Development of the Flux-Adjusting Surface Data Assimilation System for Mesoscale Models

KIRAN ALAPATY,*,+ DEV NIYOGI,# FEI CHEN,@ PATRICK PYLE,& ANANTHARMAN CHANDRASEKAR,** AND NELSON SEAMAN++

*Division of Atmospheric Sciences, National Science Foundation, Arlington, Virginia
#Purdue University, West Lafayette, Indiana
@National Center for Atmospheric Research,## Boulder, Colorado
&North Carolina State University, Raleigh, North Carolina, and Purdue University, West Lafayette, Indiana
**Indian Institute of Technology, Kharagpur, India
++Department of Meteorology, The Pennsylvania State University, University Park, Pennsylvania

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ABSTRACT

The flux-adjusting surface data assimilation system (FASDAS) is developed to provide continuous adjustments for initial soil moisture and temperature and for surface air temperature and water vapor mixing ratio for mesoscale models. In the FASDAS approach, surface air temperature and water vapor mixing ratio are directly assimilated by using the analyzed surface observations. Then, the difference between the analyzed surface observations and model predictions of surface layer temperature and water vapor mixing ratio are converted into respective heat fluxes, referred to as adjustment heat fluxes of sensible and latent heat. These adjustment heat fluxes are then used in the prognostic equations for soil temperature and moisture via indirect assimilation in the form of several new adjustment evaporative fluxes. Thus, simulated surface fluxes for the subsequent model time step are affected such that the predicted surface air temperature and water vapor mixing ratio conform more closely to observations. The simultaneous application of indirect and direct data assimilation maintains greater consistency between the soil temperature–moisture and the surface layer mass-field variables. The FASDAS is coupled to a land surface submodel in a three-dimensional mesoscale model and tests are performed for a 10-day period with three one-way nested domains. The FASDAS is applied in the analysis nudging mode for two coarse-resolution nested domains and in the observational nudging mode for a fine-resolution nested domain. Further, the effects of FASDAS on two different initial specifications of a three-dimensional soil moisture field are also studied. Results indicate that the FASDAS consistently improved the accuracy of the model simulations.

1. Introduction

In recent years, much of the research designed to improve atmospheric boundary layer (ABL) simulations has focused on the surface boundary conditions used in atmospheric models. For a given synoptic condition and in the absence of strong advection, both entrainment fluxes at the top of the ABL and, especially, the surface fluxes generally control ABL structure and evolution. Thus, multilevel soil models coupled with vegetative canopy submodels (e.g., Noilhan and Planton 1989; Chen and Dudhia 2001) have become more common and have been coupled with rainfall estimates to provide case-specific soil moisture profiles (e.g., Chen et al. 1996, 2007; Chen and Dudhia 2001). While these submodels and their detailed representation of surface–atmosphere interactions have generally improved simulations, considerable uncertainty in model simulations remains because of a lack of specification of many additional input parameters, some of which may not be available from routine meteorological measurements. Among these input parameters, soil moisture is

+ Current affiliation: Office of Biological and Environmental Research, Office of Science, U.S. Department of Energy, Washington, D.C.
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Corresponding author address: Dr. Kiran Alapaty, Program Director, U.S. Department of Energy, SC-23.3 Germantown Bldg., 1000 Independence Ave. SW, Washington, DC 20585-1290.
E-mail: kiran.alapaty@science.doe.gov

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