Learner Version

Advanced Warning Operations Course
IC Core 4
Data Quality
Lesson 5

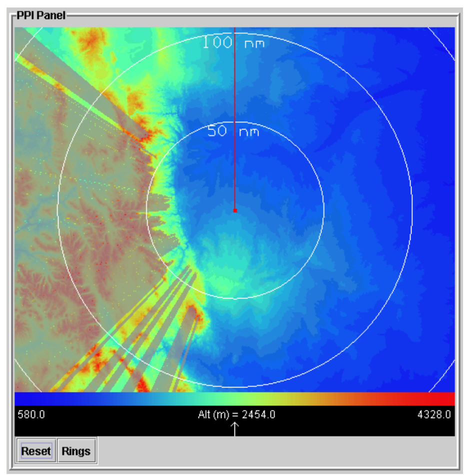
VCP Explorer Job Sheet 1
VCP Explorer V2.x

<u>Objective</u>: The objective of this exercise is to learn the basic operations of VCP Explorer and to use VCP Explorer to examine radar ground clutter patterns.

In this exercise, "LM" refers to the left-mouse button, "MM" refers to the middle mouse button, and "RM" refers to the right-mouse button.

1. Start VCP Explorer and change the active radar to Denver (KFTG).
   [File → Choose Radar → KFTG]

2. Turn on the Ground Clutter (beam blockage) view.
   [GC button]

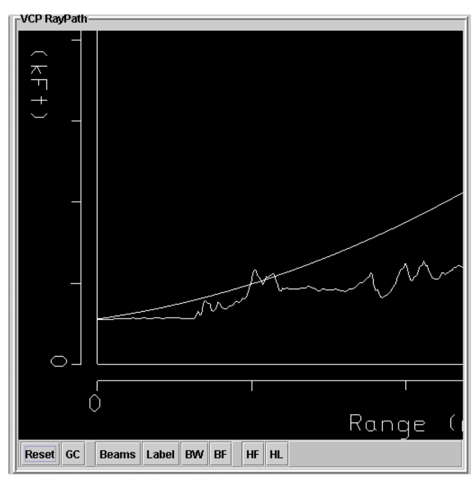


3. Zoom on the PPI display so that the 100 nmi range ring fills the display as shown in the figure to the right.
   [Shift+RM+Drag]

4. Turn on the beam-width display.
   [BW or BF button]

5. Examine the character of the ground clutter pattern by looking at various azimuths between 270° and 312° and between 198° and 230°. Note the relative amounts of beam filling by the terrain that occur with different azimuths.
   [type various azimuth numbers in the Azimuth box and press Enter]

6. Change the azimuth to 235°. If *super-refractive* conditions were to occur (as opposed to the "normal" conditions assumed by the 4/3 earth's radius model), at what range might beam blockage at 0.5° begin to appear? What is the "normal" beam height at that azimuth and range?
   [type 235 in the Azimuth box and press Enter. Zoom



(Shift+RM+Drag) and/or pan (RM+Drag) the RHI plot to obtain a view similar to the figure to the right. Use the cursor readout function (MM+Drag or LM+RM+Drag) to get the value].

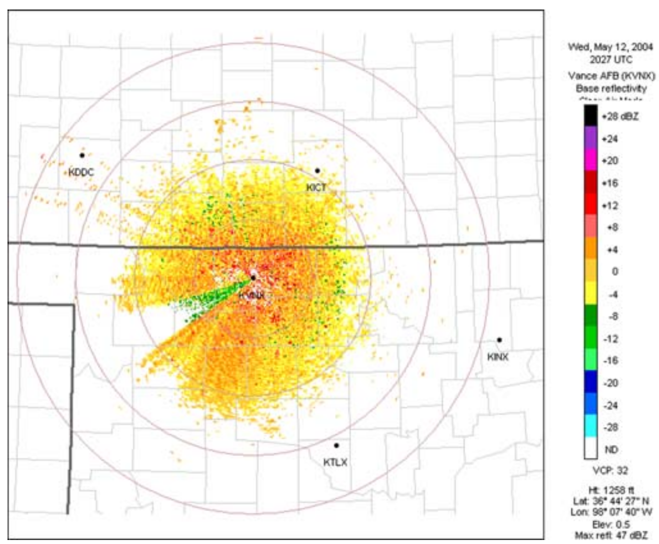
7. Change the VCP to VCP 12. Change the azimuth to 260°. At what range does the beam blockage start on the lowest tilt?

   Under "normal" propagation conditions, speculate about any beam blockage on the second tilt (0.9°). At what range might you expect it to begin?

   Change to the second tilt to check your answer.
   [click the  **button]**

   Turn on the ground clutter shading for 0.9° and describe the pattern.
   [GC button]

8. The image to the right is a base reflectivity image from late afternoon from the Vance Air Force Base (KVNX) WSR-88D at 0.5° on a well-mixed day. Note the beam blockage southwest of the radar between the 238º and 253º azimuths. Use VCP Explorer to speculate on the cause of the beam blockage. Hint: try to make VCP Explorer mimic the observed beam blockage pattern by changing the elevation angle and the beam blockage percentage values.



9. Use VCP Explorer to investigate any beam blockage or ground clutter patterns from your own radar(s) by using the functions shown in Steps 1-7 above. If your local radars do not exhibit beam blockage, you may choose one of the radars below:

Western Region		
ATX – Seattle	BBX – Beale AFB	EMX – Tucson
EYX – Edwards AFB	IWA – Phoenix	MTX – Salt Lake City
PDT – Pendleton	TFX – Great Falls	VTX – Los Angeles
Central Region		
GJX – Grand Junction	PUX – Pueblo	UDX – Rapid City

Southern Region		
ABX – Albuquerque	EPZ – El Paso	MRX – Morristown
SRX – Fort Smith		
Eastern Region		
CXX – Burlington	ENX – Albany	FCX – Roanoke
GSP – Greer	GYX – Portland, ME	LWX – Sterling
Alaska/Pacific Regions		
PACG – Biorka Island	PAEC – Nome	PAKC – Anchorage
PHKI – South Kauai	PHMO – Molokai	PHWA – South Shore

If you have any questions about this job sheet, please send e-mail to iccore4@wdtb.noaa.gov.

Answer Key

1-4. ***Perform the operations as directed.***

5. ***This series of images illustrate the beam blockage between 198° and 230°. Similar images would result between 270° and 312°. Between 198° and 230°, various azimuths are blocked by terrain obstacles including the following locations:***

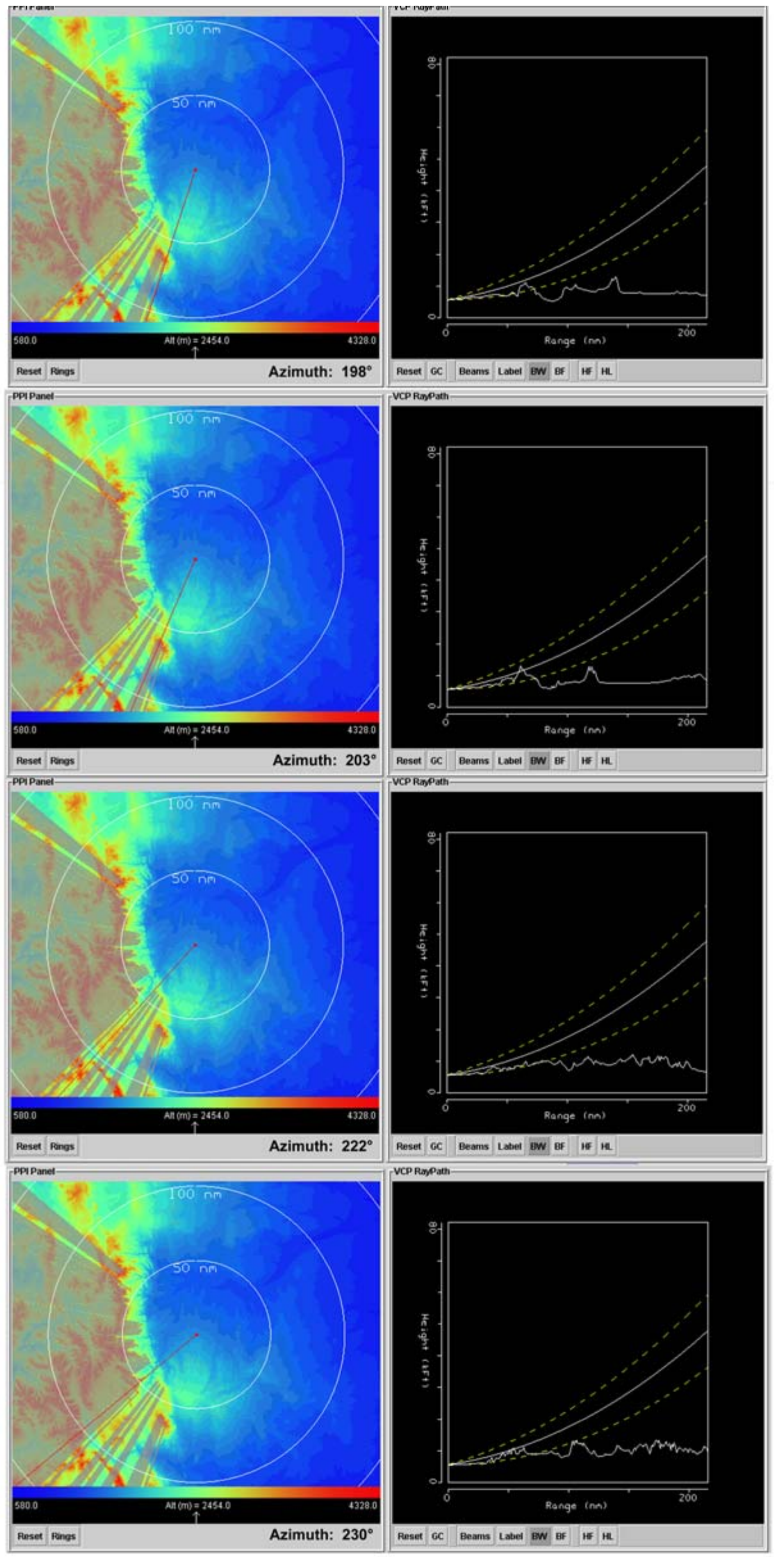
- ***60 nmi between 198° and 206°***
- ***43 nmi between 210° and 220°***
- ***56 nmi at 225°***

198°

203°

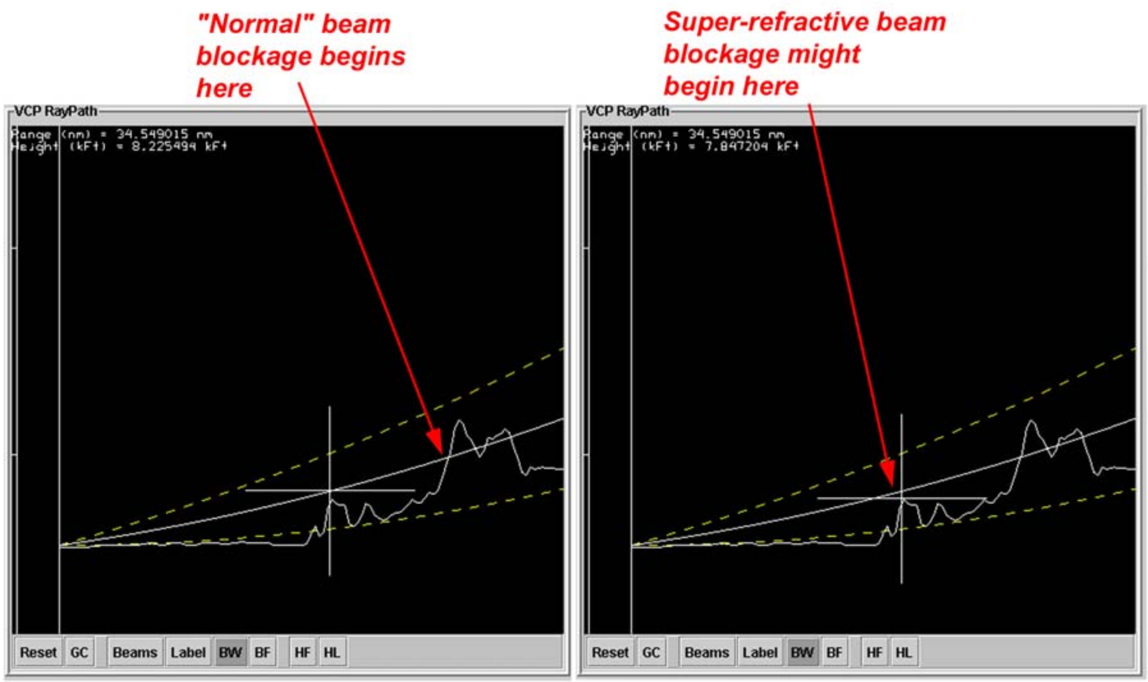
222°

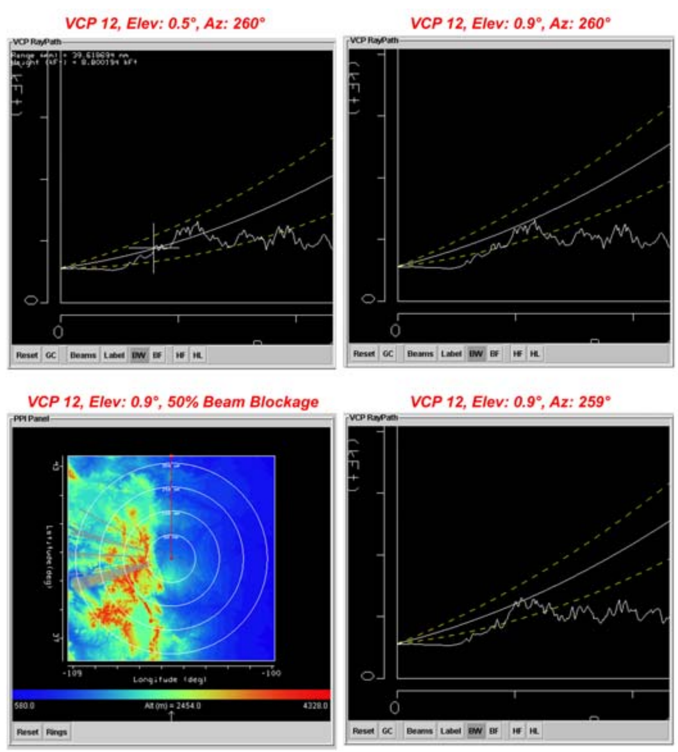
230°



Answer Key

6. ***This graphic illustrates where the beam blockage might begin under super-refractive conditions. The cursor readout is at a range of 34.55 nmi. From the right figure, the terrain height is 7847 feet. From the left figure, the normal beam height is 8225 feet.***





7a. ***The range is ~40 nmi.***

7b. ***The terrain goes significantly above the 0.5º beam centerpoint between 49 nmi and 58 nmi. The terrain at those ranges may be high enough to reach the centerpoint of the 0.9º tilt.***

7c. ***At 260°, the terrain is barely under the 0.9° beam centerpoint. Changing the azimuth to 259° reveals that the terrain goes above the 0.9° beam centerpoint for 50% beam blockage.***

7d. ***The largest area of ground clutter that impacts the 0.9° elevation angle is located between the 250° and 259° azimuths.***

***8.** Starting with the default values and taking the beam blockage percentage down to 10% at the 0.5º tilt provides no 10% or greater beam blockage. Using an elevation angle of 0.3º results in 10% beam blockage between the 2º and 6º azimuths. Using an elevation angle of 0.2º provides more areas of 10% beam blockage but not between the 238 and 253 azimuths where the real beam blockage is observed. By using these values (which have become increasingly unrealistic), it becomes evident that VCP Explorer cannot model the beam blockage from KVNX. Therefore, it is likely that this beam blockage pattern results from causes other than simply terrain.*

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VCP Explorer Job Sheet 2
VCP Explorer V2.x

Objective: The objective of this exercise is to use VCP Explorer to visualize the sampling of the lower atmosphere by the precipitation-mode VCPs.

In this exercise, "LM" refers to the left-mouse button, "MM" refers to the middle mouse button, and "RM" refers to the right-mouse button.

1. Start VCP Explorer and use the KIWA radar. Make sure the VCP is set to VCP 21. Turn on the beam width, beam labels, and beam filling functions. Note how the beams for the individual tilts are adjacent to one another.
   [Click the Beams, Label, BW, and BF buttons]

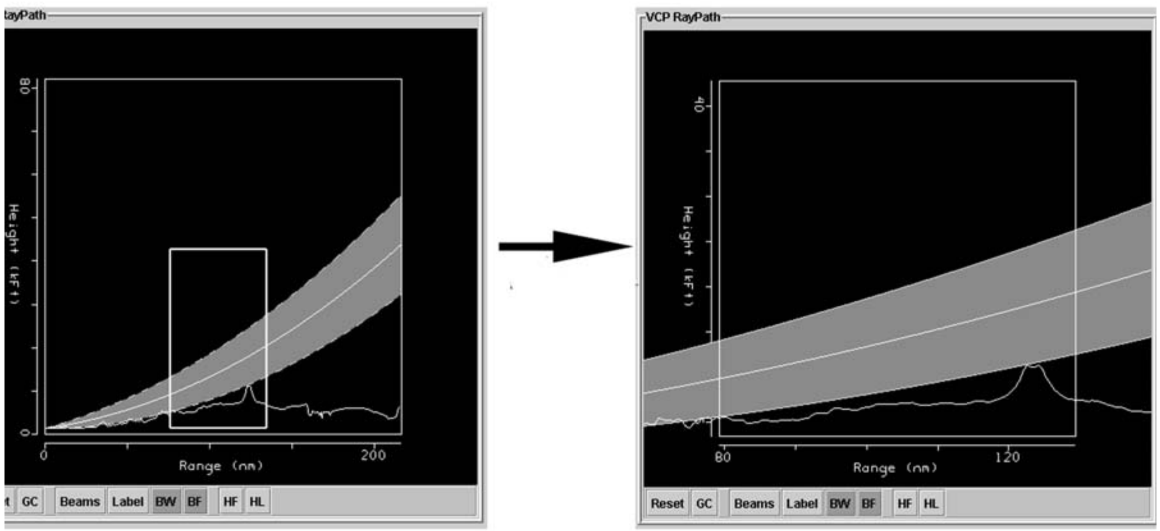
2. Change the VCP to VCP 11. Although there are more tilts, the beams are still adjacent to one another. Turn off the Beams function and successively cycle through adjacent elevation angles to see the relationship between adjacent tilts.
   [Click the Beams button. Click on 0.5, 1.45, 2.40, 3.35, 4.30, etc. in sequence]

3. Change the VCP to VCP 12, and successively cycle through the tilts below 8.0°. What is noticeably different between VCP 11 and VCP 12?

4. Change the VCP back to VCP 11. Choose the 0.5° elevation scan and turn on the beam filling option.

   `[Click the BF button]`

   Zoom the RHI display so that the vertical scale is between 5 and 40 kft and the horizontal (range) scale is between 80 and 120 nmi as shown in the figure below.



   `[Use Shift+LM+Drag to draw a zoom box for the desired area]`

   Use the cursor-readout feature to see the lower and upper extent of the beam at 100 nmi.
   `[MM+Drag or LM+RM+Drag]`

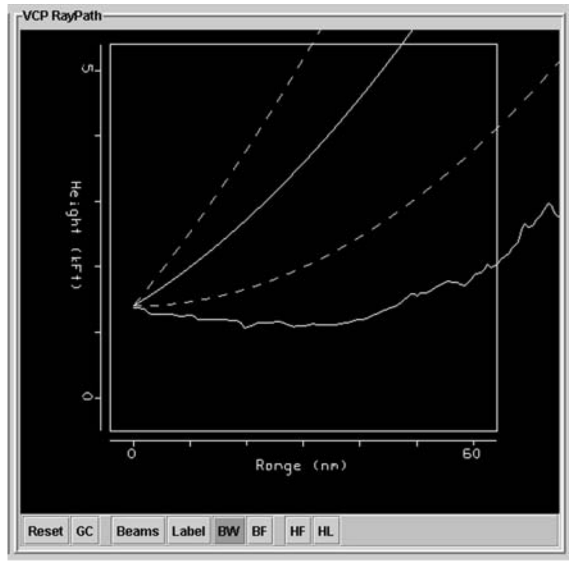
   Fill out the following table for a range of 100 nmi:

Tilt	Elevation	Lower Beam Height	Upper Beam Height
VCP 11 Tilt 1			
VCP 11 Tilt 2			
VCP 12 Tilt 1			
VCP 12 Tilt 2			
VCP 12 Tilt 3			

5. Using the table from Question 4, what tilts would sample a mass of reflectivity at 100 nmi that extended 5,000 feet upward from a base of 12,500 feet?

6. What impact would the choice of VCP 11 versus VCP 12 have on algorithms such as VIL that accumulate reflectivity in a vertical column?

7. A low-level cold pool extends vertically from the surface upwards to 2,000 feet above the surface. Assume this cold pool can be observed by KIWA at an azimuth of 300º. Beyond what range will the 0.5º beam not sample *any portion* of the cold pool? (Hint: zoom the RHI plot so that the vertical scale goes from 0 to 4000 ft and the horizontal scale ranges between 0 and 60 nm as shown).
`[To zoom, Shift+RM+Drag; To draw a zoom box, Shift+LM+Drag]`



8. For the KIWA radar, the 0.5º tilt does not have 50% beam blockage at the 357º azimuth (i.e., the GC button does not shade the 357º azimuth). Assess the implications of the terrain on the radar's ability to sample winds in the lowest 4000 ft of the atmosphere (MSL) at the 357º azimuth.

If you have any questions about this job sheet, please send e-mail to iccore4@wdtb.noaa.gov.

Answer Key

***1-2.** Perform the operations as directed.*

***3.** The low level beams for VCP 12 overlap one another (because there is less than 0.95º, the width of a single beam, of separation between the individual tilts).*

4.

Tilt	Elevation	Lower Beam Height	Upper Beam Height
VCP 11 Tilt 1	*0.5°*	*7.9 kft*	*18.7 kft*
VCP 11 Tilt 2	*1.45*	*18.1*	*28.6*
VCP 12 Tilt 1	*0.5*	*7.9*	*18.7*
VCP 12 Tilt 2	*0.9*	*12.1*	*22.8*
VCP 12 Tilt 3	*1.3*	*16.5*	*27.1*

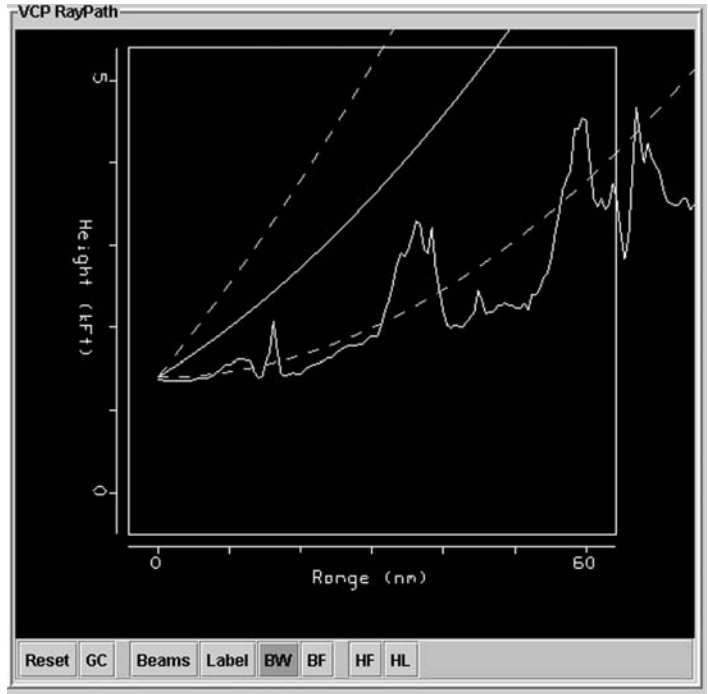
Note: These values are approximate.

***5.** The needed vertical range is 12,500 through 17,500 feet. Using VCP 11, only Tilt 1 sees this vertical area. Using VCP 12, Tilts 1, 2, and 3 all see this range.*

***6.** The same mass of reflectivity could contribute multiple times to a vertical integration in VCP 12.*

***7.** The KIWA radar's feedhorn is at an elevation of 427 m (MSL), or 1,401 feet. Therefore, 2000 feet AGL is 3401 feet MSL. By clicking on the BW button to see the beamwidth and using the cursor tracking function* `[MM+Drag]`*, we can see that the lower "edge" of the 0.5º radar beam at 3.4 kft is located at 55 nmi. Thus the radar beam would completely overshoot a cold pool that was 2000 feet deep beyond 55 nmi. The range that the beam center-point crosses 2000 feet AGL (3.4 kft MSL) is 28 nmi. Thus the radar's observations of the cold pool would become progressively degraded between 28 nmi and 55 nmi, until being no longer sampled by the radar beyond 55 nmi. This case is more complicated, however, because the terrain is not flat. The terrain is approximately 300 feet higher at 55 nmi than at the radar. As an aside, changing the azimuth to 358º, reveals that there is not 2000 feet between the terrain and the lower edge of the radar beam until at least 90 nmi, and not permanently until after about 110 nmi.)*

***8.** The radar's wind measurement is an average of the motion of the scatters in a pulse volume. There are significant ground returns (i.e., zero velocity contributions to the average) at the following ranges at the 357º azimuth: 16 nmi, 31-39 nmi, 56-60 nmi). Therefore the radar underestimates the radial velocity at those ranges along the 357º azimuth.*



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VCP Explorer Job Sheet 3
VCP Explorer V2.x

Objective: The objective of this exercise is to use VCP Explorer to understand the sampling of a steady state thunderstorm at different ranges by a given VCP.

`In this exercise, "LM" refers to the left-mouse button, "MM" refers to the middle mouse button, and "RM" refers to the right-mouse button.`

1. Start VCP Explorer, and change to the KMQT radar. Set the VCP to VCP 11. Assume you have a thunderstorm that is 40,000 feet tall. Click on the HL button and move the horizontal green line down to 40,000 feet.
   [click on the green box at the right endpoint of the line and drag it to 40 kft]

   This section is mostly applicable to the operation of the WSR-88D's suite of algorithms, which assume that an echo must reach a particular beam's center point to be observed by that beam. The yellow line given by the HL option shows the difference between the radar's perception (the closest beam center point that is below the echo) and reality (the echo itself).

2. Click on the Beams button (it may already be selected) and the Label button. What tilt samples the 40,000 foot level at a range of 135 nm?

   What is the height of that tilt's center point at 135 nm?

   What is the difference between reality and the radar's perception?

3. The thunderstorm has moved 15 nautical miles farther away from the radar. Now, what is the difference between reality and the radar's perception of the 40,000 foot level?

4. The thunderstorm has moved 5 more nautical miles farther from the radar. By how much distance does the radar underestimate the 40,000 foot level at this range?

5. Click the HF button and toggle off the HL button. The colors represent the difference in height between an actual echo (at a given range and height) and the nearest beam center-point that is below that range/height location. For

example, at a range of 150 nmi and a height of 37 kft, has a yellow/orange color value. Sliding the pointer under the Ht Underestimate color bar to the yellow/orange range reveals the height underestimate is ~13 kft. This means that the radar thinks the actual 37,000 ft echo is at the 0.5 beam centerpoint which is at 24,000 ft. (37,000 ft – 24,000 ft = 13,000 ft).

6. Assume a steady-state thunderstorm moves away from the radar. What is the height underestimate for the 30,000 foot level at the following distances from the radar?

Range	Height Underestimate	Range	Height Underestimate
30 nmi		60 nmi	
75 nmi		85 nmi	
95 nmi		120nmi	
125 nmi		135nmi	
150 nmi		170 nmi	

What implications does this table have on algorithm performance for a storm that moves away from the radar?

If you have any questions about this job sheet, please send e-mail to iccore4@wdtb.noaa.gov.

Answer Key

***1.** Perform the operations as directed.*

***2a.** Tilt 2, 1.45º.*

***2b.** Cursor tracking `[MM+Drag]` on the yellow line at 135 nm (or the 1.45º beam center line) provides a value of about 34 Kft.*

***2c.** 40,000 – 34,000 = 6000 ft.*

***3.** Approximately zero, because the center of the 1.45º beam is ~ 40 Kft at 150 nmi.*

***4.** At 155 nmi, the radar assumes it will sample the 40,000 foot level with the 0.5º tilt because the echo is below the center point of the 1.45º tilt. The center of the 0.5º beam at 155 nmi is 25 kft, so the radar will underestimate the 40,000 foot level by 15,000 feet.*

***5.** Perform the operations as directed.*

6.

Range	Height Underestimate	Range	Height Underestimate
30 nmi	***zero***	60 nmi	***zero***
75 nmi	***~6 kft***	85 nmi	***< 3 kft***
95 nmi	***~10 kft***	120 nmi	***< 1 kft***
125 nmi	***~13 kft***	135 nmi	***~10 kft***
150 nmi	***~7.5 kft***	170 nmi	***< 1 kft***

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VCP Explorer Job Sheet 4
VCP Explorer V2.x

Objective: The objective of this exercise is to use VCP Explorer to understand the effect of the VCP on the sampling of a steady state thunderstorm at a given range from the radar.

In this exercise, "LM" refers to the left-mouse button, "MM" refers to the middle mouse button, and "RM" refers to the right-mouse button.

1. Start VCP Explorer, and change to the KGLD radar. Set the VCP to VCP 21. Assume you have a hail core located at 25,000 ft MSL that is 75 nmi away from the radar. Click on the HL button and move the horizontal green line down to 25,000 feet. The line will serve as a reference guide through this exercise. Click on the HF button.
   [click on the green box at the right endpoint of the line and drag it to 25,000 feet]

2. In VCP 21, what tilt observes the hail core?
   What is the height of the beam centerpoint?
   What is the height underestimate of the hail core?
   [move the arrow under the color bar to the appropriate color, cyan]

3. In VCP 11, what tilt observes the hail core?

4. In VCP 12, what tilt observes the hail core?
   [Hint: To refresh the HL line, you may need to move it away from the 25,000 level and then move it back]

   What is the height of the beam centerpoint?

   What is the height underestimate of the hail core?

   Based upon this consideration alone, which VCP would improve the detection of the hail core by the HDA?

5. Repeat this exercise with a hail core that is 20 nmi but at 35,000 ft.

If you have any questions about this job sheet, please send e-mail to iccore4@wdtb.noaa.gov.

Answer Key

***1.** Perform the operations as directed.*

***2a.** 1.45º*

***2b.** 19.5 kft*

***2c.** ~7500 ft*

***3.** The bottom tilts of VCP 11 and 21 are the same, so there is no difference between VCP 11 and VCP 21 sampling of this hail core.*

***4a.** 1.8º.*

***4b.** 21.6 kft.*

***4c.** < 3000 ft*

***5.** VCP 11: 14º, centerpoint 34.7 kft, underestimate < 1500 ft*
VCP 21: 9º , centerpoint 23.6 kft, underestimate ~12000 ft
VCP 12: 12.5º, centerpoint 32.2 kft, underestimate ~4000 ft

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VCP Explorer Job Sheet 5
VCP Explorer V2.x

Objective: The objective of this exercise is to use VCP Explorer to visualize the effect of temperature and humidity profiles on radar beam propagation

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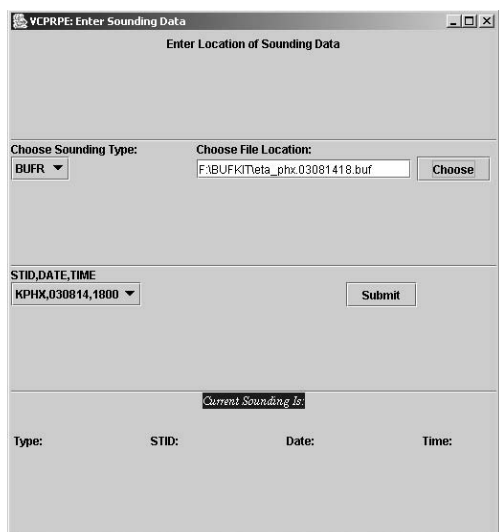
In this exercise, "LM" refers to the left-mouse button, "MM" refers to
the middle mouse button, and "RM" refers to the right-mouse button.
```

1. In order to do this exercise, you will need access to a sounding in BUFR or AWIPS NetCDF format. In particular, you will also need the 18Z BUFR file from the Eta model for Phoenix on August 14, 2003 at which is located at http://wdtb.noaa.gov/courses/AWOC/ICCore4/lesson5/eta_phx.03081418.buf. Place this file in an easy-to-find location on your computer.

2. Start VCP Explorer, and change to the KIWA radar. Set the VCP to VCP 21.

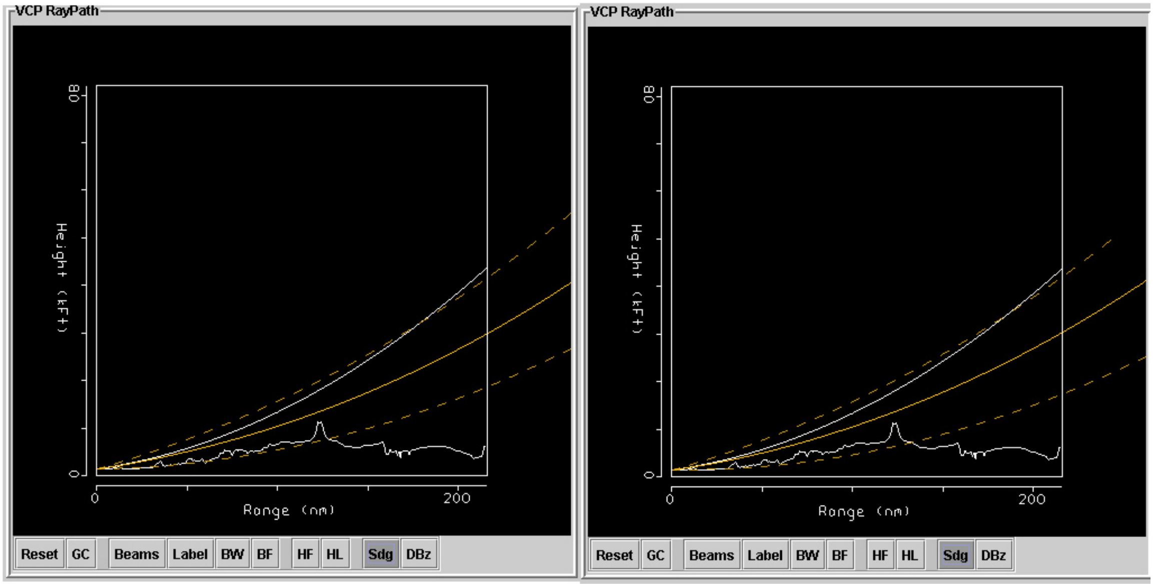
3. Load the Phoenix BUFR file into VCP Explorer.
   [Compare → **Sounding. When the sounding window comes up, make sure the Sounding Type is BUFR. Click the Choose button and navigate on your computer to choose the eta_phx.03081418.buf file.**]



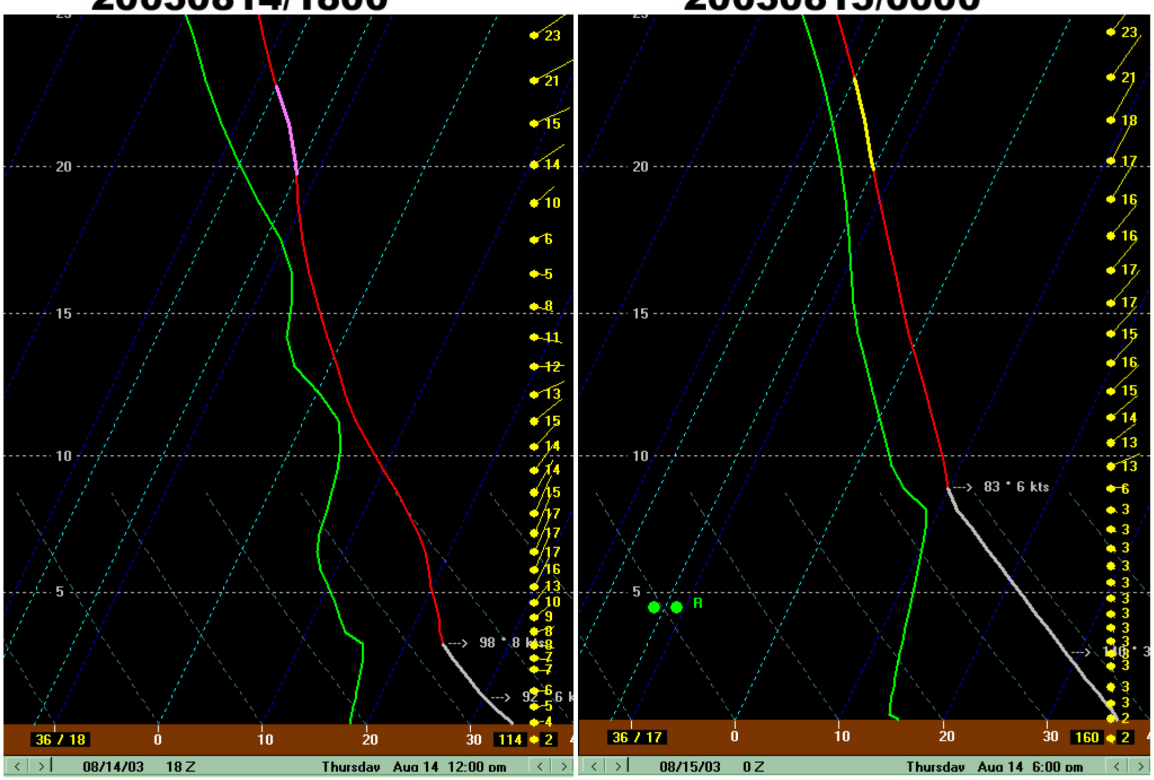
4. Choose the KPHX sounding for 08/14/2003 at 1800 UTC.
   [Click the Submit button. Do not close the Sounding data window.]

5. In the main VCP Explorer window, click on the Sdg button. Notice that the actual beam path differs significantly from the beam path assumed by the standard atmosphere.

6. Change the sounding time to 08/15/2003 at 0000 UTC. What happened to the radar beam?
[In the Sounding window, change the sounding to KPHX,030815,0000 and click the submit button.]



20030814/1800 **20030815/0000**



7. Step through the elevation angles to see the effect of the sounding profile on higher radar tilts.

8. Since the actual beam path differs from the beam height assumed from the standard atmosphere, speculate on the ramifications of this difference on downstream WSR-88D products. In particular, what impact would a lower-than-theoretical radar beam have on the hail detection algorithm if the actual beam were above the 0ºC and/or -20ºC threshold levels?

9. Repeat this exercise using your own sounding data with your local radar.

If you have any questions about this job sheet, please send e-mail to iccore4@wdtb.noaa.gov.

Answer Key

1-4. ***Perform the operations as directed.***

5. ***The actual beam center point is closer to the surface than the theoretical beam. The difference between the actual beam and the theoretical beam increases with increasing range from the radar.***

6. ***The beam from the well-mixed atmosphere at 0000 UTC is broader than the beam from 1800 UTC. The 0000 UTC beam samples more ground targets than the beam from 1800 UTC.***

7. ***The difference between the theoretical beam and the sounding-derived beam decreases with increasing elevation angle because the higher tilts overshoot the boundary layer more quickly.***

8. ***Answer: With the particular sounding used in this exercise, the theoretical radar beam almost always overestimates the sounding-derived beam height, with the greatest differences occurring on the lowest tilts at far ranges from the radar, beyond the domains of some of the algorithms. Smaller differences, however, do occur nearer to the radar in the domains of many of the algorithms. Obviously the vertical depths of circulations detected by the radar may be suspect.***

The Hail Detection Algorithm assumes the presence of hail if reflectivity greater than 40 dBZ exists above the freezing level. The algorithm gives more weight to reflectivity greater than 50 dBZ and to areas above the -20ºC level. The algorithm also relies on the vertical depth of reflectivity above these temperature threshold levels. If the theoretical beam is higher than the actual beam and both beams are above these two threshold levels where the algorithm "grows" hail, then more subfreezing reflectivity actually occurs than the algorithm detects. The result is that the hail algorithm may underestimate the various hail output parameters.

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VCP Explorer Job Sheet 6
VCP Explorer 2.x

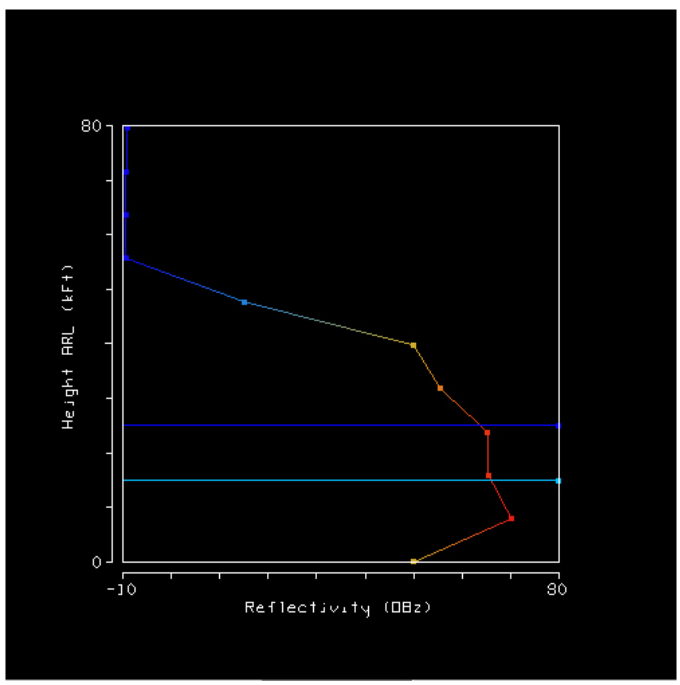
Objective: The objective of this exercise is to use VCP Explorer to visualize the impact of radar sampling through various VCPs upon parameters of the HDA algorithm.

In this exercise, "LM" refers to the left-mouse button, "MM" refers to the middle mouse button, and "RM" refers to the right-mouse button.

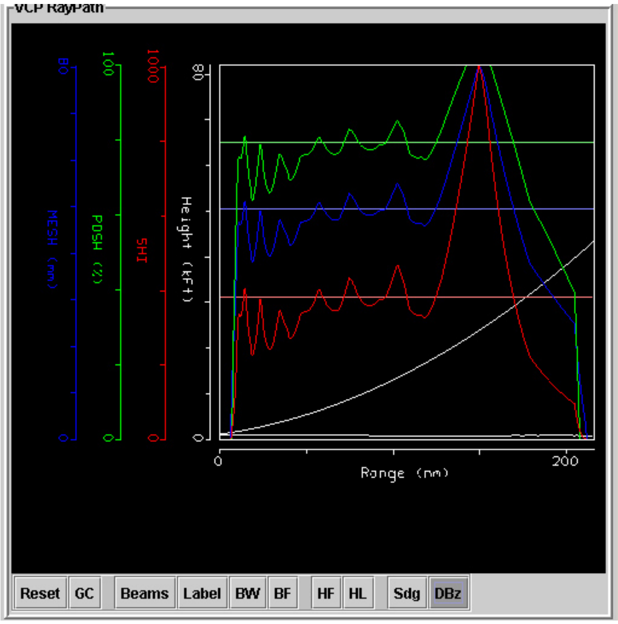
1. Start VCP Explorer, and change to the KILN radar. Set the VCP to VCP 21.

2. VCP Explorer can calculate three parameters of the Hail Detection Algorithm. These parameters are the Probability of Severe Hail (POSH), Maximum Expected Hail Size (MEHS), and Severe Hail Index (SHI). The HDA calculations require a reflectivity profile plus the heights of the 0ºC and -20ºC isotherms. Use the DBz option under the Compare menu to enter the following profile.

Reflectivity Profile	
Height ARL (kft)	**Reflectivity (dBZ)**
0	50
7.9	70
15.9	65
23	65
31.8	55
39.7	50
48	15
55+	-10
Temperature Profile	
Temperature	**Height (ft)**
0ºC	14,890
-20ºC	24,985



[Compare → DBz. When the profile window comes up, click the small squares on the vertical line and drag them left or right to generate the profile. Drag the horizontal dark blue line to set height of the -20ºC level. Drag the horizontal cyan line to set the 0ºC level. Click on the Submit button when finished. The profile window may not disappear after clicking the Submit button.]



3. Display the HDA parameters by choosing the DBz button under the RHI window. Zoom and/or pan the image until you see the MEHS, POSH, and SHI axes. **[To zoom, use Shift+RM+Drag and to pan, use RM+Drag.]**

4. The three horizontal lines represent the "true" output of the HDA as if the radar perfectly sampled the reflectivity profile. The curves indicate how the HDA output varies by range by taking into account the height of the radar beams (in the standard atmosphere) and the altitudes at which the beams actually would sample the reflectivity profile. When a curve is below its corresponding horizontal line, the HDA value is underestimated.

5. The familiar output parameters of the HDA (i.e., POSH and MEHS) are calculated from the SHI.

$$\mathbf{SHI = \int f(Z)\, W(Z)\, W_t(z)\, dz},$$

where f(Z) is a semi-empirical function of reflectivity, W(Z) is a reflectivity weighting function and $W_t(z)$ is a temperature weighting function, and dz is the vertical increment.

W(Z) = 0 if reflectivity < 40 dBZ.
W(Z) is between 0 and 1 when 40 < reflectivity < 50.
W(Z) = 1 if reflectivity > 50 dBZ.

$W_t(z)$ = 0 if the beam height is below the freezing level.
$W_t(z)$ is between 0 and 1 when the beam height is between the 0ºC and -20ºC isotherms.
$W_t(z)$ = 1 if the beam height is above the -20ºC level.

For the reflectivity profile shown above, use the reflectivity and temperature weighting functions to determine which reflectivity levels are used in the computation of the HDA parameters. Fill out the following table with your answers.

Reflectivity Profile			
Height ARL (kft)	**Reflectivity (dBZ)**	**Use Level? (Yes/No)**	**Reason**
0	50		
7.9	70		
15.9	65		
23	65		
31.8	55		
39.7	50		
48	15		
55+	-10		

Temperature Profile	
Temperature	**Height (ft)**
0ºC	14,890
-20ºC	24,985

6. What is responsible for the sharp increase of the SHI, MEHS and SHI values from 0 near the radar to their peaks at 14 nm away from the radar?

7. Why are the curves maximized at a range of 153 nmi?

8. How well would the HDA perform if this reflectivity profile were observed by the radar using VCP 21 and at a range of 83 nmi?

9. Change the VCP to VCP 12. What impact does the VCP have upon the accuracy of the HDA parameters?

10. Lower the heights of the 0ºC and -20ºC isotherms. What happens to the range where the algorithm values are maximized?

If you have any questions about this job sheet, please send e-mail to iccore4@wdtb.noaa.gov.

Answer Key

***1-4.** Perform the operations as directed.*

5.

Reflectivity Profile			
Height ARL (kft)	**Reflectivity (dBZ)**	**Use Level? (Yes/No)**	**Reason**
0	50	***No***	***Level below 0ºC***
7.9	70	***No***	***Level below 0ºC***
15.9	65	***Yes***	***Level above 0ºC and reflectivity > 50 dBZ***
23	65	***Yes***	***Level above 0ºC and reflectivity > 50 dBZ***
31.8	55	***Yes***	***Level above -20ºC and reflectivity > 50 dBZ***
39.7	50	***Yes***	***Level above -20ºC and reflectivity > 50 dBZ***
48	15	***No***	***Reflectivity < 40 dBZ***
55+	-10	***No***	***Reflectivity < 40 dBZ***

Temperature Profile	
Temperature	**Height (ft)**
0ºC	14,890
-20ºC	24,985

***6.** The zero values left of the peak result from the radar's cone of silence.*

***7.** At the range of 153 nmi, the lowest tilt intercepts the -20ºC isotherm. Hence all reflectivity (greater than 40 dBZ) observed by the radar has maximum weight in the HDA calculations.*

***8.** The HDA parameters would be underestimated at that range. [This profile, at a different radar, produced at least 4-inch hail.]*

***9.** There is less variance in the parameters closer to the radar with VCP 12 because there is less vertical distance between the beams with VCP 12 than with VCP 21.*

***10.** The maximized values should move closer to the radar because lower freezing levels will be sampled by the bottom radar tilt closer to the radar.*