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Year-round forest-floor greenhouse gas fluxes in a subalpine coniferous forest: drivers and budgets

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Forest ecosystems play an important role in the global carbon (C) cycle by sequestering a large fraction of anthropogenic carbon dioxide (CO_2) emissions and by acting as important methane (CH_4) sinks. Nevertheless, how the forest C sink will respond to climate change is still largely unknown. The forest-floor GHG flux is one of the major processes to consider when determining the C balance of forests. Although winter fluxes are essential to determine the annual C budget of forests, there have been very few studies that have examined long-term, year-round forest-floor GHG fluxes in high elevation forests. Especially during snowy periods, forest floor GHG fluxes are difficult to measure and are therefore often missing from studies. In this study, we used four years of forest-floor CO_2, CH_4 and nitrous oxide (N_2O) fluxes (2017, 2020, 2021 and 2022; N_2O not available for years 2021, 2022). Fluxes were measured year-round with four automatic chambers at the ICOS Class 1 station Davos, located in a subalpine coniferous forest in Switzerland. We applied random forest models to investigate the environmental drivers and to gap-fill the flux time series for calculating annual sums of CO_2 and CH_4 fluxes. More specifically, the aims of this study were to i) investigate the seasonal and annual variations in climate variables and forest-floor CO_2, CH_4 and N_2O fluxes; ii) evaluate the environmental drivers of forest-floor GHG fluxes including the effect of snow cover and snow melt, and iii) calculate annual budgets of the forest-floor GHG fluxes. We hypothesized that the main drivers of soil CH_4, CO_2 and N_2O fluxes are soil temperature and soil moisture (e.g., higher CH_4 uptake in warmer and drier soils). Additionally, we hypothesized that winters with little snow and early melting can lead to reduced soil moisture later in the year, which could lead to higher CH_4 uptake. First results show that the forest-floor CO_2 efflux generally follows soil temperature. However, the dynamics in the CO_2 efflux cannot be entirely explained by soil temperature, e.g., a large increase in CO_2 efflux in 2022 compared to other years. Furthermore, we found that the forest-floor is a consistent sink for CH_4, however with large short-term dynamics, and that the magnitude of the sink is mainly driven by air temperature and snow cover. N_2O fluxes are very low, i.e., probably below the detection limit of our method, which is why we consider them negligible for the overall forest-floor GHG budget at our site.