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Double and single ITCZs with and without clouds

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Aqua-planet simulations are a convenient way to investigate general aspects of the large-scale circulation, because the absence of surface inhomogeneities facilitates the interpretation of model results. However, in simulations with prescribed surface temperatures two distinct inter-tropical convergence zones (ITCZs) appear on both hemisphere in a multitude of models. Two distinct ITCZs can locally also occur on Earth, especially over the eastern Pacific and over the Indian Ocean in boreal summer, but climate models tend to produce two ITCZs too frequently and too distinctively. Therefore, understanding the factors controlling the position of the ITCZ in aqua-planet experiments will improve our ability to accurately model tropical precipitation on Earth and help us to better understand important interactions between the hydrological cycle and the general circulation.
Several mechanisms contributing to the ITCZ position have been proposed, such as the coupling between convection and large-scale circulation and too weak meridional surface-temperature gradients, but there is still no coherent theory. We tackle this problem by investigating how various aspects of the interaction between cloud-radiative effects (CREs) and the large-scale circulation influence the ITCZ position.
To this end, we use a developmental version of the new Geophysical-Fluid-Dynamics-Laboratory atmosphere model version 4. We perform numerous simulations in an idealized aqua-planet setup, in which the longwave and the shortwave CREs are turned off separately or jointly in the lower and/or in the upper troposphere. Preliminary results suggest that the double ITCZ found in our control simulation merges into one single ITCZ at the equator, if the shortwave CRE is turned off. In contrast, the ITCZs move further poleward, if the longwave CRE is turned off. Thus the longwave CRE pulls the ITCZ equatorward while the shortwave CRE pulls the ITCZ poleward. Furthermore, we find that the longwave CRE of clouds in the upper troposphere has a considerably larger influence on the ITCZ position than that of clouds in the lower troposphere.