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Impact of land surface representation and surface data assimilation on the simulation of an off-shore trough over the Arabian Sea

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ABSTRACT

The accurate simulation of location and evolution of the off-shore trough and its associated inland precipitation is sensitive to the representation of the surface processes within a mesoscale model. The objectives of this study are (i) to investigate the effect of the Noah land surface model (LSM) over a multi-level soil slab model and (ii) focusing on an off-shore trough formed over the Arabian Sea during June 2002, assess the impact on the simulation of improved surface representation using surface data assimilation (SDA) and four-dimensional data assimilation (FDDA). The model used in this study is the Fifth Generation Mesoscale Model (MM5). Four sets of numerical experiments were performed to illustrate the study objectives, and the results of these different simulations are compared with one another, with the analysis, and with the observations. The inclusion of the Noah LSM was observed to contribute to a decrease in the surface moisture content and an increase in the ground temperature over the land regions during the day. These effects in turn resulted in an increase in the surface sensible heat flux and a decrease in the surface latent heat flux over the land during the day. Also, the inclusion of Noah LSM has strengthened the horizontal east–west gradients of the surface humidity due to land sea contrasts and simultaneously reduced the north–south gradients of surface humidity over the land during the day. As is evident in the comparison with ship observations, the inclusion of detailed land surface processes as well as surface data assimilation resulted in improved simulation of surface-sensible and latent heat fluxes. Moreover, the SDA run simulated the strongest vertical wind velocity fields as well as the associated potential vorticity fields as compared with the other runs. We conclude that the improvements in the land surface representation and surface data assimilation not only resulted in more accurate land surface boundary conditions, but also more accurate evolution of the dynamical processes which provided a more accurate simulation of the off shore trough.

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1. Introduction

The earth's land surface is characterized by inhomogeneities in terrain, moisture, vegetation and soil characteristics. These inhomogeneities give rise to horizontal gradients of fluxes in mass, momentum, and energy that provide for three-dimensional circulations which alter the dynamical and thermodynamical structure of the atmosphere. Numerical models need to accurately represent these inhomogeneities of land surface characteristics in order to properly simulate the effects of the land-atmosphere interactions. Also, the numerical models must utilize good quality datasets, to ensure accurate land surface characteristics. The moisture content of the soil and air, and the nature and distribution of vegetation undergoes large changes during the Indian summer monsoon period. Hence, not

entirely surprising is that the regional climate over India during the monsoon rainy season is influenced by land use change and vegetation dynamics (Niyogi et al., 2002; Yasunari et al., 2006; Pielke et al., 2003; Fedemma et al., 2005). A number of studies exist in the recent literature providing positive evidence of the importance of land surface processes both in large-scale atmospheric models (Zhao et al., 2001; Xue et al., 2004), and also in regional and mesoscale atmospheric models (Chen and Dudhia, 2001; Pleim and Xu, 2003; Fu, 2003; Holt et al., 2006; Niyogi et al., 2006; Pielke et al., 2003; Douglas et al., 2006).

A numerical weather prediction model coupled to a land surface model, may not automatically lead to an accurate forecast. Large errors in the atmospheric boundary layer (ABL) simulations may occur due to incorrect surface parameters as well as inappropriate boundary layer formulations and other model deficiencies (Alapaty et al. 1997; Niyogi et al. 1999; Alapaty et al. 2001). These inaccuracies in the ABL simulations can lead to inadequate performance of numerical weather

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