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Gaussian Process Regression – A tool for improved climate index reconstructions

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We present a flexible non-linear framework of Gaussian Process Regression (GPR) for the reconstruction of past climate indexes such as the Atlantic Multidecadal Variability (AMV). These reconstructions are needed because the historical observation period is too short to provide a long-term perspective on climate variability. Climate indexes can be reconstructed from proxy data (e.g. tree rings) with the help of statistical models. Previous reconstructions of climate indexes mostly used some form of linear regression methods, which are known to underestimate the true amplitude of variability and perform poorly if noisy input data is used.

We implement the machine-learning method GPR for climate index reconstruction with the goal of preserving the amplitude of past climate variability. To test the framework in a controlled environment, we create pseudo-proxies from a coupled climate model simulation of the past 2000 years. In our test environment, the GPR strongly improves the reconstruction of the AMV with respect to a multi-linear Principal Component Regression. The amplitude of reconstructed variability is very close to the true variability even if non-climatic noise is added to the pseudo-proxies. In addition, the framework can directly take into account known proxy uncertainties and fit data-sets with a variable number of records in time. Thus, the GPR framework seems to be a highly suitable tool for robust and improved climate index reconstructions.