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An eddy covariance derived annual carbon budget for an arctic terrestrial ecosystem (Disko, Greenland)

Alistair McConnell (1), Magnus Lund (2), and Thomas Friborg (1)

(1) Department of Geosciences and Natural Resource Management, University of Copenhagen, Geosciences, Copenhagen, Denmark, (2) Department of Bioscience, Aarhus University, Aarhus, Denmark

Ecosystems with underlying permafrost cover nearly 25% of the ice-free land area in the northern hemisphere and store almost half of the global soil carbon. Future climate changes are predicted to have the most pronounced effect in northern latitudes. These Arctic ecosystems are therefore subject to dramatic changes following thawing of permafrost, glacial retreat, and coastal erosion. The most dramatic effect of permafrost thawing is the accelerated decomposition and potential mobilization of organic matter stored in the permafrost. This will impact global climate through the mobilization of carbon and nitrogen accompanied by release of greenhouses gases, including carbon dioxide.

This study presents the initial findings and first full annual carbon (CO_2) budget, derived from eddy covariance measurements, for an Arctic landscape in West Greenland. The study site, a terrestrial Arctic maritime climate, is located at Østerlien, near Qeqertarsuaq, on the southern coast of Disko Island in central West Greenland (69° 15' N, 53° 34' W) within the transition zone from continuous to discontinuous permafrost. The mean annual air temperature is -5 C and the annual precipitation as rain is 150–200 mm.

Arctic ecosystem feedback mechanisms and processes interact on micro, local and regional scales. This is further complicated by several potential feedback mechanisms likely to occur in permafrost-affected ecosystems, involving the interactions of microorganisms, vegetation and soil. The eddy covariance method allows us to interrogate the processes and drivers of land-atmosphere carbon exchange at extremely high temporary frequency (10 Hz), providing landscape-scale measurements of CO_2, H_2O and heat fluxes for the site, which are processed to derive daily, monthly and now, annual carbon fluxes. We discuss the scientific methodology, challenges, and analysis, as well as the practical and logistic challenges of working in the Arctic, and present an annual carbon budget demonstrating that there was a net uptake of carbon by the ecosystem for the 2013-2014 year. Here we present inter annual variability in the exchange of CO_2 from the an area of discontinuous permafrost and discuss the controlling factors.

Ongoing work to model and upscale from our study site to Western Greenland and beyond will aid our understanding of what might happen over the coming decades and centuries, as vast volumes of permafrost across the world begin to thaw for the first time in millennia.