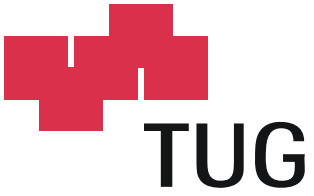

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Digital Photogrammetry in Experimental Hydraulics

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What is Experimental Hydraulics?

- Relevant for the design, operation and maintenance of hydraulic structures, waterways and hydropower plants
- Study of flow and sediment transport in streams and hydraulic structures by means of small-scale models
- Measurement of flow velocities, water level, pressure distribution, air entrainment, …
- Results can be transferred on the prototype using model laws


ST. Veit
M 1:40
Trockenfotos

St. Veit HPP (Salzach River)

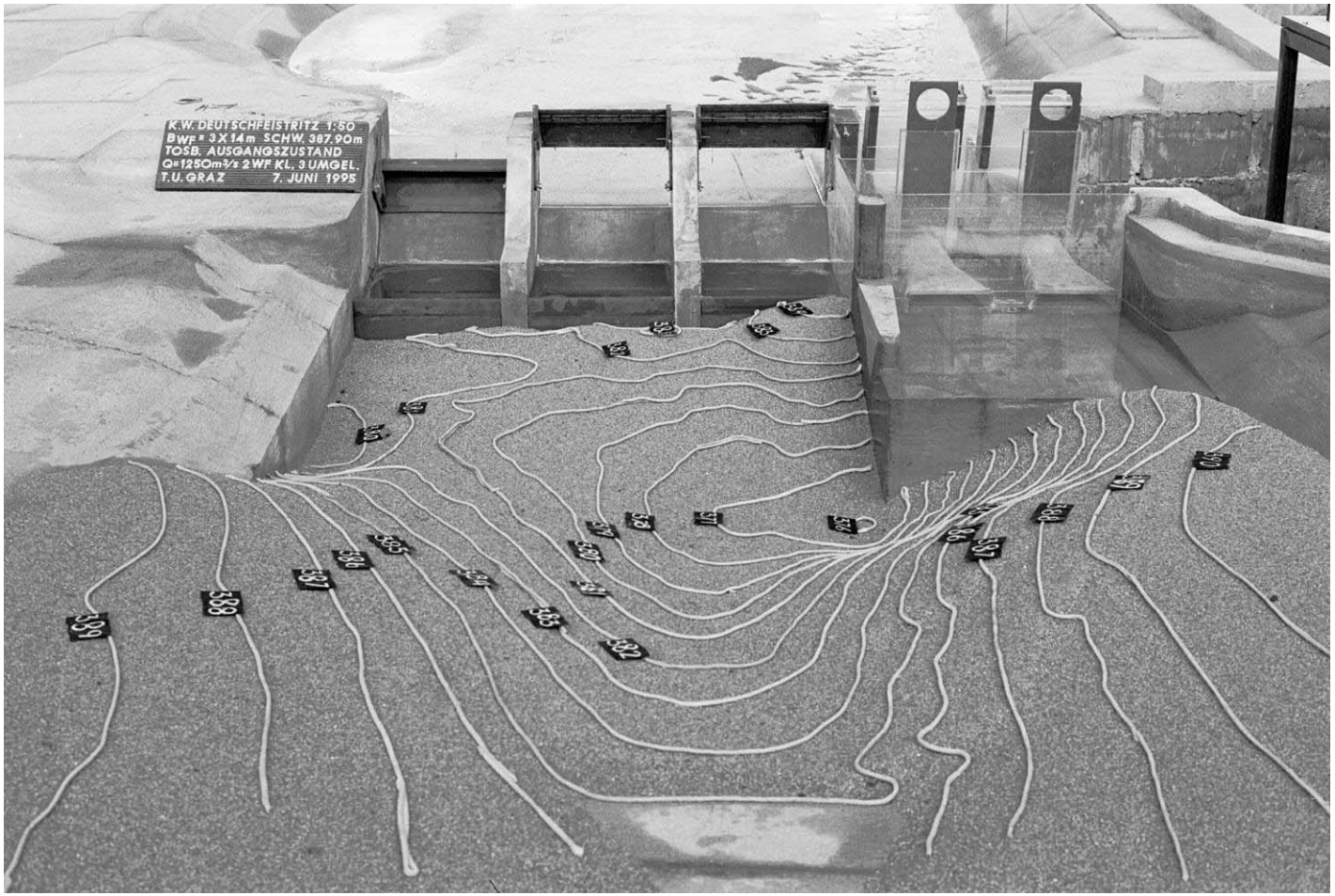
Prototype

Scale Model 1:40

Modelling of Sediment Transport

- Realistic modelling of sediment transport helps to evaluate the effect of structural measures on the natural stream-bed
- Stream-bed is being modelled by sand of appropriate particle size and specific gravity
- Area of sediment erosion and/or deposition is identified by 3D-measurement of stream-bed
- Level of accuracy depends on the technique that is used to register the topography of the stream-bed

Contour Mapping with Wool Threads



Contour Mapping with Wool Threads

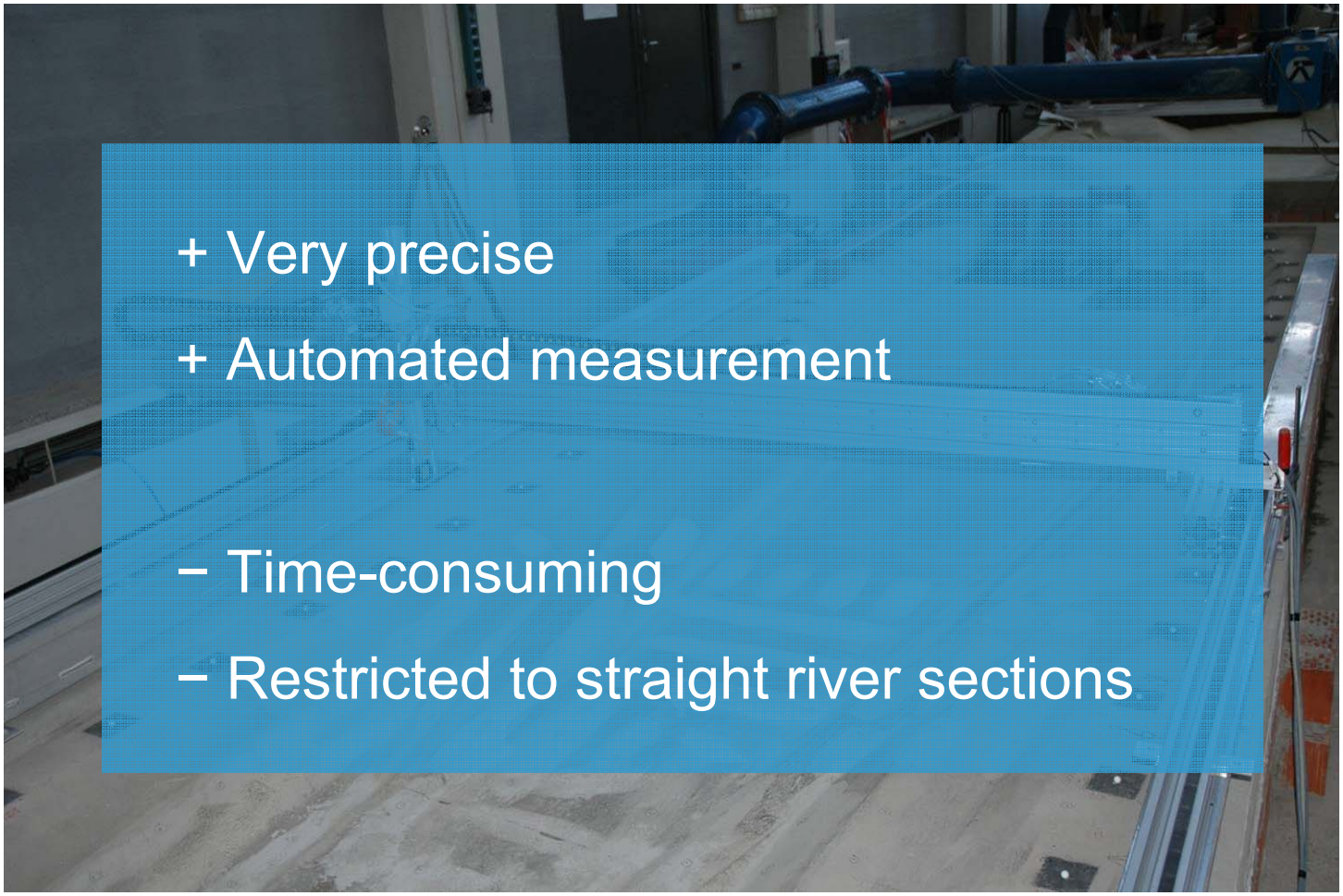
+ Simple and reliable

− Time-consuming

− Labor-intensive

Sequential Point-based Method (Laser Distance Sensor)

Sequential Point-based Method (Laser Distance Sensor)



+ Very precise
+ Automated measurement

− Time-consuming
− Restricted to straight river sections

Digital Close-range Photogrammetry

- HR Wallingford (Chandler et al. 2001), EPFL Lausanne (2002)
- TUG (2003): Development of a own low-cost, easy-to-use measurement system based on software developed by Joanneum Research and other institutions

- System components:

Nikon D70
(6.1 MegaPixel)

+ 35mm lens + processing software (JR)

Calibration of Camera Configuration

- Calibration field (Institute of Photogrammetry and Remote Sensing, TUG)
- Calibration tool: CALWIN (JR)
- Lens distortion correction: ORIENT (Vienna University of Technology)

Definition of 59 Control Points

- Fixed above the water surface on both sides of the stream
- White-enamelled metal balls (15mm diameter)
- Accurate Survey (Institute of Engineering Geodesy and Measuring Systems, TUG)

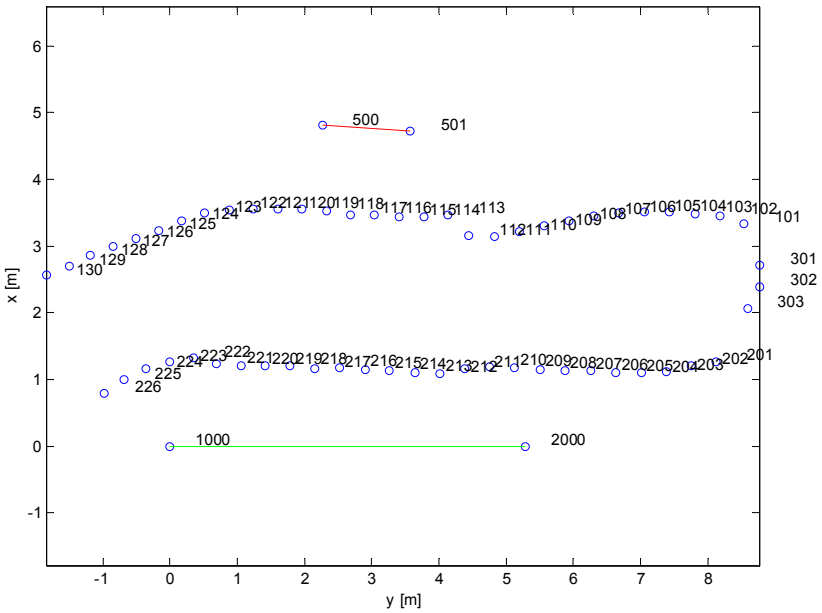


Image Acquisition

- Flying Height 4-5m above stream-bed
- 60-70% overlapping area
- 16 images for a 12m-long stream section

- No artificial lighting (camera flash only)
- No special measuring bridge (crane only)

- Acquisition time: 30 minutes

Image Processing

- Computation of transformation matrix for each different camera position with CALWIN
- DEM generation based on tunnel measurement system DIBIT™

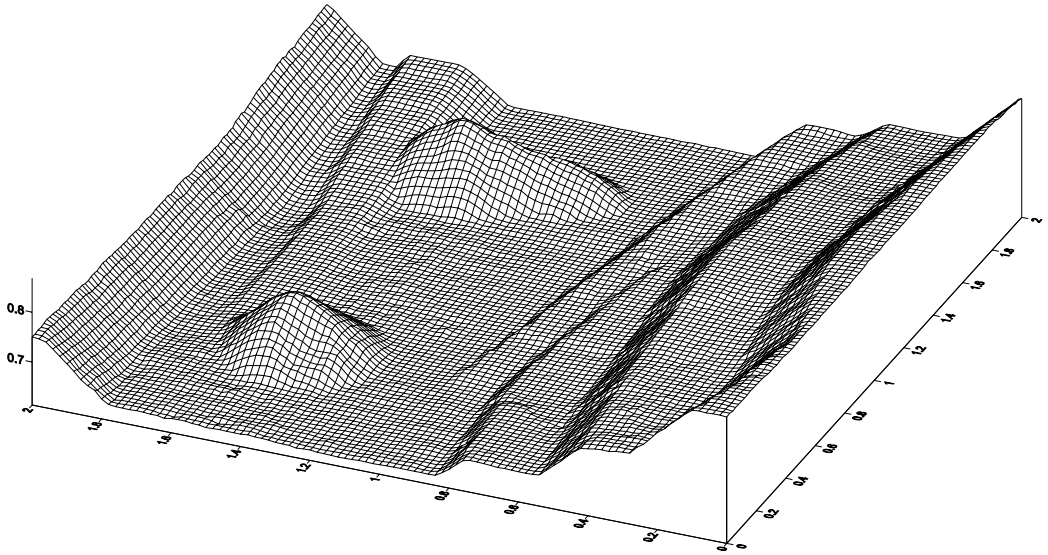
1. Matching of stereo-pairs (cross-correlation combined with HFVM method)
2. Computation of spatial coordinates of surveyed stream bed
3. Subsampling of generated 3D model with a regular grid (5x5mm)
4. Assembly of rectified images for representation of the whole model surface (image and structure)
5. Export of 3D coordinates and the corresponding pixels coordinates

- Only a few manual inputs
- Runs on conventional laptop (P4 with 2.80 GHz, 512 MB RAM)

Data Analysis with Surfer™

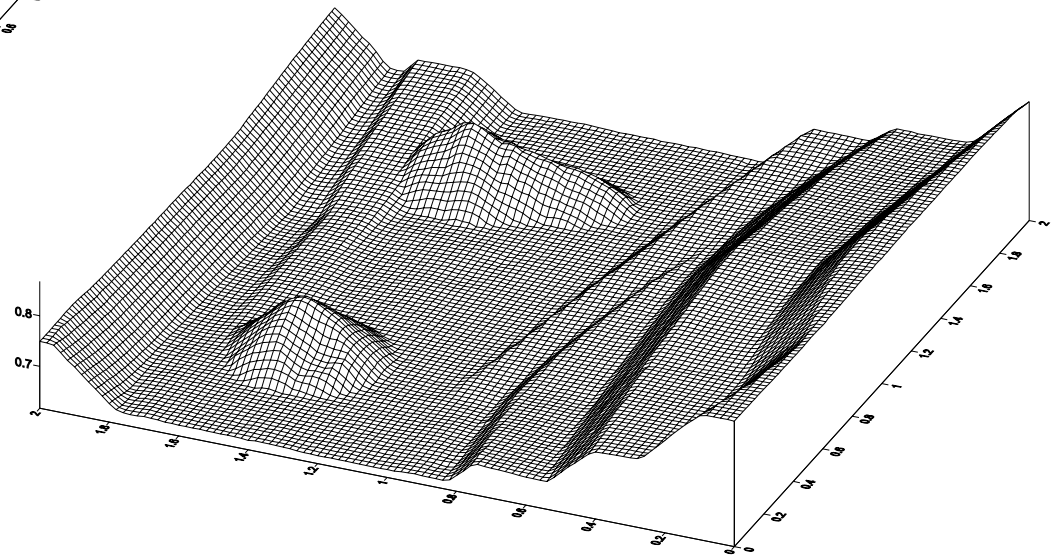
- Visualisation
- Cross-section calculation
- Volume calculation

Comparative Survey (2m x 2m)



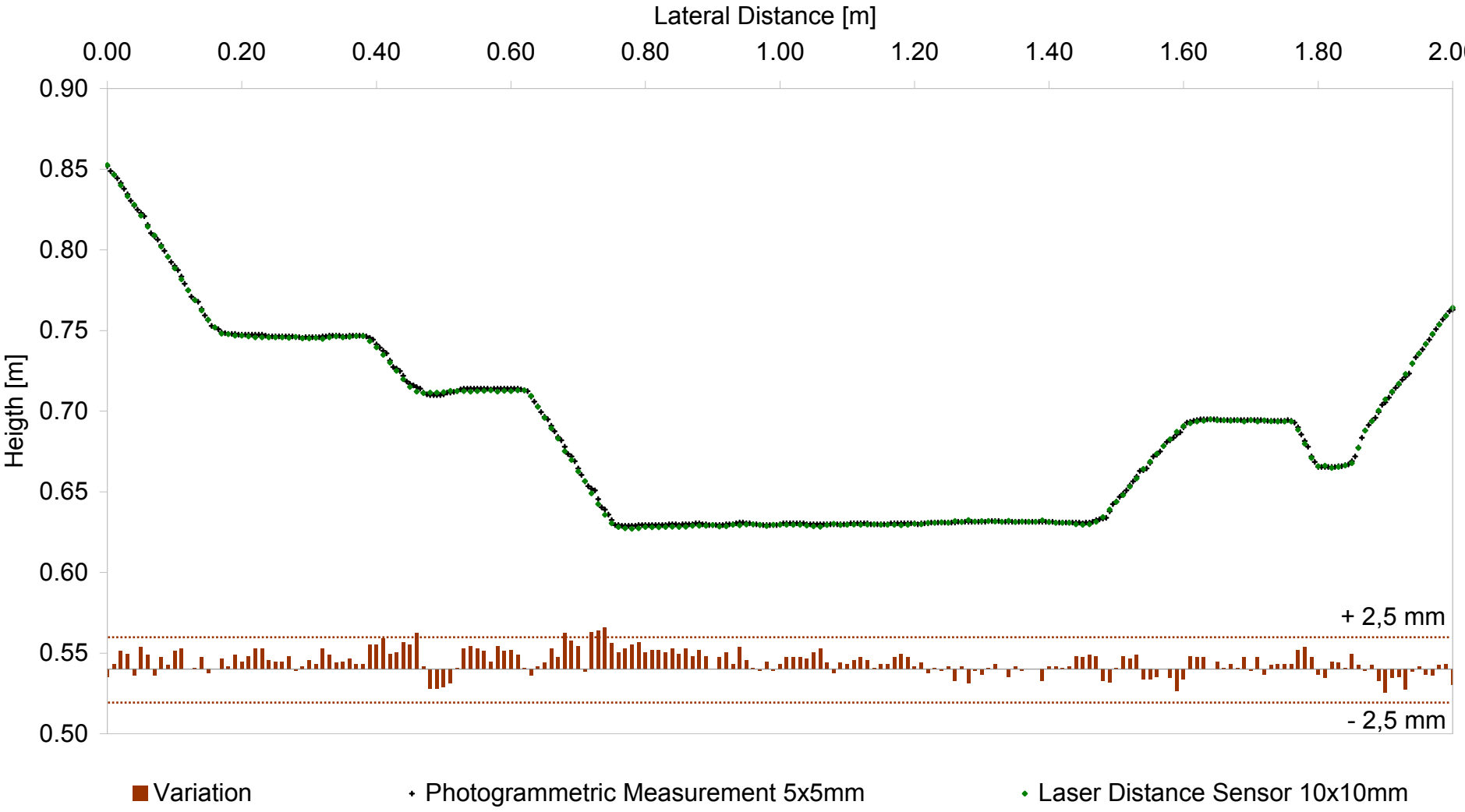
Digital Photogrammetry

160,801 points (5mm grid)
Processing time: 2h



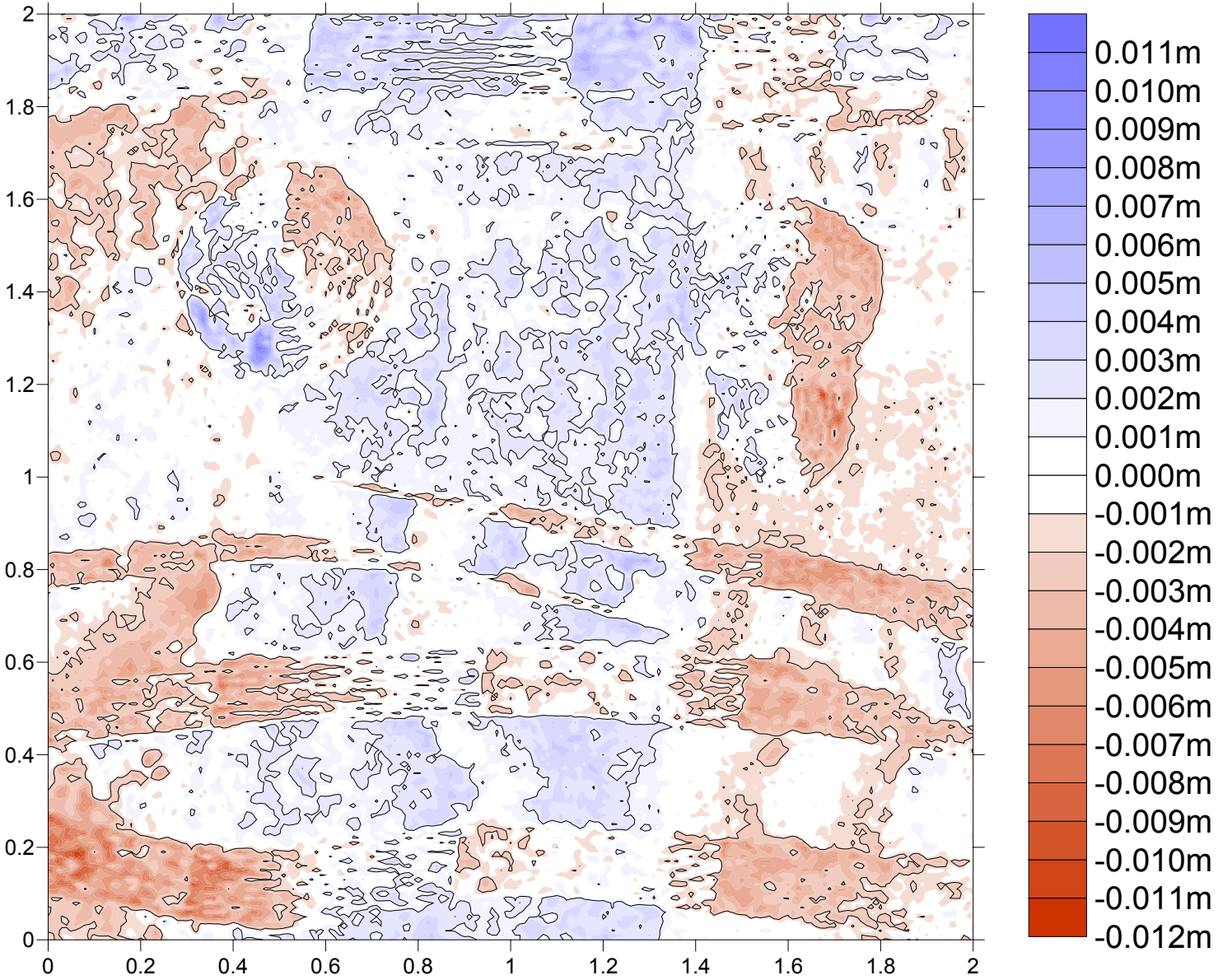
Laser Distance Sensor

40,401 points (10mm grid)
Processing time: 48h !


Lateral Distance [m]
0.00
0.20
0.40
0.60
0.80
1.00
1.20
1.40
1.60
1.80
2.00
Heigth [m]
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
+ 2,5 mm
- 2,5 mm
Variation
Photogrammetric Measurement 5x5mm
Laser Distance Sensor 10x10mm

Contour plot showing deviation *d* between the two data sets

(solid line *d* = 2mm)



Conclusions

Photogrammetric stream-bed surveys can be considered an appropriate and accurate method to be applied in experimental hydraulics due to the following advantages:

- Good accuracy in combination with high point density
- Realistic representation of the stream-bed
- Immediate results at low cost
- High flexibility and easy handling

Thank You for Your Attention!

www.hydro.TUGraz.at
www.joanneum.at/dib
www.dibit.at