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A Critical Zone Approach to Carbon Fluxes in the Arctic Tundra

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Arctic tundra is currently undergoing significant changes induced by the effects of a rapid temperature rise, that in the Arctic is about twice as fast as in the rest of the world. The response of the system composed by the permafrost active layer, soil and vegetation is especially relevant. In fact, it is still unclear whether the system will turn from a carbon sink to a carbon source, owing to the interplay of two opposite phenomena: the increasing time span of the growing season, favouring Net Ecosystem Production (NEP), and the increasing soil temperatures, favouring degradation of organic matter through heterotrophic respiration (HR) and then creating a positive climate feedback. In this work, we analyse soil-vegetation-atmosphere CO_2 flux data of a field campaign conducted in the Bayelva river basin, Spitzbergen, in the Svalbard Archipelago (NO) during summer 2019, measured by a portable accumulation chamber. We use a “Critical Zone” perspective, considering the multiple interactions between biotic and abiotic components. We measured the Net Ecosystem Exchange (NEE) and Ecosystem Respiration (ER) along a slope gradient at different degrees of soil humidity and active layer depths, relating flux data to climate and environmental parameters, soil physical-chemical parameters and vegetation type. The statistical empirical relationships between variables are analysed to identify the main drivers of carbon exchanges. An empirical data-driven model is built to describe the coupled dynamics of soil, vegetation, water and atmosphere that contributes to budgeting the carbon cycle in the Arctic Critical Zone. A comparison of the carbon fluxes obtained with the accumulation chamber method and an Eddy Covariance tower located in the same area is also addressed.