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REGIONAL SCALING OF AIRBORNE FLUX MEASUREMENTS OVER ARCTIC REGIONS

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Arctic ecosystems are undergoing a fundamental restructuring due to the global warming and their response to climate change plays an important role in understanding the changes in atmospheric methane concentrations, Arctic carbon cycle and global energy budget. These ecosystems are coupled to the global climate system by vertical exchange fluxes of energy and matter. Therefore, it is crucial to understand how surface-atmosphere exchange fluxes of heat, water vapor, and greenhouse gases in the Arctic will respond to any changes in climate related parameters. However, attribution of these responses is challenging because measured fluxes are the sum of multiple processes that respond differently to environmental factors.

Ground-based measurements of surface fluxes in Arctic regions provide continuous in-situ observations of the surface-atmosphere exchange. However, these observations cover only small areas that may not be representative of the region of interest, because usually greenhouse gases are released to the atmosphere by spatially and temporally heterogeneous sources, indicating that local observations cannot easily be extrapolated to represent global scales. Airborne eddy covariance measurements across large areas can reduce uncertainty and improve spatial coverage and spatial representativeness of flux estimates. We used the research aircraft POLAR 5 and the helicopter-carried measurement system “Helipod” equipped with a turbulence probe, fast temperature and humidity sensors, and a fast response greenhouse gas analyzer to measure turbulent fluxes across the Alaskan North Slope, the Mackenzie Delta in Canada, and the Lena River Delta in Russia.

After thorough data pre-processing, Reynolds averaging is used to derive spatially integrated fluxes. To increase spatial resolution, we then use wavelet transforms of the original high-frequency data. This enables much improved spatial discretization of the flux observations and determine biophysically relevant land cover properties in the flux footprint. A boosted regression trees technique is then employed to extract and quantify the functional relationships between the fluxes and the environmental drivers. In order to extrapolate the airborne eddy covariance flux measurements the environmental response functions were estimated quantitatively linking surface-atmosphere exchange fluxes over Arctic regions to environmental drivers in the flux footprints. The supplemented simulations from the Weather Research and Forecasting (WRF) model were used to explore the changes of atmospheric boundary layer and to examine results of extrapolation.