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Comparison of characteristics associated with super cyclonic storm 'Amphan' using numerical model WRF-ARW analysis and ERA5 reanalysis

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ABSTRACT

The numerical simulation is performed to study the super cyclonic storm (SuCS) 'Amphan' by using the advanced research weather research and forecasting (WRF-ARW) model with 9 km resolution and in single domain while running WRF Pre Processing System (WPS) over the Bay of Bengal (BoB). The super cyclonic storm (SuCS) 'Amphan' originated over south Andaman Sea, which touched southeast BoB on 13th May 2020. The super cyclonic storm (SuCS) 'Amphan' underwent rapid intensification into a very severe cyclonic storm (VSCS) on 17th May 2020 and subsequently converted into extremely severe cyclonic storm (ESCS) on 18th May 2020 and finally into a super cyclonic storm (SuCS) around 1200 UTC of 18th May 2020 till next 24 hours, before weakening into ESCS and laid down as a low-pressure region over north Bangladesh and neighbourhood around mid-night of 21st May 2020. In this study, high resolution advanced research weather research and forecasting (WRF-ARW v4.1.2) with the combination of the Yonsei University (YSU) planetary boundary layer (PBL), Kain-Fritsch (KF) cumulus convection, and Ferrier microphysics scheme, is used for the simulation of SuCS 'Amphan'. Spatial distribution of wind, potential vorticity (PV), and vertical integrated moisture transport (VIMT) are analysed for the intensity and the behaviour of the characteristics of SuCS 'Amphan'. Fifth generation of European center for medium-range weather forecast (ECMWF) atmospheric reanalysis of global climate (ERA5) resolves the atmosphere with 137 levels from the surface at the height of 80 km. ERA5 gives hourly estimations of a big number of atmospheric variables and covers the Earth on a 31 km grid. ERA5 observations are used for the validation of WRF-ARW model results. It is observed that spatial distribution of wind and vertical integrated moisture transport (VIMT), are well matched with the observations. The study is a prelude for sensitivity analysis and data assimilation using four-dimensional variational data assimilation (4DVAR) technique.

Keywords: WRF-ARW Model, Tropical cyclone, Bay of Bengal, Super Cyclonic Storm (SuCS) Amphan, ERA5 Reanalysis.

INTRODUCTION

The Bay of Bengal (BoB) and Arabian sea (AS) are contributing almost seven percent of entire tropical cyclones (TCs) around the world (IMD Atlas, 2008). According to Indian Meteorological Department (IMD), tropical cyclones (TCs) over Bay of Bengal (BoB) are more frequently occurring than tropical cyclones (TCs) over Arabian sea (AS) (WMO, 2008). Every year tropical cyclones (TCs) are originating in North Indian Ocean (NIO) ranging in various categories and some of them are very much harmful for loss of life and economy of the larger area of Indian states. These tropical cyclones (TCs) are influenced by the bathymetry, and dynamical characteristics over North Indian Ocean (NIO), socio economic conditions, and dense population. The non-landing tropical cyclones (TCs), in general, are more frequent than landfalling tropical cyclones (TCs) over the Bay of Bengal. 8 cases of 10 highly severe tropical cyclones (TCs) that occurred in different part of world were from the Bay of Bengal (BoB) and Arabian sea (AS) (IMD Atlas, 2008). The simulation of the tropical cyclones (TCs) using mesoscale model is a necessary aspect to analysis of various parameters associated with the prediction of tropical cyclones (TCs). Therefore, the advanced research weather research and forecasting (WRF-ARW) model is used to study various parameters. The WRF-ARW model refers to the weather research and forecasting (WRF) model with the advanced research weather research and forecasting (WRF) dynamical core. This version of the weather research and forecasting (WRF) model uses a more advanced set of equations and algorithms for atmospheric simulations, allowing for high-resolution and accurate weather forecasting. The comparison of the results WRF-ARW model and fifth generation of European center for medium-range weather forecast (ECMWF) atmospheric reanalysis of global climate (ERA5) reanalysis datasets are also shown in this study. Various global and mesoscale models e.g WRF-ARW model and, fifth generation of European center for medium-range weather forecast (ECMWF) atmospheric reanalysis of global climate (ERA5) reanalysis datasets, have been developed to improve at least 48 hours tropical cyclones TCs track prediction, intensity, and precipitations (Gupta, 2021). Many attempts have been made to improve performance of the model through nested domains, improving initial and boundary conditions (IBCs), and physical parameterizations, etc. Ooyama, (1969) simulated the life of tropical cyclones and discussed the basic mechanism of tropical cyclones (TCs). A cumulus parameterization (CP) scheme is studied to parametrize the convection in the models. Cumulus convection is an important factor in the progress and strengthening of tropical cyclones (TCs) (Anthes, 1977). Kain and Fritsch, (1990) have studied the dependency of cumulus parameterization (CP) scheme on the rate of sub grid