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.

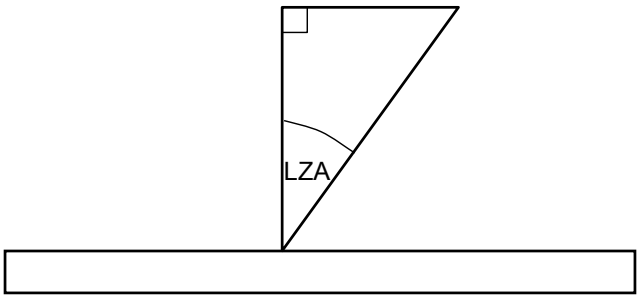
Performance Objective

- 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.

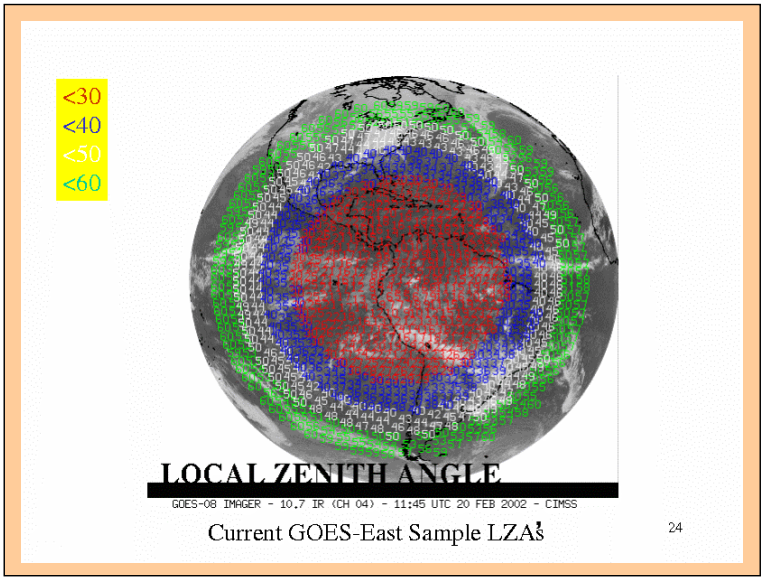
GOES Local Zenith Angle

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



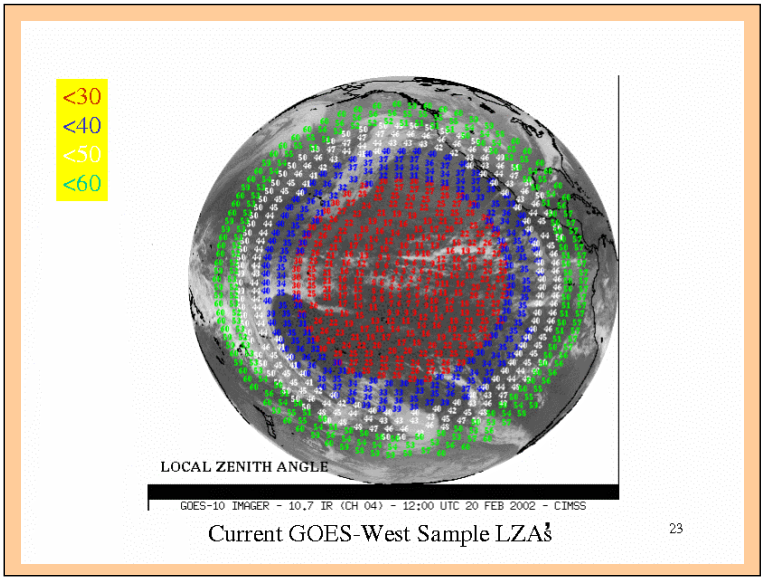
The parallax error and effective pixel resolution depend on your GOES Local Zenith Angle (LZA for short). The LZA becomes zero when the satellite is overhead and you're at its nadir (looking straight down). If the satellite is on your horizon, the LZA approaches 90°.

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.

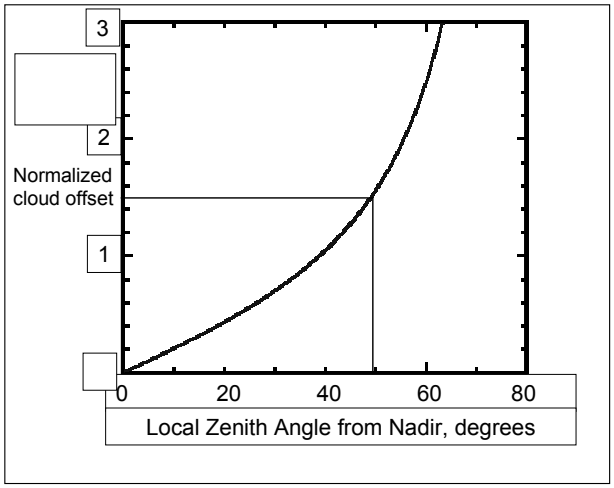
GOES-W LZA



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

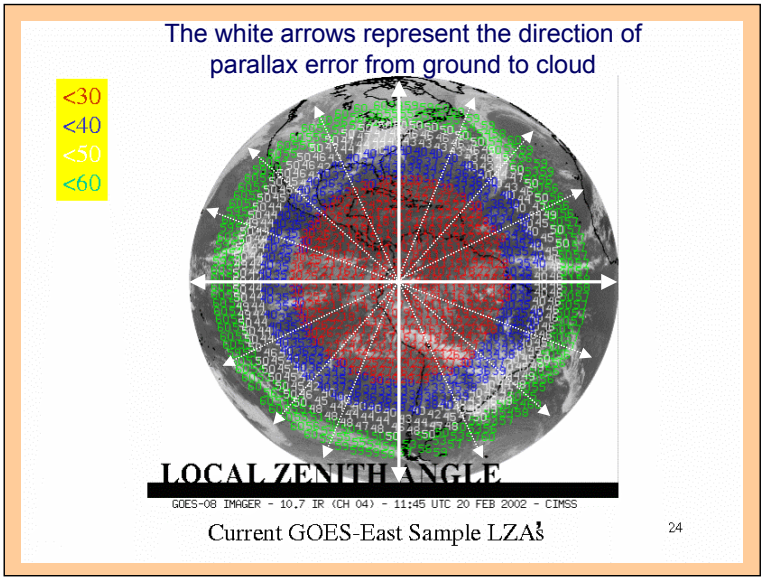
1. Use the previous pages to determine your LZA from Nadir
2. Multiply the height of your cloud by the Normalized cloud offset to get the horizontal parallax error magnitude



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

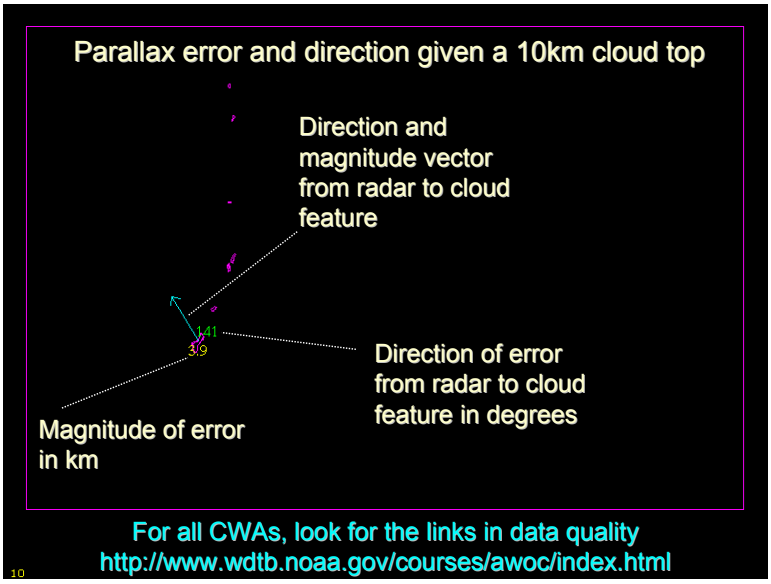


For the direction of your parallax error, the arrow overlays on your LZA map radiate away from the nadir point of the GOES.

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

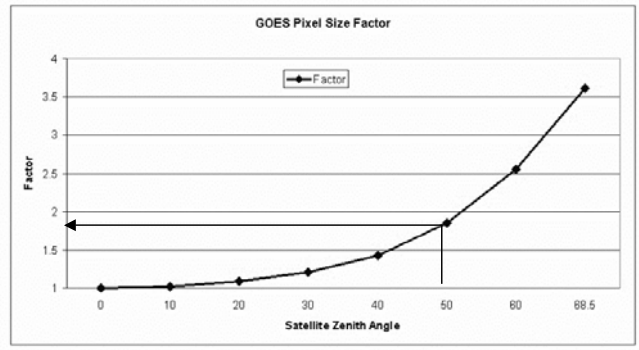


The Guam weather office is special since we do not have an LZA map for this area. You get special treatment. However, in this case, we gave you a fixed 10 km map and the magnitude of the error in km. For maps with all CWAs for both satellites, take a look at the website above and find the links to satellite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



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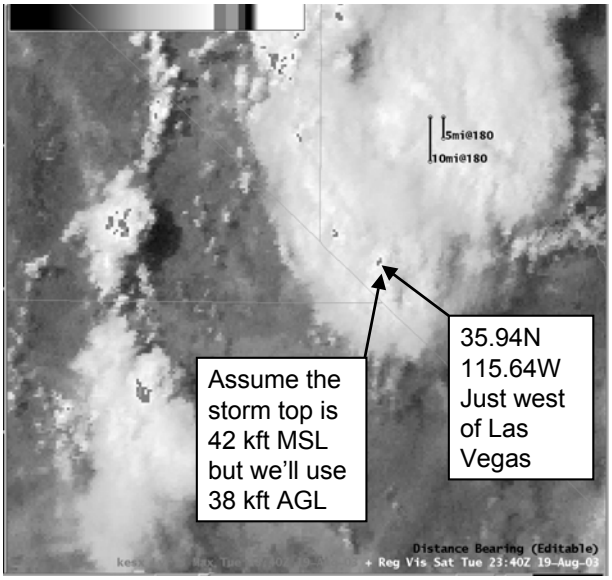
GOES effective pixel resolution operates in the same way as parallax error magnitude. Match your LZA with your 'Factor' so that both meet at the dark blue curve. Multiply the area of the nadir IFOV (Instantaneous Field Of View) by the 'factor' to get the IFOV over your CWA. In my example, my LZA of 49.5° 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?

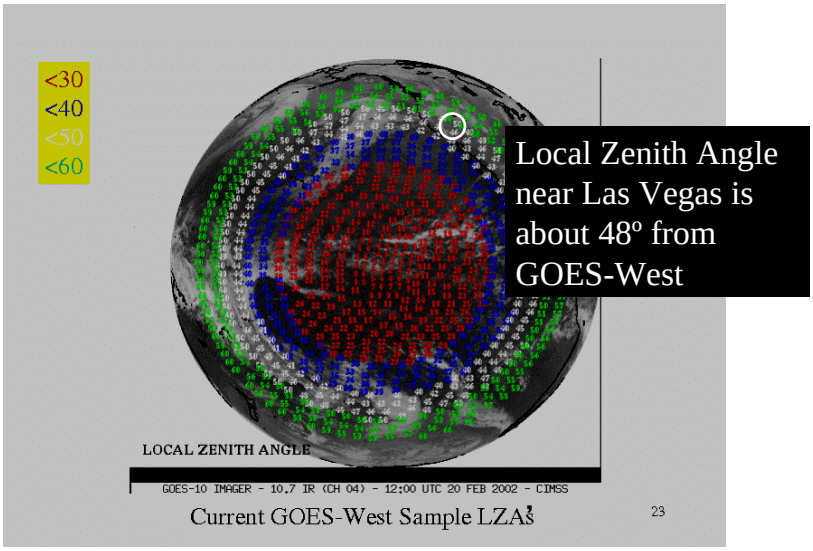


Here is an example given a overshooting top west of Las Vegas and your radar died. You need to locate the actual position of the storm top in order to figure out the nearest town to be affected.

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).

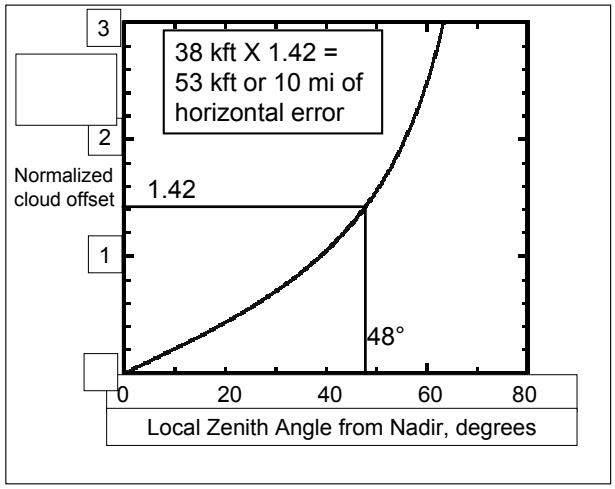
Example



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.

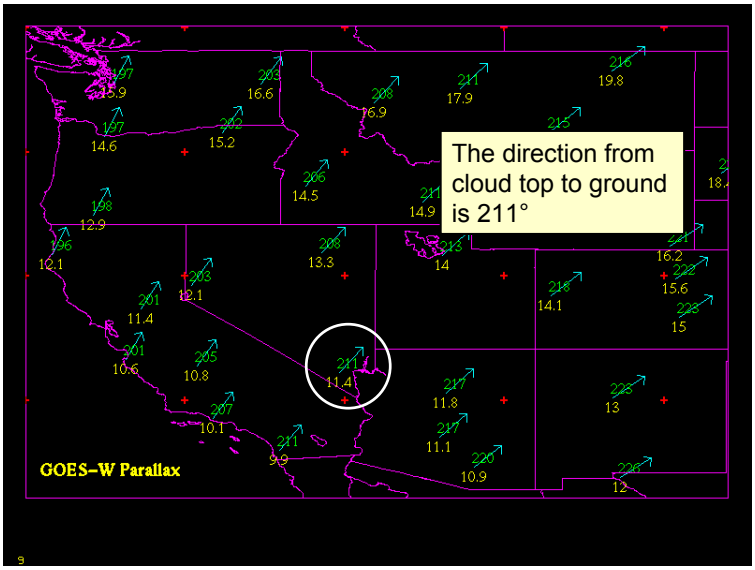
Example



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.

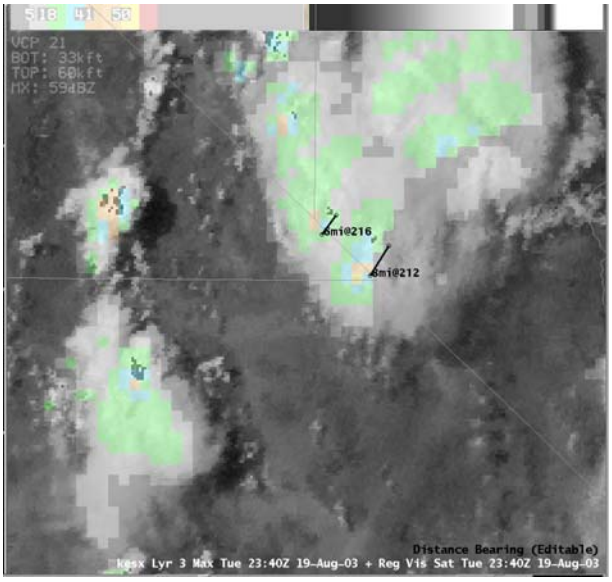
Example



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:

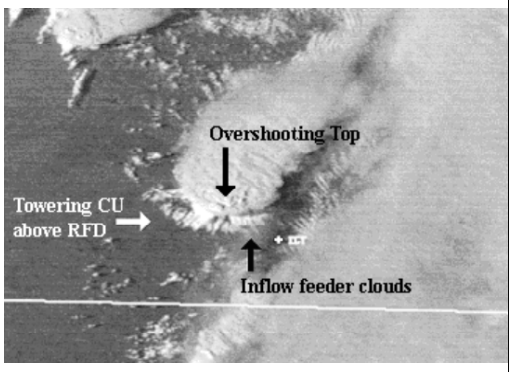
Central Region: Detroit, MI
Eastern Region: Pittsburg, PA
Southern Region: SR SSD or Tulsa, OK
Western Region: Monterey, CA
Pacific Region: Honolulu, HI
Alaska Region: Anchorage, AL

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**



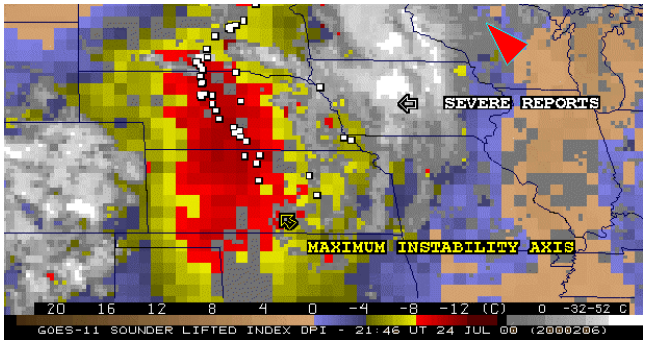
RSO imagery allows you to track the growth rates of towering cumulus, and track the motion of individual boundary layer clouds.

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.