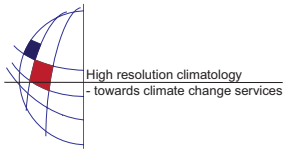
EMS Annual Meeting Abstracts
Vol. 7, EMS2010-646, 2010
10th EMS / 8th ECAC



A novel approach to climate reconstructions using Ensemble Kalman Filtering

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Past climate states are usually reconstructed based on the empirical relationship between climate proxy records and climate variables during the past century. This approach, however, is applicable only to a small set of climate variables for which robust linear relationships with climate proxies can be found. Furthermore, climate proxies are spatially incomplete and noisy, thus limiting the level of detail of such reconstructions. Climate model simulations driven with reconstructed forcing time series, on the other hand, provide spatially explicit information about all variables modelled. From a sufficiently large set of simulations differing in initial conditions, we can further derive the statistical properties of the climate system at any one time. By combining simulations with proxy records, we are able to compute comprehensive reconstructions that are consistent with both the proxy data and model physics.

We reconstruct the period from 1600 to 1870 using a set of 30 simulations with the ECHAM5 model driven with reconstructed climate forcings such as SSTs, land surface properties or solar irradiance. Apart from the varying boundary conditions and forcings, the simulations are unconstrained. In a second step, we assimilate climate proxy data in the aggregated model output using the Ensemble Kalman Filter (EnKF). In contrast to empirical-statistical reconstructions, the EnKF approach allows us to exploit the state dependent relationship between different climatic variables estimated from the ensemble of model simulations to constrain variables that are only loosely related to climate proxies. Among these analyses of past climate states, we select the optimal analogue as our best guess of a reconstructed climate state using a simple cost function. Finally, we concatenate all optimal analogues resulting in a reconstructed time series of various climatic parameters with global coverage. The thus reconstructed time series are then compared to existing reconstructions to demonstrate the validity of the proposed approach.