Importance of Ocean Heat Uptake Efficacy to Transient Climate Change

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Abstract

We propose a modification to the standard forcing/feedback diagnostic energy balance model to account for 1) differences between effective and equilibrium climate sensitivities and 2) the variation of effective sensitivity over time in climate change experiments with AOGCMs. In the spirit of Hansen et al (2005) we introduce an efficacy factor to the ocean heat uptake. Comparing the time-evolution of the warming in high and low efficacy models demonstrates the role of this efficacy in the transient response to CO$_2$ forcing. Abrupt CO$_2$ increase experiments show that the large efficacy of the GFDL CM2.1 AOGCM sets up rapidly after a change in forcing. The use of an efficacy is necessary to fit this model’s global mean temperature evolution in periods with both increasing and stable forcing. The inter-model correlation of transient climate response with ocean heat uptake efficacy is greater than its correlation with equilibrium climate sensitivity in an ensemble of climate models used for the 3rd and 4th IPCC assessments. The efficacy is variable amongst the models but is generally greater than 1 and averages between 1.3 an 1.4.