Dynamics of high-altitude environments as a life-support system to wild herbivores:

carbon and moisture cycling, biodiversity and landscape modification

ECOPOTENTIAL Storyline: **M1**

Pilot PA: **Gran Paradiso National Park** (Italy)

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ECOPotential General Meeting
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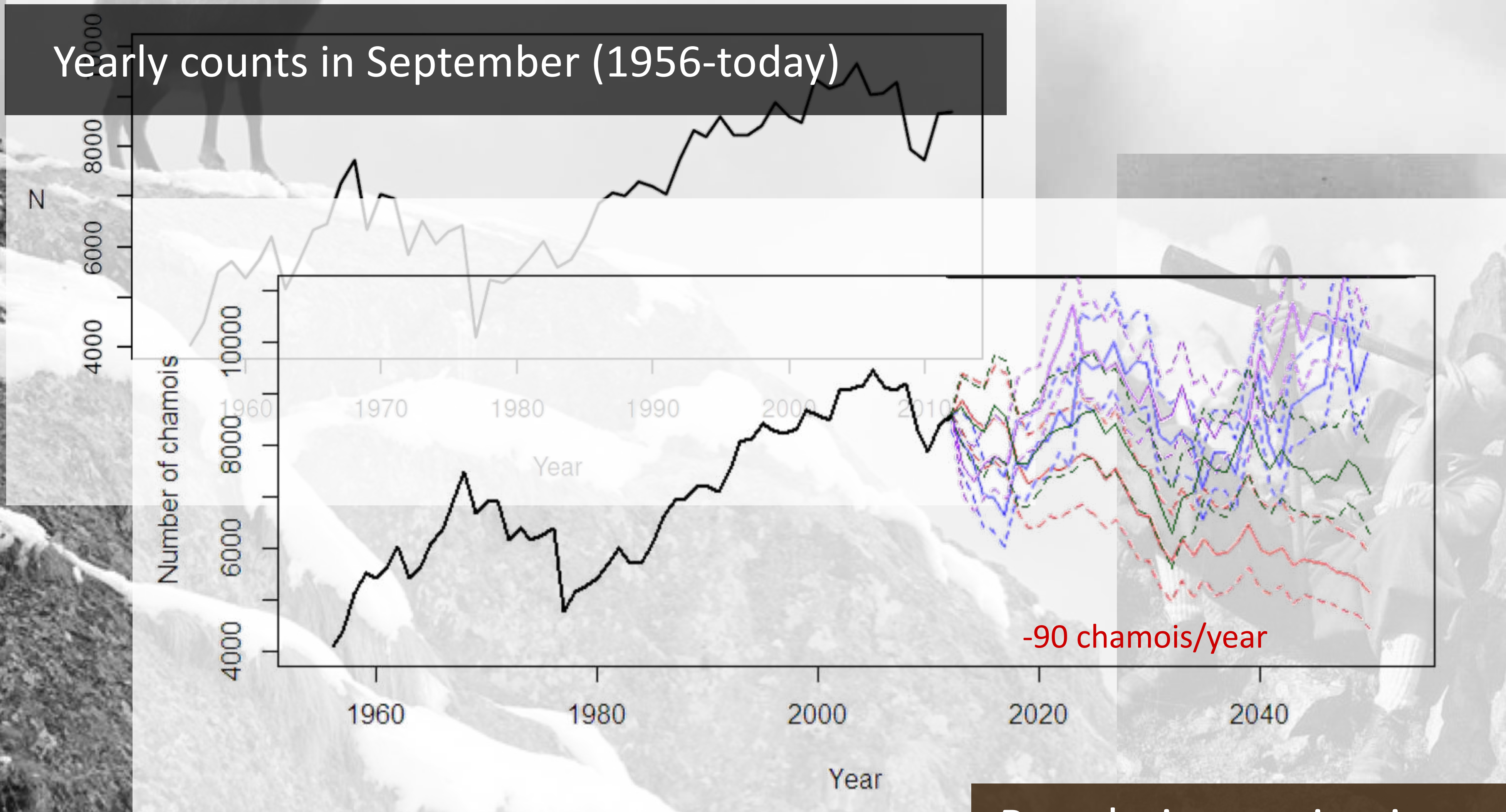
Alpine chamois (*Rupicapra rupicapra*)

Yearly counts in September (1956-today)



Population projections

Processes in Alpine Grasslands

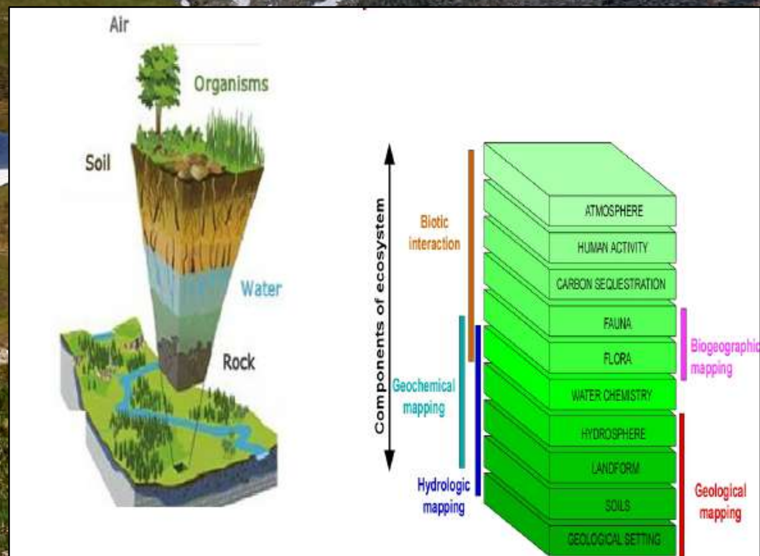
Alpine grasslands – characteristic ecosystems at the high altitudes – provide essential ecosystem services: **habitat** for endemic or rare species, **water** provision, **carbon** storage

Mountains are climate change hotspots – the measured and expected increase in temperature is higher in mountains

Climate change, together with the abandonment of pastures, are major drivers of change and lead to pressures that modify alpine grasslands

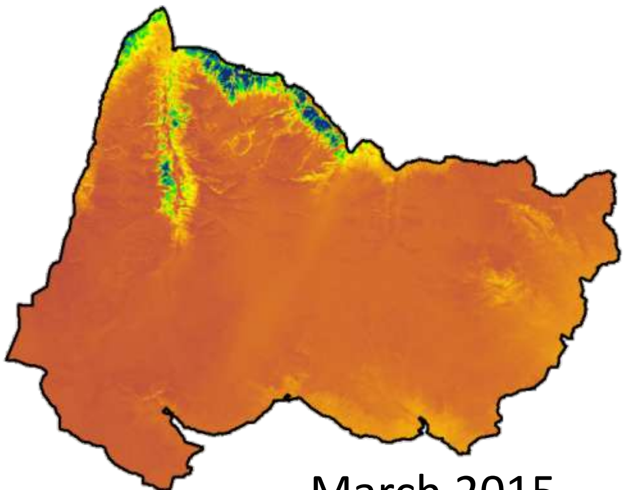
Such pressures may effect:

Species richness and composition
Soil nutrients concentrations
Evapotranspiration / soil humidity
Nutrient and Carbon cycling and consequently atmosphere/ bio-geosphere CO_2 fluxes

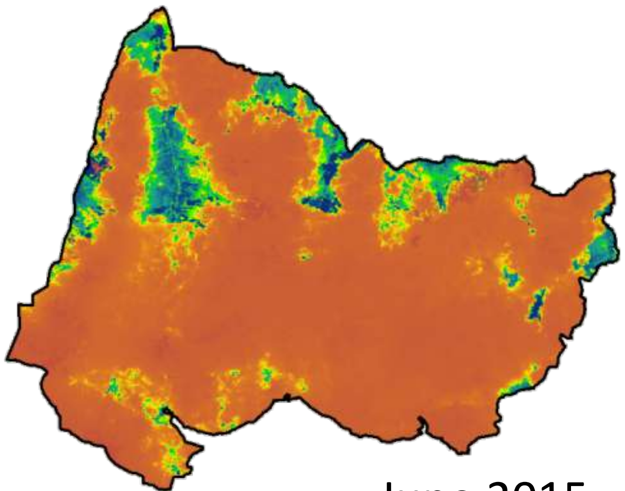


EURAC research

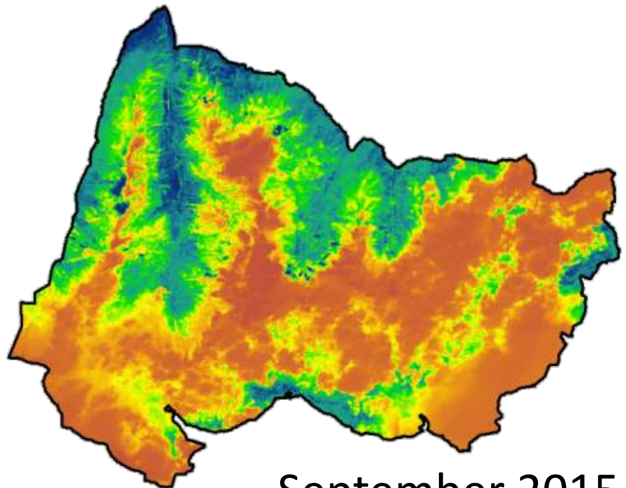
RS data: NDVI and Snow cover duration



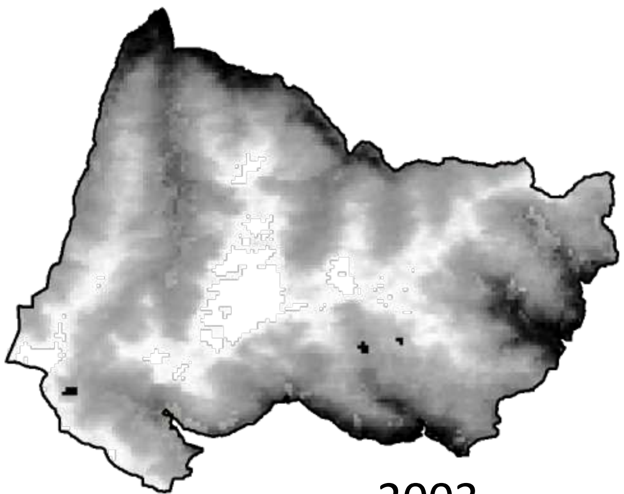
March 2015



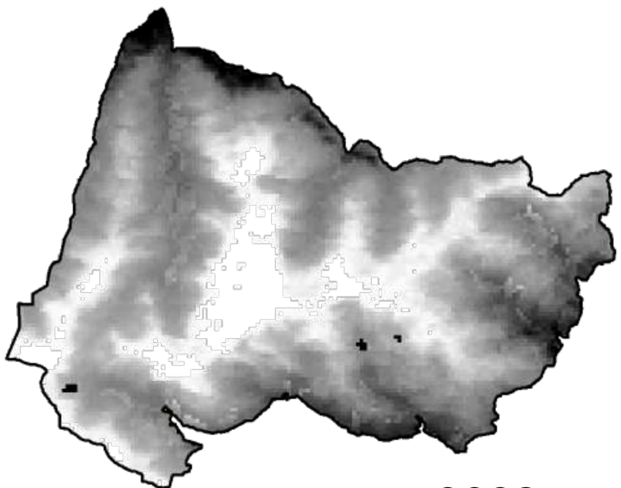
June 2015



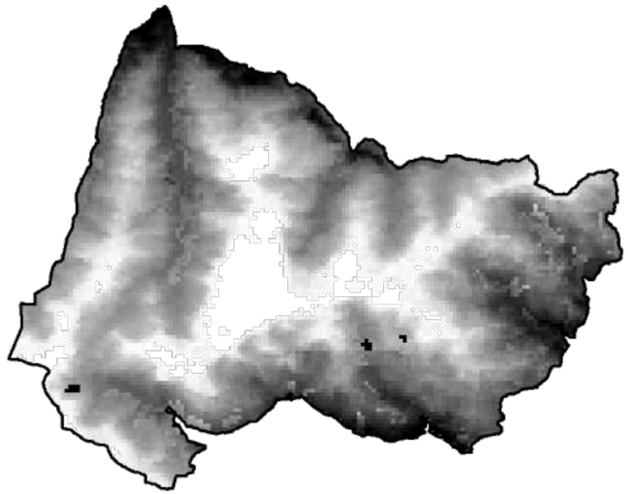
September 2015



2003



2008



2013

Net ecosystem CO_2 exchange to detect ecosystem response to drivers

Net CO_2 flux from grassland varies largely in time scale (short and long-term) in response to many factors, such as meteorological drivers, changes in the ecosystem structure (including natural and anthropogenic disturbances like changes in land use and management) or physiological response to climate.

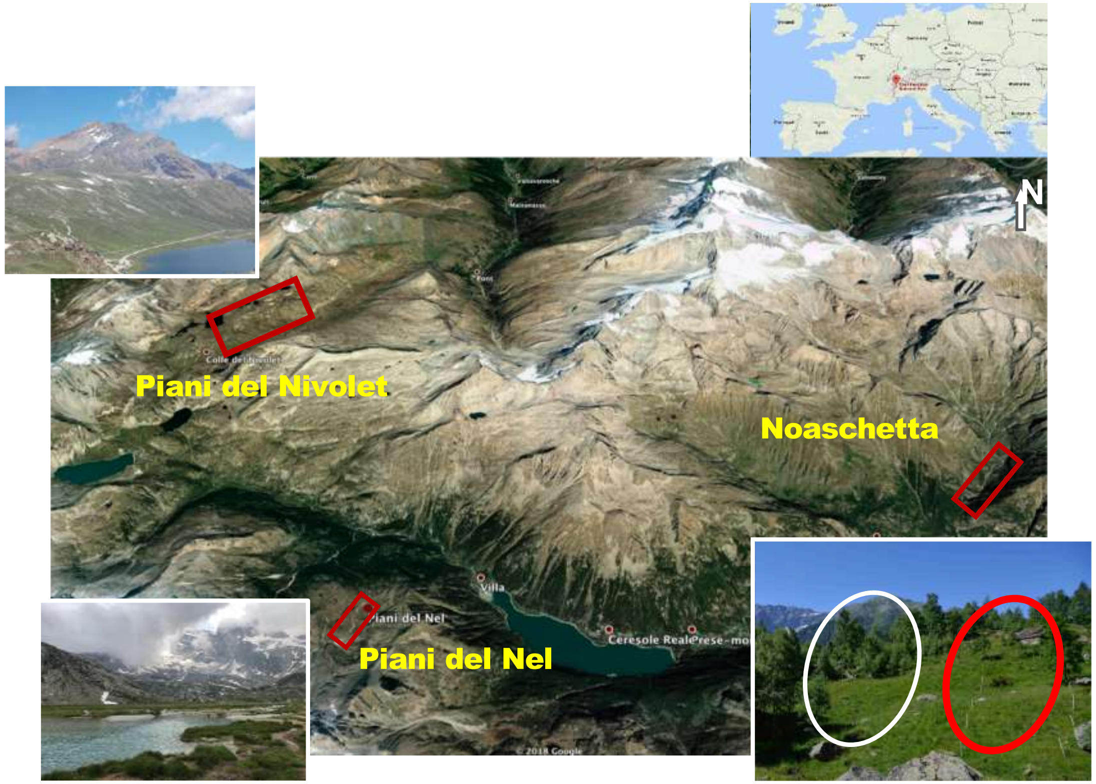
In order to investigate short-term adjustment of the grasslands' CO_2 fluxes to climate variability and anthropogenic disturbances we started a long-term observations and monitoring in 2016.

Study sites

A **<u>long-term monitoring programme</u>** started in 2016 aimed to:

1) evaluate the effects of a well managed grazing system on animal and plant biodiversity;
2) compare the evolution of managed and non-managed areas (portions of the meadows excluded from grazing);
3) quantify the processes of carbon and nutrients exchange in high altitude alpine grasslands in order to understand actual state and future behaviour, also related to climate and environmental changes.

In 2017 a **Critical Zone Observatory** (CZO) has been estabilished in order to <u>the study impact of environmental conditions on Critical Zone dynamics</u>. In the short term question addressed here is how CO_2 fluxes in grasslands are modulated by the characteristics of the underlying bedrock, by the soil physical and chemical conditions and by meteoclimatic parameters such radiance and temperature.



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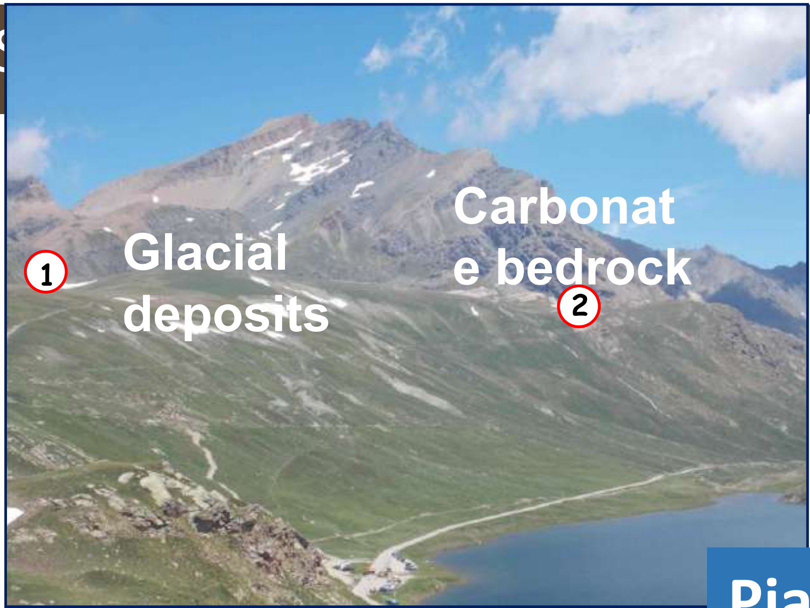
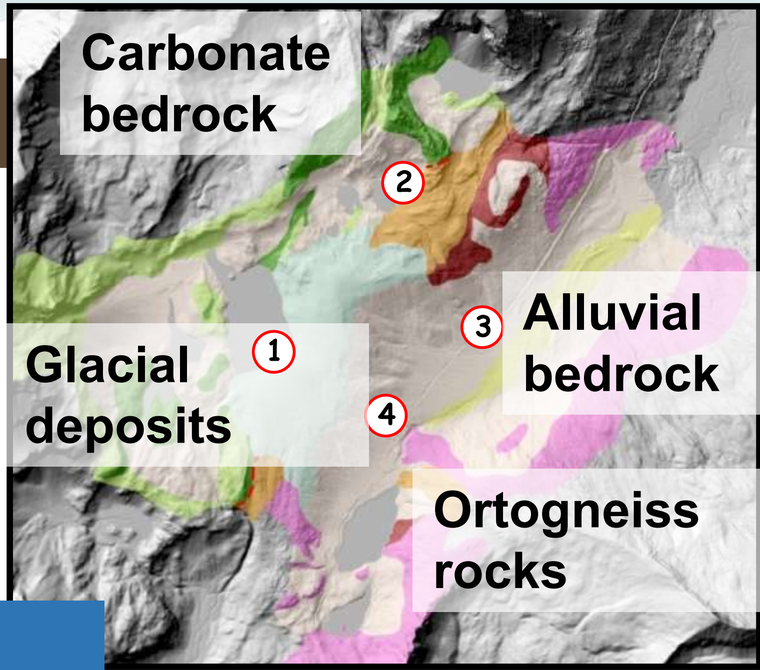
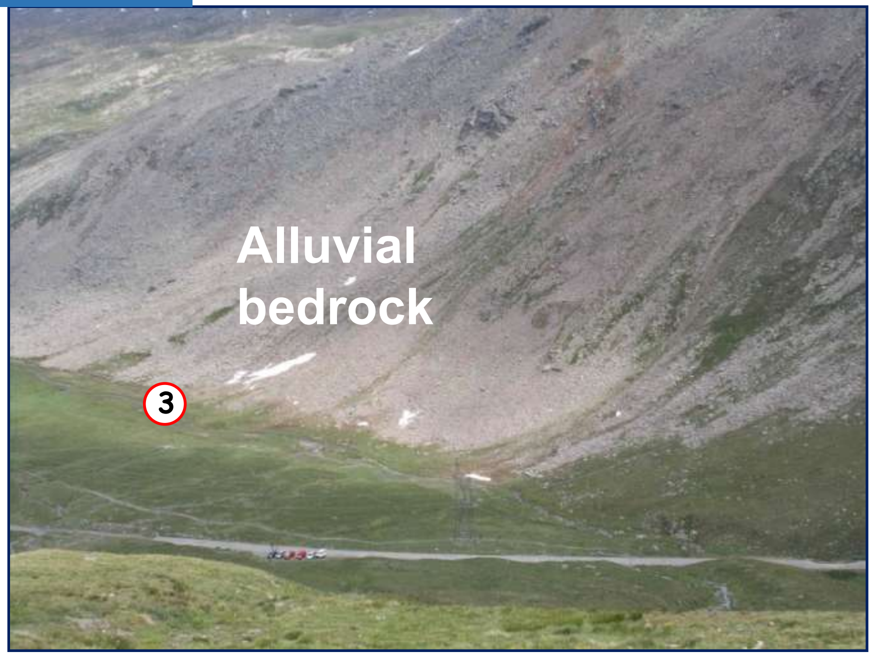




Pian del Nivolet



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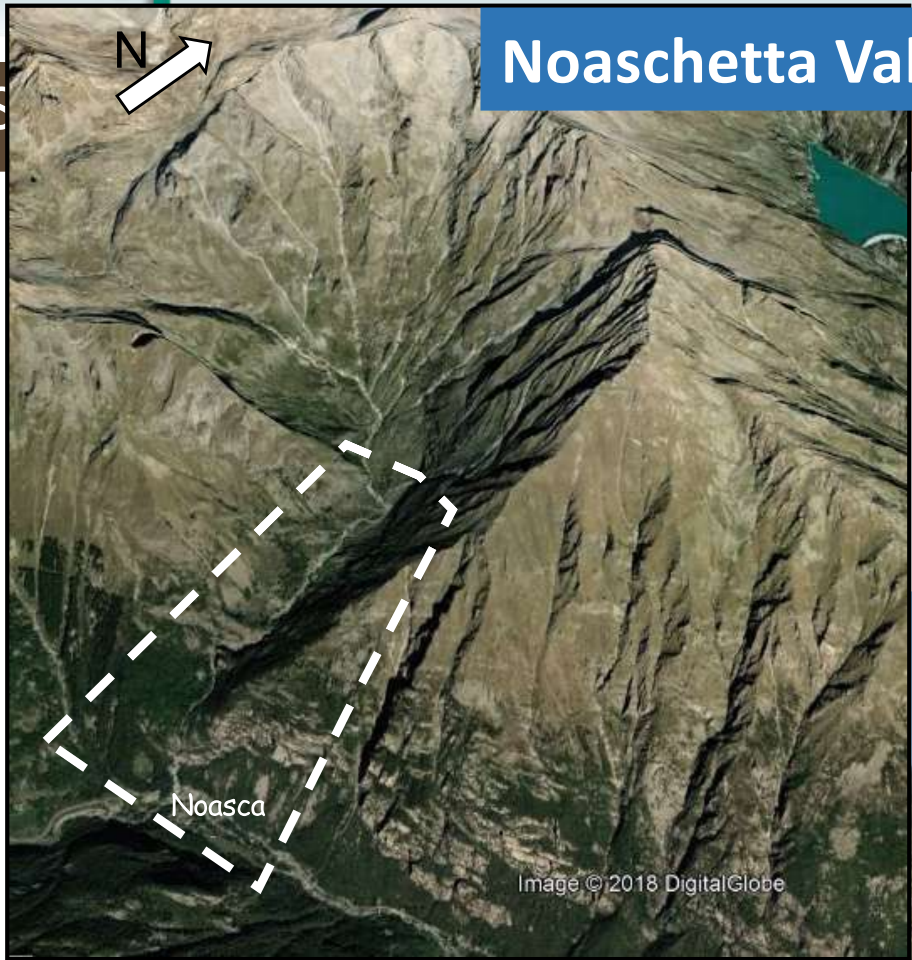
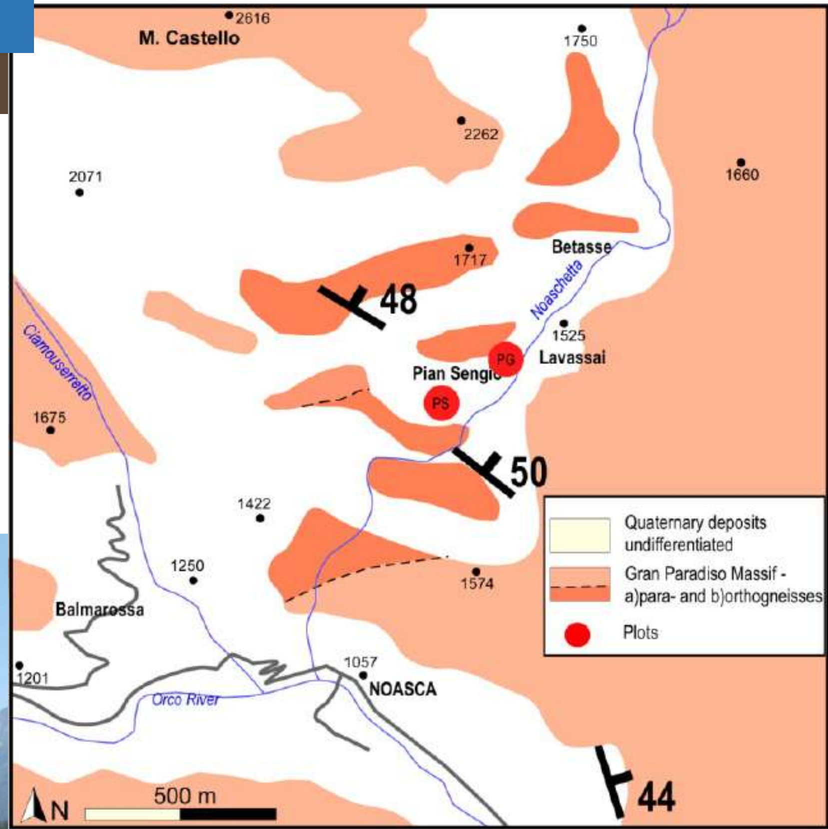
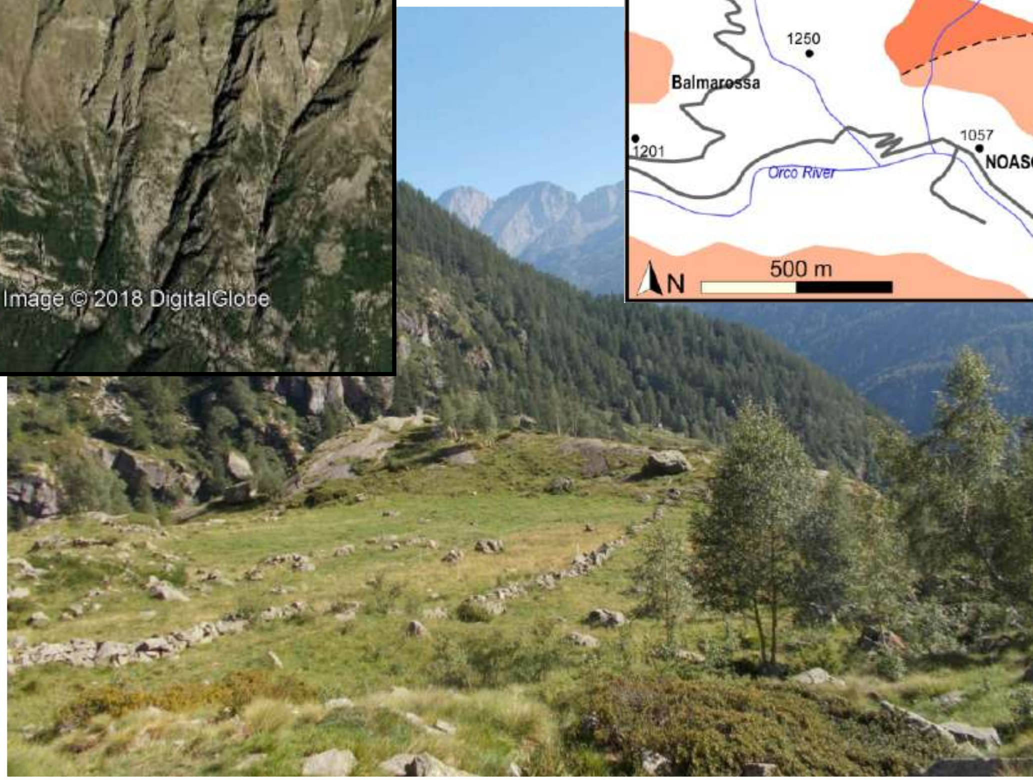
Noaschetta Valley

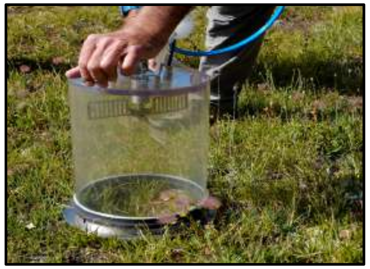






Methods

CO_2 Fluxes



Accumulation chamber measurements

Eddy Covariace tower equipped for CO_2 fluxes and for micrometeorological monitoring

Soils and waters

Soil profile

Water geochemistry

Soil biogeochemical-isotopic characteristics

Biodiversity and vegetation

Vegetation: biometrical, physical, geochemical, biochemical and physiological characterization

Measures and sampling in Noaschetta Valley

Soil samples taken in 11 plots

In each plot: samples inside and outside the fence at 5 and 15 cm depth.

Parameters: pH, conductivity, TIC, TOC, TN - undergoing

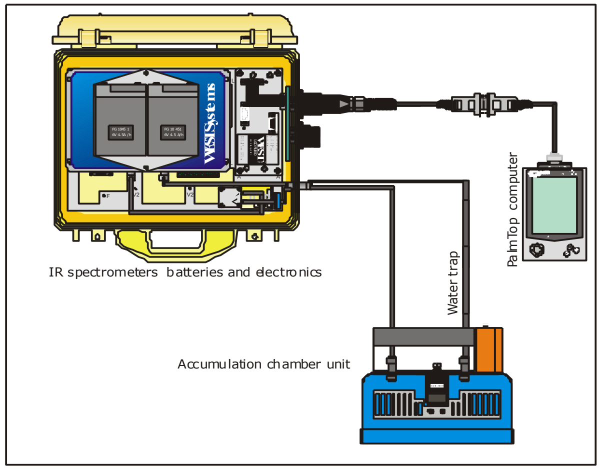
Dynamic Flux Chambers: what are they?

CO_2 fluxes are measured from July to October with a mobile flux chamber provided with a transparent chamber and a LI-COR LI 820 Licor analyser + GPS.

Radiance (305-2800 nm) and soil temperature and humidity are measured at each sampling point.

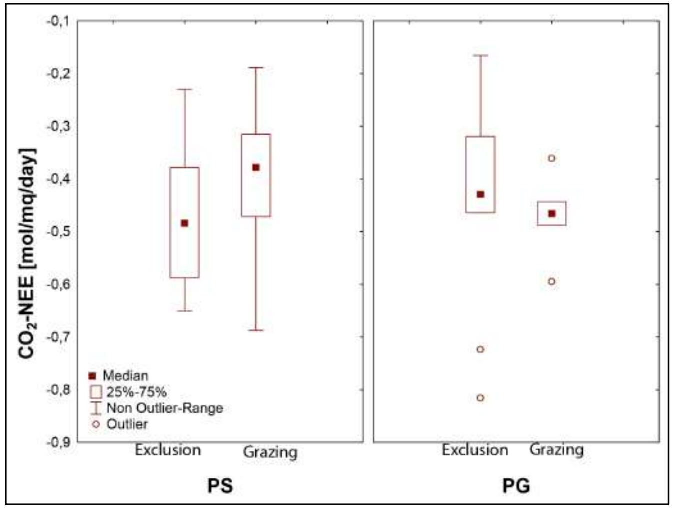
Measures are taken at daylight (NEE) and dark (respiration).

Spatial flux maps have been calculated using geostatistical methods (kriging).

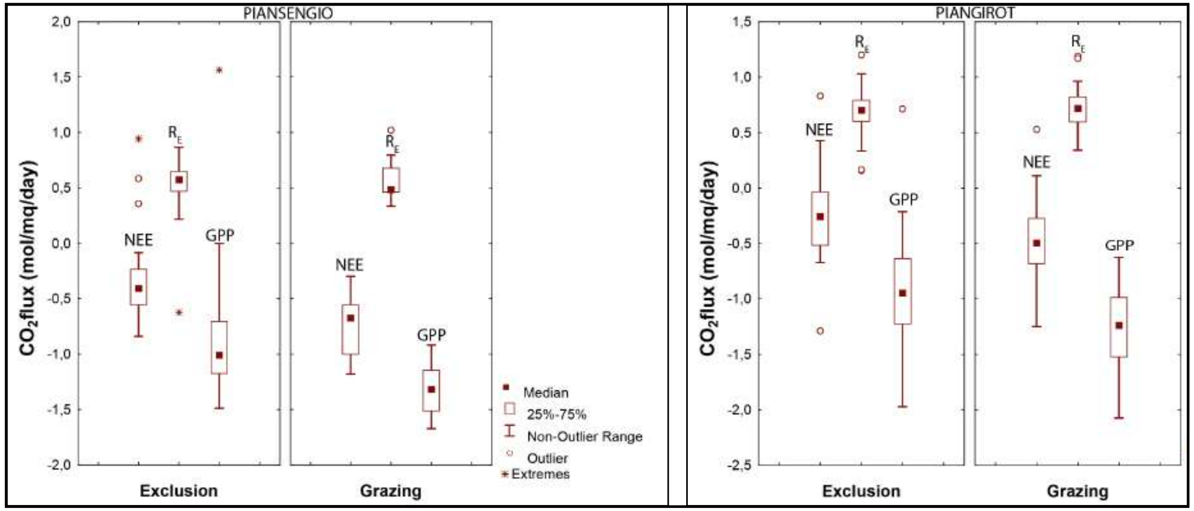


CO_2 fluxes at Noaschetta 2016 - 2017

2016 survey



2017 survey



In 2016 (left) 2 plots (PG and PS) inside and outside the fence were equivalent as the grazing exclusion experiment did not start yet.

Statistical tests (Wilcoxon Rank Sum Test) showed that the net CO_2 fluxes were not statistically different.

In 2017 the grazing exclusion started. Diagrams on the right show that **NEE and GPP are higher where there is no grazing** according to the Wilcoxon Rank Sum Test (significativity: 5%).

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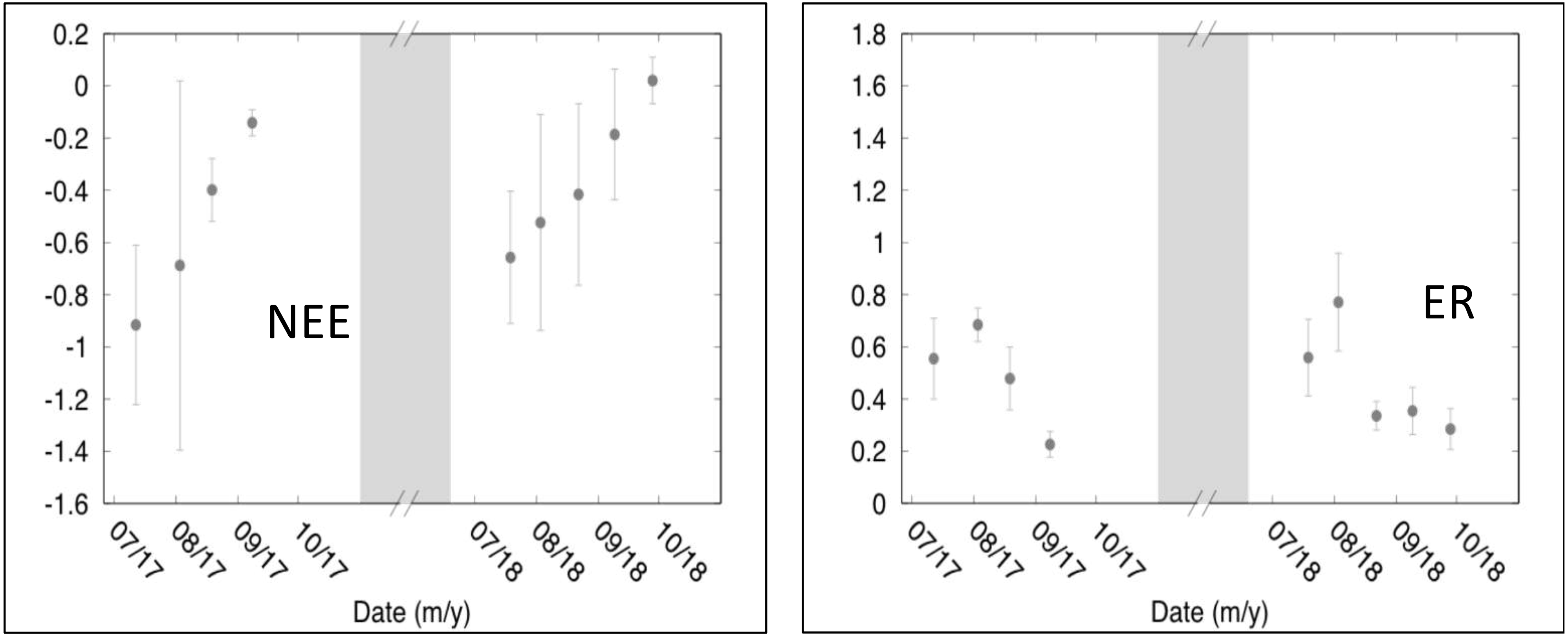
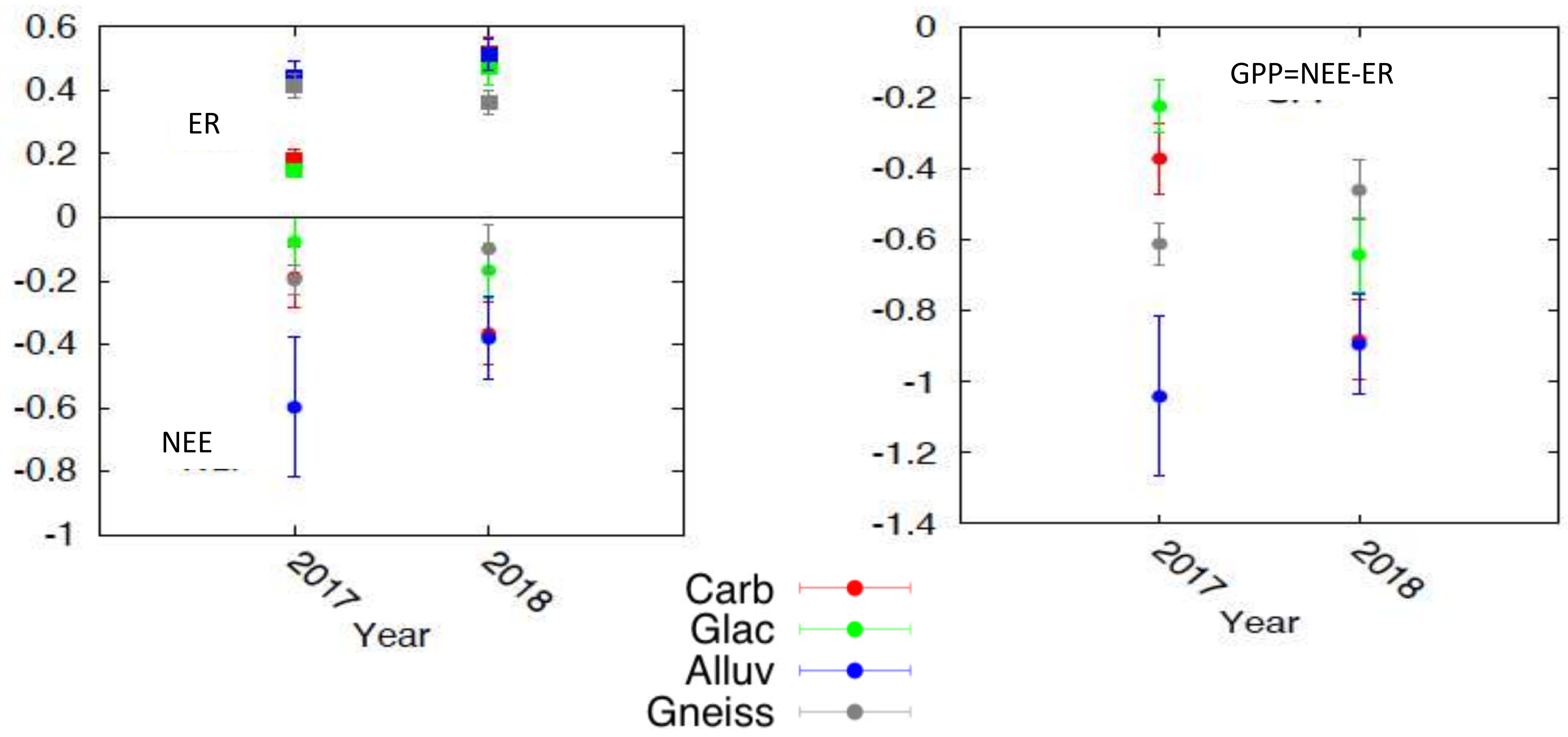
CO_2 Fluxes from the Accumulation chamber: Nivolet Plain



Average values of NEE and ER for the gneiss plot, for the 9 campaign dates in 2017 and 2018. Errors bars are 1σ rom the ensemble of the individual measurements on each measurement date and plot.

CO_2 Fluxes from the Accumulation chamber: Nivolet Plain



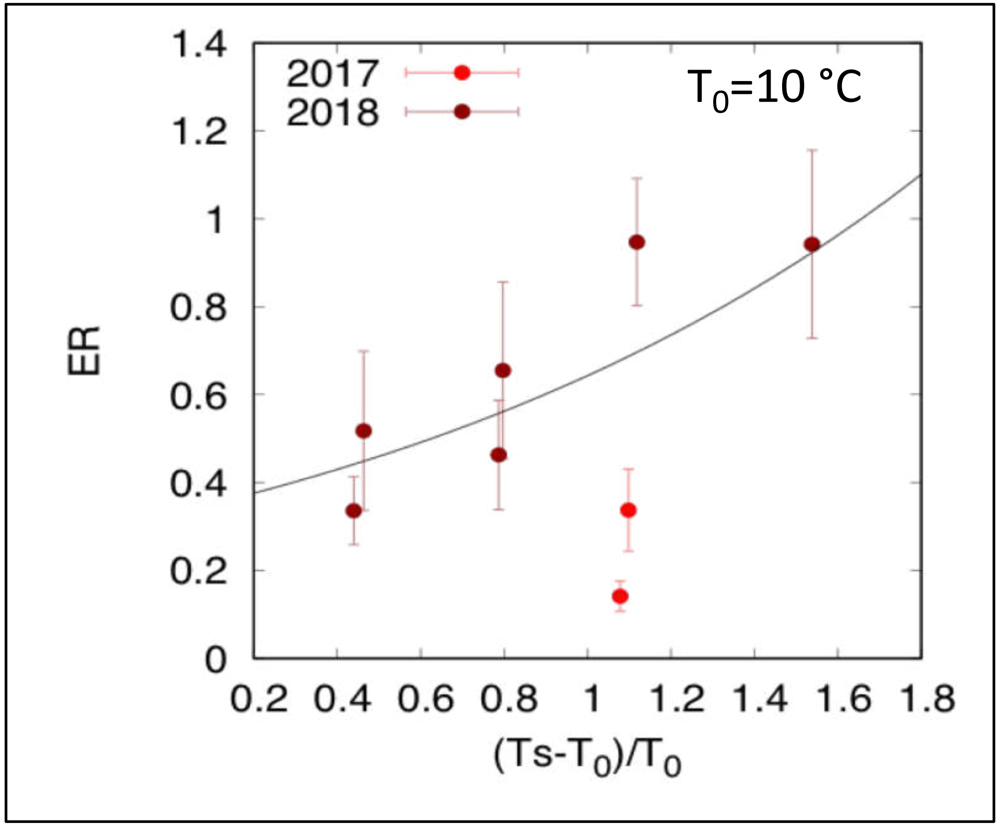
Average values of NEE, ER and GPP for the four plots, for summers 2017 and 2018 respectively.

CO_2 Fluxes from the Accumulation chamber: Nivolet Plain

Plot	ER	NEE	GPP
Carbonate	NONE	Soil moisture	Soil moisture
Alluvial	Soil moisture	Soil temp.	Soil temp.
Glacial	Radiation, soil moisture	Radiation, soil moisture	Radiation, soil moisture
Gneiss	Radiation, soil moisture, soil temp	Radiation, soil moisture, soil temp	Radiation, soil moisture, soil temp

Using a different approach, univariate analyses of the linear dependence of the standardised ER, NEE and GPP on environmental parameters have indicated the following significant dependencies, with up to 70% of the variance explained by soil moisture in some cases.

CO_2 Fluxes from the Accumulation chamber: Nivolet Plain



ER versus soil temperature for the 2017 and 2018 campaigns, for the carbonate plot as an example. The curve is the standard fit $ER=ER_0 \; Q_0^{[(T-T0)/T0]}$. GPP=NEE-ER is then fitted to a Michaelis-Menten functional form as a function of solar radiation. Over the two years, we observe significant dependence of ER on soil temperature for CARB, GN and FV plots. Significant dependence of GPP on radiation is observed for the glacial and gneiss plots.

Conclusion

1) There is a strong internal variability in carbon fluxes and environmental parameters within each plot.

2) Univariate linear regressions of ER, NEE and GPP=NEE-ER versus environmental parameters indicate relevance of soil moisture, followed by soil temperature and, for the glacial and gneiss plots, of radiation. In some cases, soil moisture by itself explains more than 70% of the variance in the data.

3) Using standard nonlinear expressions relating GPP to radiation and ER to soil temperature, we obtain a significant dependence of ER on soil temperature for the carbonate, the gneiss and the alluvial plots, and significant dependence of GPP on radiation for the glacial and gneiss plots.

4) At the moment, limited differences between the four plots is observed. Further analysis is ongoing on this.

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in Earth System Dynamics

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Course 2019

Critical Zone and Ecosystem Dynamics across Space and Time

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Directors of the course
Timothy White, Pennsylvania State University, USA
Antonello Provenzale, CNR IGG, Pisa, Italy

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