THE EARTH SURFACE PLAYGROUND

Investigating the processes that shape the Earth – from the past and from the modern perspective

ENVIRONMENTAL SEISMOLOGY

GRAIN-SIZE DATA MODELLING

LUMINESCENCE FRAMEWORK

SUBITOP PROJECT MANAGEMENT

GFZ
Helmholtz Centre
POTSDAM

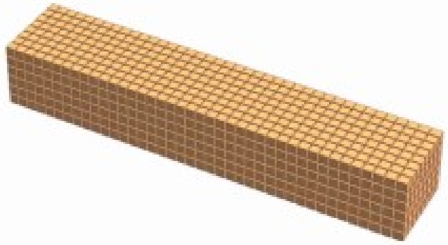
Listen to a spectre

The potential role of seismology in desert (margin) research

Michael Dietze[1] and a long list of collaborators and friends

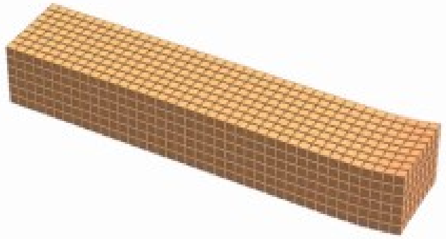
1 – GFZ German Research Centre for Geosciences, Geomorphology Section

Seismology for Earth surface research?

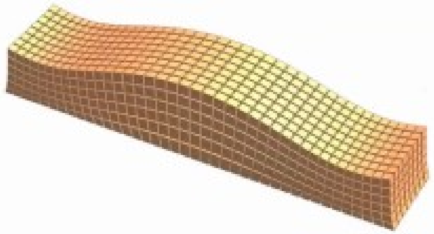


Body waves

P waves

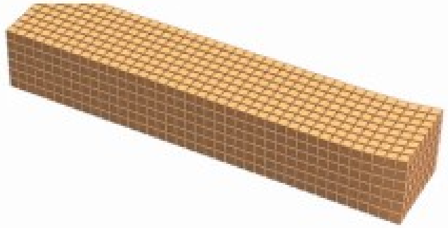


S waves



Surface waves

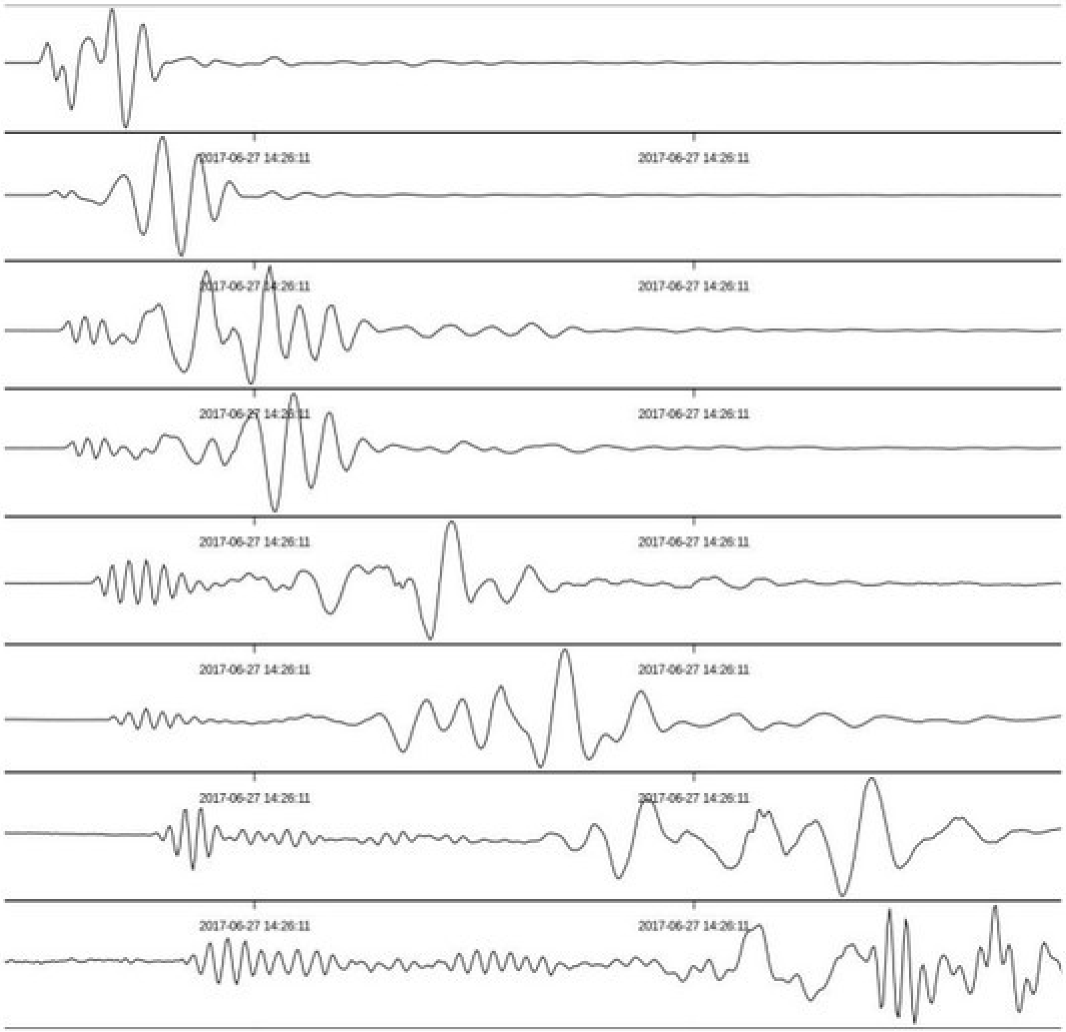
Rayleigh waves



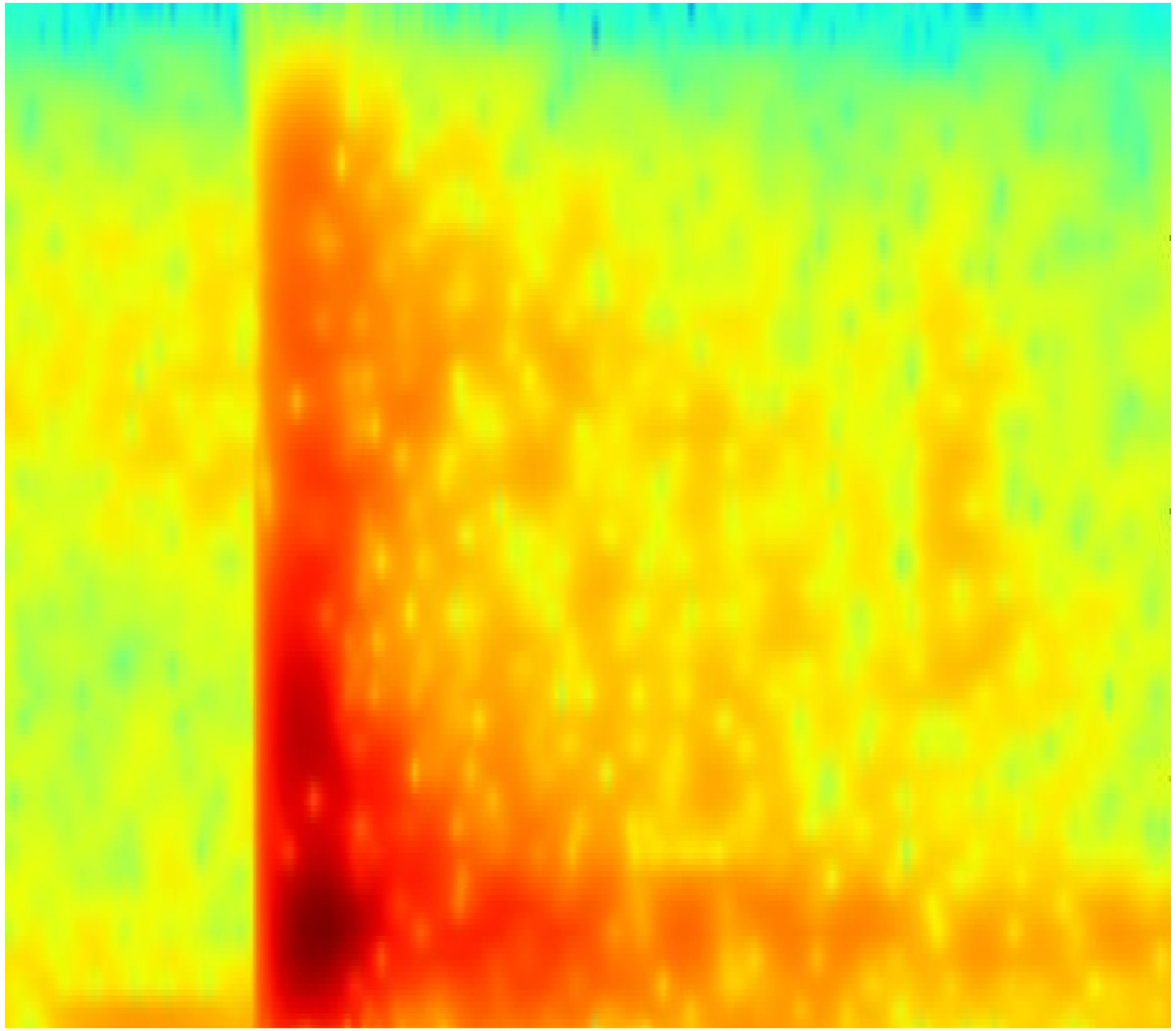
Love waves

Seismology for Earth surface research?

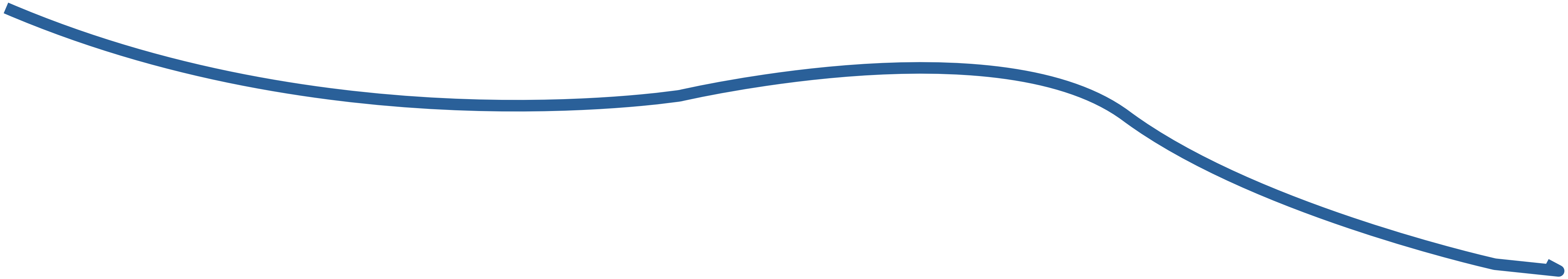
What have measured? Sets of seismograms



Another way to display the same signals: spectrograms



The fluvial domain



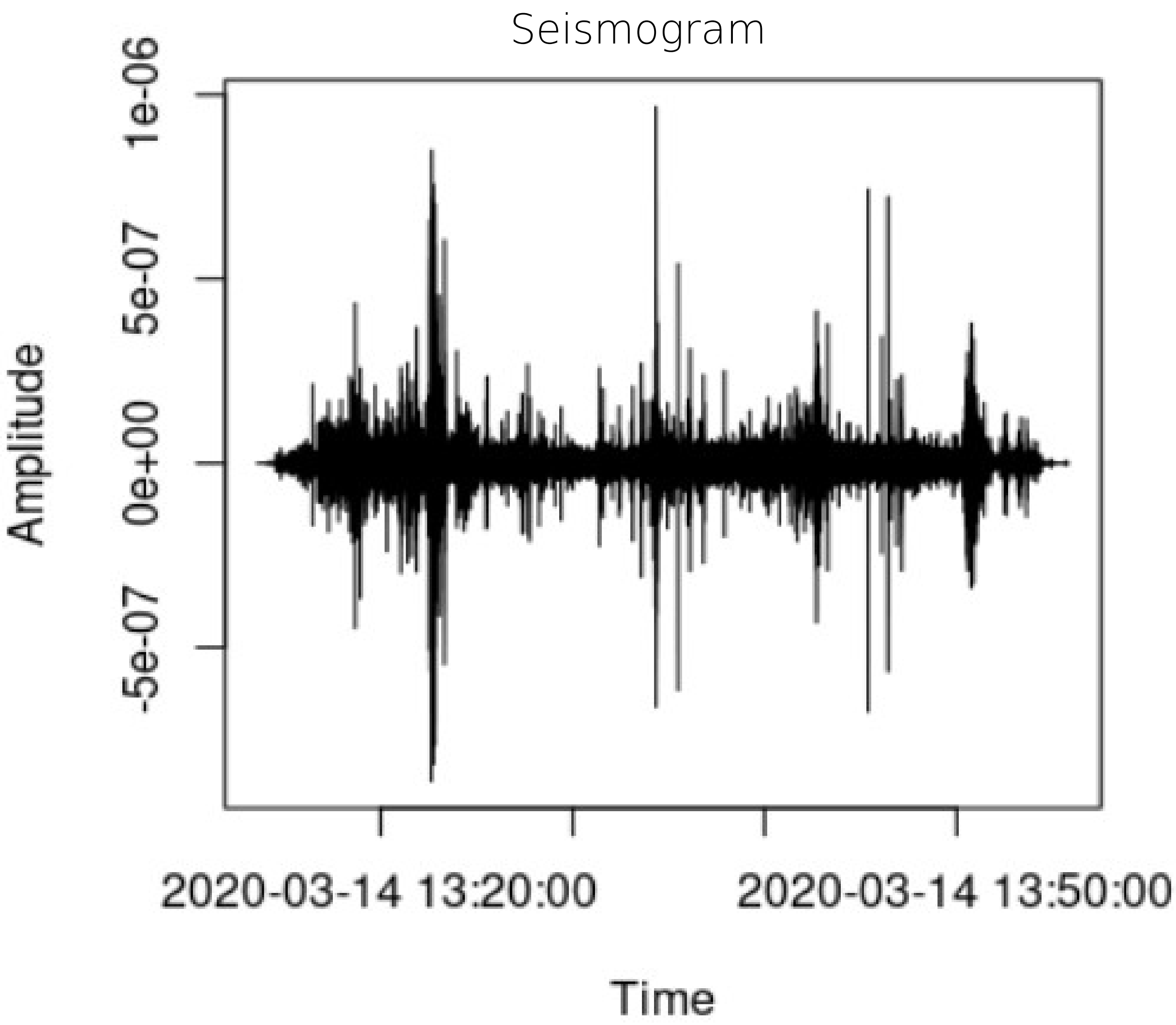
The fluvial domain

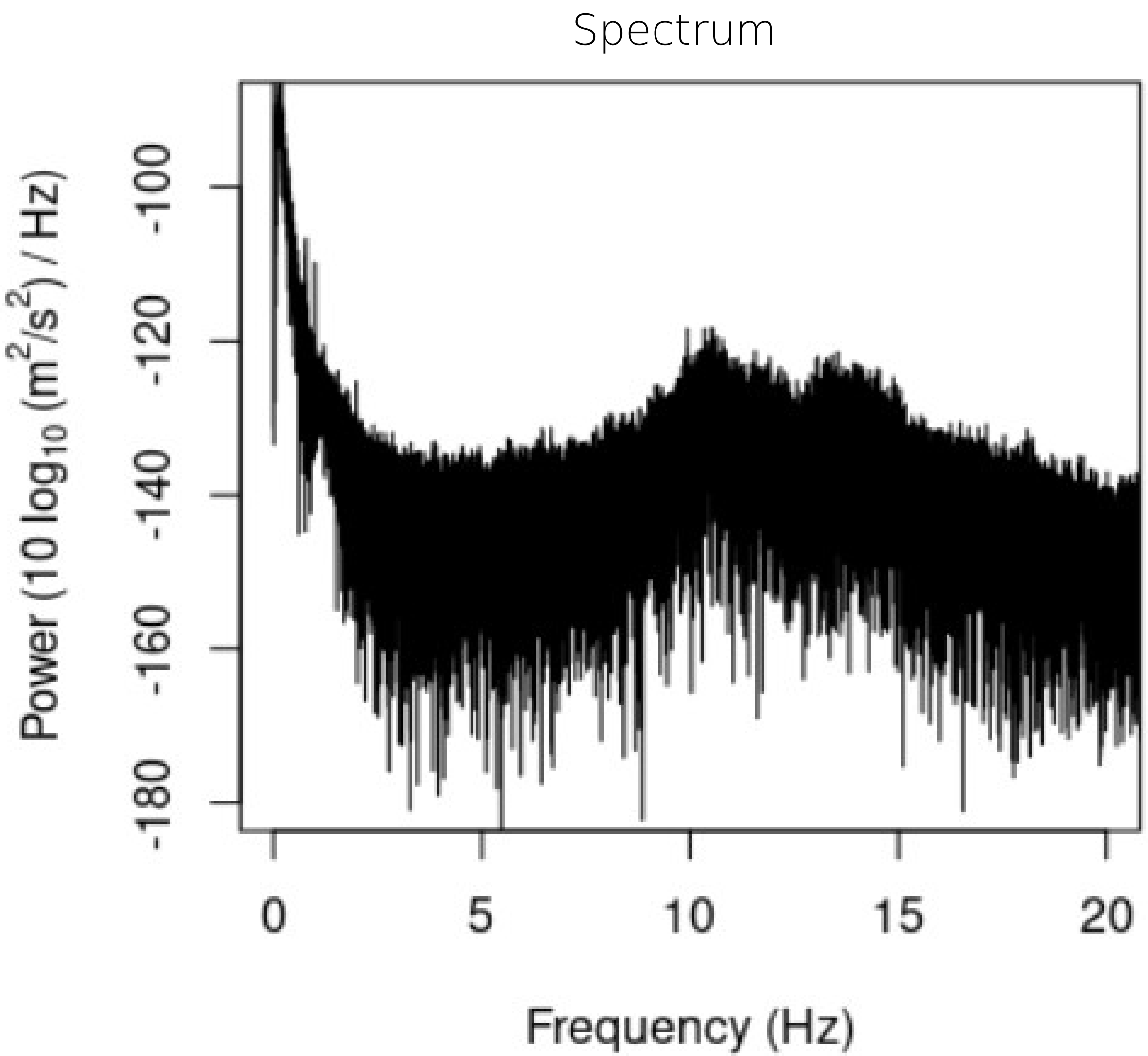
Fish River, Namibia, 2020

The fluvial domain

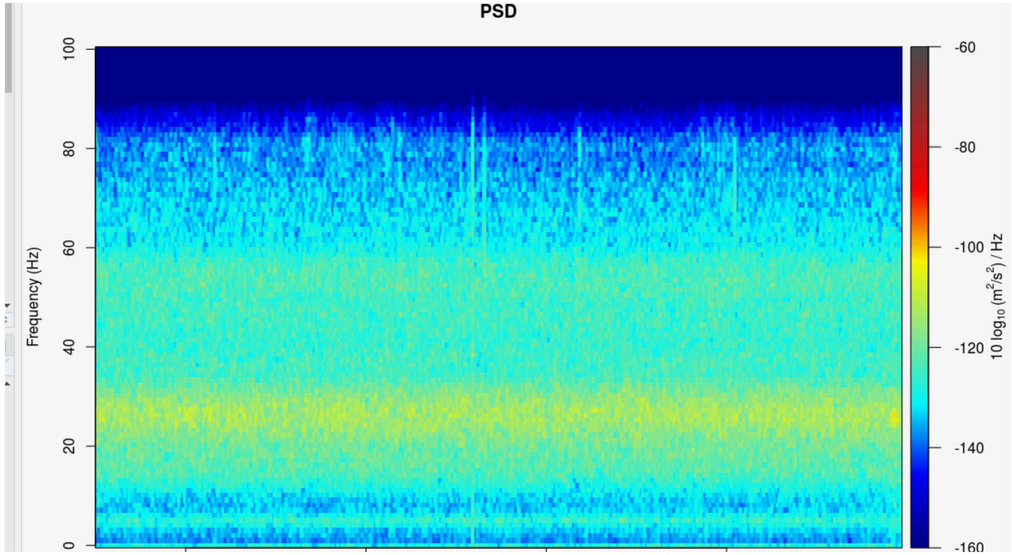
Fish River, Namibia, 2021

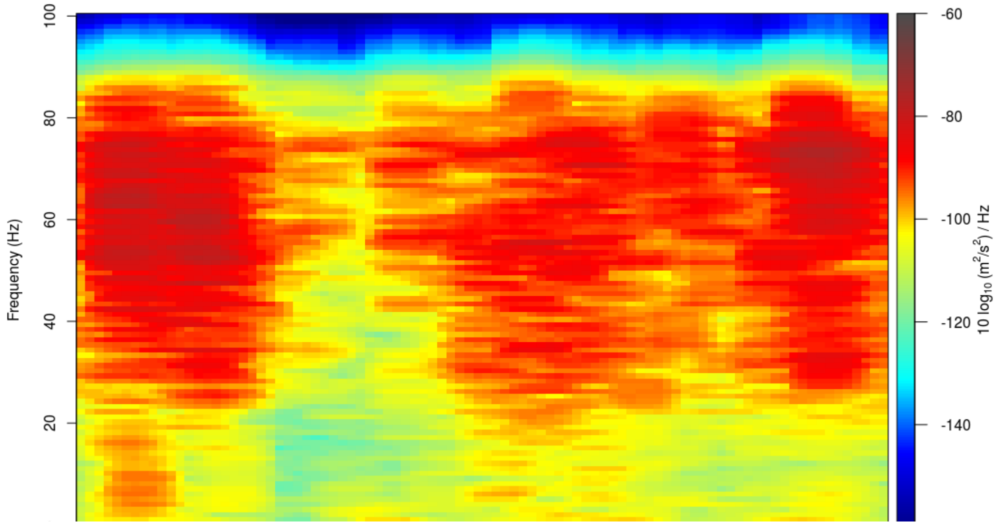
The fluvial domain





The fluvial domain



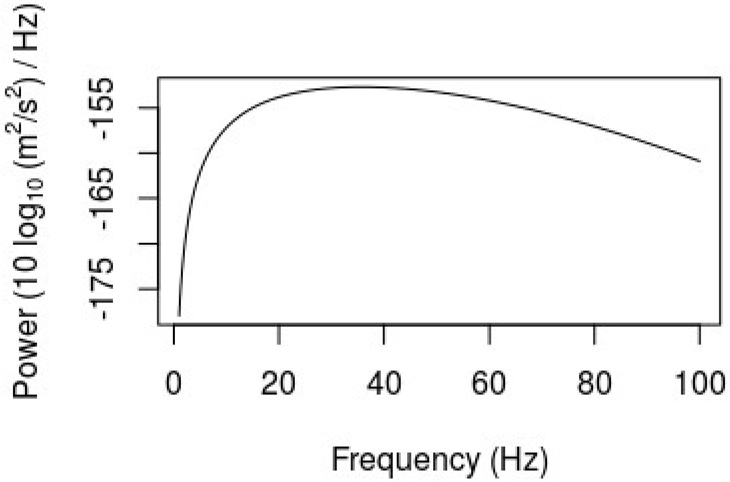


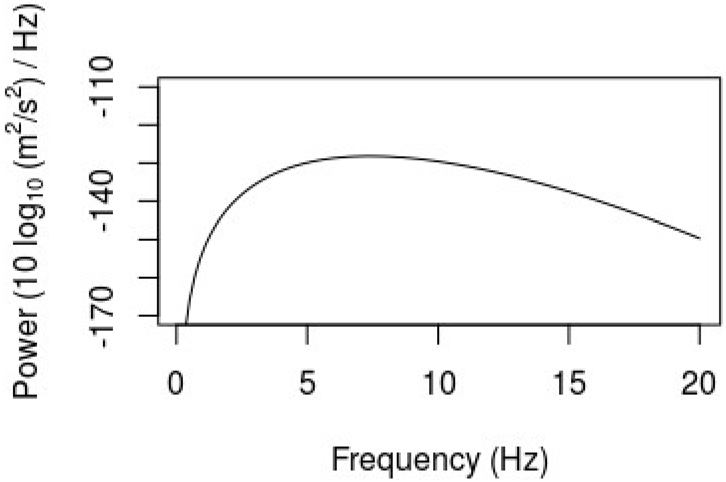
River Feshie, Cairngorms, Scotland, 2020

The fluvial domain

```
model_turbulence(d_s = 0.03,
                 s_s = 1.35,
                 r_s = 2650,
                 h_w = 0.8,
                 w_w = 40,
                 a_w = 0.0075,
                 f = c(1, 100),
                 r_0 = 10,
                 f_0 = 1,
                 q_0 = 10,
                 v_0 = 2175,
                 p_0 = 0.48,
                 n_0 = c(0.6, 0.8))
```

```
model_bedload(d_s = 0.7,
              s_s = 0.1,
              r_s = 2650,
              q_s = 0.001,
              h_w = 4,
              w_w = 50,
              a_w = 0.005,
              f = c(0.1, 20),
              r_0 = 600,
              f_0 = 1,
              q_0 = 20,
              e_0 = 0,
              v_0 = 1295)
```



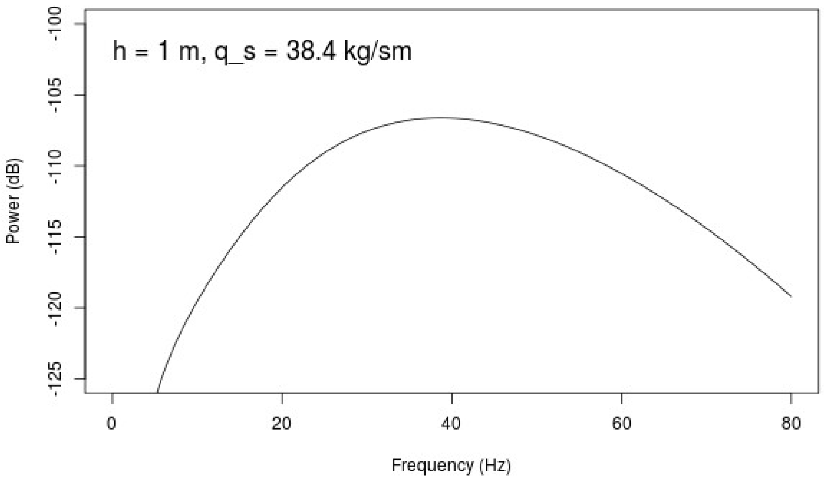


The fluvial domain

In essence:

- Continuous estimate of water level and bedload flux
- Safe out-of-stream deployment of robust and cheap system

```
h = 0.54 m, q_s = 0.4 kg/sm
```

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model_turbulence(d_s = 0.03,
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                 f = c(1, 100),
                 r_0 = 10,
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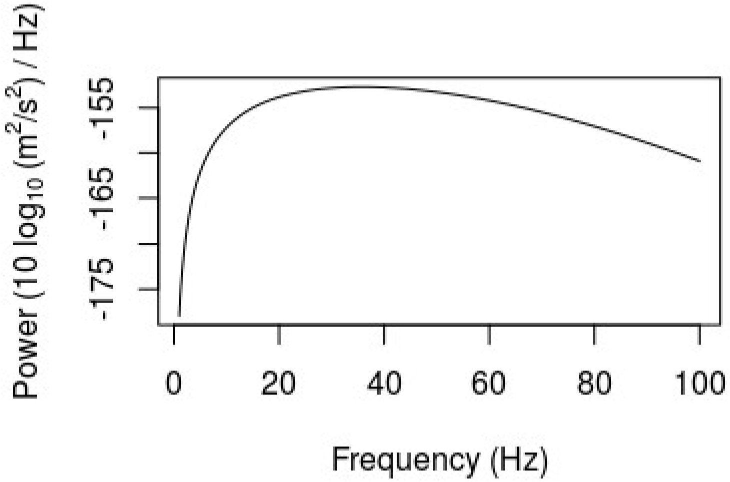
                 v_0 = 2175,
                 p_0 = 0.48,
                 n_0 = c(0.6, 0.8))
```




```
model_bedload(d_s = 0.7,
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              r_s = 2650,
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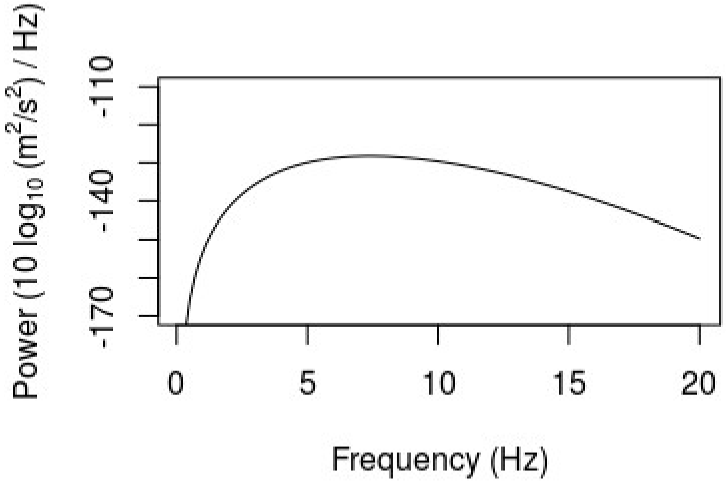
              w_w = 50,
              a_w = 0.005,
              f = c(0.1, 20),
              r_0 = 600,
              f_0 = 1,
              q_0 = 20,
              e_0 = 0,
              v_0 = 1295)
```



Dietze et al. (2019)

Gimbert et al (2014), Tsai et al (2012)

The fluvial domain

In essence:

- Continuous estimate of water level and bedload flux
- Safe out-of-stream deployment
  - Of robust and cheap system

What could we do with it?

- Early warning and magnitude estimate of flash floods
- Quantification of erosional fluxes
- Tracking bedload waves down stream
- Inspecting thresholds for onset of motion

The fluvial domain

In essence:

- Continuous estimate of water
  - level and bedload flux
- Safe out-of-stream deployment
  - Of robust and cheap system

What could we do with it?

- Early warning and magnitude estimate of flash floods
- Quantification of erosional fluxes
- Tracking bedload waves down stream
- Inspecting thresholds for onset of motion

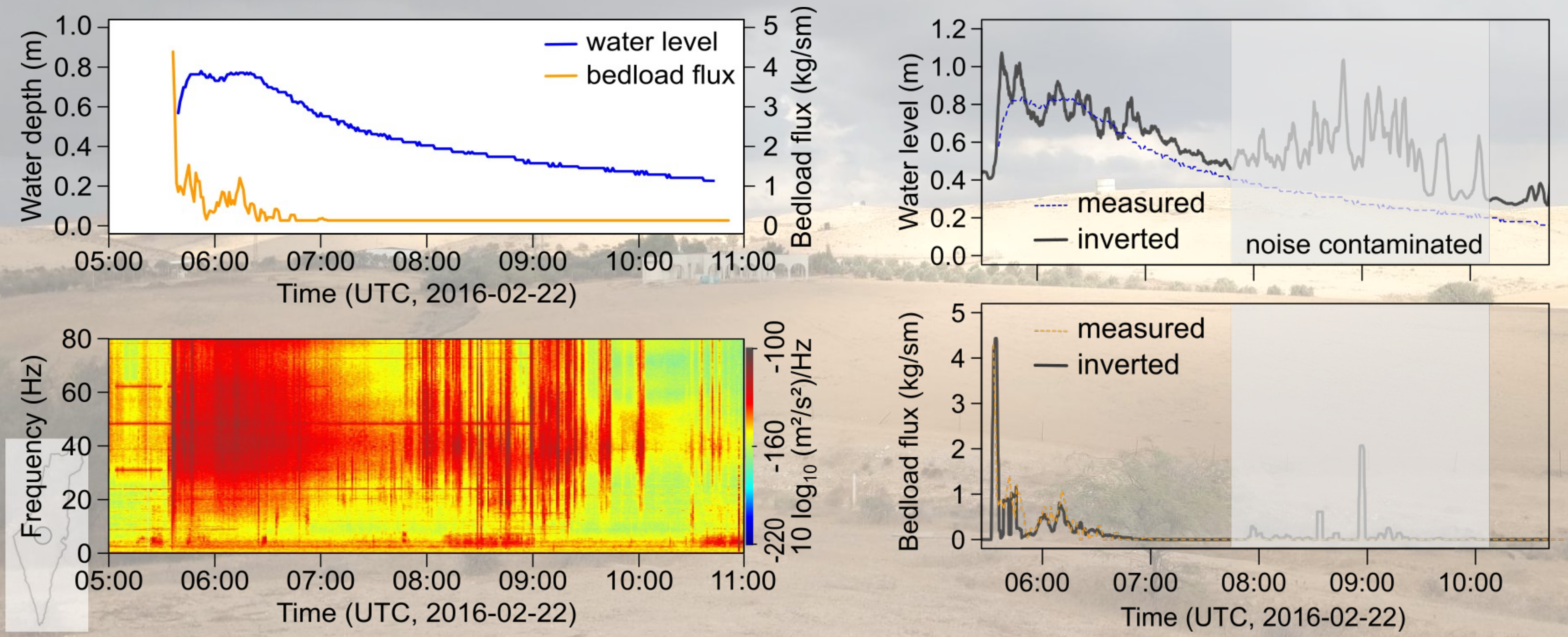
But: how well does it work?

The fluvial domain

Nahal Eshtemoa valley, Negev Desert, Israel, 2018

The fluvial domain

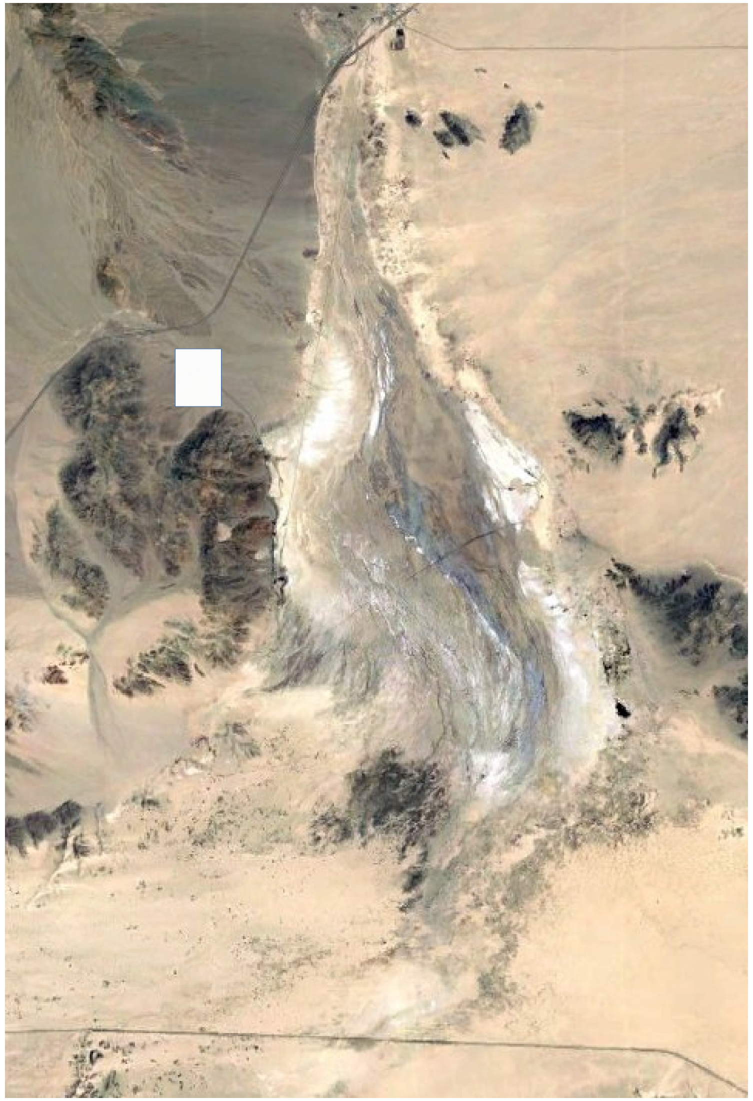
The fluvial domain

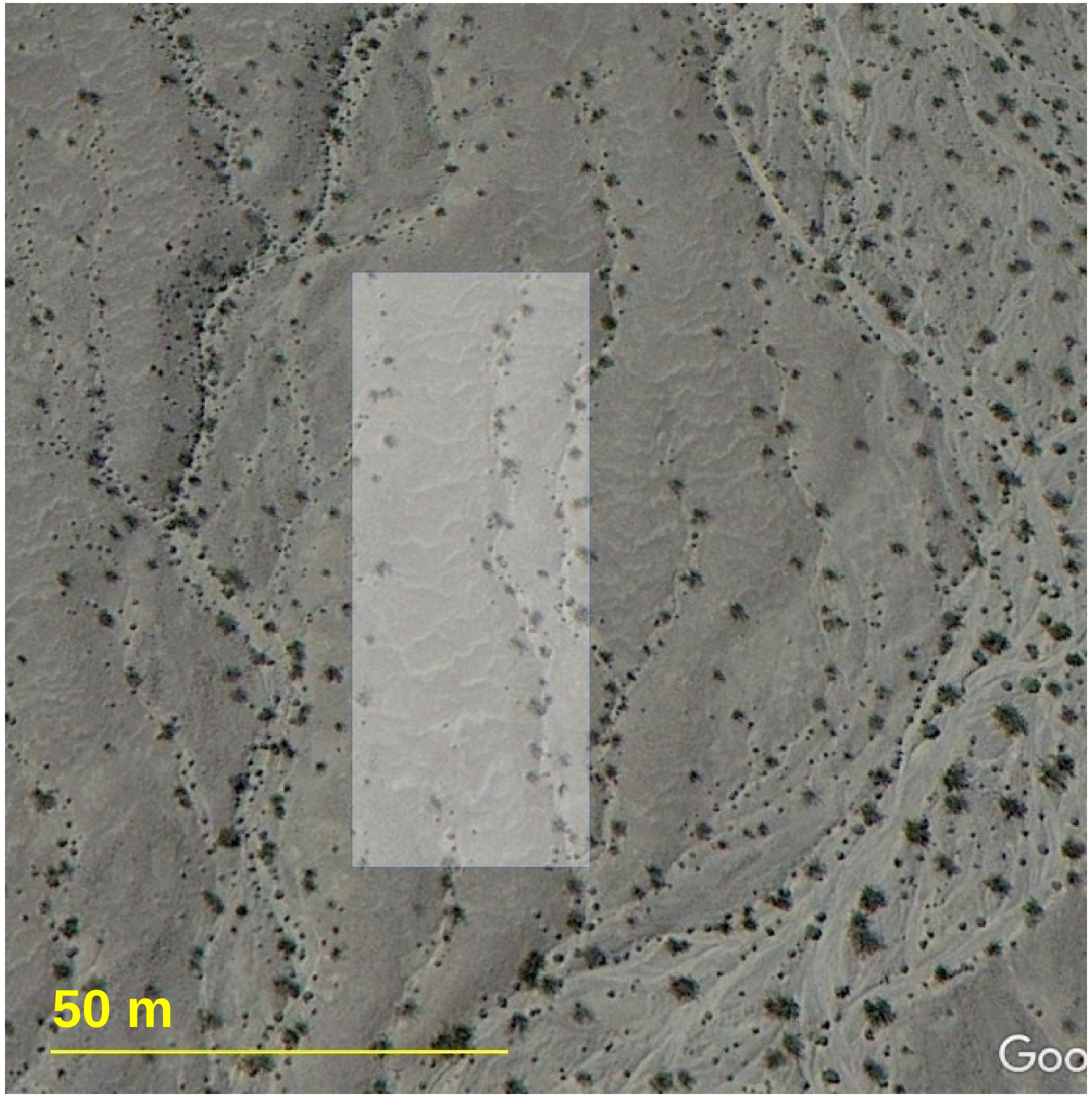


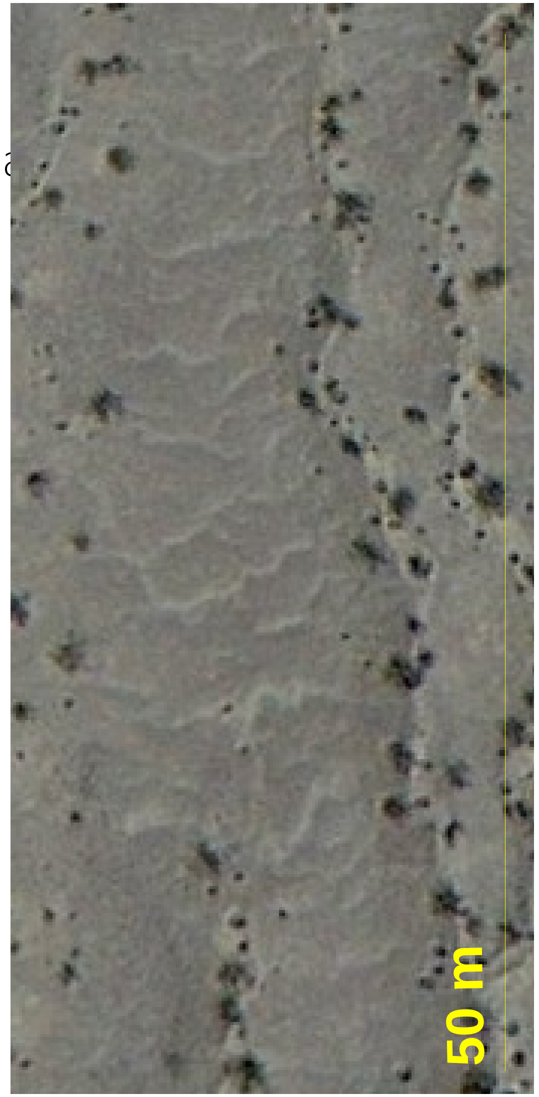
Dietze et al. (2019)

The hillslope domain

The hillslope domain – Rare (but violent) overland flow events





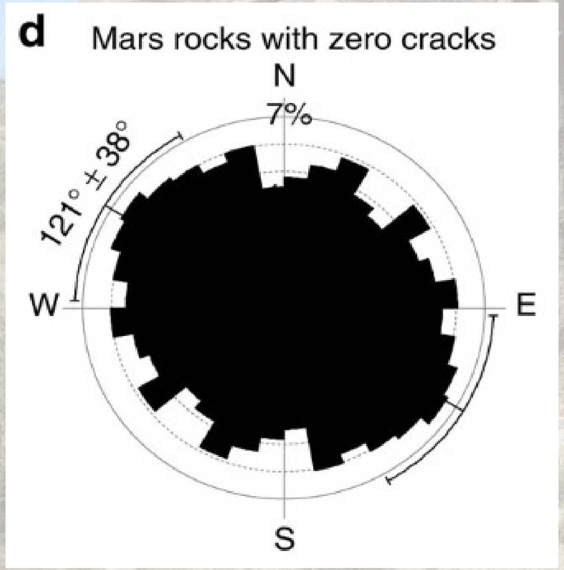


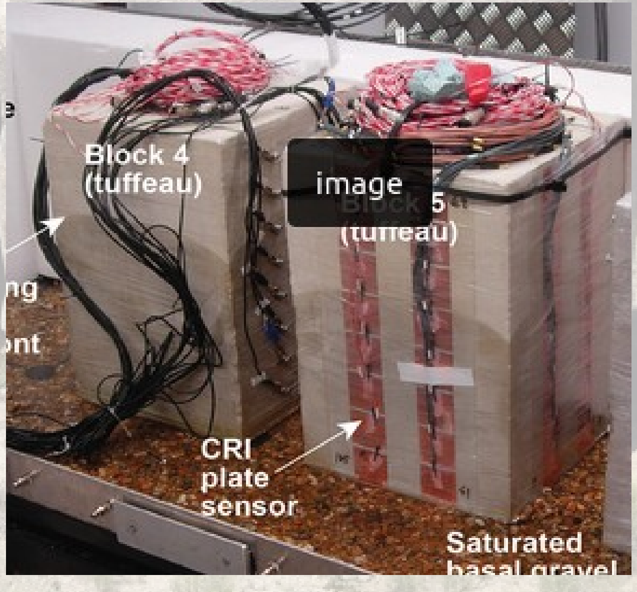
Soda Mountains–Soda Lake Playa, Mojave Desert, USA, 2016

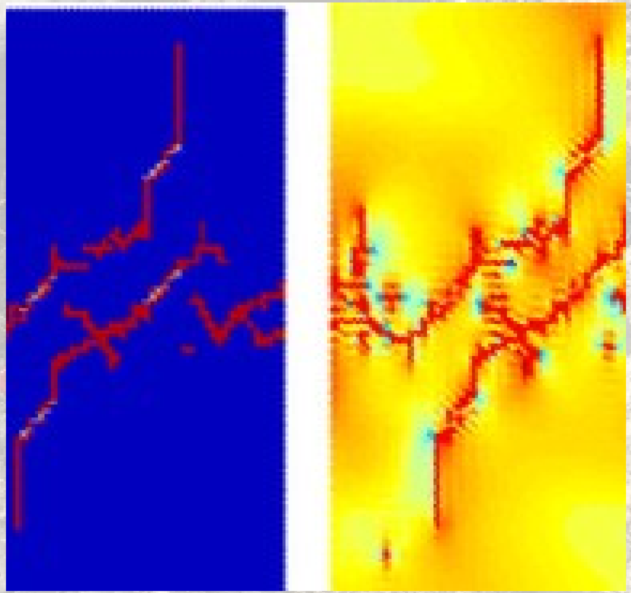
The hillslope domain – thermal weathering

Teutonia Peak & Cima Volcanic Field, Mojave Desert, 2018

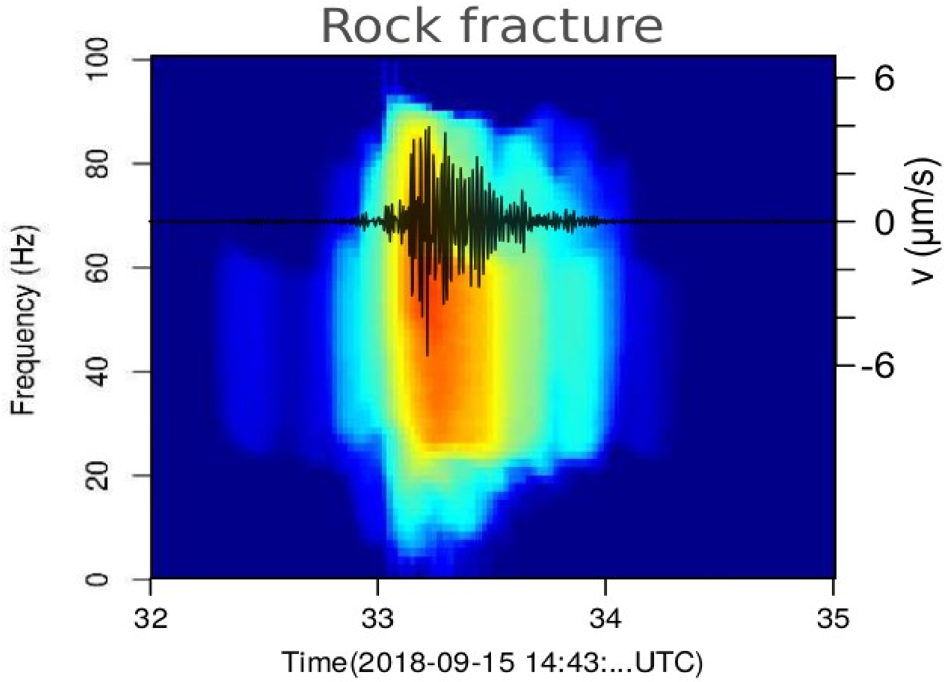
The hillslope domain – thermal weathering

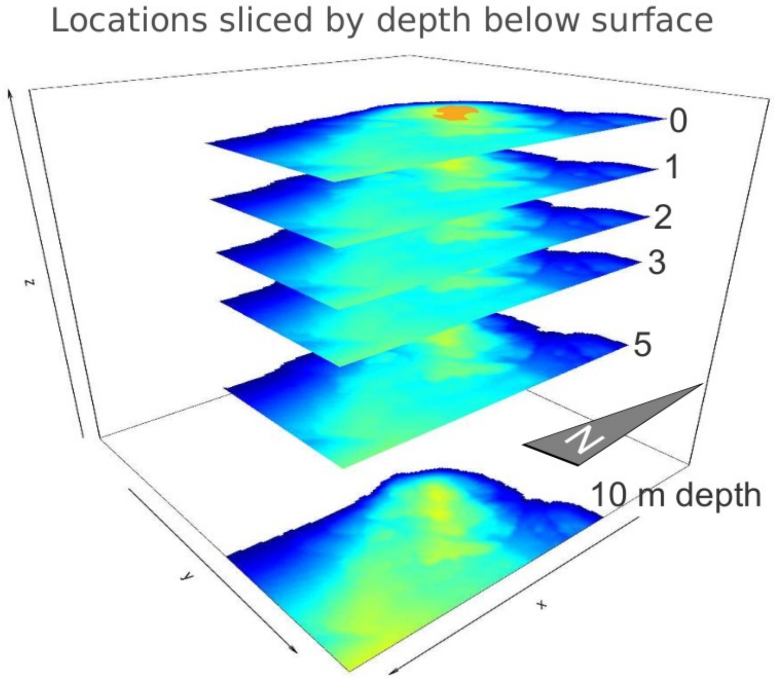






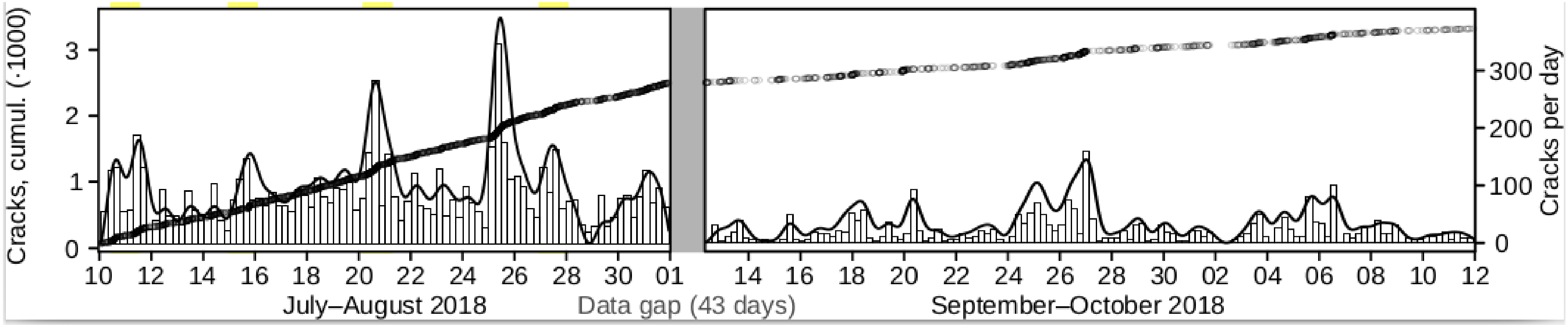
The hillslope domain – thermal weathering



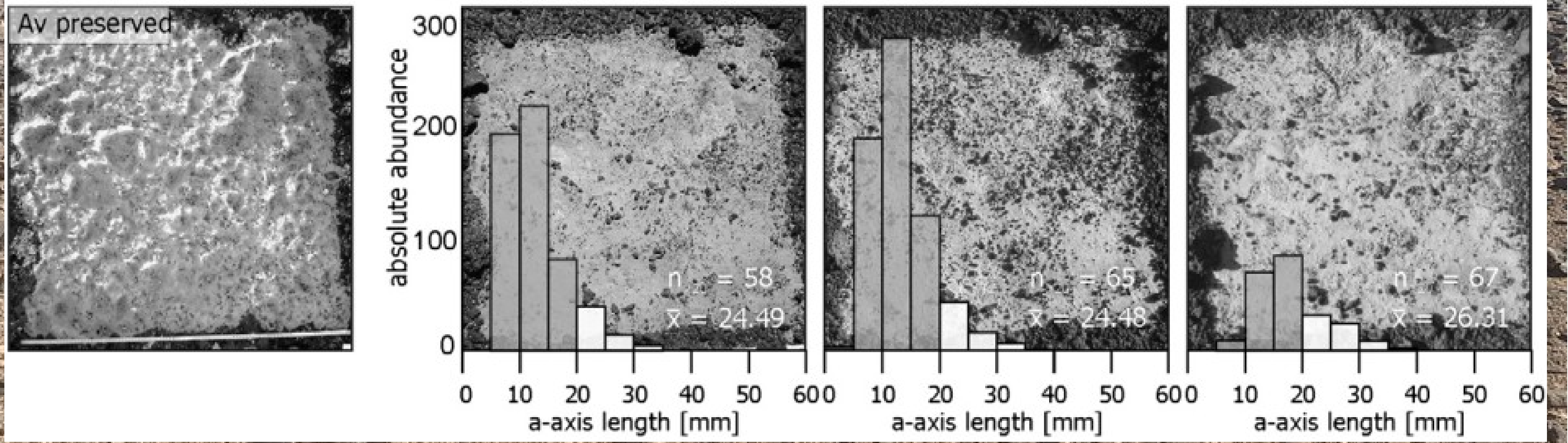


What could we do?

- Detecting crack signals due to thermal forcing
- Locate crack in 3D space
- Build multi-year time series of crack activity and link it to environmental forcing.

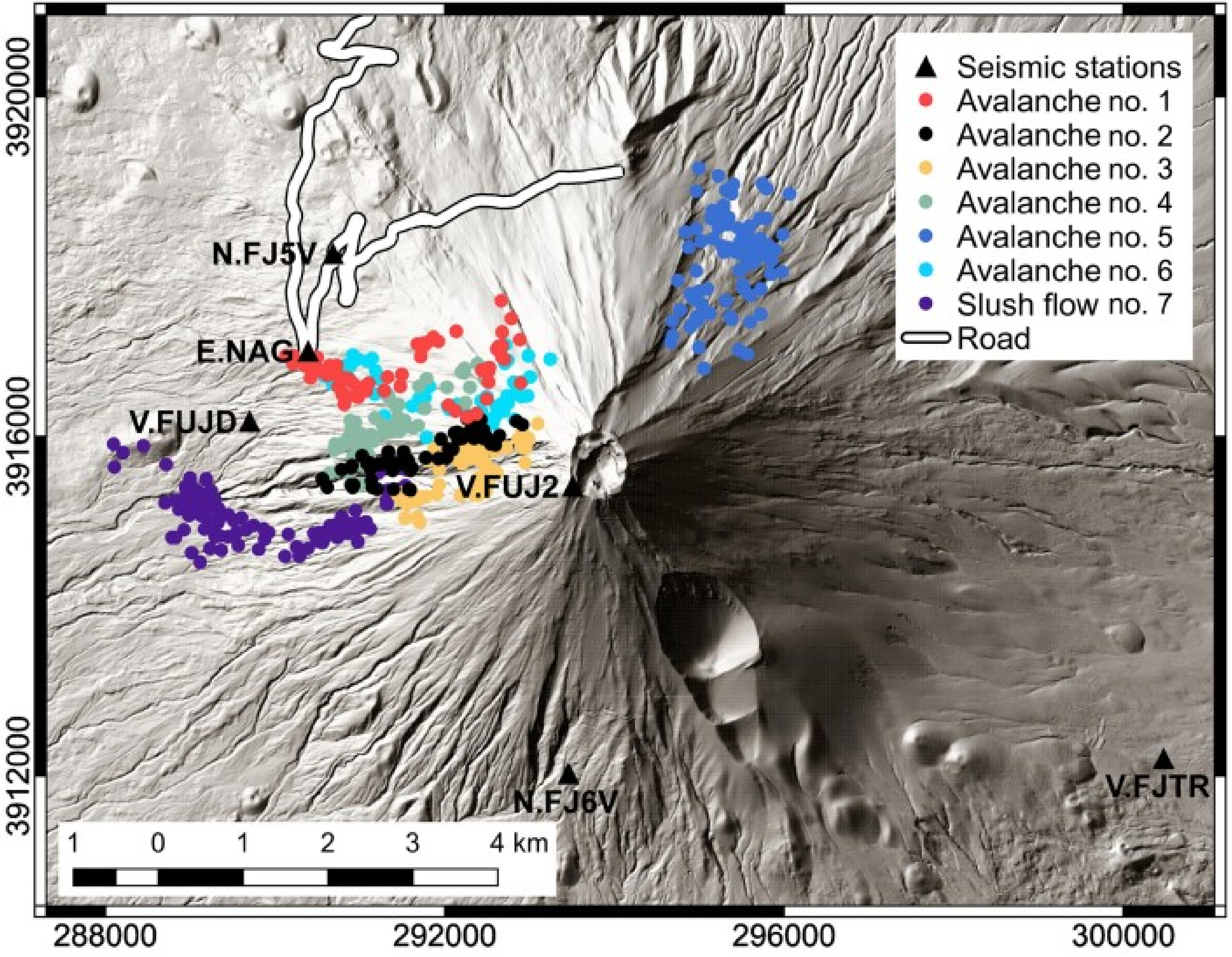


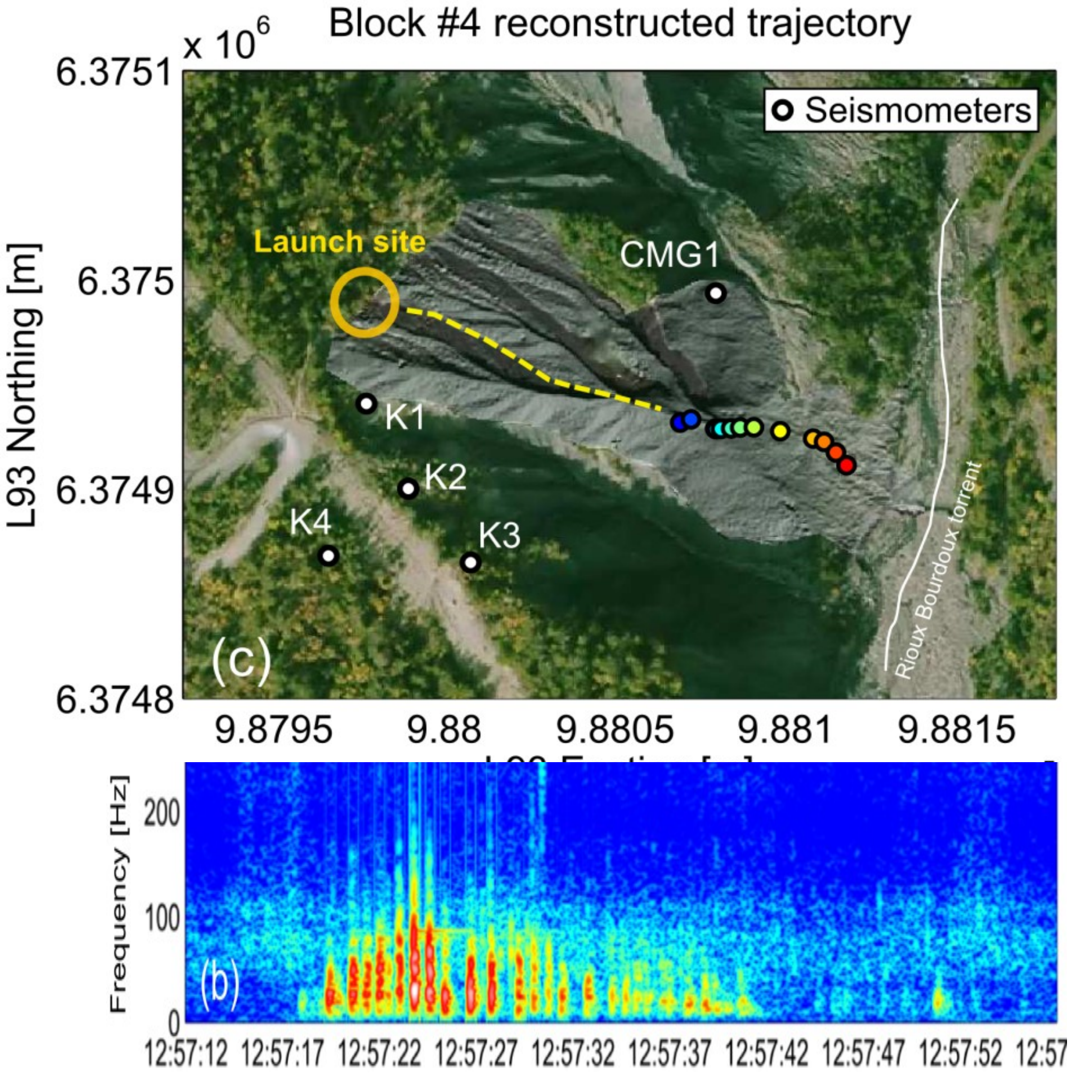
The hillslope domain – gravitational mass wasting



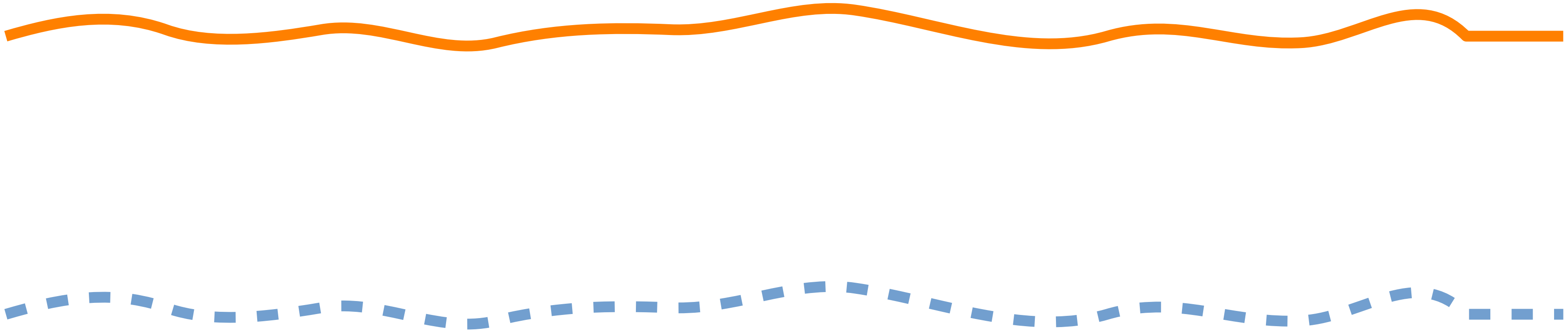
Bateman et al. (2012), Dietze & Kleber (2012)

The hillslope domain – gravitational mass wasting





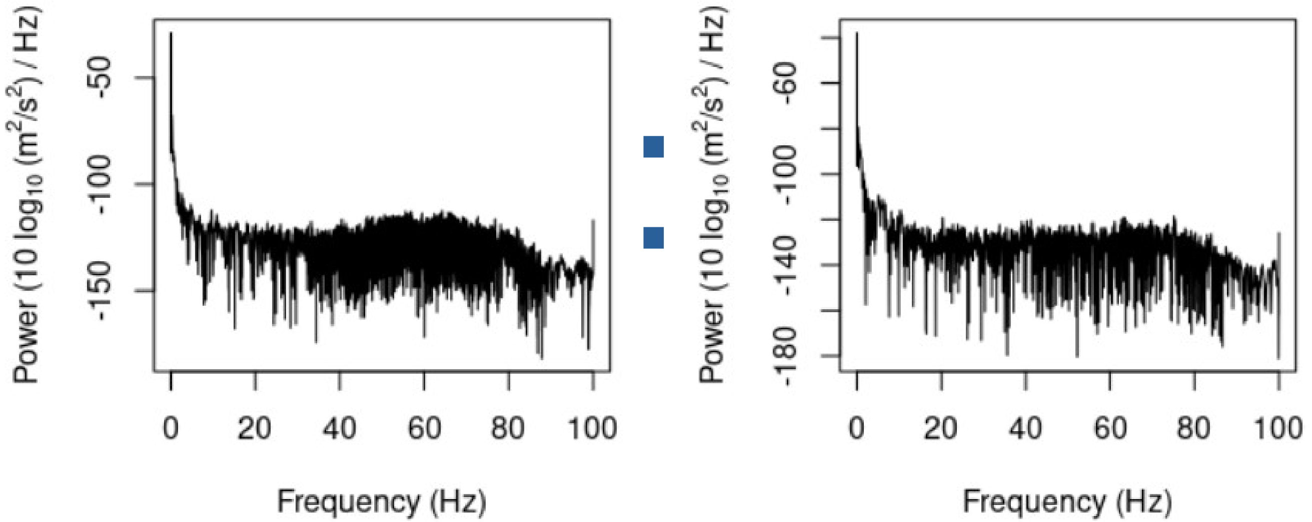
The ground below our feet



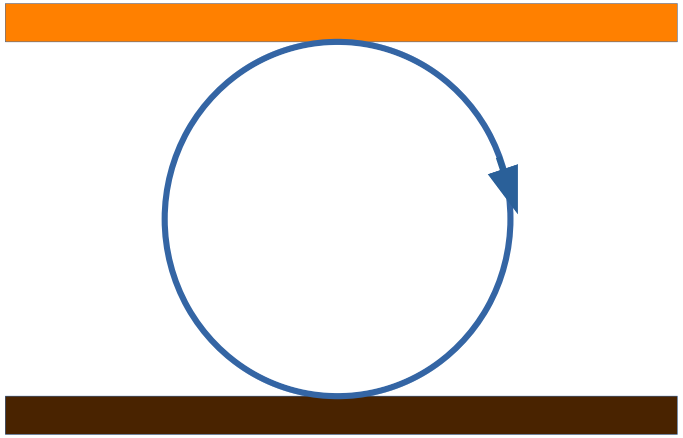
The ground below our feet

The ground below our feet

HVSR – Horizontal to Vertical Spectral Ratio



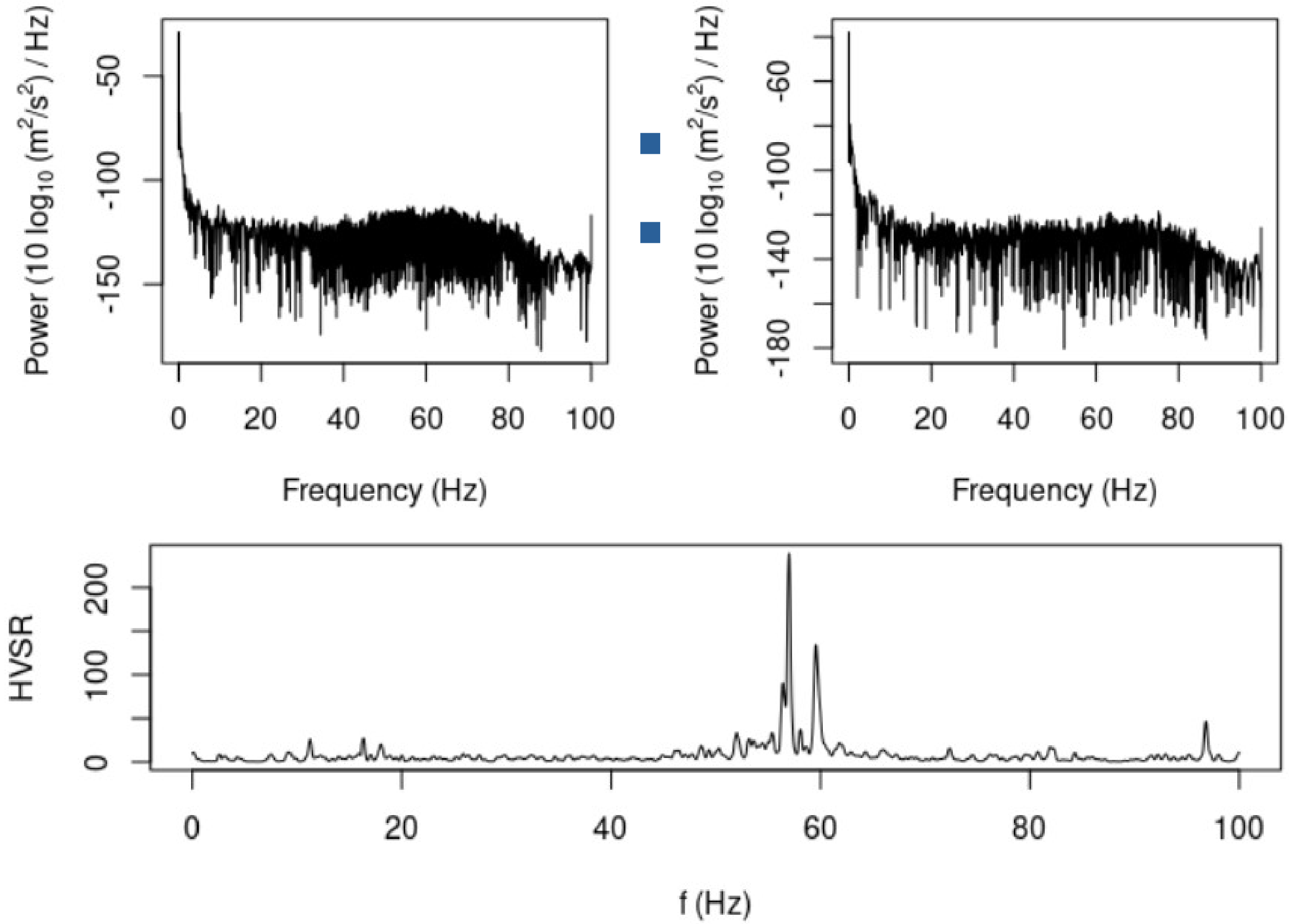
The ground below our feet



D = v_s / (4 · f_peak)

v_s shear wave velocity
f_peak HVSR peak frequency

HVSR – Horizontal to Vertical Spectral Ratio



The ground below our feet

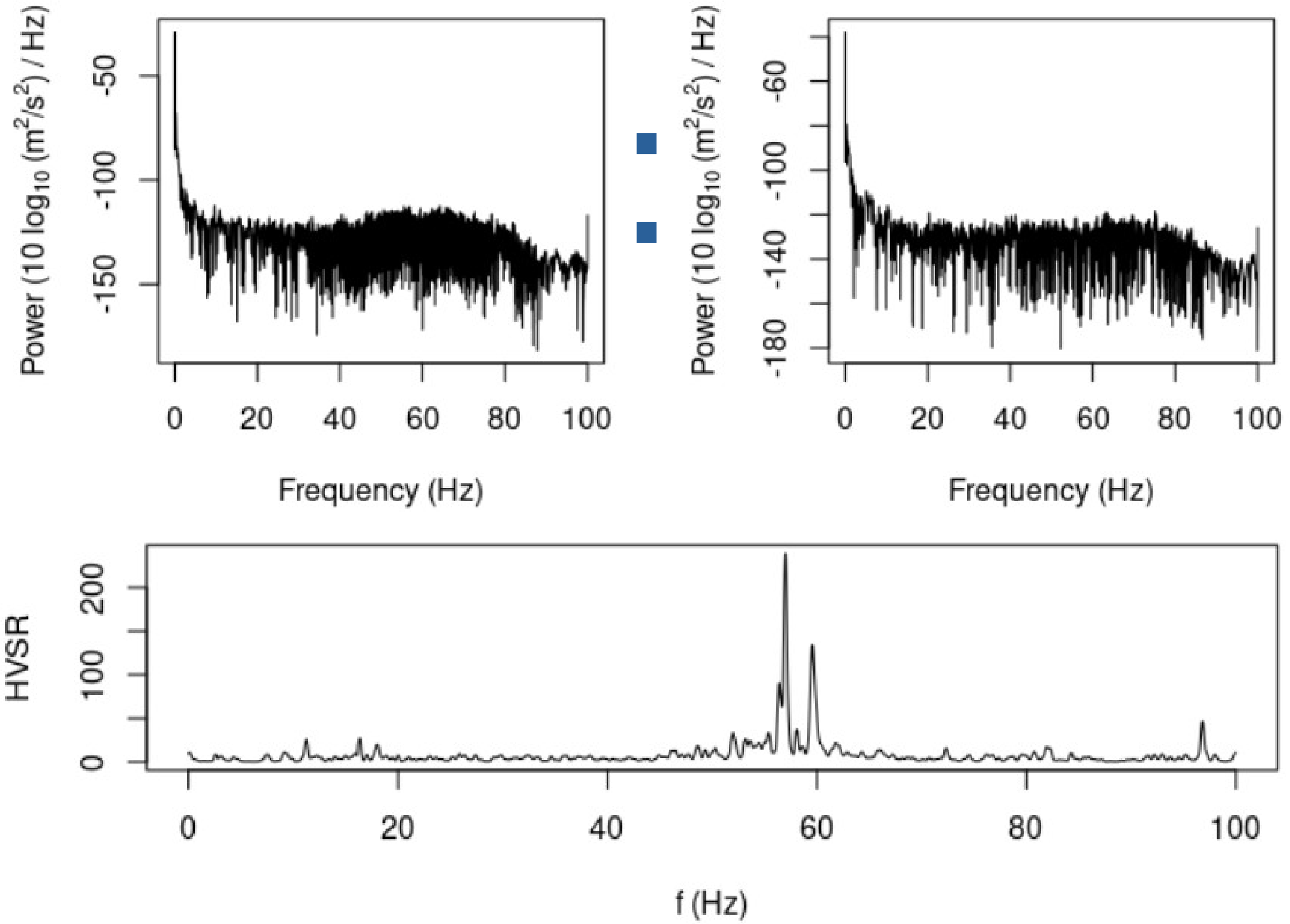
Efficient depth probing with some 5–10 m footprint

D ~ 52 cm

D = v_s / (4 · f_peak)

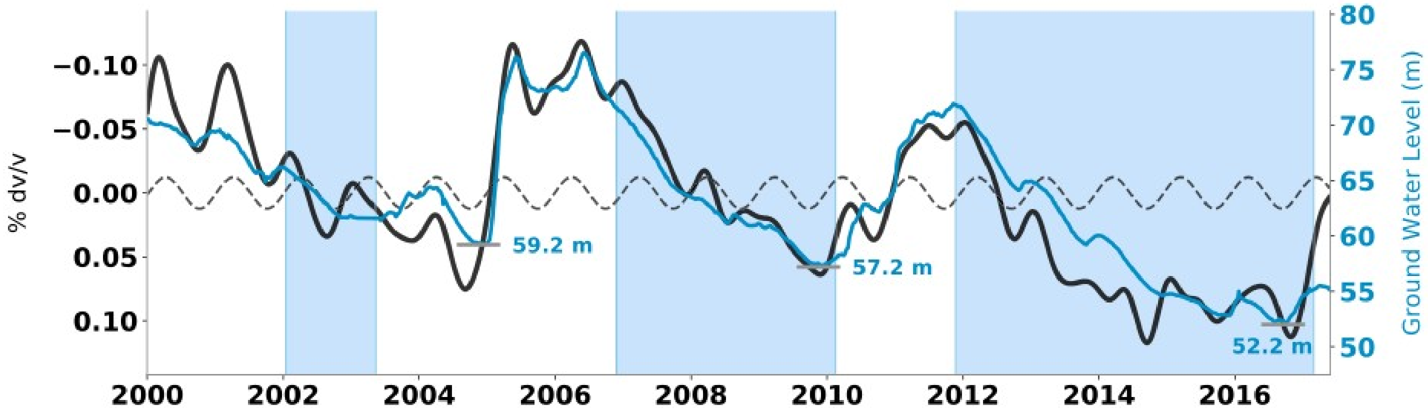
v_s shear wave velocity ~ 120 m/s
f_peak HVSR peak frequency ~ 58 Hz

HVSR – Horizontal to Vertical Spectral Ratio

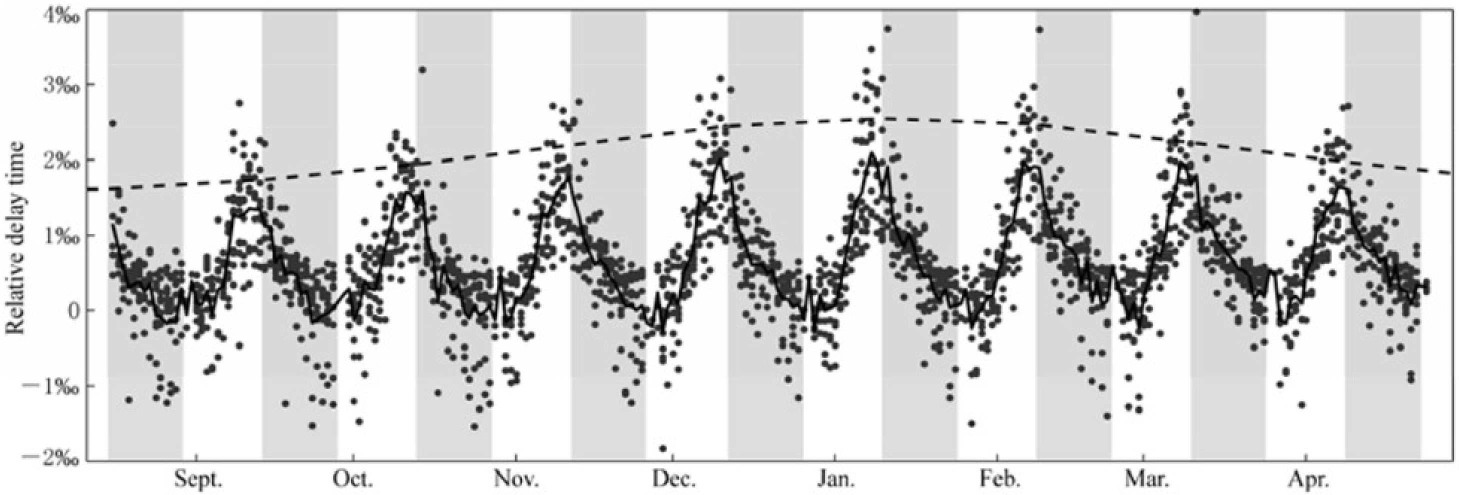


The ground below our feet

Coda wave interferometry – sensing the change in seismic wave velocity with time (dv/v)



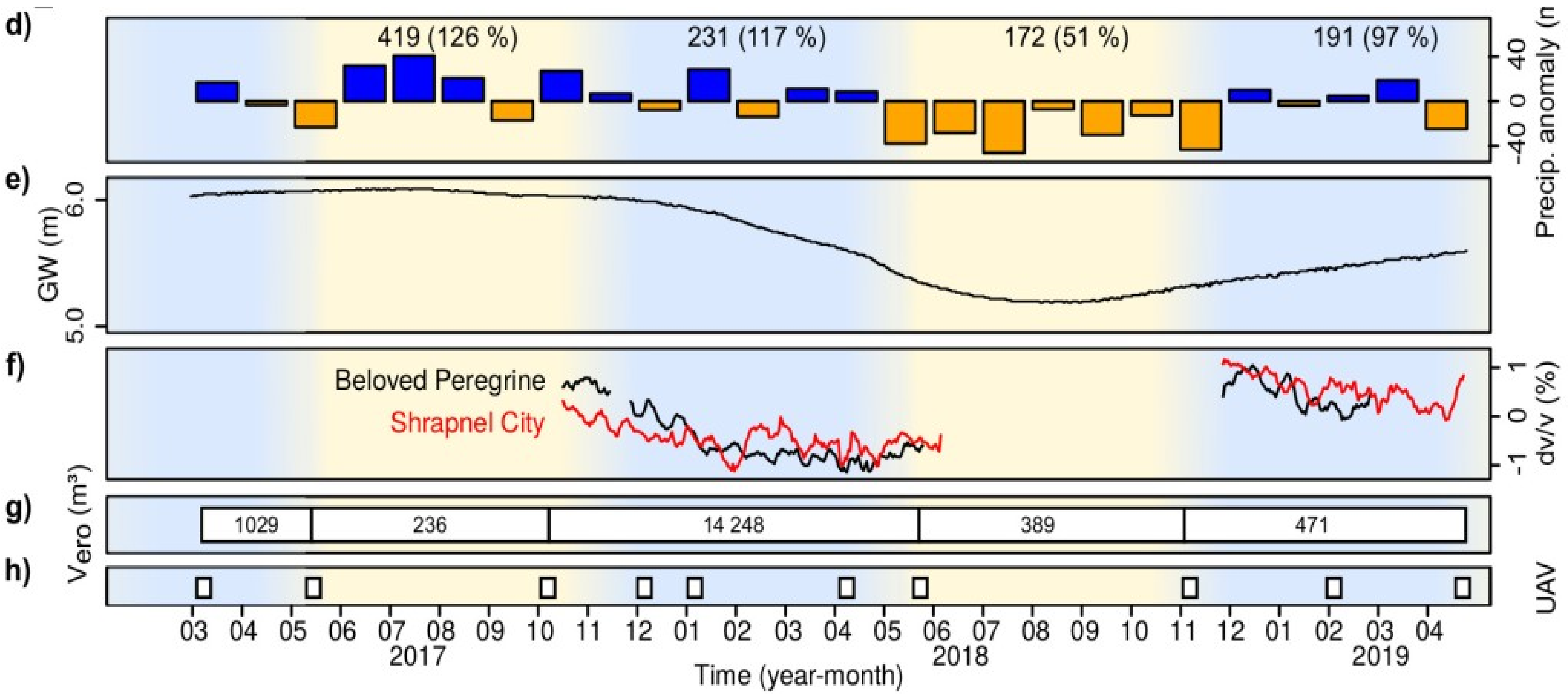
dv/v as proxy for groundwater in (semi)deserts, SW USA



dv/v as proxy for thermal stress on the moon

The ground below our feet

Coda wave interferometry – sensing the change in seismic wave velocity with time (dv/v)



dv/v as proxy for soil moisture evolution, Island of Rügen, Germany

Dietze et al. (2020)

Thanks!