Interpretation of products

- With the installation of the state-of-the-art radar, a lot of weather data and information is now available to the public.

- However, with the new technology, there is much to learn and understand.

- There are now many new products available, however there are some phenomena that must be mentioned and understood, to avoid misinterpreting the radar images.

DWR generates three types of base data

1. Reflectivity (i.e. the amplitude of the backscattered signal;

2. Radial velocity (i.e. the rate of movement toward or away from the radar site);

3. Spectrum width (i.e. measure of turbulence)

Reflectivity

Reflectivity is a measure of the energy returned by the atmosphere to the radar. it is measured in decibels of reflectivity (dBz).

It is essentially a measure of the strength of the reflected energy. The stronger is the dBz value, the stronger is the intensity of the precipitation detected by the radar.

However, not all particles of the same size will have the same reflectivity.

Reflectivity of a cloud is dependent on the number and type of hydrometeors, which includes rain, snow, and hail, and the hydrometeors' size.

In general, the larger the precipitation particle, the better it will detected by radar.

WHAT IS dbZ

❖Logarithmic Scale for Measuring Radar Reflectivity Factor

❖ It is expressed in decibels of reflectivity (dBZ). It is essentially a measure of the intensity of the scattering medium (usually clouds or precipitation).

❖ The stronger the scattering, the stronger is the intensity of precipitation detected by the radar, and the higher is the reflectivity value.

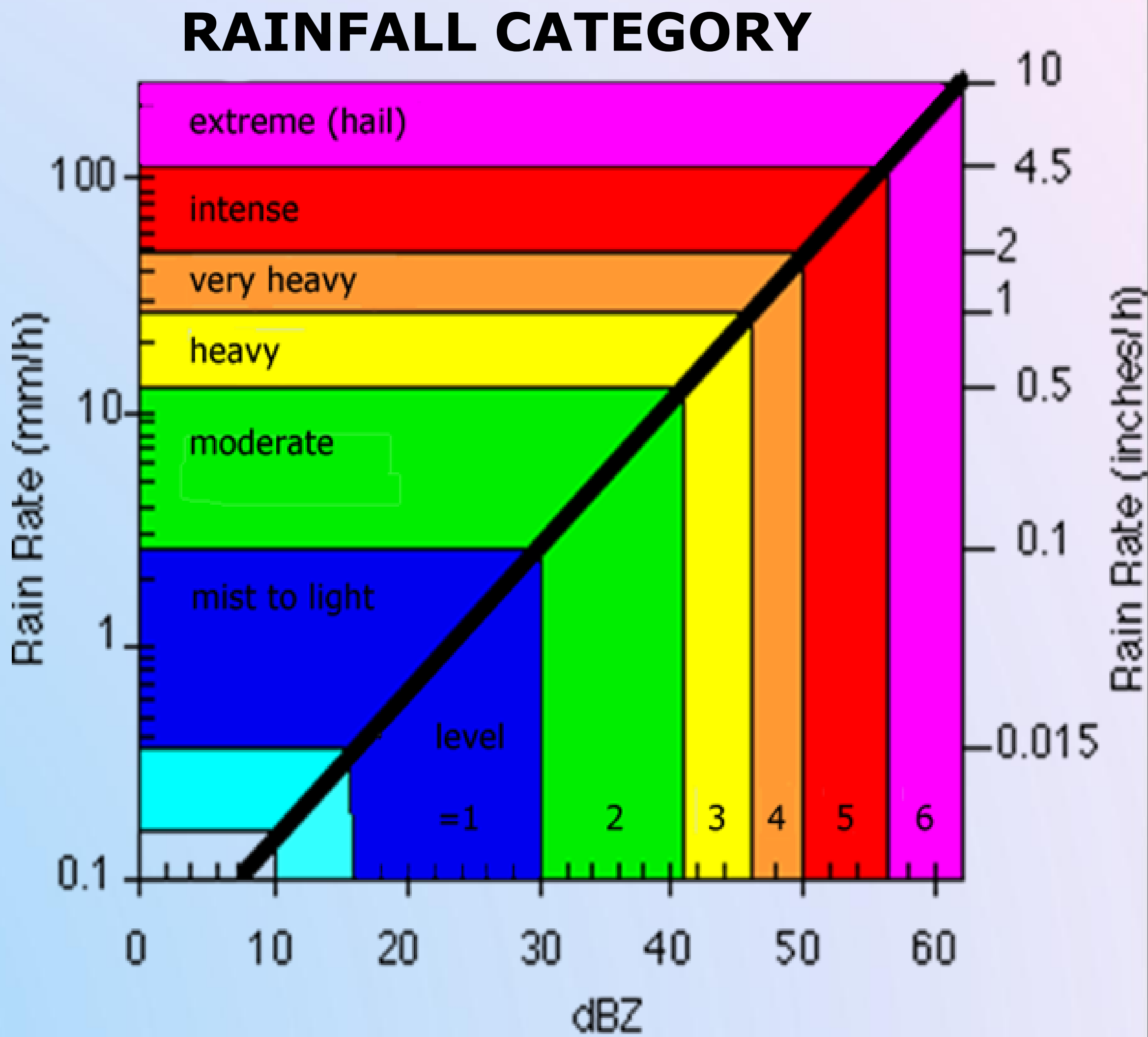
dBz Value	Interpretation	Rain Rate mm/hour
Less then 20	Clouds	----
20 to 30	Light steady rain	up to 2.5mm
30- 40	moderate Showers	2.5 mm to 10mm
40 to 50	heavy to very heavy	10 mm to 50mm
50 to 60	intense to extreme	50 to 100mm
60 > above	Extreme (hail)	above 100 mm

In this radar images are colour coded to indicate precipitation intensity the light blue colour is the Lightest precipitation and purple and white are the heaviest

Green radar return, indicating usually light precipitation and little to no turbulence, leading to a possibility of reduced visibility.

Yellow radar return, indicating moderate precipitation, leading to the possibility of very low visibility, moderate turbulence and an uncomfortable ride for aircraft passengers.

Red radar return, indicating heavy precipitation, leading to the possibility of thunderstorms and severe turbulence.



Radial Velocity

❖**Definition of radial velocity is " wind motion toward or away from Doppler RADAR".**

❖Radial Velocity indicates –

❖ Wind field around the station

❖Rapid variations in atmosphere can be seen on PPI-V

❖ Veering and backing of wind with height

❖ Shows variations in wind due to Thunder clouds

Spectrum Width

It is a measure of turbulence and it is of immense use in nowcasting for the occurrence of microburst, wind shear etc for aviation

When turbulence exists in the atmosphere, individual hydrometeors within the radar pixel volume have vastly different radial velocities.

It is the standard deviation of the velocity distribution within a single pixel.

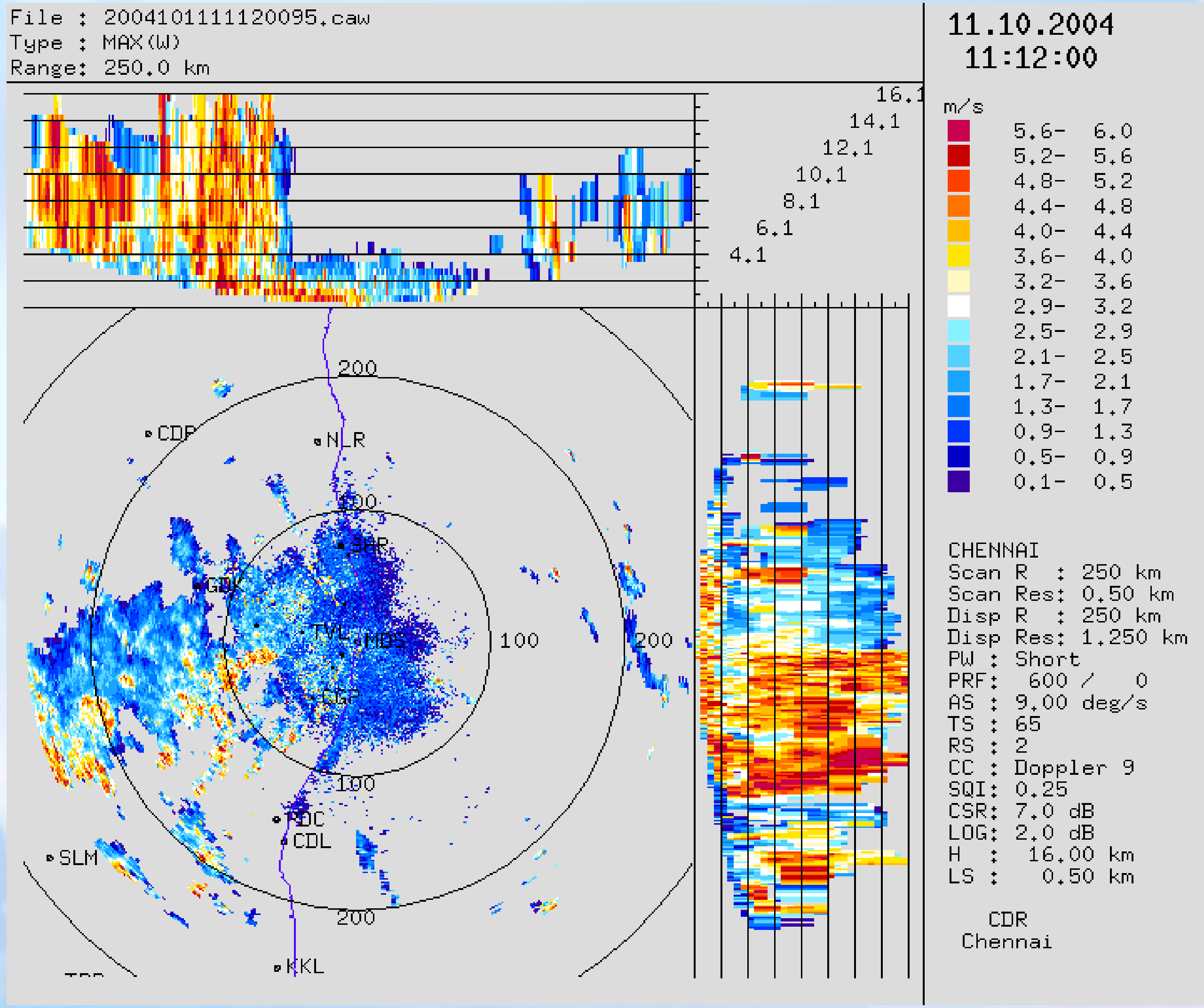
Spectrum Width

Spectrum width exceeding 4.8 mps (a condition for moderate to severe turbulence) was noticed up to 14 km

If W > 5 mps ➔ severe turbulence

If W > 4 mps ➔ moderate turbulence

Low value of spectrum width shows uniform wind flow and high value of spectrum width shows turbulence

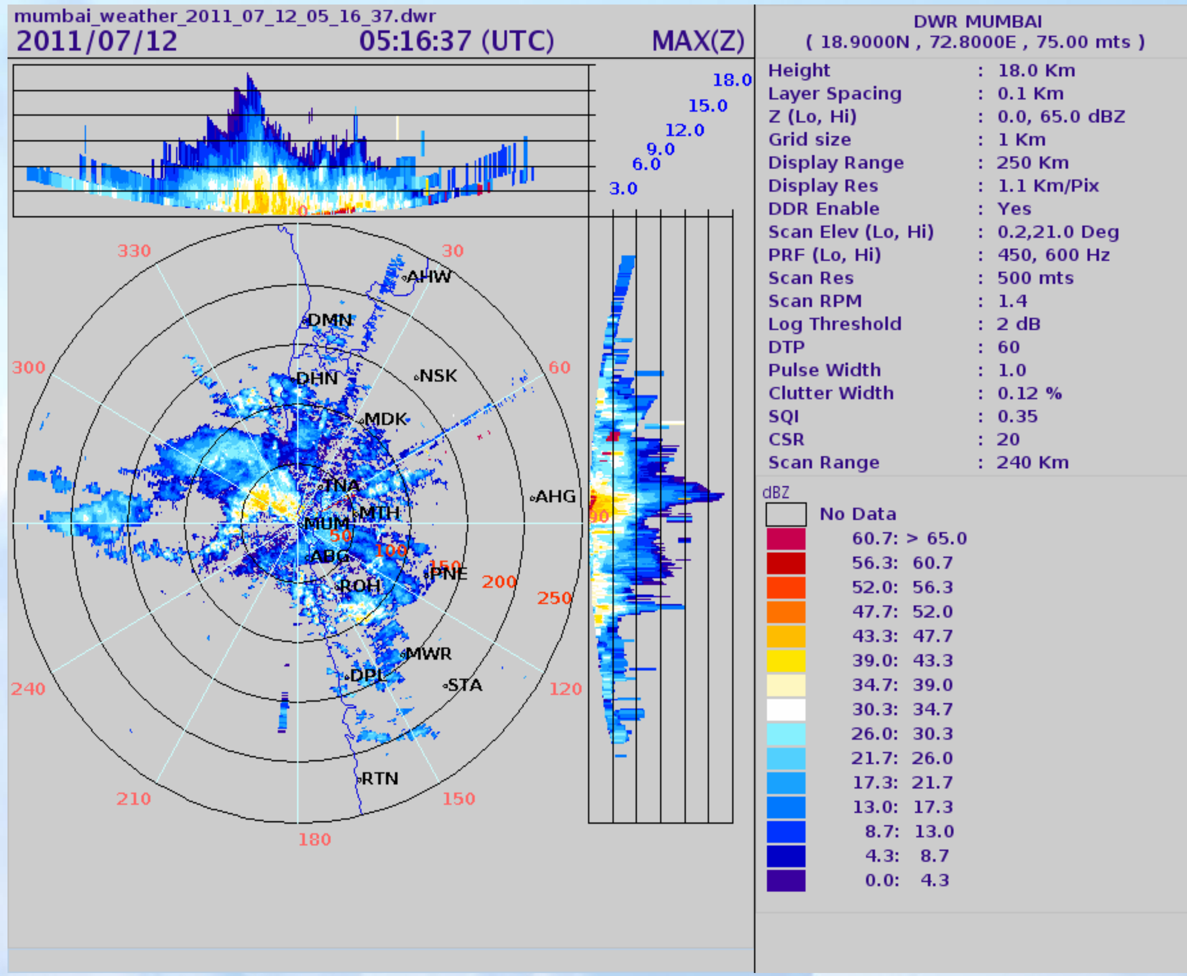


Standard Meteorological Products

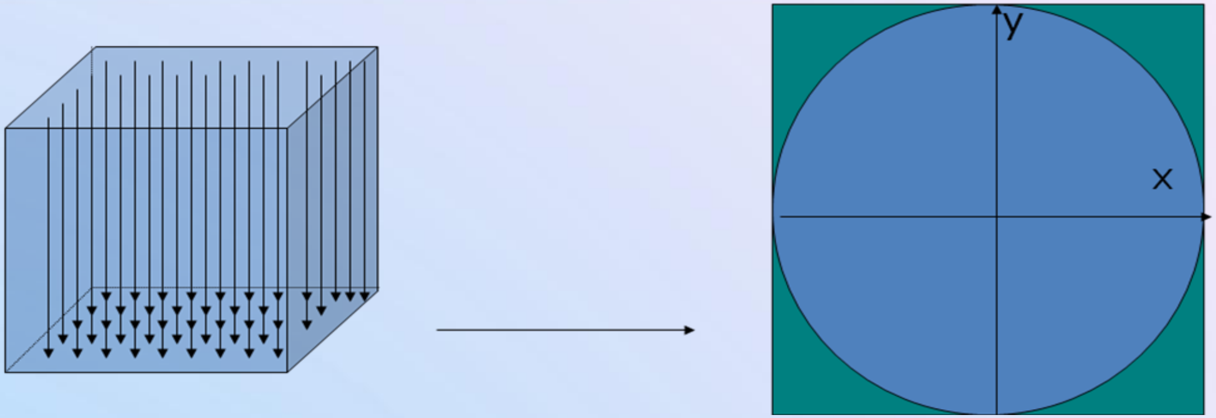
- Plan Position Indicator (PPI)(Z,V,W)
- Range Height Indicator (RHI) (Z,V,W)
- Max - Maximum display (MAX) (Z,V,W)
- Constant Altitude PPI (CAPPI) (Z,V,W)
- Pseudo CAPPI (PCAPPI) (Z,V,W)

Radar products Max-z

- MAX Z is a maximum display of reflectivity data. After the radar has made a series of scans at different elevations, known as a volume scan,
- It shows us, the maximum reflectivity value for each pixel coordinate.
- To determine what height these are values are from, the user can compare the cross sections included in the image.
- The cross section at the top of the image is taken is on a west to east axis.
- The cross section on the right is on a north to south axis
- Height scales are provided for *X* and *Y* direction view of imageries placed at the top and right-hand side.

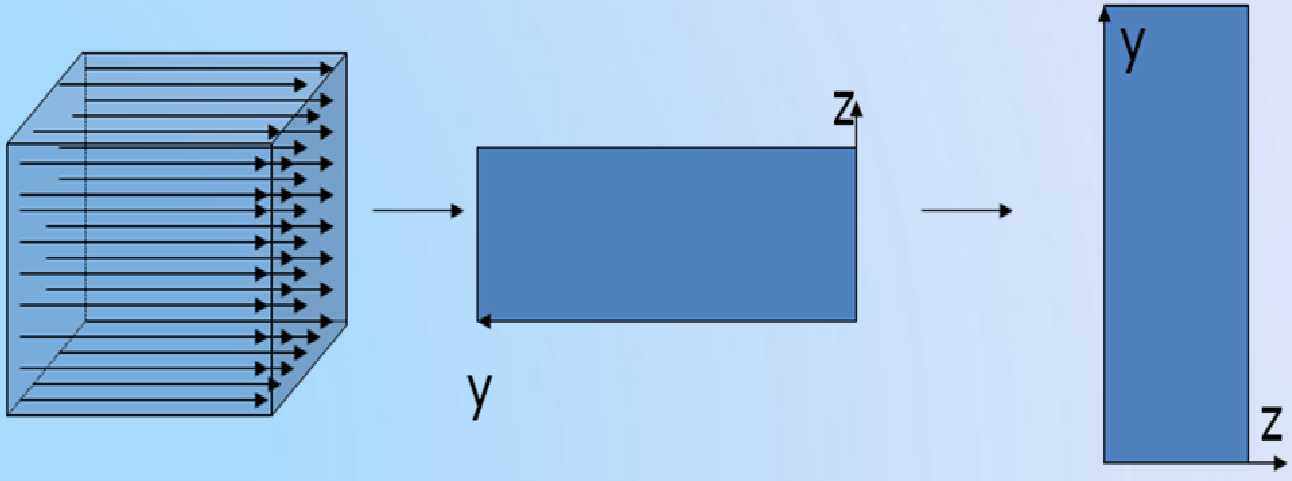


TOP VIEW



N-S VIEW

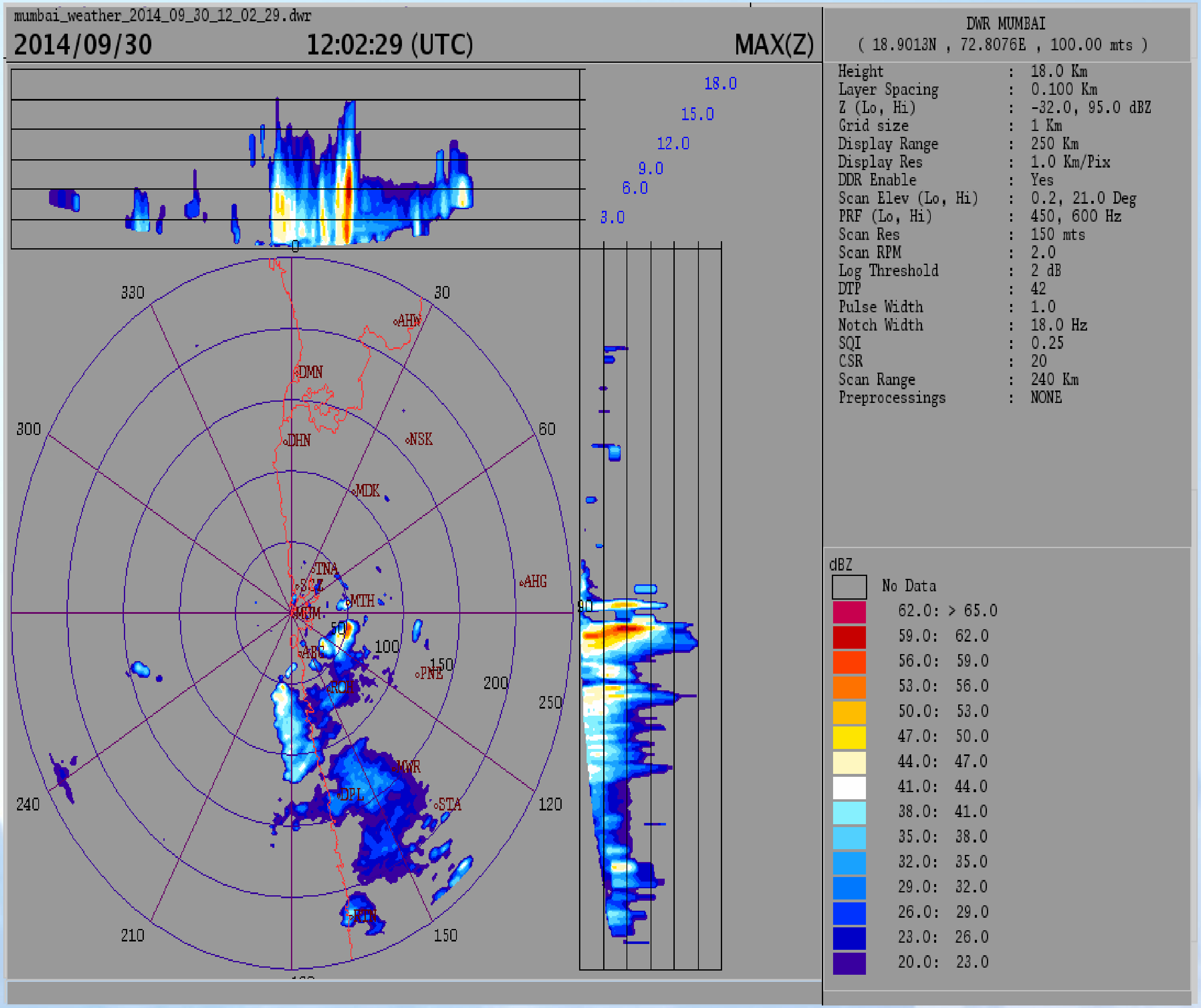
E-W VIEW

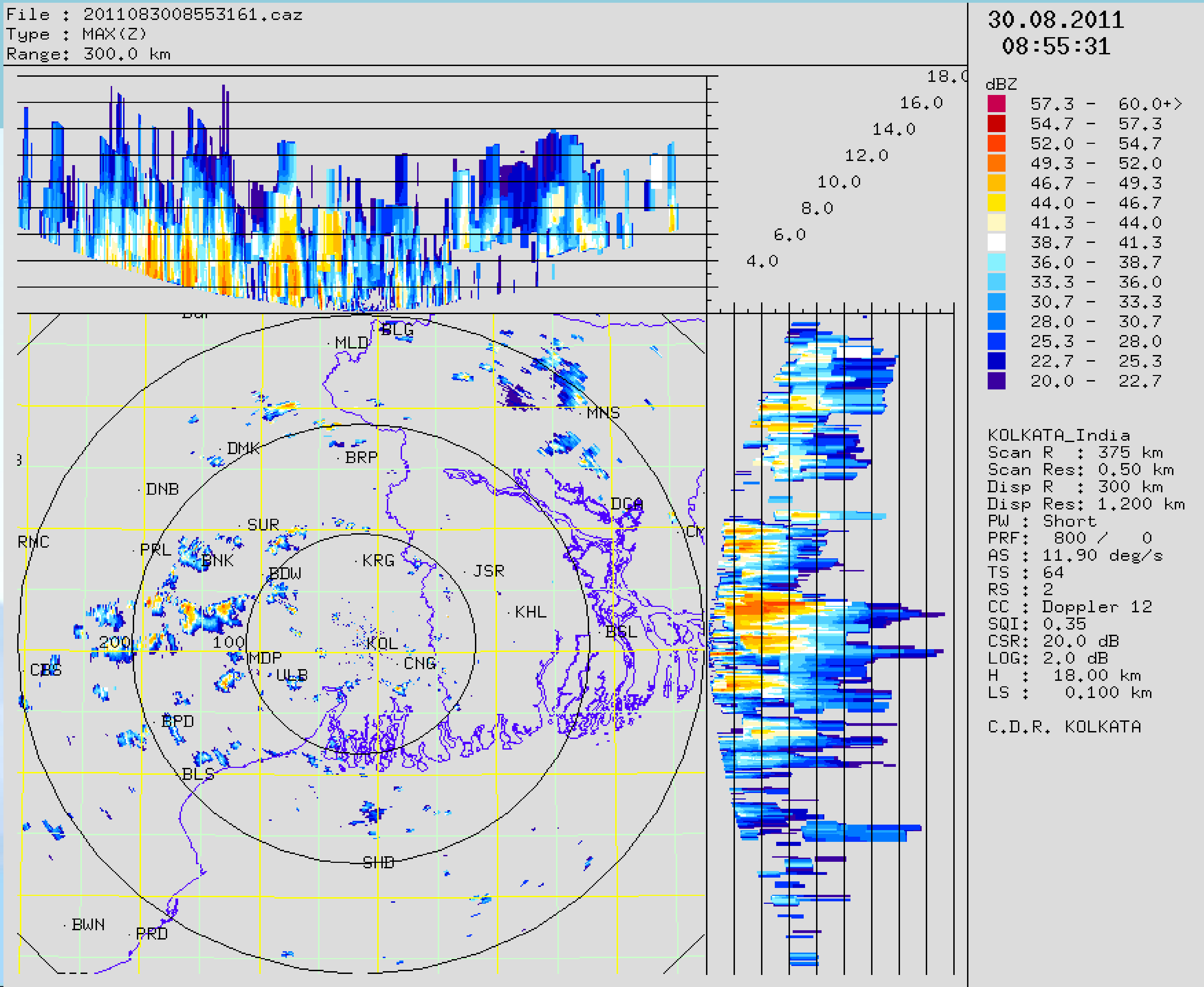


- Stronger energy returns are shown in yellow and red while weaker returns are in light blue.

- In this particular example there are several clusters of thunderstorms (in yellow and white) Outflow boundaries from these storms can be seen in light

  blue.



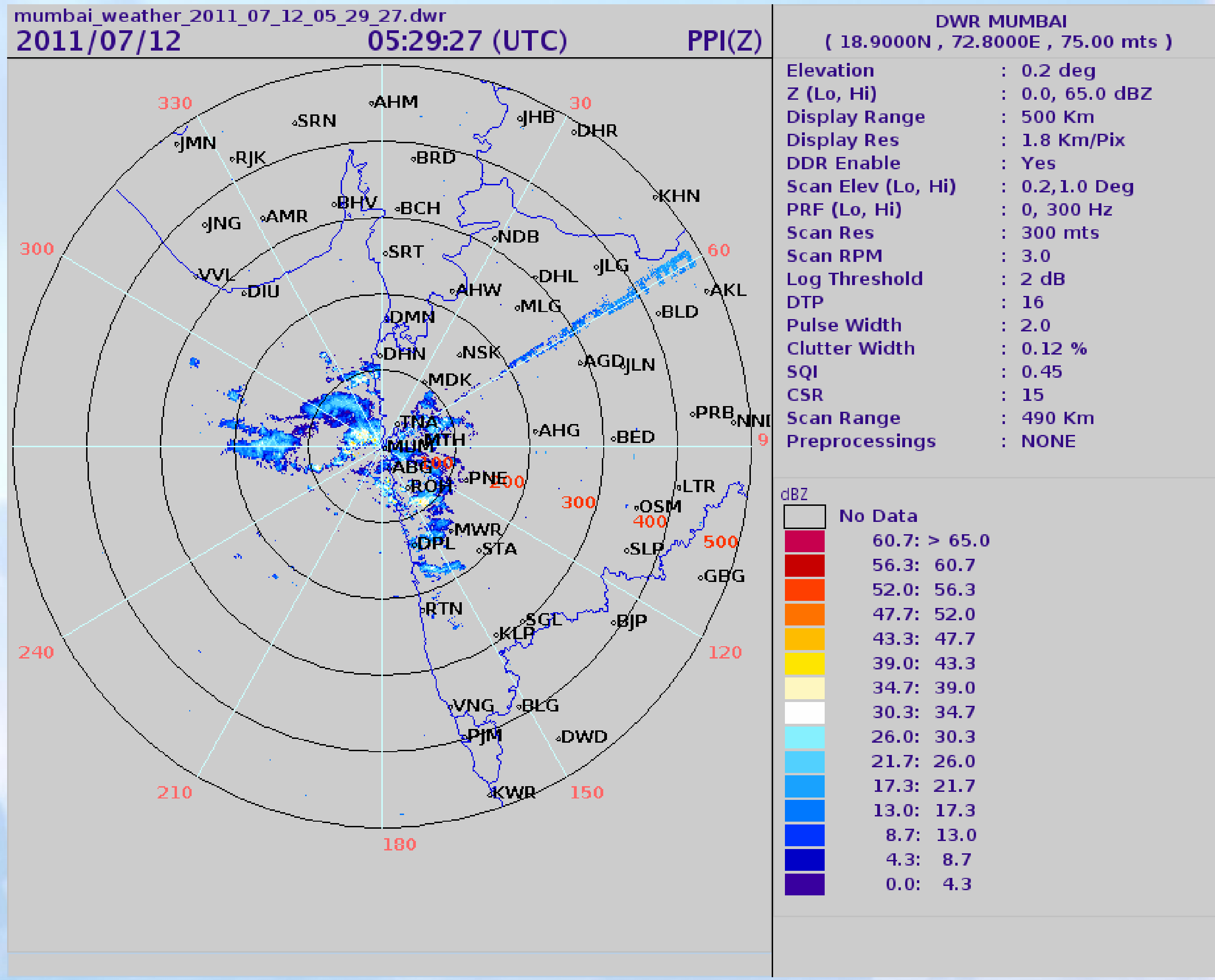

File : 2011083008553161.caz
Type : MAX(Z)
Range: 300.0 km
30.08.2011
08:55:31
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
dBZ
57.3 - 60.0+>
54.7 - 57.3
52.0 - 54.7
49.3 - 52.0
46.7 - 49.3
44.0 - 46.7
41.3 - 44.0
38.7 - 41.3
36.0 - 38.7
33.3 - 36.0
30.7 - 33.3
28.0 - 30.7
25.3 - 28.0
22.7 - 25.3
20.0 - 22.7
KOLKATA_India
Scan R : 375 km
Scan Res: 0.50 km
Disp R : 300 km
Disp Res: 1.200 km
PW : Short
PRF: 800 / 0
AS : 11.90 deg/s
TS : 64
RS : 2
CC : Doppler 12
SQI: 0.35
CSR: 20.0 dB
LOG: 2.0 dB
H : 18.00 km
LS : 0.100 km
C.D.R. KOLKATA
BLG
MLD
MNS
DMK
BRP
DNB
DCA
SUR
RNC
PRL
BNK
KRG
JSR
BDW
KHL
200
100
KOL
BSL
MDP
CNG
ULB
BPD
BLS
SHD
BWN
PRD

Use of max-z

- Max-Z gives vertical extent of cloud
- Indicates rainfall intensity
- Type of cloud – convective or stratiform Organisation of cloud
- Successive scans indicates development
  or dissipation
- In case of low pressure systems likely
  rainfall pattern over reasonable area

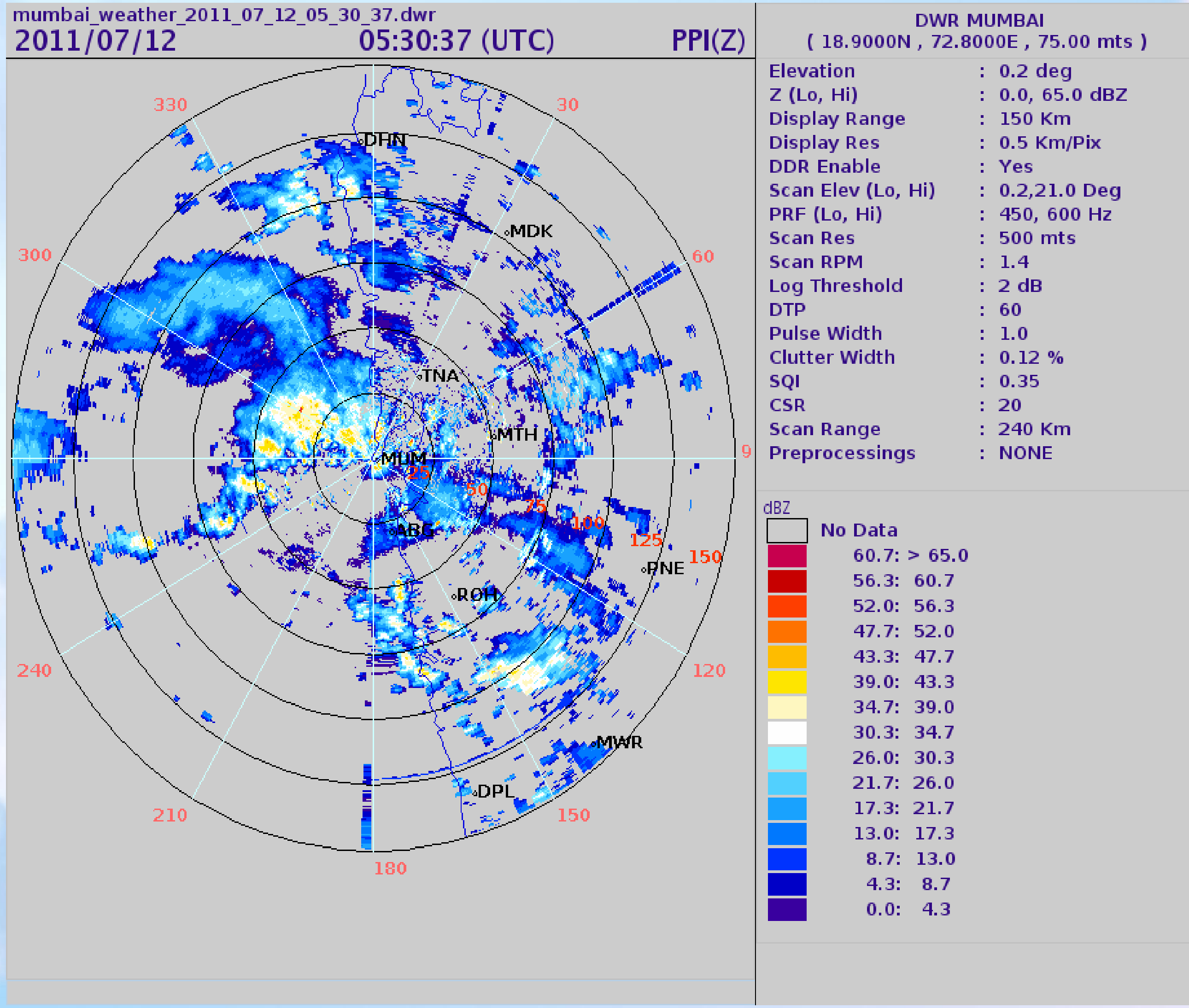
Plan position indicator (Z)

- When scanning in PPI mode, the radar holds its elevation angle constant but varies its azimuth angle.
- If the radar rotates through 360 degrees, the scan is called a "surveillance scan“
- If the radar rotates through less than 360 degrees, the scan is called a "sector scan".
- It is for a given elevation at all azimuth values, with colour-coded schemes for display and storage in digital form.
- This display is possible for all elevations at which data are collected. At the display range of 500km..



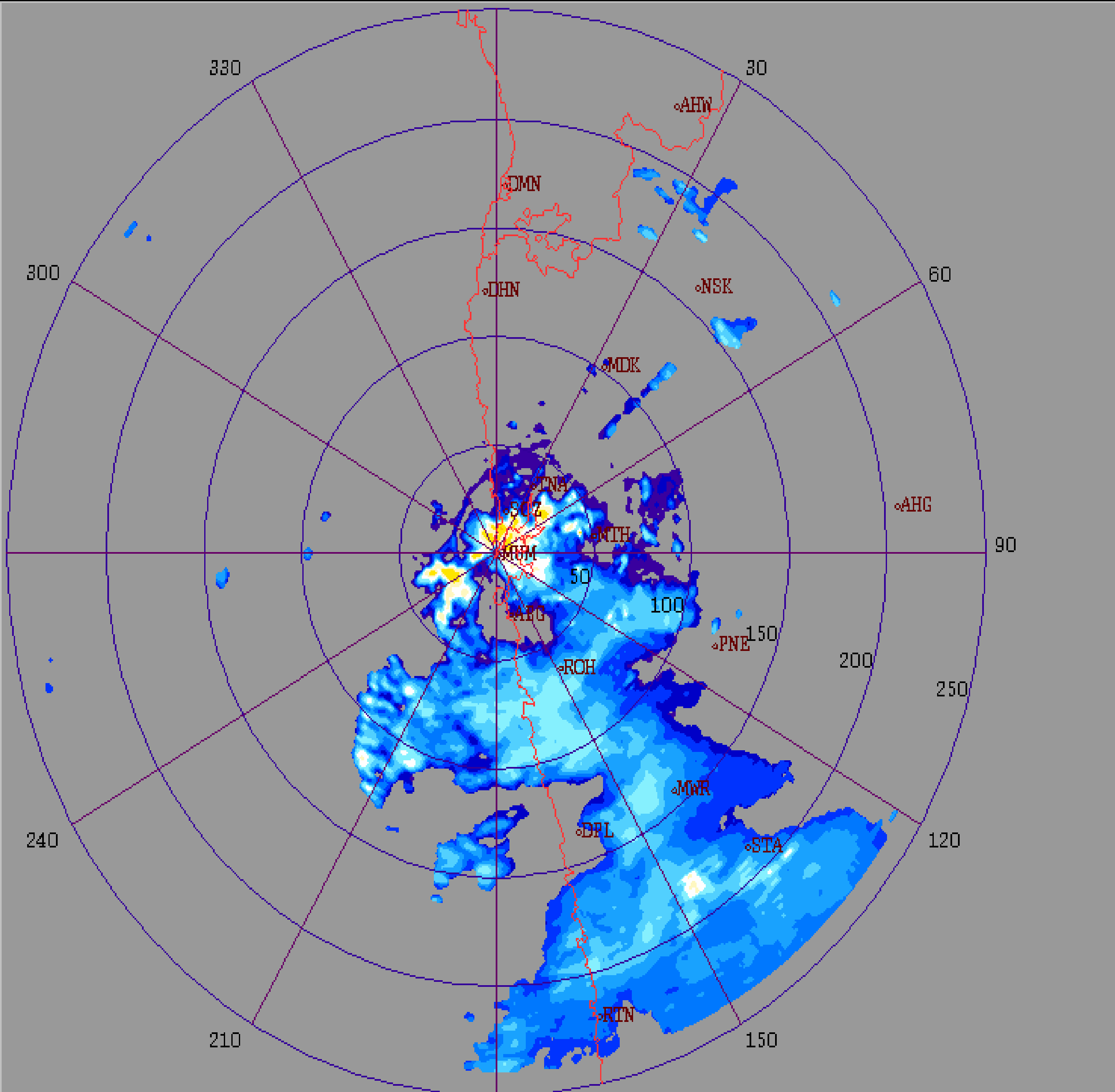
Plan Position Indicator (Z) –Close Range

Radar data are digital information. This property is easily seen by enlarging a radar image and noting the small rectangular areas of one color.



mumbai_weather_2014_09_30_13_32_28.dwr

2014/09/30 13:32:28 (UTC) PPI(Z)



DWR MUMBAI
(18.9013N , 72.8076E , 100.00 mts)

Elevation	:	0.2 deg
Z (Lo, Hi)	:	-32.0, 95.0 dBZ
Display Range	:	250 Km
Display Res	:	0.8 Km/Pix
DDR Enable	:	Yes
Scan Elev (Lo, Hi)	:	0.2, 21.0 Deg
PRF (Lo, Hi)	:	450, 600 Hz
Scan Res	:	150 mts
Scan RPM	:	2.0
Log Threshold	:	2 dB
DTP	:	42
Pulse Width	:	1.0
Notch Width	:	18.0 Hz
SQI	:	0.25
CSR	:	20
Scan Range	:	240 Km
Preprocessings	:	NONE

dBZ

No Data
60.7: > 65.0
56.3: 60.7
52.0: 56.3
47.7: 52.0
43.3: 47.7
39.0: 43.3
34.7: 39.0
30.3: 34.7
26.0: 30.3
21.7: 26.0
17.3: 21.7
13.0: 17.3
8.7: 13.0
4.3: 8.7
0.0: 4.3

Volume Velocity Processing(2)

The VVP(2) product displays horizontal wind speed and direction in a column above the radar site

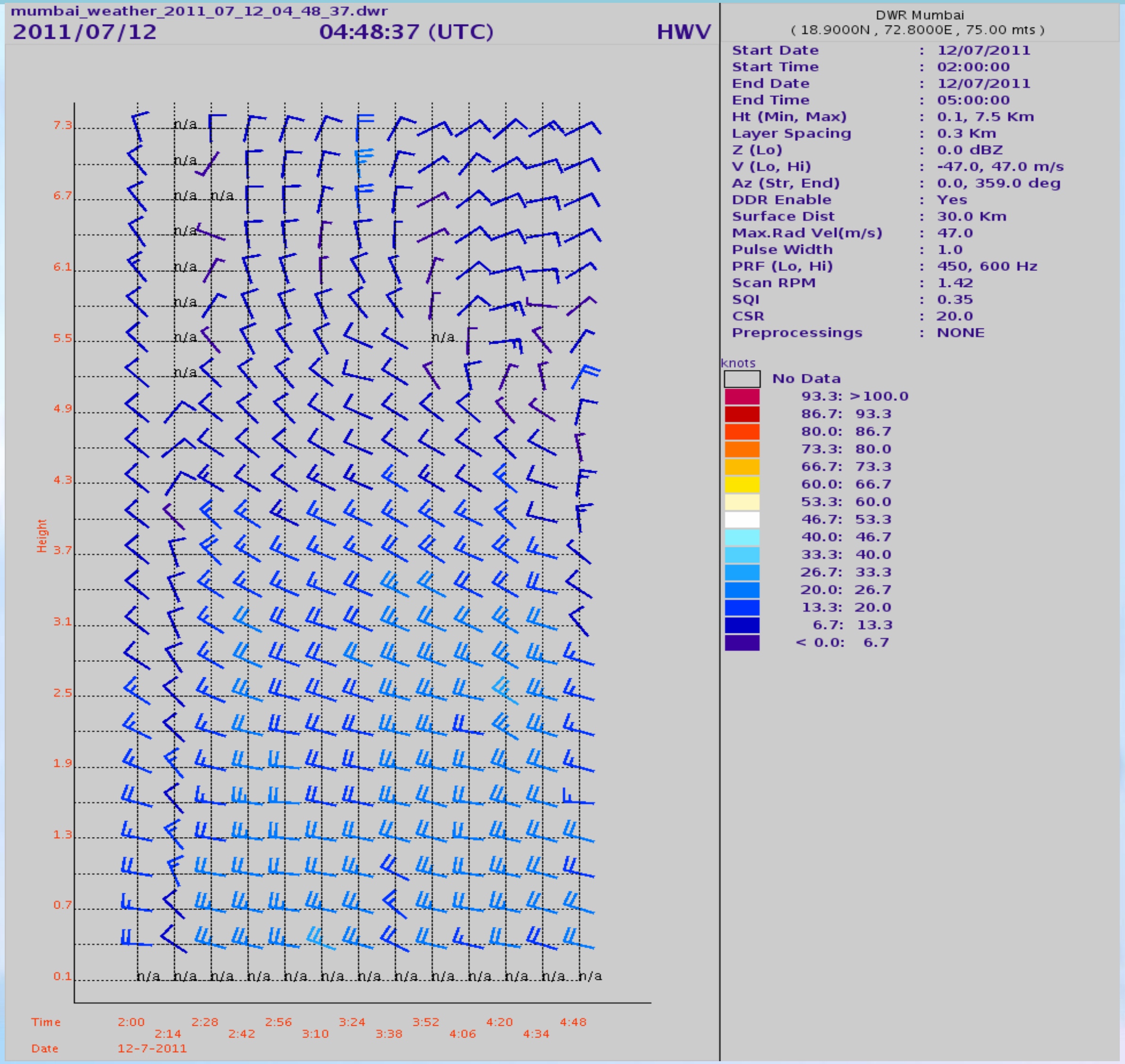
From a volume scan, horizontal wind is estimated for each elevation.

A plot of horizontal wind at different heights is made against time

The winds are representative of the radius circle selected (maximum range restricted to 25 – 30 km)

. Wind speed and wind direction are derived from a volume velocity data set using a linier linier wind field model.

Wind barbs: wind barbs are shown for each height over time.

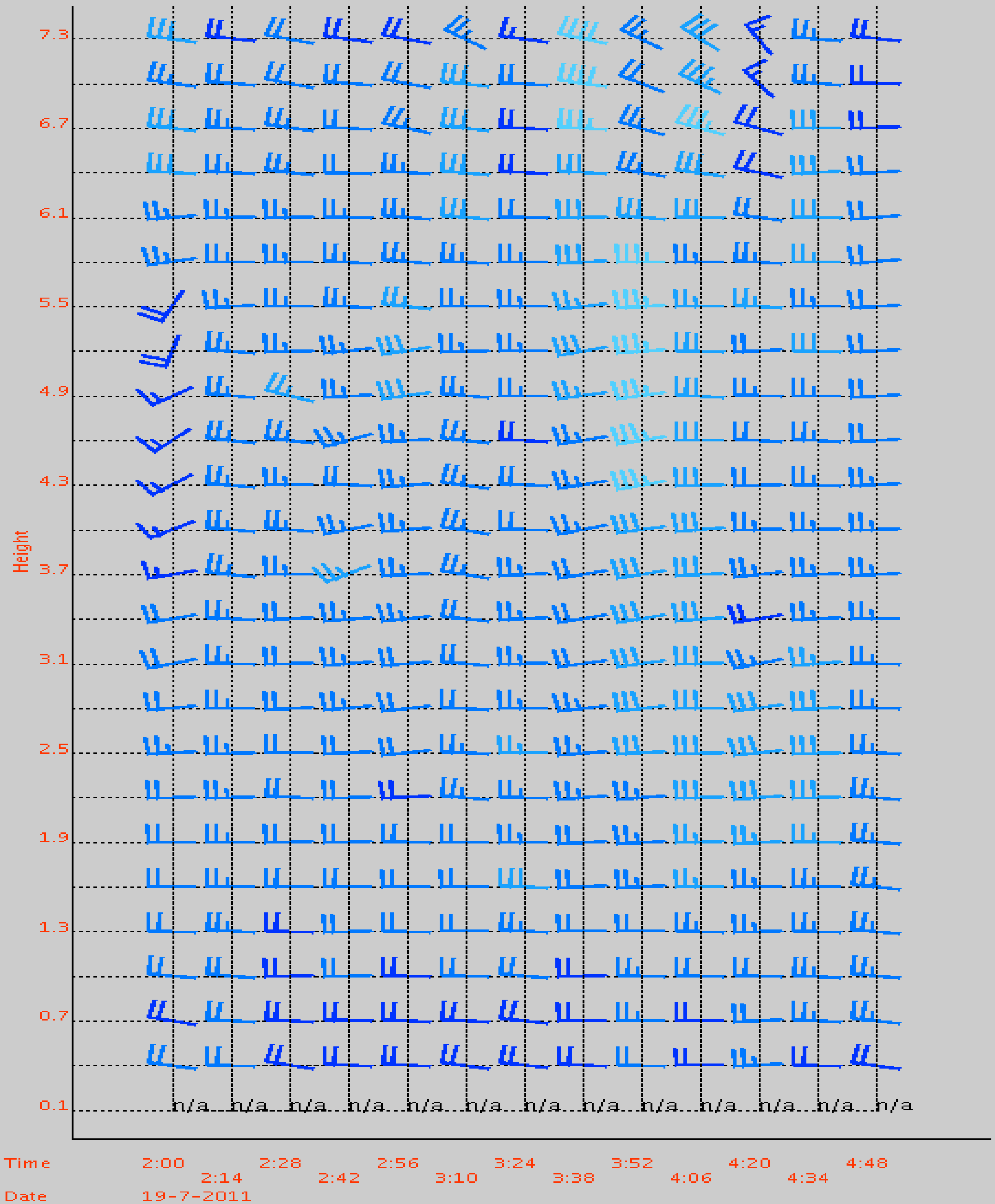


Use of Volume Velocity Processing (VVP2)

- Horizontal wind estimation from radial wind measured by DWR & subsequently used for wind shear estimation
- Vertical profile of prevailing velocity can be plotted around the radar site (< 30 km radius)
- Horizontal divergence and hence vertical velocity can be estimated.
- Vertical wind shear can be estimated from the hor. wind derived
- Repeated volume scans can be used to give a sequence of vertical profiles of wind. From this sequence it is possible to trace the movement of a weather system.

mumbai_weather_2011_07_19_04_48_24.dwr

2011/07/19 **04:48:24 (UTC)** **HWV**



DWR Mumbai

(18.9000N , 72.8000E , 75.00 mts)

Start Date	:	19/07/2011
Start Time	:	02:00:00
End Date	:	19/07/2011
End Time	:	05:00:00
Ht (Min, Max)	:	0.1, 7.5 Km
Layer Spacing	:	0.3 Km
Z (Lo)	:	0.0 dBZ
V (Lo, Hi)	:	-47.0, 47.0 m/s
Az (Str, End)	:	0.0, 359.0 deg
DDR Enable	:	Yes
Surface Dist	:	30.0 Km
Max.Rad Vel(m/s)	:	47.0
Pulse Width	:	1.0
PRF (Lo, Hi)	:	450, 600 Hz
Scan RPM	:	1.42
SQI	:	0.35
CSR	:	20.0
Preprocessings	:	NONE

knots

No Data
93.3: >100.0
86.7: 93.3
80.0: 86.7
73.3: 80.0
66.7: 73.3
60.0: 66.7
53.3: 60.0
46.7: 53.3
40.0: 46.7
33.3: 40.0
26.7: 33.3
20.0: 26.7
13.3: 20.0
6.7: 13.3
< 0.0: 6.7

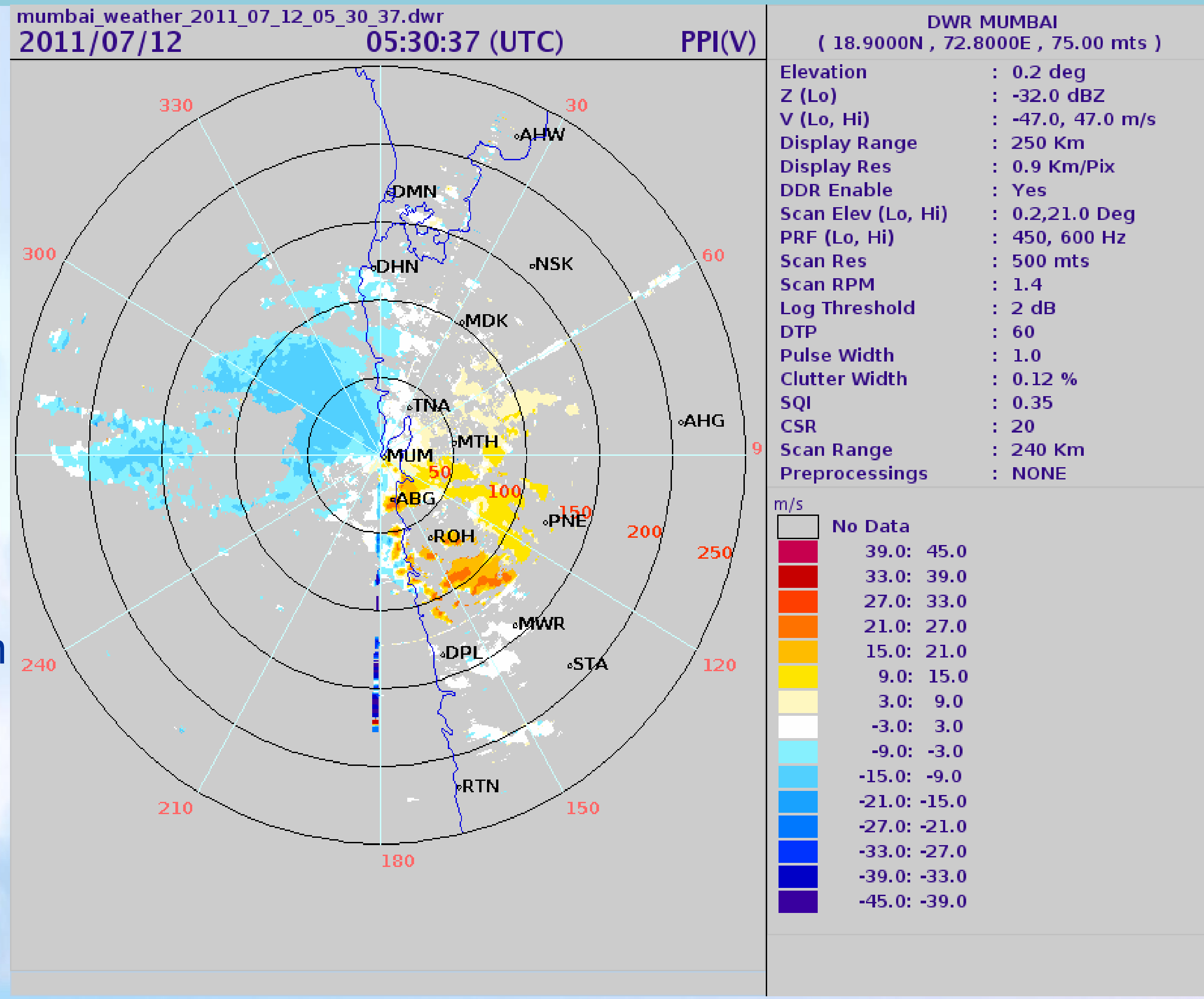
PPI (V)

- The radial wind component towards (–ve) and away (+ve) from the radar site

- Colour like yellow and red are used for going away velocity and cool colours like blue for approaching

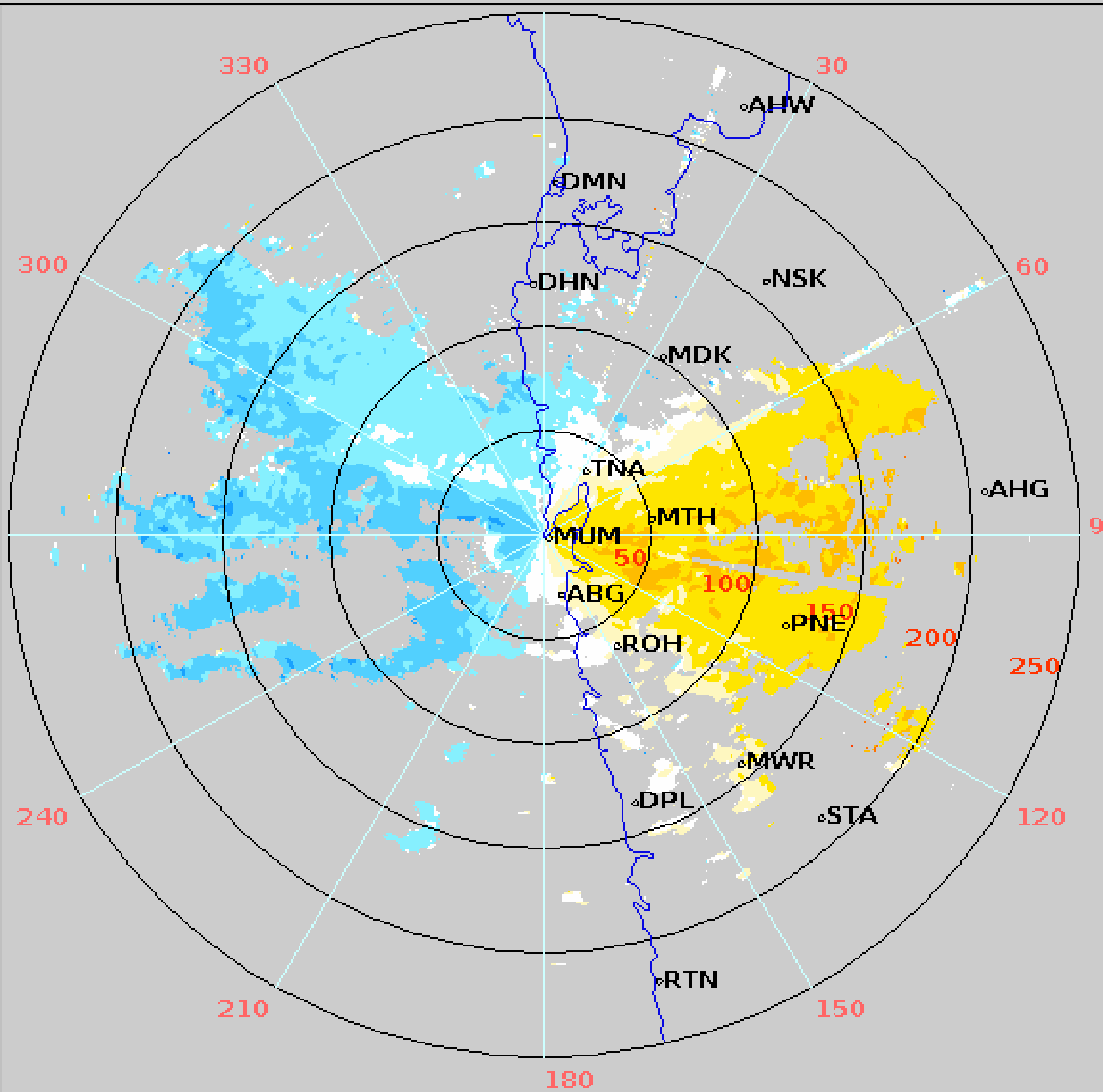
- This is importance for the tracking of weather systems and in aviation forecasting.

- The PPI(*V*) gives the *radial velocity* (for a selected elevation) on a PPI scope.



mumbai_weather_2011_07_19_05_30_24.dwr

2011/07/19 **05:30:24 (UTC)** **PPI(V)**



DWR MUMBAI
(18.9000N , 72.8000E , 75.00 mts)

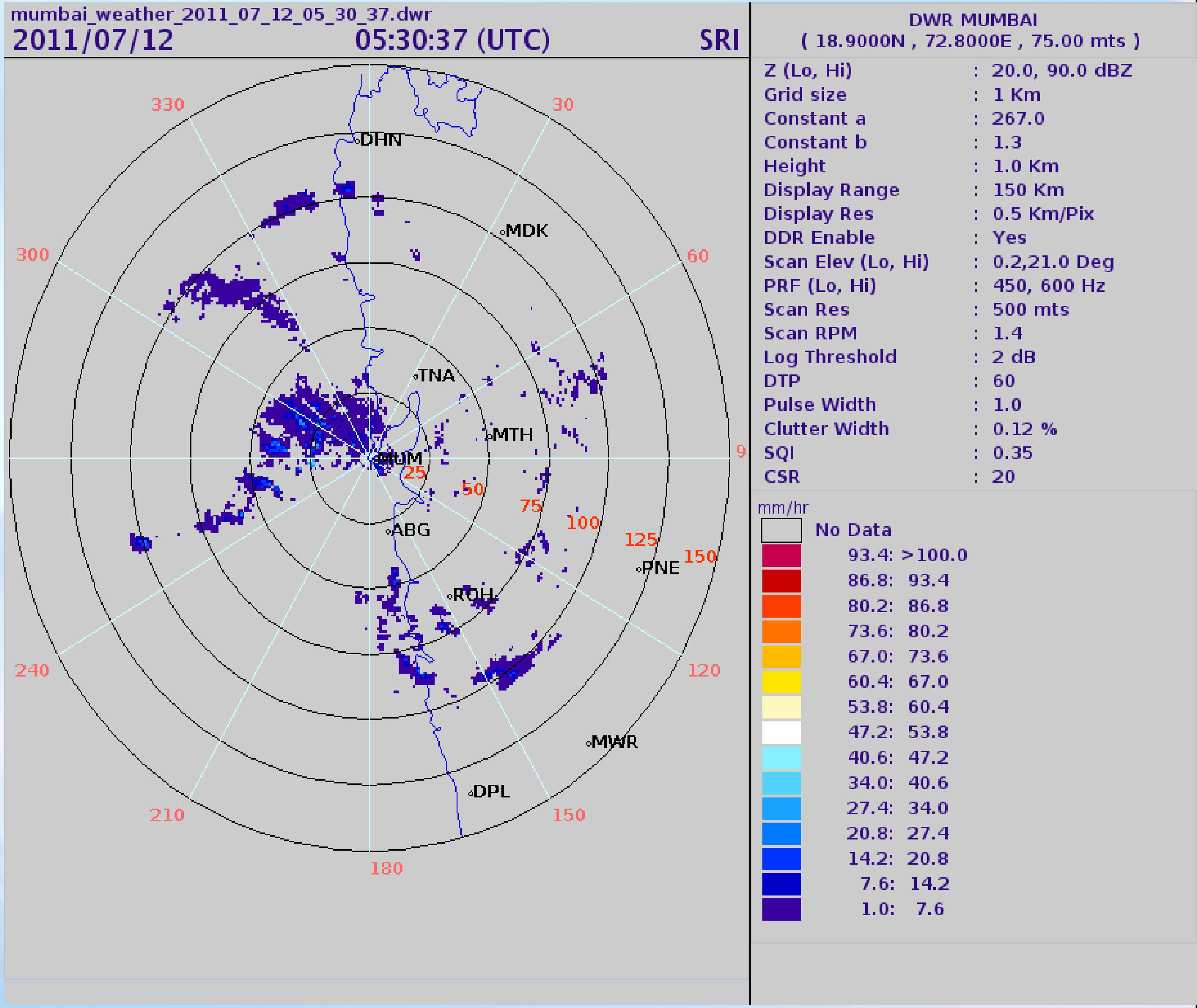
Elevation	:	0.2 deg
Z (Lo)	:	-32.0 dBZ
V (Lo, Hi)	:	-47.0, 47.0 m/s
Display Range	:	250 Km
Display Res	:	0.9 Km/Pix
DDR Enable	:	Yes
Scan Elev (Lo, Hi)	:	0.2,21.0 Deg
PRF (Lo, Hi)	:	450, 600 Hz
Scan Res	:	300 mts
Scan RPM	:	1.4
Log Threshold	:	2 dB
DTP	:	60
Pulse Width	:	1.0
Clutter Width	:	0.12 %
SQI	:	0.35
CSR	:	20
Scan Range	:	240 Km
Preprocessings	:	NONE

m/s

No Data
39.0: 45.0
33.0: 39.0
27.0: 33.0
21.0: 27.0
15.0: 21.0
9.0: 15.0
3.0: 9.0
-3.0: 3.0
-9.0: -3.0
-15.0: -9.0
-21.0: -15.0
-27.0: -21.0
-33.0: -27.0
-39.0: -33.0
-45.0: -39.0

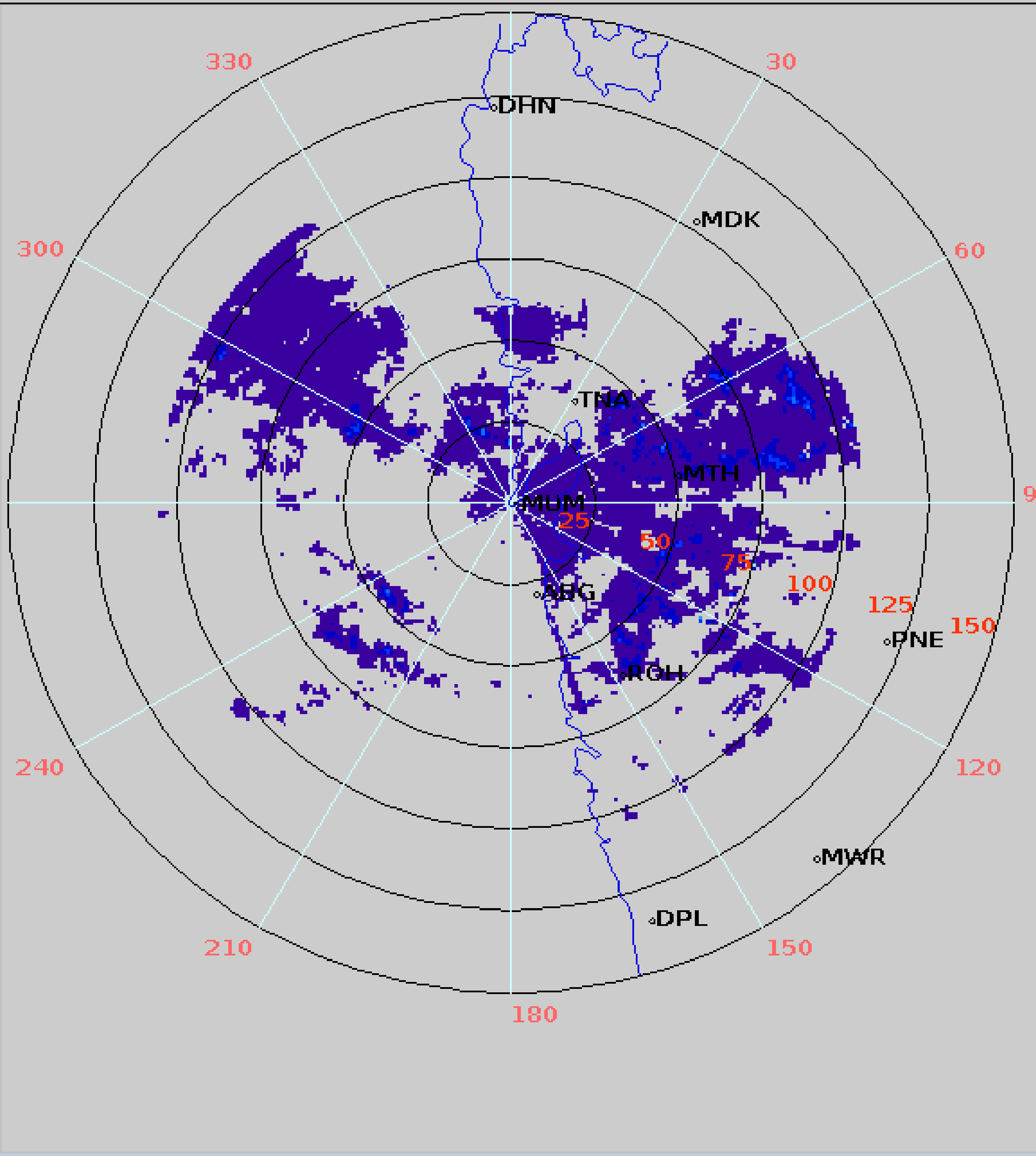
Surface Rainfall Intensity

❖ It is an image of the rainfall intensity in a user selectable surface layer.



mumbai_weather_2011_07_19_05_30_24.dwr

2011/07/19 05:30:24 (UTC) SRI



DWR MUMBAI
(18.9000N , 72.8000E , 75.00 mts)

Z (Lo, Hi)	:	20.0, 90.0 dBZ
Grid size	:	1 Km
Constant a	:	267.0
Constant b	:	1.3
Height	:	1.0 Km
Display Range	:	150 Km
Display Res	:	0.5 Km/Pix
DDR Enable	:	Yes
Scan Elev (Lo, Hi)	:	0.2,21.0 Deg
PRF (Lo, Hi)	:	450, 600 Hz
Scan Res	:	300 mts
Scan RPM	:	1.4
Log Threshold	:	2 dB
DTP	:	60
Pulse Width	:	1.0
Clutter Width	:	0.12 %
SQI	:	0.35
CSR	:	20

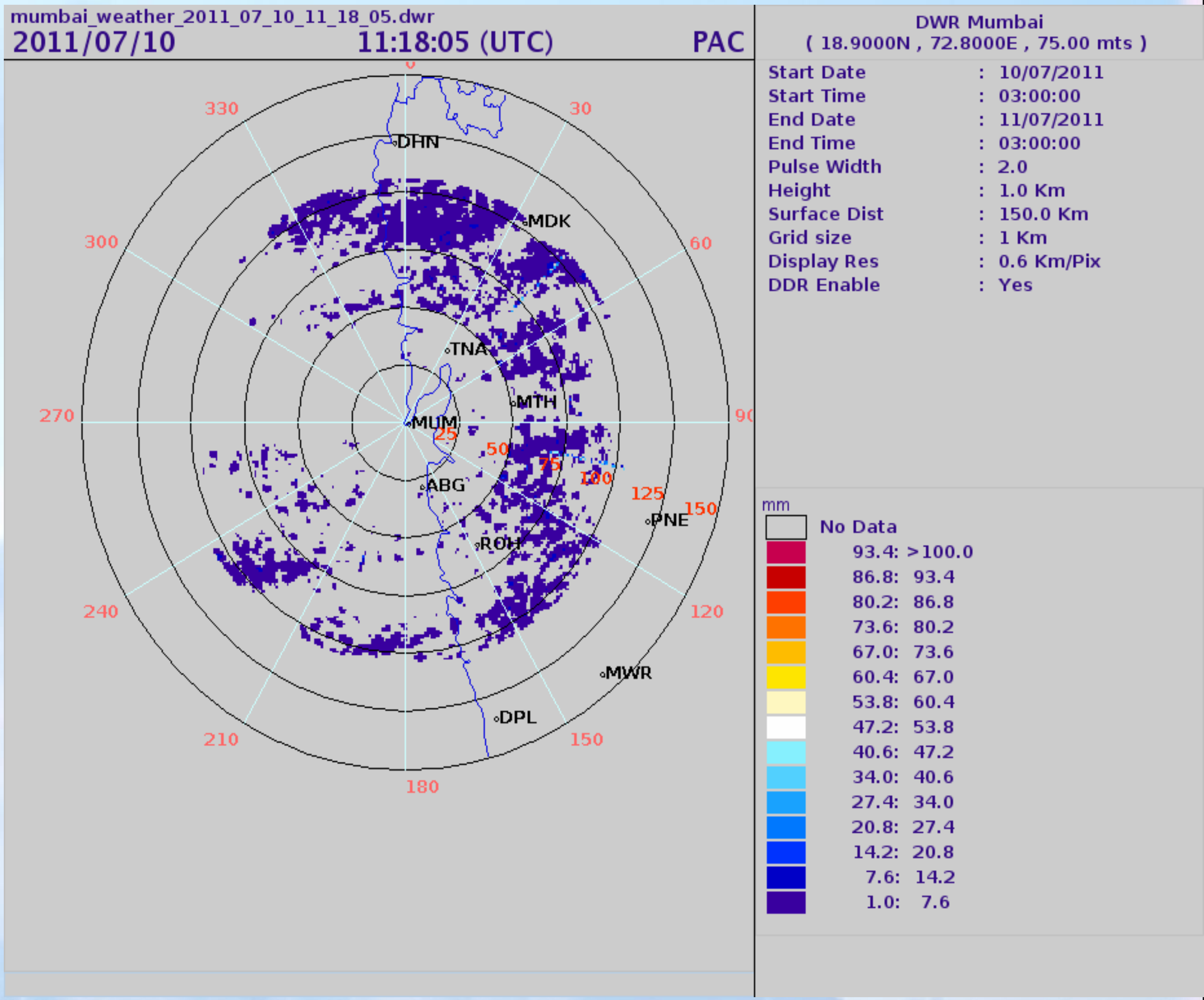
mm/hr

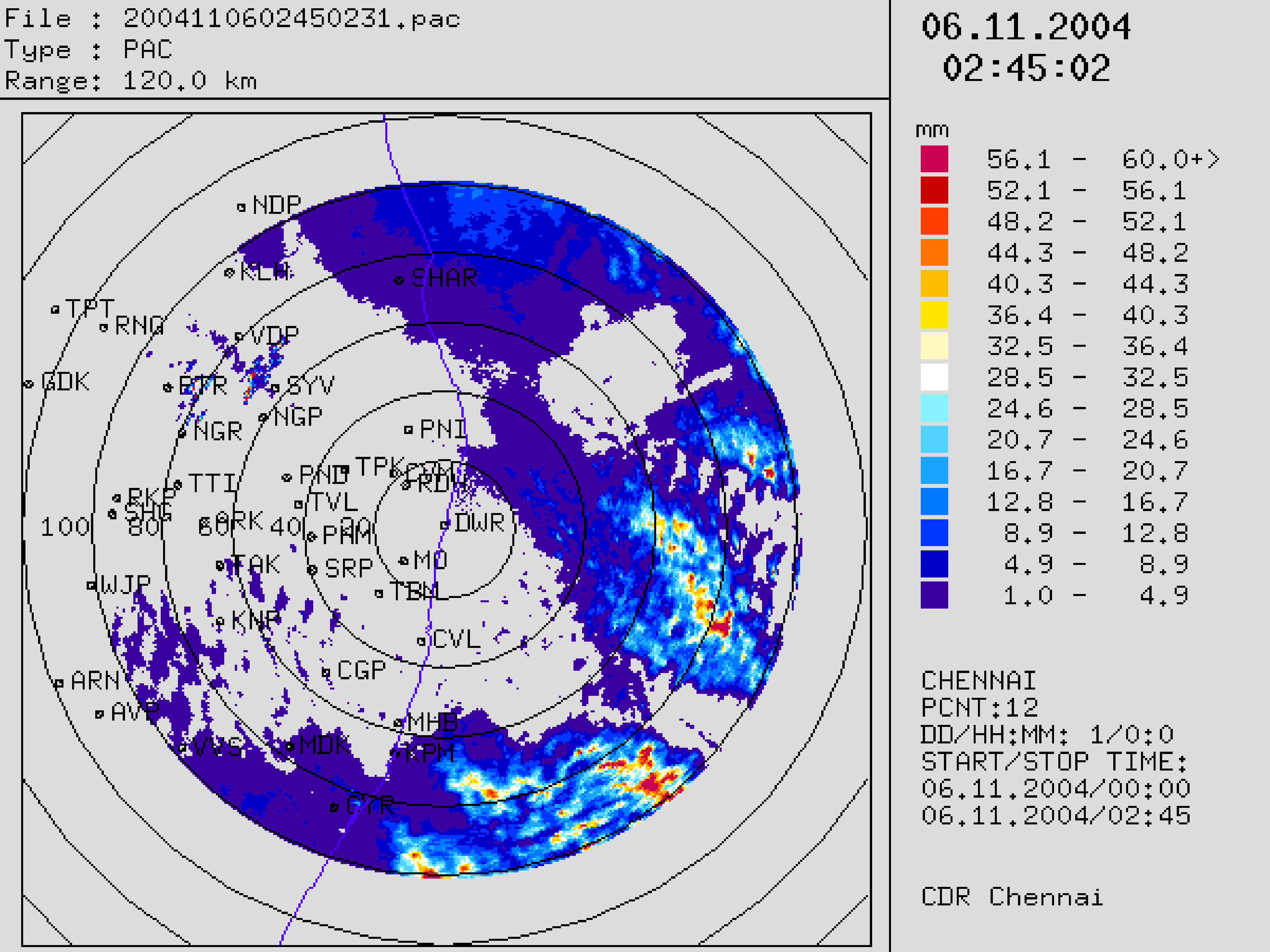
No Data	
93.4:	>100.0
86.8:	93.4
80.2:	86.8
73.6:	80.2
67.0:	73.6
60.4:	67.0
53.8:	60.4
47.2:	53.8
40.6:	47.2
34.0:	40.6
27.4:	34.0
20.8:	27.4
14.2:	20.8
7.6:	14.2
1.0:	7.6

Precipitation Accumulation (PAC)

The PAC product is a second level product. It takes SRI products of the same type as input.

- Radar does not measure precipitation rate directly, but rather estimates that rate from the back scattered energy received from precipitation particles
- The accurate measurement of precipitation plays a very important role in hydrology, agriculture, climatology, and weather forecasting..
- Precipitation accumulation estimation by the Radar can be useful for inflow in catchments, flood forecasting in almost real time basis in the absence of conventional rain gauge network





File : 20041106024502З1.pac
Type : PAC
Range: 120.0 km
06.11.2004
02:45:02
mm
56.1 - 60.0+>
52.1 - 56.1
48.2 - 52.1
44.3 - 48.2
40.3 - 44.3
36.4 - 40.3
32.5 - 36.4
28.5 - 32.5
24.6 - 28.5
20.7 - 24.6
16.7 - 20.7
12.8 - 16.7
8.9 - 12.8
4.9 - 8.9
1.0 - 4.9
NDP
KLH
SHAR
TPT
RNG
VDP
GDK
BTR
SYV
NGP
NGR
PNI
PND
TPK
TTI
TVL
DWR
100
80
60
40
20
SRP
TAK
MD
WJP
TBM
KNP
CVL
CGP
ARN
AVP
MHB
VVS
MDK
KPM
CHENNAI
PCNT:12
DD/HH:MM: 1/0:0
START/STOP TIME:
06.11.2004/00:00
06.11.2004/02:45
CDR Chennai

Aviation Products

(a). Radial Shear (RDS)

- The *Radial Shear product profiles the derivative of radial wind velocity in radial direction, at each measurement bin, on a single elevation polar plane. 35 .*The radial shear at a bin is calculated as the slope of the regression line (least-square fitted line) of the Doppler velocities in a radial fit window of N neighboring bins. The bin itself falls at the middle of the window. RN is an odd number greater than 2, and is selected between 3 and 11 with default value 9.
- The product is generated for a user specified single elevation. For volume-scan data files, the scan elevation nearest to the user specified elevation is selected. If the input is above half beam width of the lowest scan elevation or is below half beam width of the lowest scan elevation the shear product is not generated

Azimuthal Shear (AZS)

- The *Azimuth Shear product profiles the derivative of radial wind velocity in azimuth direction, at each measurement bin, on a single elevation polar plane.*
- The azimuth shear at a bin is calculated as the slope of the regression line (least-square fitted line) of the Doppler velocities in an azimuth fit window of „AN" neighboring azimuth bins at the same radial distance. The bin itself falls at the middle of the window. „AN" is an odd number and is greater than 2.

Elevation Shear (ELS)

- The *Elevation Shear (ELS) product profiles the absolute change of radial velocity in the elevation direction, at bin level. The ELS values are always positive.*
- The elevation shear at a bin is calculated as the gradient of the absolute difference of the radial velocities in two corresponding bins in two adjacent elevation scan surfaces; and is assigned to the bin in the lower elevation plane. The difference is normalized to (m/s)/Km, the distance being calculated from elevation difference and radial distance of the bins.

- **Velocity Azimuth Display (VAD)**

- **The VAD displays the radial velocity versus the azimuth angle for a fixed elevation and a fixed slant range. The elevation and the displayed range (slant range) are user selectable. The range of the velocity axis is always normalized from -1.0 to 1.0 by maximum unambiguous velocity. The value of the maximum unambiguous velocity is displayed in the legend. For a uniform wind field, VAD is a true sinusoidal curve. The azimuth of minima of the negative maximum radial velocity represents the direction of approaching wind. The speed can be calculated by multiplying amplitude of the sin curve with maximum unambiguous velocity of the observation. Fig.7.10 illustrates a VAD product generated by DWR Chennai.**

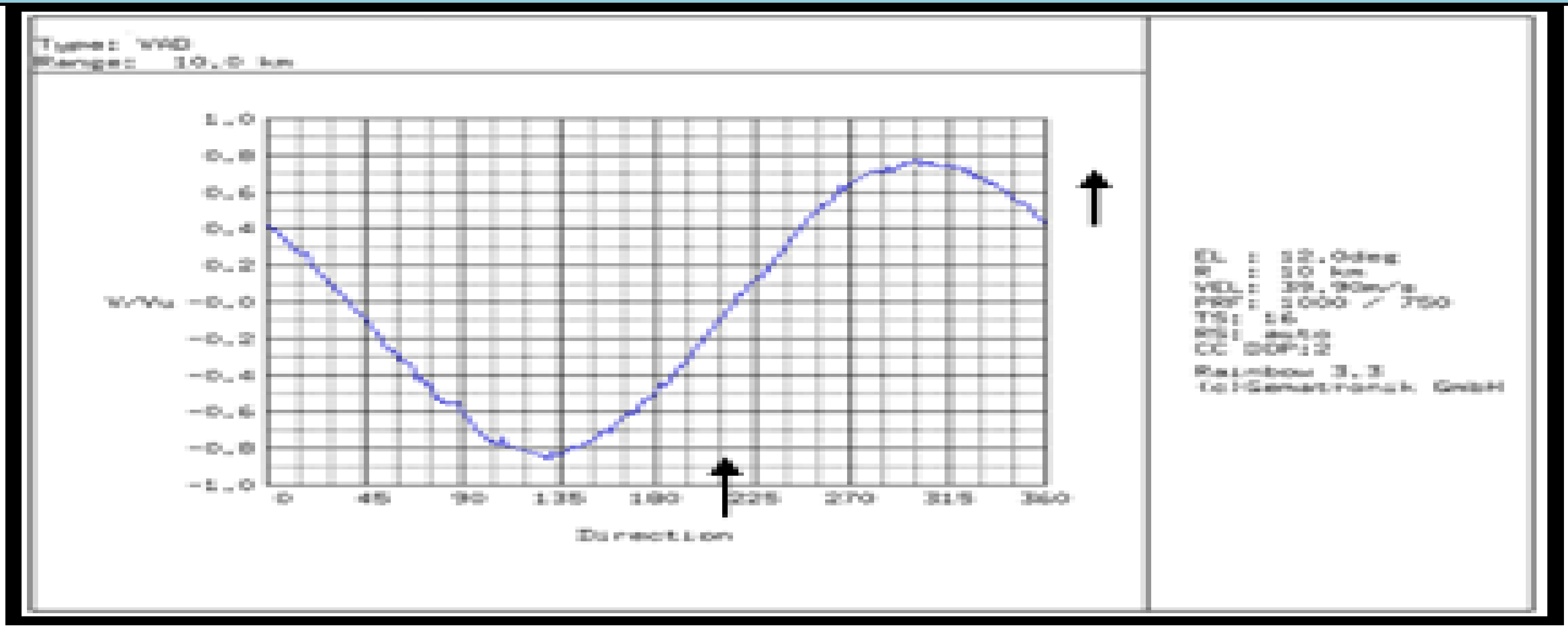


Fig. 7.10: Velocity Azimuth Display. Azimuth of the negative maximum radial velocity corresponds to direction of approaching wind. Wind speed is 0.8*39.9 =31.92 m/s

- **Volume Velocity Processing (2) (VVP_2)**

  The VVP_2 displays the horizontal wind velocity and the wind direction in a vertical column above the radar site. These quantities are derived from a volume raw data set with velocity data. A linear wind field model is used to derive the additional information from the measured radial velocity data. The algorithm calculates velocity and wind direction for a set of equidistant layers. The user can choose one of two ways to display the results:

- **Vertical profile diagram of speed and direction**

  Speed and direction are displayed in separate diagrams. The first diagram shows height over wind direction, the second diagram shows height over wind speed.

- **Wind barbs**

  This version displays speed and direction in a height over time diagram. Wind barbs are used to indicate wind speed and wind direction. A column of wind barbs shows velocity and direction for a time step, subsequent columns show the wind profile for subsequent VVP (2) product generations. VVP_2 product generated by DWR Machilipatnam is shown in Fig.7.11.

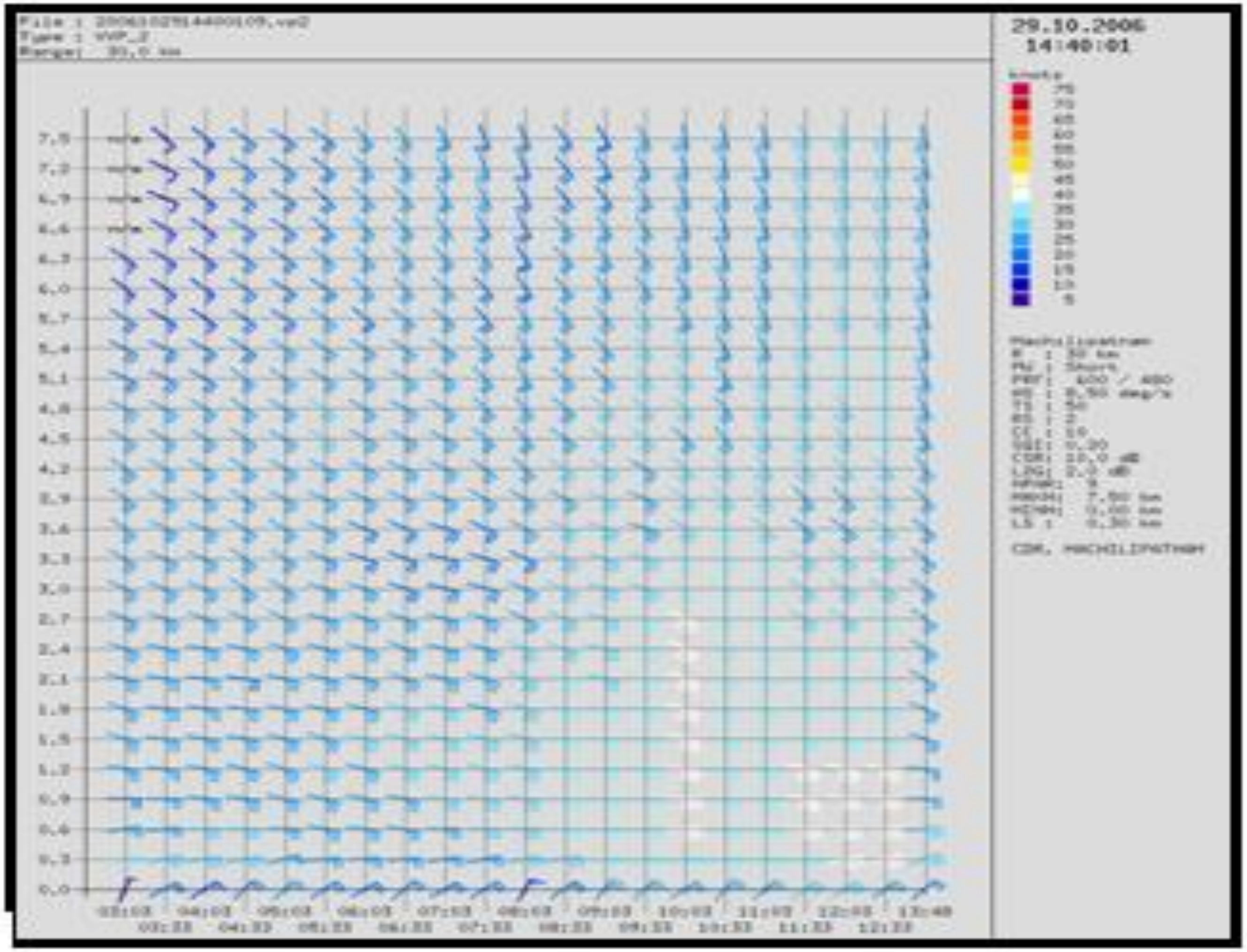


Fig. 7.11: VVP2 product. It provides vertical wind profile over DWR station

- **Warning Products**

Hail Warning (HHW)

- **Algorithm for hail detection uses only reflectivity values (thresholds) above freezing level. Two thresholds, one for probable hail and other for very probable are defined by the operator. The algorithm searches the volume data containing reflectivity values for the bins that matches the thresholds layer by layer. A pixel in the product image is set to probable hail or very probable hail if any of the bins above this pixel has a reflectivity value that is higher than or equal to the hail thresholds and is also above the freezing level. The areas of probable and very probable are marked in different colours.**

Warning (WRN)

- The warning product is a second level product. This means that the warning product depends on other products (also called first level products) and not on raw data. The idea is to take one or more first level products and to search for segments that match the conditions defined in the Product definition file. These segments are inserted in a display list and shown in the result picture. Optionally an acoustic or a visual warning is given.

Gust Front Detection (GUF)

- The surge of gusty wind on or near the ground from the meso-scale high formed by descending cold air in a downdraft from a thunderstorm is called gust front. The spreading cold air undercuts the warm air prevalent in the atmosphere and the cold air is deflected upward by ground friction and forms “precipitation roll”.

Storm Tracking (TRK)

- The tracking product is a second level product. It takes other products as input and looks for cells that match the conditions defined in the warning product definition. Some characteristic values are calculated for every cell and saved in a display list. So far this is very similar to the warning product. The tracking algorithm takes subsequent display lists as input and tries to couple the cells in these lists. This is an iterative process, i.e. if there are uncoupled cells after the first run then the algorithm starts again with less restrictive conditions until all acceptable couplings have been found. The last step is a forecast about the future movement of the cells in the latest scan. Cells are assumed to move on with unchanged speed and direction. Speed and direction are either calculated from the subsequent positions of coupled cells or, if there is no coupling, from the overall movement of all cells.

Nowcast Models of IMD utilizing radar data

- Doppler weather radar data has acquired a lot of interest in view of the importance it has got in monitoring the clouds, winds and classification of various clouds forms every 10 minutes, un-interruptedly. This enables the forecasters to monitor the weather more precisely due to the high resolution of the data, clear inputs about the wind flow patterns, rain rate information, wind shear, etc. It is further more useful in now-casting which is playing a major role these days, where temporal and special variations are to be monitored and presented for the public to alert area specific weather events.
- The NWP group of IMD is working on improving the weather forecasts using Doppler weather radar data in to the models, in a process called ingesting. There has been a significant improvement in the reliability of the forecasts due to this.
- IMD has started a set of services known as now casting in which some major city centres are equipped with servers that run now casting models like SWIRLS, ARPS, WRF-VAR etc., that regularly run the weather data for now casts. The data is updated every 6 hours or more depending on the situation. Where ever a Doppler Weather Radar is co-located the raw data is ingested to increase the reliability of the now casts.