Observational and Modeling Studies of Severe Thunderstorms over Eastern Region of India during STORM Field Experiments

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Thunderstorms, which are mesoscale systems, are major cause of natural disasters during the pre-monsoon season (April-May). Severe local storms, including tornadoes, damaging hail and wind gusts, frequently occur over the eastern and northeastern states of India during this period. They are locally called "Kal-baishakhi" or "Nor'westers". The casualties reported due to lightning associated with thunderstorms in this region are the highest in the world. The highest numbers of aviation hazards are reported during occurrence of these thunderstorms. In India, 72% of tornadoes are associated with these thunderstorms. These severe thunderstorms have significant socio-economic impact in the eastern and northeastern parts of the country. An accurate location specific and timely prediction is required to avoid loss of lives and property due to strong winds and heavy precipitation associated with these sever weather systems.

Though, many studies are conducted to understand the dynamical and thermo-dynamical structure of this severe weather phenomenon, but are mostly in the form of case studies and are limited due to lack of meso-network of observations. The improvement in prediction of these important weather phenomena is also highly restricted due to lack of mesoscale observations and insufficient understanding. Realizing the importance of improved understanding and prediction of these severe local storms over east and northeast region of India and adjoining countries namely Bangladesh, Nepal and Bhutan, Gov. of India organized a national coordinated programme on 'Severe Thunderstorm Observation and Regional Modeling (STORM)'. Earlier Department of Science and Technology (DST) sponsored the STORM field experiments, and later on Ministery of Earth Sciences (MOES). Initial pilot experiments were conducted over eastern and northeastern region of India during 2006 and 2007. As the Nor'westers also affect Bangladesh, Nepal and Bhutan, therefore, in 2009 the field experiment was extended to cover these countries as well. A coordinated field experiment named 'SAARC STORM' was conducted jointly with 4 countries during 1-31 May 2009. STORM programme focused a comprehensive observational and modeling study on genesis, evolution and life cycle of intense tropical convective activities over east and northeast regions of India during pre-monsoon period through meso-network of observations and mesoscale analysis and prediction systems. Extensive observations with modern instruments / sensors viz., Doppler Weather Radar (DWR), wind-profilers, Automatic Weather Stations (AWS) etc. are very useful to improve understanding of the physical, dynamical and thermo-dynamical characteristics of these thunderstorms.

Forecasting thunderstorms is one of the most difficult task in weather prediction, due to their rather small spatial and temporal extension and the inherent non-linearity of their dynamics and physics. The Weather Research and Forecasting (WRF) Model is a next-generation mesoscale forecast model that will be used to advance the understanding and the prediction of mesoscale convective systems. In this paper, analysis of meteorological conditions that led to a tornado and severe squall lines occurred over eastern region of India during STORM field experiments have been made. An attempt is also made to simulate these events using the Non-hydrostatic Mesoscale Model (NMM) core of the Weather Research and Forecasting (WRF) system with a spatial resolution of 3km for a period of 24 hours, starting at 0000 UTC. The atmospheric settings as resulted from synoptic, surface, upper air, satellite and radar echo studies were favorable for the occurrence of a severe thunderstorm activity. The model simulated meteorological parameters are consistent with each other and all are in good agreement with the observation in terms of the region of occurrence of the intense convective activity. The model has well captured the updraft and downdraft which is an important phenomenon related to severe thunderstorms. The core of the strongest winds is shown to be very close to the site of actual occurrence of the event. The results of these analyses demonstrated the capability of high resolution WRF-NMM model in simulation of severe thunderstorm events.