Geophysical Research Abstracts
Vol. 12, EGU2010-14122, 2010
EGU General Assembly 2010

Estimation of root water uptake as a sink term by inverse modeling

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Modeling water uptake by plant roots is essential to improve our understanding of the impact of ecosystems on hydrological cycle and climate. However, no measurement devices enable us to measure water uptake directly. Consequently, root water uptake has to be inferred by numerical methods (e.g. inverse modeling). This kind of numerical inversion is further complicated by the fact that vertical water fluxes between measurement points and water uptake by roots occur simultaneously in the soil matrix during daytime, and are difficult to separate. In order to tackle the challenge to quantify the water uptake, we split our study into two parts: First, we calibrate our soil model to estimate soil parameters during the winter time. Second, we estimate the water uptake as a sink term during daytime in summer, while assuming our soil hydraulic parameters to be known a priori. The solution is then checked during the nighttime.

For the first step, we use geostatistical interpolation techniques to derive the soil texture fields and use pedotransfer functions to specify the ranges of the soil hydraulic parameters. We then obtain optimal soil parameter sets by combining a Richards model with a global optimization algorithm. For the second step, we use the day-night differences of water content changes to derive likely root water uptake depths and profiles. Although many state-of-the-art approaches use root spatial distribution functions to allocate plants transpiration over the soil profile, we decide to follow a different approach. In our model any layer in the soil column may contribute a certain percent to the total water uptake. We will compare this approach with another inverse modeling approach, which infers water uptake by using root distribution parameters.

We expect that this new approach will offer us an opportunity to gain better understanding of vertical soil water flow and root water uptake for the several plots of differing plant diversity in the Jena Biodiversity Experiment, Germany.