Role of the Himalaya-Tibetan Plateau in Moistening the Tropopause as Inferred from the Model Simulations

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Introduction

- Water vapour in the upper troposphere and lower stratosphere plays influential roles in climate change (Solomon et al., 2010, Forster and Shine, 2002), radiation budget (Smith et al., 2001) and stratospheric chemistry (Shindell, 2001).
- Most of the water vapour present in the UTLS is transported via the tropical tropopause by atmospheric moist convection (Gettelman et al., 2009).
- Large-scale moistening of the tropopause is noted to occur during the boreal monsoon season (June-September) over South Asia (Jain et al., 2013) when convection is active over this region (Gettelman et al., 2004).

Introduction

- Observational studies have shown that the location of the water vapour maximum near the tropopause coincides with the location of upper-level Asian anticyclone (Fu et al., 2006, Park et al., 2007, Rosenlof et al., 1997) – which is one of the largest circulations in the UTLS during the boreal monsoon period.
- This enhancement of water vapour over the Asian region during the monsoon season could be due to the entrapment and isolation of air within the anticyclone (Park et al., 2009, Fu et al., 2006, Li et al., 2005).

Introduction

- The large-scale anti cyclonic circulation extends in the whole UTLS and therefore provides a gateway for moisture, as well other minor constituents, to enter into the stratosphere.
- It is generally believed that the entrapment of moisture within the anticyclone gives rise to the persistent seasonal maximum of water vapour over the Asian monsoon region, however, considering that the sources of water vapour lie in the lower troposphere, how this moisture reaches from the lower troposphere to the tropopause is still not clear?

Introduction

- Three main sources and pathways could lead to this seasonal enhancement of moisture near the tropopause (Jain and Kar, 2017, Fu et al., 2006)
- (1) transport of water vapour from the deep convective regions over the Indian subcontinent,
- (2) equator-ward transport from the extra-tropics, and
- (3) the local convection occurring over the Himalaya-Tibetan Plateau (HTP).

Model Experiment Details

Model and Simulations Details

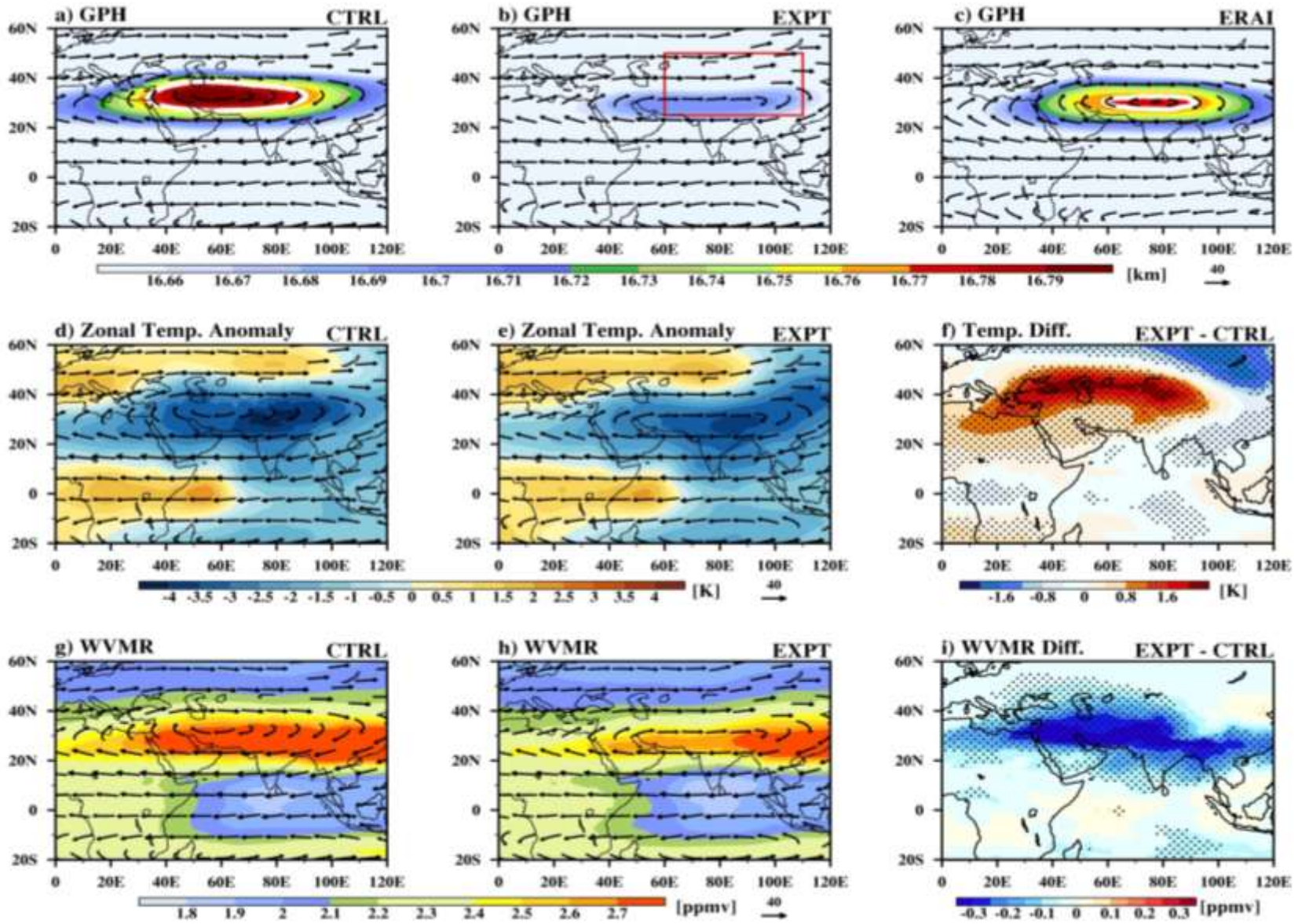
- NCAR CESM CAM 5.1 model is used with Finite Volume dynamical core and CAM4 physics option.
- All simulations are done with 0.9° × 1.25° horizontal resolution and 26 vertical levels.
- Simulation 1: Control run (CTRL), where the default orography of the model was used.
- Simulation 2: Experiment run (EXPT), where the orography over the Tibetan plateau and Himalayan region (25 °N to 50 °N, 60 °E to 110 °E) was suppressed to the mean sea level keeping all other land surface properties constant.
- The model simulations are started from 1 January initial condition and run for 5 years for each simulation. The seasonal mean distributions, the 5-years time-mean from June to September (JJAS) calculated using monthly mean data.

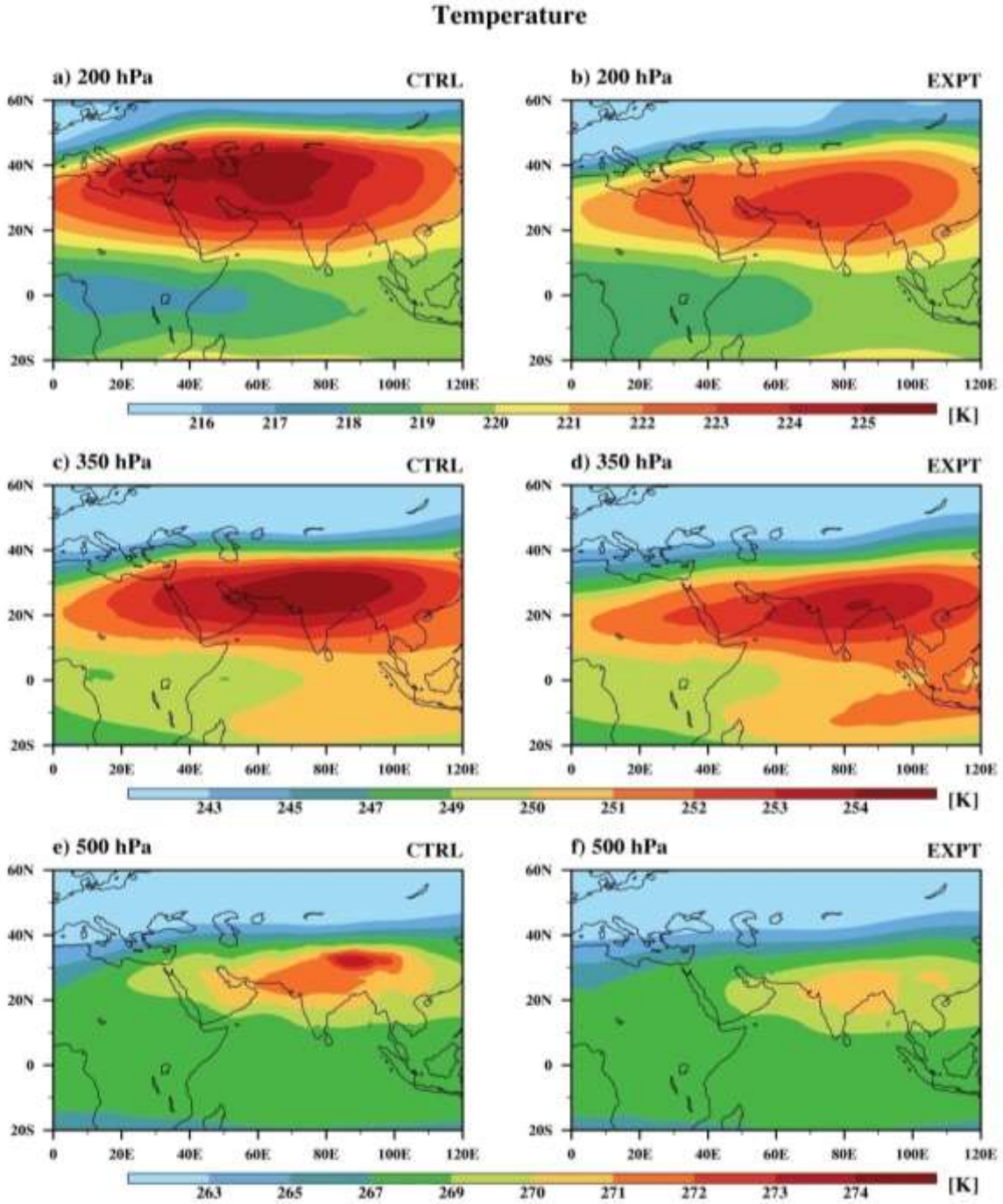
Research Question

- Considering that the sources of moisture lie at the surface, how this moisture reaches at the tropopause height is still not properly understood?

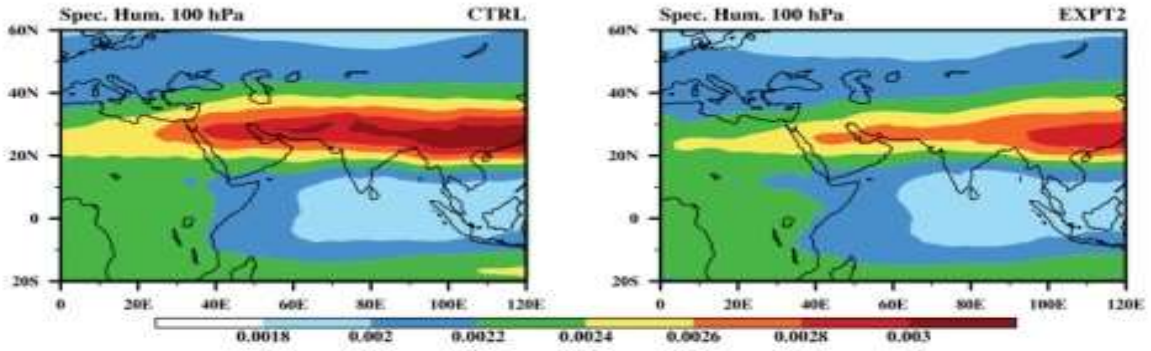
Results for Discussion

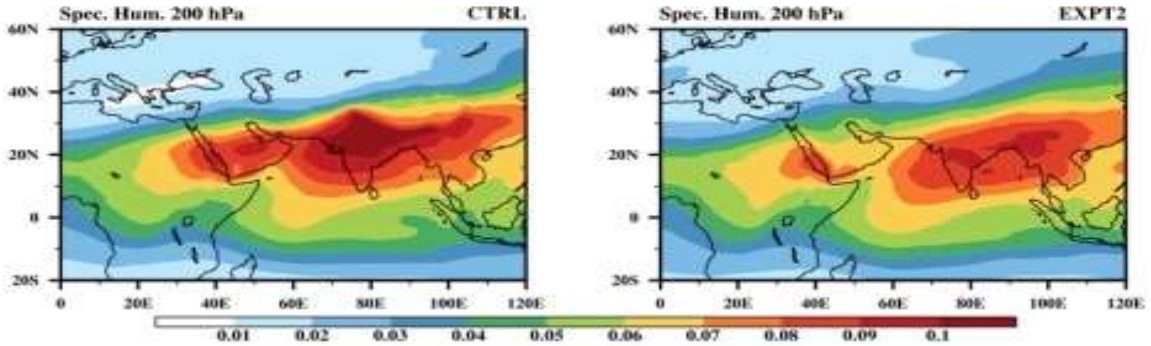
Upper-Level Asian Anticyclone

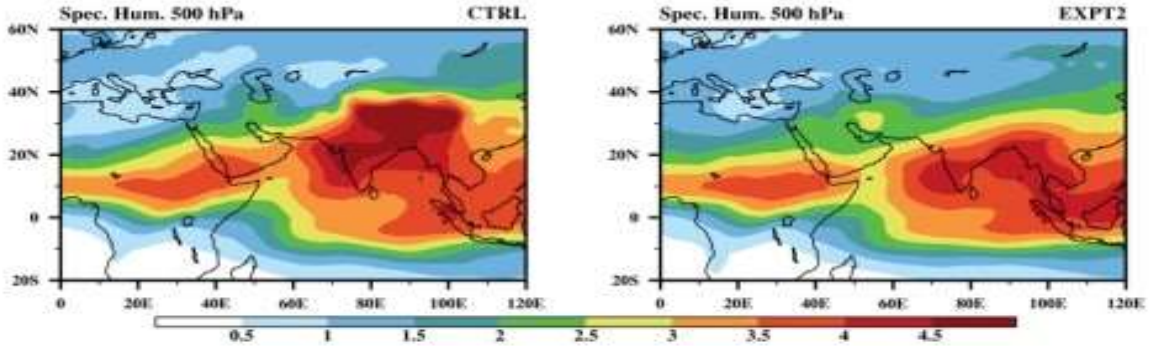


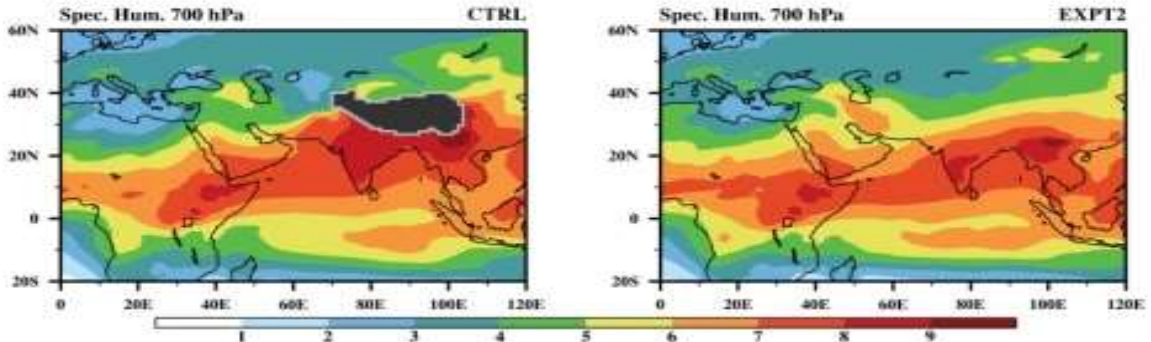


Results cont…



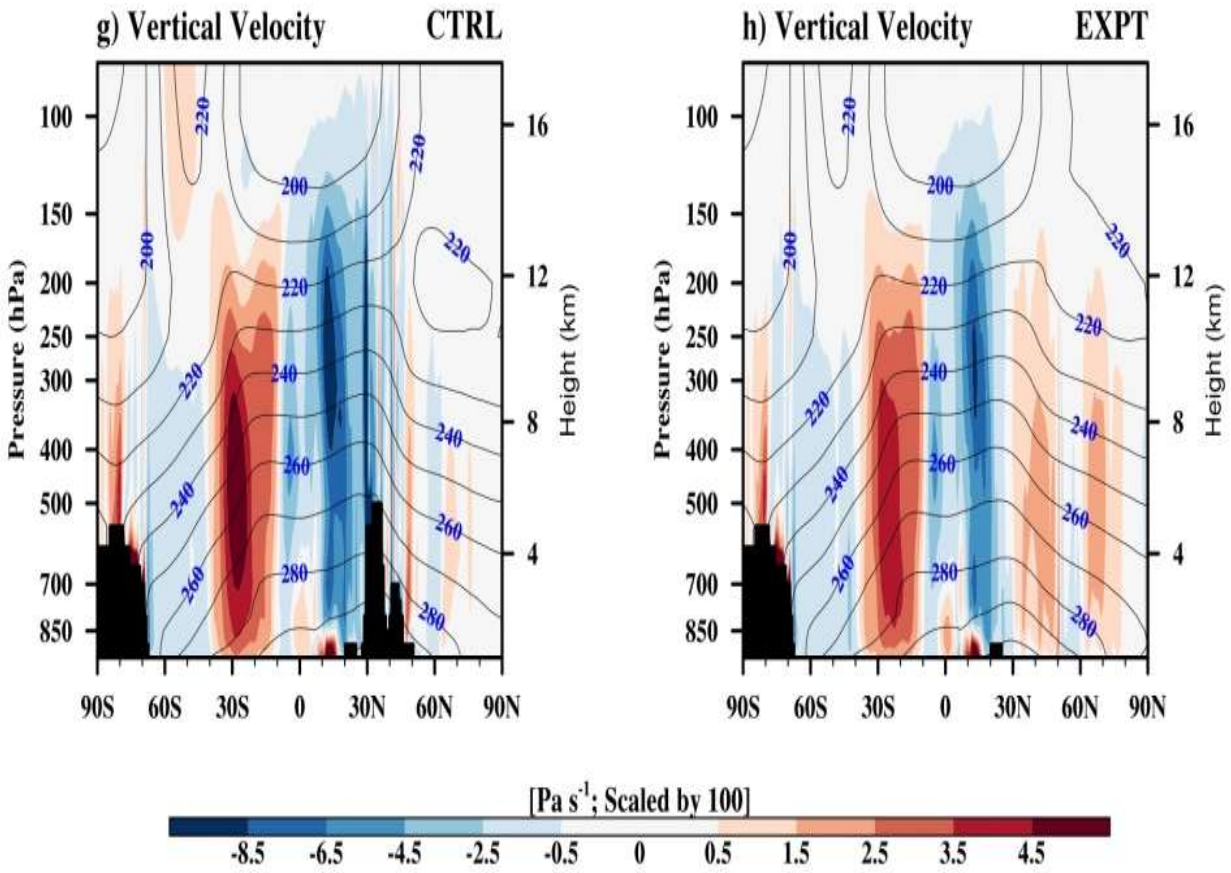






Moisture Transport

Results cont…



The maximum moisture in the tropopause lie in the proximity of Himalaya Tibetan Plateau (HTP) and how the existence of this high-elevation (average height is ~5 km from mean sea level) region influences the moisture transport to the tropopause region is examined in this study.

Conclusion

- Simulations done using a the model show that the high elevation of the HTP influences the transport of water vapour to the tropopause during boreal monsoon season.
- Around half of the seasonal increase (~50-55%) in moisture over the Asian monsoon region at 100 hPa can be caused by the high-elevation of this plateau.
- The moist convection occurring over the HTP emerges out to be the main source of moisture in mid-troposphere whereas the convection occurring over the Indian region is an important source of moisture in lower troposphere.
- In the upper troposphere, the moisture from these two different sources accumulates over the central Indian region and eventually rises into the tropopause region under the influence of Asian summer monsoon anticyclone.
- When the mountain orography is subdued to the mean sea level, the source of mid-tropospheric (500 hPa) moisture disappears, leading to a significant reduction in moisture at the tropopause level.

Conclusion

- The vertical transport over the central Indian region is also noted to weaken in the absence of this plateau, which serves as a barrier to the moisture emanating from the low-elevation convective regions over the Indian subcontinent.
- The Asian monsoon anticyclone is also noted to weaken and lie over the central Indian region in the absence of the HTP, which can, therefore, have an implication on the location and strength of the moistening in the tropopause.
- The disappearance of the moisture source from the mid-troposphere, weaker anticyclone and less vertical transport over the Indian region, collectively leads to a relatively drier tropopause in the absence of plateau and therefore suggests that the high-elevation of the HTP influences the water vapour budget of the tropopause and hence the lower stratosphere in multiple ways.

Be Mindful to

- Reduce Pollution
- Conserve Resources
- Conserve Energy
- Reduce Consumption & Waste
- Protect The Earth's Ecological Balance

Our present actions will define the future of our one and only Mother Earth

Thank You

- **Climate change is a serious issue which no one takes seriously**