Winter Storm Severity Index for Alaska

Written by Nurture Nature Center
(Dr. Kathryn Semmens, Rachel Hogan Carr, Keri Maxfield, Dr. Burrell Montz, Dr. Maggie Beetstra)
for the National Weather Service Weather Prediction Center

Potential Winter Storm Impacts

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The Winter Storm Severity Index (WSSI) is an operational CONUS product at the Weather Prediction Center (WPC) that was developed in response to user needs for easily consumable forecast information that identifies impacts and severity of an impending storm. The WSSI uses Geographic Information Systems (GIS) and gridded forecasts from the NWS National Digital Forecast Database (NDFD) to identify winter weather elements. It combines those data with non-meteorological or static information datasets (climatology, land-use, and urban areas, for instance) and results in a graphical depiction of impacts from winter weather. The WSSI is being developed to use other meteorological datasets as inputs, including numerical weather prediction output from models. This includes ensemble data from the WPC's Probabilistic Winter Precipitation Forecast, which is being used to create additional guidance products, with the ultimate goal of being able to forecast the probability of an impact. Additionally, work is underway to include additional non-meteorological factors including time of day.

The operational WSSI breaks down a storm into six components: Snow Amount, Ice Accumulation, Snow Load, Blowing Snow, Ground Blizzard, and Flash Freeze. Each component presents a different hazard, and in many cases, creates impacts specific to different users and partners. WSSI articulates these distinct impacts for audiences with a 72-hour forecast window and scales the resulting forecast severity into 6 levels: extreme, major, moderate, minor, and winter weather area. This scaling is designed to help users to quickly look at the product and identify anticipated/possible levels of social impacts. WSSI graphics are available publicly through WPC (https://www.wpc.ncep.noaa.gov/wwd/wssi/wssi.php).

Interest in extending the WSSI to Alaska spurred a social science research study investigating the distinct needs of Alaskan stakeholders and the unique nature of Alaskan climate that may warrant the creation of different and additional components. Specifically, the goal of "the Winter Storm Severity Index for Alaska" project was to support the expansion of the operational CONUS WSSI into the Alaska Region as a user-informed and tested product that will meet the distinct climate considerations of the various regions in the state.

The objectives were to:

- Ensure the product components align with the needs of Alaska Region stakeholders, including additional non-meteorological factors
- Ensure that the product's definitions and categorization of impacts align with stakeholder expectations surrounding these severity levels (extreme, major, moderate, minor, and none) by testing and calibrating the severity levels, including the extreme level, within the WSSI
- Provide recommendations that can be easily operationalized to address needs of professional stakeholder groups
- Develop lessons learned from adapting a national product to region-specific needs for other NWS products

Working towards achieving these goals, the Nurture Nature Center (NNC) and CIRES met with Alaska Weather Forecast Office (WFO) representatives from Fairbanks, Juneau, and Anchorage, along with other project partners to develop focus group scenarios specific to each of six regions: West Coast, Southwest/Bristol Bay, Southcentral/ Anchorage, North Slope, Juneau, and Fairbanks. Scenarios were developed around severe weather events, and WFO-contributed briefings and other NWS products to build out the timelines of storm progression. NNC and CIRES created mocked-up versions of WSSI for Alaska (which does not currently exist outside the CONUS) for inclusion in the scenarios (Figure 1). The research team held six virtual focus groups in June 2022, recruiting stakeholders from each region with contacts provided by the WFO partners. Stakeholders included representatives from emergency management, transportation, aviation, schools, and more. Focus group participants completed pre- and post-session surveys and participated in a two-hour discussion facilitated by Dr. Montz, answering questions related to preparedness, actions, understanding, needs, and challenges around the forecasted weather and presented products. The Alaska WSSI product and legend detail were a focus of discussion as well. The intent was to understand the needs for weather forecasting products and what impacts matter the most to each of the regions. The focus groups were recorded, transcribed, and analyzed for content themes using NVivo software.

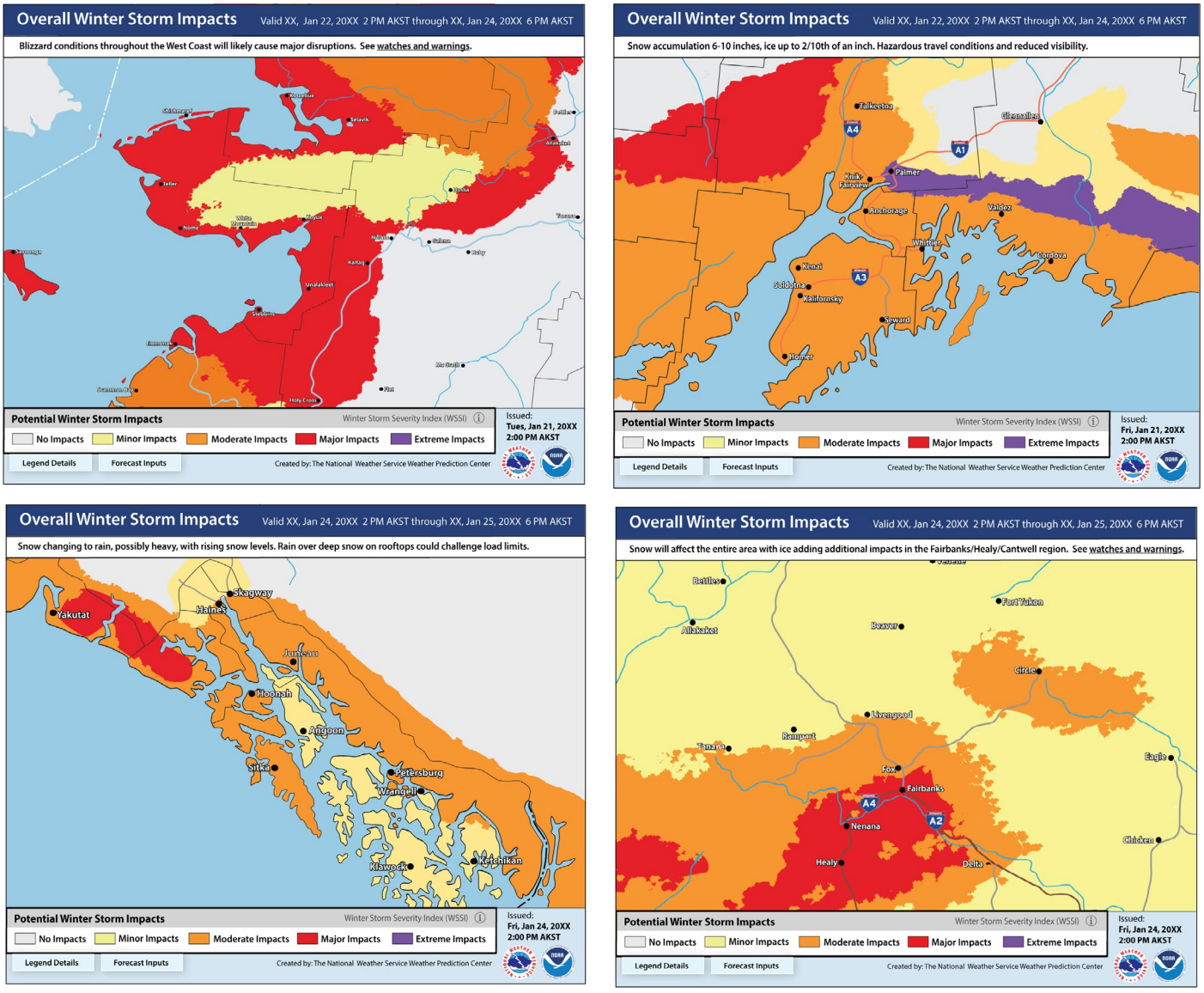
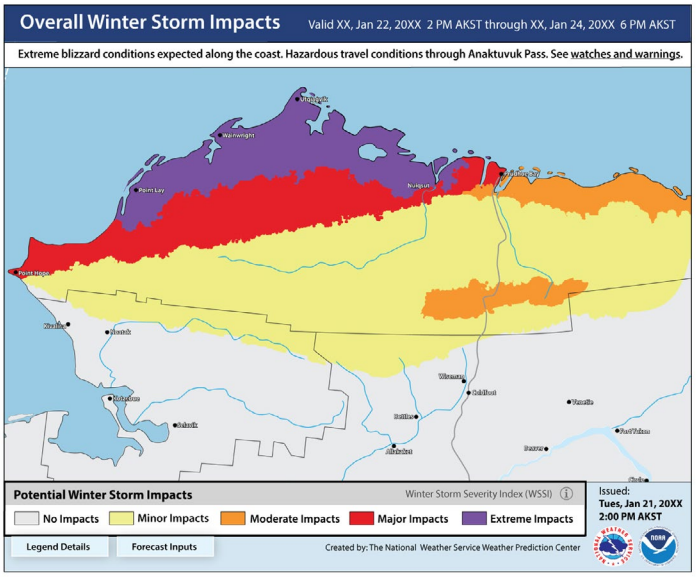
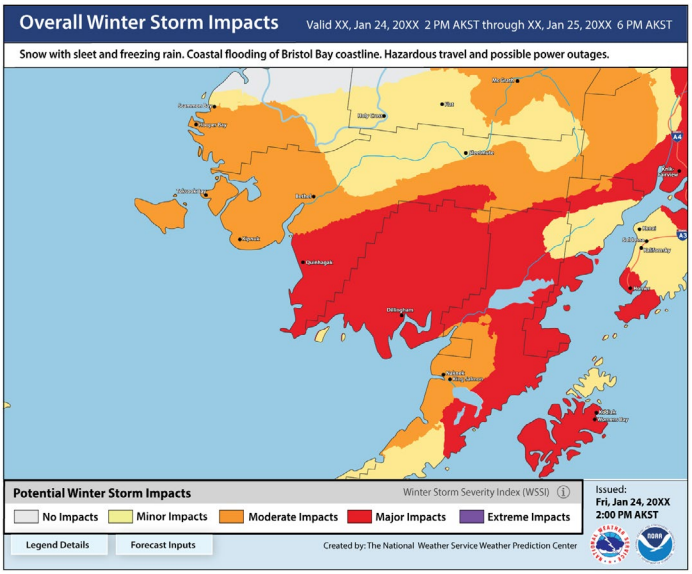


Figure 1. Examples of the mocked-up WSSI Alaska product shown in each of the six virtual focus groups West Coast (top left), Southcentral/Anchorage (top right), Juneau (bottom left), Fairbanks (bottom right); facing page North Slope (left) and Southwest/ Bristol Bay (right).





This report summarizes the findings from those focus groups and surveys, as well as feedback collected at the 2022 Alaska Federation of Natives Convention held in Anchorage in October 2022 where project staff had a booth at the exhibit hall and talked with visitors about their winter weather impacts and forecast product needs. It also details a follow-up online survey (August 2023) that tested the prototype developed by WPC and the subsequent Arctic Testbed (November 2023) that further tested those prototypes in a series of three case studies. This final report summarizes the recommendations for WPC to consider as it refines the WSSI for Alaska.

Nurture Nature Center (NNC) and CIRES met with Alaska Weather Forecast Office (WFO) representatives from Fairbanks, Juneau, and Anchorage, along with other project partners to develop focus group scenarios specific to each of six regions: West Coast, Southwest/Bristol Bay, Southcentral/Anchorage, North Slope, Juneau, and Fairbanks. Scenarios were developed around severe weather events and WFO-contributed briefings and other NWS products to build out the timelines of storm progression. ... The intent was to understand the needs for weather forecasting products and what impacts matter the most to each of the regions.

Focus Group Analysis

Surveys

Six virtual focus groups were held in June 2022. There was a total of 27 participants across all focus groups with 30% from Juneau, 17% from Fairbanks, 17% from Anchorage and the rest from rural communities (Figure 2). Those in the rural communities (North Slope, West Coast, and Bristol Bay) are grouped together due to smaller numbers. The range of demographics and positions represented is detailed in Table 1. Stakeholders ranged from operations to management with the highest number (22%) of participants in the emergency management field and 19% of participants in the risk management field.

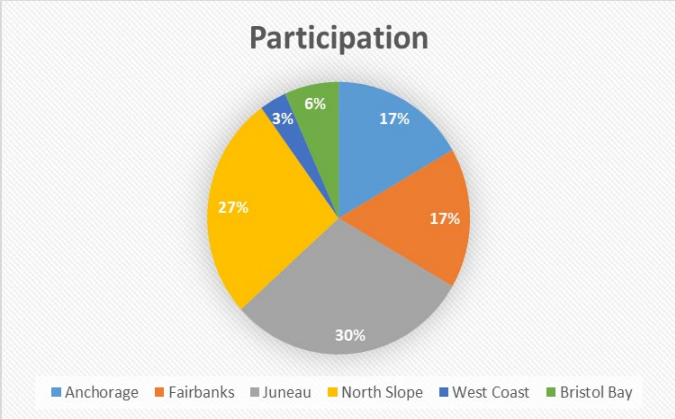


Figure 2. Overall distribution of participants by region.

Table 1. Demographic characteristics and position type for participants across all focus groups.

	Total	5	4	9	6	1	2	9	27
Age		Anchorage	Fairbanks	Juneau	North Slope	West Coast	Bristol Bay	Rural	All
	20-29	0%	0%	22%	17%	0%	0%	11%	11%
	30-39	20%	0%	44%	33%	0%	100%	44%	33%
	40-49	20%	50%	11%	33%	0%	0%	22%	22%
	50-59	20%	25%	11%	17%	0%	0%	11%	15%
	60-69	40%	25%	11%	0%	100%	0%	11%	19%
	70+	0%	0%	0%	0%	0%	0%	0%	0%
Gender									
	Male	60%	75%	56%	83%	100%	0%	67%	63%
	Female	40%	25%	44%	0%	0%	100%	22%	33%
	Prefer not to say	0%	0%	0%	17%	0%	0%	11%	4%
Education									
	HS	0%	50%	11%	83%	0%	50%	67%	33%
	Associates	40%	0%	11%	17%	100%	0%	22%	19%
	Bachelors	40%	25%	44%	0%	0%	0%	0%	26%
	Post graduate	20%	25%	33%	0%	0%	50%	11%	22%
Professional position									
	Fire/Police Chief	40%	0%	0%	0%	0%	0%	0%	7%
	Emergency Manager	20%	25%	22%	0%	100%	50%	22%	22%
	Red Cross	20%	0%	11%	0%	0%	0%	0%	7%
	Tribal	0%	25%	0%	0%	0%	50%	11%	7%
	Risk Manager	0%	0%	0%	83%	0%	0%	56%	19%
	Env. Compliance	0%	0%	11%	17%	0%	0%	11%	7%
	Avalanche	0%	0%	22%	0%	0%	0%	0%	7%
	State Oil Spill	0%	0%	11%	0%	0%	0%	0%	4%
	Geoscience Coor.	0%	0%	11%	0%	0%	0%	0%	4%
	Operations	20%	50%	11%	0%	0%	0%	0%	15%
How long have you been in your current position?									
	1 year or less	0%	25%	11%	67%	0%	50%	56%	26%
	2-4 years	60%	0%	44%	17%	100%	50%	33%	37%
	5-7 years	0%	25%	11%	17%	0%	0%	11%	11%
	8 or more years	40%	50%	33%	0%	0%	0%	0%	26%

Participants completed pre- and post-session surveys. Participants were asked how they use and access NWS information and many reported using NWS (accessed through website, email or calling NWS) for planning and response, especially for needs related to staffing and resource preparation. Winter weather impacts that participants noted included school closures, road closures (often by winds creating flooding), blizzard conditions, power outages (windstorms), rain on snow, and avalanches/landslides.

Importantly, many participants (especially in rural communities) reported they are always prepared and ready for winter weather as a way of life (generators, food supplies, heating), and some noted that the lack of winter (i.e., melting of permafrost) caused more challenges than typical winter conditions. Others readied for winter weather by preparing cars and homes, increasing staffing/resources, and notifying others about impeding weather. Accuracy of forecasts and lack of resources (big state, low population) create barriers to using and acting on winter storm forecast information.

Survey participants' specific reactions to the products shown during each focus group scenario are presented in Figure 3 – participants rated how useful each product was to their decision-making. Each focus group had a different range of products shown, produced specifically for their scenario. These products ranged from winter storm warnings to winds, snow and special weather statements, but each of the focus group scenarios included examples of the WSSI (comparison across sites is shown in Figure 4).

Figure 3. Percentage of participants rating usefulness of the products shown in each focus group scenario (Anchorage N=5; Fairbanks N=4; Juneau N=8; North Slope N=6; Bristol Bay N=2; West Coast N=1).

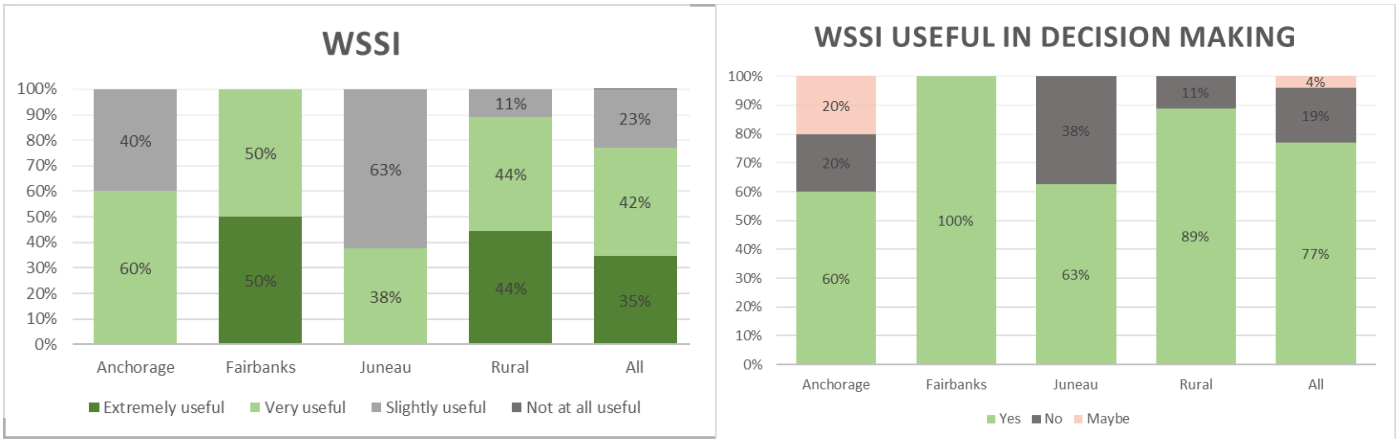


Figure 4. Usefulness ratings of the WSSI across all areas (left); WSSI's usefulness in decision making (right)

WSSI was seen as extremely and very useful by the majority of participants for all but Juneau (where 63% felt the WSSI was slightly useful). Overall, 35% of participants felt WSSI was extremely useful and 42% felt it was very useful. Further, most participants felt that WSSI was useful in decision-making, with 77% responding yes (Figure 4, right). Elaborating on its usefulness in decision-making, participants stated it would make it "easier to access more information in one location" and is a "good tool to use to help me determine the possibility of adverse weather impacts." Others said they would use it for preparedness and situational awareness and would share it with the public, stating it would be useful in telling the winter weather story to officials. Additionally, they said it would be used to determine staffing levels, educate others and relay hazards, and to anticipate and plan for outdoor-related work, hunting or travel. Importantly, participants saw value in WSSI for helping them to ask appropriate questions about preparedness and for providing "great information to build up for a response and to communicate risk."

Participants also rated the usefulness of specific product elements (Figure 5) with the six WSSI components, interactivity, map overlays and forecaster's note having the highest percentage of participants reporting a rating of extremely and very useful.

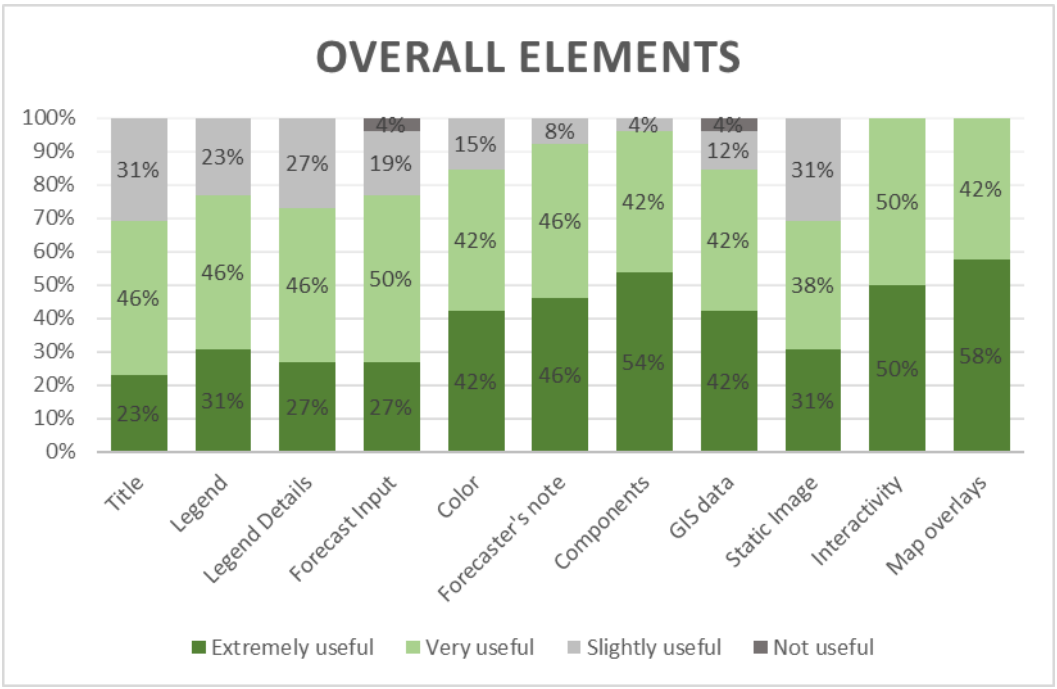


Figure 5. Percentage of participants rating the different elements of the WSSI product from extremely useful to not useful.

When asked what was missing from the impact product, participants reported wind speed and direction (48% of all participants) and precipitation amount (33%) as the top requests. A range of other impacts and winter-related phenomena was also reported, with some being specific to a particular region (see Figure 6 for which location listed each missing component).

... most participants in each location reported they were very likely to share what they learned with others, to seek NWS information about severe winter weather risks, to use the WSSI in decision-making when available, and to recommend the WSSI to others.

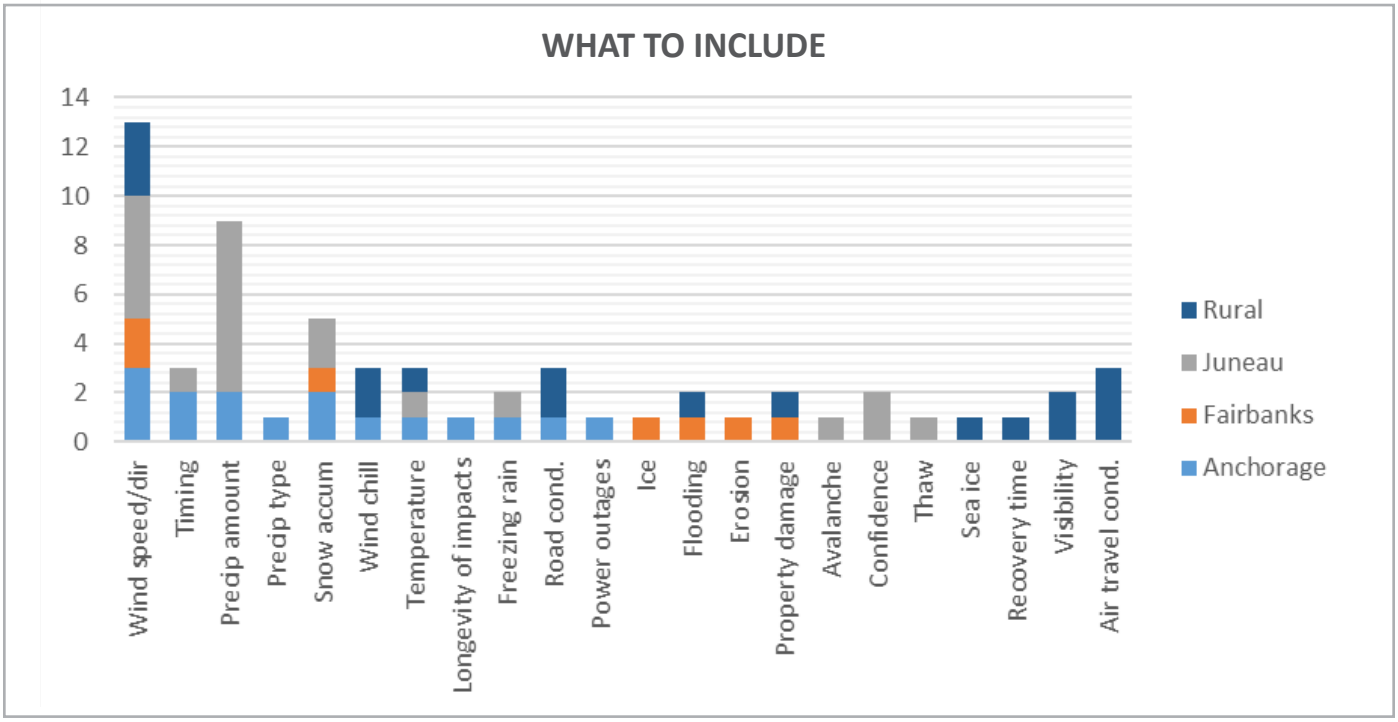


Figure 6. Missing components that should be included in the Alaska WSSI by location and number of participants.

Most participants did not find anything confusing or unclear in the mocked up WSSI product, but some desired to see quantities related to snow, rain, and wind as part of the product and others suggested more detailed descriptions of impacts. A specific question about suggested changes to the legend reiterated the desire for more details on impacts for each category, including what aspects of daily life are most likely to be disrupted and the specific locations to be affected. Further, participants requested specifics on what triggers a moderate vs. major impact and what parameters defined the moderate category. Other suggestions included: having total amounts of snow/rain/ice (again requesting quantities); aligning with the Department Of Transportation public road condition reporting system; and including visibility and wind gusts for the area.

Most participants preferred a combination of static and interactive products and a combination of graphics and text in products for understanding their winter weather risk. In the post-session survey, most participants in each location reported they were very likely to share what they learned with others, to seek NWS information about severe winter weather risks, to use the WSSI in decision-making when available, and to recommend the WSSI to others.

Participants also suggested it would be useful to have access to archived information, and information on storm trajectories and the frequency of storms, so that compounding storm impacts could be considered in decisions they have to make. Participants noted that Alaska suffers from a lack of data points (for example, it needs more weather stations) and that flights are crucial to the ability to transport everything and everyone, thus requiring wind and visibility data.

Focus Group Discussion

Focus group discussions were recorded, transcribed, and analyzed using NVivo software for several thematic terms. The more frequently discussed topics largely reflected the findings from the surveys. Overall, information about storm transitions (such as the change in precipitation type and storm trajectories), interactivity, and wind forecasts (strength, direction, and effect on visibility) were prominent topics.

Participants emphasized that the **storm transition** between precipitation type was a critical time for impacts and understanding the timing was important to preparedness: "One of the things we experienced a lot this last winter, especially towards the end of last calendar year, was a lot of freeze-thaw and then precipitation on top of the freeze. And so, I guess, yeah, transitional type information like that would be helpful, especially for transportation and driving conditions" (Anchorage participant).

Also important were the direction and duration of the storm; as such **storm trajectory** information helped with planning resources and staff effectively. The path of the storm also gave insights into the type of storm and what kinds of impacts to expect, as explained by a West Coast participant, "So just knowing the kind of where, what direction the storms are coming from can give us a better idea of how much snow might involve versus how much wind is going to be involved. Because the northern storms have had a lot of wind...where the southern storms tend to have more moisture, so we get more snow."

Many participants highlighted the usefulness of **interactivity**, seeking ways to customize the product, layer components or elevation, search by zip code, and easily flip between maps/data: "If there's any way to be able for the user to be able to customize it for what it is that they want to see, that would be fantastic" (Juneau participant). This desire to customize may reflect the differing needs of the various stakeholders and regions in Alaska, though it is important to note that most of the comments requesting interactivity were from urban areas, while static product options are necessary in the more rural areas where there is less access to technology and therefore limited ability to make use of the interactivity.

Wind was by far the most talked about as a winter weather impact and as a missing component that is needed in the Alaska WSSI. Information on both wind strength and direction was seen as necessary for understanding impacts which ranged from flooding, tides, power outages, to transportation disruptions and visibility concerns (blowing snow/ground blizzards). For instance, on the West Coast "knowing how fast the wind is projected or predicted to be ... gives us an indication of potential structural and power line damage" and "knowing the direction of the wind is a huge factor in how the snowfall is going to affect" them. It is important to note that high winds in areas of Alaska have a higher threshold than many other areas – for instance 70 mph winds in Juneau are not exceptional. In addition to speed and direction, wind chill has an important impact due to many people traveling by snow machines.

Precipitation was another component raised as missing and important for the Alaska WSSI. One Juneau participant reflected that "precipitation would be valuable because... I think if I could toggle between snow amount and precip amount, those two are going to give me a snapshot of like how heavy, how light, like what's the snow density?" A participant from Fairbanks noted that "the snowfall amount and then the rainfall amount is usually what we ask for when we call [the Weather Forecast Office] direct. And then the timing of transition times is when we're really looking for when is the snow going to turn to rain or vice versa."

In addition to wind and precipitation, **flooding (through precipitation), erosion (through wind and water)**, tides, snow depth, and temperature were brought up as helpful components for the Alaska WSSI, while snow load and flash freeze were seen as less helpful in the region. In Bristol Bay, a participant reflected, "I don't know how helpful snow load and flash freeze would be in our area. We're more concerned about **visibility and wind gusts and extreme temperatures that could happen**." In Juneau, flooding was identified as a missing but necessary element, with one participant noting "I don't really see in these index categories anything on flooding. And I feel like that would be maybe a good way to capture that daily precip concept, because a lot of times that's like one of the major impacts that we get when there's already snow on the ground, and it rains a lot. We'll have local flooding. So, yeah, that just

seems to be one of the major winter storm factors that's not really represented in this yet." In Juneau, the proximity to sea level made the tidal chart and wind information very valuable.

Expected temperatures were noted in Fairbanks as helpful for determining if the precipitation would be snow or rain. For transportation officials, **ice is considered the most difficult** element to deal with and the progression of temperatures during a storm event is crucial for understanding how to manage impacts: "The ice is huge for us, and the large snow amounts add to the difficulty and then the winds just top it off. The one thing I would like to see is with something this close to an event is a three-day lookout after the event stopped. So, we're going to see how long we've got to clean this up before it's going to be totally, we're going to get shut down by cold or it's going to be totally stuck to the road for the rest of the winter" (Fairbanks participant).

Participants also provided feedback on the proposed legend details, pointing out that the meanings of **moderate and "disruption to daily life" are vague** and not helpful. One Anchorage participant questioned, "Disruption to daily life, what does that mean? You know, do you stay home or is it just you slow down, or you know, what?" and in Juneau a participant commented "For the moderate one, it just seems kind of vague. Expect hazards, travel conditions, possible closures and disruption of daily life. So. And moderate, that would be vague, you know." Property damage and roof collapses mentioned in the legend and forecasts rarely happen according to participants, but blowing trash and debris from wind create real damage on a more routine basis, and participants suggested including those impacts, as well as wind impacts (especially related to sea wave height) in the impact forecast details.

Across the focus group locations, **communication approaches** varied, ranging from radio to print and fax (especially in rural areas) to social media and email. Many participants saw value in having the WSSI with its different components as a way to have more information in one place. In Anchorage, one person commented, "What's nice is it's all at your fingertips. All the information, no matter where you want to go. You can go there from one page instead of having to dig out what you need to know." Participants also echoed this value of having access to relevant information easily in their comments about the **forecaster's note** (the white bar at the top of the mocked up WSSI graphic that provides a place for a succinct summary of impacts and links to watches or warnings or other relevant information). In Anchorage the forecaster's note was thought as "useful to be able to give people access to go find more information for themselves" and in Fairbanks it was noted that "Any way of getting more information is better." Special Weather Statements and Winter Storm Warnings were additional information products that were highly valued. One Bristol Bay participant noted that for the Special Weather Statements, "I think people take these a little bit more seriously than they do the precipitation map, and things like that tend to be off. So, these statements are a little more helpful."

Across the focus group locations, **communication approaches** *varied, ranging from radio to print and fax (especially in rural areas) to social media and email. Many participants saw value in having the WSSI with its different components as a way to have more information in one place.*

Further to this idea of having more information, several participants wanted information about **past storms**, how impacts were characterized, and to be able to see how storm impacts were changing over time. Understanding if storms are increasing in severity helps with planning staff, resources, and budgets, as one Fairbanks participant commented, "If we're seeing an increase in weather events or types, that historical information is really important in that." A post-event summary was also requested, in order to understand how the storm rated and to see how the index performed (ground-truthing in order to provide confidence).

Overall focus group summary

Alaskans for the most part are accustomed to winter, and the state covers a diversity of weather and community conditions. That said, winter weather impact information for situational awareness is valued. Wind, precipitation, ice, and erosion are important considerations in winter storm impacts for all regions, while coastal areas are further concerned about tides and sea ice. Transportation is a prominent issue with frequent air travel requiring favorable visibility and wind conditions.

Based on this analysis, several recommendations are suggested for moving forward with developing the WSSI for Alaska.

- Wind and precipitation are key components to include in WSSI.
- Consider adding wind (strength and direction) or combining ground blizzard and blowing snow.
- Consider adding precipitation (rain).
- Consider adding temperature.
- Consider removing snow load and flash freeze.
- Have the map broken down by regions and/or census areas and consider having the ability to search by zip code.
- Address impacts related to flooding, erosion, flight, visibility, landslides/avalanches - Air travel is a critical concern for many, and wind and visibility impacts should be included.
- Consider adding a forecaster's note – the forecaster's note was highly valued and provided critical highlights and connection to other relevant information.
- Consider a way to show progression/direction of storms and highlight transition periods.
- Explore presenting components in conjunction with or allowing for layering to make primary impact obvious (for example, showing components side by side, etc.).
- Develop legend descriptions that reflect the unique Alaskan winter conditions and experiences including clarifying the specific impact details from the weather events.

Alaska Federation of Natives Convention

Project staff attended the AFN Convention from October 20-22, 2022 and had a booth in the exhibit hall to introduce the project to the convention attendees/public and gain insight into winter weather information needs and issues. This information gathering was not an official part of the study protocol and is considered as an informational supplement only. This is a summary of discussions with convention attendees and other exhibitors, as well as NWS WFO and RFC staff that attended.

Alaskans are well acquainted with dealing with typical winter weather. Snow is mainly heavy/wet in the Southcentral areas (Valdez/Cordova). The north and west are tundra/dry desert-like with high winds and ground blizzards. It is when the weather conditions deviate from normal or expected that creates significant impact, for instance, having a melt/refreeze event in mid-winter (shoulder season conditions in winter/mid-season thaws) that leads to icing conditions or river ice break up in January. A rain event in December in Fairbanks led to ice that stayed until April. AFN attendees reiterated that changes were of concern with many bringing up effects of climate change and how winter is warmer than in the past leading to ice, rain, flooding, and thaw that affect transportation.

Many towns and villages are connected by one road or require air travel. Fluctuating temperatures around freezing and visibility are the biggest impacts for travel between these communities. Snow on ice is slick until it packs down (old, cold ice is better than new, wet ice and fresh, compacted snow is drivable but fresh snow on ice is not). Wind was also highlighted for travel concerns, erosion, and sea ice impacts (wind can push house sized blocks of sea ice up on shore!) but wind is not an issue until 90 mph, as 70 mph is usual.

Dirt roads are sensitive to water, and freeze/thaw creates ruts; dirt roads are good when they freeze but have issues when they thaw and get wet. Alaska University Transportation Center is looking at microclimates and wants 24–72-hour future road conditions. The DOT currently gives once-a-day real time conditions, but this is obsolete because the public needs future information – if they are going from Fairbanks to Anchorage they want to know if they will make it without problems.

For those working in aviation, visibility and wind speed and direction are important. They use ForeFlight and automated weather cameras and check weather a half hour prior to flight due to weather changing so quickly.

Snow load was not considered to be much of an issue except for Valdez and Cordova (the National Guard had to be brought in to shovel roofs after a storm dumped 3-4 ft), as most heavy snow producers come up from the south. For the northern part of the state, ground blizzards are frequent, and visibility is a major concern. Blizzards can last for days and are hard to predict because it is difficult to know the amount of transportable snow (though DOT partners help the WFO by measuring snow amount).

The Housing Authority stated that knowing how to find information about severe weather was needed and suggested having a dashboard for monitoring that would have past weather so that landlords could verify weather if there was a trip fall claim from an ice hazard. They also suggested having the ability to get an email alert at specific thresholds (for instance if the impact would be major) and noted that TV and radio were the best ways to reach the population. There is a significant homeless population in some of the urban areas (especially Anchorage) which is impacted by extreme cold temperatures and wind chill.

Overall, the biggest impacts noted include ground blizzards, thaw, rain, ice, and visibility. The Inuit Circumpolar Council (ICC) stressed that climate change was the biggest impact, especially as melting/rain creates ice which is hard on equipment and hunting and makes transportation impossible.

Follow-up Online Survey of WPC WSSI Alaska Prototype

The focus group analysis was shared with WPC which worked to develop a WSSI Alaska prototype in spring 2023 for three case studies: snow amount and load, ice accumulation, and freezing spray. An example of the prototype is shown in Figure 7. The legend focused on inconvenience to daily life and transportation.

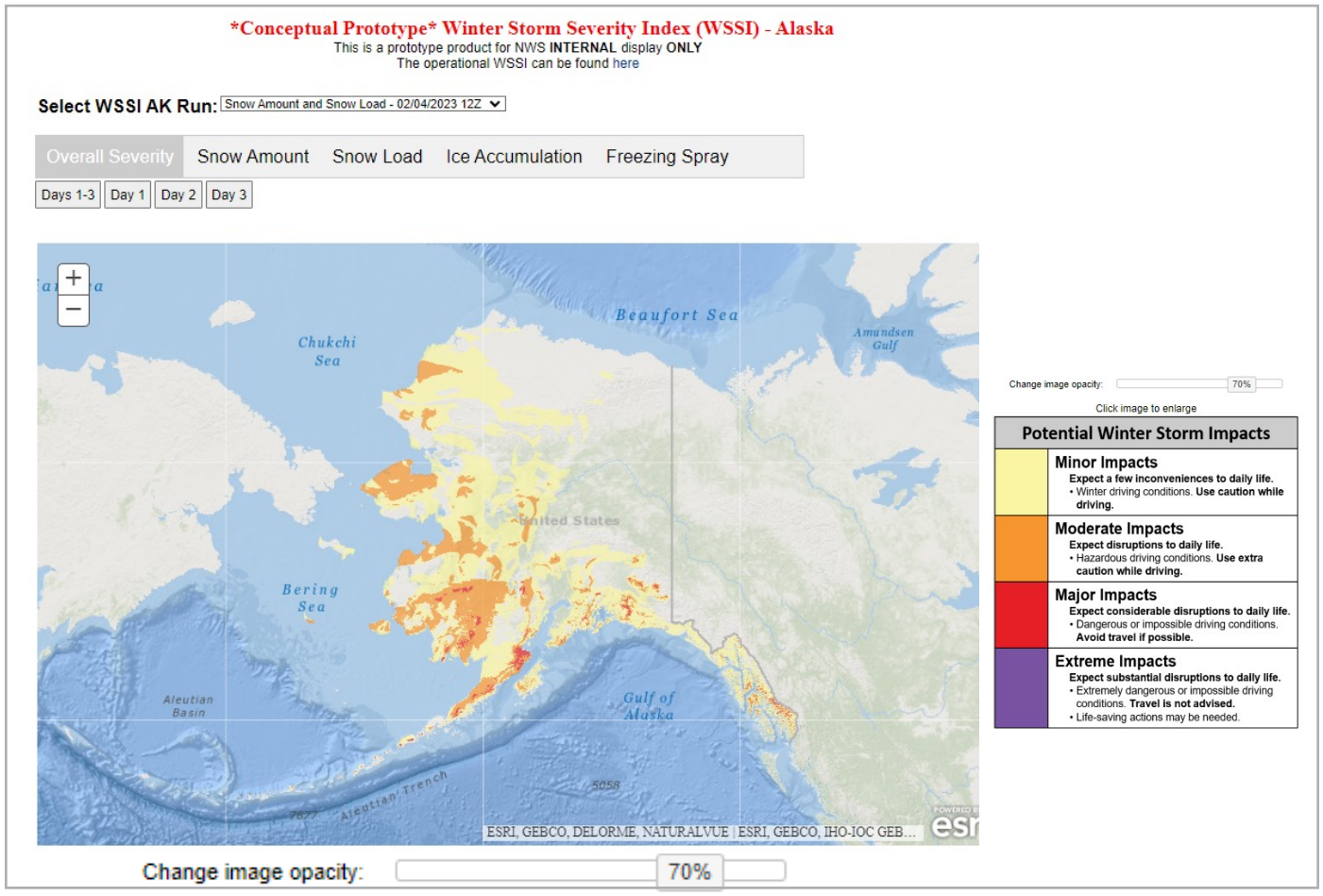


Figure 7. An example of the WPC developed WSSI Alaska prototype created after analysis of focus group findings.

To test this new prototype, the NNC research team sent out an online survey that showed the image for the three case studies and asked questions related to how helpful the products and legend descriptions were, how the information would be used and if there was anything missing or that should be changed. Survey completion requests were sent in August 2023 to 30 previous focus group participants, along with 94 new participants from contact lists provided by Alaska WFO partners. These included professionals such as emergency managers, risk managers, transportation workers, and others. There were 37 responses: 28 (76%) new participants and 9 (24%) previous focus group participants (Figure 8).

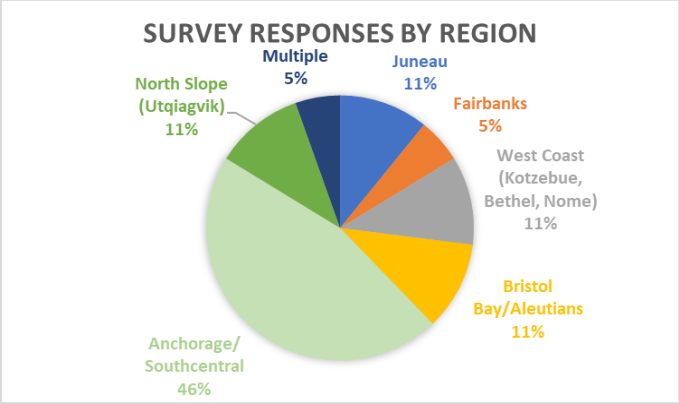


Figure 8. Percentage of respondents for the follow-up online survey by region.

Overall, the WSSI was seen as useful for providing a heads-up/situational awareness about an impending weather event, but lacked certain details necessary for informing some decisions, as illustrated in this response: "The general warning a storm is coming is helpful but deploying assets / altering schedules based on a prediction isn't something I would do." Further, many responses highlighted the need to include wind speed and direction (a finding from the focus groups that was not implemented in the prototype yet). Flooding was also noted as an important impact to include, along with timing information, and many wanted more specifics about the legend definitions with some asking for examples to inform their understanding. Further to this was the need for clarity on what is included/not included in the product and what thresholds are used. Specifically, as shown in Figure 9, the snow amount component and Day 1 time scale were seen as the most helpful WSSI elements shown. Freezing spray was the least helpful, and several felt snow load was not as helpful.

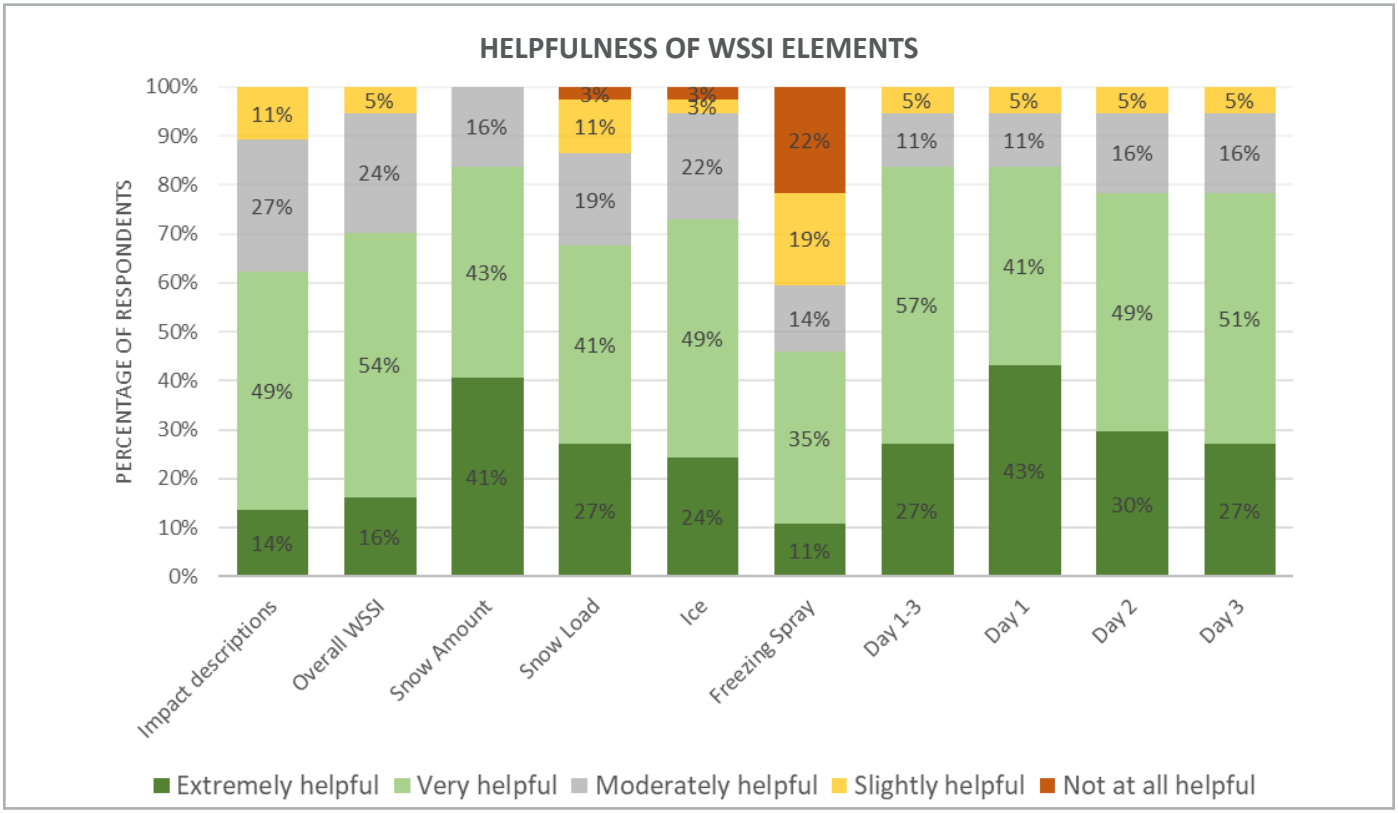


Figure 9. Percentage of respondents in the online follow-up survey testing the WPC WSSI Alaska prototypes reporting level of helpfulness for various WSSI elements, including the components, impact descriptions, and time scales.

In explaining their responses to the helpfulness question, about 41% of respondents noted the graphical, easy to understand format of the WSSI: "I found the maps easy and intuitive to read" and "this is very good information with visual display, it will be helpful when tracking the direction of the weather." One response clarified that it would be "good for regional impacts but not more localized impacts." A couple of respondents expressed the need to ground-truth and use the product before being able to determine the degree of usefulness. Several responses (11%) suggested the need for more details about the categories and descriptions, and a couple wanted more geographically localized information and details. The need for more details is seen in responses such as "Not sure we'd agree on what would categorize major vs extreme" and "The term 'disruption to daily life' is pretty subjective – at ANC airport 8" snow barely gets attention while in SCC closes everything."

A majority of respondents (84%) would use the WSSI Alaska product if available while the remaining were not sure (Figure 10). Three-quarters of respondents reported they would share the WSSI information within their organization if available and more than half would use it for their own knowledge and decision-making (Figure 11). While only a small percentage reported an intent to share with the public, it is important to note that the 'intent to share with the public' responses was not a given option in the survey, so the public related responses were written in as an 'other' response. Thus, intent to share with the public may have been higher if it was an included option choice.

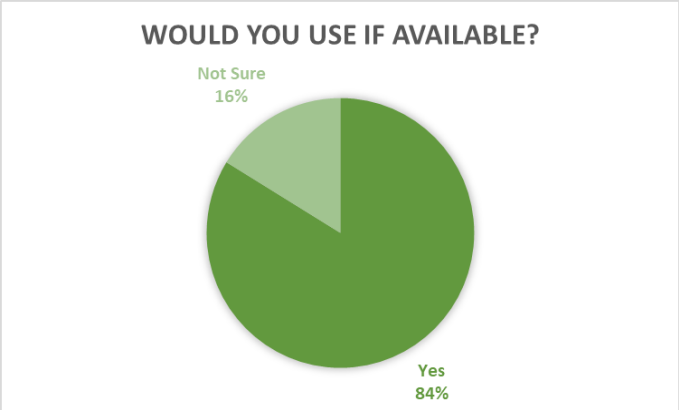


Figure 10. Percentage of respondents that would use the WSSI Alaska product if available.

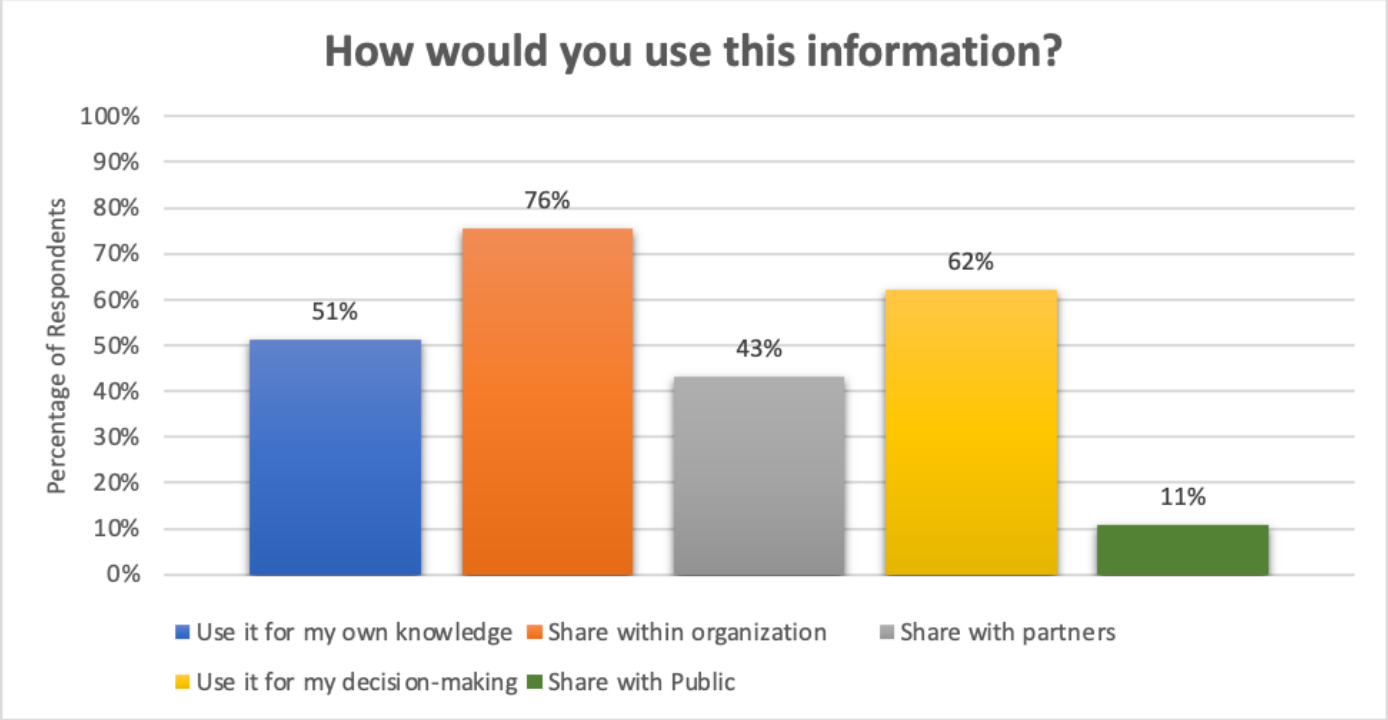


Figure 11. Percentage of respondents in the follow-up online survey that reported the different ways they would use the WSSI Alaska information.

The intent to use the WSSI Alaska product if available was expounded upon as being related to decision-making and informing partners and the public. Situational awareness and disseminating information were also mentioned For example, it would be used "to gauge the severity of incoming storms when planning the level of public safety and public works response" and "as a guide to support community alerts."

When asked if there was anything confusing about the WSSI Alaska prototype product, 78% responded no. Others suggested the need for borders of land and sea, the need for zoom ability, and more differentiated colors. One response requested more details related to transportation impacts: "Capabilities of different types of vehicles is not addressed, is this for the average car? Truck? Snowmachine? Boat?"

When asked what changes to the product would be helpful, 78% responded none. Other responses again referred to the need for more zoom ability and for more details – examples of what each impact category means (i.e. specify what is a 'large load'). Flooding was requested as an addition as well.

Further, when asked what components/information were missing and should be included, several suggestions were presented which echoed previous focus group findings:

- Wind – wind speed and information related to blowing snow/blizzard type conditions
- Flooding – "Flooding is the primary winter disaster in southeast and probably many other parts of Alaska."
- Certainty/confidence levels - "How certain are these predictions? How much confidence is there, especially for the 'day 3' statement?"
- More details/data - "Perhaps ability to drill down or link to other weather products with more quantitative data like wind speed and snowfall amounts"
- Timing information - hourly component of when the storm is forecasted to start and finish.

Other helpful impact information mentioned including information on road closures and slippery/icy road conditions, snowmelt and precipitation for landslide risk, spring break-up information, projected wave heights and storm surge (in Kachemak Bay and Cook Inlet), and more accurate weather predictions.

In summary, the follow-up online survey findings support the utility of the WSSI Alaska product along with the need for additional components (wind, flooding) and more details (especially related to categories/definitions).

Arctic Testbed 2023

The WPC-developed WSSI Alaska prototype for the three case studies was also tested within a testbed environment with NWS forecasters. The testbed evaluation occurred during the 2023 Arctic Testbed and Proving Ground held November 7-8th at the Alaska Region Headquarters. Six Alaska forecasters participated in three case studies: snow amount (case study 1), ice accumulation (case study 2), and freezing spray (case study 3). After a presentation by WPC staff about the WSSI Alaska prototype and by NNC staff about the social science research and focus group findings, the forecasters used weather data to create a forecast for several case studies. After an initial forecast determination, the WSSI Alaska was added for consideration. Testing procedures involved first analyzing weather data to make a briefing, then the WSSI Alaska was added for consideration and the forecasters made a second briefing. Short surveys were completed after each case study analysis through the Mentimeter platform, and the participants debriefed/reflected on whether WSSI helped with the forecast and briefing development and why. After all case studies were completed, a longer final survey was administered and used as the basis of a discussion led by NNC staff Rachel Hogan Carr and Kathryn Semmens at the end of the testbed. This summary highlights key takeaways from survey responses.

Short survey after each case study:

Over all three case studies, the highest level of agreement (on a scale of 1 to 5 with 5 being high agreement) was with the statement "I would use WSSI Graphics in my briefings to partners (inclusive of public) if available" with average ratings of 4.2 (case study 1), 3.8 (case study 2), and 2.5 (case study 3) (Figure 12).

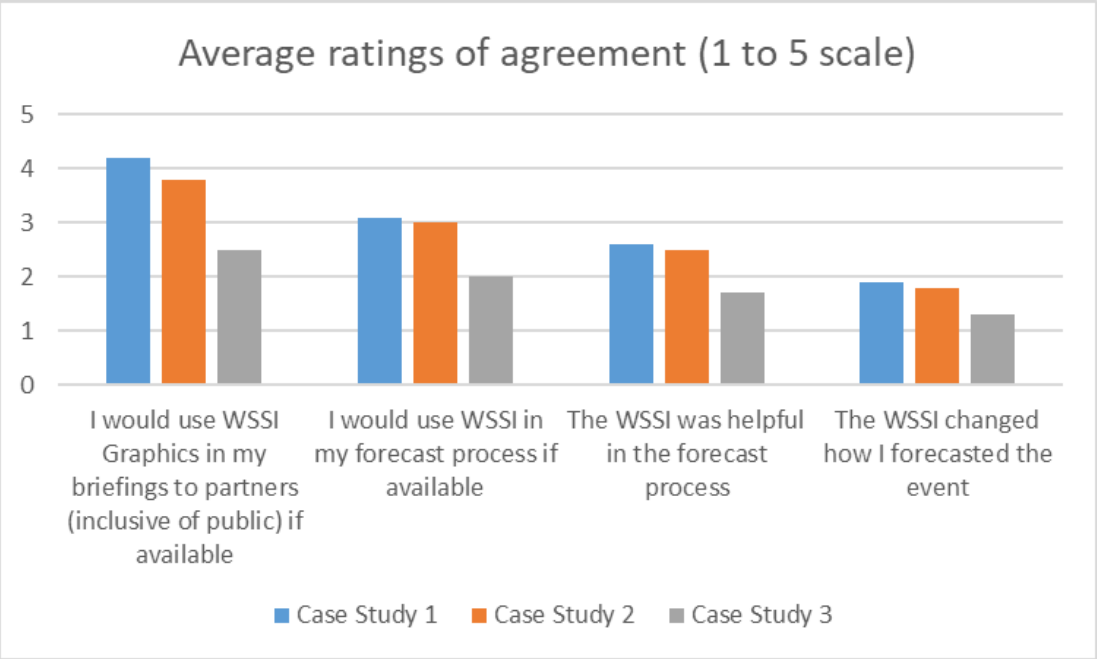


Figure 12. The average rating of agreement of forecasters in the Arctic Testbed for three different case studies involving the WSSI – Alaska prototype.

This was followed by statements:

- "I would use WSSI in my forecast process if available" with 3.1 (case study 1), 3 (case study 2), and 2 (case study 3).
- "The WSSI was helpful in the forecast process" with 2.6 (case study 1), 2.5 (case study 2), and 1.7 (case study 3).
- "The WSSI changed how I forecasted the event" with 1.9 (case study 1), 1.8 (case study 2), and 1.3 (case study 3).

Location was the most frequently mentioned across all the case studies when asked "What did you find helpful about the WSSI in your forecast process?" This echoes discussion related to how the WSSI provided situational awareness and allowed the forecasters to see the areas of most concern so they could focus their attention.

Wind was the most frequently mentioned response when asked "What other information or features do you wish the WSSI had?" in case study 1. In case study 2, there were suggestions for labeling of cities and roads, as well as to change the impact descriptions to include infrastructure and not just travel. Information on precipitation transitions was also noted as valuable. In case study 3, winds, sea ice coverage, and wave height were mentioned as additional information needed.

Final survey:

After all the case studies were complete, a final survey was disseminated and completed (see the Appendix for detailed responses). All but one participating forecaster indicated they would share the WSSI with others, with most indicating they would share it with other forecasters or with core partners but noting caution for sharing with the public. The one 'maybe' response about sharing mentioned concerns with data being unrealistic. Another indicated there could be some utility for sharing with the public later in the product's development: "I think this is a useful tool for forecasters to have, and the ability to generate quick graphics (as well as the interactive display) could make it a useful tool for partners and the public."

The majority of participants felt that there were components missing from the product. Echoing the focus groups and survey findings, wind was called out as a critical need with forecasters suggesting the use of the NDFD grids for that data. Antecedent and/or cumulative snow and precipitation conditions were also mentioned as a needed element, especially in relation to rain on snow events. Additionally, blowing snow was mentioned by one forecaster: "We have blowing snow forecast grids with the following categories: no blowing snow, blowing snow to 1 mile visibility, blowing snow to 1/2 mile, and blowing

snow to 1/4 mile. I think running a simple algorithm (if wind speed > x and snowfall > y, then there will be z visibility) might overdo things, so we try to be very intentional about where we put blowing snow. Maybe it would be useful to simply import our blowing snow grids just so we have easy, updated graphics to share?"

In addition to reflecting on missing components, the forecasters also provided feedback on the elements that were included and shown in the prototype. The forecast time period was described as "semi-useful" with an increase in temporal resolution for the first 48 hours requested along with longer lead times being needed for rural Alaska. Severity levels seemed reasonable for most, especially if based on climatology. One forecaster did discuss aligning minor and moderate: "Part of me wants to have a level between 'minor' and 'moderate' impact. In my head, a special weather statement aligns with 'minor', a warning aligns with 'moderate', and an advisory would fall somewhere in between. At the same time, as we talk about moving towards hazards simplification and folding SPS and advisories together, it does make sense to me to associate these products more with 'minor' impacts." The legend impacts were not seen as the right definitions for Alaska. Driving was asked to be removed and replaced with traveling due to lack of roads in rural Alaska. They also asked that infrastructure be added to the definitions. In areas with low population, several respondents felt the impacts should be the same as in higher population areas, though a few mentioned travel impacts would be different between higher population areas and rural areas. One explained: "My impression is that rural communities tend to have stronger *individual* resilience but lower *community* resilience because they are underserved."

The forecasters also reflected on how the WSSI could be used in communication. In communicating routine high-impact events, one forecaster suggested focusing on location-specific recurrence intervals for events, while another felt it was for the local WFO to decide how to message as they would know the communities better and what their impacts would be. Having a baseline climatology and analogues (referencing recent events that happened) were noted as helpful as well.

Specific recommendations for the WSSI included adding locations/markers for people to orient themselves, changing legend descriptions to be more Alaska-focused, and providing links to take people to their respective local weather forecast offices. Zoom capability was praised and one noted that smoothing needs to be done carefully due to the complex terrain in Alaska.

Some additional feedback included seeing value in the WSSI if "it is incorporating multiple wx elements and the climatology" referencing context for the storms because of time of year or breaking records. Another noted that model forecast uncertainty was an issue and made it "more difficult to use a deterministic tool like the WSSI here in Alaska." Also, it was noted that, due to data gaps, it is difficult to verify impacts and to accurately assess the WSSI.

The survey responses together with the final discussion at the end of the testbed led to a few takeaways detailed here. The WSSI was not seen as helpful for the forecasting process itself – the forecasters saw value in the product as a situational awareness monitor and would use it as a heads up, and then use other data for developing the forecast. As such, some forecasters saw it as something they might share with partners, noting it is great for a first quick glance and highlights those areas of most impact. Several noted that it could be used to draw attention to locations to focus on and to flag if an event is historic. They emphasized that this is especially useful because they have such a large area to cover in Alaska.

As noted throughout the study findings, there is a strong need to include wind in the WSSI Alaska product – partners, professional stakeholders and forecasters all reiterated this need. Forecasters noted that wind and visibility matter more than snow in most locations in Alaska, and it was suggested to remove freezing spray from the overall WSSI calculation as they have this all the time, and it is only an issue in certain locations and times of year. Additionally, it would be helpful to have an extended time frame because in Alaska planning is generally on the order of five to seven days so an eight-day standard would be valuable. Further, inclusion of precipitation type and transition, and timing of impact were valued.

There was significant discussion around snow load, snow accumulation, and the cumulative impact of snow. In Alaska it was noted that snow sticks around and while any single event is not going to hit the major impact criteria,

multiple events could add up to have a major impact. Having accumulated snow data running in the background would be immensely helpful, as it could highlight if the accumulation is above or below normal snowpack (this is available at SNOTEL sites which have on the ground measurements, but not other locations). Additionally, there was discussion about adding point locations for SNOTEL sites to the interactive WSSI product to provide extra layers of information of on the ground snow water equivalent (SWE) data to supplement the impact based WSSI. This was discussed as a visual enhancement that could be toggled on and off, but not part of the official WSSI calculation.

Further discussion related to how snow load is defined, noting that the definition most assume is not what the data included in the WSSI is really getting at – WSSI is providing an instantaneous weight of the snow, not the traditional definition of force per unit area on a structure/ roof. Ideas for what this WSSI component could be called were discussed among the forecaster group and WPC staff, but nothing was determined. At the same time, it was noted that the season-long traditional snow load information (accumulated snow referenced above) was useful along with this instantaneous SWE data. In sum, snow characteristics are important for understanding and forecasting impacts – whether it is dry vs. wet or light vs. heavy – so providing ways to show these characteristics (e.g. snow ratio with a scale from wet to dry) would be useful.

Overall, the WSSI Alaska product was seen as a valuable addition to the forecasters' toolbox. Several actionable steps for refining the prototype were clarified and the WPC staff felt well poised to make next steps with its development. Importantly, the forecasters participating in the testbed appreciated the opportunity to provide feedback on and inform the continued development of the WSSI for Alaska, so much so that they requested to be involved earlier in such processes in the future.

Overall, the WSSI Alaska product was seen as a valuable addition to the forecasters' toolbox. Several actionable steps for refining the prototype were clarified and the WPC staff felt well poised to make next steps with its development.

Appendix: Detailed responses to the final survey during the Arctic Testbed

Overall, describe how you would integrate the WSSI product into your forecasting process.	I would definitely utilize it for most winter partner briefings. Seeing this would be a great SA start to the day to hone in on areas that are the big issues.	used as an SA tool to help determine where to focus meteorological analysis	I think I would use it as a SA tool. In theory, we should have an idea already when we are making the forecast.	Use as additional tool to investigate potentially high impact areas further during the forecast process. Depending on how useful the event WSSI graphics are, you likely use them in IDSS messaging to partners on potential impacts and most likely areas to be impacted.	For forecasting alone, it would be to see where we currently have impacts in the grids and see where adjustments need to be made.	In terms of forecasting, I think it could be useful for situational awareness, especially if I would need to spin up very quickly. It would be useful for deciding what weather element(s) and what time periods to target.
Would you share the WSSI with others?	Yes	Maybe	Yes	Yes	Yes	Yes
If you would share the others, please describe with whom? (other forecasters, core partners, public, etc.) **If you would not share it, please explain why not.**	I am a SOO! I would have the office look, learn and use it.	As discussed, some of the data was unrealistic (i.e. ndfd masks, freezing spray over ice/land, etc)	I would share it with other forecasters. I would also give it to core partners as a quick SA tool.	Would most likely share with other forecasters and core partners. Would still use a lot of caution before sharing with the public attm.	A visual is helpful to go along with a briefing to partners or in social media. It would be mostly an "overview" type of slide because people would still want snow amount.	I'd share the tool with everyone, but I'd like it to be internal to NWS for at least the beginning of the rollout. I think this is a useful tool for forecasters to have, and the ability to generate quick graphics (as well as the interactive display) could make it a useful tool for partners and the public. My biggest concerns with sharing it outside NWS are: (1) WSSI may overdo severity for somewhat impactful, but ultimately not too uncommon, wintertime hazards. I think it could take some fine-tuning to ensure that doesn't happen, especially when it comes to potential problem areas we discussed earlier in the workshop ('extreme' pixels along the mountaintops due to data gaps in the climatology, topography bleed onto higher elevation road networks, etc). (2) Since the WSSI output is not tied 1:1 with our forecast, there is the potential for conflicting forecast messages. I think a lot of what we forecast is highly uncertain, especially when it comes to ice accumulation. In those situations, we tend to stay pretty general; we even stray away from forecasting specific snow amounts at times. I worry that what we have in our grids (since we HAVE to have something in the grids) may not be exactly what we want the public to pay attention to. For example, we're 3 days out and trying to highlight the potential for heavy snow in Anchorage while grappling with poor model agreement. Meanwhile, WSSI (going off our forecast and the climatology) is showing moderate to major impacts, which may not be what we'd want to message given the forecast uncertainty.

How are the components in the WSSI useful to your forecast process? Please explain	For now, snow and ice are beneficial and would be useful, but primarily snow.	situational awareness	I would say WSSI has limited value for the forecast process. Where WSSI is great is as a tool for situational awareness tool and as a quick look for our partners	Like how it takes different variables and highlights potential for impacts using that information. Would use the information to further investigate the forecast for those areas and the potential impacts.	I think that snow amount is useful but would like to see other tabs that show what is going into "overall severity" tab.	I think the snow amount/snow load components are most useful. I like that it compares our forecast to climatology, so we can get a sense for how unusual an event like that can be. Like I mentioned earlier with situational awareness, I think WSSI could give a quick, easily digestible starting point for forecasters. As for the other components, my short time in Alaska gives the impression that ice accumulation can be so challenging to forecast that I have very low confidence in what's in the forecast grids, which means that WSSI would derive from a very low confidence forecast. Maybe people with more forecast experience would give a differing opinion, but I think that could make it difficult to use.
Are there components missing that would be useful?	Yes	Yes	Yes	Yes	Yes	Not sure
If yes, please describe what is missing. Do you have ideas for what data sources to include to address gaps?	Wind, temperature. We have wild winds in the area. Just 7 miles south of downtown, we've had gusts of wind over 100 mph, while areas in town are barely at a breeze.	Antecedent conditions. Rain on hard pack snow is a high impact event. It can take a long time to melt 1" of snowpack with 36F rain. Maybe add extreme cold/wind chill.	Having wind information is important. The NDFD grids would be great to use for wind data.	Wind and antecedent conditions, or cumulative conditions such as several measurable snow events within a relatively short timeframe.	Wind is an important factor that partners noted and I agree. In SE, often a wind shift to the south will have the highest speeds but also cause a change over to rain. Wind is largely a marine impact as well but not in just winter. For freezing spray considerations would want to see wind and waves. Many SE partners seemed to want flooding as a factor, but require knowledge of antecedent conditions (rain on snow or already saturated ground) so I'm not sure how that would be included. Plus flooding is not limited to the winter season, but is often a fall issue in SE.	I think blowing snow and blizzard could be useful. There would be a lot of challenges with this (as discussed earlier in the workshop), like accounting for antecedent conditions. We have blowing snow forecast grids with the following categories (if I remember correctly): no blowing snow, blowing snow to 1 mile visibility, blowing snow to 1/2 mile, and blowing snow to 1/4 mile. I think running a simple algorithm (if wind speed > x and snowfall > y, then there will be z visibility) might overdo things, so we try to be very intentional about where we put blowing snow. Maybe it would be useful to simply import our blowing
How does the forecast period of the WSSI align with users' needs for impact forecasts?	It's only semi useful. Alaskan require a longer lead time, especially in rural areas. adding through day 5 and even beyond would be immensely helpful.	3 days is good, but increase temporal resolution in first 48hrs to better identify timing of impacts	I think it is fine	Aligns pretty well, though it may be useful to partners if it had a 5-7 day range so they have time to move resources or request mutual aide.	Three days seems fine, but we often have back to back systems with only 12hr breaks in between.	I think the 3-day forecast period is helpful for planning; any further out, and forecast confidence greatly diminishes. As we progress, moving towards smaller time chunks or a rolling window (ex: different partners conduct operations at different times of day) would make this even more useful.
Reviewing the legend impact definitions, are these the right definitions?	No	No	No	No	No	No
If no, what would you recommend changing in the legend?	Remove any reference to driving. It should be travelling, instead. Referencing the map I shared showing locations on the road system, most of rural Alaska is only accessible via plane, snowmachine (our way to say snowmobile) and or boat. Yes, some villages and towns have cars and a few miles of roads, nearly all are not connected.	remove driving bullets and focus on travel	For Alaska, get rid of references to driving.	Change "driving" to "traveling". Add infrastructure impacts.	Change all "driving" phrases to "travel". Remove "impossible". Keep infrastructure impacts.	I'd like to reiterate the earlier recommendations to shift from 'driving' conditions to just 'travel' conditions. I think it was also brought up that 'daily life' can be a bit vague... I think it's worth considering that 'daily' life for rural Alaskans may include subsistence activities (fishing trips, multi-day hunts) that leave them more vulnerable to the elements. I'm not sure what would be a better substitution... and perhaps it's ultimately up to individual forecast offices to understand their users' needs and speak to this in their own messaging.

Regarding the severity levels, how do the stated severity levels match your audiences' expectations?	I think they work	not sure	I think in some cases they match, in other cases they don't	Pretty well	Reasonable IF they are based on snow climatology of each part of the state. SE is not the same as the north slope (Florida vs. Montana).	I think the severity levels match our audiences' expectations. Part of me wants to have a level between 'minor' and 'moderate' impact. In my head, a special weather statement aligns with 'minor', a warning aligns with 'moderate', and an advisory would fall somewhere in between. At the same time, as we talk about moving towards hazards simplification and folding SPS and advisories together, it does make sense to me to associate these products more with 'minor' impacts.
In developing the WSSI for CONUS, we heard concerns about whether a common impact can be an extreme impact; in Alaska, we heard that extreme conditions are normal, and in fact, the lack of winter (i.e., warming temperatures) is a bigger risk. How do you think WSSI should communicate routine high-impact events?	I think it would really key in on when the worst of the worst would occur and help to highlight those areas to our partners.	Focus on location based recurrence intervals of events. Southern panhandle doesn't get 8-12"/24hr snow is probably a 5-10 year RI, but N panhandle is 1-2 year	For routine high-impact events we should message the impact, even if it happens a lot.	I think that would fall more on the forecast office in deciding how to use the WSSI to message impacts as they are more in-tune with how routine, high-impacts events may impact various communities. What may be an issue for one community might not be that big of an issue for another.	Not everything can be "extreme", that would be crying wolf. But having those values over the mountain peaks seem reasonable and I believe that our customers would understand that and be able to visualize that on a map.	I think part of it comes back to the core of WSSI, which is having a baseline climatology and speaking to deviations from this climatology (ex: 99th percentile). I think it's also helpful to have analogues, which is perhaps something that could be discussed more with local forecast offices. For example, I think something we messaged for either the 2nd or 3rd of last year's back-to-back-to-back heavy snow events in Anchorage was something to the effect of "we are expecting about the same or a little bit less snow than the event earlier this week". This gives people an indication of what to expect and (at least in this case) speaks to a high-impact event that happened with unusual frequency that month.
How should impacts be defined in areas with low population?	The same	less travel for isolated communities don't have the impacts large population sources do	We should use climatology to the best we can.	It might have lower impacts for some weather hazardous, but other impacts may impact them more than a higher population center given lack of resources. I think here, availability of resources would make some lower impact weather events more impactful for lower population centers. Not sure how to define this though. Maybe the distance to nearest airport that can accommodate those potential larger resources?	Impacts in areas where there is greater population is where there are going to be road and a "commuting" population and therefore that would more impactful.	I don't know that impacts should be defined too differently. Probably the biggest differences relate to transportation - less road traffic, greater reliance on travel via boat/plane/snowmachine. My impression is that rural communities tend to have stronger *individual* resilience but lower *community* resilience because they are underserved. I would really love to hear what these communities have to say on this.
What recommendations would you make for the design of the WSSI? Consider the colors of severity levels, legend presentation and details, titles, and overall presentation.	Adding in of locations, references would be useful.	none	I think the colors are fine. For the legend we need to think about Alaska wording.	I haven't checked the colors in a color-blind test, but having colors that are friendly for the color-blind users would be necessary.	The mapping and smoothing has to be done carefully due to the complex terrain. The fact that the map can be zoomed in on is great, because we have such a large area, however the base map doesn't have cities/towns on until zoomed in quite far. Not sure whether or not snow load is needed as the definition is challenging. All of our partners know "snow load" as what is already on their roof + new snow. Would consider removing the tab or changing the title to something else. A couple years ago, our office created "dual points" along all of our coastline so that snow accumulation and wave heights would not get masked over pixels that had both marine and land areas within it.	I think the WSSI design is pretty good as is. I think the colors are fine, but I've also heard that using purple (rather than red) to indicate highest severity could be a bit confusing for some people. I'm sure this will come up as the prototype continues advancing, but I'd like to see more markers for people to orient themselves (community names, river names, road networks). And if there's an Alaska-specific webpage for this, maybe a link to take people to their respective forecast offices if they click on a point.

Is there anything else you would like to share related to winter weather impacts and forecasting in Alaska?	Great work! I am looking forward to how we can hone this in!	it's hard		It is true that Alaskans considered themselves self-reliant, but they are still impacted by weather and those impacts still result in loss of life, loss of income (or equivalent), and increased strain on local resources. I think something like this is still useful as long as WSSI can be flexible until we figure out what tends to work well for Alaska.	In SE, we go back and forth from rain to snow quite often in the winter, which is completely different from SE. This is why I believe the partner survey results showed less likelihood of use for the WSSI. I think our partners would still want to know how much snow is going to fall, so if the WSSI is ONLY having snow as a factor then it is not adding any value. The only value I see in the WSSI is if it is incorporating multiple wx elements and the climatology. For example, is the snow storm in April more impactful because it is a record? Or unusual for this time of year?	My impression (having only forecast for the Anchorage forecast office) is that we struggle a lot more with model confidence up here. I think this could be seen with how the forecast remained in flux for Anchorage even the day before today's (11/8/2023) winter storm was expected to impact the area. The Anchorage office is barely getting into probabilistic forecasting and messaging, but I think generally higher forecast uncertainty may contribute to it being more difficult to use a deterministic tool like the WSSI here in Alaska. Perhaps this is the case for lower 48 offices as well; I'm not entirely sure. In terms of impacts, as we saw with data gaps in the climatology, it's very difficult to verify impacts in some areas. This means it may be difficult to accurately assess WSSI and how useful it is for these areas.

Potential Winter Storms Impacts

THE NURTURE NATURE CENTER

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