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Impact of different estimations of the background-error covariance matrix in a climate reconstruction

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Different methods exist to estimate the state of the atmosphere in the past. One of the techniques is data assimilation, which provides a framework to combine two sources of information: numerical models and observations. By optimally blending the local information of observations with the spatially complete climate fields given by model simulations, we can obtain the best estimate of the atmospheric state.
We use the Ensemble Kalman Fitting method that is derived from the Ensemble Square-Root Filter to reconstruct monthly climate states between 1601 and 2005. Our observational network consists of monthly resolved documentary and instrumental data together with annually resolved tree-ring proxy records, whose information is incorporated into the model simulation with 30 ensemble members. The background-error covariance matrix is estimated for each assimilation step from the ensemble. Because only a limited number of members are computationally affordable, sampling errors of the estimated background-error covariance matrix are a problem. To eliminate spurious long-range covariances, the spatially distant covariances have to be removed by the so-called localization technique.
The accurate estimation of the background-error covariance matrix is an essential part in data assimilation. Hence, we conduct several experiments in order to optimize the estimate of the background-error covariance matrix: 1) doubling the number of ensemble members, 2) using both horizontally isotropic and anisotropic localization functions, 3) blending the time-dependent covariance matrix estimated from the ensemble with a climatological covariance matrix, 4) implementing temporal localization of monthly resolved data. We evaluate the results with instrumental data sets to analyse which methodological modifications lead to the largest improvement.