Geophysical Research Abstracts,
Vol. 10, EGU2008-A-04598, 2008
SRef-ID: 1607-7962/gra/EGU2008-A-04598
EGU General Assembly 2008

Assimilation of remote sensing data into a coupled land surface – boundary layer model for mapping evapotranspiration and microclimate

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Detailed knowledge of microclimate and land surface fluxes, especially evapotranspiration, is important for analysing soil and vegetation processes. However, it is difficult to estimate them accurately at the regional scale. Evapotranspiration and microclimate depend on feedback effects between the land surface and the atmosphere and on the spatial and the temporal variability of surface characteristics. In order to analyse such dependencies and to predict microclimate and land surface fluxes we have developed a coupled atmospheric boundary layer - land surface model which accounts for the landscape heterogeneity and we have implemented appropriate procedures for assimilating remote sensing data into the model. The developed model combines a 'Big Leaf' formulation of the surface fluxes and a simplified representation of the atmospheric boundary layer in unstable condition. It can simulate the interactions between the surface and the atmospheric boundary layer throughout the day making it possible to predict the evolution of land surface fluxes and microclimate. The heterogeneity of the land surface is accounted for by using a « tiled approach » which requires the introduction into the model of the various proportions and characteristics of the main vegetation types that covered up the landscape. Some of the required surface characteristics, such as LAI and albedo, can be estimated from remote sensing images in the solar domain. Other important characteristics, such as the soil moisture in the root zone and the aerodynamic roughness, are impossible to access directly. In order to solve this problem, we have developed a variational data assimilation method,

which requires the minimization of a cost function that includes observed surface temperatures (from thermal infrared images), background information in the form of an a priori information on the parameters to retrieve (aerodynamic roughness and soil moisture), and information on measurement errors. The adjoint model of the coupled surface – boundary layer model has been derived in order to reduce the computing cost of the minimization (as a large amount of information has to be located: aerodynamic roughness and soil moisture of each pixel in the image).

The theoretical analysis of the method (synthetic experiments) gave satisfactory results, showing that the method was suitable for monitoring surface fluxes from thermal remote sensing data. It was then applied on Mediterranean farmlands in France (Alpilles area and Crau-Camargue area in the lower Rhone Valley) and in Spain (Barrax area in the province of Albacete) showing good agreement with in situ measurements of energy fluxes. The developed method also gives better flux estimates than classical remote sensing approaches which consist in directly introducing surface temperature in the sensible heat flux equation. This is particularly true when the impact of the errors in remote sensing estimation of surface temperature, LAI and albedo are introduced in the analysis.