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KTT workshop for Hydropower

Gletscherbett- und Eisdickenbestimmung in den Schweizer Alpen

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Gletscherbett- und Eisdickenbestimmung in den Schweizer Alpen

Content:

1. Motivation and Project Objectives
2. Ground Penetrating Radar (GPR)
3. Status of the project
4. Conclusion and Outlook

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1. Motivation

- runoff
- natural

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The role of glacier retreat for Swiss hydropower production

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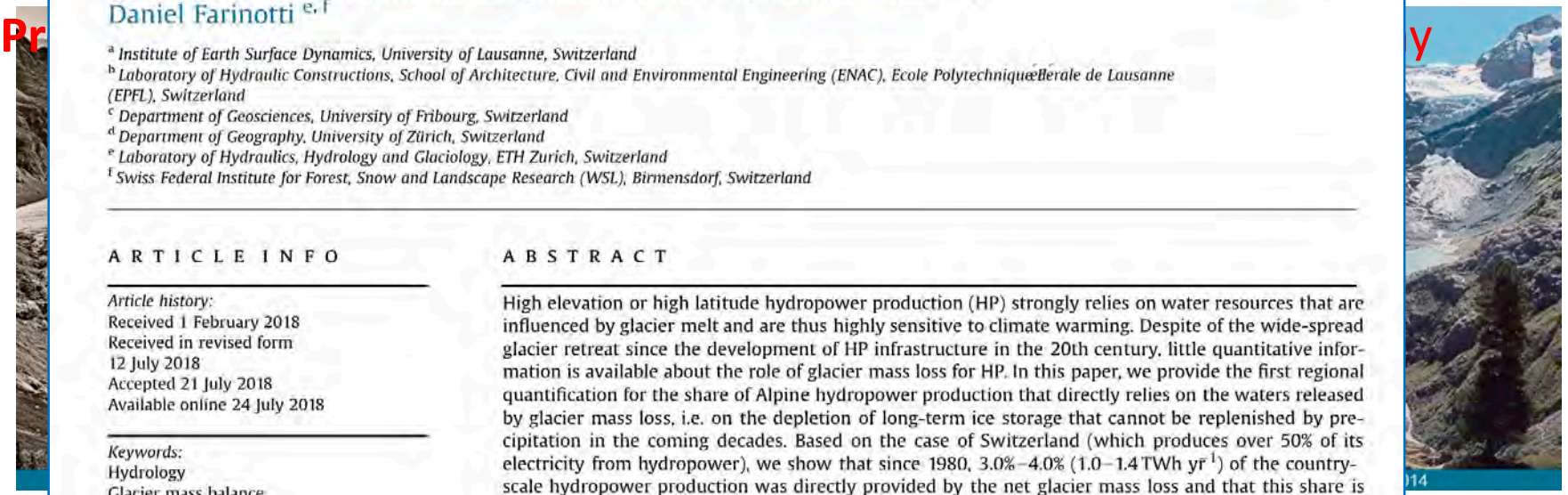
ABSTRACT

High elevation or high latitude hydropower production (HP) strongly relies on water resources that are influenced by glacier melt and are thus highly sensitive to climate warming. Despite of the wide-spread glacier retreat since the development of HP infrastructure in the 20th century, little quantitative information is available about the role of glacier mass loss for HP. In this paper, we provide the first regional quantification for the share of Alpine hydropower production that directly relies on the waters released by glacier mass loss, i.e. on the depletion of long-term ice storage that cannot be replenished by precipitation in the coming decades. Based on the case of Switzerland (which produces over 50% of its electricity from hydropower), we show that since 1980, 3.0%–4.0% (1.0–1.4 TWh yr^{-1}) of the country-scale hydropower production was directly provided by the net glacier mass loss and that this share is likely to reduce substantially by 2040–2060. For the period 2070–2090, a production reduction of about 1.0 TWh yr^{-1} is anticipated. The highlighted strong regional differences, both in terms of HP share from glacier mass loss and in terms of timing of production decline, emphasize the need for similar analyses in other Alpine or high latitude regions.



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2. Ground penetrating radar - surveying principle

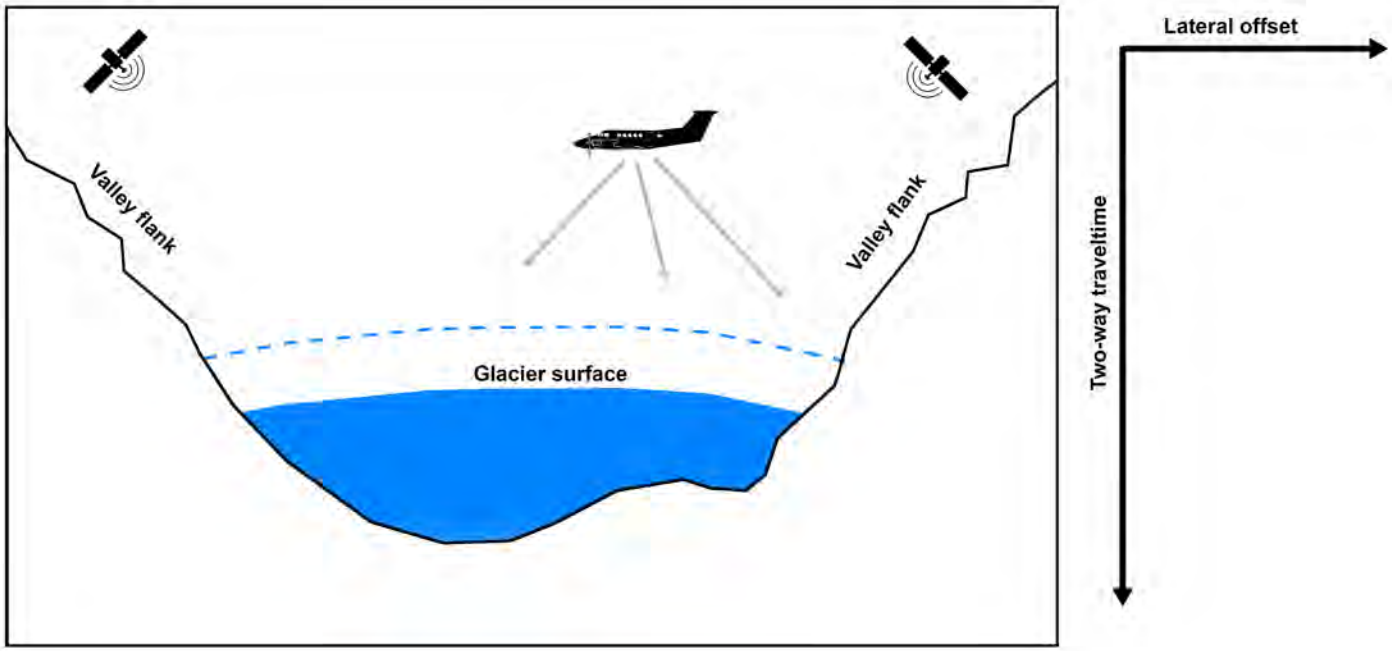
Components of the GPR-System

GPR in action

More Details → Poster session

2. Ground penetrating radar - surveying principle

- Glacier bed topography and current state of ice-thickness from helicopter-borne GPR
- Once the glacier bed is known: Future updates for the ice volume can be obtained from photogrammetric and satellite data



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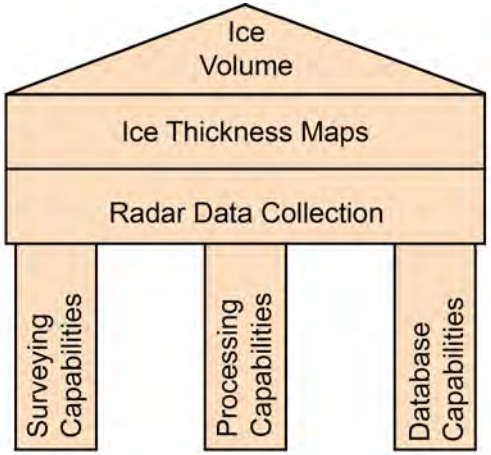
3. Current status of the project

Towards a complete glacier inventory



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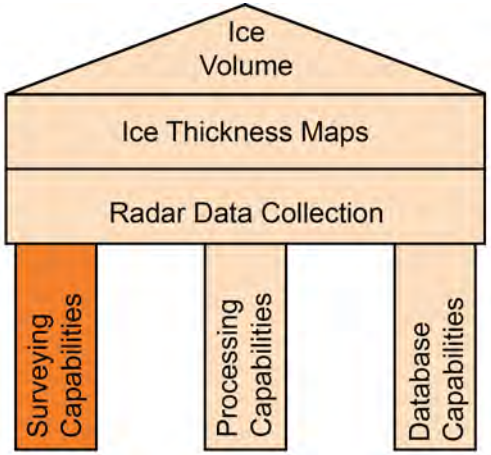
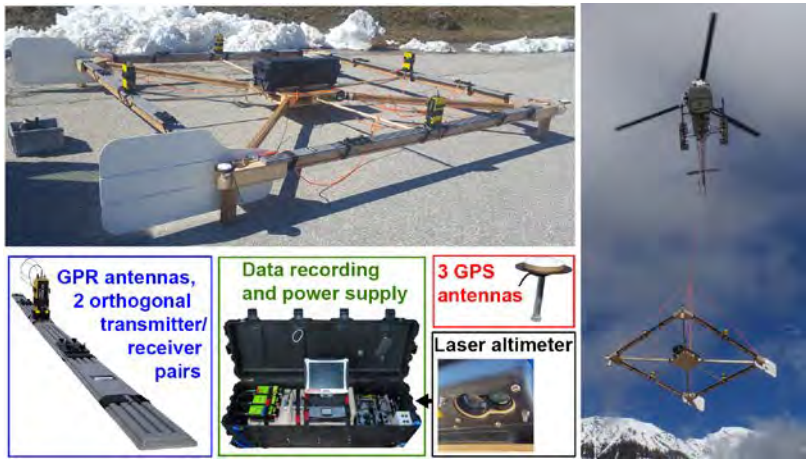
Towards a complete glacier inventory



Surveying Capabilities:



More Details → Poster session

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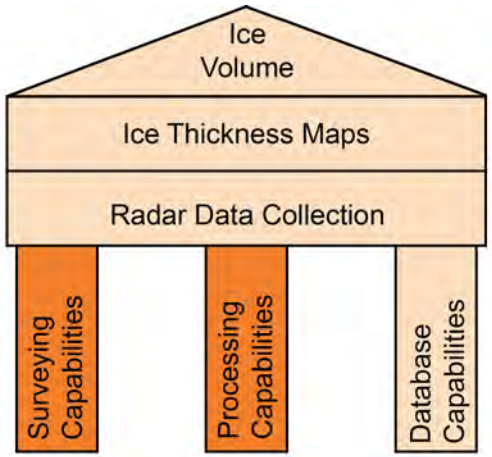
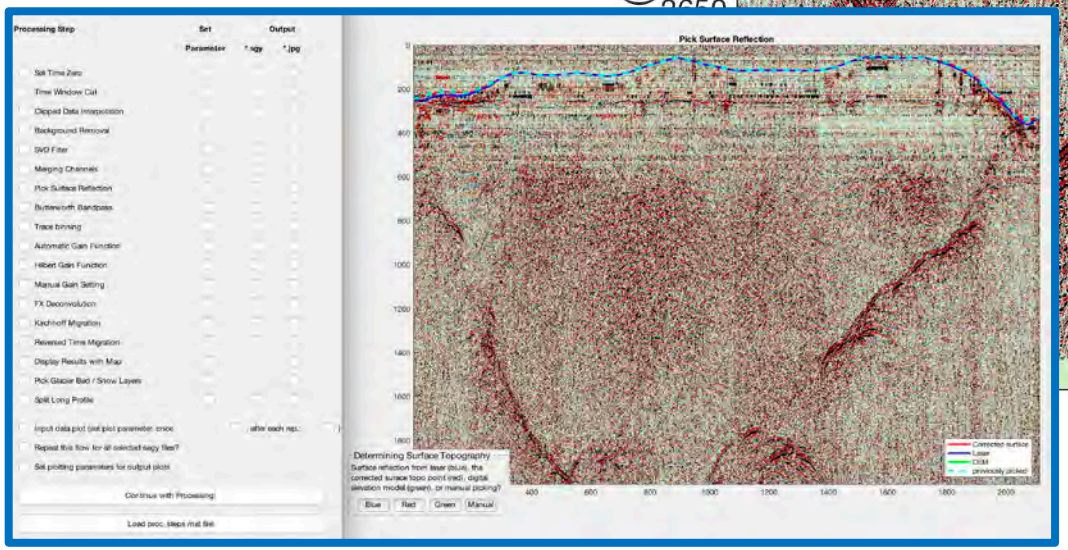
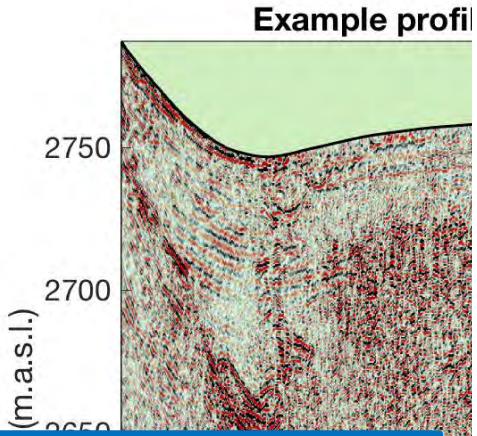
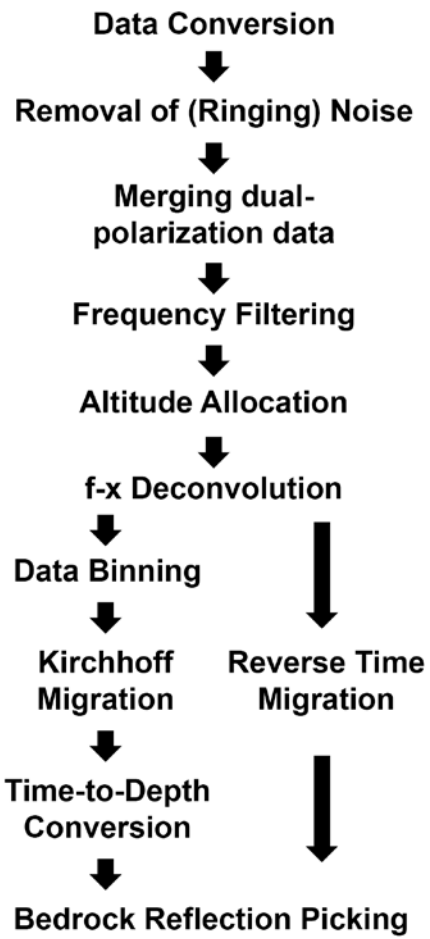
Towards a complete glacier inventory



Processing Capabilities:







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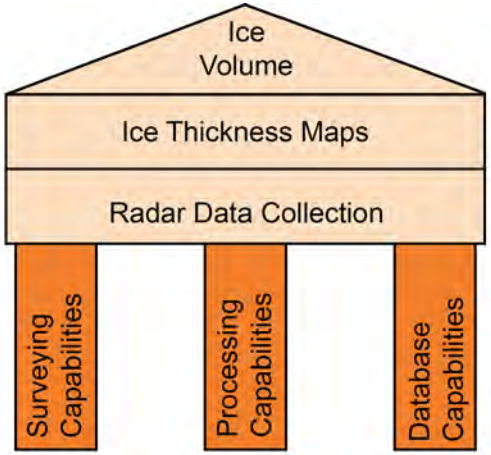
Towards a complete glacier inventory

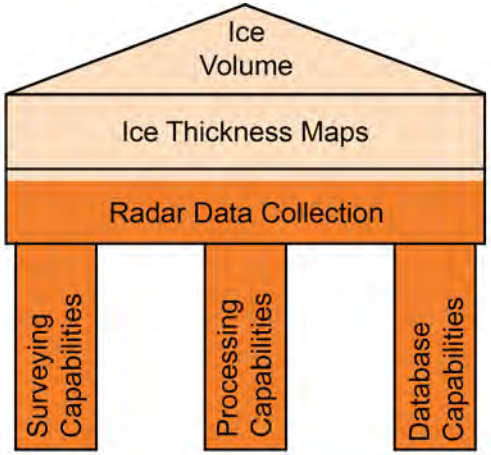


Database Capabilities:

- Data storage organized on local database
- Publicly available, on national or international data centres (e.g. GLAMOS, WGMS,…), once final result is obtained

3. Current status of the project

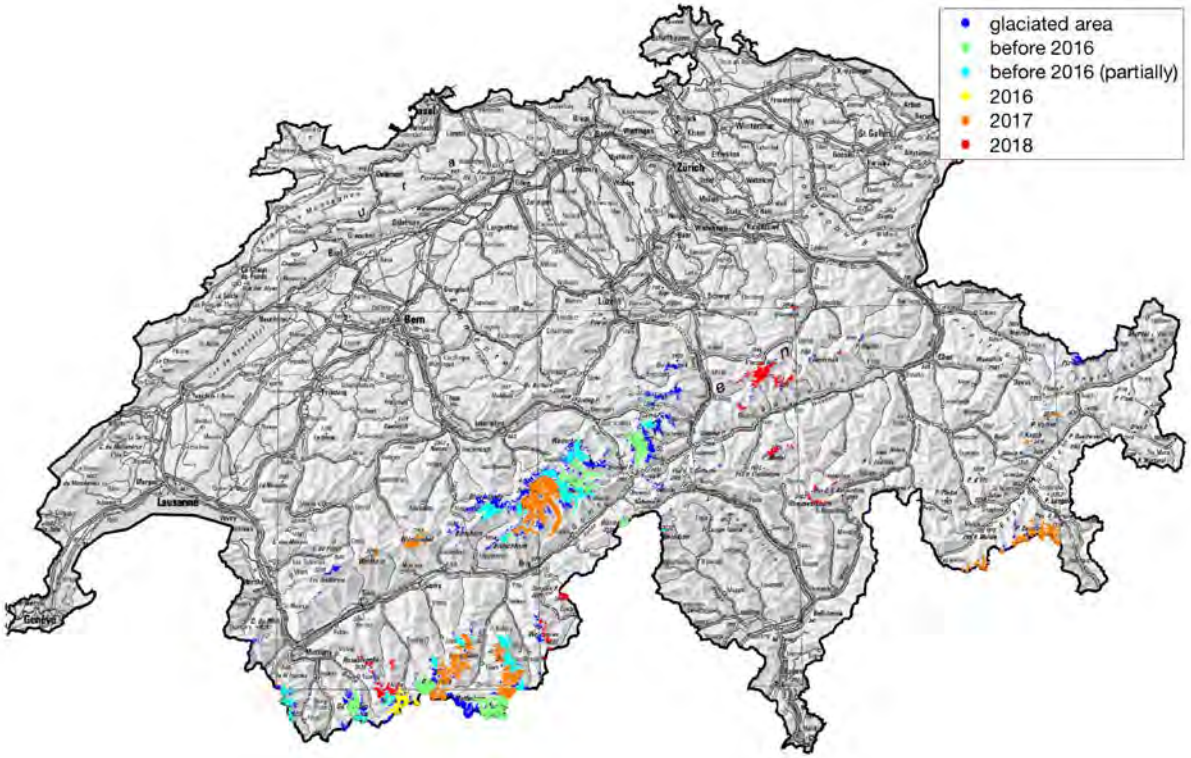
Towards a complete glacier inventory



	Number of profiles	Cumulative length
Datasets recorded with various systems		
1999 - 2015	1672	1369 km

Datasets recorded with current system		
2016	123	160 km
2017	566	515 km
2018	337	270 km
Total:	**2698**	**2314 km**

Radar data collection:



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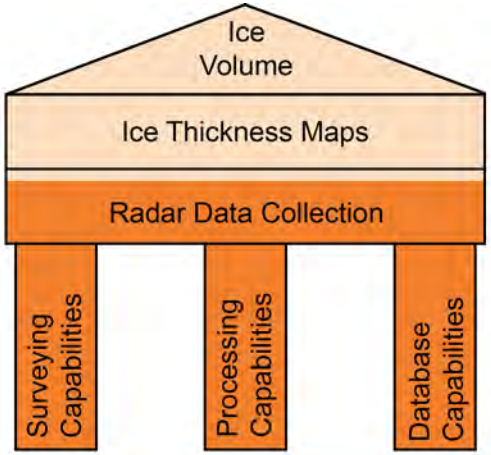
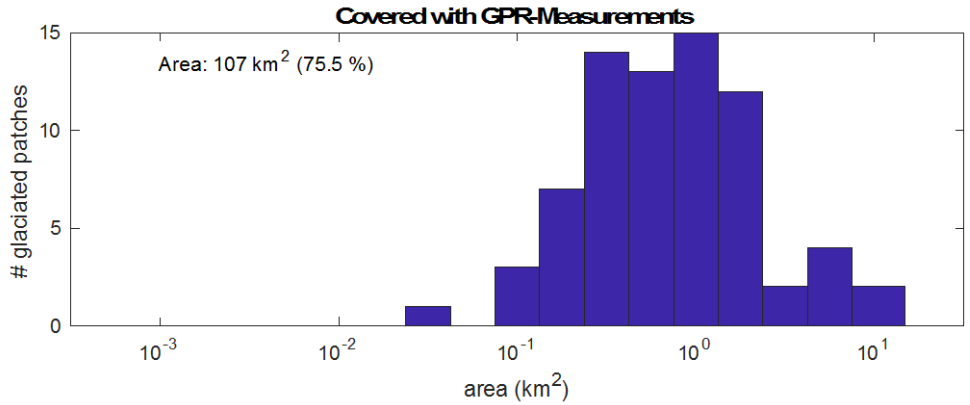
3. Current status of the project

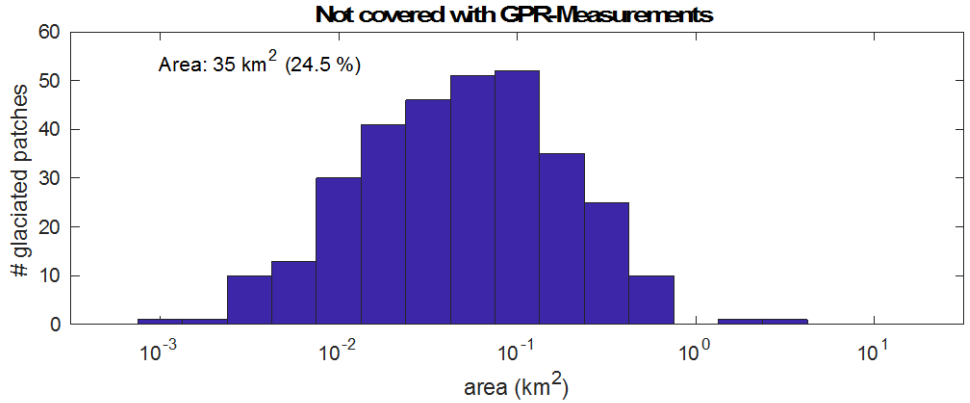
Towards a complete
glacier inventory



Radar data collection:

Eastern Swiss Alps (East of Reuss/Ticino)





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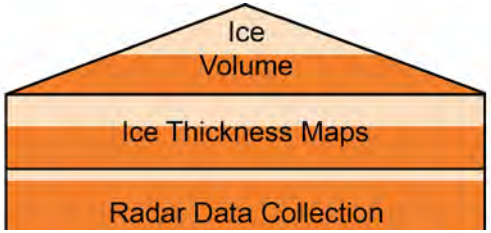
Towards a complete glacier inventory



Ice thickness maps and ice volume

Glaciological modeling for interpolation between GPR-profiles

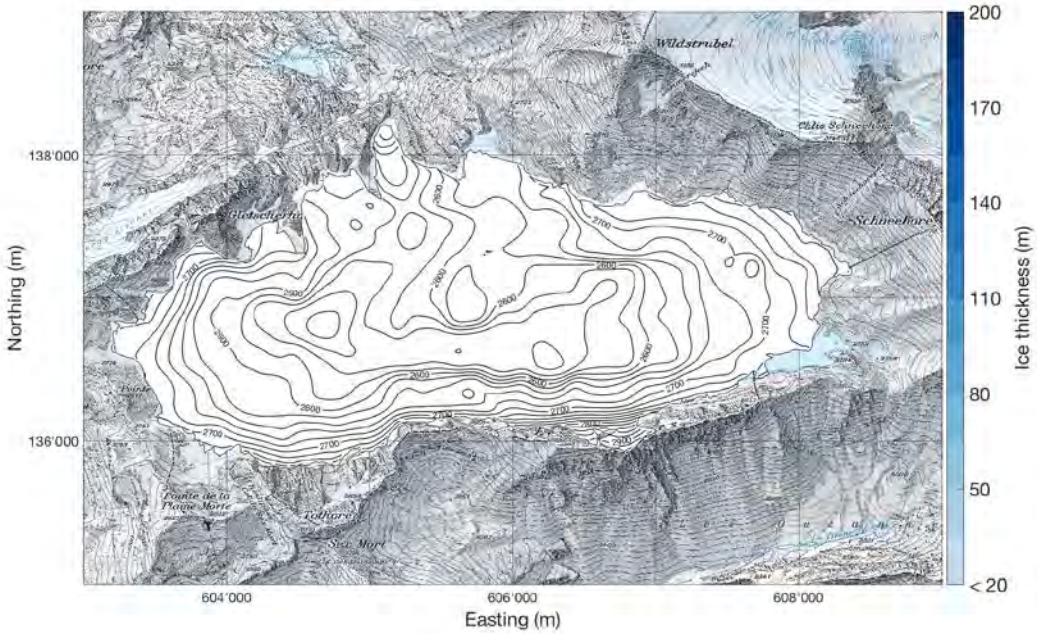
Glaciological modeling:

- Physics of the ice flow
- Mass conservation

Input Parameters:

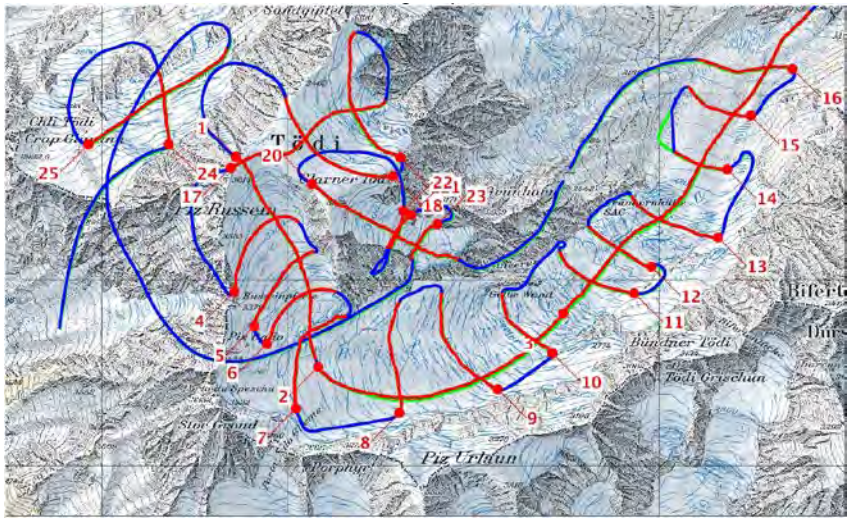
- Ice thickness from GPR-profiles
- Surface topography from digital elevation model
- Glacier outline
- Smoothness constraint

More Details → Poster session

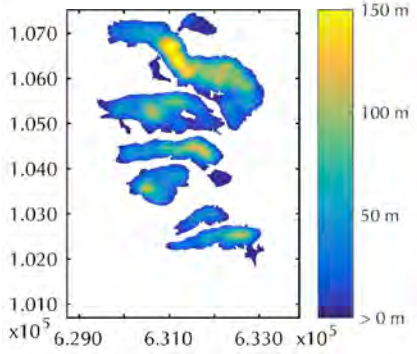


3. Current status of the project

Sparse GPR-grid for large-scale
ice volume estimation (e.g. Tödi)

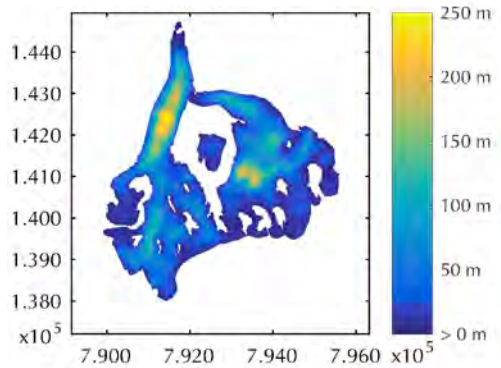


Dom Region



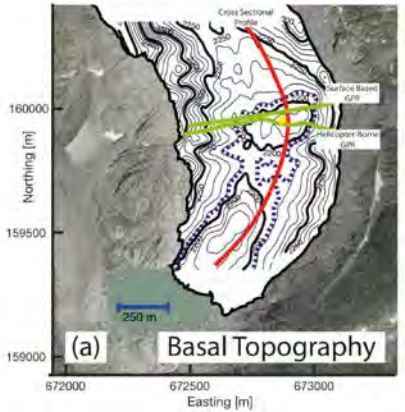
Langhammer (2018)

Morteratsch Glacier

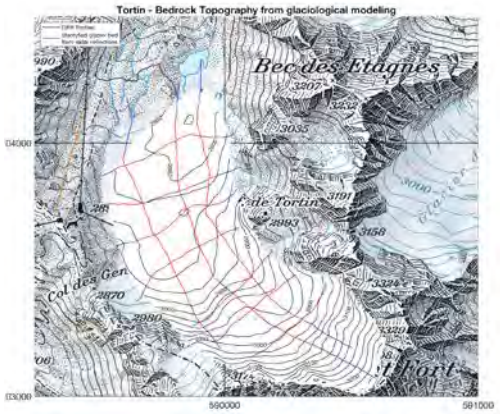


Langhammer (2018)

Denser GPR-grid for more detailed bedrock investigations:



G. Church et al. (2018)



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4. Conclusion and Outlook

- **70 % of glacier area covered or partially covered with GPR (around 2400 km of profiles)**
- **Data processing completed, interpretation and glaciological modeling in process**
- **Data uncertainty**

  ± 5 to 10 m for GPR data (shallow/deep glaciers)

  Uncertainty of the Ice thickness map:

  Depends on density of the GPR grid

  Glaciological modeling ≈ “interpolation”
- **Some more measuring campaigns planed in the near future**
- **Updated ice volume estimate of Swiss glaciers during 2019 (publication in 2020?)**

Thank you for your attention!

Questions?

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