Hydrological Land Surface Response in a Tropical Regime and a Midlatitudinal Regime

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ABSTRACT

A statistical–dynamical study was performed on the role of hydrometeorological interactions in the midlatitudes and the semiarid Tropics. For this, observations from two field experiments, the First International Satellite Land Surface Climatology Project Field Experiment (FIFE) and the Hydrological Atmospheric Pilot Experiment (HAPEX)–Sahel, representative of the midlatitudes and the semiarid tropical conditions, and simulated results from a land surface model, Simplified Simple Biosphere (SSiB) model were statistically analyzed for direct and interaction effects. The study objectives were to test the hypothesis that there are significant differences in the land surface processes in the semiarid tropical and midlatitudinal regimes and to identify the nature of the differences in the evapotranspiration exchanges for the two biogeographical domains. Results suggest there are similarities in the direct responses but the interactions or the indirect feedback pathways could be very different. The arid tropical regimes are dominated through vegetative pathways (via variables such leaf area index, stomatal resistance, and vegetal cover); the midlatitudes show soil wetness (moisture)–related feedback. In addition, for the midlatitudinal case, the vegetation and the soil surface acted in unison, leading to more interactive exchanges between the vegetation and the soil surface. The water-stressed semiarid tropical surface, on the other hand, showed response either directly between the vegetation and the atmosphere or between the soil and the atmosphere with very little interaction between the vegetation and the soil variables. Thus, the semiarid Tropics would require explicit bare ground and vegetation fluxes consideration, whereas the effective (combined vegetation and soil fluxes) surface representation used in various models may be more valid for the midlatitudinal case. This result also implied that with higher resource (water) availability the surface invested more in the surrounding environment. On the other hand, with poor resource availability (such as water stress in the tropical site), the surface components retain individual resources without sharing.

1. Introduction

Land surface processes (LSPs) have a significant impact on the meteorological features both in the semiarid Tropics and in midlatitudinal domains. The changes in the surface processes modulate the surface and subsurface hydrological behavior and the surface energy balance. This modulation leads to changes in the overall boundary layer structure. Higher soil moisture and vegetation cover can lead to enhanced water vapor (latent heat) flux, which for the same incoming solar radiation can lower the sensible heat flux (Entekhabi et al. 1996; Alapaty et al. 1997; Niyogi and Raman 1997).

Several studies have been reported on the sensitivity of land surface processes on the hydrometeorological feedback. For example, using a coupled prognostic modeling study, Deardorff (1978) and Noilhan and Planton (1989) showed that changes in the soil moisture and soil temperature have a direct feedback on the surface energy balance and on mesoscale weather regimes. Using a combination of modeling and analyses data, Pielke et al. (1991) provided evidence that the changes in land use patterns have significant impact on the regional climate and that the effects of small-scale landscape variability need to be resolved explicitly in modeling studies. Using GCMs, Xue and Shukla (1993) and Xue (1997) identified several feedback pathways on the glob-

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