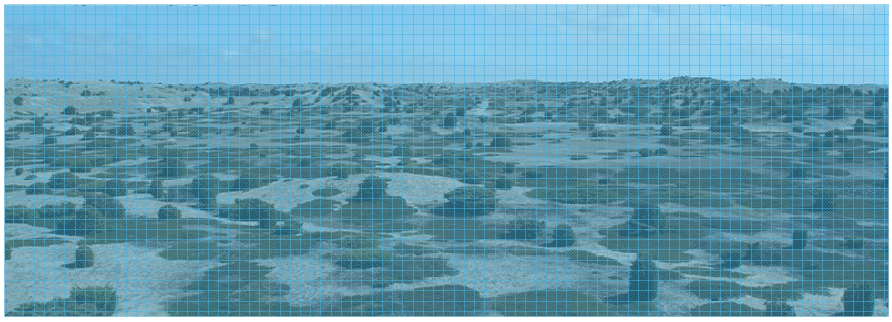

Climate change effects on vegetation characteristics and groundwater recharge

Ruud Bartholomeus & Flip Witte

Rotterdam, 29 September 2010

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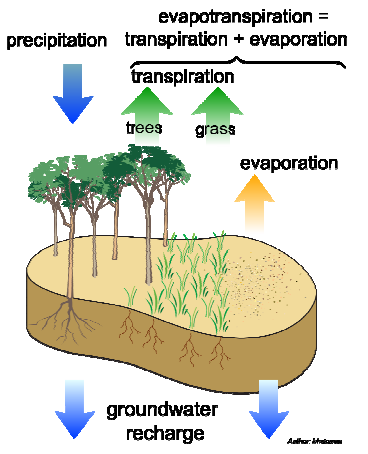
Problem statement

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



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Climate change

Temperature ↑
CO_2 ↑
Extreme precipitation ↑
Prolonged dry periods ↑

→ To predict the effect on groundwater recharge, we need to know the vegetation response to climate change

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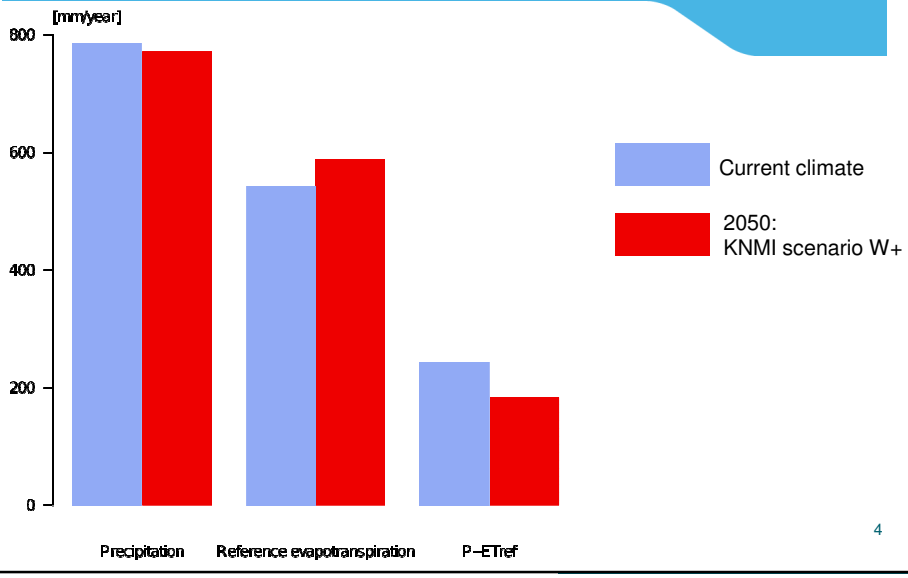
Neglecting vegetation feedbacks: Future groundwater recharge will decrease



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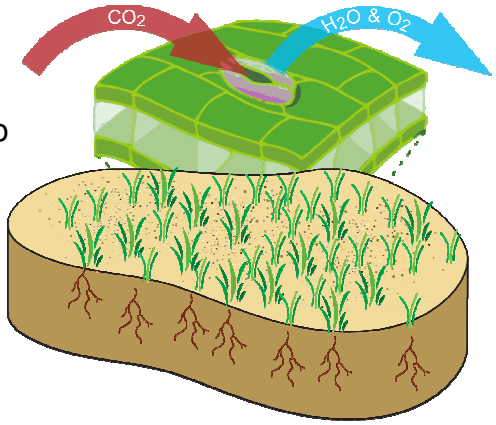
Vegetation response to climate change

Higher water use efficiency due to increased CO_2 [1]

Decreased soil cover due to increased drought [2]



1. Kruijt, B., P. Witte, A.J. Dolman and C. Moors, 2008. Effects of climate change on the water balance of wetlands: A practical approach for the Netherlands. Journal of Hydrology, 349(3-4): 257-267.

2. Witte, J.P.M., P.C. Baltus, H. Kramer, C.W.J. Beltman and G. van Walsum, 2008. Ecohydrological effects of climate change and land use change: A practical approach for the Netherlands.

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Vegetation on north vs south facing surfaces

North slopes

South slopes

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Theory on drought stress and vegetation on slopes

Solar radiation south surface > north surface
- → potential evapotranspiration: south > north
- → soil moisture contents: south < north
- → xeric vegetation: south > north
- → biomass and plant cover: south < north

Drought stress: primarily determines vegetation characteristics [1]

Other stresses affecting vegetation (wind, temperature) are initiated by drought stress [1]

1. Porporato, A., Laio, F., Ridolfi, L. and Rodriguez-Iturbe, I., 2001. Plants in water-controlled ecosystems: active role in hydrologic processes and response to water stress: III. Vegetation water stress. Advances in Water Resources, 24(7): 725-744.

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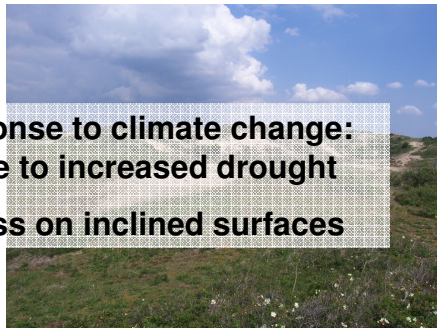
Vegetation on north vs south facing surface



Possible vegetation response to climate change: decreased soil cover due to increased drought

→ Simulate drought stress on inclined surfaces

North slopes **South slopes**

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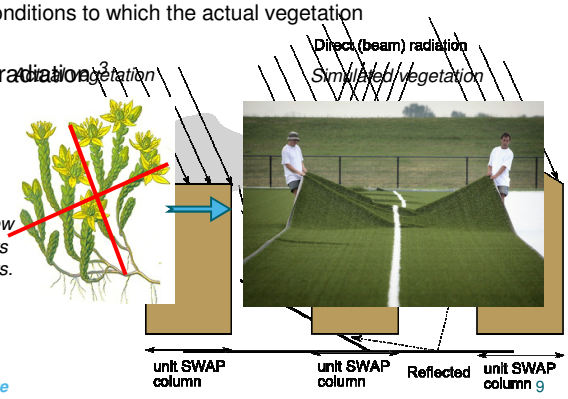
Estimate drought stress on inclined surfaces

- Drought stress: insufficient soil moisture for transpiration
- SWAP model for the unsaturated zone [1]
- Reference stress [2]
  - Estimate potential stress conditions to which the actual vegetation is adapted
- Correction for global (solar) radiation [3]
- Correction for precipitation [4]



Hoogland, T., J. van den Akker, et al. (2010). "Simulating the effects of inclined surfaces on drought stress in sparse crops using the agro-hydrological model SWAP." Ecological Modelling, 221(5): 640-650.

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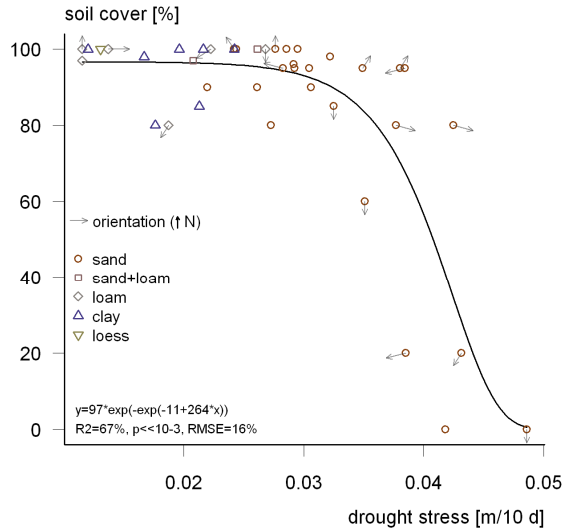
Empirical relationship between drought stress and soil cover



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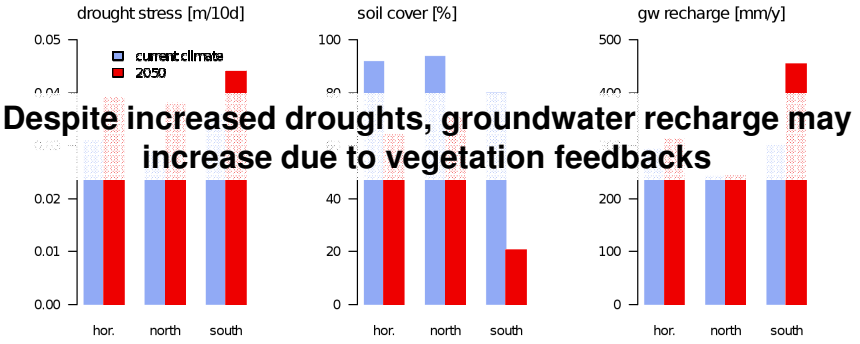
Possible climate change effects on future freshwater availability (scenario W+)



Despite increased droughts, groundwater recharge may increase due to vegetation feedbacks

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Future groundwater recharge: need for robust estimation of evapotranspiration

Future groundwater recharge can only be assessed if we understand how:

1. Vegetation responds to changing climatic conditions
2. Vegetation feedbacks on groundwater recharge through altered ET_{actual}

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Feedbacks to be investigated

Climate change may lead to:

- Increased fraction of mosses and lichens → high interception
- Decreased soil organic matter → low water holding capacity of soil
- Increased water repellency → preferential flow paths
- …

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