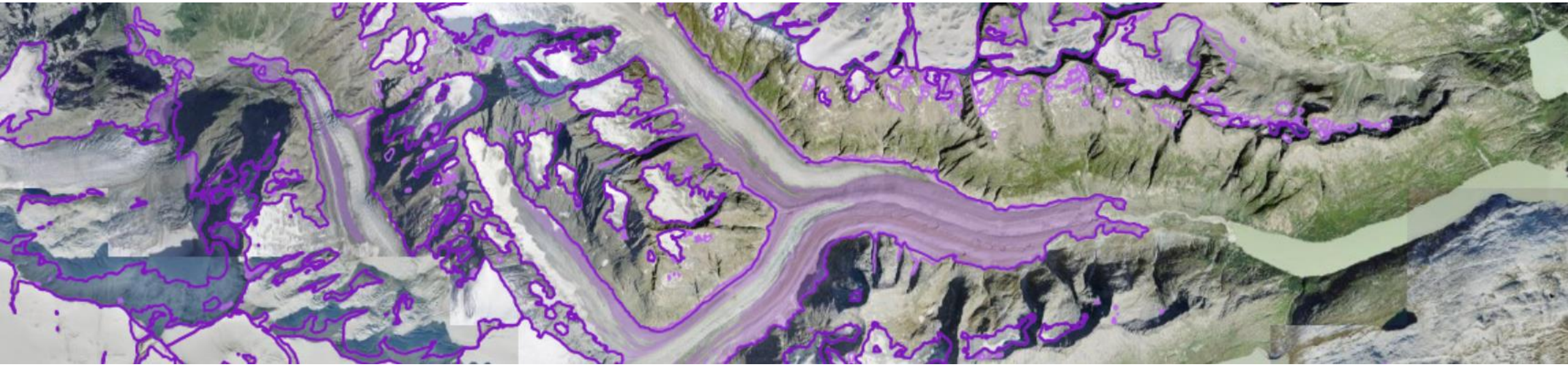

The new Swiss Glacier Inventory SGI2020: From a topographic to a glaciological dataset

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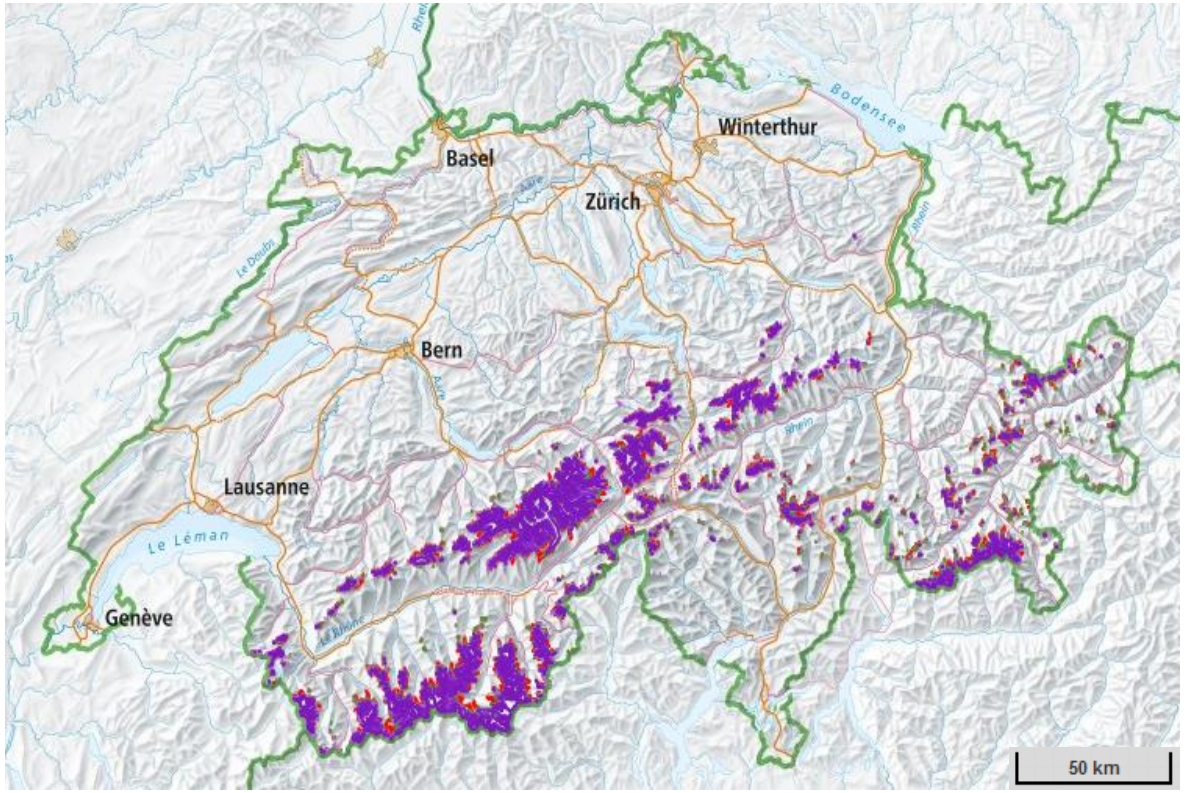
Aim: A new glacier inventory for the Swiss Alps

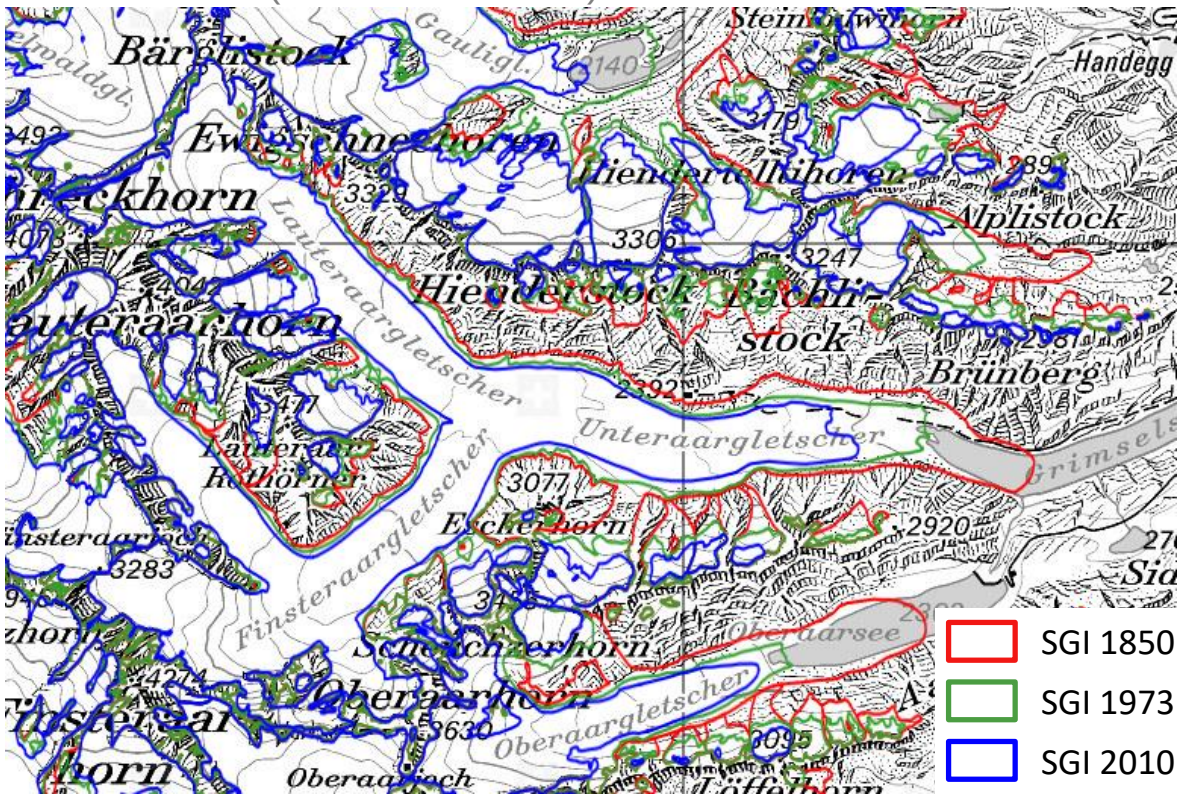
- Last official Inventory for Switzerland: Swiss Glacier Inventory 2010 (SGI2010) (Fischer et al. 2014)
- SGI2010 was produced by manual digitization from high-resolution aerial orthophotographs from swisstopo
- Federal Office of Topography, Swisstopo
  - provides high-quality aerial images (25 cm)
  - derives object classes «glaciers» and «debris cover»
- GLAMOS (Glacier Monitoring Switzerland, www.glamos.ch)
  - responsible for repeated Swiss Glacier Inventories (SGI's)
  - derives the glaciological dataset SGI based on the object classes «glaciers» and «debris cover»



Previous Work: glacier inventories for the Swiss Alps

Based on maps, aerial images and manual digitizing:

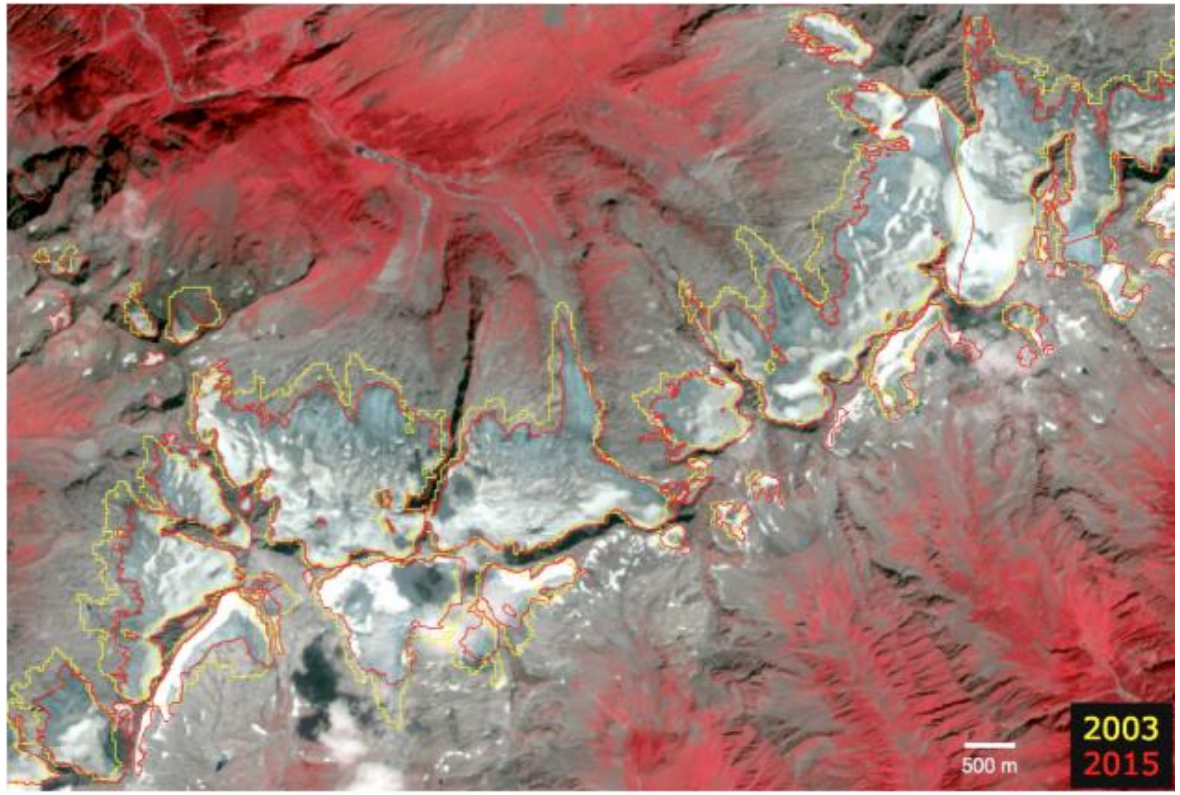
- SGI 1850 (Müller et al. 1976)
- SGI 1973 (Maisch et al. 2000)
- SGI 2010 (Fischer et al. 2014)



Weidmann et al. 2019

Based on satelite images and semiatomatic mapping

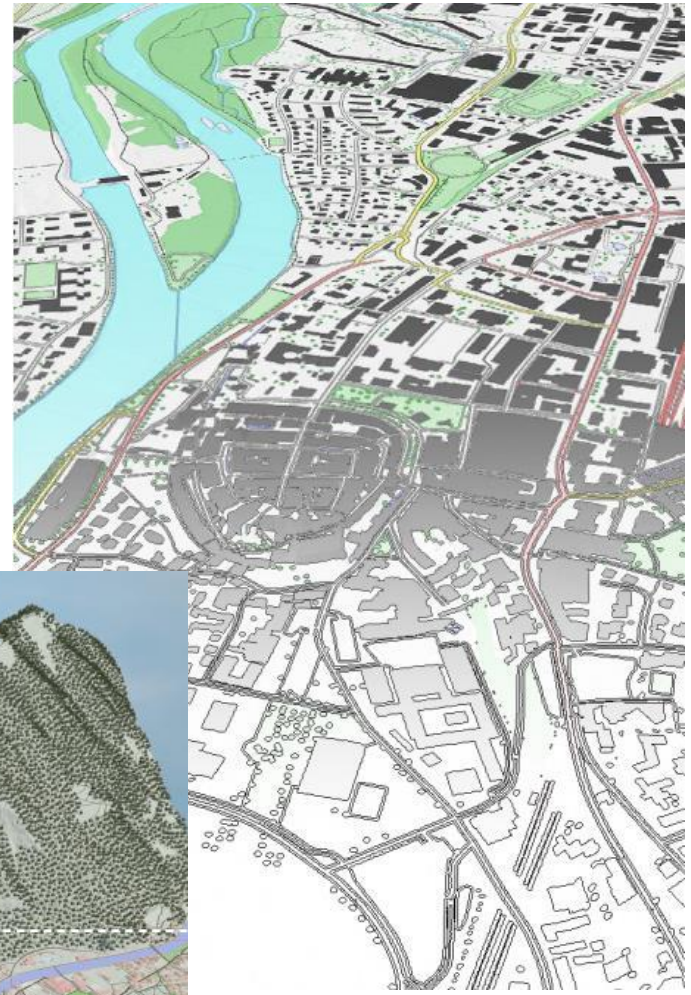
- SGI 2000 (Paul et al. 2002)
- Glacier inventory Alps 2003 (Paul et al. 2011)
- Glacier inventory Alps 2015 (Paul et al. 2019/subm.)

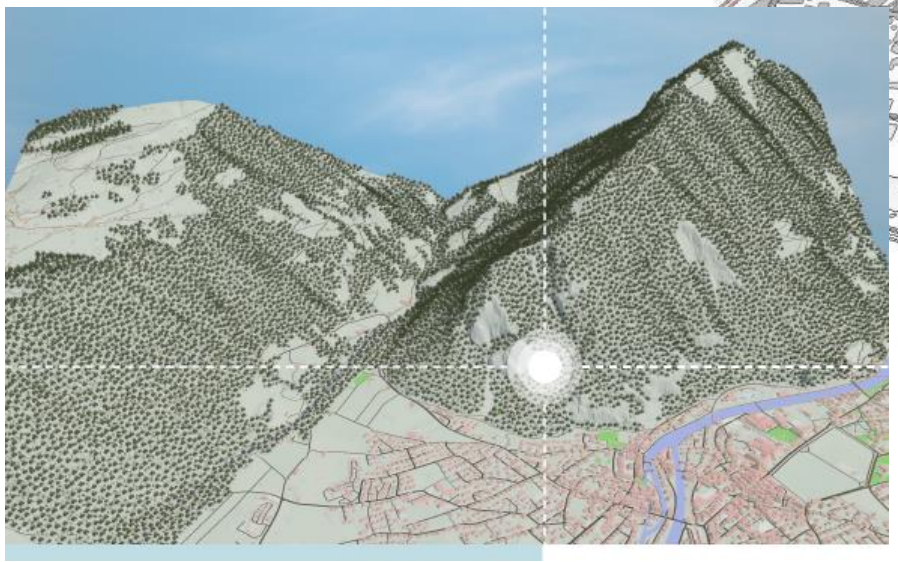


Paul et al. 2019/subm.

Swisstopo’s topographic landscape model «swissTLM3D»

- Large-scale topographic landscape model of Switzerland with:
  - natural and artificial landscape features
  - name data in vector form
- high degree of accuracy
- incorporation of a third dimension
- most extensive and accurate 3D vector dataset of Switzerland

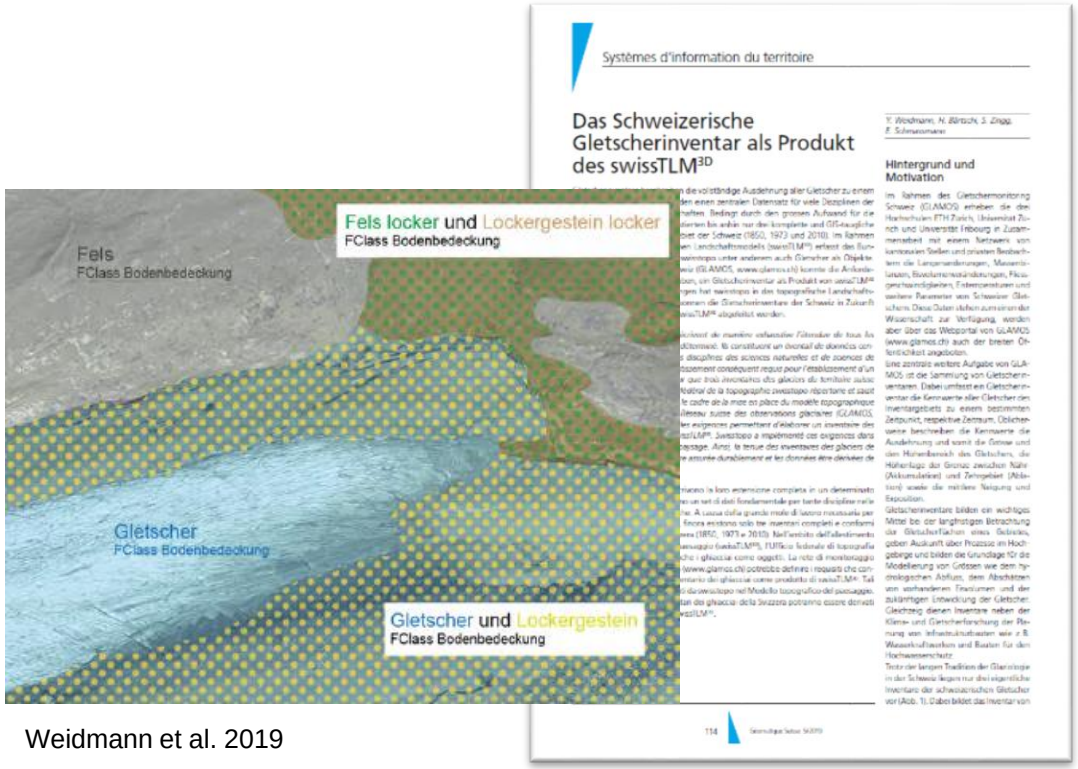




https://shop.swisstopo.admin.ch/en/products/landscape/tlm3D

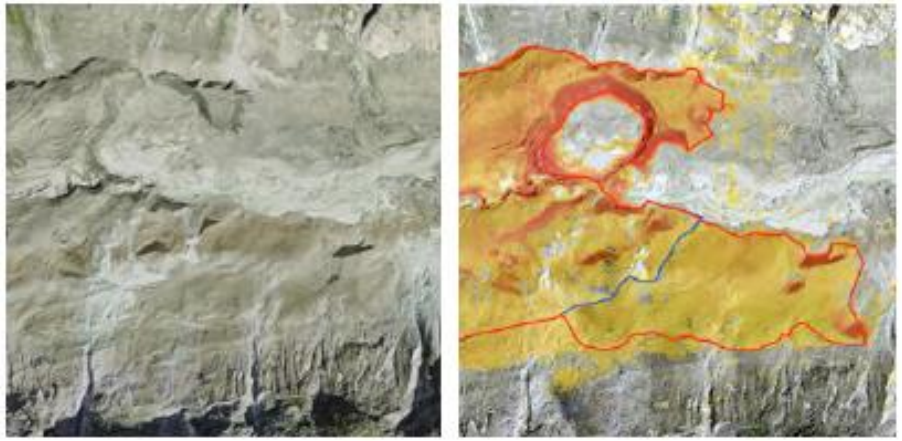
Object class «glaciers» in «swissTLM3D»

- Requirements defined by GLAMOS
- Primarily a landcover dataset
- Produced according to guidelines for topographical purpose



Weidmann et al. 2019

- Problem: glacier delineation in debris covered areas
- Techniques and data used for digitization by swisstopo (professional operators):
  - High quality aerial orthophotos from different years (3-yearly period)
  - DEM-Differences in high resolution (see Fig.)
  - Stereo-metric 3D acquisition



Weidmann et al. 2019

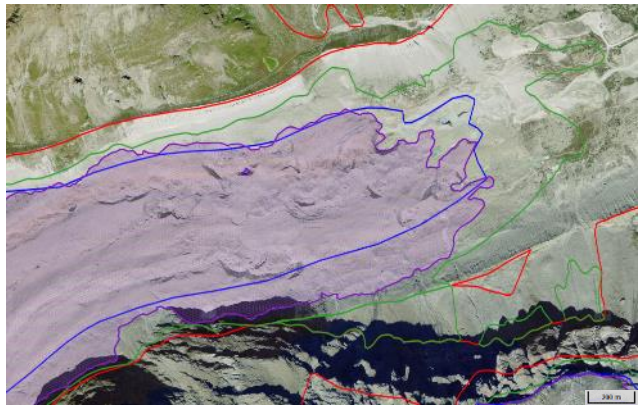
Topographic «glacier class» vs. Glaciological «glacier inventory»

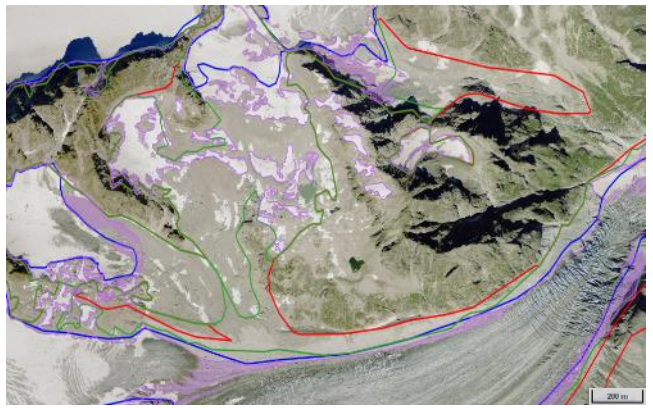
Topographic swissTLM3D «glacier class» → TLM 2019

- Digitizing guidelines for operators
  - Developed based on a workshop with swisstopo operators and GLAMOS glaciologists
  - Derived upon requirements from glaciologists
  - Fitted for topographical purpose
- Digitizing accuracy and the level of detail is extremely high
- Digitizing revealed many details, debris covered glacier parts

Problems to derive a glacier inventory

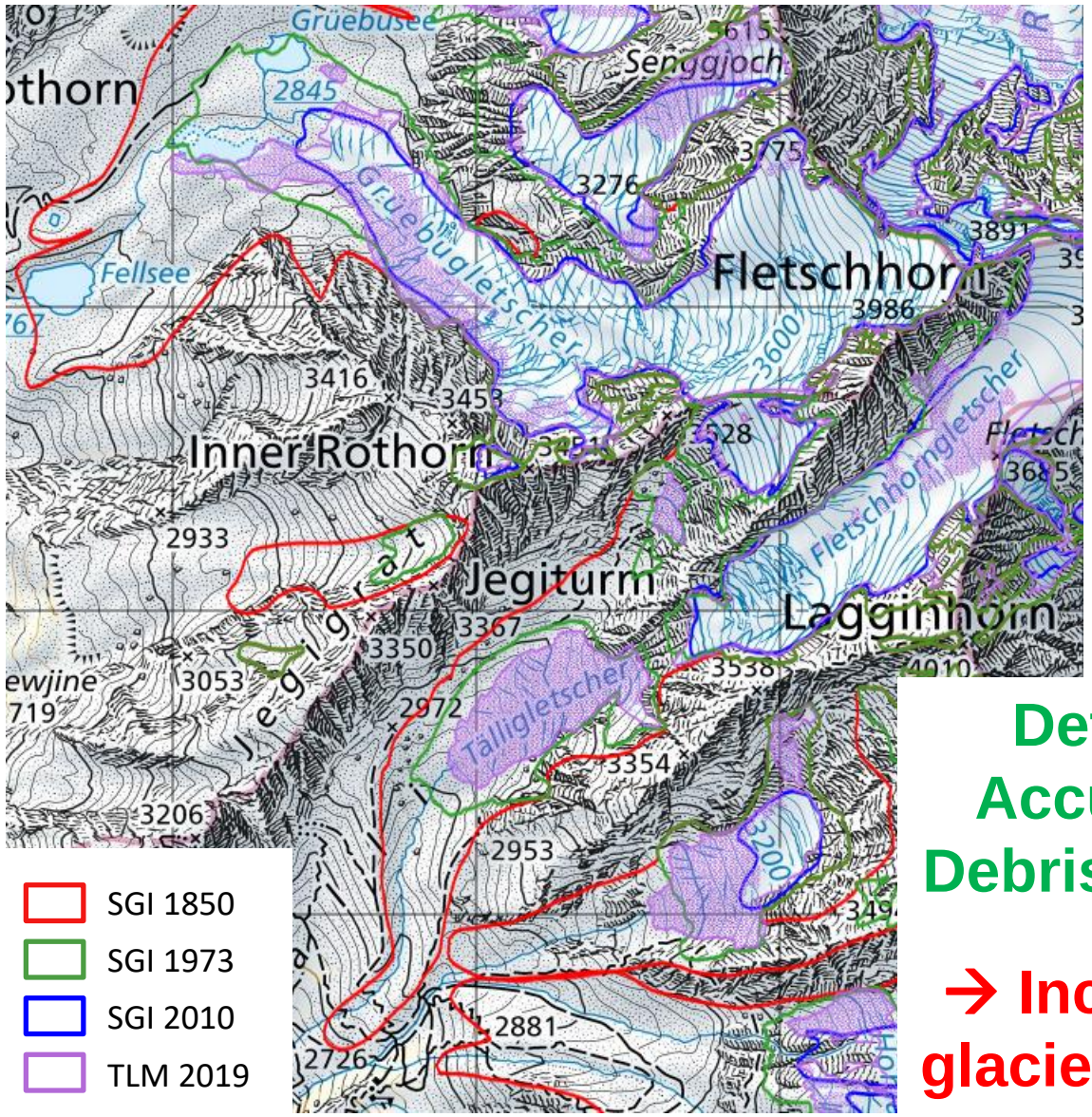
- Digitizing is still dependent on operators/ interpretation and glaciological knowledge
- Partly problematic definitions of glacier boundaries related to snow coverage and/or supraglacial debris



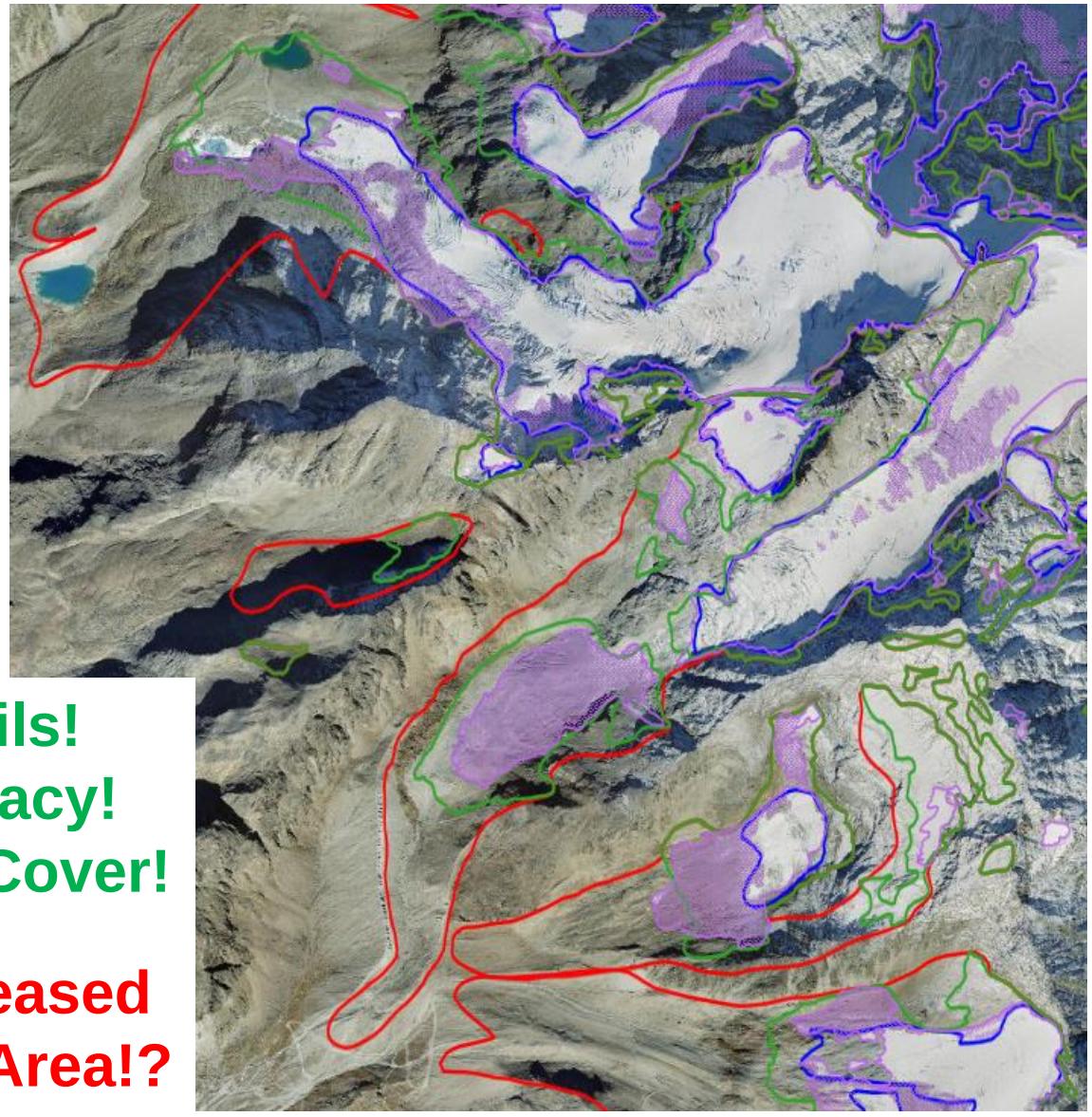


The swissTLM3D «glacier class» (TLM 2019) is in first order a landcover dataset and not a glaciological glacier inventory.

TLM 2019 «glacier class» compared to previous SGI's

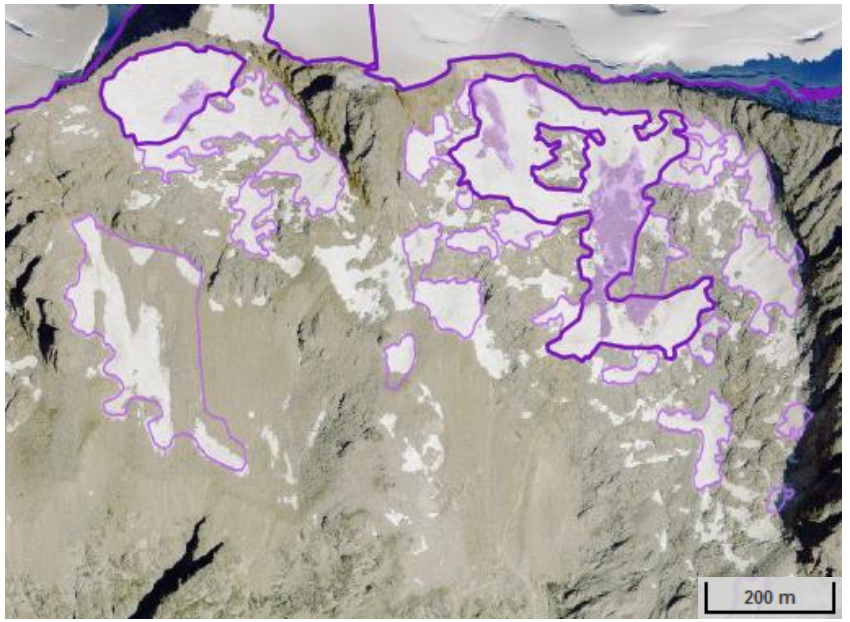


Details!
Accuracy!
Debris Cover!
but
→ Increased glacier Area!?

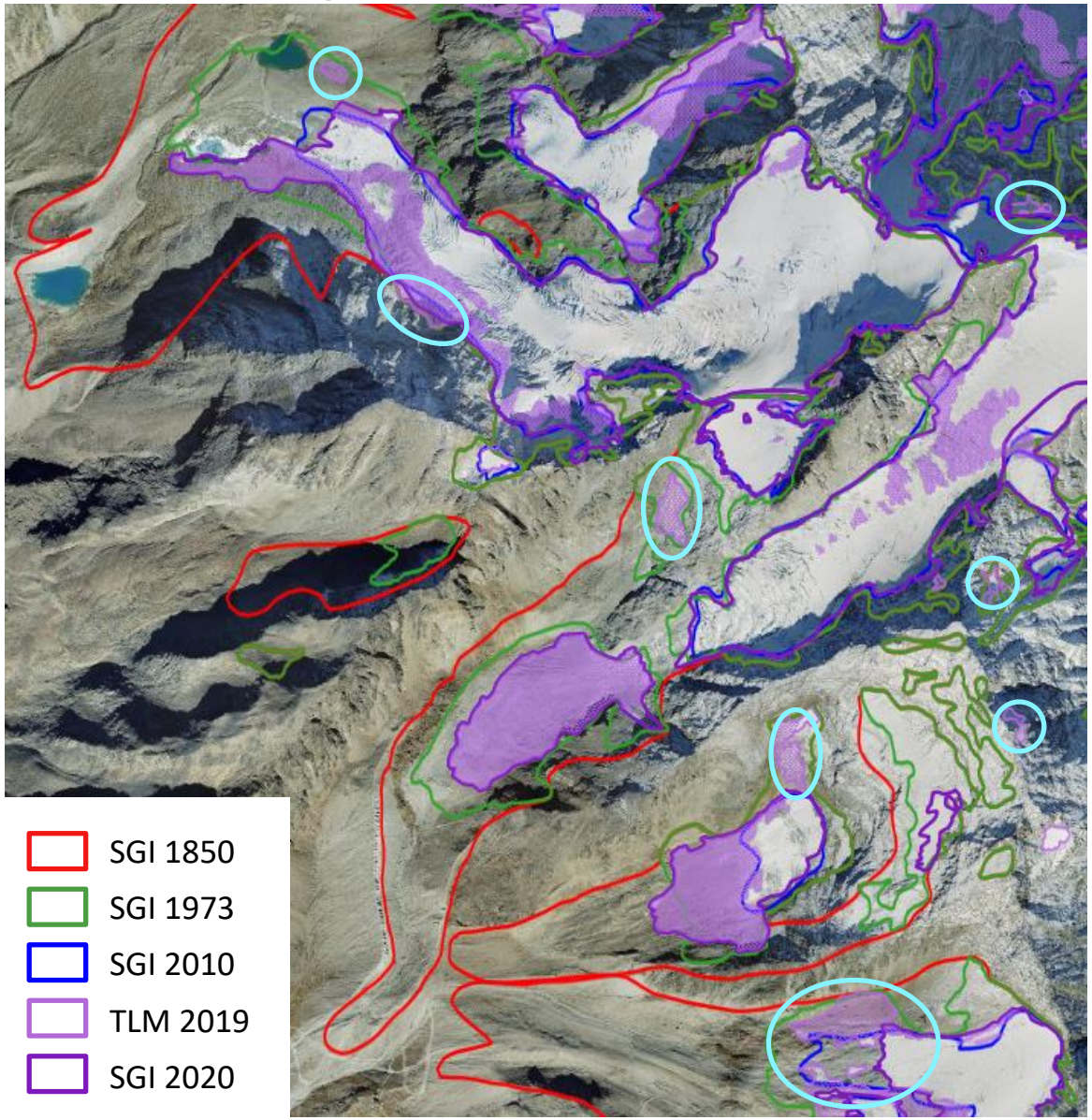


From the TLM 2019 «glacier class» to the outlines of the SGI 2020: Adaptations and workflow:

1. Application of **area size threshold**: 0.01 km2 (Leigh et al. 2019, Paul et al. 2019/subm.)
2. **Expert meeting** (GLAMOS staff): Discussion of TLM 2019 release, identification of problematic areas:
   - seasonal snow, avalanche deposits
   - dead ice bodies / debris covered ice, not dynamic anymore
   - dead ice, debris covered ice at edges of large glacier tongues
   - simplification of glacier outlines (bulges)
3. Digitizing **clipping mask**: by GLAMOS Staff based on Expert meeting, digitizing scale 20-50 m (not as accurate as swisstopo),
4. **Harmonization and Generalization** of clipped glacier outlines
5. Application of **area size threshold**: 0.01 km2
6. Derive **glacier inventory attributes** based on DEM SwissAlti3D



Resulting SGI 2020 after adaptations



Products of SGI 2020 dataset

- **Glacier outline** layer with attributes
- **Ice divides** layer
- **Debris cover** layer
- **Glacier centroid point** layer

Total of glacierized area according to:

- SGI 1850: 1788 km^2
- SGI 1973: 1311 km^2
- SGI 2010: 944 km^2
- TLM 2019: 1014 km^2
- **SGI 2020: 961 km^2**

Is the new SGI 2020 comparable with the last official SGI 2010?

Changes in numbers from the SGI 2010 to the SGI 2020

- Number of glaciers decreased (-142), but not for glaciers > 1km^2 (+5)
- Length of glacier outlines increased (all: +1763 km; > 1km^2:+ 898 km)
- Area of glaciers is more ore less the same (all: +17 km^2; > 1km^2: -1 km^2)

	selection	*count*	*length (km)*	*area (km2)*
SGI 1850	all glaciers	2384	9289	1788
	galciers > 1km2	311	5006	1377
SGI 1973	all glaciers	3051	8658	1311
	galciers > 1km2	212	3939	987
SGI 2010	all glaciers	1999	5617	944
	galciers > 1km2	155	2821	742
TLM 2019	all glaciers	5961	10246	1014
	galciers > 1km2	163	4114	754
SGI 2020	all glaciers	1857	7380	961
	galciers > 1km2	160	3719	741

Properties of SGI 2020
→ Higher Accuracy
→ Higher level of detail
→ Mapped more debris covered glacier parts

Change assessment is not possible!

Work in progress: **New reference dataset for SGI 2010**
→ **statistical upscaling for change assessment**

- Objective: **Re-digitization of SGI 2010 outlines**, “through the glasses of swisstopo” in relation to debris-covered areas, but with the same resources as available for the SGI 2010.
- Sample of 100 randomly selected glaciers (from all regions and size classes)
- Manually digitization of glacier outlines by GLAMOS staff, according to rules:
  - SGI 2010 outlines must not be used
  - SGI 1973 can be used, to determine the glacier that has to be digitized
  - Ice divides of SGI 1973 will be used
  - SWISSIMAGE journey through time backwards should/can be used (but not forward in time)

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