

Meteorology – Lecture 19

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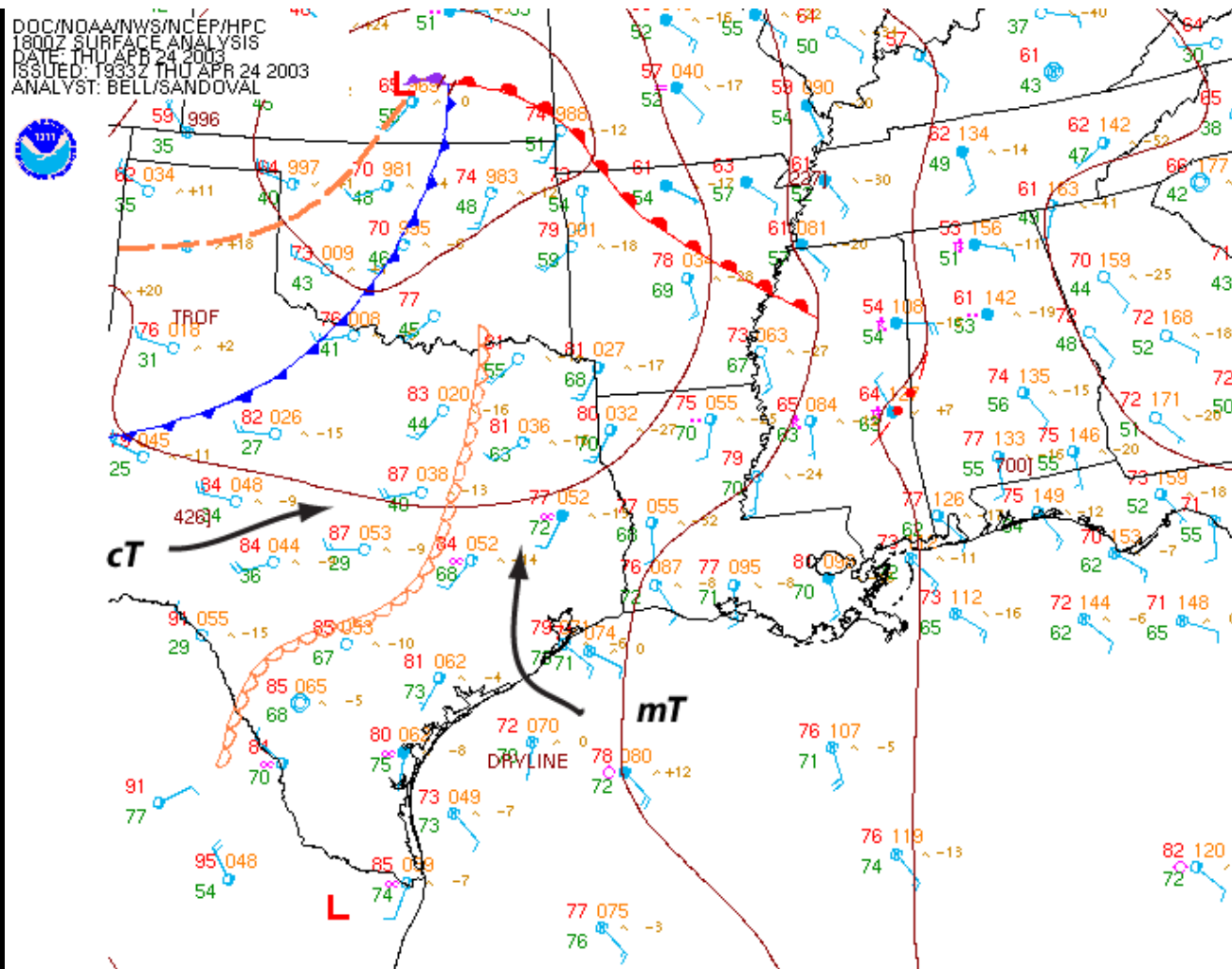
Important notes

- These slides show some figures and videos prepared by Robert G. Fovell (RGF) for his “Meteorology” course, published by The Great Courses (TGC). Unless otherwise identified, they were created by RGF.
- In some cases, the figures employed in the course video are different from what I present here, but these were the figures I provided to TGC at the time the course was taped.
- These figures are intended to supplement the videos, in order to facilitate understanding of the concepts discussed in the course. *These slide shows cannot, and are not intended to, replace the course itself and are not expected to be understandable in isolation.*
- Accordingly, these presentations do not represent a summary of each lecture, and neither do they contain each lecture’s full content.

Animations linked in the PowerPoint version of these slides may also be found here:

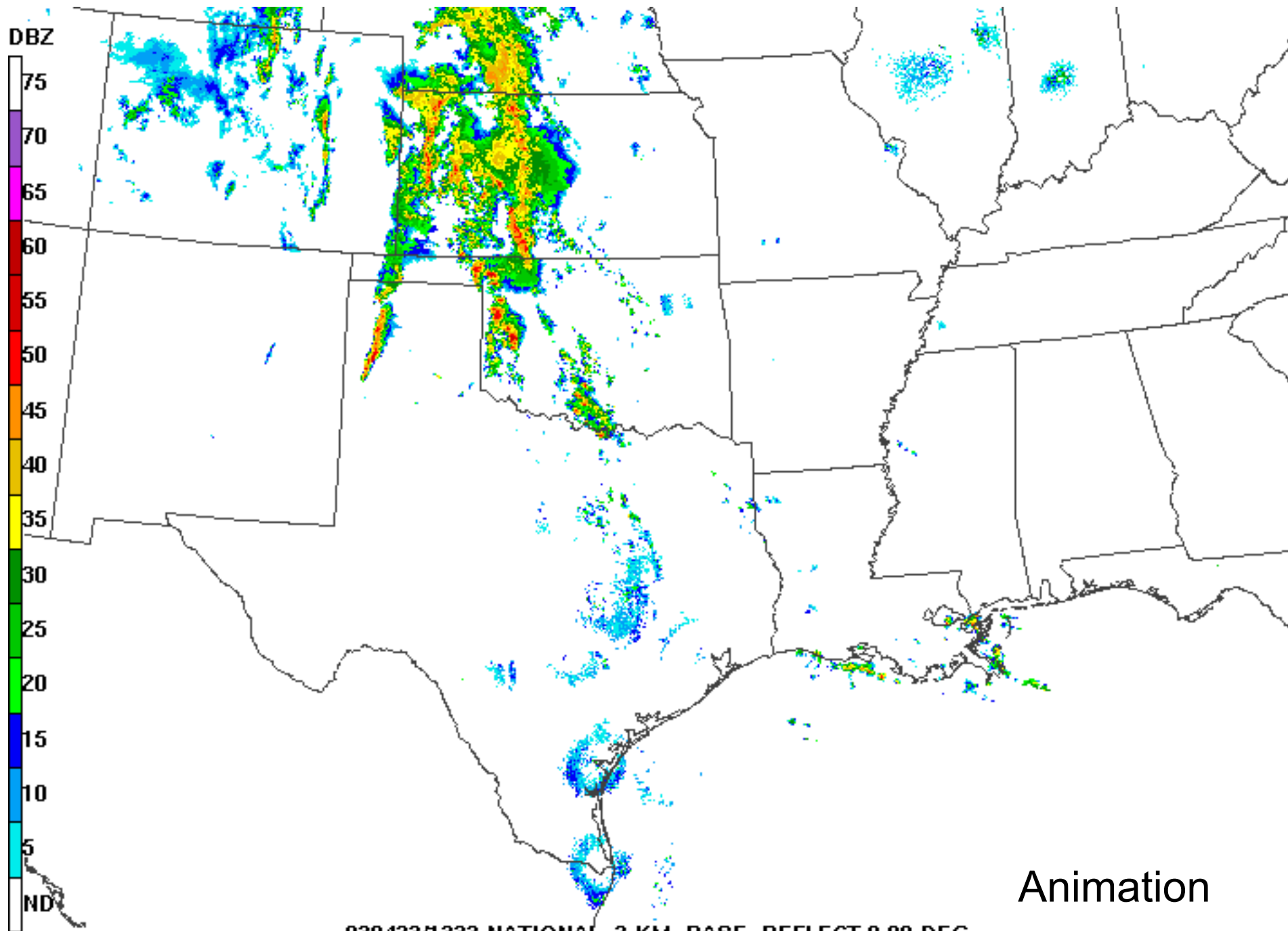
<http://people.atmos.ucla.edu/fovell/meteo/>

Mesoscale convective systems (MCSs) and drylines



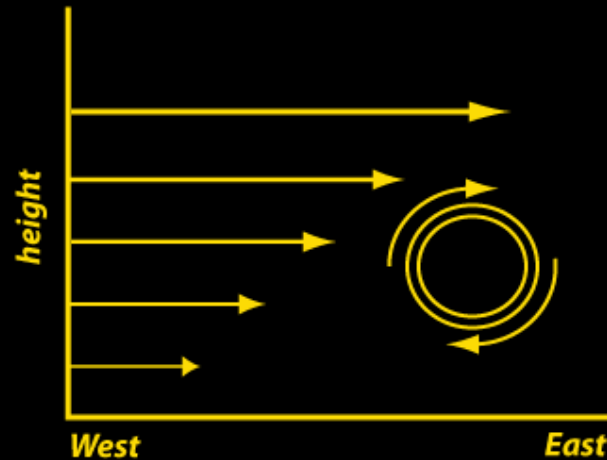
This map shows a dryline that formed in Texas during April 2000. The dryline is indicated by unfilled half-circles in orange, pointing at the more moist air.

We see little T contrast but very large TD change.
Dew points drop from 68F to 29F -- huge decrease in humidity 5



Animation

Supercell thunderstorms



The secret ingredient for supercells is large amounts of vertical wind shear. CAPE is necessary but sufficient shear is essential.

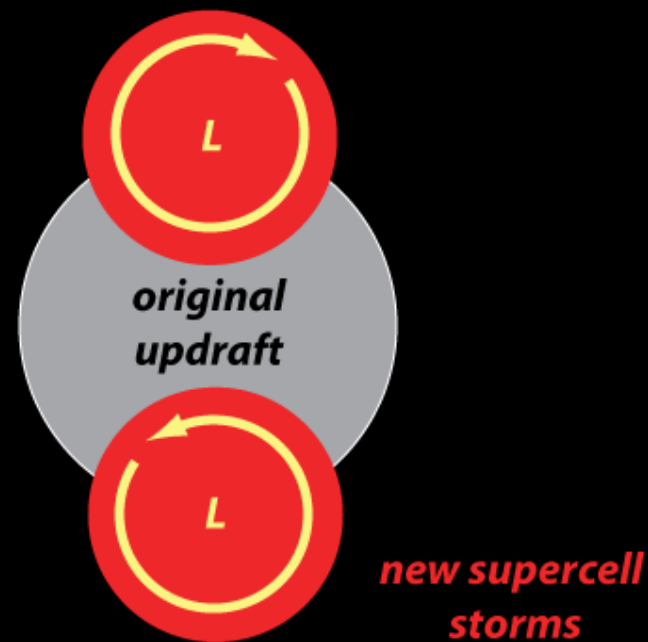
It is shear that makes the difference between an ordinary multicellular thunderstorm and the rotating supercell. The shear implies rotation. But, this rotation needs to be TILTED.



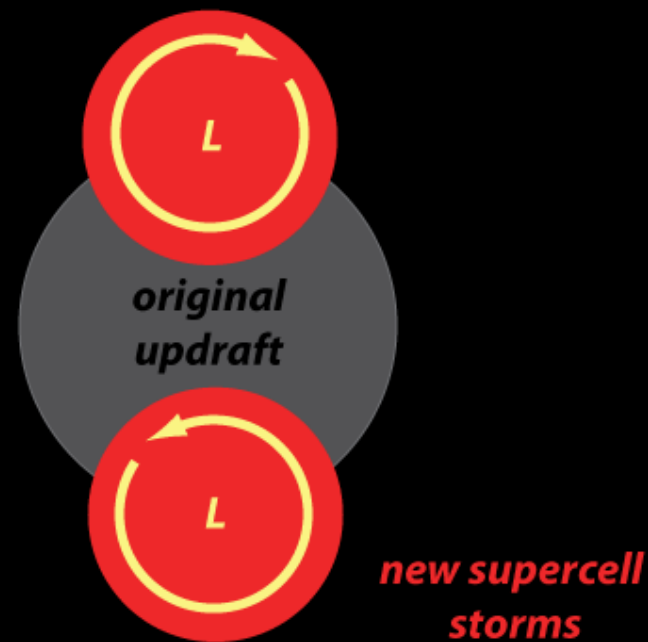
Look at this from the top down. Here's the original cloud's updraft, the one that lifted and tilted the vortex tube. This storm is NOT ROTATING.



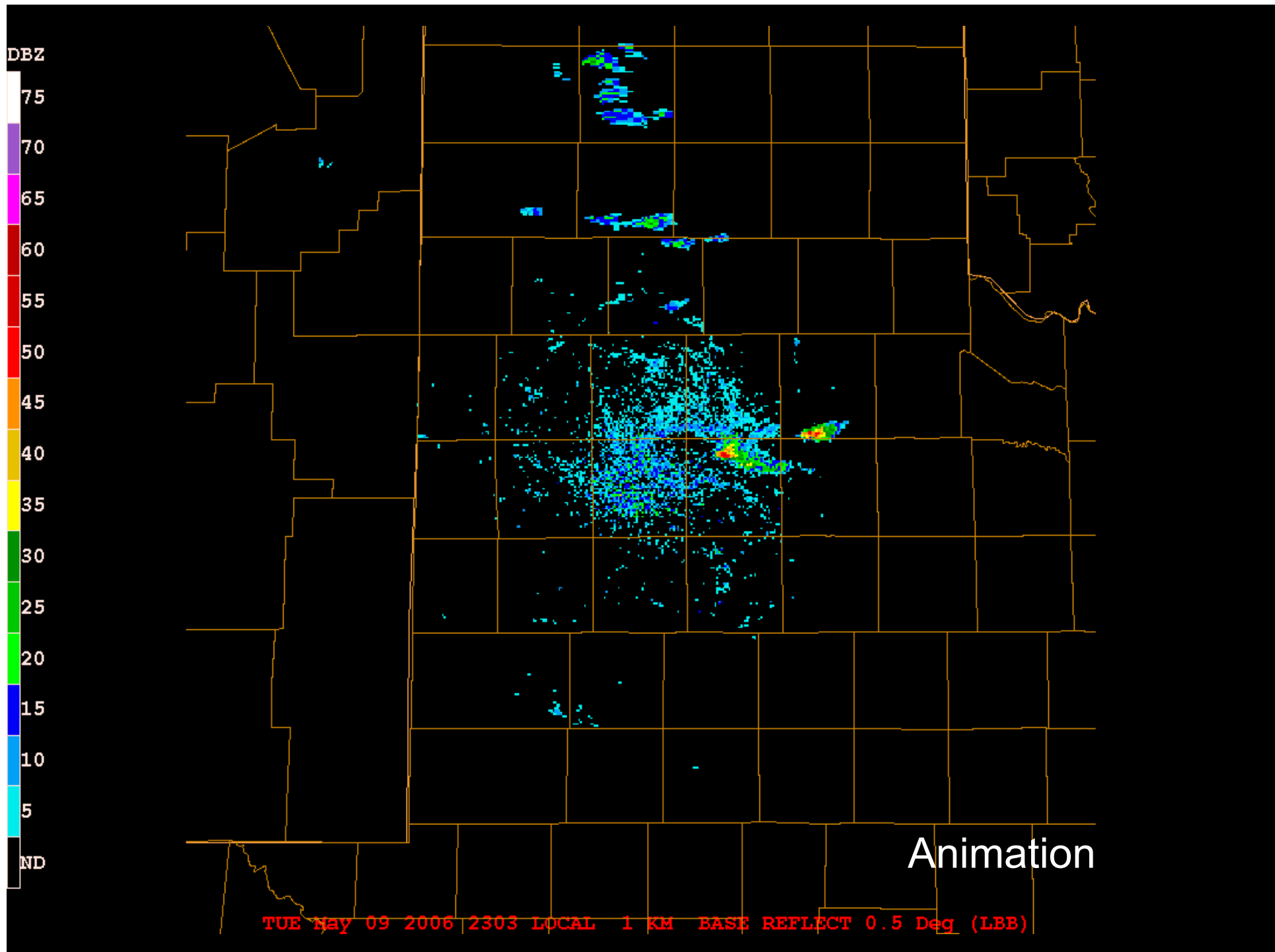
The vortices create low pressure, on the flanks of the original updraft. Since the shear is westerly, the vortices are on the N and S flanks. **THIS IS NOT A SUPERCCELL.** There is still no NET sense of rotation.¹⁰

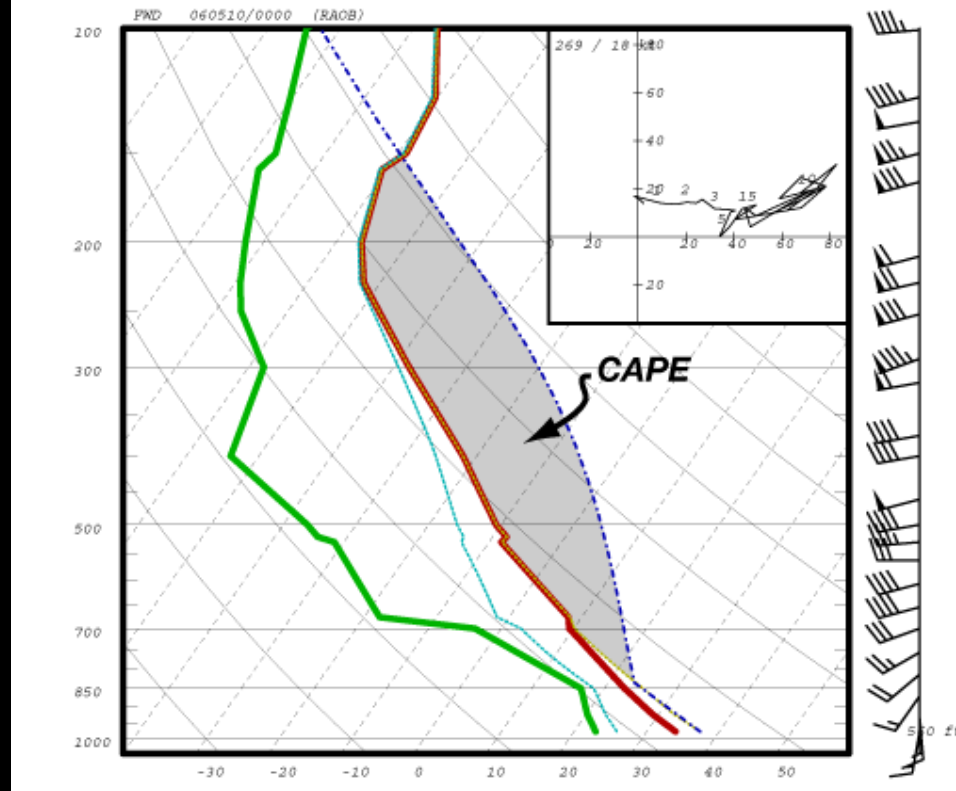


The low pressure is in the midtroposphere, and the upward-directed PGF draws air up. New storms are created on the flanks of original. These are ROTATING supercell storms. Note the northern one is CW rotating as seen from above.



Finally, the original, ordinary cell updraft dies, as ordinary cells are wont to do. The rotating supercells survive. The storm appears to have SPLIT, though as we have just shown, that's an ILLUSION.





The sounding taken to the east of where the storms were forming shows an incredible amount of CAPE, and no convective inhibition. A surface parcel lifted to 300 mb undiluted would be 18C or 32 F warmer than the environment.

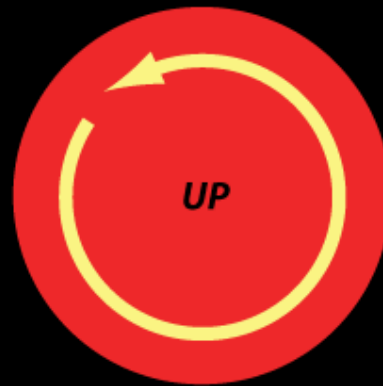
Supercell motion



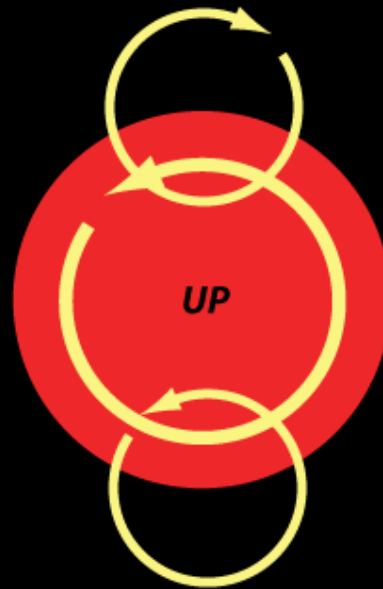
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1 of 25
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Animation

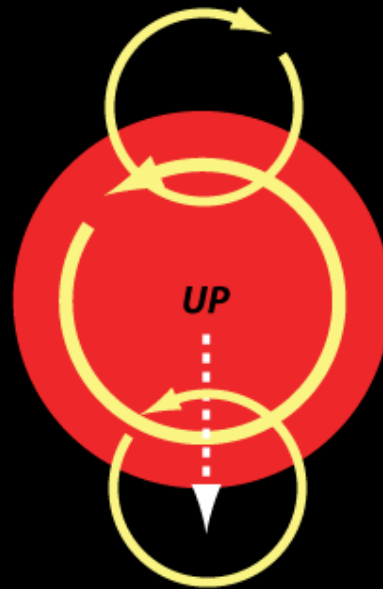
$V_{i=50}$



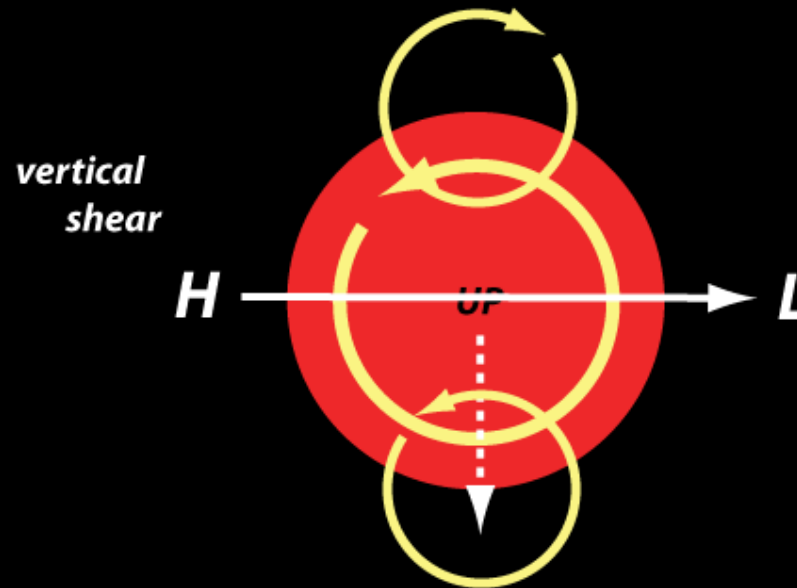
Here's our right mover's updraft. It's a rotating updraft, spinning CCW.



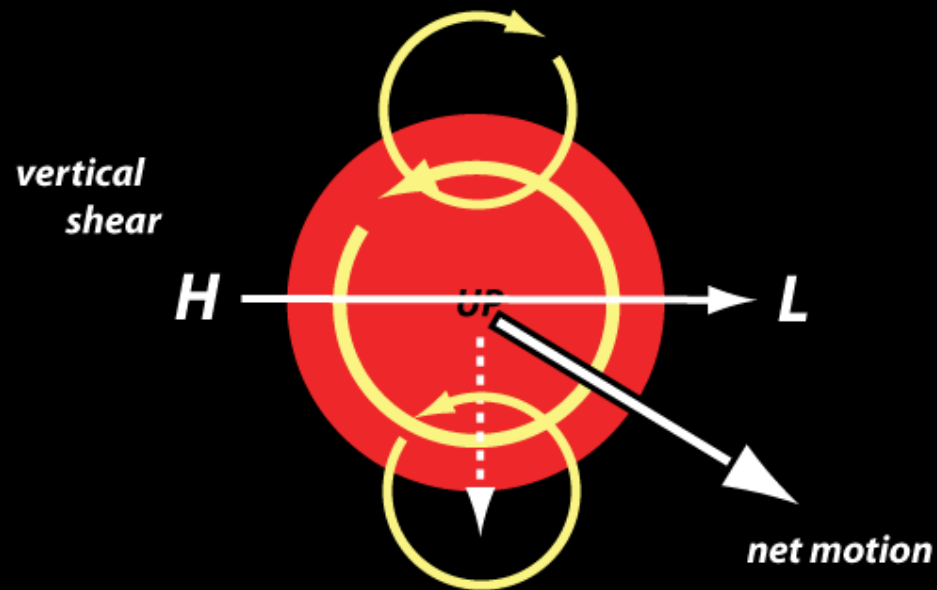
The updraft is still tilting vortex tubes, and so CW and CCW rotation are still being induced on the flanks, just as for the original ordinary cell.



But this time, the updraft is part of a rotating supercell. The storm moves towards the flank with the same sense of rotation. Here, to the south. For the left mover, that would be to the north.

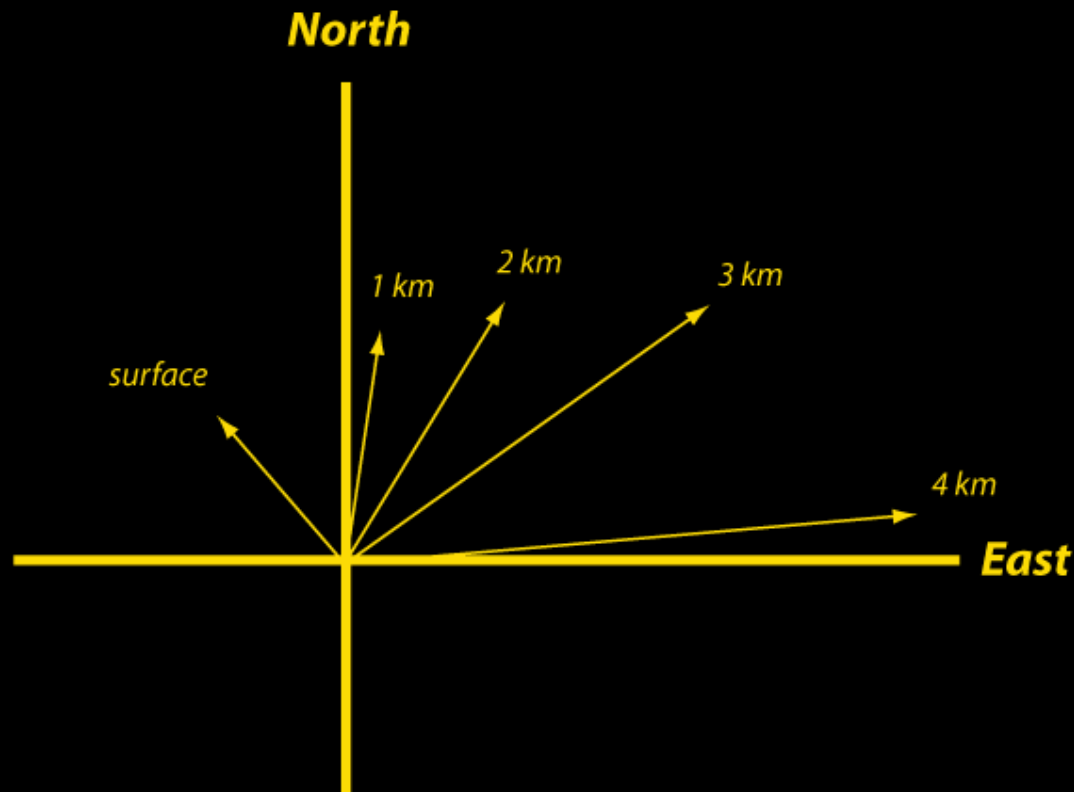


We also have westerly vertical shear. And shear also creates pressure perturbations: low pressure on the downshear side, high pressure upshear. This makes storm want to move to the EAST.



The combination of these two effects is to make the storm move to the SE of the shear and the winds.
Here's our RIGHT MOVING storm.

Why right-movers are favored in the midwestern US



Typical Great Plains **hodograph** (Greek = ‘path-graph’). This shows my surface winds are from the SE. It’s very likely mT air coming up from the Gulf. The hodograph reveals **directional wind shear**.

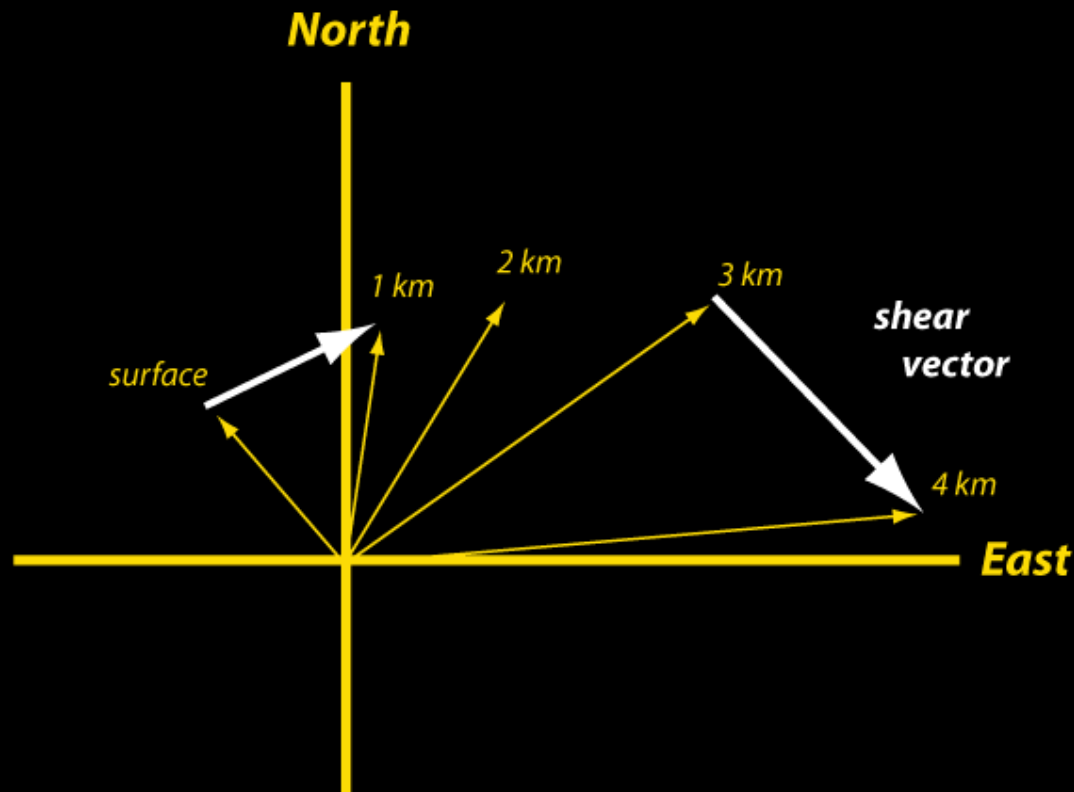


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1 of 25
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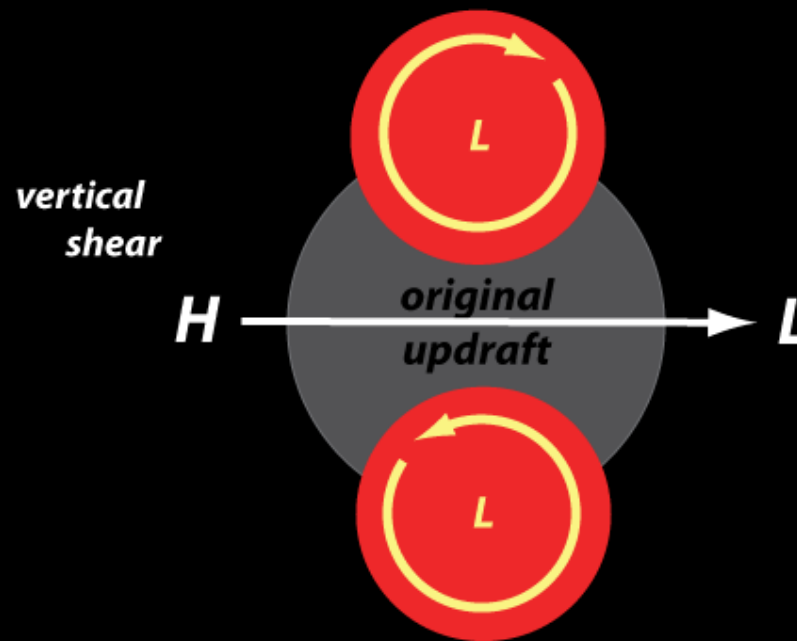
Animation

$V_{i=50}$

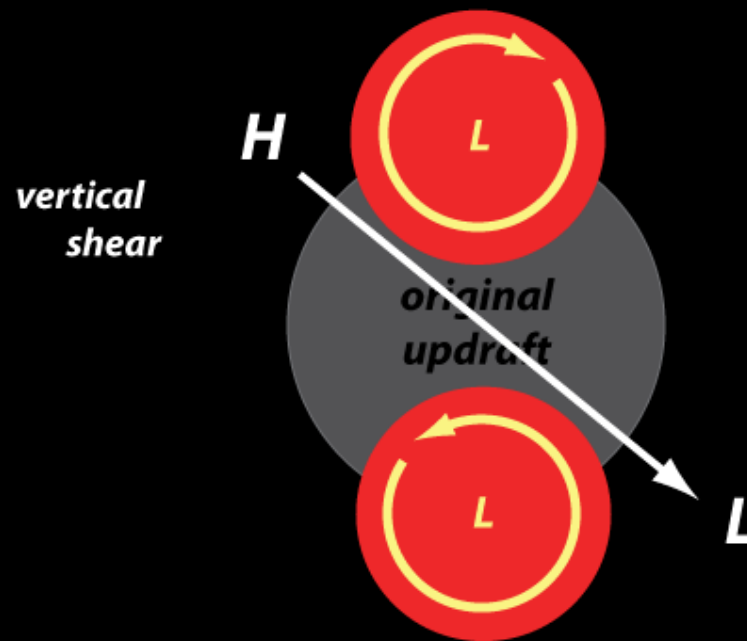
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I've drawn on a couple of shear vectors.
Note the shear vectors TURN with height. In the
midtroposphere, its pointing northwesterly rather than
westerly.

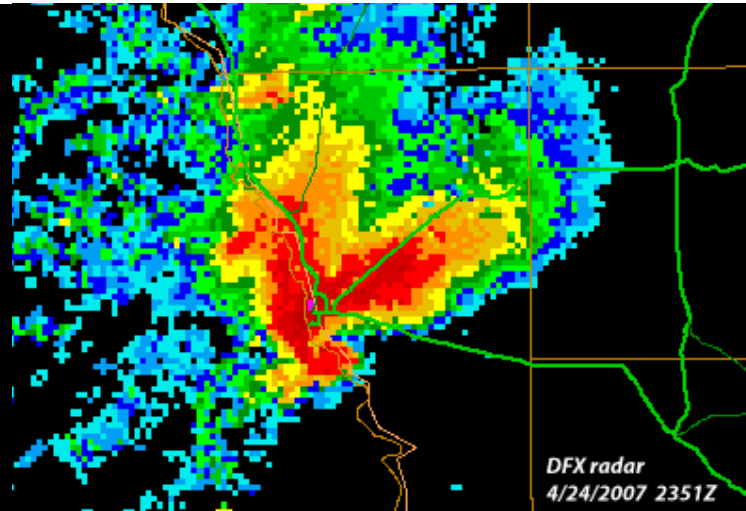


Originally, the shear vector was westerly, and did not favor either of the new split storms.

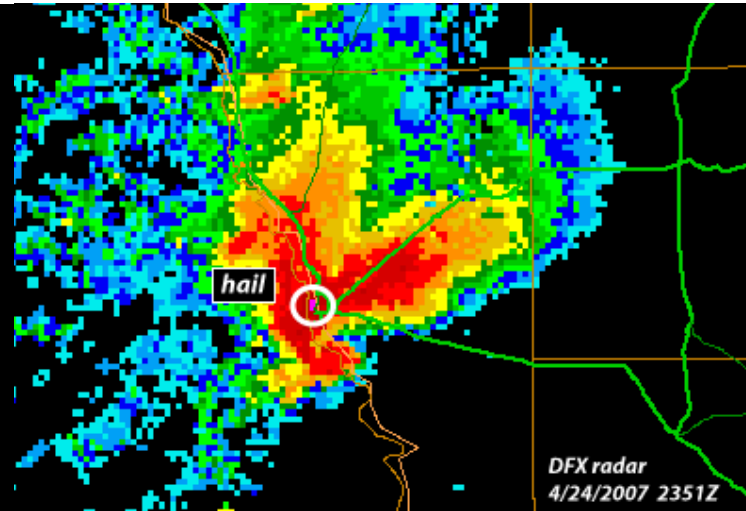


But now, because of the directional shear, the midtropospheric shear now points more towards the right mover, putting the low pressure on the DOWNSHEAR side in position where it can help its updraft. The high on the upshear side is SUPPRESSING the ascent in the left mover.

Hook echo

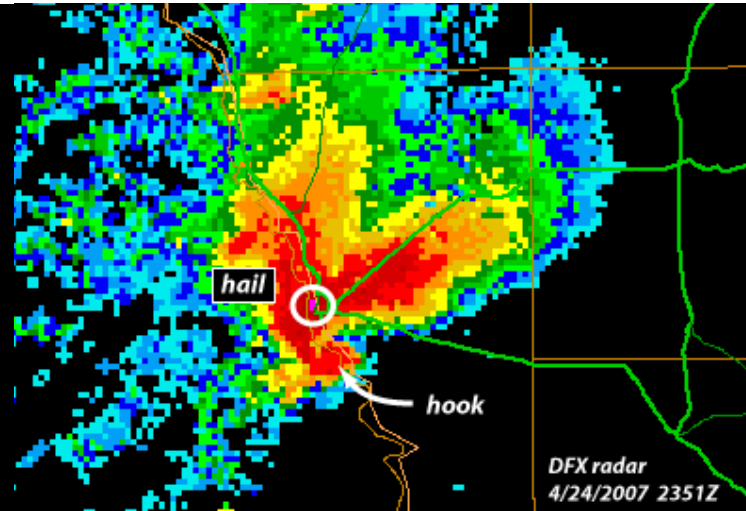


This image is from Laughlin AFB radar, on April 24, 2007, at 2351Z, just before 7PM local time.

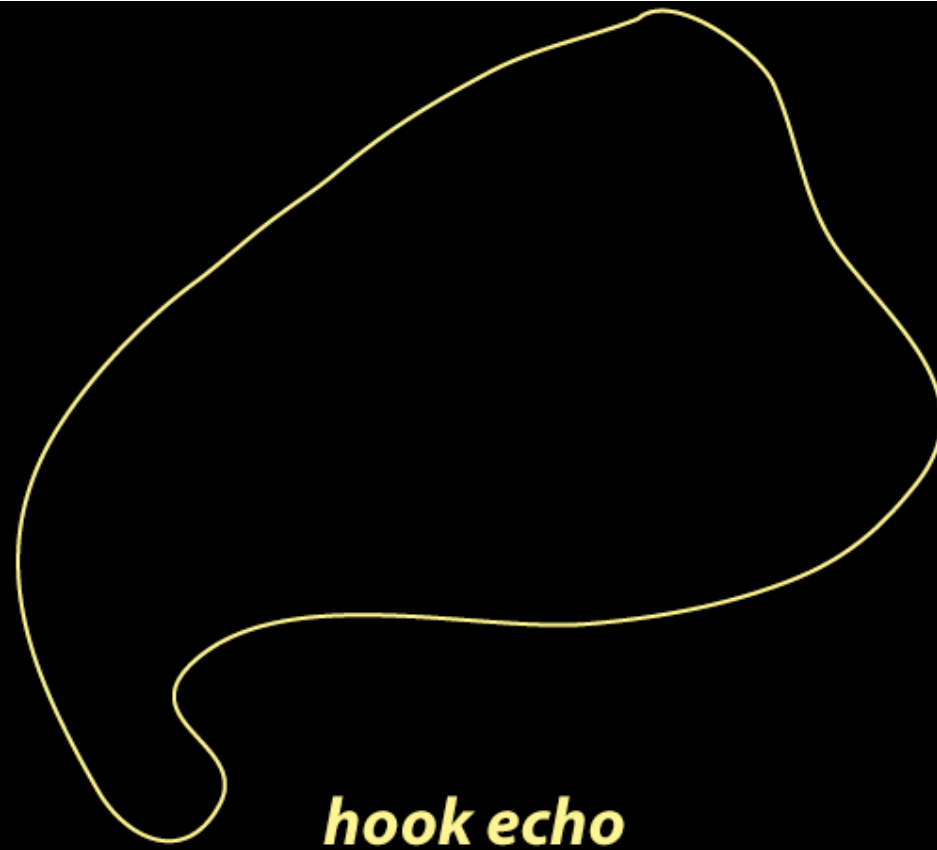


This image is from Laughlin AFB radar, on April 24, 2007, at 2351Z, just before 7PM local time.

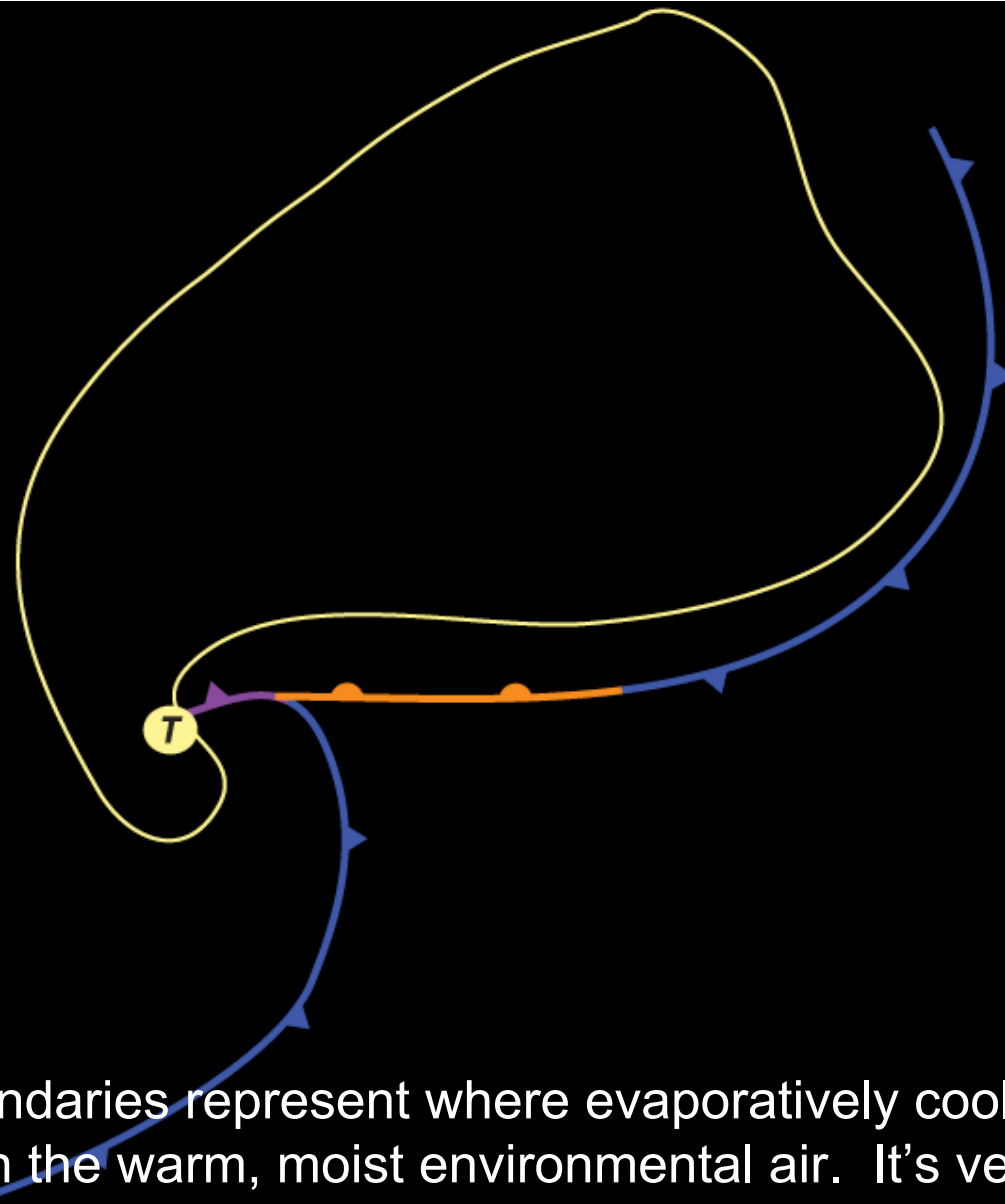
The small area of purple color (representing 65 dBZ) usually indicates hail. Only wet hail is reflective enough to produce echoes of this magnitude on this logarithmic scale.



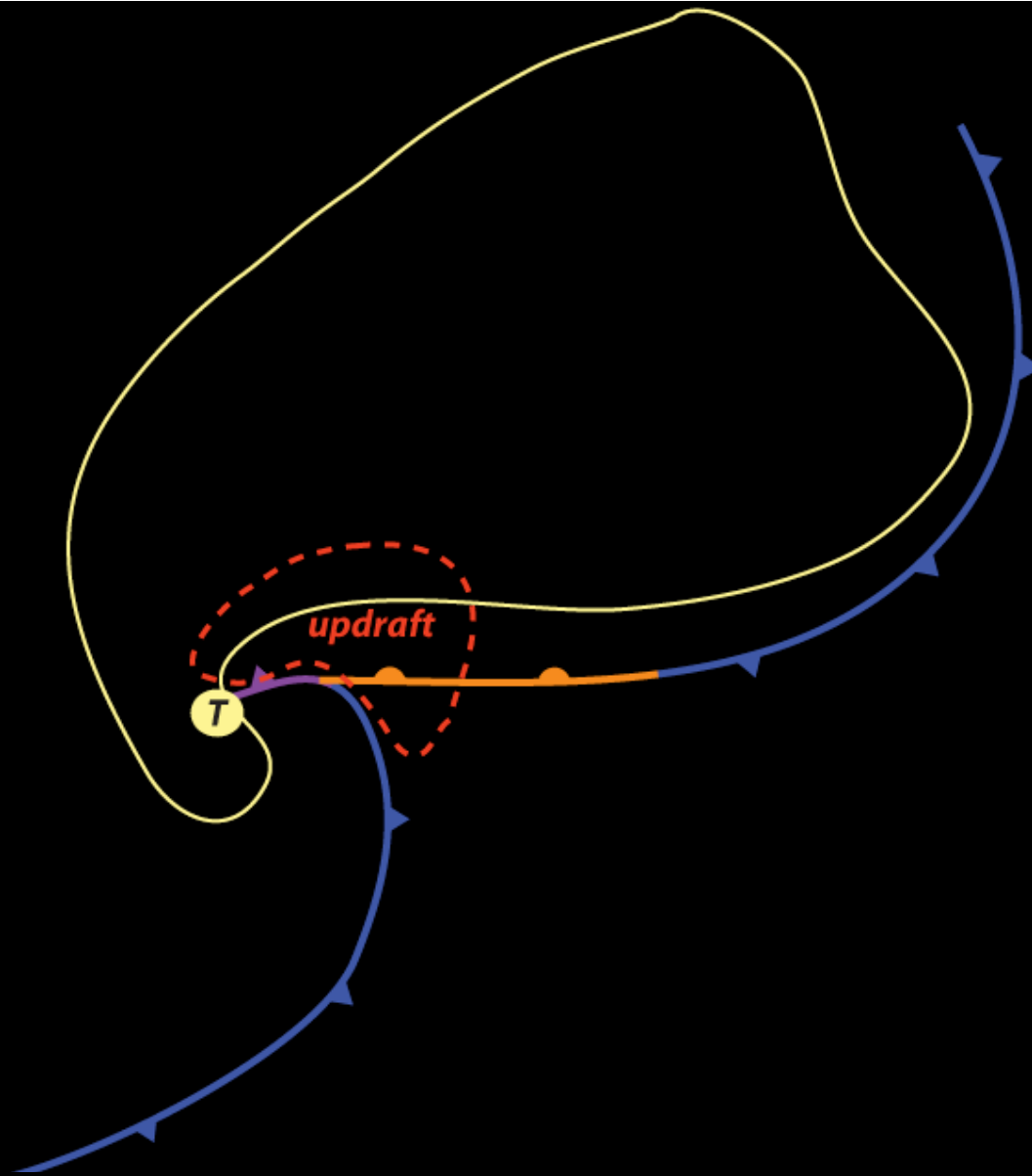
The hook is at the echo's south end. A tornado touched ground in Eagle Pass, TX, a few minutes later, killing 5 and injuring 41.



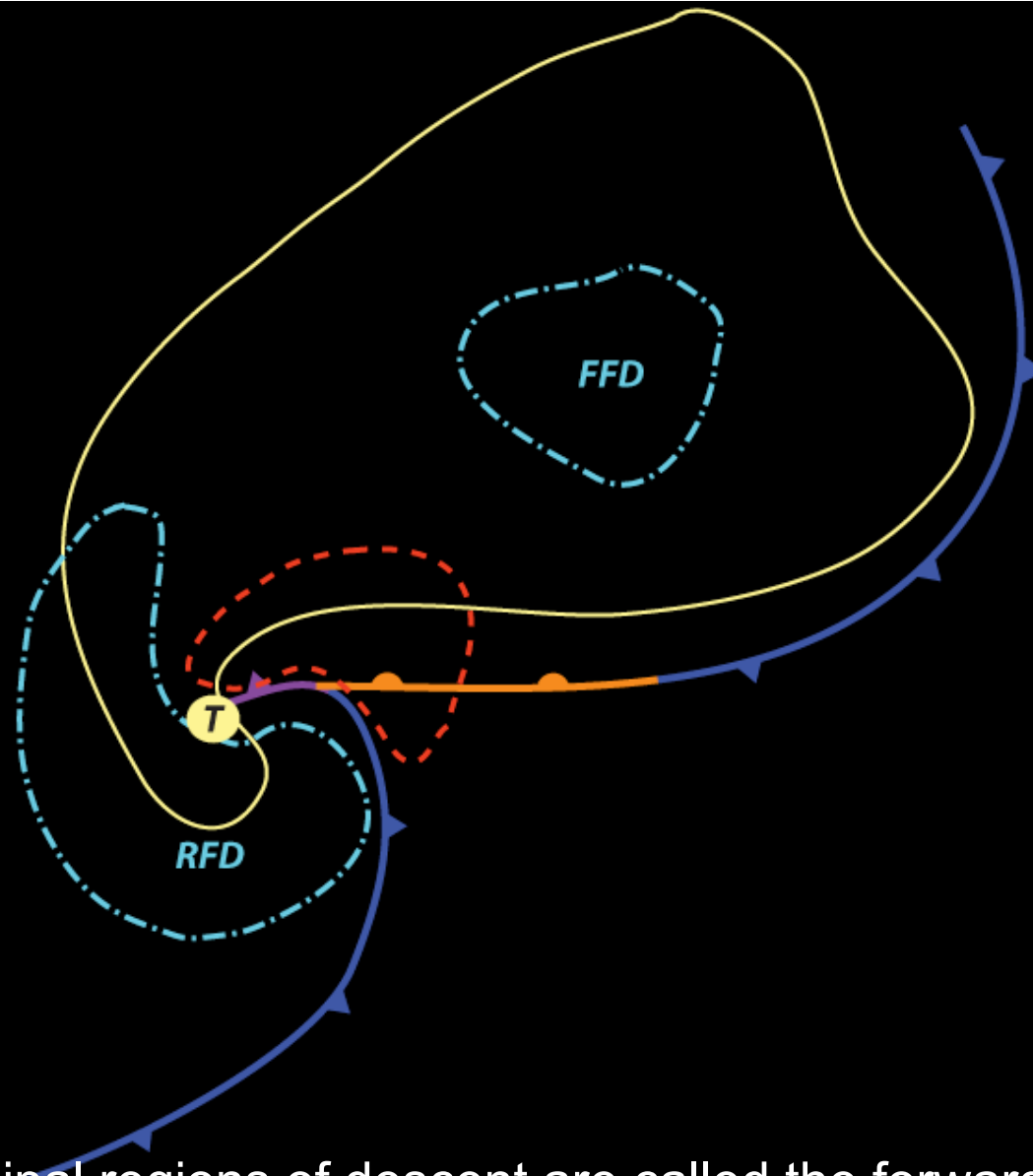
We start with the basic hook echo shape.



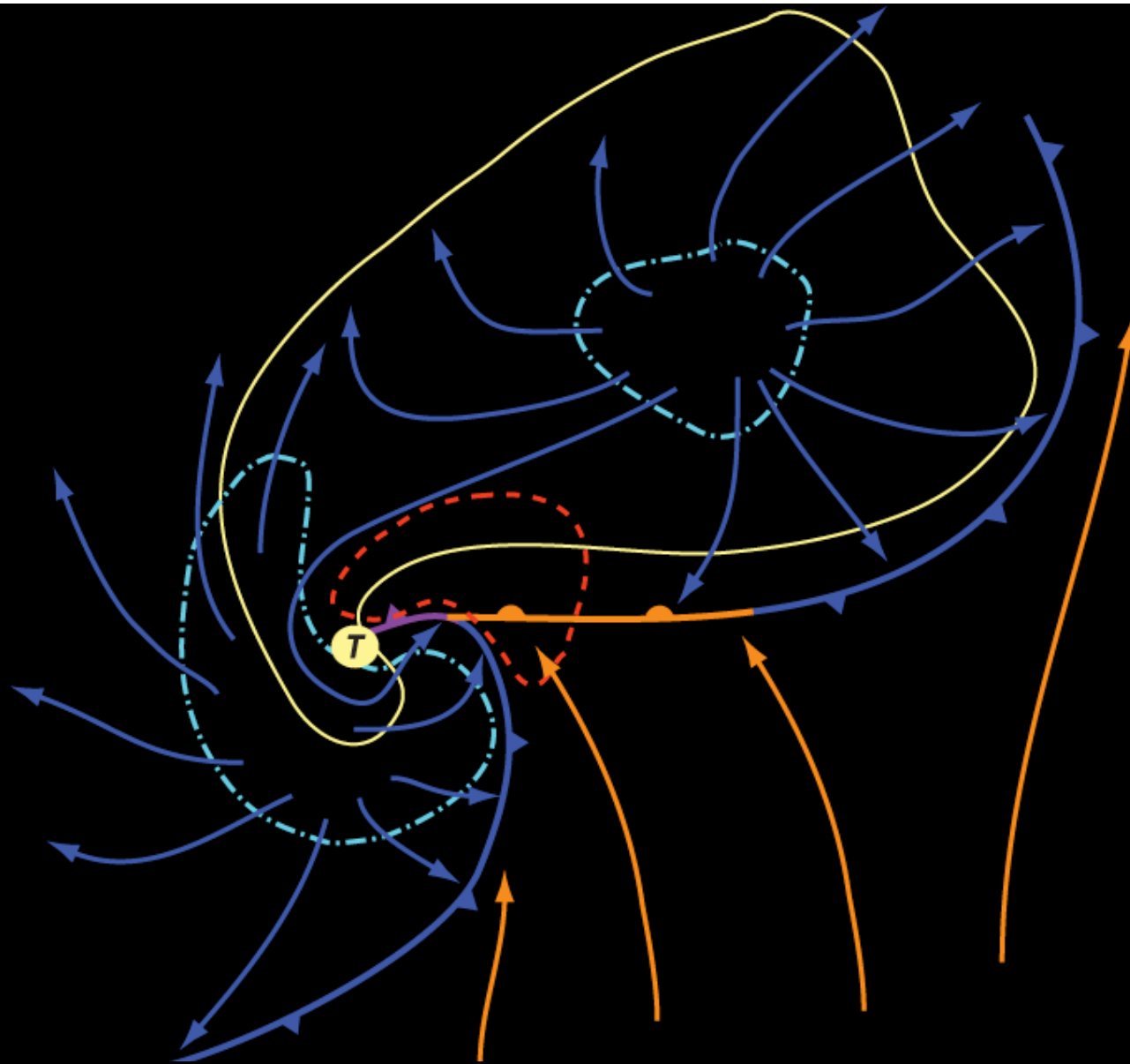
The frontal boundaries represent where evaporatively cooled air collides with the warm, moist environmental air. It's very reminiscent of an occluded extratropical cyclone, though MUCH SMALLER scale. It's called a **mesocyclone** and the tornado might be found there.



Nearby is the main storm updraft...



The two principal regions of descent are called the forward flank and rear flank downdrafts (FFD and RFD).

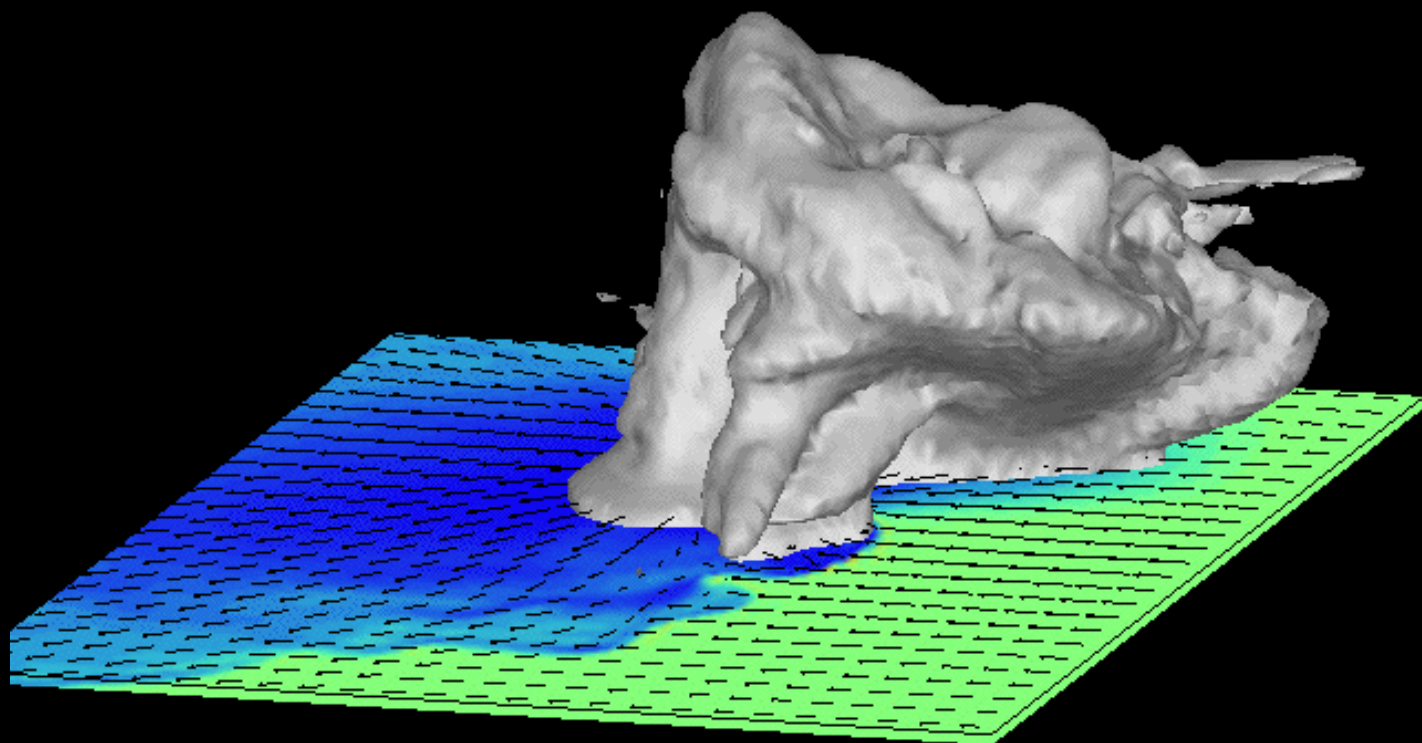


Here's the surface airflow around the storm. The updraft is being fed by unstable air from the mesocyclone's warm sector.

3D view of a supercell thunderstorm

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1 of 46
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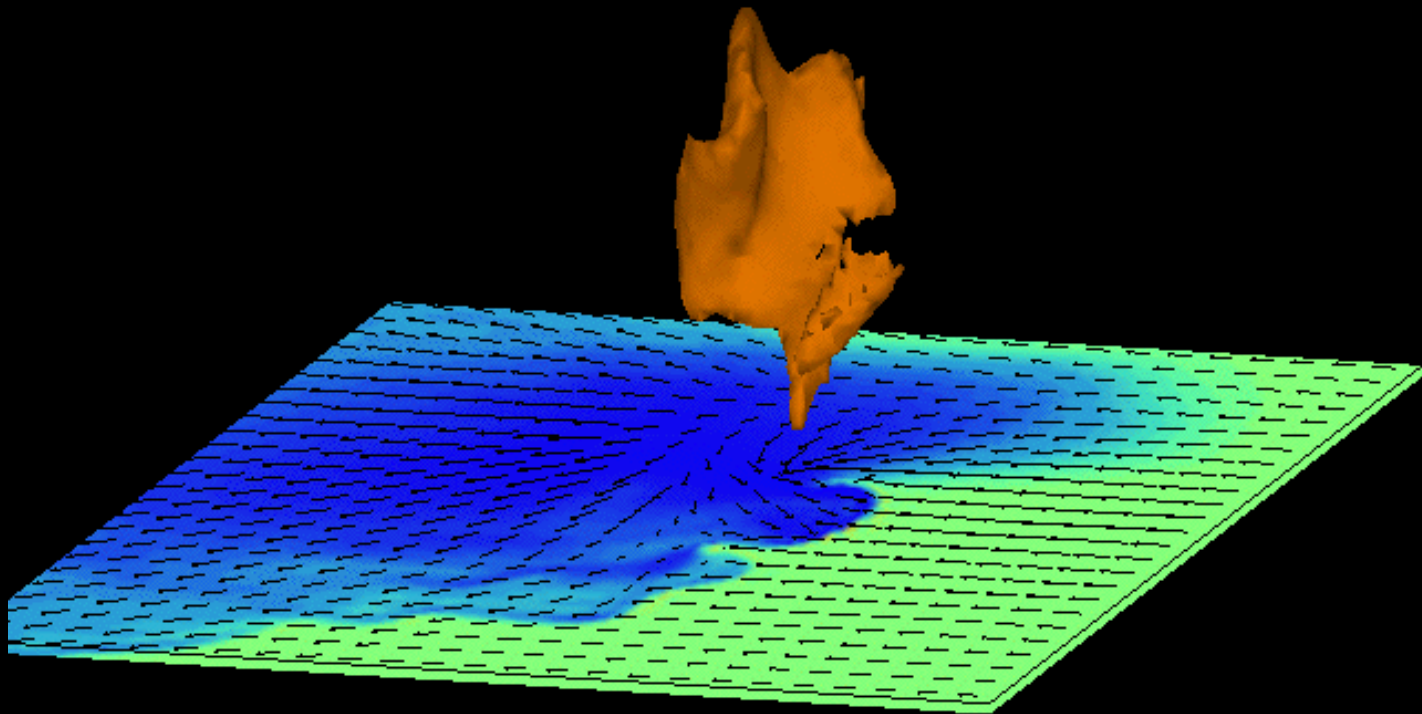
Cloud outline



Animation

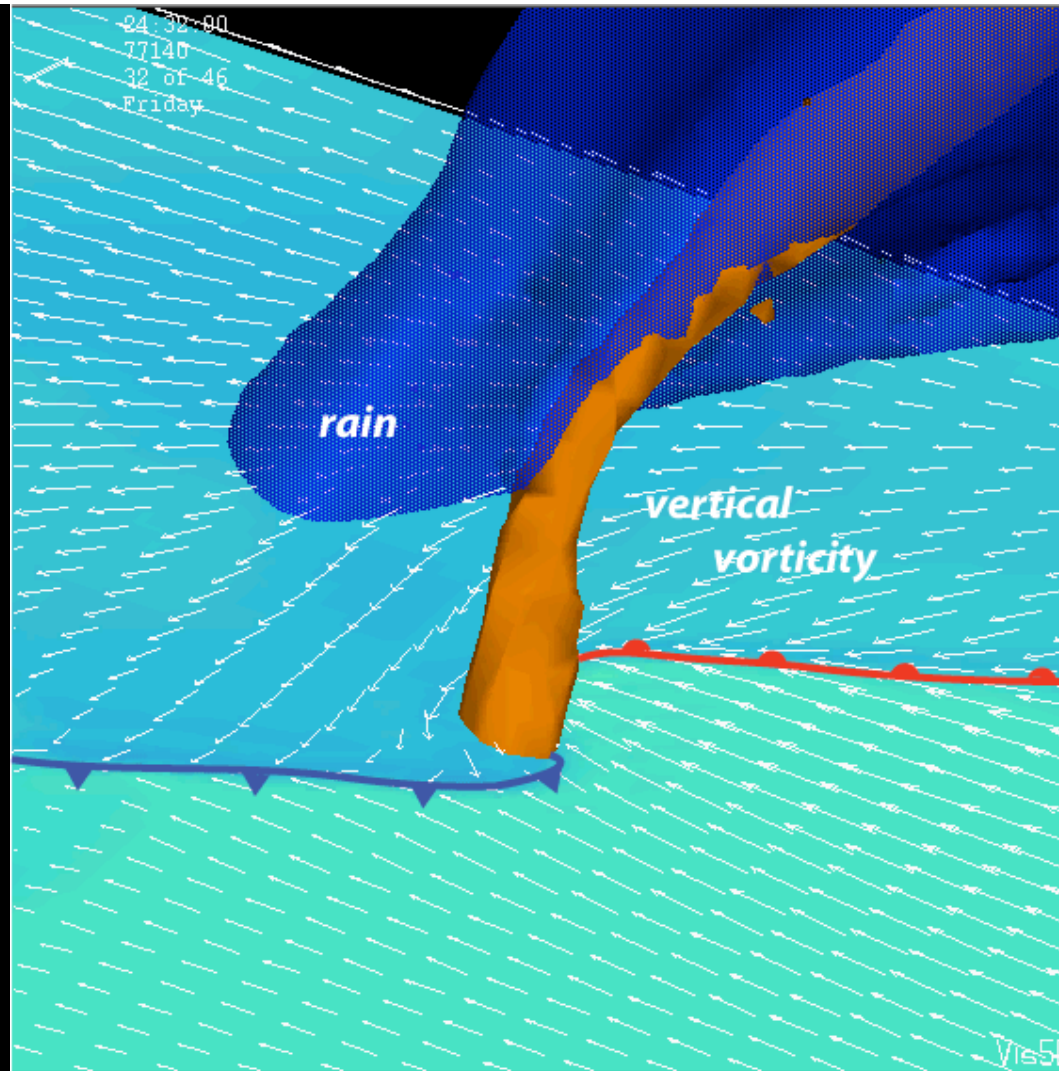
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Updraft hidden within

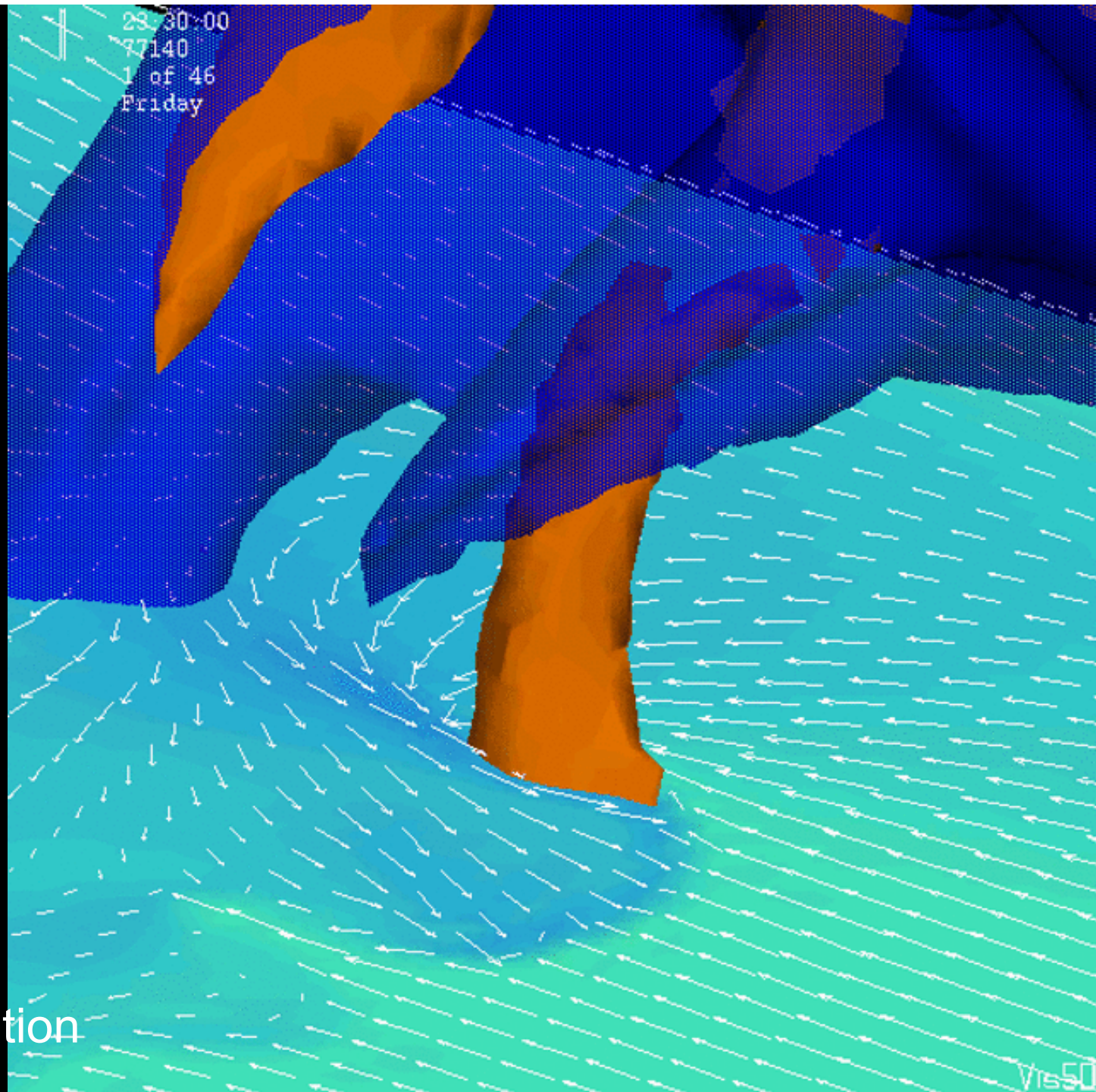


Animation

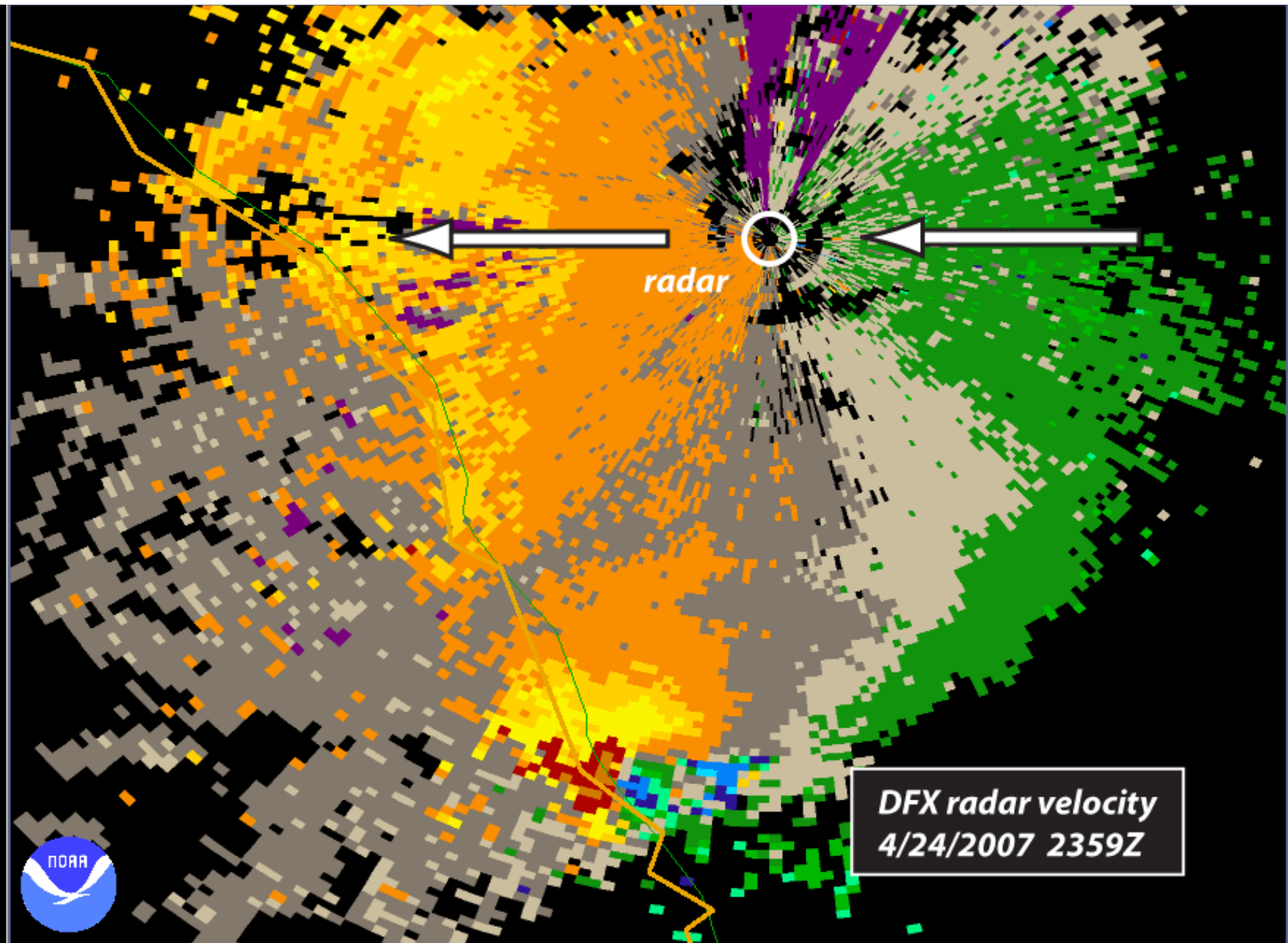
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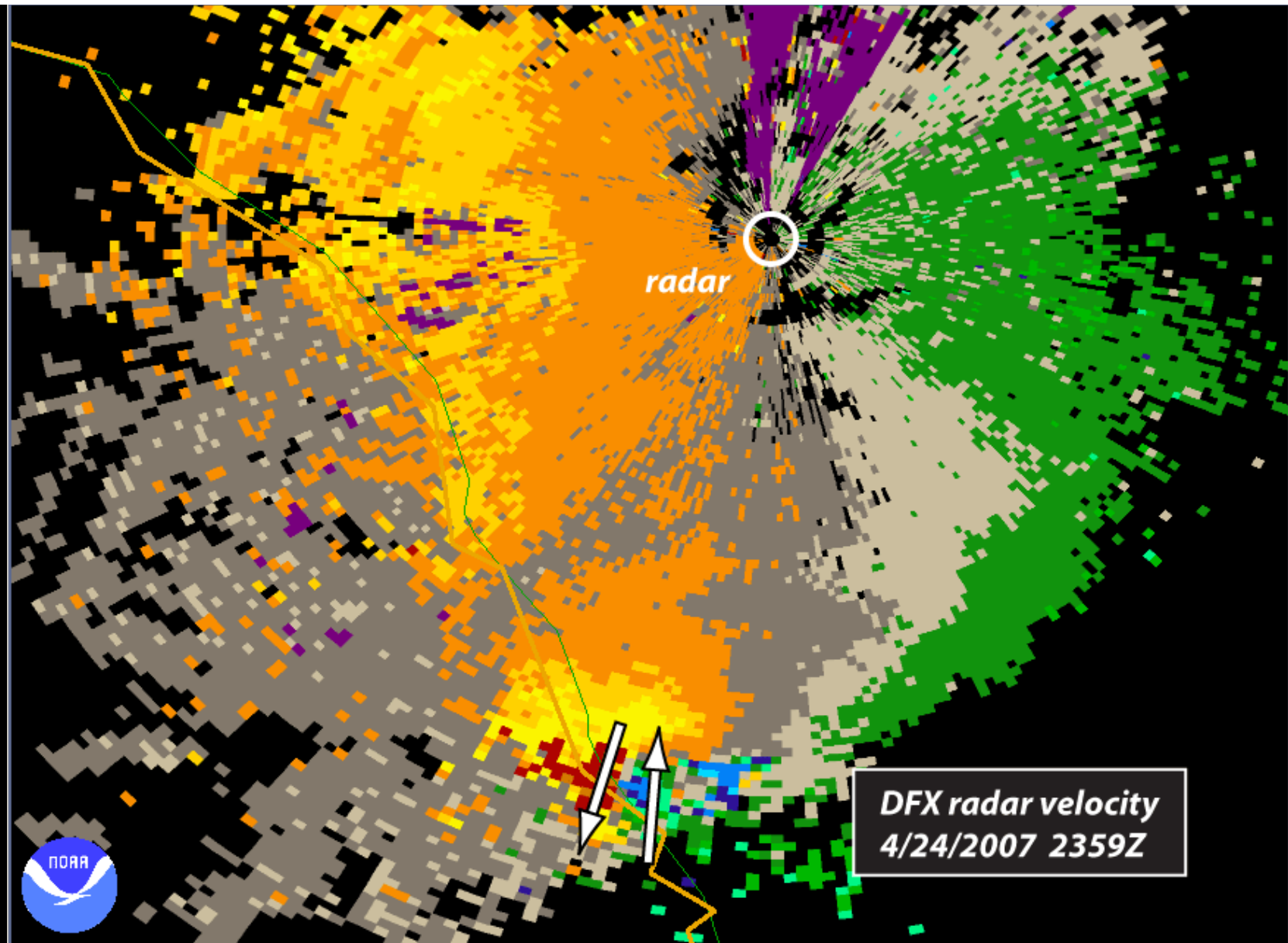
Zoom in BENEATH the cloud. The deep blue area is the rainshaft or rain curtain. The orange tube indicates is where large, concentrated rotation is. Large vertical vorticity. Large spin. Is this a tornado?



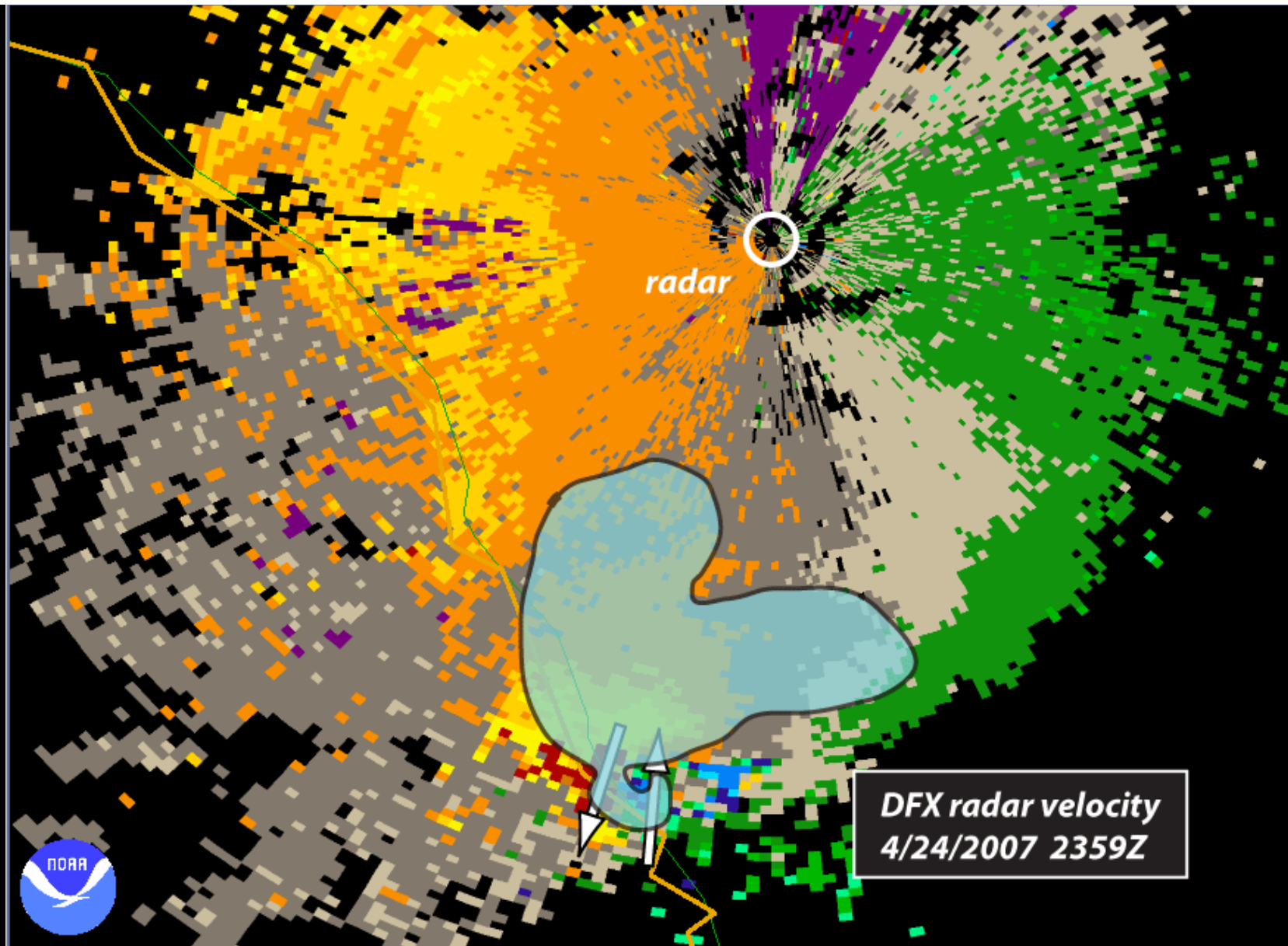
Animation



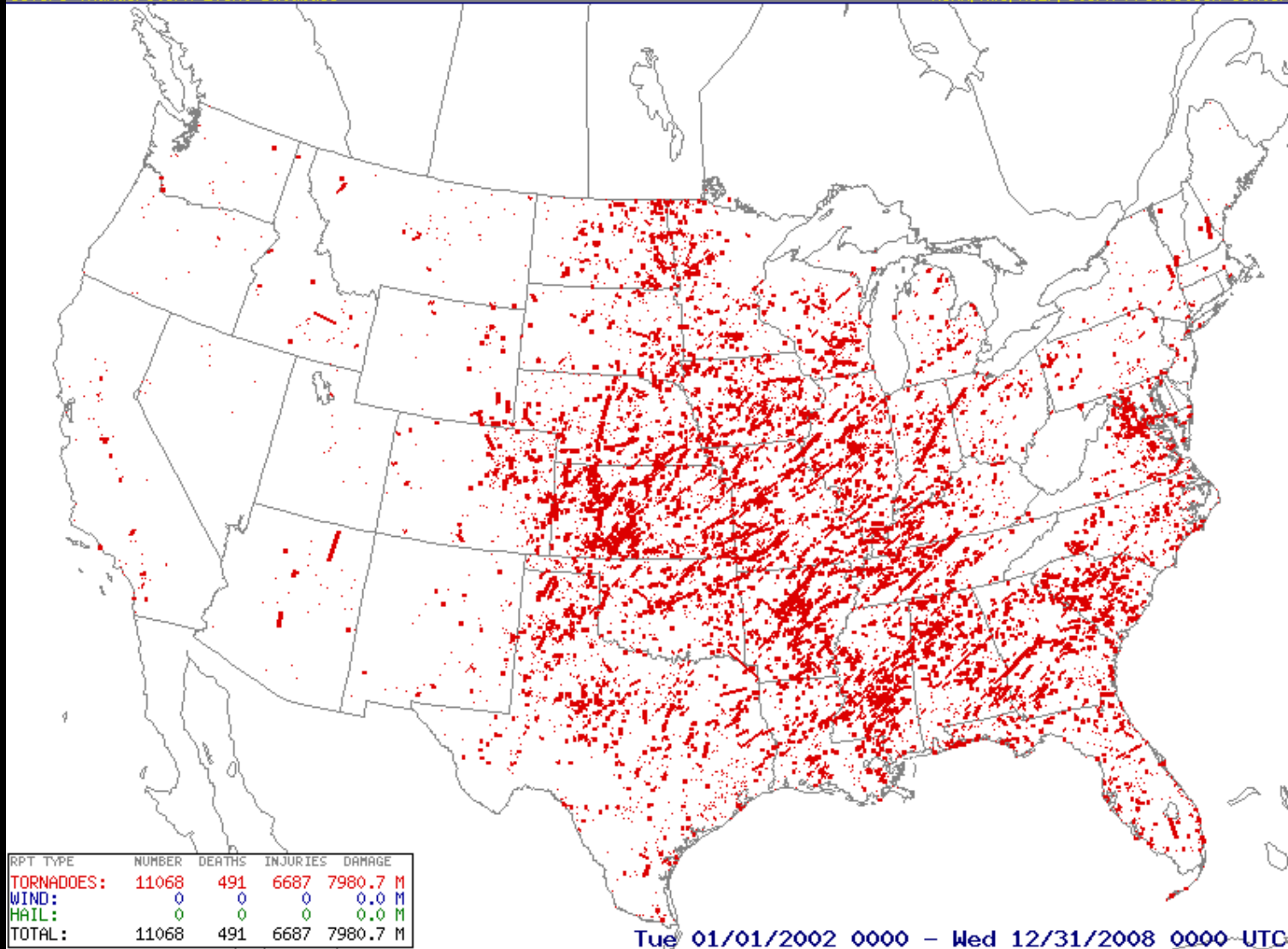
Radar image from Laughlin, TX, at the time the tornado was reported on the ground. Flow relative to the radar shown: cool towards, warm away₄₂



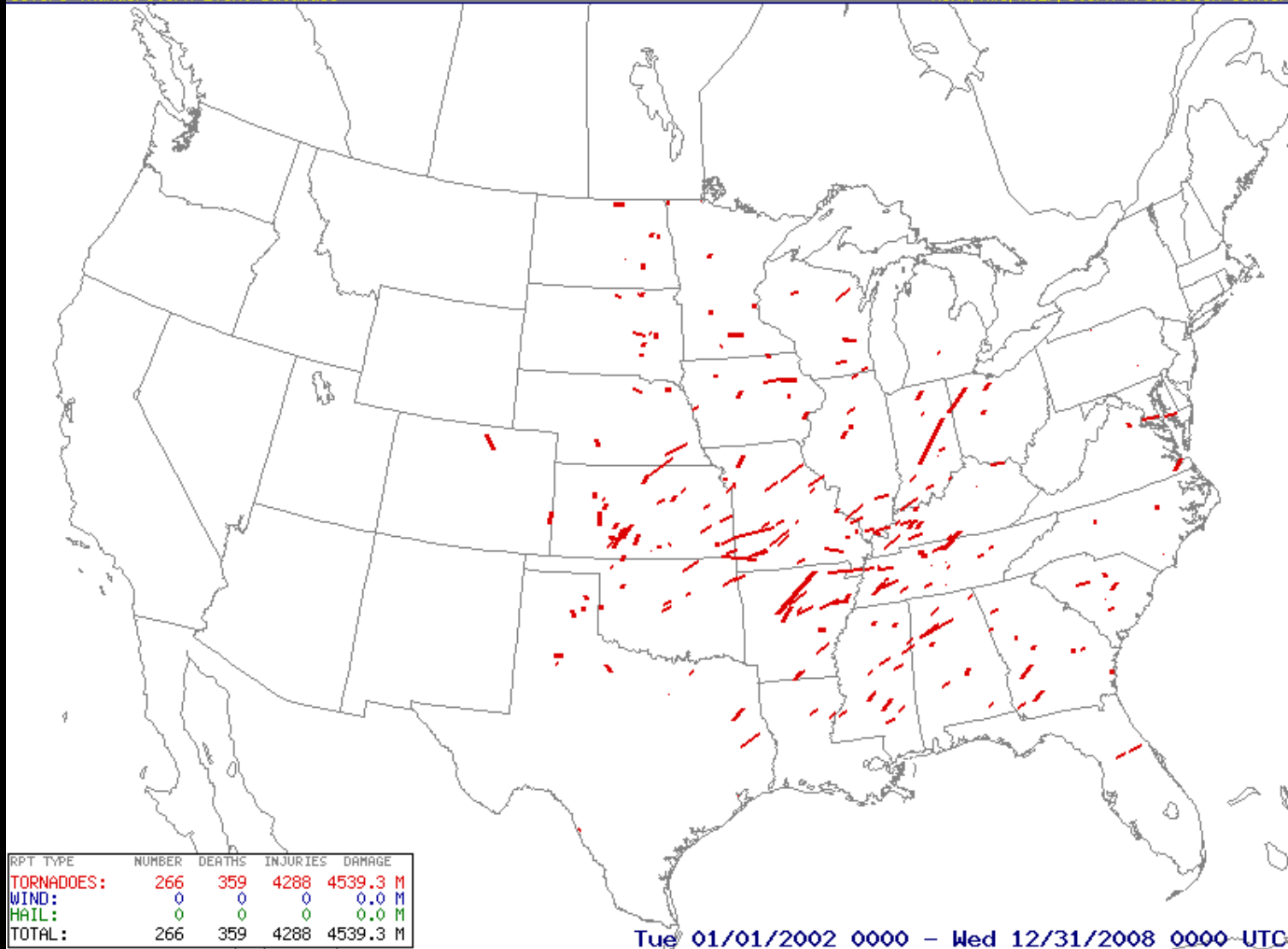
The tornado is indicated by the cool and warm colors in close proximity. This is the only part we can see, as the rest is parallel to the radar line of sight.



Sketched on the hook echo from reflectivity display. We're seeing the intense circulation of mesocyclone, if not the tornado ITSELF.



Map of all tornado reports for a 7 year period ending 2008. Over 11000 reports are mapped. These cases resulted in 491 deaths and over 6500 injuries.

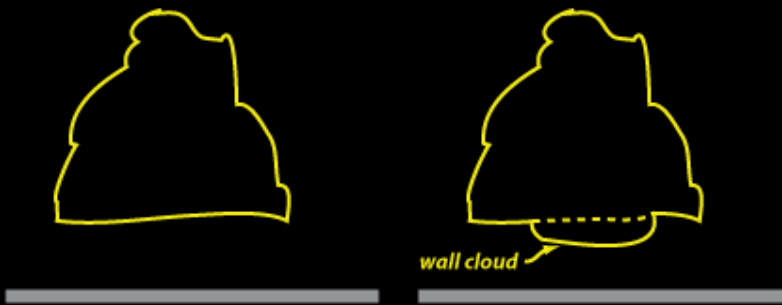


Tornado frequency for same period, limited to Fujita scale F3-4-5.
Less than 3% of total for this period, but accounted for almost
three-quarters of fatalities.

WALL CLOUD

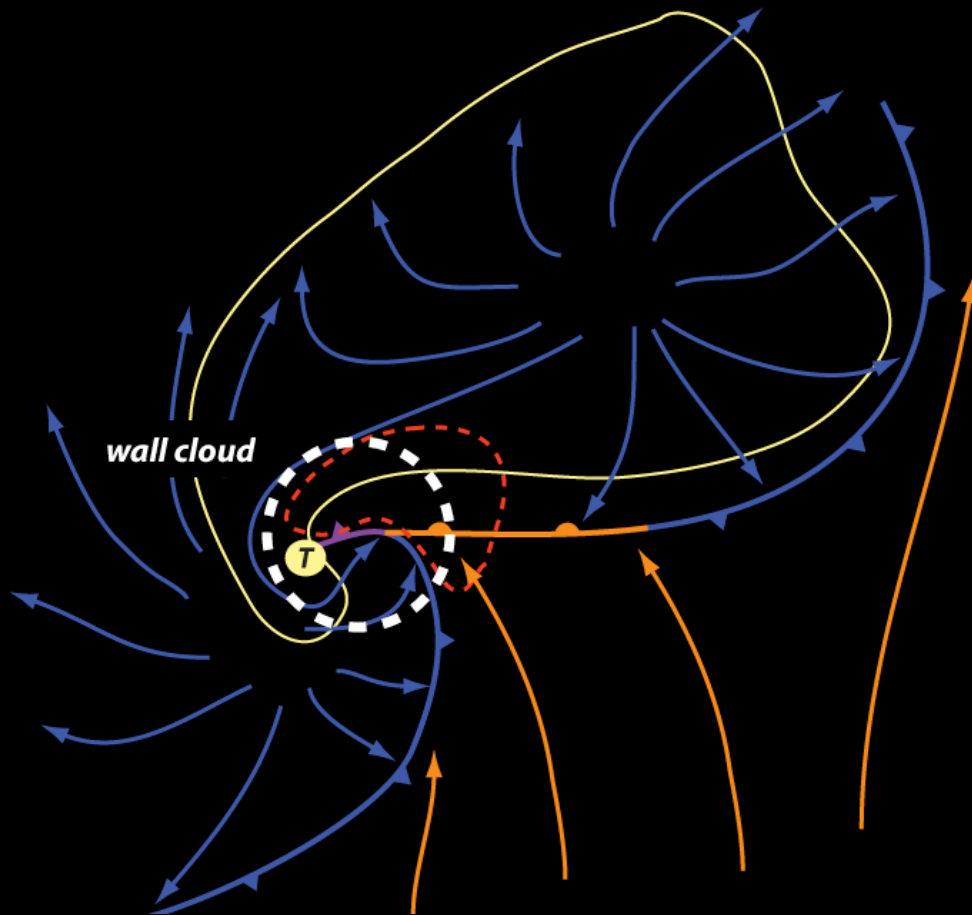


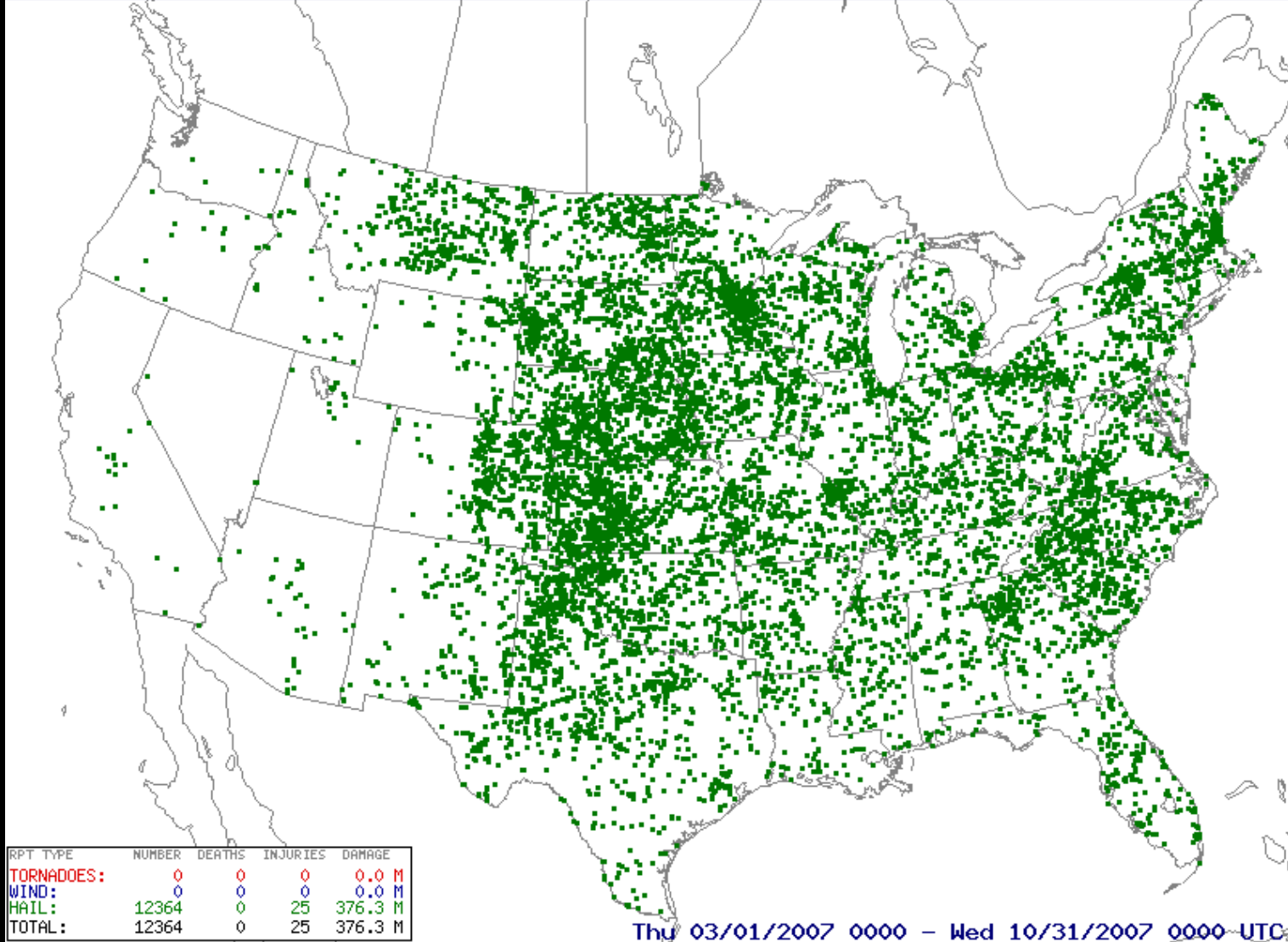
Photo by Prof. Kristen Corbosiero



The WALL CLOUD is a distinctive feature of the supercell and a possible tornadic precursor.

It's a place where the supercell's cloud base is ominously lowered.





Another severe weather hazard is hail. There are over 12000 reports of hail exceeding penny size on this map, but representing only 8 months of 2007.

[end]