Climate Change Research: Evaluation and Policy Implications
S. Zwerver, R.S.A.R. van Rompaey, M.T.J. Kok and M.M. Berk, (Eds.)

Regionalization and parameterization of exchange processes at the land surface-atmosphere interface

P. Kabat, A.J. Dolman, W.G.M. Bastiaanssen, M.J. Ogink-Hendriks & J.A. Elbers

DLO-Winand Staring Centre for Integrated Land, Soil and Water Research (SC-DLO), P.O. Box 125, 6700 AC Wageningen, the Netherlands

Abstract

Regionalization of local scale modelling concepts is of paramount importance for realistic predictions of climate by Global Climate Models and for improved accuracy in regional hydrological modelling. A series of land surface experiments are providing a methodology and a unique dataset to develop and test regionalization algorithms. Most of this data is successfully used in analysis of local scale phenomena and the physical interpretation of remote sensing data. SC-DLO is currently integrating these results into regional atmospheric and hydrological models.

1. SCOPE

Coupled hydrological and meteorological models are the basic tools to study the effects of changes in land use on water resources and climate. These models operate on spatial scales many times larger than for which the physics was originally developed, and at which the land surface changes appreciably. It is important to test the applicability of small scale physics at large scales and to develop parameterizations that take into account the heterogeneity of the landscape. In the development of the models, aggregation and disaggragation methods meet through a physically based description of the relevant processes (Fig. 1).

The World Climate Research Program (WCRP) and the International Geosphere Biosphere Program (IGBP) have initiated a series of experiments to provide the required data to test and develop these parameterizations. The experiments have taken place or are planned in areas which suffer from human induced or climatic pressure on natural resources such as the Mediterranean (Bolle et al., 1992), the Sahel (Goutorbe et al., 1993) and the Amazon basin (Dolman et al, 1994). The basic

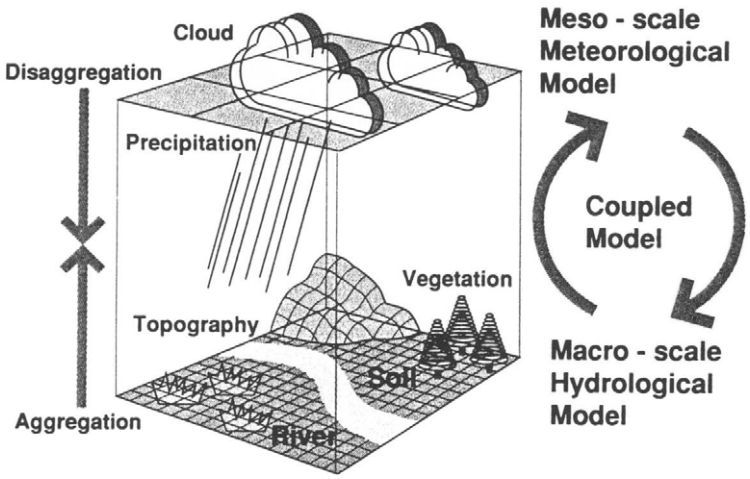

Figure 1. Domain of mesoscale and macro scale models

strategy in these experiments in which the Staring Centre is participating is to combine simultaneous measurement of water, CO_2 and energy fluxes across the landscape at various scales with interpretive modelling and remote sensing at these scales. The basic aim of the modelling is to test and develop rules for deriving "effective" parameters for large scale applications from a knowledge of the small scale variability and the physics involved in defining the area averaged fluxes.

2. MEASUREMENTS

Surface fluxes of evaporation, sensible heat, momentum and CO_2 are measured by eddy correlation; a technique which measures turbulent fluxes by correlating high frequency deviations from a mean for vertical wind speed and temperature, CO_2 an humidity. HAPEX-Sahel (Goutorbe et al., 1993) was the first experiment where these techniques were applied for such a long period under harsh environmental conditions. This data froms the basis for the development of detailed Soil Vegetation Atmosphere Transfer schemes (SVATs) which will link atmospheric exchange processes of energy and momentum with biophysiological control mechanisms in the vegetation.

Preliminary results of SC-DLO measurements in HAPEX-Sahel show that the land-surface heterogeneity presented by two typical land cover types in the Sahel appears to have little effect on average seasonal evaporation (Fig. 2). In contrast,

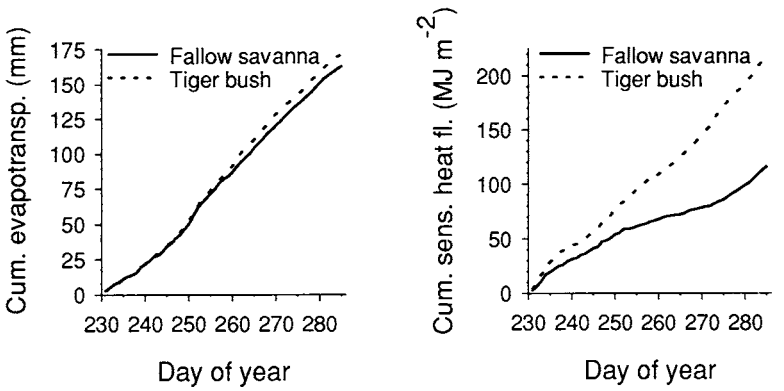

Figure 2. Cumulative latent and sensible heat fluxes at West-Central Supersite during the HAPEX-Sahel field experiment.

the sensible heat release into the atmosphere differs considerably between both land cover types. This means that high resolution parameterization schemes for mesoscale modelling are needed to be able to describe the interaction of the land surface with the regional climate.

3. MODELLING

Models describing the control the vegetation exerts over transpiration and the flow of water through the unsaturated soil are calibrated for homogeneous land surfaces with the measurements obtained by micrometeorological techniques. These SVAT models form the basic unit of the larger scale models (mesoscale) which operate with grid resolutions from several hundred meter to tens of kilometers. A non-hydrostatic mesoscale model (KAMM, Adrian and Fiedler, 1992) is used to study the effect of landscape heterogeneity on area averaged fluxes. The area averaged fluxes produced by this 3-D model are then compared with simpler representations (parameterizations) in which the heterogeneity is integrated into a single "effective" parameter for a large area.

4. REMOTE SENSING

Remote sensing provides the third corner in the strategy of these experiments by providing the means for areal extrapolation of locally obtained results. A new algorithm (SEBAL, Bastiaanssen et al., 1994) has been developed and tested for

the EFEDA (Bolle et al., 1992) and HAPEX-Sahel field experiments to produce the regional distribution of the latent and sensible fluxes.

5. CONCLUSIONS

The series of land surface experiments are providing a methodology and a unique dataset to develop and test regionalization algorithms. Most of this data is successfully used in analysis of local scale phenomena and the physical interpretation of remote sensing data. SC-DLO is currently integrating these results into regional atmospheric and hydrological models.

6. REFERENCES

Adrian, G. and Fiedler, F., 1991. Simulation of unstationary wind and temperature fields over complex terrain and comparison with observations. *Beitr. Phys. Atmosph.* 64: 27-48.

Bastiaanssen, W.G.M., Hoekman, D.H. and Roebeling, R.A., 1994. *A methodology for the assessment of surface resistance and soil water storage variability at mesoscale based on remote sensing measurements.* Wallingford, IAHS, IAHS Special Publication No. 2.

Bolle, H.-J., André, J.-C., Arrue, J.L., Barth, H.K., Bessemoulin, P., Brasa, A., de Bruin, H.A.R., Cruces, J., Dugdale, G., Engman, E.T., Evans, D.L., Fantechi, R., Fiedler, F., van de Griend, A., Imeson, A.C., Jochum, A., Kabat, P., Kratzsch, T., Lagouarde, J.-P., Langer, I., Llamas, R., Lopez-Baeza, E., Melia Miralles, J., Muniosguren, I.S., Nerry, F., Noilhan, J., Oliver, H.R., Roth, R. Saatchi, S.S., Sanchez Diaz, J., de Santa Olalla, M., Shuttleworth, W.J., Søgaard, H., Stricker, H., Thornes, J., Vauclin, M., and Wickland, D., 1993. EFEDA: European field experiment in a desertification-threatened area. *Ann. Geophys.* **11**: 173-189.

Dolman, A.J., Kabat, P., Gahs, J.H.C., Noilhan, J., Jochum, A.M. and Nobre, C., 1994. A large scale field experiment in the Amazon Basin (LAMBADA/ BATERISTA). *Proc. CEC Climatic Change Symposium.* Brussels, in press.

Goutorbe, J.P., Lebel, T., Tinga, A., Bessemoulin, P., Brouwer, J., Dolman, A.J., Engman, E.T., Gash, J.H.C., Hoepffner, M., Kabat, P., Kerr, Y., Monteny, B., Prince, S., Said, F., Sellers, P. and Wallace, J.S., 1994. HAPEX-Sahel: a large sclae study of land-atmosphere interactions in the semi-arid tropics. *Ann. Geophys.* **12**: 53-64.