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Transport of turbulence in the surf zone of a field-scale laboratory beach

Introduction

Turbulence beneath broken waves is organized in vortices, which can stir sediment from the bed and keep it in suspension. Suspended sediments are then transported with the turbulent vortices by wave orbital velocities and the mean current. The direction of transport by wave-induced currents depends on phase-coupling with turbulence events. As a first step to better understand sand transport processes in the surf-zone, we here examine turbulence characteristics under random plunging waves under field-scale laboratory conditions.

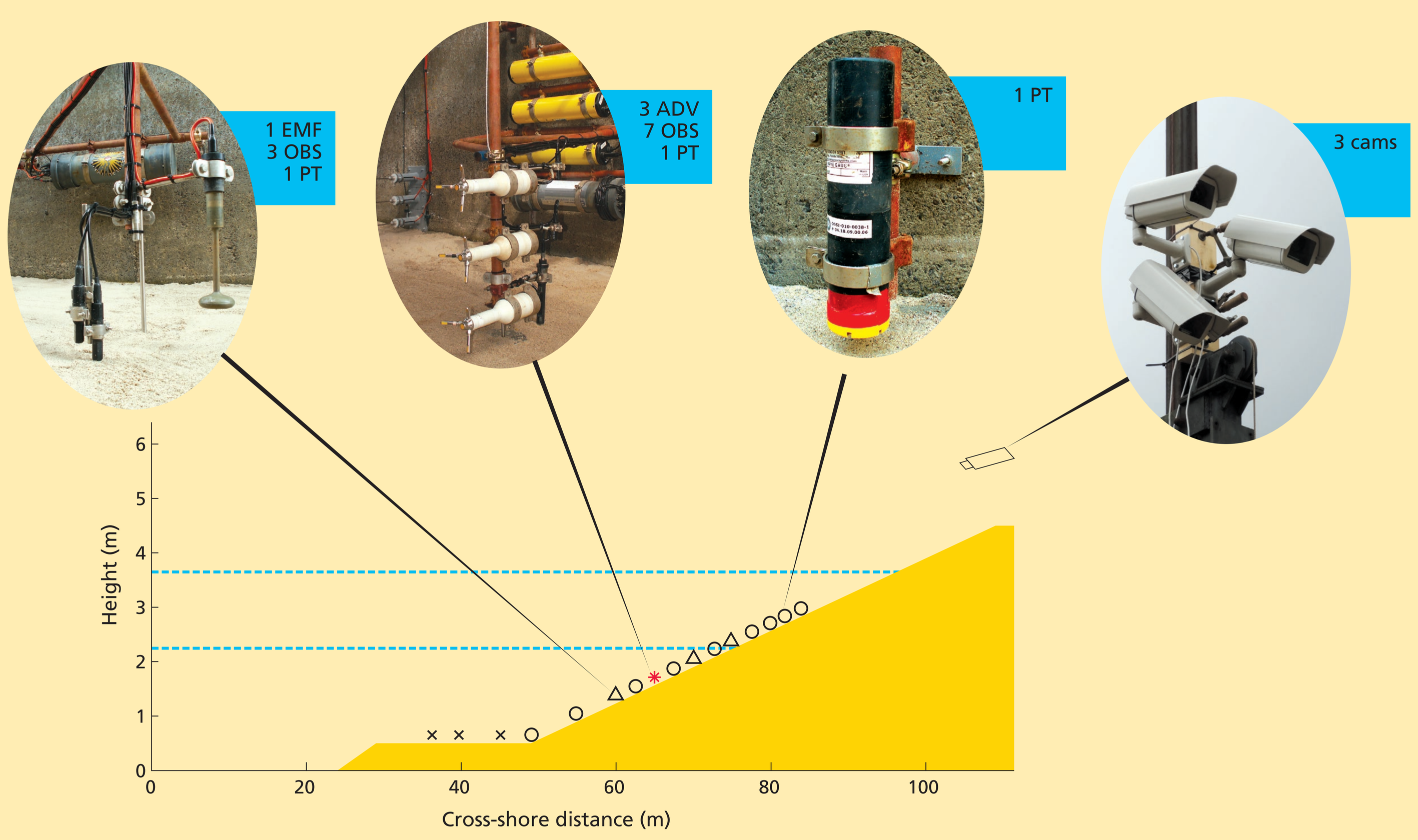
Methods

Measurements

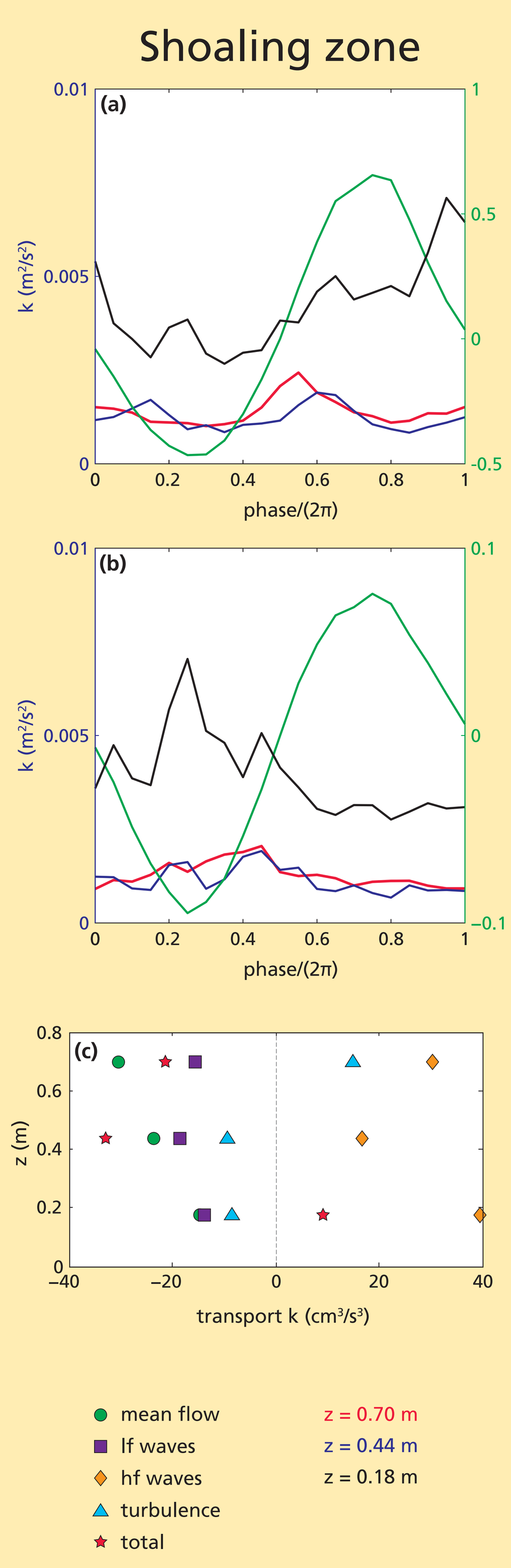
- Bardex II laboratory experiment with extensive array of instruments
- H_s 0.6-0.9m, T_p 8-12s, Q_b 0-0.5 (at turbulence rig)

Data analyses

- Turbulent kinetic energy → $k = \sqrt{0.5(u'^2 + v'^2 + w'^2)}$, with u', v' and w' representing the cross-shore, along-shore and vertical turbulent velocities
- Cross-shore wave orbital velocities are separated in a high-frequency (hf, f >0.05Hz) and low-frequency (lf, f<0.05Hz) component
- Turbulence transport → $k = \langle k'u' \rangle$, $\langle k'u_{hf} \rangle$, $\langle k'u_{lf} \rangle$, $\langle k'\overline{u} \rangle$, $\langle k'u \rangle$
- Wave phase calculated with Hilbert transform for hf and lf waves



Results

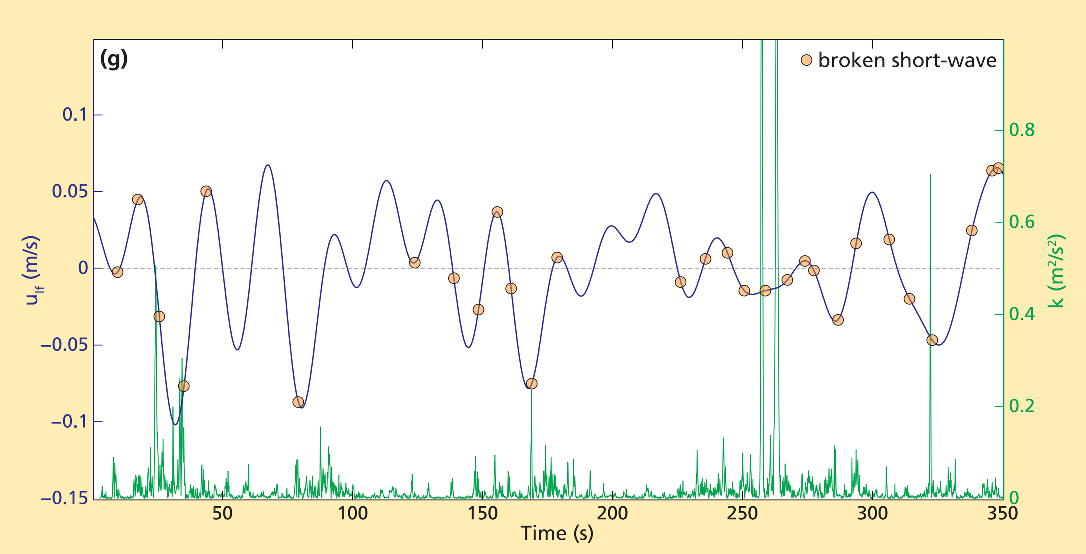


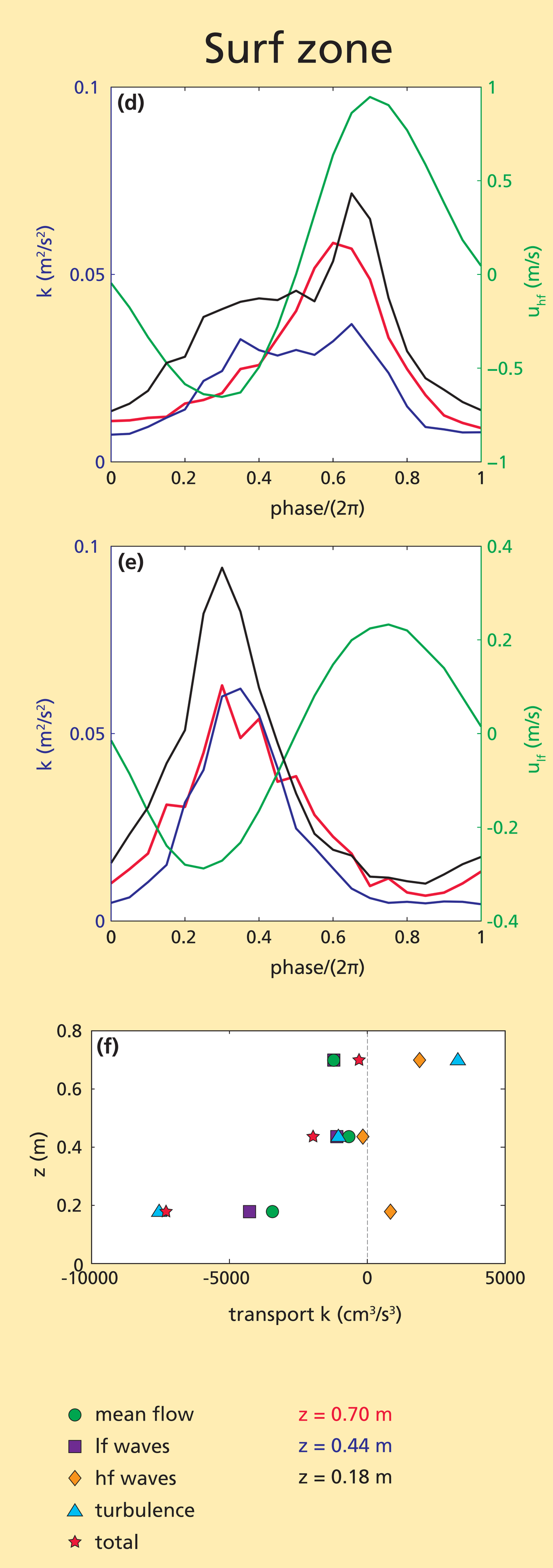
Shoaling zone (H/h < 0.475)

- Turbulent kinetic energy low, but largest close to the bottom, this suggests bed-generated turbulence (a)
- Phase coupling of turbulence events close to the bottom with short-wave orbital motion, most turbulence after passing of wave crest (a)
- Also phase coupling with infragravtiy waves near the bed, most turbulence in infragravity troughs (b)
- Onshore transport of turbulence close to the bottom (c)

Surf zone (H/h > 0.675)

- High degree of vertical mixing, with high turbulent kinetic energy present under the wave face (d)
- Large k beneath wave face higher in the water column suggests surface-generated turbulence (d)
- Turbulence events also strongly modulated on infragravity timescale (e)
- Offshore transport by infragravity motion and undertow (f)
- 2/3 of wave breaking occurs in infragravity troughs (g)





Conclusions

- Change from bed-generated to surface-generated turbulence from shoaling to surf zone.
- The lower water level in the infragravity trough results in stronger wave orbital motion close to the bed, moreover surface-induced turbulence is more likely to reach the bed.
- Importance of infragravity waves for sand transport in the surf zone is suggested by strong modulation of turbulence events on infragravity timescale.

Further research

The next step is to investigate the link between turbulence events and the suspension and transport direction of sand.

STW Enabling new technology