Aare delta's underflows triggers and spatial distribution remain mysterious

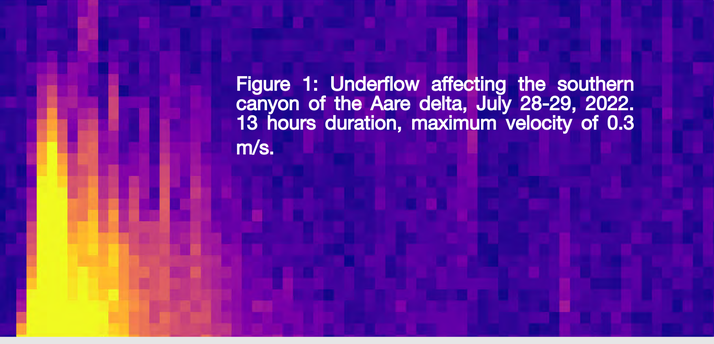

Figure 1: Underflow affecting the southern canyon of the Aare delta, July 28-29, 2022. 13 hours duration, maximum velocity of 0.3 m/s.

Monitoring of river-induced bottom currents in Swiss lacustrine deltas

Gaétan Sauter[1], Damien Bouffard[2], Koen Blanckaert[3], Katrina Kremer[1,4]

[1]Institute of Geological Sciences, University of Bern, Baltzerstrasse 1+3, CH-3012 Bern
[2]Eawag, Seestrasse 79, 6047 Kastanienbaum
[3]TU WIEN Research Unit Hydraulic Engineering and Environmental Hydromechanics
[4]Swiss Seismological Service, ETH Zurich, Sonneggstrasse 5, CH-8092 Zurich

Introduction

Deltaic slope failures are important sediment transport processes and represent a natural hazard as they can be tsunamigenic or affect offshore infrastructure[1]. However, their underlying processes and causes are not yet fully understood. Our study aims to better understand the small-scale, and more recurrent, current events responsible for erosion and deposition in deltas. The Aare Delta represents an ideal test site, with two well-developed subaquatic canyons. Among other Swiss deltas, it is known to have failed in the past[2,3].

Methods

To monitor the underflows in the Aare Delta of Lake Brienz, two downward looking Acoustic Doppler Current Profilers (ADCPs) were deployed in each canyon (Figure 2) between June 10 to September 14, 2022. ADCPs allow to measure the water velocity and particle concentration. The acquired data is compared with hydrological and meteorological data (FOEN and Meteoswiss).

Results

Major ☆ and minor ☆ events show increases in current, sediment concentration and temperature (Figure 3).

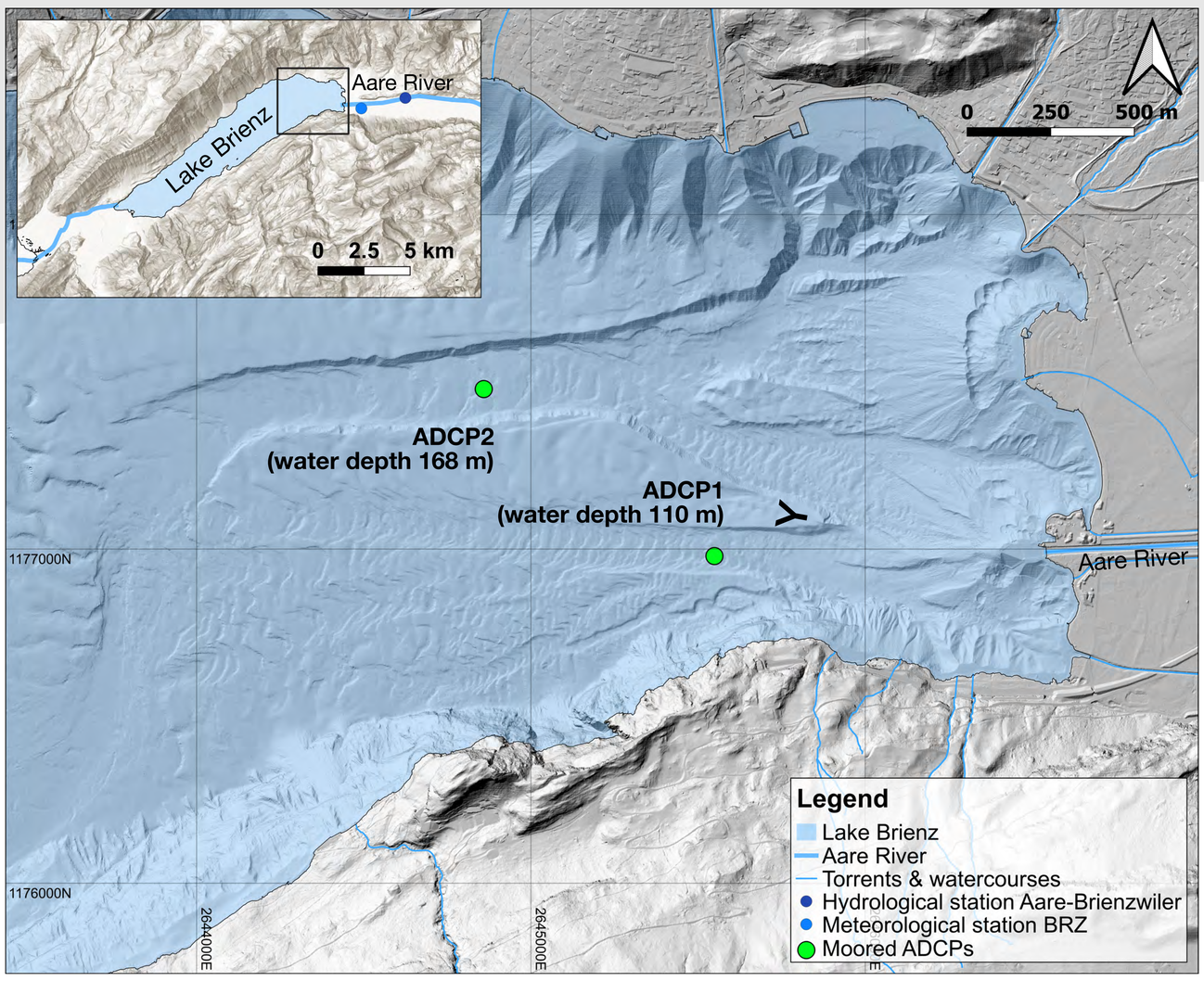

Figure 2: Map showing the Aare delta (Swisstopo) in Lake Brienz and ADCPs mooring localisations. ADCP1 is moored in the southern canyon, 27 m above lake floor. ADCP2 is in the northern principal canyon, 37 m above bottom. "Y" indicates the canyon split. Instruments operated at 600 kHz, measured data at 0.5 m depth intervals and had a sampling time interval of 20 minutes.

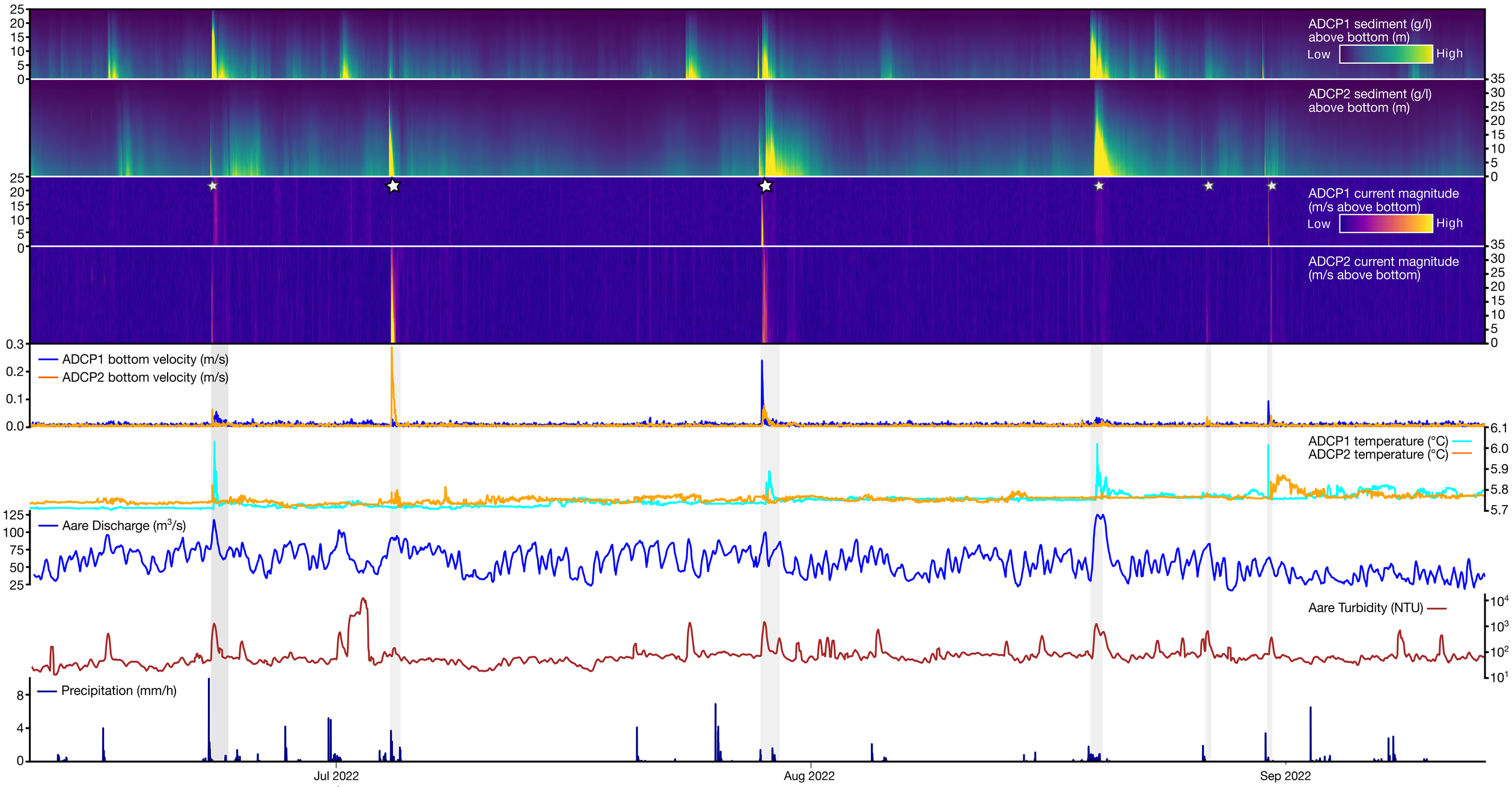

Figure 3: Overall view for the 3-month deployment. Major ☆ and minor ☆ events. Sediment concentrations derived from backscattering for a 60 µm grain size, Current magnitude (m/s) in each canyon, Bottom velocity (5 m above lake floor), Temperature (°C) at 37 m above lake floor (southern canyon), and 27 above lake floor (northern canyon), Aare discharge (m^3/s), Aare turbidity (NTU), and Precipitation (mm/h).

Discussion

Why do underflows occur either in the northern, southern, or both canyon and with different magnitude?

Underflows are unevenly directed due to the Y-shaped split of the canyons (Figure 2). Or localized intense rainfalls could influence small torrents and, as a result, impact each canyon differently

Why are some underflows related to high discharge and turbidity of the Aare River, but not all? And why does not all high discharge and turbidity systematically generate underflows?

Aare River behavior plays a role in the occurrence of many events, but additional parameters need to be explored to understand initiation of others.

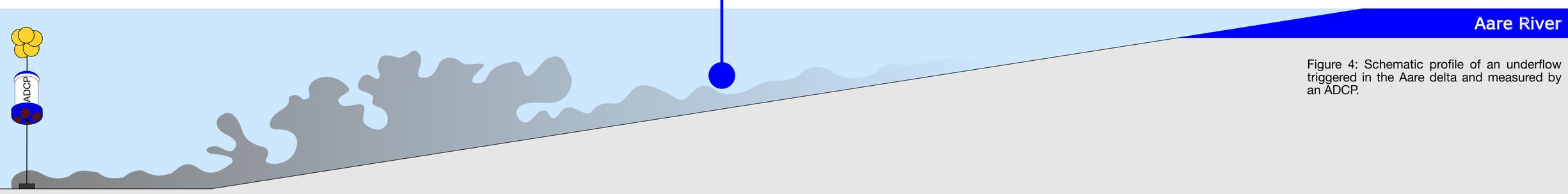

Figure 4: Schematic profile of an underflow triggered in the Aare delta and measured by an ADCP.

[1]Clare, M. A., Hughes Clarke, J. E., Talling, P. J., Cartigny, M. J. B., & Pratomo, D. G. (2016). Preconditioning and triggering of offshore slope failures and turbidity currents revealed by most detailed monitoring yet at a fjord-head delta. Earth and Planetary Science Letters, 450, 208-220. https://doi.org/10.1016/j.epsl.2016.06.021
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