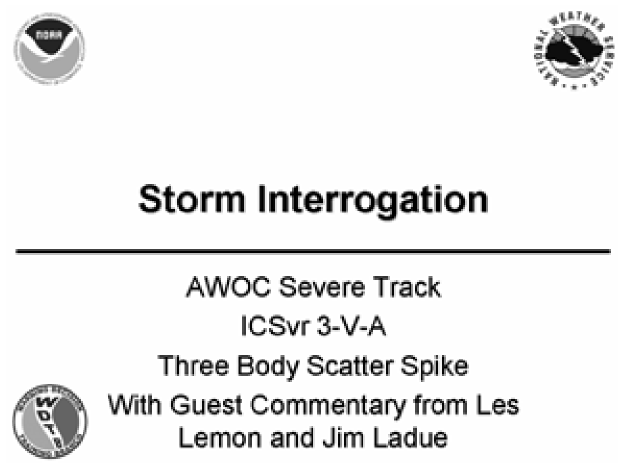
1. Storm Interrogation

Instructor Notes:

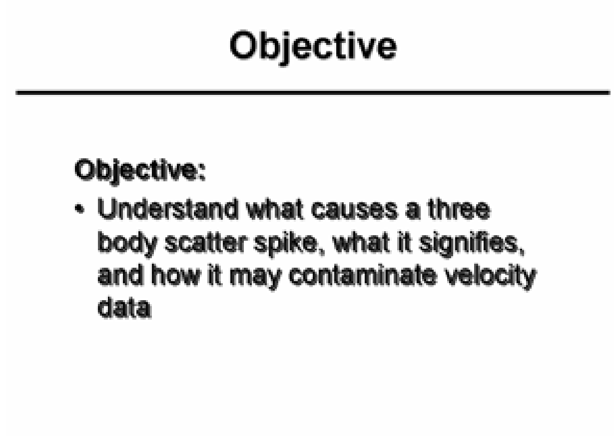
Student Notes:



2. Three Body Scatter Spike (Hail Spike)

Instructor Notes:

Student Notes:



3. Three Body Scatter Spike (Hail Spike)

Instructor Notes:

Student Notes:

Three Body Scatter Spike

- A feature, like many others, that is not all-inclusive: If the signature is in the data, it is nearly a guarantee of severe hail, but with many severe hail storms it is not visible

  - Can be masked by "real" reflectivity behind the main core

4. Hail Spike

Instructor Notes: Step by step process 1. radar pulse from radar to hail core 2. strongly reflecting large, wet hydrometeors are encountered, and scatter the signal in all directions, including downward 3. The trees, earth, and vegetation reflect the energy diffusely 4. reflected energy illuminates the hail core once more 5. the reflected energy from the ground has been found to drop off as r-3 (r is the distance the energy travels from the ground to the hail core) 6. for a second time, the large, wet hydrometeors scatter the energy, but this time a significant amount of the ground reflected energy is backscattered and received by the radar 7. the radar "sees" this entire event as occurring along the same radial, and due to the longer traversed paths of the triple reflected signals, the spike appears at a range downradial from the hail core 8. The hail spike begins down the radial at a distance exactly equal to the height of the hail core above the ground 9. Note that each successive range gate along the hail spike will have progressively lower reflectivities because of the r-3 decrease of power with distance from the scatterers 10. 1st gate of the hail spike will have maximum reflectivities

Student Notes:

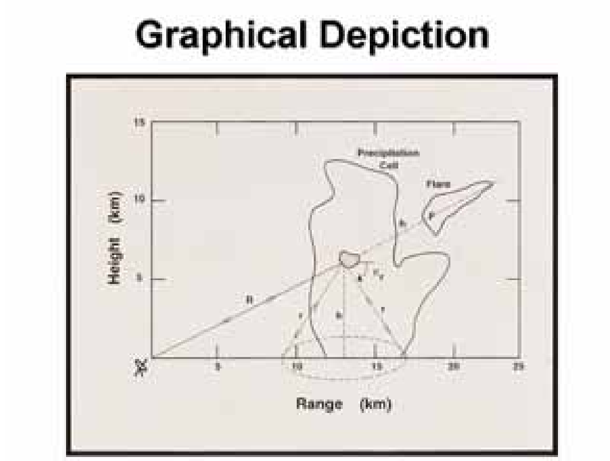
Animation of the formation of a TBSS

- If visible, it is the most robust indicator of severe hail

5. Slide 5

Instructor Notes: You get a range of possible reflection regions from the ground back to the hail stone, such that a “cone” of possible reflection areas are possible. This is precisely why the flare extends for various lengths down radial, as the reflection along dotted line h is both quickest and strongest (again, returned power falls off as R^3). Power returned from the edges of the cone takes longer and is weaker, thus the flare extends further downradial and decreases intenstity the further down radial you look.

Student Notes:



6. Hail Spike

Instructor Notes: The factors affecting the strength of the hail spike is important to comprehend. Extremely wet hail, in very high quantities, even though it could be “small”, can produce a hail spike. Most storms with large hail or large quantities of small hail likely produce hail spikes, it’s just that typically the precipitation core is too broad or there are other storms down radial such that the hail spike is not visible.

Student Notes:

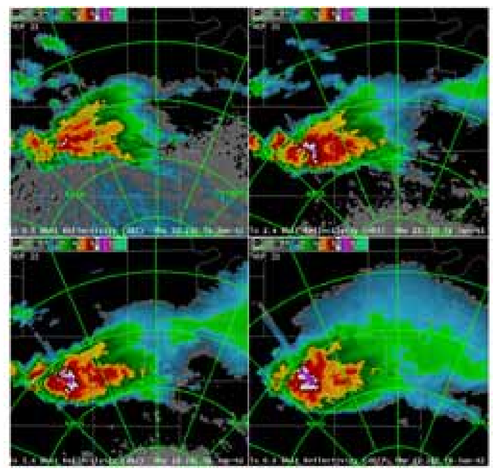
Summary of How TBSS Forms

- position of hail spike along the radial is proportional to core altitude above the surface
  - → Precisely why it is seen primarily at higher altitudes in the storm
- strength of hail spike proportional to: hail size, **concentration**, **wetness**, and vertical extent of core
- must be no precipitation behind core along radial

7. Slide 7

Instructor Notes: 4 panel reflectivity. Hail spike shows up on tilts 2.4 degrees and above, but not at 0.5 degrees TBSS begins at a range from the radar that is the range to the hail core plus the twice the height above the ground the beam hits the core. AT 0.5 degrees the core is closest to the ground, and thus the TBSS begins very near the back side of the hail core, and the reflectivities are so low in the hail spike that the actual reflectivities from the northwest portion of the storm “drown” them out Rapid hail stone growth occurs aloft in mid-levels, in wet growth making them highly reflective, and at 6 degrees the core is hit at 33 kft, thus the TBSS is much longer and extends a long distance down radial behind the core.

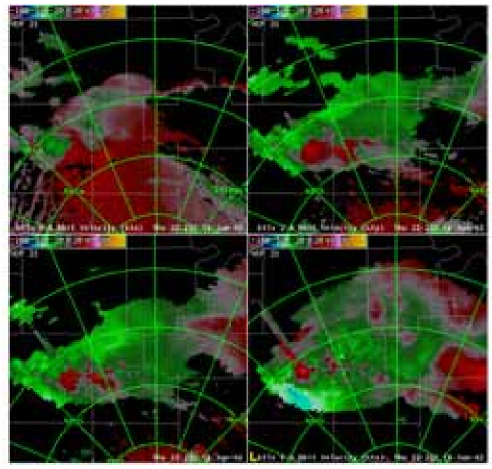
Student Notes:



8. Slide 8

Instructor Notes: 4 panel velocity: Velocities are low in the TBSS At each range gate you are combining both horizontal and vertical air motions, and hail is normally falling relative to the ground Thus, velocities are low negative velocities within the TBSS, but you are combining returns at each range gate withint TBSS from multiple areas within the hail core, both horizontal and vertical motions. Velocities themselves are meaningless, but generally low and negative.

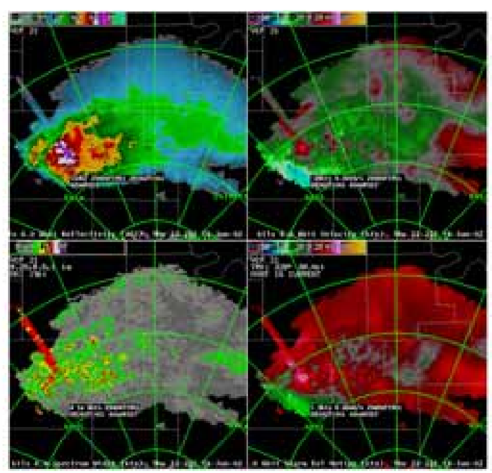
Student Notes:



9. Slide 9

Instructor Notes: 6 degree Z (top left), V (top right), SW (lower left), and SRM (lower right) Horizontal region in Velocity away from radar in the hail region itself that is outbound, then another region further down radial of the core that is also outbound: this is created by the TBSS, velocity contamination and is an unfortunate result of TBSS SW has very high values within the TBSS: each location along the TBSS is a combination of several different motions both horizontally and vertically from multiple locations within the hail core. The spectrum is very broad as as result and is very near white noise along the TBSS. SW can help identify TBSSs. TBSS means you have a serious core, but just because you don't see it doesn't mean the storm cannot produce very large hail. It is a "sufficient condition" for knowing large hail exists in the storm, but it not a "necessary condition". TBSS is not an algorithm, if you see it, you should be completely confident that large hail is occurring with the storm.

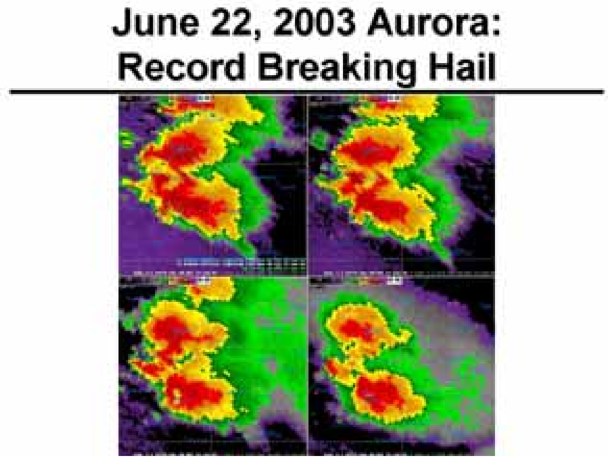
Student Notes:



10. June 22, 2003 Aurora:Record Breaking Hail

Instructor Notes: No hail spike with this storm at any time, although technically it would be very hard to see.

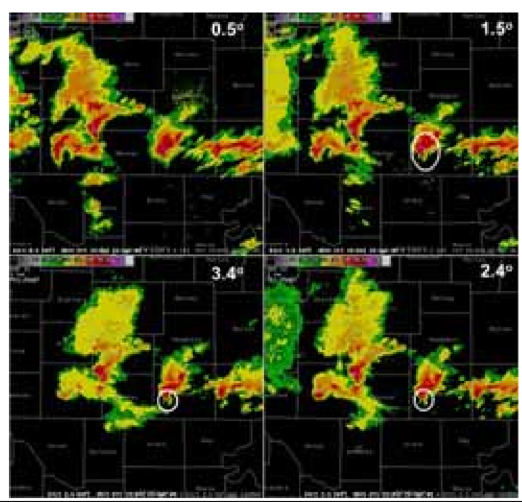
Student Notes:



11. April 23, 2004 Supercell near ICT

Instructor Notes: Examine this loop of reflectivity from morning supercell. The hail spikes are very small, and could be mistaken for an appendage on the southern flanks of the storm. Always investigate velocity (and SW if available) and zoom far in on any potential hail spikes to verify their presence.

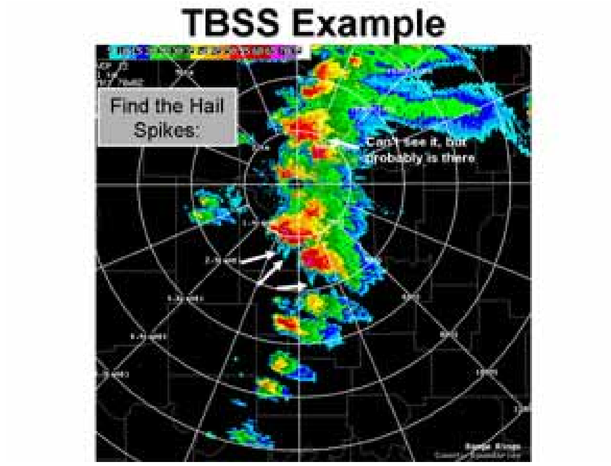
Student Notes:



12. Hail Spike Example

Instructor Notes: It is your job to find the hail spike in this image. Golfball to baseball hail was reported with these storms, although around this time just 1-1.5 inch hail falling out of any one storm. The storm entering Logan county “should” have a hail spike but the spike is obscured due to echoes all around behind the main core. I would point this out.

Student Notes:



13. Pop Quiz on the TBSS

Instructor Notes:

Student Notes:

14. Hail Spike: Summary

Instructor Notes: Another important point Lemon brings up in his paper is the additional threat of severe winds. With large hail and/or large quantities of wet hail, downburst potential is very high due to precipitation drag, and thus storms with hail spikes ALSO are likely to contain severe damaging winds, as is the case with this storm.

Student Notes: