WDSS-II software for support to Nowcast Service of IMD

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भारत मौसम विज्ञान विभाग
INDIA METEOROLOGICAL DEPARTMENT

Warning Decision Support System (WDSS-II) 1

- **Infrastructure** to support application development, data ingest and distribution, configuration, and output data formats.

- **Real-time and off-line data integration** of data from multiple radars.

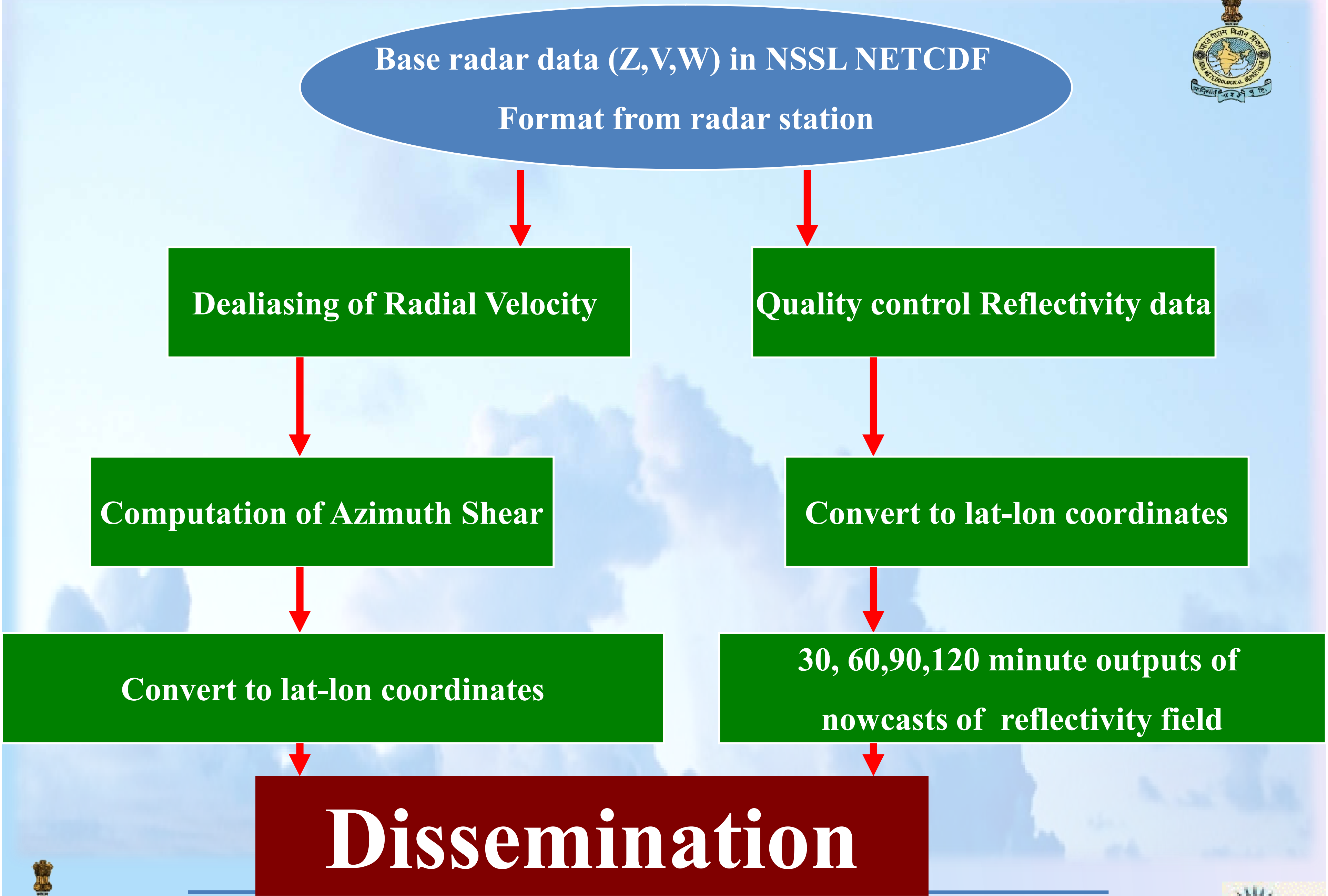
- **Interactive 4D Display** designed specifically to effectively manage and provide rapid access to the most important information for decision-making

- **Multi-radar Algorithms** to detect, diagnose and predict severe weather events.

Lakshmanan V, Smith T, Stumpf G, Hondl KD (2007a) The warning decision support system integrated information. Weather and Forecasting 22: 596–612

•The software was developed by National Severe Storms Laboratory (NSSL) at Oklahoma and the technology was shared with IMD under USAID Mission in 2006.

•The software has since been successfully installed operationally at nine radar stations at Delhi, Chennai, Kolkata, Jaipur, Chandigarh, Nagpur, Agartala, Patna and Hyderabad till date, to provide operational real-time nowcasts for the surrounding region, for upto two hours ahead, using single doppler radar data.


Base radar data (Z,V,W) in NSSL NETCDF
Format from radar station
Dealiasing of Radial Velocity
Quality control Reflectivity data
Computation of Azimuth Shear
Convert to lat-lon coordinates
Convert to lat-lon coordinates
30, 60,90,120 minute outputs of
nowcasts of reflectivity field
Dissemination

Operational Nowcasting at stations

DWR Data from Radar Data server

/home/imd/xxx_operational/polling

/home/imd/data/RDR

Reflectivity AliasedVelocity SpectrumWidth

/home/imd/wdss2
Or
/home/imd/WDSSII

/home/imd/data/RDR, /home/imd/merger/RDR, /home/imd/nowcast/RDR

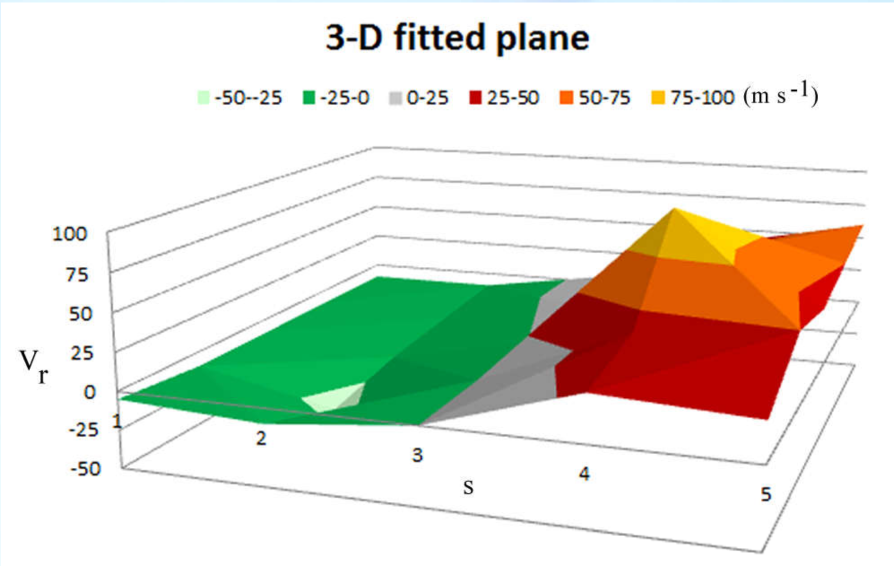
(1) Estimation of Azimuth Shear
(2) Nowcast of Track and movement of convective regions for 30, 60, 90 and 120 minute forecasts

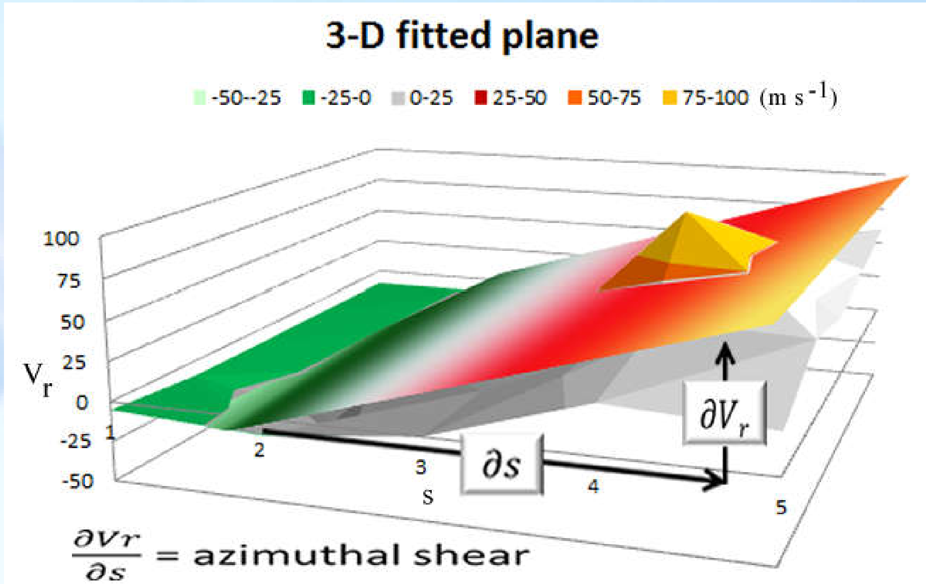
home/imd/xxx_operational/makeimage

Image Creation and Dissemination

to WEB SERVER

Velocity derived products: (Azimuth Shear)





Lakshmanan, V., T. Smith, K. Hondl, G. Stumpf, A. Witt, 2006: A Real-time, three dimensional, rapidly updating, heterogeneous radar merger technique for reflectivity, velocity and derived products. Wea. Forecasting, 21, 802-823.

Newman, J., V Lakshmanan, P. Heinselman, M. Richman, T. Smith, 2013: Range-correcting azimuthal shear in Doppler radar data. Wea. Forecasting, 28, 194-211.

Smith, T., and K.L. Elmore, 2004: The use of radial velocity derivatives to diagnose rotation and divergence. Preprints, 11th Conf. on Aviation, Range, and Aerospace, Hyannis, MA, Amer. Meteor. Soc., CD-ROM, P5.6.

Velocity derived products: (Azimuth Shear)

- Most commonly used technique relies simply on the difference of the maximum and minimum radial velocity within a rotation or divergence feature.

- The local, linear, least squares approach used in WDSS-II provides relatively smooth fields that may be used in other applications to identify features such as boundaries and vortices, as well as to accurately assess their strength and position. Hence it is an improvement.

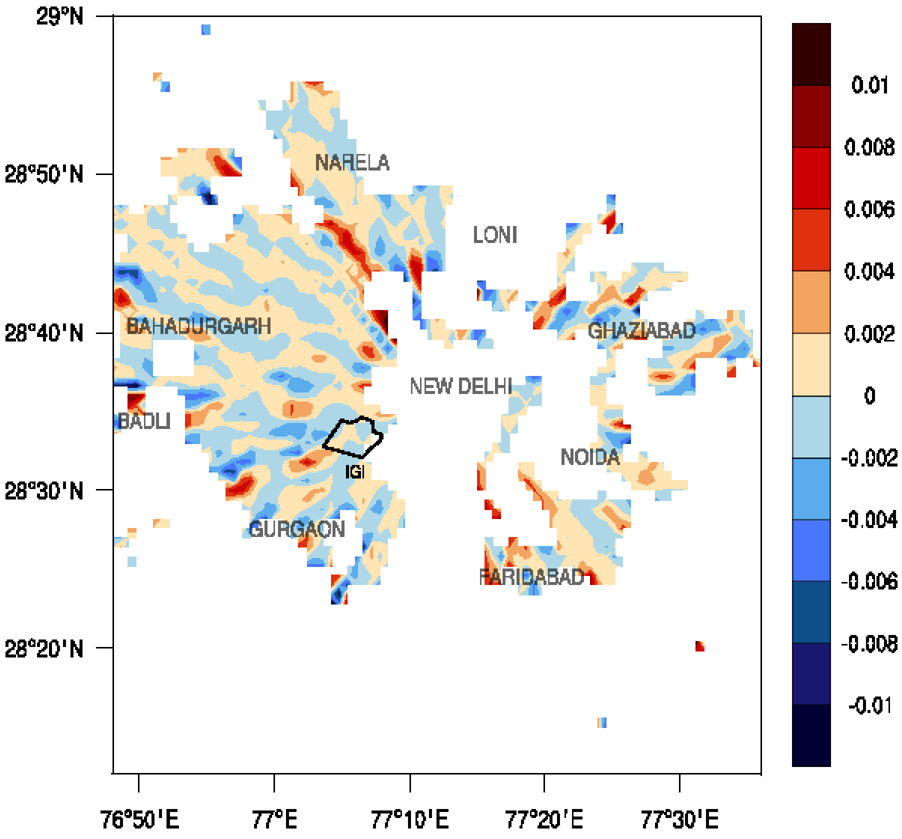
Velocity derived products: (Azimuth Shear)

AZIMUTH Wind Shear (per sec.) at 500m above ground

for Delhi and neighbourhood based on 20140530 AT 1532 hrs IST

Created at IMD using WDSS-II software from NSSL,USA

(based on DELHI Radar Data)



Areas with Shear > +-0.004 (per sec) indicate high horizontal shear zones

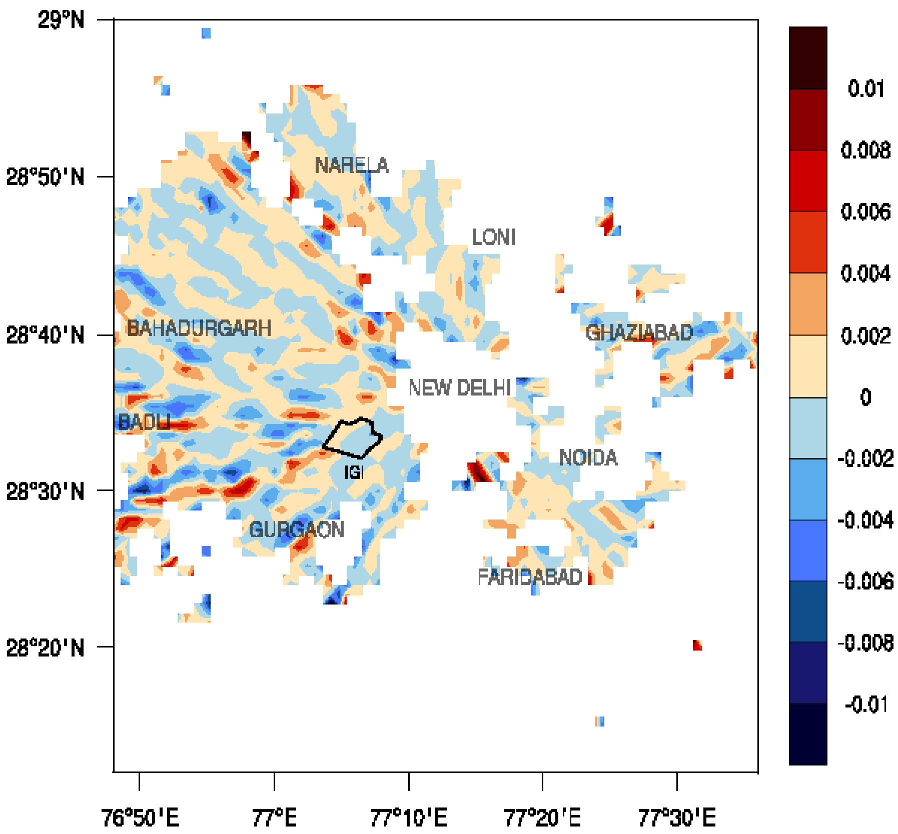
(IGI-> Indira Gandhi International Airport)

AZIMUTH Wind Shear (per sec.) at 750m above ground

for Delhi and neighbourhood based on 20140530 AT 1532 hrs IST

Created at IMD using WDSS-II software from NSSL,USA

(based on DELHI Radar Data)



Areas with Shear > +-0.004 (per sec) indicate high horizontal shear zones

(IGI-> Indira Gandhi International Airport)

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.**
4. **Merge forecasts of different scales at the same forecast time**
5. **Generate forecasts for 00, 30, 60, 90 and 120 minute**

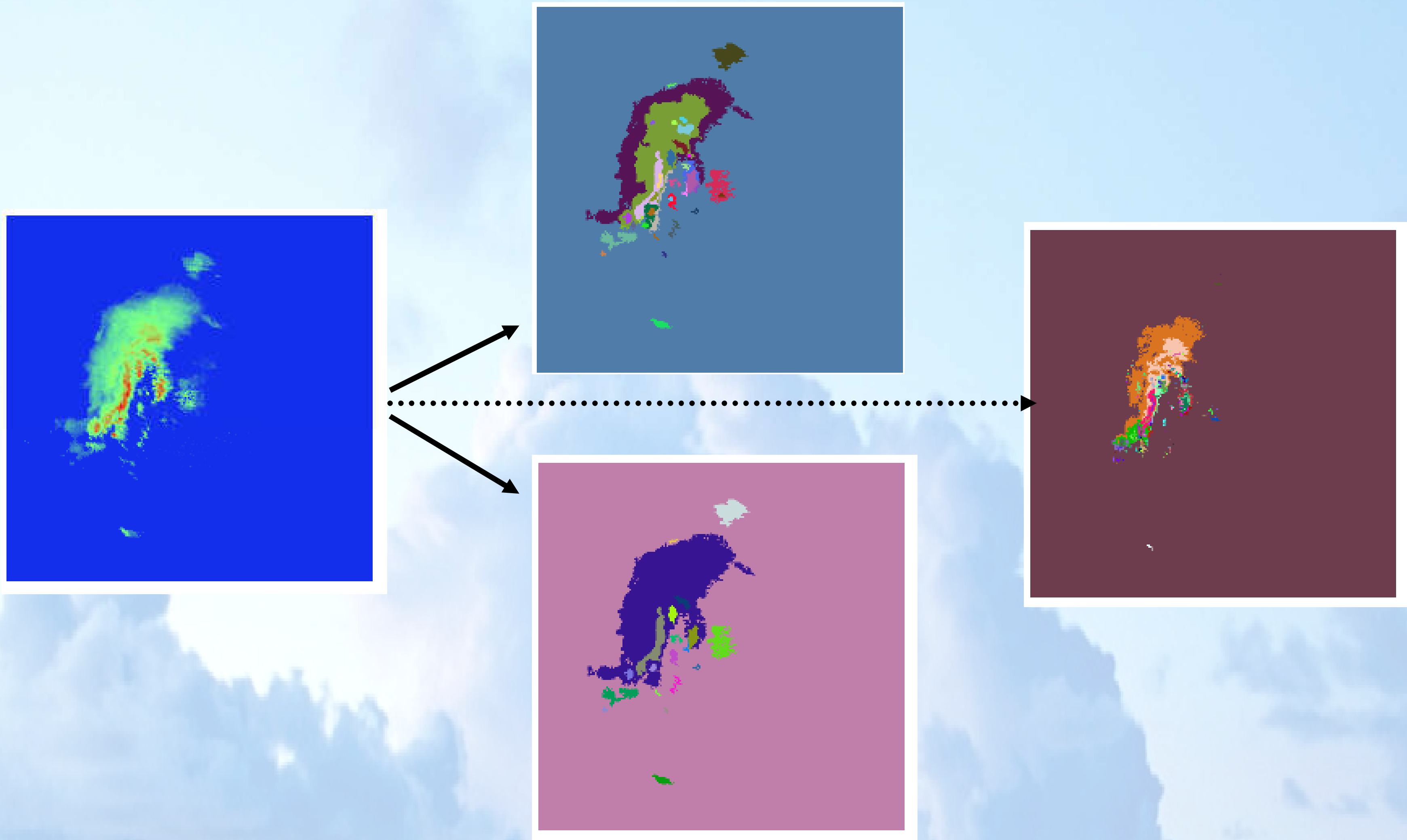
Because the motion estimates are made for storms, it is possible to interpolate between storm boundaries to obtain motion estimates at every part of the domain.

A K-Means clustering technique from Lakshmanan (2001); Lakshmanan et al. (2002) is used to identify components in vector fields. The technique provides nested partitions,i.e. the identified storms structures are strictly hierarchical. The technique works by clustering image values (reflectivity/infrared temperature, etc.) in the neighborhood of a pixel on two opposing criteria:

- ❖ Belong to same cluster as your neighbors.

- ❖ Belong to cluster whose mean is closest to your value.

Hierarchical segmentation is incorporated into the K-Means clustering technique by steadily relaxing inter-cluster distances.



Validation

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 nowcasts go wrong?

- WDSS-II relies upon processing of radar base data (Reflectivity Z, Radial Velocity V and Spectrum Width W) sequentially in elevation (lowest to highest) and also sequentially in time (oldest to latest data).

- When the VPN network from radar data generation centre to WDSS-II processing centre is slow, this sequence is destroyed and the forecast product may become erroneous.

Further articles for more information:

- Lakshmanan V, Rabin R, DeBrunner V (2003) Multiscale storm identification and forecast. J Atmos Res. 67: 367–380.
- Lakshmanan V, Smith T, Hondl KD, Stumpf G, Witt A (2006) A real-time, three-dimensional, rapidly updating, heterogeneous radar merger technique for reflectivity, velocity, and derived products. Weather and Forecasting 21(5): 802–823
- Lakshmanan V, Smith T, Stumpf G, Hondl KD (2007a) The warning decision support system integrated information. Weather and Forecasting 22: 596–612
- Lakshmanan V, Fritz A, Smith T, Hondl K, Stumpf G (2007b) An automated technique to quality control radar reflectivity data. J Appl Meteor Climat. 46(3): 288–305
- Lakshmanan V, Hondl K, Rabin R (2009) An efficient general-purpose technique for identifying storm cells in geospatial images. J. Atmos. Oceanic Technol., 26: 523–537.
- 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
- Roy Bhowmik S.K., Soma Sen Roy, K. Srivastava, B. Mukhopadhay, S. B. Thampi, Y. K. Reddy, Hari Singh, S. Venkateswarlu and Sourav Adhikary, 2011: Processing of Indian Doppler Weather Radar Observations for mesoscale applications, *Meteorology and Atmospheric Physics* , 111, 133-147
- Soma Sen Roy, V Lakshmanan, S K Roy Bhowmik and S B Thampi, 2010: Doppler Weather Radar based nowcasting of Cyclone Ogni, *J. Earth Syst Sci*, 119, 183-200

Thank you

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