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Architecture of X-Band Data Product Generator

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Abstract: Architecture of X-Band Data Product generator deals with background concepts for development of software for Dual Polarimetric X-Band Doppler Weather Radar (DWR), which is used for weather forecasting. It works on X-Band frequency, and has scan range (radius) of 100 km. Data Product generator is stand-alone offline application, which is exclusively used by scientists. This software generates a set of more than 37 data products (of DWR) from the measurements of DWR Mark-II radar data format, archived in files. DWR provides data file containing information about base products like Reflectivity (Z), Radial velocity (V),Spectrum width (σ).This information is in form of binary data for a set of parameters (time, azimuth and elevation). These base data or derived product can be displayed as image.

All data products use various weather forecasting algorithms to generate output. This whole system generates images depicting rainfall or various hydrometers over a geographical area, such images are used for analysis of weather. The proposed system provides user interface through which it can accept DWR data file. This system generates images for the products like Plan position indicator (PPI), rain rate estimation products, hydrometer classification product, etc. The user interface allows user to select products and corresponding parameters. Once the image is generated, it can be saved in storage device.

Keywords: Radar, Data Products, weather forecasting, Doppler Effect, X-Band frequency, Mark-II data

I. INTRODUCTION

A. *About Radar:*

A convenient definition of RADAR lies in its word origin, which is Radio Detection and Ranging. It detects reflecting objects and locates them in range and angle by transmitting a signal of known waveform (usually a repetitive train of short duration pulses) and observing the nature of the received echoes. Radar can be designated to locate weather targets during conditions of haze, fog, snow, rain and darkness. The radar is a system or technique for detecting the position, movement and nature of a remote object by means of radio waves reflected from its surface [3].

B. *How Doppler Radar Works?:*

Radars are most commonly used in detecting and predicting weather conditions. What information we hear on the use has an actual scientific process behind it. Most weather radars use the Doppler Effect while there are still a few using microwave signals. Doppler radars are much more accurate than the older style radars [5]. DWR is an important sensor for operations and research in the atmospheric and meteorological sciences and presently is becoming an indispensable tool in the measurement and forecasting of atmospheric phenomena. The DWRs basically operate by exploiting the phase and amplitude information contained in the return electromagnetic signal. DWR which operates at X-band of frequency is capable of monitoring clouds, precipitation systems and winds over area of 100 km from the radar location; they are light weighted, portable.

II. REQUIREMENTS

A. *Objective:*

Offline data product generator and display software will acquire the base data namely Reflectivity (Z), Velocity (V), Spectrum Width (σ) from scan file archive (Mark-II data format), process it and displays the data as a color coded data product such as PPI (Plan Position Indicator), SRI (Rain rate estimation), HWV (horizontal wind velocity), [11] etc. As per different requirement of observations, display of plot can be modified using different Product Parameter settings. Image of plot can be generated using 8-colors, 16-colors or 32-colors. Main requirement of the software is, to be able to do batch processing, of different products simultaneously, or process different sets parameters of same products simultaneously. This software mainly focuses on radar which works on X-Band frequency, which means, scan data will have range of 100Km. As this software is incorporated with algorithm which can compute data having both horizontal and vertical components. So, it can be called as data product generator for dual-polarimetric DWR. This system generates images depicting rainfall or various hydrometers over a geographical area, such images are used by scientist for analysis purpose.

B. Interface:

The proposed system provides a graphical user interface through which it can accept DWR data file. This system provides algorithm for generation of images for the products-rain rate estimation products and hydrometer classification product. The user interface allows the user to select a product and corresponding product parameter file to generate image. Once the image is generated, it is displayed and can be saved. The main feature of this application is batch processing, which means multiple products can be selected at a time, or same products can be added to product list with different parameter sets. All these different set of products and parameters generates different images. All these images are saved into storage media, and simultaneously displayed to user separately as tabs. So, Analysis of DWR data is carried out efficiently

III. DATA PRODUCTS

The Base Products and Primary Products [4] derived from Doppler weather radar for applications in meteorology are:

A. Reflectivity:

The target echo returned to radar is formed from the backscatter individual hydrometeors contained within the volumetric resolution cell of the radar. The large number of reflecting particles contained within the volume resolution cell forms a distributed target the reflectivity of which is characterized by its average backscattering coefficient η. The reflectivity generally increases as the fourth power of frequency. This is the parameter from which liquid water content and rainfall rate is measured.

B. Radial Velocity:

The power spectrum of the received echo generally allows determining the wind fields associated with the weather disturbance. The mean Doppler frequency associated with the power spectrum is a measure of the radial velocity of the hydrometeors within volumetric cell under measurement. Pulse Pair Algorithm is used for the estimation of Velocity and the Spectrum Width.

C. Spectrum width:

Spectrum Width of the Doppler power spectrum is a measure of the difference in radial velocities between various hydrometeors within the radar volumetric cell. The spectrum width is generally determined by four effects wind, shear, wind turbulence, beam broadening and distribution velocity. This is also estimated from the autocorrelation coefficients.

IV. SYSTEM FEATURES

The functional requirements highlights the major functionalities involved in the system, their descriptions and the flow in which the functionalities are used.

a. Data file collection
b. Reading and processing the data
c. Display

A. Data collection:

All the scan files which are received from DWR should be stored in hard disk. If all scan files are stored in "Default folder", it reduces the software run time activity.

B. Reading and Processing the Data:

Scan files can be filtered according to requirement, like-station name, mode of working, scan time interval (duration of time). Selected file is then processed with required weather forecasting algorithm (data product), like PPI, SRI, HWV etc. Processing of multiple products can be done together for selected file(s). Display properties can be configured before processing and generating the plot image [1-2]. The scan-file consists of two parts:

•Header part
•Data part

a. Header Reading: the header part for mark-2 format is of 12513 byte. The header part contains various information regarding scan file. Following are the header information that can be obtained through the operations provided by this module:

Date	Number of elevations
Latitude	Longitude
Number of azimuth	Number of range-bins
Radar range	Range resolution
Start time	Elevation values

b. **Data reading:** This may involve reading of one elevation data for particular parameter or reading all elevation data for a particular parameter [6-7]

Algorithm for Reading single parameter data for a particular elevation

a) Open the file for reading the data
b) Skip the header part. I.e. file pointer should skip 12513 bytes.
c) The data part of file contains set of a elevations data one after the other. So skip certain set of elevations data until the file pointer arrives to the required set of elevation data.
d) For all the azimuth from start to end azimuth
i. Skip 2 bytes of data which represents the elevation value
ii. Read two bytes of data as integer which represents the azimuth, store the data in an array.
iii. For all the bins from start bin to end bin
(i). Skip initial bytes until the file pointer arrives to the required format
(ii). Read the data in to a array
(iii). Skip end bytes that are present after reading the required parameter so that file pointer moves to next bin data.
(iv). End of for loop
iv. End of for loop
e) End of for loop
f) Return the array of data.

Algorithm for Reading single parameter data for all elevation:

a) Open the file for reading the data

b) Skip the header part. I.e. file pointer should skip 12513 bytes.
c) The data part of file contains set of a elevations data one after the other. So skip certain set of elevations data until the file pointer arrives to the required set of elevation data.
d) For all the elevations from start to end elevation
i. For all the azimuth from start azimuth to end azimuth
(i). Skip 2 bytes of data which represents the elevation value
(ii). Read two bytes of data as integer which represents the azimuth .store the data in an array
(iii). For all the bins from start bin to end bin
(iv). Skip initial bytes until the file pointer arrives tothe required format
(v). Read the data in to an array
(vi). Skip end bytes that are present after reading the required parameter so that file pointer moves to next bin data.
(vii). End of for loop 4.1.3
(viii). End of for loop 4.1.2
ii. End of for loop 4.1
e) End of for loop 4
f) Return the array of data.

C. Display:

After reading the data, removal of unwanted data, is carried out. Then data is displayed, in human understandable format [8-9]. Data is configured before plotting, according to location based on elevation, azimuth, and range bin. Thus for every ray of data being plotted the range bin number of values of a particular parameter is plotted. Range Bins in a Scan indicate the range resolution of the area being scanned by radar.

V. PLAN POSITION INDICATOR (PPI)

Plan position Indicator (PPI) shall profile the variation of a single base product (Reflectivity (Z), Doppler Velocity (V), or Spectrum Width (σ)) over the surface of the scan cone at a fixed elevation. The parameter value for each sample volume along the slant range is plotted as per a predefined color code pattern.

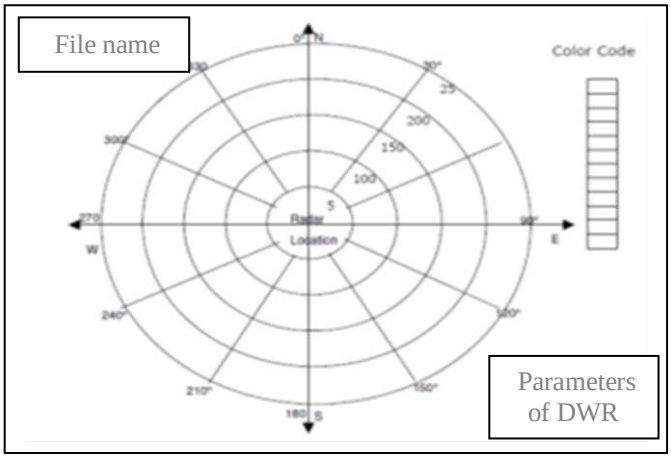

Figure1. Sample Layout for a PPI plot

VI. RAIN FALL INTENSITY

The product Surface Rainfall Intensity (SRI) plot shall display surface rainfall using the Z-R relationship over the radar scan area as a 2-D color-coded product [10-11]. Rainfall intensity computation process shall estimate the water precipitation rate in the atmosphere falling within the radar scan range, over a selected surface area. See fig 2.

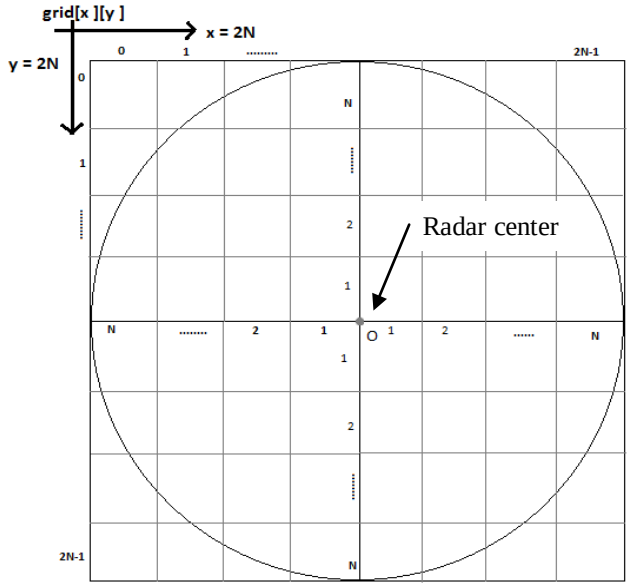

Figure 2 Sample Layout of Rain rate (SRI) grids

VII. HORIZONTAL WIND VELOCITY

The product Horizontal Wind Velocity plot (HWV), shall display the horizontal wind velocities (direction and magnitude) at different heights including divergence and convergence. The horizontal wind velocity, both direction and magnitude, shall be represented through standard feather diagrams. (1 m/s of speed = 2 knots). See Fig. 3.

VIII. OUTPUT PLOTS

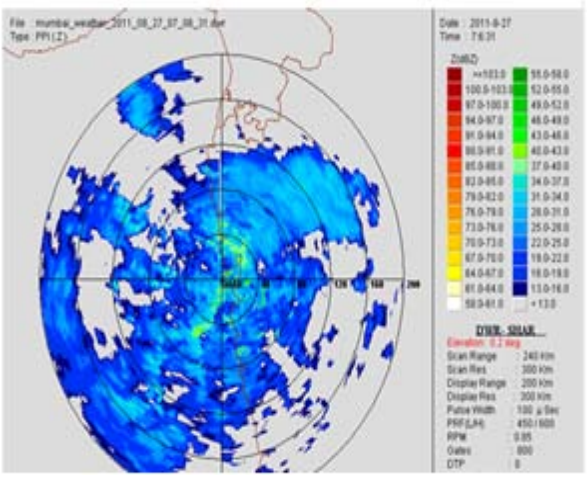

Figure.4. PPI-Z plot in 32-colours

Symbol	Knots	Wind speed range in knots
○	calm	$0.0 \le v < 1.0$
—	1 – 2	$1.0 \le v < 2.5$
⟋	5	$2.5 < v < 7.5$
⟋	10	$7.5 \le v < 12.5$
⟋	15	$12.5 \le v < 17.5$
⟋	20	$17.5 \le v < 22.5$

Figure.3.

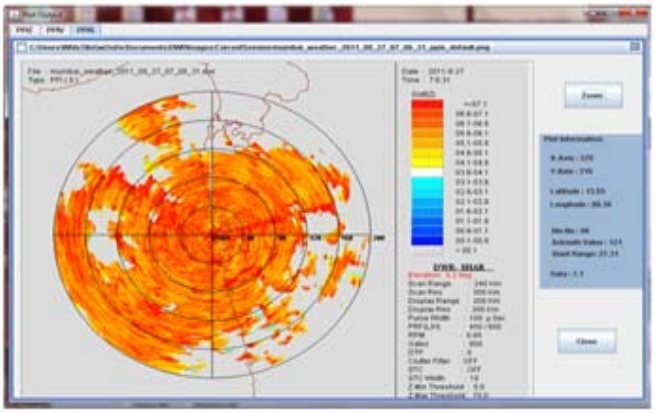

Figure. 4 Output panel with PPI-S plot in 16-colours

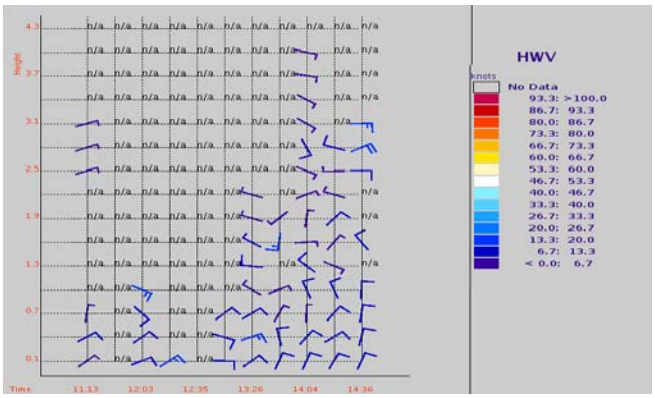

Figure. 5 HWV plot in 16-colours

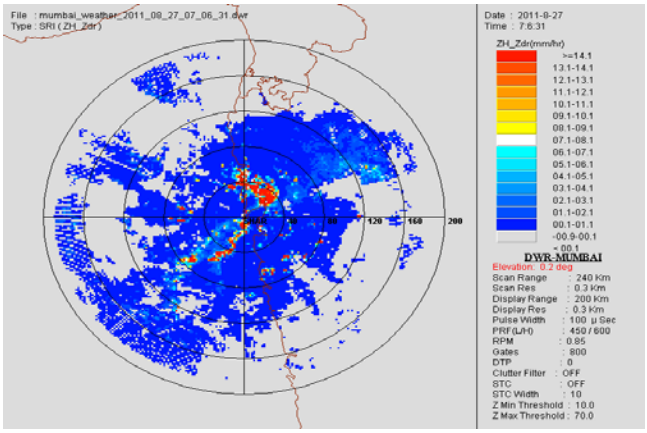

Figure. 6 SRI plot in 16-colours

IX. CONCLUSION

Data Product generator for X-Band dual-Polarimetric Doppler weather Radar is platform independent stand-alone application, which generates offline plot of scan files, which can be used by scientists for weather forecasting and similar analysis using DWR, being able to do batch processing of different products at a time, analysis is carried out fast and efficiently.

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XI. REFERENCES

[1] Lakshmanan V, Hondl K, Stumpf G and Smith T "A Quality control of weather radar data using texture features and a neural network", 5th Int. Conf. on Adv. In Pattern. Recogn., IEEE, Kolkata, 2003

[2] Eilts M D and Smith S D," Efficient dealiasing of Doppler velocities using local environment constraints", Journal of atmospheric and oceanic technology, 1990.

[3] Merrill Skolnik, Radar Handbook, TMH, Third Edition, 2008.

[4] G. Franceschetti, R. Lanari, "Synthetic Aperture Radar Processing," CRC Press ,New York, 1999.

[5] Doviak, R. J., V. Bringi, A. Ryzhkov, A. Zahrai, and D.Zrnic," Considerations for polarimetric upgrades to operational WSR-88D radars", J. Atmos. Oceanic Tech., 2000

[6] S.Rajendran, K.Amar Jyothi , "A Note On the Algorithms for Dual Polarization S Band Radar ", DPOL_ALGO/RDA/ISTRAC/01,2010.

[7] S.Rajendran, K.Amar Jyothi "Polarimetric Doppler weather radar – Notes ", DPOL/RDA/ISTRAC/02, Bangalore, 2010.

[8] Herbert Schildt, JAVA 2 : The Complete Reference , TMH 4th Edition, 2002.

[9] Kernighan, B. W., and D. M. Ritchie, The C Programming Language (Second Edition), Englewood Cliffs, NJ: Prentice Hall, 1988

[10] Kozu, T Nakamura, K, Rainfall Parameter Estimation from Dual-Radar Measurements Combining Reflectivity Profile and Path-Integrated Attenuation, Journal of Atmospheric and Oceanic Technology JAOTES, Vol. 8, No. 2, p 259-270, April 1991.

[11] S.S Roy et al, Doppler weather radar based nowcasting of cyclone Ogni, Indian Academy of sciences, J. Earth Syst. Sci. 119, No. 2, pp. 183–199, April 2010,