



Coastal Vulnerability Mapping in Alaska

Strategies for Small Populations in Data-Sparse Regions



Overview

Coastal communities in arctic and subarctic Alaska are increasingly exposed to high-energy storm surge events as climatic trends lead to reduced durations of protective sea ice. To provide these communities with the tools that are necessary for immediate emergency planning and to address imminent adaptation decisions, the Alaska Division of Geological & Geophysical Surveys (DGGGS) is conducting a multi-year project funded by the federal Coastal Impact Assistance Program (CIAP) to design a series of coastal vulnerability products that are tailored to the diverse geologic and socioeconomic character of the Alaska coastline. Traditional approaches to inundation and shoreline change mapping must be modified to accommodate:

1. a coastal development pattern characterized by small, isolated communities,
2. a widespread lack of significant baseline data about the coastal environment,
3. ice-related geohazards and uniquely arctic emergency response needs,
4. strong subsistence-based relationships between residents and the coastal environment, and
5. a decentralized coastal management system.

By showcasing ongoing data contributions and preliminary products for communities such as Shishmaref and Port Heiden, Alaska, we introduce some of the field methods and map products that our program is developing to quantitatively investigate, document, and catalog changes in the coastal zone and to map coastal vulnerabilities in rural Alaska.

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Community-focused Science

- Detailed coastal vulnerability studies for Alaska's entire continuous coastline are infeasible due to length of the coast
 - DGGGS uses an approach that focuses on areas immediately around developed coastal communities
- Regularly mobilizing field crews to remote parts of Alaska, or installing sensors in harsh environments is expensive
- DGGGS leverages opportunities to work with residents and community-based observers to improve data collection

Flood Inundation Extent



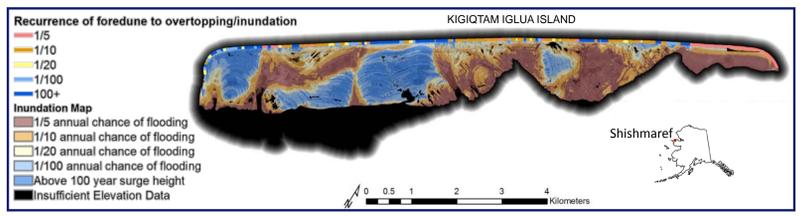
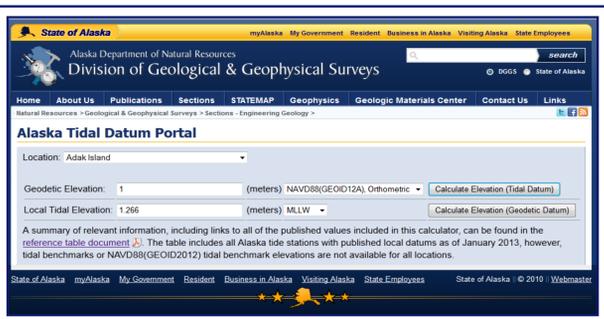
- Alaska no longer participates in the Coastal Zone Management Program; the Alaska Coastal Management Program, designed to oversee the responsible development of coastal uses and resources, sunset in July of 2011
- DGGGS vulnerability products are designed for use by planners and coastal managers at the local level, with an emphasis on ease of access and educational outreach to promote informed and coordinated decision-making that will benefit all Alaskans

Critical Baseline Data for Storm Surge Inundation and Erosion Mapping In Alaska

	'Topo-Bathy' Surfaces and Coastal Morphology	Storm Surge Water Levels	Local Tidal Datums and Offsets	Contemporary and Historical Shoreline Positions
Defined Need	<ul style="list-style-type: none"> • Need continuous elevation surfaces to model nearshore hydrodynamics, wave runup and overland flow during flooding events • Characterization of dominant landforms and sediment dynamics reveal mechanisms of coastal modification and change 	<ul style="list-style-type: none"> • Recurrence intervals for total water levels in extreme events can be used to make inundation maps, which enable informed community planning • Improved storm surge forecasts facilitate emergency preparedness • Elevated water durations = wave impact hours and ice push vulnerability 	<ul style="list-style-type: none"> • Datum offset values allow water level predictions to be combined with terrestrial elevations • Long-term records reveal relative sea level trends • Tidal datums establish the boundaries of land ownership in the coastal zone 	<ul style="list-style-type: none"> • A time series of shoreline positions can be used to calculate rates of shoreline change and to identify erosion hot spots • Spit growth and/or inlet migration can reveal sediment transport patterns
Data Availability and Challenges	<ul style="list-style-type: none"> • The National Elevation Dataset is a 2-arc-second product for most of Alaska • Limited lidar coverage exists • There is very little ground control, particularly in rural areas • Therefore, new statewide, satellite-based elevation products have poor vertical accuracies and are of limited use for community-scale inundation maps (e.g. IfSAR vertical LE90 = 3 m) • Local digital surface models are in assorted vertical datums 	<ul style="list-style-type: none"> • Most of Alaska's coastline is not instrumented to measure surge heights • Modeled storm surge recurrence intervals are only available in a select number of communities and are not generally validated by in situ observations • National Weather Service's Meteorological Development Laboratory (MDL) provides total water level predictions up to 5 days in advance of a storm 	<p>VDatum ← Does not exist for most of Alaska</p> <p>Status of Tidal Datums in AK</p> <ul style="list-style-type: none"> • Populated Places • Established Tidal Datums (n=209) • Published Geodetic Elevations (n=89) • Published Tidal Benchmark Sheets (n=172) <ul style="list-style-type: none"> • Alaska has only 26 active tide stations in the entire state • Northwest Alaska - 3 gauges/2,000+ miles vs. Delaware - 3 gauges/30 miles 	<p>"Less than 10% of Alaska has contemporary shoreline data [1960 or newer] and less than 1% is mapped annually."</p> <p>– National Geodetic Survey, Coastal Mapping Program, 2012</p> <ul style="list-style-type: none"> • Anecdotal and qualitative reports of erosion are widespread • Several sets of scanned aerial photographs cover most of Alaska (1950s, 60s, 70s and 80s) and are freely available from the USGS, but only a selection of these have been orthorectified • Few aerial or satellite image collections are tide-coordinated
DGGGS Coastal Program Contributions	<p>In cooperation with the Western Alaska Landscape Conservation Cooperative, DGGGS has acquired a portable sonar system for low-cost operation on vessels of convenience in rural communities</p> <ul style="list-style-type: none"> • Photo-identifiable ground control, for the generation of more accurate elevation models, is collected in rural Alaska • Testing innovative methods incl. Structure From Motion (e.g. PhotoScan elevations) and multispectral classification (e.g. WorldView-2 bathymetry) • Coastal morphology and sediment characteristics are classified in the field 	<p>Measured Water Levels</p> <p>Wave Run-up Limit</p> <p>Modeled Water Levels</p> <ul style="list-style-type: none"> • DGGGS staff work with modelers to ensure that the best available data and most appropriate assumptions are incorporated into projects • Field measurements are routinely supplied for model validation • New model partnerships include: <ul style="list-style-type: none"> - USGS Storm-induced water levels on St. Lawrence Island (Li Erikson, lead PI) - NOAA High-resolution model of Western Alaska storm surge (Robert Grumbine, lead PI) - NOAA MDL Extratropical Water Level Guidance • For more on runup modeling, see <i>Smith and others, OSM Poster 027-328</i> <p>↑ DGGGS field scientists respond in the wake of significant storm events to:</p> <ul style="list-style-type: none"> - Measure flood inundation extents - Measure peak water levels - Document areas of erosion or overtopping - Collect photos and video from local residents - Strandline elevations and overwash deposits are mapped during baseline data collection in each community 	<p>Tide Shed – October 2013</p> <p>GPS Survey of Tidal Benchmark</p> <ul style="list-style-type: none"> • DGGGS installs temporary water level sensors to collect tide-coordinated data • To enable datum offset calculations, GPS positions for tidal and fixed benchmarks are submitted to the National Geodetic Survey OPUS database • For more on long-term sea level trends as interpreted from tidal benchmark reoccupations in Alaska see <i>Tweet and others, OSM Poster 079-2559</i> 	<p>Position of Vegetation Line</p> <ul style="list-style-type: none"> • Organization, orthorectification and compilation of a time series of vertical images covering at-risk coastal communities is underway • Contemporary shoreline positions are collected from both imagery and direct measurements in the field • Identification and delineation of appropriate photo-identifiable features for use as proxy shoreline position indicators in arctic and sub-arctic environments – improved with extensive on-site examination of the coastline • Continually seeking new ways to acquire historic shoreline positions within Alaska and contemporary positions from sources such as aerial lidar

Existing Tools and Preliminary Product Highlights

- Annotated Bibliography Series for Alaskan Coastal Communities
- Online Tidal Datum Calculator
 - A stopgap tool, in lieu of VDatum, for calculating local vertical datum offsets in Alaska. Includes Alaska-specific information regarding tidal datums (such as Modified Tidal Datum Epochs) and links to source data at external NOAA websites.
- ↓ Preliminary Flood Vulnerability Mapping: near Shishmaref, Alaska
 - In response to ongoing planning decisions, an inundation and overtopping map and report was prepared for a barrier island adjacent to the community. A lidar-derived elevation model was available for this project.

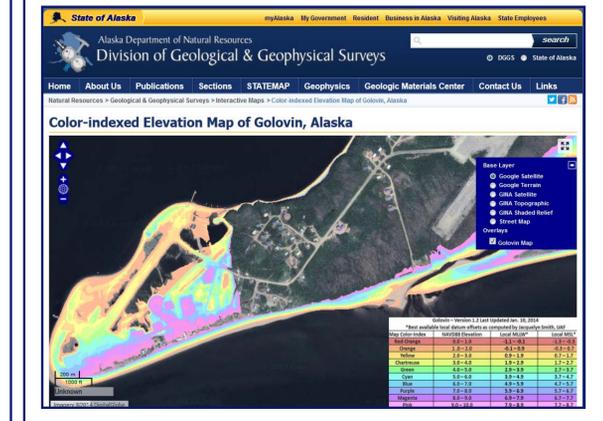


- Preliminary Erosion Vulnerability Mapping: Meshik, Port Heiden, Alaska
 - In response to reports of accelerated erosion that was threatening critical local infrastructure, such as the fuel header and fuel storage tanks, a pilot shoreline change map was prepared for this community. Eight sets of orthorectified aerial or satellite imagery were incorporated into the calculations and combined with field observations to produce the draft report.

- Raw Data Releases/Reports:
 - Oblique Aerial Imagery of the Alaska Shoreline
 - Nearshore Bathymetric Measurements in the Vicinity of Coastal Communities
 - Storm-Induced Water Levels During the November 2011 Bering Sea Storm

New Tools and Interactive Maps

- In cooperation with the Alaska Ocean Observing System, DGGGS is developing an interactive online database for baseline and repeat coastal elevation profiles similar to tools available in other regions of the US
- Comprehensive flood inundation and erosion vulnerability maps for Alaskan coastal communities will be delivered in an online format, accompanied by traditional reports that provide an overview of the local coastal processes and landforms
- ↓ Focus on new communication tools to deliver critical information to residents during emergency response activities (e.g. color-indexed elevation maps linked to tidal datum offset values)



Research Opportunities

- DGGGS is seeking partners to co-fund a baseline collection of coastal lidar along the low-lying western coast of Alaska
 - We are searching for innovative and low-cost solutions for monitoring water levels in remote areas during storm surge events
 - Our program is dedicated to advancing coastal science in Alaska; we can provide information, data resources and connections for researchers interested in working on our diverse coastline
- The University of Alaska Fairbanks and Alaska Division of Geological & Geophysical Surveys have a Memorandum of Agreement in place to jointly support qualified graduate students through applied research internships. For more information, please contact nicole.kinsman@alaska.gov

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