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THE WSR-88D COMMON OPERATIONS AND DEVELOPMENT ENVIRONMENT AND ENHANCEMENTS TO ORPG ALGORITHM INFRASTRUCTURE SERVICES

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1.0 INTRODUCTION

The Open Radar Product Generator (ORPG) includes a system architecture that has already provided an opportunity to increase the pace of technology infusion and the deployment of new algorithms into the operational weather radar. The use of the ORPG's Common Operations and Development Environment (CODE) for algorithm research and development is promoting the production of software that can more easily be integrated into the operational ORPG.

The recent versions of WSR-88D CODE have improved support for algorithm development for the WSR-88D. Recent enhancements to the WSR-88D ORPG infrastructure services (included with Open Builds 2 and 3), expanded guidance for algorithm development, and enhanced data analysis utilities contribute to the improvements in CODE. This paper summarizes the current status of CODE and summarizes future plans.

2.0 ENHANCEMENTS TO ORPG SERVICES

2.1 *Algorithm Configuration*

In the legacy system, integration of new science inevitably involved RPG source code changes. In ORPG, ASCII configuration files were introduced which specified properties of the algorithms and products that the algorithms produced. These configuration files replaced "hard-coded" tables in the legacy system. In ORPG, these tables are now populated from information in the configuration files as part of the ORPG startup and initialization.

This did not completely eliminate the need for ORPG changes whenever new algorithms were introduced. The product request message reserves space for as many as 6 product dependent parameters (e.g., elevation angle, center range, center azimuth, etc). Each product generated reserves space for up to 10 product dependent parameters. In order to associate the generation of a product with its request, in order for the product to be distributed to the end user, there was a mapping table for mapping the 6 parameters in the request message to the 10 parameters in the product message. To eliminate the need for this mapping table, 2 things were done. One was to impose rules on the placement of product dependent parameters in the product message and the other was to include both the request parameters and the corresponding product parameters in an additional header prepended to the product message. This header and these parameters allow the product server's to match product requests with the product generation responses independent of the product being generated. This header is stripped off the product just prior to product transmission to the end user.

2.2 *Algorithm API Services*

The ORPG architecture includes infrastructure software written in C / C++ and the Legacy algorithms written in FORTRAN. The ORPG includes algorithm API services to support both FORTRAN algorithms and a new ANSI-C binding. The C API has been a subset of the FORTRAN version but is rapidly being expanded.

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In 2002, services were added to the C API in order to support products generated via a one-time request that include parameters other than elevation angle in the request message. A related capability added is the ability for an algorithm to detect an error in a request for one of its products and abort only that individual product.

Another capability added to support algorithm development in C are services that can provide information about the current volume scan and the volume scan strategy. Functions to obtain the current volume number and elevation index were improved. In addition, functions were added to access the parameters that describe the volume coverage pattern currently being used by the RDA. This information includes the elevation angle associated with the current index and the total number of elevation scans being produced with the current scan strategy. This is not hard-coded information. Algorithms that use these services correctly will not fail when a new scanning strategy has been added to the WSR-88D.

A significant capability recently added to the ORPG is product compression. Many of the products being added are full resolution data arrays and are quite large compared to the Legacy 16-level displayable products. Even with advances with network bandwidth capabilities, there is a need to reduce product size. The header portion of the final product format has not been changed, but an option to compress the data portion has been added. The header includes a flag to indicate the type of compression used and the size of the product when uncompressed. Currently, the commonly available BZIP2 compression library is used.

3.0 IMPROVEMENTS TO CODE

Ganger 2002, provides including documentation an overview of the CODE support for algorithm development. A more complete discussion of the CODE development utilities is provided by Stern 2002. A summary of changes made during the past year follows.

3.1 *CODE Development Utilities*

3.1.1 *CODEview Text (CVT)*

CODEview Text (CVT) is a text based data analysis and product display tool that can display inventories of linear buffer messages and display selected information contained in WSR-88D product messages. CVT displays formatted output of the blocks and data packets of ICD compliant products (NWS Radar Operations Center, 2002).

CVT was limited to reading products from the intermediate product linear buffers and the configured product database linear buffer. Last year CVT was enhanced to provide the ability to read messages from an archived copy of the database linear buffer and to read product message that had been extracted to individual binary files. This enhancement provides the ability to save test cases in the form of copied database files for later analysis and to exchange individual product messages with other developers via binary files.

CVT was modified to recognize the new ORPG compressed products and to automatically uncompress the data prior to display.

3.1.2 CODEview Graphics (*CVG)*

CODEview Graphics (CVG) is an X-Windows/Motif application that provides a graphic display capability for existing WSR-88D products and new products (a few product message types including the RCM are not supported). CVG provides a graphical display using standard color palettes defined in the product specifications. New color palettes can be defined and new products configured for display.

CVG includes a display zoom capability, data interrogation (information about the data under the cursor), and has a basic animation capability. A time series animation displays selected products from successive volume scans; CVG can also animate elevation products through all of the available elevation scans within a volume. CVG has the ability to display two products side by side and link the two displays for animation and data interrogation.

CVG displays a color bar in the legend indicating threshold levels associated with the color displayed. The newer digital products typically have 256 data levels rather than the 8 or 16 levels in legacy products that were intended for display by the WSR-88D PUP.

Prior to 2002 CVG could display digital products but the threshold levels in the legend were not precise and the actual colors assigned to data levels were often not what was intended. A system of parameters fully describing the encoding of data into these digital products, using data packet code 16, was developed (Ganger, 2003) and added to the CVG product configuration preferences. Figure 1 contains the automatically calculated legend labels for a digital velocity product displayed by an older version of CVG. The labels are symmetrical but only approximate. Figure 2 depicts the accurately calculated labels displayed by the current version of CVG. Note that each flag value is assigned a unique color which is not the case with earlier versions of CVG.

In addition, for those products that do not use the typical encoding, CVG can be configured to explicitly state the individual threshold levels. One example is the digital High Resolution Vertically Integrated Liquid (HRVIL) product. The data values for HRVIL are linearly described for low values and logarithmically described for higher values. This is shown in Figure 3. The gray colors represent the linear portion of the encoding and the remaining colors the logarithmic portion. The custom threshold configuration also permits control over the text label used for the flag values.

CVG was modified to recognize the new ORPG compressed products and to automatically uncompress the data prior to display. Improvements were made to the product animation capability and an automatic update feature added. Auto update will display the most current version of the selected product and automatically display a new product as the product database is updated.

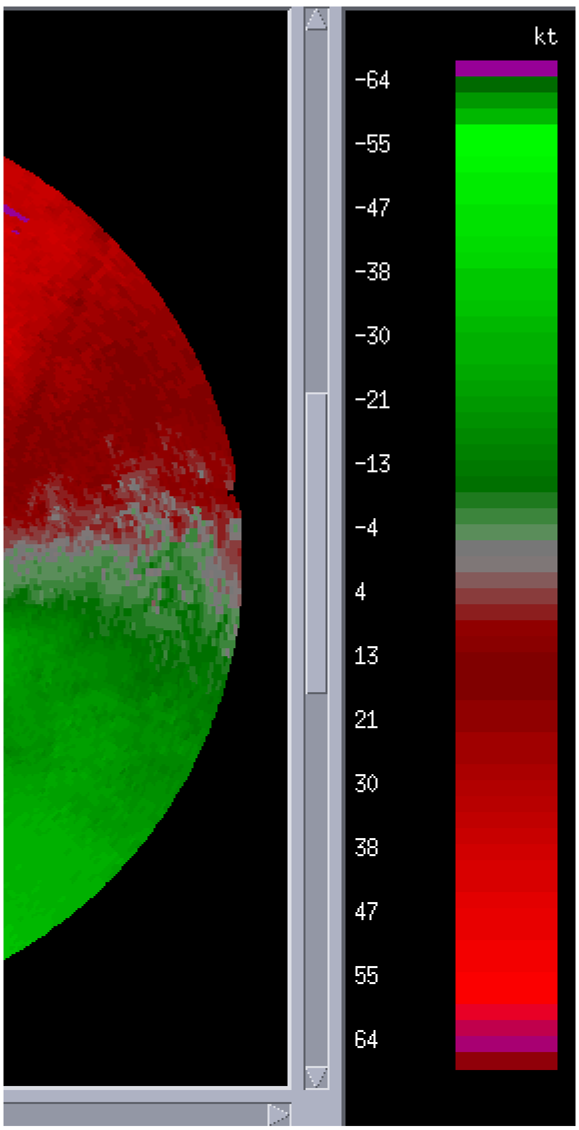

Figure 1. CVG Version 2 Calculated Legend

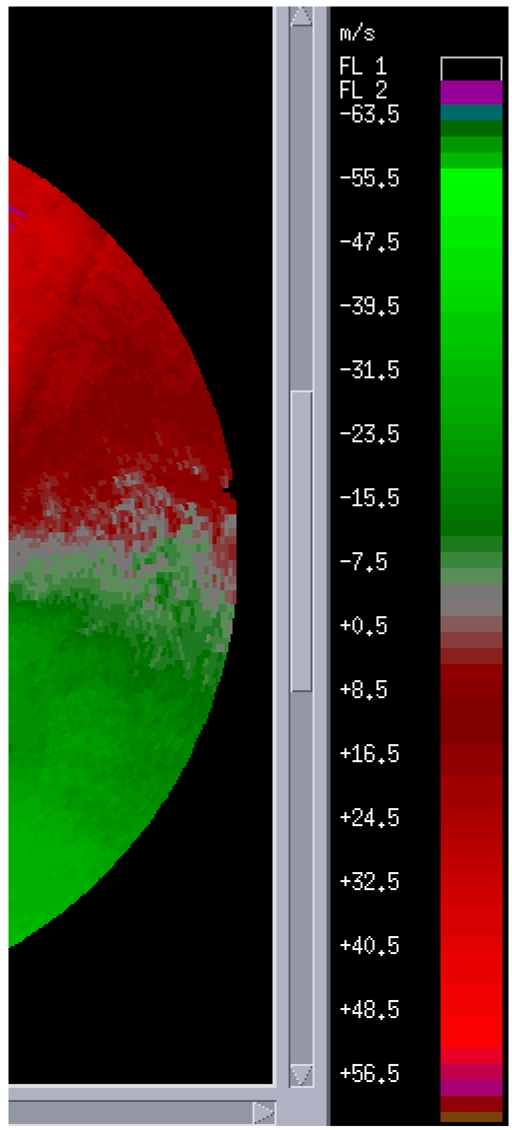

Figure 2. CVG Version 3 Calculated Legend

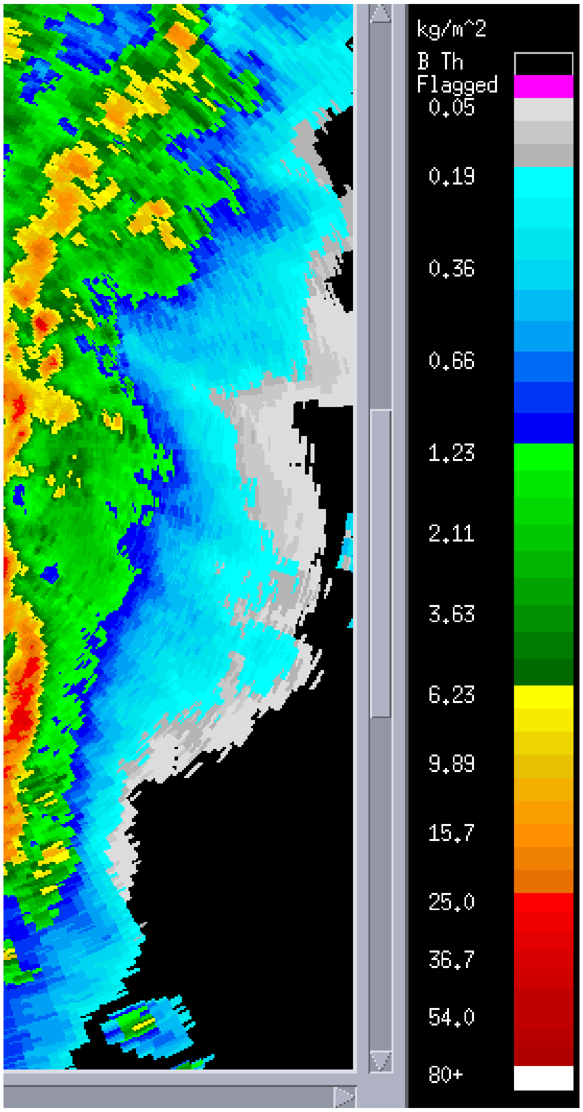

Figure 3. HRVIL Custom Legend Display

3.1.1 *New Utilities*

Several additional utilities were added to CODE.

In a development environment, radar data from many different WSR-88D sites can be used to provide special test cases for algorithm analysis and for test and verification purposes. A simple tool was developed that quickly changed the necessary site dependent adaptation data (including the hydro files) to reflect the source of the data being used. Not only is this required to properly display background maps, the ORPG configuration must also be changed to support any algorithm dependent upon antenna elevation and location and beam attenuation due to terrain.

Two utilities were added to enhance the product display by CVG. A palette editing tool was added to aid in creating new color palettes of any specified size (up to 256 colors) and a Map Background tool can be used to create basic background maps that include selected features such as county and state lines and river and water body boundaries.

3.2 *CODE Documentation*

The CODE documentation has been updated to cover the enhancements made to the ORPG algorithm API services. This included changing the sample algorithms provided with CODE.

The instructions for the configuration of new algorithms were expanded adding significant detail for individual product attributes and for the configuration of intermediate products. The configuration of intermediate products that are produced for each elevation scan is a special case that is covered in detail. The NWS Radar Operations Center (ROC) Engineering branch made infrastructure changes in this area, which provide more flexibility in using elevation-based intermediate products as input for volume-based products.

Formalized rules for use of product dependent parameters were added. These rules reflect the infrastructure changes discussed in Paragraph 2.1. One consequence of this formalization is that product requests for legacy and new products of the same type will have identically formatted request messages.

The guidance for proper structure of algorithms was expanded and additional sample algorithms provided.

4.0 *Future Plans*

Though responsibility for maintenance and enhancement of the ORPG and CODE are assumed by different organizations, the two must continue to evolve together. The brief summary of future plans provided here is from the perspective of support for algorithm development rather than operational capability / meteorological advances.

4.1 *Algorithm API*

Much of the Legacy FORTRAN common modules have not been included in the ANSI-C version of the algorithm API. Many of the functions in these modules are useful to only one algorithm (or a narrow class of algorithms) and could be considered an algorithm component rather than a library routine. However, many are useful but would require rewrite in order to be used in a C library.

An existing ANSI-C Run Length Encoding (RLE) module for radial data will be converted to a generic service and included in a common library. Additional functions currently planned for Build 4 are: RLE for raster data, date/time conversions, and data conversions. Data conversions would accomplish a two-way translation between the encoded binary data included in product arrays and base data radials and the real world floating point values in the appropriate physical unit of measure (e.g., dBZ, meters/sec, etc.).

Another area that is coming under consideration is the definition of new data packet structures for final products (Ganger, 2003) and ORPG internal product data (intermediate products). A standard internal data structure would facilitate the creation of a reusable data manipulation / science library.

4.2 *CODE Documentation and Guidance*

The NWS Systems Engineering Center is working with the NWS ROC in developing guidance and instructions for the preparation of an algorithm for handoff to the ROC for integration into the operational system. This documentation will include coding standards and guidance for algorithm testing and documentation.

Concerning algorithm structure, guidance for improving algorithm performance and use of the algorithm abort routines are two topics needing attention.

Certain conventions for use of product header information should be formalized. This includes the use of the 16 threshold fields in non-RLE products and the 10 product dependent parameter fields (Ganger, 2003).

4.3 *CODE Utilities*

CVG can be enhanced in several areas. Currently the number of data bins in a radial structure is limited to 920 with an associated 1840x1840 grid size limit for Cartesian data. While this is sufficient for current WSR-88D products, there will be a need for larger data arrays in order to display certain products produced from TDWR data. The product animation feature of CVG would be much more useful with a mechanism to specify the size of the animation loop.

Additional CVG capabilities planned include providing a Latitude / Longitude reference in addition to the position relative to the radar antenna and the ability to place a symbol on the graphic at a specified location for documentation purposes.

5.0 SUMMARY

The ORPG algorithm API services and the Common Operations and Development Environment have supported distributed development of new WSR-88D algorithms for more than a year of rapid technology infusion (Istok, 2003). Future enhancements to programming services, documentation and guidance, and development and analysis utilities will continue to make this activity more productive.

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