1. Storm Interrogation

Instructor Notes: Welcome to the AWOC Severe Track lesson IC3-II-C on examining severe convective updraft structural signatures. This lesson is 19 slides long and should take 20 minutes.

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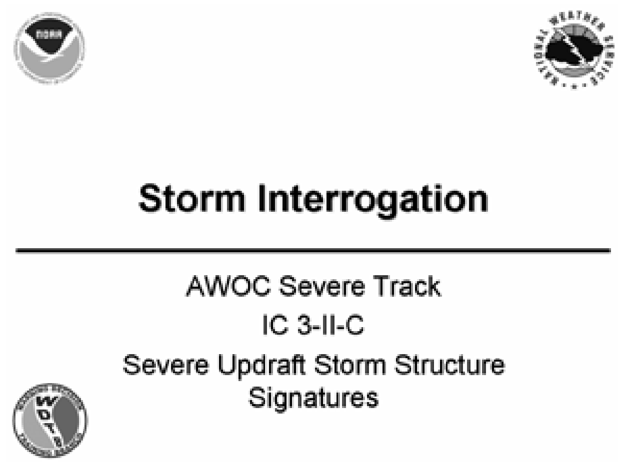

2. Severe updraft structural signatures

Instructor Notes: This session adds onto the session on the height of reflectivity profiles. For severe storms, however, signatures appear that are unique to this class of convection beyond that of vertical reflectivity profiles. The objective in this lesson is to understand the signatures in reflectivity and velocity that indicate a severe updraft is in progress. Again, what is meant by severe updraft is one that is often accompanied by large hail and severe straight line winds. As a performance objective, you should understand how Weak Echo Regions, Bounded Weak Echo Regions and stormscale velocity patterns contribute to recognizing a severe storm. *Note that some conceptual models have been revised from previous training materials.

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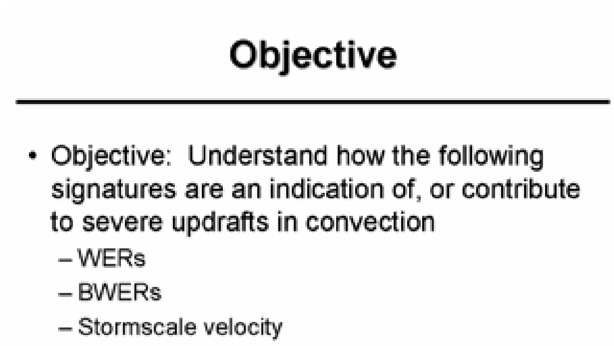

3. Severe updraft structural signatures

Instructor Notes: As a motivator, this lesson introduces a revised stormscale conceptual model that Lemon (1977) introduced and is widely used today. Velocity is also integrated into the Lemon (1977) technique and an analogous conceptual model is also introduced to discriminate severe and nonsevere linear convective systems.

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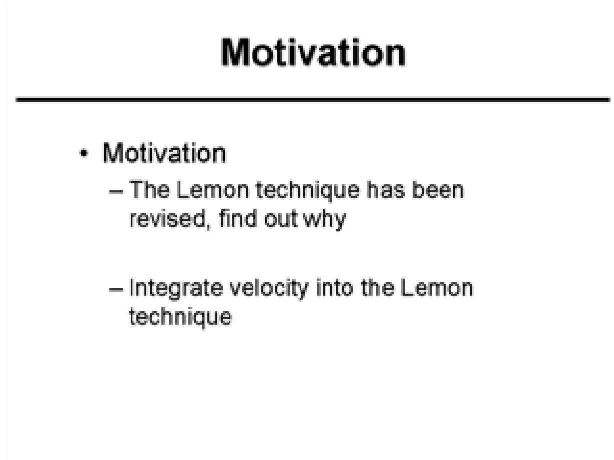

4. Nonsevere storm structure

Instructor Notes: We compare the classic nonsevere convective cell conceptual model with the revised version. There are several changes which corrects subtle features. 1. Heights of the upper-level reflectivity contours (dashed) in the horizontal cross section are with respect to the -20° C level. We also placed temperature contours on the vertical cross section to emphasize that features in the reflectivity core depend on the temperature more than some fixed arbitrary height. This change in thinking helps account for sheared convection in diverse thermodynamic profiles. Note the reflectivity contours nearly match the cloud boundaries above the -20° C level. The anvil is composed of snowflakes and graupel with the precipitation particle sizes decreasing with increasing distance from the updraft core. Anywhere there is anvil cloud, there is at least 0 dBZ reflectivity and most likely values in the teens. The downdraft and cold pool region have been added to show that the gust front severely undercuts the updraft base. Otherwise, both diagrams reflect the lack of an echo overhang, and the multicell nature of nonsevere convection. The upper-level reflectivity core and storm summit are located over the lower level core centroid. Note that the reflectivity values fall off well below the updraft summit. With respect to velocity, the nonsevere sheared shows weak low-level convergence and upper-level divergence with no significant rotation, though some weak shear may exist in the updraft at midlevels. There is shallow convergence at the base of the updraft.

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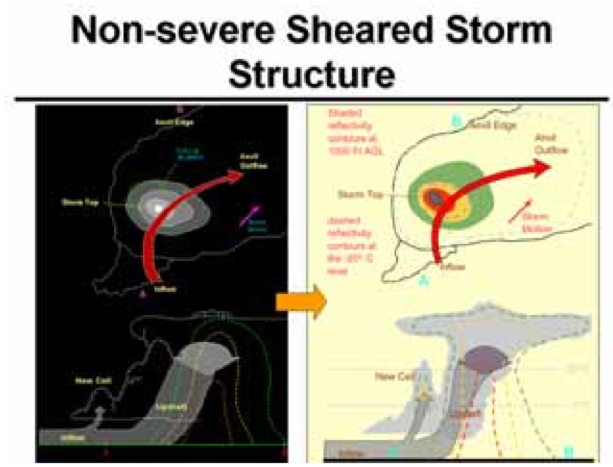

5. Severe sheared storm structure

Instructor Notes: Increasingly intense storms may still exhibit multicell behavior, however, the initiation of new cells occur close enough to the primary cell so as to appear like the storm is more steady state in nature. A WER may be more persistent as new cells contribute to a more steady state intense echo overhang. The anvil is sharper and contains higher reflectivities than with the nonsevere cell. Some of the echo overhang occurs as echoes > 45 dBZ spread into the anvil outside the lowerlevel udraft. The updraft summit is displaced over the WER and the low-level reflectivity gradient. Higher reflectivities press upward closer to the storm summit than with the nonsevere storm. The session "The Nature of the WER" applies to these kinds of storms and supercell reflectivity morphologies. Note in the newer version, there are actually three cells in different stages in their lifecycle, the old cell being the descending intense reflectivity core (purple), the middle one containing an elevated intense core, and the new one just beginning to develop a core. The three cells contribute to give the appearance of one strong semi continuously propagating cell. The cold pool boundary remains closer to the main updraft but there is still some low-level outflow undercutting the lowering or wall cloud. In velocity, these storms may contain short-lived but significant mesocyclones, strong and more persistent updraft summit divergence, and strong low-level convergence ahead of the gust front. This convergence may be deeper than with nonsevere storms, though not always so.

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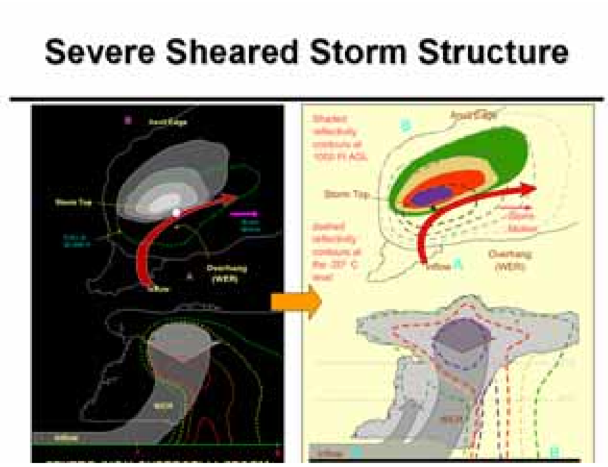

6. Trailing mesocyclone supercell updraft storm structure

Instructor Notes: Going to a supercell signature, we add the classic reflectivity signatures that indicate significant rotation to those associated with a severe nonsupercell storm. Here we define a supercell as that kind of cell that contains significant rotation, at least partly correlated with updraft, and the updraft is quasi persistent for much longer than the transit time of any air parcel through the updraft. The reflectivity envelope in the early version of the Lemon diagram has been lifted such that even the highest reflectivity values reach nearly to the updraft summit. The BWER remains the same but now the top of the BWER extends just a bit above the -20° C level. In some supercells, the top of the BWER may extend higher but it is generally capped by intense reflectivities no matter the height of the BWER. The cold pool boundary bends back toward the low-level updraft region in response to strong inflow into the updraft side of the mesocyclone. The cold pool swirls around the back side into the RFD region

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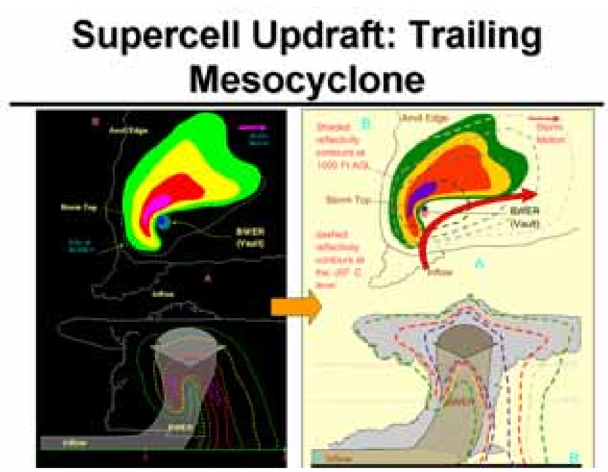

7. Interim summary: Revised lemon technique

Instructor Notes: To summarize the modifications to the Lemon (1977) technique, we increased the reflectivities in the anvil region to account for part of the anvil comprising the intense echo overhang above the WER. Reflectivities have been increased near the storm summit for the severe storm updrafts. Finally, any references to height coordinates in describing upper-level reflectivity cores have been changed to temperature so as to increase the relevance of these diagrams for a wide variety of storm environments.

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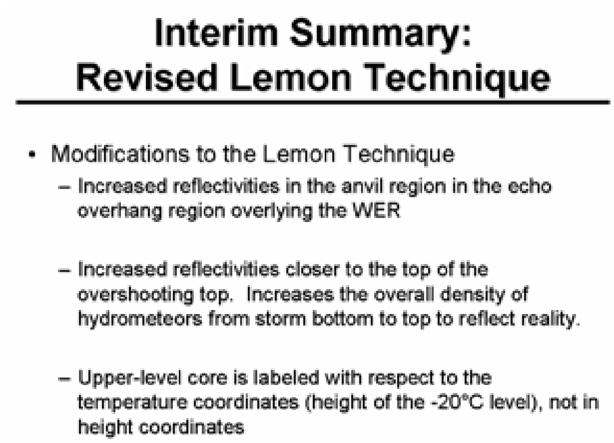

8. Example of a nonsevere sheared storm

Instructor Notes: This is a single image captured from a continuously evolving low topped multicell in a marginal shear environment (0-3km shear - 15-20 kts, equivalent to 30-40kts of 0-6 km shear). This storm exhibited little in the way of a sustained WER. Any initial elevated reflectivity core quickly descended to ground within one or two volume scans. In most times, the reflectivity core weakened with height well before the storm summit suggesting a relatively weak updraft most. Updraft summit velocity difference was weak, about 40-50 kts. This same case is presented in the lesson on "Updraft reflectivity height" This storm produced dime size hail but since it was anchored to a boundary triple point, the storm produced huge amounts of hail and large rainfall totals, both leading to quite a bit of disruption to communities.

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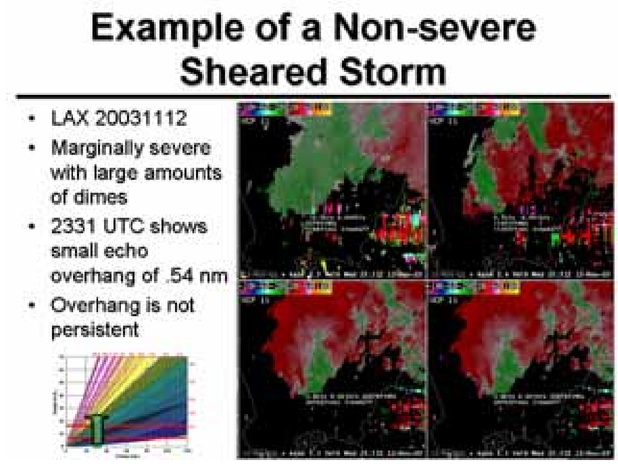

9. Severe sheared updraft intensity – BWER detection

Instructor Notes: BWERs are fickle features to detect by radar owing to their relatively small sizes, and many false BWERs that exist. This VCP chart is overlaid with a light gray zone indicating where BWERs typically exist. The example on the right represents a storm with a range of about 63 mi and is marked by the rectangle where the BWER was found. This storm example was taken from June 11, 2003 in northern Minnesota and produced baseball hail and 90 mph winds. To avoid the false BWER detection, make sure that a BWER is an upward extension of a WER and that it is capped by high reflectivities in higher elevation slices. The BWER usually reaches up to just above the -20° C level whatever its height, but significant variability exists in its vertical dimensions. BWERs are typically too small to be viewed much beyond 80 miles .

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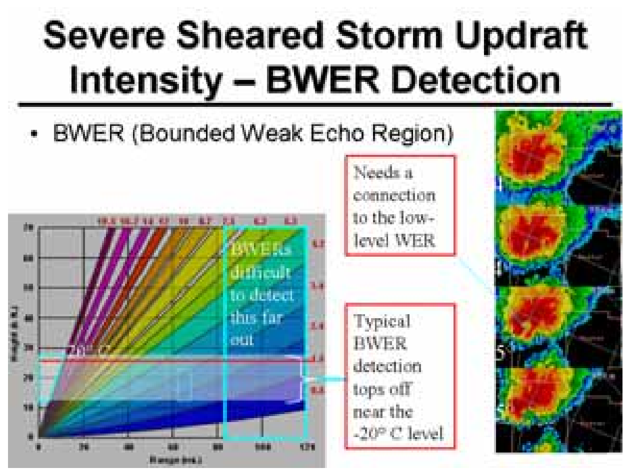

10. Classic severe updraft signature case

Instructor Notes: This all-tilts scan shows shows a supercell in the middle of it producing extreme sized hail. You may recall the hailstone diameter record being broken in Aurora, NE on June 22, 2003. This is what the storm appeared to warning forecasters about 5-10 minutes before the record hail fell on the town. This is a classic supercell with normal horizontal dimensions and a BWER approximately 2 mi in diameter. What is unusual in this case is that the BWER appears to extend to 45 kft and above the highest scan presented here. This BWER is an upward extension of the WER below but the high reflectivities over the top of it is not shown here. Given the vertical continuity of this echo hole and the fact that it's coexistent with other intense supercell reflectivity features, the echo hole is likely a BWER with intense updraft to extreme altitudes.

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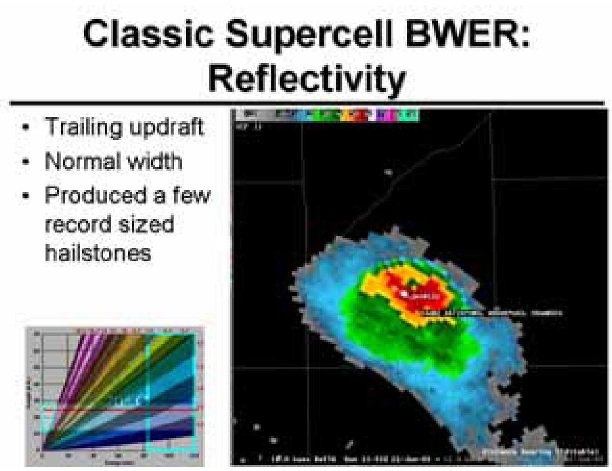

11. Classic severe updraft signature case

Instructor Notes: At the storm summit, top diagram, the divergence center appears to be more colocated with the high reflectivity core just south of the BWER suggesting it is not associated with the most intense updraft at this altitude. Note that the velocity difference between the maxima on both sides is above 150 kts, a good confirmation to the severity of the updraft suggested by the reflectivity structure.

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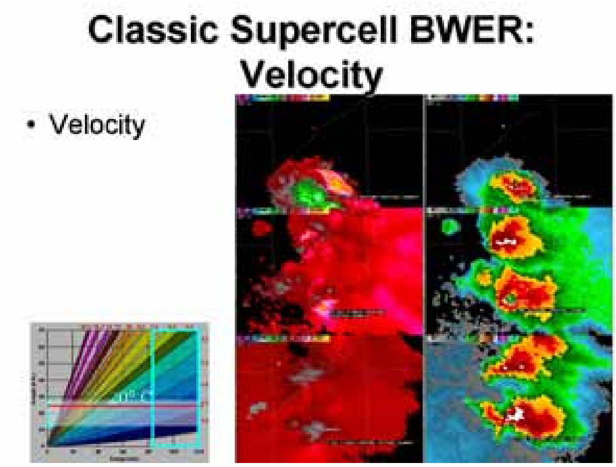

12. Wide, lower topped supercell updraft

Instructor Notes: A different case shows what an extremely wide BWER appears to be at similar ranges to this radar as the Aurora, NE storm is to the Hastings, NE radar. The small vertical rectangle in the VCP inset shows the vertical dimensions of this BWER. It is in the right spot of where BWERs can be sampled. In this case, the soon to be Ft. Worth hailstorm of 2003 shows a classic BWER, with a long dimension northeast-southwest of 4 mi. The BWER is an extension to a large WER and is capped overhead by high reflectivities. An elongated BWER like this has been suggested by some researchers to be an especially favorable signal for large amounts of extreme hail. Note, however the storm summit is only a little above 33 kft. This storm produced almost $1billion in damage in the Ft. Worth, Dallas metroplex.

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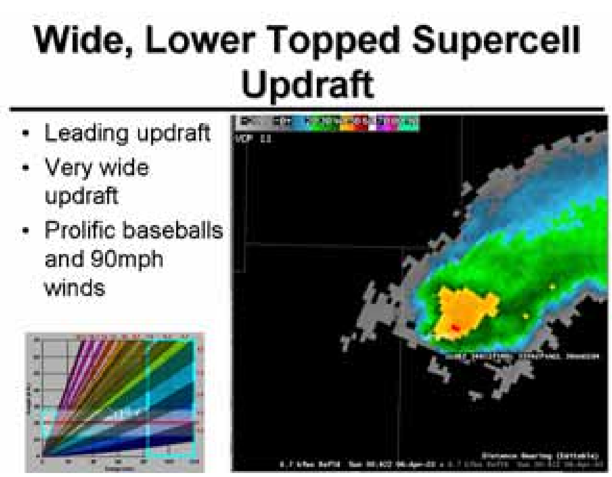

13. Same supercell at max BWER detection range

Instructor Notes: 75 minutes earlier, this same supercell was located 78 nmwest of the radar, and was producing especially damaging hail here too. This is the first scan in which a BWER was detected by the Ft. Worth radar and it appeared to be of similar size as when it closed within 40 nm of the radar. This graphic shows that even large BWERs are difficult to detect beyond even 75 nm from the radar. Note that the VCP chart ranges are in statute miles while the cursor readout is in nautical miles.

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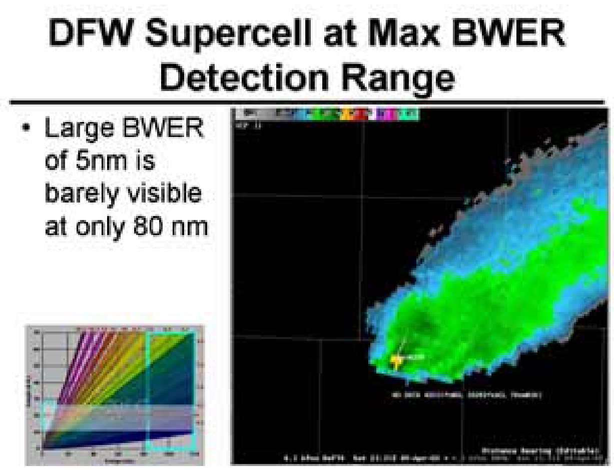

14. Same supercell at two very different ranges

Instructor Notes: Multiple radars were viewing this storm from a wide variety of ranges. Going back to the 0042 Z timefame as the storm was within 40 nm of the KFWD radar, the storm was also being viewed by the KFDR radar from nearly 90 nm away. This large BWER is clearly outside the range of detectability from KFDR. There are fewer BWERs larger than this one on record.

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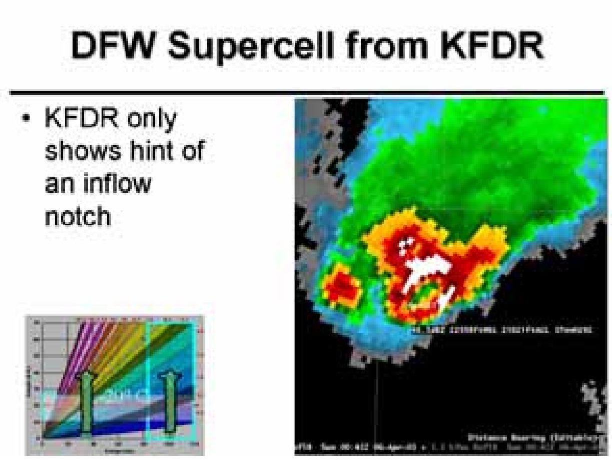

15. Can you apply the Lemon technique here?

Instructor Notes: Can the traditional Lemon technique, or even a revised one be applied to assess the severity of a linear multicell system? Here is a case of a severe squall line west of Binghamton, NY on 21 July 2003. This segment of the line is just about to begin its bowing out process. The stom summit is shallow but there are several signatures suggesting the updraft below is very intense. There is a front-end WER, sharp reflectivity gradient, even a suggestion of a BWER, to indicate an upright updraft strong enough to create these features.

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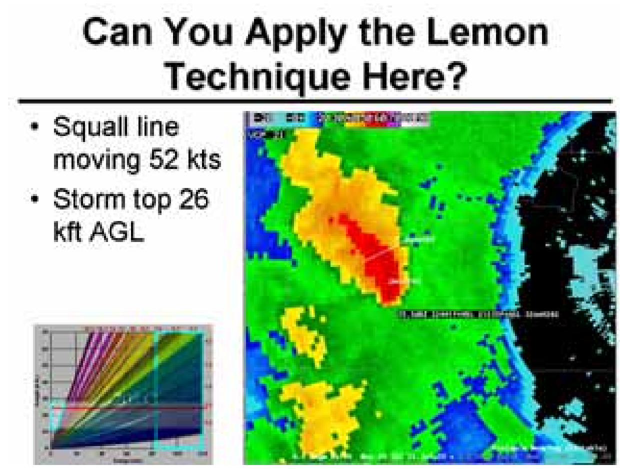

16. Can you apply the Lemon technique here?

Instructor Notes: Discerning a WER on the leading edge of a squall line has the complication that you have to remove any spurious echo overhangs as the squall line moves forward during the volume scan completion time. This artificial WER becomes more exaggerated closer to the radar site since the radar needs to scan more elevation slices before getting to the echo overhang. A line moving at 55 kts may create up to 5 miles of artificial echo overhang. Still, a real echo overhang jumps forward rapidly in a few thousand feet which is noticeable between the 3.4 deg slice (upper right) and 4.3 deg slice.(lower left) with even a linear echo hole at 4.3 deg on the front end of the intense bowing echo.

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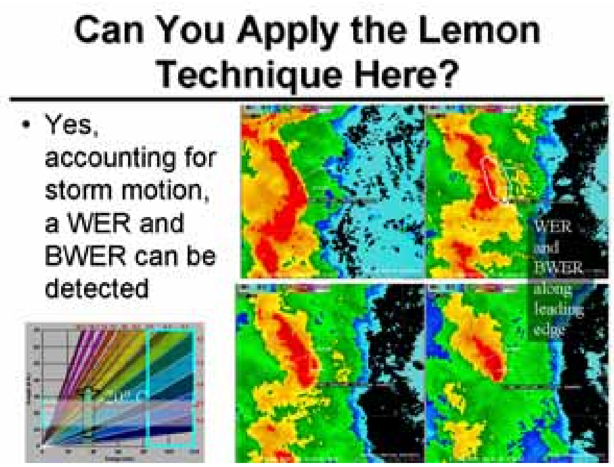

17. Conceptual model of a severe linear system

Instructor Notes: A conceptual model of a high-end severe linear system shows the same features we've seen in the example from New York. One is a leading edge WER and even a small linear BWER. The updraft is upright.for several km before sloping back over the cold pool dome. The leading gust front exhibits a steep slope and the Rear Inflow Jet (RIJ) behind it remains nondescending until within the heavy reflectivity core of the leading edge. However, the gust front remains underneath the low-level updraft providing a strong initial updraft through convergence. A Mid Altitude Radial Convergence Zone (MARC) is pronounced between 3 and 5 km above ground level and is the zone where the RIJ reaches the heavy convective line where it sharply turns downward. Differential velocities exceeding 50 kts are common in MARCs during and preceding localized severe wind events. The MARC is a component of a Deep Convergence Zone (DCZ) which represents the interface between the ascending branch of air and the descending branch of the RIJ and deep cold pool. Depending on the line-normal upper-level storm-relative flows, some anvil material may flow ahead of the line. This is not a requirement for a severe linear updraft. The high end severe systems appear to consist of one unbroken leading edge updraft and trailing reflectivity core. You will see little evidence of discrete cellular behavior over the leading edge of the cold pool.

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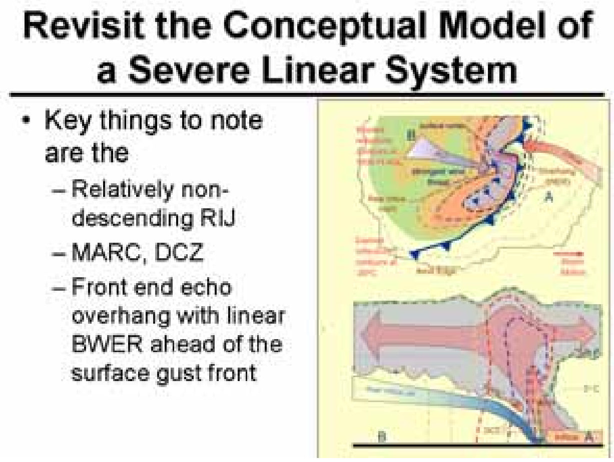

18. Conceptual model of a nonsevere linear system

Instructor Notes: A weak linear system is depicted here as one that has no WER, or deep convergence (DCZ means Deep Convergence Zone) or Mid Altitude Radial Convergence (MARC). The gust front is shallow and quickly advances faster than the cells above it, leaving them behind and over the cold pool. As a result, you see multiple discrete cells forming over the gust front which congeals into a region of strong reflectivity in a roughly linear shape well behind the surface gust front. Remember that even a shallow sloped, weak updraft linear system may still produce severe winds. However, the high-end severe linear systems tend to have the structure presented to you in the previous page.

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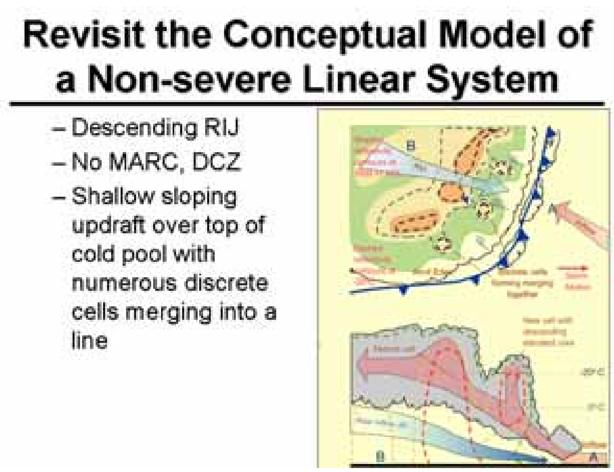

19. Summary: Severe updraft signatures

Instructor Notes: Summary: Severe Updraft Signatures The most severe updraft signatures tend to have these features common, even for linear systems. BWER WER Deep, intense reflectivity cores * *Severe linear updrafts tend to have somewhat shallower cores than discrete severe updrafts A storm top displaced over the WER A deep convergence zone**   **This is a weak requirement as many discrete severe updrafts may not exhibit this. For example, classic or Low Precipitation (LP) supercells mostly fail to show any deep convergence and yet have extremelyi ntense updrafts.

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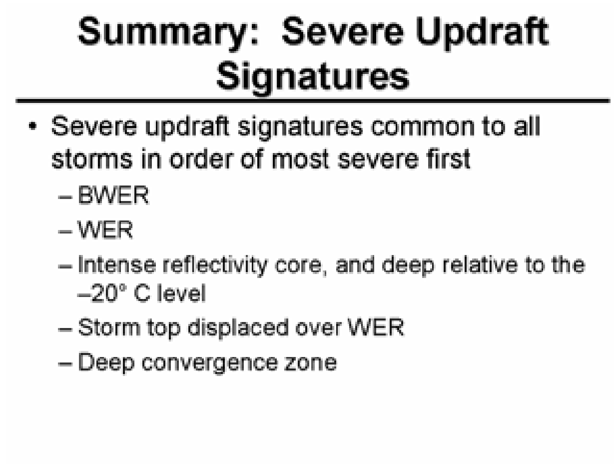

20. Contact info

Instructor Notes:

Student Notes: