Geophysical Research Abstracts
Vol. 12, EGU2010-10981, 2010
EGU General Assembly 2010

A stochastic physics parameterization in regional-scale climate simulations based on Markov random fields

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Recent studies on seasonal re-forecasts suggest that climate model ensembles based on stochastic-dynamic parameterizations have the potential to outperform multi-model ensembles. Traditionally, parameterizations describe the evolution of grid-mean quantities that can not be described by fundamental physical laws. These parameterizations do not take into account higher moments of such variables, or the effect of energy backscatter from unresolved scales to larger scales. Stochastic parameterizations try to consider these aspects and have been shown to result in more realistic energy spectra in climate model simulations. We present a novel stochastic parameterization implemented in a regional climate model based on the concept of Markov random fields. Physical tendencies as well as turbulent exchange coefficients are perturbed by a stochastic scheme that rests on the concept of a Markov random field. Markov random field models represent data at a spatial location as a linear combination of data at neighboring (spatial and temporal) locations, thus inducing dependence through this auto-regression and the neighborhood structure in the data. In our approach, the stochastic forcing is scaled by tendencies that represent sources of energy backscatter such as wind tendencies resulting from convective activity. We show the results of several stochastic 10 years simulations over the European domain using the regional climate model REMO. The dependence of the results on the strength of the perturbation as well as on the quantities that are perturbed is discussed in detail.