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Reanalysis dataset-driven assessment of super cyclonic storm Fani and extremely severe cyclonic storm Amphan over the Bay of Bengal, India

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ABSTRACT

This study uses European centre for medium-range weather forecasts (ECMWF) reanalysis 5 (ERA5) and Indian monsoon data assimilation and analysis (IMDAA) reanalysis datasets, to examine the characteristics and evolution of extremely severe cyclonic storm Fani and super cyclonic storm Amphan over the Bay of Bengal. Key parameters analysed include track, track error, mean sea level pressure, maximum sustained wind, potential vorticity and wind vector. For Amphan, all the parameters are assessed, while for the Fani, potential vorticity, and wind vector are not included. Results from both reanalysis datasets are compared with IMD observations. The comparison reveals that IMDAA provides better representation of most dynamical and structural features such as landfall-time track, mean sea level pressure, maximum sustained wind, potential vorticity, and wind fields particularly for Amphan. Conversely, ERA5 performs slightly better in estimating track errors for both cyclones. Overall, IMDAA dataset emerges as more reliable for analysing the tropical cyclones over the Bay of Bengal.

Keywords: Tropical cyclones**,** Fani**,** Amphan**,** Reanalysis datasets, Bay of Bengal.

INTRODUCTION

Tropical cyclones pose major threats to coastal regions due to strong winds, storm surges, and landfall impacts. About 80 tropical cyclones occur globally each year, with the North Indian Ocean contributing nearly 7%, including 1% over the Arabian Sea and 6% over the Bay of Bengal (McBride and Fraedrich, 1995; Kalnay et al., 1996). Tropical cyclone 'Fani' rapidly intensified into an extremely severe cyclonic storm before striking Odisha, causing widespread damage despite effective evacuations. One year later, 'Amphan' became the first super cyclone over the southeast Bay of Bengal in two decades, resulting in severe socio-economic impacts.

Recent studies using mesoscale models and data assimilation have improved understanding of tropical cyclone track, structure, and intensity (Montgomery et al., 2006; Rajasree et al., 2016). This study highlights the role of global reanalysis datasets, which are available at resolutions from 0.25° to 0.125°, and are essential for diagnosing tropical cyclone behaviour, conducting climatological analyses, and providing initial and boundary conditions for regional forecasting models (Thorne and Vose, 2010).

Extensive studies have examined the use of reanalysis datasets and numerical simulations for diagnosing tropical cyclone behaviour over the North Indian Ocean (Mohanty et al., 2004; 2010; Osuri et al., 2013). Reanalysis-based studies have contributed to tropical cyclone climatology, large-scale mechanisms of tropical cyclone evolution, power dissipation estimates, and analyses of tropical cyclone track, intensity, and life cycle (Maloney et al., 2000; Sriver and Huber, 2006; Schenkel and Hart, 2012). Metrics for representing outer wind structures in reanalysis datasets have also been refined (Murakami, 2014; Bian et al., 2021). Despite forecasting improvements, further advancements in track and intensity prediction remain necessary (Mohapatra et al., 2013a, b; 2015)

Several recent studies have focused on 'Fani' and 'Amphan'. Alam (2020) assessed weather research forecast (WRF) parameterization sensitivities for simulating Fani, while Mohan et al. (2022) examined sea surface temperature-driven intensification mechanisms of both cyclones.

Naskar and Pattanaik (2023) linked cyclone intensity to environmental factors such as sea surface temperature, instability, moisture, wind shear, and latent heat flux and Hossain et al. (2022) evaluated weather research forecast model performance for the genesis and intensification of Fani.

Besides, Johari et al. (2023) analysed land surface model impacts on track, mean sea level pressure, maximum sustained wind, and rainfall and Kumar et al. (2024a) analysed that spatial distribution of wind and vertical integrated moisture transport using weather research forecast model are well matched with the ERA5 reanalysis datasets. Apart from these studies, Kumar et al. (2024b) simulated tropical cyclone 'Amphan' using weather research forecast model.

Present study compares two reanalysis datasets-ERA5 and IMDAA by evaluating key characteristics of landfalling tropical cyclones 'Fani' and 'Amphan' over the Bay of Bengal. The analysis focuses on track, track error, maximum sustained wind, mean sea level pressure, wind vectors, and potential vorticity. Additionally, the study relates potential vorticity fields to their mathematical formulations and examines synoptic features associated with both cyclones to improve understanding of their evolution and dynamics.