# Unwanted scour holes in morphodynamic experiments: seeking necessary and sufficient conditions:

Maarten Kleinhans, Wouter Marra, Jasper Leuven, Lisanne Braat, Anne Baar, and Mohamed Nabi*

*Deltares

Universiteit Utrecht
Faculty of Geosciences
River and delta morphodynamics
m.g.kleinhans@uu.nl

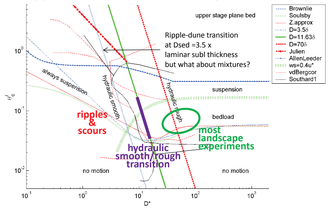
www.geo.uu.nl/fg/mkleinhans

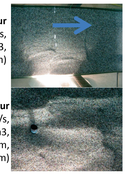
Ideas? Data?
Please contact
Kleinhans!

## Problem definition

- Often unrealistically large scour holes (2x5 cm) in river / delta landscape experiments (Kleinhans et al. 2014 ESR)
- Related to ripples (hydraulic smooth boundary)?
- What conditions? How to prevent? D90>laminar sublayer?

**Hypothesis: bedform stability fields and hydraulic smooth/rough transition**



**Self-formed scour**
(u 0.132 m/s,
rho 1200 kg/m3,
D50 1.1e-3 mm)

**Provoked scour**
(u 0.132 m/s,
rho 1200 kg/m3,
D50 1.1e-3 mm,
diameter obstacle 15 mm)

## Methodology

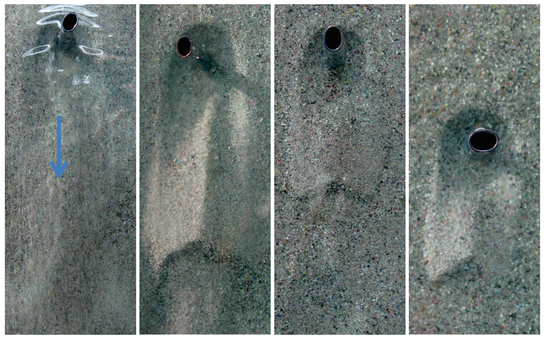
- Grain-size dependence of ripples or dunes in LES + sediment dynamics model (Nabi et al. 2013, WRR)
- Grain-size and density dependence in 400 experiments:

1. Just below and above beginning of sediment motion
2. Self-formed scours and ripples
3. Provoked scours, do they disappear afterwards?

## Results: effect of velocity

- Scours mostly independent of velocity
- Disappear with high sediment mobility

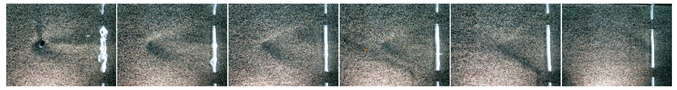
($\rho_s$ 1200 kg/m$^3$, D50 0.57 mm, 15 mm obstacle), Increasing velocity → (0.097, 0.101, 0.154, 0.207 m/s)



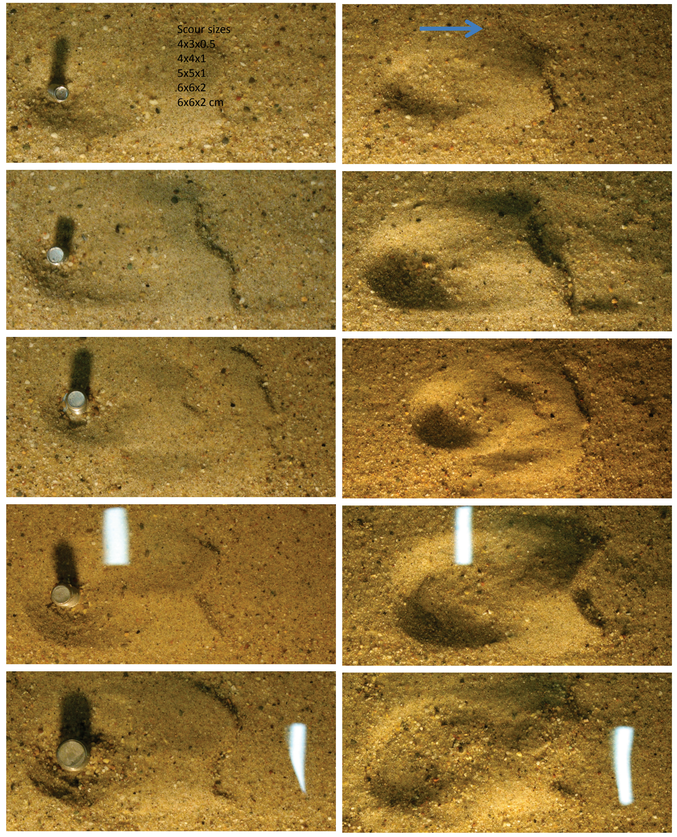
## Results: effect of obstacle size

- Weak relation between size of scour and provocateur
- Scours continue to exist below beginning of motion
- Scours disappear above motion when coarse sediment

Filling scour ($\rho_s$ 1200 kg/m$^3$, D50 1.6 mm, u = 0.167 m/s, 15 mm obstacle)

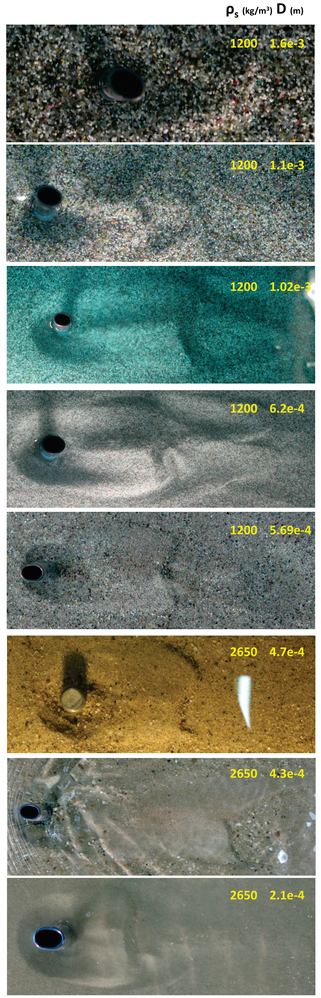


Increasing obstacle diameter (4, 6, 8, 11, 15 mm) ($\rho_s$ 2650 kg/m$^3$, D50 0.43 mm, u = 0.269 m/s)



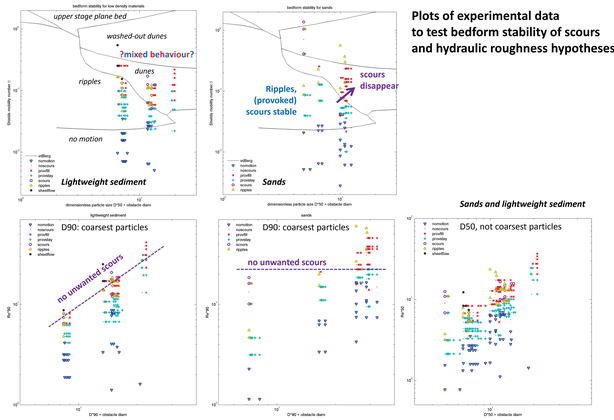

## Results: effect of sediment

- Fine to coarse: tendency to ripple
- Well/poorly sorted: laminar sublayer
- Low density sediments and sands




## Analyses

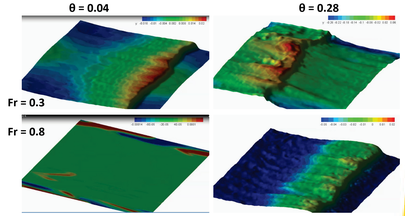
- Scour holes occur in same regime as ripples
- Scouring tendency disappears with larger grain size D50 and D90
- Provoked scours disappear in higher sediment mobility
- Lightweight sediments misbehave… why??




Plots of experimental data to test bedform stability of scours and hydraulic roughness hypotheses

## Modelling at ripple-dune transition, 0.5 mm sand

- Confirms bedform stability: Ripply dunes
- Flat in high Froude with low mobility
- TBD: runs with provoked scours




## Conclusions & questions

- Scours preventable in poorly sorted sand D90 > thickness laminar sublayer? $Re_{p90}$>20?
- Scours disappear in high sediment transport alluvial fan experiments unproblematic?
- Why different behaviour in lightweight sediment?
- Is scouring + rippling indeed a smooth hydraulic boundary phenomenon?

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