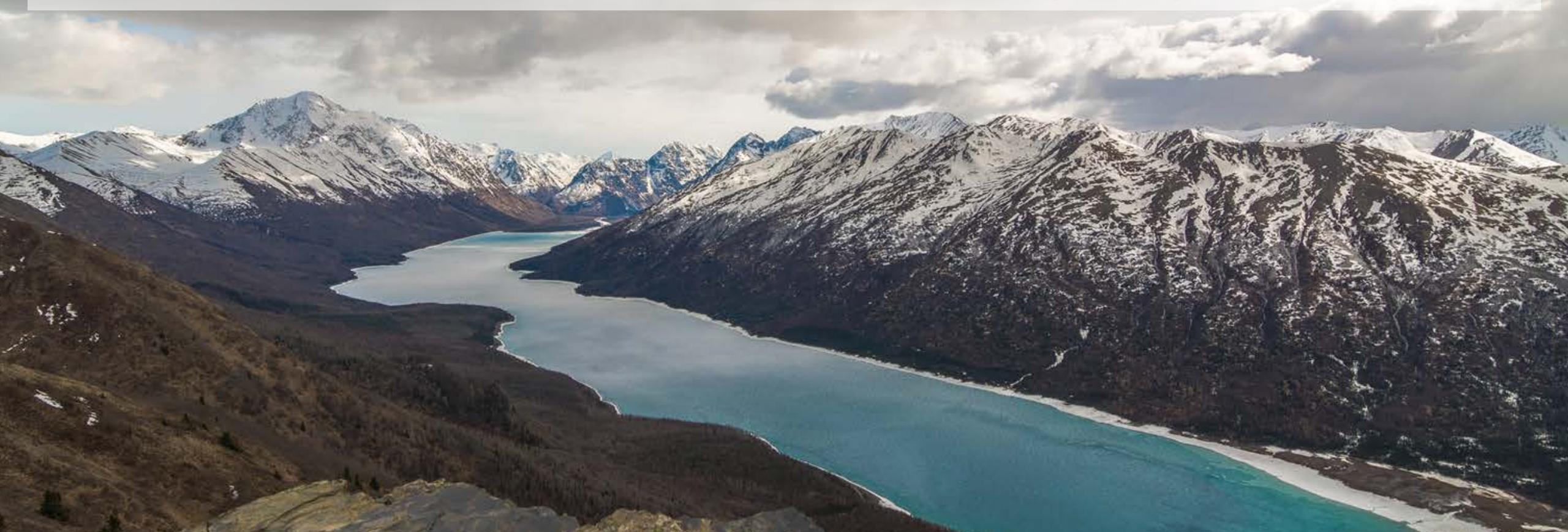


Calculating Geodetic Mass Balance for Eklutna Glacier, Alaska via Structure from Motion (SfM) Methods



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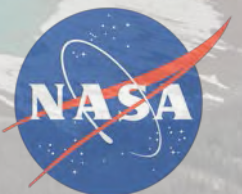


Photo: Dan Moran



Motivation **Alaskan glaciers are shrinking**

Eklutna Glacier Terminus: 1915



Photo: Stephen Reid Capps, USGS

Repeat photo: 2010

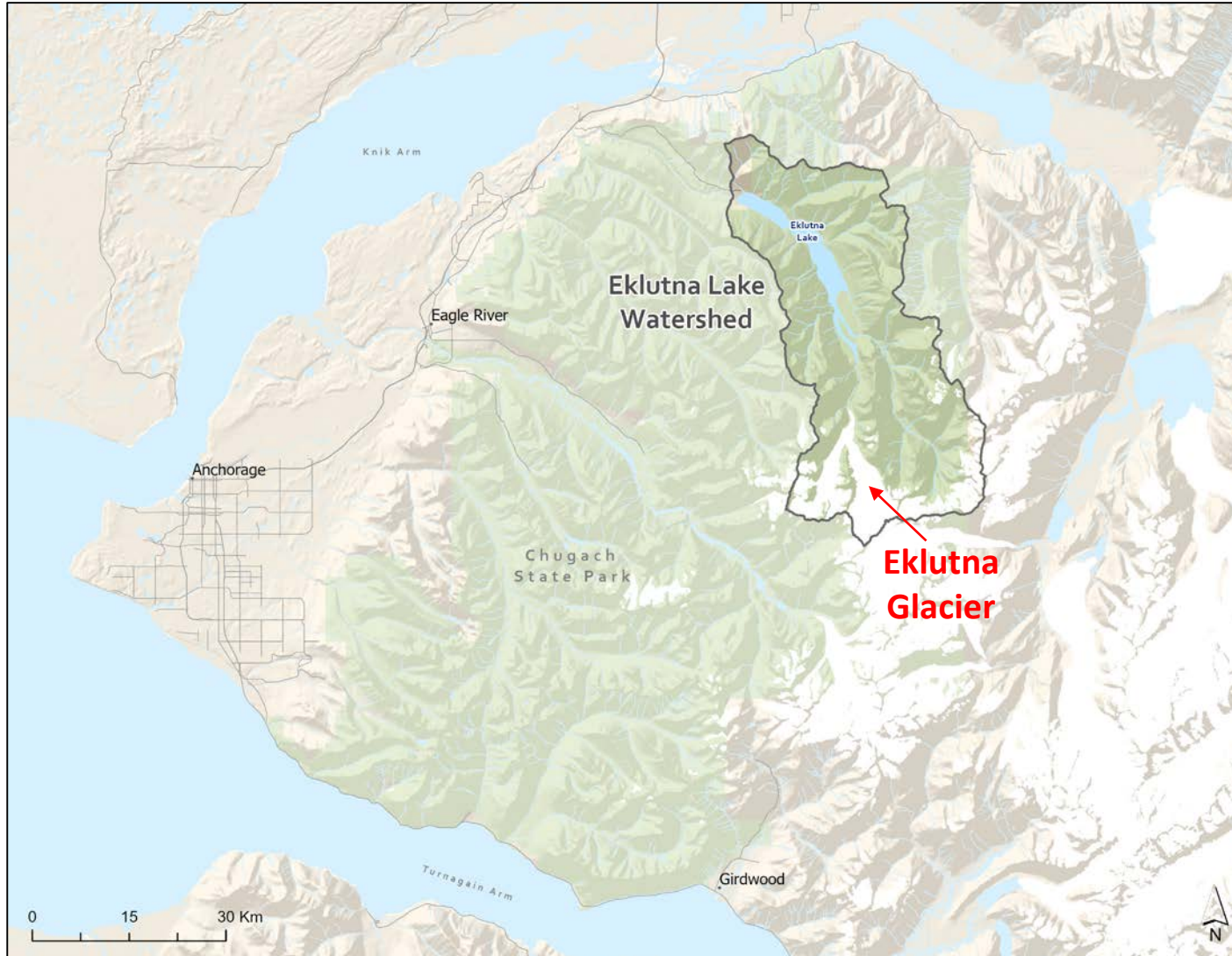


Photo: Ron Karpilo



Motivation **Eklutna Lake water reservoir**

Water from Eklutna lake provides ~90% of Municipality of Anchorage (MOA) drinking water and 10-15% of the power supply yearly (AWWU, 2019)





Eklutna Hydroelectric Project



Sharing resources

Necessity of Eklutna Glacier
monitoring for impacts on
Eklutna Lake water supply

Drinking water

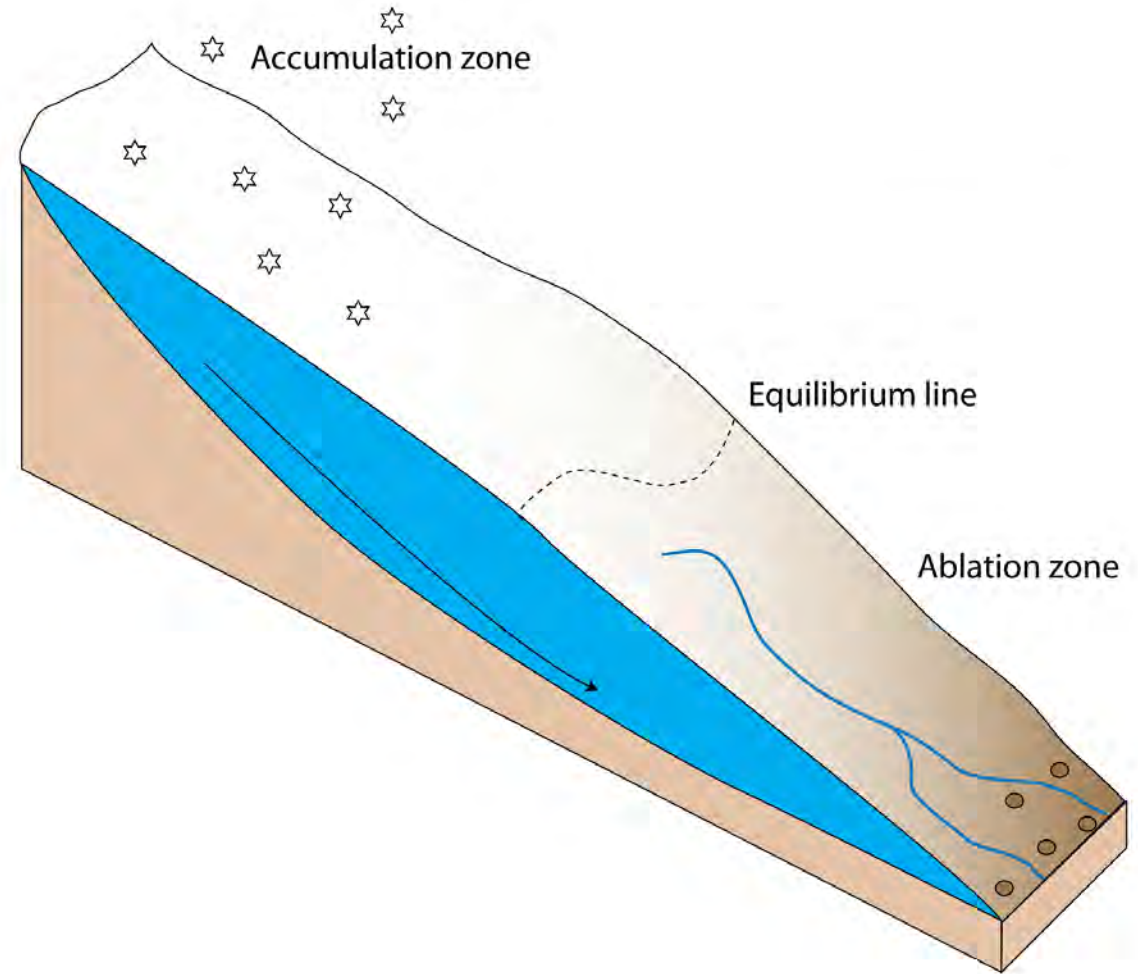




How to monitor glacier change?

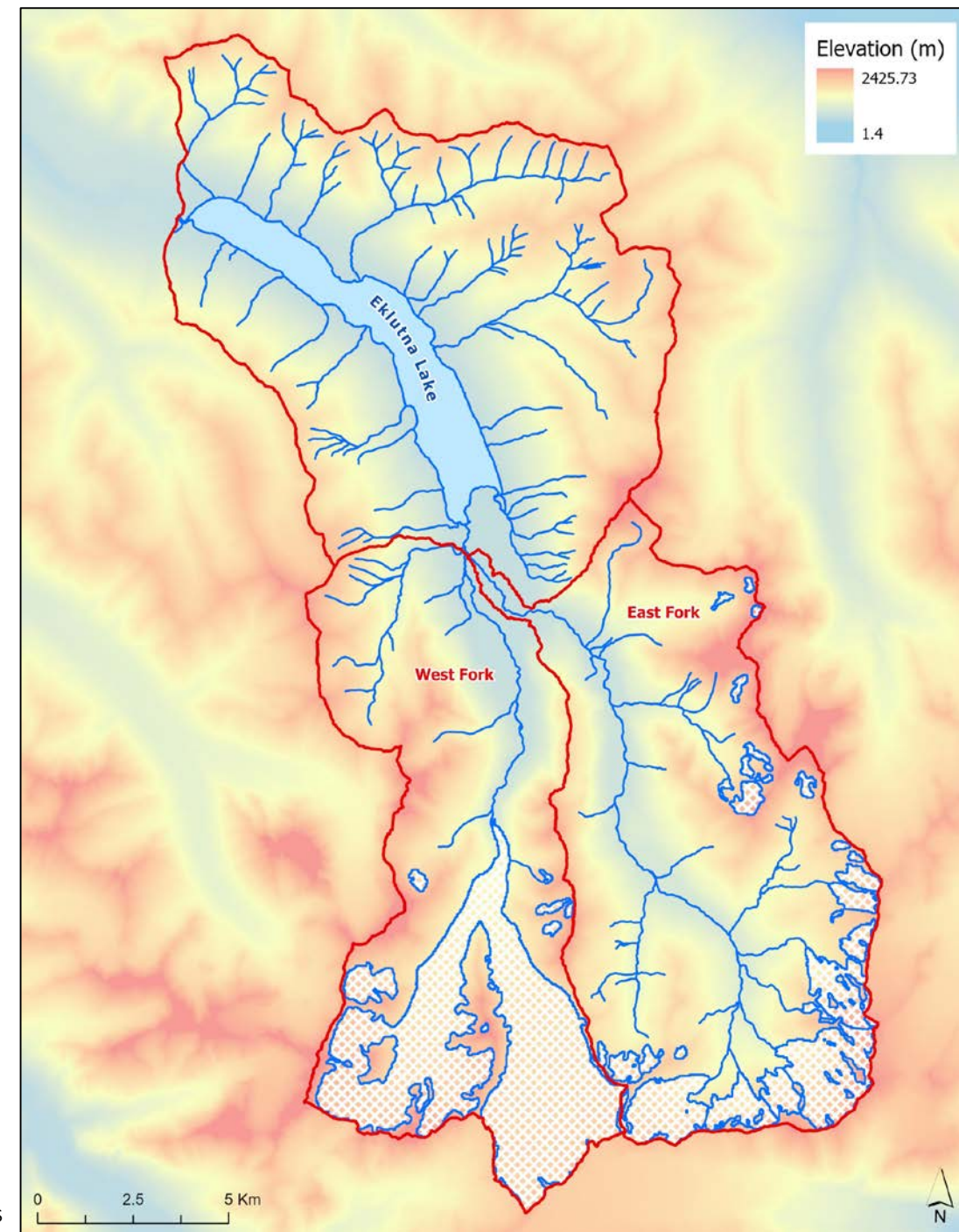
Mass Balance

- Mass balance is the sum of **accumulation** and **ablation**
- Often reported as a rate of ice loss over time
- Units: meters water equivalent (w.e.)
- **Geodetic mass balance** uses remote sensing techniques to analyze glacier change
- **Specific mass balance** reports the surface difference per unit area over time (m w.e. a^{-1})



Objectives

- 1) Use an in-house mapping system to build a digital elevation model (DEM) and image orthomosaic of Eklutna Glacier in 2019
- 2) Compare our DEM product to existing high quality elevation datasets
- 3) Calculate the **geodetic mass balance** of Eklutna Glacier by comparing the produced 2019 dataset with our existing 2018 dataset

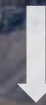




How do we map this complex topography?



Collect aerial photographs from a fixed wing plane



Structure from Motion (SfM)
Photogrammetric method for creating 3D models of topography from 2D overlapping photos

*Eklutna Glacier
West Fork*

*Eklutna Glacier
Main Fork*

*Eklutna Glacier
Terminus*



Methods Mapping System

Instrumentation

- Aircraft (Cessna 185)
- DSLR Camera (Nikon 850D)
- GPS (Trimble 5700)
- Flight Management System (Aviatrix: Aeroscientific, 2019)

Mounted to plane door

Records camera position at each photo capture

Automatically drives camera for photo capture at chosen intervals during flight



Cockpit view of Flight Management System with laptop controls necessary for software use

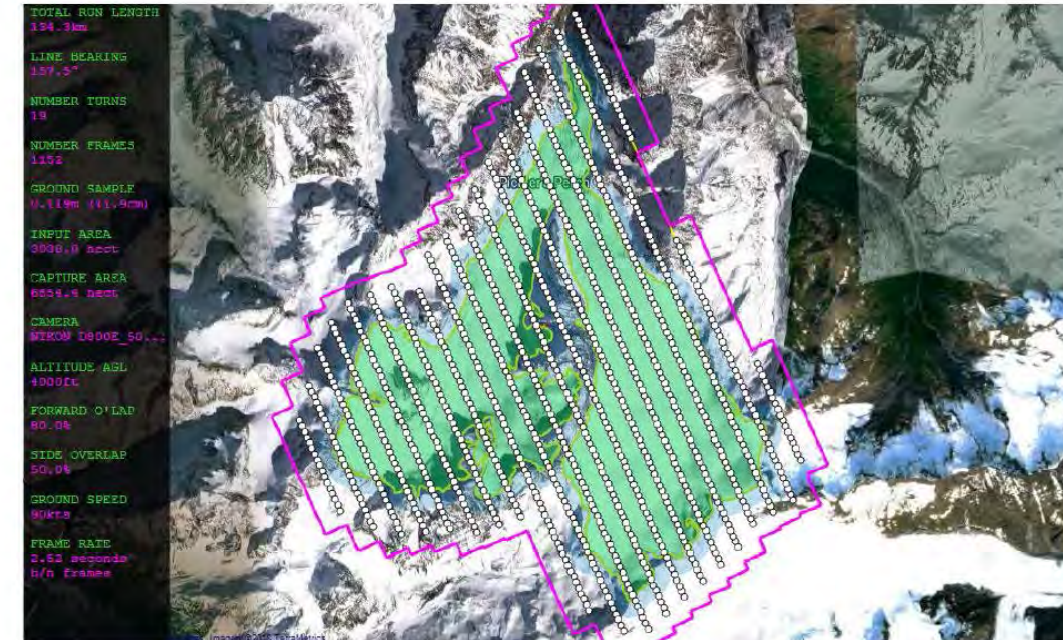


Nikon 850D camera mounted within plane door

Software

- Flight planning (FlightPlanner Pro: Aeroscientific, 2019)
- Building 3D structures (Photoscan: Metashape, Agisoft, 2019)

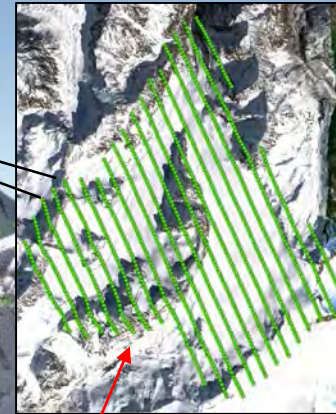
Flight path produced with FlightPlanner Pro to identify target photo centers



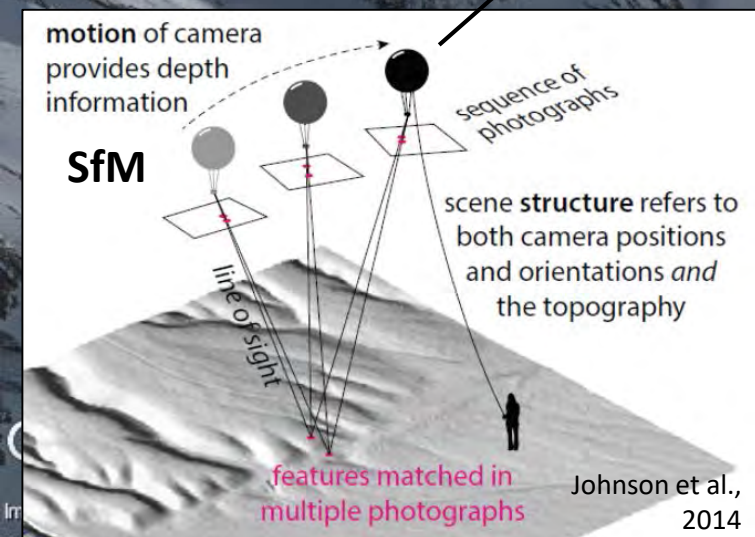


Methods Photo Acquisition

Photo capture locations



Aerial view
Eklutna Glacier



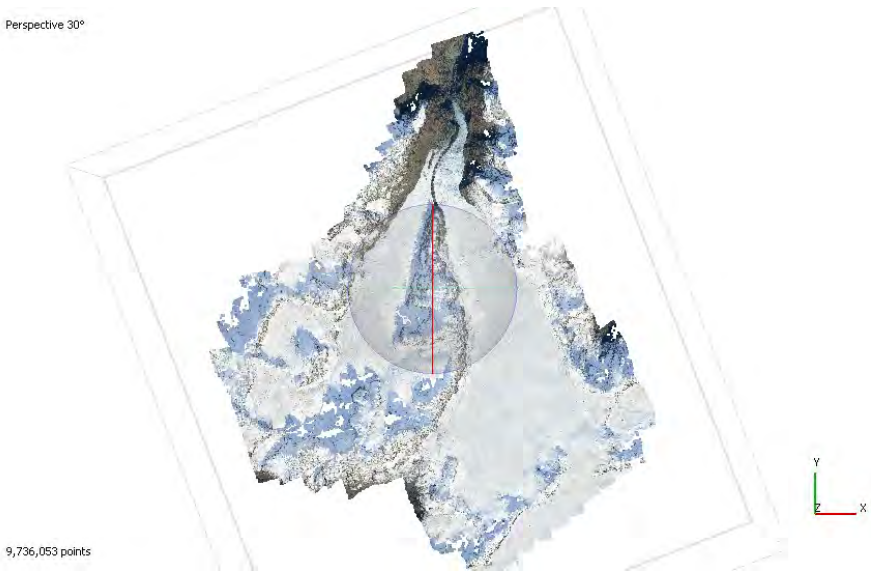
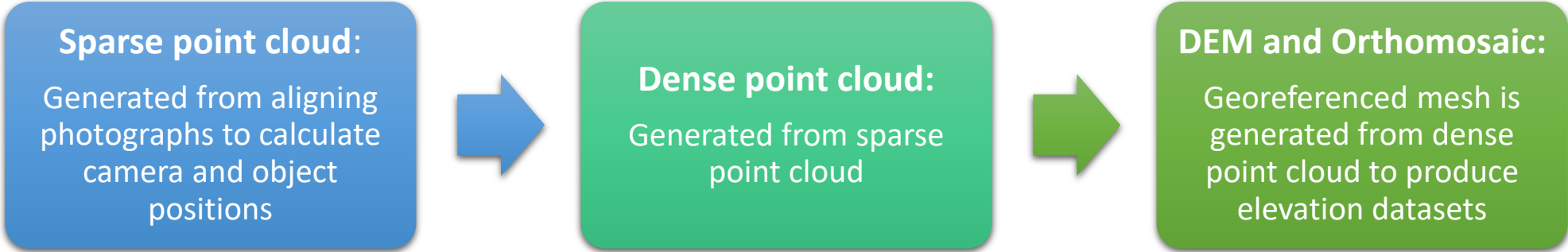
Photos are taken with
60% side overlap and
80% forward overlap

Existing dataset:
Sept. 29, 2018
n = 1,448 photos
New dataset:
Sept. 26, 2019
n = 1,134 photos

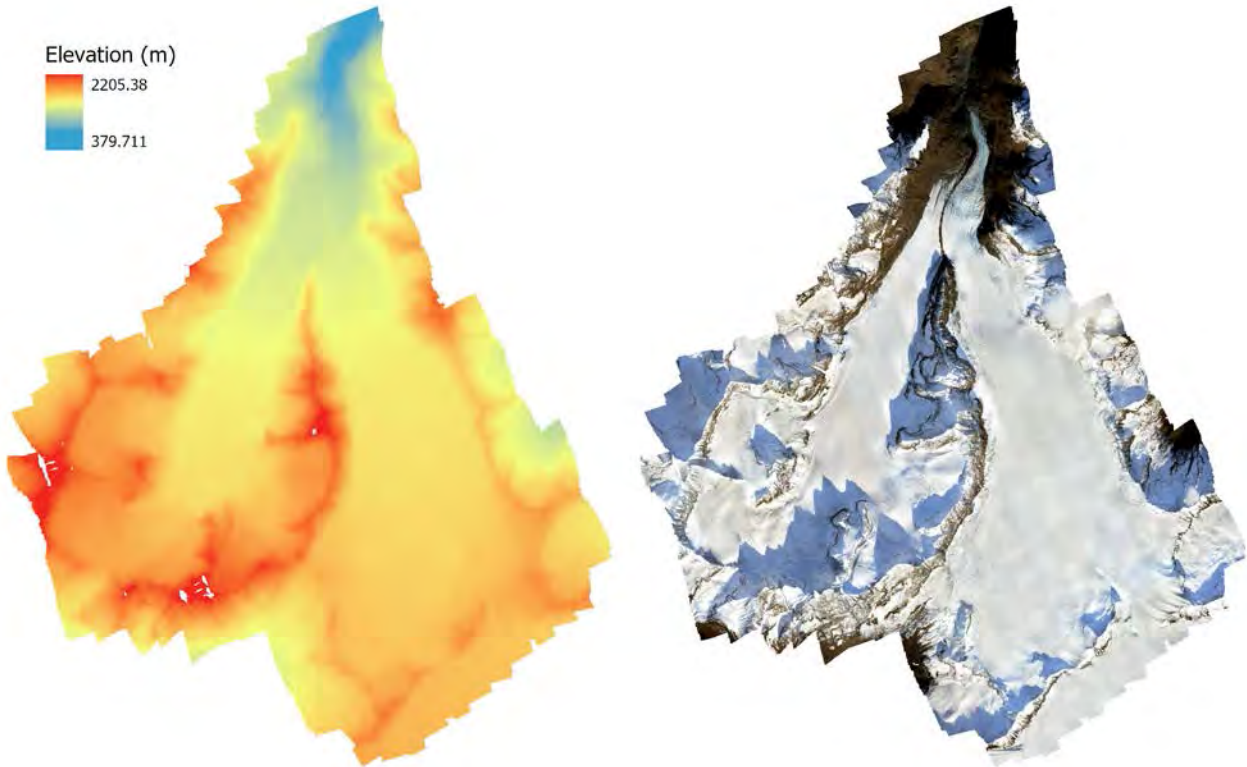
Scene:
Google Earth

Methods SfM Processing

Agisoft Photoscan



Sparse point cloud



DEM (left) and
orthomosaic (right),
Sept 26, 2019

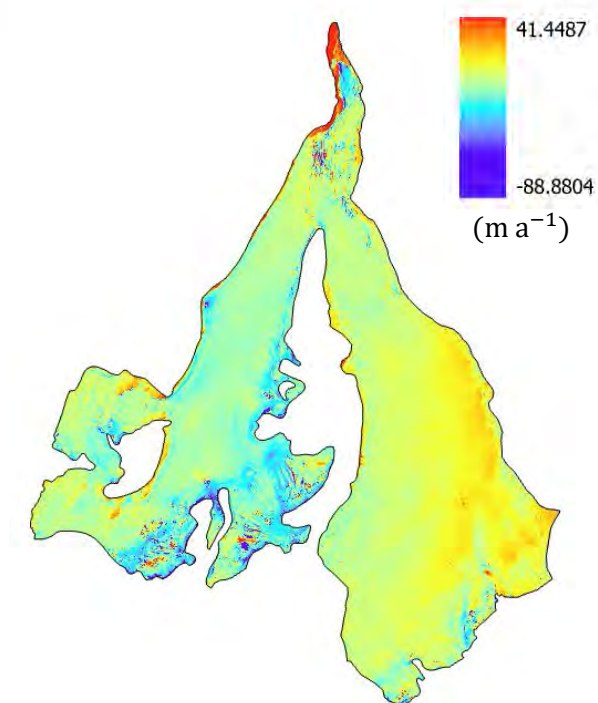
Methods Data Analysis

Mass Balance Calculation

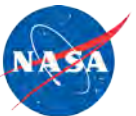
- Difference 2019 and 2018 DEMs
- Obtain mean surface difference per unit area (pixel) as height (m)
- Multiply by glacier ice density: 900 kg m^{-3}
 - Assume mass lost is ice

Validation of our DEM to existing high quality elevation data

- Compare non-glaciated, bare earth terrain subsets to:
 - G-LiHT (NASA Goddard's LiDAR, Hyperspectral & Thermal Imager)
 - 2018 <https://glihtdata.gsfc.nasa.gov/alaska/index.html>
 - IFSAR (USGS GeoSAR Interferometric Synthetic Aperture Radar)
 - 2011 <https://earthexplorer.usgs.gov/>



Surface elevation change over
Eklutna Glacier 2018 - 2019



Goddard
Space Flight Center



Results

Specific mass balance from our system: **-3.3 m w.e. a⁻¹** (2018-2019)

- Compared to -0.74 m w.e. a⁻¹ (2010-2015) Sass et al. 2017

Mean vertical difference from our DEM over 1.5km² subset:

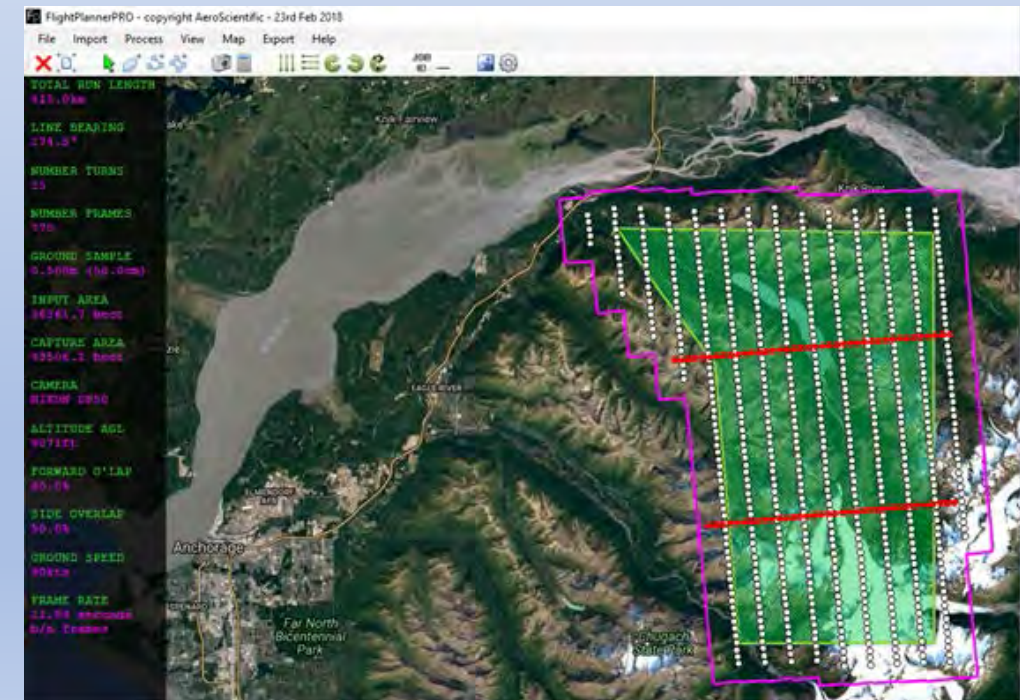
- G-LiHT: **2.7m**
- IFSAR: **0.6m**

Conclusions

- Negative mass balance indicates ablation exceeded accumulation
- A large mass balance result compared to literature indicates need for higher quality GPS
- Contributing to an already extensive archive of valuable data coverage of Eklutna glacier and watershed

Next Steps

- Correct datum conversion to improve results
- Develop mapping system with addition of new GPS
- Initiate flight missions in 2020 to continue monitoring program
- Expand to whole watershed →



Example flight plan produced in FlightPlanner Pro over Eklutna Watershed