Response of landfalling North Indian Ocean cyclonic disturbances to warming climate and associated environmental parameters

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Most of the studies focusing on cyclonic disturbances (CDs) concentrate on their frequency. However, the system that causes destruction to nearby coastal areas is the landfalling one. The impact of warming climate on landfalling CD activity is an interesting topic. Thus, the present study focuses on the landfalling activity of CDs formed over North Indian Ocean (NIO) and associated environmental parameters responsible for the same. The study is divided into two epochs i.e. pre-warming period (PWP) 1891-1946 and current warming period (CWP) 1947-2016 based on the sea surface temperature anomaly variation.

Over NIO, nearly 88 and 84.80% of systems made landfall over coastal areas associated with Bay of Bengal (BOB) basin and the respective percentages are 53.03 and 39% for AS during PWP and CWP respectively. The percentage of landfalling CDs shows a decreasing and stable trend respectively during PWP and CWP for BOB sub-basin. Over AS, the Kendall’ s coefficients are found to be −0.255 and −0.0024 during PWP and CWP respectively. The study reveals that Bangladesh, Andhra Pradesh (AP), and Tamil Nadu (TN) are more vulnerable to severe cyclones formed over BOB during the current warming climate. Whereas, for Arabian Sea (AS) region, Gujrat (GJ) is prone to severe cyclones and Arabian Peninsula countries are vulnerable to cyclonic storms during the current warming climate. For pre-monsoon season, among all NIO coastal states, Bangladesh and Arakan face a greater number of CD landfalls during CWP for BOB systems. Whereas, for post-monsoon season, AP, TN and Bangladesh suffered maximum landfalls. The seasonal landfalling activity of CDs over AS shows that Arabian Peninsula is more vulnerable than GJ in pre-monsoon season during CWP. However, for post-monsoon season, both Arabian Peninsula and GJ are significantly prone to landfalling CDs. During PWP, most of the systems formed over middle sector of BOB recurve in north-eastward direction. Whilst, one climatological track is found to be recurving towards Bangladesh, another one is towards AP during CWP. CDs formed over southern sector of BOB prefers two tracks, one being westward towards TN and the other is in north-east direction towards Bangladesh during CWP. The enhanced genesis over southern and middle sector of BOB is mainly responsible for more landfalls over AP, TN and Bangladesh. The CDs formed over the eastern AS basin recurve to make landfall over GJ or Oman during PWP. However, during CWP, another preferable track towards Yemen is also seen for the systems formed over eastern AS.

The climatological vertically integrated (mass-weighted) tropospheric wind pattern near TN coast has changed direction from westward during PWP to north-westward during CWP (Figure 1), favouring more landfall over AP and TN. Over the central part near the latitude 14˚N, change in the magnitude has occurred with change in the direction of the winds from NW-N to NE. Because of the prevailing wind steering pattern, the systems that formed over the middle and southern BOB do not prefer to make landfall to WB and Odisha during CWP. Over AS, the wind is mostly directed towards GJ irrespective of the period considered, which favours more landfalling of CDs over the place. These winds are primarily part of mid-latitude westerly troughs. For BOB, the SST gradient is in meridional direction and hence most of the systems formed, suffer landfall over Indian coastal states and other rim countries face less landfalls. Over AS, SST gradient is zonally distributed and therefore, the eastward deflection of CDs is more observed, making the Indian state of GJ to be the most affected region. The study is expected to be helpful in the decision-making process in view of socio-economic impacts of landfalling CDs.

Keywords: Cyclonic disturbances, North Indian Ocean, Landfall, Bay of Bengal, Arabian Sea

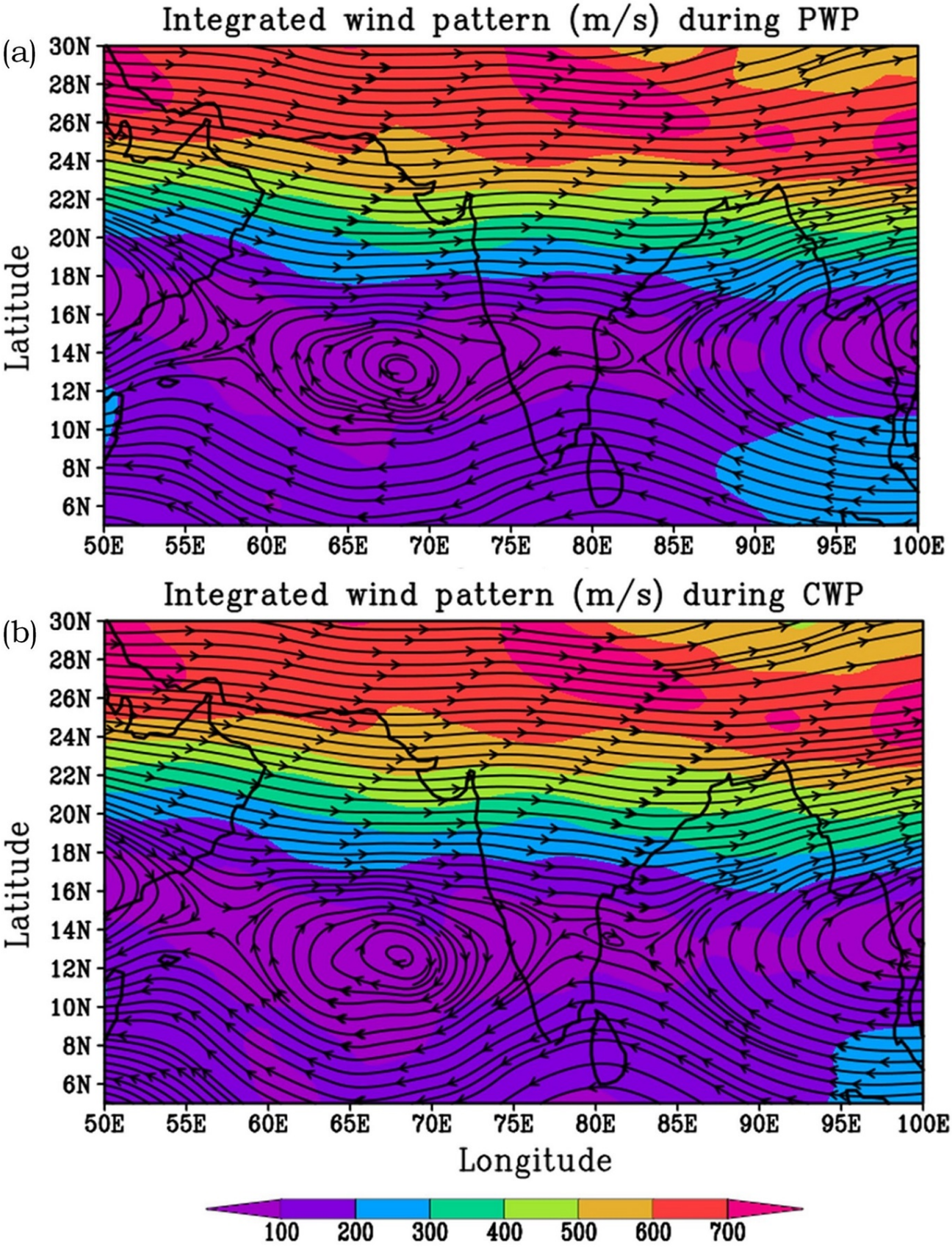

Figure 1: Climatological variation of mass weighted vertically integrated tropospheric wind magnitude (shaded) and wind pattern (vector) in m/s over NIO for the period 1891-2014 during PWP (a) and CWP (b). Here, NOAA-CIRES global re-analyses data set is used.

