

Experimental recreation of large-scale coastal bedforms and Hummocky Cross-Stratification in sheet flow conditions

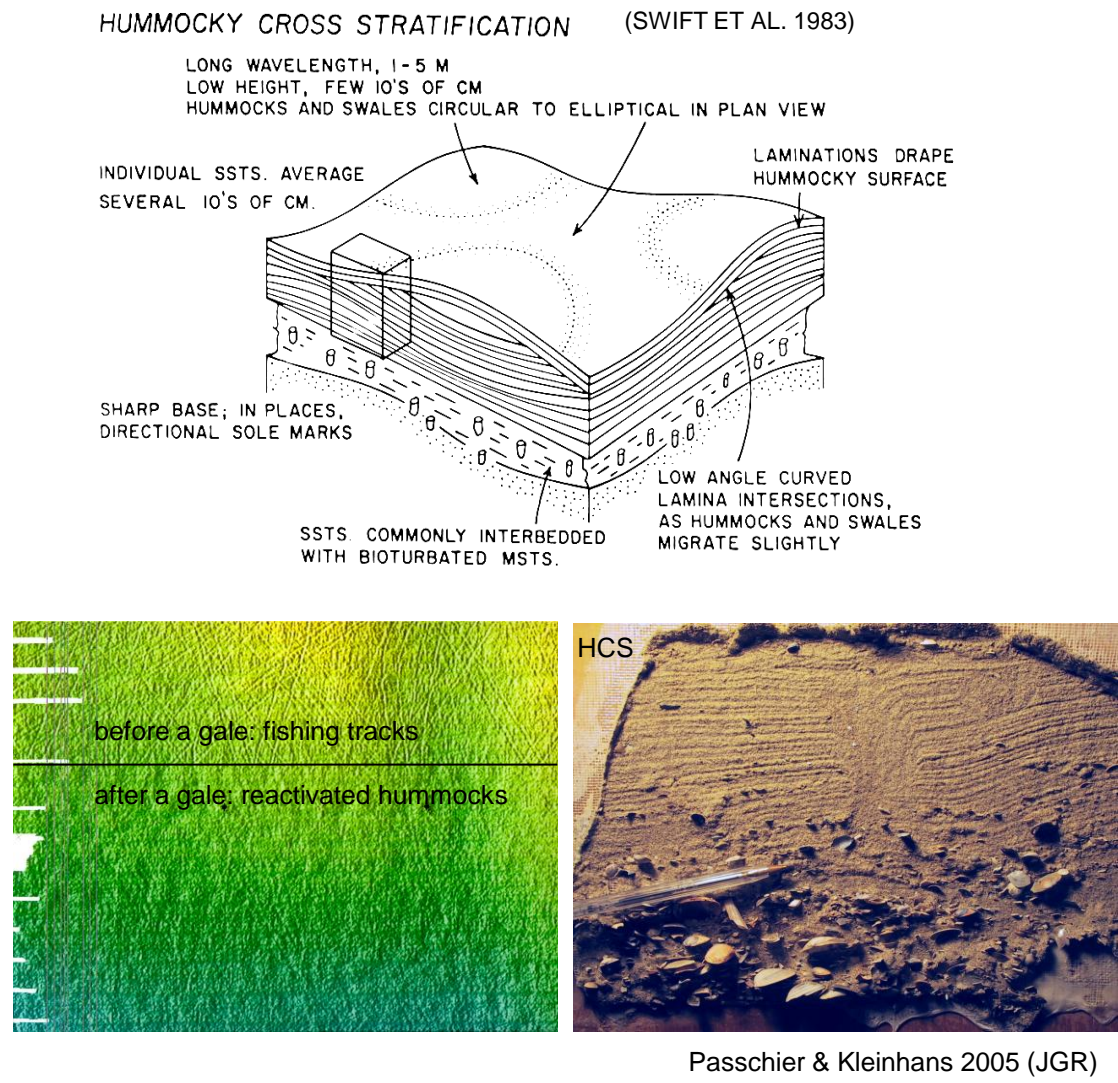
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Maarten Kleinhans

Research group
River and delta morphodynamics

What are hummocks and HCS?



Objectives

- understand formative mechanism of large-scale bedforms particularly the enigmatic hummocks
- assess relation between these bedforms and Hummocks and Hummocky Cross-Stratification (HCS)

Hypotheses

- Hummocks are distinct from Short Wave Ripples:
 - higher energy formative conditions
 - different stratification (found abundantly in shelf settings)
- Hummocks form in
 - either waves only
 - or waves plus weak currents
- and
 - either at higher energy than sheet flow onset
 - or in waning storms from suspension fallout at transition from sheet flow to rippled bed

Previous work

- oscillatory flow tunnel work by Southard et al.
- sedimentological field observations (e.g. Swift, Amos)
- large-scale bedforms in the coastal zone (Werner)
- Long Wave Ripples (e.g. Hanes)
- and some obnoxious bed waves in very large flumes that made measurements on sheet flow difficult (us)

Methods & materials

Analysis of data from literature

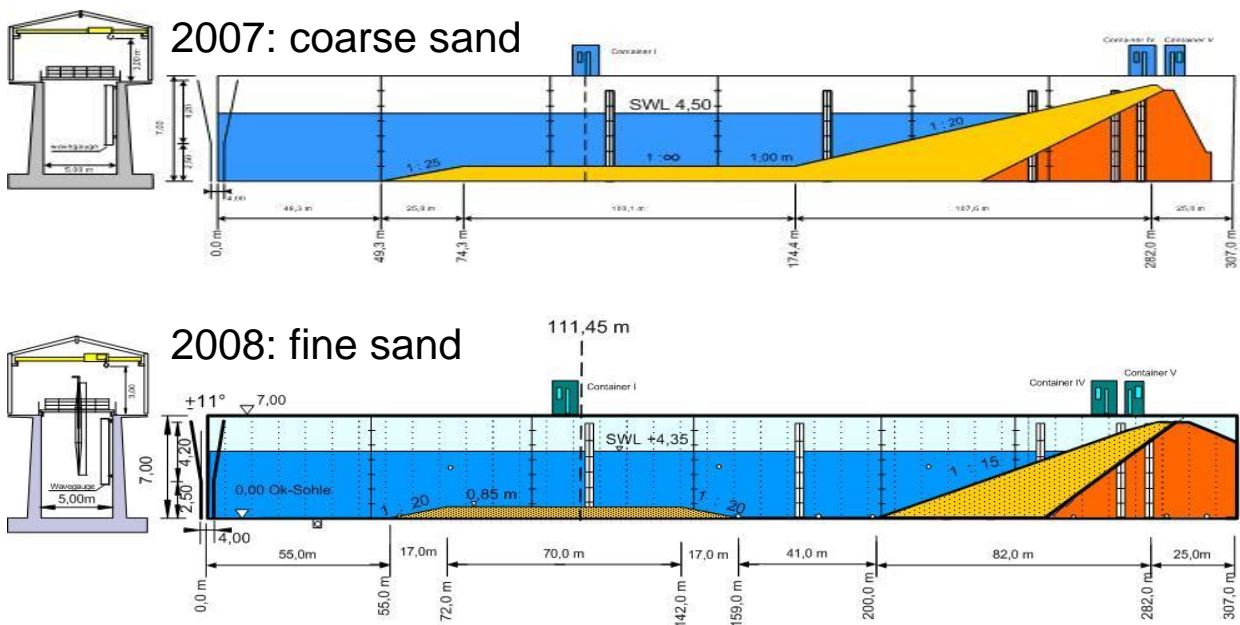
- nondimensional sizes and sediment mobility
- bedform stability diagrams

Full-scale waves in a large flume: Hannover Große Wellen Kanal (Germany)

- 300 m long, 5 m wide, 7 m deep
- 0.7-1.7 m wave height, 5-7.5 s period
 - regular trochoidal
 - irregular
- two sands: 0.26 mm (2007) and 0.14 mm (2008)

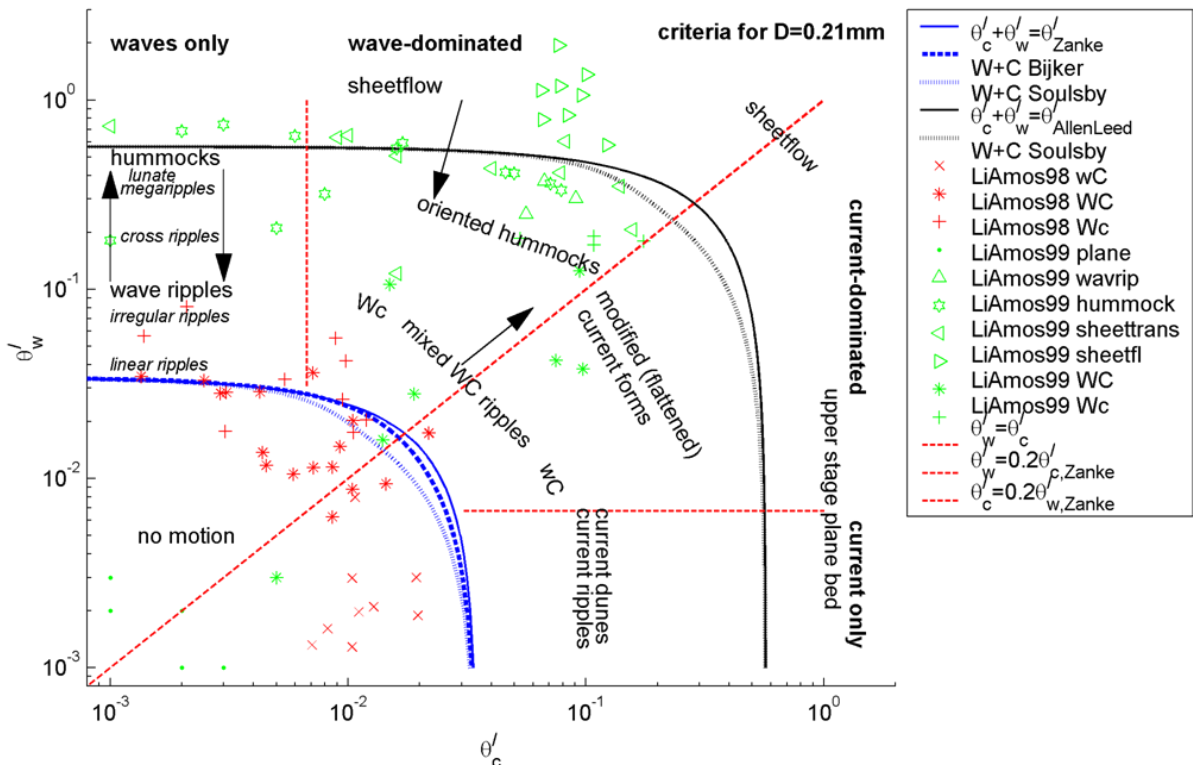
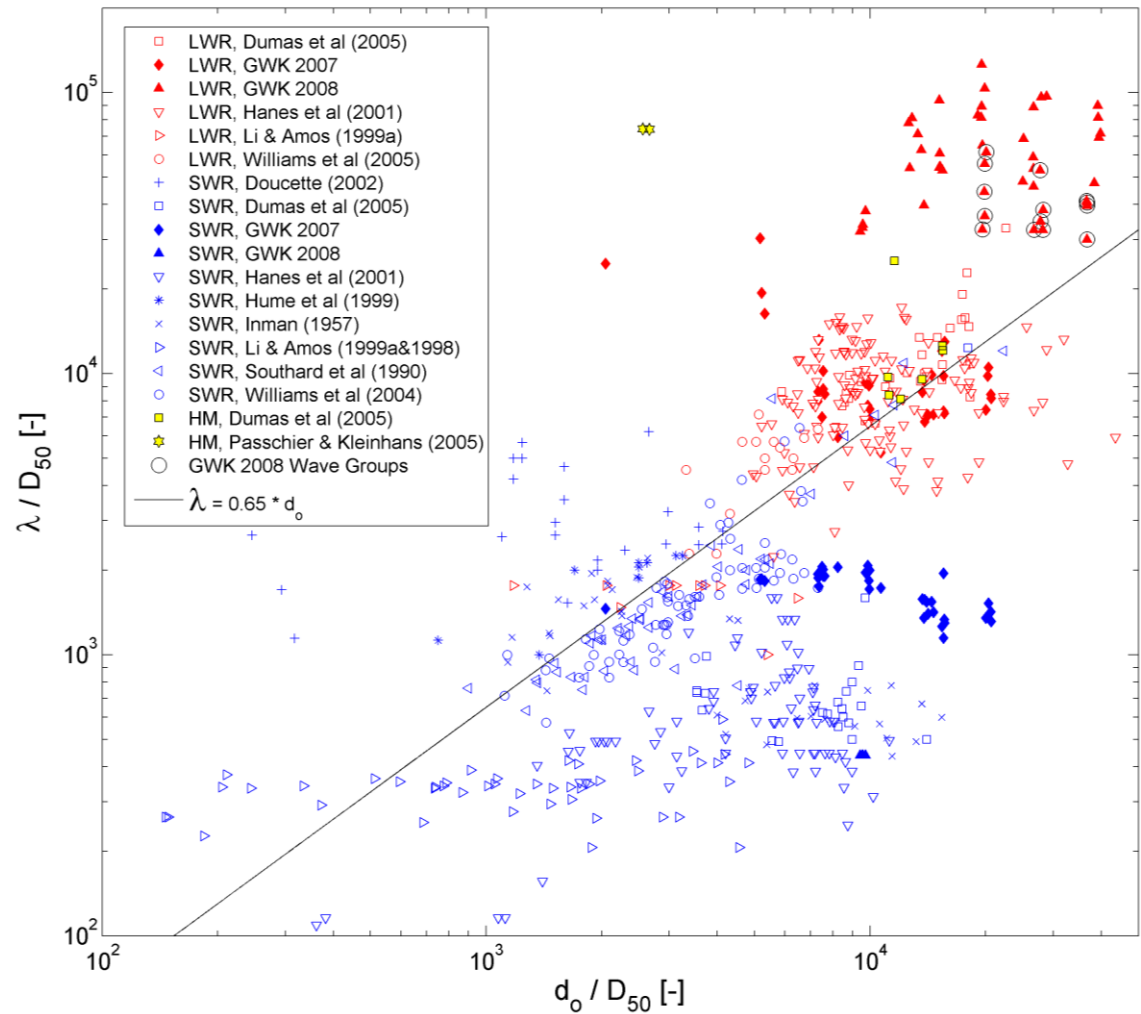
Data collection

- measure bed profiles, near-bed flow (EMF, UHCM), suspension (ABS) and sheet flow layer (CCM)
- bed profile decomposition by LOESS filtering
- lacquer peels

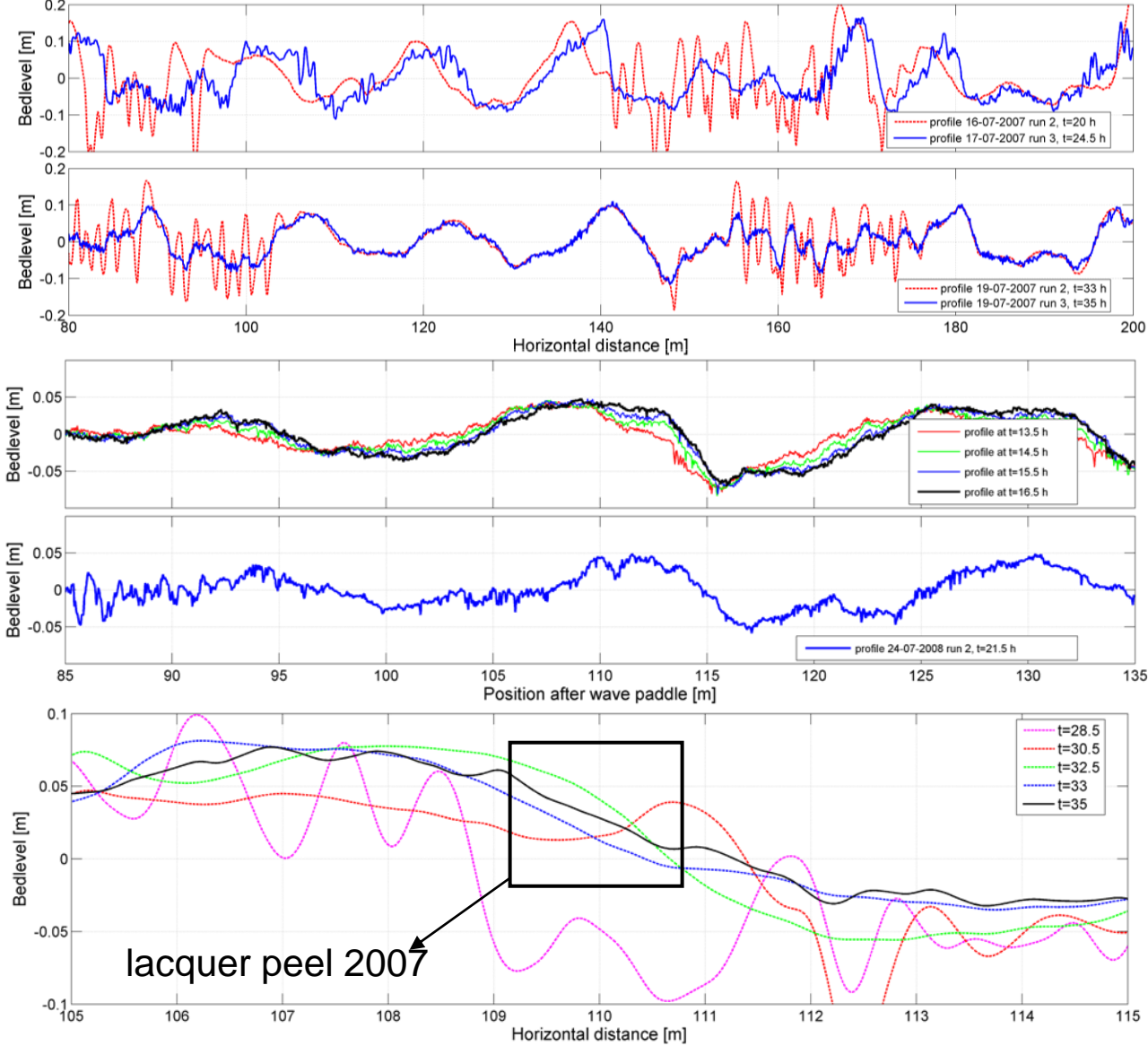


Discussion

- YES! we formed hummocks! But how?
- Formative conditions:
 - large-scale bedforms form in sheet flow conditions
 - but persist as relics in low energy conditions with short wave ripples superimposed
- What about Hummocks and Hummocky Cross-Stratification??
 - (shoreward) net bedload transport → migration → formation of stratified deposits, subhorizontal in sheet flow conditions = HCS
 - Large Wave Ripples ≈ Hummocks scale as orbital ripples, even when anorbital ripples are superimposed



Example profiles



Conclusions

- First ever experimental reproduction of full-scale hummocks
- LWR form in sheet flow conditions (when SWR are washed out) and scale as orbital ripples
- Large Wave Ripples are Hummocks
- Hummocky Cross-Stratification forms when LWR migrate in sheet flow
 - under asymmetrical waves
 - under weak currents

Ripples formed in low energy

Hummocky Cross-Stratification in our experiments

10 cm