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Robust and non-robust impacts of atmospheric cloud-radiative interactions on the tropical circulation and its response to surface warming

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Clouds and the circulation are tightly coupled. Here, we study the impact of cloud-radiative interactions on the tropical circulation and its response to surface warming by comparing aquaplanet model simulations with enabled and disabled cloud-radiative interactions in eight global atmosphere models. The simulations are part of the Clouds On-Off Klimate Intercomparison Experiment (COOKIE). We find that in a present-day-like climate, cloud-radiative interactions strengthen the Hadley cell, narrow and strengthen tropical ascent, and widen subtropical descent. We suggest that these robust cloud impacts result from four fundamental properties of the atmosphere: i) tropical deep-convective clouds decrease tropical-mean precipitation, ii) tropical precipitation is predominantly generated by deep ascent, iii) tropical free-tropospheric temperatures are nearly uniform in the horizontal, and iv) the Hadley circulation conserves mass. As for the circulation response to surface warming, changes in cloud-radiative interactions have no robust impact across models but strongly amplify the model spread in the ascent response.