



Flume experiments on the initiation and evolution of transverse bedforms

Paul Jarvis and Nathalie Vriend

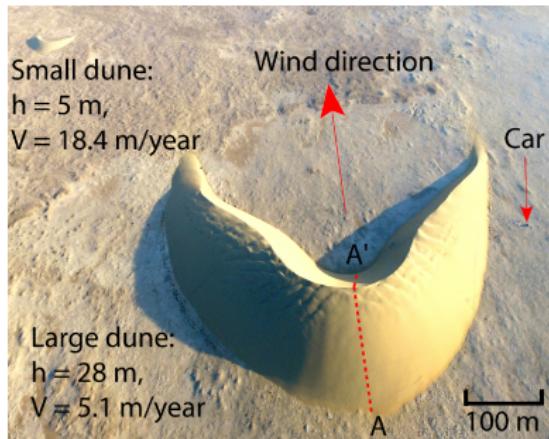
Department of Applied Mathematics and Theoretical Physics
University of Cambridge

paj35@cam.ac.uk

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Aeolian ripples and dunes

Pair of barchan dunes, Umm Said desert, Qatar



Credit: Sylain Michel

Height $\sim O(1 - 10) \text{ m}$

Wind ripples, Sistan, Afghanistan



Height $\sim O(1 - 10) \text{ cm}$

Sediment transport

If $\tau > \tau_c$ then transport is possible

Mass conservation

$$\frac{\partial z}{\partial t} + \frac{\partial q}{\partial x}$$

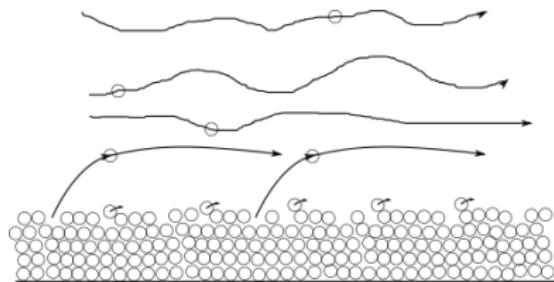
Sediment transport

$$q_{\text{sat}} = q_{\text{sat}}(\tau - \tau_c)$$

Transient relaxation

$$L_{\text{sat}} \frac{\partial q}{\partial x} = q_{\text{sat}} - q$$

General equations valid for different modes of transport



Differences:

- Functional form of transport law
- Physical origin of L_{sat}

Mode of transport determined by flow and particle Reynolds numbers

$$Re = \frac{UD}{\nu}, \quad Re_p = \frac{Ud}{\nu}$$

Aeolian and subaqueous comparison

Aeolian dunes:

- Typical wind speed
 - $U \sim O(10) \text{ m s}^{-1}$
- Kinematic viscosity of air
 - $\nu \sim O(10^{-5}) \text{ m}^2 \text{ s}^{-1}$
- Grain size
 - $D \sim O(10^{-3}) \text{ m}$

Subaqueous ripples:

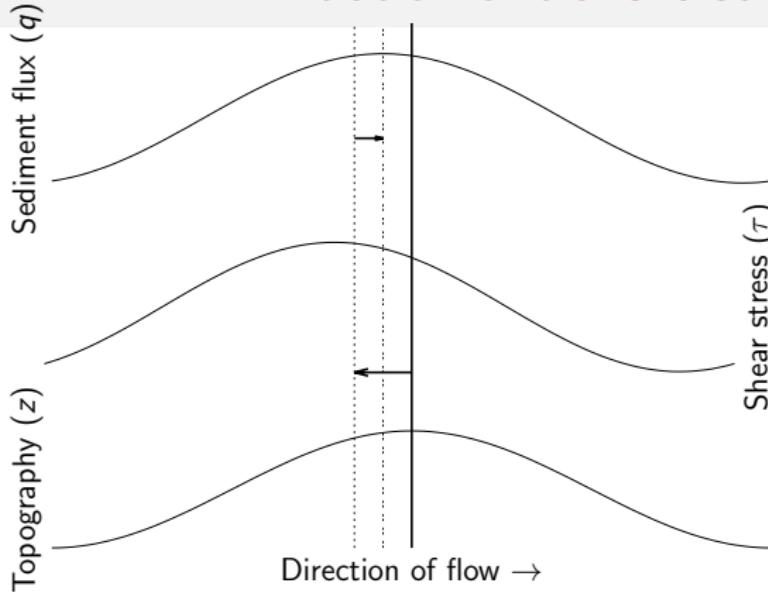
- Typical flow speed
 - $U \sim O(1) \text{ m s}^{-1}$
- Kinematic viscosity of water
 - $\nu \sim O(10^{-6}) \text{ m}^2 \text{ s}^{-1}$
- Grain size
 - $D \sim O(10^{-3}) \text{ m}$

$$Re_p \sim \frac{(10 \text{ m s}^{-1})(10^{-3} \text{ m})}{10^{-5} \text{ m}^2 \text{ s}^{-1}} = 10^3$$

$$Re_p \sim \frac{(1 \text{ m s}^{-1})(10^{-3} \text{ m})}{10^{-6} \text{ m}^2 \text{ s}^{-1}} = 10^3$$

Similar Re_p suggest subaqueous flume experiments can provide insights on aeolian dunes

Initiation of transverse bedforms



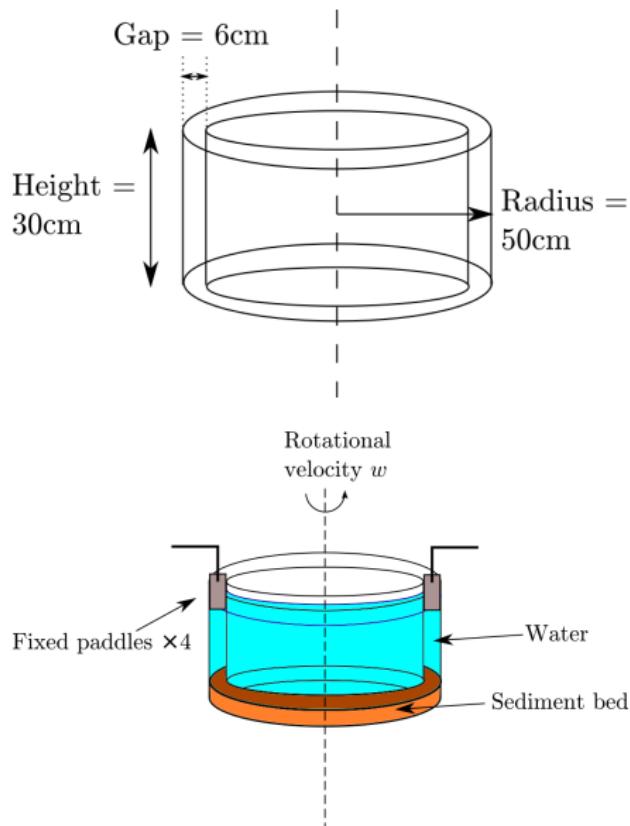
L_{sat} delays transport response

Phase shift between topography and shear stress

Causes small disturbances to grow and propagate

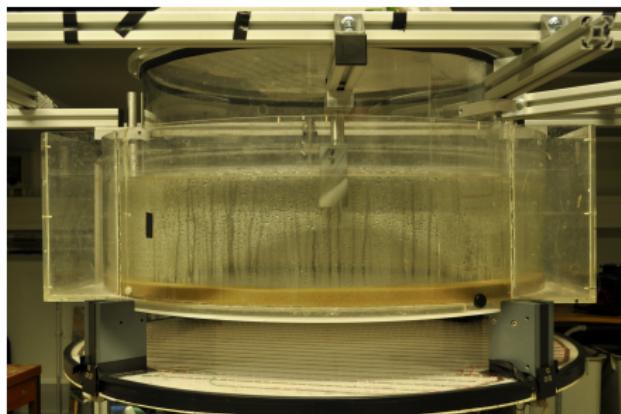
Initial λ set by saturation length

Experimental system - Annular flume

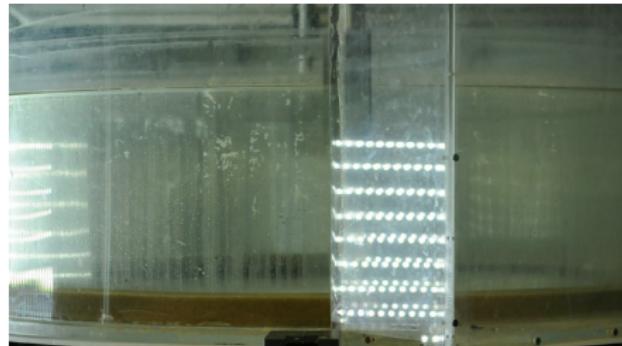


No need to replenish - can perform long term experiments

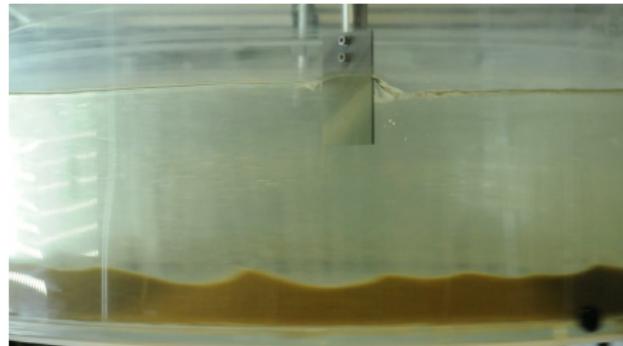
Small gap-radius ratio leads to transverse bedforms



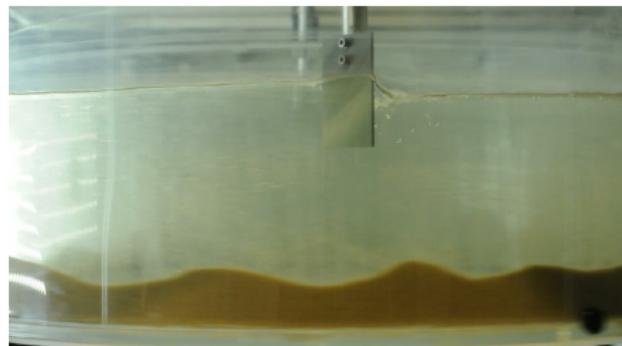
Example experiment



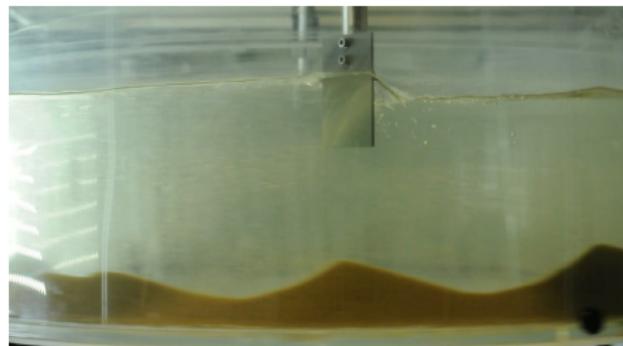
$t = 0 \text{ s}$



$t = 100 \text{ s}$



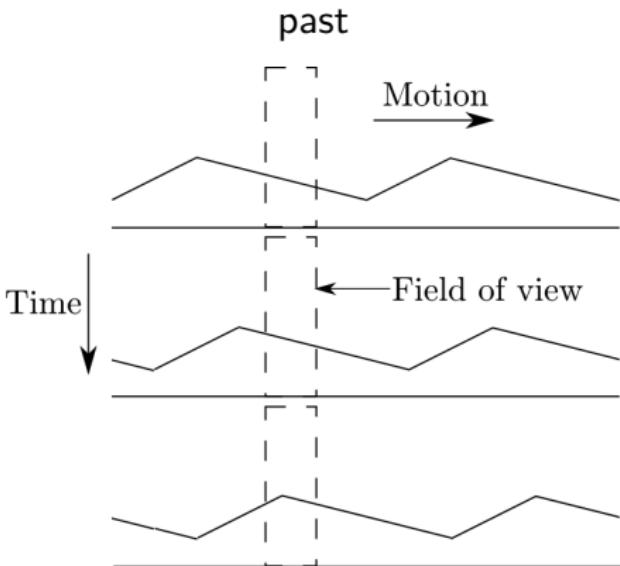
$t = 200 \text{ s}$



$t = 300 \text{ s}$

Data aquisition

Photograph thin area as tank rotates



Frame rate = 200 fps

Spatial resolution = 14 mm px^{-1}

