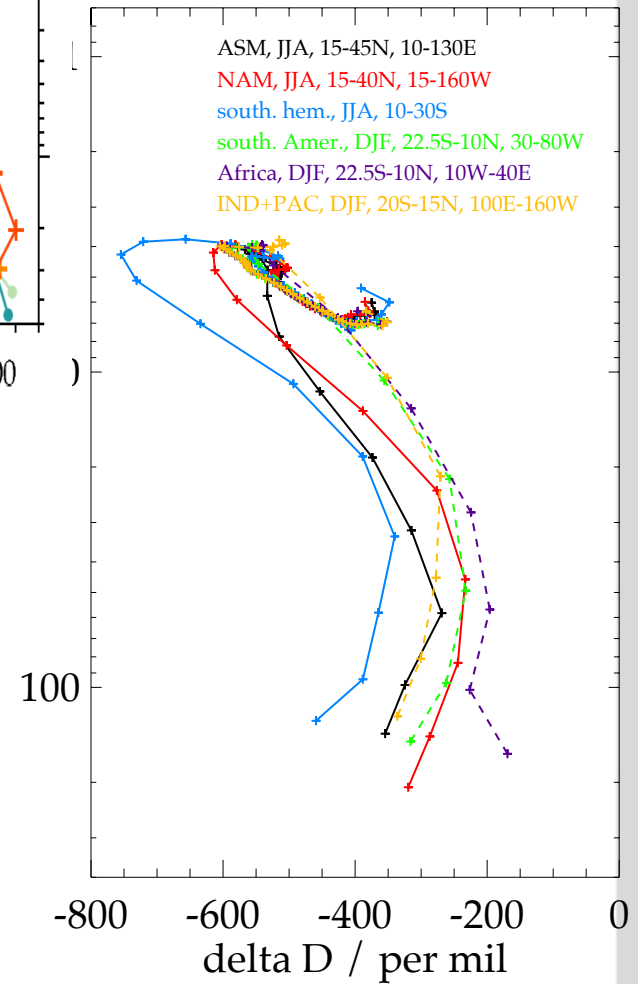
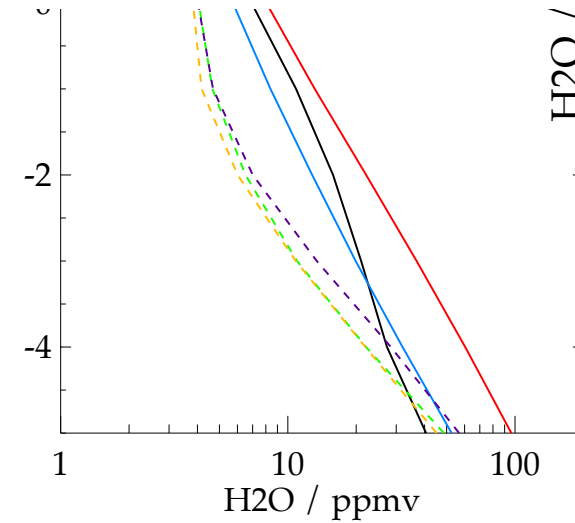


Seasonal

Altitude wrt Tp / km



Altitude w

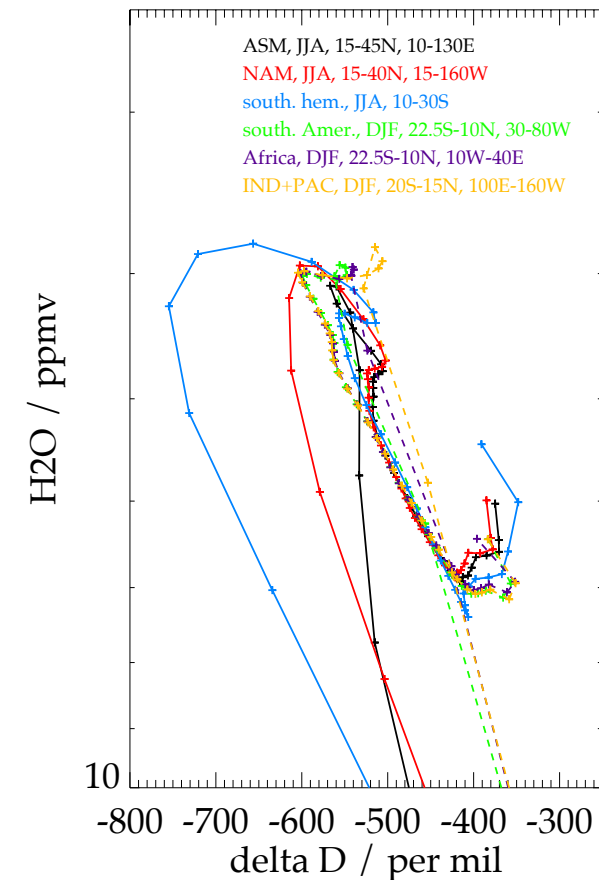


Preliminary conclusions and further work

- In contrast to analyses on pressure/altitude/ T_{pot} levels the tropopause-following analysis demonstrates that water vapor (WV) **minima** are located below and at the monsoon tropopauses
- Above the tropopause WV is slightly (~ 0.5 ppmv) increased above the monsoon systems, compared to the rest of the tropics
- The Asian monsoon WV minimum is directly connected to that over the West Pacific/maritime continent
- ΔD helps to understand the phase transition processes during water WV uplift into the stratosphere
- The monsoon regions have about the same ΔD depletion as other convective regions over land, but are less depleted than the SH inner tropics, and H₂O is higher
- Both findings hint towards uplift and deposition of ice in the TP region (± 2 km) to play a more dominating role than in the SH inner tropics
- Convective processes over the Bay of Bengal and the Caribbean produce clearly enhanced ΔD values hinting towards strong ice lofting processes
- Future work: refine analysis using also radio occultation temperature data, studying the intra-seasonal variation, and resolving this mystery:

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