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Climate change effects on vegetation characteristics and groundwater recharge

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Climate change is among the most pressing issues of our time. Increase in temperature, a decrease in summer precipitation and increase in reference evapotranspiration might affect the water balance, freshwater availability and the spatial distribution and type of vegetation. Precipitation and evapotranspiration (ET) largely determine groundwater recharge. Therefore, climate change likely affects both the spatial and temporal freshwater availability for nature conservation, agriculture and drinking water supply. Moreover, in the coastal (dune) areas, the groundwater recharge is crucial to the maintenance of the freshwater bell and the dynamics of the fresh – salt interface. Current knowledge, however, is insufficient to estimate reliably the effects of climate change on future freshwater availability.

Future groundwater recharge, the driving force of the groundwater system, can only be assessed if we understand how vegetation responds to changing climatic conditions, and how vegetation feedbacks on groundwater recharge through altered actual ET. Although the reference ET (i.e. the ET of a reference vegetation, defined as a short grassland completely covering the soil and optimally provided by water) is predicted to increase, the future actual ET (i.e. the ET of the actual 'real' vegetation under the 'real' moisture conditions) is highly unknown. It is the dynamics in the actual ET, however, through which the vegetation feeds back on the groundwater recharge.

In an earlier study we showed that increased atmospheric CO2 raises the water use efficiency of plants, thus reducing ET. Here we demonstrate another important vegetation feedback in dune systems: the fraction of bare soil and non-rooting species (lichens and mosses) in the dune vegetation will increase when, according to the expectations, summers become drier. From our calculations it appeared that on south slopes of dunes, which receive more solar radiation and are warmer than north facing surfaces, the fraction of vascular plants may drop from 70 to 20 percent in the future (2050) climate due to increased moisture deficits. ET of bare soil and non-rooting species is much lower than that of vascular plants and thus the vegetation composition feeds back on the soil moisture conditions.

Knowledge on such feedback mechanisms is indispensable in the analysis of climate change effects on the future groundwater recharge. Important questions are how, in the course of time, climate change will affect both groundwater table depth and dynamics, and how water management could adapt to these changes. We pursue a dynamic modeling approach that takes account of the interacting processes in the soil-plant-atmosphere system, including feedback mechanisms of the vegetation. This allows us to analyze climate change effects on groundwater recharge and thus future freshwater availability.