GEOPHYSICAL RESEARCH LETTERS, VOL. 36, L15826, doi:10.1029/2009GL037781, 2009

Possible relation between land surface feedback and the post-landfall structure of monsoon depressions

Hsin-I Chang,[1] Dev Niyogi,[1] Anil Kumar,[1,2,3,4] C. M. Kishtawal,[5] Jimy Dudhia,[2] Fei Chen,[2] U. C. Mohanty,[6] and Marshall Shepherd[7]

Received 16 February 2009; revised 15 May 2009; accepted 29 June 2009; published 14 August 2009.

[1] The effect of pre-storm land surface on the monsoon depressions (MDs) is studied. The Weather Research Forecast (WRF) model was configured with two nested domains to explore the sensitivity of MDs to antecedent soil moisture and land surface representation for selected three landfalling MDs during August 2006. Results indicate that WRF had good ability to simulate the MDs, and the post landfall model response was sensitive to antecedent soil moisture and modestly dependent on land surface representations. This was verified by reviewing the climatology of 125 MDs (1970–2003) which revealed that if the surface received heavier rainfall a week ahead of MD landfall, the inland intensity was maintained for a longer duration. The gradient in surface heat fluxes as the depression made landfall affected the evolution of the MDs over India. In particular, warmer, wetter (cooler, drier) land surface can intensify (weaken) the landfalling MDs over the Indian monsoon region. **Citation:** Chang, H.-I., D. Niyogi, A. Kumar, C. M. Kishtawal, J. Dudhia, F. Chen, U. C. Mohanty, and M. Shepherd (2009), Possible relation between land surface feedback and the post-landfall structure of monsoon depressions, *Geophys. Res. Lett.*, *36*, L15826, doi:10.1029/2009GL037781.

1. Introduction

[2] A monsoon depression (MD) over the Indian monsoon region (IMR) is a weak cyclonic disturbance formed over the Bay of Bengal that moves northwestward into the Indian sub-continent. The occurrence of MDs is considered a dominant factor for the total rainfall received over the IMR.

[3] The offshore evolution of MDs is well studied [e.g., *Goswami*, 1987]. However, as the MD approaches land, there is poor understanding about the land – atmosphere interactions [*Vinodkumar et al.*, 2009]. We seek to examine the effect of pre-storm land surface processes as MDs make landfall over the IMR. The research hypothesis is that even though MDs are dictated by synoptic feedbacks, land surface representation and the pre-storm soil moisture condition over the warm IMR will affect the landfalling MD.

2. Study Period and Numerical Experiments

[4] We selected three consecutive landfalling MDs that occurred in August 2006: MD1 (August 2–7), MD2 (August 11–15), and MD3 (August 15–20). MD1 was a large (~500 km) and intense tropical system. A deep depression (988 mb central pressure) was observed on August 3 (MD1), which weakened to a low pressure system (995 mb) after 48h. The system had a long inland track and caused widespread flooding over northeast India, before dissipating over northwest India. MD2 formed as a low-pressure system over the northwest Bay of Bengal on August 11. The system though short-lived, led to isolated heavy rains over most of India. MD3 formed on August 16 and moved northwestward.

[5] There is no research-grade surface-flux or radar/profiler observations archived over the study region. The Indian Meteorological Department (IMD) monitoring forms the backbone of available observations. Eleven surface stations and sounding sites (Figure S1) were used for the model verification and analysis of the results.[8] These stations were selected on the basis of proximity to the storm tracks and data availability. These were supplemented by TRMM Precipitation Analysis (TMPA) [*Huffman et al.*, 2007].

[6] We performed experiments using the Weather Research and Forecasting model (WRF2.2-ARW). We tested different parameterizations over IMR [*Chang et al.*, 2009]. Present study uses two nested domains (30 km, 10 km grid spacing; Figure S1) with the YSU PBL scheme, Grell-Devenyi convective parameterization, RRTM longwave and Dudhia shortwave radiation. 6-hourly 1° NCEP global final analysis provided the model initial and boundary conditions.

[7] The approach was to assess the impact of the land surface feedback, if any, on the three MDs. The WRF model was run with three different land surface schemes: Noah, Slab and Noah-GEM. The Slab model [*Dudhia*, 1996] has no explicit vegetation representation and only soil temperature is estimated prognostically, while soil moisture is a function of land use category only. The Noah model [*Chen and Dudhia*, 2001] has prognostic soil moisture/soil temperature equations and a moderately complex vegetation representation. Noah-GEM [*Niyogi et al.*, 2009] is more complex than Noah with a photosynthesis-based canopy resistance formulation. In this study, the Noah run is the control, while the Slab and

[1]Department of Agronomy and Department of Earth and Atmospheric Sciences, Purdue University, West Lafayette, Indiana, USA.
[2]National Center for Atmospheric Research, Boulder, Colorado, USA.
[3]Now at Hydrological Sciences Branch, NASA Goddard Space Flight Center, Greenbelt, Maryland, USA.
[4]Now at Earth System Science Interdisciplinary Center, University of Maryland, College Park, Maryland, USA.
[5]Indian Space Research Organization, Ahmedabad, India.
[6]Indian Institute of Technology, New Delhi, India.
[7]Department of Geography, University of Georgia, Athens, Georgia, USA.

0094-8276/09/2009GL037781$05.00

[8]Auxiliary materials are available in the HTML. doi:10.1029/2009GL037781.