Geophysical Research Abstracts, Vol. 8, 05271, 2006
SRef-ID: 1607-7962/gra/EGU06-A-05271

Probabilistic projections of climate change fields from a multivariate Bayesian analysis of climate model data

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Recent work on probabilistic climate change projections has focussed mainly on the evolution of global mean temperature. However, impacts and adaptations are determined mostly by local climate change and thus require a quantitative picture of the expected change on regional and seasonal scales. Here, we present probabilistic projections for fields of future climate change using a multivariate Bayesian analysis. The statistical technique is based on the assumption that spatial patterns of climate change can be separated into a large scale signal related to the true forced climate change and a small scale signal from model bias and variability. The different scales are represented via a dimension reduction technique in a hierarchical Bayes model. Posterior probabilities are obtained using a Markov chain Monte Carlo simulation technique. The approach is applied to simulations of climate of the twentieth century and several scenarios for the twenty first century from coupled atmosphere ocean general circulation models used in the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. In contrast to other techniques, the method presented here takes into account uncertainty due to the use of structurally different climate models. It explicitly models the spatial covariance of the global fields, thus providing PDFs of localized climate change that are nevertheless coherent with the distribution of climate change in neighboring locations. We present probability density functions for the projected temperature in different regions as well as probabilities of exceeding temperature thresholds aggregated over space. By the end of the century in the SRES A1B scenario, 40% of the land regions are found to very likely (90% probability) warm more than two degrees Celsius relative to the preindustrial era in boreal winter (38% in boreal summer).