1. Storm Interrogation

Instructor Notes: This lesson examines aspects of updraft intensity as a function of the height and intensity of the upper level reflectivity core. This is approximately 19 slides long and should take .

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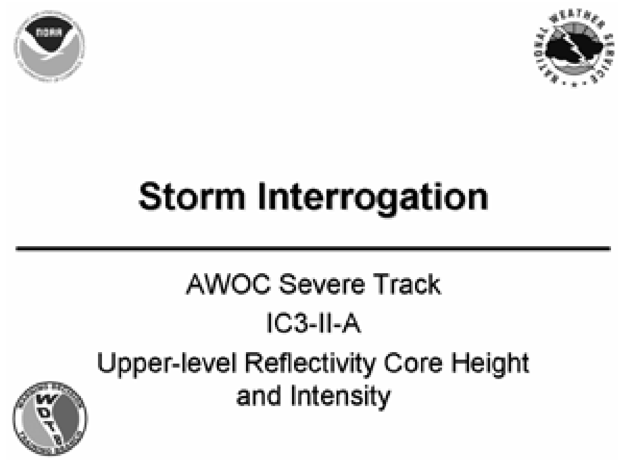

2. Upper-level reflectivity core height and intensity

Instructor Notes: The primary objective of this lesson is to provide you guidance on assessing whether an updraft may lead to severe weather based on the height and intensity of the upper-level reflectivity core. Much of the guidance will be based on the same principles on which the Hail Detection Algorithm or HDA, is based. I believe you will find this useful since this technique uses the height and intensity of the reflectivity core above the 0° and -20° C levels, and therefore helps to account for widely varying severe weather scenarios. As a companion to this lesson, we have provided you a tool in which you can enter in your own reflectivity values, the heights of those values, the 0° and -20° C heights, and the height of your radar so that you can use this tool to help determine how to apply this lesson to real world examples in your CWA.

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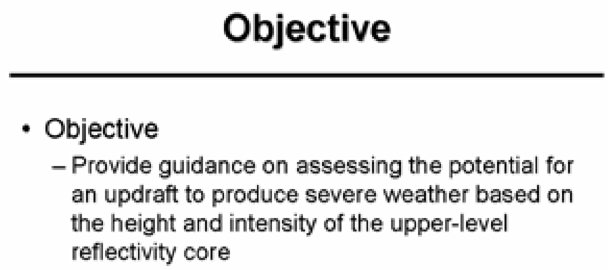

3. Upper-level reflectivity core height and intensity

Instructor Notes: The motivation for this session is that estimating updraft intensity from using the height of the intense reflectivity core is the most common technique used by warning forecasters. In this lesson, however, we will look at this technique with respect to heights relative to critical temperature levels and not just height alone.

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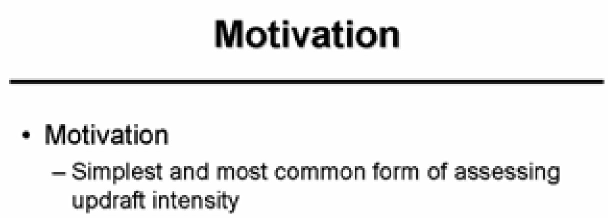

4. Upper-level reflectivity core height and intensity

Instructor Notes: When estimating the potential intensity of the updraft, the premise is that the more intense the updraft, the higher the height of the peak reflectivity will be as well as the maximum height of specific values of reflectivity. We usually look at reflectivity values exceeding 45 dBZ, and especially, 55 dBZ. We will consider heights alone and then add heights relative to the 0° and -20° C levels.

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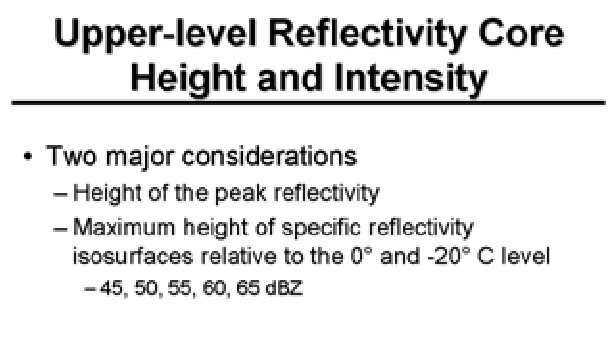

5. Reflectivity height for pulse storms

Instructor Notes: For pulse severe storms, or storms in environments with low 0-6 km wind shear, the height of the intense reflectivity core is the most commonly used parameter to estimate updraft intensity with respect to its capability to produce severe weather. Cerniglia and Snyder (2002) examined a large number of pulse storms in the Northeastern US for the skill of many parameters, including reflectivity height, in anticipating severe weather (either wind or hail). We will show their results next.

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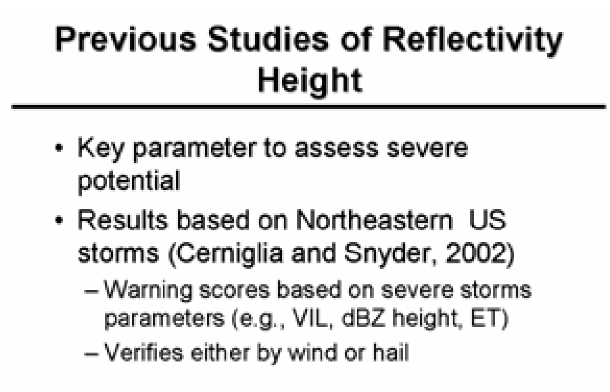
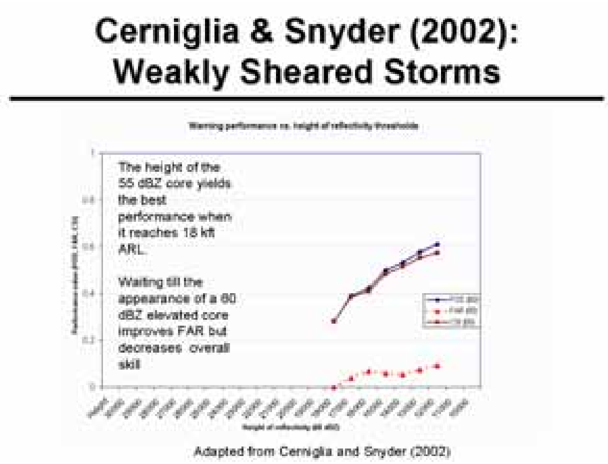


6. For weakly sheared storms

Instructor Notes: There are three graphs in this slide which shows the skill scores of the 50, 55 and 60 dBZ maximum heights in a storm in anticipating severe weather. Cerniglia and Snyder (2002) calculated the False Alarm Rate (FAR), the Probability of Detection (POD), and the Critical Success Index (CSI) by thresholding the height of a specific threshold reflectivity, then calculating each parameter by comparing wind and hail reports vs storms that succeeded, or failed to succeed in reaching or exceeding the two thresholds. The first graph shows the results for the 50 dBZ echo height. Note how the POD continuously decreases as the height of the 50 dBZ core increases.   This is not surprising. For example, a warning forecaster that warns on any storm with a 50 dBZ echo at a low height will detect virtually all severe weather events. However, such a liberal warning threshold also results in a high FAR. On the other hand, a warning forecaster who stringently waits for the 50 dBZ echo to reach a high altitude experiences a lower POD, which is undesireable, but also achieves a desireably low FAR. Somewhere in the middle, the combination of POD and FAR will reach the most favorable combination, represented by a peak in the CSI. That peak comes when the warning forecaster waits till the 50 dBZ echo reaches or exceeds 19 kft ARL. However, the next graph shows that the CSI for the 55 dBZ threshold height of 18 kft actually gives a higher peak in CSI than that of 50 dBZ. Perhaps waiting for the 55 dBZ to reach this altitude is a better strategy for improving warning performance.   What about using higher reflectivity thresholds? As it turns out, when Cerniglia and Snyder (2002) tested the 60 dBZ echo CSI, the CSI continuously rose with progressively lower altitudes. In other words, the presence of 60 dBZ anywhere in the storm was sufficient by itself to be associated with severe reports. Unfortunately, waiting for the 60 dBZ echo to reach a increasing altitudes resulted in more missed detections. Remember that Cerniglia and Snyder's study chose only pulse, low vertical wind shear storms in New York, Pennsylvania and further east during the summer months. It would be dangerous to apply their specific thresholds of maximum CSI to other situations since the thermodynamic environment may be warmer or cooler than theirs. However, the point of their results does apply; that convection is more likely to be severe as the heights of intense reflectivities > 50 dBZ increased.

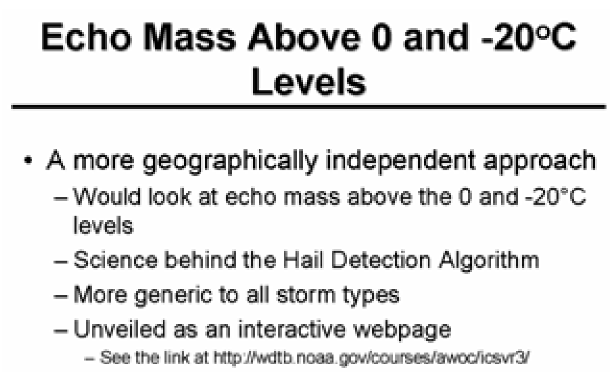
Student Notes:



7. Upper-level reflectivity core height and intensity

Instructor Notes: In order to generalize Cerniglia and Snyder's height-based results to more general cases, we will use the methodology behind the Hail Detection Algorithm (HDA) to account for the changing thermodynamic profiles for a couple cases.   This approach should be more geographically independent since it looks at the mass of echo above the 0° and -20° C levels, and has a broad verification database that is used in the HDA. It should be more generic to a larger spectrum of storm environments and geographic locations. The methodology behind the HDA is revealed using a tool that is available at the website listed in this section. You will be able to enter in the reflectivity heights and values, the 0° and -20° C level, and the radar height to come up with similar values for these cases. One word of caution, I should mention. This technique's verific-aiton is based on hail reporting only. There is no verification on severe winds as there is with Cerniglia and Snyder. As will be discussed in another lesson, pulse storm down-drafts depend mostly on the total potential energy derived from negative buoyancy owing to evaporational cooling potential and precipitation loading. Most storms generate enough precipitation for evaporational cooling down to ground, even from weak updrafts. However, it is the precipitation loading potential that increases as the volume and inten-sity of the reflectivity core increases. This is especially true for reflectivity values exceeding 60 dBZ. Therefore, updraft intensity should have a significant effect on even-tual downdraft intensity. Just remember that updraft strength is not the only forcing for downdraft strength, thus this caution also applies to any technique comparing severe winds to the height of reflectivity values.

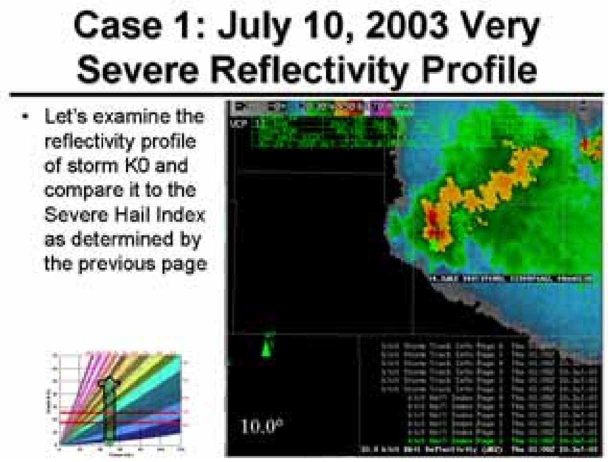
Student Notes:



8. Case 1: July 10, 2003 very severe reflectivity profile

Instructor Notes: Here is a case with storms in a warm environment characterized by steep midlevel lapse rates, moderate shear (0-6 km = 30 kts), and a high equilibrium level over central Kansas. Note how close the 0° and -20° C levels are on the VCP chart inset (these levels are marked by the two horizontal red lines) The HDA output is overlaid on an all-tilts scan for storm K0 (center), located about 45 nm from the radar. Going through the all tilts scan, this storm shows all the characteristics of a severe updraft including a Weak Echo Region, even a Bounded Weak Echo Region (BWER). In addi-tion, intense reflectivities extend to very high altitudes.

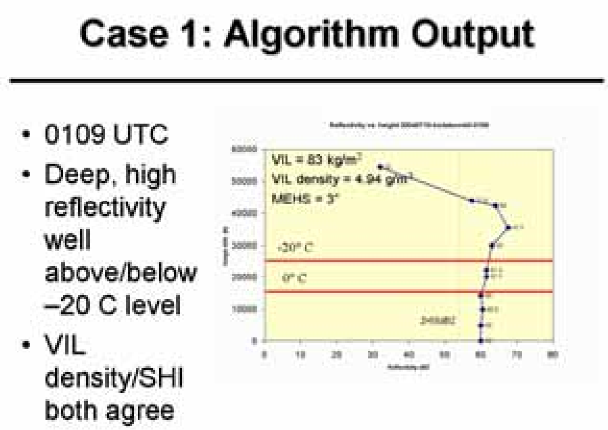
Student Notes:



9. Case 1: July 10, 2003 very severe reflectivity profile

Instructor Notes: Here is a vertical reflectivity profile taken off the all-tilts scan for storm K0. Reflectivities stay high nearly to the storm summit. Values are highest above the -20° C level reaching up to 67 dBZ at 35 kft. Using the HDA/VIL tool on the webpage, including the freezing and -20° C heights, and the height of the radar, we derive very high VIL, VIL density and Maximum Expected Hail Sizes. Baseball hail was reported with this storm. The HDA derives its Probability of Severe Hail, or POSH, and the Maximum Expected Hail Size (MEHS) from a parameter called the Severe Hail Index (SHI). The SHI increases slowly at first for reflectivities between 40 and 50 dBZ for temperatures between 0 and -20° C, then rapidly increases for reflectivities exceeding 50 dBZ below -20° C. Take a look at the next page to see the vertical profile of SHI for this storm.

Student Notes:



10. Case 1: July 10, 2003 very severe reflectivity profile

Instructor Notes: The HDA works by integrating upward in height and accumulating the SHI values until it reaches the highest slice with reflectivities > 40 dBZ. We can calculate for any atmosphere given the heights of the 0° and -20° C level, a threshold SHI for a high POSH, in this case the 90% POSH is marked by the vertical amber line. This storm exceeds that by a long ways. If this storm does not have a warning out for it, one should be ready to go for very large hail. Given the steep lapse rates and intense reflectivities, any downdraft has good potential to be severe as well. As shown in the all-tilts scan, other reflectivity and velocity signatures of a severe supercell storm add confidence that this storm is very severe. Tornado potential, on the other hand, depends on other characteristics of this storm that are outside this lesson.

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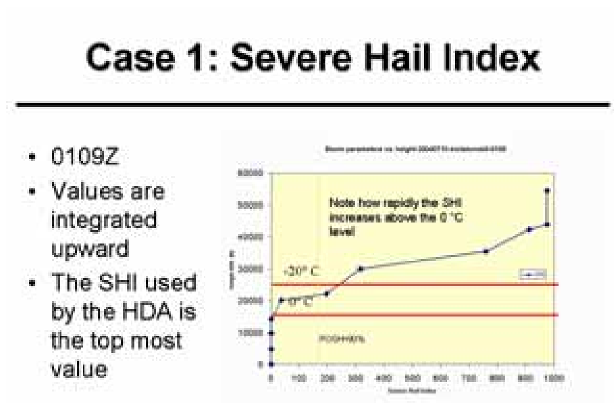
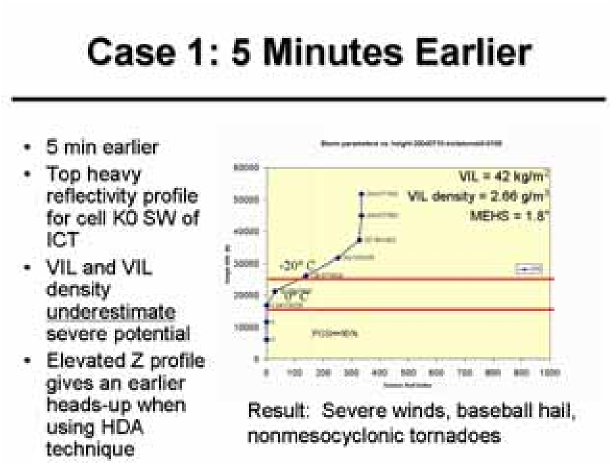


11. Case 1: July 10, 2003 very severe reflectivity profile

Instructor Notes: Just 5 minutes earlier, this same storm was too young for its precipitation core to have reached the ground. Note the elevated reflectivity core with intense values, all above the freezing level. Going to the SHI plot, we can see SHI values are still high and exceeding the 90% POSH threshold. However, the VIL and VIL density are still low enough that a warning forecaster may not think about issuing a warning solely based on their values. Here is where waiting for VIL or VIL density to reach warning threshold will cost a warning forecaster several minutes and may result in zero leadtime.

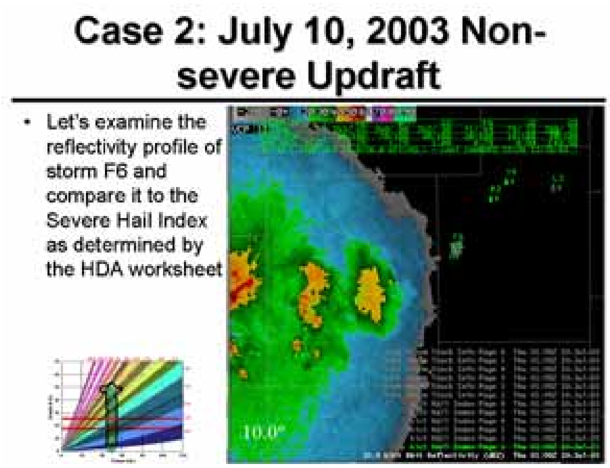
Student Notes:



12. Case 2: July 10, 2003 Nonsevere updraft

Instructor Notes: Not all similar environments produce similar storms. A case in point is storm F6 northeast of the KICT radar on the same day. The vertical reflectivity profile here is quite anemic and the HDA results in only 1" hail.

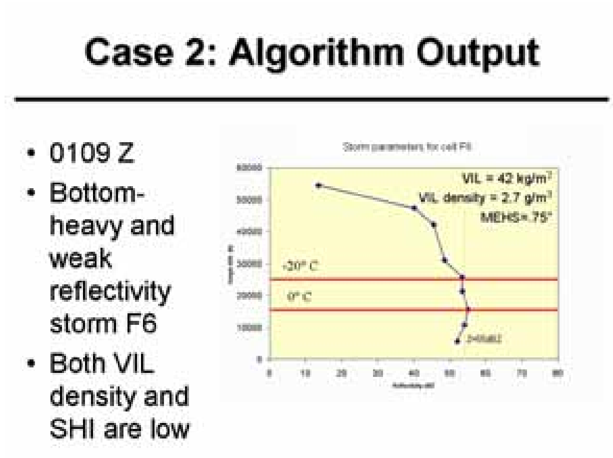
Student Notes:



13. Case 1: July 10, 2003 nonsevere reflectivity profile

Instructor Notes: Comparing the massive storm to the southwest with this one, we find this bottom-heavy reflectivity profile shows marginal 50 dBZ in the sub - 20° C air.

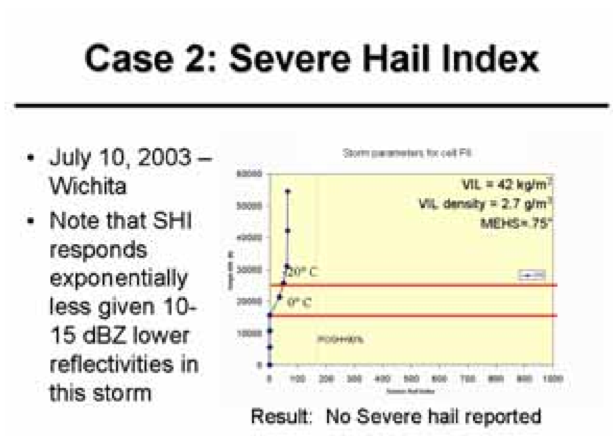
Student Notes:



14. Case 1: July 10, 2004 nonsevere reflectivity profile

Instructor Notes: SHI values are much lower, almost 10 times lower given a 15-20 dBZ lower reflectivity profile in the sub -20° C air. VIL, VIL density, and the HDA output all agree that this storm is below severe limits. This storm still could produce severe downdrafts if the DCAPE was high enough.

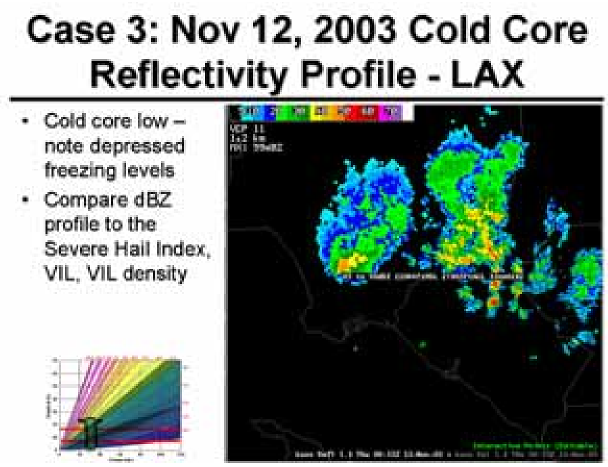
Student Notes:



15. Case 2: Nov 12, 2003 Cold core reflectivity profile - LAX

Instructor Notes: This second example represents a completely different convective environment from our Kansas one. This is a cold core convective case in the Los Angeles basin where a cell is anchored to converging seabreezes and east of the hills at the Rolling Hills Estates. Note the depressed 0° and -20° C levels.

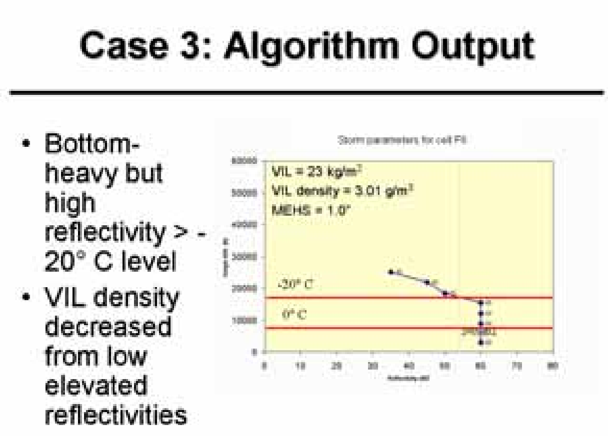
Student Notes:



16. Case 2: Nov 12, 2003 Cold core reflectivity profile - LAX

Instructor Notes: Reflectivities are somewhat bottom heavy in this case but the values are 60 dBZ in the 0° to -20° C layer. Because of the decreasing reflectivities well below storm top at this time, the VIL density is fairly low. At the time of this all-tilts scan, this storm appears to be below severe limits. The MEHS is still giving 1" hail size, mainly because of the low freezing level. About 90 minutes earlier, a significant updraft pulse resulted in a more top heavy reflectivity profile and a much greater chance of severe hail. Given the cold thermodynamic profile, and relatively little dry air or CAPE, the DCAPE was fairly low. We examine this case with respect to downdraft potential in another lesson.

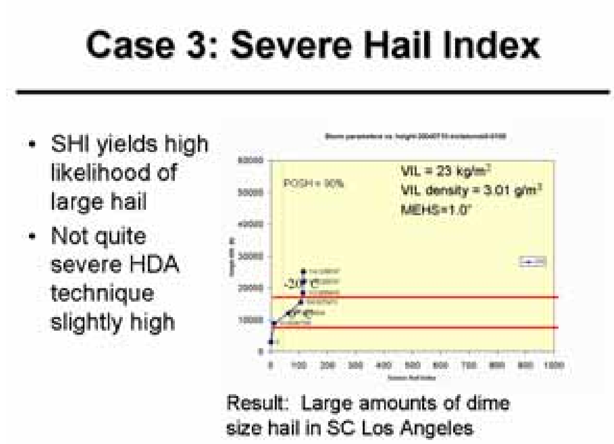
Student Notes:



17. Case 2: Nov 12, 2003 Cold core reflectivity profile - LAX

Instructor Notes: Note that the SHI for 90% POSH is very low. The actual SHI is much larger along with the MEHS. In this case, the upper-level reflectivity profile is rather weak and the HDA is keying off the high reflectivities between the 0° to -20° C layer. Such a profile in SHI and upper-level reflectivity at levels colder than -20° C but well below the equilibrium level suggest that this is a case where the updraft is likely not very strong and the core is descending. Perhaps this example shows why a single time is not adequate to assess whether or not there is a strong updraft. Earlier, there was a strong updraft pulse which may have led to this descending core of hail. This storm produced large amounts of dime size hail, not necessarily severe but given the huge amounts of hail due to the depressed freezing level and long duration over South Central LA, the economic impact of the hail, not including the rain, was rather extreme. Recall the pictures in the news of front end loaders clearing out three foot deep hail drifts and impounded vehicles.

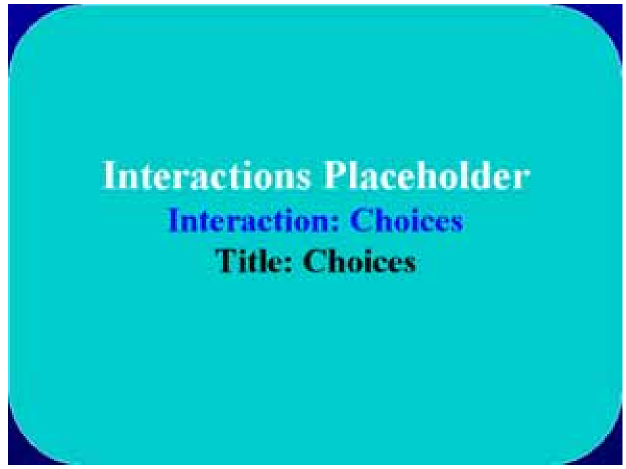
Student Notes:



18. Interim summary

Instructor Notes: To summarize, we've seen strong evidence of how strong the relationship between severe weather likelihood and the height of the upper level reflectivity core can be. We've also seen a case where a strongly initiating storm results in a large hail indication as a function of its intense upper-level reflectivity core and yet VIL density understates the storms intensity. Conversely, we've seen a storm with a high hail signal but where the reflectivity profile falls off in the sub -20° C air resulting in a low VIL density, and perhaps correctly. In either case, a strong updraft should contain strong reflectivities, and those reflectivities should extend well into the sub -20° C air and close to the equilibrium level.

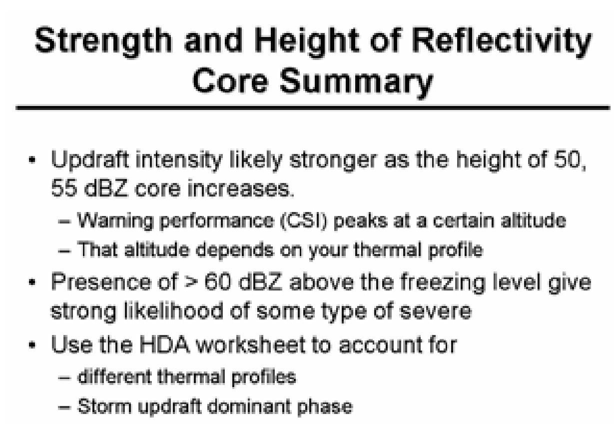
Student Notes:



19. Summary contd

Instructor Notes: Updraft intensity increases the odds of severe weather as it is capable of lofting larger hailstones, and increasing downdraft intensity through heavy precipitation loading. Remember that updrafts evolve through time and looking at storm trends to discern when the maximum updraft intensity is the most important consideration. Also note that hail takes time to grow, and in the process traverse through complicated 4 dimensional paths, something that the HDA or these techniques do not consider. And remember that downdraft and outflow intensity is not solely a function of updraft intensity.

Student Notes:



20. Contact info

Instructor Notes:

Student Notes:

Summary Continued

- Updraft intensity that governs potential for severe
  - Hail size through lofting larger hailstones
  - For severe winds, precipitation loading
- Updraft intensity not the only factor
  - Hail size also a function of updraft width, trajectory paths
  - Severe microbursts a function of DCAPE even more than CAPE