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Climate change effects on groundwater dependent temperate forest ecosystems

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Many attempts have been made to predict the influence of changing climate on ecosystems. Models developed for this purpose most often concentrate on vegetation in connection with soil moisture but usually omit groundwater. However in temperate climate groundwater can have a profound effect on the reaction of vegetation to climate change, because it strongly influences the spatial temporal distribution of soil moisture and therefore water and oxygen stress of vegetation. Here we focus on the qualitative and quantitative effect of climate change on the zonation of vegetation and groundwater dynamics along a hill slope. To study this we developed a fully coupled hydrological-vegetation model, for a groundwater influenced temperate forest ecosystem.

The vegetation model is based on the carbon assimilation model of Farquhar et al. (1980) and the extension of Daly et al. (2004), which includes transpiration of vegetation and accounts for the response to low soil moisture content. We modified this model to account for vegetation response to high soil moisture contents due to high groundwater levels, and we extended the model to include light competition, phenology and vegetation growth. To simulate the hydrological system the saturated-unsaturated flow model by van Beek (2002) has been used.

This coupled model was first compared to measured semi-hourly flux tower data of H_2O and CO_2, showing good results. Than simulation runs of 1000 years were performed to study the effect of climate change on soil water, groundwater and vegetation. We performed simulation runs with competition between wet and dry adapted species using different precipitation scenarios. Studying a system with a fixed ground-

water table, the results show that changing rainfall regimes have a small but significant influence on transpiration and carbon assimilation of the vegetation, but it has a large influence on interception evaporation and therefore groundwater recharge. This causes hardly any response in vegetation dynamics. When we study a system along a hill slope with a dynamic groundwater level near the surface, vegetation is much more affected, causing large shifts in vegetation zonation of the dry and wet adapted species along the slope. On the other hand, effect on growth rate of vegetation in areas where groundwater is deeper is very small. This is caused by the buffering capacity of both the vegetation and the hydrological system, resulting in relatively small changes in vegetation dynamics.

This study shows the importance of using a coupled groundwater vegetation model when studying temperate lowland areas. The coupled hydrological-vegetation model allows for detailed studies of qualitative and quantitative changes in spatial temporal patterns of vegetation under changing climate.