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National Climate Observing System

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Global Climate Observing System – GCOS Switzerland





4.2 Greenhouse gas fluxes

Observing greenhouse gas fluxes is important in order to understand their sources and sinks, to validate national inventories, and to assess mitigation strategies. At ecosystem scale, fluxes are often measured by the eddy covariance technique. At regional to global scales, atmospheric measurements are combined with transport simulations and inverse modelling.



Measurements in Switzerland

Carbon dioxide (CO₂) fluxes are measured at two urban and six ecosystem sites. The six ecosystem sites are part of the Swiss FluxNet network, maintained by ETH Zurich (Grassland Sciences group). CO₂ fluxes have been measured for 10 to 20 years at two forest sites (Davos, Lägeren), three grassland sites of different management intensity (Chamau, Frübüel, Alp Weissenstein), and one cropland (Oensingen). At Chamau and Davos, methane (CH₄) and nitrous oxide (N₂O) fluxes are also measured. In addition, the University of Basel (Meteorology, Climatology and Remote Sensing Group, MCR) maintains two stations (Basel Klingelbergstrasse, Basel Aeschenplatz) for urban CO₂ fluxes. Data and metadata collected at the ecosystem sites by ETH Zurich are all uniformly processed and openly available through ETH Zurich and international databases. Data from the urban sites are stored in the MCR database and are freely available upon request.

Regional greenhouse gas emissions are quantified by Empa (Swiss Federal Laboratories for Materials Science and Technology), University of Bern and ETH Zurich using atmospheric inverse modelling, combining atmospheric concentration measurements and transport simulations. CO₂ and CH₄ concentrations are monitored at two sites: Jungfrauoch (Empa) and Beromünster (University of Bern). Furthermore, continuous measurements of N₂O and halogenated greenhouse gases are performed at the high-altitude site Jungfrauoch (Empa). The two stations Davos and Jungfrauoch are the Swiss contribution to the European Infrastructure programme ICOS RI (Integrated Carbon Observation System Research Infrastructure), both part of the ICOS-CH network.



Greenhouse gas flux stations
(brown dot: forest: CH-DAV, CH-LAE; red dot: grassland, CH-CHA, CH-FRU, CH-AWS; orange dot: cropland, CH-OE2; black dot: urban, BKLI, BAES).

Long time series and their importance

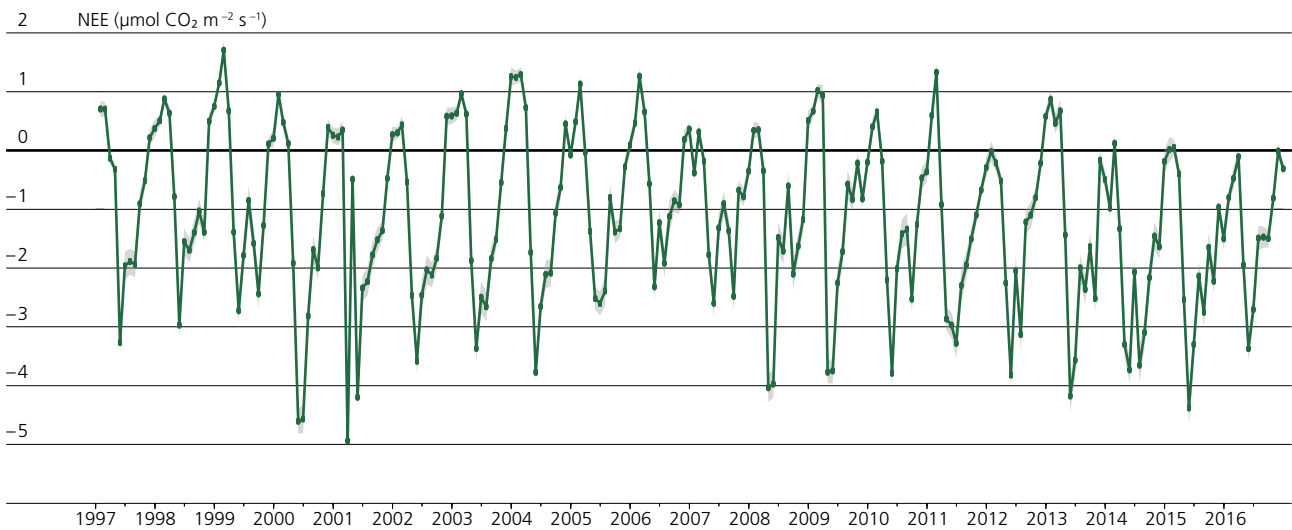
CO₂ flux measurements in Davos started in 1997, resulting in one of the longest time series globally. Measurements above different land use types within Swiss FluxNet provide unique information on Swiss greenhouse gas fluxes. Their high temporal resolution permits investigating functional relationships and responses of the biosphere to environ-

mental change. Furthermore, impacts of management activities and anthropogenic emissions can be directly measured.

The measurements of anthropogenic greenhouse gases at Jungfrauoch began in 2000. Currently, CO₂, CH₄, N₂O, sulfur hexafluoride (SF₆), and over 50 halogenated synthetic

gases are monitored (→ Chapters 2.11 and 2.12). These time series are combined with models to derive emissions at regional and national scales. Resulting emission estimates are used as independent estimates in comparison to Switzerland's national greenhouse gas inventory report as reported to the UNFCCC.

Davos ICOS Flux Site 1997–2016



Long-term net ecosystem CO₂ fluxes (NEE) measured at the ICOS site Davos since 1997. The green line shows the average monthly fluxes measured between 1997 and 2016; the grey area shows the standard error of the mean. Negative fluxes depict CO₂ uptake by the ecosystem, positive fluxes depict CO₂ losses from the ecosystem. The subalpine Norway spruce forest has been a carbon sink ever since measurements started. It shows a remarkable growth during the early season which peaks typically in May and then gradually declines until winter dormancy. Hence, climate change affecting the early season (May) is expected to have a much stronger influence on tree growth and thus on the C sequestration of this forest than changes affecting summer or autumn.

International integration

All Swiss FluxNet sites are part of the global FLUXNET, while both urban stations are part of the Urban Flux Network. In addition, the forest site Davos and the atmospheric station Jungfrauoch are in the process of becoming official ICOS RI Class 1 stations. Thus, quantification of greenhouse gas emissions as well as carbon sink and sources across Europe will be achieved in a standardised way within ICOS RI. These data will be open-access, also to the relevant political stakeholders, e. g. for Switzerland's National Inventory Report. The measurements at Jungfrauoch are part of the World Meteorological Organization (WMO) Global Atmosphere Watch (GAW) programme and the international Advanced Global Atmospheric Gases Experiment (AGAGE) network, and are made available through the World Data Center for Greenhouse Gases (WDCGG). Furthermore, emission estimates will play a key role in a future global survey system (e. g. IG3IS, Integrated Global Greenhouse Gas Information System).

Resources required

Swiss FluxNet, the measurements of halogenated compounds at Jungfrauoch, and all computational activities at the Swiss National Supercomputing Center and the Empa Linux cluster are financed through short-term research projects. The measurements at Jungfrauoch are largely financed through the National Air Pollution Monitoring Network (NABEL: FOEN, Empa). The sites Davos and Jungfrauoch currently receive funding from the Swiss National Science Foundation (SNSF) within the ICOS-CH Network.



- ETH Zurich:
 - Swiss FluxNet
 - ICOS-CH
- CarboCount-CH

- Empa – Climate Gases
- Swiss climate reporting under the UNFCCC



Legal basis

The Federal Office for the Environment (FOEN) produces an annual greenhouse gas inventory according to obligations of the United Nations Framework Convention on Climate Change (UNFCCC). The revised Swiss carbon dioxide (CO₂) law (SR 641.71) requires a reduction of nationally emitted greenhouse gases by 2020 of at least 20% compared to 1990. Validation of these goals is not regulated, but measurements are harmonised at European level within ICOS RI, both to quantify biosphere-atmosphere exchange as well as for inverse modeling of emissions on national and continental scales.