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Gap-filling meteorological variables with Empirical Orthogonal Functions

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Gap-filling or modelling surface-atmosphere fluxes critically depends on an, ideally continuous, availability of their meteorological driver variables, such as e.g. air temperature, humidity, radiation, wind speed and precipitation. Unlike for eddy-covariance-based fluxes, data gaps are not unavoidable for these measurements. Nevertheless, missing or erroneous data can occur in practice due to instrument or power failures, disturbance, and temporary sensor or station dismounting for e.g. agricultural management or maintenance.

If stations with similar measurements are available nearby, using their data for imputation (i.e. estimating missing data) either directly, after an elevation correction or via linear regression, is usually preferred over linear interpolation or monthly mean diurnal cycles. The popular implementation of regional networks of (partly low-cost) stations increases both, the need and the potential, for such neighbour-based imputation methods.

For repeated satellite imagery, Beckers and Rixen (2003) suggested an imputation method based on empirical orthogonal functions (EOFs). While exploiting the same linear relations between time series at different observation points as regression, it is able to use information from all observation points to simultaneously estimate missing data at all observation points, provided that never all observations are missing at the same time. Briefly, the method uses the ability of the first few EOFs of a data matrix to reconstruct a noise-reduced version of this matrix; iterating missing data points from an initial guess (the column-wise averages) to an optimal version determined by cross-validation.

The poster presents and discusses lessons learned from adapting and applying this methodology to station data. Several years of 10-minute averages of air temperature, pressure and humidity, incoming shortwave, longwave and photosynthetically active radiation, wind speed and precipitation, measured by a regional (70 km by 20 km by 650 m elevation difference) network of 18 sites, were treated by various modifications of the method. The performance per variable and as a function of methodology, such as e.g. number of used EOFs and method to determine its optimum, period length and data transformation, is assessed by cross-validation.

Beckers, J.-M., Rixen, M. (2003): EOF calculations and data filling from incomplete oceanographic datasets. J. Atmos. Ocean. Tech. 20, 1839-1856.