

WSR-88D Tropical Cyclone Operations Plan

09/02/2004

- 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 for a link to a place in this document, a link to an e-mail address, a link to an Internet address, or an alphanumeric value entered in an adaptation data menu. **Red** is for a menu or menu selection. **Green** is for a special note. **Yellow** is for a box around a **very** special note.
- Note that by default the 8-level 0.54 nm Velocity product, the 0.54 nm Composite Reflectivity product, and the 8-bit (256-level) Velocity product are not available to Class 2 (non-associated or dial) users according to the baseline product set defined in the current Guidance on Adaptable Parameters (WSR-88D Handbook Volume 4, RPG). (See <http://www.roc.noaa.gov/ssb/sysdoc/Operations.asp> .) However, these products should be made available to the Tropical Prediction Center (TPC), a Class 2 user, by modifications to the RPG Product Generation Table and RPG Product Distribution Control Table (procedure 9, below).
- The most important parts of this plan for both Class 1 (associated) users and Class 2 (non-associated) users are (1.) the availability of the 8-level and 256-level velocity products and (2.) changes associated with the 8-level Velocity product (procedures 6, 8a, and 9). The advantage of using the 8-level Velocity product is that the maximum wind in or near the eyewall can be clearly displayed while leaving the standard 16-level Velocity product (-64 kt to +64 kt) alone for routine use.
- **Note: While temporary additions of these products can be made on-site, each time the RPG is rebooted or the VCP/weather mode is changed, the lists will be replaced with the baseline. Therefore, it is suggested that you record your local "default" adaptable parameters before implementing any changes and document all changes that are made. Keep this information near the MSCF in case the data need to be restored.**

Execute procedures 1 and 2 before doing any other procedures. Procedure 2 for Build 5 systems requires an RPG reboot, which would cause the recommended adaptation data changes to be lost. Nearly every procedure

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 "default" values. Refer to the current Guidance On Adaptable Parameters (WSR-88D Handbook Volume 4, RPG) for system-wide defaults and your own notes for your site-specific ones.
- All recommended changes are performed by the WFO using the URC level of change authority. See the note after **A.** (below) regarding password entries.
- For questions or comments that need an immediate response, contact the [WSR-88D Hotline](#) (800-643-3363) at the Radar Operations Center. Other questions about this document can be addressed to [Colin McAdie](#) (Tropical Prediction Center) or [Dan Berkowitz](#) (Radar Operations Center).

Here is a brief summary of the contents of this document:

1. [Generator Fuel](#)
2. [Reinitializing Precipitation Accumulations](#)
3. [Clutter Suppression](#)
 - a. [Setting Up a Minimal CSR](#)
 - b. [Selecting an Existing Clutter Suppression Region File](#)
4. [VCP Selection](#)
5. [Mitigation of Range Folding](#)
6. [Velocity Measurement Increment](#)
7. [Algorithms](#)
 - a. [Mesocyclone Algorithm Optimization](#)
 - b. [Mesocyclone Detection Algorithm Optimization](#)
 - c. [Tornado Detection Algorithm Optimization](#)
 - d. [Precipitation Estimate Optimization](#)
 - i. [Z/R Relationship](#)
 - ii. [MXPRA](#)
8. [Selectable Product Parameters](#)
 - a. [Velocity Data Display Levels](#)

- b. [Precipitation Product Display Levels](#)
- 9. [Generation and Distribution of Products for National Centers](#)
- 10. [Archive Level II](#)
- 11. [AWIPS Data Archiving](#)
- 12. [AWIPS Data Requests from Adjacent Radars](#)
- 13. [AWIPS Minimum RPS Lists](#)

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

*Note: All commands for procedures 1-10 begin from the HCI (RPG Control/Status window) and may require the URC-level password. If this password is required, click on the lock button in the upper right corner of the window; in the small password pop-up window, select **URC**, type in the password, and press the **<Enter>** key on your keyboard. There are no commands requiring Agency- or ROC-level passwords.*

1. Generator Fuel

Well 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 before commercial power is restored in the aftermath of a significant tropical cyclone and fuel delivery will likely be delayed.

- On the right side of the HCI (the Applications column), select **RDA Performance Data**, then select **Tower Utilities**.
(Check % of **Gen Fuel Level** and order fuel as deemed necessary.)

2. Reinitializing Precipitation Accumulations

2a. Reset the precipitation products to begin accumulating rainfall at the onset of the Tropical event. To accomplish this, certain buffers used by precipitation processing need to be reinitialized.

Note 1: Since one or two volume scans of data will be lost due to an RPG reboot, ensure this procedure is performed prior to any weather concerns. Build 6 software allows you to execute reinitialization without doing a Shutdown of RPG applications.

- From the RPG **Control** menu, click **Off** under Shutdown and confirm.

- When the State shows as "Shutdown", click **Options** under Restart.
- Unlock the RPG Init Options screen using the **URC** password.
- Select **Hydromet (excludes Gage Database)**, then **Activate** and confirm.
- **Close** the Options Window, select **All Tasks** under Restart, confirm, and **Close** the RPG Control window.

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

Note 2: Rain Area Threshold (RAINA) should be approximately the same as the pre-Build 5 value for Nominal Clutter Area in the Precipitation Detection Function (which is now only used for automatic initiation of precipitation mode, not precipitation accumulation). Likewise, 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.

- From the RPG **Products** menu, choose **Algorithms**, then select Adaptation Item: **Hydromet Preprocessing**.
- 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** km² that is typical for the non-precipitation residual clutter area (i.e., not eliminated from reflectivity by clutter suppression in procedure 3 below).

Note 3: An appropriate setting for RAINA should be determined locally during fair weather. Use the area detected in the Precipitation Status window 22.0 dBZ line as a guide. (This amount is not necessarily the same as the area being used by the Precipitation Processing Subsystem, as reflected in the Supplementary Precipitation Data (SPD) alphanumeric product.)

- Select the box to the right of **Precip Cat:** (below the USERS icon).
- Read the value to the right of 22.0 dBZ under Area (km²) Detect.

3. Clutter Suppression

Ensure that minimal clutter suppression is in effect. Use "Bypass Map" whenever possible. This will improve rainfall estimates and overall algorithm performance. If significant clutter or anomalous propagation (AP) becomes apparent, change to a Clutter Suppression Region (CSR) file that has greater coverage.

3a. Setting Up a Minimal CSR

If you need to "build" (then download) a minimal CSR, the following commands will produce one with the bypass map in control and with medium suppression applied to known ground targets.

- On the right side of the HCI (the Applications column), select **Clutter Regions**.
- Select **File**, then double-click on **Default**.
- Edit both the **Segment: Low** and **Segment: High** tables to agree with the one below.
- **Save As**, give this file a name (e.g., **“Minimum”**), **Accept**, **Close**, then **Download**, confirm changes, and **Close**.

Example of a minimal Clutter Suppression Region
With Bypass map in control

Region:	Azi1 (Deg)	Azi2 (Deg)	Ran1 (NM)	Ran2 (NM)	Select Code	Dopl Chan	Surv Chan
1	0	360	1	275	Bypass Map	Medium	Medium

Note: Avoid using “All Bins” on the High segment at all times!

3b. Selecting an Existing Clutter Suppression Region File

- On the right side of the HCI (the Applications column), select **Clutter Regions**.
- Select **File**, then double-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.)
- **Close**, **Download**, confirm download, and **Close**.

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.

4. Operational Mode - Volume Coverage Pattern (VCP) Selection

The two main considerations in VCP selection are the **strength** of tropical cyclone and the **range** from the radar to the center of the cyclone. Use VCP 11 or 12 for better vertical resolution and faster data refreshing. Use VCP 121 to alleviate range folding (or “purple haze”), which is often a major problem in tropical cyclones. VCP 121 has the same elevation angles as VCP 21, but it uses multiple PRF dealiasing, which improves velocity product usefulness by reducing range folding and providing more accurate velocity dealiasing. The downside is that VCP 121 is currently limited to velocity measurements of +/- 123 kt. (This limitation will be corrected in Build 7.) Therefore, **in a major hurricane, VCP 11 or 12 will be needed to capture the maximum winds**. A switch to VCP 21 can be made if product load shedding becomes a concern; VCP 21 will still measure the maximum winds.

Note 1: If Auto PRF is On, wait until 0.5 degree scan completes before executing these commands.

- Select **VCP** Control Panel/Window, then select **CHANGE** to RDA VCP: **11**
or
- Select **VCP** Control Panel/Window, then select **CHANGE** to RPG VCP: **121** (or **11** or **12**)
- **Confirm** and **Close**

This command invokes a "local" VCP as defined in the RDA adaptation data or a "remote" VCP stored at the RPG. Local VCPs 11 and 21 and remote VCP 121 are defined with a .97 kt Velocity Measurement Increment (VMI), which limits velocity measurements to ± 123 kt and a #5 PRF selection, which restricts the unambiguous range to 79 nm. To increase the unambiguous range to 94 nm, or to change the VMI to display winds in excess of ± 123 kt, refer to procedures 5 and 8a, respectively.

Note 2: VCP 121 does not use Auto PRF and cannot currently use the 1.94 kt VMI. (This limitation will be corrected in Build 7.)

Note 3: Some sites have reported seeing "Pedestal Dynamic Fault" messages when using VCP 12 or 121 (due to the increased rotation speed in these VCPs). This means that there is a problem with alignment in Pedestal Electronics. See <http://www.roc.noaa.gov/ops/9060.asp> or call the ROC Hotline for further information about this.

5. Mitigation of Range Folding

Remember that 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. This may become necessary to improve velocity products as the tropical cyclone approaches. The "Download" command invokes a "Remote" VCP (i.e., one stored in the RPG), with VCPs 11, 12, and 21 defined with a PRF of 4 ($R_{max} = 94$ nm).

Note 1: Ordinarily, VCP 121 will do the best job of range unfolding. As often as possible, the TPC 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, VCPs 11, 12, or 21 may need to be selected to mitigate range folding in a WFO's region of concern.

Note 2: If Auto PRF is on, wait until the 0.5 degree scan completes before executing the download command. As long as the Auto PRF is off, the unambiguous range will remain at 94 nm.

- Select **RDA Control**.
- Select **VCP** in the Control/Status window.
- Toggle Auto PRF **Off**.
- Under Download VCP from RPG, select **121** (or 11, 12, or 21).
- Confirm and **Close**.

6. Velocity Measurement Increment

If velocities are expected to exceed **124 kt**, increase the Velocity Measurement Increment (VMI) from .97 kt to 1.94 kt.

**** Note: While these changes can be made to the Current VCP, whenever other changes are made to the VCP, the original VMI will be restored. ****

Note 1: You cannot select the 1.94 kt VMI for VCP 121.

- With the **Auto PRF** remaining **Off**...
- Select **RDA Control**.
- Select **VCP** in the Control/Status window.
- For Modify VCP: select **Current**.
- Toggle Velocity Increment to **1.94 kts**.
- **Save, Download**, confirm changes, and **Close**.

Note 2: Verify PRF #4 ($R_{max} = 94$ NM) remains set for all sectors.

Note 3: If the VMI is .97 kt (1.94 kt), Table "Precip 8 / 0.97" ("Precip 8 / 1.94") in procedure 8a below applies for the 8 data level Velocity products.

7. Algorithm Adaptable Parameter Changes

Note: The Mesocyclone and Tornado Detection algorithms began to process data separately starting with WSR-88D Build 10. Procedures 7a and 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 Algorithm Optimization

The Threshold Pattern Vector (TPV) within the Mesocyclone algorithm should be reduced to **6** to improve detection of small diameter features; however, a greater

number of false alarms will also be generated.

- From the RPG **Products** menu, choose **Algorithms**, then select Adaptation Item: **Mesocyclone**.
- Change **Min # Pattrn Vec** value from 10 to 6.
- **Save**, confirm changes, and **Close**.

7b. Mesocyclone Detection Algorithm Optimization

Starting with ORPG Build 6 and AWIPS OB4 software, there is a new algorithm, Mesocyclone Detection Algorithm (MDA), which 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 mesos within the tropical cyclone.

- From the RPG **Products** menu, choose **Algorithms**, then select Adaptation Item: **MDA**.
- Change **Minimum Display Filter Rank** value from 5 to 4 (or 3).
- **Save**, confirm changes, and **Close**.

7c. Tornado Detection Algorithm Optimization

Several "default" 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 "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. Copyright 1997 by AMS."

- From the RPG **Products** menu, choose **Algorithms**, then select Adaptation Item: **Tornado Detection**.
- Change **Minimum 3D Feature Depth** from 1.5 to 2.0.
- Change **Min 3D Feat Low-Lvl Delta Vel** from 25 to 14.
- Change **Minimum TVS Delta Velocity** from 36 to 44.
- **Save**, confirm changes, and **Close**.

7d. Precipitation Estimate Optimization

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. Switching to the "tropical" Z/R will increase the estimated precipitation accumulations, especially for higher reflectivities.

Note 1: 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.

Note 2: An AWIPS program can be run in real time to create parallel versions of radar precipitation products using different Z-R relationships; i.e. you can create OHP, THP and STP products locally on AWIPS with the tropical Z/R and compare them in real time with the (default Z/R) products from the RPG. To get more information on this program, go to the AWIPS Local Application's web site (<http://www.nws.noaa.gov/mdl/awips/>) and then select Applications Database.

- From the RPG **Products** menu, choose **Algorithms**, then select Adaptation Item: **Hydromet Rate**.
- Set **Z-R Multiplier Coef. [CZM]** to **250**.
- Set **Z-R Exponent Coef. [CZP]** to **1.2**.

ii. MXPRA (Maximum Precipitation Rate Threshold)

MXPRA should be increased to allow for greater rain rates. A MXPRA of **150** mm/hr (**6** 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 current Guidance on Adaptable Parameters (WSR-88D Handbook, Volume 4, RPG), page 8-15, section 8.8.1 for more information.

- Set **Max Precipitation Rate** to **200** mm/hr (**7.9** in/hr).
- **Save**, confirm changes, and **Close**.

8. Selectable Product Parameters

8a. Velocity Data Display Levels

Velocity data (display) levels for the 8-data level products should be set to display hurricane force winds. Note the default settings for the 16-data level Velocity products display a maximum of 64 kt, which will be exceeded by even a minimal 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 1: Before making changes, record values currently being used; these will be needed after the storm passes.

- From the RPG **Products** menu, choose **Selectable Parameters**, then select Category: **Velocity Data Levels**
- Select Velocity Table **Precip 8 / 0.97** and change Code 7 to **100** and Code 6 to **80**
- Select Velocity Table **Precip 8 / 1.94** and change Code 7 to **135** and Code 6 to **115**
- **Save**, confirm changes, and **Close**

This modifies the 8-level Velocity products **ONLY**. The routine 16-level Velocity products are not affected. By entering the values above, corresponding negative values are automatically supplied.

Table "Precip 8 / 0.97" will be used if the Velocity Measurement Increment (VMI) is .97 kt and "Precip 8 / 1.94" for VMI of 1.94 kt. Refer to procedure 6, above.

Note 2: If the VMI is 1.94 kt, Storm Relative Mean Radial Velocity products (SRM and SRR) will mirror the Base Velocity products (i.e., use table "Precip 16 / 1.94").

Note 3: The velocity scale displayed with 8-bit (256-level) velocity on AWIPS is the same as the 16-level settings for Base Velocity.

8b. 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) and Three Hour Precipitation (THP), and 25.4 inches for Storm Total Precipitation (STP) and User Selectable Precipitation (USP).]

- From the RPG **Products** menu, choose **Selectable Parameters**, then select **Category: OHP/THP Data Levels**
- Change Codes 3 through 16 as desired for the current event
- **Save** and confirm changes
- Select **Category: STP Data Levels**
- Change Codes 3 through 16 as desired for the current event
- **Save**, confirm changes, and **Close**

9. Generation and Distribution of Products for National Centers

Allow NWS National Centers, such as TPC, and other non-associated (Class 2) display systems, access to:

- a.) **8-level 0.54 nm Base Velocity (V) product** (product #24)
- b.) **0.54 nm Composite Reflectivity (CR) product** (product #37)
- c.) **8-bit (256-level) Base Velocity (DV) product** (product #99)

Products 24 and 37 are already on the RPG Product Generation Table for both modes (Precipitation and Clear Air). However, only the bottom elevation angle is specified for product 24. TPC would like to see the **bottom four** elevation angles of this product. All of these products need to be added to the RPG Product Distribution Control Table.

***** Note: While these changes can be made to the Current RPG Product Generation**

Table and the Current Product Distribution Control Table using URC level of change authority, any RPG reboot or weather mode change will restore "default" settings, removing any additions or changes you have made. ***

- From the RPG **Products** menu, select **Generation List** to obtain the RPG Product Generation Table Editor list.
- Select **Current**.
- Change the Code **#24** (Base Velocity: 8 level/0.54 nm) row as follows: **Cut(s)** to **-4**.
- Change the Code **#99** (Base Velocity Data Array: 256 level/0.13 nm) row as follows: **Gen** to **1**, **Sto** to **1**, and **(mins)** to **60**.
- **Save**, confirm changes, and **Close**.

- Select the **USERS Products** menu (Product Distribution Control menu).
- Under "User Class" select **Class 2 Users [Permission]**.
- Ensure there is a check mark under **A** for codes **24**, **37**, and **99**.
- **Save**, confirm changes, and **Close**.

Note: The TPC has found the 8-bit (256-level) velocity product absolutely critical to its operations. Until it is available via WAN One-Time Requests (OTRs) from AWIPS (ORPG Build 6 and AWIPS OB4 software), OTRs for these products should be restricted to the national centers (TPC and SPC) and sites having warning responsibility in affected regions and requested only when absolutely necessary.

10. Archive Level II

For sites still recording Archive Level II data by tape, ensure the device remains active. For non-collocated RDA/WFO sites, plan ahead to ensure the Archive II jukebox is loaded with new tapes. (Sites sending Level II data directly to NCDC need to ensure that the LDM connection through the BDDS is working properly. The status can be checked by going to <https://www.radarservices.org/members/imap.php>)

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

11. Data Archiving

It is strongly encouraged that local data archival is performed.

12. Data Requests from Adjacent Radars

Initiate "radar multiple requests" to adjacent radar sites. Continuously monitor adjacent

sites since significant tropical cyclone phenomena are based in the lower levels, and the closest radar will sample the environment best.

13. Minimum RPS Lists

A set of suggested "minimum RPS lists" were 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 WSR-88D RPS list on AWIPS includes the products on the suggested lists (below).

Also, Storm Relative Mean Radial Velocity products (SRR, SRM) should be generated often via One-Time Requests with individual or field motions **manually input** by the radar operator. The algorithms may not be able to produce a useful motion on their own due to the rotational aspects of tropical cyclones.

If 8-bit (256-level) velocity is on your RPS List, your AWIPS will generate an 8-bit SRM; change the motion parameters by selecting **Tools** and, when the window appears, select **Custom Storm Motion** and use the slider bars to adjust the values as necessary. If the SRM was being displayed prior to these changes, clear the display and reselect the product; the new motion will now be applied.

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

Product	Elevation Angle	Data Resolution	Data Levels
	(degrees)	(nautical miles)	
Base Reflectivity	0.5	1.1	16
	1.5	1.1	16
	0.5	.54	16
	1.5	.54	16
	2.4	.54	16
	3.4	.54	16
Base Velocity	0.5	.54	16
	1.5	.54	16
	2.4	.54	16
	0.5	.54	8
Composite Reflectivity		.54	16
Vertically Intergrated Liquid			
Storm Total Precipitation			

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

Product	Elevation Angle	Data Resolution	Data Levels
	(degrees)	(nautical miles)	
Base Reflectivity	0.5	1.1	16

	0.5	.54	16
	1.5	.54	16
	2.4	.54	16
	3.4	.54	16
	6.0	.54	16
Base Velocity	0.5	.54	16
	1.5	.54	16
	2.4	.54	16
	3.4	.54	16
	0.5	.54	8
Composite Reflectivity		.54	16
Vertically Integrated Liquid			
Storm Total Precipitation			

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

Product	Elevation Angle	Data Resolution	Data Levels
	(degrees)	(nautical miles)	
Base Reflectivity	0.5	1.1	16
	0.5	.54	16
	1.5	.54	16
	2.4	.54	16
	3.4	.54	16
	6.0	.54	16

Base Velocity	0.5	.54	16
	1.5	.54	16
	2.4	.54	16
	3.4	.54	16
	0.5	.27	16
	1.5	.27	16
	0.5	.54	8
Composite Reflectivity		.54	16
Vertically Integrated Liquid			
Storm Total Precipitation			

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

Product	Elevation Angle	Data Resolution	Data Levels
	(degrees)	(nautical miles)	
Base Reflectivity	0.5	1.1	16
	0.5	.54	16
	1.5	.54	16
	2.4	.54	16
	3.4	.54	16
	6.0	.54	16
	9.9	.54	16
Base Velocity	0.5	.54	16
	1.5	.54	16
	2.4	.54	16

	3.4	.54	16
	0.5	.27	16
	1.5	.27	16
	0.5	.13	16
	0.5	.54	8
	1.5	.54	8
Composite Reflectivity		.54	16
Vertically Integrated Liquid			
Storm Total Precipitation			

Note: *This document is a living document and will be updated as necessary (e.g., due to new research or software changes).* For the most recent version, see http://www.ofcm.noaa.gov/nhop/wsr-88d/nat_trop_cyc_wsr-88d_ops_plan.pdf.

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