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Towards a Soil CO_2 Observation System for the North American Arctic

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Abstract:

Arctic regions hold vast reserves of carbon in soil organic matter in cool anaerobic soils, and/or permafrost. These areas are warming rapidly, and soil emissions are expected to accelerate. Since the feedback on atmospheric CO_2 and CH_4 concentrations is potentially large and of international interest, soil gas fluxes should be monitored in a systematic long-term manner. This poster describes research moving towards an integrated Arctic Soil CO_2 observation system, initially in Canada and the United States. This research has three main components: Soil Flux Instrumentation; Network Design; and Ecoinformatics architecture. Robust monitoring instrumentation is the precondition for an automated Arctic soil gas flux sensing system. Existing soil-based CO_2 flux instrumentation is labour intensive and generally not appropriate for long-term unattended deployments. We have developed a new technique for measuring soil CO_2 fluxes, called Continuous Timeseries-Forced Diffusion (CT-FD), consisting of a Vaisala CO_2 sensor, PVC casing, and tear/UV resistant membranes. The probe has no moving parts, is relatively affordable, and delivers continuous flux data (equivalent to automated chambers) by forcing a specific diffusive regime between the soil and the atmosphere. It can be used in harsh winter conditions and also under snow. Tests of the instrumentation in these environments have been successful, and are continuing. This solid-state instrument allows us to consider observational systems for soil CO_2 flux that are similar in context to those of the Meteorological Services. Of course, a successful network will deploy this instrumentation in a scientifically sound configuration - balancing the need to capture hotspots of emission, with the needs for representativity, site access, etc. To address these needs, we have applied a Simulated Annealing-based process to optimize sampling densities and distributions according to various factors. For North American sites, our network optimization makes use of several different CO_2 emission estimates generated using the Canadian Regional Climate model forecasts and other datasets. Results highlight the need for soil flux observational nodes in several parts of the North American Arctic, but particularly in Alaska and in the eastern Canadian Arctic Archipelago. Lastly, any soil CO_2 sensing network should feed an Ecoinformatics architecture like that of the Meteorological Services, where observational data is fused with modeling in real-time. This modeling effort should aim to establish relationships between soil respiration and driving climatic factors on many timescales, and our group is making headway in particular on modeling approaches that can be applied to short-term data, which is necessary for good process-based understanding. This presentation will link these research threads, and discuss plans to implement an Arctic Soil CO_2 observation system.