Objective
Nonlinear triad interactions redistribute energy which:
• Transforms the shape of sea-swell waves (SS, f = 0.03 - 2 Hz)
• Generates 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 lose energy by:
• Transferring it back to (former) SS spectral peak
• IG-IG transfers that cause IG waves to steepen and to eventually break
Here, we investigate energy transfer patterns for different types of beaches, using the model SWASH.

Variable bathymetries
We use SWASH to simulate wave propagation over a low (1/80), mild (1/50) and steep (1/20) sloping beach, and a 1/80 beach with a sandbar, with \( H_b = 0.1 \) m, and \( T_p = 2.25 \) s.

Low slope, strong IG wave growth, low \( R^2 \)

Steep slope, weak IG wave growth, high \( R^2 \)

Figure 2: (a) \( h_* \) and (b) \( h_{mg} \). Panel (c) shows corresponding bottom profiles. Reflection \( R^2 \) in inner surf \((h = 5 \) cm). Sand bar dimensions correspond to \( \Delta h = 70 \) cm, \( \Delta x = 80 \) m, \( \alpha = 1.80 \) m in the field.

Energy transfers
The nonlinear source term \( S^*_n \) accounts for energy transfers to and from a frequency \( f \). \( S^*_n \) is estimated by integrating the product of the imaginary part of the bispectrum and a coupling coefficient following Herbers et al. 2000. Figure 5 shows the \( S^*_n \) term for each of the four bispectral zones as defined in the box ‘Bispectral analysis’, for the 1/20 and 1/80 slopes.

Low slope (1/80)

Inner surf zone

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

Sandbar
At bar locally stronger transfers, shoreward of the bar weaker transfers

Figure 5: \( S^*_n \) terms plotted versus \( f \) and \( x \). Vertical dashed line is the cut-off between IG and SS frequencies. Horizontal dashed line is the edge of the surf zone.

Figure 6: Difference in \( S^*_n \) of bar minus non-barred 1/80 slope, plotted versus \( f \) and \( x \).

Bispectral analysis
The bispectrum \( B_{f1f2f3} \) detects phase-coupling between frequency components in a triad. The discrete bispectrum is defined as,
\[
B_{f1f2f3} = E[f_1 f_2 f_3]
\]
\[
A_{f1f2f3} = A_{f1} A_{f2} A_{f3}^*
\]
\[
\tilde{E}_{f1f2f3} = \text{ensemble average of } B_{f1f2f3}
\]
\[
\tilde{A}_{f1f2f3} = \text{complex Fourier coefficients}
\]
\[
\tilde{A}_{f1f2f3}^* = \text{complex conjugation}
\]
To obtain insight in the different triad interactions, four zones are defined, for which nonlinear energy transfers are calculated.

Figure 4: The imaginary part of the bispectrum at \( x = 26.8 \) m.

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.
• At a sandbar locally stronger transfers, this is compensated by weaker transfers shoreward of the bar.

Outlook
• Other wave conditions
• Other bar dimensions, concave/convex beach shapes