Using a record of bedload transport from Leverett glacier in western Greenland to understand proglacial sediment transport processes from the ice sheet

Marjolein Gevers[1], Davide Mancini[1], Stuart Lane[1], Ian Delaney[1]
[1] Institut des dynamiques de la surface terrestre (IDYST), Université de Lausanne, Lausanne, Switzerland

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Context

/ Increased glacier melt impacts the sediment transport within proglacial areas as well as downstream ecosystems and geomorphology

/ Currently lacking long term field observations of erosion, sediment yield and environmental drivers of sediment fluxes in cold regions [Li et al., 2020, Carrivick and Tweed, 2021], particularly for bedload and erosion rates [Zhang et al., 2022].

Aim

/ Evaluate bedload transport in glacial meltwater stream of Leverett glacier in summer 2022

/ Understand proglacial sediment transport processes from the Greenland Ice Sheet using these bedload transport records

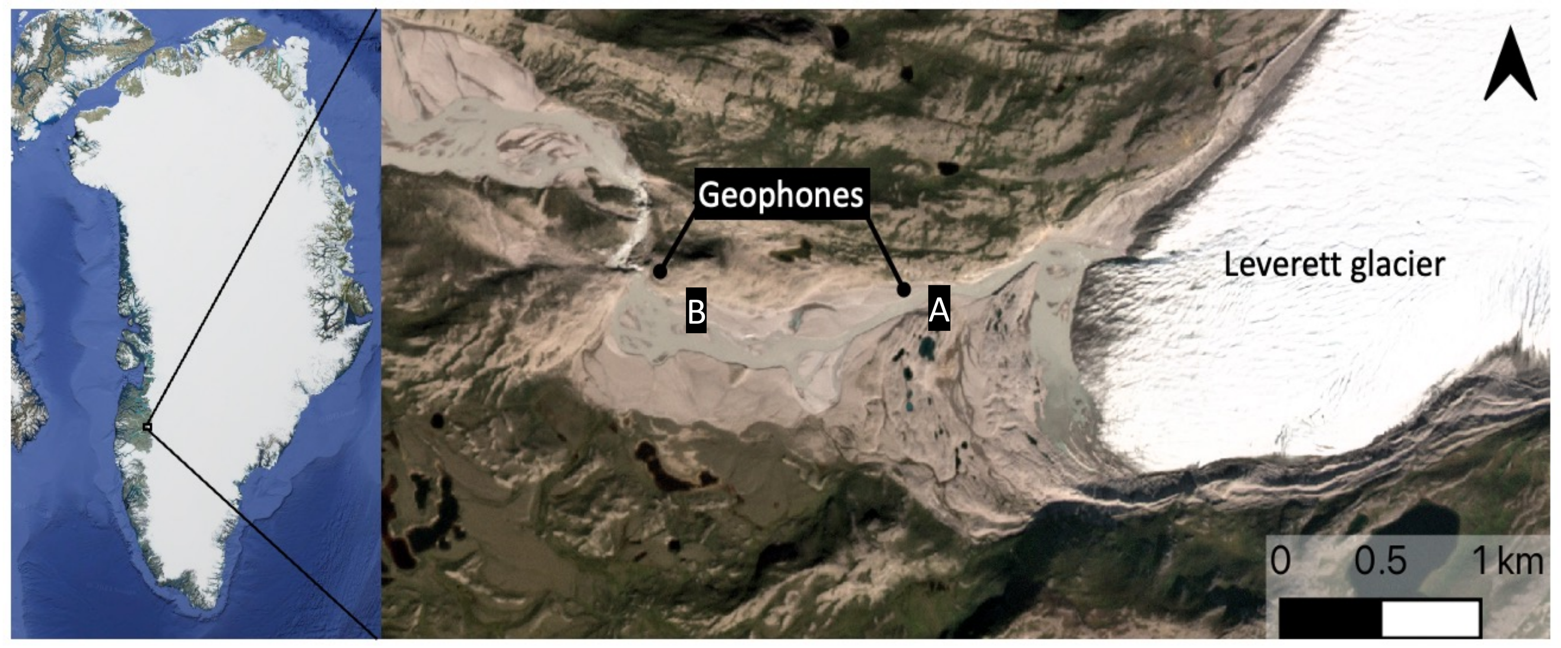

Figure 1. Map of the study site Leverett glacier, west Greenland with the locations of the geophones indicated with A and B. Location A also has a hydrological gauging station.

Methods

Figure 6 Geophone before installation

/ Two geophones (4.5Hz PE6/B) were installed next to the meltwater stream at Leverett glacier (Fig. 1 & Fig 6) during summer 2022 with sampling frequency 100 Hz

/ Acquired data was plotted as a power spectral density plot (Fig. 2)

/ For further analysis the data was split in two groups, one for stage (0 – 20 Hz) and one for bedload (20 – 50 Hz) (Fig. 3) [Burtin et al. 2011, Schmandt et al. 2013, Gimbert et al. 2016]

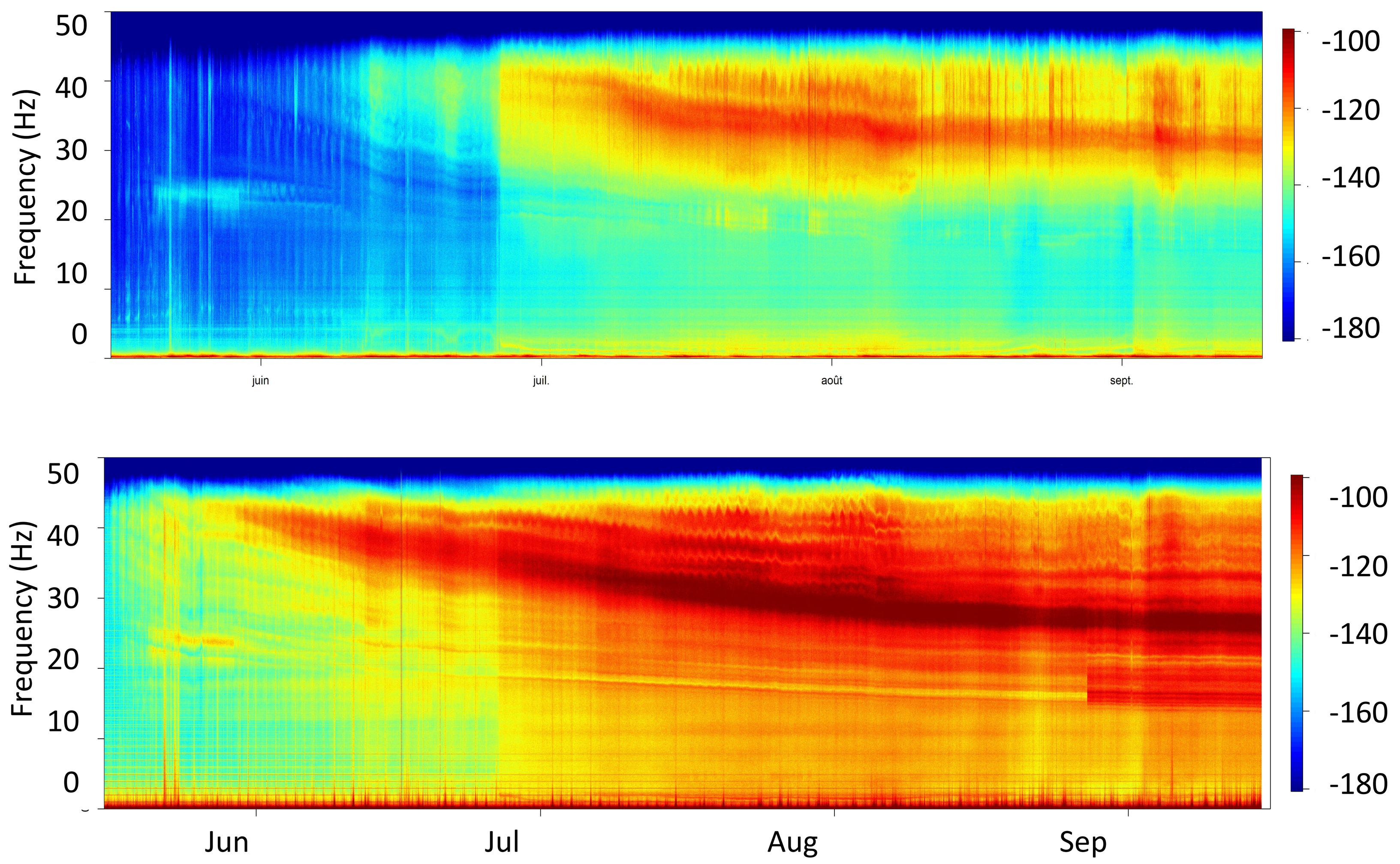

Figure 2. Power spectral density plots from the seismic station close to the river (A) and at the waterfall (B) from summer 2022. Vertical axis is showing the frequencies in Hz, the colours represent the seismic power.

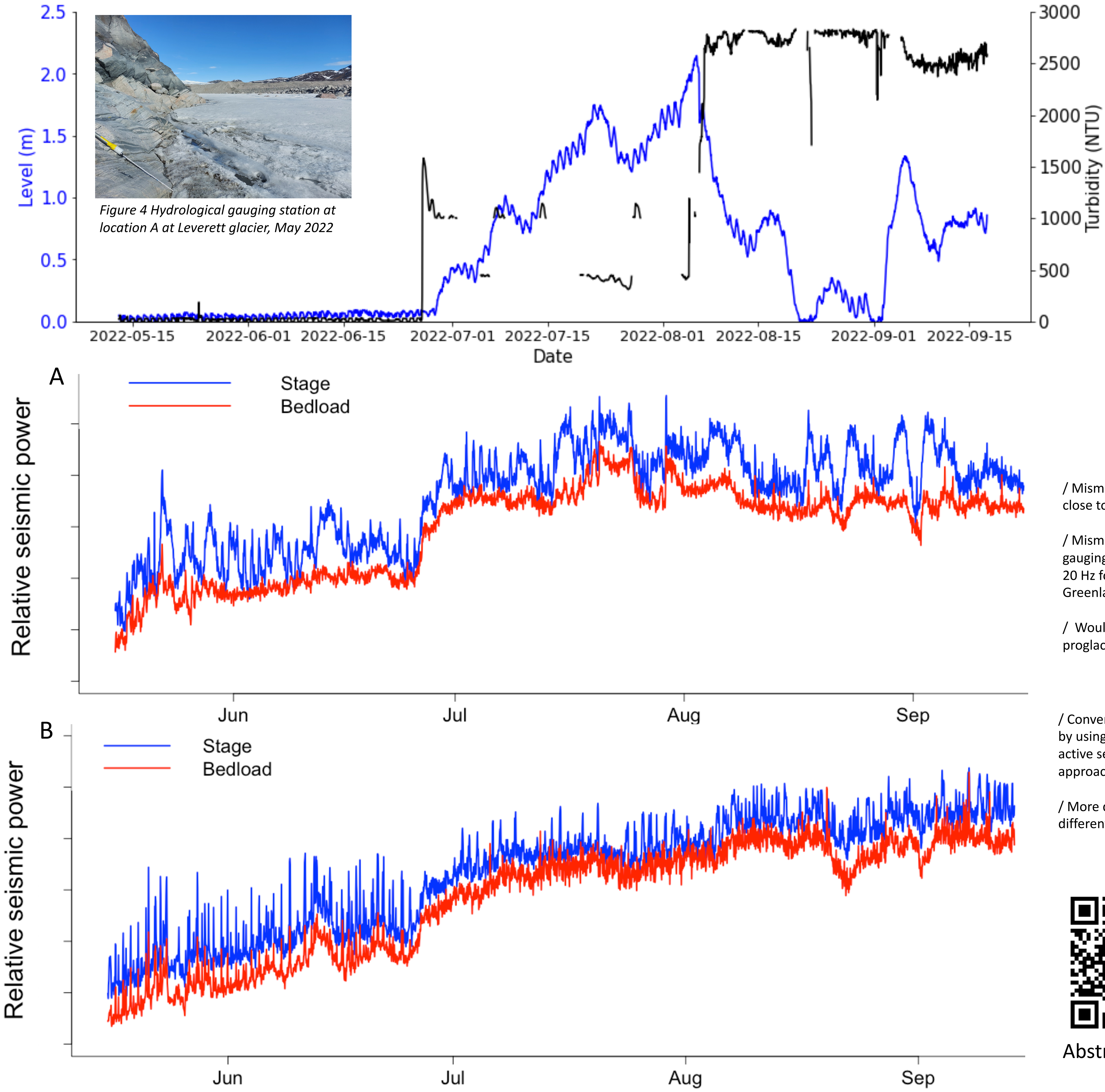

Figure 4 Hydrological gauging station at location A at Leverett glacier, May 2022

Figure 3 Time series from the hydrological gauging station and geophones at location A and the geophones at location B at Leverett glacier, showing relative stage and bedload transport over summer 2022. The blue line, interpreted as relative stage, represents the sum of the 0 – 20 Hz frequency range, while the red line, interpreted as relative bedload, represents the sum of the 20 – 50 Hz frequency range.

Figure 5 Proglacial area of Leverett glacier, May 2022

Some thoughts..

/ Mismatch between stage and bedload at location A, close to the glacier – is this supply limited?

/ Mismatch between measured stage at the hydrological gauging station from the seismics – is the division for 1 – 20 Hz for stage and 20 – 50 Hz accurate for the Greenland Ice Sheet?

/ Would location B represent the processes in the proglacial area and location A the subglacial processes?

Where to go next...

/ Converting the recorded seismic data into bedload flux by using a Fluvial Inversion Model, calibrate by using the active seismic surveys conducted as well as statistical approaches to evaluate the physical parameters.

/ More data collection in summer 2023; same locations; different turbidity sensor,

Abstract

Marjolein Gevers
marjolein.gevers@unil.ch

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A record of bedload transport from Leverett glacier in western Greenland

INTRODUCTION

Increased glacier melt leads to a change in sediment transport capacity below glaciers, which impacts the sediment transport within proglacial areas as well as donwstream ecosystems and geomorphology. The glacial sediment discharge consist of two components; coarse and fine sediment. The suspended sediment content represents the fine part of the sediment discharge, whereas the coarse part of the sediment discharge consists of bedload transport. Bedload is grains rolling, sliding or bouncing along a river channel (Syvitski et al., 2022). Bedload has been traditionally harder to measre and so is less well understood (Lane et al., 2017). Long-term field observations of erosion, sediment yield, and the environmental drivers of sediment fluxes are lacking in cold regions [Li et al., 2020, Carrivick and Tweed, 2021], particularly for bedload and erosion rates [Zhang et al., 2022].

Previous work on Alpine glaciers shows that strong diurnal discharge variations lead to fluctuations in sediment transport capacity such that deposition and erosion can occur in the proglacial area over the course of the melt season. However, the exact processes controlling sediment transport at the outlet glaciers of ice sheet margins and in their proglacial areas remain uncertain, given that the diurnal discharge variatiosn are substantiall reduced and baseflow is much larger at the Greenland Ice Sheet compared to alpine environments

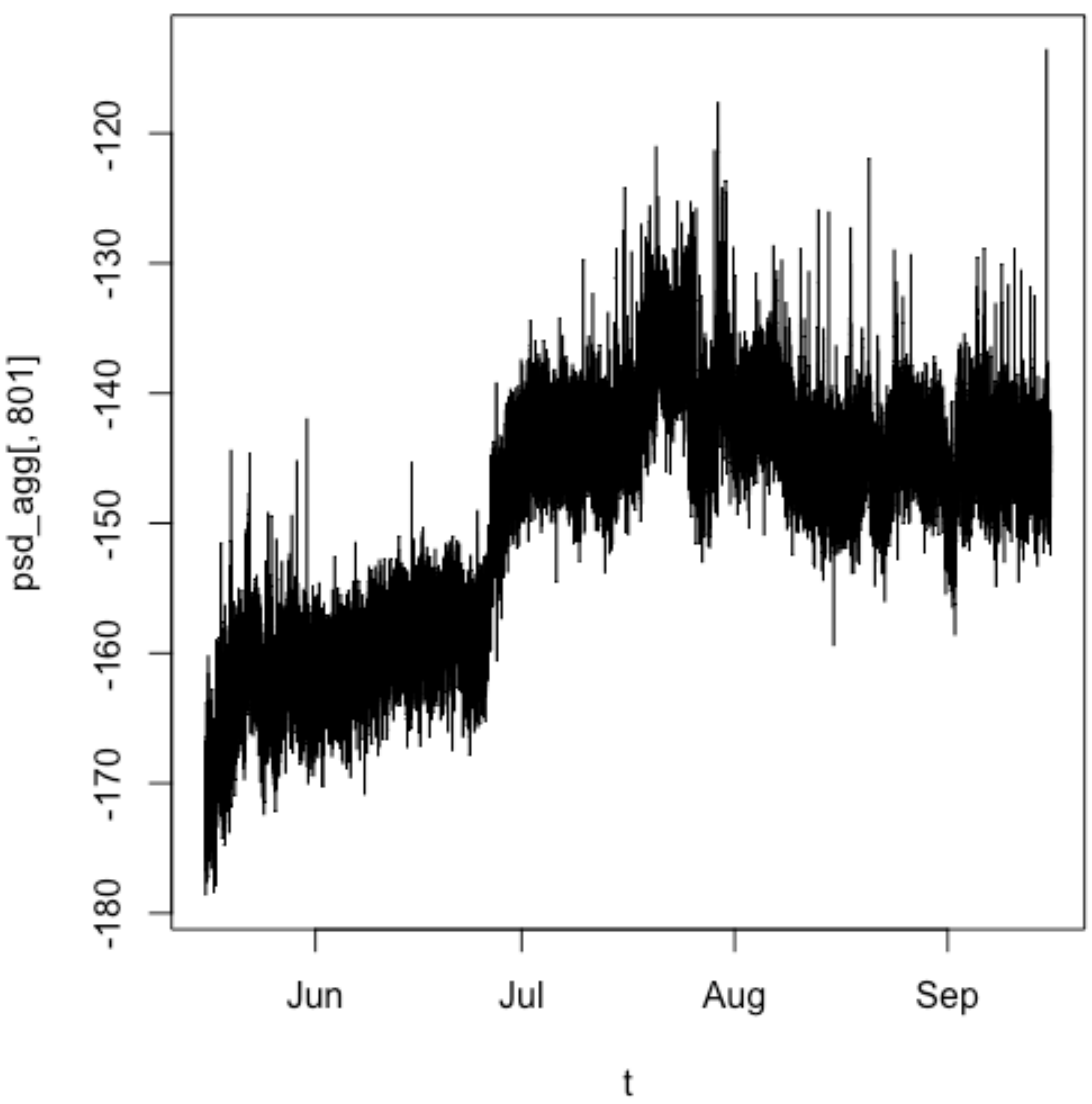
CONTEXT

/ Increased glacier melt impacts the sediment transport within proglacial areas and downstream ecosystems and geomorphology

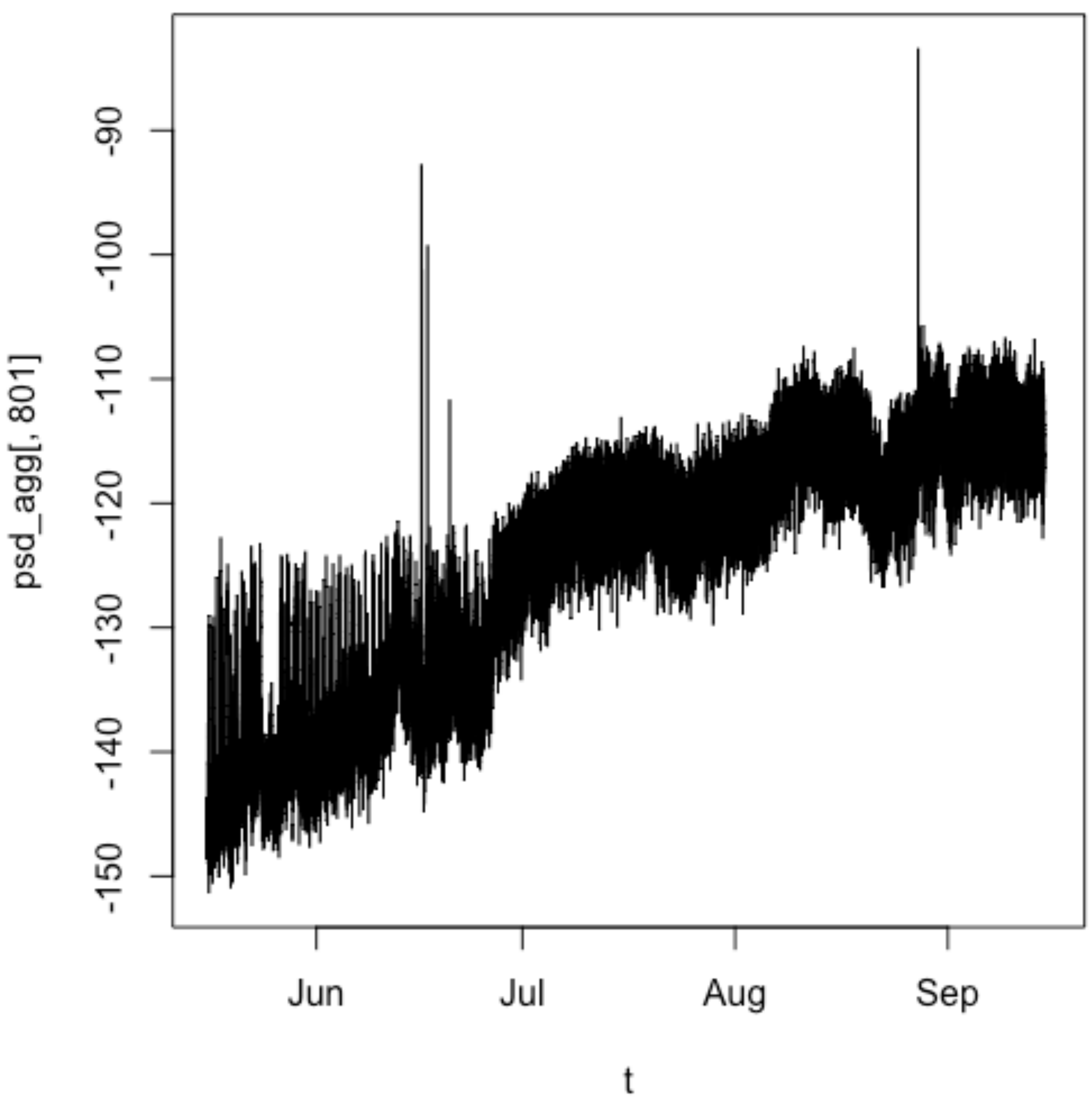
/ Sediment transport consists of suspended sediment (fine sediment) and bedload transport (coarse sediment)

/ Lacking long term field observations of erosion, sediment yield and environmental drives of sediment fluxes in cold regions [Li et al., 2020, Carrivick and Tweed, 2021], particularly for bedload and erosion rates [Zhang et al., 2022].

BK2 CLOSE TO GLACIER



BK3 WATERFALL



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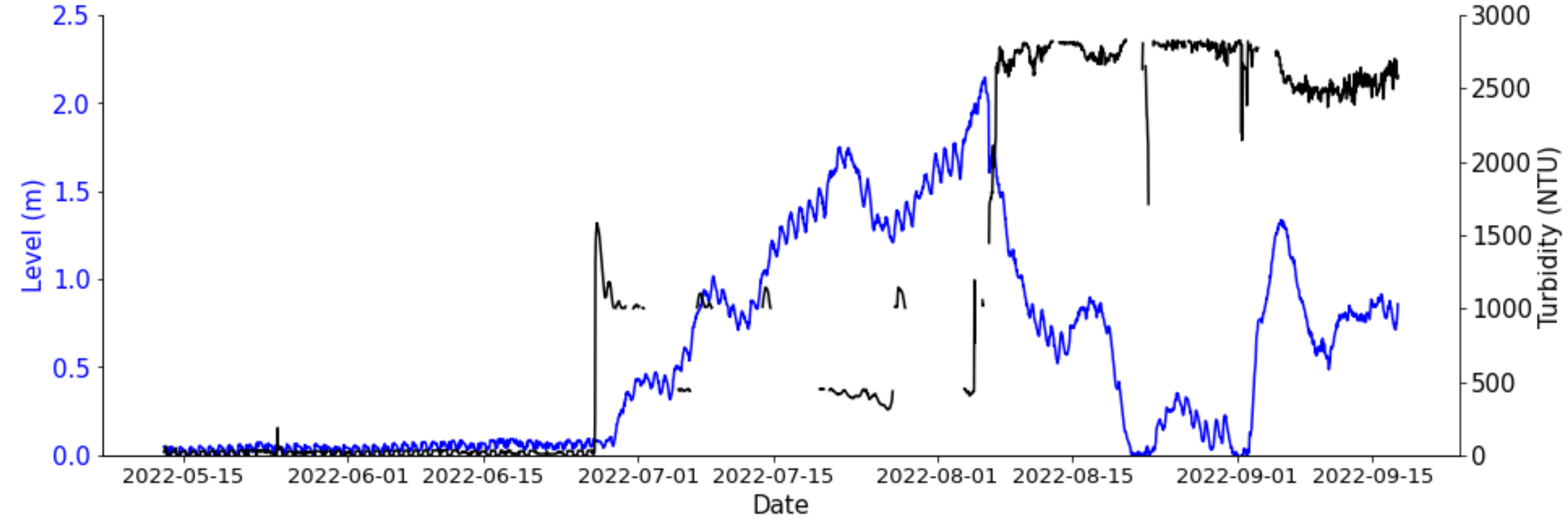
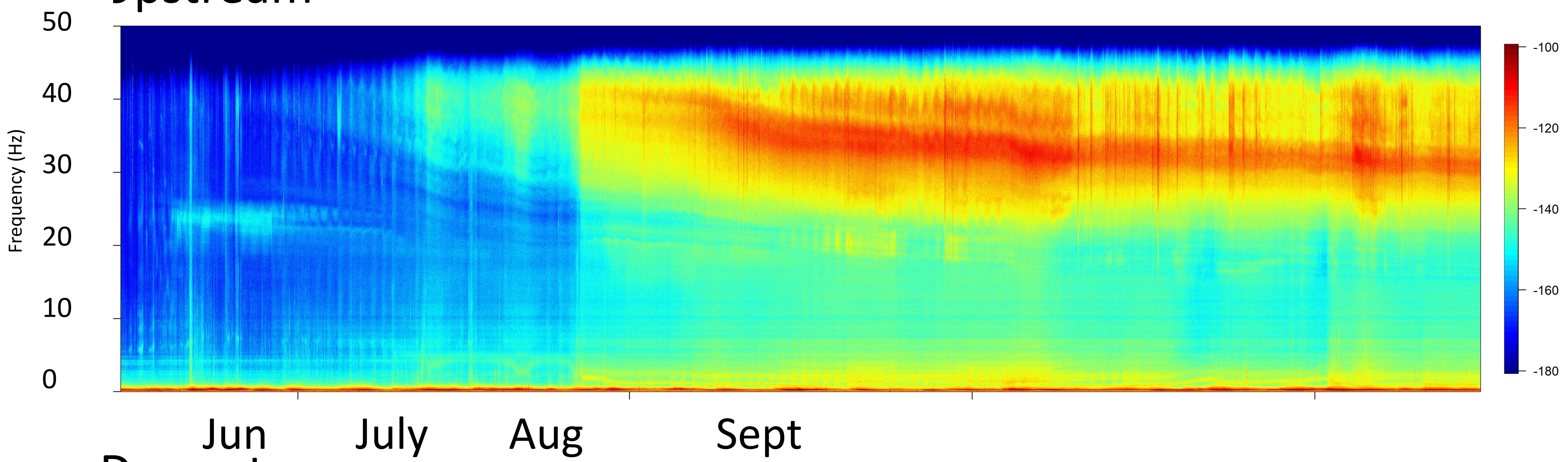
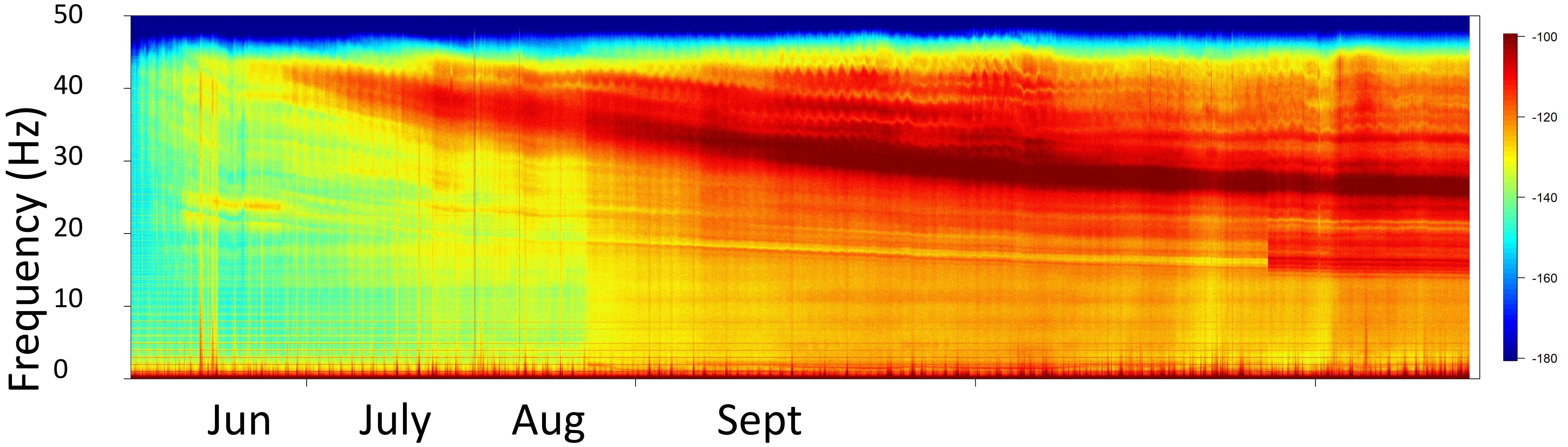
Upstream



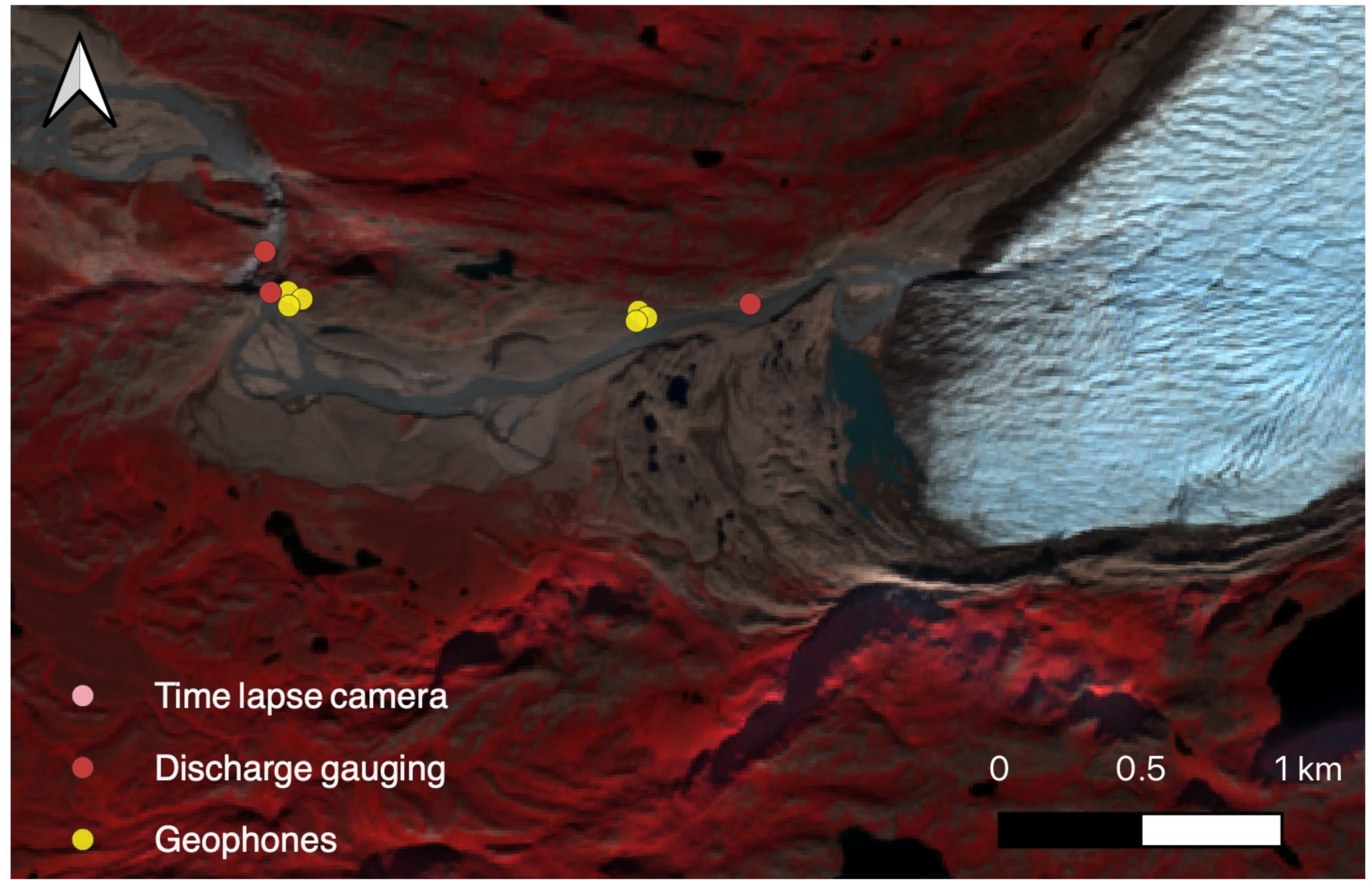
Upstream

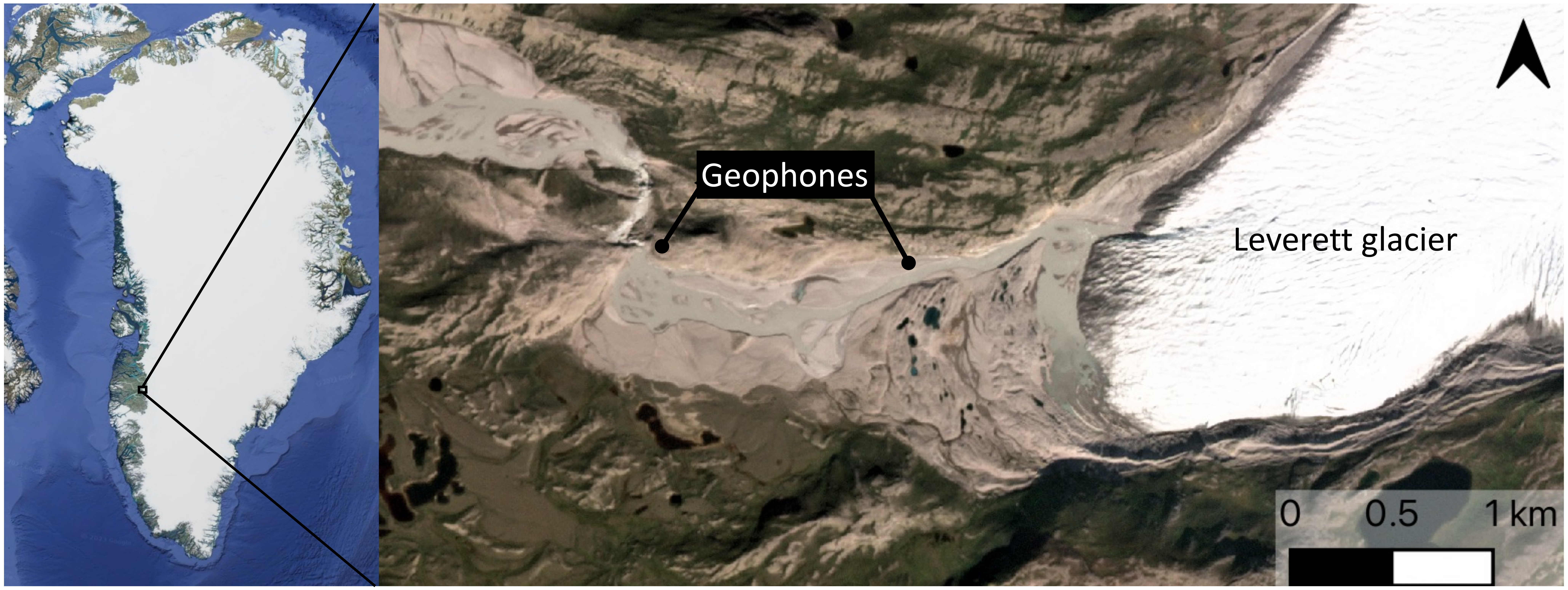


Downstream

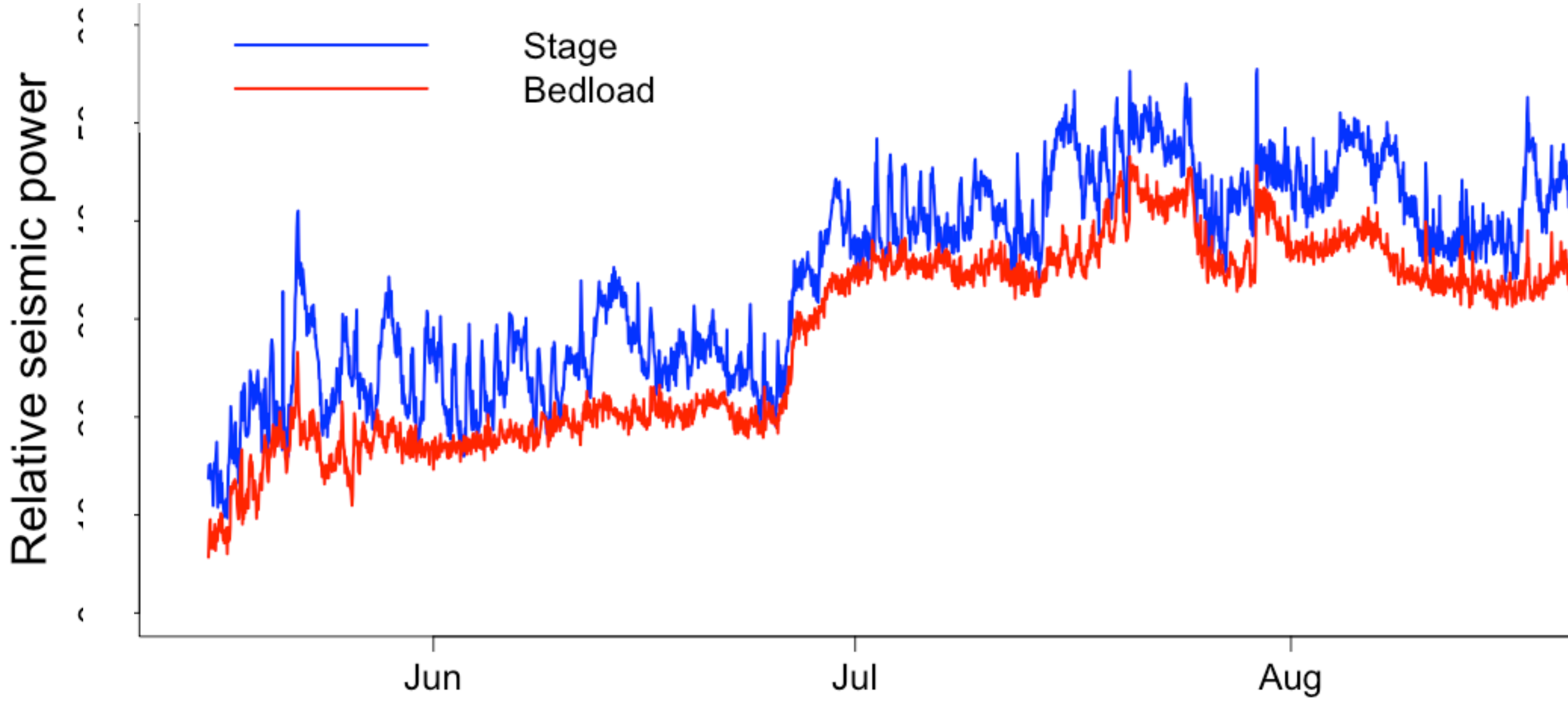


Leverett glacier

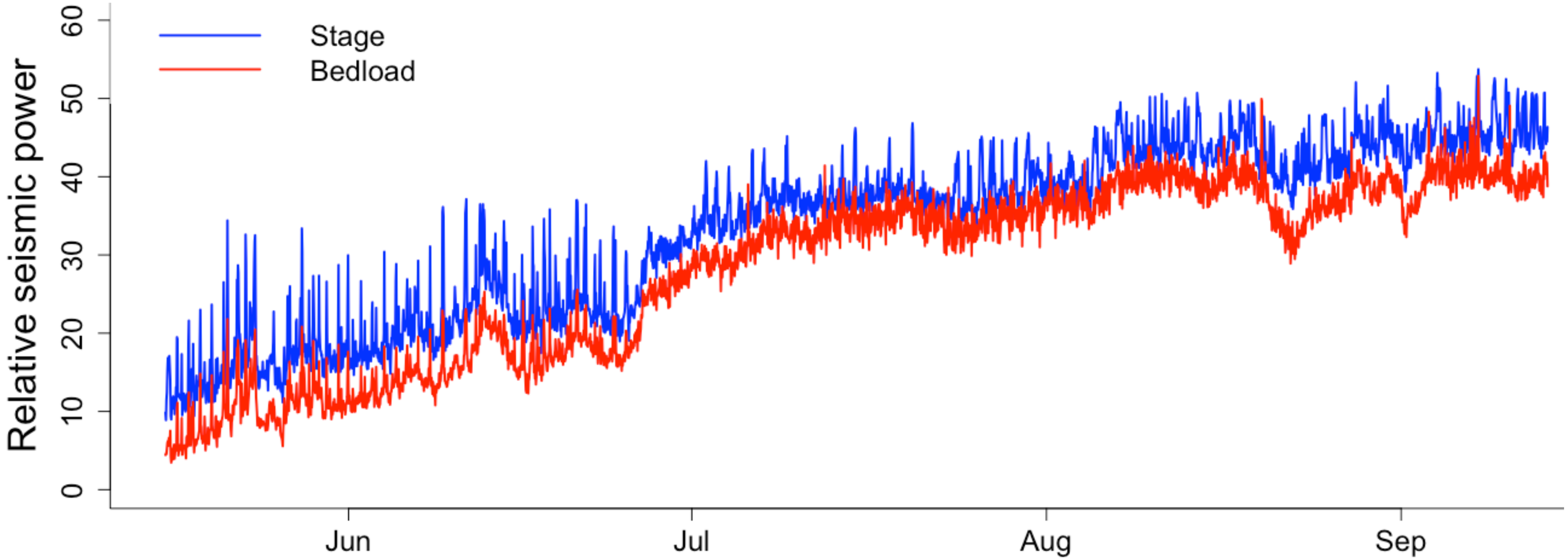




Geophones
Leverett glacier
0
0.5
1 km



Relative seismic power
Stage
Bedload
Jun
Jul
Aug



Relative seismic power
Stage
Bedload
0
10
20
30
40
50
60
Jun
Jul
Aug
Sep