Geophysical Research Abstracts,
Vol. 10, EGU2008-A-05637, 2008
SRef-ID: 1607-7962/gra/EGU2008-A-05637
EGU General Assembly 2008

Considering the heat flow in the unsaturated zone for estimations of soil water budgets

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Soil temperature and soil water content measurements, performed in the frame of REKLIP-Project (Disse, 1995), have been analyzed. The purpose is to investigate the importance of temperature measurements, which are ease to carry out in the field, for the calibration of a soil-plant-atmosphere model and for the estimation of soil water budgets. The analysis has been performed using COUPMODEL (Jansson & Karlsberg, 2004), which simulates mass and energy transport in the system soil-plant-atmosphere. The analyzed data concern two 15-days periods. The first one is a wet period with a precipitation height of 90mm whereas the second one is a dry period with precipitation height of 4mm. The test site is an area covered with grass in south western Germany. Temperature and water content have been measured at different depths until 120 cm below the soil surface. Meteorological data including air temperature, air velocity, solar radiation and air humidity have been measured in a station nearby to the test site. Further, rough estimates of the soil retention curves and the vegetation parameters (leaf area index and root depth) are available.

For the model calibration, in addition to the soil retention curves and the vegetation parameters a number of parameters required for the description of the plant water processes (transpiration, interception, water uptake by roots) and the soil evaporation have to be adjusted. Due to the large number of parameters, the attempt has been undertaken to adjust groups of parameters independently from each other.

It has been found that two of the parameters of COUPMODEL, which strongly influence evapotranspiration (ET), namely the extinction coefficient in Beer's law (k_{rn}) and the resistance of the crop canopy (r_{alai}), can be estimated in a first calibration step by adjusting the calculated time series of the temperature near the soil surface to the measured temperature time series, using for the soil and plant parameters the available rough estimates. The moisture distribution resulting from this first step of the calibration can differ considerably from the moisture distribution measured in the field. A sufficient approximation of the measured soil moisture distribution and consequently of the components of the soil water budget, is then achieved in a second step by modifying the soil and plant parameters. Despite of the fact that the finally estimated values of the soil and plant parameters can considerably differ from their values used in the first calibration step, the simulated temperature time series change negligibly compared to those obtained in the first calibration step. This implies that soil temperature distribution and soil moisture distribution are weakly dependent. This weak dependence is due to the existence of the vegetation. Vegetation decouples the soil moisture and the soil temperature in the sense that water extraction from the soil caused by the plant (water uptake by roots, transpiration) influences strongly the water budget of the soil but it affects negligibly the energy budget of the soil. The energy budget of the soil is mainly influenced by soil evaporation due to latent heat required for this process.

The weak dependence between soil moisture and soil temperature, which, as shown here provides some possibilities to adjust groups of parameters of the soil-plant-atmosphere models independently from each other, reduces the importance of soil temperature measurements as well as of the remotely sensed surface temperature as an additional measure for soil water budget estimations.

Jansson, P-E. & Karlsberg, L. (2004). Coupled heat and mass transfer model for soil-plant-atmosphere systems. Royal Institute of Technology, Dept. of Civil and Environmental Engineering, Stockholm, 435 pp.

Disse , M. (1995). Modellierung der Verdunstung und der Grundwasserneubildung in ebenen Einzugsgebieten. Dissertation, Institut fuer Hydrologie und Wasserwirtschaft, Universitaet Karlsruhe.