Continuous measurement of soil carbon efflux with Forced Diffusion (FD) chambers in a tundra ecosystem of Alaska

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Soil is a significant source of CO_2 emission to the atmosphere, and this process is accelerating at high latitudes due to rapidly changing climates. In order to investigate the sensitivity of soil CO_2 emissions to high temporal frequency variations in climate, we performed continuous monitoring of soil CO_2 efflux with Forced Diffusion (FD) chambers at an interval of a half hour, within three representative Alaskan soil cover types with underlying permafrost. These sites were established during the growing season of 2015 located on the Seward Peninsula in western Alaska. The chamber system is conceptually similar to a dynamic chamber, but the FD is more durable, water-resistant and consumes less power, which lends itself to remote deployments. We first conducted methodological tests, testing different frequencies of measurement, but did not observe a significant difference when collecting data at 30-min measurement intervals, or at 10-min measurement intervals (averaged half-hourly) (p<0.001). At the study sites, we observed cumulative ecosystem respiration of 62.0, 126.3, and 133.5 gC m^{-2} for the growing period, at sphagnum, lichen, and tussock, respectively, corresponding to 83.8, 63.7, and 79.6% of annual carbon emissions. All sites showed strong sensitivity to air temperature rather than soil temperature. Growing season soil carbon emissions extrapolated over the region equated to 0.17 ± 0.06 MgC over the measurement period, which is 47% higher than previous estimates from coarse-resolution manual chamber sampling, presumably because it better captured high efflux events. This finding demonstrates how differences in measurement method and frequency can impact interpreted seasonal and annual soil carbon budgets. We conclude that annual CO_2 efflux-measurement with FD chamber networks would be an effective means to quantify growing and non-growing season soil carbon budget, and would optimally be paired with time-lapse imagery to track local and regional changes in environment and climate in a warming Arctic.