BSc and MSc Theses 2024/25 (updated Jan 2025)

Prof. Nina Buchmann, Grassland Sciences, ETH Zurich, Switzerland

Living in the heat: Survival strategies of urban trees

Urban trees play a crucial role in mitigating urban climate challenges through their ecosystem services. However, urban stressors can impact the trees' health and functionality. Despite their importance, much remains unknown about how these trees respond to urban stress. This project aims to investigate the ecophysiological processes of urban trees, focusing on their water usage, cooling effect, and adaptation strategies Zurich and Basel.

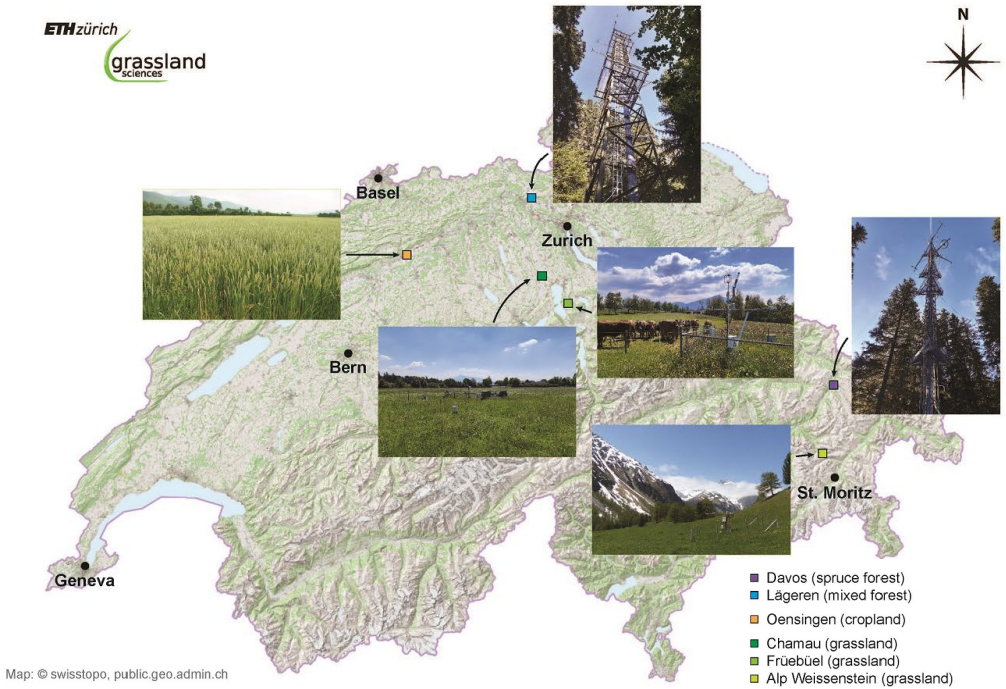
- The goal is to investigate the ecophysiology of urban trees, examining their water usage, response to urban heat and cooling mechanisms, to enhance knowledge of their adaptation strategies in urban settings.

Please contact: Sophie Emberger,
sophie.emberger@usys.ethz.ch

Evapotranspiration of Swiss ecosystems

Globally, **evapotranspiration** (ET) has increased during the last decades. However, direct ET measurements of grasslands, cropland and forests are scarce, typically models are used to quantify ET, e.g., to come up with the “essential climate variable” ET for MeteoSwiss. Within the **Swiss FluxNet**, which covers all three land use types in Switzerland, we measure ET since 20 to 25 years with the eddy-covariance technique, depending on the site. **How much did ET change during the last decades? What are the drivers of change?**

- The goal is to quantify and understand ecosystem ET over the last decades. Drivers will be identified using machine learning, e.g., random forest and SHAP analyses.
- Eddy covariance as well as management and meteo data are available. Good R skills are a plus.



Please contact: Prof. Dr. Nina Buchmann
Depending on the site, other persons will supervise as well.

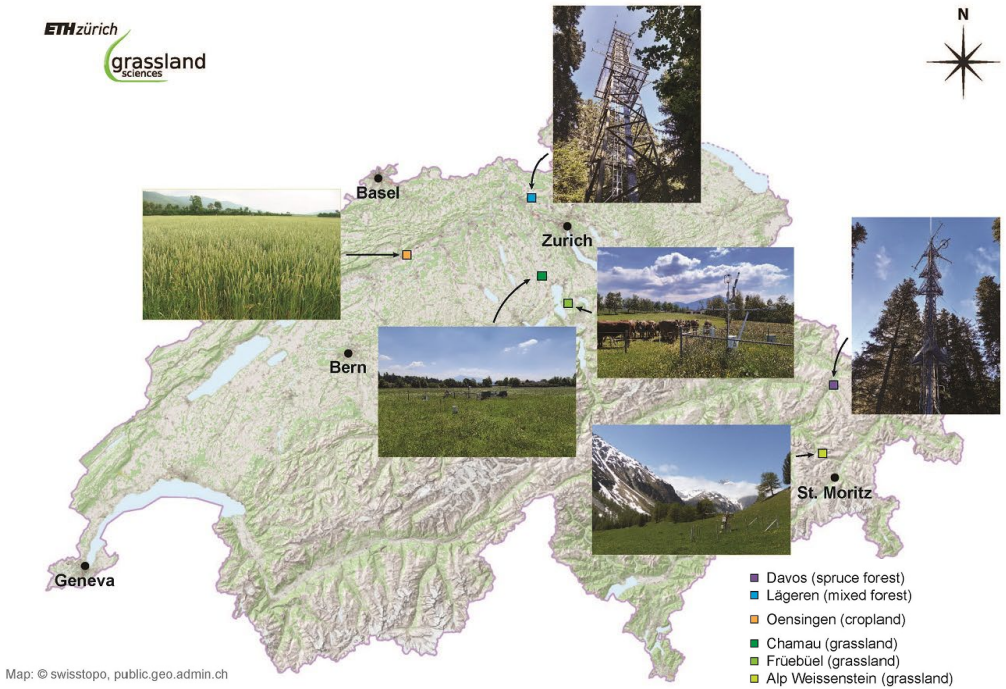
Effects of climate on net GHG fluxes

Within **Swiss FluxNet**, we measure net ecosystem CO_2 and H_2Ov fluxes since >15 years at agricultural sites (grasslands and cropland). At two sites, also CH_4 and N_2O fluxes are available. But how do these systems react to weather and climate? Did functional relationships with climate variables already change, ultimately affecting productivity?

- The goal is to understand cropland and grassland responses to weather and climate. **Do we already see climate change effects?**
- Eddy covariance as well as meteo data are available.
- Effects and drivers will be identified with machine learning, e.g., random forest and SHAP analyses Thus, good R skills are a plus.

Please contact: Prof. Dr. Nina Buchmann

Depending on the site, other persons will supervise as well.



Effects of extreme events on net GHG fluxes

Within **Swiss FluxNet**, we measure net ecosystem CO_2 and H_2Ov fluxes since 15 to 25 years, depending on the site. At some sites, also CH_4 and N_2O fluxes are available. Sites cover all three land use types in Switzerland, grassland, cropland and forests. **But how do these systems react to extreme events**?

- The goal is to understand ecosystem responses to extreme or unusual events. These events can include harsh vs. mild winters, warm falls, dark springs, dry spells and droughts during spring and summer
- Eddy covariance as well as meteo data are available.
- Effects and drivers will be identified with machine learning, e.g., random forest and SHAP analyses Thus, good R skills are a plus.

Please contact: Prof. Dr. Nina Buchmann

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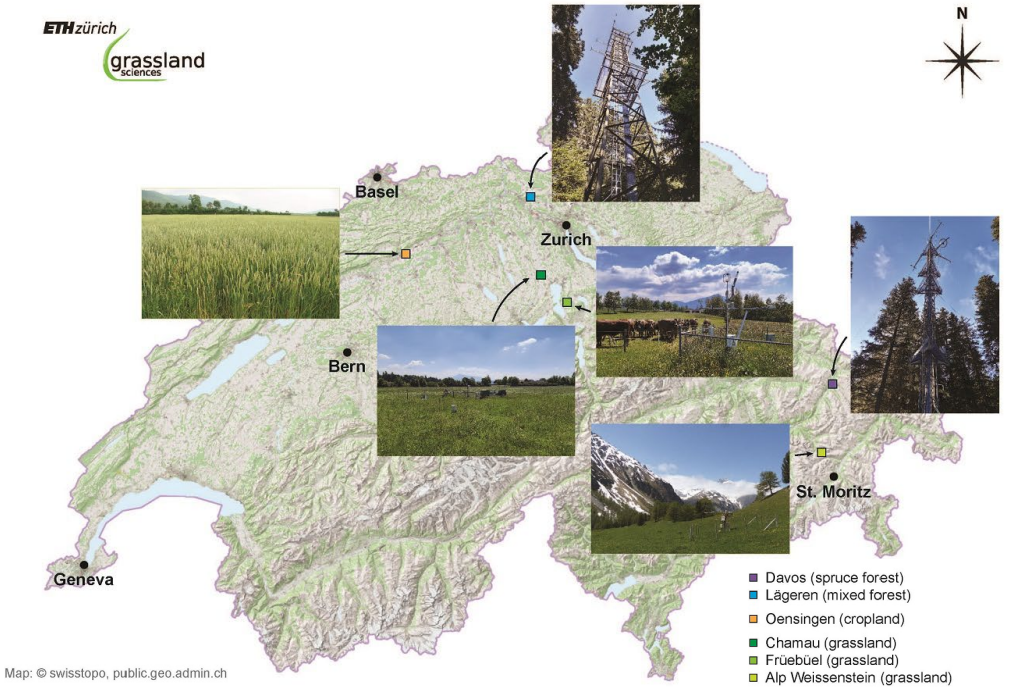
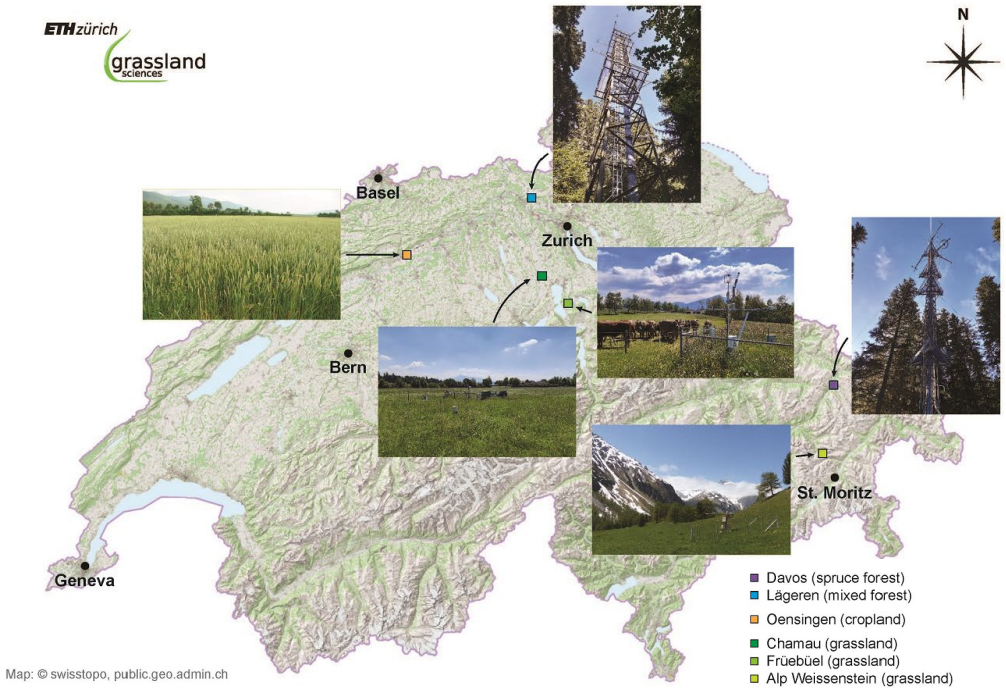


Changes in ecosystem WUE over decade(s)

Within **Swiss FluxNet**, we measure net ecosystem CO_2 and H_2Ov fluxes since 15 to 25 years, depending on the site. Sites cover all three land use types in Switzerland, grassland, cropland and forests. At all sites, air temperatures have increased during this time. **What effect did a changing climate have on the ratio of GPP to ET?**

- The goal is to understand ecosystem responses to climate. The focus will be on changes of gross primary production (GPP) vs. evapotranspiration (ET).
- Eddy covariance as well as meteo data are available.
- Effects and drivers will be identified with machine learning, e.g., random forest and SHAP analyses
  Thus, good R skills are a plus.

Please contact: Prof. Dr. Nina Buchmann
Depending on the site, other persons will supervise as well.



Evapotranspiration von Wiesen, eine «essential climate variable» für GCOS

Forschungsstandorte
Chamau und **Früebüel**

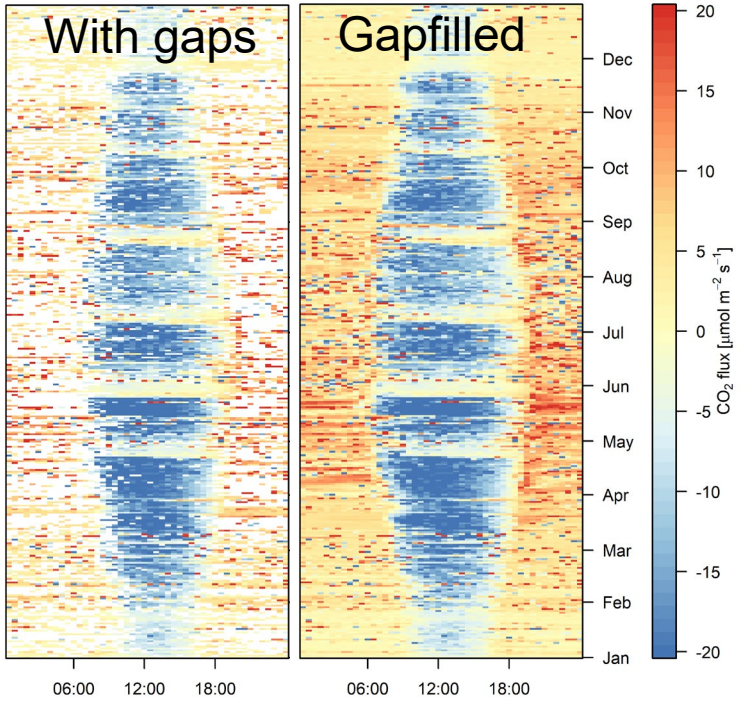
eingebunden in Langzeit-Projekte und GCOS (Global Climate Observing System)

- Berechnung der Verdunstungsraten aus langjährigen Messreihen mit der Eddy-Kovarianz-Technik
- Abschätzung des Wasserhaushalts der beiden Grasländer
- Im Sommer: Messung der Transpirationsraten
- Arbeit kann auch im Winter stattfinden!
- Betreuung: Dr. Iris Feigenwinter, Dr. Lukas Hörtnagl

Effect of different gapfilling approaches on the ecosystem carbon budget

Greenhouse gas (GHG) fluxes measured with the **eddy covariance** technique need to be **quality checked and filtered** before analyses, which causes **gaps** in the data. For estimating **GHG budgets** (e.g., on an annual scale), these gaps need to be filled again. Established methods for gapfilling exist, but recently more attention has been given to new approaches using **machine learning** (e.g., random forest models).

- The goal is to compare different methods to gapfill GHG fluxes (MDS, random forest, XGBoost, etc.) and to assess their effect on the overall carbon budget.
- Data from the Swiss FluxNet are available. Data analyses and gapfilling will be done using R or Python.



Please contact: Dr. Iris Feigenwinter

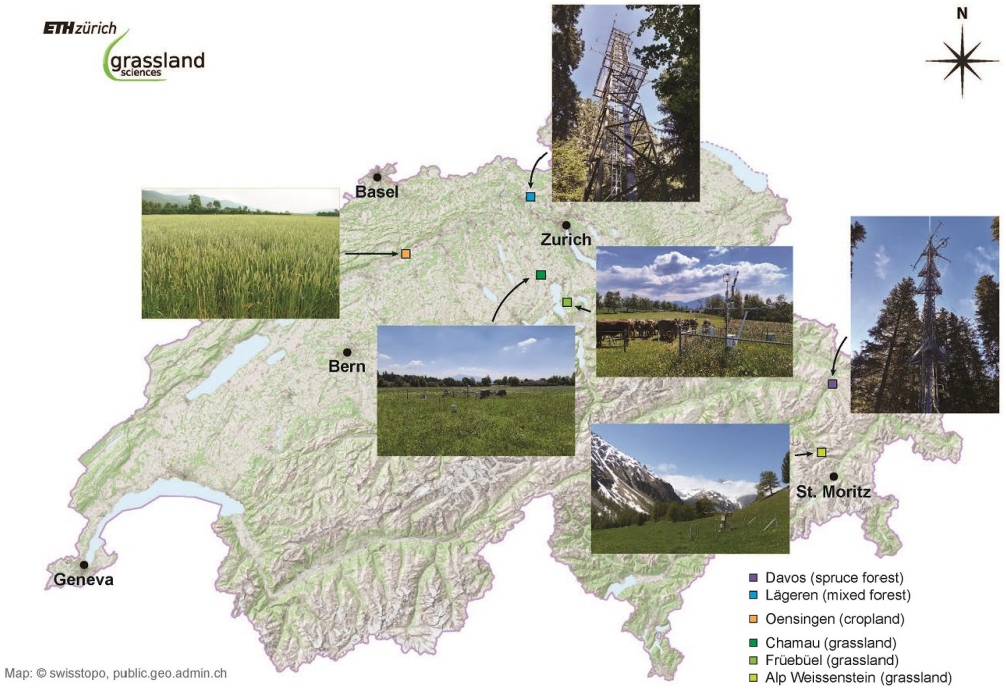
Simulate climate smart farmers with climate and phenology data ?

Over the last decades, climate changed, with increasing frequency and intensity of extreme events. Farmer decide based on climate and phenology of their crops or grasslands. Can we simulate these decisions with climate and crop/grassland phenology data?

- The goal is to simulate farmers' management decisions with climate and phenology data.
- Long-term eddy covariance as well as meteo, phenocam pictures and management data are available. Good stats skills are a plus.

Please contact: Prof. Dr. Nina Buchmann

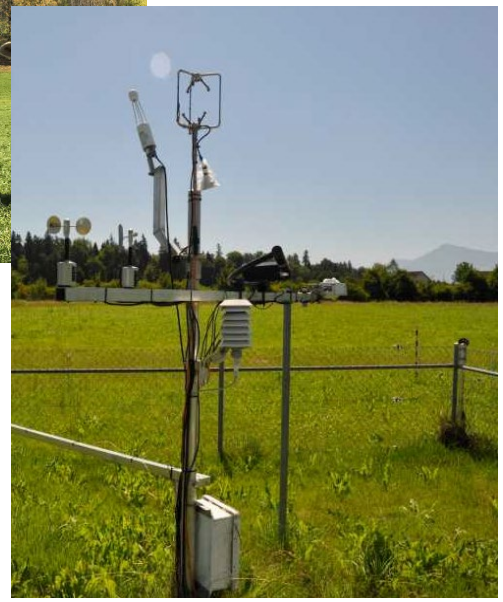
Depending on the site, other persons will supervise as well.



Differences in regrowth of grasslands over time

Within the **Swiss FluxNet**, we measure net ecosystem CO_2 and H_2Ov fluxes since >15 in three different **grasslands**. Two sites are managed as meadows, one is grazed. Since climate has changed over the last decades, we are interested to identify if regrowth after cut or grazing changed over the years.

- The goal is to identify changes in grassland regrowth after management, i.e., ecophysiological acclimation of growth.
- Eddy covariance as well as meteo data are available. Good R skills are a plus.



Please contact: Prof. Dr. Nina Buchmann

Depending on the site, other persons will supervise as well.

Changes in soil C stocks in grassland soils over time

Eddy-covariance measurements like at the long-term grassland site **Früebüel** (1000 m a.s.l.) provide direct insights into the CO_2 dynamics of ecosystems. If the grassland is a CO_2 sink or source is being determined. However, to determine if the site is a C sink or source, inputs and outputs need to be considered, validated with soil C stock measurements.

- Goal: Resample the soil C stocks (soil organic carbon, bulk density) and compare the new stocks to those of 2006.
- Field work can be done in spring/summer/autumn.
- Supervision: Prof. Dr. Nina Buchmann, Dr. Iris Feigenwinter

Effects of snow on greenhouse gas exchange in Alpine grassland

Snow depth has been decreasing in the Alpine region due to climate change. Earlier snowmelt causes the **growing season** to start earlier but does not necessarily lead to more CO_2 uptake during summer, as other factors, such as temperature, radiation and soil water content also affect the **CO_2 uptake** in addition to growing season length.

- The goal is to determine the effects of snow depth and growing season length on the summertime CO_2 exchange using eddy covariance and chamber flux measurements.
- Eddy covariance as well as meteo/snow data are available. Good R skills are a plus.

Please contact: Dr. Kukka-Maaria Kohonen

N_2O fluxes of arable soils

Within the DONA project, we measure net ecosystem CO_2 and H_2Ov fluxes as well as CH_4 and N_2O fluxes over **arable systems** (Tänikon, Forel). In addition, we are interested in soil GHG fluxes, particularly of N_2O. **Precision farming practices** are also employed, e.g., less fertilization or inclusion of plantain in a temporary ley. Plantain is known as **biological nitrification inhibitor**. However, the magnitude of N_2O fluxes and the effectiveness of such measures are rather unknown.

- The goals are to quantify N_2O fluxes measured with automated or static chambers (depending on the site), compare them to eddy-covariance N_2O fluxes, and identify their drivers.
- Topic includes field work during the cropping season. Eddy covariance as well as meteo data are available. Good R skills are a plus.

Please contact: Prof. Dr. Nina Buchmann
Fabio Turco (Tänikon), Lorenz Allemann (Forel)

Effectiveness of nitrification inhibitors on N_2O losses of arable soils

Swiss agriculture aims to reduce the nutrient losses from arable fields, including N losses via nitrate leaching and N_2O fluxes. Nitrification inhibitors might be a good solution, particularly **biological nitrification inhibitors** (NIs) such as plantain. Together with Agroscope, we set up a lysimeter experiment (32 lysimeters with 60 cm in diameter) and will test the effectiveness of multiple chemical and biological NIs for different arable crops (salad, winter wheat, maize, temporary ley).

- The goals are to quantify soil N_2O fluxes with static chambers, nitrate leaching by collecting leachates, and various plant variables. Soil climate will be measured as well.
- Field work during the cropping season is mandatory. Crop species depends on timing in crop rotation.

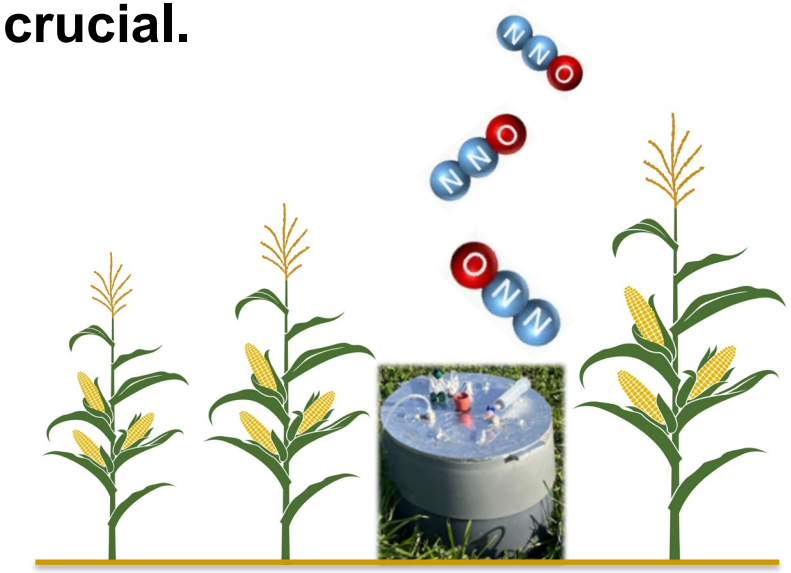
Please contact: Prof. Dr. Nina Buchmann
Co-supervised by Dr. Frank Liebisch and Agroscope staff

Origins and drivers of N_2O fluxes from cropland

Nitrous oxide (N_2O) is one of the most **important anthropogenic greenhouse gases.** Intensive use of N fertilizers caused **increasing N_2O emissions over the last decades**. Management, soil microclimate and plant performance are the main drivers of N_2O emissions,nitrification and denitrification the main pathways. T**o reduce N_2O emissions from agriculture, knowing the temporal variability of N_2O emission pathways and drivers is crucial.**

Goal: determine the origins and drivers of N_2O fluxes during meadow destruction and maize establishment

- Field work in Forel (VD) and laboratory work at ETH Zurich
- Automatic/Static chamber measurements in the field
- Analyse of N_2O isotopomeres to determine N_2O origin
- Quantify of soil and plant nitrogen concentrations
- Evaluate and interpret the data



Supervisors:
Prof. Dr. Nina Buchmann
Dr. Matti Barthel (Sustainable Agroecosystems)
Lorenz Allemann, lorenz.allemann@usys.ethz.ch

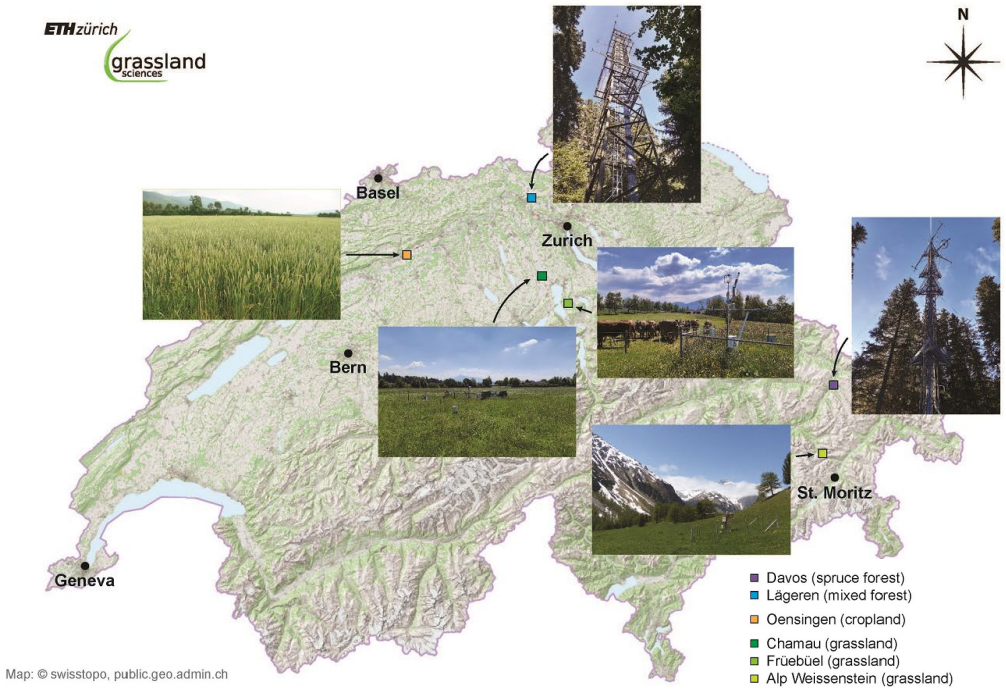
Start: April 2025
Requirement: Driving license

Do crop species differ in their reactions to climate?

Within **Swiss FluxNet**, we measure net ecosystem CO_2 and H_2Ov fluxes since >17 years over cropland (Oensingen, SO), managed with a 4-year crop rotation. Do the various crop species grown here (i.e., winter wheat, winter barley, rapeseed, temporary grassland, potato, pea) react differently to climate? **What crop species would be better in a future climate?**

- The goal is to understand crop responses to climate.
- Eddy covariance, management as well as meteo data are available. Good R skills are a plus.

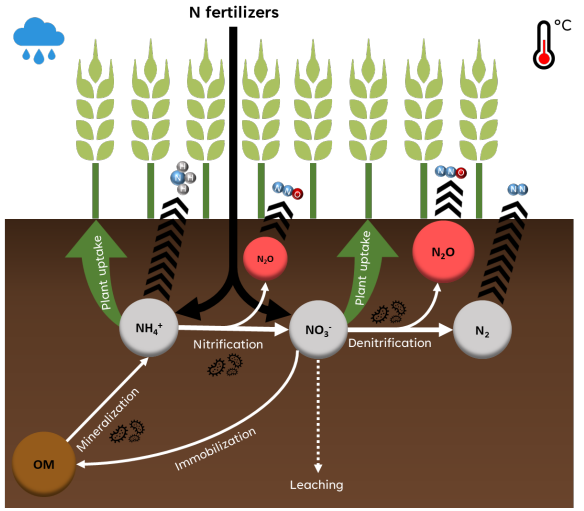
Please contact: Prof. Dr. Nina Buchmann
Dr. Regine Maier, Fabio Turco



Biogeochemical modelling of N_2O emissions from cropland

Nitrous oxide (**N_2O**) is a potent greenhouse gas emitted primarily by the agricultural sector as a result of the use of nitrogen (N) fertilizers. Process-based biogeochemical models are powerful tools to develop climate-smart management practices by predicting GHG emissions in response to environment and management. However, state-of-the-art models showed poor performance in predicting N_2O emissions.

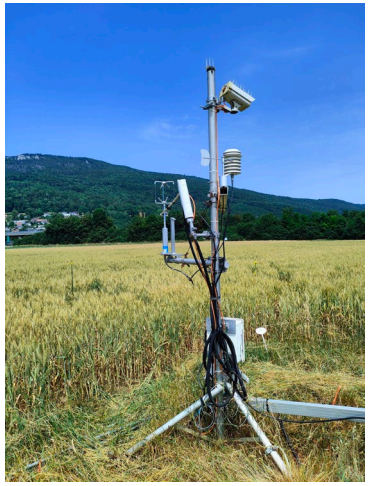
Your thesis: Using a biogeochemical model (e.g., DNDC, DayCent) to simulate N_2O emissions from croplands. This involves collecting and preparing the input data, operating the biogeochemical model, and analyzing the model output in comparison with measured data (from Eddy Covariance station). Possibly, you would help in the data collection during 2024 (vegetation and soil measurements).



Time frame: flexible but ideally the start would be this spring/summer 2024

Contact: Fabio Turco (fabio.turco@usys.ethz.ch)

Estimation of crop N uptake using remote sensing and phenocam images



Nitrous oxide (**N_2O**) is a potent greenhouse gas emitted primarily by the agricultural sector as a result of the use of nitrogen (N) fertilizers. Recent studies have highlighted the overlooked role of plant-microbe N competition in determining the magnitude of N_2O emissions. To fill this research gap, high-resolution data on crop N uptake are essential.

Your thesis:

1. **Estimate N uptake** using ground truth data, **satellite** imagery (Sentinel-2) and **phenocam** imagery from past years (+ 2024) using **machine learning** (phenocam data) and regression models (satellite data).
2. Analyze relationships between estimated N uptake and N_2O emissions.
3. Possibly you assist in 2024 data collection (monthly during the growing season) with destructive sampling and related laboratory work.

Time frame: flexible but ideally the start would be this spring/summer 2024

Contact: Fabio Turco (fabio.turco@usys.ethz.ch)

Where does the carbon go in a spruce forest?

At the Swiss FluxNet site **Davos**, we measure net ecosystem CO_2 fluxes since 1997. Ever since measurements started, this forest was a C sink. Since 1998, we also measure stem radius changes at high temporal resolution.

- The goal is to relate stem growth to ecosystem CO_2 uptake and carbon sequestration at the site Davos, based on existing measurements.
- Growth at different temporal scales, from daily over seasonal to decadal can be studied.
- Tree water relations are the key to growth and the carbon budget of a forest. Water uptake, transport, storage, and transpiration can be simulated and analyzed in order to investigate underlying mechanisms.

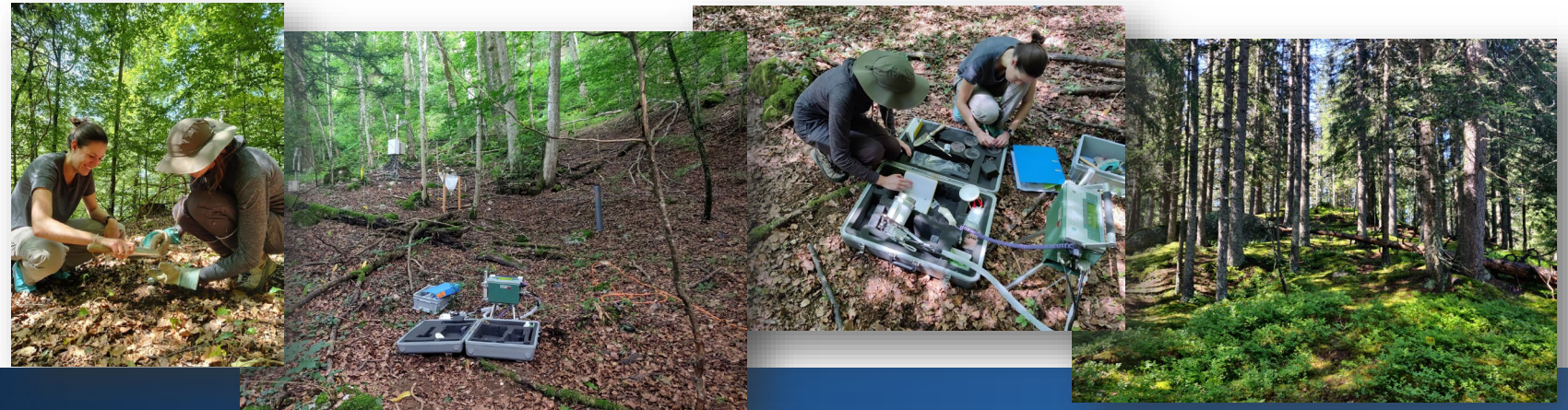
Please contact: Dr. Roman Zweifel (WSL), Prof. Dr. Nina Buchmann

How large is the spatial heterogeneity in the footprint of our forest flux stations?

Soil CO_2 fluxes are a large fraction of the forest CO_2 exchange. At ecosystem scale, we integrate over the entire forest, but spatial heterogeneity at soil level is not known.

- The goal is to quantify soil CO_2 fluxes at two forest sites (Davos & Lägeren), with ecophysiological and manual chamber flux measurements. Since understory vegetation is highly heterogeneous, spatial variations in soil respiration need to be addressed. Ready for field work?

Contact: Liliana Scapucci (doctoral student)
Luana Krebs (doctoral student)



Day vs. night: Differences in night- vs. daytime respiration in terrestrial ecosystems

Ecosystem respiration is increasing faster than gross primary productivity with increasing temperature due to global warming. This bears the risk of reducing the carbon sink capacity of ecosystems. We often observe very **high air dryness** and **high temperatures at night**, and aim to understand how the effects on the CO_2 fluxes differ among different ecosystems.
Within the Swiss FluxNet, we measure CO_2 fluxes with the eddy-covariance technique in different ecosystems, e.g., of deciduous and evergreen forests, croplands, alpine and lowland grasslands.

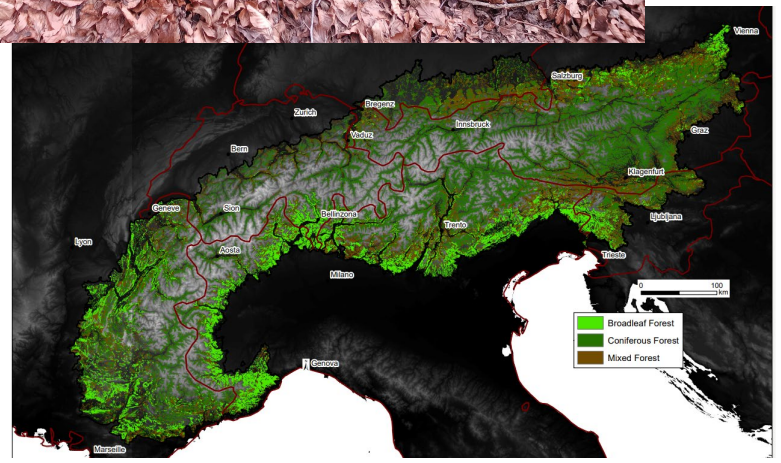
The **goal** is to quantify the differences in nighttime vs. daytime respiration, determine the main drivers with machine learning, and assess the effect of high temperatures on nighttime respiration.

Please contact: Liliana Scapucci (doctoral student)
lscapucci@ethz.ch

Water storage capacities in forest-floor litter layers

The litter layer on the forest floor stores a significant amount of annual precipitation and evaporation from this layer significantly influences the moisture within forests.

- The goal is to assess the storage capacity, retention and evaporation timescales of water from the forest-floor litter layer. Students will conduct a series of laboratory experiment in climate chambers and use an existing pan-Alpine data & sample collection to assess the role of the forest floor litter layer in the water cycle.



Please contact: Dr. Marius Floriancic,
Prof. Dr. Nina Buchmann

Ihr Vorschlag für Ihre Bachelor/Master-Arbeit?

- Auf einem unserer Standorte oder unter kontrollierten Bedingungen?
- Ihr Lieblingsthema
- Eingebunden in laufende Projekte: http://www.gl.ethz.ch/research.html

Betreuung: Prof. Dr. Nina Buchmann oder jemand aus der Gruppe Graslandwissenschaften