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Eddy covariance carbon dioxide flux measurements above a small lake – micrometeorological land of plenty or nightmare?

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With the growing interest in greenhouse gas emissions from freshwater ecosystems, which up to very recently were neglected in continental and global scale budgets, an increasing number of studies have started to quantify the lake-atmosphere exchange of carbon dioxide, methane and other trace gases. Lakes, in particular smaller ones, however pose a number of challenges for the application of the eddy covariance method, which require careful consideration in order to arrive at defensible flux estimates. Here we report on three years of eddy covariance carbon dioxide, latent and sensible heat flux measurements from Lake Lunz (Austria), a small (68 ha) pre-alpine lake situated in a steep and narrow valley surrounded by coniferous forest. Eddy covariance flux measurements were made from a floating platform and two places on the shore at opposing sites of the lake. A characteristic feature of the data set is a tremendous variability in carbon dioxide flux estimates, which contradicts our experience and process understanding of the magnitude and drivers of lake-atmosphere carbon dioxide exchange processes. The following analyses were conducted: flux footprint analysis in order to make sure the flux source area is confined to within the lake; multiresolution flux decomposition in order to determine the optimal averaging time; (co)spectral analyses in order to investigate the dominant time scales of transport; quadrant analysis in order to determine joint occurrence of transport processes of different scalars; flux variance similarity in order to compare measurements against established theory. The results of these analyses are discussed with respect to the observed variability in carbon dioxide fluxes and practical conclusions are drawn for flux measurements at similar settings.