The community Noah land surface model with multiparameterization options (Noah-MP): 1. Model description and evaluation with local-scale measurements

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[1] This first paper of the two-part series describes the objectives of the community efforts in improving the Noah land surface model (LSM), documents, through mathematical formulations, the augmented conceptual realism in biophysical and hydrological processes, and introduces a framework for multiple options to parameterize selected processes (Noah-MP). The Noah-MP's performance is evaluated at various local sites using high temporal frequency data sets, and results show the advantages of using multiple optional schemes to interpret the differences in modeling simulations. The second paper focuses on ensemble evaluations with long-term regional (basin) and global scale data sets. The enhanced conceptual realism includes (1) the vegetation canopy energy balance, (2) the layered snowpack, (3) frozen soil and infiltration, (4) soil moisture-groundwater interaction and related runoff production, and (5) vegetation phenology. Sample local-scale validations are conducted over the First International Satellite Land Surface Climatology Project (ISLSCP) Field Experiment (FIFE) site, the W3 catchment of Sleepers River, Vermont, and a French snow observation site. Noah-MP shows apparent improvements in reproducing surface fluxes, skin temperature over dry periods, snow water equivalent (SWE), snow depth, and runoff over Noah LSM version 3.0. Noah-MP improves the SWE simulations due to more accurate simulations of the diurnal variations of the snow skin temperature, which is critical for computing available energy for melting. Noah-MP also improves the simulation of runoff peaks and timing by introducing a more permeable frozen soil and more accurate simulation of snowmelt. We also demonstrate that Noah-MP is an effective research tool by which modeling results for a given process can be interpreted through multiple optional parameterization schemes in the same model framework.

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1. Introduction

[2] Land can remember weather events or climate anomalies through variations in its heat and water storages. In turn, land heat and water storage anomalies (the filtered signals of noisy weather events) can affect climate predictability through their effects on surface energy and water fluxes [*Roesch et al.*, 2001; *Jiang et al.*, 2009, and references therein]. For instance, anomalous heat storage due to anomalous snow accumulation in winter can affect the warming in spring or early summer through melting. Anomalous water stored in reservoirs (snowpack, soil, and aquifer) during wet seasons can feed back to the atmosphere through evapotranspiration (ET) in subsequent dry seasons; this effect can be more efficient in vegetated areas through plant stomata and root uptakes of soil water. Soil water anomalies can persist from weeks to seasons [*Pielke et al.*, 1999; *Schlosser and Milly*, 2002] and affect climate predictability through the

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