Impact of Reanalysis Forcing Data – NCEP-FNL, NASA-MERRA and ECMWF-ERA Interim on Tropical Cyclone Forecasts: An Analysis over the North Indian Ocean

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Accuracy of cyclone models is heavily dependent on the representation of vortex in the model initial condition and the amount of data coverage to initialize tropical cyclone (TC) environment condition. Numerical models are steadily progressing in accurately predicting cyclone track and intensity in the last decade and are able to simulate physical mechanisms associated with TCs, but still heavily rely on initial and boundary forcing provided through the reanalysis data as model input and every reanalysis data behaves in a differently and has different bias for each region. This study investigates the impact of boundary forcing data provided by three reanalysis systems – National Centers for Environmental Prediction Final Analysis (NCEP-FNL), National Aeronautics and Space Administration Modern Era Retrospective-Analysis for Research and Applications (NASA-MERRA) and European Centre for Medium-Range Weather Forecasts-ERA Interim (ECMWF-ERA Interim) on the TC simulations over North Indian Ocean (NIO). NCEP-FNL is produced with 1.0 degree resolution and 26 vertical levels prepared operationally every six hours but initialized three hours later than NCEP-GFS analysis data to include more surface observation and is one of the widely used reanalysis data set. NASA-MERRA is conducted with Atmospheric Data Assimilation System (ADAS) that includes GOES-5 model with Grid-point Statistical Interpretation (GSI). The output data resolution is 1/2 × 2/3 degrees with 72 vertical layers prepared at higher frequencies and aims to improve upon the hydrological cycle in the previous generation reanalyses. ERA-interim is the next generation extended reanalysis envisaged at ECMWF and produces output with resolution 1.5 degrees and 37 vertical levels. Although these analyses systems assimilate almost the same input data, they differ among each other in data processing, model structure and the horizontal and vertical resolutions of various physical parameterizations. The synoptic wind circulation and other atmospheric parameters from these data sets contain inherent biases. The objective of this study is to study the impact of these reanalysis data products on cyclone prediction in the NIO basin using high resolution mesoscale model.

All experiments have been performed with Advanced Hurricane WRF (AHW) which is a sub-set of WRF-ARW model with domains configured over Bay of Bengal (BOB) and Arabian Sea (AS). The domain

resolution used is 12:4:1.33 km with moving nests of the inner two grids and are two way nested. The study involves seven recent cyclones over the Indian monsoon region (IMR) and results are analyzed for different cyclone characteristics. Particular emphasis is on two cyclones – Laila in the BOB and Phet in the AS. Track, intensity, PV analysis and Domain bias study is conducted to clearly bring out the impact of boundary forcing on cyclone forecasts. The simulated track and intensity of cyclones significantly differ with different reanalyses and the intensity of TCs is generally over estimated. Analysis of synoptic winds at 850 and 500 hPa show differences in vortex initialization with differences in wind speeds across domain. The initial model state also differs in potential vorticity and potential temperature fields with notable impact of reanalysis datasets in the first 48 hours of simulation. MERRA based simulation resulted in good agreement with the intensity of cyclones Laila and Phet and relatively better minimum sea level pressure in comparison with other two forcings but had a negative bias in moisture representation leading to decreased precipitation patterns. However, overall analysis of all seven cyclones shows that NCEP – FNL forcing based simulations produced better track, intensity and central pressure relative to NASA-MERRA and ECMWF-ERA Interim. The results from this study would likely benefit and guide the TC simulations over the IMR using high resolution mesoscale models.

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