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OBSERVING AND CHARACTERIZING INFRAGRAVITY WAVES THROUGH DIFFERENT SAMPLING DEVICES: A CASE-STUDY OFF THE BELGIAN COAST

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1 INTRODUCTION

Infragravity waves are surface waves with relatively longer periods in comparison to periods of the spectrum-dominant gravity waves. They are characterized by oscillations between 20 and 300 seconds (0.0033 Hz < f < 0.05 Hz), amplitudes that range from a few millimeters to tens of centimeters, and wavelengths of kilometers (Munk, 1950; Holman and Bowen, 1982; Ardhuin et al., 2014). Their forcing is linked to, amongst others, nonlinear interaction between sea swell waves, varying wave heights causing the breaking point of the waves to vary with height, and height variation of incoming waves (Bertin et al., 2018). Infragravity waves play an important role in coastal dynamics (Svendsen, 2005) and have been reported to trigger nearshore hazards such as beach and dune erosion (de Vries et al. 2008; Roelvink et al., 2009), development of seiches in harbors (Melito et al., 2006; Cuomo and Guza, 2017), wave-driven coastal inundation (Gent, 2001; Stockdon et al., 2006), and ice shelves collapsing (Bromirski et al., 2010). Therefore, revealing infragravity wave characteristics is of utmost importance to understand their potential to generate hazards in a certain region, especially at sites strongly influenced by human occupation and activities. Their consideration in coastal safety planning can avoid damages, as several locations have already experienced in the past (Yamanaka et al., 2019).

Implementing optimal sampling strategies for observing and characterizing infragravity waves might be challenging. By nature, these waves are hard to measure accurately due to their low amplitude. Their evolving characteristics in an environment marked by pronounced bathymetric features, such as the sand bank systems off the Belgian coast, add a degree of complexity that requires testing of different approaches, and at different sites. Within this context, this work first revisits observational approaches, instrumentation, logistics, and sampling techniques that have been used to study this phenomenon on the Belgian Coast. The advantages, challenges and limitations of different approaches are discussed, and best practices for collecting high-quality data in the field are addressed.

To do so, this study explores multi-sensor in situ deployments conducted at four selected sites off the Belgian coast (**Figure 1**) (Nieuwpoort, Raversijde (inshore and offshore Stroombank), and Trapegeer) within the context of the "*Influence of infragravity sea waves during storms on the hydro- and morphodynamic processes along hybrid soft-hard coastal defence structures with a shallow foreshore*" project, an FWO-funded initiative being conducted in collaboration between UGent, VLIZ, and KULeuven and with support of Agency for Coastal and Maritime Services (AMDK). More specifically, field observations were conducted using multipurpose mooring frames equipped both with (i) Acoustic Doppler Current Profiles (ADCPs) to sample pressure (0.1% FS), current, and sea surface elevation through acoustic surface tracking and (ii) high-accuracy quartz pressure sensors (accuracy 0.01 % FS). Both ADCPs and pressure sensors were set to measure continuously at 4 Hz being, therefore, able to capture both infra- and gravity waves. Furthermore, the moorings were collocated with standard wave buoys from AMDK. Data was collected continuously for about 3 months, covering storm and calm wave conditions. Finally, the measurements from ADCPs (pressure and acoustic) and pressure sensors were compared and used to derive the infragravity wave characteristics, as well as cross-validated against wave buoy data.

2 PRELIMINARY CONCLUSIONS

Preliminary conclusions will focus on in-situ observations of infragravity waves in both storm and calm conditions, and discuss the impact of difference in pressure sensor resolution of ADCP pressure sensors and highly accurate Quartz sensors on the calculated Hm0,IG and Hm0,SS. Furthermore, possible differences in the measurement of free IG-wave heights between the different pressure sensors will be addressed.

The approach with multi-sensor in-situ deployments also enables conclusion on the occurrence of infragravity waves along the Belgian coast, revealing valuable insights into their magnitude, generation, propagation, and relationship with sea swell waves and bathymetric features along the Belgian Coast. From our preliminary results we can conclude:

(1) The infragravity waves' contribution to total wave height is negligible during calm conditions, but important during stormy periods. In the most impacting observed event, infragravity waves contributed to up to 12.5% of the total wave height.

(2) The complex bathymetry off the Belgian coast, marked by a system of sandbanks, seems to impact the infragravity wave dynamics. One important observation is that infragravity waves are higher at locations inshore the sandbanks during stormy periods when compared to exposed sites.

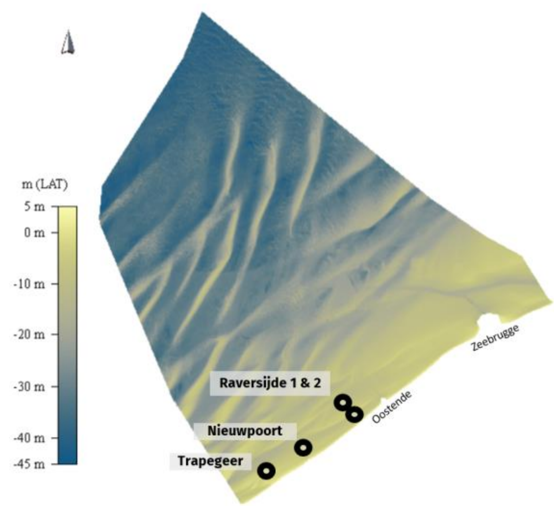

Figure 1: Measurement locations along the Belgian Coast Winter 2022-2023

REFERENCES

Ardhuin, F., Rawat, A., Aucan, J., 2014. A numerical model for free infra-gravity waves: Definition and validation at regional and global scales. Ocean Modelling 77, 20–32.

Bertin, X., de Bakker, A., van Dongeren, A., Coco, G., Andro, G., Ardhuin, F., et al. (2018). Infragravity waves: From driving mechanisms to impacts. *Earth-Science Reviews*, 177, 774–799.

Bromirski, D., Olga V., MacAyeal R. (2010). Transoceanic infragravity waves impacting Antarctic ice shelves. *Geophysical Research Letters*. 37

Cuomo, G. and Guza, R.T., (2017). Infragravity seiches in a small harbor. Journal of Waterway, Port, Coastal, and Ocean Engineering 143.

Gent, M.R.v., 2001. Wave runup on dikes with shallow foreshores. Journal of Waterway, Port, Coastal, and Ocean Engineering 127, 254–262.

Holman, R., Bowen, A., 1982. Bars, bumps, and holes: models for the generation of complex beach topography. Journal of Geophysical Research: Oceans 87, 457–468.

Melito, I., Cuomo, G., Bellotti, G., Franco, L., 2006. Field Measurements of Harbour Resonance at Marina di Carrara. *Coastal Engineering Proceedings, 30*. San Diego, U.S.A. p. 1280-1292.

Munk, W. H. (1950). Origin and generation of waves. Coastal Engineering Proceedings, 1. Long Beach, USA, p. 1-4.

Roelvink, D., A. Reniers, A. van Dongeren, J. van Thiel de Vries, R. McCall, and J. Lescinski. 2009. Modeling storm impacts on beaches, dunes and barrier islands. *Coastal Eng.* 56 (11–12): 1133–1152.

Stockdon, H. F., R. A. Holman, P. A. Howd, and A. H. Sallenger. 2006. Empirical parameterization of setup, swash, and runup. *Coastal Eng*. 53 (7): 573–588.

Svendsen, Ib A. (2005) *Introduction to Nearshore Hydrodynamics*. World Scientific. ISBN: 978-981-270-612-6.

de Vries, J.v.T., Van Gent, M., Walstra, D., Reniers, A., 2008. Analysis of dune erosion processes in large-scale flume experiments. Coastal Engineering 55, 1028–1040.

Yamanaka, Y., Matsuba, Y., Tajima, Y., Shibata, R., Hattori, N., Wu, L., & Okami, N. (2019). Nearshore dynamics of storm surges and waves induced by the 2018 Typhoons Jebi and Trami based on the analysis of video footage recorded on the coasts of Wakayama, Japan. *Journal of Marine Science and Engineering*, 7(11), 413.