Xinjiang Department of Water Resources, P.R. China

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Early Warning and Hazard Assessment of Glacial Lake Outburst Floods, Karakoram Mountains, China

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www.geotest.ch

Problem

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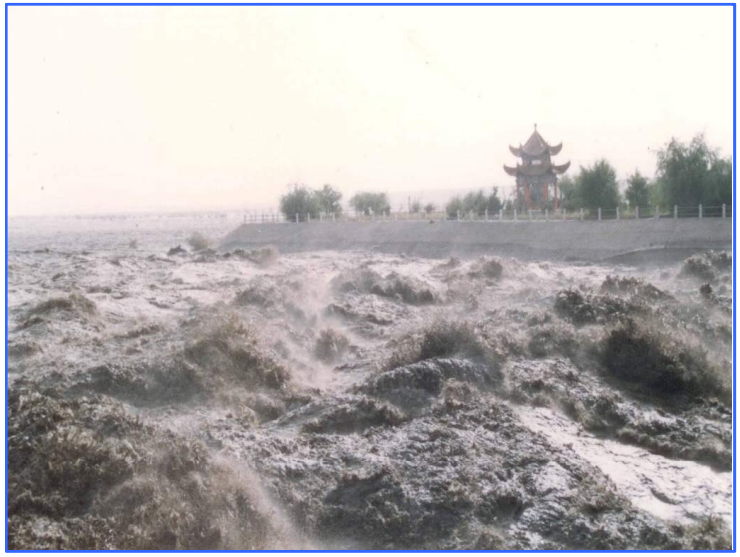
- Threat for > 1 Mio inhabitants
- Annual monetary loss > 10 Mio Euro



Flooding along Yarkant River due to Glacial Lake Outbursts Floods (GLOF)

Objectives

Objectives of the Yarkant River Project

> Establishment of an **Early Warning System** for GLOFs

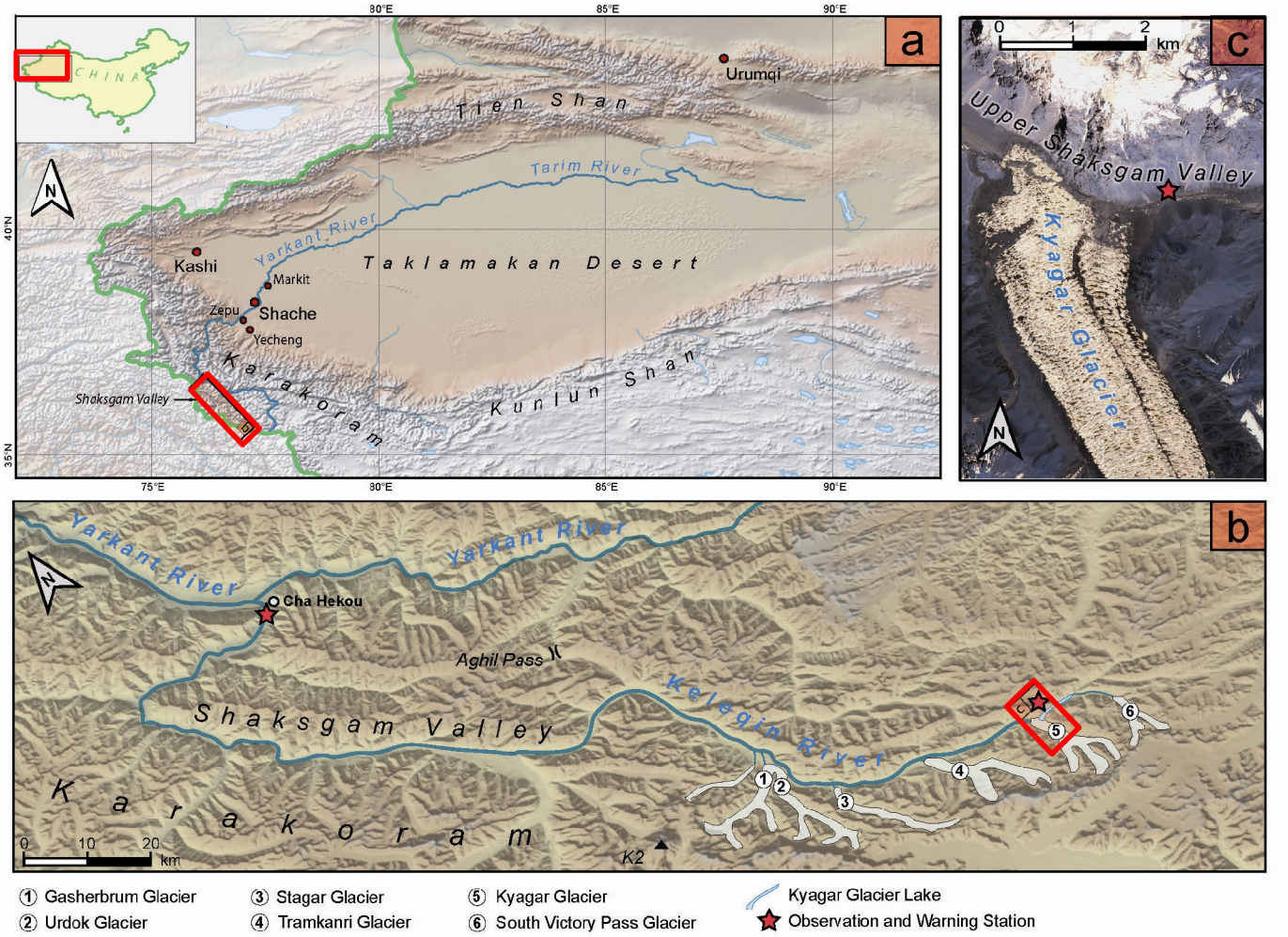
> **Risk management** for the potential flood areas

> **Climate Change monitoring**

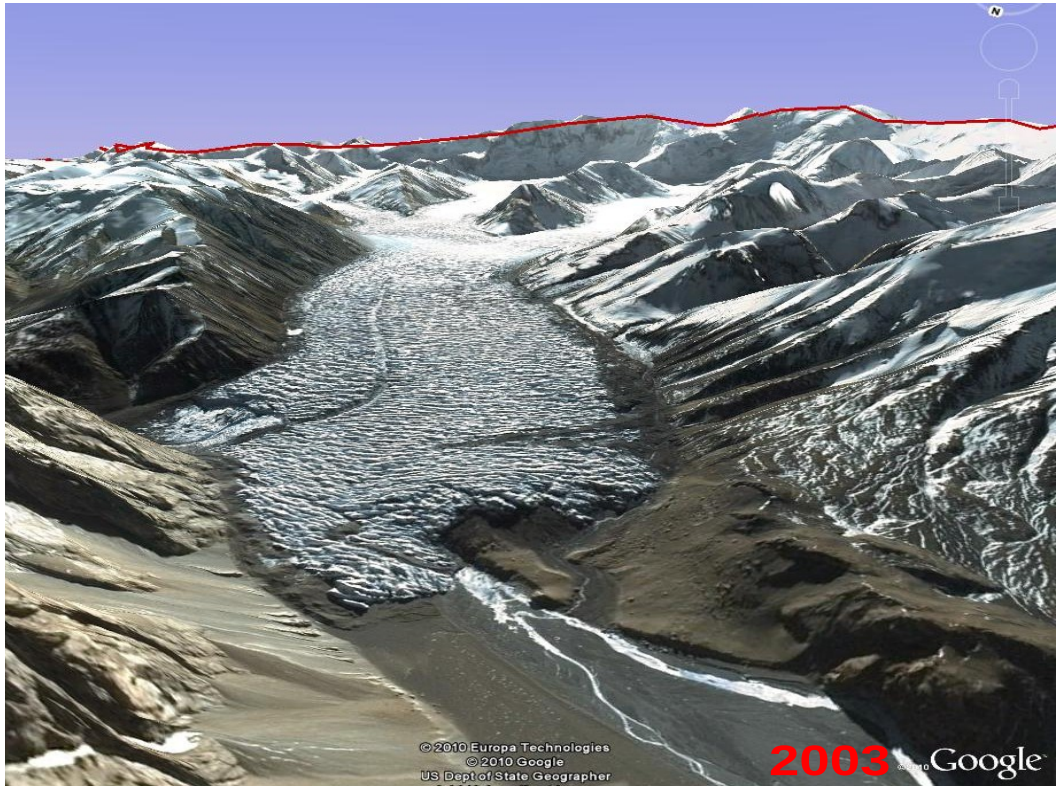
The project aim is to **avoid the unmanageable** (mitigation – land-use planning) and to **manage the unavoidable** (adaptation to climate change – Early Warning System).

Installation works by GEOTEST in China

Area of Interest



Kyagar Glacier

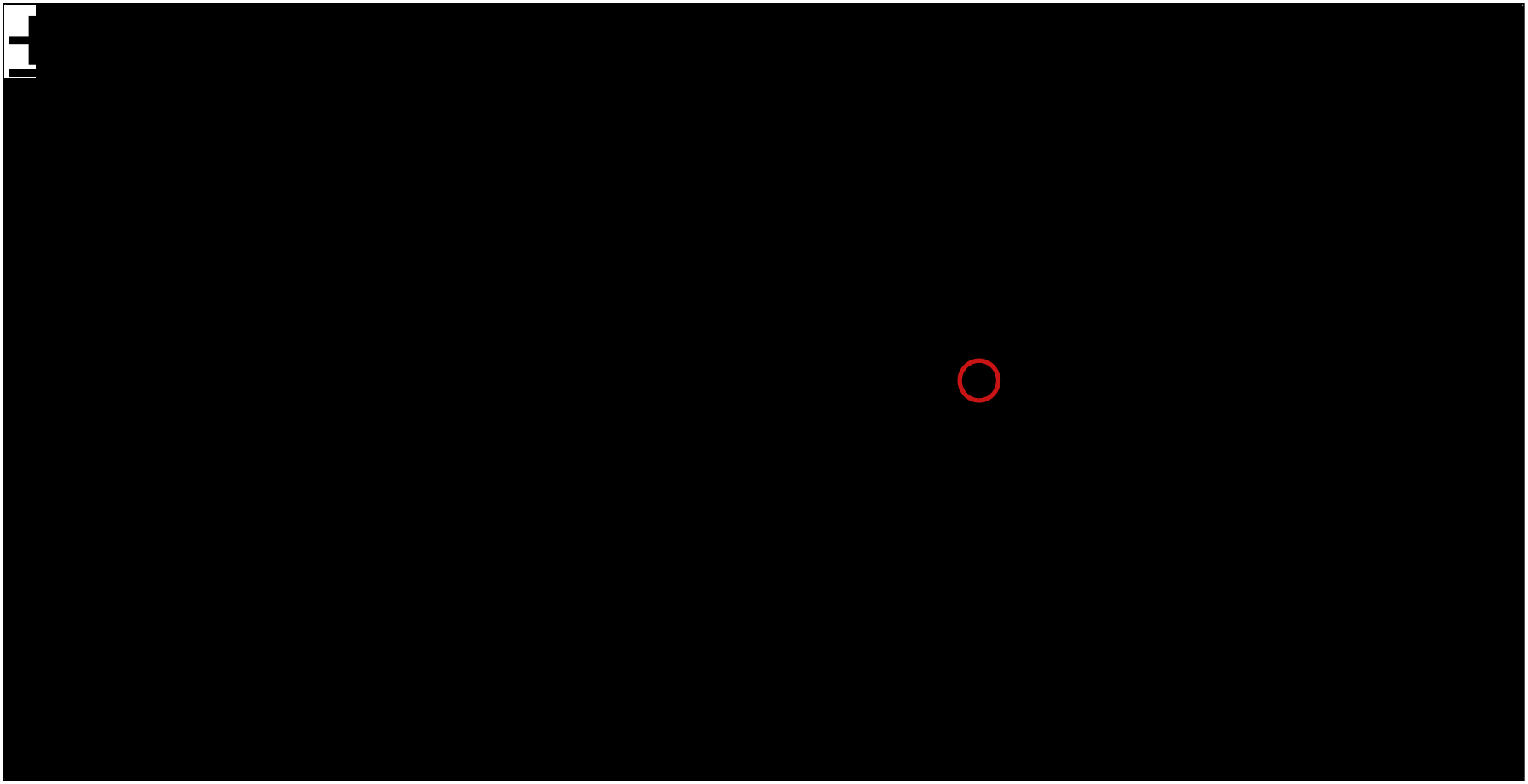


Length [km]	Average width of glacier tongue in 2011 [km]	Maximum height of the ice dam in 2011 [m]	Area [km^2]	Terminal altitude (valley floor) [m a.s.l.]	Altitude of firn line [m a.s.l.]	Highest altitude [m a.s.l.]
22	1.5 - 2	150	110	4’700	5’400	7’720

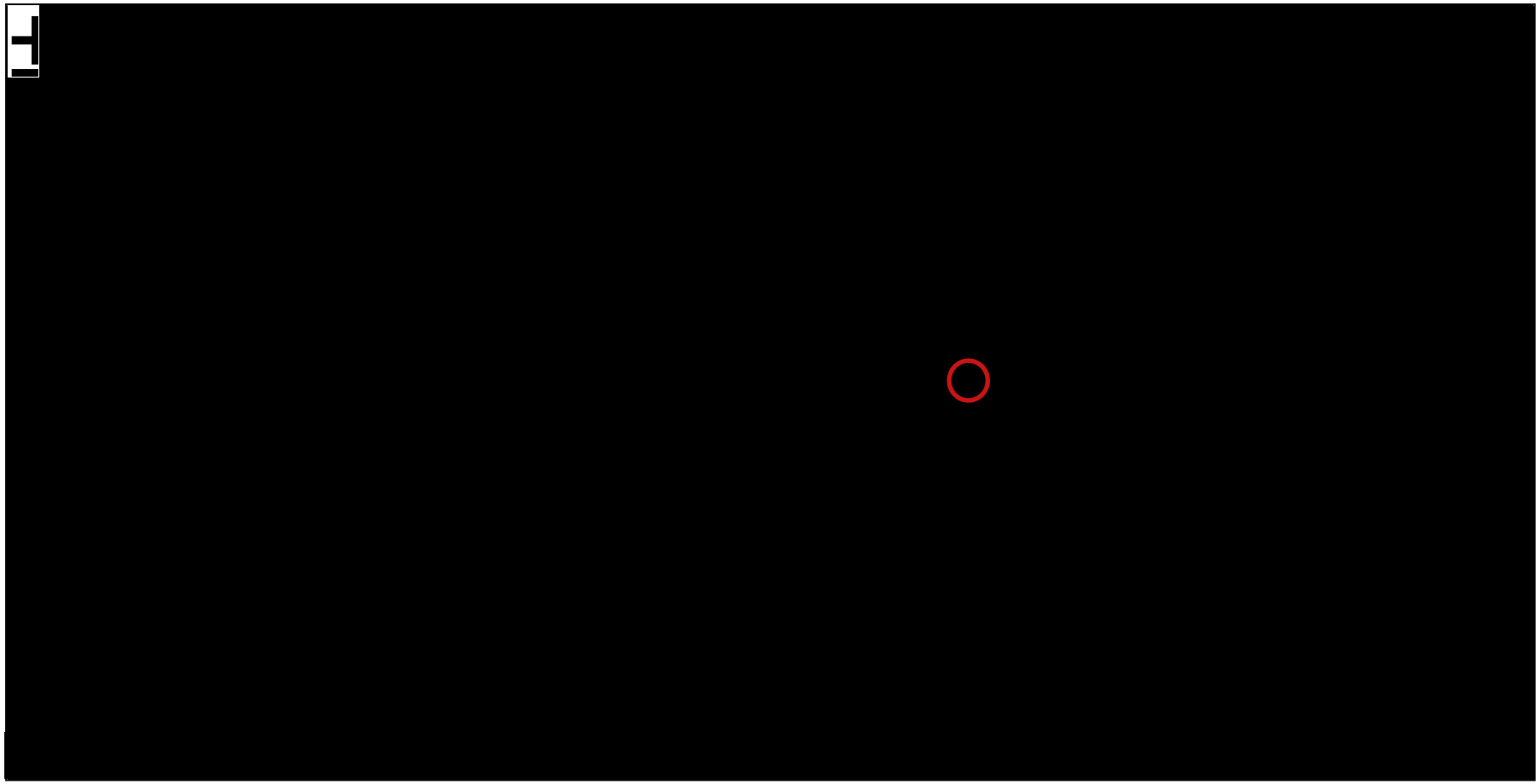
Kyagar Glacial Lake

Kyagar Glacial Lake

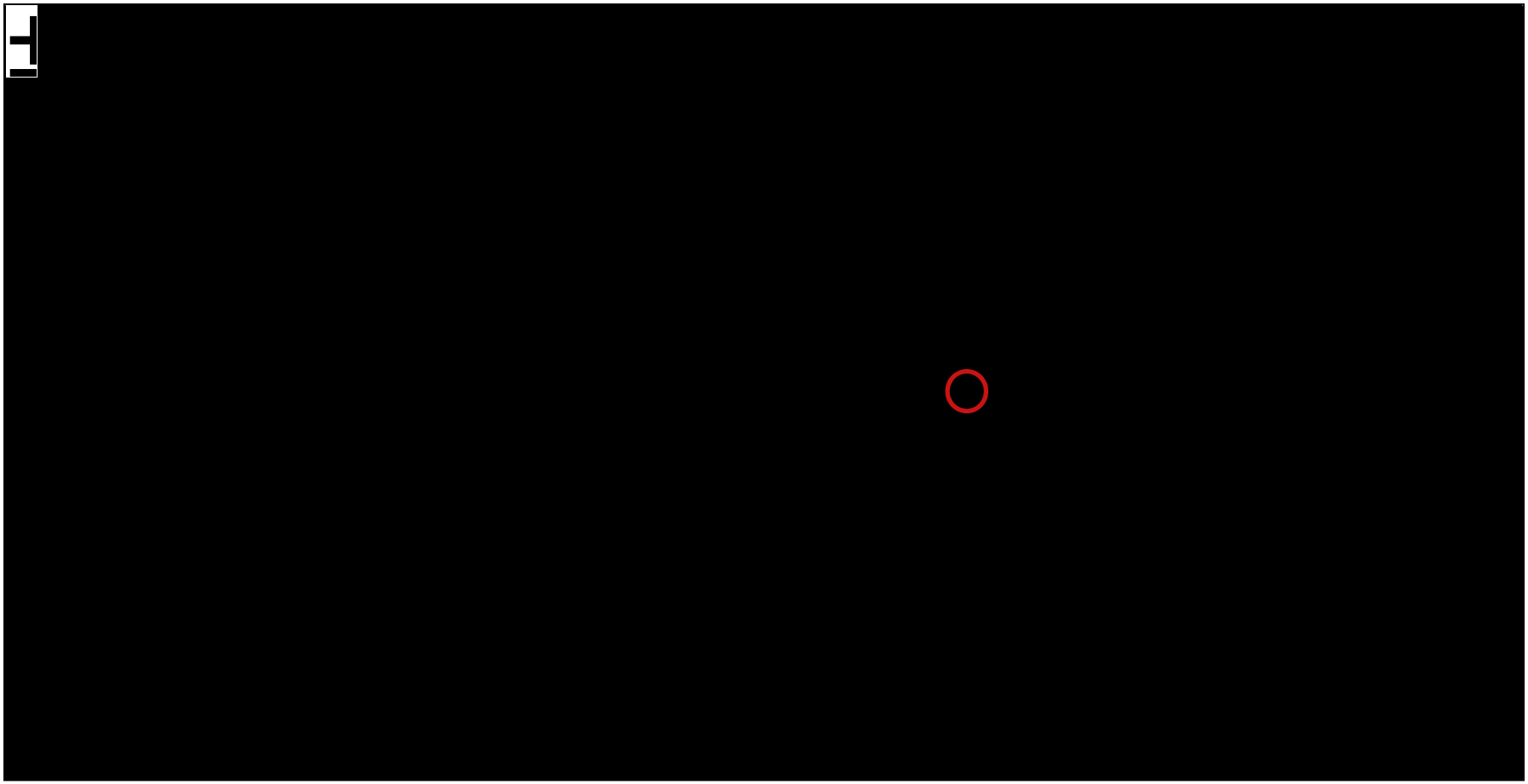
Kyagar Glacial Lake



Kyagar Glacial Lake



Kyagar Glacial Lake



Kyagar Glacial Lake

Kyagar Glacier lake with the damming glacier tongue in the front (1986).

Causes of floods

> **Snowmelt** in the upper catchment area (Karakorum Mountains)

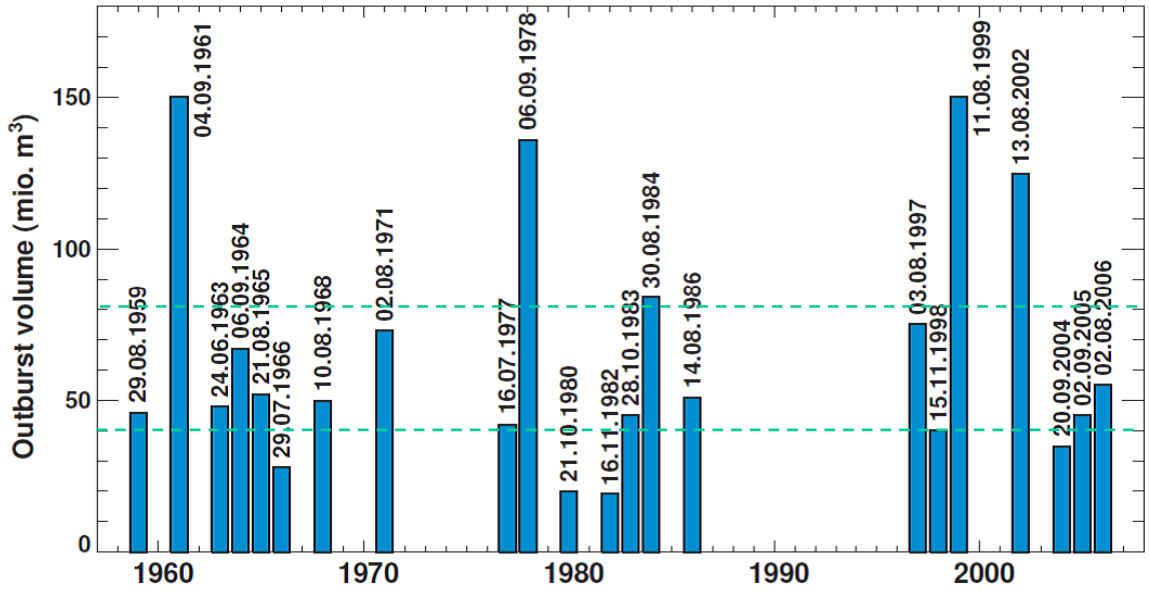
> **Rainfall** in the Yarkant River catchment (approx. 50'000 km^2)

> **Glacier Lake Outburst Floods** from the Shaksgam Valley (Keleqin River as triburary of Yarkant River)

Characteristics of Kyagar GLOFs

- 1954 – 2012: **22 floods** were classified as GLOFs.
- most GLOFs had outburst volumes between **40 – 80 million m³**.
- GLOFs mostly occurred during **late summer to early autumn**.

Reconstructed Glacier Flood Volumes



Data redrawn after Zhang (1992) and Chen (2010)

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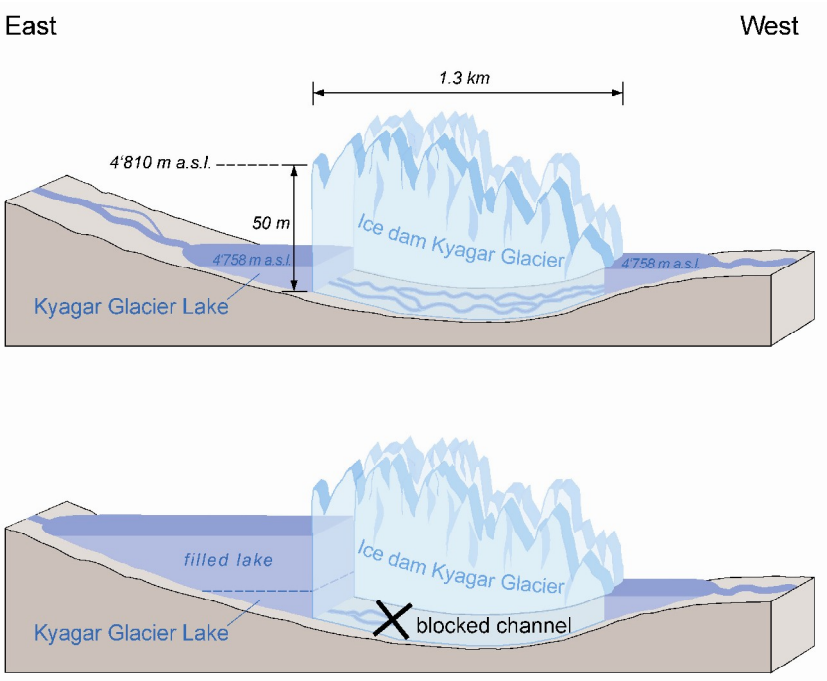
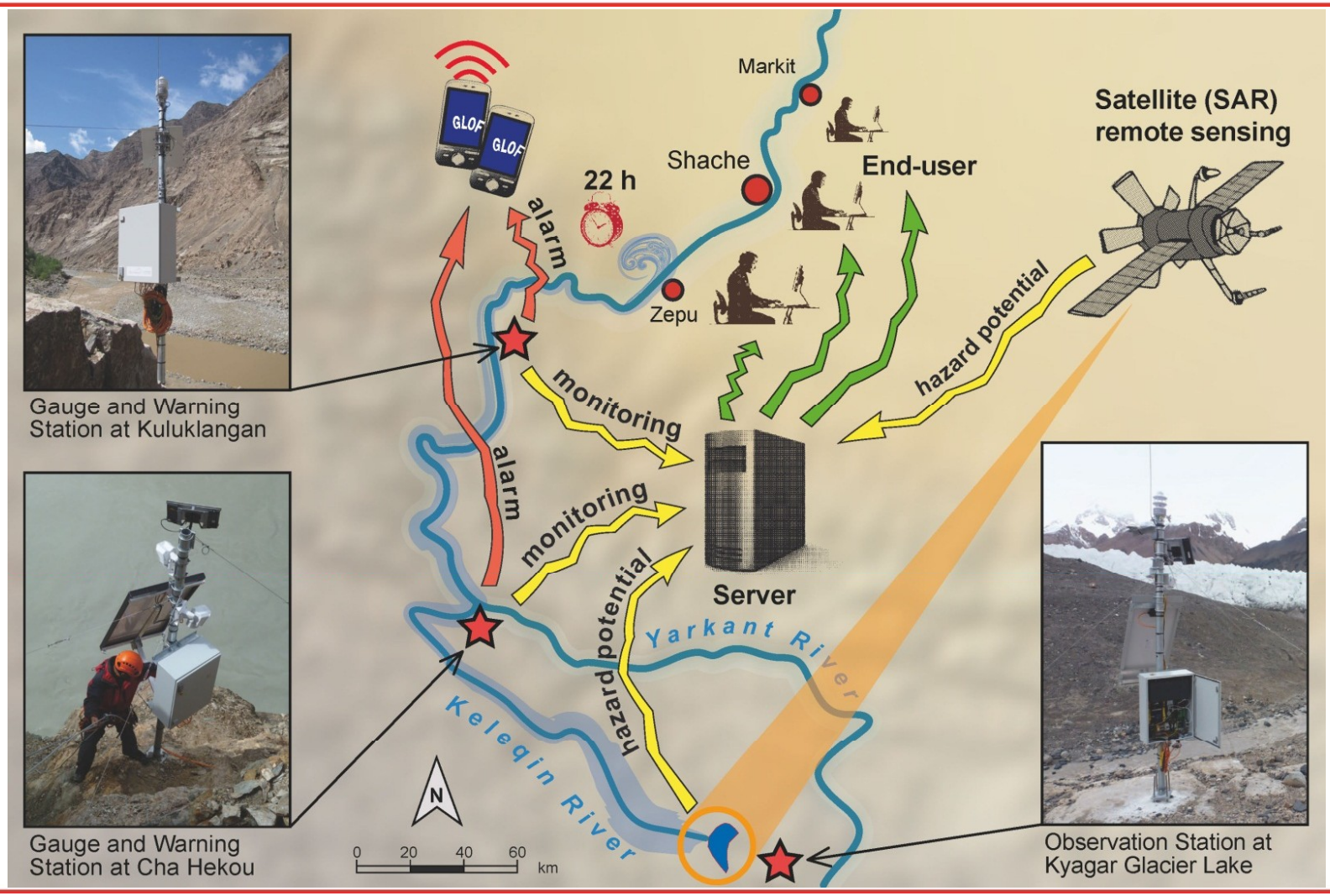
Outburst mechanism

subglacial drainage



Early Warning System



Cha Hekou Station

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2 radar sensors

Control unit: data logger, 2 cameras, satellite commuinaction unit, solar panel

Kuluklangan Station

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- > covers a large catchment area
- > warning: melt-water, rainstorm and GLOF

Expedition to Kyagar

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Daily camera images

Early Warning System

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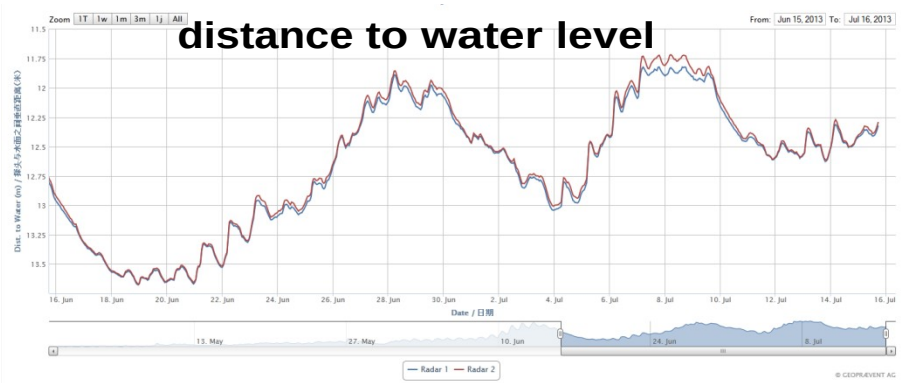
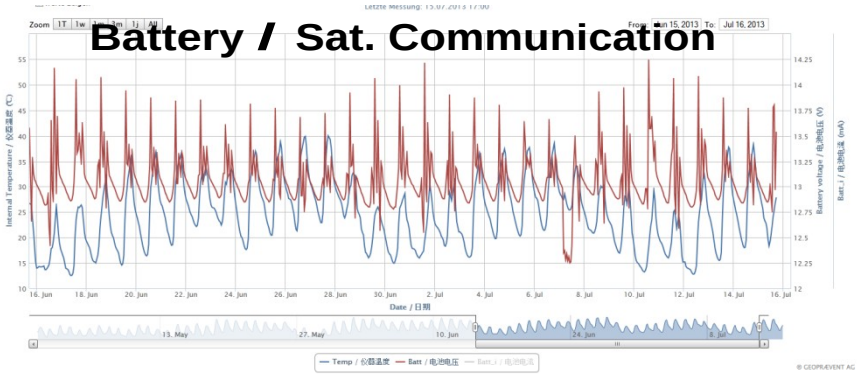
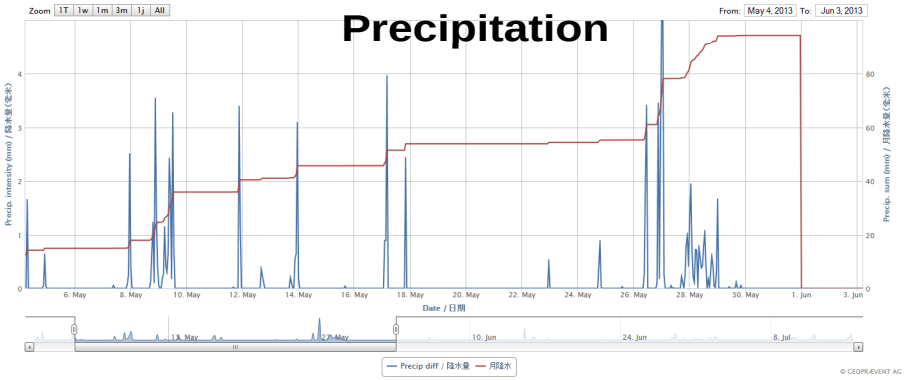
Water level



Daily System Check



Climate monitoring



Kyagar Glacier 2002 - 2011

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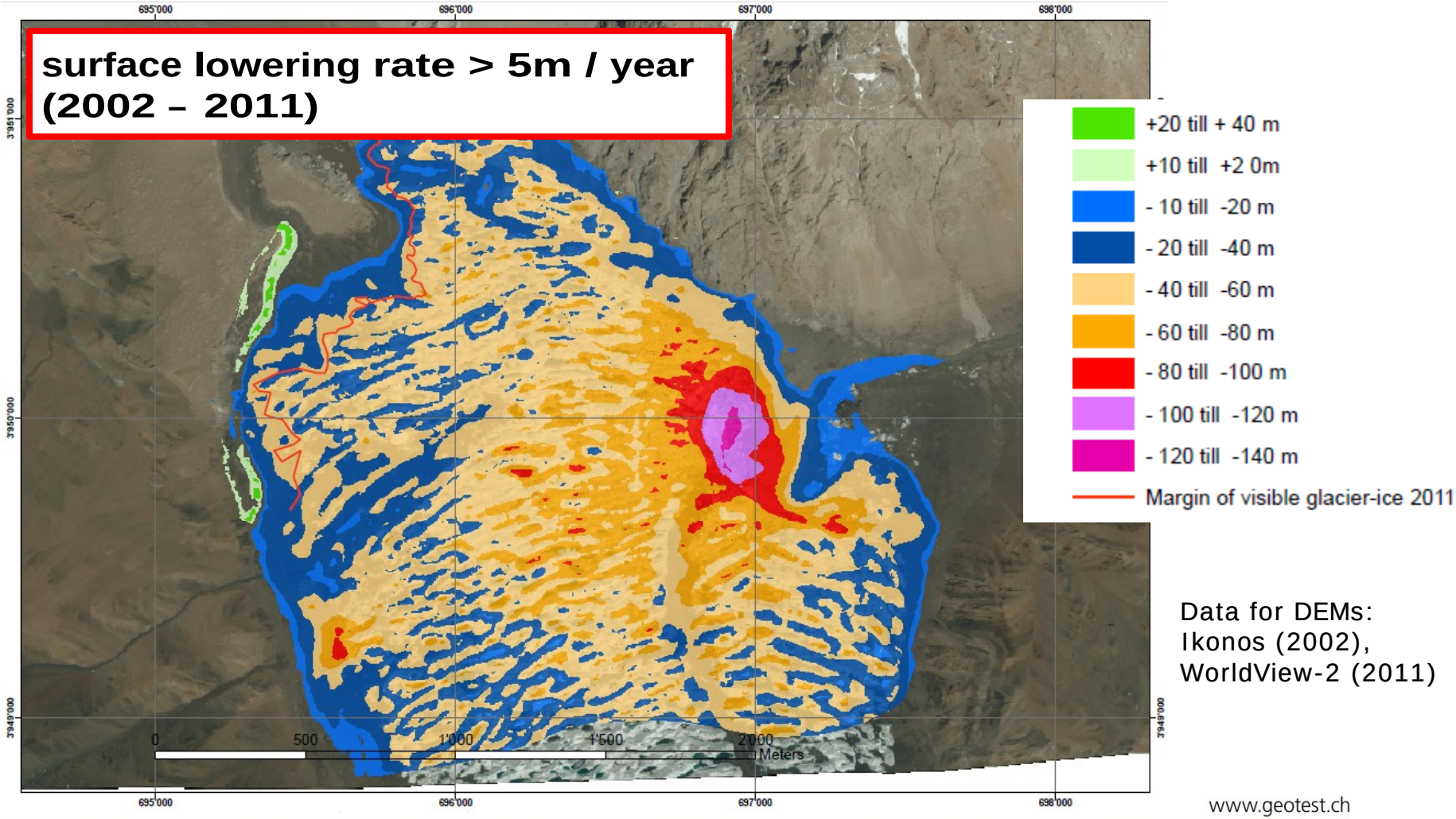

Data for DEMs:
Ikonos (2002),
WorldView-2 (2011)

Expedition to Kyagar

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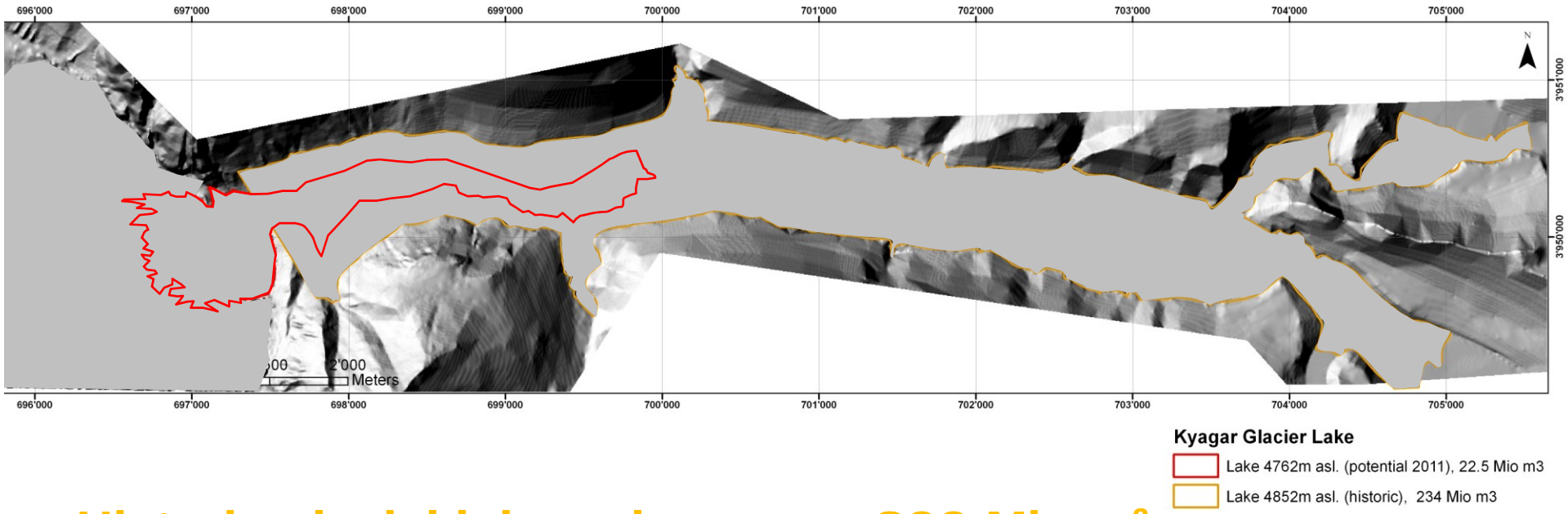
Kyagar Glacial Lake

Danger of GLOFs in the past and at present

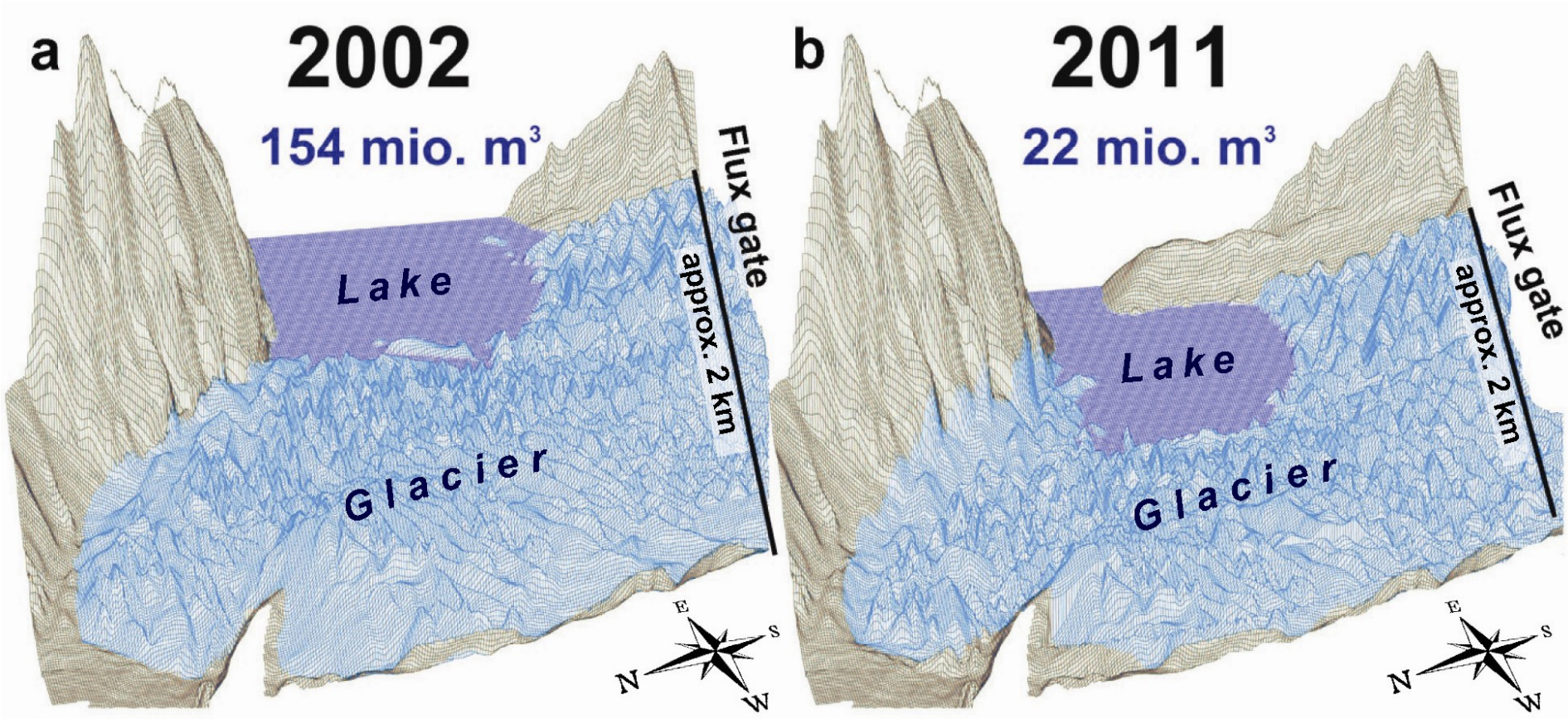


Historic glacial lake volumes: > 200 Mio m^3

Potential glacial lake volume 2014: 22 Mio m^3

Kyagar Glacial Lake

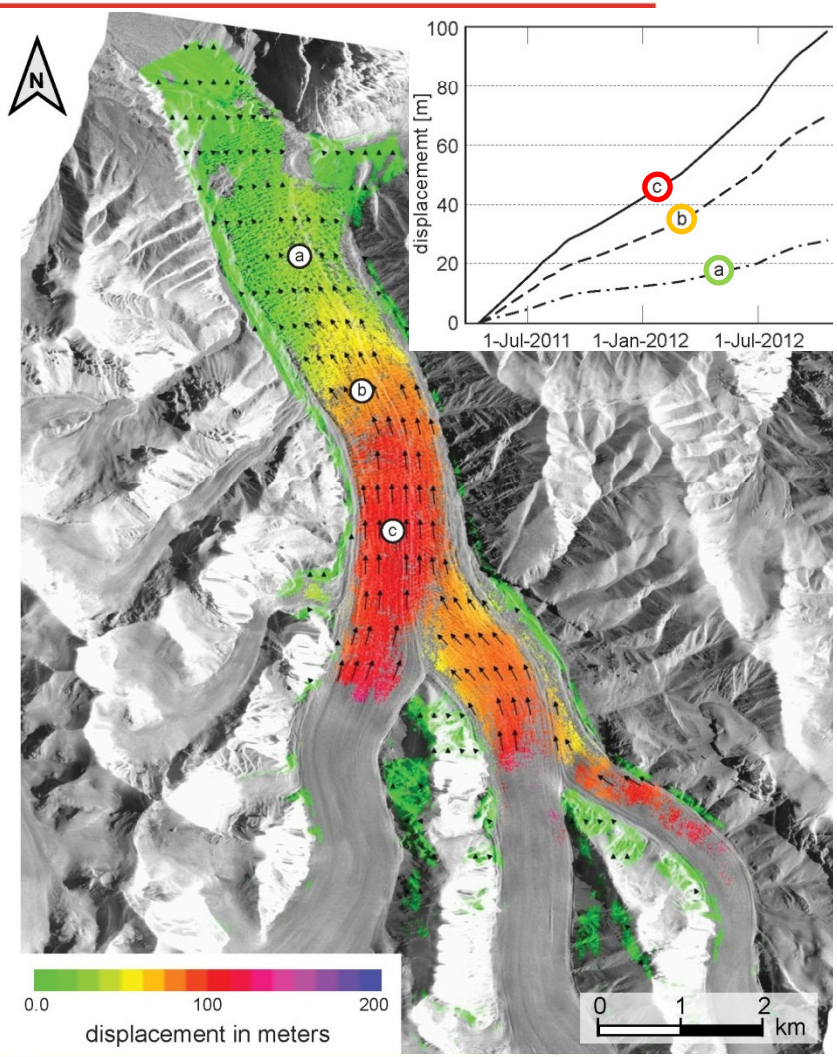
Consequences?



Results: Kyagar Glacier

Ice-flow speed derived from SAR offset tracking

- Highest flow speeds are found below the confluence of the two main branches of Kyagar Glacier.
- Clear **seasonal variation** in ice flow speed is observed along the entire ablation area.
- Slow-down during the winter season. **→ reduced meltwater input → basal sliding**
- Pattern is typical for a **surge-type glacier** in quiescent phase.



Data: 21 TerraSAR-X scenes (2011 – 2012)

Risk Management

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Modeling of floods caused by GLOFs

→ Hazard indication map

→ Land-use planning

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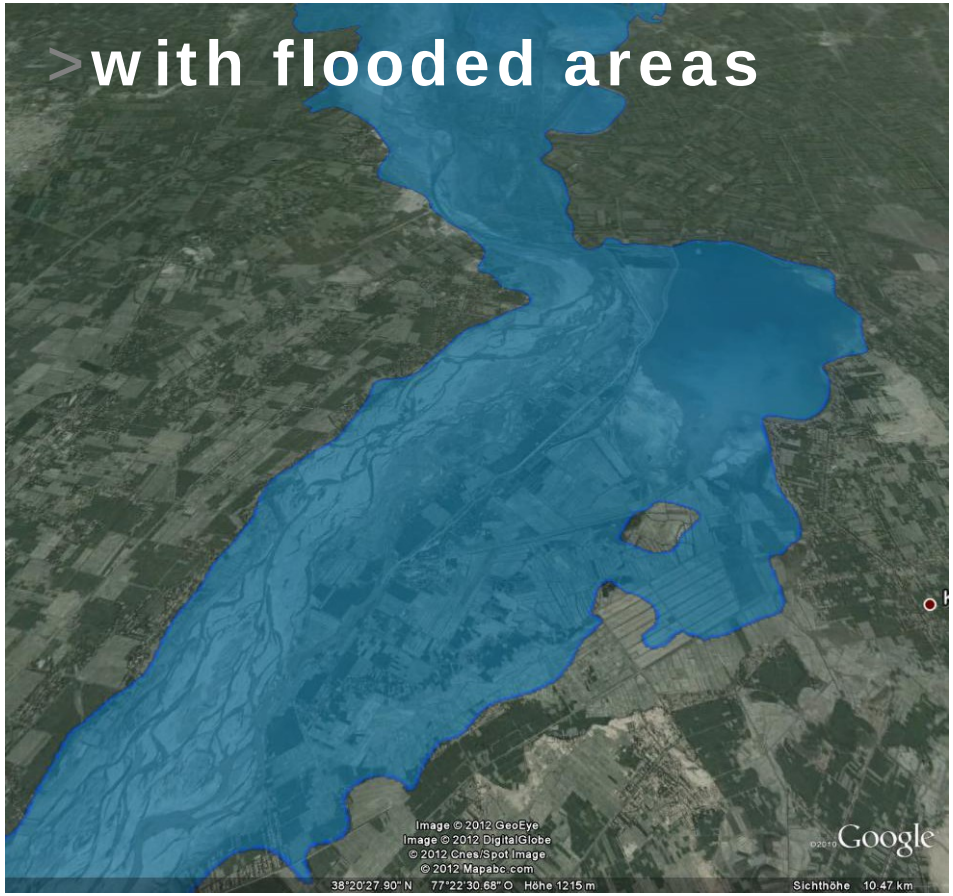

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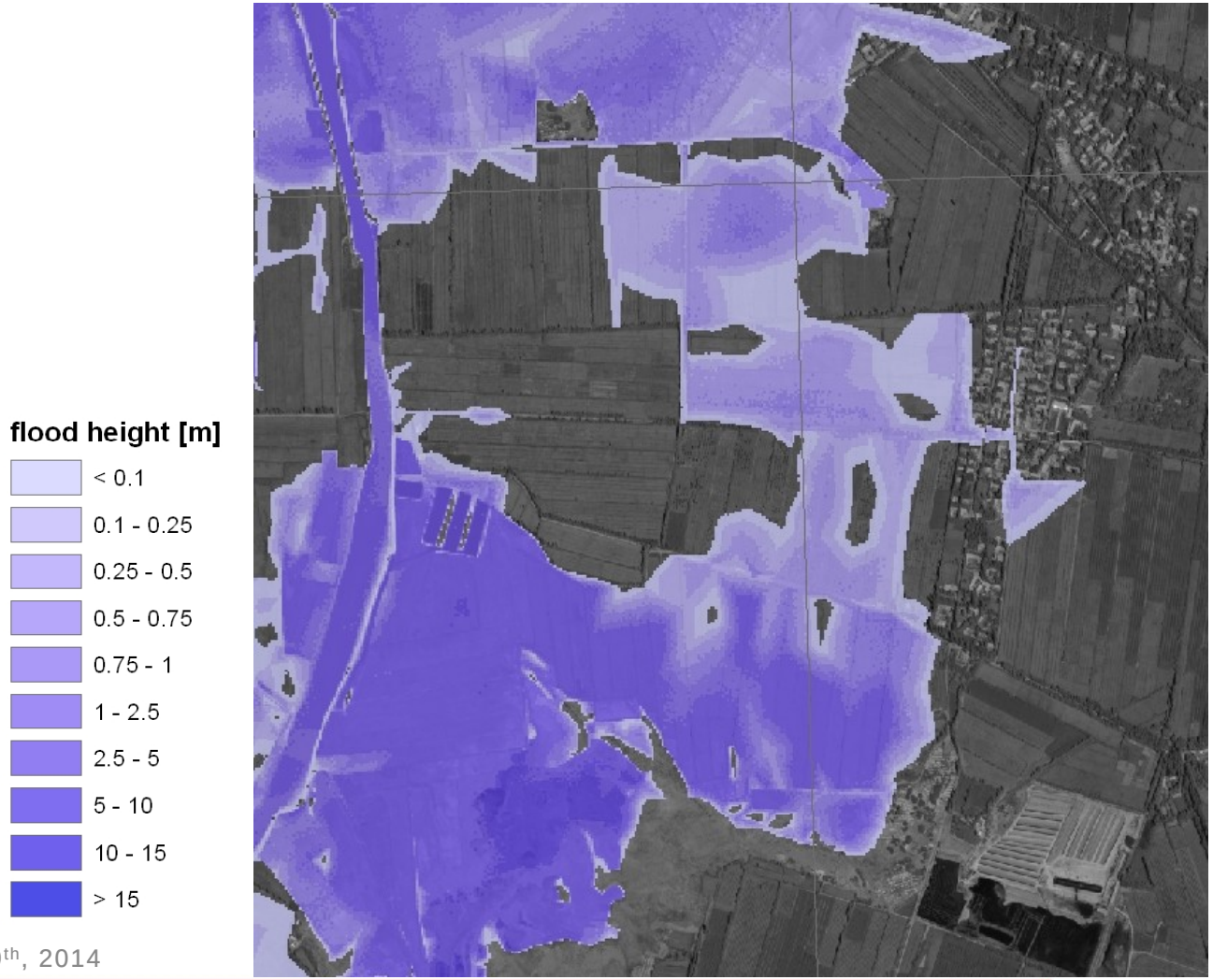
Modeling results



Conclusions

- Climate Change adaptation is a global issue and therefore needs a close **cooperation** on the international level.
- Fully functional **Early Warning System** (satellite remote sensing and terrestrial observation and alarming stations) was established.
- During the last decade, the **height of the ice dam decreased** by more than one-third due to strong melt. Hence, the potential maximal glacial lake volumes decreased by more than 80% to approx. 22 million m^3 in 2011.
- When a new surge front reaches the glacier tongue, this could lead to a thickening of the ice dam and hence an increase of the **GLOF hazard potential** in the near future.


melt on the Greenland ice-cap

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