Infragravity Period Oscillations In A Channel Harbor Near A River Mouth

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Study site: Port of Bayonne

Bay of Biscay

Mesotidal environment

- Mean tidal level: 2.5 m above chart datum
- Tidal range of 1.7–4.7 m

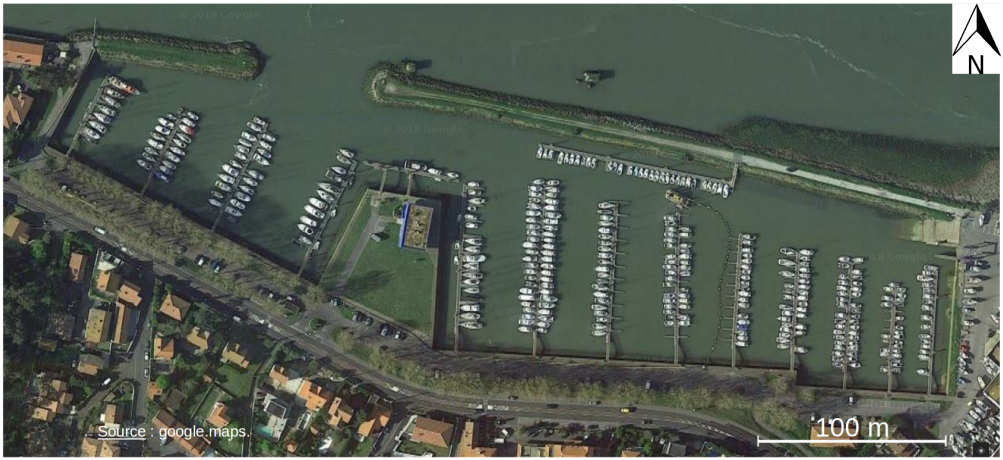
Wave climate

- Exposed to large long-period swells

Marina

Open-ended basin

- Study site
- Methods
- Field campaign
- BOSZ model
- Conclusion



Seiche (Rabinovich, 2009)

- Harbor resonance
- Generated by long waves
- Standing waves: vertical oscillations and horizontal currents

Channel harbor

Situated near the river mouth of the Adour

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Channel harbor

Situated near the river mouth of the Adour

Surge motion of moored ships (Van der Molen et al., 2006)

- Moored ship = oscillating system with natural frequency
- Generated by long waves

Problems for harbor security and operations

Channel harbor

Situated near the river mouth of the Adour

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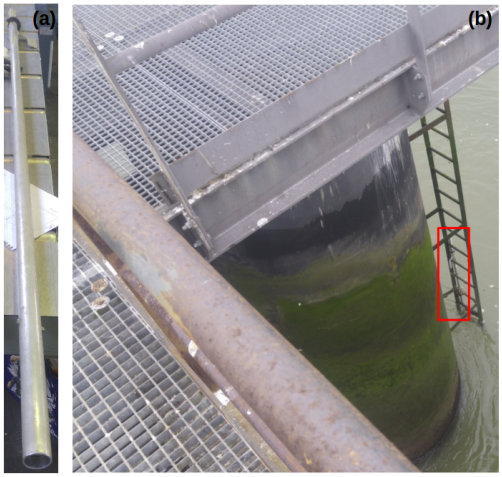
Problems for harbor security and operations

Methodology

Field campaign

- Characterize the hydrodynamic behavior of the harbor
- Fixing mechanism: access ladder to docks



Numerical model

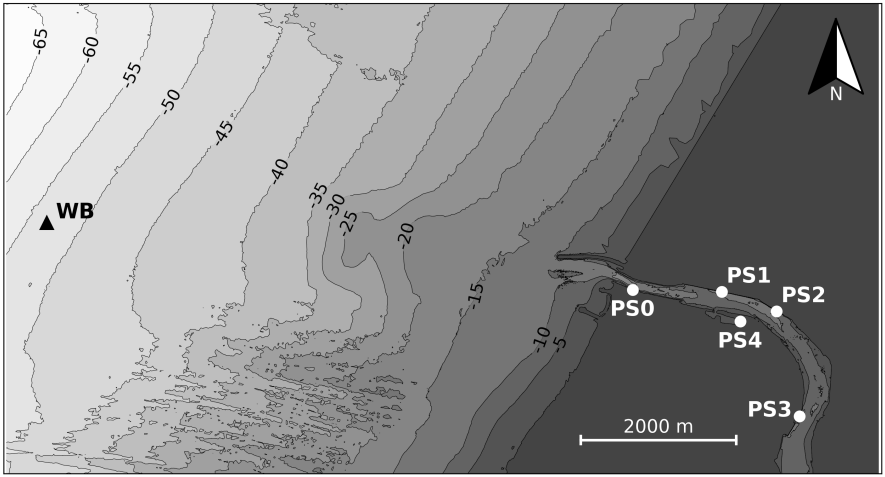
- Study of external forcing generation processes

Field campaign

Offshore wave conditions (WB): directional wave buoy moored in 50 m water depth
Channel harbor: pressure sensors (PS0 to PS3)

- 0.3 ; 1.4 ; 2.2 and 3.7 km from the river mouth

Marina: pressure sensor (PS4)
Sampling frequency: 1 Hz



Annual storm event: Hugo, March 23, 2018

Annual storm event

Storm Hugo

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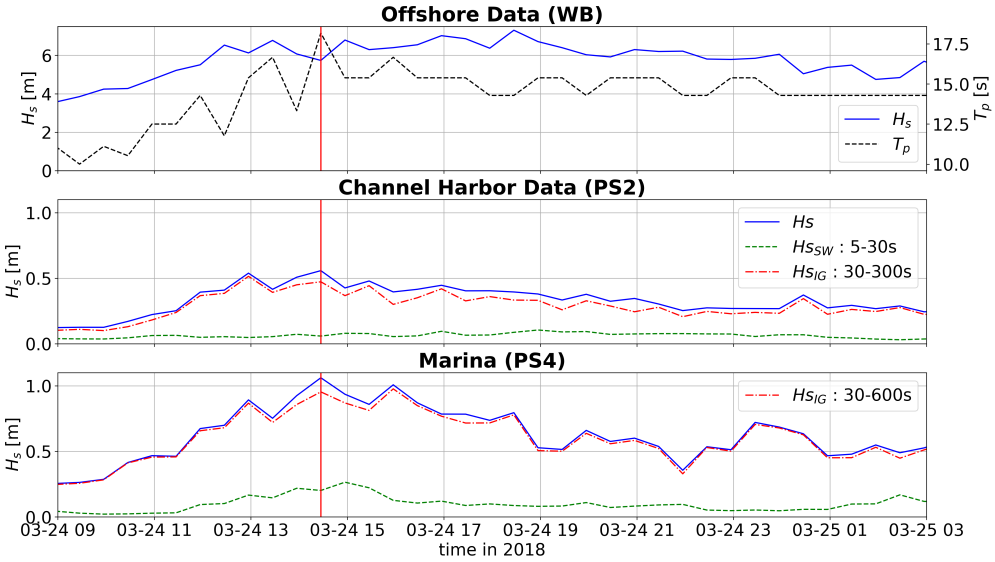
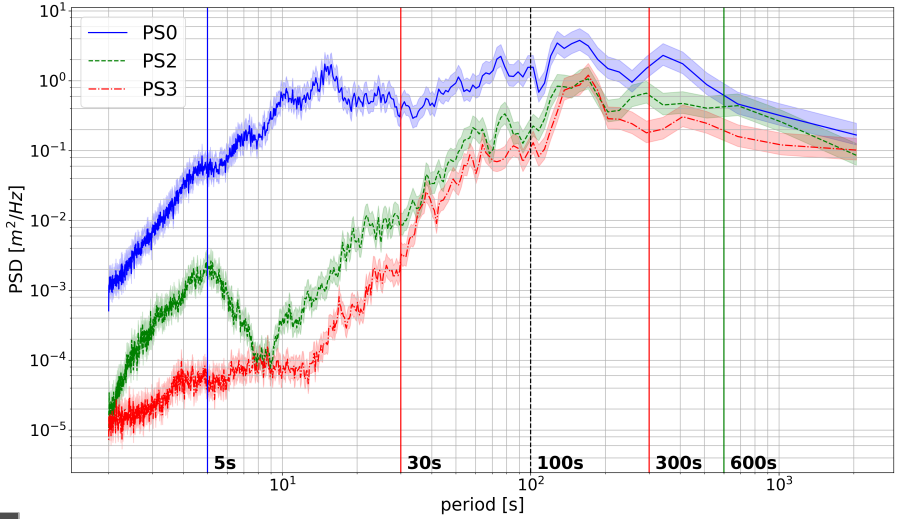
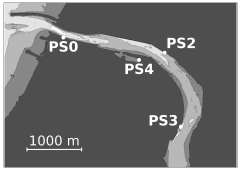


Power spectral density and Hs

Channel harbor

- Study site
- Methods
- Field campaign
- BOSZ model
- Conclusion





	Hs	Hs_{SW} 5-30s		Hs_{IG} 30-300s		Hs_{VLW} 300-600s		Hs_{IG1} 30-100s		Hs_{IG2} 100-300s	
	m	m	%	m	%	m	%	m	%	m	%
PS0	1.28	0.99	61	0.72	32	0.16	2	0.54	18	0.47	13
PS2	0.35	0.07	4	0.31	79	0.08	6	0.18	28	0.25	50
PS3	0.27	0.02	1	0.25	86	0.06	6	0.12	20	0.22	64

Power spectral density and Hs

Marina

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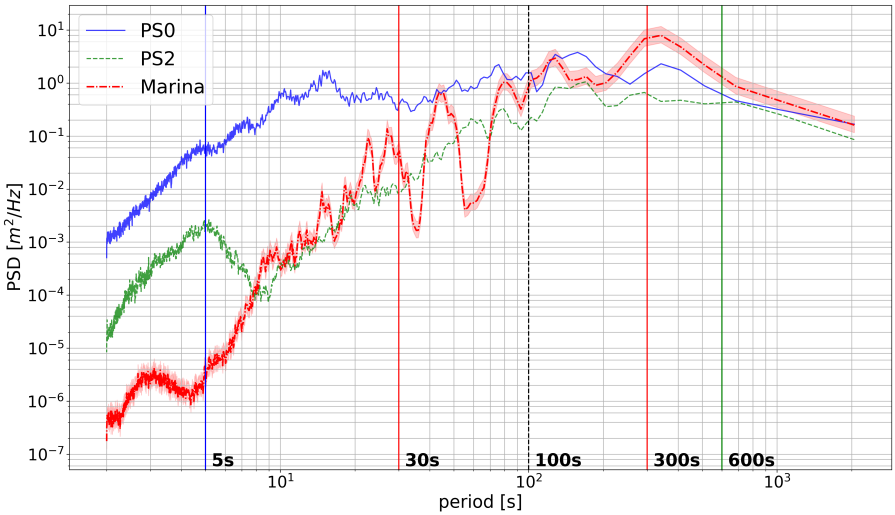

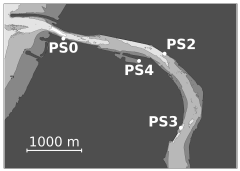

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PS2	0.35	0.07	4	0.31	79	0.08	6	0.18	28	0.25	50
Marina	0.67	0.12	3	0.53	62	0.28	17	0.28	18	0.44	43

Conclusions of field data

Efficiency of breakwaters: to protect the harbor against incoming swell and sea waves

Harbor oscillations due to IG waves : 80% of energy in IG frequency band

Channel harbor : waveguide

- Free propagation of IG waves without amplification
- Low energy dissipation for periods > 100 s

Marina : coastal seiche

- Harbor resonance (Rabinovich, 2009)
- Resonant periods of basin: Merian formula

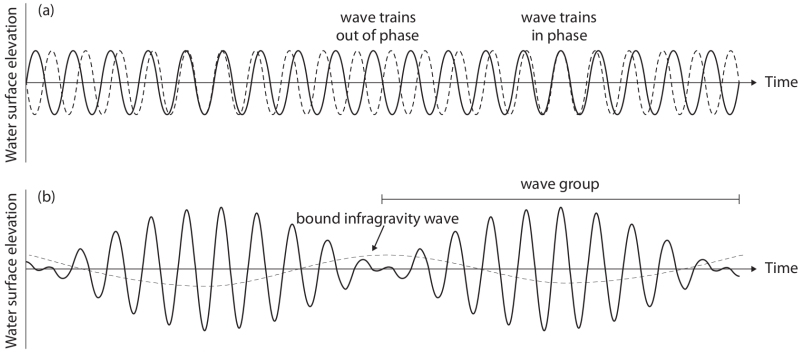
Infragravity waves (IG)

Mechanisms for generation?

Periods: 30 to 300 - 600 s (5 -10 min)

Mechanisms for the generation

- Second-order nonlinear wave-wave interactions between wind waves (Longuet-Higgins, 1962 and Hasselmann, 1962)



- Temporal variation of the breakpoint (Symonds,1982 and Schäffer, 1993)

Phase resolving approach: governing processes of the IG waves

Boussinesq model: BOSZ

Model setup

BOSZ model (Roeber, 2010 and 2012): conservative form of the equations of Nwogu (1993)

Selected event: March 24 2018, 14h30 - 15h00 (UTC)

- **Offshore conditions**: H_s = 5.70 m - T_p = 18 s - θ_p = 299°- σ_θ = 19°
- **Low tide**: measured water level = 1.97 m above CD (sd = 0.05 m)
- **Adour flow**: 430 m^3/s - annual mean flow: 300 m^3/s

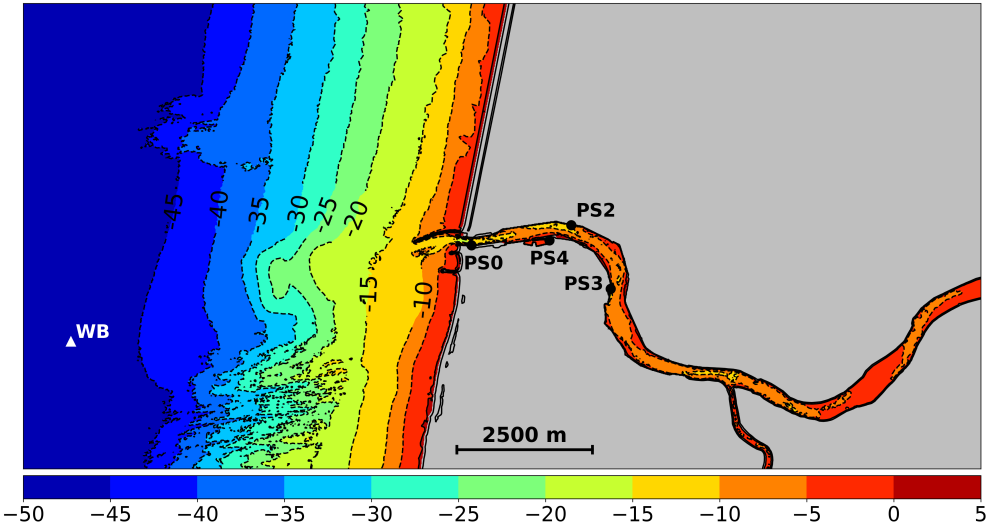
Model simulation period: 4h

- **Model initialization**: 30 min (still water level)
- **Spectral analysis**: 30-min averaged segment

No tidal and no river current forcing

Boussinesq model: BOSZ

Numerical domain



Grid resolution	m	**10**	**6.5**
Cells	millions	1.5	3.5
Wet cells	%	49	47
Computational time	days	1	3.5
12 cores: Intel Xeon x5675 @ 3,06 GHz			

Measurement and model result comparison

Channel harbor

- Study site
- Methods
- Field campaign
- BOSZ model
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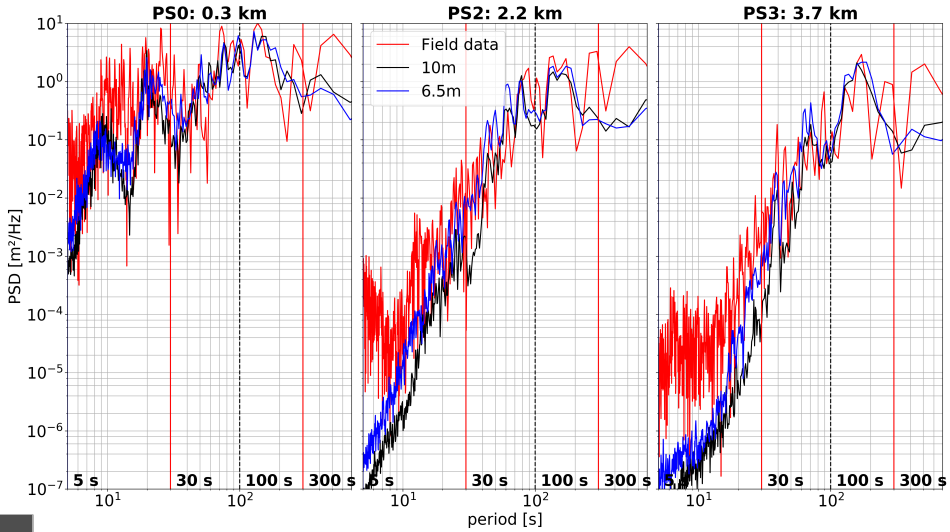

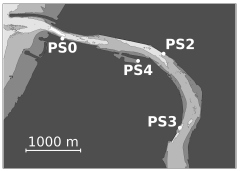

	Hs			Hs_{SW} 5-30 s			Hs_{IG} 30-300 s		
	Meas.	6.5 m	10 m	Meas.	6.5 m	10 m	Meas.	6.5 m	10 m
PS0	1.62	1.06	1.00	1.22	0.63	0.57	0.94	0.83	0.79
PS2	0.56	0.44	0.38	0.06	0.03	0.02	0.47	0.42	0.35
PS3	0.37	0.36	0.30	0.02	0.01	0	0.31	0.34	0.29

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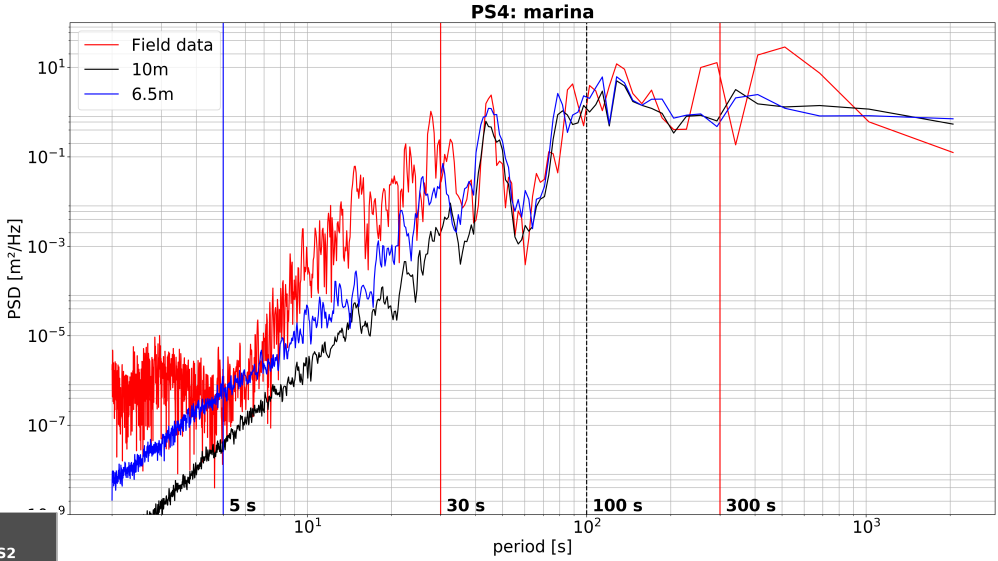

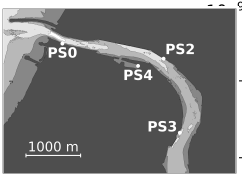

	Hs			Hs_{SW} 5-30 s			Hs_{IG} 30-300 s		
	Meas.	6.5 m	10 m	Meas.	6.5 m	10 m	Meas.	6.5 m	10 m
Marina	1.06	0.68	0.56	0.20	0.05	0.01	0.77	0.62	0.49

H_s map

- Study site
- Methods
- Field campaign
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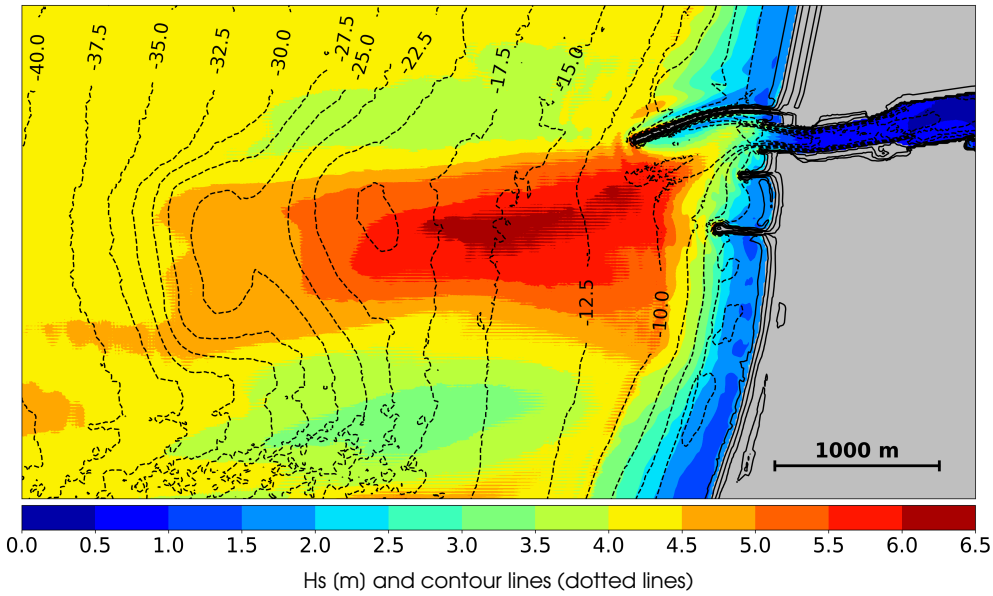

Local nearshore bathymetry effects: deposit of dredged material

Hs map

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- Field campaign
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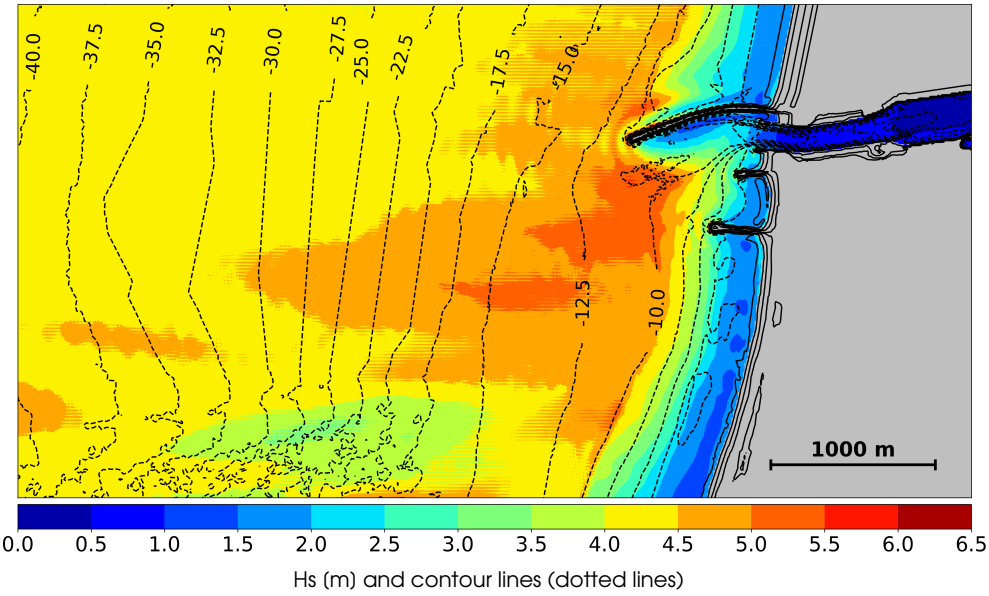
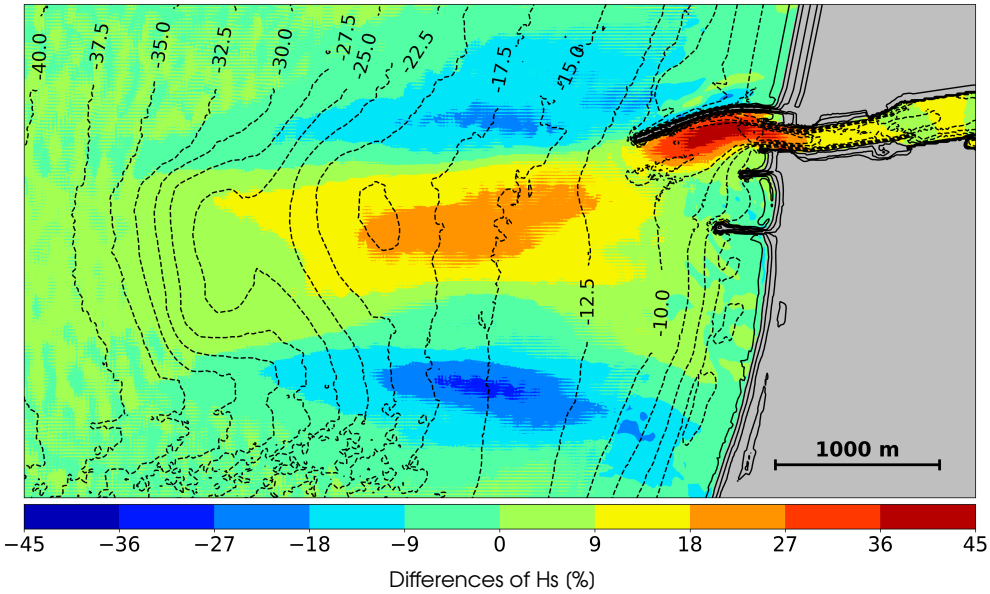
Removed deposit: uniform slope (initial bathymetry)



Local nearshore bathymetry effects: deposit of dredged material

Differences of Hs

Removed deposit: uniform slope (initial bathymetry)



Effect of the deposit of dredged material

Locations of numerical gauges

- Study site
- Methods
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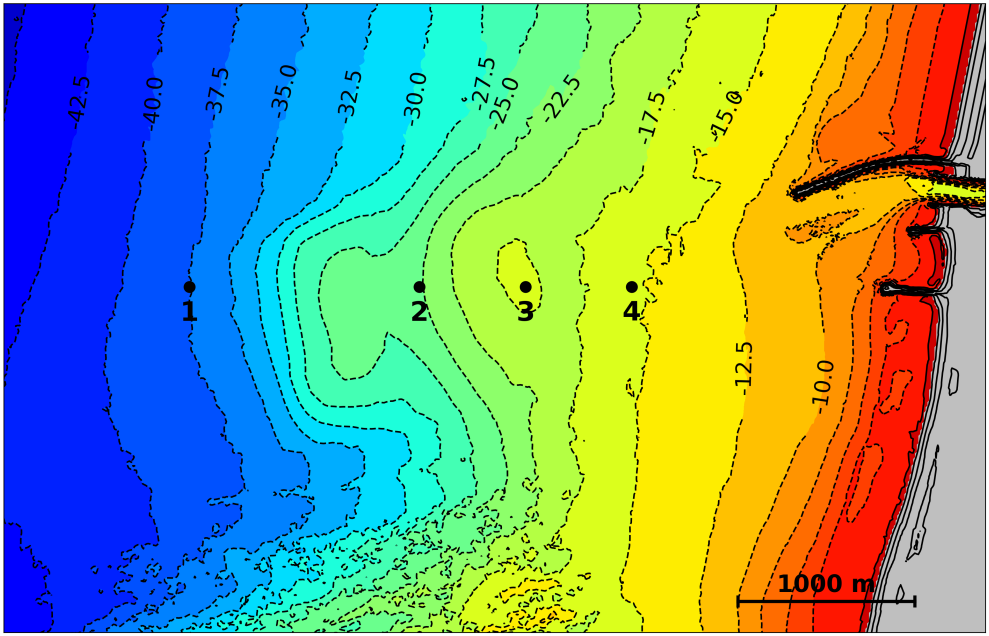
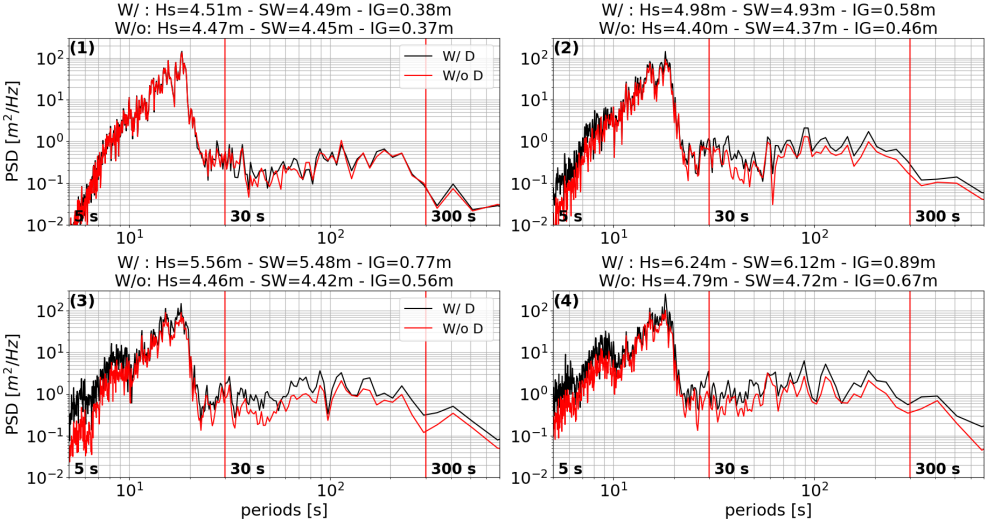


Effect of the deposit of dredged material

Power spectral density



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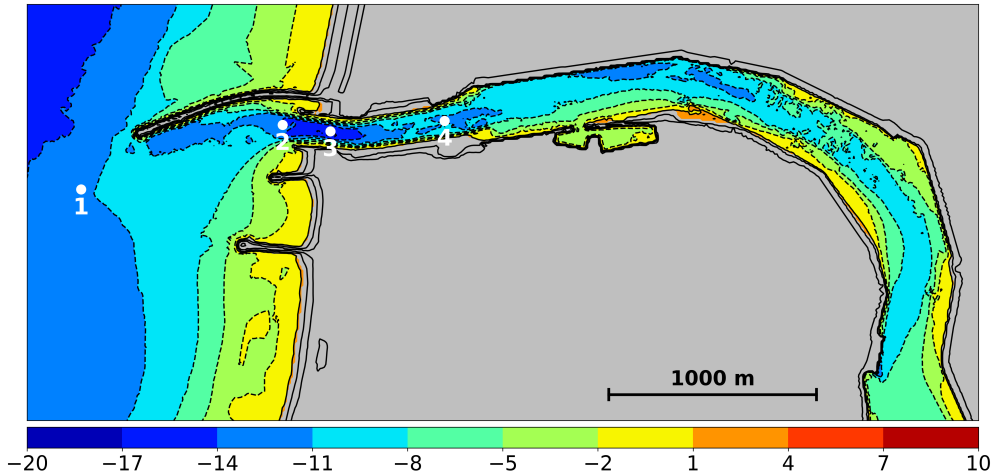

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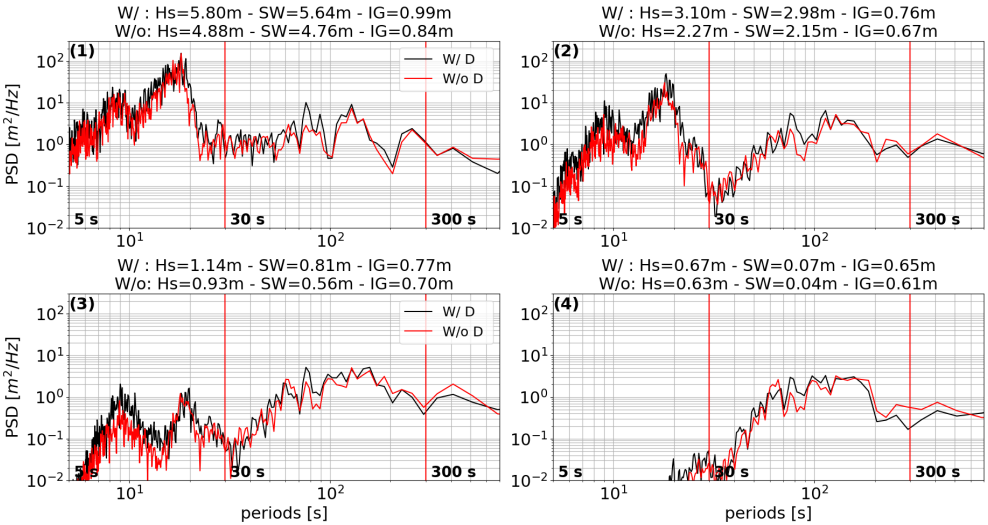

Conclusion

Governing processes for generation of IG waves

- Associated with wave groups: nonlinear wave interactions

Local nearshore bathymetry: deposit of dredged material

- Focusing wave energy: shoaling of incident waves
- Favors generation of IG waves

Further work:

- Effects of tide and river currents
- Upstream propagation of long waves in the river

Thank you!

CONTACT

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