Heterotrophic and autotrophic soil respiration in an alpine grassland

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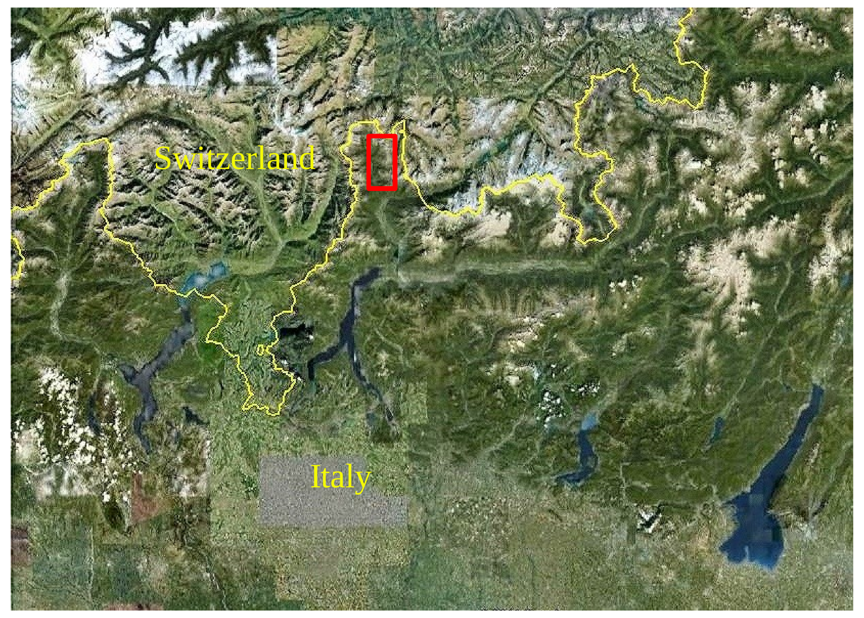
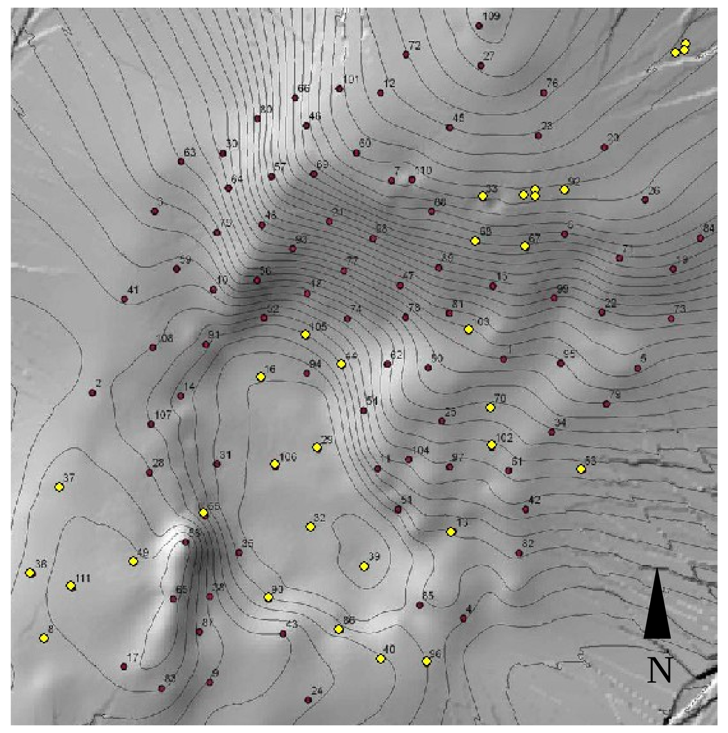
Introduction and Objectives

While soil respiration has been well characterized for a wide range of forest ecosystems, comparatively little is known for grasslands.
Our study was aimed at monitoring of soil CO_2 efflux and at its partitioning into heterotrophic and autotrophic contributions in a pasture of Italian southern Alps.
Based on the relationships identified between soil parameters and vegetation types, it was finally possible to spatialize CO_2 fluxes, using vegetation and topography as indicators of soil respiration.

Study Area



The study site is a 1.5 ha doline of Italian southern Alps (Valchiavenna, Lombardy) used as cattle pasture, at about 1900 m a.s.l.



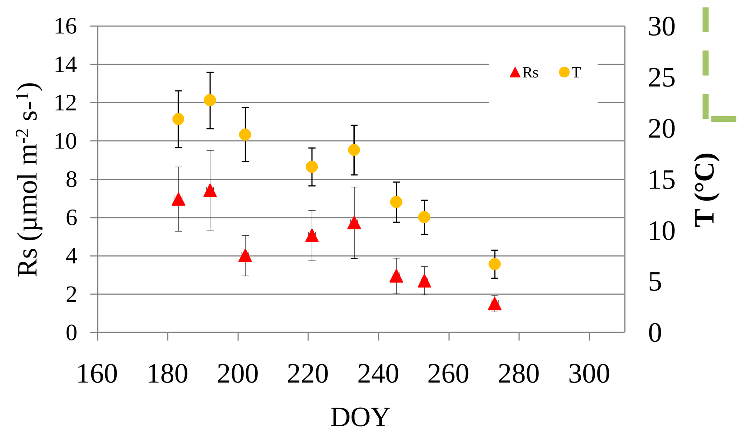
The area was characterized from soil, plant cover and topographic point of view at 120 sampling points; among these, 35 points were selected (yellow circles in figure) as representative of the main soil and vegetation types and of the different topographic features.

Materials and Methods

a) Soil CO_2 fluxes were carried out during 8 dates, in absence of snow (June-September 2010), using a portable infrared gas analyzer (EGM4, PP SYSTEMS) with a closed dynamic chamber; aboveground vegetation was removed before the beginning of the measurements;
b) together with soil respiration, soil temperature and soil water content were measured;
c) at the conclusion of the experiment, samples were collected from the upper 10 cm of the soil to determine root density (<2 mm; 2-5 mm; >5 mm diameter) and soil organic carbon content;
d) autotrophic (Ra) and heterotrophic (Rh) components of total soil respiration were separated applying the indirect method of linear dependence of soil respiration (adjusted at no-limiting soil water content) on soil organic carbon and root density;
e) cumulative CO_2 emissions were computed as the sum of hourly fluxes, estimated using the dependence of respiration from continuous soil temperature values;
f) data were processed by statistical (multiple regression and neural network analysis) and geostatistical techniques.

Results

Soil respiration



$$Rs = 0{,}36 \cdot T - 0{,}23 \cdot CN - 0{,}02 \cdot S + 0{,}86 \cdot Rf + 0{,}06 \cdot P + 0{,}17 \cdot C + 0{,}02 \cdot WFPS - 4{,}5$$

$$R^2 = 0{,}62$$

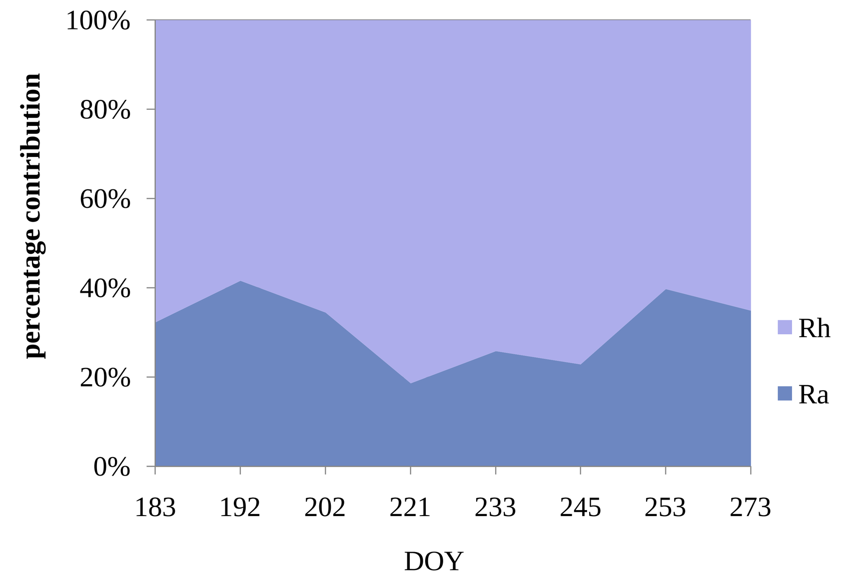
The soil respiration (mean ±SD) was 4.5±2.4 µmol CO_2 $m^{-2}s^{-1}$, ranging from 1.5 (September) to 7.4 (July).
The pedological, pedoclimatic and topographic factors, which significantly affect CO_2 fluxes from soils (p value <0,05), were identified.

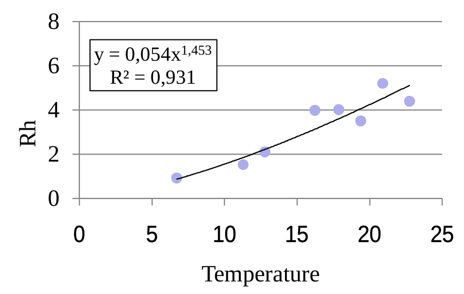
	*Rs (µmol m^{-2} s^{-1})	*T (°C)	S (%)	CN	Rf (kg m^{-2})	P (%)	C (Kg m^{-2})	*WFPS (%)
average	4.5	16.0	23	11	0.4	70	4.94	43
st.dev.	2.4	5.5	16	1	0.2	5	1.49	18
min	0.6	4.1	5	9	0.1	60	2.00	7
max	11.8	31.0	51	14	1.3	81	8.07	83

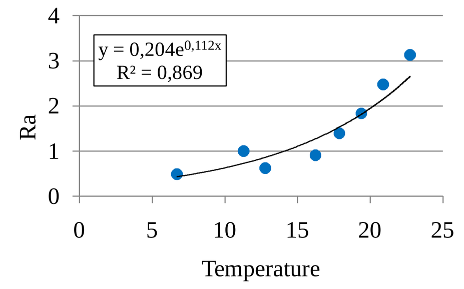
Rs: Soil respiration; T: soil temperature; S:slope; CN: C/N ratio; Rf: fine root (<2mm); C:organic carbon; WFPS: soil water content.
35 sampling points
* 8 measuring dates

Partitioning of soil respiration

The partitioning of the CO_2 fluxes revealed that the heterotrophic component prevailed, counting for more than 60%.
Surface soil temperature well controlled both the heterotrophic and autotrophic respiration.







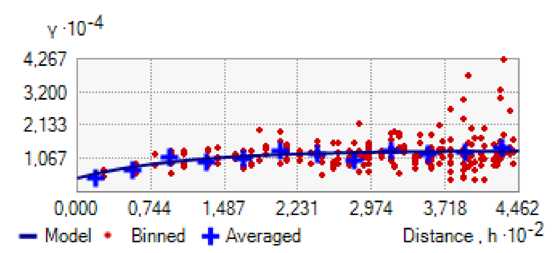
Spatialization of soil respiration

The vegetation types (*Nardetum*, *Seslerio-Semperviretum*, earth hummocks, rich pasture, cattle resting) were correlated with the soil characteristics. Making use of the relationships between cumulative respiration, plant cover and topographic factor (combination of slope and aspect), obtained for the 35 selected points, it was possible to spatialize the CO_2 fluxes to the whole doline.

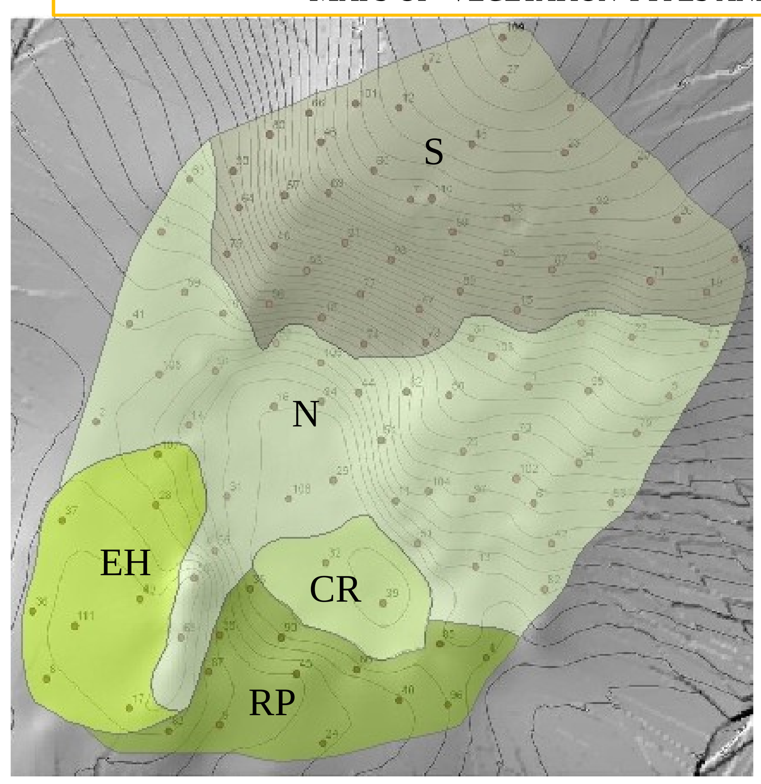
Vegetation type:

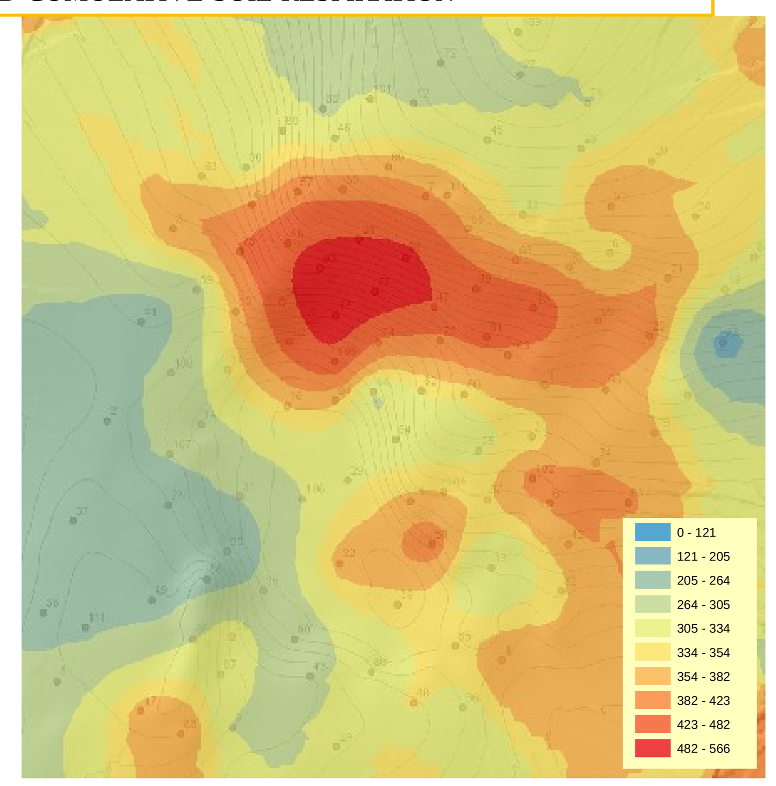
- *Nardetum* (N)
- *Seslerio-Semperviretum* (S)
- earth hummocks (EH)
- rich pasture (RP)
- cattle resting (CR)

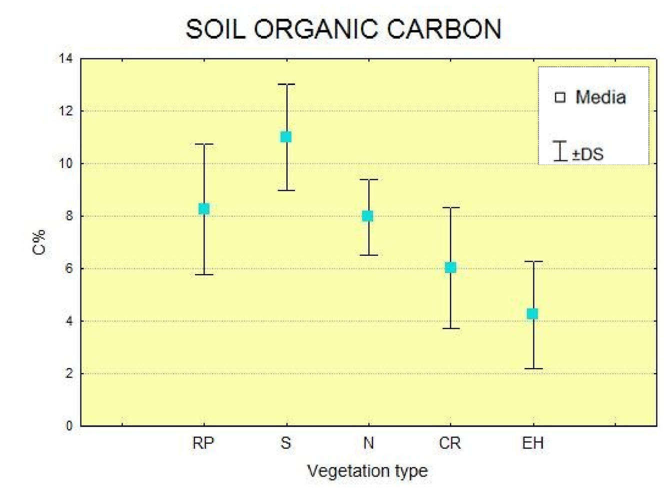
Semivariogram

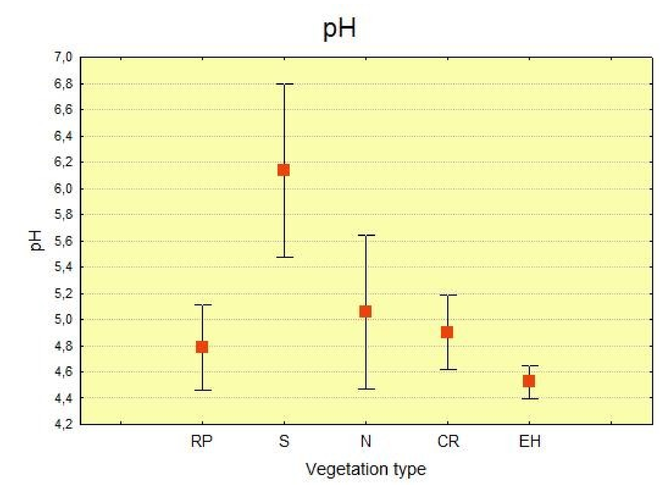


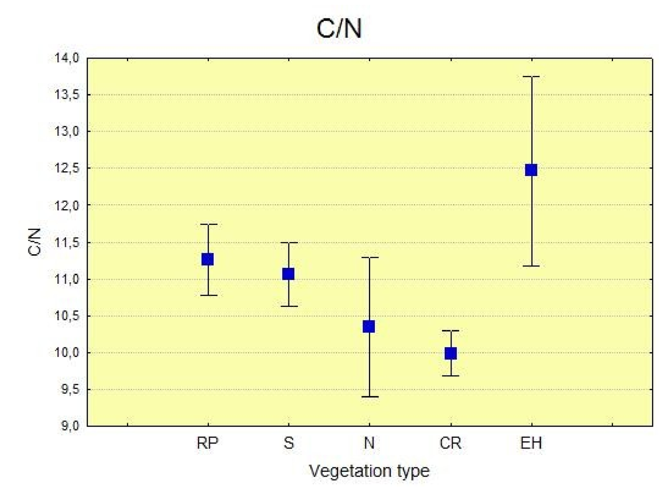
Maps of vegetation types and cumulative soil respiration

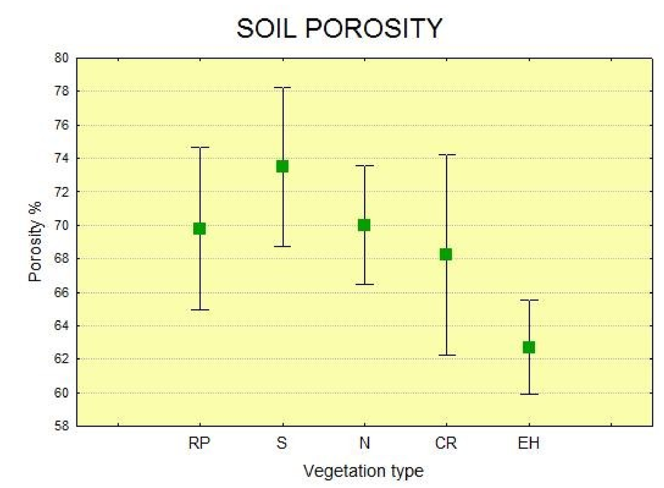












Conclusions

The heterotrophic soil respiration prevailed, accounting for more than 60% of the total CO_2 efflux; the relative contributions changed during the investigated period, suggesting that temporal trend of soil respiration is affected not only by soil temperature, but probably also by phenological stage of pasture plants.
The vegetation map reflects the spatial distribution of main soil and pedoclimatic properties which affect the respiration rates, revealing itself as a good indicator for prediction of soil CO_2 efflux.

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