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Climate sensitivity, adjusted radiative forcing and ocean thermal inertia of CMIP5 AOGCMs

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In this study, we analyze climate models within the framework of a linear 2-box energy balance model (EBM) (Held et al, 2010; Geoffroy et al, 2012a). An analytical solution of the EBM is given. This solution gives a didactic description of the contribution of the equilibrium, the fast and the slow responses during a transition regime. It also allows a simple and physically-based procedure to adjust the EBM parameters from an AOGCM step forcing experiment. The method is applied to 12 CMIP5 AOGCMs using the abrupt $4xCO_2$ experiment. It is shown that the EBM is efficient in representing step-forcing, linear forcing (and stabilization when available) experiments for each AOGCM. However the calibration method lies partly on the Gregory et al (2004) linear fit method that has some limitations in representing the radiative imbalance evolution during a climate transition and then in computing the equilibrium climate sensitivity and the adjusted radiative forcing. In a second step the benefit of the introduction of an efficacy factor of deep ocean heat uptake (Winton et al, 2010, Held et al., 2010; Geoffroy et al, 2012b) is investigated. The addition of this property allows to take into account the change of the radiative feedbacks strength during the transition due to the modification of the temperature pattern induced by the deep ocean heat uptake. It is shown that the radiation imbalance evolution is accurately represented by the simple model. The calibration method, validated for the 12 CMIP5 AOGCMs, constitutes a new method for estimating consistently the equilibrium climate sensitivity, the amplitude of the adjusted radiative forcing and the thermal inertia global properties of an AOGCM from a step-forcing centennial experiment. Finally, the contribution of each of these properties to the multimodel spread of the transient climate response is quantified using a analysis of variance method.