Synopsis (the study in two lightning minutes)

Contents lists available at ScienceDirect

Geomorphology

journal homepage: www.elsevier.com/locate/geomorph

Hmm, how far can we lean out, without even knowing where, when and how fish disturb/mobilise the bed?

Sex that moves mountains: The influence of spawning fish on river profiles over geologic timescales

Hi, I am *oncorhynchus mykiss*. I move 10 cm large cobbles, but I am so hard to detect in doing so...

Hi, and I am a geophone. I can sense your fin flaps, 24/7, at 20 m away, with 200 Hz resolution, and I can locate you.

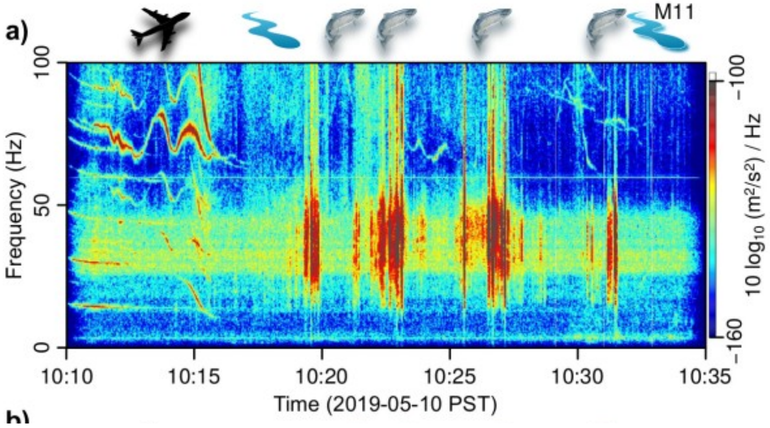
Line up of the contribution

1) Relevance of spawning fish for fluvial geomorphic systems

2) Study approach and validation effort

3) Anatomy of redd building

4) Beyond a single case event



GFZ
Helmholtz Centre
POTSDAM

Feel the vibrations

Seismic sensing of salmonid nest building and river sediment mobilisation

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2 – Washington Department of Fish and Wildlife, Washington, USA
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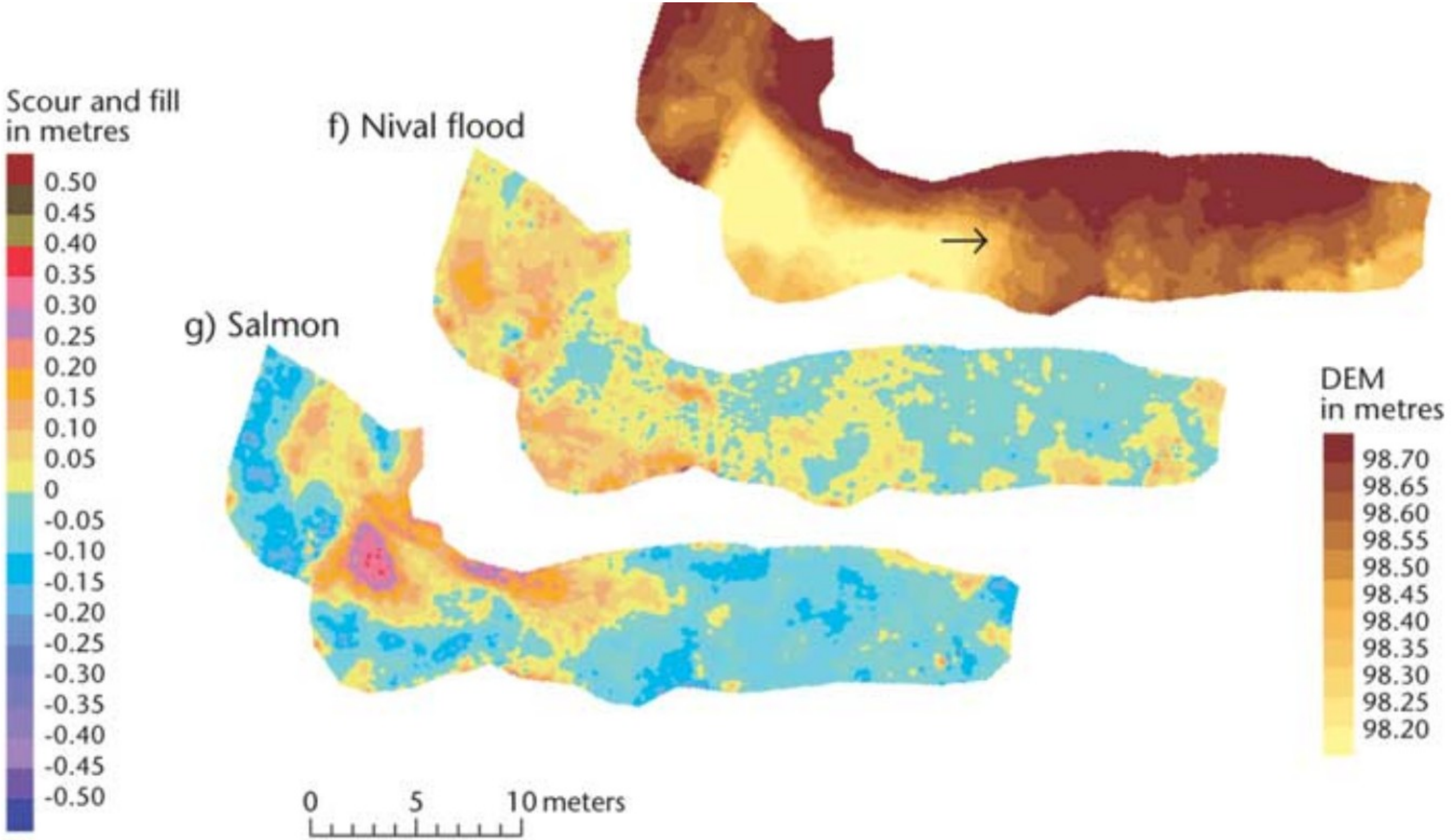
Spawning fish species – the geomorphic perspective



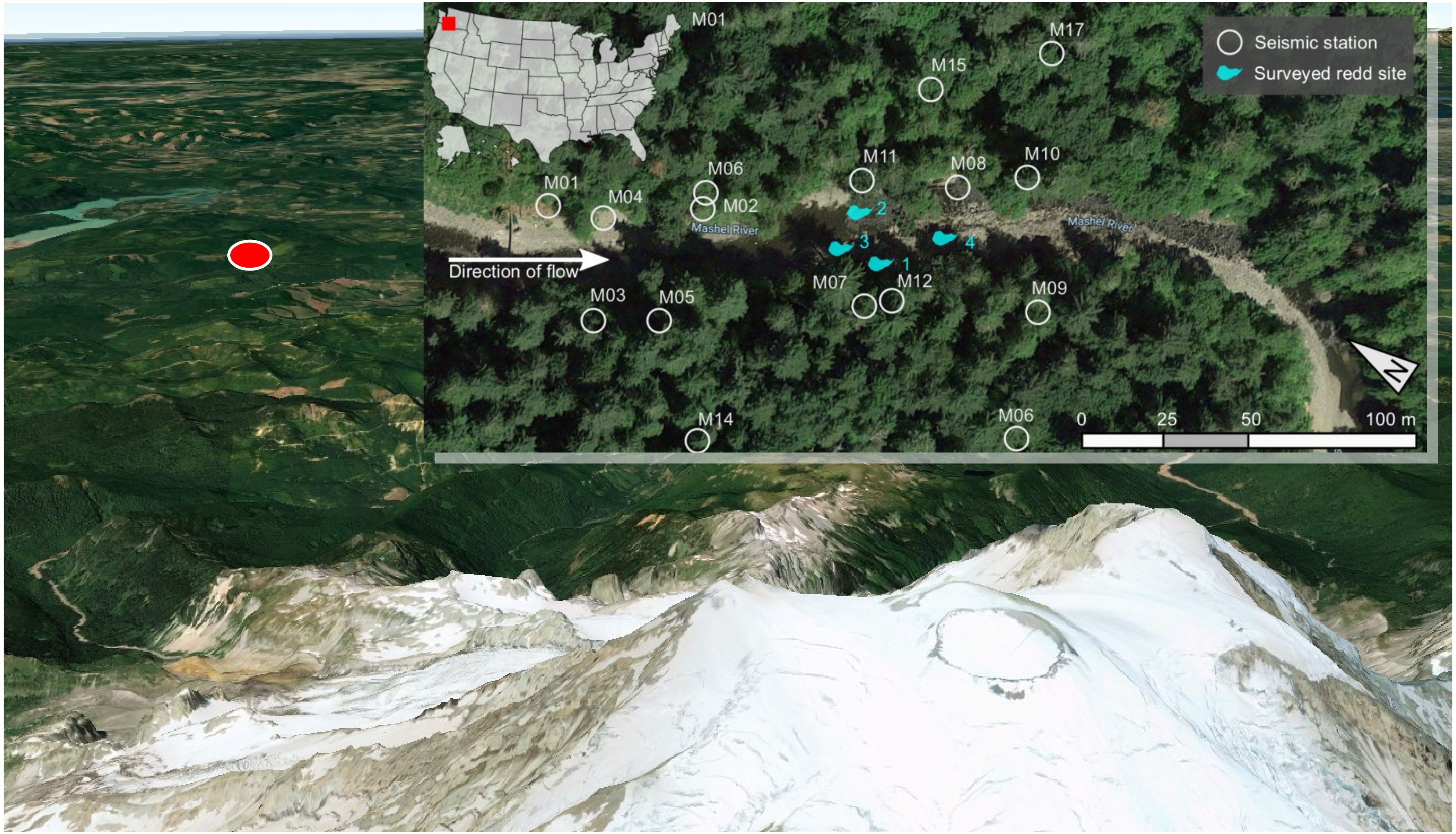
Salmonid’s redding activity can export as much sediment as flood driven dyna-mics.

Effects:
- sediment export
- higher roughness
- less armouring
- additional relief

- habitat engineering
- ambivalent effects on subsequent floods

Hassan et al. (2008)

The seismic approach



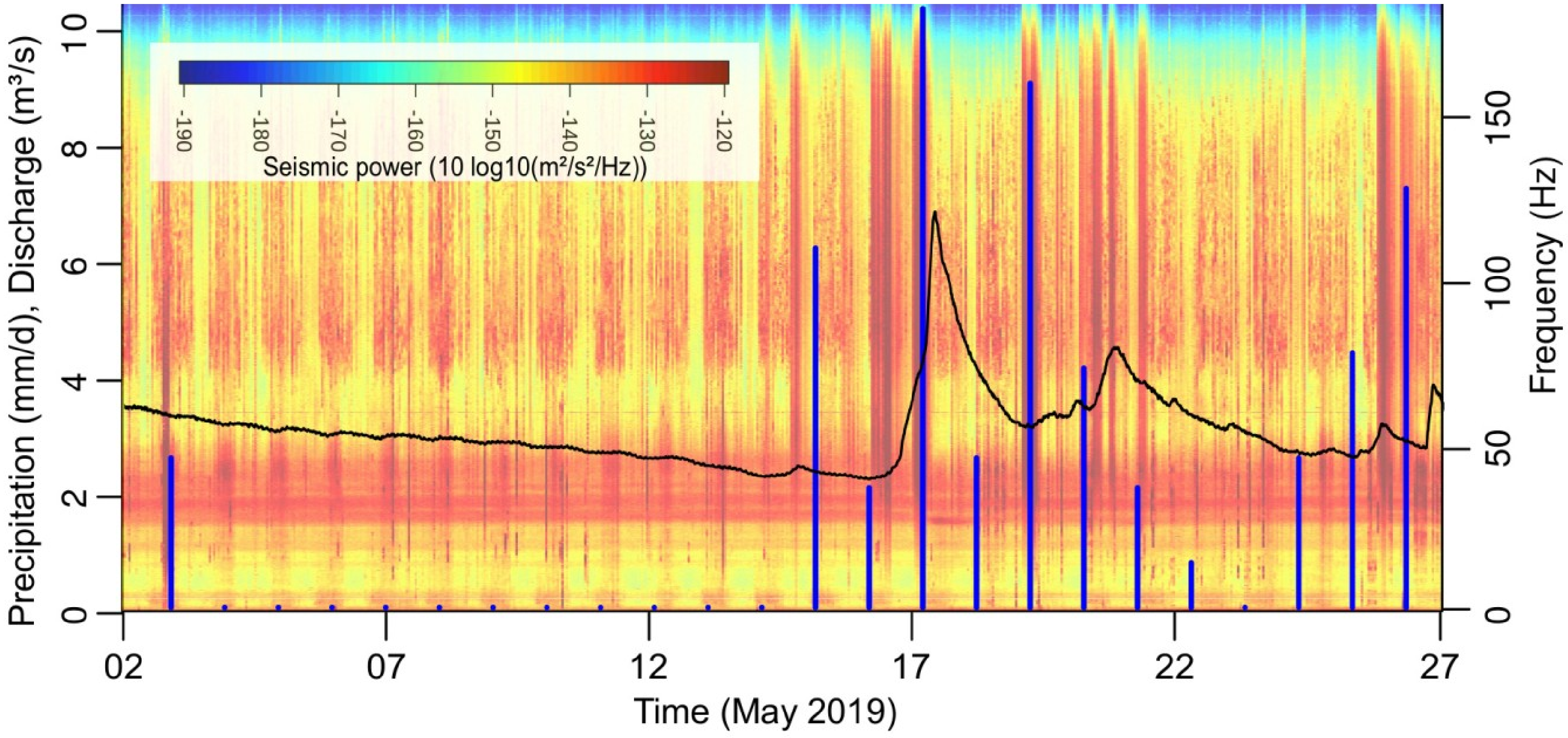
30 km west of Mount Olympia, Washington State, USA, the Mashel River winds towards the Nisqualli.

A straight reach of the 25 m wide stream has been instrumented with 17 PE6B geophones, logged at 400 Hz by Digos DataCube³ext recorders, in May 2019.

Redds were mapped manually at weekly intervals (light blue signatures in map).

Oblique view picture, based on Google Earth imagery, map see Dietze et al. (2020)

The seismic approach

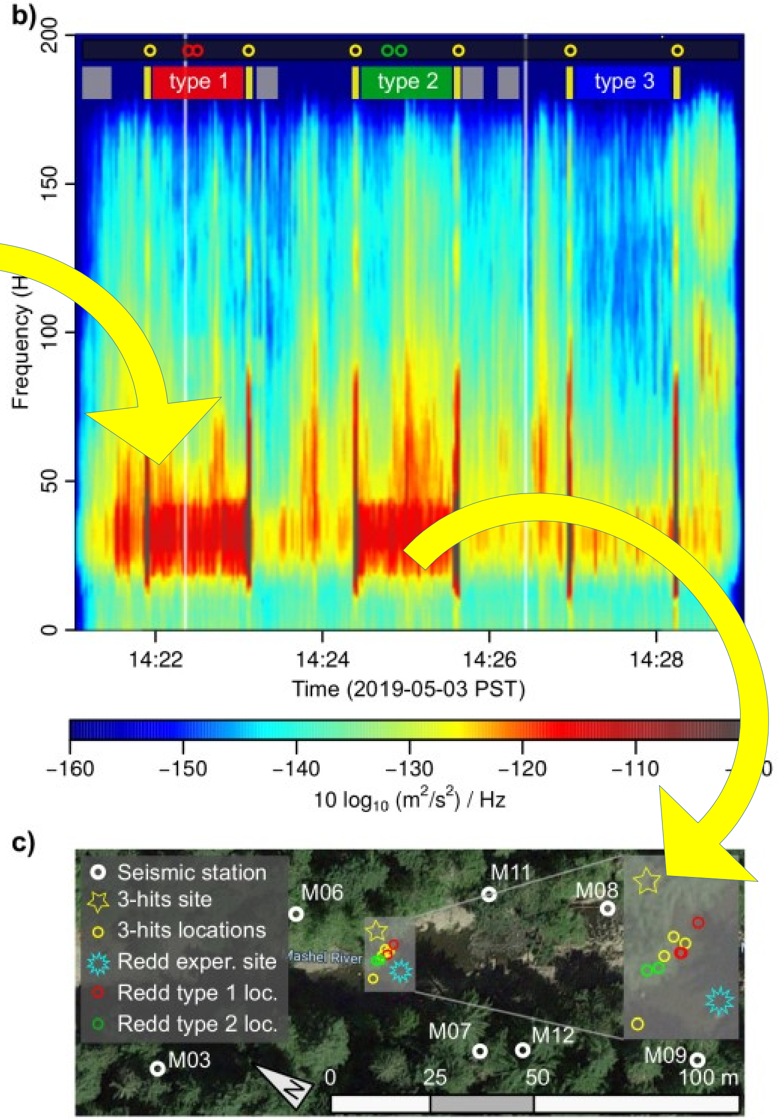


Spectrogram of station M11, overlain by hydrograph (black line) and daily rain sums (blue bars) of station some 50 km away.

The river showed a few minor rain-induced floods, but no flood-induced bedload events.

Seismically, the river turbulence signal dominates the 30-50 Hz range, rain events appear as spikes at 40-200 Hz, traffic has a diurnal pattern at 70-130 Hz.

Testing the validity of the approach – man made sediment agitation



To test if gravel agitation can be seismically detected and located, we did a controlled experiment

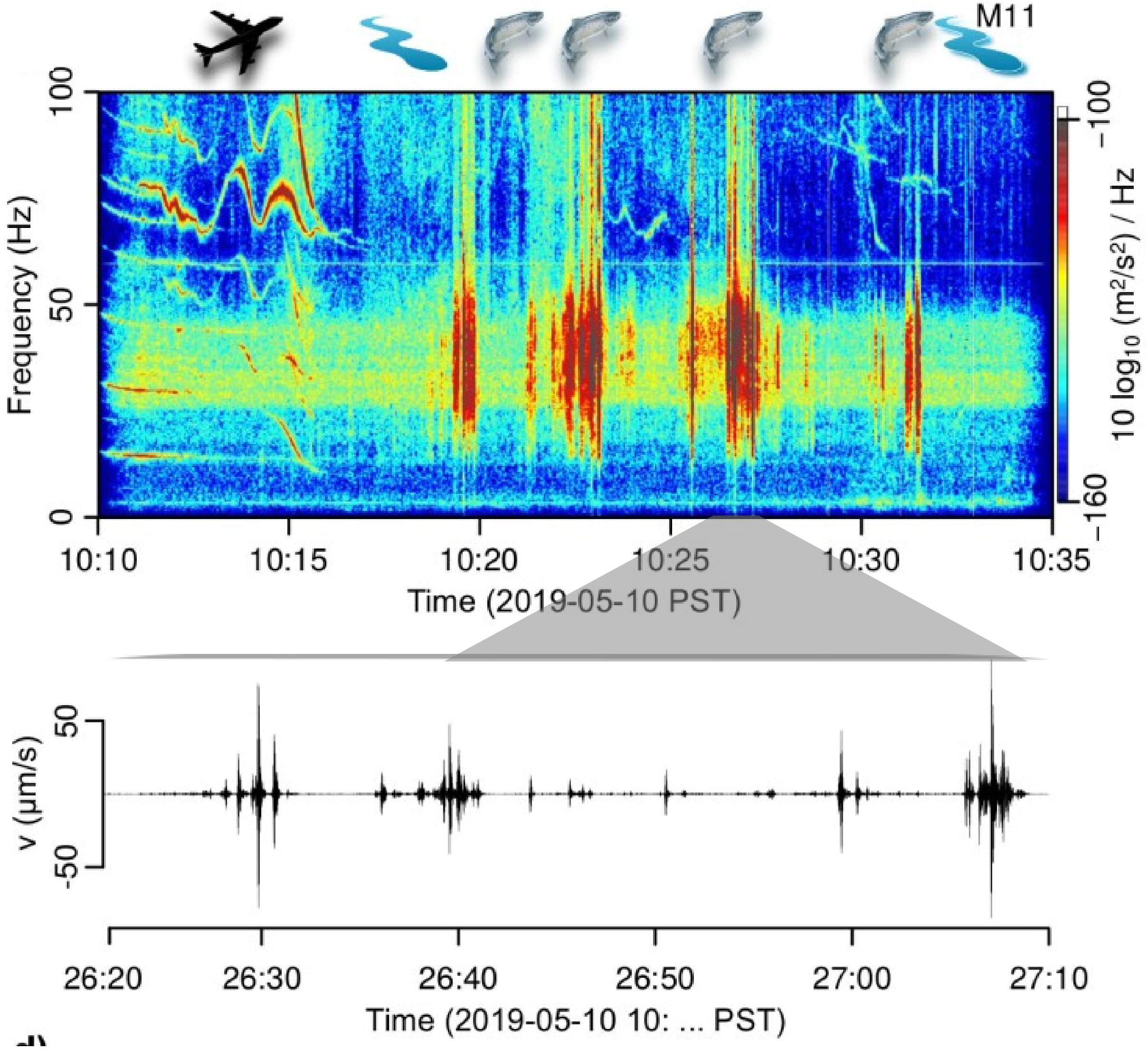
Type 1: pebbles entrained by diving fin flaps

Type 2: pebbles entrained by feet

Type 3: movements of stiff paddle

Entrained pebbles have a clear signature and location.

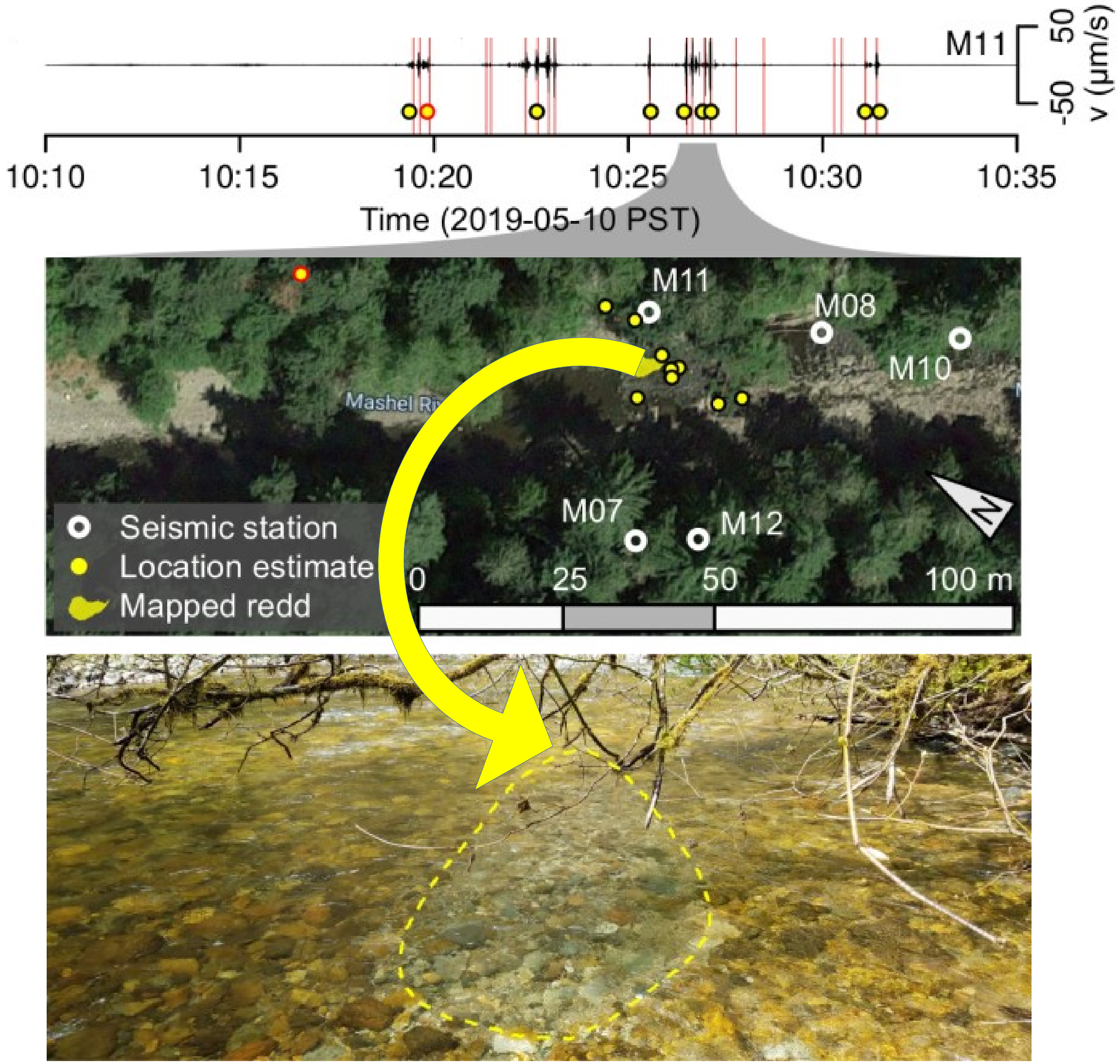
Anatomy of animal born river sediment agitation – an example



The geophones detect a lot of activity, from planes to river noise.

Redd building activity is expressed as 20 to 60 Hz spikes, lasting less than a second per pulse. Each flap of the fin is recorded, forming characteristic sequences of pebble agitation.

Anatomy of animal born river sediment agitation – an example



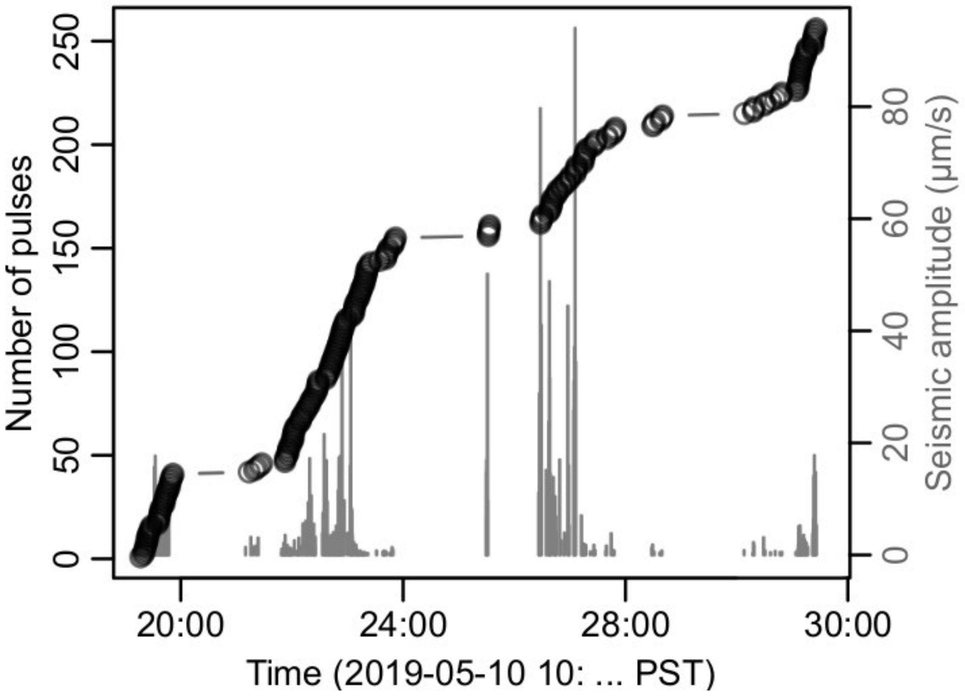
Each pebble agitation pulse can be located, with average uncertainties of 22 m, but with < 5 m for pooled estimates.

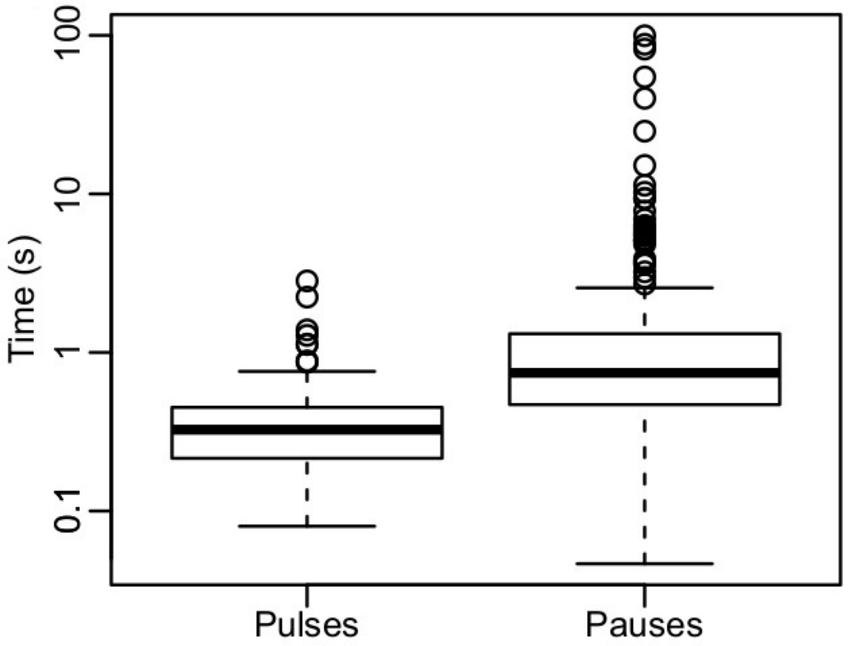
Better accuracy is possible with higher sampling rate and a denser network.

The approach allows to discriminate different redds, if they are spaced by more than 5 m (here: 15–27 m).

Dietze et al. (2020)

Anatomy of animal born river sediment agitation – an example



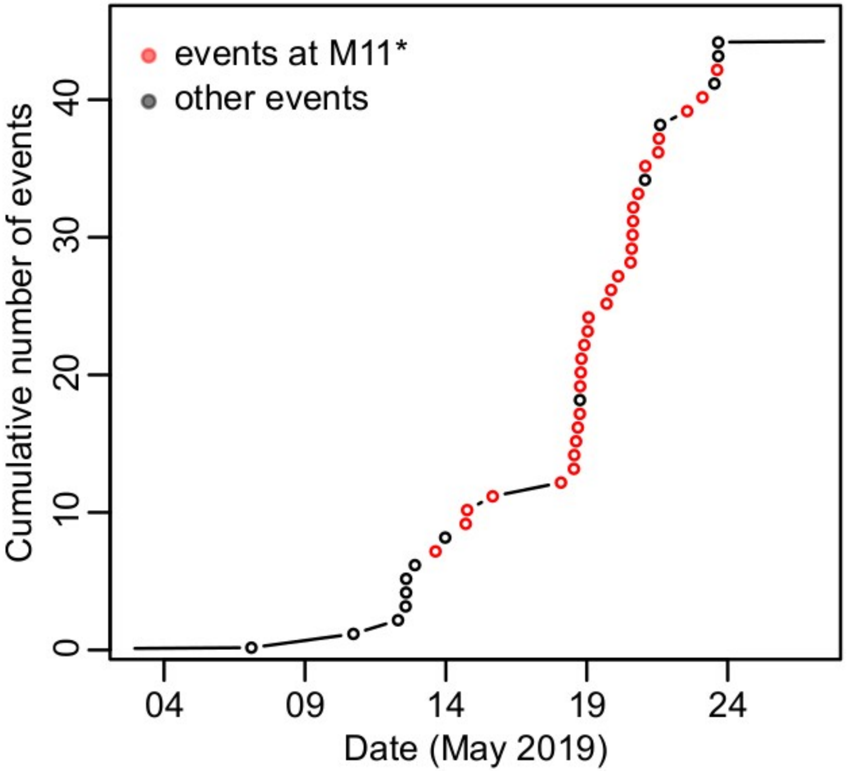


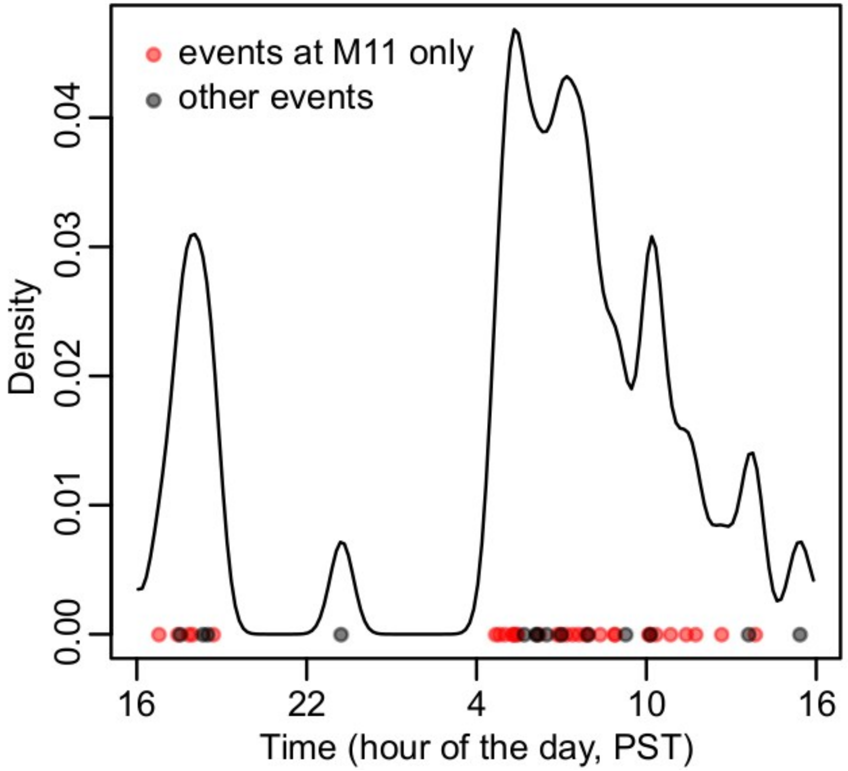
Looking at one exemplary event:

Redd building events consist of > 250 flap signals (0.33 s each), lasting 12 min. Flaps occur as 2-3 min long clusters of 50–100 hits, spaced by periods of calmness of the same duration.

The activity is exhausting for the fish, data is in agreement with sparse eye witness information and biomechanics.

Anatomy of animal born river sediment agitation – an example



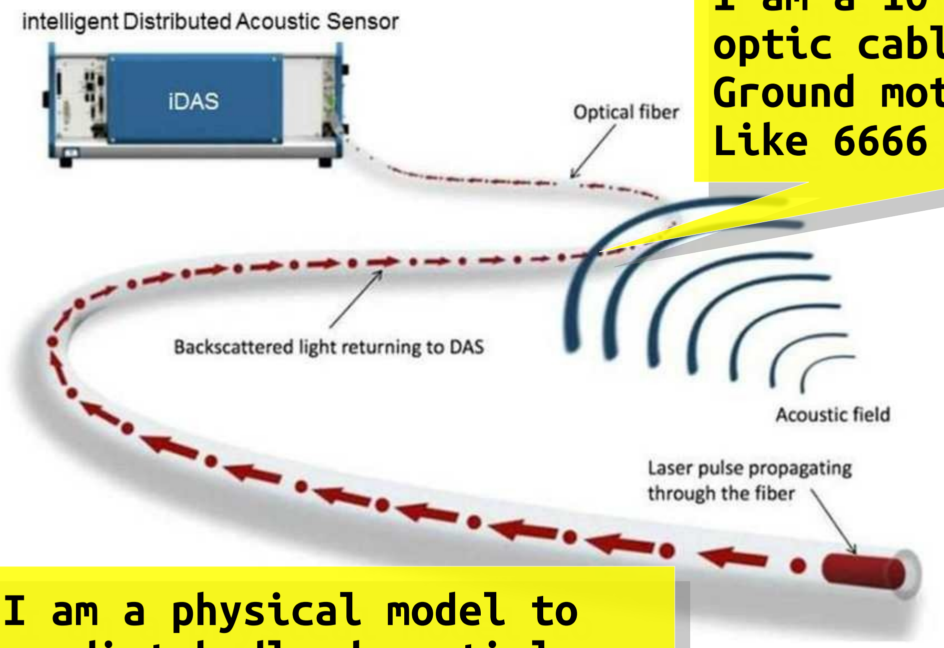


Looking at all identi-fied events:

Spawning activity is focused on about a week, with one redd being active for 6 days.

90 % of spawning took place during daylight hours, 60 % in the morning, before noon.

Where next?



I am a 10 km long fibre optic cable that can sense Ground motion every 1.5 m, Like 6666 linear geophones.

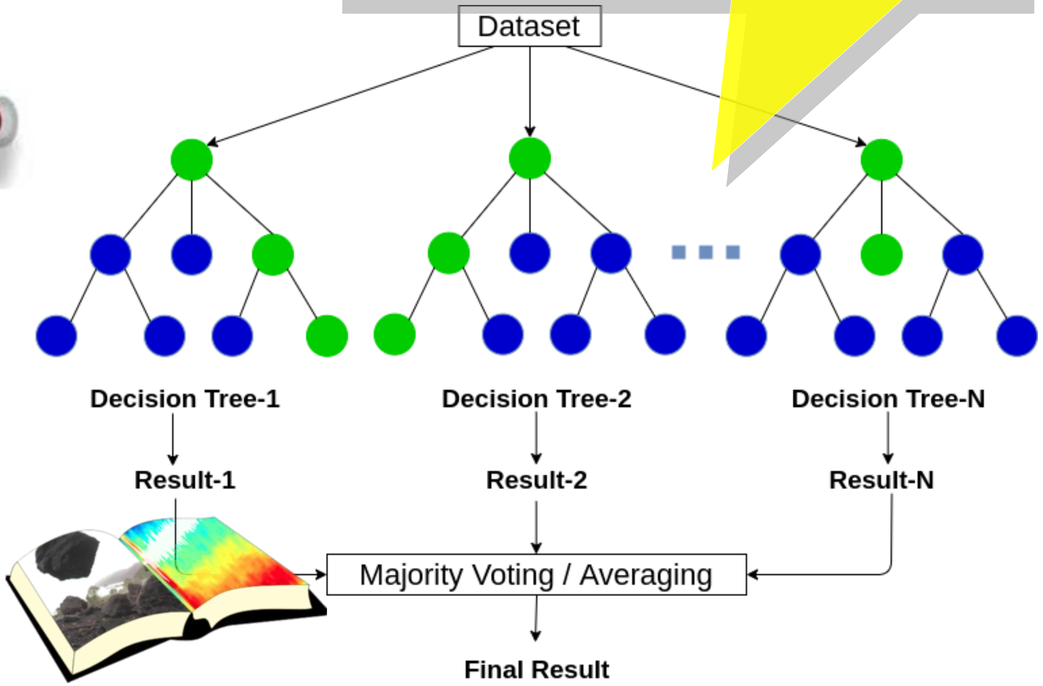
I am a physical model to predict bedload particle flux from seismic data. I am available in eseis, too.

Tsai et al. (2012)

$$P_v(f;D) \approx \frac{n}{t_i}\frac{\pi^2 f^3 m^2 w_i^2}{\rho_s^2 v_c^3 v_u^2}\chi(\beta)$$

$$\dot{u}(f,x) = 2\pi i f F(f,x_0) G(f,x;x_0)$$

I am a random forest, able to classify seismic events. I am a machine learning algorithm available in eseis.



Avenues of future activity:

Using distributed acoustic sensing (DAS) for higher resolution and longer reach coverage for longer vinterval (months).

Apply machine learning to effectivey isolate redding-caused seismic signals.

Convert seismic signal to sediment flux, compare to fluvially driven fluxes.

Pictures taken from Researchgate.net, equations taken from Tsai et al. (2012)