

11. August 2010

ESF short visit grant 2863 – Scientific report

Title

Future precipitation change experiments – a review

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Purpose of the visit

The aim of the exchange visit to CREAM in Spain was to review and synthesize our knowledge related to manipulation experiments involving changes in precipitation based on the CLIMMANI workshop in Basel (CH). The visit specifically aimed to provide an overview of our current understanding and to advise future research directions and methodologies in precipitation research and to produce a review as a manuscript for a scientific journal.

Key research questions are:

- ◆ What are the experiences from past water experiments – technically as well as scientifically
- ◆ How do we define the scenarios we want to test experimentally?
- ◆ What is a true “control” or reference for precipitation change experiments?
- ◆ What are the technical challenges and possibilities in whole ecosystem water experiments?
- ◆ How can we best integrate modelling and experiments, and how can ecosystem models be used to guide future experiments?

Description of the work carried out

The visit involved three main activities:

- ◆ Updating the CLIMMANI meta database of climate change experiments involving water manipulations based on a literature review and a recent meta-analysis (Josep Penuelas - co-author)
- ◆ Analysing the past and ongoing precipitation change experiments with respect to their climate space representation
- ◆ Writing a draft manuscript based on the literature review, the analyses of the meta database and discussion reports from the CLIMMANI meeting in Basel

Description of the main results

Updating the CLIMMANI meta database of climate change experiments involving water manipulations based on a literature review and a recent meta-analysis

The existing CLIMMANI spreadsheet of past and ongoing climate change experiments was updated by use of a recent meta-analysis of warming and precipitation experiments (Garbulsky *et al.*, 2010) and a literature review. The spreadsheet was updated for the precipitation change experiments by adding new experiments and by adding new information about the experiments (latitude, altitude, mean annual temperature, mean annual precipitation and the type of water experiment (addition, removal or variability). The updated spreadsheet has been uploaded to the CLIMMANI website.

Analysing the past and ongoing precipitation change experiments with respect to their climate space representation

Based on the updated spreadsheet the current coverage of the climate space was analysed. 92 published past and existing experiments conducted in natural and seminatural ecosystems was analysed showing that the majority of experiments have been conducted at medium latitudes (30-60°) and only very few studies exist at latitudes < 30° and > 60° (Fig. 1). Furthermore there is a strong lack of experiments in the Southern hemisphere, especially experiments representing Africa is totally missing.

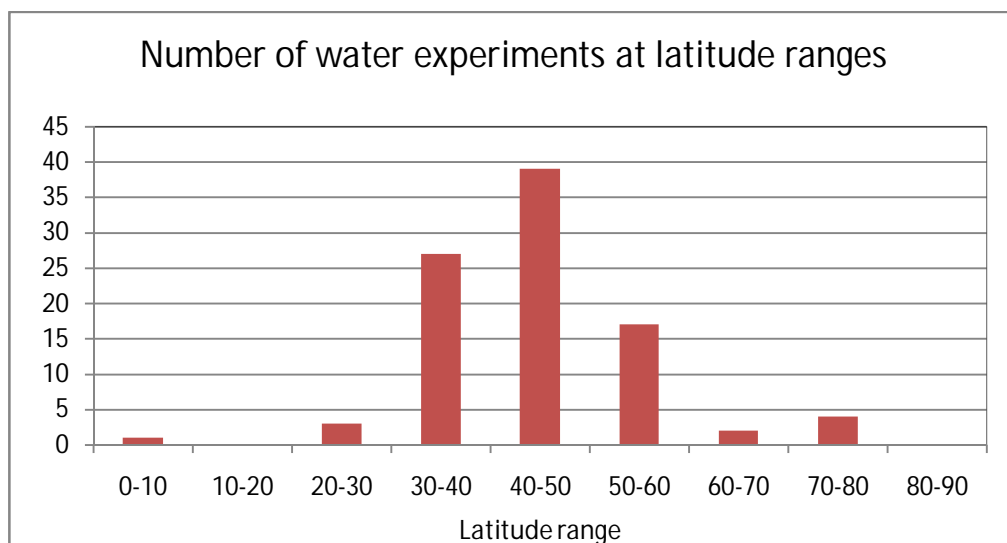


Fig 1

Water experiments from literature (independent on experimental type and other characteristics (n=92)) as distributed by latitude (sites at similar latitude ranges on S and N hemisphere are merged into same group).

When the experiments were analysed according to experimental characteristic and ecosystem types across the global climate space (temperature and precipitation) (Fig. 2), it became clear that most studies on precipitation have been “addition only” or “removal only” and only relatively few studies have tested altered variability scenarios. Furthermore, the majority of the experiments have been carried out at temperatures ranging from 5-15 °C. Within that “medium” temperature range the coverage in terms of experimental types and ecosystem types seem quite broad, although there is a tendency that systems at the moist and dry ends (xeric and hydric) are understudied. On the contrary, very few studies have been carried out at cold (arctic/semi arctic) and warm (tropical/subtropical) conditions. Furthermore, the relatively few studies focussing on precipitation variability have mainly been conducted at mesic systems and mainly in grasslands, with a few pulse event studies in arid systems as exceptions. Finally, only a handful of sites (not shown) include interactions with other global change drivers and nutrients.

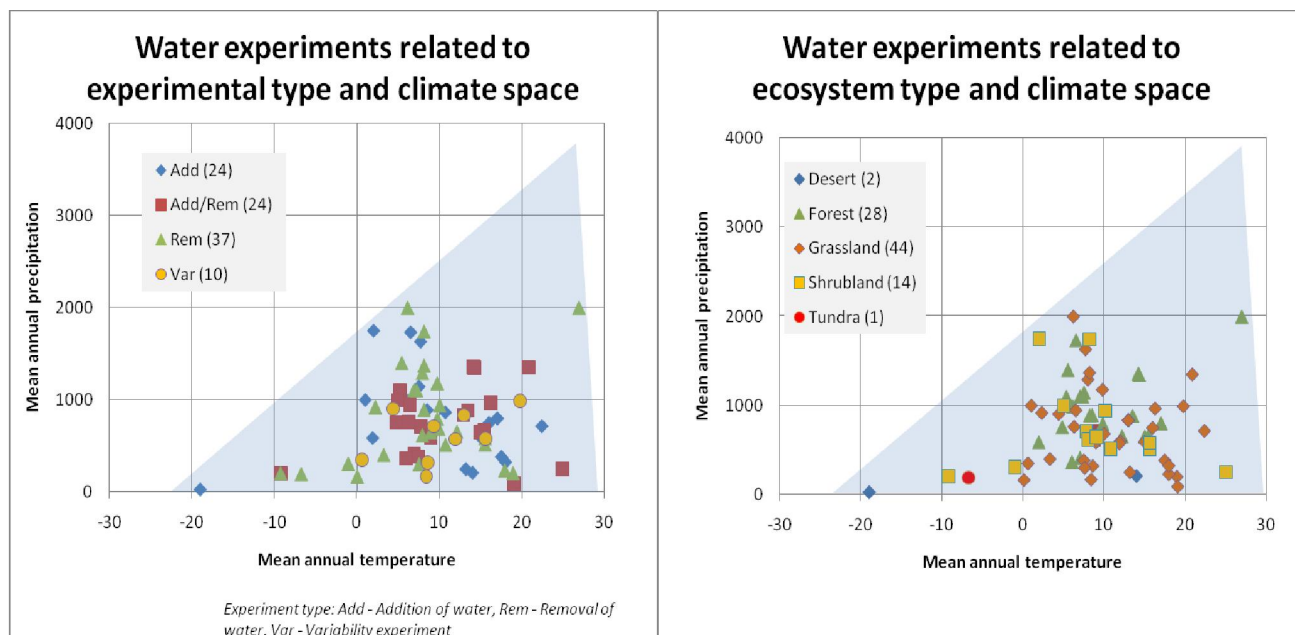


Fig 2

Water experiments distributed along the climate space defined by Mean Annual Temperature (MAT) and Precipitation (MAP) according to a) manipulation type (Addition, Removal, Removal and Addition and variability) and b) ecosystem type. Blue area shows global climate space from global climate database (see Garbulsky et al., 2010).

Writing a draft manuscript based on the literature review, the analyses of the meta database and discussion reports from the CLIMMANI meeting in Basel

A draft manuscript was prepared presenting the analyses of the precipitation change experiments and the main scientific and practical experiences from these. Based on the analyses and review the main challenges at the ecosystems, drivers and data levels for future experiments are discussed and key design and measurement considerations are presented and discussed. Finally the following recommendations are provided:

Manipulation scenarios, flexibility and duration.

Recommendation of studies which:

- are climatically as well as ecologically relevant, based on realistic climate scenarios combined with site specific hydrological modelling.
- Address changes in rainfall variability and threshold exceedance for important ecosystem processes
- Run for longer time periods (>10 yrs) and address important structural changes in the ecosystem
- Address changes in precipitation in understudied areas of the globe, especially moist and warm environments and cold and semi-cold environments.

Multifactor and multi control experiments

Recommendation of studies which:

- Involve multifactor experiments with focus on interactions among climate change factors including precipitation variability as well as interactions with resources and ecosystem complexity.
- Employ multi controls to disentangle the treatment effects from the random natural climate variability

Functional responses, feedbacks and modeling

Recommendation of studies which:

- Include, in addition to study specific responses, a standard set of response measurements related to ecosystem functioning, ecosystem structure and biosphere-atmosphere feedbacks.
- Close interacts with modellers in the design as well the evaluation phase of the project
- Develop ecosystem models to include and test threshold exceedance and dynamic ecosystem structural changes (e.g. vegetation and biodiversity).

Future collaboration

Based on the visit and recommendations in the paper, attempts to advocate or initiate precipitation change experiments will be done. Further collaboration in studying the effects of precipitation change will be done based on existing experiments.

Projected publications/articles resulting from the grant

A paper "Next generation of precipitation manipulation experiments – Challenges and recommendations" have been drafted and are expected to be submitted to BioScience in October/November.

Comments

None