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Comparison of Hydrological Cycle and Sensitivity Between Multiscale Modeling Frameworks with and without a Higher-order Turbulence Closure

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Current conventional global climate models (GCMs) produce a weak increase in global mean precipitation with anthropogenic warming in comparison with the lower-tropospheric moisture increases. The motive of this study is to understand the relatively small differences in the hydrological sensitivity between two multiscale modeling frameworks (MMFs) that arise from the different treatments of turbulence in order to aid to the understanding of the large model spread among conventional GCMs. We compare the hydrological sensitivity and its energetic constraint from MMFs with (SPCAM-IPHOC) or without (SPCAM) an advanced higher-order turbulence closure. SPCAM-IPHOC simulates higher global hydrological sensitivity (3.7%/K) than SPCAM (3.0%/K) and GCMs (2.52$\pm$0.22%/K). This is mostly related to the higher sensitivity of surface sensible and latent heat fluxes and radiative cooling to surface warming and a higher ratio of latent heating to radiative cooling. The two MMFs differ greatly in the hydrological sensitivity over the tropical lands, where the simulated sensitivity of surface sensible heat fluxes to surface warming and CO_2 increase in SPCAM-IPHOC is weaker than in SPCAM. Furthermore, the different divergences of dry static energy flux simulated by the two MMFs contribute to the difference in regional precipitation sensitivity between the two models. Implications of these results to conventional GCMs will be discussed at the meeting.