Sand loss during bed load measurements
experiments in a tilting flume

Dipl.-Ing. Karin Banhold
Dr. Roy M. Frings
Prof. Dr.-Ing. Holger Schüttrumpf

Institute of Hydraulic Engineering and Water Resources Management
RWTH Aachen University

Introduction

- **Sand loss during bed load measurements**

Objective: Complete bed load data

Bed load sampler bags consist of mesh net

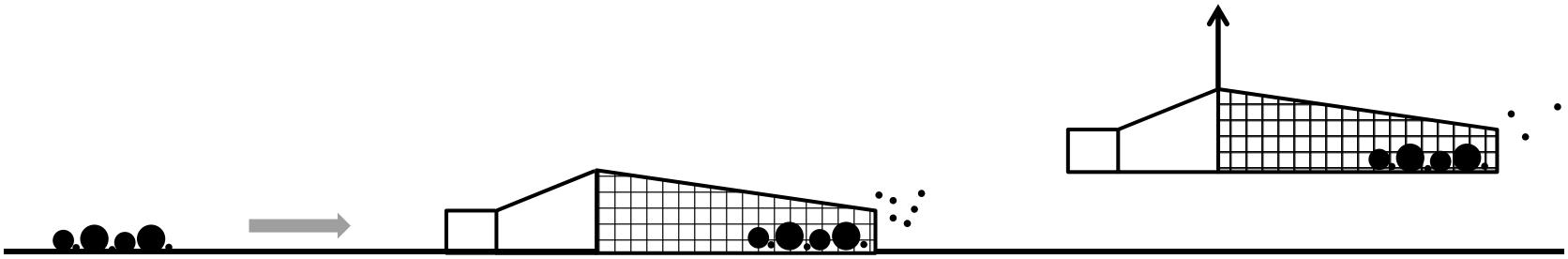
→ sediment smaller than meshes can pass

→ UNDERESTIMATION

Introduction

- Scientific objective:
  - Quantify the sand loss during bed load measurements
  - Identify influencing parameters
    (Mesh size? Filling degree? Coarse gravel content? Sand content?)

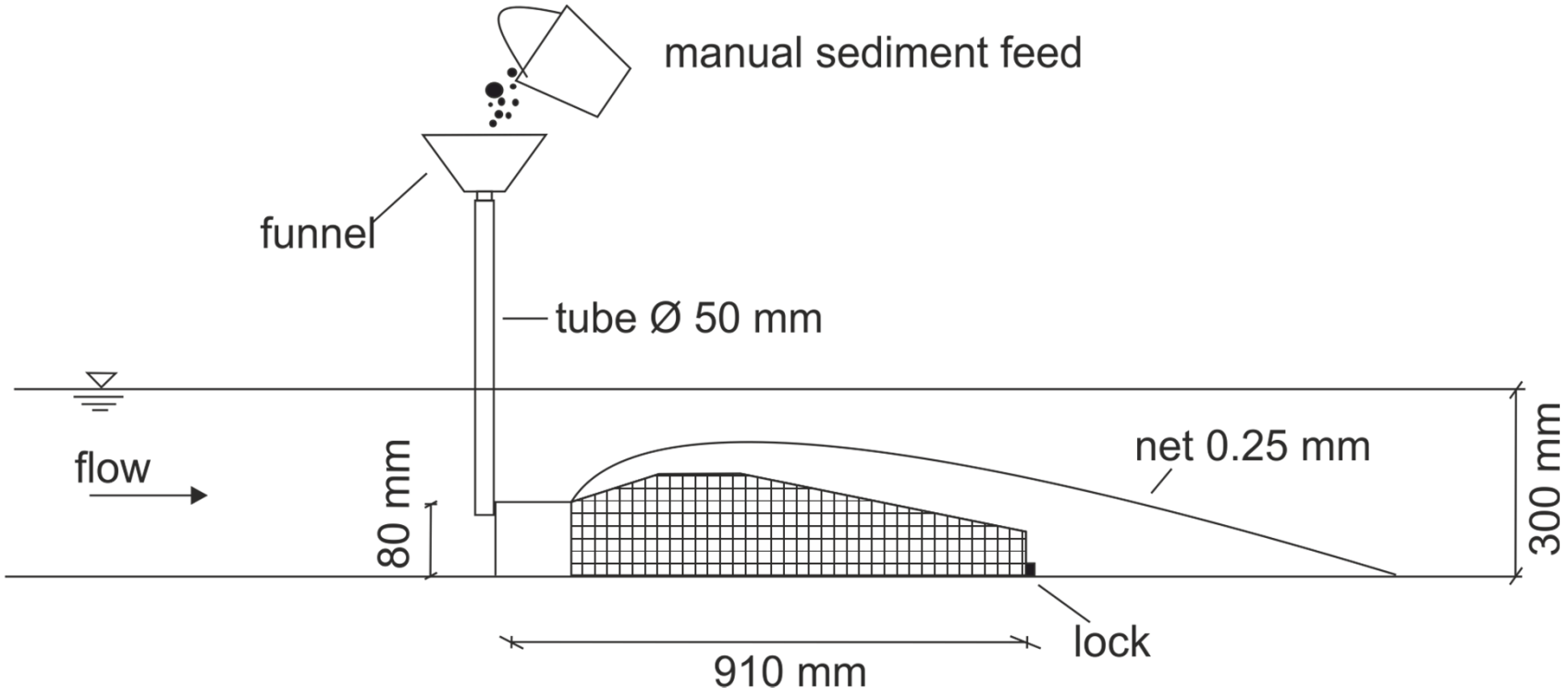
- Bed load measurement: 1) Sampler remains on river bed
  2) Sampler is pulled back to ship



Bed load ➡ river bed tests ➡ lift up tests

Bed Tests – Method

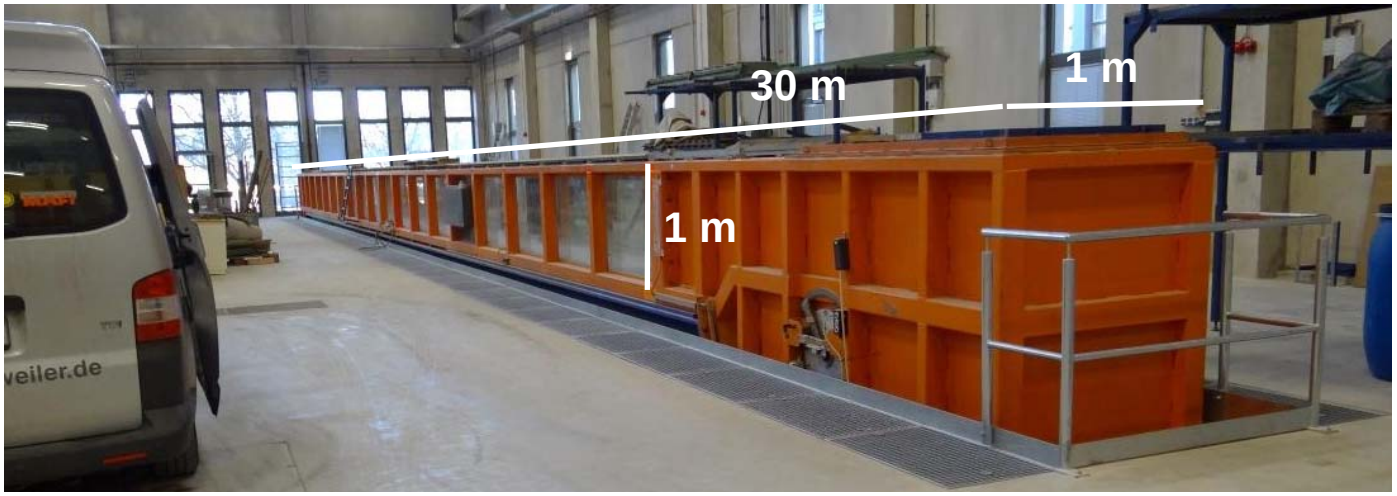
- Experimental setup:



- duration on bed: 300 s

Bed Tests – Method

- Tilting flume in the laboratory of the IWW
- Slope: 0.05 %



Bed Tests – Method

- Parameter — Variations

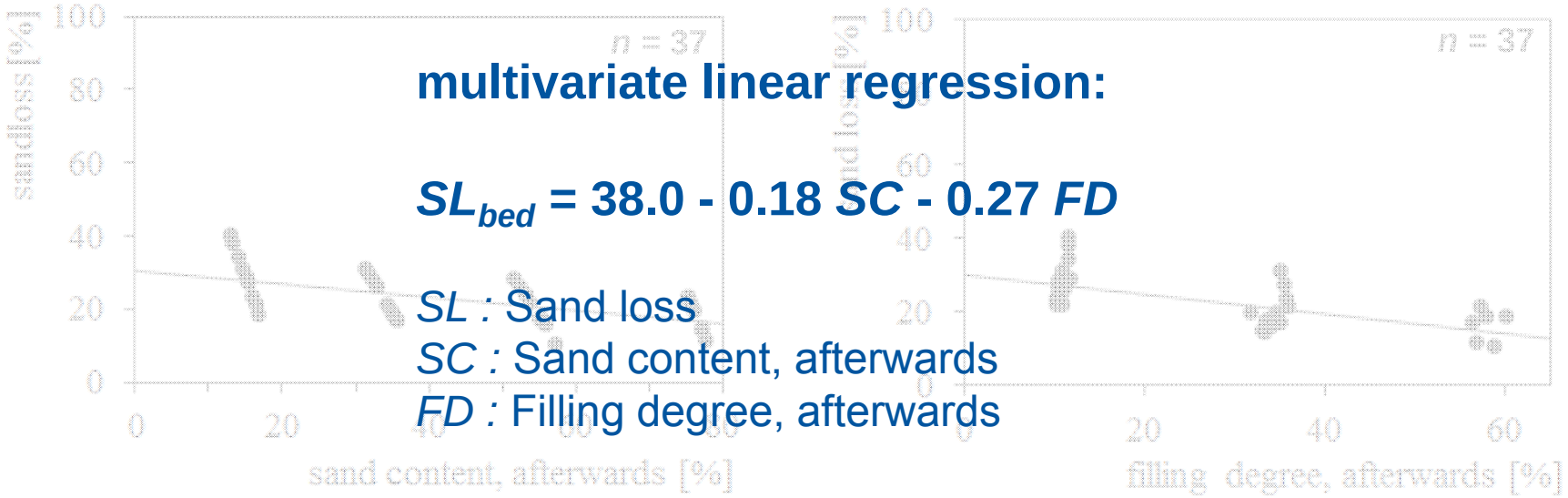
Capacity of sampler: 20 kg

Parameter	Variations
Added mass	2.5 kg 7.5 kg 12.5 kg
Sand content	20 % 40 % 60 % 80 %
Coarse gravel content (16 – 32 mm)	10 % 40 %
Mesh size	0.5 mm 1.4 mm

80 experiments

Bed tests – Results

- Calculation of loss:
  difference between added sediment and content after measuring
- Mesh size 0.5 mm: average loss = 23 %



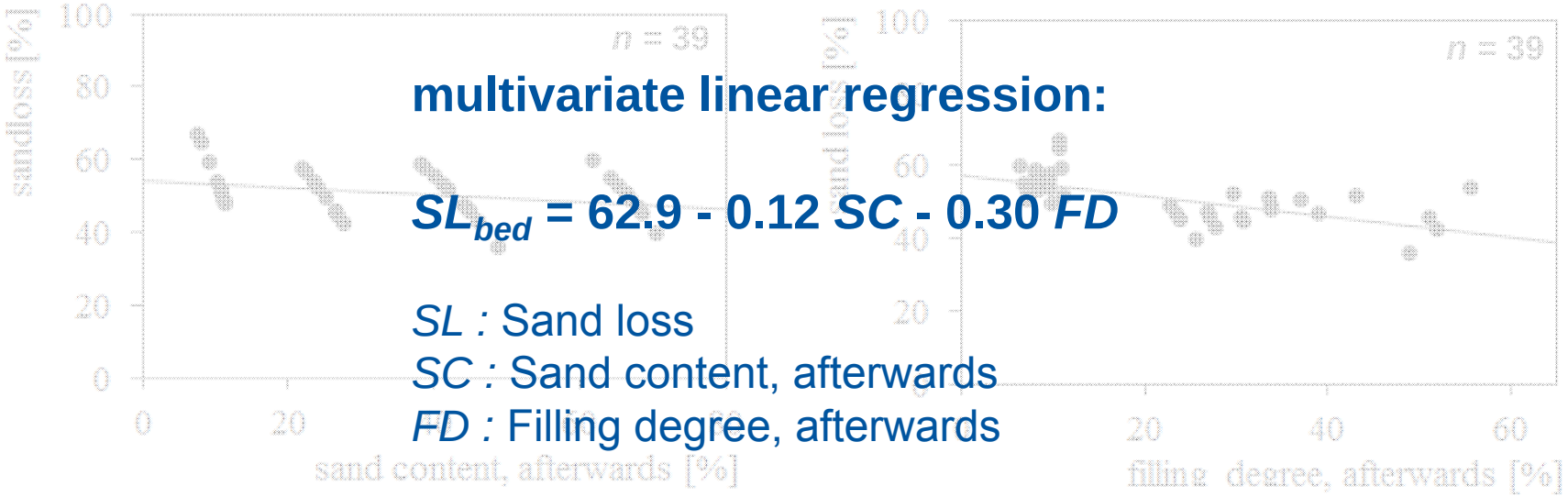
multivariate linear regression:

$$SL_{bed} = 38.0 - 0.18\ SC - 0.27\ FD$$

SL : Sand loss
SC : Sand content, afterwards
FD : Filling degree, afterwards

Bed tests – Results

- Calculation of loss:
  difference between added sediment and content after measuring
- Mesh size 1.4 mm: average loss = 50 %



multivariate linear regression:

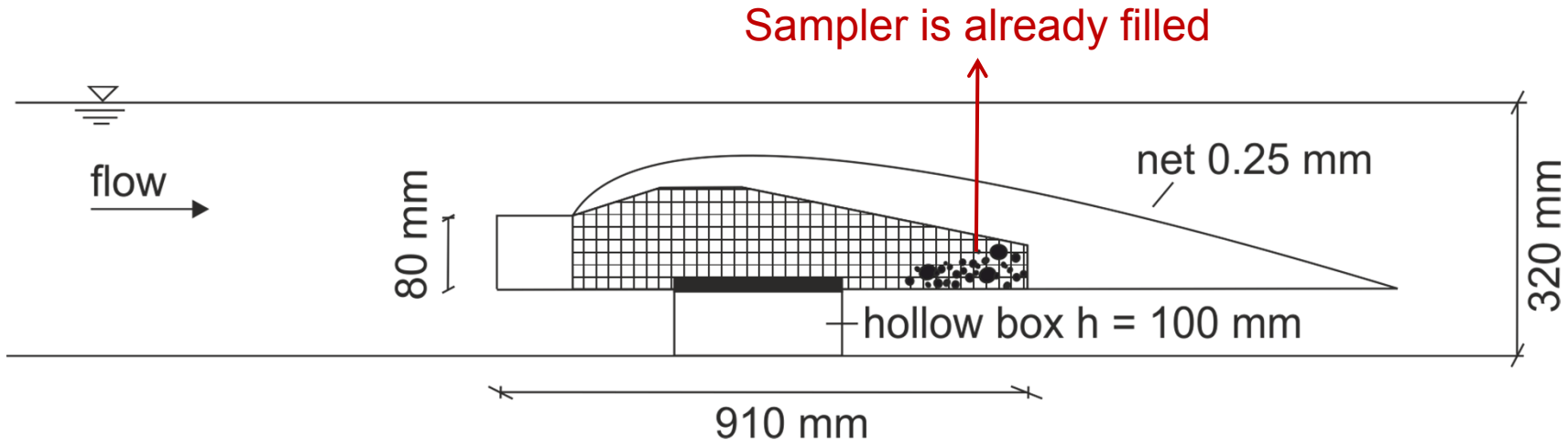
$$SL_{bed} = 62.9 - 0.12\,SC - 0.30\,FD$$

SL : Sand loss
SC : Sand content, afterwards
FD : Filling degree, afterwards

Lift-up – Method

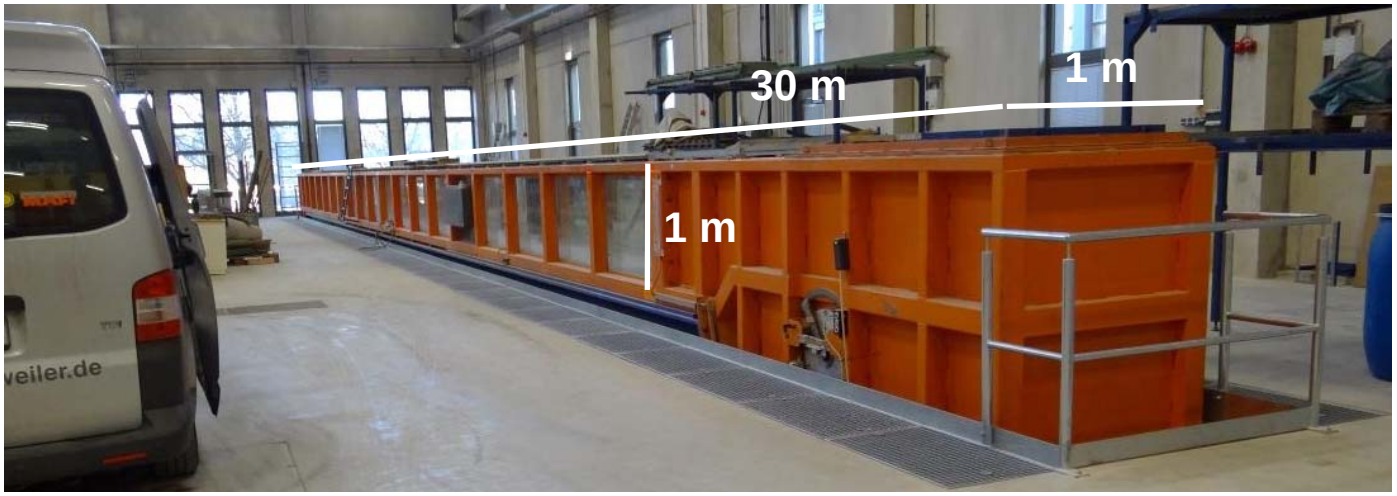
- Lift-up tests simulate the pulling back to ship

  Sampler is in the water body, duration: 30 s



Lift-up – Method

- Tilting flume in the laboratory of the IWW
- Slope: 0.05 %



Lift-up – Method

- Parameter — Variations

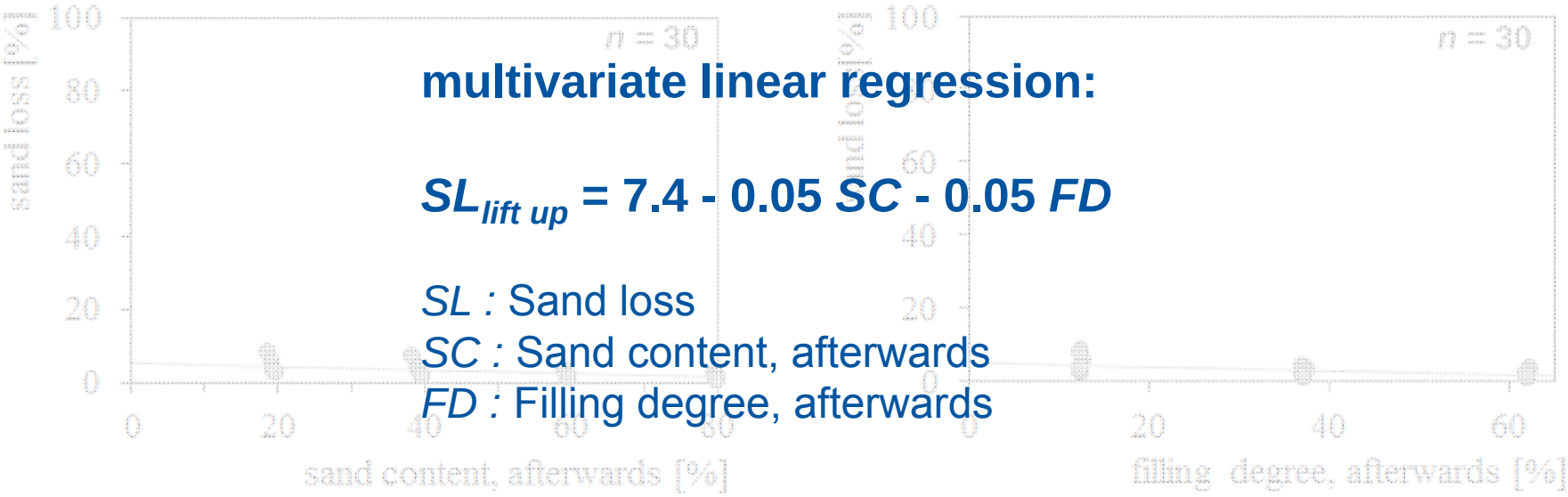
Capacity of sampler: 20 kg

Parameter	Variations
Added mass	2.5 kg 7.5 kg 12.5 kg
Sand content	20 % 40 % 60 % 80 %
Coarse gravel content (16 – 32 mm)	10 % 40 %
Mesh size	0.5 mm 1.4 mm

66 experiments

Lift-up – Results

- Calculation of loss:
  difference between added sediment and content after measuring
- Mesh size 0.5 mm: average loss = 3 %



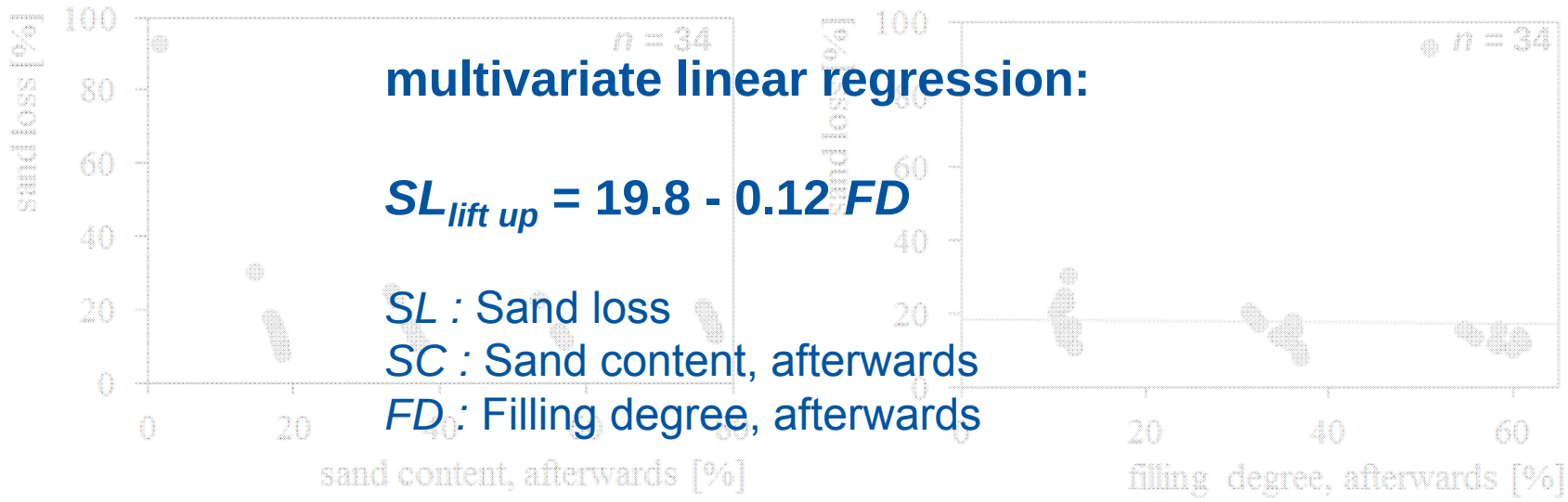
multivariate linear regression:

$$SL_{lift\ up} = 7.4 - 0.05\ SC - 0.05\ FD$$

SL : Sand loss
SC : Sand content, afterwards
FD : Filling degree, afterwards

Lift-up – Results

- Calculation of loss:
  difference between added sediment and content after measuring
- Mesh size 1.4 mm: average loss = 16 %

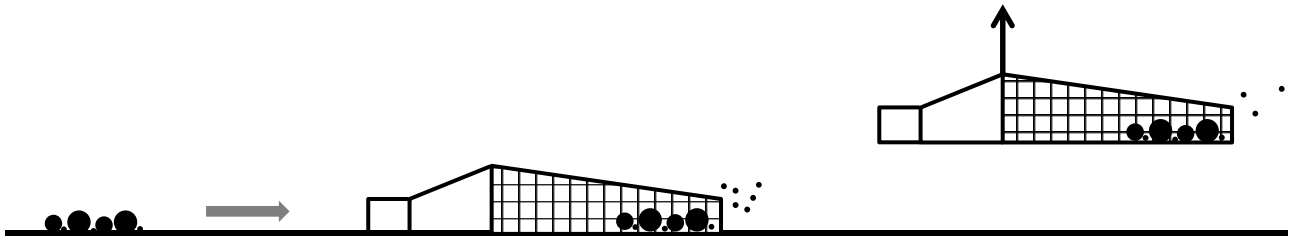


multivariate linear regression:

$$SL_{lift\ up} = 19.8 - 0.12\ FD$$

SL : Sand loss
SC : Sand content, afterwards
FD : Filling degree, afterwards

Combination – Results



- Sand loss during complete measurements:

$$SL = 1 - (1 - SL_{bed}) \cdot (1 - SL_{lift\text{-}up})$$

SL : Sand loss during entire measurement [-]
SL_{bed} : Sand loss during measurement on river bed [-]
$SL_{lift\text{-}up}$: Sand loss during lift-up [-]

- Application: correction of bed-load data
- German River Rhine: 1.5 - 3.1 times more sand transported as bed load

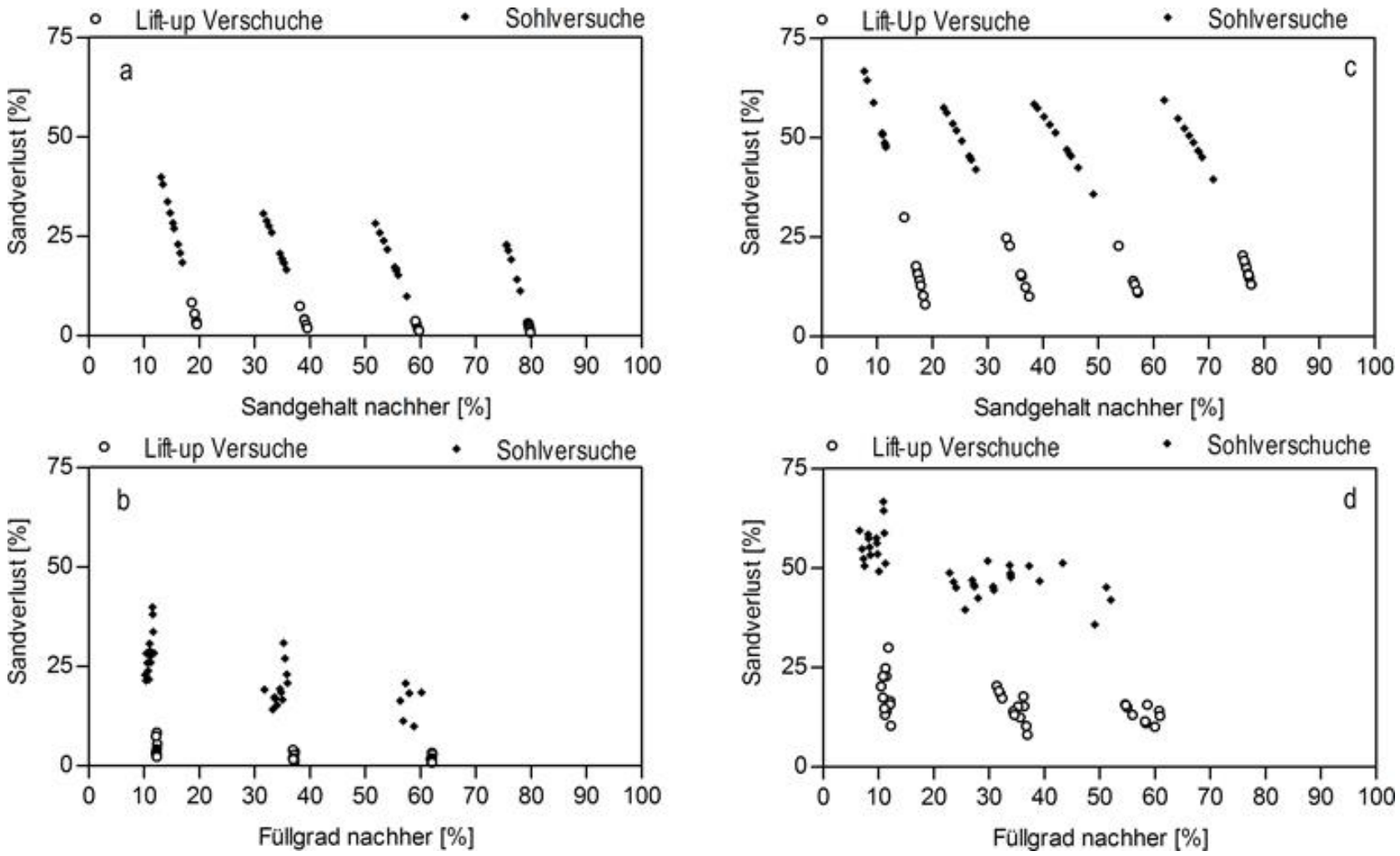
Conclusion

- Sand loss increases with increasing mesh size
  - ➢ Sand passes big mesh easier
- Sand loss decreases with increasing filling degree
  - ➢ Sand hides in spaces of other particles
- Sand loss decreases with increasing sand content
  - ➢ Mesh of sampler bag clogs
- Sand loss is higher during measurement on river bed than during lift-up process
  - ➢ Sand hides in spaces of other particles

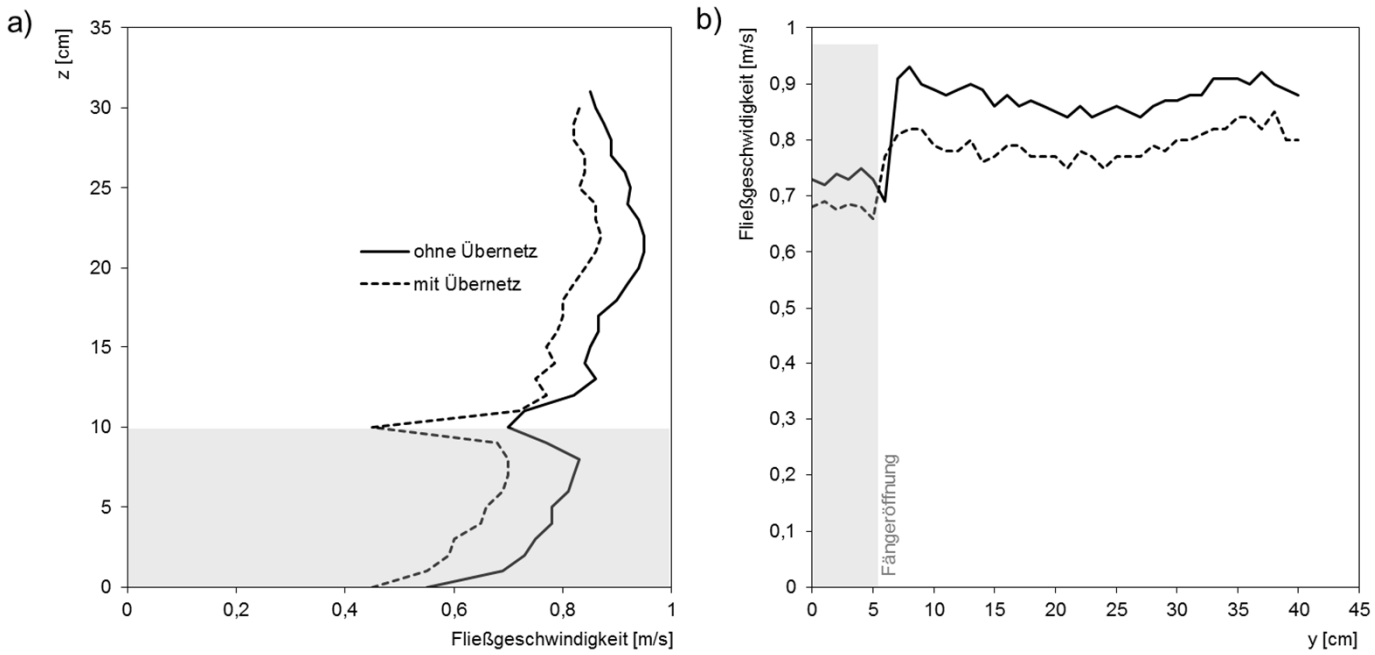
Thank you

- Federal Institute of Hydrology, Referat M3:
  B. Astor, N. Gehres, G. Hillebrand, S. Vollmer
- J. Judt (Bachelor Thesis)
- Student research assistants:
  L. Staggenborg and others

… for your attention

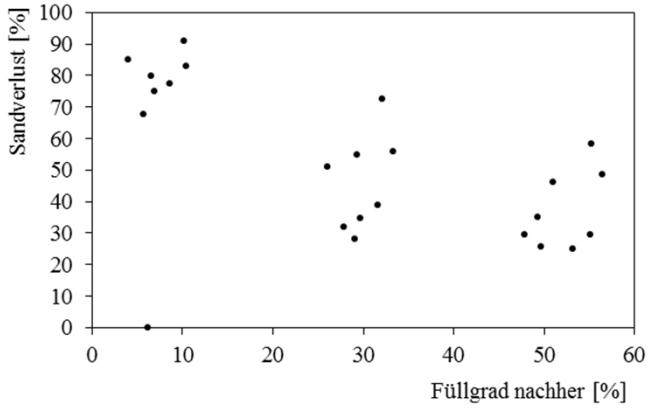

Lift-up Verschuche
Sohlversuche
a
Sandverlust [%]
Sandgehalt nachher [%]
Lift-Up Versuche
Sohlversuche
c
Sandverlust [%]
Sandgehalt nachher [%]
Lift-up Versuche
Sohlversuche
b
Sandverlust [%]
Füllgrad nachher [%]
Lift-up Verschuche
Sohlverschuche
d
Sandverlust [%]
Füllgrad nachher [%]

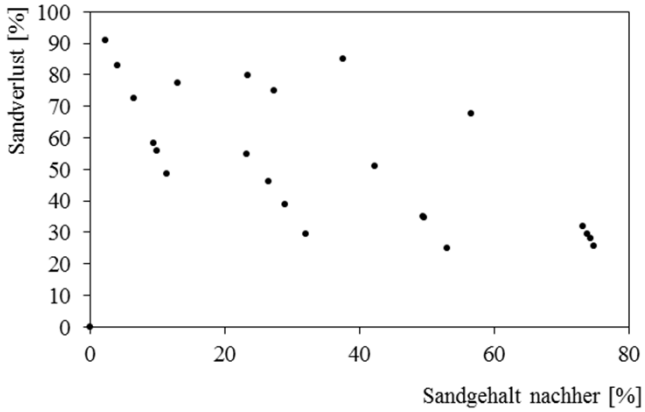
0.25 mm-net


a)
z [cm]
35
30
25
20
15
10
5
0
0
0,2
0,4
0,6
0,8
1
Fließgeschwindigkeit [m/s]
ohne Übernetz
mit Übernetz
b)
Fließgeschwindigkeit [m/s]
1
0,9
0,8
0,7
0,6
0,5
0,4
0,3
0,2
0,1
0
Fängeröffnung
0
5
10
15
20
25
30
35
40
45
y [cm]

Delft-Nile-Sampler *DNS* (NL)

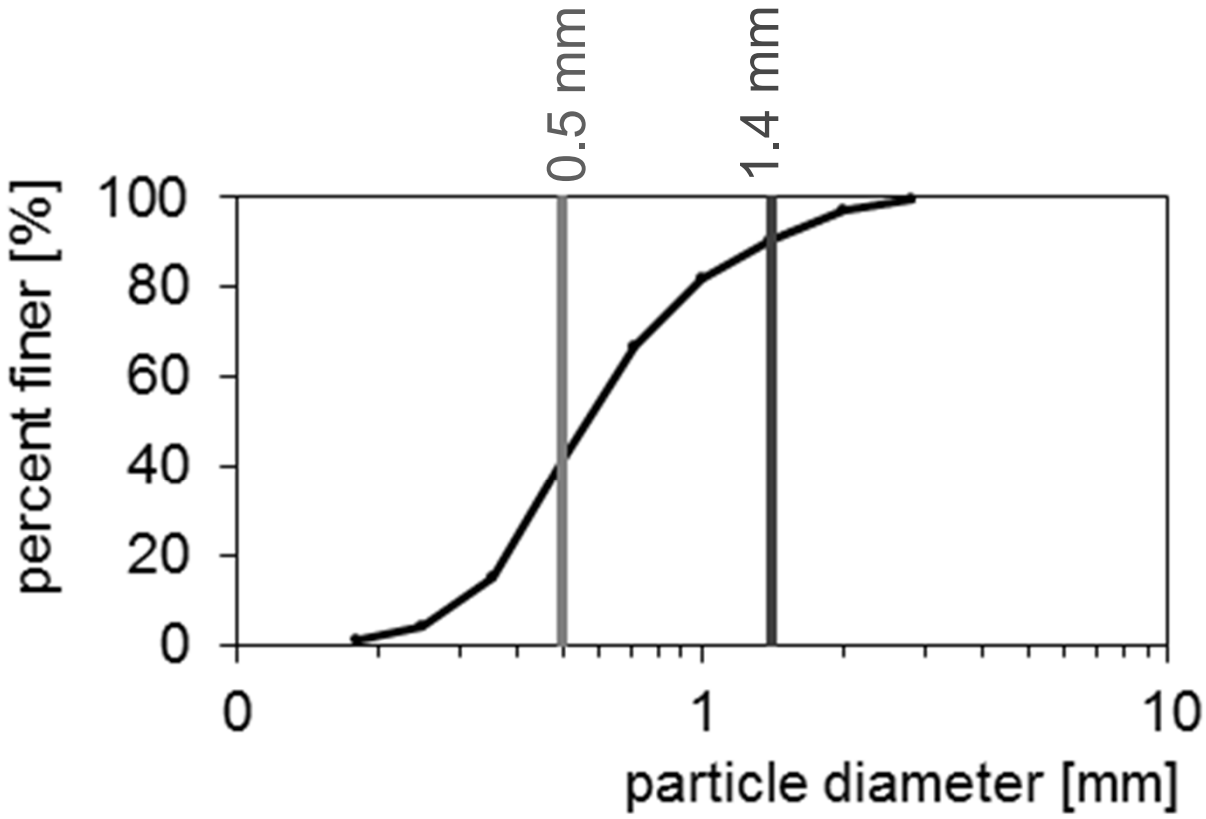
- Additional tests with modified DNS: mesh size 1.4 mm



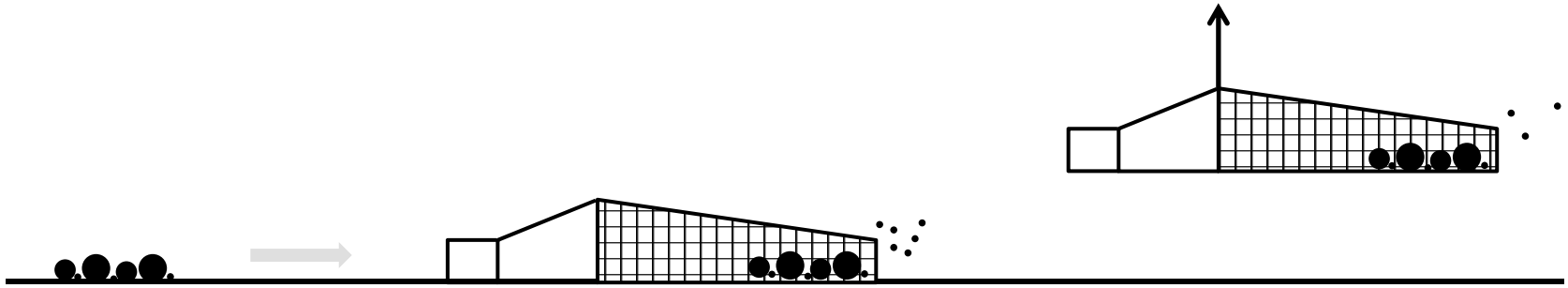


Maximum lost

- How much sand could possibly pass the mesh net?



Combination – Results



Bed load ➡ Sampling ➡ Lift-up

- Example – calculate sand loss

100 %	- 50 %	- 20 %
1,000 g	500 g	400 g
		remains in sampler