Haunui research catchment: Earthflow dynamics and sediment load contributions in a headwater catchment

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Why earthflows?

- One of the most common types of mass movement globally (Keefer and Johnson, 1983).
- Occur throughout New Zealand's soft-rock hill country, ranging from shallow (<2m) to deep seated (>10 m) features, and may exceed 100 ha in area.
- Most prominent on crushed mudstone and argillite (Basher, 2013), and tend to contribute fine-grained clay particles to the channel network, which dominate light attention leading to reduced visual clarity (Davies-Colley and Smith, 2001).
- Degraded visual clarity impacts aquatic biota, and reduces the cultural and recreational value of aquatic environments.

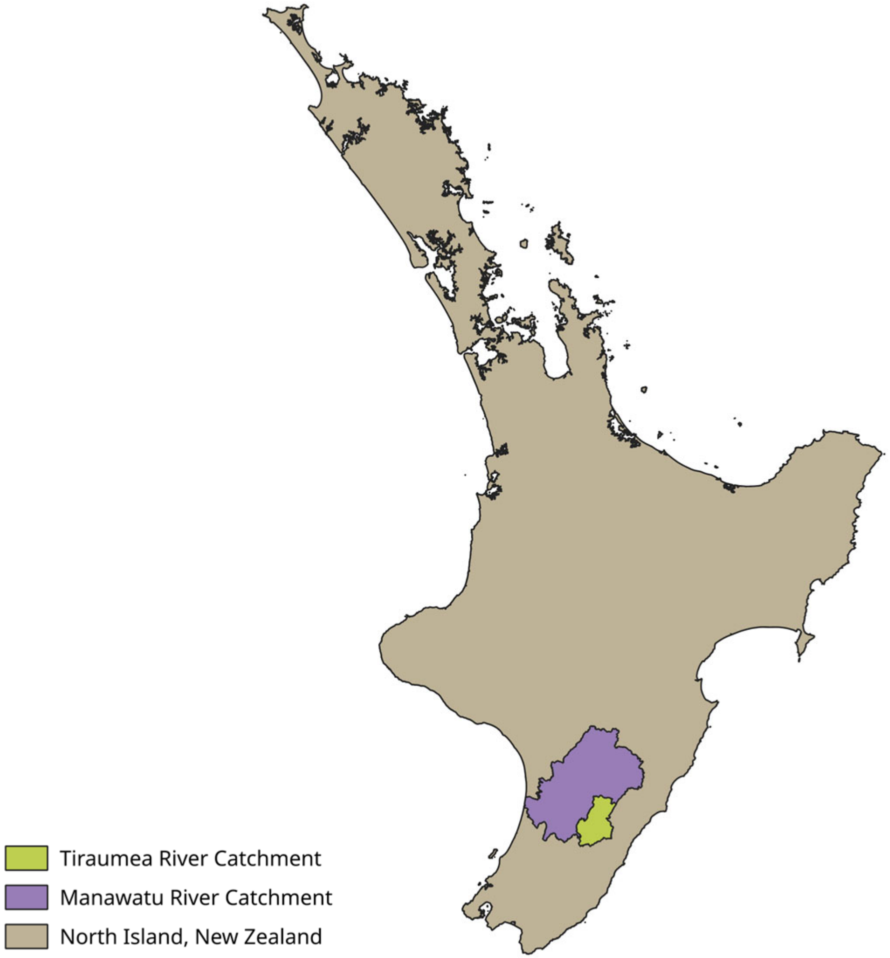
Research objectives

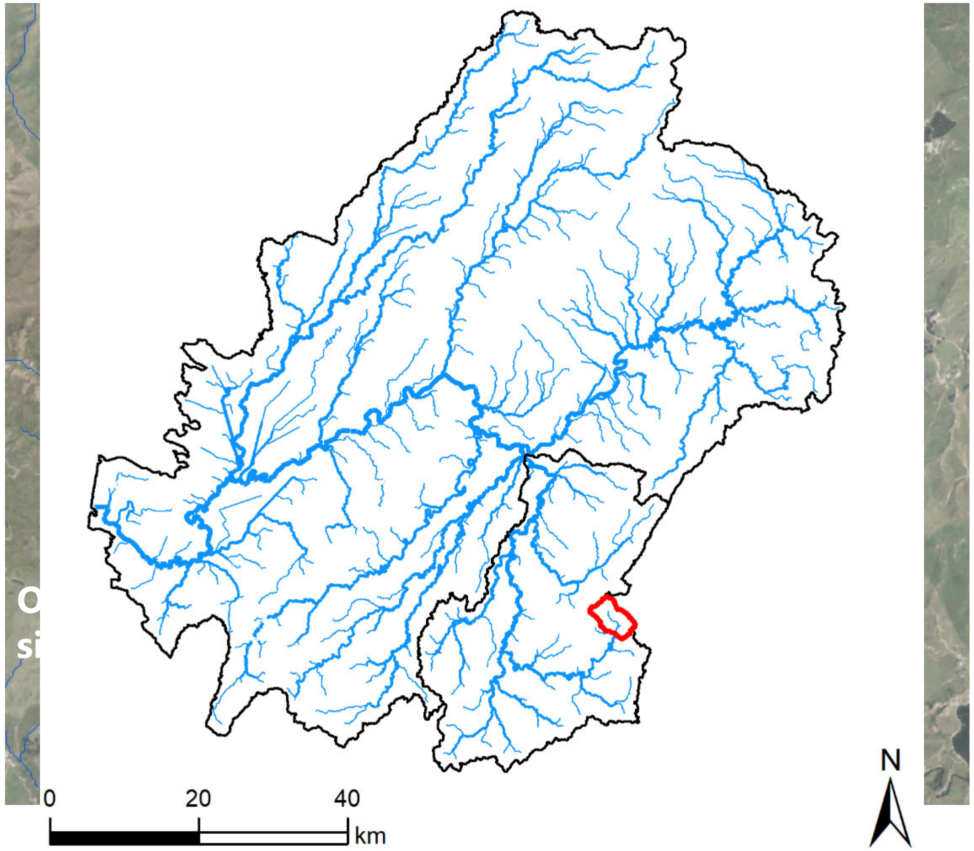
- **Aim 1:** Better understand the spatio-temporal patterns and hydro-climatic drivers of earthflow movement
  - What drives earthflow movement?
  - How does movement vary within an earthflow and through time?

- **Aim 2:** Better understand the contribution of earthflows to catchment sediment budgets and water quality issues
  - What is the magnitude of sediment contribution from earthflows to suspended sediment loads, and how does this vary temporally?

Haunui Research Catchment

- 20 km^2 hill country catchment – headwater of the Tiraumea River, a tributary of the Manawatū River.





Instrumentation

Earthflow

- Multitemporal rtk-dGNSS and UAV SfM surveys to quantify annual movement and volumetric change
- Continuous GNSS to record sub-daily movement
- Piezometers to monitor piezometric head

Catchment

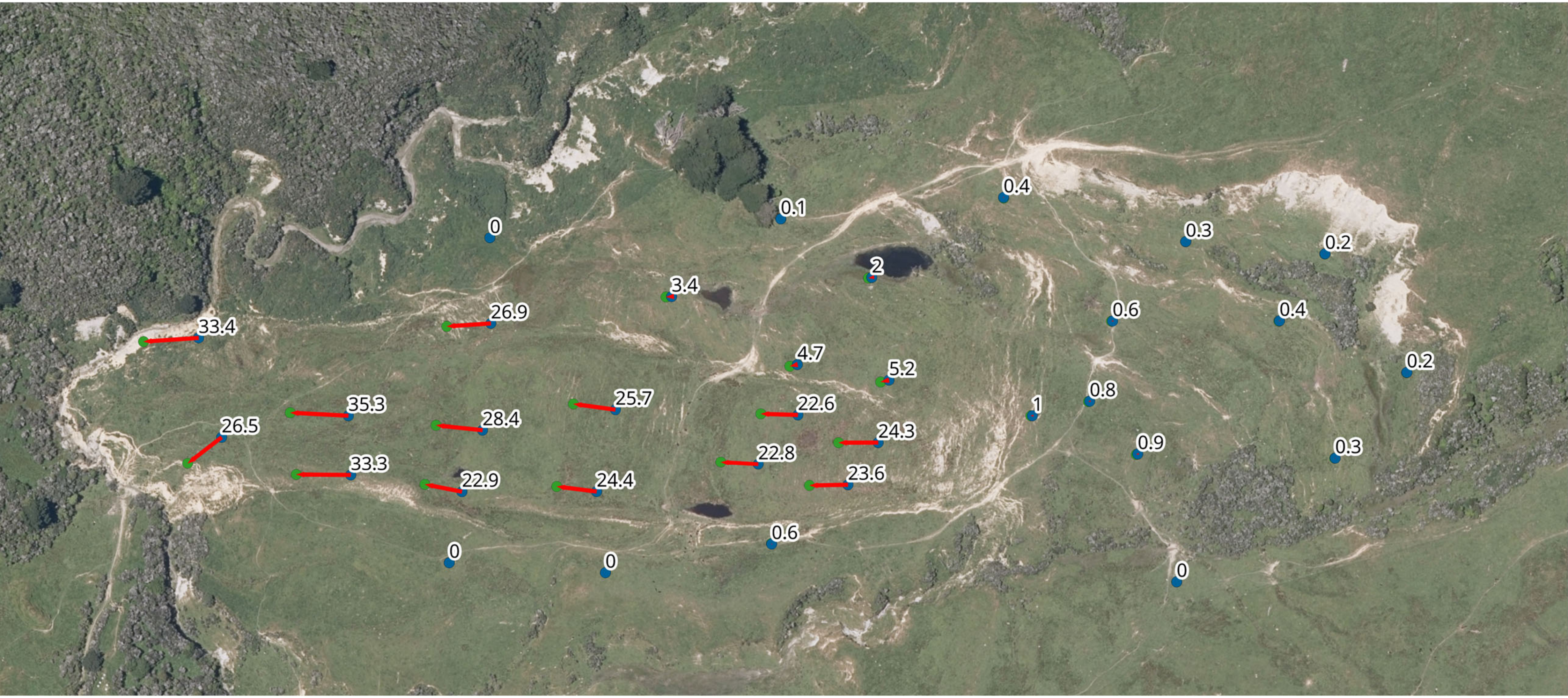
- Meteorology station
- Continuous turbidity monitoring for outlet suspended sediment loads



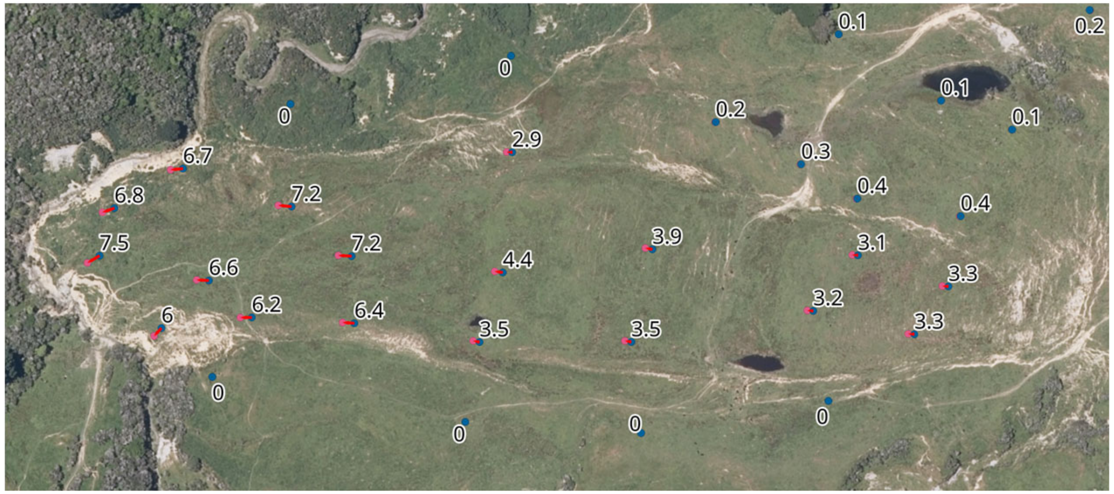



Movement dynamics and drivers

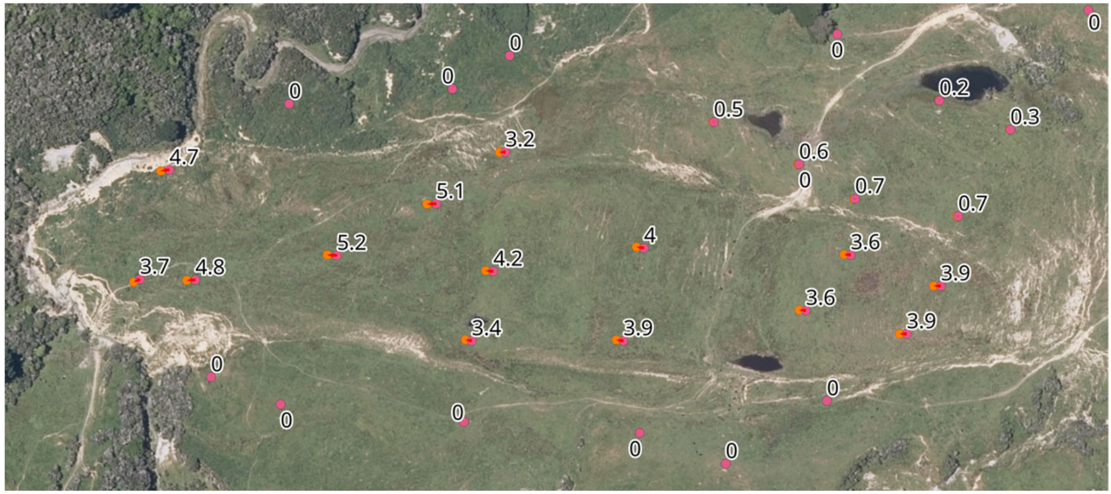
Total displacement (m) Dec 2018 – March 2023



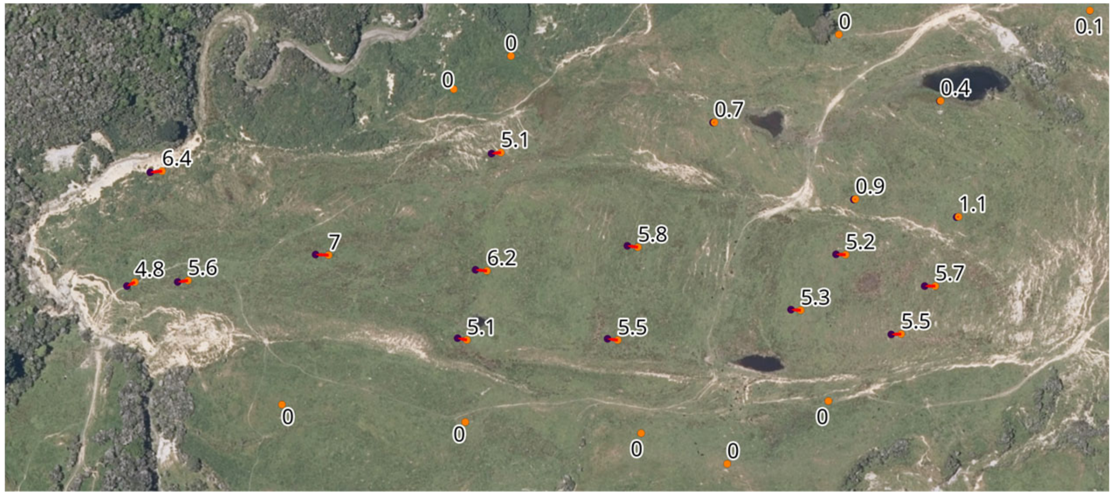
Dec 2018 – Nov 2019



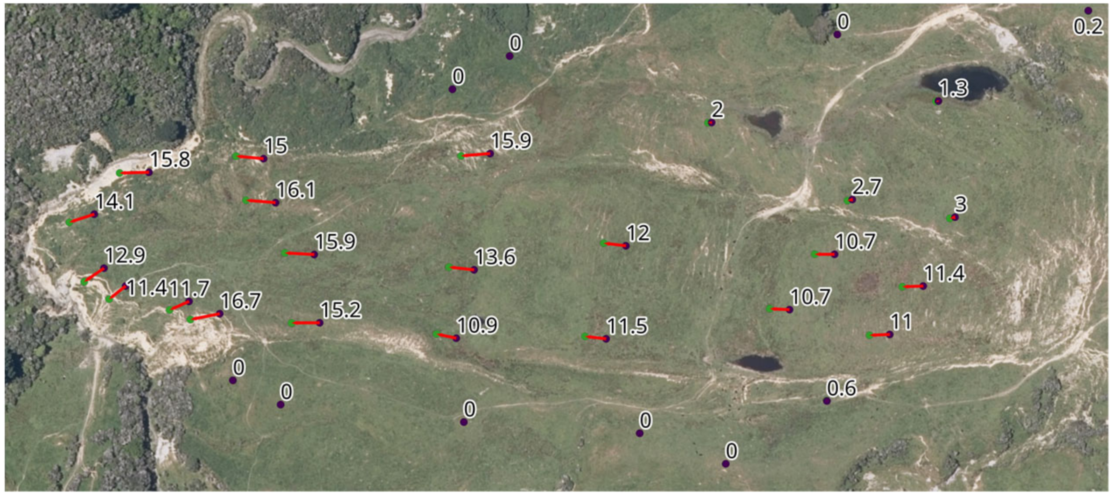
Nov 2019 – Feb 2021



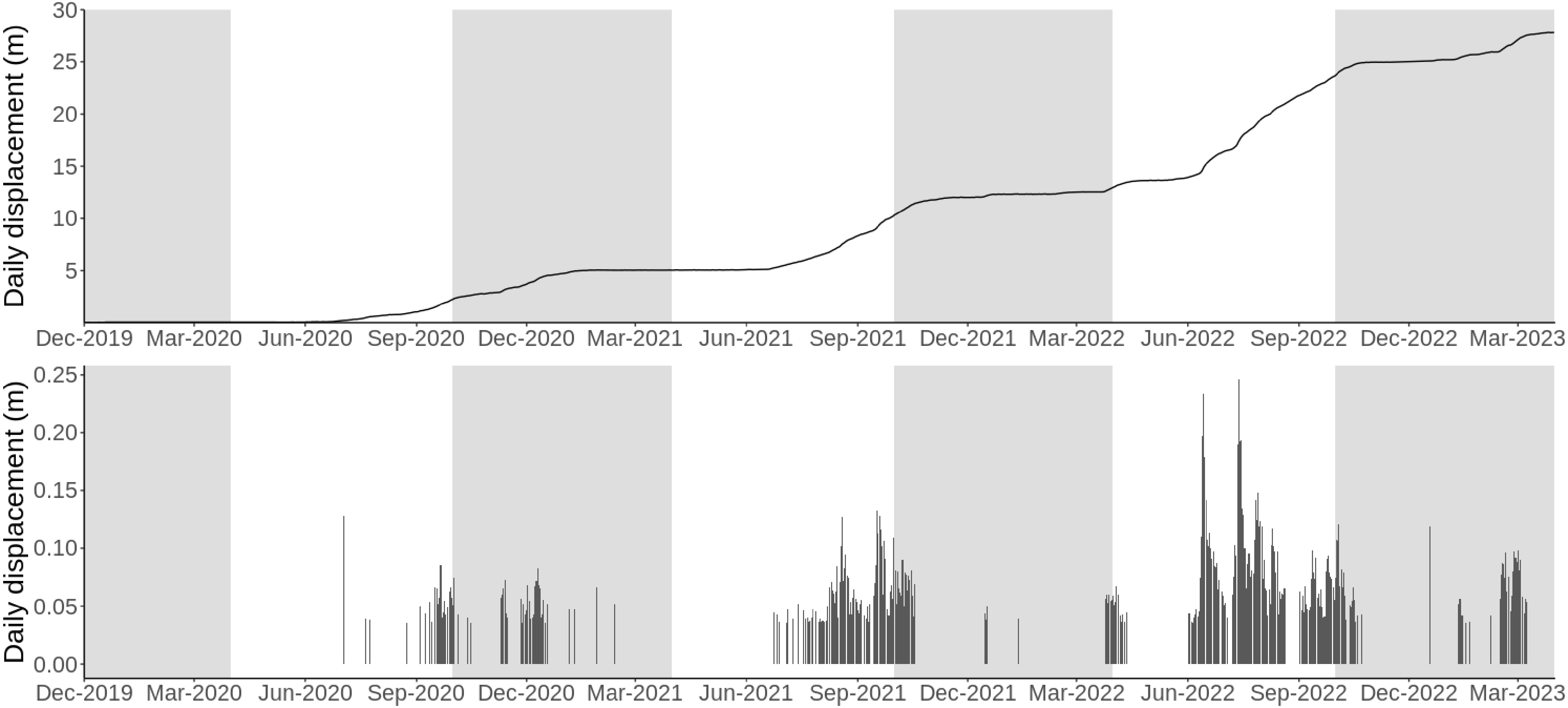
Feb 2021 – Dec 2021



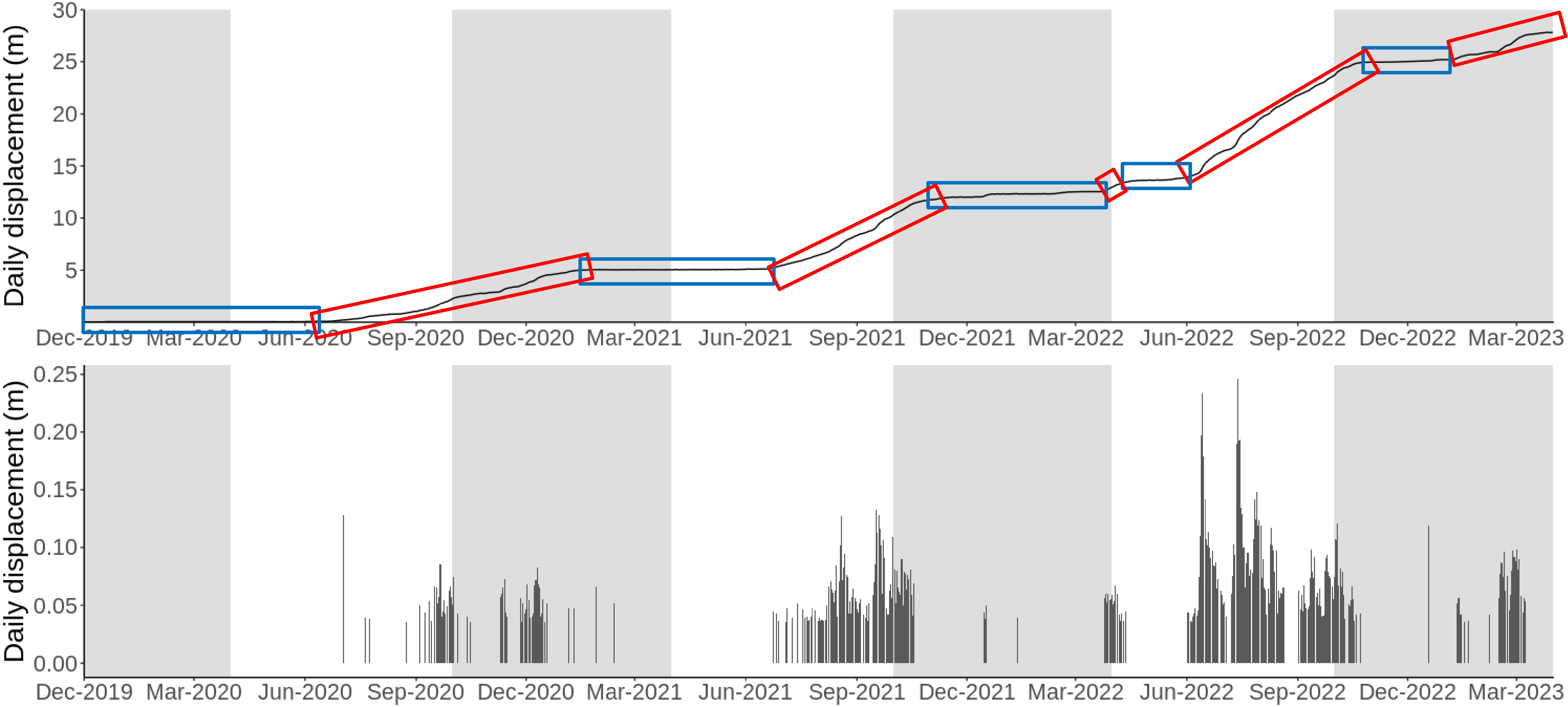
Dec 2021 – Mar 2023



Temporal Dynamics



Temporal Dynamics



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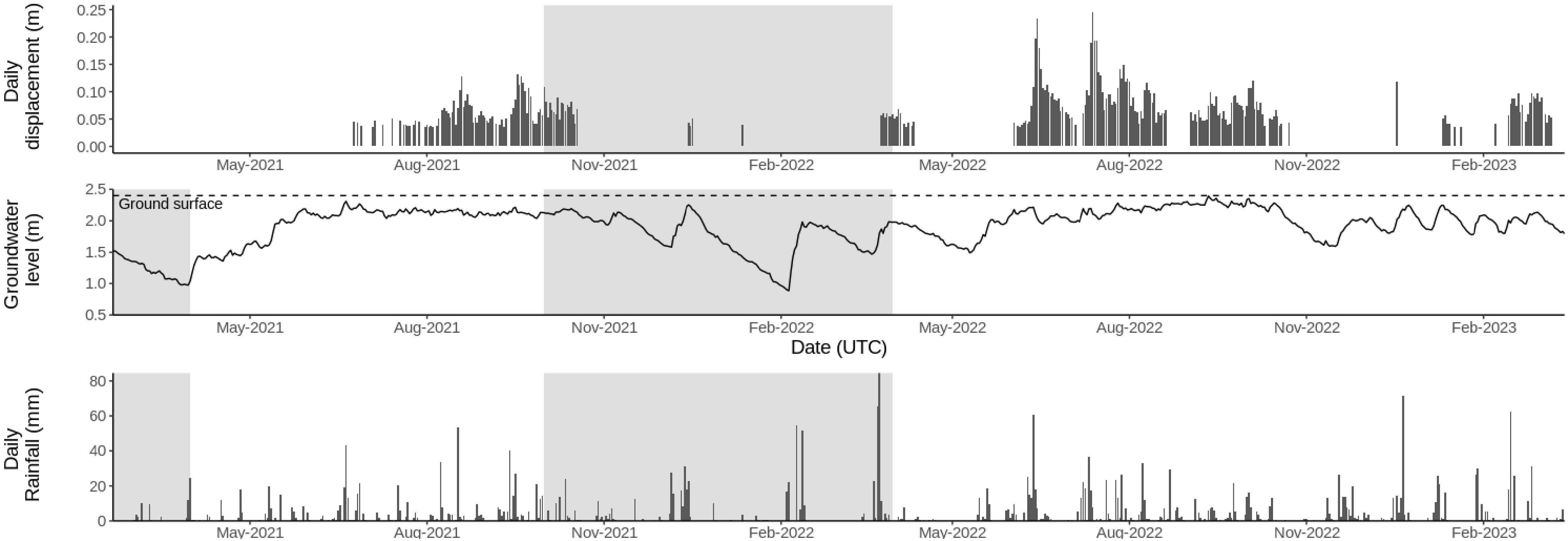
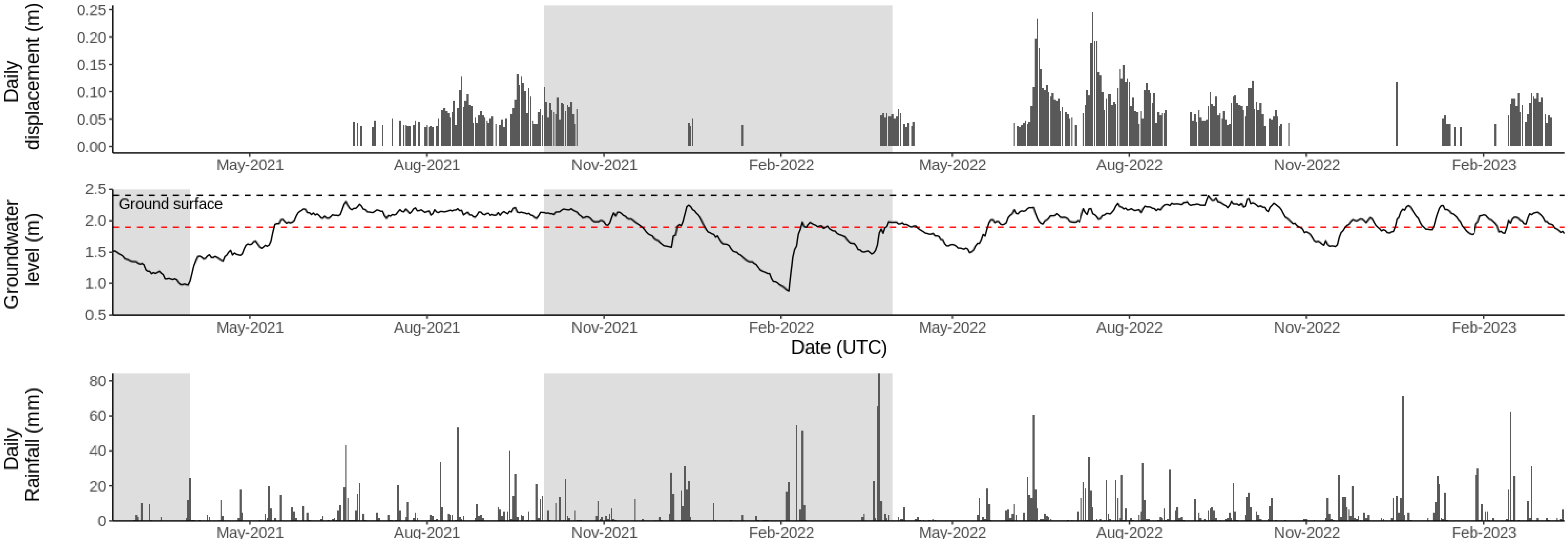
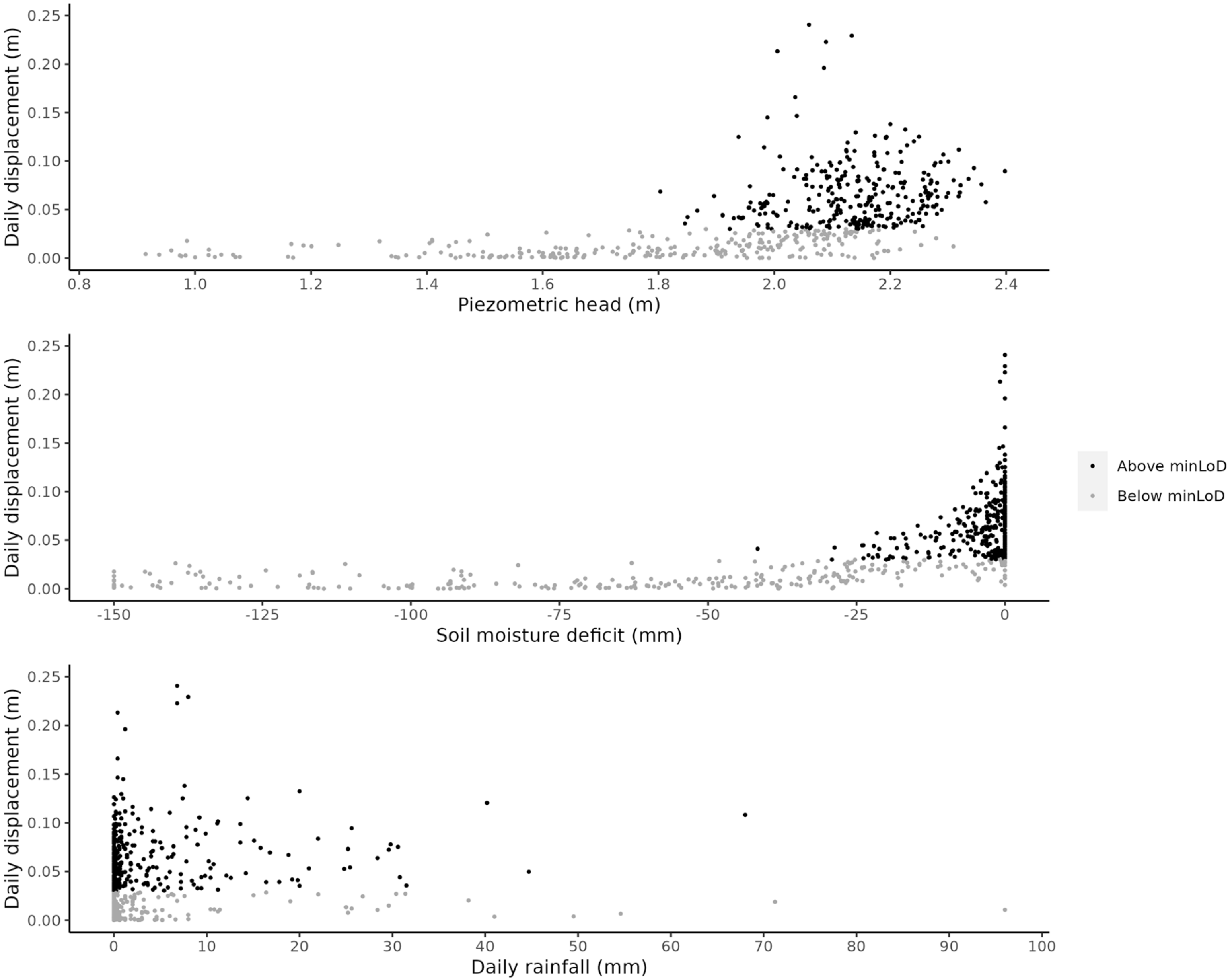
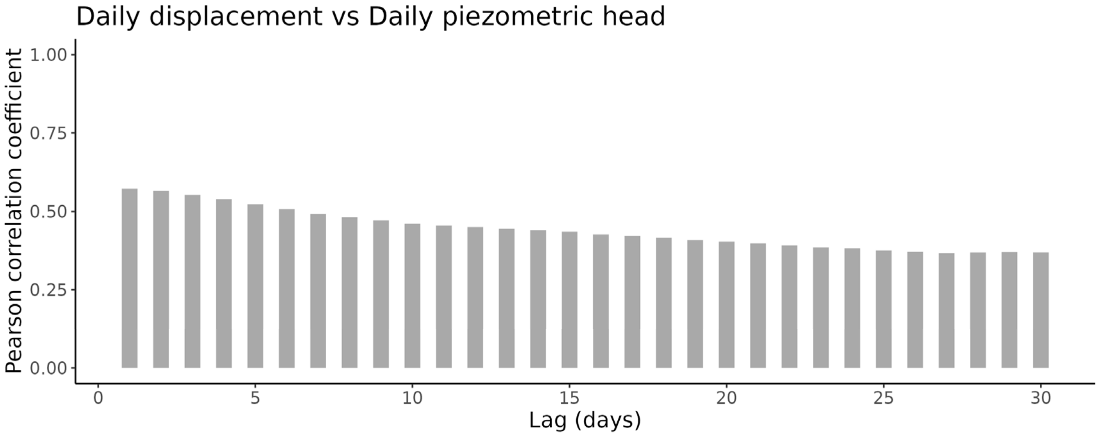


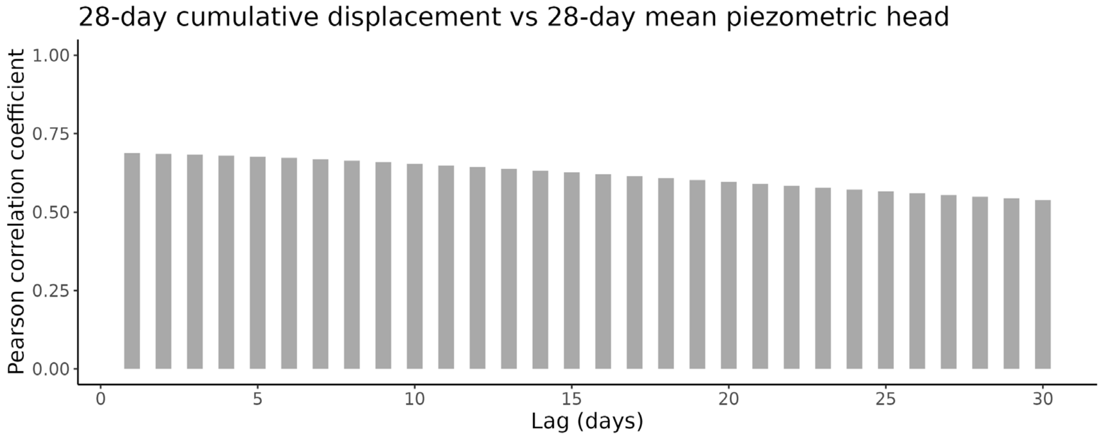
Temporal Dynamics

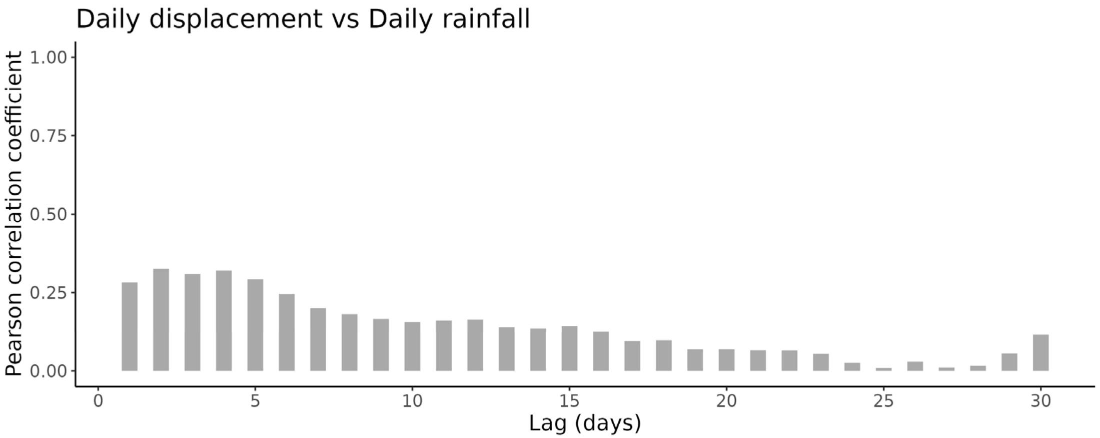


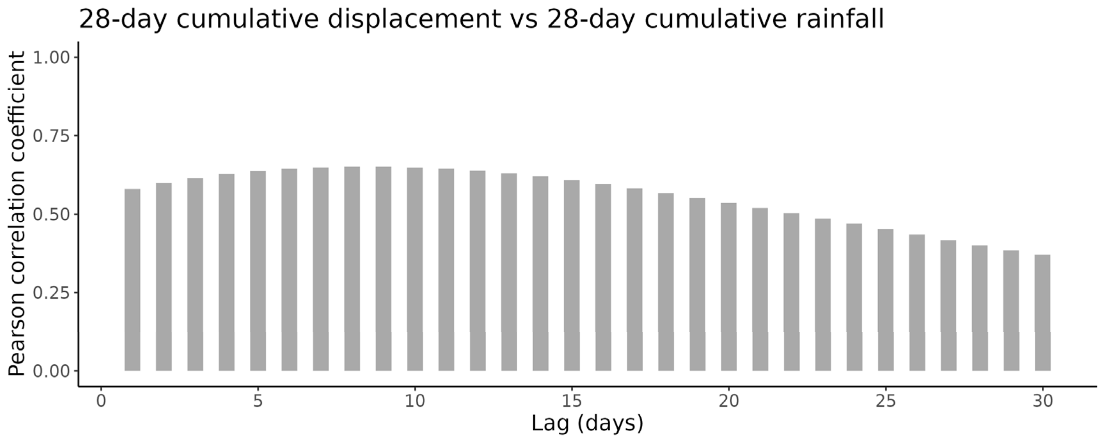

Daily displacement (m)
0.00
0.05
0.10
0.15
0.20
0.25
0.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
Piezometric head (m)
Daily displacement (m)
-150
-125
-100
-75
-50
-25
0
Soil moisture deficit (mm)
Above minLoD
Below minLoD
Daily displacement (m)
0
10
20
30
40
50
60
70
80
90
100
Daily rainfall (mm)

Relationships

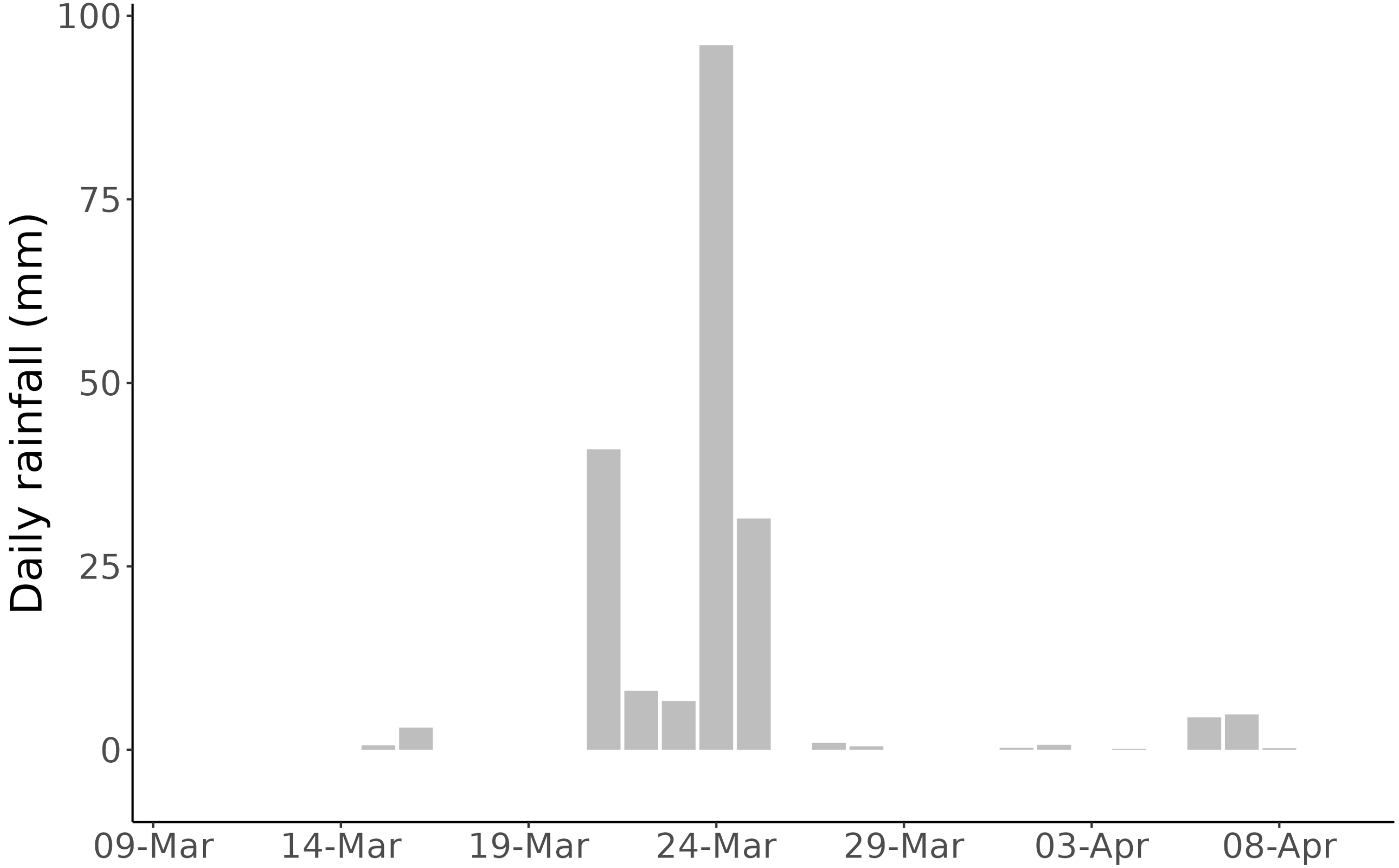








Example timeseries



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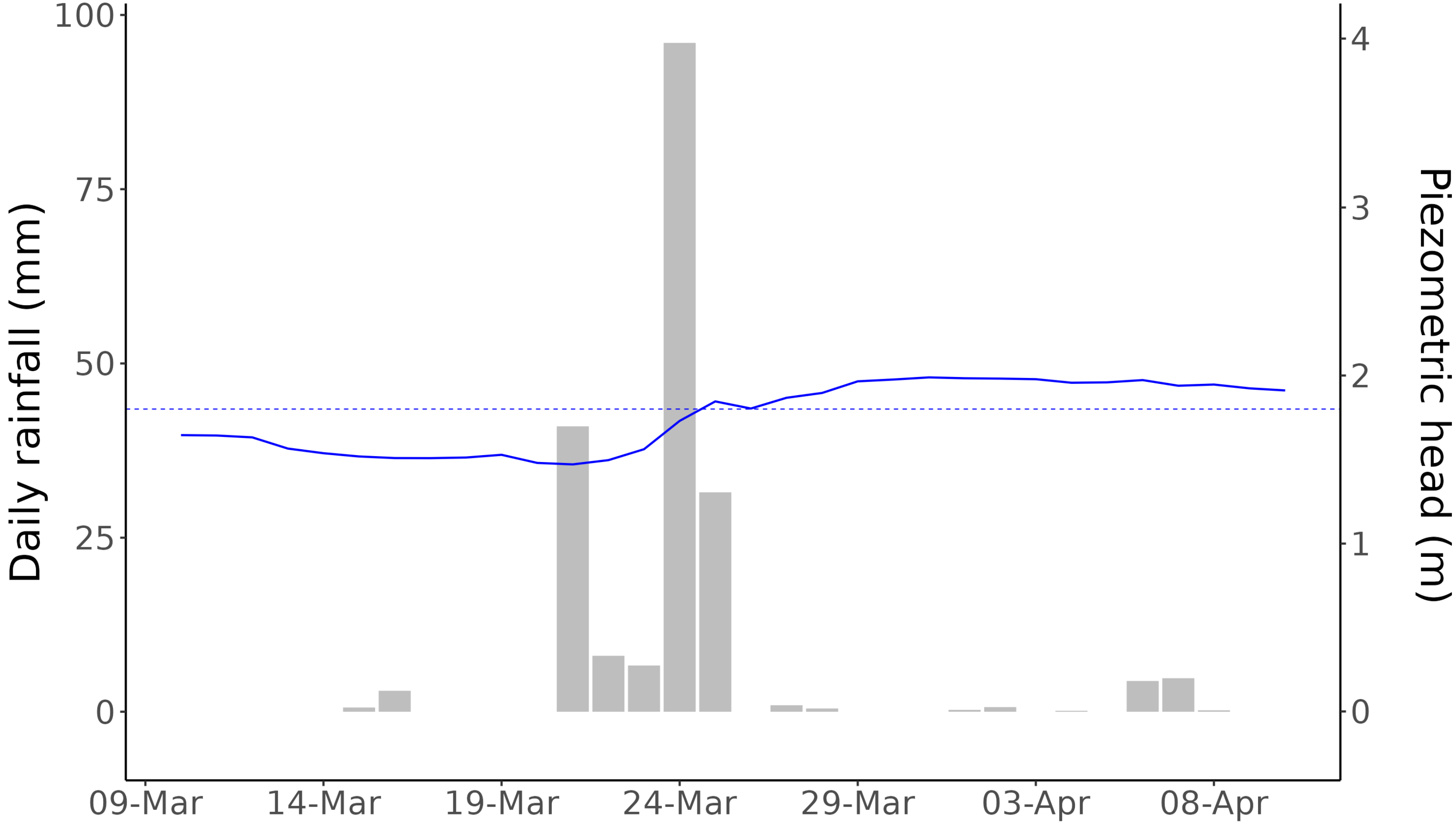

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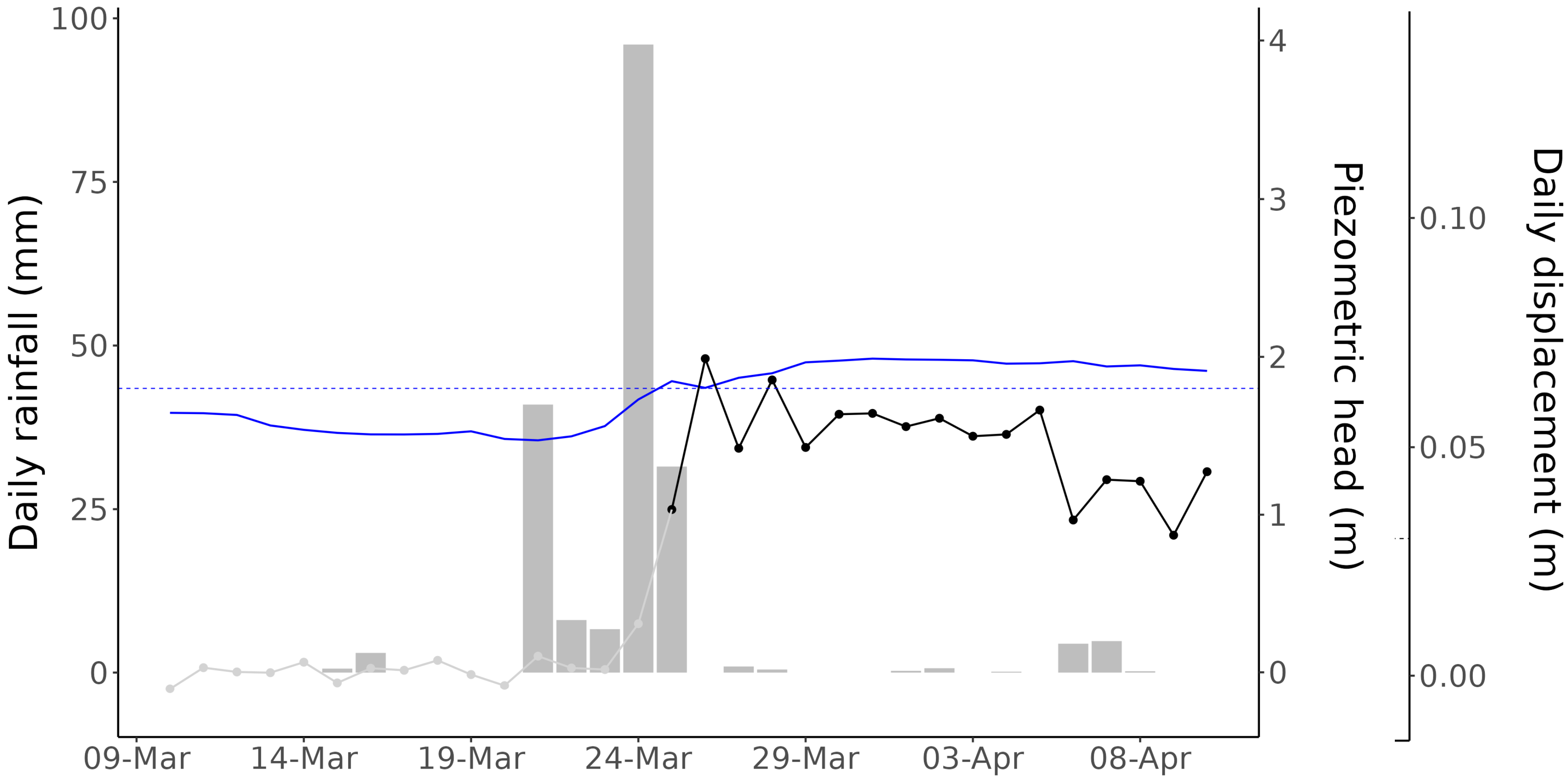
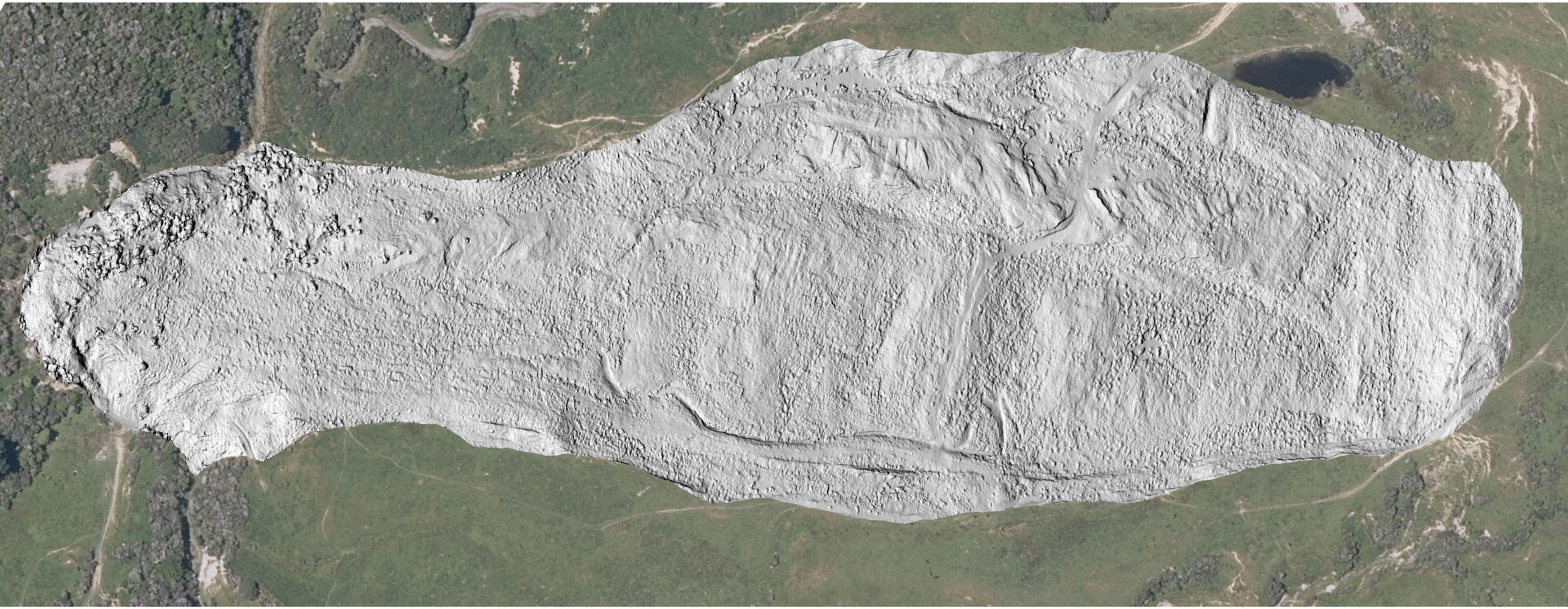
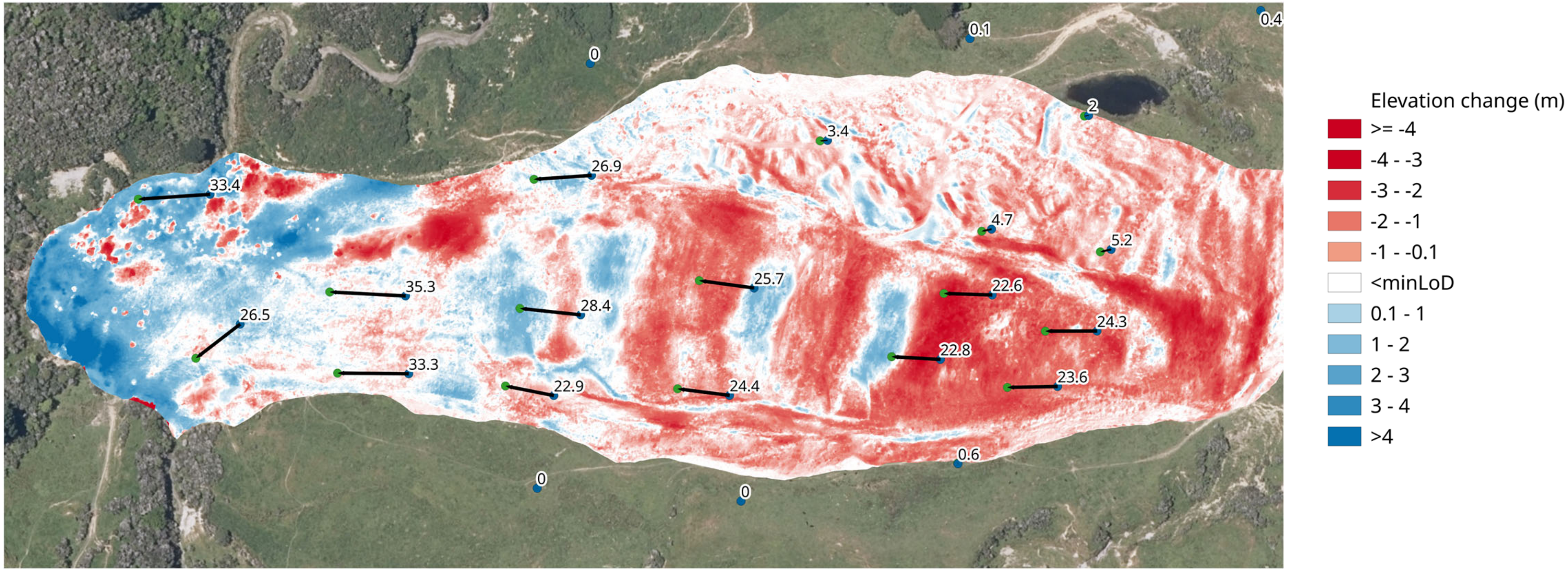


Sediment load contributions



2020

Sediment contribution



Period	Net Volume Change (m³)
Jan 2020 – Jan 2021	-600 ± 3,100
Jan 2021 – Jan 2022	-3,500± 2,900
Jan 2022 – Mar 2023	-16,000 ± 5,000
Jan 2020 – Mar 2023	-20,000 ± 5,600

AN0

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AN0 Update to match GSNZ abstract

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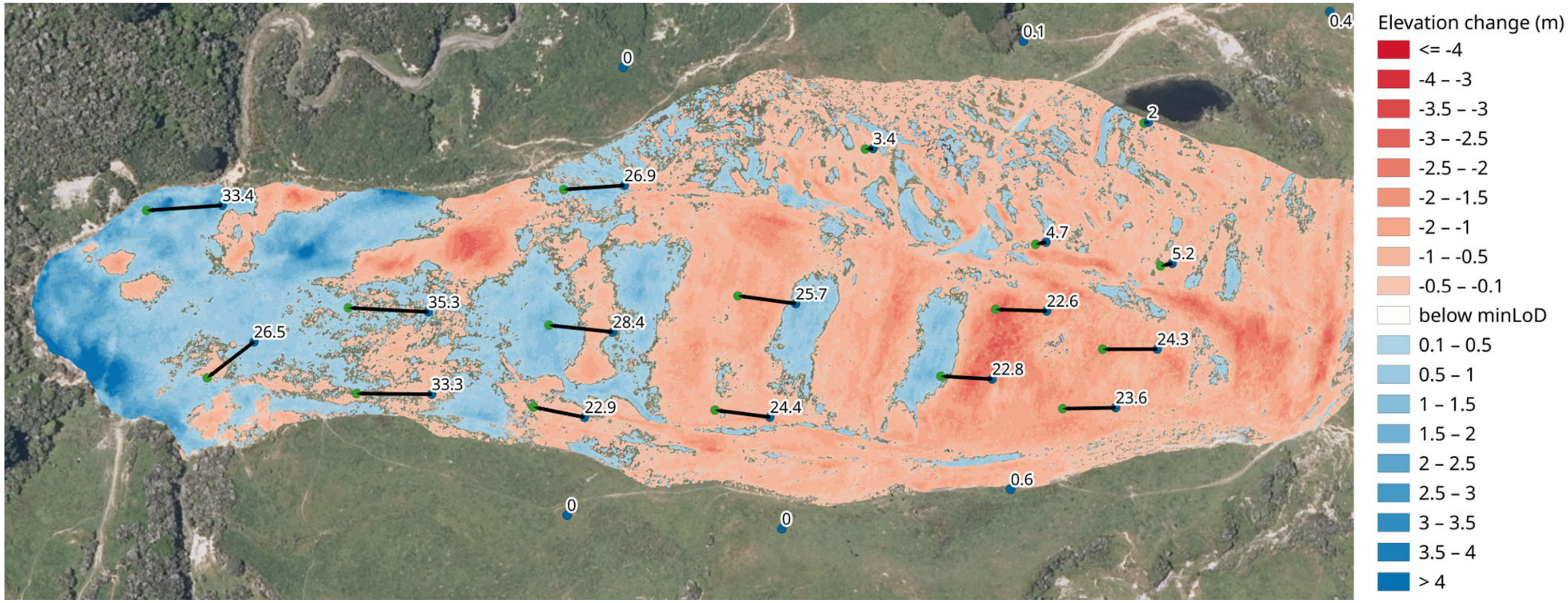
Sediment contribution



Period	Net Volume Change (m³)
Jan 2020 – Jan 2021	-1,200 ± 3,400
Jan 2021 – Jan 2022	-4,400± 3,300
Jan 2022 – Mar 2023	-11,000 ± 5,000
Jan 2020 – Mar 2023	-16,000 ± 5,400

Catchment loads and earthflow contribution

Year	Catchment load (tonnes)	Earthflow equivalent contribution (tonnes)
2020	13,600	950 (7%)
2021	16,500	5,500 (32%)
2022	47,000	25,600 (54%)
Total	**77,100**	**32,000 (42%)**

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AN0 Update to match GSNZ abstract and Simons data
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Catchment loads and earthflow contribution

Period	Catchment load (tonnes)	Earthflow equivalent contribution (tonnes)
Jan 2020 – Jan 2021	14,100	2,000 (14%)
Jan 2021 – Jan 2022	16,000	7,100 (44%)
Jan 2022 – Mar 2023	63,200	17,300 (27%)
Jan 2020 – Mar 2023	**93,200**	**25,700 (28%)**

Conclusions

- Multi-temporal 3D data is important for understanding earthflow dynamics
- Earthflow movement primarily occurs in winter and spring when groundwater levels are high
- Movement may be accelerated by rainfall or high flow events
- Earthflows may be significant sources of fine sediment when:
  - Soils remain saturated for longer periods
  - In the absence of higher magnitude storm events when other processes are triggered
- Mitigations should aim to reduce water in the earthflow body
- Modelling of future trajectories for seasonal rainfall and soil saturation will be critical for understanding the potential changes in earthflow dynamics under future climate

Key findings and conclusions

- Piezometric pressure at the failure surface was the primary driver for displacement
- Displacement was continuous while piezometric pressure remained elevated during winter and spring
- Rainfall events accelerated displacement, but only when piezometric pressure was high
- Cumulative displacement is a product of the magnitude and temporal distribution of rainfall
- Earthflows may be significant sources of fine sediment when:
  - Soils remain saturated for longer periods
  - In the absence of higher magnitude storm events when other processes are triggered
- Mitigations should aim to reduce water in the earthflow body
- Changes in earthflow dynamics under future climate are likely to be driven by changes in the magnitude and temporal distribution of rainfall

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