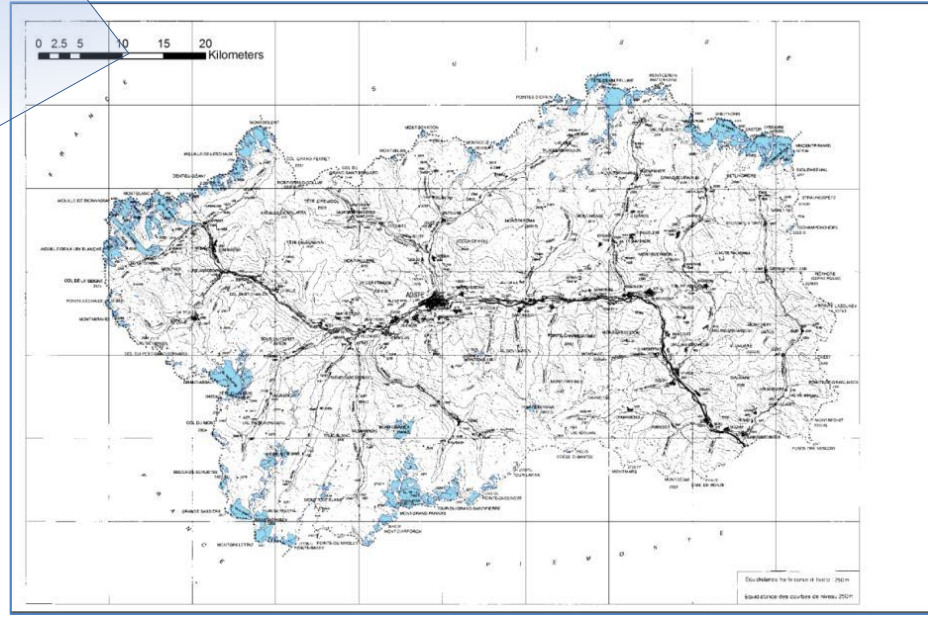


GLACIAL RISKS MONITORING IN AOSTA VALLEY, IT

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Aosta Valley is located NW Italy, bordered with Switzerland and France. Its territory is completely mountainous and glaciers, scattered all over the region, cover about 135 km², nearly 4% of the whole territory.



Location and extent of glaciers in Aosta Valley



Human settlements and infrastructures often reach high-mountain environment, mainly because of tourism development. Furthermore the characteristics of the territory make phenomena magnitude much more important: more than 50% of the territory is above 2000 m asl and steep valley sides contribute to high energy gravity phenomena and cascade effects.



Many past events are known

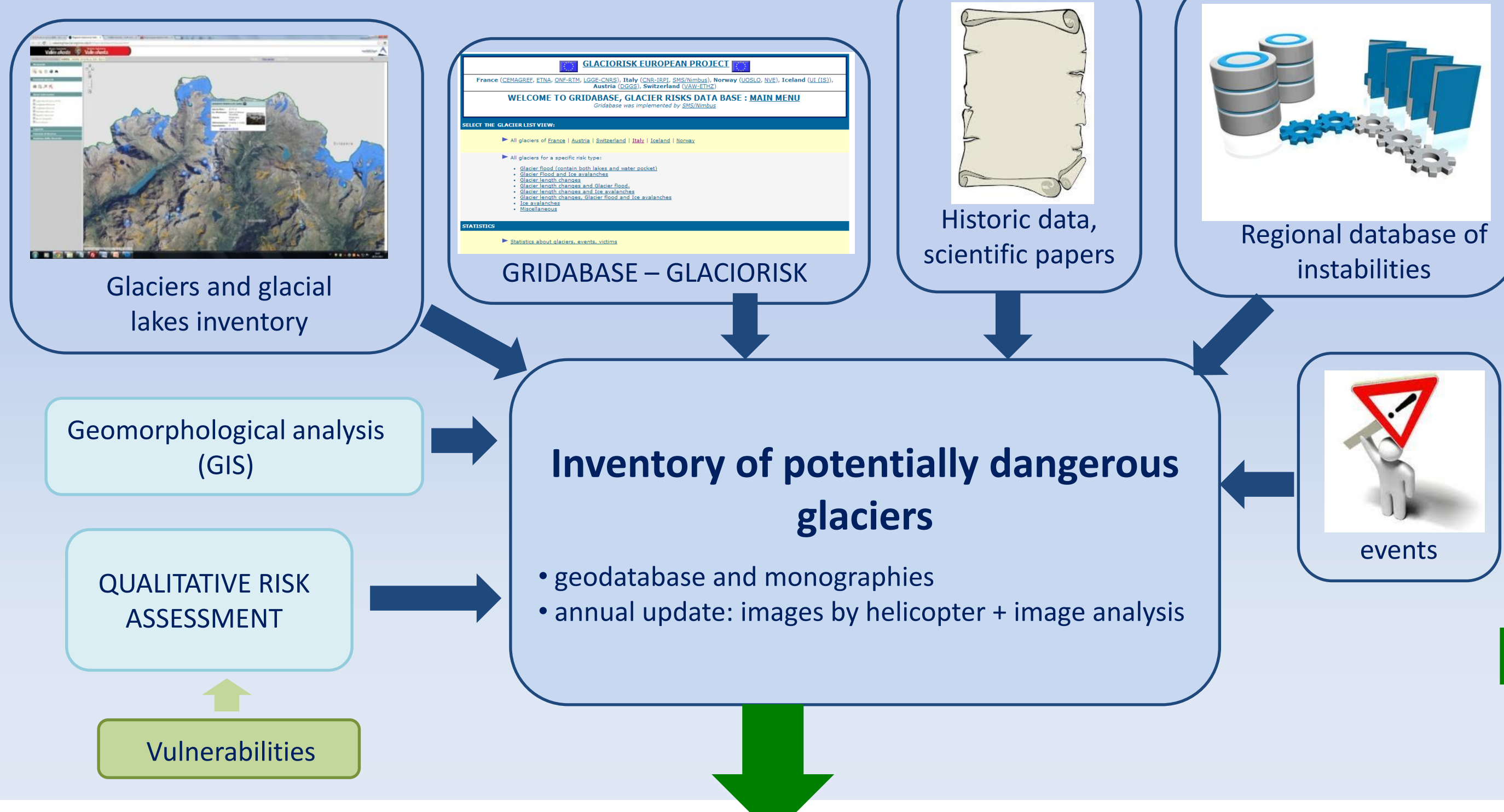


Debris flow triggered by an outburst flood from Planpincieux glacier, 1984; the debris flow reached the valley floor threatening a camping

Glaciers-related risk monitoring plan

In order to take into account glaciers hazards in land management and civil protection practices, the Regional Geological Service by means of Fondazione Montagna sicura set up a Glaciers-related Risk Monitoring Plan (GRMP) in 2012 aimed to inventory glaciers hazards, detect new hazards arising from glaciers evolution, and survey cases involving risk.

GRMP starts from an historical analysis of past instability events (icefalls, glaciers break-off, GLOFs), implemented by a geomorphologic analysis of the present glaciers state, to detect whether hazards are still actual. Potential runout areas have been evaluated and vulnerabilities are reported, highlighting potential dangerous glaciers



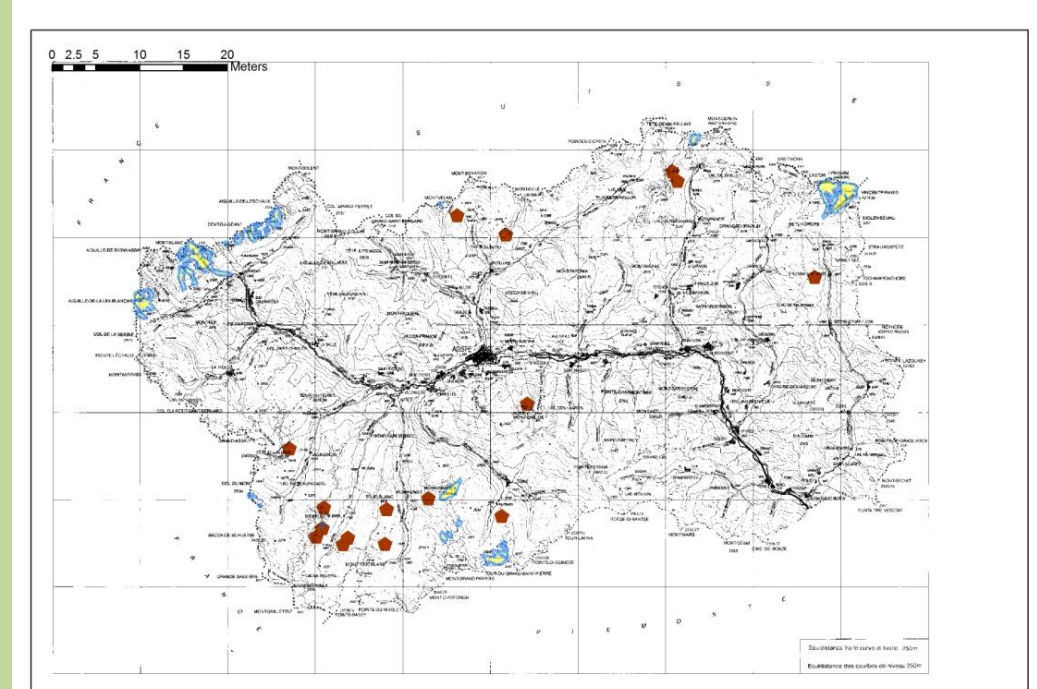
An yearly photographic aerial survey is carried out on all the glaciers of the territory; this allows to observe changes and a qualitative analysis of glaciers evolution in order to detect new possible hazards or asses changes in recognized risk cases.



Images comparison showing evolution of Planpincieux glacier

Instability events involving glaciers are recorded for about **30 glaciers**, among with only **22** are considered "dangerous" at present.

All available data about glaciers (geometry, presence of water, past events records, images, existing hazard scenarios...) are collected into a purpose made **geodatabase** to allow easy access.



Map above shows glaciers assessed to be "dangerous" after historical and geomorphologic analysis (yellow). Permafrost-related risk cases are also considered (brown dots)

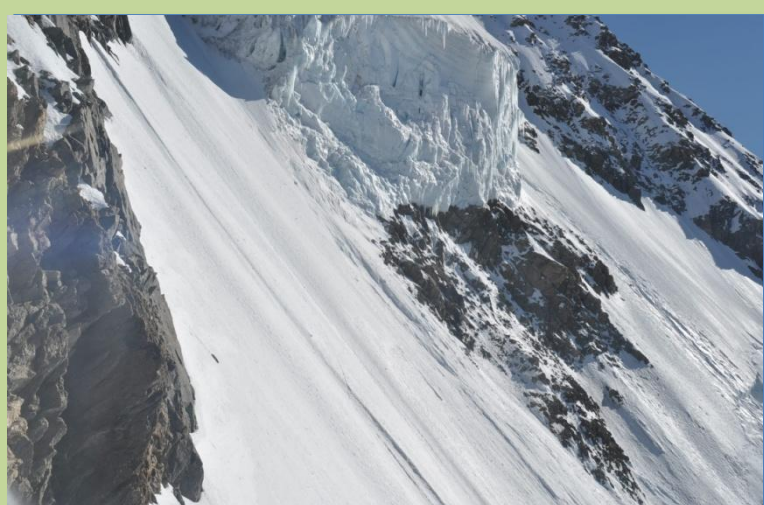
Specific monitoring for actual risks

So far, three cases required a specific monitoring system, as they can represent an actual risk for inhabited areas or infrastructures. These cases (Grandes Jorasses Glacier, Planpincieux Glacier and Lys Glacier) comprehend the three main types of glaciers-related hazards, i.e. icefalls from cold hanging glaciers, break-off of temperate or polythermal glaciers, and glacial lakes outburst. Considering the characteristics of these phenomena different monitoring systems for these three cases were adopted, to prevent risks, but also to assess techniques performance when applied in extreme conditions.

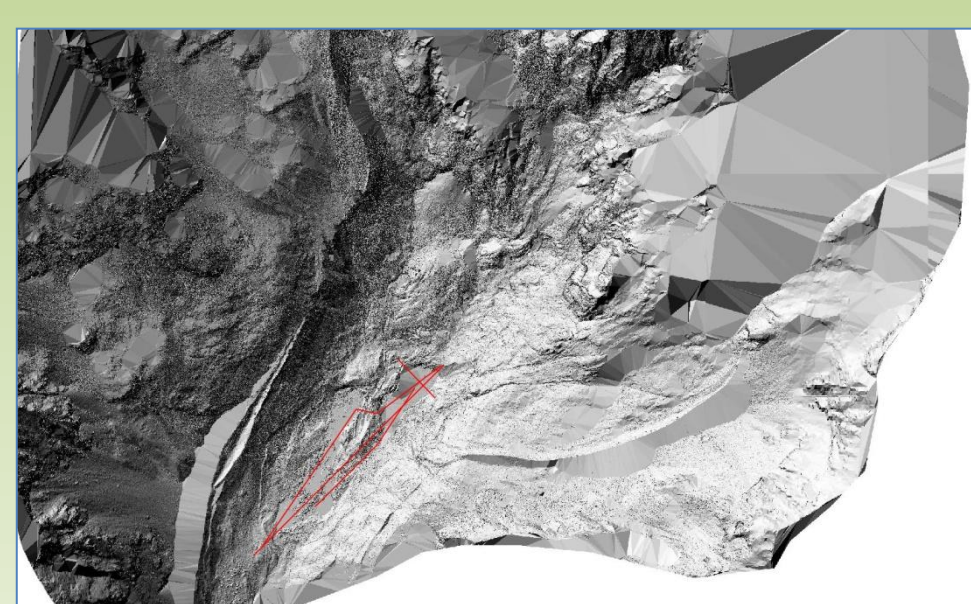
Grandes Jorasses hanging glacier



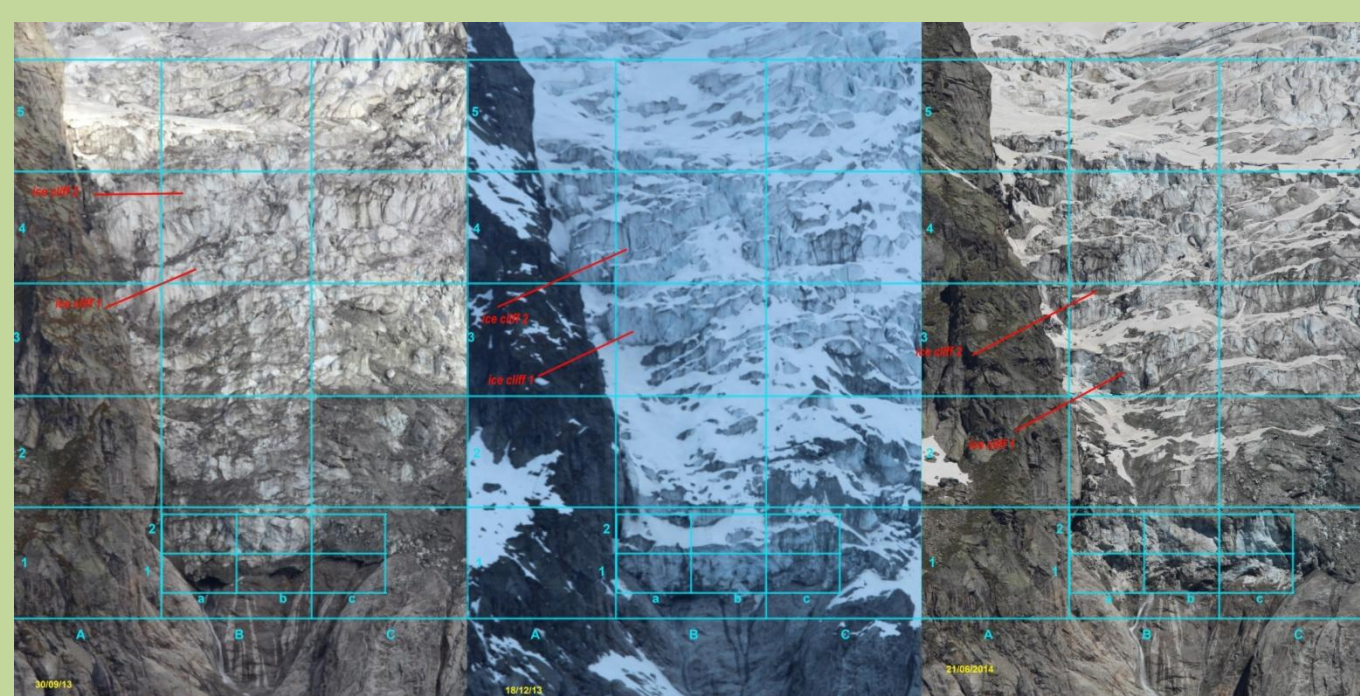
3 on-site remote controlled camera to evaluate morphological evolution



Photographic survey and photogrammetric model to assess volumes



Planpincieux temperate glacier

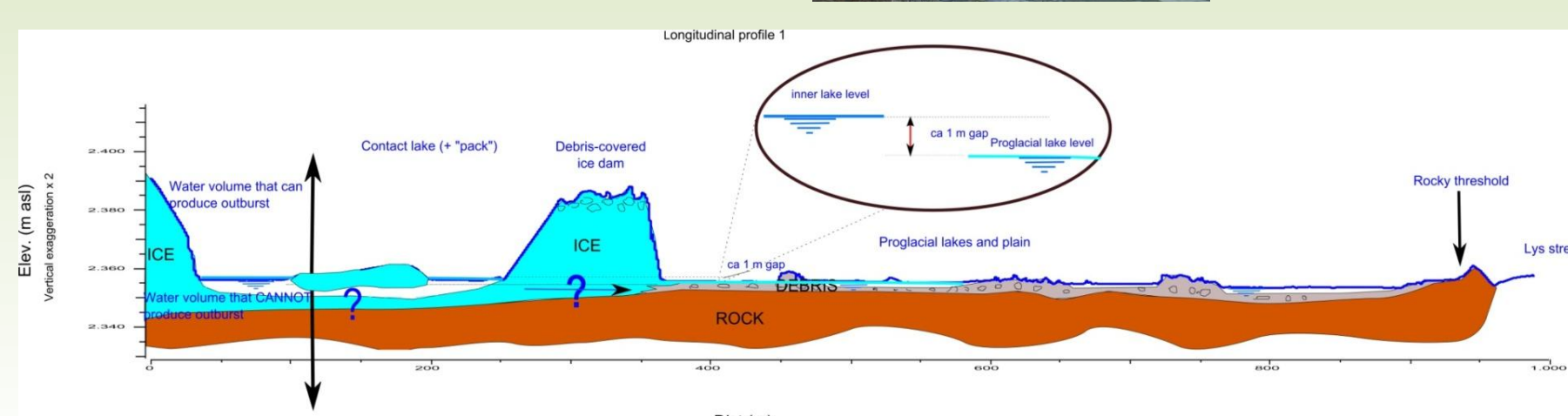
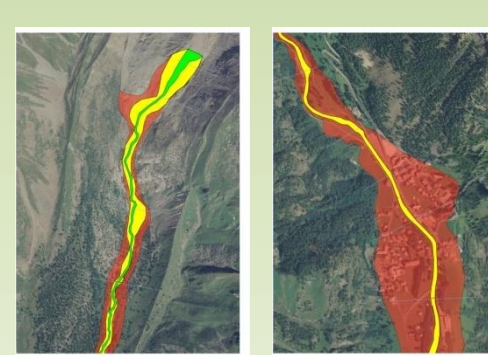


Qualitative and semi-quantitative analysis of images coming from a camera sited on the opposite side of the valley

Lys glacier contact lake



Water level monitoring
Flood scenarios assessment



Challenges for the future

- ✓ Early detection of glacial lakes, in particular englacial lakes, at regional scale
- ✓ Geomorphological modelling of glaciers to localize future lake positions
- ✓ Improve models to predict hanging glaciers falls
- ✓ Improve tools adapted to high mountain environment for monitoring
- ✓ Improve knowledge of temperate glacier dynamic (prediction of collapses)