



RESEARCH NOTE

The aggregate description of semi-arid vegetation with precipitation-generated soil moisture heterogeneity

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Abstract

Meteorological measurements in the Walnut Gulch catchment in Arizona were used to synthesize a distributed, hourly-average time series of data across a 26.9 by 12.5 km area with a grid resolution of 480 m for a continuous 18-month period which included two seasons of monsoonal rainfall. Coupled surface-atmosphere model runs established the acceptability (for modelling purposes) of assuming uniformity in all meteorological variables other than rainfall. Rainfall was interpolated onto the grid from an array of 82 recording rain gauges. These meteorological data were used as forcing variables for an equivalent array of stand-alone Biosphere-Atmosphere Transfer Scheme (BATS) models to describe the evolution of soil moisture and surface energy fluxes in response to the prevalent, heterogeneous pattern of convective precipitation. The calculated area-average behaviour was compared with that given by a single aggregate BATS simulation forced with area-average meteorological data. Heterogeneous rainfall gives rise to significant but partly compensating differences in the transpiration and the intercepted rainfall components of total evaporation during rain storms. However, the calculated area-average surface energy fluxes given by the two simulations in rain-free conditions with strong heterogeneity in soil moisture were always close to identical, a result which is independent of whether default or site-specific vegetation and soil parameters were used. Because the spatial variability in soil moisture throughout the catchment has the same order of magnitude as the amount of rain falling in a typical convective storm (commonly 10% of the vegetation's root zone saturation) in a semi-arid environment, non-linearity in the relationship between transpiration and the soil moisture available to the vegetation has limited influence on area-average surface fluxes.

Introduction

This research note addresses the question, 'In the extreme case of the semi-arid environment subject to convective rainfall, are the ensuing real patterns of soil moisture such that they have significant impact on the area-average description of vegetation in meteorological models?' It is best read as a sequel to Arain *et al.* (1996).

Arain *et al.* investigated the adequacy of simple rules for defining the effective, area-average (or aggregate) value of the vegetation-related parameters required to specify surface-atmosphere interactions for heterogeneous mixes of vegetation covers. They used data from the First International Satellite Land Surface Climatology Field Experiment (FIFE; Sellers *et al.*, 1988) to validate and initiate the BATS-ABL coupled model of interac-

tions between land surfaces and the atmospheric boundary layer (Arain *et al.*, 1996). In most conditions they found that so-called aggregation rules (Shuttleworth, 1992) can provide area-average values of vegetation parameters which, when applied within the Biosphere-Atmosphere Transfer Scheme (BATS; Dickinson *et al.*, 1986), calculate values of surface fluxes that are acceptably similar to those calculated with explicit recognition of different patches of vegetation cover in the coupled model.

As a side-issue in their paper, Arain *et al.* (1996) discovered that when they included a significant proportion of irrigated crops amongst heterogeneous vegetation in an otherwise dry landscape, the performance of the hypothetical aggregation rules was compromised. This result