

Does Ambient Deep-Tropospheric Vertical Wind Shear Influence Tornado Occurrence during Landfalling Tropical Cyclones?

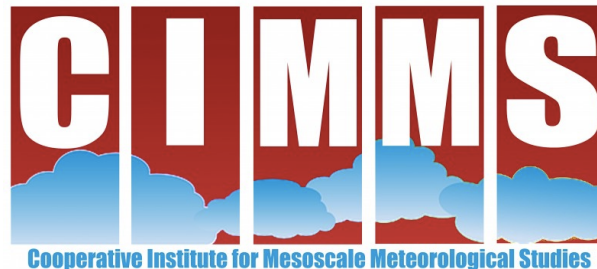
Ben Schenkel¹ (benschenkel@gmail.com),

Nusrat Yussouf^{1,2}, and Roger Edwards³

1: OU/NOAA CIMMS, 2: National Severe Storms Laboratory, 3: Storm Prediction Center

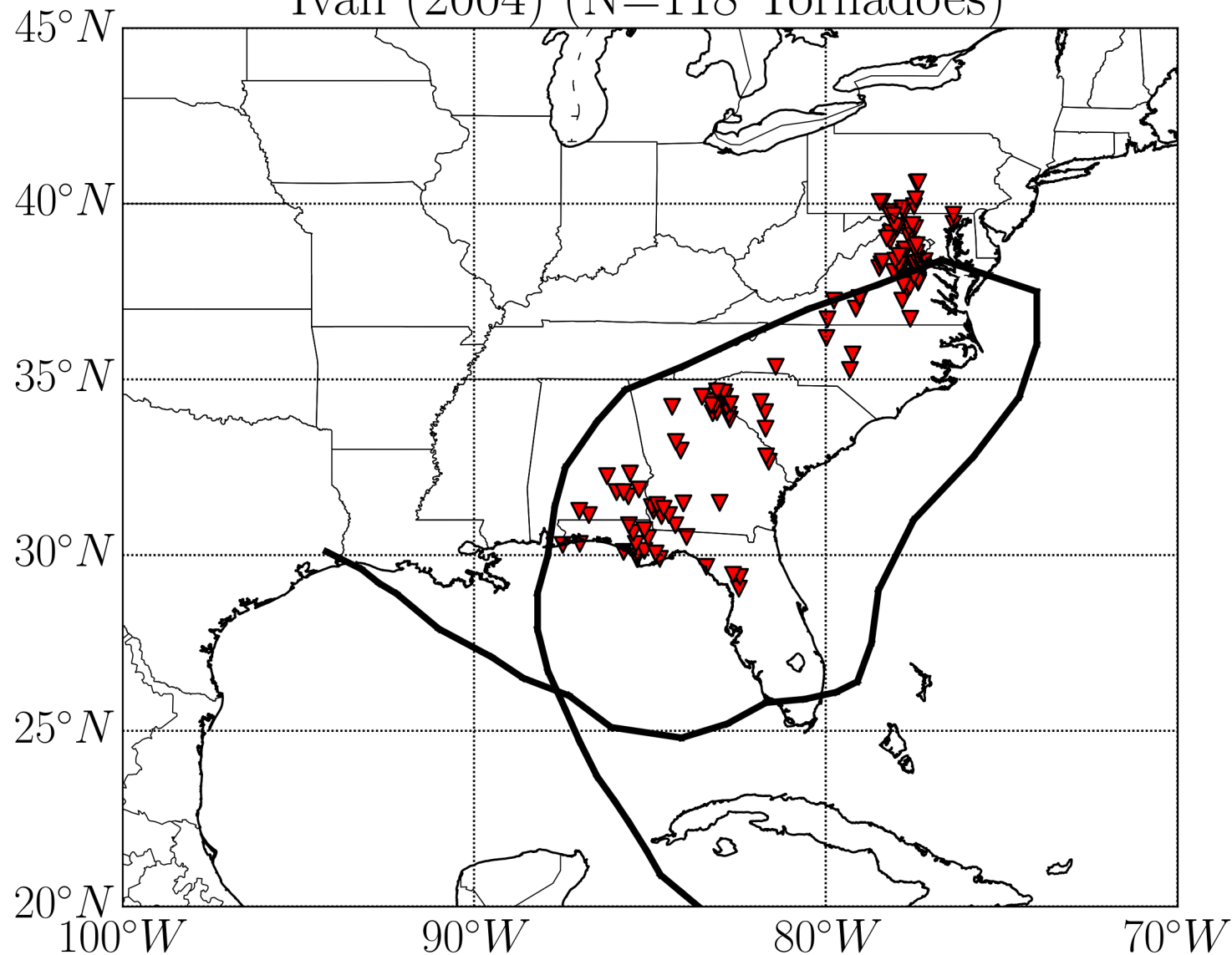
2018 AGU Fall Meeting

12/14/2018



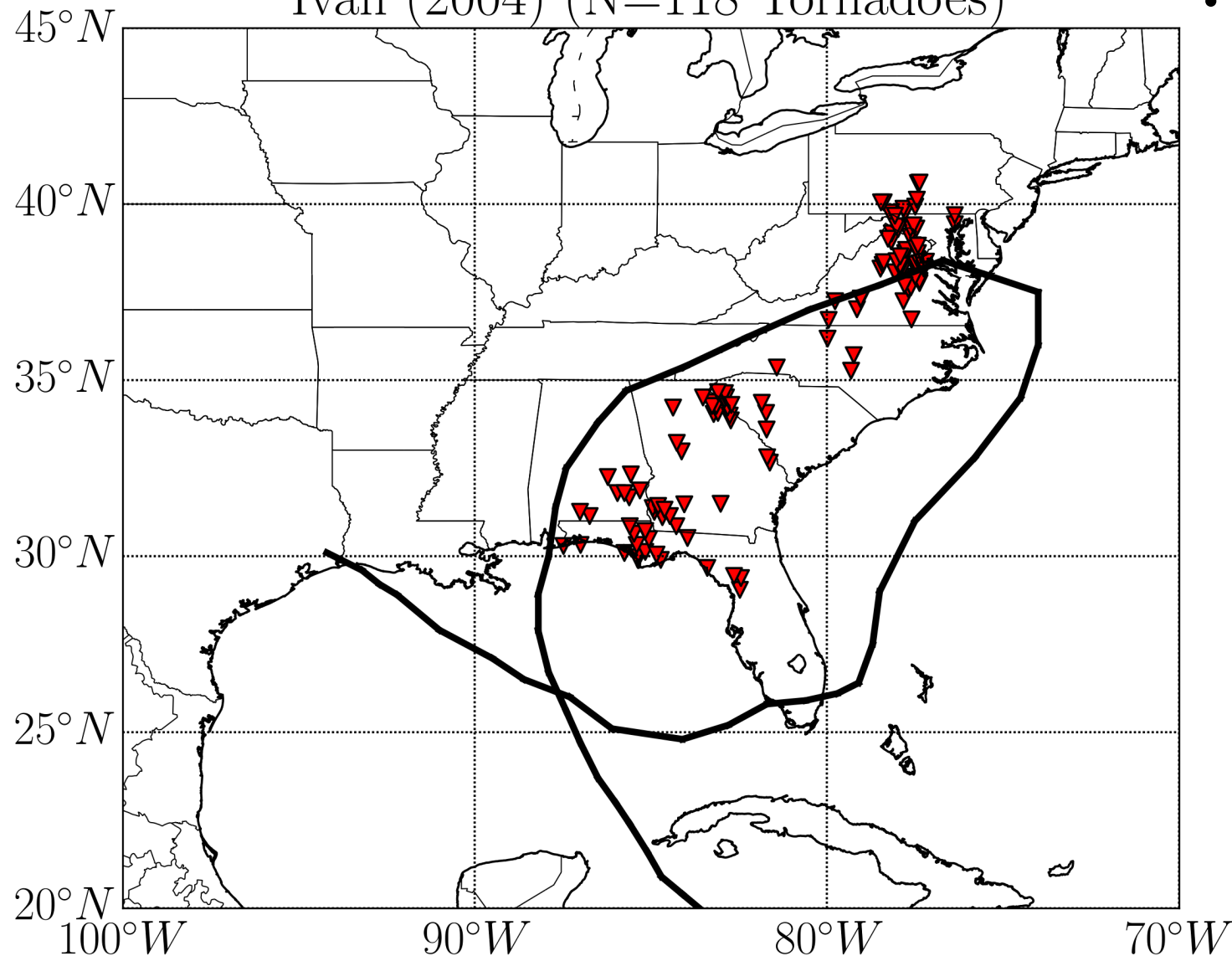
TCs with Similar Landfall Locations and Intensities

Ivan (2004) (N=118 Tornadoes)



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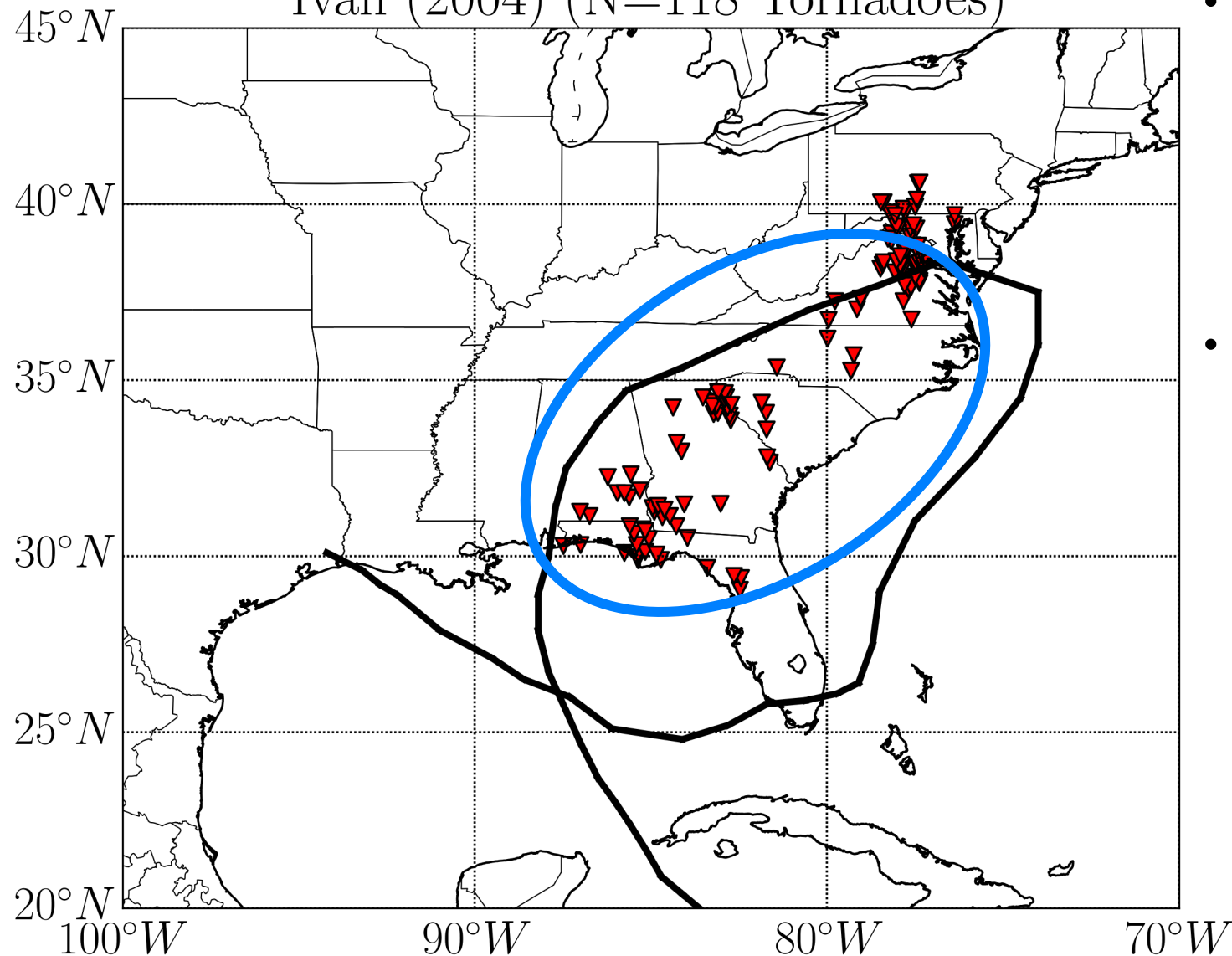
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- Hurricane Ivan (2004) produced greatest number of tornadoes on record

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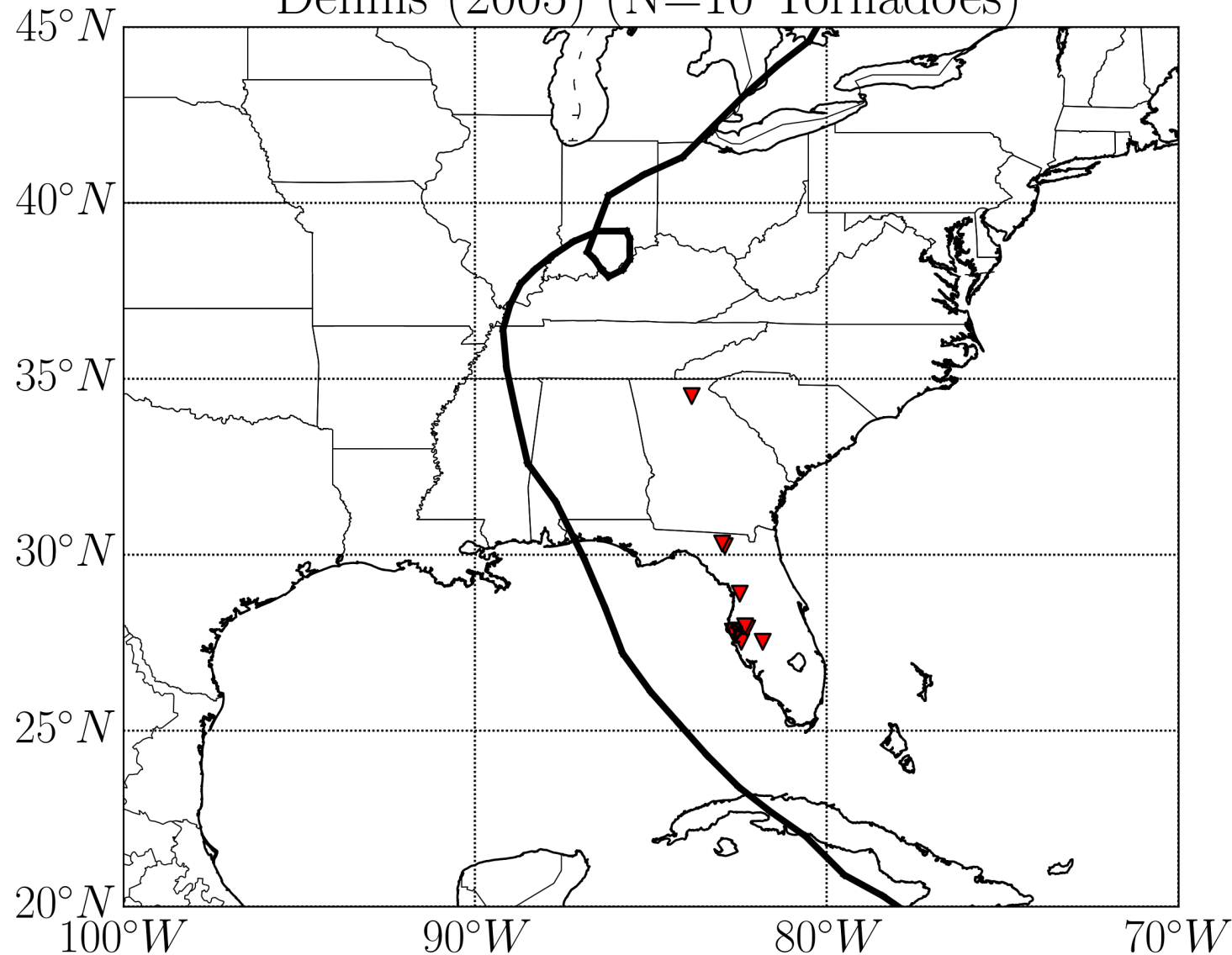
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- Tornadoes produced during and after first landfall

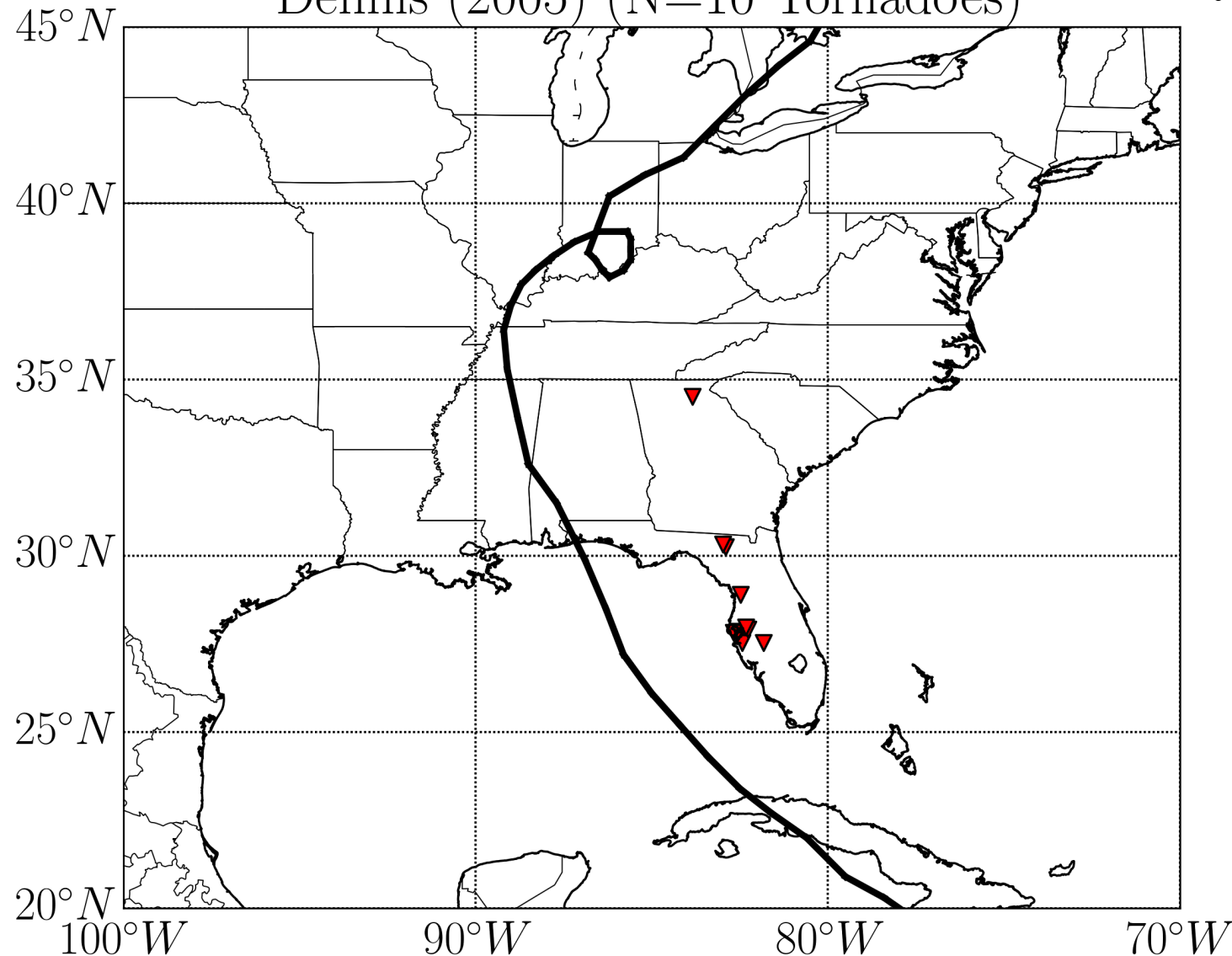
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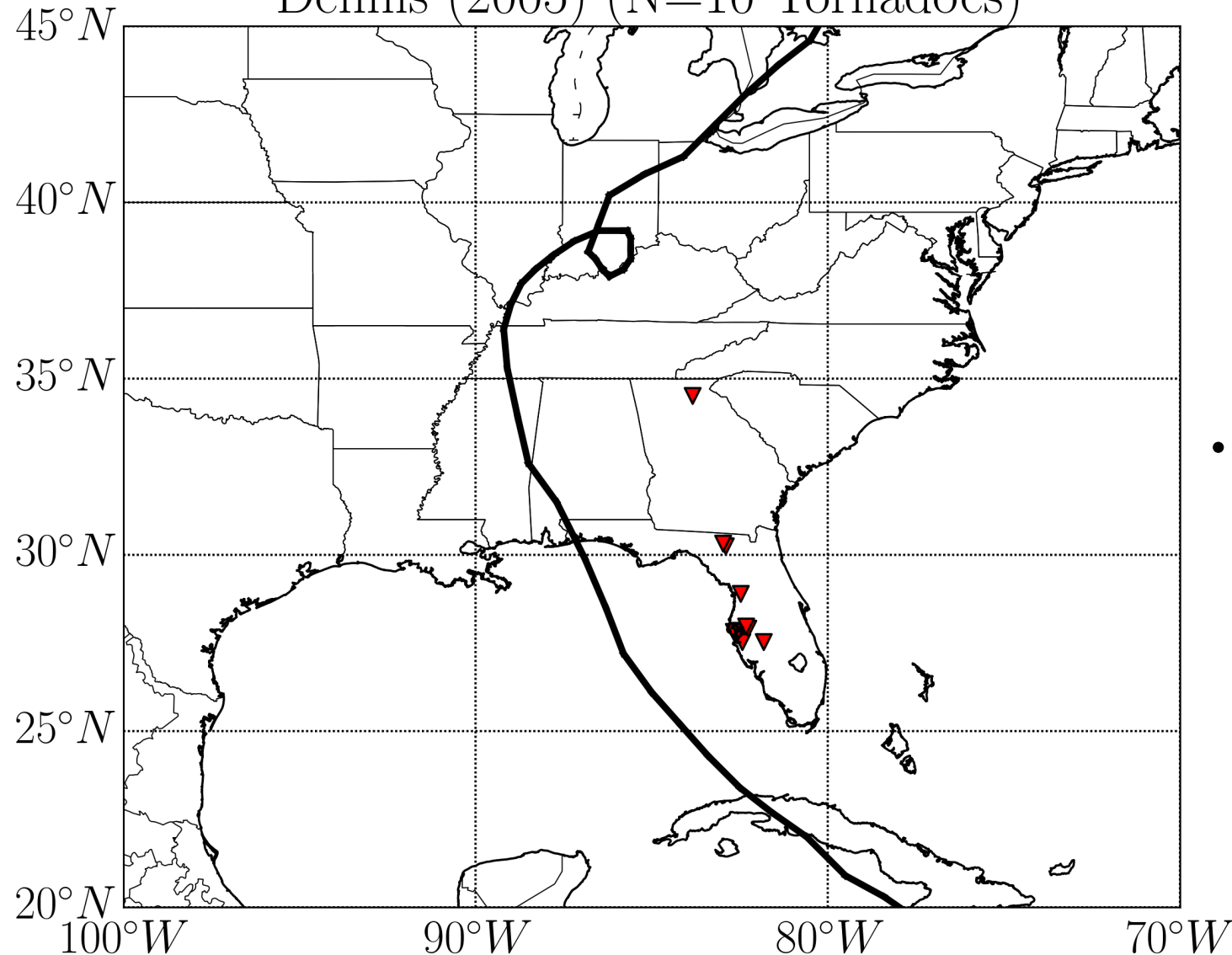
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- Landfall location and intensity of Hurricane Dennis (2005) similar to Hurricane Ivan (2004)

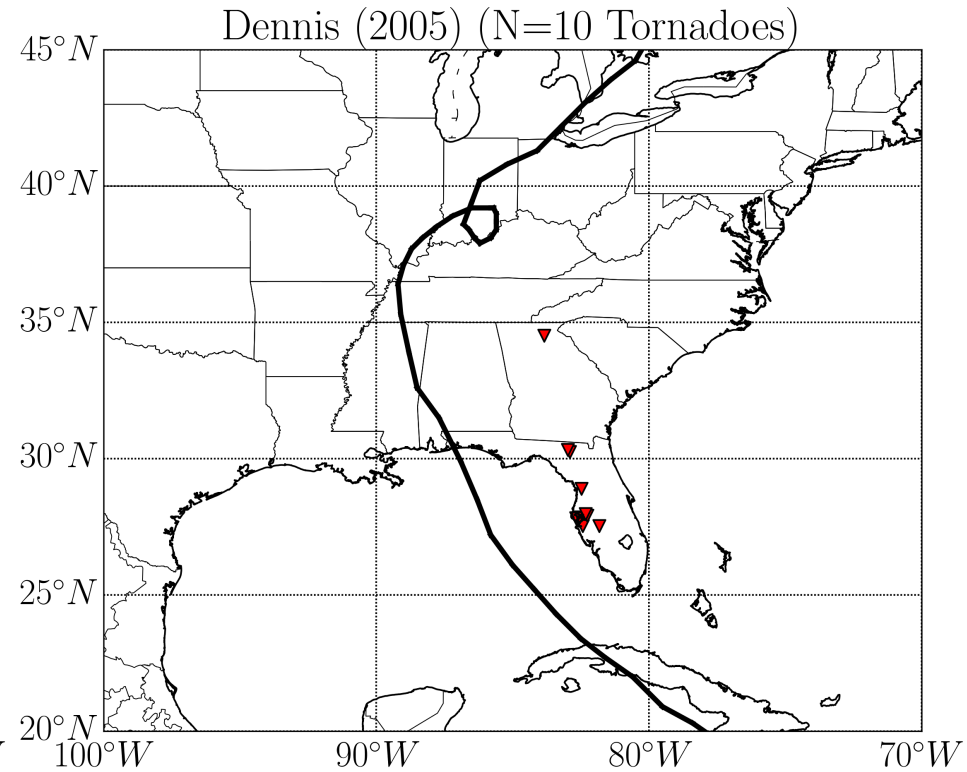
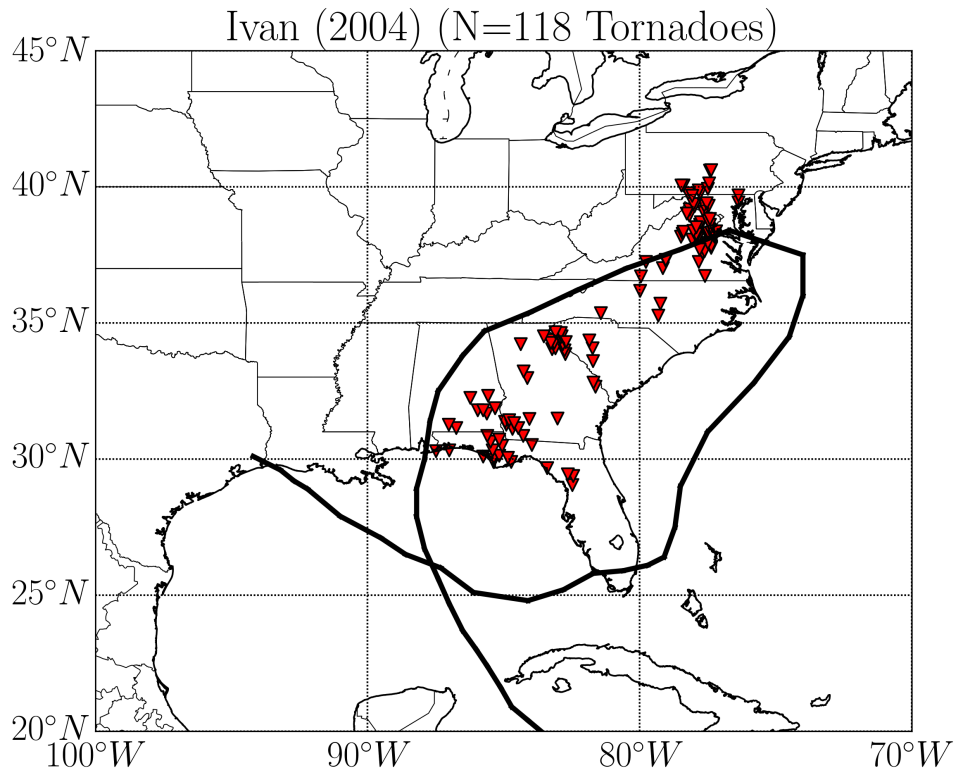
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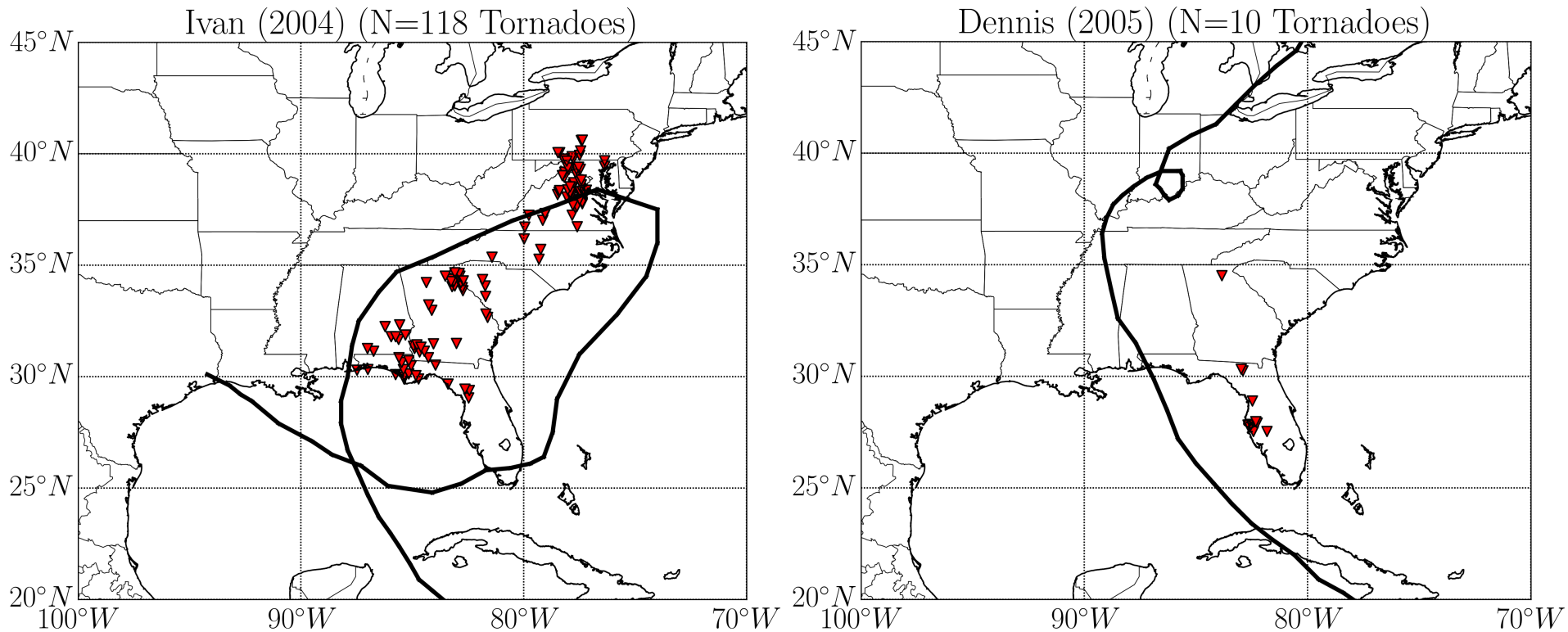


- Landfall location and intensity of Hurricane Dennis (2005) similar to Hurricane Ivan (2004)
- Order of magnitude difference in number of tornadoes produced

TCs with Similar Landfall Locations and Intensities

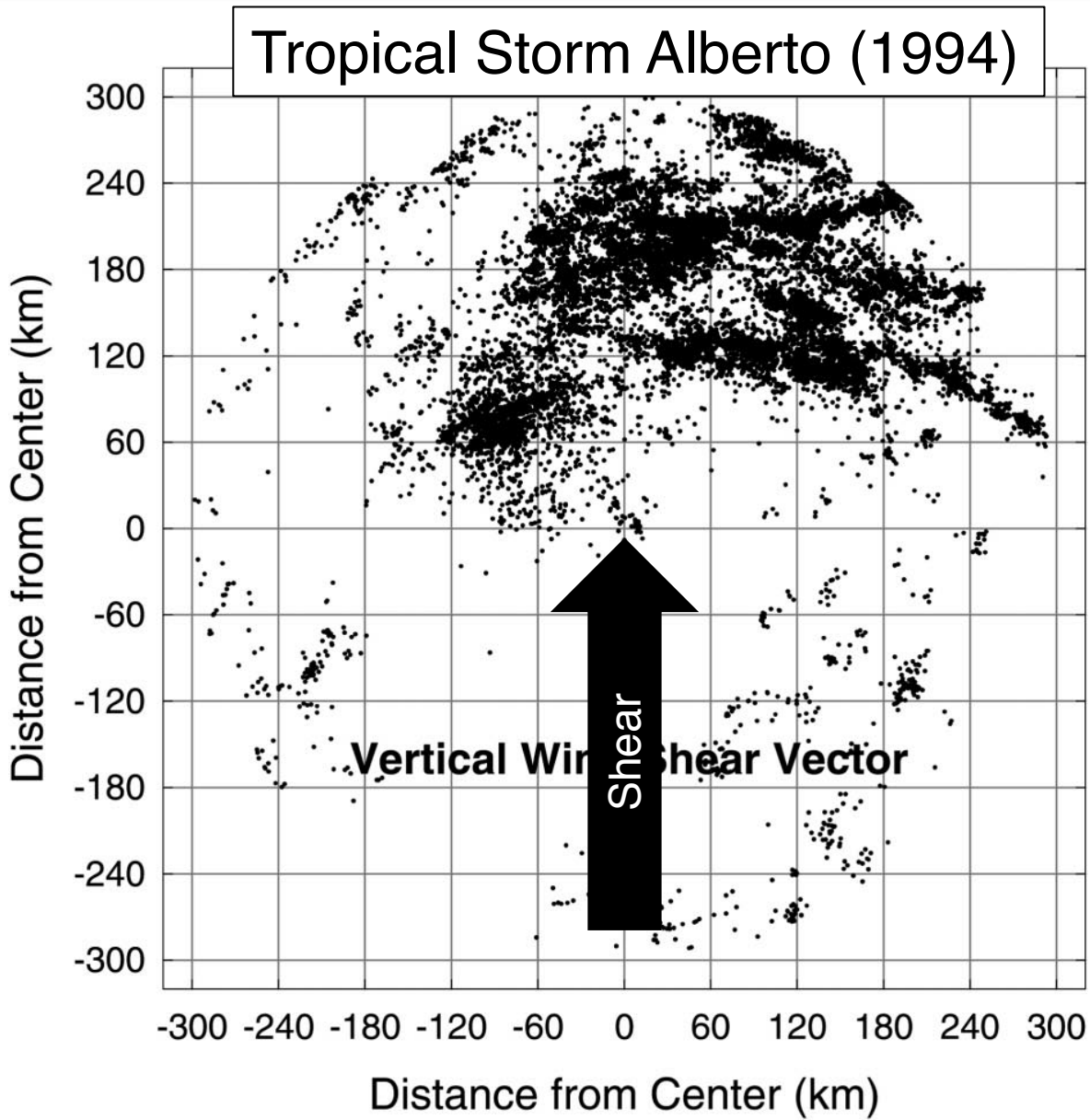


TCs with Similar Landfall Locations and Intensities



Why is there large variability in the *frequency and location* of tornadoes produced by landfalling TCs?

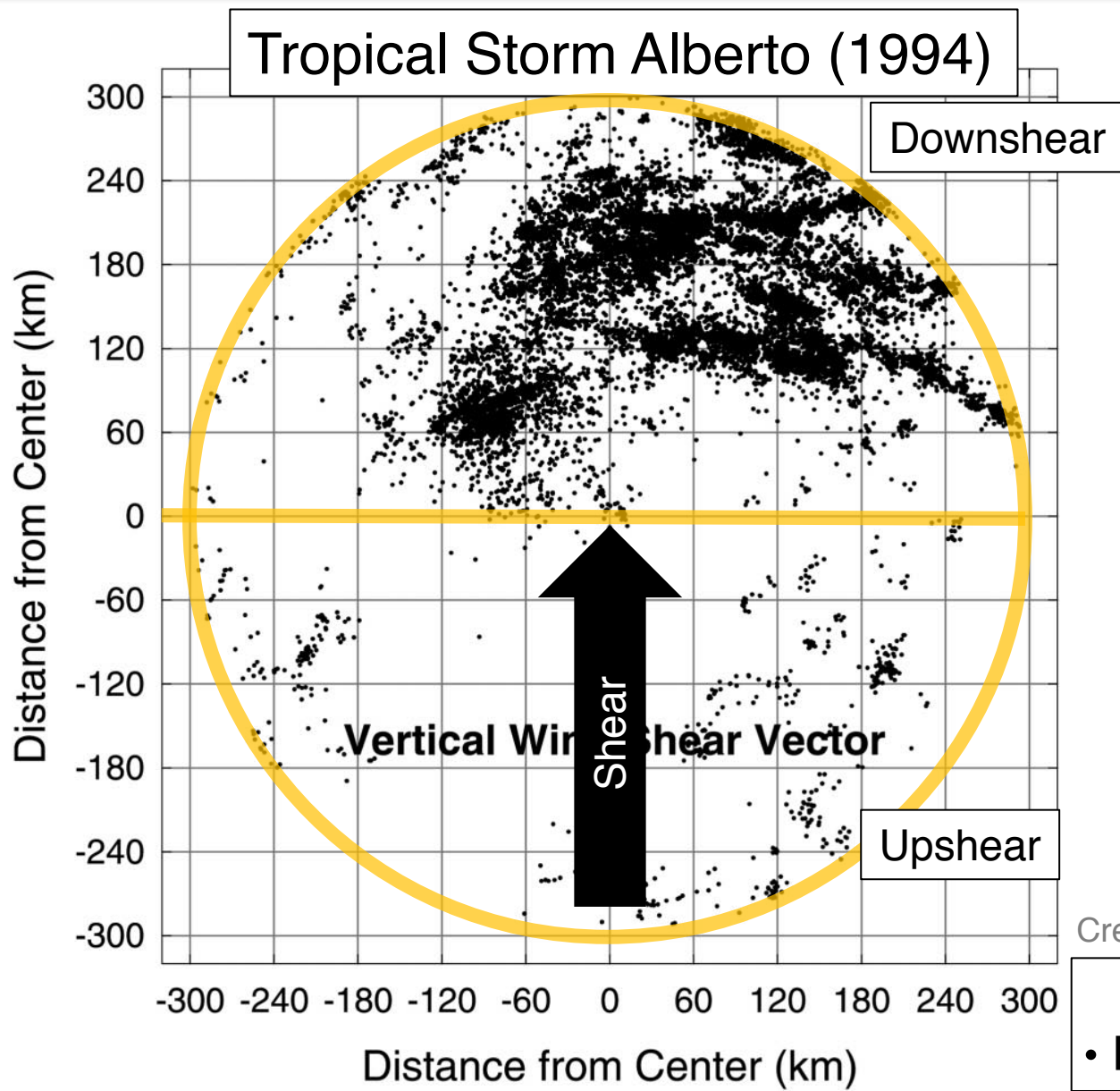
How Does Ambient Vertical Wind Shear Impact TCs?



Credit: Corbosiero and Molinari (2002)

Legend
• Lightning Strike

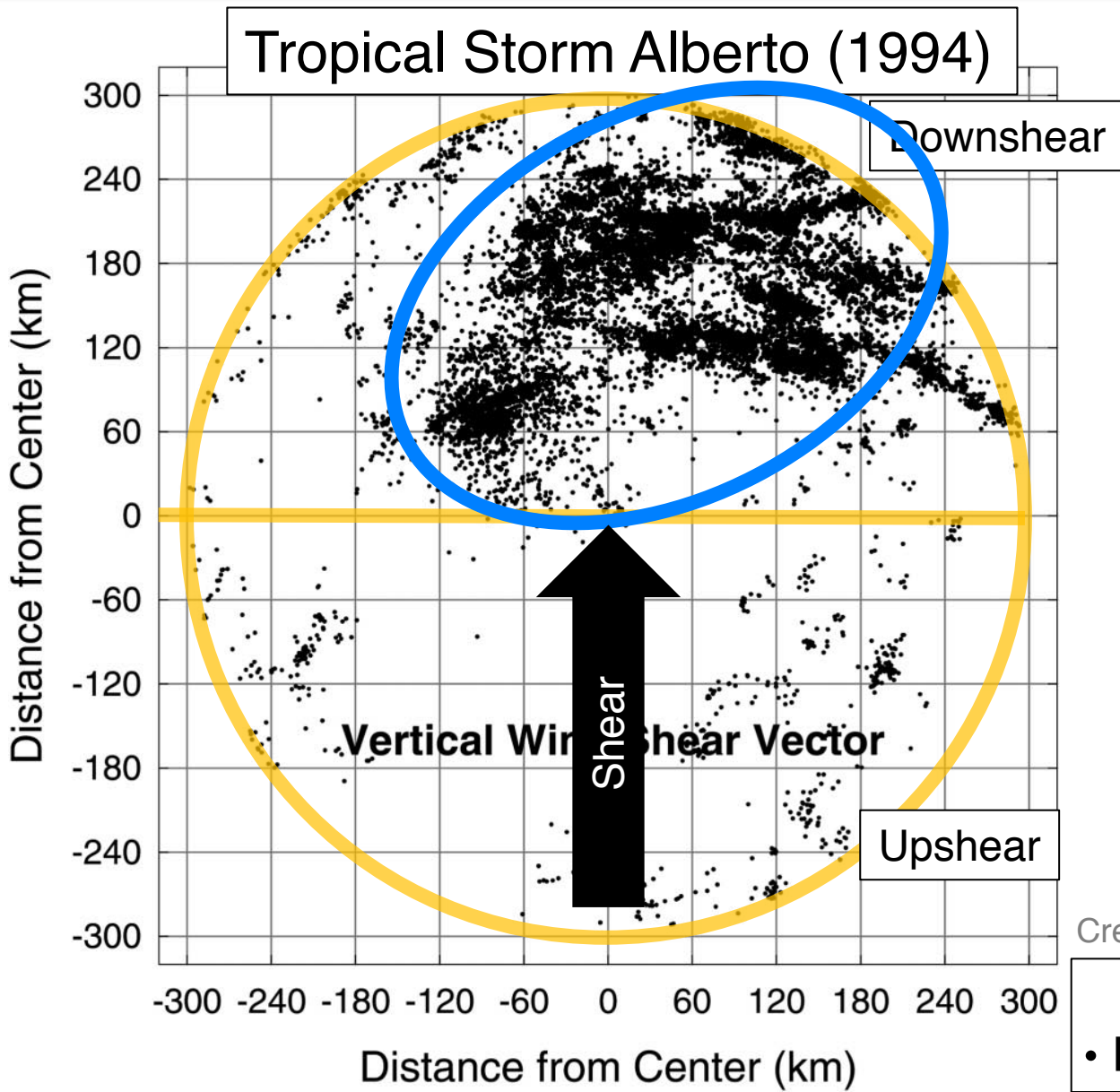
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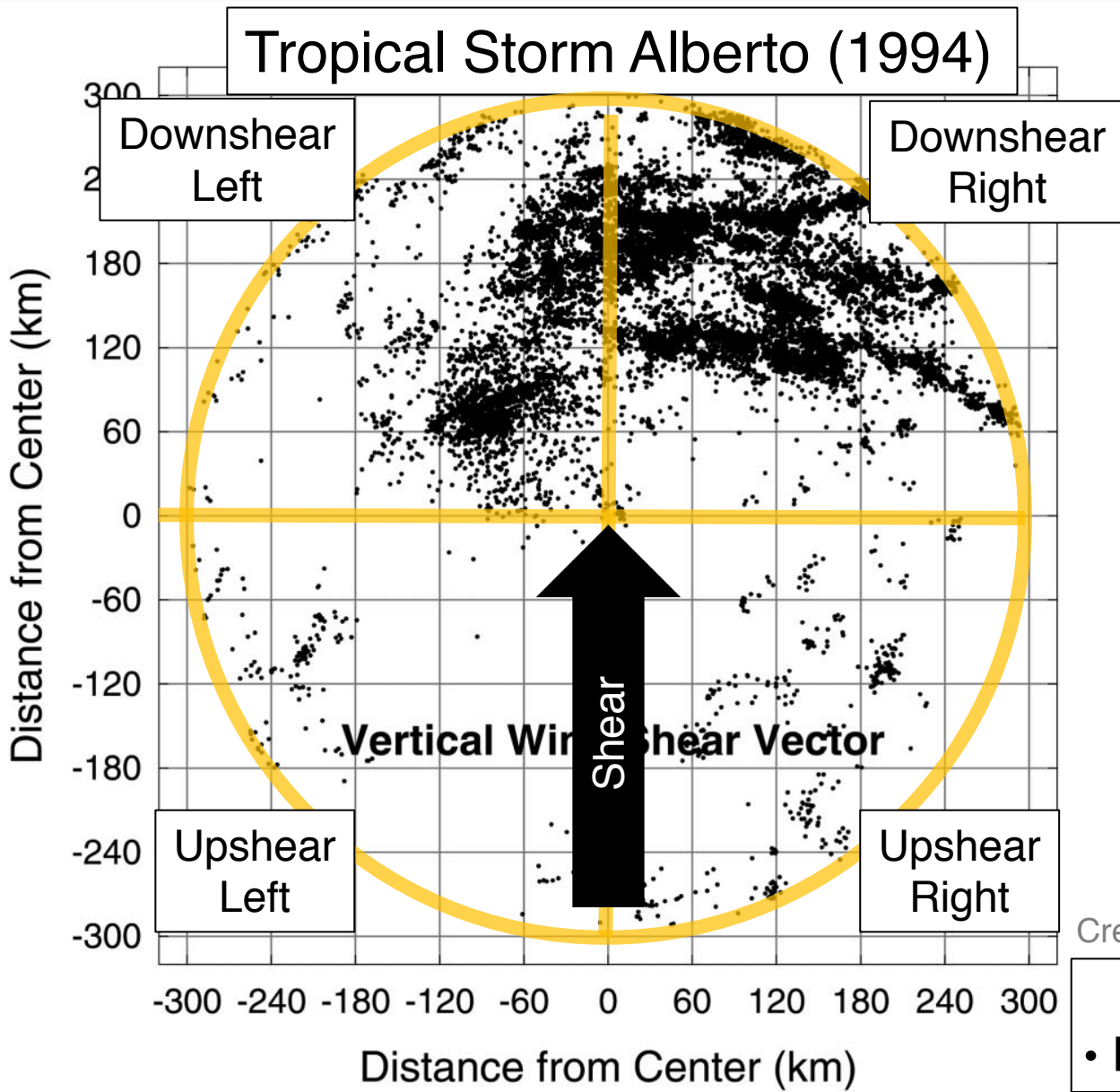
- Deep convection concentrated in **downshear** quadrant due to ascent from ambient shear

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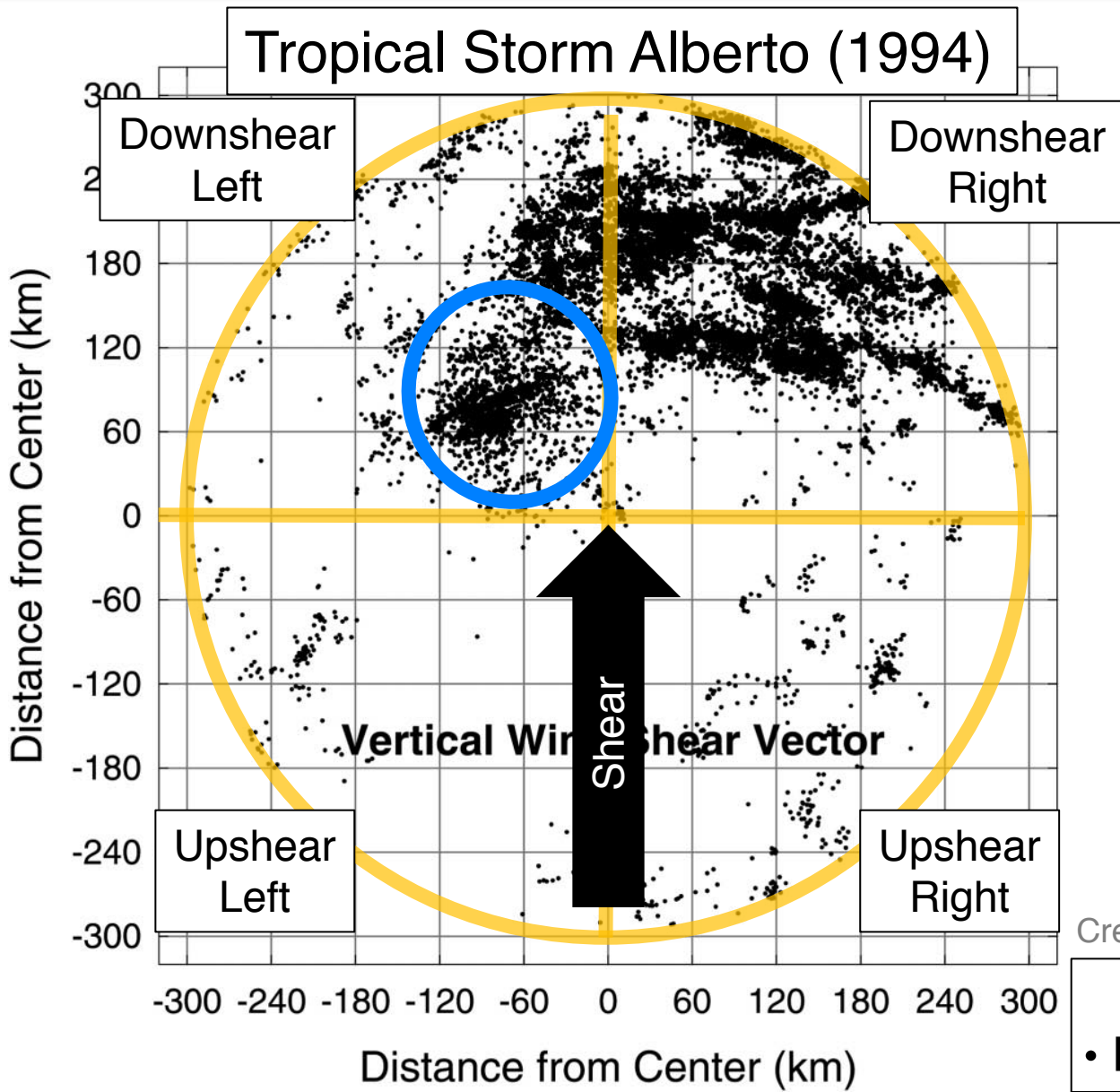
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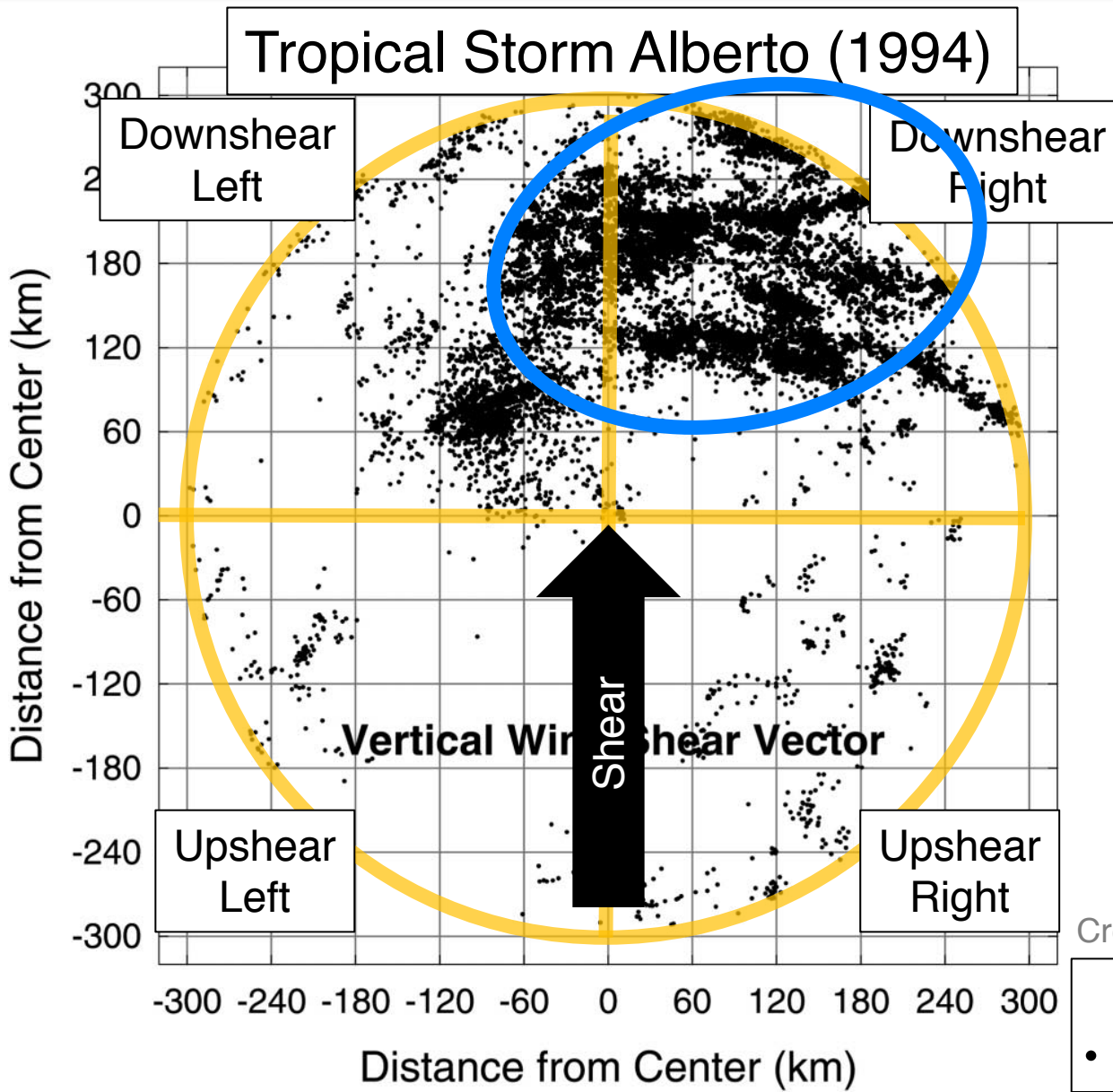
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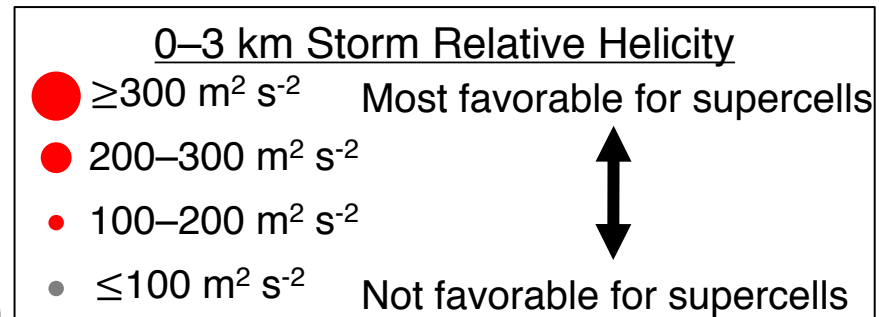
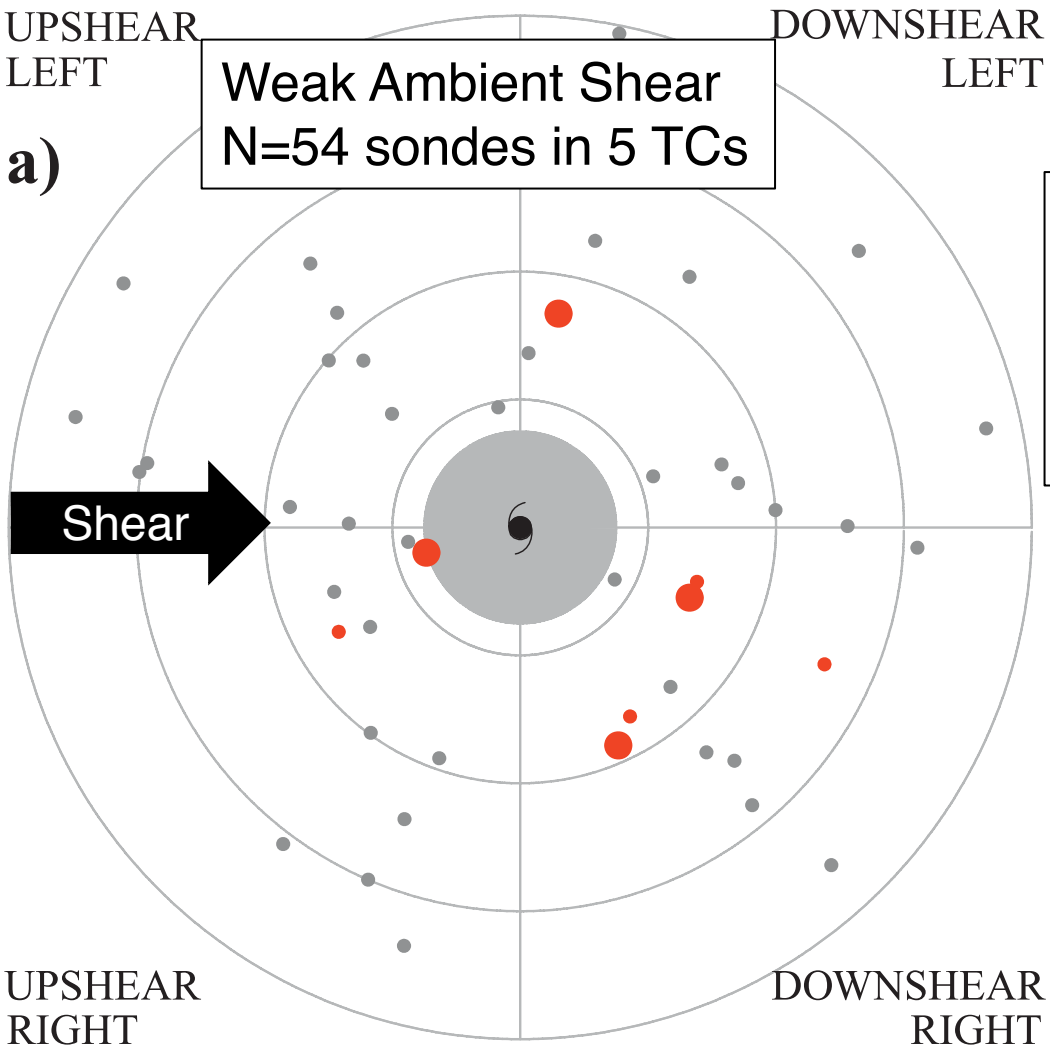
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- Lightning closest to TC center located downshear left quadrant
- Lightning at outer region largely located in downshear right quadrant

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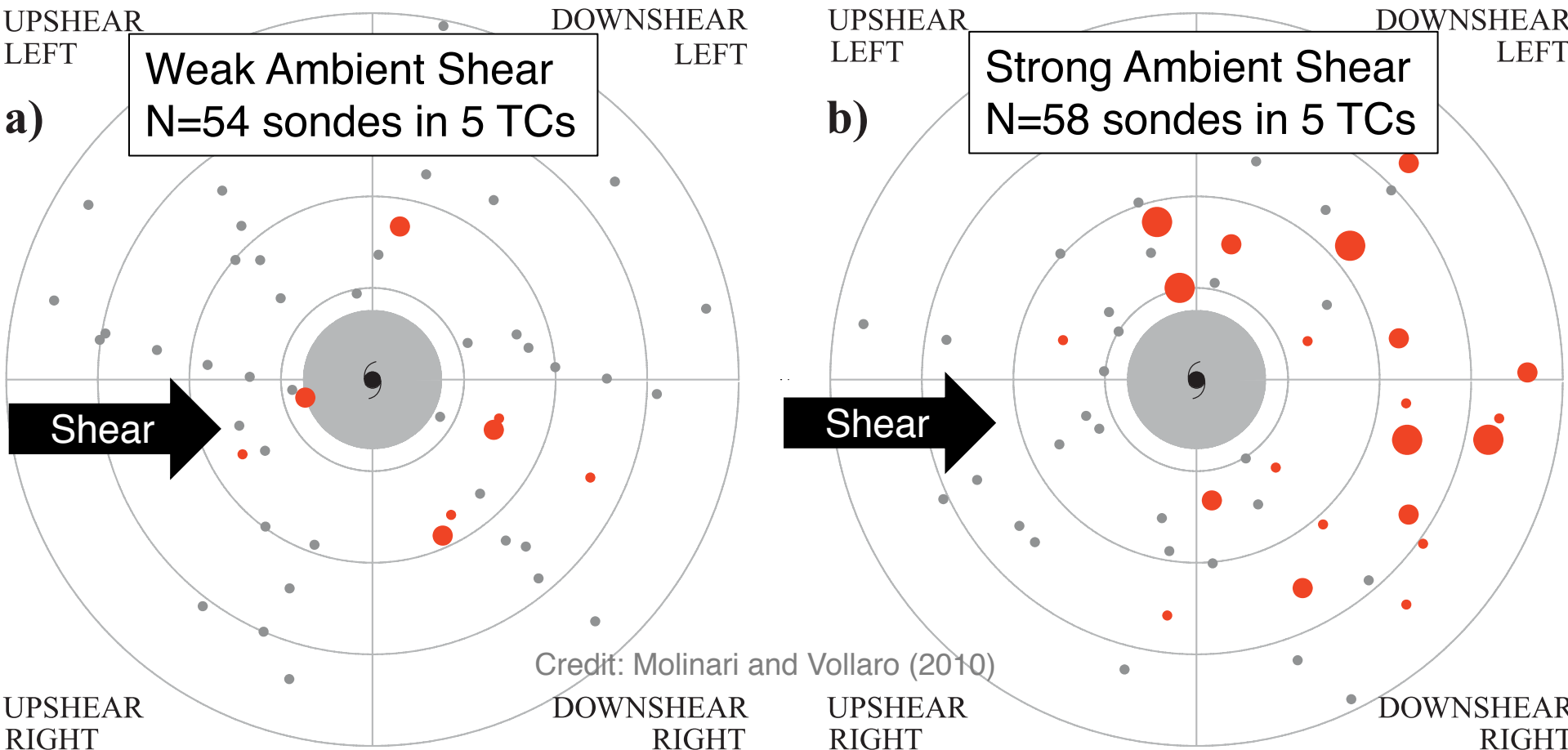
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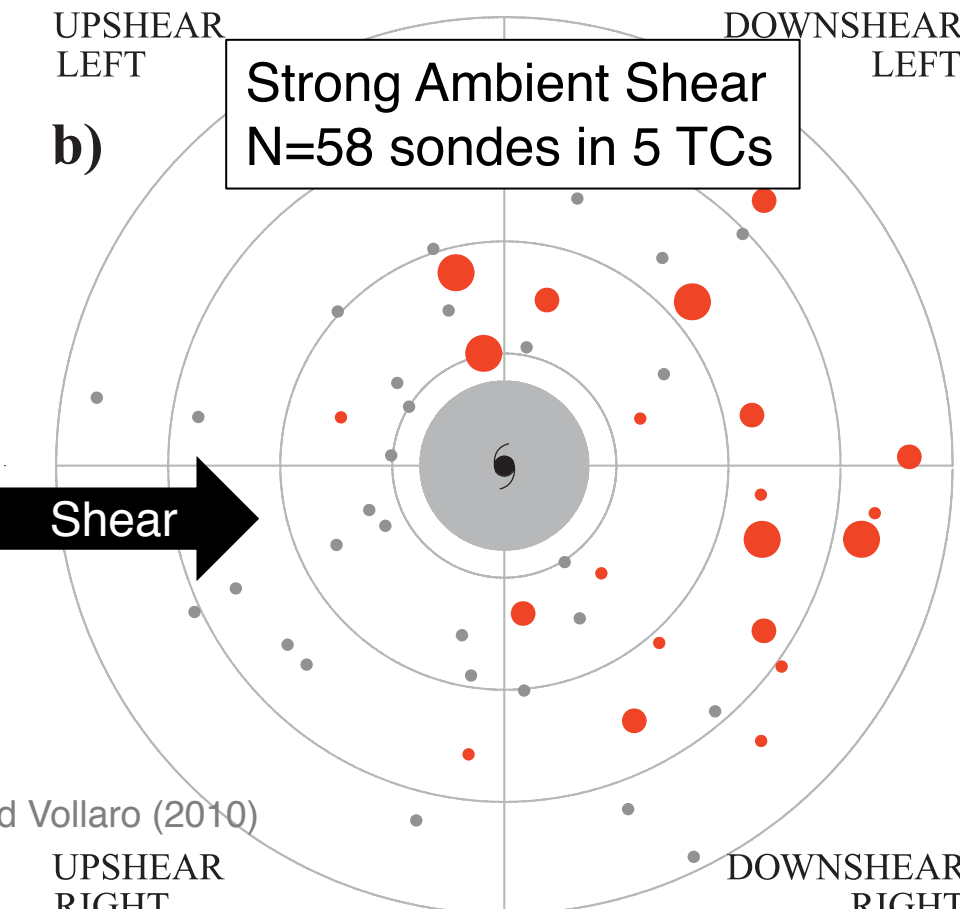
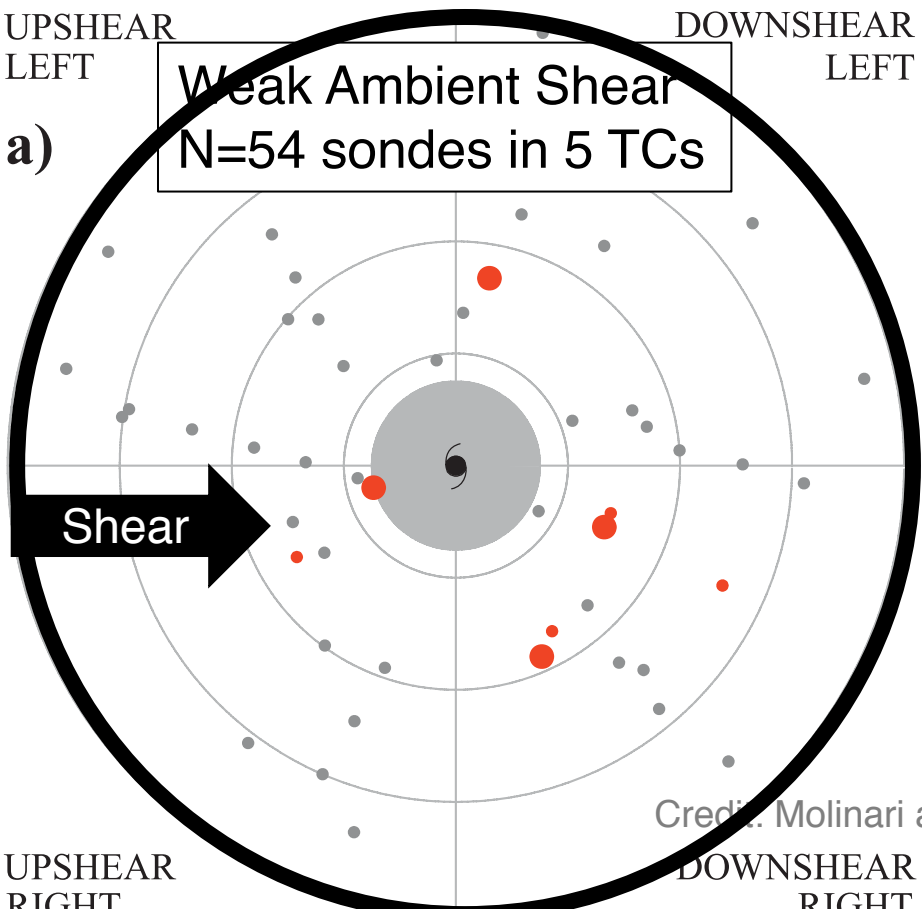
How Does Ambient Vertical Wind Shear Impact TCs?



0–3 km Storm Relative Helicity

- $\geq 300 \text{ m}^2 \text{ s}^{-2}$ Most favorable for supercells
 - $200\text{--}300 \text{ m}^2 \text{ s}^{-2}$
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 - $\leq 100 \text{ m}^2 \text{ s}^{-2}$ Not favorable for supercells
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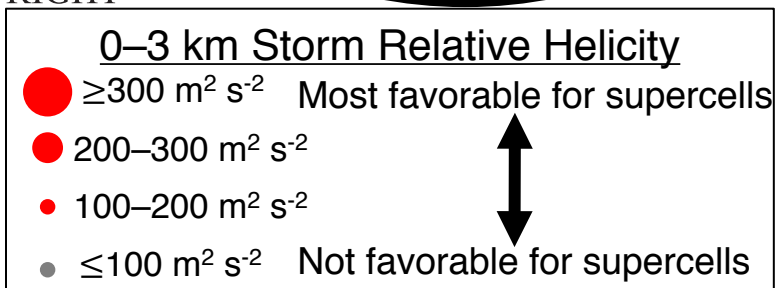
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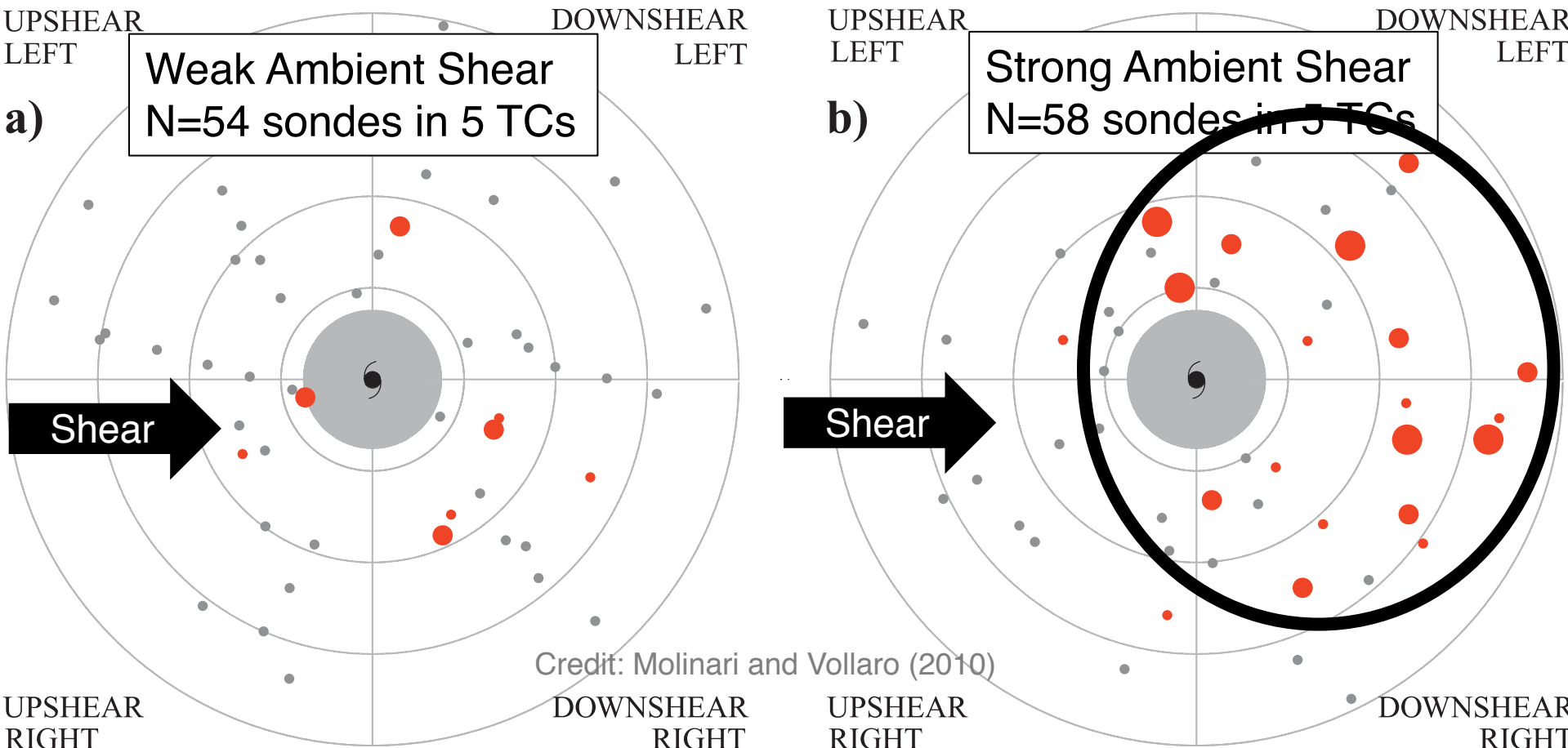
UPSHEAR RIGHT DOWNSHEAR RIGHT

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- Weak ambient shear TCs yield environments generally do not support supercells

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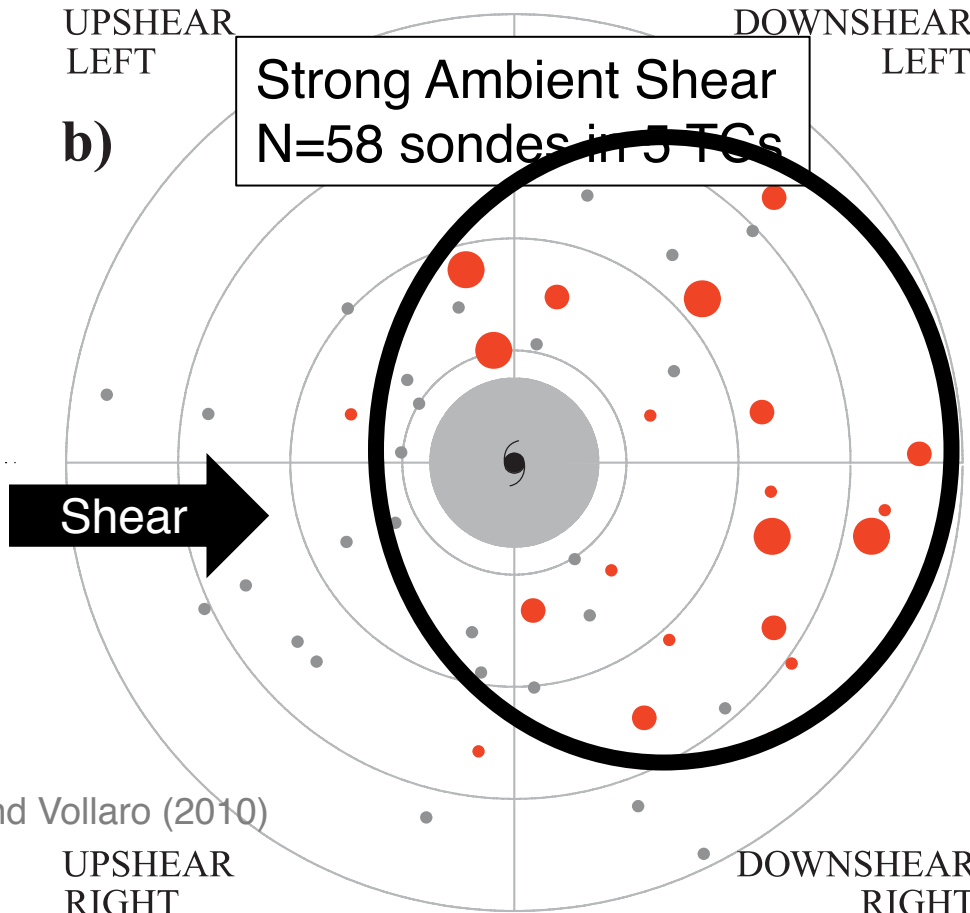
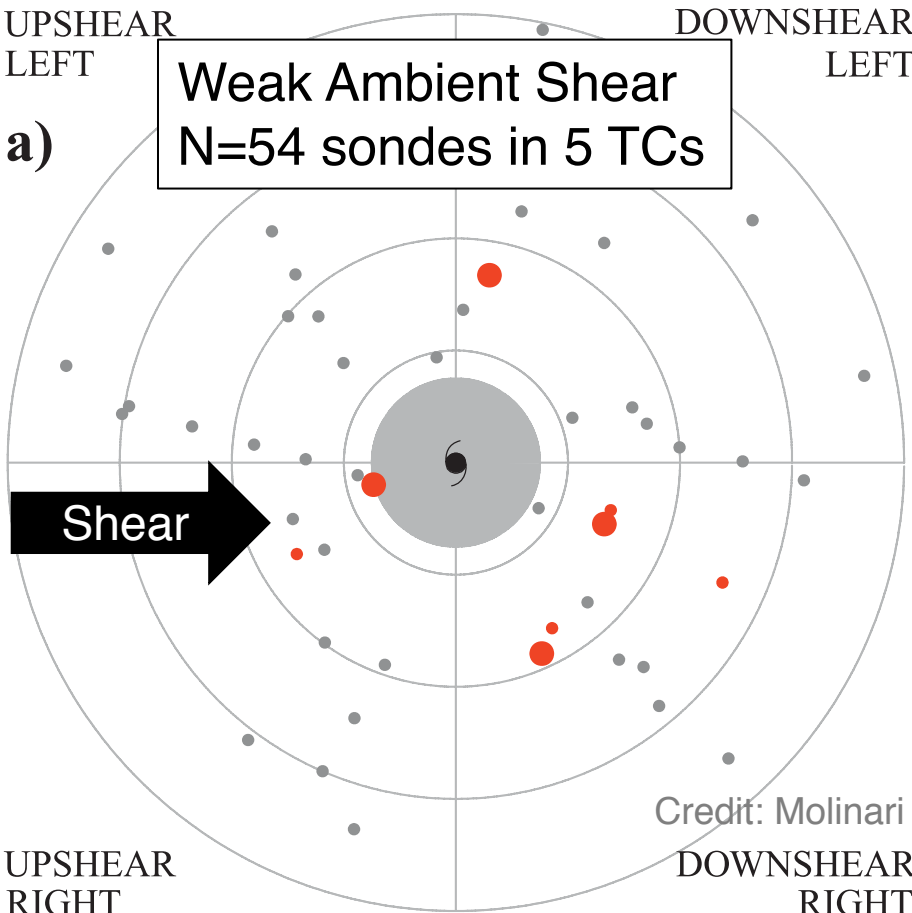
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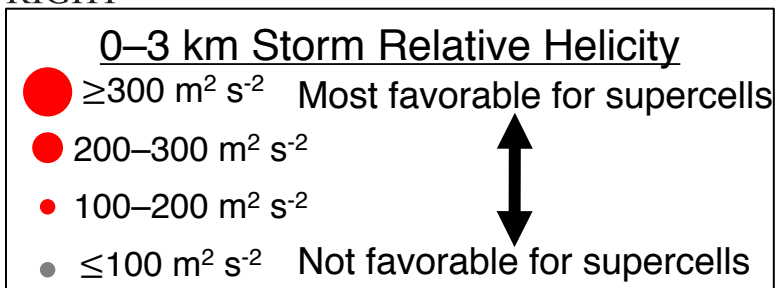
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- Weak ambient shear TCs yield environments generally do not support supercells
- Strong ambient shear TCs yield environments support supercells only in **downshear quadrants**

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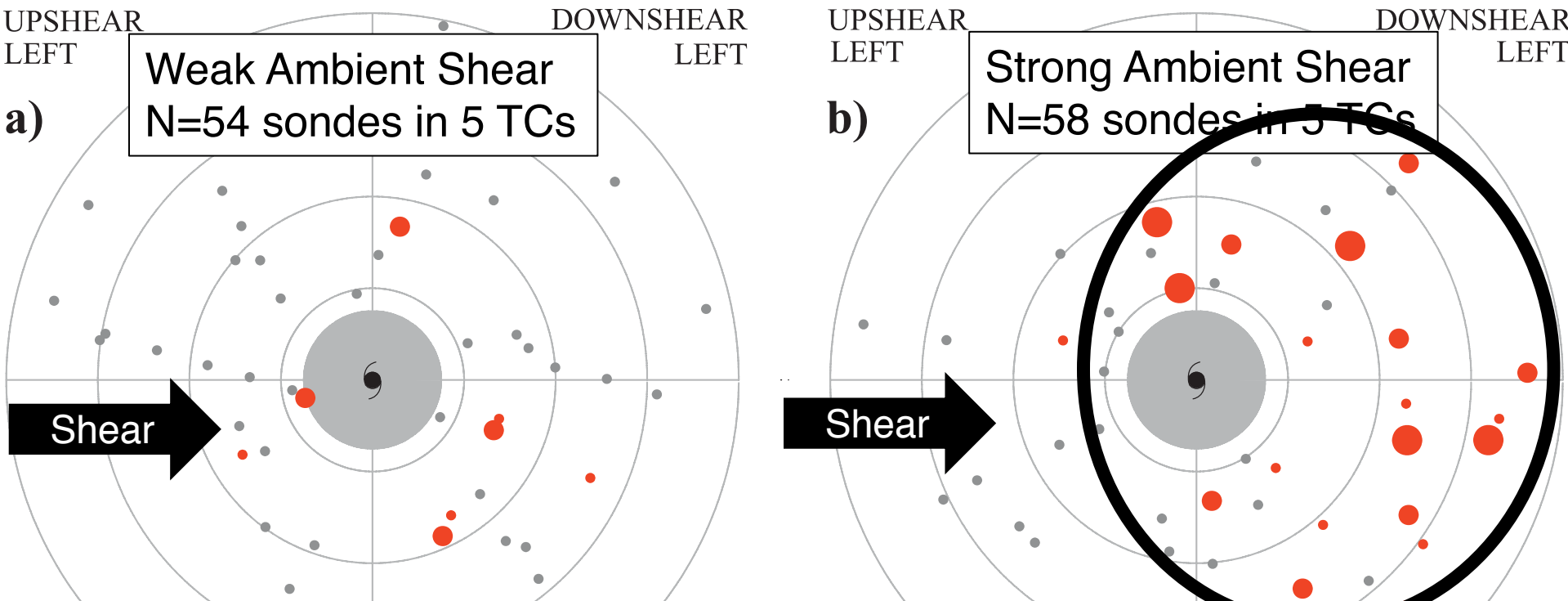


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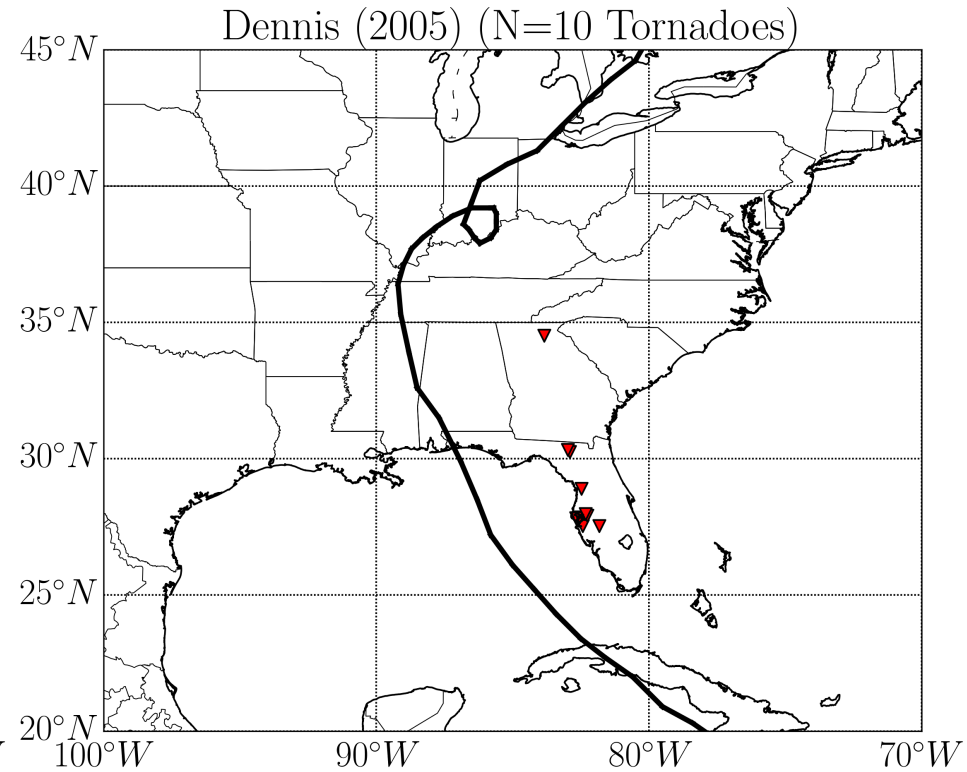
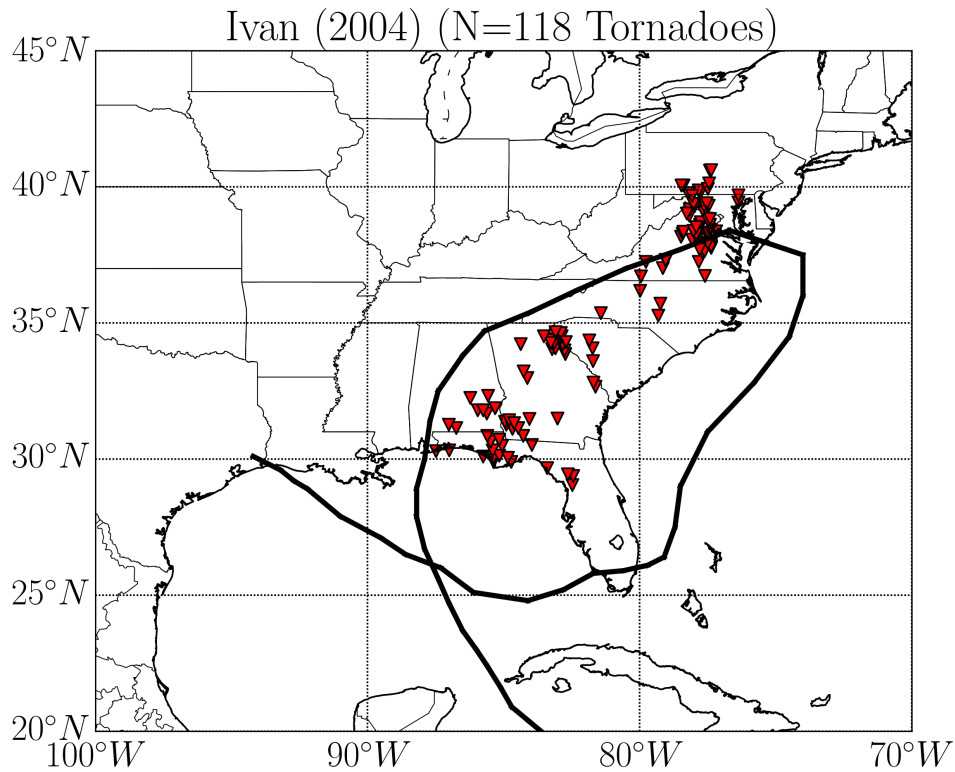
- Supercells favored due to enhanced veering from both TC winds and ambient winds

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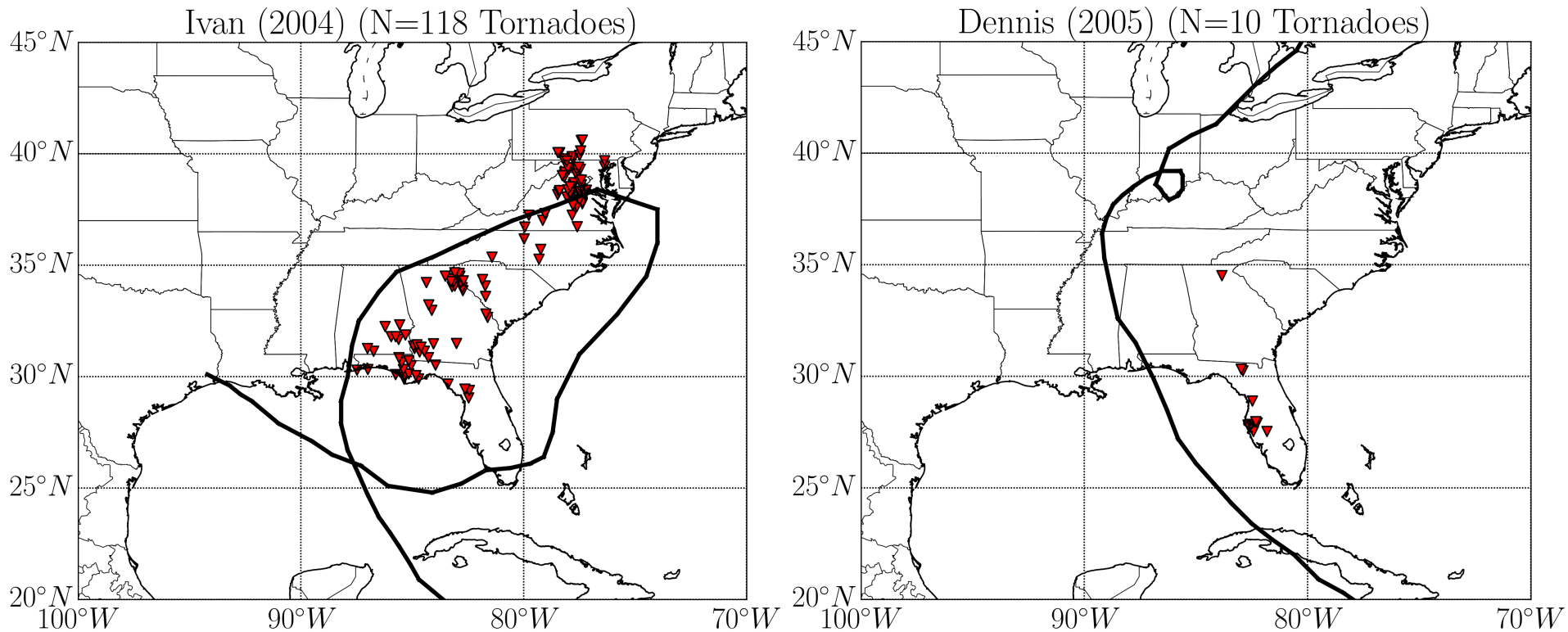


Summary: Ambient vertical wind shear provides favorable environments for deep convection and supercells in downshear quadrants of TC

TCs with Similar Landfall Locations and Intensities



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Can ambient deep-tropospheric vertical wind shear explain the differences among TCs in tornado frequency and location?

Data and Methods

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 2. Compute **850–200-hPa vertical wind shear** from wind field without TC and average within 500 km radius of TC center

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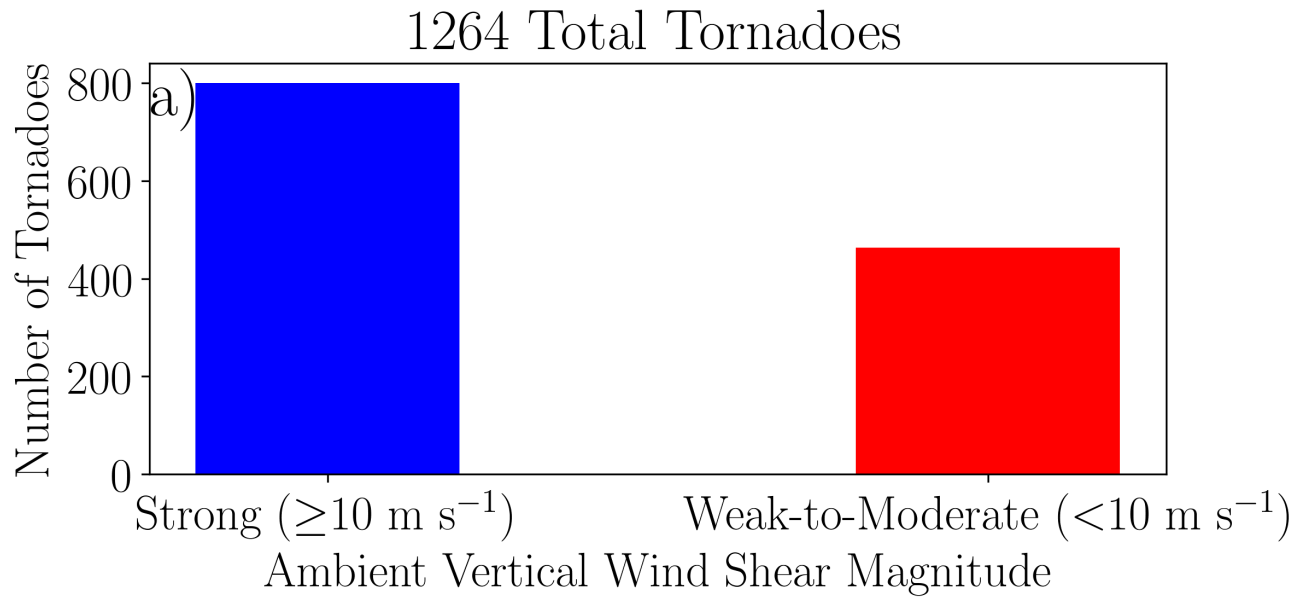
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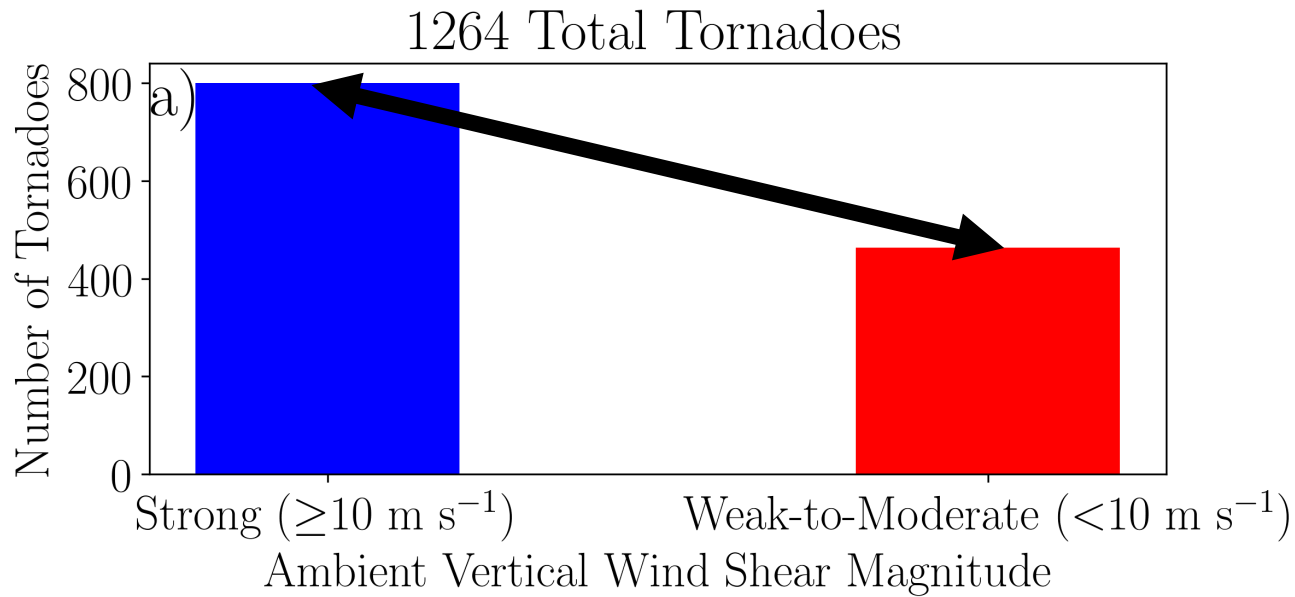
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- Analysis will assess sensitivity of tornado frequency and location in TCs binned according to strong or weak-to-moderate ambient vertical wind shear

Variation of TC Tornado Frequency with Ambient Vertical Wind Shear

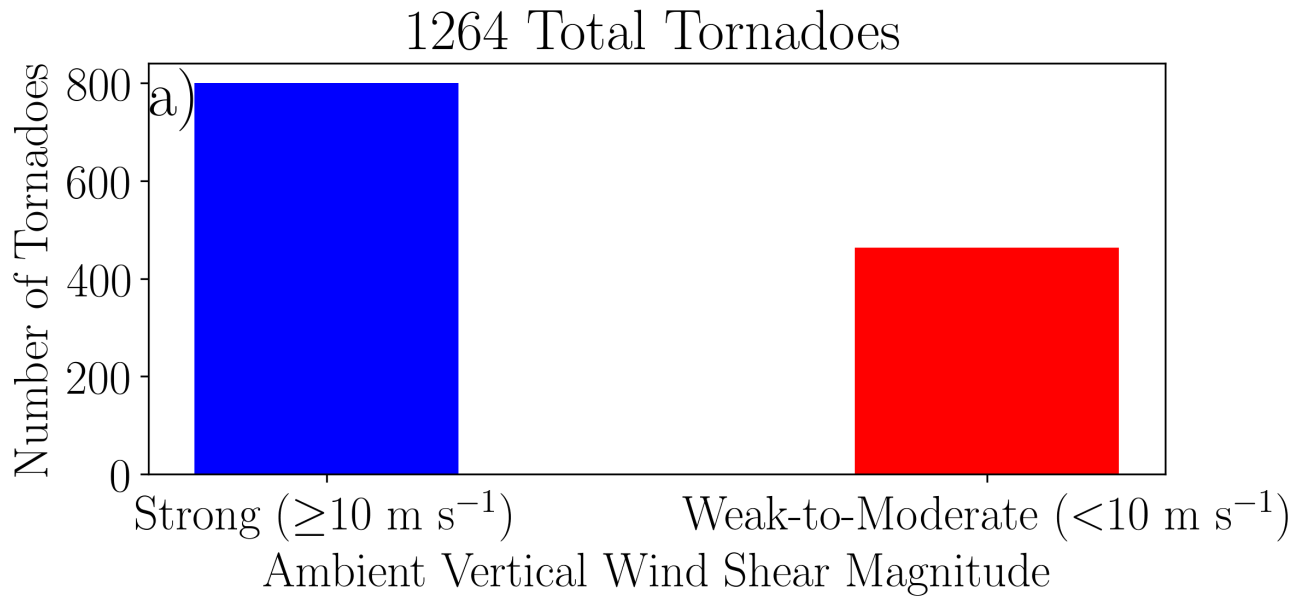


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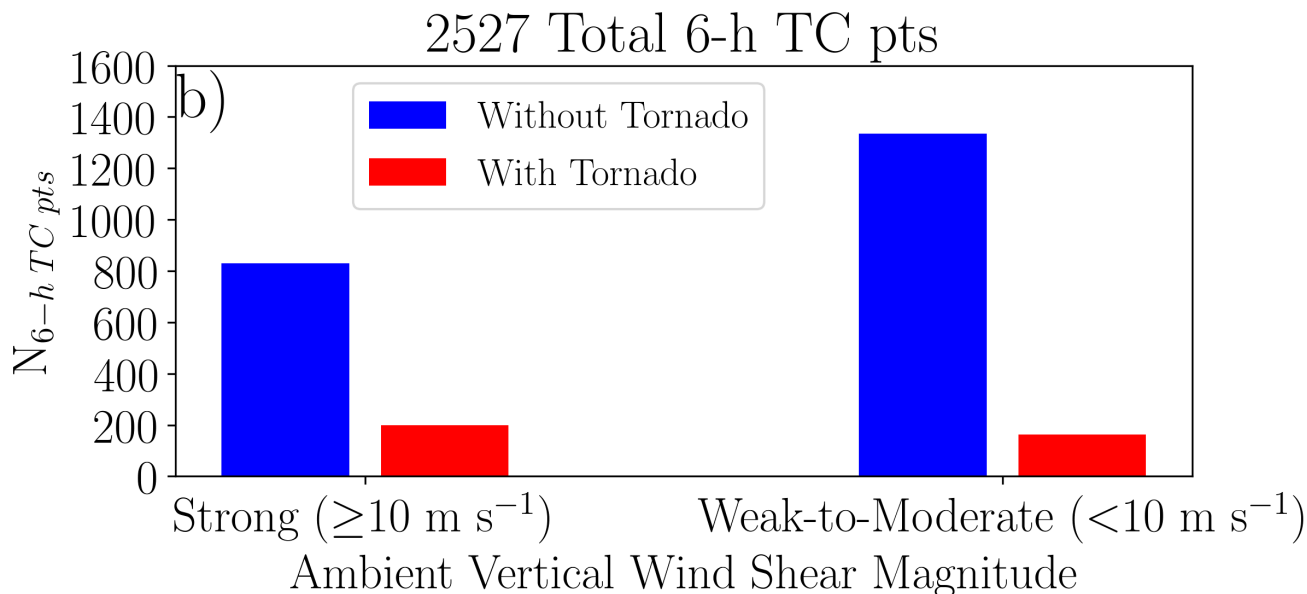


- Majority of tornadoes occur in strongly sheared TCs

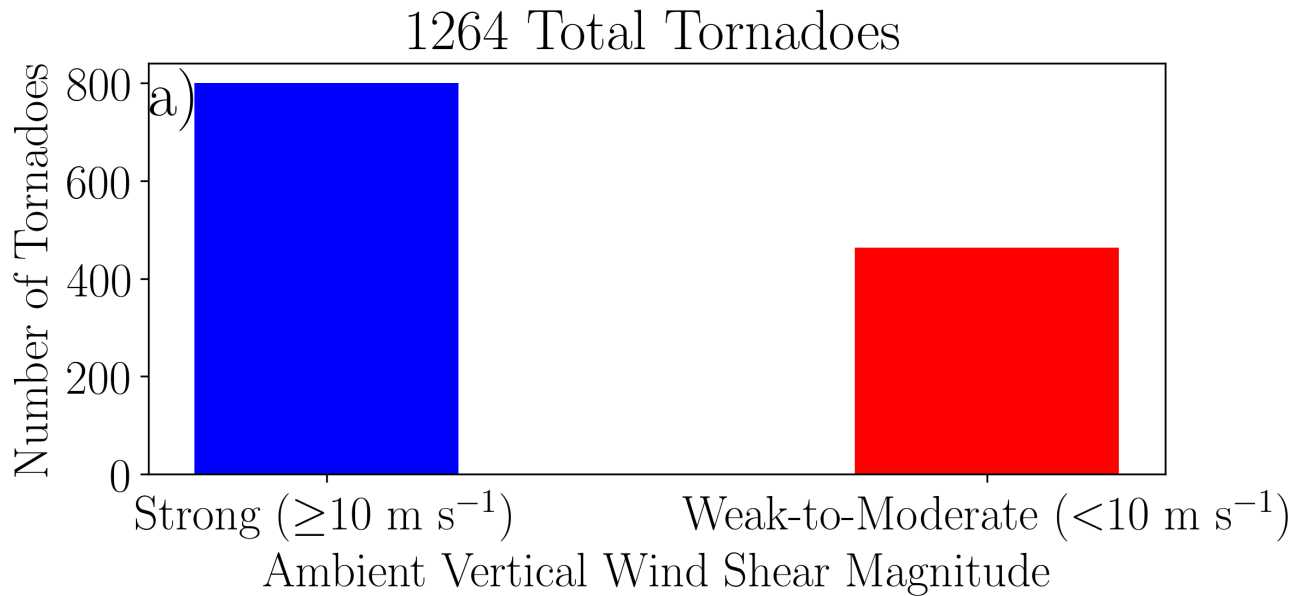
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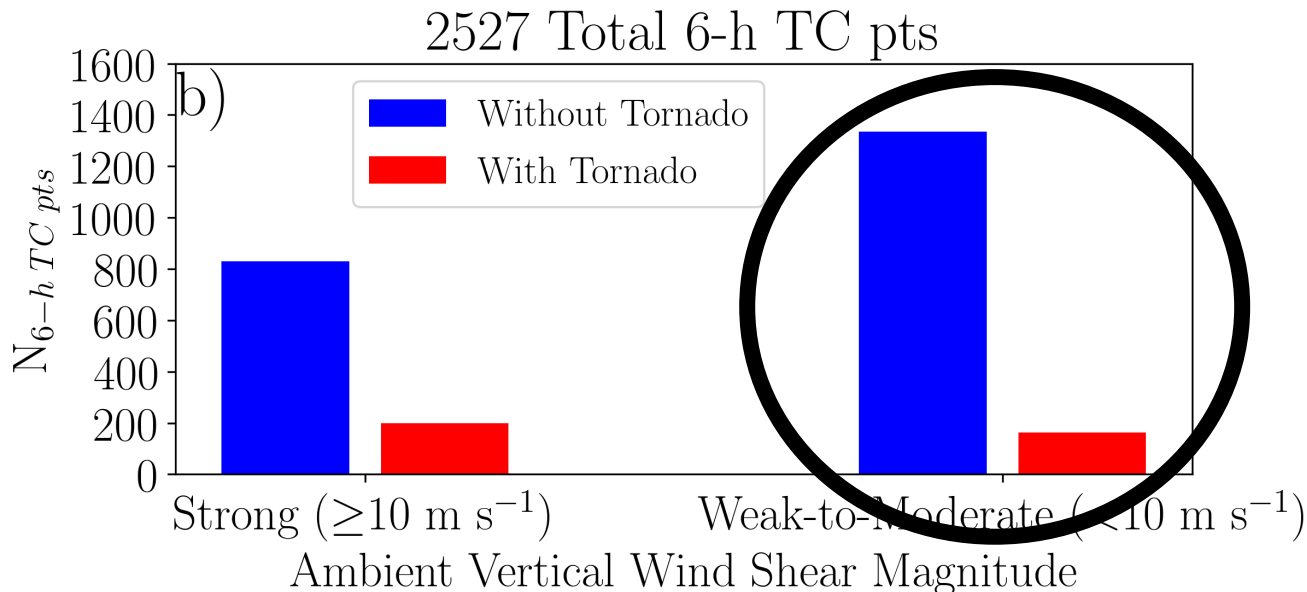
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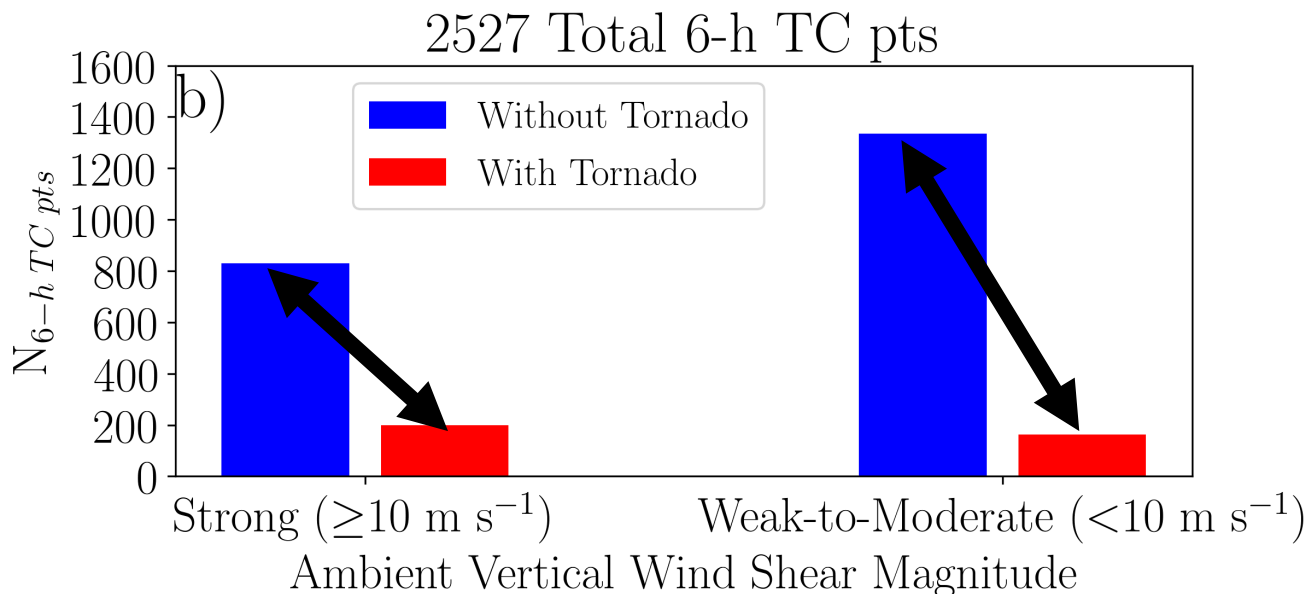
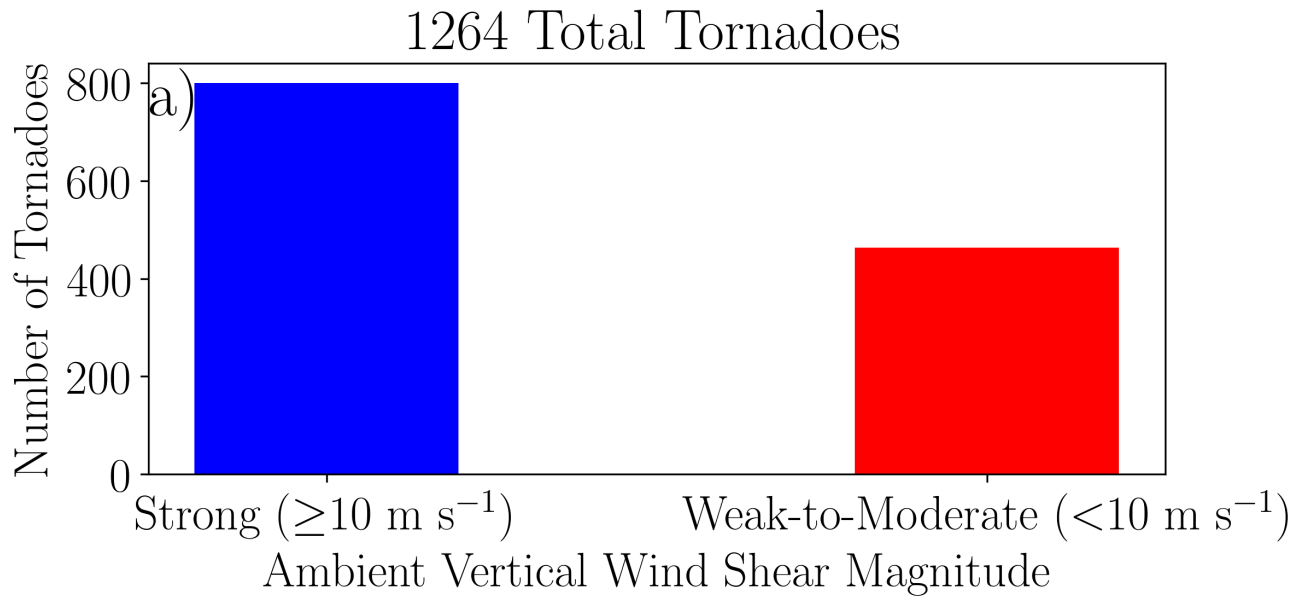
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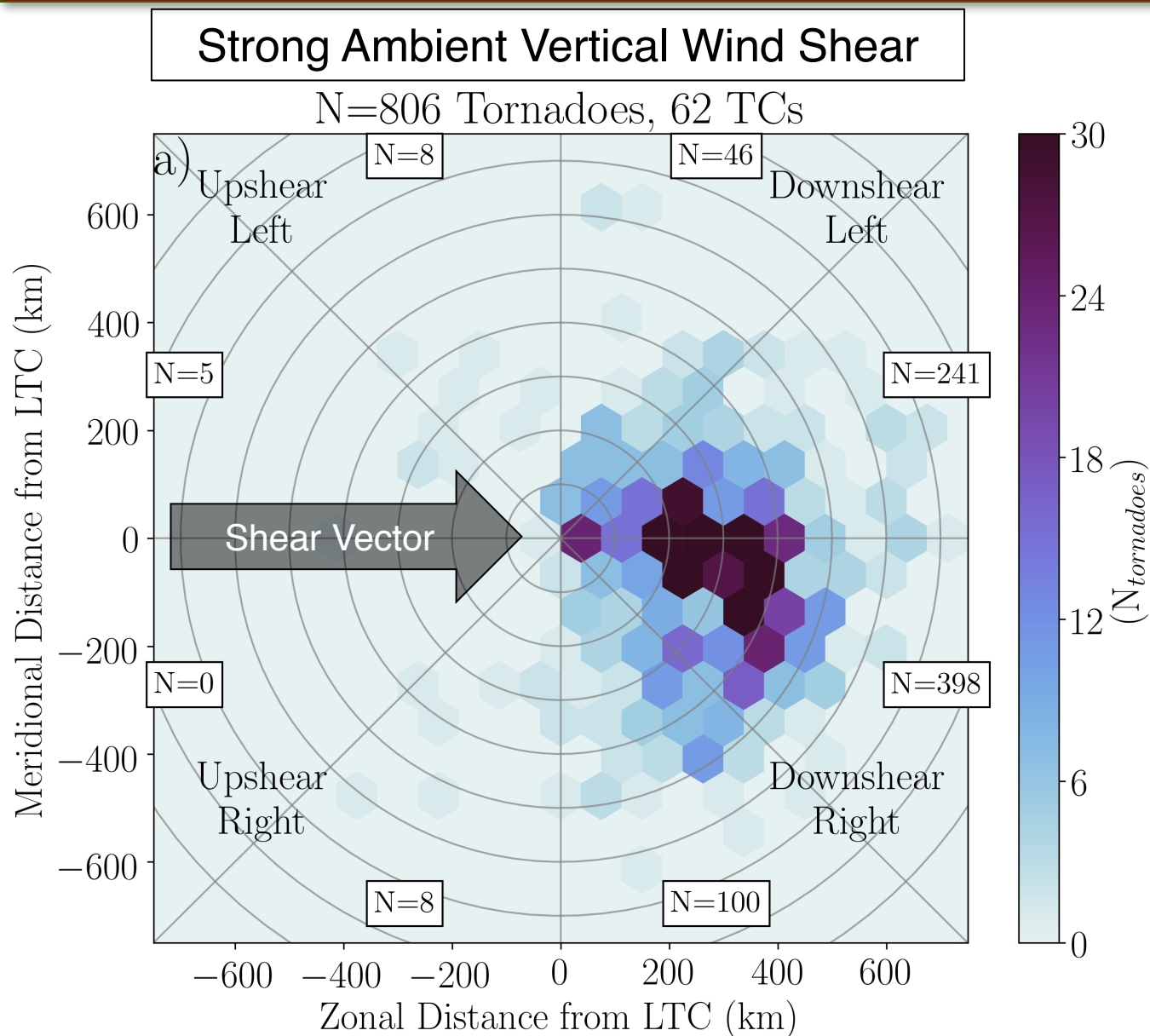


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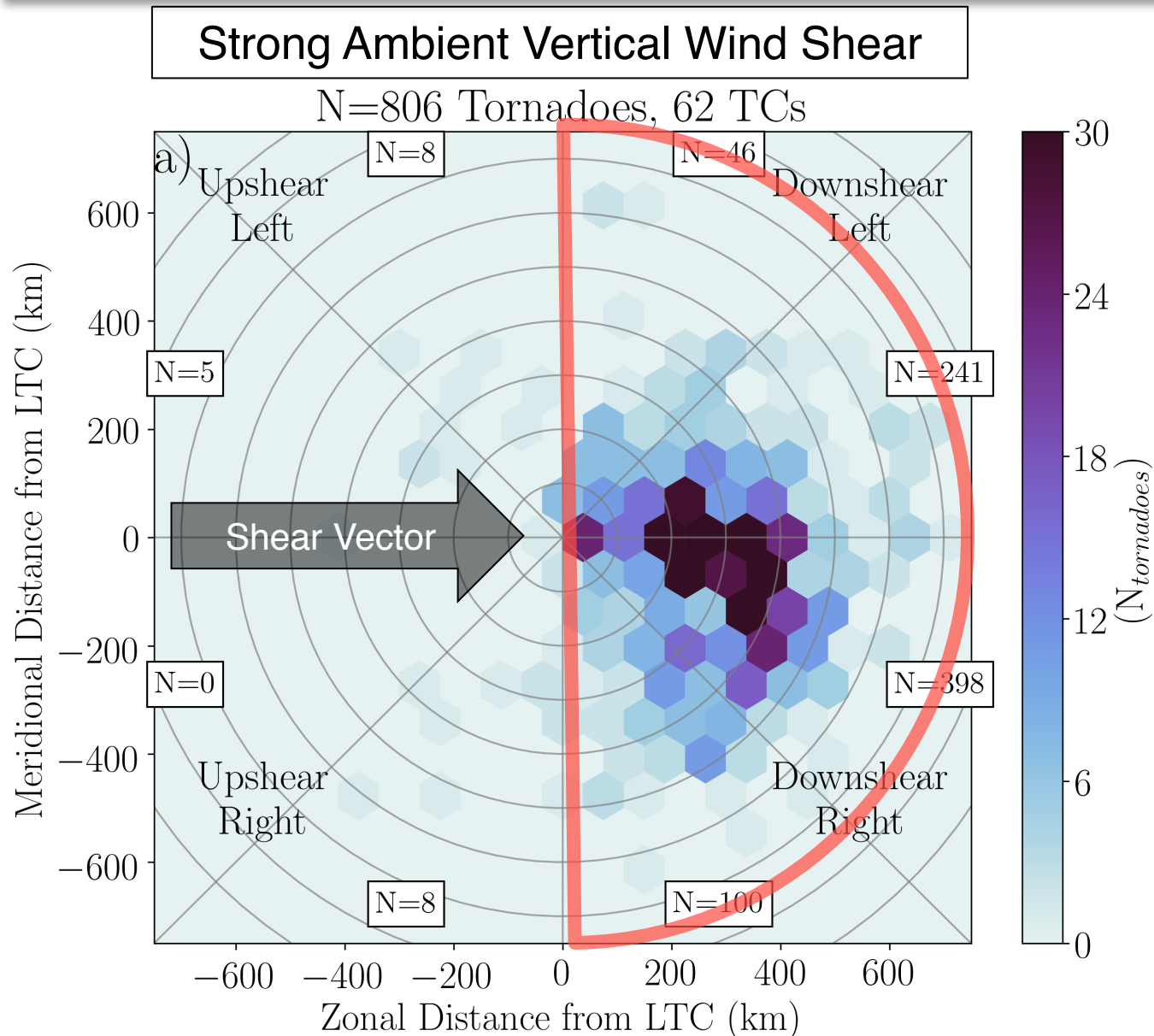


- Majority of tornadoes occur in strongly sheared TCs
- Landfalling TCs undergo weak-to-moderate ambient vertical wind shear
- Strongly sheared landfalling TCs produce tornadoes at greater percentage of time

Tornado Location for TCs in Strong Ambient Vertical Wind Shear



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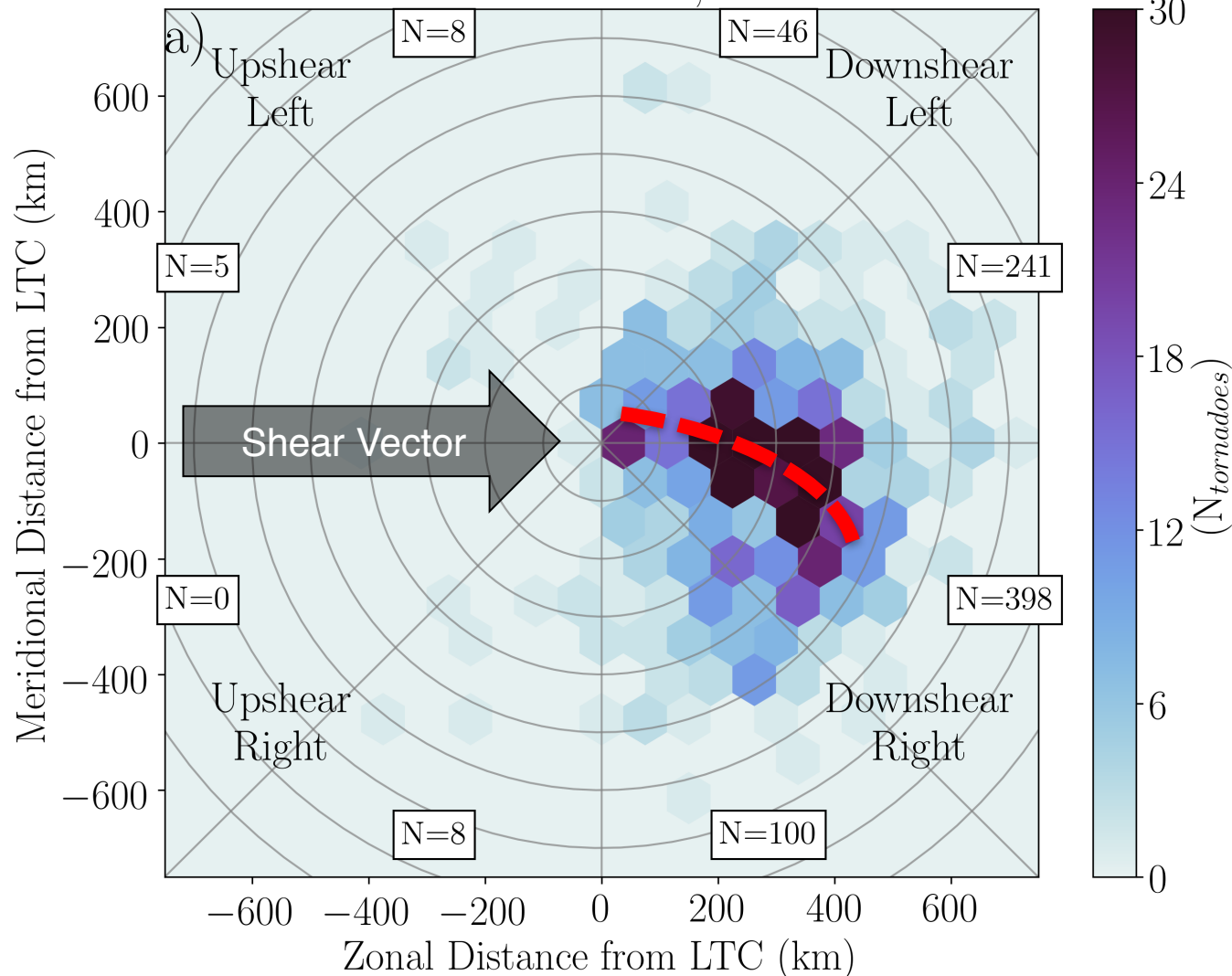


- Nearly all tornadoes occur in **downshear half of TC**

Tornado Location for TCs in Strong Ambient Vertical Wind Shear

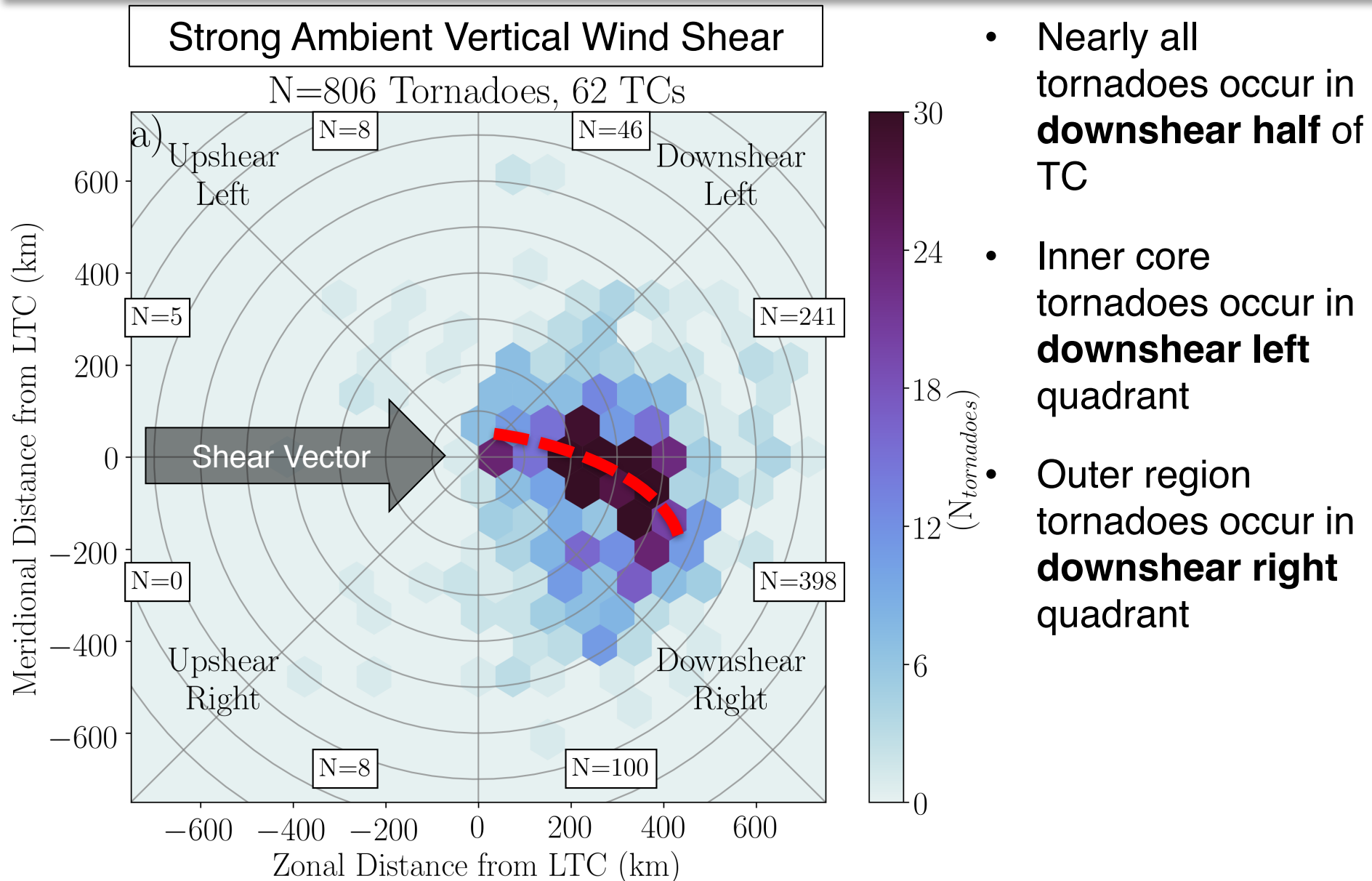
Strong Ambient Vertical Wind Shear

N=806 Tornadoes, 62 TCs

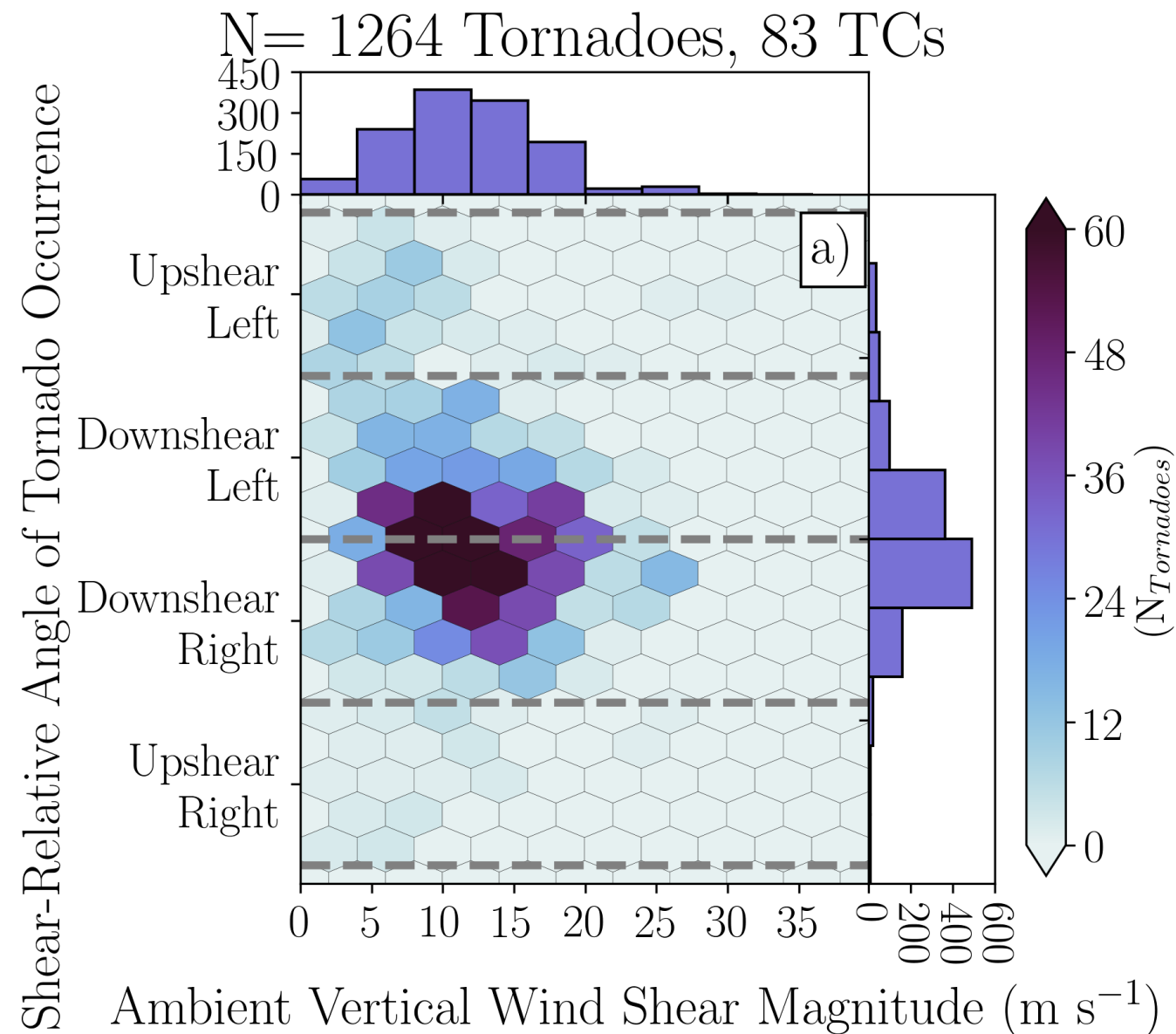


- Nearly all tornadoes occur in **downshear half of TC**
- Inner core tornadoes occur in **downshear left quadrant**

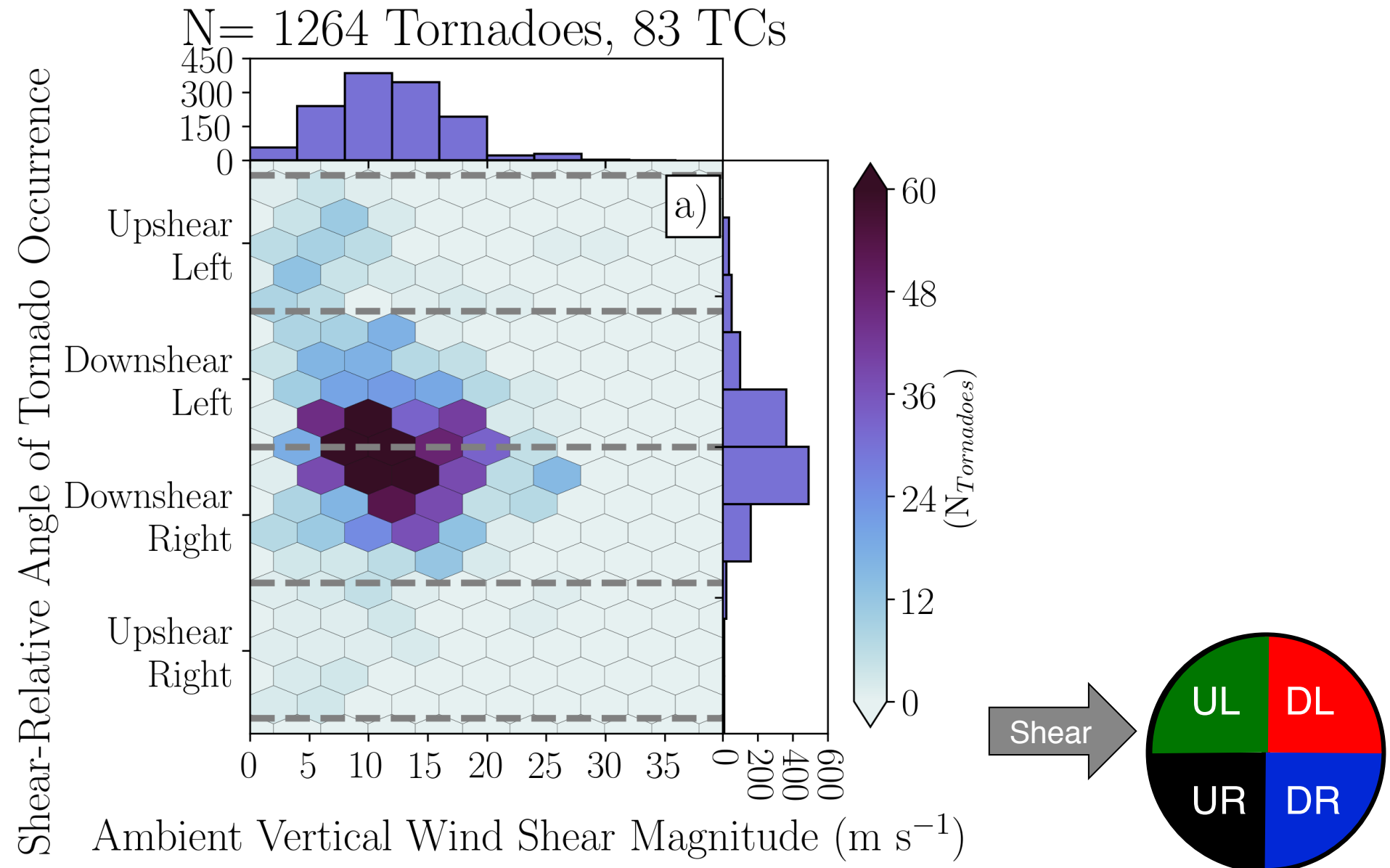
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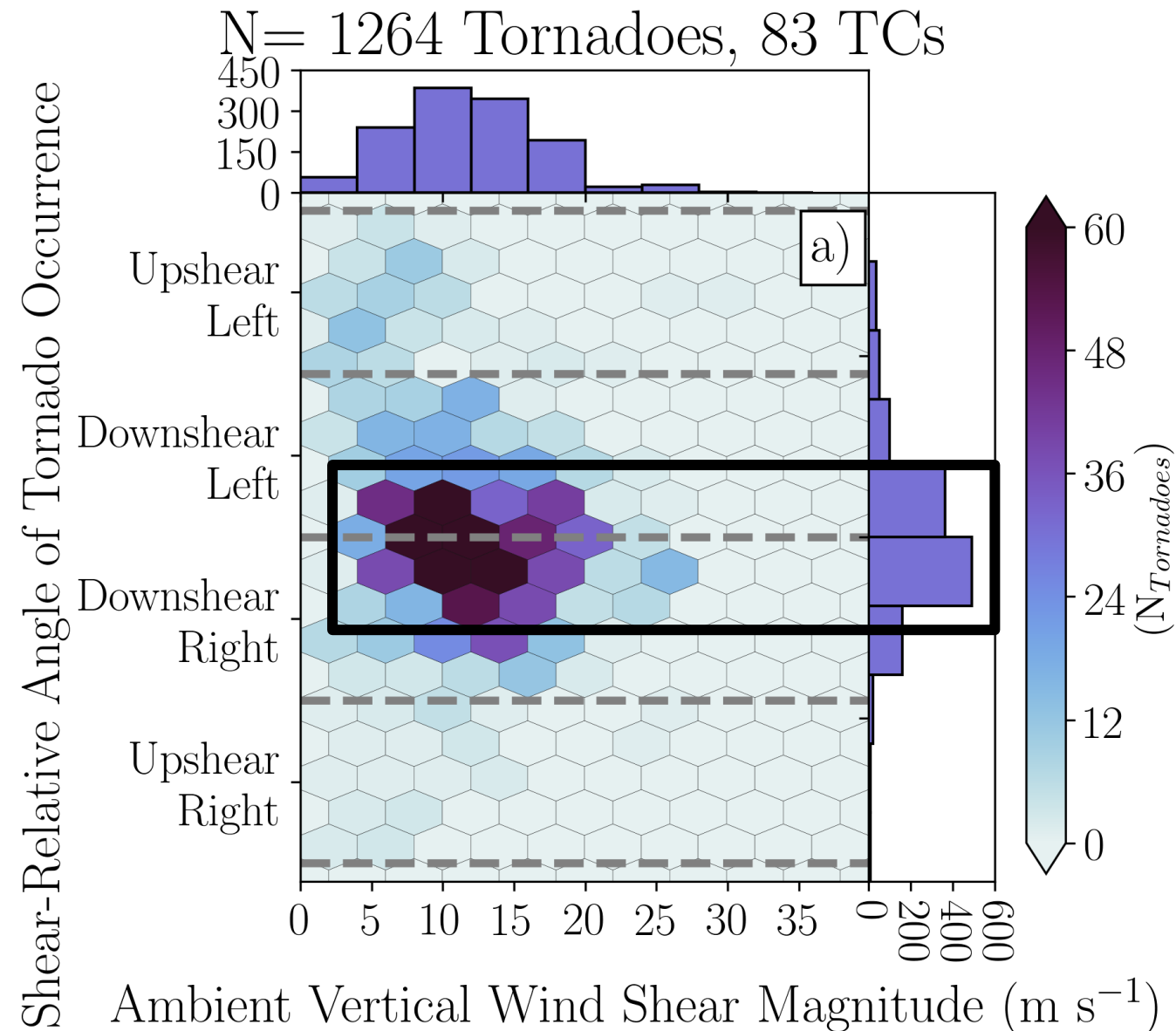
Tornado Location Dependence on Ambient Vertical Wind Shear



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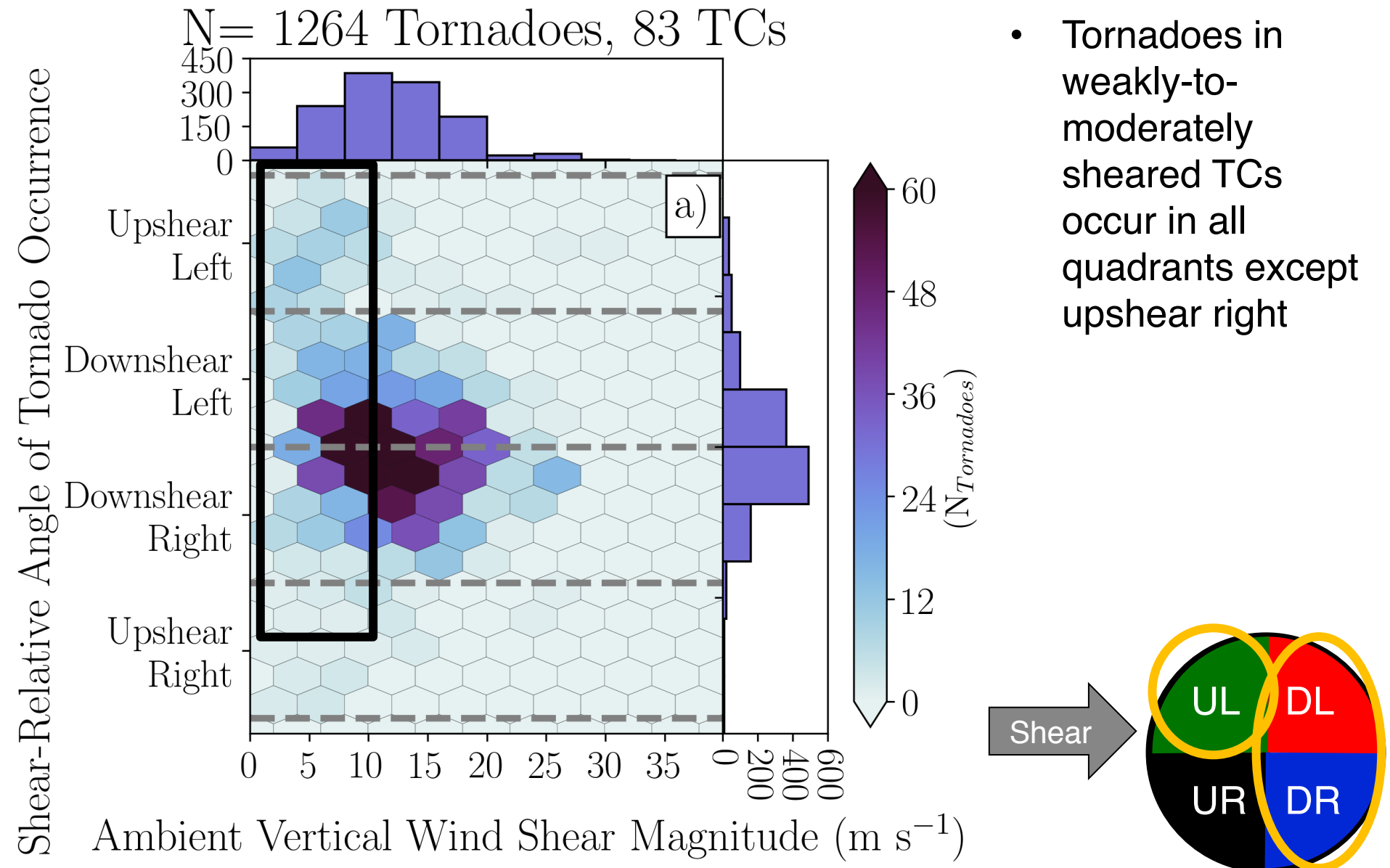


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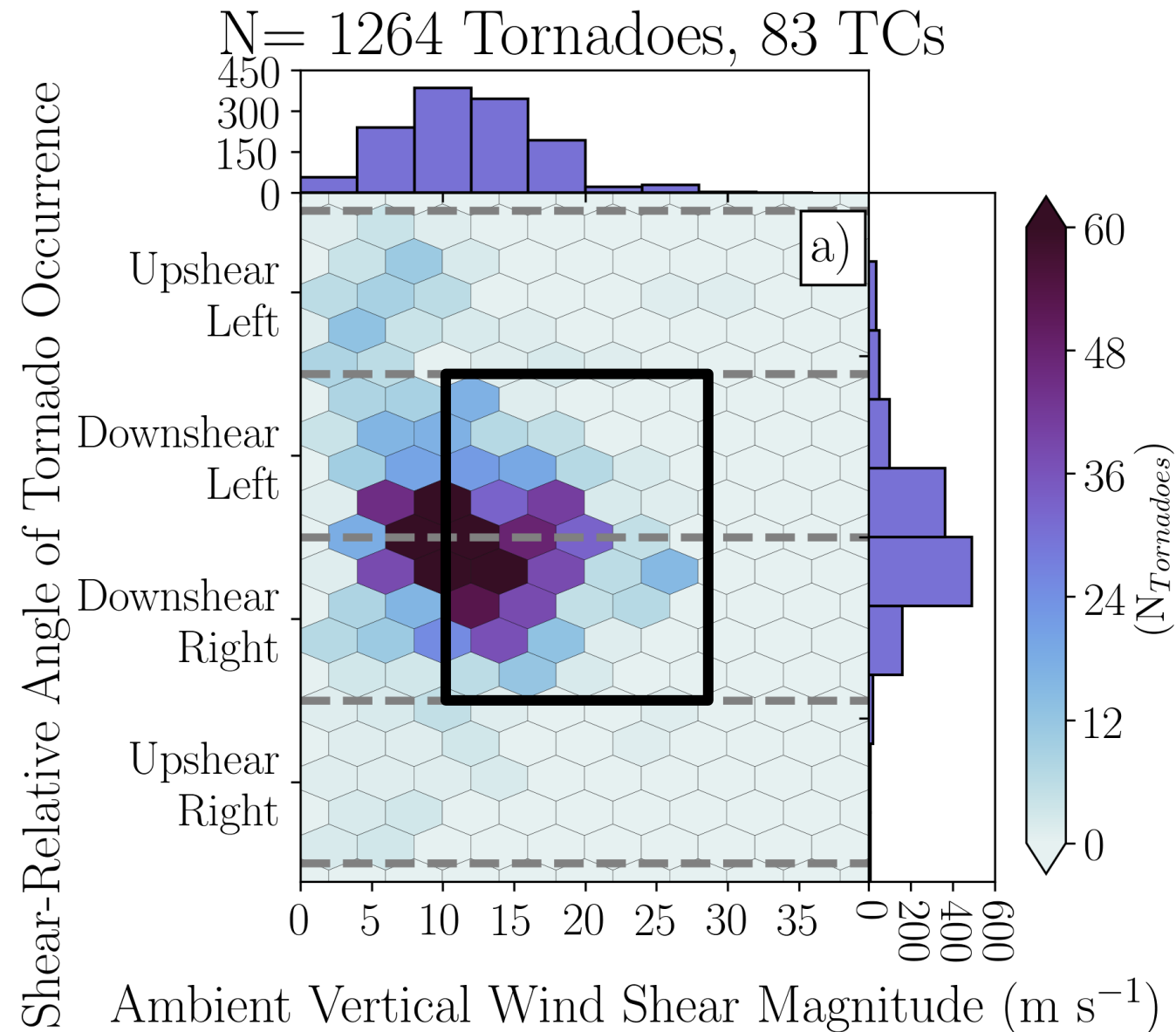


- Tornadoes primarily occur in downshear quadrants regardless of ambient shear magnitude

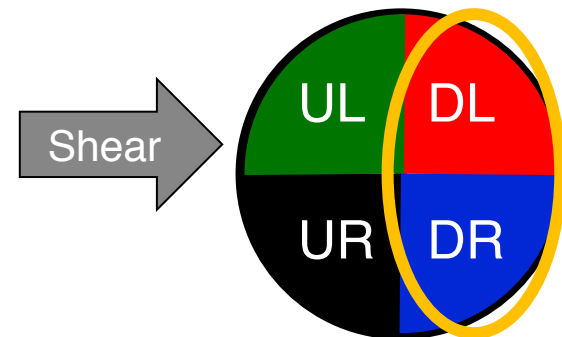
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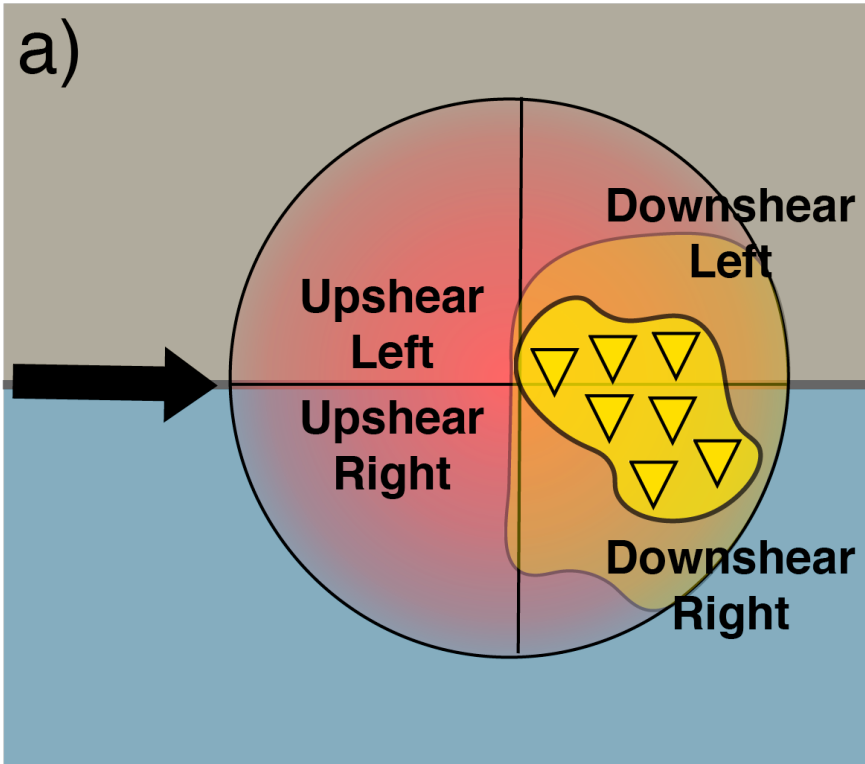


- Tornadoes in weakly-to-moderately sheared TCs occur in all quadrants except upshear right
- Nearly all tornadoes occur downshear in TCs undergoing strong ambient shear



Summary and Discussion

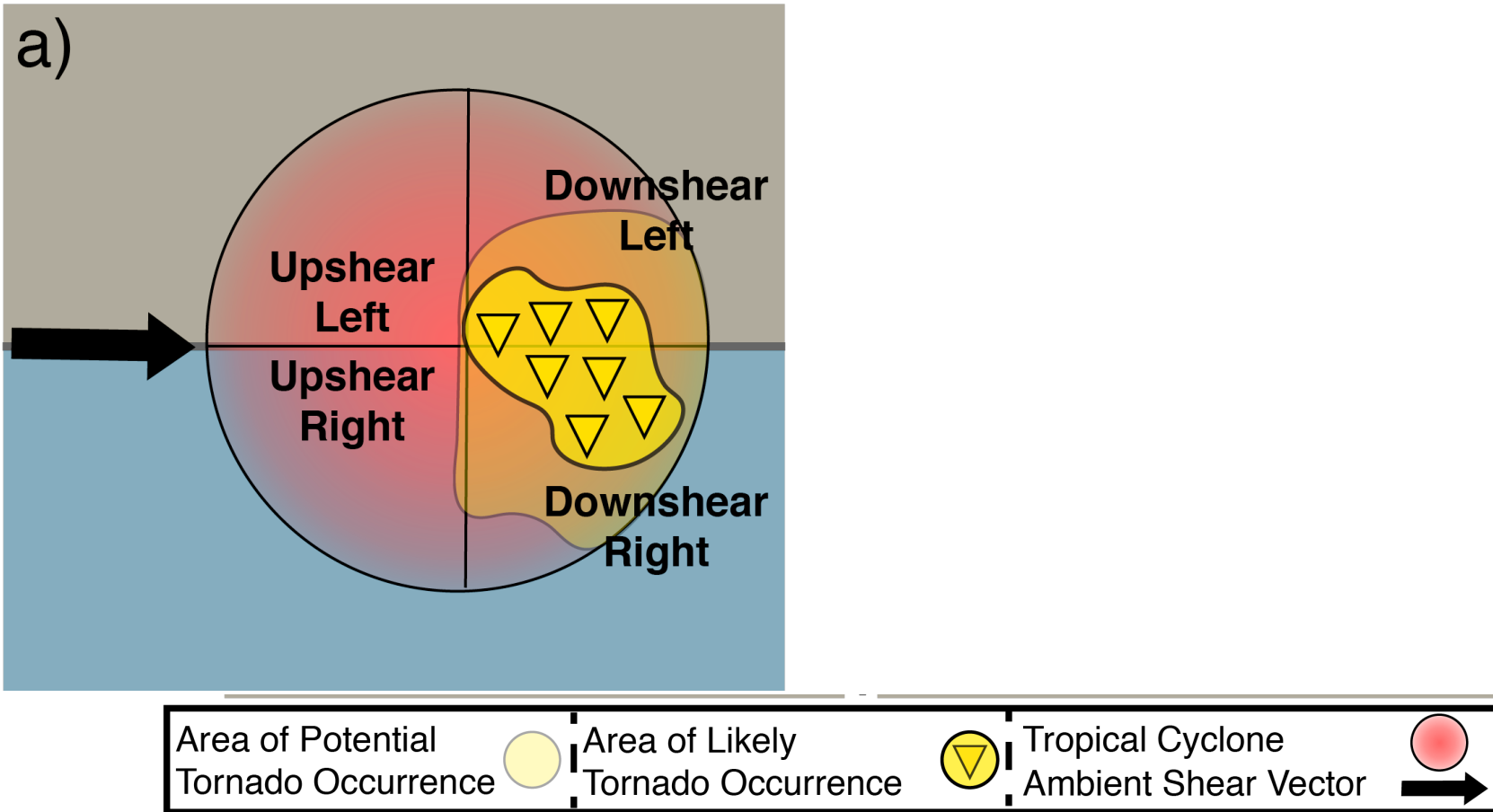
Strong Ambient Shear



Area of Potential Tornado Occurrence		Area of Likely Tornado Occurrence		Tropical Cyclone	
				Ambient Shear Vector	

Summary and Discussion

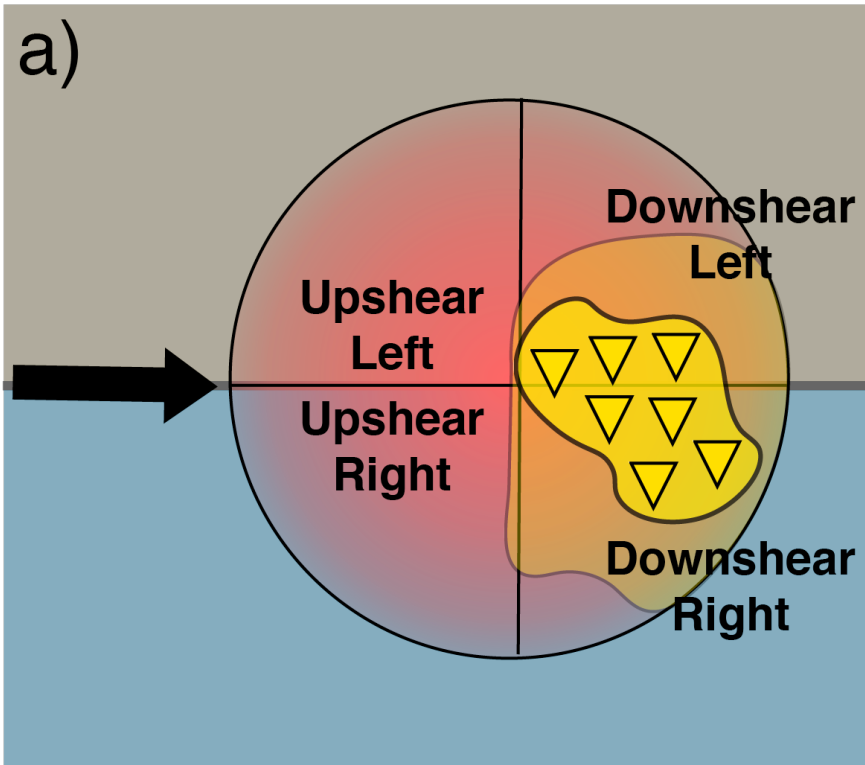
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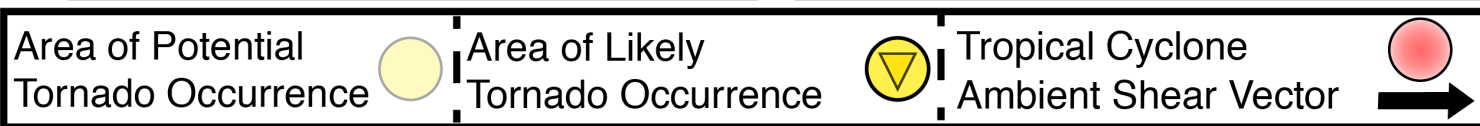
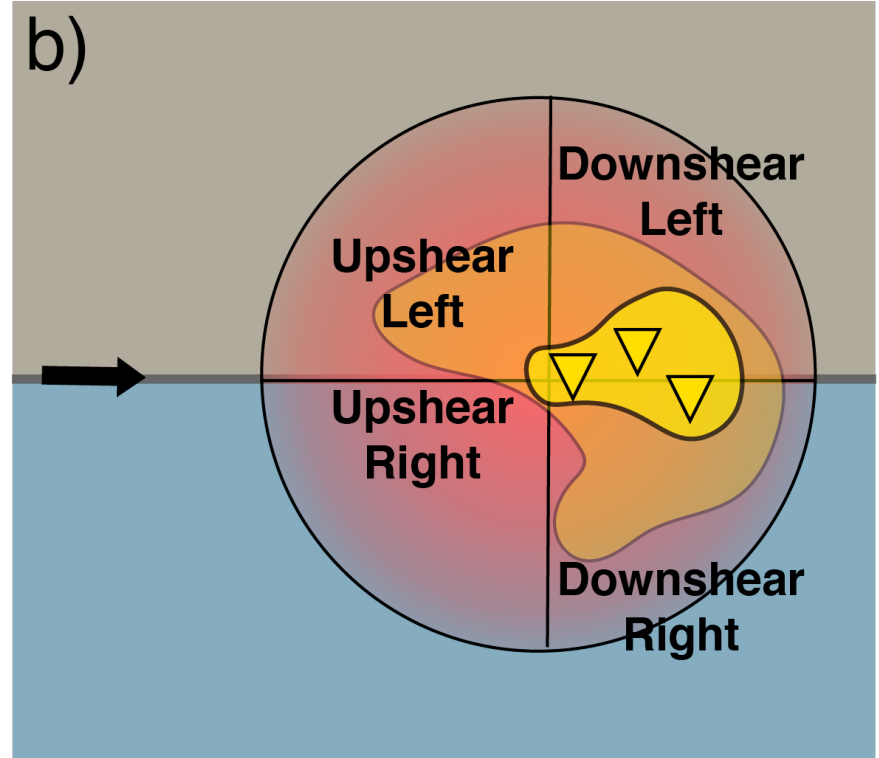
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Summary and Discussion

Strong Ambient Shear



Weak-to-Moderate Shear



Strong ambient shear: 1) *more* tornadoes and 2) tornadoes *exclusively* occur in downshear quadrants

Weak-to-moderate shear: 1) *fewer* tornadoes and 2) *most, but not all* tornadoes occur in downshear quadrants