WATER RESOURCES RESEARCH, VOL. 49, 3589–3600, doi:10.1002/wrcr.20301, 2013

# Enhancement of inland penetration of monsoon depressions in the Bay of Bengal due to prestorm ground wetness

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Received 28 December 2011; revised 2 May 2013; accepted 2 May 2013; published 20 June 2013.

[1] Observations of 408 monsoon low-pressure systems (MLPSs) including 196 monsoon depressions (MDs) that formed in the Bay of Bengal during the 1951–2007 period, and the gridded analysis of daily rainfall fields for the same period, were used to identify the association of antecedent rainfall (1 week average rainfall prior to the genesis of MLPS) with the genesis of MLPS and length of inland penetration by MDs. Prestorm rainfall is treated as a surrogate to prestorm ground wetness conditions due to unavailability of historical soil-moisture data over the monsoon region. These observations were analyzed using self-organizing maps (SOMs) to group nine different prestorm monsoon rainfall patterns into different transition states like active, active-to-break, break-to-active, break, etc. The analysis indicates that MLPS are four times more likely to form on a day during active monsoon state compared to break state. Analysis of MLPSs linked to each monsoon state represented by SOM nodes shows that MDs with higher inland penetration were associated with higher antecedent rainfall. On the other hand, there was no significant difference in low-level atmospheric circulation for MDs with shortest and longest inland penetration.

**Citation:** Kishtawal, C. M., D. Niyogi, B. Rajagopalan, M. Rajeevan, N. Jaiswal, and U. C. Mohanty (2013), Enhancement of inland penetration of monsoon depressions in the Bay of Bengal due to prestorm ground wetness, *Water Resour. Res.*, *49*, 3589–3600, doi:10.1002/wrcr.20301.

## 1. Introduction

[2] Monsoon lows and monsoon depressions (MDs hereafter), together termed as monsoon low-pressure systems (MLPSs) are arguably the most important rain-bearing weather systems for the Indian subcontinent during the Indian summer monsoon (ISM) season. *Yoon and Chen* [2005] reported that MDs contribute to about 45%–55% of the total monsoon seasonal rainfall. About 9–10 MLPSs form in each monsoon season providing copious amounts of rainfall along their tracks [*Krishnamurti*, 1979; *Sikka*, 1977]. The rainfall structure in a MLPS is maintained by moisture convergence coupled with lower tropospheric circulation. The unique topography of Indian peninsula and Indo-China/Myanmar region favors the formation and development of MDs in warm and moist air over the Bay of Bengal [*Holt and Sethuraman*, 1986]. Latent heat release due to organized convection [*Shukla*, 1978], barotropic instability [*Krishnamurti et al.*, 1980; *Nitta and Masuda*, 1981] as well as moist baroclinic instability [*Arakawa and Moorthi*, 1988; *Krishnakumar et al.*, 1992; *Aravequia et al.*, 1995] has been shown to be an important mechanisms for the genesis and development of MDs. After their genesis in the Bay of Bengal, the MLPS move on the west-northwest track along the monsoon trough to the warmer and drier heat low regions of northwest India and Pakistan. *Goswami* [1987] concluded that the west-northwest movement of the MLPS is due to the generation of mixed Rossby-gravity waves to the west of the initial diabatic heat source over the Bay of Bengal. This creates maximum moisture convergence in the west-northwest direction, leading to a continuous positive feedback loop.

[3] Due to the significance of the MLPS in the ISM rainfall, the distance of their inland penetration and the amount of time spent by these systems over the land can often lead to widespread flooding and loss of life and property and is of significant interest for hydrological, meteorological, and agricultural applications. Tropical systems weaken rapidly after landfall due to the lack of surface moisture fluxes [*Kaplan and DeMaria*, 1995]. Heterogeneities in the landscape structure (e.g., soil moisture, surface roughness, albedo, vegetated land cover, and stomatal conductance) tend to create mesoscale boundaries that can impact mesoscale circulation, convection, and precipitation [*Anthes*, 1984; *Avissar and Liu*, 1996; *Segal and Arritt*, 1992; *Pielke*, 2001; *Pielke and Niyogi*, 2010]. Soil moisture plays a predominant role because of its key influence on the partitioning of energy into sensible and latent heat fluxes at the

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0043-1397/13/10.1002/wrcr.20301