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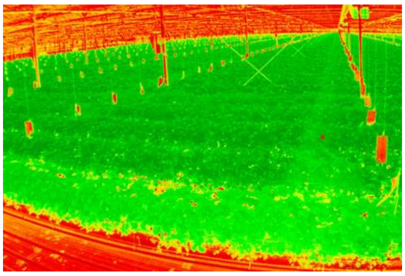
PROJET 2020FA205 – 3DCAM



205FA/2020 - Multi-spectral, 3D camera monitoring of alpine plant communities after experimental warming

Résumé du projet

Climate change is threatening the structure and functioning of mountain plant communities. However, so far, future scenarios are mostly based on static modelling approaches that focus on abiotic drivers and ignore biotic interactions, transient dynamics, and potential acclimatization of species traits and phenology. To better understand dynamic responses of plant communities to climate change, scientists have recently started large-scale transplant experiments where entire little ecosystems are translocated to places with environmental conditions resembling those expected in the future. While these experiments allow studying fine-resolution, long-term responses of different facets of plant community structure and functioning to climate change, sampling all the necessary data within and across years remains extremely time consuming. Therefore, with CamCom we propose to develop and test a workflow based on close range remote sensing techniques with multi-spectral cameras and a 3D sampling approach towards a more time efficient, spatio-temporally finer resolved, and better standardized monitoring method. We base this test on our ongoing transplant experiment that since 2016 exposes 40 m^2 of alpine plant communities to climate warming and 40 m^2 of sub-alpine plant communities to climate cooling. We propose to collect once every 10 days during the growing season a high number of visible and near-infrared images from the alpine and sub-alpine experimental site with hand-held cameras and to analyze them using machine learning techniques that allow generating 3D, geo-localized ortho-mosaics with multi-spectral information. We will then compare the 3D, multi-spectral representations of the vegetation to data from the ongoing field-sampling. More specifically we ask, whether our proposed imagery-based approach is able to capture the differences in the dynamic vegetation functioning and structure between the four treatments in the transplant experiment (alpine *vs.* sub-alpine control, warming *vs.* cooling) with regard to (1) α- and β-species and trait diversity, (2) the timing of the phenological sequences of 10 focal species, and (3) individual level species identity, trait values, and growth rates.

Mots clés : Alpes, camera multispectrale, phenologie, traits, éco-systèmes

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Collaborations : LESSEM, SAJF
Début du projet : 2020.

Projet scientifique

Climate change is threatening the structure and functioning of ecosystems across the globe (Grimm et al., 2013). Mountain plant communities are particularly affected because they are limited by steep climatic gradients and changing abiotic conditions over short distances (Gottfried et al., 2012). As a consequence, mountain plants do not only have to cope with a warmer climate, increased droughts and prolonged vegetation periods but also with the arrival of new competitors which are moving uphill to follow their climatic niche and are better adapted to the novel abiotic conditions (Alexander et al., 2015). To better understand climate change impacts on mountain vegetation, models have been proposed to predict their future distributions. However, so far, future scenarios are mostly based on space-for-time substitutions along gradients and static species distribution models that account neither for biotic interactions nor for transient dynamics and acclimatization of species traits and phenology (Thuiller et al., 2008). Thus, we still know little about the combined dynamic impacts of abiotic and biotic changes on plant species' composition, abundance structure, inter- and intraspecific trait distribution, productivity, and timing of phenological stages. However, these impacts on the structure and functioning of mountain plant communities will determine their fate in the future. To better understand dynamic responses of mountain vegetation to climate change, scientists have recently started large-scale transplant experiments where entire little ecosystems are translocated to places with environmental conditions resembling those expected in the future (Alexander et al., 2016). While these experiments allow studying fine-resolution, long-term responses of different facets of plant community structure and functioning to climate change under (almost) natural conditions, sampling all the necessary data within and across years remains extremely time consuming. Moreover, this type of data sampling typically requires the support of many people, which, even with well-documented protocols, can introduce considerable uncertainty in the database. The challenge is thus to develop an approach that is more time efficient and better standardized than current field-based sampling. Here, we propose to use close-range remote sensing techniques with multi-spectral cameras and a 3D sampling approach to meet this challenge (Kolyaie et al., 2019). The overarching aim of CamCom is to test the value of ultra-high-resolution imagery (UHR, <1 cm) for monitoring changes in the structure and functioning of mountain vegetation under climate change.

We base this test on our ongoing transplant experiment that since 2016 exposes 40 m2 of alpine plant communities to climate warming and 40 m2 of sub-alpine plant communities to climate cooling. We propose to collect once every 10 days during the growing season a high number of visible and near-infrared images from the alpine and sub-alpine experimental site with hand-held cameras and to analyze them using machine learning techniques that allow generating 3D, geo-localized orthomosaics with multi-spectral information. We will then compare the 3D, multi-spectral representations of the vegetation to data from the ongoing field-sampling. More specifically we ask, whether our proposed imagery-based approach is able to capture the differences in the dynamic vegetation functioning and structure between the four treatments in the transplant experiment (alpine vs. Subalpine control, warming vs. cooling) with regard to (1) α- and β- species and trait diversity, (2) the timing of the phenological sequences of 10 focal species, and (3) individual level species identity, trait values and growth rates (including newly arriving species). CamCom is well integrated in the UGA context (three OSUG units involved, strong links to the CDP Trajectories and – via machine learning approaches – to the MIAI chair 6.1). The ultimate goal of CamCom is to ensure the long-term monitoring of an already implemented transplant experiment and its climate change triggered trajectories at high spatio-temporal resolution.

Moreover, our ambition is to use CamCom and the herein developed workflow as a proof of concept for a larger future project (i.e. ANR, Biodiversa) to establish multiple representative transplant gradients across the French Alps. This will provide us with an unprecedented database on the dynamic responses of vegetation structure and functioning with high spatio-temporal resolution and standardization – thus paving the way for a more comprehensive understanding of how and when different facets of vegetation respond to climatic changes.