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Sand suspension beneath sea-swell waves on a field-scale laboratory beach

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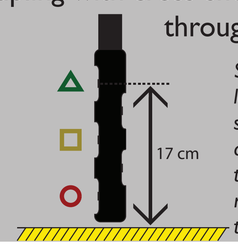
Motivation

Breaking waves and bores inject large amounts of turbulence into the water column as vortices, which can travel downward and entrain sand from the bed. **The timing of sand entrainment with respect to the wave orbital motion determines the magnitude and direction of sand transport by sea-swell waves.** Coastal evolution models rarely include the effect of this surface-induced turbulence on sand suspension and subsequent transport to predict surf-zone morphodynamics.

Here, we compare sand stirring by breaking waves to non-breaking waves above ripples by using laboratory measurements collected during the Barrier Dynamic Experiment II (BARDEXII).

Methods

- Field-scale laboratory experiment, irregular waves
- One imposed tidal cycle
- Turbulence at three heights above the bed
- Sand concentration at seven (three shown here) heights above the bed
- Coupling with cross-shore wave-orbital motion (u_{hf}) through phase-averaging

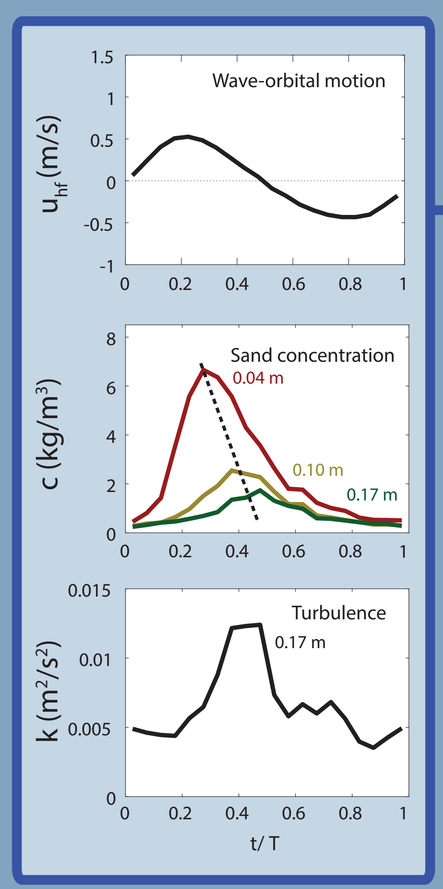


Schematic representation of the lowest five sand concentration sensors between 4 and 17 cm above the bed. Three are used for the analyses here, indicated with a red circle, yellow square and green triangle.

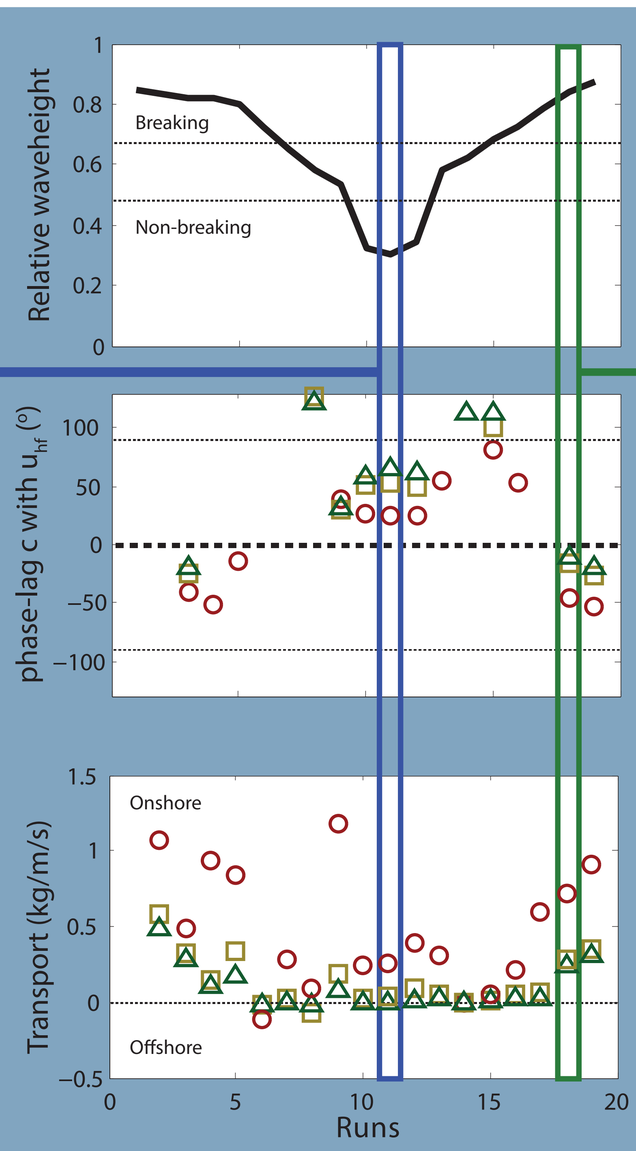
The measurement rig in the flume. The sand concentration instruments are encircled. Turbulence was measured using the three ADVs.

Results

Non-breaking waves above vortex ripples

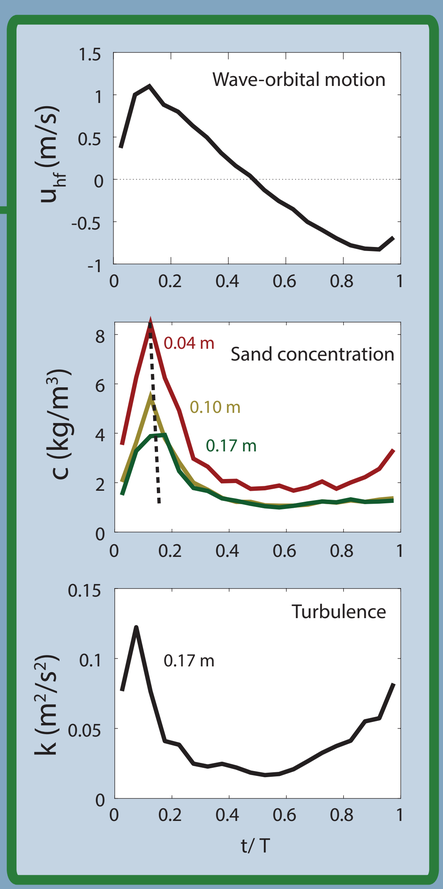


- phase-lag positive
- phase-lag increases upward
- c and k peak simultaneously
- wave-driven transport onshore close to bed



Sand suspension is phase-coupled for low (non-breaking) and high (breaking) relative waveheights.

Breaking waves above subdued ripples



- phase-lag negative
- phase-lag decreases upward
- peak in k preceeds peak in c
- wave-driven transport onshore throughout water column

Conclusions

- Non-breaking waves above ripples:
  - phase-lag increases upwards
  - Thus only (onshore) wave-driven sand transport close to bed
- Breaking waves:
  - small negative phase-lag
  - during offshore phase only suspension close to the bed
  - onshore wave-driven transport throughout the water column

Sand suspension is phase-coupled to the short-wave orbital motion and highly depends on the wave conditions.

Plunging breaker during BARDEXII in the Delta Flume.

Next

The study will be extended with field measurements to include transport;
- beneath spilling breakers
- in the inner surf-zone.

The ultimate aim will be to develop a parameterization that quantifies the effect of surface-induced turbulence on sand transport beneath broken waves and can be embedded in operational models.

The measurement rig deployed in the field.