



# Now-casting using Doppler Weather Radar

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**INDIA METEOROLOGICAL DEPARTMENT**



**Nowcasting is defined as weather forecasts for a period of less than 6 hours**

Before Cloud signature in the Radar

- Thermodynamic Indices from RS/RW
- GNSS
- Meso-scale models

After Cloud signature in the Radar

- Cloud characteristics
- Extrapolation techniques
- Dual polarization products
- Expert nowcast systems
- Warning/Alerting systems
- Dual Doppler



# Cloud characteristics

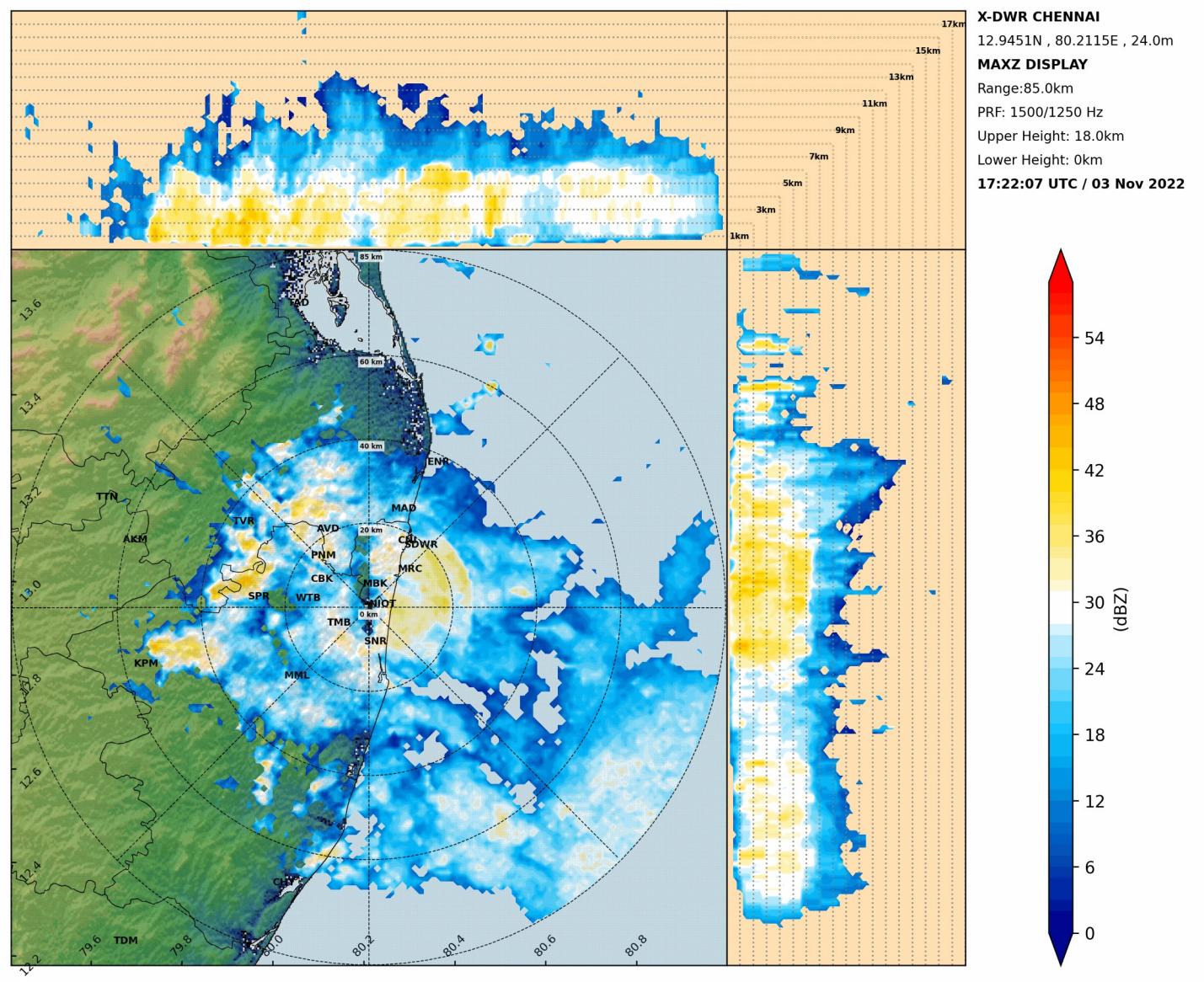
- Stratus precipitation
- Single cell storms
- Multicell storms
- Squall lines
- Super cells



## Stratus precipitation

- ❖ Widespread cloud formation covering large areas
- ❖ The formation is usually associated with depression, cyclonic storms, monsoon rains
- ❖ The life of the storms are long with rainfall throughout the day/s.
- ❖ The reflectivity values are less with varying rainfall intensity[ mostly light to moderate]





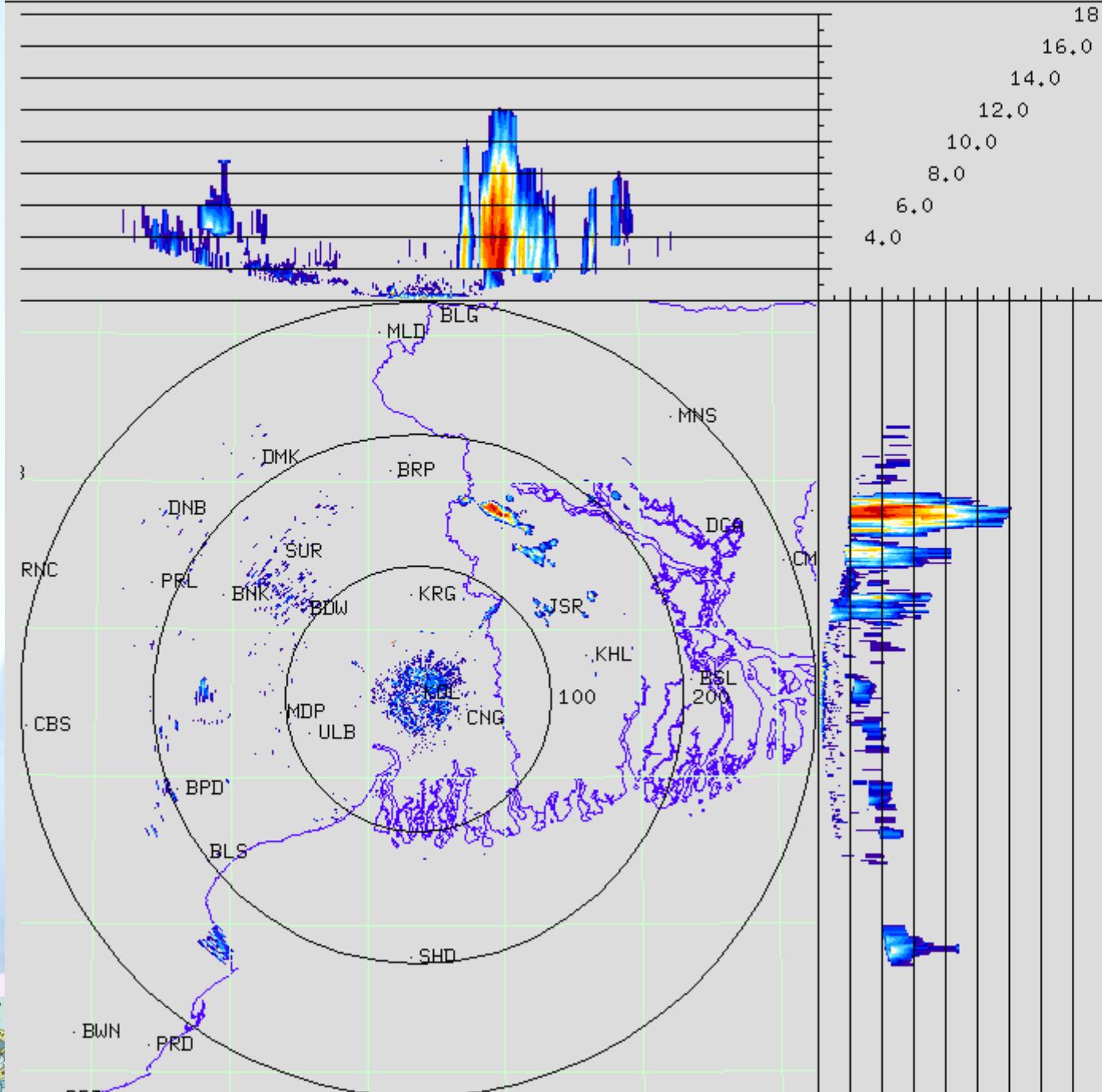
## Single cell storms

- ❖ A single cloud development moves independently without merging with any other cloud is termed as a single cell storm.
- ❖ Such storms normally occur in environments where winds are relatively light and vertical wind shear is small.
- ❖ The life of such storms is usually 60-90 mts from development to dissipation.



Type : MAX(Z)  
Range: 300.0 km

03.04.2004  
18:57:18



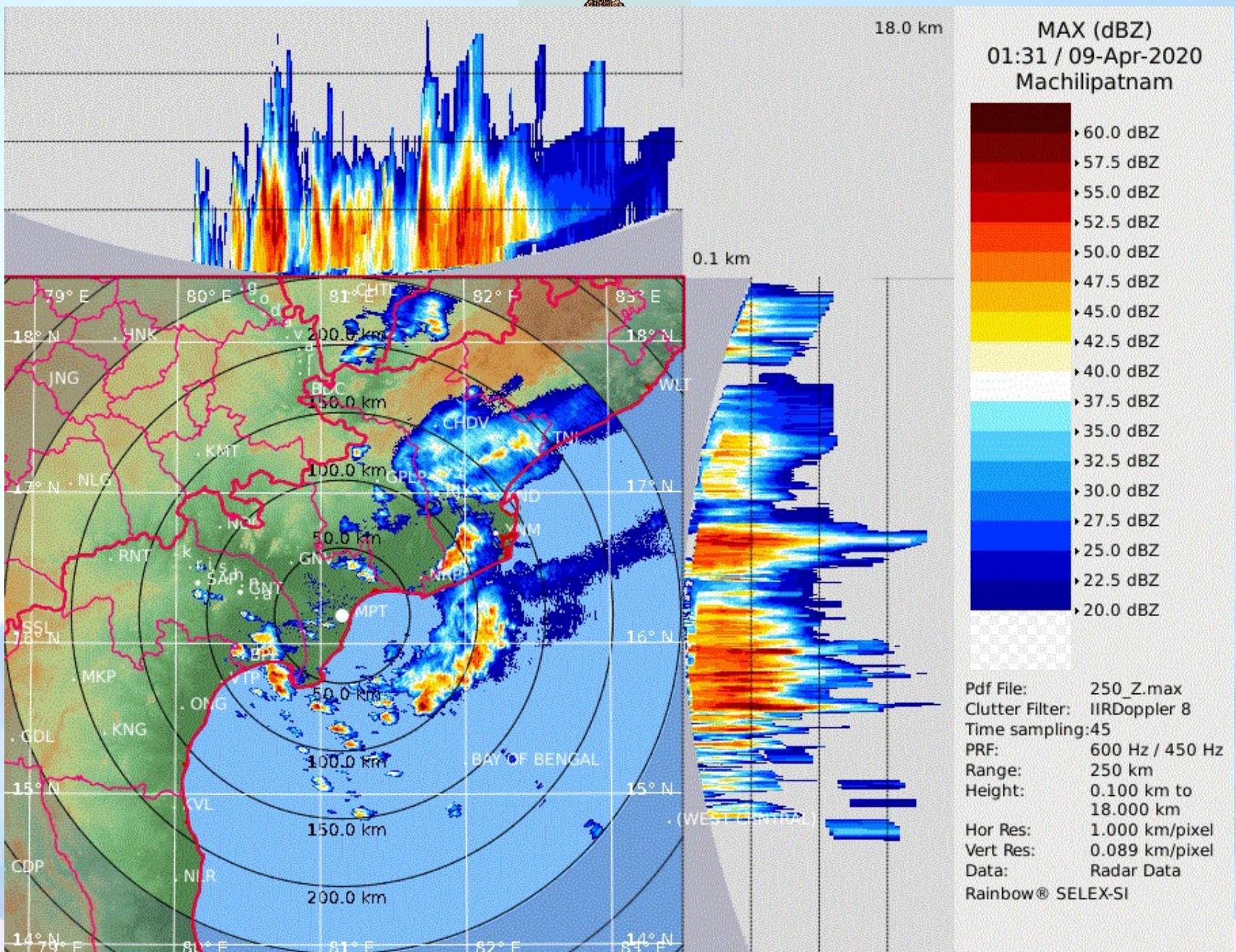
CALCUTTA  
Scan R : 250 km  
Scan Res: 0.50 km  
Disp R : 300 km  
Disp Res: 1.200 km  
PW : Short  
PRF: 600 / 450  
AS : 7.50 deg/s  
TS : 48  
RS : 1  
CC : Doppler 5  
SQI: 0.25  
CSR: 30.0 dB  
LOG: 2.0 dB  
H : 18.00 km  
LS : 0.100 km  
  
Doppler Weather Radar  
Kolkata



## Multi cell storms

- ❖ These storm systems consist of a series of evolving cells which typically form on or near the storm periphery at 10-15 minutes intervals.
- ❖ Each cell eventually becomes the dominant cell of the storm complex, building to higher levels as it approaches and finally merges with the main storm complex.
- ❖ The life of such storms is usually 2-3 Hrs from development to dissipation.





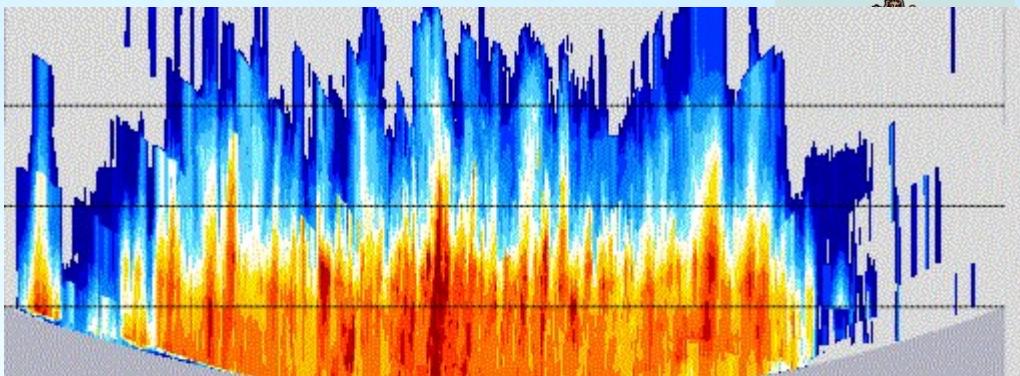
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**INDIA METEOROLOGICAL DEPARTMENT**



# Squall Line

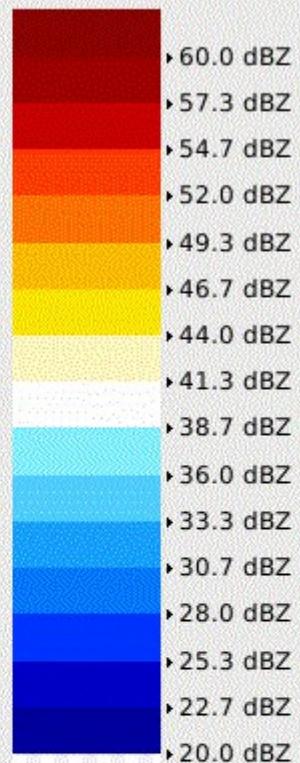
- A chain of thunderstorms joined together with length more than 60 km.
- Width to length ratio 1:10.
- Structure is sometimes linear but most of the times as a “BOW Echo”.
- More the convex is the structure, more intense is the system.
- The life of such storms is usually 3-6 Hrs from development to dissipation.



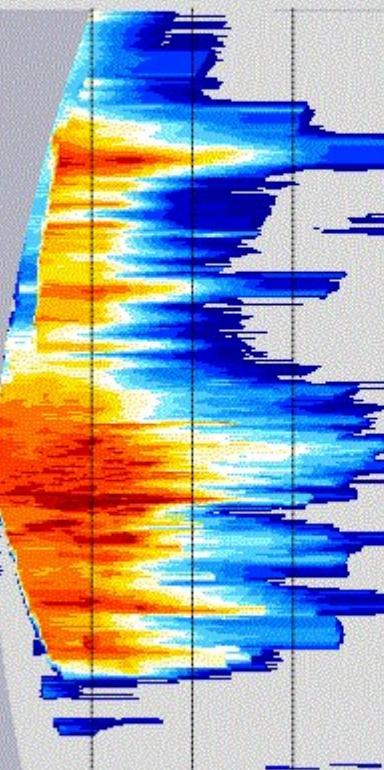
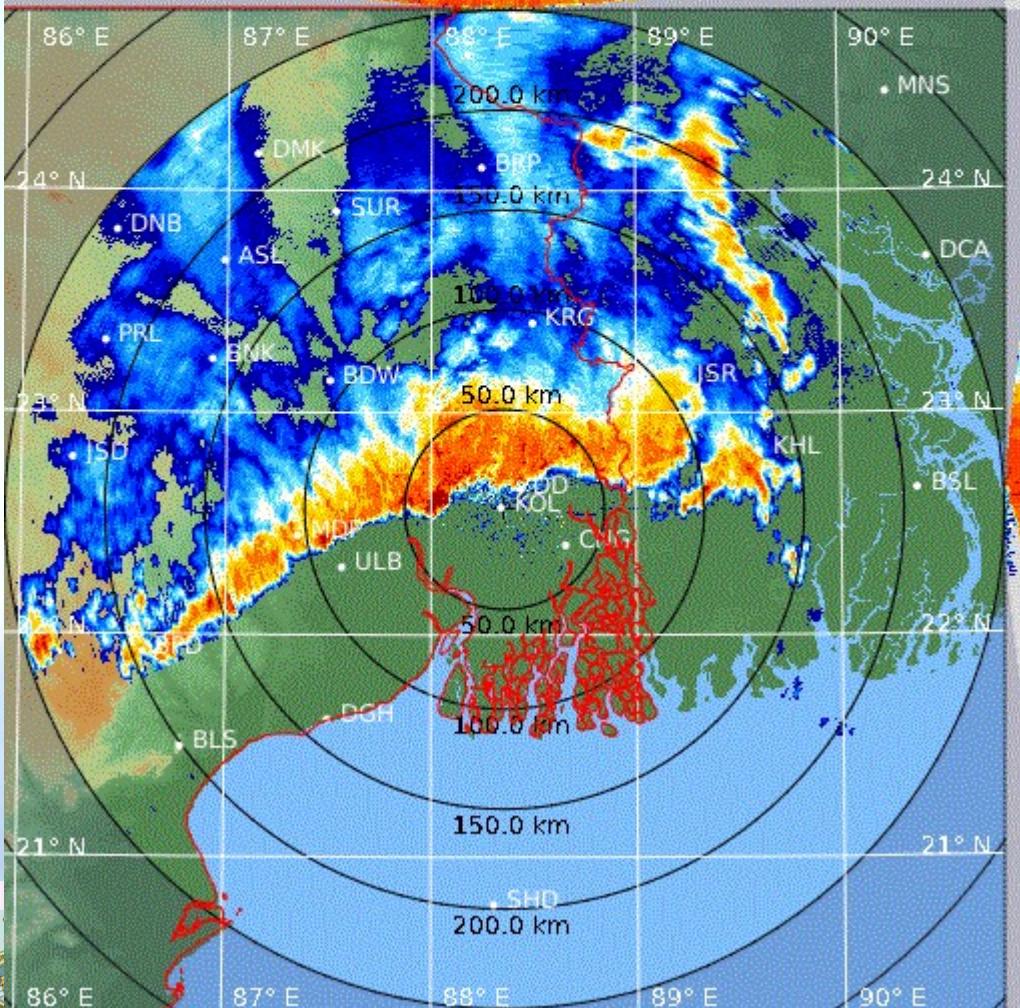


18.0 km

MAX (dBZ)  
03:04 / 31-May-2014  
Kolkata



0.1 km



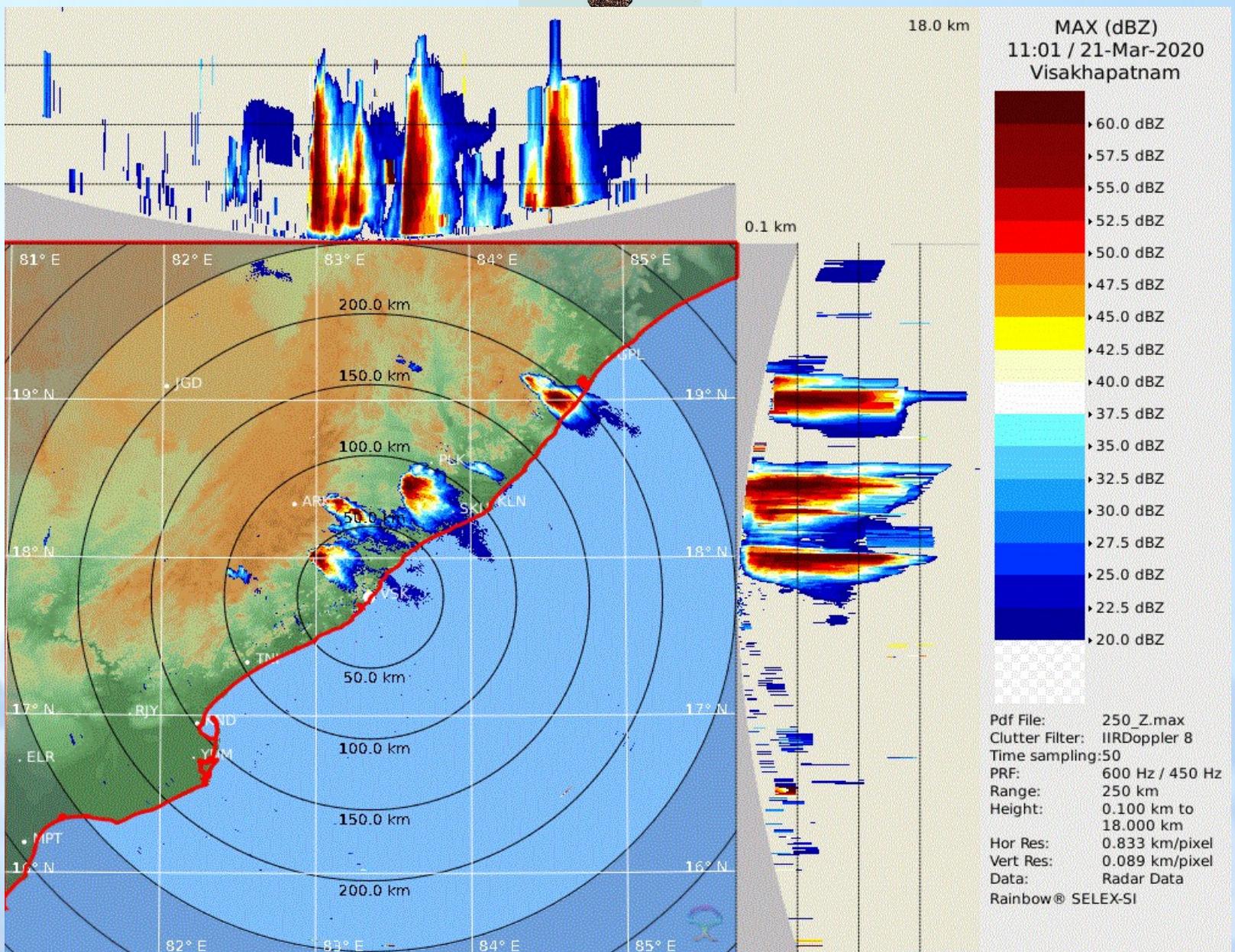
Pdf File: 250Z.max  
Clutter Filter: IIRDoppler 8  
Time sampling: 44  
PRF: 600 Hz / 400 Hz  
Range: 250 km  
Height: 0.100 km to  
18.000 km  
Hor Res: 1.000 km/pixel  
Vert Res: 0.089 km/pixel  
Data: Radar Data  
Rainbow® SELEX-SI



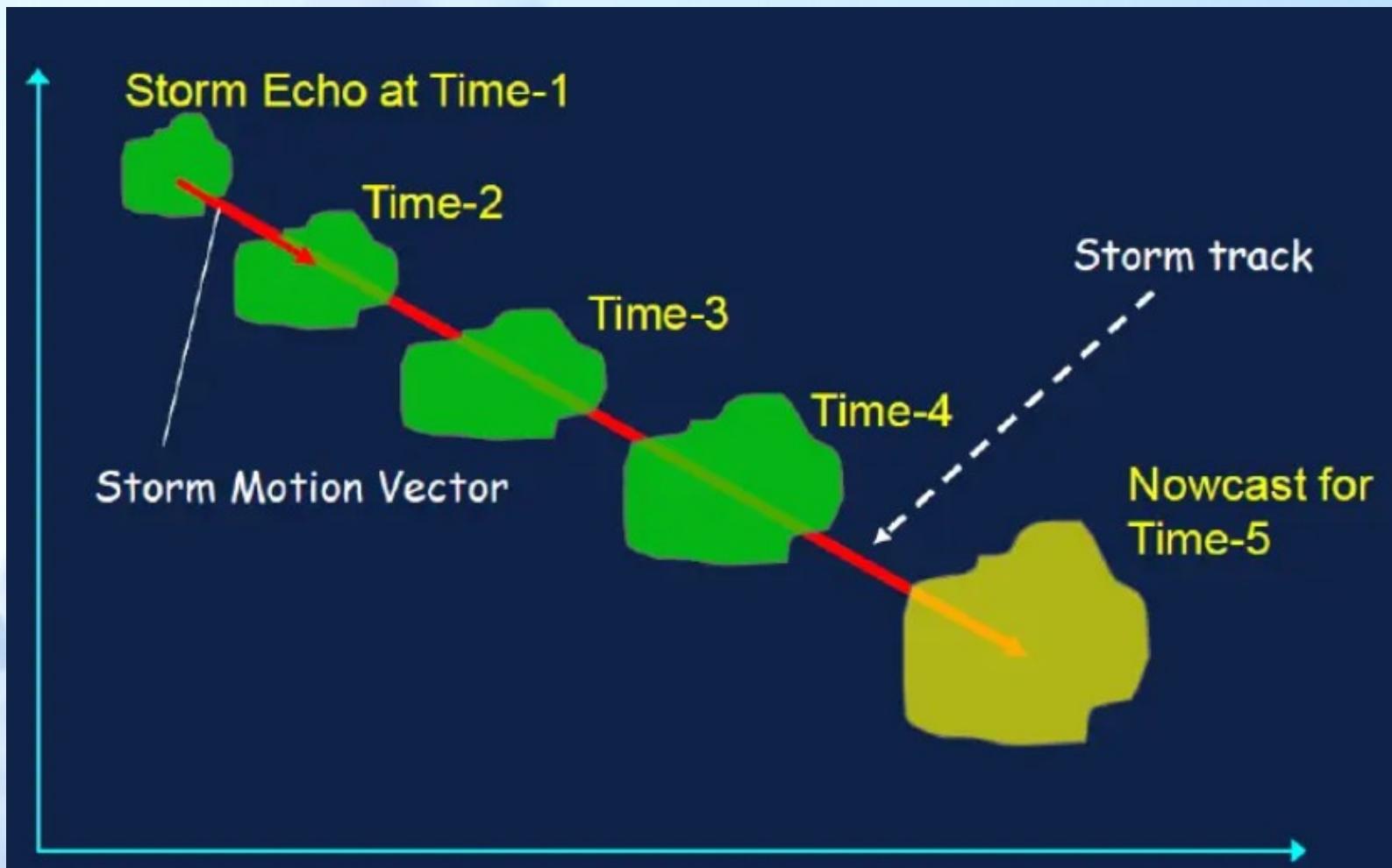
# Super Cell Thunderstorm

- Supercell storms are larger, intense and persistent and normally produce more severe weather than other type of thunderstorms.
- A highly organized internal circulation that reaches a nearly steady state enables the super cell to propagate continuously.
- Usually associated with Hailstorms and Tornadoes.
- The life of such storms is usually upto 6-8 Hrs from development to dissipation and sometimes more.

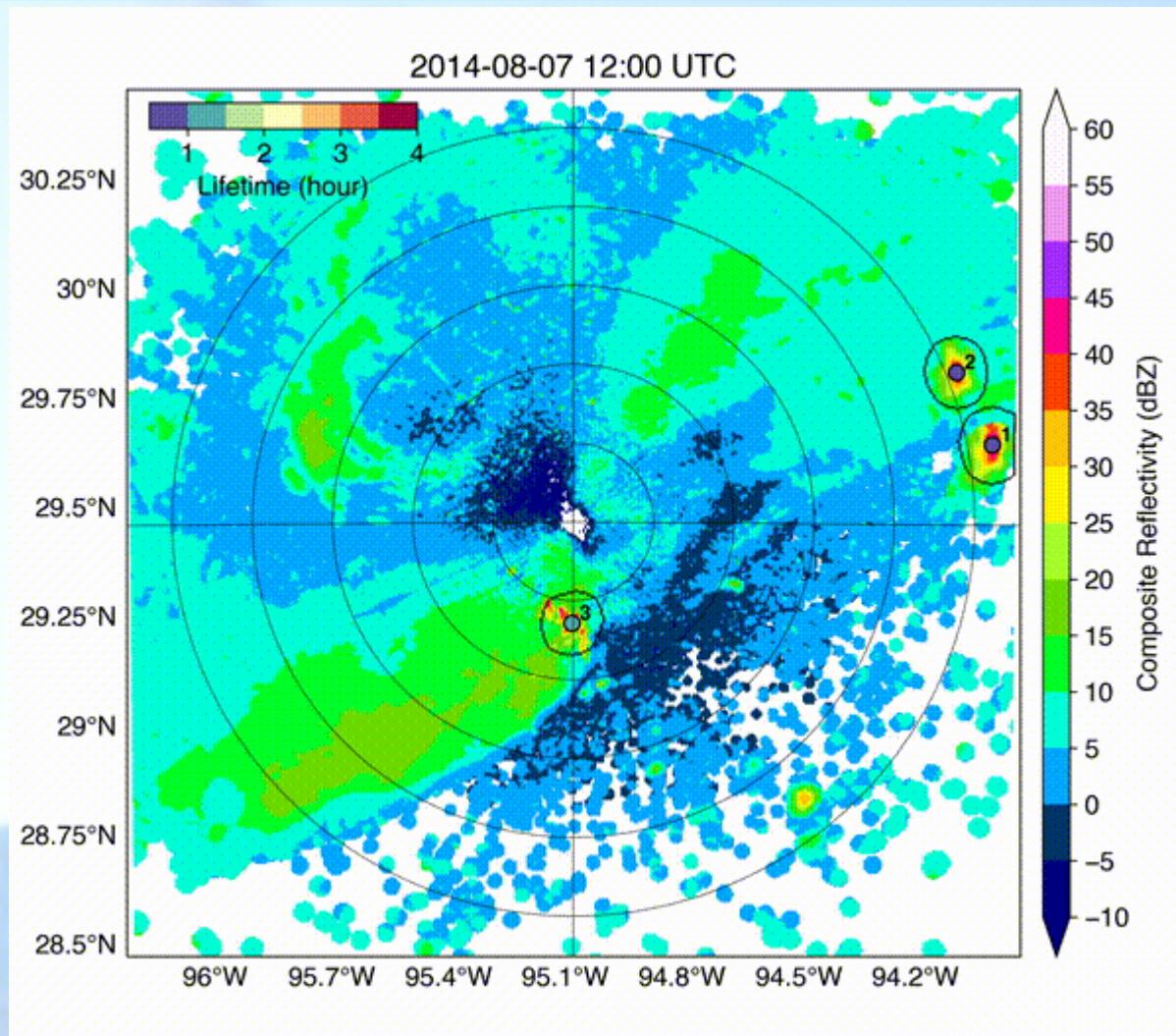




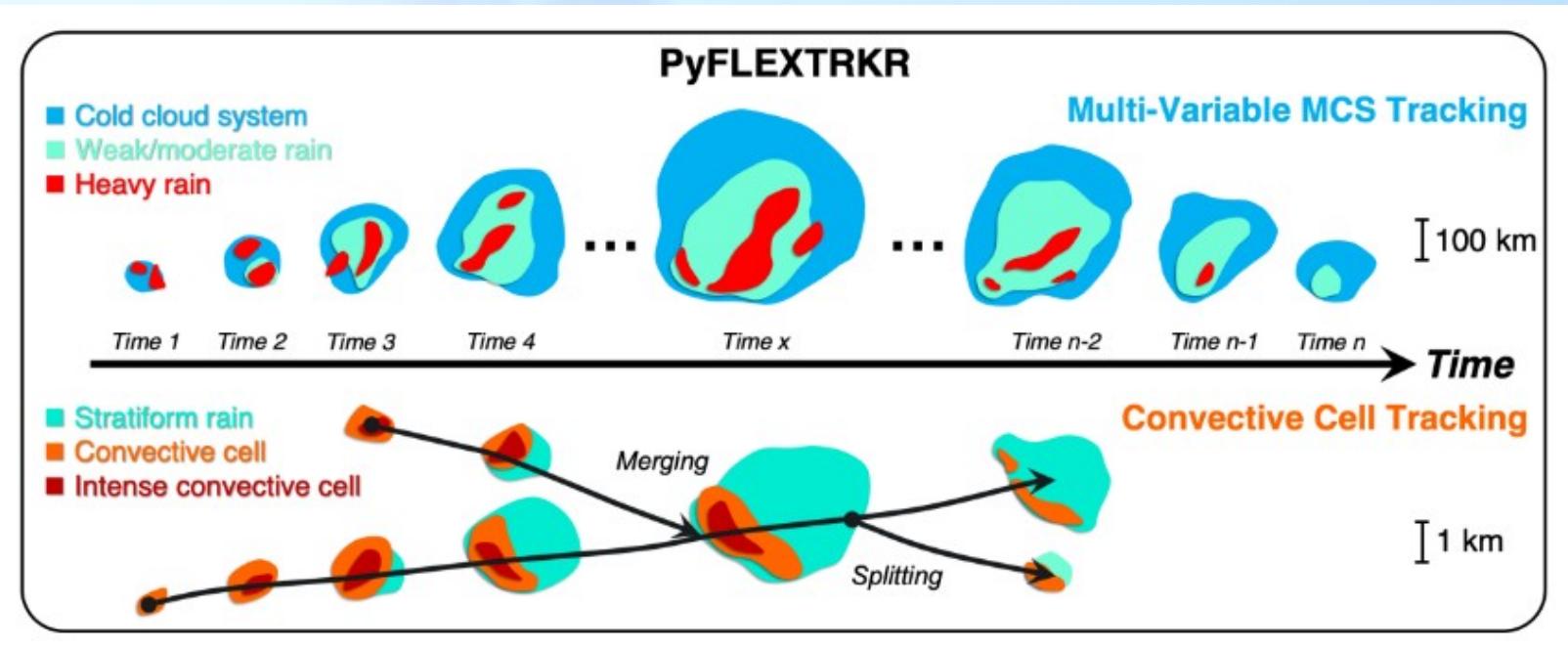
# Extrapolation techniques



# Extrapolation techniques

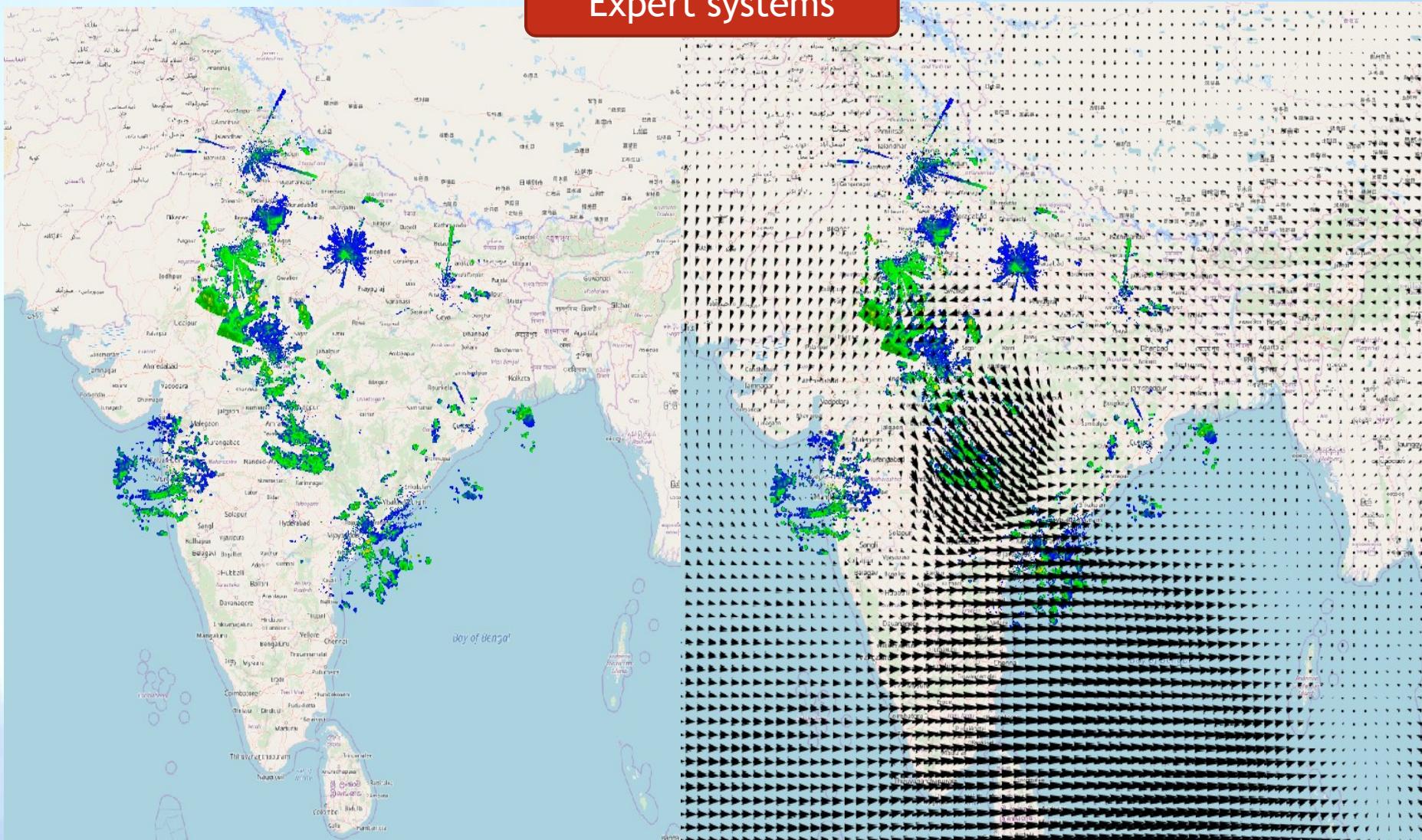


# Extrapolation techniques

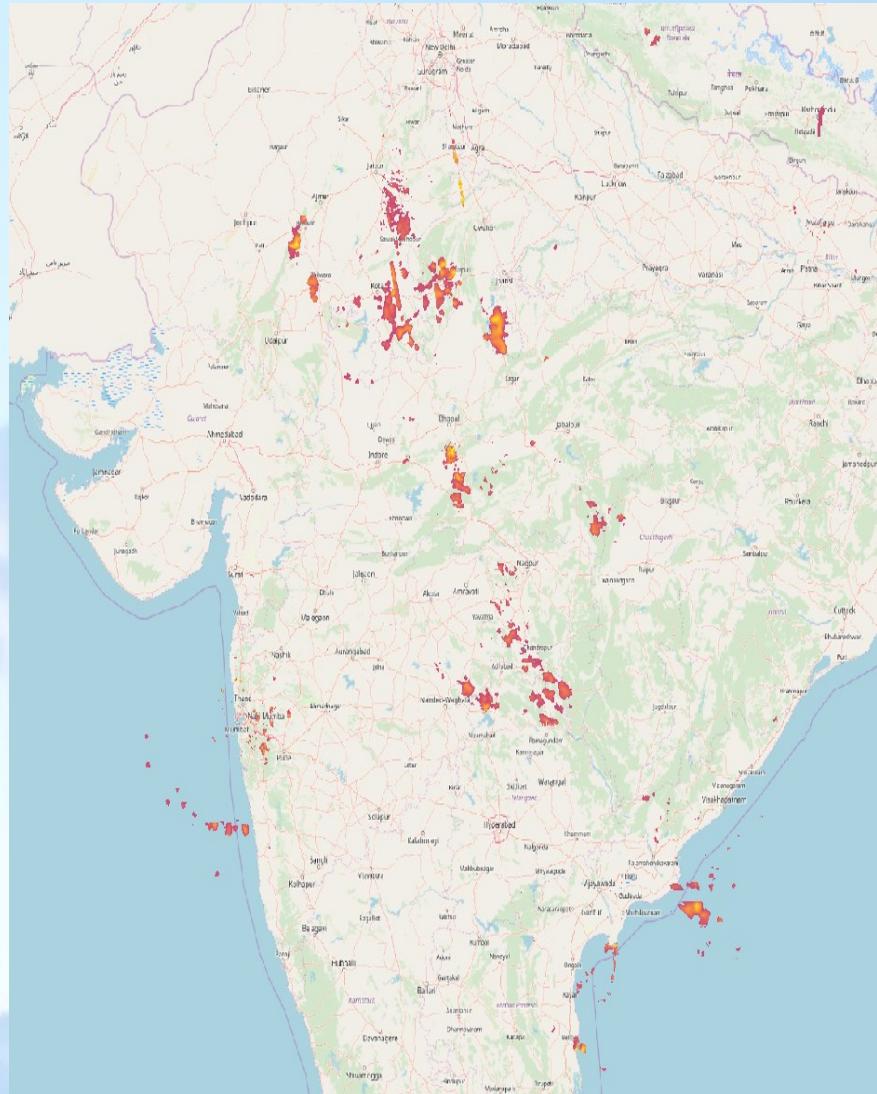
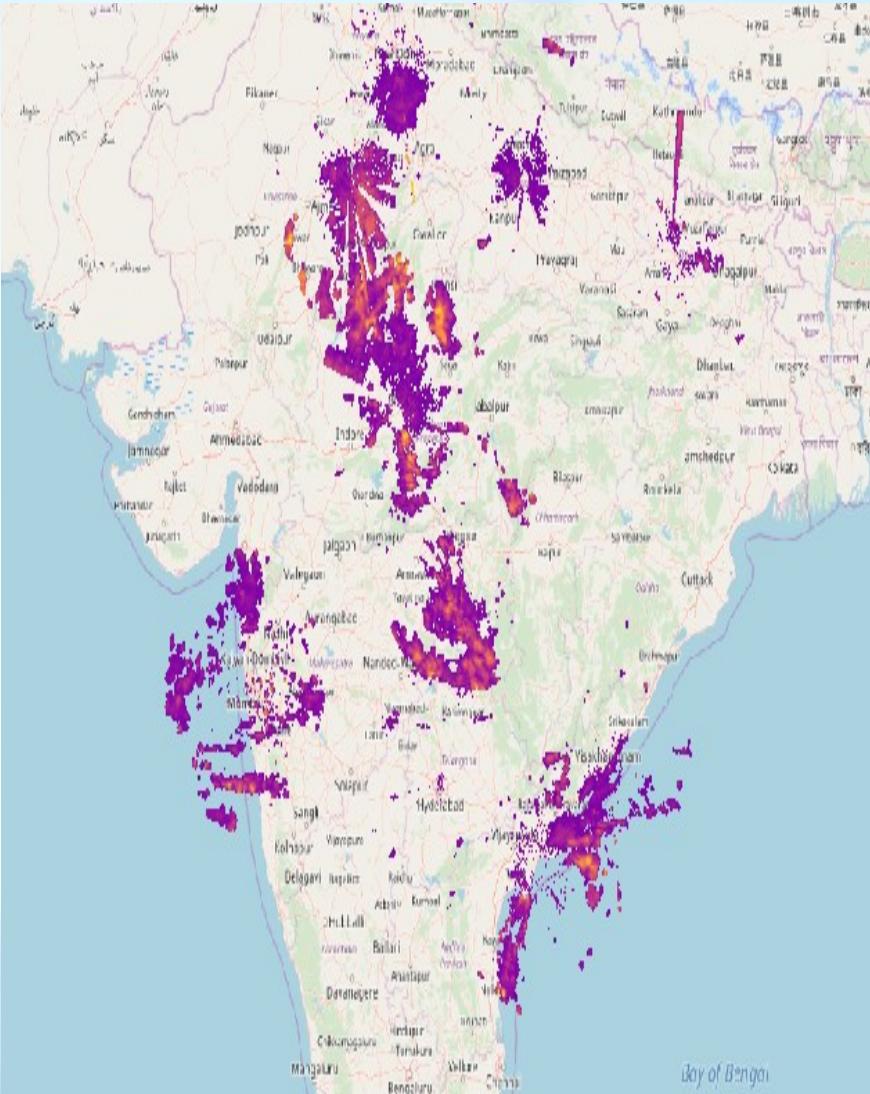


# Now-cast model

Expert systems



# Deterministic 60 minute nowcast



# Probabilistic one hour nowcast

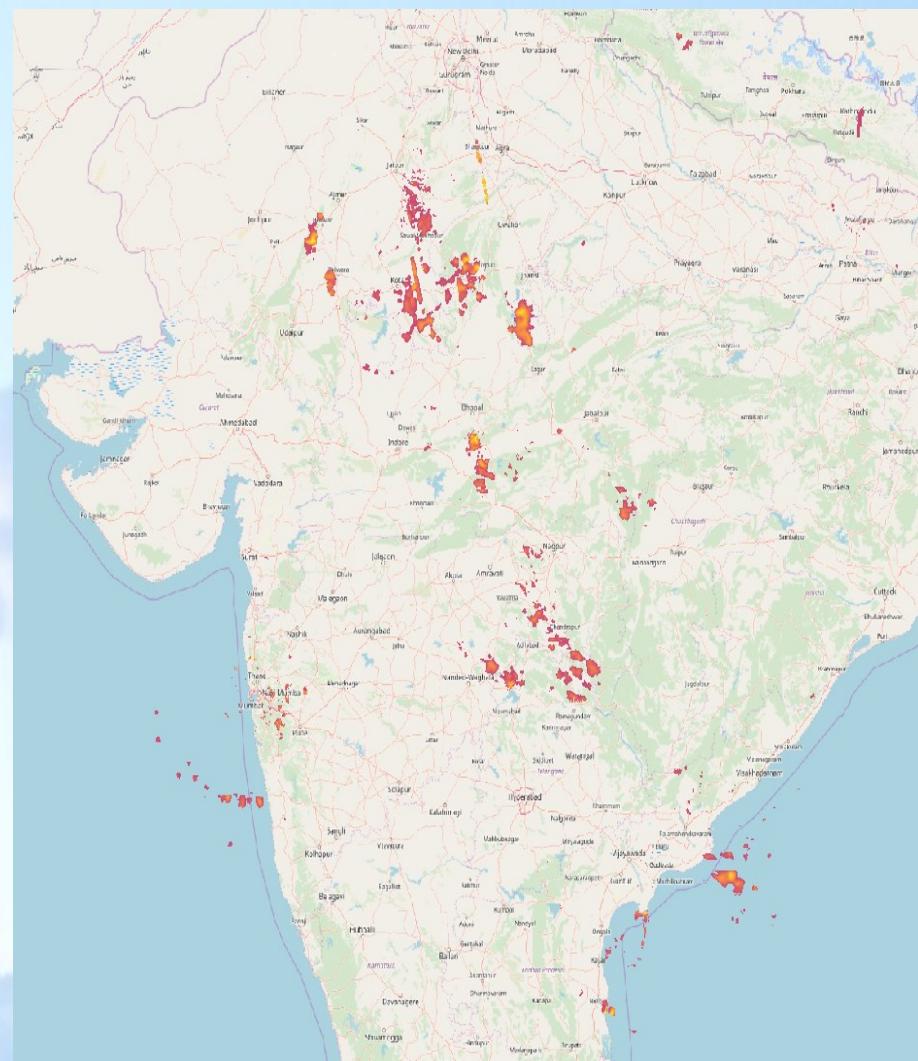
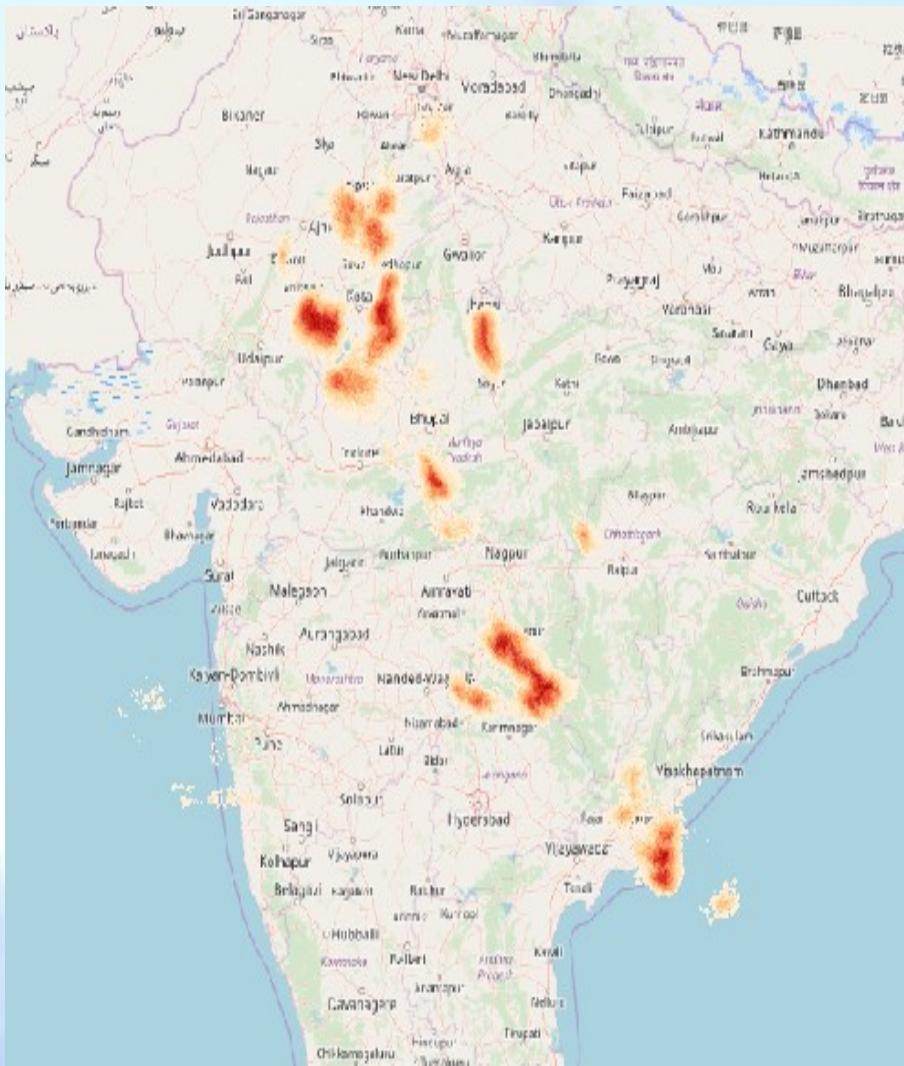


TABLE 1 (contd.)

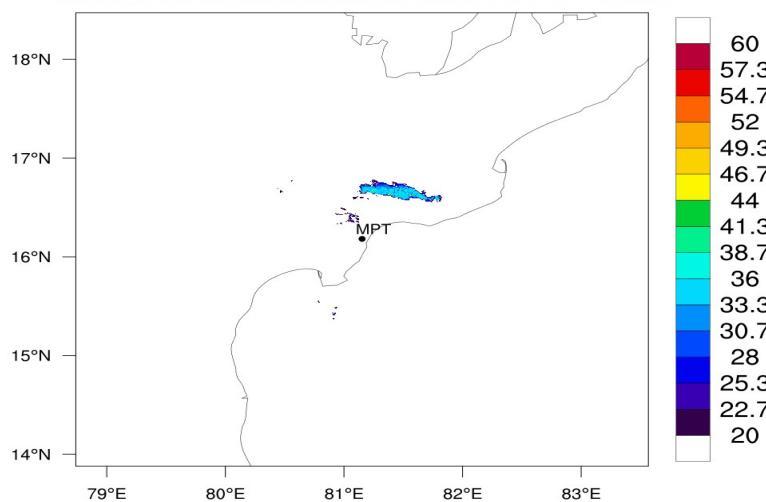
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	
RainCast <sup>2</sup> / COTREC <sup>2</sup> (Continuity of Tracking Radar Echoes by Correlation vectors)	Czech Republic since 2003, Switzerland	Novak, 2007, Schmid <i>et al.</i> , 2000	PseudoCAPPI 2 km-elevation reflectivity with 1-km horizontal resolution, Raingauge data	PseudoCAPPI 2 km-elevation reflectivity with 1-km horizontal resolution	90 min in 10-min time steps	Area Tracker, the echo motion field is determined by comparing two consecutive radar images using mean absolute difference as the similarity criterion. Motion wind field is constant in time and no growth/decay of radar echo	ARMOR <sup>4</sup> (Adjustment of Rain from Models with Radar)	Operationally run fo Cont US by WDT Technologies	DuFran <i>et al.</i> , 2009	Precipitation forecast from a NWP model, series of radar mosaics over the same domain	Average precipitation rate	10 hour forecast at 15 minutes intervals at 5 km grid spacing	Radar reflectivity mosaic is converted to precipitation rates and accumulated to 15 minute intervals. Intensity correction is applied to the model forecast, using corresponding pixels in the model and radar	
S-PROG <sup>3</sup> (Spectral Prognostic nowcaster)	BAMS (Australia). Also used in STEPS	Seed, 2003	Rain field, in terms of reflectivity Z [dBZ] or rain intensity R [mm/h]	Rain field, in terms of reflectivity Z [dBZ] or rain intensity R [mm/h]	5 min, 30 min & 60 min forecast of track	Spectral decomposition model which uses scale dependent temporal evolution to formulate forecasts	Nimrod <sup>3</sup> (Nowcasting and Initialisation for Modeling Using Regional observation Data System)	UK Met Office	Golding, 1998	Radar-based rain analyses, satellite IR and visible radiances and NWP model forecasts	Precipitation field, probability of occurrence of fog, visibility.	0-6 hours at 10 minute intervals, updated every 20 minutes	Extrapolation algorithm for short term, which is merged with NWP model output for longer term forecast	
MAPLE <sup>3</sup> (McGill Algorithm for Precipitation Nowcasting by Lagrangian Extrapolation)	Korea Meteorological Administration, Canada, U.S.A.	Germany Zawadzki, 2004	Radar derived Reflectivity, precipitation rate, precipitation accumulation Quantitative precipitation estimation	Hourly Precipitation forecasts, probabilistic QPF	9-12 hours	Variational echo-tracking with semi-Lagrangian advection of radar reflectivity and correlation of the forecast with the observation. Area tracking method	VSRF <sup>3</sup> (Very-Short-Range-Forecast of precipitation)	Japan, Korea	Sugiura, 2013	Radar-raingauge Analyzed precipitation field	1 hour accumulated precipitation	1 to 6 hours	1. Forecast of precipitation by simple extrapolation method up to 3-hour 2. Merging with numerical prediction model (Meso-scale Model (MSM)) for 6-hour forecast	
MUSIC <sup>3</sup> (Multiple-Sensor Precipitation Measurements, Integration, Calibration and Flood forecasting)	European Commission	Burton <i>et al.</i> , 2003	Radar, Meteosat and raingauge observations	Rainfall estimation and forecasting	6 hours ahead with a spatial resolution of about 2 km	Decompose a radar image into features. These are tracked from one image to the next using an object-oriented methodology. The tracking uses lag-correlation to estimate velocity	HRPN (High-resolution Precipitation High-resolution Precipitation Nowcasts) <sup>4</sup>	Japan	Kigawa, 2014	Radar-based rain analyses and NWP model forecasts	250 m resolution Precipitation	0-30 minutes	Extrapolation algorithm for short term, which is merged with NWP model output for longer term forecast	
STEPS <sup>3,4</sup> (Short-Term Ensemble Prediction System)	UK Met Office,	Bowler <i>et al.</i> , 2006	Radar-based rain analyses and NWP model forecasts	Probability of precipitation at threshold rain rates of 0.125, 0.25, 0.5 and 1 mm h <sup>-1</sup>	10-90 min at 1 km resolution, updated every 10 minutes	Decompose NWP and rainfall field into a cascade Blend each level in the radar & NWP cascades using weights that are a function of scale and lead time dependant forecast error. Add noise component to the deterministic blend. Combine the cascade levels to form a forecast	CINESat <sup>5</sup> (Central Austrian met. Institute (ZAMG) and the German met. office (DWD))		Scheiber, 1998	Image pixel data of a satellite image, vertical temperature profiles	Atmospheric Motion Fields, Predicted Satellite Images, Predicted Trajectories, Cloud Contour Prediction, Cloud Development Maps, Convective Cells	1, 2 and 3 hr forecasts	Forecasts are based on motion fields that describe the movement of clouds from one image to the next one	
Severe Weather Automatic Nowcast System (SWAN)	China	Feng, 2012	Weather radars base data + MYNOS+SWIFT data	Reflectivity and Quantitative precipitation forecast (QPF)	Greater than 1 hour	A regional 3D reflectivity mosaic is produced. COTREC (continuous tracking radar echo by correlation) vectors are derived from moving radar reflectivity patterns through grid-to-grid cross-correlation blended with mesoscale numerical prediction model output for 2-3 hour nowcasts.	ADSTAT <sup>6</sup> (Advection-Statistical system)	National Weather Service, (USA)	Kitzmiller <i>et al.</i> , 1999	Precipitation field, Radar reflectivity, lightning, gauge measurements and Meteosat Second Generation (MSG) satellite data and Eta model forecasts	Probabilities of rainfall exceeding 2,5,12, 25 and 50 mm) at any one location within a grid box and forecast of maximum rainfall amount within the grid box for given precipitation intervals	Precipitation forecasts for the subsequent 3 hr period, updated at 30 minute intervals, at 40 km grid boxes	Predictive algorithm is based on a advection statistical approach	
Shanghai Typhoon Institute-WRF ADAS-3DVar Rap Refresh system (STI-WARR)	China	Wang Habin <i>et al.</i> , 2016	NWP model data	NWP model variables			NOW <sup>6</sup>	Czech Republic	Sokol and Pesice, 2009	Precipitation field, Radar Products, lightning, gauge measurements, Meteosat Second Generation (MSG) satellite and NWP model	Probabilities of reaching or exceeding thresholds for mean 3-hourly precipitation	Precipitation forecasts for the subsequent 3 hr period in 9 km by 9 km boxes	Employs logistic regression to describe relationships between predictands and predictors. Similar technique to that of the ADSTAT model	
GRAPES-SWIFT <sup>4</sup> (Global/Regional Assimilation and Prediction System- Severe Weather Integrated Forecast Tool)	China	Liang <i>et al.</i> , 2010	Radar derived reflectivity field and NWP model output	Reflectivity, precipitation rate, precipitation accumulation, Quantitative precipitation estimation, Wind, Initiation, growth decay, Hail, strong winds		THESPAS <sup>8</sup> (Thunderstorm Environment Strike Probability Algorithm)	BAMS (Australia)	Dance <i>et al.</i> , 2010	Automated thunderstorm cell detections and tracks from TITAN and WDS	Graphical and text products from the data after being edited by forecasters	Post-processing software. Interactively producing severe weather warnings and other forecasts from thunderstorm tracks, automatically diagnosed from radar data			Semi-automated expert system: identify collision of convergence zones with radar echoes for the possibility of growth and decay using fuzzy logic and model outputs. Low level winds derived by VDRAS (Variational Doppler Radar Analysis System)
						COSMO <sup>9</sup>	COSMO member countries	Doms & Schattler, 2002	NWP Model output for boundary conditions. Radar reflectivity and satellite data	Numerical model outputs	- Hourly between 0.0 to 12.0. - Half hourly between 12.0 to 24.0. - Two Hourly between 24.0 to 48.0	Non-hydrostatic limited area atmospheric prediction model for short range weather forecasts		
						ALADIN <sup>9</sup> (Aire Limitee Adaptation Dynamique developpement International)	Czech Republic, Algeria	ALADIN, 2004	Numerical model for short range weather forecasts	Numerical model outputs	Forecasts are generated with 1 h time step up to 54 h	Mesoscale hydrostatic limited area model for short range weather forecasts		
						ARPS <sup>9</sup> (Advanced Regional Prediction System)	USA, India	Xue <i>et al.</i> , 2000	Radar data, NWP model for boundary conditions	Numerical model outputs	20 minute intervals for upto 21 hours	Non-hydrostatic forecast model for short range weather forecasts		
						University of Wisconsin Convective Initiation (UWCI) nowcasting algorithm <sup>10</sup>	USA	Sieglaff, <i>et al.</i> , 2011	Geostationary Satellite Imager data	Convective initiation	1 hour	Extrapolation		

**Source:**  
**A\_review\_of\_Nowcasting\_of\_convective\_weather\_over\_Indian\_Region, Soma et al.**

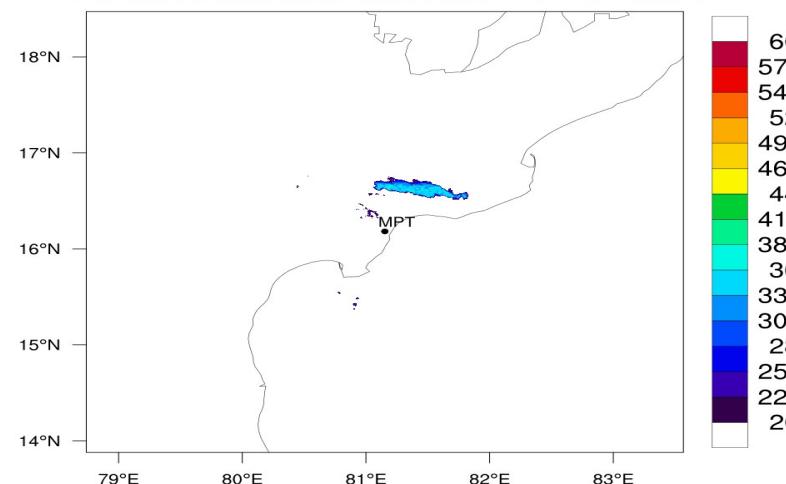


# SWIRLS NOWCASTING SYSTEM

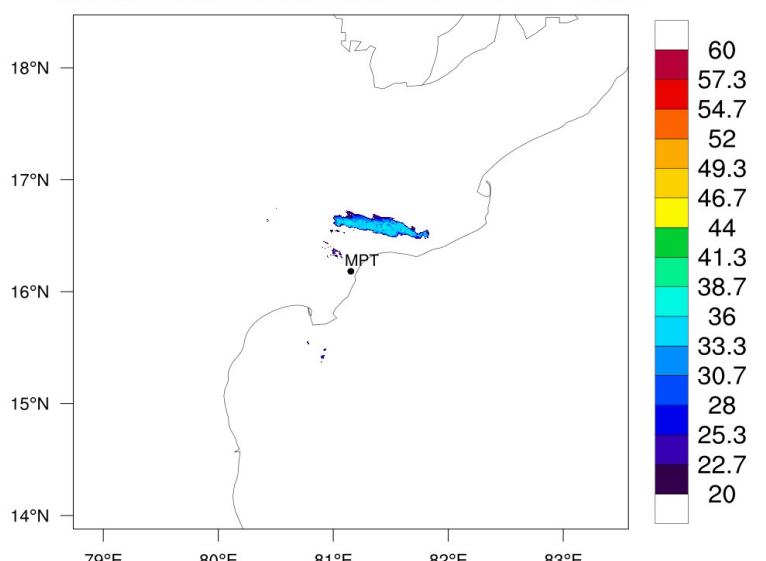
000 min forecast based on 20180911 at 1711 hrs IST



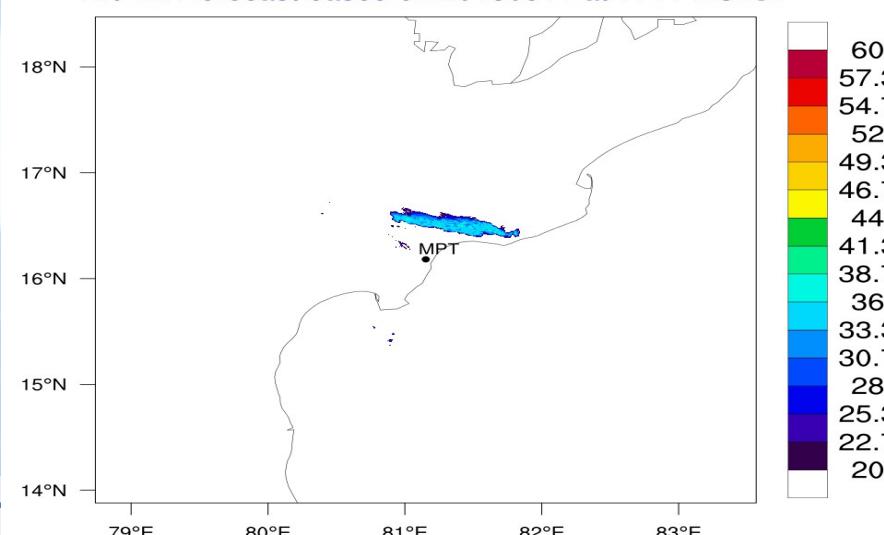
030 min forecast based on 20180911 at 1711 hrs IST



060 min forecast based on 20180911 at 1711 hrs IST

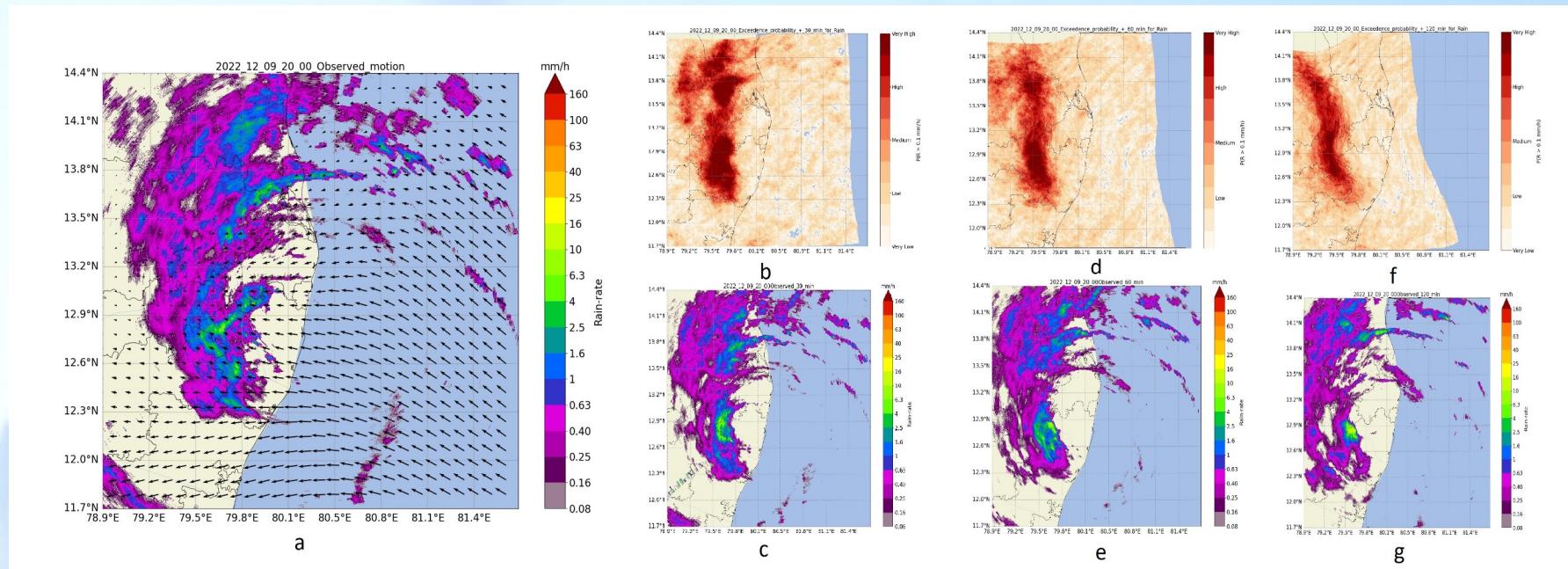


120 min forecast based on 20180911 at 1711 hrs IST



# Nowcast Module

Cyclone Mandous Dec 9<sup>th</sup> 2022



# Now-cast model

## Warning /Alerting system

- SSA – Storm Structure Analyses
- MESO – Mesocyclone Detection
- TVD – Tornado Vortex Detection
- VERG - Vergenceetection
- GF – Gust Front Detection
- SWI – Severe Weather Indicator
- ZHAIL – Reflectivity-based Hail Warning
- HAILSZ – Hail Size Estimation
- DSD – Dust Storm Detection
- DPFLA – Dual Polarization Freezing Level Analysis
- VADC – Volcanic Ash Detection and Classification
- VATR – Volcanic Ash Tracking
- VBIRD – Vertical Bird Distribution
- SCCL – Stratiform-Convective Classification
- ZSWCL – Z-based Severe Weather Classification



# Now-cast model

## Warning /Alerting system

**Hail Warning** Unit: SI

**Image**

Range: 100 km  
Size: 500 Pixel

**Algorithm**

Reflectivity Threshold: 45 dBZ  
Freezing Level:  Select manually 3.0 km  
 Load from file  
Hail Excess Height: 1.4 km  
Transition Interval: 3.0 km  
Beam Broadening Factor: 0.2

**Lightning Risk Forecast** Unit: SI

**Image**

Range: 100 km  
Size: 500 Pixel

**Lightning Risk ETOP Heights**

Minimum Reflectivity: 30.0  
Moderate-Risk Height: 8.0 km  
High-Risk Height: 10.0 km

**Forecast Times**

1. Step: 15 min  
2. Step: 30 min

**Data**

Adjust Cell Motion to CTR Global Motion  
 Add Movement Data to Product

**Stratiform-Convective Classification** Unit: SI

**Image**

Range: 100 km  
Size: 500 Pixel

**Classification**

Parameter File:

**Z-based Severe Weather Classification** Unit: SI

**Image**

Range: 100 km  
Size: 500 Pixel

**Heights**

Freezing Level: 3.0 km  
-22°C Level: 6.0 km  
Tropopause Height: 12.0 km  
Surface Height: 0.7 km  
Convection Excess: 1.0 km

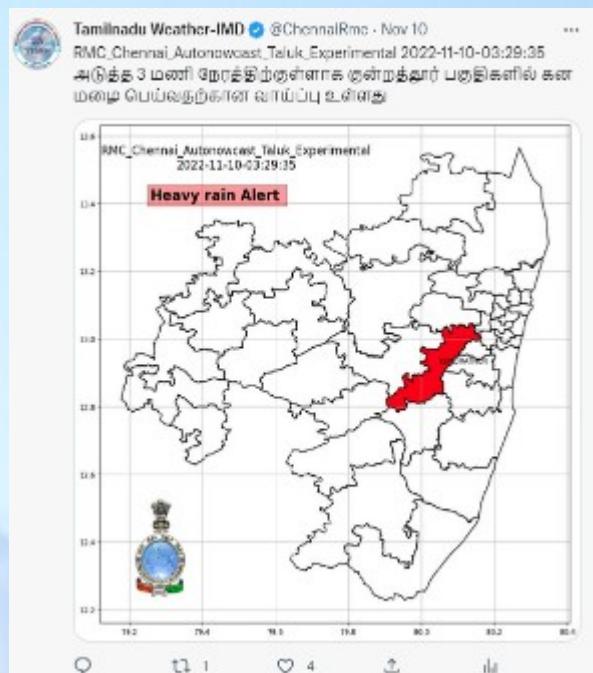
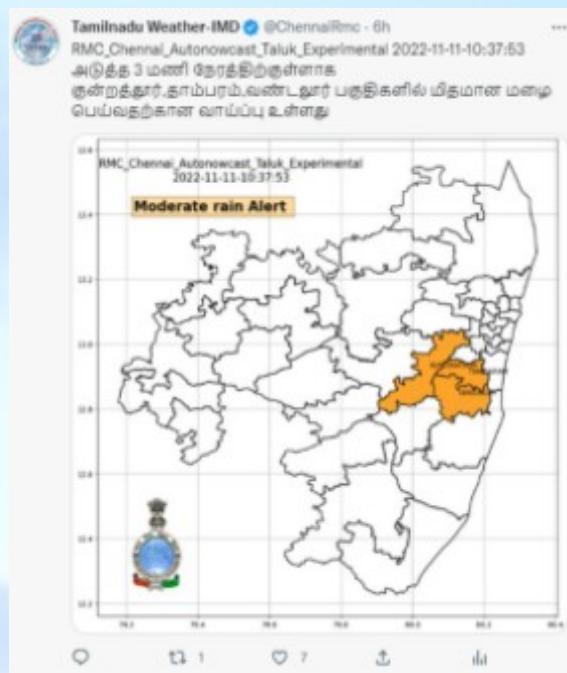
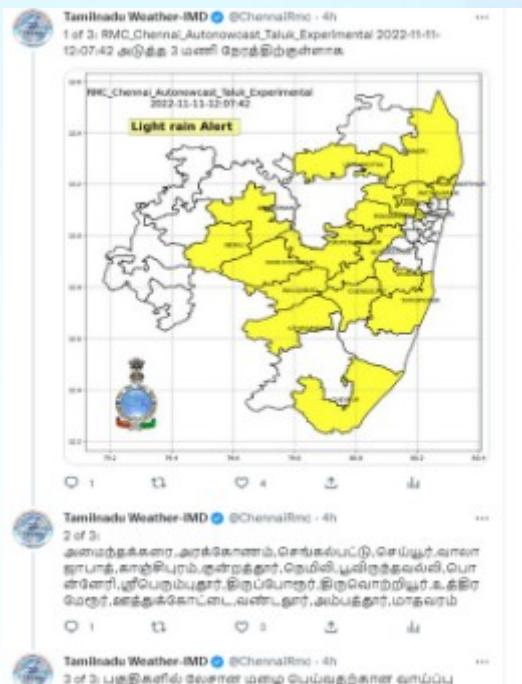
**Icing Height Parameters**

A: 0.4  
B: 0.4  
C: 0.2

0	No echo
1	Upper and middle layer cloudiness
2	Stratus
3	Precipitation, light
4	Precipitation, moderate
5	Precipitation, severe
6	Cumulus
7	Shower, light
8	Shower, moderate
9	Shower, severe
10	Thunderstorm, probability 30-70%
11	Thunderstorm, probability 71-90%
12	Thunderstorm, probability >90%
13	Hail, light
14	Hail, moderate
15	Hail, severe
16	Squall, light
17	Squall, moderate
18	Squall, severe
19	Tornado
31	No data



# Output Module



IMD\_NEWDEHLI\_Autonowcast2023-04-05-22:54:31 [Inbox x](#)



nowcastdelhi.imd@gmail.com  
to nowcastdelhi.imd, xbandrmchennai

Wed, Apr 5, 5:22 PM (13 days ago)

IMD\_NEWDEHLI\_Autonowcast 2023-04-05-22:54:31 Light rain very likely to occur over CHANAKAYAPURI,DEFENCE\_COLONY,GANDHI\_NAGAR,HAUZ\_KHAS,KALKAJI,KANJHAWALA,KOTWALI,MAYUR\_VIHAR,NARELA,NAZUL,PREET\_VIHAR,SAKET,SARITA\_VIHAR,SEEMAPURI,SHAHDRA,VIVEK\_VIHAR areas within next 2 hours

[Reply](#)

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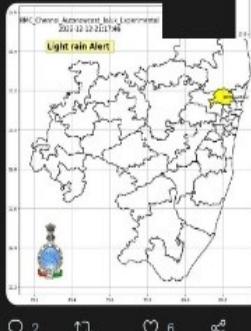
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INDIA METEOROLOGICAL DEPARTMENT



# RADCAST

Appreciation from public in Twitter

Tamilnadu Weather-IMD  
RMC\_Chennai\_Autonowcast\_Experimental 2022-12-12-21:1  
மணி நேரத்திற்குள்ள  
பகுதிகளில் வேசான  
பெய்வதற்கான வாயு



GURUBALAN C  
@GuruBalan3

Replying to @ChennaiRmc  
But perfect marking in the map!  
9:22 pm · 12 Dec 22 · Twitter for Android

TSM 🌩️ 🌦️ @The\_Storm\_Man · 1h  
Superb! 🍀🍀

@Tamilnadu Weather-IMD 🔍 · 1h  
RMC\_Chennai\_Autonowcast\_Taluk\_Experimental 2022-11-21-19:57:47  
அடுத்த 3 மணி  
நேரத்திற்குள்ளாக  
பல்லவரம்பி, சின்னமயிலாப்பூ...

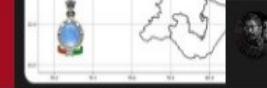


Giridharan KESAVAN 🇮🇳  
@girikesavan  
Wow. Highly localized.

@Tamilnadu Weather-IMD 🔍 · 1h  
RMC\_Chennai\_Autonowcast\_Taluk\_Experimental 2022-11-12-18:57:41 அடுத்த 3 மணி  
நேரத்திற்குள்ளாக மதவம்  
பகுதிகளில் வேசான மெழு  
பெய்வதற்கான வாய்ப்பு என்று



1:29 pm · 08 Nov 22 · IMD Chennai  
Retweet 2 Likes



Hari.Om 🌈 🇮🇳 @WatcherNo... · 2d  
It is a pity that IMD is doing such a  
wonderful job and is not getting enough  
support.

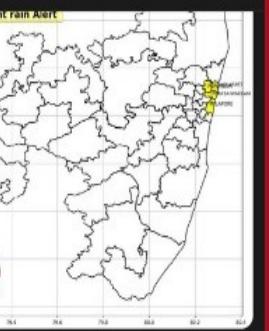
#chenairains #ChennaiRain  
#NEM2022 #monsoon2022

@Tamilnadu Weather-IMD 🔍 · 2d  
RMC\_Chennai\_Autonowcast\_Taluk\_Experimental 2022-11-01-04:57:47  
அடுத்த 2 மணி  
நேரத்திற்குள்ளாக  
எழுப்பும் மாம்பலம் மயிலாப்பூ...

Thanga Kumar @thangakuma... · 10h  
Replying to @ChennaiRmc  
Right prediction



← Tweet

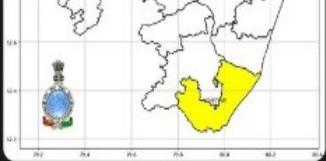


7:28 am · 31 Oct 22 · IMD Chennai

1 Retweet 1 Like

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bhaskaran( BS ) @BHASKARA... · 6m  
Replying to @ChennaiRmc

Sridhar V @srividhar781808 · 1h  
Replying to @ChennaiRmc  
Accurate prediction. Great work IMD.

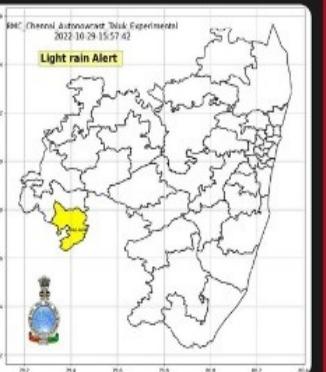


8:18 pm · 27 Oct 22 · IMD Chennai

1 Retweet 2 Likes

Parama Sivam 🌈 Parama\_Siv · 3m  
Replying to @ChennaiRmc  
இப்படி தமிழ்நால் பதிலிடுதல்  
நலம்

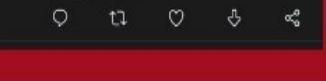
வாழ்த்துகள் 🍀🍀



3:58 pm · 29 Oct 22 · IMD Chennai

3 Likes

Shanmugam @Tweet2shamy · 1h  
Replying to @ChennaiRmc  
Expecting more like this 😊  
Keep it up....

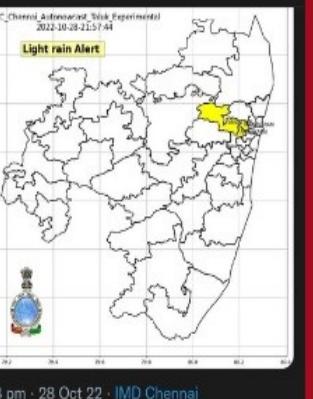


Devi Yogha @DeviYogha · 13m  
Good job by #IMD @ChennaiRmc giving  
hourly updates and it rains exactly as  
specified  
#chenairains @CMOTamilnadu

@Tamilnadu Weather-IMD 🔍 · 1h  
1 of 3:  
RMC\_Chennai\_Autonowcast\_Taluk\_Experimental 2022-11-03-00:07:49  
அடுத்த 3 மணி  
நேரத்திற்குள்ளாக  
Show this thread



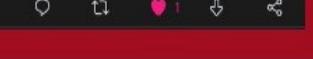
← Tweet

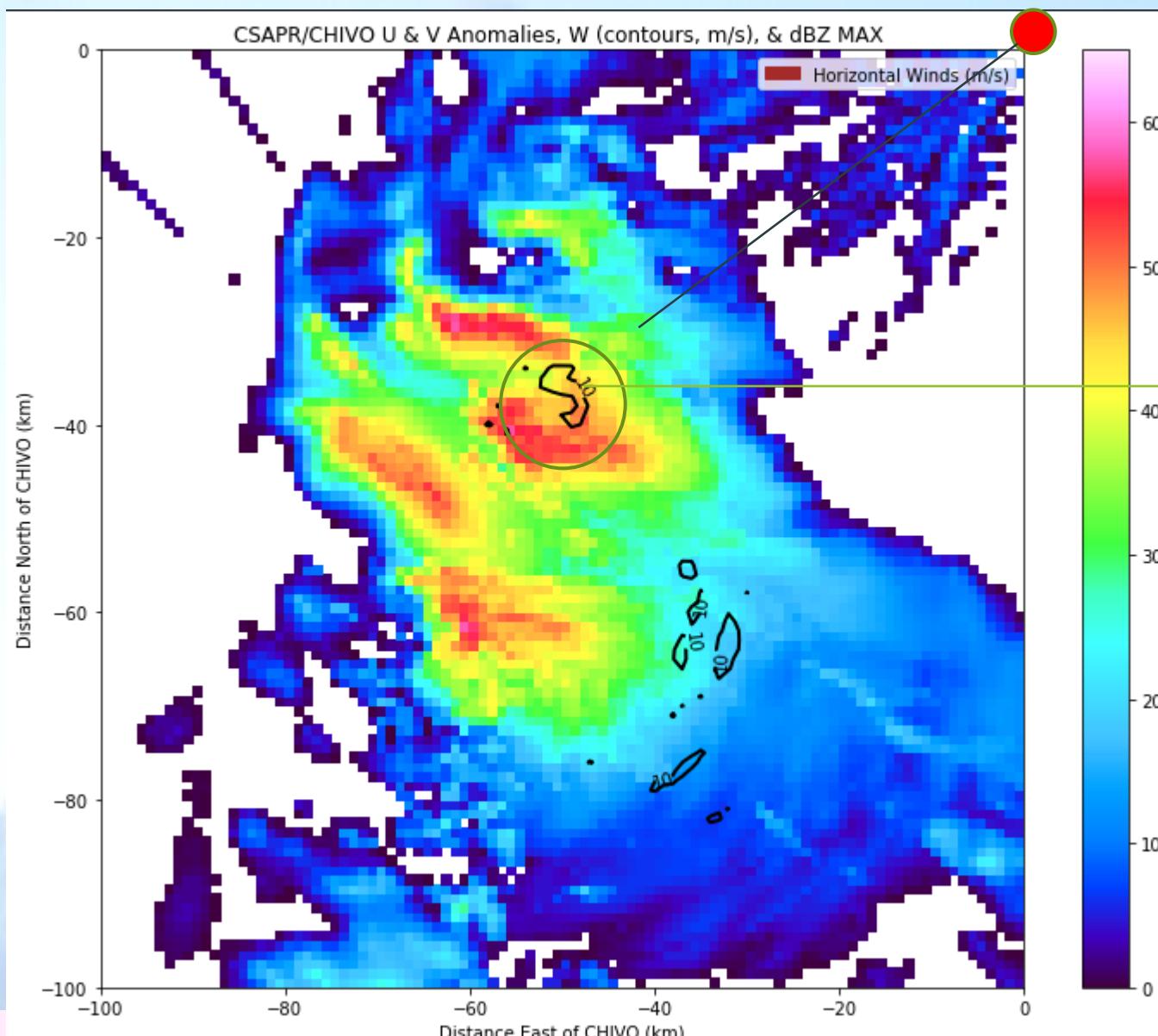


9:58 pm · 28 Oct 22 · IMD Chennai

1 Like

You and this Tweeter share some mutual follows  
bhaskaran( BS ) @BHASKARA... · 6m  
Replying to @ChennaiRmc  
Perfect just came to know that it is  
raining at Ayanavaram.

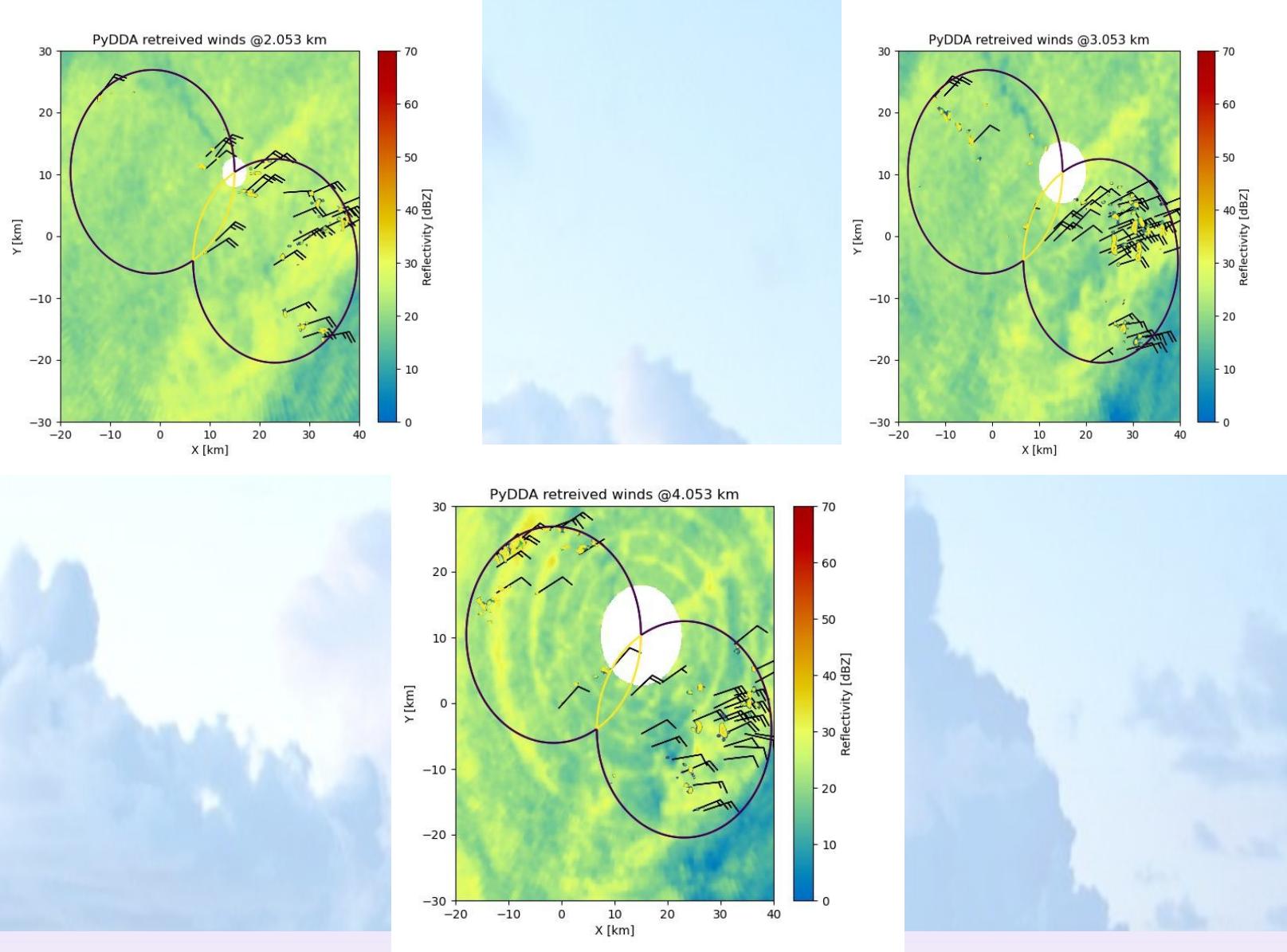




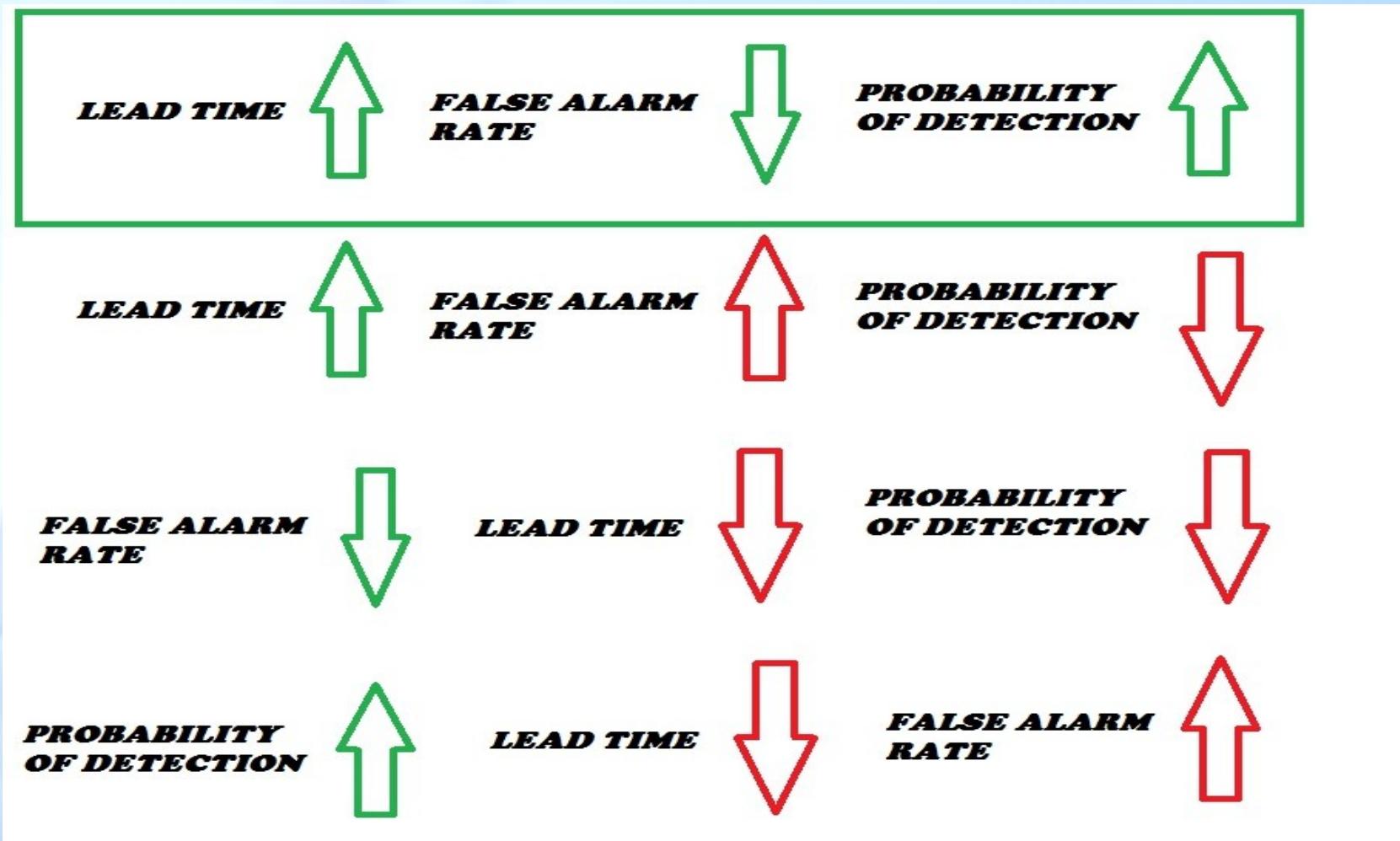
Region of Updraft  
seen before  
the High  
Reflectivity



# Multi Radar Data and Analysis- Chennai



# Challenges in Nowcasting



Thank you  
Any Questions?  
**[bibraj.r@imd.gov.in](mailto:bibraj.r@imd.gov.in)**

