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A new gap-filling method to avoid systematic bias in carbon balance estimates in northern ecosystems

Henriikka Vekuri¹, Juha-Pekka Tuovinen¹, Liisa Kulmala^{1,2}, Dario Papale³, Pasi Kolari⁴, Mika Aurela¹, Jari Liski¹, Tuomas Laurila¹, and Annalea Lohila^{1,4}

¹Finnish Meteorological Institute, Climate System Research, Helsinki, Finland (henriikka.vekuri@fmi.fi)

²Institute for Atmospheric and Earth System Research, Forest Sciences, University of Helsinki, Helsinki, Finland

³Euro-Mediterranean Center on Climate Change CMCC IAFES, Viterbo, Italy

⁴Institute for Atmospheric and Earth System Research, Physics, University of Helsinki, Helsinki, Finland

Climate change mitigation requires – besides greenhouse gas emission reductions – actions to increase carbon sinks and storages in terrestrial ecosystems. However, quantification of sources and sinks of carbon depends on reliable estimates of the net ecosystem exchange of carbon dioxide (CO₂). This also involves the eddy covariance technique (EC), a key method to directly measure the CO₂ fluxes between ecosystems and the atmosphere. Various methods have been used to impute, or gap-fill, missing EC data and previous comparisons have shown that the accuracy of the best-performing methods, e.g. the widely-used marginal distribution sampling (MDS), is reaching the noise limit of measurements. However, knowledge on the performance of gap-filling methods is lacking from northern ecosystems.

By analyzing an extensive global data set, we show that MDS causes significant carbon balance errors for northern ecosystems. MDS systematically overestimates the carbon dioxide (CO₂) emissions of carbon sources and underestimates the CO₂ sequestration of carbon sinks. We discuss reasons for the errors and show how a machine learning method called extreme gradient boosting or a modified version of MDS can be used to minimize the northern site bias.