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Sensitivity of Microphysics parameterizations for a super cyclonic storm

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Abstract

The study focuses on simulating Super Cyclonic Storm AMPHAN, which formed in the Bay of Bengal from May 16-21, 2020. Initially a depression, it intensified into a Super Cyclonic Storm before making landfall on May 20, 2020 as a very severe cyclonic storm along the West Bengal-Bangladesh coast. Using the WRF model with NCEP FNL data at 0.25° x 0.25° resolution and varying Microphysics schemes, the study aims to evaluate model accuracy in predicting rainfall and wind along AMPHAN's path, comparing results with IMD best track data of Mean sea level pressure, wind etc. While the model effectively captures rainfall patterns in some regions, discrepancies in wind speeds and rainfall underscore the importance of standardized cyclone monitoring techniques. Additionally, the study utilizes model-derived Sea Surface Temperature (SST) and high-resolution NOAA SST data (0.25° resolution) with the model derived SST. Optimal scheme combinations have yielded favorable outcomes, emphasizing the potential of the WRF model for cyclone simulation and forecasting.

1. Introduction

Predicting the devastating tropical cyclone and its track and intensity was a challenging thing for the Indian economy especially in the agriculture sector with causes loss of crops harvesting. Many Numerical weather prediction models are accurately predicting its track and reducing the loss of life and properties. At present, India Meteorological Department (IMD) is using high resolution numerical models for early detection and prediction of maximum intensity. The super cyclonic storm AMPHAN originated from Bay of Bengal in the pre monsoon season. It intensified into super cyclonic storm and crossed at West Bengal-Bangladesh coasts. The total length of the track is 1765 Kms. According to WMO (world Meteorological Organization) AMPHAN is the costliest cyclone in North Indian Ocean with reported economic loss of approximately USD 14 billion. The accuracy of the models was based on lateral boundary conditions, computational power and observations. Many studies were carried out on the sensitivity of physics schemes for tropical cyclone simulations. (Pattanayak et al., 2012; Osuri et al., 2012; Rambabu et al., 2013;). There were several authors who carried out sensitivity of different physics schemes like cumulus schemes, microphysics schemes and planetary boundary layer schemes (Choudhury et al 2017, Islam et al 2015, Chandrasekhar and Balaji 2012).
The objective of our present study is to find the sensitivity of Microphysics schemes for the super cyclonic storm AMPHAN with different combinations of other schemes. So, that which microphysics scheme is better representing the intensity of the cyclone.

2. Data & methodology

Initial conditions for the WRF model were used from National Center for Environmental Prediction (NCEP-FNL) of 0.25˚ X 0.25˚ for every six hourly. For AMPHAN cyclone the model integration is started from 00UTC of 16th May 2020 with one single domain of 27Kms resolution. IMD best track data is used for comparison of model and IMD observation data. In this study, by differing microphysics schemes and rest of all physics schemes are fixed were used for the study of AMPHAN cyclone. SST (Sea Surface Temperature) data is obtained from NOAA OI SST from https://psl.noaa.gov/data/gridded/data.noaa.oisst.v2.highres.html. INSAT-3D satellite Thermal Infrared channel image were used. IMD AWS station is used for comparison of model derived rainfall, mslp etc with observations. Conducted different experimental model runs with all the microphysics schemes like Kessler, Lin et al, WSM3 and WSM6 etc.

3.Results & Conclusions:

3.1 Figures

Figure 1 shows the IMD observed track of AMPHAN cyclone from 16th May 2020 to 21st May 2020 with different stages. Figure 2 shows the INSAT-3D satellite image of Thermal Infrared channel with clear EYE formation on 18th May 2020.
Figure 3 shows the NOAA SST averaged from 16th May to 22nd May 2020.
For this study we used WRF model of Version 4.5 with initial conditions from NCEP FNL data of every six hourly. This study is carried out to check the sensitivity of Microphysics for a super cyclonic storm AMPHAN. AMPHAN cyclone has formed as Depression on 16th May

2020 in the pre-monsoon season and intensified into higher stages till super cyclonic storm on 17th May 2020 at 0600UTC and it made land fall near West Bengal-Bangladesh coast in the stage of very severe cyclonic storm. AMPHAN cyclone has made a most severity devastation in the recent decades.

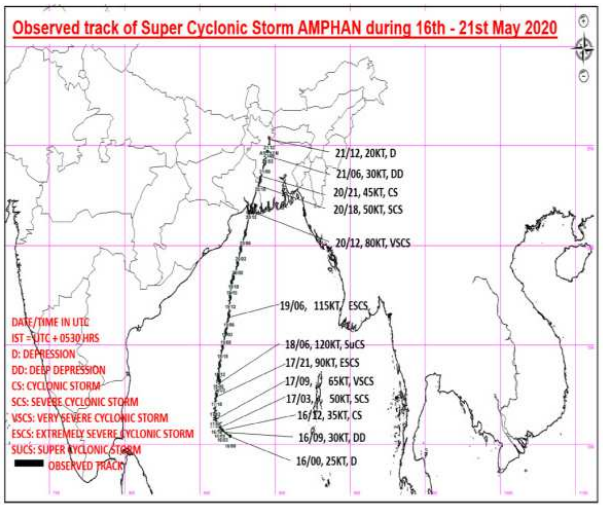

Figure 1. IMD observed track of AMPHAN cyclone from 16th May 00UTC to 21th May 1200UTC 2020.

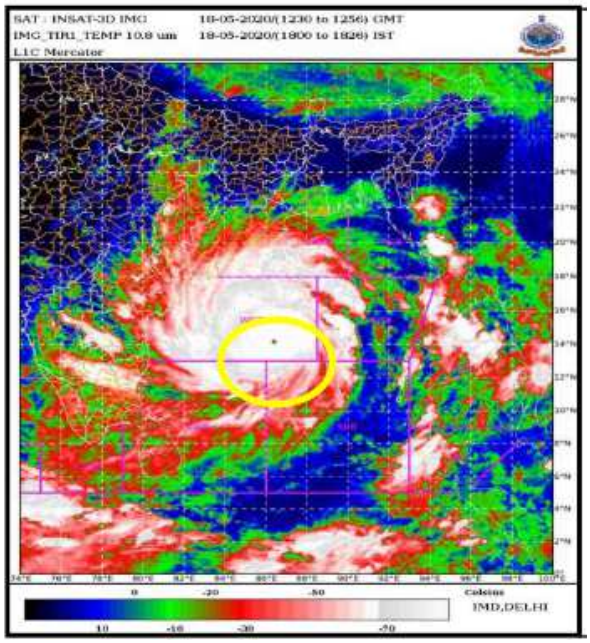

Figure 2. INSAT-3D satellite image of AMPHAN cyclone on 18th May 1200UTC showing clearly the EYE of a cyclone.

WRF model domain was considered from 10 ˚N to 25 ˚ N and 75 ˚E to 100 ˚ E. In this study, model was setup with the above mentioned domain and run with all the different microphysics schemes like WSM6, WSM3, Lin and

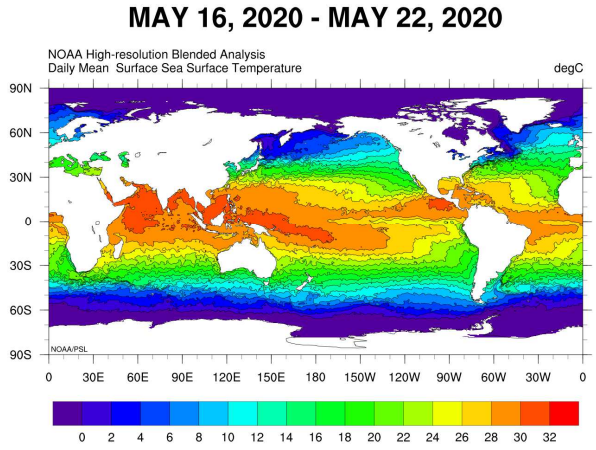

Figure 3. NOAA SST from 16th May to 22nd May 2020

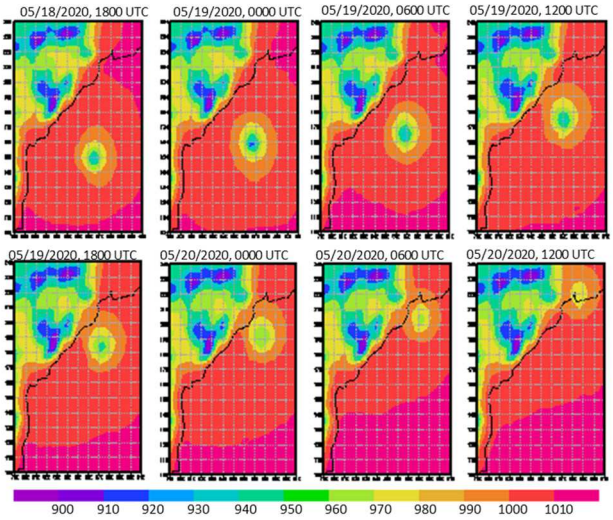

Figure 4. MSLP of AMPHAN cyclone from 18th May 2020 1800UTC to May 20th 1200UTC.

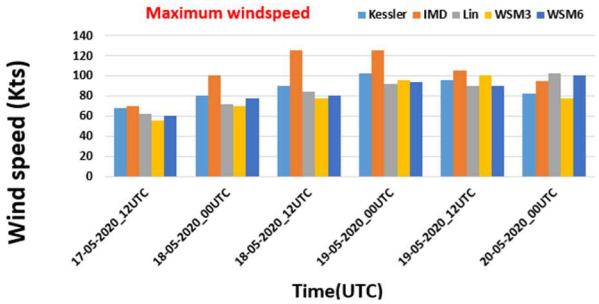

Figure 5. Maximum wind speed derived from different microphysics schemes along with IMD observations.

Thompson. Planetary boundary layer scheme selected for this study is YSU scheme and cumulus scheme is Kain Fritsch. AWS rainfall data for some stations which are passing near to the track were considered in the states of Odisha and West Bengal All microphysics schemes has performed well in simulating rainfall and intensity but coming to track errors WSM6 has performed well. Table 1 shows the IMD AWS and model derived rainfall of the

Table 1 shows the IMD AWS and model derived rainfall of the cyclone AMPHAN

Rainfall (station)	Model(mm)	AWS(mm)
AWS1	25	42
AWS2	87.4	80.0
AWS3	25	50

cyclone AMPHAN for WSM6 microphysics scheme on 19th May 2020 when the system is in Extremely Severe cyclonic storm stage. From the table it is clearly shown that model is able to capture rainfall for some stations well. Figure 4 shows the mean sea level pressure of AMPHAN cyclone for WSM6 microphysics scheme showing the lowest pressure movement from super cyclone stage to land fall with very severe cyclonic stage.Figure 5 shows the maximum wind speed derived from the model with all the schemes of microphysics from 17th May 2020 1200UTc onwards where it was in a very severe cyclonic storm stage and considered before to land fall. Ist clearly shows that WSM6 was performing well with the IMD observations. According to our study all the schemes have performed well but Kessler scheme was very near to observation w.r.t surface pressure and for maximum surface winds the best performed scheme was WSM6.

6. Acknowledgements

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