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ENVIRONMENTAL SCIENCES

NWO

The relative effect of heterogeneities in rainfall and soil properties on soil moisture on a regional scale

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Introduction

Proper knowledge of the spatial soil moisture distribution is the key to understanding the interaction between land and atmosphere in terms of energy and water. Here, we examine the effect of spatial heterogeneity of rainfall and of soils/vegetation on soil moisture.

Rainfall

We use radar rainfall data collected as part of the SMEX '03 campaign that took place between 20 May and 31 July 2003. The total field is 240 by 240 km around the Little Washita SCAN site, with a resolution of 4 km. A typical daily rainfall field can be seen in figure 1.

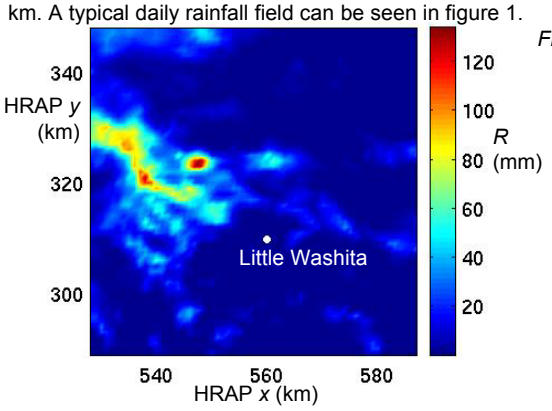

Fig. 1: Total rainfall for 14 June 2003. The location of the Little Washita SCAN site is given by the white dot.

Soil moisture model

A point-scale soil moisture model is used with the rainfall described above for each grid cell. The basic equation of the model is:

$$\frac{d\theta}{dt} = \frac{1}{L}(T - Q - q - S)$$

with throughfall T (=R-canopy storage), runoff Q (saturation excess), drainage q (see inset b) in figure 5) and evapotranspiration S (see inset in figure 4). The model is run 100 times using values of the saturated hydraulic conductivity k_s drawn from a truncated lognormal distribution with $\mu_{\ln(k_s)}$=5.98 and $\sigma_{\ln(k_s)}$=1.88, and values of leaf area index ξ drawn from three normal distributions: 70% of the grid cells: μ_ξ=1.9, σ_ξ=0.2; 20%: μ_ξ=1.1, σ_ξ=0.5; and 10%: μ_ξ=4.0, σ_ξ=0.6. The mean of θ of these 100 runs for the Little Washita SCAN site is compared to actually measured soil moisture in figure 2. To analyze the effect of spatially averaging the rainfall and/or the soil/vegetation properties, the model has been run with these properties heterogeneous and homogeneous. Results for θ and the different hydrological fluxes are shown in figures 3-6.

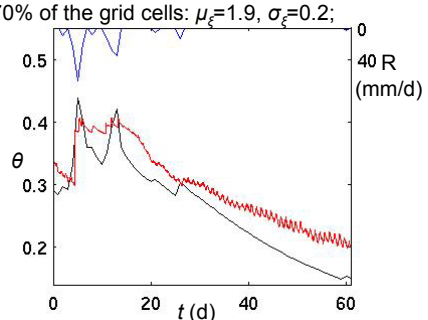

Fig. 2: Modeled and measured soil moisture at the Little Washita SCAN site. Also shown are daily rainfall accumulations.

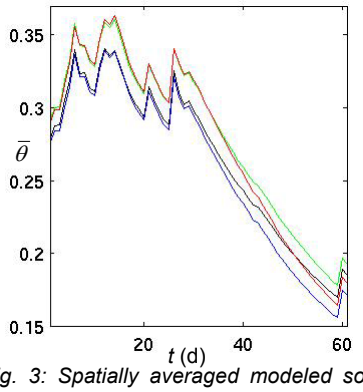

Fig. 3: Spatially averaged modeled soil moisture. Heterogeneous R and heterogeneous soils/vegetation; hom. R and het. soils/veg.; het. R and hom. soils/veg.; hom. R and hom. soils/veg.

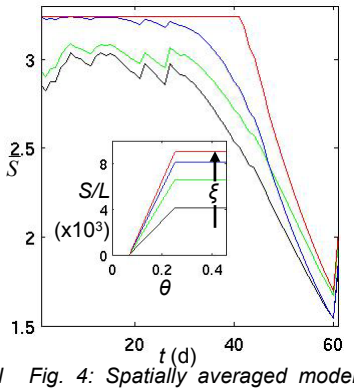

Fig. 4: Spatially averaged modeled evapotranspiration (see legend of figure 3 for colors). Inset: model curves for different values of ξ (1, 2, 3, 4)

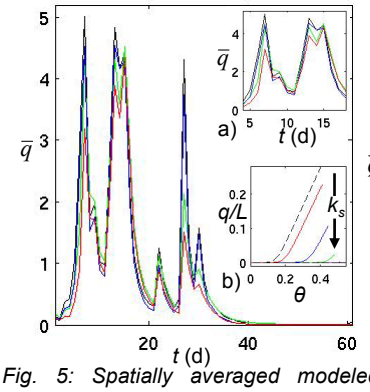

Fig. 5: Spatially averaged modeled drainage (see legend of figure 3 for colors). Inset a): enlargement. Inset b): model curves for different values of k_s (10^1, 10^2, 10^3, 10^4)

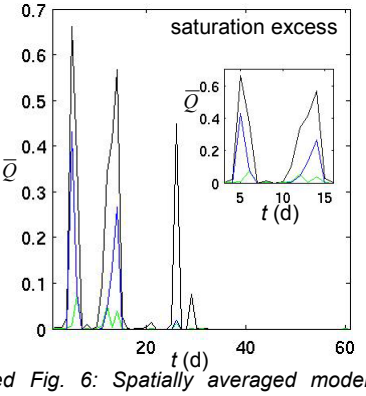

Fig. 6: Spatially averaged modeled runoff (see legend of figure 3 for colors). Inset: enlargement.

Conclusions

Although the spatial variation in soil moisture decreases dramatically when spatially averaging soil and vegetation properties (see figure 7), the relative effect of averaging rainfall is larger than when soil/vegetation properties are averaged. However, the spatially averaged fluxes react differently to averaging rainfall or soil/vegetation properties. This can be explained by the curves that the model uses (which are generally accepted) to calculate fluxes from soil moisture, and by the large differences in the rainfall within the total field

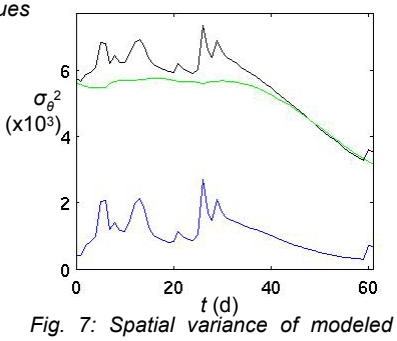

Fig. 7: Spatial variance of modeled soil moisture (see legend of figure 3 for colors).

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