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Revisiting the analog method to obtain uncertainty estimates for proxy surrogate reconstructions

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Proxy surrogate reconstructions are a computationally cheap method to combine information from spatially sparse proxy records or instrumental data series with the spatially complete fields from climate simulations to increase our knowledge about past climates. The method assumes that the analog pool includes the entire bandwidth of the state-space of the variable under consideration. As proxy records are uncertain indicators of the state of past climate variables, the analog search should ideally allow for the inclusion of the variance unexplained by the proxy indicator in the variable of interest, i.e. it should quantify the uncertainty of the reconstructions based on the signal strength in the proxy records. Upto this point traditional implementations have not considered this uncertainty. This presentation details assumptions based on the calibration correlation of the proxies which result in an ensemble pool of analogs consistent with the proxy record at each data point and explicitly considering the noise in the proxy record. The proxy-pool of the Euro2K-reconstruction and the MPI-ESM-COSMOS ensemble of simulations of the last millennium provide the data to obtain a set of proxy surrogate field estimates for the June, July and August summer near surface air temperature of the last 750 years for the European domain. The restrictions imposed on the analog selection can result in failure to find suitable analogs. The underlying assumptions allow to construct an uncertainty envelope for the areal mean of the field reconstructions. The ensemble of fields further highlights the ambiguity of field reconstructions constrained by a limited set of proxies. Additionally, the uncertainty envelope, its median estimate and the respective best estimate can be used to easily validate reconstructions obtained with more complex methods. That is, the proxy surrogate reconstruction estimates agree very well with the Euro2K-reconstruction over the last 750 years. They also well represent the local proxy variations even under uncertainty. An additional reconstruction of western European standardized precipitation indices highlights the limitations of the approach not least because the reconstructions strongly depend on the variability in the used proxies and in the available analog pool.