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Extrapolation error quantification of the Arctic flux network across space and time, with data driven network optimization.

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Unprecedented change is occurring in the Northern high latitude regions as a result of climate change. With related degradation of large carbon stocks sequestered in Arctic permafrost, it is essential that the carbon cycle, and its changes over time, is properly monitored. Greenhouse gas (GHG) fluxes can directly be monitored through the eddy covariance (EC) method and flux chambers. However, harsh weather conditions and remoteness make it difficult to establish and keep such monitoring sites running in the Arctic, and accordingly the past and current data coverage is comparatively sparse.

In this study, we aim to evaluate the coverage of the existing network of high latitude GHG flux monitoring sites, and quantify uncertainties in our understanding of regional-scale vertical carbon exchange processes. Our intent is to outline the limits of this network both spatially and temporally. We investigate how changes over time in flux observations affect the networks extrapolation potential, and how gaps in the network extent could best be filled. For this purpose, we applied and extended the network representativeness metric used for the FLUXCOM project. First we calculate an extrapolation index, which indicates the relative error when predicting fluxes at increasing dissimilarity in environmental conditions from the existing sites in the network. Here we train a model to predict fluxes based on the top 10 predictor variables from FLUXCOM of the nearest locations in variable space to reference flux data. We then correlate prediction errors to distance in variable space, which allows us to quantify prediction errors for each location and time step in our domain.

This analysis uses an extended version of our database of high latitude GHG flux monitoring sites produced in previous studies. This information is also available as an online mapping tool, which facilitates a variety of science applications. Although coverage is improved over past epochs, large gaps still remain in Russia and Canada, and across the Arctic wintertime. The most consistent year-round coverage of GHG fluxes occurs in Alaska and Europe. Our study prioritizes locations for network extension in Russia, Canada, and select locations in Alaska, and highlights where upgrades in instrumentation and battery capacity (e.g., extend monitoring into shoulder seasons and winter) would be most efficient.