PhD Defense Announcement
Alexandra Naegele
November 13, 2020 at 10:00 a.m.

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PhD Defense

Friday, November 13, 2020
10:00 a.m.

Defense
Virtual (Teams link to follow)

Post Defense Meeting
Virtual

Committee:
David Randall (Adviser)
Kristen Rasmussen
Susan van den Heever
Michele Betsill (Political Science)

The Influence of Cloud Radiative Effects on Hydrologic Sensitivity and Variability

The global-mean precipitation change in response to CO_2-forced warming, normalized by global-mean surface warming, is referred to as the hydrologic sensitivity. It is estimated at 1-3% K^{-1}, much lower than the rate of increasing atmospheric moisture availability. Here, we study the role of cloud radiative effects (CREs) in constraining the hydrologic sensitivity. Often, the change in clear-sky atmospheric radiative cooling (ARC) is used to constrain the change in precipitation, but this constraint is incomplete. CMIP5 model data are analyzed to show that although the all-sky ARC increases at a lower rate than the clear-sky ARC, the smaller change in ARC due to CREs is balanced by the change in the surface sensible heat flux. Together, the change in the all-sky ARC with the change in the surface sensible heat flux provide a more accurate and complete energetic constraint on hydrologic sensitivity than by using the clear-sky radiative cooling alone.

Idealized aquaplanet simulations using SP-CAM are analyzed to assess the temperature dependence of the atmospheric cloud radiative effect on the hydrologic cycle and the large-scale circulation. We examine the response of the hydrologic cycle and the large-scale circulation to CREs at a range of sea surface temperatures (SSTs), including a cool (280 K) SST that is representative of the mid-latitudes; typically, the extratropics have been less studied than the tropics in similar idealized simulations. In particular, we use simulations with uniform SSTs to test the hypothesis that CREs enhance precipitation variability at cool temperatures, and reduce precipitation variability at warm temperatures. In these simulations, our hypothesis is confirmed. In less idealized simulations with a more realistic SST pattern, the influence of CREs on precipitation variability is obscured by other factors.

Can the hydrologic response to CREs be explained by the large-scale circulation response to CREs? Using the same idealized simulations, changes in the vertical velocity due to CREs—used here as a measure of circulation changes—are compared to changes in precipitation due to CREs. We find that the influence of CREs on vertical velocity variability is similar to their influence on precipitation variability.