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## The variability of landfalling cyclonic disturbances over North Indian Ocean and consequent rainfall contribution to India in warming climate scenario

Kasturi Singh<sup>1</sup> and Jagabandhu Panda<sup>2</sup>

<sup>1</sup>National Atmospheric Research Laboratory, Department of Space, Andhra Pradesh, India (kasturi.env@gmail.com)

<sup>2</sup>Department of Earth and Atmospheric Sciences, National Institute of Technology Rourkela, Odisha, India (jagabandhu@gmail.com)

Tropical cyclones (TCs) and warming climate, both possess significant importance to human life. Both of these aspects are quite interesting for several researchers as TCs are one of the deadliest systems formed over the ocean and the warming climate either enhances or suppresses their formation. Moreover, the landfalling TCs are the primary reason that causes a high death toll and property loss every year. Limited studies focused on the impact of the warming climate on the landfalling cyclonic disturbances (CDs) of the North Indian Ocean (NIO), and consequently the vulnerable states of India to TC landfall and rainfall occurrence. In order to conduct the study, the pre-warming period (PWP) is defined from 1880-1946 and the current warming period (CWP) from 1947 onwards based on the sea surface temperature (SST) variations over NIO.

The analysis of the impact of warming climate on landfall activity of NIO CDs reveals that Bangladesh (BD), Andhra Pradesh (AP), and Tamil Nadu (TN) are more vulnerable to severe cyclones formed over the Bay of Bengal (BOB) during the CWP. Among western coastal states, Gujarat (GJ) is prone to severe cyclonic storms and Arabian Peninsula countries are vulnerable to cyclonic storms formed over the Arabian Sea (AS) during CWP. During PWP, the most vulnerable places to landfalling CDs were Odisha (OD), AP, and West Bengal (WB). Overall changes in the tracks of the CDs are noted during the CWP. Accordingly, BD and Arakan are found to be more vulnerable to landfalling CDs in the CWP pre-monsoon season, whereas in post-monsoon months, AP, TN, and BD are more prone coastal areas of BOB. The seasonal analysis of change in genesis location of CDs during PWP and CWP over both BOB and AS agrees well with the overall landfall locations. Altering in wind direction from NW to N-NW and increased meridional SST during CWP over BOB are found to be encouraging the landfall activity near AP and TN coasts. The W-SW and zonally distributed SST possibly supports landfall activity over Gujarat.

Furthermore, the CD contributed rainfall (CDR) over India is also investigated using high-quality reliable daily rainfall data during CWP. Among eastern coastal states, the AP, TN, OD, and southern WB, and among western coastal states, Karnataka (KA) and Kerala (KL) suffer maximum rainfall from pre-monsoonal CDs. Gujarat received ~70%, and both AP and TN received up to 20-30% of CDR during pre-monsoon months. During the post-monsoon season, coastal AP, TN,

OD, KA, and coastal KL received higher accumulated CDR. During the post-monsoon season, Gujarat, OD, and AP received a maximum rainfall contribution of up to 50%. Owing to the stable CDR trend along with decreasing CD frequency, the results indicate an increased rainfall contribution by CDs during the post-monsoon months. The current study would be highly beneficial for disaster management plans while India is experiencing developmental growth.