Tightening of Hadley Ascent and Tropical High Cloud Region Key to Precipitation Change in a Warmer Climate

*Hui Su[1], Jonathan H. Jiang[1], J. David Neelin[2], T. Janice Shen[1], Chengxing Zhai[1], Qing Yue[1], Zhien Wang[3], Lei Huang[4], Yong-Sang Choi[5], Graeme Stephens[1], Yuk L. Yung[6]

1. Jet Propulsion Laboratory, California Institute of Technology, 2. University of California, Los Angeles, 3. University of Wyoming, 4. Joint Institute for Regional Earth System Science and Engineering, UCLA, 5. Ewha Womans University, 6. California Institute of Technology

The changes of global-mean precipitation under global warming and interannual variability are predominantly controlled by the changes of atmospheric longwave radiative cooling. Here we show that the tightening of the ascending branch of the Hadley Circulation is a key process coupled to the decrease of tropical-mean high cloud fraction when the surface warms. The magnitude of high cloud shrinkage is a primary contributor to the inter-model spread in the rates of tropical-mean outgoing longwave radiation (*OLR*) and global-mean precipitation change per unit surface warming (dP/dT_s) for both interannual variability and global warming. Compared to observations, most CMIP5 models underestimate the rates of interannual *OLR* and precipitation increase with surface temperature, consistent with the muted high cloud shrinkage. We find that the five models that agree with the observation-based interannual dP/dT_s all predict dP/dT_s under global warming higher than the ensemble mean dP/dT_s from the ~20 models analyzed in this study.

Keywords: hydrological sensitivity, high cloud shrinkage, tightening of Hadley ascent

