# Evaluating the Vortex Detection And Characterization (VDAC) technique using real multiple-Doppler observations of supercells

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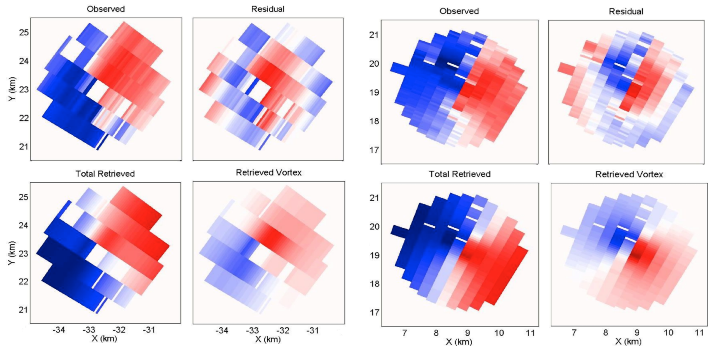
## The Vortex Detection and Characterization (VDAC) Technique

- Utilizes fine observational resolution and overlapping coverage of CASA-like radar networks
- Radial velocity observations from 2+ radars fit to low-order model of vortex and environment
- Retrieved model parameters used to identify intense vortices and characterize their size, strength
- Tested using CASA, Shared Mobile Atmospheric Research & Teaching (SMART), Doppler on Wheels (DOW) radar observations
- See Potvin et al. (2009, 2011) in *Mon. Wea. Rev.*




**Top Figure:** Wind retrieval of 30 May 2004 Geary, OK supercell using velocity data collected by two SMART radars. The retrieved vortex is embedded within a larger circulation (visible in the plots) that produced F-2 damage.

**Bottom Figure:** Wind retrievals of weak tornado using velocity data collected by two DOW radars near Attica, KS on 5 June 2001. The technique successfully distinguishes the tornado from the larger-scale circulation. Results are shown for two different times.

## LOW-ORDER MODEL

**Broadscale Flow**

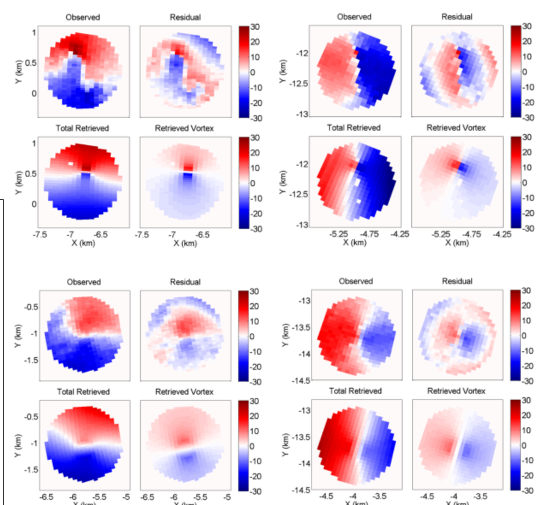
$$V_x = a + b(y - v_b t) + c(x - u_b t) + gz,$$
$$V_y = d + e(x - u_b t) + f(y - v_b t) + hz,$$

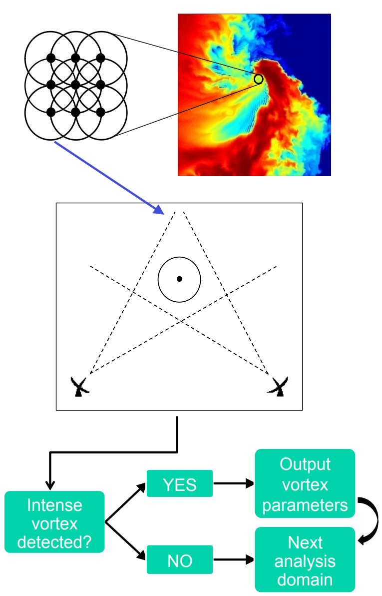
**Vortex Flow**

$$v_\theta = \begin{cases} \frac{r}{R} V_T, & r < R \\ \frac{R^\alpha}{r^\alpha} V_T, & r < R \end{cases} \qquad v_r = \begin{cases} \frac{r}{R} V_R, & r < R \\ \frac{R^\beta}{r^\beta} V_R, & r < R \end{cases}$$

$$r = \sqrt{(x - x_0 - u_v t)^2 + (y - y_0 - v_v t)^2}$$

| Parameter | Description |
|---|---|
| $a$, $d$ | uniform flow (m s$^{-1}$) |
| $b$, $e$ | horizontal shear strength (s$^{-1}$) |
| $c$, $f$ | horizontal divergence strength (s$^{-1}$) |
| $g$, $h$ | vertical shear strength (s$^{-1}$) |
| $u_b$, $v_b$ | broadscale translation (m s$^{-1}$) |
| $x_0$, $y_0$ | vortex center (m) |
| $u_v$, $v_v$ | vortex translation (m s$^{-1}$) |
| $R$ | radius of max wind (m) |
| $V_T$, $V_r$ | max tangential, radial wind (m s$^{-1}$) |
| $\alpha$, $\beta$ | vortex, inflow decay exponents |




## OUTLINE OF METHOD

1) Identify regions containing strong rotation
2) Within each region, set up grid of analysis domains
3) Within each domain, retrieve model parameters
4) After each retrieval, apply vortex detection criteria
5) For each detection, output retrieved vortex parameters

## RETRIEVAL PROCEDURE

1) Fix vortex parameters at zero, retrieve broadscale flow

2) Subtract retrieved broadscale flow from observations to get "residual" wind field (vortex flow now more dominant)

3) Retrieve all parameters for residual flow

4) Repeat (1) – (3) using new analysis domain that is:

- Centered on vortex retrieved in (3)
- As small as possible while encompassing stronger vortex winds (so vortex more dominant)

## VDAC TECHNIQUE STRENGTHS

- Retrieved vortex characteristics reasonably accurate
- Detects vortices obscured by surrounding flow in radar imagery (e.g., tornado within a mesocyclone)
- May be useful for characterizing mesocyclones in single-radar WSR-88D data

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