CArbon dynamics in Mountain Ecosystems: analyzing Landscape-scale Effects Of aNthropogenic changes (CAMELEON)

Keywords: climate and land use change, carbon cycle, mountain ecosystems, land management

Partnership:

- **Laboratoire de Sciences du Climat et de l'Environnement (LSCE)** *CEA Saclay*
  Orme des Merisiers, 91190 Gif sur Yvette, France
- ***Zone Atelier Alpes (CNRS)****:*

1. *Laboratoire d'Ecologie Alpine (LECA), (UMR 5553 CNRS/UJF),*
2. *Ecosystèmes Montagnards (EMGR) (UR CEMAGREF)*
3. *Laboratoire d'étude des Transferts en Hydrologie et Environnement (LTHE)*

- ***NOVELTIS,*** *153 rue du Canal, 31670 Labège, France.*
- ***Institut für Ökologie***, ***Universität Innsbruck***, *Innrain 52, 6020 Innsbruck, Austria.*
- ***Centre Tecnològic Forestal de Catalunya ,*** *Ctra Sant Llorenç de Morunys km 2, 25280 Solsona, Spain.*

Total project cost: 389289 €

Funding from CIRCLE2-Mountains: 223149 €

Project objective:

The combination of climate and land use changes has triggered important land cover mutations in European mountains over the last 50 years. These landscape modifications may accelerate in the 21st century with the expected climate change. The linkages between vegetation dynamics and primary productivity of mountain ecosystems and their ability to mitigate carbon emissions are still poorly understood. The purpose of the CAMELEON project is to improve our knowledge of the carbon cycling of mountain ecosystems. Key objectives are (i) to understand how land use changes translate into changes in plant functional diversity (ii) to model the carbon cycling in mountain ecosystems at the landscape scale using detailed accounts on climate forcing and plant functional diversity and (iii) to forecast the potential changes in the carbon stocks and fluxes in mountain ecosystems.
Our project targets three long-term mountain research areas located in the Eastern Pyrenees (Alinya valley, Spain), the South-Western Alps (Vercors plateau, France) and the Eastern Alps (Stubai valley, Austria), representing contrasting historical and climatic contexts.

Main project results:

Firstl, the project has allowed us to sunthetize an unprecedented dataset of climate and ecological data for the three targeted regions. High resolution maps of historical land cover changes since 1950 were developed. Stakeholders were directly involved in the research program to define, for each site, several land use change scenarios for the near future (2030) based on different hypotheses about climate change and the socio-economic development of each region. Figure 1 show an example of change in forest cover estimated for the Vercors Plateau.

A large set of ecophysiological data was also assembled including CO_2CO_2 flux measurements, functional traits and botanical surveys. This provided a comprehensive assessment of the biodiversity patterns and the ecosystem functioning of the mountain ecosystems.

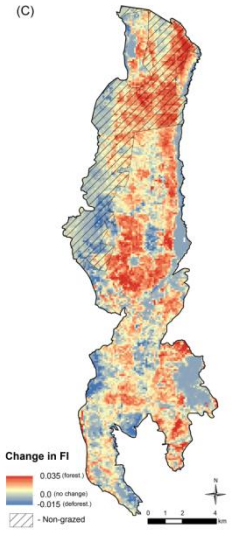

Figure 1: Change *of forest cover in Vercors between 1950 and 2010 (red=reforestation, blue=deforestation)*

Series of simulations using the ORCHIDEE Terrestrial Ecosystem Model (TEM) was conducted (1) To estimate the past and future change in ecosystem productivity and carbon mitigation potential. (2) To understand what are the main drivers (e.g. land use and climate change...) of these changes; and (3) To estimate possible adaptation of land management to improve productivity and carbon storage. The ORCHIDEE model has been previously calibrated for the three sites using remote sensing data and *in situ* flux measurements. The three sites exhibit contrasted responses. For Stubai, we found a relatively large increasing trend in productivity both for the historical period and for the future. This induces an increase of carbon storage, even if the increase of productivity is partly canceled by the increase of soil respiration. The opposite trend was found for Alinya, after a productivity increase during the historical period, there is an expected progressive decrease due to increasing summer droughts under climate change scenarios.

This led to a carbon lose after 2050. The French Alps showed an intermediate response with increasing productivity during historical period and stabilization after 2050. Then the soil carbon sink decreased progressively.

As an example, figure 2 shows the impact of climate, CO2 and land use on simulated changed of the carbon fluxes for the future for Stubai and Vercors

For Stubai, the first driver of productivity increase is temperature, followed by the CO_2 fertilization effect. For Alynia, On the contrary, climate has a negative effect for Alinya mainly driven by the decrease of precipitation. This negative effect is partly compensated by the positive effect of CO_2. For Stubai, the increase of productivity should allow the increase of the animal production for more than 30%.

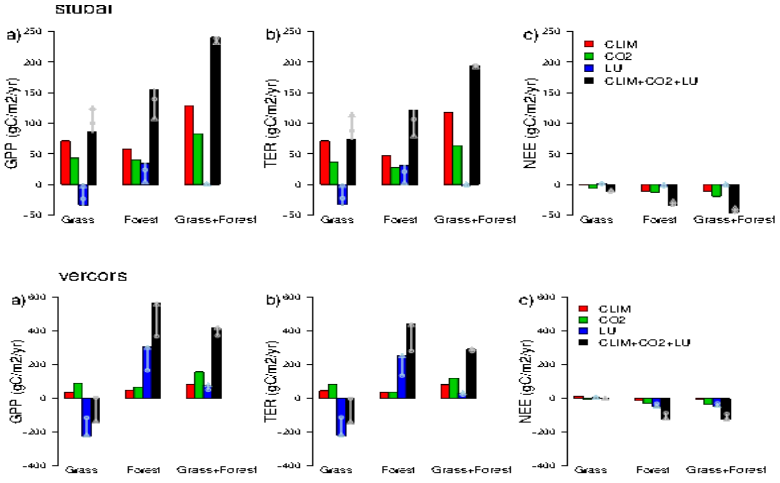

Figure 2: *Attribution of climate, CO2 and land use*, changes on *future carbon fluxes*.(Gross Primary Productivity, Total Ecosystem Respiration, Net Ecosystem Exchange)

A second set of simulation was conducted to see how the grassland system can adapt to the projected change in grassland productivity in particular in term of sustainable animal number that can be produced for each region.

Climate effect on carbon cycling should be counterbalanced by projected land use changes that mainly consist in a decrease of intensively managed (cut) grassland surfaces and an extension of forested areas. For Alinya, the projected increase of droughts in the future should decrease the potential of animal production. Notheless, the land use trend since historical times in Alinya suggests strong pasture abandonment and thus increased forested area. For Vercors, the system is more complex as animals are only in the mountains during summer whereas they stay in the La Crau plain (South of France) during winter. As for Alinya, La Crau should experience an increase of droughts

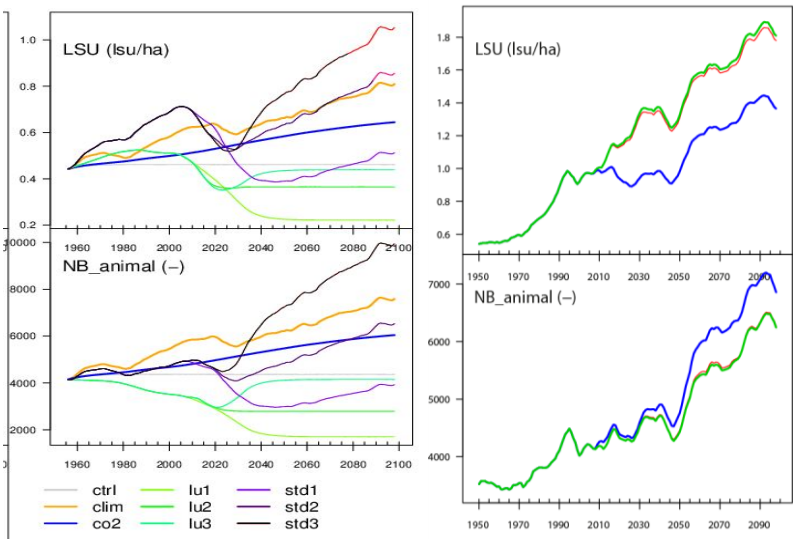

Figure 3: *Evolution of sustainable livestock unit (LSU) and total number of animals for (a) Stubai and (b) Vercors and considering several driving factors and land use scenarios*

This will limit the possible increase of animal productivity, even if grassland productivity should increase in Vercors. This situation could be compensated by the increase of the grazing season length in Vercors. Hence current animal pressure could be maintained for the future in this area.

The CAMELEON project is the first attempt to provide reliable and comparative regional-scale simulations of carbon dynamics in European mountain ecosystems that incorporate our best ecological knowledge of these biodiversity hot-spots. The project is a milestone towards a better understanding of climate and land use change impacts on carbon cycle in European mountains.

Scientific papers

Carlson, B. Z., C. Randin, I. Boulangeat, S. Lavergne, W. Thuiller, and P. Choler. *in press*. Working toward Integrated Models of Alpine Plant Distribution. Alpine Botany.

Carlson, B. Z., J. Renaud, P.-E. Biron, and P. Choler. *(in press)* . Long-Term Modeling of the Forest-Grassland Ecotone in the French Alps: Implications for Pasture Management and Conservation. Ecological Application. http://dx.doi.org/10.1890/13-0910.1

Vicca S., Bahn M., Estiarte M., Alberti G., Ambus P.; Arain M.A.; Beier C., Bentley L., Borken W., Buchmann N., Collins S.; de Dato G., Dukes J. et al. (submitted) Can current moisture responses of soil respiration be extrapolated into a future with altered precipitation regimes? A synthesis of precipitation manipulation experiments. Submitted to Global Change Biology