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Time variation of effective climate sensitivity in GCMs

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Effective climate sensitivity is often assumed to be constant (if uncertain), but some previous studies of General Circulation Model (GCM) simulations have found it varying as the simulation progresses. This complicates the fitting of simple models to such simulations, as well as having implications for the estimation of climate sensitivity from observations. This study examines the evolution of the feedbacks determining the climate sensitivity in GCMs submitted to the Coupled Model Intercomparison Project. Apparent centennial-timescale variations of effective climate sensitivity during stabilisation to a forcing can be considered an artefact of using conventional forcings which only allow for instantaneous effects and stratospheric adjustment. If the forcing is adjusted for processes occurring on timescales which are short compared to the climate stabilisation timescale then there is little centennial timescale evolution of effective climate sensitivity in any of the GCMs. We suggest that much of the apparent variation in effective climate sensitivity identified in previous studies is actually due to the comparatively fast forcing adjustment.

Persistent differences are found in the strength of the feedbacks between the coupled atmosphere - ocean (AO) versions and their atmosphere - mixed-layer ocean (AML) counterparts, (the latter are often assumed to give the equilibrium climate sensitivity of the AOGCM). The AML model can typically only estimate the equilibrium climate sensitivity of the parallel AO version to within about 0.5K. The adjustment to the forcing to account for comparatively fast processes varies in magnitude and sign between GCMs, as well as differing between AO and AML versions of the same model. There is evidence from one AOGCM that the forcing adjustment may take a couple of decades, with implications for observationally based estimates of equilibrium climate sensitivity. We suggest that at least some of the spread in 21st century global temperature predictions between GCMs is due to differing adjustment processes, hence work to understand these differences should be a priority.