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Beach profile effects on nonlinear infragravity-wave interactions

Objective

Nonlinear triad interactions redistribute energy which:

- Transforms the shape of sea-swell waves (SS, f = 0.05 - 2 Hz)
- Creates energy at infragravity frequencies (IG, f = 0.005 - 0.05 Hz)

IG waves are found to be important in the erosion of beaches and dunes during storms. Recently, it has been suggested that IG waves may loose energy by:

- Transferring it back to (former) SS spectral peak
- IG-IG transfers that cause IG waves to steepen and in time break

Here, we investigate energy transfer patterns for different types of beaches, using the model SWASH

Model validation and new bathymetries

Governing equations of SWASH are the non-linear shallow water equations with non-hydrostatic pressure (Zijlema et al. 2011). We validated SWASH using the high-resolution, small-scale, Globex laboratory dataset with a 1/80 sloping beach (Ruessink et al. 2013).

Figure 1 shows the SS and IG significant wave heights of the 1/80 slope for both lab and model with H_s = 0.1 m and T_p = 2.25 s. Results for a mild (1/50) and steep (1/20) sloping beach are shown as well.

Validation

- SS wave height reproduced well
- IG wave height increase and arrest in good agreement
- IG dissipation slightly overestimated

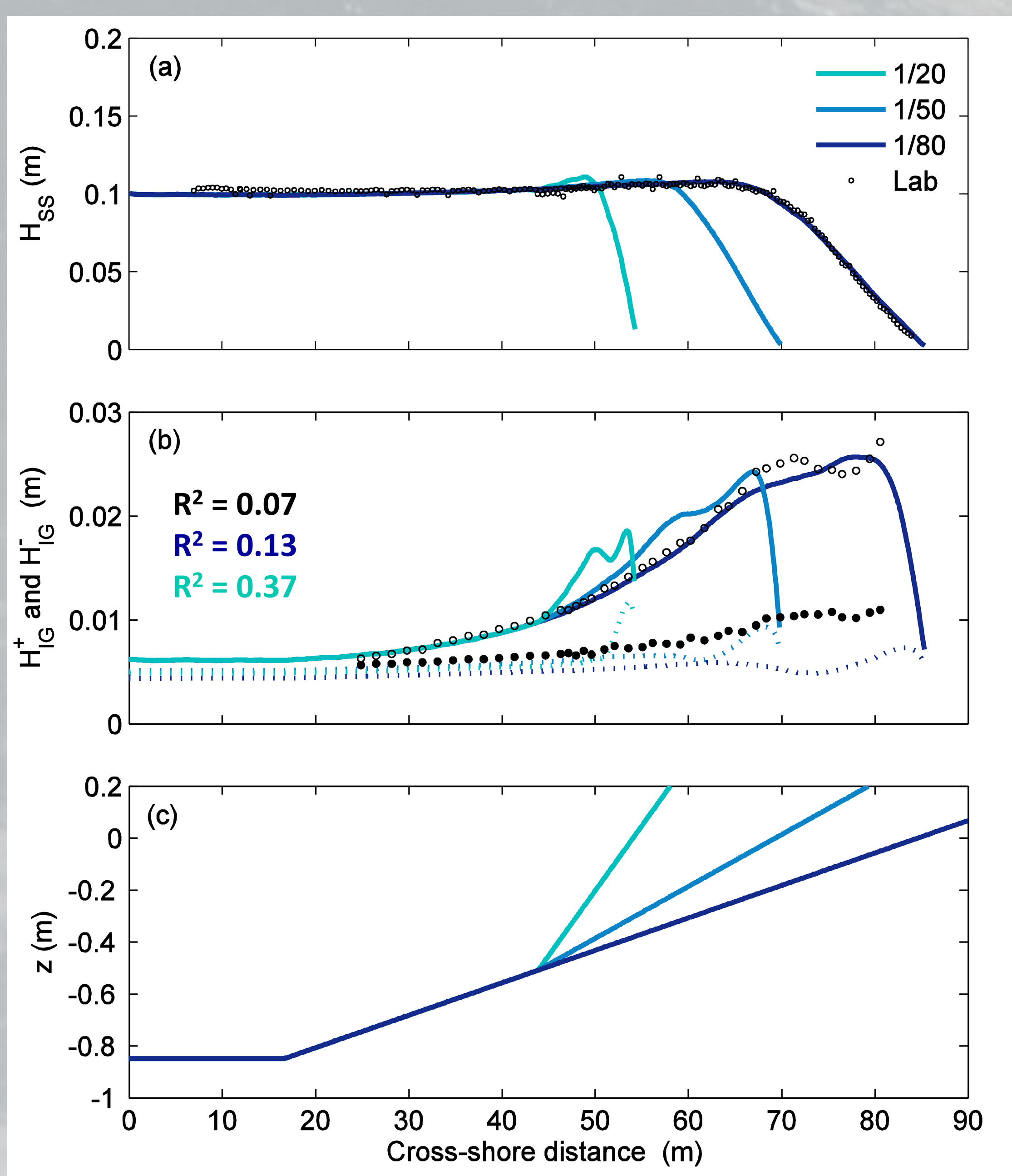


Figure 1: (a) H_{ss} and (b) incoming and outgoing H_{IG}. Panel (c) shows corresponding bottom profiles. Reflection R^2 in inner surf (h = 5 cm).

Beach slope dependence

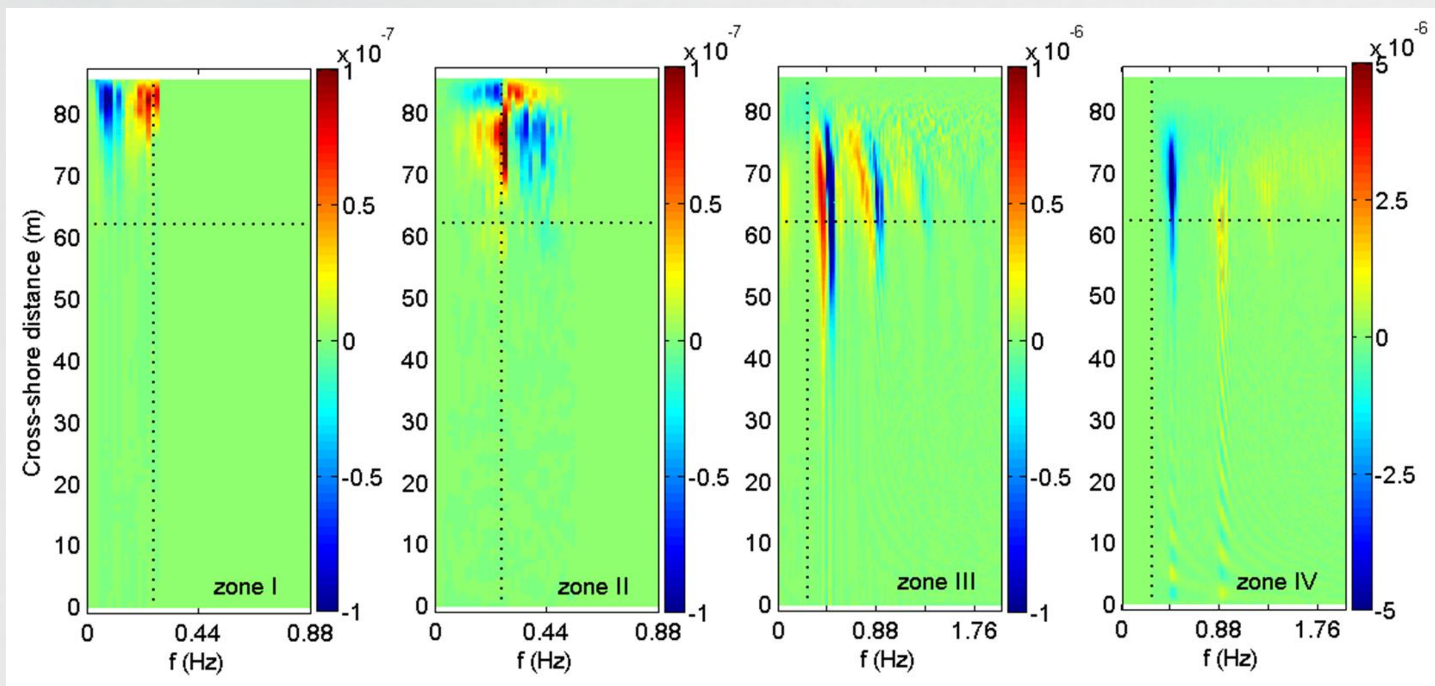
- Low slope: strong IG wave growth, low reflection
- Steep slope: weak IG wave growth, high reflection
- IG wave dissipation starts at $H_{IG}/h \sim 0.45$

Nonlinear energy transfers

The nonlinear source term S_{nl} accounts for energy transfers to and from a frequency f. S_{nl} is estimated by integrating the product of the imaginary part of the bispectrum and a coupling coefficient following Herbers et al. 2000. Energy transfers were divided into four types following de Bakker et al. (2015): triad interactions including (I) IG frequencies only, (II) two IG and one SS frequency, (III) two SS and one IG frequency and (IV) SS frequencies only.

Figure 2 shows the S_{nl} term for each of the four types for the 1/20 and 1/80 slopes.

Low slope (1/80)



Steep slope (1/20)

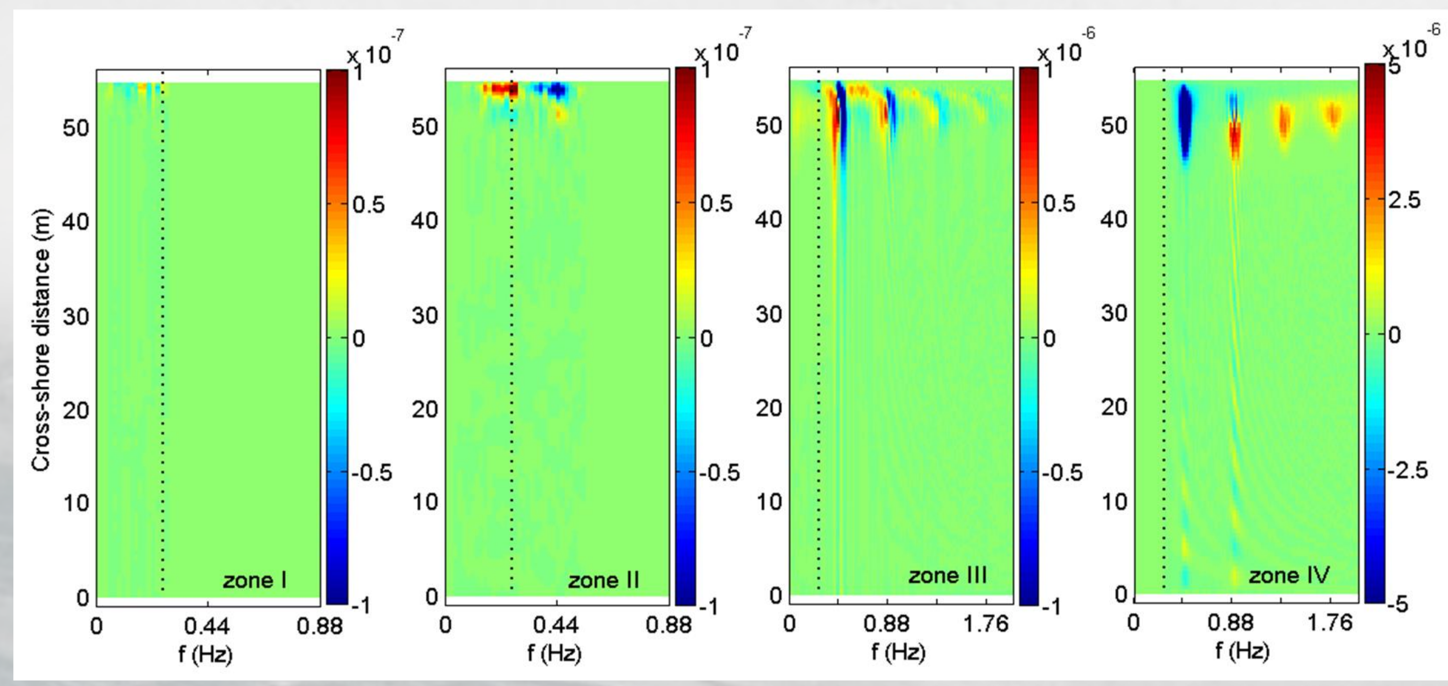


Figure 2: S_{nl} plotted versus frequency f and cross-shore position x. With (a) IG frequencies only, (b) two IG and one SS frequency, (c) two SS and one IG frequency and (d) SS frequencies only. The dashed line indicates the boundary between IG and SS.

Inner surf zone

Low slope (x > ~70 m)

- Transfers involving two or more IG frequencies dominate (I,II)
- Energy cascades from low to high IG frequencies and 'harmonics' (I,II,III)

Steep slope (x > ~50 m)

- Transfers involving two or more SS frequencies dominate (III, IV)
- IG interactions are weak, small transfer/loss

Conclusions

- **Low slope enhances IG wave growth. IG interactions dominate in shallow water, resulting in IG energy loss.**
- **Steep slope limits IG wave growth and thereby IG interactions, resulting in less IG energy loss.**

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References de Bakker et al., 2015. *J. Phys. Ocean* 45, 589-605. Herbers et al., 2000. *J. Phys. Ocean.* 30, 2723-2737. Zijlema et al., 2011. *Coast. Eng.* 58, 992-1012. Ruessink et al. 2013. *Coastal Dynamics conf., 2013.*