

How does the relationship between ambient deep-tropospheric vertical wind shear and tropical cyclone tornadoes change between coastal and inland environments?

Ben Schenkel (CIMMS/NSSL; benschenkel@ou.edu),
Michael Coniglio (NSSL), Roger Edwards (SPC)

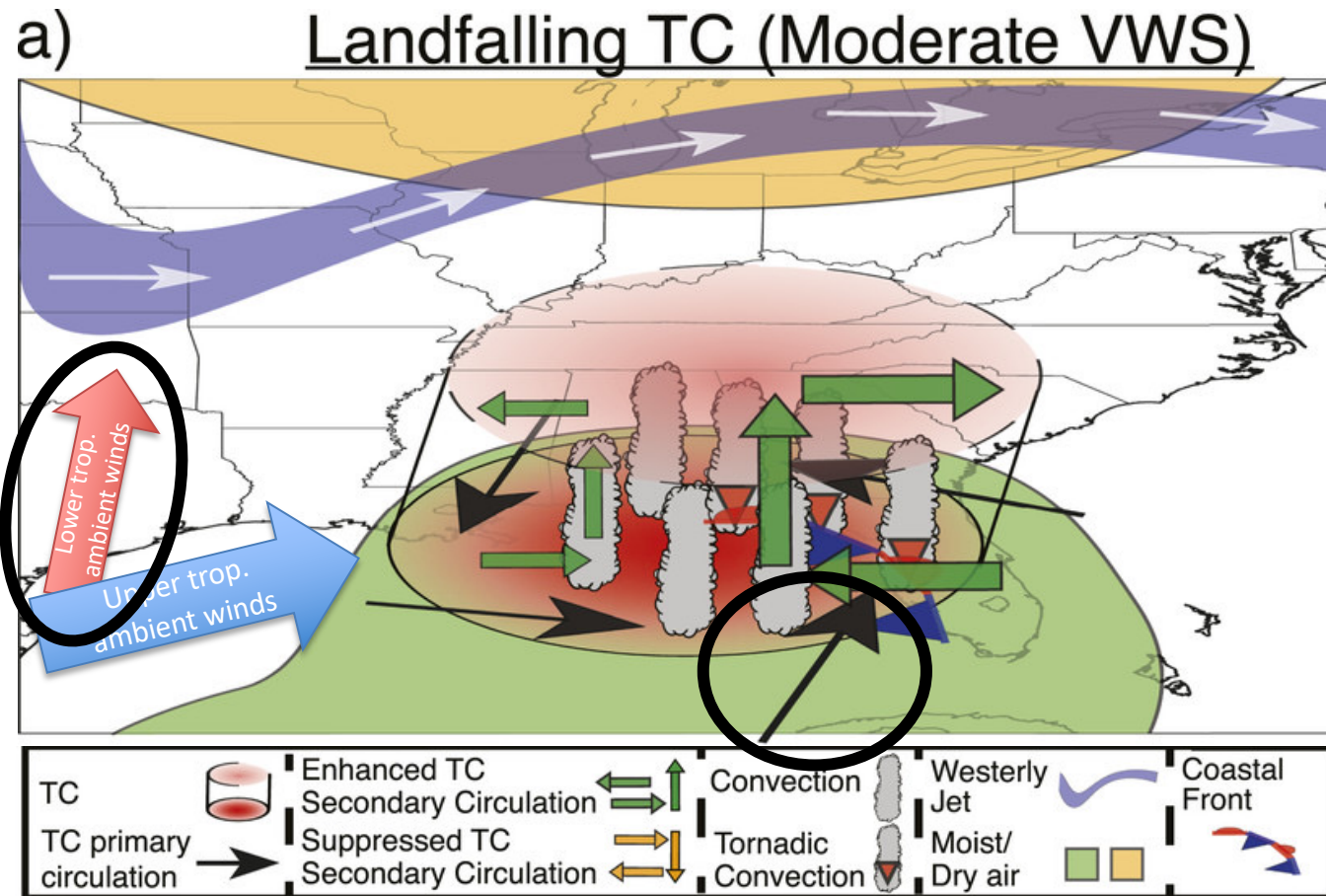
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Session: Hurricane Hazards at Landfall

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How Does Vertical Wind Shear Impact Tornadoes in Landfalling TCs?

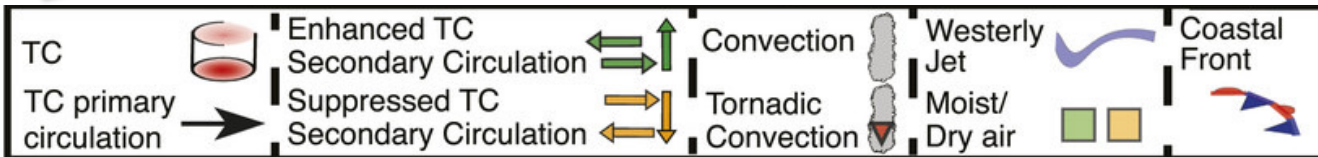
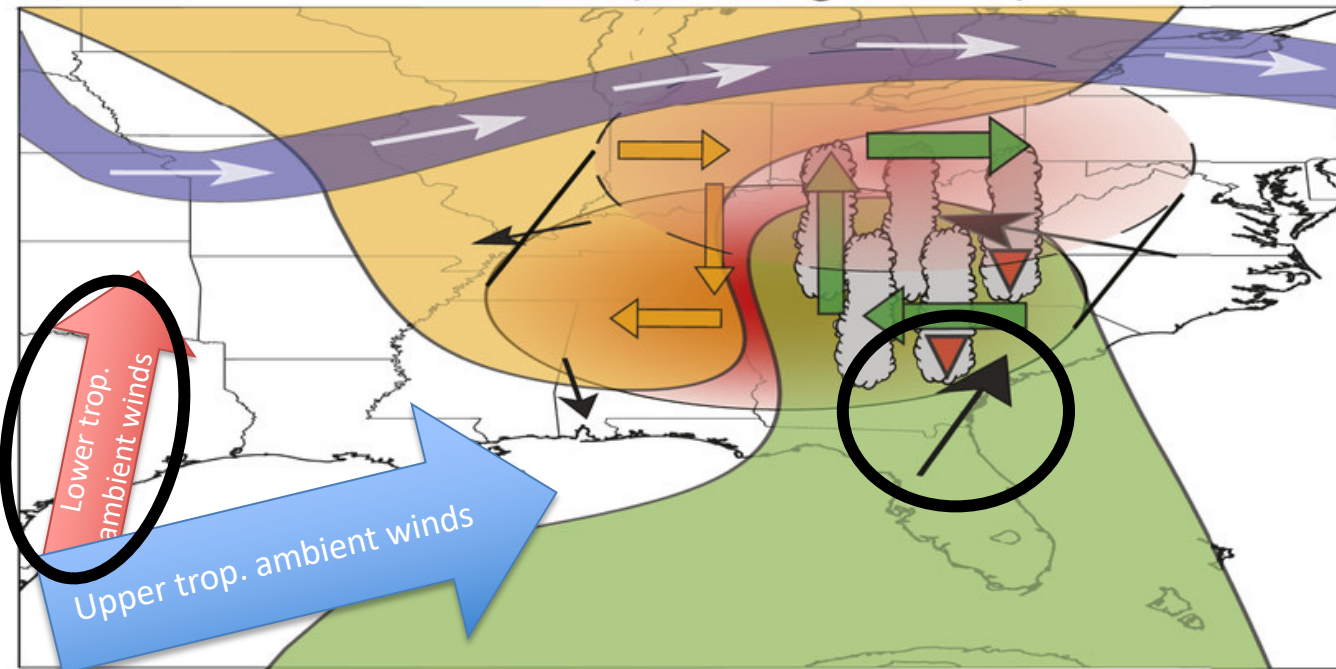


Schenkel,
Coniglio, and
Edwards (2021)

- Westerly vertical wind shear favors tornadoes in downshear half of TC due to (Schenkel et al. 2020):
 1. Enhancement of TC secondary circulation downshear (Black et al. 2002);
 2. Constructive superposition of ambient and TC winds (Molinari and Vollaro 2008).

How Does Vertical Wind Shear Impact Tornadoes in Landfalling TCs?

b) Inland TC (Strong VWS)

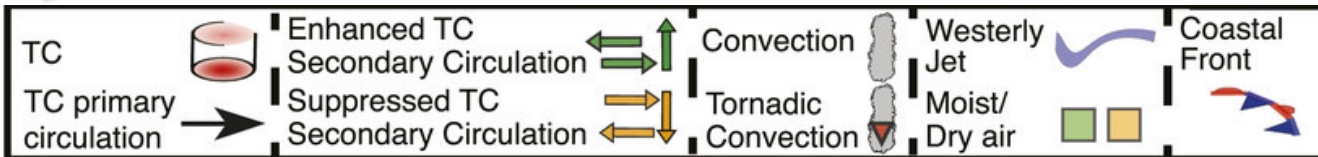
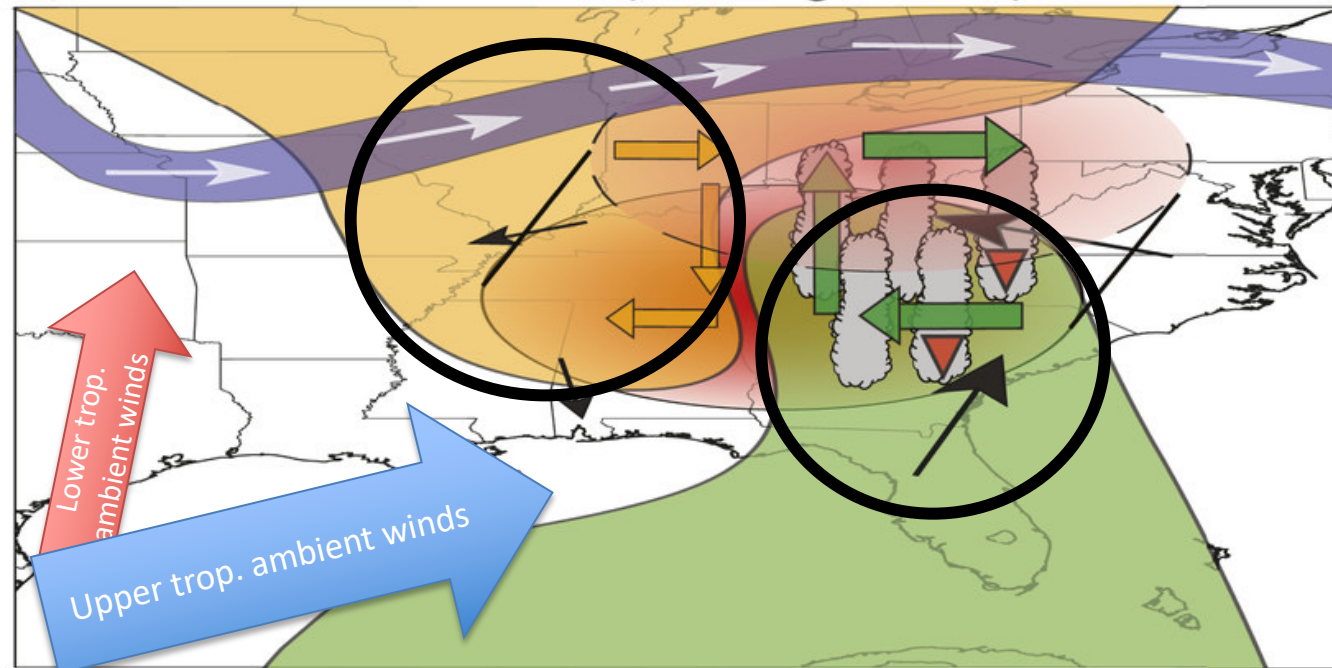


Schenkel,
Coniglio, and
Edwards (2021)

- Inland TC encounters stronger vertical wind shear further concentrating tornadoes downshear due to:
 1. Further enhancement of TC secondary circulation downshear;
 2. Stronger superposition between ambient and TC winds;

How Does Vertical Wind Shear Impact Tornadoes in Landfalling TCs?

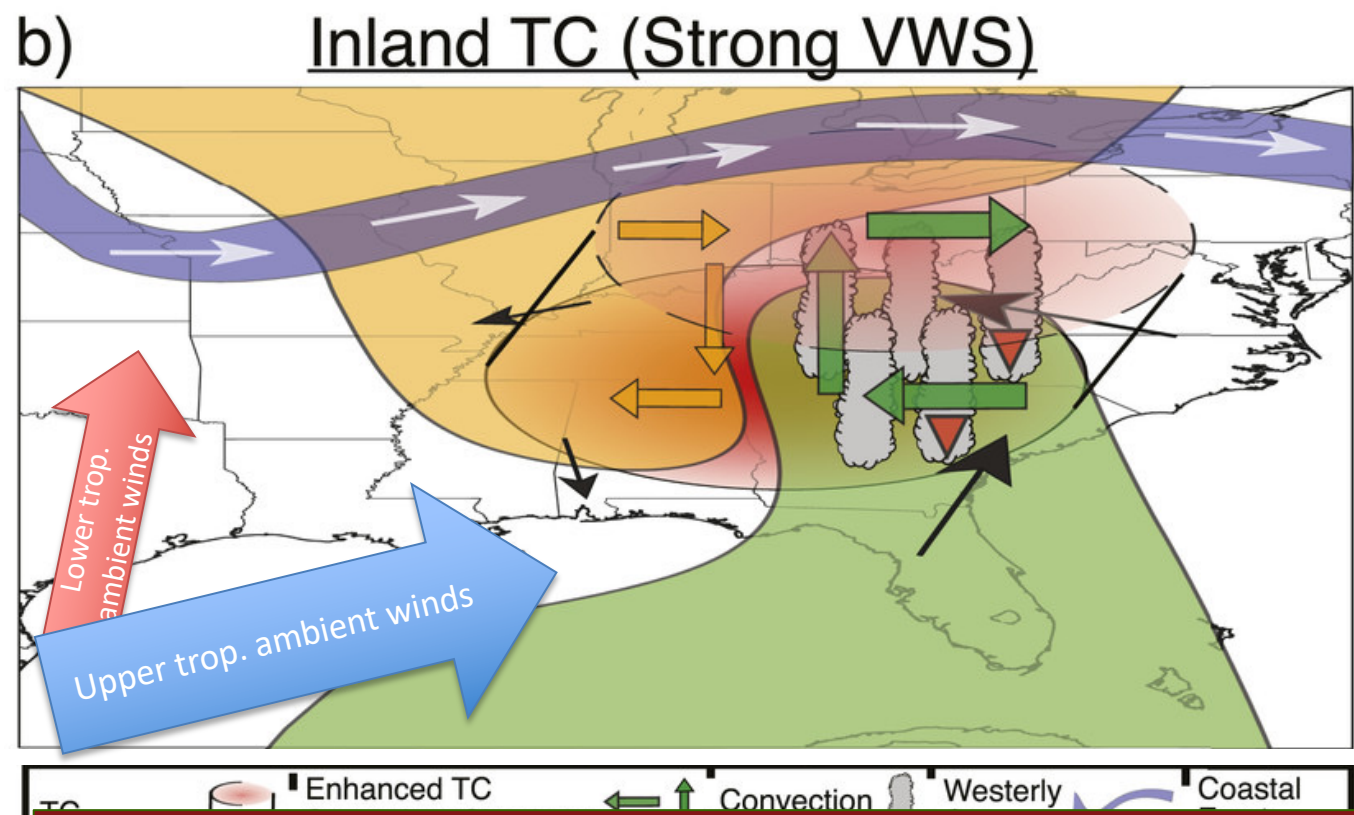
b) Inland TC (Strong VWS)



Schenkel,
Coniglio, and
Edwards (2021)

- Inland TC encounters stronger vertical wind shear further concentrating tornadoes downshear due to:
 3. Interaction of TC with pre-existing baroclinic zone.

How Does Vertical Wind Shear Impact Tornadoes in Landfalling TCs?



Does ambient vertical wind shear more strongly impact the number and location of inland TC tornadoes?

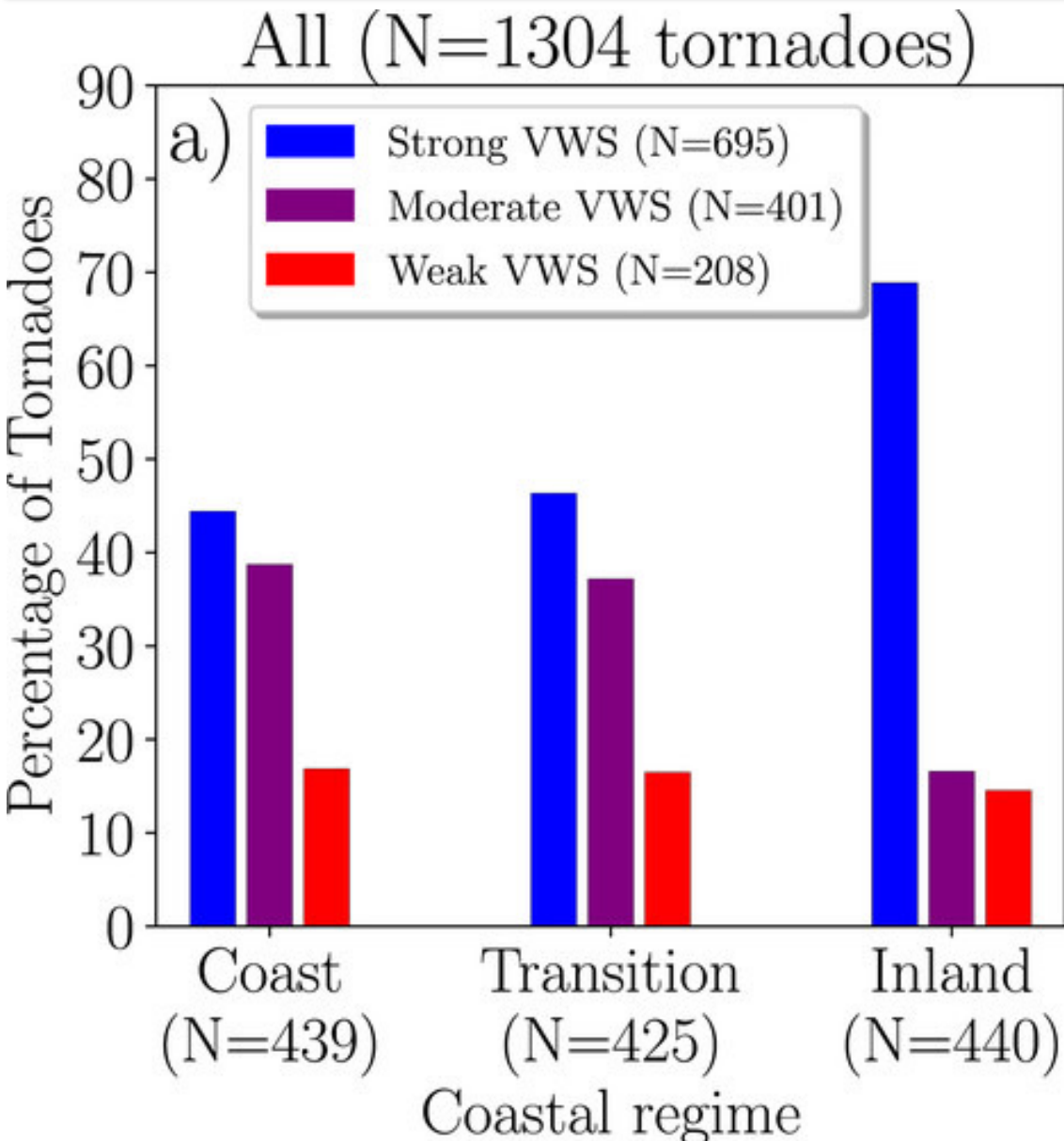
Data and Methods

- **Hypothesis:** Ambient deep-tropospheric vertical wind shear is a key factor impacting the occurrence of inland tropical cyclone tornadoes;
- **TC tornado data:** Storm Prediction Center TC tornado data from 1995–2019 (N=1304 Tornadoes, 90 TCs; Edwards 2010);
- **Ambient deep-tropospheric vertical wind shear data:** 850–200-hPa vertical wind shear (with TC wind field removed) averaged within 500 km of TC using ECMWF ERA-5 reanalysis data for all TCs from 1995–2019 (Davis et al. 2008);
- **Coastline data:** Defined using 1-km Global Self-consistent, Hierarchical, High-resolution Geography (GSHHG) data (Wessel and Smith 1996).

Data and Methods

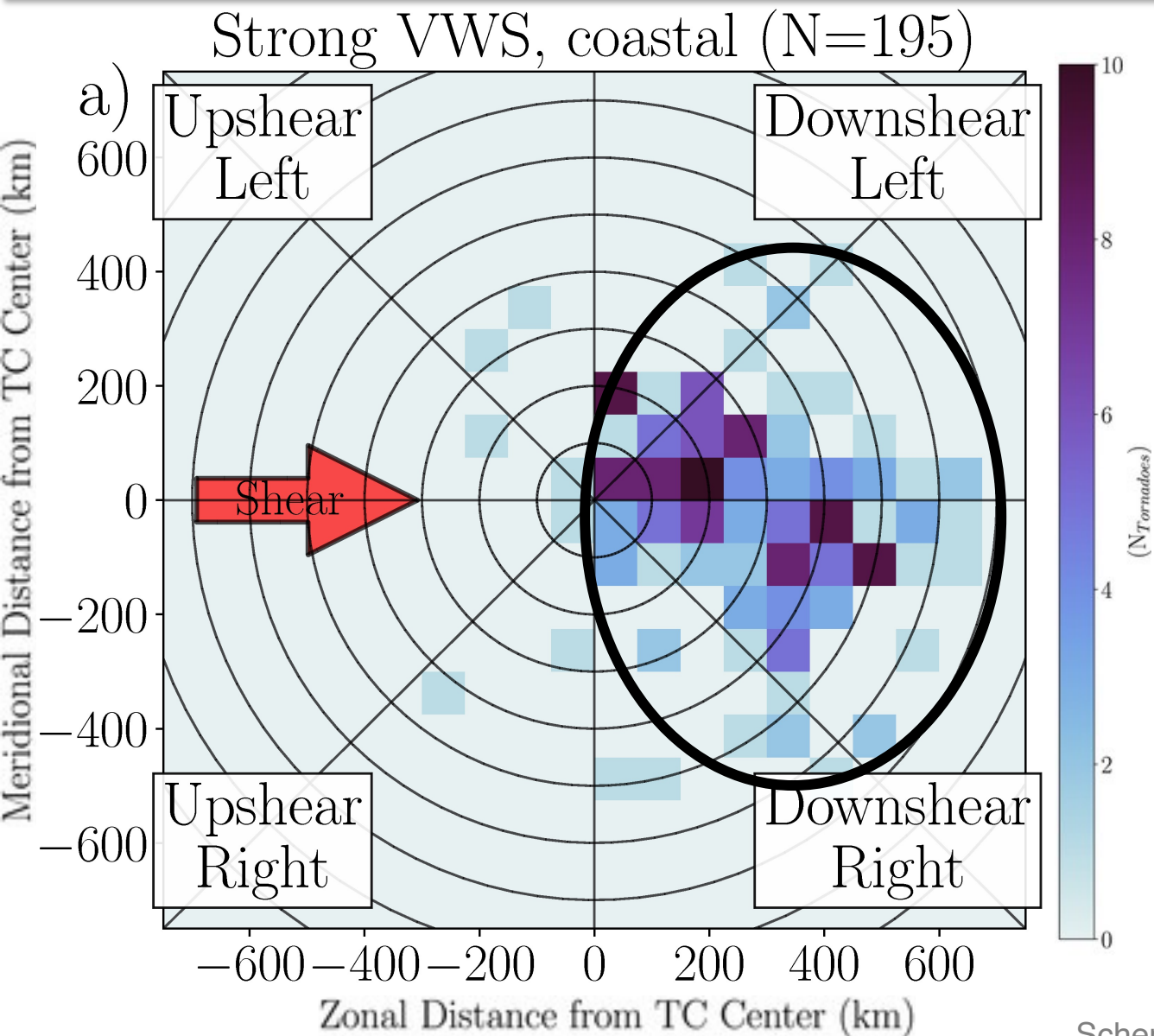
- Each TC tornado categorized by **both**:
 - **Vertical wind shear magnitude**: Based on terciles of vertical wind shear distribution for all Atlantic TCs;
 - Strong: $>11.2 \text{ m s}^{-1}$
 - Moderate: $6.8\text{--}11.2 \text{ m s}^{-1}$
 - Weak: $<6.8 \text{ m s}^{-1}$
 - **Coastal distance**: Based on terciles of TC tornado distance from coast;
 - Coastal: 0–23 km
 - Transition: 23–125 km
 - Inland: $>125 \text{ km}$
- Analyze tornado number and location for TCs among these **nine** combinations of vertical wind shear and coastal distance regimes.

Impact on TC Tornado Frequency



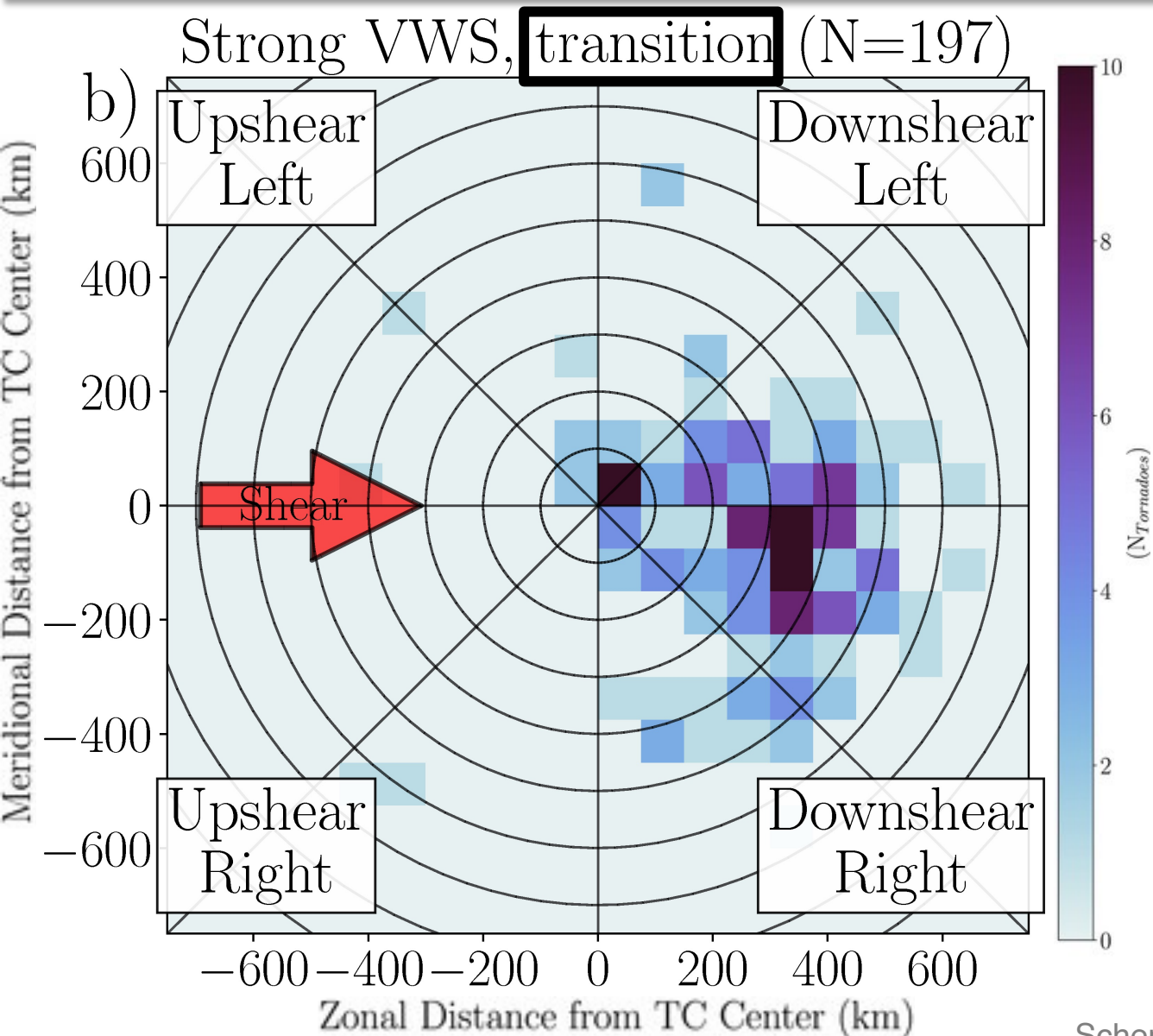
- Tornadoes most frequently occur in strongly sheared TCs in all coastal regimes;
- Larger percentage of tornadoes in inland environments occur in strongly sheared TCs compared to coast;
- Strong shear preference occurs despite landfalling TCs more often occurring in moderate shear (Schenkel et al. 2020).

Influence on TC Tornado Location



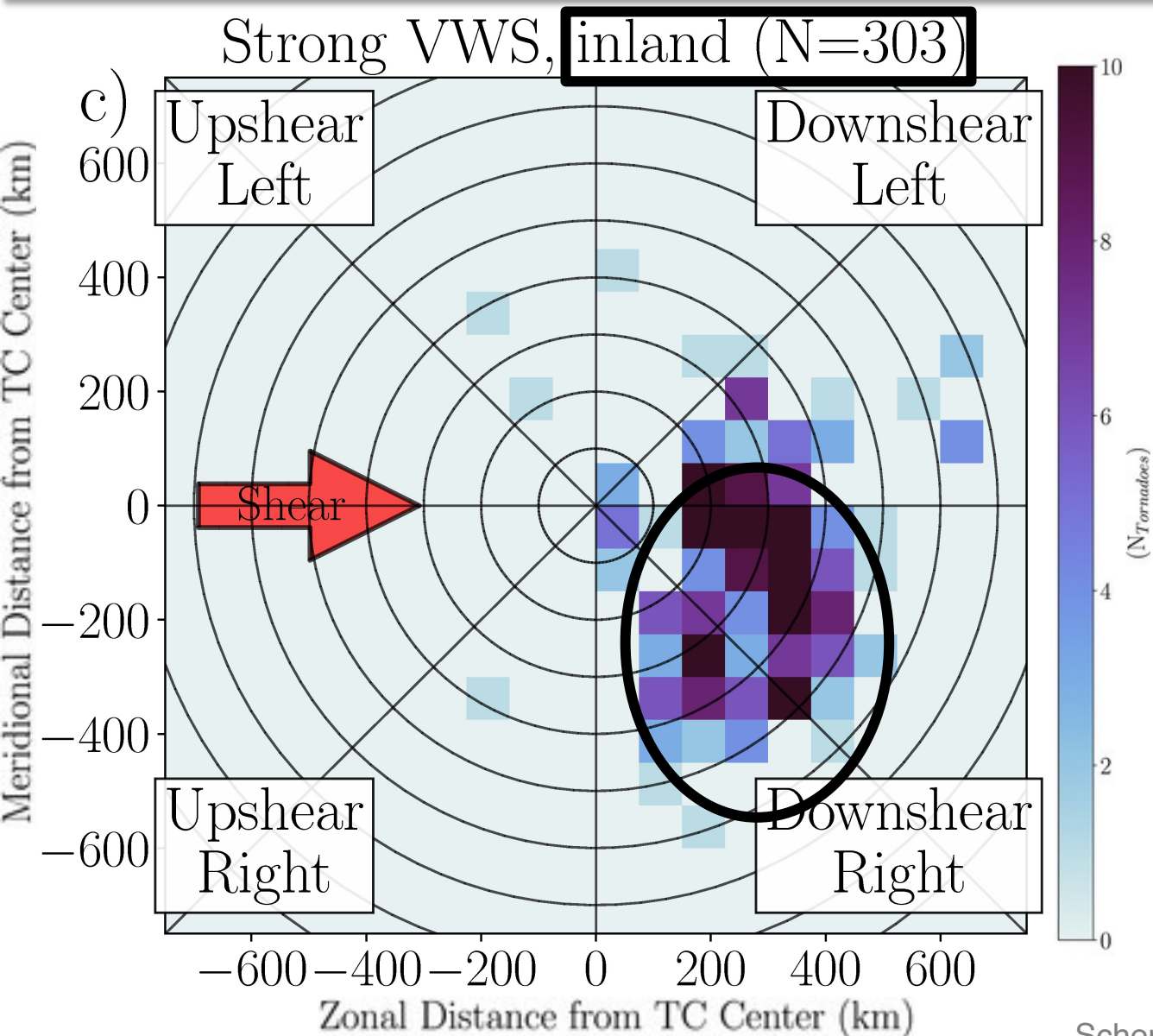
- Most tornadoes occur in downshear half of TC at **coast**;

Influence on TC Tornado Location



- Most tornadoes occur in downshear half of TC at **coast**;

Influence on TC Tornado Location

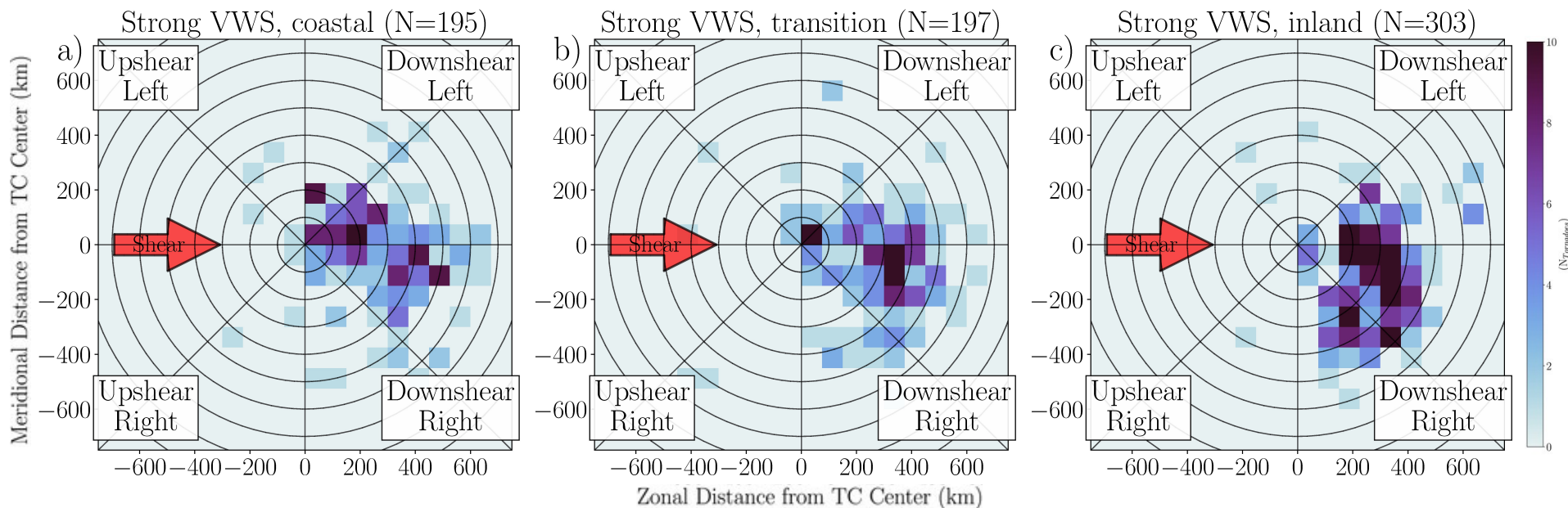


- Most tornadoes occur in downshear half of TC at **coast**;

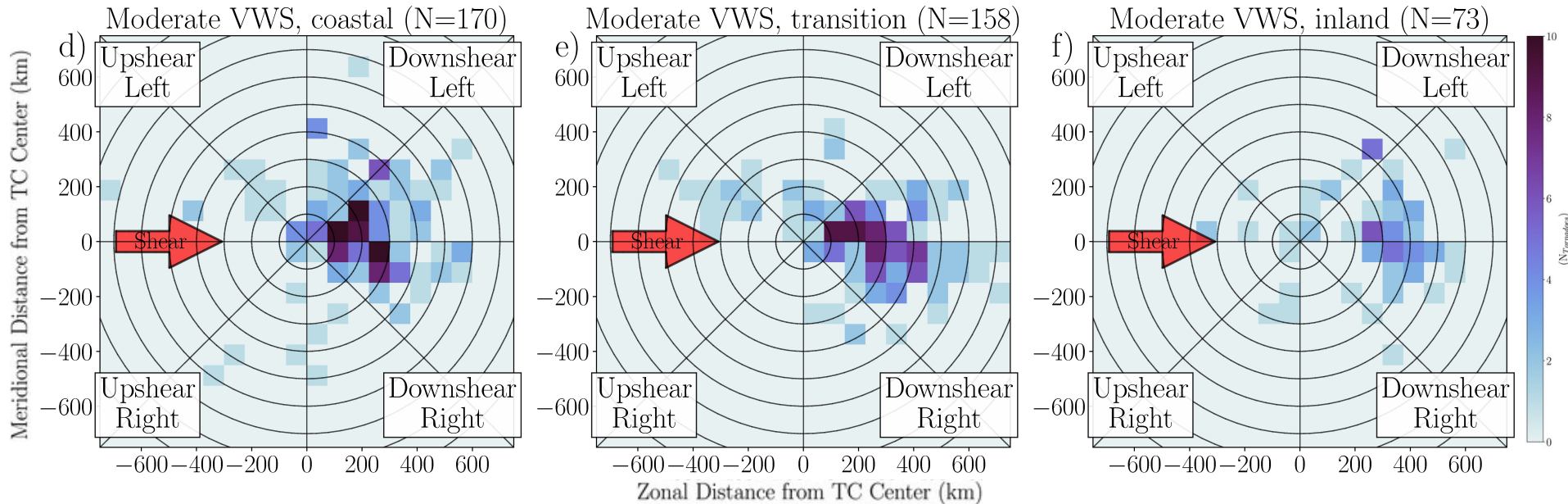
- **Inland TC** tornadoes more focused:

1. In downshear right quadrant;
2. Radially outside of 200 km from TC center.

Influence on TC Tornado Location



Influence on TC Tornado Location



- As TCs move inland, tornadoes are increasingly favored in outer regions over narrower range of downshear azimuths.

Summary and Discussion

- Used TC tornado reports to investigate sensitivity of tornado number and location to ambient vertical wind shear in coastal versus inland environments;
- Our study concluded that:
 1. Tornadoes occur more frequently in strongly sheared TCs with increasing distance inland;
 2. Tornadoes become increasingly concentrated in outer radii of downshear quadrants with increasing distance inland.
- **For more information:** Schenkel, B. A., Coniglio, M., & Edwards, R. (2021). How Does the Relationship between Ambient Deep-Tropospheric Vertical Wind Shear and Tropical Cyclone Tornadoes Change between Coastal and Inland Environments?, *Weather and Forecasting*, **36**, 539–566.