

Measurement setup to investigate near surface failures in steep bedrock permafrost

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The main goals are:

- to gain better *process understanding* of *near surface failures* in permafrost
- to work towards a real-time *early warning system* to prevent a catastrophic event

Assessing rupture in natural media remains a challenge because:

- natural media are *heterogeneous*
- the heterogeneity is difficult to *quantify and measure*
- rupture is a *nonlinear process* involving these heterogeneities

BUT **heterogeneity** is a chance - taking advantage of it!

During rupture process, weakest zones will break first!
→ *precursory signs are expected before final rupture!*

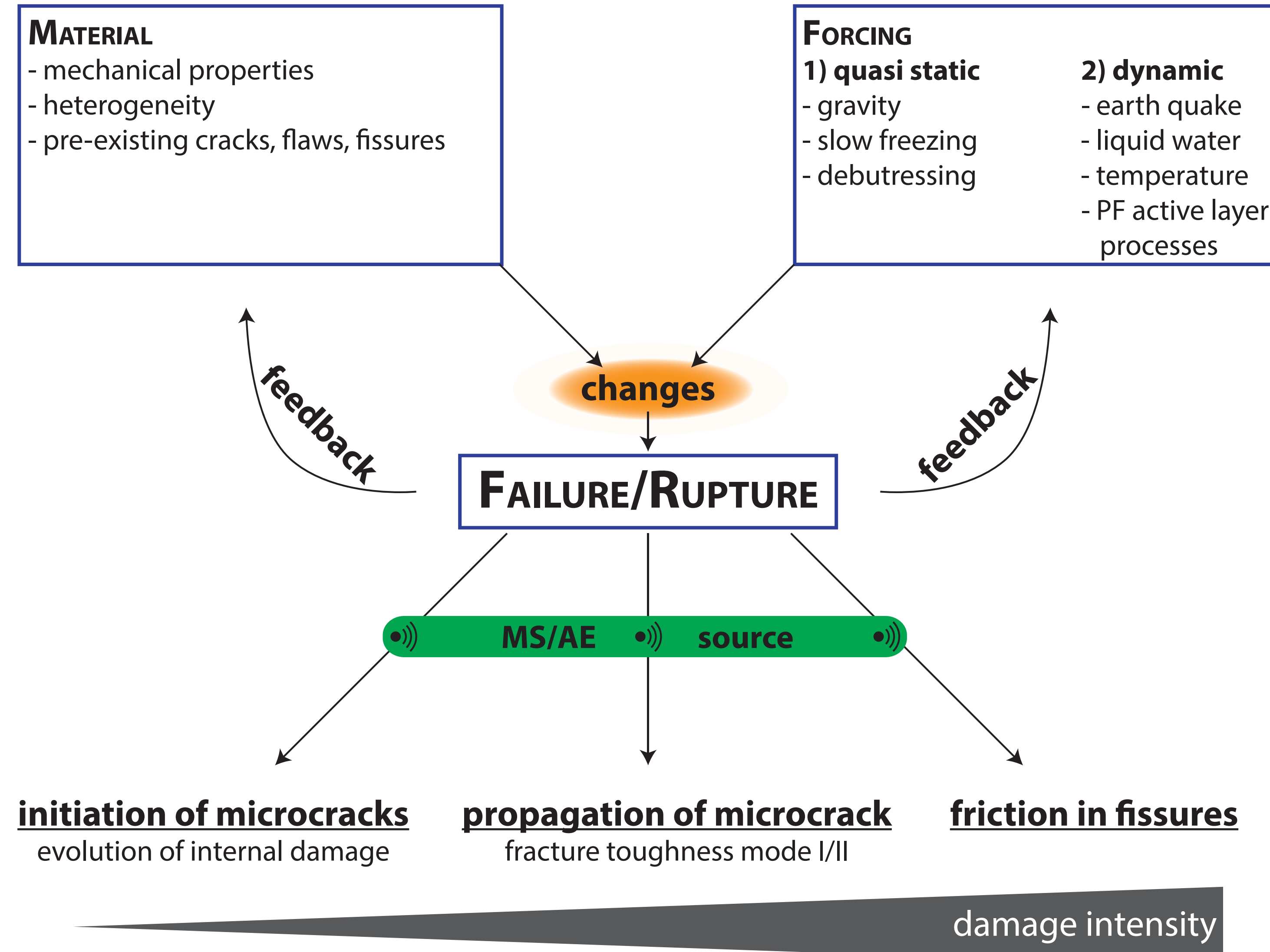
Assessing *slope stability* requires to **monitor/identify/quantify** these precursors.

Field site: Hörnli-Ridge of Matterhorn

Matterhorn, Hörnligrat (Zermatt, Switzerland)

- 3500 m a.s.l. (permafrost)
- Ice-containing clefts
- Large temperature gradients
- Rock fall 2003 (approx 1500 m³) with ice-containing scarp
- = measurement point

Gravity driven instabilities in high-alpine rock-slopes



Sensor setup to monitor changes

External changes:

PermaSenseL1-GPS (large scale)

- daily position accuracy:
 - 1-2 mm horizontal
 - 3-5 mm vertical
- ublox LEA-6T receiver
- wireless communication
- all-inside mast design
- remote configurable

Temperature

- rock surface
- at depth

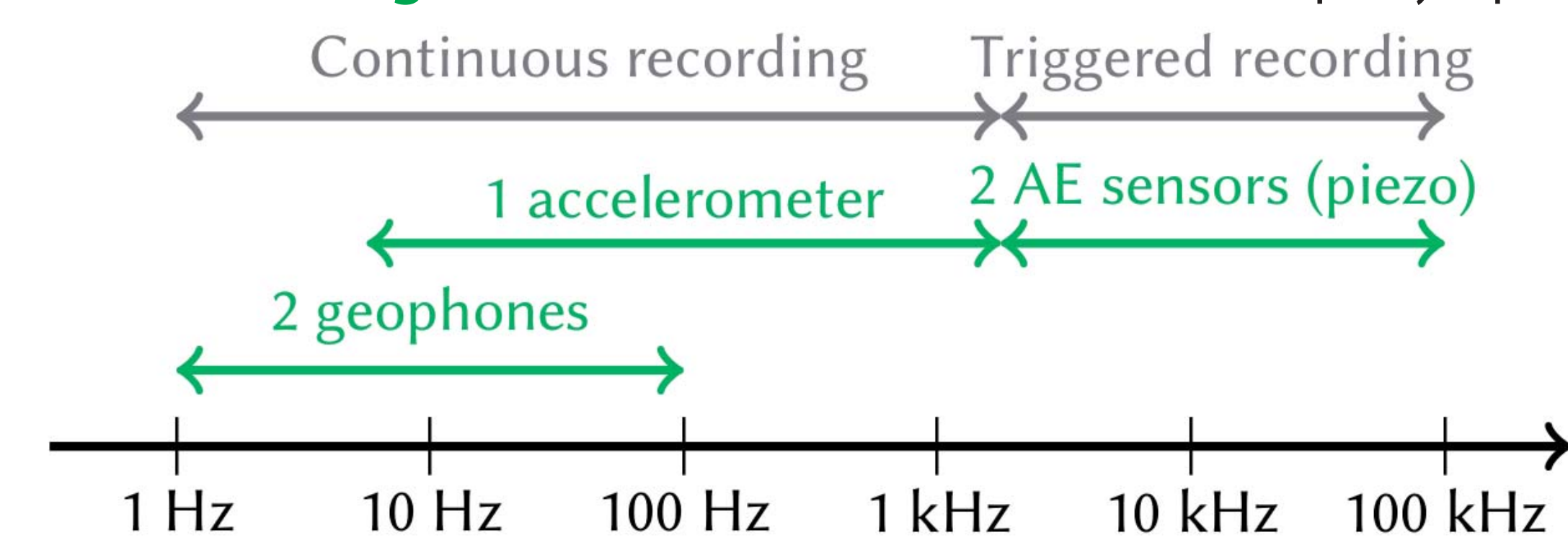
Camera

- Nikon D-300
- Axis

Weather station

- Vaisala WXT520

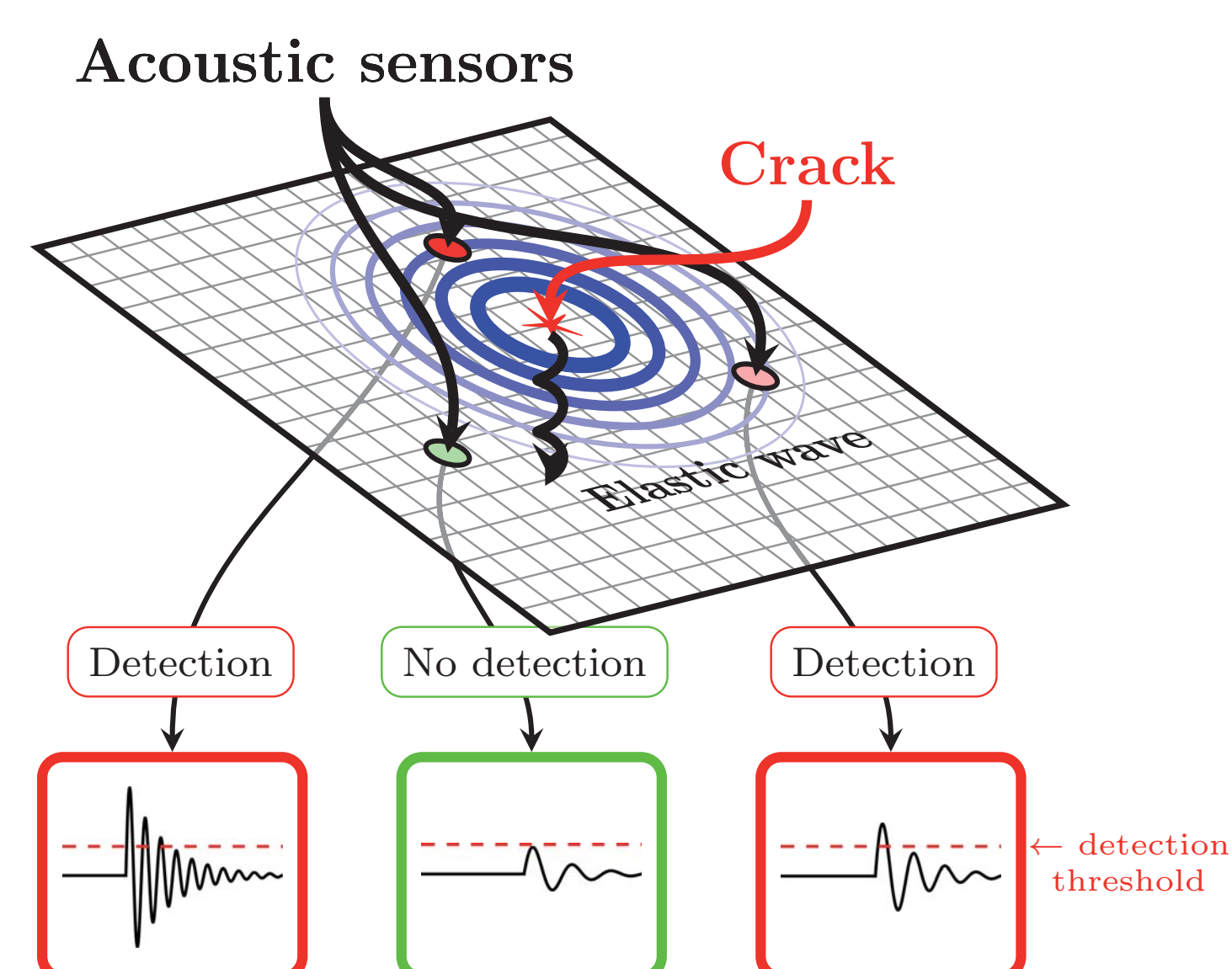
Internal changes: Acoustic/micro-seismic (scale frequency dependent)



Planned analysis - **attenuation**, codetection, size frequency distribution

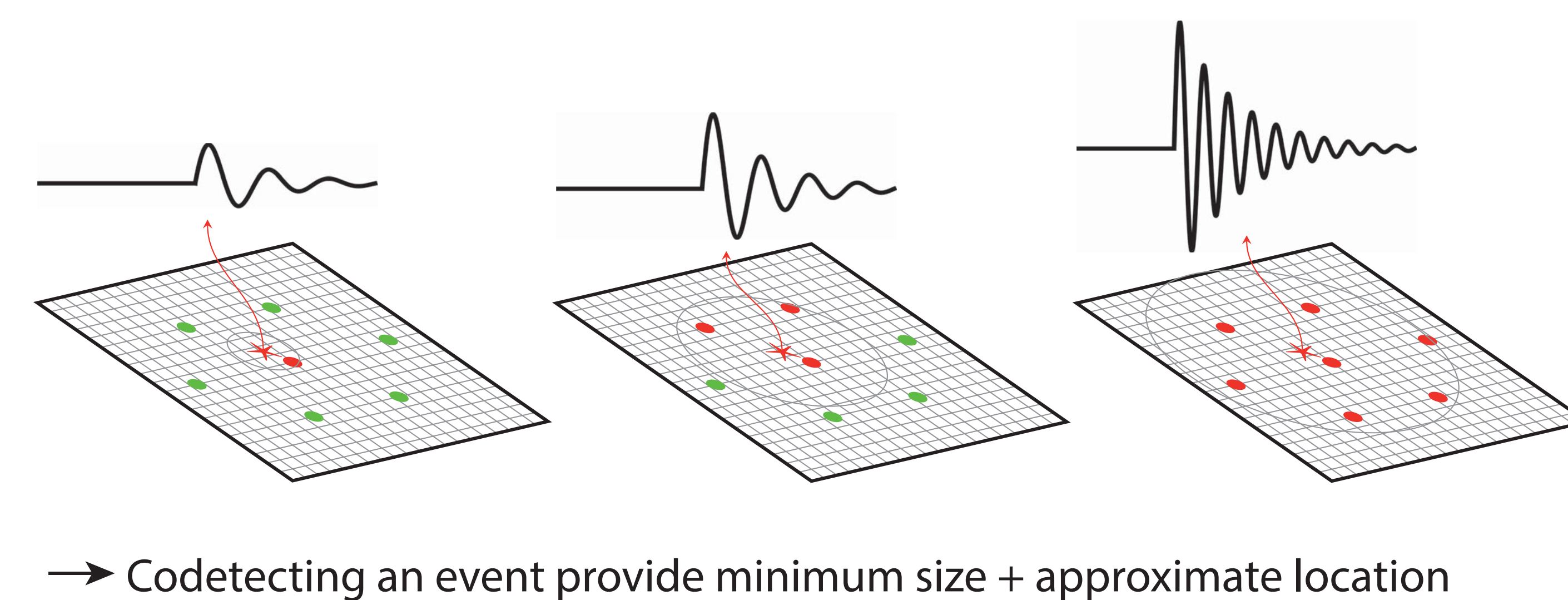
Attenuation

Natural medium = low pass filter,
depends on distance/size of source



Taking advantage of attenuation phenomenon: codetection

Simultaneous detection of an event by more than one sensor
only if its *initial size* is large enough (sensor network geometry + threshold)



Data analysis

e.g., *b*-exponent evolution in time

