Infragravity wave forcing in the surf and swash zone.

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Abstract

Infragravity waves, also known as surf beat, are important morphodynamic drivers in shallow water, especially inside the surf and swash zone where the short wave energy is dissipated due to breaking. In the past decades, great progress has been acquired in the understanding of surf beat and its implication in the coastal environments. However, many key features are still not fully understood, especially for complex natural systems. This thesis investigates infragravity wave dynamics in the surf and swash zone through a re-analysis of laboratory data, new numerical modelling and novel field measurements.

The generation of infragravity waves in the surf zone is commonly associated with two individual mechanisms: release of second-order group-forced long waves and long waves generated by group-induced surf zone breakpoint oscillations. Both mechanisms are forced by radiation stress gradients, but due to their individual nature, different relationships between short and infragravity waves are expected. Determining these relationships, their effectiveness, and the governing hydrodynamic and morphodynamic conditions for each mechanism is complex. In the field, observations are still, to some extent, limited and generally restrained to small wave conditions.

The first part of the thesis presents a comprehensive study of different infragravity wave generation mechanisms that includes a critical literature review, a re-analysis of previous laboratory data and an extensive numerical modelling investigation. This work provided new information about the implication of the different processes associated to bound wave shoaling, release and dissipation. In addition, key aspects related to the propagation patterns of infragravity waves have been identified. From the numerical investigation and the large amount of laboratory data re-analysed, clear and distinct relationships between the breakpoint and shoreline excursion have been established for each generation mechanism. The second
part of the thesis presents a novel method to determine the dominant infragravity mechanism in the inner surf and swash zone in the field. In the field, the breakpoint oscillations and the shoreline motion are measured remotely via video and their relationship identified via cross-correlation. The identification of the dominant forcing mode, either bound wave or breakpoint, is interpreted based on the specific relationships previously determined.

The results of thirteen field data sets collected from three different beaches indicate that, inside the surf zone, the dominance of bound wave or breakpoint forcing is strongly dependent on the surf zone width and the type of short wave breaking. Infragravity generation by bound wave release was stronger for conditions with relatively narrow surf zones and plunging waves; breakpoint forcing was dominant for wider surf zones and spilling breaker conditions, suggesting also that the bound waves remained forced inside the surf zone, being dissipated during short wave breaking. The numerical and laboratory results have also suggested a similar interpretation.

This thesis has shown that the breakpoint and shoreline oscillations are relevant features to interpret the surf beat mechanics. The adopted methodology is based on commonly used techniques that can be easily implemented in remote sensing systems used for regular coastal monitoring, enabling easier data collection in more extreme wave conditions.