Forecast of rapid intensification and structure of severe cyclonic storm over the Bay of Bengal using high resolution WRF and WRF-3DVAR assimilation system

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INTRODUCTION

- The initial structure and strength of cyclonic vortex is not sufficient, due to the lack of observations (conventional) over the oceans.
- Model initial condition can be improved with assimilation of non-conventional observations specially satellite radiances and hence forecast of the cyclonic storms over the region.
- Due to increasing intensity and hence rapid intensification and structures of extremely severe cyclonic storms (ESCSs wind speed more than 90 knots) has become a research problem and need to improve.
- It is expected that using a high resolution [horizontal (6 km and 9 km) and vertical (73 levels)] model with improved initial conditions through data assimilation technique will provide a better forecast.
- In the present work, an extremely severe cyclonic storm that developed over the Bay of Bengal region in October 2013 named 'Phailin' is considered.

OBJECTIVE

An evaluation on forecast of rapid intensification and structure of severe cyclonic storm Phailin using high resolution modeling system with improved initial condition.

METHODOLOGY

- In the study, regional background error statistics are used in data assimilation.
- The Advanced Research Version of the WRF (ARW) model 3.6.1 was used in the study.
- Two simulations were carried out in a double nested domain of horizontal resolution i) 27 km and 9 km, ii) 18 km and 6 km with the vertical levels about 73.
- The initial condition is improved for both the experiments (9 km and 6 km) through assimilation of satellite radiances (AMSU-A, AMSU-B, HIRS, MHS) and PREBUFR observations in the WRF-3DVAR.
- The initial and boundary conditions are taken from high resolution NCEP GFS analysis and forecasted datasets with 0.5°×0.5° horizontal resolutions.
- The model physics, dynamics, domain selection, vertical levels, and details of assimilation of satellite radiances are taken from previous studies (Singh et al., 2019, 2022).
- Forecasted intensity, structure, rapid intensification, and reflectivity were compared with available observations [India Meteorological Department (IMD) best-fit track data, and Doppler weather radar (DWR) observations].

RESULTS

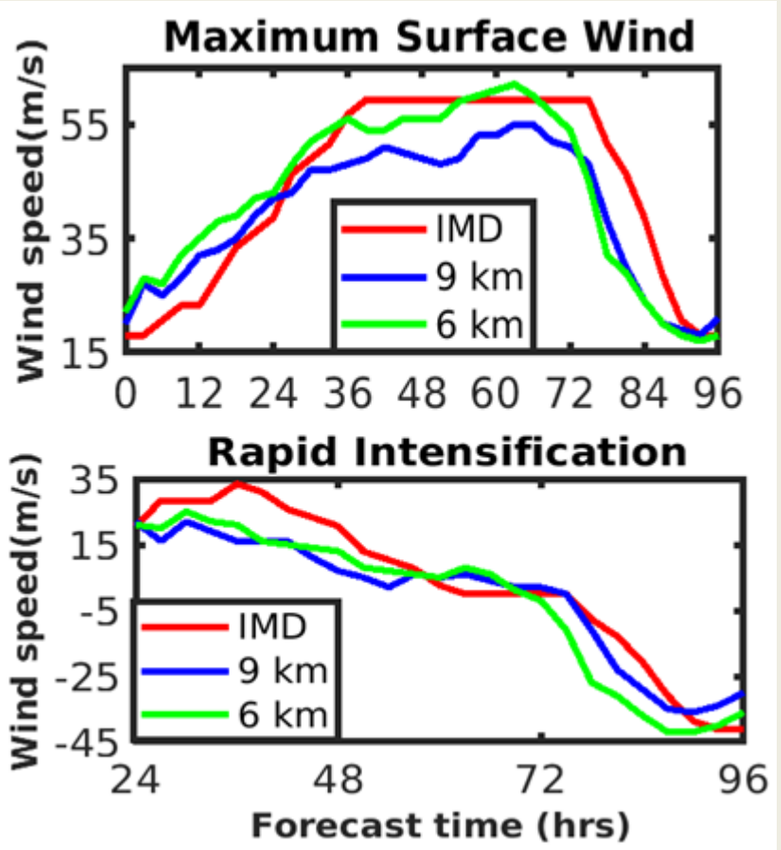

Fig 1: Maximum surface wind (in m/s) and RI (in m/s) during model simulations for ESCS Phailin at 9 km and 6 km respectively.

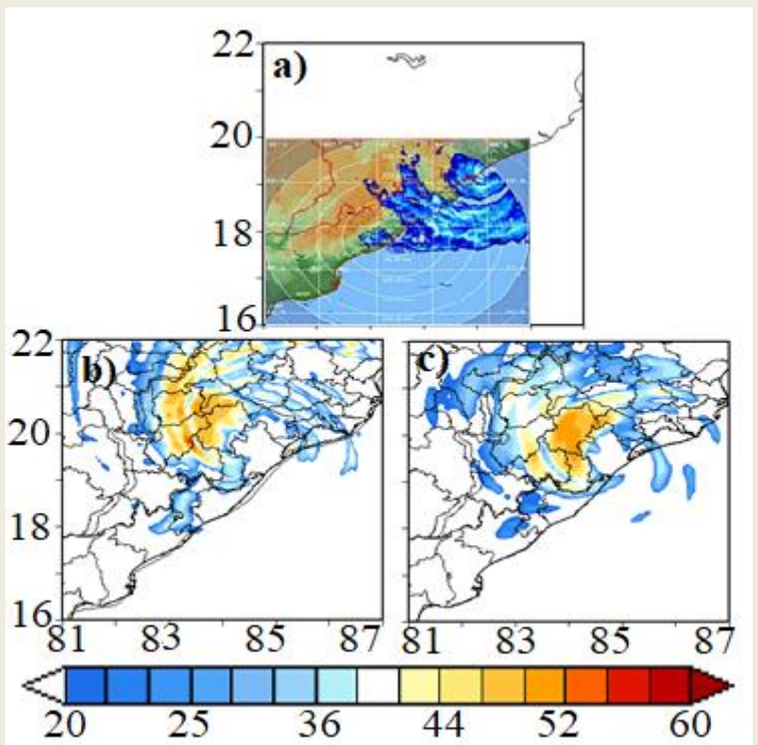

Fig 2: Observed (a) and simulated (b) 6 km (c) 9 km maximum reflectivity at 16 UTC on 12 October 2013.

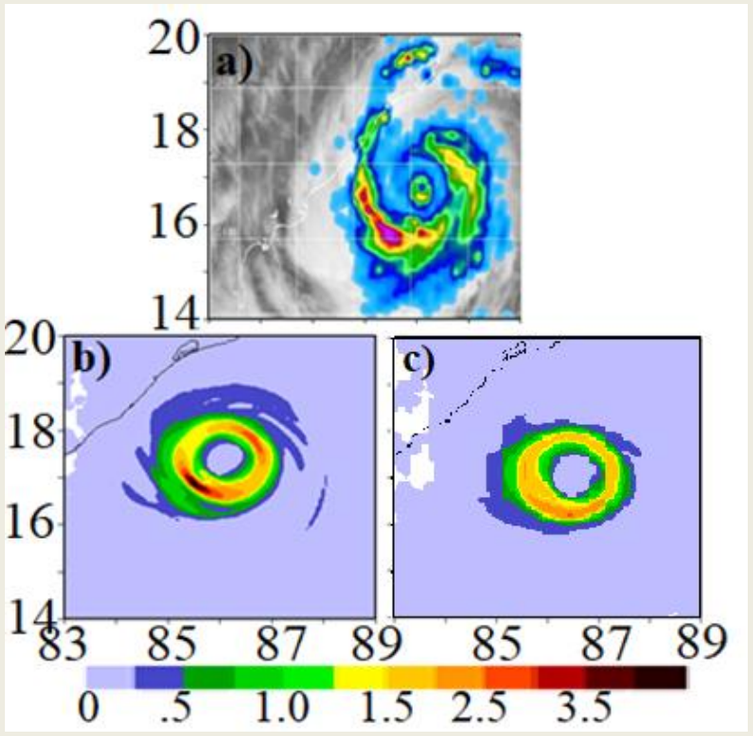

Fig 3: Observed (a) and simulated (b) 6 km (c) 9 km rain-rate at 00 UTC on 12 October 2013.

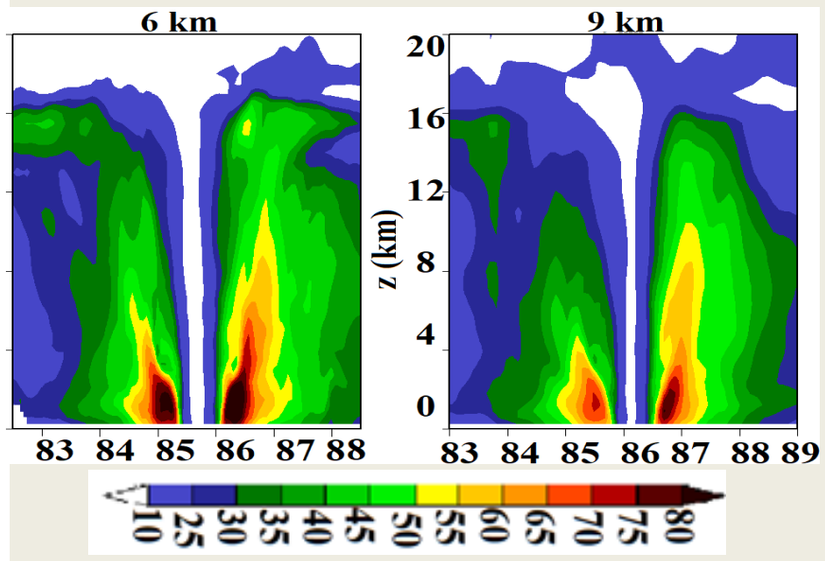

Fig 4: Horizontal wind speed (in m/s) through the center of the storm at 03 UTC on 12 October 2013 at 6 km and 9 km resolution

CONCLUSIONS

- Assimilation of satellite radiances are important to improve the model initial condition and hence improved the forecast of the cyclonic storm Phailin over the Bay of Bengal region.
- The intensity in terms of the maximum surface wind (MSW) of the cyclone was well captured at high horizontal resolution 6 km compared to the 9 km.
- Even though RI and MSW were under-predicted by the model at 9 km horizontal resolution and improved the intensity and rapid intensification at 6 km horizontal resolution.
- The increased horizontal resolution improves the forecast of intensity, rapid intensification, horizontal wind speed, maximum reflectivity and rain-rate of the extremely severe cyclonic storm Phailin.

REFERENCES

- Singh, K.S., Thankachan, A., Thatiparthi, K., Reshma, M.S., Albert, J., Bonthu, S. and Bhaskaran, P.K., 2022. Prediction of rapid intensification for land-falling extremely severe cyclonic storms in the Bay of Bengal. *Theoretical and Applied Climatology*, *147*(3), pp.1359-1377.
- Singh, K.S., Mandal, M. and Bhaskaran, P.K., 2019. Impact of radiance data assimilation on the prediction performance of cyclonic storm SIDR using WRF-3DVAR modelling system. Meteorology and Atmospheric Physics, 131(1), pp.11-28..

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