Data Quality

Advanced Warning Operations Course

IC Core 4

Lesson 1: Radar

Warning Decision Training Branch

Welcome to the IC Core 4 Data Quality portion of the Advance Warning Operations Course (AWOC). Lesson 1 will focus on the impacts poor radar data quality can have on the warning process and external users. This lesson should about 20 minutes long.

Overview of Data Quality

- Lesson 1: Radar
- Lesson 2: Spotter Reports
- Lesson 3: Ground Truth
- Lesson 4: Satellite
- Lesson 5: VCP Explorer

Before we begin Lesson 1…I would like to give you a brief overview of the five lessons that comprise the Data Quality portion of AWOC.

Lesson 1: Radar – we'll cover in just a moment.

Lesson 2: Spotter Reports – gives a brief background on the source of spotter reports, their strengths and limitations, and some basic steps to quality control these reports.

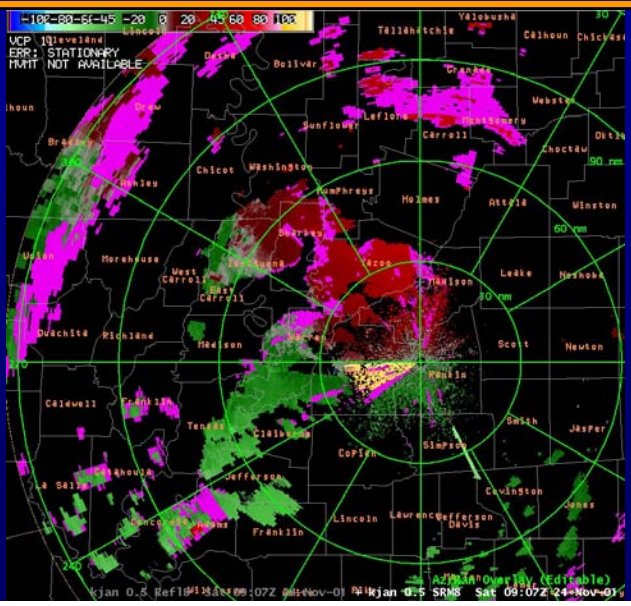
Lesson 3: Ground Truth – discusses the different types of ground truth data available, the limits of that data, and how to mitigate potential problems due to those limitations.

Lesson 4: Satellite – describes data quality issues that most strongly impact the interpretation of satellite data during warning operations such as: parallax errors, reception delays, resolution and the quality of derived products.

Lesson 5: VCP Explorer – The VCP Explorer job sheet is an **OPTIONAL** exercise that examines the source of ground clutter patterns and radar sampling limitations regarding echo heights as a function of different VCPs. The learner can also examine the impacts of nonstandard atmospheric refractivity on the path of the beams and the resulting ground clutter. There is **NO exam** for lesson 5.

The exam for IC CORE 4 will be a multiple choice exam and cover Lessons 1 through 4.

Data Quality - Lesson 1
Radar



Of all the lessons in the Data Quality portion of AWOC, IC Core 4, Lesson 1 should be the one you are most familiar with. This will be a very brief review of AP, Range Folding, and Improperly Dealiased Velocities, focusing on the impacts each has on operations and emergency managers. You will be directed to the WDTB web site for training resources that focus on radar data quality mitigation techniques latter on in the presentation.

Learning Objectives

- Radar (Lesson 1)
  1) Identify the impacts of poor data quality on:
     a. radar interpretation at the local office
     b. outside decision makers (EMs)
  2) Identify training resources for data quality mitigation techniques,
     a. from the legacy system (DLOC)
     b. from system upgrades (RPG and ORDA builds)

As is our policy at WDTB, the exam questions will be based upon the stated objectives.

(Read the Learning Objectives with the emphasis on **IMPACTS** and **TRAINING RESOURCES**)

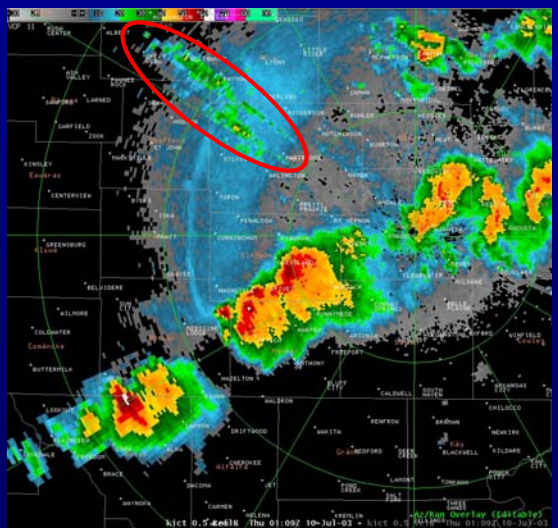
Performance Objective

- <u>Radar</u>
  1) Using any or all of the three base moments (REF, VEL, SW) demonstrate the ability to detect and then mitigate:
     a) anomalous propagation
     b) range folding
     c) improperly dealiased velocities

Performance Objectives are precise, measurable statements of the behaviors that trainees will be able to demonstrate **On-The-Job**. They often specify the condition under which the behaviors will be demonstrated as well as the criteria for acceptable performance. (The Performance Objective will **NOT** be part of the examination process)

Anomalous Propagation

- Where's the AP ?



Take a look at this 0.5 degree reflectivity product and locate the area of anomalous propagation (AP). Remember that AP is caused by super refraction of the radar beam…therefore it will appear along radials and can extend out to great distances from the RDA. Once you think you located the AP…arrow over and we'll see how you did. (The area of AP is located NW of the RDA)

Impacts of Not Suppressing AP

- Can affect precipitation estimates
- Can affect algorithm output
- Can be misinterpreted by users:
  - aviation
  - emergency managers
  - media
  - public
- Can impact the warning process

-Precipitation can be overestimated.

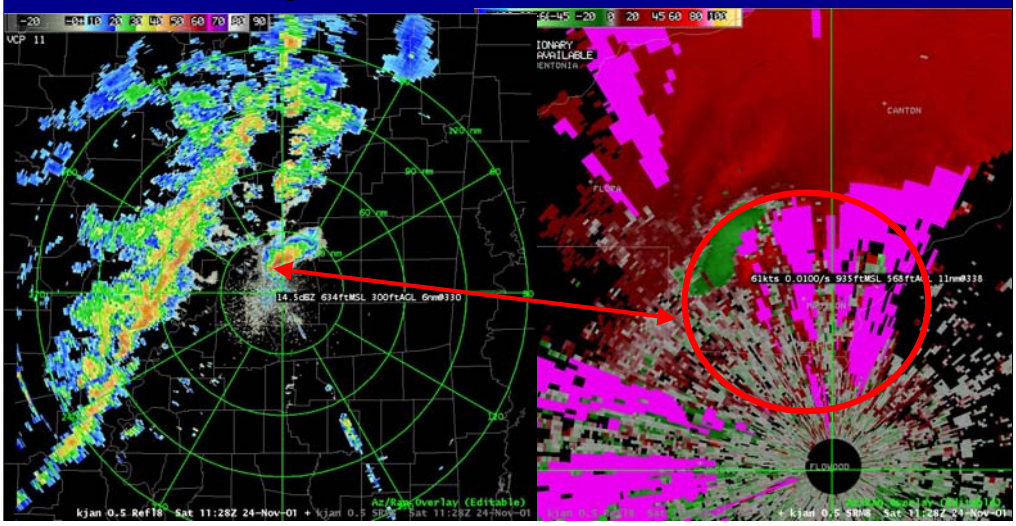
-Garbage-in…Garbage-out

-Diversion of aircraft…time/money, misdirection of spotters, false reports and panicked public…lose of confidence in products.

-All of the above can contribute to the impact on the warning process.

Range Folding

- RF causing problems?



Possible “Hook” near the radar on the reflectivity product…you zoom-in on the velocity product to check out the circulation... and then *things come to a screeching halt*… Range Folding is obscuring your view. In addition, the obscured data is not available for algorithm processing. This is an excellent example of how Range Folding can impact the warning process.

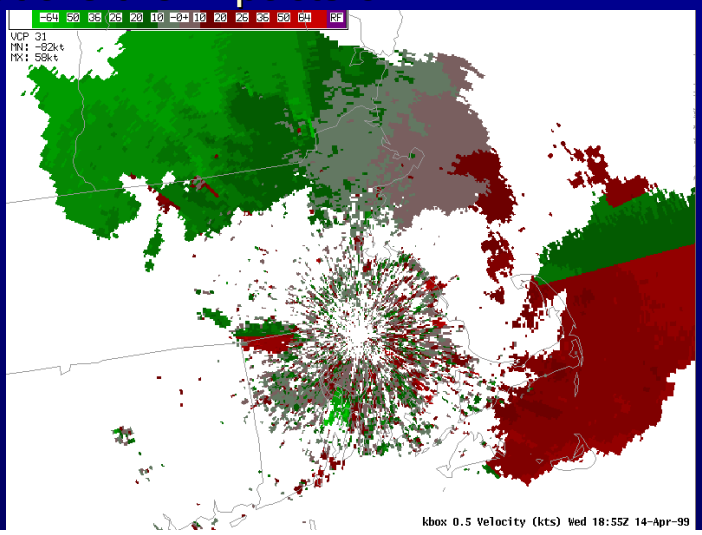
Impacts of Range Folding

- Obscures velocity and spectrum width data
- Obscured data is not available for algorithm input
- Can impact the warning process

(Read bullets referring back to previous slide)

Improperly Dealiased Velocities

- What are the impacts of IDV?



I'd like you to think about the impacts of IDV…if your head starts to hurt go to the next slide…but before you do…I got a question for you: What is the one step YOU can perform at the RPG HCI that could help reduce IDV? A hint: EWT…(update the Environmental Winds Table!)

Impacts of IDV

- Can affect the preservation of meteorological features such as:
  - TVS
  - Mesos
  - Shear
- Can affect algorithm output
- Generates strange azimuthal shears
- Can impact the warning process

-Improperly Dealiased Velocities can mask the analysis of significant meteorological features.

-Garbage-in…Garbage-out.

-IDV can “create” features that do not exist…areas of shear that just aren’t there!

-All of the above can significantly impact the warning process.

Response Item

- Which of the following is(are) true?
  a) Range folding obscures both velocity and reflectivity data.
  b) Range folded (obscured) data is not available for algorithm input.
  c) Range folded data can not impact the warning process.
  d) None of the above.

Read the question…after the student responds review the correct and incorrect responses.

a) RF “Purple Haze” (obscured data) only appears on VEL and SW products. RF can (rarely) occur on REF products, however it is NOT obscured with “Purple Haze”.
b) CORRECT ANSWER - RF data, both VEL and SW, is not available for algorithm input.
c) Lack of VEL and/or SW data can seriously impact the warning process (circulations, VEL reliability, etc.)
d) Fagitaboutit!

Response Item

- Which of the following is(are) an impact(s) of not suppressing AP?
  a) Precipitation estimation
  b) Misinterpretation by users
  c) Algorithm output
  d) All of the above

Read the question…once the student responds review the answers.

a) If you do not suppress AP the algorithm may interpret AP as a meteorological target and use the REF data to calculate precipitation estimates.

b) Users (aviation, EMs, media, etc.) may not have the training to distinguish met. targets from AP.

c) Garbage-in…garbage-out!

d) All of the above are impacts…therefore (d) is the CORRECT answer!

Training Resources
-- Legacy System --

- DLOC
  - IC 5.3: Principles of Meteorological Doppler Radar (student guide/presentation)
    - Clutter Suppression
    - Range Unfolding
    - Velocity Dealiasing

http://wdtb.noaa.gov/

If you need to review the algorithms and procedures used to mitigate the effects of AP, RF, and IDV…I strongly recommend that you visit WDTB's web site (URL on the bottom of slide) and look for the Information by Topic section and select DLOC…then selection IC 5.3: Principles of Meteorological Doppler Radar. You will find both the student guide (PDF) and the presentations that pertain to this topic.

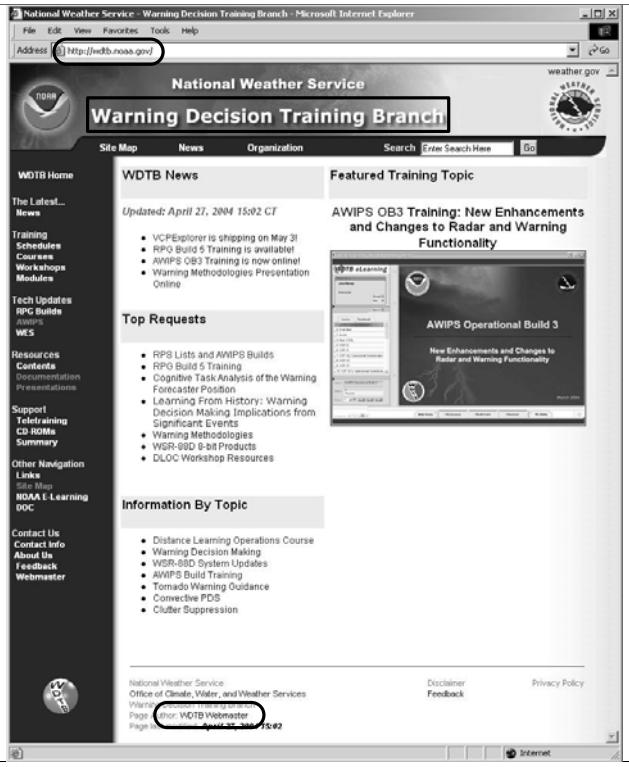
Training Resources
-- System Upgrades --

- Build training
  - RPG (student guide/presentation)
    - Beta (synchronous)
    - Deployment (asynchronous)
  - ORDA (calendar year 2005)
    - Beta
    - Deployment

http://wdtb.noaa.gov/

In addition to the legacy information on the previous slide, as RPG and ORDA (2005) Builds are released WDTB develops training materials for these Builds. Once again go to WDTB's web site (URL on bottom of slide) looking for the Information by Topic section and select WSR-88D System Upgrades…then select the Build you are looking for. You will find both the training guide (PDF) and the presentations that pertain to this topic.

- Living document



- Check often

- Provide feedback

This is what the WDTB web site should look like. I say should because as a “living” document it is frequently being changed to reflect the latest training material. We recommend that you check this site often. The WDTB Webmaster would appreciate your feedback if things are not working as planned (click on Webmaster hyperlink near bottom of page).

Response Item

- An excellent location to find training resources that help mitigate the impacts of poor data quality is(are)?
  a) WDTB's web site: http://wdtb.noaa.gov
  b) WDTB's web site: http://wdtb.noaa.gov
  c) WDTB's web site: http://wdtb.noaa.gov
  d) All of the above

Read question…emphasize importance of training resources available at WDTB's web site:

-Legacy data quality mitigation…DLOC.

-Build training material…RRPG and ORDA.

Impact of Data Quality on External Users

- You are a data provider.
  - In today's information-sharing environment, external decisions are based upon radar information ***you*** provide.
  - External use of WSR-88D data will grow as the private sector redistributes Level II (wideband) data along with products based on Level III.
- Bottom Line: Importance of high-quality radar data cannot be overstated.

Let's take a look at the impact of Data Quality on our external users…focusing on Emergency Managers. Remember… that we rely on these folks to be our "eyes in the storm" and to help get the word out about significant weather events. (Read bullets with emphasis on the Bottom Line)

Emergency Managers (EMs)

- EMs are particularly important external users.
- Modern EMs utilize radar as one of their tools.
- Most EMs have a ***local*** geographic area of responsibility.
- EMs often manage human resources – directing responders as well as positioning spotters.

(read bullets – with an emphasis on developing and maintaining partnerships)

Radar Applications for Emergency Managers

- Find boundaries in non-convective situations: firefighting, haz-mat, homeland security, etc.
- Close roads/bridges preemptively for flooding.
- Monitor conditions for safety of outdoor workers & responders.
- Making decisions of how best to alert the public of severe weather (sirens, police sirens, cable TV override, etc.)

(Read bullets – ask students to check with their WCM on any additional applications that may specifically apply for their local EMs.)

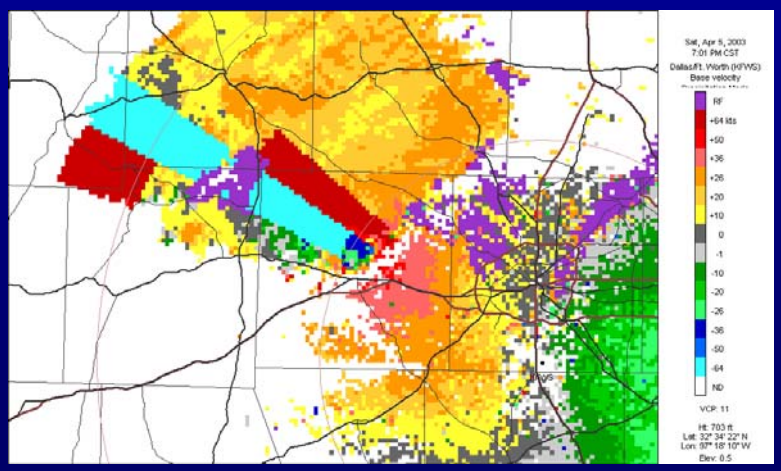
Data Quality Impacts for EMs

- Improperly Dealiased Velocities/Range Folding:
  - obscure significant features
  - possible misdirection of spotters due to false signatures

(read bullets – with an emphasis on developing and maintaining partnerships…verbally relate back to the AP/RF/IDV slides presented earlier… additional examples follow)

Example 1

What does an *untrained* EM think:

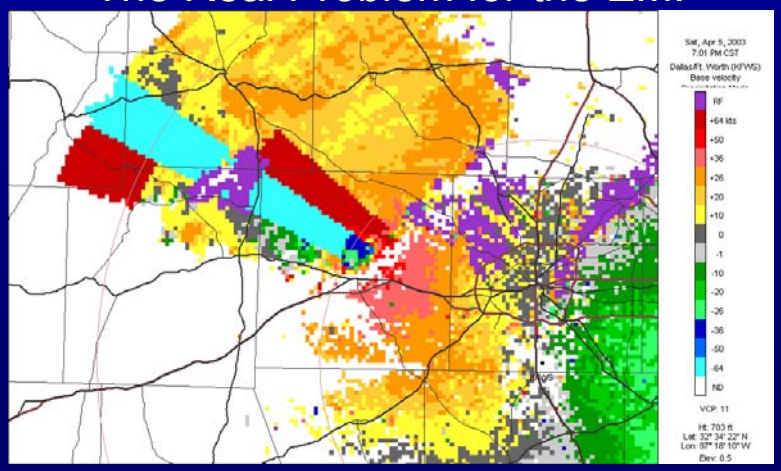


"Man, that's the *biggest* circulation I ever saw!!!"

(Read question posed…and response…HAM it up!)

Example 1

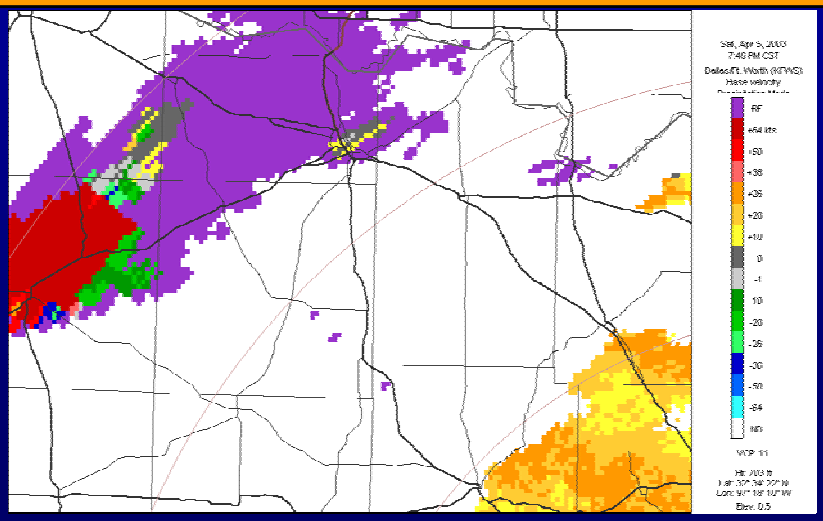
The Real Problem for the EM:



Improperly Dealiased Velocities mask real circulation → difficult to direct spotters.

(This slide basically speaks for itself…popup text…read statements.)

Example 2



Supercell masked at times by improperly dealiased velocities and/or range folding

(Animation – emphasis placed on the area of IDV and RF)

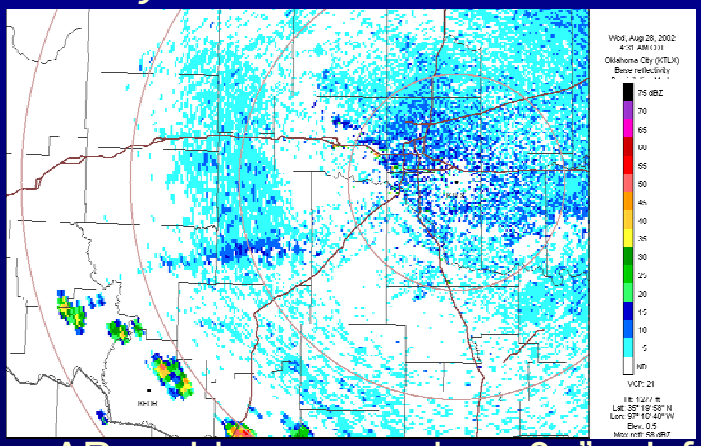
Data Quality Impacts for EMs

- AP can lead to:
  - misdirection of spotters
  - spurious rainfall accumulations
  - no reset of storm-total rainfall

(Read slides – similar slide 7)

Example 3

Rainfall Products are used by EMs and
many other downstream users

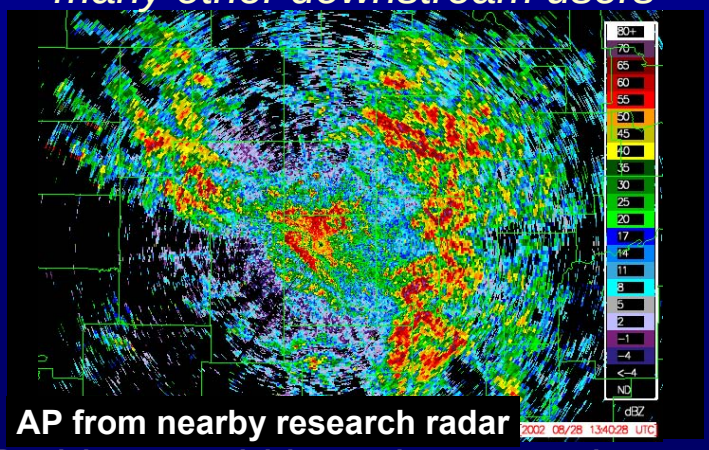


Severe AP problems: spurious 3+” rainfall total!

This animation is an example of how AP can cause erroneous precipitation estimation problems for EMs. Look at the small area of 3+” of rainfall near El Reno…it’s only AP. (This is an animation..it has to be run to see the affect)

Example 3

Rainfall Products are used by EMs and
many other downstream users



AP from nearby research radar

Problem could have been much worse!

Remember…the WSR-88D is only as smart as the operator. The radar does not know if this is reflectivity (input for precipitation processing) or AP (erroneous input). Garbage-in…Garbage-out!!!

Data Quality Impacts for EMs

- Emergency managers often use algorithm output from the attribute table in the composite reflectivity product.
- Any data quality issue that affects the performance of Mesocyclone, TDA, SCIT, Hail, or Rainfall algorithms may impact the operations of an emergency manager, especially an *untrained* EM.

These are some additional IMPACTS that poor data quality has on the EMs. (read bullets) Remember…we have more and more people looking at our data who are decision makers…we need to provide them with the best quality products we can.

Response Item

- Emergency Managers are concerned with which of the following impacts of poor data quality?
  a) Misdirection of spotters
  b) Obscured significant meteorological features
  c) Algorithm performance
  d) All of the above

Read question…once student responds review answers.

a) AP, IDV, and RF can all cause misinterpretation and misdirection of spotters.

b) RF and IDV can obscure significant met. features for both the trained and untrained EMs.

c) EMs are now using algorithm output as part of their job…therefore accurate algorithm performance is essential.

d) Correct answer…EMs are concerned about all three impacts!

Data Quality
Lesson 1: Radar -- Objectives

- Radar (Lesson 1)
  1) Identify the impacts of poor data quality on:
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http://wdtb.noaa.gov/

This is a review of the objectives for IC Core 4 Data Quality Lesson 1: Radar. (Emphasis on the terms **IMPACTS** and **TRAINING RESOURCES)**

End of Lesson 1

Questions about Lesson 1

iccore4@wdtb.noaa.gov

You have completed Lesson 1 of AWOC IC Core 4!!!! Remember…there are four more lessons in IC Core 4. If you have any questions about this lesson: 1) first ask your SOO 2) if you need additional help send an e-mail to….(instructor's group – answers will be cc:'d to the SOO and considered for the FAQ page.) The test should be taken as soon as possible after completing IC Core 4 Lesson 4.

Remember…the exam ONLY covers Lessons 1 – 4 and it is multiple choice.

Slide 1

Data Quality

Advanced Warning Operations Course
IC Core 4
Lesson 2: Spotter Reports
Warning Decision Training Branch

Welcome to the AWOC Data Quality lesson on spotter reports. This lesson should last for approximately 20 minutes.

Slide 2

Learning Objectives

1. Identify the various sources of storm reports along with their strengths and weaknesses
2. List the ways reports can be erroneous
3. List steps used to mitigate erroneous reports from impacting severe weather operations

This lesson has three learning objectives:

To identify the different sources of spotter reports for a forecast office during warning operations. Students should be able to identify each source and know their strengths and limitations.

To list several ways for errors to enter storm reports. In some cases, the observation or method of observations is erroneous. In other cases, the communication of that report induces error. Students should be able identify these common sources of error.

To know the basic steps to mitigate erroneous storm reports during warning operations. These steps can be taken to quality control bad reports and minimize their negative impact on warning operations. Students should know how to implement these different steps.

Slide 3

Performance Objectives

1. Demonstrate the ability to mitigate erroneous spotter reports from impacting severe weather operations

In addition to the three learning objectives, there is one performance objective for this lesson:

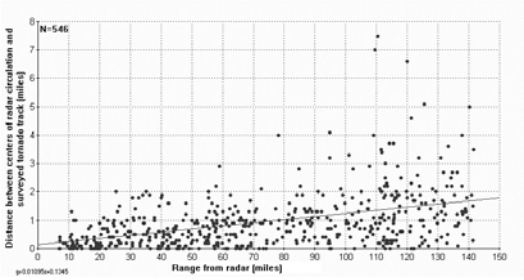
NOTE: Performance Objectives are precise, measurable statements of the behaviors that trainees will be able to demonstrate On-The-Job. They often specify the condition under which the behaviors will be demonstrated as well as the criteria for acceptable performance. (The Performance Objective will NOT be part of the examination process)

The performance objective for this lesson is to demonstrate the ability to mitigate erroneous spotter reports from impacting severe weather operations. It's not expected that all errors will be eliminated or corrected. However, reports with obvious errors should be recognized through simple QC procedures.

Slide 4

Importance of Spotter Reports

- Radar and spotters are crucial in warning ops
- Radar data have limitations
- Spotters help overcome those limitations



We're all familiar with the importance of spotters since observations of any kind are crucial during warning operations. While all observational data have value, radar data and spotter reports are usually heavily weighted during short-fuse warning operations. Radar data, with all of its benefits, do have some significant limitations, especially when looking at small features at long ranges. The graphic above shows that the distance between a tornado track and radar circulation can increase significantly at long ranges (Speheger and Smith, 2004). Spotters are the forecasters eyes and ears in the field. They are very much like other "sensors" that provide observations to the forecast office and help overcome some of radar data's limitations.

Slide 5

Spotter Network Composition

- NWS trained spotters
- Media
- Other "experienced" spotters
- General Public

Like surface observations, spotters compose their own network of sensors. Using this analogy, there are numerous types of sensors in your spotter network. The primary source of data from your spotter network comes from the locally-trained spotters. In a little bit, we'll get into why that's a good thing.

In many parts of the country, the media are also active components of your spotter network. Even in areas less active, the media is an informative communicator. In an ideal environment, they can provide something that the forecaster cannot get anywhere else…real-time video!

In addition to your locally trained weather spotters, you may have other "experienced" spotters in your area. Many times, these other spotters might be storm chasers, researchers, or enthusiasts who are in your area because of the severe weather potential. Many of these folks are very educated about severe weather and are very knowledgeable spotters. They clearly want to help you do your job better. However, there are always a few, let's just call them "yahoos", that are more trouble than they are worth. The difficult thing for you as a forecaster is knowing which kind of person you're observation is coming from. If you are not familiar with a particular chaser, and have questions about their report, it would be wise to be skeptical of the report.

Besides the previously mentioned groups, you also have the general public. This group contains the average citizen, but can also include emergency personnel or other first responders to a weather induced emergency that have no experience or training in severe weather.

All of these different groups, or “sensors”, compose your spotter data network.

Slide 6

NWS Trained and "Other" Spotters

Pros

- Most accurate
- Knowledgeable
- Pro-active

Cons

- Dispatcher relay issues
- Can be "characters"
- Chaser familiarity w/area?

Results

- Best quality reports come from these spotters
- Most mistakes are honest ones
- "Characters" can result in occasional headaches

Since trained and "other" spotters have many of the same strengths and limitations, they have been grouped together for this discussion:

The strength of these spotters is that they provide the most accurate reports of severe weather that you are likely to get. They are generally knowledgeable about severe weather threats and how they form. They are pro-active. Many use vehicles to track storms and follow a threatening storm. This dedication, understanding, and accuracy make them the backbone of any spotter network.

The most significant downside to reports from this group is due to communication. Many spotters have HAM radio and communicate directly with the WFO. However, some spotters pass reports to the Emergency Manager (or even a dispatcher, who passes along to the EM or forecast office). This "chain" of communication can lead to a data quality issue. Moller (2004) indicated one of the next improvements in spotter training will be to address this issue.

Another potential problem is your local "characters". While these folks may be few and far between, there are probably a couple in everyone's CWA. Many times there may be a political or personal reason for their behavior. Knowing the cause may often help mitigate any problems that occur. Besides local "characters", there can be some issues with chasers. Chasers, while knowledgeable about phenomena, may not have the best grasp of the local area. Errors may creep into these reports as a result.

The bottom line on spotters is that much of the early progress in warning operations are due to these programs. Forecasters have relied on them for up to 60 years in some areas to help detect severe weather. The vast majority of these folks are excellent, although they may make an occasional honest mistake. The people who volunteer to be spotters are generally dedicated and very professional. On average, the most error-prone point in this group is when information takes several steps to make it to the forecast office.

Slide 7

Media

Pros
- Strong communicators
- Timely information
- Video…sometimes

Cons
- Errors from timeliness
- Not optimal for operations
- Passive communication

Results
- Coverage slanted toward larger populations
- Video is invaluable information
- Partnership is critical to long-term success

While the media's involvement in severe weather coverage varies around the country, these statements are generally true for broadcast media.

In some areas, the media can be very knowledgeable spotters who provide timely information. In the case of TV reports, they have the potential to provide visual feedback in way of pictures or video footage. Media are also strong communicators who are efficient at getting important information out to people, including forecast office.

The downside to their timeliness is that, because of time pressures, they can relay information that is incorrect. The media may broadcast information in a manner that ultimately results in higher ratings, not in a manner that is optimal to the forecast office. If information is received through broadcast reports, the forecasters have to take the effort to contact the media about any questions they have, which reduces timeliness of the information.

The bottom line with the media is that they vary from market to market. In general, the information that is broadcast by the media will tend to be skewed towards larger populations (more urban info, less rural). If media crews are following a storm and are able to broadcast live, the resulting video is a great benefit to forecasters. A positive partnership between the media and the WFO is critical to the long-term success of both in disseminating severe weather information to the general public.

Slide 8

General Public

Pros
- Population size
- Help with verification

Cons
- Less knowledgeable
- Serendipitous
- Less timely

Results
- Reports come from direct impacts to public
- Report quality hampered by relaying
- Most inaccuracies in reports come from public

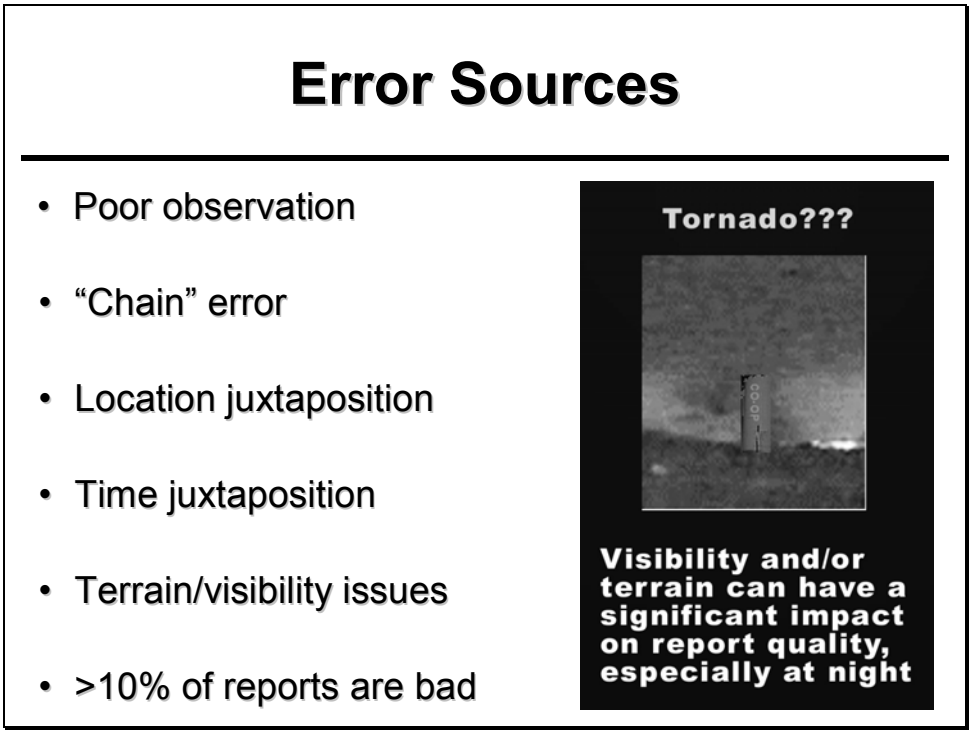
The general public can help fill gaps in your spotter network that are not well covered by your spotter programs or the media.

The general populations greatest asset is in their numbers. In most areas, the general public will outnumber trained spotters by at least an order of magnitude. Having more people means you have a greater chance of observing an event. Even if you do not receive their information in real-time, the general public can still be a great help with verification.

The downside to public reports is that they lack the experience or knowledge about what they are looking at. May people do not know how to relay information to the Weather Service, so these reports are often 2nd (or 3rd) hand. This information may be corrupted in transmission. Many people do not know how to relay information to the weather service if they do see it. These reports tend to be more serendipitous and come in later than other sources.

The bottom line with the general public is that they can provide good information, but it usually has to have a direct impact on them (i.e., damage to house, basement flooded). Since the reports are primarily relayed through a third party, it can be very difficult to clarify any questions that forecasters have about the report. The relaying process itself may even cause errors. Because of their lack of knowledge, their lack of familiarity with communicating reports to the forecast office, and the time lag in getting reports, most inaccuracies in spotter reports come from this group.

Slide 9



Now that we have discussed the sources of reports, lets talk some more about the common sources of error with these reports. Some of these topics were touched on already.

Poor observations – Some observations are just bad, while others are just honest mistakes. For instance, a tornado may stop having a visible funnel cloud near the ground but still produce significant damage. Many times, though, these reports can come in from people lacking the proper knowledge about storms.

"Chain" error – The more people that a report has to go through, the more likely the information will be misreported to the forecast office. Even among knowledgeable people, this process can cause error. Anyone who has played the childhood game "Operator" is familiar with this process.

Location juxtaposition – This problem is a subset, or example, of the "chain" error. This error occurs when someone writes the spotters location down as the location of the phenomenon.

Time juxtaposition – This problem is similar to the previous one, except that it occurs when the received time is written down for the report time. Both this error and the previous one may occur more frequently when there are staffing or workload issues involved.

Terrain/visibility issues – Sometimes a report may be bad because it's just not possible to observe the phenomenon. Remote storms and rain-wrapped (or nocturnal) tornadoes are all examples of this problem. Sometimes even a harmless smoke stack or silo (as in the graphic) can be confused with a possible tornado.

This list is not all-inclusive. However, this list does contain the more common ones. As a result, it should not be a surprise that there is a significant error associated with incoming spotter reports. We are providing a conservative estimate of 10%. Some research suggests that the number could be as high as 30% in some areas of the country (Witt et. al, 1998).

Slide 10

Mitigating Inaccurate Reports

- Maintain good SA
- Match reports to radar
- Try to avoid "chain"
- Know the report's origin
- Can reduce errors by half

Now that we have discussed the sources of error, here are some simple steps to mitigate their impact.

First off, you should maintain good situation awareness. You probably will not be able to quality control every report as it comes in due to time or staff issues. But, with good SA, you should be able to spot the more obvious bad reports.

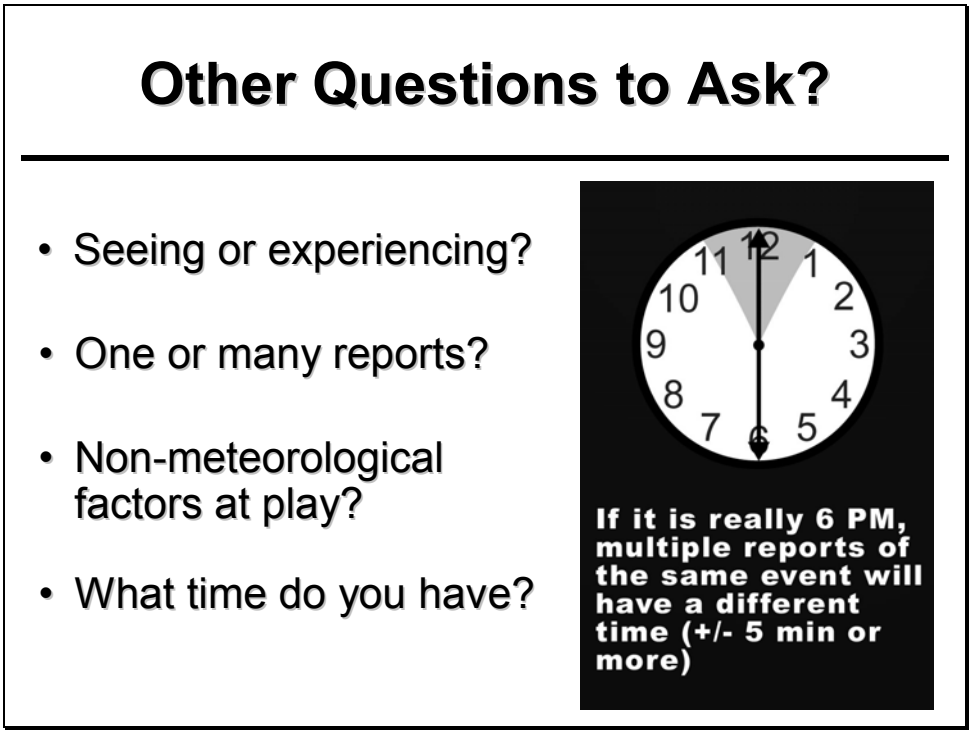
Second, you should use radar data to help QC incoming reports. In some offices, an AWIPS workstation is located next to the HAM radio and phone areas. It is very helpful if these folks can take the time to try and match up incoming reports with radar data for those areas. Many questionable reports can be flagged in this manner. Even if you cannot do this step during warning operations, it is recommended that you do this step as part of any post-mortem exercise.

Another good way to mitigate problems is to avoid "chain" errors. If you get the report from a dispatcher (or even an EM), it's probably a second hand report. It's possible for these folks to receive numerous phone calls from different people with different reports. In such a case, it is easy for some reports to get mixed up, times and locations to be misread, etc. You can't prevent this process from happening, but you can do something about it. If you have received a questionable report that is being relayed through a third party, consider contacting a spotter in that area directly and determine if they can corroborate the questionable report.

Besides knowing if a report is being relayed, it's important to know what type of spotter made the report. Is it a NWS spotter, media person, or the general public? If the report comes from a county with a good spotter network, 80-100% of the events in that county will have at least on spotter report. Conversely, a poor spotter network may only receive reports from 30% of events (Baumgardt, 2004). While anyone can make an inaccurate report, trained spotters are the best source of information during events. If a member of the general public or media has provided a report that appears questionable, getting a report from a trained spotter in that same area may help clarify the issue.

You probably won't catch every bad report using these steps, but you may be surprised by how many you do. These simple steps could reduce your inaccurate reports by half, maybe more.

Slide 11



Here are some other questions to ask yourself (or better yet, the spotter)…

Are they seeing it, or are they experiencing it? For instance, does the person see a tornado, or has the tornado just ripped off their roof? The farther physically removed from something we are, the more likely we are to make a mistake in observing it. A common example is the apparent change in the size of the moon between moonrise and its peak in the sky. It looks so much bigger at moonrise because we have objects next to it to give it a frame of reference. Our eyes can be deceived by storm features that are far away much easier than by more material evidence (such as storm damage).

Is there only one report? Let's face it, there will always be times when only one report is received for a particular storm. During the May 3rd tornado outbreak in OK and KS, 17% of the tornadoes were reported by only one source (Speheger et al., 2001). Since most storms will not garner that much interest from knowledgeable spotters, the percentage for most severe weather events will be higher than that. It's always nice if you can get multiple spotter reports of an event, but many times it just will not be possible.

Are there any non-meteorological factors at play? Using the graphic above, how many reports do you expect to get from a forest vs. a large subdivision?

What time do you have? You may think a report sounds inaccurate, but the reason may be the observer's watch is off. Witt et al. (1998) used a +/- 3 min window on all severe reports in Storm Data to verify a radar algorithm because of uncertainty in the reports. A variation of +/- 5 minutes is probably a reasonable variance to assume with incoming

reports. That's a volume scan, give or take. In extreme cases, it's possible for reports from fast moving storms, or even storms far from the radar, to appear bad because the observer just kept incorrect time.

Slide 12

Conclusions

- Data quality varies depending on source
- Important to know who's making reports
- Need to know how reports can go bad
- Taking basic QC steps can help mitigate the problem
- No better time than the present to review local office policy!

A key point of this lesson is that the quality of information we receive from spotters depends on the source of that information. Experts make mistakes and novices can give very accurate information. However, it's still important to know the source of the information because it can give you a hint of the general quality of the information.

Besides knowing the source of the information, you need to know how a report can go bad. While bad data is a single destination, there are many ways to get there. Being familiar with the more common sources of error will help you identify a bad report when it comes in. Identifying a bad report allows you to mitigate the impact that report has on your operations. Several ways to help do that were presented here, but you may have some of your own. In fact, your office may have some local policies that may help address some of the error situations presented. Now is as good a time as any to review your local policies to make sure you understand them.

Slide 13

Questions???

If you have any questions about this lesson:

1. First ask your SOO
2. If you need additional help, send an e-mail to iccore4@wdtb.noaa.gov (Instructors group – answers will be CC'd to the SOO and considered for the FAQ page)

Take test as soon as possible after Lesson 4

If, after going through this lesson you have any questions, first ask your SOO. Your SOO is your local facilitator and should be able to help answer many questions. If you need additional information from what your SOO provided, send an e-mail to the address on the slide. This address sends the message to all the instructors involved with this IC. Our answer will be CC'd to your SOO so that they can answer any similar questions that come up in the future. We may also consider the question and answer for our FAQ page. Thanks for your time and good luck on the exam!

References

Speheger, D. A., and R. D. Smith, 2004: On the imprecision of radar Signature locations and storm path forecasts. In submission.

Moller, A., 2004: Personal communications.

Witt, A., M. D. Eilts, G. J. Stumpf, J. T. Johnson, E. D. Mitchell, and K. W. Thomas, 1998: An enhanced hail detection algorithm for the WSR-88D. *Wea. Forecasting*, **13**, 286-303.

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Slide 1

Data Quality

Advanced Warning Operations Course
IC Core 4
Lesson 3: Ground Truth
Warning Decision Training Branch

Welcome to the AWOC Data Quality Lesson #3 on Ground Truth data. This presentation should last approximately 25 minutes.

Slide 2

Learning Objectives

1. Identify the sources of ground truth measurements

2. Explain the limitations associated with each type of ground truth measurement

There are two learning objectives for this lesson. First, you should be able to identify the five different sources of ground truth measurements discussed. Next, you should be able list the limitations associated with each of these types of measurement and how they impact the data's effectiveness.

Slide 3

Performance Objective

1. Demonstrate the ability to collect quality controlled ground truth measurements

In addition to the two learning objectives, there is one performance objective for this lesson.

NOTE: Performance Objectives are precise, measurable statements of the behaviors that trainees will be able to demonstrate On-The-Job. They often specify the condition under which the behaviors will be demonstrated as well as the criteria for acceptable performance. (The Performance Objective will NOT be part of the examination process)

The performance objective for this lesson is to demonstrate the ability to collect accurate ground truth measurements during warning operations. Part of the discussion in this lesson will be on some ways to mitigate the impact of poor ground truth measurements through some basic quality control steps.

Slide 4

Topics

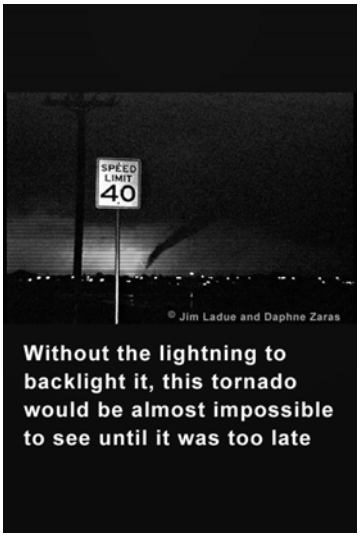
- Spotting storm features and tornadoes
- Hail size
- Wind speed estimation
- Rain gauge measurements
- Snowfall measurements

There are five sources of ground truth data that will be discussed in this lesson. These sources are: spotter-identified storm features (primarily tornadoes), hail size reports, wind speed and damage reports, rainfall measurements, and snowfall measurements. We will next discuss data quality issues and mitigation techniques for each source of data.

Slide 5

Spotting Storm Features and Tornadoes

- Cloud features misidentified by some
- Problem magnified at night
- Lightning illumination
- Power flashes

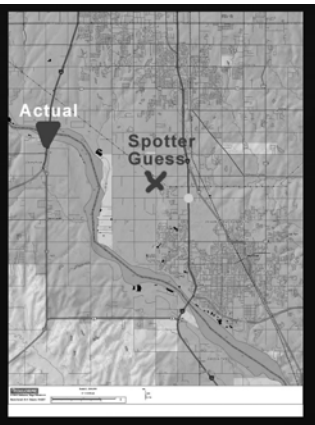


Inexperienced storm spotters can often misidentify cloud features. These well-meaning folks may interpret low-hanging scud cloud as a rapidly rotating wall cloud, funnel, or even a tornado. While educating people helps with this problem during the day, its a bigger problem at night. In low-lighting conditions, even expert spotters may have trouble identifying storm features. Many times the best source of light will be from lightning. Another potential identifier of a nocturnal tornado are power flashes. Just remember that power flashes may also occur with strong straight line winds, even strong inflow winds.

Slide 6

Spotting Storm Features and Tornadoes (Cont)

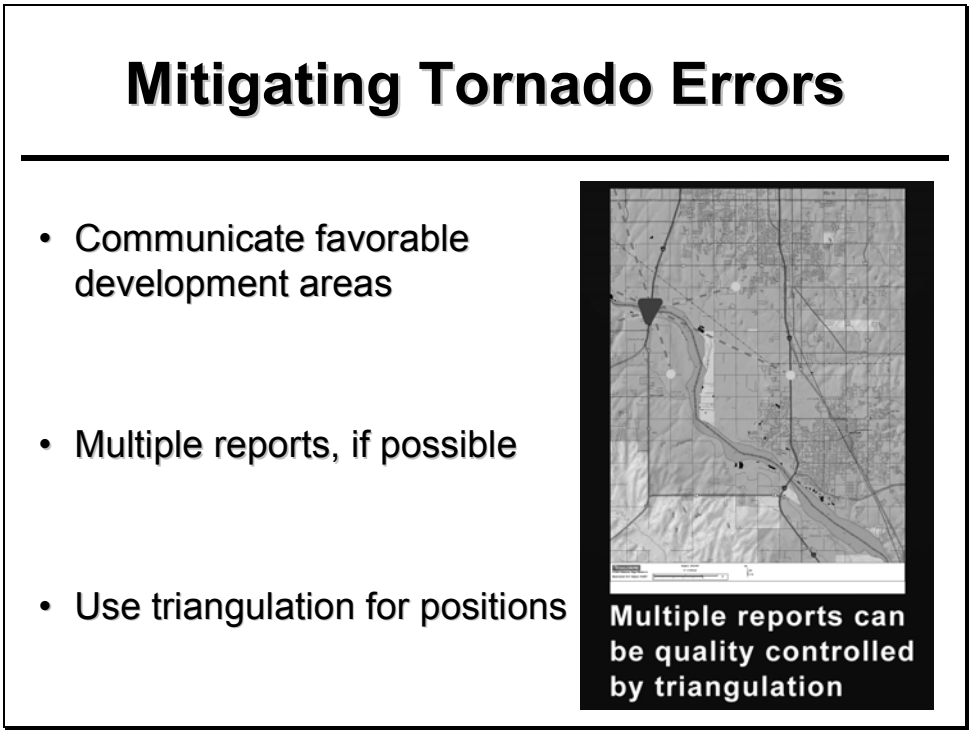
- Difficult to gauge distance
- Lack of reference points
- Actual distance double (or more) of estimate



A single spotter report can be hard to quality control

Besides spotting a storm feature, estimating distance to a feature can also be a problem. Objects in the sky at a distance tend to appear closer than they actually are. The problem is due to a lack of intermediate reference points. For example, say a spotter only provides an estimated tornado location. If that estimate is off significantly, it can cause problems. However, if you also know the spotter's location, or even which direction they are looking, then that additional info can help if the estimate is incorrect. After all, the actual distance to the object that the spotter is seeing may be two or more times the estimated distance. No one wants to send the wrong group of people into their storm shelters.

Slide 7



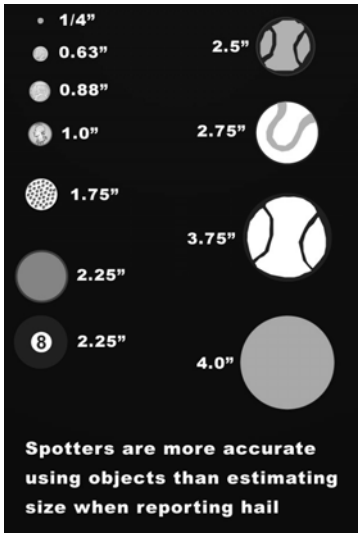
To mitigate these errors and their impact, one thing you can do is to effectively communicate areas that are favorable for tornadic development to spotters. You don't want to come right out and say you are looking for information about a possible tornado in such and such location. What you do want is to communicate to spotters where the storms are and where the biggest threat may occur without leading spotters in a way that results in a self-fulfilling forecast. Doing so will help spotters focus on key areas and should help eliminate spurious reports.

Another way to help eliminate some errors is to get as many reports of a specific tornado as possible. If you do get a questionable location, having multiple reports of the tornado, funnel cloud, or wall cloud will help you triangulate (Speheger, 2004), as in the example shown. Even comparing reports of a tornado with radar data can help clarify the tornado's location.

Slide 8

Hail Size Errors

- Spotters density
- Major time/location errors
- Spotters underestimate small hail
- Positive size bias?
- Using objects for size?



There are a variety of issues with hail size. While the studies may seem contradictory at times, the overall conclusions that can be drawn are consistent.

Changnon (1968) determined that you need an observing network with a density of one observer per square mile to accurately measure hail size. Most spotter networks are less dense than that, which introduces error.

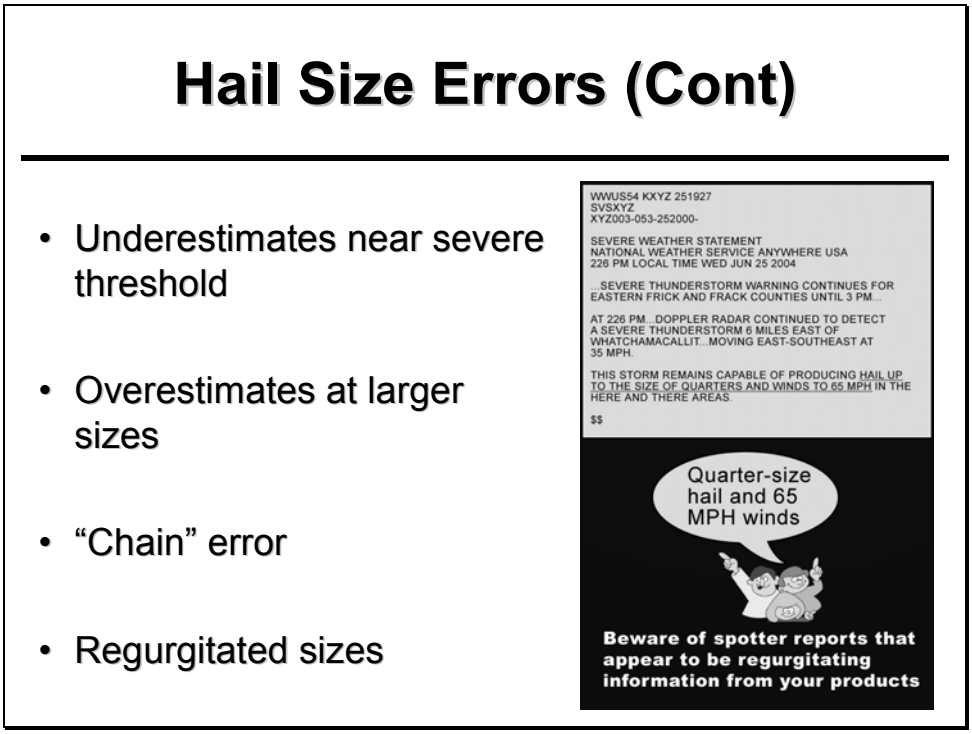
Witt et al. (1998) found that a small sample (115) of hail reports from OK and FL had an error rate of about 30% for time or location. This percentage was based on hail reports being located on the edge of a cell or over 50 km away from the radar-defined storm. (The same study used a range of 30 km to associate a hail report with a storm) While a detailed study has not been conducted, in talking with various experts it's believed that a more representative percentage for a large sample size of storm reports (wind and tornado included) would be closer to 10%.

Herzog and Morrison (1994) state that there is evidence that hail sizes in Storm Data have a substantial bias towards larger hail stones. However, Baumgardt et al. (2001) found that, lacking an objective measuring tool, spotters tend to underestimate hail smaller than golf ball size. At golf ball size and larger, the bias is less significant, but the standard deviation in estimated sizes increases. This result suggests that, as hail gets larger, it is easier to get an overestimate in hail size.

The same group found in a later study that spotters are more accurate identifying hail size by comparable object (egg, golf ball, etc.) than by objective measure (one inch,

half-inch, etc.). While this result would seem to help, Edwards and Thompson (1998) shows a graphic that suggests that hail reports tend to accumulate at sizes corresponding to certain objects, including golf ball and baseball sized hail. In addition, the climatological record contains some errors with regard to hail being compared to certain sized objects that do not match the measured amount listed (i.e., softball size hail is often listed as 4.5", but the largest regulation softball is 3.75").

Slide 9



Based on these previous research studies here's how hail sizes may impact operations.

The general public and hasty spotters will tend to underestimate the size of small hail. When I say small, I mean smaller than golf ball size. However, the significance of the underestimation is really at 1" or smaller since the severe criteria is ¾".

Around golf ball size and larger, overestimation is a more significant problem. At golf ball size and smaller, ~75% of estimates are smaller than the actual size. By 2.5", it's down to around 55-60% of estimates are below the actual size (Baumgardt et al., 2001). These distributions were based on numerical measurement estimates. Another impact at this range of sizes is with comparable objects. Below golf ball size, there are numerous coins and other objects commonly used to identify hail size. At golf ball size and larger, there are fewer objects that people can identify with a hail stone. This would explain the clustering of hail size distributions around golf ball, baseball, and softball size hail that was seen in Edwards and Thompson (1998).

Many times the spatial and temporal errors with hail reports are due to "chain" error. The more people that handle a particular spotter report, the greater likelihood there is going to be an error associated with that measurement. Some of the size (as well as time and location) errors seen may be attributed to this problem.

Yet another possible source of size bias is when a report repeats the hail size mentioned in NWS products, media broadcasts, or algorithms. While we want to provide

the general public and our other customers some kind of an estimate of the threat from potential hail, it's important to pay attention to how closely the reports coming in match the forecast hail size. If you are getting multiple reports of the same size hail, and just happens to match your products, you might want to view the reports cautiously. There likely is hail at those locations, but the size estimates may be way off. This phenomenon may balance out some of the biases discussed previously and help make the research findings the murky picture that they are.

Slide 10

Mitigating Hail Errors

- Rulers rule!
- Objects: give many options
- Question regurgitated sizes
- Better accuracy, better info

WWUS54 KXYZ 251927
SVSXYZ
XYZ003-053-252000-

SEVERE WEATHER STATEMENT
NATIONAL WEATHER SERVICE ANYWHERE USA
226 PM LOCAL TIME WED JUN 25 2004

...SEVERE THUNDERSTORM WARNING CONTINUES FOR EASTERN FRICK AND FRACK COUNTIES UNTIL 3 PM...

AT 226 PM...DOPPLER RADAR CONTINUED TO DETECT A SEVERE THUNDERSTORM 6 MILES EAST OF WHATCHAMACALLIT...MOVING EAST-SOUTHEAST AT 35 MPH.

THIS STORM REMAINS CAPABLE OF PRODUCING HAIL UP TO THE SIZE OF QUARTERS AND WINDS TO 65 MPH IN THE HERE AND THERE AREAS.

$$

Beware of spotter reports that appear to be regurgitating information from your products

Experienced spotters are very good about carrying rulers with them to measure hail. Those reports will be the most accurate.

If a spotter doesn't have a ruler, try to get them to compare the hail size to an object. In doing so, try to give them several options. This process is especially important at larger hail sizes. There's a big gap between a golf ball and a tennis ball, or a baseball and a softball!

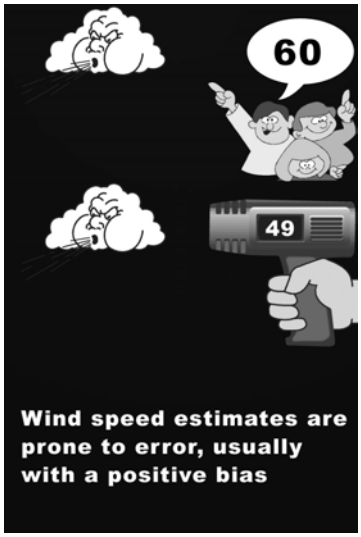
If you receive hail sizes that appear to repeatedly match forecast sizes, algorithm sizes, etc., rely on sizes provided by trusted spotters. You should expect some variability in your reports that come in, but a measurement from a proven spotter should dismiss concerns of inaccuracy.

While some of these steps may be time consuming, their goal is to provide you with more accurate, and better, information.

Slide 11

Wind Speed Estimation

- Most prone to error?
- Overestimated, generally
- More marginal events?



Of all of the information that forecast offices receive from spotters, wind speed estimates may be the most prone to error. Some reports are based on damage while others are based on spotter-derived estimates. These estimates are very subjective! While spotters do their best, they tend to overestimate wind speed (LaDue, 2003). This problem can be a particular problem at marginally severe or sub-severe speeds since more attention has been paid to observing these events over the last couple of decades (Weiss et al., 2002).

Slide 12

Wind Speed Estimation (Cont)

- Not enough damage info
- Significant tree damage at sub-severe speeds
- How do you know what's right?

Storm Reports: Severe Wind

Location	Time	Report
Circleville	17:00	60 MPH gust
Arbortown	17:10	65 MPH gust
Purchell	17:15	40-45 MPH winds
Twin Lakes	17:30	50-60 MPH winds
Big Cedars	17:30	Tree down on home

20-25% of wind reports have details about damage, the rest usually just have a wind speed estimate

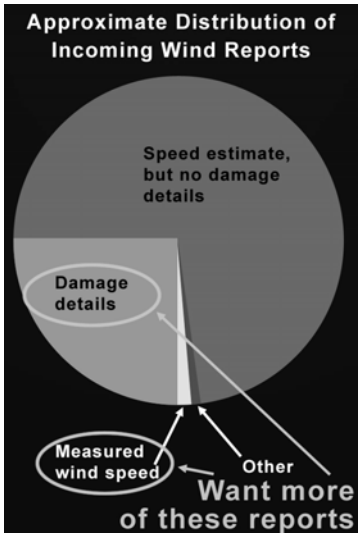
In the cases where damage is reported, there is at least some objective result to the wind event. The problem is that wind damage is often not well reported (or not well documented before it gets to the warning forecaster). One study (Weiss and Vescio, 1996), found that ¾ of all thunderstorm wind reports over a 30-year period were listed as "wind damage" with little or no detailed information about the type of damage. In a review of a small sample of events, we found that reports in phone logs generally had some flavor of wind damage listed in only 1 in 5 reports.

Even if damage is reported, much of the wind damage reports are characterized by tree damage. It's doubtful that many spotters know much all the factors that may impact how strong winds have to be to do tree damage. In some areas of the country, significant tree damage can occur at wind speed below the severe critieria. The point is that it's very easy for spotters to misjudge the intensity of thunderstorm winds. How are warning forecasters supposed to know if spotters are getting it right?

Slide 13

Mitigating Wind Errors

- Gust values unreliable
- 2/3 of reports have a speed estimate
- Did damage occur (Y/N)?
- More measured wind speeds



While wind gust estimates may not always be accurate, they do have value. Much like hail reports, forecasters should be aware of people seeming to repeat back forecast wind speed values from your products.

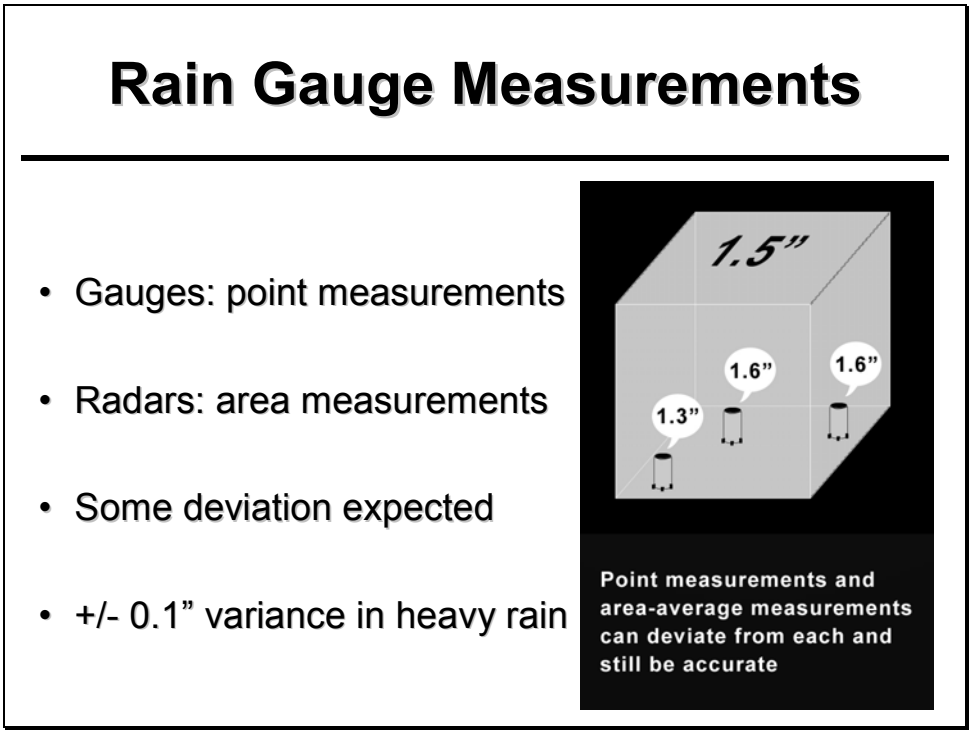
In a review of some previous events, it was found that about 2/3 of wind reports included some kind of wind estimate. Instead of focusing on the numerical value of the wind estimate, it might be better to look at the range of estimates relative to the severe threshold. Say something like 0-20 (light), 20-45 (strong, but definitely sub-severe), 45-65 (marginally sub-severe to marginally severe), 65-80 (definitely severe), and 80+ (take cover now). The numbers will, and should, vary depending on your CWA. One key to such a system is to have a good idea at what wind speed tree and other wind damage occurs in your CWA. Why you ask? So you can use reports of wind damage to QC the wind estimates.

Of course, you can't use wind damage to QC estimates if you don't receive reports of damage. When a report comes in, especially if you are receiving a first hand report, always ask if there was any damage. Make sure you document the answer! You are likely to forget in a few minutes if you have a lot of reports coming in.

Another good way to QC wind estimates, if possible, is to use measured wind speeds from METARs, mesonet sites, or spotters (via portable or hand-held anemometers) located near by. It is helpful if peak gust values from these sites can be recorded on spotter log sheets as storms move through. Even if the data comes in

minutes (even an hour) later, it helps to get that information in your logs. You will want that information for any post-mortem event review that you perform.

Slide 14



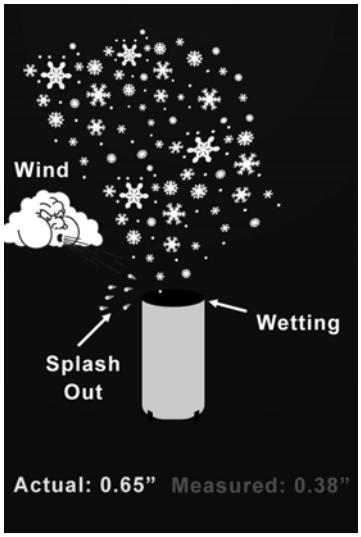
When errors associated with rainfall totals are usually mentioned, the focus is on radar measurement errors. Here will take a few moments to discuss rain gauge measurement errors and the acceptable variations between point and area-averaged data. While the errors with rain gauges are usually smaller than that with the radar estimates, they can still be significant. An important point to remember when talking about rainfall totals is the difference between the two data sources. Rain gauge rain totals are point measurements. They tell you the rainfall amount at a given point in space. The radar rain total is an area-averaged measurement. These data tell you the rainfall amount over an area defined by the radar specifications and algorithms. Some deviation between the two values is to be expected, especially under certain circumstances.

The previous biases really just impact the difference between the point measurement at a rain gauge and what the rain gauge should have measured. There is also the difference between what a point gauge measures and the area-averaged value for a radar measurement. In heavy rain, the standard deviation for a point measurement vs. the area average can be 0.05” or more (Duchon et al., 1995). That means that it is not unusual for accurate rain gauge measurements to deviate from a radar measurement by up to 0.1” or more just based upon the difference type of measurement.

Slide 15

Rain Gauge Measurements (Cont)

- Undercatch: wind, splash out, and wetting
- Tipping bucket gauge issues
- Rain: 3-10% low bias
- Snow: 50% or higher!

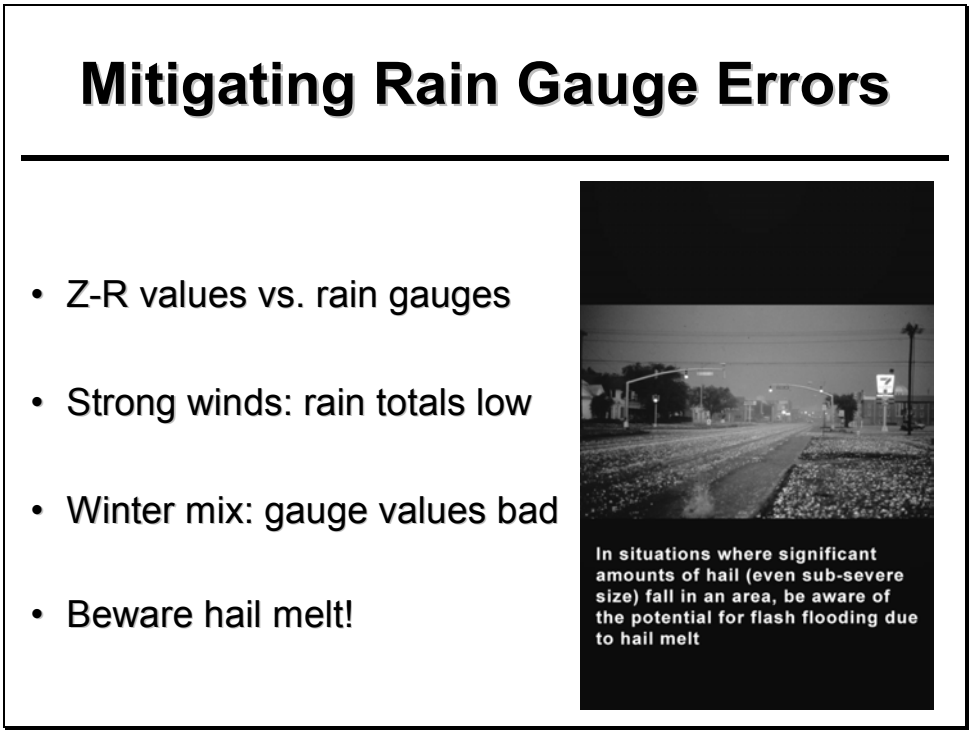


An important thing to remember about rain gauges is that they primarily have a negative bias. The reason for this tendency is that most of the error sources in a rain gauge result in less rain being measured by the gauge than what actually has fallen. These errors sources include wind-induced undercatch, heavy rain splash out, and gauge wetting. Undercatch is an issue that effects just about ever rain gauge, including ones with features (like wind and splash guards) used to minimize them.

Another source of undercatch not in the above list occurs with tipping bucket gauges. In heavy rain, tipping bucket gauges measure less rainfall than a standard rain gauge by up to 12% (Trammel, 2004). The undercatch is a result of some precipitation being lost in the process of the buckets tipping. Another issue with tipping bucket gauges, double tipping, can actual result in a positive bias. Double tipping can occur if a rain gauge is unevenly sited, which is extremely rare for most NWS observing sites. However, it is a possibility with some COOP or spotter sites, if they are using an automated, tipping bucket rain gauge (which is uncommon). Because the positive bias will generally be very rare, the discussion will focus on the low bias issues.

In general, the low bias for rain only events is approximately 3-10% (Groisman and Legates, 1994). While this value may not seem like much, it can be significant when you are talking about heavy rainfall occurring in a short time span. For snow and wintry mixes, the low bias is significantly larger. It can be 50% or higher! This bias makes most rain gauge measurements of liquid equivalent useless during a weather event that has winter precipitation for any significant amount of time.

Slide 16



Here are a few things to remember when dealing with possible rain gauge errors:

Don't be surprised if Z-R rainfall values end up being a little high, especially in heavy rainfall areas. In areas that have received 2-5" of rain, rain gauge measurement errors could account for an undercatch of .25-.5". Even if radar estimated rainfall rates are poor, warning forecasters should realize that the rain gauge measurement may have errors, also. If measured rainfall amounts approach 90% of flash flood guidance, there is a possibility that the actual rainfall amounts could be approaching 100%.

When storms with strong winds (especially severe thunderstorm intensity winds) move through an area, rain gauge measurements should be expected to be low. While it's difficult to say the exact bias for each site without detailed study of the instrument, 10% may be a good guess. Besides the fact that it falls in the range of rain gauge bias values, it's probably one of the easier values to figure out in a time sensitive situation. You just want to come up with a number that you feel comfortable with as being accurate enough to make a good warning decision.

In winter warning situations, it's best to avoid rain gauge totals from any site that has received any significant snowfall during the measuring period. When trying to determine liquid equivalent rain measurements, you will almost always get more accurate values from snowpack measurements than from rain gauge measurements.

One last issue about mitigating rain gauge errors is with regards to hail melt. If you have a significant hail storm in your county warning area that results in hail covering

the ground, forecasters should beware of the impact hail melt will have on flood prone areas. This problem is especially true in urban areas. Since little, if any, hail will accumulate in a rain gauge, the measured rainfall total is likely to be a lot less than the actual rain and hail liquid equivalent that has fallen in that area. Combine that deficiency with the fact that melting hail has a habit of clogging man-made drainage areas and you can have a major problem in low-lying areas.

Slide 17

Snowfall Measurements

- Climatological vs. real-time
- Timing of observations key
- Climate: every 6 hrs to 1/day
- Real-time: every 1-6 hrs

Real-Time Observations

Location	Time	Amount
Circleville	7:00 AM	1”
Circleville	8:00 AM	0.5”
Circleville	9:00 AM	2.0”
Circleville	11:00 AM	3.3”

Climatological Observations

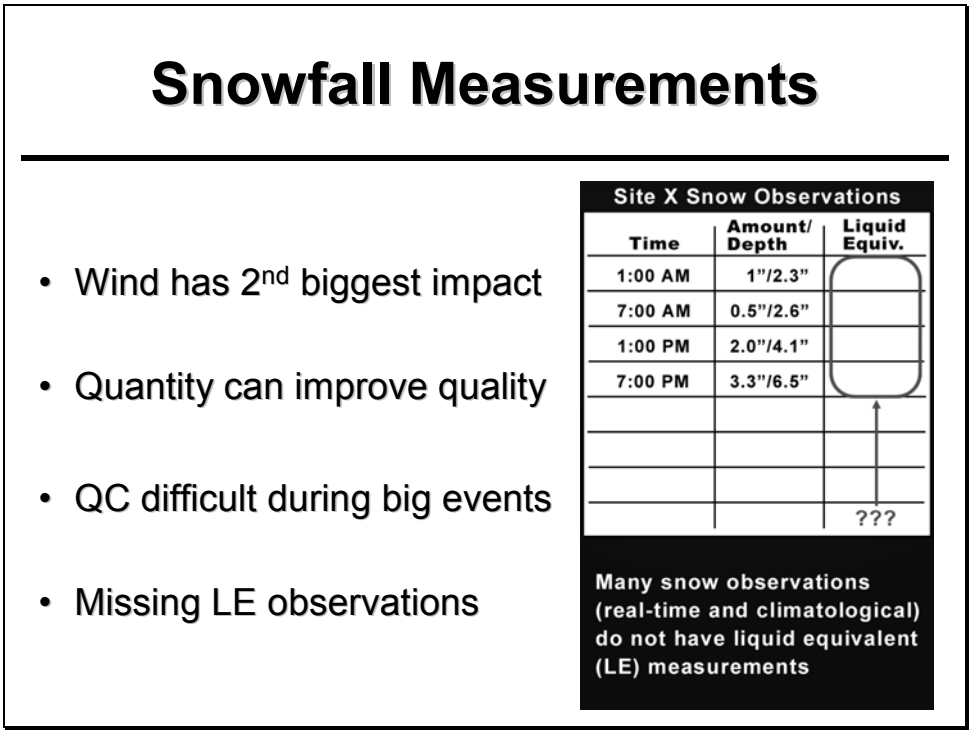
Location	Time	Amount
Circleville	6:00 AM	5.1”
Circleville	12:00 PM	1.1”
Circleville	6:00 PM	0.3”
Circleville	12:00 AM	0.0”

When discussing snowfall measurements for ground truth purposes, it’s important to discuss the two different types of snowfall measurements available to forecasters: climatological and real-time measurements. The difference between the two measurements is primarily in the timing of the observations (NOAA, 1997).

Climatological snowfall observations, which most of you are familiar with, are taken anywhere from once a day to every 6 hours. The reports include (or should include) new snowfall, snow depth, and liquid equivalent. These reports are used as part of the climatological record of snowfall.

Real-time snowfall observations occur more frequently than climatological observations, usually on the order of every 1-6 hours. The observations are useful to the warning forecaster to help them determine intensity and duration of an event in a particular area and issue products accordingly. However, because these reports are taken more frequently than every 6 hours, the snow doesn’t have enough time to settle so these measurements are not accurate enough for snow total measurements.

Slide 18



Besides the frequency of observations, one of the biggest impacts on snowfall measurement accuracy is wind. While sites are usually picked to minimize the impact of wind, that is not always an option. Also, strong winds (i.e., blizzard conditions) can still have an impact on drifting at sites that are selecting specifically to minimize the effect of drifting. In some regions of the country, where the land is generally flat and lacks sufficient tree coverage, it is virtually impossible to get accurate snowfall totals during blizzard conditions.

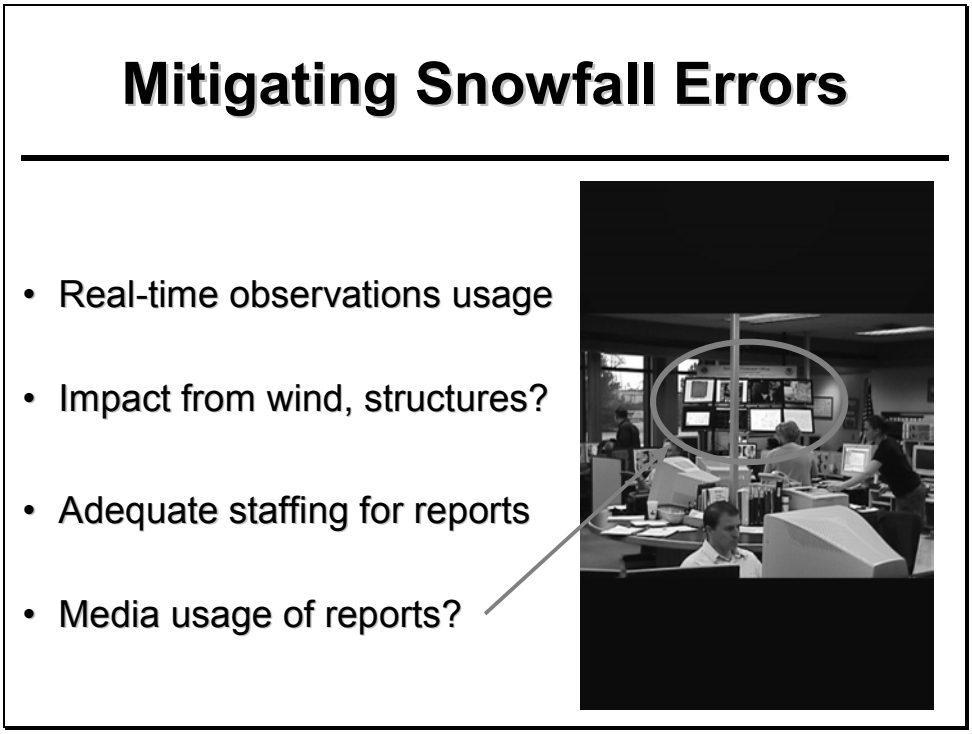
It is important, as a result, to have a good quantity of observers available to you. The volume of information may at times be difficult to handle. When you are impacted by a mesoscale winter weather event, having accurate, detailed real-time observations of the event may be the only good way to keep on top of the event and maintain good SA.

The volume of these reports, if you have a large number of spotters, may make QC of incoming reports difficult. This problem is worse the more real-time observations you receive because of the shear volume of reports (BUF office had about 15 real-time observers per county, on average, back in 1997; that number may be closer to 20 by now).

While real-time reports may focus primarily on intensity, liquid equivalence (LE) is important, too. LE is a variable that is not impacted by the frequency of observations. However, climatological reports (1-4 a day) often do not contain LE amounts, let alone reports that are coming in every hour or so. Many times, LE reports from spotters may

be the only reliable means for forecasters to know the amount of precipitation that has fallen (due to unreliability of rain gauges during winter weather).

Slide 19



Based upon my previous statement, it's clear that have real-time snow spotters is a big help. In a service assessment of a significant lake effect snow storm in western NY, one of the recommendations was for forecast offices to develop a network of real-time snow spotters to work in conjunctions with climatological snowfall observers. The real-time observers have had a major impact in the BUF CWA during several events since then (NOAA, 1997).

It's important to note again that real-time observations of snowfall are good at determining snowfall intensity, not snowfall totals. Most times snowfall totals from hourly measurements will exceed climatological measurements because the snow has not had a chance to settle and compact during the hourly measurements.

Just like with severe storm spotters, communication is always important. The more information you can get about the observation the better. Were the winds strong at the measurement site? Are there any structures nearby that may have had an impact on the measurement? Anything you can learn (and document) that might have a data quality impact on the measurement is important.

Of course, to handle this flow of information you will need to make sure there is adequate staffing for taking and quality controlling the reports.

You will also need staffing to handle one potential side effect of gathering these real-time snowfall observations: media reports. It's possible the media, not knowing the difference between climatological and real-time snowfall measurements, will sum up the

real-time snowfall measurements and report the totals to the public. If there is a significant deviation between the official totals you report and the media's report, you may get phone calls from confused people wondering which number is correct.

Slide 20

Conclusions

- Understand ground truth data quality issues and mitigate when possible
- You can find some, but not all errors, during warning operations
- Goal is to find the obvious errors, corroborate questionable reports
- Adequate staffing, good communication key

Regardless of the type of ground truth data, the most important thing is to understand the issues that can affect data quality and know how to mitigate those issues when possible. Many times, you will not be able to prevent the error from occurring, but you can prevent the bad data from impacting your operations. While some ways to mitigate data errors are provided here, it's important to realize that no technique will be perfect. You will not be able to catch every bad ground truth report. With a little hard work, however, you should be able to determine if a report has an obvious error. With a little luck, you may even be able to corroborate or dismiss reports that you receive and identify as questionable. All you are trying to do is get the best information possible. To take these steps, it's important to make sure you have an adequate number of staff available to you during warning operations and that good communication is maintained prior to and during the event with the people who are making the ground truth observations for you.

Slide 21

Questions???

If you have any questions about this lesson:

1. First ask your SOO
2. If you need additional help, send an e-mail to iccore4@wdtb.noaa.gov (Instructors group – answers will be CC'd to the SOO and considered for the FAQ page)

Take test as soon as possible after Lesson 4

If, after going through this lesson you have any questions, first ask your SOO. Your SOO is your local facilitator and should be able to help answer many questions. If you need additional info from what your SOO provided, send an e-mail to the address on the slide. This address sends the message to all the instructors involved with this IC. Our answer will be CC'd to your SOO so that they can answer any similar questions that come up in the future. We may also consider the question and answer for our FAQ page. Thanks for your time and good luck on the exam!

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AWOC data quality

Lesson 4 - GOES satellite data issues

Welcome to the AWOC data quality lesson covering satellite data quality. This presentation is 25 slides long and should take 30 minutes to complete

Learning Objectives

- Satellite (Lesson 4)
  1) Through an understanding of satellite parallax, identify the correct geographic location for which a satellite-observed storm top is observed.
     a. Understand approximate magnitude and direction of parallax for storm tops of 10 km given your geographic location
  2) Understand the effective spatial resolution for 4 imagery channels on the Geostationary satellite used for your CWA
     a. Understand limitation
     b. List potential errors in storm top heights as measured by AWIPS

There are too many aspects of satellite data quality to cover in such a short section. We chose to limit our data quality issues to those that are most helpful to warning operations. We have 5 objectives that we will cover in this lesson:

1. The first objective is really a combination of data quality and interpreting satellite data. Satellite parallax hinders the user's ability to interpret combined radar and satellite data. Luckily there are methods to correctly correct for parallax error for features such as storm tops. You will be able to identify the correct geographic location of any storm top at the end of this lesson. The information we give you here should allow you to do this without having to resort to equations.
2. Determining the effective spatial resolution of an individual Instantaneous Field Of View (IFOV) is a related data quality issue to parallax in that both depend on the zenith angle of the satellite from your position. You will be able to understand the effective spatial resolution of the GOES IR and visible imagery over your location. Specifically, you will see how the spatial resolution limits your ability to see certain features and potential problems in detecting small features.

Learning Objectives

- Satellite (continued)
  3) Understand the impact of varying temporal resolution on warning operations:
     a. State the time delay between the satellite scan and receipt at AWIPS for Rapid Scan Operations (RSO) and normal operations.
     b. Know how to call for GOES RSO
  4) Understand the data quality issues of Geostationary satellite derived product imagery:
     a. LI
     b. PW

3. The third objective covers the impact of varying temporal resolution on warning operations. You should be aware of the time delay of between the satellite scanning your CWA to receipt of that imagery at your AWIPS workstation during normal and Rapid Scan Operations (RSO). You should be aware of how to call for GOES RSO operations.

4. The final objective briefly covers data quality issues of GOES derived product imagery and how they may affect your near storm environment analysis.

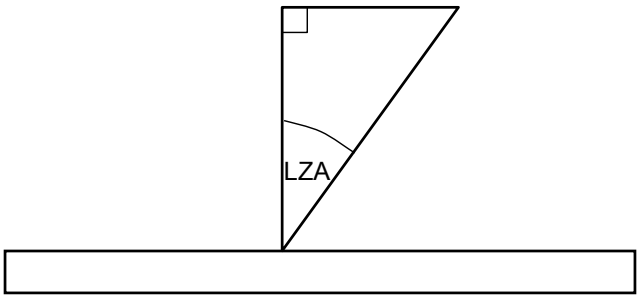
Performance Objective

- Satellite
  1) Calculate the direction of parallax error from GOES satellite when adjusting the apparent satellite position of a cloud top to its actual position at ground.

A performance objective for this lesson will require you to calculate the direction of parallax error from a GOES satellite when adjusting the apparent satellite position of a cloud top to its actual position at ground.

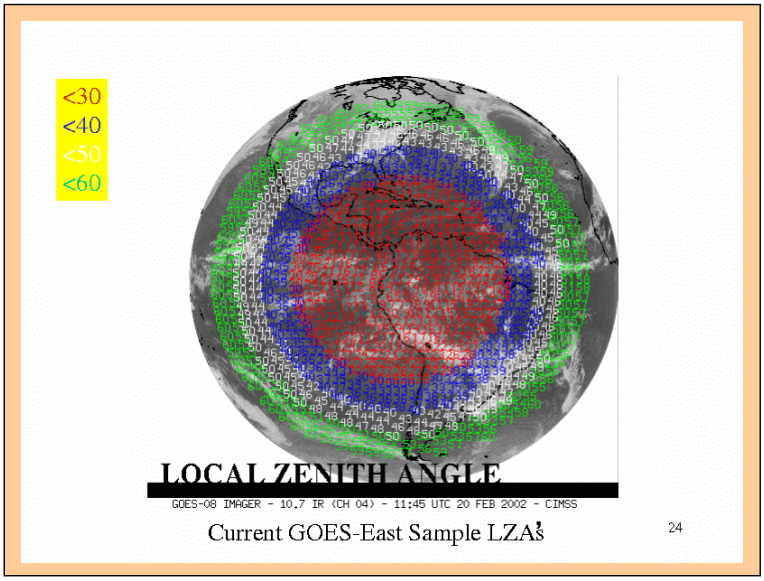
GOES Local Zenith Angle

- GOES Local Zenith Angle (LZA) impacts
  - your parallax error magnitude
  - Your effective pixel resolution



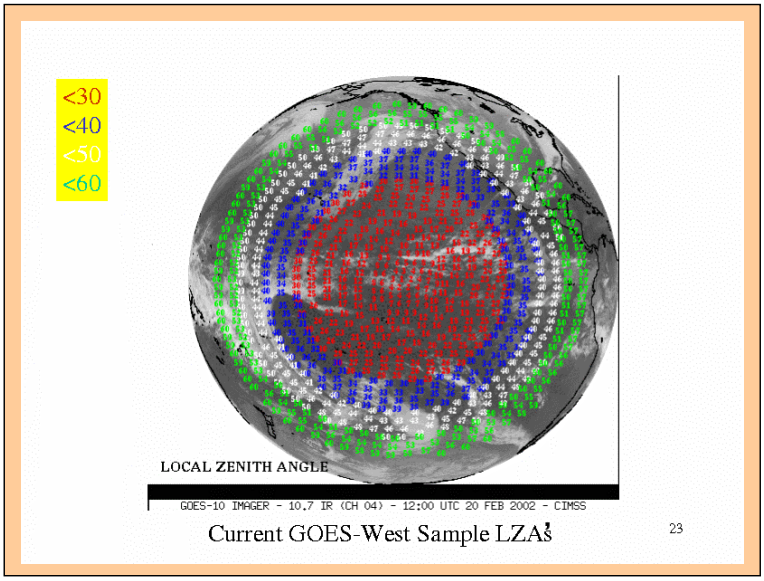
The parallax error and effective pixel resolution depend on your GOES Local Zenith Angle (LZA for short). The LZA becomes zero when the satellite is overhead and you're at its nadir (looking straight down). If the satellite is on your horizon, the LZA approaches 90°.

GOES-E LZA



Here is a map of the LZA angles depicted for GOES-E when it is over 75° west longitude. Pick the LZA for your area and keep it handy. You may need it later on.

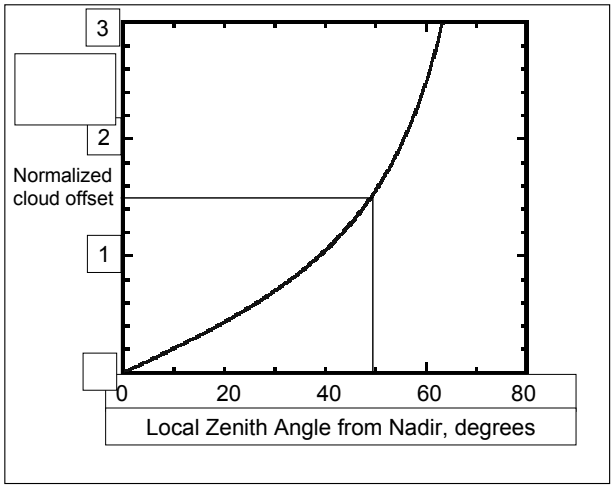
GOES-W LZA



Likewise, GOES-W viewing area LZA map is presented here and is valid for a GOES-W position of 135° west longitude. If your LZA appears to be less than 60°, keep the number handy for your CWA.

Satellite Parallax errors

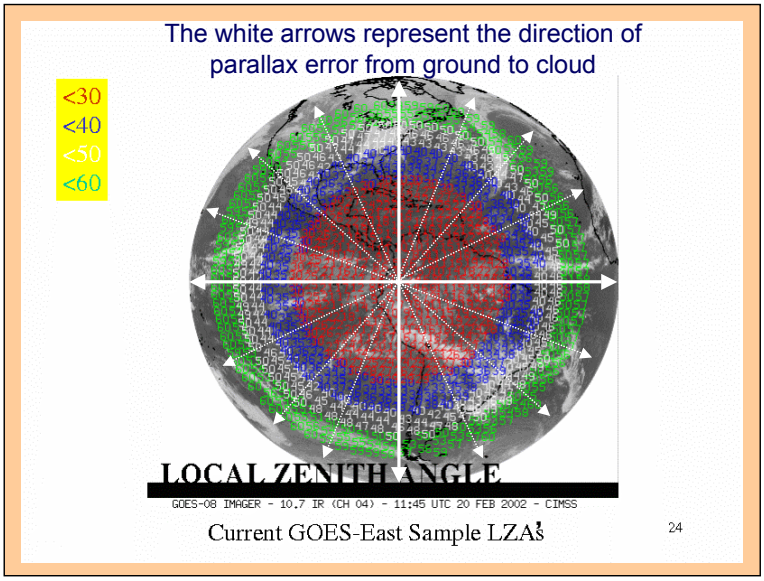
1. Use the previous pages to determine your LZA from Nadir
2. Multiply the height of your cloud by the Normalized cloud offset to get the horizontal parallax error magnitude



You can now take your LZA, and apply it to this graph to view the horizontal error for any feature of any height. To apply this, look up your LZA on the X-axis. I will look up one of 49.5°. Then take a line straight up to the blue curve. Then go left to the axis labeled “Normalized cloud offset”. I get a Normalized cloud offset of 1.5. Now for any feature for which you have an idea on the height, multiply its height by the Normalized cloud offset to get the horizontal parallax error in the same units as the height of your feature.

Horizontal parallax error = Height of your feature X Normalized cloud offset

GOES Parallax direction

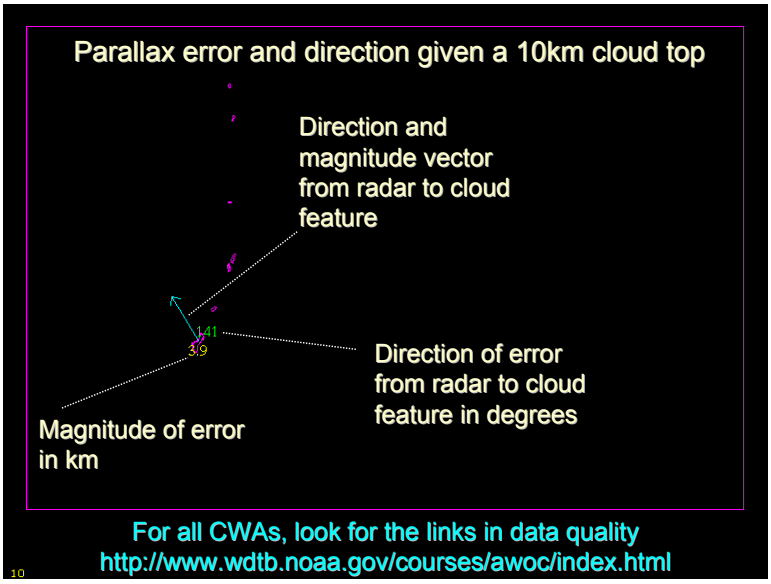


For the direction of your parallax error, the arrow overlays on your LZA map radiate away from the nadir point of the GOES.

The arrows represent the parallax error direction if you want to see where a ground object, or a storm on radar, is located at where the satellite thinks it should be. That is called parallax error from ground to cloud.

If you are looking at a cloud and want to know what direction its ground position should be, follow the direction opposite to the arrows to your feature's ground position.

GOES parallax magnitude and direction

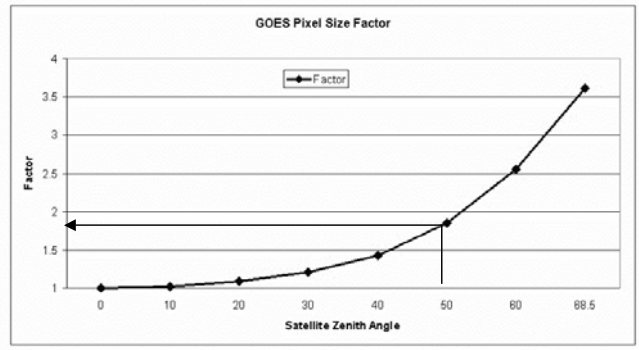


The Guam weather office is special since we do not have an LZA map for this area. You get special treatment. However, in this case, we gave you a fixed 10 km map and the magnitude of the error in km. For maps with all CWAs for both satellites, take a look at the website above and find the links to satellite parallax corrections. They will be found in the Data Quality section.

GOES effective pixel resolution

1. Determine your Local Zenith Angle

2. Multiply the GOES pixel resolution (IR, vis, WV) by the factor (y axis)

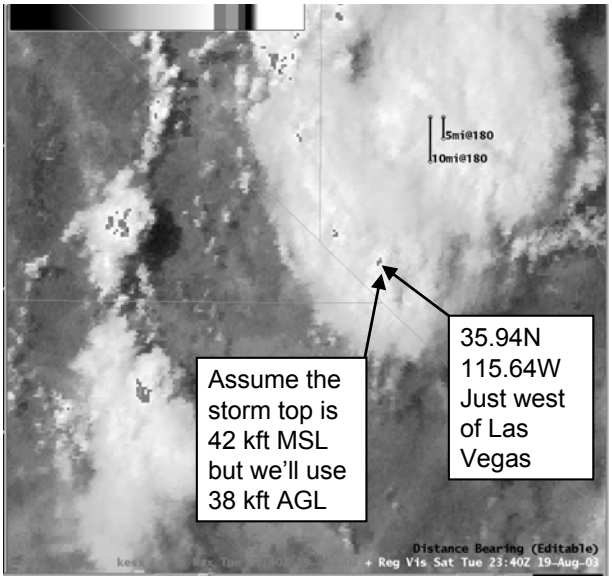


25

GOES effective pixel resolution operates in the same way as parallax error magnitude. Match your LZA with your 'Factor' so that both meet at the dark blue curve. Multiply the area of the nadir IFOV (Instantaneous Field Of View) by the 'factor' to get the IFOV over your CWA. In my example, my LZA of 49.5° corresponds to a factor of 1.8, roughly. Let's see what my 10.7um IR resolution really is overhead. The GOES IR resolution at nadir is something like 2 X 4 km or 8 km^2. Multiply 8 by 1.8 to get 14.4 km^2 . The shape of your IFOV is no longer a box. It is more like a long parallelogram with the long dimension in the direction of your parallax error direction.

Example

- Assume you have no radar and need to issue a warning based on satellite only
- Where is the the overshooting top located?

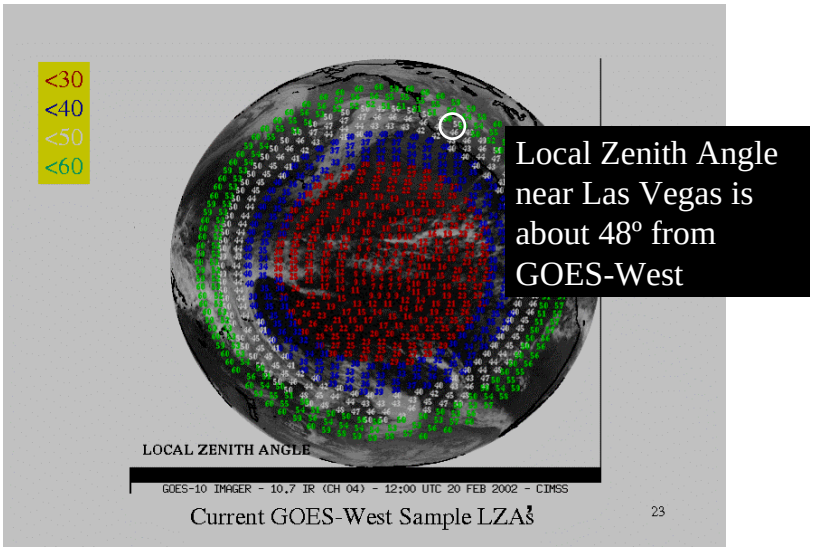


Here is an example given a overshooting top west of Las Vegas and your radar died. You need to locate the actual position of the storm top in order to figure out the nearest town to be affected.

The satellite position of the storm top as seen by satellite is 35.94 N and 115.64 W, just west of Las Vegas.

The storm top given to me by the AWIPS cloud height algorithm is about 42 kft MSL. With the ground there, we'll revise to 38 kft AGL (that will vary).

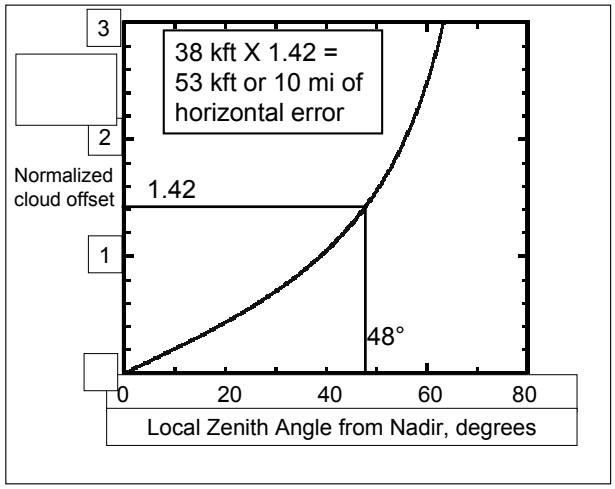
Example



Local Zenith Angle near Las Vegas is about 48º from GOES-West

From GOES-W the LZA for Las Vegas is about 48°. The direction from cloud top to ground is going to be roughly to the southwest, from my point to the satellite.

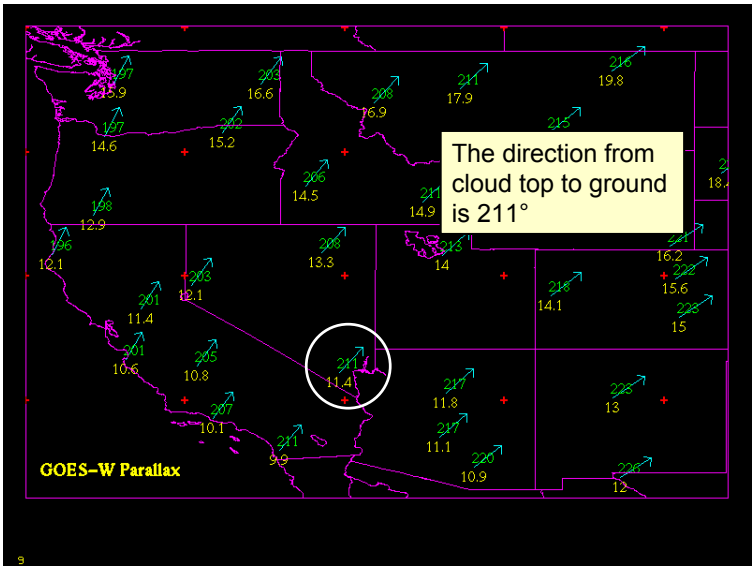
Example



I convert my LZA to the Normalized cloud offset to reveal that any error will be 1.42 times the height of the feature.

Therefore, my parallax error for the storm top is about 10 mi.

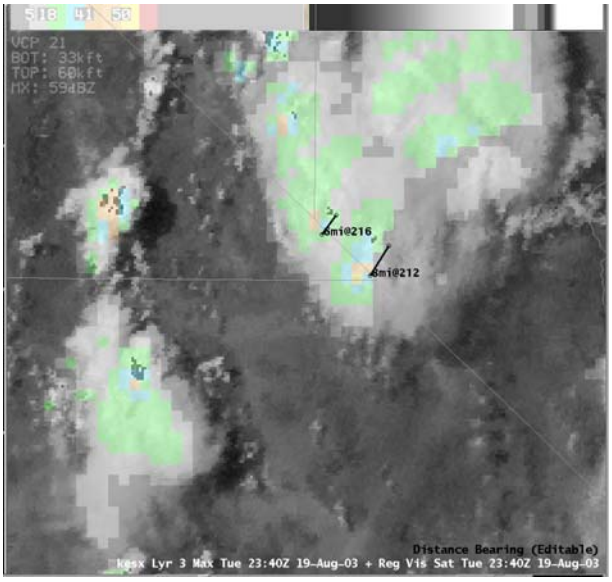
Example



This map shows the direction of my parallax error. I thought it was approximately to the southwest and indeed it is. The vectors in this map point to where an object over the correct ground position will be according to the GOES-W. But I'm going in the opposite direction and therefore I adjust my storm top towards 211° by 10 miles.

Example

- From the LRM high product, I adjust my visible overshooting top 212° at 8 mi.



The radar suddenly came on to allow me to verify my estimation. I will use the LRM high product to spot the cores that may be close to the overshooting top. Indeed, the actual errors are pretty close to my calculation. The radar locations of the storm top are to the southwest anywhere from 8-12 miles.

Impact of RSO on Warning Operations

-- RSO can capture atmospheric phenomena that occur on time scales less than 15 minutes

-- Allows a better analysis of the mesoscale environment, leading to increased warning times

-- Satellite images are received more often (normally 8 per hour compared to 4, except during full-disk times) and more quickly

Let's change subjects and discuss the impact of RSO on your warning operations.

I cannot even come close to talking about all the benefits RSO has on your warning operations. There are at least three excellent teletraining sessions from VISIT that cover all the meteorological benefits. To be brief, anytime you expect hazardous mesoscale weather to evolve on timescales less than the normal 15 minute scan, you should request RSO. The key advantage is with RSO, you get 8 images per hour, twice the normal, except for the three hourly full-disk scans (these are 1745-1815, 2045-2115, 2345-0015, 0245-0315, 0545-0615, 0845-0915, 1145-1215 UTC).

Impact of RSO on Warning Operations

Example:

GOES Image Time:	**19:37 UTC**
Last Line at NESDIS:	**19:42 UTC**
Transmitted to AWIPS:	**19:43 UTC**
Displayed by AWIPS:	**19:44 UTC**

** During normal operations images take 20-25 minutes after scan to appear on AWIPS

RSO benefits not only with more frequent imagery but also you get more timely receipt of imagery. For example, a GOES image time of 1937 UTC takes about 5 minutes to complete so that the last scan, somewhere south of Florida for GOES-E, is really getting a 1942 UTC scan. The data takes about a minute to transmit to AWIPS so the 1937 time stamp is now 6 minutes old.

Add another minute to be displayed on your D2D workstation, and you will see the image 7minutes after the time stamp. Remember that for southern sites, the actual scan is a few minutes after the time stamp so you are actually seeing more recent imagery than 7 minutes.

For normal operations, 15 minute imagery, you may not see that image for up to 25 minutes after its time stamp. Southern sites only shave a few minutes off that lag time.

How are RSO calls made?

-- SPC GOES-12 autotrigger for Day 1 Moderate Risk or greater

-- TPC autotrigger for Hurricane watch/warning

-- Any office can call RSO for a variety of reasons, including severe weather, winter weather, fog, fires, etc.

RSO focal points for each region:

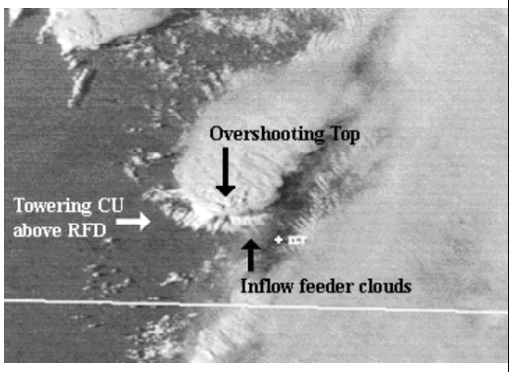
Central Region: Detroit, MI
Eastern Region: Pittsburg, PA
Southern Region: SR SSD or Tulsa, OK
Western Region: Monterey, CA
Pacific Region: Honolulu, HI
Alaska Region: Anchorage, AL

RSO calls are made for these three reasons:

1. RSO operations are automatically triggered if SPC issues a MDT or High risk, and then only for GOES-12.
2. Any time a hurricane watch or warning is issued, the GOES will autotrigger into RSO mode.
3. Finally, you can call your regional RSO focal point to issue RSO for any satellite for as long as you think necessary and for any legitimate reason.

Advantages of RSO

- **With RSO, you have a better chance antipicating which towering cumulus clouds will evolve into CBs, improving convective initiation forecasts/nowcasts**
- **Other thunderstorm features evolve fairly quickly in time, so RSO is *very* helpful in identifying them**



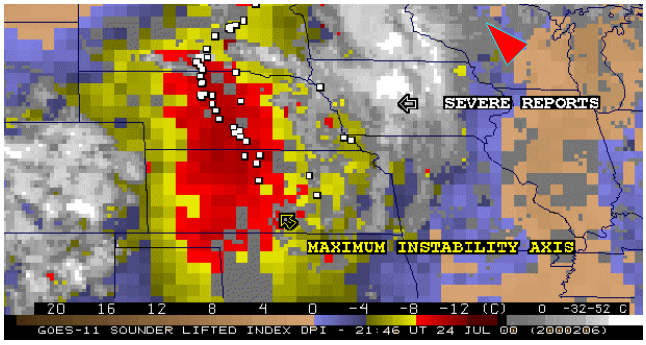
RSO imagery allows you to track the growth rates of towering cumulus, and track the motion of individual boundary layer clouds.

RSO is able to track thunderstorm features such as outflow boundaries, onset of feeder bands, and the growth rate of the anvil.

As an aside, the growth and decay of overshooting tops is one feature with faster evolution that standard RSO can handle. If the GOES is in SuperRSO mode, even these features can be tracked and trended successfully.

Derived product imagery – LI and TPW

- Trends in values more useful than actual values
- Horizontal gradients in LI, TPW, CAPE are easy to identify



This is a brief introduction to GOES Derived Product Imagery (DPI) and data quality issues associated with it. We cannot give the time needed to cover all the aspects of the value of DPI. But there are some issues with the quality of DPI that help you to make efficient use of the data.

The GOES DPI includes useful parameters for assessing the near storm environment. Sixteen channels of sounder radiance data is converted to vertical temperature and moisture profiles with the assistance of a model first guess analysis. We have found that the thermal components to the DPI vary little from the model first guess. The moisture fields, on the other hand, offer a greater improvement to the model first guess than that of temperature. However, the vertical resolution for both temperature and moisture is limited owing to the limited number of sounder channels, and the broad depth of the atmosphere that contributes information to each channel. For example, there are only three watervapor sounding channels available to derive a vertical moisture profile in the GOES DPI.

The bad news is that the lack of vertical resolution, the GOES DPI is not suited well to analyzing fine details in the vertical structure of temperature and moisture. However, the good news is that the horizontal gradients and trends in moisture and temperature that contribute to the parameters (LI, CAPE, TPW), can be detected very well by the GOES sounder and should provide good value to the analysis of the near storm environment.

An example shown here depicts the GOES Lifted Index (LI) where the red values are less than –8. The shape and time trends of this field began to show rapid destabilization in a meridional corridor south of a developing supercell. The storm was moving south and a major forecast question was how far south the storm would be able to go. The GOES DPI indicated a long path of highly unstable air to its south. The storm lasted almost six hours and produce a continuous swath of wind and hail damage as can be seen by the white storm reports.

Derived product imagery – LI and TPW

- Imagery not available in cloudy regions
- Sounder resolution more coarse than imager
  - Field of view is ~16 X 11 km at latitude=37°
- All parcels are surface-based
  - No consideration for elevated LI/CAPE

Caveats to using the GOES DPI imagery do abound. Unfortunately, the sounder is IR-based, and therefore, clouds are opaque. Anywhere with clouds of any altitude, even thin ones, will prevent the sounder from collecting anything meaningful. The field of view is roughly 16 X 11 km at mid latitudes, and in order to smooth out the noise, the operational DPI imagery averages five of these together to produce a relatively coarse grid. Newer techniques in using single IFOV values have not been deployed yet.

Finally, the LI and CAPE fields are surface-based. This product will not work well for elevated instability.

Satellite Data Quality issues: Summary

- We have covered
  - Satellite parallax errors and a method to correct for it
  - Effective pixel resolution
  - Advantages of Rapid Scan operations
  - Derived product data quality

To summarize, we have covered:

1. satellite parallax and methods to correct for it without equations,
2. how to find out effective pixel resolution over your CWA,
3. advantages to RSO data,
4. and some data quality issues for GOES DPI.

Satellite Data Quality issues: Summary

- There is much more to satellite data quality
  - GOES imagery FAQ
    - http://www.cira.colostate.edu/ramm/visit/goesfaq.asp
  - GOES imagery sensitivity
    - http://www.comet.ucar.edu/class/satmet/kidder/sensitivity.html
  - Virtual Institute for Satellite Integration Training
    - http://www.cira.colostate.edu/ramm/visit/visithome.asp
  - NASA GOES page
    - http://rsd.gsfc.nasa.gov/goes/

There are many more training sessions than we have time for to cover all warning-related satellite issues.

However, here are some websites that you are welcome to review.

That is the end of this lesson.

Learner Version

Advanced Warning Operations Course
IC Core 4
Data Quality
Lesson 5

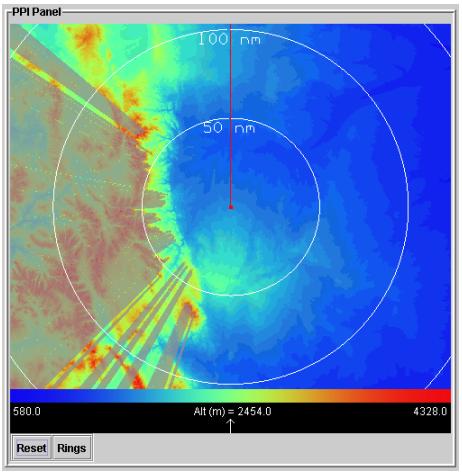
VCP Explorer Job Sheet 1
VCP Explorer V2.x

Objective: 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]

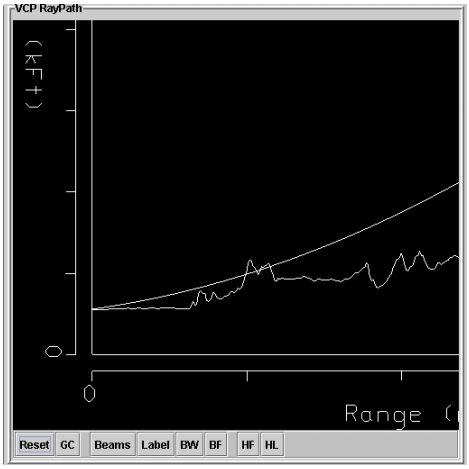
2. Turn on the Ground Clutter (beam blockage) view.
   [GC button]



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].

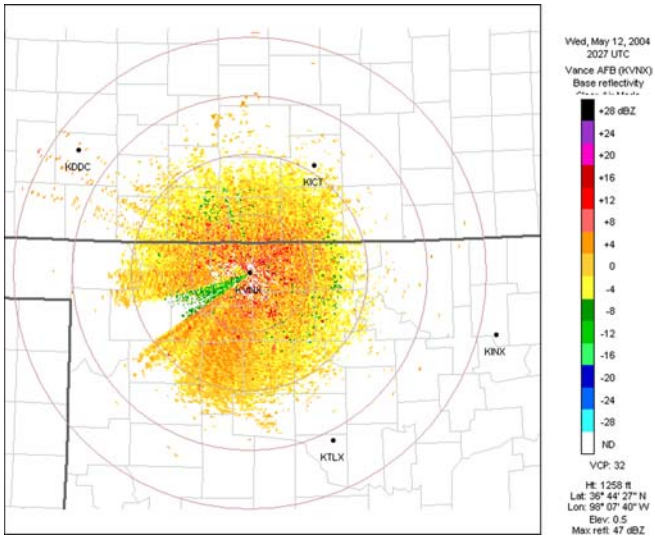
7. Change the VCP to VCP 12. Change the azimuth to 260°. At what range does the beam blockage start on the lowest tilt?

   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.

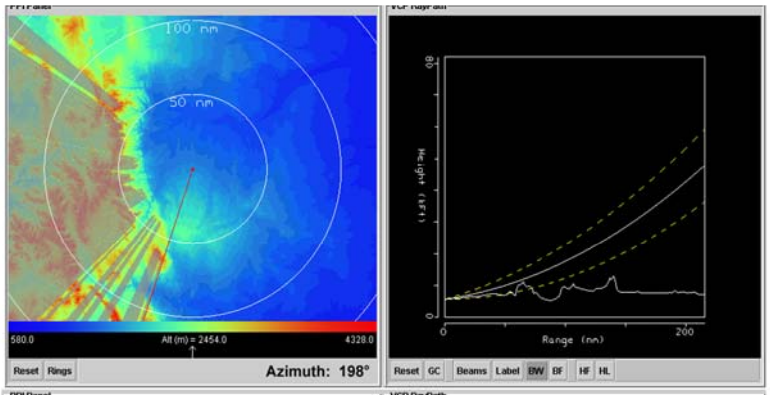
Answer Key

1-4. Perform the operations as directed.

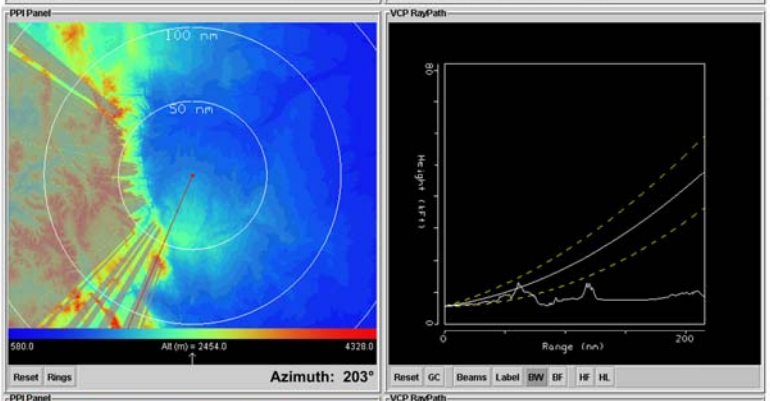
5. This series of images illustrate the beam blockage between 198° and 230°. Similar images would result between 270° and 312°. Between 198° and 230°, various azimuths are blocked by terrain obstacles including the following locations:

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

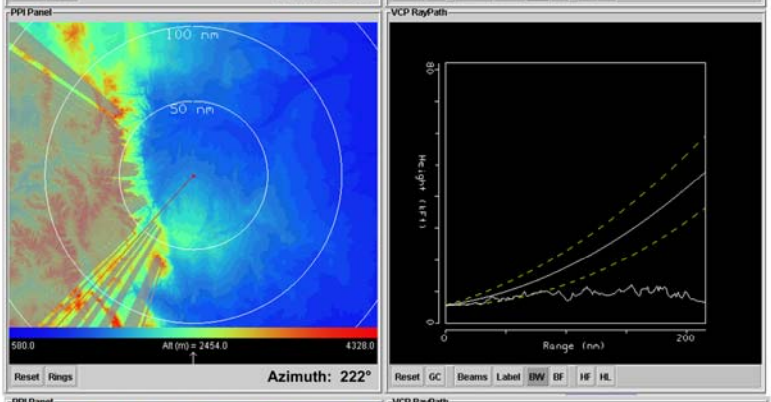
198°



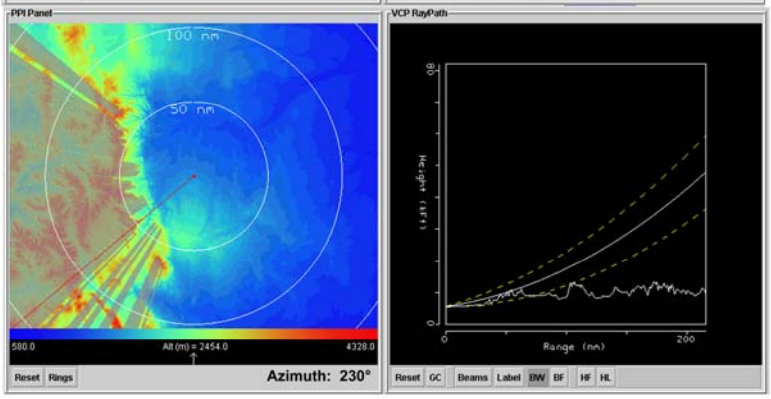
203°



222°

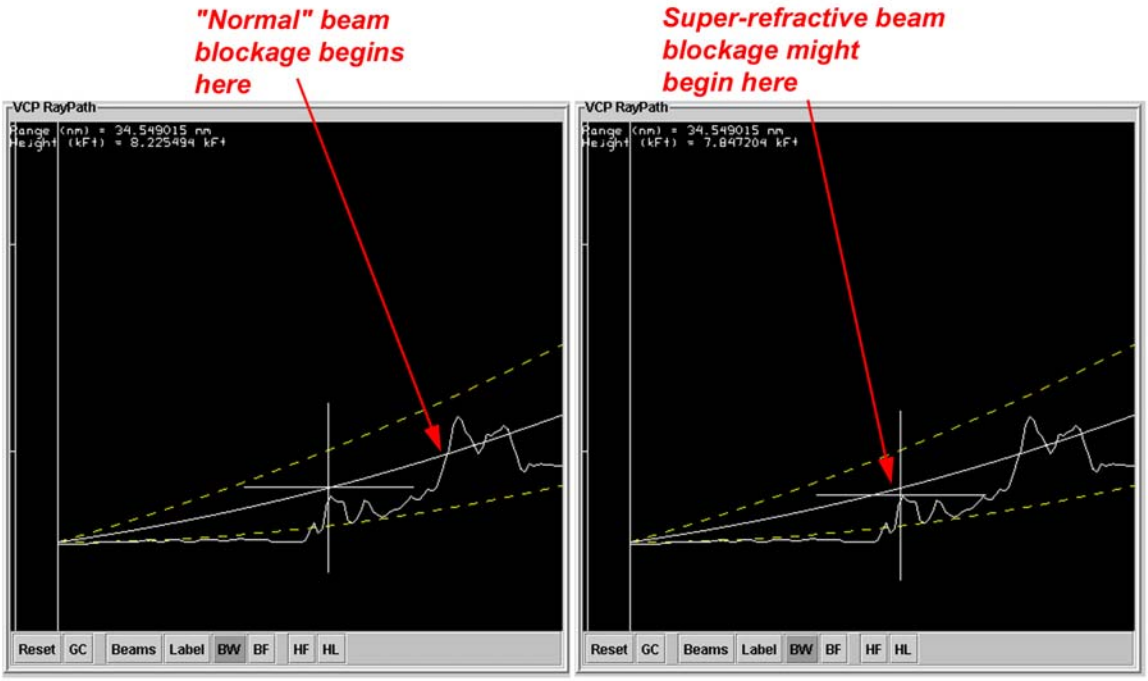


230°



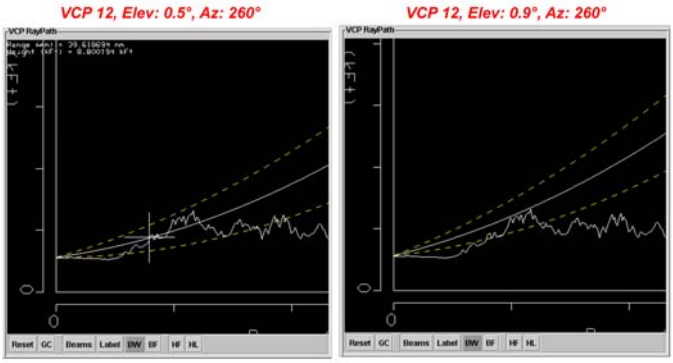
Answer Key

***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.*

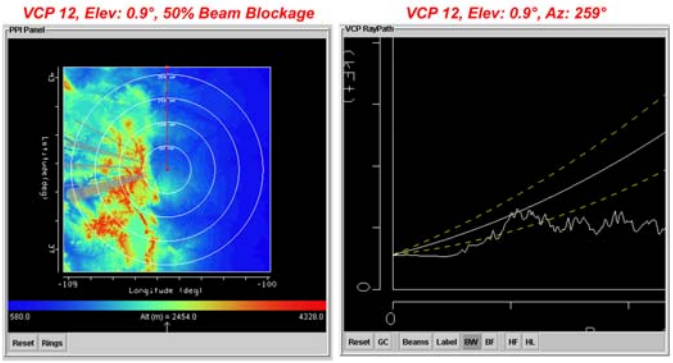


***7a.** The range is ~40 nmi.*

***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.*

Answer Key

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.***

Learner Version

Advanced Warning Operations Course
IC Core 4
Data Quality
Lesson 5

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]`

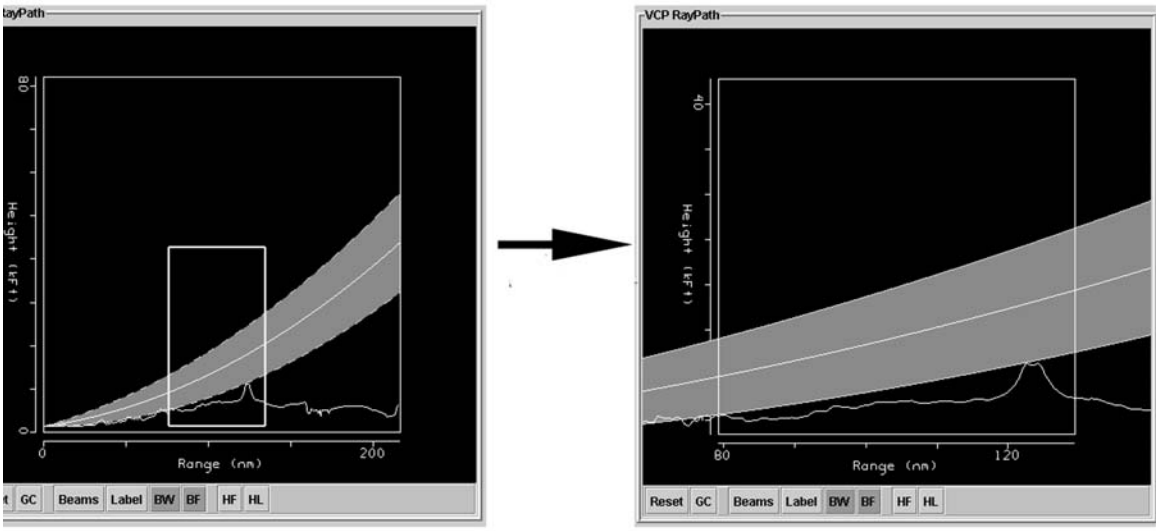
2. Change the VCP to VCP 11. Although there are more tilts, the beams are still adjacent to one another. Turn off the Beams function and successively cycle through adjacent elevation angles to see the relationship between adjacent tilts.
   `[Click the Beams button. Click on 0.5, 1.45, 2.40, 3.35, 4.30,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

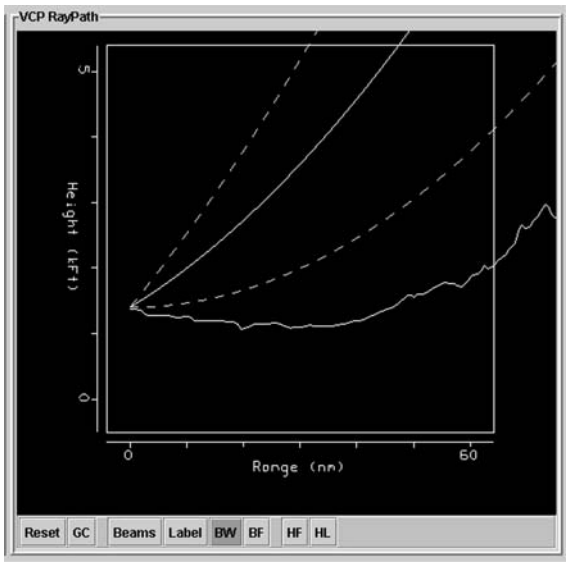
   Fill out the following table for a range of 100 nmi:

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*

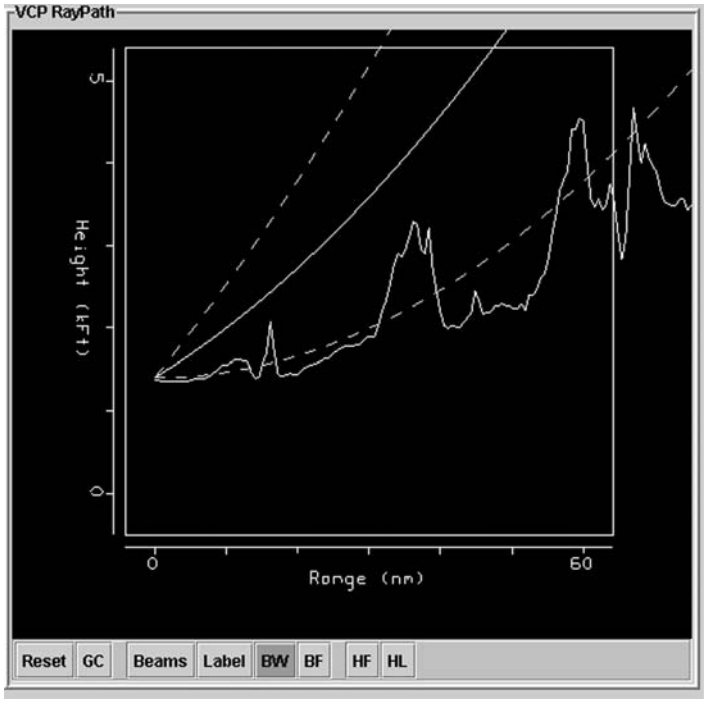
Note: These values are approximate.

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.***



Learner Version

Advanced Warning Operations Course
IC Core 4
Data Quality
Lesson 5

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***

Learner Version

Advanced Warning Operations Course
IC Core 4
Data Quality
Lesson 5

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

Learner Version

Advanced Warning Operations Course
IC Core 4
Data Quality
Lesson 5

VCP Explorer Job Sheet 5
VCP Explorer V2.x

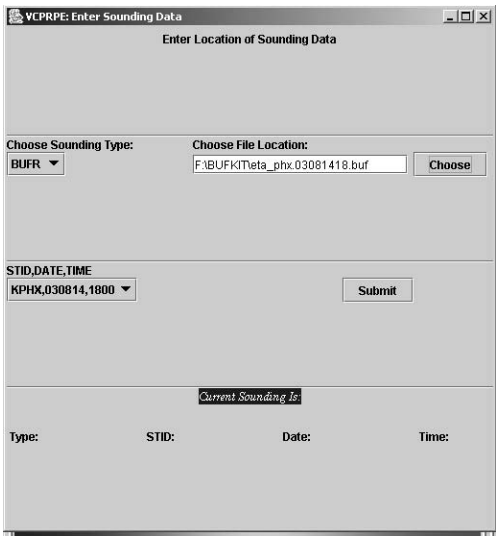
Objective: The objective of this exercise is to use VCP Explorer to visualize the effect of temperature and humidity profiles on radar beam propagation

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.

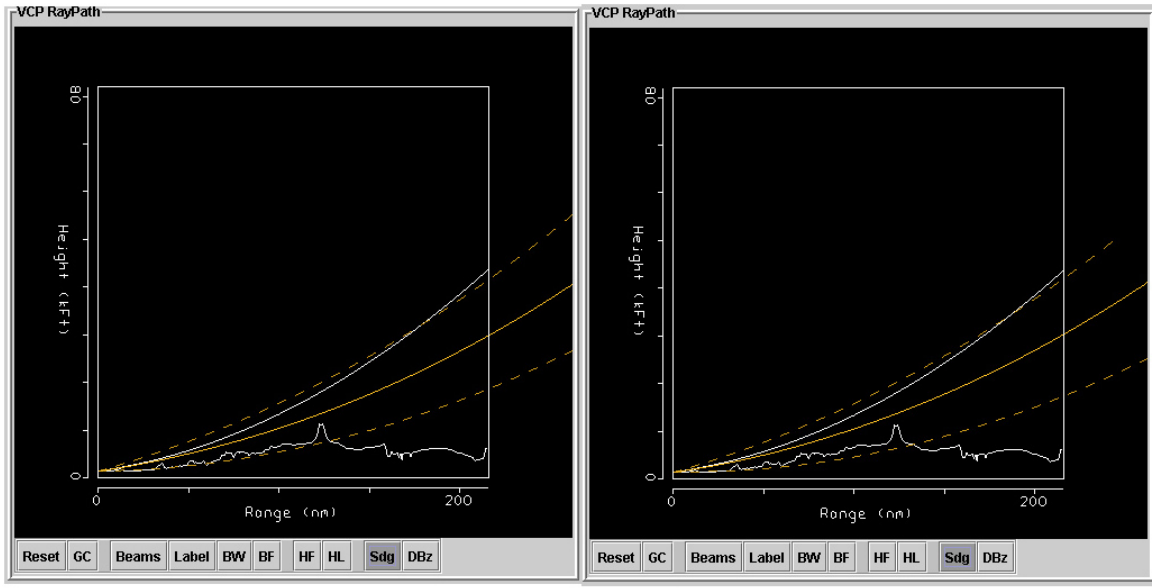
3. Load the Phoenix BUFR file into VCP Explorer.
   [Compare → Sounding. When the sounding window comes up, make sure the Sounding Type is BUFR. Click the Choose button and navigate on your computer to choose the eta_phx.03081418.buf file.]



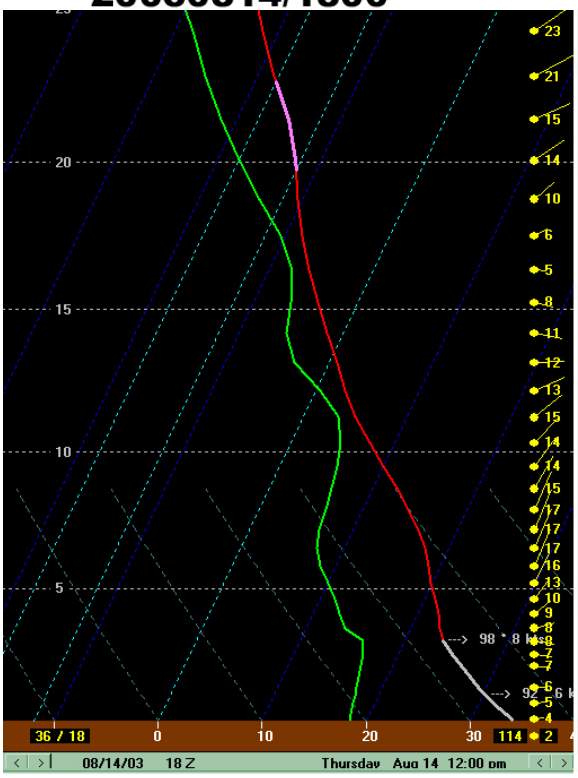
4. Choose the KPHX sounding for 08/14/2003 at 1800 UTC.
   [Click the Submit button. Do not close the Sounding data window.]

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.

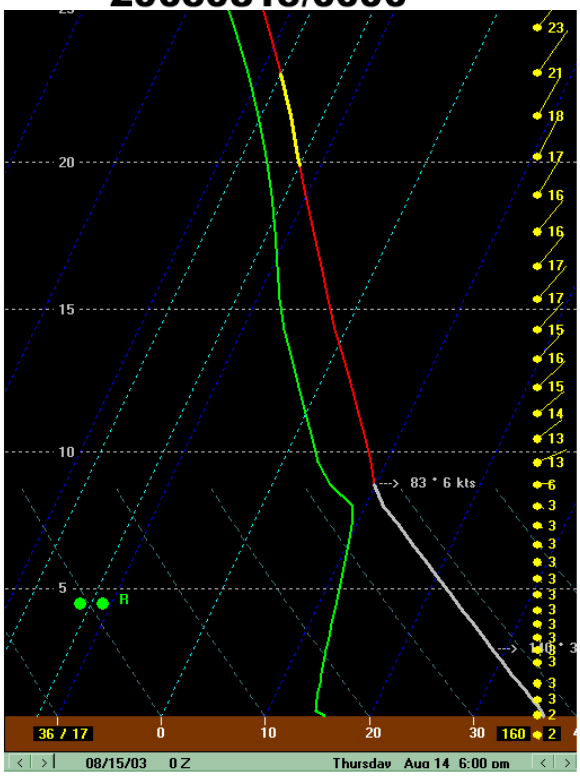
6. Change the sounding time to 08/15/2003 at 0000 UTC. What happened to the radar beam?
   [In the Sounding window, change the sounding to KPHX,030815,0000 and click the submit button.]



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.

Learner Version

Advanced Warning Operations Course
IC Core 4
Data Quality
Lesson 5

VCP Explorer Job Sheet 6
VCP Explorer 2.x

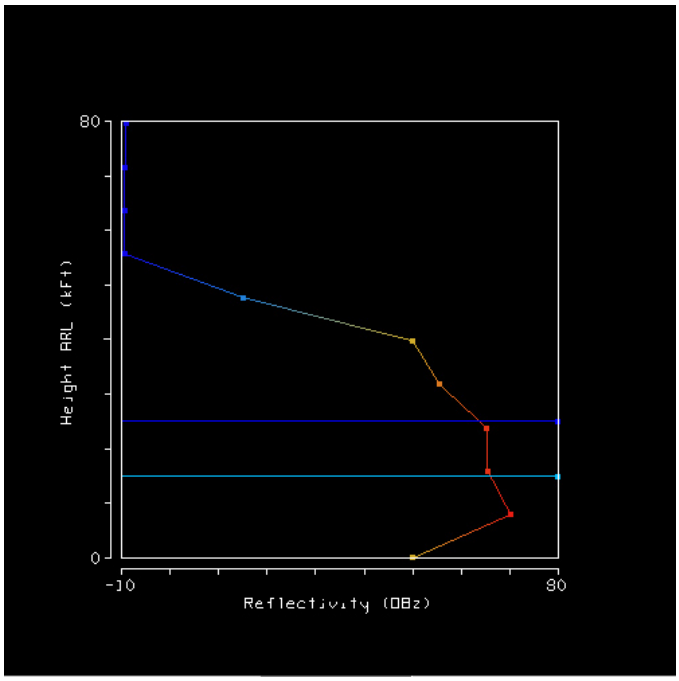
Objective: The objective of this exercise is to use VCP Explorer to visualize the impact of radar sampling through various VCPs upon parameters of the HDA algorithm.

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.

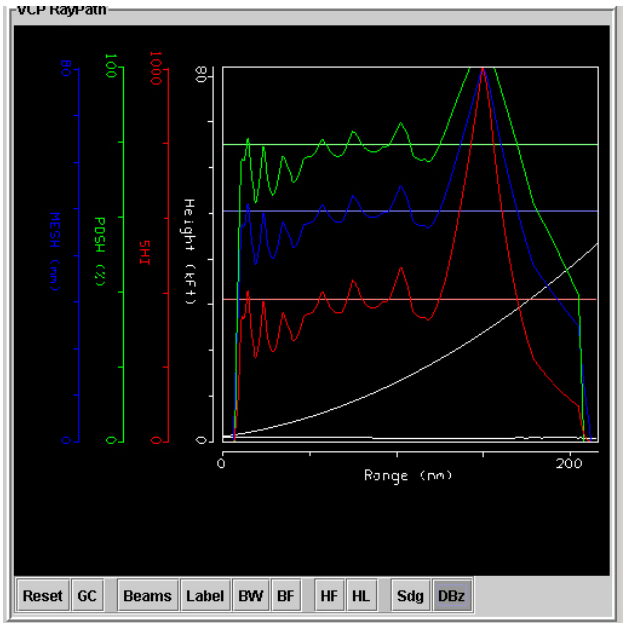
2. VCP Explorer can calculate three parameters of the Hail Detection Algorithm. These parameters are the Probability of Severe Hail (POSH), Maximum Expected Hail Size (MEHS), and Severe Hail Index (SHI). The HDA calculations require a reflectivity profile plus the heights of the 0ºC and -20ºC isotherms.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