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Empirical orthogonal functions in soil CO_2 efflux mapping

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Empirical orthogonal functions (EOF) derived from a principal component analysis (PCA) have successfully been used to identify recurring spatial patterns in repeated grid sampling datasets of soil moisture in the past (Perry and Niemann, 2008; Korres et al., 2010). Here, we test in a case study whether the same applies to field-scale datasets of soil CO_2 efflux, which are known to challenge geostatistical analysis and modelling (Rochette et al., 1991; La Scala et al., 2000; Rodeghiero and Cescatti, 2008; Herbst et al., 2009).

Our test dataset consists of chamber measurements on 28 dates within a transect of 18 points spaced 10 m apart on a gently sloping mid-latitude bare soil field. Transformation of the 28 single-date patterns into few dominant EOFs could indeed improve the (geo)statistical analysis and empirical modelling of spatiotemporal CO_2 efflux variability. In particular, the first EOF exhibited a much smaller nugget effect in the semivariogram, and clearer statistical relations to soil properties, than most single surveys. However, unlike for many other variables, for soil CO_2 efflux PCA qualified a very large portion (about 50%) of the total spatiotemporal variability as "noise", i.e. as variability associated neither with spatial autocorrelation nor with spatial correlation to soil properties. This is supported by cross validation, which indicates that only the first EOF (32% variance) definitely improves the predictive skills of an EOF-based regression model as well as of a Canonical Correlation based model (Graf et al., submitted). The non correlated half of spatiotemporal variability is not necessarily due to random measurement errors, but to a (hypothetically greater) part to fluctuations on a too small spatial and/or temporal (Graf et al., 2011) scale. The correlated half indicated that at our site, temperature was the most important driver of temporal variability of the spatial average of soil CO_2 efflux, while soil moisture was the most important driver of spatial variability. Both the temperature and the moisture dependence were in agreement with common model assumptions. Relations to soil biochemical parameters, on the other hand, were weak and sometimes counter-intuitive.

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