Climate change effects on vegetation characteristics and groundwater recharge

Ruud P. Bartholomeus[1,], J.P.M. Witte[1,2], D.G. Cirkel[1,3]*

Introduction

Estimates of future freshwater availability are not reliable, as vegetation feedbacks to climate change are generally not accounted for in the computation of actual evapotranspiration (ET_{act}). An example of such a feedback is the increased water use efficiency, and thus reduced transpiration of plants due to increased atmospheric CO_2 concentration [1]. Here we focus on another vegetation feedback: the response of vegetation cover to increased drought [2] (Figure 1).

Figure 1. Soil cover on north (top) and south facing slopes in a dune area in the Netherlands.

Method

- Simulate vegetation drought stress (in terms of Transpiration Reduction [3]) on inclined surfaces in the Netherlands with SWAP [4], taking account of differences in meteorological conditions, like incoming solar radiation [5] and precipitation [6];
- Relate soil cover to drought stress;
- Predict future (2050) vegetation cover based on future drought stress and simulate future groundwater recharge.

Results & Conclusions

Initial simulations show that:

- Climate change (IPCC-scenario A_2 and A_1B) will result in increased drought stress, amongst others on both north and south slopes (Figure 3A);
- Increased drought stress results in decreased soil cover (Figure 2 and 3B);
- Decreased cover raises the future groundwater recharge, especially on south slopes (Figure 3C).

Our explorative analysis demonstrates the importance of considering vegetation dynamics in predicting the effects of climate change on future freshwater availability.

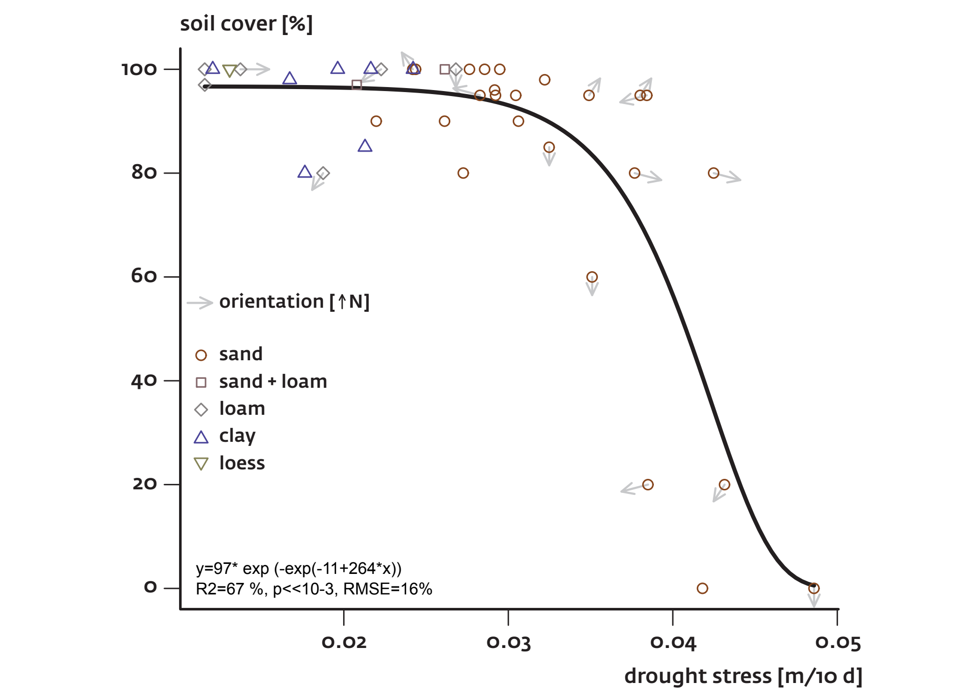

Figure 2. Relationship between drought stress (Transpiration Reduction) and total soil cover. We used this relationship to predict future soil cover (Figure 3B).

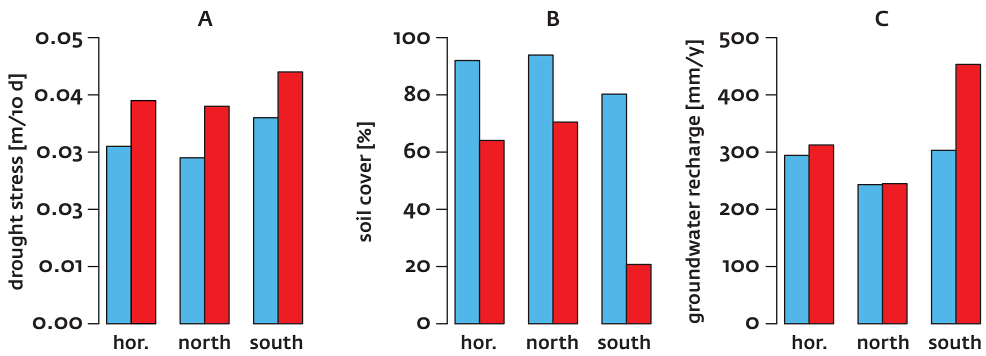

Figure 3. Simulated drought stress (A), predicted soil cover (B) and simulated groundwater recharge (C) for horizontal, north and south facing slopes of 15°. Results are given for both the current and future (2050) climate conditions.

Outlook

- Extend analysis with data from different climatic regions;
- Take account of effects of soil cover on microclimate;
- Explicit and dynamic simulations of transpiration, evaporation and interception for different plant functional types.

References

[1] **Kruijt, B., Witte, J.P.M., Jacobs, C.M.J., and Kroon, T.**, *Effects of rising atmospheric CO_2 on evapotranspiration and soil moisture: A practical approach for the Netherlands*. Journal of Hydrology, 2008. 349 (3-4): p. 257-267.

[2] **Witte, J.P.M., Bartholomeus, R.P., Cirkel, D.G., and Kamps, P.W.T.J.**, *Ecohydrologische gevolgen van klimaatverandering voor de kustduinen van Nederland*. 2008, Kiwa rapport KWR 08.006: Nieuwegein.

[3] **Bartholomeus, R.P.**, *Moisture Matters; Climate-proof and process-based relationships between water, oxygen and vegetation*. 2009, VU University: Amsterdam. p. 128.

[4] **Van Dam, J.C., Groenendijk, P., Hendriks, R.F.A., and Kroes, J.G.**, *Advances of modeling water flow in variably saturated soils with SWAP*. Vadose Zone Journal, 2008. 7(2): p. 640-653.

[5] **Šúri, M. and Hofierka, J.**, *A new GIS-based solar radiation model and its application to photovoltaic assessments*. Transactions in GIS, 2004. 8(2): p. 175-190.

[6] **De Lima, J.L.M.P.**, *The effect of oblique rain on inclined surfaces: a nomograph for the rain-gauge correction factor*. Journal of Hydrology, 1990. 115: p. 407-412.

KWR Watercycle Research Institute

1) KWR Watercycle Research Institute, P.O. Box 1072, 3430 BB Nieuwegein, the Netherlands
2) VU University, Department of Systems Ecology, Amsterdam, the Netherlands
3) Wageningen UR, Department of Soil Physics, Ecohydrology and Groundwater Management, Wageningen, the Netherlands
* Corresponding author: ruud.bartholomeus@kwrwater.nl - phone: +31 (0)30 6069 530