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A new idea to display the uncertainty of reconstructed climatological fields

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Often climate reconstructions are only carried out for certain locations as point reconstructions. However for comparison with climate model data there is a demand for reconstructed fields that are physical consistent and have the same spatial scale as climate models. Our reconstruction method, based on the Variational Analysis, has already successfully been applied to reconstruct temperature fields of the Eemian Interglacial.

The Variational Analysis is a valuable tool for reconstructing fields as it allows for a comprehensive analysis of proxy information from a large number of locations. Further it is possible to include physical information into the analysis as a constraint. This helps to stabilize and smooth the results in a reasonable way and assures that the analysis yields physical consistent results.
Within the analysis the solution is computed by minimizing a cost function. From the Hessian at the cost function minimum it is possible to calculate the covariance matrix of the analysis error. The reconstruction result can be regarded as a mean vector of a multivariate normal distribution with the analysis error as covariance matrix.
From this normal distribution we resample a variety of alternative fields, which all can be regarded as possible realization of the past climate. We use the Mahalanobis Distance to quantify the range between the solution of the Variational Analysis and the resampled field as a measure for its likeliness.
By showing some of these alternative fields together with the “mean” solution the uncertainty is not only displayed by a simple plus/minus range but also in terms of uncertainty in the spatial patterns.

We show the most interesting results from reconstructions for four different time slices: 13000, 12000, 8000 and 6000 before present. As proxy data we use pollen and macrofossil data from more than 50 locations in Europe in an area from the Mediterranean to Southern Scandinavia and the British Isles the Ukraine. These reconstructions were done within the Euroclimate project DECVeg (Dynamic European Climate Vegetation impacts and interactions).