



Kotzebue, AK flooding in October 2024.
Photo by Michelle Kubalack

Arctic Observation Storylines: Coastal Flooding

WHY OBSERVING MATTERS AND HOW WE CAN MAKE IT BETTER TOGETHER

The challenge

Coastal flooding poses an increasing threat to many Alaskan communities, particularly Alaska Native villages along the western and northern coasts. Over 30 communities face imminent risks, forcing them to decide whether to protect existing infrastructure, retreat, or relocate entirely. These communities and many others are also located on tidally influenced rivers.

A primary driver of increased flooding risk is the significant reduction in protective sea ice. Annual sea ice duration is decreasing, leaving coastlines exposed to powerful storms for longer periods. These storms, which are increasing in frequency and intensity, can generate destructive storm surges and waves. The effects of coastal storm surges in combination with high river flows add further complexity to flood hazards at upstream communities. Three major storm systems in the last four years, including Typhoons Merbok and Halong in 2022 and 2025, have exposed long-standing gaps in federal and state resources for storm preparedness, infrastructure management, and disaster recovery.

Beyond damaging infrastructure, storm events threaten food security and cultural continuity by disrupting essential subsistence activities and destroying vital equipment. In the short term, a lack of reliable sensor equipment and real-time data limits the accuracy of storm forecasts, constraining early warning systems that could otherwise provide longer lead times, enhance community preparedness, and strengthen decision support ahead of an event. For long-term resilience, decision-makers need forward-looking adaptation tools, such as flood maps that account for future risk scenarios and updated infrastructure guidelines, to ensure that new and replacement infrastructure can withstand future conditions.

See [Resources and Further Reading](#) for references that support this summary (page 13).

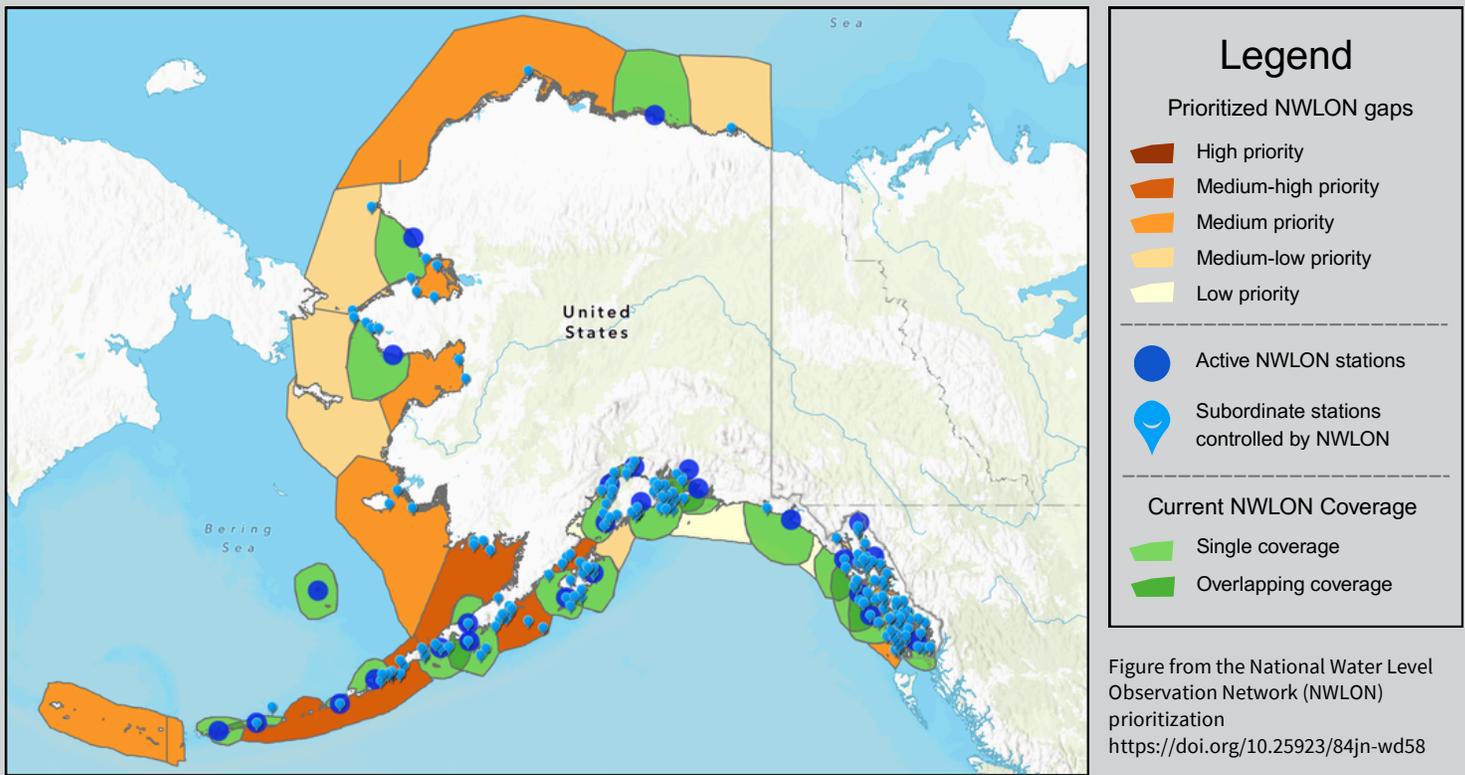


ARCTIC OBSERVATION STORYLINES: COASTAL FLOODING



Why coastal flooding observations are important

Observations of coastal water levels, sea ice, waves, bathymetry, topography, and other dynamic phenomena inform model development, community preparedness, and response to flooding events. Real-time ocean and weather data are essential for monitoring coastal storms and producing accurate early warning forecasts. Critical baseline datasets support long-term planning tools, such as sea level rise projections. Recent efforts in Alaska's coastal mapping, modeling, and observations have allowed organizations to begin creating needed tools that improve early warnings and informed decision-making. This US Arctic Observing Network (US AON) Technical Brief was created to clarify the importance of these current capabilities and highlight the impacts of persistent data gaps on Alaskans.



The light yellow to dark brown polygons represent the prioritized National Water Level Observing Network (NWLON) gaps from lower to higher priority, respectively. The green polygons show the current NWLON coverages with the darker green polygons depicting the overlap of coverage areas. The dark blue dots represent active NWLON stations. The light blue pins represent subordinate stations controlled by NWLON.

Acknowledgements

The subject matter experts who contributed to this assessment were: Nora Nieminski (DGGs), Taylor Borgfeldt (AOOS), Ed Plumb (NWS-retired), Rich Buzard (ANTHC, formerly USGS), Erin Trochim (UAF), and Maddi McArthur (UAF). The societal benefit ratings were informed by the 2017 International Arctic Observing Assessment Framework. The technical brief was reviewed by Li Erikson (USGS), Timothy Steffen (NOAA), and Michael Mercer (NOAA).

Recommended Citation

US AON. 2026. Arctic Observation Storylines: Coastal Flooding. BENEFIT Assessment Risk Management and Hazard Mitigation Technical Briefs. <https://www.usaon.org/sites/default/files/2026-03/Arctic%20Observation%20Storylines%20Coastal%20Flooding%20v1a.pdf>

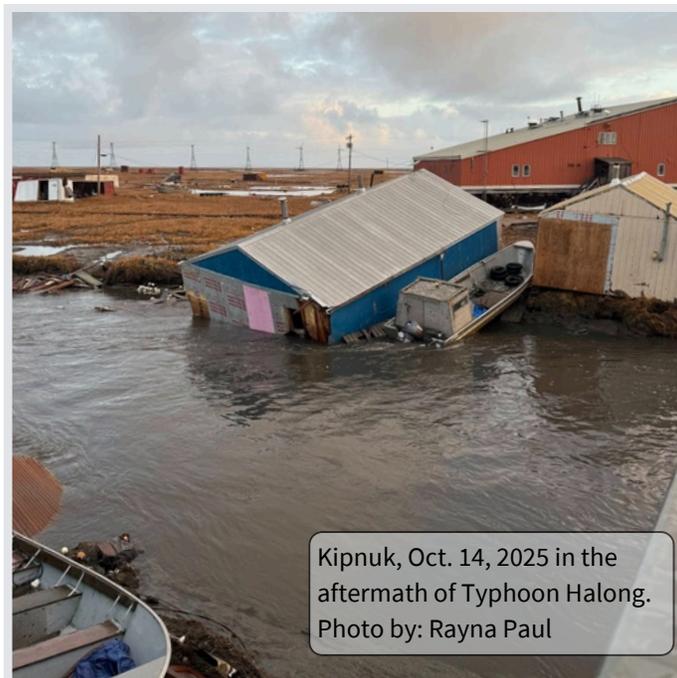


News flash: Damaging Storms Flood Western Alaskan Communities

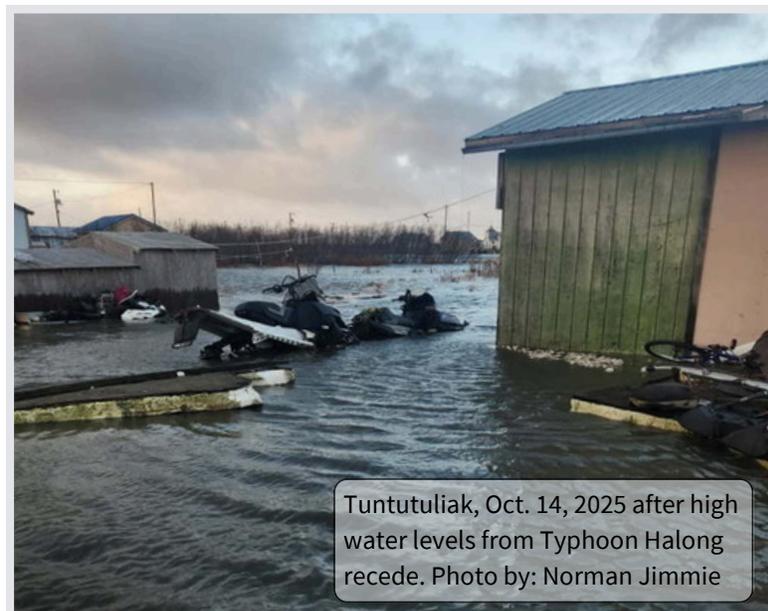
Early October 2025 brought two devastating, back-to-back storms that displaced approximately 1,600 people. The first was a strong low-pressure system that moved toward Alaska on October 6, bringing west-southwesterly storm-force winds that caused coastal flooding, high surf, and erosion from Kotzebue Sound along the Northwest Arctic Borough coast. Water levels, which peaked on October 8, prompted evacuations in Kotzebue and Kivalina. Immediately following came the remnants of Typhoon Halong, which brought widespread damaging winds exceeding 100 mph in some Yukon-Kuskokwim Delta communities and a record-breaking storm surge that caused catastrophic flooding across west coast communities. Particularly devastating flooding occurred in Kipnuk and Kwigillingok, where Alaska Division of Geological & Geophysical Surveys (DGGs) water level sensors recorded record highs before being damaged by the storm. The cost of recovery will be high; \$25 million in federal disaster relief has already been approved.

In response to initial storm forecasts, DGGs and the U.S. Geological Survey (USGS) provided hydrologically connected flood extent maps to the National Weather Service (NWS). These models, combined with DGGs flood impact assessments, were critical for NWS forecasts as storms developed. DGGs also updated the Alaska Flood Inundation Tool (AK-FIT) with 24 additional Still Water Inundation Models (SWIM), bringing impact forecasting and safety planning capabilities to 32 communities total. This online tool helps inform flood preparedness by allowing users to visualize modeled flood extents at various forecasted water levels. USGS provided valuable storm wave data collected near coastal communities that feed into more advanced hydrodynamic flood models.

Following the storms, DGGs contracted imagery collections and ground surveys to collect high-water marks and coastal elevation profiles in the ten most impacted communities and coordinated with NWS to collect survey data in three communities most affected by the first storm. Community engagement proved invaluable, with residents documenting impacts during the storms and helping gather critical data. DGGs, USGS, and NWS continue processing pre- and post-storm data and collecting additional geospatial information to report on historical impacts and produce products that help decision makers and communities build resilient futures.



Kipnuk, Oct. 14, 2025 in the aftermath of Typhoon Halong. Photo by: Rayna Paul



Tuntutuliak, Oct. 14, 2025 after high water levels from Typhoon Halong recede. Photo by: Norman Jimmie

ARCTIC OBSERVATION STORYLINES: COASTAL FLOODING



What is included in this report

US AON engaged with over 60 entities involved in environmental risk management and hazard mitigation in Alaska to inform this and other topical technical briefs. Through analysis of these discussions, coastal flooding emerged as a priority concern intersecting with the missions of federal and state agencies, Tribal organizations, academic institutions, and non-governmental organizations. While coastal flooding is intrinsically linked to phenomena such as coastal erosion and sea ice, this technical brief specifically addresses the key products and services related to flooding. Although many river communities face similar risks, this assessment focuses on the coastal zone. See [Future Work](#) (page 7) for US AON's plans to incorporate these additional topics in future assessments, and visit our website for [additional technical briefs](#) on risk and hazards topics.

The organizations and efforts listed in Table 1 develop Key Products, Services, and Outcomes (KPSOs) from Earth observations that address coastal flooding. **Table 1 is not comprehensive, but emblematic of critical flood-related forecasts, tools, and programs.** Key operational decision-makers on this issue include the US Coast Guard, the US Army Corps of Engineers (USACE), and the State of AK Division of Home Security and Emergency Management; their effectiveness depends on the KPSOs featured in this assessment.

Table 1. Key Products, Services, and Outcomes (KPSOs) included in this assessment

Mission Area	Responsible Organization*	KPSOs* (for details see pages 8-12)
Informing Community Planning	AOOS and AWLW Partners	Alaska Water Level Watch (AWLW)
	DGGS	DGGS Risk Assessment Reports
	USGS	USGS Forward Looking Models
	USACE, UAF	Topobathy LIDAR DEMS
Forecasting and Forecast Support	AOOS and AWLW Partners	Alaska Water Level Watch (data are deliverable to NWS for forecasting)
	USGS	USGS Forecast Support
	NWS	NWS Flood Products and Decision Support Services
	DGGS	DGGS Alaska Flood Inundation Tool
Informing Emergency Response	NWS	NWS Flood Products and Decision Support Services
Informing Post-Storm Recovery	NWS	NWS Flood Products and Decision Support Services
	AK-DGGS	DGGS Flood Events Database

* Acronyms on page 13

ARCTIC OBSERVATION STORYLINES: COASTAL FLOODING



Priority actions

Table 2. Priority Actions to ADVANCE capabilities toward fully meeting their requirements.	Relevant Organizations
A1. Expand and diversify coastal water level observation networks, filling spatial gaps beyond existing National Water Level Observing Network (NWLON) stations with more datum-referenced water level stations for improved regional understanding.	NOAA, AOOS, DGGGS, USGS
A2. Enhance geospatial data collection: more temporal & spatial coverage for bathymetry, elevation data, and post-storm recollection in impacted coastal communities.	USACE, NOAA, DGGGS, USGS
A3. Expand modeling capabilities like the Coastal Storm Modeling System for Alaska (CoSMoS-AK) to the 60 previously identified communities for resilience planning and forecasting. Accelerate topobathy lidar processing for new products.	USGS
A4. Boost community engagement and citizen science through activities like social media sharing and high-water mark recording after storms to build relationships and gather valuable data.	AOOS, DGGGS, NOAA/NWS
A5. Improve data transmittal by addressing telemetry issues across the state.	Infrastructure and development entities.

Table 3. Priority actions needed to SUSTAIN high performing and critical current capabilities.	Relevant Organizations
S1. Continue support for essential water level observation networks, covering station and sensor installations, data management, and visualization on portals. Continue support for regular and repeat geospatial data collection.	AOOS, AWLW, NOAA, DGGGS, USGS
S2. Maintain federal-state partnerships that enable DGGGS data collection and product development.	DGGGS
S3. Continue supporting the Coastal Storm Modeling System for Alaska (CoSMoS-AK), including hazard exposure and risk analysis tools (e.g. HERA), by updating data access and tool functionality. Ensure that end-user tools are intuitive and effective.	USGS
S4. Maintain strong collaborative partnerships with communities and Indigenous Knowledge holders, Integrated Ocean Observing System (IOOS) regional associations, and local agencies to assure effective resource leveraging and information exchange.	AWLW, AOOS NOAA/NWS
S5. Continue supporting the integration of diverse data sources, including complementary satellite data and reanalysis/climate data products, to enable comprehensive understanding.	NOAA, USACE, USGS

For more details about these Tables 2 & 3, see page 6. Individual assessments are on pages 8-12 and reference these priority actions (e.g., A1, S2). Acronyms on page 13.

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People wade through flooded streets in Kotzebue , AK. Photo by Lance Kramer

About priority actions

Priority Actions (page 5) are categorized into two groups. The category "ADVANCE" identifies opportunities to enhance capabilities in order to fully meet requirements. This category includes observing systems or data products rated below 70/100 for requirement satisfaction and with a criticality rating of 6/10 or higher. The category "SUSTAIN" encompasses actions necessary to maintain current, high-performing capabilities. It includes observing systems or data products rated above 70/100 for requirement satisfaction and with a criticality rating of 6/10 or higher. Actions are categorized based on ratings assigned by subject matter experts to observing systems or data products that support their key products, services, and outcomes (KPSOs).

Relevant organizations are those most directly involved in implementing priority actions. Academic and community partners are also widely engaged in these actions but are not specifically highlighted in this table.

Coastal observing and societal benefit

As illustrated by the individual assessments (pages 8-12), subject matter experts mapped the potential impacts of implementing the priority actions identified on Page 5 onto relevant societal benefit areas in the International Arctic Observing Assessment Framework. The priority actions would advance:

Disaster Preparedness – Expanding observations and models will improve forecaster awareness, flood forecasts, and Impact-based Decision Support Services (IDSS) for emergency managers. Increased access to community reports will provide real-time verification and enhance preparedness actions.

Infrastructure and Operations – Improved data (e.g., first-floor elevations, real-time water levels) and consistent datums will ensure secure design, safe operation, and better planning by predicting infrastructure impacts.

Sociocultural Values – Boosting community engagement and maintaining partnerships recognizes the value of Indigenous Knowledge and local context for storm histories and vulnerable areas. This ensures public messaging is relevant and useful to the specific community.



About this assessment

About US AON BENEFIT assessments on Risk Management and Hazard Mitigation

The US Arctic Observing Network (US AON) is a sub-body of the Interagency Arctic Research Policy Committee (IARPC) that aims to enhance observational and data sharing systems for broadly shared societal benefits. It has developed the BENEFIT assessment methodology and visualizations in alignment with other agency and interagency efforts. These assessments illustrate the performance levels of current observing capabilities and provide actionable recommendations to build on strengths and address gaps. IARPC has requested that US AON apply the BENEFIT assessment to risk management and hazard mitigation in Alaska.

US AON collaborates with its partners to create compelling narratives about the strengths and gaps in Arctic observations and data sharing systems. This publication informs decision-makers at all levels about critical capabilities that must be advanced or sustained to maximize societal benefits from these investments. US AON is funded by NOAA's Global Ocean Monitoring and Observing Program/Arctic Research Program and the National Science Foundation.

Assessment process

Subject Matter Experts (SMEs, see [Acknowledgements](#)) identified during the scoping phase completed a BENEFIT assessment for their Key Products, Services, and Outcomes (KPSOs, Table 1). Each assessment resulted in a visualization that illustrates the value chain connecting observing system assets, data products, and relevant societal benefits. The U.S. Arctic Observing Network (US AON) utilizes the societal benefit areas outlined in the [International Arctic Observing Assessment Framework](#) as performance benchmarks within the BENEFIT assessment.

SMEs provide quantitative ratings and rationales for each link in the value chain, highlighting strengths and gaps that affect the systems' ability to meet their requirements. The coastal flooding SME cohort agreed on an approach to their ratings of coastal observing, modeling, and related efforts, which largely reflects the inadequate spatial coverage of necessary assets, such as water level sensors and LIDAR surveys. Where available, the technologies themselves often produce high-quality data.

SMEs use a standardized BENEFIT rating rubric, and the results of each assessment, along with this document, undergo both collective and independent reviews. Many of the KPSOs listed in Table 1 are interconnected. The SME cohort collaborated to establish a common language and interpretation of performance and criticality; however, in some instances, they applied different ratings to KPSOs that support societal benefit areas based on the specific context. For more information, visit <https://usaon.org/evaluation-and-planning/benefit-assessment>.

Future work

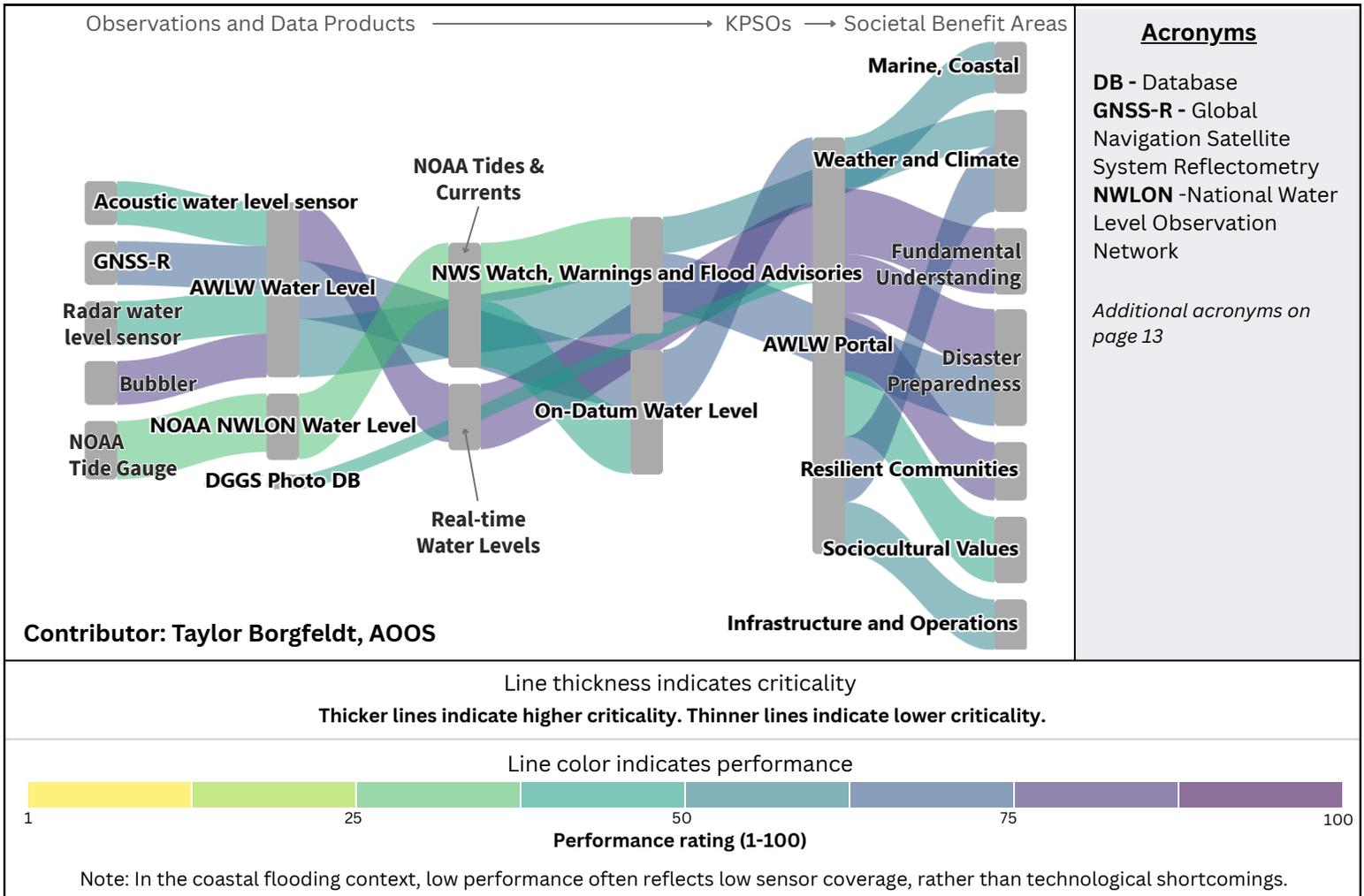
This US AON Technical Brief includes a range of capabilities across the diverse mission areas in which organizations are working on coastal flooding in Alaska. It is not an exhaustive list and is open to future revision.

Reference datasets such as digital elevation models, bathymetry, and other reference data (e.g., Vdatum) provide essential support for these efforts. High-resolution imagery is also invaluable for storm response, allowing for the examination of infrastructure (like runways) and assessment of storm impacts. Drone monitoring programs will likely see increasing use following storms. Given the scope and complexity of these capabilities, US AON will produce a technical brief specific to this work. Additionally, a technical brief on coastal erosion will be developed, including the important and emerging role of drones in helping communities track changes.

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Fig 1. Alaska Water Level Watch Data Portal



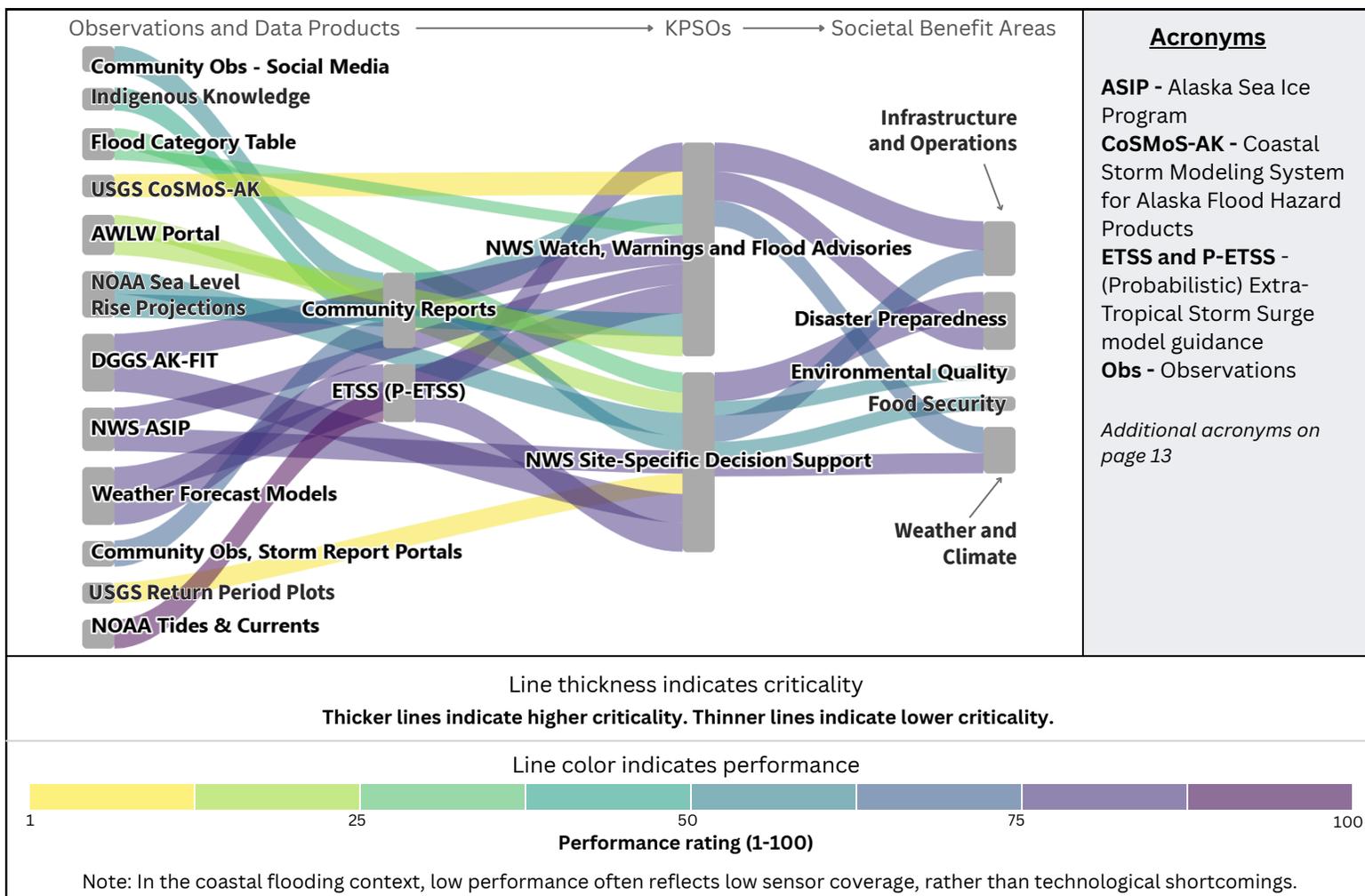
This assessment centers on the Alaska Water Level Watch (AWLW), which coordinates water level observations across the Alaska region from federal, state, and local agencies, researchers, and other contributors. It supports the standardization, centralization, and public accessibility of these data from diverse sources. This initiative exemplifies strong coordination among varied data providers and stakeholders to ensure water level information is consistent, accessible, and useful for a broad audience - including emergency managers, scientists, and local decision-makers - for improved planning and response to coastal hazards. Data are accessed via the AWLW Portal.

While Alaska currently has a limited number of coastal water level observations, the range of existing and potential future applications is substantial. Increasing the number of high-quality, datum-referenced water level stations will support current uses while expanding opportunities for community involvement and storm monitoring. Coastal water level resilience depends on sustained support for observation networks, including expanding stations beyond existing NWLON sites, maintaining high-quality NWLON data, and supporting ongoing data management and visualization (Tables 2 & 3: A1, S1). Strong partnerships with communities and Indigenous Knowledge holders, IOOS Regional Associations, and local agencies—paired with expanded community engagement and citizen science—are equally critical to improving data coverage, information exchange, and regional understanding (Tables 2 & 3: A4, S4).

ARCTIC OBSERVATION STORYLINES: COASTAL FLOODING



Fig 2. NWS Flood Products and Decision Support Services



The assessment focuses on coastal flooding prediction efforts supported by the Alaska Region of the National Weather Service. Specifically, it looks at critical inputs needed to support NWS Flood Products (watches, warnings, and advisories) and NWS Site-Specific Impact-based Decision Support Services (IDSS) functions. Accurate Flood Products depend on real-time sensors, community observations, flood maps, and defined flood thresholds. IDSS is crucial for informing communities about potential impacts to vulnerable infrastructure and assisting with operational decisions. IDSS products incorporate flood maps for visualizing inundation and use flood category tables for quick assessment of affected infrastructure. Both efforts provide critical support for US AON Societal Benefit Areas related to Disaster Preparedness, Weather and Climate, Infrastructure and Operations, Environmental Quality and Food Security.

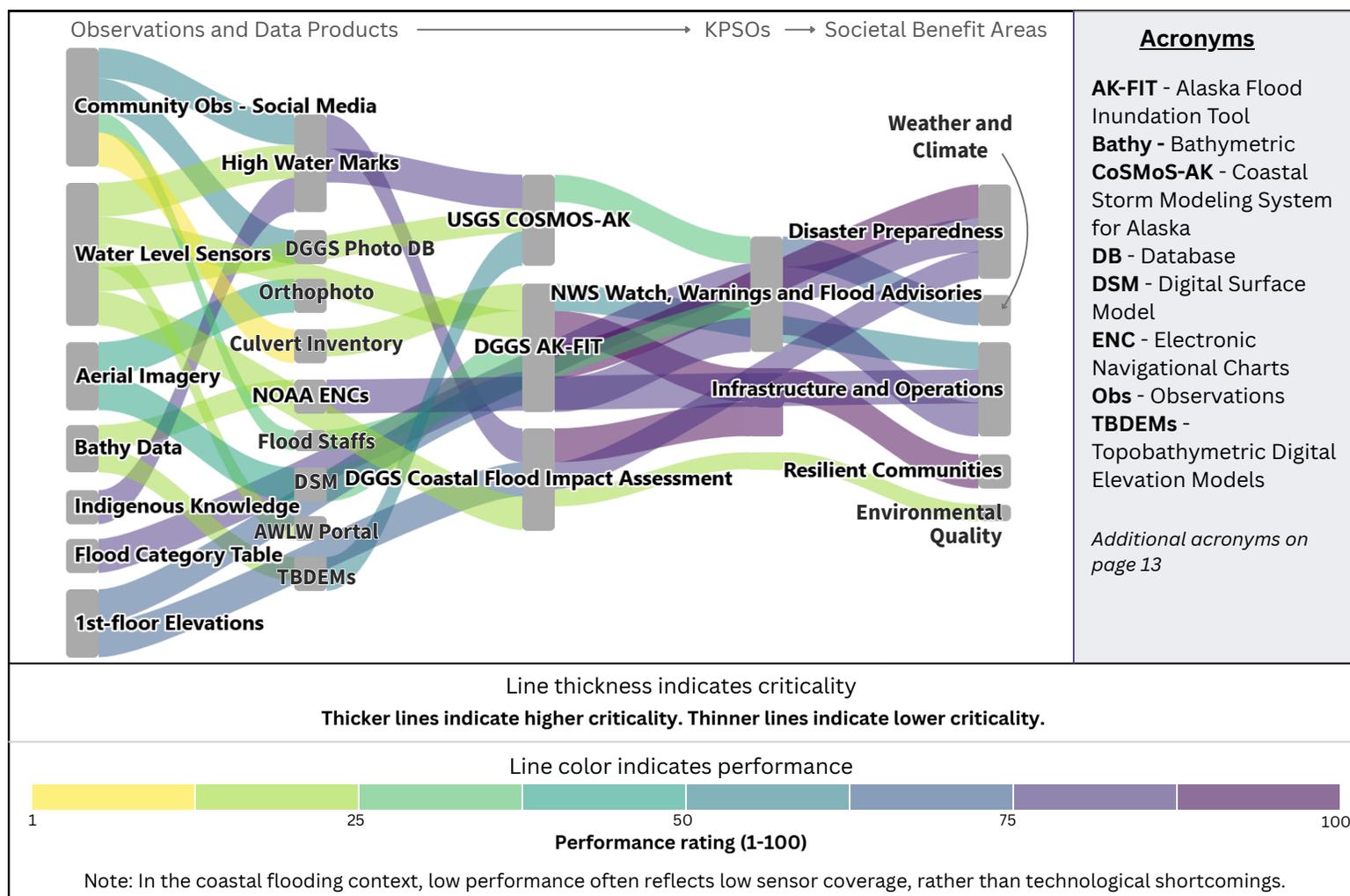
A key takeaway from this assessment is that forecast accuracy is heavily impacted by spatial gaps in water level sensors (Table 2 & 3: A1, S1); efforts like Alaska Water Level Watch (AWLW) fill gaps with non-NWLON sensors, but inconsistent datums remain a major challenge because they prevent NWS forecasters from viewing all water-level platforms on the same reference frame used in NWS flood products (Table 2: A1). Crucial flood guidance from products like USGS COSMOS-AK support forecasts (Table 3: S3), but are not available for many at-risk communities (Table 2: A3).

Contributor: Ed Plumb, NWS-retired

ARCTIC OBSERVATION STORYLINES: COASTAL FLOODING



Fig 3. Alaska DGGs Products and Tools for Coastal Flooding



DGGs's Coastal Hazards Program (CHP) works to serve environmentally threatened communities that experience risks of coastal and/or riverine flooding. CHP publishes community-specific reports that include flood histories and height estimates for past floods, along with a flood risk category map showing current infrastructure and previous floods. DGGs CHP collects and compiles written or verbal accounts, photographs, historical and modern imagery, and elevation models. CHP is also publishing its methodologies and is developing new tools to engage with stakeholders and to make products reproducible and more directly useful to the communities at risk.

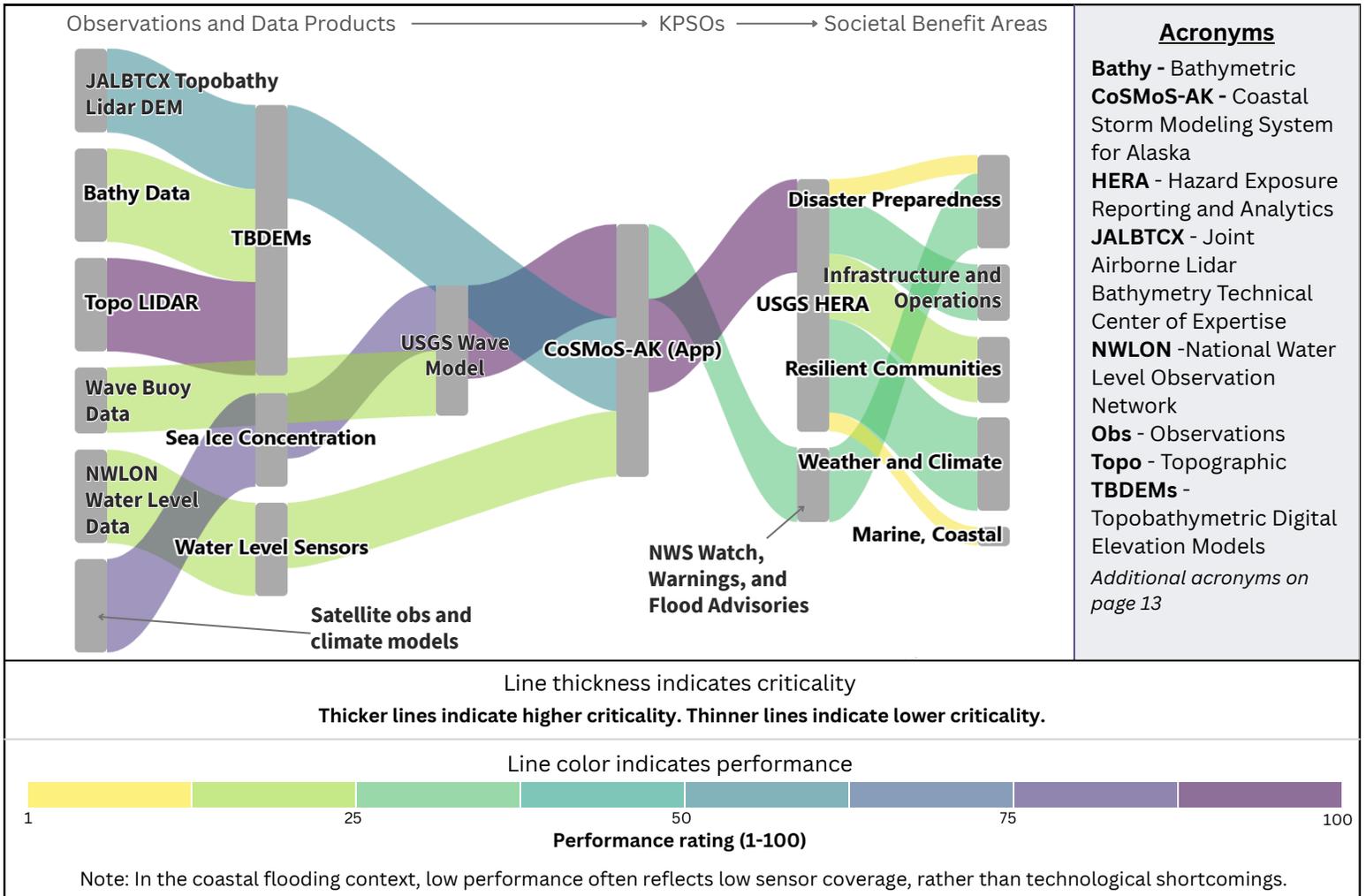
Key takeaways from this assessment include the need for more spatial and temporal (i.e., repeat data) coverage of water-level and flood-related data statewide (Tables 2 & 3: A2, S1, S2) in order to continue to provide water level observations (Table 3: S1) and produce critical, community-specific flood impact assessments to inform decision makers (Table 3: S2) and support forecasts. Sustaining collaborative partnerships with village residents is also critical to collect accurate and timely flood information and improve flood extent models (Table 2: A4). Community observations and integration of Indigenous knowledge help make risk assessment products more accurate.

Contributor: Nora Nieminski, DGGs

ARCTIC OBSERVATION STORYLINES: COASTAL FLOODING



Fig 4. USGS Coastal Storm Modeling System for Alaska Flood Hazard Products



This assessment focuses on USGS modeling and information service capabilities—CoSMoS-AK and HERA—related to coastal storms. Such capabilities directly address future coastal hazards by developing predictive models and mapping tools that incorporate climate change impacts like sea level rise. They also enhance preparedness for rapidly approaching events by improving forecasting capabilities based on real-time observations and foundational data. Performance ratings related to CoSMoS-AK reflect that the dynamic flood model is currently targeted to only cover one-third of communities potentially exposed to increasing coastal flood hazards.

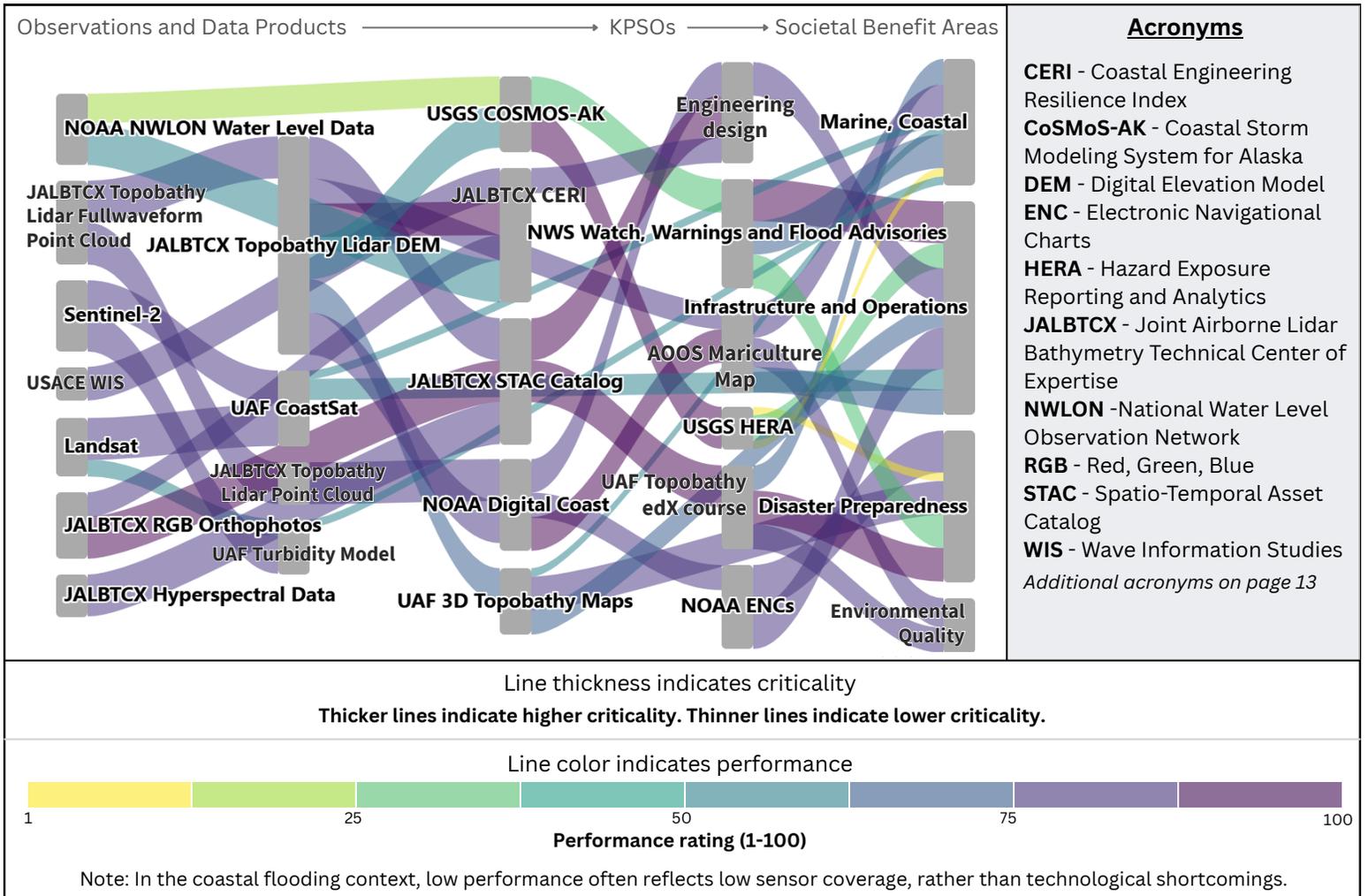
This assessment illustrates several strengths and gaps in the value chain from observations to societal benefits, importantly: Spatial coverage for crucial foundational data, like bathymetry and water level sensor coverage, is extremely poor (Table 2: A1 and A2). This gap prevents accurate storm modeling and severely limits the creation of essential Topobathymetric Digital Elevation Models (TBDEMs; Table 2: A2). The utility of critical modeling tools is crippled by limited coverage (Table 2: A3). The dynamic flood model, CoSMoS-AK, is only available to cover just one-third of vulnerable communities (Tables 2 & 3: A3, S3).

Contributor: Rich Buzard, ANTHC (formerly USGS)

ARCTIC OBSERVATION STORYLINES: COASTAL FLOODING



Fig 5. Coastal Mapping in Alaska Using Topobathy Lidar



This assessment examines the topobathymetric ("topobathy") lidar ecosystem and its role in supporting decision-making in Alaska's coastal communities. Central to this ecosystem are high-resolution topobathy lidar DEMs that capture submerged and non-submerged land surfaces along coastlines, providing essential data for coastal management and planning. The U.S. Army Corps of Engineers JALBTCX collects topobathy lidar data as part of the National Coastal Mapping Program. UAF and Woolpert partnered with JALBTCX to establish the Alaska Coastal Mapping Technical Center of Expertise. This assessment includes three applications: the UAF Turbidity Model, UAF CoastSat, and UAF 3D Topobathy Maps. It traces the flow from initial observations through processing into topobathy lidar DEMs and ultimately into decision-support tools. These products connect with broader geospatial systems managed by NOAA, USGS, UAF, AOS, and JALBTCX, supporting key societal benefits: Disaster Preparedness, Environmental Quality, Marine and Coastal Ecosystems and Processes, and Infrastructure and Operations.

A key takeaway is that topobathy lidar is essential for coastal flooding mission areas, from community planning to recovery efforts. The current technology provides excellent data where available, but spatial coverage is limited. Topobathy lidar data collection should be advanced, along with post-storm recollection in impacted communities (Table 2: A2). Sustained integration of complementary data sources, including satellite and climate data products, is also recommended.

Contributors: Erin Trochim, UAF; Maddi McArthur, UAF

ARCTIC OBSERVATION STORYLINES: COASTAL FLOODING



Resources and further reading

- Alaska Native Tribal Health Consortium. *The Unmet Needs of Environmentally Threatened Alaska Native Villages*. 2024. <https://anthc.org/resource/unmet-needs-report/>
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- Buzzard, Overbeck, Christ, Enders, Plumb. *Coastal Flood Impact Assessment for Alaskan Communities*. 2024. https://aos.org/wp-content/uploads/6_Other_Obs_Storm_History_Buzard.pdf
- Horen, K.C., Poisson, A.C., Christian, J.E., and Nieminski, N.M. Methods for Evaluating Flood Impacts in Coastal Communities. 2024. Alaska Division of Geological & Geophysical Surveys <https://dggs.alaska.gov/pubs/id/31279>
- Merbok Disaster Supplemental was used to fund continuous terrestrial LIDAR from around Kipnuk to Wales. Funding was awarded to USGS, then passed to NOAA OCM to manage the contract. <https://www.usgs.gov/programs/cmhrp/science/typhoon-merbok-disaster-emergency-recovery-efforts>
- Williams, Dee and Li H. Erikson. *Knowledge Gaps Update to the 2019 IPCC Special Report on the Ocean and Cryosphere: Prospects to Refine Coastal Flood Hazard Assessments and Adaptation Strategies With At-Risk Communities of Alaska*. 2019. doi: 10.3389/fclim.2021.761439

List of Acronyms

ANTHC - Alaska Native Tribal Health Consortium

AOOS - Alaska Ocean Observing System

AWLW - Alaska Water Level Watch

DGGS - Division of Geological & Geophysical Surveys

IOOS - Integrated Ocean Observing System

KPSO - Key Products, Services, and Outcomes

NOAA - National Oceanic and Atmospheric Administration

NWS - National Weather Service

SME - subject matter expert

UAF - University of Alaska Fairbanks

US AON - US Arctic Observing Network

USGS - United States Geological Survey