Hydraulics Laboratory: Sediment Mechanics Research Group
Department of Civil Engineering
Kasteelpark Arenberg 40, B-3001 Heverlee, Belgium
erik.toorman@kuleuven.be - www.kuleuven.be/hydr

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.

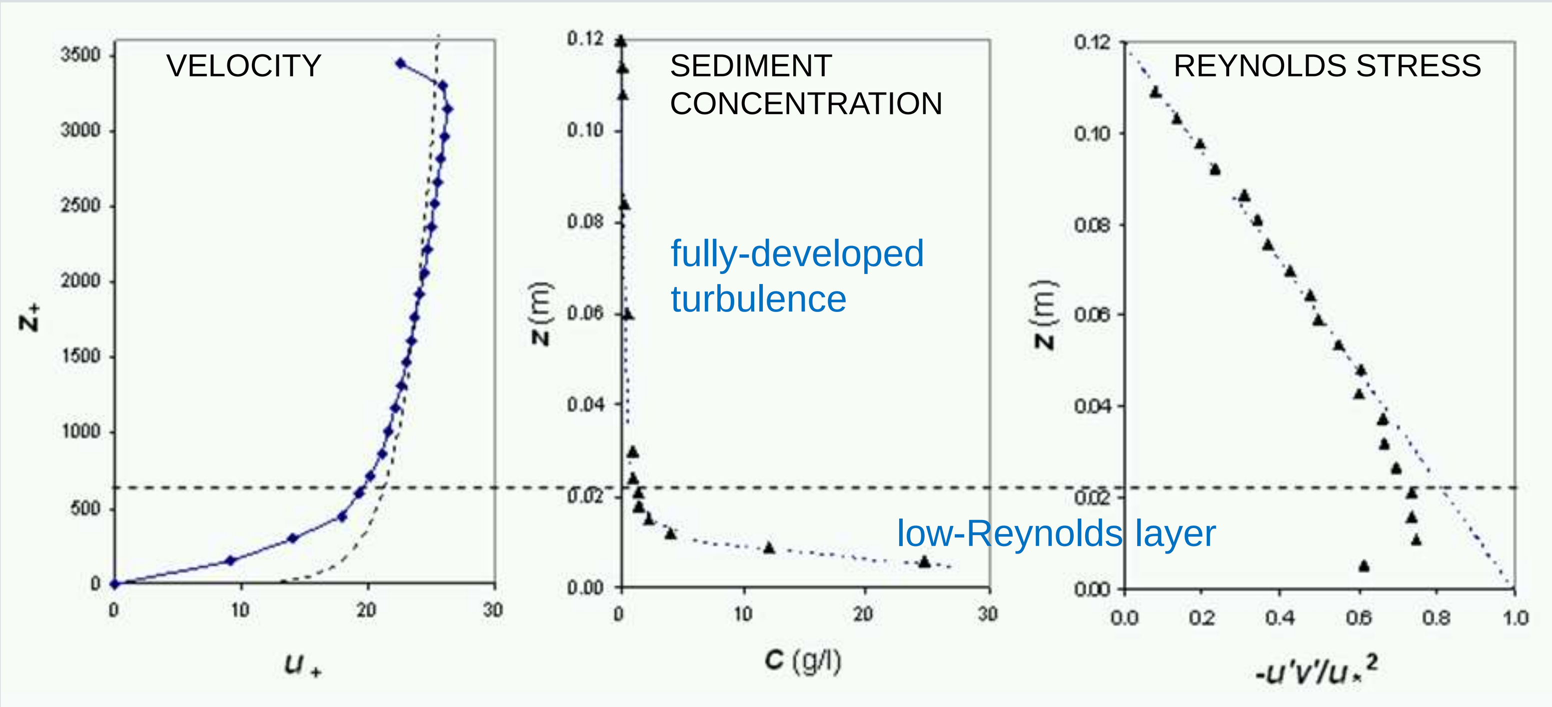

Figure 1. Cellino (1998) data for run Q40S003

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-ε* turbulence model exaggerate buoyancy damping effect	➔ standard *k-ε* 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)

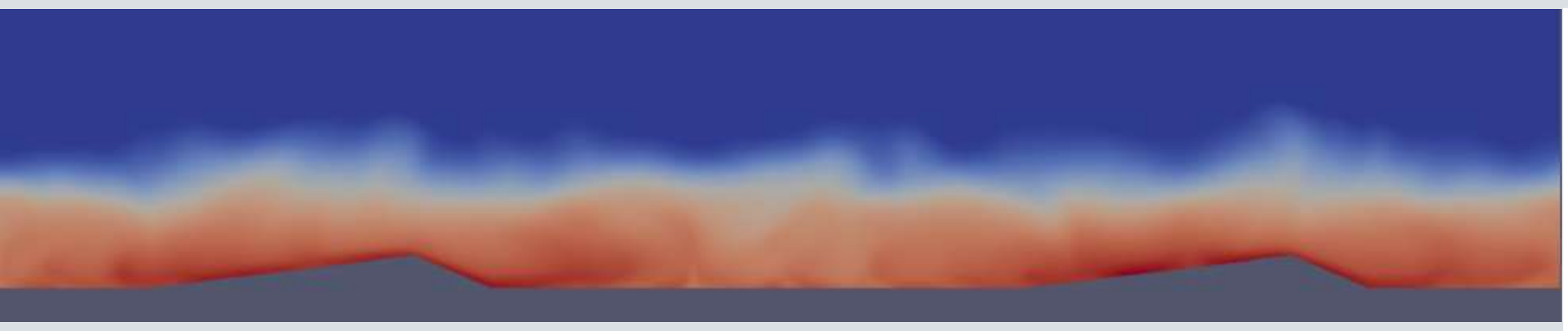

Figure 2: Sand transport over rippled bed simulated with mixtSedFOAM

- Application of an in-house developed physics-based, generalized friction law, covering all hydraulic conditions (laminar ⇔ hydraulic smooth ⇔ hydraulic rough) ➔ figure 3.
- Upscaling for large scale 3D and 2DH morphodynamic models – implementation in TELEMAC (www.openTELEMAC.org).

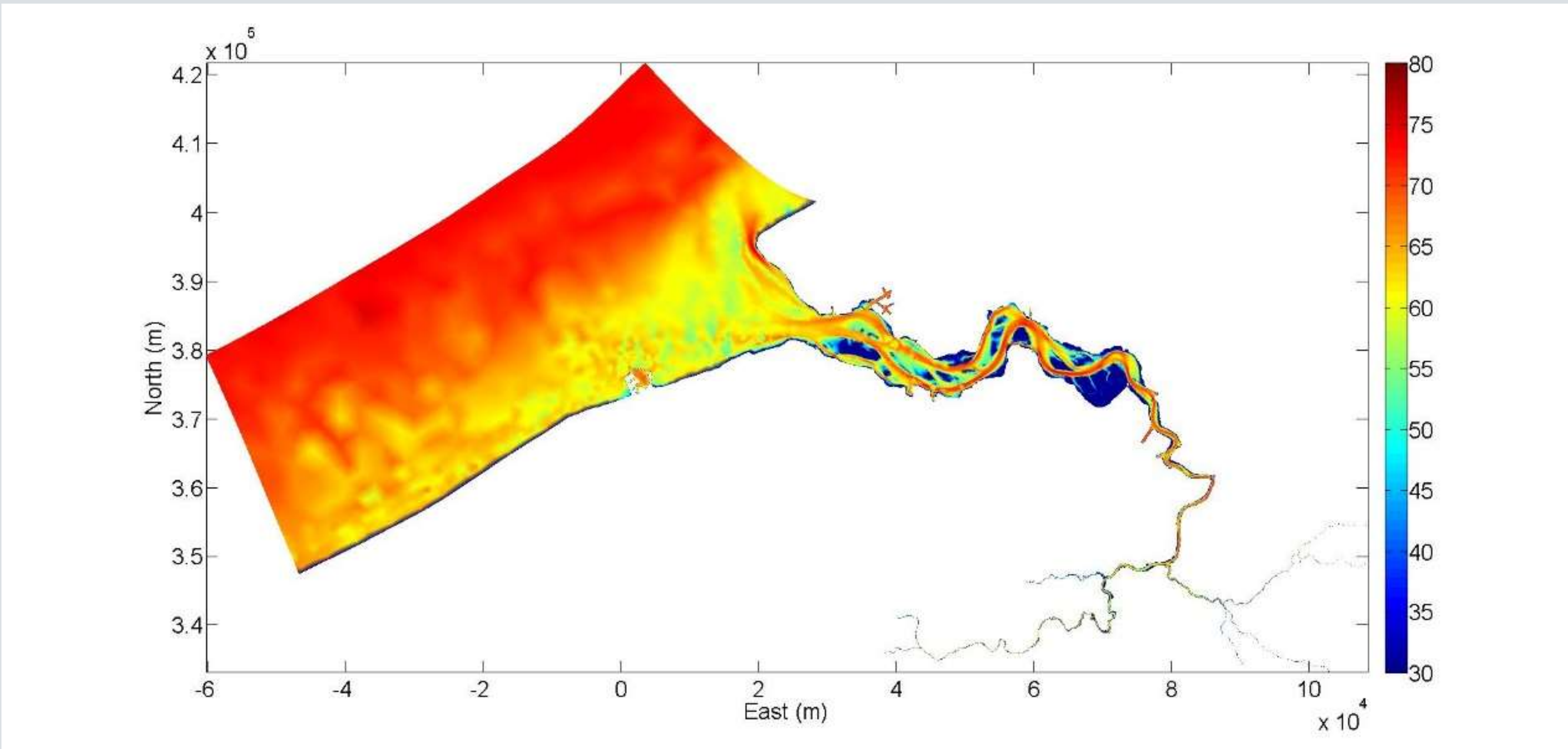

Figure 3: Map of instantaneous Chézy friction coefficient values computed online during simulation with TELEMAC-2D of sediment transport along the Belgian coast and the Scheldt estuary (Bi & Toorman, *Ocean Dynamics* 65, 2015).

This work is a contribution to:

Belgian Science Policy Office belspo
BRAIN.be
INDI67 project

SBR project
AGENTSCHAP INNOVEREN & ONDERNEMEN Vlaanderen is ondernemen
CREST CLIMATE RESILIENT COAST
www.CRESTproject.be