Storm interrogation

AWOC Severe Track

IC3-III-E

Part 2: Near range tornadogenesis signatures viewed by the TDWR

Welcome to the

AWOC Severe Track

IC3-III-E

Part 2: Near range tornadogenesis signatures viewed by the TDWR

This part follows part 1 of near range tornadogenesis signatures by the WSR-88D.

It is approximately 13 slides long and should take about 10 minutes to complete.

Part 2: Near range TDWR tornadogenesis signatures

- Objectives
  - Familiarize yourself with the applications and weaknesses of using Terminal Doppler Weather Radar (TDWR) for analyzing close range tornadogenesis signatures
  - Be familiar with the characteristics of the TDWR

As objectives, you should familiarize yourself with the applications and weaknesses of using the TDWR for analyzing close range tornadogenesis signatures. The same applications and weaknesses should apply to the interrogation of many meteorological features.

This lesson will also help you become more familiar with the characteristics of the TDWR.

At this point, development is underway to send TDWR data to WFOs on an operational basis. Thus for any site that has a TDWR in your CWA, this lesson will have more relevance to you.

Part 2: Near range TDWR tornado signatures

- TVS and mesocyclone appearance at close range
- Low-level convergence
- Hook echoes
- Debris

We will look at the similar events as with part 1, a close range mesocyclonic tornado formation case in Norman, OK, and a nonmesocyclonic case from Salt Lake City, UT. You will see how TVS signatures and mesocyclones appear in the TDWR, how low-level convergence signatures appear, how hook echoes become more complicated, and the sensitivity of the TDWR to debris signatures.

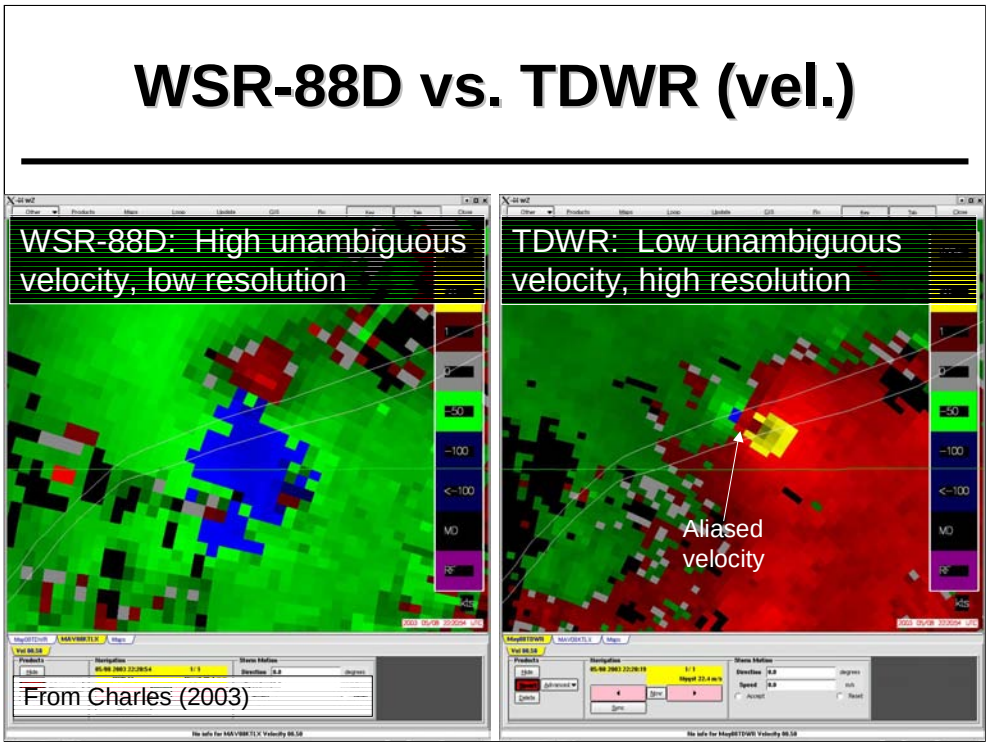
TDWR vs WSR-88D

	WSR-88D	TDWR
wavelength	10 cm	5 cm
Volume scan time	4 minutes in VCP 12	1 minute 0.5°, 2.5 min for other angles
Beam width	1.25°	0.5°
Range gate	.13 nm in velocity .54 nm in reflectivity	.067 nm
Max unambigious velocity	Up to 62 kts with a PRF = 1293.10 s^{-1}	20 - 30 kts

The TDWR operates at 5 cm and is more susceptible to attenuation in heavy precipitation. However, this wavelength is more conducive to detecting most nonprecipitating echoes such as insects.

One of the TDWR volume scan strategies allows for one minute sampling at the 0.5° angle while sampling other elevation angles on a 2.5 minute basis. The real advantage comes with the 1 minute sampling when a storm is undergoing tornadogenesis.

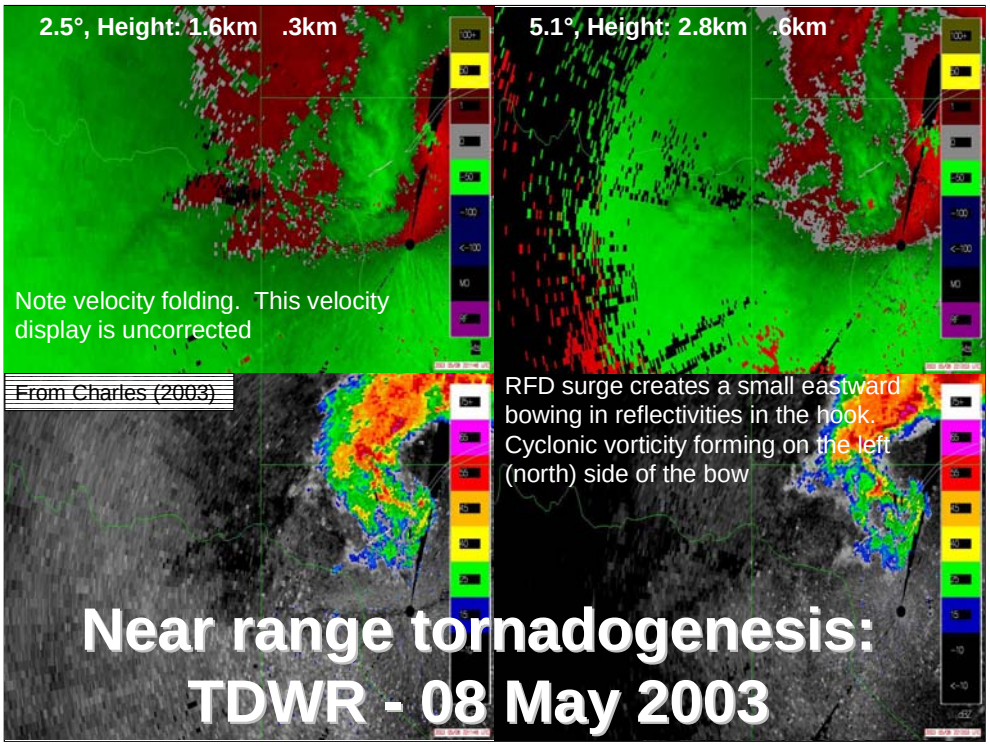
The beam width of the TDWR is half that of the WSR-88D. Add a shorter range gate due to a faster PRF, and the TDWR delivers much higher resolution, 8 times more data than a single range gate from the WSR-88D. The tradeoff is that the maximum unambigious velocity (from here on, V_{max}) is a lot lower for the TDWR. Examples will show the effects on real information coming next.



Here are two views of a mature tornado cyclone with a 8 mile range to radar. The WSR-88D, left adequately samples the high velocities associated with the right flank of the tornado cyclone but washes out the tight velocity couplet that should be there given that the tornado is in its mature stage.

The resolution of the TDWR produces a much tighter velocity couplet on the same order of size as the damage track being produced by the tornado (within the area bounded by the thin white perimeter). But notice that some aliased velocities exist near the circulation center, just on its left side. An even more clear example

Much of the May 08, 2003 results are from a paper by Mike Charles (2003) while working with the NWS OUN as a summer student in the Research Experiences for Undergraduates (REU) program and with Dave Andra, Dan Miller, and Mike Foster serving as mentors.

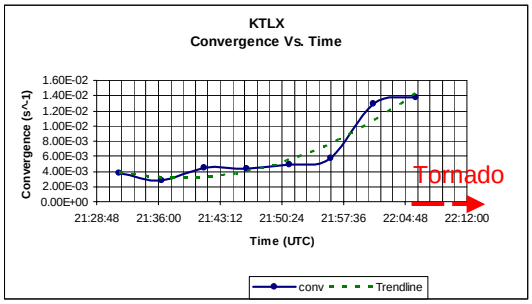


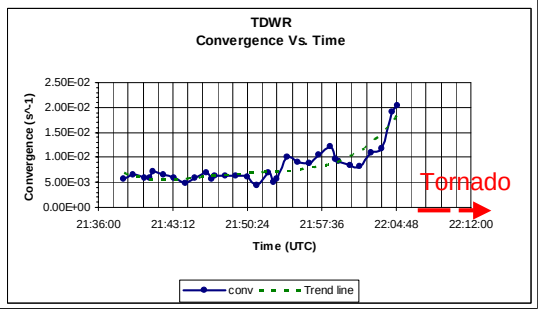
Displayed here is a 4 panel image of the

The first few times show the strong inbounds south of the developing hook echo, and above 1.6 km AGL. The inbounds are folded once to outbounds and then again to inbounds again in the

Near range tornadogenesis signatures

- Both radars show increase in low-level convergence exceeding .01 s^{-1} prior to tornadogenesis
- Values are higher for the TDWR





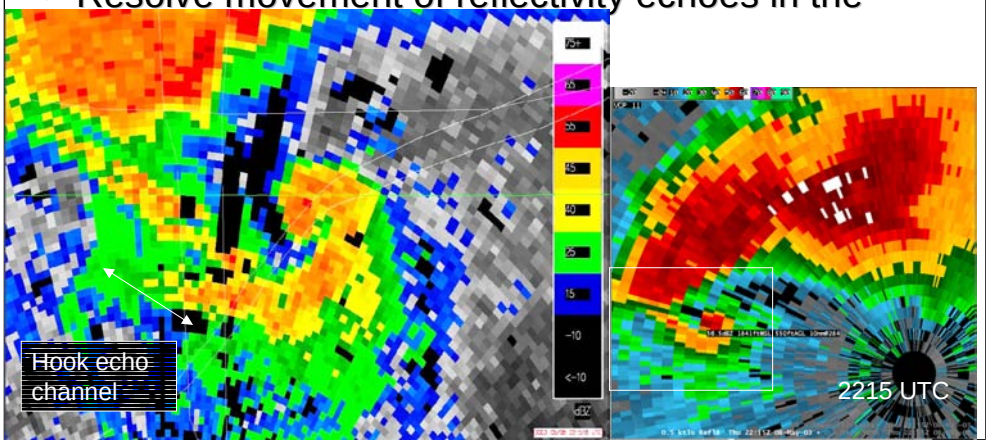
Adapted from Charles (2003)

An analysis of maximum convergence found at the lowest elevation from both radars show increasing values before first tornado. The improved TDWR temporal resolution results in more noise and sharper increases in the RFD convergence. Note that both show rapid increase in convergence less than 5 minutes before tornado time. Note that the trend line in the WSR-88D shows a false picture of slowly increasing convergence. Unfortunately, you only see the convergence represented by the data points and thus the WSR-88D gives you less lead time to convergence increase than the TDWR.

The TDWR maximum convergence exceeds .02 s^{-1}, a third higher than that of the WSR-88D.

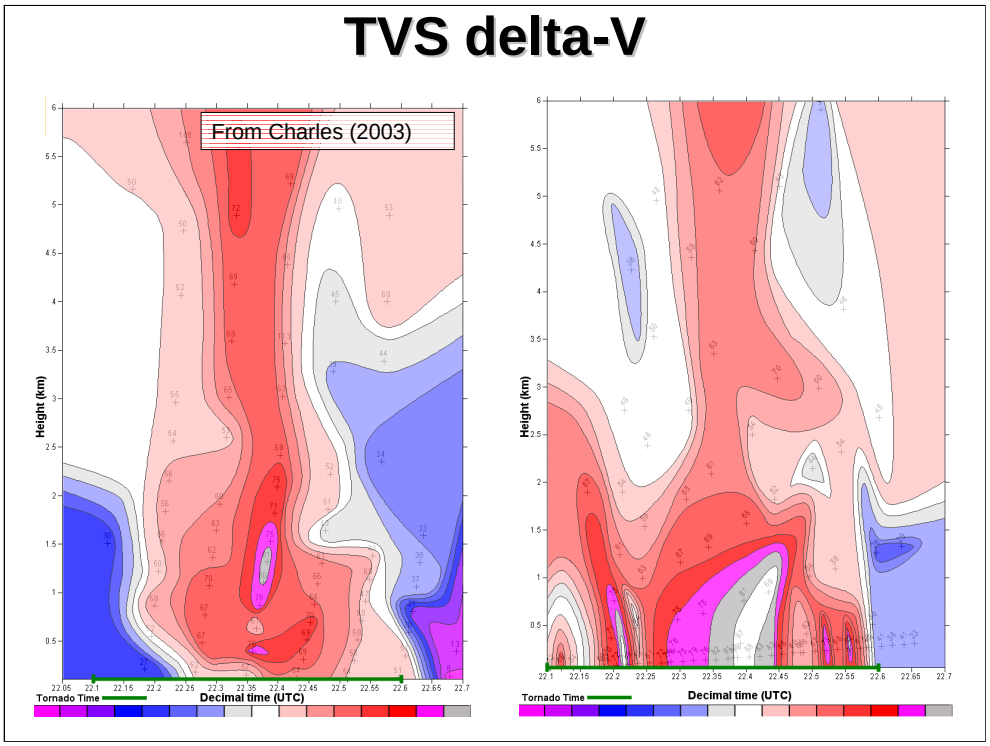
Near range tornadogenesis TDWR reflectivity signatures

- TDWR offers 1 minute scans at 0.5°
- Debris signature only resolved by TDWR
- Resolve movement of reflectivity echoes in the



The one minute resolution of the TDWR is just about enough to track individual reflectivity patterns northwest to southeast along the hook echo channel. As this loop proceeds, the onset of the debris signature in the TDWR occurs right as the damage track begins. The WSR-88D cannot detect it so early.

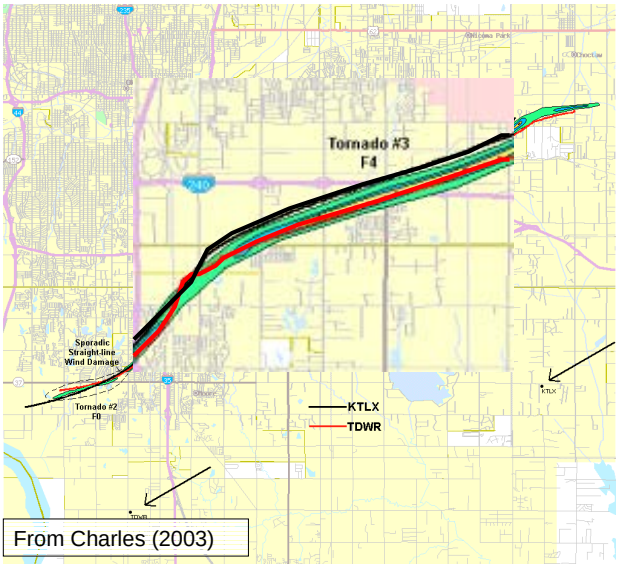
During the event, forecasters, and ham radio operators were able to relay minute by minute positions of the tornado as it plowed through Moore and South Oklahoma city. This level of communication helped emergency responders at a level not done before.



The TDWR should provides stronger values of velocity difference in the TVS signature than the WSR-88D. Stronger may not be necessarily better when assessing tornado potential since just about all TVS may appear stronger with finer resolution. However, the chance for early detection of a tornadic circulation is much sooner with the TDWR. Given the better temporal resolution, the structure of the time/height trends show more detail. In either case, both KTLX and the TDWR clearly show the TVS signature strengthen during the mature stages of the tornado.

Accuracy of WSR-88D and TDWR TVS track vs. damage

- WSR-88D in black
- TDWR in red
- Both are accurate < 1 km but the TDWR is more accurate

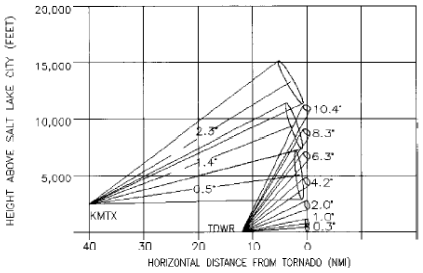


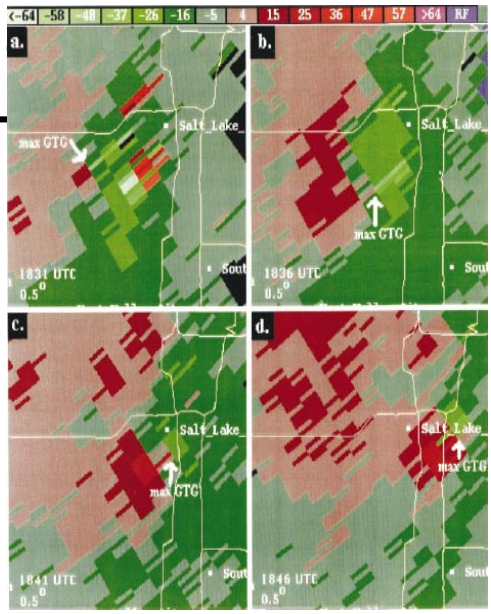
From Charles (2003)

Finer resolution does mean finer accuracy in positioning the tornado with the TDWR. Upon zooming in on the F-scale contour damage map, the lowest slice circulation center of the WSR-88D (black line) is a quarter mile off from the axis of worst damage. The TDWR track (red line) is just about dead center on the damage.

TDWR:

- 11 August 1999 – SLC
- Weak circulation noted in the 0.5° slice from KMTX



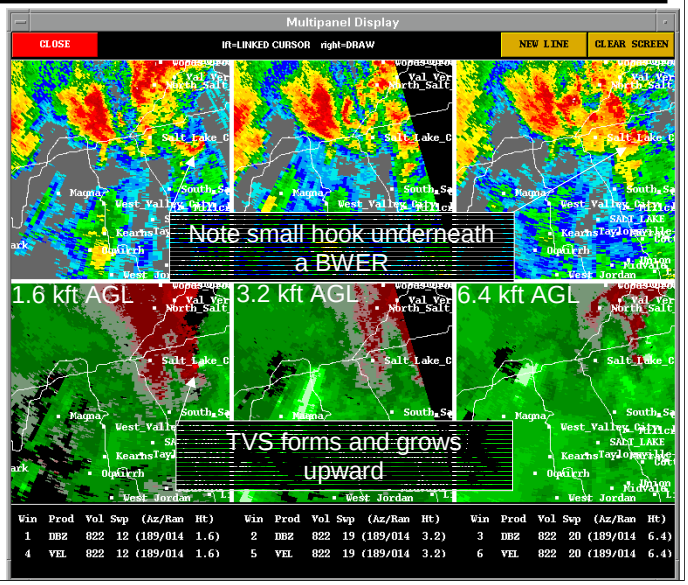


From Dunn and Vasiloff, 2001 (WAF)

Another case has been published in Weather And Forecasting by Larry Dunn and Steve Vasiloff where the TDWR data were compared to the WSR-88D for the Salt Lake City tornado. The differences in distance between these two radars is much greater, with the TDWR in close proximity to the damage track. The fine resolution and number of beams below the 0.5° slice of the KMTX WSR-88D make the TDWR there indispensable for analyzing small features in the Salt Lake Valley. The tornadic storm here barely showed any gate to gate signature, labeled as “max GTG” with the storm as it scoured a damage path through downtown.

TDWR case #2

- TDWR is closer and is able to show these that the WSR-88D could not
  - Boundary
  - TVS
  - Hook, BWER



The TDWR data, only 14 km (8nm) in range, and with numerous low slices below the lowest slice of KMTX, shows an accurate evolution of this tornado as a near surface-based vortex extending upward into the storm near 1840 UTC. A small hook echo feature and even a BWER forms around the vortex at the end of the loop. This TDWR did not have a one minute lowest slice sampling period but with its proximity, provided high quality information on the tornado vortex.

Summarizing: TDWR vs. WSR-88D in near range tornadoes

- WSR-88D
  - Poorer resolution
  - Good unambiguous velocities
  - Poor temporal frequency
  - Low attenuation
  - Good coverage
  - Poor siting on mountain tops
  - NWS control
- TDWR
  - Better resolution
  - Poor unambiguous velocities
  - Good temporal frequency
  - High attenuation
  - Poor coverage (20 cities)
  - None sited on mountain tops
  - FAA control

The TDWR offers you excellent resolution and temporal frequency. However, given other factors favoring the WSR-88D, the TDWR will serve as an enhancement to the current network, and certainly not a replacement. Note the strengths of each radar are colored in yellow. The WSR-88D's advantages lie in its coverage, high

It is not known at this time how the TDWR data will be made operational to the NWS forecasters. Work will need to be done that will be defined during the course of AWOC delivery. As the details are worked out on delivering the data to the field, WDTB will provide more training on the use of TDWR data.