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Soil Respiration using Forced Diffusion: From the Tundra to the Savanna

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Eddy Covariance (EC) systems have been widely used across the globe for more than 20 years, offering researchers invaluable measurements of parameters including Net Ecosystem Exchange (NEE) and Ecosystem Respiration (Reco). Measurements of soil respiration (RS) at the ground level are critical to properly assess and partition the individual components of respiration in order to better understand the processes that contribute to Reco. While chamber systems have been used for many decades to study Rs, little work has been done on partitioning Reco because commonly used manual chamber approaches do not offer adequate temporal frequency for comparison. More recently, researchers have employed automated chamber systems for this purpose, however the cost of these systems and their spatial constraints relative to the EC footprint means they have not been widely used. The recently developed Forced Diffusion (FD) method allows for inexpensive and autonomous measurements of soil CO_2 flux and provides a scalable approach to matching the EC footprint compared to other chamber systems.

Here we present two studies where the FD technique is used in conjunction with EC measurements to help understand Rs and Reco. The first study is from Zackenberg, Greenland where the FD method is employed in a permafrost area that has experienced strong warming during the last two decades. Reco measurements at the site indicate a continuous increase in respiration rate with warming, however, the initial increase in gross primary production (GPP) has levelled off at the high end of observed temperature range (Lund et al. 2012). The FD chambers are deployed in a Cassiope heath plant community; a vegetation type that covers approximately 10% of the high and middle Arctic areas and is a dominant contributor to ecosystem fluxes. The second study is a 2-month monitoring campaign in a Californian oak savanna, where the FD chambers are similarly deployed in the footprint of a long-running EC tower. This site is located in an area where summer drought typically reduces Reco and Rs to near zero before increased rainfall in the autumn causes a gradual increase in Reco and Rs that is abbreviated by short-lived respiration pulses after each rainfall event. Because of the transient nature of these pulse events, other Rs measurement methodologies have difficulty capturing their timing and magnitude, therefore their contributions to Reco remains uncertain. Throughout these two studies, we will focus primarily on the comparison between the Rs and Reco measurements, and the ability of the FD technique to help with partitioning of Reco into its constituent components.