25 September 2025

We thank Reviewer 2 for the thorough and constructive review. The comments helped us improve the clarity, structure, and presentation of our manuscript. Below we provide a detailed, point-by-point response. Reviewer comments are reproduced in italics, and our responses follow each comment. All line numbers refer to the original version of the manuscript. All the revised figures and captions are available at the bottom of this document.

*Detailed comments to the paper*
*"**Water flow timing, quantity, and sources in a fractured high mountain permafrost rock wall**"*
*by Matan Ben-Asher, Antoine Chabas, Jean-Yves Josnin, Josué Bock, Emmanuel Malet, Amaël*
*Poulain, Yves Perrette, and Florence Magnin*

***Major/moderate comments.***

1. *Data analysis relies upon a "moving window cross-correlation" scheme. While this is cited at lines 256-258, no explanations on the algorithm are provided. How is the algorithm parametrized in terms of moving window size? How does the choice of the moving window impact on the analysis? The Authors should also carefully describe between which variables are cross-correlations evaluated as this is somehow not clear throughout the manuscript. Finally, the results of the cross-correlation analysis are depicted in a figure included in the supplementary (Figure S3), thus limiting their visibility. I suggest the Author carefully explaining what they did, adding more details about the advantages and the limitation of the method employed, and including these results (onto which the data presentation and discussion then build upon) in the main body of the paper.*

Following this important comment, we added a more detailed explanation of the method in section 3.5.2. We also inserted a new figure (now Figure 8) that includes the results of the cross-correlation analysis for the 2022 season. The 2023 season is presented in the supplementary materials - Figure S3.

2. *The presentation of the data in the Results section (Section 4) is somehow long, and some parts could be better rendered and communicated to the reader through graphical representations. Data description appears somehow "scattered" as it is divided in many subsections. I suggest increasing the quality of graphical representations (see also comment #3) and shortening data description merging sub-subsections (for example: merge 4.1.x in a single subsection 4.1).*

The results section was significantly shortened, mostly by reducing the details of flow behaviour. All subsection 4.1.x were merged into the main 4.1 section, as suggested. All figures were edited to improve their resolution, increased text size where needed, labeled panels and more detailed caption text.

3. *Increase the overall quality of all figures and associated figure captions. While the datase tcollected by the Authors is relevant, the graphical representation of the*

*results is extremely poor. I strongly suggest revising all figures, with particular focus on Figure 7. Here, some y-axis labels are missing. Figure captions are also extremely synthetic, unclear, and/or incomplete. Each caption should fully explain figure content and describe each sub-panel.*

All the figures were edited and are now clearer with more informative and detailed captions:
Figure 1: Panels were labeled, and the caption refers to each panel specifically.
Figure 3: Unnecessary details were omitted. Text size was enlarged. Caption was edited.
Figure 4: Panels were labeled, text in the figure was refined. Caption was elaborated with an improved description of the experiment setup.
Figure 5: Panels were labeled, and the transparency of the water volume and air temperature colors were reduced to improve visibility.
Figure 6: Column bars of the monthly flow volume were widened to improve the distinction between 2022 and 2023 data.
Figure 7: Caption was edited and is now much more detailed. Missing y-axis labels were inserted. Panels were labeled.
Figure 8: A new figure that was in the supplementary materials. Added with labeled panels and detailed caption.
Figure 9: Panels were labeled, and the caption refers to each panel specifically.
Figure 10: No changes
Figure 11: Caption was edited. Text size increased. A new distribution was added – tunnel air temperature.

*Minor comments.*

*4. Please carefully revise the use of English language.* The text was revised and edited.
*5. The date format is not consistent throughout the text.* All dates were edited to a single format.
*6. Some internal references to figures/tables are missing throughout the text (e.g., lines 272, 281 etc).* This error was fixed.
*7. Line 15. Replace "fluorescent tracers" with "fluorescence of tracers".* Done.
*8. Line 18. Acronym "AT" has not been defined yet. Avoid acronyms in the abstract for clarity.* Done
*9. Line 159. What does "original mineral water" mean? Is it water collected from the site?* It means that the original mineral water content that came in the bottles was used to produce the tracer solution. The sentence was edited for clarity: The solutions were prepared and carried in "Ondine®"
*10. Line 162. Replace "new concentrations" with "new solutions". Then, specify concentrations at which solutions are prepared.* Done.
*11. Lines 165-166. A verb is missing in this sentence.*Edited the sentence: The dyes powders were inserted directly into the bottles with the original mineral water.
*12. Line 174. Replace "isolate from" with "isolate them from".* Edited the sentence: The holes with the coin-sized sensors were filled with gray polymer clay to insulate the sensors from direct solar radiation on the metal sensor.

*13. Line 199. There is a typo, "Acid-Amino-G" should be "Amino-Acid-G".* Corrected.
*14. Line 234. There is an extra numbering "3.6".* Deleted.
*15. Lines 241 to 247. Punctuation in the equations is missing.* Punctuation was added.
*16. Line 263. The sentence "these include data from 109" is somehow incomplete and unclear.* Deleted.
*17. Line 368. "zero-curtain period" should not be italic.* Done
*18. Line 421. What do you mean by "corrected at 25°C"?* Since water conductivity is influenced by temperature, the values are normally reported after correction to room temperature. The sentence was rephrased: "…after correction to a standard temperature of 25°C."
*19. Line 441 (caption of Figure 10). "temperature" instead of "T".* Done.

We believe that these revisions address all the reviewer's concerns and have substantially improved the manuscript. We thank Reviewer 2 again for their constructive feedback and valuable suggestions.

## Figures

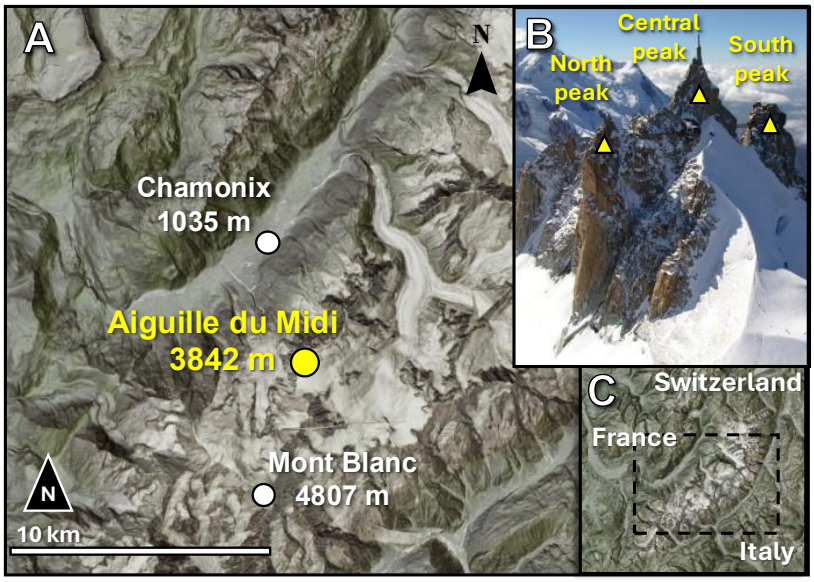


**Figure 1: A) Location of the Aiguille du Midi in the Mont Blanc massif. B) view of the three peaks at Aiguille du Midi. (Picture: S. Gruber). C) Location of the Mont Blanc massif on the border of France, Italy and Switzerland. Maps provided by the Swiss Federal Office of Topography swisstopo.**

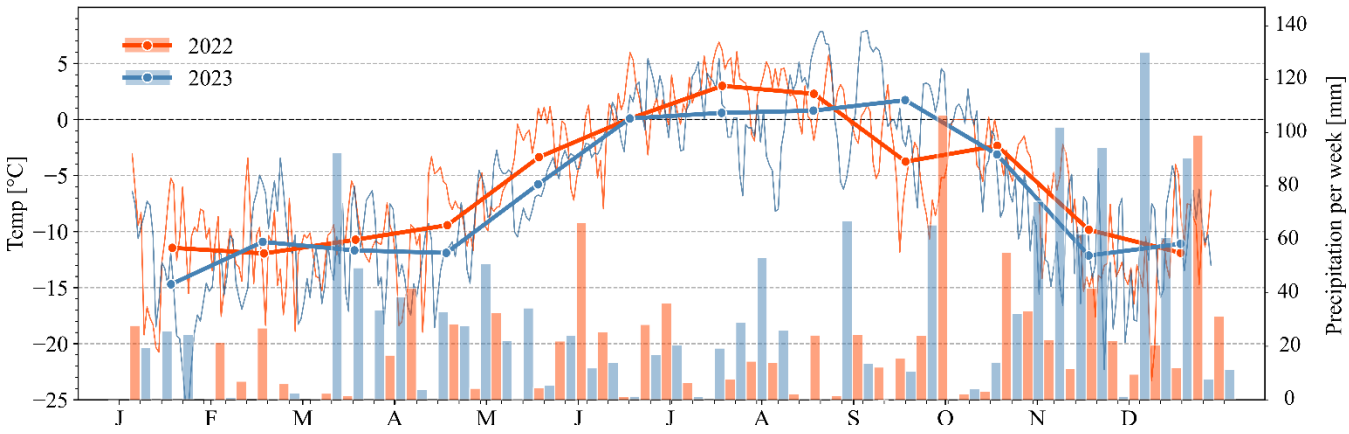


**Figure 2: Daily (thin lines) and monthly (thick lines) air temperature and weekly precipitation in 2022 and 2023 (bars). Air temperature was measured at the top of the Aiguille du Midi and precipitation was measured in Chamonix (1042 m asl). Data provided by Météo France.**

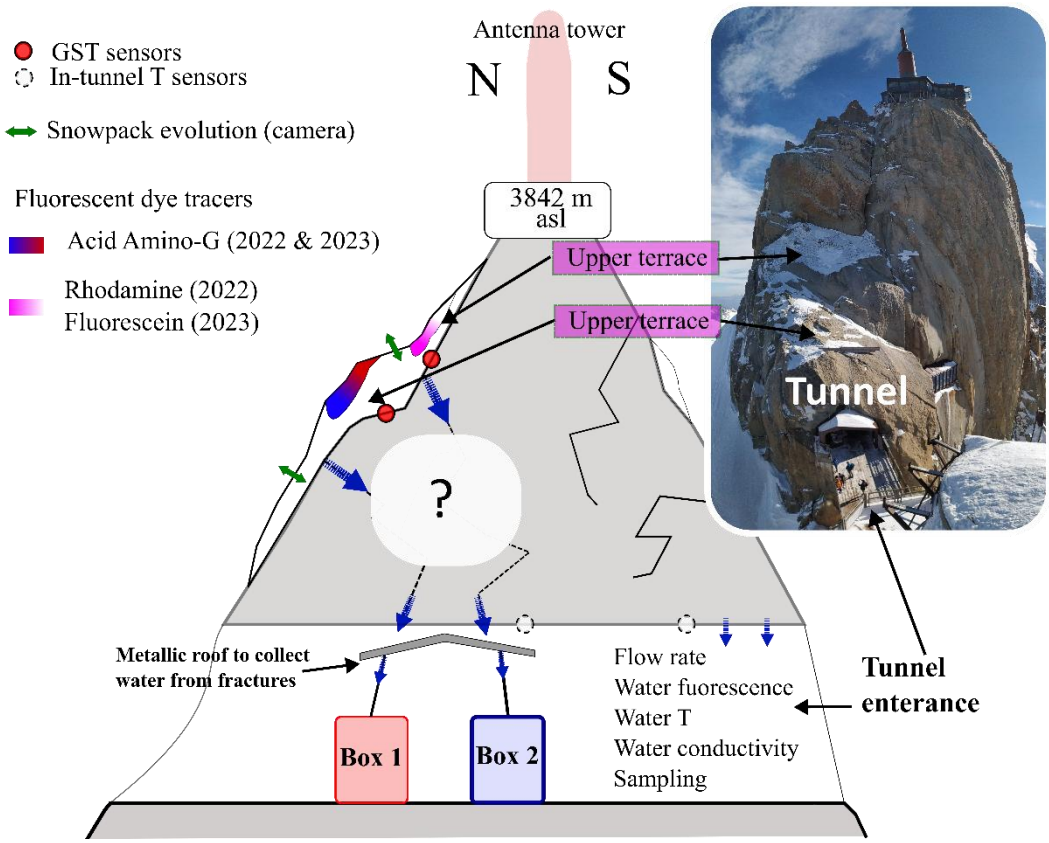


**Figure 3: Sketch of the methodological approach to track and monitor water flows in the Aiguille du Midi central pillar. Note the location of the insertion locations of the dye tracers in the snowpacks on the terraces above the water monitoring boxes.**

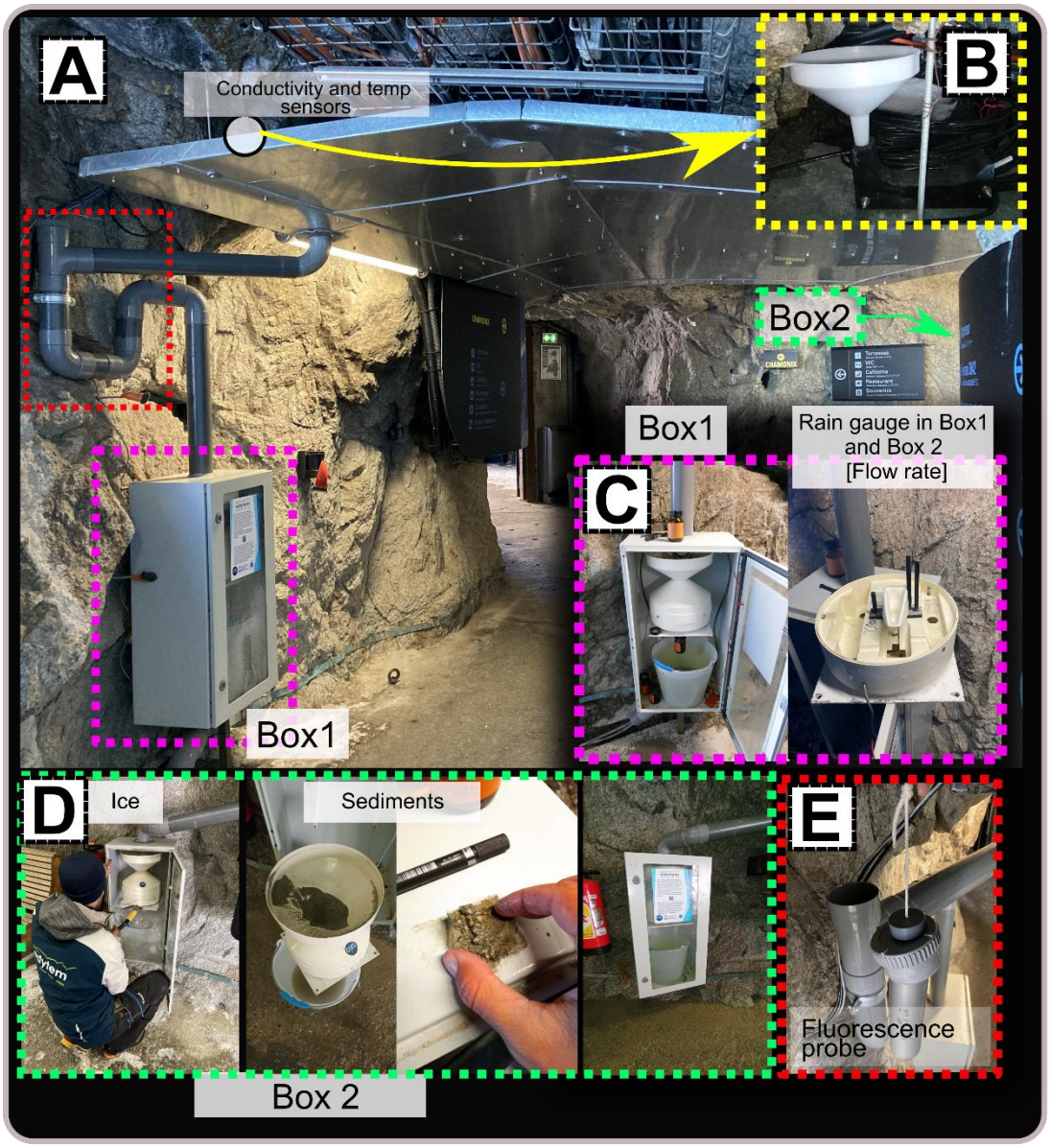


**Figure 4: Real-time monitoring system in the tunnel. A) Metal roof draining to Box 1 (pink dashed frame). B) A 3D printed siphon that was placed directly under the water output from the fracture, quipped with T and conductivity sensors (yellow dashed frame). C) Box 1 interior with rain gauge to monitor flow rate, and a sampling bottle and bucket. D) Box 2 with sediments (green dashed frame). E) Fluorescence probe by TRAQUA located in the a specially designed siphon for continuous real time monitoring of the dye tracers.**

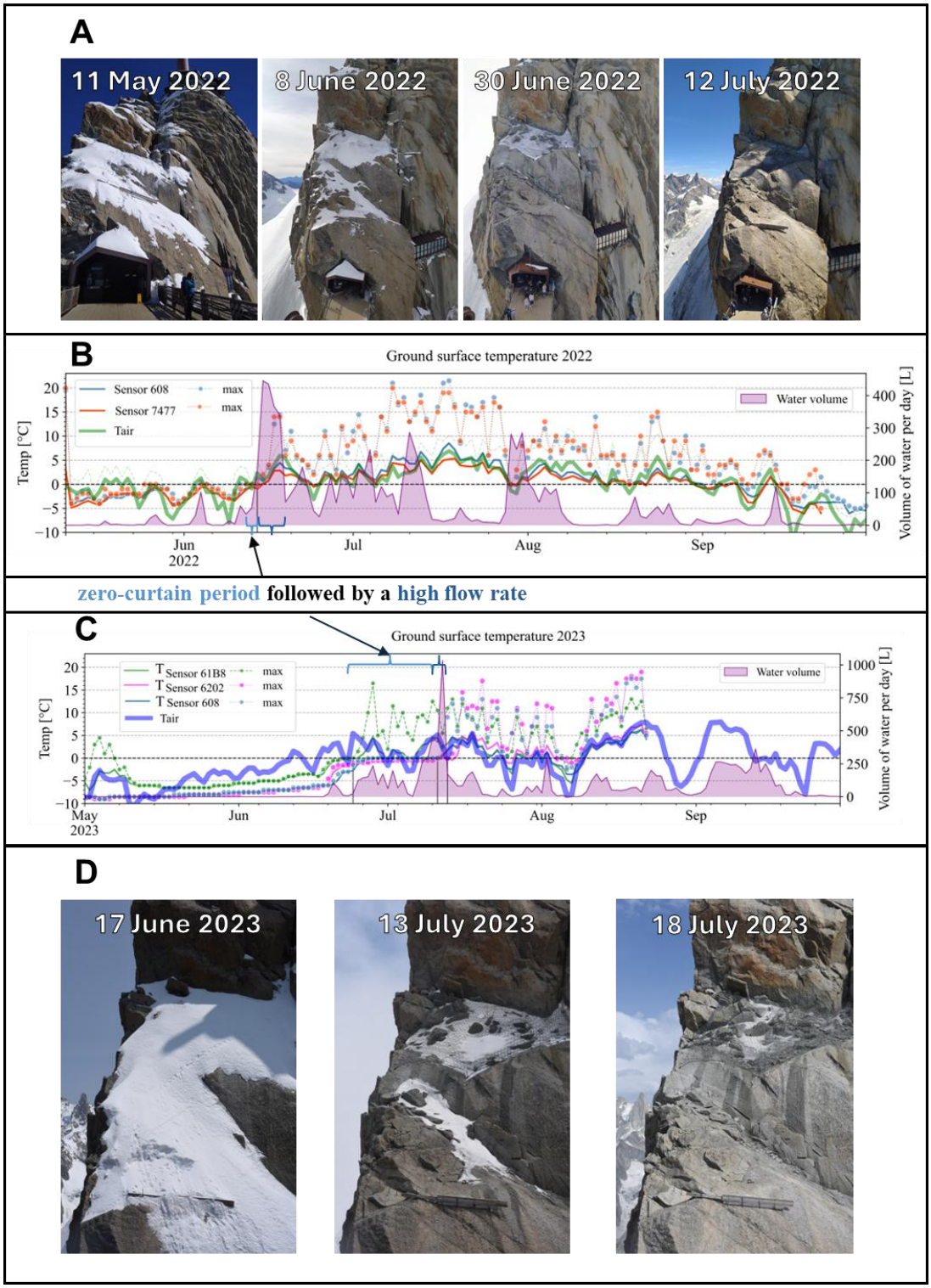


**Figure 5: A) Photos showing the evolution of the snow cover on the NE face during the thawing seasons in 2022. Note the change in snow cover. B) 2022 season AT, GST measured on the NE face, above the tunnel entrance, directly above the monitoring system, and flow rate measured at output from rock fractures in the tunnel wall. Solid lines represent the daily mean. C) 2023 season AT, GST measured on the NE face, above the tunnel entrance, directly above the monitoring system, and flow rate measured at output from rock fractures in the tunnel wall. Solid lines represent the daily mean. Note the zero curtain period which marks the thawing of the snowpack and exposure of the rock surface to atmospheric heating. D) ) Photos showing the evolution of the snow cover on the NE face during the thawing seasons in 2023.**

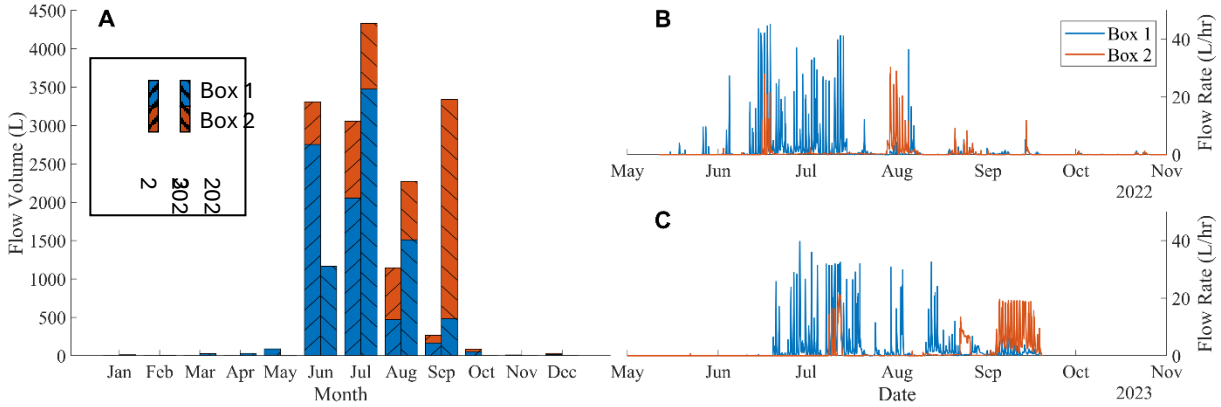


**Figure 6: A) Monthly distribution of flow volume in Box 1 and Box 2 during the 2022 and 2023 seasons. B) Measured flow rate vs. time in 2022. C) Measured flow rate vs. time in 2023.**

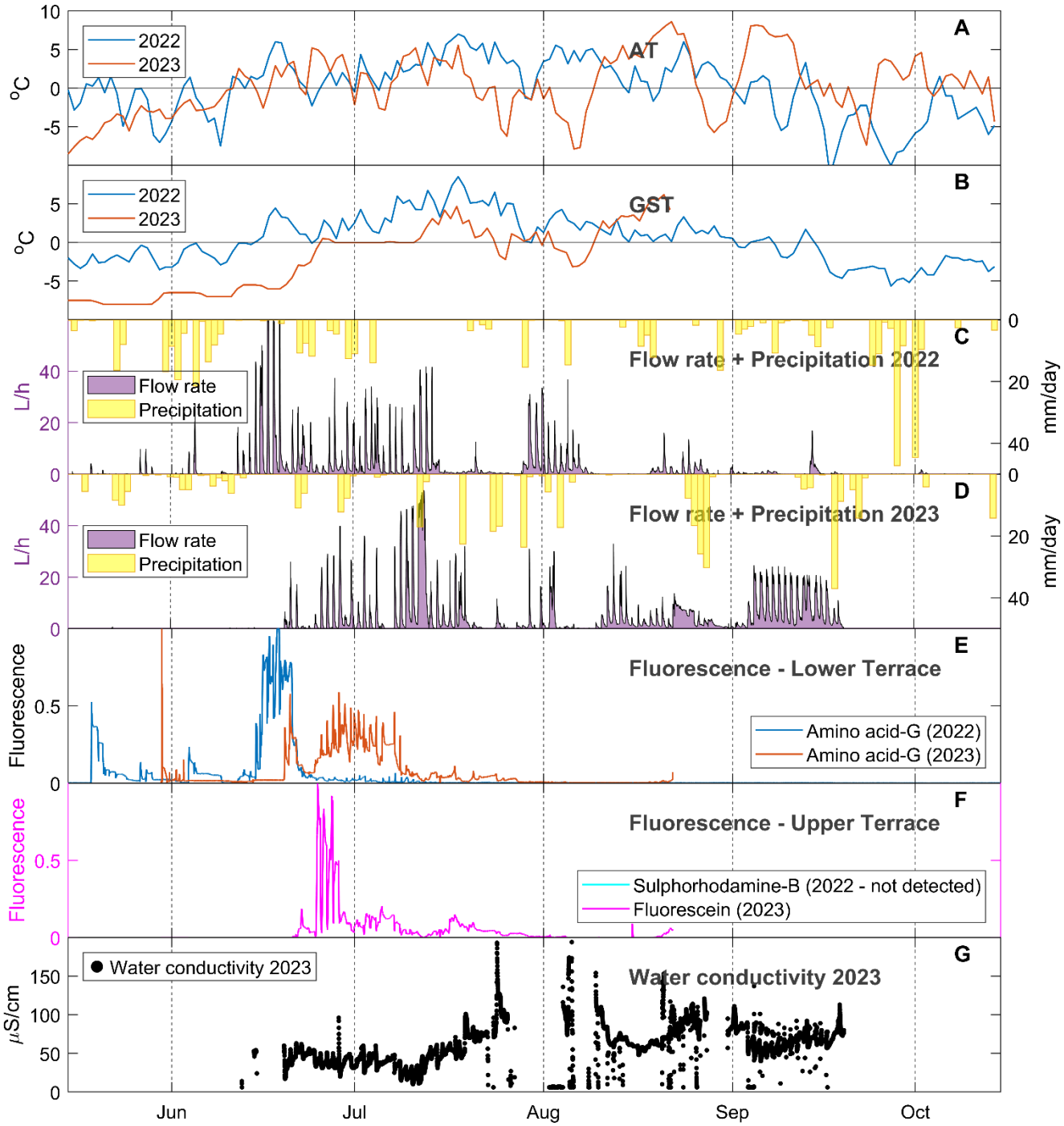


**Figure 7: Annual time series. A) Air temperature (AT) measured by Météo-France in Aiguille du Midi. B) Ground surface temperatures (GST) measured using iButtons at the rock surface on rock slope above the water collecting system, near the location of fluorescent dyes injection. C-D) Flow rate measured in both box 1 + box 2 (purple) and daily precipitation measured in Chamonix meteorolocical station (Météo-France) (yellow bars). E) Normalized fluorescence signal of amino acid-G dye tracer that was inserted in the upper terrace in both seasons (2022 and 2023). F) Normalized fluorescence signal of Sulphorhodamins-B (inserted in 2022) and Fluorescence (inserted in 2023) dye tracers. The Sulphorhodamins-B dye was never detected. G) Water conductivity that was monitored continuously at the outlet of water from the fracture in the tunnel.**

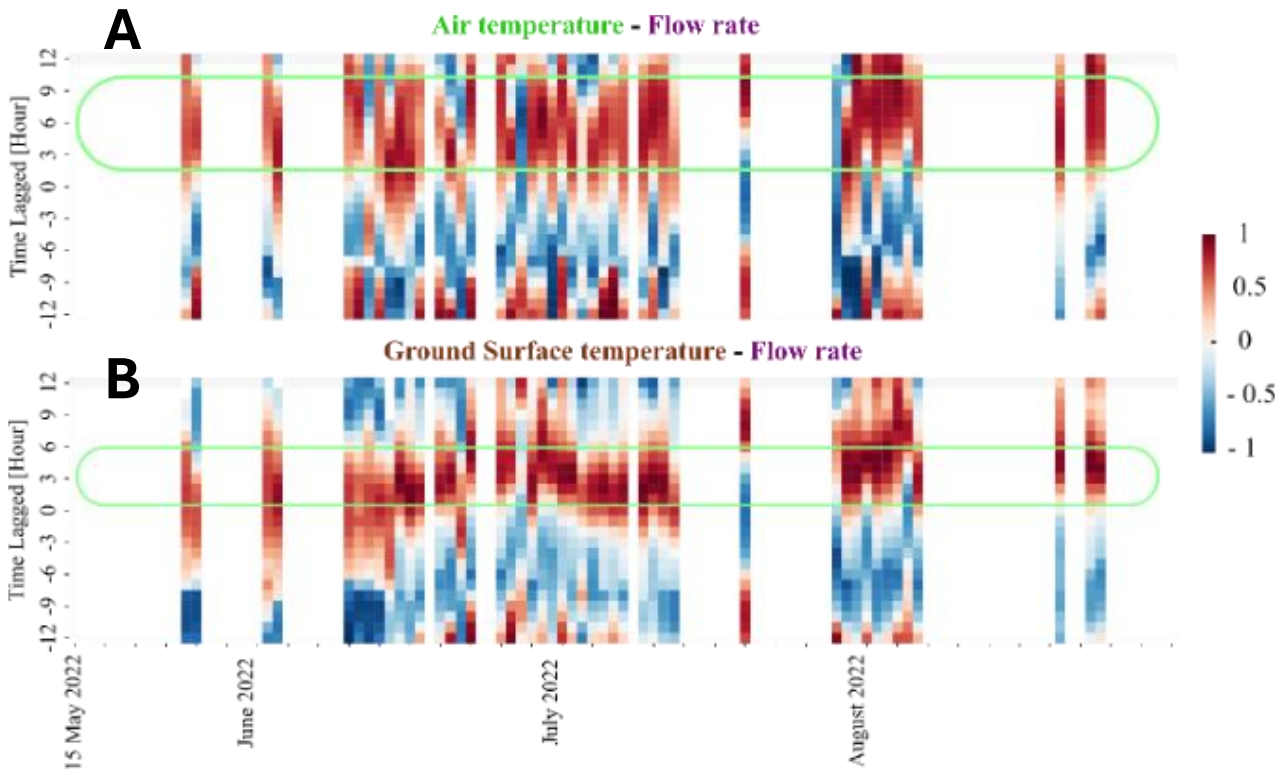


**Figure 8: Results of moving-window cross-correlation analysis of water flow with (A) air temperatures (AT) and (B) ground surface temperatures (GST), during 2022 season. The horizontal axis represents the days, and the vertical axis represents the size of the lag time, in hours, between the flow rate time series with AT (upper plot) and GST (lower plot). The color bar represents the value of the Pearson correlation coefficient (PCC) (1: high correlation, 0: no correlation, -1: reverse correlation). The green frame marks the range of lag times that show high PCC. Results of the cross-correlation analysis of 2023 season show similar results and can be found in the supplementary materials, in figure S3.**

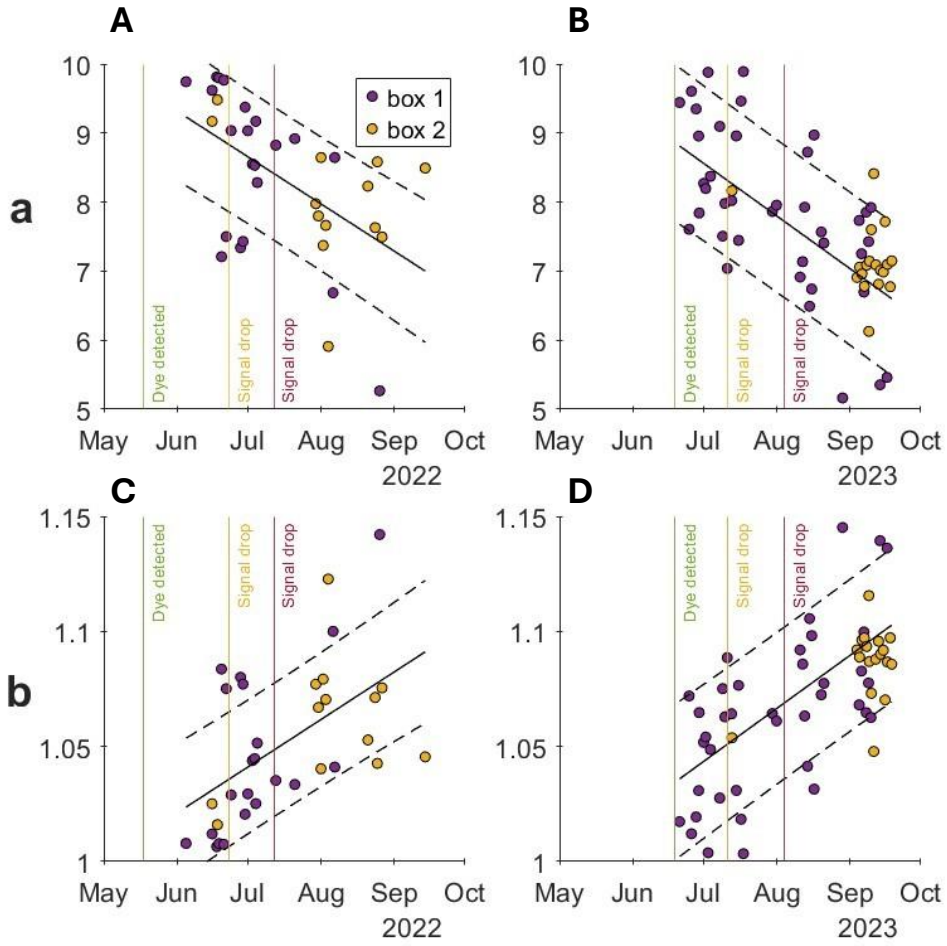


**Figure 9: Values of the recession curve exponential coefficients a (top) and b (bottom) in 2022 (left) and 2023 (right) vs. time. A) values of the 'a' coefficient of the recession curves of flow events in 2022 in box 1 (purple circles) and box 2 (yellow circles). B) values of the 'a' coefficient of the recession curves of flow events in 2023 in box 1 (purple circles) and box 2 (yellow circles). C) values of the 'b' coefficient of the recession curves of flow events in 2022 in box 1 (purple circles) and box 2 (yellow circles). D) values of the 'b' coefficient of the recession curves of flow events in 2023 in box 1 (purple circles) and box 2 (yellow circles). Values obtained from curves with $R^2$ values below 0.8 were omitted from the analysis. The black line is the linear regression of all the points (box 1 + box 2) with ±standard error (dashed black lines). The vertical lines indicate the timing of the detection of the fluorescent dye in the water that exits the fractures (green), the rapid drop of the signal intensity (orange), and the disappearance of the signal (red).**

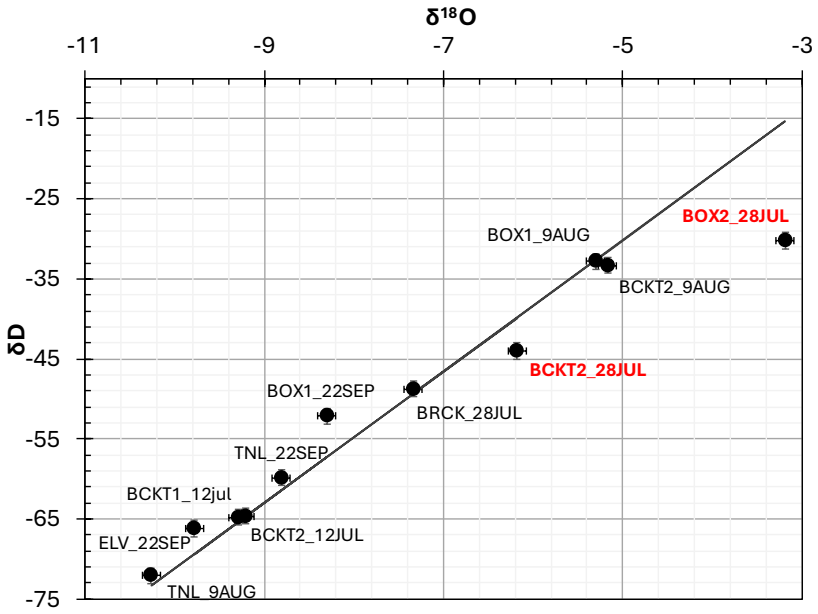


**Figure 10: Stable isotopes $\delta^{18}O$ and $\delta D$ in water samples. Note the two outliers (labeled in red) from the global meteoric water line (GMWL, black line) in samples taken from Box 2 on 28 July 2022.**

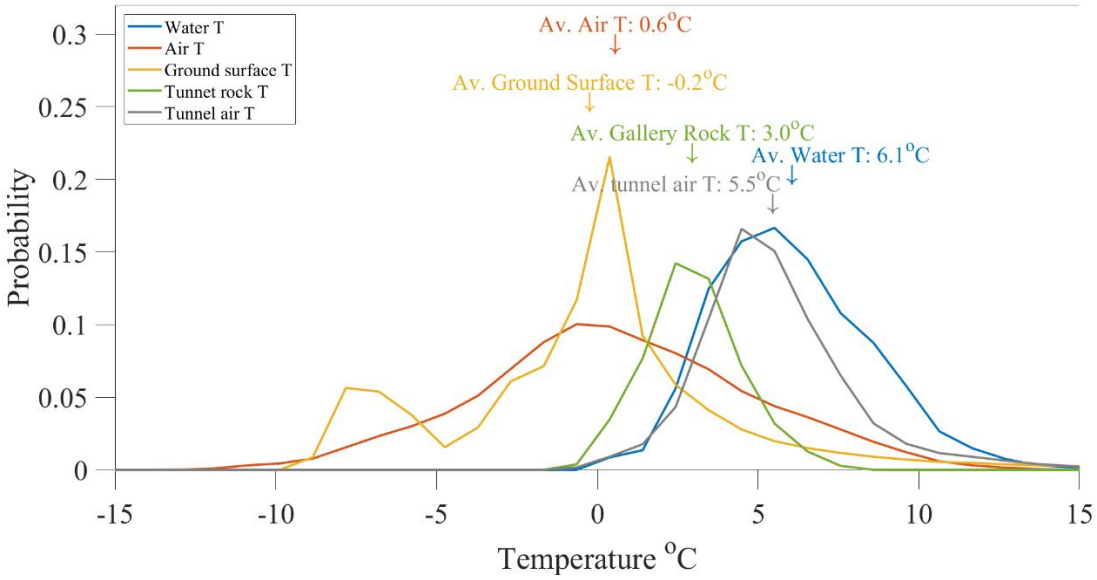


**Figure 11: Probability distribution of temperatures monitored during flow events (blue), atmospheric ATs (orange), ground surface temperatures (yellow), and tunnel wall (green). All distributions show data from the thawing season in 2022 and 2023 (15 May – 15 September). Note that the water temperature distribution (blue) shows only data when water flow was detected in the monitoring system, while the other temperature distributions represent the entire data within the thawing season.**