WSR-88D Algorithm Report

For Build 10 Software Release

WSR-88D Operational Support Facility

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PREFACE

The purpose of this report is to make a snapshot of the meteorological (and related) algorithms that are currently running in the latest software (Build 10 released in November of 1998) for the Weather Surveillance Radar, 1988 Doppler (WSR-88D). While some of the material, especially in the introduction, has been extracted from the *NEXRAD Algorithm Report, November 1985,* many algorithms that appeared in that document have been removed from this report because they have not been implemented and are not likely to be implemented in the future. The Data Dictionary Section of the 1985 algorithm report has also been omitted for this report because a large proportion of the entries were for algorithms that were not implemented. However, the adapatable parameter section has been improved. Each algorithm is identified by name and the default and functional range for each parameter is listed.

As was anticipated in the earlier document, some of the originally fielded algorithms have been replaced by improved versions (specifically, the Storm Identification and Tracking suite, Hail Detection, and TVS). Those replacement algorithms whose processing differed substantially from the original algorithm have been assigned new numbers by the WSR-88D Operational Support Facility's Applications Branch. Moreover, because some of the numbers duplicated those that had been used in the 1985 report (for algorithms not implemented), it seemed simplest to keep the new numbering and omit the algorithms that were never implemented. One algorithm, Turbulence, is no longer an operational algorithm and so has been removed while another algorithm, Clutter Removal, is new for Build 10. Velocity Dealiasing is included in this report as an algorithm because of its importance to the success of the velocity-based algorithms. However, it has no number assigned to it. Finally, we have included descriptions of some product generation algorithms such as Cross-Section and Weak Echo Region. These, too, have no numbers assigned. The source for the descriptions of Velocity Dealiasing and product generation algorithms are the Computer Product Development Specification for Build 10 (in draft). The Applications Branch invites comments about the usefulness of this report. Comments may be directed to the e-mail address listed below.

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1. INTRODUCTION

The automation of meteorological and hydrological analyses is a NEXRAD Program requirement for the WSR-88D System and must provide the principal users in the Departments of Commerce, Defense, and Transportation with rapid and reliable identification of significant weather phenomena. This identification must be automated to the maximum extent possible and be consistent with the objectives of high probability of detection and low false alarm rate. While this report describes the current suite of WSR-88D meteorological (and related) algorithms, during the life of the WSR-88D system (from acquisition through operational use), the Government expects to modify the algorithms and to develop new algorithms.

The WSR-88D System is migrating to a new open systems processing environment that the Government expects will accelerate the development of new algorithms. In this way the Government expects the WSR-88D System to keep pace with future advancements in the processing of weather radar data. It is essential that all of the WSR-88D algorithms be reviewed and tested for both scientific validity and operational utility. The purpose of this report is to give the algorithms a wider audience for testing.

1.2 Background

During the initial deployment of the WSR-88D system the Government determined that the meteorological and hydrological analysis techniques necessary were only available within the Government. Thus, the Government assumed responsibility for providing those meteorological and hydrological algorithms. The algorithms were documented in a standardized format based on the Documentation Standards Handbook (DSH). This approach defines the algorithms in functional terms and removes implementation dependencies that result from certain configurations or programmer biases. This approach results in

- System flexibility,
- System growth capability, and
- A modular design.

These characteristics are essential to the usefulness and life of the system.

All the algorithms came from techniques originating in research and development programs. The documentation process produced a functional specification which provides the scientific requirements free of any implementation-dependent details. The link between the meteorologists and hydrologists and the systems analysts and computer scientists is provided by the DSH procedures. The DSH provides a communication link by enabling both of these groups to "speak the same language," i.e., both groups understand the logic and application of the algorithms.

1.3 Implementation Considerations

1.3.1 Documentation Conventions

Although the intent is to document the WSR-88D algorithms in a PDL that is transparent to the implementation, it is not possible to do this in all cases. In order to document the algorithms, certain conventions are required to consistently and logically describe the processing. These conventions are not necessarily desirable in a specific algorithm implementation. For example, a coordinate system must be selected before trigonometric calculations can be specified; however, the calculations could be done equally well in another coordinate system if correctly transformed. As long as the display outputs are correct, internal calculations may be modified for speed or efficiency. While some uncertainties remain in some algorithms, the information available should be sufficient to ensure successful implementation of the selected algorithms.

Other algorithm documentation conventions include:

a. Volume scans are described as being processed in sequence from the bottom up, with clockwise antenna rotation.

b. Many algorithms are described in terms of specific numbers or sizes of sample volumes as a unit of computation. These require adjustment to the sampling parameters of the selected radar.

c. Algorithm output resolution sometimes reflects either an initial implementation or an arbitrary choice. These may require adjustment for the selected display product.

d. Data quality checks may be indicated with the algorithm, particularly if the algorithm is sensitive to certain data errors. The data quality check may be implemented either as part of the algorithm or in previous processing.

e. Data units were selected somewhat arbitrarily, and are not necessarily optimal for final output and/or display.

f. Processing steps and equations are listed in logical order, not optimized for real-time processing.

g. Equations have not been combined or analytically solved for optimum processing.

h. Outbound Doppler velocities are designated as positive.

i. In algorithms using arc tangent, the computations are to be made such that the resultant angles are placed in the quadrant consistent with the signs of the numerator and denominator.

j. The INPUT IDENTIFICATION and COMPUTATION NOTATION sections of each algorithm specify the precision to which internal computations shall be carried. For example, the statement, "Precise to 10^{-3} radians.", means 1.24568... may be rounded up to 1.246 for use in internal computations. The intent of the precision statements is that none of the accuracy required in the NTR be lost due to rounding errors. Consequently, precisions are stated one decimal place finer than measurement accuracy.

1.4 Data Quality Control

Many of the algorithms contain specific data quality checks. As noted under Implementation considerations, these may alternatively be done in pre-processing. For other algorithms, explicit quality checks are not listed, but accurate base data are required for proper algorithm performance. For example, the MESOCYCLONE DETECTION (002) algorithm requires that range and velocity folding be removed from base velocity data before it operates on the data. Testing has shown that velocity aliasing can severely degrade the performance of this algorithm.

Although the net effect is not usually as dramatic with reflectivity contamination, certain algorithms suffer from ground clutter and anomalous point returns. For example, return from an aircraft in a moderate shower will cause a false high maximum reflectivity value to be assigned. For the Precipitation (017-021) algorithms, reflectivity accuracy is extremely critical. In the event that pre-processing does not properly control the base data quality, additional processing steps may be needed within an algorithm.

1.5 Future Algorithm Development and Implementation

The Government is in the process of migrating its Radar Product Generator (RPG) software from a monolithic computer to an open systems environment. The new open platform offers the opportunity to introduce new and improved algorithms more quickly into the WSR-88D system. One such vehicle to facilitate to speed up the "pipeline" process is the Common Operations and Development Environment known by its acronym CODE. As mentioned earlier, the Government provided the initial set of algorithms that were developed by government agencies and federally funded research and development facilities. Currently, many NWS forecast offices, universities and DoD organizations conduct algorithm testing through off-line post-event studies using the WSR-88D Algorithm Testing and Display System (WATADS) and Level II archive data. By contrast, CODE is intended to provide a programming infrastructure at two different levels: the Application Programming Interface (API) and the Visual Programming Tool (VPT). The object of both approaches is to allow an algorithm developer access to the same data in real time that will be available to the ORPG in a safe, non-interfering manner. The linked paper "The Use of CODE (Common Operations and Development Environment) at the WSR-88D Operational Support Facility" by Anderson White, William J. Armstrong, and J. T. Johnson provides a more comprehensive overview of CODE and lists other references. It is provided as an appendix to this report.

1.6 References

Computer Program Development Specification, (B5) CPCI-03, Radar Product Generation (Build 10.0), in draft.

Next Generation Weather Radar Algorithm Report, December 1985.

White, Anderson, William J. Armstrong, and J. T. Johnson, 1999: The use of CODE (Common Operations and Development Environment) at the WSR-88D Operational Support Facility. Preprints, *29th Conf. on Radar Meteorology*, Montreal, Quebec, Amer. Meteor. Soc.