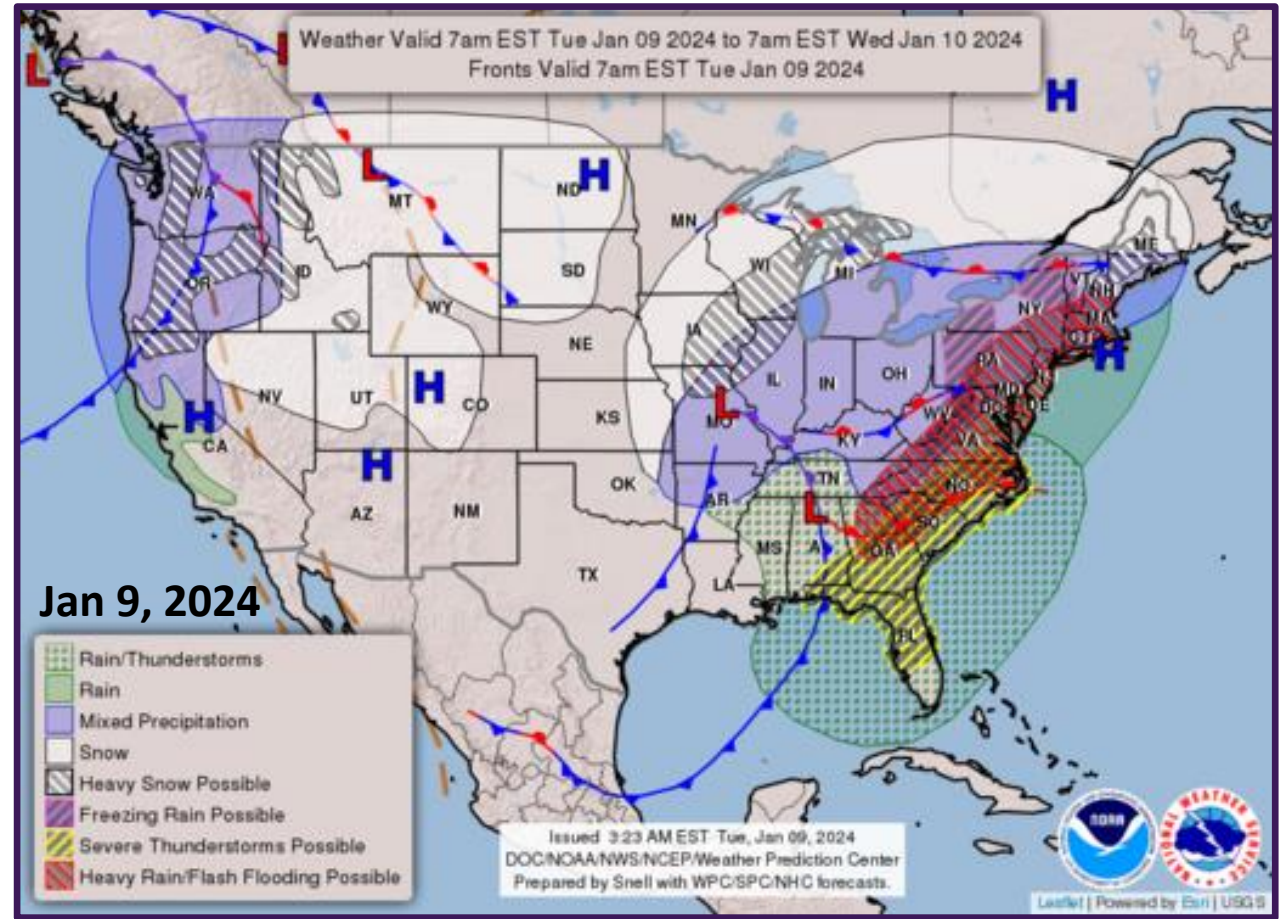


# Encroachment of the severe weather season on late winter

Accounting for the increase in early season high-impact events



PIs: Andrea L. Lang (UW), Jonathan E. Martin (UW), Victor Gensini (NIU)



Northern Illinois  
University



WISCONSIN  
UNIVERSITY OF WISCONSIN-MADISON



# Project Vision

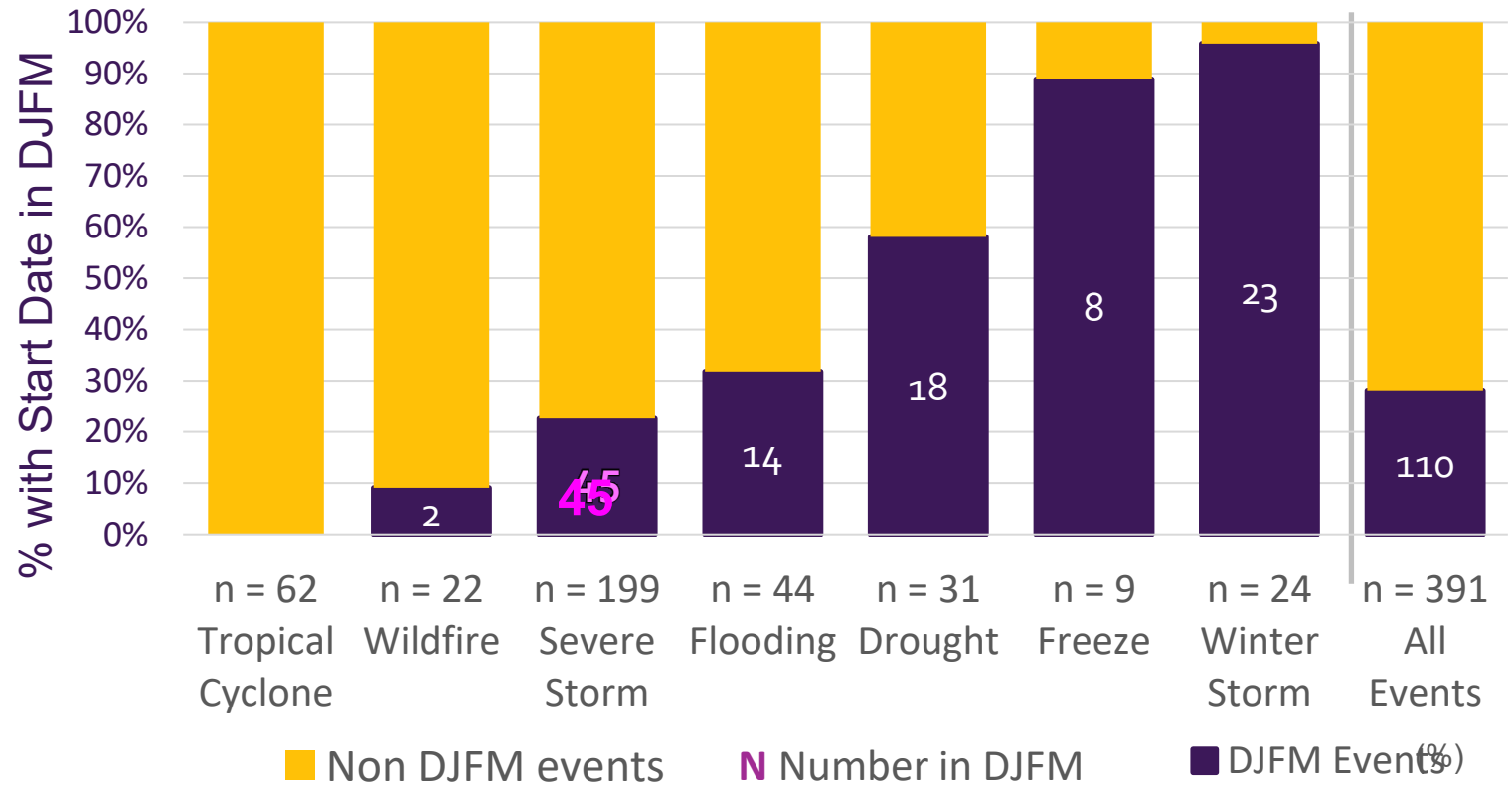
## This project will:

Assess the growing number of cold-season billion-dollar disasters from severe convective storms.

## This project targets:

- Examining compound peril events and changes in risk associated with winter severe convective storms.
- Increasing our understanding of the variability and increase in high-impact winter severe convective storms.

DJFM U.S Billion Dollar Weather & Climate Disasters  
(Jan 1980–Jun 2024)



NOAA National Centers for Environmental Information (NCEI)  
U.S. Billion-Dollar Weather and Climate Disasters (2024)  
<https://www.ncei.noaa.gov/access/billions/>



# Need and Relevance



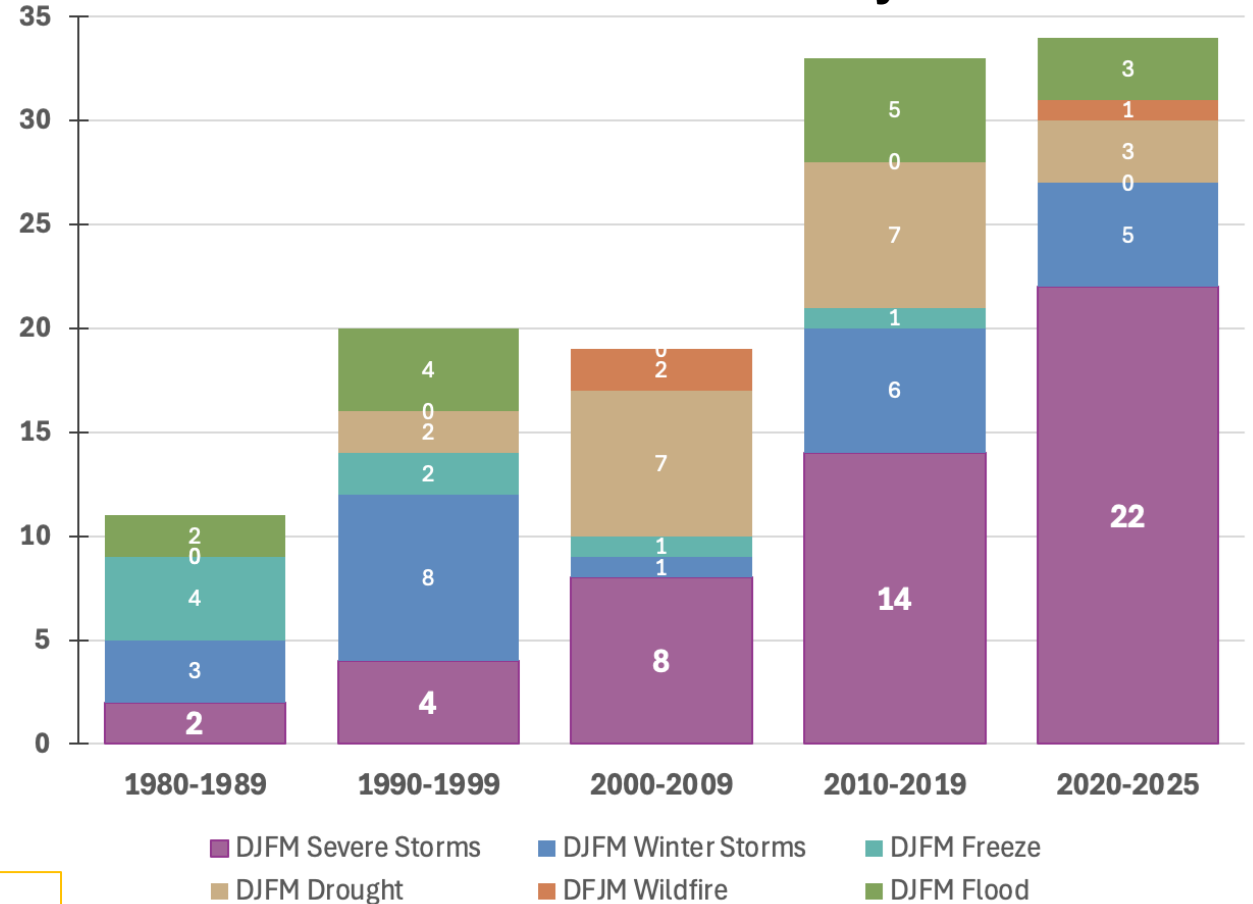
Feb. 9, 2024, A confirmed EF2 tornado northwest of Evansville, Wis. (Anthony Wahl//The Janesville Gazette, AP)

EVANSVILLE, Wis. (AP) — The first tornadoes ever recorded in Wisconsin in the usually frigid month of **February** caused more than **\$2.4 million** in damage, officials said Wednesday.

**Severe convective storms are #1 type of U.S. billion-dollar disaster in DJFM**

An under-researched problem

## DJFM Billion-Dollar Events by Decade



Jan 1980 – March 2025

<https://www.climatecentral.org/climate-services/billion-dollar-disasters/events>



# Approach

- 1) Establish an accessible database of historic winter SCS events that assesses location and intensity, frequency, and trends in compound hazards with SCS.

*Liaise with industry to better capture high-impact events*

- 2) Assess the local environment, climate variability, and trends to understand the processes that enhance the growing winter SCS threat.

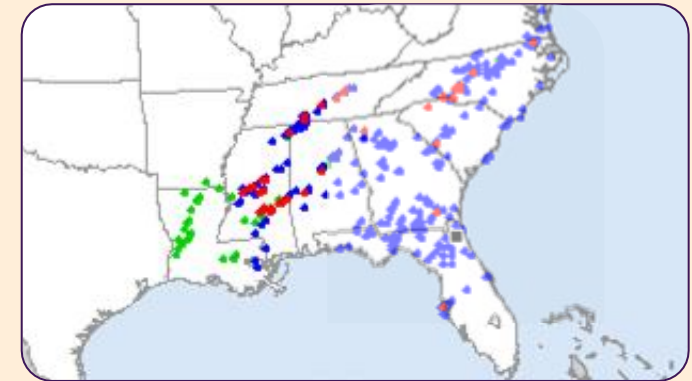
*Inform Q1 assessments and CAT modeling capabilities*

- 3) Quantify changes in probability and uncertainty in the synoptic-environment, climate variability, and trends in SCS and compound events in winter. Inform our understanding of future events and predictability of current events.

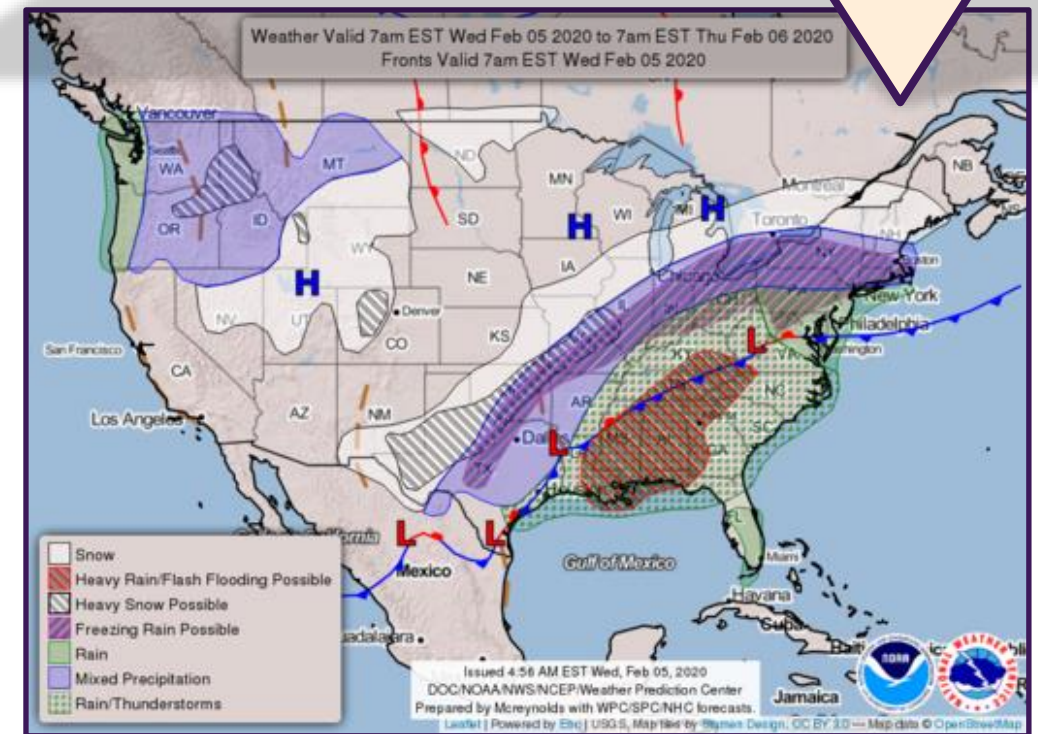
*Assess historic events for how well traditional SCS metrics capture DJFM events to inform increase model performance*

## February 5-7, 2020: Severe Weather Outbreak

- 66 confirmed tornados
- 38 severe hail reports
- >300 severe wind reports
- \$1.5 billion in losses
- 3 deaths



NOAA/SPC Storm Reports, Feb 5–6 2020



NOAA/WPC Weather  
Hazards Map valid  
Feb 5–6 2020



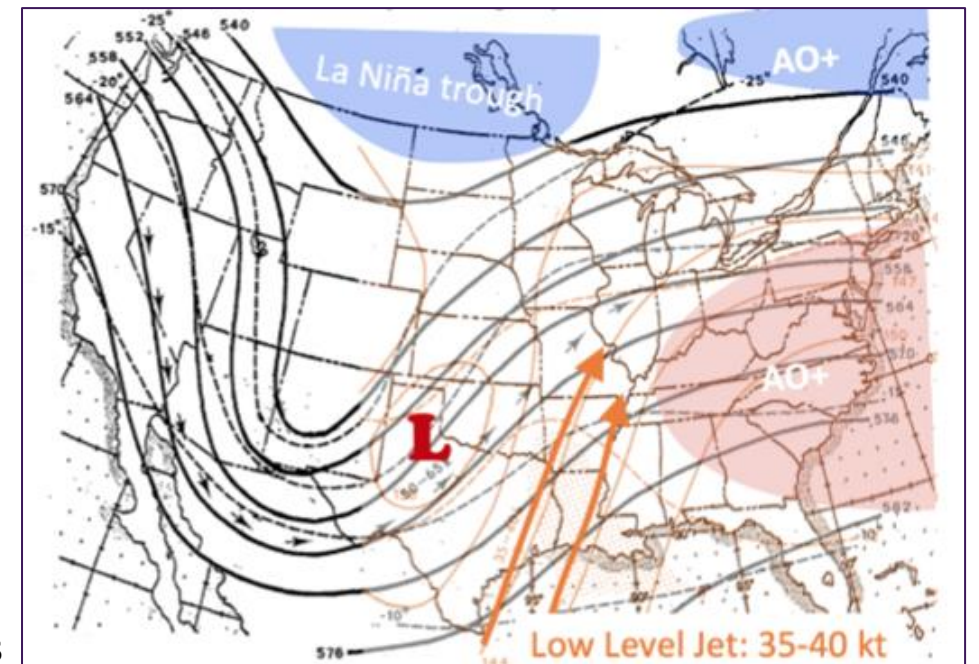
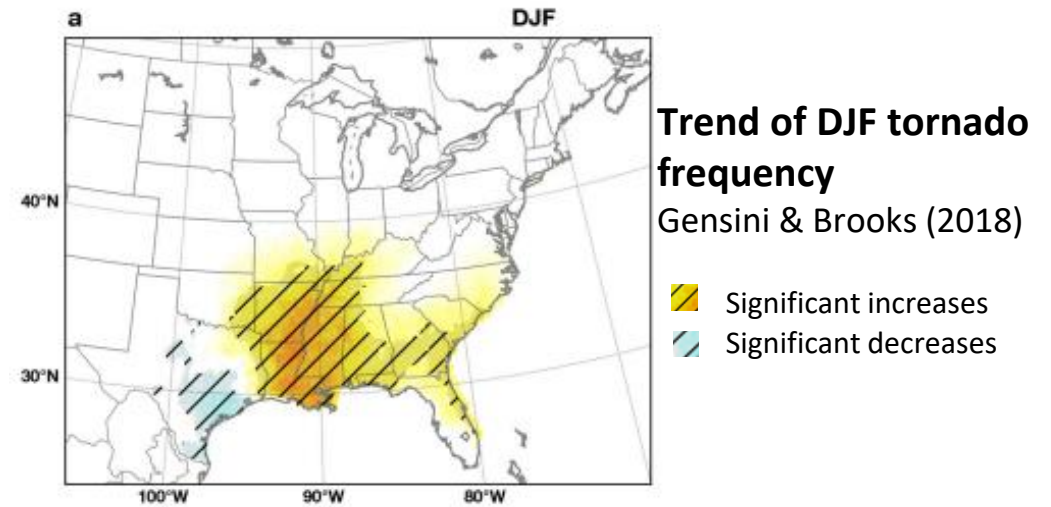
# Approach

**Key point:** Unlike the majority of warm season SCS events, most winter SCS events in the U.S. are associated with low-CAPE/high-shear conditions, along with high-amplitude flow at upper levels and an active low-level jet.

- Consider how environments of winter SCS differ compared to warm season events. (e.g., what CAT models should include to capture seasonal difference)
- Assess variability and trends separate from warm season diagnostics. (e.g., accelerating number of late winter events make quiet quarter more active)
- Analyze key winter SCS and compound event ingredients in historic and forecast data.

**DJF composite map of south central U.S. tornado outbreaks**  
Geopotential height & winds at 500 hPa (**black**) & 850 hPa (**orange**)

Annotated regions indicating typical 500-hPa geopotential height anomalies (**negative** & **positive**) during La Niña and AO+ conditions.

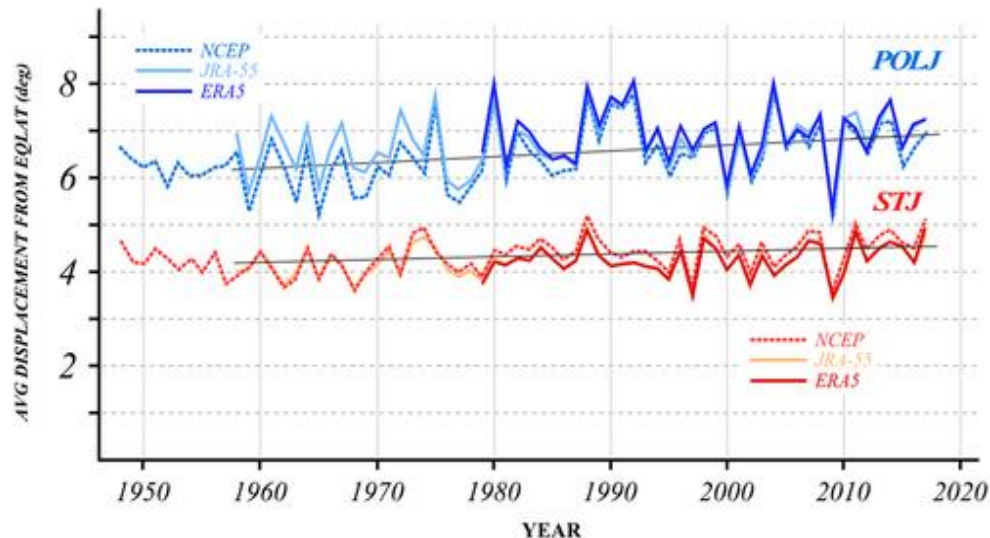


Adapted from Galway & Pearson (1981)

# Approach

## Related work:

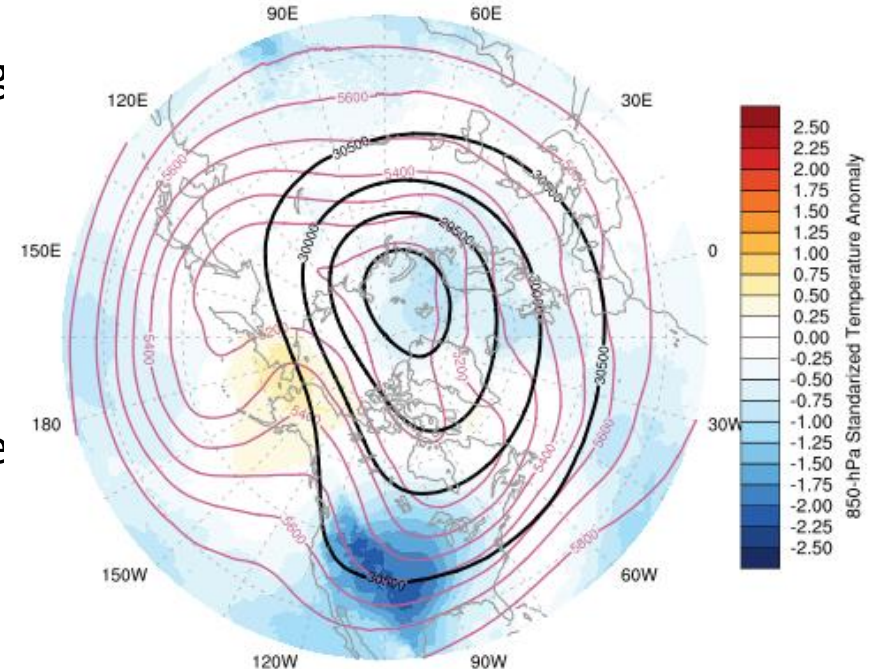
- Winter climate change signal: DJF jet stream waviness is increasing (Martin 2021) and can impact flow amplitude and high-shear regions.
- Cold season tornado frequency: more closely linked to extratropical variability (Arctic Oscillation) than ENSO.
- Other winter extremes: Cold air outbreaks are linked to large-scale variability in the stratospheric polar vortex. A type of variability that does not exist in the warm season.



Time series of the “waviness” of the polar and subtropical jet streams in different reanalysis datasets.

Martin (2021)

The strength of the climate signal in the stratospheric polar vortex is an open area of research



The 850-hPa standardized temperature anomaly (fills) and geopotential height at 500 hPa (pink) and 10 hPa (black) for a composite of 57 cold air outbreaks between 1959-2021.

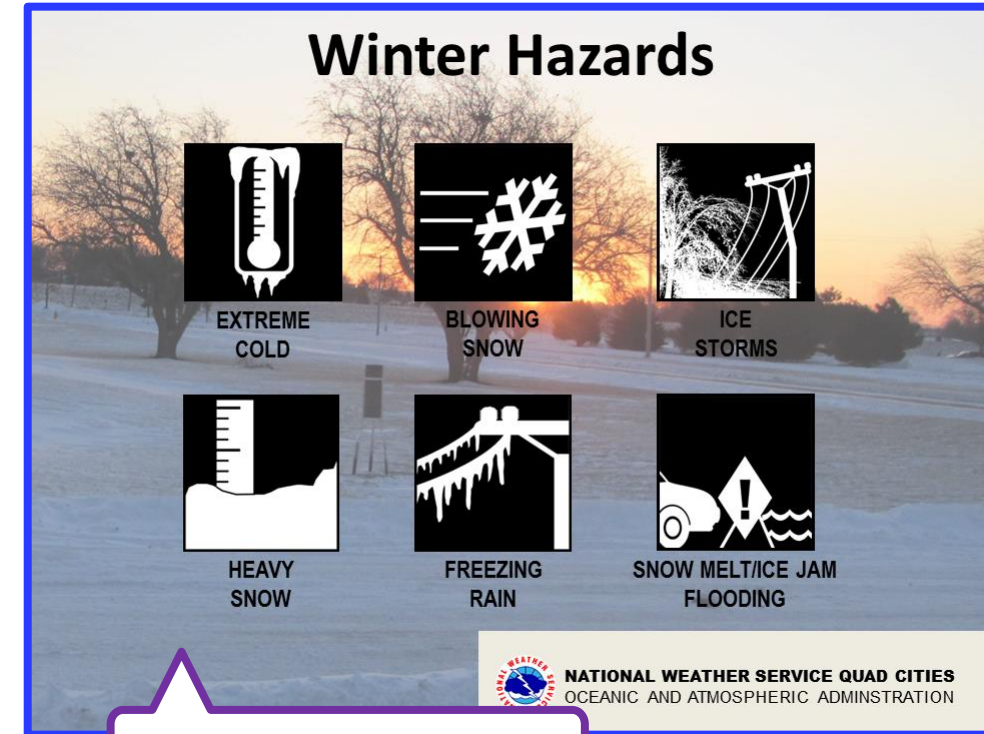
# Outcomes and Deliverables

- Event catalog and summary datasets
  - Catalog of winter SCS/compound events including relevant weather & climate diagnostic indices, hazards, and impacts
  - Composites of similar events and impact frequency maps in the context of weather & climate indices and winter diagnostics
  - Assessment of events by population & impact vulnerability metrics.
- Open-source code.
  - Sample workflows and documentation of code and data.
- Adaptable work plan with input from industry members.
  - Prioritize assessment of historic and recent events to assess events relevant for decision making
- Dissemination of results.
  - Accessible datasets & summary reports, talks as workshops & conferences, and peer-reviewed publication.



# Impacts

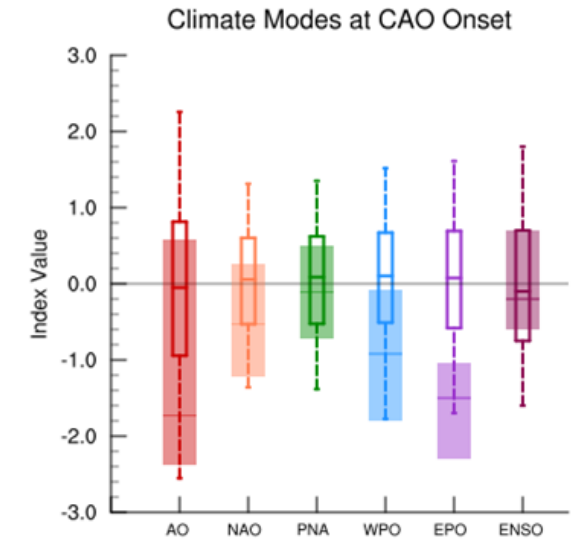
- A thorough assessment of winter SCS and compound events, highlighting potential changes in Q1.
  - Under-researched topic with high impacts
- A focused analysis and diagnosis of the metrics and trends for wintertime SCS and compound event.
  - Opportunity for new insights to inform CAT modeling
- The development of an accessible event catalog and database of key metrics, documentation, and code for further analyses.
  - Generate a new dataset for internal analysis and of future work on assessment of predictability of SCS.



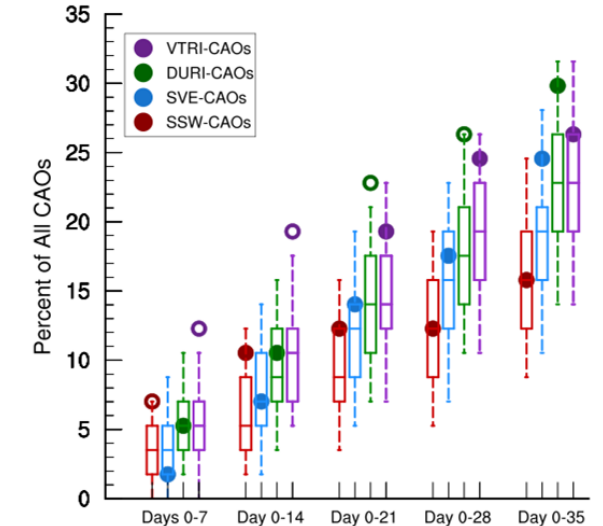
# Project Duration

## Timeline:

- **Year 1** (Winter SCS event analysis and catalog):
  - Semester 1 – Hire student and build winter SCS and compound event catalog.
  - Semester 2 – Assess synoptic and large-scale variability of events in database. Build accessible dataset.
  - Summer – Assess trends in variability of historic cases.
- **Year 2?** (Assess predictability and reliability of metrics)
  - Assess predictability of winter SCS
  - Quantify reliability of traditional vs. winter SCS metrics for prediction



Example analysis from work on Cold Air Outbreak events



# Project Budget

- **Personnel: \$81k**
  - PIs Lang and Martin
  - Graduate student support (stipend + tuition)
- **Materials and Supplies: \$11k**
  - Compute time
  - Data storage
- **Travel: \$7k**
  - Travel to CIRCS annual meeting
  - Conference attendance & presentation (AMS SLS 2026)
- **Other: \$3k**
  - Open-source publication fee
- **Total: \$102,000**

