Monitoring drought effects on soil structure and hydrological soil functions

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HYDROLOGY

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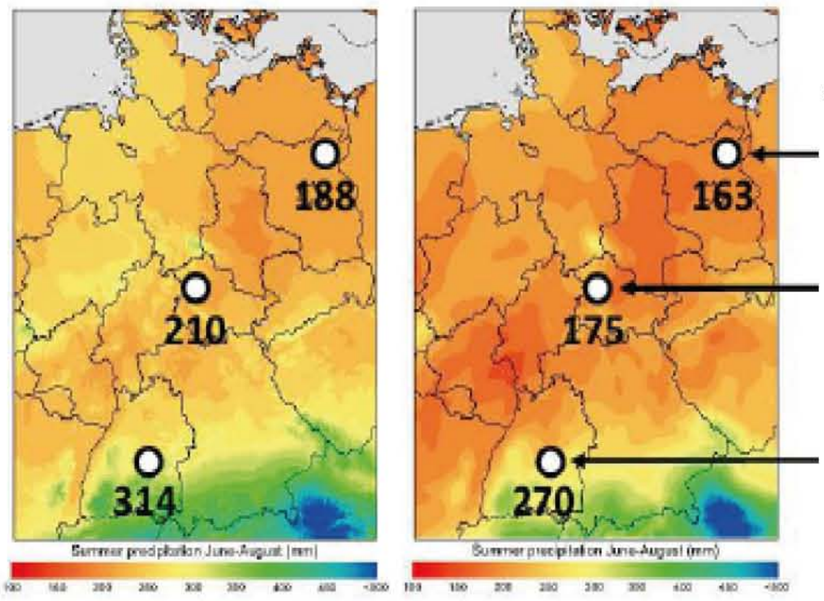
Introduction

Climate change is predicted to severely affect precipitation patterns across central Europe. Soil structure is closely linked to the activity of soil microbiota and plant roots, which modify flow pathways along roots, organic matter and water repellence of soils.



A) Mean summer precipitation (June - August) for Germany from 1930 - 1990

B) Mean summer precipitation (June - August) predicted for 2021 - 2050 according to the A1F1-scenario

Study site	prognosted depletion
Schorfheide (Brandenburg	25 mm
Hainich (Thüringen)	35 mm
Schwäbische Alb (Baden-Württemberg)	44 mm

Through shrinkage and fracturing of soil aggregates, soil structure is also responding to changing climate (in particular drought) conditions.

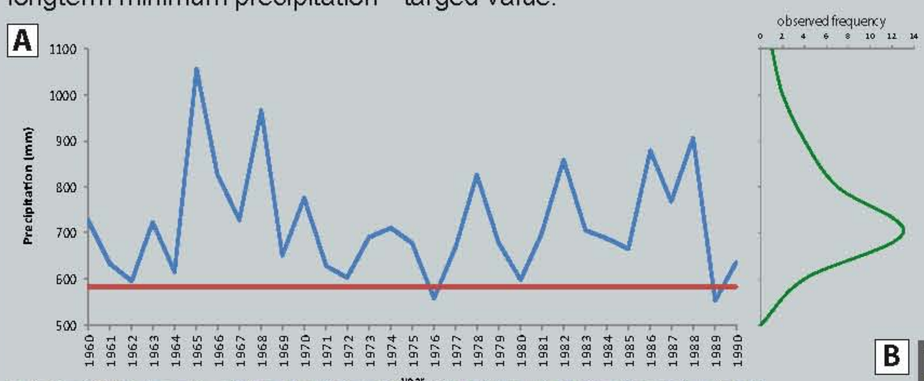
The ecosystem response to reduced water supply will depend on the system´s stability. Soil hydrological properties not only affect plant functioning but, in turn are strongly influenced by the vegetation.

Our research is focused on the direct and indirect effects of drought on different parts of the forest-understory-soil-system.

Drought = Reduction of Precipitation

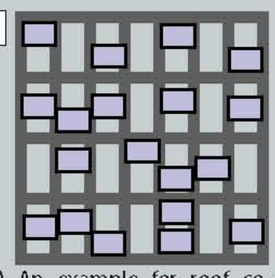
We established adaptive roofing systems which allow a flexible reduction of the precipitation in order to achieve the longterm minimum precipitation of a site. The 2.5-percentile of annual precipitation sums obtained from climate data of the years 1960 - 2010 was used as targed value.

To reproduce the natural variation within the annual precipitation cycle, we used a 'seasonal factor'.

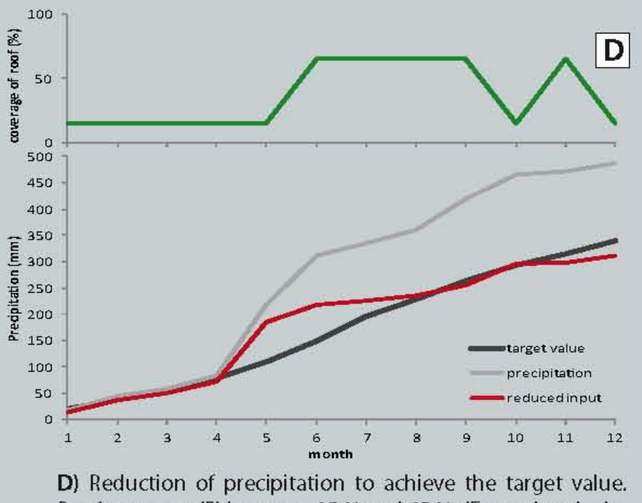


A) Climate data (example from area in Baden-Württemberg) with mean annual precipitation, target value obtained from this data, and observed frequency of occurance (annual precipitation).

C) Roofing construction with cenral tree.



B) An example for roof coverage of 45 %. The roofing elements are moved randomly every month according to needed coverage.



D) Reduction of precipitation to achieve the target value. Roof coverage (B) between 15 % and 65 %. (Example calculated for the year 1982 to test the feasibility)

Hypotheses

Drought will change the hydraulic functions of the soil via alteration of the soil structure.

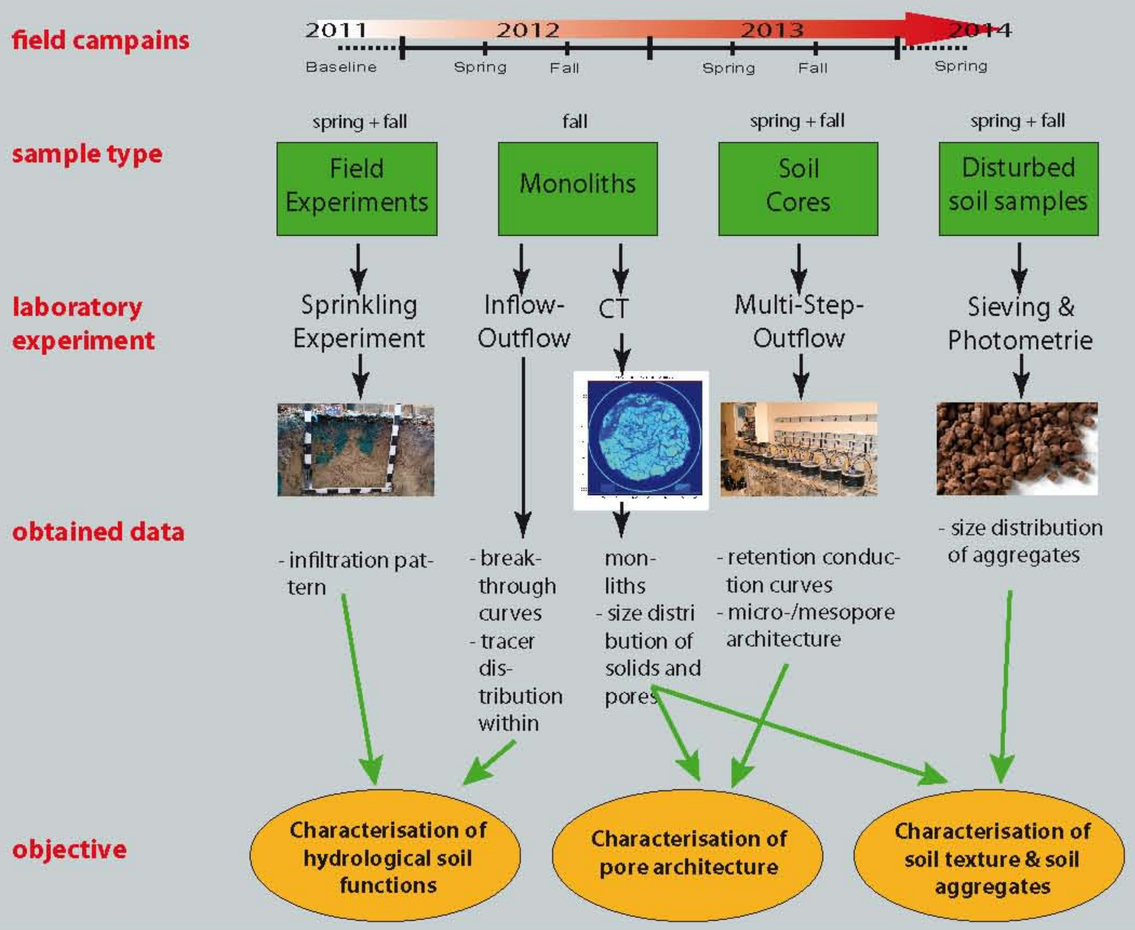
a: Soil structure is site-specific and depends on the management intensity and the diversity of plant and soil-microbial communities.

b: Drought will cause a change in soil structure, due to shrinkage and fracturing of soil aggregates. This will affect hydrological soil functions, specifically preferential flow.

c: Ecosystem responses to drought, in particular changes in rooting patterns and microbial community composition will influence and possibly enhance bypass flow, water uptake and water redistribution in soils.

Laboratory experiments

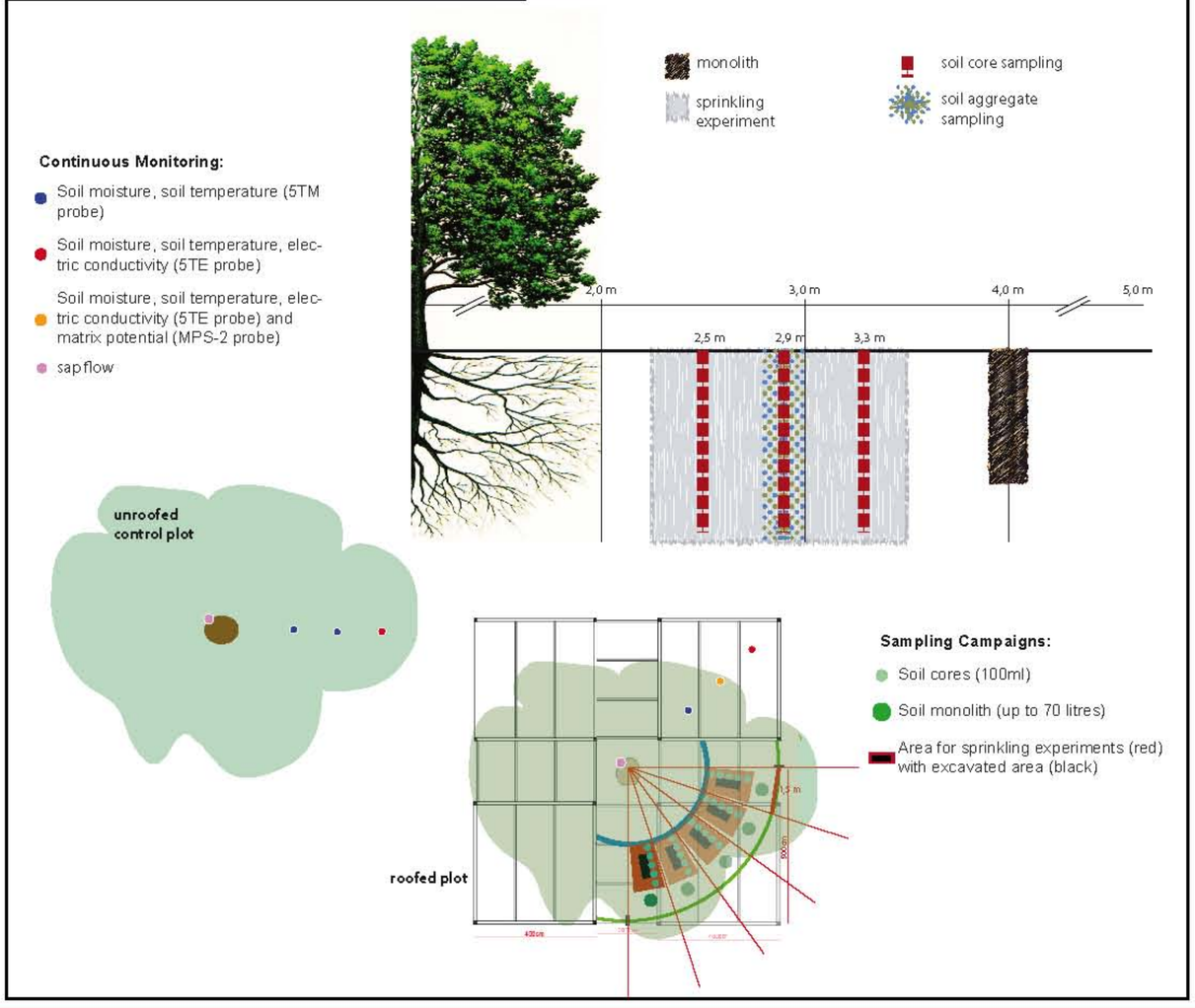
In order to test hypothesis a) and to characterize the architecture of macro-, meso- and micro-pores, undisturbed soil samples are analyzed by imaging techniques, computed tomography and hydraulic flow experiments. Temporal dynamics of the soil structure are monitored through repeated soil sampling at a profile wall. Rooting density and patterns are also monitored continuously. Effects of soil-structural changes on the hydrological soil functions are assessed by continuous soil water and soil matric potential monitoring, infiltrations and dye pattern experiments. Observed soil-structural changes are linked to changes in rooting patterns and changes in hydrophobicity.



Monitoring and Sampling

The effects of the imposed precipitation reduction are continuously monitored on the roofed and in parts on the control plots (soil moisture, soil temperature, electric conductivity, air temperature and humidity, roof runoff and sapflow).

The effects of the imposed drought on soil structure and hydrological soil functions are monitored in repeated measuring/ sampling campaigns in spring and fall.
In addition, experiments for hydrophobicity and aggregate structure are conducted on site.



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