Geophysical Research Abstracts
Vol. 13, EGU2011-10110, 2011
EGU General Assembly 2011

Simulation of water and energy fluxes in a cowpea cultivated field in Northeast Brazil

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The cowpea is a crop of enormous economic and social importance for the farmers in northeast Brazil since it is the main food for the poorest population. The understanding and the quantification of water and energy exchanges are important for meteorological, agronomical and hydrological purposes. The complex and coupled biophysical processes involve transfer in the non-saturated zone, infiltration, plant root uptake, plant growth and turbulent exchanges above and within the canopy. Modelling tools able to assess the influence of management practices, changes in land use and climate on crop yields and/or water resources are very valuable for sustainable agriculture and environmental management. Among these tools, the physically based SiSPAT (Simple Soil Plant Atmosphere Transfer) model (Braud et al. 19951) is used here to simulate the coupled water, both in liquid and vapor phase, and energy exchanges in the soil-plant-atmosphere system. Although SiSPAT was intensively used in various environments prevailing in Europe and Africa, it was never applied from our knowledge in conditions of Northeast Brazil. The objective of the study is to evaluate the the model against measured values collected in a cowpea cultivated field during the rainy season occurring in this region from beginning of March to end of May. The soil is classified as Oxisoil The data were obtained in a 4 ha-plot at the Experimental Station of the Agricultural Sciences Center, of the Universidade Federal de Pernambuco, municipality of Areia, PB (6o 58' S, 35o 41' W, 620 m ASL). The plot was equipped with an automatic micrometeorological tower allowing the estimate of the components of the energy balance by the Bowen ratio method as well as with a recording tipping rain gauge (both being recorded every 60 s and stored in a data logger every 30 min). Daily measurements by neutron probes, tensiometers and temperature profiles (three replicates) at different depths (from the surface down to 1.20 m) were also performed for estimating the soil water balance including the actual evapotranspiration of the cowpea. In addition, time evolution of the crop height and ground cover was weekly recorded. The model was applied to representative periods of the main phenological stages of the crop (emergence, vegetative, reproductive, fructification, senescence). A sensitivity analysis was carried out to evaluate the impact of parameter uncertainties on model outputs. The results show that SiSPAT is able to correctly reproduce the features of the daily time evolution of the measured components of the energy balance (net radiation, latent, sensible and soil heat fluxes), as well as the soil water content, temperature profiles and cumulative evapotranspiration of the cowpea in the most varied field conditions encountered all along the experiment ranging from no rain (40 days of the 84 days of the studied period) to 33 days with 10 mm of rain and 11 days with higher rainfall including a daily 34 mm storm.

Reference:
Braud I., Vauclin M., Thony J.-L., Dantas Antonino A., Ruelle P., 1995. A Simple Soil-Plant Atmosphere