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Conference Abstract

Forest ecosystem functioning in a changing climate: Fluxes, drivers, feedbacks at multiple scales

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Abstract

Biogeochemical processes within and across ecosystems are core to understand the functioning of terrestrial ecosystems, i.e., forests and agroecosystems, in particular under changing environmental conditions. Measurements are necessary at multiple scales, e.g., for forests at soil, forest floor, tree, canopy, and forest ecosystem scales, using methodology from many different disciplines. Data should be available in high temporal resolution, preferentially for long time periods, to quantify and understand short-term responses to environmental drivers and management, but also to detect and identify long-term responses to climate change.

The SwissFluxNet is a network of six long-term research sites in Switzerland with ecosystem-scale eddy-covariance (EC) measurements of biosphere-atmosphere greenhouse gas (GHG) exchange (i.e., CO_2, H_2O vapor, CH_4, N_2O; Fig. 1).

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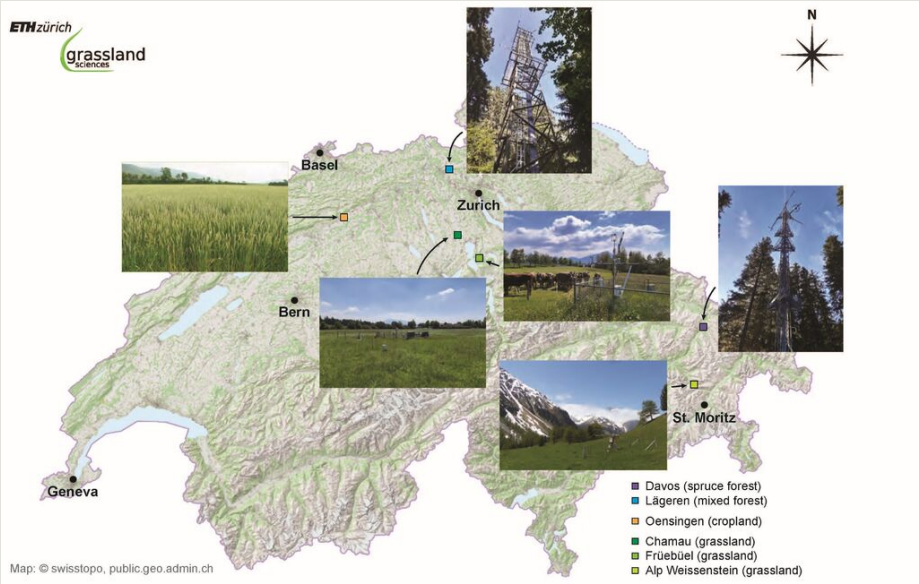

Figure 1. doi

Swiss FluxNet with six long-term sites for flux measurements across three land-use types.

The Swiss FluxNet offers exactly these opportunities, namely long-term, high-temporal resolution GHG flux data and serves as a research platform for many other studies and research programs. It covers the major land-use types in Switzerland: forest (mixed deciduous: Lägeren, CH-Lae; evergreen: Davos, CH-Dav), grassland (Chamau, CH-Cha; Früebüel, CH-Fru; Alp Weissenstein, CH-Aws), and cropland (Oensingen, Ch-Oe2), and is complemented by project-based flux stations which run for 2-4 years (currently, two below-canopy stations in the two forest sites, one young forest plantation, and two cropland sites). Thus, including data of 2024, we provide 129 site-years of continuous GHG flux measurements to the scientific community (19-28 years per site, and continuously growing…), since all data are open access and have been downloaded from FLUXNET and ICOS over 35'250 times between November 2016 and December 2024.

In the talk, we will focus on the two forest sites, Davos and Lägeren. At Davos, above-canopy EC flux measurements of CO_2 and H_2O vapor started in 1997; measurements of above-canopy CH_4 and N_2O fluxes were carried out between 2016 and 2023 and complemented by below-canopy flux measurements of CO_2 and H_2O vapor (since 2021) as well as of CH_4 (since 2023). Data on forest floor CO_2, N_2O and CH_4 fluxes, measured automatically by chambers, tree phenology, sap flow and stem diameter changes are available for many years as well. Since 2019, Davos is an ICOS RI Class 1 Ecosystem station, where highest standards apply. At Lägeren, EC flux measurements of CO_2 and H_2O vapor are available since 2004, complemented by below-canopy flux measurements of CO_2 and H_2O vapor since 2014 as well as by phenology, soil respiration and tree ecophysiology measurements. At both sites, meteorological (above and within the

canopy) as well as soil climate variables (soil profiles, 0 to 60/80 cm soil depth) are recorded continuously as well. Thus, measurements from multiple scales for long time periods allow studying short- and long-term responses to changing environments at both forest sites.

We will provide selected highlights from almost 50 site-years of measurements, about the short-term responses of forests to weather extremes such as drought and heatwaves as well as about the long-term carbon sink behaviour of both forests and their vulnerability. Results based on machine learning approaches about the environmental and biological drivers of GHG fluxes at multiple scales will be presented along with their temporal contributions within and across years. Disentangling the role of climate vs. nitrogen (N) deposition for water-use efficiency of both tree species beech and spruce as well as linking tree to forest responses across scales will be discussed. Our experiences clearly demonstrate that using long-term, highly equipped EC sites as research platforms for additional research projects, nesting research programs within large-scale research infrastructure networks, and sharing data openly following FAIR principles, pays out, for one's own curiosity, for career development of the next generation scientists, for policy advice and science at large!

Keywords

biosphere-atmosphere exchange, greenhouse gas fluxes, temperate forests, forest functioning, open science, FAIR data

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Presented at

KEYNOTE

Conflicts of interest

The authors have declared that no competing interests exist.