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Increase in north-east monsoon precipitation by rapid Indian Ocean warming and a strengthening inter-ocean thermal gradient

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Indian monsoon, being one of the most important and regular tropical climate phenomenon, shapes the livelihood of one-sixth of the global population. Compared to its boreal summer counterpart, a cause-effect relationship of winter monsoon precipitation receives less attention. The North-easterly wind picks up moisture from the Bay of Bengal (BoB) and provides heavy to moderate over southern India and this winter monsoon phase (Oct-Dec) is commonly referred as North-east monsoon (NEM). In contrast to the steady decrease of summer monsoon precipitation over central parts of the Indian subcontinent, southern India has witnessed a substantial increase in NEM precipitation in past decades. The causal factors behind the intensification of NEM precipitation remain enigmatic due to a dearth of investigations.

In the present study, the roles of sea surface temperature (SST), tropical cyclone heat potential (TCHP) and mixed layer heat content (MLHC) in BoB have been studied to provide a detailed perspective of NEM precipitation pattern over southern India. For this purpose, gridded climate dataset (CRU, NOAA ERSST, ECMWF ORAS4, NCEP/NCAR Reanalysis) at a finer spatial resolution has been used.

Our study shows that SST, TCHP, and MLHC are positively correlated with NEM precipitation and MLHC yields the highest correlation ($R=0.64$, $P<0.05$) with the winter monsoon precipitation for the past 60 years. These factors result in the enhanced moisture evaporation from BoB is related to the increasing trend of SST, TCHP and MLHC which in turn are governed by atmospheric parameters like total cloud cover, downward solar radiation flux, wind stress curl and freshwater flux from the major rivers (like Irrawaddy and Salween flowing through Myanmar) to ocean.

The intensity of north-easterly wind has also been monitored for the last 60 years as its intensity plays a crucial role in the transport of precipitable water content from BoB to southern India. It has been observed that the air-temperature gradient between the north-western Pacific and Arabian Sea warm pool governs the north-easterly wind intensity ($R=0.58$, $P<0.05$). The progressive increasing temperature difference between north-western Pacific and Arabian Sea warm pool is thus attributed to the increase in horizontal transport of precipitable water. Our study also identifies the changes in upward vertical transport of precipitable water in BoB and downward transport in southern India in order to assess the role of the Walker circulation. The regression analysis exhibits an increasing trend of upward transport in the BoB and downward transport in southern India. In conclusion, the regional factors (SST, TCHP, and MLHC) in combination with the remote forcing parameters (the air-temperature gradient and Walker circulation) are responsible for governing NEM precipitation pattern over southern India.