P1.5 THE RESEARCH RADAR DATA ANALYSIS TOOL (RRAT)

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1. INTRODUCTION

Over the past year a number of Doppler radar data sets have been collected at the National Severe Storms Laboratory (NSSL) to support ongoing and future weather research efforts. Traditionally, Doppler radar data sets have been comprised of the standard Doppler moments: Reflectivity, Velocity, and Spectrum Width. However, given the rapid increase in computational capabilities of today's computers (processor speed, bandwidth, and storage), it has become feasible to record full volume datasets comprised of both moment and time series (I/Q) data. To put the amount of data collection in perspective, a typical WSR-88D level II data volume contains about 14 MB of moment data for VCP 11 (16 cuts/14 levels in 5 minutes). The corresponding time series data would equal about 1.5 GB; roughly 100 times the moment data. Over a 6-hour period, the amount of data collected could reach in excess of 100 GB.

Currently, operational meteorological algorithms for the WSR-88D process moment data only. Zrnic and Doviak (1984) have demonstrated that useful information can be found in time series spectra that are not discernable in the moment data (i.e., positive indication that a tornado has formed within a broader circulation). Therefore, it may be useful to develop new meteorological algorithms based on time series radar data as input.

Analyzing time series data is a daunting task given the nature and size of the data sets. Developing new algorithms which process time series radar data require special tools and environments that allow a scientist to easily peruse and analyze the data searching for appropriate indicators. These tools need to be fast and be able to provide visual feedback to the analyst.

This paper describes a new software package, the Research Radar data Analysis Tool (RRAT) that has been developed to provide a visual link between moment and time series radar data. It could be very useful for scientists wanting to develop a new algorithm based on time series data. The major components of this software package are discussed in this paper.

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2. RRAT ENVIRONMENT

RRAT was designed to run on a Unix platform in an X Windows/Motif environment. The software, written in C, is portable to both big and little endian platforms. The following libraries are required: GNU scientific library (libgsl) and the Open Radar Product Generator (ORPG) infrastructure library (libinfr). The GNU scientific library provides the Fast Fourier Transform routines required to generate time series power spectra. The ORPG infrastructure library provides byte-swapping support for little endian platforms.

RRAT uses several configuration files to setup its display environment and define various properties. These files reside in the directory defined by the "HOME" environment variable. Traditionally, this is the users login directory. Each of these configuration files use an ASCII format which can be displayed/edited using a text editor.

The configuration file ".rrat.conf" defines the settings for most RRAT data and display attributes. It is updated by RRAT whenever one of these attributes is changed allowing one to restore an RRAT session whenever it needs to be restarted.

The configuration file ".rrat.colors" defines all of the color tables used to display moment data. Each entry in this file is selectable from the RRAT color menu. A color table entry can be defined for one or more of the spectral moments. Color tables can be defined using up to 64 colors.

The configuration file ".rrat.help" contains HTML help text which can be displayed in a browser supporting HTML. The specific browser can be defined by an entry in the ".rrat.conf" configuration file. If a browser is not defined then the data are displayed as plain text.

3. RRAT PREPROCESSOR

RRAT uses a preprocessor to simplify RRAT processing by creating specially formatted output files for moment and time series data. The output moment file contains byte swapped moment data (if running on a little endian platform) followed by a table of all of the radial headers. RRAT reads the table into memory when a new radar volume is selected. When a new moment or cut is selected for display, pointers to the specific radials in the cut can be quickly located in the table and the data read.

Unlike the moment output file, the time series output file contains only a lookup table of time series radial headers. Since a typical time series radar data file is very large (> 1 Gb), the preprocessor does not make a copy of the original time series radar data in the output file; only a table of headers of each radial in the file with pointers to radials in the original time series radar data file. This saves storage space and time. Since time series spectra are generated at user selected gates interactively, time series data are read in from the original time series radar data file whenever a new gate is selected (any byte swapping is done at that time).

The RRAT preprocessor can be run manually from the command line using the command "rrat_pp". However, it is typically invoked internally by RRAT if it determines that a selected radar volume file set has yet to be processed.

4. RRAT DISPLAY

RRAT provides several moment data views along with a graphical display of corresponding time series spectra data and numerous selections to control which data are displayed. A typical RRAT display is presented in Figure 1.

The right two thirds of the window is devoted to displaying a PPI along with selections to control the moment and elevation cut. In addition, information pertaining to the latest selected gate is presented below the moment and elevation cut selections.

The remaining third of the window contains some additional control selections, a reconstructed RHI view along the azimuth containing the selected gate, and one or more spectral plots. In addition, below the spectral plots, are selections to control how the spectral plots are generated/displayed.

4.1 PPI Display Region

The PPI display region is the focal point for all RRAT activities. Typically, the first step in any analysis is to select an elevation cut and display a PPI view of a selected moment. The next step is to identify a feature in the PPI view and select it for further analysis. When a new radar file is opened, the cut and moment menus are updated accordingly to reflect the information contained in the file.

The mouse buttons have special meaning when the cursor is located over the PPI view. If "raw" mode is active (Raw radio button set), selecting the left mouse button changes the active gate to the gate closest to the location of the cursor in the corresponding radar data. Information about the gate is displayed at the bottom of the PPI display region. This information includes: location of the gate (in azimuth/range coordinates), the value of the gate, and the height of the gate AGL.

In most instances, it is desirable to magnify the display over a smaller region; especially when targeting a gate that is close to the radar. If "zoom" mode is active (Zoom radio button set), selecting the left mouse button increases the magnification factor by 2, and resets the window center to the location of the cursor when the button was selected. This can be repeated until the magnification factor is 128. Selecting the right mouse button decreases the magnification factor by 2 and resets the window center to the location of the cursor when the button was selected. This can be repeated until the magnification factor is 1. Selecting the center mouse button only resets the window center to the location of the cursor when the button was selected.

The radial containing the active gate is highlighted in the PPI view by a flashing line. The line changes between three states: white, black, and transparent. The active gate is highlighted by a "+" symbol.

In addition to moment data, the PPI view can also display map overlays as well as other types of overlay information. RRAT provides a simple ASCII format for creating overlays to display lines, labels, and symbols.

Selections are provided in the PPI display region for stepping through and looping previously displayed PPI data. This can be helpful when identifying the properties of a feature in both space and time. It

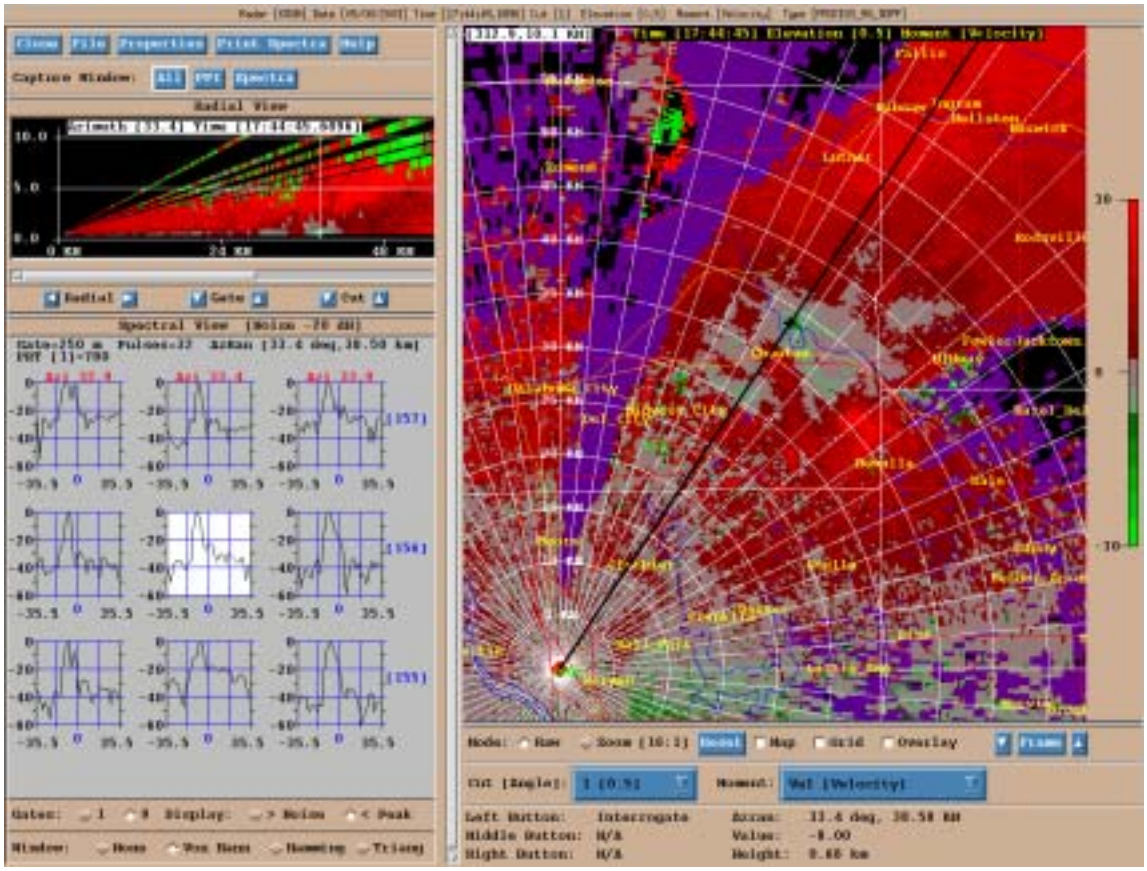

Figure 1. Sample RRAT Display

also provides the capability to quickly toggle the display between different moments.

4.2 RHI Display Region

RRAT provides a reconstructed range-height indicator (RHI) view of moment data along the radial containing the selected gate. The user can define both the horizontal and vertical domain for the display. Buttons are provided below the RHI view for selecting the adjacent gate along the radial or the adjacent radial to the radial containing the active gate in both the azimuth and elevation directions. These buttons are especially useful when analyzing time series spectra gate-by-gate.

The moment displayed in the RHI corresponds to the currently selected moment in the PPI view. Positioning the cursor over the gate location in the RHI view and selecting the left mouse button changes the active gate. The location of the active gate is highlighted by a flashing vertical line containing the "+" symbol.

4.3 Spectra Display Region

The main purpose of RRAT is to display the spectra of time series data linked to specific moment data which themselves were created from the time series data. Since time series data contain the raw pulses for each gate, a display similar to a PPI or RHI is not feasible. A more desirable way to present the time series data are as individual spectral plots for all pulses at a given gate. It would be undesirable to display spectra for all gates in a particular elevation cut since the number of plots would typically number in the tens of thousands.

RRAT provides the capability to display a single spectral plot for the active gate or for the active gate and all immediately surrounding gates (total of 9). If multiple spectra are displayed, the spectrum for the active gate is displayed in the middle. Selections are provided below the spectra display to select a single gate or 9 gates.

At the top of the spectral plot(s) are information pertaining to the gate, such as, gate spacing,

number of pulses, location, and pulse repetition time. The radial azimuth is displayed above the plot(s) and the range to the right.

The user can display each plot as power (in dB) below peak or above noise. The noise value can be chosen from the data or set by the user.

RRAT provides a choice of several window filters to use on the input data before the spectra are generated. The filter options are: None, Von Hann, Hamming, and Triangular. The definitions of these window filters can be found in Zrnic and Doviac (1984).

5. SUMMARY

A new software package, called the Research Radar data Analysis Tool (RRAT), has been developed to aid in the analysis of time series Doppler radar data. The main strength of RRAT is the ability to link time series radar data, gate-by-gate, to a graphical moment display, allowing an analyst to interactively select new gates with the mouse. One possible use would be as a prototype for displaying time series spectra in an operational environment at selected locations (i.e., in regions where automated algorithms have detected mesocyclones and tornado vortex signatures). It is planned that the software will evolve into a tool that can be used to develop new spectral algorithms. More capabilities will be added to the package as its use increases.

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7. REFERENCES

Zrnic, D. S., and Doviak, R. J. (1984). “Doppler Radar and Weather Observations”, Academic Press, Orlando, Florida