Fine-scale Monitoring of climate change Effects on the high-MountaIn gRassland Ecosystem in the Romanian Carpathians (MEMOIRE)

Report on TASK 2 (2019)

Summary of TASK 2

The second task of the project had to accomplish four main activities: Act 2.1. Analysing data and samples already collected from the field; Act 2.2. Planning, coordinating and implementing the field campaigns in the Carpathians; Act 2.3. Validating the remotely sensed estimates of snowmelt date (Normalized Difference Snow Index - NDSI) and productivity (Normalized Difference Vegetation Index - NDVI) by using field parameters; and Act 2.4. Assembling ecological data gathered from the field and remote sensing in a georeferenced dataset following the Inspire format (http://inspire-geoportal.ec.europa.eu/editor/).

All these activities have been successfully accomplished. We carried out all field work for gathering data, as well as the analysis, in comparison with the estimations obtained from remote sensing.

Introduction

Task 2 was based on two major components: data gathered from the field and data estimated based on remote sensing.

The second field campaign (2019) has been accomplished to complete the field data from the previous year with the ones from this year. During this campaign, we found data loggers and Rooibos tea bags. Subsequently, recorded data have been downloaded from loggers, and tea bags were weighed to estimate mass loss. All these data, together with the ones from task 1 (2018) have been assembled into an original dataset of MEMOIRE project.

Using numerical analysis, data from loggers have been analysed. Using scripts to calculate several indices, we obtained the time of snow melt and cumulated temperature. Snow duration and intensity of freezing were also calculated. These parameters, as well as chemistry, biomass weight and tea mass loss were incorporated into the database.

We validated the estimations of snow melt time and productivity indices (NDVI) with the ones obtained from the data loggers HOBO and weight of biomass at local scale. Basically, the results of the correlations showed that satellite images might be used for assessing the physical and phenological parameters of local ecosystems.

The possibility of using remote sensing estimation of meadow phenology (NDVI) and temperature conditions (growing degree days) allow us to better understand ecosystem conditions at regional scales.

Act 2.1 - Analysing data and samples already collected from the field

During this activity, we introduced data from 2018 and 2019 into a common dataframe in R. In this dataframe we included site identification codes, GPS coordinates, and local ecosystem properties: elevation, biomass, percentage of tea mass loss, and chemical parameters of soil and biomass (C, N, P, soil pH).

We also created a species composition dataframe, using site codes (releves) and species abundance.

We compiled R scripts to analyse data automatically. We analysed various pairs of parameters (linear relationships), such as: biomass vs. elevation, biomass vs. soil chemical properties. We also constructed a PCA to explore the relationships between species composition and environmental gradients.

These scripts were meant to do exploratory analyses to better understand data quality and potential scientific hypotheses.

Act 2.2. - Planning, coordinating and implementing field campaigns in the Carpathians (continued from task 1, 2018)

Field access was planned by days, according to mountain ranges (Rodna, Parâng, Apuseni). We used methods to precisely locate the sites based on our prior experience. We used descriptions of the area, GPS coordinates and pictures. For loggers, we mostly used permanent marks in the field.

Location of some MEMOIRE site in the Romanian Carpathians. Left: Parâng (Mohorul peak, PARMOHCCU). Right: Rodna near Cearcănul peak (RODCEANST)

We collected field materials and devices: HOBO loggers, Rooibos teabags, soil. For data loggers, we replaced the batteries to ensure continuous monitoring of local temperatures. We also located tea bags close to the loggers, and we collected them to store paper bags prior of weighing. For some remote sites, we also collected soil samples for chemical analyses.

We downloaded data from loggers, using HOBO and CSV files. In total we had 28 sites because one in Parâng was damaged by human intervention.

We sent soil and biomass samples for chemical analyses at an external laboratory for C, N, P and soil pH. We first needed to prepare the samples in the form of powder. The methods were: total organic carbon (using TOC analyser), Kjeldahl nitrogen and total phosphorus (using ICP-MS).

Tea bags were sorted and cleaned, dried and weighed. We calculated the mass loss as a percentage of remaining mass from the initial mass.

Soil and biomass samples prepared as powder for laboratory analyses

Act 2.3. Validating the recordings from remote sensing of snowmelt date by using "Normalized Difference Snow Index (NDSI)" and productivity by "Normalized Difference Vegetation Index (NDVI)" by using field parameters

Snow melt time from loggers was calculated by extracting data from the CSV files. The snow melting time was the moment when variation in temperatures during one day did not exceed 1-2 degree C. The time of snow melt using remote sensing was calculated by changes in NDVI. We used series of MODIS (250 m X 250 m) images arranged chronologically. The time of snow melt was when NDVI exceeds a threshold value.

The calculation of local grassland productivity was based on biomass collected in the field at one square meter. This is a very accurate estimation of primariy productivity. Then, using a satellite image from the summer period, we calculated NDVI for MEMOIRE sites (coordinates). Based on the protocol, NDVI is (NIR – red)/(NIR + red), unde NIR = near infrared, red = red band.

Validation of indices obtained by remote sensing with those obtained locally was based on using linear relationships. Both snowmelt time and productivity showed strong relationships between local and remotely sensed indices. However, some differences existed, which might be due to difference in scale or methods of estimation (NDVI vs. local biomass weighed). In conclusion, the validation was successful.

Act 2.4. Assembling ecological data gathered from the field and remote sensing in a georeferenced dataset following Inspire format (http://inspire-geoportal.ec.europa.eu/editor/)

Conversion of MEMOIRE data into the Inspire format was based on plotKML package in R. The spMetadata function was used to generate metadata for spatial objects in which we incorporated the data. The spMetadata function was designed to look for the metadata file in the working folder, and if there are not metadata files, (.XML extentions), it creates such a file following Inspire format. Therefore, the spMetadata allowed us to construct a metadata file based on Inspire format.

Conclusions and perspectives

Our research had good results, and this was the result of our activities being successfully done and at the right time. We managed to maintain long-term monitoring sites (by replacing the batteries of loggers). An important part of the field activities was to enrich the number of sites by instrumentalizing new ones, in the Parâng Mts., as a densification of the network of monitoring sites (installed in 2018). We included new situations, with various environmental properties and elevations.

We managed to assemble two years data (2018, 2019) into a common database containing key ecosystem properties. Subsequently, we extracted bioclimate indices from loggers and satellite images, using automatic R scripts.

Location of a new long-term MEMOIRE monitoring site on Păpușa peak in the Parâng Master Site (view from the paved road in Rânca resort).

We also managed to analyse the possibility of using satellite images at regional scale to estimate productivity and bioclimate indices (snow dynamics) in mountain environments, which are characterized by a sharp microrelief. MEMOIRE network of climate monitoring points (sites) will be maintained to study the influence of climate change on biodiversity and ecosystem properties in mountain meadows in Romania.

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