



Local onset of monsoon defined by critical values of atmospheric variables: Indian summer monsoon case

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Monsoon onset is the most awaited event for more than a billion people in India because monsoon rainfall is a source of life for the population. The abruptness of the transition to monsoon and its spatial and temporal variability from year to year are key features of the phenomenon that makes predicting the monsoon's onset a scientific challenge. According to Ananthakrishnan and Soman, 1988, [1], the onset of a monsoon is a transition from a regime of sporadic rainfall to spatially organized and temporally sustained rainfall. Our recent study [2] added a single word to this definition by discovering that a transition to monsoon is a 'critical' transition. We defined two states in the transition: pre-monsoon and monsoon. Between two states must be a critical point - a threshold in the atmospheric variables (near-surface air temperature, relative humidity). We found that the monsoon begins when the variables overcome a critical threshold. This finding allowed us to develop and successfully implement [3] the methodology of the long-term forecast of monsoon onset and withdrawal in Central India, Northern Telangana, and Delhi: 40 days before the onset date and 70 days before the withdrawal date. Building on these findings, I move forward to understand how to describe the critical conditions for a local onset and withdrawal of monsoon in every state in India, where the monsoon forecast desperately needs.

Here, I present a definition of monsoon onset for every location based on critical values of three atmospheric variables: temperature (T_c), relative humidity (RH_c), and outgoing longwave radiation (OLR_c). The OLR is included in the critical points set because it is a crucial indicator for the upcoming monsoon characterizing convective activity, implying scarcity or deep convective clouds. The critical values (T_c , RH_c , OLR_c) for every location can be revealed from the historical observations: near-surface temperature and relative humidity at 1000 hPa from NCEP/NCAR reanalysis and OLR data from NOAA. The three critical points do not always appear simultaneously; the dates might differ from one to three days. Hence, monsoon onset occurs when all three variables pass a critical threshold. I anticipate the definition to be a starting point for other monsoon-related applications, such as planning agriculture season, the water and energy resources management.

Importantly, a vulnerable period could appear between monsoon onset and sustainable rainfall - a

dry spell after initial rainfall strongly affecting the agriculture sector. I work towards a deeper understanding of the precursors of a dry spell and its extremes and uncover how to avoid false alarms that are disastrous for farming.

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[1] Ananthakrishnan R., and M. K. Soman, 1988: The onset of southwest monsoon over Kerala: 1901-1980. *J. Climatol.*, 8, 283–296.

[2] Stolbova, V., E. Surovyatkina, B. Bookhagen, and J. Kurths (2016): Tipping elements of the Indian monsoon: Prediction of onset and withdrawal. *GRL* 43, 1–9 [doi:10.1002/2016GL068392]

[3]<https://www.pik-potsdam.de/members/elenasur/forecasting-indian-monsoon/welcome-to-the-pik-monsoon-page-1>