ClimMani

Climatic change - Manipulation experiments in terrestrial ecosystems

EUROPEAN SCIENCE FOUNDATION

3rd Scientific Workshop
The Importance of Time and Timing in Climate Change Manipulation Experiments
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Minutes

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1. Welcome and introduction

CB, the chair of ClimMani, as well as SLI, our local host, welcomed the workshop participants to Vindeln and the third ClimMani workshop and thanked all participants warmly for coming. Practical information on reimbursement was given.

CB briefly introduced ClimMani and explained the background of the programme as well as the main aims and objectives. Also, work already done and future plans were described.

2. Adoption of the programme

The programme of the workshop was adopted after slight rearrangements.

3. Time and timing issues in manipulation experiments

During two days oral talks on different subjects within the workshop theme were given in five different sections as seen below. A short summary is supplied for each section.

I. *Impacts of Climate Change on phenology* (Chair: Sune Linder)

- Satellite observations of forest greenness changes (Ranga Myneni, US)
- Environmental controls of vegetation succession and ecosystem fluxes on the pristine volcanic island, Surtsey (Bjarni Sigurdsson, IS)
- The role of time, space, and complexity in global change experiments (Sebastian Leuzinger, CH)

Summary Section I:
The first session during the workshop focused on long-term observations of changes in greenness at northern latitudes and the role of time, space, and complexity in global change experiments and modelling. All three speakers stressed the need for long-term observations/experiments and that caution should be exercised when making predictions about the future, based on our current understanding of global change impacts on the biosphere.

Ranga Myneni (US) - Satellite observations of forest greenness changes: RM summarised research on satellite-sensed greenness of northern forests based on records from NOAA meteorological satellites (1981-2006) and the NASA's Terra satellite (2000-2009). These three decades had exceptional variations in global circulation anomalies and one large volcanic eruption (Mount Pinatubo) resulting in large changes in global temperature and precipitation patterns. These climatic variations are seen in the satellite greenness data as changes in the timing of spring greening, autumn browning, and growing-season length of northern forests.

Bjarni Sigurdsson (IS) - Environmental controls of vegetation succession and ecosystem fluxes on the pristine volcanic island, Surtsey: BS presented a unique series of observations on how organisms colonize and form ecosystems on Surtsey, an island created in 1963 by a volcanic eruption in the North Atlantic Ocean close to Iceland. 40 years after the primary succession started the surface cover of vascular plants, soil properties, and ecosystem respiration rates, were strongly related to the density of seagull nests. Hence, the most important factor for vegetation succession and ecosystem function on Surtsey seems to be the amount of nitrogen, and other nutrients brought in by the seagulls.

Sebastian Leuzinger (CH) - The role of time, space, and complexity in global change experiments: SL had analysed the role of time, space, and complexity in global change experiments. He found

that the relative size of an effect, regardless of the nature of both the treatment and the studied parameter, tends to decrease with increasing spatial and temporal scales, as well as with increasing levels of complexity. The findings have far-reaching implications for the interpretation and conclusions drawn from existing experiments and model predictions, as well as the design of future experiments and models. In particular, short-term experimental results from artificial, homogenous systems are likely to overestimate long–term and large–scale responses of the biosphere to global change.

II. ***Phenological acclimation and adaptation to Climate Change*** (Chair: Josep Peñuelas)

- Acclimation of plant energy metabolism to changes in temperature (Vaughan Hurry, SE)
- Drought as a driver of phenology and trade-offs between growth and reproduction in Mediterranean ecosystems. Experimental and interanual variability in the timing of drought (Marc Estiarte, ES)

Summary Section II:
Vaughan Hurry (SE) - Acclimation of plant energy metabolism to changes in temperature: VH presented studies on acclimation of plant energy metabolism to changes in temperature. He highlighted that exposure to chilling or high temperatures results in an immediate reduction in net CO_2 exchange in the light but that in response to sustained exposure to changes in growth temperature, rates of photosynthesis often thermally acclimate. He presented the mechanistic changes that underpin this acclimation response and briefly considered their dynamics. He finally discussed whether there are general responses that might be utilized in modeling scenarios. An additional issue raised in his talk and in the posterior discussion was the importance of metabolomics to follow and to disentangle phenological and ontogenical changes.

Marc Estiarte (ES) - Drought as a driver of phenology and trade-offs between growth and reproduction in Mediterranean ecosystems. Experimental and interanual variability in the timing of drought: ME presented studies on drought as a driver of phenology and trade-offs between growth and reproduction in Mediterranean ecosystems. He focused on the different effects of timing of drought and indirect effects on phenology and growth. Furthermore, he highlighted the effects of drought on growth and reproduction, and on their timing, which may also be extended to wet periods as result of trade-offs between both functions. His presentation and the posterior debate highlighted the importance of considering not only spring or autumn phenology, but also summer phenology.

III. ***Trophic mismatches and interactions as an effect of Climate Change*** (Chair: Ivan Janssens)

- Climate change and invasion: the role of inter vs. intra-annual variation in precipitation (Melinda Smith, US)
- Matching phenology of community plant odour and pollinators in a Mediterranean shrubland (Iolanda Filella, ES)
- Responses of soil micro- and mesofauna in grassland mesocosms exposed to climate extremes (Krassimira Ileva-Makulec, PL)

Summary Section III:
Melinda Smith (US) - Climate change and invasion: the role of inter vs. intra-annual variation in precipitation: MS gave a presentation about climate change manipulation experiments on grasslands in the Central Great plains in the United States. She showed that the number of genotypes of the dominant grass species declined in response to climate change, but also that these remaining genotypes became more dissimilar. Future work will focus not only on continuous climate manipulation, but on the responses to increased climate variability (extreme events).

Iolanda Filella (ES) - Matching phenology of community plant odour and pollinators in a Mediterranean shrubland: IF explored the relationships between seasonal variations in plant species abundances, flower reward, and emitted floral volatiles with the presence of pollinators in a plant-pollinator community. The seasonal timing of the emitted volatiles in the community was found to be related to changes in supply and demand of flower products by pollinators.

Krassimira Ileva-Makulec (PL) - Responses of soil micro- and mesofauna in grassland mesocosms exposed to climate extremes: KIM gave a presentation about the effects of imposed climate extremes in grassland mesocosms on the soil micro- and mesofauna community composition. While the total abundance of these soil animals was not affected by the climate extremes, species richness, diversity, and multivariate structure of the animal communities, especially of soil nematodes, were affected by the imposed soil drought and warming.

IV. *Importance of timing and duration in manipulation experiments* (Chair: Claus Beier)

- Lagged and postponed responses to temperature and precipitation manipulations (Rebecca Sherry, US)
- Manipulating precipitation regimes in grasslands: The value of extending climate change experiments in time and space (Alan Knapp, US)
- Effects of seasonal climate manipulations on ecosystem processes in a sub-arctic bog (Rien Aerts, NL)

Summary Section IV:
Rebecca Sherry (US) - Lagged and postponed responses to temperature and precipitation manipulations: RS showed how changes in temperature and water may strongly affect the phenological behavior of the plants in the ecosystem. In general spring flowering plants have their flowering advanced by increased temperature, while autumn flowering plants are delayed. The long-term consequences for the individual plants as well as the ecosystem are still to be tested, but changes in species composition is likely to occur.

Alan Knapp (US) - Manipulating precipitation regimes in grasslands: The value of extending climate change experiments in time and space: AK gave a presentation about how tall grass prairies are strongly limited and increase their production in response to water addition. Of great importance to the long-term responses is the fact that the treatments caused a long-term change in species composition to favor plants with a higher production and thereby a significant shift in the overall production of these systems. Also, grassland ecosystems under more water limited conditions are clearly sensitive to changes in water variability, where also the timing and the size of events seems to interact with variability itself leading to variable responses.

Rien Aerts (NL) - Effects of seasonal climate manipulations on ecosystem processes in a sub-arctic bog: RA showed how arctic bogs are responding to warming by increasing the loss of “old” carbon, while surprisingly the plant species composition did not change. The discussion particularly focused on the factors controlling the biogeochemical responses in both water manipulations in the grassland ecosystems as well as the heating of arctic bogs.

V. Experimental approaches in Climate Change experiments (Chair: Christian Körner)

- A whole forest ecosystem warming experiment: Carbon balance response and possible mechanisms (Tom Gower, US)
- Seasonality in tree below-ground C allocation and intra-annual variability in C isotope fractionation during tree photosynthesis (Peter Högberg, SE)
- The impact of elevated [CO_2] and temperature in a boreal Norway spruce forest (Göran Wallin, SE)

Summary Section V:
Tom Gower (US) - A whole forest ecosystem warming experiment: Carbon balance response and possible mechanisms: TG presented a warming experiment located in Manitoba, Canada, heated with soil heating cables. The system allowed for accurate soil warming of +5 °C above control soil temperature. In each soil-warming plot, a greenhouse chamber was nested. The greenhouses manipulated air temperature + 5°C above outside control air temperature. The warming response of above- and belowground processes differs in their direction, rate of response, and magnitude. Bud burst was 7-10 days earlier for the soil + air warming treatment, compared to control and by the third year of warming produced significantly longer shoots. Within the first year of air + soil warming, fine root mass significantly decreased. In contrast to belowground processes, aboveground tissues showed no significant difference between treatments.

Peter Högberg (SE) - Seasonality in tree below-ground C allocation and intra-annual variability in C isotope fractionation during tree photosynthesis: PH described two studies. The first was a $^{13}CO_2$-labelling experiment, in which tree photosynthate was labelled in June or in August. Allocation of C to roots and soil microorganisms was five times higher in August, which indicates that allocation can be sensitive to changes in climate. The second study was from long-term N addition experiments, in which the climatic controls on stable C isotope fractionation during tree photosynthesis were examined. The expected relations between $\delta^{13}C$ and dry/wet years were found, and indications that N-enriched forests are more sensitive to variations in rainfall, but also an unexplained long-term trend in $\delta^{13}C$.

Göran Wallin (SE) - The impact of elevated [CO_2] and temperature in a boreal Norway spruce forest: GW presented two experiments where whole-tree chambers were used to expose old field-grown Norway spruce at Flakaliden in Sweden to elevated [CO_2], 700 μmol CO_2 mol^{-1}, in combination with fertilisation (exp 1) and elevated air temperature (exp 2). Elevated air temperature resulted in c. three weeks longer season of photosynthetic activity. Elevated [CO_2] had little or no effect on the recovery rate or autumn depression, but light saturated photosynthesis was on average stimulated by ~50% during the seasons. Elevated air temperatures also resulted in an earlier commencement of bud development and faster shoot elongation, while [CO_2] had no effect. Elevated air temperature had no effect on developed shoots while light-saturated photosynthesis in elevated [CO_2] was stimulated by ca 50%. The result suggests that current-year shoots will assimilate their own mass in terms of carbon 20-30 days earlier in a future climate.

4. Overall remarks

The programme allowed for discussions after each session and in the end of the workshop. After the discussions, the following conclusive remarks have been produced:

Driver vs biological change approach: Many experiments typically take a ”driver” point of view instead of a ”biology” point of view, meaning that we focus on a specific change in driver independent on the associated change in the biology. We might learn something new if we choose to push the system to achieve a certain biological response, e.g. a certain change in phenology.

Scenarios: We should on the one hand link to realistic scenarios, but at the same time have a stronger focus on testing ecosystems and processes sensitivity and resilience to changes. It may for example be changes exceeding certain thresholds that may be the most important driver for change in the future, rather than “continuous” changes along response surfaces. This should also include more testing of extreme events.

Existing data: There is still a lot to be learned by examining existing datasets and long-term observations on for example phenological changes along gradients. Such data may be particularly

relevant to examine effects of mismatches in timing (e.g. plant phenology and pollinators). On the other hand, such data are not likely to provide significant information on linkages between these phenological changes and changes in biogeochemistry and ecosystem functioning, which still require combinations with experiments.

Interactions with models and modelers: We still need to interact more closely with modelers in order to propose and test hypotheses and guide experimental scenarios and response measurements. If models are used more intensively in the design phase of experiments, they can be used to test/propose the sensitivity of a range of timing and variability scenarios that would be impossible to test experimentally, and from that the specific experimental scenarios can be selected and the responses to measure decided upon.

Use of existing ecosystems: Since variability and sensitivity to constant changes in timing may be important to determinate ecosystem responses, it may be useful to study existing ecosystems already prone to such variability more intensively in order to investigate what characterizes the sensitivity or stability of such ecosystems to handle the sensitivity.

5. Field trip

A field trip was organized to the Vindeln area, where three major ecosystem studies were visited:

- a long term forest monitoring site;
- a field scale bog manipulation site (manipulations with temperature, water and nutrients);
- the Flakaliden field site with nutrient, water, temperature and management manipulations.

Manipulation design and strategies as well as key results from monitoring and field experiments were presented and discussed.

6. Date and venue of next ClimMani workshop

The meeting was rounded off by CB and SLI. The meeting was finalised and the local hosts were thanked for the excellent arrangements.

The next ClimMani workshop will be held in cooperation with the US initiative “An **I**ntegrated **N**etwork for **T**errestrial **E**cosystem **R**esearch on **F**eedbacks to the **A**tmosphere and **C**limat**E”** **(I**NTERFACE) and date and venue are still not determined. Read more about INTERFACE on their web site: http://www.bio.purdue.edu/Web-Interface/index.php

Look for information for the coming meeting on the ClimMani web sites: www.esf.org/climmani and www.climmani.org.