The Winter Storm Severity Index (WSSI) Suite of Products

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WSSI Overview

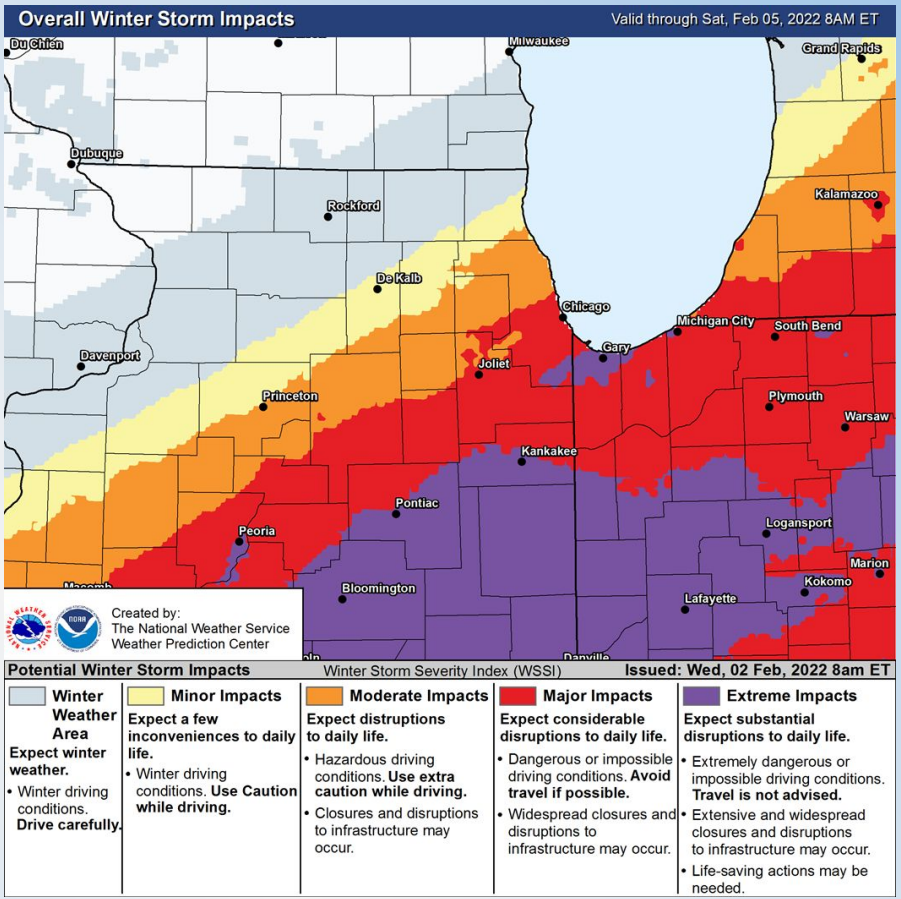
- New model for impact-based decision support services (IDSS) and communication
  - Translates the forecast into a digestible impact-based forecast
    - Am I going to be impacted? How severe will the impact be? From which hazard(s) should I expect impacts?
- Operational forecast product that allows NWS forecasters, stakeholders, and the public to maintain **situational awareness** of the significance of potential winter-weather-related **impacts**
- Uses GIS to combine **meteorological and non-meteorological** data (including climatology) to communicate the spatial distribution of the potential impacts
- Produces 4 impact levels for a series of sub-components, and overall impact

Overview

- Goal of the Product
  - Summarize multiple winter weather impacts from a storm into an easily consumable graphic
  - 72 Hour forecast
    - 24 HR breakouts w/ rolling 24 HR display
    - Data comes from the NWS National Digital Forecast Database (NDFD)
    - Updates every 2 hours
- Summary graphic is a composite of the maximum impact from any of the six components
- Output available as a web display, static image or GIS data (KML/KMZ and SHP)
- Rolling 30 day archive located here

Components:

Snow Amount - Snow Load - Ice Accumulation - Blowing Snow - Ground Blizzard - Flash Freeze

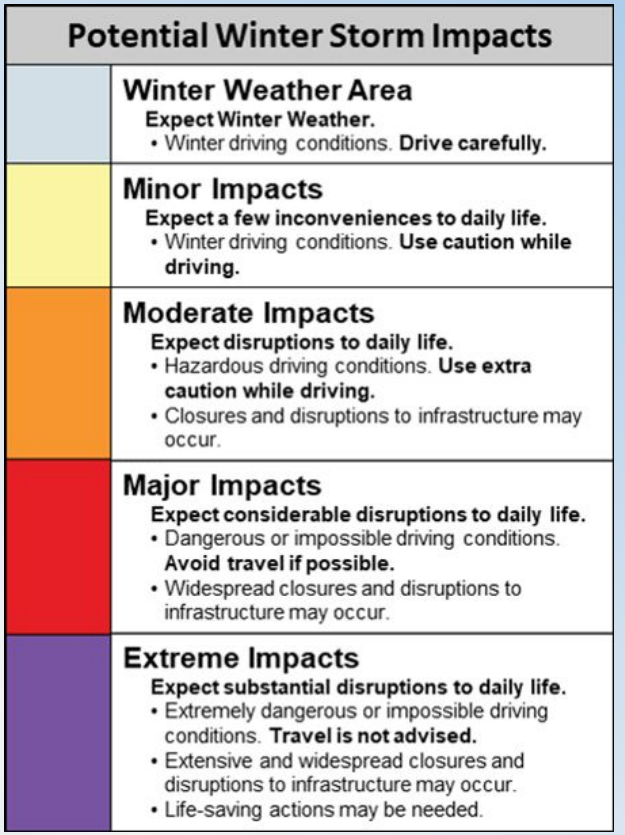


A **User Guide** for the WSSI can be found here

Impact Scale Definitions

- Definitions were shaped by a two year social science engagement

- Focus groups revealed winter weather impact of most concern
  1. Travel disruptions
  2. Power outages and other infrastructure disruptions
  3. Disruptions to schools and business



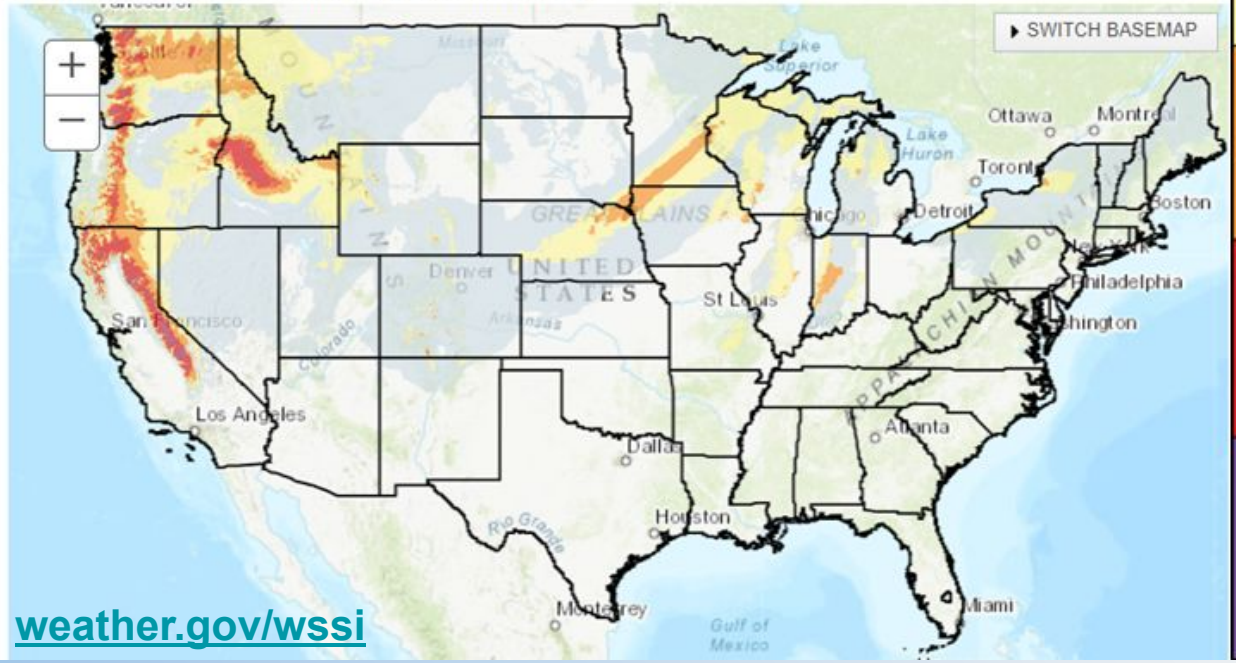
Overall Impact | Snow Amount | Snow Load | Ice Accumulation | Flash Freeze | Blowing Snow | Ground Blizzard

Overall Impact: Maximum impact from any of the components.

Days 1-3 | Day 1 | Day 2 | Day 3

Select Zoom Area: [CONUS] CONUS

Winter Storm Severity Index - Effective From Tue, Nov 29, 2022 10 AM ET Through Fri, Dec 02, 2022 07 AM ET
Last Updated: Tuesday November 29, 2022 10:19 AM ET



weather.gov/wssi

Potential Winter Storm Impacts

Winter Weather Area
Expect Winter Weather.
- Winter driving conditions. **Drive carefully.**

Minor Impacts
Expect a few inconveniences to daily life.
- Winter driving conditions. **Use caution while driving.**

Moderate Impacts
Expect disruptions to daily life.
- Hazardous driving conditions. **Use extra caution while driving.**
- Closures and disruptions to infrastructure may occur.

Major Impacts
Expect considerable disruptions to daily life.
- Dangerous or impossible driving conditions. **Avoid travel if possible.**
- Widespread closures and disruptions to infrastructure may occur.

Extreme Impacts
Expect substantial disruptions to daily life.
- Extremely dangerous or impossible driving conditions. **Travel is not advised.**
- Extensive and widespread closures and disruptions to infrastructure may occur.
- Life-saving actions may be needed.

WSSI Suite of Products Overview

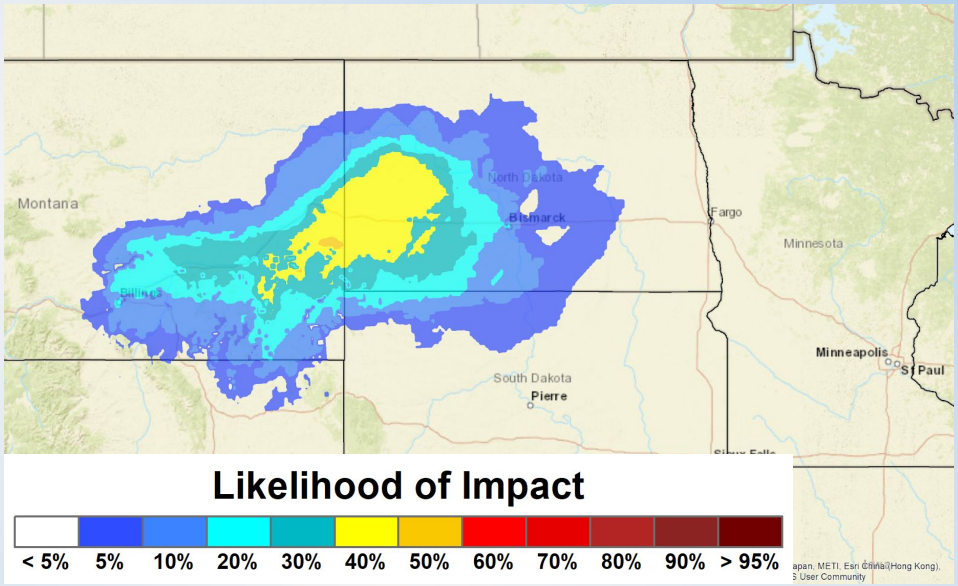
	Deterministic WSSI: WSSI	**Probabilistic WSSI: ProbWSSI**	**Hourly WSSI: WSSI Travel**
NWS Status:	Operational	Experimental	Internal Prototype
Time Covered:	Days 1 -3	Days 1 -7	0 - 48 hours
Input:	NDFD	WPC Super Ensemble	HRRR
Components:	Snow Amount Ice Accumulation Snow Load Blowing Snow Ground Blizzard Flash Freeze	Snow Amount Snow Rate Blowing Snow Snow Load Ice Accumulation	Snow Rate Snow Amount Ice Accumulation Liquid Rate Blowing Snow*

* Developed, will implement soon

Probabilistic Winter Storm Severity Index

The Probabilistic Winter Storm Severity Index (PWSSI) is a numerical weather prediction ensemble driven tool designed to help maintain situational awareness and to help communicate a general level of potential societal impacts and their spatial distribution for winter weather.

Extreme - 36H Forecast Valid: 12 UTC April 13 2022



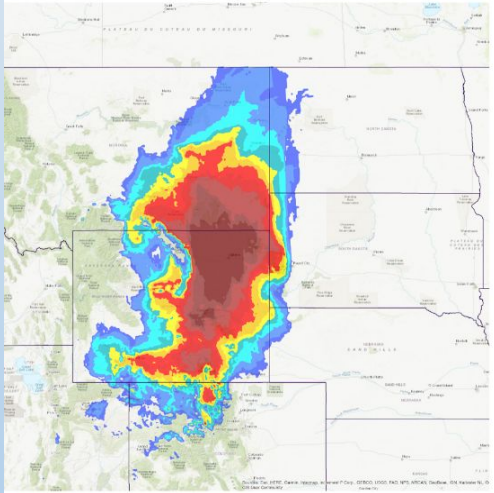
PWSSI Nuts and Bolts

- The PWSSI is generated from 6 hour forecasts from the WPC Super Ensemble (WSE) members
  - The WSE has 60 total members comprised of CAM, Global deterministic and Global Ensemble members
  - This is the same ensemble used to generate the Probabilistic Winter Precipitation Forecast (PWPF) guidance
- Probabilities are generated for minor, moderate, major, and extreme
  - Current components: Snow Amount, Snow Rate, Snow Load, Blowing Snow, Ice Accumulation, Overall
  - *NOTE* Snow Rate and Snow Amount are separated out in PWSSI; they are combined in the deterministic WSSI
  - *Also, NOTE* NWS forecast grids and ensemble grids include ice pellets into snow accumulations
- Probability of impact guidance
  - Will help answer the question how likely is an impact from a winter storm and how likely is it going to be minor, moderate, major or extreme
  - “What is the probability of a Major Impact?”

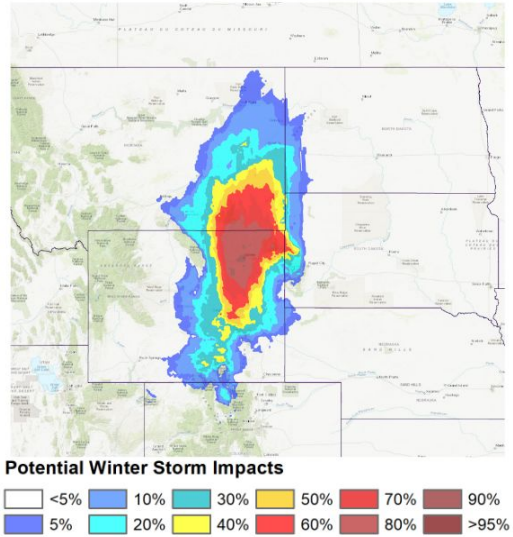
Experimental Probabilistic WSSI Output

Depicts probability of reaching an impact level for winter hazards using the WSSI impact thresholds

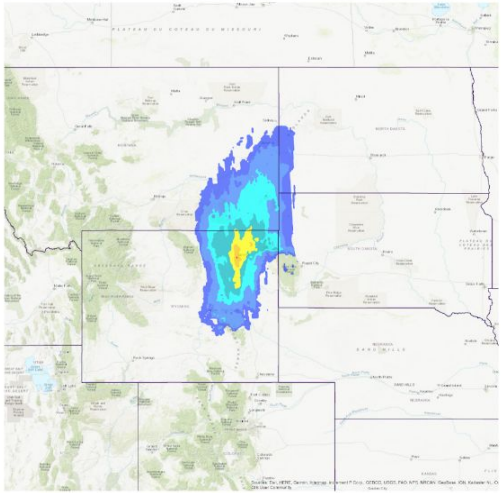
Minor Impact



Moderate Impact



Major Impact

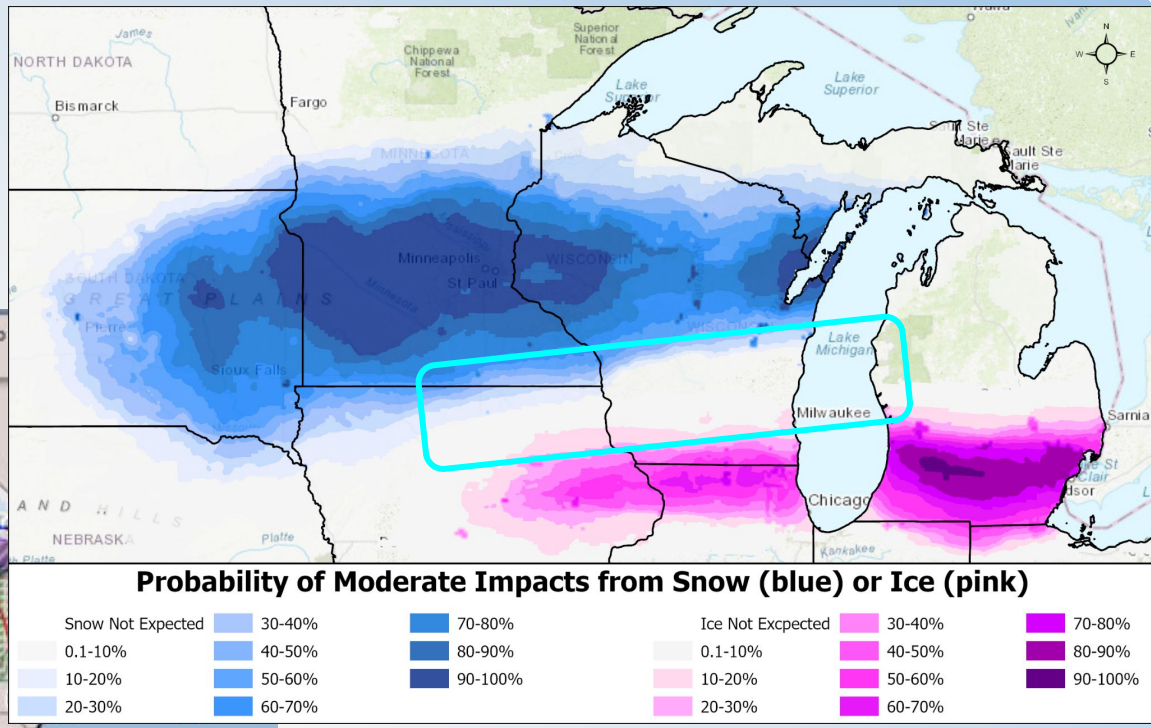


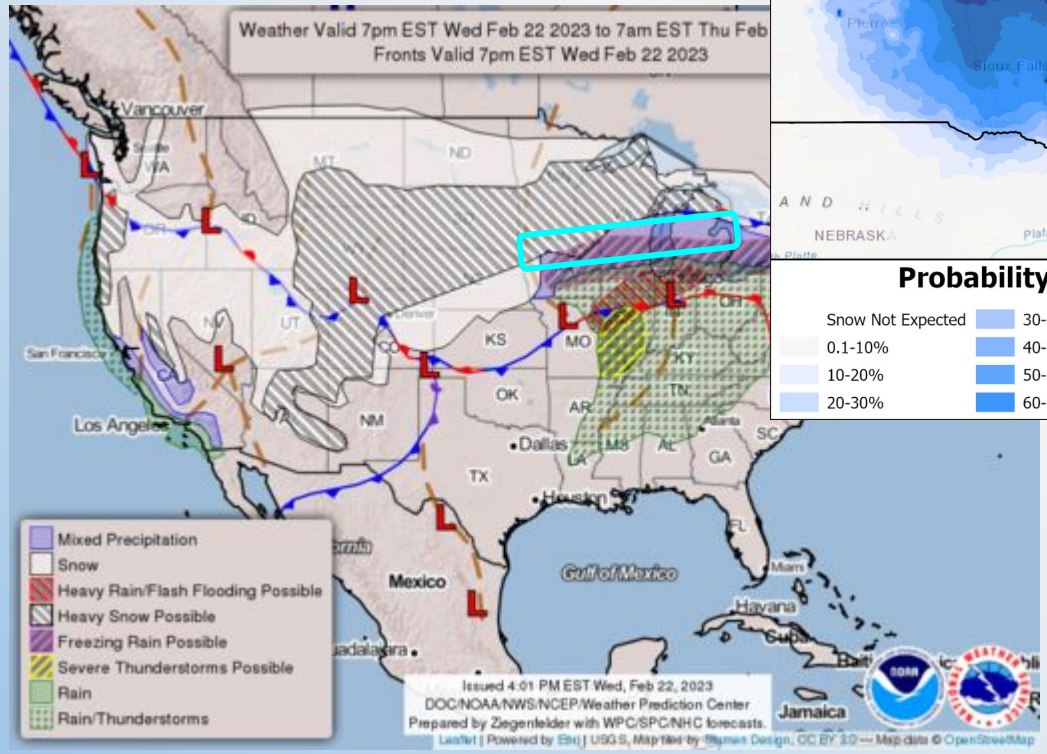
Higher probabilities of minor provide a good envelop of impacts for a the storm.

High probabilities of moderate impacts show where there is likely going to be disruptions to daily life.

The highest probabilities of major (or extreme) depict were the most severe impacts are likeliest to occur.

Transition Zones





Indicates transition zone

- ProbWSSI does a good job showing the probabilities of impact for snow and ice
- However, there is an opportunity for improvement in transition zones where probabilities can drop

WSSI Travel

- WSSI product in development at WPC
  - Currently NWS internal
- Focus on impacts to travel and transportation hazards
- Based on High-Resolution Rapid Refresh (HRRR)
  - High spatial and temporal resolution
    - 3 km spatial resolution
    - Hourly output out to 48 hr (00 UTC, 06 UTC, 12 UTC, 18 UTC)
- Hourly outputs help target precipitation rate impacts
  - Increasing precipitation rates typically decrease visibility
  - Poor visibility and adverse road weather conditions can make travel hazardous or nearly impossible

What does WSSI Travel Include?

- **Weather Conditions**
  - Snow rate, liquid rate, precipitation type (more on this next slide!)
  - Temperature, wind speed, visibility
- **Parameterized Road Surface Conditions (*Untreated Roads*)**
  - Incorporate the Probability of Subfreezing Roads (ProbSR; Handler et al. 2020)
  - e.g., are roads: Wet? Snowy? Slushy? Icy?
- **Transportation-Related Data**
  - Time of day factors
    - How likely is a crash to occur at that hour of the day?
      - Combination of crash counts and vehicle counts
    - How impactful is a crash that occurs at that hour?
      - Combination of injuries, fatalities, and vehicles involved
    - How many vehicles are typically on the road at that time?
      - Weekday, weekend, or holiday

Components of WSSI Travel

- Snow Amount
  - Total accumulation since HRRR initialization
  - Based on the operational WSSI thresholds
    - Impacts also account for other weather and road conditions
- Ice Accumulation
  - Total accumulation since HRRR initialization
  - Lower thresholds than operational WSSI
    - Focus on transportation impacts, not “breaking things” (e.g., downed tree limbs or power lines)
- Precipitation Rate
  - Liquid Precipitation Rate (Rain and Freezing Precipitation combined)
  - Snow Rate (Snow and Ice Pellets combined)
  - Pink outlines to denote overlapping liquid and snow precipitation types
- Blowing and Drifting Snow
  - Developed, but not yet added!
  - Converts blowing and drifting snow to visibility reductions

How are Precipitation-Type Impacts Accounted for?

- Based on HRRR precipitation type categories and hourly accumulations
- Snow and ice pellets are in the “Snow Rate” component
- Rain and freezing rain are in the “Liquid Rate” component
- Each precipitation type (rain, snow, freezing rain, and ice pellets) has its **own time of day curve**
  - Freezing rain has a higher impact weighting than rain
    - e.g., 0.25”/h of freezing rain will be more impactful than 0.25”/h of rain
  - Ice pellets have higher impact weighting than snow
    - e.g., 0.5”/h of ice pellets will be more impactful than 0.5”/h of snow
- Liquid precipitation rates and snow precipitation rates have their **own impact thresholds**
  - 0.5”/h of snow corresponds to a higher impact level than 0.5”/h of rain

WSSI Travel Prototype Website

Potential Travel Impacts	
	Adverse Weather Area • Poor driving conditions. **Drive carefully.**
	Minor Impacts • Adverse driving conditions. **Use caution while driving.**
	Moderate Impacts • Hazardous driving conditions. **Use extra caution while driving.** • Closures and disruptions may occur.
	Major Impacts • Dangerous or impossible driving conditions. **Avoid travel if possible.** • Widespread closures and disruptions may occur.
	Extreme Impacts • Extremely dangerous or impossible driving conditions. **Travel is not advised.** • Extensive and widespread closures and disruptions may occur. • Life-saving actions may be needed.

Additional Information
Snow Rate Impacts Solid outlines Less transparent
Liquid Rate Impacts No outlines More transparent
Mixed Impacts Snow and Liquid Overlap Pink outlines

*****Prototype*** Winter Storm Severity Index (WSSI) Travel**

This is a prototype product for NWS **INTERNAL** display **ONLY**

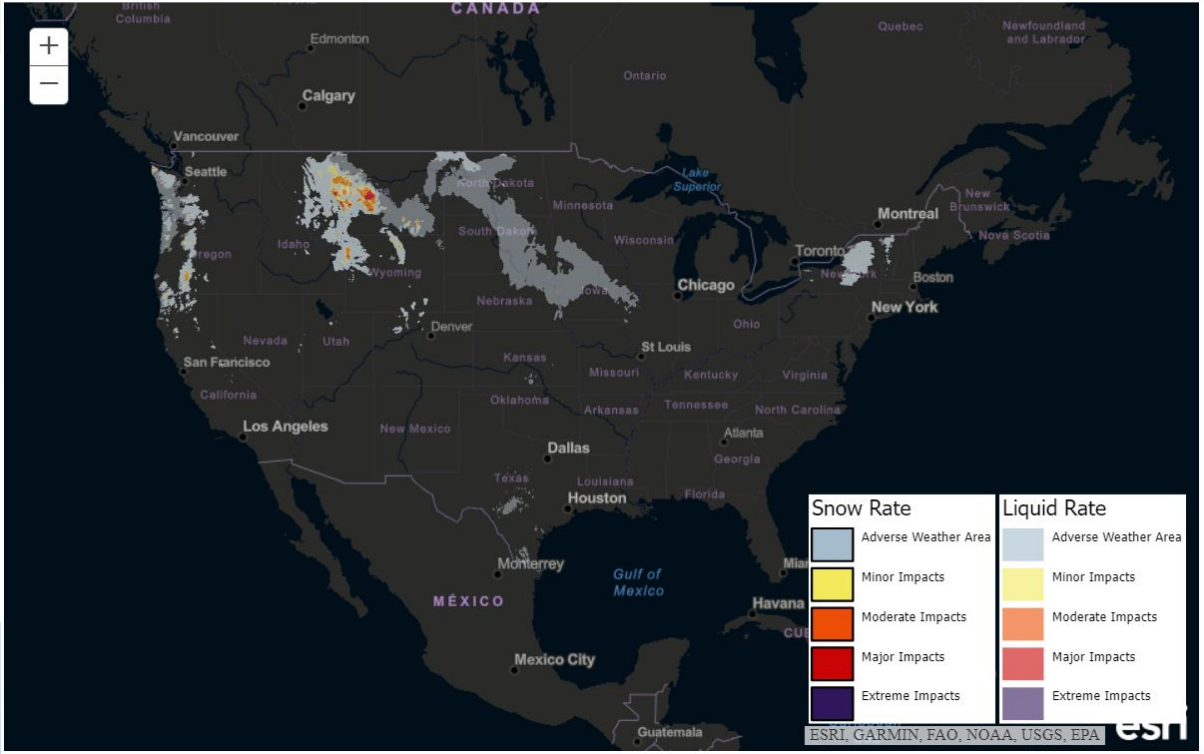
The operational WSSI can be found here

Select WSSI Travel Run: Apr 19, 2023 06z

Precipitation Rate | Snow Rate | Liquid Rate | Snow Accumulation | Ice Accumulation

Drag the slider to display the 1 hour WSSI Travel forecast

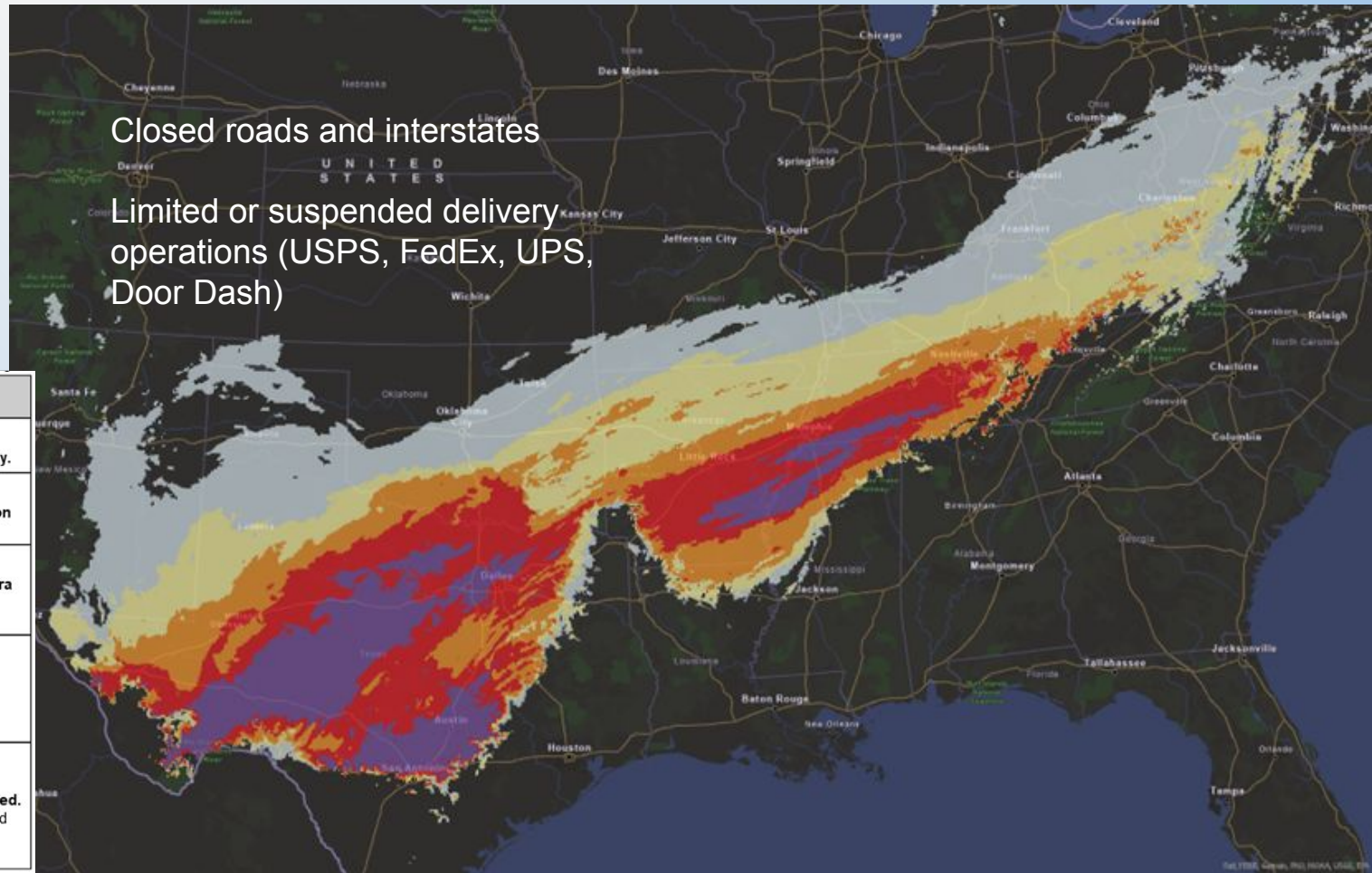
Forecast HR: 1 Valid Wednesday, April 19, 2023 at 12 AM PDT [7 UTC 4/19/2023]



WSSI Travel Ice Accumulation

31 January 2023

12Z run, fhr 36



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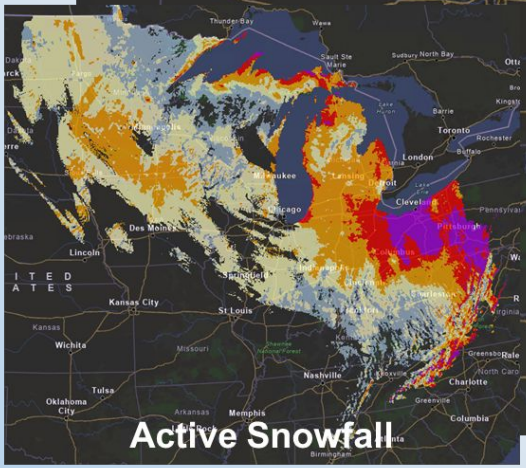
Blowing & Drifting Snow at 12Z on 23 Dec 2022

(valid around the time of several crashes and pileups in Ohio)

5 vehicle pileup (2 injuries)

51 vehicle pileup (73 injuries, 4 fatalities)
Extended turnpike closure



Combined!

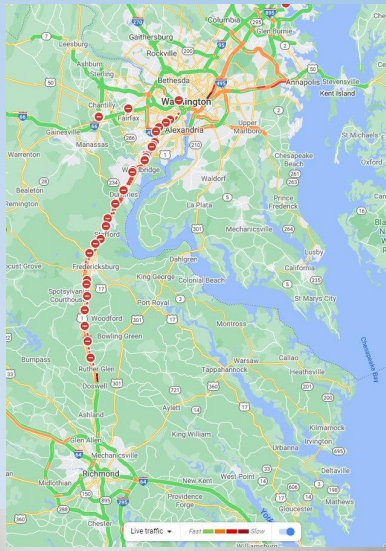
WSSI Travel Test Case: February 17, 2021 – 12 UTC

Arkansas I-40 closures

Crash w/ 7 semis initiated a 30-mi long slow series of chain-reaction crashes

WSSI Travel Test Case: January 3, 2022 – 06 UTC

I-95 shutdown
Major crash w/ semis
Vehicles stranded >24h

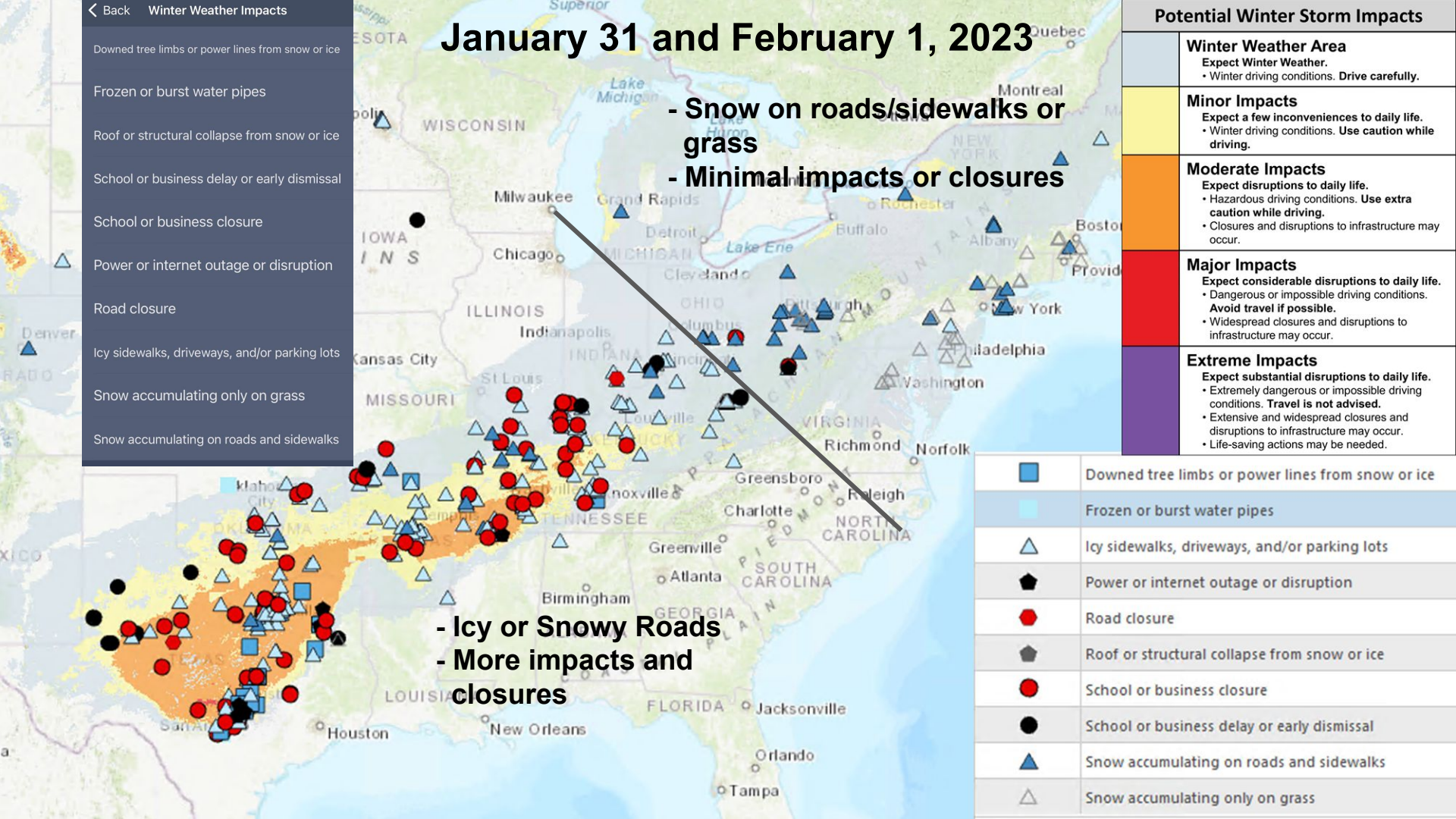


Future of WSSI Travel

- Currently NWS Internal
  - Hope to make it a public prototype this winter (stay tuned!)
- Continue to tweak and improve algorithms
  - Ensure the product corresponds well to transportation impacts
- Additional non-meteorological factors
  - “Bridges freeze before roads”
  - Localized traffic volumes
    - Higher potential impacts with more vehicles on the roads
  - Regional variations
    - e.g., higher impacts for regions that are less-equipped to handle snowfall
  - Travel around the holidays, not just the holiday itself
    - This period can change each year!

Verification of WSSI Suite of Products

- mPING Verification - Experimental (example next slide)
  - Worked with the mPING development team to add Winter Weather Impacts category
    - Reports are tangible impacts, not subjective and shows great promise
  - Obtained all mPING reports for the 2022-23 winter season since implementation (15 Dec 2022)
- Power Outage
  - Plan to use EAGLE-I data to compare power outages to WSSI impact levels and components
- RTMA WSSI
  - Primarily used to compare snowfall thresholds
- WSSI comparison to Storm Data
  - Subjective analysis, usually done by LaPenta interns


Back
Winter Weather Impacts
Downed tree limbs or power lines from snow or ice
Frozen or burst water pipes
Roof or structural collapse from snow or ice
School or business delay or early dismissal
School or business closure
Power or internet outage or disruption
Road closure
Icy sidewalks, driveways, and/or parking lots
Snow accumulating only on grass
Snow accumulating on roads and sidewalks
January 31 and February 1, 2023
- Snow on roads/sidewalks or grass
- Minimal impacts or closures
- Icy or Snowy Roads
- More impacts and closures
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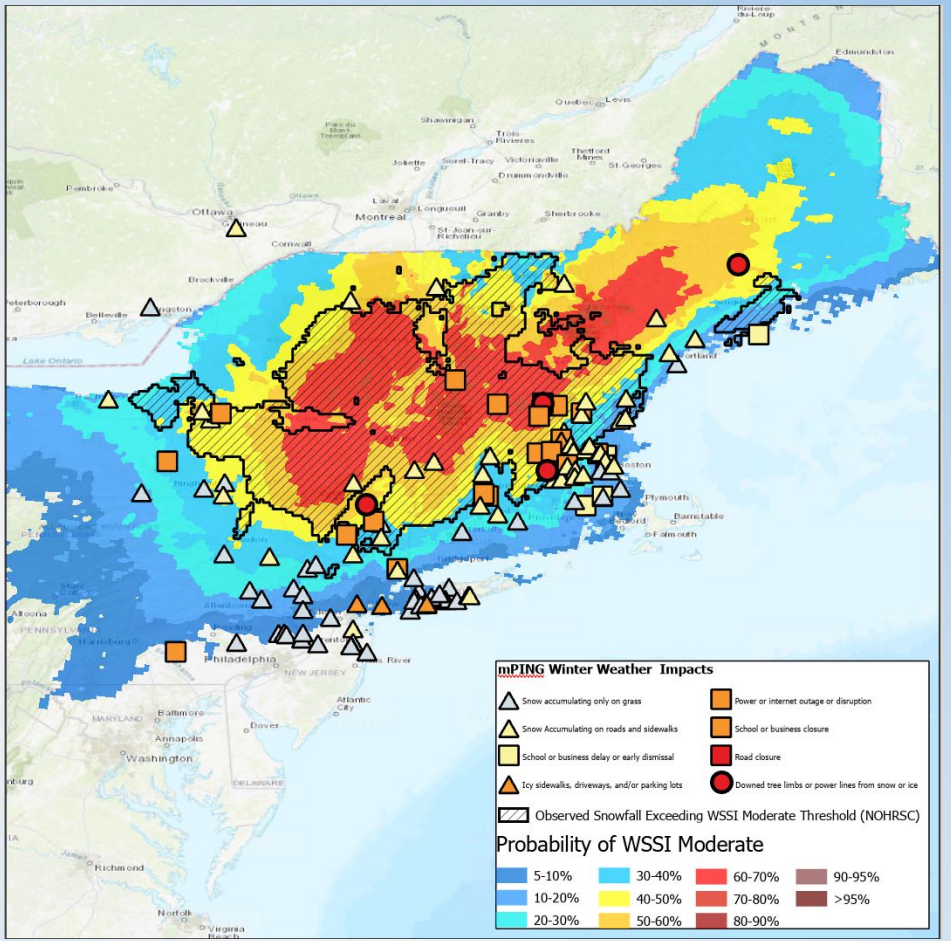
Milwaukee
Chicago
Indianapolis
Kansas City
St Louis
Houston
New Orleans
Atlanta
Birmingham
Charlotte
Greensboro
Raleigh
Richmond
Norfolk
Jacksonville
Orlando
Tampa
Montreal
Boston
New York
Philadelphia
Washington
Buffalo
Detroit
Cleveland
Pittsburgh
Grand Rapids
Albany
Rochester
Greenville
WISCONSIN
IOWA
ILLINOIS
MISSOURI
MICHIGAN
OHIO
INDIANA
VIRGINIA
NORTH CAROLINA
SOUTH CAROLINA
GEORGIA
FLORIDA
TENNESSEE
LOUISIANA
Lake Michigan
Lake Erie
Lake Huron
Superior
Quebec
Denver

Combined Verification

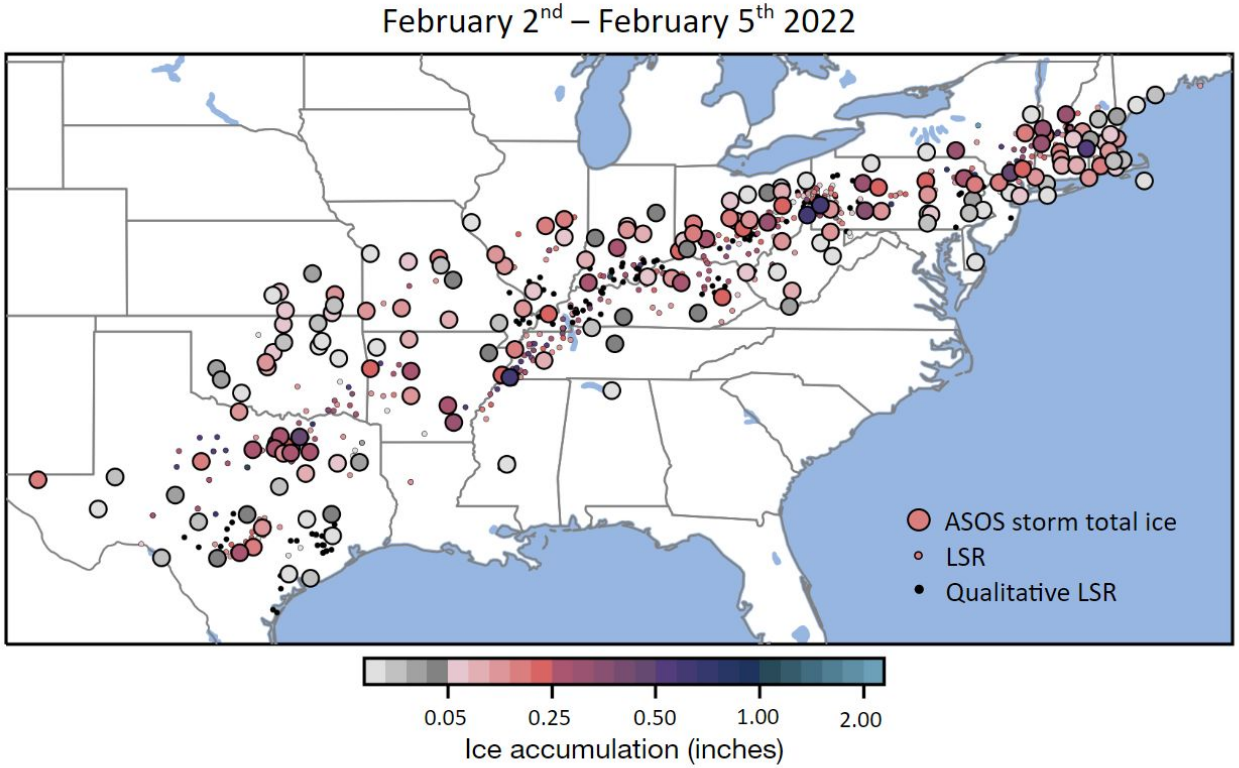
- Combing mPING reports with NOHRSC Analysis provides a more comprehensive verification
  - Probability of moderate impact - ProbWSSI (shaded colorfill)
  - mPING (symbols)
  - NOHRSC ≥ moderate (black hatching)



Verification of Ice Accumulation

- Current ice accumulation observations are point-based, with no reliable interpolation methods between points
  - Precipitation types and accumulations can be highly variable over short distances
  - WPC is currently experimenting with ice interpolation methods (natural neighbor interpolation)
- Improved verification of ice will help improve forecasts and verification of complex precipitation types
- Project currently underway at NSSL to supplement ice accumulation reports and also produce a gridded “observed” ice accumulation dataset

Evaluation of Ice Accumulation LSRs as a Verification Source

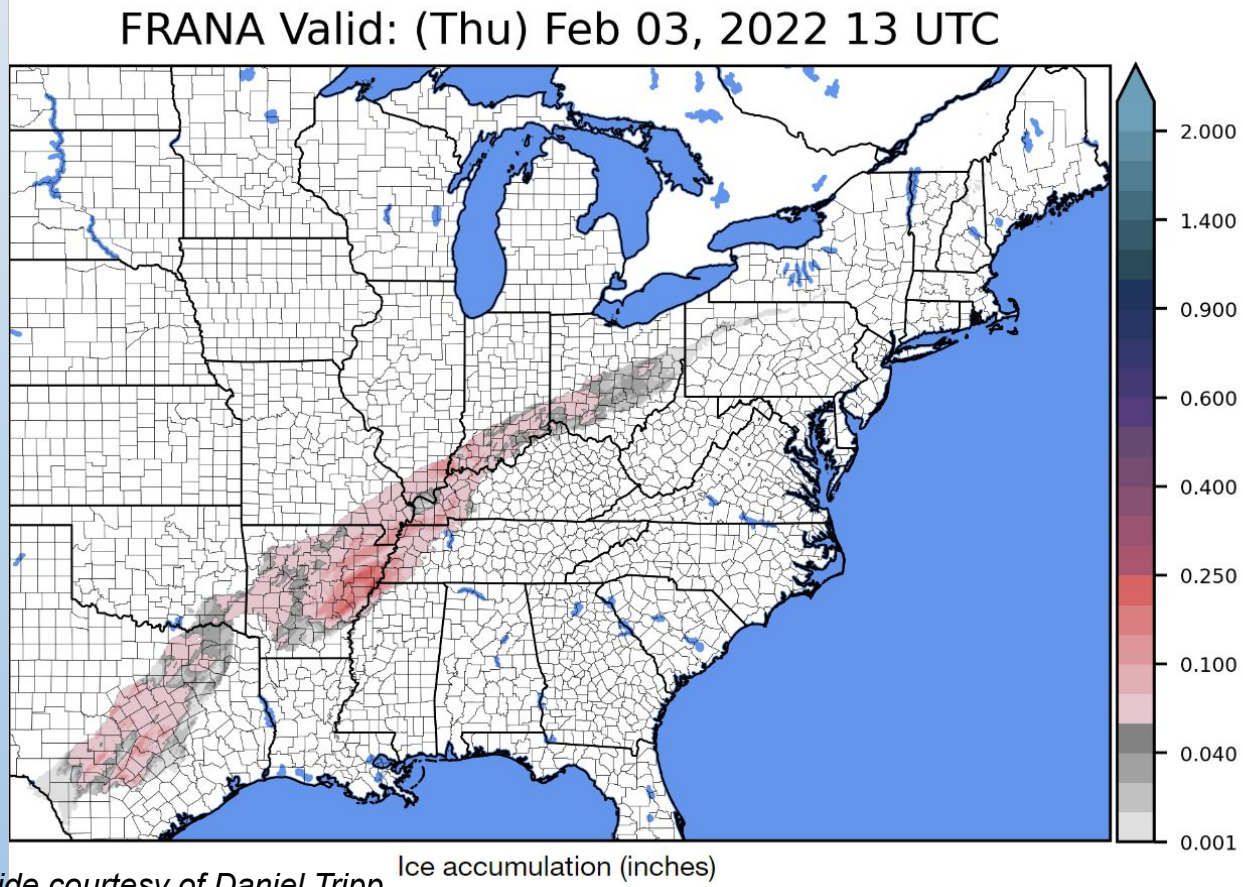


Slide courtesy of Adam Werkema

- ASOS Goodrich ice sensors are perhaps the best source for ice accumulation verification.
- However, the ice sensor network is sparse (~ 800 across the CONUS).
- NSSL is evaluating the validity and value of using ice accumulation Local Storm Reports (LSRs) as a supplemental source of verification.

Freezing Rain Accumulation National Analysis (FRANA)

(Pronounced like Hannah!)



- FRANA is a national gridded analysis of ice accumulations from freezing rain.
- NSSL will be running FRANA experimentally on the Multi-Radar Multi-Sensor (MRMS) platform during the 2023-2024 winter season.
- The algorithm utilizes MRMS QPE, base reflectivity, SBC precipitation type, HRRR model analyses, and the Freezing Rain Accumulation Model (FRAM) to declare ice accumulations on the 1km MRMS grid.

Slide courtesy of Daniel Tripp

Wish List!

- Gridded ice pellet forecasts!
  - (more of a NWS request…)
  - Allow us to represent ice pellet impacts separate from snowfall
- Improved precipitation type prediction in the HRRR (and other high-resolution hourly forecast products)
  - Allow us to improve impact-based **forecasting**
  - Specific emphasis on freezing drizzle!
- Improved precipitation-type verification
  - Allow us to improve impact-based **verification**

Contact Information and Links

- Questions or Comments? Please Reach out to:
- NWS Project Lead
  - Jim Nelson (james.a.nelson@noaa.gov)
- WSSI Scientists and Developers
  - Lead: Josh Kastman (joshua.kastman@noaa.gov)
  - Dana Tobin (dana.tobin@noaa.gov)
- WSSI Website
- ProbWSSI Website