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On the climate sensitivity in global aqua-planet simulations

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A number of recent studies conclude that uncertainty of cloud radiative effects in global circulation models (GCMs) with respect to imposed warming is on the same order of magnitude as the radiative forcing due to the increase in greenhouse gasses since the industrial revolution. This uncertainty persists over generations of GCMs and imposes a key limitation on better understanding of the climate sensitivity of the whole coupled Earth system. Because physical processes in the atmosphere are highly nonlinear and coupled it is not well understood which processes are at the heart of the uncertainty problem. To shed light to this question, we perform a series of global aqua-planet simulations with prescribed sea surface temperature (SST) using the Weather Research and Forecasting (WRF) Model. This series of simulations represents a simplified yet realistic framework in which climate change is represented by an increase in the SST. We investigate the sensitivity of the WRF model climate response (in particular clouds) as a function of different combinations of the dynamical and physical parameterization options. We show that physical parameterizations are responsible for the majority of the uncertainty of the WRF model response. Specifically we find that the WRF is highly sensitive to the parameterization of turbulent mixing, which depends on the combination of boundary layer and convection parameterizations. We anticipate that these findings will be helpful for more focused development of GCMs.