The Winter Storm Severity Index (WSSI) "Suite of Products"

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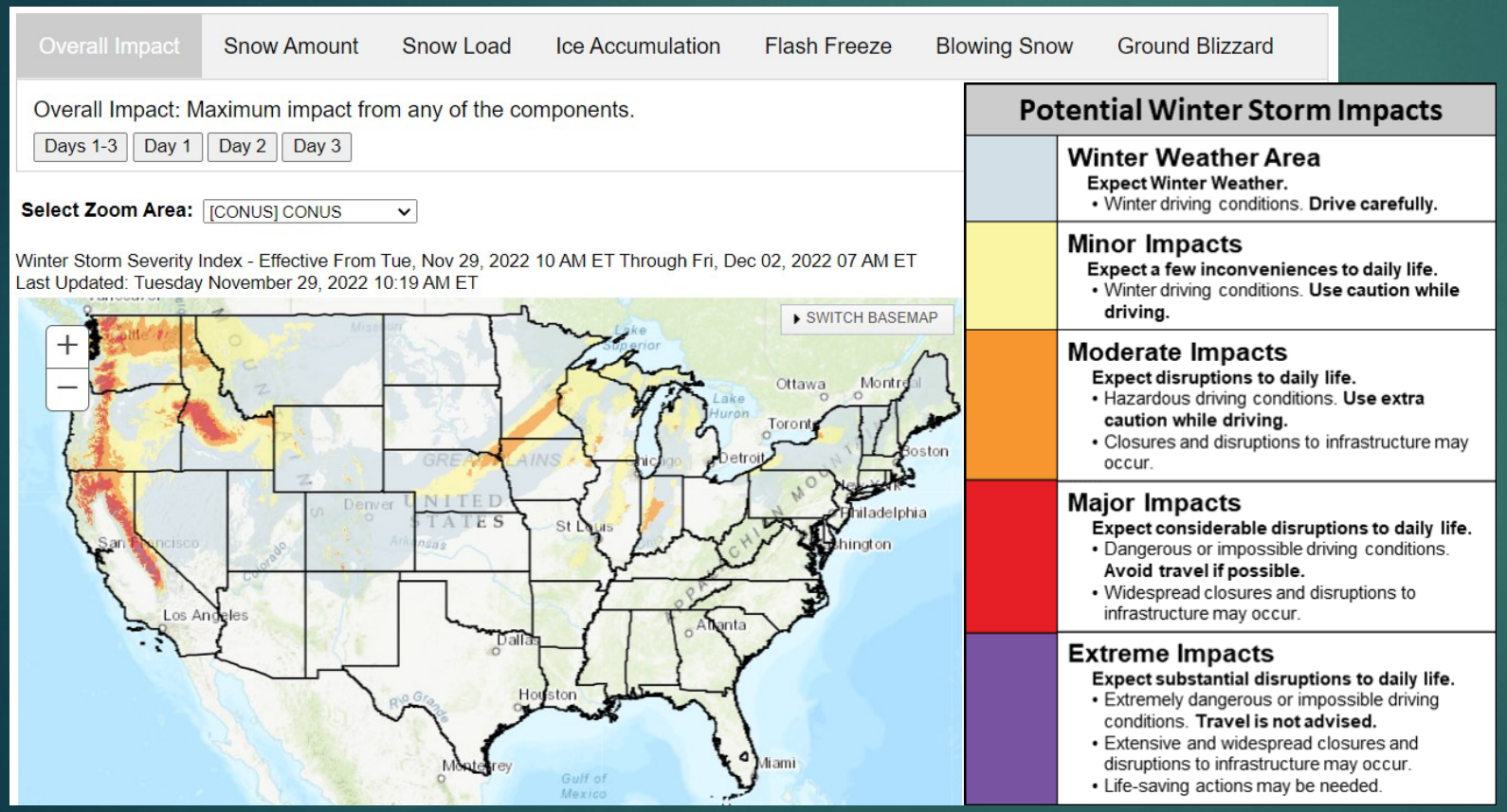
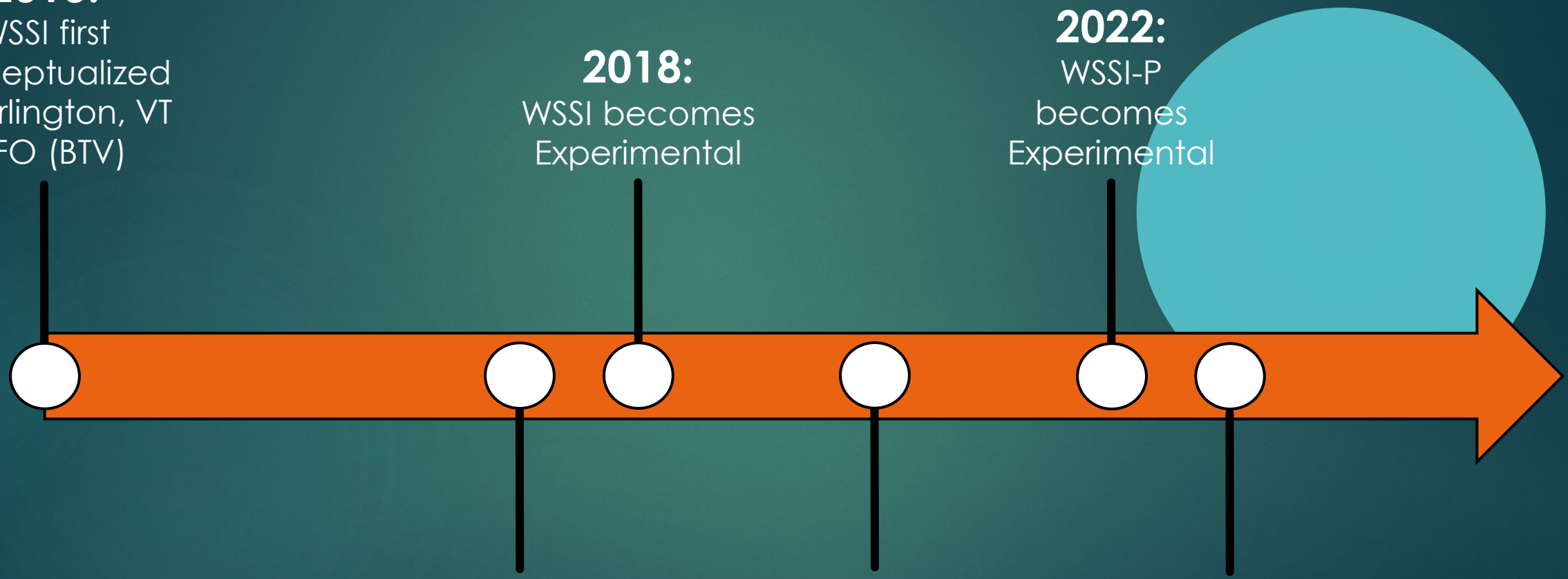
The Winter Storm Severity Index (WSSI)



- 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

Timeline of WSSI



The WSSI "Suite of Products"

- Deterministic WSSI (operational)
  - National Digital Forecast Database (NDFD) based
  - Days 1-3 in 24h breakouts, and a 3-day summary
  - High-glance summary of the potential societal impacts based on official NWS forecasts
- Probabilistic WSSI (WSSI-P; operational)
  - WPC Super Ensemble based
  - Days 1-7 in 24h rolling breakouts
  - Deeper dive into the probabilities and potential for societal impacts
- Hourly WSSI (WSSI-H; internal prototype in development)
  - High-Resolution Rapid Refresh (HRRR) based
  - Hours 1-48 (for synoptic runs) in hourly breakouts
  - High spatial and temporal resolution of impact forecasts in the short-term, designed to aid in travel decisions and awareness

WSSI Product Workflow

- Days 7 → 3
  - Only WSSI-P is available
  - "Keep an eye out" for potential impacts from winter storms
- Days 3 → 1
  - WSSI as a quick-glance for impending impacts
  - WSSI-P as a deep-dive into impact probabilities
  - WSSI-H as the event is unfolding (now – 48 h)

WSSI-P Example – April 2022 Blizzard

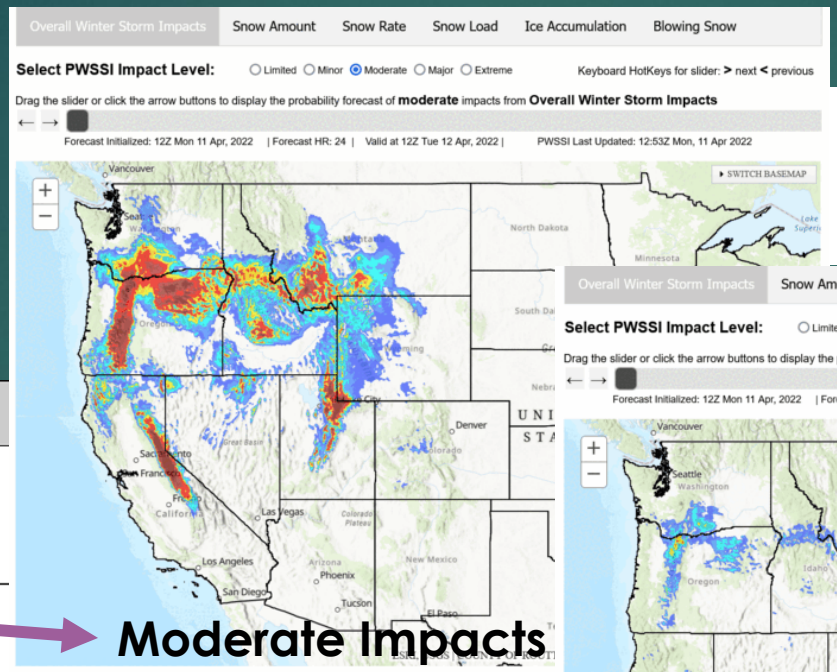
Potential Winter Storm Impacts

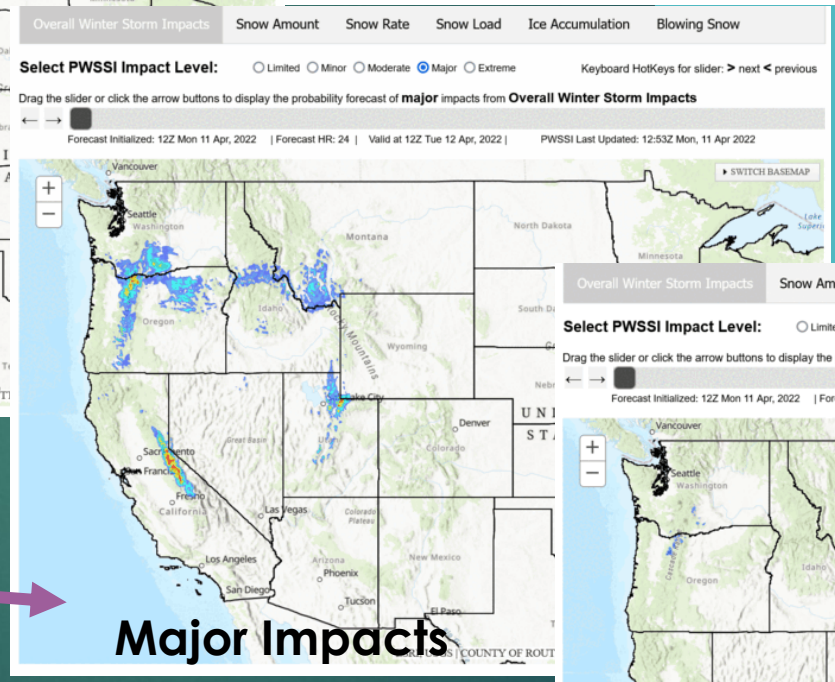
Minor Impacts
Expect a few inconveniences to daily life.
- Winter driving conditions. **Use caution while driving.**

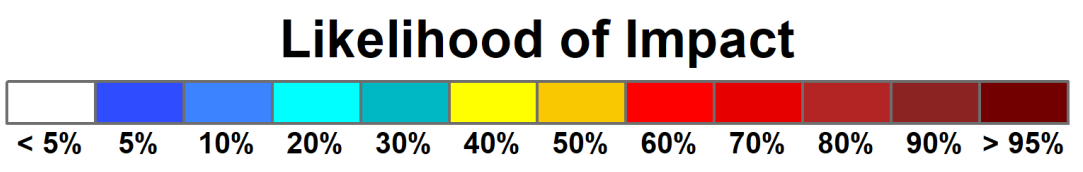
Moderate Impacts
Expect disruptions to daily life.
- Hazardous driving conditions. **Use extra caution while driving.**
- Closures and disruptions to infrastructure may occur.

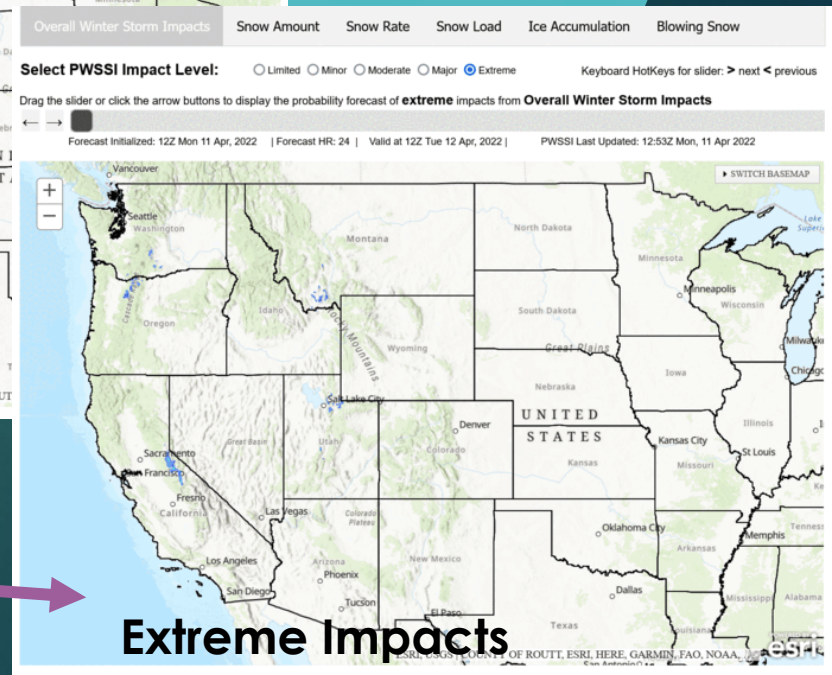
Major Impacts
Expect considerable disruptions to daily life.
- Dangerous or impossible driving conditions. **Avoid travel if possible.**
- Widespread closures and disruptions to infrastructure may occur.

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.







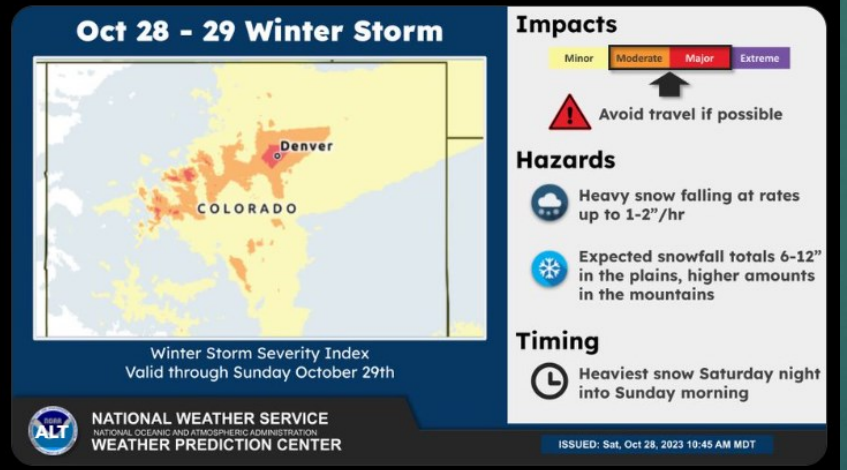


Examples: Deterministic WSSI

National Center (WPC)

NWS Weather Prediction Center
@NWSWPC

⚠️❄️ A winter storm will bring heavy snow to parts of Colorado later today through Sunday morning. Our Winter Storm Severity Index indicates that Denver and some of the higher peaks of the Rockies may see Major impacts from this event. Avoid travel in these areas if possible!



1:13 PM · Oct 28, 2023 · **21.7K** Views

Local WFO

NWS Las Vegas
@NWSVegas

Another round of gusty winds & winter weather are on tap through Tue AM; but this will only be a preview of what's to come as the bulk of the system will move through on Wednesday.

The graphic shows the Winter Storm Severity Index thru Thursday AM.

#NVwx #CAwx #AZwx

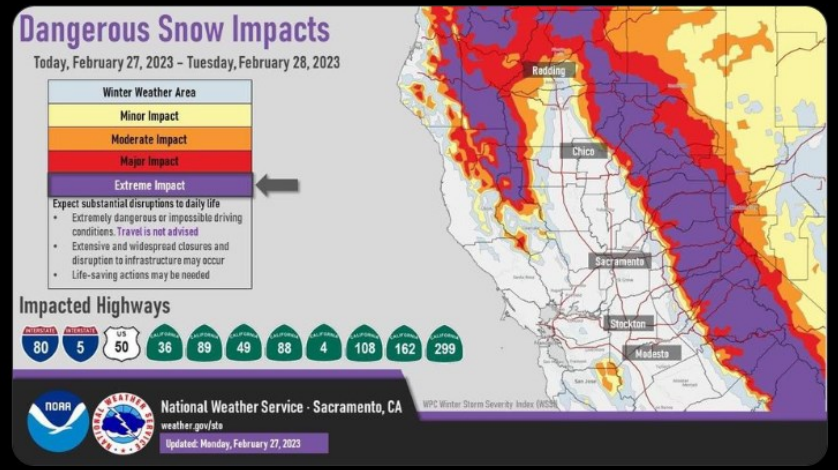
6:40 PM · Feb 27, 2023 · **7,114** Views

Partners

CHP Truckee
@CHP_Truckee

HERE IT COMES!! 🆘 If you are planning to risk traveling over Donner Summit the next couple days expect dangerous travel conditions!! Expect long delays, high winds, zero visibility, and road closures... TRAVEL IS HIGHLY DISCOURAGED!!

(2/27/23 8:15am)



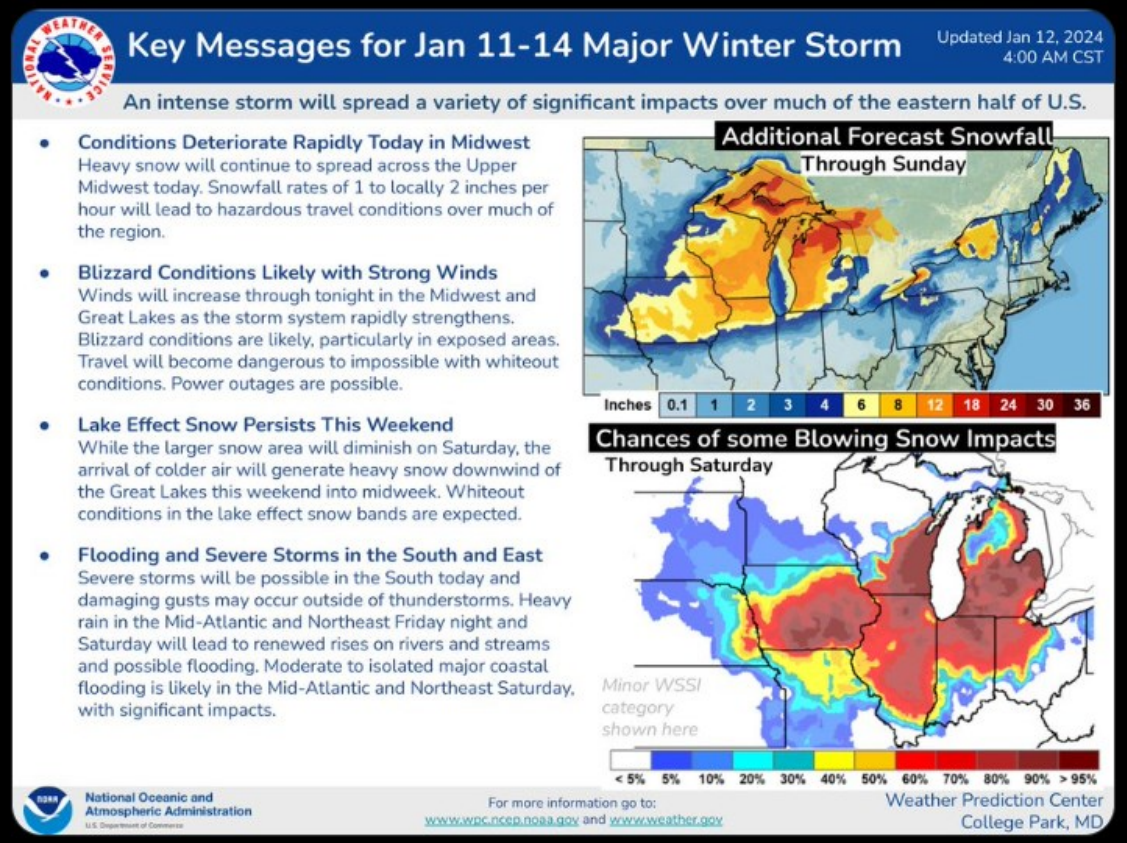
11:26 AM · Feb 27, 2023 · **46.5K** Views

Examples: Probabilistic WSSI (WSSI-P)

National Center (WPC)

NWS Weather Prediction Center
@NWSWPC

Midwest Blizzard to Prolonged Lake Effect Event Update

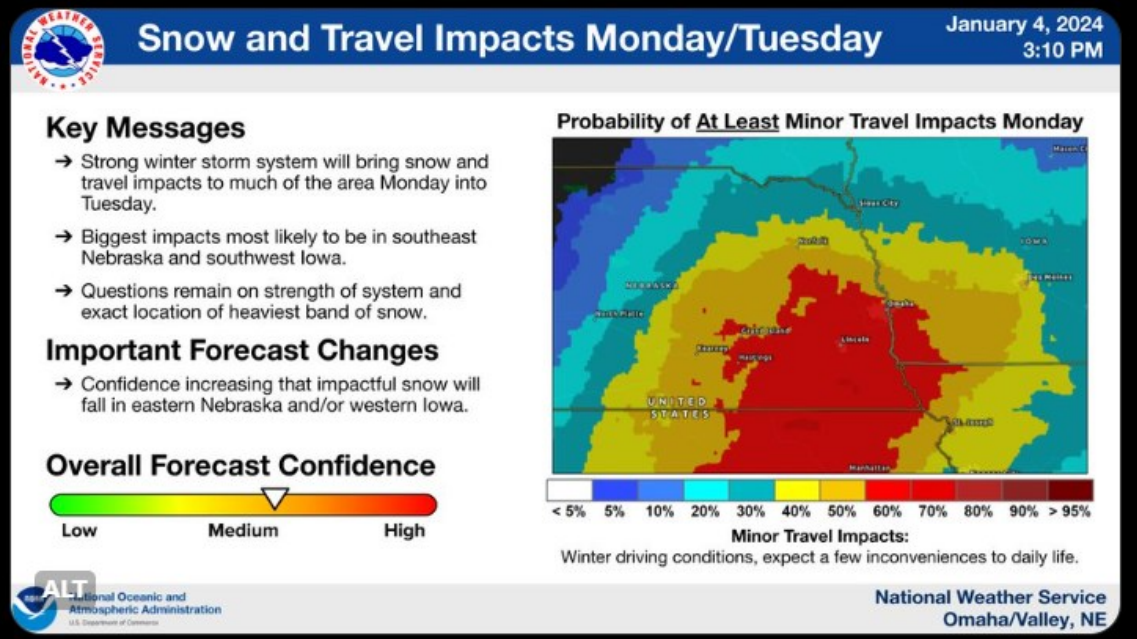


5:33 AM · Jan 12, 2024 · **26K** Views

Local WFO

NWS Omaha
@NWSOmaha

It's going to snow.
Plows will be out.



5:18 PM · Jan 4, 2024 · **74.5K** Views

WSSI Components

- Snow Amount (all products)
  - Impacts due to the accumulation of snowfall
    - Does not include any snowfall prior to initialization
- Snow Rate (WSSI-P and WSSI-H)
  - Impacts due to the rate of snowfall
    - Baked into the Snow Amount component for WSSI
- Ice Accumulation (all products)
  - Impacts due to ice accretion
    - Does not include any accumulations prior to initialization
    - Accumulations are killed off after 24 h for WSSI and WSSI-P

WSSI Components

- Ground Blizzard (WSSI)
  - Impacts due to the resuspension of previously fallen snow
    - Uses NOHRSC to identify areas of prior snowfall
- Blowing Snow (all products)
  - Impacts due to blowing and/or drifting of falling snow
- Flash Freeze (all products)
  - Impacts due to the freezing of liquid precipitation and/or snowmelt
    - Snowmelt is brand new!

What are Impacts??

- Anything that disrupts daily life
  - School or business closures/delays
  - Traffic disruptions (Delays, closures, crashes, speed restrictions, vehicle bans)
  - Utility disruptions (Power or internet outages)
- Damage to vegetation or infrastructure
  - Downed trees and/or power lines
  - Damaged foliage and vegetation
  - Structural collapses
  - Frozen or burst water pipes*
- Health-related issues
  - Cardiovascular issues from shoveling heavy snow
  - Hypothermia or other cold-weather risks*

*Not accounted for yet!

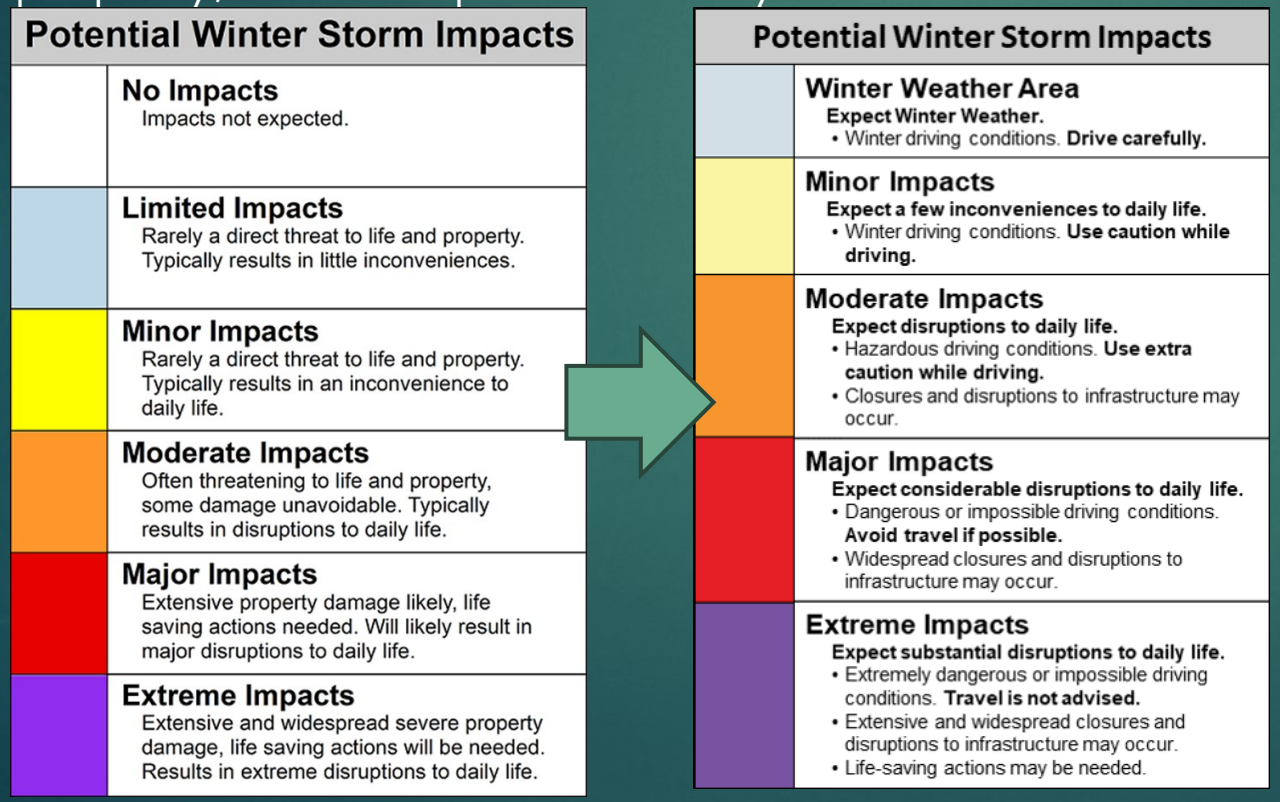
What are Impacts??

- Mitigation efforts are *also* considered impacts!
  - Staying home and *avoiding travel* is an impact
    - Travel plans altered due to the weather
    - Reduced mobility for discretionary travel
- Quantifying all of these impacts is challenging…
  - Impacts are holistic; cannot just examine one aspect or data source
    - Example: Crash data has limitations (e.g., closed roads have no crashes!)
  - More on this later…

Improvements from Social Science Engagements

Old Definitions and Colors

- Focus on the impacts to life and property, and disruptions to daily

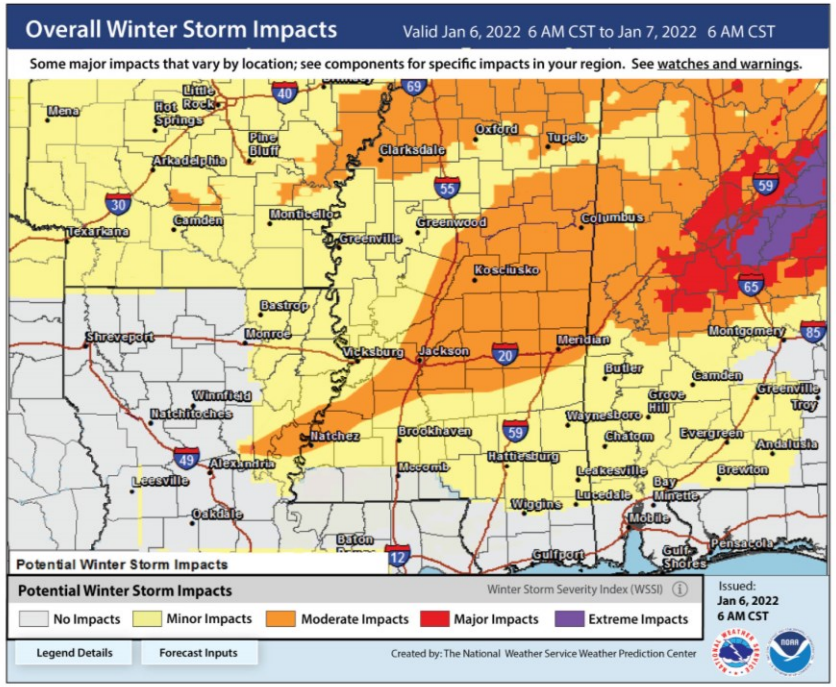


New Definitions and Colors

- Improved and color-blind friendly colors
- Primary emphasis on the disruption to daily life
- Emphasis on transportation and driving conditions
- Inclusion of potential closures and disruption to infrastructure
  - e.g., roads, businesses, schools, utility lines, delivery services
- Removal of "Limited Impacts"
  - Replaced with "Winter Weather Area": Winter conditions are expected to occur, but not disrupt daily life

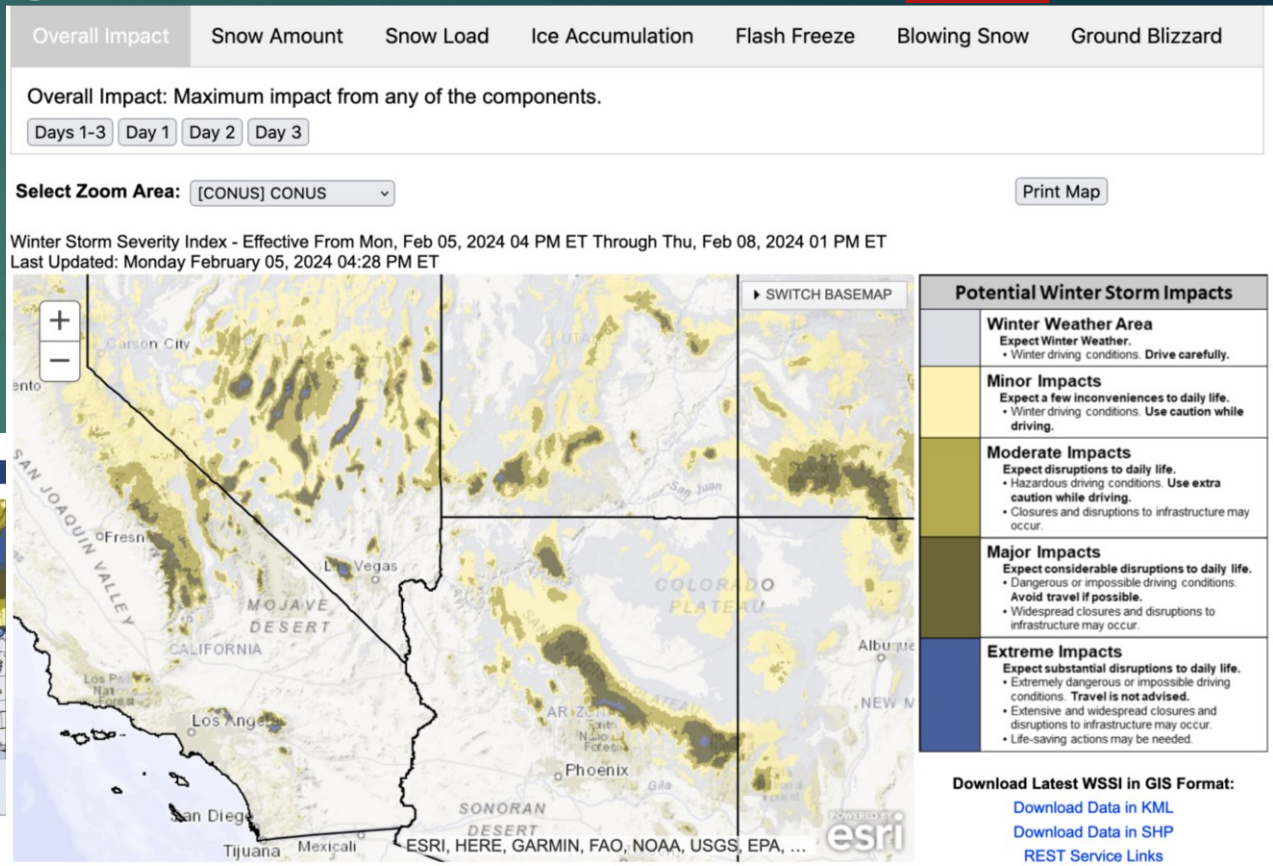
Color Blindness Testing

Revised WSSI - Overall Winter Storm Impacts Round 2



Protan Color Vision Deficiency (insensitivity to red light)

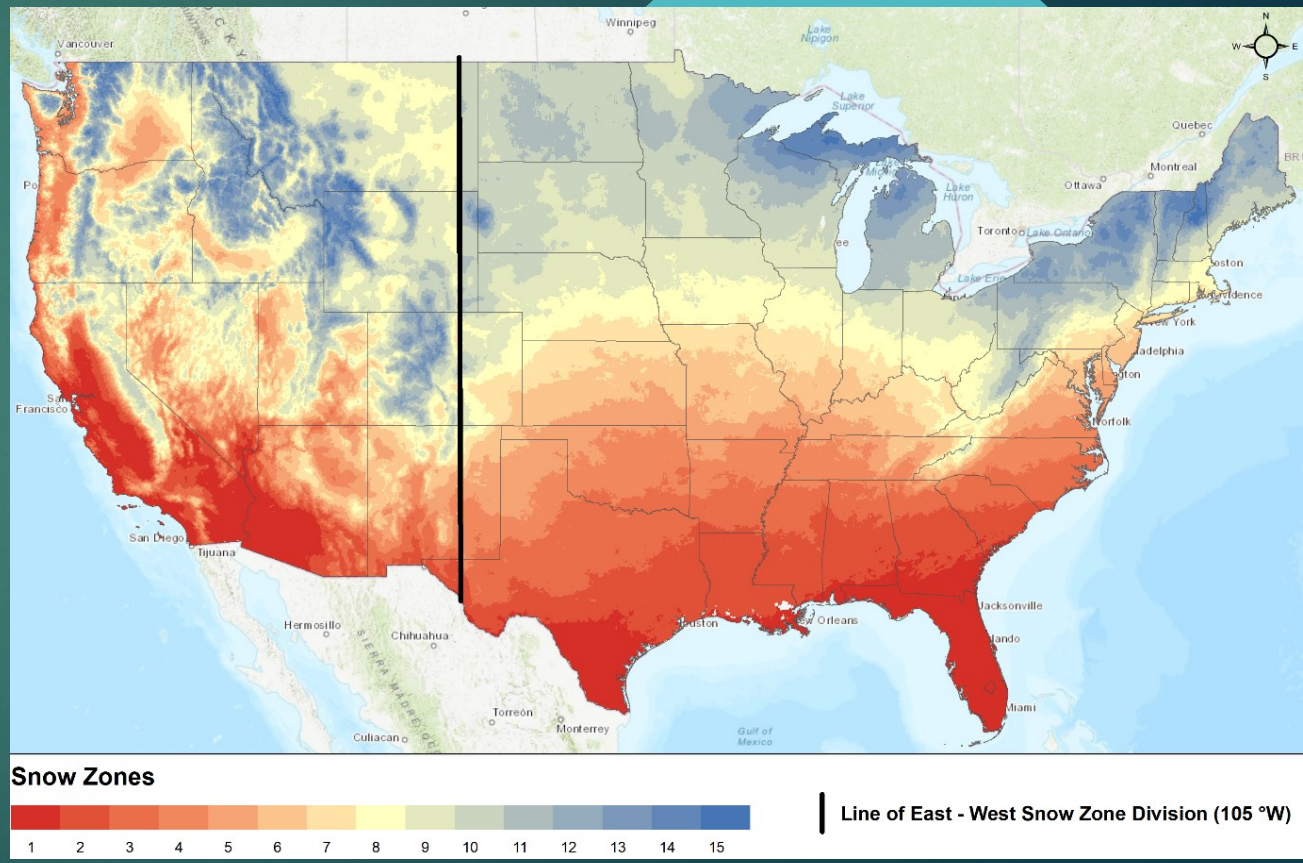
Deutan Color Vision Deficiency (insensitivity to green light)



THE NURTURE NATURE CENTER

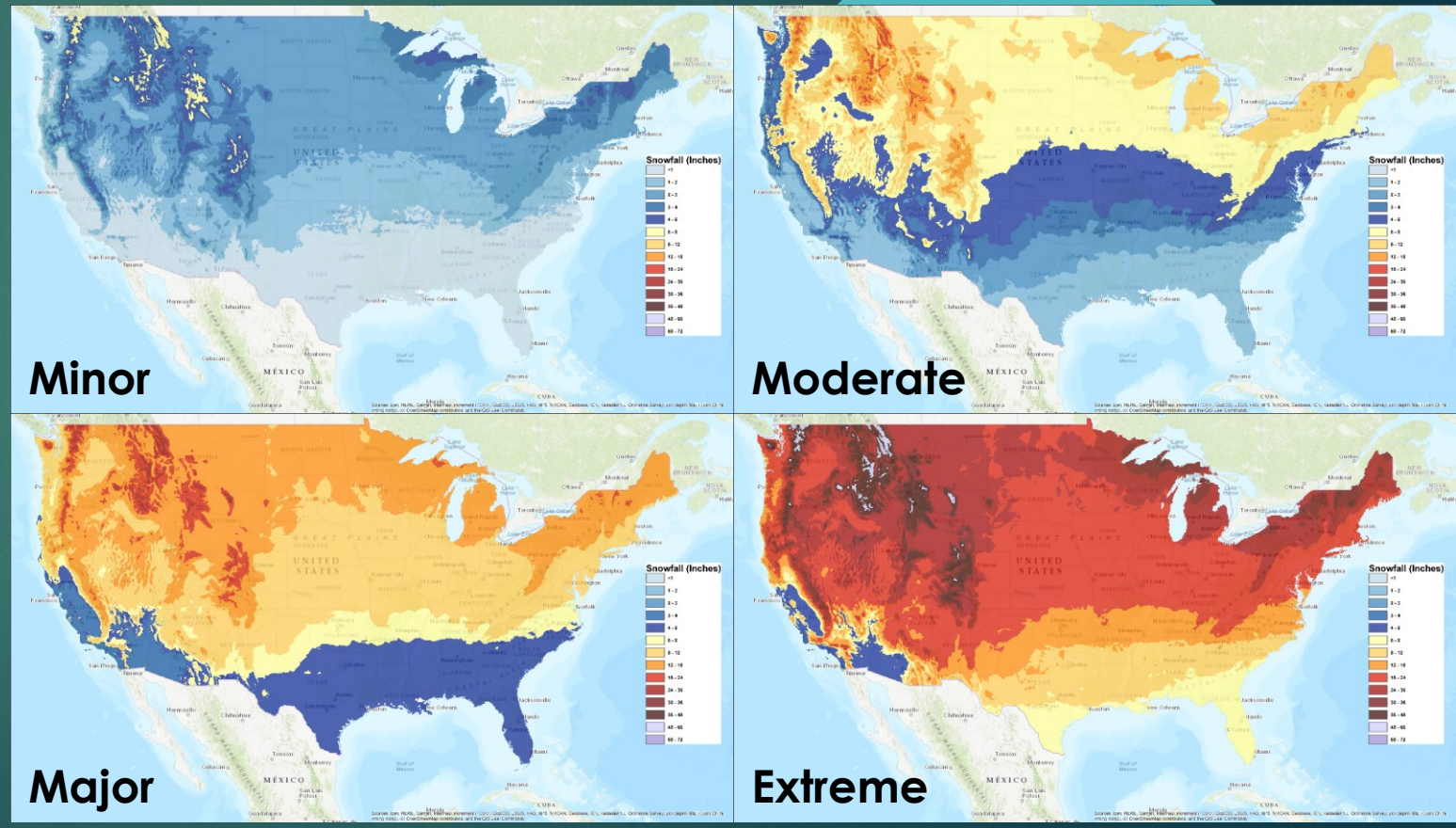
Improved WSSI Snow Amount Climatology

- Recently updated for the 2022-2023 winter season
- Used 2-day GHCN observed snowfall data
- Grouped stations by annual average 2-day snowfall frequency ("Snow Zones")



Improved WSSI Snow Amount Climatology

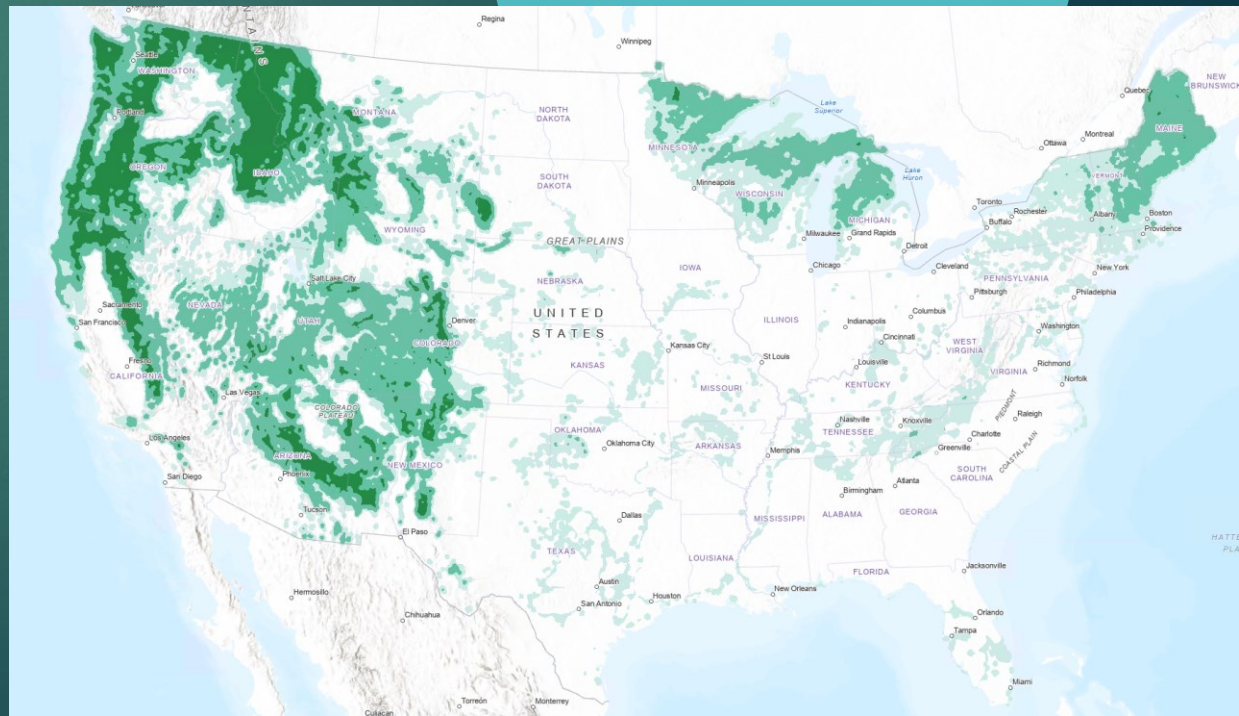
- Impact levels based on average statistics performed on stations within each snow zone
  - **Minor:** 0.75 x (mean – 1 σ of the annual *85th percentile* snowfall)
  - **Moderate:** mean – 0.25 σ of the annual *99th percentile* snowfall
  - **Major:** mean + 1 σ of the annual *99th percentile* snowfall
  - **Extreme:** 99th percentile + 1 σ of the annual *maximum* snowfall



Improved Snow Load Algorithms

- Improved handling of tree types
  - Coniferous forest density replaces tree type data
    - Higher coniferous tree density reduces snow load impacts
      - Coniferous trees can handle snow loading better!)
      - Up to a 60% reduction of snow loading
    - Removes the pock-marking effect on output

Coniferous forest density

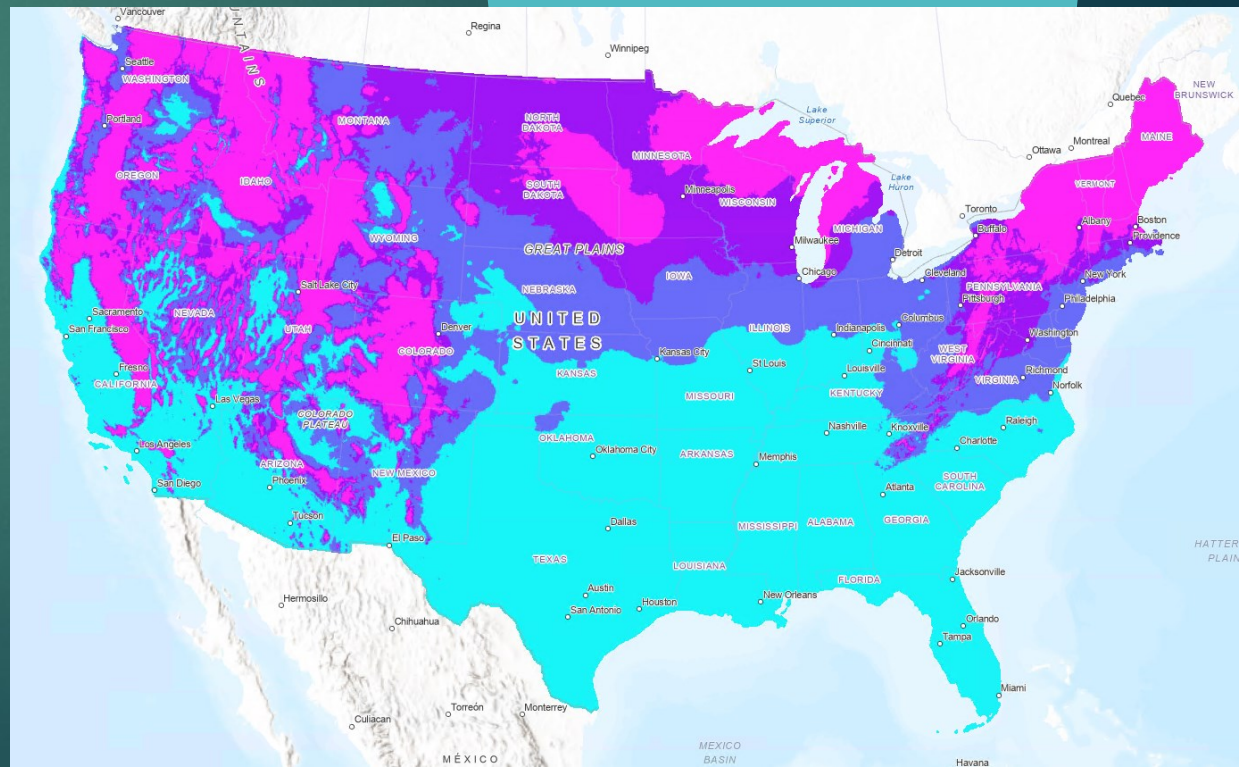


Darker green = Denser coniferous forest
(Soft pines removed)

Improved Snow Load Algorithms

- Obtained American Society of Civil Engineers (ASCE) data
  - 50-year mean recurrence interval (MRI) of snow load data
  - Use these to factor in exposure / resiliency to wet, heavy snow
    - Impacts adjusted accordingly (e.g., slightly lower impacts for higher snow load data)
      - Similar to adjusting snow amount thresholds based on climatology

Snow Load Adjustments



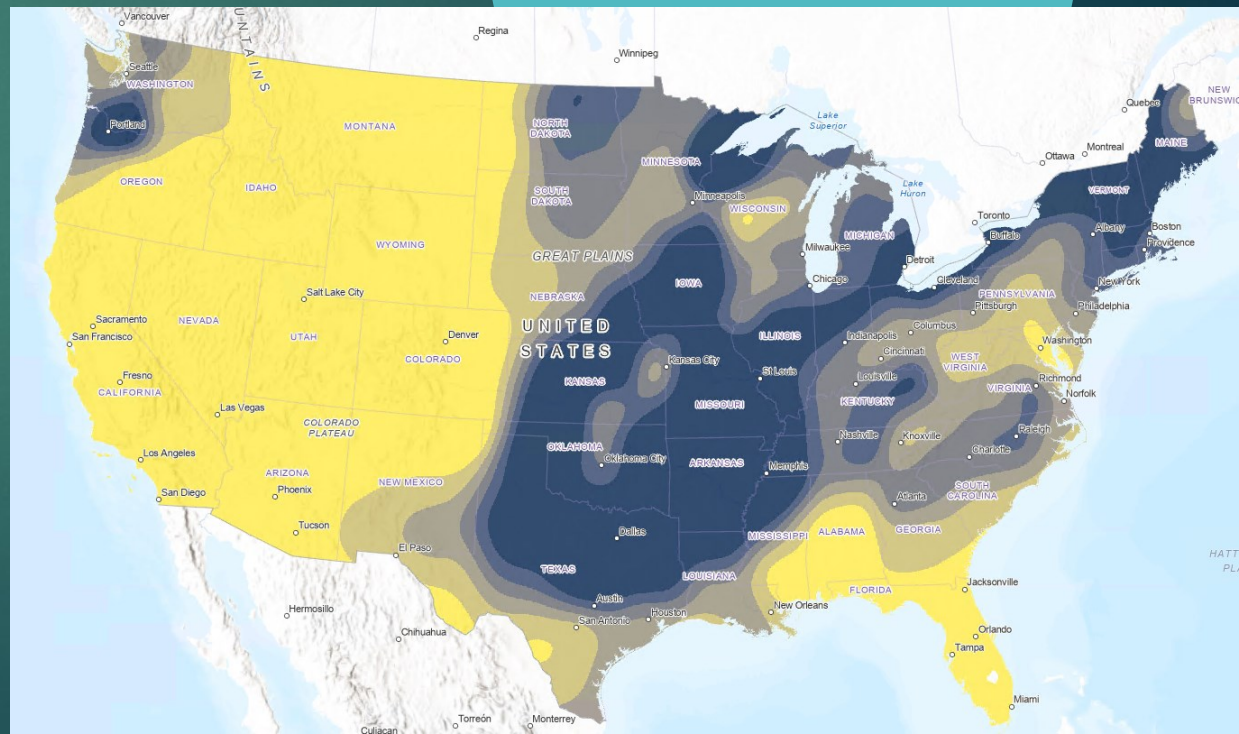
Pink = Higher exposure/resiliency (higher thresholds)
Cyan = Lower exposure/resiliency (lower thresholds)

Improved Ice Accumulation Algorithms

- 250-year MRI data for ice accumulation (from ASCE)
  - Use to factor in exposure / resiliency to ice
    - Higher impacts for areas with lower values
- Complete overhaul of the algorithms
  - Barjenbruch and Sanders ice + wind methodology
- Adjusted thresholds
  - Minor and Moderate to capture transportation impacts
  - Major and Extreme reserved for power line and tree limb impacts

Blue = Higher exposure/resiliency (higher thresholds)
Yellow = Lower exposure/resiliency (lower thresholds)

Snow Load Adjustments

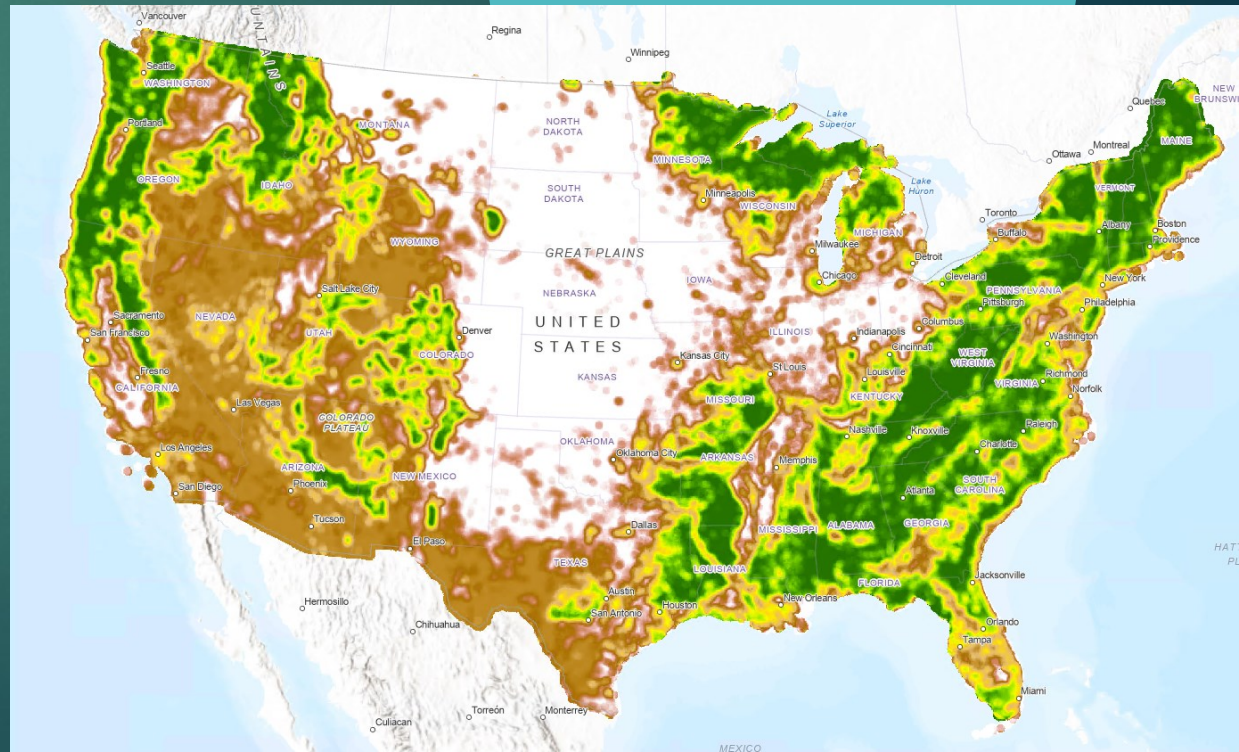


Improved Blowing Snow Algorithms

- Smoothed the land use data layer
  - Removes pock-marking effect on output
  - Maximum wind speed reductions decreased from 90% to 50%
    - Forested and urban areas were too "shielded" from impacts
- Complete overhaul of the algorithms
  - Estimate visibility in blowing snow
  - Impacts based on visibility estimates
    - Moderate impacts for ≤¼ mi visibility
    - Major and Extreme reserved for longer durations of low visibility (e.g., >12 and >24 h)
      - Again worked with the northern plains SOOs! Highlighted the need for including *duration*

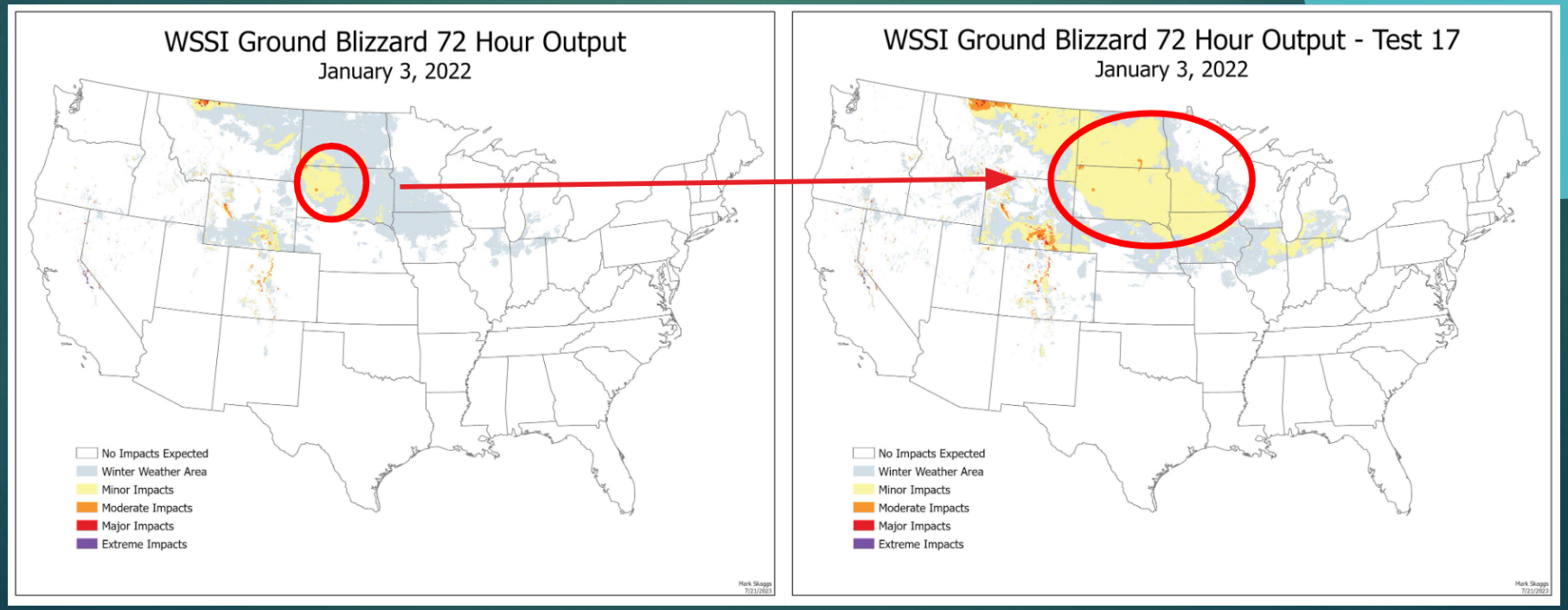
White = No Wind Speed Reduction
Dark Green = 50% Wind Speed Reduction

New Land Use Factor



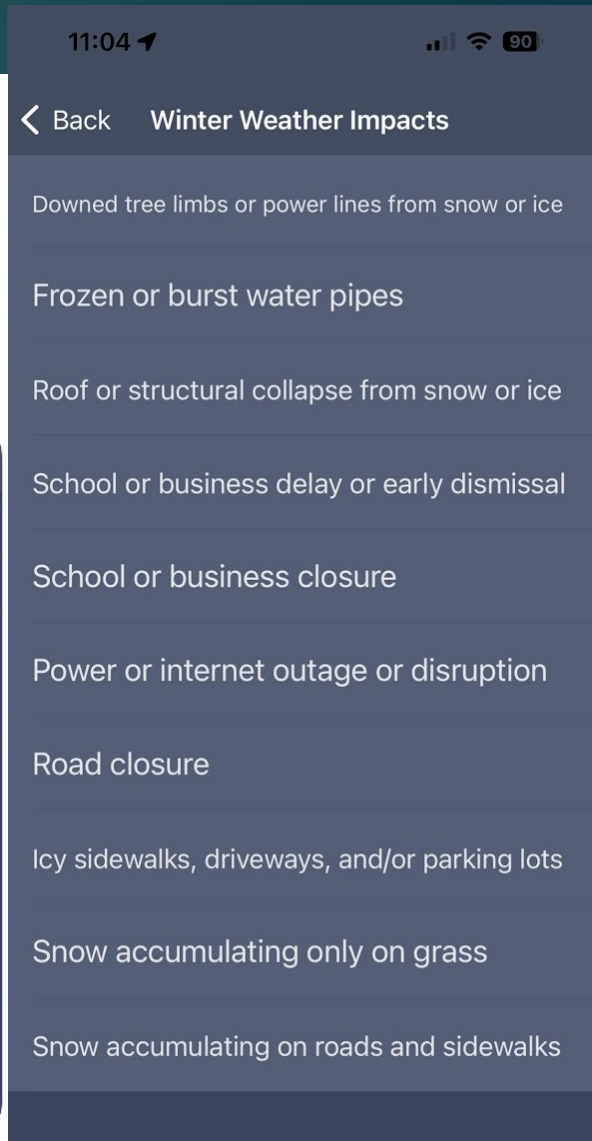
Improved Ground Blizzard Algorithms

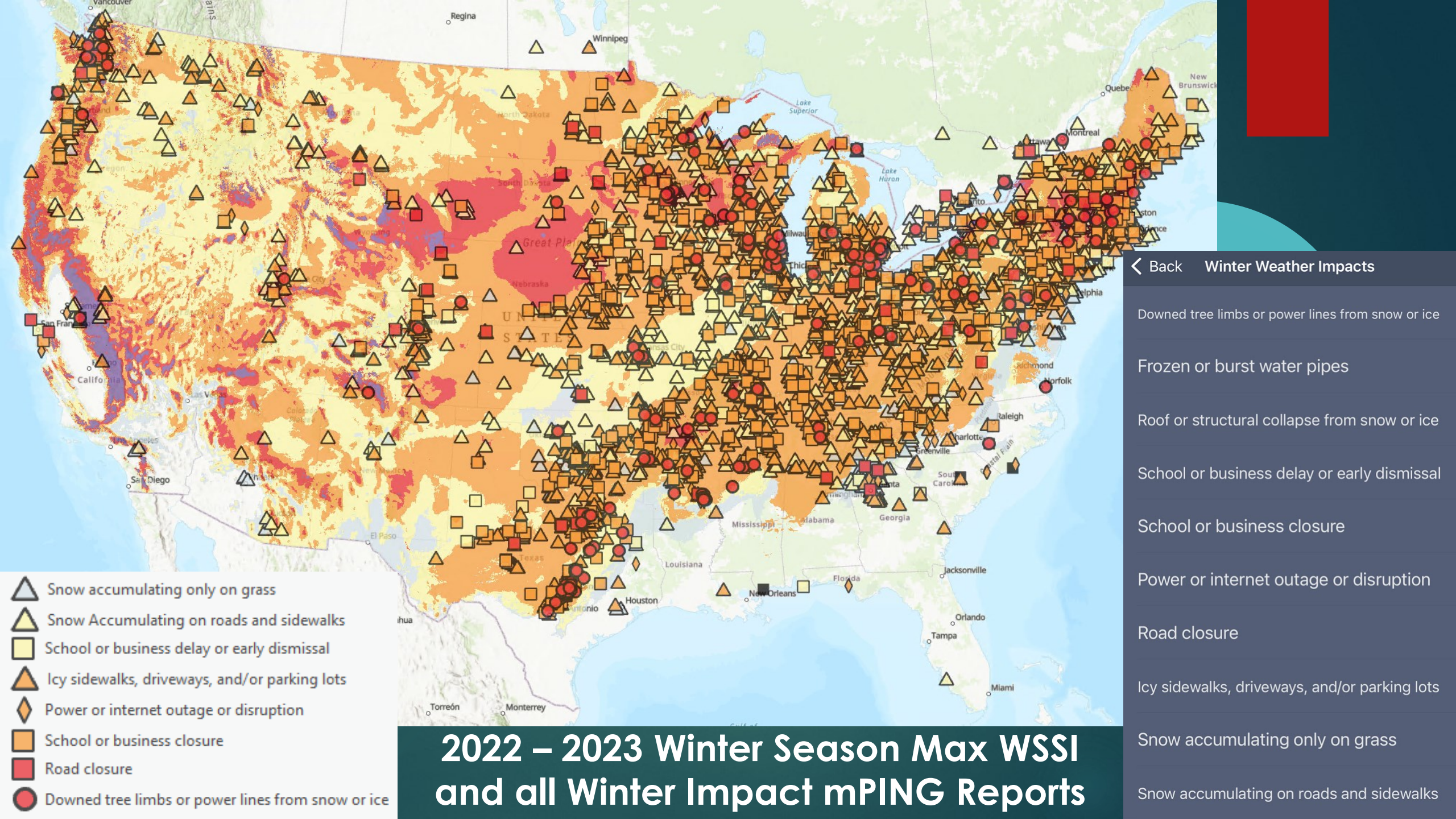
- Request from northern plains SOOs to improve the GB component
- Worked with the group and a summer intern to tweak the algorithms
- Improved Land Use Factor also included



Verifying WSSI with mPING

- Worked with the NSSL mPING development team to introduce a Winter Weather Impacts category of *tangible* impacts in Dec 2022
  - Damages
    - Downed tree limbs or power lines from snow or ice
    - Frozen or burst water pipes
    - Roof or structural collapse from snow or ice
  - Infrastructural Disruptions
    - School or business delay or early dismissal
    - School or business closure
    - Power or internet outage or disruption
    - Road closure
  - Surface Conditions
    - Icy sidewalks, driveways, and/or parking
    - Snow accumulating only on grass
    - Snow accumulating on roads and sidewalks




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
Snow accumulating only on grass
Snow Accumulating on roads and sidewalks
School or business delay or early dismissal
Icy sidewalks, driveways, and/or parking lots
Power or internet outage or disruption
School or business closure
Road closure
Downed tree limbs or power lines from snow or ice
2022 – 2023 Winter Season Max WSSI
and all Winter Impact mPING Reports

Prototype WSSI-H

- Formerly known as WSSI Travel
- Currently NWS internal on the WWD internal site
- Current components
  - Snow Rate
  - Liquid Rate (rain and/or freezing rain)
  - Snow Amount
  - Ice Accumulation
  - Blowing Snow

Non-Meteorological Factors

- Just like the algorithms for the other WSSI products, WSSI-H has non-meteorological factors that are used to adjust impacts
  - Impacts adjusted anywhere from a 10% reduction to a 25% increase
- Climatological factoring for snow amount
- Disruption Factors -- All components
  - Based on ambient weather and parameterized *untreated* road conditions
  - Account for how "disruptive" the driving conditions are to traffic flow
- Time-of-Day Factors – Precipitation rate components only
  - Address how time of day *typically* influences crash risk and severity

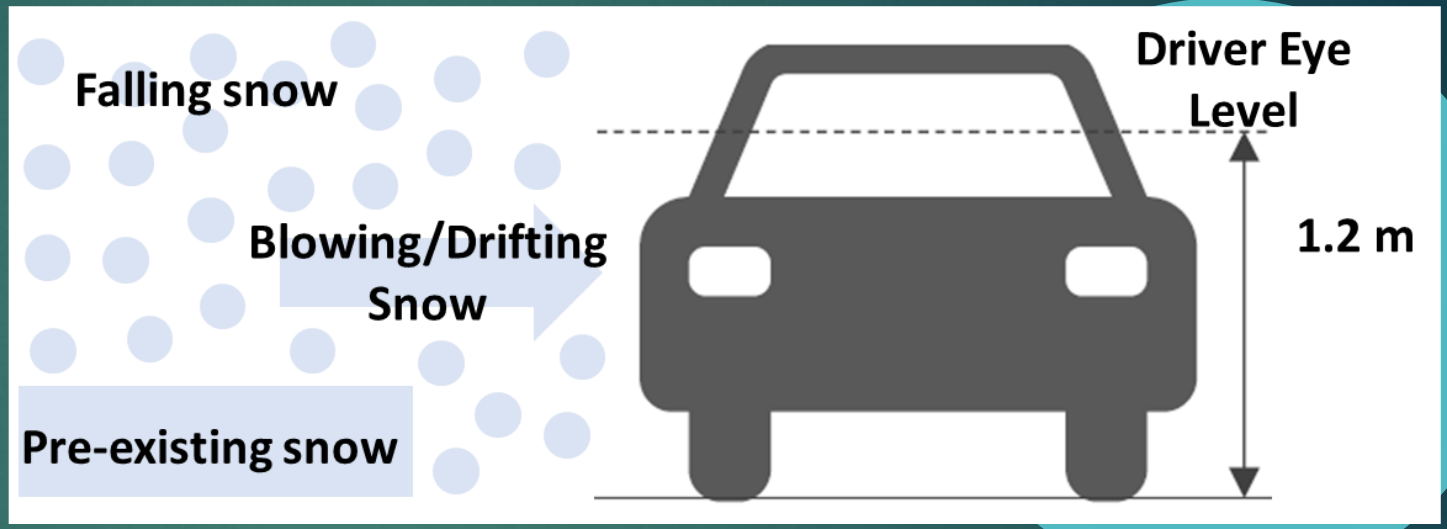
WSSI-H Snow Rate Impact Ranges*

	Low End	–	High End
3.0”/h:	Major	–	Extreme
2.0”/h:	Moderate	–	Major
1.0”/h:	Minor	–	Moderate
0.5”/h:	No Impacts	–	Minor

*Actual impact levels based on the non-meteorological factors (e.g., a lower impact for overnight hours)

WSSI-H Blowing Snow Component

- Algorithms estimate the visibility at driver eye level (~1.2 m)



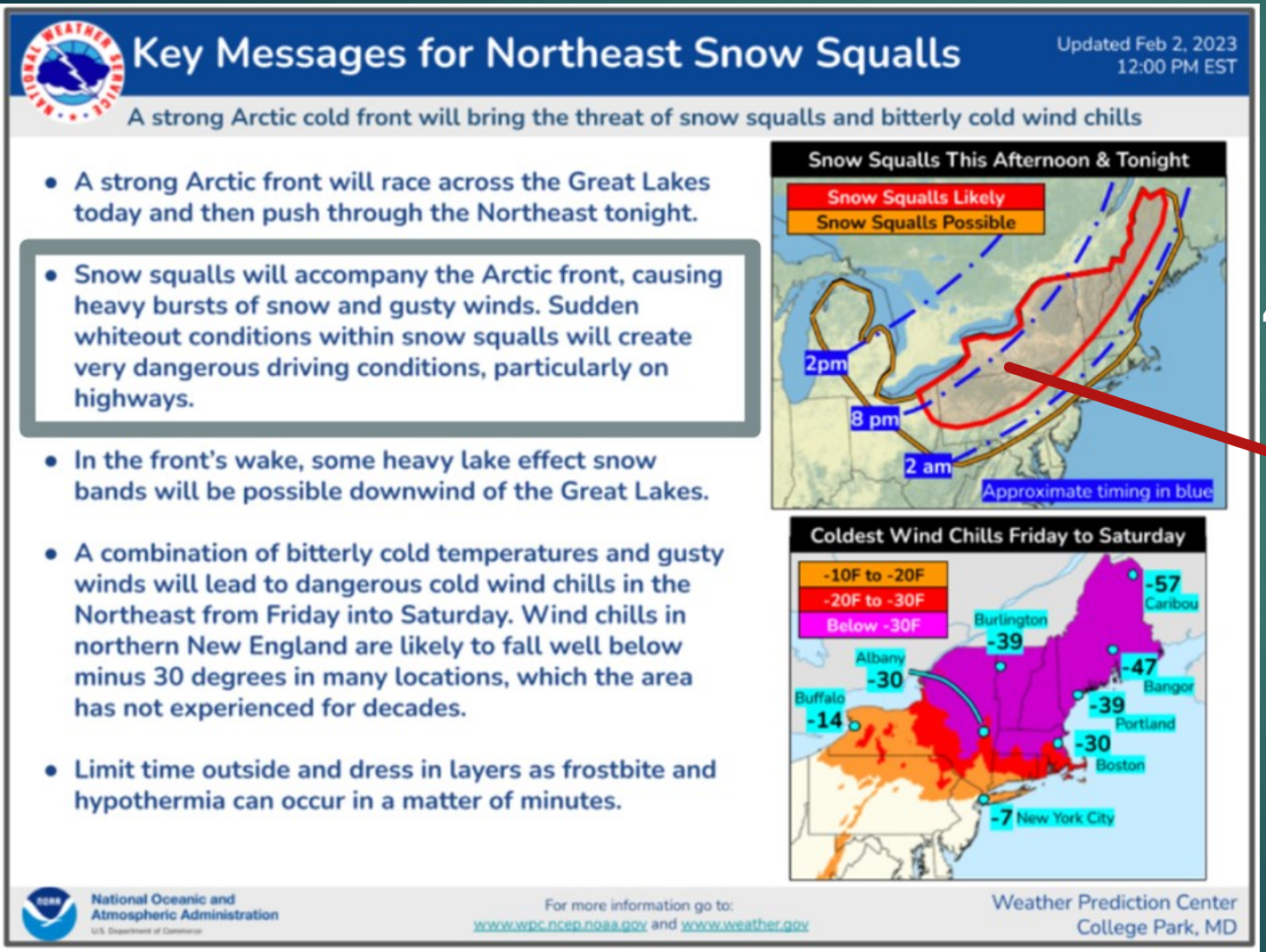
Approximate Visibility Thresholds:

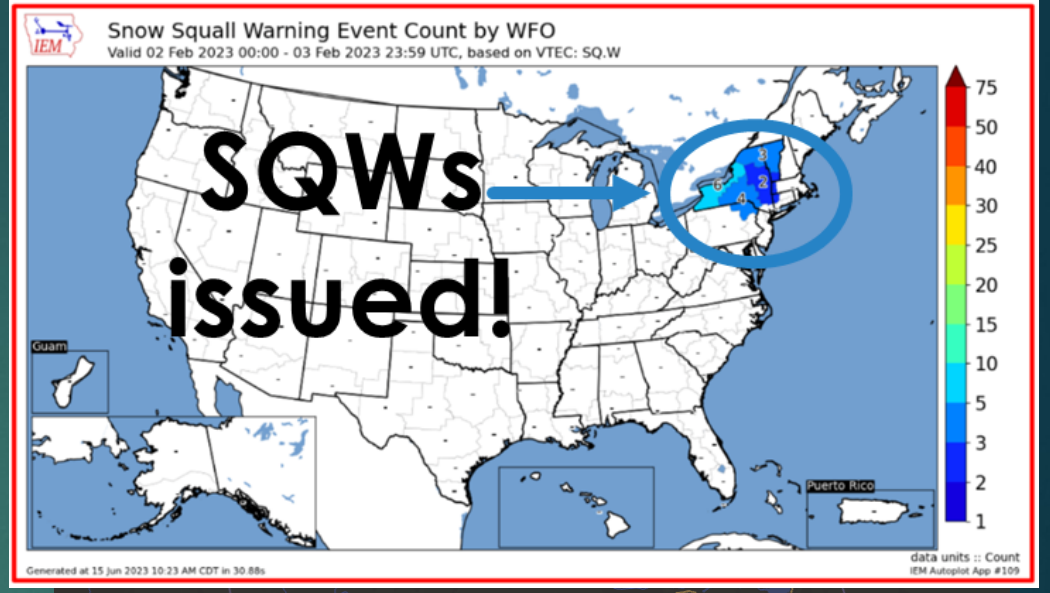
≤1/32 mi: Extreme
≤1/16 mi: Major
≤1/4 mi: Moderate ← Warning Criteria!
≤1/2 mi: Minor
<1 mi: Adverse Weather Area

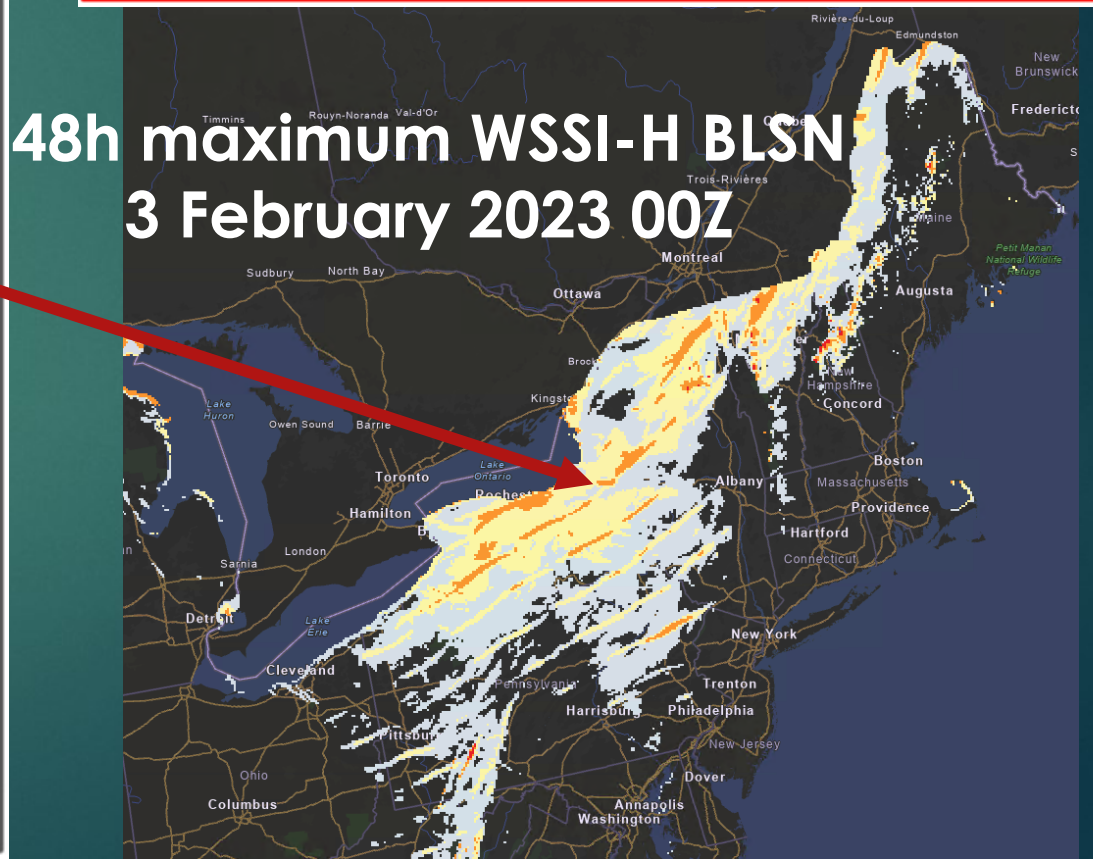
WSSI-H BLSN for Snow Squalls???

- Internal testing shows WSSI-H can help to highlight the threat of snow
  - Output could be used to help target potential snow squall areas and timing

- Streaky-ness due to hourly HRRR data
  - Picking up on fast-moving squall-like hazards
- WSSI-H BLSN highlights same area as KM





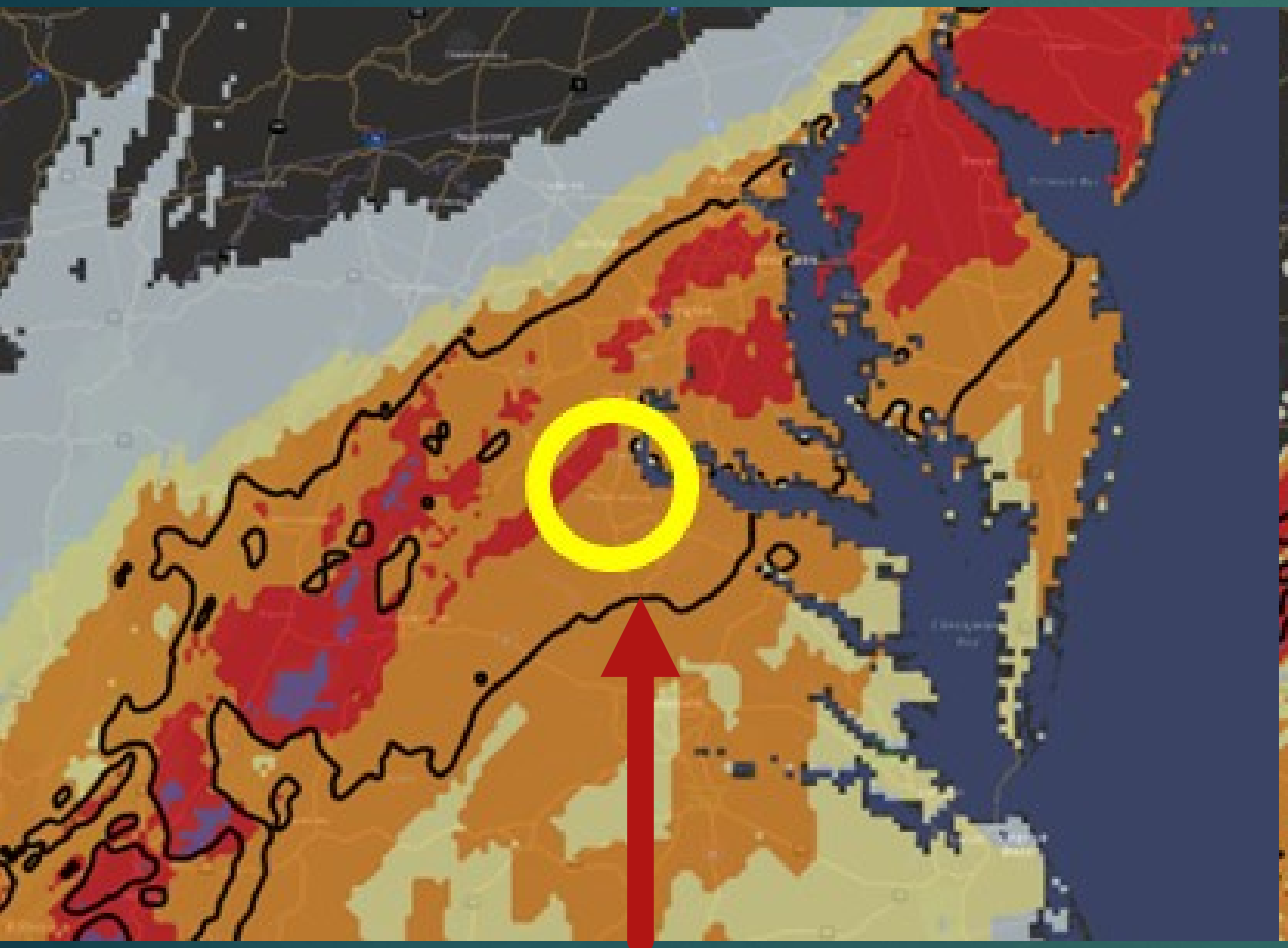


Added Capabilities from Hourly Output: Duration of Impacts

- Long-duration events can have prolonged or cascading impacts
  - Recovery efforts may not begin until after weather has subsided
  - Potential inability to "keep up" with ongoing hazards
    - e.g., plows inundated by accumulations, more calls than first responders can manage
- Extended periods of hazardous weather can become life-threatening
  - e.g., stranded motorists from closures

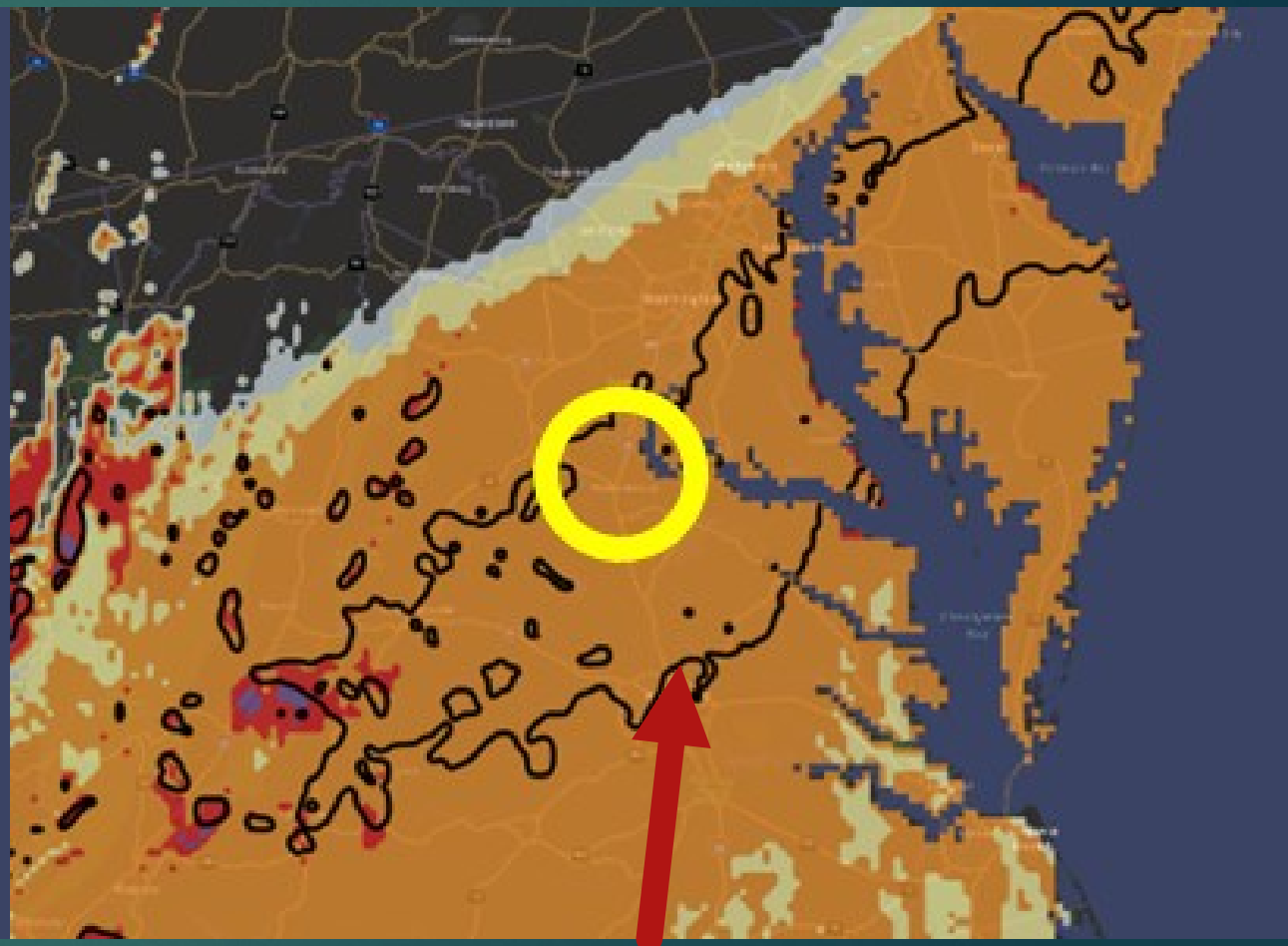
48h maximum WSSI-H Output – 3 January 2022 06Z

Snow Rate



4+ consecutive hours of Moderate Impacts

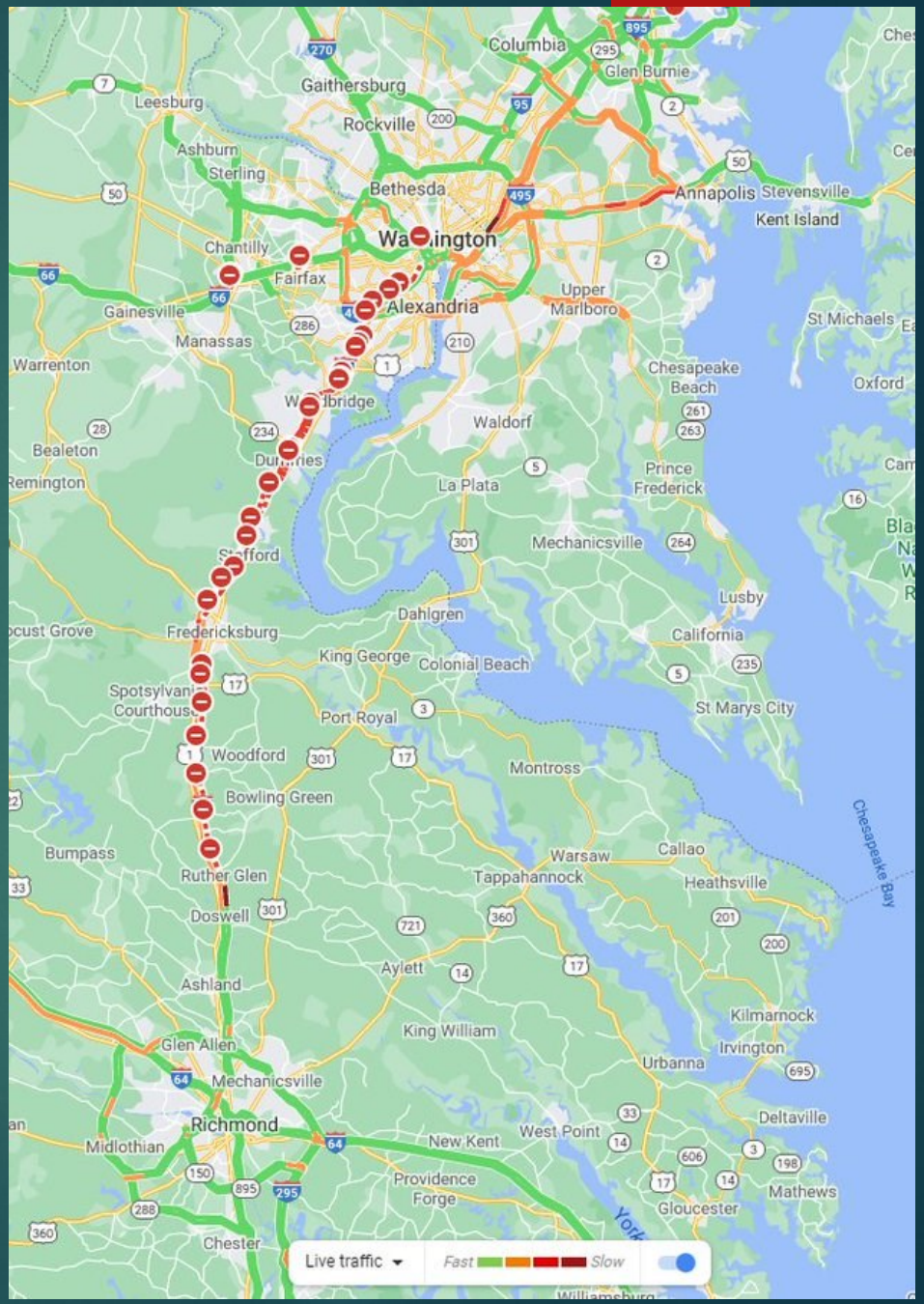
Blowing Snow



6+ consecutive hours of Moderate Impacts

In Virginia, hundreds of people were stranded in their cars with little food and water for hours when I-95 closed due to snow.

This image provided by the Virginia department of Transportation shows a closed section of Interstate 95 near Fredericksburg, Va. Monday Jan. 3, 2022. Virginia Department of Transportation via AP



The Future of WSSI

- WSSI for Alaska!
- Cold weather impacts
  - Stand-alone component or product
- Additional non-meteorological factors and improvements
  - e.g., first snowfall, population density, holiday travel
- Web-based improvements and additional capabilities
- Additional verification
- Hourly Probabilistic WSSI (WSSI-HP??)

Help us Improve WSSI!

- Forecasters
  - Let us know how WSSI is performing!
  - Work with us to figure out solutions/improvements
- Researchers
  - Help us bring great research into operations!
  - Have a great idea? Work with us to pursue future funding opportunities

- Connect with us!
  - Dana Tobin dana.tobin@noaa.gov
  - Kirstin Harnos kirstin.harnos@noaa.gov
  - Jim Nelson james.a.nelson@noaa.gov