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Noah-GEM and Land Data Assimilation System (LDAS) based downscaling of global reanalysis surface fields: Evaluations using observations from a CarboEurope agricultural site

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ABSTRACT

This study provides the first assessment of the Noah and Noah-GEM (photosynthesis-based Gas exchange Evapotranspiration Model) land surface model using observations from the Avignon, France CarboEurope agricultural site during 2006 and 2007. Noah and Noah-GEM are integrated within a Land Data Assimilation System (LDAS) framework. The LDAS fields of soil moisture, temperature field, and surface and subsurface water and energy budget terms are useful for meteorological model initial conditions, and agricultural applications. The models were integrated using 1 km grid spacing with meteorological forcing from the Japanese global reanalysis (JRA). Consistent with results compiled over the US Southern Great Plains, the Noah and Noah-GEM based model performance was comparable for sorghum and wheat cropland. Both models had a relatively better performance during the low LAI plant growth stage however the performance deteriorated during peak green conditions and the bias between the observed and modeled latent heat flux was consistently higher by 100 W m^{-2}. To further diagnose this bias, a series of experiments were undertaken by considering observed biweekly dynamic leaf area index (LAI), vegetation height, roughness length (z_0), and albedo changes. These experiments were conducted using Noah-GEM because of similar results between Noah and Noah-GEM and also because Noah-GEM has an explicit C3 and C4 photosynthesis model. The results were compared with the default model run as well as in situ surface flux and soil moisture/temperature observations. Prescribing onsite characteristics led to modest improvements in the model fields, however the model still could not capture the peak growing heat flux values of sensible heat for both C3 and C4 plants. Additional experiments were undertaken to investigate the inconsistencies in model parameterization. These include experiments with a CO_2-based transpiration and thermal roughness formulation in surface-layer physics; the surface coupling coefficient through the "Zilitinkevich constant"; effect of soil texture and model spin-up time. Based on the study results and the experiments, we conclude that a high resolution LDAS/Noah setup can be driven using global reanalysis fields producing reasonably good results when evaluated against point observations. The model performance was enhanced after using dynamic LAI and albedo feedback; however the key feature was the tuning of the model structure through coupling and modifying V_{max} as a function of LAI. These results highlight the need for improvements in the turbulent surface layer and plant physiological modules, and model deficiencies cannot be overcome by onsite biophysical data alone.

1. Introduction

A number of agricultural and environmental applications require spatiotemporal soil moisture/soil temperature fields for the surface and subsurface. Soil parameters however are difficult to monitor and the sensors require routine maintenance, have a localized footprint, and are expensive. Satellite remote-sensed products can be an alternative to in situ soil moisture/temperature measurements (Jackson, 1993). However remote-sensed products also have limitations such as they typically have a coarser resolution and can provide the skin/surface conditions with a limited ability to

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