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Drivers of carbon dioxide fluxes in high-Arctic tundra: data-driven models

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Arctic regions are extreme environments where ecosystems are undergoing significant changes induced by the temperature rise, that is progressing about twice faster than in the rest of the world. In the high-Arctic, the Critical Zone (CZ) has a thin above-ground component, consisting of tundra vegetation, and a highly seasonal below-ground component, with varying extension and chemical-physical characteristics. The complexity of this system makes future projections of the Arctic CZ a challenging goal. In particular, it is still unclear whether the system will turn from a carbon sink to a carbon source. On the one hand, the uptake of carbon dioxide (CO_2) by vegetation is expected to increase in future years owing to the widening growing season and the shift in community composition but, on the other, increasing soil temperatures are fostering carbon release by thawing permafrost and degradation of organic matter through heterotrophic respiration in deglaciated soils. In this work, we identified the main biotic and abiotic drivers of CO_2 emissions (Ecosystem Respiration, ER), and CO_2 uptake (Gross Primary Production, GPP), in the Arctic tundra biome. During summer 2019 we extensively measured CO_2 fluxes at the soil-vegetation-atmosphere interface, basic meteoclimatic variables and ecological descriptors at the Critical Zone Observatory of Bayelva river basin (CZO@Bayelva), Spitzbergen, in the Svalbard Archipelago (NO). Flux measurements were obtained by a portable accumulation chamber, allowing for the statistical analysis of fluxes variability at small scale. Together with flux measurements, we sampled soil temperature and humidity at the chamber base and local air temperature, pressure and humidity. In addition, the vegetation cover was obtained from digital RGB pictures of the sampled surfaces. By means of multi regression models, we related flux data to environmental parameters, vegetation cover extent and vegetation type, thus obtaining empirical data-driven models that describe the coupled dynamics of soil, vegetation, water and atmosphere that contribute to the present budgeting of the carbon cycle in the arctic CZ. This work may help in assessing the possible future evolution of high-Arctic environment under projected changes in vegetation community composition and abiotic parameters.