Introduction

The tropical tropopause layer is the transition region between the tropical troposphere and the stratosphere. It controls the concentration of the stratospheric water vapor (Randel and Jensen 2013). Recent studies also suggested that temperature at the tropical tropopause may influence the intensity of tropical cyclones (Emanuel et al. 2013). Models robustly predict a warming and a downward shift of the tropical tropopause under global warming (Gettelman et al. 2010, Kim et al. 2013). Yet the detailed mechanism is not well understood. Here, we examine changes of the tropical tropopause in two idealized experiments. By analyzing the heat budget at the tropical tropopause, we identify the responsible physical processes and quantify their contributions.

Experiments and Methodology

GFDL AM3: (1) quadrupling $CO_2$; (2) globally uniformly increasing SST by 4K.

Summary and Conclusion

Both quadrupling $CO_2$ and increasing SST by 4K lead to ~1 K warming of the tropical cold point tropopause. The tropopause also shifts upwards in the 4KSST experiment.

In the 4xCO2 experiment, the warming of the tropopause mainly comes from the direct radiative effect of $CO_2$.

In the 4KSST experiment, the warming at 100 hPa is mainly contributed by the radiative effect of the warmer troposphere. The cooling at 63 hPa, on the other hand, results mainly from the enhanced Brewer-Dobson circulation, which cools lower stratosphere both adiabatically and radiatively via changes in ozone. The warming-below-cooling-above pattern leads to an upward shift of the tropopause. The higher tropopause allows convection to penetrate deeper and more clouds to form near the tropopause, both of which leads to warming at the tropopause layer. The upward shift of the tropopause also reduces the static stability around the 100 hPa level, which cancels the dynamical cooling from the enhanced Brewer-Dobson circulation at this level.

Contact

Pu.Lin@noaa.gov

References


Acknowledgement

This report was prepared under award NA08OAR4320752 from NOAA. The statements, findings, and conclusions are those of the author(s) and do not necessarily reflect the views of NOAA.