Listening from the ocean bottom:

A broadband view of ocean waves

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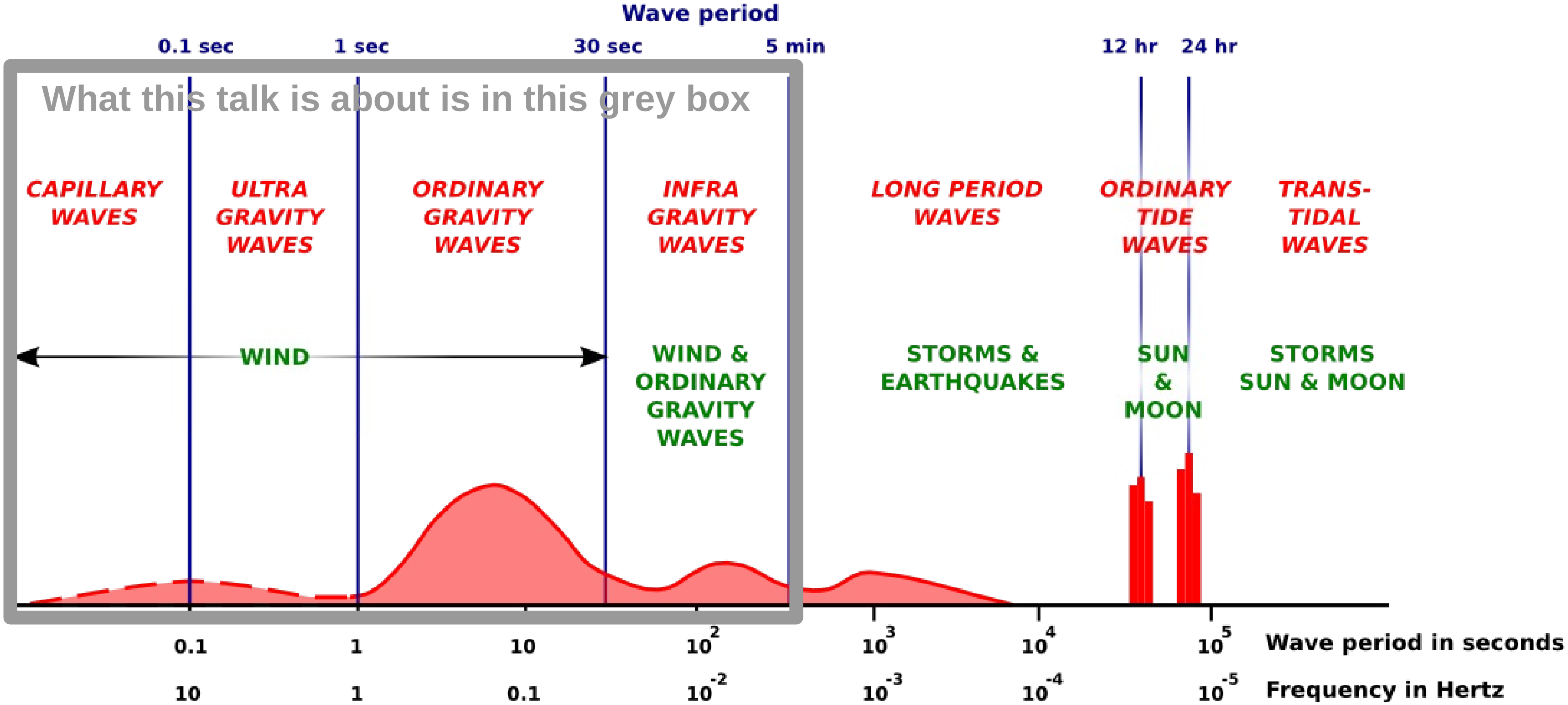
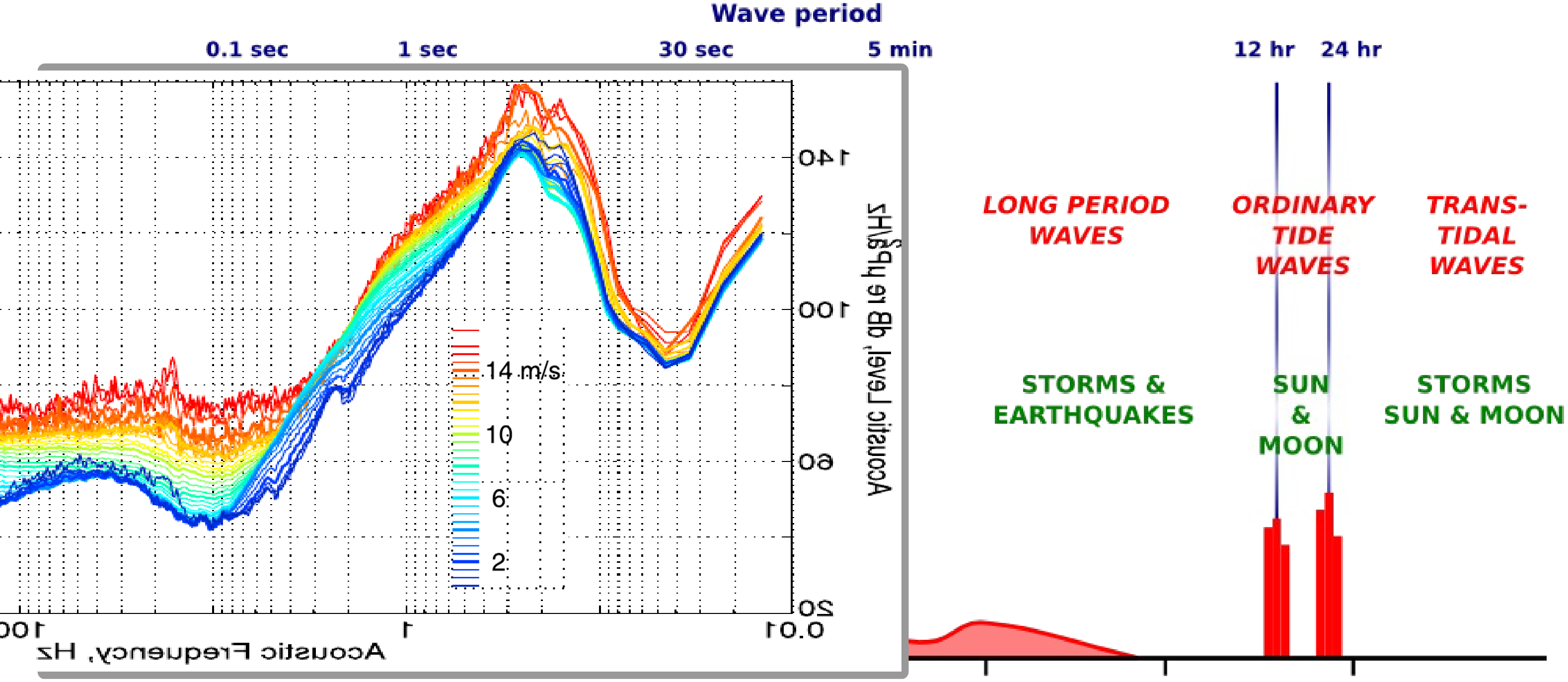
1. The surface wave spectrum



1.5 m 150 m **15 km** 200 km Wavelength

adapted from Walter Munk (1950)

1. The surface wave spectrum



100 10 1 0.1 0.01 Acoustic frequency

? 5 0.5 0.1 0.01 Surface gravity wave frequency

And it can all be recorded from the ocean bottom

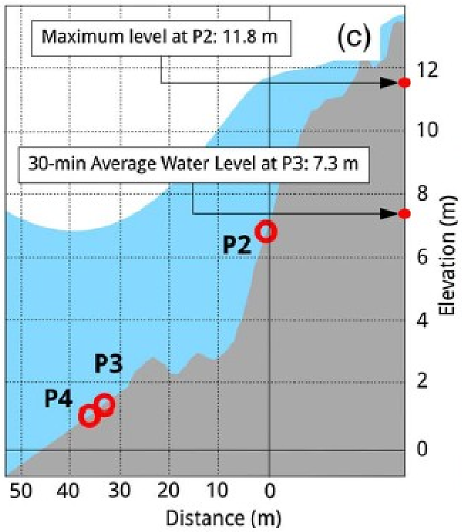
(Duennebier et al. JGR 2012)

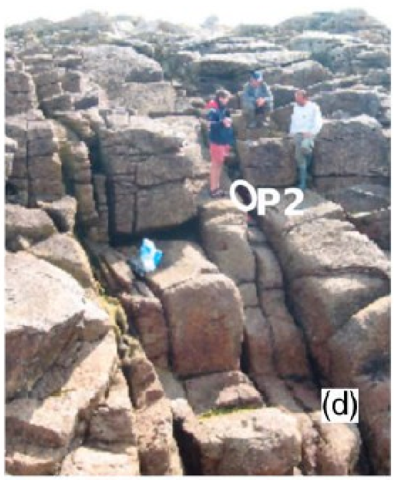
2

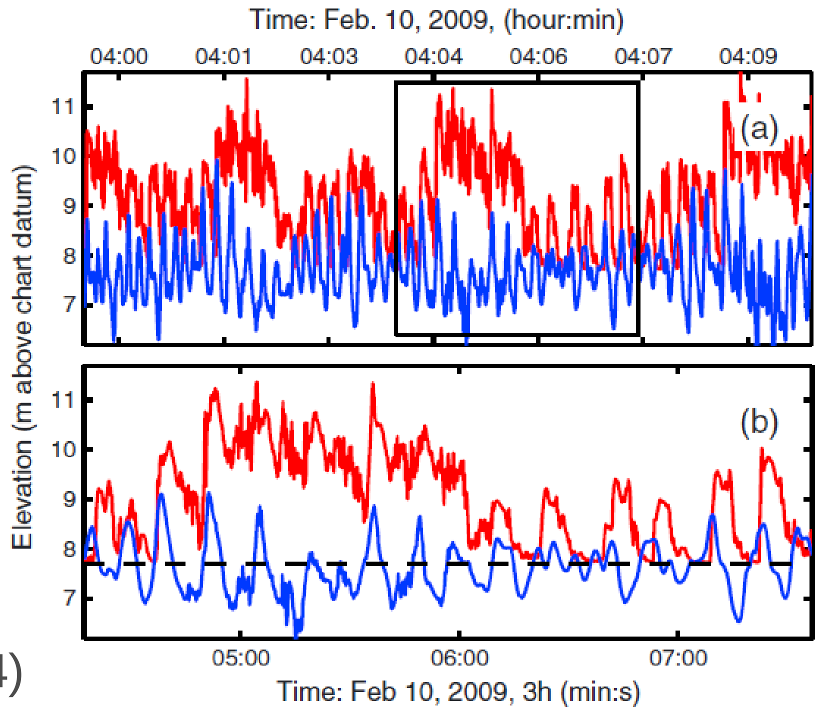
Let's start with the very low frequencies: IG waves

2. IG waves

IG waves can be really big, and contribute to flooding
(see recent storms in Fidji …)







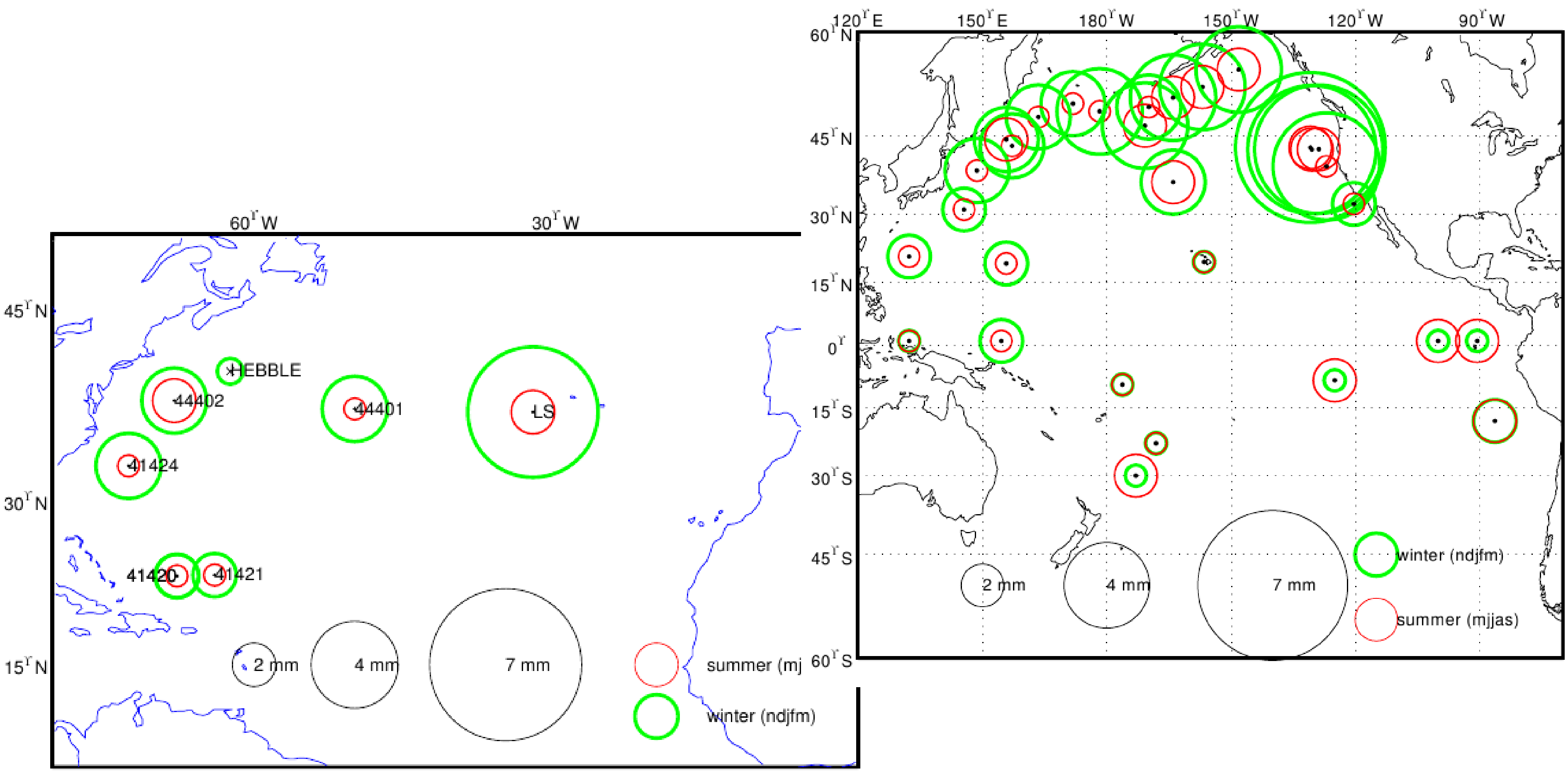
Here are some local examples:

(Sheremet et al., GRL 2014)

2. Open ocean IG wave data

But we have very little data available

- Review by Webb et al. (JGR 1991) : few data, ~ 1 cm height
- Aucan & Ardhuin (GRL 2013) : analysis of tsunami warning stations :

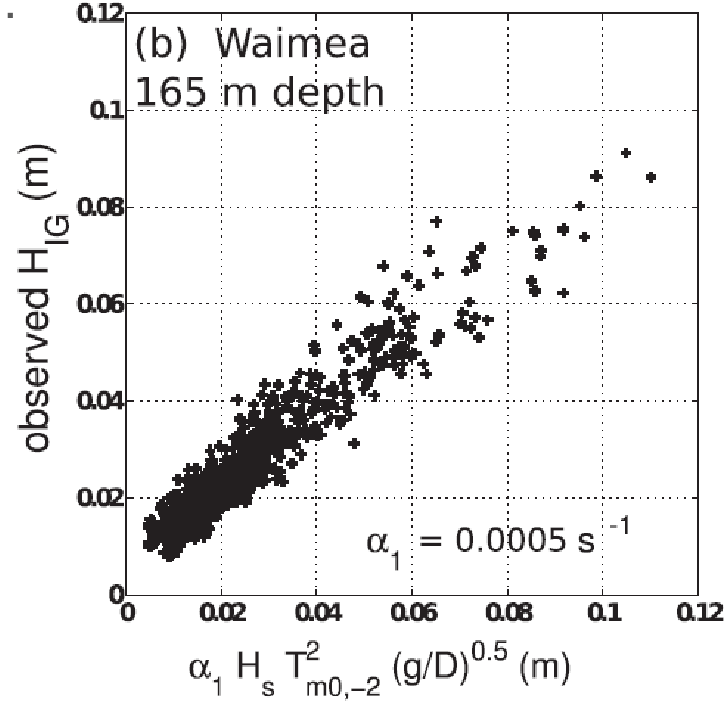


2. model for Infragravity waves

Coastal sources

→ further analysis by Ardhuin et al. (OM 2014) :
  - New experiments (Waimea 2012)
  - Use of various datasets

$$H_{IG} \simeq \alpha_1 H_s T_{m0,-2}^2 \sqrt{g/D}$$



Location	Depth (m)	Start date	Duration (days)	α_1 (s^{-1})	Correlation (r)
A (Duck, NC)	12	1994/09/10	100	8.1×10^{-4}	0.97
F (Duck, NC)	33	1994/09/10	100	4.6×10^{-4}	0.97
H (Duck, NC)	50	1994/09/10	100	4.0×10^{-4}	0.97
I (Duck, NC)	87	1994/09/10	100	4.0×10^{-4}	0.96
51201 (Waimea, HI)	165	2012/01/18	100	5.3×10^{-4}	0.95
Crozon (France)	110	2011/09/10	15	7.9×10^{-4}	0.86
Bertheaume (France)	23	2004/01/19	104	4.4×10^{-4}	0.88
Banneg island (France)	5	2009/12/03	89	5.0×10^{-4}	0.85
DART 46407	3266	2008/01/01	366	5×10^{-4}	(with lag: 0.89)

2. model for Infragravity waves

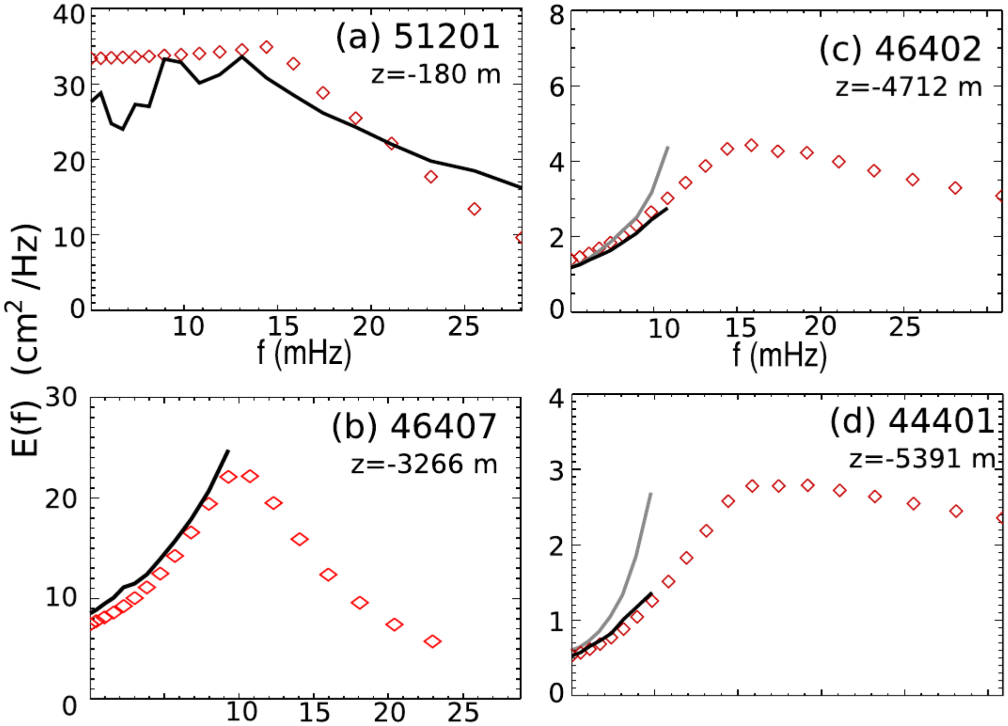
Coastal sources

→ Frequency dependance? Empirical relation based on very few data ….

$$A_{IG} = H_s T_{m0,-2}^2,$$

$$E_{IG}(f) = 1.2\alpha_1^2 \frac{kg^2}{C_g 2\pi f} \frac{(A_{IG}/4)^2}{\Delta_f} \left[\min(1., 0.015\mathrm{Hz}/f)\right]^{1.5}$$

$$E_{IG}(f,\theta) = E_{IG}(f)/(2\pi),$$



2. Infragravity waves

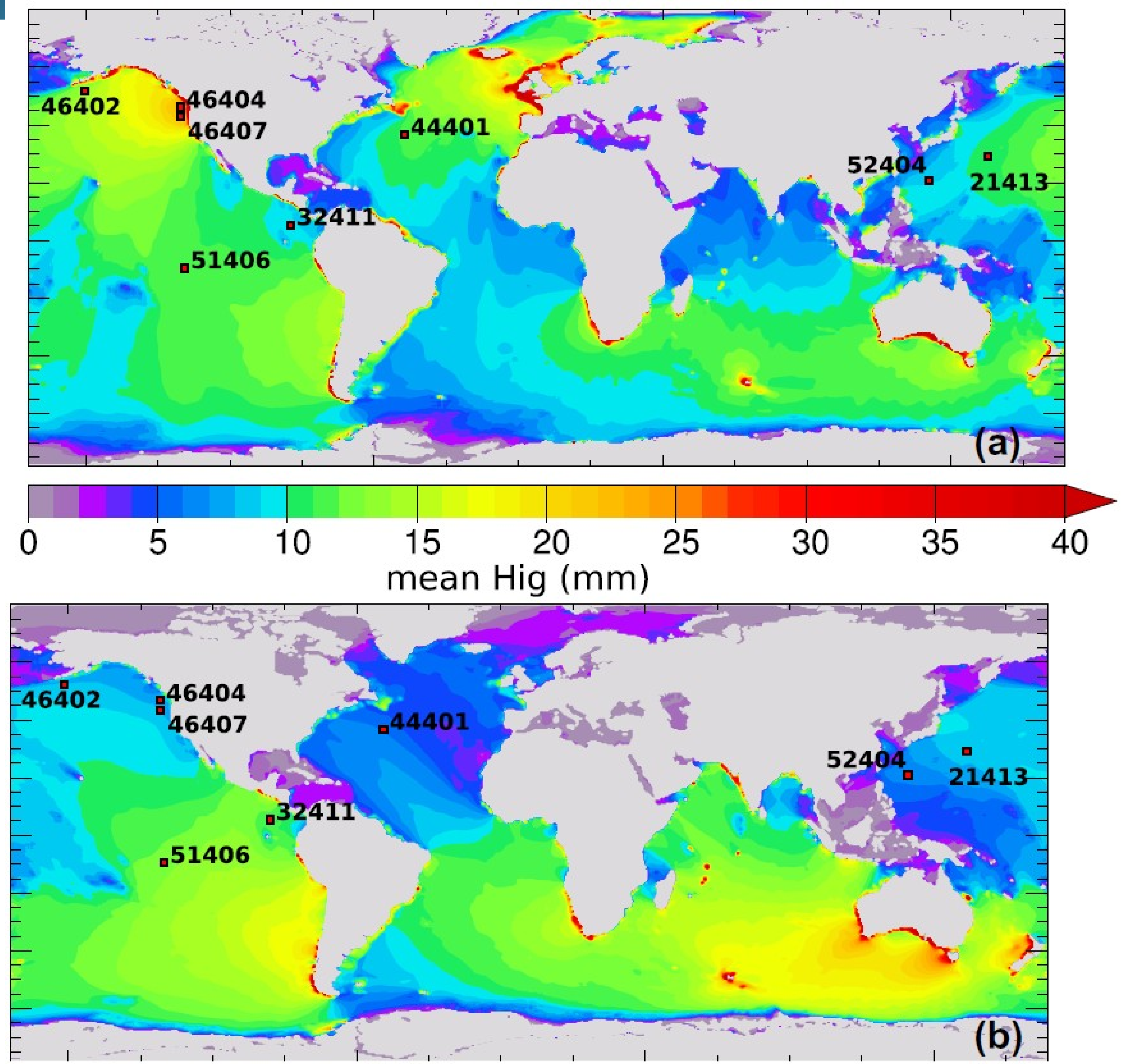
Global model result

Global map of free IG wave heights :

Top : Jan & Feb

Bottom: July & August

For year 2008



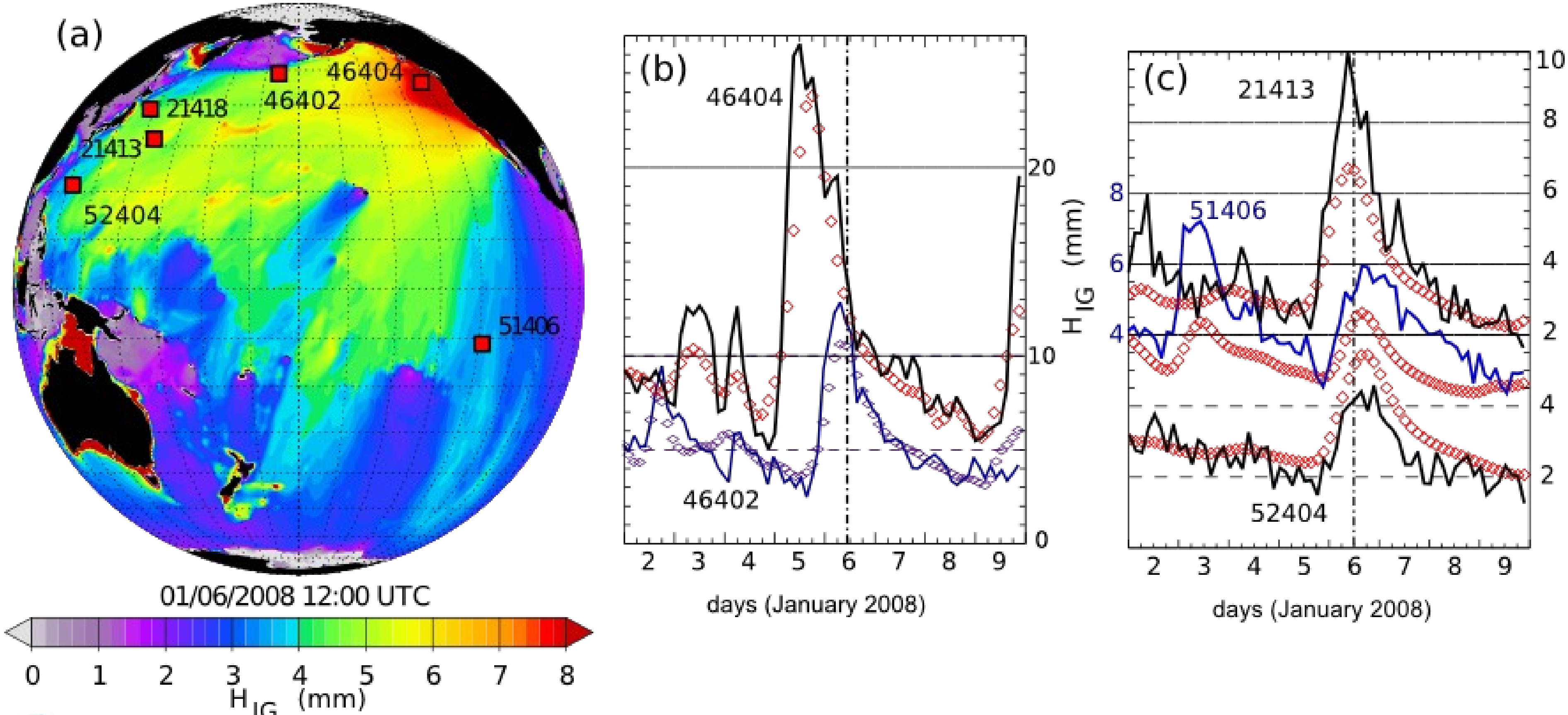
2. Building a global IG wave model

Model validation : global scale

Sources of IG waves recorded off Japan are in North America

(Rawat et al., GRL 2014)

But big errors in South Pacific …



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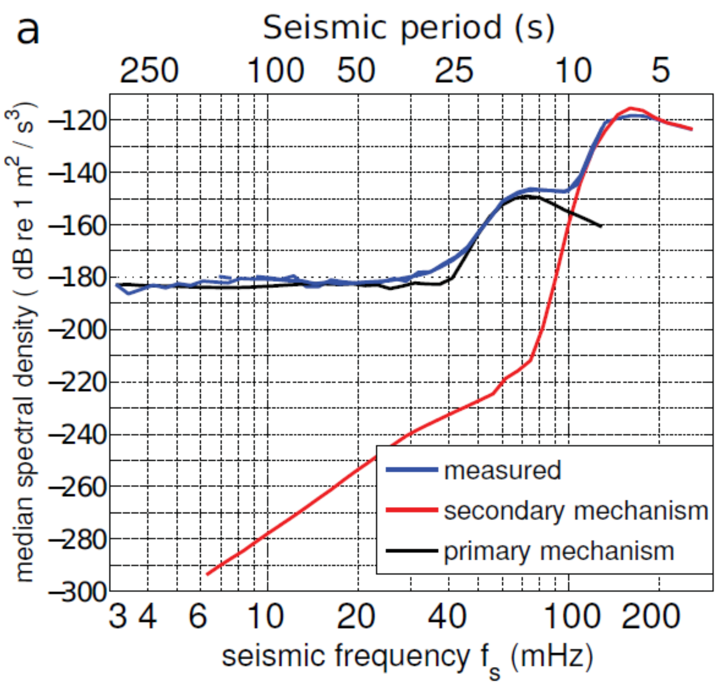
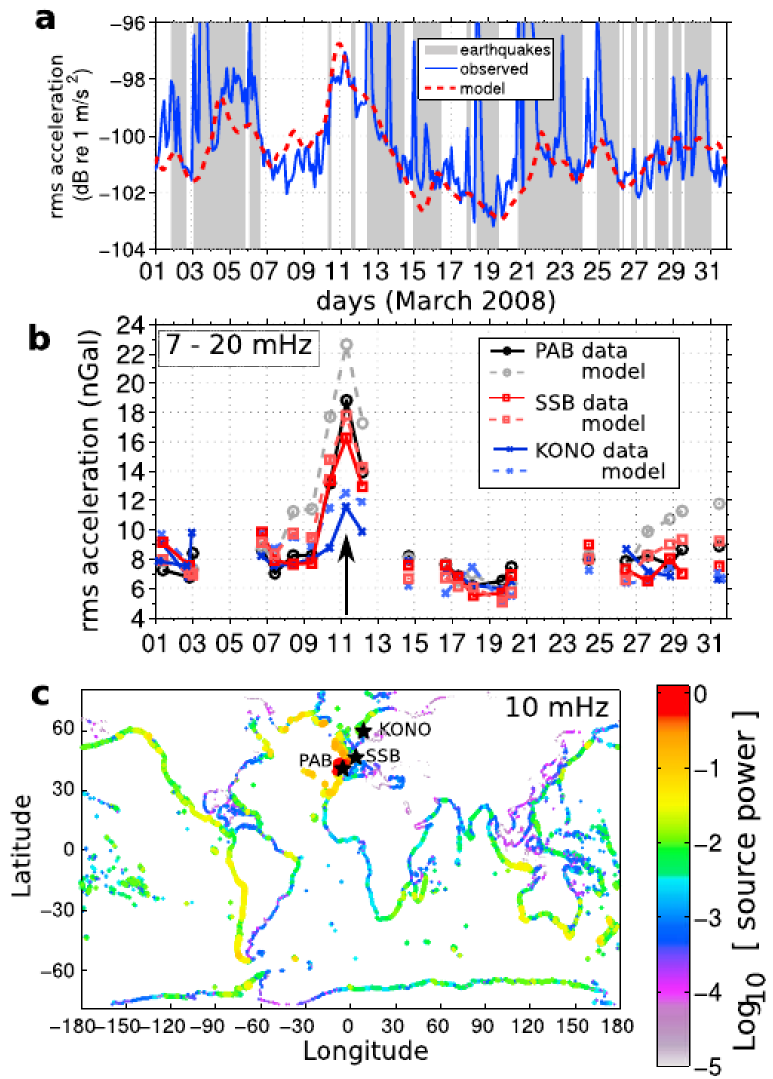
IG waves and Earth's hum

Model application : estimation of sources of microseisms (the hum)...

first validation by Ardhuin et al. (GRL 2015)

Ongoing work (Deen et al. at IPGP)

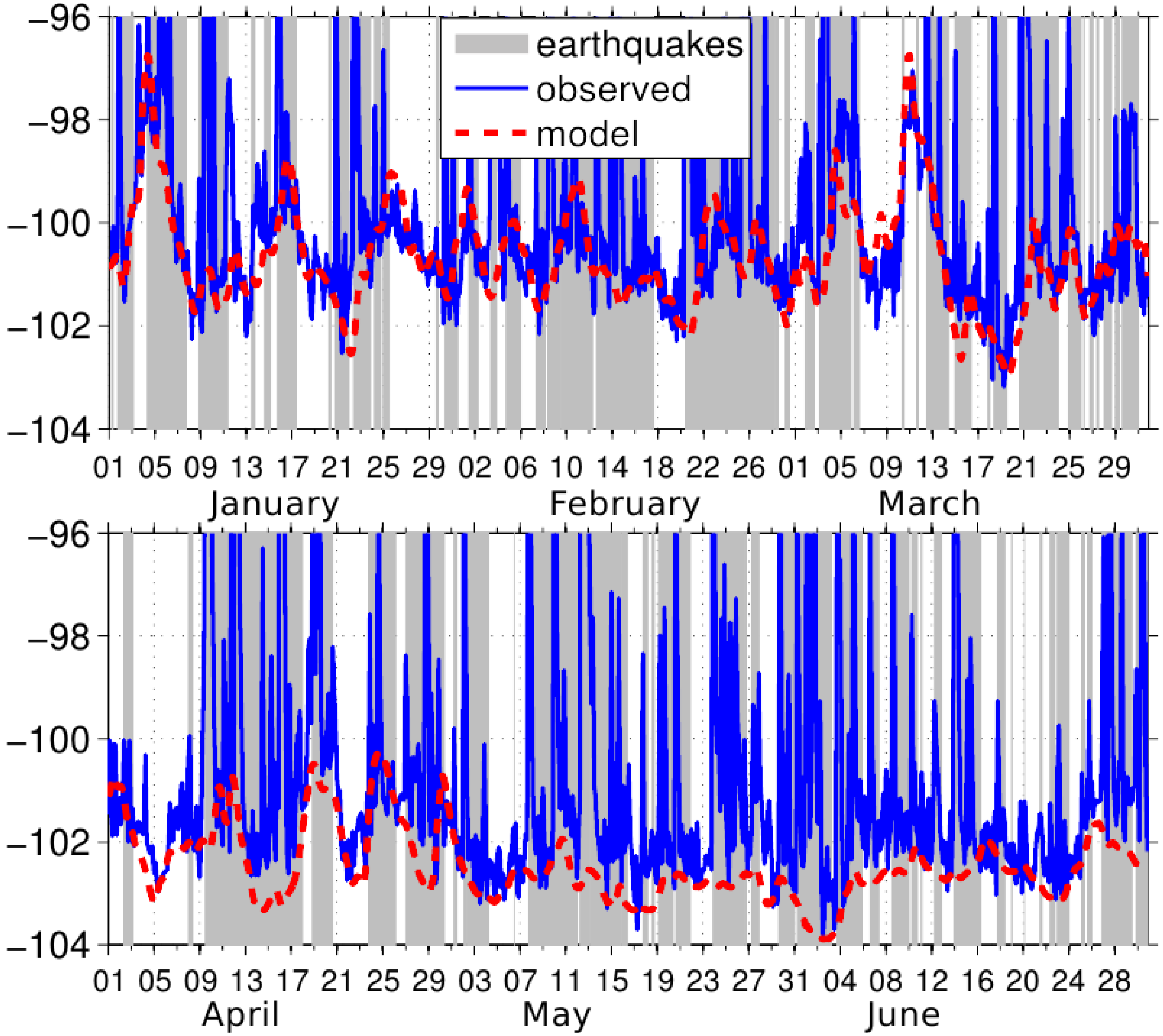




3. IG waves and hum sources

And throughout the year …

rms accelerations,
at SSB (LHZ)
7 to 20 mHz
(dB re 1 m/s2)



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Conclusions and perspectives

Conclusions

1) Very long periods (30 to 300 s) and short periods (< 2 s) are poorly known.

Both can be observed at the ocean bottom :

- Linear response in infragravity waves
- Non-linear interactions for short waves (e.g. Farrell & Munk 2008, Duennebier et al. 2012, Ardhuin et al. JASA 2013 …)

Observation needs : long time series on the ocean floor with broadband instruments

2. Building a global IG wave model

It works … not well everywhere...

Verification of same model at global scale :
using DART bottom pressure recorders