Dynamical processes and transport influencing the water vapor budget in the UTLS

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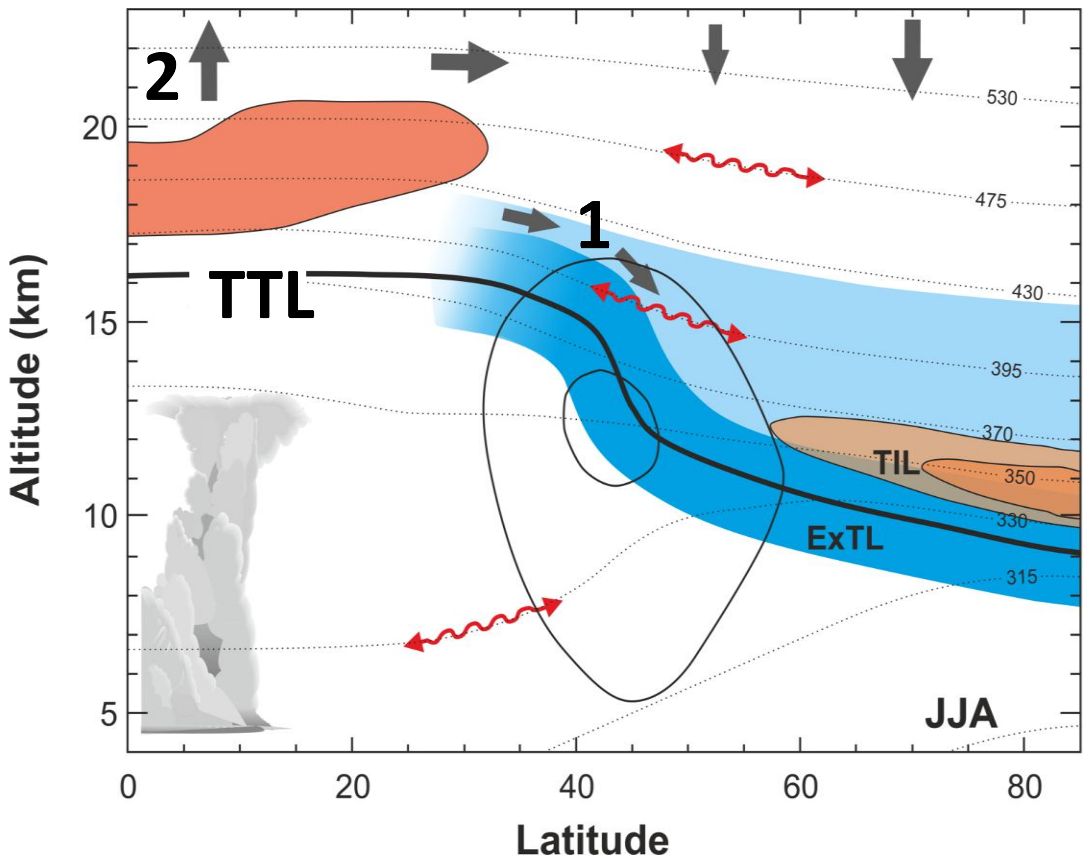
Content

- Horizontal transport of water vapor from the TTL into the LMS
- Influence of major warmings on vertical water vapor transport into the deep stratosphere



adapted from Gettelman et al., 2011 (Fig. 2a)

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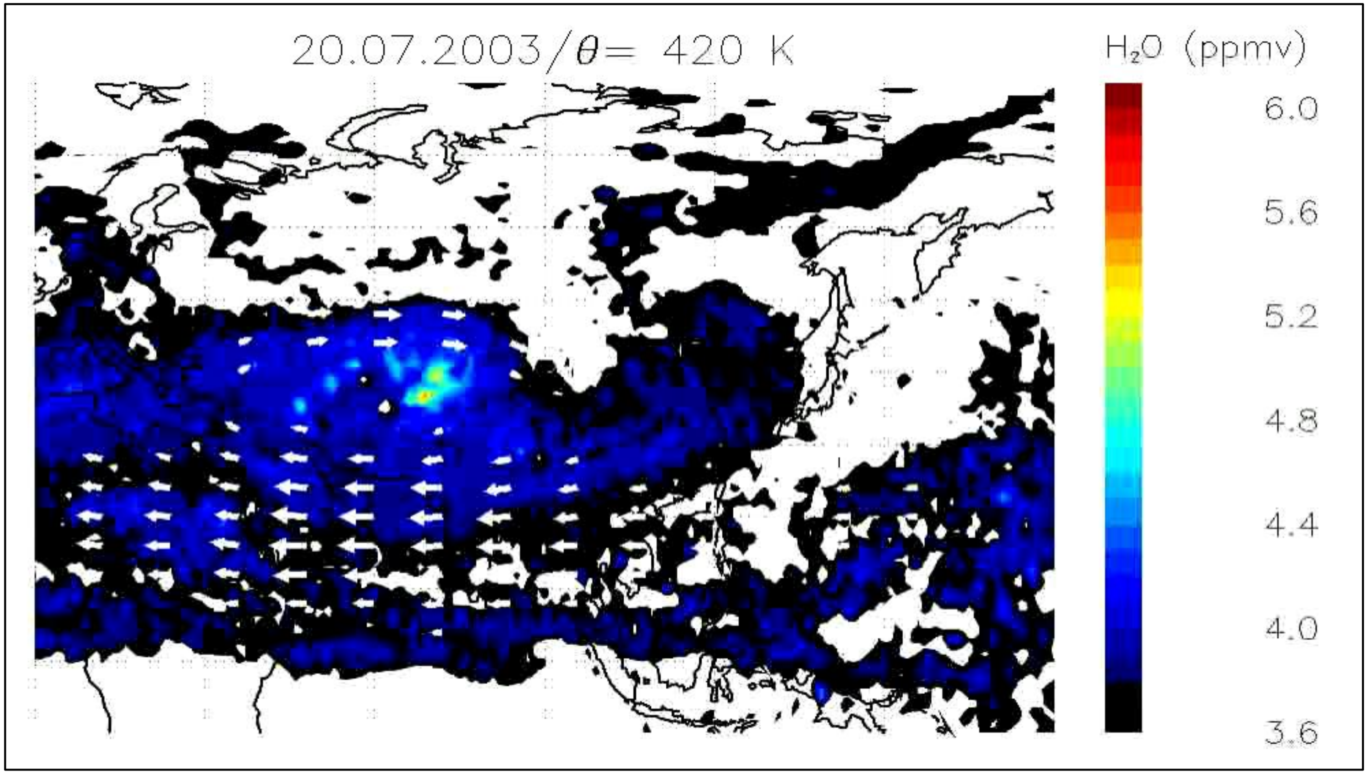
Horizontal transport into the extratropical LMS

H_2O at 420 K (18 km) from July until Dec'03



CLaMS driven by ERA-Interim

- Upward transport during summer in the region of the AM
- Important for propagation of moisture towards higher latitudes.

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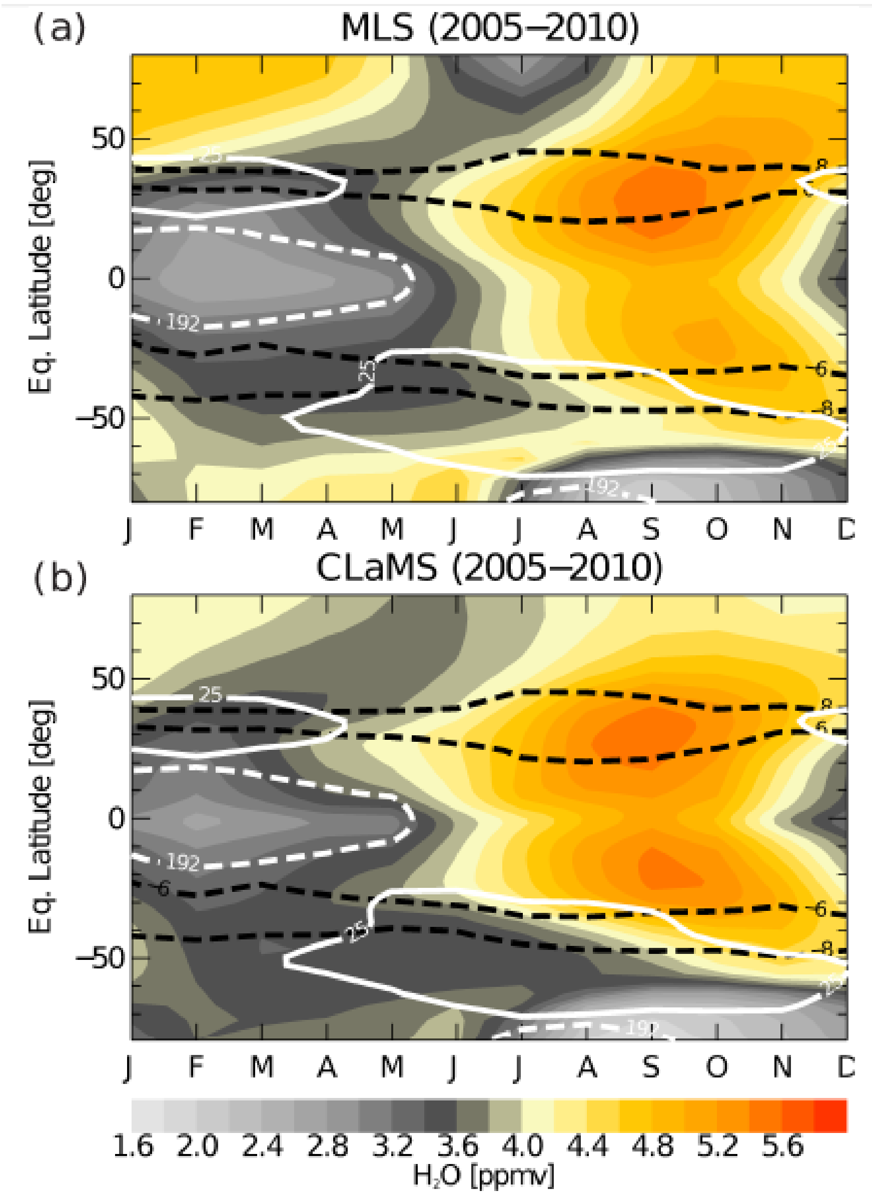
Seasonal cycle of H_2O transport into the LMS (390 K)



- Maximum H_2O values in the subtropics during Monsoon season
- Propagation of moist air into the extra-tropical LMS in summer/fall

Plöger et al., JGR, 2013

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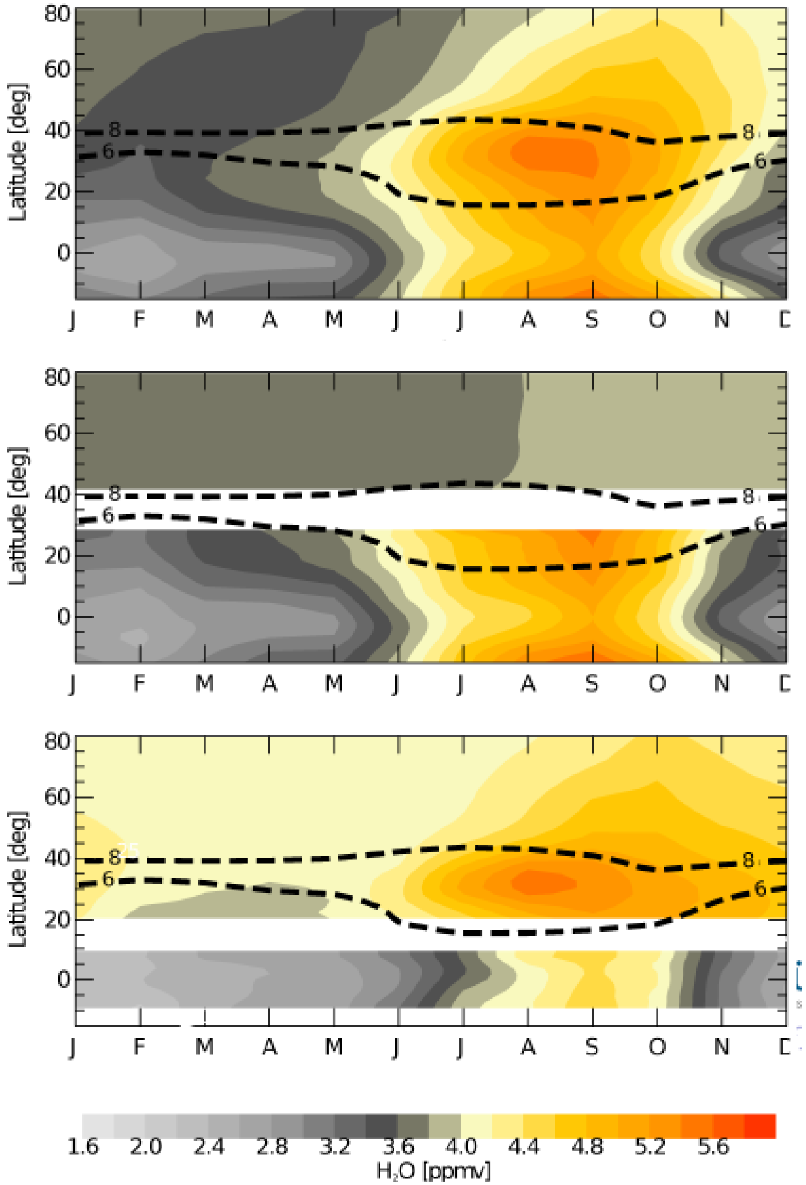
Subtropical control in moistening the LMS (390 K)



Artificial transport barrier experiments

- Summer/fall maximum in LMS caused by transport from subtropics

Plöger et al., 2013

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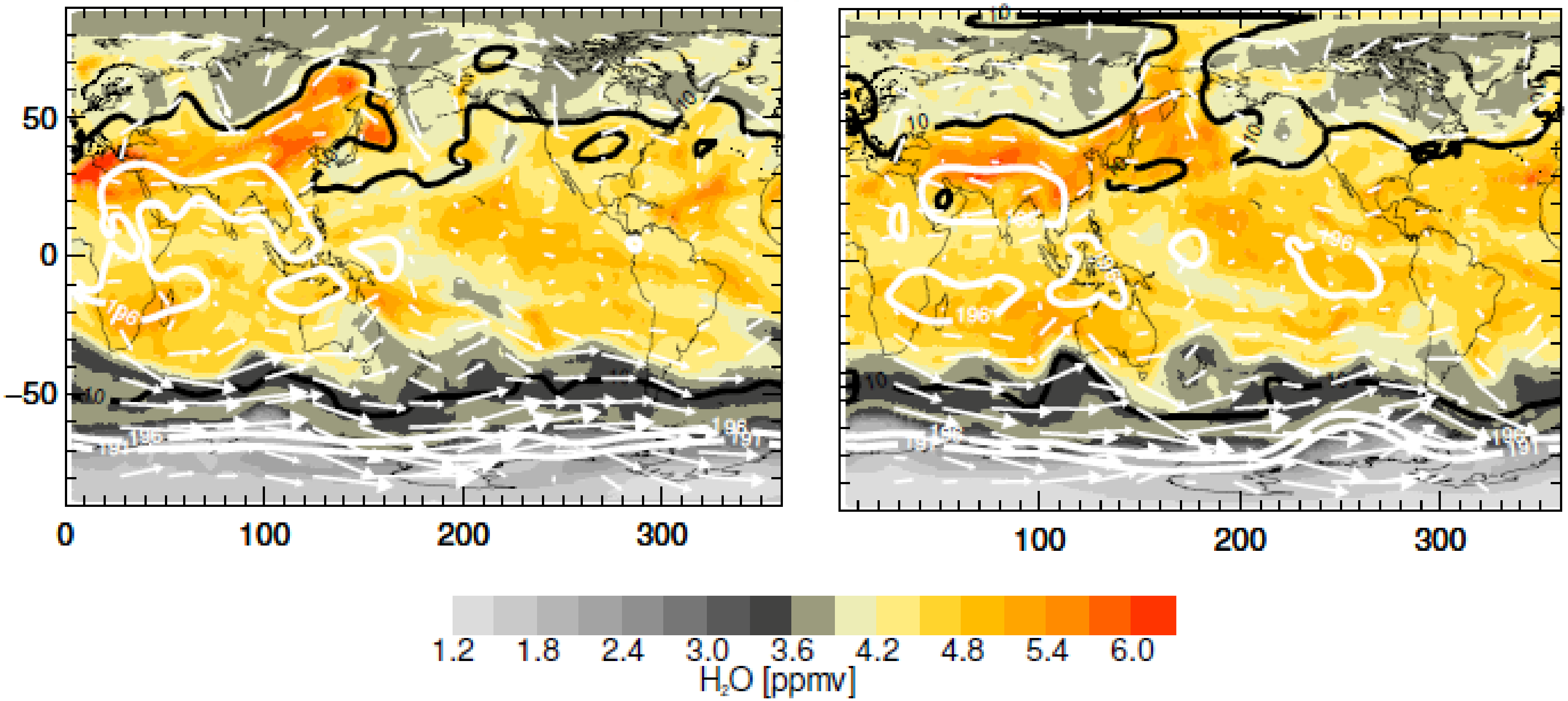
Role of intrusions (tongues)

August 12, 2005, 400K

August 17, 2005, 400K



- Importance of large scale eddy transport

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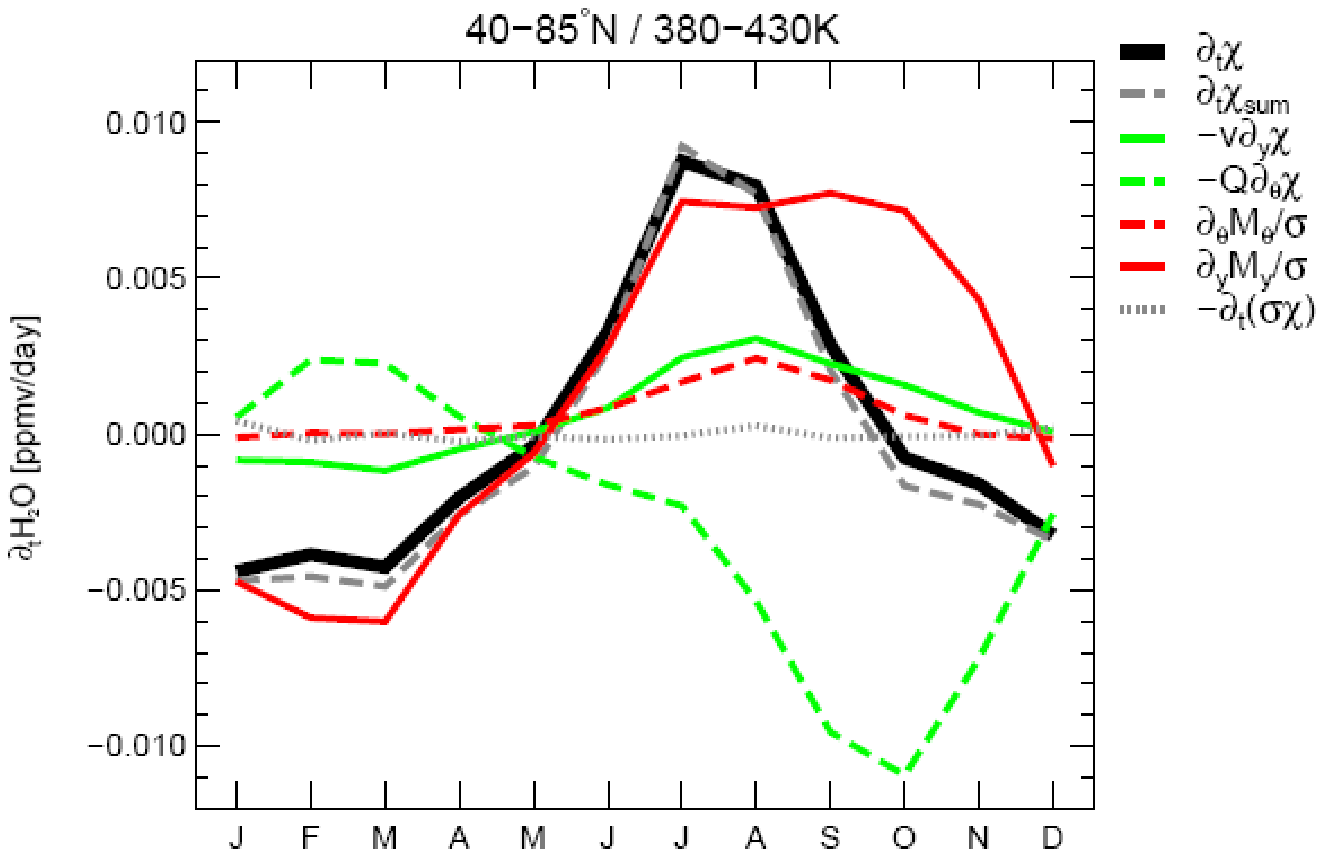
H_2O tendencies in LMS



$$\partial_t \overline{\chi} = -\overline{\mathrm{v}}^* \partial_y \overline{\chi} - \overline{\mathrm{Q}}^* \partial_\theta \overline{\chi} + \frac{1}{\sigma} \nabla \cdot \boldsymbol{M} - \frac{1}{\sigma} \partial_t (\overline{\sigma' \chi'})$$

resid. circulation eddy mixing

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Conclusions Part-1

- Convective uplift of moist air by the Asian monsoon, in combination with quasi-horizontal transport from the sub-tropics, leads to a summer/fall maximum of H_2O in the extra-tropical LS

- Poleward of about 40-50^0 N this transport is dominated by wave-driven eddy mixing.

- Close to the subtropics, the water vapour increase during summer/fall is related to horizontal advection in the shallow branch of the BD circulation (not shown in my talk, see Plöger et al., 2013).

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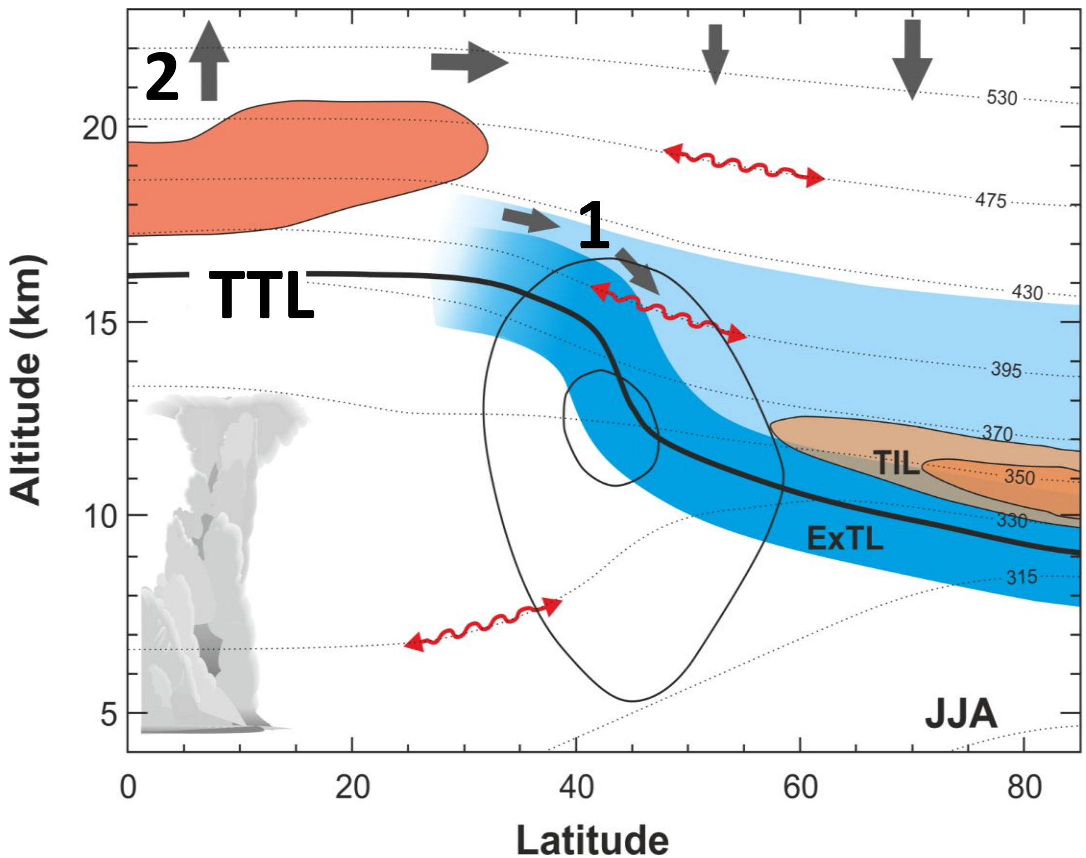

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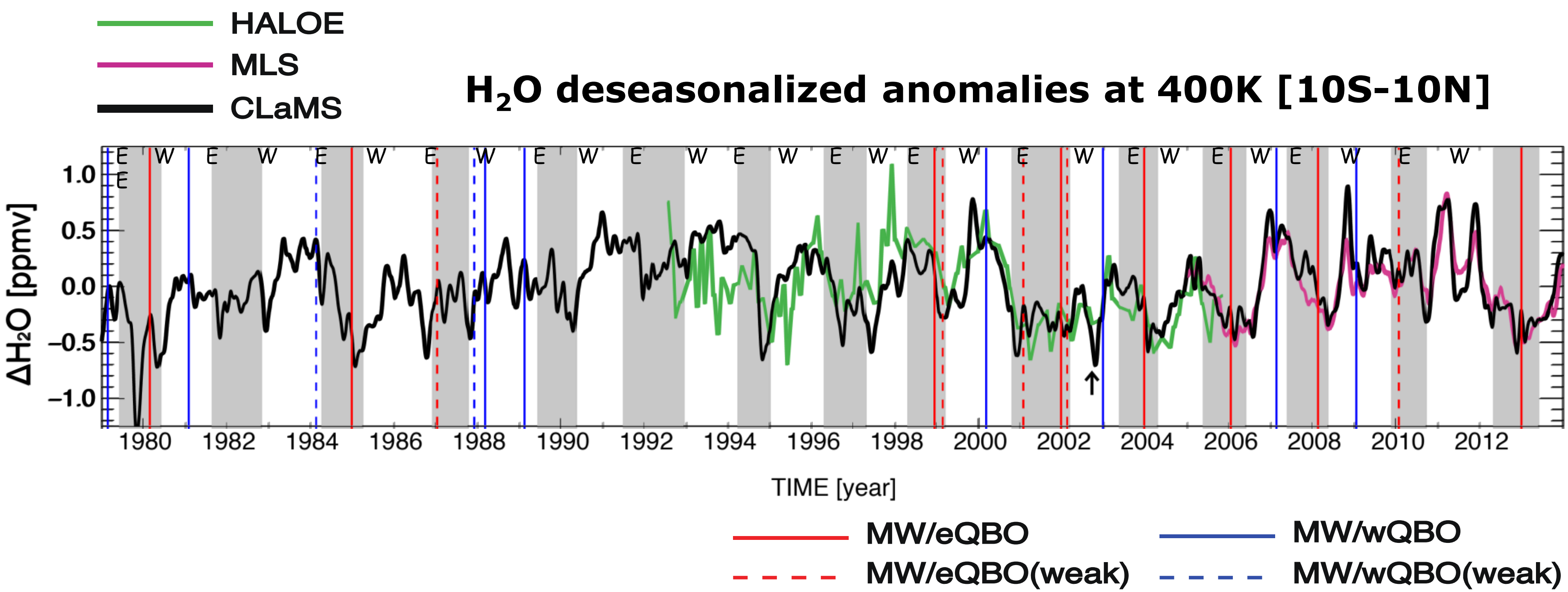
35y CLaMS simulation of H_2O variability in tropics (400 K)



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Tao et al., GRL, 2015

Tao et al. submitted to GRL

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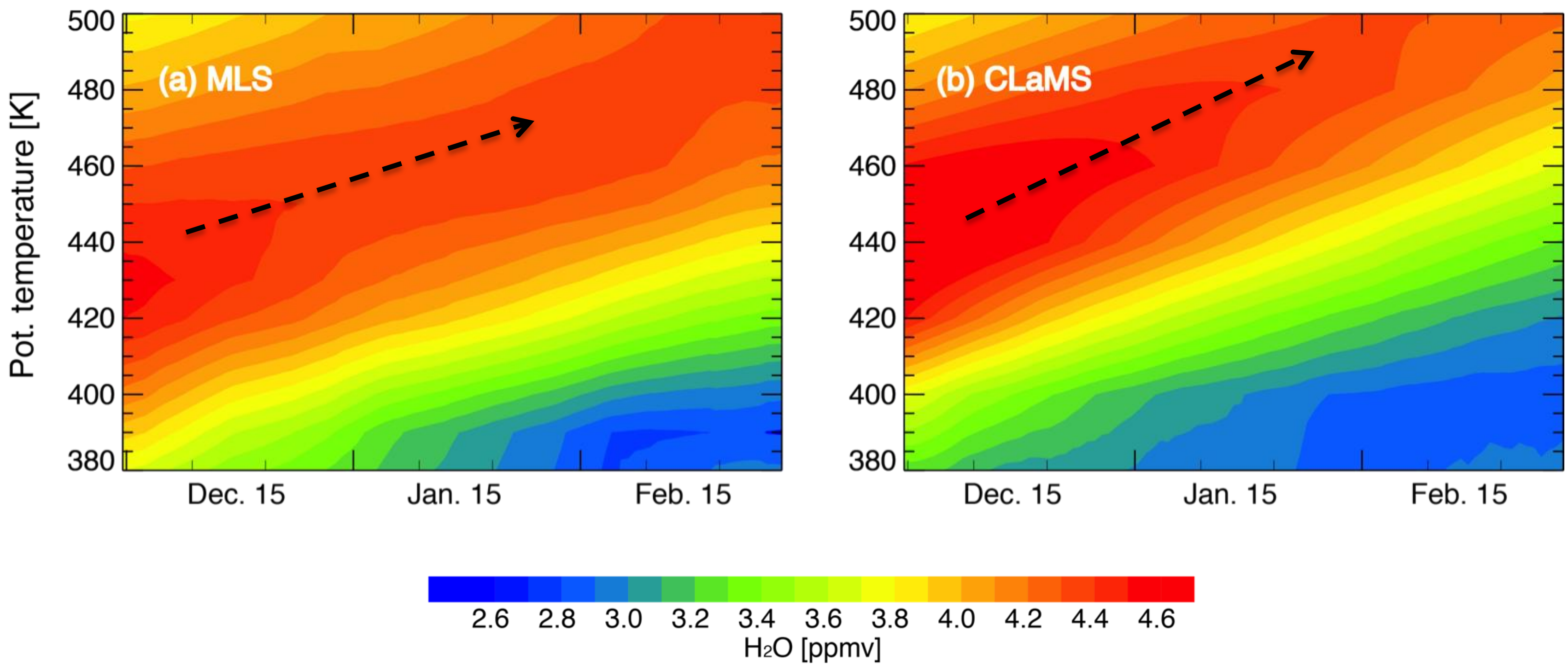
Tape recorder in MLS and CLaMS

Tropical water vapor climatology (10^0S to 10^0N; 2005 to 2013)
during boreal winter (DJF)



- Faster upward propagation in CLaMS (ERA-Interim)

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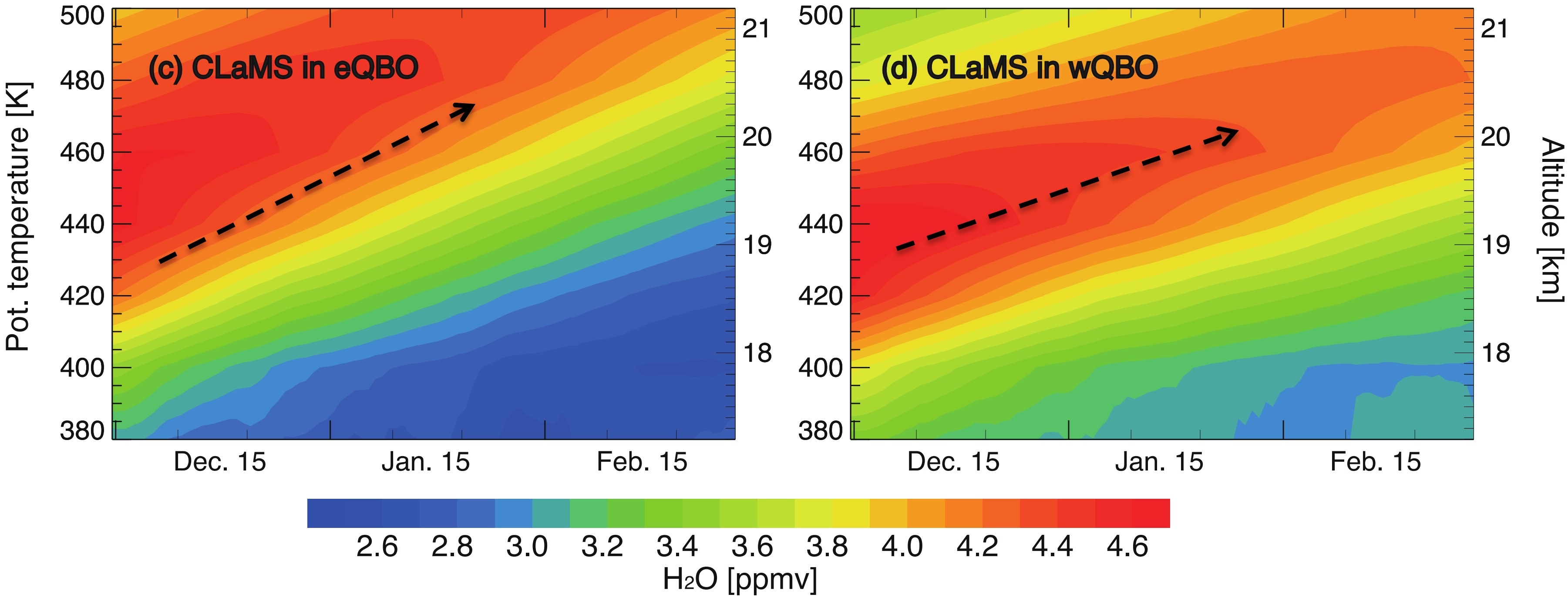
Difference between eQBO and wQBO in CLaMS



- Stronger upwelling in eQBO than in wQBO winters
- Lower temperature & H_2O around tropical tropopause in eQBO than in wQBO winters
- Consistent with QBO-induced H_2O variation of about 0.5 ppmv (Randel et al., 2004)

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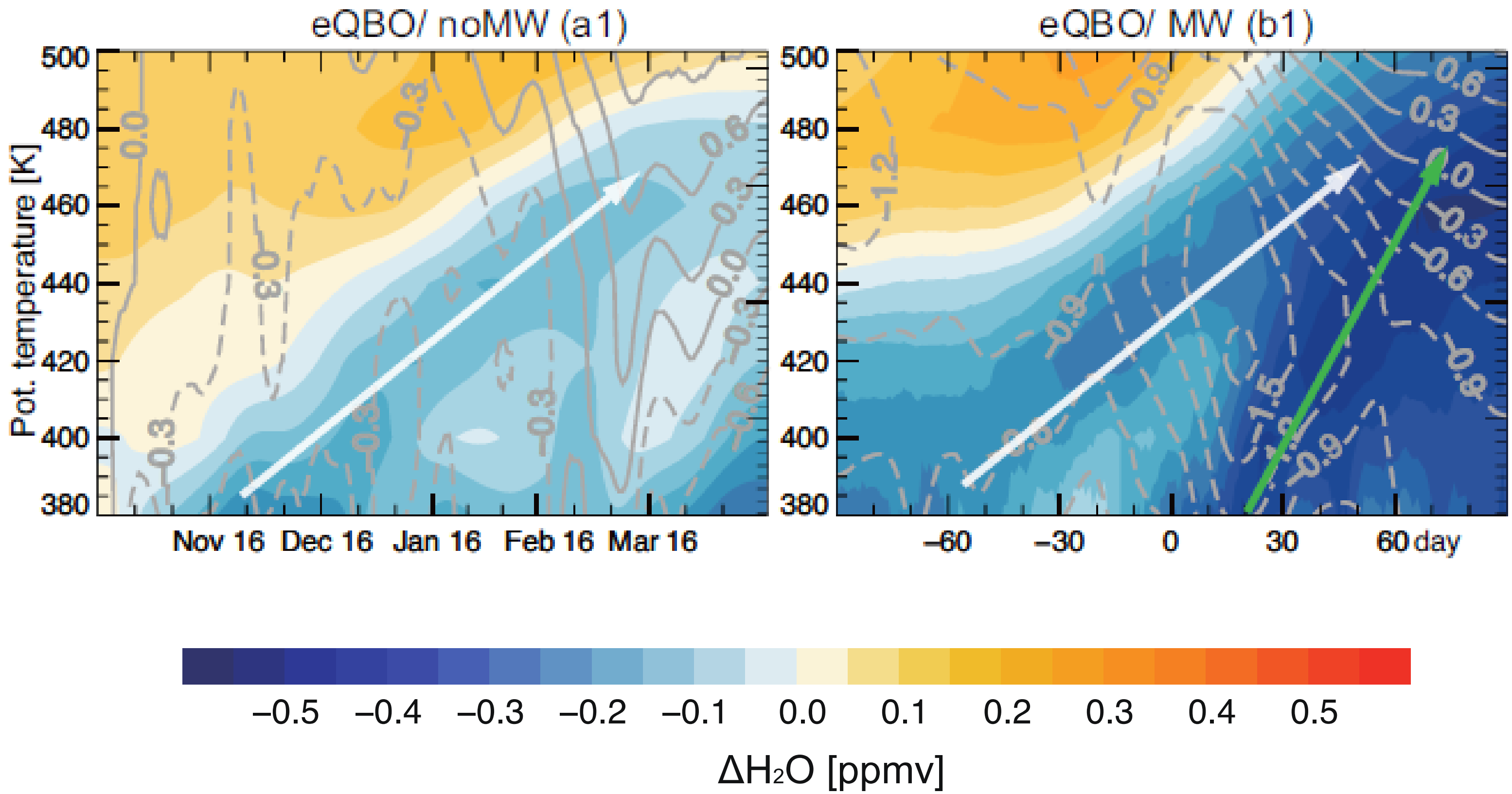
Additional water vapor drop after MWs (eQBO)

Composite of anomalies



- Additional upward propagating branch for winters with MWs
- Signal is also present during wQBO, but much less pronounced

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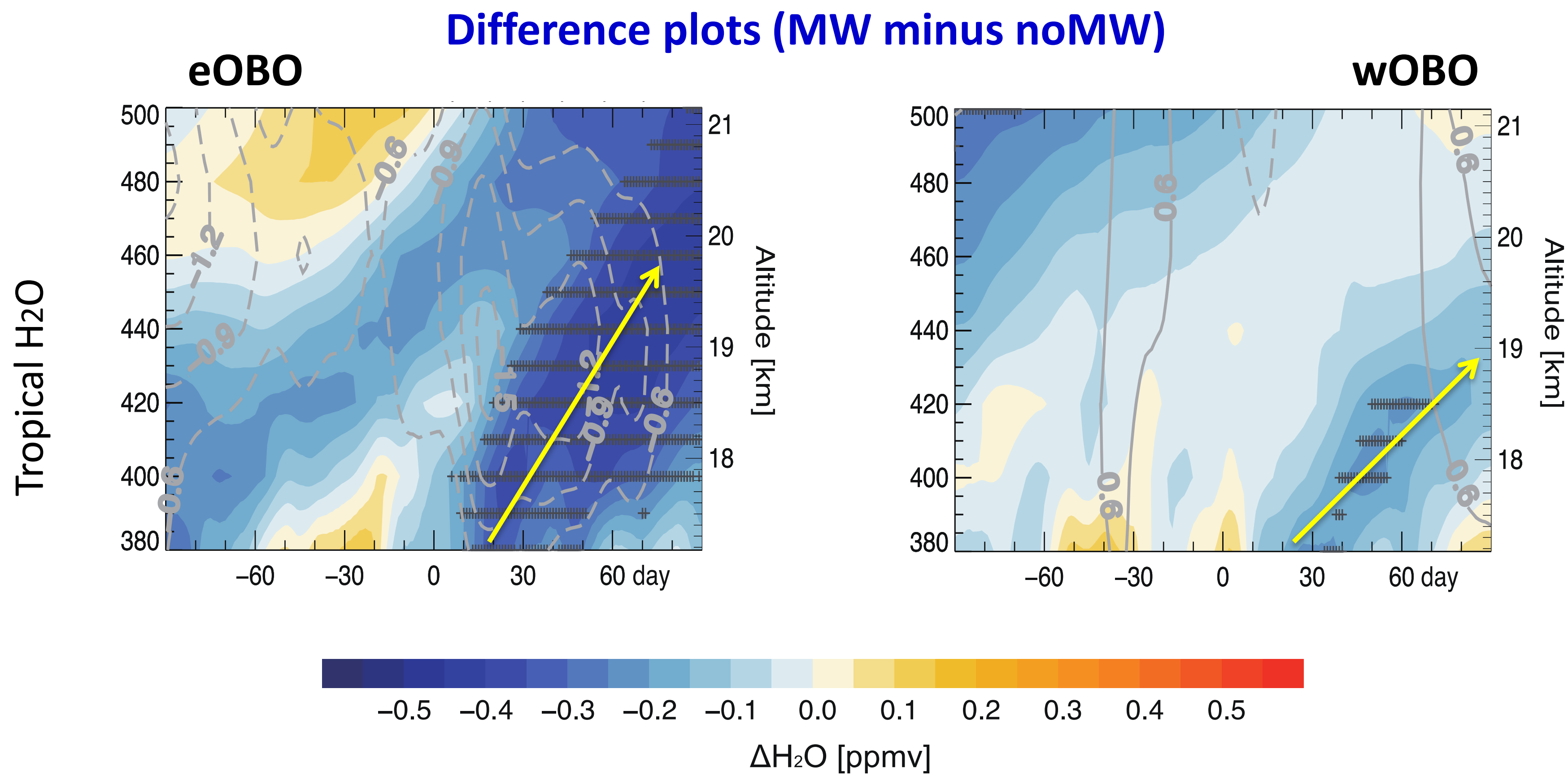
MW induced additional dehydration during eQBO and wQBO



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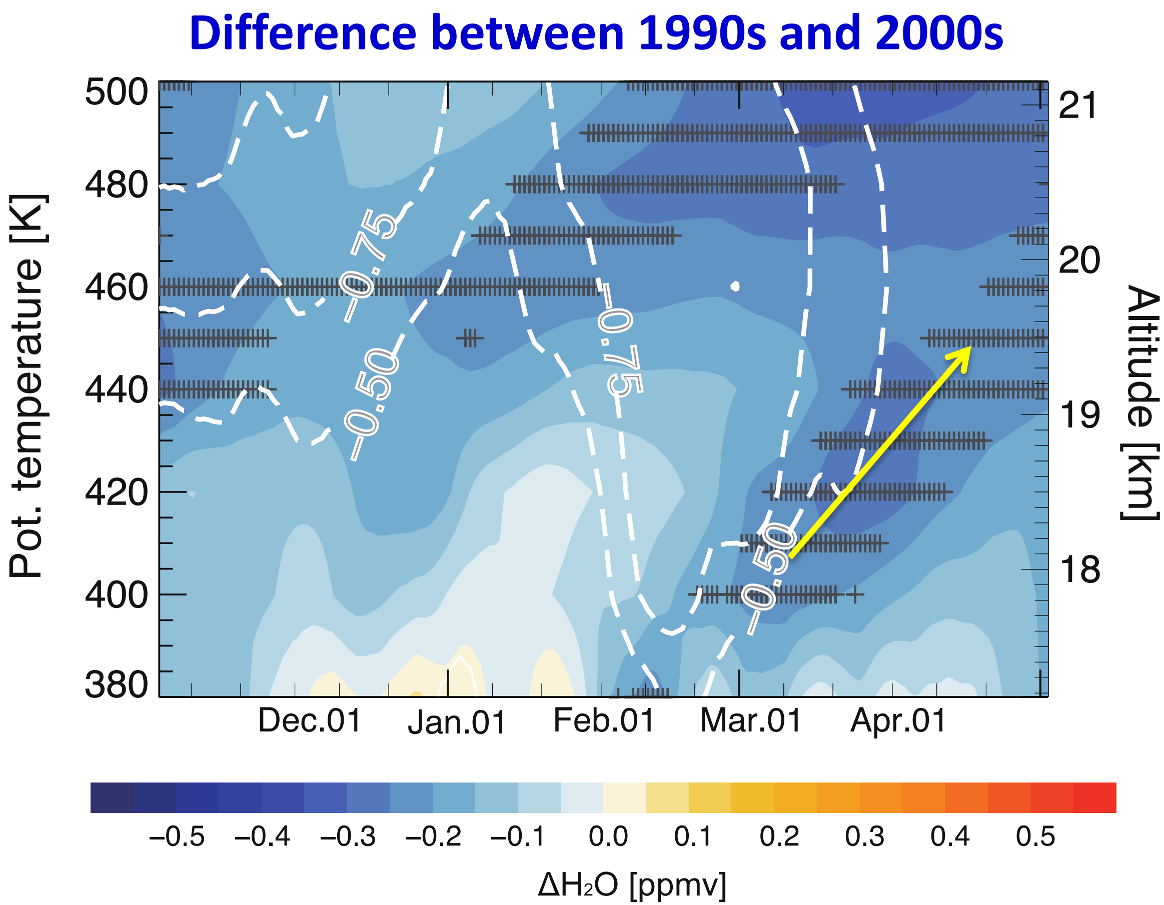
Influence of additional dehydration on decadal water vapor variability?



- 1 winter with MWs in 90s; 9 winters with MWs in 00s
- Signature of MWs can be clearly seen; contribution to lower H_2O values

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Conclusions Part-2

- MW-related enhanced upwelling results in a clear drying at the tropical tropopause by ~0.3 ppmv around 3 weeks after the MW in the eQBO phase.
- In the wQBO phase this drying signature is also present but considerably less pronounced (see Tao et al., 2015)
- MW-associated dehydration introduces a significant difference between the lower stratospheric water vapor in boreal late winter and spring of 2000s and 1990s.