Geophysical Research Abstracts,
Vol. 11, EGU2009-4006, 2009
EGU General Assembly 2009

Constraints on climate sensitivity from radiation patterns in climate models

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The estimated range of climate sensitivity, or the equilibrium warming resulting from a doubling of the atmospheric carbon dioxide concentrations, has not decreased substantially in past decades. New statistical methods for estimating the climate sensitivity have been proposed and provide a better quantification of relative probabilities of climate sensitivity within the almost canonical range of 2 K - 4.5 K, but large uncertainties remain, in particular for the upper bound. Simple indices of spatial radiation patterns are used here to establish a relationship between an observable radiative quantity and the equilibrium climate sensitivity. The indices are mainly computed for the CMIP3 multi-model data set along with the perturbed physics ensemble from climate*prediction*.net, where the latter provides some insights into the robustness of our findings using the CMIP3 models. The indices offer a possibility to constrain climate sensitivity by considering radiation patterns in the climate system. The ERA40 and the NCEP/NCAR reanalysis data sets are used as observational reference values. High correlations between the indices and climate sensitivity are found in the longwave regime, most likely related to the uncertainty in cloud feedbacks, which are still the largest source of uncertainty for climate sensitivity. The largest fraction of the estimated climate sensitivities lies in the range between 2.5 K - 5.0 K for both data sets. For indices with a correlation coefficient above ± 0.5, the ERA40 and NCEP/NCAR reanalysis give a median estimate of 3.7 K for the climate sensitivity. The results suggest that values for the sensitivity below 1.5 K are inconsistent with observed radiation patterns given the structure of current climate models, whereas large values up to 9.3 K seem possible but rather unlikely. While these ranges cannot be interpreted properly in terms of probability, they are consistent with other estimates of climate sensitivity and reaffirm that the current climatology provides a strong constraint on the lower bound of climate sensitivity even in structurally different models.