Geophysical Research Abstracts
Vol. 17, EGU2015-2221-2, 2015
EGU General Assembly 2015

Precipitation and circulation response to warming shaped by radiative changes of clouds and water vapor

Aiko Voigt (1) and Tiffany Shaw (1,2,3)

(1) Lamont-Doherty Earth Observatory, Columbia University, New York, United States (aiko@ldeo.columbia.edu), (2) Department of Earth and Environmental Sciences, Department of Applied Physics and Mathematics,Columbia University, New York, United States, (3) Department of Geophysical Sciences, University of Chicago, Chicago, United States

The atmospheric circulation controls how global warming will be expressed regionally, in particular by locally altering the hydrological cycle through changes in moisture transport. While climate models robustly project an increase of global-mean precipitation at a rate of 1-3% per degree warming, there is much less consensus on how the global-mean increase will be distributed regionally, and confidence in long-term projections of regional precipitation changes remains much lower than for temperature. Here, two CMIP5 aquaplanet models, MPI-ESM and IPSL-CM5A, and their response to a uniform 4K increase of sea-surface temperatures are compared to study how radiative changes of clouds and water vapor influence the regional response of precipitation and the circulation to global warming, and to investigate to which extent uncertainty in clouds and water vapor lead to uncertainty in the precipitation and circulation response. Using the cloud and water-vapor locking method it is shown that cloud-radiative changes dominate the response of deep-tropical precipitation and the strength of the Hadley circulation, and lead to disagreement between the two models. In MPI-ESM changes in tropical ice clouds cause a narrowing of the inter-tropical convergence zone (ITCZ) and a strengthening of the Hadley circulation, whereas they lead to a widening of the ITCZ and a weakening of the Hadley circulation in IPSL-CM5A. Radiative changes of clouds and water vapor also impact the subtropics and extratropics. Cloud changes are found to amplify the poleward expansion of the tropical belt and the poleward shift of the extratropical jet, consistent with the fact that they stabilize the tropical atmosphere. In contrast, water vapor changes destabilize the tropical atmosphere and contract the tropical belt and jet towards the equator. Both models show the opposing impacts of cloud and water vapor changes on the jet shift, but the degree of compensation between cloud and water-vapor changes is model-dependent. These results demonstrate that radiative changes of clouds and water vapor are not only integral to the magnitude of future global-mean temperature but also to regional climate change. A deeper understanding of the radiative coupling between clouds, water vapor and the circulation and how this coupling might respond to climate change is thus needed to understand and predict changes in the hydrological cycle.