

# Antarctic Time Machine

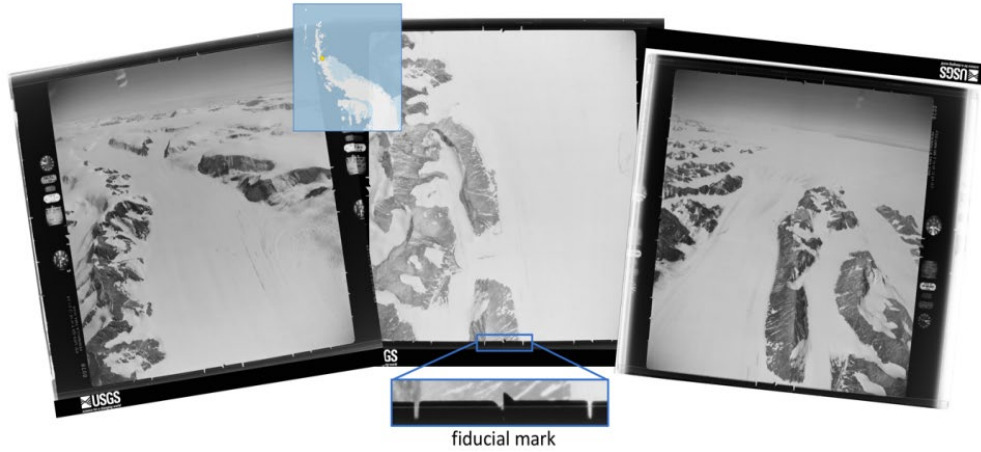
3D Reconstruction of Glaciers in the  
Antarctic Peninsula using Historical  
Structure-From-Motion

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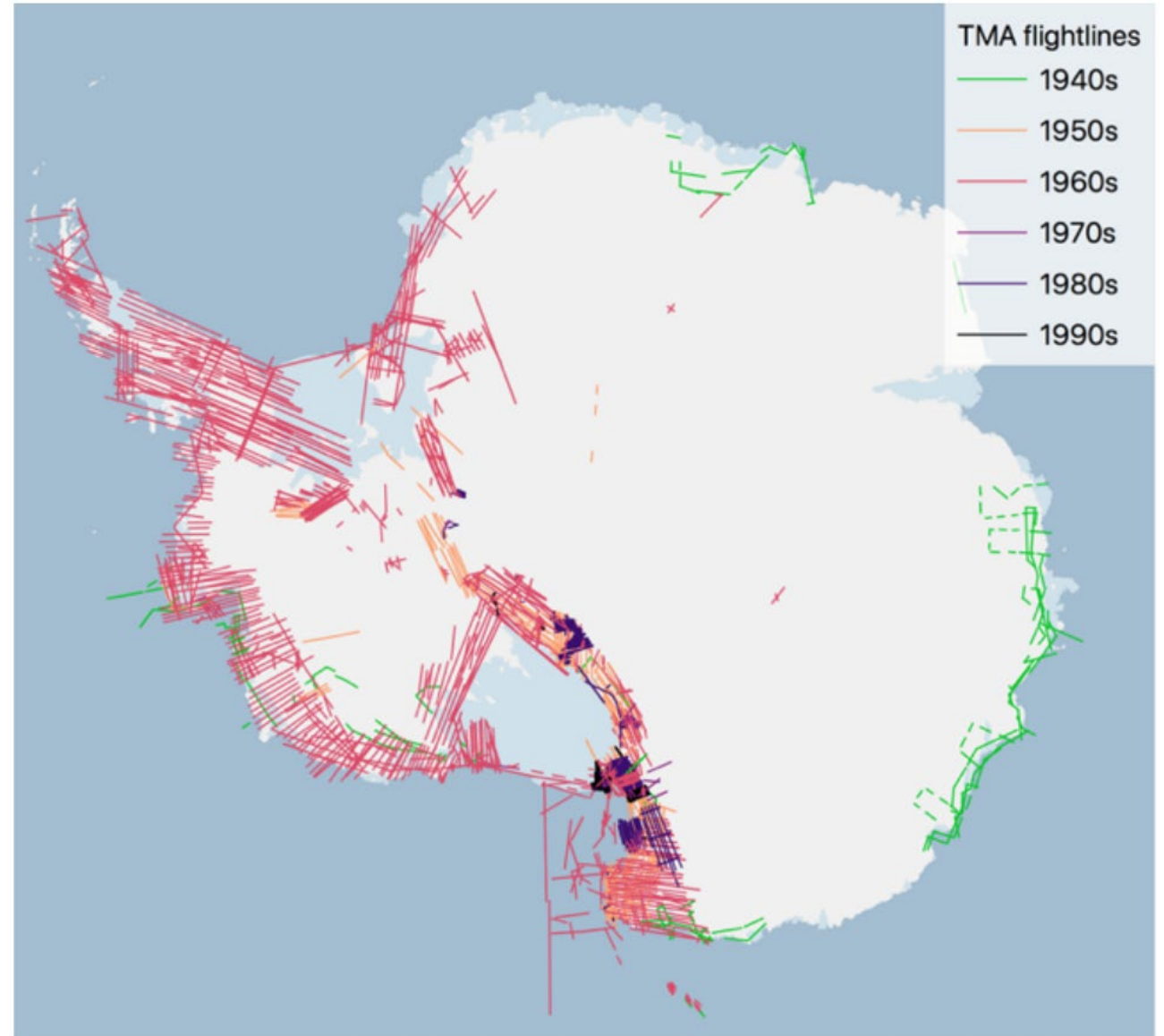
Felix Dahle



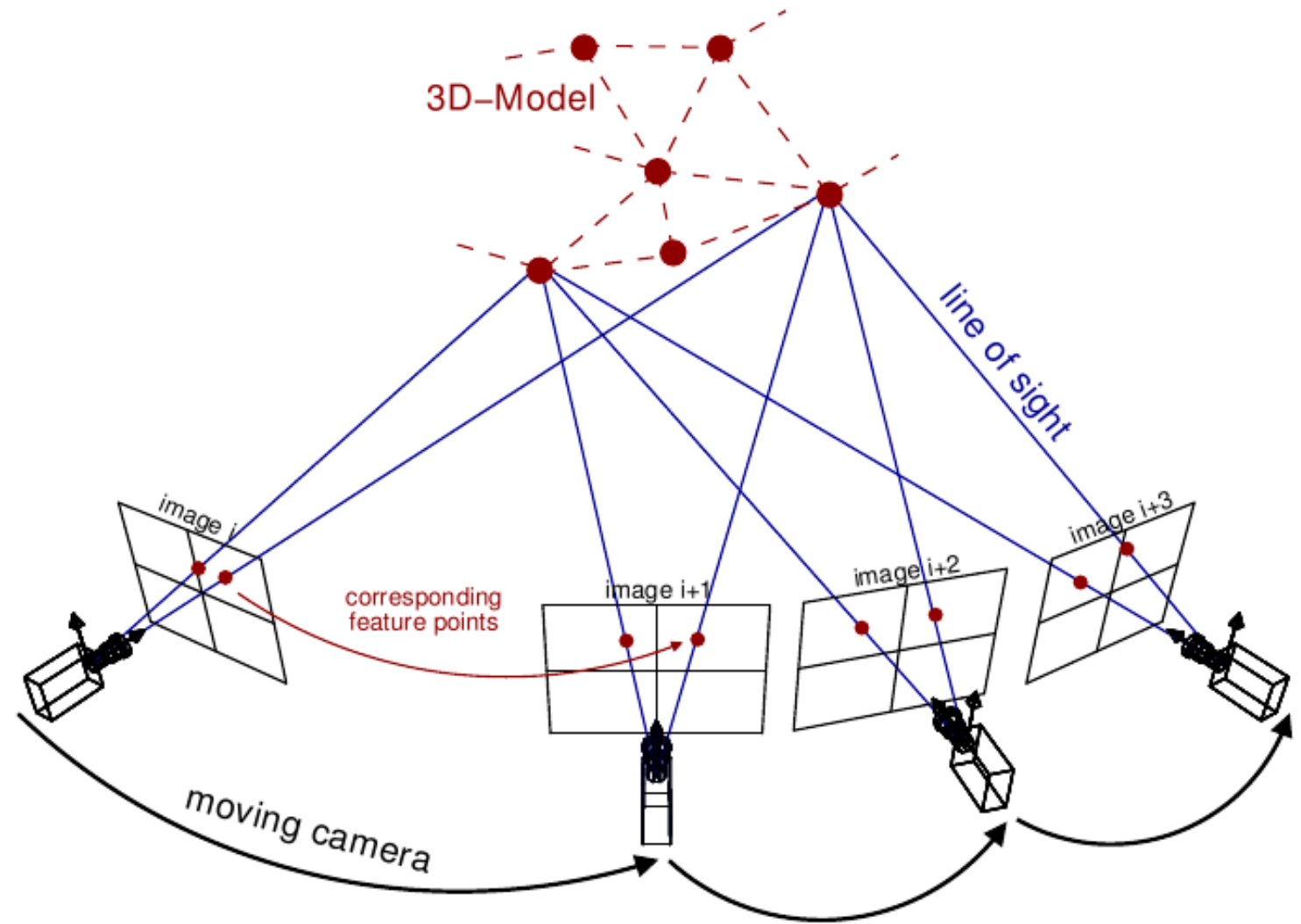
# TMA archive



- Collection of photographs retrieved by the U.S. Navy between 1946 and 2000
- 125.000 locations, totalling to about 230.000 images
- Taken along flightpaths: straight lines with more or less same height
- Unique insights into Antarctica from 70 years ago



- Transform a collection of flat, overlapping photos into a single 3D model.
- Thousands of common features shared across different images are required.
- Depth is mathematically calculated by analyzing how these features move relative to the camera.
- Simultaneously reconstructs the 3D shape of the scene and the exact path the camera took.



# The plan

- **Reconstruct the Past**

Transform the entire archive of 230,000 images into 3D models of historical Antarctica.

- **Automate the Process**

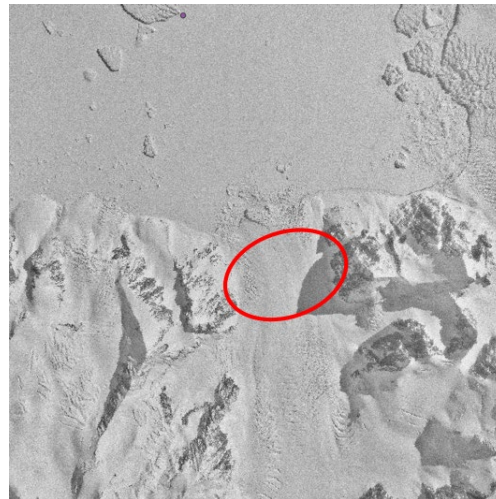
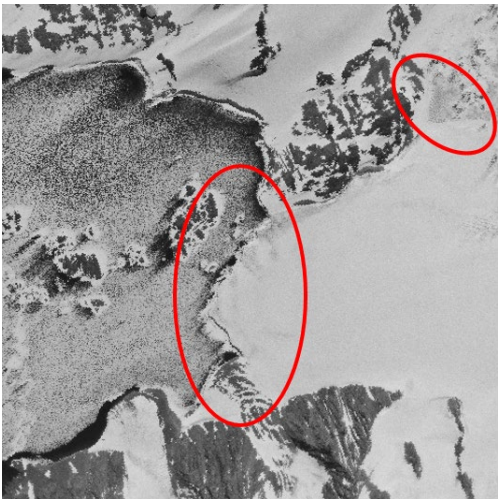
Develop intelligent algorithms to process this massive dataset automatically, without manual work.

- **Validate the Truth**

Compare our historical models against modern elevation data to detect changes in the ice layer.

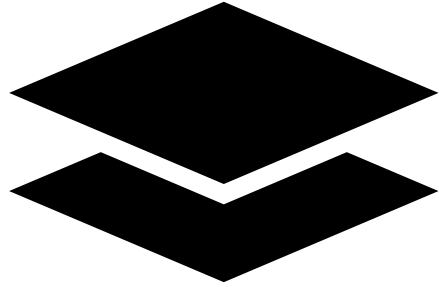
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Close the gap – Experience glaciers in 3D

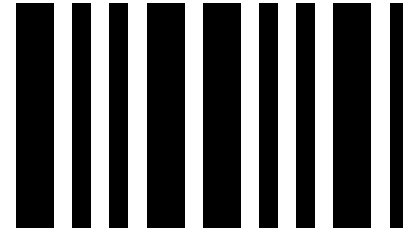


# How to approach this

1. Segment the images



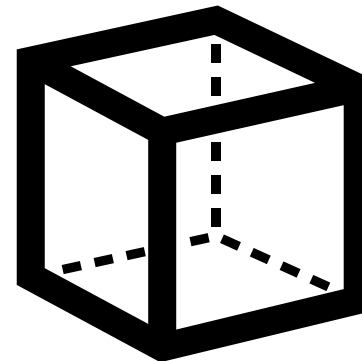
2. Extract metadata from the images



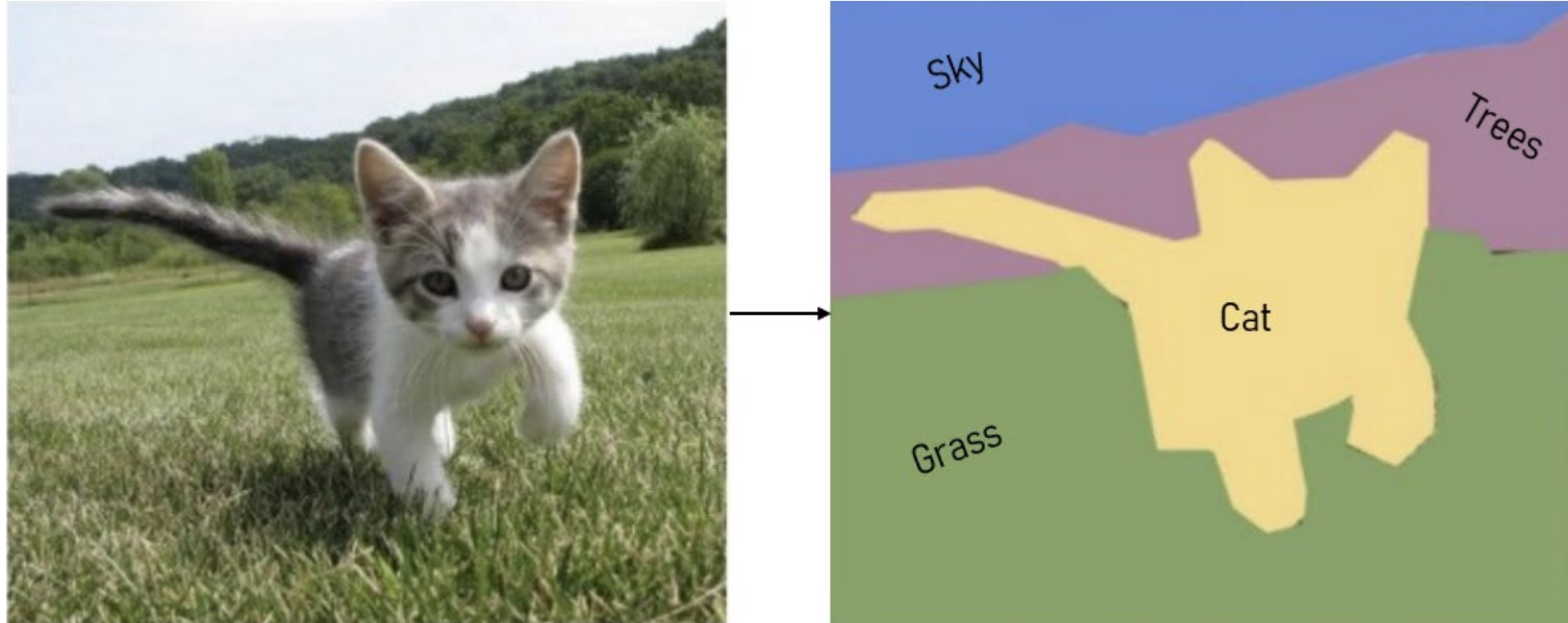
3. Geo-reference the images



4. Convert the images into 3D models

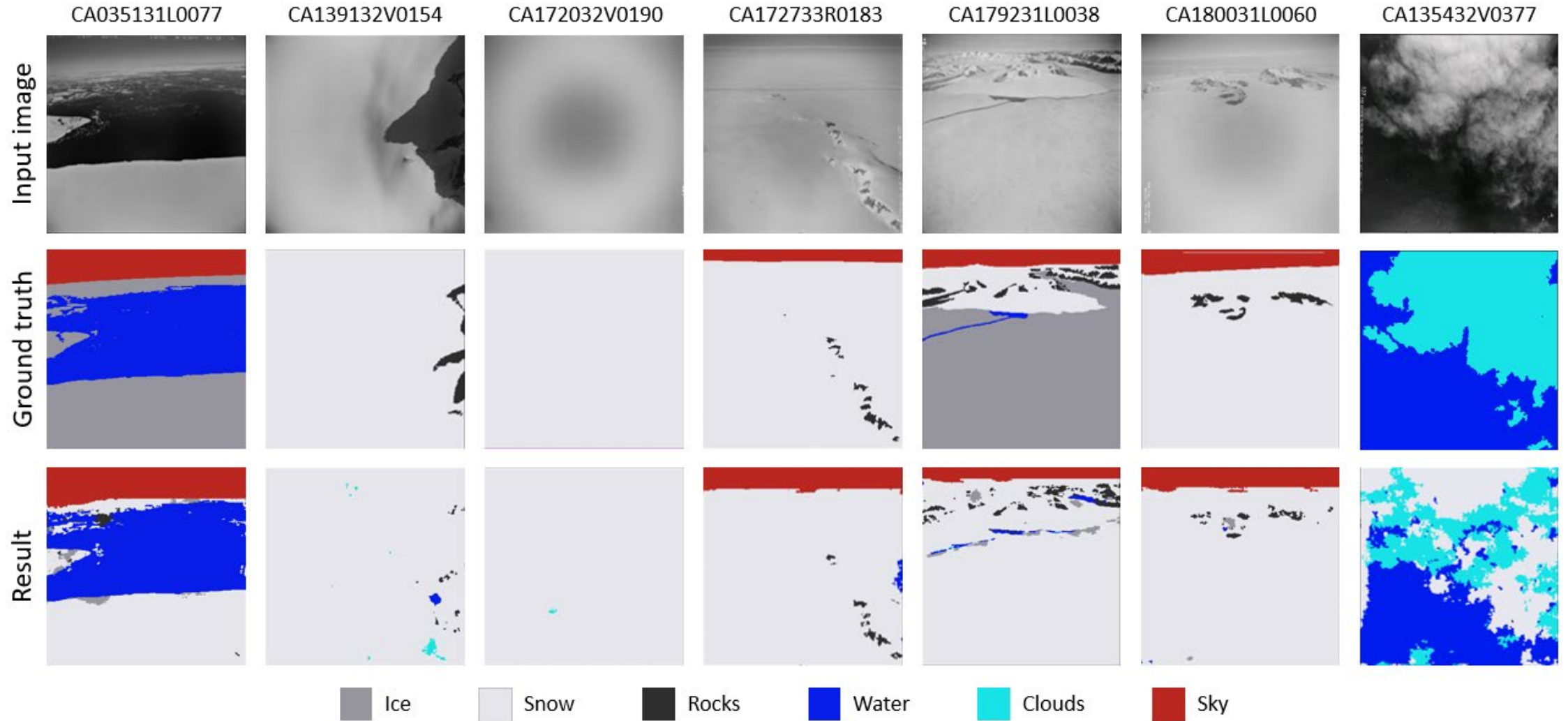


# Part I: Segmentation



**Semantic segmentation:** assigning a specific class to every individual pixel in an image to understand what is where

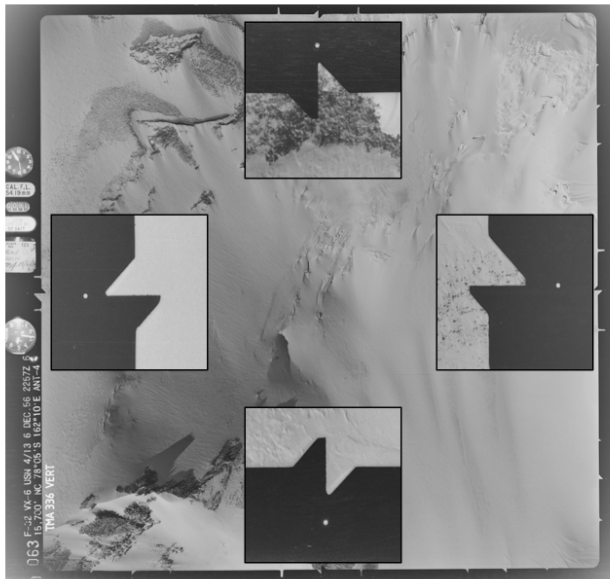
# Part I: Segmentation



# Part II: Metadata extraction

The image itself tells **what** is there, but there is more that can tell **how** the image was captured. Three clues are present in the images:

## Fiducial marks



## Data stamp

6 19 700 40 78 05 8 18 10 E ANT-4  
F32 R1-1-8 9/26/64 15000 153 40MM ANT PEN TMA1357

H1500 FL152.27 TMA-2560.V

219 VX6/USN BALLENY ISLANDS / STURGE ISLAND  
F31 M8-2-12 12/28/64 1000 155 25MM TMA1535

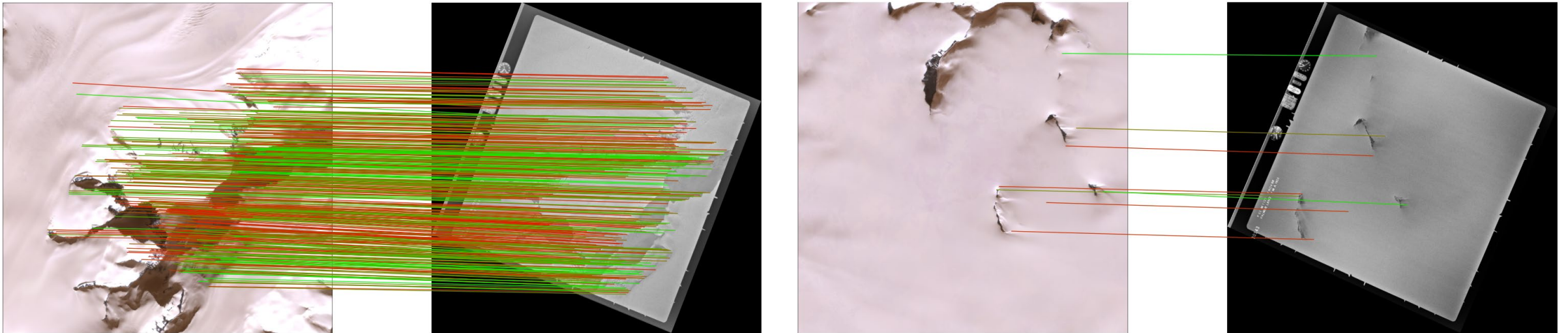
77 F31 B18-2-2 12/14/64 25000 151 40MM HERIT TMA1495

## The Altimeter

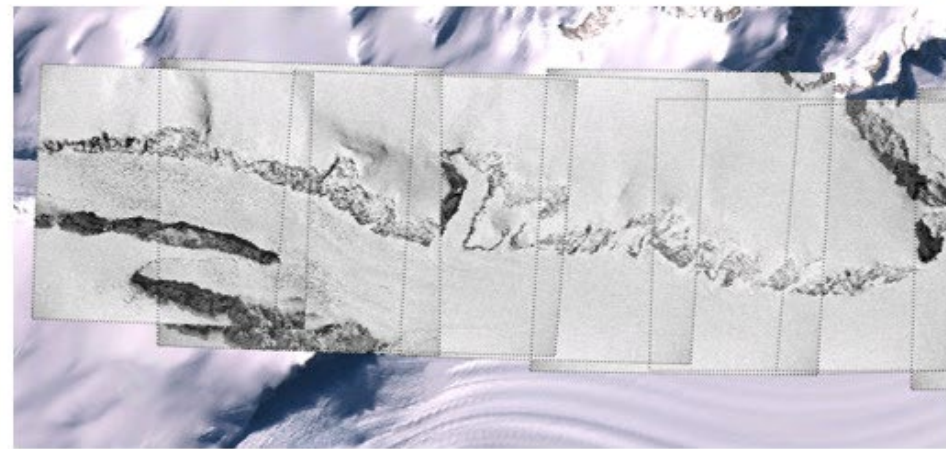
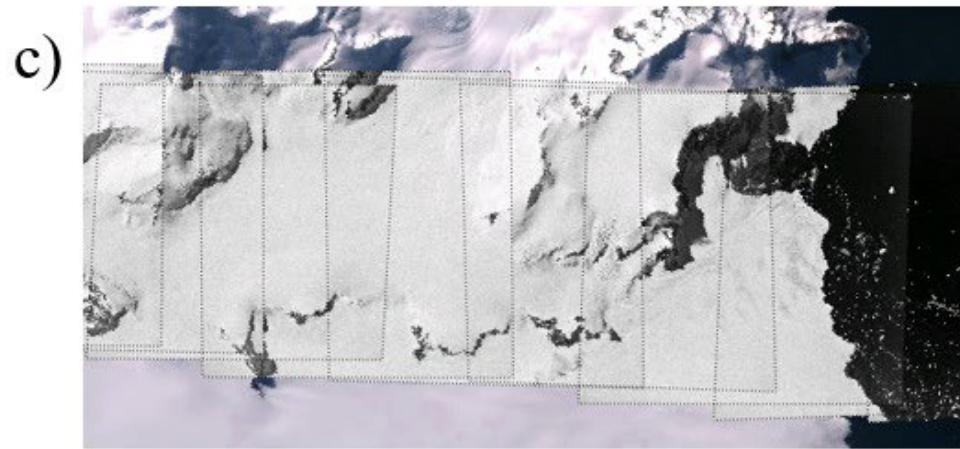
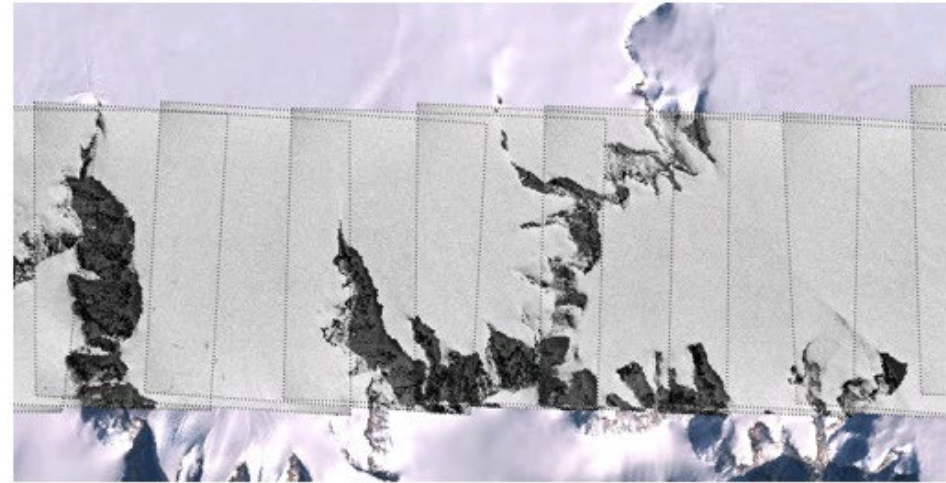
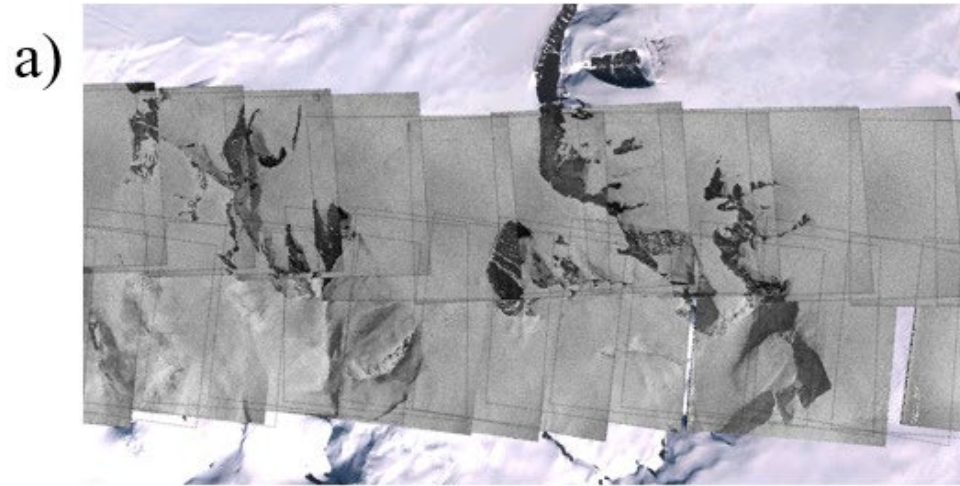


# Part III: Georeferencing

- Convert the **approximate position** of cameras to **exact footprints**
- Based on modern **machine-learning based tie-point matching** between historical images & modern satellite imagery (Sentinel-2)



# Part III: Georeferencing



# Part IV: Model creation

The screenshot displays a photogrammetry software interface. The main window shows a 3D model of a terrain with a network of camera positions (blue and red) and their respective fields of view (green lines). A color scale on the left indicates elevation from 1 to 10000 meters. The interface includes a menu bar (File, Edit, View, Workflow, Model, Photo, Ortho, Tools, Help, SCC), a toolbar, and several panels.

**Reference**

Cameras	Easting (m)	Northing (m)	Altitude (m)	Accuracy (m)
CA214732V0045	-2382079.961	1267832.418	4572.000	1e+04/
CA215731L0047	-2380236.467	1251193.919	4572.000	1e+04/
CA215731L0048	-2381554.432	1253576.393	4572.000	1e+04/
CA215731L0049	-2382872.397	1255958.868	4572.000	1e+04/
CA215732V0047	-2380236.467	1251193.919	4572.000	1e+04/
CA215732V0048	-2381554.432	1253576.393	4572.000	1e+04/

Markers	Easting (m)	Northing (m)	Altitude (m)
GCP_020	-2374285.000	1256295.000	186.711
GCP_022	-2380385.000	1252625.000	469.672
GCP_019	-2381725.000	1262435.000	470.109
GCP_017	-2376945.000	1250595.000	494.734
GCP_014	-2378725.000	1257285.000	522.195
GCP_006	-2378285.000	1247325.000	553.438

**Scale Bars**

Distance (m)	Accuracy (m)	Error (m)
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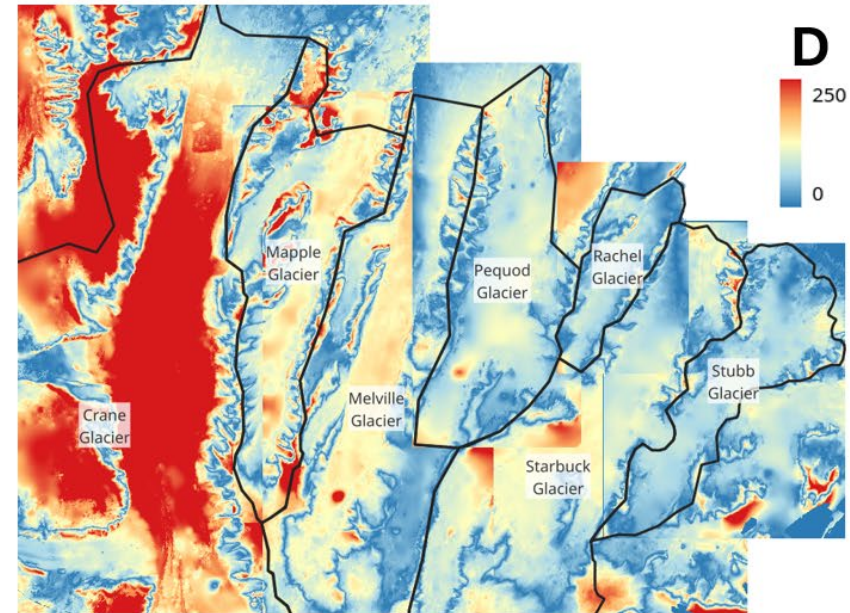
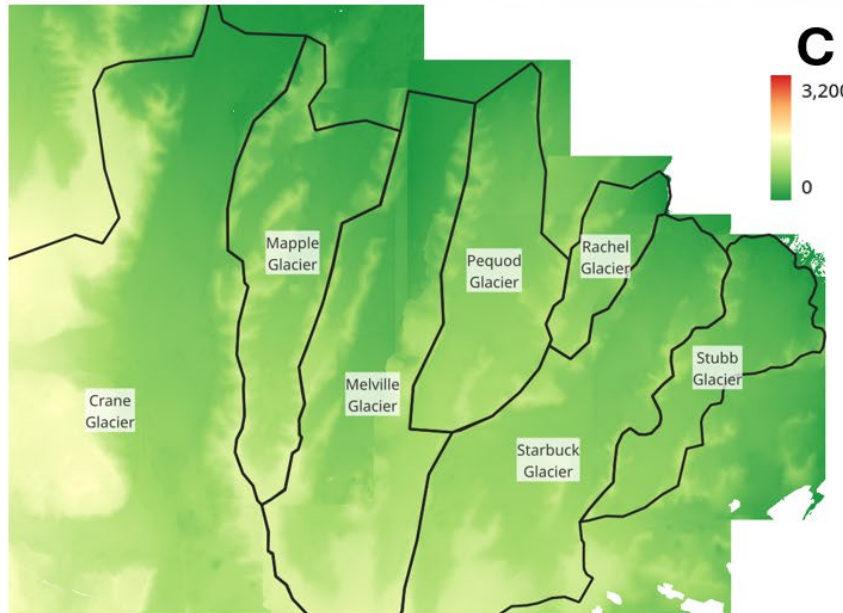
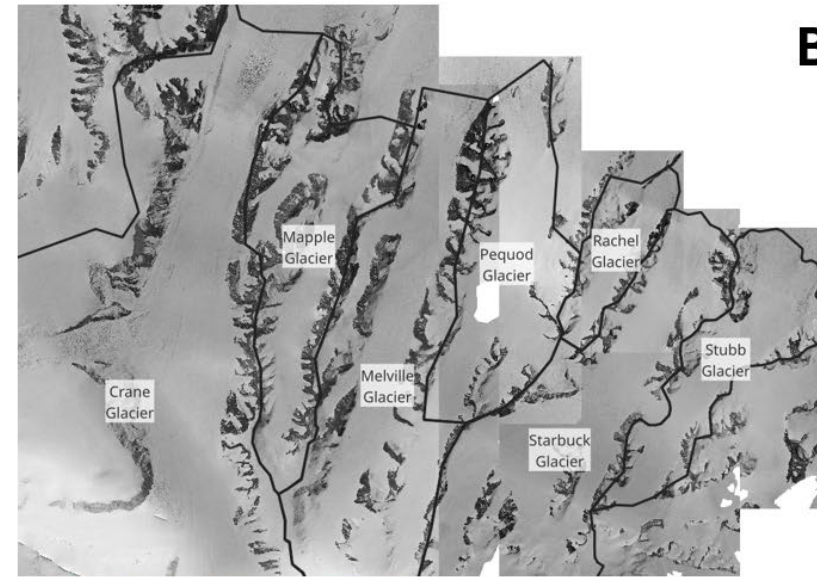
**total Error**

Control scal...  
Check scale ...

**Photos**

Workspace Reference Photos Jobs

# Part IV: Model creation



## 1. Scale up

- We've tested our tools on a small slice of Antarctica.
- Applying this method to the entire global archive to unlock decades of hidden climate history.

## 2. Improve

- Workflow is sometimes limited by the quality of images
- Integrating "one-shot" 3D methods to unlock data from even the most challenging single-view images.

## 3. Predict

- To know where we are going, we have to know where we've been.
- These 3D maps help to measure ice loss more accurately than ever before, leading to better predictions of sea-level rise

Thank you for your attention!

