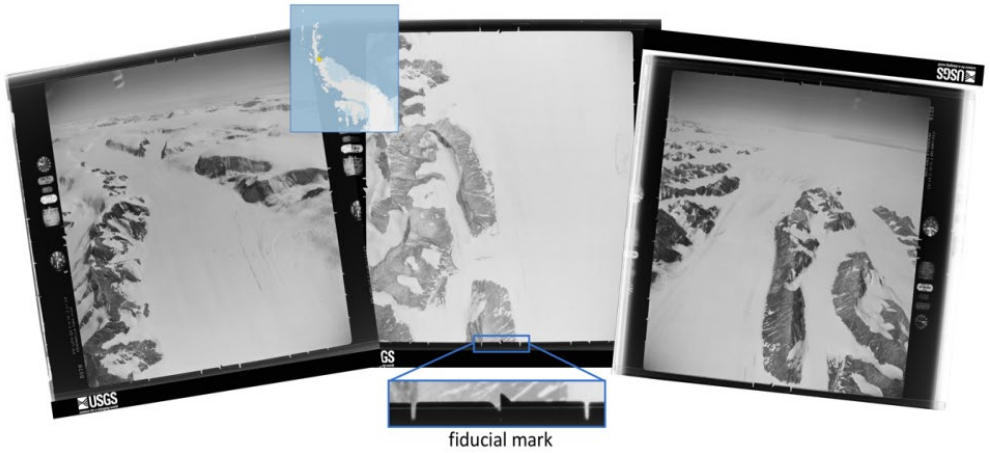
Antarctic Time Machine

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

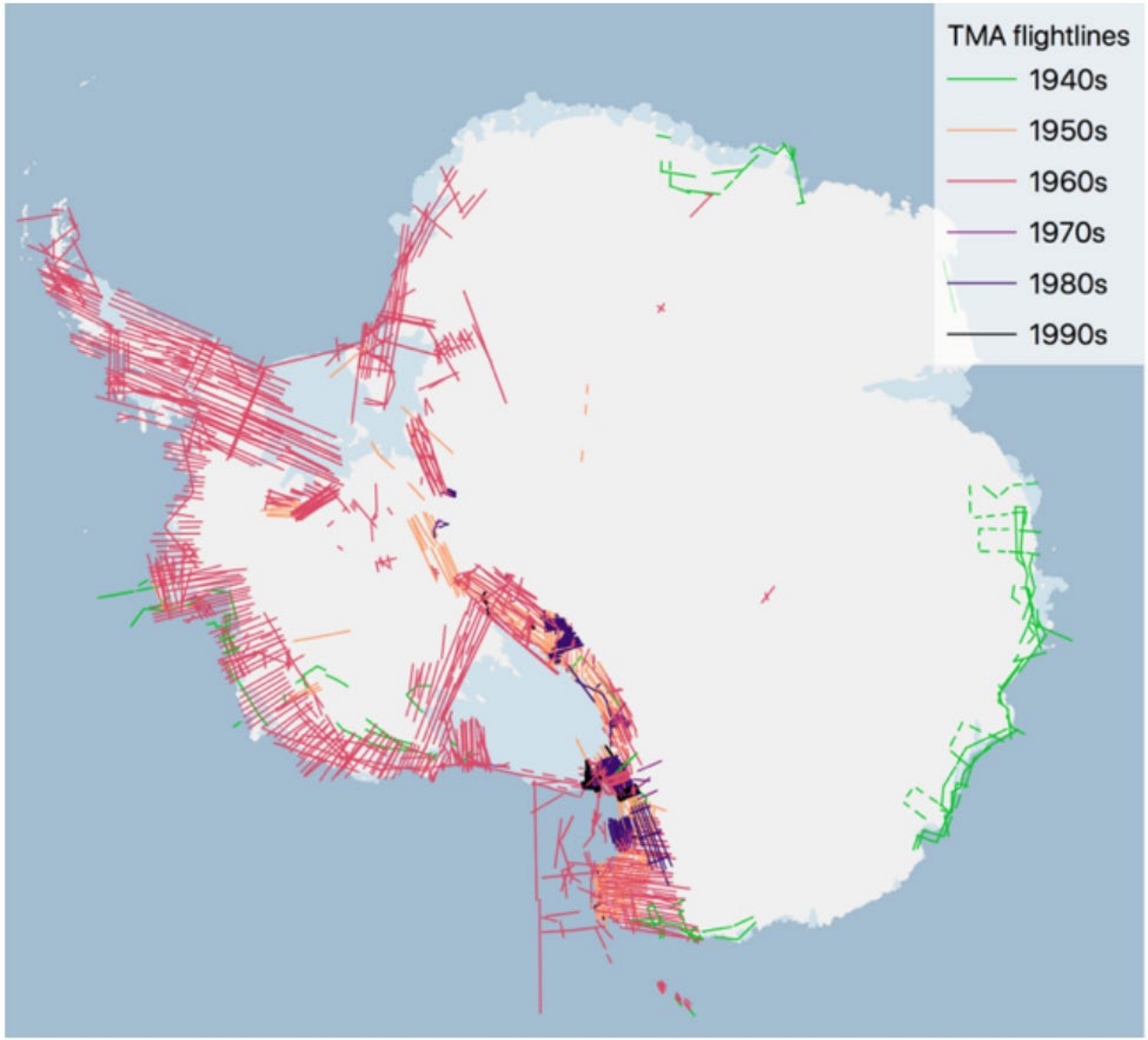
Felix Dahle

TU Delft

TMA archive

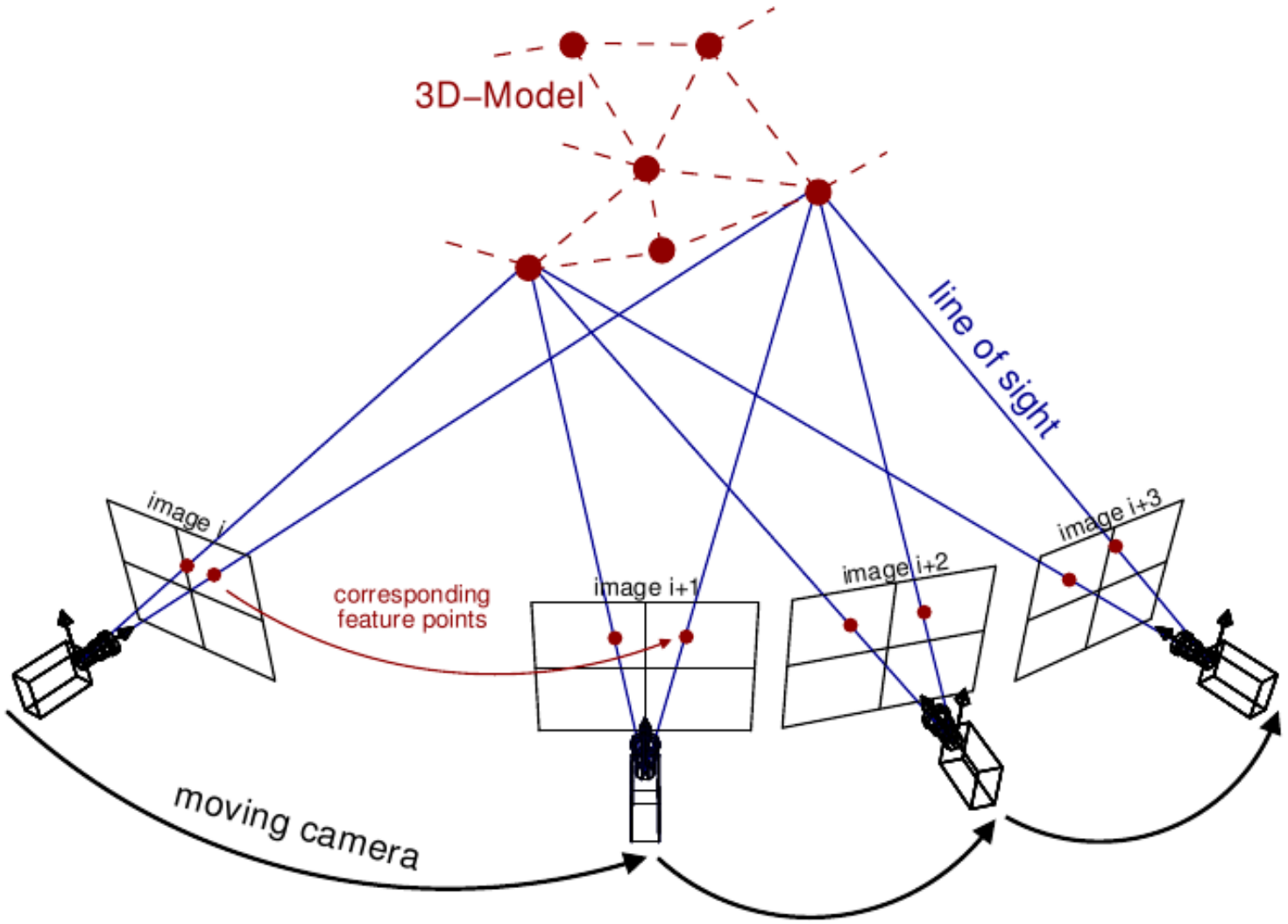


- Collection of photographs retrieved by the U.S. Navy between 1946 and 2000
- 125.000 locations, totalling to about 230.000 images
- Taken along flightpaths: straight lines with more or less same height
- Unique insights into Antarctica from 70 years ago



Structure-from-Motion

- 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.

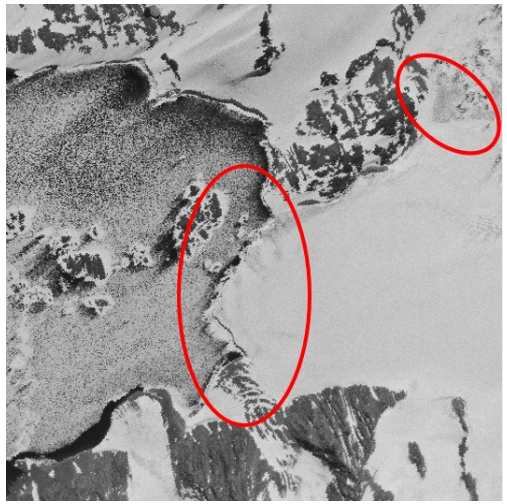
- **Automate the Process**

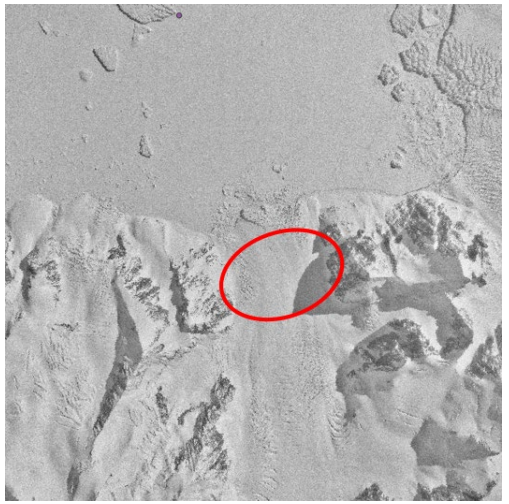
Develop intelligent algorithms to process this massive dataset automatically, without manual work.

- **Validate the Truth**

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

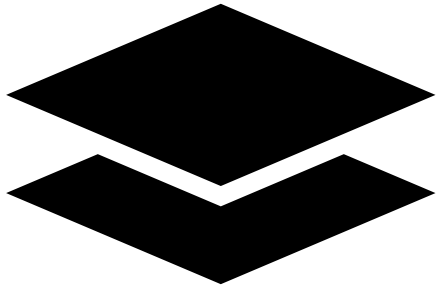
Close the gap – Experience glaciers in 3D



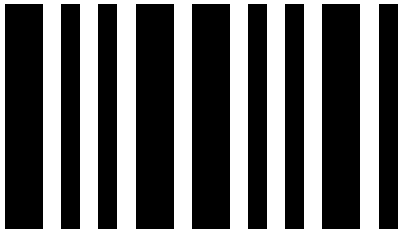



How to approach this

1. Segment the images

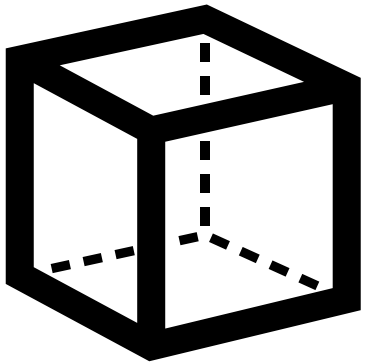


2. Extract metadata from the images

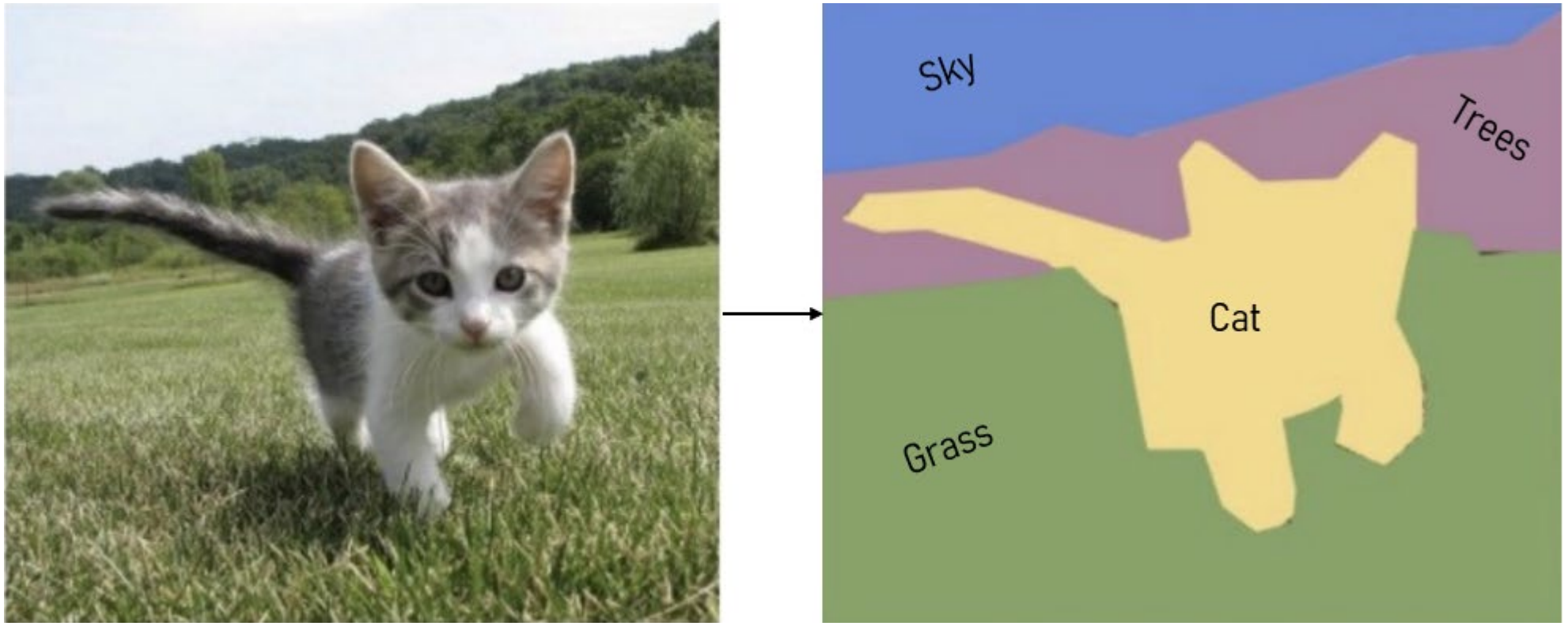


3. Geo-reference the images

4. Convert the images into 3D models

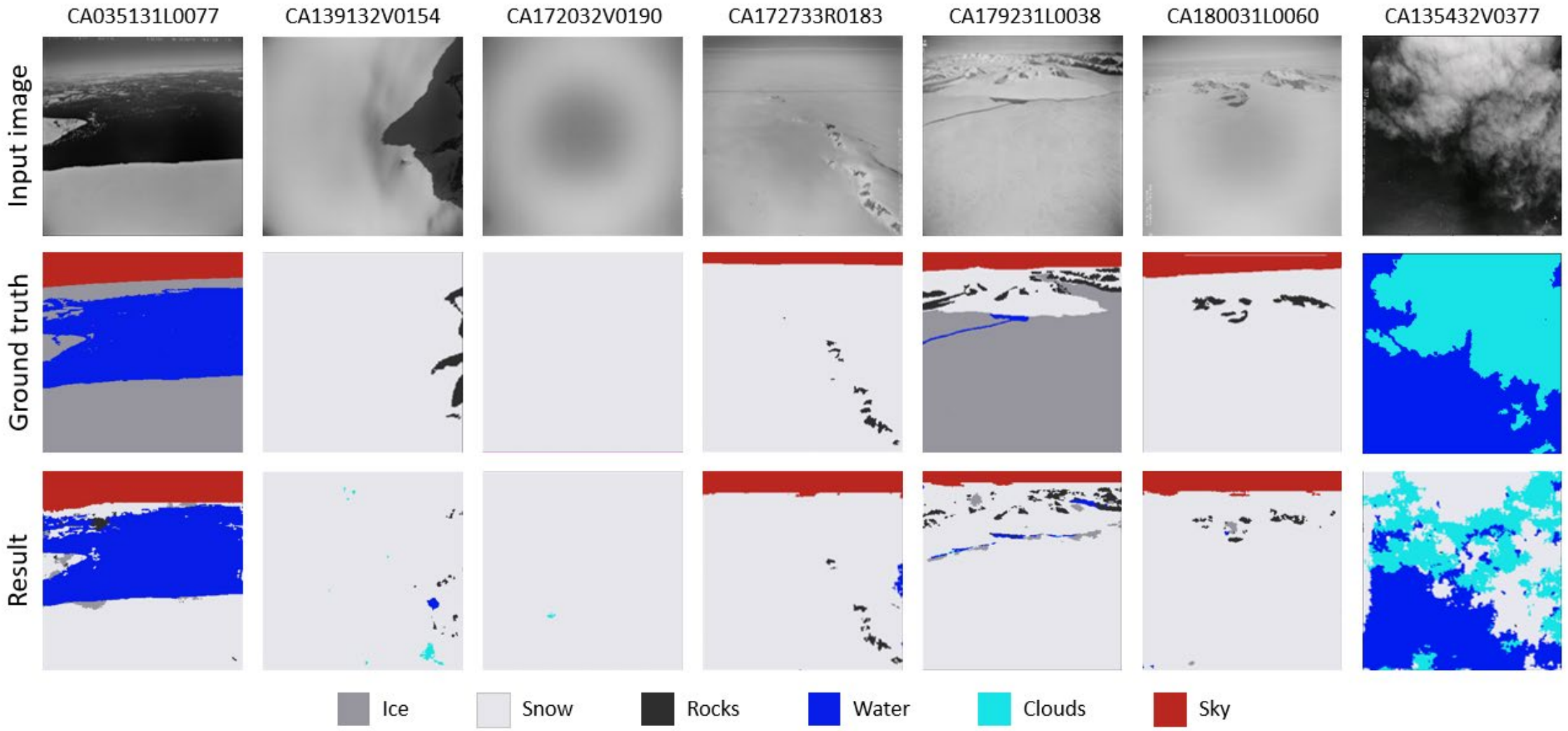


Part I: Segmentation



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:

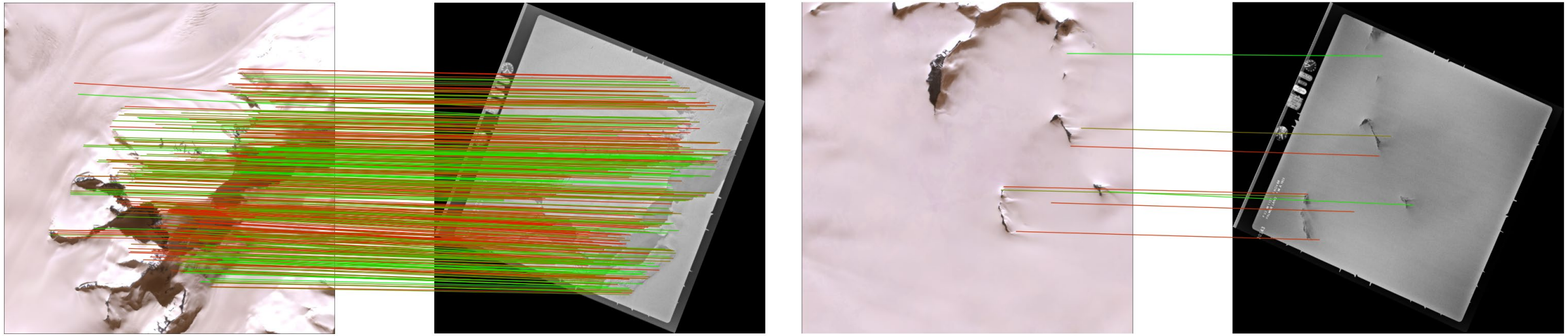
Fiducial marks

Data stamp

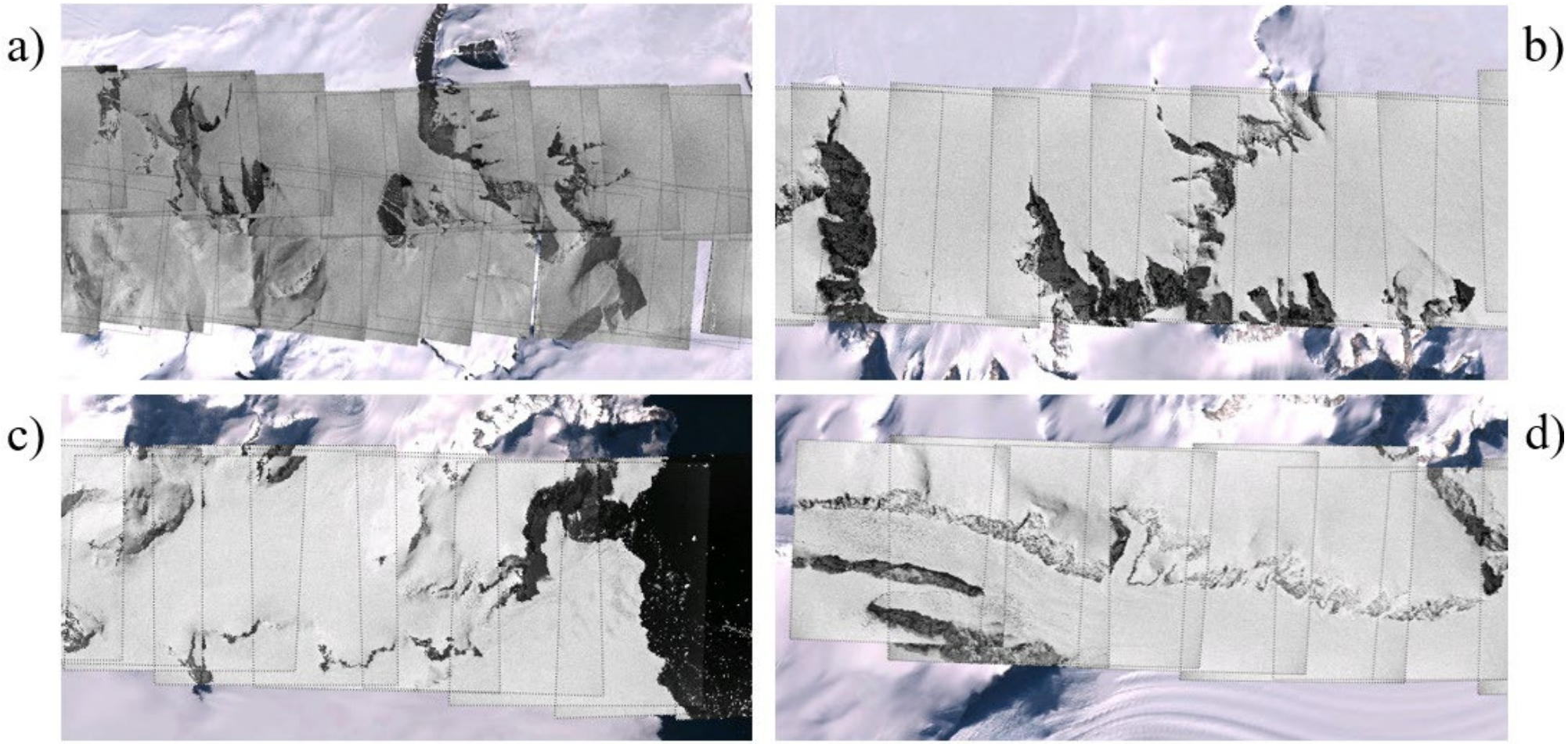
The Altimeter

Part III: Georeferencing

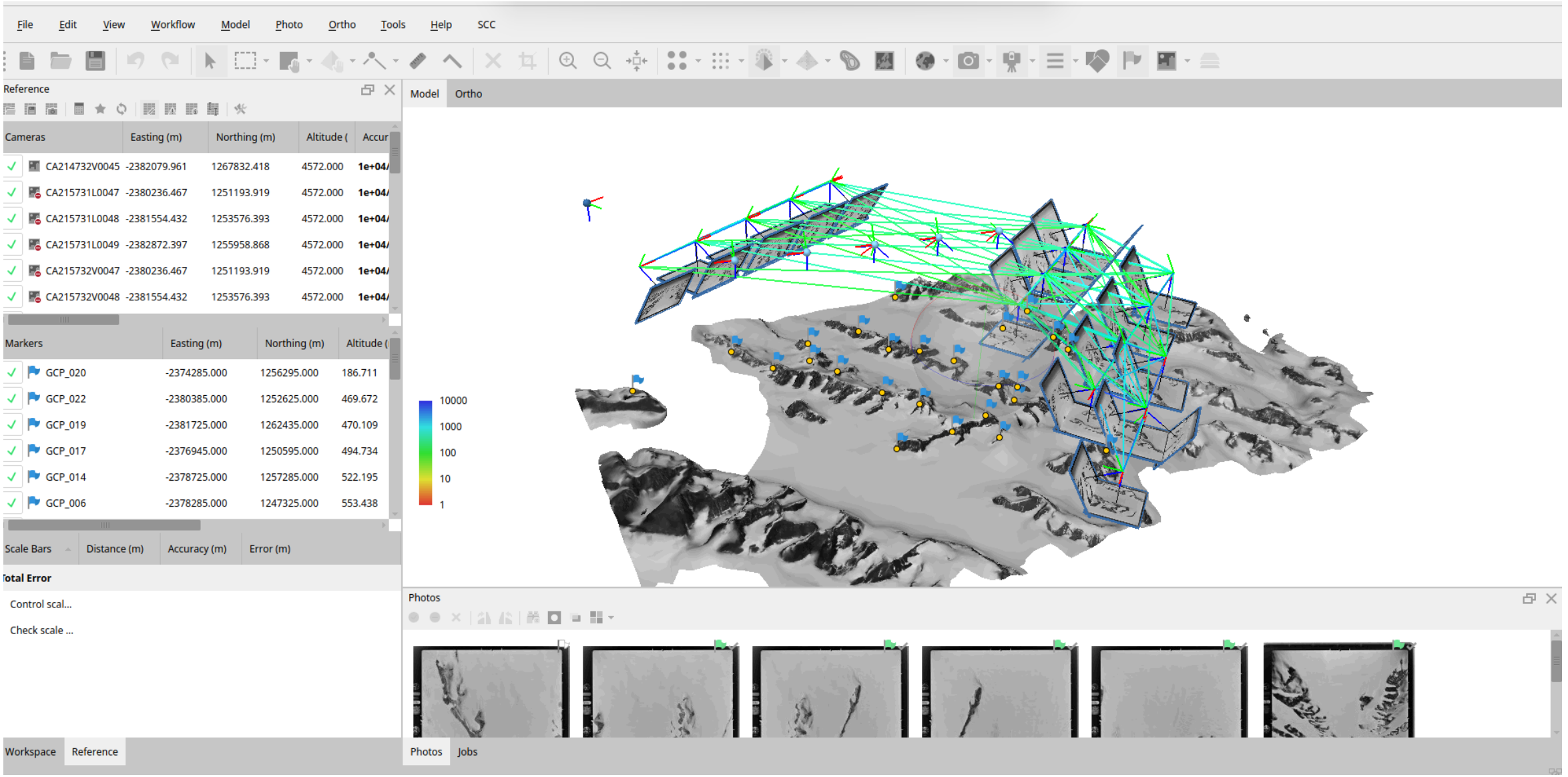
- Convert the **approximate position** of cameras to **exact footprints**
- Based on modern **machine-learning based tie-point matching** between historical images & modern satellite imagery (Sentinel-2)



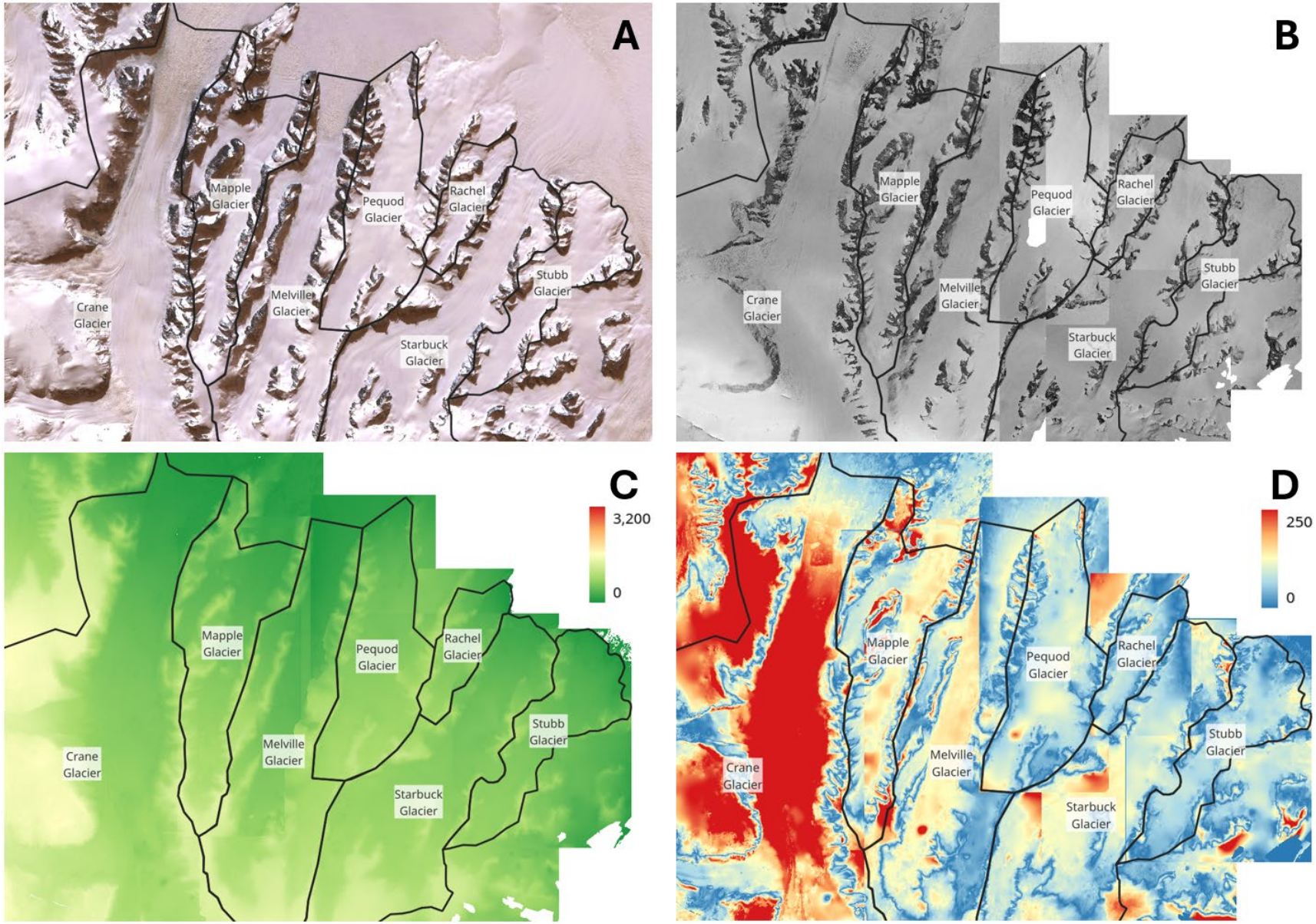
Part III: Georeferencing



Part IV: Model creation



Part IV: Model creation



The Road Ahead

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!

TU Delft