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Temporal downscaling of soil CO_2 efflux survey measurements based on time-stable spatial patterns

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Chamber measurements of soil CO_2 efflux are known to require repetitions at different points in space in order to achieve a high accuracy time series of the area average. In the absence of multiple gas analyzers, which are a limiting factor in most field studies, this is usually achieved either by automatic multiplexing or by manual surveys. As a trade-off, if t_1 is the interval between two measurements and N the number of different measurement points used to reduce the error in determining the area average, the new improved-accuracy time series of the area average has a reduced temporal resolution characterised by the interval $t_2 = N * t_1$.

However, if measurement points keep their (relative) deviation from the area average for a time considerably longer than t_2, this additional information can be used to either reduce measurement effort or reconstruct an estimated unbiased time series of any resolution between t_1 and t_2. The former has already been demonstrated for soil moisture and soil CO_2 efflux.

Here, we give an overview of simple scaling methods that can be used to achieve the latter objective, i.e. temporal downscaling. The raw time series consisting of different measurement points is decomposed into a moving average over all points, a temporally stable deviation of each point from this, and a residual term comprising both fast temporal variability and random errors. By removing the second term, a time series of any resolution $t_3 = t_1 * n, n = 1...N$ can be regained, which is subject to an increasing random error with decreasing n but not biased due to systematic deviations of single points from the area average.

With respect to the time scale of stability and to the definition and removal of the stable deviation of each point from the area average, several variations of this method can be distinguished, e.g. constant offset, constant factor, constant relative offset or first order regression (offset and factor). We compared these methods for a dataset of circular repeated soil CO_2 efflux measurements on transects of up to 30 points ($t_2 = 1.5$ h). Rapid meteorological changes in environmental conditions are used to qualitatively assess the ability of the method to describe short-term changes in the area average of soil CO_2 efflux.