Geophysical Research Abstracts, Vol. 9, 02302, 2007
SRef-ID: 1607-7962/gra/EGU2007-A-02302

Generation of probabilistic climate change projections by Bayesian Model Averaging

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The quantification of uncertainties is a crucial task in order to create reliable climate change projections. To assess this problem we use Bayesian Model Averaging (BMA) which is an observation-constrained method for weighting models in order to their performance in a certain training period. As result the method delivers a weighted Probability Density Function (PDF) based on the internal variability in the training period. We apply BMA to a multi-model-ensemble of 21 IPCC AR4-AOGCMs and generate a probabilistic prediction of 21st century surface air temperature changes on global and continental scale. Training is performed on the period of 1950-99 with consideration of long term changes only. This is done by calculating Legendre Polynomial coefficients from the training time series.

The results of two different approaches for gaining model weights, Bayes Factors (BF) and EM-algorithm (EM) are compared with the results of the Arithmetic Ensemble Mean (AEM). Both, BF and EM, tend to select a few high-skilled models and leave out the others with EM doing an even stricter model selection. The resulting PDFs show multi-modal structures after the middle of the 21st century, while this behavior is not clearly seen in the unweighted PDFs. Further BF and EM produce broader PDFs in the 95% percentiles than AEM as well as higher means. On continental scale multi-modality is stronger than on global scale, but here BMA has little effect on 5% and 95% percentiles.

The results indicate that the ensemble is to small for capturing the internal variability correctly and that observation-constrained methods can be sensitive to the method of training. On continental scale it is suggested to apply a more physically-based multi-variate approach instead of calculating weights for every region separately.