

RADAR INTERPRETATION GUIDE

Purpose: Provide forecasters quick reference for information/techniques to aid in identification, interrogation, and forecast of meteorological phenomena using the **Gibson Ridge** radar software.

1. [Severe Weather Identification – “Rules-of-Thumb.”](#)
2. [Cross-section Techniques](#)
3. [Lightning](#)
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[Attachment 1 – Quick Reference VCP Comparison Table](#)

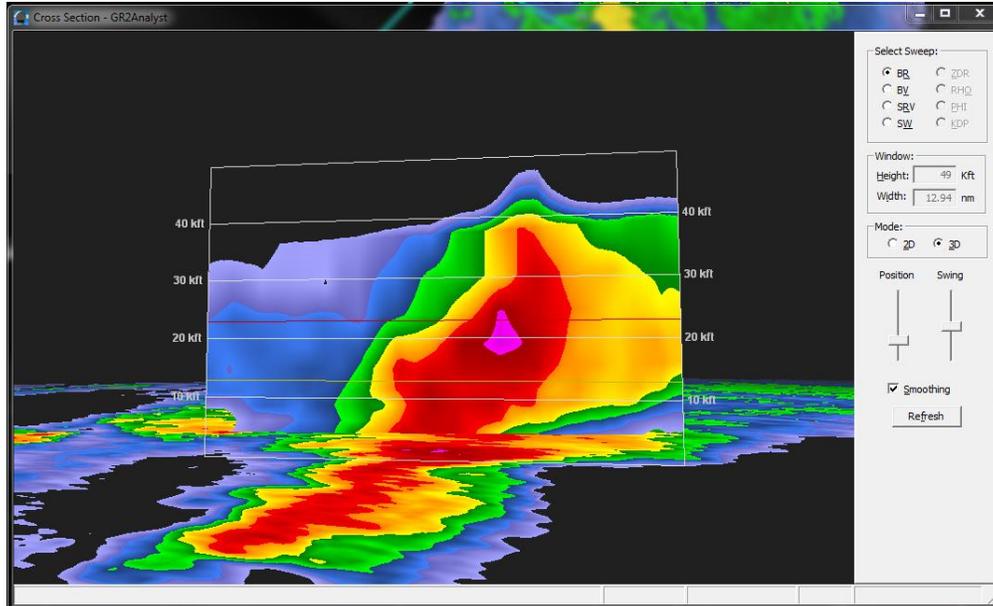
[Attachment 2 - WSR-88D Dual-Pol Radar Decision Aid](#)

NOTE: Additional radar reference material:

- [557 WW/TN-15/001 Interactive Meteorological Techniques](#) (Select “Miscellaneous Elements” and select the “Doppler Radar” or “Dual-Pol” buttons)
- [26 OWS Radar Imagery Reference File \(RIRF\)](#) (under “Technical Resources”)

1. Severe Weather Identification – “Rules-of-Thumb”

a. **Echo Intensity.** Maximum reflectivity cores of 50dBZ or greater extending to 27,000 ft AGL or higher should be categorized as severe.



b. Echo Tops.

(1) Echo tops exceeding 50,000 feet, or echo tops that penetrate the tropopause by 5,000 feet or more are severe.

(2) Tops penetrating the tropopause by 10,000 feet is considered a good indicator of a tornado-producing thunderstorm.

c. Echo Speed.

(1) Echo speeds exceeding 40 knots should be considered an indicator of severe storm development.

(2) At a minimum, the echo speed by itself is probably sufficient to merit a warning for wind in excess of 35 knots.

(3) You will have to consider other factors to determine if 45 to 50 knots is warranted.

d. Erratic Echo Movement.

(1) Erratic echo movement, or echo motion substantially different from that of surrounding cells should be an indicator of the potential for severe weather.

(2) Most cells and conglomerations of cells will move with the 700mb wind or with a mean wind between 5,000 and 20,000 feet.

(3) Severe echoes are likely to move in a direction (0-45 degrees) to the right of this steering wind.

e. Converging Echoes.

(1) When separate thunderstorm echoes, moving at different speed and direction, merge into a single larger echo, the potential for severe weather is enhanced.

(2) At a minimum, large hail and wind is probable in the region of cell convergence.

(3) If unusually high echo speeds are involved (exceeding 40 knots), the probability of tornado development is greatly increased at the junction of the cell merger.

f. Splitting Echoes.

(1) During transformation from a non-severe to a severe storm, some echoes will split in a well-defined manner.

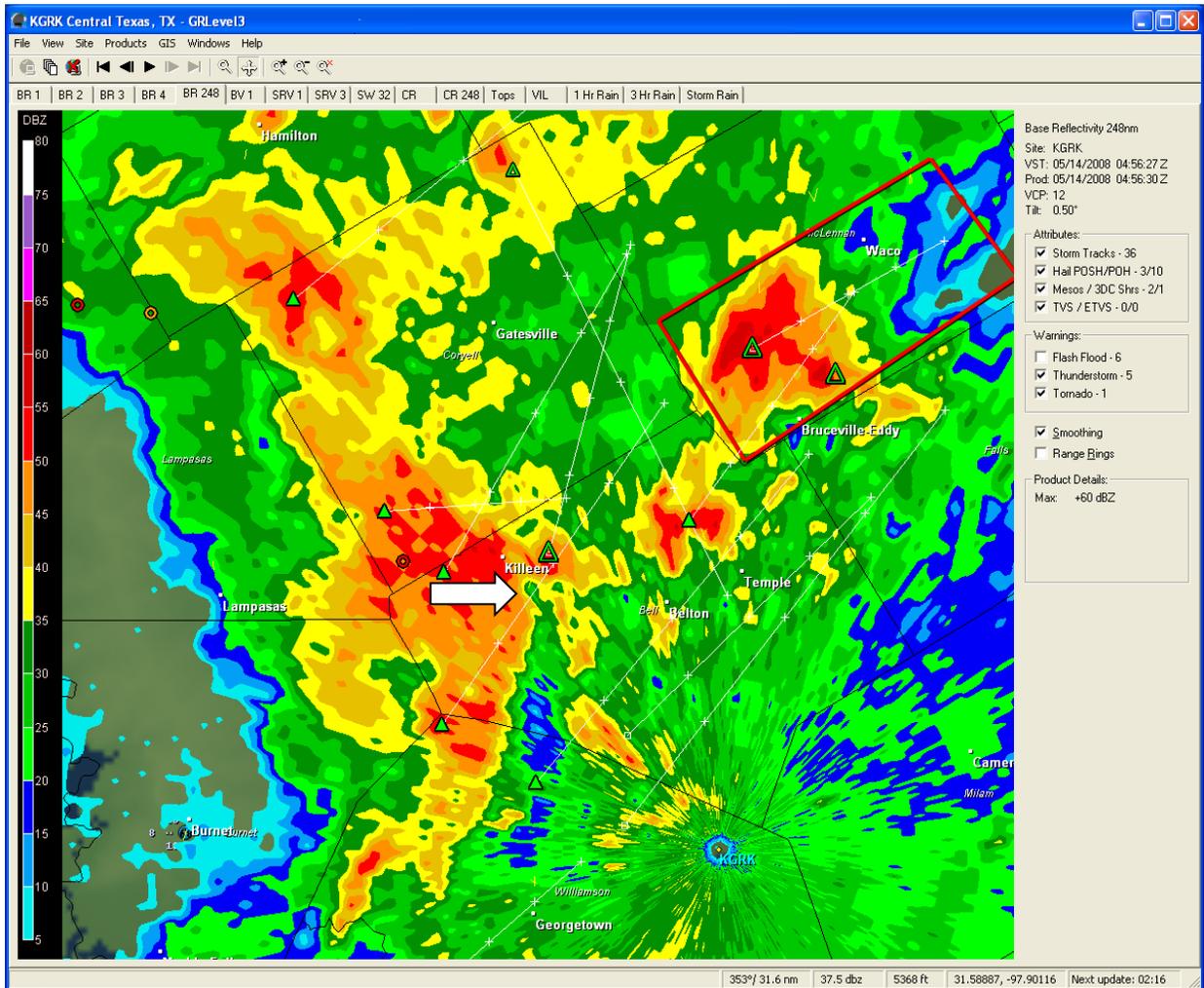
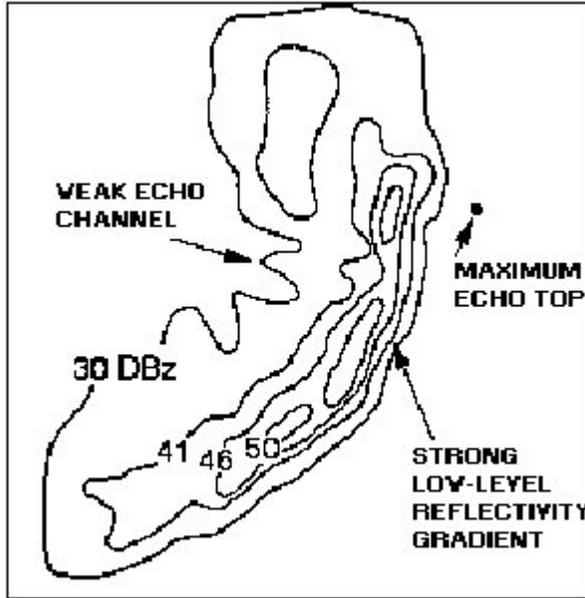
(2) Two separate reflectivity cores form from the separation of the original core, along an axis parallel to the storm motion.

g. Bow Echoes.

(1) The bow echo is a line of storms that accelerates ahead of the main line of storms. The bow echo forms from strong thunderstorms with a gust front. A strong downburst develops and the line echo wave pattern (LEWP) begins to "bow." A well developed bow echo or "spear head" is associated with the mature stage of the downburst. Strong winds and tornadoes are possible near the bow.

(2) Strong to severe straight-line wind is likely to exist if four specific characteristics of the bow echo are present:

- The low-level echo configuration is concave downstream (bowed)
- Weak echo channels exist
- A strong reflectivity gradient along the leading edge of the concave-shaped echo
- The maximum echo top is over or ahead of the strong low-level reflectivity gradient



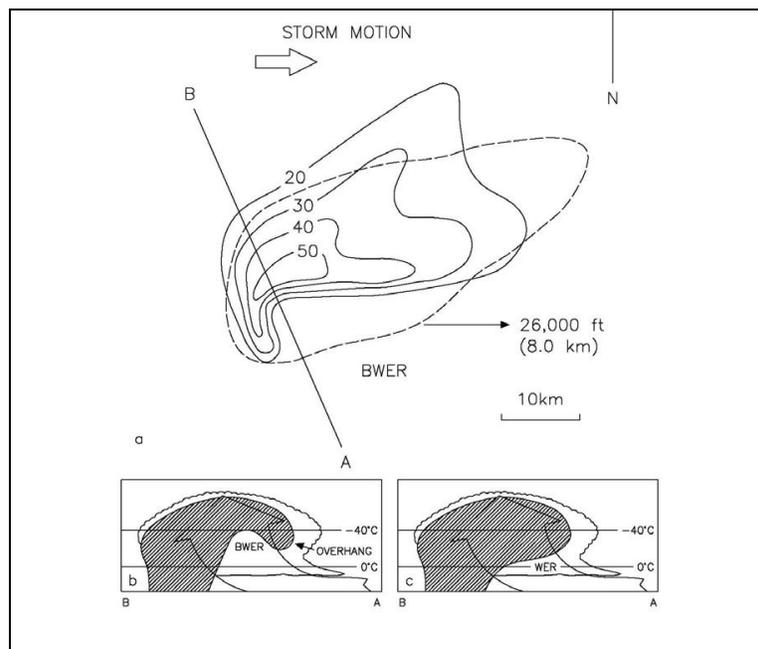
GRK ASOS/FMQ-13 recorded 45 knots // HLR ASOS recorded 61 knots

h. Radar Reflectivity Structure of thunderstorms. The three-dimensional reflectivity field of a storm's radar echo and its evolution contain a great deal of information about the storm's intensity and severe weather potential (tornado, hail, strong winds, turbulence).

(1) Storm top shifted over a tight low-level reflectivity gradient and large WER/BWER capped by high reflectivity cores well aloft are indicators of a very strong and potentially rotating updraft that can support development of severe weather specifically large hail.

(2) **Weak Echo Regions (WER).** The WER is created in part as a direct result of the updraft. A portion of the WER results when there is a sparsity of radar detectable precipitation particles within the rapidly rising air in the updraft column. The echo weakness is due to the air rising so rapidly that precipitation does not have time to grow to detectability within the lower and mid-levels of the updraft. Additionally, precipitation formed elsewhere is unable to penetrate or fall through the updraft.

(3) **Bounded Weak Echo regions (BWER).** With increasing updraft (or sometimes as a result of better resolution at closer range), a bounded weak echo region (BWER) appears because air within the updraft core ascends still higher in the updraft before radar detectable precipitation particles form. In a horizontal cross section, the weak echo region is completely surrounded, or bounded, by higher radar reflectivity values and results in the BWER.



FMH-11B-Part B Figure 8-8

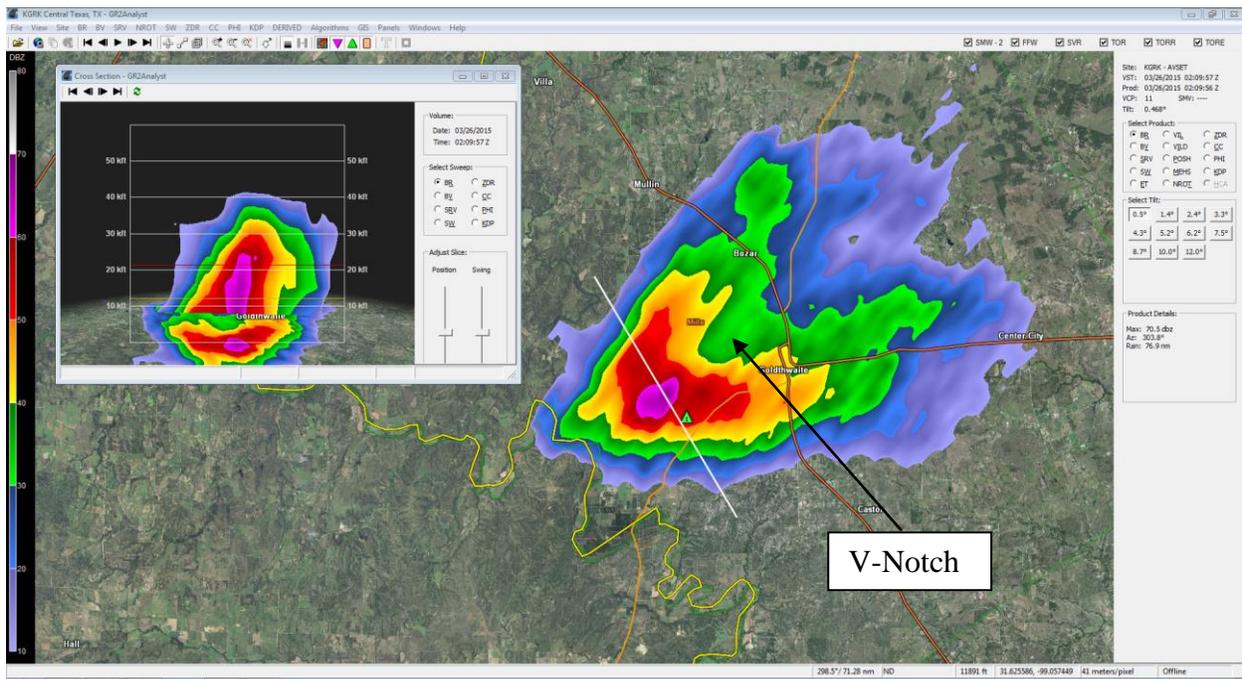
- (a) Plan view of a right-moving supercell with a BWER. Solid lines are low-level and dashed lines are mid-level reflectivity in dBZ. Black dot is storm top (Lemon 1980). (b) Vertical cross section along line AB in (a). The extent of the radar echo (nominally 20 dBZ) is indicated by hatched shading and the location of the steady-state updraft and inflow is denoted by a bold arrow. Cloud outlines are also sketched (Browning 1977). (c) Vertical section along AB for a lesser developed storm than depicted in (a) and (b); here the weak echo region is unbounded.

(4) A persistent WER/BWER is found on the updraft flank. A WER is very common for most supercells, even those with weak mesocyclones. A WER is persistent, and capped by high reflectivities (>45 dBZ) above. The WERs not overlaid by strong reflectivities imply weak or no updraft, such as an overspreading, downshear, anvil layer.

(5) The BWER is less common, but may also develop within the WER of the supercell. The BWER is conically shaped and decreases in width with height, extending to a height one-half to two-thirds of the storm depth. The BWER is indicative of a broad, strong (25 to perhaps 60 ms⁻¹; 49 to 115 kts) updraft that contains small cloud particles, but little precipitation. The storm top is located directly over the BWER and is over the updraft storm flank. When the storm is at moderate to long distances the BWER may not be detectable.

(6) A high-reflectivity core (the hail zone) extending all the way to the ground borders the BWER on its left and rear flank resulting in a strong reflectivity gradient there. The largest hailstones are typically located in the strong reflectivity gradient next to the BWER, with smaller hail and rain at increasing distances to the left and left forward of the BWER. This is a size sorting effect associated with the descent of hail within rising air that is also flowing toward the storm's left flank.

(7) **V-Notch.** Isolated supercell storms when viewed in reflectivity products are often characterized by a down-shear “V-notch” or “winged” appearance. An extensive plume is observed on radar and this forms part of a much larger visible anvil that extends downstream from the main storm core aloft. At low levels, the echo is situated mainly on the storm's left flank coincident with the forward flank downdraft, but the echo may extend toward the right in the form of a hook-shaped appendage that is located mainly in the region of the rear flank downdraft.



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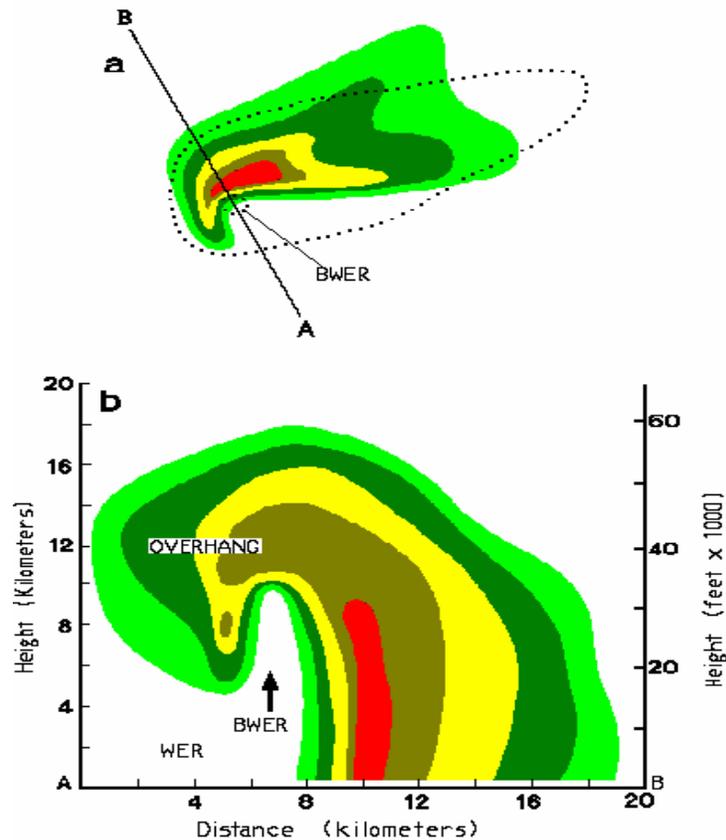
2. Cross-section Techniques

a. Cross-sections using GR2A are excellent tools to identify:

- (1) The height and extent of the maximum reflectivity core.
- (2) Storm tilt and mid-level overhang.
- (3) Weak Echo Regions and Bounded Weak Echo Regions.

b. Rules for cutting Cross-sections:

- (1) Cut the cross section from a 0.5 degree elevation slice Base Reflectivity product.
- (2) Cut the cross section parallel to the low-level inflow.
- (3) Cut the cross section through the maximum reflectivity gradient in the inflow quadrant of the storm.
- (4) Make the inflow side endpoint far enough away from the 0.5 degree maximum reflectivity gradient so you capture the mid-level overhang in the cross section.

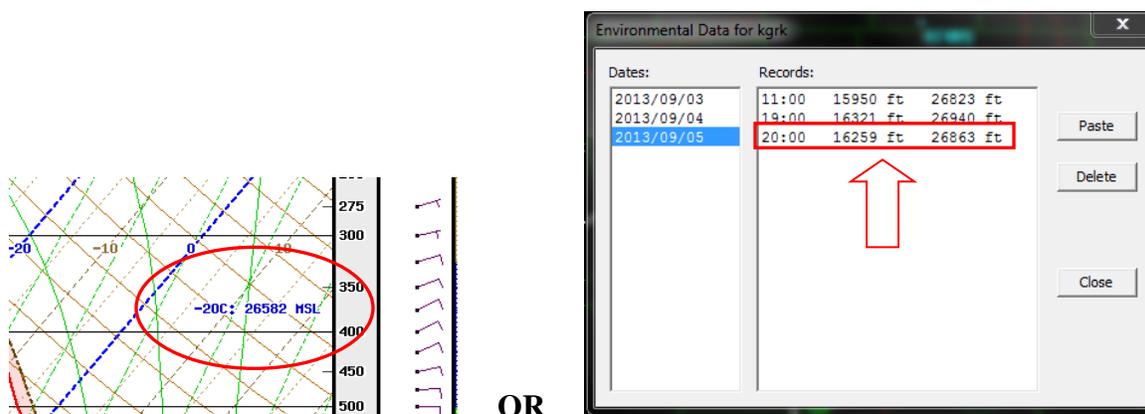


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3. Lightning

a. **First**, determine the height of the -20°C isotherm by using a forecast and/or observed (KFWD) Skew-T. The height can also be obtained from within GR2A (Select “Algorithms,” from the Main Menu and then select “Environment Settings...”

NOTE: The Environmental Data within GR2A is pulled from the NCEP 32km RAP model.



OR
Figure 1

b. **Second**, complete a cross-section. The -20°C will be displayed on the altitude grid by a solid red line and the freezing level will be a solid yellow line. Usually cells with reflectivity values **20 – 30 dbz** extending at the -20°C level lightning initiation may be imminent.

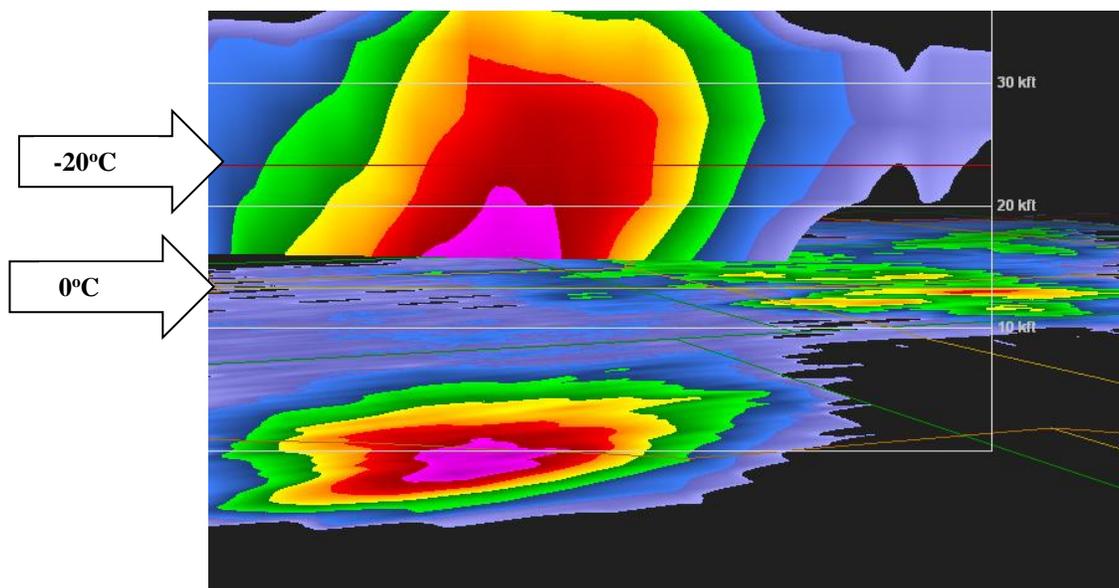


Figure 2

c. **ET Product.** Look for tops that extend above the -20°C height. The height of the data for the cursor position is displayed on the **Status Bar** at the bottom of the display.

d. **Lightning Data Display within GR.** The lightning data viewed within the GR software is a separate paid data service provided by AllisonHouse.com. The data is from Earth Networks Total Lightning Network (ENTLN)*.

(1) Specifications:

- Location accuracy < 250 meters
- Detection efficiency > 95%
- Average delivery (start-to-end) of 60 seconds

(2) The data incorporates **in-cloud (IC)** and **cloud-to-ground (CG)** lightning detection:

- **CG** lightning actually accounts for only a small percentage of the total lightning discharges that occur in the atmosphere.
- **IC** lightning flashes, on the other hand, account for the vast majority of lightning activity. (*<http://www.earthnetworks.com/networks/lightning/>)

IMPORTANT: *It is for this reason the forecaster must interrogate the radar data to fully evaluate the threat/potential of lightning and not solely rely on the lightning network data.*

(3) **Displayed is a summary of all lightning within an area and is displayed as a single icon.** Shape, color, and size of the icons distinguish frequency and time for lightning displayed. This provides the same level of information as traditional displays, but without cluttering other data on the screen--perfect for overlaying on radar.

Size Means Time	Color Means Intensity
Tiny Icon Means <input type="text" value="60"/> minutes or less	Fourth Row means more strokes than third row
Small Icon Means <input type="text" value="30"/> minutes or less	Third Row means <input type="text" value="6"/> strokes or less
Medium Icon Means <input type="text" value="5"/> minutes or less	Second Row means <input type="text" value="2"/> strokes or less
Large Icon Means <input type="text" value="2"/> minutes or less	First Row means <input type="text" value="1"/> strokes or less

• Default

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4. Hail

a. **General.** VIL has proven to be the best tool for hail identification, but it is always best when combined with other products such as Dual-Pol data. Storm top divergence is another method to determine hail size. Cross-sections can be used to verify information found on other products.

IMPORTANT: The values in the techniques below should be used as general guidelines only; values for Central Texas may differ. In addition, the closer you are to the radar, the more accurate most of the following interpretation techniques will be.

b. **VIL Density (Determining Hail Size).** Open the VILDensity (VILD) product (preferably in conjunction with a BR, ZDR, and RHO product in a 4-panel mode). Mouse over individual data plots, and locate the exact value of the plot (as labeled on the status bar).

HAIL SIZE VERSUS VIL DENSITY THRESHOLDS	
VIL Density < 3.0	Mostly non-severe/small hail but a few dime to nickel size severe cases.
VIL Density = 3.0-3.4	About half the cases non-severe hail, and half of cases severe with dime to nickel size.
VIL Density = 3.5-3.9	Nearly all severe cases, with most dime to nickel size, with a couple one inch size.
VIL Density = 4.0-4.4	All severe hail cases, with most dime to nickel size but several an inch or more and a few golfball size.
VIL Density = 4.5-4.9	All severe hail cases, with half of cases dime to nickel size and half of cases an inch in diameter or more, including several golfball size or larger.
VIL Density > 4.9	All severe hail cases, with most over an inch in diameter and a number of events larger than golfball size.
Hail Size > 1 inch	VIL Density > 4.0 in 91% of the cases.
Hail Size > Golfball	VIL Density > 4.3 in 88% of the cases.

NOTES:

(1) The following are the results of a study conducted by the Louisville, KY NWS office, so the values should be used as general guidelines only; values for Central Texas may differ.

(2) These values are calculated using a VIL value capped at **56dbZ**. To cap the VIL algorithm go to the Algorithms menu, select Algorithm Settings, then set the Max VIL DBZ to 56. If you do not do this, these numbers will be extremely over-forecast.

(3) In this study, most of the low VIL Density storms that produced severe hail occurred in fast moving bow echo events, where storm motion and tilt were maximized. Therefore, threshold VIL Density values for fast moving/strongly tilted storms may be > **3.3**. For slow moving, vertical storms, threshold VIL Density values may be >**3.8-4.0**.

c. **Storm Top-Divergence.** Upper level divergence exists in the upper levels of a convective cell and is indicative of updraft strength. Upper level divergence has been quantitatively related to maximum hailstone size. There are three methods to determine storm top divergence (STD). The first method is navigating through elevation slices until you reach the top of the storm, the second is cutting a cross section of the storm, and the third is developing a volume section of the storm. The first two are more accurate, while the third will give you a general idea of the STD.

(1) **Method 1:** Open a velocity product. Navigate through the elevation slices until you reach the top of the storm, and locate the divergent couplet. Mouse over your maximum inbound and outbound velocities and get the speed of those data plots (the actual speed will be located on the status bar). Add the absolute value of the two numbers together.

(2) **Method 2:** Cut a cross section of the storm, change the product to a velocity product. Locate your divergent couplets, mouse over them and determine the speed of those data plots (the actual value will be located in the status bar). Add the absolute value of the two numbers together.

(3) **Method 3:** (*Least Reliable*): Create a volume section of the storm, change the product to a velocity product, and then change the type to “Isosurface.” Move the isovalue up until the maximum inbound and outbound values disappear at the top of the storm. Make a note of when the values disappear, and then add the absolute value of the two numbers together.

VELOCITY DIFFERENCE (ΔV) GUIDELINE VALUES TO HAIL SIZE	
<u>ΔV (knots)</u>	<u>Max Hail Size</u>
75 - 109	3/4" or greater
110 - 135	Golf Ball (1.75")
136 - 175	Tennis ball (2.50")
176 - 225	Baseball (2.75")
≥ 226	Softball/Grapefruit (>4.00")

NWS EHB 6-539 Reference Card 08

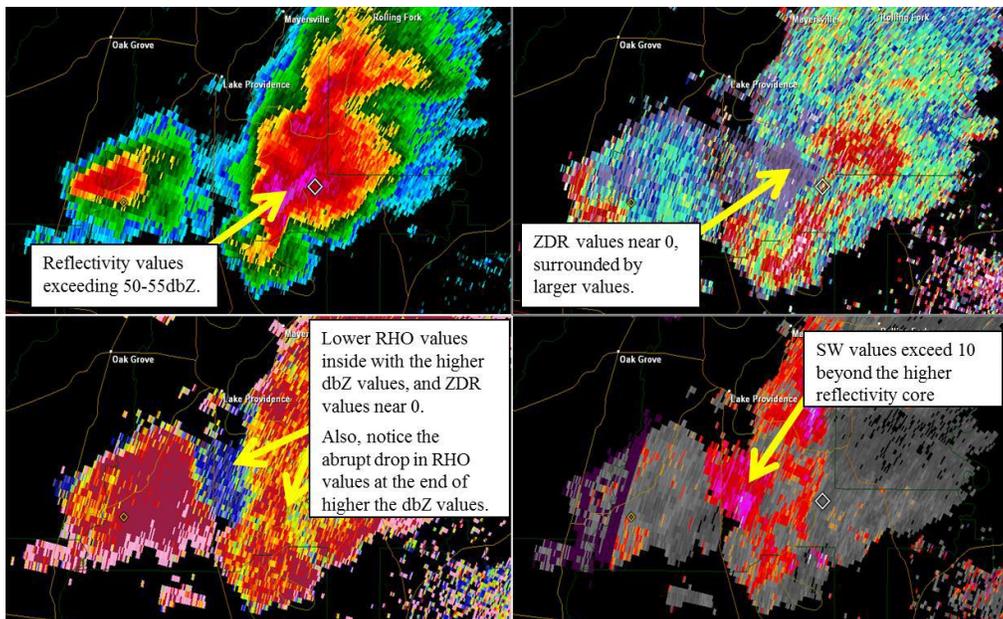
d. Dual-Pol Data.

IMPORTANT: None of these factors alone constitute hail; a combination of these products must be used together. Also, if you verify hail inside a storm using radar it does not mean hail is reaching the ground.

- (1) Open a Four-panel display with **BR, ZDR, RHO, and KDP (or SW)** products.
- (2) Place a marker in area of the strongest reflectivity values.
- (3) The values you will want to look for to identify hail are:
 - (a) High Base Reflectivity signature of **55 dbZ+**
 - (b) ZDR value near **0db**
 - (c) **Low RHO** value*
 - (d) KDP values **between 1-4°/km**** (or SW values **over 10 knots**)

* The low RHO values will typically extend along the same radial beyond where the hail is physically located inside the storm. In this area of lower RHO, there will also be significantly larger SW values, and no KDP values. All these factors combined increase the confidence of hail being in the storm at that time. In addition, in cases where a significant amount of small hail is falling, you will typically have a higher RHO value. In this instance, there will be high Base Reflectivity returns, with low ($-2-0^{\circ}/\text{km}$) KDP values.

**KDP values can also be larger and smaller than $4^{\circ}/\text{km}$ and still produce large hail.



Example

e. **Identifying strong updrafts with Dual-Pol Data.** Dual-Pol data can be used to help determine storm cells with stronger updrafts in a weakly sheared environment with pulse-type cells.

IMPORTANT: The following procedures are to be used BEFORE the storm has started producing significant radar signatures—this could help increase forecast lead-time.

(1) After a storm is identified to just being precipitating on the lowest elevation, cut a cross section of the storm. On the **BR** product, look for higher reflectivity values above the freezing level (the yellow line.)

(2) Switch to the **ZDR** product. You should notice a cluster of large values at and below the freezing level, with a small area of higher (**1-3db**) values reaching above the freezing level (this is referred to a “ZDR column”). This is indicative of large water droplets reaching above the freezing level.

(3) Switch to the **KDP** product. You should notice small (**<1°/km**) values within the ZDR column above the freezing level. This occurs due to smaller water content inside strong updrafts.

(4) Switch to the **RHO** product. You should notice slightly smaller numbers in the area of the ZDR column as ice particles start to form in the precipitation.

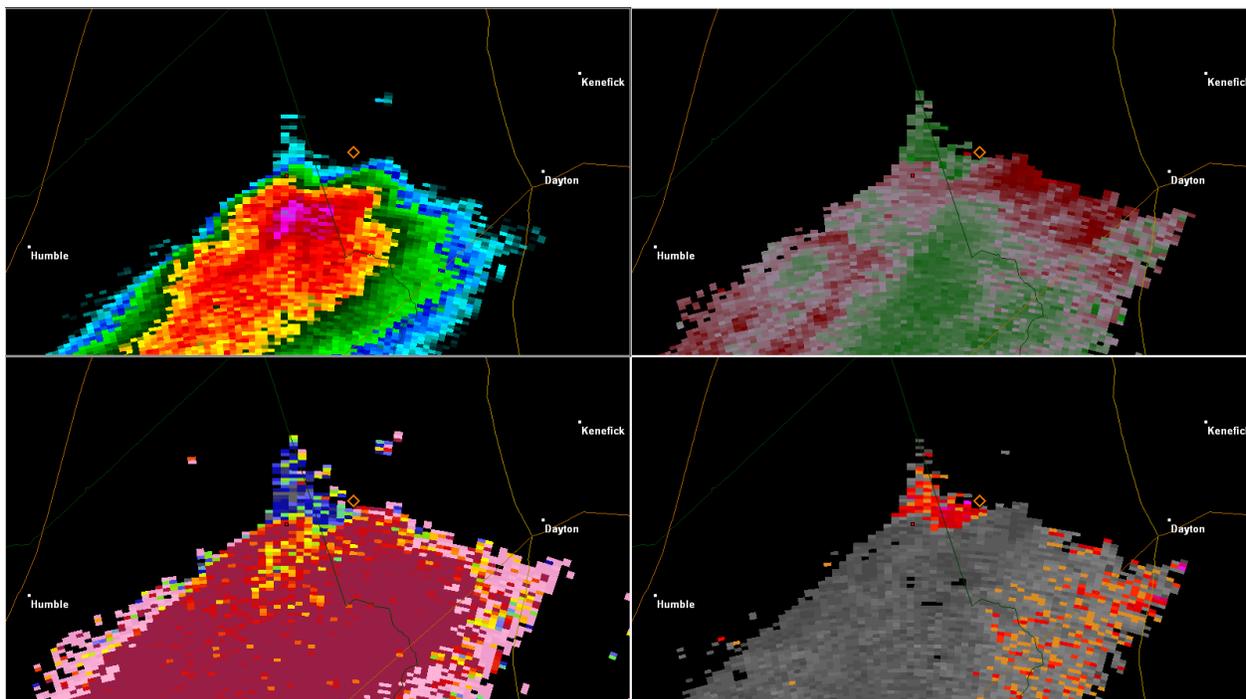
(5) It is possible to view updrafts in a highly sheared environment.

f. **Velocity Signatures.** Using velocity data to identify mid-level rotation inside the core of a storm will indicate a strong updraft adequate to support large hail updrafts. Also, a 2D Cross-section indicating **50+ knots** of mid-level convergence is also indicative of a potent updraft capable to support large hail (**35+ knots** would indicate a moderate hail potential).

g. **Three-Body Scatter Spike (TBSS) or (3BS).** This is a phenomenon that occurs in storms with large hail, or storms with an extreme amount of small hail. If the signature is seen, unlike most radar signatures, it means hail is falling or is imminent.

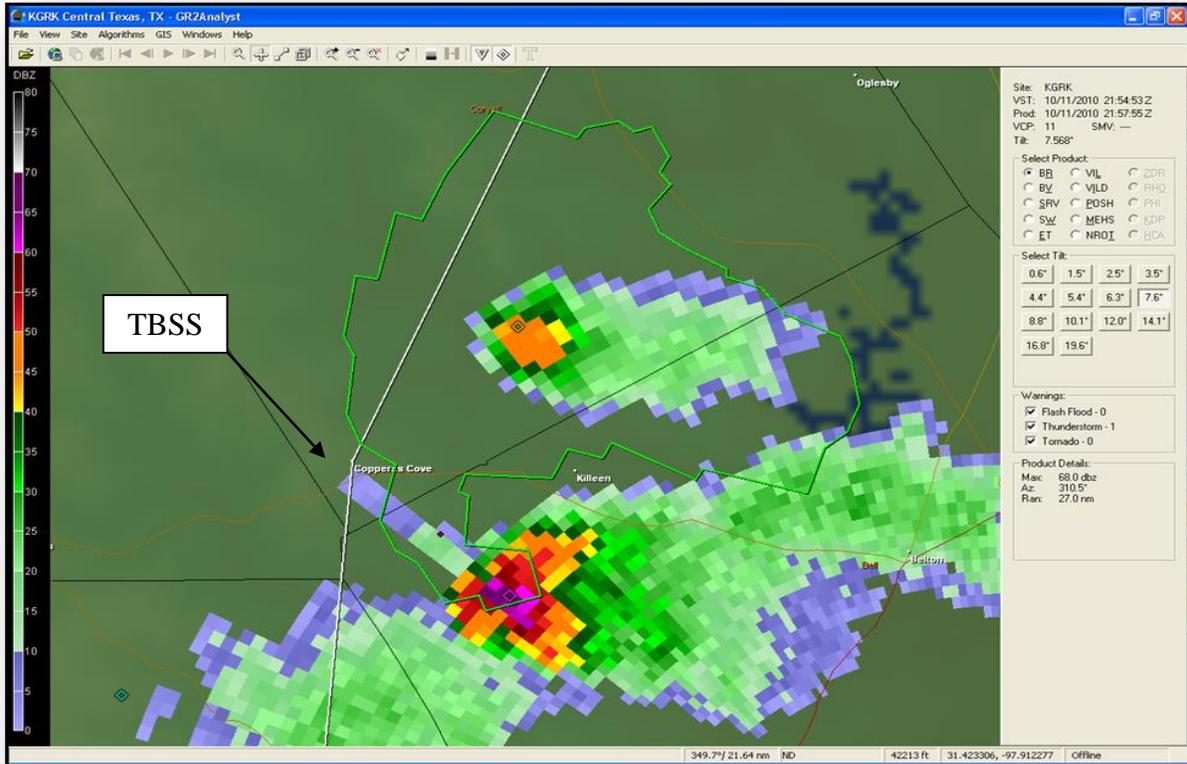
(1) It is displayed on radar as a series of values exceeding past a hail core along the same radial as the hail. These are best viewed using the unsmoothed Base Reflectivity, Spectrum Width, Base Velocity, RHO/CC, and ZDR products.

(2) The values existing in a TBSS will generally be of low values. For BR signatures, look for values lower than 15, inbound BV signatures less than 10KTS, low RHO immediately beyond the hail, and low ZDR values. In regards to the SW values, those will be abnormally large beyond the hail core. A four-panel image of BR-BV-RHO- can be seen below.



(3) The spike extends a proportional distance past the hail core to the distance to the RDA. For instance, if the cell is 40NM from the RDA, the spike will extend 40NM past the hail core.

(4) Lastly, in order to view a TBSS, there has to be no precipitation directly beyond the hail core, because this will clutter the products and inhibit the viewing of a TBSS.



Example TBSS- GR2A BR Product (KGRK), 11 Oct 2010 - 1 inch hail reported at GRK

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5. Wind

IMPORTANT: The values in the techniques below should be used as general guidelines only; values for Central Texas may differ. In addition, the closer you are to the radar, the more accurate most of the following interpretation techniques will be.

a. Wet-Microburst Wind Gust Potential.

(1) Open a VIL and ET product, side-by-side of each other. Determine the highest ET and highest VIL of a particular cell by placing the cursor over particular data plots and finding the value in the status bar. Compare the VIL and ET values according to the Wind Gust Potential Chart below:

		T O P S									
		250	300	350	400	450	500	550	600	650	700
V I L	35	45	42	37	31	23					
	40	49	46	42	38	30	19				
	45	53	50	47	42	36	28	14			
	50	57	55	51	46	41	34	24			
	55	60	57	54	50	45	39	31	18		
	60	63	61	57	54	50	44	37	27		
	65	66	64	61	58	53	48	42	33	21	
	70	69	67	64	61	57	53	46	39	29	
	75	72	70	67	64	60	56	50	44	35	22
	80	75	72	70	67	63	59	54	48	40	29

(2) After you calculate your wind gust using the chart above, **add 1/3 of the mean low-level wind speed** to the value in the table to predict the wind gust from the potential microburst. The mean low-level wind can be obtained from the **VWP** using **GR3** or another reliable source (i.e., Skew-T).

(3) **Limitations:** This method is only intended for pulse-type airmass storms. This will not help when forecasting straight-line wind events associated with strong, self-sustaining super cellular or linear structured storms.

b. **Airmass Thunderstorm Downburst Wind.** The following information is preliminary based off a study conducted by the Shreveport NWS WFO.

(1) Cut a cross section of an airmass thunderstorm. Ensure your cross section is *parallel* to the radar beam.

(2) Use the following guidelines for issuing a **severe** thunderstorm warning (≥ 50 knots) for a downburst:

(a) High reflectivity core of **50 dBZ** to heights of **25,000 ft AGL**, along with...

(b) Convergence of **50 knots** using an SRV product somewhere in the layer **5000 - 11,000 ft AGL** in or near the high reflectivity core.

(3) Use the following guidelines for issuing a **moderate** (35-49KT) thunderstorm warning for a downburst:

(a) High reflectivity core of **45 dBZ** to heights of **25,000 ft AGL**, along with...

(b) Convergence of **35 knots** using an SRV product somewhere in the layer **5000 - 11,000 ft AGL** in or near the high reflectivity core.

(4) A low-level divergence of wind will occur as the downburst contacts the ground (Fujita 1981). This feature will be detected by the radar only if the storm is within 20-30 miles of the radar (due to beam height restrictions), but is assumed to be present in storms at ranges beyond 30 miles, when SVC is detected. SVC extends the range of detection of downburst-producing single cell thunderstorms to about 90 miles from the radar.

c. **Determining Straight-Line Wind.**

(1) When a storm is between the KGRK RDA and the Fort Hood Reservation use a base velocity (BV) product (lowest available elevation slice—0.5°). Place the cursor over areas of strongest inbound/outbound velocities and find the exact value associated with the storm to get an approximation of expected surface wind.

(2) **Limitations:** If the storm is not moving directly towards, or away from the radar the values will be under-estimated. In addition, if the storm is too far from the RDA, the lowest available radar beam will be too high and not give a good depiction of expected surface wind. (The KGRK radar beam varies from 2,000 feet AGL at the most southern edge of the reservation to over 3,600 feet AGL at the northern edge.)

d. **MARC Signature.** MARC (Mid-Altitude Radial Convergence) is a phenomenon that occurs behind a bow echo-squall line. It occurs as the descending rear inflow jet (RIJ) converges with the ascending leading-edge flow causing persistent areas of enhanced radial convergence within the larger zone of convergence along the leading edge of the convective line. This is a good method for forecasting damaging straight-line wind associated with a squall line because it usually occurs 10-20 minutes before the onset of severe wind.

(1) Best viewed using BR and BV products looking for convergent couplets with elevation slices intersecting the mid-levels of the squall line. You can also cut a velocity Cross-section through the bow of the line.

(2) Characteristics:

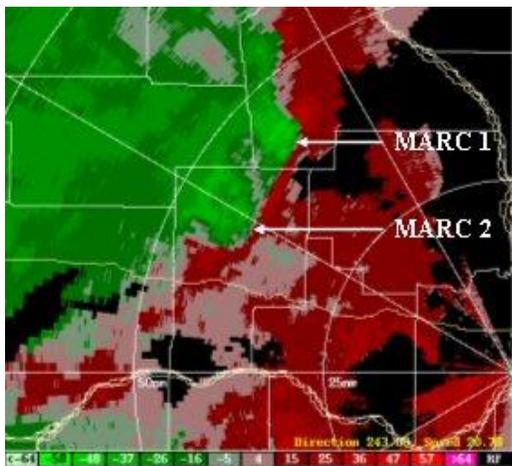
(a.) Horizontal Extent: One to three convergent couplet maxima embedded within a larger region of convergence extending from 20 - 90 nm in length.

(b) Magnitude: Velocity differences (max inbound + max outbound) of 50-60 knots are typically associated with damaging wind at the surface.

(c) Height AGL: Range from 10,000-21,000 feet; average 15,000 feet.

(d) Width: 1-3 NM.

(e) Depth: Range from 4,500-20,000 feet; average 13,000 feet.



NOTE: the viewing angle is extremely important when viewing the MARC signature. The convective line must be moving nearly directly toward or away from the radar.

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6. Mesocyclone/Tornado

IMPORTANT: The values in the techniques below should be used as general guidelines only; values for Central Texas may differ. In addition, the closer you are to the radar, the more accurate most of the following interpretation techniques will be.

a. **General ways to identify rotation.** Open a 2- or 4-window screen configuration.

(1) **2-Window Configuration:** Open the lowest available Base Reflectivity (BR) product next to the 2nd or 3rd lowest (0.9°/1.3° or 1.5° or 1.8°/2.4°) Storm Relative Velocity (SRV) product. (The 0.5 SRV is usually over-cluttered and not good for METWATCH, because if you have strong rotation on the 0.5 elevation slice, you probably already missed the tornado.)

IMPORTANT: Ensure the Storm Motion Vector has been set. In addition, you can substitute one or more of the SRV products for an NROT product.

(2) **4-Window Configuration:** Open the lowest available BR product next to the lowest SRV product, then on the other two windows open the 2nd and 3rd lowest SRV products.

(3) Use the BR to identify any severe or tornadic reflectivity signatures (Hook Echo/V-Notch) in the vicinity of a rotational couplet on the SRV product(s).

NOTE: There is no ability to “link the cursors” like the OPup, but you can place a marker/home icon on the screen to match the locations.

b. **Mesocyclone Verification.** Mesocyclones are indicative of tornadic development, but verifying one does not constitute a tornado being present in the storm. It does, however indicate the storm is most likely severe.

(1) Open desired windows as described in paragraph a., so you can view low to mid-level velocity products (SRV). Look for areas of rotation inside of a storm cell--find the **absolute value of your maximum inbound and outbound velocity values and divide by 2**. Do this by placing the cursor over the individual pixels which contain these values, and identifying the value on the status bar.

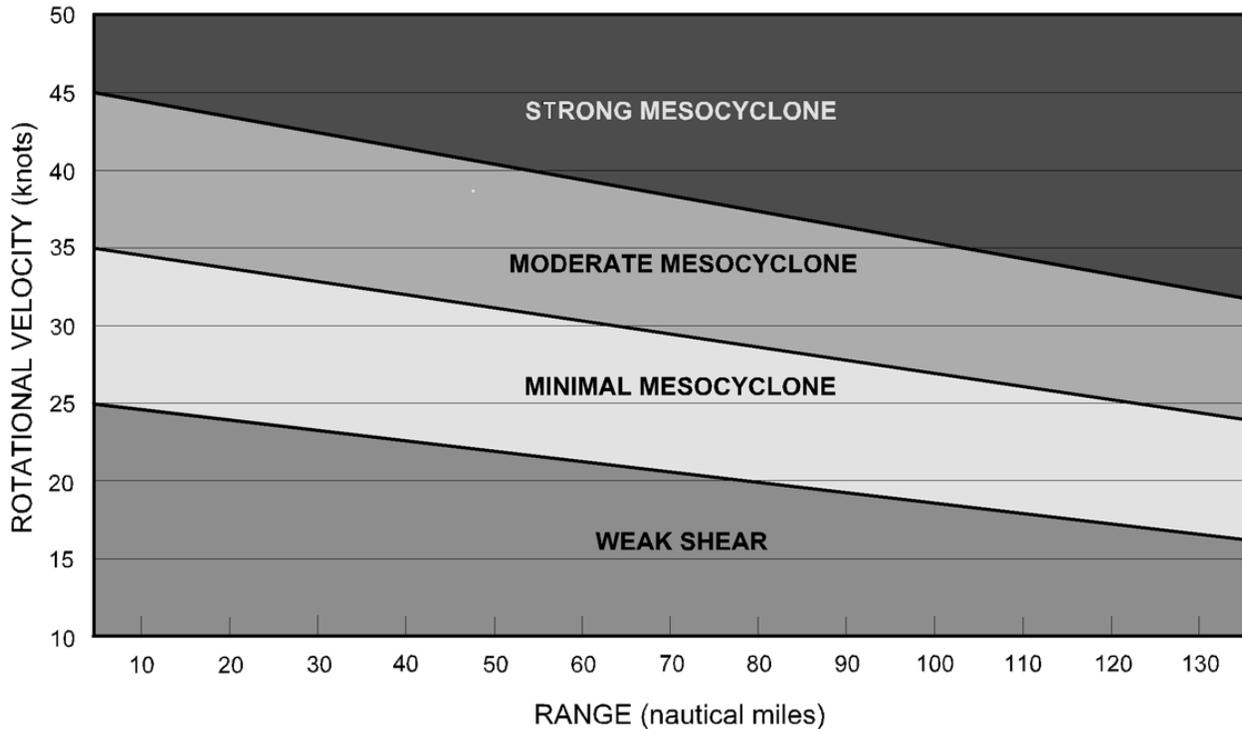
ROTATIONAL VELOCITY: $V_r = (|V_{in}| + |V_{out}|) / 2$, use mid-range values

NOTE: Gate-to-Gate shear is not required or likely when using **GR2A**. The resolution of the product is such, that there will be many data pixels in any given 5NM wide ring.

(2) A Mesocyclone exists if all the observation criteria listed below are made in association with the updraft portion of the storm.

- **Core Diameter:** $\leq 5\text{NM}$
- **Vertical Extent:** Rotation extends at least 10,000 feet
- **Time Continuity:** Circulation signature must persist for at least two successive volume scans.

(3) When the absolute value is calculated, compare it to the chart below.



NWS EHB 6-539 Reference Card 05

CAUTION: Use other data sources, such as environmental characteristics, weather reports / observations as part of the Cooperative Weather Watch, unofficial weather reports from credible sources, and storm reports (spotters) to help determine if a tornado warning condition exists.

(4) You can also perform a velocity Cross-section across the radial (perpendicular to the radar beam) and switch to the SRV product. It will provide a depth estimate (need 10,000 feet) and location of the circulation.

(5) You can also perform a 3D Volumetric Display of the area of rotation, and then switch the product to the Rotation sweep. It is easiest to view the rotation by switching the mode to ISOSURFACE, then adjusting the ISOVALUE to where you can see your rotational column's vertical extent. This will give you a vertical overview of how strong and how high the rotation extends.

c. TVS (Tornadic Vortex Signature) Verification.

(1) Open desired windows as described in paragraph a., so you can view low to mid-level velocity products (SRV). Perform the same analysis techniques used to find the Mesocyclone value, but focus on the lower evaluation slices, instead of the mid-levels. A tornado may or may not be associated with a pre-existing Mesocyclone; however, most strong or violent tornadoes are preceded by a strong Mesocyclone.

NOTE: Gate-to-Gate shear is not required or likely when using **GR2A**. The resolution of the product is such, that there will be many data pixels in any given 5NM wide ring.

(2) A TVS exists if all the following observation criteria are met within a Mesocyclone:

- **Azimuthal Shear: Azimuth-to-azimuth (gate-to-gate) difference between maximum inbound and maximum outbound velocity is > 90 knots within 30NM or > 70 knots from 30 to 55 NM.**
- **Vertical Extent: Rotation extends several thousand feet, or through at least two elevation angles.**
- **Time Continuity: Rotation persists for at least two consecutive volume scans.**

NOTE: Vertical extent and time continuity criteria do not necessarily have to be met for confident TVS recognition. **Shear is the most important criterion.**

CAUTION: Use other data sources, such as environmental characteristics, weather reports / observations as part of the Cooperative Weather Watch, unofficial weather reports from credible sources, and storm reports (spotters) to help determine if a tornado warning condition exists.

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7. Wind Shear

- a. **Velocity** is the best product for identifying areas or layers of wind shear. These areas/layers show up as abrupt changes in the velocity pattern.
- b. Associated with these abrupt changes are the areas of high **Spectrum Width** values.
- c. The **VWP** can also be valuable for identifying layers of wind shear. However, low-level wind shear may not always show up in the VWP. Many cases have been observed in which the shear is only a few hundred feet in depth and can only be found in the **Base Velocity**.

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8. Turbulence

- a. Turbulence, although not directly measured by the radar, can be inferred within areas of abrupt **velocity** changes. **Velocity** cross-section products can be useful in evaluating the likelihood of turbulence.
- b. Also, higher **Spectrum Width** values may be indicative of turbulent airflow and eddies.
- c. The **VWP** may help identify layers of potential turbulence, but the vertical resolution of these velocity estimates may be too coarse for specific turbulence measurements.

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9. Icing/Melting Layer

a. **Base Reflectivity** and **Spectrum Width** can be used to monitor the melting level. With the increased sensitivity, it is easy to determine the depth of the moisture, not just the precipitation. The melting level will show up as a ring, or a partial ring, of slightly higher reflectivities and Spectrum Width values.

b. **Base Velocity** and **Spectrum Width** can be used to monitor the possible lowering/raising of the melting level due to an approaching boundary.

c. The **GR3** has a Melting Layer (ML) product. It is a series of lines showing the position of the melting layer relative to the radar beam for a given tilt.

(1) The melting layer itself is determined by the radar using three methods:

(a) Automated detection of the melting layer signature in **CC (Correlation Coefficient—Dual-pol product)** and **BR** (when possible).

(b) Environmental model data (RAP). The freezing level is the top and the bottom is assumed to be 500 meters below.

(c) Manual entry of the melting layer top and bottom.

(2) Since the radar beam increases in height with range, the melting layer lines typically form rings around the radar site. These rings are not typically perfect circles due to two factors:

(a) The melting layer heights can vary around the radar site

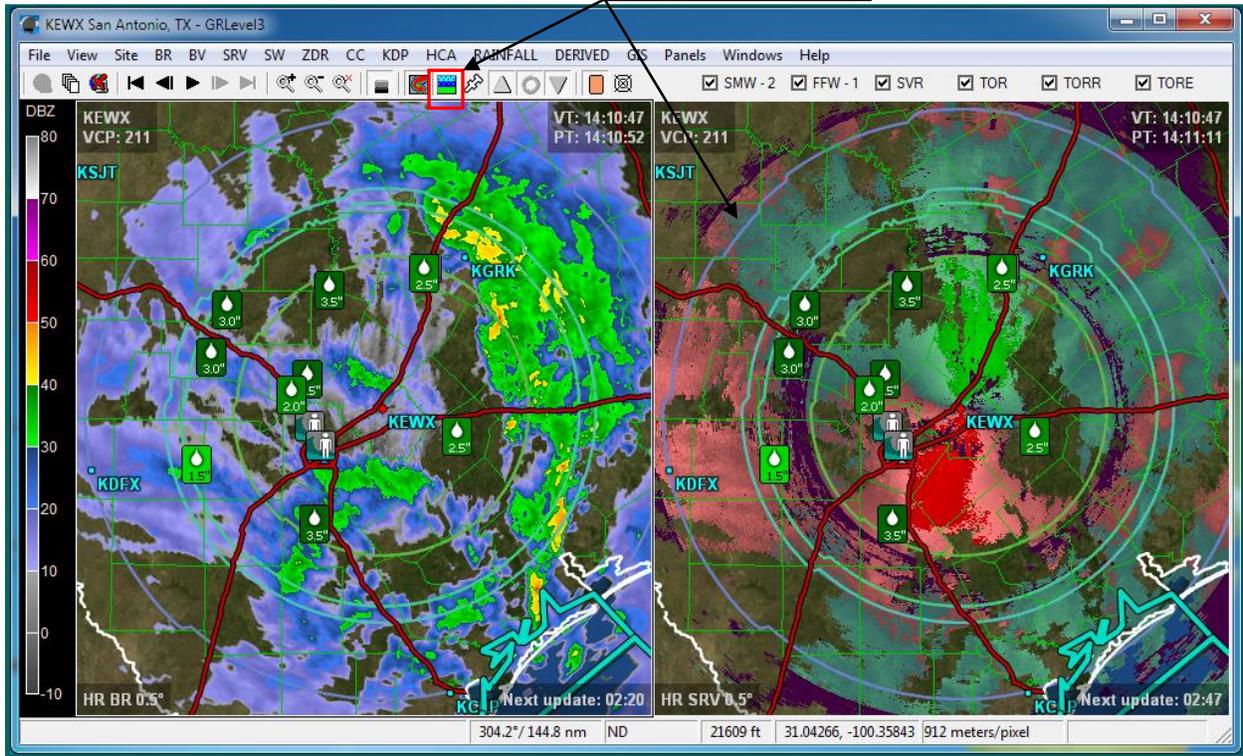
(b) The beam elevation angle varies with azimuth (typically at the start of a tilt).

(3) **GR3** only shows a particular tilt of the melting layer when its corresponding graphical radar product is displayed. For example, **ML 0.5° only shows up on BR/BV/SRV 0.5°**. There are up to four ML lines shown:

Inner Light Gray Ring	Where the beam top enters the Melting Layer
Inner Solid White Ring	Where the beam center enters the Melting Layer
Outer Solid White Ring	Where the beam center leaves the Melting Layer
Outer Light Gray Ring	Where the beam bottom leaves the Melting Layer

(4) In winter you will sometimes only see the outer ML rings and/or partial ML rings because the bottom of the melting layer is below the radar site itself.

Select icon to turn on or off the ML display



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10. Stratiform Precipitation

- a. The high sensitivity of **Base Reflectivity** helps determine the depth of the clouds associated with stratiform precipitation. The **Composite Reflectivity** can help isolate areas of embedded shower activity or heavier rainfall.
- b. **VIL** should be used to isolate convective activity.
- c. **Velocity** can be used to identify the moisture conveyor belt and upper-level influences that will affect the aerial coverage and intensity of precipitation. Velocity has also been used to identify stationary bubble highs that cause heavy precipitation to persist over small areas.
- d. **Echo Tops** will identify the top of the 18 dBZ return, highlighting areas of convection.
- e. The **VWP** can also help identify and track changes in the atmospheric flow aloft.

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11. Non-precipitation Echoes / Non-meteorological Echoes

a. Non-precipitation Echoes.

(1) The high sensitivity of the WSR-88D will allow the detection of frontal boundaries, troughs, inversions, and other discontinuity lines or objects. These phenomena are detected on the **Base Reflectivity** product between the displayed values of -15 to $+8$ dBZ.

(2) These phenomena can also be identified in the **Velocity** fields as areas of sharp changes within the velocity pattern.

(3) The **VWP** product is also helpful in identifying the depth of the moisture layer and the atmospheric support for severe convective development (e.g. shear).

(4) As with the other base products, areas of higher **Spectrum Width** aid in the identification of various atmospheric discontinuities.

(5) In addition, cloud layers (particularly ice crystals) can be identified in the Base Reflectivity, Velocity, and Spectrum Width. Bases and tops can be easily identified and are very accurate.

b. Non-meteorological Echoes.

(1) These echoes will first be identified on the **Base Reflectivity** product. Select a higher tilt (elevation slice) and ground clutter/AP will normally disappear.

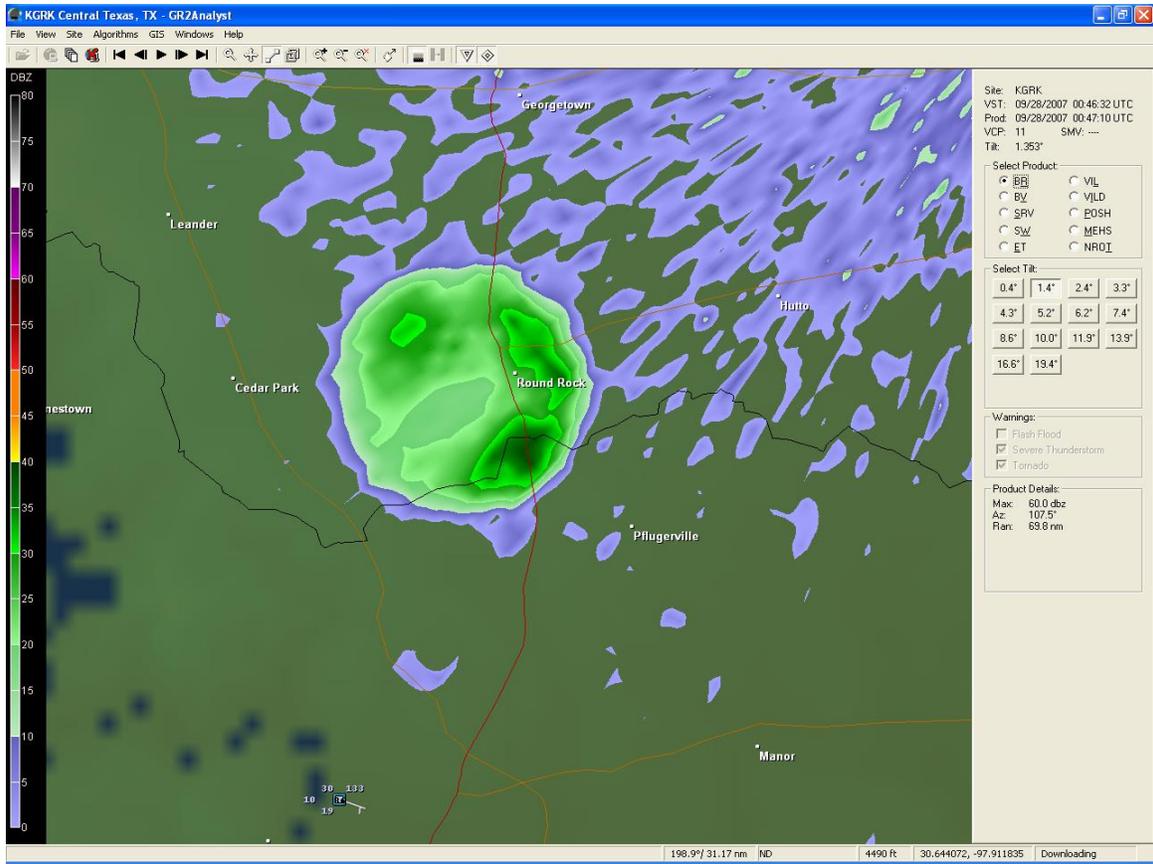
(2) **Spectrum Width** product used in conjunction with **VIL** should also show low or nonexistent values.

(3) Lastly, **Velocity** will be noisy, erratic, and will not reflect the environmental flow.

(4) The detection of ground clutter and biological scatterers is improved with dual-polarization radar. Ground clutter, such as trees, buildings, and high terrain, is usually represented on dual-polarization imagery by:

- Noisy Z, sometimes as high as 80 dBZ
- Noisy ZDR with a mixture of positive and negative values
- CC less than 0.90
- No display of KDP, because CC is less than 0.90

(5) The appearance of biological scatterers, such as birds and insects, depends on their orientation with respect to the radar beam. Birds will sometimes be represented by noisy, positive values of ZDR. In other cases, ZDR may be low or negative. Insects are indicated by positive values of ZDR. Birds and insects both result in CC less than 0.90. Also, biological scatterers can often be distinguished from stationary ground clutter because they produce non-zero velocity values.



Bats leaving their cave to feed at sunset.

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12. Heavy Rainfall / Flash Floods

a. **VIL** used in conjunction with **Storm Tracks** will identify areas of potential heavy precipitation and the relative speed of movement of these areas.

b. **Base Reflectivity** may also be helpful in isolating high precipitation areas.

c. **Base Velocity** can be used to locate the moisture conveyor belt, identify an upper-level impulse that enhances the rate and/or aerial coverage of precipitation. Base Velocity can also be used to identify bubble highs that tend to cause heavy precipitation to persist over small areas.

d. **Echo Tops** can be used to highlight shower embedded within large areas of precipitation.

e. **Dual-polarization** radar can help distinguish between different types of heavy rainfall.

(1) Look for the following indications of heavy **tropical rainfall**:

- Z of 40 to 55 dBZ
- ZDR of 0.5 to 3 dB (due to relatively small drops)
- CC of 0.98 or 0.99
- KDP greater than 1.0 deg/km

(2) Continental heavy rainfall is typically associated with deep, sometimes severe, convection. The following signatures are indicative of heavy **continental rainfall**:

- Z of 50 to 60 dBZ
- ZDR of 2 to 5 dB (drops are larger than in a tropical environment)
- CC greater than 0.96 (anything less indicates a mixture with hail)
- KDP significantly higher than 1.0 deg/km
- Z of 40 to 55 dBZ
- ZDR of 0.5 to 3 dB (due to relatively small drops)
- CC of 0.98 or 0.99
- KDP greater than 1.0 deg/km

f. If the storm is producing much of its rainfall from warm rain processes, the default Z/R relationship may **underestimate rainfall rate** owing to high concentrations of small droplets. These storms are marked by deep warm clouds, little lightning, and the greatest reflectivity located below the freezing level.

g. **Multi-cell Storm Motion and Storm Training.** Multi-cells have a tendency to produce flash flooding because of their regenerative nature. Back-building, or “training” of echoes, typically occurs when the component of a system's motion arising from cell regeneration nearly cancels the effects of motion attributed to mean steering-layer flow. Successive cells associated with the multi-cell complex can reach maximum intensity and produce maximum rainfall over the same geographical area.

h. **Storm Motion with Respect to Forcing.** Forcing mechanisms play an integral role in the development and motion of convection. A forcing mechanism can be defined as any type of boundary (front, gust front, outflow, etc.) or a topographic feature (i.e., mountains). How convective storms form and move with respect to the boundary can determine whether you are dealing with isolated updrafts or line segments. Flow perpendicular (parallel) to the boundary produce isolated (linear) convection. **Slow moving boundaries with linear convection provide the greatest duration for a general area.**

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13. Tropical Storms

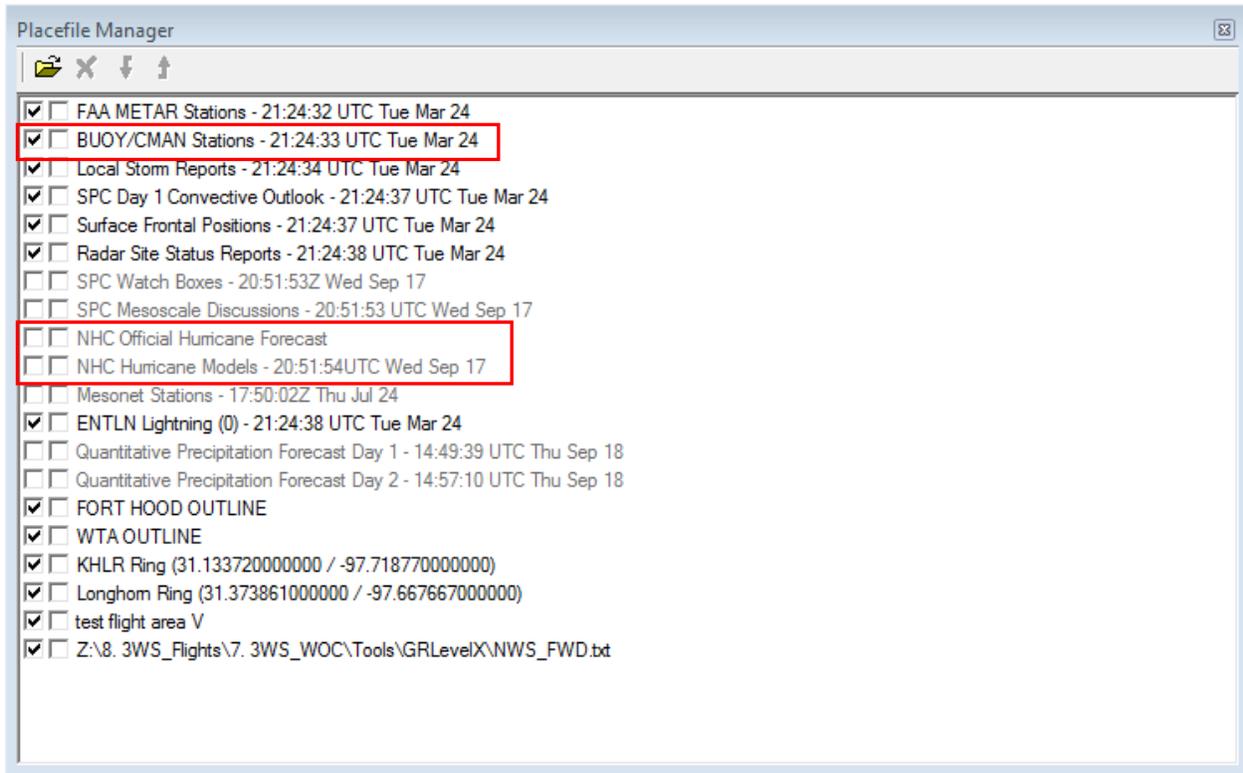
a. **Composite Reflectivity** can be used to view the aerial extent of the storm within the radar range. **Base Reflectivity** should be used to identify the bands and possible heavier precipitation areas with **VIL** used to isolate the heaviest rainfall areas.

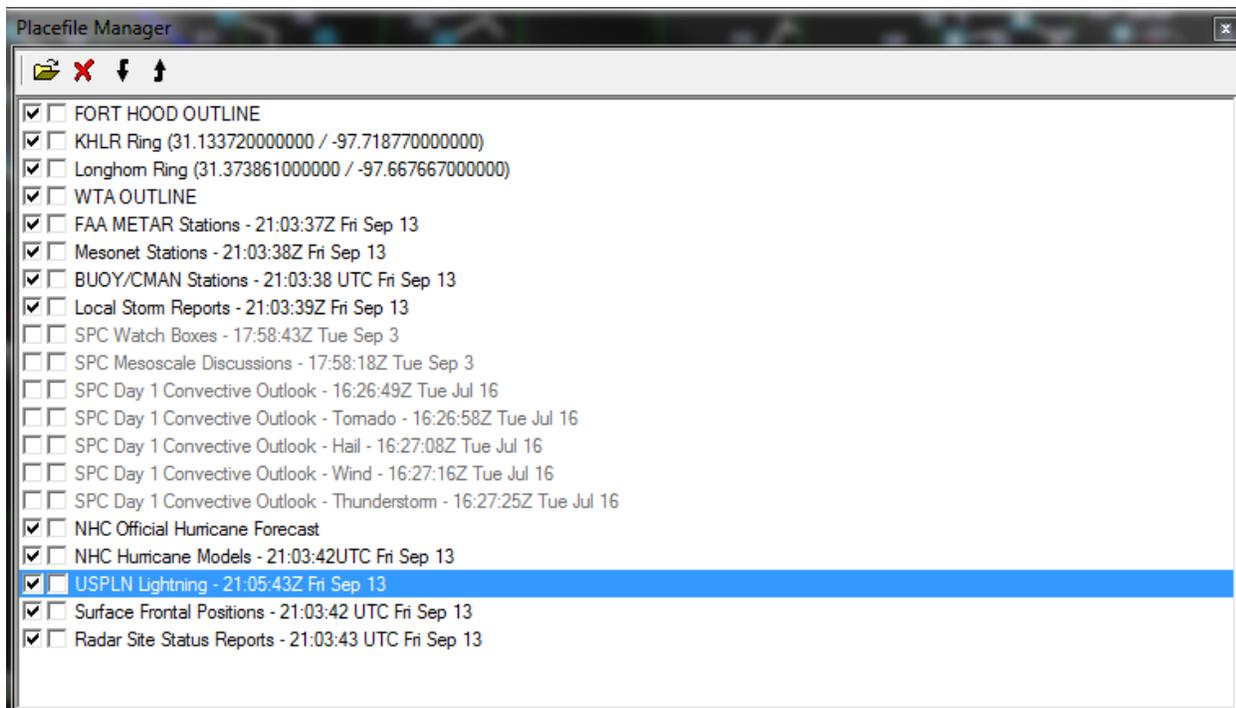
b. **Base Velocity** used with **Reflectivity** will help pinpoint the eye location when within the radar range. **Base Velocity** will also be best for determining velocity characteristics within the tropical storms for mesocyclonic circulation and/or the existence of a TVS.

c. **Echo Tops** will show the height of the 18 dBZ return, but will not provide much other information.

d. **Cross-sections** can provide additional information on structure.

e. **Placefiles:** The NHC official hurricane forecasts and NHC hurricane models are available as place files to overlay the radar products. BUOY/CMAN stations in the Gulf of Mexico can also be displayed.





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Quick Reference VCP Comparison Table for RPG Operators					February 2014
Slices	Tilts	VCP	Time*	Usage	Limitations
	14	11	5 mins	Severe and non-severe convective events. Local 11 has Rmax=80nm. Remote 11 has Rmax=94nm.	Fewer low elevation angles make this VCP less effective for long-range detection of storm features when compared to VCPs 12 and 212.
		211	5 mins	Widespread precipitation events with embedded, severe convective activity (e.g. MCS, hurricane). Significantly reduces range-obscured V/SW data when compared to VCP 11.	All Bins clutter suppression is NOT recommended.
	14	12	4 mins	Severe convective events. Extra low elevation angles increase low-level vertical resolution when compared to VCP 11.	High antenna rotation rates slightly decrease accuracy of the base data estimates.
		212	4½ mins	Rapidly evolving, widespread severe convective events (e.g. squall line, MCS). Increased low-level vertical resolution compared to VCP 11. Significantly reduces range-obscured V/SW data when compared to VCP 12.	All Bins clutter suppression is NOT recommended. High antenna rotation rates slightly decrease accuracy of the base data estimates.
	9	21	6 mins	Non-severe convective precipitation events. Local 21 has Rmax=80nm. Remote 21 has Rmax=94nm.	Gaps in coverage above 5°.
		121	6 mins	VCP of choice for hurricanes. Widespread stratiform precipitation events. Significantly reduces range-obscured V/SW data within 230 km when compared to other VCPs.	All Bins clutter suppression is NOT recommended. High antenna rotation rates slightly decrease accuracy of the base data estimates. PRFs are not editable. Gaps in coverage above 5°.
		221	6 mins	Widespread precipitation events with embedded, possibly severe convective activity (e.g. MCS, hurricane). Reduces range-obscured V/SW data out to 300 km when compared to other VCPs.	All Bins clutter suppression is NOT recommended. Gaps in coverage above 5°.
	5	31	10 mins	Clear-air, snow, and light stratiform precipitation. Best sensitivity. Detailed boundary layer structure often evident.	Susceptible to velocity dealiasing failures. No coverage above 5°. Rapidly developing convective echoes aloft might be missed.
		32	10 mins	Clear-air, snow, and light stratiform precipitation.	No coverage above 5°. Rapidly developing convective echoes aloft might be missed.

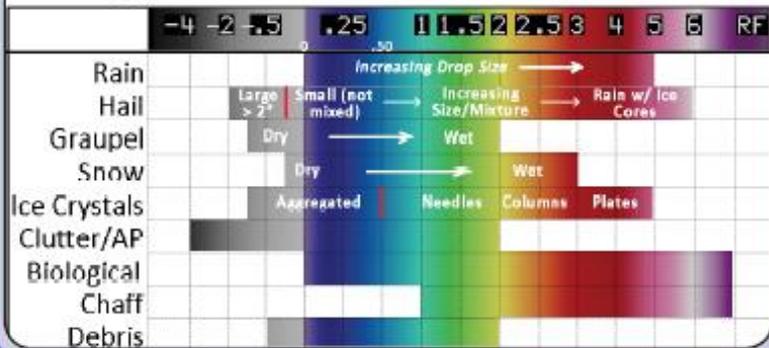
*VCP update times are approximate.

WSR-88D Dual Polarization Guide

Differential Reflectivity (ZDR)

Definition: The horizontal reflectivity minus the vertical reflectivity.

Typical Values for ZDR (dB)



Hydrometeor Classification (HC)

HC Applications

- Primary input for rainfall estimation
- Safety net for novices attempting hydrometeor identification using base data

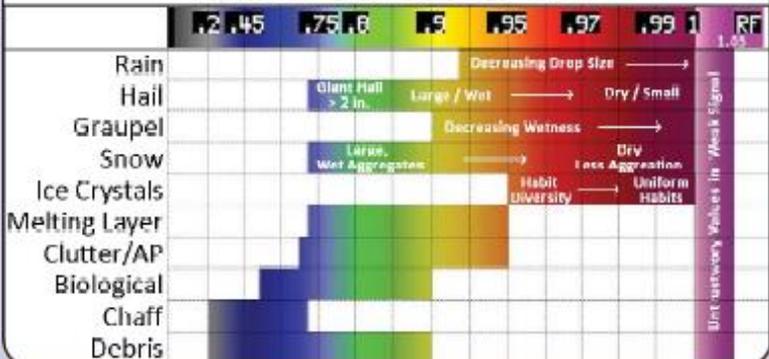
HC Limitations

- Uncertainty in classification not presented
- Relies on accurate Melting Layer Detection Algorithm output for successful classifications
- Overlapping product characteristics leads to improper classification
- Often will not represent what is occurring at the ground

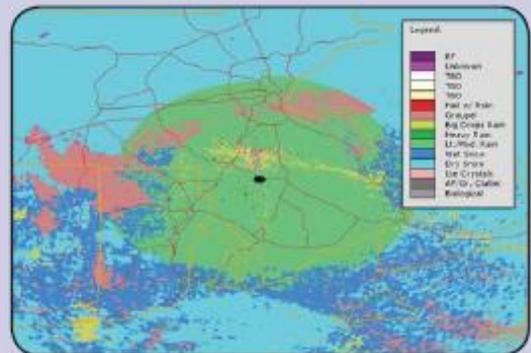
Correlation Coefficient (CC)

Definition: The measure of the consistency of the shapes and sizes of targets within the radar beam.

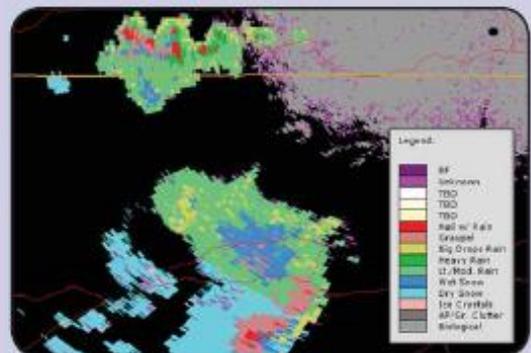
Typical Values for CC



Cold Season Example:



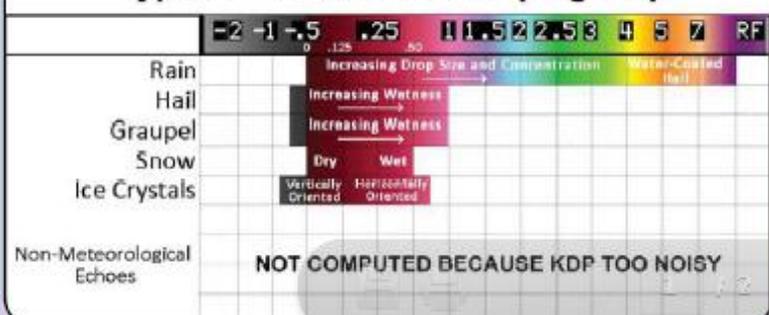
Warm Season Example:



Specific Differential Phase (KDP)

Definition: Indicator of liquid water content sampled within the radar beam

Typical Values for KDP (deg/km)



HC Recommendations

- The HC product can provide a first guess in specific areas of interest
- You should always compare the HC product with environmental and radar base data
- When you are convinced it is accurate, the HC product provides an easily understood image for your audience
- Hard boundary at the melting layer may convey the wrong message to viewers (especially in Summer)
- Beware below beam effects!

Identifying Meteorological Echo vs. Non-Meteorological

Meteorological

White Ovals:

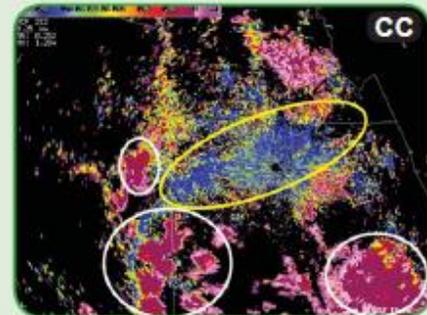
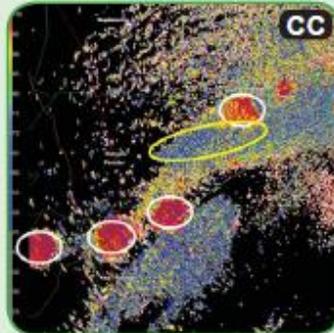
Z: > 15 dBZ
 CC: usually > 0.80



Non-Meteorological

Yellow Ovals:

Z: usually < 20 dBZ
 CC: usually < 0.80



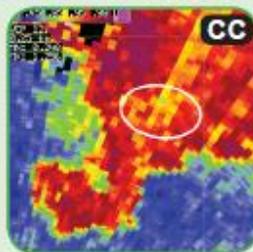
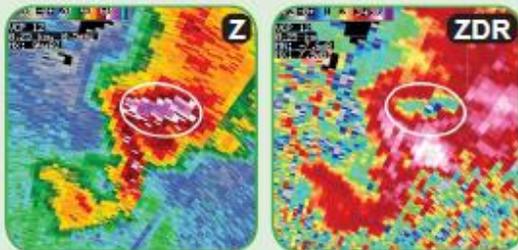
Hail Detection

What to look for:

- Z: local maximum (> 50 dBZ)
- ZDR: local minimum (< 2 dB)
- CC: local minimum (0.7-0.95)

*Specific hail size unknown

*Hail may not reach the ground



Heavy Rain Detection

What to look for:

- KDP: local maximum (> 1°/km) & evidence of melting hail (> 5°/km)

*Amount of rain reaching ground dependent on below beam conditions

