Finite amplitude sand waves in shallow seas

Modelling of spatial and temporal variations in offshore sandwaves

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Sand waves in the North Sea

[U.K.]

[The Netherlands]

[Hulscher & Van den Brink, 2001]
Contents

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Initial formation

Water surface

Net residual flow in water motion

Seabed
Navigation & dredging
Simulation model

\[ \frac{\partial u}{\partial t} + u \frac{\partial u}{\partial x} + v g \frac{\partial \zeta}{\partial x} + v \frac{\partial^2 u}{\partial z^2} = 0 \]

- **2DV Shallow water equations**

\[ \frac{\partial u}{\partial x} + \frac{\partial v}{\partial z} = 0 \]

- **Free surface**

\[ S_b = \alpha \left( \tau_b - \lambda_1 \frac{\partial h}{\partial x} - \lambda_2 \frac{\partial h}{\partial x} \right) \]

- **Bed load transport**

\[ \frac{\partial h}{\partial t} + \frac{\partial S_b}{\partial x} = 0 \]

- **Sediment balance**
Simulation model

- Chebyshev polynomials
- Implicit time-stepping
- (Non-)periodic

- Validated mathematically by comparing with linear stability analysis
Water motion
Results: Amplitude evolution

- Water depth
- Pattern
- Saturation in decades
- No flow separation
Results: Amplitude evolution

- Water depth
- Pattern
- Saturation in decades
- No flow separation
Dredging
Water depth

(a) wavelength vs. average water depth (m)
(b) sand wave height vs. average water depth (m)
(c) height/average water depth (%) vs. average water depth (m)
Suspended transport

- Closer to shore
- Bed load transport
- Suspended sediment transport
- Storms
Conclusions

• Sand wave evolution

• Saturation at 20% of water depth for typical North Sea conditions

• Balance shear stress & slope effect
Questions?