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COUPLED SHORT-IG WAVE DYNAMICS OVER A SHALLOW BARRIER REEF

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1 INTRODUCTION

Reef barriers play a major role many coral islands, by sheltering the lagoon from the ocean wave energy and then creating a unique habitat for many species. This filtering action becomes increasingly crucial for ecosystems health and shoreline protection in the context of climate change and related sea level rise, degradation of coral systems and modification of wave conditions. A strong research effort has therefore been engaged by the coastal oceanographers community for the last two decades to improve our knowledge and prediction skills of wave dynamics over coral reef systems. A widely reported observation is the importance of infragravity waves (IG) over wave-driven reef systems, whether fringing or barrier reefs. IG are primarily forced by groups in the incoming short-wave (SW) field, either by the release of bound waves or the breakpoint oscillations (Bertin et al. 2018). IG period typically ranges between 30 and 200s, which makes them prone to excite or interact with natural seiching modes in reef-lagoon systems often ranging in the Very Low Frequency (VLF) band. Further research efforts are now necessary to better understand the interaction between long IG/VLF oscillations and SW field. In particular, long waves are expected to play a dynamic depth-filtering role on SW energy, acting as long carrier wave able to promote the propagation of larger SW groups by IG/VLF crests. More generally, the spectral energy transfers over the reef crest-flat system and their relative importance w.r.t. frictional and breaking dissipation are not fully understood over the complete range of surface waves.

The aim of the present study is to analyse and to discuss a series of field observations performed on the barrier reef of Maupiti Island, French Polynesia. A particular focus is placed on the interaction between SW and IG wave fields across the reef crest-flat system.

2 FIELD EXPERIMENT

The present study focuses on the data recovered over a single cross-barrier transect located in the south-west barrier of Maupiti Island, from 5 to 18 July 2018 (Figure 1). The recovered dataset has already been analysed in terms of momentum flux (Sous *et al.*, 2022) and SW frictional dissipation (Sous *et al.*, 2023) . The focus is here placed on the coupled SW-IG dynamics using bottom-moored pressure sensors deployed on the barrier. The sensors were repeatedly positioned by GNSS-RTK during the experiment. The pressure data were continuously acquired at 10 Hz.

3 RESULTS

Figure 2 depicts the wave dynamics for a selected 2-h long event on July, 9, 2018, for sensors OSS2, OSS3 and OSS4. The incoming wave height and peak period at S4 station are 3.2 m and 14.7 s, respectively. Left plots (Fig. 2A,C,E) display illustrative timeseries of free surface elevation over a 25 min burst, combined with low-pass ($f<0.03$ Hz) and envelopes signals. Right plots (Fig. 2B,D,F) display the spectral analysis over the complete 2 h duration restricted to the low frequency range below 0.04 Hz. The time-series highlight the strong coupling between SW envelope and low-frequency pulsations: large wave groups are generally associated with crests of long waves. The coupling strenghtens during propagation from the reef crest (OSS2) to the reef flat (OSS4). The spectral analysis displayed in Figure 2B,D,F provides finer insight on the frequency-dependency of the SW-IG coupling. At OSS2, a strong coherence combined with a nearly null phase lag is observed below 0.01Hz, meaning that SW groups tend to be phase-locked with long waves in this band. At higher frequency ($0.01<F<0.03$Hz), while the coherence progressively decreases, the phase lag shifts to around $-\pi/2$ indicates that wave groups tends to propagate at the front of long waves. This time lag may be associated with enhanced energy transfers. Further on the reef flat, the decrease of wave group energy is associated with a weaker and nearly phase-locked SW-IG coupling.

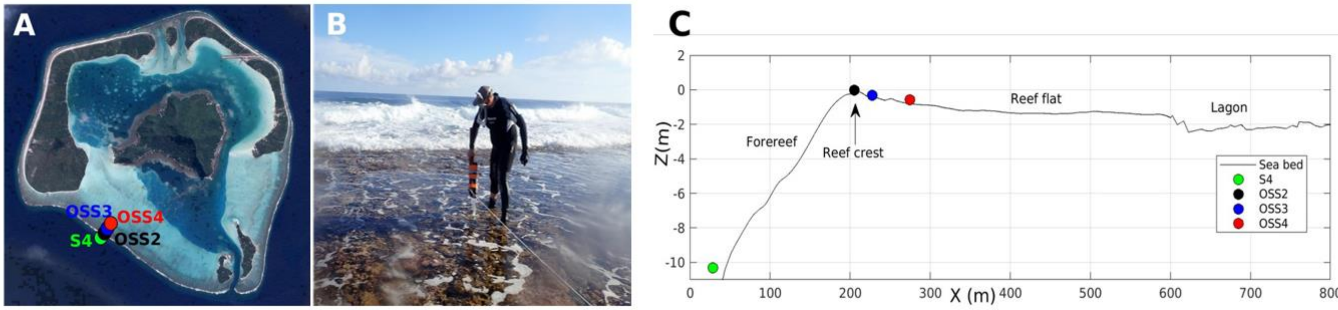

Figure 1. A: the Maupiti island with instrumented transect. B: OSS2 deployment. C: bathymetric profile with sensors location.

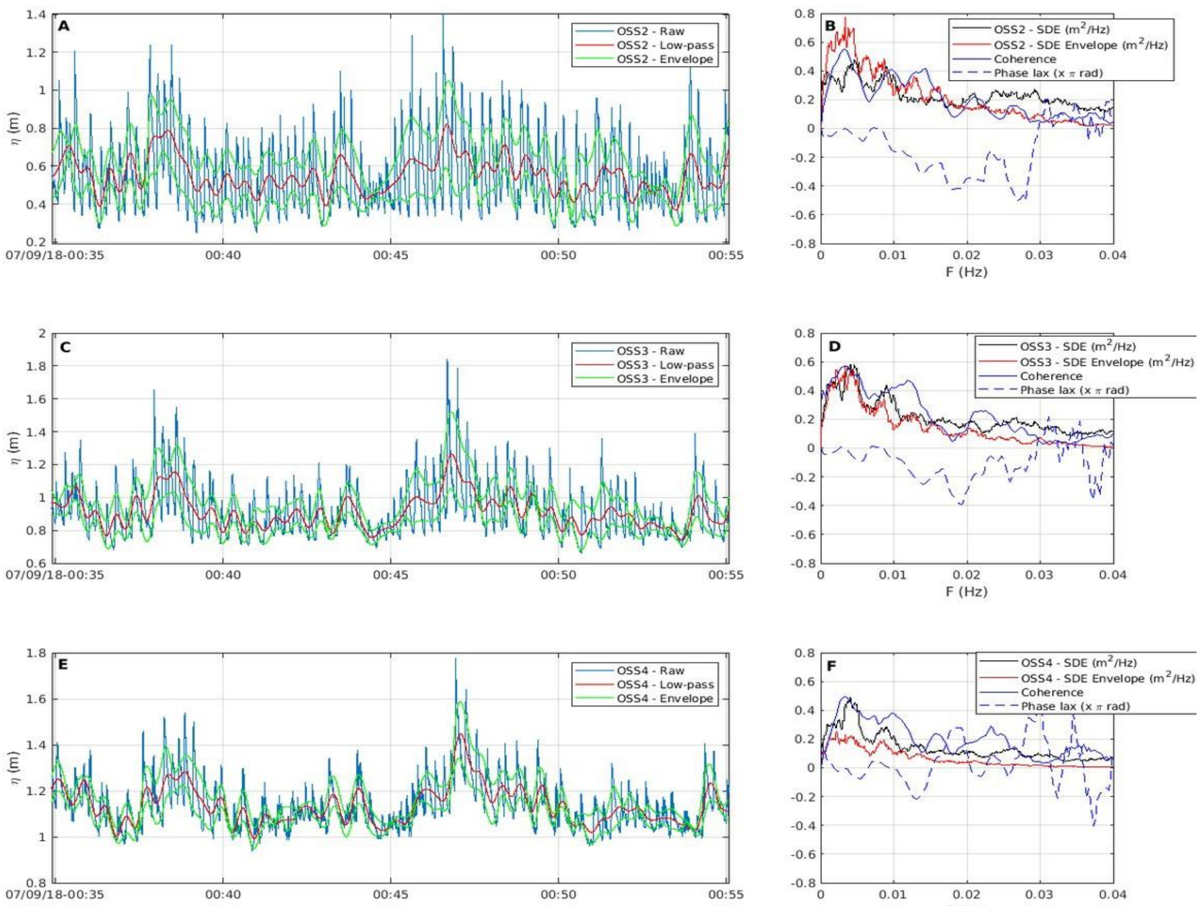

Figure 2. A, C, E: time-series of instantaneous free surface, low-pass and envelope signals for OSS2, OSS3 and OSS4. B, D, F: Spectral Density of Energy for instantaneous signal, envelope and spectral coherence and phase lag for OSS2, OSS3 and OSS4

4 CONCLUSIONS

The present field study discusses the coupling between short and low wave over a barrier reef. For the selected case, long waves mainly act as depth-dependent filter for SW. Further analysis is ongoing to understand the energy transfers between the different wave components and to extend the finding to a more complete set of observations.

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