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The Analog-Method: Reconstruction of highly resolved Atmospheric Forcing Fields

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In this study we test and apply a new method to reconstruct highly resolved atmospheric forcing fields for Northern Europe since 1850 AD. As a simple statistical upscaling method, the analog-method is used to find best fitting atmospheric fields (predictand) to a given variable from long historical station measurements (predictor). The atmospheric fields are taken from a regional climate simulation and serve as a pool of analogs to match the local climate information of station measurements. An important advantage of this non-linear approach is the conservation of full variability in the reconstruction which is generally underestimated by linear regression methods by more than a factor of two.

In a first step, the analog method is tested within the model domain serving as surrogate climate. Atmospheric fields (0.25° x 0.25°) of SLP, wind components, temperature, relative humidity, total cloud cover and precipitation are reconstructed by the analog-method using different amounts of grid points (5-25) as synthetic stations. Within the regional model, reconstructions of atmospheric forcing fields for the variables SLP and wind components show excellent skills ($r \sim 0.8$) when being reconstructed by daily SLP as predictor. For temperature, rel. humidity, total cloud cover and precipitation, SLP is a weak physical predictor leading to lower skills but significantly better than their climatological mean. Using daily air temperature as predictor instead of SLP, temperature fields are reconstructed with very good skills ($r > 0.5$ for summer and >0.7 in winter).

In a second step, the same approach is repeated with real daily SLP data from 23 stations as predictor spanning the period from 1850 to 2009. Limited by the length of the model simulations, 25 years (1958-1982, 1983-2007) are used as calibration and validation periods. The forcing fields for SLP and wind (u,v) show correlations >0.7 for the validation periods. Although the physical link between SLP and relative humidity, total cloud cover and precipitation is weak, the analog-method is able to reconstruct these fields with significantly better skills than their climatological means. Precipitation fields show generally high regional differences in their skill with a mean correlation of about 0.5.

In contrast, the temperature fields are only insufficiently explained by SLP as predictor. Hence, long historical monthly station temperatures since 1850 are used as predictor to reconstruct monthly temperature fields. To retain the consistent daily variability, the daily temperature anomalies reconstructed by SLP are projected on the reconstructed monthly means of temperature. This procedure makes also sure that effects on temperature are taken into account which are not explained by SLP (like e.g. changes in the solar forcing).

It can be concluded that the analog-method is a very good non-linear upscaling method to reconstruct highly resolved atmospheric fields from local station data (or proxies) on the basis of a pool of regionally downscaled analogs of atmospheric fields.