Infragravity wave behaviour on a low sloping beach

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Introduction

Although infragravity waves are known to be important to beach and dune erosion, several aspects of infragravity-wave dynamics are not well understood. As an example, existing field and laboratory data indicate that infragravity waves dissipate energy in the very-shallow nearshore (Van Dongeren et al., 2007). Several dissipation mechanisms have been put forward, however there is little field evidence supporting either of these hypotheses. The present study, part of a field campaign on Ameland from September until November 2010, is aimed at establishing the level of energy dissipation at infragravity frequencies and at pointing to the dominant mechanism for this dissipation on a low sloping beach.

Methodology

The instruments were placed in a cross-shore array in the intertidal zone. The total cross-shore distance was around 200 m. The maximum water depth was around 2.5 m at high tide at the most seaward sensor. Along this transect three small frames and one larger frame were placed, each equipped with a pressure sensor, optical backscatter sensors, and velocity meter(s). Furthermore, ten OSSI pressure transducers were placed along the transect. The equipment typically operated continuously when submerged with a sampling frequency of 4 Hz. DGPS measurements surveys were performed several times during the campaign to measure changes in the cross-shore beach profile.

Results

Cross-shore wave pattern (Figure 1)

- 90 s wave: nodal structure,phase jumps at minimum, and reflection coefficients above 0.5
  → standing wave pattern.
- 45 s wave: nodal structure but monotonic increase in phase
  → mixed standing/progressive wave pattern.
- 22.5 s wave: no nodal structure, steeper phase gradient, and reflection coefficients less than 0.1
  → progressive wave pattern.
- At shorter infragravity periods (< 50 s) dissipation takes place in very shallow water (0.5 - 1 m), suggesting that breaking is the dominant dissipation source.

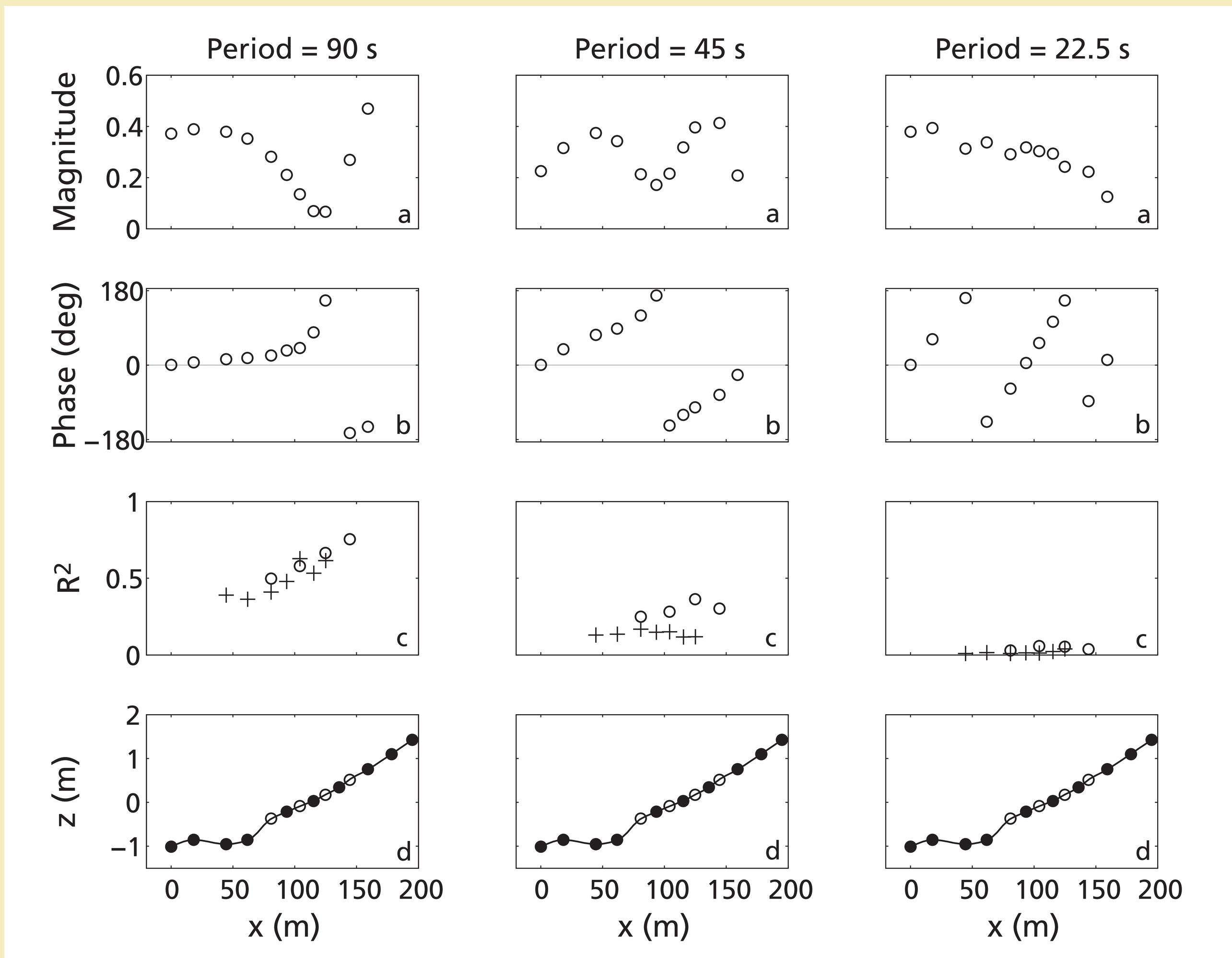

Figure 1: Three infragravity wave periods during high energetic conditions. a) eigenfunction dominant cross-shore structure, b) phase, c) reflection coefficient R^2, circles (plusses) show the Sheremet et al., 2002 (Van Dongeren et al., 2007) method, d) cross-shore transect, closed (open) circles show the positions of the OSSI's (frames).

Infragravity wave breaking parameter – β_H (Figure 2)

- $\beta_H = \frac{h_x T}{2\pi}\sqrt{\frac{g}{H}}$ with h_x ~ 1:70 is bed slope, T is period, g is gravitational acceleration and H is incoming wave height.
- A clear dependence of R on β_H.
- Long (short) periods are in the steep (mild)-sloping regime.
- Transition at $\beta_H \approx 1.5$, consistent with Van Dongeren et al.'s [2007] laboratory experiments. This implies that shorter-period infragravity waves are indeed breaking.

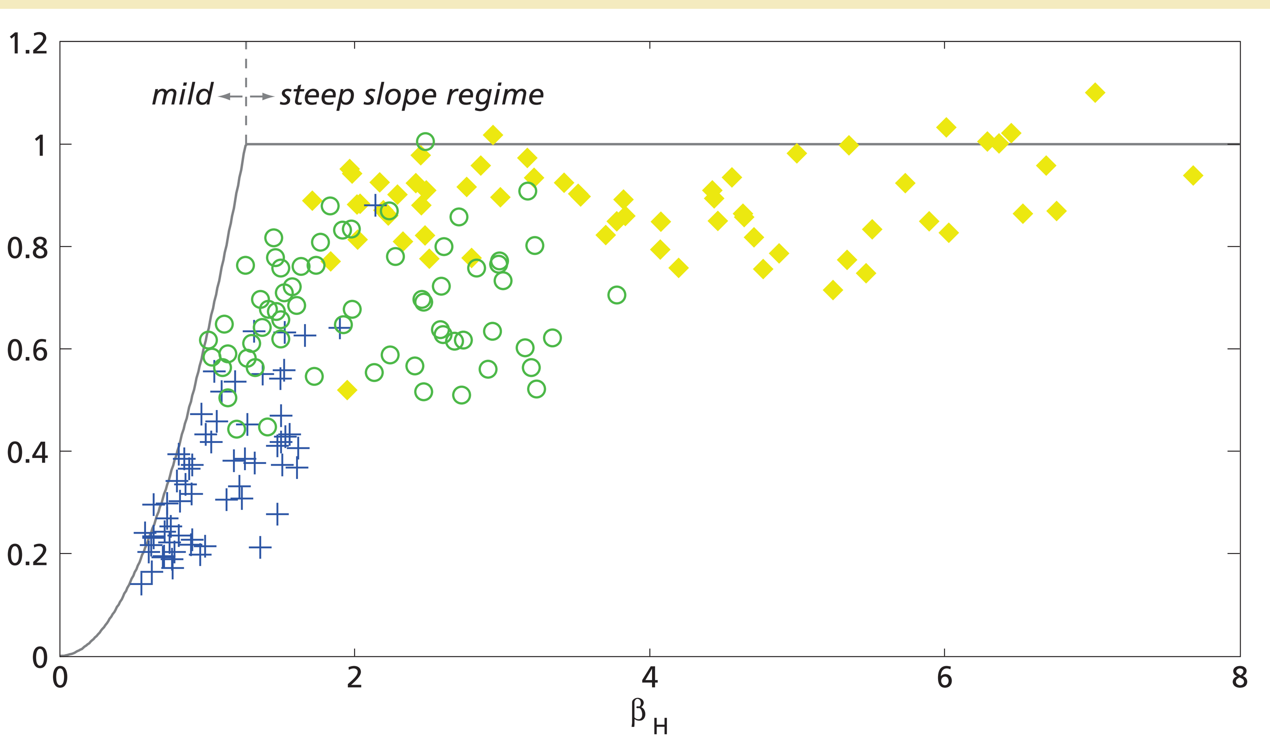

Figure 2: Shoreline reflection coefficient R versus β_H parameter. Plusses represent the 22.5 s waves, circles the 45 s waves and diamonds the 90 s waves. The fitted line is the relation between R and β_H after Battjes [1974], $R = 0.2\pi\,\beta_H^2$.

References

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