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Water flows monitoring and geochemistry in high-mountain rockwall permafrost: main results of a 2-year investigation at Aiguille du Midi (3842 m a.s.l., the Mont Blanc massif).

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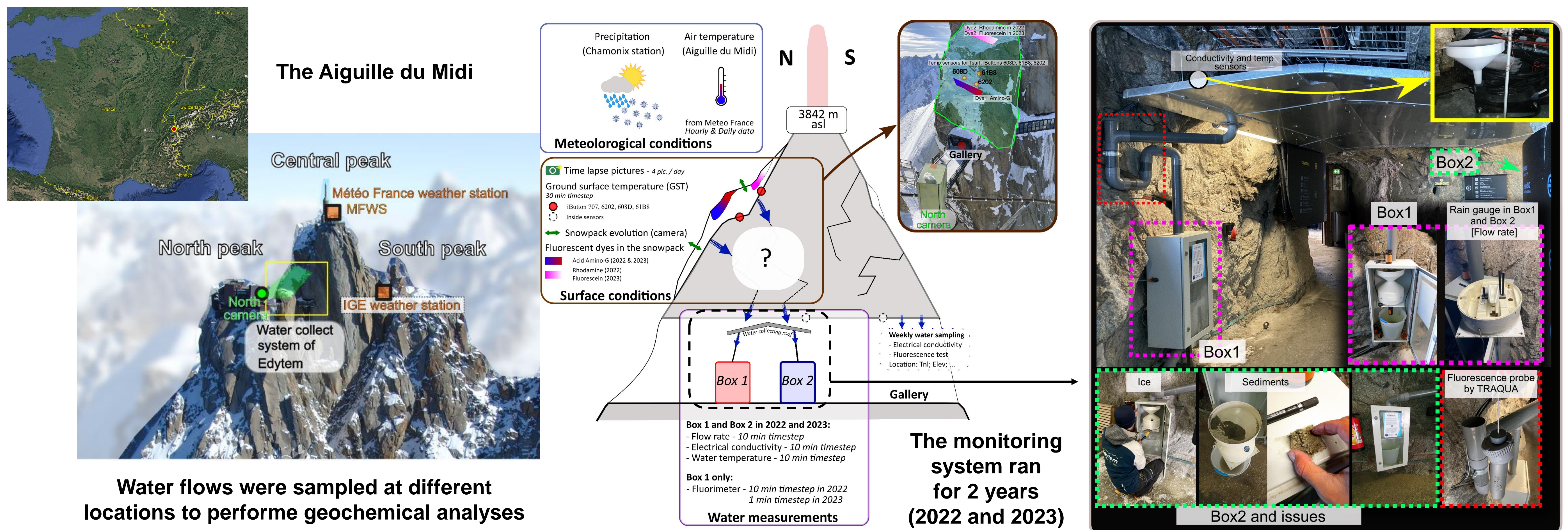
Context

Understanding water-related processes in steep alpine bedrock is crucial to better understand permafrost degradation, and especially the non-linear response to atmospheric warming, as well as steep rock slope destabilisation

Objectives of this investigation

Gaining real-time water flow data in a steep alpine bedrock site to better assess (i) water flows timing, (ii) water flows quantity, (iii) the link between atmospheric variables and water flows, (iv) water residence time (relative age)

Study site and Methods

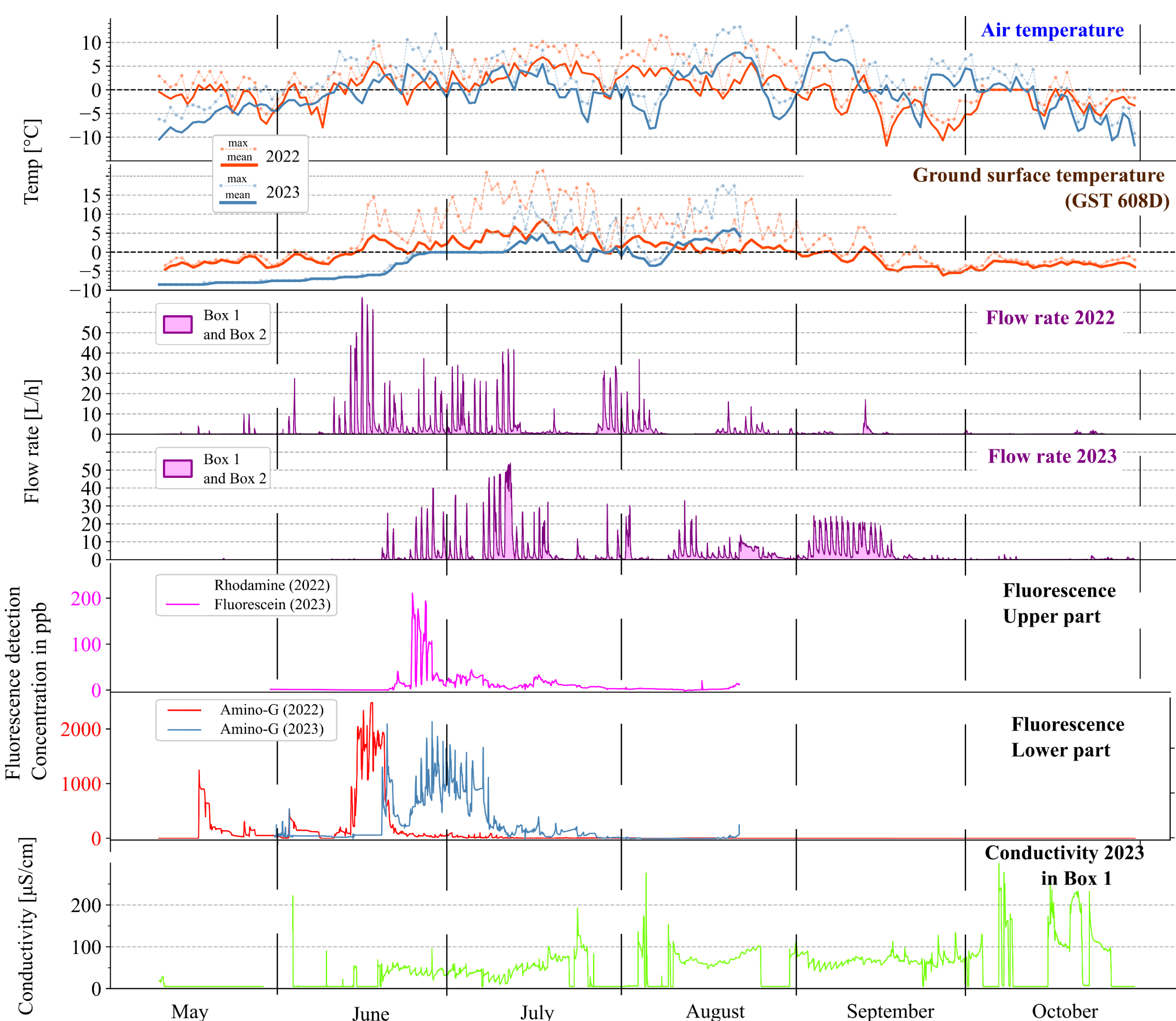


Water flows were sampled at different locations to perform geochemical analyses

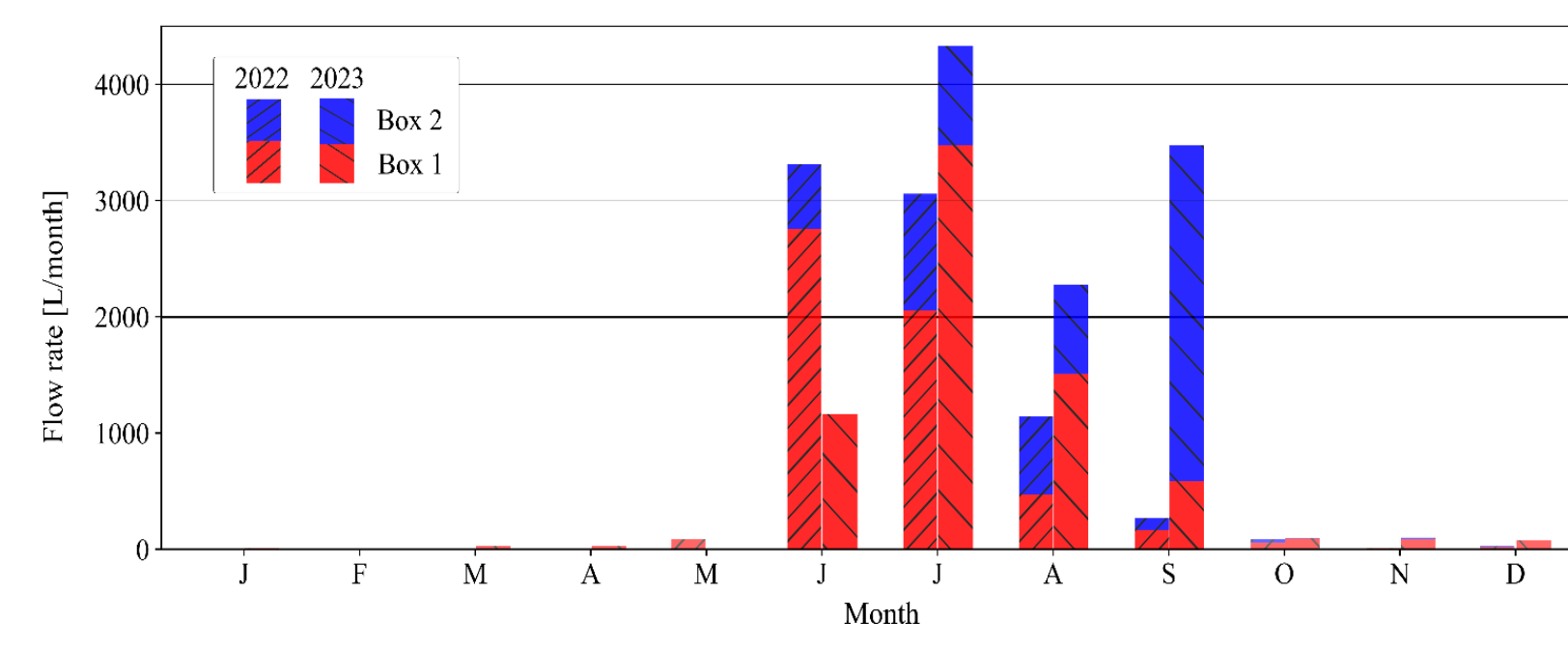
The monitoring system ran for 2 years (2022 and 2023)

Main results

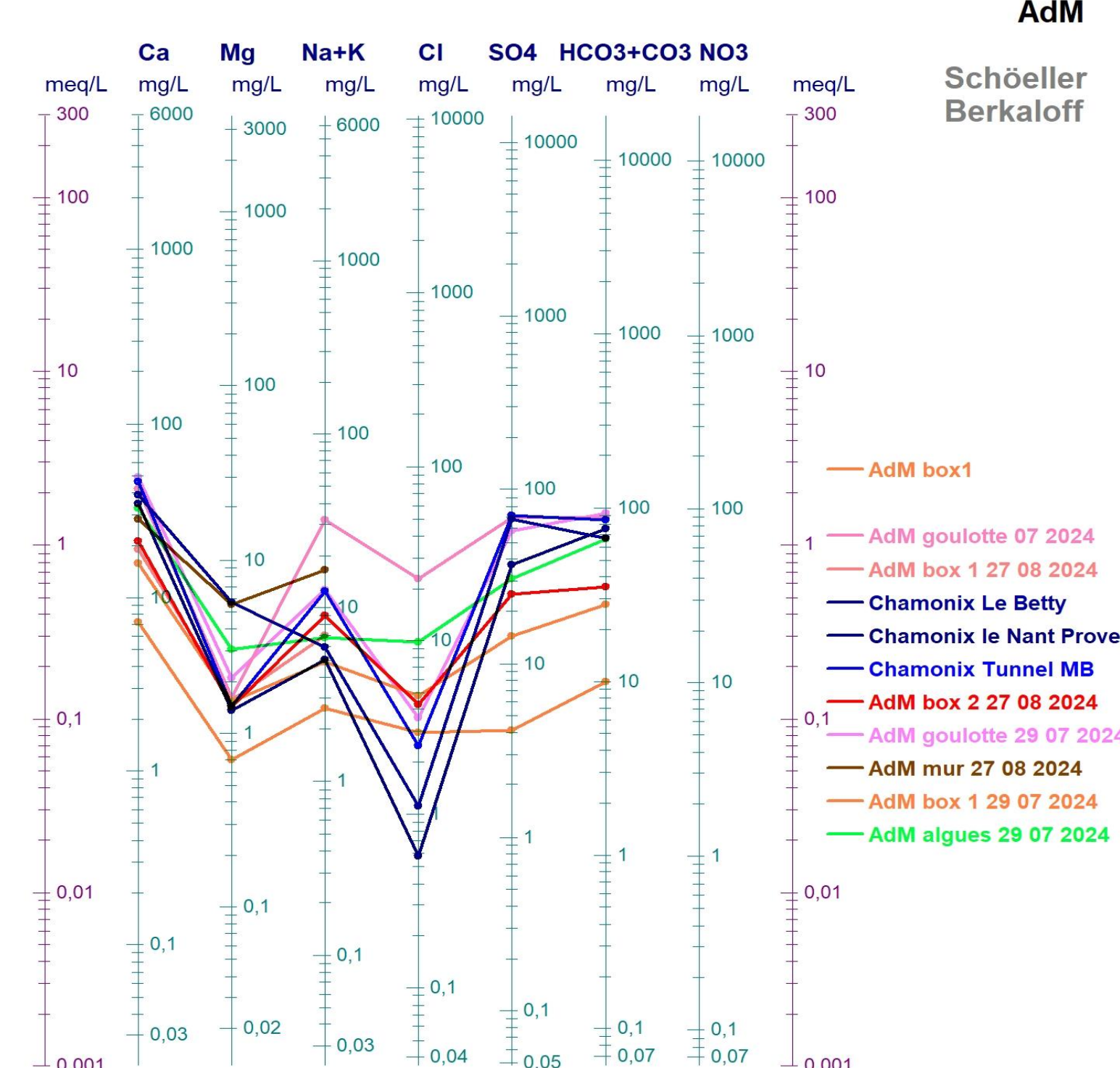
Water monitoring data



Cumulated water quantity /month and /year

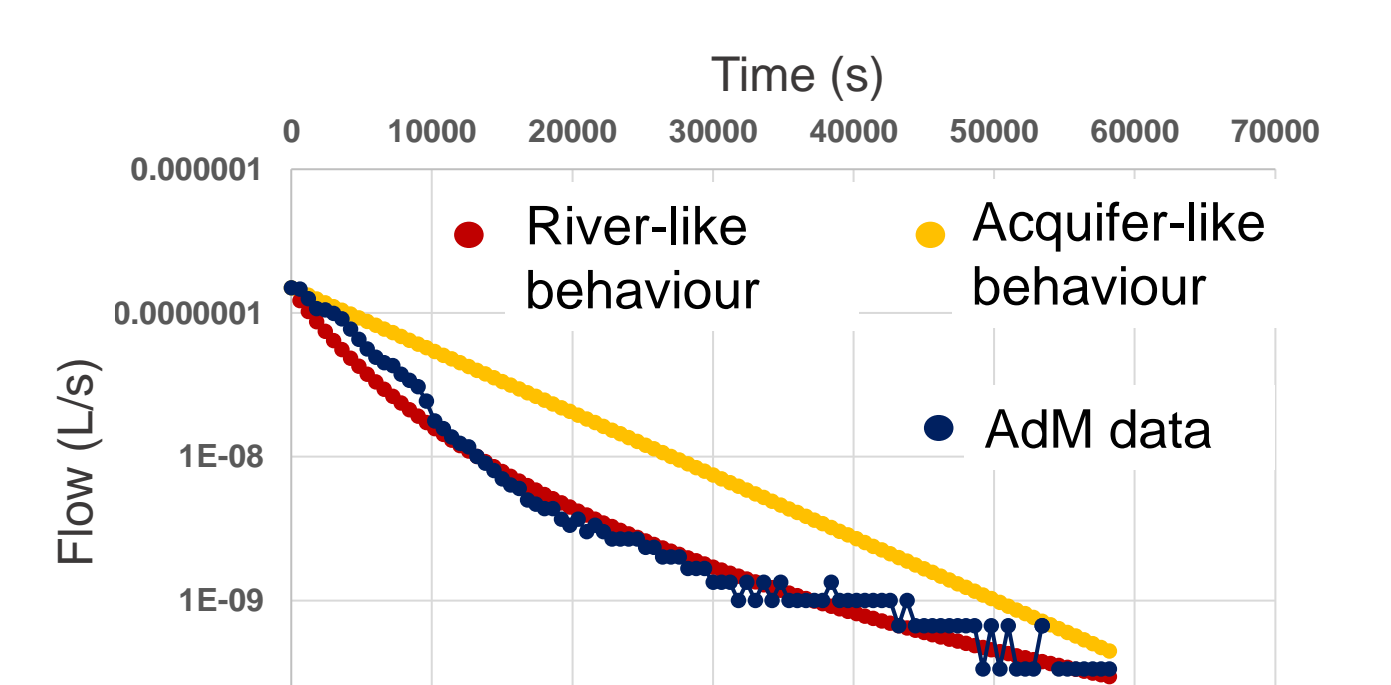


Major elements analysis

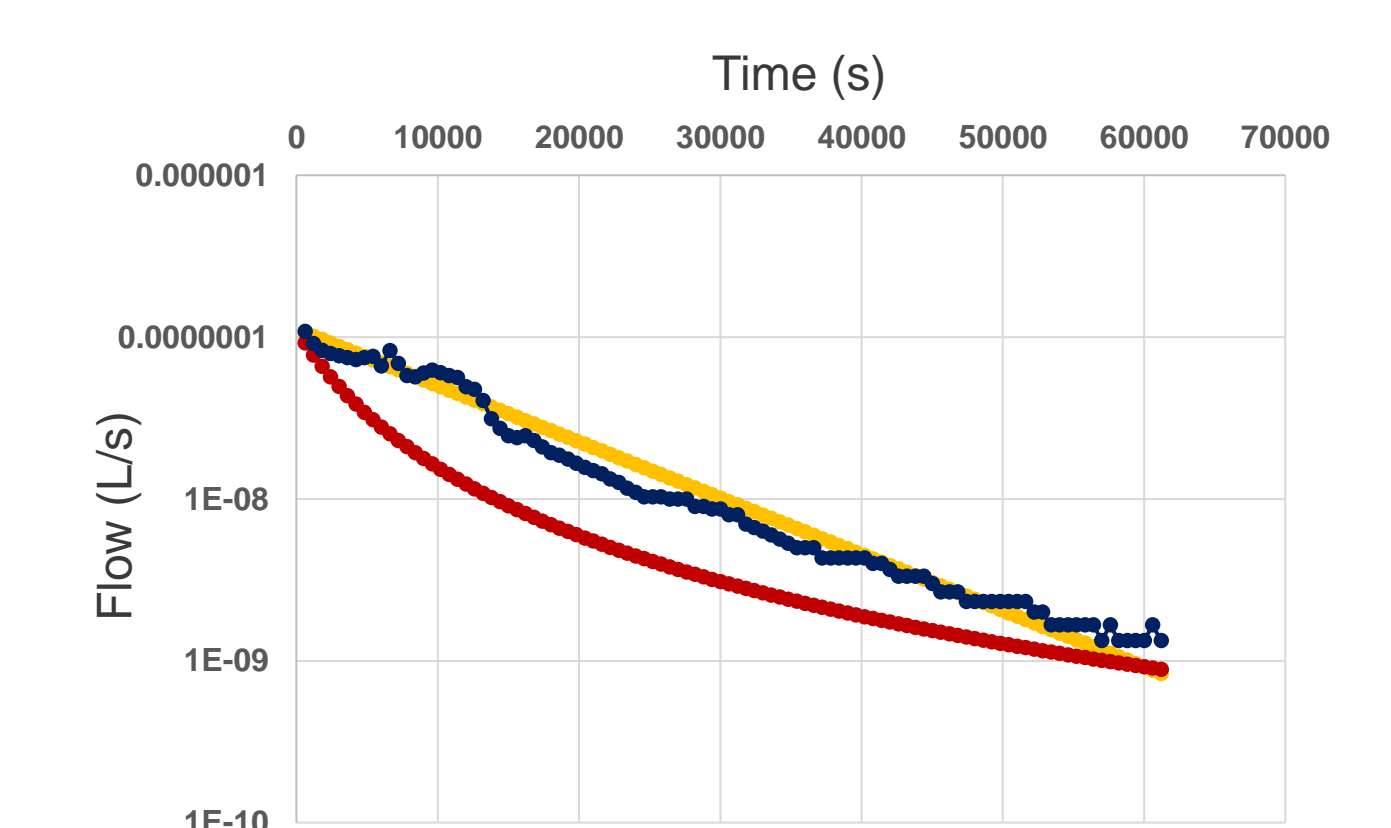


Recession curves

Two formulas were applied to characterise the type of water flow



26th May 2022 : the recession curve fits the river-like behaviour



3rd August 2022 : the recession curve fits the aquifer-like behaviour

Main results

- Water flows are affected by daily to seasonal cycles
- Water flow start with snow melting and then occur with precipitation
- Differences in water flow timing between Box 1 and 2 suggests that water flows are also controlled by active layer thawing from the surface to depth and the progressive melting of ice infill in fractures
- Dye tracers show that fractures are connected
- Electrical conductivity values suggest that water experiences a relatively high residence time as values are far above the snow value (9.2 µS/cm)
- Analyses of major elements showed that some concentrations are unexpectedly similar than at the foot of the mountain flank
- Recession curves show a complex water flow patterns with variable behaviours depending on the atmospheric conditions and fracture connectivity

Implications

These direct observations of water flows and their characterisation show that they are strongly linked to snow melting and precipitation. Possible indications of residence time suggest highly mineralised water that could be an effect of repeated freeze and thaw cycles and the desquamation of fracture walls, or evidence of the melting of old ice infill. Those results will help to build forcing data for coupled thermal and hydrogeological models to better assess the role of water in permafrost degradation and rockwall destabilisation.