

Should I Stay or Should I Go?

Mapping *The Clash* of coastal hazards in Alaskan communities



Nicole Kinsman

Coastal Geologist, Alaska Division of Geological & Geophysical Surveys



March 13, 2015

UAF GEOG 339 – Mapping and Landscape Analysis



Coastal Hazards Program at DGGS

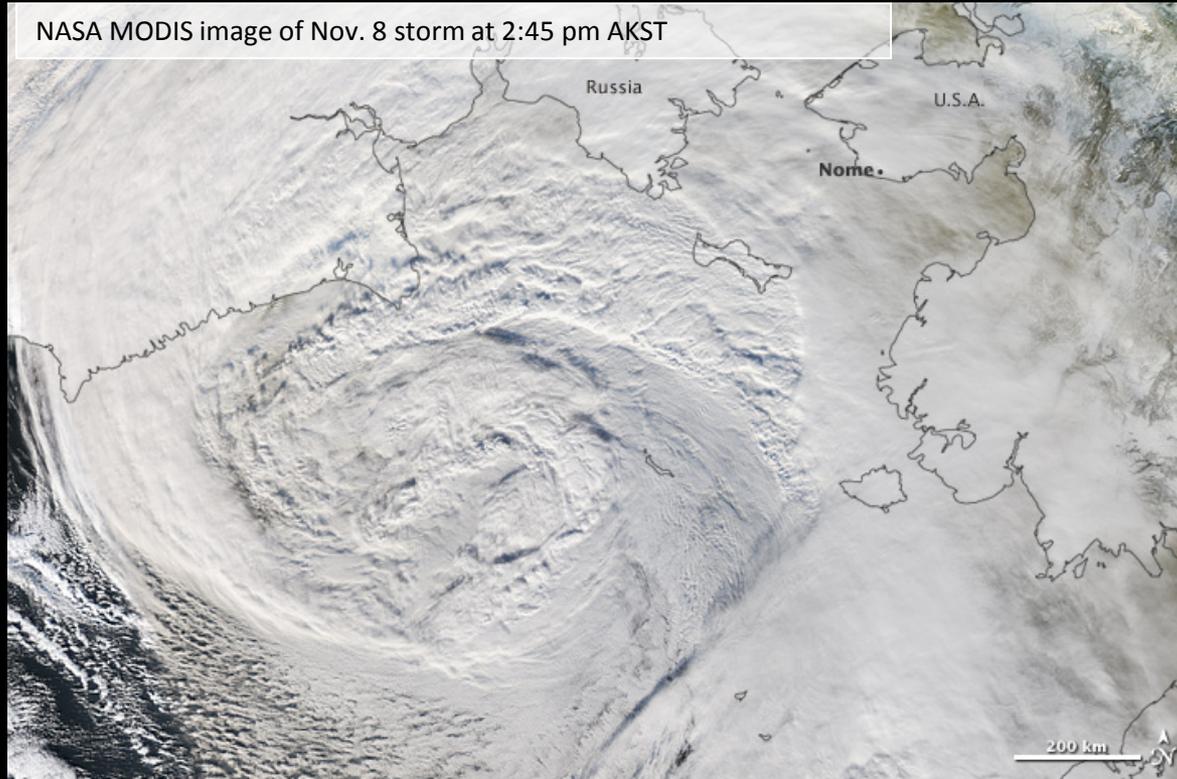


Division of Geological & Geophysical Surveys



- Program launched in 2011, initial funding from Coastal Impact Assistance Program
- Available to field coastal questions from stakeholders (~10-20 weekly requests)
- Program objectives:
 - Increase quality/quantity of coastal baseline data
 - Provide shoreline change and coastal inundation tools
 - Encourage/develop coastal management resources for an Alaskan audience

NASA MODIS image of Nov. 8 storm at 2:45 pm AKST



What are

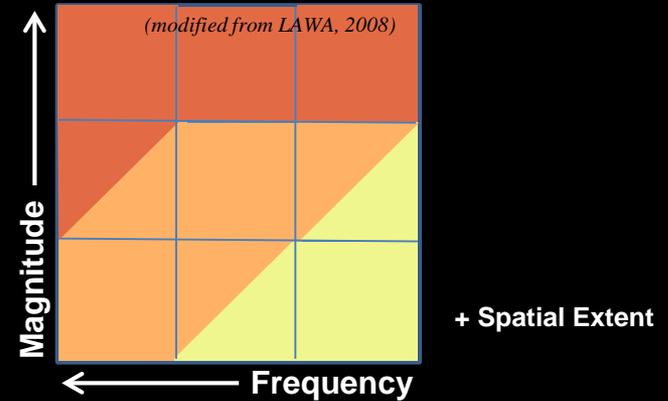
COASTAL HAZARDS?

Coastal Hazard Process List

- Beach erosion
- Landslides
- Wave attack
- Storm surge
- Cyclones (& hurricanes)
- Tsunami
- Relative sea level rise (inundation & salination)
- Ice push (ivu)
- Salt spray

Coastal Hazard Timescales

Hazard Classification



Catastrophic

- Storm Surge
- Tsunami

vs.



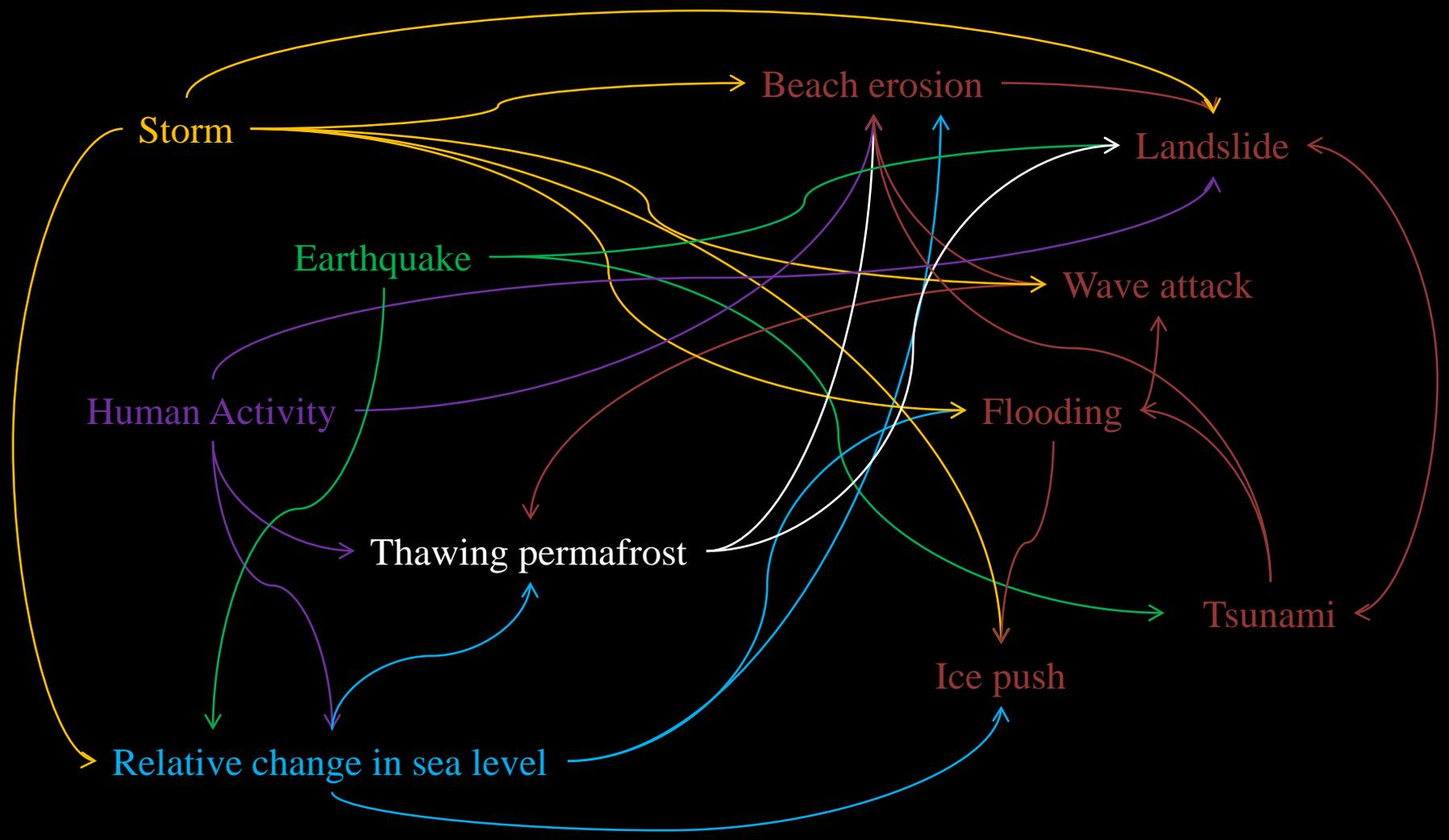
Gradual

- Permafrost melt
- Gravel mining
- ATV use on dunes

Coastal Hazards are Interconnected

Triggers

Hazards



EROSION

The primary mechanism of erosion in the coastal zone is wave action

Beaches undergo cyclic patterns of erosion and accretion

Coastal erosion is highly episodic

Erosion of bluffs and cliffs is irreversible on a human timescale

This coastal hazard can be most directly linked with human actions

- Beach mining
- Vegetation removal
- Altered sediment sources
- Blocked sediment paths



Reversible

Irreversible



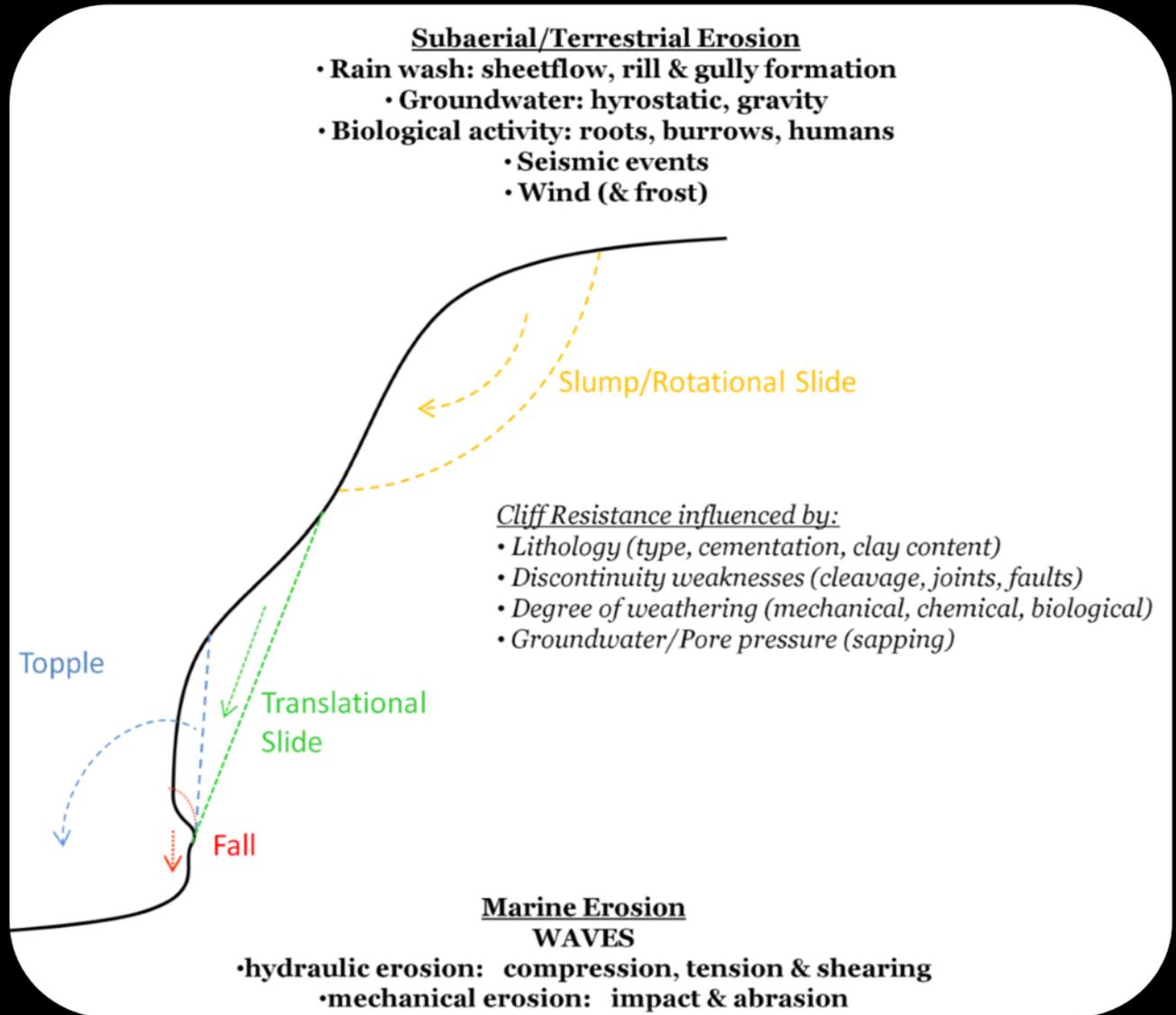
LANDSLIDES & SLOPE FAILURE



Bluff Failure
Kivalina,



Slumping Bluff
South of Unalakleet



ARCTIC BLUFF EROSION

Thermal erosion – warm sea water against permafrost rich bluffs

Bluffs on North Slope = 50-70% ice

Characterized by catastrophic failures

Average retreat rates can be >10 m/yr



USGS on North Slope (Erikson et al., 2008)

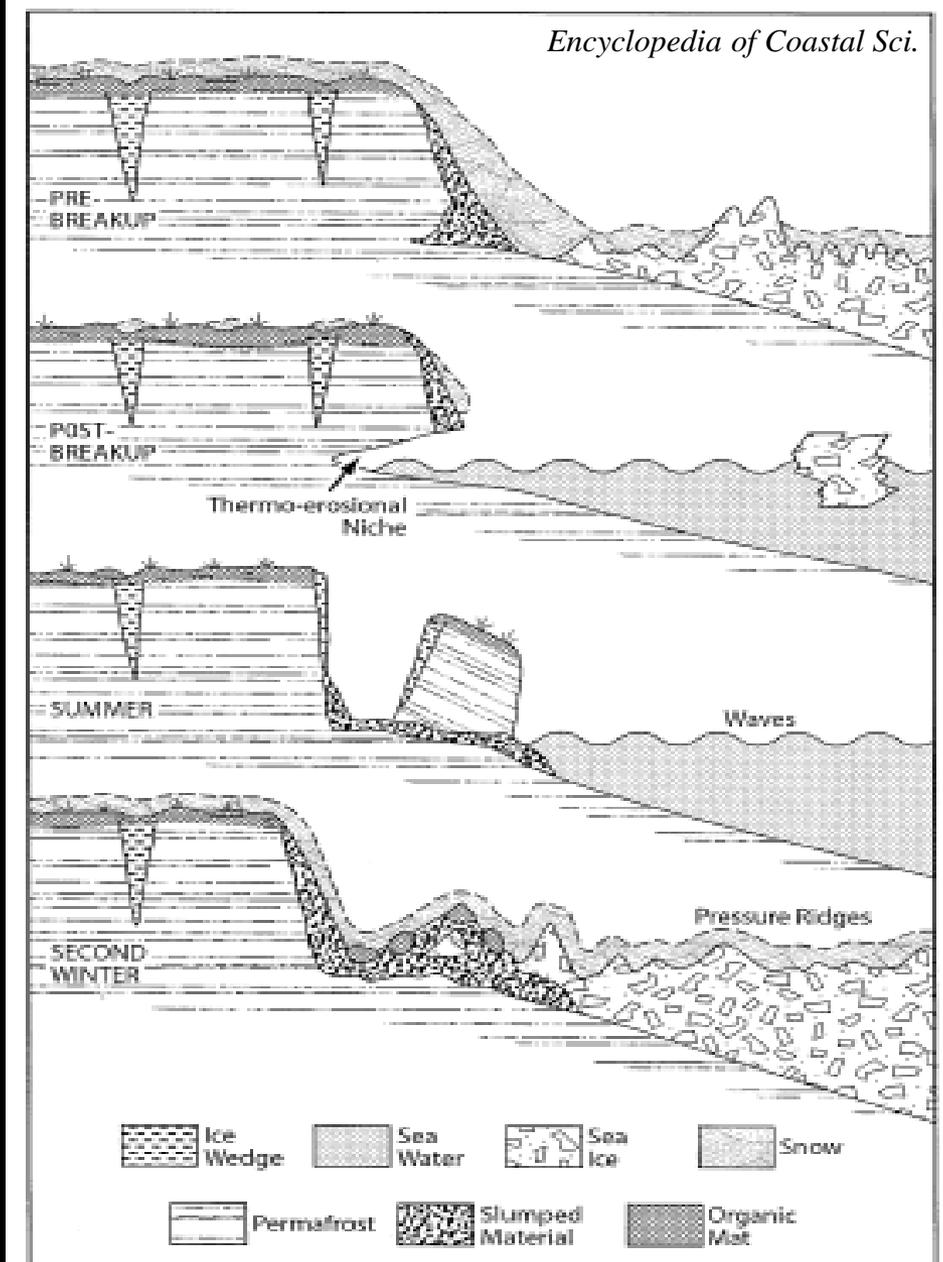


Figure A32 Block collapse and erosion along permafrost coastlines.

IVU

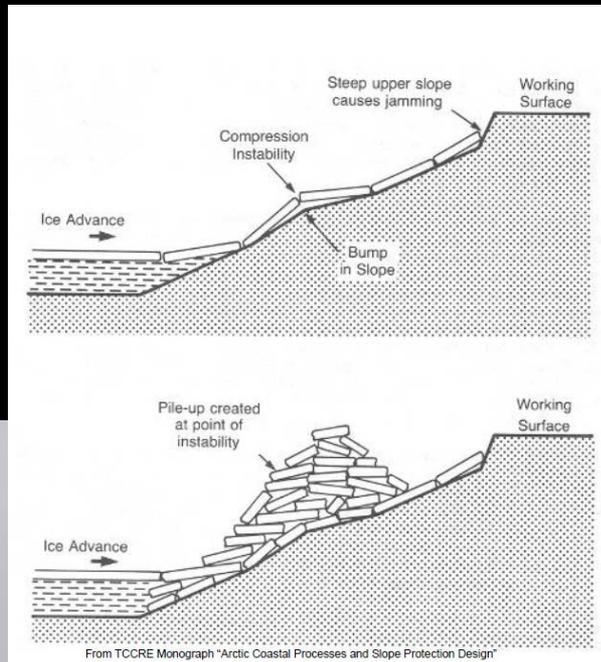
A ride-up & accumulation of ice on the coast

Typically occur atop slope breaks or other irregular coastal features

Often wind-driven during storm surge events

Extremely destructive to man-made structures

Not well studied & very difficult to predict



Ivu (Ice Push)
Nome, AK - May 2004

(Tom Busch 2004)

SALT SPRAY

December 2010

Power outage in Savoonga

“Winter storms are not at all a rare occurrence in village Alaska, and especially on St. Lawrence Island. In this particular instance however, a severe winter storm occurred with high wind from the northeast and salt spray was picked up from the ocean that is normally covered with sea ice. The extreme cold caused the salt spray to freeze on electrical equipment. Initial outages were caused by line slap from iced-up conductors, but later problems were caused by electrical arcing through conductive salt. We are concluding that the lack of sea ice was a major contributor to this situation.”

- Meera Kohler, CEO for Alaska Village Electric Cooperative Inc.

Savoonga



Conductive salt spray caused arcing to burn this transformer and bushing. Burns similar to this occurred on other transformers and bushings, especially those closest to the ocean.

WAVE ATTACK

Poses enhanced danger when debris is present

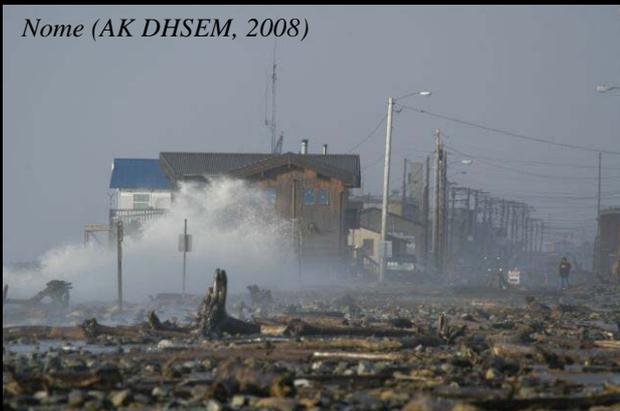
- Ice
- Driftwood
- Man-made objects

The elevation that water can reach on the shore is called the run-up height

Overtopping & overwash

Breaking waves exert an incredible amount of force on the coast

Nome (AK DHSEM, 2008)



TSUNAMI

A long period wave - behaves like a shallow water wave

- Steepens rapidly on shelf
- Faster than a commercial jet airplane in open ocean

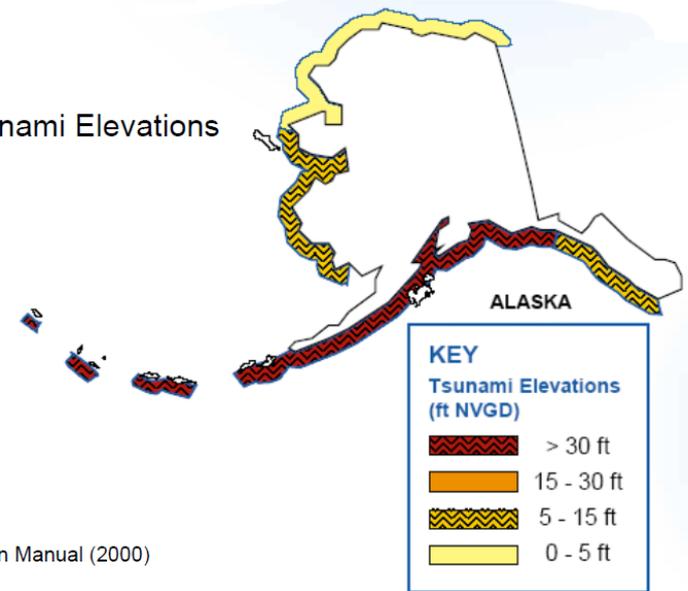
Triggered by seismic activity, landslide or submarine landslide

May be preceded by a drawdown

1958 Lituya Bay event had an inundation elevation of $>500\text{m}$

1964 Good Friday EQ tsunami caused extensive damages along the southern coast

Alaska Tsunami Elevations



From FEMA Coastal Construction Manual (2000)



STORM SURGE

Total surge level =

- Tide
- + Barometric bulge
- + Wind-driven pile
- + Waves

8-12 feet is a typical large surge in AK

30 feet = Katrina surge

43 feet = max. documented (Australia)

Storm surges do not necessarily occur at the same time as high winds

The effects of a storm surge can be enhanced in small ocean basins, sounds

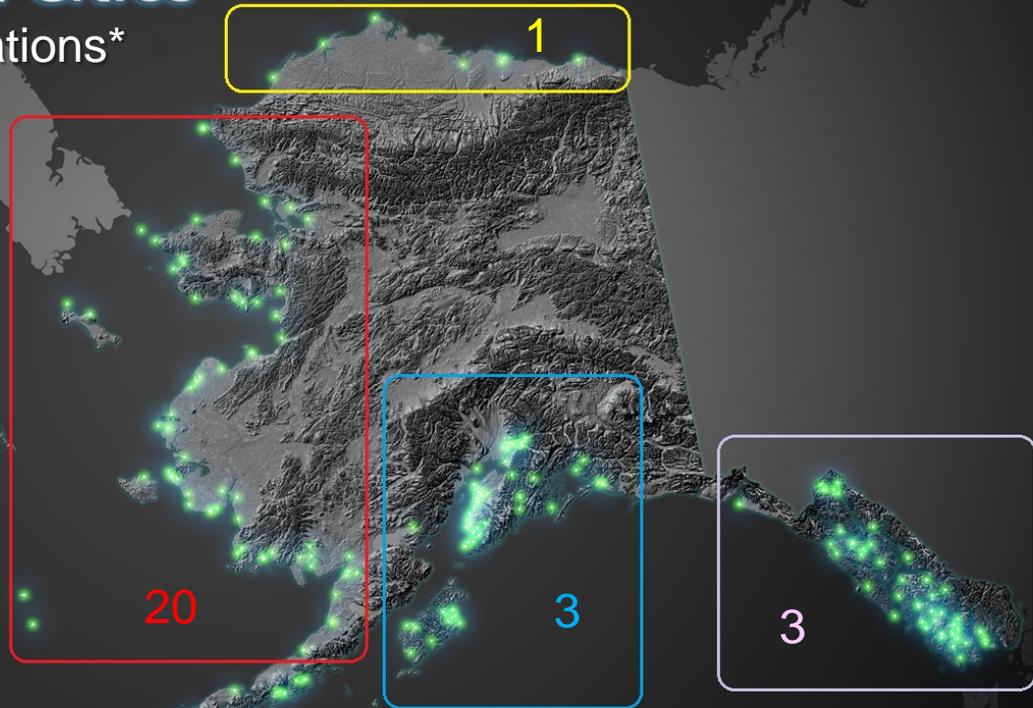
Elevated water levels allow for the translation of other coastal hazards further inland during surges





Alaskan Coastal Cities

State Disaster Declarations*
Coastal Storms
1978-2013



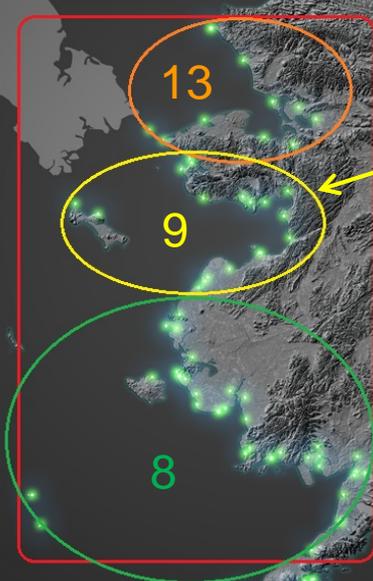
*Declarations often consist of multiple storms





Alaskan Coastal Cities

State Disaster Declarations
Coastal Storms
1978-2013



2003-2013
6 Declarations,
4 Presidential

Typical Season: August – November
with exceptions



SEA LEVEL RISE

Eustatic SL rise:

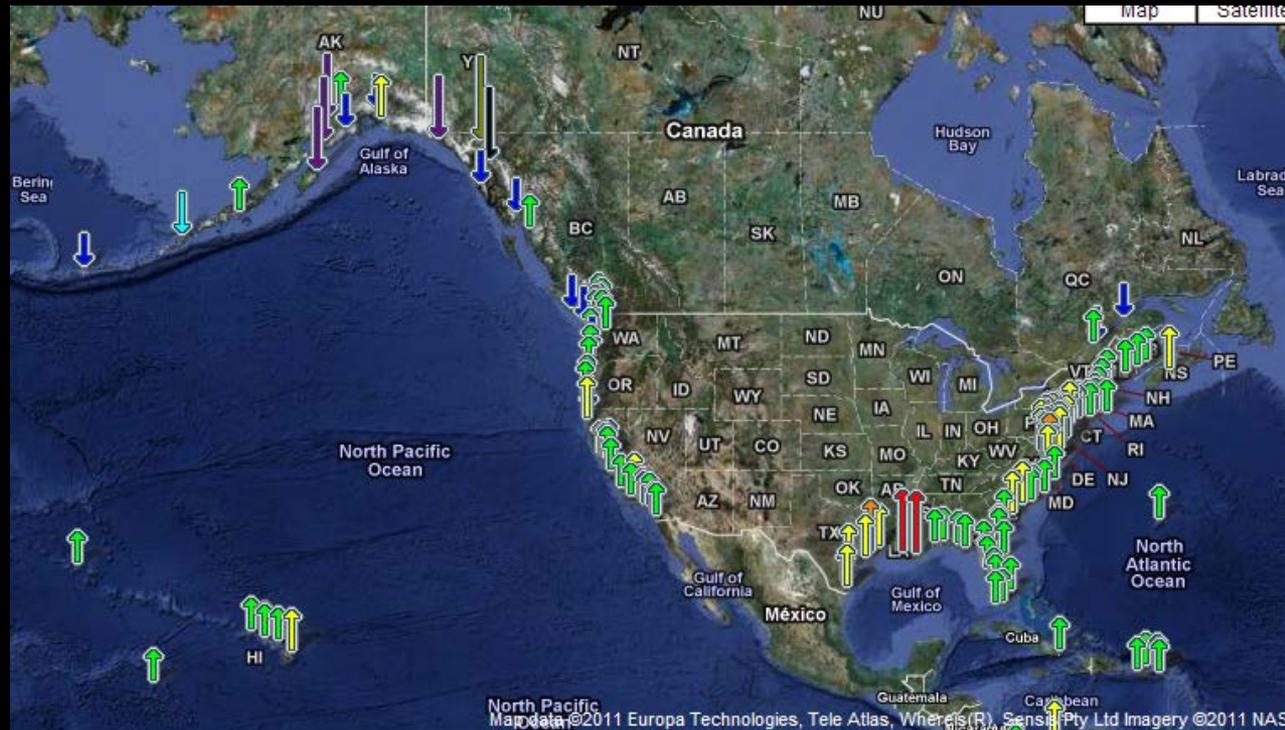
- Steric expansion
- Ice melt

Relative SL:

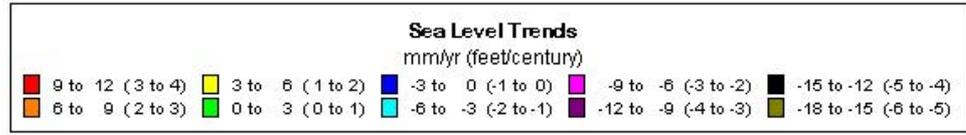
- Isostatic rebound./subsidence
- Seismic activity
- Extraction subsidence

Relative sea level trend information is limited

The role that sea level trends need to play in coastal hazard planning differs greatly throughout the state

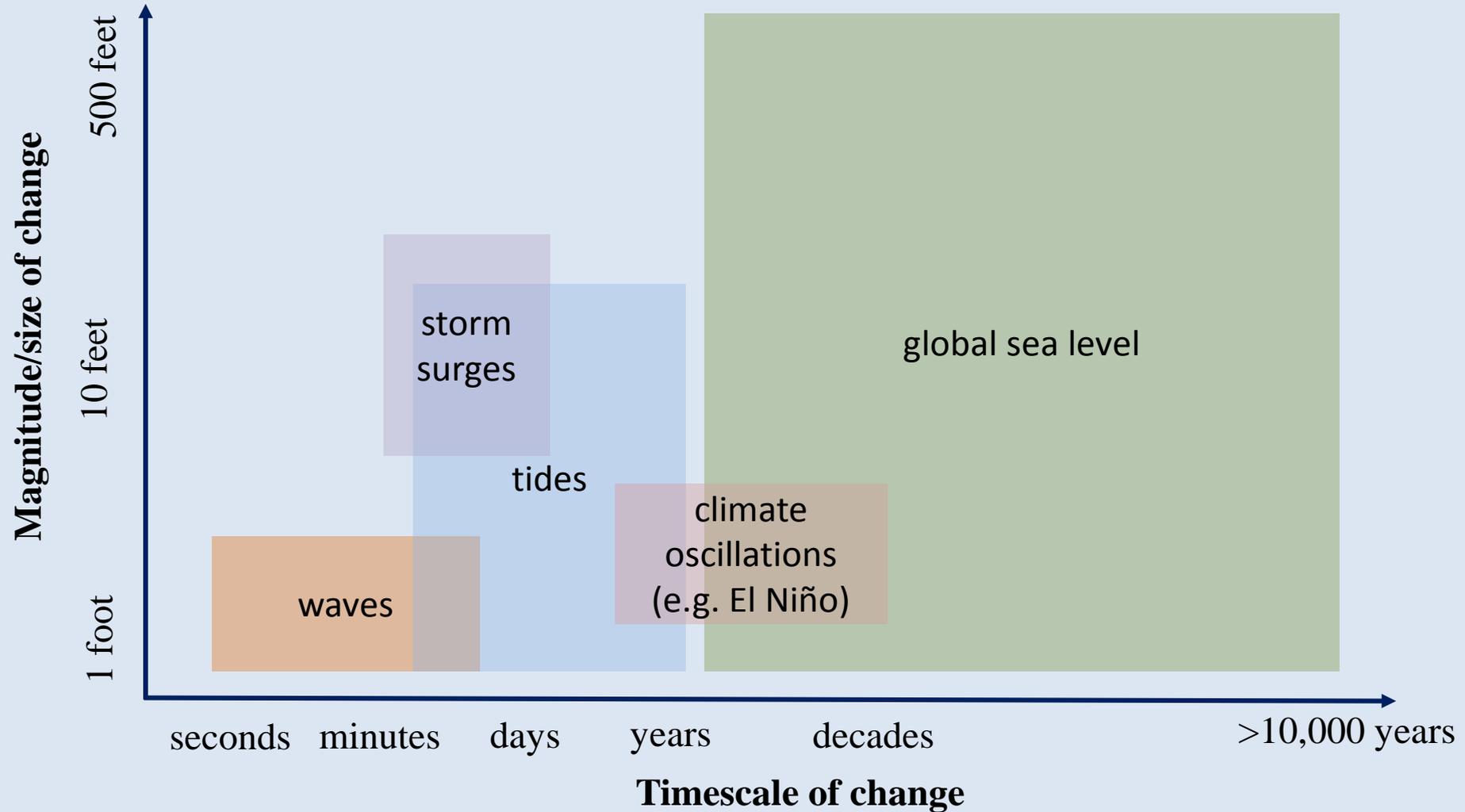


Map above illustrates regional trends in sea level, with arrows representing the direction and magnitude of change. Click on any arrow for additional information about that station.

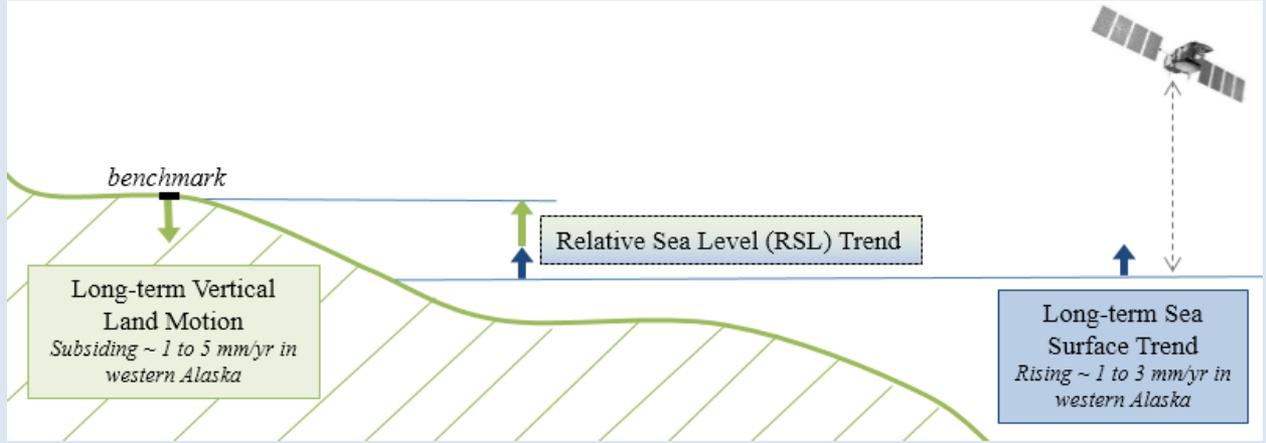
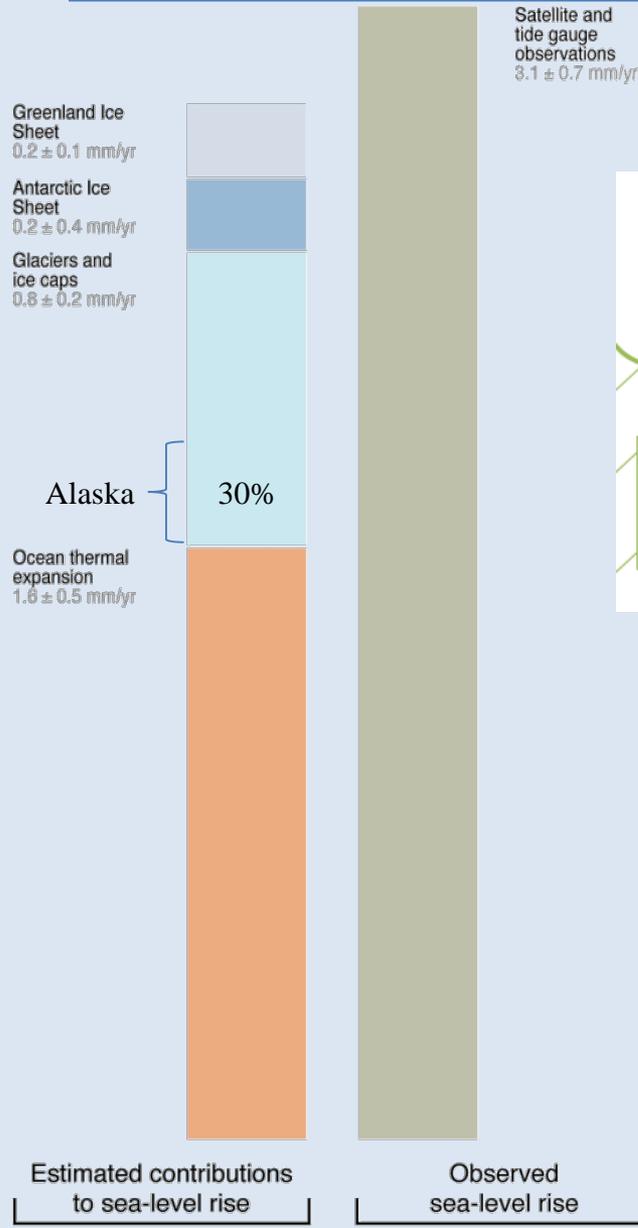


NOAA SL Trends, 2010

Ocean Surface Variability



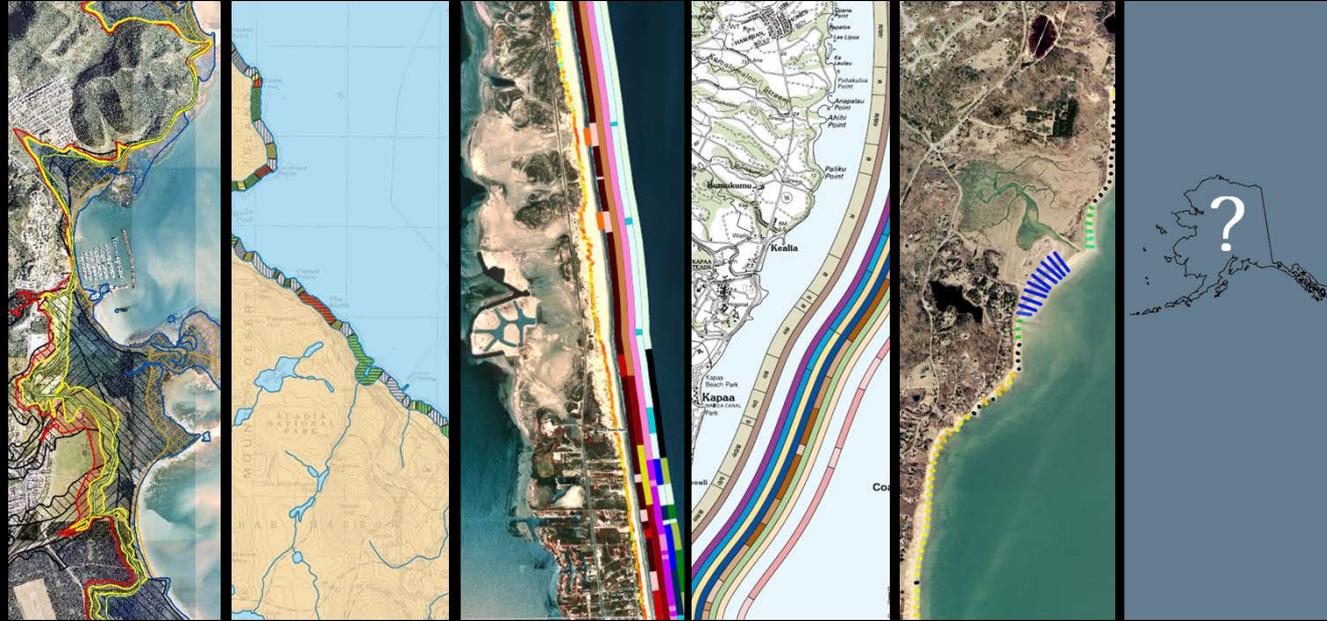
What Processes Change Global Sea Levels?



1. Melting Land Ice

2. Thermal Expansion

Hugo Ahlenius, 2007



Why

**ARE THERE NOT BETTER
COASTAL MAP PRODUCTS IN
ALASKA?**

COASTAL VULNERABILITY MAPPING – ALASKA CHALLENGES



Shaktolik, AK

(Kinsman 2011)

vs.



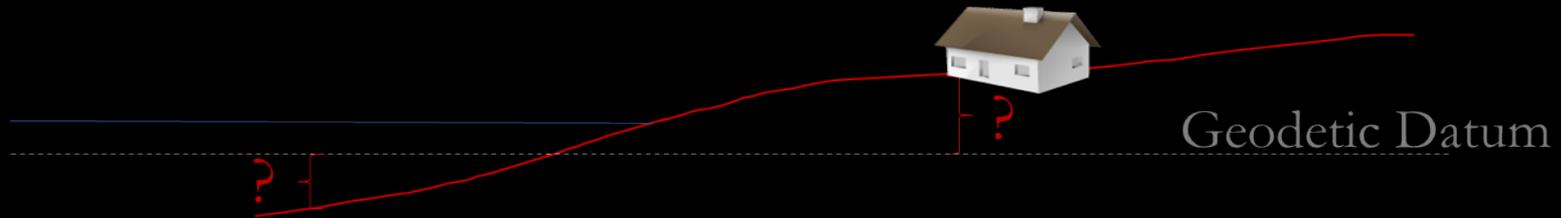
San Diego, CA

(www.oceanlight.com)

- Existing methodologies designed for densely populated coastlines
- Unique hazards & different emphasis
- Longest coastline in the United States - very diverse coastal environments
- Extremely limited baseline data
 - Water levels, historic event record, aerial imagery, topography & bathymetry
- Coastal economics are fundamentally different

Elevation Models

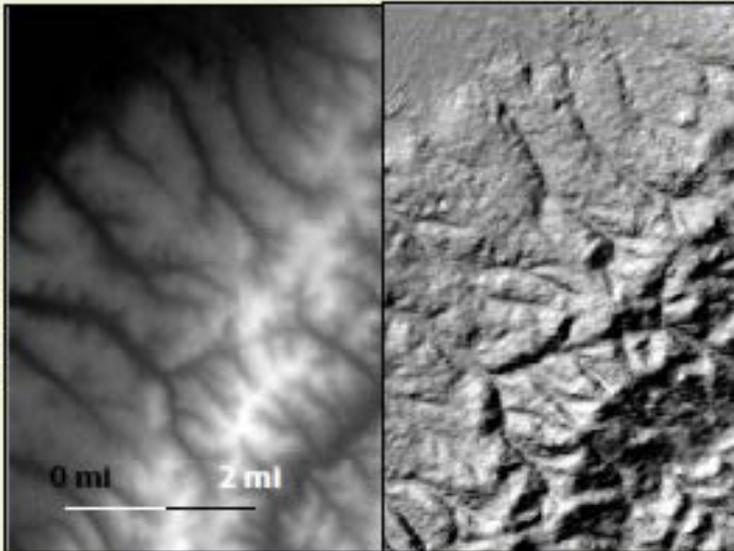
→ How high is the land and how deep is the water?



ALASKA

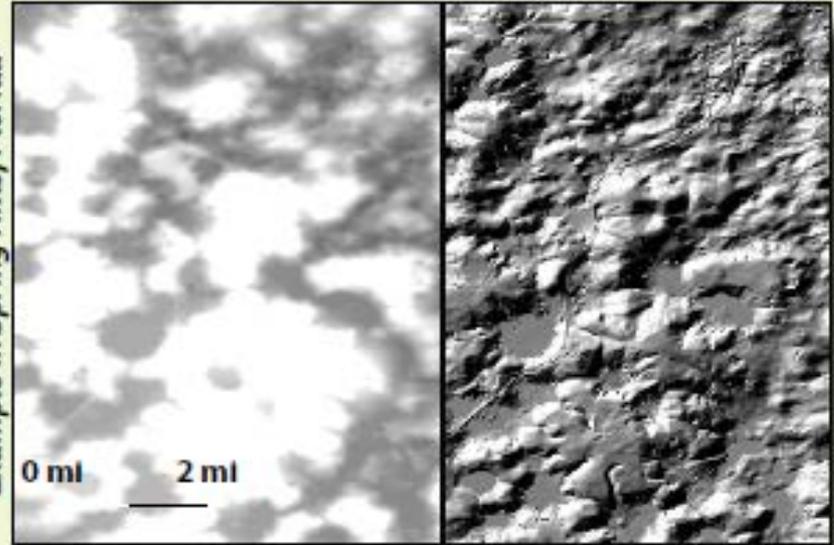
THE LOWER 48

Example along the east shore of Norton Sound



Full Coverage, 30 m spatial resolution

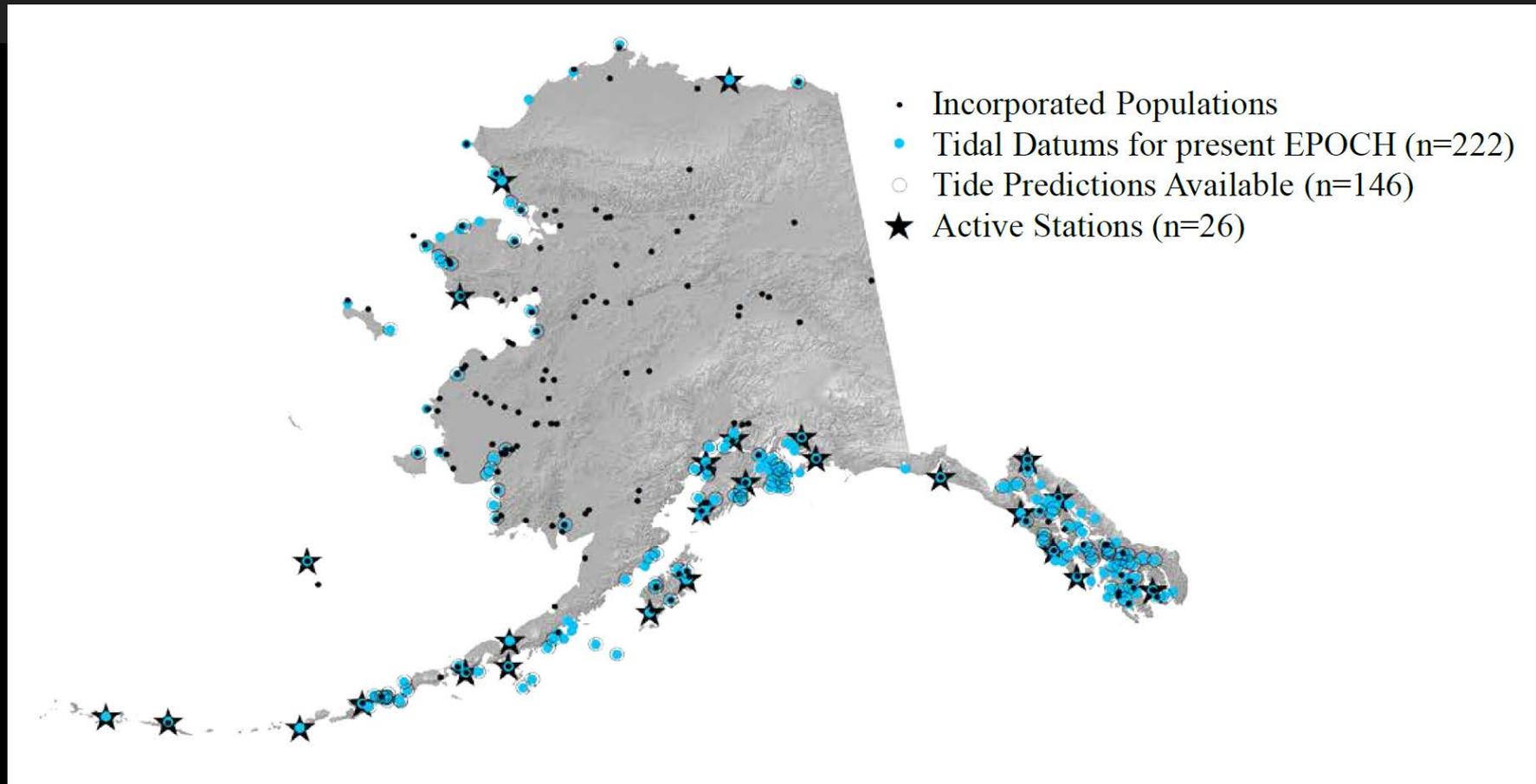
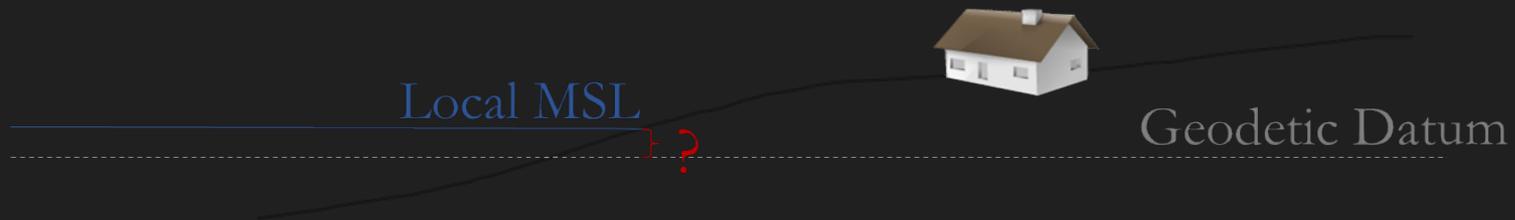
Example in Spring Hills, Florida



Full Coverage, 10 m spatial resolution

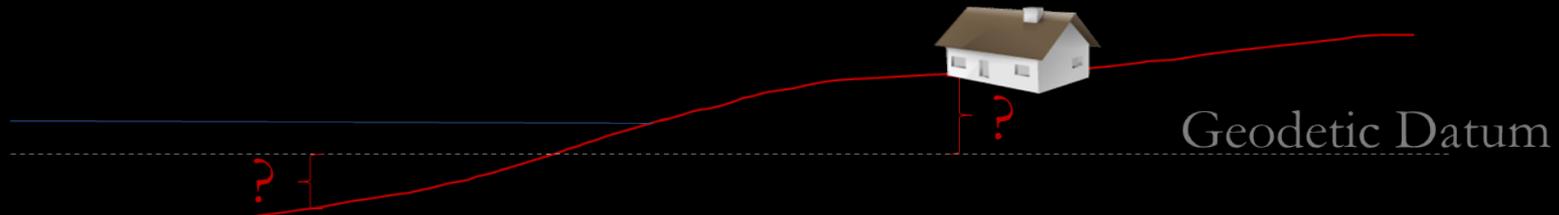
Tide Gauges

→ Where is the water relative to land?



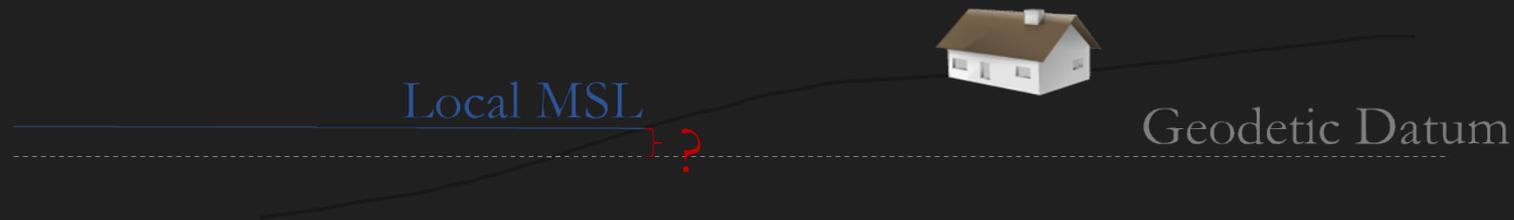
1. *Elevation Models*

→ How high is the land and how deep is the water?



2. *Tide Gauges*

→ Where is the water relative to land?



3. *Storm Surge*

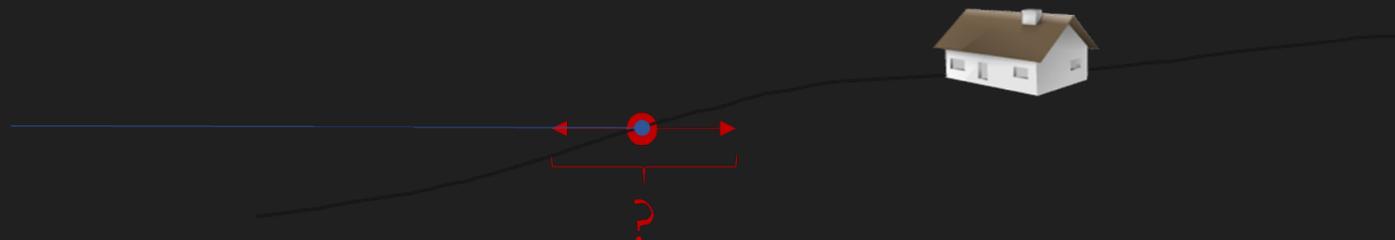
→ How do ocean and waves behave in a storm?

Storm Surge (+ tide, setup, and runup)

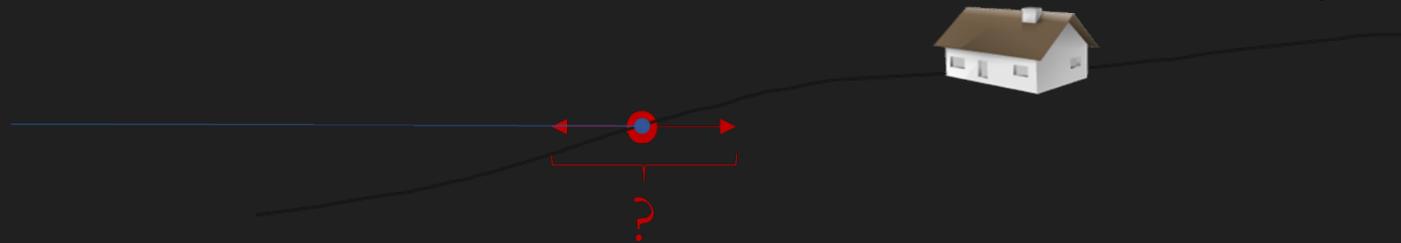


4. *Shoreline Positions*

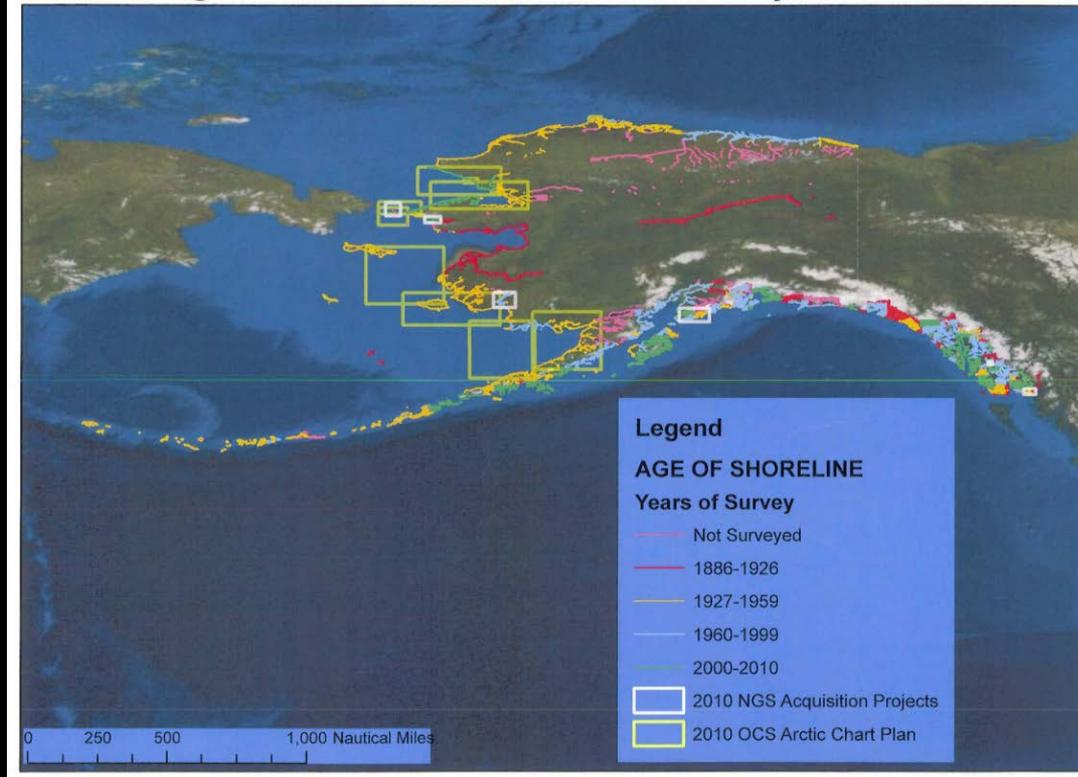
→ Where is the coast and where was it in the past?



Shoreline Positions → *Where is the coast and where was it in the past?*



Vintage of NOAA Shoreline Surveys in Alaska

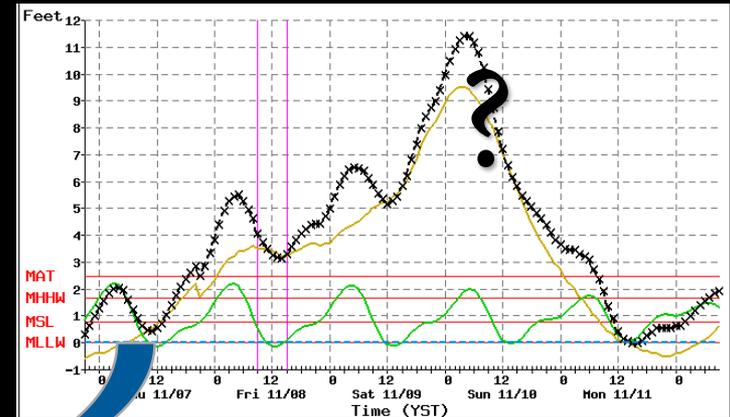


“Less than 10% of Alaska has contemporary shoreline data [1960 or newer] and less than 1% is mapped annually.”
 - NGS, 2012

Qualitative → Quantitative Observations



SHAKTOOLIK, NOVEMBER 2011



Baseline Data is the Foundation for Evaluating Change



PORT HEIDEN, 2006 (SHOREZONE)



PORT HEIDEN, 2013

~~Rapid Erosion
is occurring~~

38.2 ft/year of
Erosion



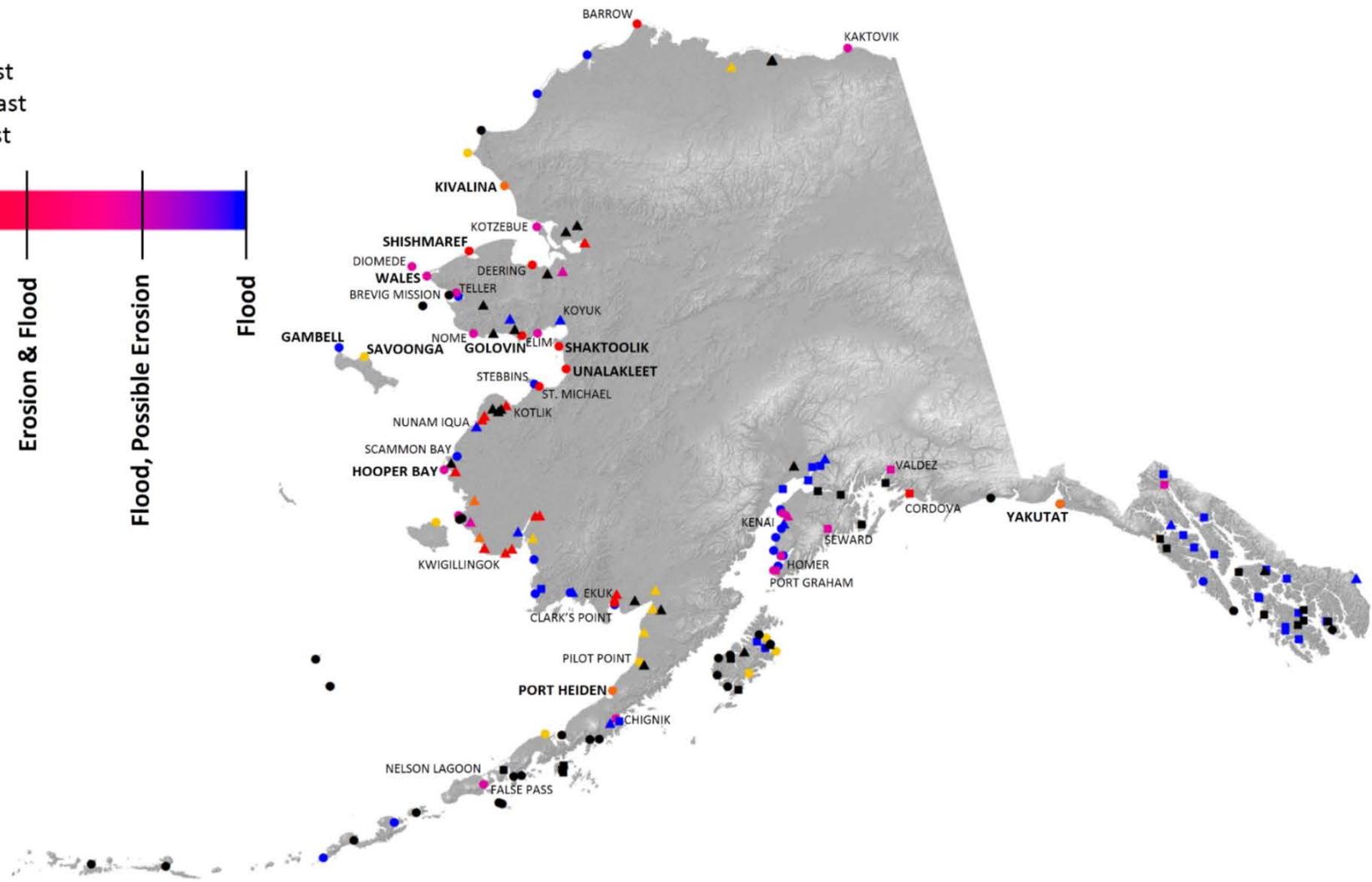
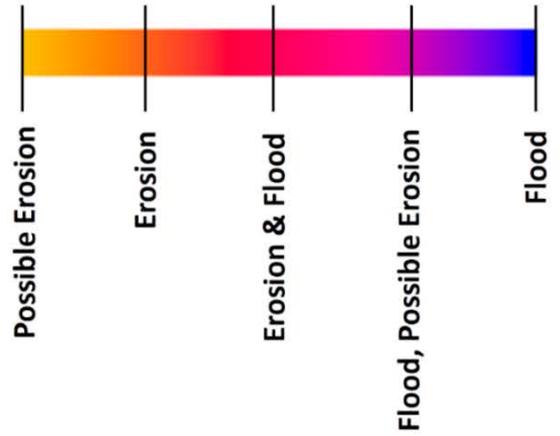
DGGS is

COLLECTING BASELINE DATA

Alaska Coastal Populations Vulnerable to Flooding and Erosion

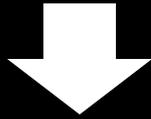
Key

- Exposed Coast
- Sheltered Coast
- ▲ Riverine Coast



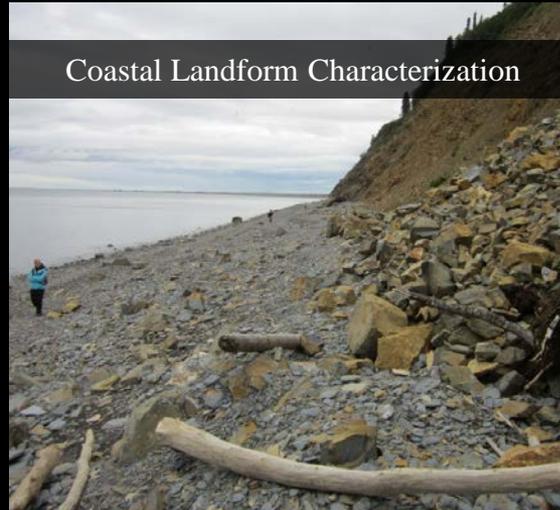
BASELINE DATA COLLECTION

What has shaped the coast?
What is shaping the coast now?



Benefits of documenting coastal processes in detail:

- Map areas of vulnerability
- Establish baselines to monitor changes in event timing, frequency and magnitude
- Design effective mitigation strategies
- Understand how modifications will influence the coastal environment
- Improve mathematical models that predict hazard impacts
- Provide forecasters with known values to test accuracy



Sediment Sources and Grain size

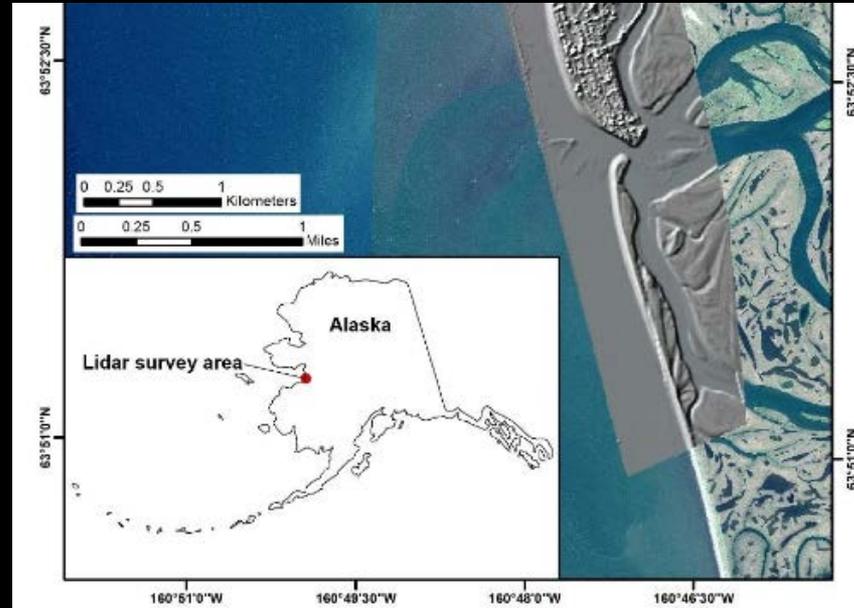


Distribution of Overwash Deposits (and erosion features)

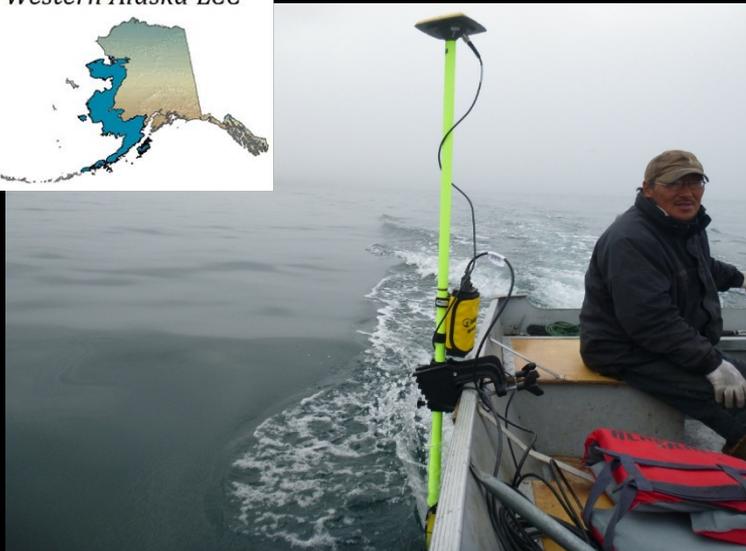


EXAMPLE: New Aerial Imagery and Elevation Models

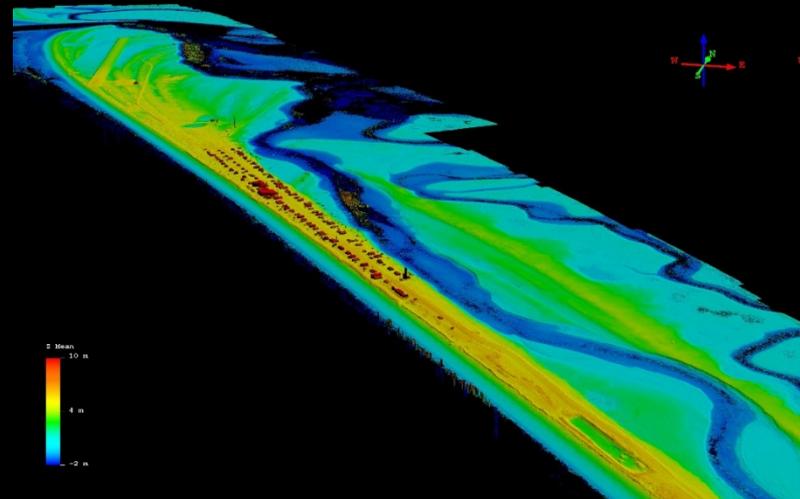
- Coastal imagery:
 - Oblique and orthoimages
 - Historical and contemporary
- Elevation data:
 - Topography
 - Nearshore bathymetry
 - Ground control
 - Tidal datums



Archive lidar release, Unalakleet (2005) – [DGGS Raw Data File 2014-2](#)

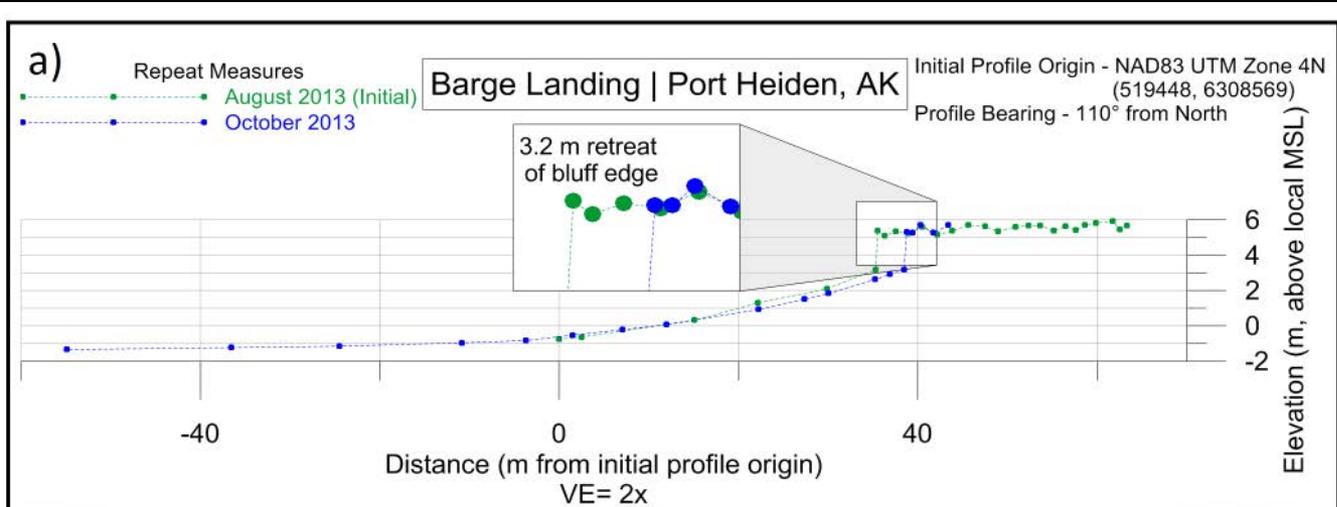


Portable sonar work with Dylan Iya, Savoonga (2013)



Photogrammetric DEM, Shaktoolik, Alaska (2014) –
in [DGGS Misc. Publication 154](#)

EXAMPLE: Coastal Profiles (Snapshots of Beach Elevation)



EXAMPLE: Mapping Shoreline Positions



New Water Level Sensor in Unalakleet

Purpose: To monitor water levels and improve overall understanding of how storm surges occur in western Alaska.

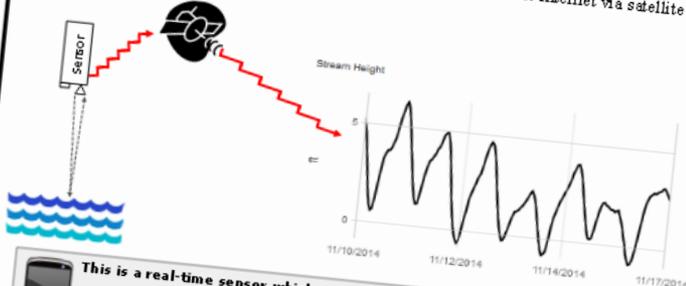
The Alaska Division of Geological & Geophysical Surveys (DGGS) and the National Weather Service (NWS) will use this information to improve storm surge planning resources and forecasts.

Where is it?
Mounted on the south side of the bridge that crosses the slough →

How does it work?
An acoustic range-finder measures the height of the water (or ice) once per hour and relays this information over the internet via satellite connection.



New continuous water level stations:
Tununak and Unalakleet (2014)
– NWS and [AOOS Real-Time Sensor Map](#)



This is a real-time sensor which means you can check out the water level live!
Just visit <http://binvurl.com/AOOSPortal-UnalakleetGauge>
Or <http://binvurl.com/RFC-UNK>

Let us know what you think!
Contact: nicole.kinsman@alaska.gov



Measured limit of wave run-up – [DGGS Report of Investigations 2012-2](#)

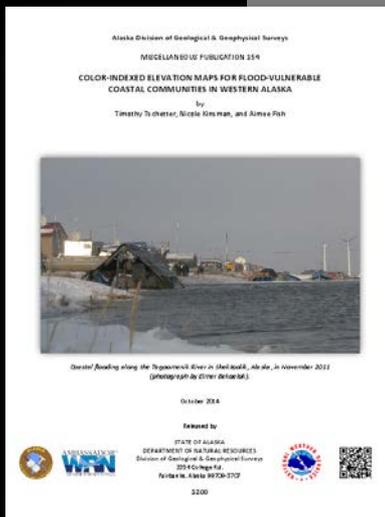




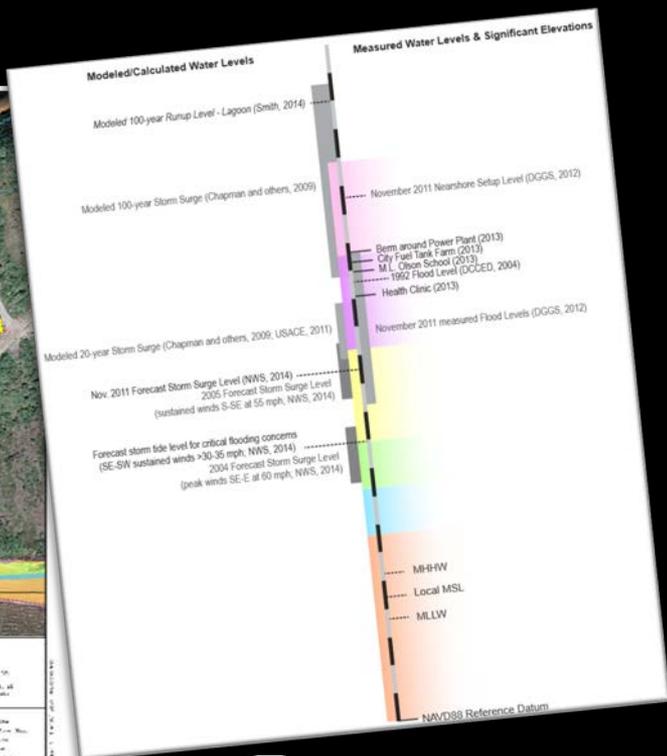
New &
Upcoming

COASTAL MAPS AND RESOURCES

Color-Indexed Elevation Maps for Coastal Communities



- Resource to improve 2-way communication about flood impacts
- Pilot project in 5 locations: UNK, SKK, GLV, SHH and KVL
- A stopgap tool on the way to flood maps



Interactive Mapping Tool for Coastal Elevation Profiles

State of Alaska myAlaska My Government Resident Business in Alaska Visiting Alaska State Employees

Alaska Coastal Profile Tool (ACPT)

Alaska Division of Geological & Geophysical Surveys

State of Alaska > Natural Resources > Geological & Geophysical Surveys > Maps > ACPT

TO USE:

1. Click to zoom to a Region (○)
2. Select a Coastal Profile:
 - One measurement
 - Repeat measurements
3. Elevation Plot will appear. Adjust the vertical exaggeration to change the visible level of relief.
4. View multiple time-series, if available, by highlighting more than one Collection Date (*hold down Shift key*).

This interactive tool enables access to beach elevation profile measurements collected throughout Alaska since the 1960s. Users can explore profile measurements collected by DGGs and others as time-series plots and location-based images of the shoreface environment. The map has been designed to accommodate datasets collected with differing techniques, including differential leveling, survey-grade GPS or extraction from lidar-derived digital elevation models.

Lines on the overview map depict the position and shape of the most recent data at each coastal profile; remeasured profiles are displayed as coincident for comparative purposes, however, the precise location of past measurements may vary due to differing collection methods.

[Source data](http://www.dggs.alaska.gov/pubs/id/27359) for this application is available for download. For complete citation information, contributor and funding acknowledgements and metadata, please see <http://www.dggs.alaska.gov/pubs/id/27359>

Alaska Coastal Profile Tool: maps.dggs.alaska.gov/acpt/

Interactive Mapping Tool for Coastal Elevation Profiles

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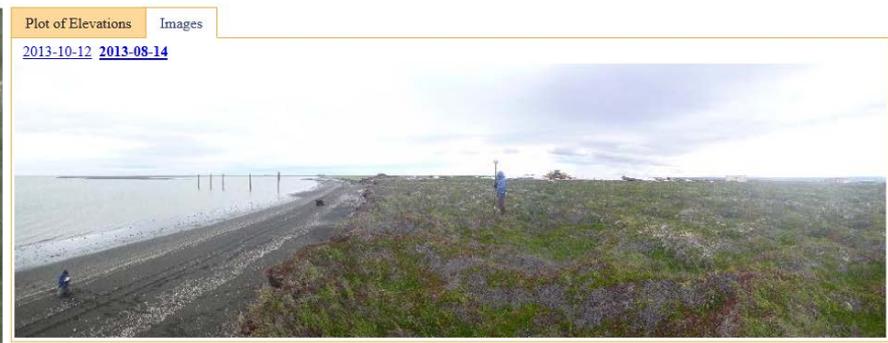


TO USE:

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2. Select a Coastal Profile: — One measurement — Repeat measurements
3. Elevation Plot will appear. Adjust the vertical exaggeration to change the visible level of relief.
4. View multiple time-series, if available, by highlighting more than one collection Date (*hold down Shift key*).

Plot of Elevations Images

2013-10-12 2013-08-14



1000 m
6000 ft
Unknown
Google

Profile ID: Port Heiden 9

Vertical Exaggeration: Maximum

Collection Dates:
2013-10-12
2013-08-14

2013-10-12
2013-08-14

Elevation (meters)

Distance (meters)

This interactive tool enables access to beach elevation profile measurements collected throughout Alaska since the 1960s. Users can explore profile measurements collected by DGGS and others as time-series plots and location-based images of the shoreface environment. The map has been designed to accommodate datasets collected with differing techniques, including differential leveling, survey-grade GPS or extraction from lidar-derived digital elevation models.

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- [DGGS Digital Data Series 7](#)
- New datasets each month
- Raw data download
- Non-DGGS contributions welcome

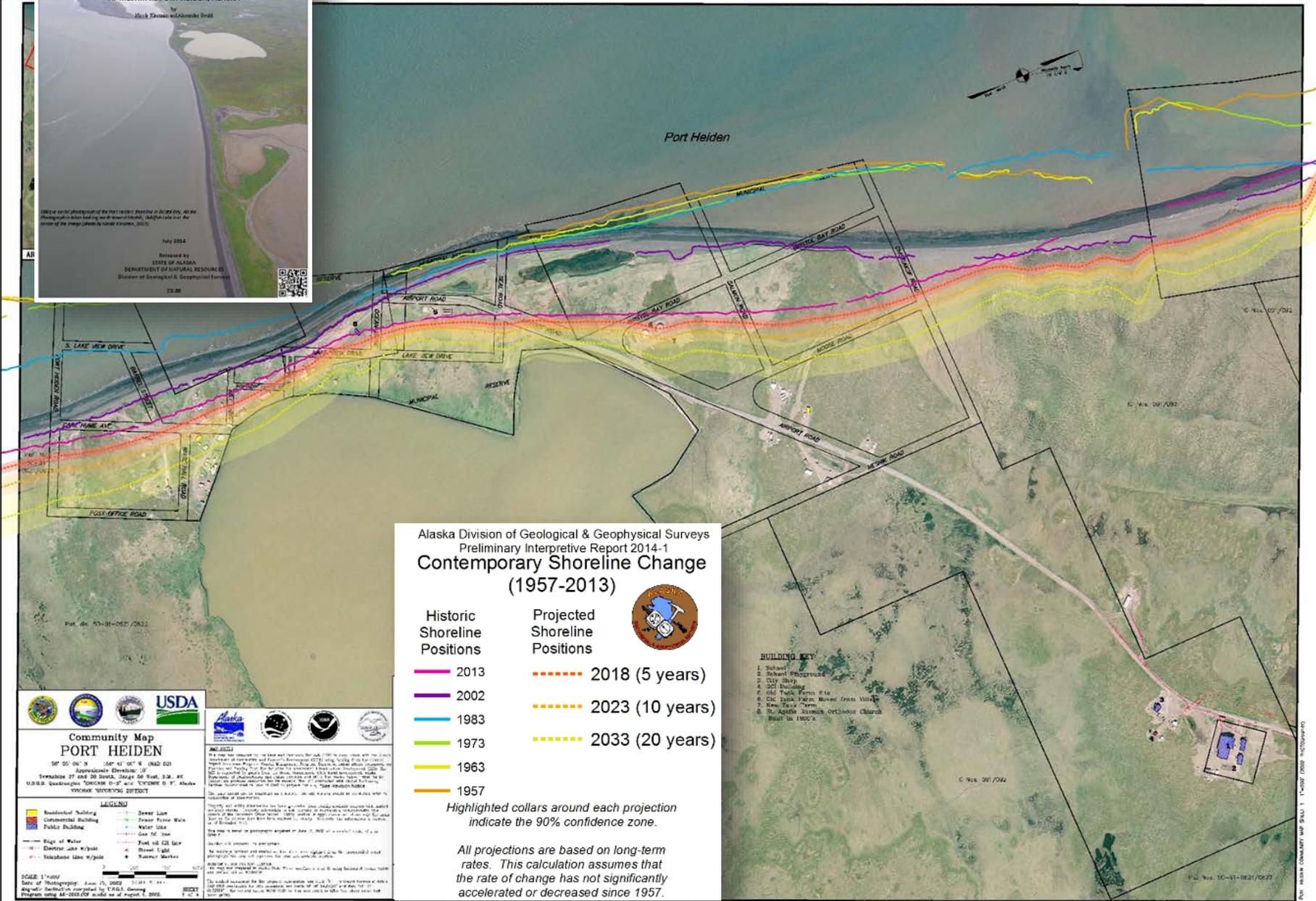
Shoreline Change and Projected Shoreline Position Maps

Division of Geological & Geophysical Surveys
 PRELIMINARY INTERPRETIVE REPORT 2014-1
**CONTEMPORARY SHORELINE RETREAT RATES
 AT MESHIK IN PORT HEIDEN, ALASKA**
 by
 Nick Krause and Aleksandra Orulic

July 2014

Released by
 STATE OF ALASKA
 DEPARTMENT OF NATURAL RESOURCES
 Division of Geological & Geophysical Surveys

73.00



Alaska Division of Geological & Geophysical Surveys
 Preliminary Interpretive Report 2014-1
**Contemporary Shoreline Change
 (1957-2013)**

Historic Shoreline Positions	Projected Shoreline Positions
2013	2018 (5 years)
2002	2023 (10 years)
1983	2033 (20 years)
1973	
1963	
1957	

BUILDING KEY

- School
- Sheriff's Office
- City Shop
- GC Building
- Old Public Farm #14
- Old Public Farm Moved from Village
- New Public Farm
- St. Agatha Russian Orthodox Church Built in 1900's

**Community Map
 PORT HEIDEN**

50° 55' 00" N 156° 41' 00" W (NAD 83)
 Approximate Elevation: 0'

Termination 17 and 30 South, Stage 66 West, 2.5" X 4"
 U.S.G.S. Quadrangle "DENKIN D-3" and "DENKIN D-4" Alaska
 TOWNHIP TOWNSHIP DISTRICT

LEGEND

Residential Building	Sewer Line
Commercial Building	Power Pole Walk
Public Building	Water Line
	Gas Line
	Fuel Oil (2) Line
Edge of Water	Broad Light
Electric Line w/pole	Runway Markers
Telephone Line w/pole	

SCALE: 1"=500'
 Date of Photogrammetry: June 25, 2002
 Date of Aerial Photography: 1957-2013
 Program using ArcGIS 9.3.1

Highlighted collars around each projection indicate the 90% confidence zone.

All projections are based on long-term rates. This calculation assumes that the rate of change has not significantly accelerated or decreased since 1957.

UPCOMING: Interactive Mapping Tool for Shoreline Change

State of Alaska

myAlaska My Government Resident Business in Alaska Visiting Alaska State Employees



Shoreline

Alaska Division of Geological & Geophysical Surveys

State of Alaska > Natural Resources > Geological & Geophysical Surveys > Maps > Shoreline



Port Heiden [\[Zoom to extent\]](#)

- 1957
- 1963
- 1973
- 1983
- 2002
- 2009
- 2011
- 2013
- 2020 Projected
- 2025 Projected
- 2035 Projected

Unalakleet [\[Zoom to extent\]](#)

This interactive tool displays historic and predicted shoreline position throughout Alaska. Users can explore the coasts of the state to see where shoreline has been in the past, and where it will be in the future. Historic shoreline positions were determined by looking at aerial photographs and satellite imagery dating back to the 1950s. Using the Digital Shoreline Assessment Tool (DSAS), rates of shoreline change were calculated. These rates were then used to project shoreline positions. Each predicted shoreline has an uncertainty, shown by a collar of dashed lines, that represents a 90 percent confidence that the shoreline will be within that area for that year. Currently, historic shoreline data are available for download but predicted shoreline positions are not.

UPCOMING: New Aerial Imagery and Elevation Models

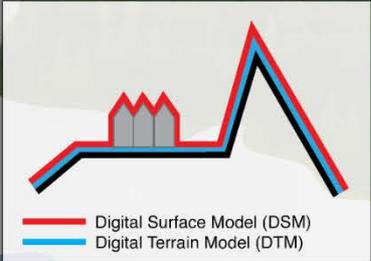


Radar	
EQUIPMENT	
COST	\$\$\$
TIME	
CONTROL	
Digital Terrain Model (DEM)	

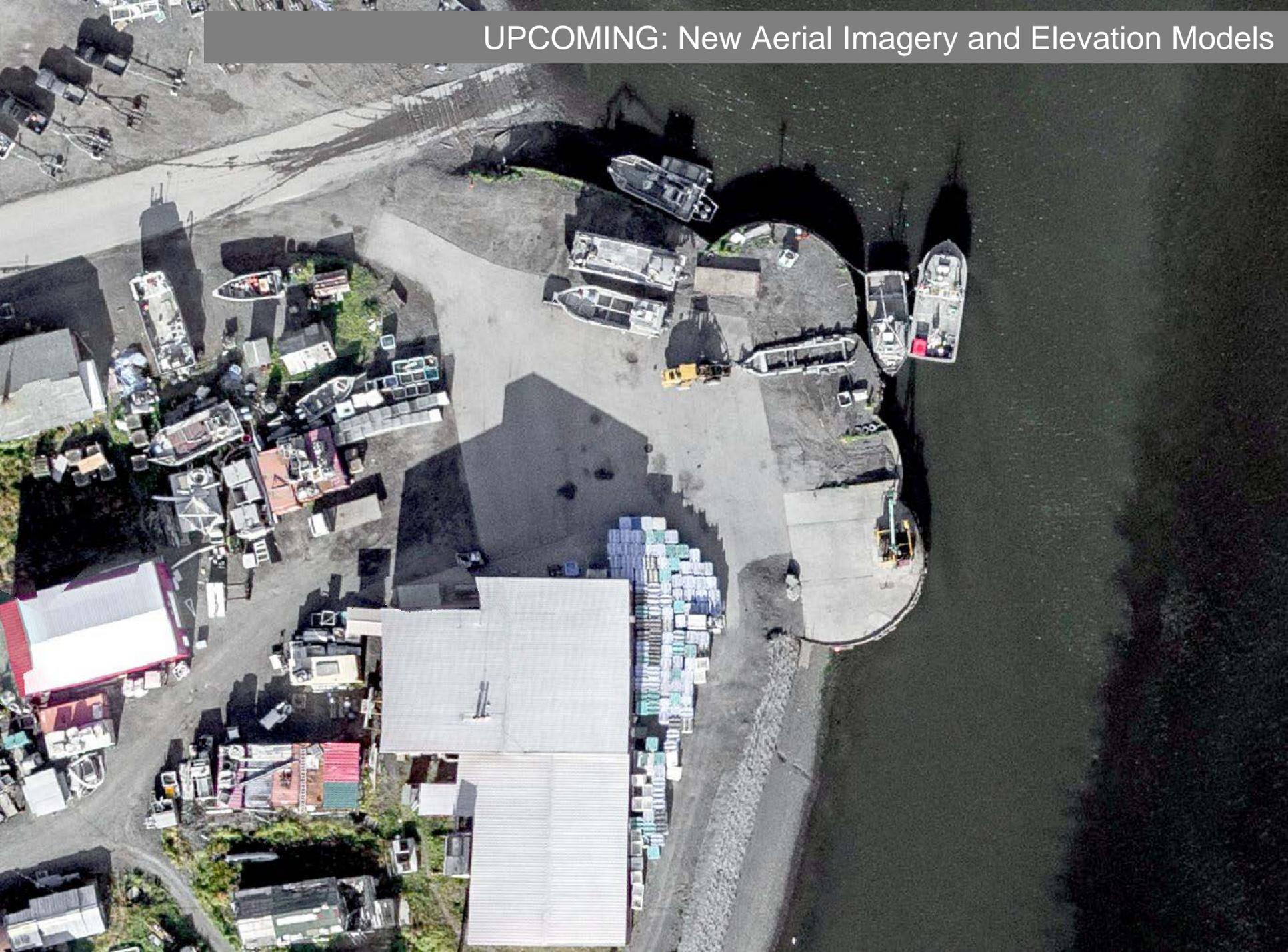
Lidar	
EQUIPMENT	
COST	\$\$\$
TIME	
CONTROL	
Digital Terrain Model (DTM) & Digital Surface Model (DSM)	

Photogrammetry	
EQUIPMENT	
COST	\$\$\$
TIME	
CONTROL	
Digital Surface Model (DSM) & OrthoPhotos	

Photogrammetry (SfM)	
EQUIPMENT	
COST	\$
TIME	
CONTROL	
Digital Surface Model (DSM) & OrthoPhotos	



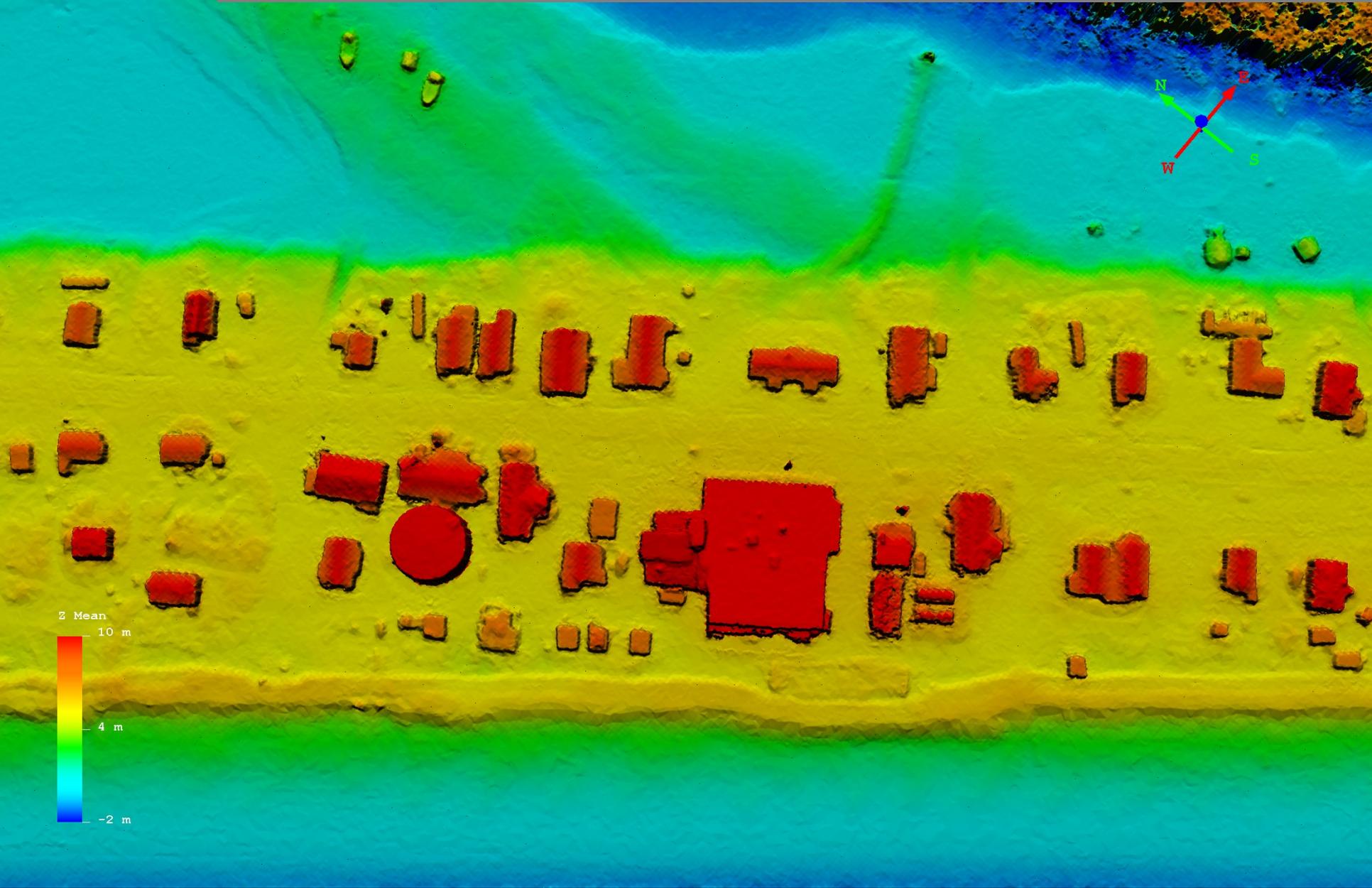
UPCOMING: New Aerial Imagery and Elevation Models



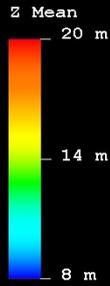
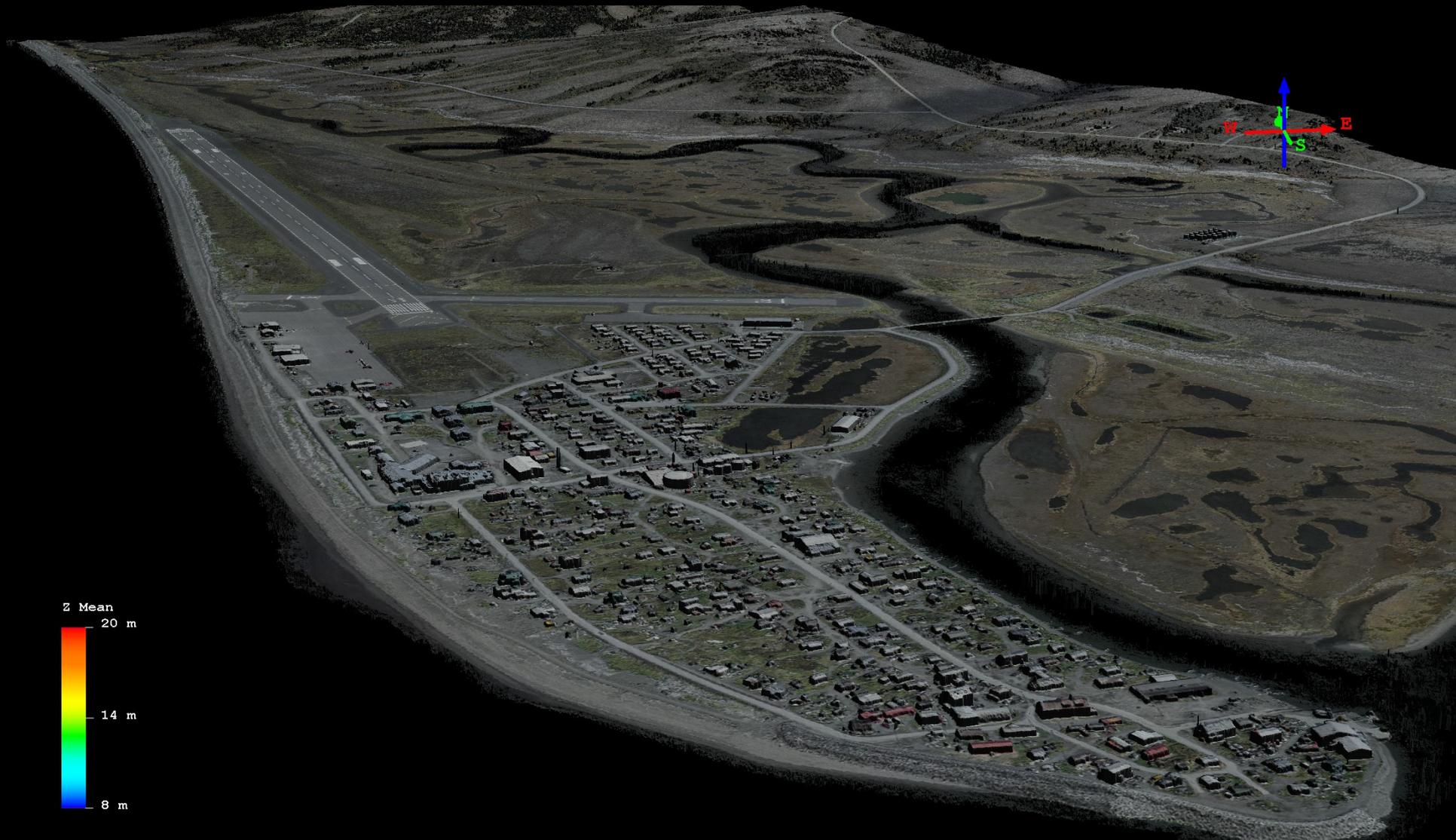
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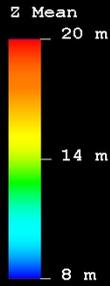
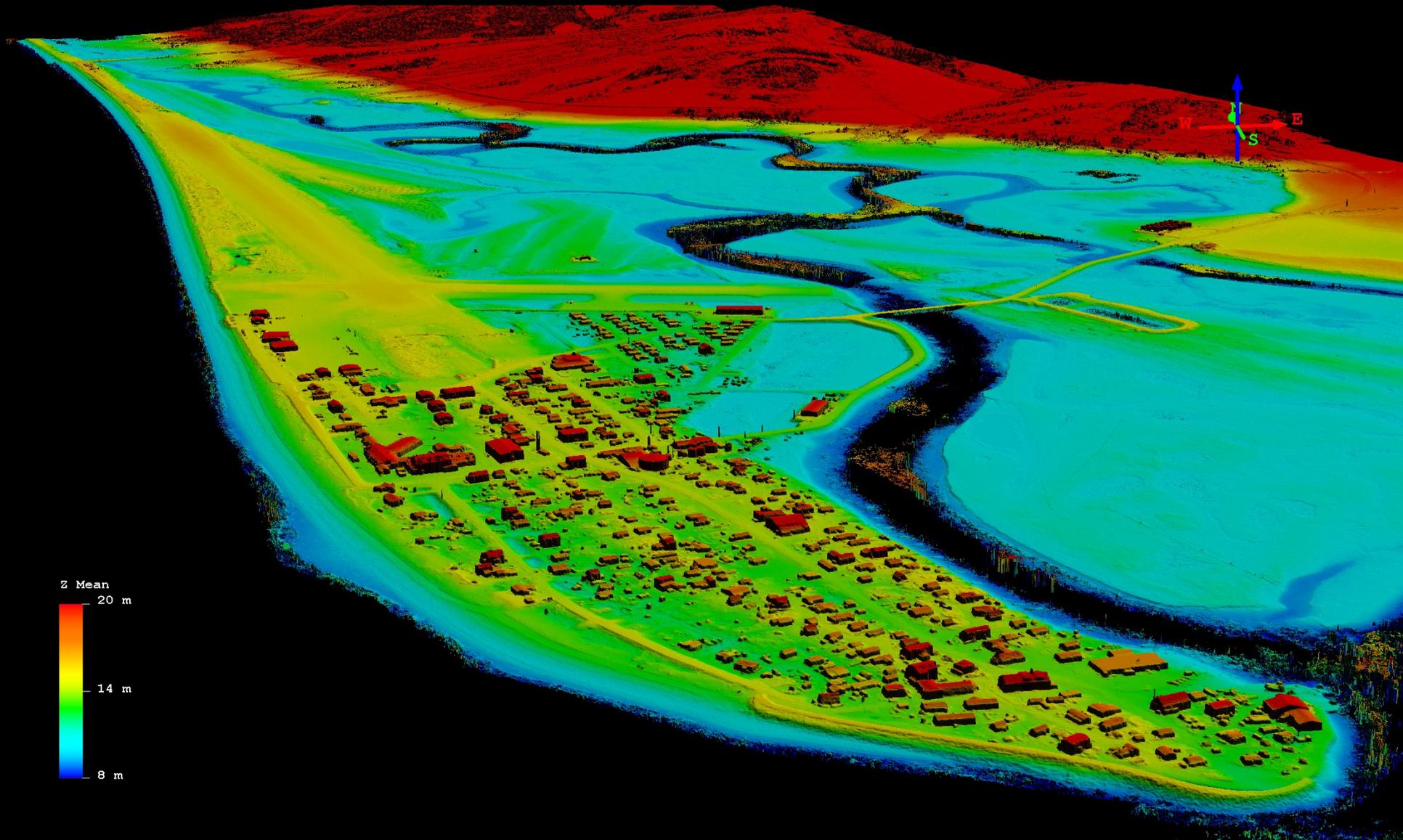
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RESIDENT INVOLVEMENT

Increase Local Observation Capabilities

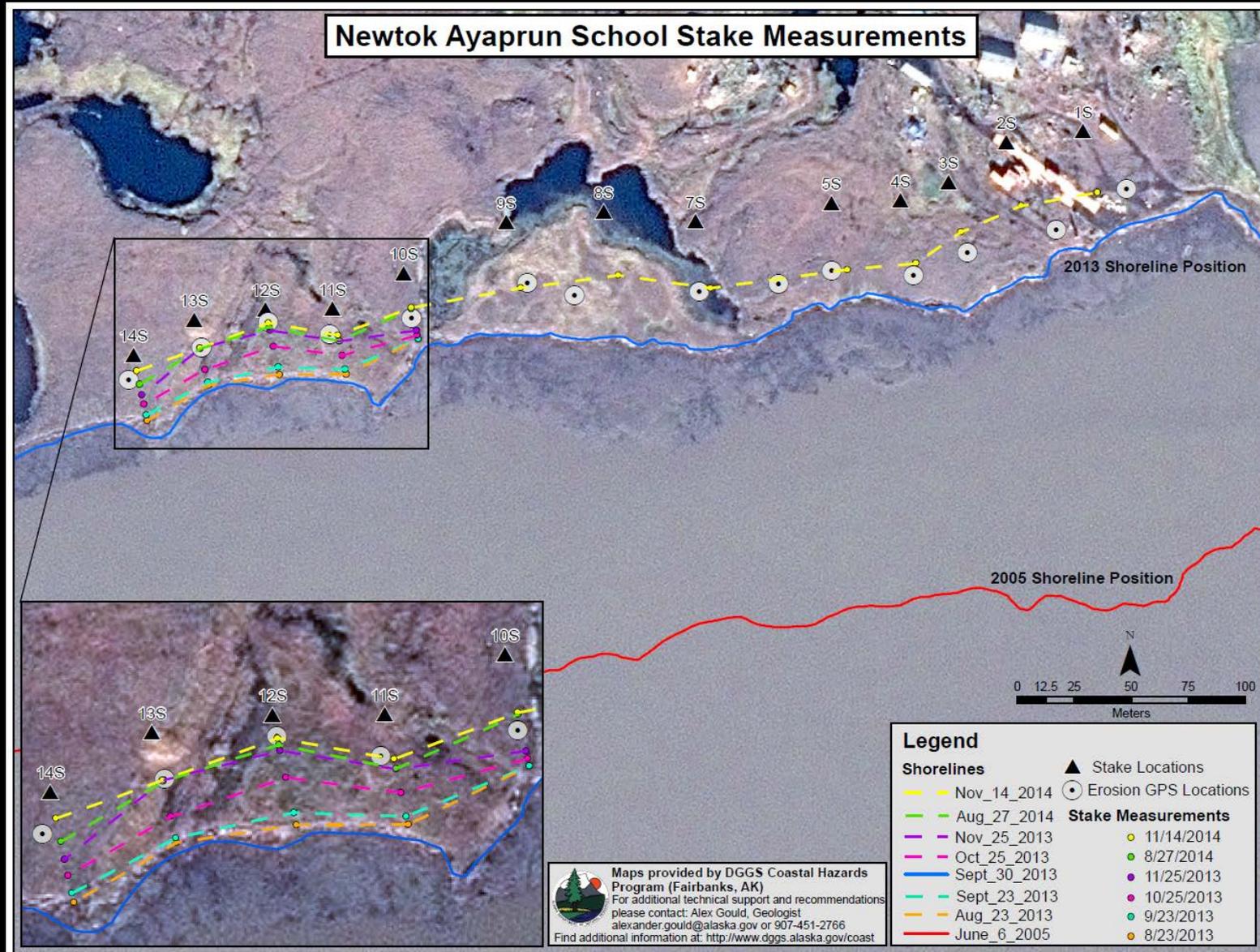


Coastal Elevation Profile - 'Emery Rod' Data Sheet

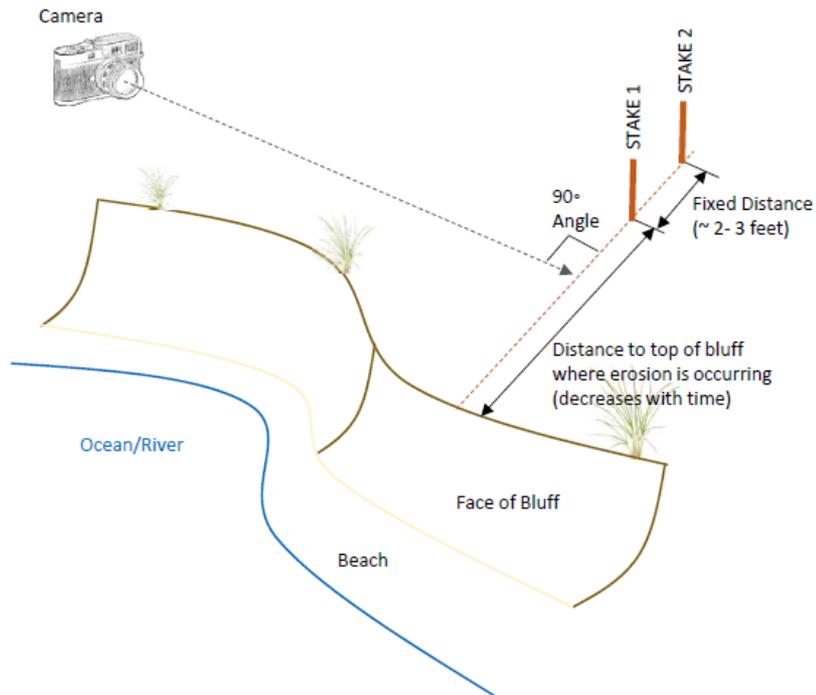
Coastal Observation Program
Division of Geological & Geophysical Surveys
Fairbanks, AK 99709
<http://www.alaska.gov/>

Date: 8/29/14
Data collection team (names): Lisa Miller, Eden Miller, Sammie Miller, Lisa Fuenfs, Veda Larsen
Location: Cannon Beach
Time at start: 10:00 a.m. Line number: 1
Fixed staking (length of rope): 15' 7"
Weather/wave conditions: Sunny, partly cloudy
Horizon visibility: good
Compass bearing: 219°

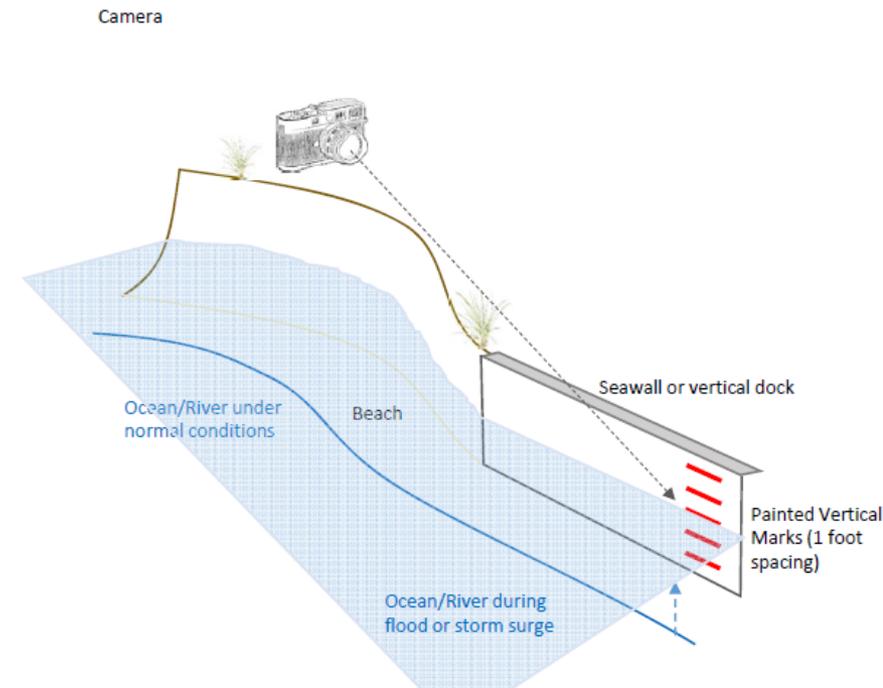
Segment #	Staking	Change in elevation	Sediment grain size or other notes
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	<input type="checkbox"/> fixed or <input type="checkbox"/>	1.6m <input type="checkbox"/> up <input type="checkbox"/> down	
	<input type="checkbox"/> fixed or <input type="checkbox"/>	1.1m <input type="checkbox"/> up <input type="checkbox"/> down	
	<input type="checkbox"/> fixed or <input type="checkbox"/>	1.6m <input type="checkbox"/> up <input type="checkbox"/> down	
	<input type="checkbox"/> fixed or <input type="checkbox"/>	1.1m <input type="checkbox"/> up <input type="checkbox"/> down	
	<input type="checkbox"/> fixed or <input type="checkbox"/>	1.6m <input type="checkbox"/> up <input type="checkbox"/> down	



Stake Erosion Monitoring in Combination with Time-Lapse Camera*



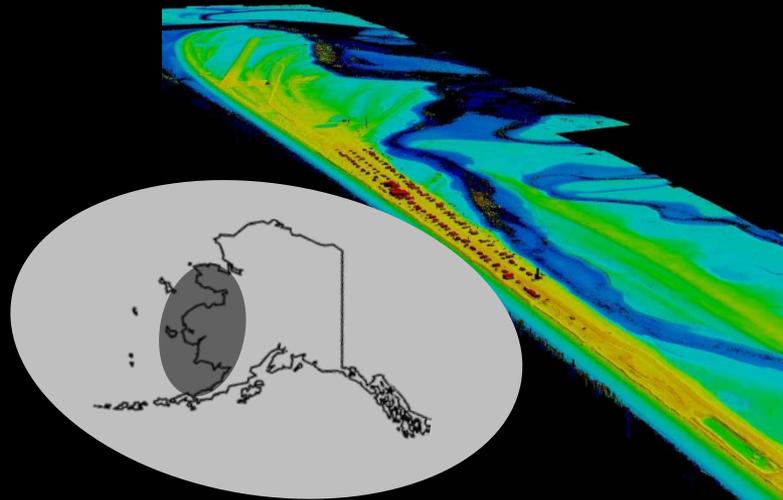
Water Level Monitoring with Time-Lapse Camera*



Baseline measurements (2-3 places on Y-K Delta, post-storm) intern?



New western Alaska aerial image & elevation collection



Expand water level monitoring network



Build a toolbox of resources and support local monitoring efforts

