

## Marine turbulence in nearshore and surfzone areas How sediment transport affects turbulence

Erik A. Toorman & Mohamed Ouda

### Observation:

Flume experiments of sand transport (Cellino, EPFL, 1998) - figure 1 - show significant deviations from what (standard) numerical models predict.

No model can really predict these experiments.

These data have been confronted with typical large-scale engineering software for sediment transport and two-phase flow theory, revealing major short-comings.

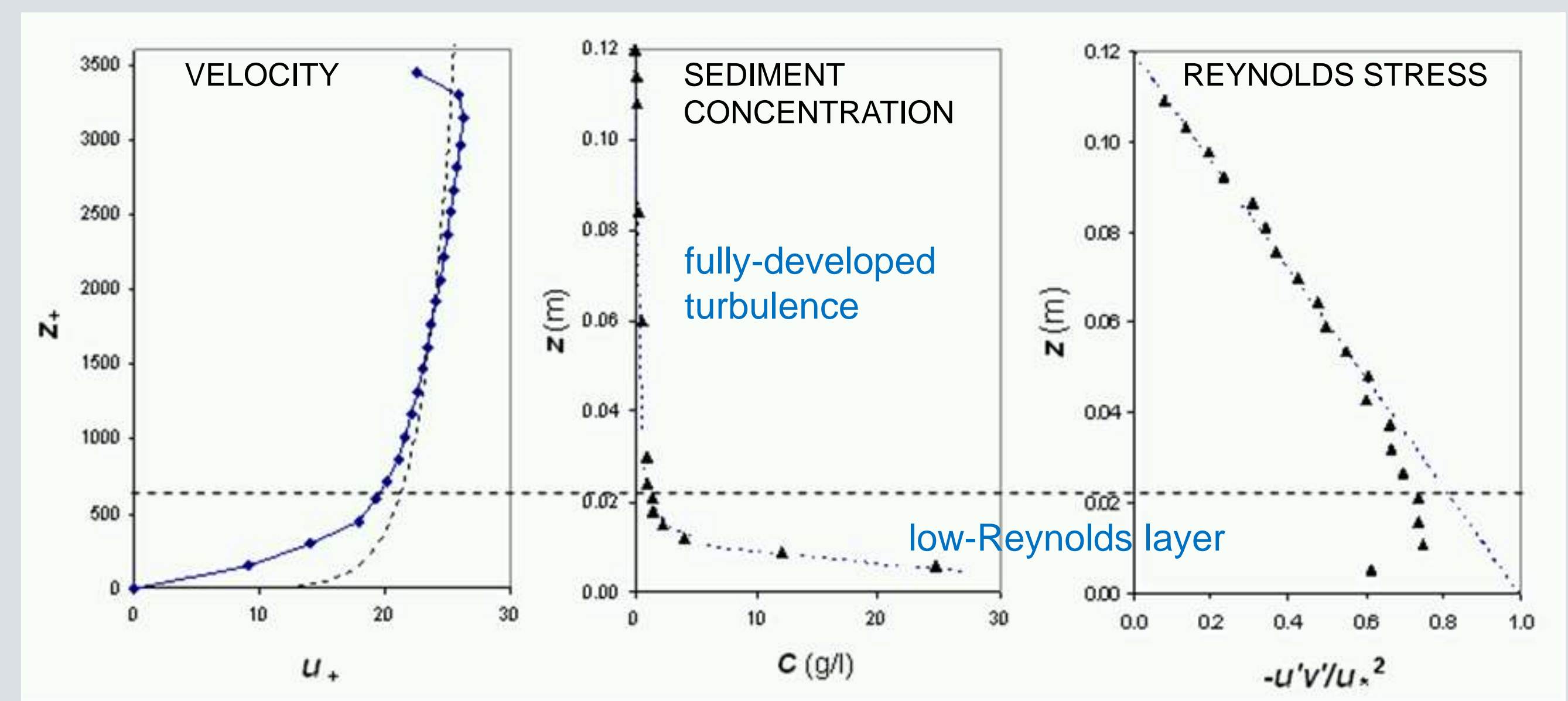


Figure 1. Cellino (1998) data for run Q40S003

Major flaws	Consequences
• Energy required for sediment transport cannot go to turbulence production	→ standard near-bottom boundary conditions overpredict turbulence generation by bottom shear
• Standard constants of $k-\epsilon$ turbulence model exaggerate buoyancy damping effect	→ standard $k-\epsilon$ turbulence model predicts excessive drag reduction
• Most models assume only hydraulic rough conditions	→ problematic for intertidal areas
• Physics-based modelling of particle-turbulence interaction is very difficult (+ hampered by instrument limitations)	→ processes not exactly accounted for & no experimental validation possible

### Research strategy:

- High-resolution 2-layer low-Reynolds turbulence model (*bottom-layer resolved for bed load transport*) applied to small scale 1DV steady (*uniform open-channel flow*) and 2DV time-dependent test cases (*oscillating flow and wave flume*) – implementation in OpenFOAM – figure 2 - and (in-house developed) FENST-2D.

### Applications (projects):

- Fluid mud in front of the Belgian coast (BELSPO BRAIN.be project INDI 67)
- Belgian coast beach erosion (VLAIO SBR project CREST: Climate Resilient Coast)
- Rosetta (Egypt) beach erosion (KU Leuven IRO PhD scholarship)



Figure 2: Sand transport over rippled bed simulated with mixtSedFOAM

- Application of an in-house developed physics-based, generalized friction law, covering all hydraulic conditions (laminar  $\leftrightarrow$  hydraulic smooth  $\leftrightarrow$  hydraulic rough) → figure 3.
- Upscaling for large scale 3D and 2DH morphodynamic models – implementation in TELEMAC ([www.openTELEMAC.org](http://www.openTELEMAC.org)).

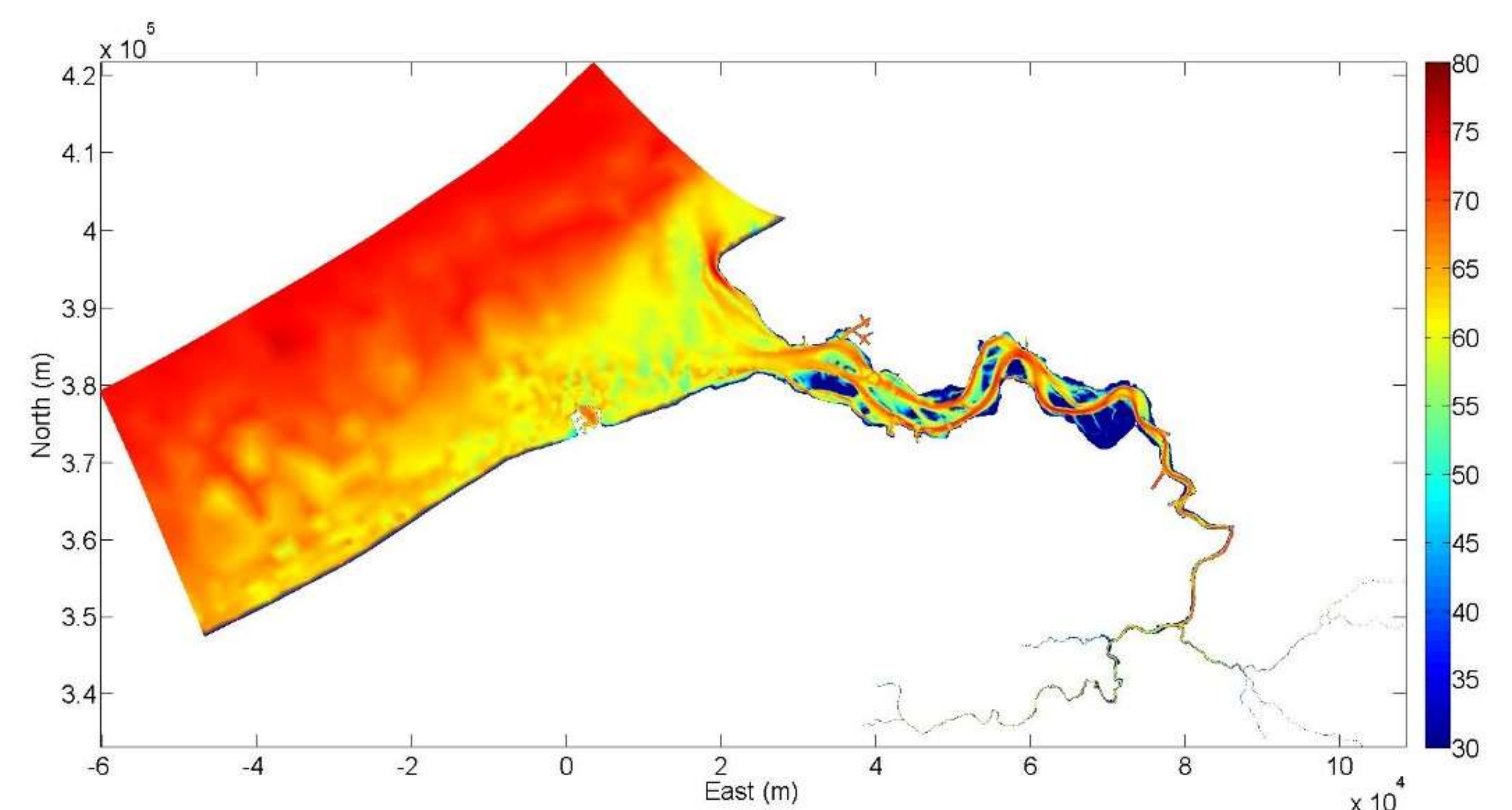


Figure 3: Map of instantaneous Chézy friction coefficient values computed online during simulation with TELEMAC-2D of sediment transport along the Belgian coast and the Scheldt estuary (Bi & Toorman, *Ocean Dynamics* 65, 2015).

This work is a contribution to:

