1. Objectives

Process-based modeling of sediment concentrations under waves requires a description of the vertical sediment mixing, which is usually parameterized as the sediment diffusivity, $\varepsilon_{s,z}$. We analyze the distribution using new full-scale measurements, bed states and sediment concentrations obtained with a triple-frequency Acoustic Backscatter Sensor. We then compare the obtained $\varepsilon_{s,z}$ profiles to existing formulations.

2. Introduction

- Sediment concentrations under waves decrease with height above the bed...

  BUT HOW?

- Process-based models: $C \frac{dC}{dz} = F(\varepsilon_{s,z})$
- Various shapes and models suggested for $\varepsilon_{s,z}$ [m$^2$/s], see Figure 1 and 2.

![Figure 1: Various shapes used for $\varepsilon_{s,z}$](image)

3. Experimental set up

- Two bed sediments:
  - Fine: $D_{50} = 137$ $\mu$m, $D_{50, \text{suspended}} = 118$ $\mu$m
  - Coarse: $D_{50} = 256$ $\mu$m, $D_{50, \text{suspended}} = 106$ $\mu$m
- Hydrodynamical conditions:
  - Ripple and sheet flow regime expected; nonetheless ripples did not form in the fine sediments
  - Period $T = 6.5$ sec, Water depth $h = 3.5$ m
  - Various wave heights $H = [0.7-1.5$ m$]$

![Figure 3: ‘Twente-Utrecht’ Wallframe in the Großer Wellen Kanal, Hannover, Germany (GWK) with length = 300 m, depth = 7 m and width = 5 m. Used instruments on the frame to measure sediment concentrations: a triple frequency Acoustic Backscatter Sensor (ABS) at 80 cm above the initial bed, a Transverse Suction System (TSS) and Ultra High Concentration Meter (UHCM).](image)

4. Results and observations

- Shape of $\varepsilon_{s,z}$ profile for coarse- and fine-grained conditions (A,C) is comparable under high-energetic conditions.
- $\varepsilon_{s,z}$ profiles increase more gradually for the low-energetic conditions (B,D) compared to high-energetic conditions (A,C), possibly due to vortex induced mixing in the ripple regime.
- Parabolic shape in upper-part of the $\varepsilon_{s,z}$ profiles is enforced by the assumption in ABS processing that concentrations go to zero between the bed and the ABS.
- Magnitude of observed $\varepsilon_{s,z}$ for fine-grained conditions (A,B) a factor 10 higher than for coarse-grained experiments (C,D), possibly due to large difference between $D_{50}$ and $D_{50, \text{suspended}}$.
- The shape and magnitude of the lower-part of the observed $\varepsilon_{s,z}$ profiles are predicted well by the formulation of Bijker (1971), especially for fine-grained conditions (A,B).

![Figure 4: Modelled (lines) and observed (red dots) sediment diffusivities for high- and low energetic conditions. A) $H = 1.5$ m, fine. B) $H = 0.7$ m, fine. C) $H = 1.5$ m, coarse. D) $H = 0.7$ m, coarse.](image)

5. Conclusions

- Shape of observed $\varepsilon_{s,z}$ profiles is slightly parabolic under all conditions.
- Observed $\varepsilon_{s,z}$ profiles are in the same range as those predicted by existing formulas and are predicted well by the formulation of Bijker (1971).

Acknowledgements:

Dr. J. Ribberink (Twente University, Enschede), Drs. J.L.M. Schretlen (Twente University, Enschede), Technicians Physical Geography (Utrecht University).