Effect of Land–Atmosphere Interactions on the IHOP 24–25 May 2002 Convection Case

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ABSTRACT

Numerical simulations are conducted using the Coupled Ocean/Atmosphere Mesoscale Prediction System (COAMPS) to investigate the impact of land–vegetation processes on the prediction of mesoscale convection observed on 24–25 May 2002 during the International H_2O Project (IHOP_2002). The control COAMPS configuration uses the Weather Research and Forecasting (WRF) model version of the Noah land surface model (LSM) initialized using a high-resolution land surface data assimilation system (HRLDAS). Physically consistent surface fields are ensured by an 18-month spinup time for HRLDAS, and physically consistent mesoscale fields are ensured by a 2-day data assimilation spinup for COAMPS. Sensitivity simulations are performed to assess the impact of land–vegetative processes by 1) replacing the Noah LSM with a simple slab soil model (SLAB), 2) adding a photosynthesis, canopy resistance/transpiration scheme [the gas exchange/photosynthesis-based evapotranspiration model (GEM)] to the Noah LSM, and 3) replacing the HRLDAS soil moisture with the National Centers for Environmental Prediction (NCEP) 40-km Eta Data Assimilation (EDAS) operational soil fields.

CONTROL, EDAS, and GEM develop convection along the dryline and frontal boundaries 2–3 h after observed, with synoptic-scale forcing determining the location and timing. SLAB convection along the boundaries is further delayed, indicating that detailed surface parameterization is necessary for a realistic model forecast. EDAS soils are generally drier and warmer than HRLDAS, resulting in more extensive development of convection along the dryline than for CONTROL. The inclusion of photosynthesis-based evapotranspiration (GEM) improves predictive skill for both air temperature and moisture. Biases in soil moisture and temperature (as well as air temperature and moisture during the prefrontal period) are larger for EDAS than HRLDAS, indicating land–vegetative processes in EDAS are forced by anomalously warmer and drier conditions than observed. Of the four simulations, the errors in SLAB predictions of these quantities are generally the largest.

By adding a sophisticated transpiration model, the atmospheric model is able to better respond to the more detailed representation of soil moisture and temperature. The sensitivity of the synoptically forced convection to soil and vegetative processes including transpiration indicates that detailed representation of land surface processes should be included in weather forecasting models, particularly for severe storm forecasting where local-scale information is important.

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