OBS Seismology:

The ambient noise characteristics in the ocean bottom environment offshore Taiwan

分析寬頻海底地震儀資料探討台灣海域背景噪音特徵

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Advisor : Pei-Ying Patty Lin 林佩瑩

Motivations

- OBS data often contains significant noise sources that happens in the water column.
- Spectrum analysis can be used characterize the background noise signals at different region.

Ocean Bottom Seismograph (OBS)

Battery +
Data logger

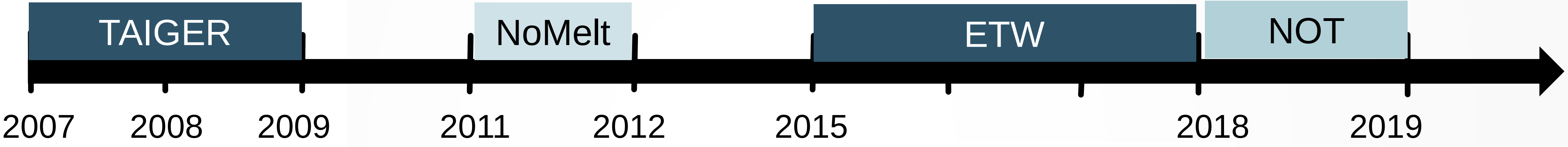
電池＋記錄器

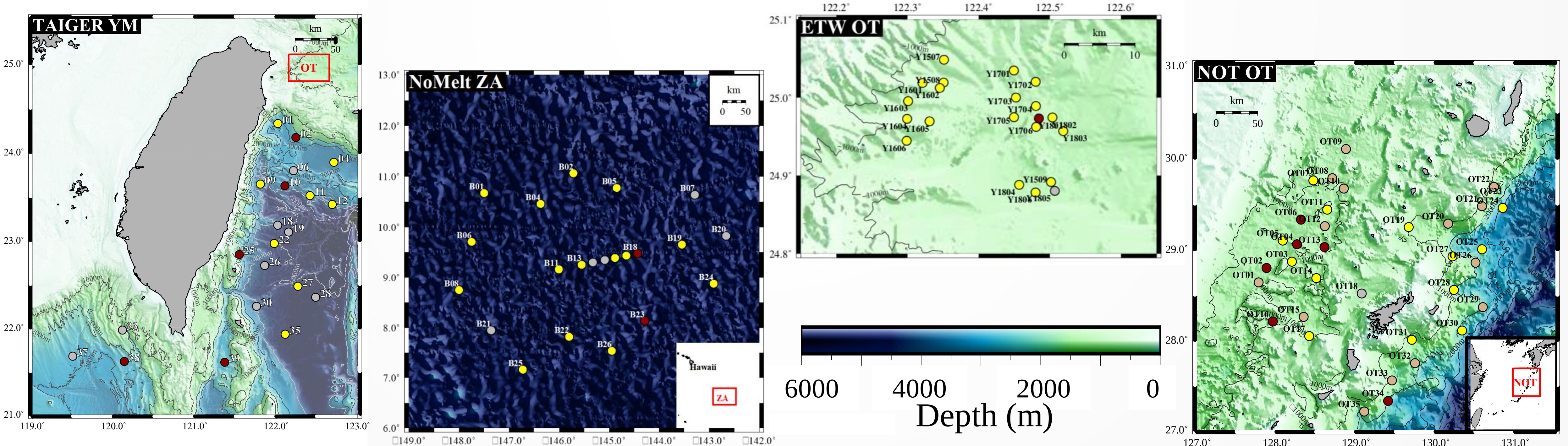
Broadband
Sensor
(3 components)

寬頻感震器

Objectives

- We analyze data from OBS deployed in northeastern (ETW) and eastern Taiwan (TAIGER project) to investigate the ambient noise characteristics near offshore Taiwan.
- We also compare the ambient noise characteristic in central pacific (NoMelt project) and north Okinawa Trough (NOT project)

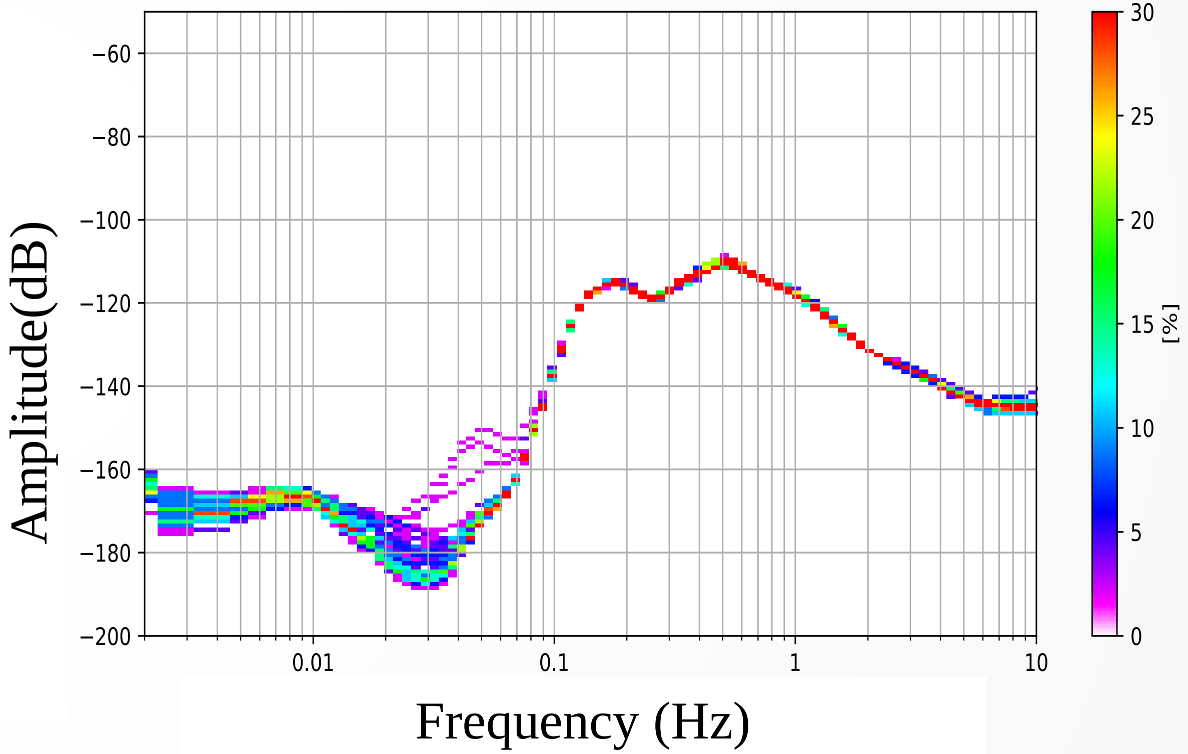




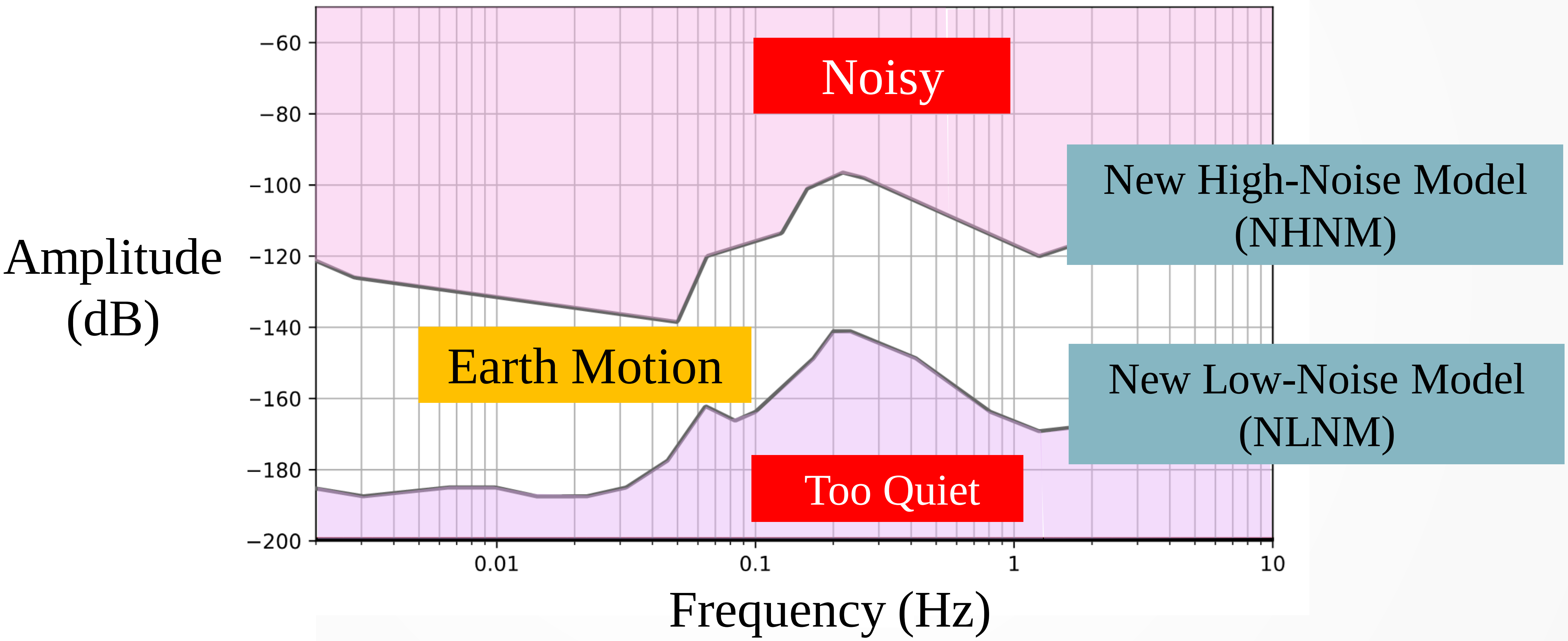
Power Spectral Densities (PSD)

showing the noise spectra of the data as function of frequency

- Can be used to observe long-term noise level variations
  - ✓ Instrument problems
  - ✓ Station location environment
  - ✓ Ocean wave strength
  - ✓ Seasonal variations
  - ✓ Earthquake



Power Spectral Densities (PSD)



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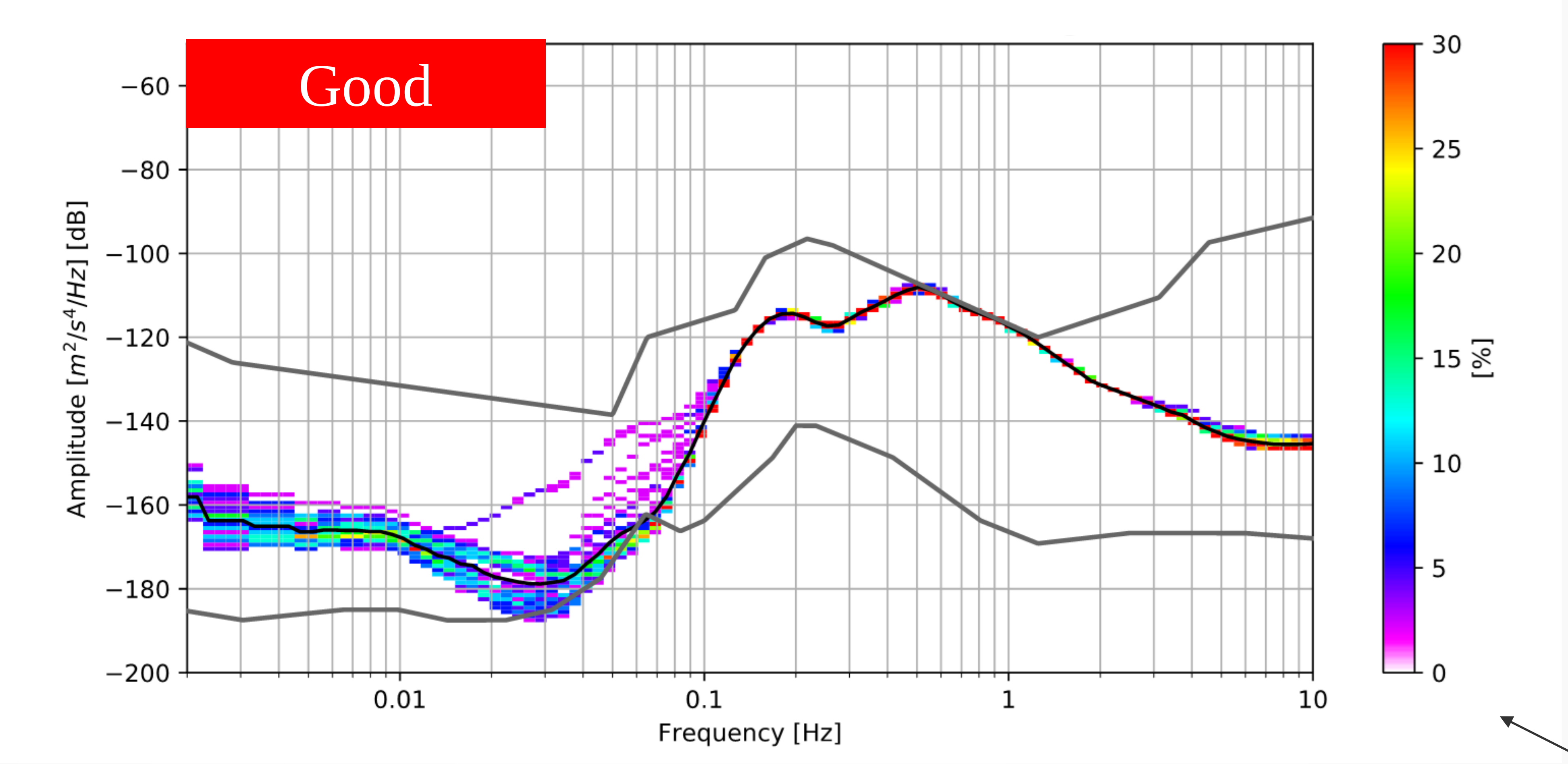

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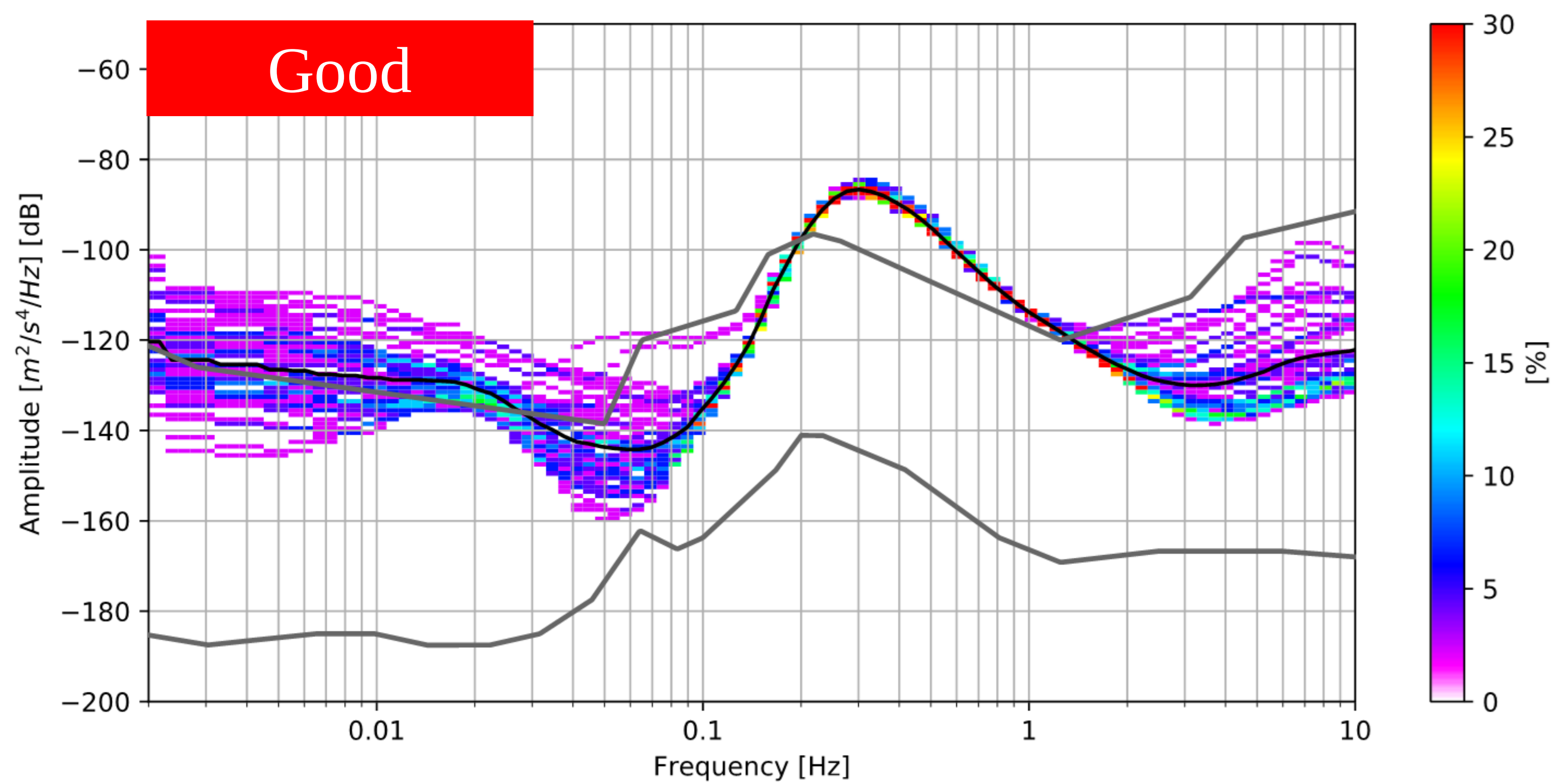

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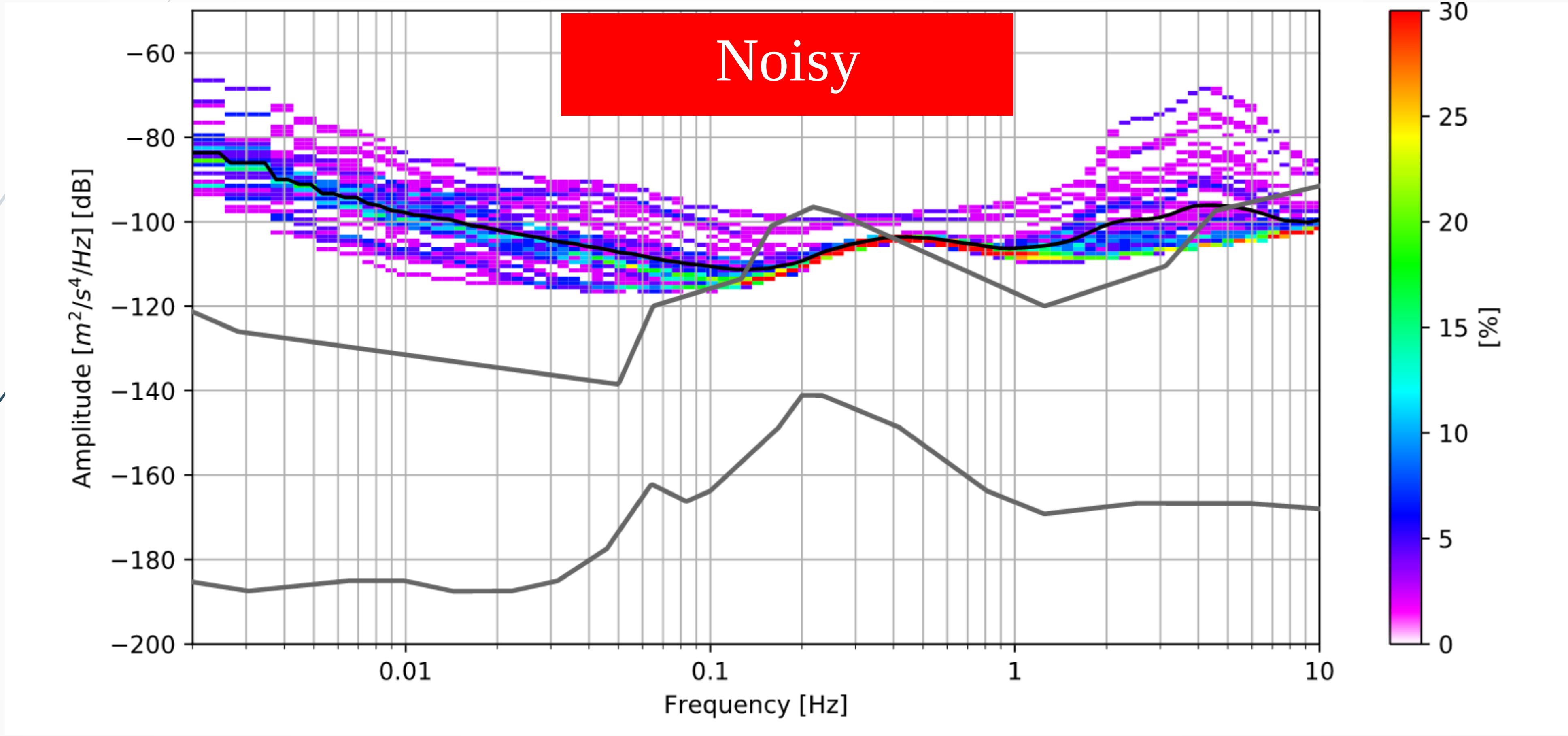
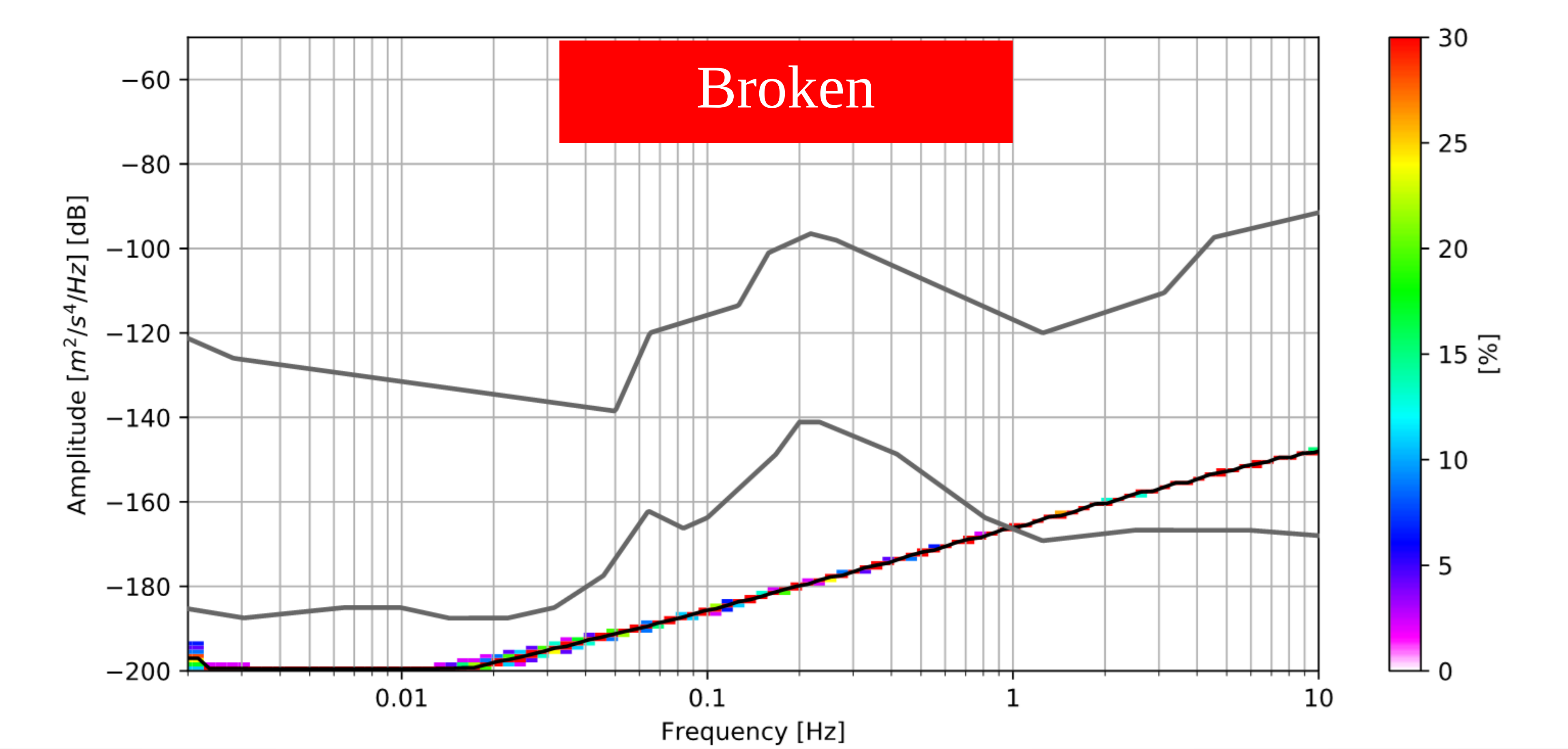


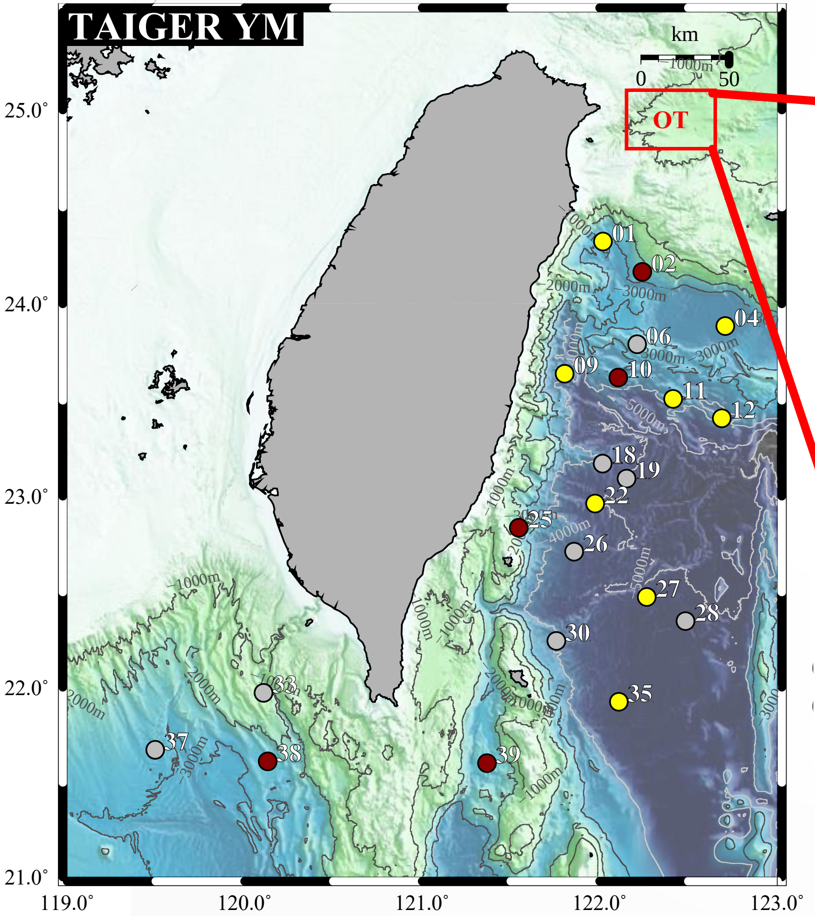
Power Spectral Densities (PSD)



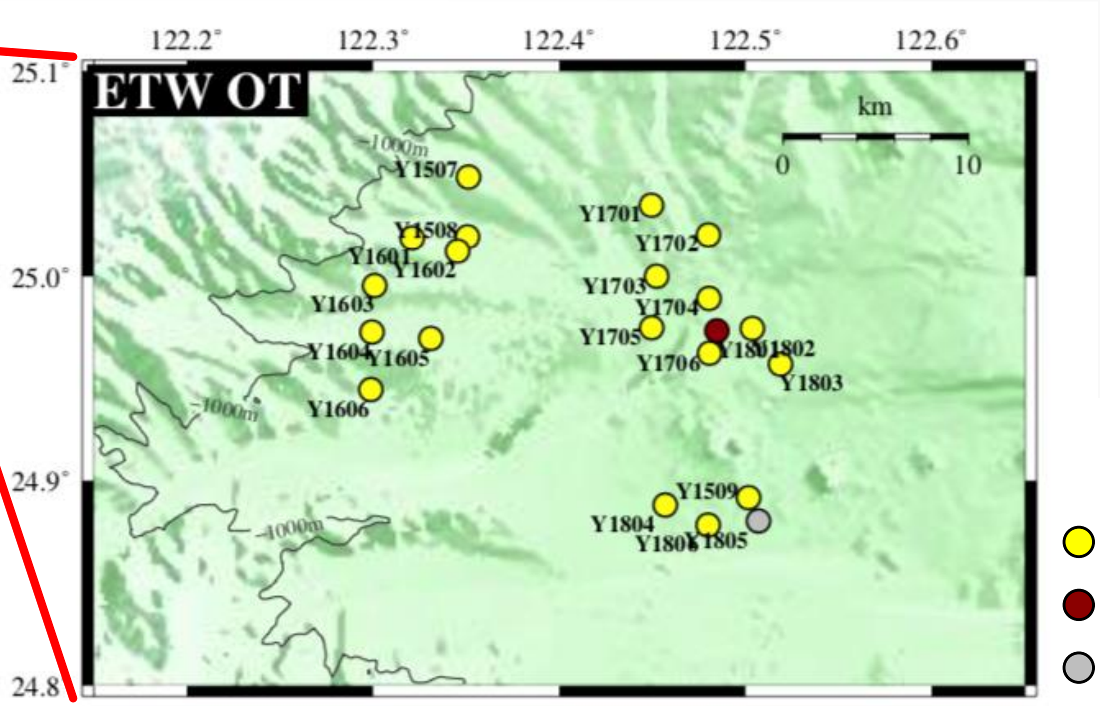
TAIGER | NoMelt | ETW | NOT

TAIGER 2007-2009
(TAiwan Integrated GEodynamics Research)

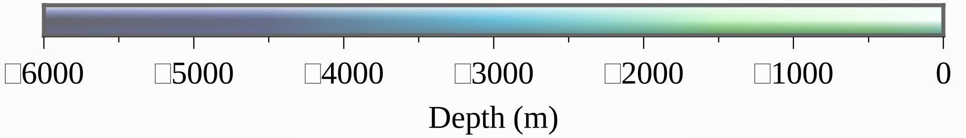
ETW
2015-2018 (6-months experiments)



Good : 8
Noisy : 5
Broken : 8

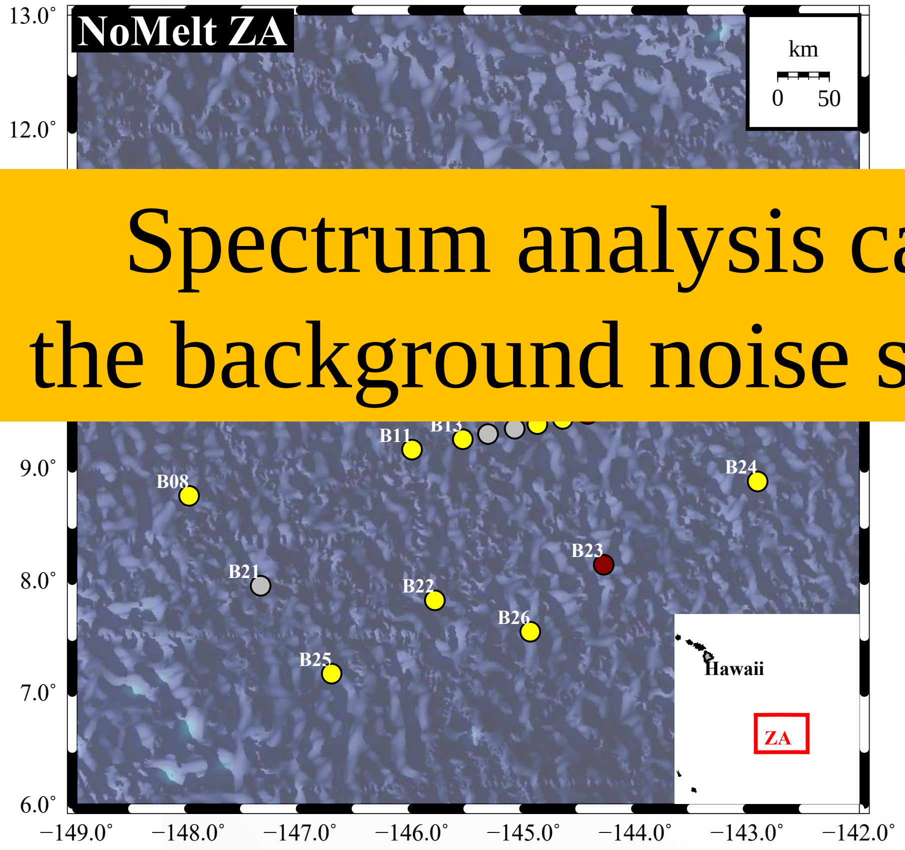


Good : 19
Noisy : 1
Broken : 1



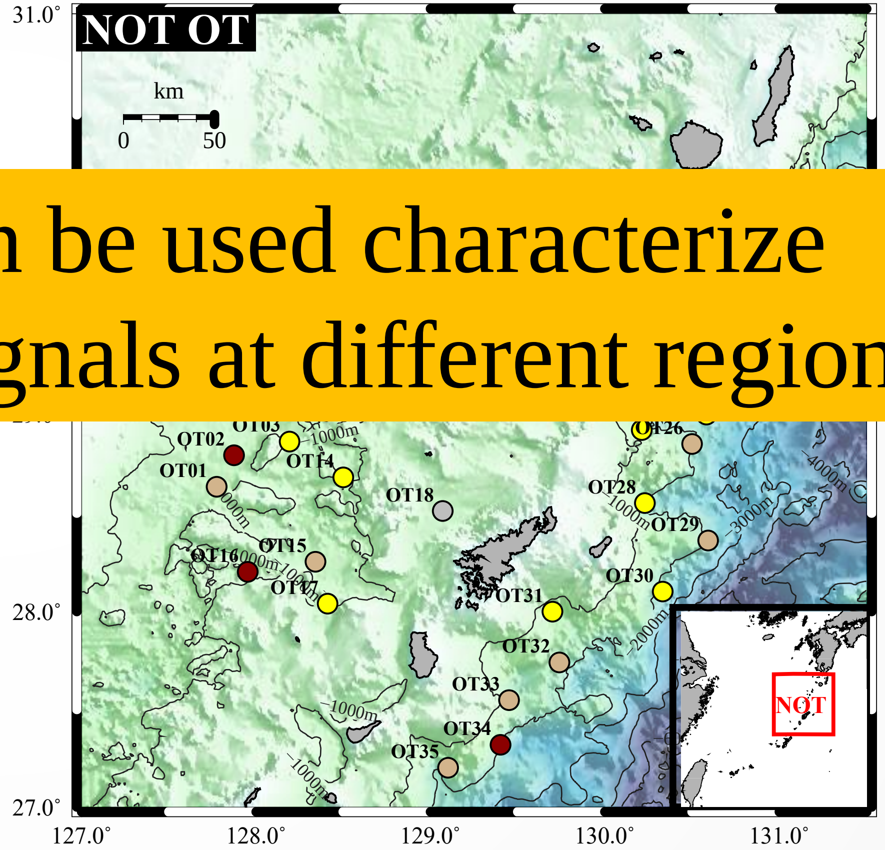
TAIGER | NoMelt | ETW | NOT

NoMelt	NOT
2011year-end -2012	2018-2019



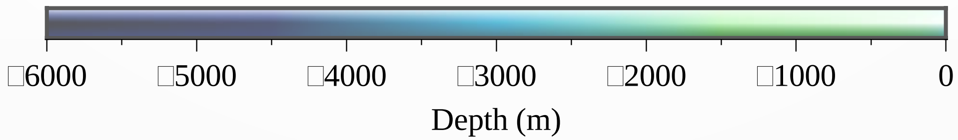
- Good :15
- Noisy : 2
- Broken : 5

Spectrum analysis can be used characterize the background noise signals at different region.



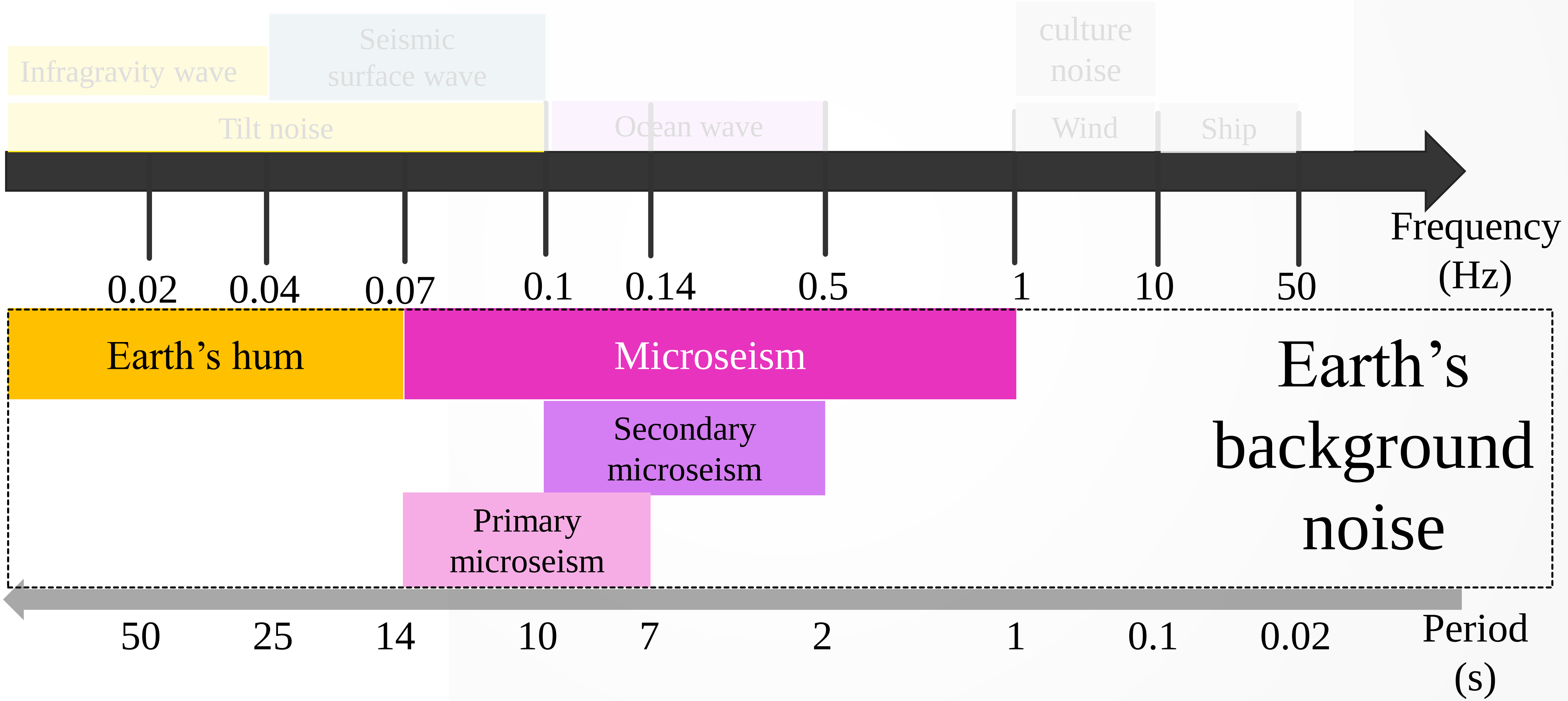
Symbol

- Good : 13
- Noisy : 7
- No data : 14
- Broken : 1



Signals in Frequency Domain

Sphar C. Webb (1998)
Pawa Dewagan (2018)
Nori Nakata (2019)



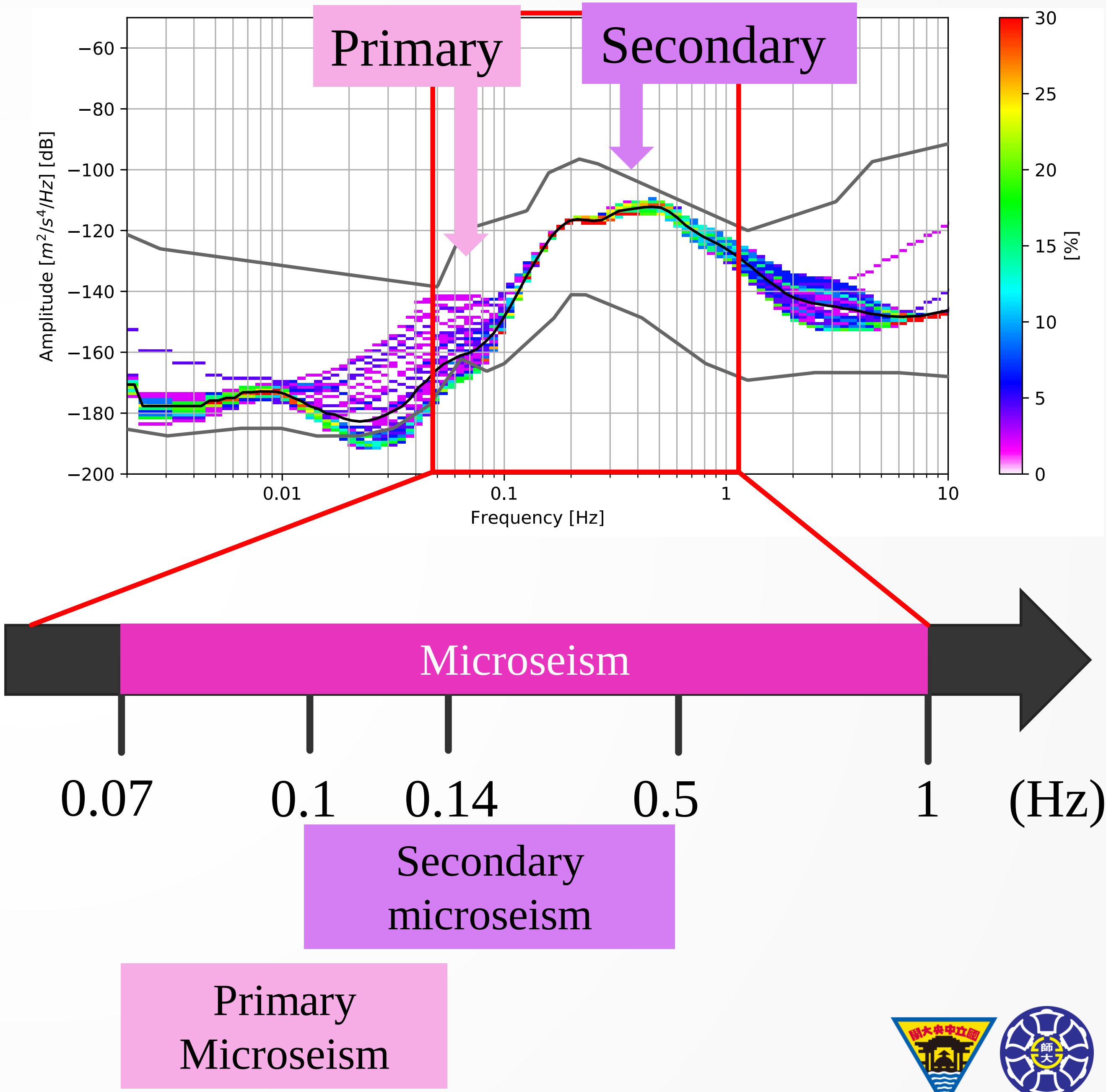
Microseism (0.07-1Hz)

Primary Microseism

Can be generated by ocean gravity waves (pressure variations) coupling with the seafloor topography

Secondary microseism

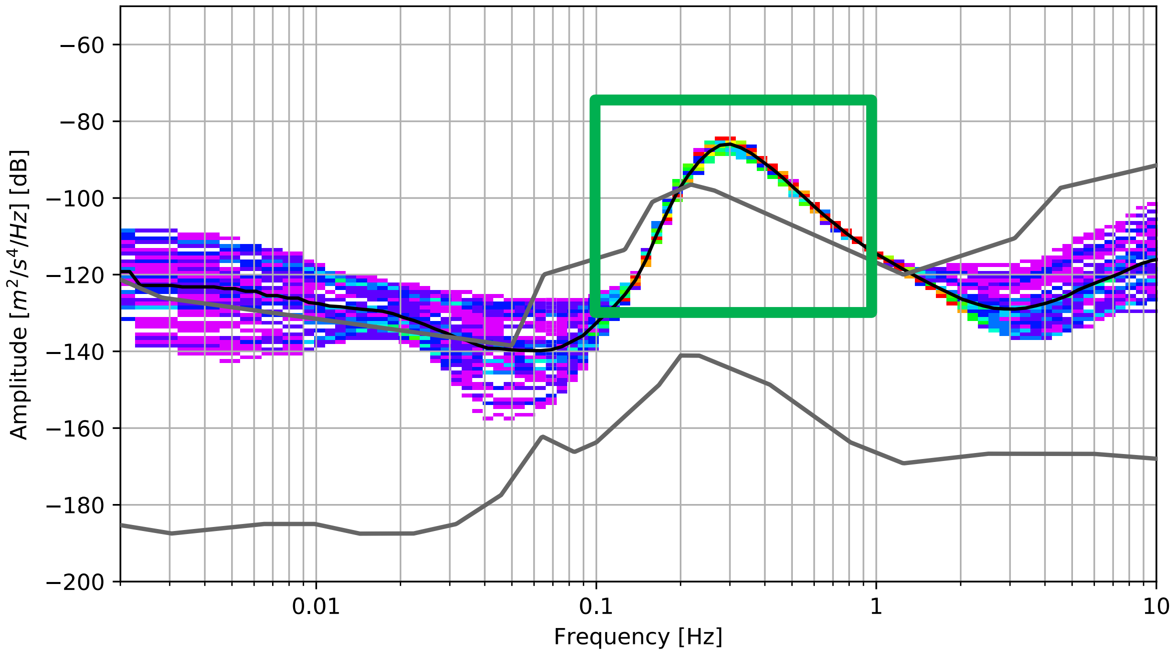
Ocean waves traveling in opposing direction reflect along coastlines or applied on the deep seafloor



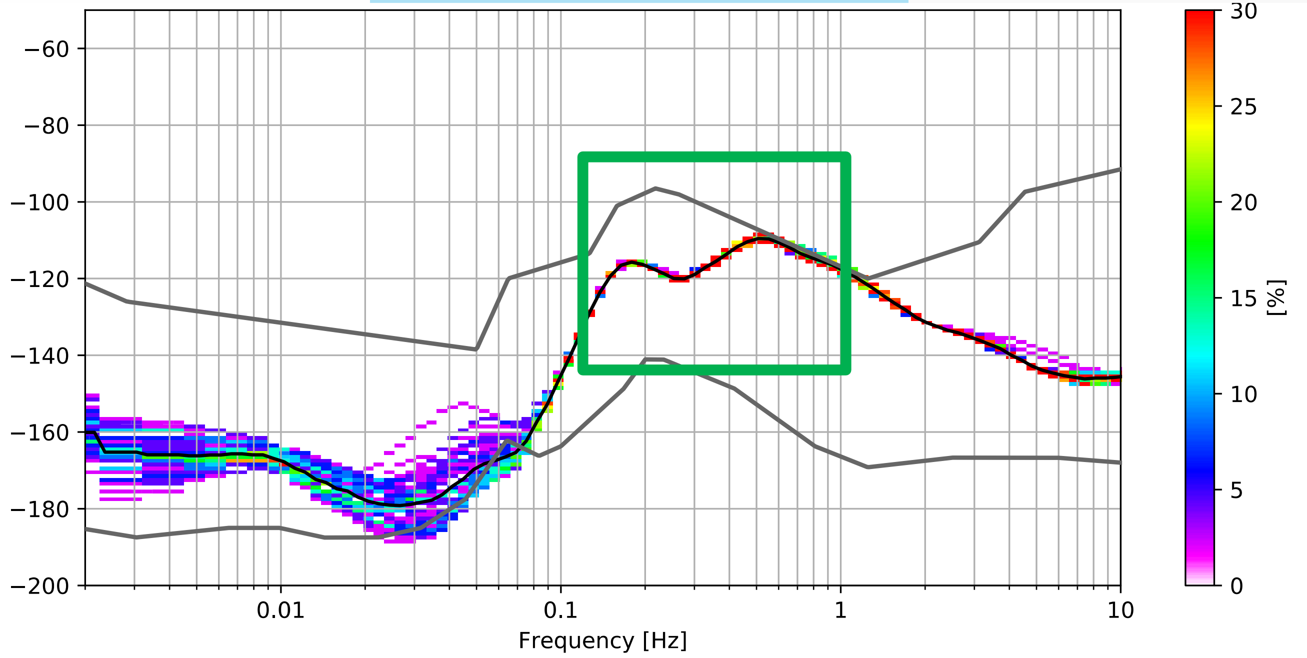
Hasselmann (1963)
Nori Nakata (2019)
Lucia Gualtieri (2019)

Secondary Microseism (0.1-0.5Hz)

Offshore Taiwan



Central of Pacific



Single peak

Microseism energy is higher

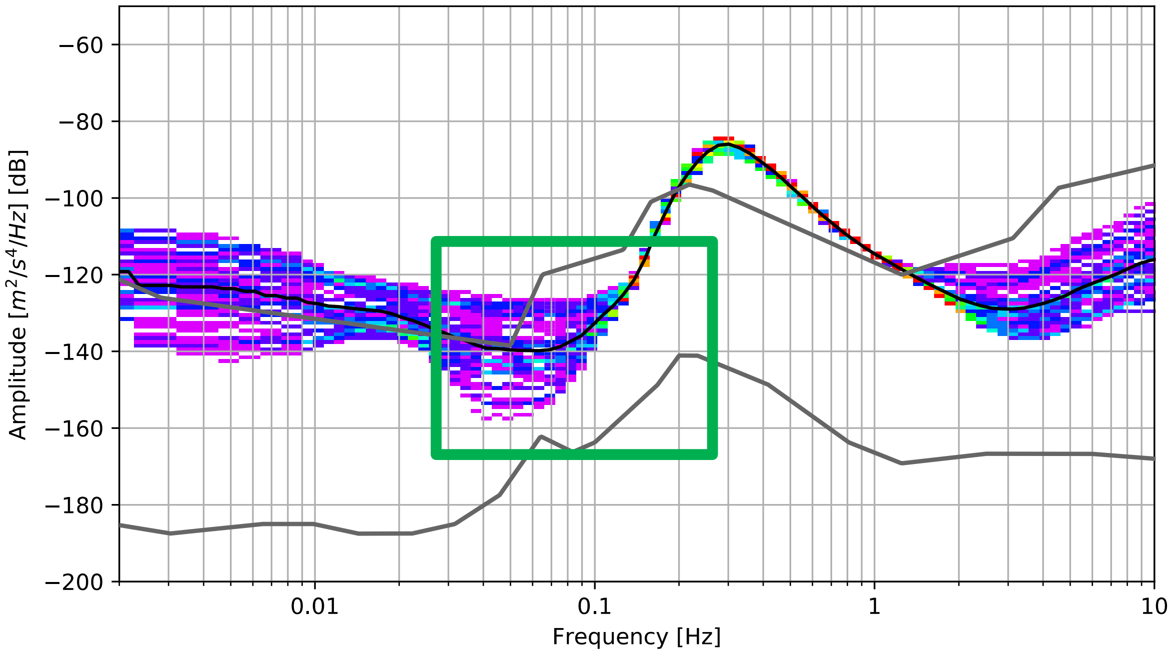
Double peak

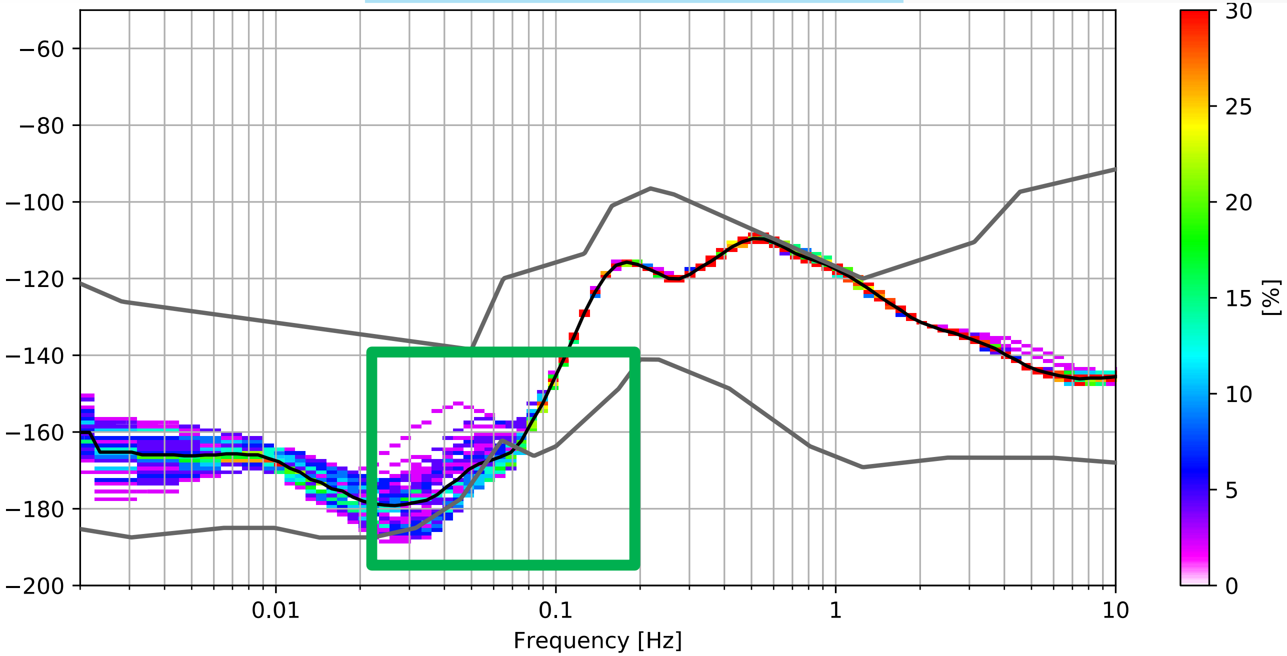
Deep water generated double frequency microseism energy

Primary Microseism (0.07-0.14Hz)

Offshore Taiwan

Central of Pacific



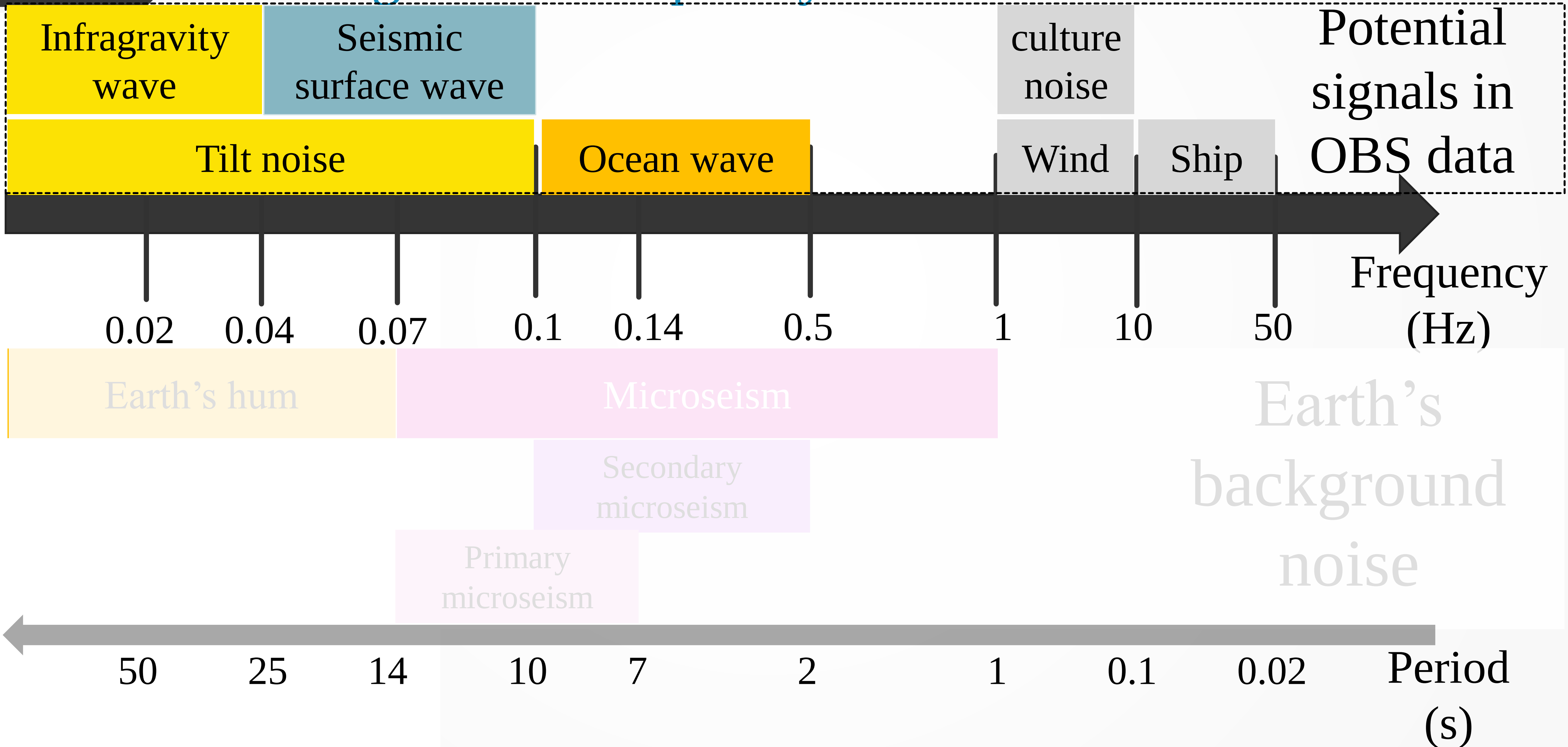


No peak

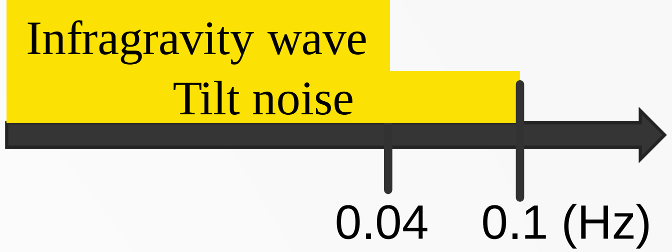
Tiny peak

Sphar C. Webb (1998)
Pawa Dewagan (2018)
Nori Nakata (2019)

Signals in Frequency Domain



Infragravity wave & Tilt Noise

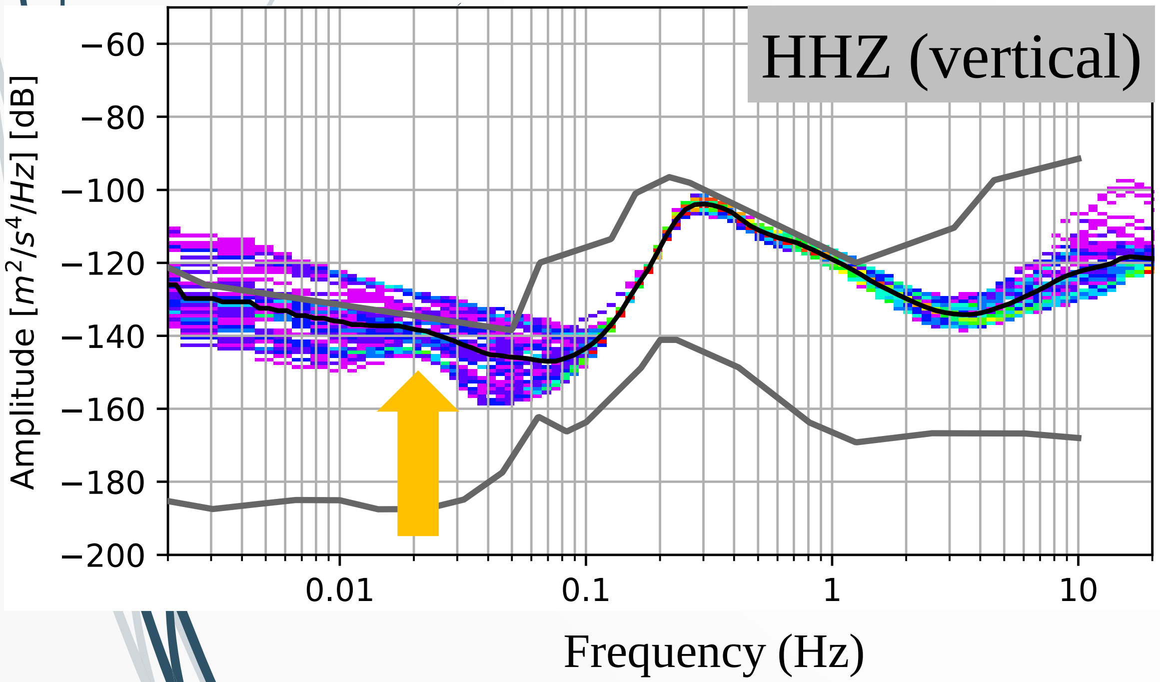


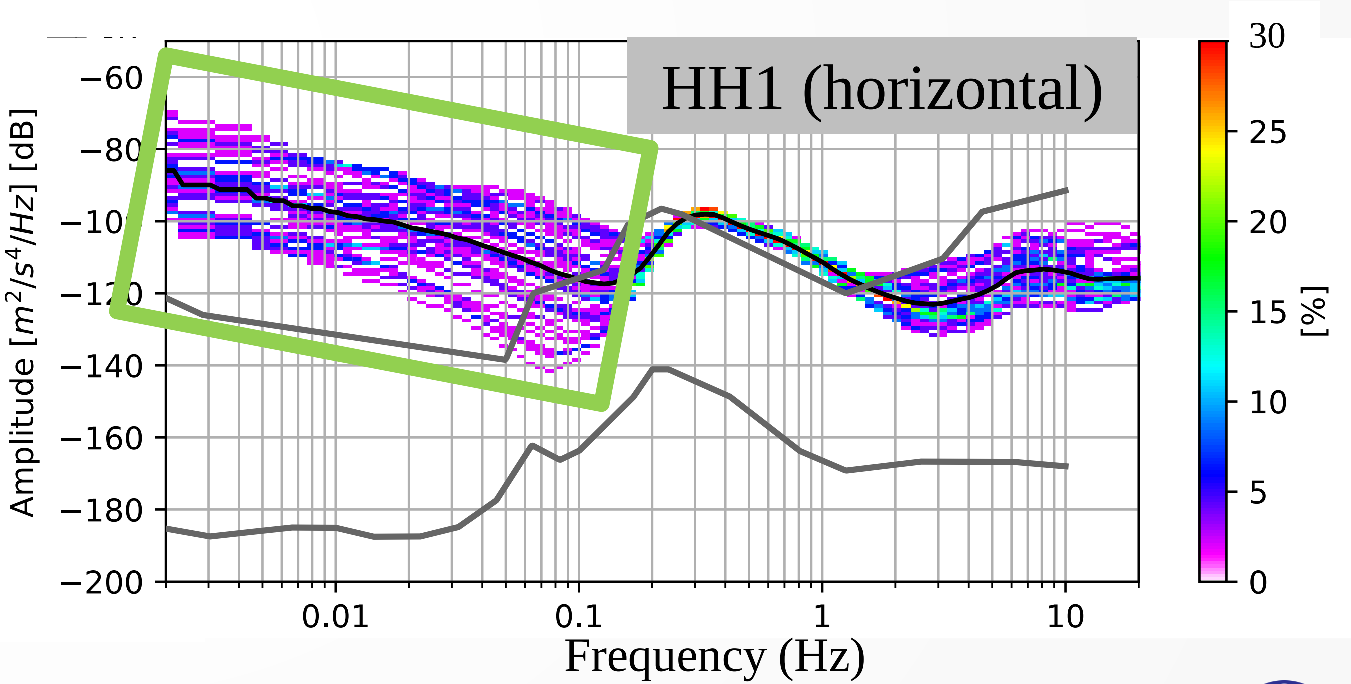
- Mainly due to nonlinear processes from the wind wave

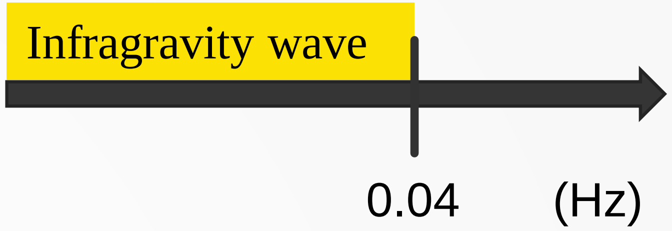
Particular on vertical components

- Mainly due to bottom current

Particular on horizontal components



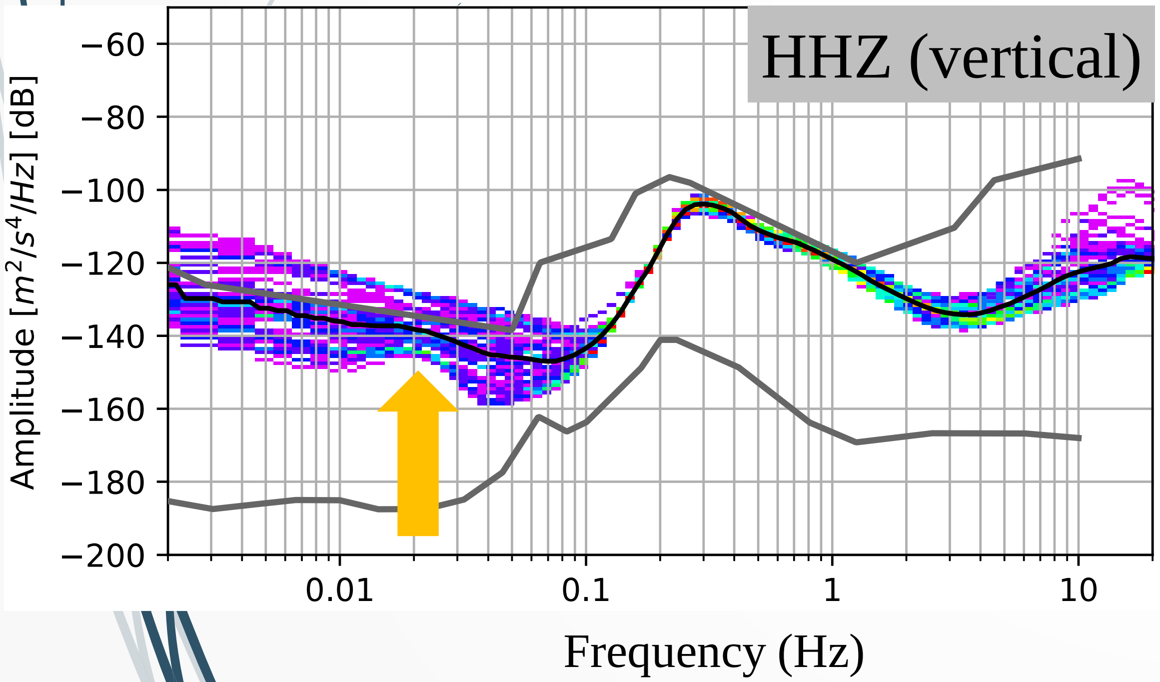




Infragravity wave (<0.04 Hz)

- Mainly due to nonlinear processes from the wind wave

Particular on vertical components



$$\omega^2 = gk * \tanh(kH)$$

Angular frequency

Water depth

$$\omega \propto \frac{1}{H}$$

Sphar C. Webb (2000)
Ban-Yuan Kuo (2014)

Infragravity wave (<0.04 Hz)

$$\omega^2 = gk * \tanh(kH)$$

Angular frequency

Water depth

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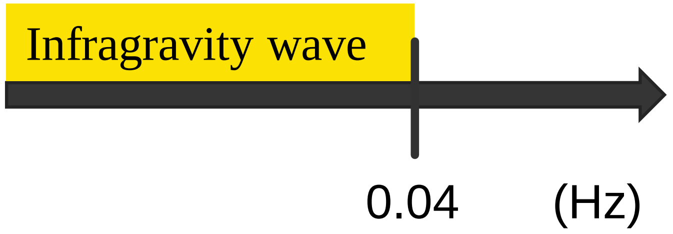
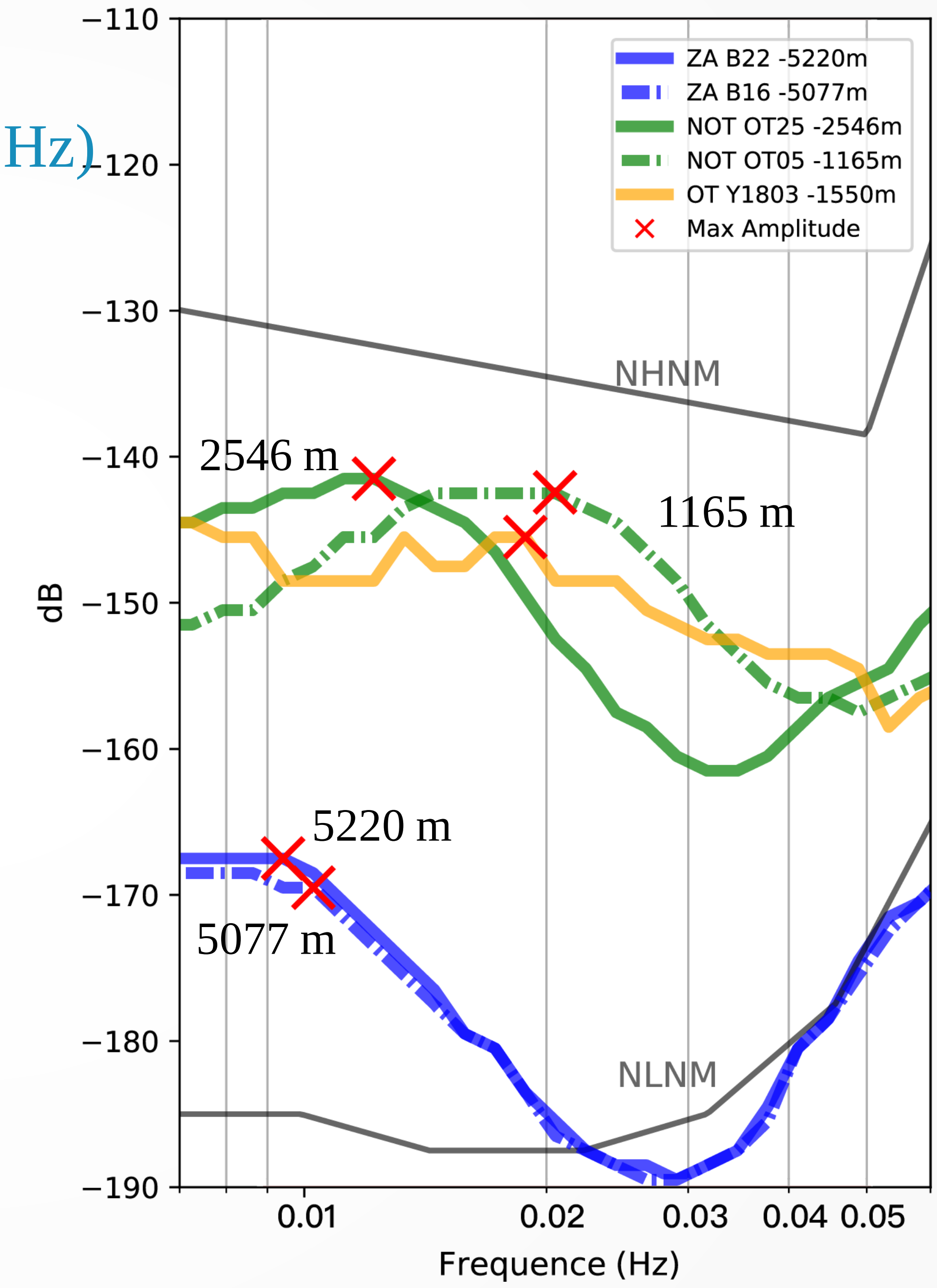
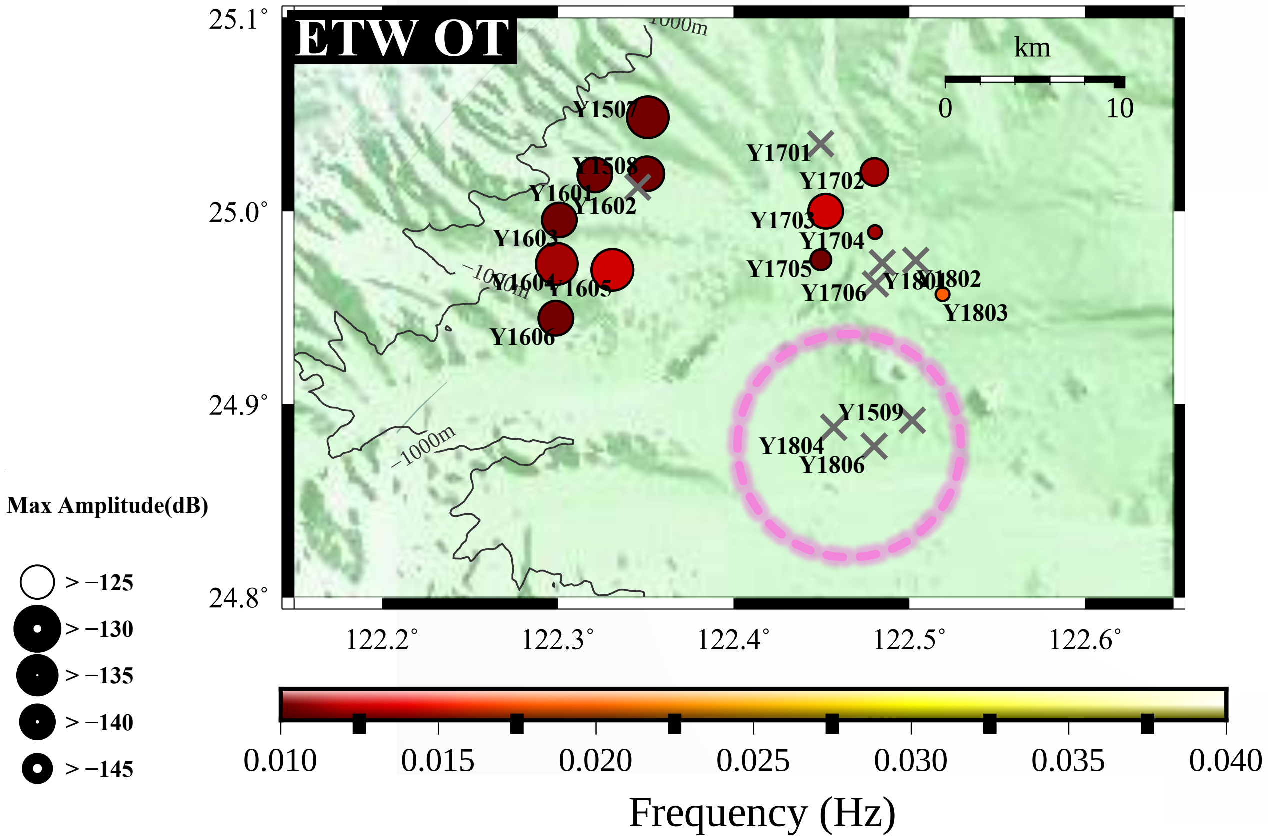
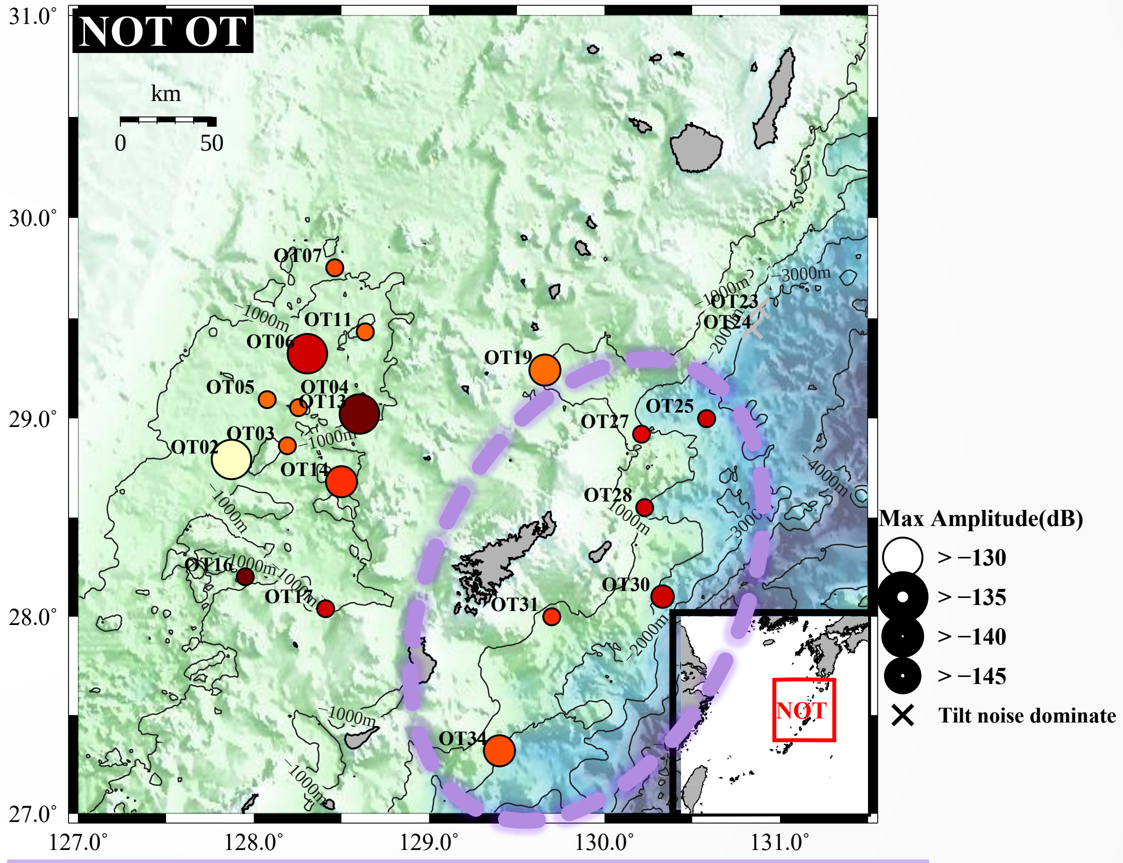




Infragravity wave (<0.04 Hz)

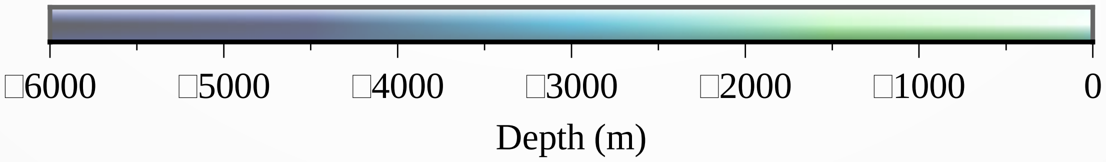
$$\omega \propto \frac{1}{H}$$





In the deeper water, tilt noises dominate

In the deeper water, the color is more red

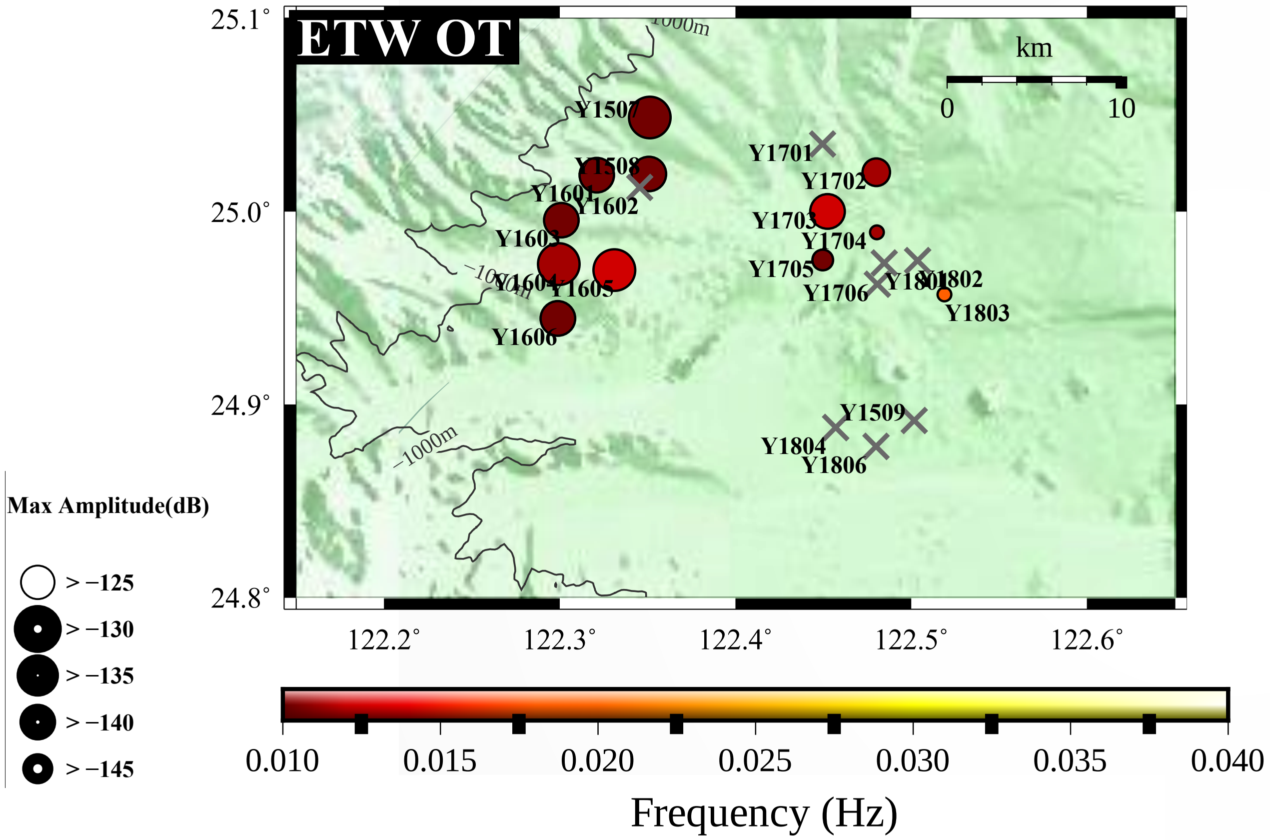


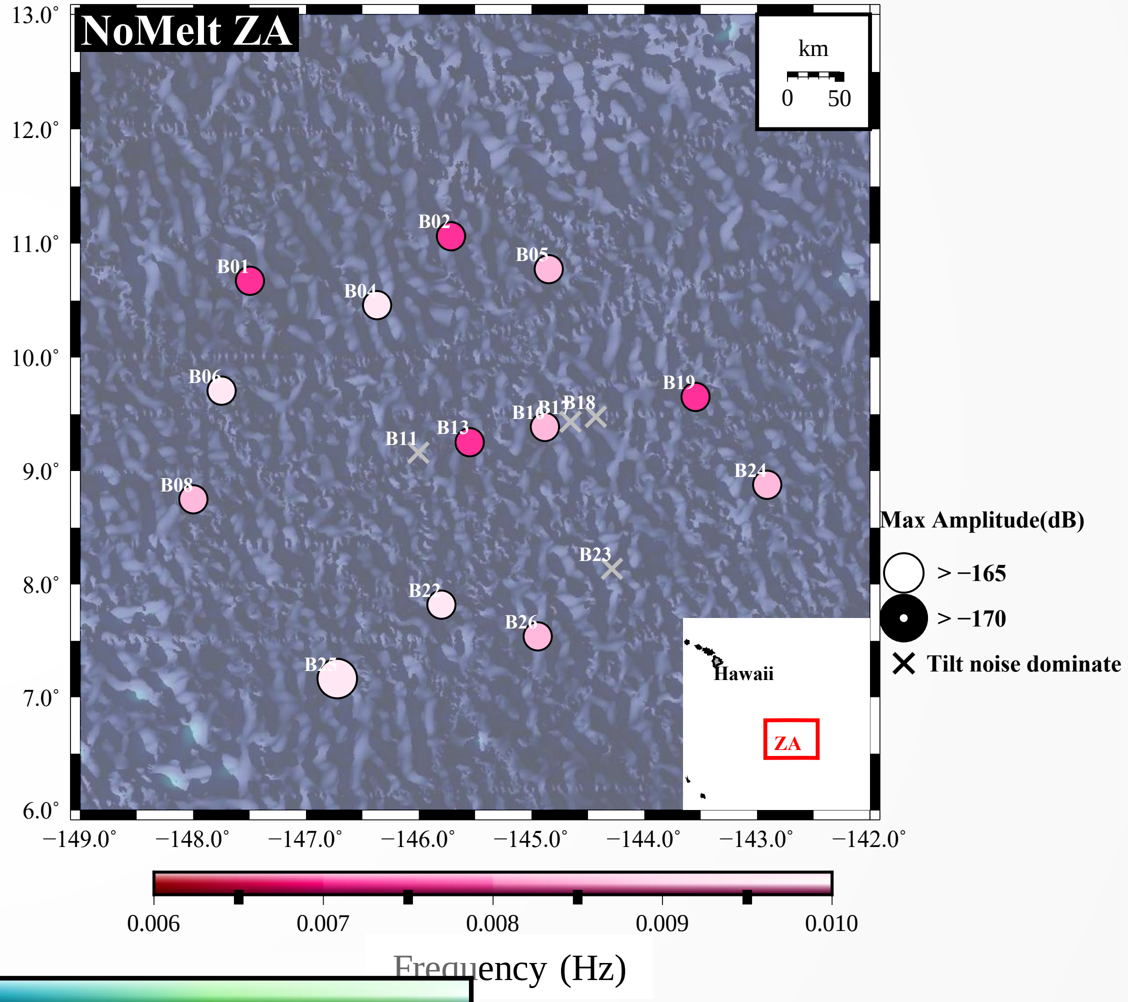
Color

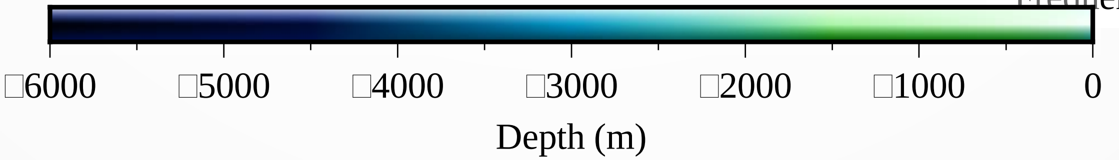
Circle size

Infragravity wave (<0.04 Hz)

$$\omega \propto \frac{1}{H}$$







Findings and conclusions

- From PSD plots, the noise level among these experiments:

  NoMelt < ETW < NOT < TAIGER

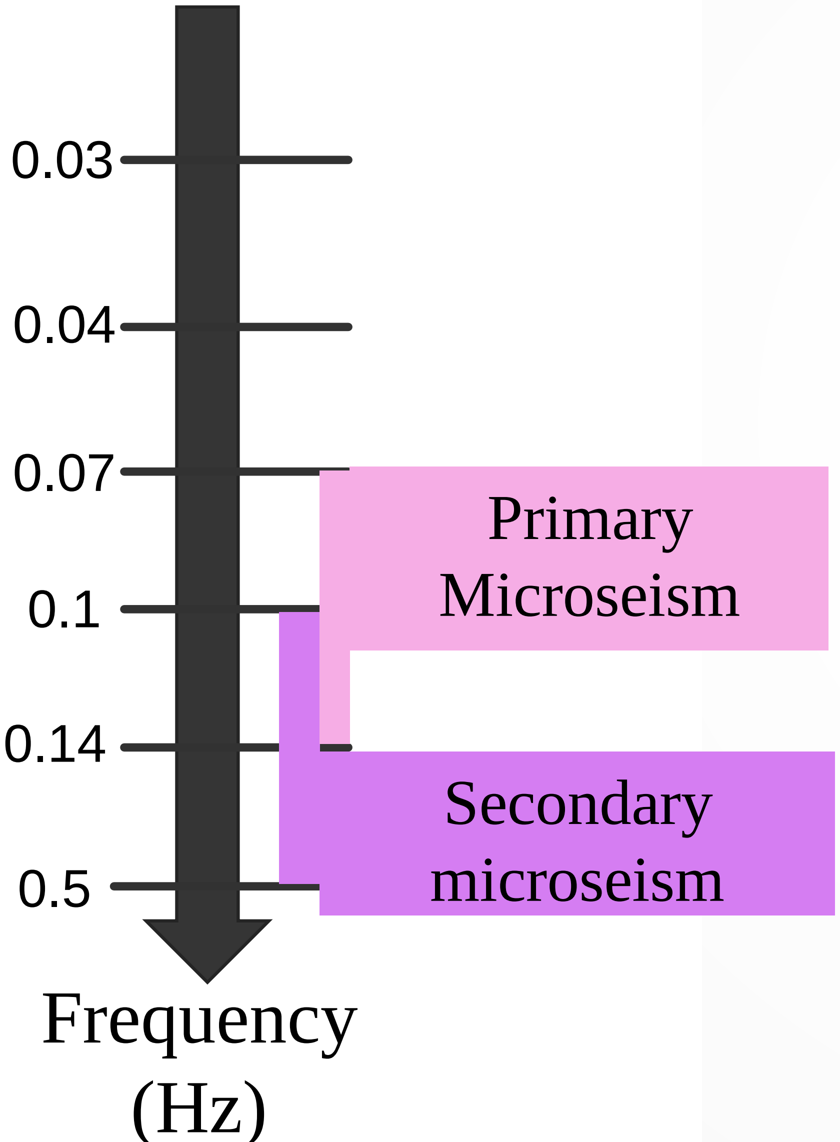
- The tilt noise heavily contaminates the both vertical and horizontal signals in broadband OBS data in TAIGER project.

  might be due to stronger bottom currents in Eastern Taiwan or instrument-designs disadvantages

- Only in NoMelt, the vertical components is not affected by tilt noise.

  might be due to quiet ocean bottom environment in central Pacific

Findings and conclusions



- No clear PM signals offshore Taiwan, but in NoMelt

  PM is not only stronger close to offshore, and might be controlled by the slope of the bathymetry.

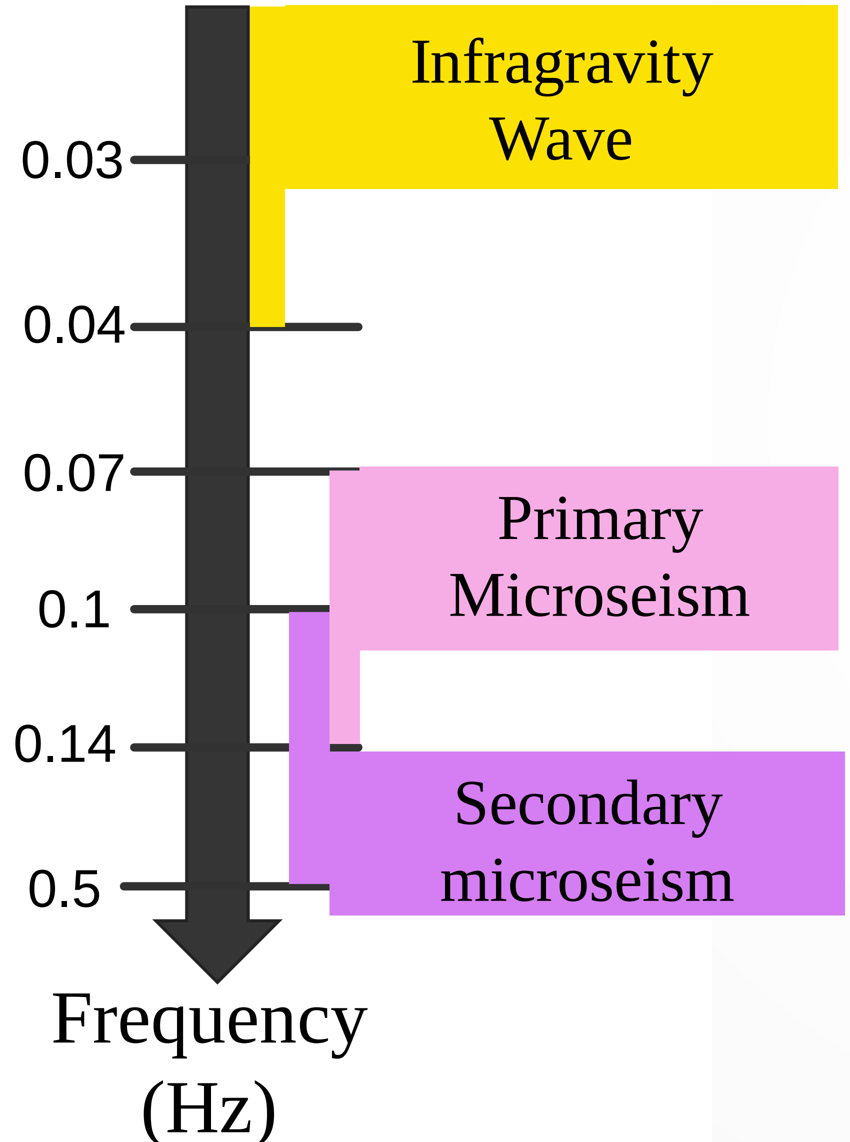
- A single SM peak shows at offshore Taiwan and NOT, and the energy is larger than global model.

  The OBS data offshore has stronger SM energy than land stations.

- In NoMelt, clear double peaks in SM, especially during the summer.

  SM energy has seasonal variations, might due to wave-wave interactions by the cyclones

Findings and conclusions



- IW appears at lower frequency in deeper water depth

Experiments	NoMelt	TAIGAR	NOT		ETW
Depth (m)	~5000	~2000-5000	~2000	~1000	~1300
Frequency (Hz)	~0.008	Tilt noise dominate	~0.013	~0.017	~0.011

Please stop by the poster to see more details

Acknowledgments

- We thank the OBS teams at IES , IUT, LDEO and TORI for developing and maintaining OBS
- I would like to thank people in Planetary Seismology Lab and NTNU, especially administrative staff, Ze, CM and Patty!
- The data set was downloaded and processed using python and the seismological community scientific library obspy (Krischer et al., 2015).
- Generic Mapping Tools (GMT) were used for plotting map view figures.

python™

ObsPy
A Python Framework for Seismology

THE GENERIC MAPPING TOOLS

Thanks for your listening !