Glaciers, Harbor Seals, and Chinook Salmon: What your K education can do for you

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Remote Sensing

Remote Sensing: gathering of information about an object or phenomenon without making physical contact with the object.

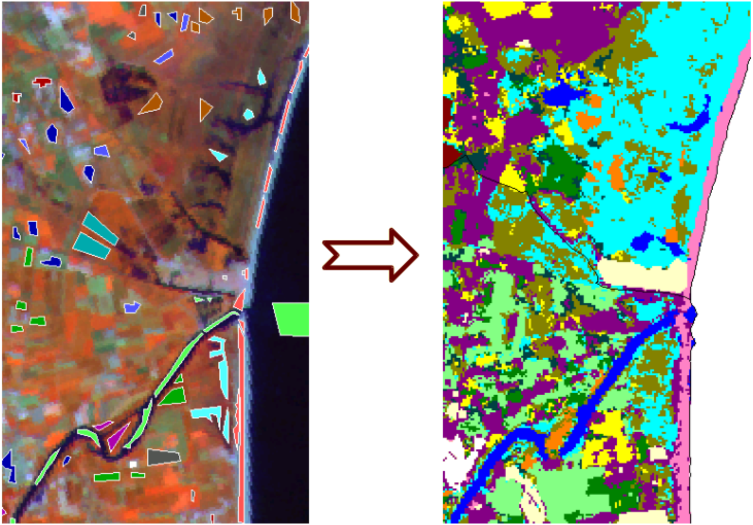
- This acquisition is typically done with satellites
- Active Remote Sensing
  - Send energy to a target, see the response
  - RADAR, LiDAR are most common examples
- Passive Remote Sensing
  - Collect only energy reflected/emitted by target
  - Most common light source: reflected sunlight
  - Cameras!

Alaska is rather big

Image classification

- Pixel-based: use “color” of pixel to determine class
  - Unsupervised classification: look for structure without any input from user
  - Supervised classification: user tells computer what to look for based on test cases
- Typically fast, not very hardware-intensive
- Can give “patchy” results for high-resolution images
- Assumes similar features will have similar responses, and that those responses are unique to those features

Pixel-based results



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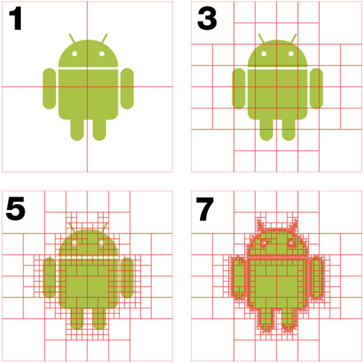

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    - Proximity to other objects/classes

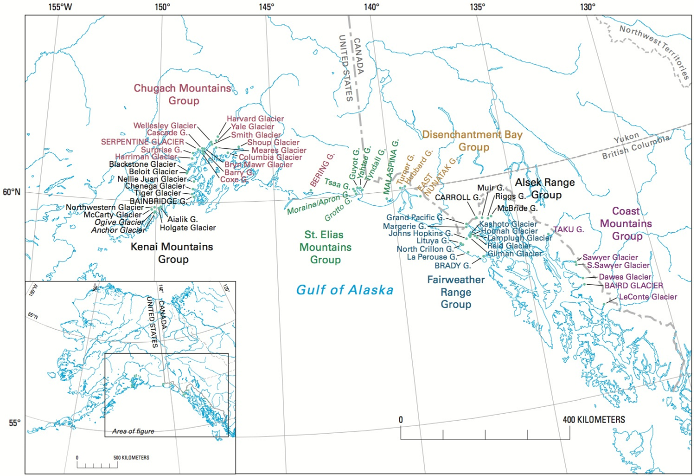
Image segmentation

- Have already seen "chessboard"
- Contrast split: maximize separation between "light" and "dark" objects

Alaska has glaciers

Some of them end in the ocean

Gulf of Alaska tidewater glaciers



Molnia, 2008

Fjord ecosystems

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  ⇒ birds, mammals, fish, and non-charismatic, non-megafauna



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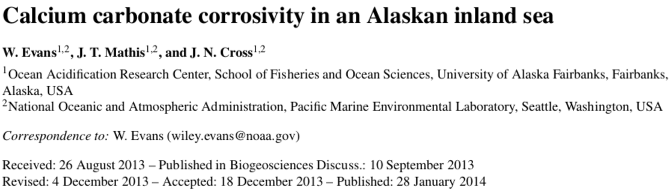
- Freshwater inputs to marine environments
  $\Rightarrow$ impacts beyond the immediate fjord environment, incl. circulation, acidification, productivity, etc.



Calcium carbonate corrosivity in an Alaskan inland sea

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- Freshwater inputs to marine environments
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- In Alaska, salmon (and crab, pollock, other fisheries) is the other king
  ⇒ ∼\$6 billion annually, ∼80,000 jobs

Local effects of glacier change

- Harbor Seals in Alaska use icebergs
  ⇒ Resting, birthing, molting, evading predators
- ↓ population ⇐ ↓ ice cover?
- What might we expect for the future?

Quantifying ice habitat

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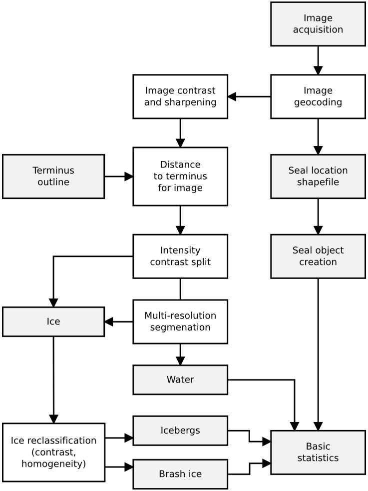
  ⇒ First, need to break image into objects, then classify

Harbor Seal surveys

- 8 years of aerial surveys (2007-2014)
  ⇒ plane equipped with GPS, IMU, SLR camera
- Surveys conducted in June (pupping) and August (molting)
- Typically ∼4 surveys per month (∼8 year)
  ⇒ weather permitting, of course
- Each survey generates ∼1000 images
- Images have ∼4 cm ground resolution

Quantifying ice habitat



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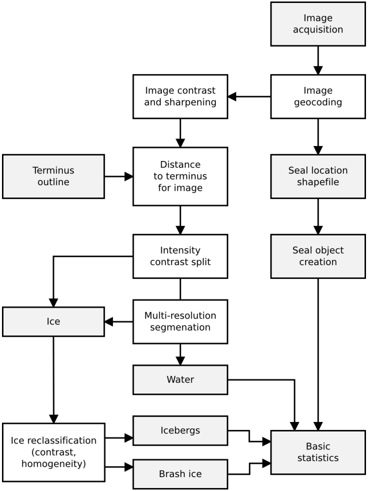
Image acquisition

Image geocoding

Image contrast and sharpening

Seal location shapefile

Terminus outline

Distance to terminus for image

Seal object creation

Intensity contrast split

Ice

Multi-resolution segmenation

Water

Ice reclassification (contrast, homogeneity)

Icebergs

Brash ice

Basic statistics

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    - Bright objects: icebergs

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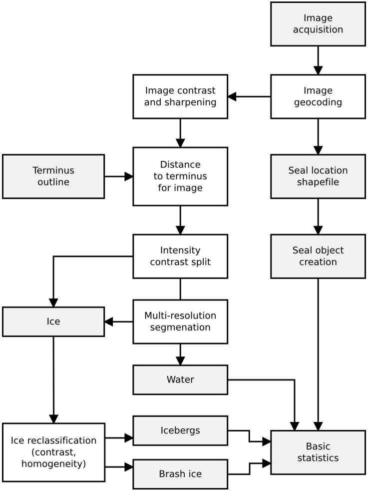
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  - Smooth objects: water

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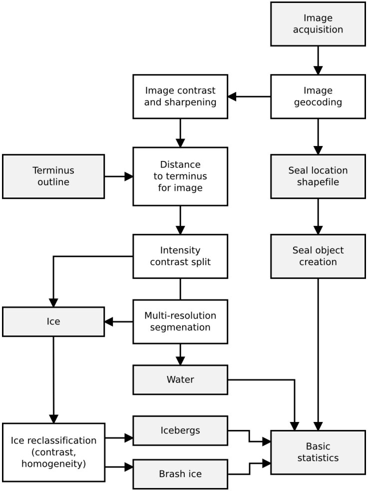

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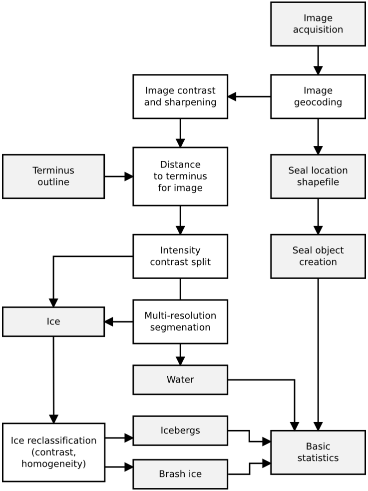

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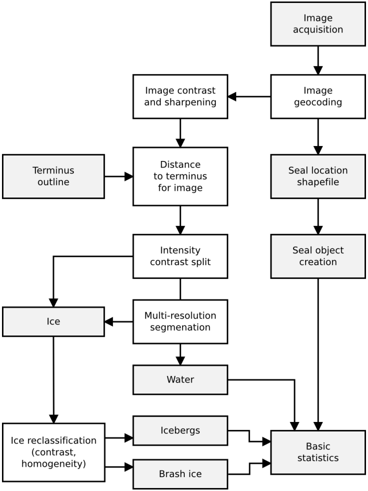

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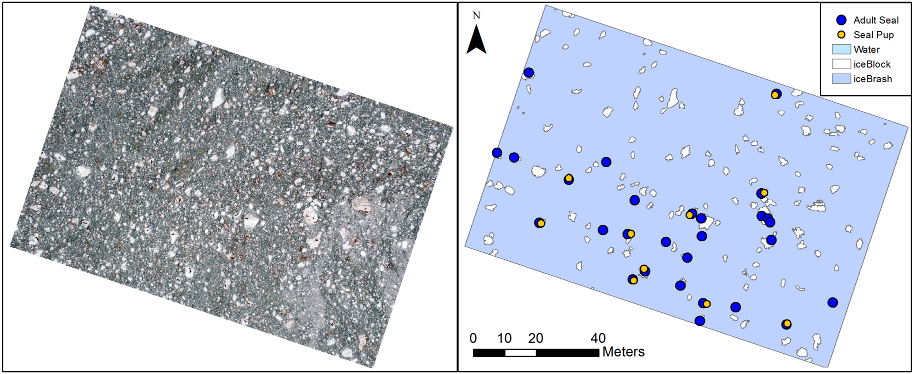
- Re-segment and re-classify ice based on intensity, size
- Generate statistics (size, angularity, distance from glacier, etc.)

Ice coverage results



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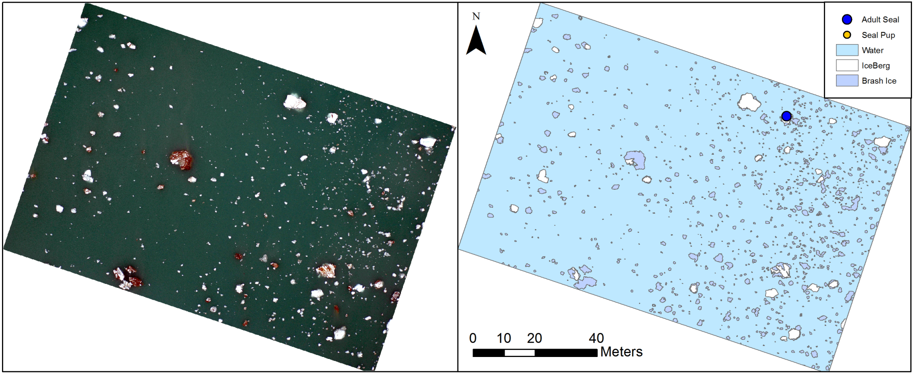

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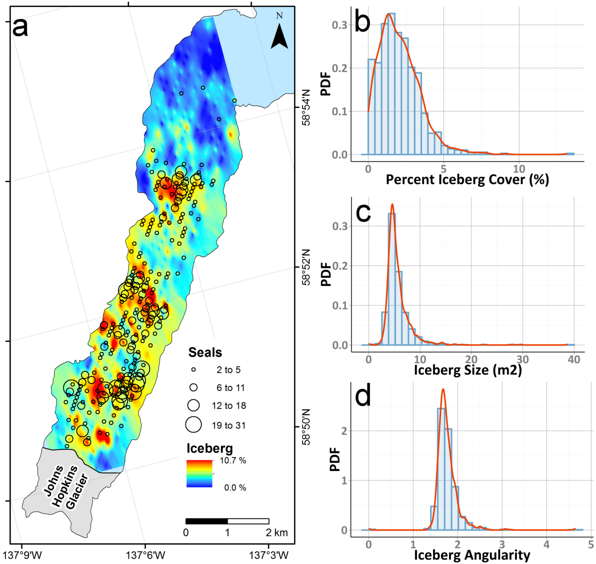
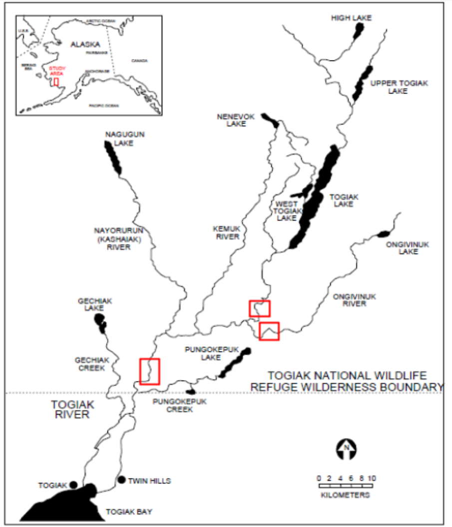
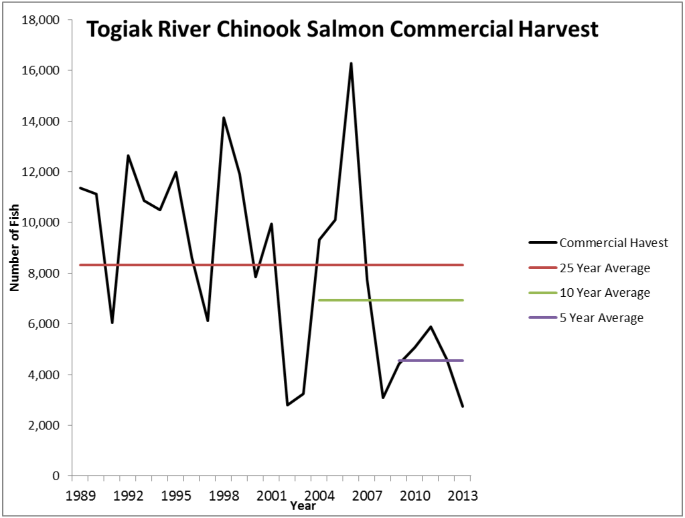


Togiak Drainage



Togiak Drainage Salmon Harvest



Riffles

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- Work classifying Chinook habitat is ongoing

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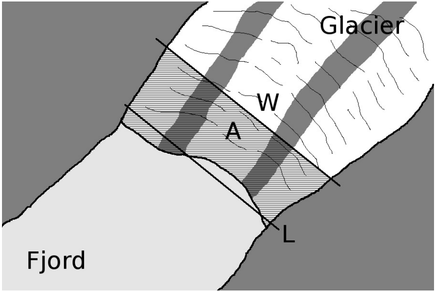
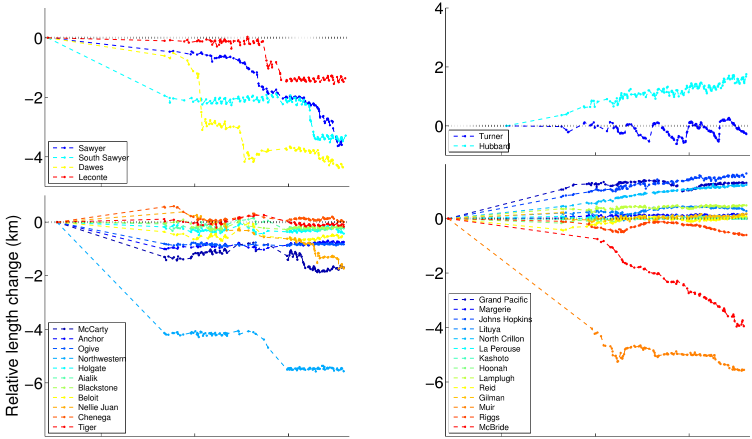
- need to measure length change, frontal ablation (calving)

Determining Glacier Length Change

- USGS topographic maps (ca. 1950) give baseline
- Manually digitized for each Landsat scene
  ⇒ >10,000 outlines total
- Length change calculated using "Box Method"
  ⇒Average distance from terminus to an arbitrary reference line



Alaska tidewater glacier length changes



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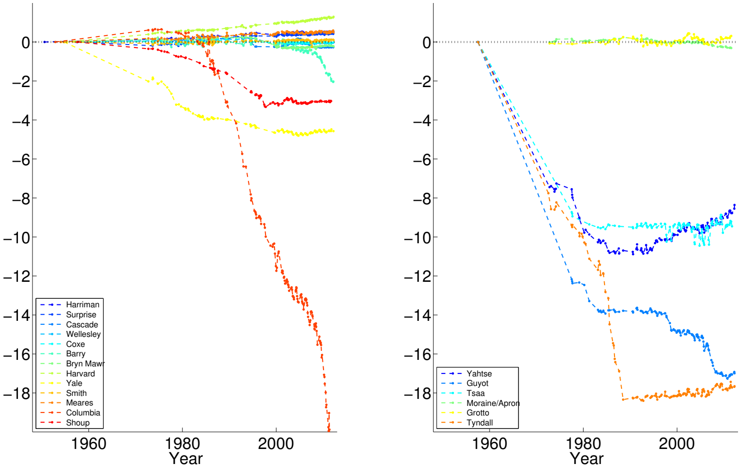

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- Need: surface velocities, ice thickness near terminus, length change

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- Manual co-registration of scenes when required ($<$1% of scenes)

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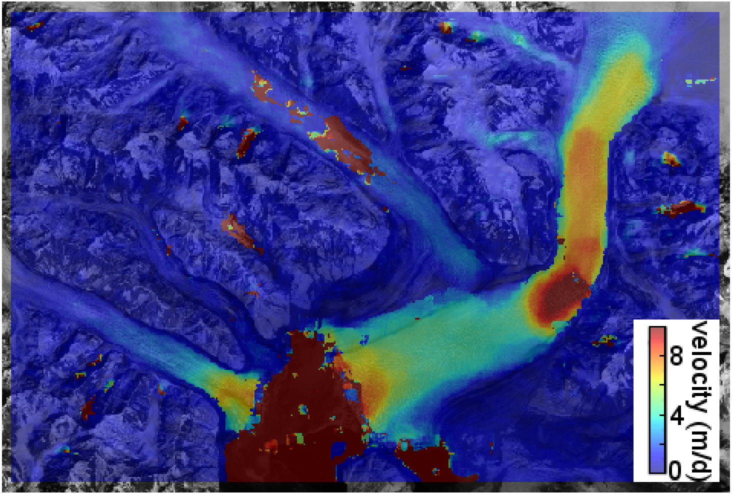


Estimating ice thicknesses

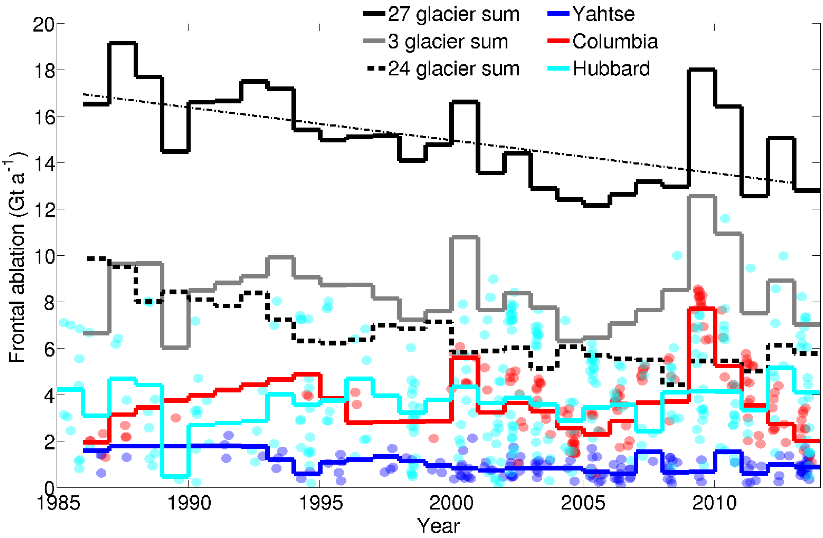
- Method based on Huss and Farinotti (2012)
  $\Rightarrow$ Mass conservation, inverts surface topography for ice thickness
- Initialized with assumed zero frontal ablation
- These thicknesses are used to calculate frontal ablation time series for each glacier.
- Resulting rates of frontal ablation input to ice thickness model.
  $\Rightarrow$ Repeat until (hopefully) converges
- Comparison with measured ice thicknesses yields agreement of $\sim$10%

Estimating Frontal Ablation

$$u_{\mathrm{f}} = u_{\mathrm{c}} - \dot{m} = u_{\mathrm{t}} - \frac{\partial L}{\partial t}$$

- Difference between rate of ice flow to the terminus u_{v} and rate of length change of the glacier $\partial L / \partial t$
- Integrate this rate over a surface to obtain a flux.
  $\Rightarrow$ choose a flux gate upstream of terminus
- Correct for ice thickness changes dh/dt
- Correct for surface mass balance $\dot{b}$

Alaska tidewater glacier frontal ablation, 1985-2013



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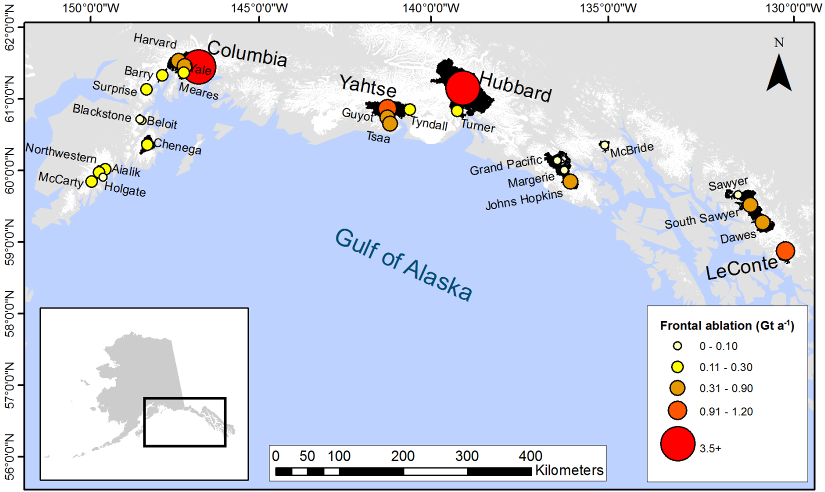

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  ⇒ see also Larsen et al., 2015, *GRL*