Detailed Glacier Area Change Analysis in the European Alps with Deep Learning

Codruț Diaconu[1, 2], Jonathan Bamber[2, 3]

[1] Remote Sensing Technology Institute, German Aerospace Center (DLR)
[2] Technical University of Munich
[3] University of Bristol

MUNICH SCHOOL FOR DATA SCIENCE
HELMHOLTZ | TUM | LMU

DLR

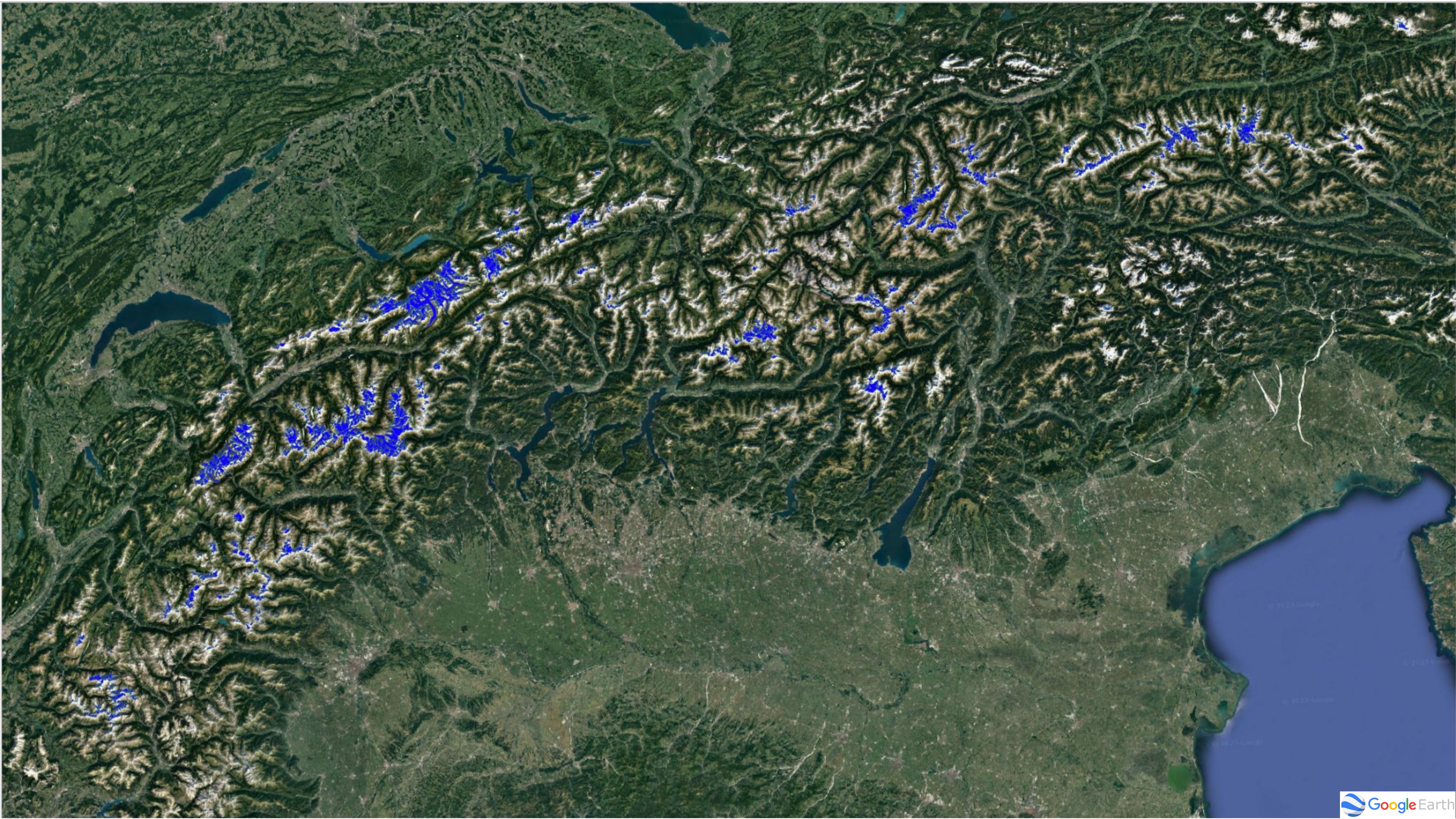
Glacier shrinkage in the Alps continues unabated as revealed by a new glacier inventory from Sentinel-2

Frank Paul[1], Philipp Rastner[1], Roberto Sergio Azzoni[2], Guglielmina Diolaiuti[2], Davide Fugazza[2], Raymond Le Bris[1], Johanna Nemec[3], Antoine Rabatel[4], Mélanie Ramusovic[4], Gabriele Schwaizer[3], and Claudio Smiraglia[2]

Project overview & motivation

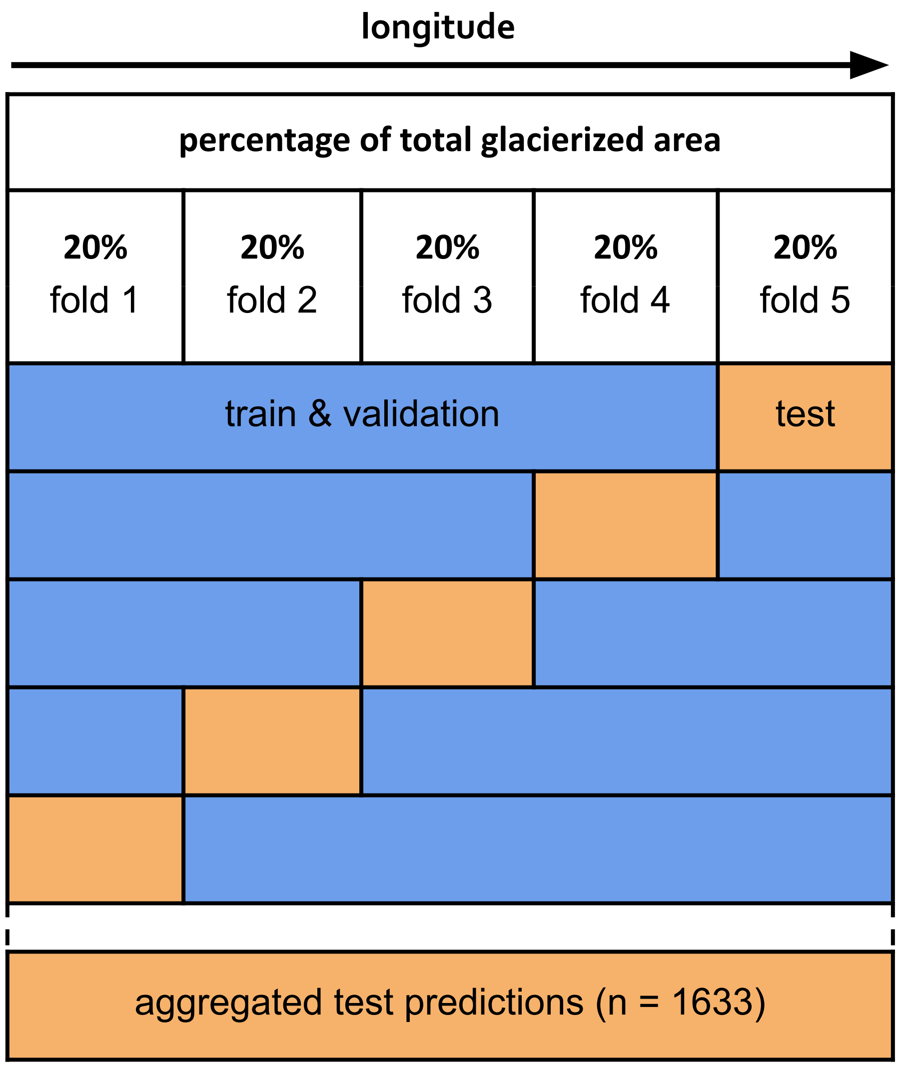
- a recent study (Paul et al., 2020) estimated a total glacierized area of ca. 1800 km^2 in the European Alps
  - used satellite images (Sentinel-2), mostly from 2015
  - previous inventory (based on images from 2003): 2100 km^2 => a shrinkage of ca. 14% (−1.2% a^{-1})
- what happened after 2015? can we use Deep Learning to track their surface over time?
- our contributions:
  - we are exploiting this new inventory with a DL approach for automatically mapping glaciers in this region
  - we make a step further and look into surface area changes over time **at glacier level**
  - we make publicly available the processed datasets


Google Earth

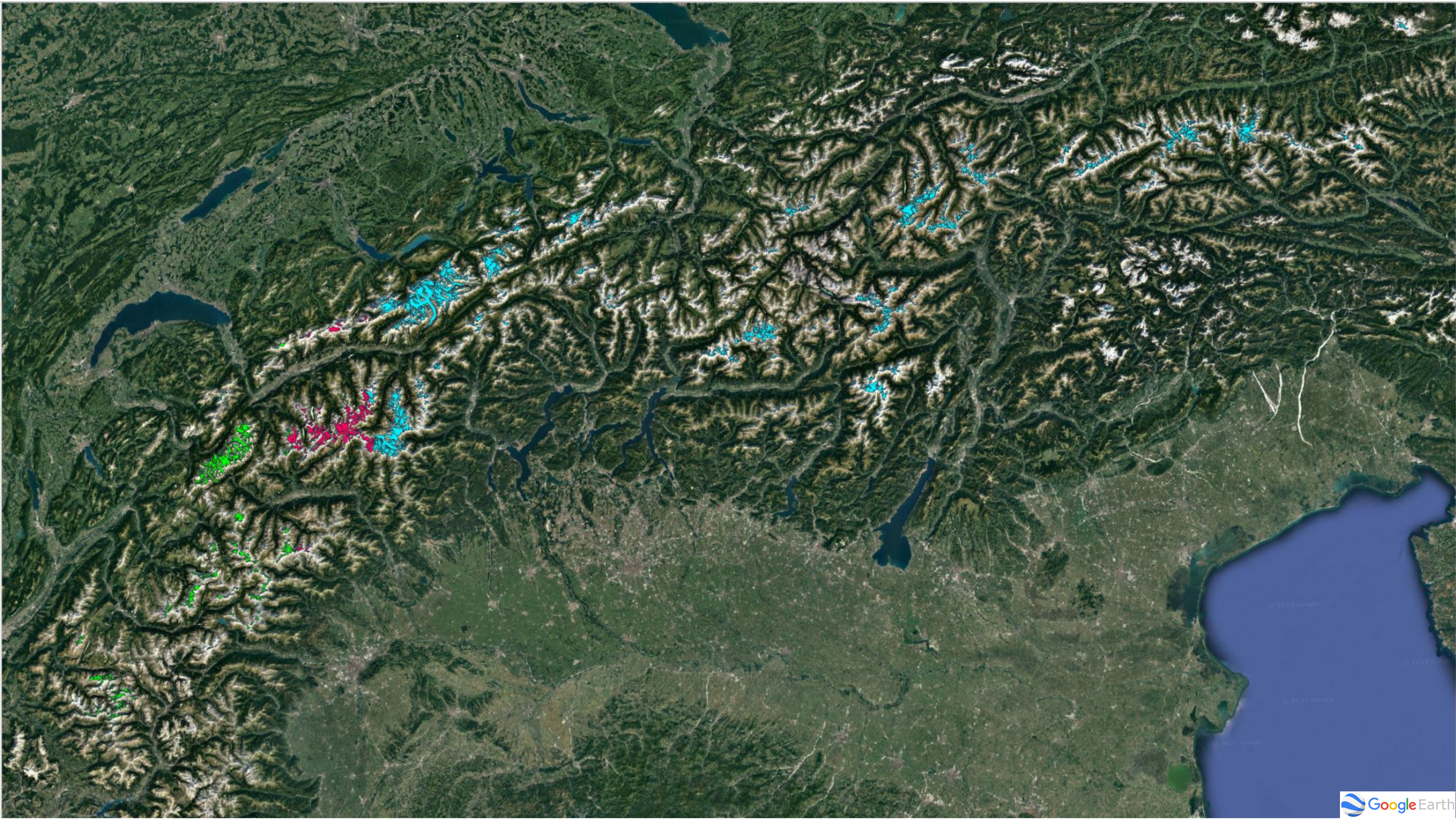

Google Earth

Model training & evaluation

- following existing works on glacier mapping (e.g. Xie et al., 2021) we use U-Net, with surface elevation as an additional input
- we perform a five-fold cross-validation scheme with a regional split
  - then we collect all the test predictions



We use a regional cross-validation mainly for obtaining predictions for each data point (i.e. glacier) rather than evaluating the model.



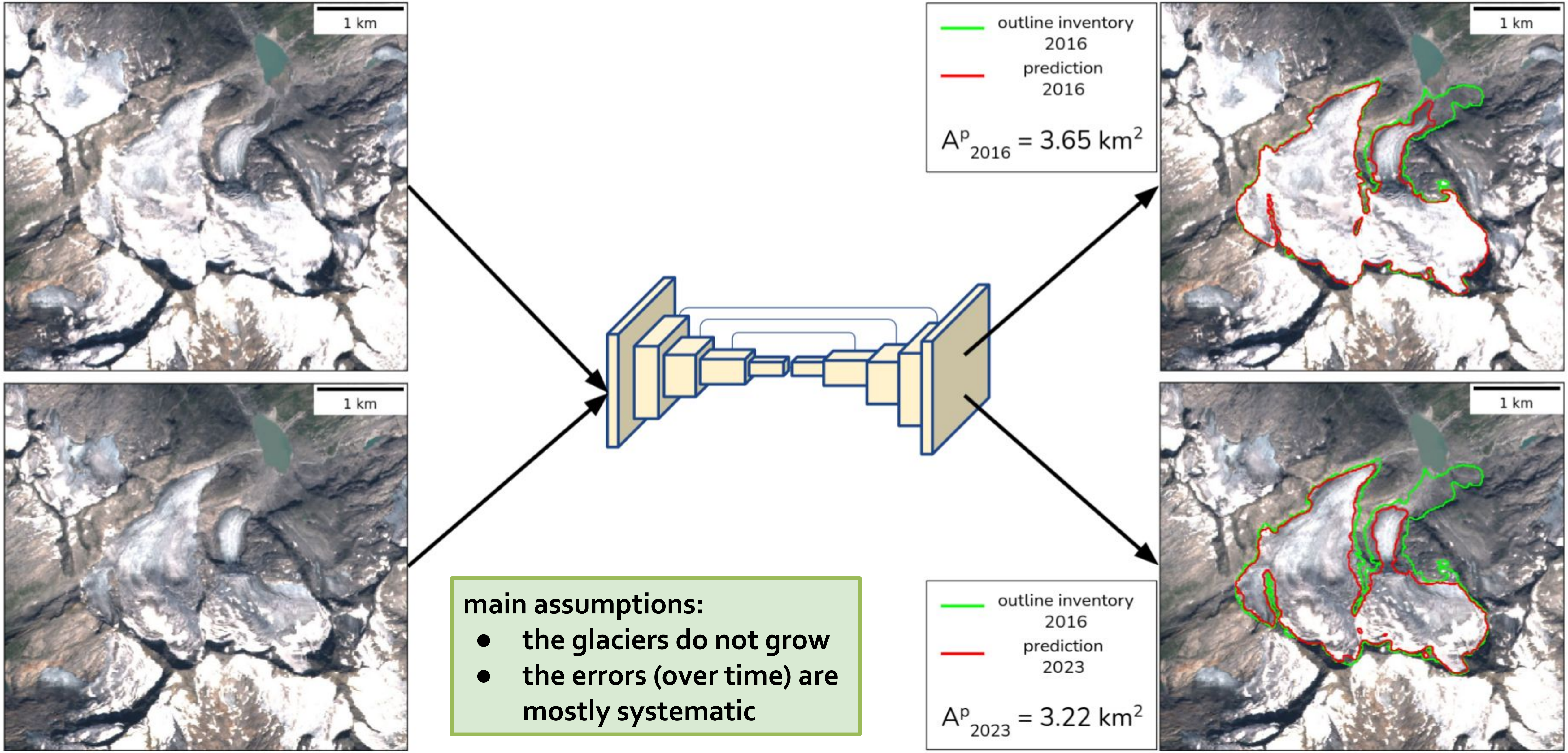
Data collection for 2023

For 2023, we implemented the next steps:

1. choose the **least cloudy five tiles** (110x110 km^2, centered on 01.09)
   - using the provided tile-level cloud percentage
2. **for each glacier**, keep the least cloudy day
   - this reduces the average cloud coverage from 4% to only 0.1%

We significantly decrease the average cloud coverage for 2023 by picking the best data for each glacier individually.

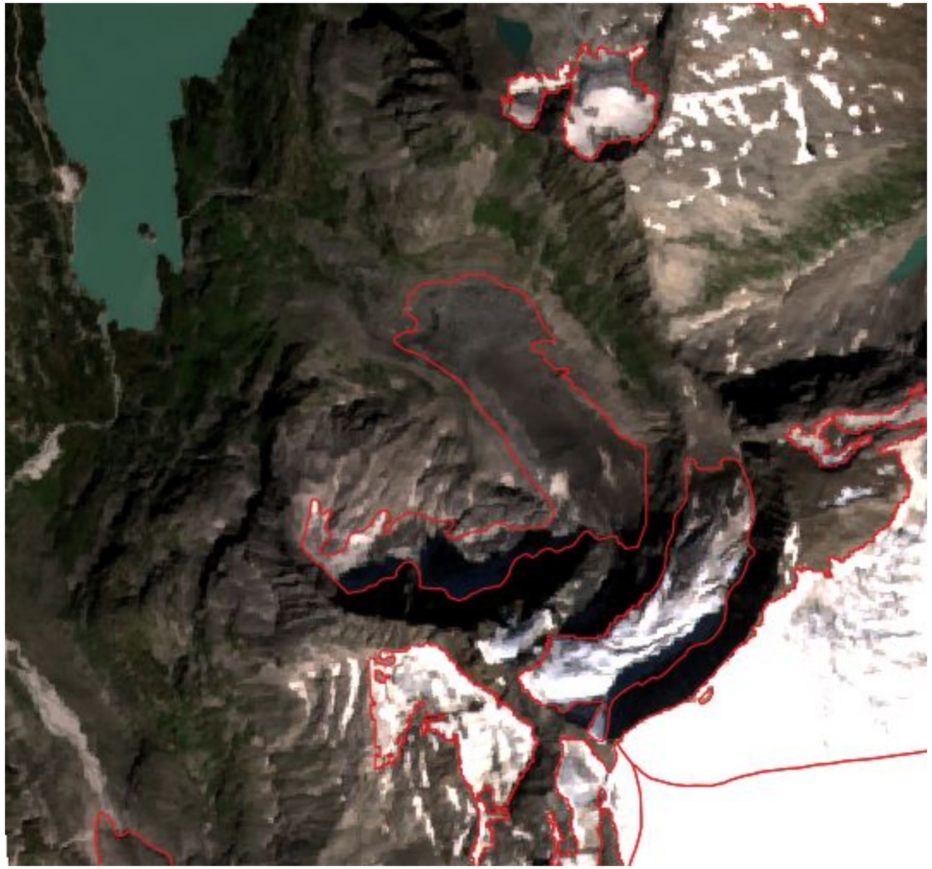
The approach exemplified for a glacier in the Obersulzbach valley, AT

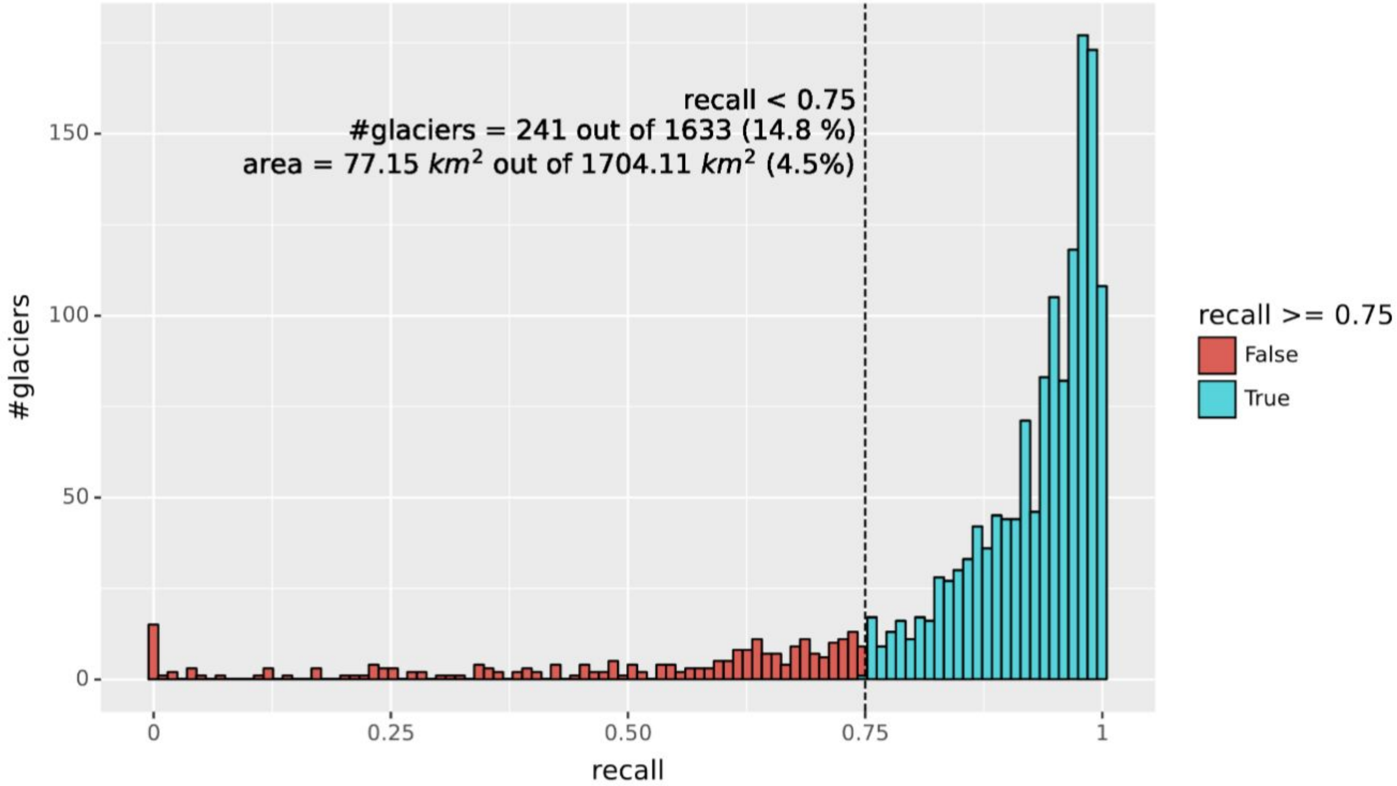


main assumptions:

- the glaciers do not grow
- the errors (over time) are mostly systematic

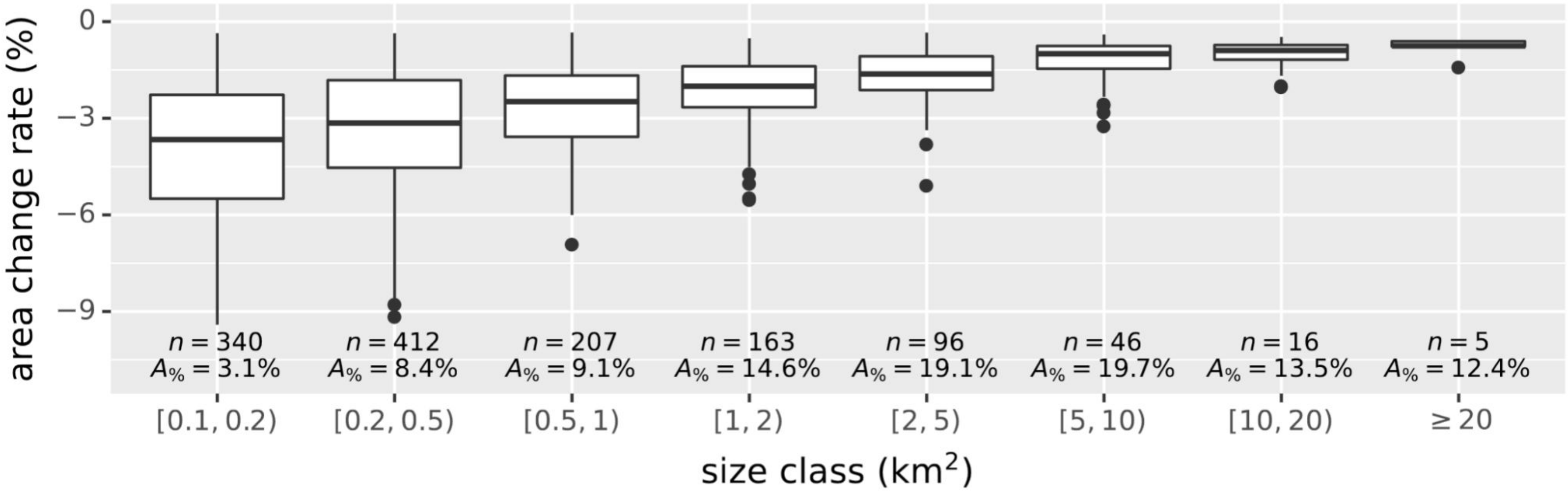
Sometimes seeing the glaciers from space is difficult





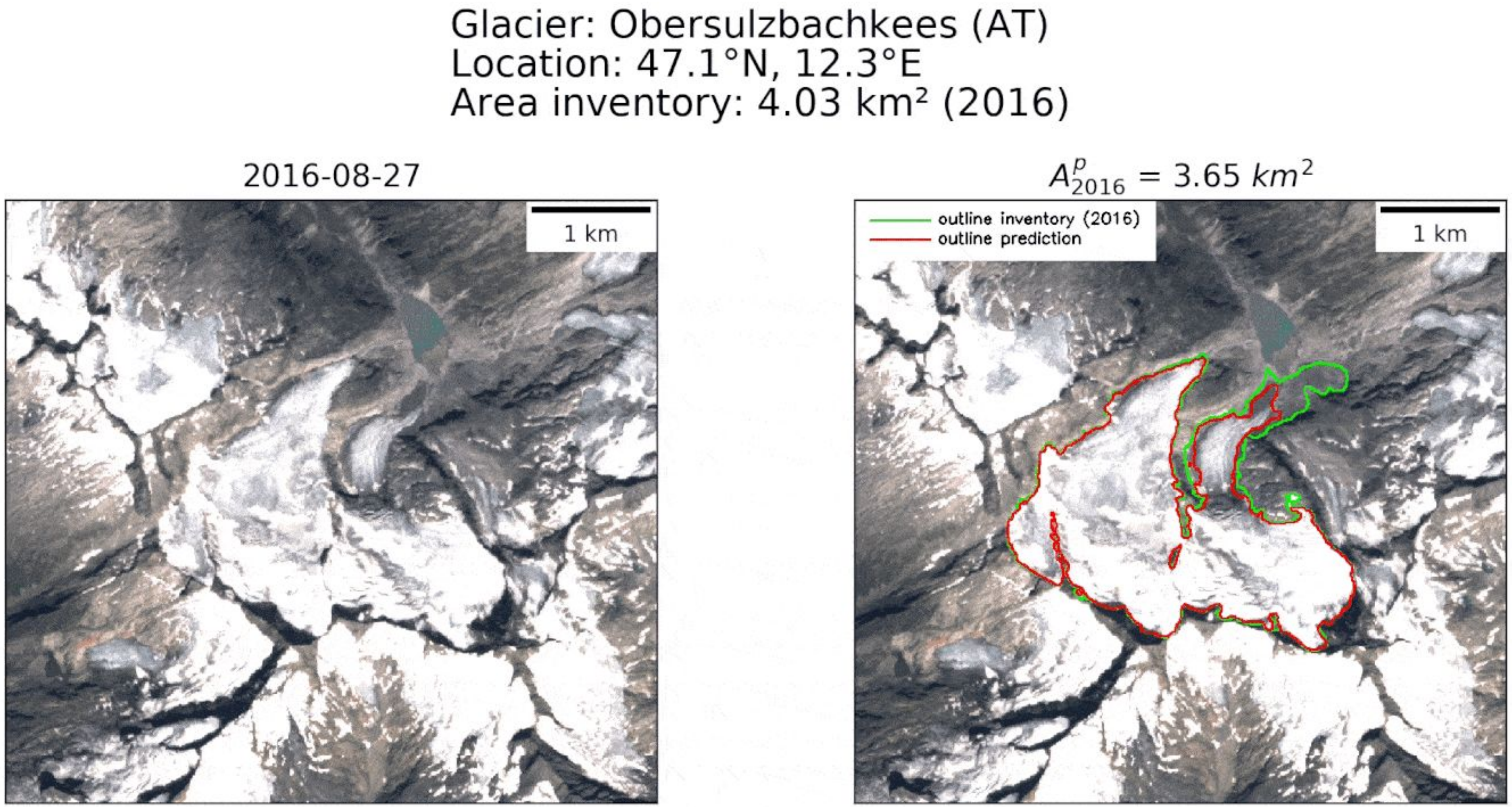
We use the testing performance as an uncertainty measure for selective prediction.

Analyzing all the remaining glacier-level shrinkage rates



Our regional area loss estimate is around -1.8% a^{-1} but we observe large inter-glacier variations.

Thanks for your attention!



GitHub