Geophysical Research Abstracts
Vol. 18, EGU2016-11093, 2016
EGU General Assembly 2016

Processes linking the hydrological cycle and the atmospheric radiative budget

Stephan Fueglistaler (1,2) and Tra Dinh (2)

(1) Princeton University, Geosciences, Princeton, United States (stf@princeton.edu), (2) Program in Atmospheric and Oceanic Sciences, Princeton University, Princeton

We study the response of the strength of the global hydrological cycle to changes in carbon dioxide (CO_2) using the HiRAM General Circulation Model developed at the Geophysical Fluid Dynamics Laboratory (GFDL), with the objective to better connect the well-known energetic constraints to physical processes. We find that idealized model setups using a global slab ocean and annual mean insolation give similar scalings as coupled atmosphere-ocean models with realistic land and topography. Using the surface temperatures from the slab ocean runs, we analyse the response in the atmospheric state and hydrological cycle separately for a change in CO_2 (but fixed surface temperature), and for a change in surface temperature (but fixed CO_2). The former perturbation is also referred to as the "fast" response, whereas the latter is commonly used to diagnose a model's climate sensitivity. As expected from the perspective of the atmospheric radiative budget, an increase in CO_2 at fixed surface temperature decreases the strength of the hydrological cycle, and an increase in surface temperature increases the strength of the hydrological cycle. However, the physical processes that connect the atmospheric radiative energy budget to the sensible and latent heat fluxes at the surface remain not well understood. The responses to the two perturbations are linearly additive, and we find that the experiment with fixed surface temperature and changes in CO_2 is of great relevance to understanding the total response. This result points to the importance of local radiative heating rate changes rather than just the net atmospheric radiative loss of energy. Although larger in magnitude, the response to changes in surface temperature is dominated by the temperature dependence of the water vapor pressure, but in both cases changes in near-surface relative humidity are very important.