The Rapid Intensification of Hurricane Irene (1999)

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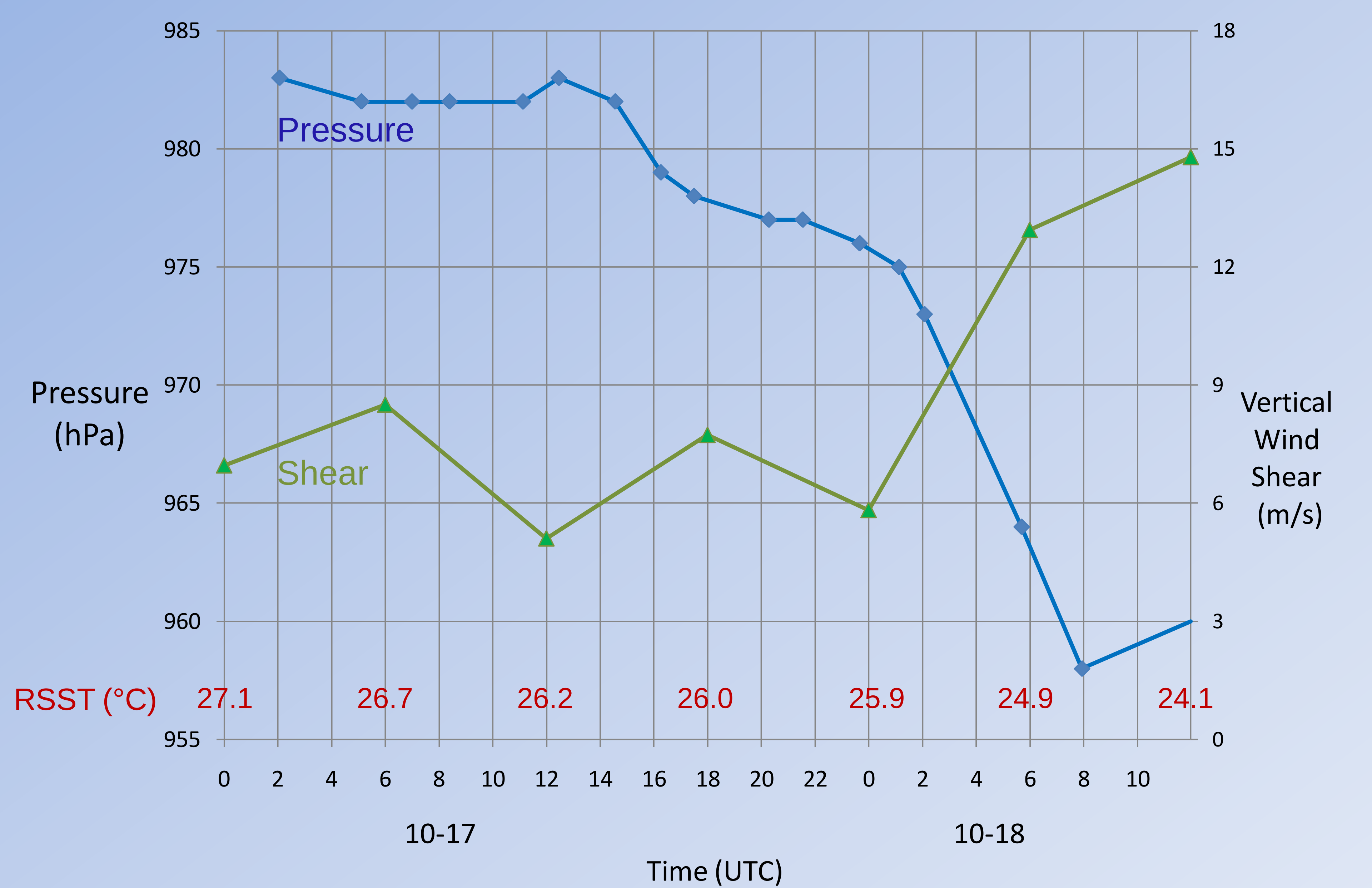
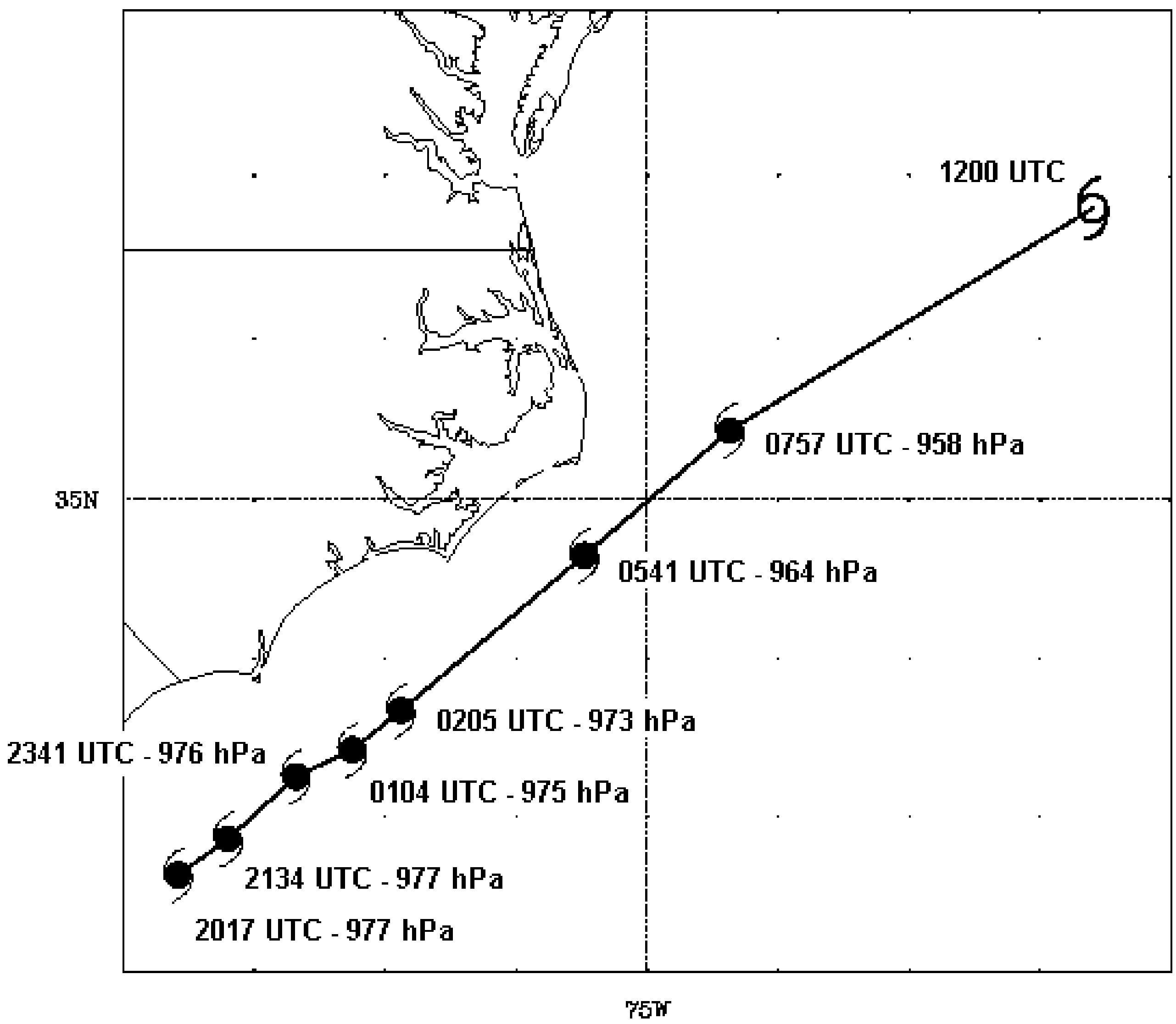


Pressure
Shear
Pressure (hPa)
Vertical Wind Shear (m/s)
RSST (°C)
27.1
26.7
26.2
26.0
25.9
24.9
24.1
985
980
975
970
965
960
955
18
15
12
9
6
3
0
0
2
4
6
8
10
12
14
16
18
20
22
0
2
4
6
8
10
10-17
10-18
Time (UTC)

Hurricane Irene track: 10/17 – 10/18 1999



Overview

- Look at evolution of Irene during rapid intensification period using aircraft reconnaissance, base reflectivity and radial velocity from WSR-88D radars, lightning.

I. Evolution of structure over time.

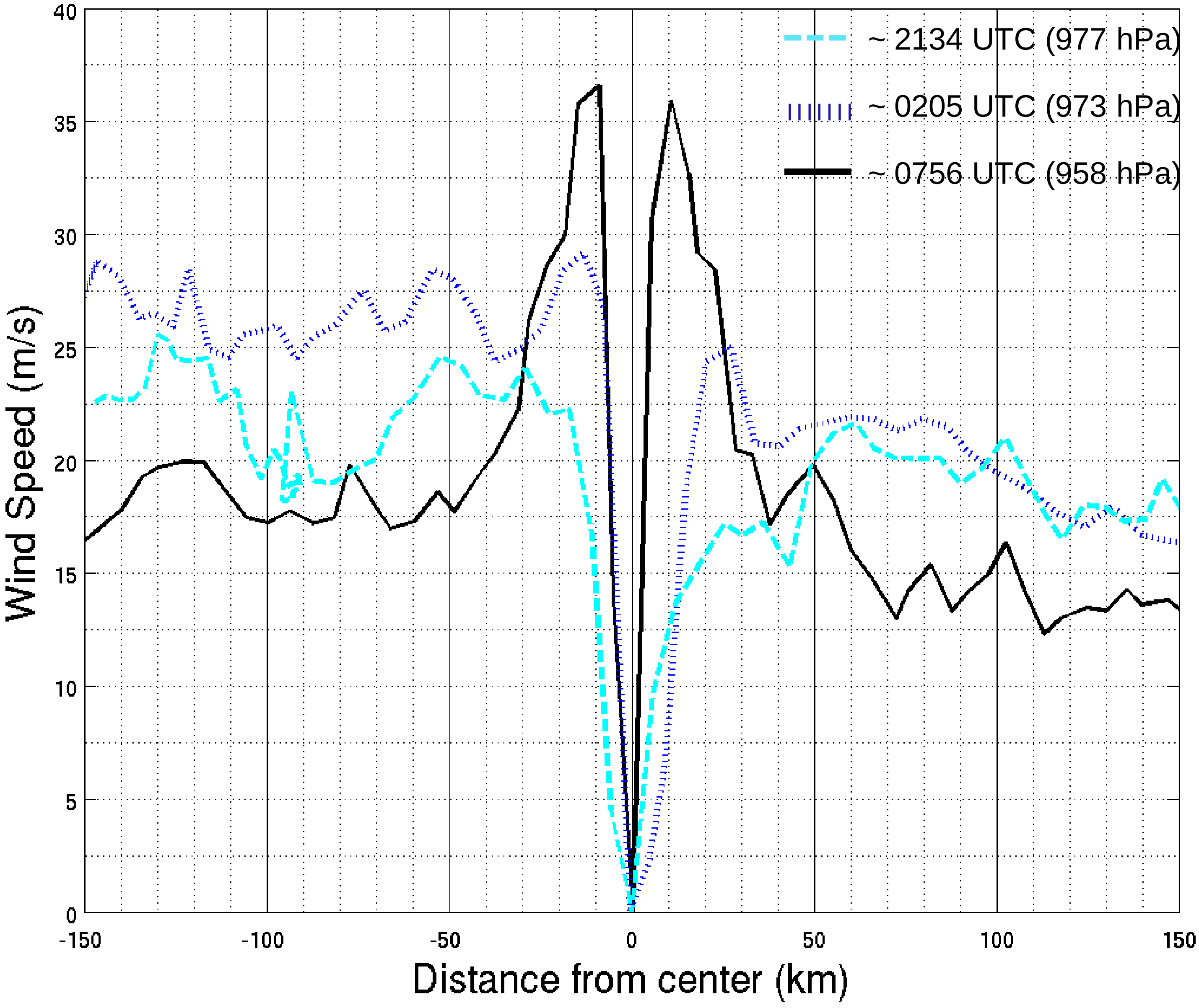
II. Evidence of vortex tilt due to increasing shear.

III. Convective asymmetry in the eyewall/inner band regions.

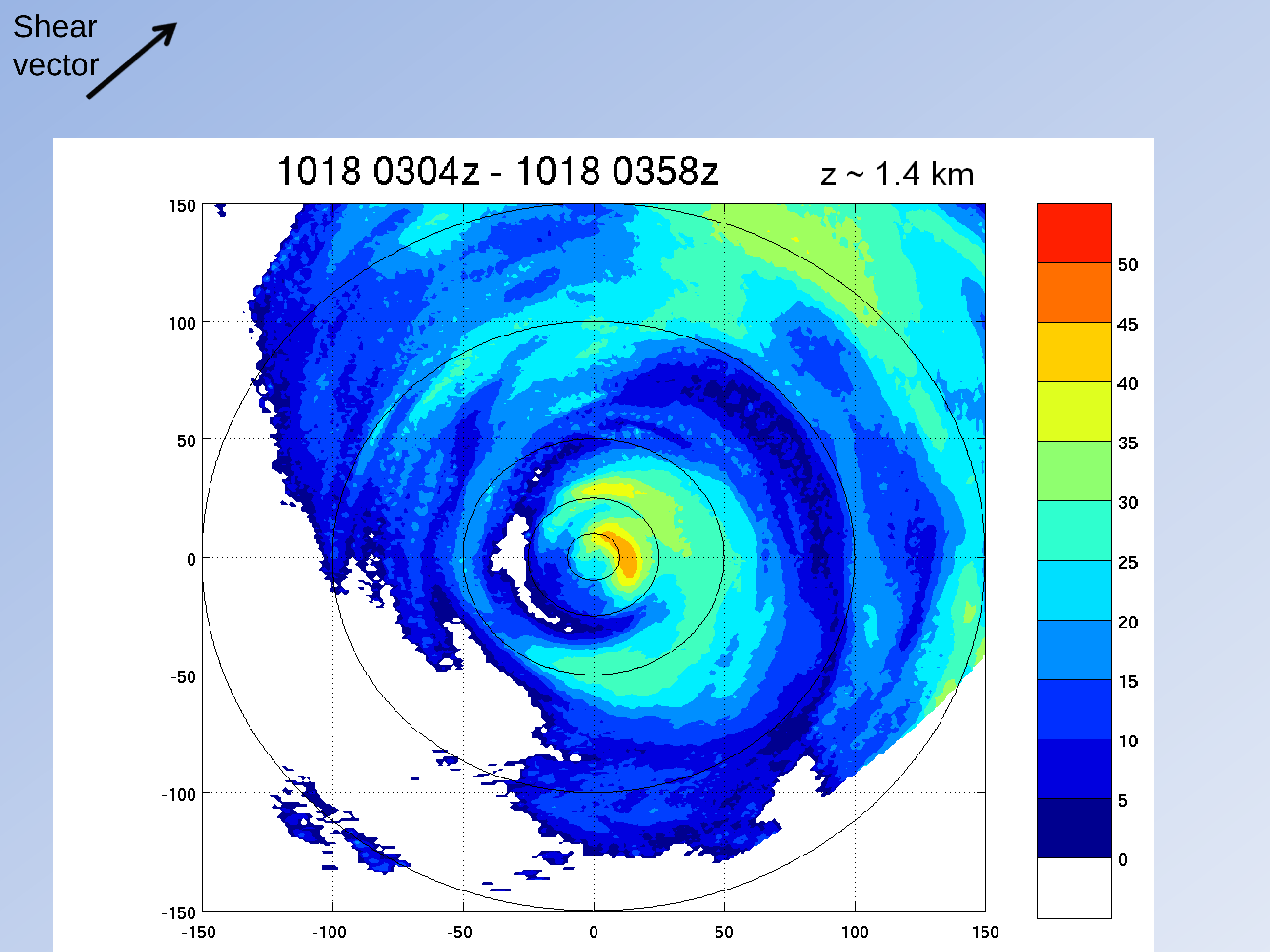
IV. Extremely tall eyewall towers.

V. Summary

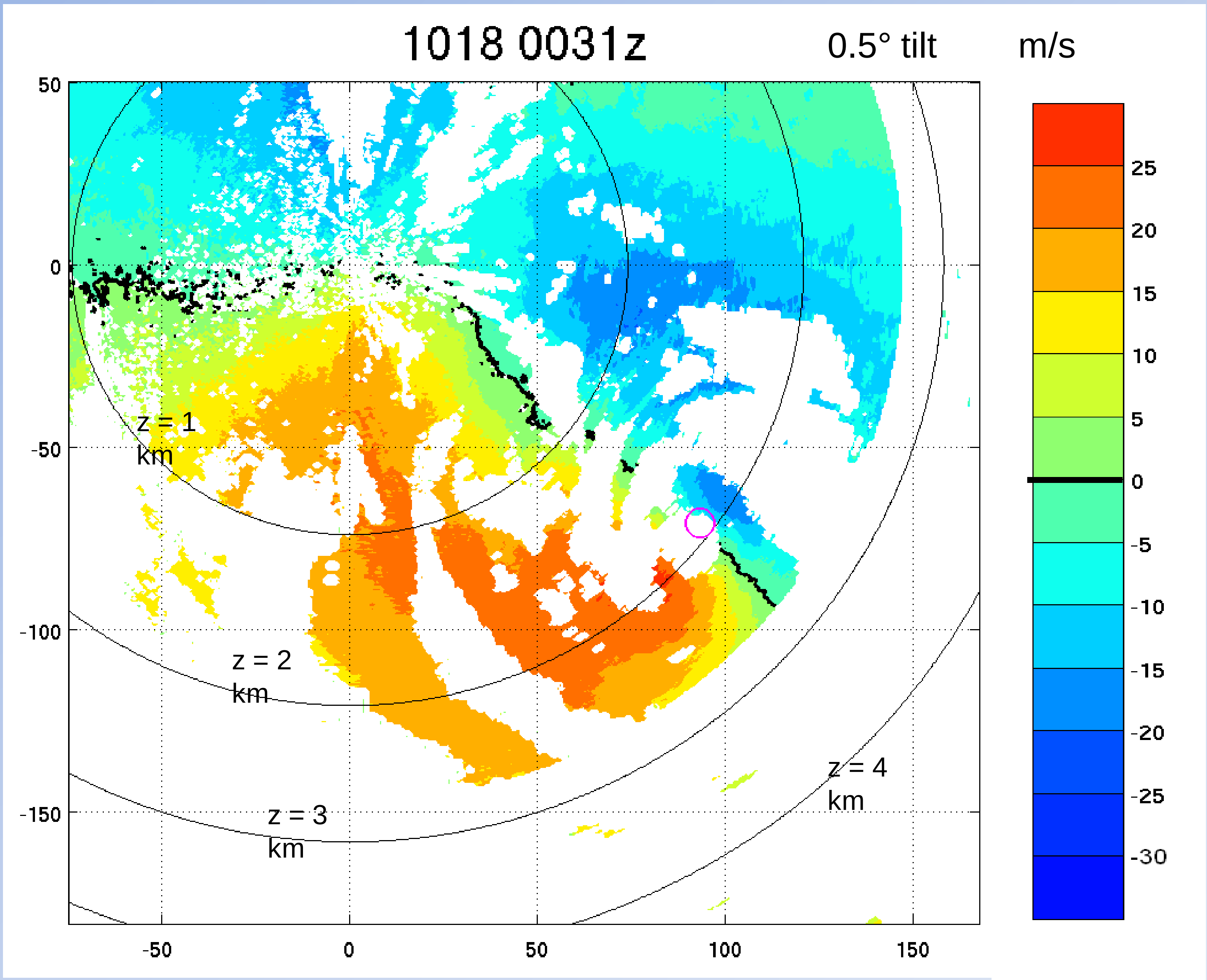
Storm-relative tangential wind



- Max FL (850 hPa) winds increased from about 65-70 kt (00-01 UTC) to 114 kt (08 UTC).
- 129 kt wind at 902 hPa from dropsonde (inside 10 km).



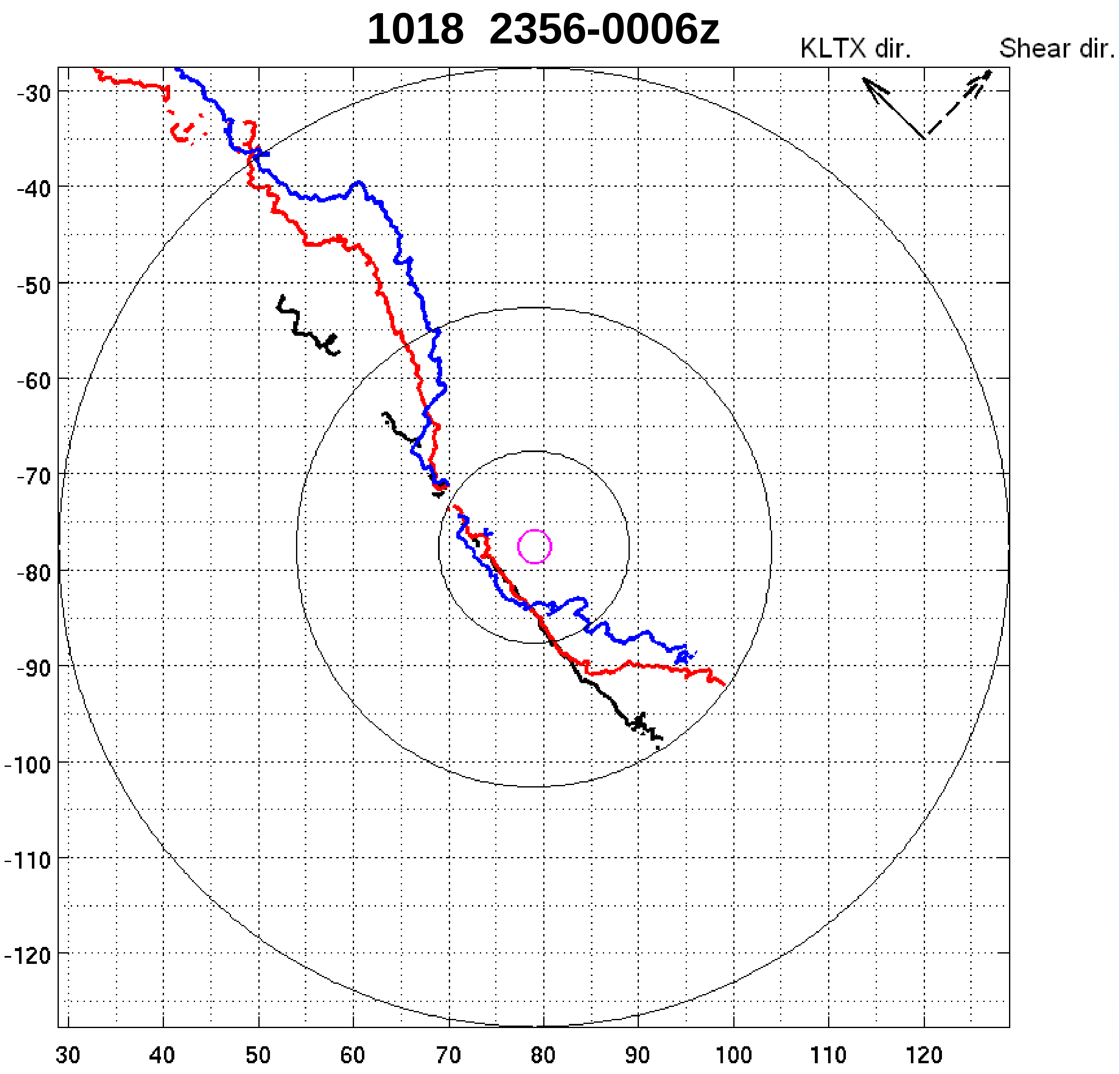
Shear vector
1018 0304z - 1018 0358z
z ~ 1.4 km
150
100
50
0
-50
-100
-150
-150
-100
-50
0
50
100
150
50
45
40
35
30
25
20
15
10
5
0



Outbound from radar

Zero isodop

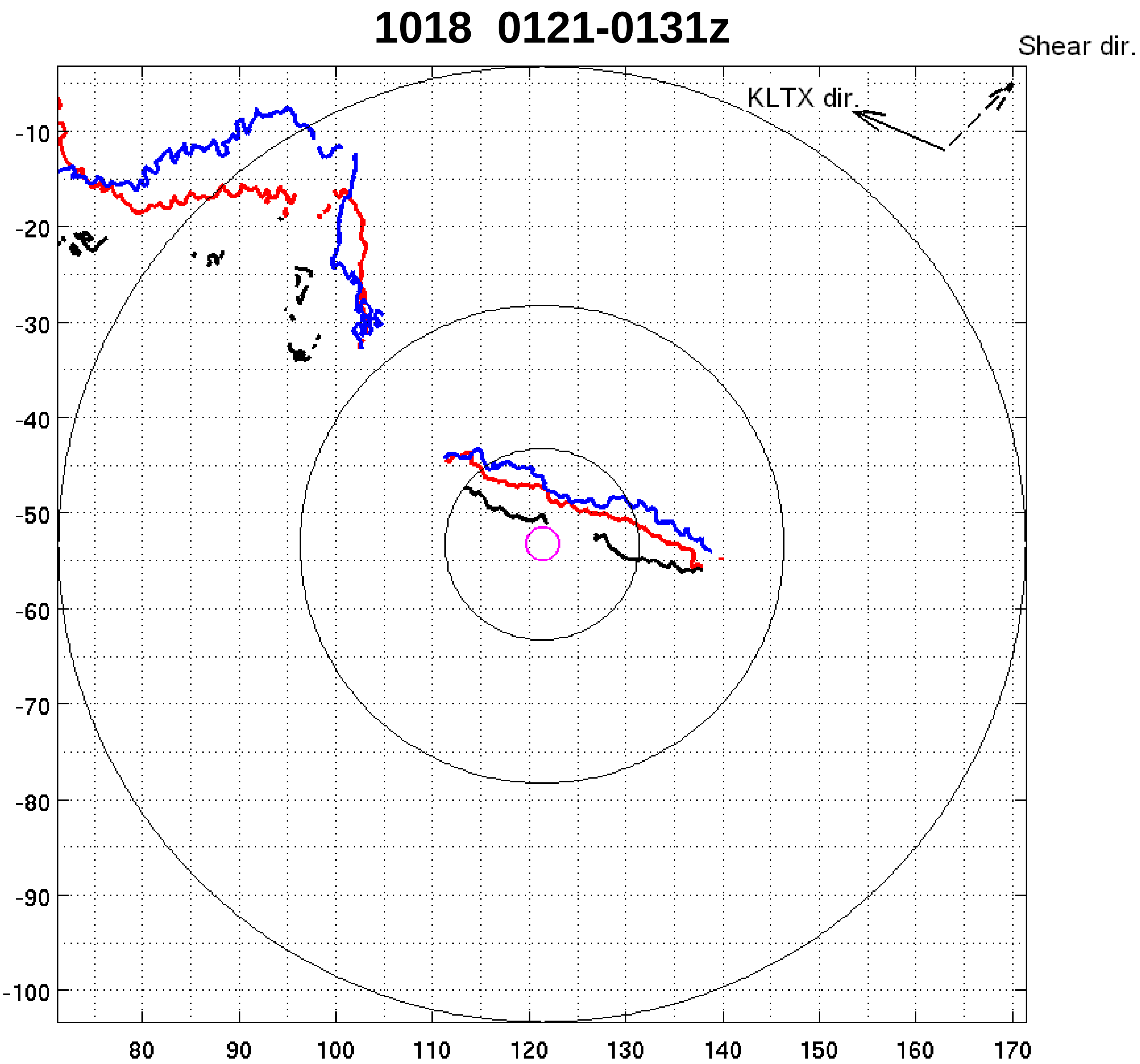
Inbound towards radar



Zero isodop at:

- Black = 0.5 deg. tilt
- Red = 1.5 deg. tilt
- Blue = 2.5 deg. tilt

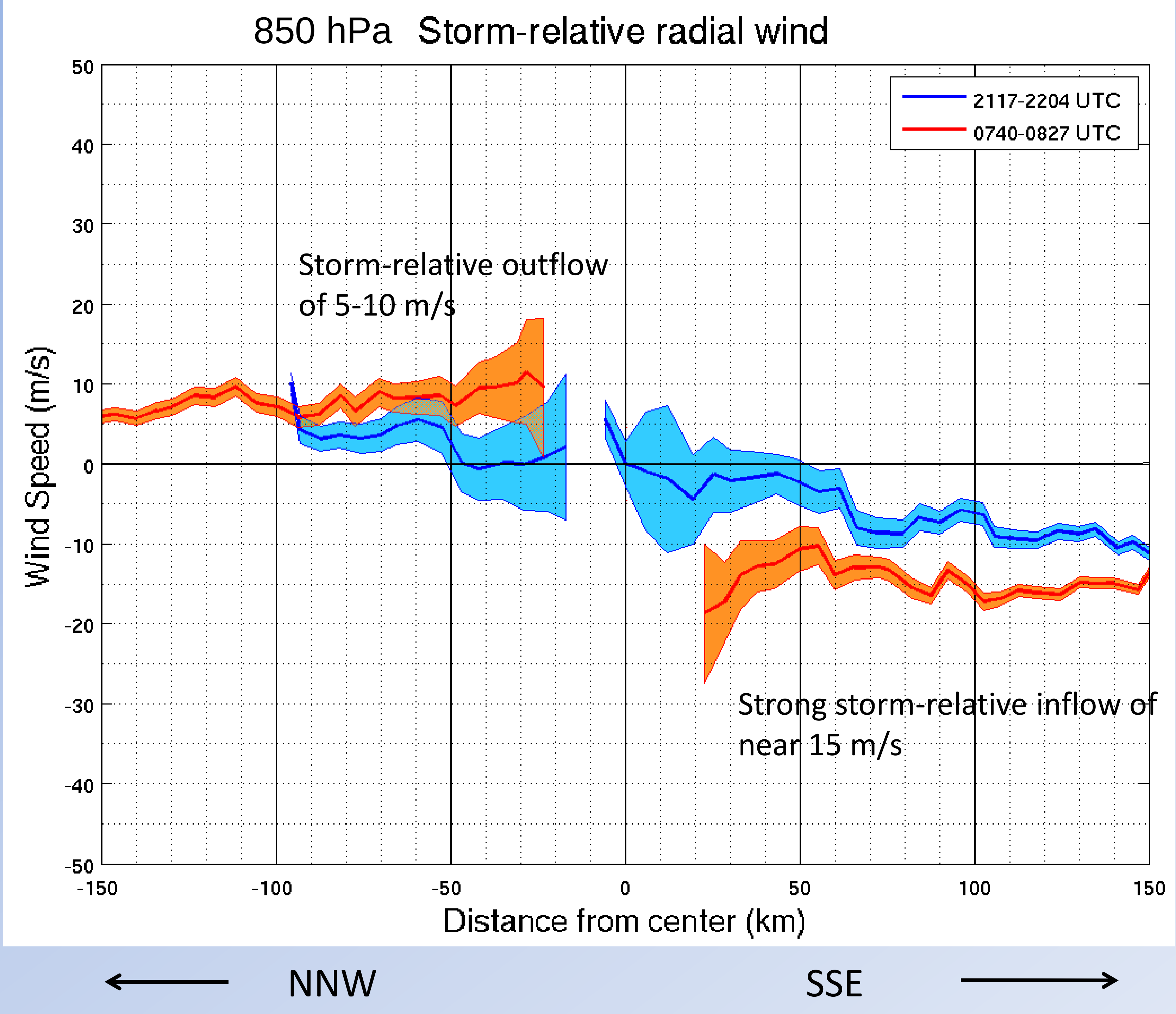
- Vortex tilts downshear w/height at outer radii (~ 15 km horiz. / 3 km vertical)
- But very little tilt at inner radii.



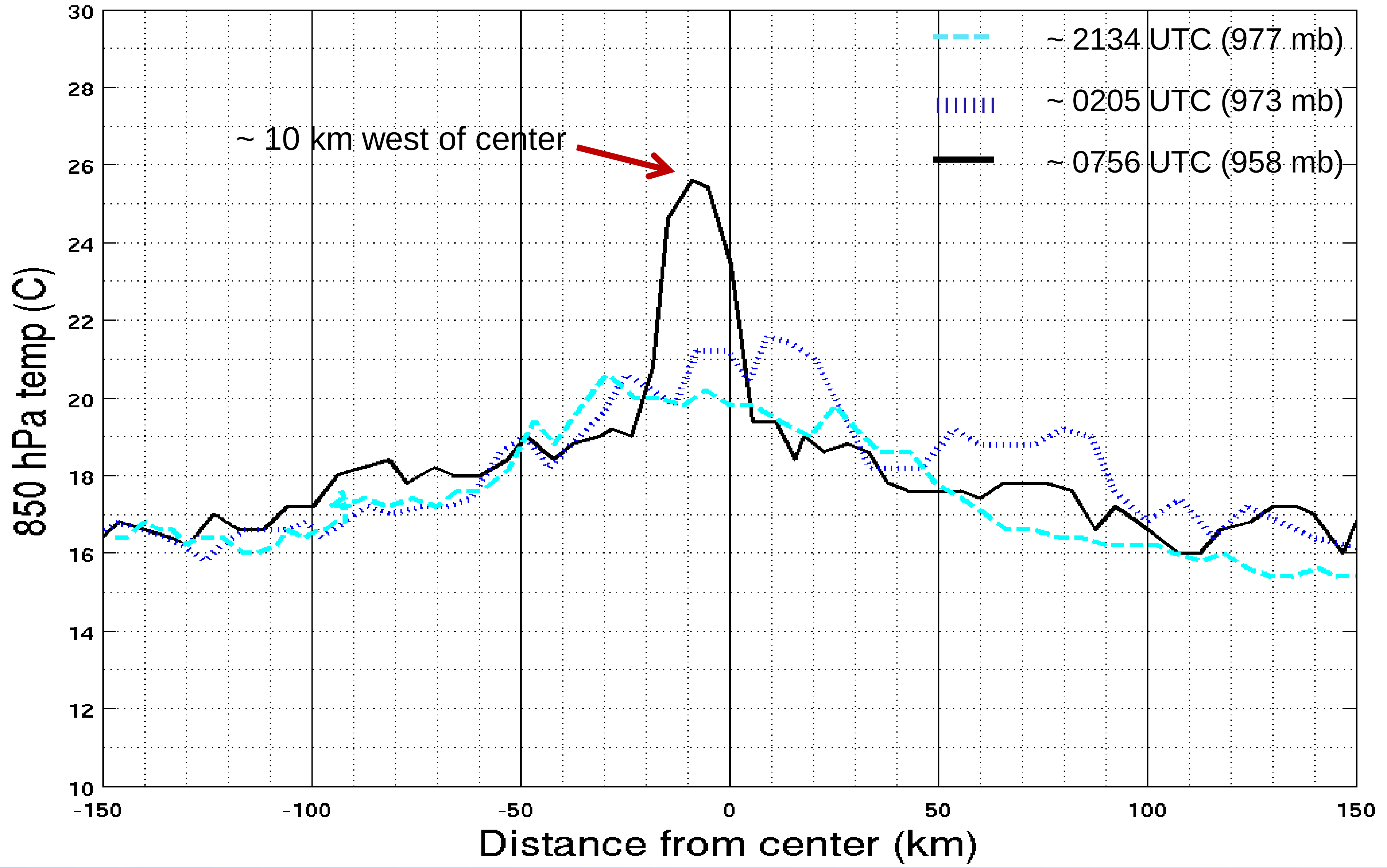
Zero isodop at:

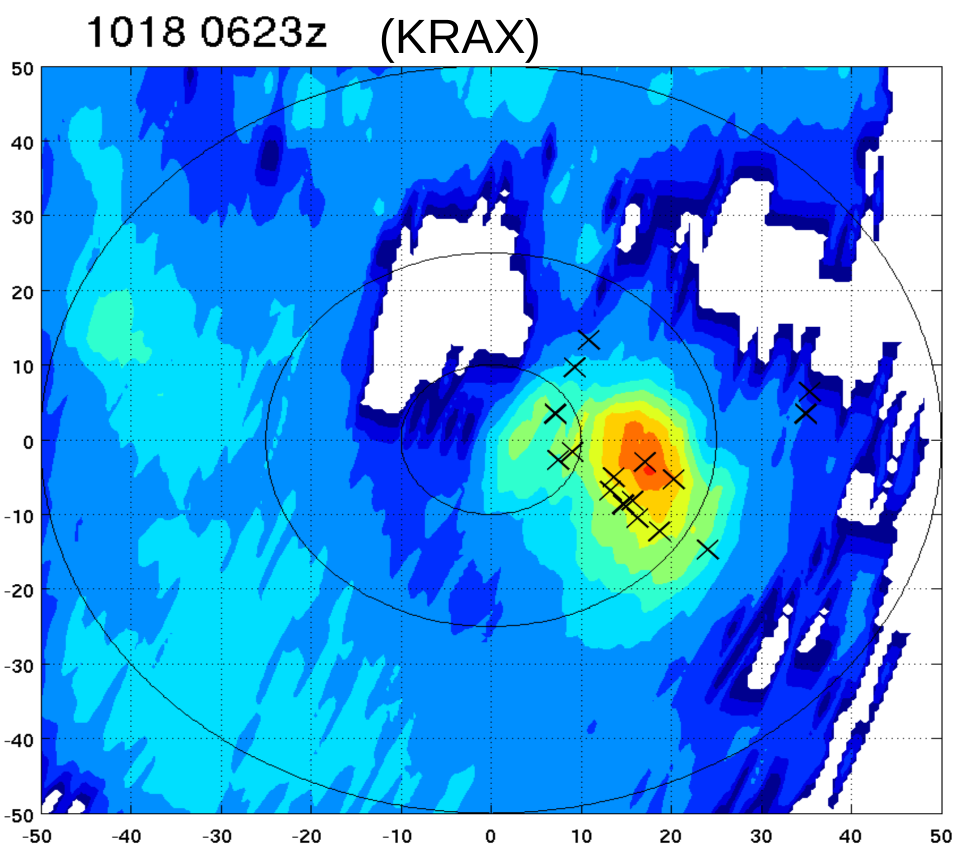
- Black = 0.5 deg. tilt
- Red = 1.5 deg. tilt
- Blue = 2.5 deg. tilt

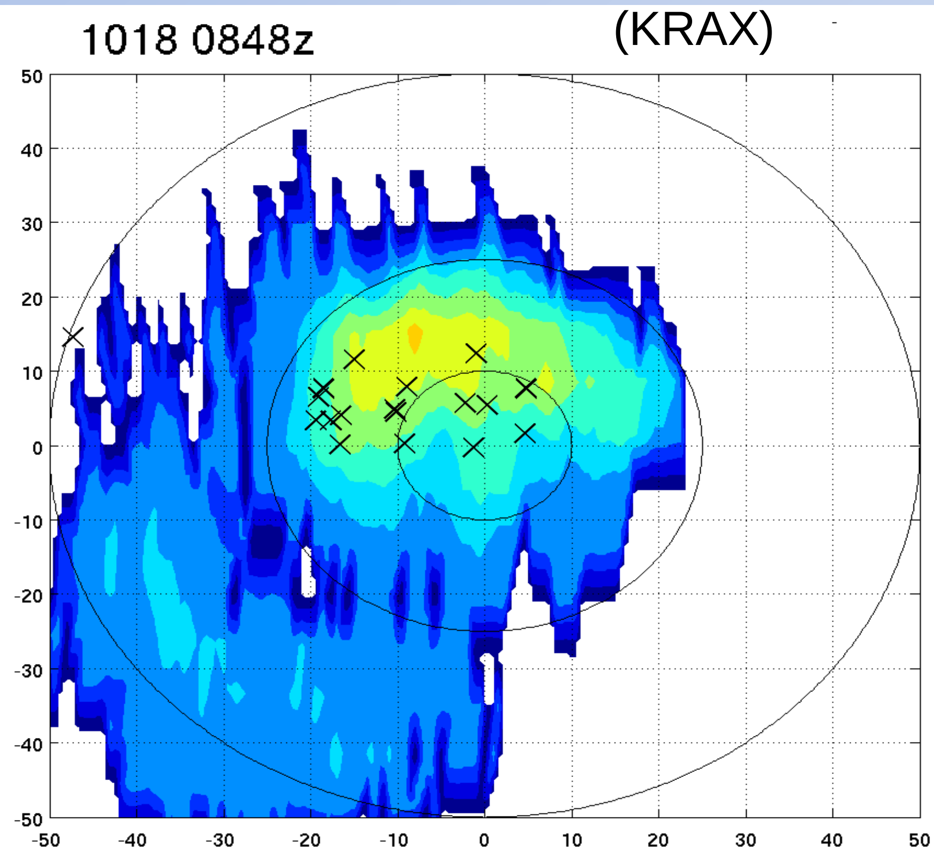
- Vortex now exhibits increased tilt at inner radii.
(~ 6 km horiz / 4.5 km vertical)


850 hPa Storm-relative radial wind
2117-2204 UTC
0740-0827 UTC
Storm-relative outflow
of 5-10 m/s
Strong storm-relative inflow of
near 15 m/s
Wind Speed (m/s)
50
40
30
20
10
0
-10
-20
-30
-40
-50
-150
-100
-50
0
50
100
150
Distance from center (km)
NNW
SSE

850 hPa temperature







52 dBz at z = 10.1 km

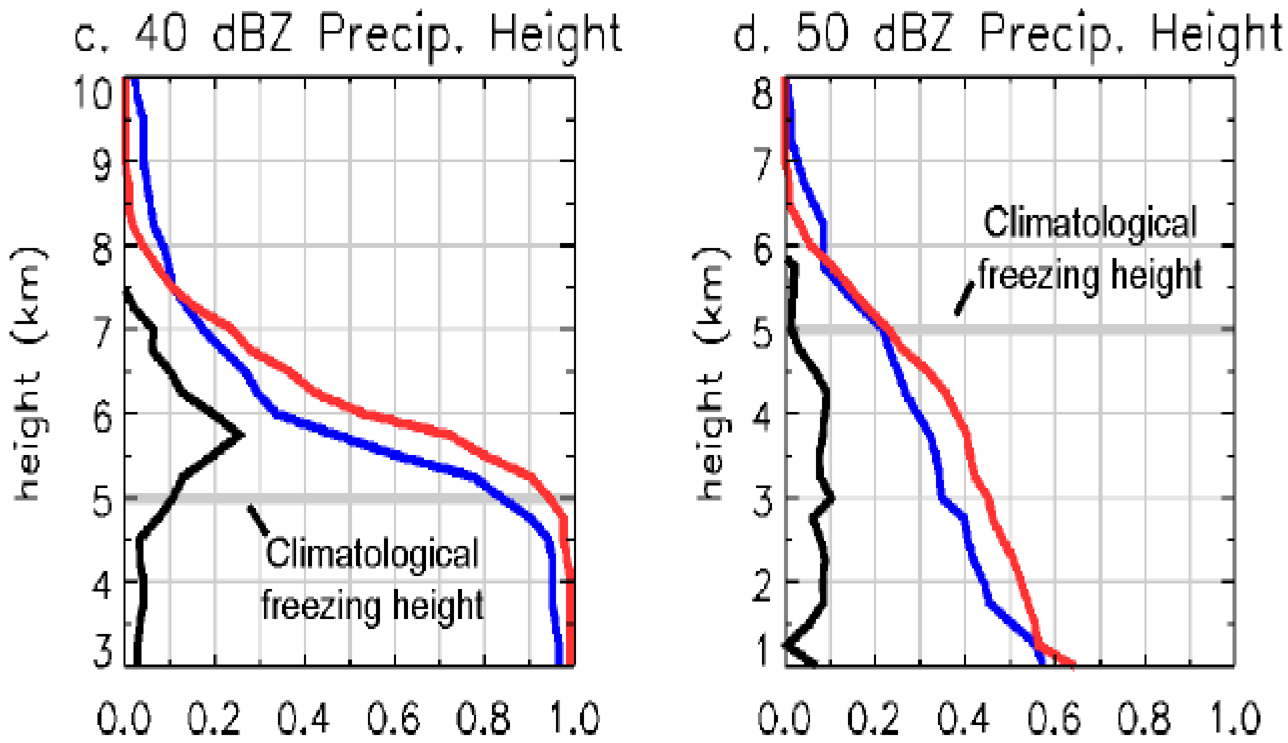
43 dBz at z = 14.8 km

x = lightning strike
detected by NLDN
within 5 min of radar

35 dBz at z = 17.3 km

* Irene = (14.8 km)

* Irene = (10.1 km)



(Kelley 2008)

Figure 3.3. The Cumulative Distribution Function (CDF) of radar reflectivity. The data are 269 tropical cyclone overflights observed by the TRMM Precipitation Radar during the first nine years of the mission (1998 to 2006). Red is for intensifying tropical cyclones, blue is for non-intensifying tropical cyclones, and black is the difference between the red and blue lines. The vertical axis is the height of the tallest TRMM Precipitation Radar pixel observed in the eyewall at the radar reflectivity threshold given in the title of each of the four panels. The approximate precipitation rates associated with these reflectivity thresholds are stated in Table 2.2.

Summary of Time Evolution

<u>Prior to 22 UTC 10/17: Before RI</u>

- Lack of convection within 50 km of center.
- Very broad wind and temperature fields.

<u>22 UTC 10/17 - 01 UTC 10/18: Onset of RI</u>

- Bands spiral inwards, forming closed eyewall by around 00 UTC.
- Large precip-free moat region between eyewall and rainbands.

<u>01-09 UTC 10/18: RI → peak intensity</u>

- Evidence of vortex tilt due to increasing shear: wavenumber-1 convective asymmetry, WSR-88D velocity profile, 850 hPa radial wind.
- Strongly peaked wind and temperature profiles.
- Small RMW (10 km).
- Incredibly tall and intense eyewall towers downshear.

Questions to address

- Most fundamentally: Why did a minimal hurricane rapidly intensify under seemingly unfavorable conditions:
    1) Vertical wind shear increasing from about 7 m/s to 13 m/s.
    2) Marginal SST of around 25-26°C.

- What caused the extremely tall eyewall towers to form? What role, if any, did they play in the rapid intensification?

- To what extent is this event representative of symmetric or asymmetric intensification?