Operational forecasting models: Nowcast models

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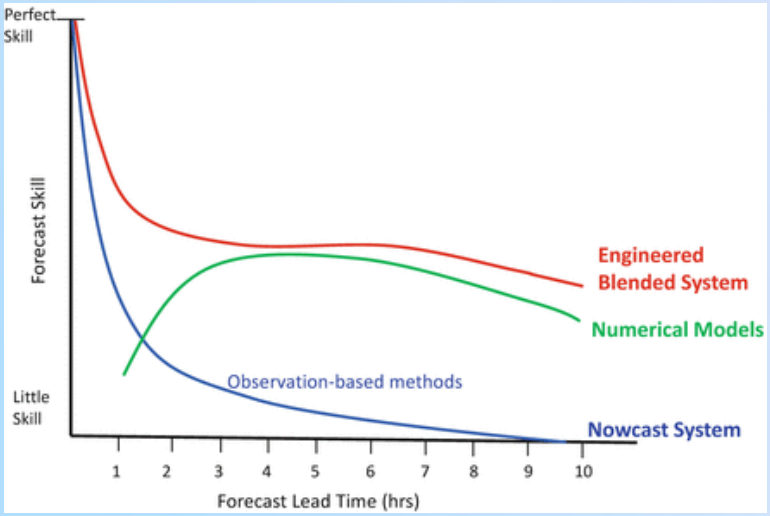
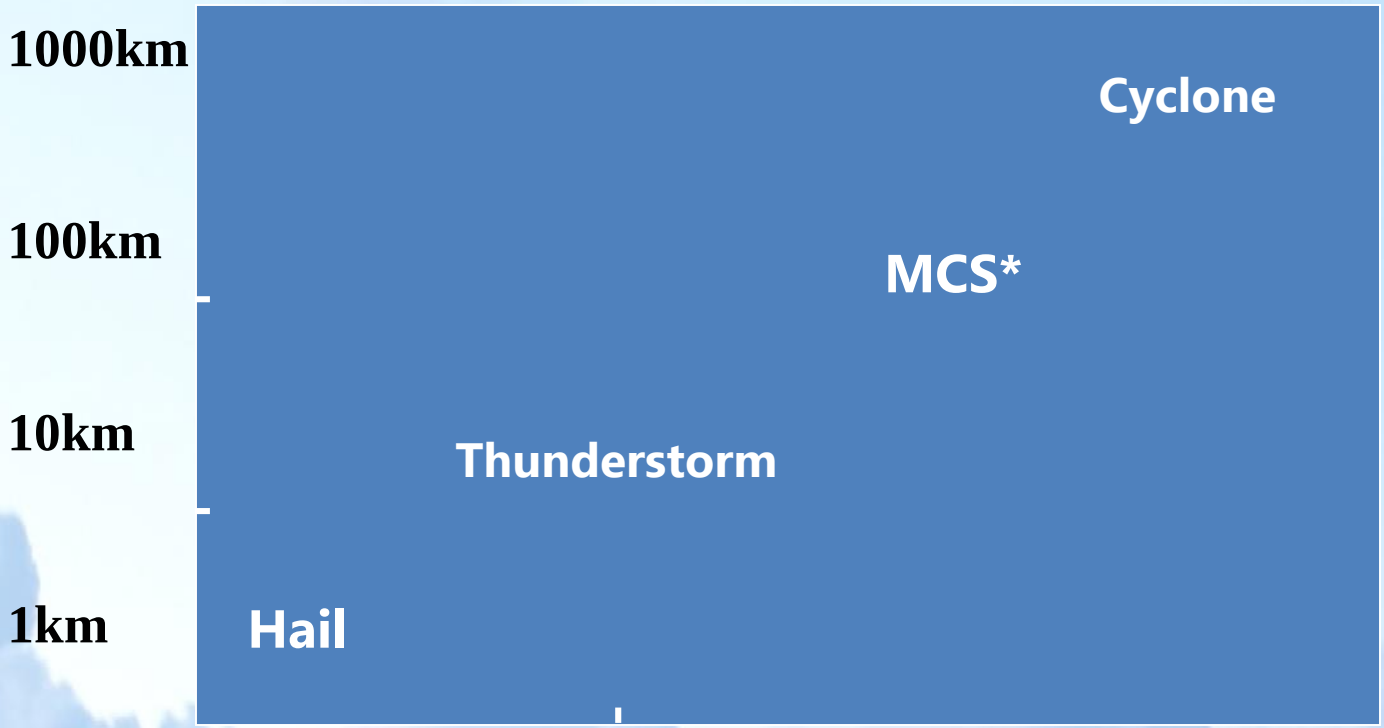
NWP models (most accurate analysis and forecast fields!)	Nowcast models (immediate dissemination of output !)
Assimilation of observations from different sources to create the best possible analysis field	Minimum assimilation methodology
Grid point extrapolation to the future by solving partial differential equations based on seven primitive equations	Grid point extrapolation of current observation, through various techniques



Haupt S.E. (2018) Short-Range Forecasting for Energy. In: Troccoli A. (eds) Weather & Climate Services for the Energy Industry. Palgrave Macmillan, Cham. https://doi.org/10.1007/978-3-319-68418-5_7

Scales of Motion & Predictability

* Mesoscale Convective System



Lifetime	10mins	1 hr	12hrs	3 days
Predictability	30mins	3 hrs	36hrs	9 days
Nowcast	5mins	30min	6hrs	36hrs

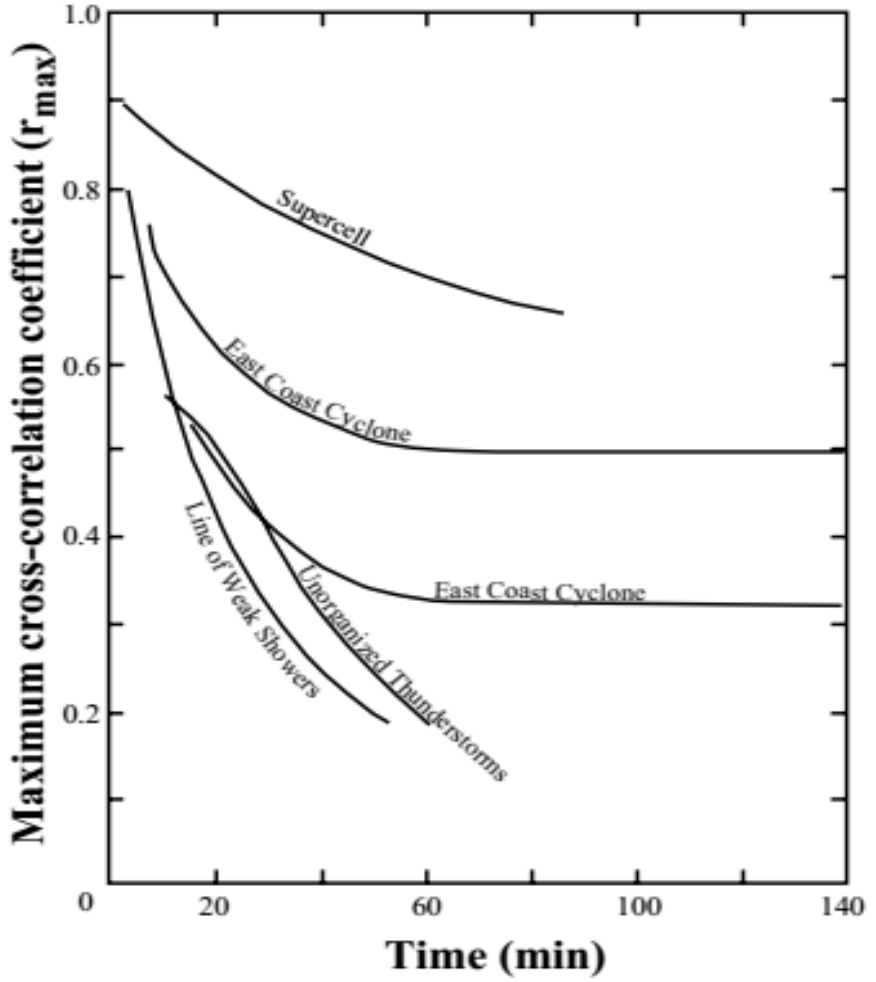


FIG. 2. Magnitude of the maximum cross correlation (r_{max}) between radar echo patterns as a function of time for different types of storms (from Wilson 1966). Here r_{max} is a measure of echo lifetime and was obtained by cross-correlating echo patterns by the indicated time period.

Wilson, J.W., Crook, N.A., Mueller, C.K., Sun, J. and Dixon, M., 1998. Nowcasting thunderstorms: A status report. *Bulletin of the American Meteorological Society*, *79*(10), pp.2079-2100.

Nowcast Softwares

- **Cell Tracker and Extrapolation**
  - **TITAN, CARDS** (Canada), **OPIC**(Meteo Swiss/Meteo France), **CONO (COnvection Nowcasting Objects) in SIGOONS**

- **Area Tracker and Extrapolation**
  - **SWIRLS**(HKO), **COTREC**(Czech), **MAPLE** (Canada), **SWAN** (China), **CINESat** (Austria), **UWCI** (USA)

- **Spectral decomposition and Extrapolation**
  - **WDSS-II (now MRMS)** (USA), **STEPS** (UK), **S-PROG** (Australia), **MUSIC** (Europe)

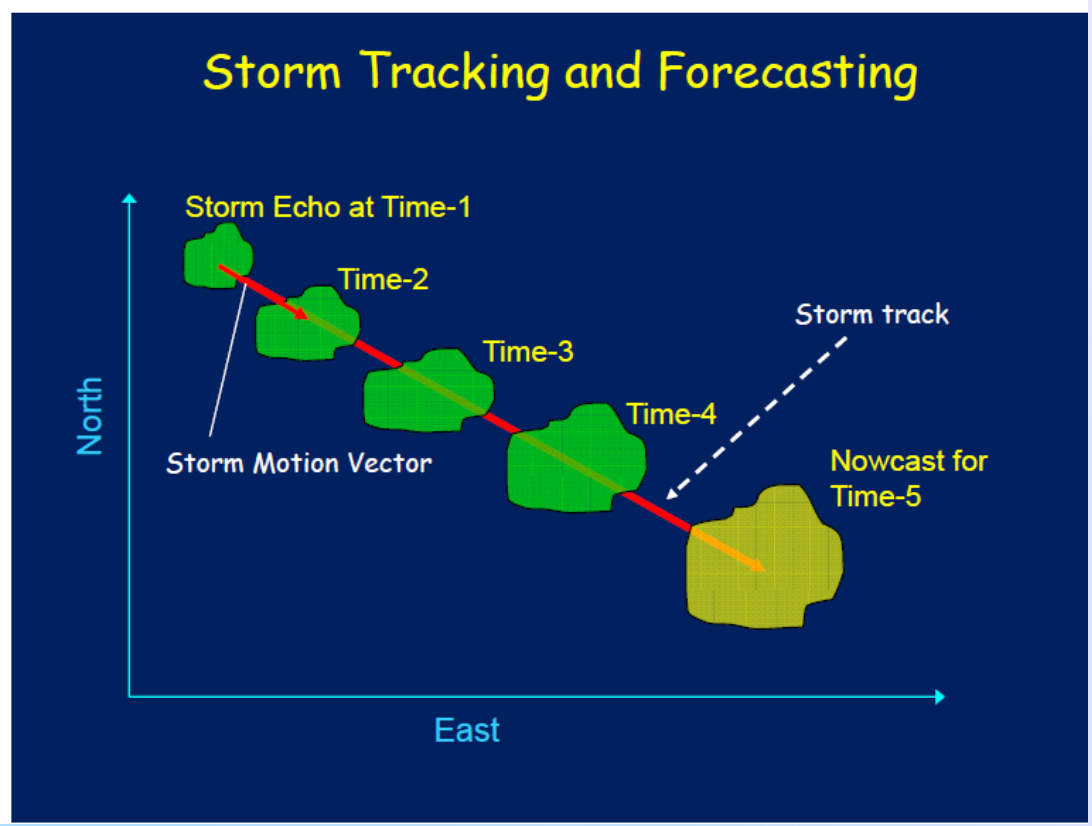
Nowcast Softwares

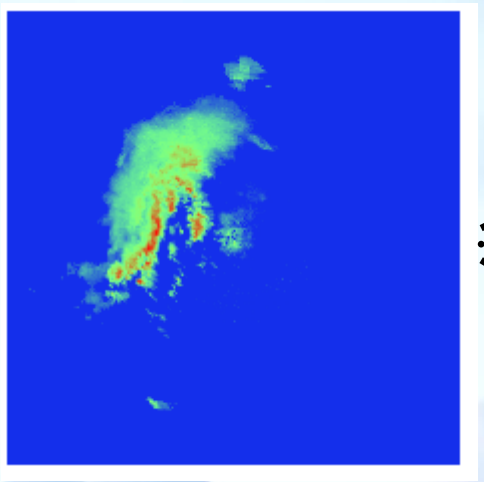
- **Area Tracker, Blending with NWP data and Extrapolation**
  - **UKPP**(UK), **STEPS** (UK), **VSRF**(Japan, Korea)

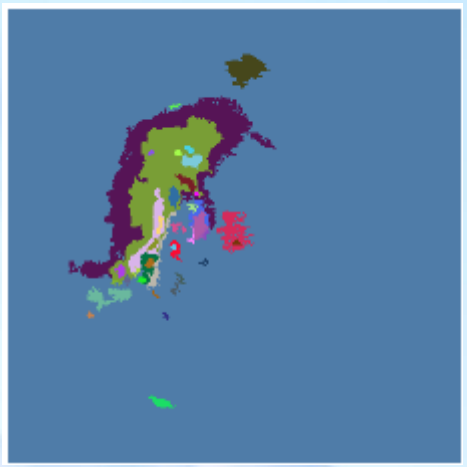
- **Expert System**
  - **Autonowcast** (USA), **NIMROD** (UK), **Trident** (USA)

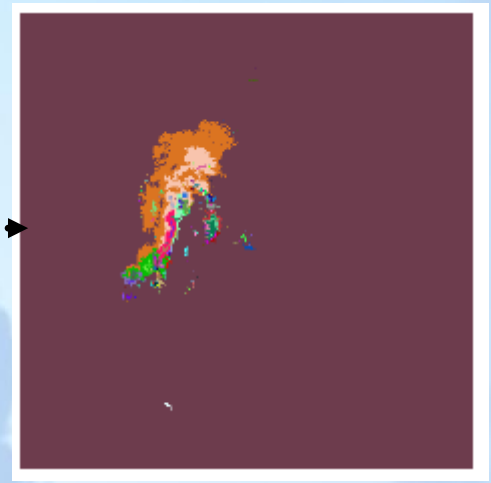
Nowcasting by extrapolation

- First proposed by Ligda (1953)









WDSS-II nowcast algorithm

The major steps in the technique are:

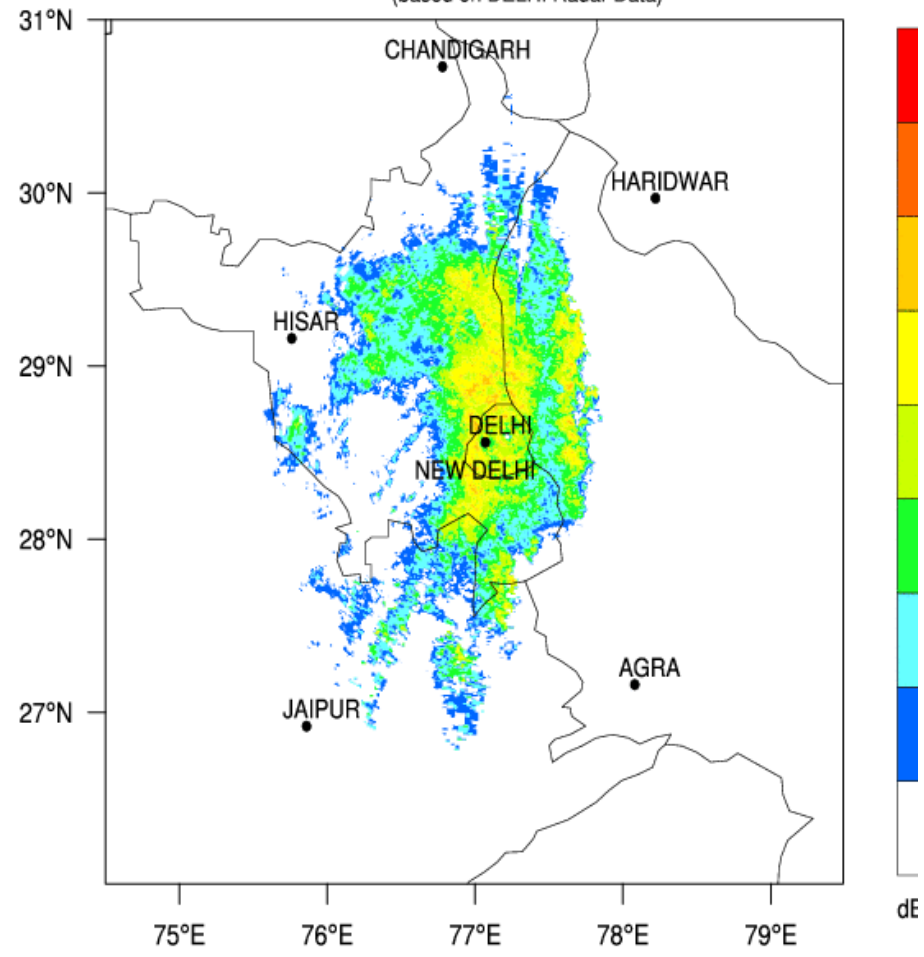
- **1. Find storms at different scales.**
- **2. Estimate motion at the various scales.**
- **3. Forecast for different periods using motion at different scales.**

Because the motion estimates are made for storms, it is possible to interpolate between storm boundaries to obtain motion estimates at every part of the domain.

IMD WDSSII 00 min Reflectivity Forecast for Delhi and neighbourhood based on 20170126 AT 1542 hrs IST

Adopted from NSSL,USA

(based on DELHI Radar Data)



Areas with Reflectivity > 30 dBZ have high probability of rainfall occurrence

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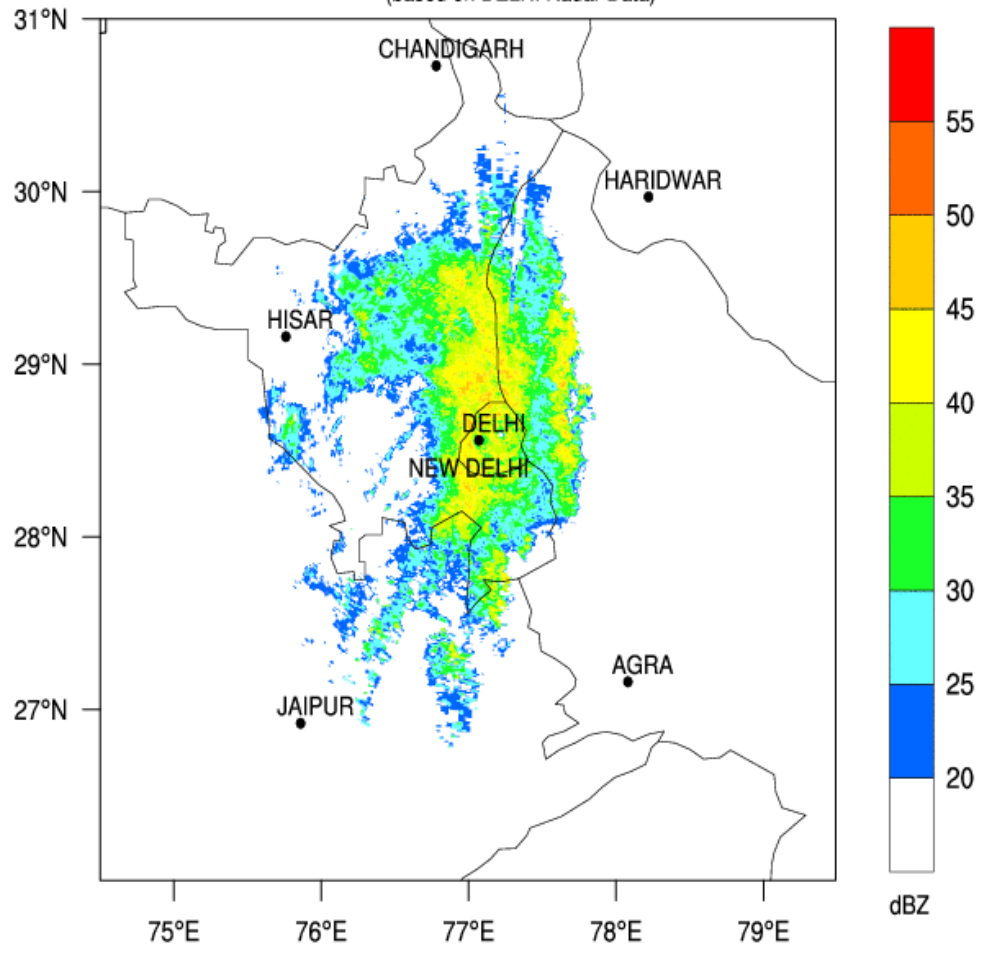
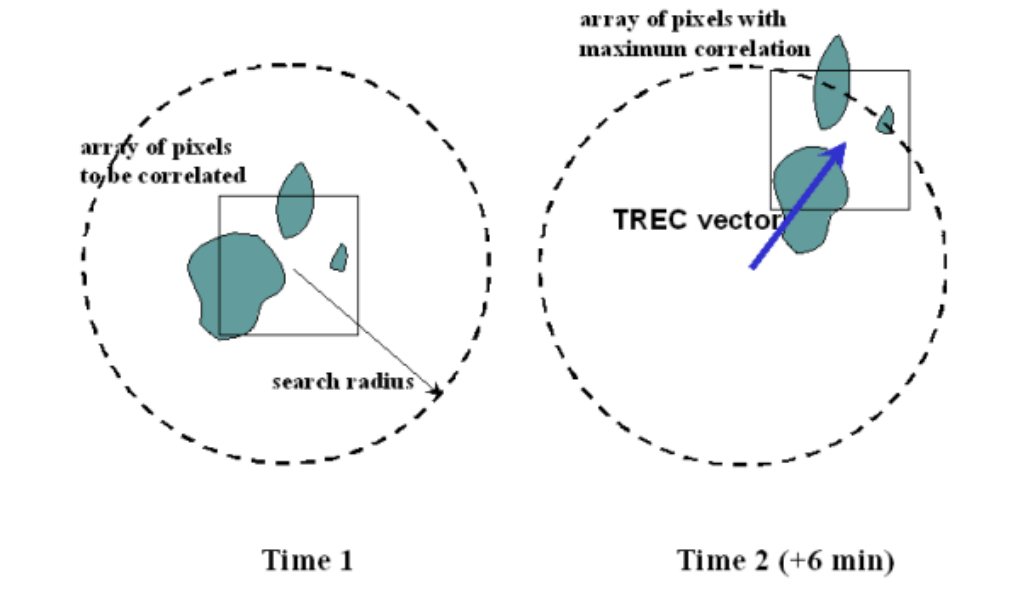


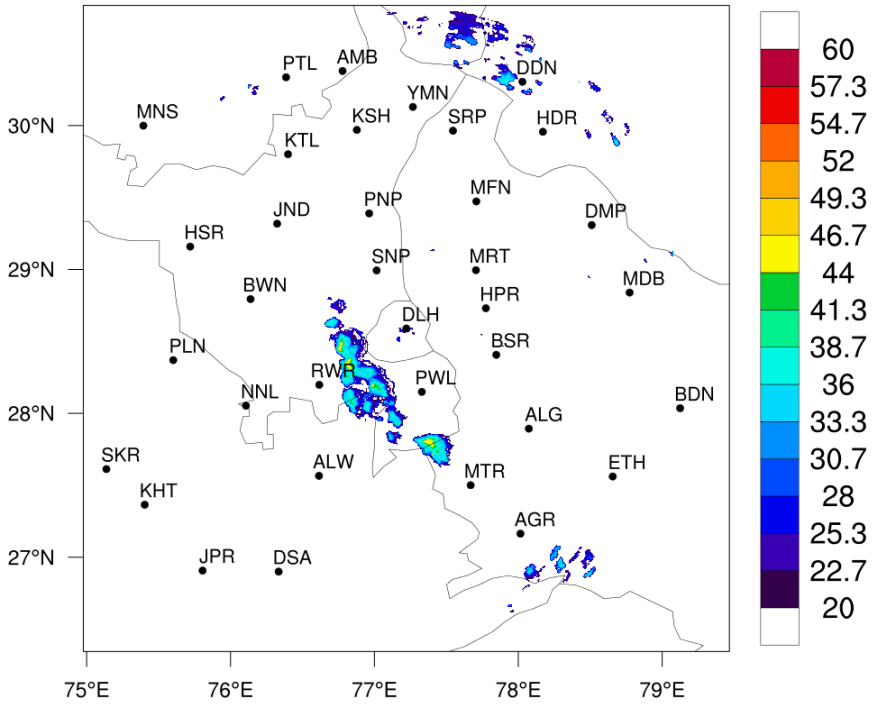
Areas with Reflectivity > 30 dBZ have high probability of rainfall occurrence

Nowcast model : SWIRLS

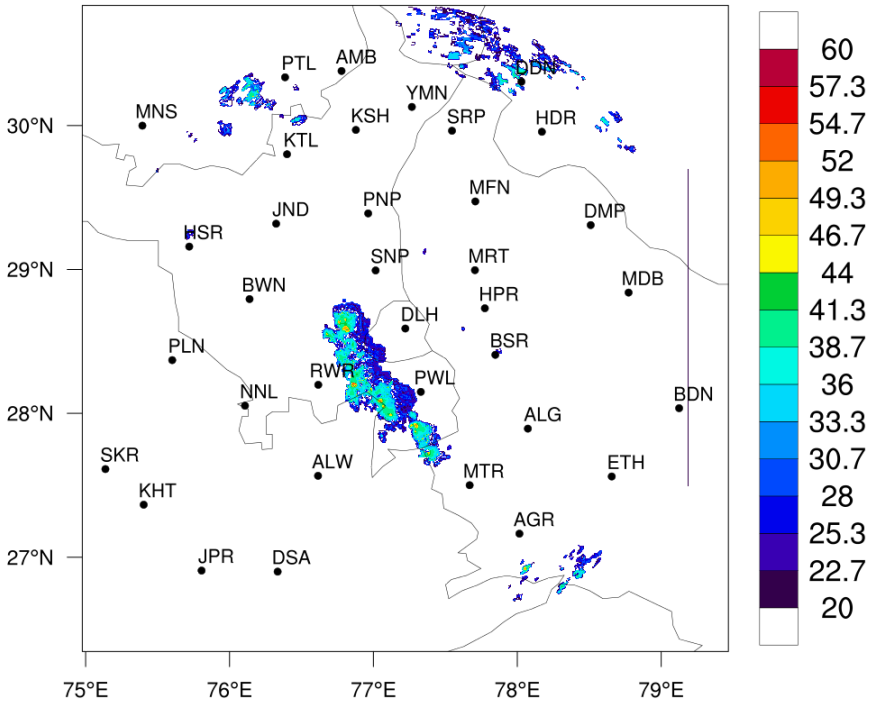
- **"Short-range Warning of Intense Rainstorms in Localized Systems" SWIRLS software was developed by Hong Kong Met Office. It was initially shared with IMD during Commonwealth Games in 2010. Recently the Community SWIRLS has been shared with IMD in 2018.**
- **Through analyzing radar echoes in two successive radar scans, SWIRLS computes the direction and speed of movement of rain areas to obtain information for the distribution of high-resolution radar echo motion distribution.**
  - ***After analyzing the motion of the radar echoes over the whole area SWIRLS extrapolates the radar echoes according to the speed and direction of movement at each point, thereby projecting the future location of rain areas and hence the rainfall that they will bring to the region in the next few hours.***



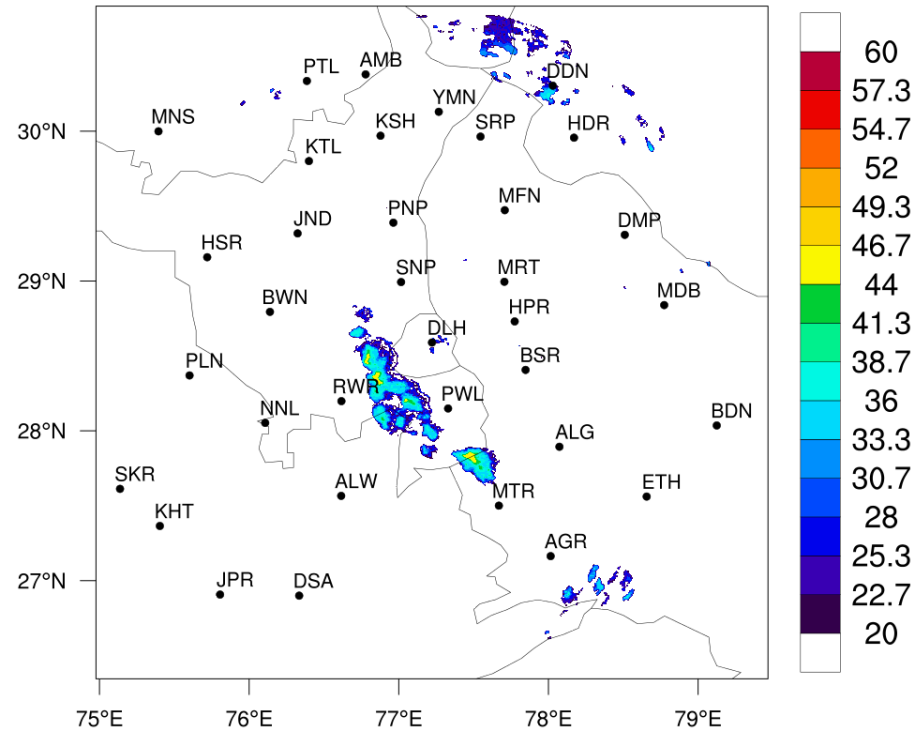
030 min forecast based on 20180513 at 1522 hrs IST



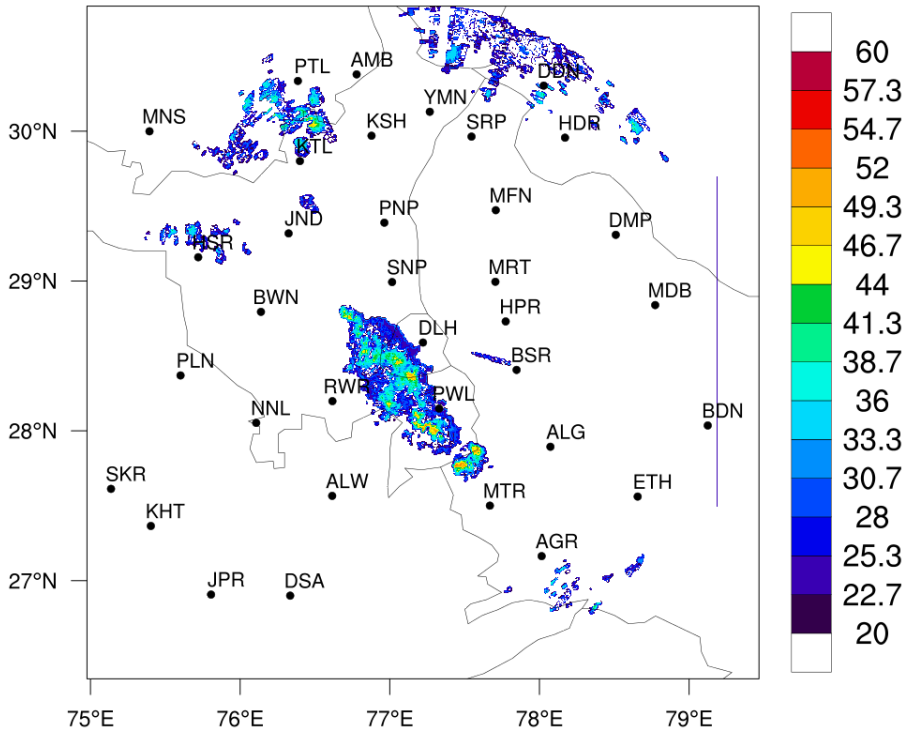
000 min forecast based on 20180513 at 1552 hrs IST



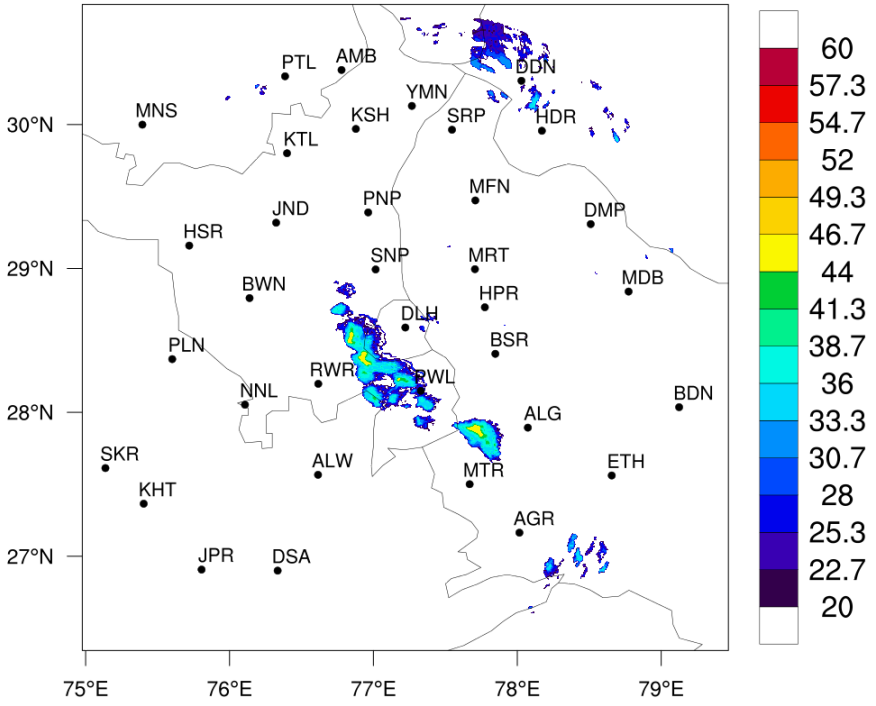
060 min forecast based on 20180513 at 1522 hrs IST



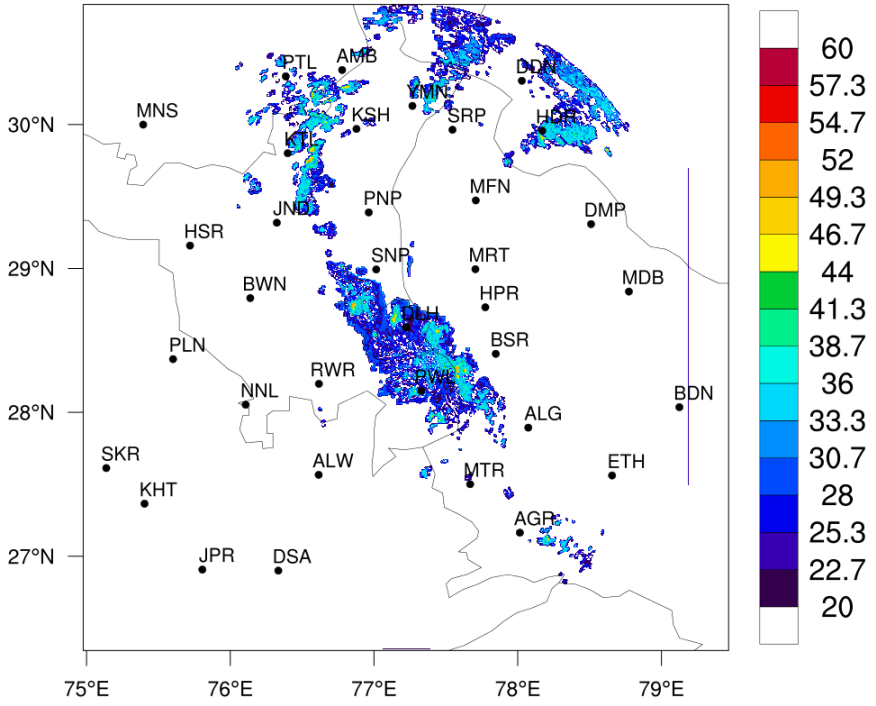
000 min forecast based on 20180513 at 1622 hrs IST



120 min forecast based on 20180513 at 1522 hrs IST



000 min forecast based on 20180513 at 1722 hrs IST



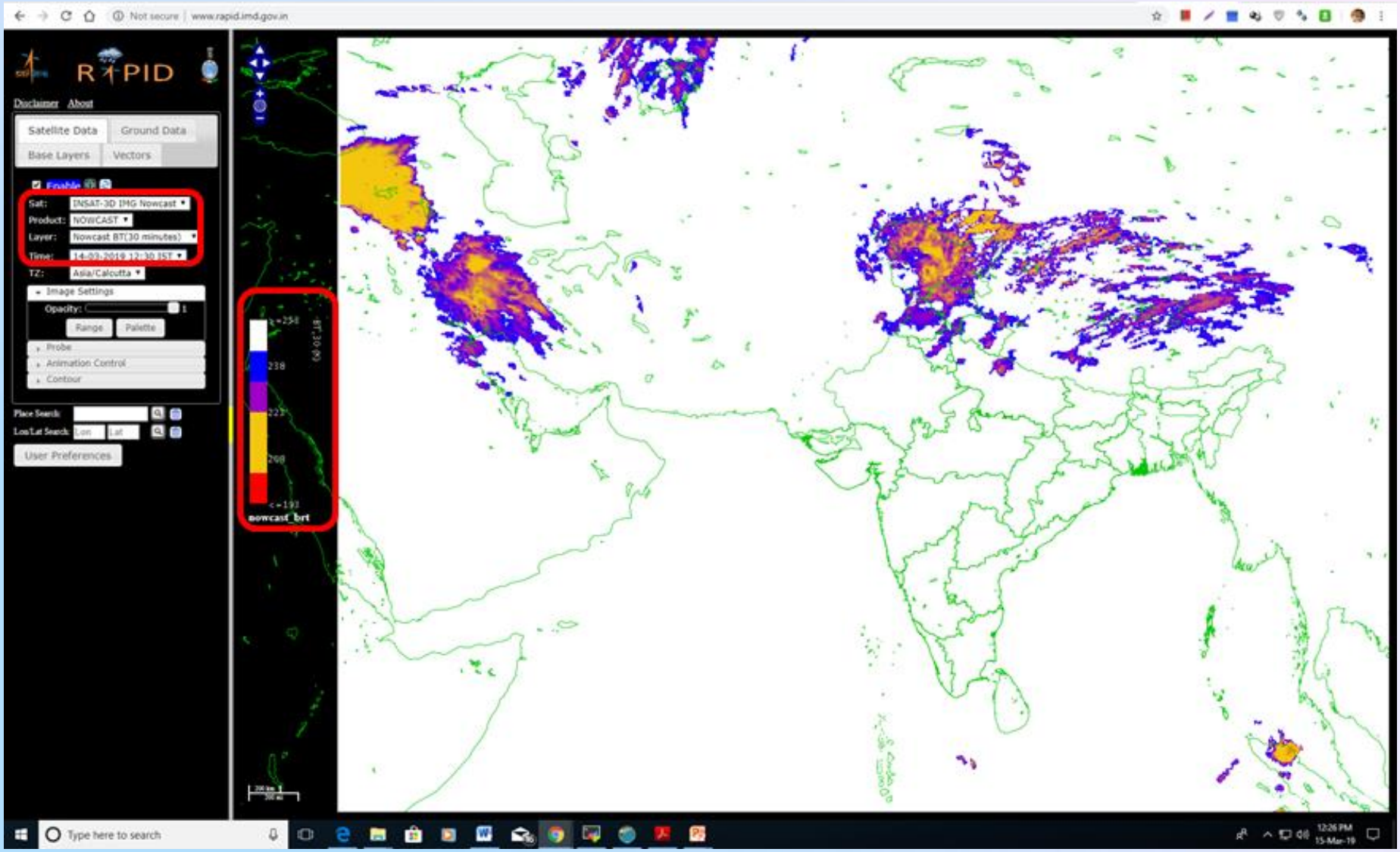
Satellite based nowcasting

The main steps of the algorithm are the following:

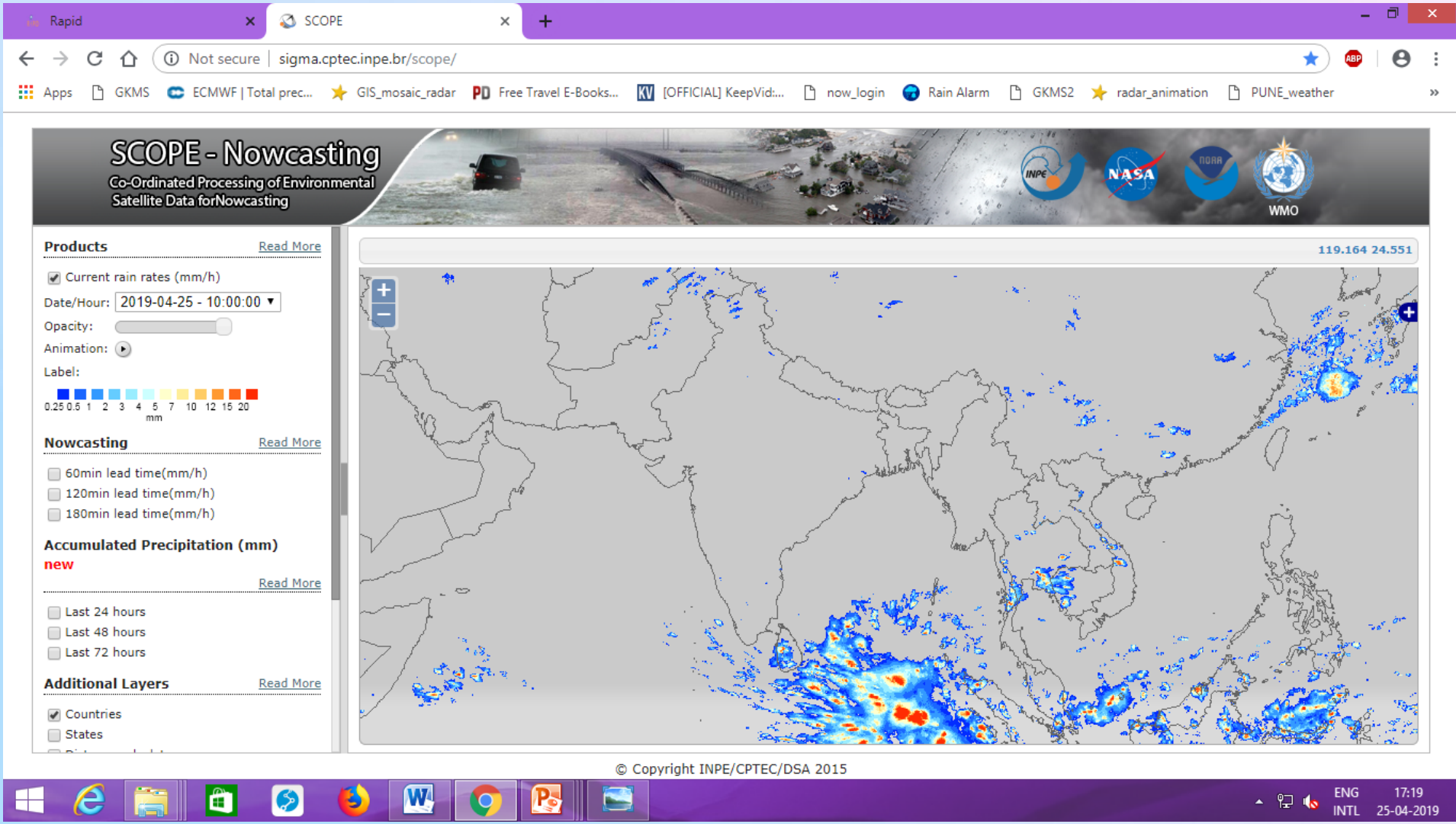
- **A cloud cluster detection method based on size > 2400 sq km. and temperature threshold < -38°.**
- **A statistical module to identify morphological and radiative parameters of each MCS**
- **A tracking technique based on Mesoscale Convective System (MCS) overlapping areas between successive images.**
- **A forecast module based on MCS evolution in previous time steps.**
- **Another algorithm "floodfill" is developed locally which creates the information of minimum Cloud Top Temperature (CTT), Area of cloud cluster Centroid of cloud cluster and latitudinal and longitudinal extent of cloud cluster.**

INSAT-3D based nowcasting - Gives BT(Brightness temperature) upto next 3 hours

http://www.rapid.imd.gov.in/



SCOPE Nowcast System



Validation of WDSS-II nowcasts

Sen Roy Soma, Subhendu Brata Saha, SK Roy Bhowmik, and P. K. Kundu. 2014: Optimization of Nowcast Software WDSS-II for operational application over the Indian Region. Meteorology and Atmospheric Physics , 124(3) (2014), 143-166

Method of comparison

- Prior to operational nowcasting over the Indian region, the parameters of the nowcast algorithm tool of the software were optimized, and accuracy was evaluated for various weather systems over Delhi.

- MODE - Object based validation technique was applied to compare 60 minute nowcasts from the model with respect to observations

- Data and products which were available at ten minute intervals were analyzed for multiple events, each spread over 1-3 days.

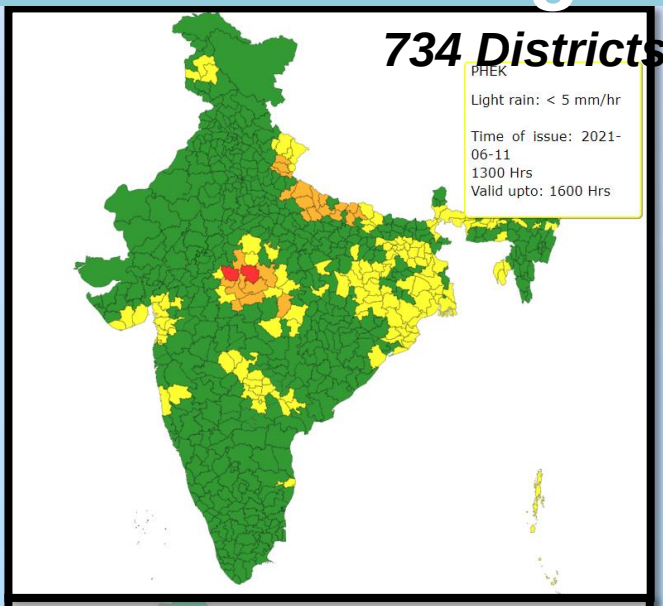
WDSS-II Nowcasting

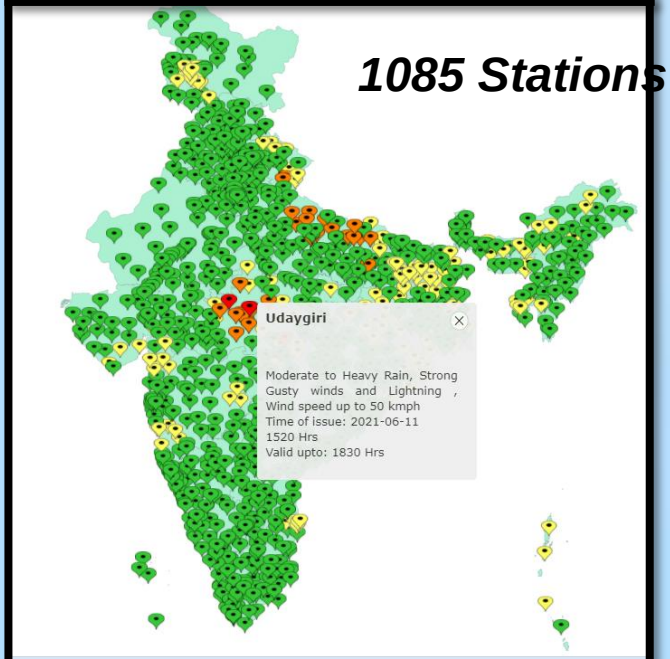
- **The inter-event comparison indicates that the**
  - **Low intensity convective line zones, which are characteristic of winter and early pre-monsoon weather systems (November to February), have the most rapid temporal change in the overall area under convection. This leads to larger area errors during nowcasting of these systems.**
  - **Pre-monsoon systems (March to June and October), comprising mostly of isolated cells that reach great heights and move very fast, do not have much horizontal area growth. The error in the nowcasting of these systems is mostly in respect of location error, as well as error in forecast of the intensity of the cells.**
  - **The overall error in nowcasting is least for the monsoon systems (July to September) over the Delhi region. These systems do not move very fast and have long lifetimes.**

Why do nowcast models fail?

- Data communication from radar to forecaster server, and from forecaster to user.
- Inability to initiate and decay thunderstorms at observed rates
- Exponential rate of growth and decay and short lifetimes of most actual thunderstorm systems
- Varying speed of movement.

Three hourly nowcasting





i) No weather

ii) Light rain: < 5 mm/hr

iii) Light snow < 5cm/hr

iv) Light Thunderstorms with maximum surface wind speed upto 40 kmph

v) Slight dust storm: If the wind speed is up to 40 kmph and visibility is less than 1,000 metres but more than 500 meters due to dust

vi) Low cloud to ground Lightning probability (< 30% probability of lightning occurrence)

vii) Moderate rain: 5-15 mm/hr

viii) Moderate snow: 5-15 cm/hr

ix) Moderate Thunderstorms with maximum surface wind speed between 41 – 61 kmph (In gusts).

x) Moderate dust storm: If the wind speed is between 41- 61 kmph and visibility is between 200 and 500 metres due to dust

xi) Moderate cloud to ground Lightning probability (30 - 60% probability of lightning occurrence)

xii) Heavy rain: >15 mm/hr

xiii) Heavy snow: >15 cm/hr

xiv) Severe Thunderstorms with maximum surface wind speed between 62 - 87 kmph (In gusts).

xv) Very Severe Thunderstorms with maximum surface wind speed > 87 kmph (In gusts).

xvi) Thunderstorms with Hail

xvii) Severe dust storm: If surface wind speed (in gusts) exceeding 61 kmph and visibility is less than 200 metres due to dust

xviii) High cloud to ground Lightning probability (> 60% probability of lightning occurrence)

Thank you