Observations of the Streamwise Vorticity Current from Project TORUS

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TORUS – Collaborating Institutions and Instrumentation

University of Nebraska

- Mobile mesonet, support for unmanned aircraft system (UAS) flight operations

Texas Tech University
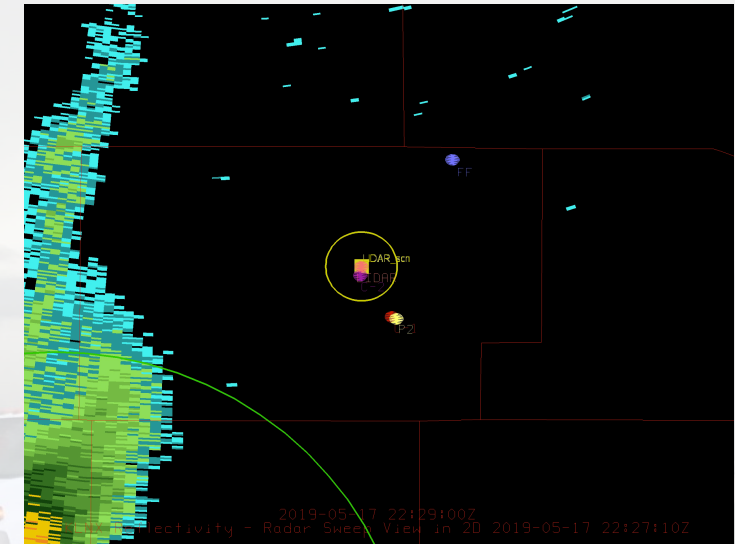
- TTUKa mobile Doppler radars

University of Colorado (Research and Eng Center for Unmanned Vehicles)

- Unmanned aircraft system (UAS) development, flights

University of Oklahoma / National Severe Storms Laboratory

- NOXP radar
- Mobile sounding system
- Mobile mesonets
- NOAA P-3

Overarching Goal: To establish the relationship of storm-generated boundaries to the generation/amplification on near-surface rotation

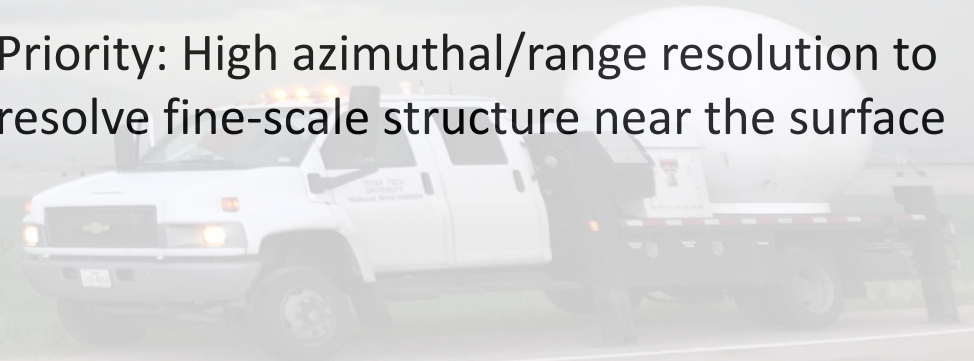*Animation of asset positions on 17 May 2019 (TORUS19 IOP #1)*
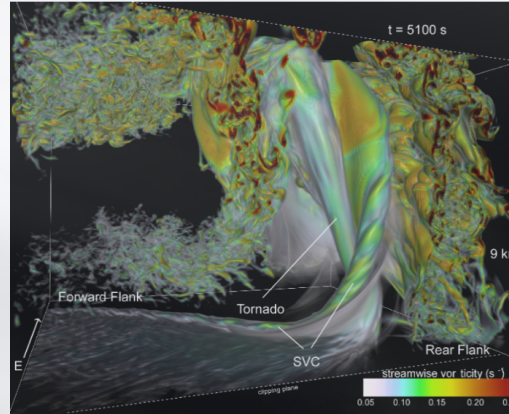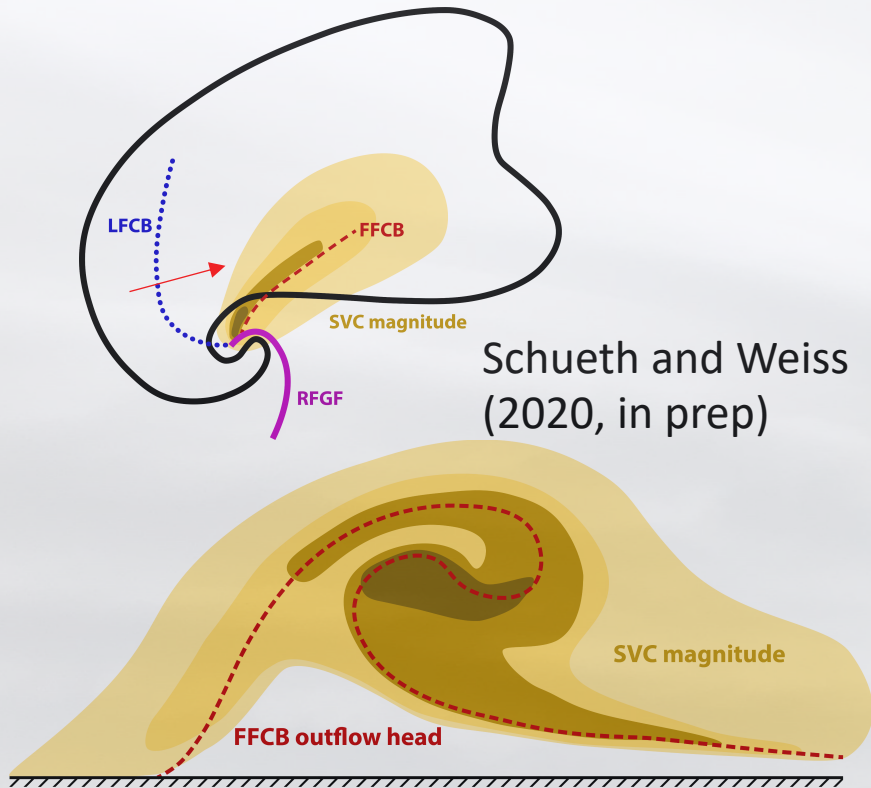
TTUKa Mobile Doppler Radars

TTUKa Specifications

Transmit Frequency	35 GHz
Transmit Power	200 W
Transmitter Type	TWTA
Antenna 3dB beamwidth	0.33 deg
Polarization	Linear (HH)
Gate spacing	12 m

Priority: High azimuthal/range resolution to resolve fine-scale structure near the surface

Streamwise Vorticity Currents (SVC)

Schueth and Weiss (2020, in prep)

Orf et al. 2017
Streamwise vorticity (shaded)

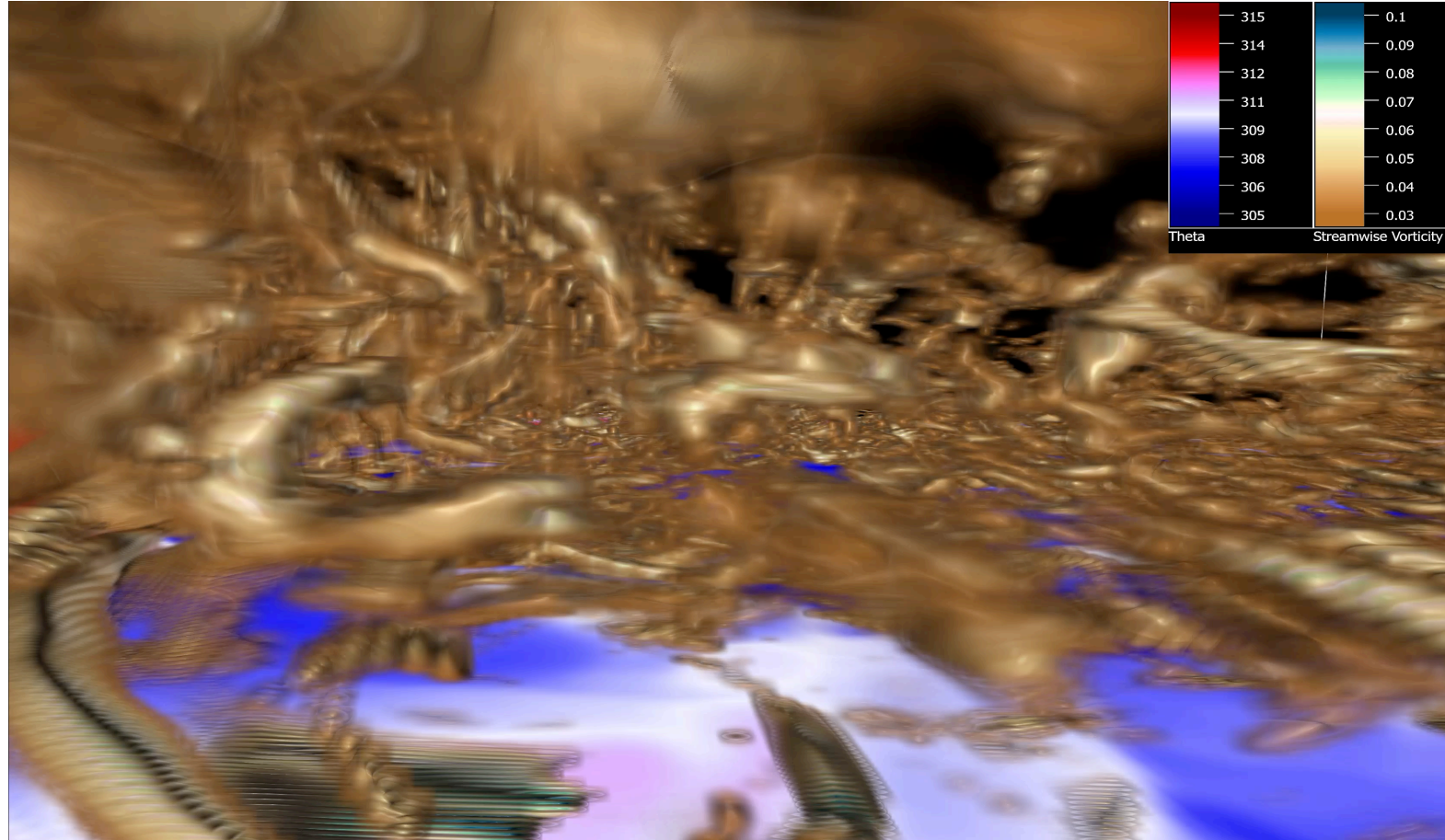Time lapse of supercell near Booker, TX (Mike Olbinski)

- SVCs have been shown to exist in recent high-resolution numerical simulations of supercell storms (e.g., Orf et al. 2017; Schueth and Weiss 2020 (in prep))

- Most pronounced in lowest 500 m AGL, running along left/forward flank

- Horizontal vorticity stretches and is tilted/stretched vertically by primary updraft

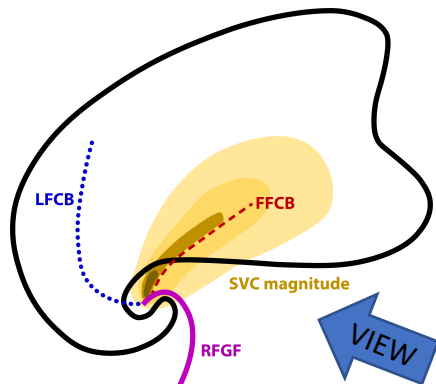- Tornado development (sometimes) occurs in the presence of intense SVCs in simulation
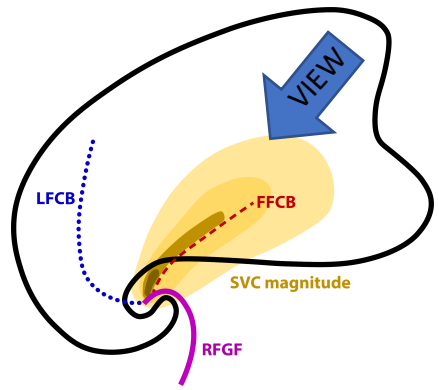
Simulations of the SVC

Streamwise vorticity (brown shade) and θ (colored)
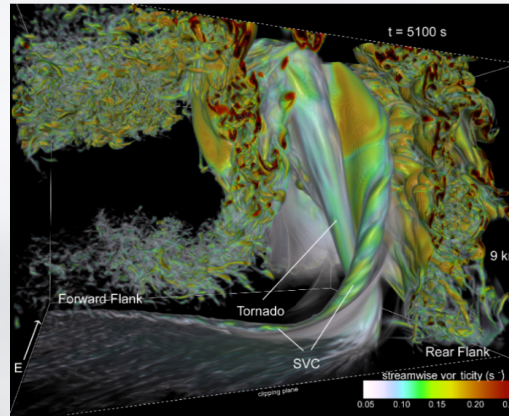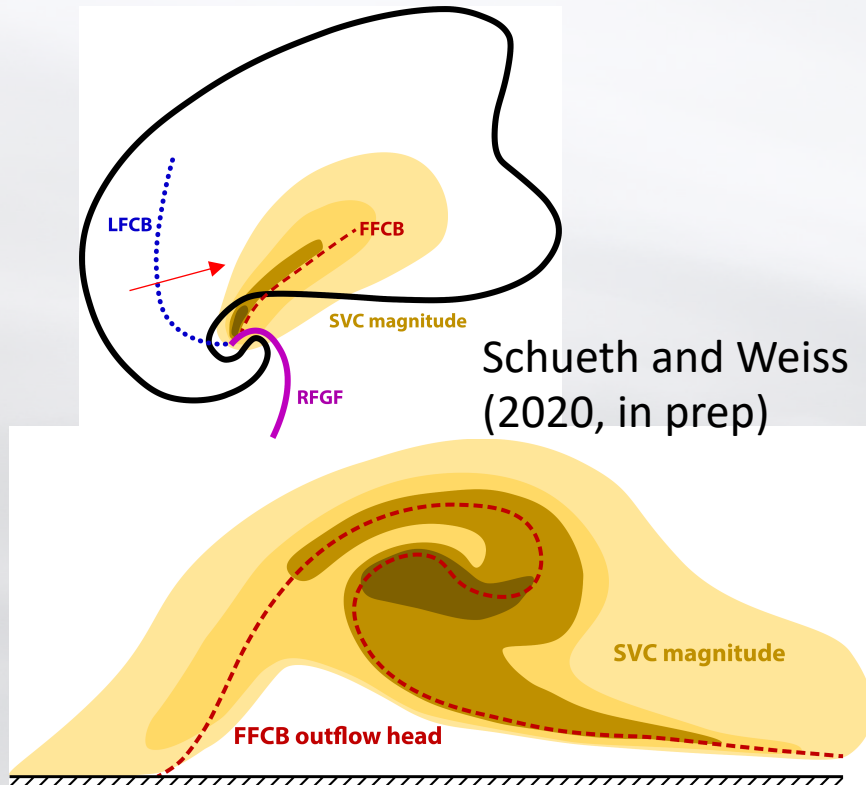
[A. Schueth, Texas Tech (M.S. thesis)]
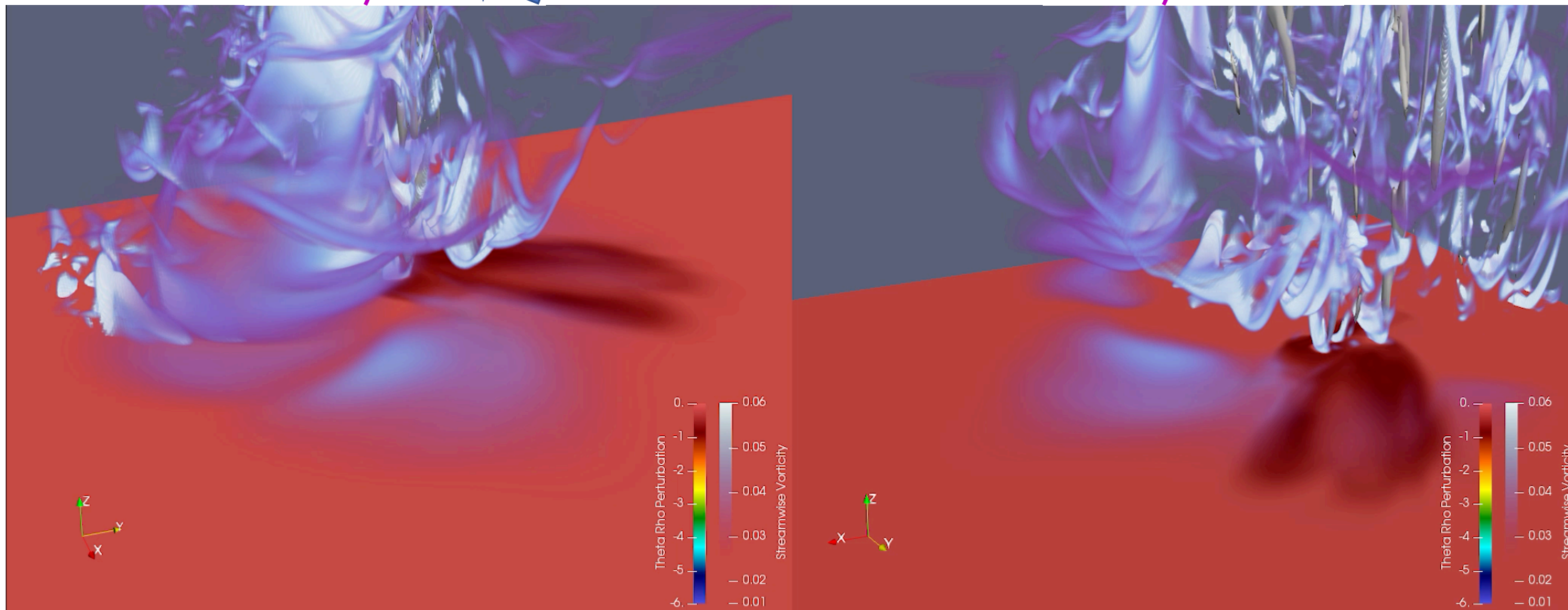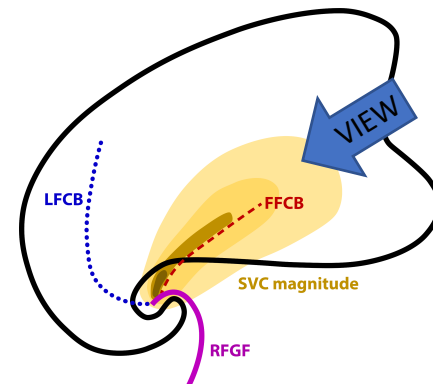
Streamwise vorticity (white shade) and $\theta_\rho{}'$ (colored)

Streamwise Vorticity Currents (SVC)

Schueth and Weiss (2020, in prep)

Orf et al. 2017 Streamwise vorticity (shaded)

Time lapse of supercell near Booker, TX (Mike Olbinski)

- SVCs have been shown to exist in recent high-resolution numerical simulations of supercell storms (e.g., Orf et al. 2017; Schueth and Weiss 2020 (in prep))

- Most pronounced in lowest 500 m AGL, running along left/forward flank

- Horizontal vorticity stretches and is tilted/stretched vertically by primary updraft

- Tornado development (sometimes) occurs in the presence of intense SVCs in simulation

- BUT...DO THEY EXIST?
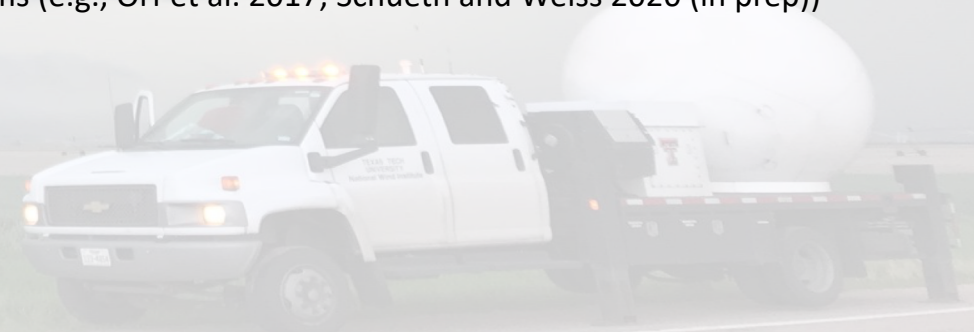
TORUS – 2019 Year in Review

Active!
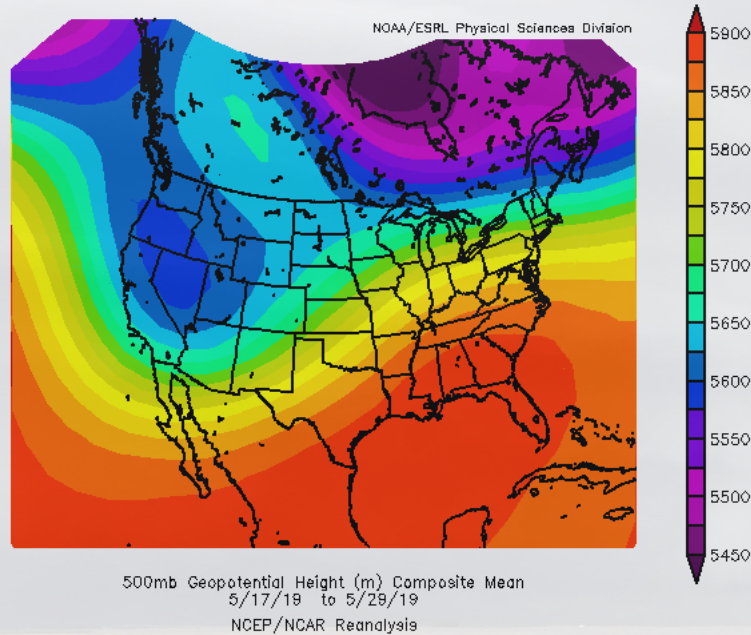
Mean 500 hPa GPH 17-29 May 2019

Date	Location(s)	Description
5/17/19	McCook, NE	Tornadic supercells
5/18/19	Jet, OK	Multicell storms
5/19/19	Gould, OK, Benjamin, TX	Supercells (nontornadic for duration of TORUS sample
5/23/19	Lipscomb, TX	Two supercells, one nontornadic, one tornadic
5/24/19	Matador, TX	Nontornadic supercell
5/25/19	Cotton Center, TX	Two supercells, one nontornadic, one tornadic
5/26/19	Wiley, CO	Supercell (nontornadic during sample, tornadic later)
5/27/19	Ft. Morgan, CO	Tornadic supercells
5/28/19	Beloit, KS	Tornadic supercell (data collection during decay)
6/1/19	Dalhart, TX	Nontornadic supercell
6/8/19	Goodland, KS	Tornadic supercell
6/11/19	Greensburg, KS	Nontornadic supercell (clear-air data collected earlier i
6/13/19	Boise City, OK	Nontornadic, embedded supercell structures
6/14/19	Perryton, TX	Clear-air data collection
6/15/19	Vega, TX	Right-moving and left-moving nontornadic supercells

TTUKa Deployment Days

Field days: **27**
Operations days: **16**
Total supercell storms intercepted: **19**
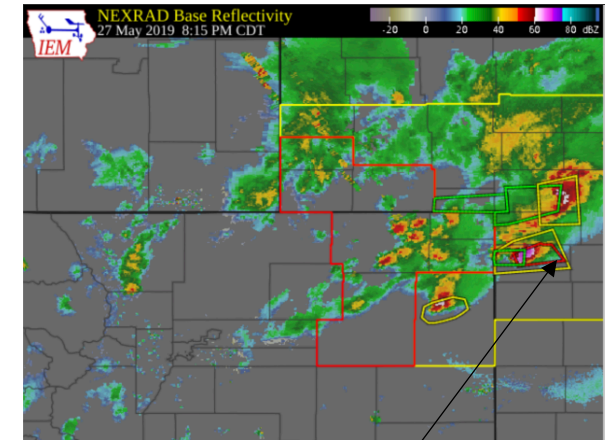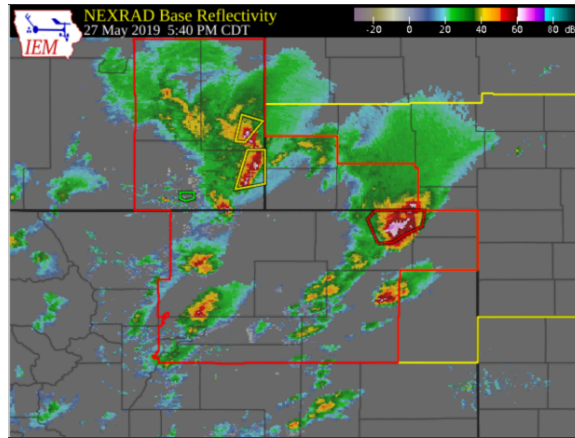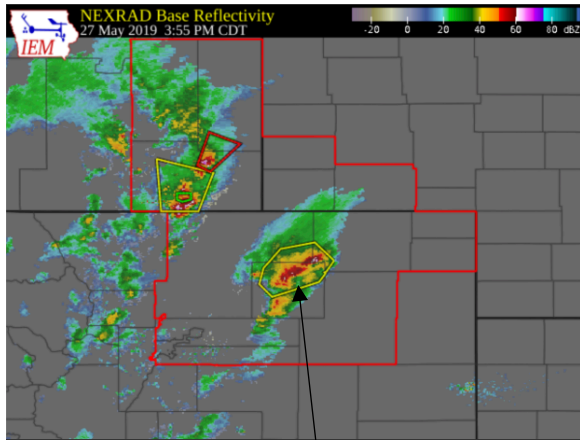Tornadic storms: **8**
TTUKa deployments: **67**
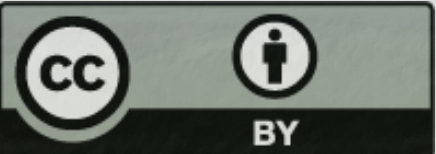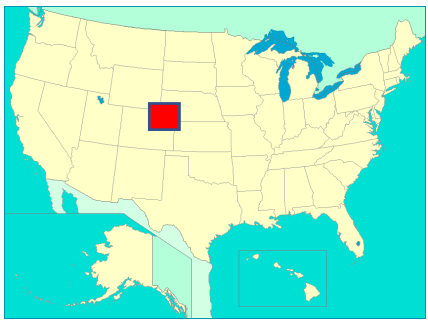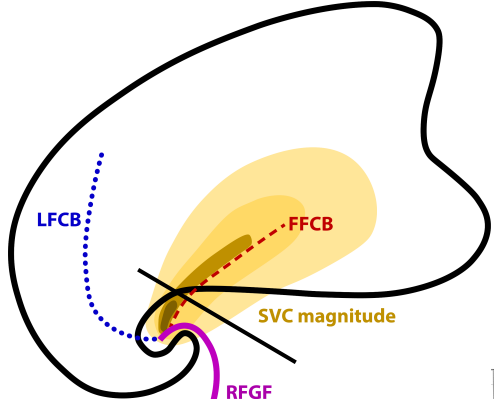
Example Case – 27 May 2019
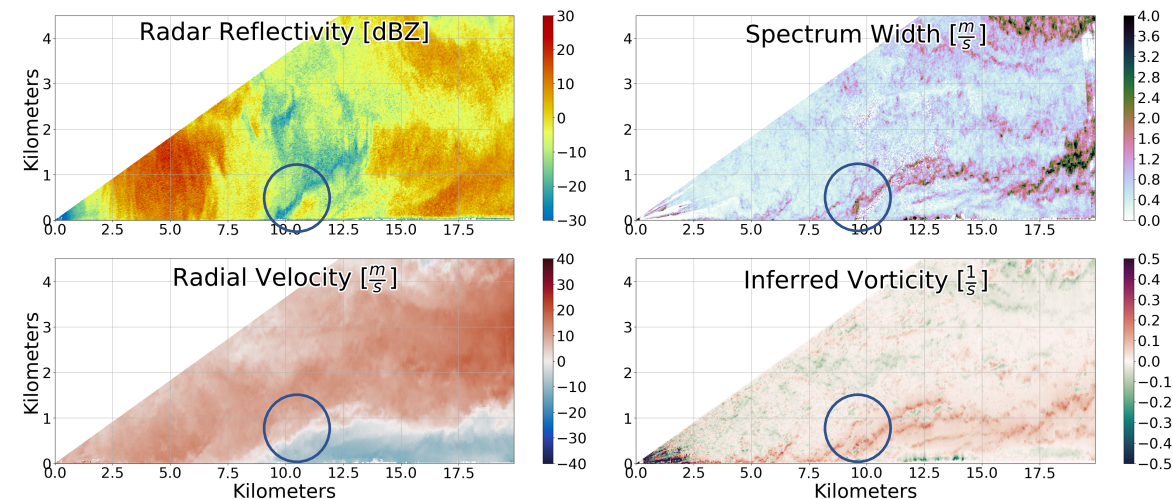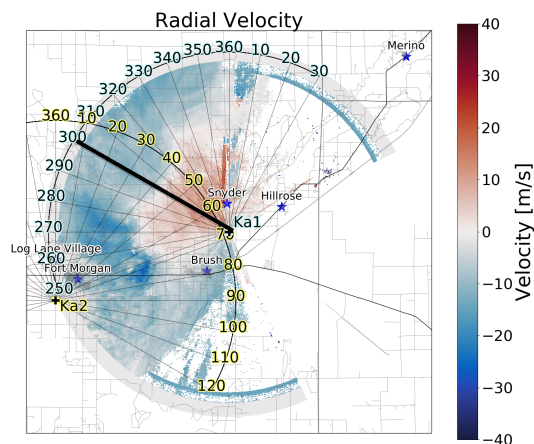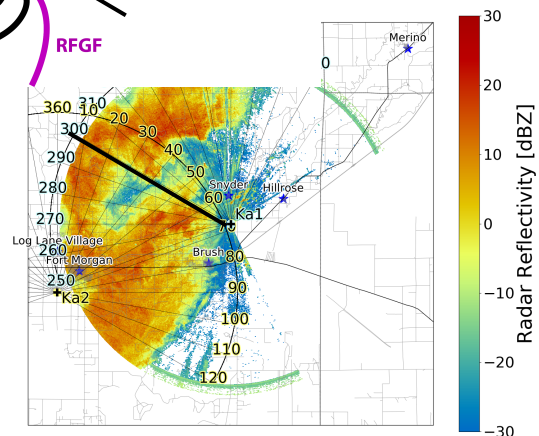
A

B

NWS WSR-88D reflectivity and warnings (polygons)

TTUKa Data – 27 May 2019
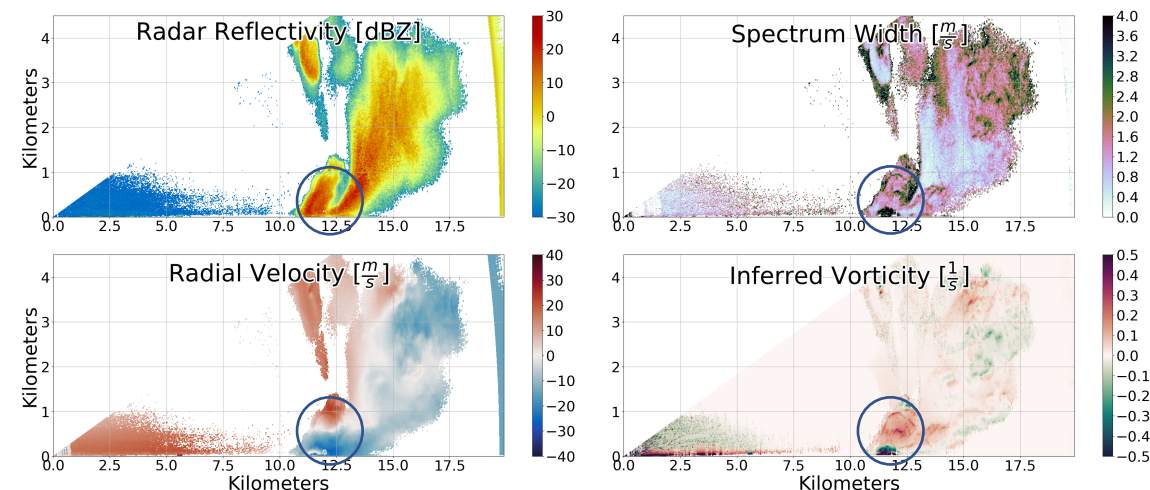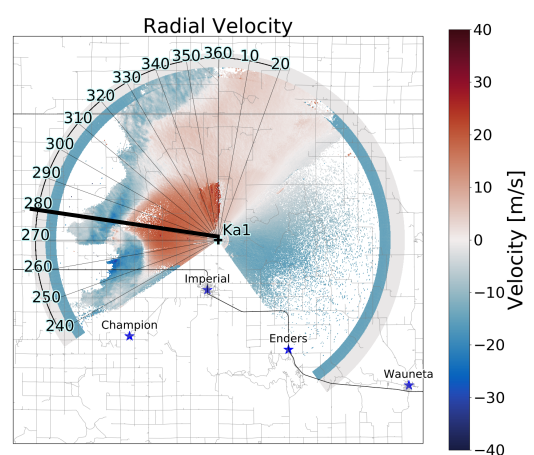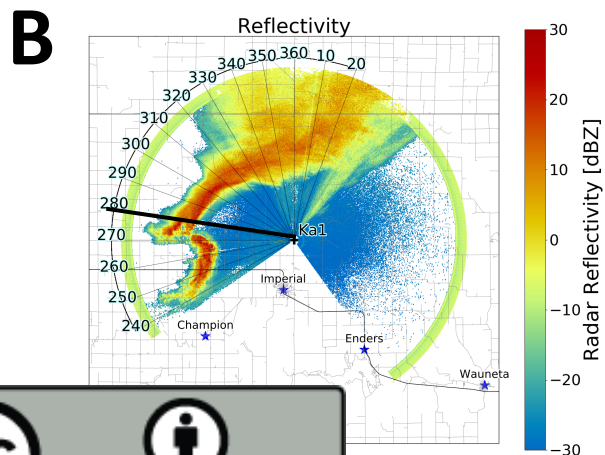
Sequence of TTUKa RHIs
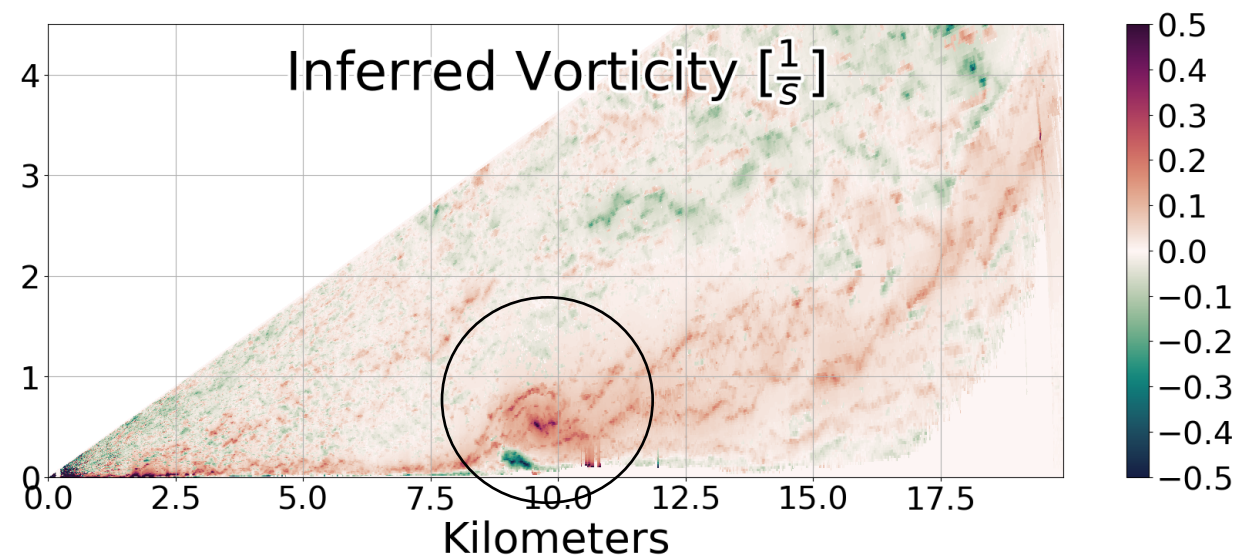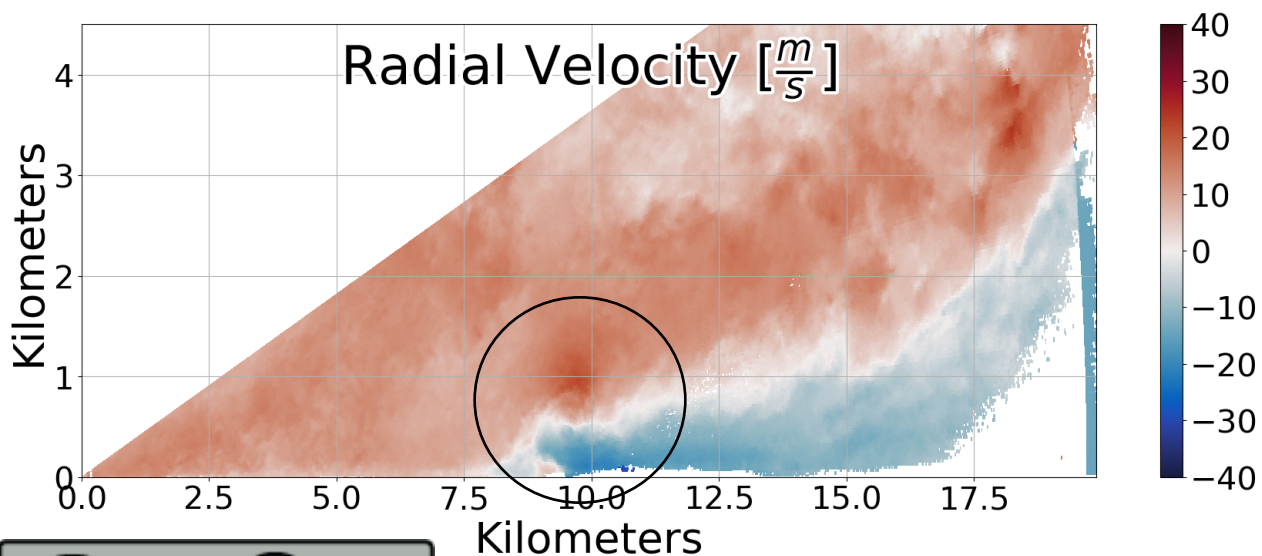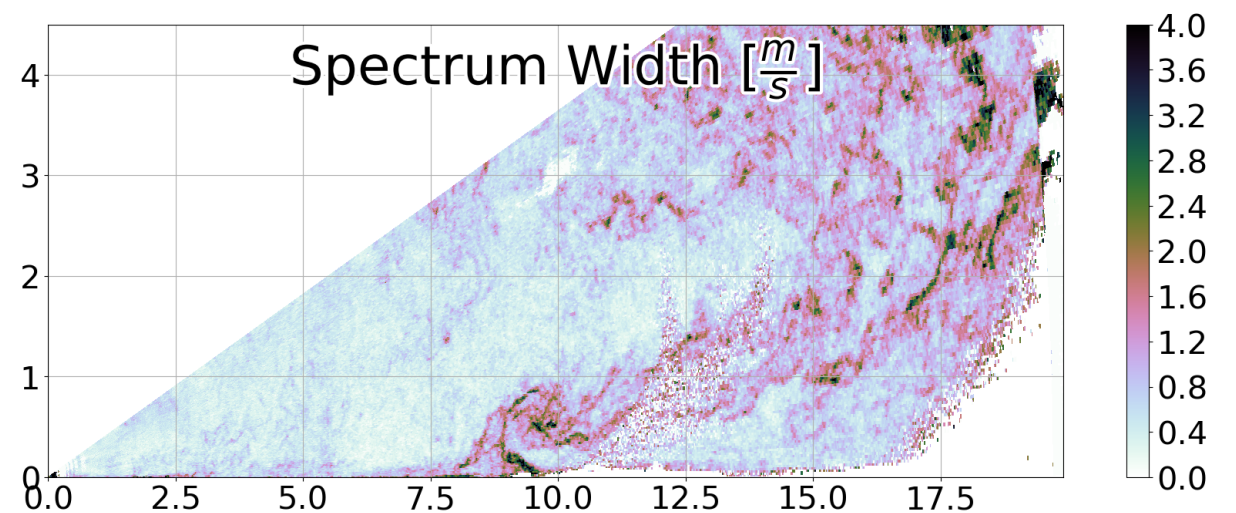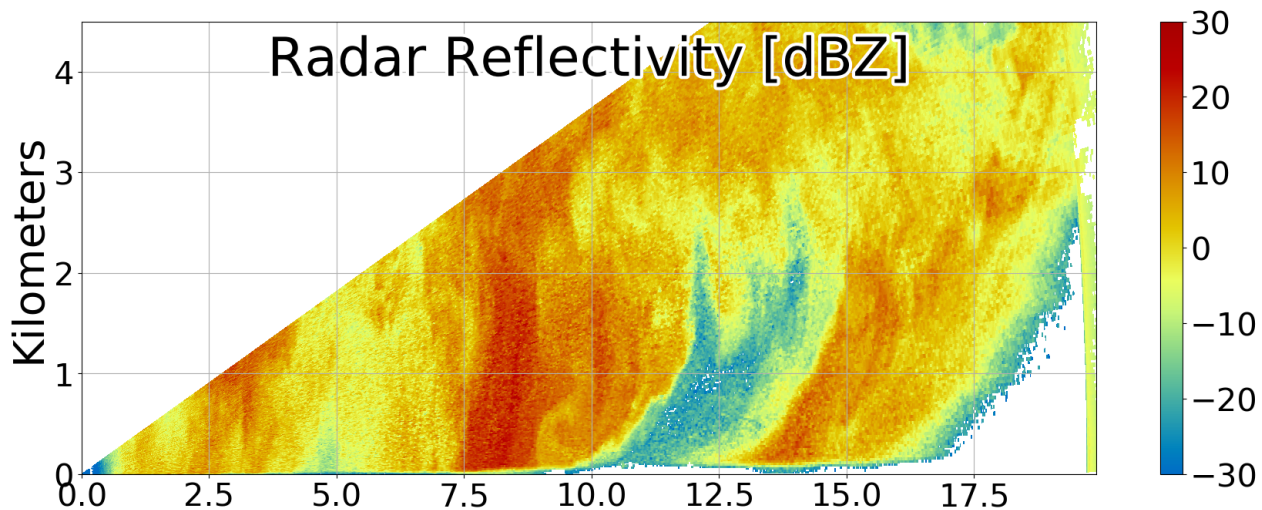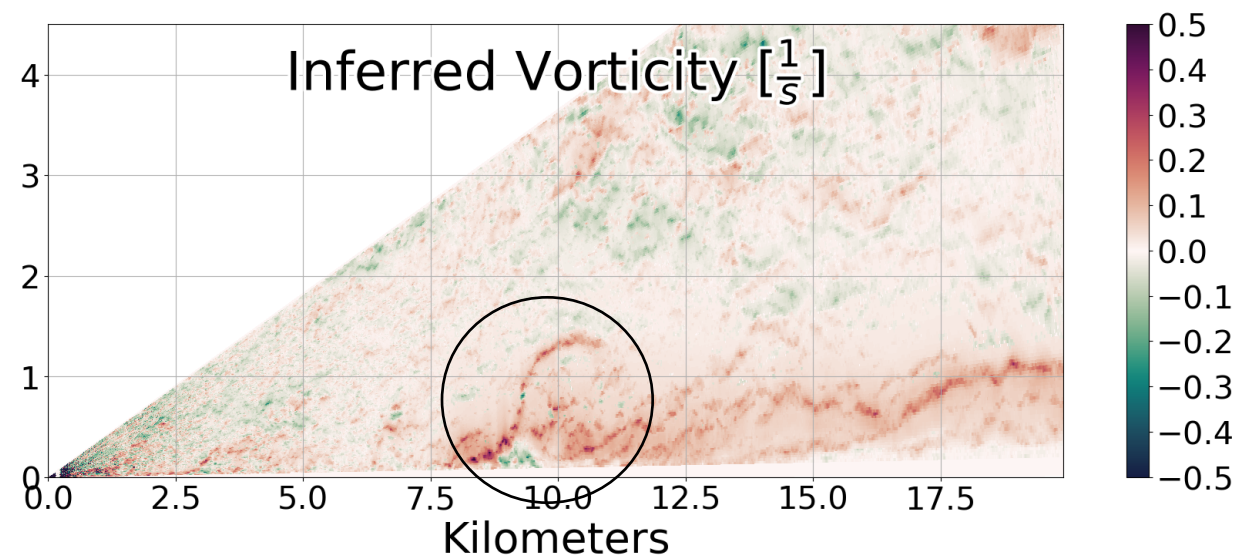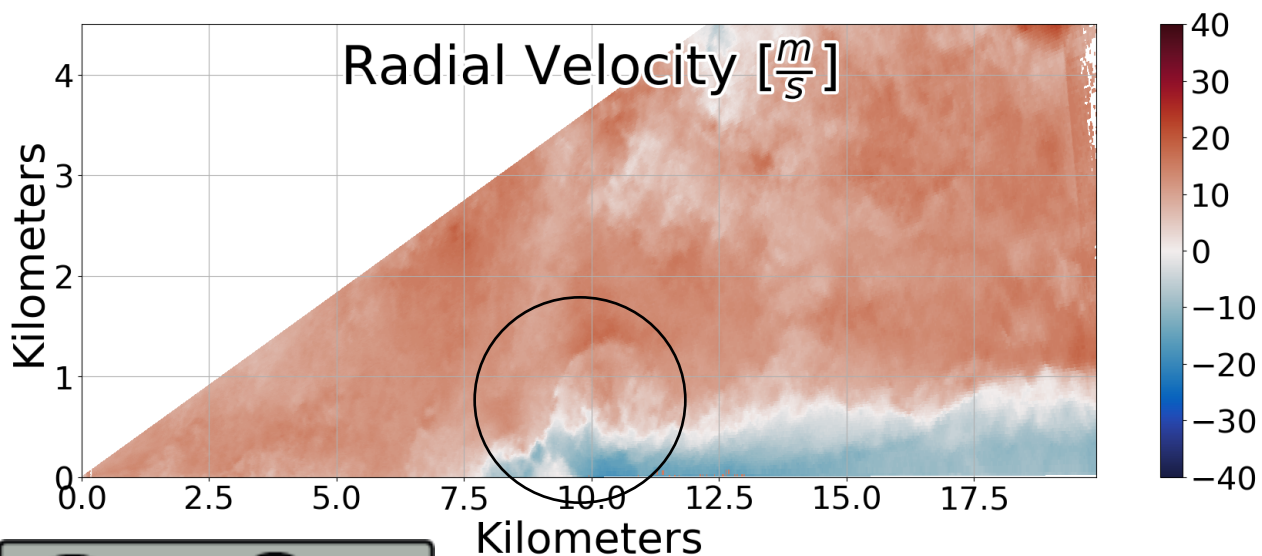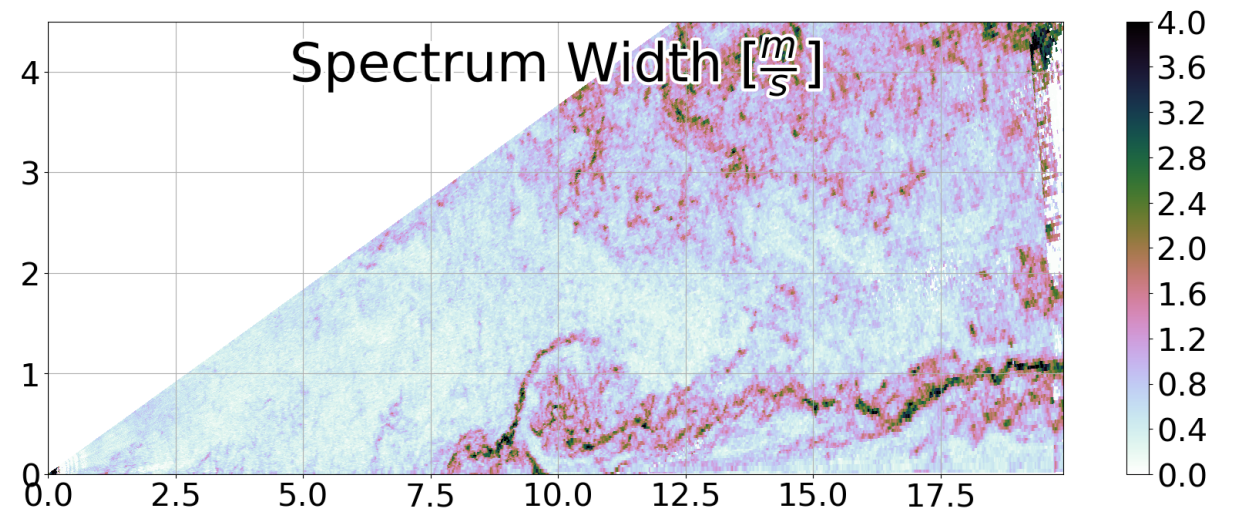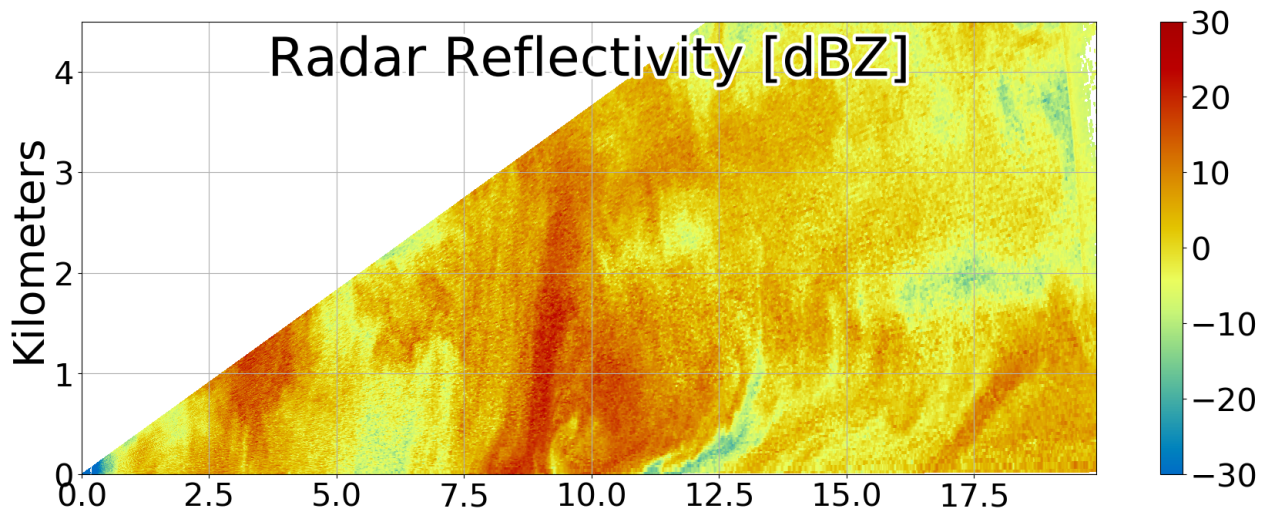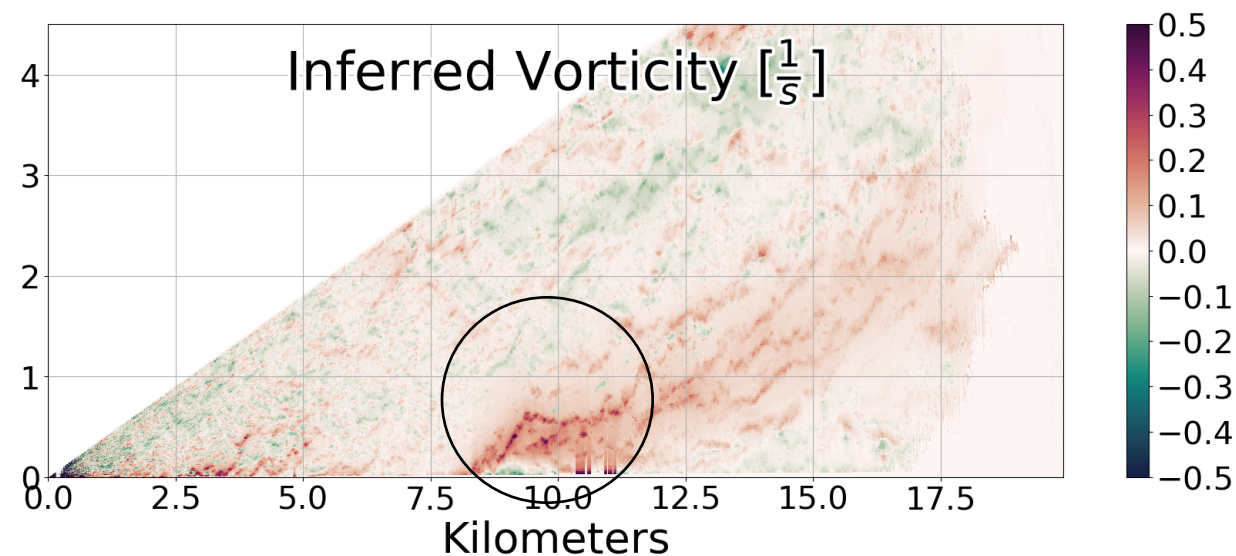
Ka1 0.5° PPI 05/27/19 21:05 UTC
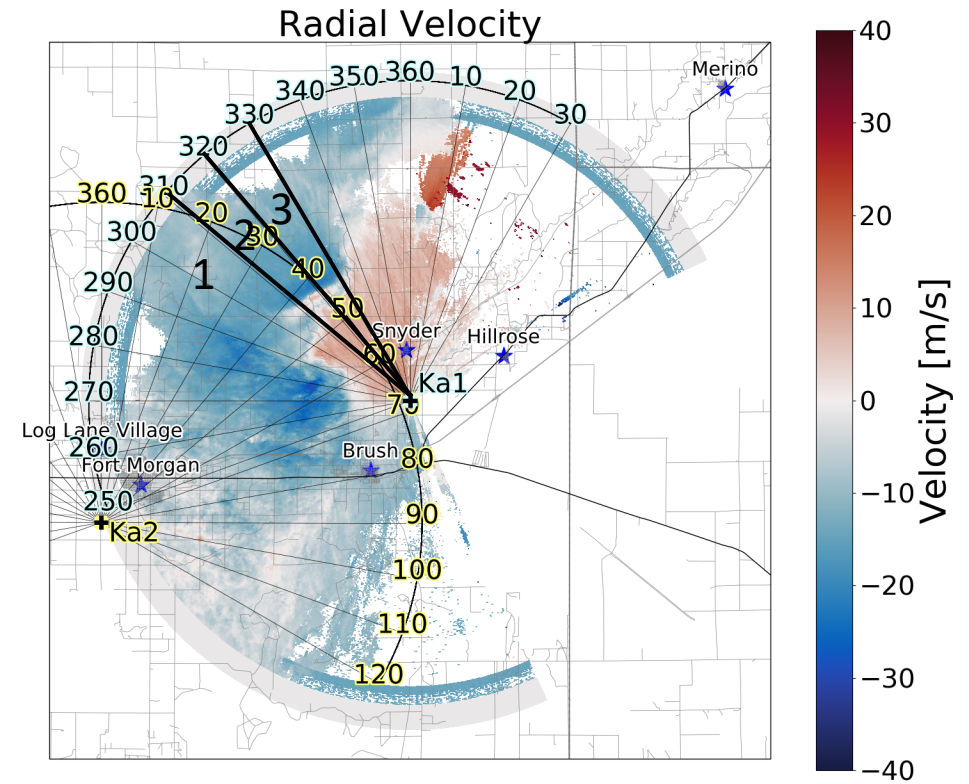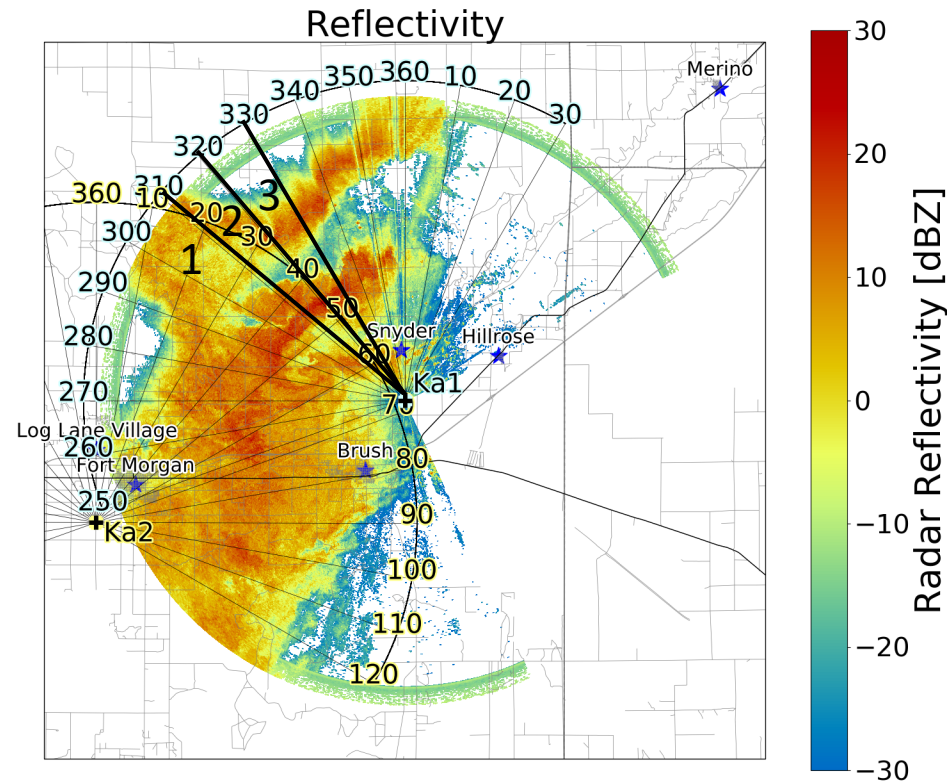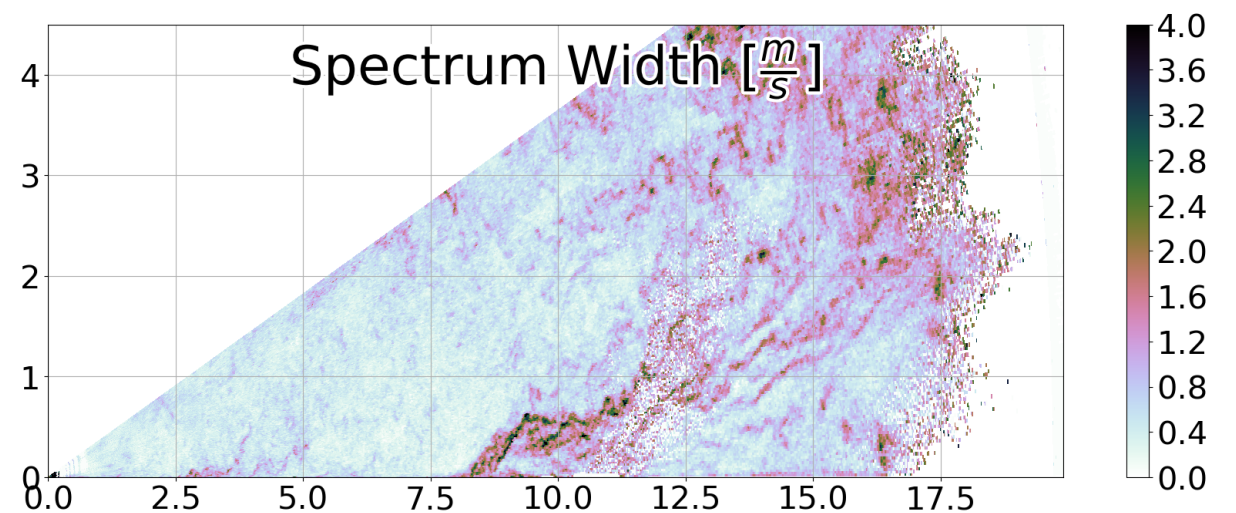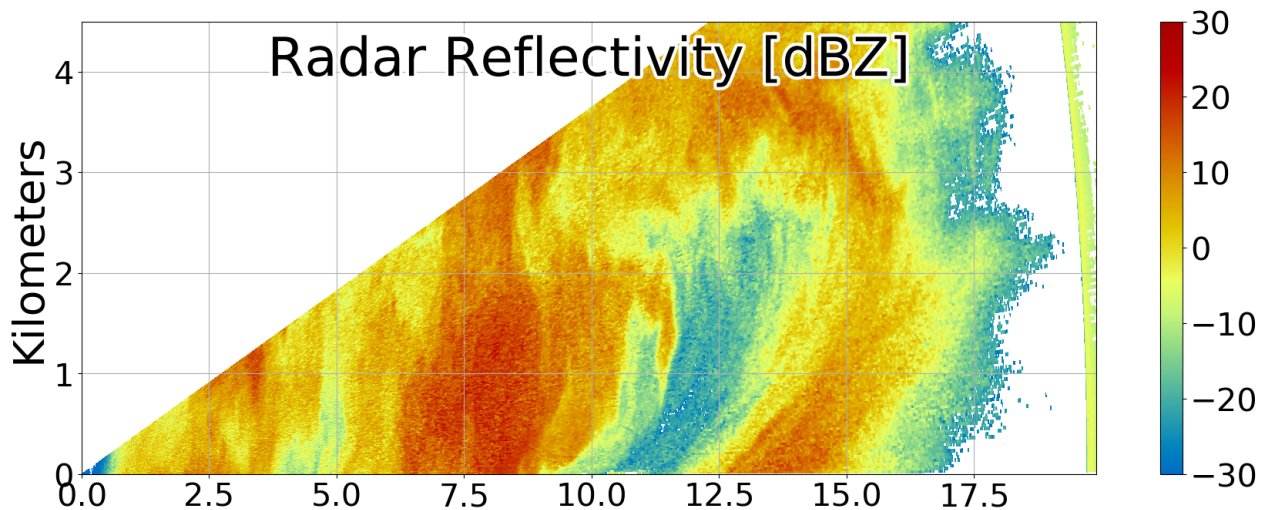
Ka1 RHI az:320 21:03:42 UTC

RHI #2 (center)

Ka1 RHI az:310 21:03:42 UTC

RHI #1 (west)
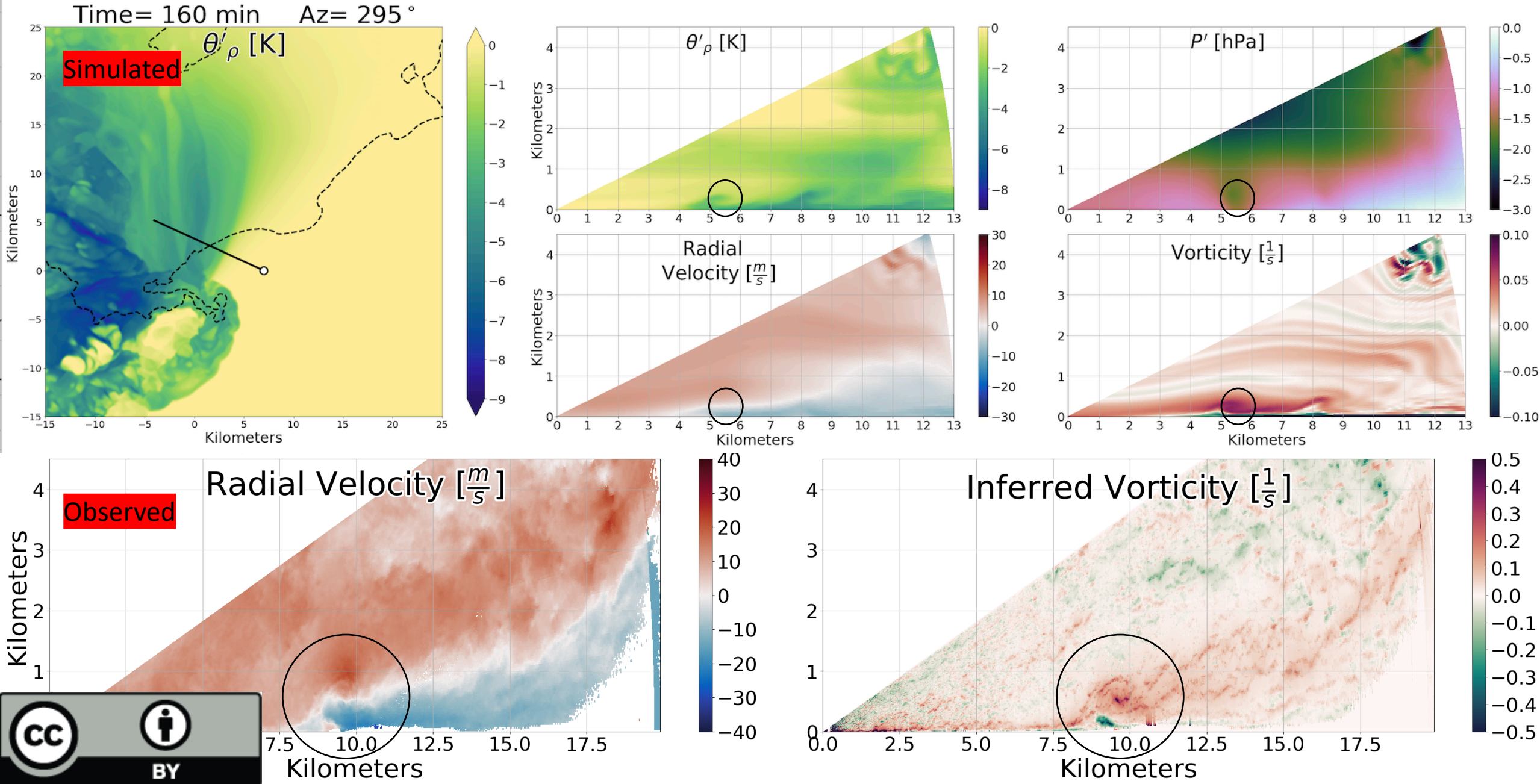
Ka1 RHI az:330 21:03:42 UTC
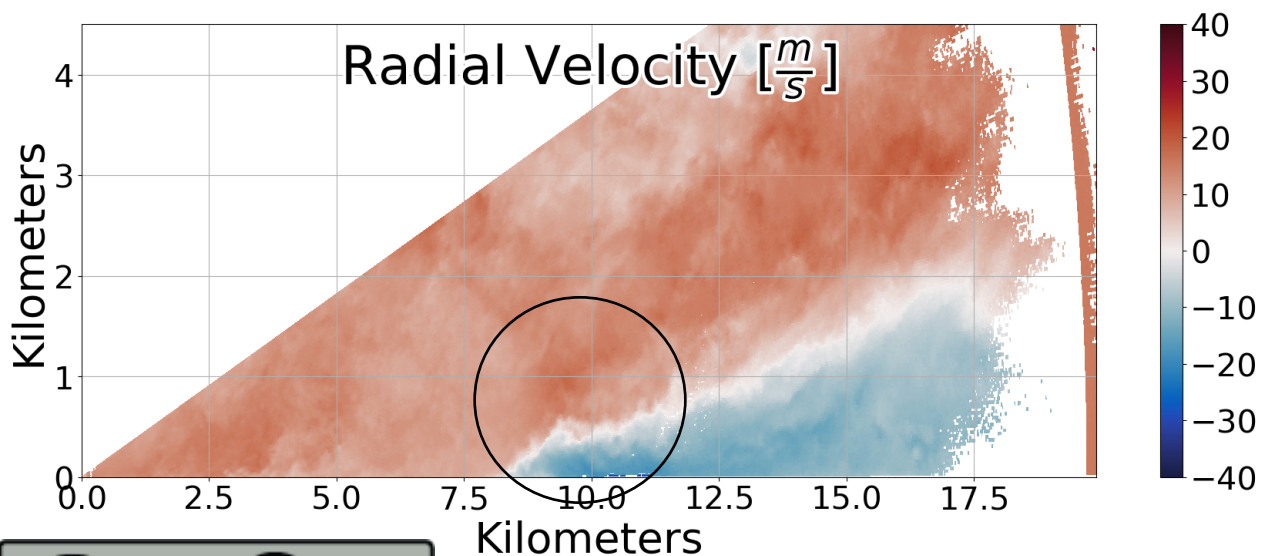
RHI #3 (east)

Comparison of Observations to Simulations

Comparison of Observations to Simulations

Time= 160 min   Az= 295°

θ'_ρ [K]

Simulated

θ'_ρ [K]

P' [hPa]

Radial Velocity [$\frac{m}{s}$]

Vorticity [$\frac{1}{s}$]

Radial Velocity [$\frac{m}{s}$]

Observed

Inferred Vorticity [$\frac{1}{s}$]
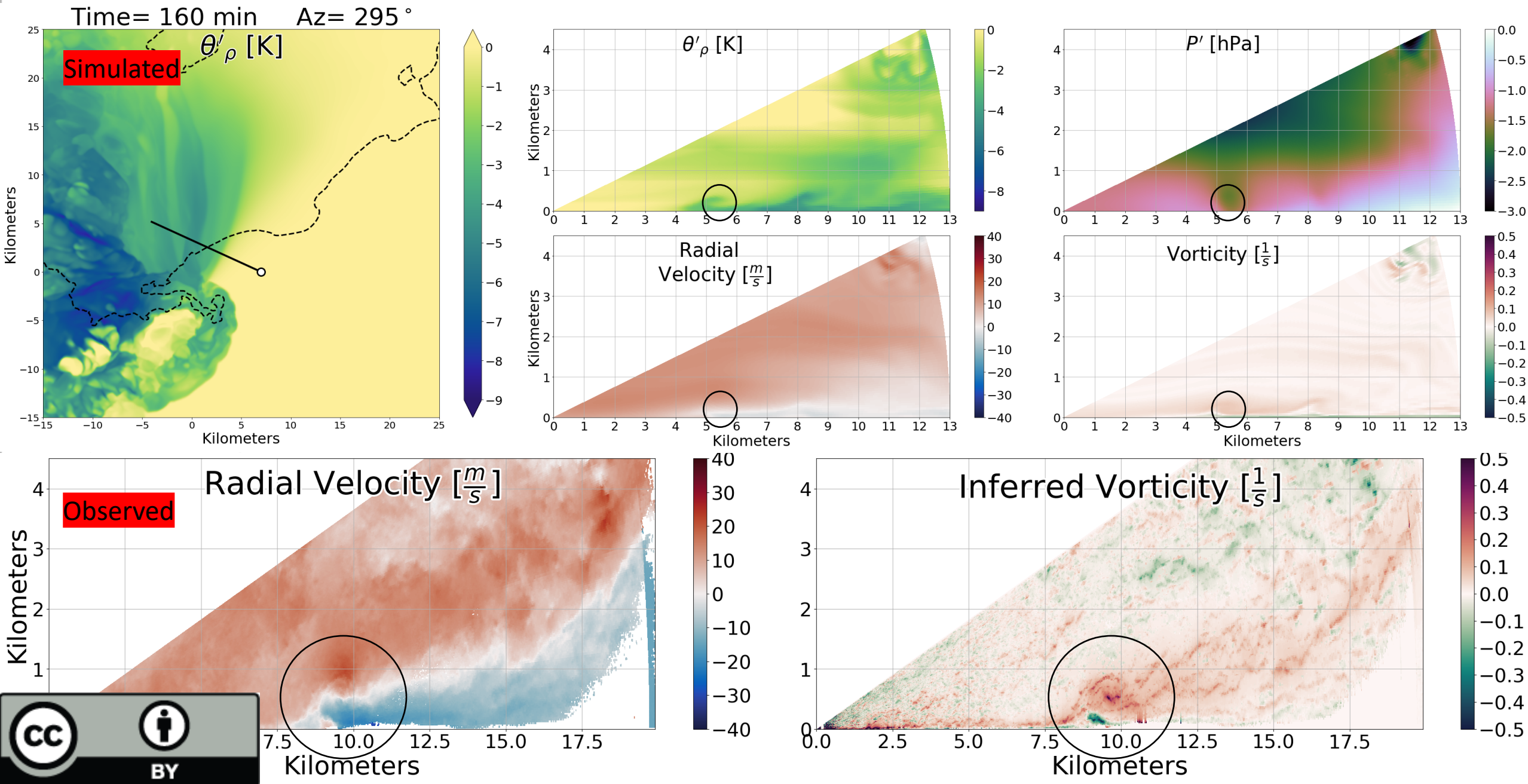
Video time lapse of possible SVC

5/27/2019
near Imperial, NE

Summary and Future Work

- Observations of suspected SVCs collected during TORUS-2019 field phase
  - Many traits appear similar to simulations
    - Location: <=500 m AGL
    - Inferred magnitude of horizontal vorticity: $O\sim(10^{-1}\ s^{-1})$
  - Forthcoming: Integration of thermodynamic measurements from unmanned aircraft and mobile mesonets

- Next up: TORUS-2020 field phase (mid-May through mid-June)

- Analysis, hypothesis testing on 2019 and 2020 cases (SVC and other objectives)