Seismic noise and rotational component measurements

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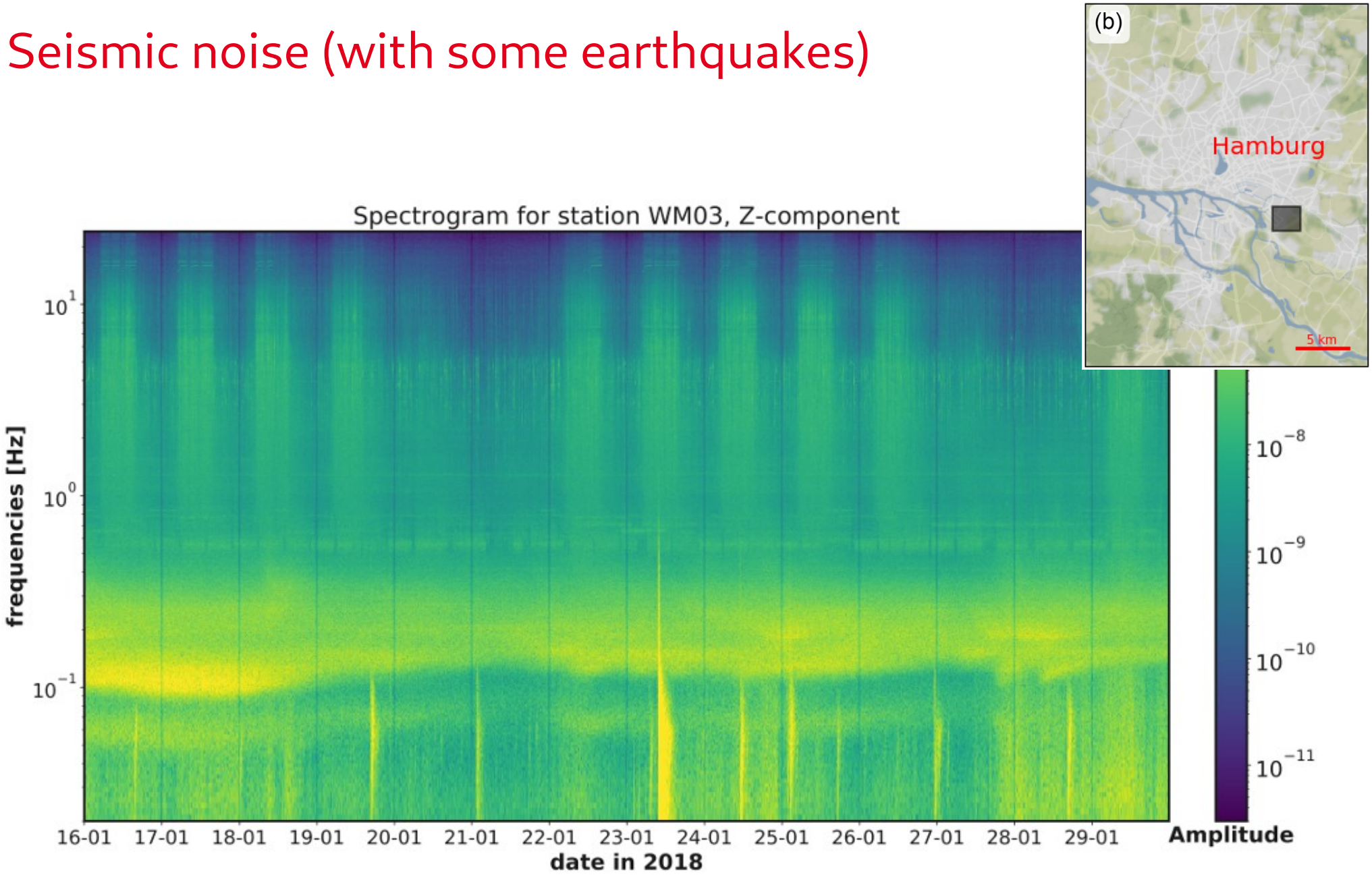
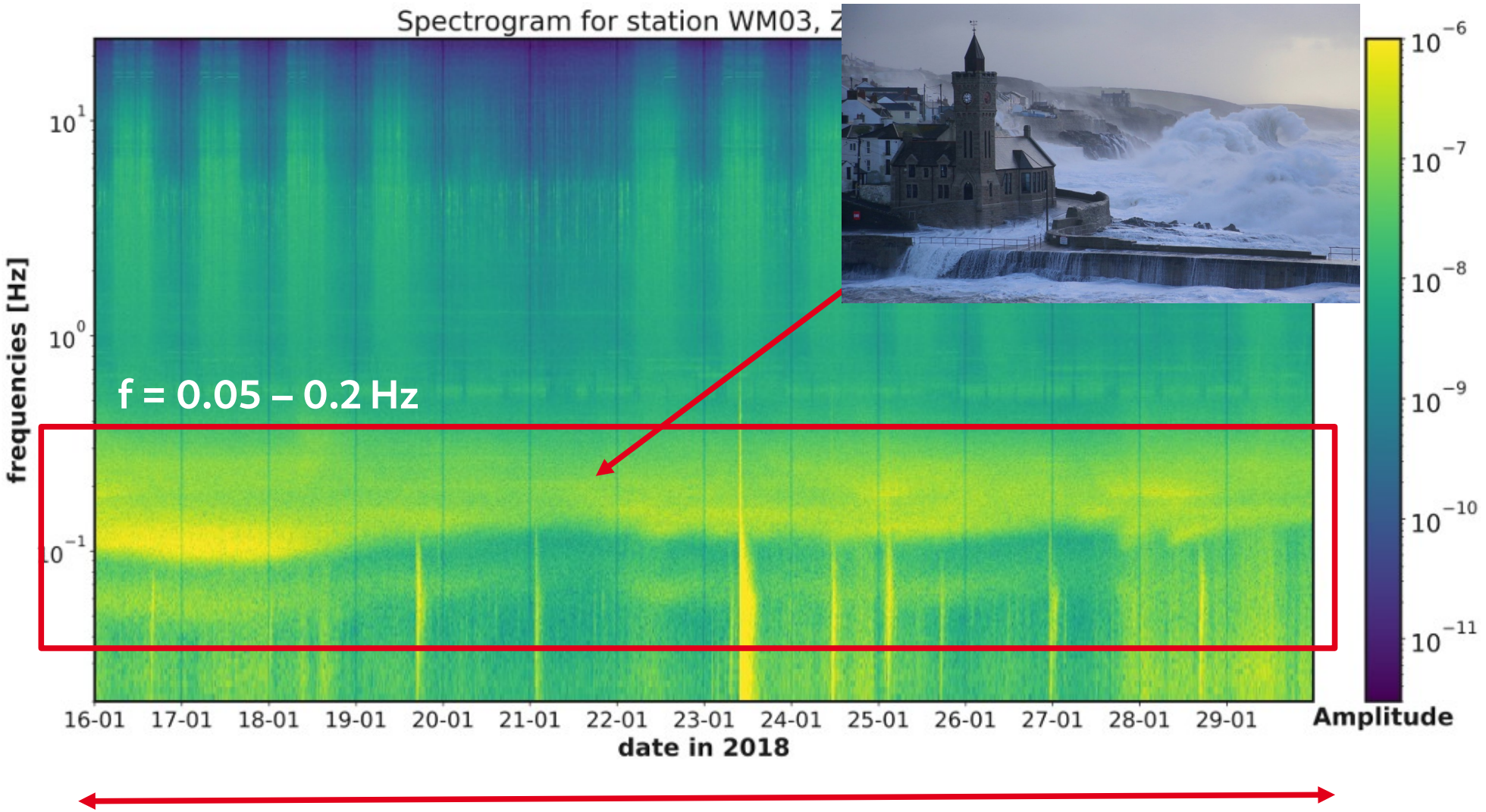
Seismic noise (with some earthquakes)



2 Weeks

*Steinmann et al., **2020**, GJI*
*Becker et al., **2020** JGR Solid Earth*

Seismic noise: carries imprint of the oceans



2 Weeks

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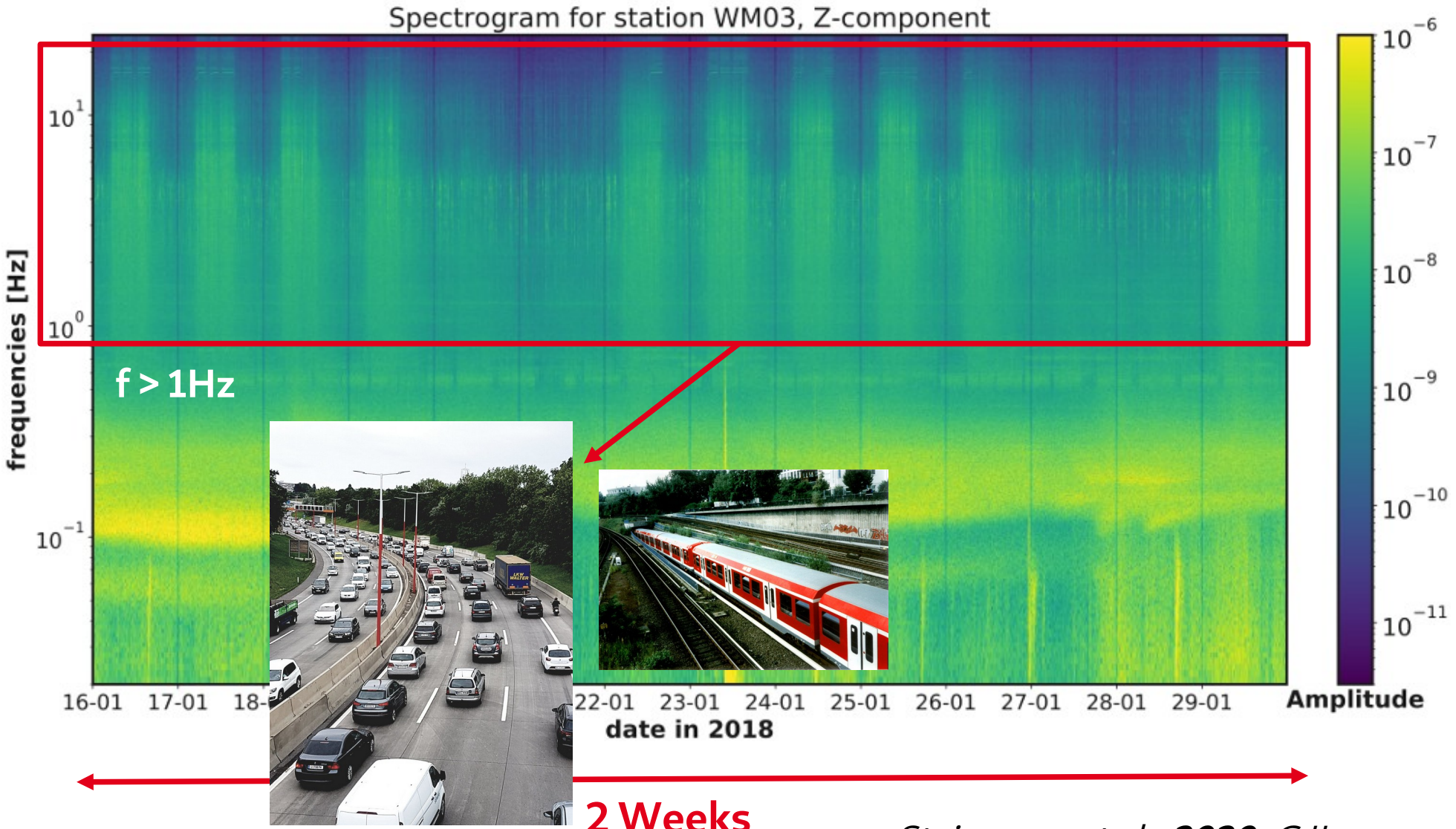
Seismic noise: carries imprint of human activity



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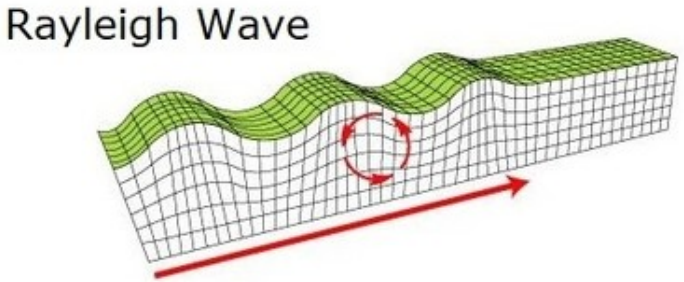
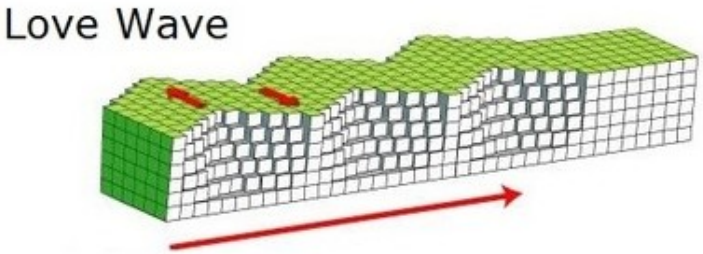
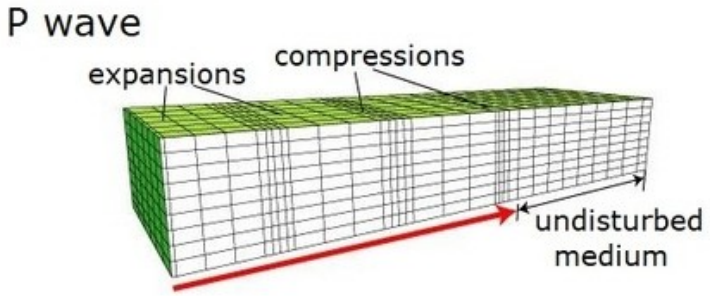
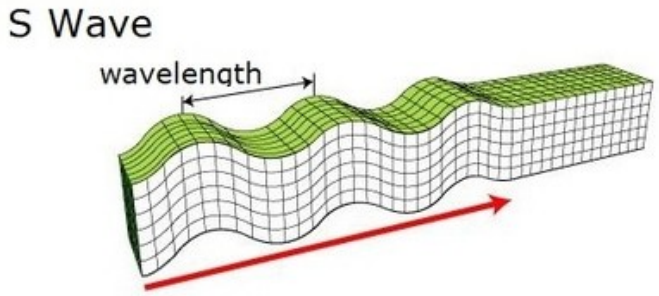
Becker et al., ***2020*** *JGR Solid Earth*

Seismic noise: different wave types, 'polarizations'









Surface waves:

- ground motion amplitude decays exponentially with depth
- most seismic noise composed of surface waves
- Rayleigh waves associated with tilting

Body waves:

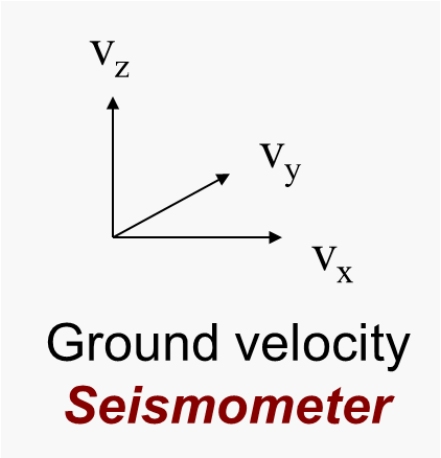
- Larger relative contribution to ground motion wavefield at depth
- Ocean activity generates some body waves
- Remote noise sources (e.g. storms) can be detected

Seismic noise: complete ground motion wave field?

Entire ground motion, all degrees of freedom

$$u(x+\delta x) = u(x) + \varepsilon\,\delta x + \omega \times \delta x$$

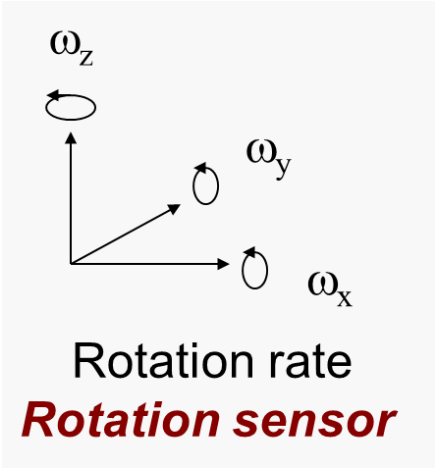
3C Translation + 6C Strain + 3C Rotation



Ground velocity

Seismometer

Strainmeter; DAS



Rotation rate

Rotation sensor

New sensor technology allows us to measure all 12 degrees of freedom

Seismic noise: complete ground motion wave field?

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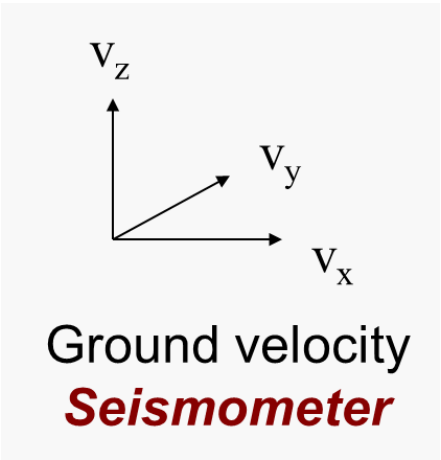

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Seismometer

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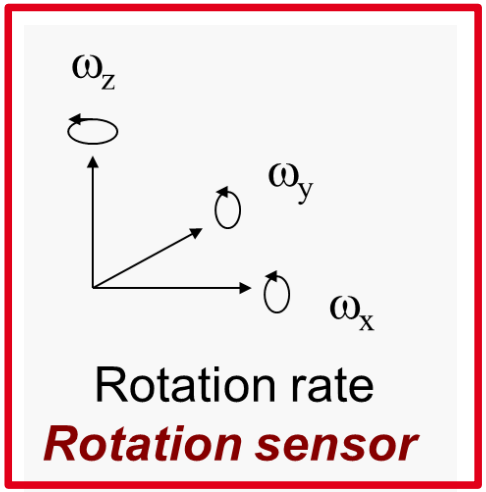


Rotation rate

Rotation sensor

New sensor technology allows us to measure all 12 degrees of freedom

Advantages of rotational motion:

- wavetype filter
- direction and phase velocity with single-station measurement

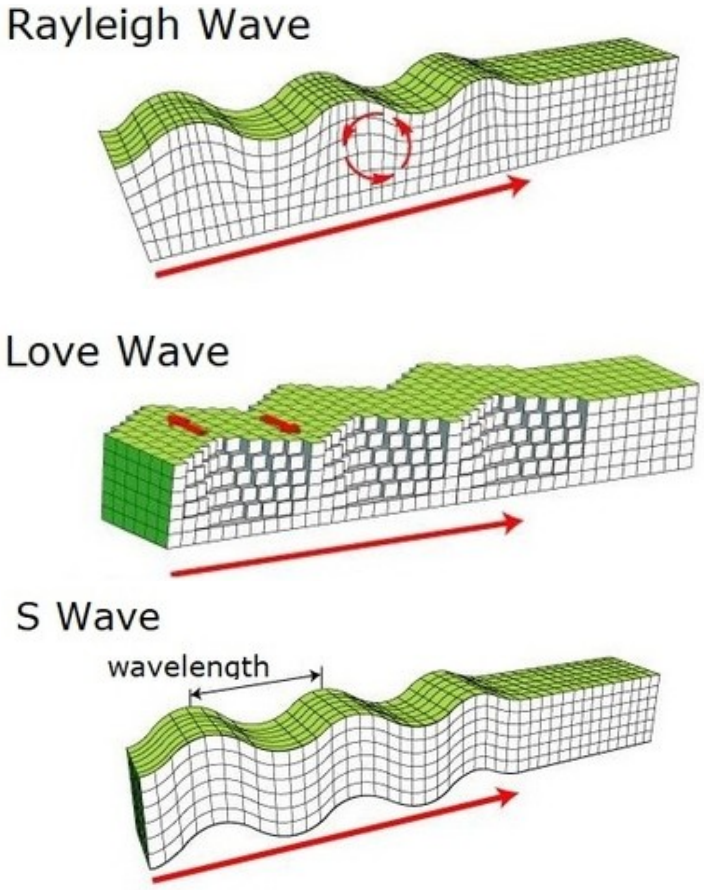
Advantages of rotational motion:

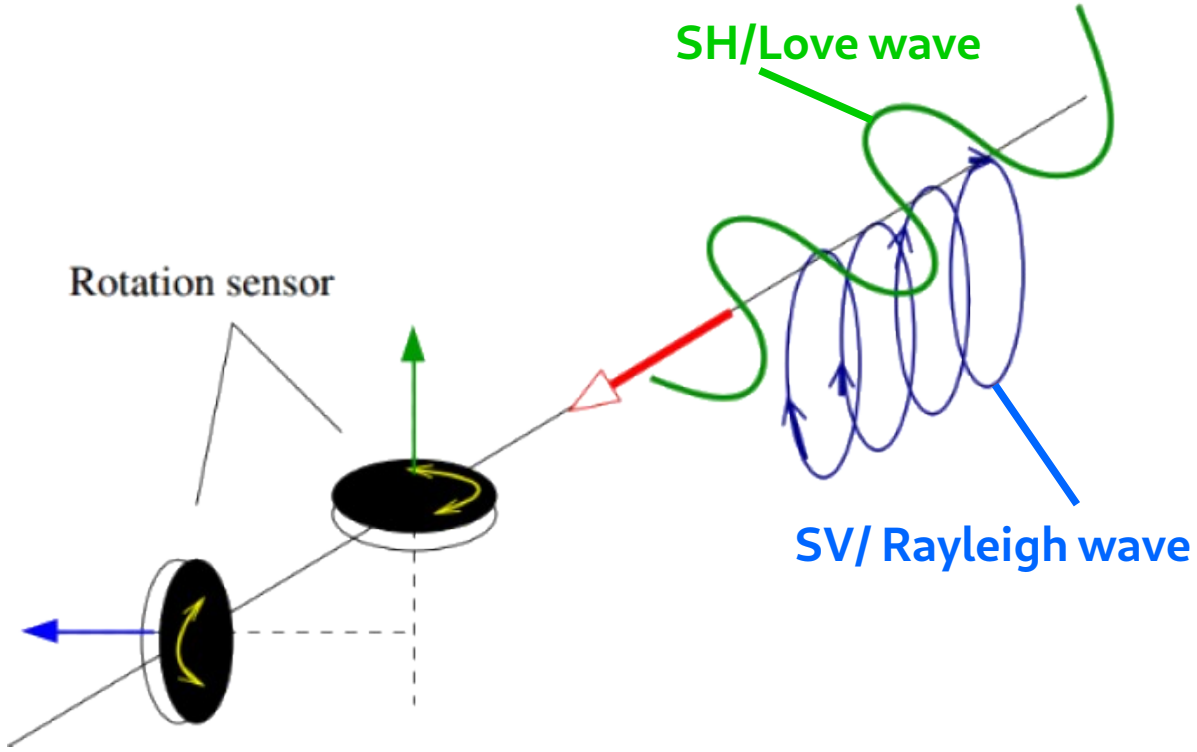
... acts as a wavetype filter

"Wavetype filter"

vertical rotation **records Love & SH waves**

horizontal rotation **records Rayleigh & SV waves**

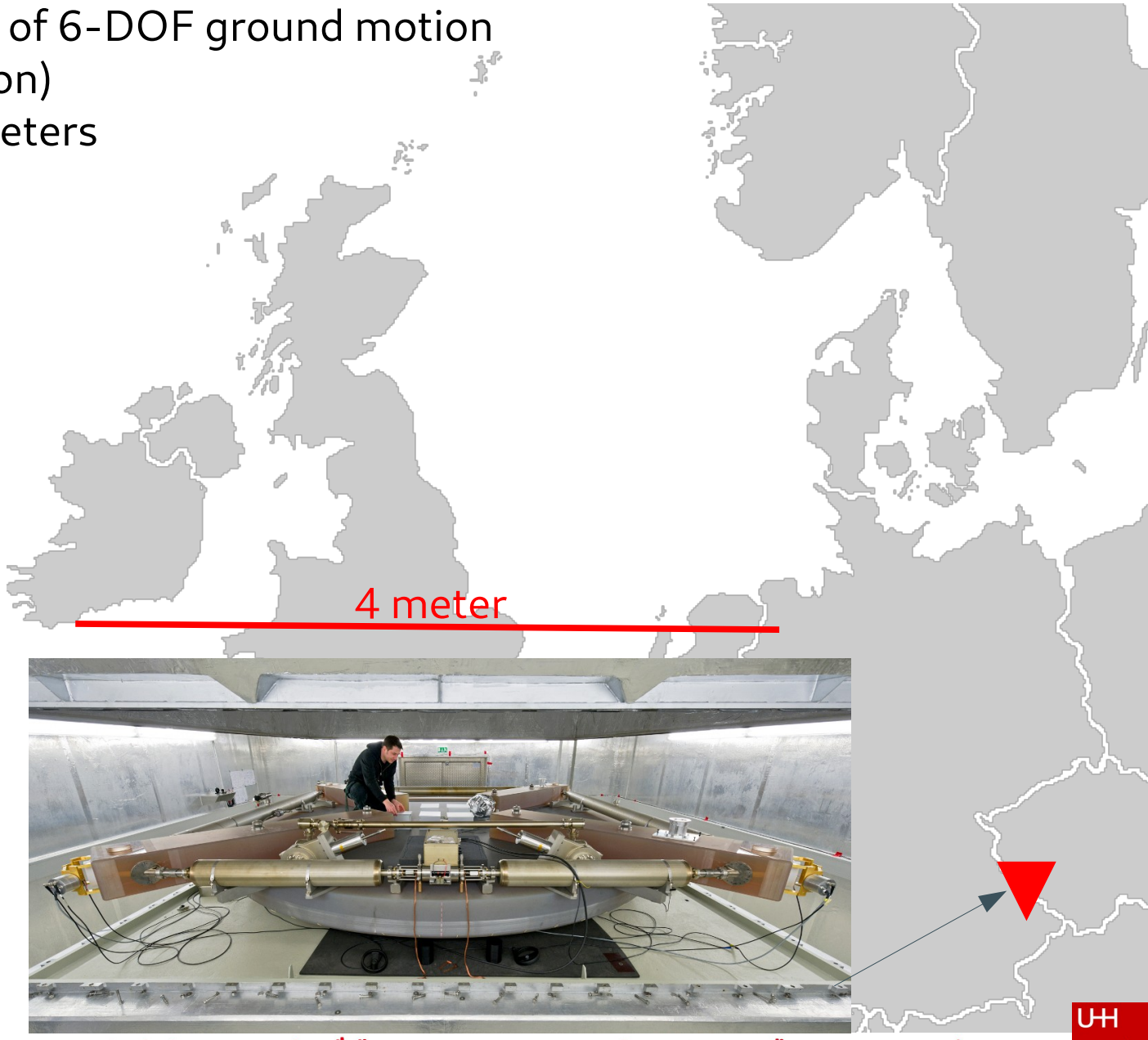




Advantages of rotational motion:

...direction and phase velocity with single-station measurement

Single point measurement of 6-DOF ground motion
(3C translation + 3C rotation)
... using Sagnac interferometers



Advantages of rotational motion:

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Single point measurement of 6-DOF ground motion
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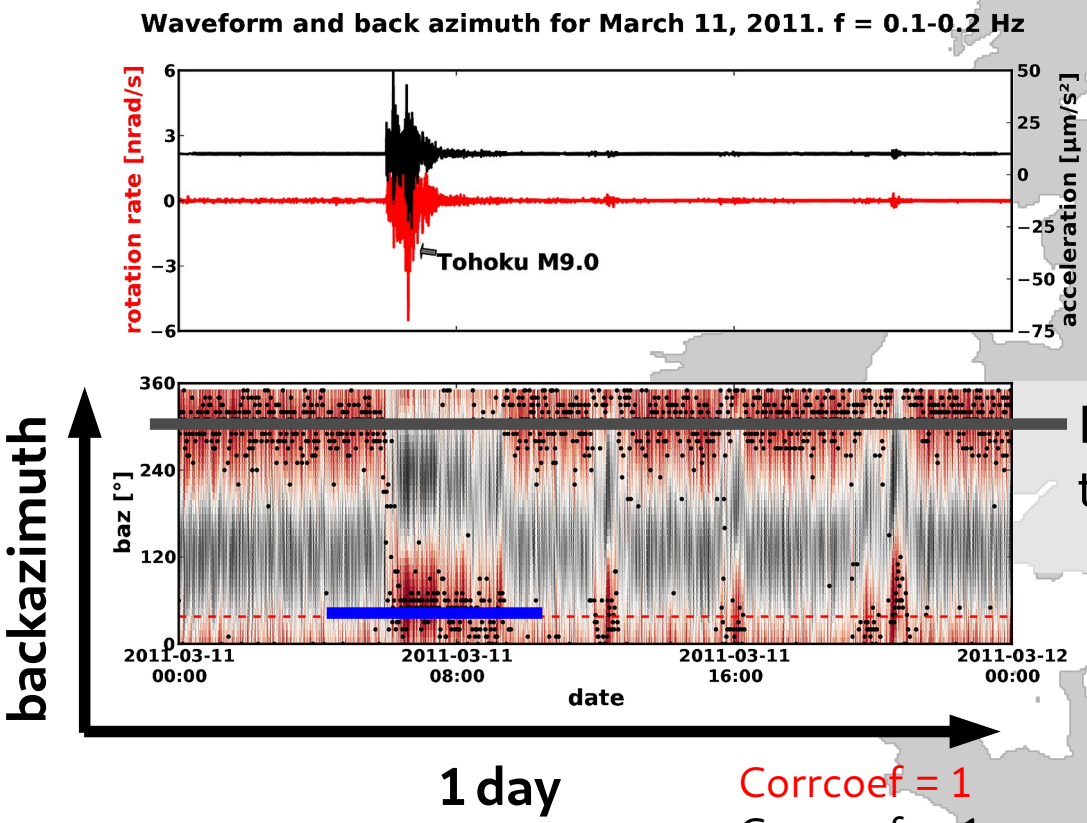
→ ***Seismic noise ..where does it come from?***

Filtered 0.1 – 0.2 Hz



Dominant noise source towards Northwest

2011 Tohoku earthquake

Ocean-generated seismic noise

Corrcoef = 1
Corrcoef = -1

Hadziioannou et al. 2012, SRL

Characterizing urban seismic noise

...how?

Characterize seismic noise in 6 degrees of freedom

using rotational sensors (FOG)
separate contributions from different wave types/polarization
direct access to source direction, wave speed

Currently: very **rapid development** of new sensor tech in seismology
and **associated methodology**
Other interesting development: using **train noise** as "opportunistic source"
→ contact me for references!

Field instruments
e.g. Fiber optic gyros

BlueSeis – iXBlue

Related projects:

Giotto: rotation sensors in buildings; seismology x civil engineering

SPIN: European (H2020) training & research network focused on developing methods to exploit new sensors *(ie. rotations, DAS, dense networks)* to their full potential

References

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Giotto: https://giotto.geophysik.uni-muenchen.de/

SPIN: http://spin-itn.eu/