Identification of Mesovortexgenesis Mechanisms in QLCSs using PERiLS Radar Data

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Motivation

- The Propagation, Evolution, and Rotation in Linear Storms (PERiLS) field campaign is a unique project designed to take observations of Quasi-Linear Convective Systems (QLCSs) to better study their environmental and storm-scale processes, a topic that has garnered limited attention in literature

- QLCSs, and specifically mesovortices, are notoriously difficult to forecast, particularly in high shear, low CAPE (HSLC) environments

- Several theories have been proposed to explain the development of mesovortices:
  1. Downward tilting of gust front vorticity by downdrafts (Trapp and Weisman 2003)
  2. Horizontal shearing instability (Conrad and Knupp 2019)
  3. Convergence & stretching of frictionally generated vorticity (Schenkman et al 2012)

  There has yet to be a consensus on the dominant mesovortexgenesis mechanism
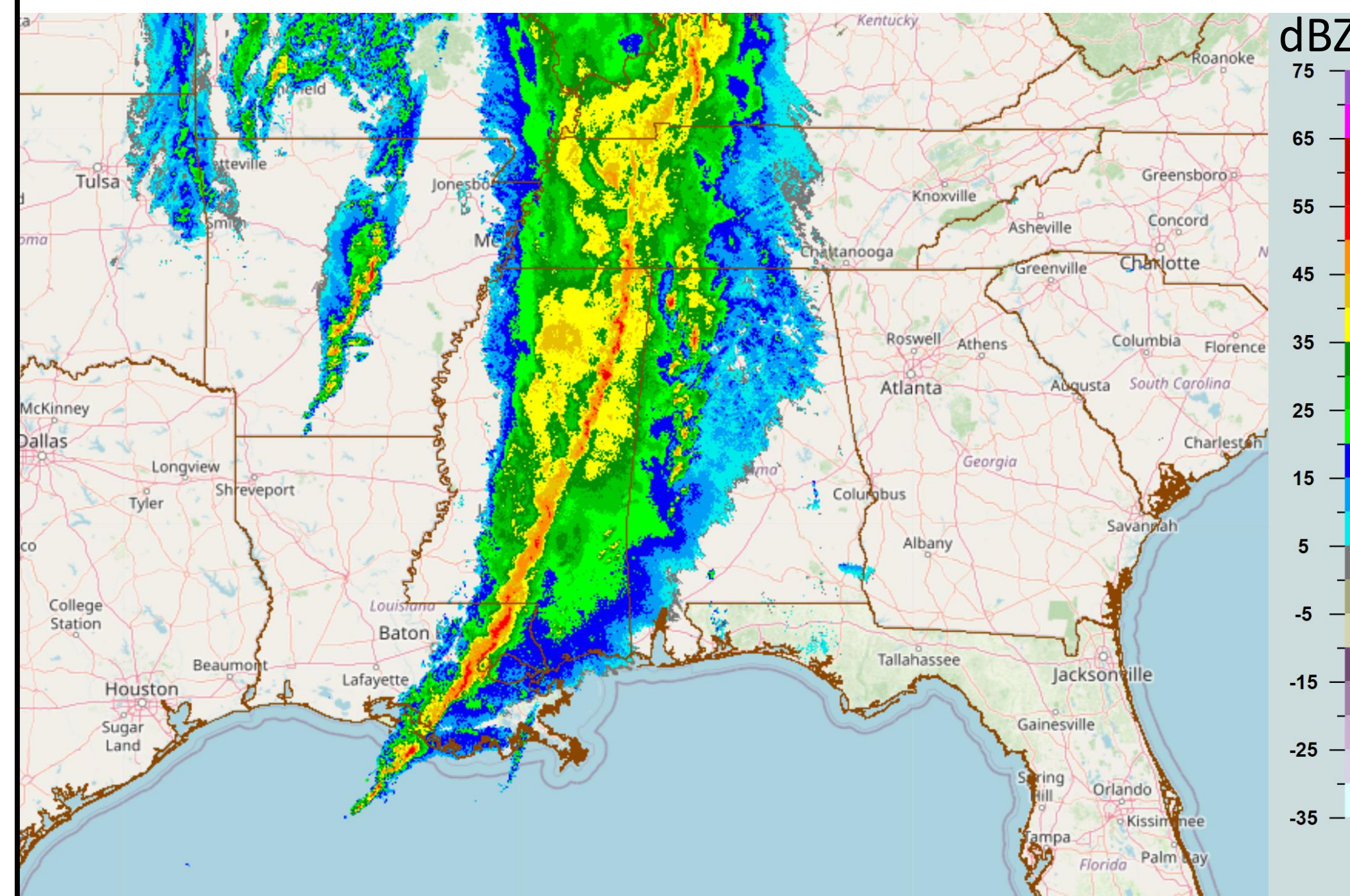
30 March 2022 Case Overview

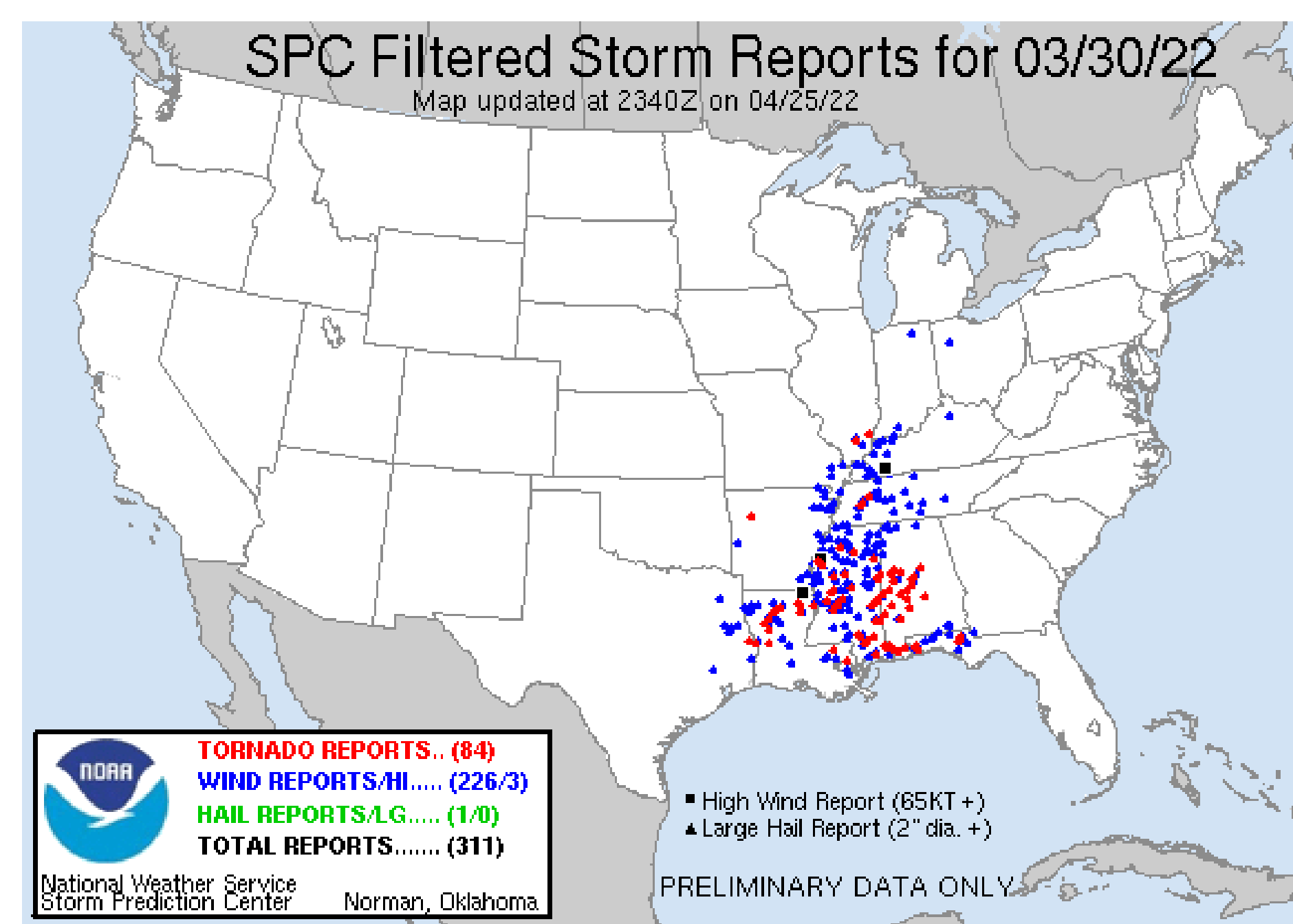FIG. 1. Reflectivity Mosaic at 23:52z on 30 March 2022

FIG. 2. Filtered storm reports from the Storm Prediction Center for 12z 30 March – 12z 31 March 2022

Methods

- Analyzed the 30 March 2022 QLCS using data from a mobile C-band (COW1), several mobile X-bands (DOWs), and a nearby NEXRAD WSR-88D radar
- Calculated radial convergence and azimuthal shear
- Computed dual-doppler lobes between COW1 & KGWX, COW1 & DOW7, and COW1 & SMART-R 2 (SR2)
- Identified mesovortices suitable for a dual-doppler synthesis (derivation of the 3D wind field)

FIG. 3. UIUC FARM's mobile C-band radar (COW1). Photo by Josh Aikens

Next Steps

- Finish a dual-doppler synthesis on the 23:51z mesovortex between the COW1 & KGWX radars
- Examine the 3D wind field of the 23:51z mesovortex created in the dual-doppler synthesis for any clues as to which mesovortexgenesis mechanism is dominant. This will include investigating:
  - Vortex lines
  - Vortex depth
  - Vortex vertical continuity
- Acquire SR2 data for a dual-doppler synthesis on the 00:30z 30 March 2022 mesovortex
- Examine year 2 quality-controlled data, specifically 3 March 2023 in which horizontal shearing instability may have been a major factor in mesovortex development
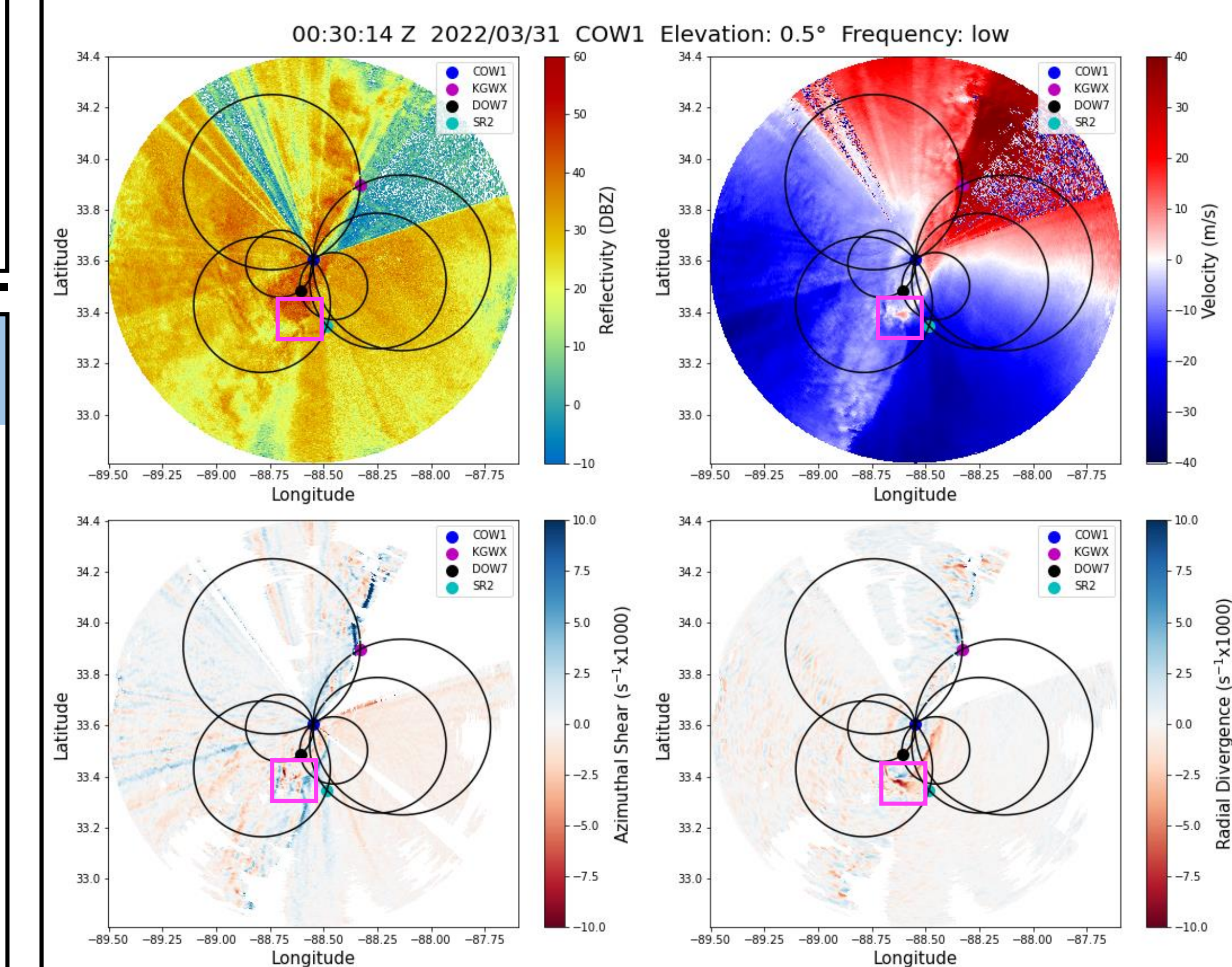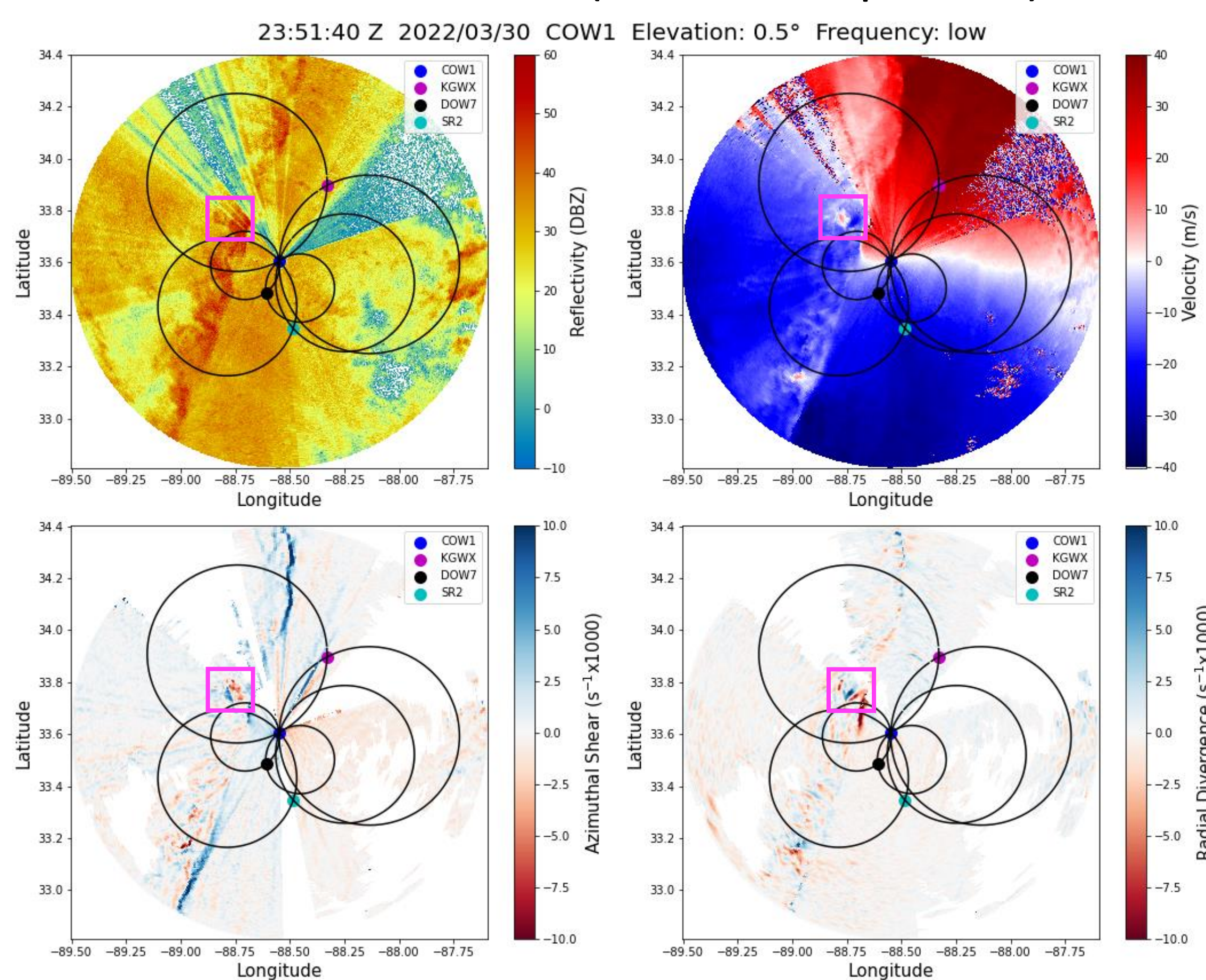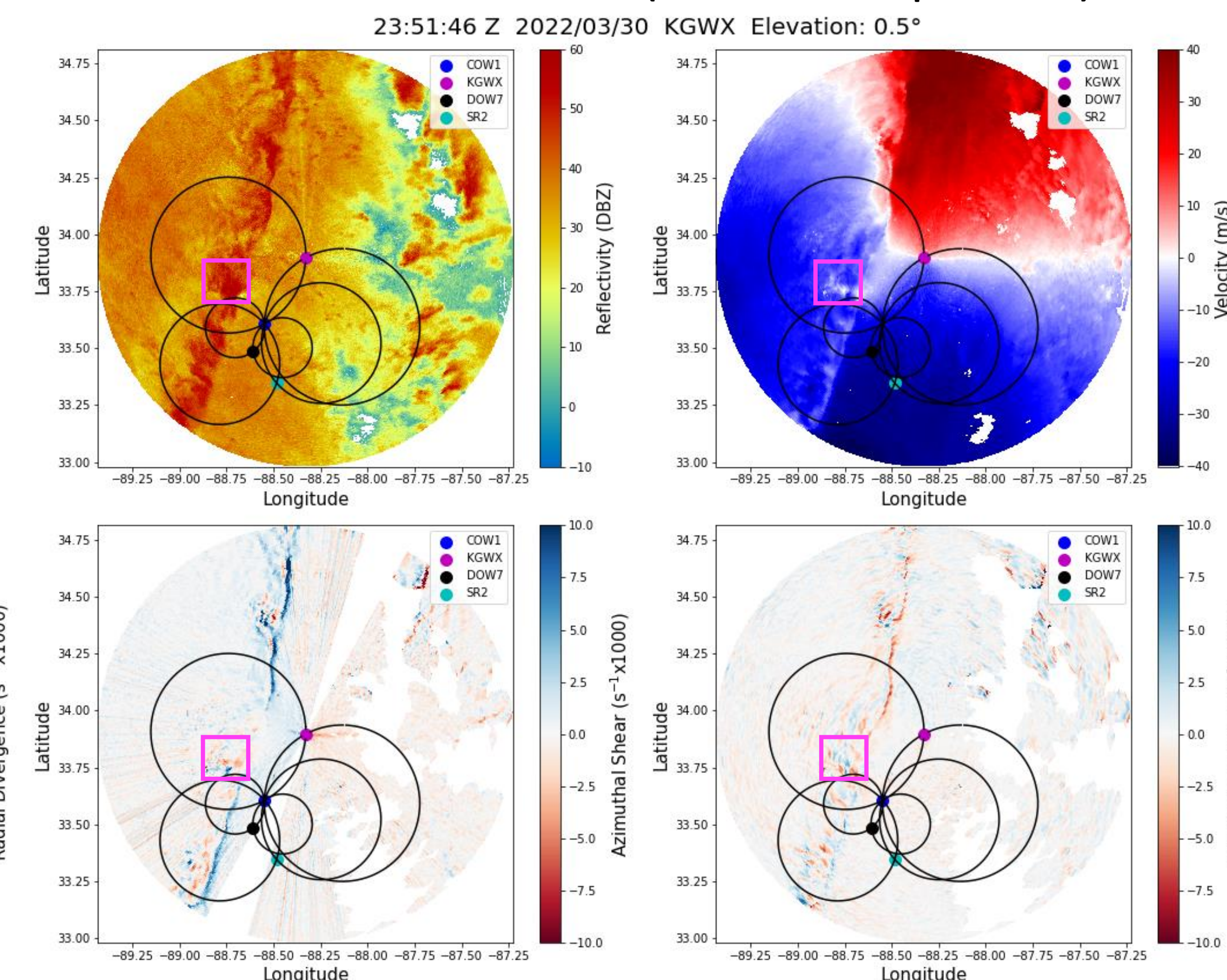
00:30z Mesovortex (COW1 Perspective)

FIG. 6. As is figure 4 but for another mesovortex occurring at 00:30:14z

Preliminary Results

23:51z Mesovortex (COW1 Perspective)

23:51z Mesovortex (KGWX Perspective)

FIG. 4. (Left) From the perspective of the COW1 radar: Reflectivity (upper left), radial velocity (upper right), azimuthal shear (lower left), radial divergence (lower right) for the COW1 radar on 30 March 2022 (IOP2). Dual-doppler lobes are represented by the black contours. The COW1, KGWX, DOW7, and SR2 radar locations are represented by the blue, magenta, black, and cyan points, respectively.

FIG. 5. (Right) As in figure 4 but from the perspective of the KGWX radar

Preliminary Thoughts

- In the azimuthal shear plot, **the pink box represents a cyclonic/anticyclonic vortex pair, which is our feature of interest for performing a dual-doppler synthesis (derivation of the 3D wind field).** This allows us to investigate the Trapp and Weisman (2003) mesovortexgenesis mechanism (theory 1).

- Very strong radial convergence present near the mesovortex as well as others not pictured.

- Cyclonic azimuthal shear present along much of the gust front throughout this case

- DOW data is very heavily attenuated, such that mesovortex velocity returns were lost

Acknowledgements

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