



## Science and Technology Updates

13 March 2025

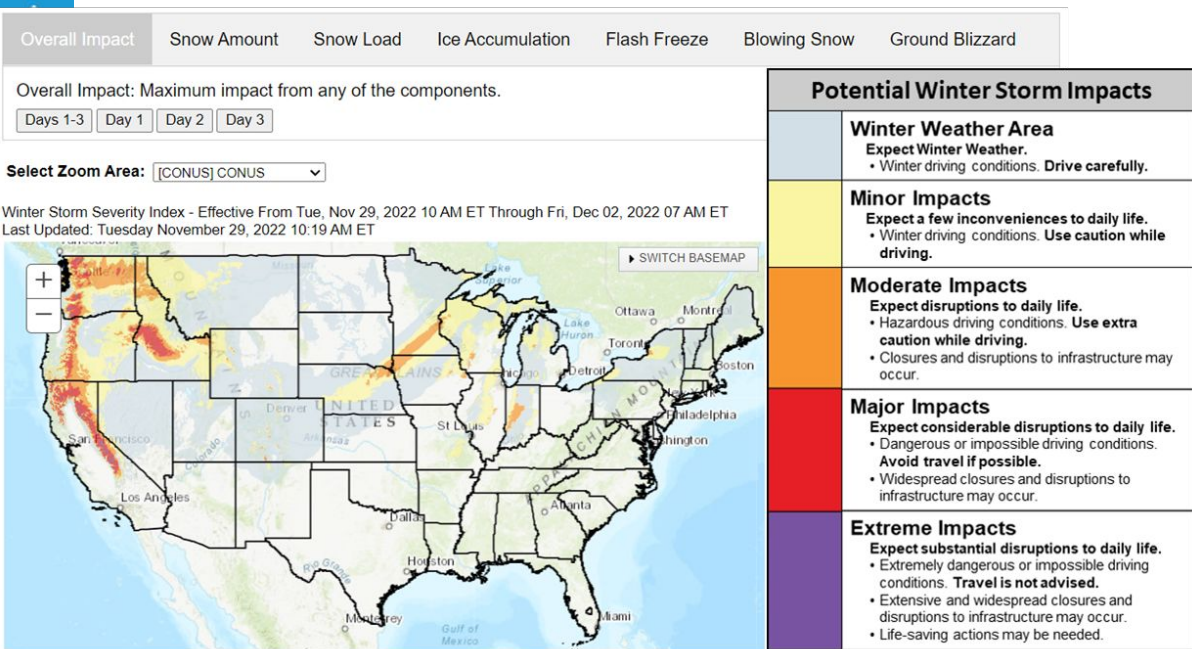
Dr. Dana Tobin, WSSI Science and Development Lead

Dr. Kirstin Harnos, WSSI Operations Lead

James Nelson, WPC DTB Chief

Jada Cordeiro, WSSI GIS Developer

# The Winter Storm Severity Index (WSSI)



- ▶ Operational NWS forecast product
- ▶ Uses GIS to combine forecast information with climatological and non-meteorological data to communicate the spatial distribution and severity of anticipated societal impacts
- ▶ Separates impacts into components to address different meteorological hazards

# WSSI 2.0!



- Complete system recode of the operational deterministic NDFD-based WSSI
- Improved coding structure to increase stability and performance
- New and updated science!
- Updates to non-meteorological factors
- Replacing current operational system on Monday, March 17 🍀



# Performance and Stability

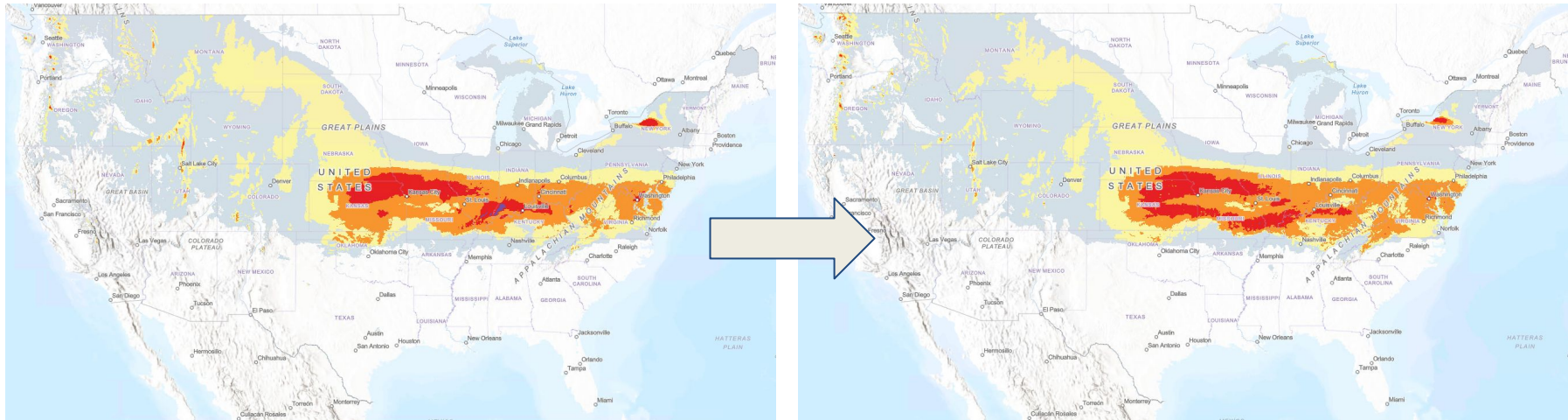
- WSSI 2.0 has been running in parallel since 6 Dec 2024
- No performance or stability issues with 2.0
  - Current operational system would “break” at least once a week
- Science run times
  - ~30 minutes for current operational system
  - ~7 minutes for WSSI 2.0
- Web and image updates take 20-25 min (both systems)

# New WSSI...Same Information



Current Ops WSSI

WSSI 2.0



“Kitchen Sink” Event, 4 January 2025 12z: Overall Component

**\*\*Front End Products and Services will remain the same\*\***

# Non-Met Factors Updates/Changes



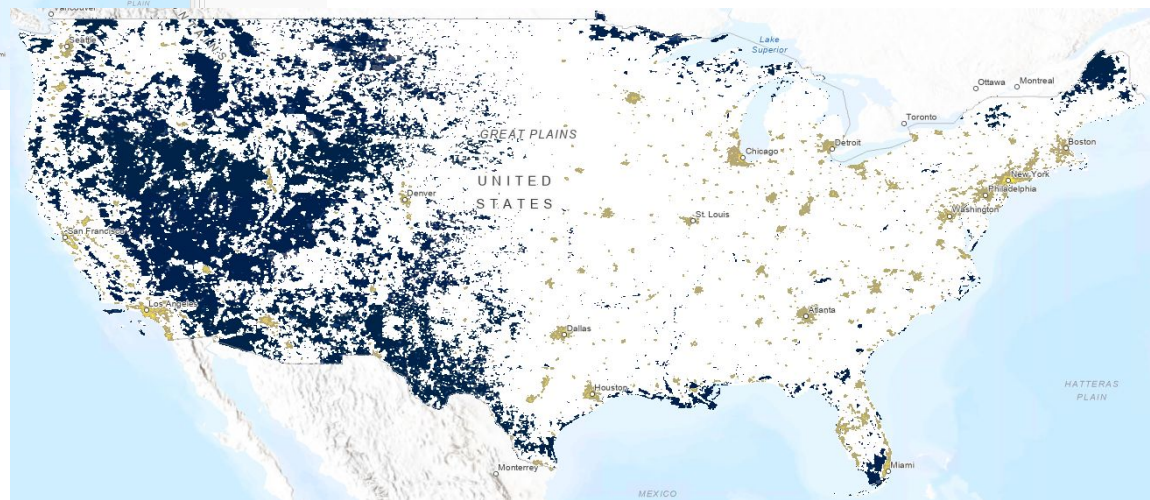
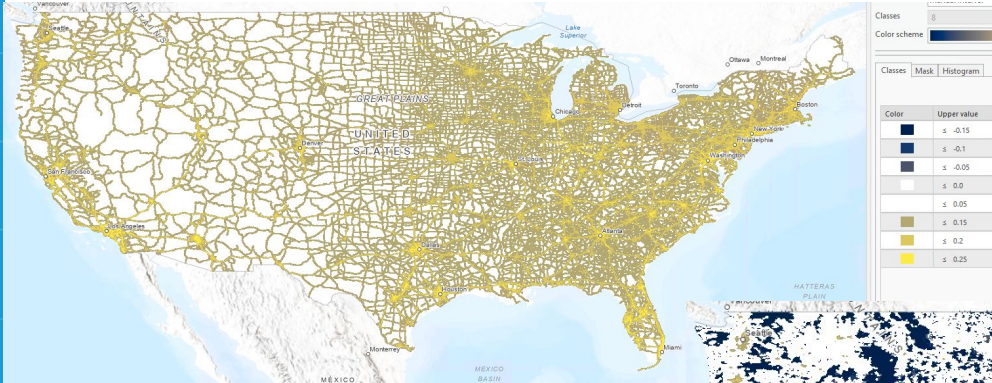
- New Land Cover dataset (2023 data)
  - Fixes an issue for blowing snow in Eastern U.S. (e.g., Erie, PA)
- New tree type and density datasets
  - Updated coniferous and deciduous tree type density maps
  - Updated leaves on/off factoring for deciduous tree types (satellite based data)
- Combined population density and traffic/road network density dataset
  - Replaces the “Urban Areas” dataset
  - Adjusts the snow and ice accumulation thresholds (up or down)
    - Lower thresholds for heavily populated or traveled areas (higher impacts)
    - Higher thresholds for areas with no people or roads (lower impacts)



# Non-Met Factors Updates/Changes

- Combined population density and traffic/road network density dataset, Cont'd
  - Weighted average between population and road factoring based on impact category
    - Minor impact category is weighted slightly more towards the road factoring
      - The road network is affected first!
    - Equal weighting for Moderate Impacts
    - More severe impact categories (Major, Extreme) are weighted increasingly towards population factoring
      - Fewer vehicles on the roads
      - Accounts for potential cascading impacts for urban areas

# Population and Traffic/Road Factors





# Component Changes: Snow Amount



- Day “X” snow amounts now include 12h prior snowfall
  - Day 1 includes appropriate 6h NDFD snow data from prior forecasts
- 36 h snowfall amounts are closer to WSSI climatology
  - WSSI thresholds are based on rolling 2-day (48h, 12Z-12Z) snowfall data
- Accounts for recent prior snowfall impacting the forecasted day
  - e.g., overnight snowfall will impact the following morning’s commute

# Component Changes: Snow Amount

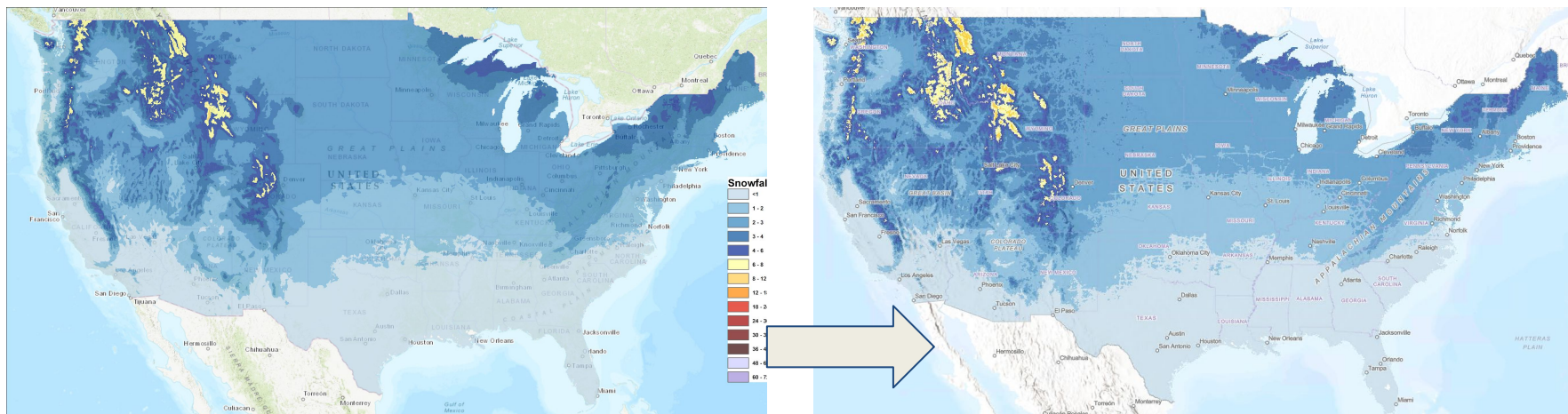


- Population and traffic/road network density datasets
  - Static datasets, added directly to the snow amount thresholds
  - Nudging/refinement of the climatologically derived thresholds to account for anthropogenic influences



# Component Changes: Snow Amount

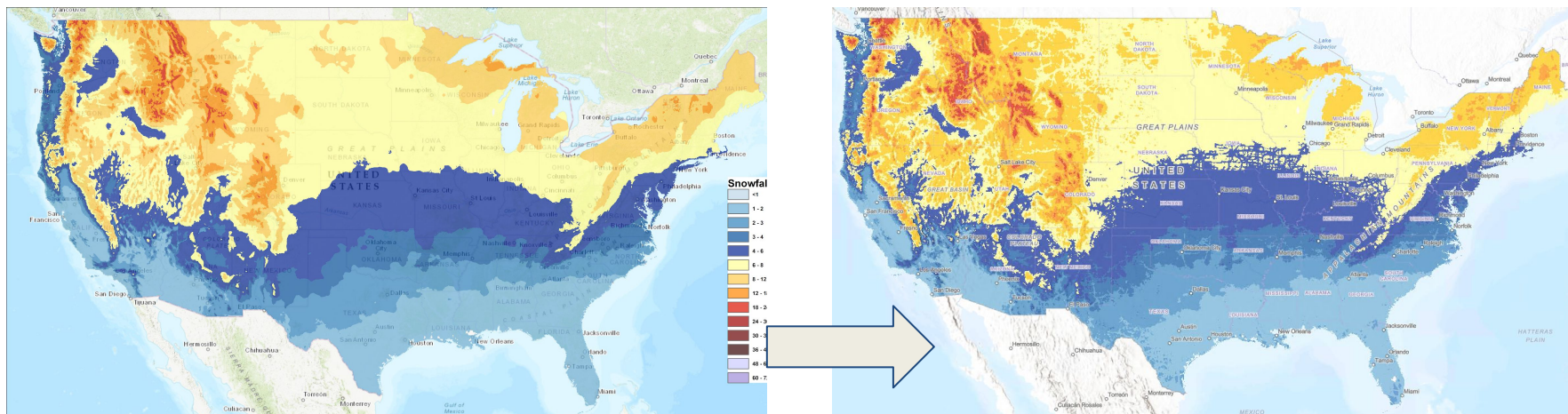
- Minor Snow Amount Thresholds
  - Population and road network factoring adjustments
    - 30% population weighting
    - 70% traffic/road network weighting





# Component Changes: Snow Amount

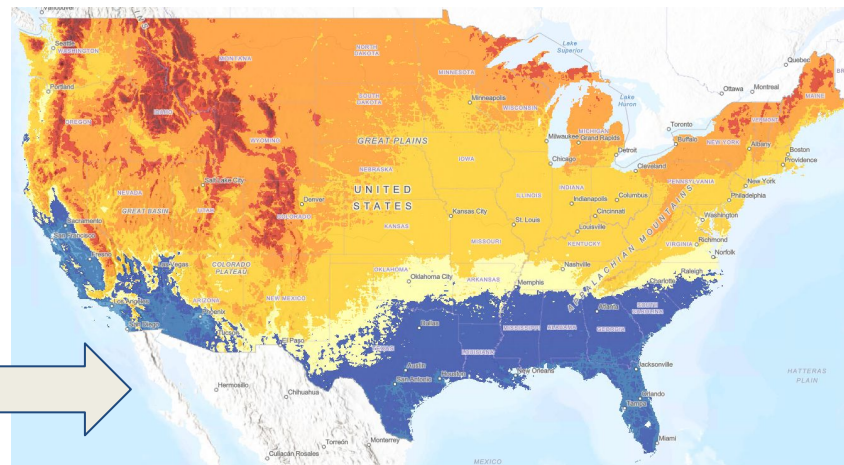
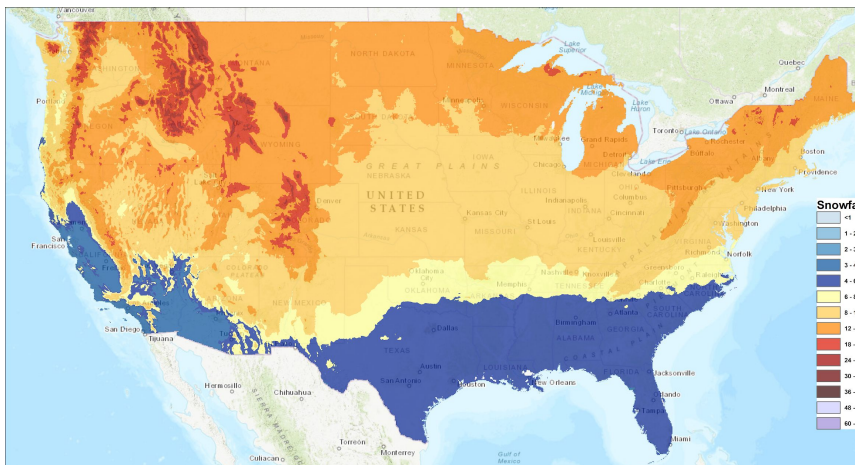
- Moderate Snow Amount Thresholds
  - Population and road network factoring adjustments
    - 50% population weighting
    - 50% traffic/road network weighting





# Component Changes: Snow Amount

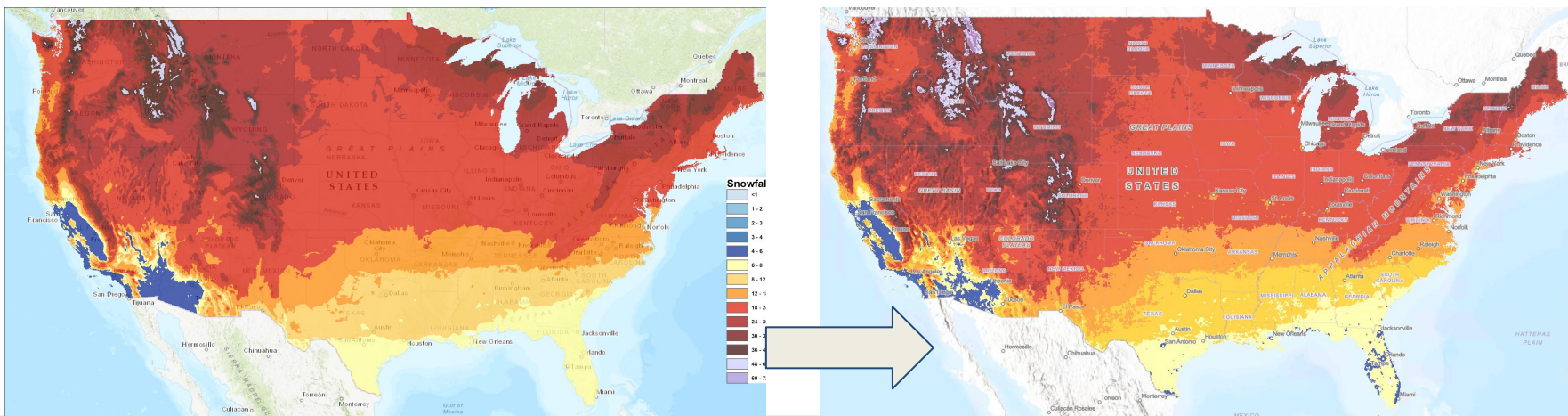
- Major Snow Amount Thresholds
  - Population and road network factoring
    - 70% population weighting
    - 30% traffic/road network weighting





# Component Changes: Snow Amount

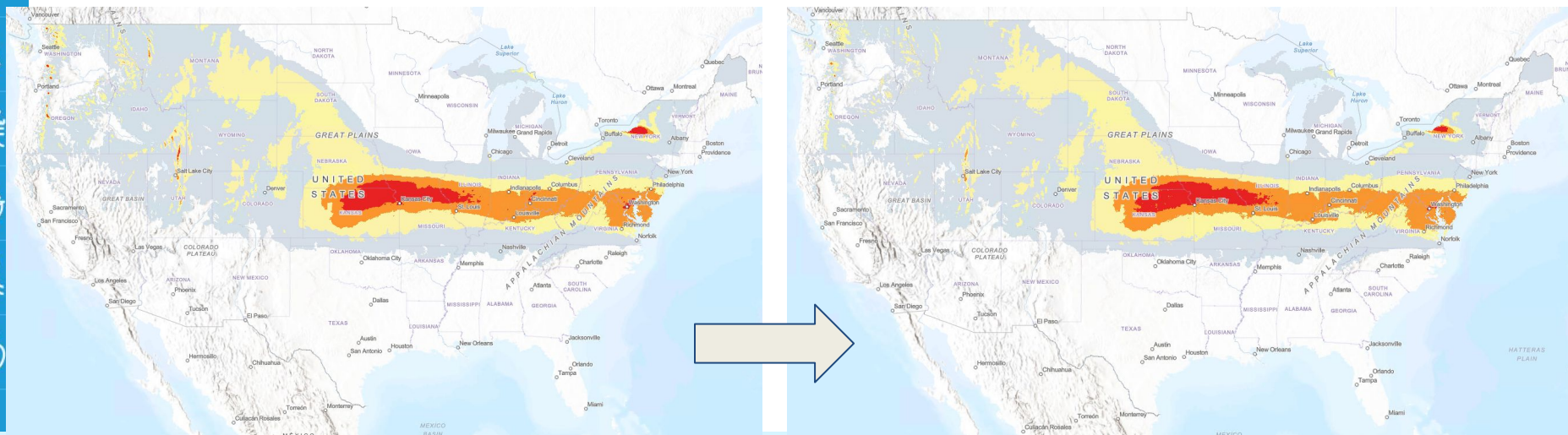
- Extreme Snow Amount Thresholds
  - Population and road network factoring
    - 90% population weighting
    - 10% traffic/road network weighting





# Ops vs 2.0 Comparison Cases

- “Kitchen Sink” Event, 4 January 2025 12Z run: Snow Amount



# Component Changes: Snow Load



**\*\*Component with the most changes!!\*\***

- Now tracks **three** separate snow-water equivalent (SWE) values
  - **New SWE:** SWE from the 36h Snow Amount accumulation periods
    - Accounts for “shovelable” snow load
  - **Total SWE:** Pre-existing SWE + SWE since initialization
    - Targets the potential for structural loading issues
  - **“Sticky” SWE:** SWE from snow that can adhere to overhead wires and/or trees
    - Targets the potential for utility disruptions and wire/tree damages



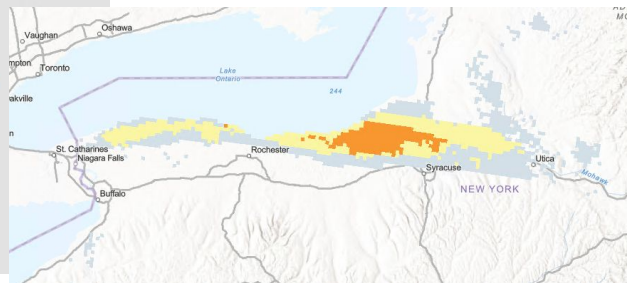
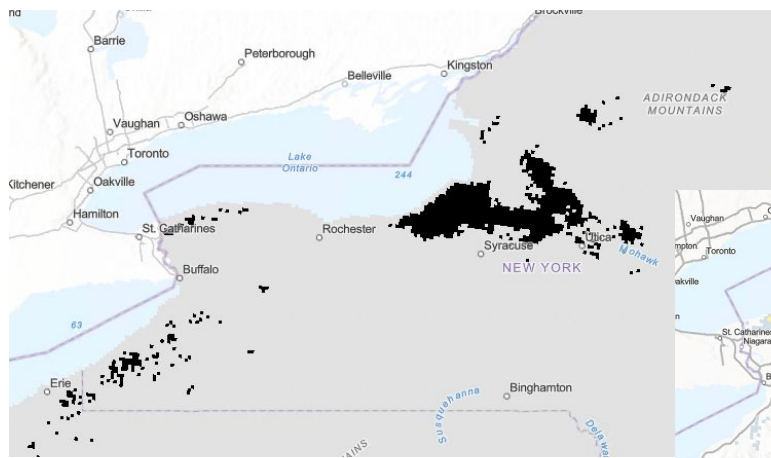


# Snow Load Changes

- Total SWE: Pre-existing SWE + SWE since initialization
  - Pre-existing SWE from Snow Data Assimilation System (SNODAS)
    - Any gaps between SNODAS data (12Z) and NDFD initialization time is filled in with appropriate previous NDFD SWE data
  - Targets impacts due to heavy cumulative snow loading
    - Structural issues (e.g., sheds, barns, poorly built structures)
  - Total SWE can increase Snow Load impacts by **one** category where:
    - New snowfall is forecasted
    - Total SWE exceeds 80% of 50-year mean recurrence interval SWE values
  - Extreme impacts can only be “unlocked” within areas of Major Snow Load impacts that **also** meet the total SWE criteria above

# What does this look like?

- Black = areas where total SWE > 80% 50-year MRI SWE
- >15 structural collapses
- Added one impact category





# Snow Load Changes

- “Sticky” SWE: SWE from snow that can adhere to overhead wires and/or trees
  - Cumulative 6h SWE totals from the 36h Snow Amount accumulation period that meet certain criteria for the snow to be “sticky”
    - Wind and temperature criteria
  - Wind-adjusted “Sticky” SWE
    - Wind factor applied to “Sticky” SWE values
      - Ratio of the **wind load** to the **snow load** of a snow-covered branch/wire
        - Maximum value of 2.0
      - Factor of wind speed squared
    - Range from “sticky” SWE (no wind) to 2x “sticky” SWE value (high wind)
    - Tree type and density datasets and leaves on/off deciduous trees are included here



# Snow Load Changes

- Impact levels are based on a combination of the 3 SWE values
  - **Extreme:** Wind-adjusted “Sticky” SWE  $\geq 2.36$  in **and** Total SWE  $>80\%$  of 50-year MRI snow load values
    - Widespread tree/wire damage **and** the potential for structural issues
  - **Major:** Wind-adjusted “Sticky” SWE  $\geq 2.36$  in
    - Widespread tree and/or overhead wire damages
  - **Moderate:** Wind-adjusted “Sticky” SWE  $\geq 1.5$  in **or** New SWE  $\geq 1.0$  in
    - Tree/wire impacts **or** cardiovascular/musculoskeletal injuries/strains
  - **Minor:** New SWE  $\geq 0.50$  in
    - Shovelable wet, heavy snowfall
    - Potential for cardiovascular injuries or musculoskeletal strains /injuries

# Snow Load Changes



Impact levels are based on a combination of the 3 SWE values

Snow Load/Snow Water Equivalent Value	Category
< 0.25 in New SWE	0 - None
≥ 0.25 in New SWE	1 - Winter Weather Area
≥ 0.50 in New SWE	2 - Minor
≥ 1.0 in New SWE or ≥ 1.5 in "Sticky" SWE	3 - Moderate
≥ 2.36 in "Sticky" SWE and ≥ 1.0 in New SWE	4 - Major
≥ 2.36 in "Sticky" SWE, ≥ 1.0 in New SWE, and Total SWE >80% 50-year MRI	5 - Extreme

## Minor:

Shovelable wet, heavy snowfall  
Potential for cardiovascular injuries or musculoskeletal strains /injuries

## Moderate:

Tree/wire impacts **or**  
cardiovascular/musculoskeletal injuries/strains

## Major:

Widespread tree and/or overhead wire damages

## Extreme:

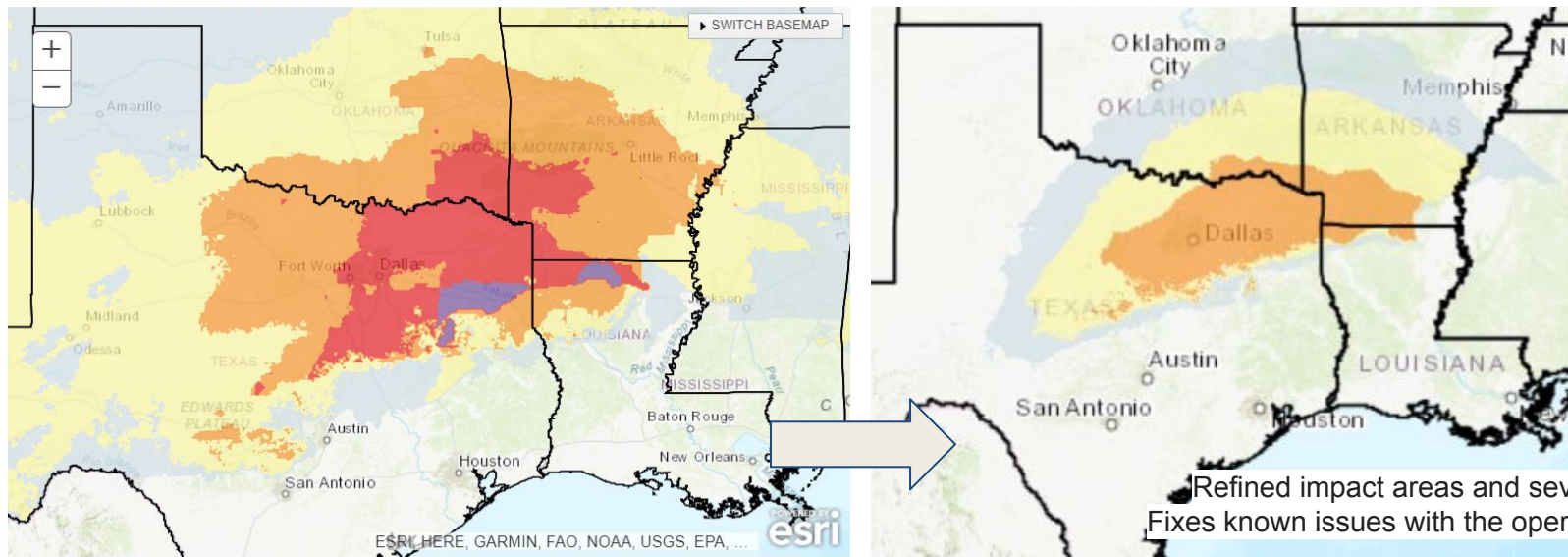
Widespread tree/wire damage **and** the potential for structural issues

\*\*Total SWE can increase Snow Load impacts by **one** category



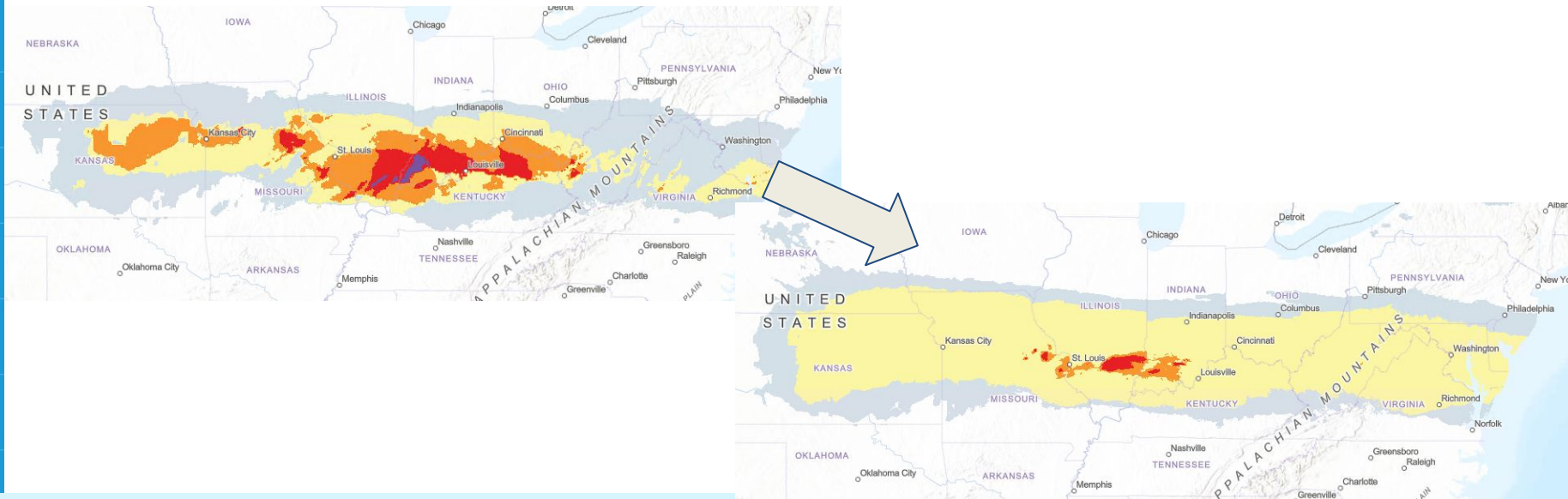
# Ops vs 2.0 Comparison Cases

- Snow Load, 10 January 2025 18Z run



# Ops vs 2.0 Comparison Cases

- “Kitchen Sink” Event, 4 January 2025 12Z run: Snow Load



# Component Changes: Ice Accumulation



- **\*\*Component with the second-most changes!\*\***
- 36h ice accumulations (Day "X" plus prior 12h)
  - Consistent with Snow Amount component methods and logic
- Radial and flat ice accumulations are both tracked separately
  - Radial =  $0.394 \times \text{Flat}$  (Ryerson and Ramsay 2007)
  - Wind-adjusted radial ice
    - Wind adjustment factor applied to radial accumulations
      - Same logic and parameters as the wind factor for "sticky" SWE
        - Different equation to account for ice (vs snow) loading geometry
    - Tree type and density datasets and leaves on/off deciduous trees are included here





# Ice Accumulation Changes

- Impact thresholds based on flat and/or wind-adjusted radial thicknesses
  - **Extreme:** Wind-adjusted radial ice  $\geq 0.5$  in
    - Widespread tree and/or overhead wire damage
  - **Major:** Wind-adjusted radial ice  $\geq 0.25$  in
    - Tree and/or overhead wire damage
  - **Moderate:** Wind-adjusted radial ice  $\geq 0.1$  in **or** flat ice  $\geq 0.25$  in
    - Warning criteria (or lower with winds)
    - Population and traffic/roads included in thresholds
    - Surface impacts **or** vegetation impacts
  - **Minor:** Flat ice  $\geq 0.05$  in
    - Population and traffic/roads included in thresholds
    - Surface impacts only

# Ice Accumulation Changes



Impact thresholds based on flat and/or wind-adjusted radial thicknesses

Ice Accumulation Value	Category
0 in	0 - None
> 0.0 in	1 - Winter Weather Area
Flat Ice $\geq$ 0.05 in	2 - Minor
Flat Ice $\geq$ 0.25 in or Wind-adjusted radial $\geq$ 0.10 in (and flat ice $\geq$ 0.05 in)	3 - Moderate
Wind-adjusted radial $\geq$ 0.25 in (and flat ice $\geq$ 0.25 in)	4 - Major
Wind-adjusted radial $\geq$ 0.50 in (and flat ice $\geq$ 0.25 in)	5 - Extreme

## Minor:

Population and traffic/roads included in thresholds

Surface impacts only

## Moderate:

Warning criteria (or lower with winds)

Population and traffic/roads included in thresholds

Surface impacts **or** vegetation impacts

## Major:

Tree and/or overhead wire damage

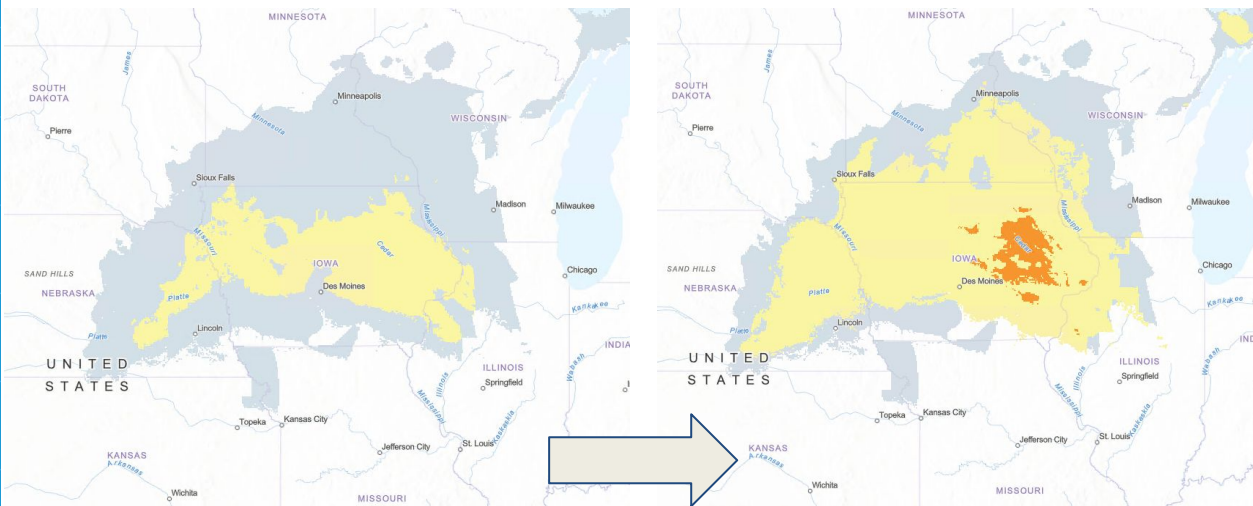
## Extreme:

Widespread tree and/or overhead wire damage



# Ops vs 2.0 Comparison Cases

- Ice Accumulation, 12 December 2024 12Z run



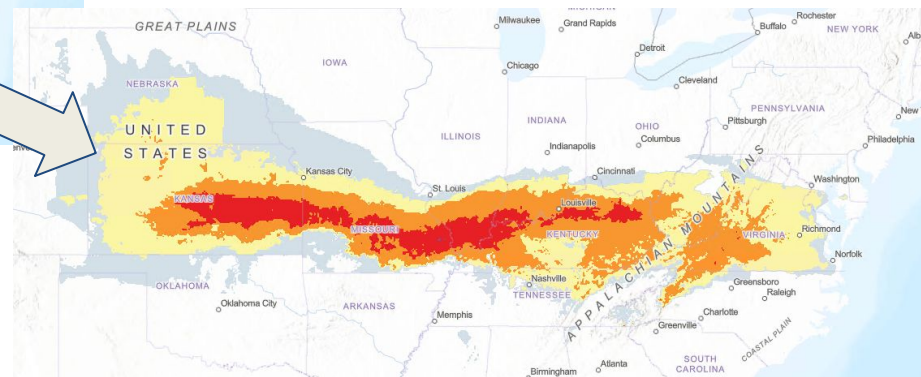
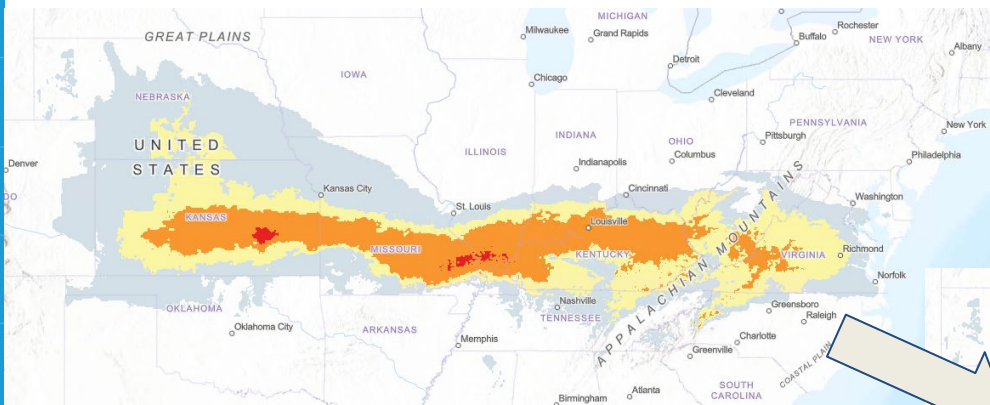
Moderate 2.0 provides better guidance for Ice Storm Warning areas than Ops

“I would love to use it today as it better represents the situation.” - WFO La Crosse, WI

# Ops vs 2.0 Comparison Cases



- “Kitchen Sink” Event, 4 January 2025 12Z run: Ice Accumulation



# Component Changes: Blowing Snow



- Recent changes to WSSI
  - Estimate visibility from snow transport rate equations (Harada et al. 2022/Takechi et al. 2016)
    - Liquid-equivalent snow rates and wind speed
    - Only for areas where blowing and drifting snow conditions are favorable
      - Temperature and wind speed criteria
  - Moderate impacts for estimated visibilities  $\leq 0.25$  mi
    - This is ***different*** than NDFD forecasted visibilities
      - (often lower than high-resolution visibility values - Tobin et al. 2024)
- Newest changes
  - Major and Extreme impacts are only “unlocked” for longer durations of visibilities  $\leq 0.25$  mi



# Blowing Snow Changes

- New changes: Duration-Based Impact Enhancements
  - Major and Extreme impacts are only “unlocked” for longer durations of visibilities  $\leq 0.25$  mi
    - Major:  $\geq 3$  (out of 4) NDFD time periods have visibilities  $\leq 0.25$  mi
    - Extreme:  $\geq 5$  (out of 6) NDFD time periods have visibilities  $\leq 0.25$  mi
  - Longer durations of higher visibilities (but still  $< 1.0$  mi) can increase impacts
    - Visibilities  $\leq 0.50$  mi (but  $> 0.25$  mi) can range from Minor to Major
    - Visibilities  $\leq 1.0$  mi (but  $> 0.50$  mi) can range from Winter Weather Area to Moderate



# Component Changes: Ground Blizzard

## **\*\*Complete algorithm overhaul!\*\***

- Apply the same logic as for Blowing Snow
  - Same algorithms for visibility, but different weather conditions
    - Pre-existing snowfall only
    - Only for areas where drifting snow conditions are favorable
      - Depends on snow depth, temperature, time since snowfall ended, maximum temperature since snowfall ended, and an integrated value of wind speeds since snowfall ended
  - Same visibility thresholds and duration-based impact enhancements

# Blowing Snow/Ground Blizzard Changes



## Duration-Based Impact Enhancements

Blowing Snow Value	Category
0	0 - None
$\leq 1.00$ mi	1 - Winter Weather Area
$\leq 0.50$ mi	2 - Minor
$\leq 0.25$ mi (no enhancement category)	3 - Moderate
$\leq 0.25$ mi plus 1 enhancement category (moderate duration)	4 - Major
$\leq 0.25$ mi plus 2 enhancement categories (long duration)	5 - Extreme

### Major and Extreme impacts

- Major:  $\geq 3$  (out of 4) NDFD time periods have visibilities  $\leq 0.25$  mi
- Extreme:  $\geq 5$  (out of 6) NDFD time periods have visibilities  $\leq 0.25$  mi

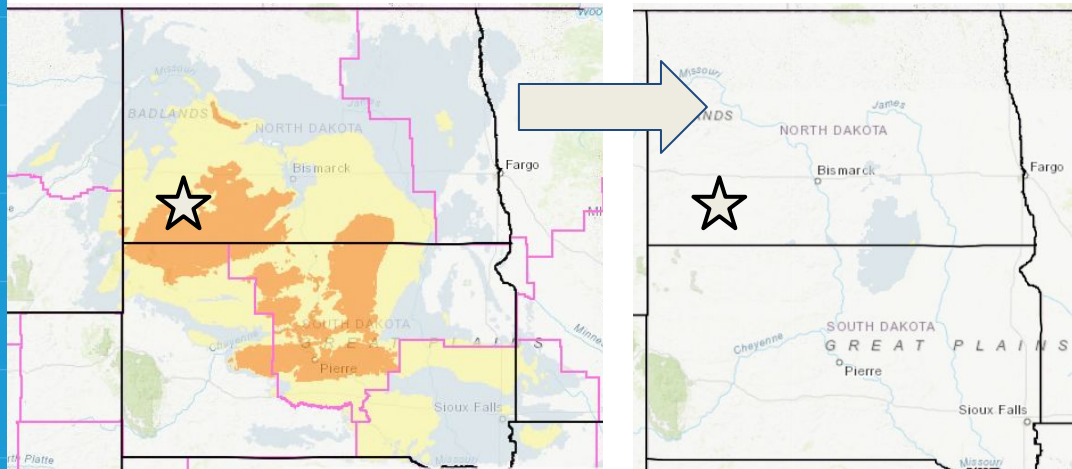
### Longer durations of higher visibilities (but still $< 1.0$ mi) can increase impacts

- Visibilities  $\leq 0.50$  mi (but  $> 0.25$  mi) can range from Minor to Major
- Visibilities  $\leq 1.0$  mi (but  $> 0.50$  mi) can range from Winter Weather Area to Moderate



# Ops vs 2.0 Comparison Cases

- Ground Blizzard, 19 December 2024 12Z run



“I can say pretty confidently that the WSSI 2.0 version appears to be working very well and is capturing conditions in southwest North Dakota much better than the older version.

[...]

I think the new GB algorithms are working great in this case, at least in my area!” - WFO Bismarck, ND



NDOT - New England - ND22468P57 - 08:18:45 - Thu Dec 19 2024 - 78° 8' - 43.6

# Component Changes: Flash Freeze



Flash Freeze Thresholds	Category
0	0 - None
Available Liquid > 0.25" or Temperature drop $\geq 10$ °C	1 - Winter Weather Area
Available Liquid > 0.50" or Temperature drop $\geq 15$ °C	2 - Minor
Available Liquid > 1.5" or Temperature drop $\geq 20$ °C	3 - Moderate

This component is dependent upon the change in temperature between 6h NDFD time blocks and the amount of liquid to freeze. **Temperatures prior to the flash freeze condition must be above 10°C with liquid and then drop below 0°C.**

# Limitations and Future Work



- Sleet and rain/snow transitions
  - Sleet is counted in the snow grids
  - 6h liquid-equivalent “snowfall” isn’t accurate for transitions or sleet
  - Can affect Snow Amount, Snow Load, Blowing Snow/Ground Blizzard
- No melting of snow or ice yet
  - Also, no “shedding” of “sticky” SWE
  - Can affect Snow Amount, Snow Load, and Ice Accumulation
- Ice improvements (summer 2025 development)
  - Regionalization for ice impacts
  - Surface temperatures
  - Melting
- WSSI-P 2.0 is in development



# Thank you!

## Questions/Comments?

### Contact Information:

For Science/Development:

Dana: [dana.tobin@noaa.gov](mailto:dana.tobin@noaa.gov)

For Operational Support:

Kirstin: [kirstin.harnos@noaa.gov](mailto:kirstin.harnos@noaa.gov)