CURRENT STATUS, CAPABILITIES AND FUTURE PLANS OF NOWCASTING IN INDIA

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Abstract

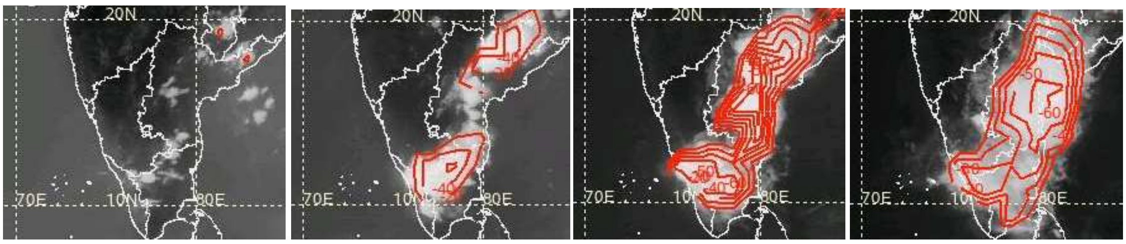
India successfully deployed Nowcast System during Commonwealth Games held in National Capital Region of Delhi in October 2010. It included augmentation of end to end real time observation, data processing, forecasting and dissemination system. In addition to High resolution WRF, specialized Nowcast systems were adopted for Indian region. Nowcasts were generated in rapid update cycle mode of three hours, one hour and thirty minutes. Nowcast products were made available on GIS Platform and disseminated in real time to all stake holders through SMS, e-mails, web, radio, television and LCD displays at stadiums and public places. Nowcast System is now become a part of Delhi Metropolitan Weather Information and Forecast System. With air pollution becoming major concern in urban areas, it is planned to include Air Quality Monitoring and Nowcast in Integrated Metropolitan Weather and Air Quality System and extend the same to all major cities

1. INTRODUCTION

Increasing awareness of the impact of weather events on various social and economic activities specially in urban areas have thrown up a challenge of providing accurate, location specific, realtime short range forecasts for major cities in India. This is especially so since the weather over India shows wide variability in space, time and intensity.The impact of extreme weather events has a direct relation to the population density and infrastructural development of the places where they strike. Very intense rainfall (94.4 cm) in Mumbai on 26 July 2005 resulted in of death of 1094 people and direct economic loss of US$ 100 million. Climate Change is likely to increase such impacts. This poses new challenges to the National Weather Service to provide accurate and timely warnings and forecast for extreme weather events for present and future cities of India. Air Quality is another area of concern in urban areas in many developing countries including India. The fact that Nowcasting can provide much higher accuracy of prediction than short and medium ranges; it is becoming the most important tool in meeting the demands of the users.The short temporal and spatial resolution of nowcasting outputs as well as their short lead time of forecasting calls for paradigm shift in observation, communication, data processing, forecasting and dissemination sub systems of National Weather Service. Such a necessity was felt by India Meteorological Department (IMD) in 2010 for providing state of art weather services for Commonwealth Games.

2. **REAL TIME OBSERVATIONS**

Observation networks such as Doppler Weather Radars, Geostationary Satellites and Automatic Weather Stations (AWS), Wind Profilers, Radiometers that monitor and provide accurate data at short spatial and temporal intervals, are the most essential component of a good nowcast system. India Meteorological Department has a network of 12 S-Band Doppler Weather Radars, 2 C-Band Polarimetric Radars and a digital EEC X-Band radar network to monitor the weather over India. IMD also receives and processes the data from INSAT 3A and Kalpana 1 Geo-stationary Satellites in real time, for use in short-range weather forecasting (Fig 1). IMD also has a huge network of AWS stations to monitor hourly values of weather parameters. There are also three reception stations for NOAA/METOP/MODIS data, which further augment the short-range forecasting ability of IMD. India has plans to have a network of Wind Profilers, and Radiometers to have continuous vertical profiles of wind, temperature and humidity which will further strengthen Nowcasting capability.



09 UTC 12 UTC 15 UTC 18 UTC

Fig 1. Cloud Top Temperature from Kalpana 1 Satellite on 4 May 2009

3. **QUALITY CONTROLLED DIGITAL OBSERVATIONAL DATA**

For the nowcast system to function automatically, stringent quality control procedures need to be in place, so that the nowcasts are reliable. Each observation source has various on-site calibration tests provided by an equipment manufacturer. However, for a vast country like India, where observation networks of any type are composed of instruments, purchased from different manufacturers by different agencies, stringent off-site tests also need to be in place for inter-calibration of the instruments as well as checking the validity of the data received, in order to remove any biases in the data received. When this data is input into any model, the output nowcasts will depend upon the initial quality control of the data. This is especially true for data received from radar networks as well as from automatic weather stations. Currently in India, the WDSS-II software is used to quality control radar data before input to numerical models (Sen Roy et al, 2011). Anomalous propagation echoes, and ground clutter are removed from the reflectivity data, and the radial velocity data is dealiased by this software, before input to nowcasting and short-range forecasting models such as ARPS (Srivastava et al, 2010 a). Qualty checks on

4. COMMUNICATION NETWORK.

The short lead time of the nowcasts, precludes any interference by forecasters in the entire chain during operational nowcasting. The communication network plays a crucial role in the real-time transfer of data from observation sites, to a central location for running the nowcast models in real-time. Similarily, the nowcast outputs need to be transmitted in real-time to forecasters and the public. Data from AWSs is received through satellite communication and enire data is available within half an hour of observation. For real-time mesoscale applications, DWR observations from DWR sites are received online continuously at a central location (IMD New Delhi). This requires high bandwidth telecommunication connectivity. A TCP protocol is used to transfer the data from station to the central location at IMD headquarters. This protocol is preferred when applications cannot tolerate any loss and reordering of the data, as in the present case. All DWR stations along with Telecom Division of IMD, New Delhi have been connected by an IP VPN network. At each VPN access point / location, connectivity with the service provider of VPN network is through a wire, which is connected with modem at VPN location. Modem is connected with router which acts as a bridge between the VPN network and the local LAN. The router is connected with switch which connects the DWR servers among themselves as well as with the router. All the DWR stations, are connected to VPN network with 256 kbps link. Since data from all the DWR stations will come to Telecom Division, New Delhi, so the Telecom Division, New Delhi is connected to VPN network with a higher bandwidth, i.e., 2mbps link. One great advantage of the VPN network is that all the VPN locations are connected with each other. So any two DWR stations can communicate with them.

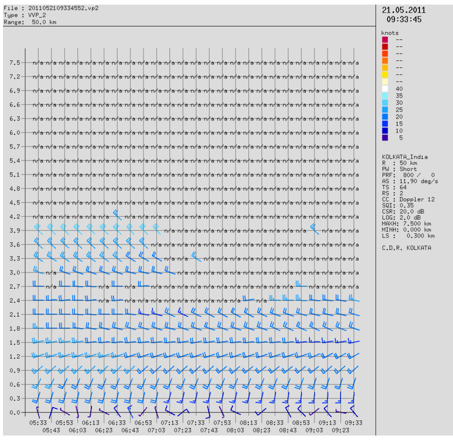
5. HEURISTIC TECHNIQUES FOR SHORT RANGE FORECASTING

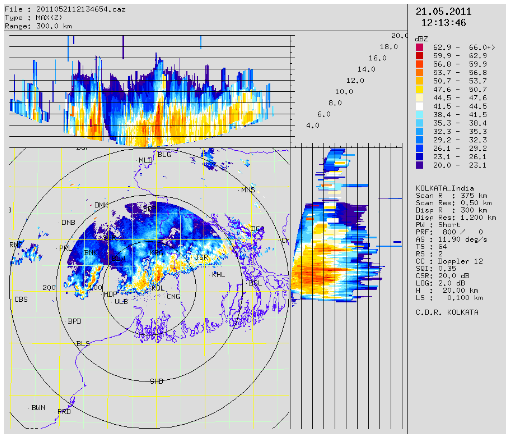
Development of nowcasting software requires knowledge of local weather conditions and quantifiable thresholds for various parameters. A number of studies have been carried out in area of aviation weather nowcasting (Suresh et al 2004), sea breeze (Suresh 2007) and radar based (Suresh 2005, Sinha and Pradhan 2006, Pradhan 2012). Doppler Weather Radar (DWR) derived product VVP_2 (Volume Velocity Processing) provides a vertical profile of the horizontal winds up to 7.5 km height at every 10 minutes interval at a step of 0.3 km.(Fig 2) The range of this product is 40 km from Doppler Weather radar and therefore the vertical profile of the horizontal winds is available round the clock over an area of radius of 40 km. In the present study the utility of this product has been discussed to predict the initiation, development and further movement of severe weather phenomena over a station where DWR is located. Kolkata is situated from the north to north west of Bay of Bengal and therefore, the winds from sea play a significant role in the incursion of moisture and subsequent development of the weather system. During pre-monsoon season when the winds at lower levels (0.3 to 1.2 km) are southerly or southeasterly and of the order of 10-15 knots (Fig 2), there is a very high probability of development of a thunderstorm in the surroundings of the Kolkata within next 2-3 hours (Fig 3). At the same time when the middle level winds (1.5 to 3.5 km) are from W/NW, the expected movement of the thunderstorm is towards Kolkata.

Research and Development work is also being carried to simulate severe weather events by high resolution WRF model (Litta and Mohanty 2008), and to optimize micro physics schemes in numerical models and cloud resolving models (Rajevan et al 2010, Srivastava et al 2010 b).

Fig 2 : Radar derived winds

Fig 3 : Development of convection to the northwest of Kolkata





6. DISSEMINATION

Nowcasting products have a very short lifespan of importance. Hence, for effective use, these need to be delivered in near real time to users, and in a format that they require. For example, total time taken by WDSS-II, from observation at radar site to product generation is 12-15 minutes. This needs to be updated not only on the IMD website, but also to mobiles and other user friendly devices. This aspect of Public Warning Dissemination, needs greater engagement between the people who generate the products and the people who use them. Forecasts need to be specially tailored to media like FM Radio, T.V., new technologies such as SMS and MMS and social network (Face Book, Twitter) which is likely to play an important role in the communication of real time dissemination of Nowcast to the public. An example of venue specific forecast issued during Common Wealth Games 2010 held at New Delhi, India is shown in Fig 4.

Venue	Temp Max (°C)	Temp Min (°C)	Humidity Max (%)	Humidity Min (%)	Wind Speed (kmph)	Wind Dir	Weather
JLN Stadium	34	23	90	45	[illegible]		
National Stadium	34	23	85	45	[illegible]		
Talkatora & SP Mkherjee Stadia	34	23	85	45	[illegible]		
Dr Karni Singh Shooting Range	33	23	90	45	[illegible]		
Kadarpur Shooting Range	34	23	90	45	[illegible]		
IG Sports Cplx	34	23	85	45	[illegible]		
Delhi University	33	22	90	40	[illegible]		
Yamuna Sports Cplx	33	23	85	40	[illegible]		
Siri Fort Stadium	34	23	85	45	[illegible]		
Tyagraj Stadium	34	23	90	45	[illegible]		
Games Village	34	23	90	45	[illegible]		
RK Khanna Tennis Cplx	34	24	85	45	[illegible]		

MIST IN THE MORNING. MAINLY CLEAR SKY.

Fig 4. Sports Venue specific Forecast issued during Common Wealth games 2010

7. CURRENT STATUS

A major initiative in operational Nowcasting and Short-range weather forecasting was undertaken for the Commonwealth Games in 2010. Towards this aim, the infrastructure of IMD was augmented, for real-time handling of large quantities of data and their processing by various numerical softwares. It involved multi-agency collaboration, for operational nowcasting, and round the clock monitoring of weather by IMD forecasters at the National Weather Forecasting Centre of IMD. The High Powered Computing System was installed at IMD New Delhi, which brought a manifold increase in the capability of IMD to run multiple numerical models operationally with the purpose of generating accurate location specific nowcasts and short-range forecast (Bhan 2012). Three nowcasting softwares were made operational in the duration of the project. These include: Warning Decision Support System (WDSS-II from National Severe Storms Laboratory), Short-range Warning of Intense Rainstorms in Localized Systems (SWIRLS: from Hong Kong Met. Office) and Delhi Post Processing System (DelhiPP: from UK Met Office). A short-range forecasting system - Advanced Regional Prediction System (ARPS:) was also implemented for real-time forecast (Fig 5). For location specific forecasts, WRF (ARW) model was run at 3km resolution (Double nested at 27 and 9 km and nestdown at 3 km). These models were all tested for the optimal assimilation and parameterization schemes in the run-up to the Commonwealth Games. All the models performed seamlessly to generate nowcasts and short-range forecasts for the Delhi and adjoining National Capital Region for the duration of the project. The location specific values of weather parameters for displayed on an interactive GIS based platform. The synergistic nature of the project involving multiple agencies and multiple scales and types of forecast was so successful, that it was shifted from project mode, and made a part of the operational set-up of IMD. Hence all these output products are available in real-time to users since more than one year.

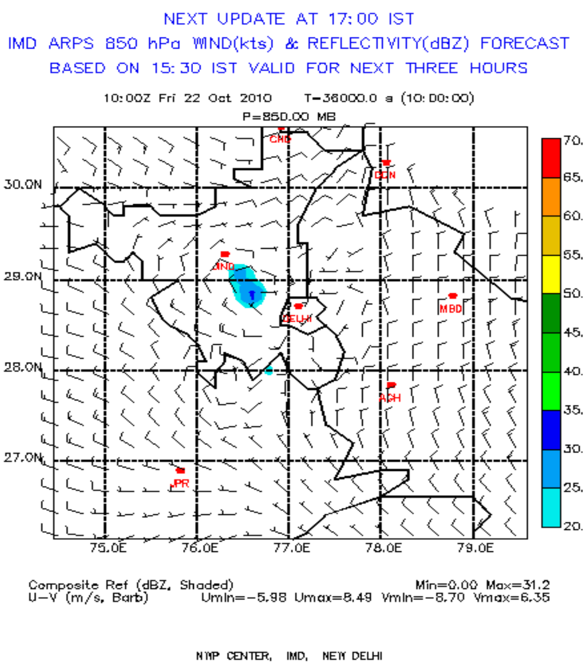


Fig 5 : ARPS Forecast valid for next three hours based on 15.30 ist of 22 Oct 2010

8. FUTURE PLANS

Among the emerging economies, India is registering a relatively higher rate of urbanization. It is expected that while India's rural population will peak around 2030, the peaking of urban population would take place only by around 2050. With this urbanization rate, many of India's small cities are expected to grow both in size and population in future. At the same time, mega cities are expected to expand and have much higher population density and infrastructural development than they have today. Socio-economic activities too would increase several fold in the next few decades. Air Quality in urban areas is another cause of concern. Therefore, Air Quality Monitoring and Prediction has been included as a part of Metropolitan Weather and Air Quality Information and Forecasting Project and will be extended to other mega cities.. India Meteorological Department is working closely with Municipal and Disaster management authorities in planning and implementation of the Project. It is hoped it will help in better management of day to day urban activities in general and of severe weather events in particular.

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