S:GLA:MO: Integrated hazard assessments of glacial lakes based on Earth Observation

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MOTIVATION

Glacial lake outburst floods (GLOFs) are the most far reaching processes within glacier hazards. Considering their remoteness and often difficult access to such lakes, remote sensing provides important approaches for their detection and monitoring.

Here we present the Slope Stability and Glacier Lake Monitoring (S:GLA:MO) service for hazard assessments of glacier lakes based on EO products. High and very-high resolution radar and optical EO data is used to derive products that provide the basis for an integrative, initial hazard assessment of glacial lakes. A particular focus of the service is the use of information on surface displacements derived from InSAR. Although slope stability is a crucial factor for the evaluation of the current hazard, the use of spaceborne surface displacement measurements is rather novel to glacial lake investigations.

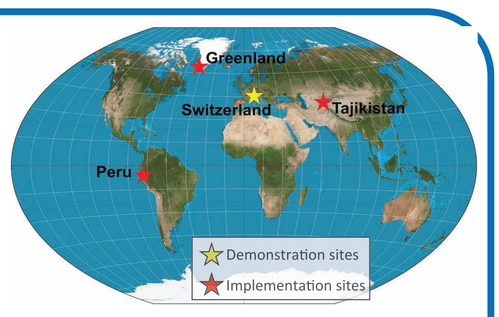
SITES

Switzerland (pilot studies) *Lake Weingarten*: Moraine dammed lake, outburst in 2001 with 12 M EUR damages. *Aletsch glacier*: Site with potential future lake formation, located below active landslide zone.

Greenland *Lake Hullet*: Lake dammed by an outlet glacier of the ice-sheet. Annual outbursts (subglacial drainage).

Peru *Lake Parón*: Biggest lake in the region, surrounded by steep rock walls, several smaller upstream lakes present and expected to form in near future. *Lake 513*: rock-dammed lake, frequent avalanching, last outburst in 2010. Drainage tunnels and EWS. *Lake Palcacocha*: Moraine-dammed lake, frequent avalanching, moraine stability issues. Above Huaraz (GLOF catastrophe in 1941 with > 1800 casualties).

Tajikistan *Lake Rivakkul*: Major lake surrounded by several small upstream lakes, some of them in critical conditions. Numerous slope deformation processes present.




Lake 513 (CARE Peru)


Lake Palcacocha (Photo: Colette Simonds)

DATA

EO based products
- digital elevation models (DEMs)
- glacier and glacial lake outlines
- glacier velocity fields
- landslide inventories based on InSAR analyses and high-res optical data

Auxiliary data
- digital elevation models (DEMs)
- lake bathymetries
- permafrost distribution maps
- geological maps

USERS

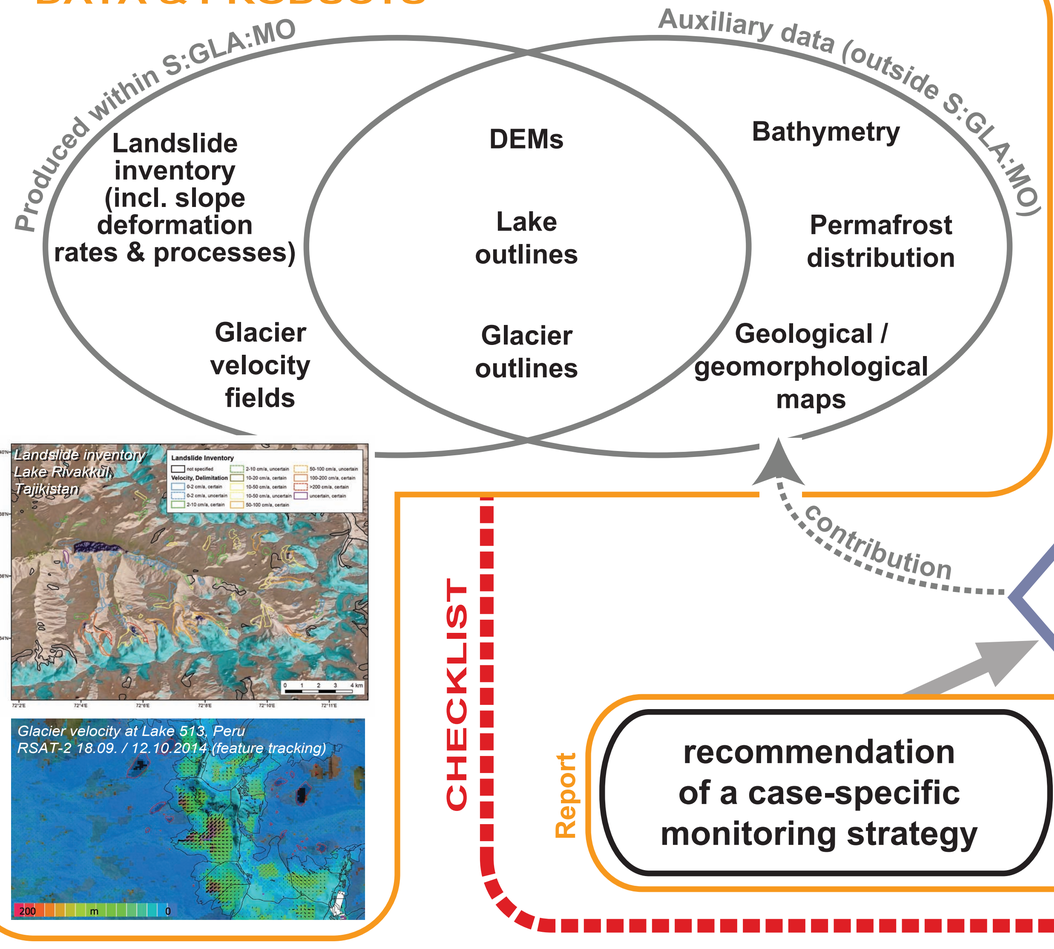
Local users
- FOEN (Federal Office of the Environment, Switzerland)
- ASIAQ (Greenland)
- UGRH/ANA (Glaciology and water resources unit of the National Water Authority, Peru)
- FOCUS (NGO, Tajikistan)

International users
- SDC (Swiss Agency for Development and Cooperation)
- GAPHAZ (IACS/IPA standing group on Glacier and Permafrost Hazards)

User workshop with ANA/UGRH

SERVICE CONCEPT

DATA & PRODUCTS

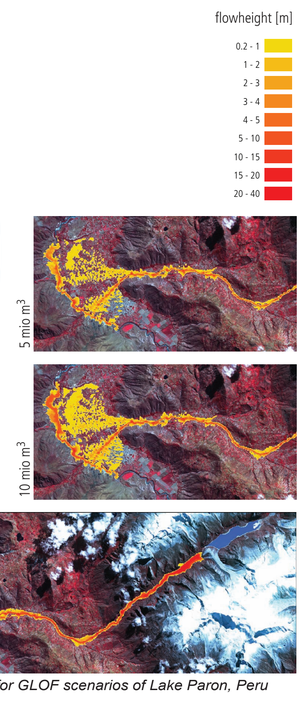


EVALUATION

- Current conditions
- Potential future developments and conditions

GLOF MODELING

- Past events (reconstructions)
- Currently possible events (simulations)
- Potential future events (scenarios)



Model results for GLOF scenarios of Lake Paron, Peru

contribution · exchange · USER

CHECKLIST

Report

recommendation of a case-specific monitoring strategy

integrative first-order hazard assessment

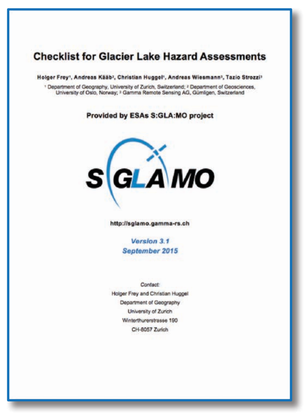
S:GLA:MO

CHECKLIST

A checklist for integrative hazard assessments of glacier lakes has been developed in the framework of S:GLA:MO. The aims of this checklist are to:

- Provide a tool for experts
- Reflect the state-of-the-art
- Provide a reference document supported by 'the scientific community' (GAPHAZ)
- include an independet and transparent expert review process

The checklist served as a basis for all assessments done within S:GLA:MO. It is a living document that can be accessed by the QR code to the right.


Checklist for Glacier Lake Hazard Assessments

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S:GLA:MO

http://sglamo.gamma-rs.ch

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FINDINGS

Main Findings
- High potential of EO data for first-order hazard assessments of glacial lakes confirmed
- InSAR products can provide valuable and unique information on slope stability
- 'No slope deformations detected' is an important result as well
- Can complement ground-based in-situ measurements
- The developed checklist proved to be a useful tool, also valid for and applicable to complex situations

Limitations
- InSAR not applicable to steep glacierized mountain faces (avalanche source zones)
- Lake level cannot be easily determined with EO
- EO products (mainly InSAR) are difficult to interpret for users, elaboration of added value products (e.g. landslide inventory) is required.

PRODUCTS

The user gets provided with:
- Hazard assessment report: Incl. monitoring recommendation (with cost estimates), according to checklist
- EO products: Landslide inventory, any other products produced within S:GLA:MO (DEM, lake/glacier outlines, glacier velocity fields)

A strong user involvement is envisaged at all stages of the service.

CONCLUSIONS & OUTLOOK

EO data and products, in particular related to InSAR, provide valuable quantitative information, difficult to obtain with other methods.

Such data and methods have the potential to provide highly valuable information for the integrative evaluation of the hazard situation of glacier lakes, timely anticipation of adverse developments, and the planning of adequate hazard and risk management strategies.

The so far little explored direct combination of optical and SAR data, in particular Sentinels-1 and -2, holds a strong potential to provide unique information in support of mountain hazard assessments.

Furthermore, the potential of integrating EO products in operational monitoring and early warning systems will be evaluated.

ACKNOWLEDGEMENTS:
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