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Relationship between surface and tropospheric water vapor variation on interannual timescale: A revisit

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It is an old question whether tropospheric water vapor at different levels changes consistently in response to the enhanced greenhouse gas in the atmosphere. Earlier studies using older versions of climate models and available data revealed a significant difference between models and observations. Water vapor changes in the interior of the tropical troposphere have been found to be more strongly coupled to changes at the surface in climate models than in observations. We reexamine this issue using four leading CMIP5 models (CCSM4, HadGEM2-A, GFDL-CM3 and MPI-ESM-MR) and more updated observational datasets (ERA-Interim and NCEP reanalysis). Focusing on the Tropics, we have calculated the correlations between interannual variation of specific humidity in all levels of the troposphere with that at the surface. It is found that the previously noted biases in the strength of the coupling between water vapor changes in the interior of the troposphere and those at the surface still exist in the updated models—the change in the tropical averaged tropospheric water vapor is more strongly correlated with the change in the surface, especially in the middle troposphere. It is argued that the vertical profile of water vapor correlations in observations is more consistent with the “hot tower” concept for tropical convections. Zonal mean correlation results and those from the moisture regime sorting method are consistent with each other, both of which indicate the role of deep convection as a mechanism to couple the middle tropospheric water vapor and that in the surface and that an inaccurate representation of deep convection as a possible cause for the discrepancies between models and observations in the coupling between middle tropospheric water vapor and those at the surface.