Influence of Atmospheric Rivers (ARs) on Ice **Storms in Great Lakes Region** <u>Kyle Dailey¹, Dr. Frank Marsik², Dr. Claire Pettersen²</u>

Motivation

- The February 22nd, 2023 ice storm in the Ann Arbor/Detroit area sparked our interest in this topic, as a strong Atmospheric River was present that fueled that storm
- In reference to the Feb. 22nd storm, "The impacts from icing were widespread, with DTE reporting nearly 3,000 downed wires and close to 500,000 customers without power. Similarly, numerous reports of downed tree limbs were reported making some roads impassable." -NWS
- The general topic of ice storms and Atmospheric Rivers, especially in the Great Lakes region, does not have a lot of research looking into their possible connection.

Research Questions

- Do Atmospheric Rivers have a significant impact on ice storms in the Great Lakes Region?
- How does the magnitude of the Atmospheric River influence the ice storm?

Methodology

- Defined Great Lakes as MN, WI, IL, IN, MI, OH, PA, and NY
- Integrated Vapor Transport (IVT) data was collected from ERA5 reanalysis of the vertical integral of northward and eastward water vapour flux and plotted as a magnitude.
- Ice Storm data was collected from the NOAA Storm Event Database and was compiled to determine significant Ice Events
- The top 10 ice storm events were selected based on two criteria: a) the event should have a minimum of 50 affected counties, and b) the maximum reported ice accumulation during the event should be at least 0.75



Figure 1: Map with all the CWAs in the designated Great Lakes Region labeled

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Methodology (cont'd)



Figure 2: Ice accumulation on branch of about 0.25 in. from Feb 22nd storm in Ann Arbor, MI (Credit: Nick Dewhirst)

"Top 10"

Table I. Selected Characteristics of Top Ten Storm Events

Time 0 (UTC)	Duration (hrs)	CWAs Affected	NOAA Ice Storm Reports (in.)	AR?	Temperature Inversion (°C)	Origin of Moisture
07:00, 03/13, 1997	45	FSD, DTX, GRR, CLE, PBZ, CTP, BGM	0.4-1	\checkmark	4.1	Atlantic Gulf
09:00, 1/05, 2005	33	ILX, DVN, IND, IWX, CLE, PBZ	IWX: 1-2, rest of area: 0.25-1	\checkmark	8.4	Gulf Pacific
13:45, 02/24, 2007	20.25	DVN, ILX, LOT, IND, IWX, CLE	0.25-2, with highest amounts in DVN	\checkmark	7.1	Gulf
00:00, 02/01, 2011	40	ILX, IND, ILN, PBZ, PHI, OKX	0.25-1	\checkmark	8.1	Gulf
22:00, 12/18, 2008	26	ILX, DVN, LSX, LOT, IND, IWX, ILN, PHI	0.25-0.75	\checkmark	11.1	Gulf Pacific
20:00, 01/04, 1998	17	MPX, ARX, DLH, GRB, MKX, MQT	0.25-0.75	\checkmark	3.7	Atlantic Gulf
23:00, 01/01, 1999	40	PAH, BGM	0.25-1	\checkmark	12.9	Atlantic Gulf
15:00, 04/03, 2003	39	MKX, GRR, DTX, BGM, BUF	0.25-1.0 with localized amounts of 1.5 in southern Mich	\checkmark	13.1	Gulf Pacific
16:00, 01/30, 2002	30	ILX, IWX, DTX, CLE, CTP, BUF	0.25-1.5, with highest amounts in ILX	\checkmark	11.5	Atlantic Gulf Pacific
22:00, <mark>01/14</mark> , 2007	29	ILX, IWX, DTX, BGM, ALY	0.25-1, the higher amounts in NY	\checkmark	6.3	Atlantic Gulf Pacific

• The magnitude of the inversion was calculated by subtracting the coldest temperature at the base from the warmest temperature at the top

• We also analyzed where the moisture was coming from for each event using the IVT plots



Figure 3: Averaged Sounding of selected Skew T Log Ps from each event retrieved from University of Wyoming's College of Engineering page

• Fig. 3 shows the general atmospheric profile, illustrating the temperature inversion from the 10 different soundings needed for freezing rain to occur.





Case Studies





Figure 5: IVT map showing the AR at 21z, 01/05

Integrated Water Vapor Transport (IVT) (kg m^-1 s^-1)



Figure 6: Surface map on 02/25 retrieved from the WPC's Daily Weather Maps page







Figure 7: IVT map showing the AR at 02z, 02/25

Conclusions

• Of the events that were analyzed:

- The largest ice accumulation occurrences were happening on the northern edge of the Atmospheric River at the 250 kg/m/s line.

- Heaviest ice totals occurred in areas that stayed in the cold sector of the storm, while ice totals were limited in areas that spent a short time period in the cold sector.

- Among the top 10 ice storm events identified in this study, it was determined that an atmospheric river (AR) was present and impacted the affected states in all of these events to some extent.

• Looking at five different storms with a similar area affected (\geqq 50 counties) but with less ice than the "Top 10" (≤ 0.5 in.), ARs were still present, reinforcing that the magnitude of an AR has little impact on the ice storms.

Future Research

• Can look at out of the total amount of Atmospheric Rivers that occurred during the winter, how many resulted in an ice storm occurring.

• Can do a formal IVT threshold analysis and explore the relationship between icing and the IVT magnitude present at the different IVT magnitudes (ex. Compare icing at 250 and 350 kg/m/s levels).

References

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