Stochastics of bedform dimensions

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Introduction

Often river dunes are considered as regular bed patterns, with a mean dune height and a mean dune length. In reality however, river dunes are three-dimensional and irregular features that cannot be fully described by their mean values.

In fact, dune dimensions can be considered as stochastic variables. Their probability distribution can be characterized by a mean value and variance. The stochastic properties of dune dimensions are relevant for (see e.g. Van der Mark et al., 2005):

- Shipping ↔ highest crests
- Pipelines & cables ↔ deepest troughs
- Modelling cross-strata sets ↔ troughs, dune heights
- Modelling vertical sorting ↔ troughs
- Modelling bed roughness ↔ dune heights

In the present research the stochastics of crest elevation, trough elevation and dune height are investigated by analysing three sets of flume experiments.

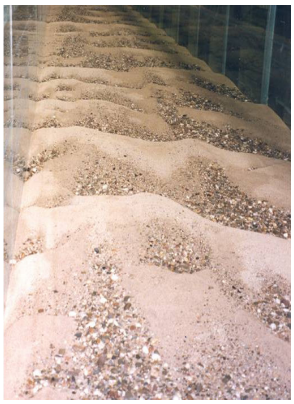

Figure 1. Flume experiment of Blom et al. (2003).

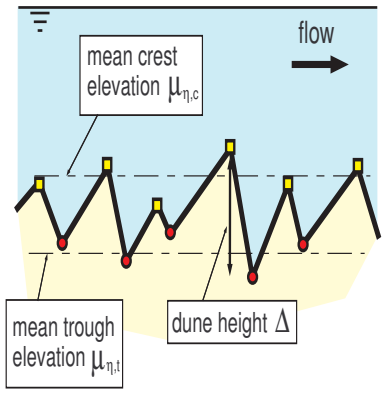

Figure 2. Definition sketch. The squares indicate the selected dune crests, the circles indicate the selected dune troughs. Dune height Δ is defined as the vertical distance between a crest and its subsequent trough.

Analysis of flume experiments

Leclair (2002) and Blom et al. (2003) independently conducted experiments under dune conditions in laboratory flumes (Fig. 1). Eleven experiments are used in this study.

From the bed elevation profiles we selected the individual crests and troughs. Then the individual dune heights were determined by taking the vertical distance between a crest and its subsequent trough (Fig. 2).
Probability density functions (PDFs) of crest elevation η_c, trough elevation η_t and dune height Δ are plotted for each experiment (Fig. 3 shows these PDFs of experiment T9 of Blom et al., 2003.

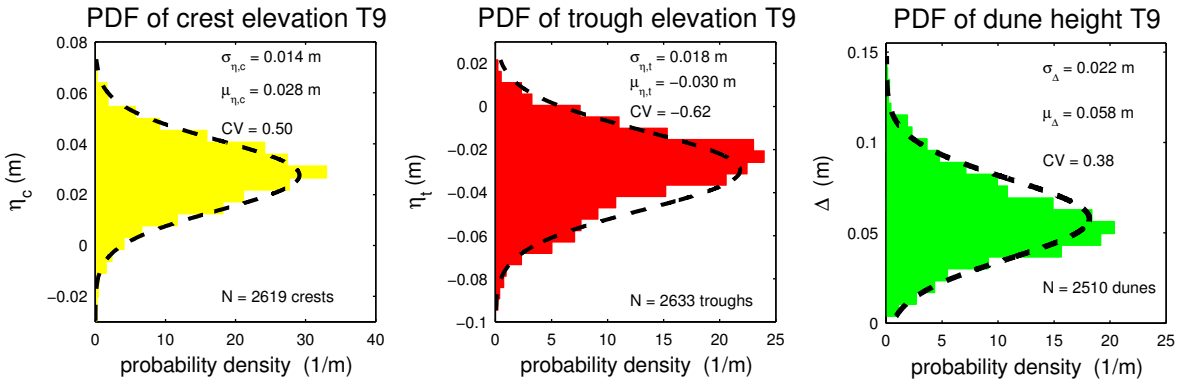

Figure 3. Probability density functions of (a) crest elevation, (b) trough elevation and (c) dune height for experiment T9 of Blom et al. (2003). A best fit normal distribution is superimposed on these measured distributions.

Conclusion – Simple models for the variability in dune dimensions

For all experiments the standard deviations σ and mean values μ of crest elevation, trough elevation and dune height are determined. Figs. 4a, b and c show that the standard deviation scales with the mean value for crest elevation, trough elevation and dune height. This means that as a first approximation the variation in dune dimensions can be modelled using:

$\sigma_{\eta,c} = 0.6\mu_{\eta,c}$ for the variation in crest elevation

$\sigma_{\eta,t} = 0.6\mu_{\eta,t}$ for the variation in trough elevation

$\sigma_{\Delta} = 0.4\mu_{\Delta}$ for the variation in dune height

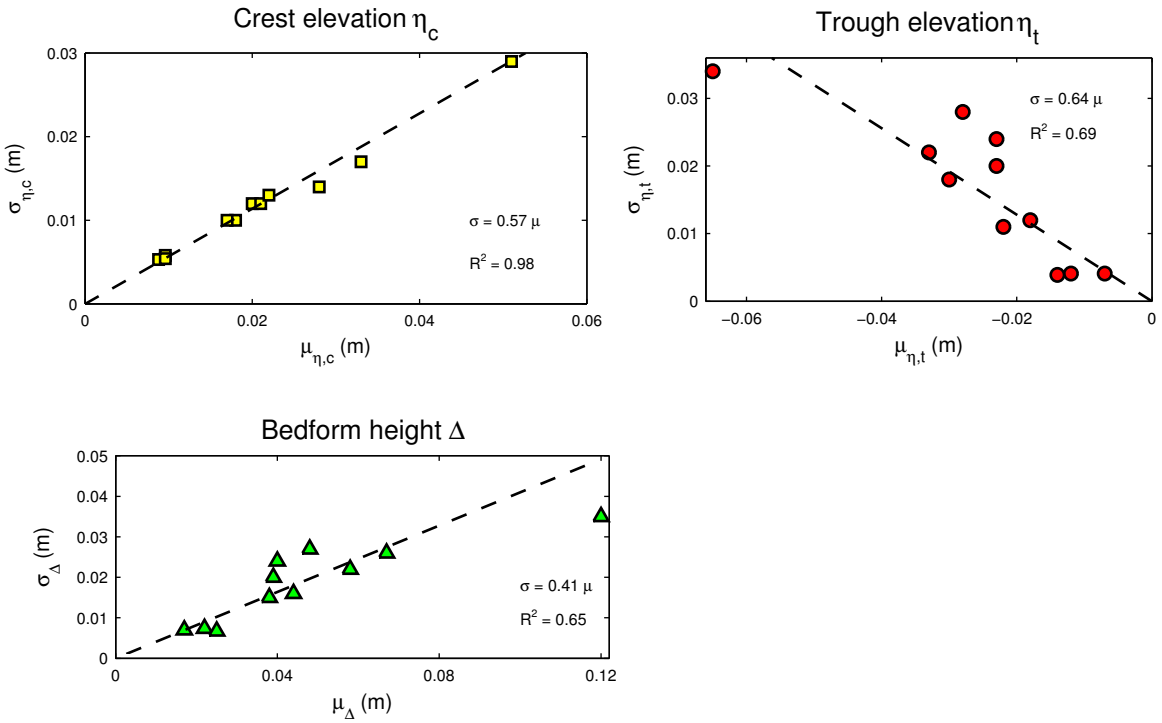

Figure 4. Standard deviation σ versus mean value μ for (top left) crest elevation, (top right) trough elevation and (bottom left) dune height.

Future work

In this case study we only focused on 2D dunes which occurred in laboratory flumes under steady flow conditions. We will extend this research on the variability in bedform dimensions by incorporating the following aspects:

- 3D bedforms
- Other types of bedforms (marine sand waves)
- Field measurements
- Non steady flow

Also we will investigate which type of probability density function is appropriate. It will be studied whether semivariogram analysis is a suitable technique to describe variability in bedform dimensions. Furthermore the effects of variability in bedform dimensions upon bed roughness will be analysed.

Acknowledgements

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References

Blom, A., Ribberink, J.S., and De Vriend, H.J. (2003). Vertical sorting in bed forms: Flume experiments with a natural and a trimodal sediment mixture. Water Resources Research, 39 (2).

Leclair, S.F. (2002). Preservation of cross-strata due to the migration of subaqueous dunes: an experimental investigation. Sedimentology, 49, 1157–1180.

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