Evaluation of Azimuthal Shear, Divergence Shear, and Velocity Gradient Products Derived from WSR-88D Base Velocity Data to Assess QLCS Severity

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Acknowledgements
Thea Sandmael, Kiel Ortega, Brandon Smith
CIMMS / NSSL

Derived Velocity Products for QLCS Interrogation

The Challenge

Traditional radar storm interrogation utilizes “Base” Velocity Data

- *Radial Velocity (V)*
- *Storm Relative Radial Velocity (SRV)*

Key features must be “manually” identified

- *Rotation - cyclonic azimuthal shear; V increasing with azimuth*
  - *Seen as a V “Couplet”*
- *Low Altitude Radial Convergence - V decreasing with range*
- *Mid Altitude Radial Convergence (MARC) - same as above*
- *High Altitude (Storm Top) Radial Divergence - V increasing with range*

Derived Velocity Products for QLCS Interrogation

Conceptual Models

Rankine Vortex Model …

- Radial Velocity Properties
- Azimuthal Shear Properties
- Azimuthal Shear Couplets

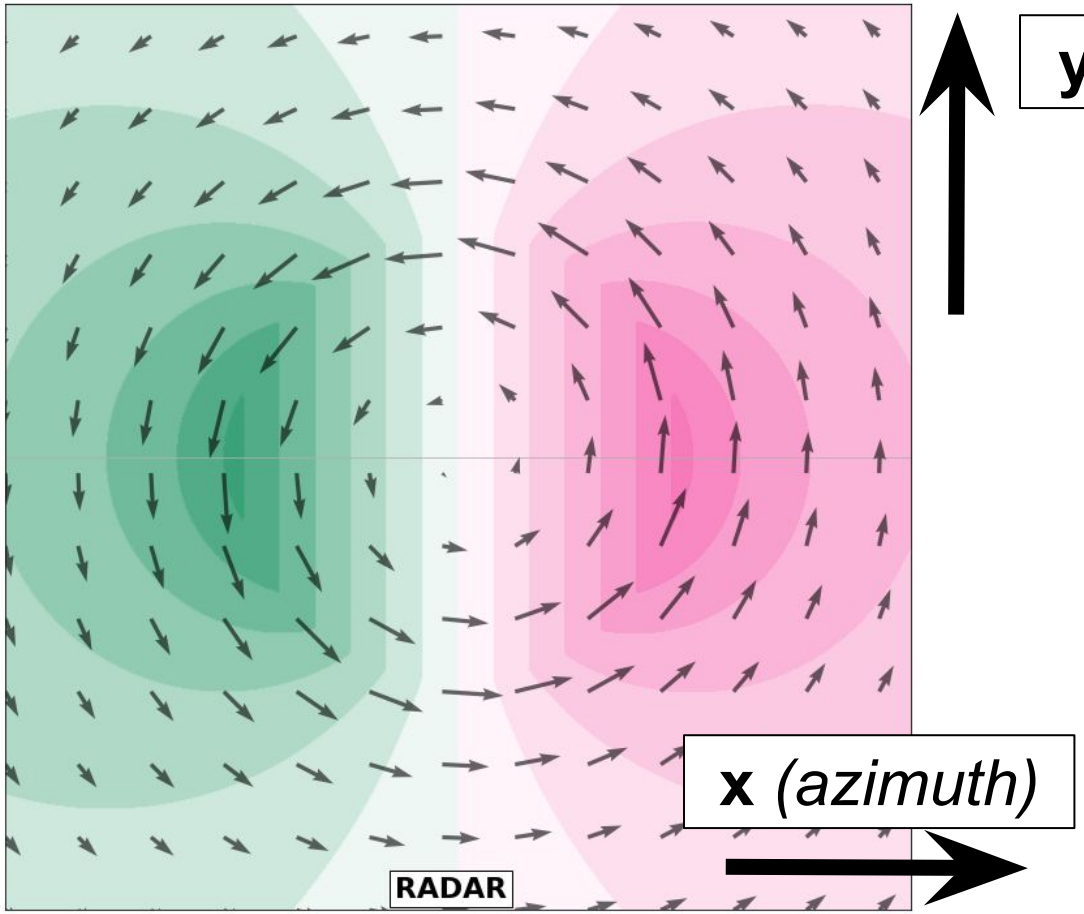
Radial Convergence Model ...

- Divergence Properties
- Divergence Shear Properties

Velocity Gradient …

- Interpreting Imbalanced Flow

Derived Velocity Products for QLCS Interrogation



y *(range)*

x *(azimuth)*

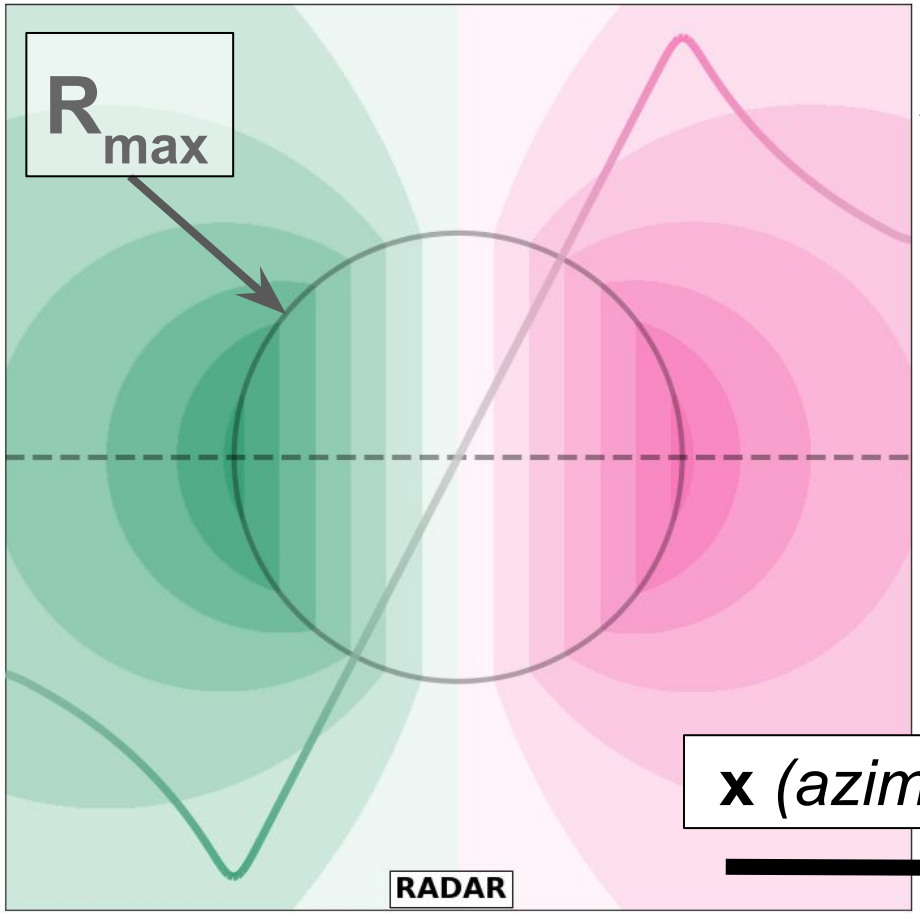
Radial Velocity (v)

Rotation inferred from couplet

Inbound (-v)

Outbound (+v)

Derived Velocity Products for QLCS Interrogation



y *(range)*

Rankine Vortex Model

$$r = \sqrt{x^2 + y^2}$$

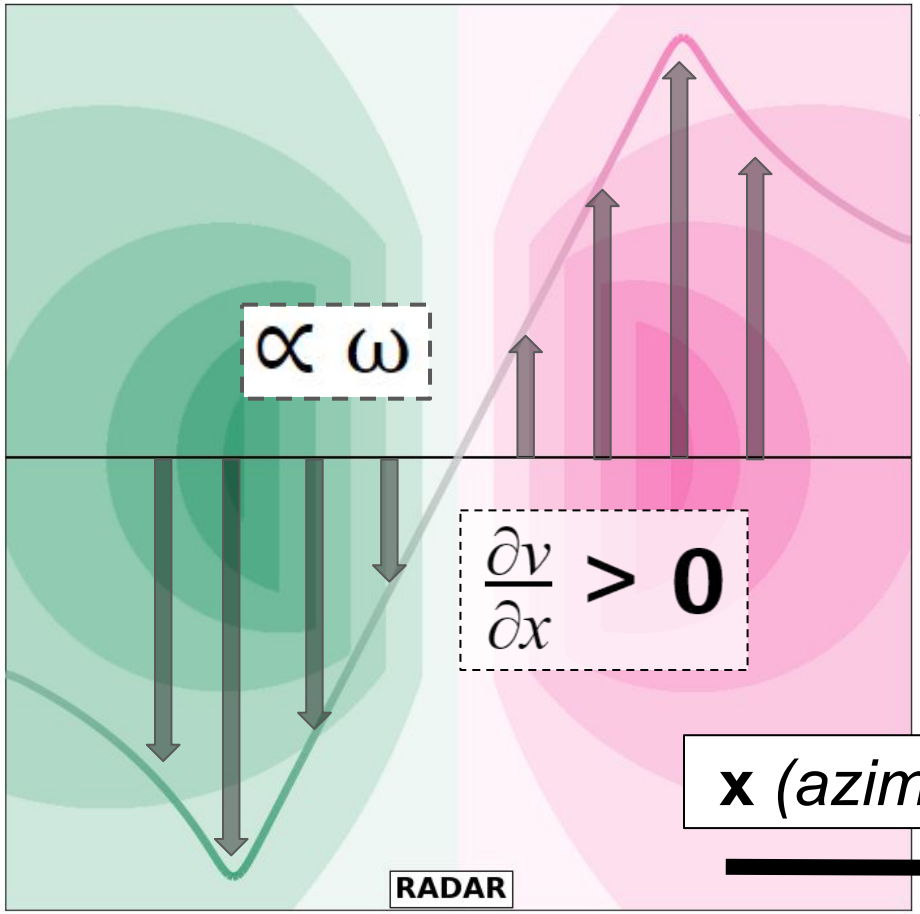
0

$r \leq R_{max} \rightarrow v \propto r$

$r > R_{max} \rightarrow v \propto 1/r$

x *(azimuth)*

Derived Velocity Products for QLCS Interrogation



y *(range)*

x *(azimuth)*

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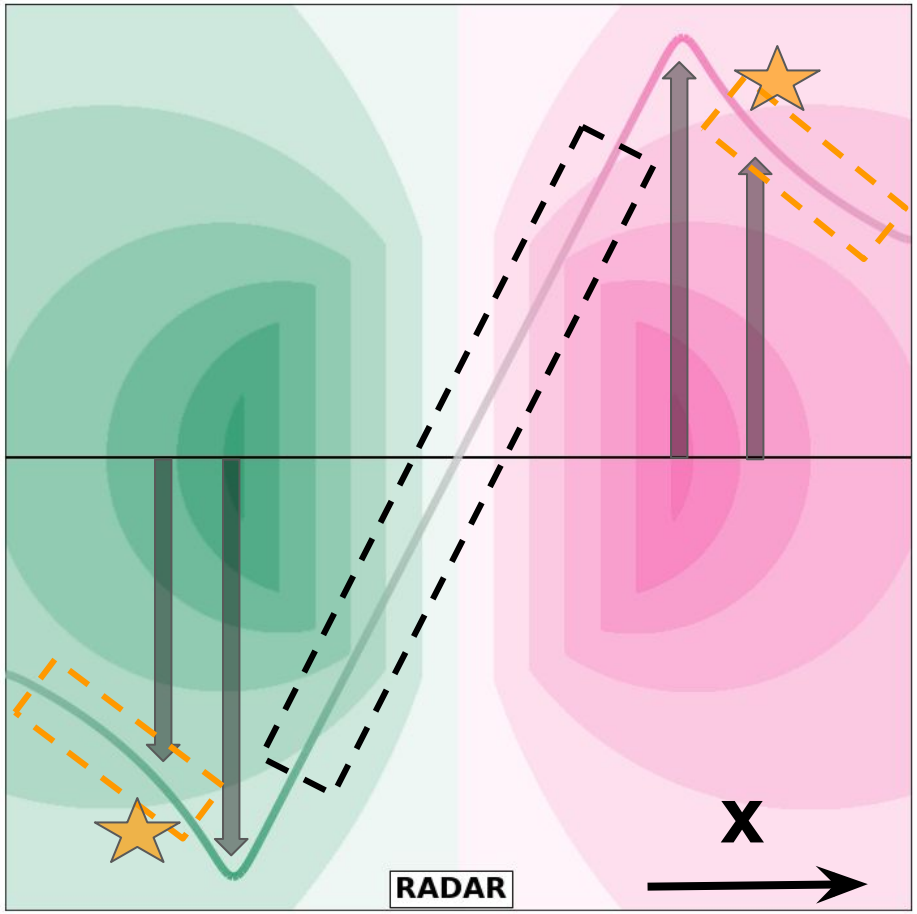


Azimuthal Shear from v

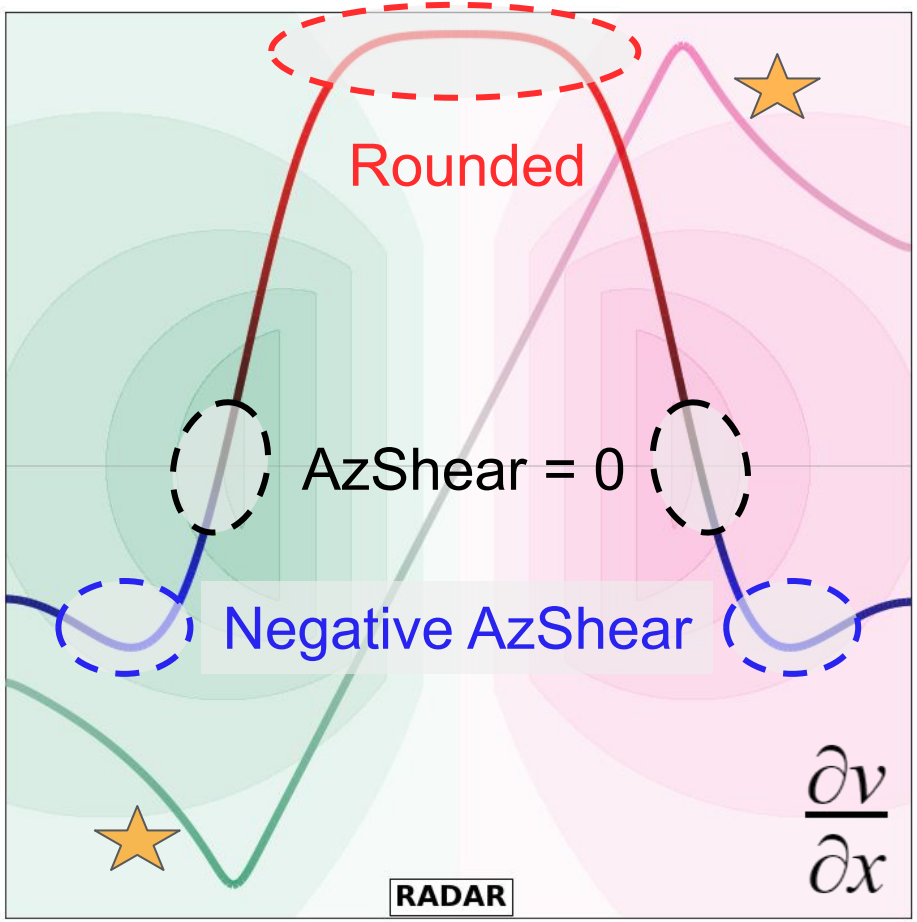
$\frac{\partial v}{\partial x} > 0$ ***Positive Shear***

$\propto \omega$

$\frac{\partial v}{\partial x} < 0$ ***Negative Shear***

Most Negative

Derived Velocity Products for QLCS Interrogation



0

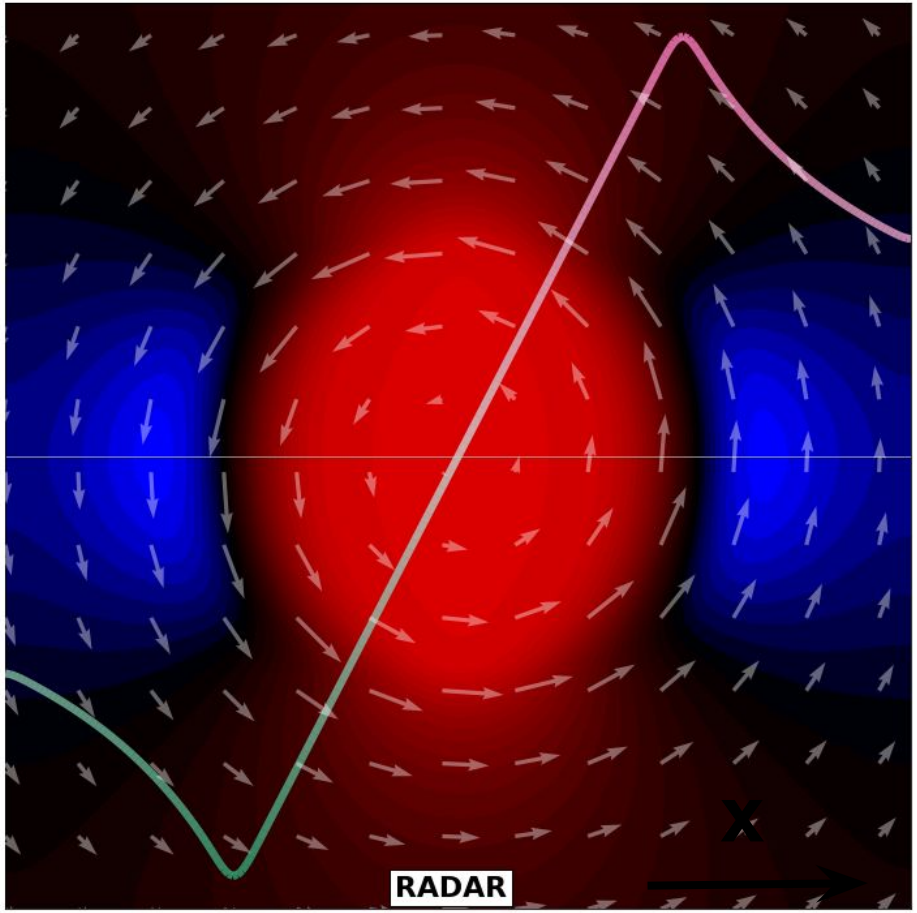
Azimuthal Shear

(and GR2Analyst NROT)

Gaussian Smoothing

$\frac{\partial v}{\partial x}$ (Cartesian equivalent)

Derived Velocity Products for QLCS Interrogation

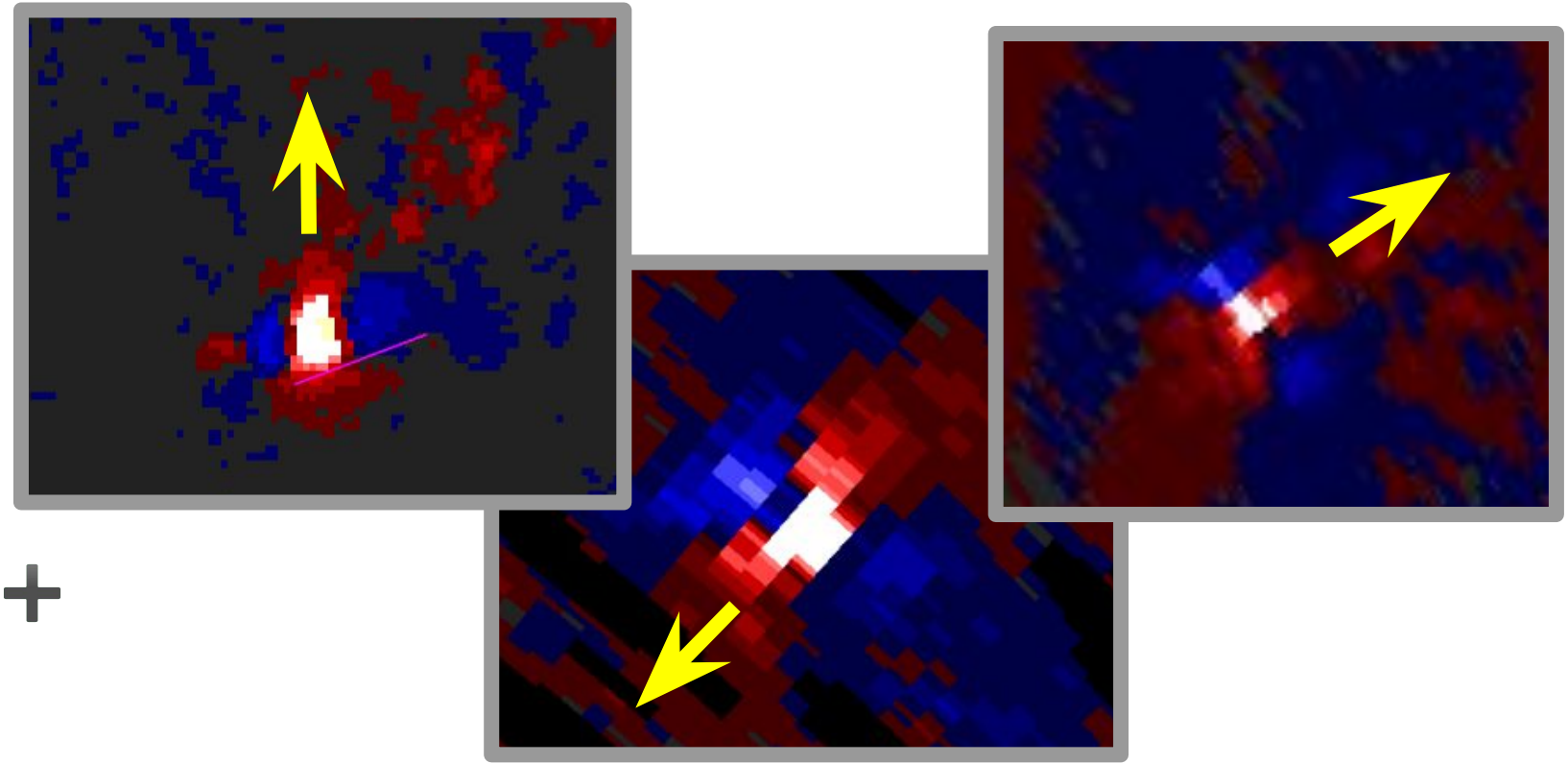


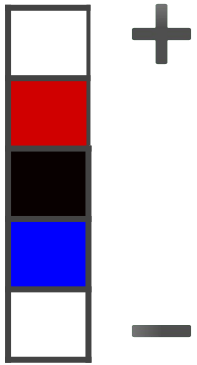
Azimuthal Shear (Gaussian Smoothed)

	Positive
	Zero
	Negative

$$\frac{\partial v}{\partial x}$$

Derived Velocity Products for QLCS Interrogation



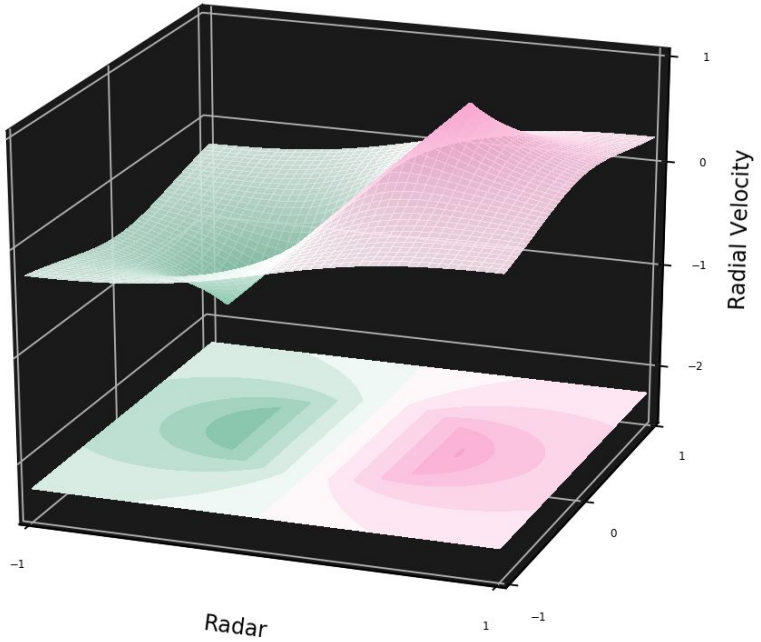


https://blog.nssl.noaa.gov/ewp/topic/azshear/

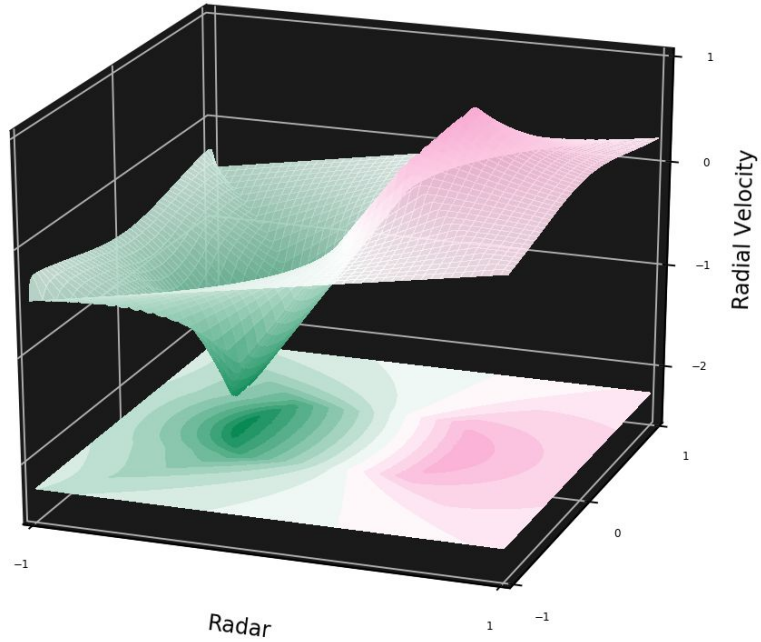
Derived Velocity Products for QLCS Interrogation

Radial Velocity Inbound Surge

Balanced



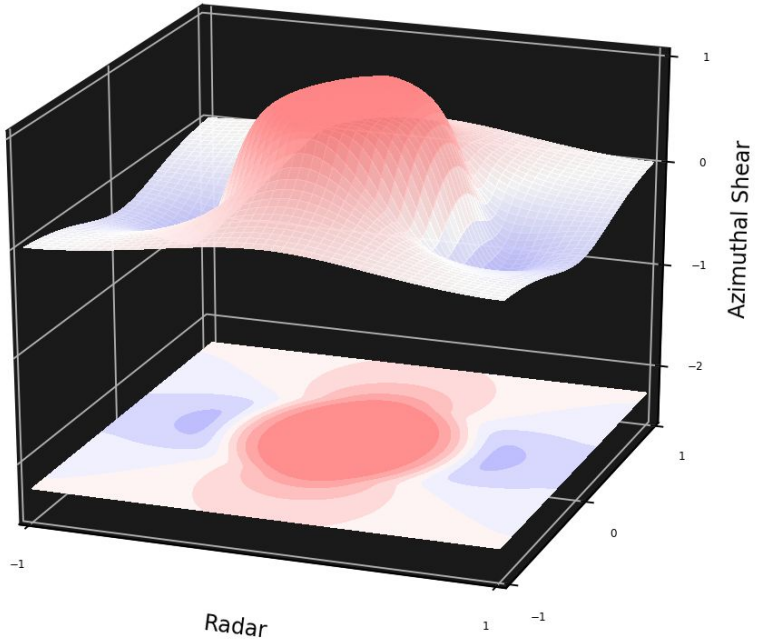
Surged



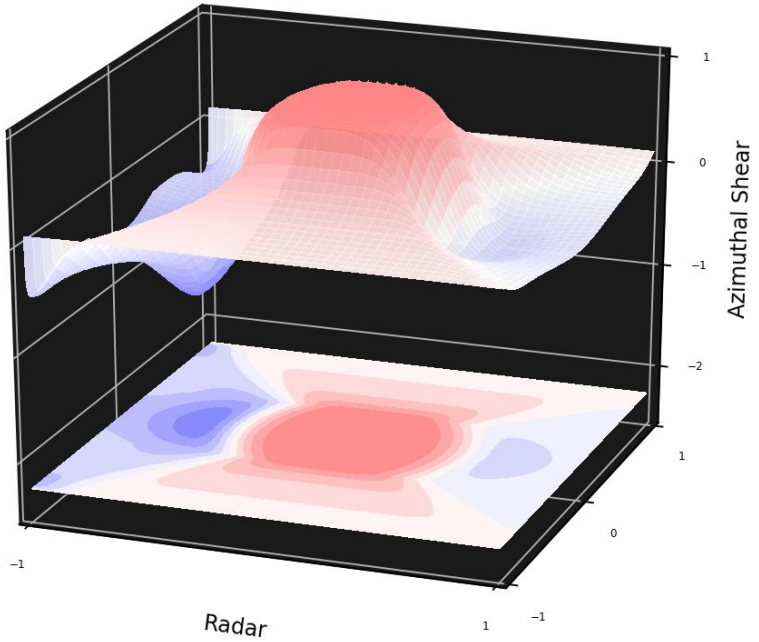
Derived Velocity Products for QLCS Interrogation

Azimuthal Shear Inbound Surge

Balanced



Surged



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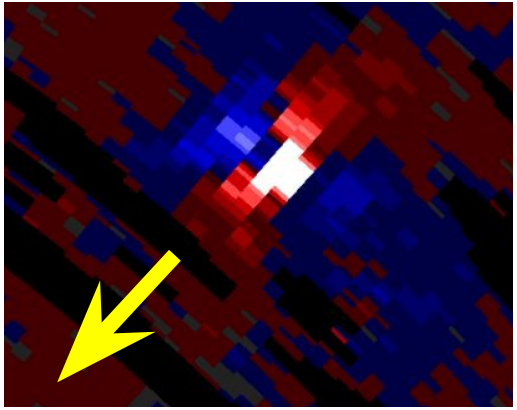
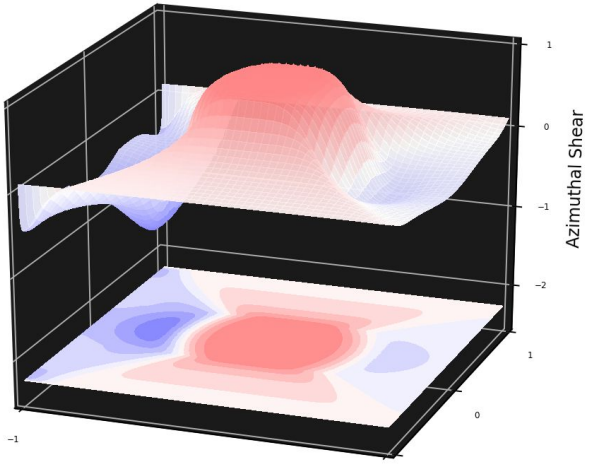
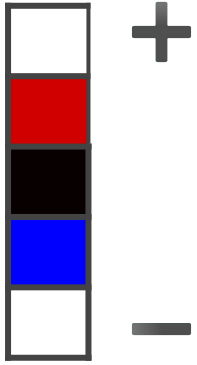


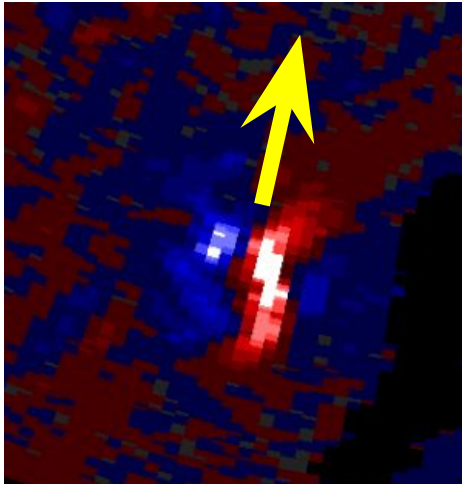
Azimuthal Shear Inbound Surge

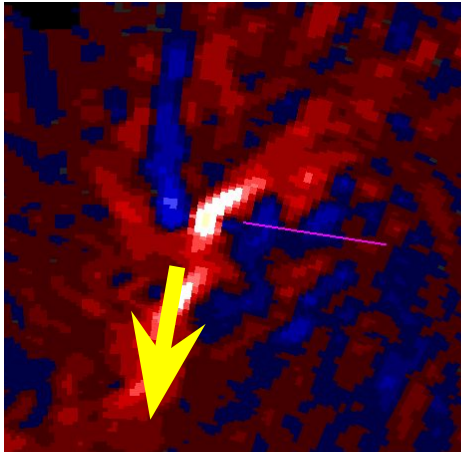
Direction to radar

(Not that it matters!)



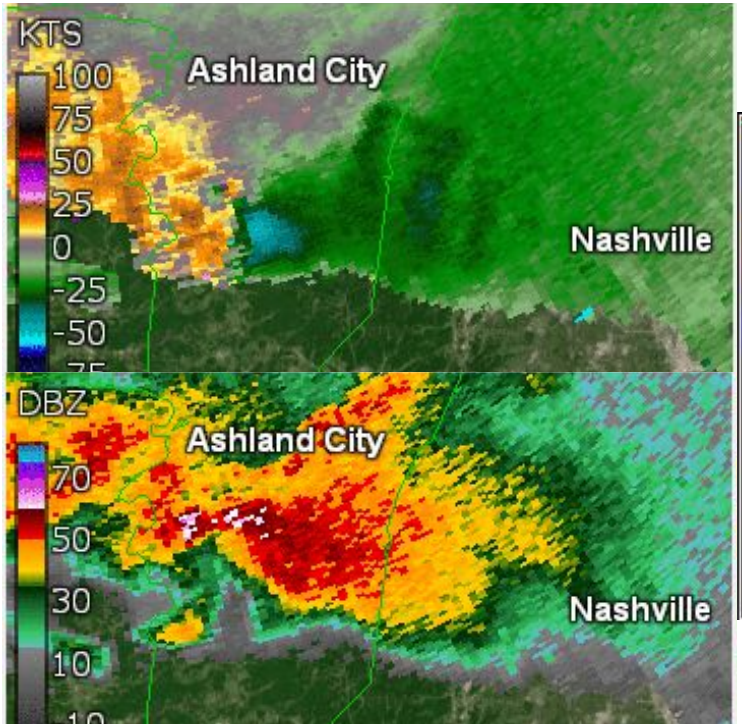




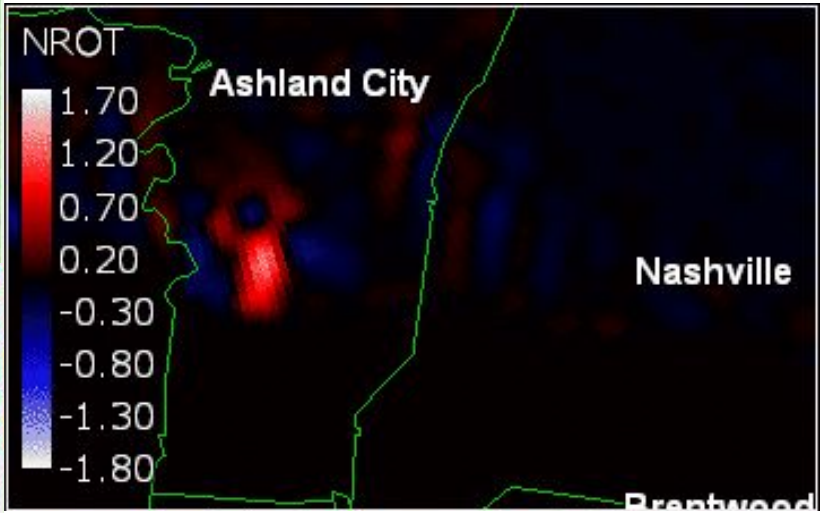


Derived Velocity Products for QLCS Interrogation

Azimuthal Shear Inbound Surge



Nashville 03/03/2020



Derived Velocity Products for QLCS Interrogation

Azimuthal Shear (AzShear) Takeaways

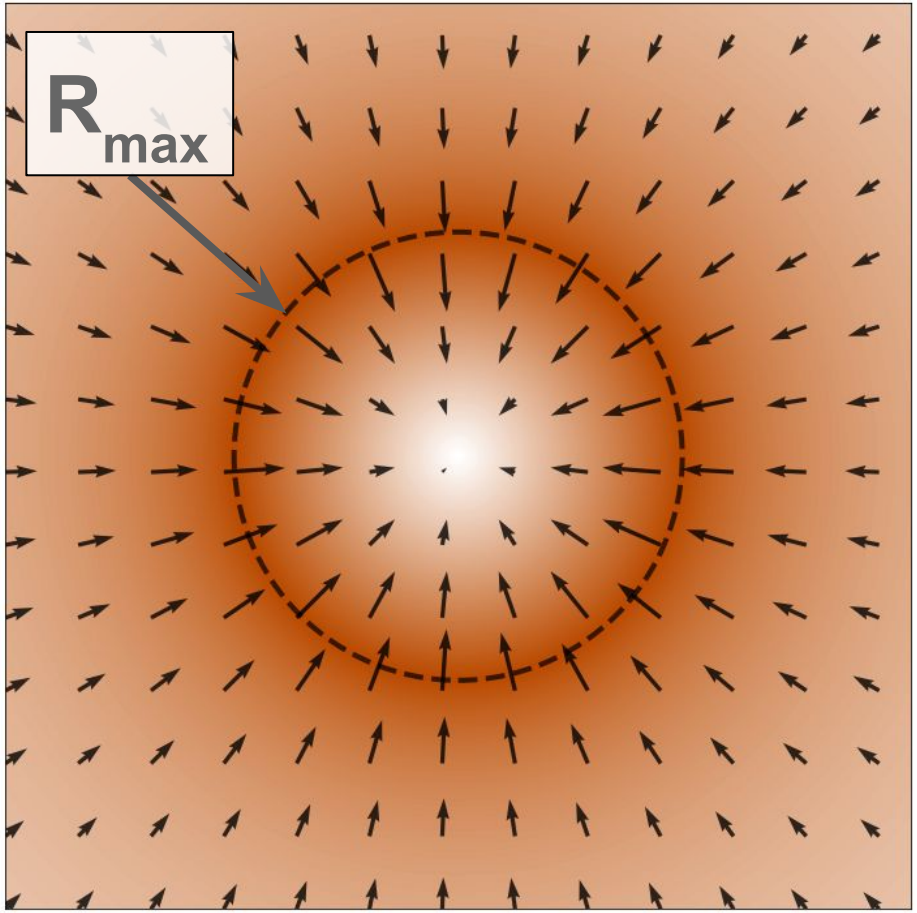
Max **Azshear** located between **Max v_{in}** and **Max v_{out}**

Zero **Azshear** found at **Max v_{in}** & **Max v_{out}** radii

Negative **Azshear** ring just beyond **Max v_{in}** & **Max v_{out}** radii

Azshear *couplets* are seen with Wind surges (RFDs, Bow echoes)

Derived Velocity Products for QLCS Interrogation



Convergence

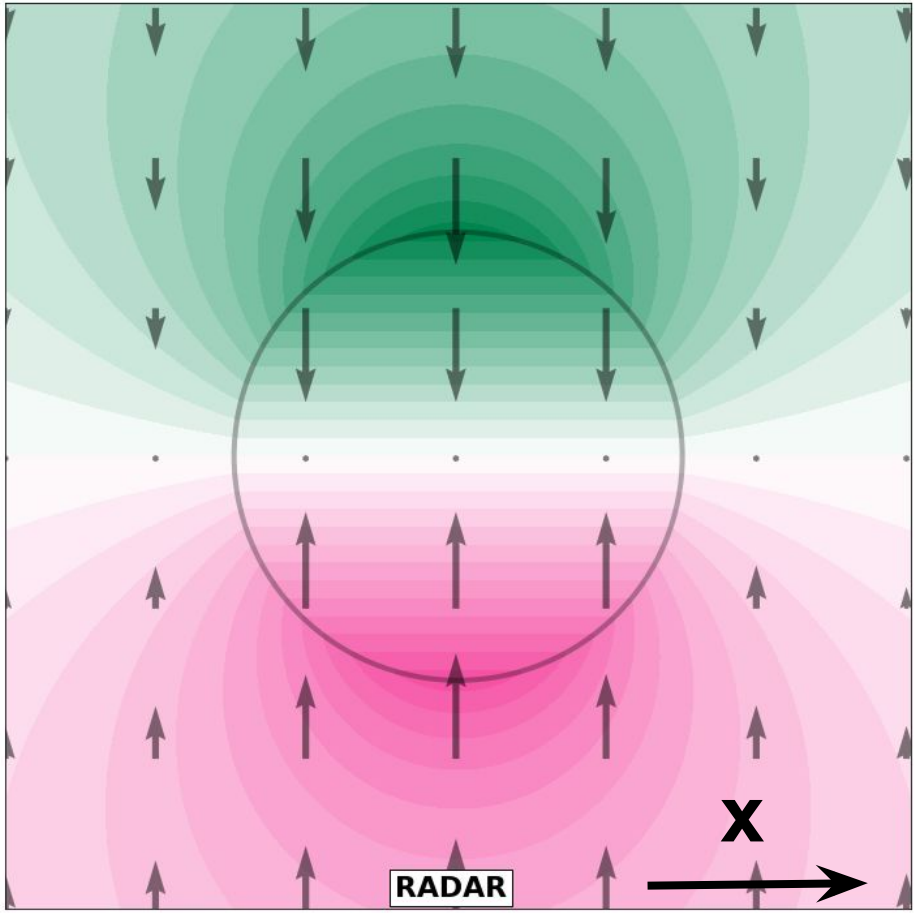
Also Using
Rankine Vortex Model

$$r = \sqrt{x^2 + y^2}$$

$r \leq R_{max} \rightarrow conv \propto r$

$r > R_{max} \rightarrow conv \propto 1/r$

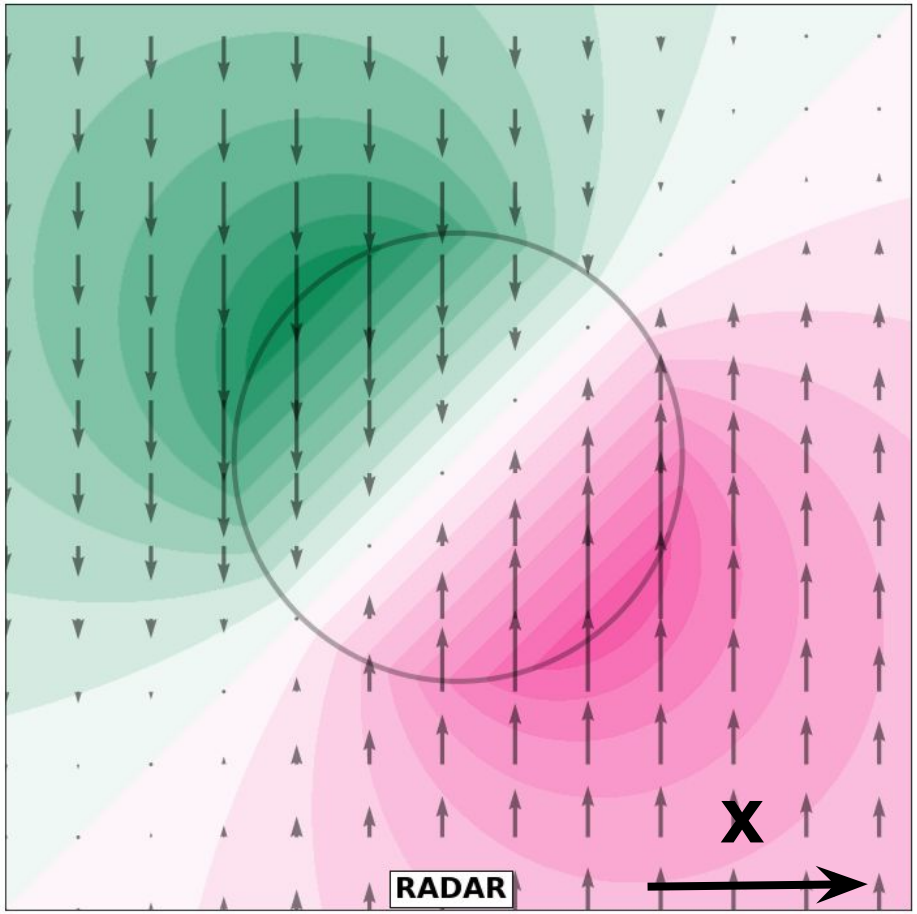
Derived Velocity Products for QLCS Interrogation



Rankine

Radial Convergence

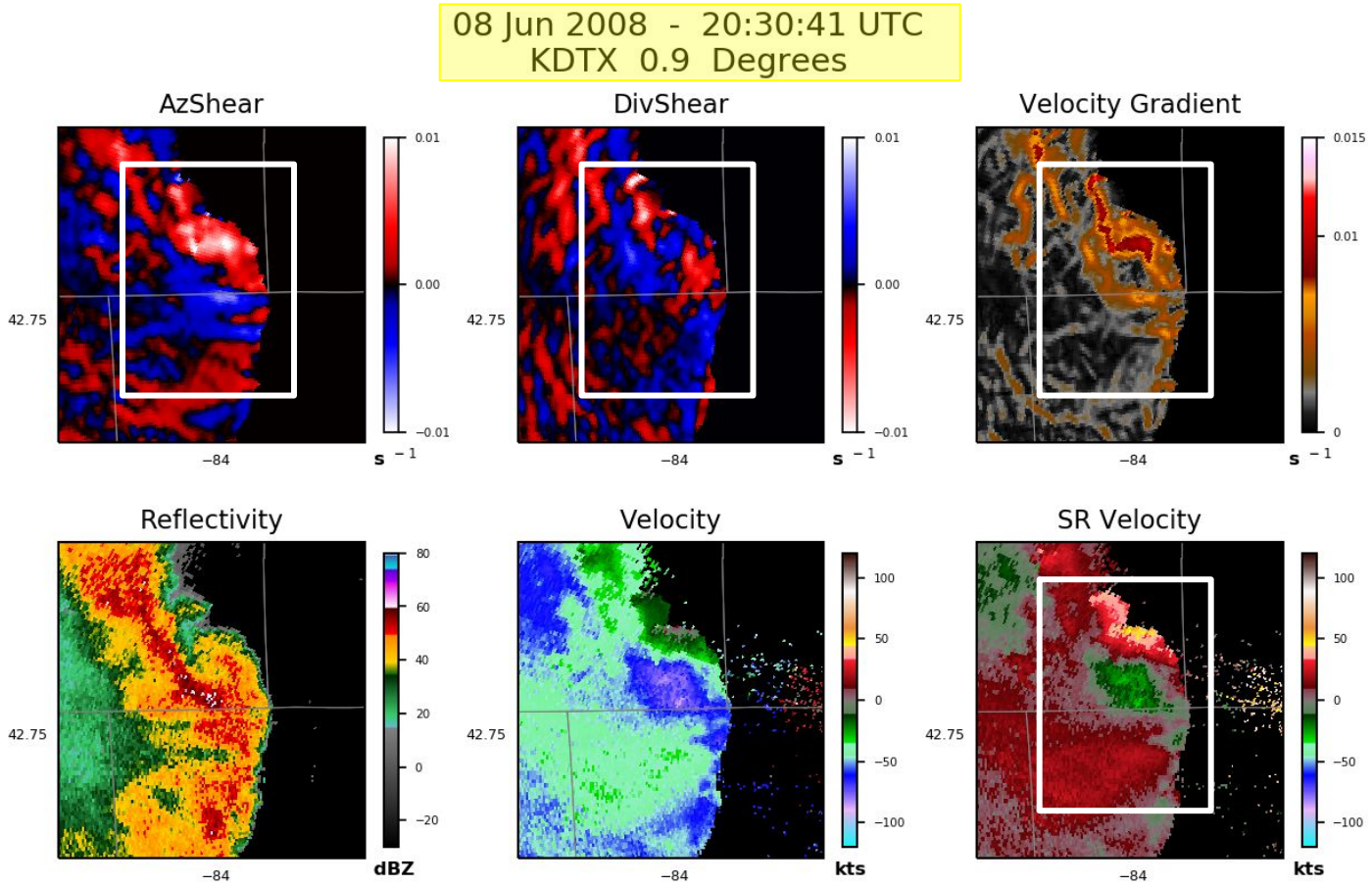
Derived Velocity Products for QLCS Interrogation



Rankine

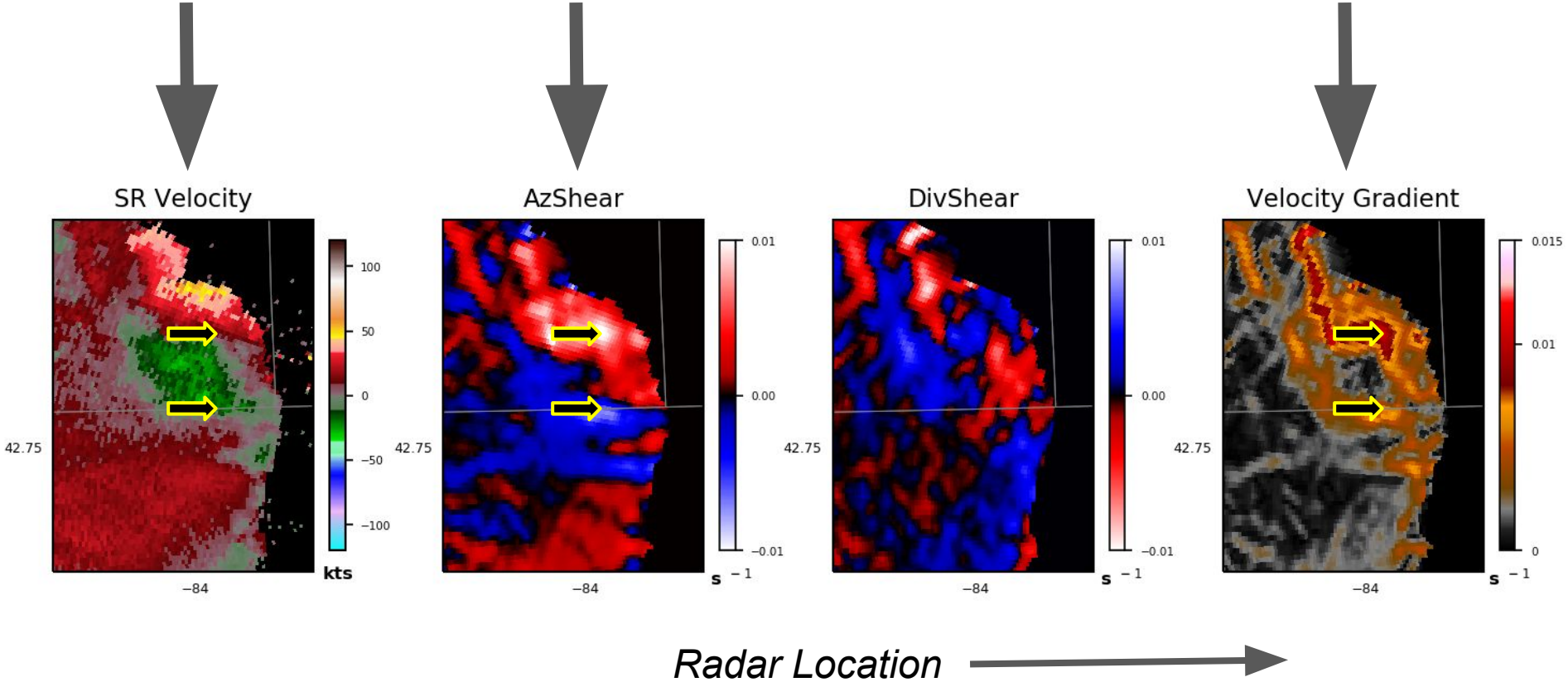
Convergence + Rotation

Derived Velocity Products for QLCS Interrogation



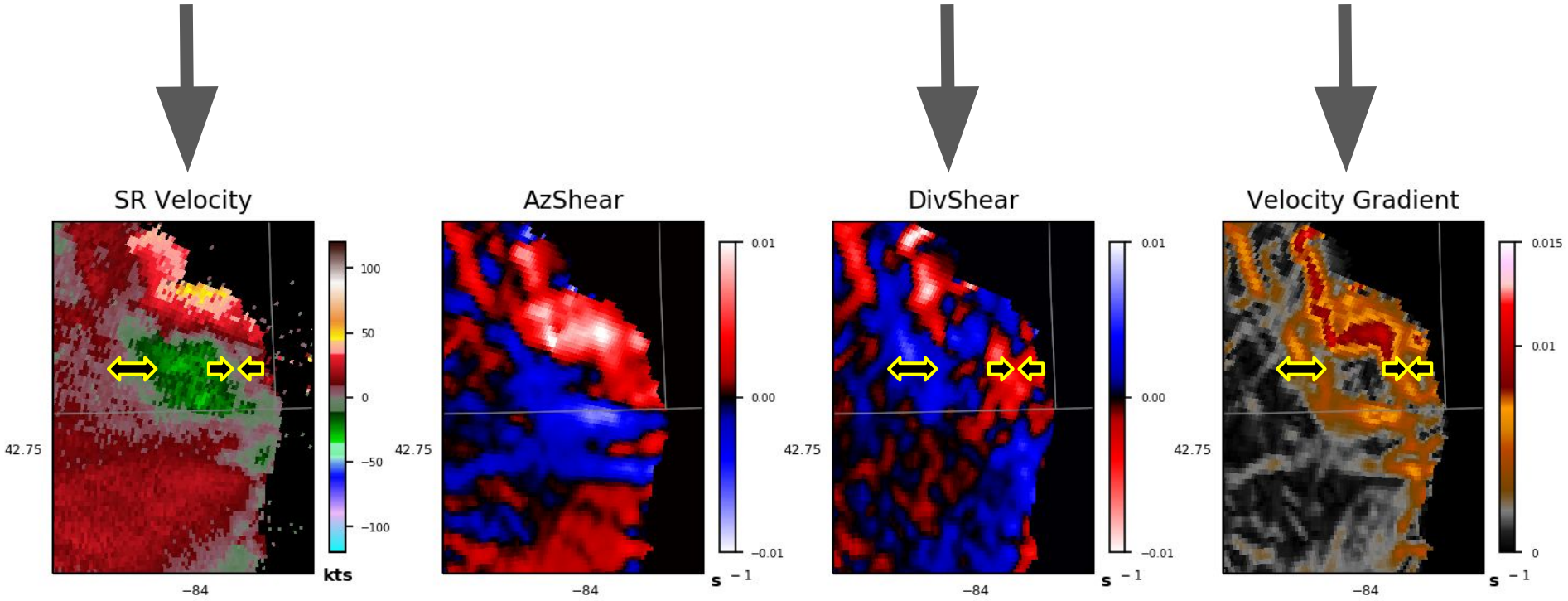
Derived Velocity Products for QLCS Interrogation

Azimuthal Shear Contribution to Velocity Gradient



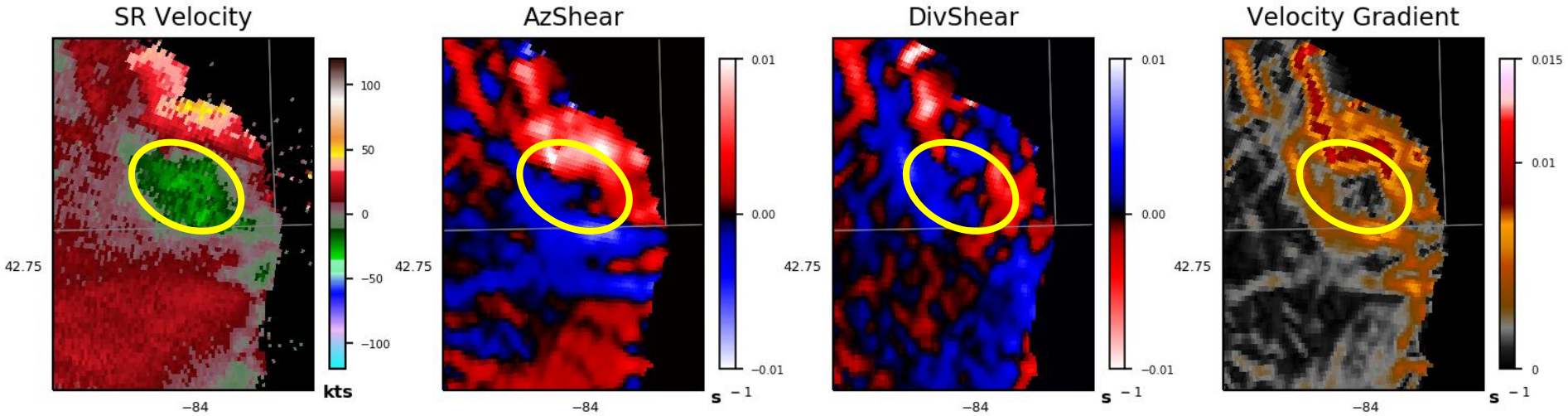
Derived Velocity Products for QLCS Interrogation

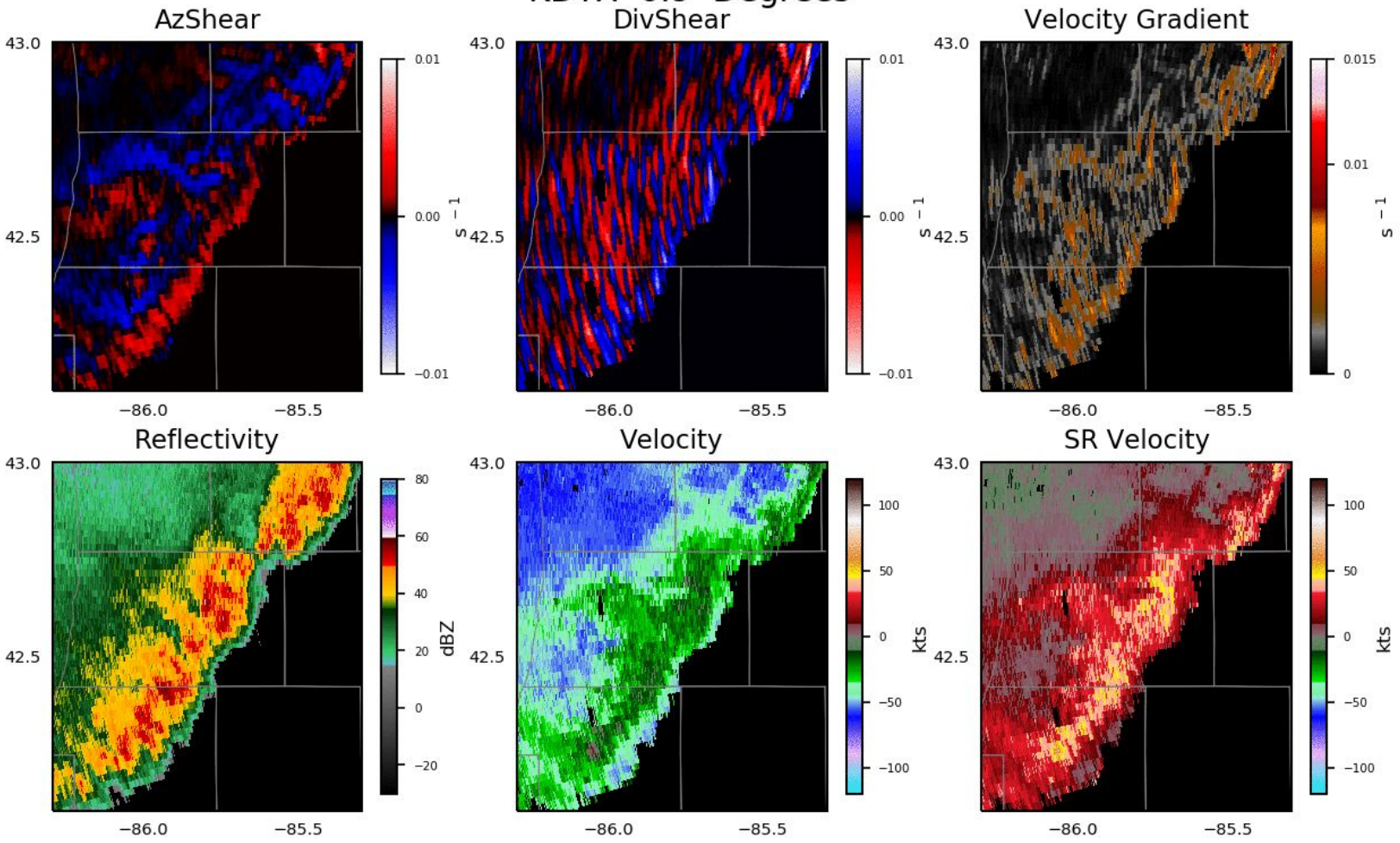
Divergence Shear Contribution to Velocity Gradient

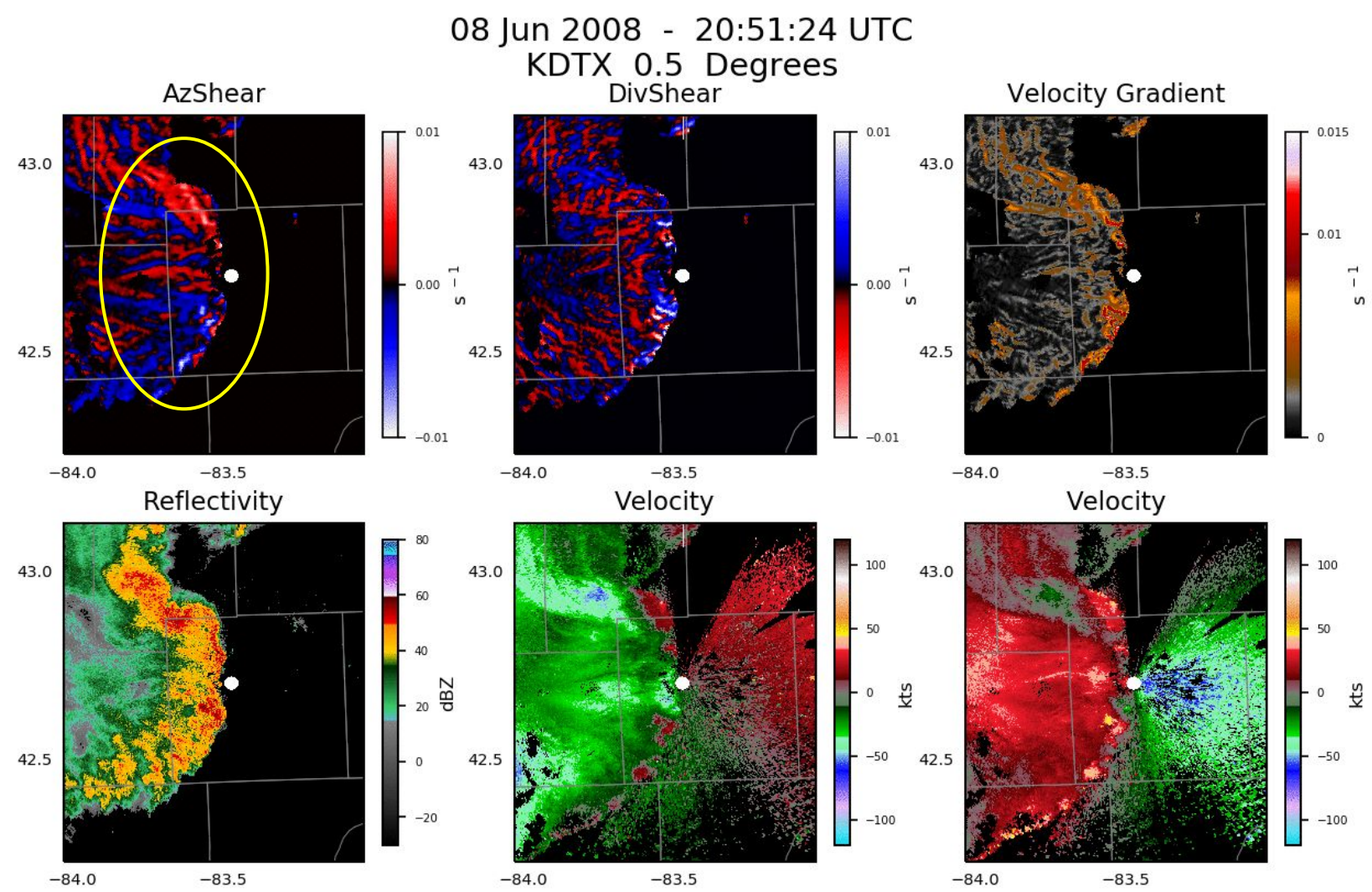


Derived Velocity Products for QLCS Interrogation

Velocity Gradient Ring from AzShear/DivShear Couplets

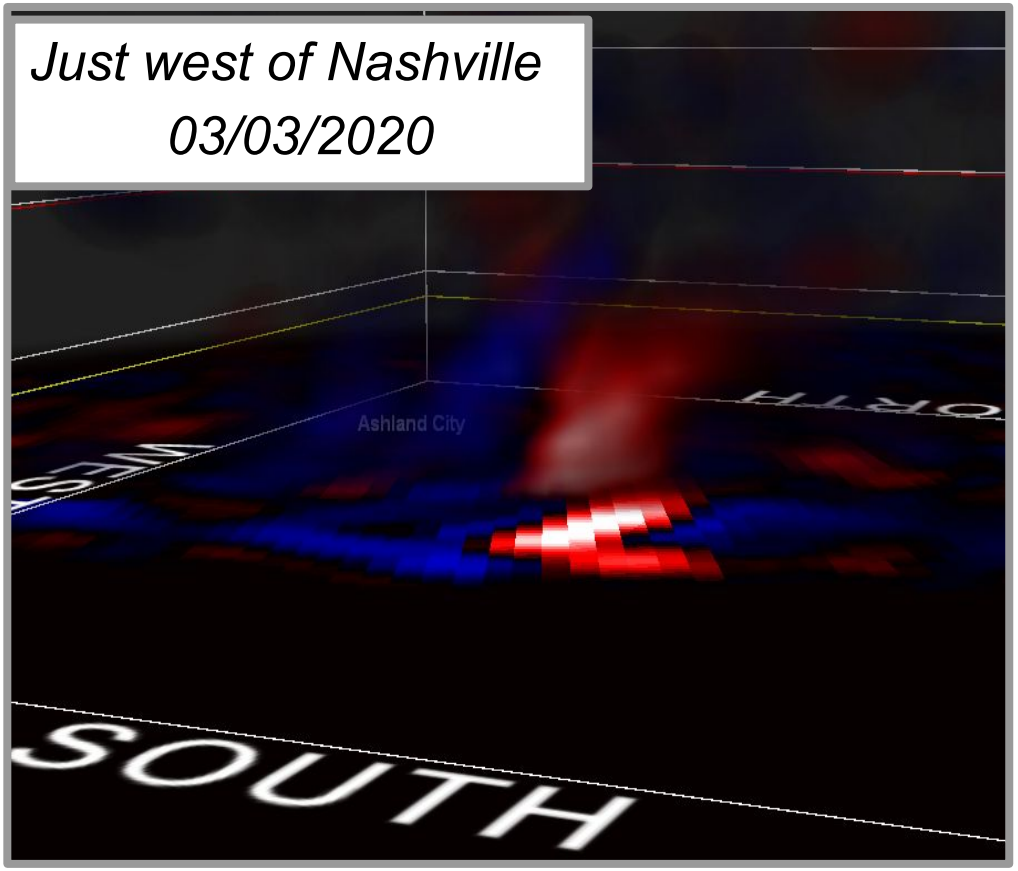



08 Jun 2008 - 19:04:37 UTC
KDTX 0.9 Degrees
AzShear
DivShear
Velocity Gradient
Reflectivity
Velocity
SR Velocity
43.0
42.5
−86.0
−85.5
0.01
0.00
−0.01
s − 1
0.015
0
80
60
40
20
dBZ
100
50
−50
−100
kts


08 Jun 2008 - 20:51:24 UTC
KDTX 0.5 Degrees
AzShear
DivShear
Velocity Gradient
Reflectivity
Velocity
Velocity
43.0
42.5
−84.0
−83.5
0.01
0.00
−0.01
s −1
0.015
0
dBZ
80
60
40
20
0
−20
kts
100
50
−50
−100

Derived Velocity Products for QLCS Interrogation

Looking Ahead



single radar AzShear in AWIPS?

MARCs and storm top divergence

DivShear / Velocity Grad in 3D

New algorithms combining other moments

Thank You!

(and let me know if want me to run a case for you)

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