

The climate sensitivity of aqua planets

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Cloud feedbacks remain a leading source of uncertainty in projections of future climate. This uncertainty arises because of the complex interactions between clouds and the environment. General circulation models (GCM) are the best available tools for studying cloud feedbacks and climate sensitivity, but are designed chiefly to simulate a realistic climate which can obfuscate the physical processes involved with feedbacks. Two state-of-the-science atmospheric GCMs using simplified aqua planet configurations are used here to understand the zonally symmetric component of climate sensitivity and the role cloud feedbacks play in it.

Using several Cess-style climate change experiments the aqua planets are compared with the full GCMs. Despite the relatively simple climate, many aspects of the aqua planets are analogous to more realistic simulations, and the climate response to an increase in sea-surface temperature captures much of the behavior of the full GCM. Cloud feedbacks, especially in the Tropics, are similar to the full GCM response. The sign of the tropical cloud feedback is opposite in the full GCMs, and the aqua planets consistently have the same sign as their parent GCM. Changes in low clouds are commensurate with the climate response, while middle and high clouds show less consistent behavior across the configurations, hinting that low clouds are of vital importance in a changing climate. If the correspondence between the climate responses of aqua planets and the full GCM is robust, the aqua planet framework suggests an attractive method for investigating processes involved in simulations of climate change. In this work, we ask whether the aqua planet climate sensitivity arises from the same physical processes as in the default GCM configuration and make recommendations for future use of aqua planets.