The DOE Water Cycle Pilot Study: Modeling and Analysis of Seasonal and Event Variability at the Walnut River Watershed

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RESEARCH OBJECTIVES

The DOE Water Cycle Pilot Study is designed to develop the use of water isotopic data (δD, $\delta^{18}O$) to constrain hydroclimate models and test process descriptions and their sensitivity at multiple scales, to better understand water cycle variability. The research objectives are to: (1) evaluate predictions of components of the water budget for several study periods, using a set of nested models with different spatial resolutions, along with archived and new field data from the Walnut River Watershed (WRW); (2) evaluate multiscale water isotope modeling as a means of tracing sources and sinks within and external to the WRW and the Atmospheric and Radiation Measurements Program Southern Great Plains (ARM SGP) site, a representative global climate model grid cell; and (3) identify water-budget-model improvements and data needs over a range of scales.

APPROACH

Water isotopic measurements of precipitation, surface water, soils, plants, and atmospheric water vapor were collected every three months and during the DOE Intensive Observing Period, April 1 to June 30, 2002 (Machavaram et al., this volume). Land-surface modeling compared 1 km fluxes for different modes and for a 50-year simulation. Different wetting and drying conditions caused by different controls were investigated. The Penn State/NCAR Mesoscale Model version 5 (MM5) was advanced with the implementation of water-isotope mass-conservation equations (Foster and Miller, this volume). Multiscale atmospheric simulations using the MM5 and radar-based data have been analyzed and are discussed below.

ACCOMPLISHMENTS

The MM5 6-hour precipitation slightly underestimates for WRW using 4 km resolution during March 1–30, 2000 (Figure 1a). MM5 lags between radar-precipitation onset at March 3. MM5 exhibits considerable accuracy in predicting precipitation occurrences, but shows less accuracy in predicting the precipitation amount. When the 4 km MM5 results are compared to radar precipitation over the entire ARM CART site (Figure 1b), accuracy is improved. MM5 may be underestimating the precipitation in the WRW, but overestimating it in the larger ARM/CART area. This allows for compensating errors, whereas the smaller WRW domain is less forgiving. At 12 km resolution, the MM5 model shows remarkable accuracy in forecasting the total precipitation. At 48 km, the size of the comparison domain becomes important; the precipitation in the WRW is significantly underestimated, while it is well represented over the entire ARM/CART site. MM5 underestimates the amount of precipitation at 4 km, because it represents the observed variability in precipitation from point-to-point.

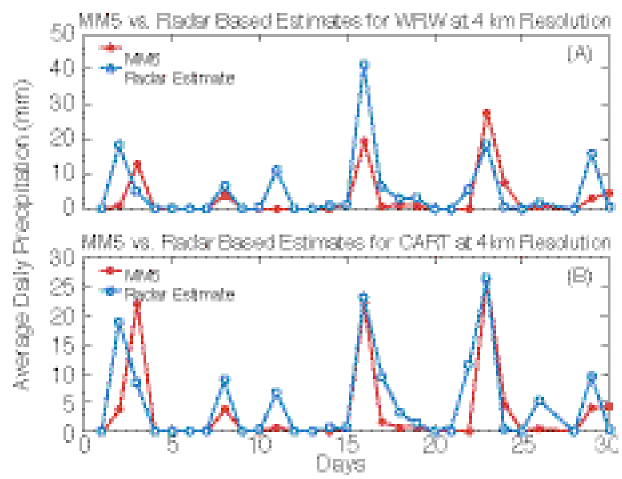

Figure 1. MM5-simulated 4 km precipitation and WSR-88D radar-derived precipitation during March 2000 for (A) WRW domain and (B) the ARM/CART domain.

SIGNIFICANCE OF FINDINGS

During March 2000, there was no convective precipitation, and hence MM5 simulations did not require use of the convective parameterization. The nonconvective precipitation scheme is inadequate at 4 km resolution. It performs better at 12 km, but significantly overestimates variability. This suggests that MM5 may be used during nonconvective situations to predict the amount of precipitation over small watersheds (tens of kilometers) in the U.S. Southern Great Plains during early spring—as long as the resolution is 12 km. Attempts to resolve local-scale precipitation features with MM5 are likely to be biased toward underestimation of precipitation amount.

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