
# On modeling the variability of bedform dimensions

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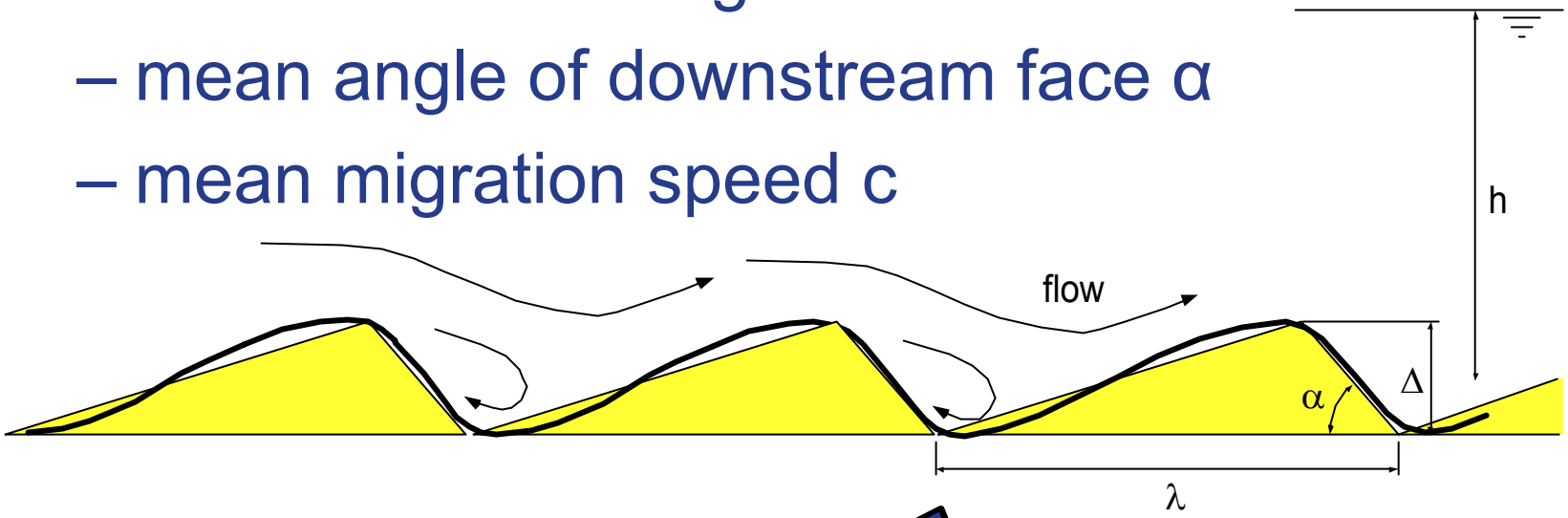
# Bedforms

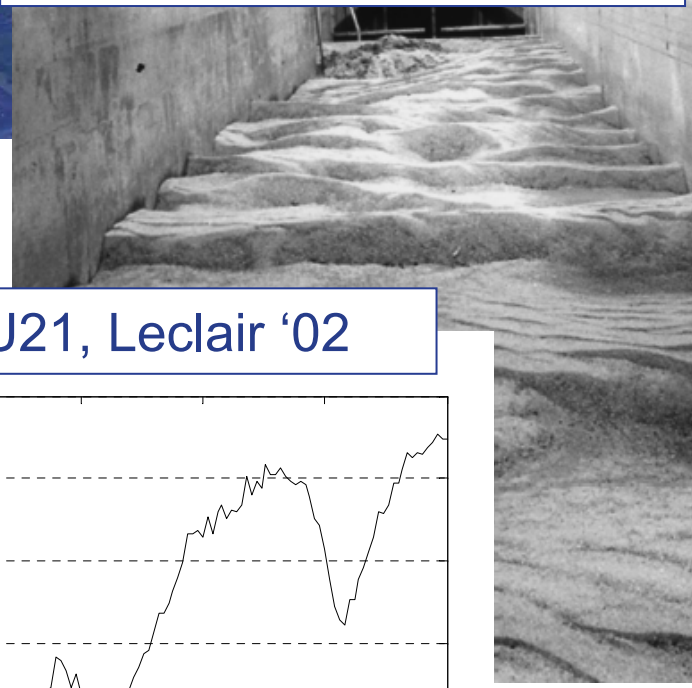
- Bedforms considered as regular features
  - mean bedform length λ
  - mean bedform height Δ
  - mean angle of downstream face α
  - mean migration speed c



# Irregular bedforms

- In reality bedforms are 3-dimensional and highly irregular in size, shape and spacing,
- even under steady flow conditions

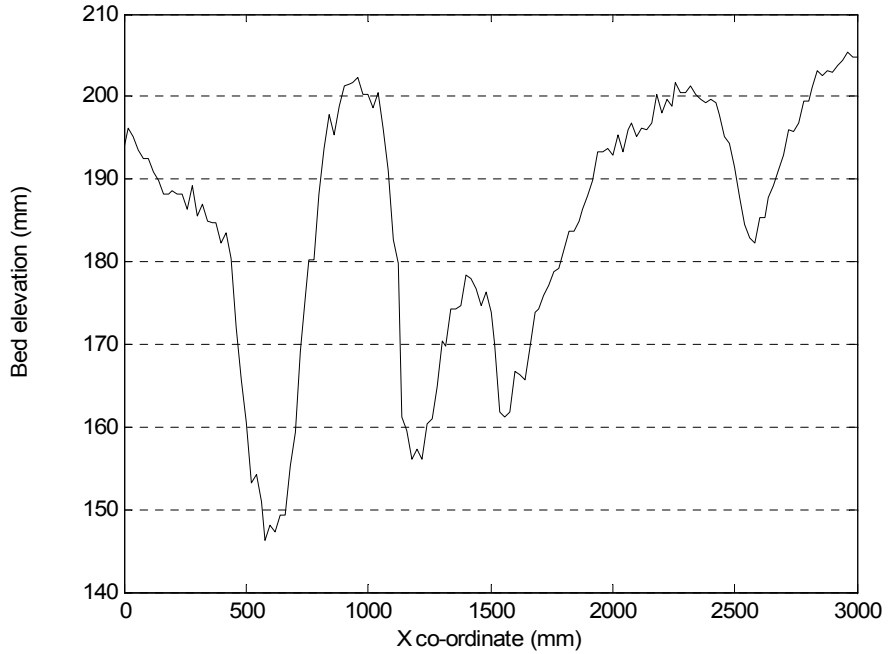
Exp SAFL34, Leclair ‘02



# Examples

Exp T10, Blom & Kleinhans ‘99

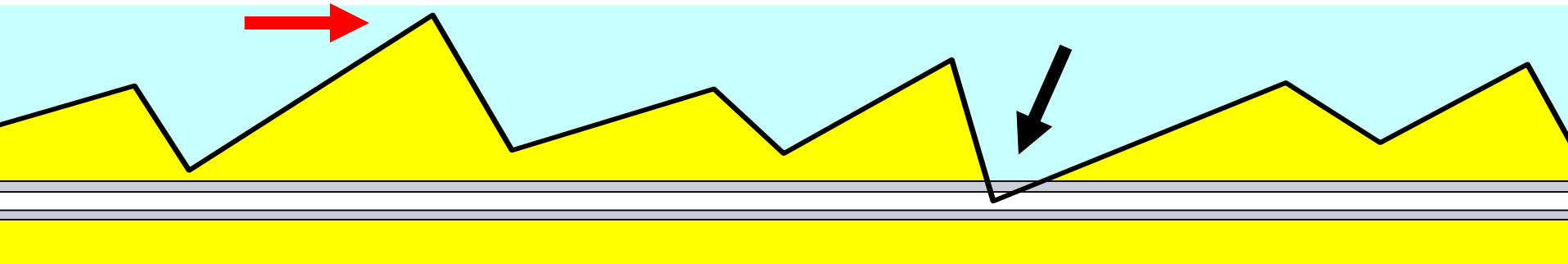
Exp BU21, Leclair ‘02




3D, irregular in height, length, shape

# Relevance

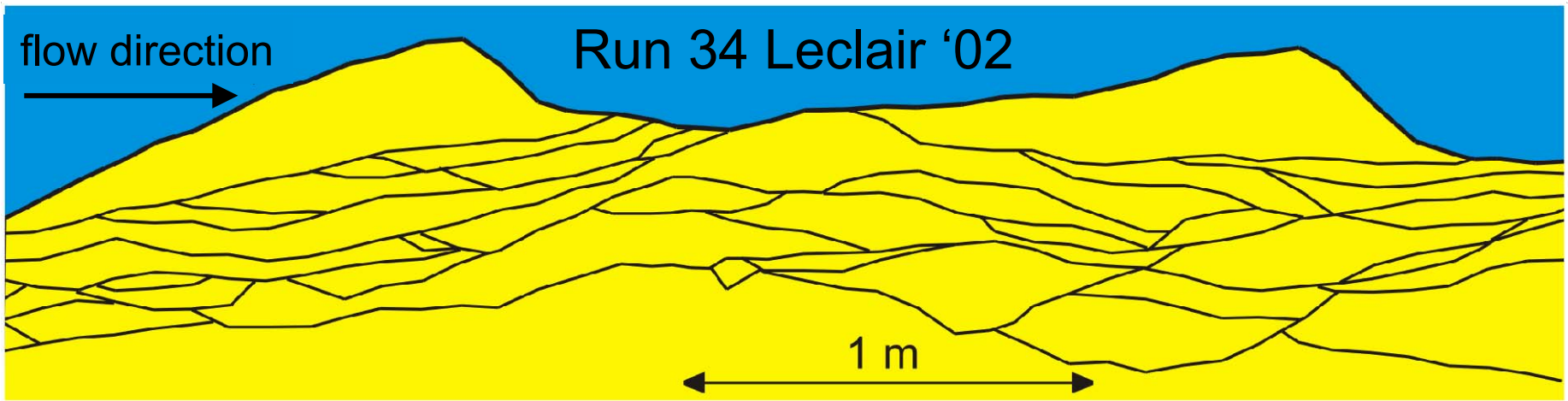
- Irregularity of bedforms needs to be taken into account:
  - Shipping & burying of pipelines and cables
  - Thickness of cross-strata sets
  - Bed roughness
  - Vertical sorting



# Thickness of cross-strata sets

Cross-strata sets:

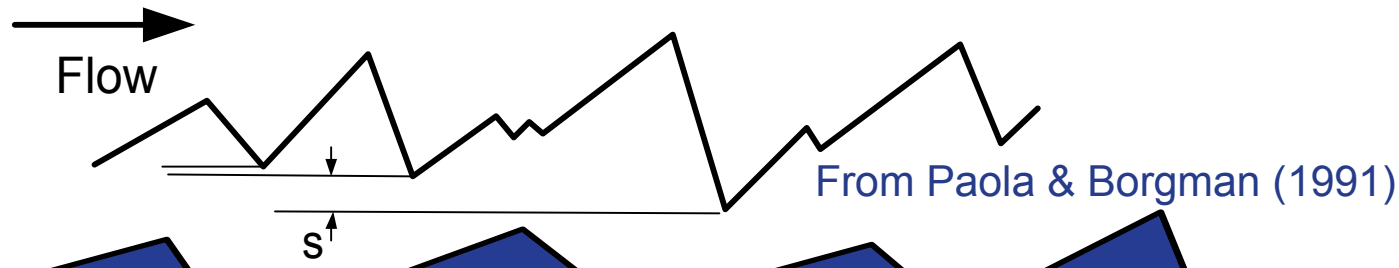
- Deposited layers within bed
- Used to interpret ancient flow conditions



# Thickness of cross-strata sets

Cross-strata sets:

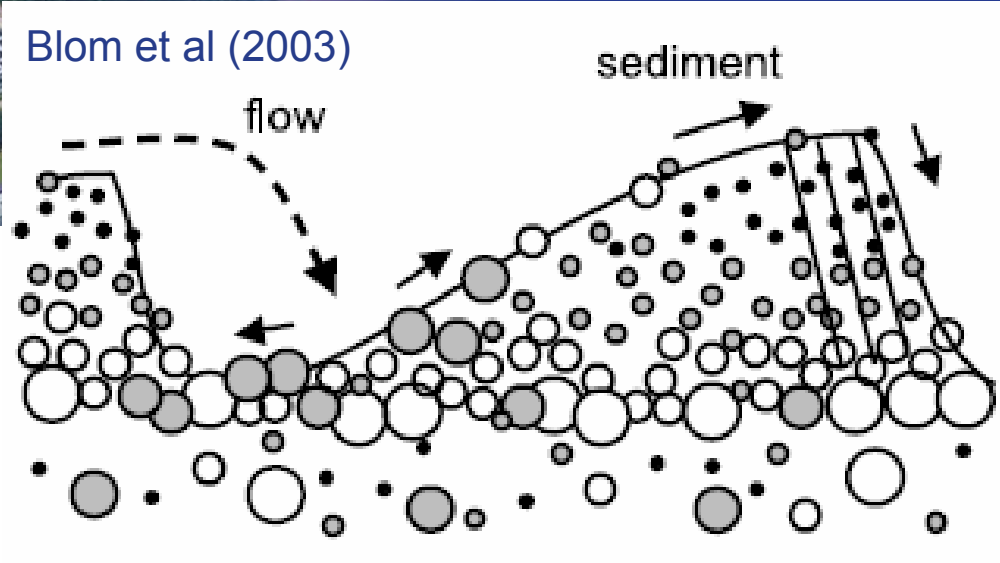
- Result from migrating bedforms
- Thickness depends on varying bedform height
- Only deepest troughs leave a record
- Necessary to incorporate the stochastics of bedform dimensions




From Paola & Borgman (1991)


# Bed roughness

- Form roughness depends on size, shape and spacing of bedforms (e.g. Nelson et al, 1993)
- We expect that variability in bedform dimensions affects the form roughness and thus the total bed roughness
- Necessary to incorporate the stochastics of bedform dimensions in roughness models




# Vertical sorting

- Vertical sorting and its adaptation time scale are strongly related to variability in trough elevations
- Vertical sorting-model of Blom & Parker (2004) requires sub-model describing (time evolution of) PDF of the trough elevation


# Objective

To develop a model for the stochastics of bedform dimensions

# Approach

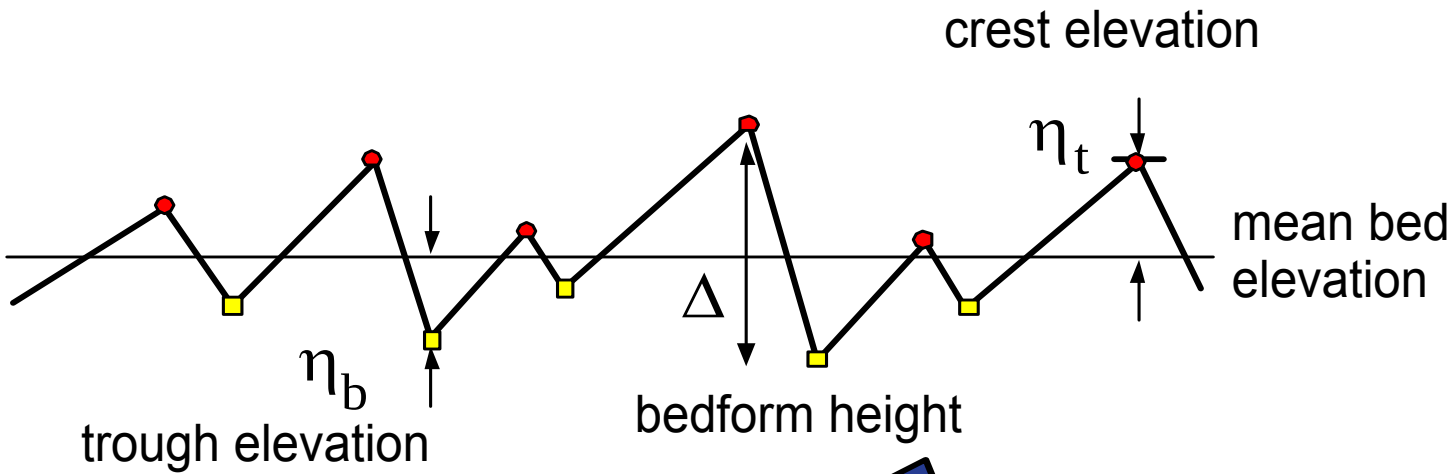
The variability of bedform height, trough elevation and crest elevation are examined by analyzing three sets of flume experiments

# Flume experiments

- 3 sets of experiments: Blom ‘00, Blom & Kleinhans ‘99, Leclair ‘02
- 11 experiments, bedforms occurred
- Steady + uniform flow
- Non-uniform sediment
- Measurements taken in equilibrium state

# Flume experiments

- Individual crests and troughs are gathered from bed elevation profiles
- Bedform height is defined as vertical distance between crest and subsequent trough

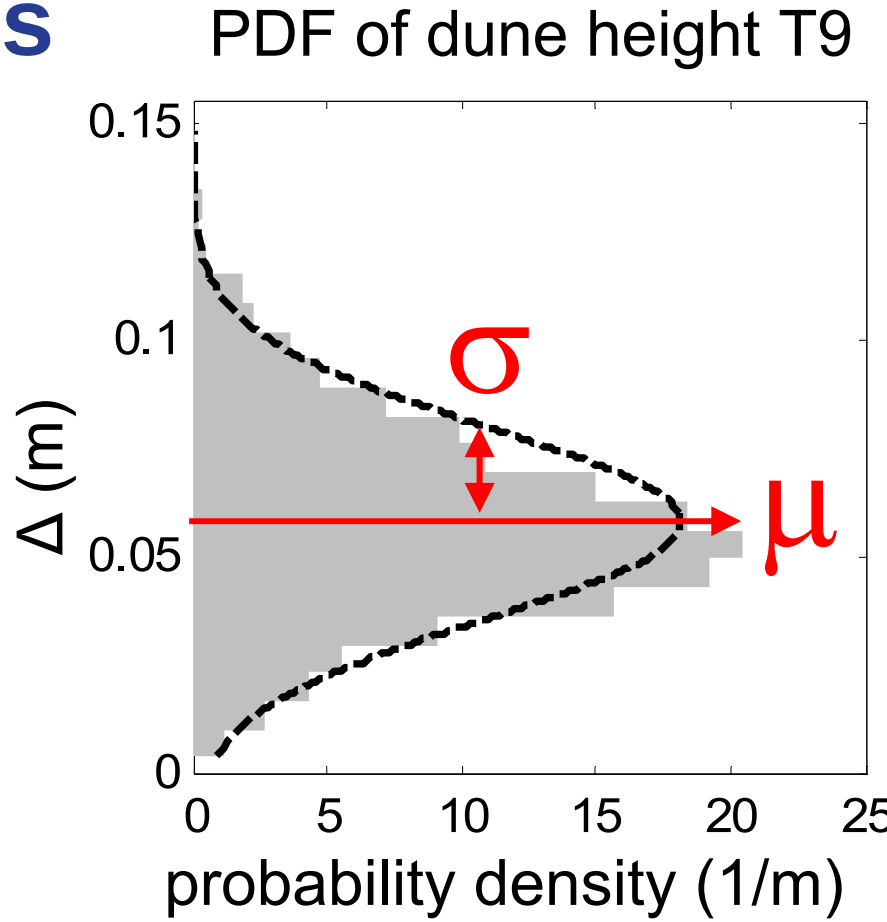


# PDFs

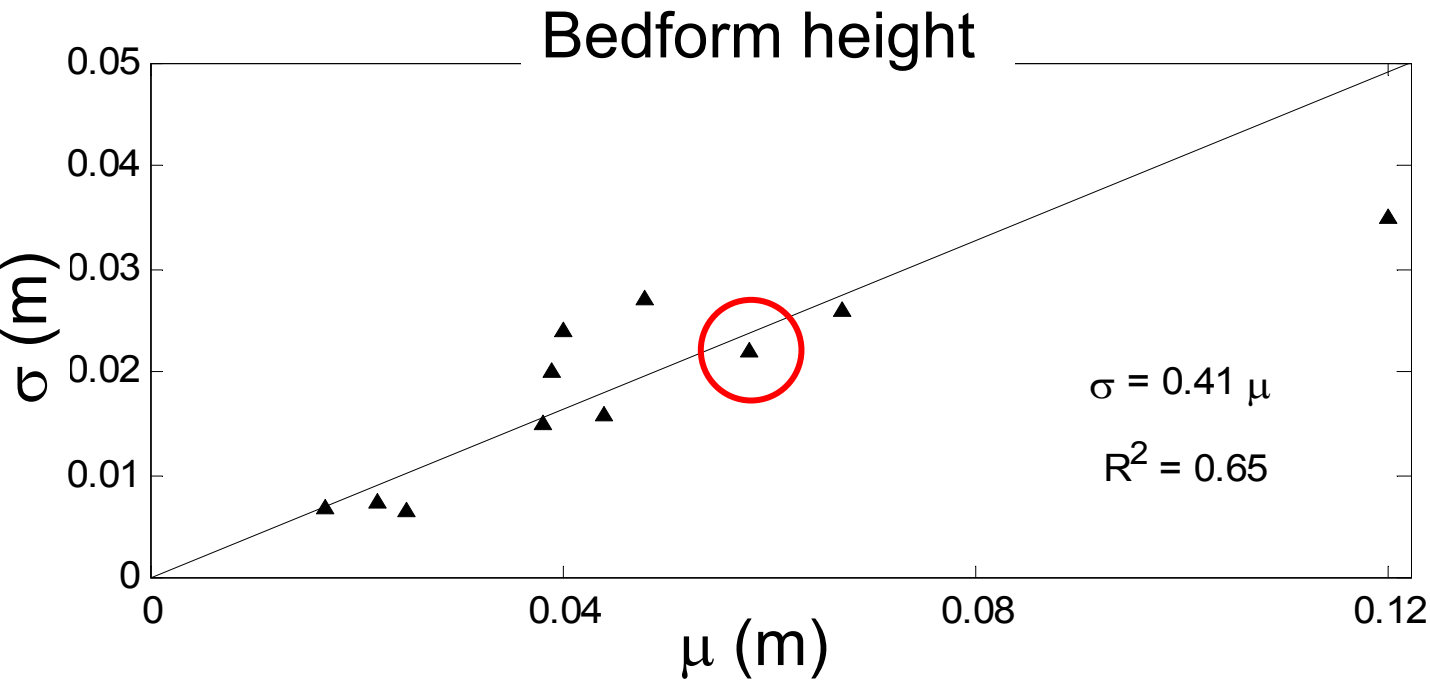
For all 11 experiments:

- PDFs of: - bedform height,
  - crest elevation
  - trough elevation
- $\mu$ and $\sigma$
- Coefficient of Variation
- For this experiment:

  $CV = \sigma/\mu = 0.38$



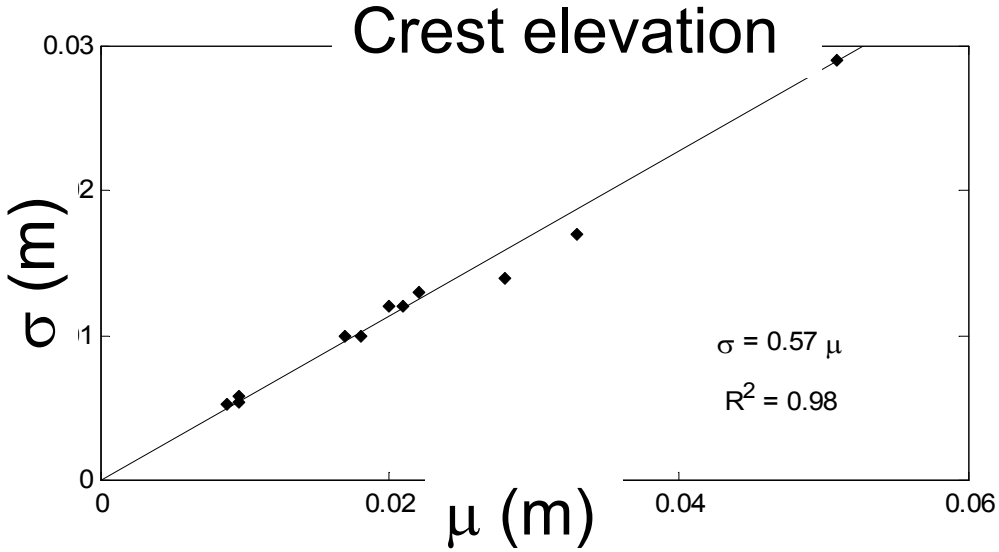
# σ versus μ for all experiments




Variation σ scales with mean μ

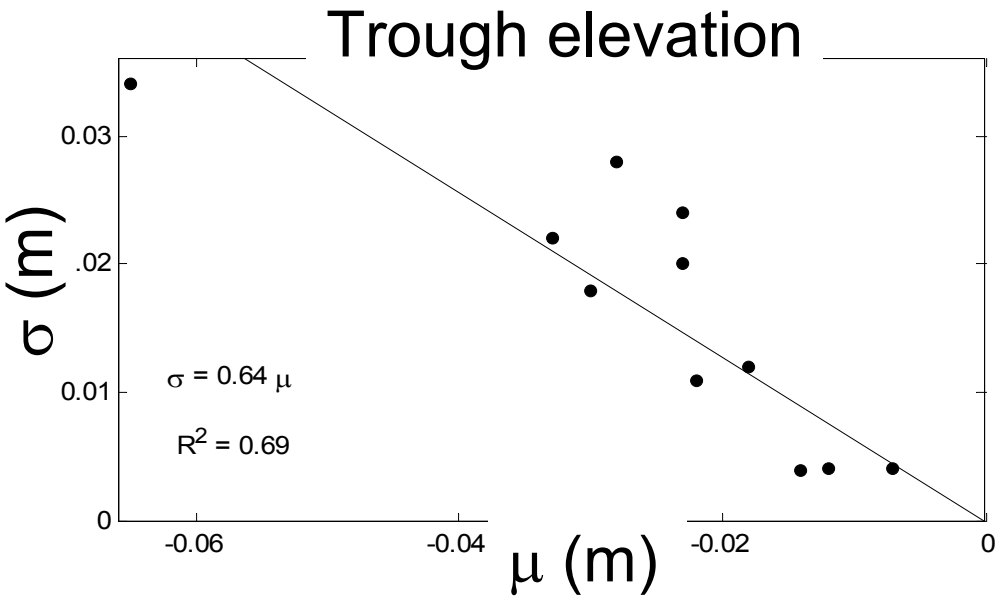
For bedform height: CV = σ/μ ≈ 0.4

Confirmed by others: e.g. Gabel '93




For crest elevation:

$\sigma/\mu \approx 0.6$




For trough elevation:

$\sigma/\mu \approx 0.6$

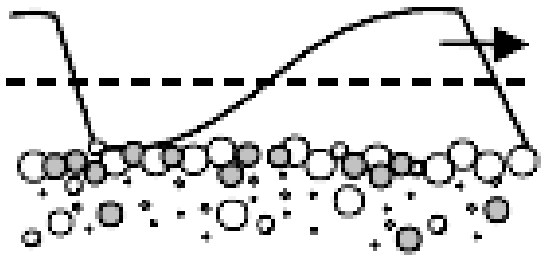

# Deviations

- Deviations from this linear trend can be seen, especially for ‘trough elevations’.

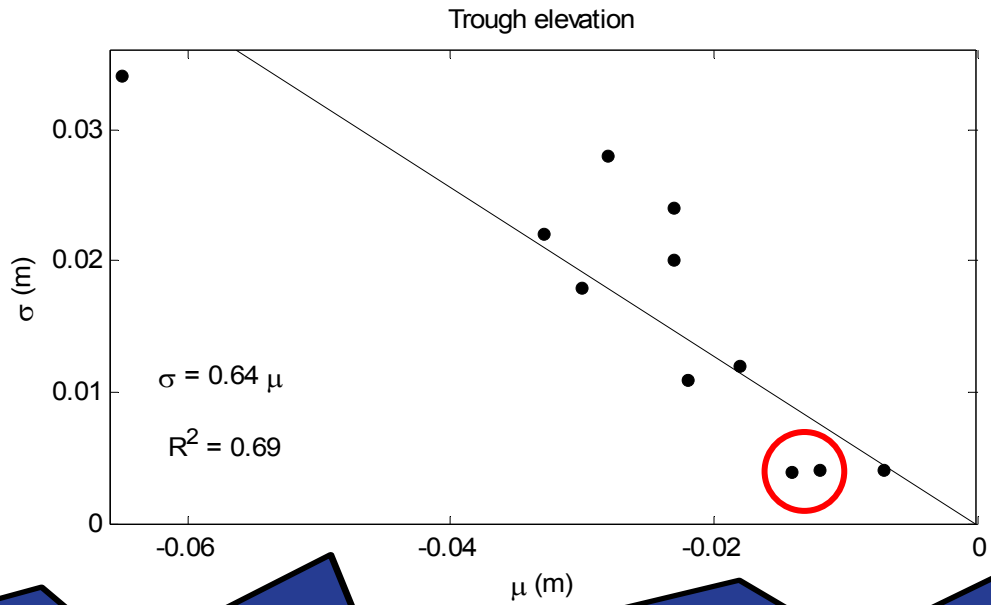
- Possible explanations:
  - Turbulent wake in troughs
  - Sediment composition within the bed

# Deviations

- Coarse bed layer underneath migrating bedforms reduces variability in trough elevations (e.g. Wilcock & Southard, 1989)



Blom et al. (2003)




# Conclusions

- The coefficients of variation for bedform height, trough elevation and crest elevation are within a narrow range
- As a first approximation, a constant CV can be used when describing the variability of bedforms
- Variability in bedform height can be modeled by only predicting the mean bedform height

# Future work

- To develop a more generic model for the stochastics of bedform dimensions:
  - 2D ↔ 3D
  - Dunes ↔ Other types of bedforms
  - Flume ↔ Field data
  - Steady ↔ Non steady flow
  - Normal ↔ Other distributions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# Definition

- How do we define bedform dimensions?
  - Lots of definitions suggested
  - No consensus in literature
  - Choice for definition is made subjectively