WSR-88D Tropical Cyclone Operations Plan

05/14/2012 Build *12* Systems *With Dual Polarization*

NOTE

For assistance with this Operations Plan at any time, call the WSR-88D Field Support Hotline.

- This plan is designed to be used as an *operational reference*. Although the basic plan as presented here has been shown to be effective in many tropical cyclone events, local modifications to the plan can and should be made as required. Be sure to consult with your local Unit Radar Committee (URC) in advance concerning any changes which result in system wide modifications. Pre-hurricane URC agreements will allow changes to be made operationally as needs arise.

- Colors are used for specific purposes in this document. **Blue** is used to indicate a hyperlink or an alphanumeric value entered in an adaptation data menu. The hyperlinks can link to a different location in this document, to an e-mail address, or to an Internet address. **Red** is for a menu or menu selection.

  There are two types of NOTES in this document. A **Green** font **NOTE** is an informational note. A box with a **Yellow** background is for a ***very*** special note, generally for operational guidance.

  Purple or **brown** is occasionally used to make individual words stand out.

- **Build 12 for Dual Polarization systems does not have Clutter Mitigation Decision (CMD) software. Therefore, instead of having ground clutter identified dynamically (i.e., automatically with each volume scan), Dual Pol Build 12 reverts to relying on Clutter Suppression Regions or a static Bypass Map, which may often result in undersuppression or oversuppression. This is discussed in procedure 3.**

- Perhaps the most important part of this plan is to **ensure that the velocity increment** (0.97 kt or 1.94 kt) **is appropriate** for the anticipated maximum velocities.

- Other important parts of this plan for both Class 1 (associated) users and Class 2 (non-associated) users (e.g., the National Hurricane Center, NHC) are the availability of the **256-data level Velocity** products at multiple elevation angles

and availability of **Super Resolution** (SR) base products (i.e., ones with 0.5 degree azimuthal resolution). SR reflectivity can be displayed to 460 km (248 nm), while SR velocity and spectrum width are displayed to 300 km (162 nm). SR only applies to split cuts (i.e., elevation angles at and below 2.5° for VCP 31 and below 1.65 degrees in all other VCPs).

- Dual Polarization (DP) variables provide information for new algorithms, particularly the Melting Layer Detection Algorithm (MLDA), the Hydrometeor Classification Algorithm (HCA), and the Quantitative Precipitation Estimation (QPE) algorithm. Operators should be familiar with these algorithms, as well as DP base data products, through training material from the Warning Decision Training Branch: (http://www.wdtb.noaa.gov/courses/dualpol/index.html listing several DP courses).

NOTE

While temporary additions of Generation List products and changes to adaptable parameters can be made on-site, each time the RPG is rebooted or the VCP/weather mode is changed, the edited Generation List and adaptable parameters will be replaced with the baseline versions. Therefore, it is suggested that you record these changes manually or backup your local "default" Generation List and adaptable parameters before implementing any changes and document all changes that are made. The "Adaptation Data Backup" procedure for Build 12 is in EHB 6-520 Table 4-34. (The Build 12 version of this document can be accessed through the Radar Operations Center Web site http://www.roc.noaa.gov/WSR88D/Program/MaintenanceManuals.aspx.)

- Whenever there are major operational changes (resetting precipitation accumulations, changing algorithm adaptable parameters, such as Z/R relationship, changing the velocity measurement increment, etc.), ***issue a Free Text Message (FTM)*** to notify neighboring offices, national forecast centers, and River Forecast Centers of your changes.

NOTE

Execute procedures 1, 2, and 3 (below) before doing any other procedures. Nearly every procedure (or section) of this document assumes that the system is already in precipitation mode and will remain that way until the tropical cyclone event ends.

- After the tropical cyclone threat has passed, return all parameters back to their

proper or "default" values. The "**Restore Adaptation Data**" procedure is in the Build 12 EHB 6-520 Table 4-35. ***Keep this information near the MSCF in case the data need to be restored.*** If you are entering the data manually, refer to the Build 12 version of "*WSR-88D Guidance on Adaptable Parameters Handbook, Volume 1, RPG"* for system-wide defaults and your own notes for your site-specific ones. The Guidance on Adaptable Parameters can be accessed at http://www.roc.noaa.gov/WSR88D/Program/OperationsManuals.aspx (which requires a security log-in). Select: 1 November 2010 Change 1.

- All recommended adaptable parameter changes in this Plan are performed by the WFO using the URC level of change authority. If the URC-level password is required in any of the procedures, click on the padlock button in the upper right corner of the window; in the password pop-up window, select the **URC** radio button, type in the password, and then press the ***<Enter>*** key. There are no commands requiring Agency- or ROC-level passwords in this document.

- This Tropical Cyclone Operations Plan has been designed for sites that have Build **12** software ***with*** *Dual Polarization enabled*. If there is a question about the RPG software build being used, check with your maintenance technicians or go to https://www.roc.noaa.gov/ops/build.asp. (Access to this site may be restricted.)

- For questions or comments that need an immediate response, contact the WSR-88D Hotline (nexrad.hotline@noaa.gov) at the Radar Operations Center (ROC). Other questions about this document can be addressed to Stacy.R.Stewart@noaa.gov and Wallace.A.Hogsett@noaa.gov (National Hurricane Center) and Daniel.S.Berkowitz@noaa.gov (ROC).

Here is a brief summary of the recommended procedures in this document:

The {Return to Contents ⮭} hypertext link has been added for your convenience after each procedure to enable a quick return to this Table of Contents.

A. At the WSR-88D RPG Human Computer Interface (HCI):

NOTE

All procedures for the RPG HCI in sections 1-9 (below) begin from the HCI Main Menu, the RPG Control/Status window, and may require the URC-level password.

1. Generator Fuel

At least two days prior to the onset of tropical cyclone rain bands, ensure that the RDA emergency power generator fuel level is maximized. It may be several days, or even weeks, before commercial power is restored in the aftermath of a significant tropical cyclone, and fuel delivery will likely be delayed. To check the fuel level:

- On the right side of the HCI, in the Applications column, select RDA Performance Data, then select the Tower/Utilities tab.
(Check % of **Generator Fuel Level** in the Power group and order fuel as deemed necessary.) If the generator is the current RDA site power source, the icon to the left of the RPG HCI's RDA icon will indicate "**Gen On**" or "**Util Avail**" and will include an illustration of a fuel tank; the fuel level is indicated within this fuel tank illustration.
{Return to Contents ⮭}

2. Reinitializing Memory and Precipitation Accumulations

2a. A restart of the RPG should be done prior to onset of the tropical cyclone.

At the HCI, click on Control in the RPG icon and a menu window will appear.
- In the RPG Control window, click Shutdown.
- Click Yes in the warning popup window to confirm your Shutdown command.
- Wait for the State (at the top of the RPG Control window) to show "SHUTDOWN."
- Unlock the Initialization Control menu portion of this window using the URC password.
- Select Product Database in the State Data group under Initialization Control.
- Select Startup under Software near the top of the RPG Control window.
- Confirm the Startup command.
- Close the RPG Control window.

Alternatively, you can do a "clean" RPG startup, but read the following NOTE first.

NOTE

If changes are made to adaptation data without doing a Backup Adaptation Data afterwards, performing a Clean Startup will erase the unsaved adaptation data from the system.

- At the HCI, click on Control in the RPG icon and a menu window will appear.
- In the RPG Control window, click Shutdown.
- Click Yes in the warning popup window to confirm your Shutdown command.
- Wait for the State (at the top of the RPG Control window) to show "SHUTDOWN."
- Unlock the Initialization Control menu portion of this window using the URC password.
- Select Clean Startup under Software near the top of the RPG Control window.
- Confirm the Startup command.
- Close the RPG Control window.

{Return to Contents ⬆}

2b. Reset both Dual Pol and legacy PPS precipitation products to begin accumulating rainfall at the onset of the tropical event, preferably at 1200Z (although 1800Z, 0000Z, and 0600Z would be good alternate times). Coordinate this and any other changes affecting precipitation accumulations with your Service Hydrologist and River Forecast Center. To accomplish this, certain buffers used by precipitation processing need to be reinitialized.

NOTE

You can reinitialize rainfall accumulations without shutting down the RPG.

To reset rainfall accumulations *only*:

- At the HCI, click on Control in the RPG icon, and a menu will appear.
- Ensure the RPG State is OPERATE, STANDBY, or SHUTDOWN.
- Unlock the Initialization Control menu portion of this window using the URC password.
- Select Legacy PPS (excludes USP Database).
- Select Dual-Pol QPE (excludes DUA Database).
- Click on Activate and confirm this command in the warning popup window.
- Close the RPG Control window.

{Return to Contents ⬆}

2c. Ensure the parameters for starting and ending accumulations have been set to reasonable numbers.

NOTE

The "Reflectivity (dBZ) Representing Significant Rain" (RAINZ) should be left at the default value of 20.0 dBZ, considered to be the lowest dBZ for liquid precipitable reflectivity. "Rain Area Threshold" (RAINA) should be the normal area of non-meteorological residual reflectivity of at least 20 dBZ (i.e., RAINZ) after proper clutter suppression has been done. An appropriate setting for RAINA should be determined locally during fair weather. Use the value for Significant Rain Area Detected in the Precipitation Status window as a guide. (This is the value being used by the Precipitation Processing Subsystem, as reflected in the AWIPS Supplementary Precipitation Data (SPD) alphanumeric product, WSRSPDxxx, where xxx is the three-letter radar identifier.) This RAINA value can be applied to the Precipitation Accumulation Initiation Function (PAIF) for DP QPE, too, as the PAIF Area Threshold.

- Select the box to the right of Precip Status: (below the USERS icon).
- Read and record the value from the Precipitation Status window for Significant Rain Area Detected.
- Click on Modify Parameters.
- Unlock this screen using the URC password.
- Set Reflectivity (dBZ) Representing Significant Rain [RAINZ] to **20.0** dBZ.
- Set Area with Reflectivity Exceeding Significant Rain Threshold [RAINA] to a value (probably ***greater than*** **80** km^2) that is typical for the non-precipitation residual clutter area for your site (i.e., not eliminated from base reflectivity by clutter suppression in procedure 3 below). The value you recorded for Significant Rain Area Detected can be your guide for RAINA if precipitation has not yet been detected.
- Click on Save and then Yes to confirm the Save command.
- Select Adaptation Item: Dual-Pol Precip from the drop-down menu.
- If the screen is locked again, unlock the padlock with the URC radio button and password.
- Set PAIF Area Threshold to the same value as RAINA (described above).
- Set PAIF Rate Threshold to 0.5 mm/hr. (Until further research has been done and guidance has been issued to field sites, this should remain the default value. The PAIF Area Threshold also may be adjusted after further research.)
- Close the Algorithms (Adaptation Item: Dual-Pol Precip) screen.
- Close the Precipitation Status window.

{Return to Contents ⬆}

3. Clutter Suppression

Use "Bypass Map" whenever possible. This will improve rainfall estimates and overall algorithm performance. Compare base reflectivity with the Clutter Likelihood of Reflectivity (CLR) and the Hydrometeor Classification Algorithm (HCA) products to see where anomalous propagation (AP) ground returns have been identified. If significant clutter or AP becomes apparent in the CLR or HCA products or base data products (reflectivity, velocity, and spectrum width), change to a Clutter Suppression Region (CSR) file that has forced suppression in the region(s) of concern. (Note that **Clutter Suppression Regions affect nearly *all* products.**)

NOTE

Refrain from using "All Bins" suppression everywhere, because it will often result in excessive suppression along the zero isodop. Never use "All Bins" in the 200-series VCPs, in VCP 121, nor at batch cut elevation angles (i.e., those from 1.65° to 6.45°) of the other (i.e., legacy) VCPs except 31 (which does not use batch processing)**.**

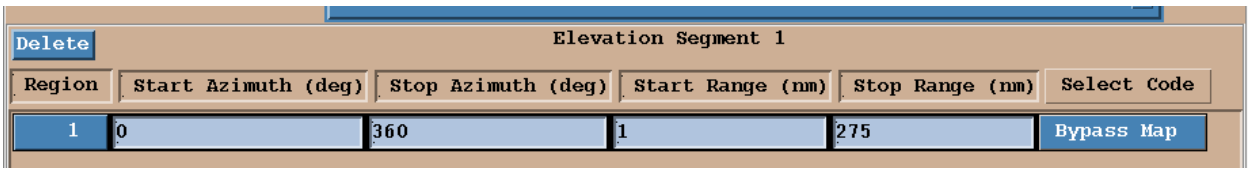
3a. Setting Up a Minimal Clutter Suppression Region (CSR)

If you need to "build" (then download) a minimal CSR, the following commands will produce one with the Bypass Map in control which applies suppression to known ground targets.

-On the right side of the HCI (the Applications column), select Clutter Regions.
- Select File.
- Select New.
- Select the Segment: 1 (Elevation Segment One) button and edit the table to agree with the one below.
- Select each of the higher elevation segments as applicable for your site, and do the same editing.
- Select Save As, give this file a name (e.g., "Minimum"), and click Accept button.
- Select Close for the Clutter Region Files.
- Select Download in the main Clutter Regions window.
- Confirm changes and Close.

Example of Clutter Suppression Definition

With Bypass Map in Control



{Return to Contents ⬆}

3b. Selecting an Existing Clutter Suppression Region File

- On the right side of the HCI (the Applications column), select Clutter Regions.
- Select File, then click on Minimum (assuming clutter suppression region file "Minimum" is a pre-built minimal suppression file)**.** (Substitute for "Minimum" the name or number of the equivalent file at your site.)
- Click on the Open button to open the selected file.
- Close the Clutter Region Files window. The selected file should now be displayed.
- Download, confirm download, and Close the main Clutter Regions window.

NOTE

If a set of clutter suppression regions has been invoked to reduce ground returns from anomalous propagation (AP), check this frequently to determine when minimum suppression can be used.

Refer to Section 3.8 in manual EHB 6-521 (Operations Instructions, Radar Product Generator (RPG) Refresh (LINUX)) for Build 12 software for more details on Clutter Regions and how to invoke or download them. (The Build 12 version of this document can be accessed through the Radar Operations Center Web site, http://www.roc.noaa.gov/WSR88D/Program/OperationsManuals.aspx .)
{Return to Contents ⬆}

4. Mode and Volume Coverage Pattern (VCP) Selection

4a. Mode Selection Function

The Mode Selection Function (MSF) uses computed reflectivity area above a specified threshold to determine when a system can automatically switch to/from Precipitation Mode and to/from Clear Air Mode. In order to ensure that automatic MSF selections don't override the VCP you have selected, put the Precipitation Switching and Clear Air Switching selections in ***Manual***.

- Select Control in the RDA icon on the HCI.
- Select VCP and Mode Control in the RDA Control/Status window.
- Select the Manual buttons under both Clear Air Switching and Precipitation Switching.
- Select the View/Edit button under Mode Automation Status.
- Select the Modify Parameters button.
- Unlock the padlock with the URC radio button and password.

- Select Yes in the "Ignore Mode Conflict Duration?" line.
- Select Save.
- Confirm this selection and Close this window.
- Close the Mode Automation Status window.
- Close the VCP and Mode Control window.
- Close the RDA Control/Status window.
{Return to Contents ⬆}

4b. VCP Selection

The four main considerations in VCP selection are (1.) the ***range*** from the radar to the center of the tropical cyclone, (2.) the location (with respect to the radar) of ***structural regions*** of the tropical cyclone, (3.) frequency of volume updates, and (4.) velocity dealiasing errors, either apparent inbound velocities where outbound should be (or vice-versa) or discontinuities that don't make sense meteorologically.

VCPs 121, 211, 212, and 221 are designed to reduce range-folded Doppler data (or "purple haze"), which is often a major problem in tropical cyclones. A reduction in range-folding results in more velocity coverage, which allows better visual pattern recognition and better performance of algorithms based on velocity (such as mesocyclone detection, tornadic vortex detection, and clutter likelihood, which is used in precipitation processing).

Structural regions include the fair weather **eye** region, the convective **eyewall**, the convective **spiral bands**, the rather stratiform rainfall outside the eyewall and between spiral bands (sometimes called a "**moat**"), pre-hurricane **squall lines**, and the cirrus **outflow**. The spiral rain bands are particularly important, because they may include smaller circulations that could produce tornadoes or other damaging winds. A good vertical resolution is often very useful when examining these regions. Using a VCP with 14 tilts (such as 211 or 212) may be very advantageous.

Frequent updates (i.e., a short time to complete a volume scan) may sacrifice data quality when the antenna rotates very rapidly. Short volume times may be desirable when monitoring severe events (e.g., tornadic circulations) within a tropical cyclone over land. In general, more frequent volumes (shorter times) are desired when the center of the tropical cyclone is close to the radar. VCPs 212 and 12 are good choices to use.

Velocity dealiasing failures can be a serious problem where there are large gaps between rain bands, and the dealiasing failures may obscure detection of maximum winds in or near the eyewall. To mitigate velocity dealiasing failures, try VCPs 121, 211, 212, and 221 in that order. VCP 12 may require an operator to make frequent PRF changes. When both range folding and dealiasing errors are problematical, VCP 121 is the VCP of choice.

The following table summarizes the recommended VCPs with their limitations and

optimal usage in tropical cyclone events:

Tilts	VCP	Time*	Usage	Limitations
9	121	6 min.	Compared to other VCPs, this one significantly reduces range-obscured V/SW data within 230 km and is also useful when a tropical cyclone has a distant center or eye with no echoes near the radar. This should be the first choice for mitigating velocity dealiasing problems.	There are gaps in coverage above 5°. All Bins clutter suppression is NOT recommended. PRFs are not editable for any tilt.
9	221	6 min.	This reduces range-obscured V/SW data out to 300 km when compared to other VCPs. It is useful when a tropical cyclone has a distant center or eye. This should be the fourth choice for mitigating velocity dealiasing problems.	There are gaps in coverage above 5°. All Bins clutter suppression is NOT recommended. PRFs are not editable for SZ-2 (Split Cut) tilts, at 0.5° and 1.5°.
14	211	5 min.	This is useful when a tropical cyclone has a center or eye relatively close to the radar. It significantly reduces range-obscured V/SW data when compared to VCP 11. This should be the second choice for mitigating velocity dealiasing problems.	All Bins clutter suppression is NOT recommended. PRFs are not editable for SZ-2 (Split Cut) tilts, at 0.5° and 1.5°.
14	212	4⅔ min.	This has increased low-level vertical resolution compared to VCP 211. Significantly reduces range-obscured V/SW data when compared to VCP 12. This should be the third choice for mitigating velocity dealiasing problems.	All Bins clutter suppression is NOT recommended. PRFs are not editable for SZ-2 (Split Cut) tilts, at 0.5°, 0.9°, and 1.3°.
14	12	4⅓ min.	This VCP is good for detecting severe convective events (e.g., TVSs) particularly for tropical cyclones over land. Extra low elevation angles increase low-level vertical resolution when compared to VCP 11. It has the fastest update rate.	Range folding needs to be monitored, ensuring that velocities around the center or eye can be clearly determined. PRFs may need to be manually changed frequently.

* VCP update times are approximate.

For a more comprehensive overview of *all* VCPs, see Figure 3-12, the "Quick Reference VCP Comparison Table for RPG Operators" in EHB 6-521.

- Select Control in the RDA icon on the HCI.
- Select VCP and Mode Control in the RDA Control/Status window.
- Unlock the padlock with the URC radio button and password.
- Select "Download VCP from RPG": 121 (or **211** or **212** or **221**)
("remote" VCPs)
- Confirm and Close this window.

All VCPs have a default 0.97 kt velocity increment (or velocity resolution), which limits velocity measurements to +/- approximately 122 kt. To change the VELOCITY INCREMENT to display winds in excess of +/-122 kt, refer to procedure 6. (Procedure 8a describes how to change the velocity scales.) As a diagnostic (if you are not sure if

the velocity increment change has been made), note that the AWIPS D2D cursor readout will indicate speeds in tenths of a knot for the .97 increment and whole knots for the 1.94 increment.

NOTE

If you see "Pedestal Dynamic Fault" messages, contact your electronics maintenance technician.

{Return to Contents ⬆}

5. Manual Mitigation of Range Folding

RPG HCI operators have the ability to move the maximum unambiguous range (R_{max}) out to a maximum distance of **94 nm** or in to a minimum distance of **63 nm** by adjusting the PRF when allowed by the VCPs described in the above table. This *may* become necessary to improve velocity products (particularly near the center of the storm) as the tropical cyclone approaches.

Local VCPs 11 and 21 (i.e., ones stored at the RDA) are defined with R_{max} = 79 nm (PRF selection #5). To increase the unambiguous range to 94 nm (or another chosen range) in a VCP other than 121, 221, 211, or 212, refer to the procedure shown below. The "Download" command invokes a "Remote" VCP (i.e., ones stored in the RPG). Remote VCPs (such as VCP 12) are defined with PRF #4 (R_{max} = 94 nm) by default. When Auto PRF is Off, the default unambiguous range will remain at 94 nm for remote VCPs. The range/PRF can then be altered in order to see velocities around the center or eye of the storm.

NOTE

The NHC prefers the R_{max} with sufficient range to provide velocity data near the eye or center of a tropical depression, tropical storm, or hurricane. However, local needs may dictate otherwise and will take precedence. Therefore, a VCP with an operator-specified PRF (e.g., VCP 12) may need to be selected to mitigate range folding in a WFO's region of concern. VCP 121 does not use Auto PRF. VCPs 211, 212, and 221 only use Auto PRF in Batch Cut tilts (i.e., above the 1.65° elevation angle).

- Select Control in the HCI's RDA icon.
- Select VCP and Mode Control in the RDA Control/Status window.
- Toggle Auto PRF Off and confirm this action in the popup window.
- Under Download VCP from RPG, select 12 (with the selected PRF(s),

which can be specified for up to three different sectors)**.**
- Confirm this selection and Close this window.
{Return to Contents ⬆}

6. Velocity Increment for Extreme Wind Speeds

NHC recommends anticipating that velocities *may* exceed **122 kt** (Category 4 and 5 hurricanes) once hurricane-force winds have been observed at the surface. Therefore, increase the velocity increment from 0.97 kt to 1.94 kt ***prior*** to getting a forecast of a Category 3 major hurricane. Winds aloft are ***always*** greater than at the surface, and radar detects winds *aloft*.

The velocity color scale displayed with all 8-bit (256-data level) Velocity products on AWIPS is the same and *may be the same for both velocity increments*, making it hard to tell which velocity increment is being used. AWIPS D2D cursor sampling of velocity products will indicate speeds in tenths of a knot for velocity increments of 0.97 kt and ***in whole knots for velocity increments of 1.94 kt***.

NOTE

Ensure the velocity increment is the last change you make when modifying a VCP (i.e., in "Modify RPG VCP"). Otherwise, changes will be lost when a VCP change is made or the system is rebooted.

- Ensure Auto PRF is Off (as displayed in the information lines below the Users icon).
- Select Control in the HCI's RDA icon.
- Select VCP and Mode Control in the RDA Control/Status window.
- Unlock the padlock with the URC radio button and password.
- Select 221 (211, 212, 121, or other desired VCP number) on the "Precipitation:" line under "Download VCP from RPG."
- Confirm that you want to download this VCP.
- Click on the Modify RPG VCP button.
- Toggle Velocity Increment (top right) to 1.94 kts.
- Save this setting, Download it, confirm changes, and Close the RDA Control/Status window.
{Return to Contents ⬆}

7. Algorithm Adaptable Parameter Changes

NOTE

Procedures 7a through 7c will independently increase the radar's detection efficiency for small, shallow circulations typically found in tropical cyclones. Precipitation algorithm changes (procedures 7di and 7dii) will result in more realistic rainfall estimates during tropical weather situations.

7a. Mesocyclone Detection Algorithm Optimization

The Mesocyclone Detection Algorithm (MDA) produces a Meso Detection (MD, #141) product and a Meso Detection Data Array (DMD, #149) product. The strength rank of the mesocyclone circulation should be lowered to enable detection of weaker circulations within the tropical cyclone. Be aware that a greater number of false alarms may be generated. Detections must be within 20 km of a SCIT-identified cell, thus reducing some false alarms.

-From the RPG Products menu, choose Algorithms, then select Adaptation Item: MDA from the drop-down menu.
- Unlock the padlock with the URC radio button and password.
- Change Minimum Display Filter Rank value from 5 to 4 (or, possibly, 3).
- Save, confirm changes, and Close this menu.
{Return to Contents ⬆}

7b. Tornado Detection Algorithm Optimization

Parameters within the Tornado Detection Algorithm (TDA) should be changed to increase the probability of detecting weak or distant tornadoes; however, a greater number of false alarms will also be generated. For more information see Lee, R.R., E.D. Mitchell, 1999: Performance of the WSR-88D Build 10 Tornado Detection Algorithm - Development of Optimal Adaptable Parameter Sets. *Preprints, 15th International Conference on Interactive Information and Processing Systems (IIPS) for Meteorology, Oceanography, and Hydrology*, AMS (Boston), Dallas, TX, 318-321. Also, see Spratt, S. M., D. W. Sharp, P. Welsh, A. Sandrik, F. Alsheimer, and C. Paxton, 1997: A WSR-88D assessment of tropical cyclone outer rainband tornadoes. *Wea. Forecasting, **12**, 479-501.* Detections must be within 20 km of a SCIT-identified cell, thus reducing some false alarms. These settings are in the Build 12 Adaptable Parameters Handbook section 7.14.2.7 (Squall Line and Other Adaptable Parameter Set):

- From the RPG Products menu, choose Algorithms, then select Adaptation Item: Tornado Detection from the drop-down menu.

- Unlock the padlock with the URC radio button and password.
- Change Min 3D Feature Depth from 1.5 to 1.6.
- Change Min 3D Feat Low-Lvl Delta Vel from 25 to 27.
- Change Min TVS Delta Velocity from 36 to 27.
- Save, confirm changes, and Close this menu.
{Return to Contents ⬆}

7c. Velocity Azimuth Display (VAD) Algorithm

If the center of the tropical cyclone is very close to the radar, it is possible that the wind barbs in the VAD Wind Profile (VWP) may become sparsely populated due to the inability of the VAD algorithm to fit the detected winds into a uniform pattern of incoming and outgoing wind. This can be mitigated by reducing the "VAD optimum slant range" (as long as the center is not within a few kilometers of the radar site).

- From the RPG Products menu, choose Algorithms, then select Adaptation Item: VAD from the drop-down menu.
- Unlock the padlock with the URC radio button and password.
- Change VAD Analysis Slant Range from the default of 30.0 to 15.0 km or another value closer to the radar than the cyclone center.
- Save, confirm changes, and Close this menu.
{Return to Contents ⬆}

7d. Precipitation Estimate Optimization

Subsections i, ii, and iv refer to legacy Precipitation Processing Subsystem (PPS) radar rainfall estimation parameters, while subsection iii refers to the Dual Polarization QPE algorithm. Note that Exclusion Zone settings (ie., the number of zones and their dimensions) should be set in the **Dual-Pol Precip** menu just like the ones in the **Hydromet Preprocessing** menu.

i. Z/R Relationship

Change the default (convective) Z/R relationship ($300R^{1.4}$) to the tropical Z/R relationship (**$250R^{1.2}$**) to provide better precipitation estimates. As potential guidance for when to change to this relationship at CONUS sites, refer to the Vertical Profile of Reflectivity (VPR) as depicted in the National Mosaic & Multi-Sensor QPE (NMQ, http://nmq.ou.edu/) to locate radar sites having a tropical identification. A warm rain microphysical process (a persistent green in the Precipitation Flag window of NMQ's Mosaic3D Derived VPR map) is more likely to benefit from the tropical relationship.

Such sites are unlikely to be under the high-level outflow regions of a tropical cyclone. (See Xiaoyong Xu, Kenneth Howard, and Jian Zhang, 2008: An Automated Radar Technique for the Identification of Tropical Precipitation. *Journal of Hydrometeorology* **9**:5, 885-902.) *Changes in Z/R relationship should be coordinated with the River Forecast Centers (RFCs) that use data from your radar.* Switching to the tropical Z/R will increase the estimated precipitation accumulations, especially for higher reflectivities (i.e., in the 30-45 dBZ range).

NOTE

Closely monitor rainfall accumulations relative to ground truth observations. If the Z/R relationship is changed too far in advance of the tropical cyclone rainbands, the radar will overestimate totals associated with pre-landfall convection. Refer to the AWIPS text product, WSRSPDxxx (where xxx is the radar 3-letter identifier), to examine the bias table; pay particular attention to radar-gauge comparisons for periods up to 168 hours. Contact your River Forecast Center(s) for guidance.

- From the RPG Products menu, choose Algorithms, then select Adaptation Item: Hydromet Rate from the drop-down menu.
- Unlock the padlock with the URC radio button and password.
- Set Z-R Multiplier Coef. [CZM] from the current setting to 250.
- Set Z-R Exponent Coef. [CZP] from the current setting to 1.2.
- Continue to the next step.
{Return to Contents ⬆}

ii. MXPRA (Maximum Precipitation Rate Threshold)

MXPRA should be increased to allow for greater rain rates. A MXPRA of **150** mm/hr (**5.9** in/hr) should be sufficient during most tropical cyclone situations. [The ROC recommends that the MXPRA ***never*** be set higher than 200 mm/hr (7.9 in/hr).] If the MXPRA is not adjusted, the default value will only allow for a maximum rate of **103.8** mm/hr (**4.1** in/hr). See the Build 12 Guidance on Adaptable Parameters (WSR-88D Handbook, Volume 1, RPG), section 7.7.1, for more information.

- From the RPG Products menu, choose Algorithms, then select Adaptation Item: Hydromet Rate from the drop-down menu.
- Unlock the padlock with the URC radio button and password.
- Set Max Precipitation Rate [MXPRA] to a value between 150 mm/hr (5.9 in/hr) and 200 mm/hr (7.9 in/hr).
- Save, confirm changes, and Close this menu and the RPG Products menu.
{Return to Contents ⬆}

iii. Dual Pol Maximum Reflectivity

Maximum Reflectivity is intended to mitigate contamination by hail, which causes rainfall overestimation. Hail is very rare in tropical cyclones, due mainly to the freezing level being higher than in most subtropical weather systems. The commonly accepted threshold for reflectivity (above which hail detection is likely) is 53 dBZ. The DP QPE parameter MAX REFLECTIVITY can be found in the **WSRSTAxxx** AWIPS text product, along with selected parameters for this and other DP algorithm products.

- From the RPG Products menu, choose Algorithms, then select Adaptation Item: Dual-Pol Precip from the drop-down menu.
- Unlock the padlock with the URC radio button and password.
- Set Maximum Reflectivity to 53.0 dBZ.
- Save, confirm changes, and Close this menu and the RPG Products menu.
{Return to Contents ⬆}

iv. Checking Precipitation Processing Adaptable Parameters

In order to confirm which Z/R relationship is being used, read the REFLECT-TO-PRECIP RATE CONVERSION MULTIPLICATIVE COEFFICIENT and REFLECT-TO-PRECIP RATE CONVERSION POWER COEFFICIENT in paired alphanumeric data with the One-Hour Precipitation (**WSROHPxxx** in an AWIPS text window, where xxx is the three-letter radar identifier). MAX PRECIPITATION RATE can be found near the bottom of the same list of parameters.
{Return to Contents ⬆}

7e. Melting Layer Detection Algorithm (MLDA) Heights

The MLDA attempts to determine the height of the melting layer (as wet snow) using elevations from 4.0 through 10.0 degrees. This melting layer information is needed for the Hydrometeor Classification Algorithm (HCA), which, in turn, is a major input to the DP QPE algorithm. The melting layer is typically higher in tropical cyclones than in subtropical systems.

- From the RPG Products menu, choose Algorithms, then select Adaptation Item: MLDA from the drop-down menu.
- Unlock the padlock with the URC radio button and password.
- Set Use MLDA Heights to Yes. (If the storm is so distant that no echoes are detected by elevation angles above 4.0 degrees, the Environmental Data will be used. See the next paragraph for that setting.)
- Save, confirm changes, and Close this menu and the RPG Products menu.

Most NWS Forecast Offices have access to computer model data via AWIPS. Such data are nearly always better (more up to date) than data input by an operator.

- On the right side of the HCI, in the Applications column, select the Environmental Data icon.

- In the Environmental Data Editor, ensure Model Update is On.

In the absence of RUC/RapidRefresh model input, the **Data Entry** button must be selected and a value for **Height 0 C (0-70 kft MSL)** would be entered, generally from a local or interpolated sounding.

- Click on the Close button and, if prompted by a "Warning Popup," confirm the setting by clicking on Yes.

{Return to Contents ⬆}

8. Selectable Product Parameters

8a. Velocity Data Display Levels

Display of 16- and 256-data level Velocity products should be optimized for the current event according to URC policies and procedures.

NOTE

If the "Backup Adaptation Data" procedure was not followed, record values currently being used before making changes. These will be needed after the storm passes.

i. 16-Level Products

Velocity data (display) levels for the 16-data level products can be set to display hurricane force winds. Note the default settings for the 16-data level Velocity products display a maximum of 64 kt, the minimum speed for a Category 1 hurricane. Begin with the suggested values, then adjust accordingly during the event to best display the maximum winds near the eye or center of the tropical cyclone.

Note that the threshold for a Category 2 hurricane is 83 knots, Category 3 is 96 knots, Category 4 is 113 knots, and (only seen with a 1.94 knot velocity increment) Category 5 is 137 knots. The Saffir-Simpson scale (summarized above) refers to winds measured 10 meters above the ground, not at the elevation of radar returns. Nevertheless, these speeds can draw your attention to locations with significant velocities. Alternative 16-level Velocity values could be 35, 65, 85, 100, 115, and 135 knots for Codes 10-15, respectively.

- Select Products in the HCI's RPG icon.
- From the RPG Products menu, choose Selectable Parameters, then select Category: Velocity Data Levels.
- Unlock the Edit Selectable Product Parameters screen using the URC password.
- Select Velocity Table Precip 16 / 0.97 (for the lower velocity increment).
- Change Code 15 to 100 or other desired number and then set the lower Code numbers to the desired speeds.
- Select Velocity Table Precip 16 / 1.94 (for the higher velocity increment).
- Change Code 15 to 137 or other desired number and then set the lower Code numbers to the desired speeds.
- Save the settings and confirm changes.
- Close the Velocity Data levels and Selectable Parameters windows.
{Return to Contents ⬆}

ii. 256-Level Products

The velocity color scale displayed with all 8-bit (256-data level) Velocity products on AWIPS is the same and *may be the same for both velocity increments*, making it hard to tell which velocity increment is being used. AWIPS D2D cursor sampling of velocity products will indicate speeds in tenths of a knot for velocity increments of 0.97 kt and ***in whole knots for velocity increments of 1.94 kt***. You can also view the scale on a 4-bit (16-level) Velocity product to confirm which velocity increment is being used. Edit the 256-level Velocity color scale on AWIPS D2D for radial velocities that exceed 100 knots (inbound or outbound) to improve the visibility of selected velocities (such as 113 kt and, at the 1.94 kt increment, 137 kt).

NOTE

The display levels of Storm Relative Mean Radial Velocity products (SRM and SRR) will probably differ from those used for Base Velocity.
{Return to Contents ⬆}

8b. Super Resolution (SR) Products

SR Reflectivity products (with a range resolution of 0.25 km and azimuthal resolution of 0.5 degree) can be displayed out to 460 km (248 nm) in the low elevation split cuts. SR Velocity products with the same resolution as SR Reflectivity can be displayed out to 300 km (162 nm). Both types of products are displayed with 256 data levels. As stated in EHB 6-521, "The finer spatial sampling of this high resolution base data may improve the identification of small or weak mesocyclones and Tornado Vortex Signatures (TVS's)." Only the split cuts are processed for SR, which is defined by azimuthal resolution. VCP 31 (long pulse) data are processed to display as though it has 0.25 km range resolution (although every pair of range bins has the same value), and its split

cuts are at and below 2.5°. All other VCPs (short pulse) have the actual 0.25 km range resolution in their split cuts (below 1.65 degrees). The only algorithm currently using SR data is the Mesocyclone Detection Algorithm. Strictly speaking, enabling Super Resolution is not a selectable product parameter but, instead, a change in the data stream from the RDA to the RPG. ***SR is enabled by default.*** If it is *not* enabled, follow these steps:

- Select the box to the right of Super Res: (in the stack below the USERS icon).
- Toggle the setting from DISABLED to ENABLED.

NOTE

There are two indicators on the RPG HCI to show if SR is enabled during the low elevation split cuts: in the text string grouping below the USERS icon and in the radome, directly under the elevation readout. In addition, the system status log (opened from Status in the RPG icon) will display "SR" at the far right of the status line for each volume scan.

SR products are available by One-Time Requests (OTRs) or Radar Multiple Requests (RMRs) from a non-associated AWIPS.

{Return to Contents ⬆}

8c. Precipitation Product Display Levels

Adjust precipitation data display levels if the potential for extremely heavy rainfall exists. [Maximum displayable values are 12.7 inches for One Hour Precipitation (OHP), Three Hour Precipitation (THP), and DP One Hour Accumulation (OHA) and 25.4 inches for Storm Total Precipitation (STP) and 4-bit DP Storm Total Accumulation (STA). User Selectable Precipitation (USP) uses the OHP/THP, OHA Data Levels unless the maximum value exceeds the level set for code 16 in that scale, in which case it uses the STP, STA Data Levels scale.]

- Select Products in the HCI's RPG icon.
- From the RPG Products menu, choose Selectable Parameters, then select Category: OHP/THP, OHA Data Levels.
- Unlock the Edit Selectable Product Parameters screen using the URC password.
- Change Codes 3 through 16 as desired for the current event.
- Save and confirm changes.
- Select Category: STP, STA Data Levels.
- Change Codes 3 through 16 as desired for the current event.

- Save, confirm changes, and Close.

NOTE

The data levels for 8-bit (256-data level) legacy storm total precipitation (DSP), one-hour DP Digital Accumulation Array (DAA), Digital User-Selectable Accumulation (DUA), and DP Digital Storm Total Accumulation (DSA) are scalable, levels set based on the maximum accumulation observed. Unlike the 4-bit (16-data level) OHP, THP, OHA, STP, and STA products, these levels are not user-adaptable.

{Return to Contents ⬆}

9. Archive Level II

Sites sending NWS, DoD, or FAA radar data to the NWS Level II Data Collection and Distribution Network need to ensure that the Local Data Manager (LDM) connection to the RPG is working properly. The status can be checked by going to http://weather.noaa.gov/monitor/radar2/ to see how current (or latent) the Level II data are. NWS sites are responsible for sending data from DoD or FAA sites they control and that disseminate Level II data (within the limitations of their communications lines).

The system status log (opened from **Status** in the RPG icon) will display "L2: 6 DP SR" in Build 12 (*with* Dual Polarization) at the far right of the status line for each volume scan when *both* Super Resolution (SR) and Dual Pol. data are being transmitted through Archive Level II (which is the default for most WSR-88D systems). In Build 12 Adaptable Parameters Handbook Chapter 7.2, SR is described as "full resolution" as opposed to "recombined." If SR data dissemination needs to be enabled (unless communications bandwidth from DoD or FAA radars do not permit it),

- Select Products in the HCI's RPG icon.
- From the RPG Products menu, menu, choose Algorithms, then select Adaptation Item: Archive II from the drop-down menu.
- Unlock the padlock with the URC radio button and password.
- There is only one parameter that can be changed in this menu. Select 6 (the default for Dual Pol. with SR data in Archive II).
- Save, confirm changes, and Close this menu.

{Return to Contents ⬆}

B. AWIPS Preparation (at an AWIPS D-2D Workstation):

10. AWIPS Severe Weather Checklist

The "health" of AWIPS systems at the WFOs is integral to radar data availability and re-distribution to the rest of the NWS. All offices in the forecast path of an approaching landfalling tropical system are asked to additionally review the AWIPS "OB9 check list for improved system performance during severe weather **4/28/10"** at: https://www.ops1.nws.noaa.gov/Secure/awips_install.htm.
{Return to Contents ⬆}

11. Data Archiving

Ensure that the Product Archiver is running for the tropical event. Left click on the graphics monitor background, select "Data Archiver," and then select "Data to Archive" or "Data to Store" and ensure appropriate products are listed.
{Return to Contents ⬆}

12. Data Requests from Adjacent Radars

Initiate "radar multiple requests" (RMRs) to adjacent radar sites for products not centrally collected nor available via SBN (procedure 14). (Refer to http://www.nws.noaa.gov/tg/noaaport_radar_products.pdf or the AWIPS OB9 System Managers Manual Tables 7.6.2 and 7.6.3 for these products.) Continuously monitor adjacent sites, since significant tropical cyclone phenomena are based in the lower levels, and the radar closest to the center will sample the environment best.
{Return to Contents ⬆}

13. Communications Backup

In advance of major land-falling tropical systems, the Radar Operations Center, Regional Focal Points, and the Office of Operational Systems will partner to evaluate and initiate preemptive telecommunication (telecom) solutions and backup scenarios as appropriate. At a minimum, our major telecom Providers will be asked to place a heightened watch on the telecoms they provide to the NWS and WSR-88D systems in the forecast path of any major land-falling tropical system.

Ensure you have printed out a copy of your latest AWIPS radar file help sheet and WSR-88D Communications Documentation. The radar file help sheets provide site-specific radar access information that could become critical information in the event default telecommunication systems become inoperative during a tropical event. Your WSR-88D Comms Documentation similarly provides telecoms information relating to your WFO's specific radar connectivity as well as the telecoms information relative to your NEXRAD tri-agency partners. Both sets of documentation are now maintained on a secure server at the ROC and ESAs at each office have been provided with the necessary information to access

those servers. Contact the WSR-88D Hotline for assistance if your ESA or technicians are not available to provide you with these documents or if they have trouble accessing either server.

Step 4 of the AWIPS Severe Weather Checklist, referenced in Step 10 above, includes the recommendation to test and verify "WAN Dedicated" backup capabilities. Your AWIPS radar file help sheet also provides guidance for WAN Dedicated operations in the section devoted to orpgBackups.txt. We cannot recommend strongly enough that this functionality be tested during benign weather and well in advance of any landfalling tropical system, as it requires pre-constructed and saved RPS Lists for each VCP for each WSR-88D to which your WFO may have access.

Along with the NWS transition to NOAAnet, WFOs deemed to be "high impact" or having problematic communications (as determined by NWS Regional HQs) have been provided with a method in the event the terrestrial NOAAnet AWIPS WAN fails. If your site has been so designated, your maintenance personnel should access the **System Modification Note 3, Revision A: NOAAnet VSAT Equipment Installation** under "NOAAnet" on NWS Headquarters' OPS1 home page (i.e., https://www.ops1.nws.noaa.gov/).
{Return to Contents ⬆}

14. Minimum RPS Lists

A set of suggested "minimum RPS Lists" was originally developed when RPS Lists were confined to only 20 products. However, the fundamental philosophy remains the same as operators interrogate tropical cyclones based on range from the radar and intensity.

NOTE

Ensure that your current WSR-88D RPS List on AWIPS includes the products on the lists shown below.

Storm Relative Mean Radial Velocity products (SRR, SRM) should be generated often via One-Time Requests (OTRs) or Radar Multiple Requests (RMRs) with individual or field motions **input frequently by the radar operator**. The algorithm that estimates storm motion may not be able to produce a useful motion on its own due to the rotational aspects of tropical cyclones.

If 8-bit (256-data level) velocity is on your RPS List, your AWIPS will generate an 8-bit SRM; change the motion parameters by selecting **Tools** and then **Radar Display Controls**. When that window appears, select **Custom Storm Motion** and use the slider bars to adjust the values as necessary or use **Storm Motion from WarnGen Track**. (The values provided by Storm Track Information (STI) may not be valid for the part of the storm that is of interest.) If the SRM was being displayed prior to these changes, clear the display and reselect the product; the new motion will now be applied.

{Return to Contents ⬆}

The following recommendations do not include products already on AWIPS National Datasets (prodList.txt). Recommended elevation angles are approximate, considering the angles available with various VCPs.

Minimum recommended RPS List: Center more than 124 nmi from radar

Product	***AWIPS Mnem.***	***RPG Code#***	***Data Levels***	***Range Resolution in km (nm)***	***Elevation Angle (degrees)***
Base Reflectivity	Z	20	16	**2** *(1.1)*	1.5
Super-Res. Reflectivity*	Z	153	256	**0.25** *(0.13)*	0.5
	Z	153	256	**0.25** *(0.13)*	1.5
Super-Res. Velocity*	V	154	256	**0.25** *(0.13)*	0.5
	V	154	256	**0.25** *(0.13)*	1.5

- **Super Resolution (SR) needs to be activated. (See Section 8b.) High resolution products (codes 94 and 99) can be replaced by SR products (codes 153 and 154).**

Minimum recommended RPS List: Center 62-124 nmi from radar

Product	***AWIPS Mnem.***	***RPG Code#***	***Data Levels***	***Range Resolution in km (nm)***	***Elevation Angle (degrees)***
Base Reflectivity	Z	19	16	**1** *(0.54)*	6.0 @
Super-Res. Reflectivity	Z	153	256	**0.25** *(0.13)*	0.5
	Z	153	256	**0.25** *(0.13)*	1.5
Super-Res. Velocity	V	154	256	**0.25** *(0.13)*	0.5
	V	154	256	**0.25** *(0.13)*	1.5

@ As a storm approaches, higher elevation angles become more important. The 6.0 degree elevation angle can be replaced by an angle between 5.0 and 6.5 degrees, depending upon the angles available in the VCP being used.

Minimum recommended RPS List: Center 32-62 nmi from radar

Product	***AWIPS Mnem.***	***RPG Code#***	***Data Levels***	***Range Resolution in km (nm)***	***Elevation Angle (degrees)***
Base Reflectivity	Z	19	16	**1** *(0.54)*	5.0 – 6.5
Super-Res. Reflectivity	Z	153	256	**0.25** *(0.13)*	0.5
	Z	153	256	**0.25** *(0.13)*	1.5
Base Velocity	V	26	16	**0.5** *(0.27)*	0.5
	V	26	16	**0.5** *(0.27)*	1.5
Super-Res. Velocity	V	154	256	**0.25** *(0.13)*	0.5
	V	154	256	**0.25** *(0.13)*	1.5

Minimum recommended RPS List: Center 0-32 nmi from radar

Product	***AWIPS Mnem.***	***RPG Code#***	***Data Levels***	***Range Resolution in km (nm)***	***Elevation Angle (degrees)***
Base Reflectivity	Z	19	16	**1** *(0.54)*	5.0 - 6.5
	Z	19	16	**1** *(0.54)*	9.9 #
Super-Res. Reflectivity	Z	153	256	**0.25** *(0.13)*	0.5
	Z	153	256	**0.25** *(0.13)*	1.5
Base Velocity	V	25	16	**0.25** *(0.13)*	0.5
	V	26	16	**0.5** *(0.27)*	0.5
	V	26	16	**0.5** *(0.27)*	1.5
Super-Res. Velocity	V	154	256	**0.25** *(0.13)*	0.5
	V	154	256	**0.25** *(0.13)*	1.5

 # The 9.9 degree elevation angle can be replaced by an angle between 7.5 and 10.0 degrees, depending upon the angles available in the VCP being used.

NOTE:

This document is a living document and will be updated as necessary (e.g., due to new research or software changes).

For another version of this document, see ***http://www.ofcm.noaa.gov/nhop/wsr-88d/*** and select the appropriate .pdf file (e.g., http://www.ofcm.noaa.gov/nhop/wsr-88d/nat_trop_cyc_wsr-88d_ops_plan_**12B12**.pdf for the 2012 version for Build 12 sites *without* Dual Polarization). Alternatively, go to the Web site of the Office of the Federal Coordinator for Meteorology (***http://www.ofcm.noaa.gov***). At the top of the OFCM home page, there is a line (**Click here** -- For the 2012 National Hurricane Operations Plan) that links to the NHOP document. A link to this WSR-88D document and to the one for non-Dual Pol systems, and to the "**QUICK CHECK**" listings for each Tropical Cyclone Operations Plan, can be found under Appendix H.

You may contact the WSR-88D Field Support Hotline (nexrad.hotline@noaa.gov) for the **"QUICK CHECK"** listing of items covered by the WSR-88D Tropical Cyclone Operations Plan (or for any other questions regarding the operation and performance of a WSR-88D radar system). The Hotline is normally staffed 24 hours a day 7 days per week by a maintenance specialist and from 7:00 a.m. to 7:00 p.m. CDT on regular workdays by a meteorologist. It *may* have a meteorologist on duty at additional times during major weather events, such as hurricanes. Someone from the Hotline may proactively contact field sites to ensure readiness for these events, especially with respect to communications. In addition, if necessary, the Hotline will contact Applications Branch specialists for problems with velocity, VCP selection, and precipitation estimation.

Acknowledgments: This document was originated by Scott Spratt and Dave Sharp (both at WFO Melbourne, FL) and by Stacy Stewart and Colin McAdie (National Hurricane Center, NHC) in the 1990s. Reviews and updates have been made by Dan Berkowitz (ROC Applications Branch) and several other people. Suggested Minimum RPS Lists and use of the 8-data level velocity product were originally provided by Stacy Stewart (NHC). Use of the 256-data level velocity was suggested by Liz Quoetone (Warning Decision Training Branch, WDTB). TPV adaptable parameter threshold and MDA settings were suggested by Robert R. Lee (ROC Applications Branch).

Additional helpful suggestions were offered by Mike Istok (NWS Office of Science and Technology, Software Engineering Center), Tim Crum (NWS Radar Focal Point, ROC), Jeff Waldstreicher (Scientific Services Division, NWS Eastern Region Headquarters), Joe Chrisman (ROC Engineering Branch), Jami Boettcher, Cynthia Van Den Broeke, Paul Schlatter, and Andy Wood (Warning Decision Training Branch), the ROC Radar Support Team (especially Dan Frashier, Tony Ray, Mark Albertelly, Stan Grell, and

Nickie Flambures), Cindy Chrisman (ROC System Documentation Section), Mark Fresch (NWS Office of Hydrologic Development), and ROC Applications Branch members Dave Zittel, Rich Murnan, and Randy Steadham.

{Return to Contents ⬆}