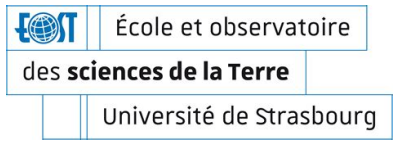
BROADBAND POSTHOLE SEISMOMETERS
FEEDBACK FROM THE FIELD

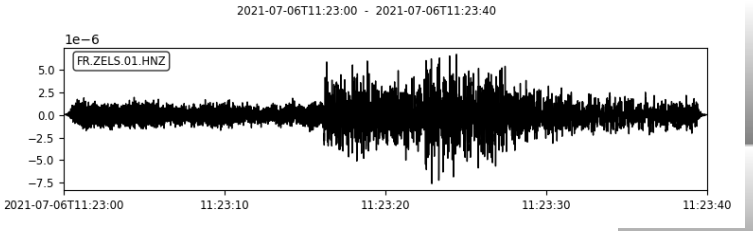
MAXIME BÈS DE BERC

GEOSCOPE OBSERVATORY 40TH ANNIVERSARY

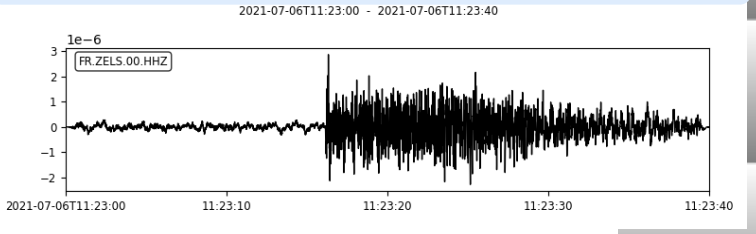


WHY POSTHOLE SEISMOMETERS ?

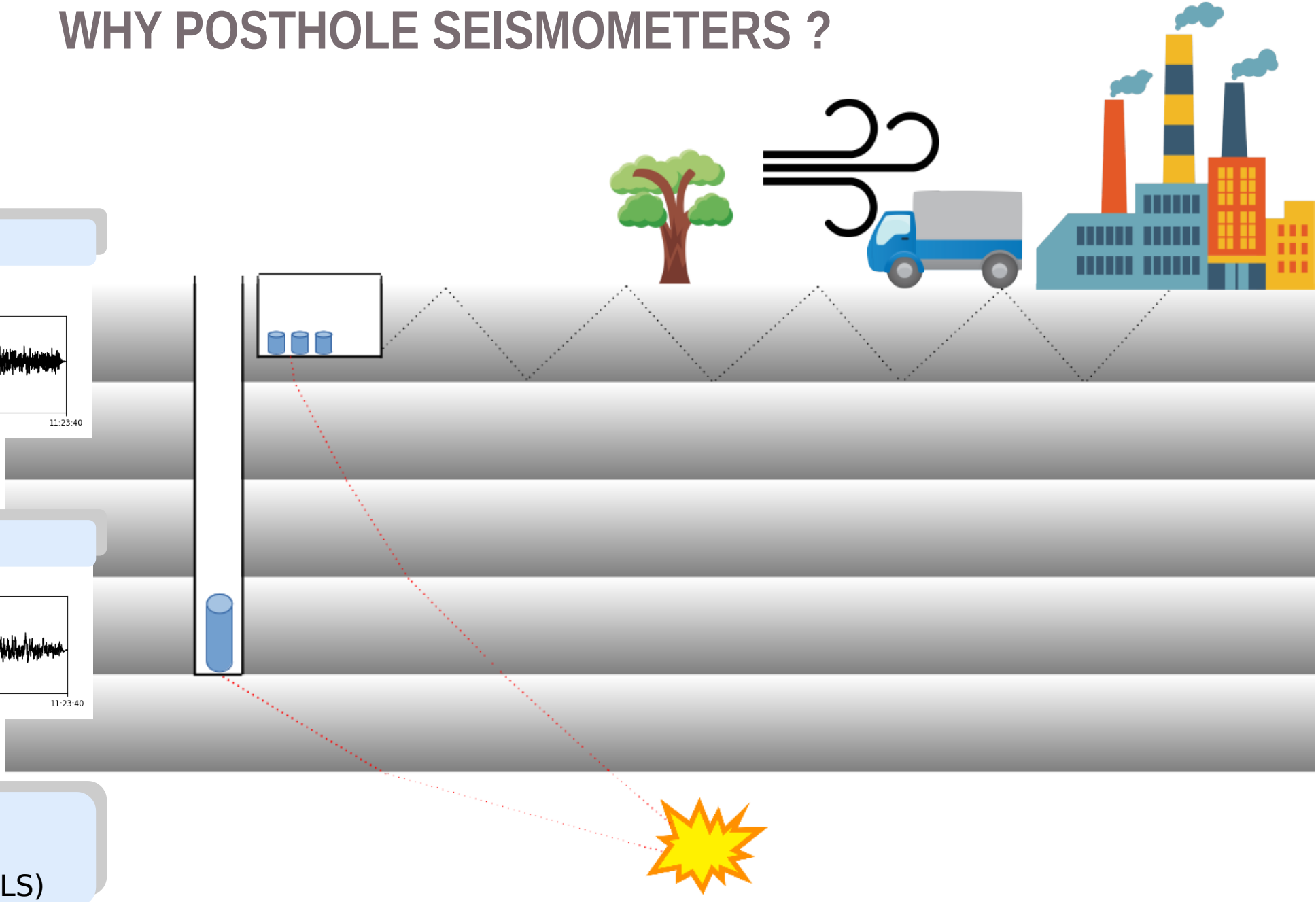
surface



depth 45m



MLv 2.4 Strasbourg
2021/07/06
recorded at 30 km (FR.ZELS)



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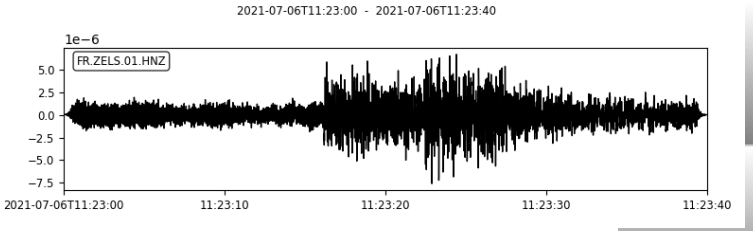

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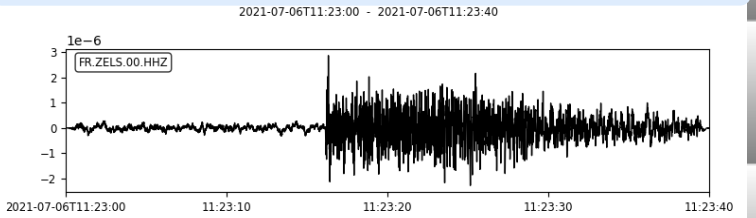

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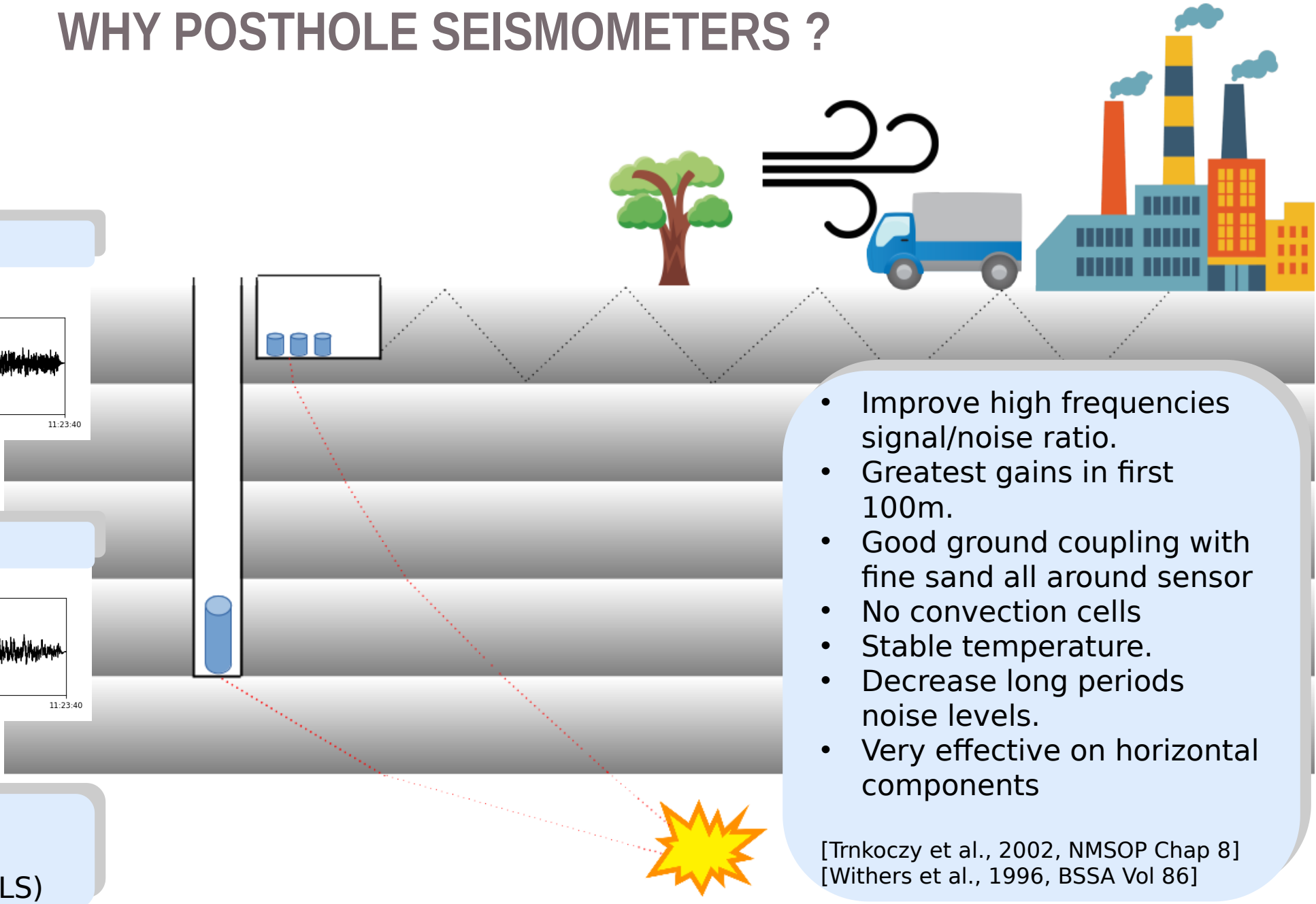


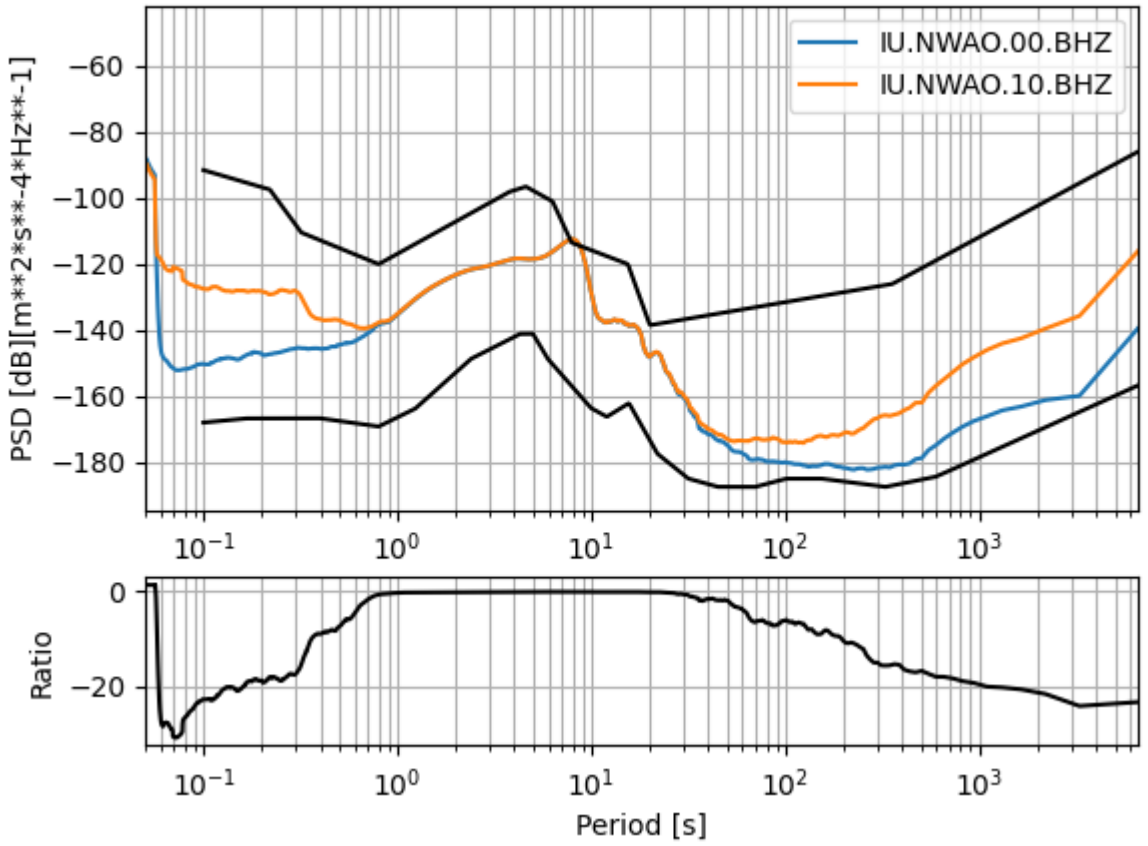
- Improve high frequencies signal/noise ratio.
- Greatest gains in first 100m.
- Good ground coupling with fine sand all around sensor
- No convection cells
- Stable temperature.
- Decrease long periods noise levels.
- Very effective on horizontal components

[Trnkoczy et al., 2002, NMSOP Chap 8]
[Withers et al., 1996, BSSA Vol 86]

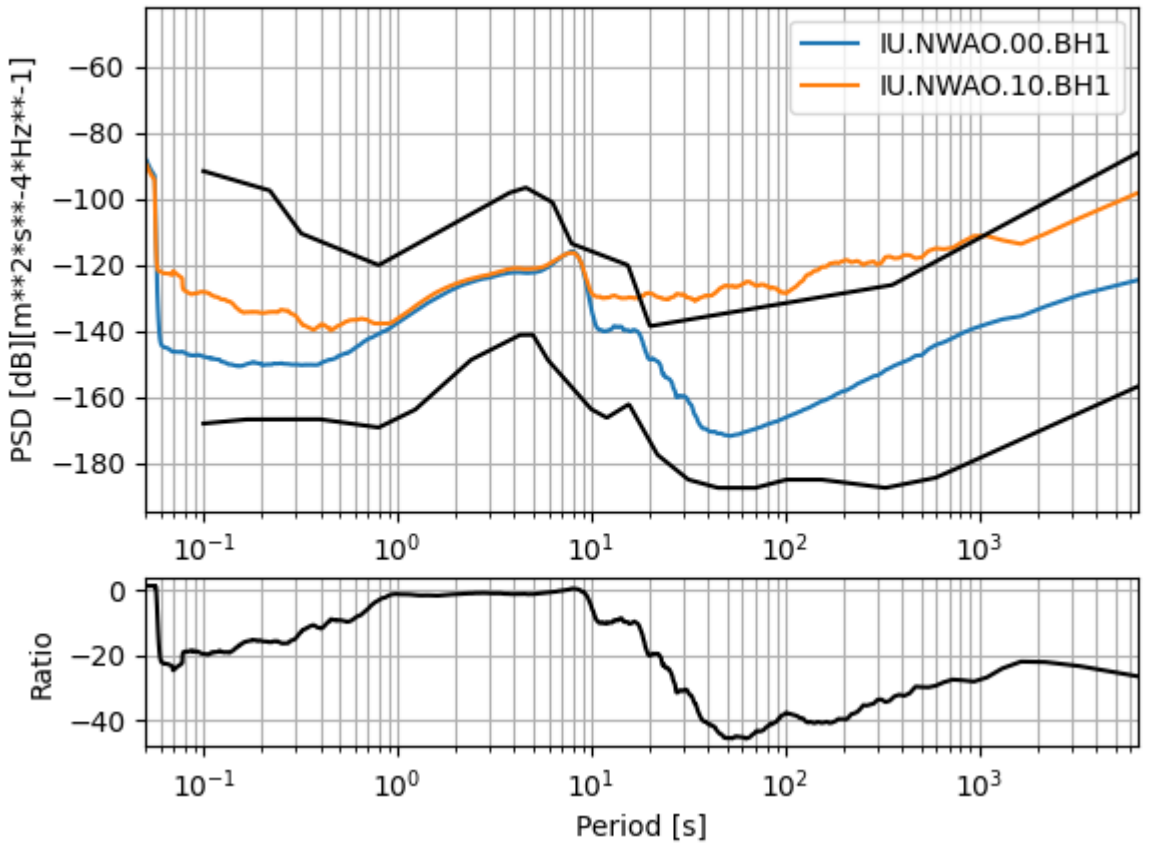
WHY POSTHOLE SEISMOMETERS ?

Power Spectral Densities of 100m-deep posthole (blue) vs surface (orange) seismometers
IU.NWAO (GSN Network) / 24 hours length (2022-06-23)

Vertical



Horizontal



RESIF-RLBP : POSTHOLES AS STANDARD

2010

2022

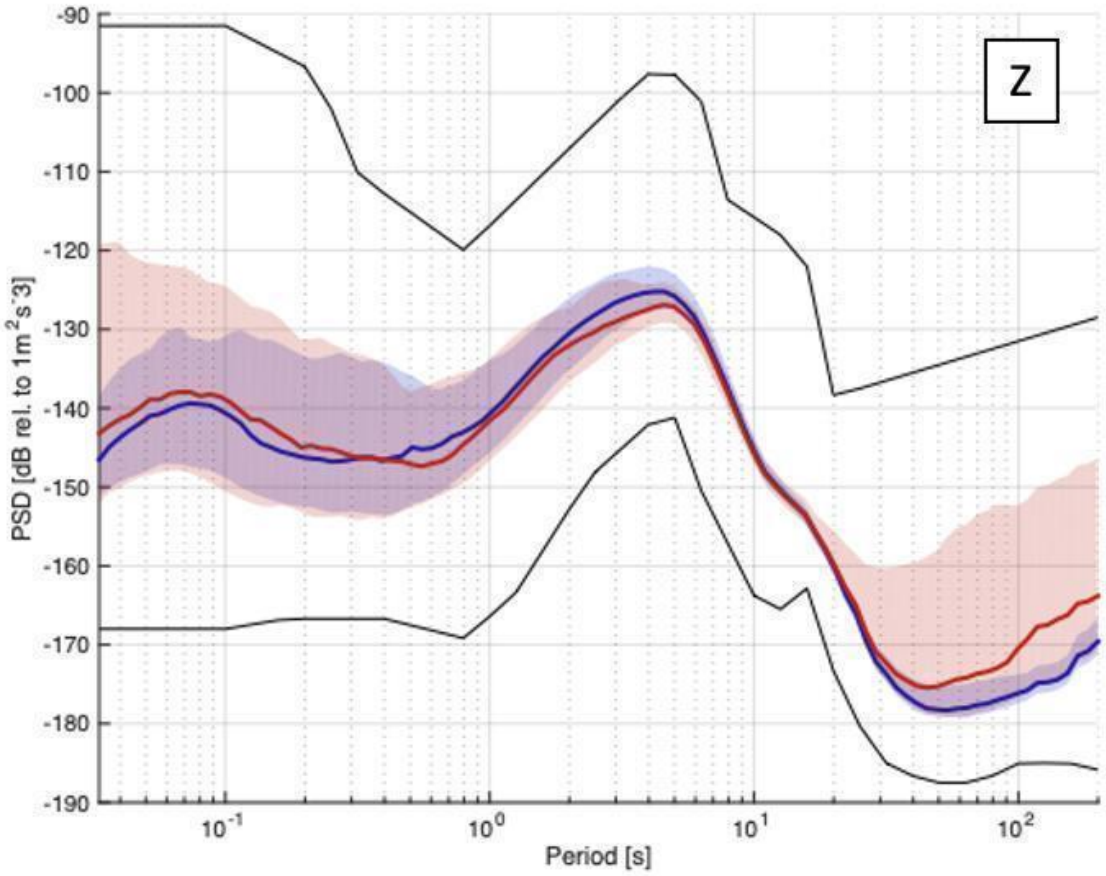
- Borehole seismometers are more expensive (+50%)
- Shallow borehole is much cheaper than a vault in free field

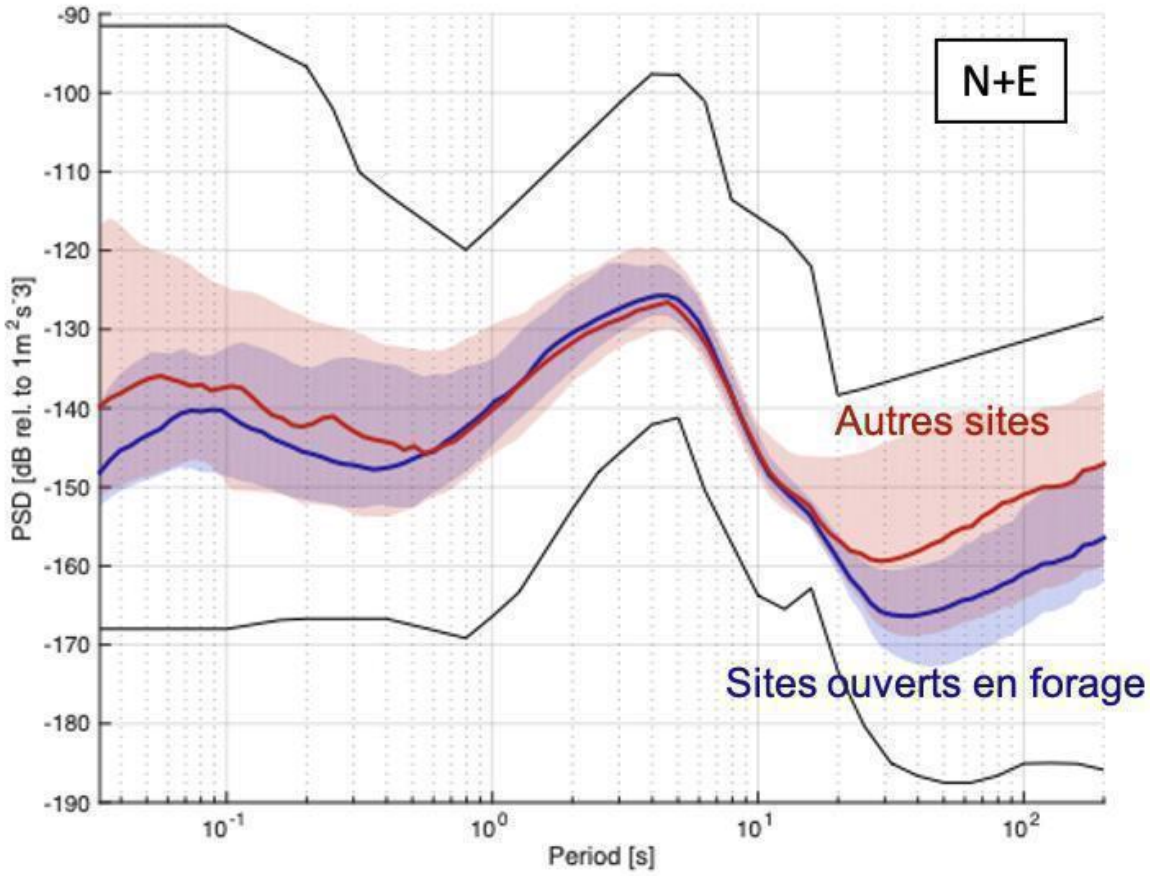
“A 15-m deep surface vault in a difficult terrain may cost more than a shallow borehole of the same depth”
[Trnkoczy et al., 2002, NMSOP Chap 8]

- ~70% boreholes
- Needs specific borehole driller (people & machine)
- Standard depth 6m, can be extended down to 18m according to local geology
- 4 days at 3 people
- 50 k€/station (all inclusive)

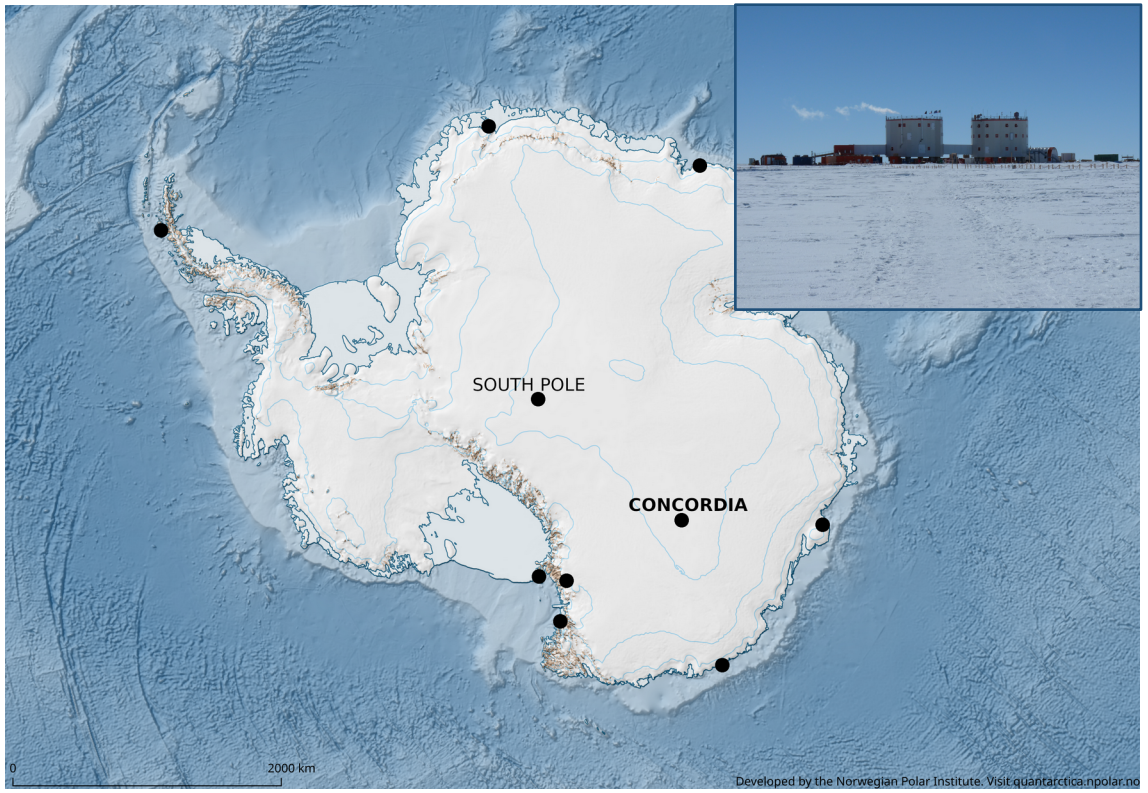
RESIF-RLBP : POSTHOLES AS STANDARD

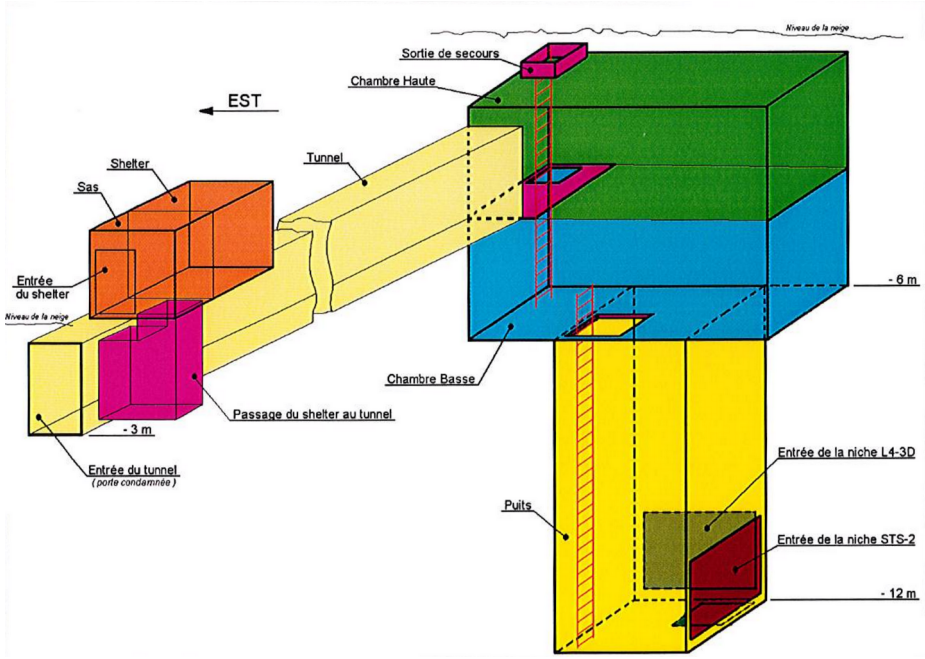
Median noise of 58 boreholes stations (blue) and 56 surface stations (red)





POSTHOLE WITHIN GEOSCOPE : THE CONCORDIA CASE

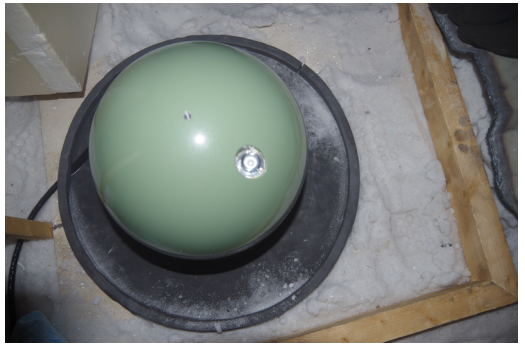




‘Historic’ infrastructure

Concordia, Antarctica:

- Franco-Italian permanent facility
- One of the 2 broadband stations on inlandsis
- Alt. 3200m, Mean T -55°C, Mean P 640 mbar



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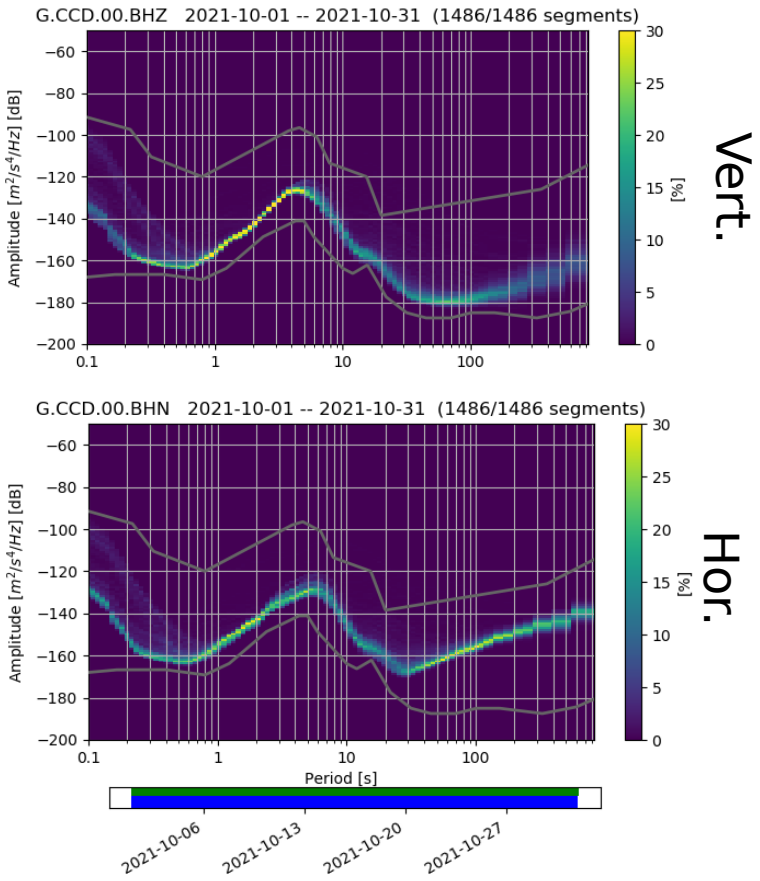
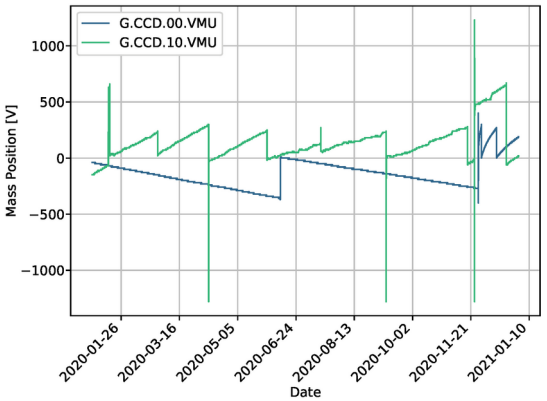
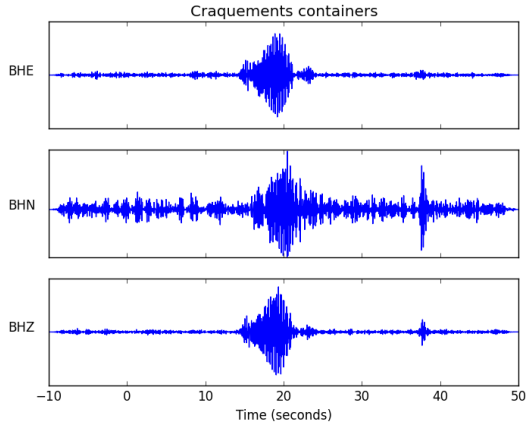


Probabilitic Power Spectra Density

Snow accumulation between 2002 to 2019

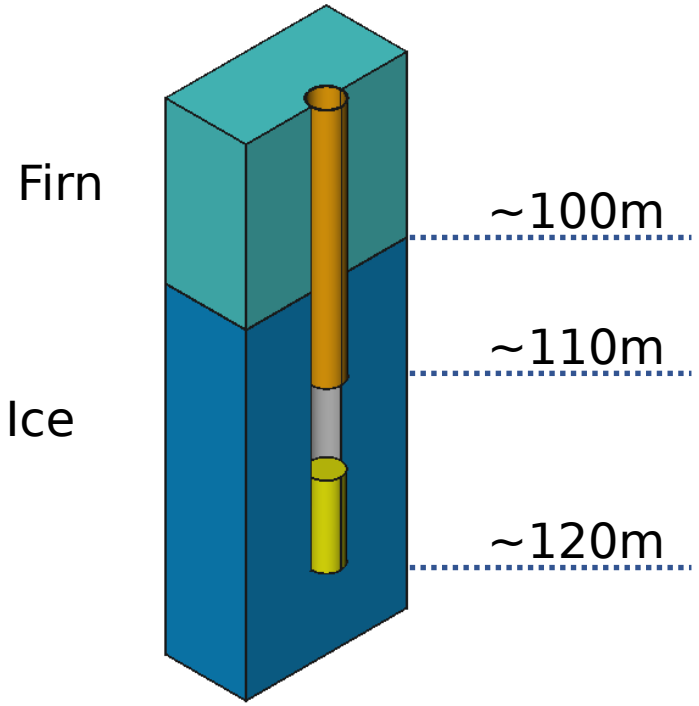


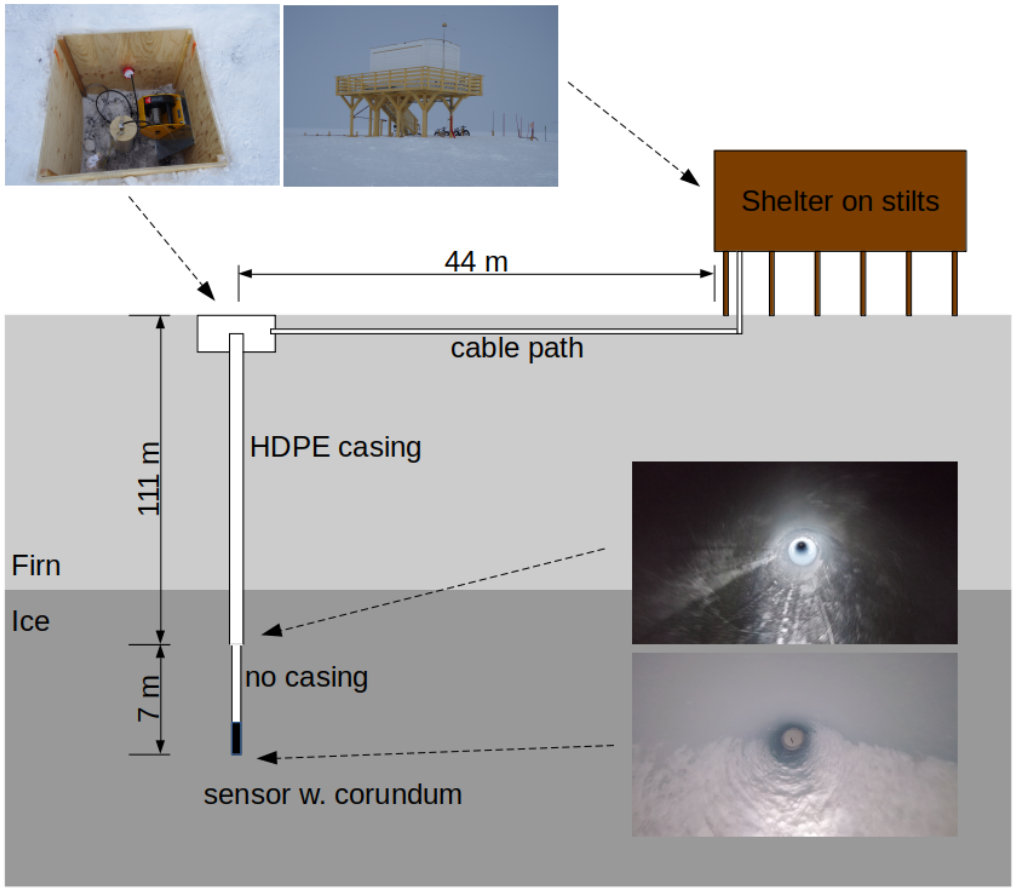
MPOS drift



Cave distortion and μ events

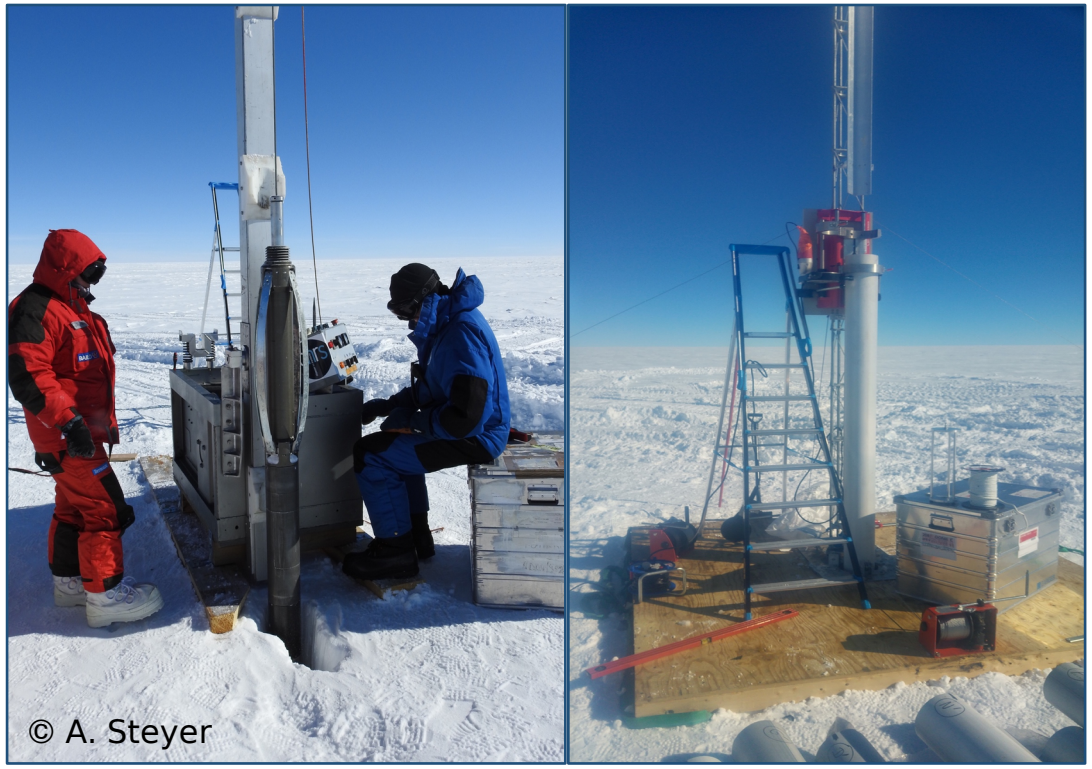
POSTHOLE WITHIN GEOSCOPE : THE CONCORDIA CASE



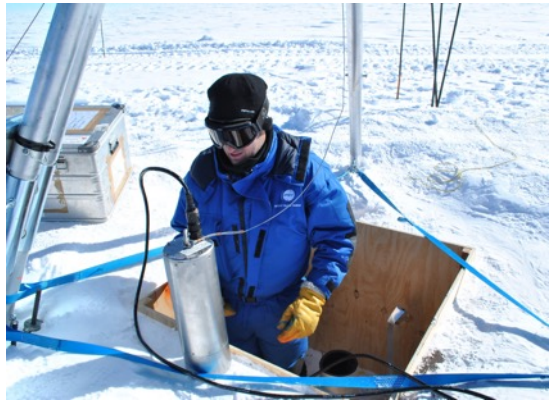


Infrastructure design
Sensor at 120m below firn layer

POSTHOLE WITHIN GEOSCOPE : THE CONCORDIA CASE


© A. Steyer

Drilling & casing (2019)


© D. Zigone

Sensor installation (2020)

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INSTITUT POLAIRE FRANÇAIS PAUL-ÉMILE VICTOR

PROGRAMMA NAZIONALE DI RICERCHE IN ANTARTIDE ITALIANTARTIDE

École et observatoire des sciences de la Terre Université de Strasbourg

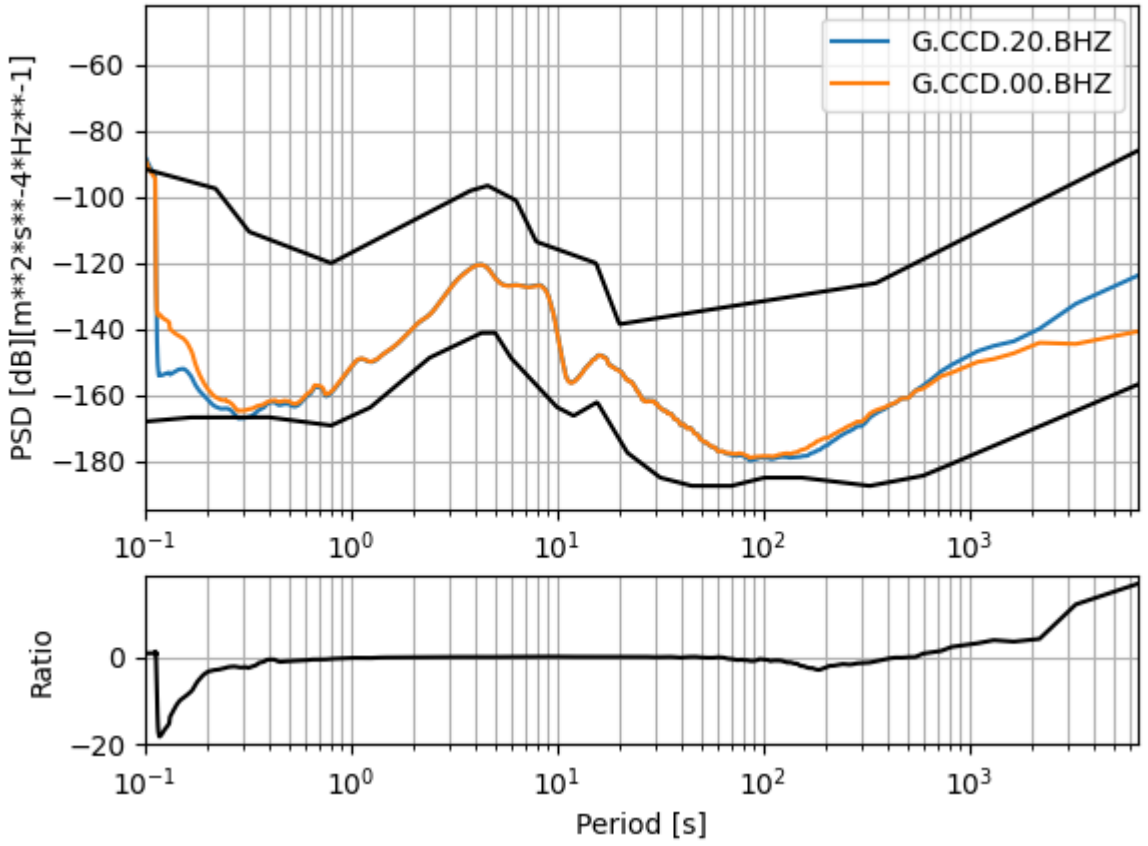
INGV

geoscope

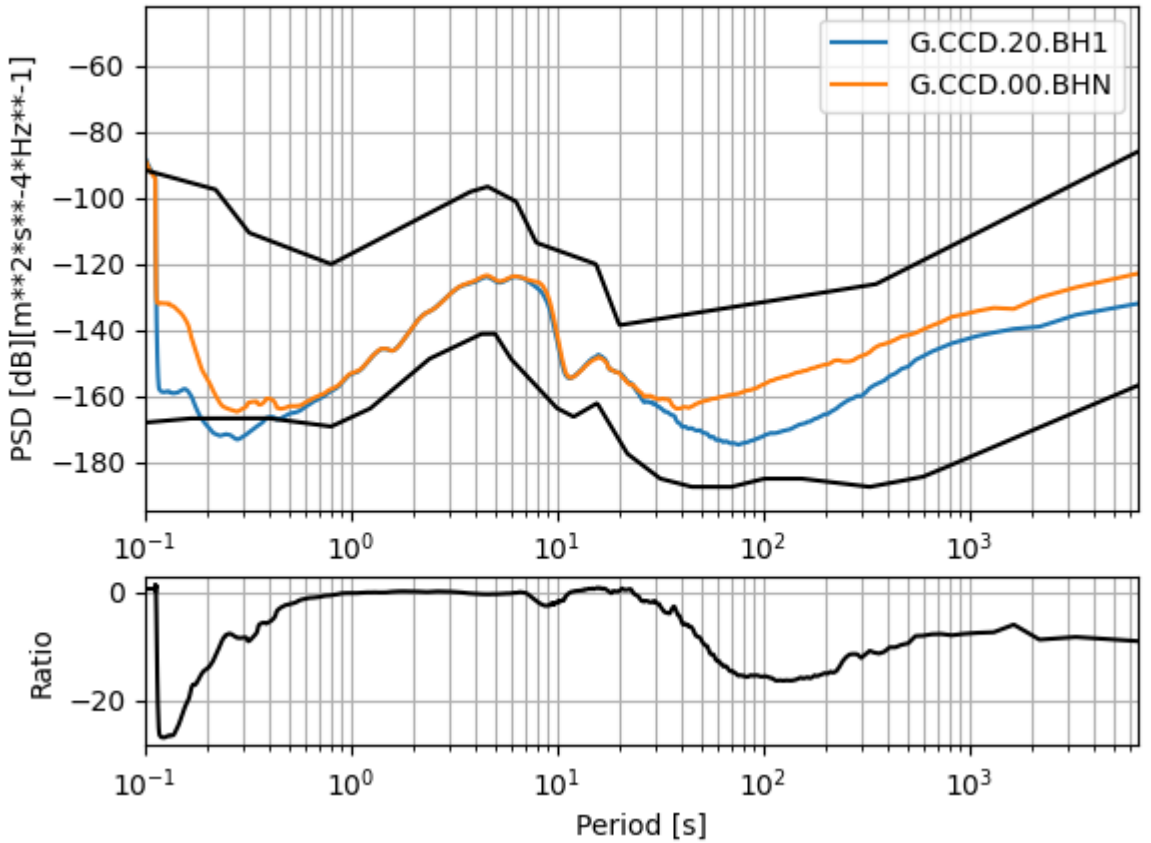
POSTHOLE AT CONCORDIA : RESULTS

Power Spectral Densities surface (orange) vs posthole (blue)
24 hours length (2022-06-23)

Vertical



Horizontal

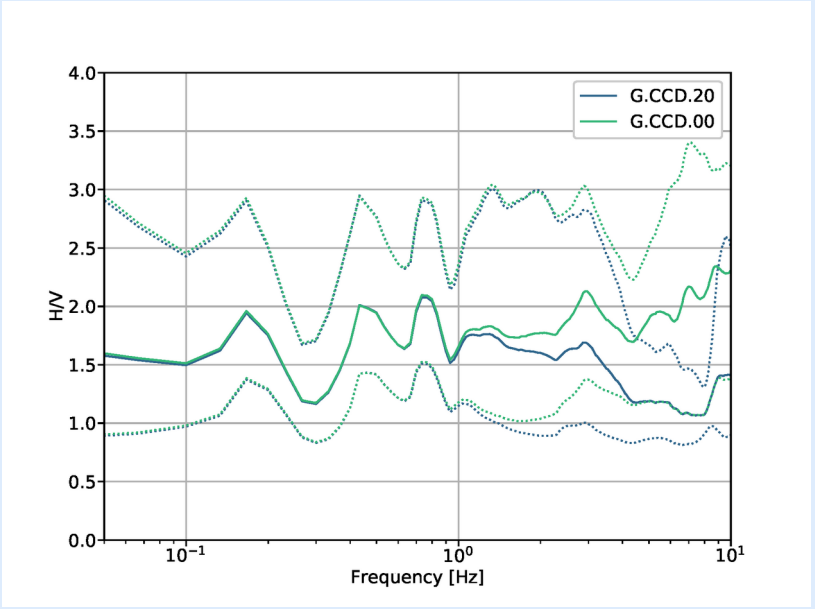


POSTHOLE AT CONCORDIA : RESULTS

Overall results

- High frequencies noise level is reduced (down to NLNM or below at 4Hz)
- Mass positions remain stable, no recentering since 2 years, providing excellent data continuity
- Gain is spectacular on horizontal components on long-periods
- H/V show firn resonance attenuation at high frequencies

[Lévêque, J.-J., Maggi, A., & Souriau, A. 2010. Seismological constraints on ice properties at Dome C, Antarctica, from horizontal to vertical spectral ratios. Antarctic Science, 22(5): 572–579.]



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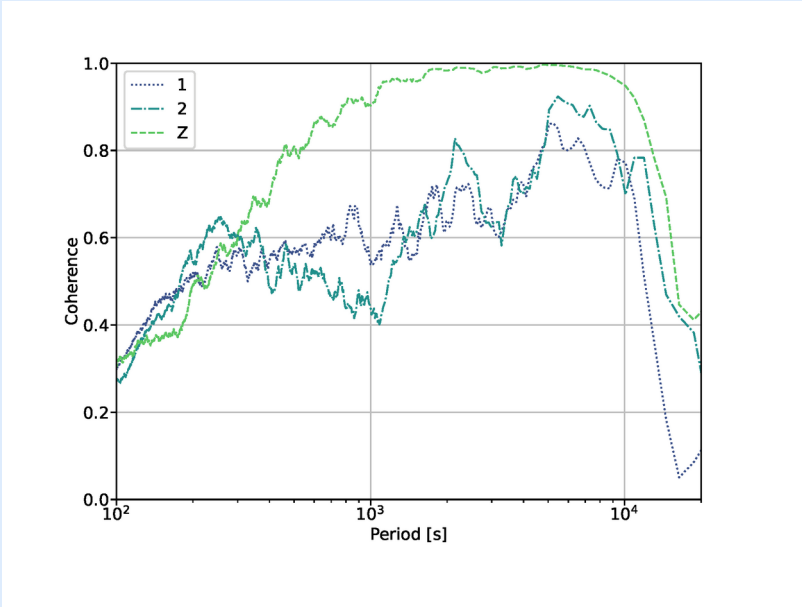

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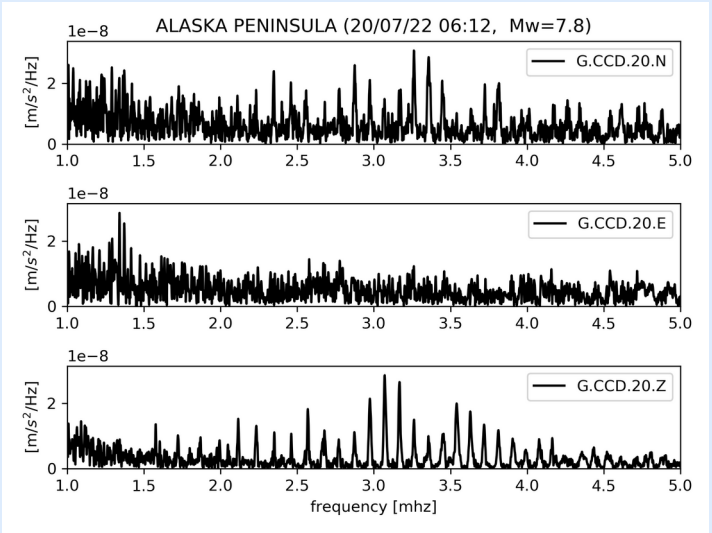
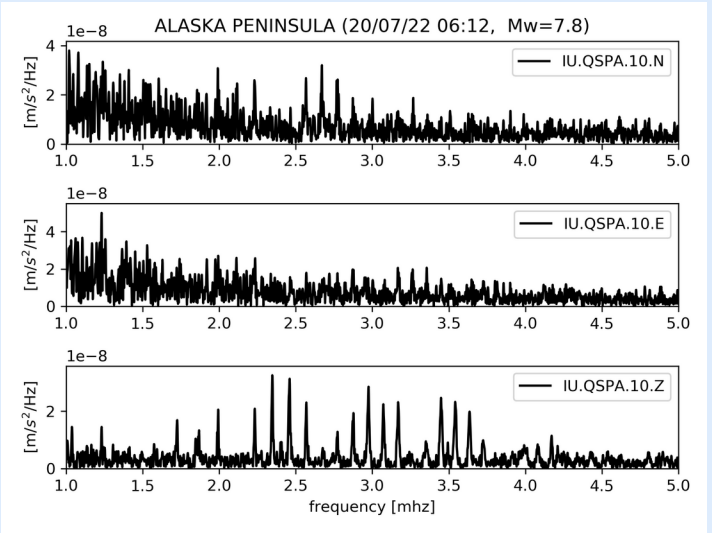
- H/V show firn resonance attenuation at high frequencies
- Strong coherency between data and atmospheric pressure (close to 1 for vert. Component).
- Provides good data for Earth Modes studies, even for horizontal components.

[Lambotte, 2021, Personal communication]



Concordia



South Pole

CONCLUSIONS

- Postholes are a technical good solution for economic issues when building a new station, even if the sensor itself is more expensive
- No need to drill very deep to obtain gain in noise levels
- Building posthole station requires suitable people and suitable machines
- Provides observatory-grade data, with continuity and stability
- May be standardized if scientific perspectives relies on low-noise horizontal long-periods
- Influence of atmospheric pressure should be deeply studied

BON APPÉTIT