Some sensitivity experiments with parameterisation of physical processes on the simulation a Bay of Bengal tropical cyclone using NCAR MM5

Dodla Venkata Bhaskar Rao* and Dasari Hari Prasad
Department of Meteorology and Oceanography
Andhra University, Visakhapatnam, India

NCAR MM5 is used to study the evolution and the movement of a Bay of Bengal cyclone, which is one of the most severe cyclones in recent times. According to the observations, a low pressure was identified over southeast Bay of Bengal at 00 UTC of 25th October 1999 which intensified into a super cyclonic storm, with a central surface pressure of 912 hPa and maximum wind speed of 70 m/sec at 03 UTC of 27th October 1999. The cyclone had its landfall near Paradip coast of Orissa state (20.5N, 86.0E) between 0430 UTC and 0630 UTC of 29th October 1999.

NCAR MM5 is designed to have three interactive domains with 90, 30 and 10 km horizontal resolutions covering the Bay of Bengal region. The initial fields and time varying boundary variables and sea surface temperatures at 12 hour interval are provided from NCEP FNL data available at 1 degree resolution. The model is integrated for 120 hr starting from 00 UTC of 25 October 1999 to 00 UTC of 30th October 1999. Three sets of sensitivity experiments were conducted to study the effect of a combination of the schemes of convection, planetary boundary layer (PBL) and resolvable cloud processes.

To study the sensitivity of convection parameterisation schemes, first set of five experiments have been performed with the different convection schemes of Anthes-Kuo (AK), Grell (GR), Betts-Miller (BM), Kain-Fritsch 1 (KF1) and Kain-Fritsch 2 (KF2) in combination with Medium Range Forecast (MRF) for the planetary boundary layer and Simple Ice (SI) for the cloud processes. The results (Figure 1a) from these experiments indicate that the movement of the cyclone is quite sensitive to the convection processes. The schemes of KF1 and KF2 produce the best track positions agreeing with the observations. All the schemes underestimate the intensification of the observations. The schemes of KF2 and GR produce the maximum cyclone intensification (Figure 2a) with CSLP of 960 hPa, better than BM and GR schemes. AK scheme does not produce any intensification and has an erratic track. These results indicate that KF2 scheme performs better than other convection schemes as evaluated from the track positions and time and strength of maximum attained intensity.

Due to the best track prediction with KF2 scheme of convection, second set of three experiments have been performed with the planetary boundary layer schemes of Blackadar (BL), MRF, Pleim-Xiu (PX) and Mellor-Yamada (MY) in combination with KF2 and simple-ice schemes. These results (Figure 1b) indicate that PBL processes play crucial role in the intensification of the storm. MY scheme produces the maximum intensification with a CSLP of 900 hPa (Figure 2b) and maximum wind of 70 msec^{-1} followed by BL and PX giving 940 hPa and MRF only 965 hPa. All the four schemes give good track prediction up to 48 hours and MRF scheme gives the better track positions as compared to the other three schemes. These results indicate that MY scheme gives the best intensification though the errors in the track position with MY scheme are slightly more than MRF.

The third set of the sensitivity experiments were conducted with explicit moisture schemes of warm rain (WR), simple-ice (SI), mixed-phase (MP) and Goddard microphysics (GM) in combination with KF2 for convection and MY for PBL processes. It is of interest to note that all the four schemes for explicit moisture, in combination with KF2 and MY show (Figure 1c) very good prediction up to 48 hr with an error of 50-80 km only. Beyond 48 hr, MP scheme gives the best prediction followed by GM; WR and SI respectively. Though the combination of KF1, MRF and SI seem to have slightly smaller track errors than KF2, MY and MP, the model intensification (Figure 2c) is better with the later combination. These results indicate that the combination of KF2, MY and MP have smaller errors than any other combination established through the consideration of model predicted track and intensity.

A simple ensemble mean of the experiments carried out, excluding Anthes-Kuo, give a very good estimate of the track positions with errors less than any single experiment (Figure 1d). The ensemble mean also produces a strong cyclonic storm with a minimum CSLP of 945 hPa (Figure 2d). Though this is a slight underestimation of the observed intensity, the time of attainment coincides with the observations.

The above few sensitivity experiments indicate that sub-grid scale processes and resolvable cloud processes are important to obtain the intensity of the tropical cyclone, where as the PBL processes contribute for the intensification.

* E-mail: dvb_1949@yahoo.com

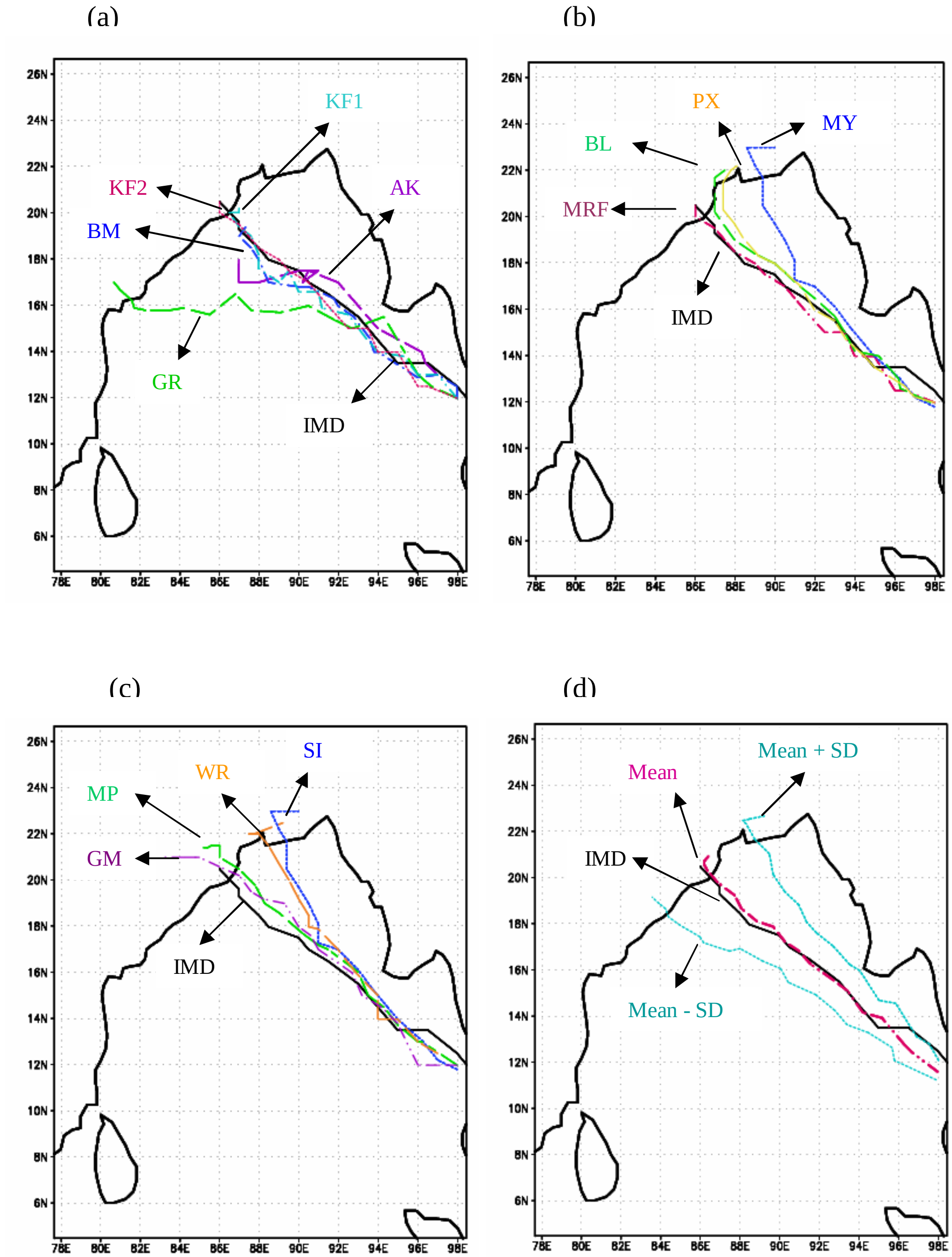

Figure 1. Model simulated track positions of the Orissa super cyclone along with IMD estimates for the experiments with (a) convection schemes (b) planetary boundary layer schemes (c) explicit moisture schemes and (d) ensemble mean

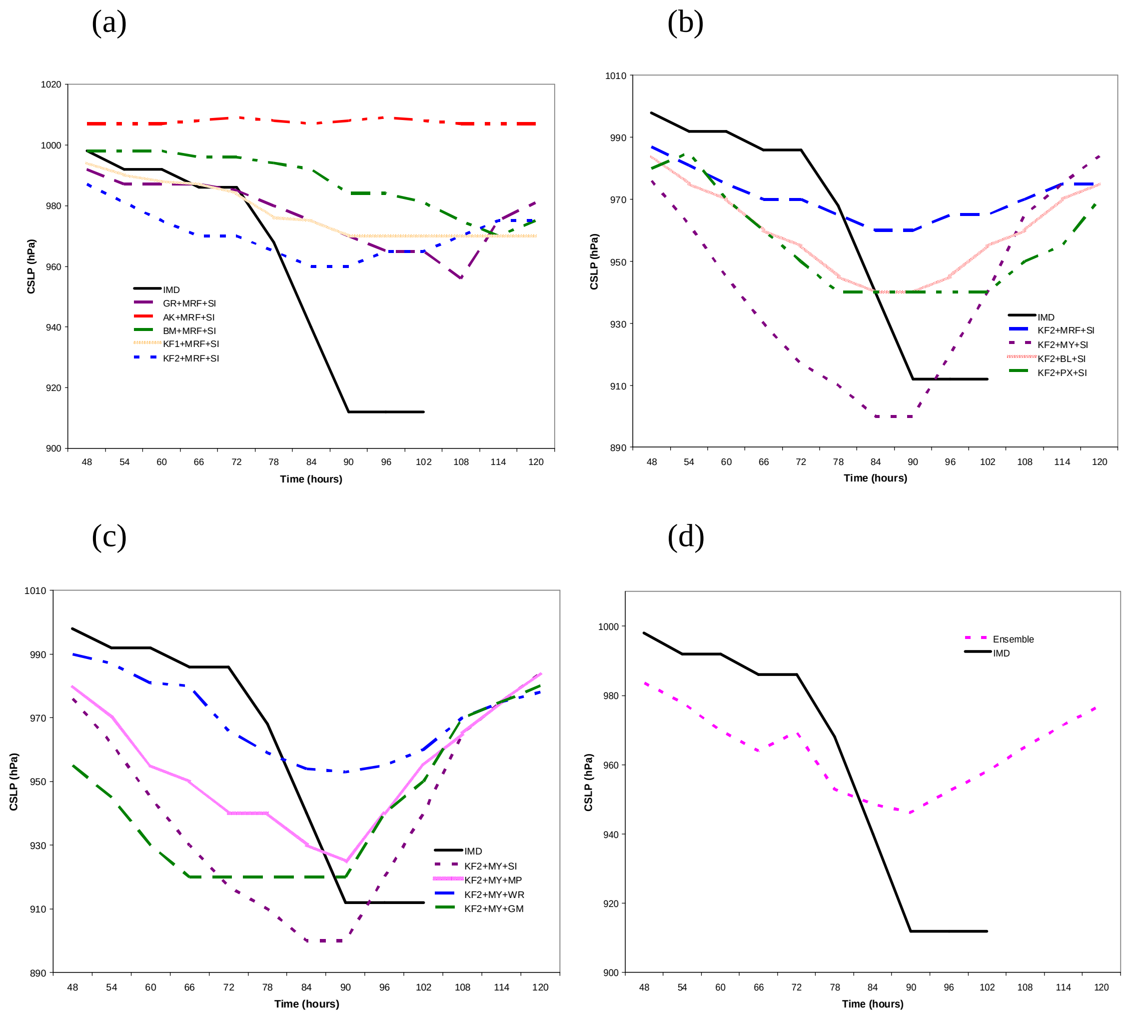

Figure 2. Model simulated central surface pressure of the Orissa super cyclone along with IMD estimates for the experiments with (a) convection schemes (b) planetary boundary layer schemes (c) explicit moisture schemes and (d) ensemble mean