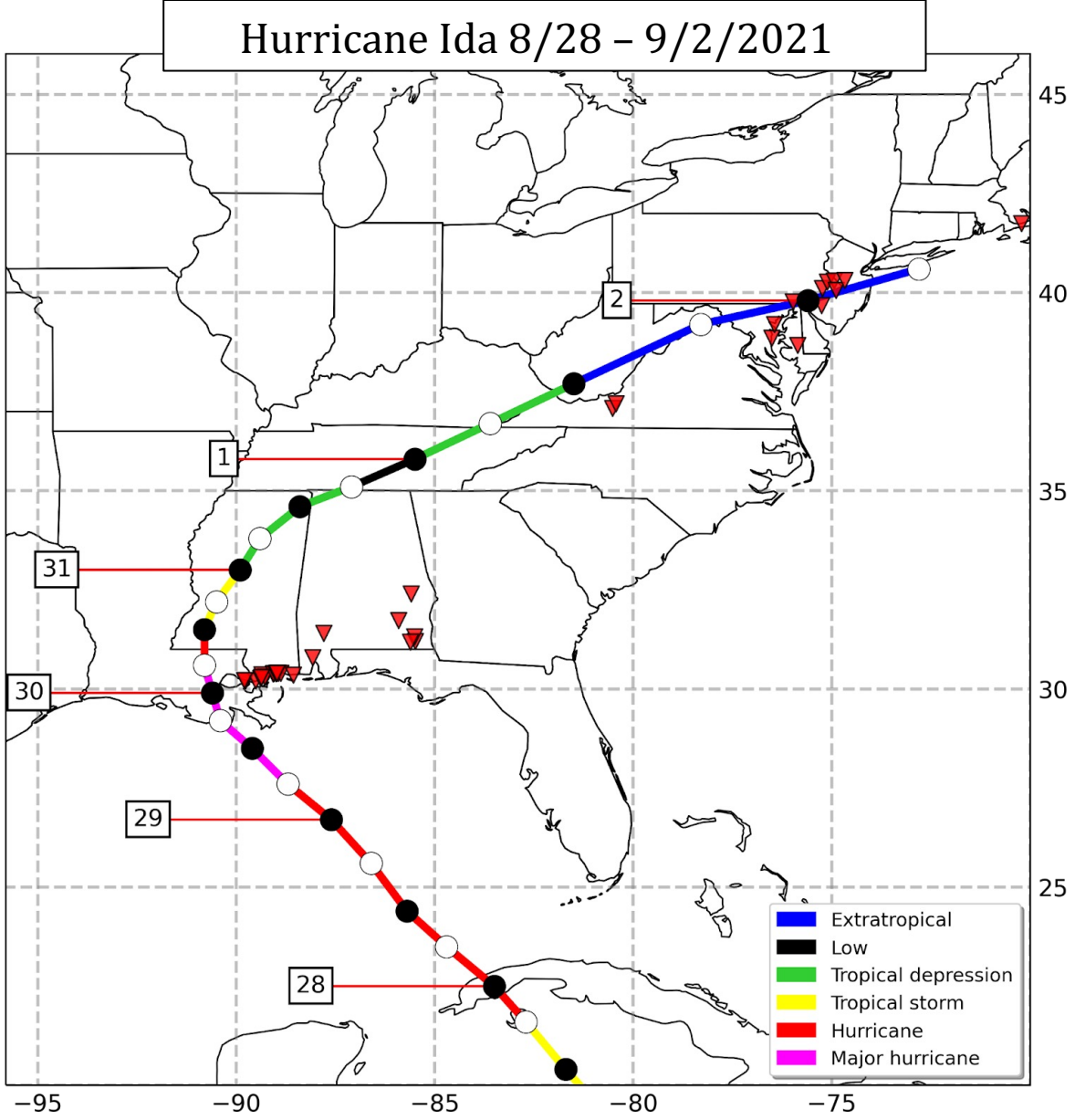
# Comparing Tornadoes in the Tropical versus Extratropical Phase of Tropical Cyclones

Kayla Wheeler[1] (kwheeler2@ou.edu)

Ben Schenkel[1,2], Nusrat Yussouf[1,2]

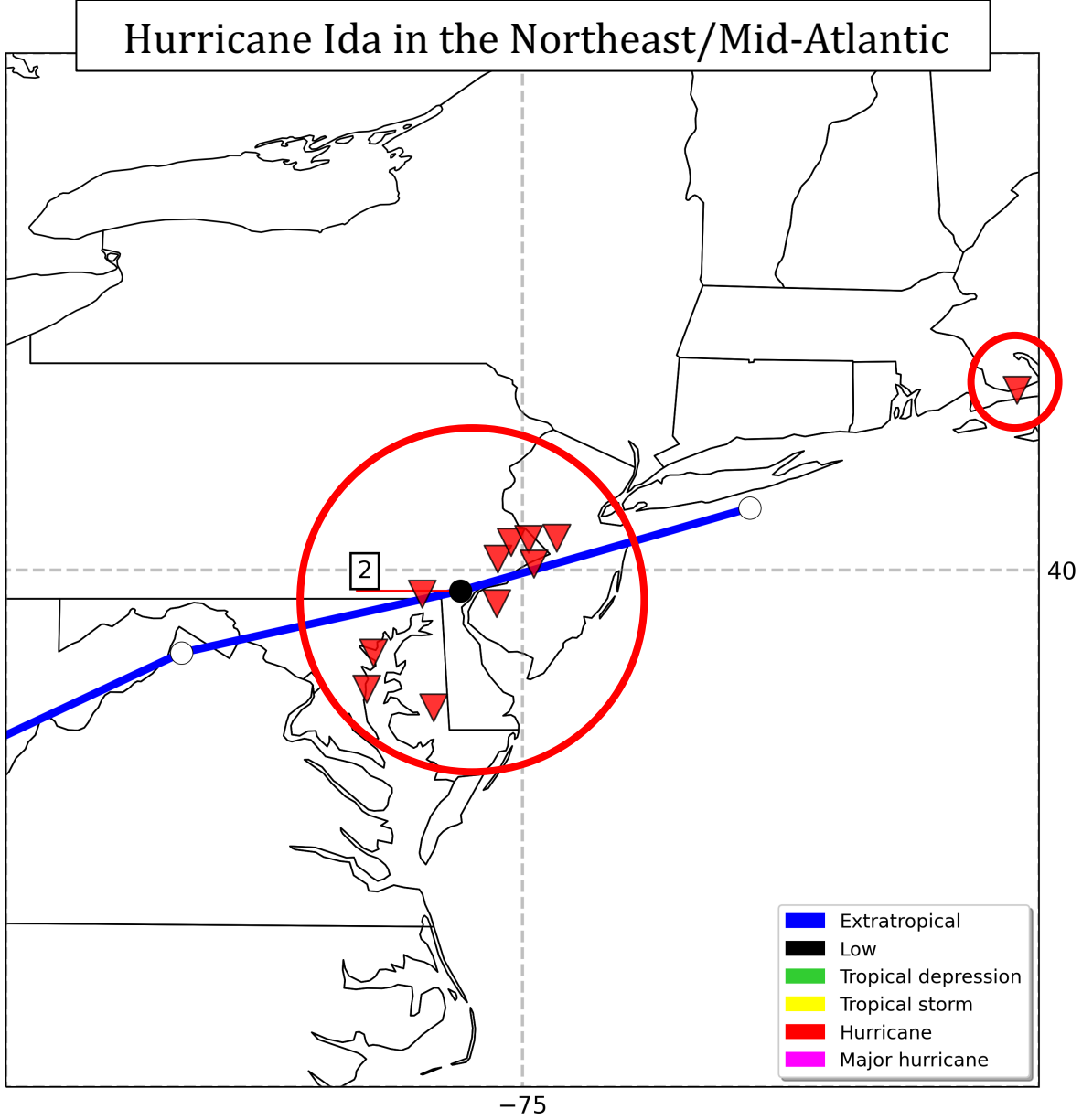
[1]University of Oklahoma, [2]National Severe Storms Laboratory

Funding from NSF AGS-2028151




# Hurricane Ida

- Category 4 Hurricane that underwent extratropical transition
- 36 known tornadoes
  - 25 in tropical phase
  - 11 in extratropical phase



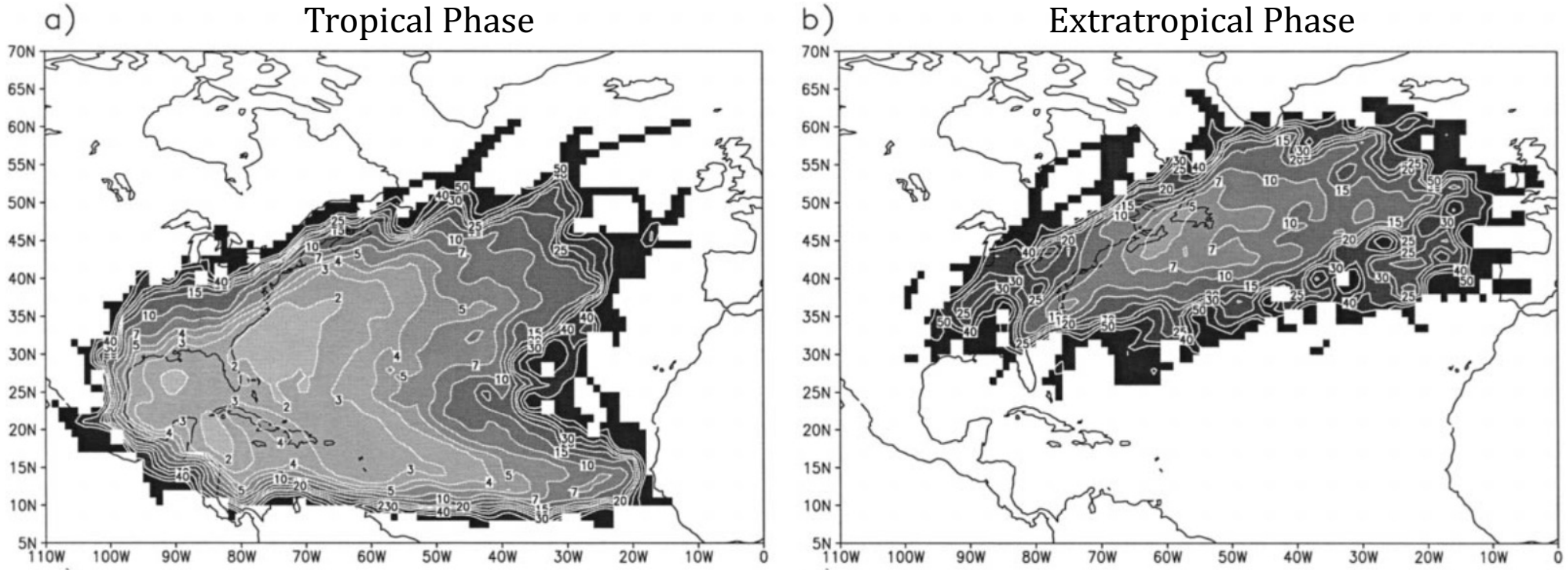

# Hurricane Ida

- Tornadoes in MD, PA, NJ, MA
- Multiple EF2s and one EF3 tornado

# Tropical vs Extratropical Phase Location

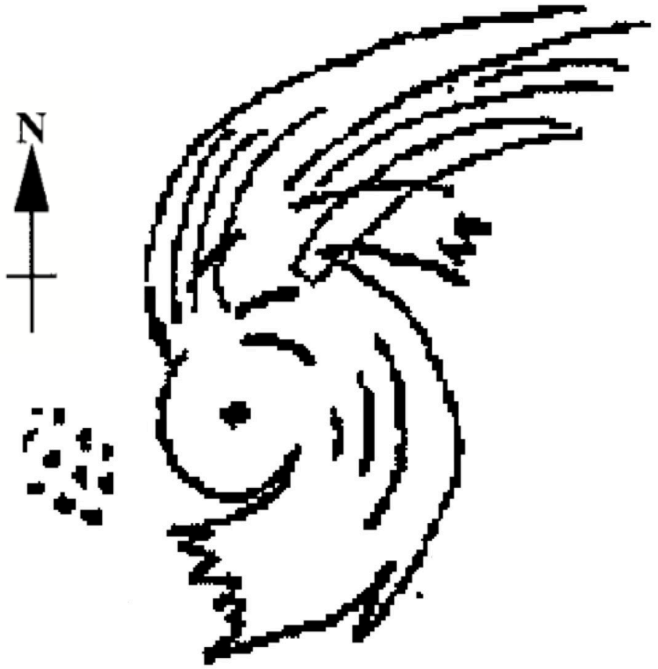
Hart & Evans (2001)

Within 111 km

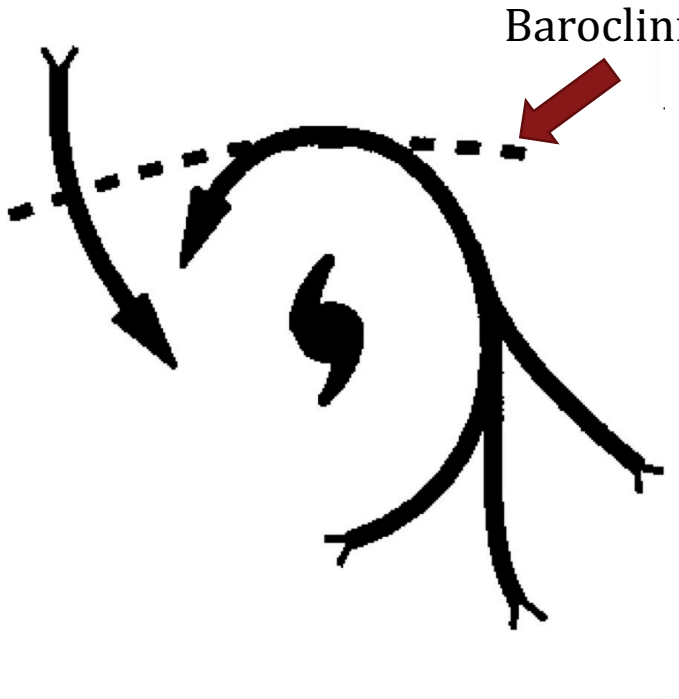



- Tropical Phase tornado return period lowest in west Atlantic, especially along Southeast coast
- Extratropical Phase tornadoes return period in north Atlantic, especially off coast of Nova Scotia

# Beginning of Extratropical Transition




Infrared Imagery

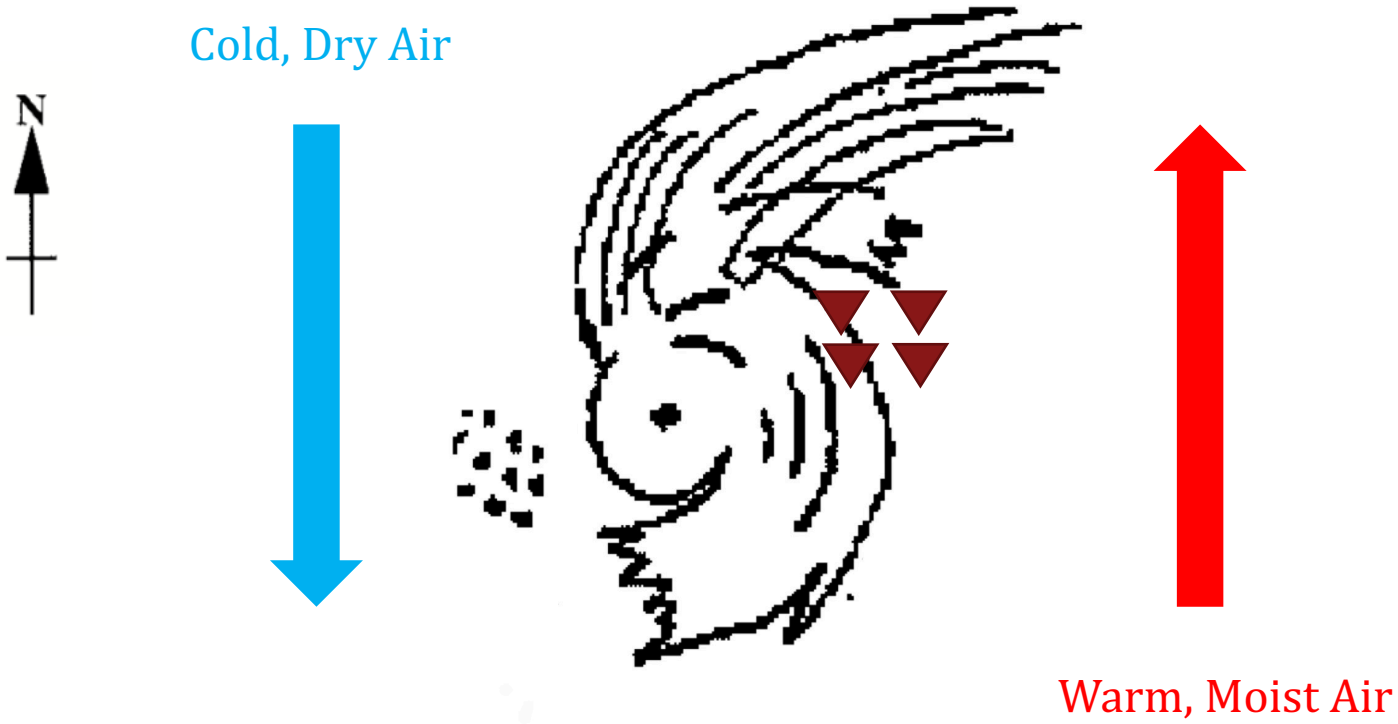



Storm Relative Trajectories

- Outer circulation interacts with the baroclinic zone
- Cold, dry air advected from north along west side
- Warm, moist air advected from south along east side
- Vertical wind shear increases

Klein et al. 2000

# Beginning of Extratropical Transition



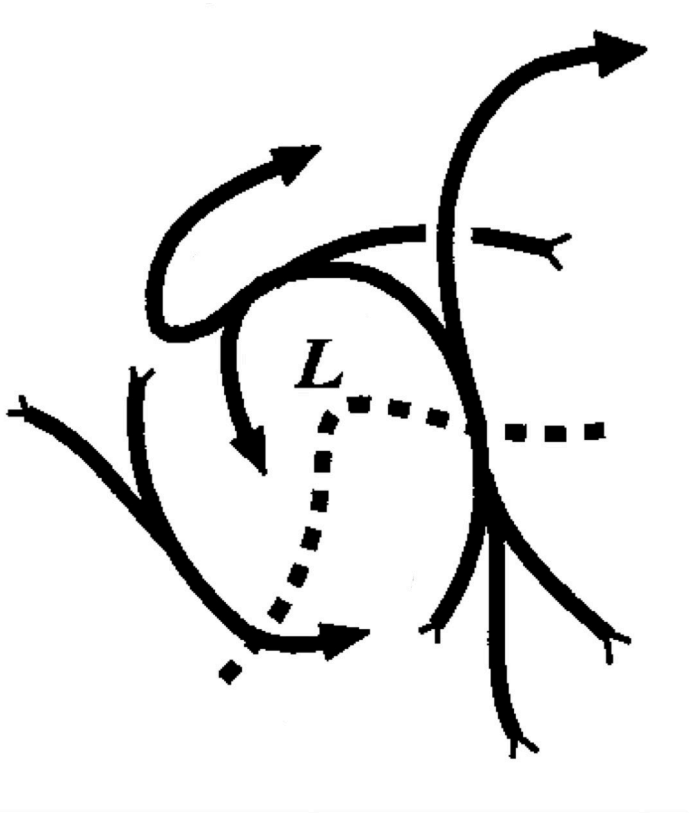

Infrared Imagery

- Outer circulation interacts with the baroclinic zone
- Cold, dry air advected from north along west side
- Warm, moist air advected from south along east side
- Vertical wind shear increases

Klein et al. 2000

# End of Extratropical Transition


Infrared Imagery

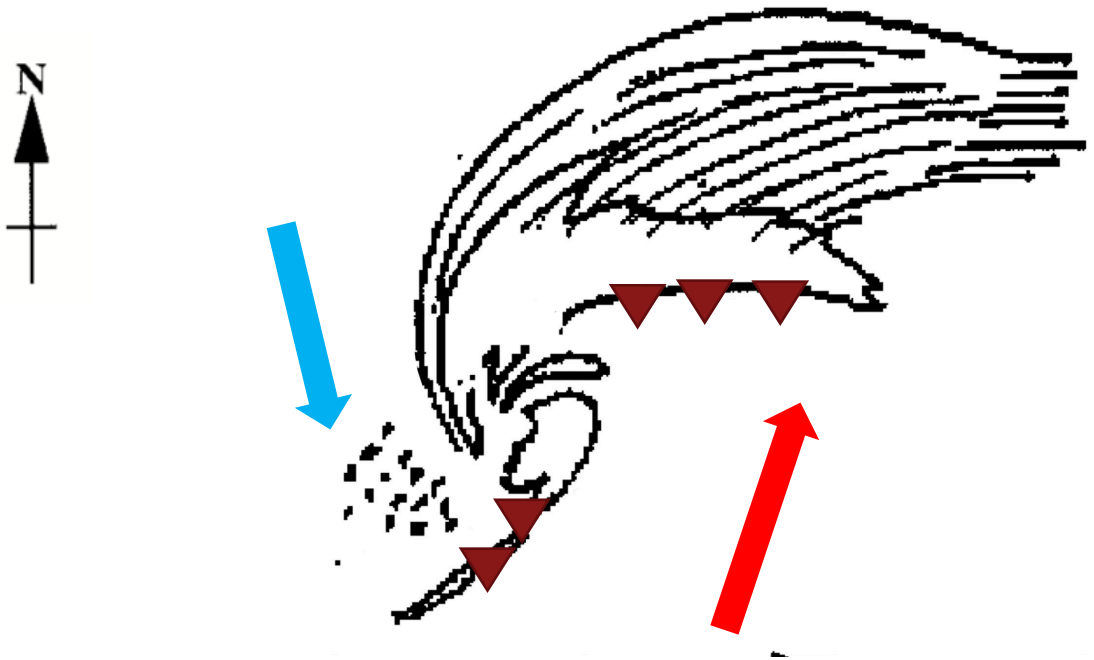



Storm Relative Trajectories

- TC moves farther into baroclinic zone
- Fronts begin to form in association with conveyor belts
- VWS continues to increase

Klein et al. 2000

# End of Extratropical Transition




Infrared Imagery

- TC moves farther into baroclinic zone
- Fronts begin to form in association with conveyor belts
- VWS continues to increase

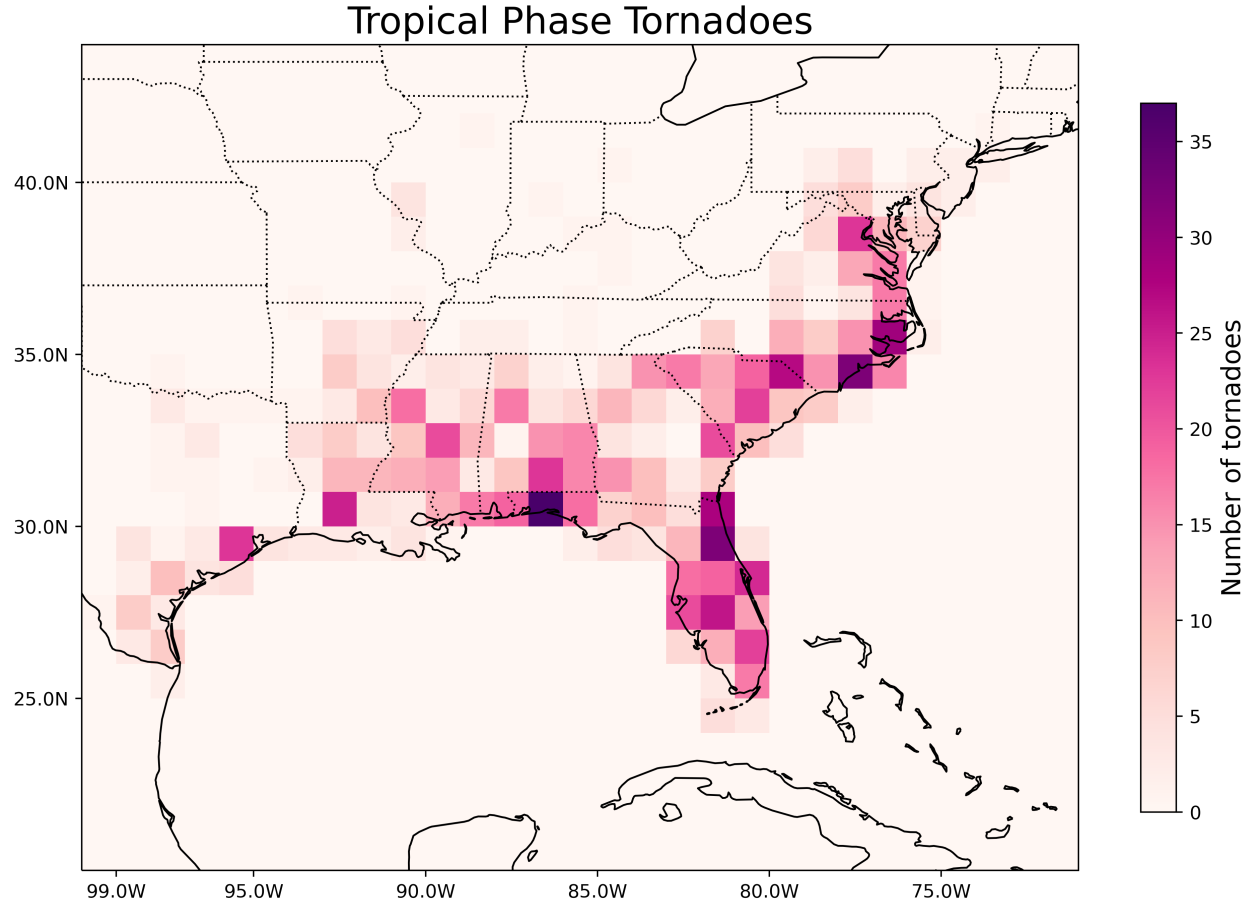
Klein et al. 2000

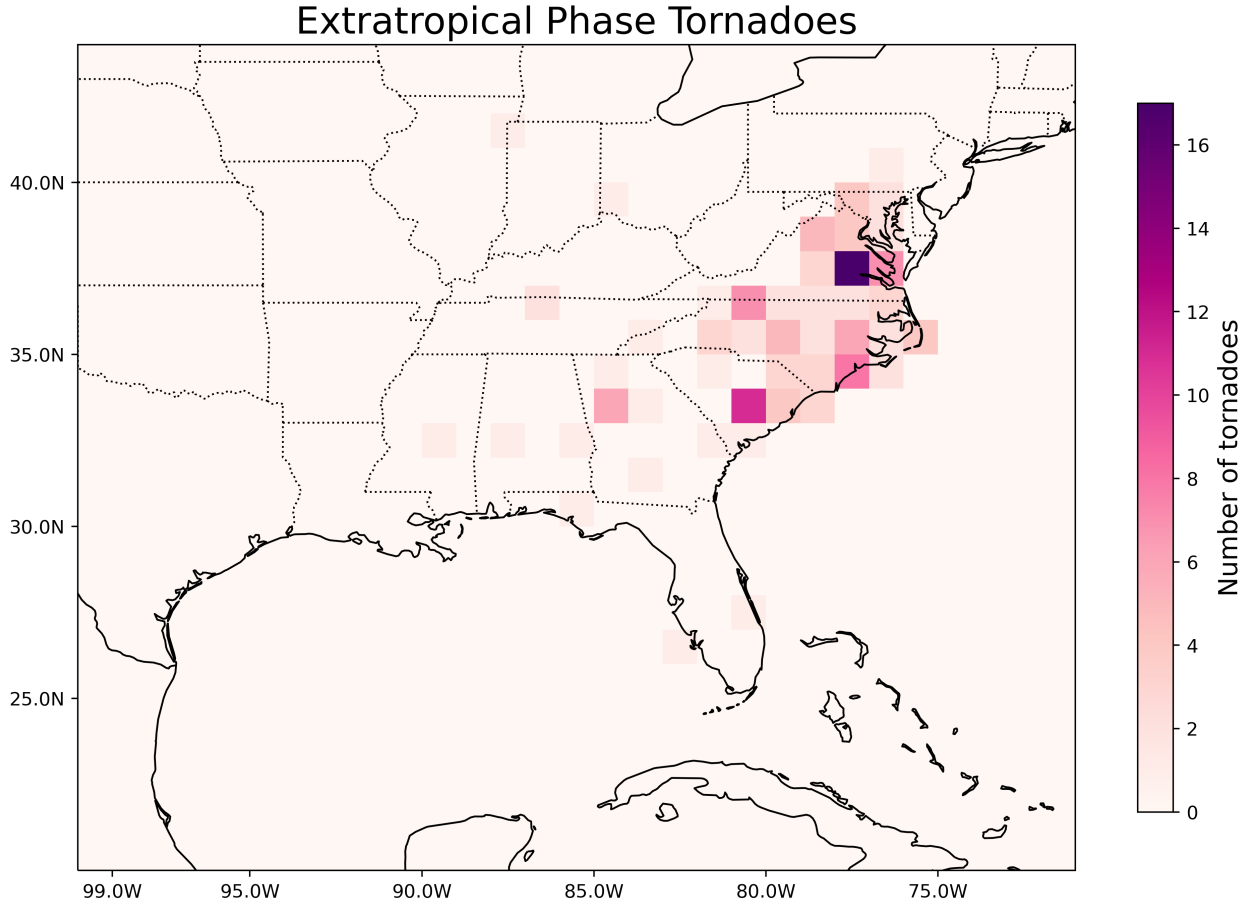
# Data and Methods

- Objective: Examine differences between number and location of tornadoes in the tropical and extratropical phases of tropical cyclones.

- TC Tornado data: Storm Prediction Center TC Tornado Data (Edwards 2010) from 1995 – 2020
- TC Track data: 6-hourly National Hurricane Center TC Intensity and Track data (Landsea and Franklin 2013)
  - Tropical and Extratropical Phase designations used
- Vertical wind shear calculated following Davis et al. 2008
  - Irrotational and nondivergent winds removed from bulk shear (850 hPa – 200hPa)

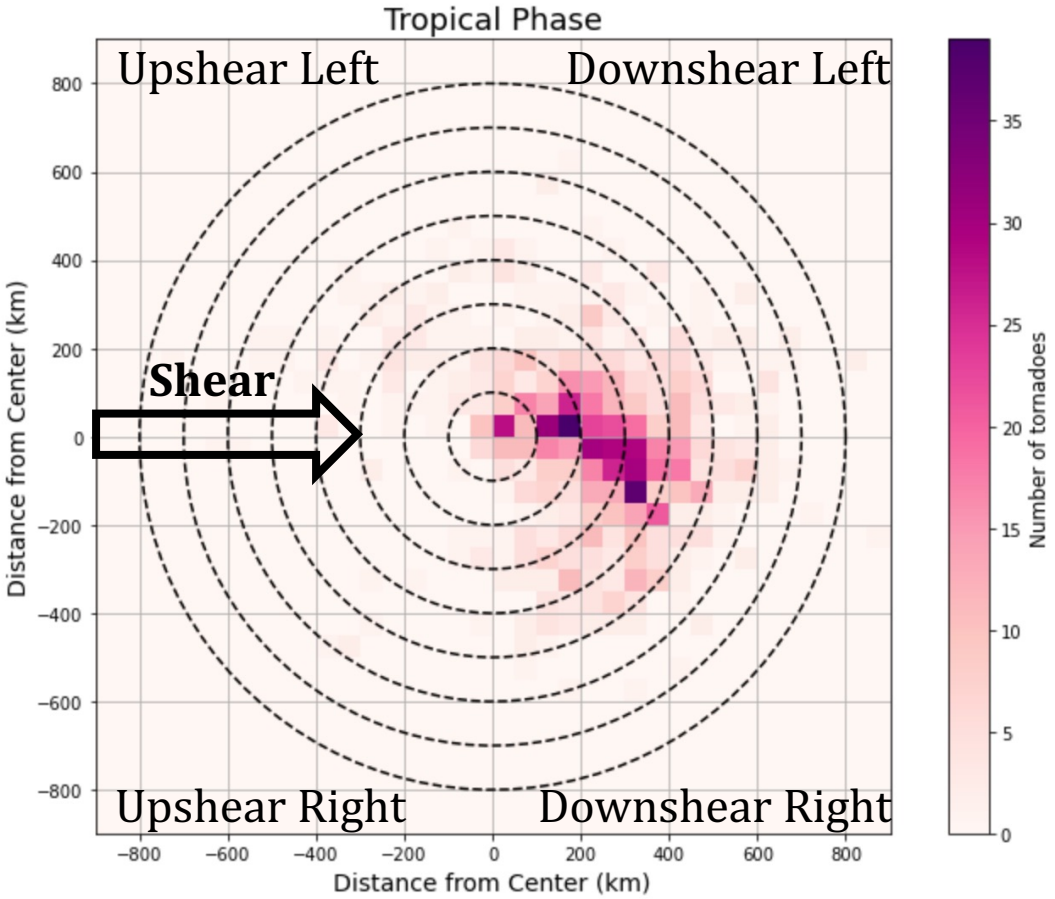
# Results: Differences in tornado location

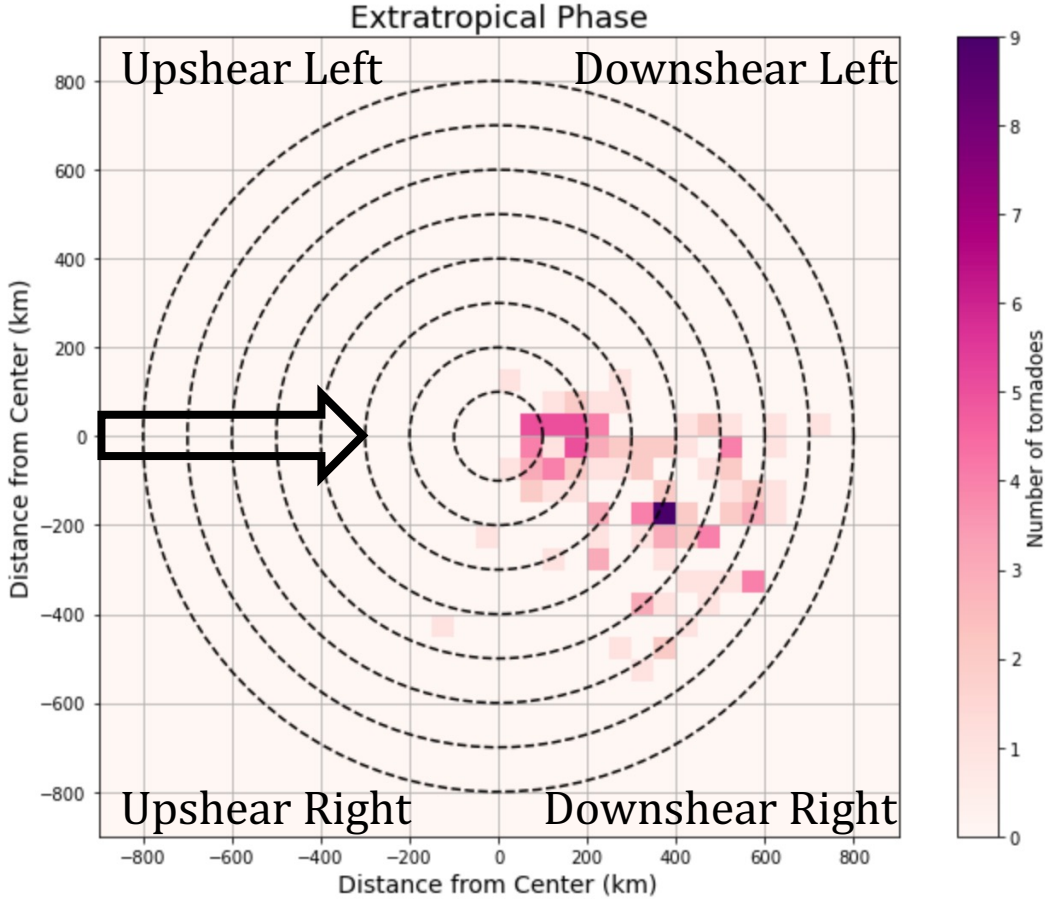



- Tropical Phase Tornadoes: Gulf, Southeast, southern Mid-Atlantic
- Extratropical Phase Tornadoes: Southeast, southern Mid-Atlantic

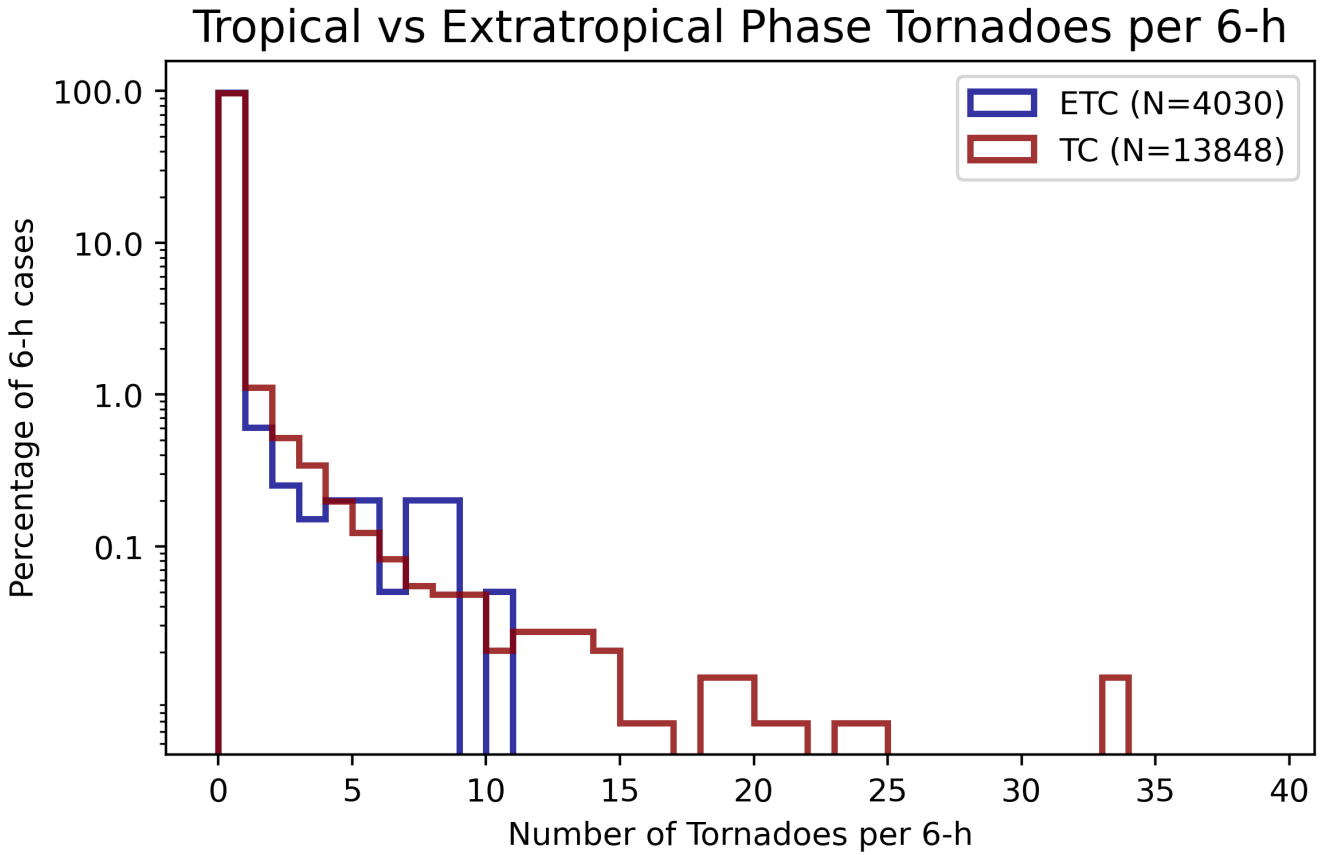
# Results: Shear-relative tornado location




- Tropical Phase Tornadoes: Downshear left in inner core, downshear right towards outer core
- Extratropical Phase Tornadoes: Mostly downshear right

# Results: Number of tornadoes




- Maximum extratropical phase tornadoes per 6-h much less than tropical
- Extratropical phase tornadoes drops off sharply after 10

# Discussion/Summary

**Tropical Phase Tornadoes**

- Occur throughout southern US, southern Mid-Atlantic
- Occur broadly downshear
- Associated with episodes of up to large numbers of tornadoes

**Extratropical Phase Tornadoes**

- Primarily occur in southern Mid-Atlantic
- Occur mostly downshear right
- Associated with episodes of smaller numbers of tornadoes

Future Work: Modeling case study of extratropical transition of Hurricane Ida