Numerical Simulation of Pre-monsoon Thunderstorms over South India - Impact of FDDA Analysis and Observation Nudging

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During the pre-monsoon season (April and May), many parts of India experience severe thunderstorms with associated typical weather of thunder, lightning, gusty winds and heavy rainfall. These have a life cycle of few hours and lashes few tens of kilometers as the storm travels. Historically, these are called norwesters over Bengal region often known for their devastation. However many other parts of India also experience these severe local storms, although with less frequency. Their shorter temporal and spatial scales precluded use of numerical weather prediction models till the recently available mesoscale models with nonhydrostatic dynamics. Even now, the numerical prediction of these systems is still in infancy due to inadequacy of representative observations over the study area. Needless to say, utilisation of remote sensing data is to be explored. Keeping in view of these limitations, the present study has been taken up to simulate two severe local storms (thunderstorm/ squall line) which occurred over Andhra Pradesh region and another of Coimbatore region of Tamilnadu. The differences in the characterisitcs due to the influence of local terrain and land use were the reasons for choosing the case studies.

An attempt is made to simulate the life cycle of the severe local storms using ARW model, designed and adapted for the localised region. ARW mode was designed to have the horizontal resolutions of 27, 9, 3 and 1 km and 40 levels in the vertical. The main area of interest, covering the life cycle of the storm, was to have 1 km resolution. The model was run for a total period of 24 hours in two steps. First the model was integrated for domains of 27 and 9 km with two-way interaction and with the parameterization of cumulus convection. Then the ouput from 9 km domain was used to run the model with 3 and 1 km resolutins, with one-way nesting and without parameterization of cumulus convection. This strategy was adopted to save time and also to avoid any discrepancies that may arise due to the different choices of parameterization for sub-grid scale convection. The initial and time varying boundary conditions were provided from global analysis at 1 degree resolution from NCEP.

Several numerical experiments were performed with and without FDDA analysis and obervation nudging to study the impact of FDDA. This has been taken up as the initial data for the model integrations was taken from global analysis at 1 degree resolution, which makes little sense in the representativeness of the local conditions which actually contribute for the development of the local storms. All available observations (surface and upper air, from conventional station locations and remote sensing) within the 3 km domain were used for assimilation. Two types of FDDA were used, one with FDDA observation nudging and the other with 6-hour analysis nudging, and with both types of FDDA. Preliminary analyses of the results indicate improvements in the simulations with FDDA. The model could simulate features similar to those of severe convection systems. The model results were analyzed to identify the structure of the system, such as vertical wind velocities (updrafts and downdrafts), mixing ratios of cloud liquid water and ice, associated rainfall rates etc and compared with the available observations.