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A novel strategy to link uncertainty in short-term eddy-covariance flux estimates with heterogeneous flux sources in the surrounding terrain

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Eddy-covariance measurements are an important tool for quantifying and understanding exchange processes between biosphere and atmosphere. Application of the eddy-covariance technique relies on a number of theoretical assumptions that often cannot be strictly observed, especially at monitoring sites in complex terrain. Failure to meet these requirements reduces the accuracy of the measurements. Reliable estimates for the uncertainty in eddy-covariance data are therefore required for a correct interpretation of the flux measurements. Besides the quantification of data uncertainty, the identification of the causes of the uncertainty is essential to produce high-quality data.

We present an approach that allows quantifying the uncertainty in eddy-covariance due to nonstationarity and random errors, and how the uncertainty varies with different meteorological conditions. The measurement uncertainty addressed here is due to the fundamental problem of inadequate sampling of the turbulent exchange processes. Both uncertainties are quantified relative to the underlying absolute flux levels. To assess the influence of terrain heterogeneity on the uncertainty estimates, we couple these results with Lagrangian Stochastic (LS) footprint modeling. Integrating LS source areas on an hourly basis over a longer time periods allows producing spatial maps of flux data quality that can highlight the uncertainty introduced e.g. by land cover changes such as clearings in a forest, or patches with different sensible or latent heat flux strength.

The approach outlined above is tested on eddy-covariance measurements of the CO2, latent heat and sensible heat fluxes collected at two nearby forested sites situated in the semi-arid East Cascades region of Oregon, US. Both sites are shown to experience similar sampling error levels during the day, while for stable conditions at night the flux variability is enhanced at one of the sites due to heterogeneity in the flux footprint, with the location of the major sources for uncertainty being reflected in the spatially integrated footprint maps. We demonstrate the applicability of the presented results as an additional quality assessment tool to improve the eddy-covariance flux database of the AmeriFlux project, allowing a more reliable data interpretation for model validation or data assimilation purposes.