1. Storm Interrogation

Instructor Notes: Welcome to the AWOC Severe Track IC3-III-F Nonmesocyclonic tornadoes This lesson is 11 slides long and should take anywhere from 10 to 15 minutes to complete

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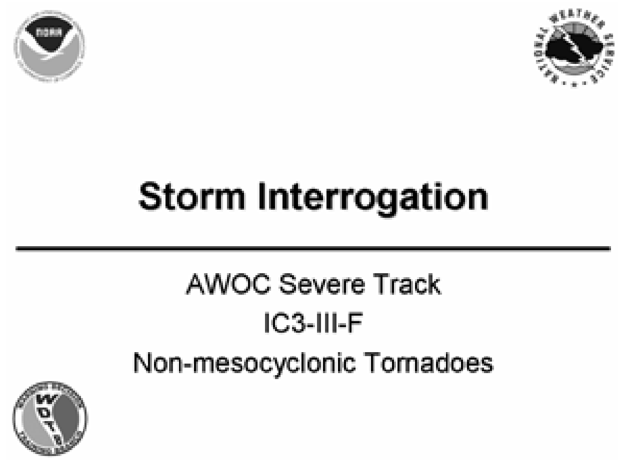

2. Nonmesocyclonic tornadoes

Instructor Notes: The objectives of this lesson are two fold: Show where pre-existing vorticity should be a significant tornado ingredient. This goes far beyond the analysis that is often shown in the SPC mesoanalysis web page using an objective analysis. Here, we go to the boundary scale using radar data, make some assumptions as to the nature of the wind field right up to the edge of either side of the boundary, then use the boundary width as a baseline from which to make an estimate of the background vorticity supply. This is probably as close as we can get to estimating what is really out there. However, note that boundary widths seem to decrease every time a newer higher resolution dataset becomes available. Determine the timing of the greatest tornado threat given the superposition of vertical vorticity, perhaps prestorm misocyclones, incipient storm updrafts, and boundary intersections and/or collisions. Again, anticipating nonmesocyclonic tornadogenesis is very difficult when no significant rotational signatures appear on radar in advance of the event. Timing the convergence the tornado ingredients, vertical vorticity, vertical vortex stretching potential, based on what is detected by radar may help, along with spotter data, to provide some lead time.

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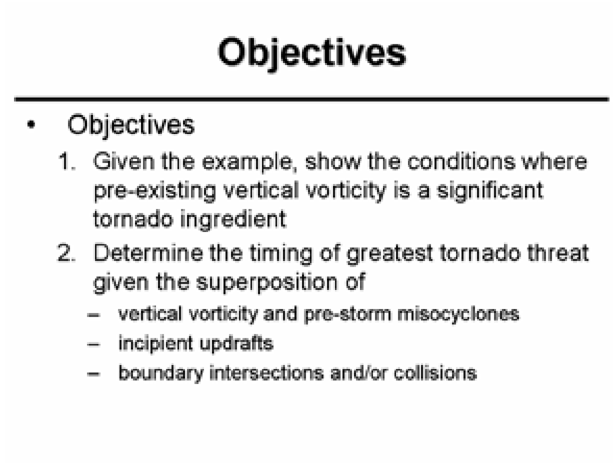

3. Nonmesocyclonic tornadoes

Instructor Notes: There are some considerations to consider: :^) Nonmesocyclonic tornadoes is a term that is gaining more favor over nonsupercell tornado because the processes in how the ingredients arrive to produce these tornadoes can occur both in supercells and nonsupercell storms. Flanking line tornadoes along the rear flank downdraft gust front of a supercell is an excellent example of a nonmesocyclonic tornado. No precursor velocity signatures on radar are common with these events. The pool of vorticity is often very small and close to ground. The misocyclones that may form when a vortex sheet breaks down into eddies are often too small to be detected. Even with mesocyclonic tornadoes, the actual pool of vorticity that directly feeds the tornado may not appear until the time of the tornado. All other vorticity signatures may be a more indirect contribution to tornadogenesis. That has yet to be determined with more research though. LCL height is not a consideration with nonmesocyclonic tornadoes. There is typically no downdraft feeding vorticity to nonmesocyclonic tornado, and therefore, downdraft buoyancy is not a factor. But allowing for strong low-level stretching is important, and therefore, these events require almost no CIN and steep lapse rates up to at least the LFC. A linear homogeneous boundary may carry very strong vertical vorticity across its interface, even mesoscyclonic in values, but it may not be enough to initiate a nonmesocyclonic tornado. Most events require some interaction with another boundary, perhaps horizontal convective rolls to ramp up the low-level vorticity even more, and perhaps provide additional stretching potential under an initiating cell.

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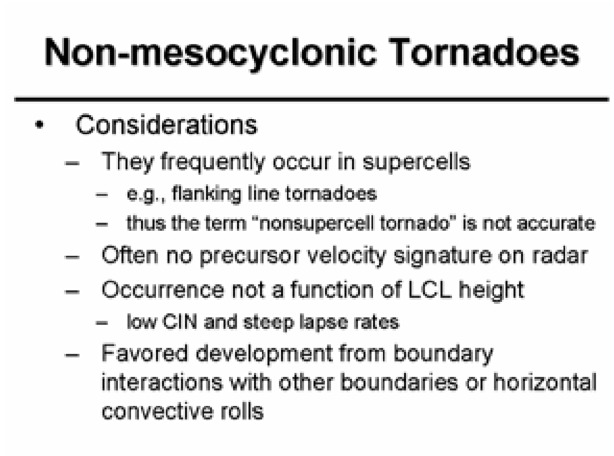

4. Sufficient pre-existing vertical vorticity

Instructor Notes: A typical well defined boundary may be one km (.54 nm) or less. Applying only 10 kts of wind in opposing directions across the width of that boundary provides the same vorticity as a 3km wide mesocyclone with a 30 kt rotational velocity. The SPC mesoanalysis plots of vertical vorticity peak out orders of magnitude less than what really is occurring. We'll show an example coming up.

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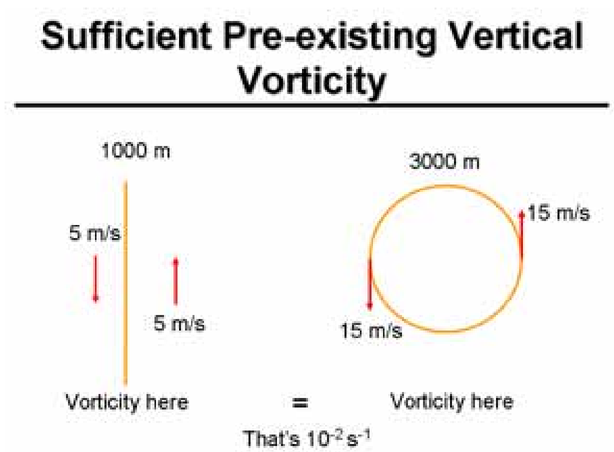

5. Pre-existing vertical vorticity

Instructor Notes: Pre-existing vertical vorticity here prior to the Salt Lake City tornado event occurred on scales of 1 km or less. The boundary is part outflow, part lake breeze effect. Regardless of its origins, the boundary showed good vertical vorticity observed from the TDWR. Note that it only existed up to about 2 kft AGL. A strong updraft initiating over the boundary resulted in the superpositioning of the background ingredients for tornadogenesis. The actual trigger to get tornadogenesis going was something that occurred on even smaller scales with little lead time observed by the TDWR. However, given the favorable background conditions, there needs to be a level of awareness that something could happen.

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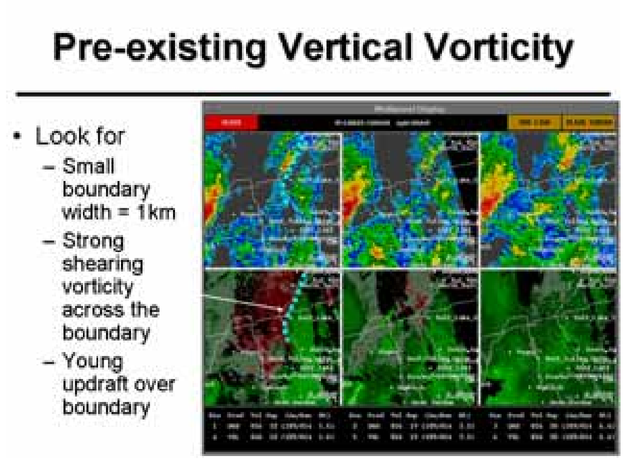

6. Another example: 09 July 2003, ICT

Instructor Notes: An excellent example of nonmesocyclonic tornadogenesis occurred with a common synoptic setup over the Plains on 09 July 2003. A cold front moved south with little temperature gradient across the interface. Steep lapse rates and almost no CIN are apparent after modifying the 18 UTC KTOP sounding with the observed afternoon temperatures. The LCL is high and there is weak low-level shear. The 0-6 km shear is sufficient for some supercells, however.

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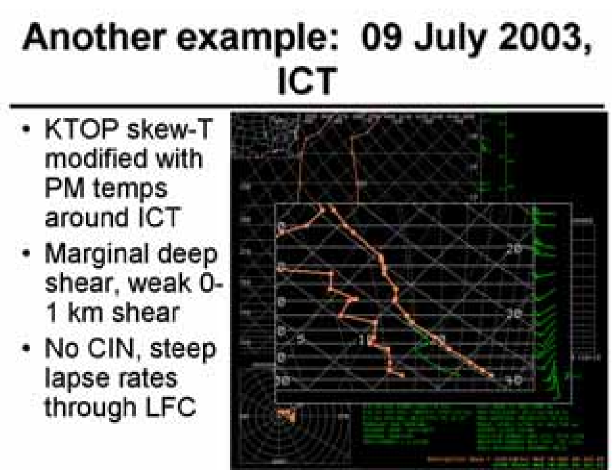

7. Pre-existing vertical vorticity:a case

Instructor Notes: The cold front boundary can be seen dropping southeast. The winds on both sides of the boundary are angled roughly 45° to the orientation of the front. I took the peak winds observed on either side of the front and assumed that these winds continued right up to either side of the boundary. Vertical vorticity can be inferred by the streamline analysis across the boundary. If only satellite data were available, I would note that the boundary contained a thin line of enhanced cumulus and that its width was less than 4 nm. The actual boundary width was narrower than the width of the cumulus line as will be shown. The slow boundary relative storm motion will also be shown by radar.

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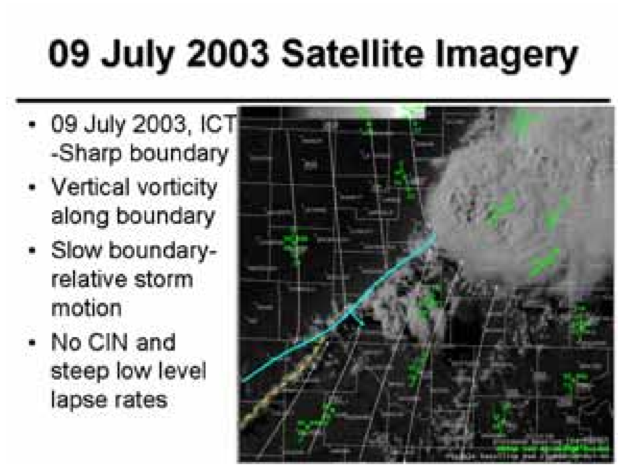

8. Pre-existing vertical vorticity:a case

Instructor Notes: Progressing through this reflectivity loop, one can see the general motion of the cold front. Also noted, an outflow boundary from the storms was coursing down the front on both sides providing an intersection point. Rapid updraft growth was occurring along and just ahead of the outflow boundary as it moved southwest. The timing of the individual updrafts was important as they were the stretching mechanisms and sources for potential tornadogenesis. I will use the young updraft marked in the upper-right panel to track as my storm motion. This is just the kind of cell that could be associated with a nonmesocyclonic tornado.

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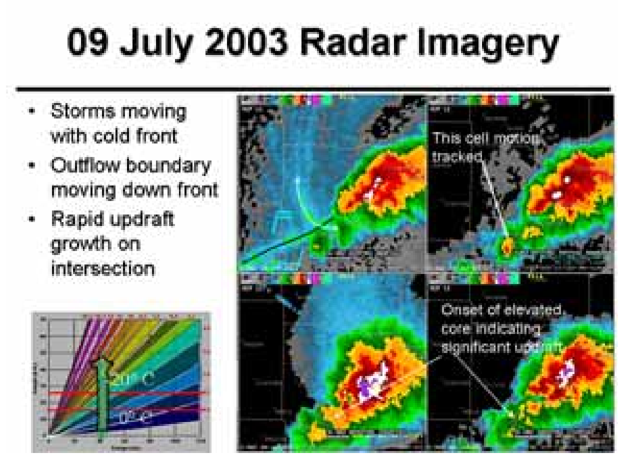

9. Pre-existing vertical vorticity:a case

Instructor Notes: Plotting the motion of the cold front on a hodograph from a nearby profiler can be done by using the distance speed tool to track the boundary in a direction orthogonal to its orientation. I get a value roughly from 348° at 23 kts. The vector (in cyan) marks the frontal motion. I can actually plot the cold front axis, again, orthogonal to the frontal motion vector shown as the cyan line. To show what the boundary-relative cell motion is, I take the observed cell motion, again using the distance speed tool, from the previous page, and I get roughly 281° at 31 kts (orange ball). Note that my storm motion lies almost on the front. This is favorable since I prefer to have an updraft reside over a low-level vorticity source for awhile. It may not take long, less than 15 minutes to stretch the vorticity into a tornado. As an aside, I can visualize the wind at any level in a boundary-relative mode. The winds at 12 to 13 km are still ahead of the boundary, and thus, they are overtaking the boundary. Conversely, all winds below 4 km are behind the boundary, and therefore, are being overtaken by the boundary. The winds from 4 to 7 km are pretty close to the boundary axis, as drawn on the hodograph, and therefore, are able to keep up with the boundary. These are the winds that are probably steering young cells in this situation.

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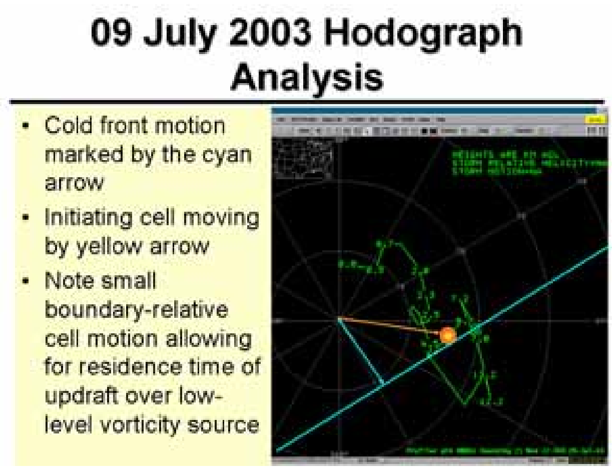

10. Pre-existing vertical vorticity:a case

Instructor Notes: To further analyze what potential background vorticity there is, I first try to directly observe it with base velocity. Unfortunately, the northeast and southwest winds are mostly tangential to the radar and therefore, I cannot use something like the Vr shear tool. Instead, I infer the larger scale winds seen in the metar data to come right up to either side of the front, at 45 ° angle to the frontal orientation (20kts). The white vectors represent the component of winds paralleling the front, and if I take 45 ° as the angle and calculate the front parallel component, I get roughly 13 kts. That corresponds to a shearing velocity difference of roughly 25 kts. The boundary width I took from the width of the fineline, noting of course that the actual width may even be smaller. Still, I get a width of 1 to 2 km. Calculating vorticity across that width is ?V/(width) ~ .01 s-1 That is easily mesocyclonic in strength for vorticity. Tornado cyclone scales need to magnify this vorticity by another factor of 10, tornado itself, a factor of 100. No problem. The outflow boundary intersection, and strong initiating updraft with slow boundary-relative storm motion is likely enough to do the job. At the time of the image, a tornado was on the ground marked by the red triangle, right under one of the updrafts at the outflow boundary intersection point.

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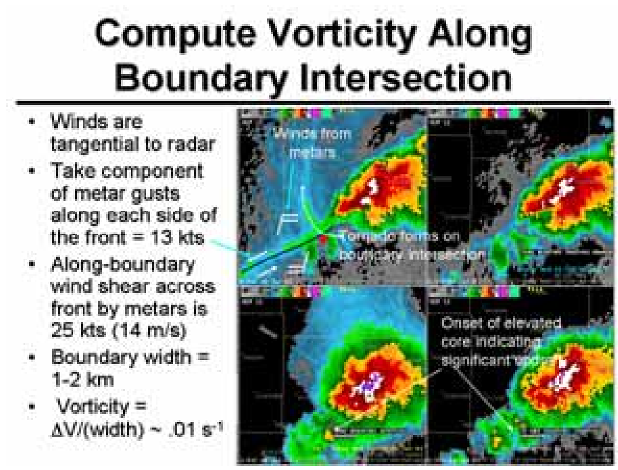

11. Choices

Instructor Notes:

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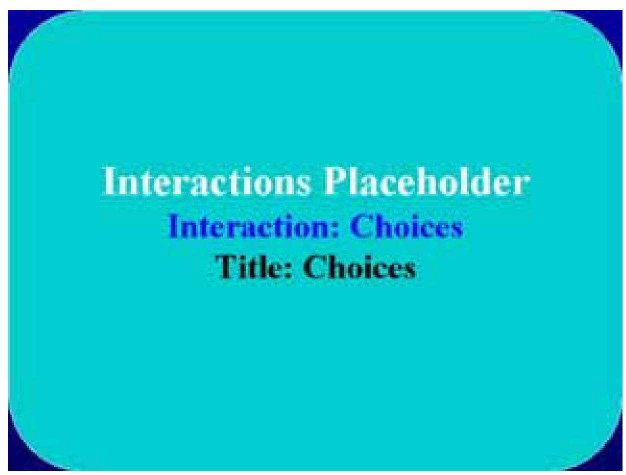

12. Summary

Instructor Notes: Nonmesocyclonic tornadoes are favored by: near zero CIN, steep lapse rates ground to cloud Sharp boundary of 1 nm width or less Prestorm vertical vorticity > .01s-1 vorticity sheet often rolls up into misocyclones Superposition of strong developing updraft over low-level vertical vorticity Often need a boost of vorticity and/or convergence from multiple boundary interaction Prefers low boundary-relative cell motion None of this will give me an adequate false alarm or POD. These conditions can occur many times before there is a hit. But the increased awareness, and time to solicit for spotter reports may help in getting a warning out in time.

Student Notes: