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Changing climate sensitivity through cloud adjustment.

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Conducting probabilistic climate projections with a particular climate model requires the ability to vary model's characteristics, such as climate sensitivity. A number of studies aimed on obtaining model's versions with different climate sensitivities have been carried out recently with different AOGCMs using a perturbed physics approach. The ranges of climate sensitivities generated in most of these studies, however, do not cover the ranges obtained based on the climate changes observed over the 20^{th} century. Moreover, in most cases, obtained values tend to cluster around the climate sensitivity of the unperturbed version of the given model.

A different approach was used in simulations with the GISS AOGCM. The model's climate sensitivity has been changed by adjusting the cloud cover used in radiation calculations and, thereby, by artificially changing the cloud feedback. A slightly modified approach was used in simulations with the MIT 2D (zonally-averaged) climate model. Namely, the cloud fraction used in radiation calculations is adjusted as follows:

$C^{rad} = C^{o} \bullet (1.0 \pm \quad \kappa \bullet \Delta T_{srf})$, (1)

where C^{o} is the cloud fraction simulated by the model and ΔT_{srf} is the difference of the global-mean surface air temperature from its values in the control climate simulation.

This adjustment is applied, with different signs, to high and low clouds. Changing high and low clouds in opposite directions is related to the fact that the feedback associated with changes in cloud cover has different signs for high and low clouds. Therefore, the use of different signs in Equation (1) depending on clouds heights allows to minimize the value of κ required to obtain desirable climate sensitivity.

This approach was extensively tested in simulations with the MIT climate model. It was shown that the cloud adjustment method for changing model climate sensitivity does not lead to any physically unrealistic changes in the model response to an external forcing. In particular, the dependency of the changes in the components of the global mean surface energy balance on changes in surface air temperature is very similar to that seen in simulations with different AOGCMs.

This approach has some advantages compared to the perturbed physics approach. In particular, the cloud adjustment approach allows varying the model sensitivity over a very wide range. Simulations with the MIT IGSM showed that any given value of climate sensitivity can be obtained with 0.1^{o}C precision using a lookup table with about 25 reference values. This, in its turn, allows conducting Monte Carlo type probabilistic climate forecast where values of uncertain parameters should not just cover the whole uncertainty range but should cover it homogeneously.

Recently the algorithm for changing cloud feedback was implemented in the CAM3 AGCM, which allows carrying out more comprehensive tests. In this paper results of equilibrium and transient climate change simulations with versions of the CAM3 in which the climate sensitivity was changed by the cloud adjustment method are compared with the results of simulations in which the CAM sensitivity was changed using the perturbed physics approach.