Numerical modelling of physical processes in Hydraulic and Sedimentation Engineering

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TUM School of Engineering and Design

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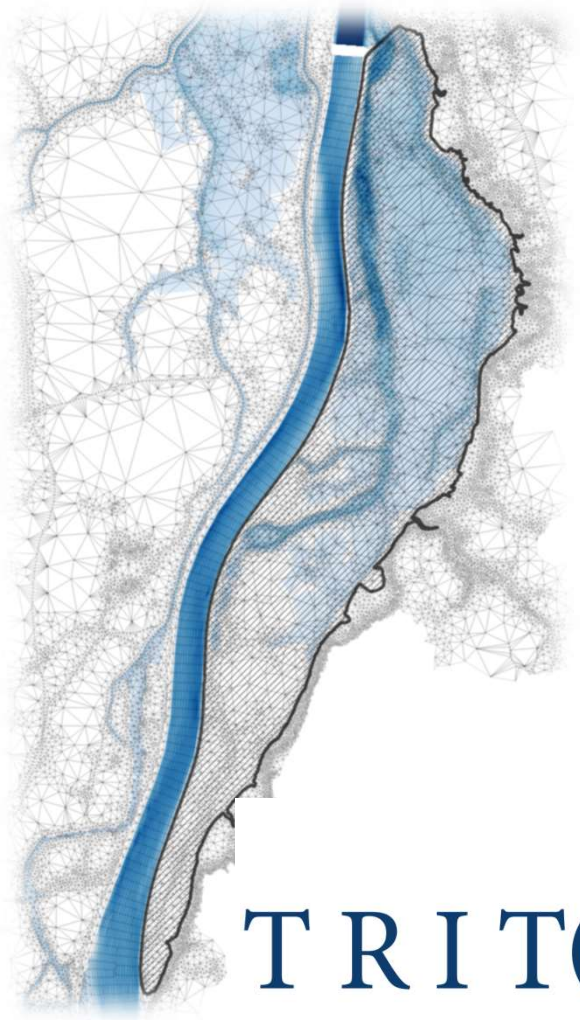
Triton Summer School, Athens, 06.09.2022



Albania, August 2014
Tomorrice river
Devoll river catchment
Photo: Nils Rüther

Binga Lake

APPLICATION CASES

Physical model studies

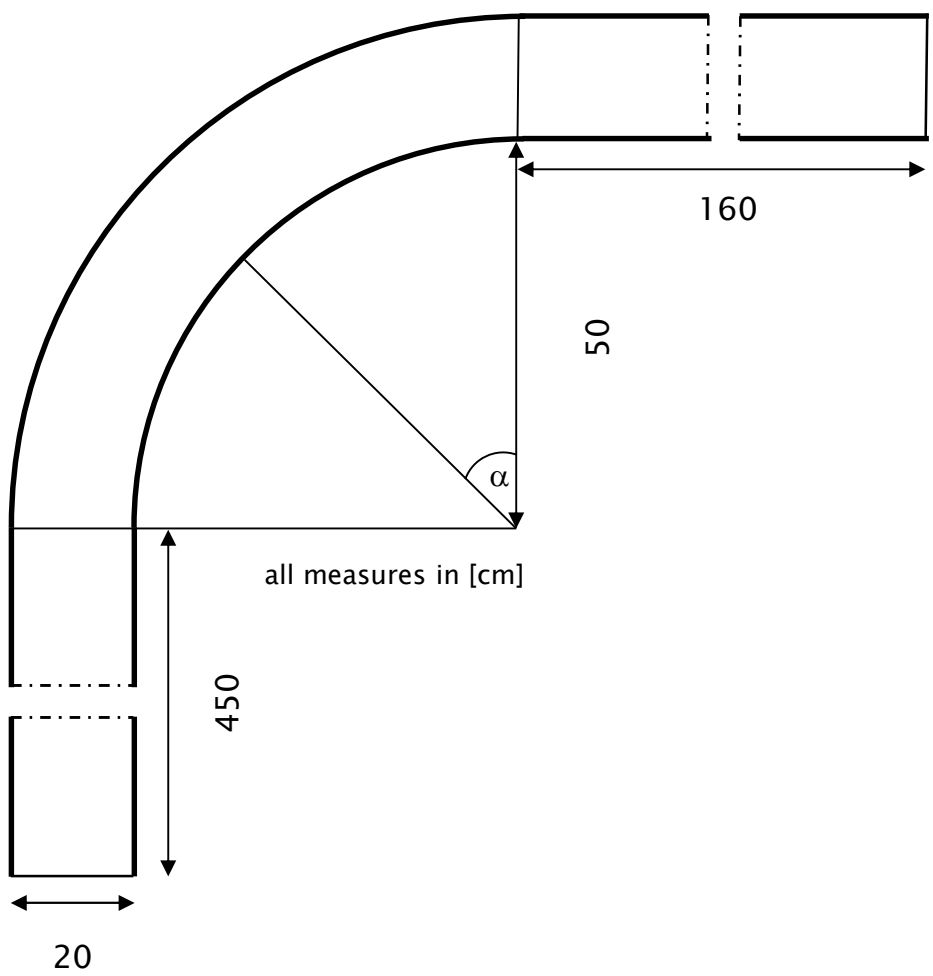
1. 90 bend - strong lateral gradients
2. 180 bend – unsteady flow and non-uniform sediments
3. Meandering channel - large width to depth ratio
4. Self-forming meandering channels
5. Sandtraps
6. Headworks
7. Rough surface Flow

Prototype scale

1. River Po – alternate bars and bends
2. Øyeren – just hugh
3. Gauging station Eggafossen

90° channel bend with non-erodable sides

Setup of the physical model



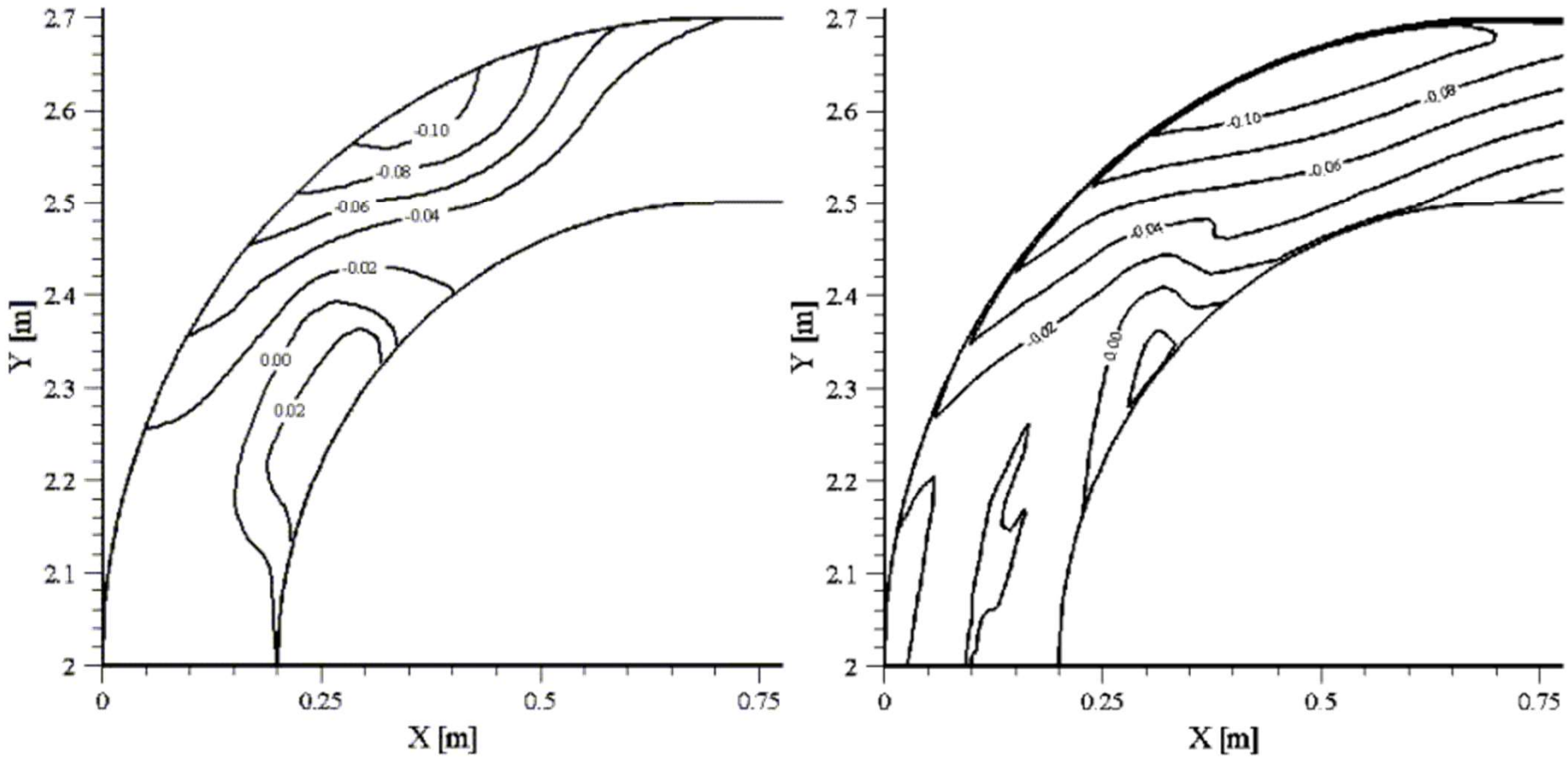
Geometry and hydraulic setup

Discharge	4 l/s
Mean flow depth	50 mm
Mean bed slope	1/300
Sediment feed	0.00144 l/s
d_{50}	0.6 mm
Shear velocity	3.7 mm/s
Froude number	0.77
Width/depth	4
Raduis/width	3

Experimental setup by Kawai & Julien (1996)

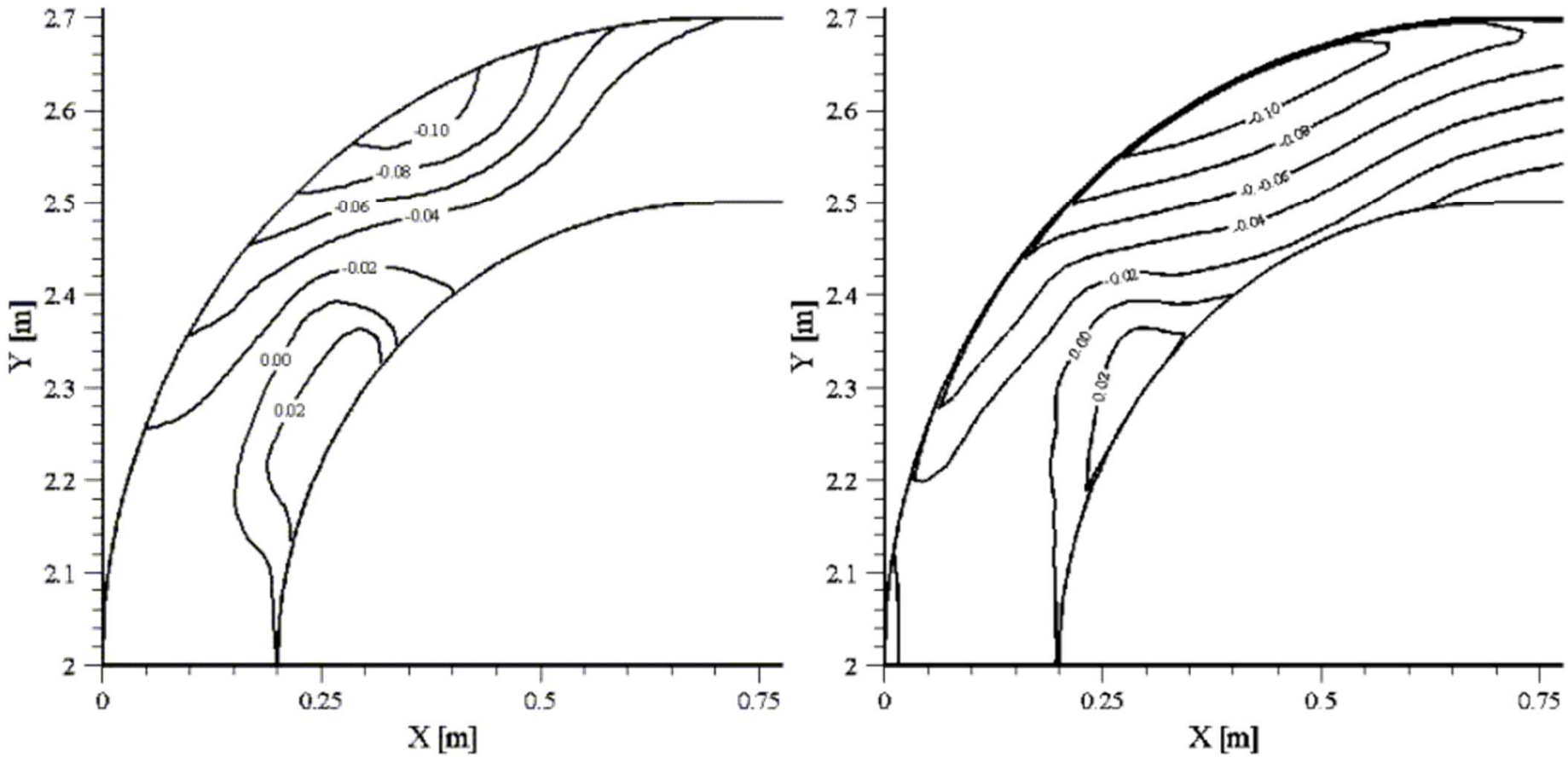
90° channel bend with non-erodable sides

Numerical model results



90° channel bend with non-erodable sides

Numerical model results



90° channel bend with non-erodable sides

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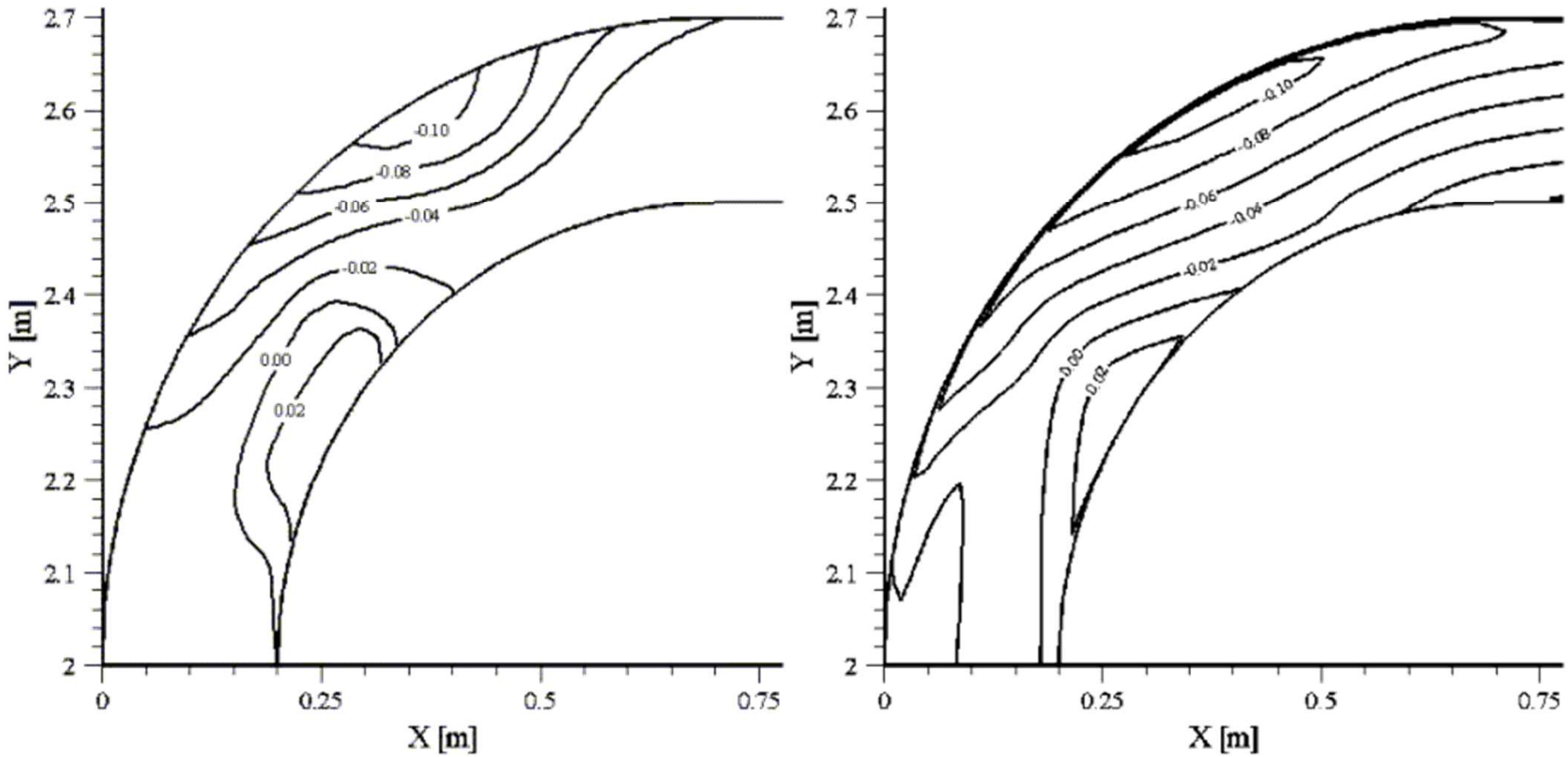
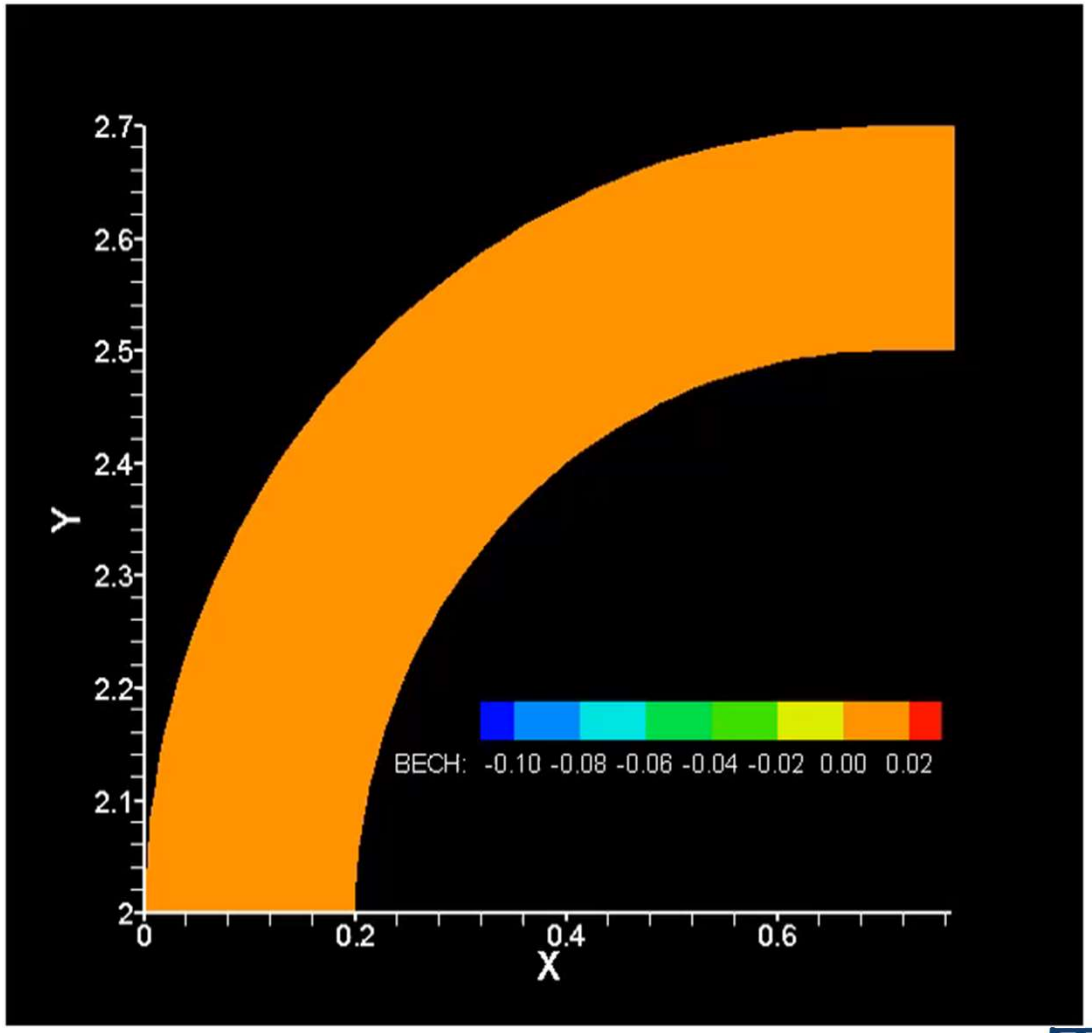


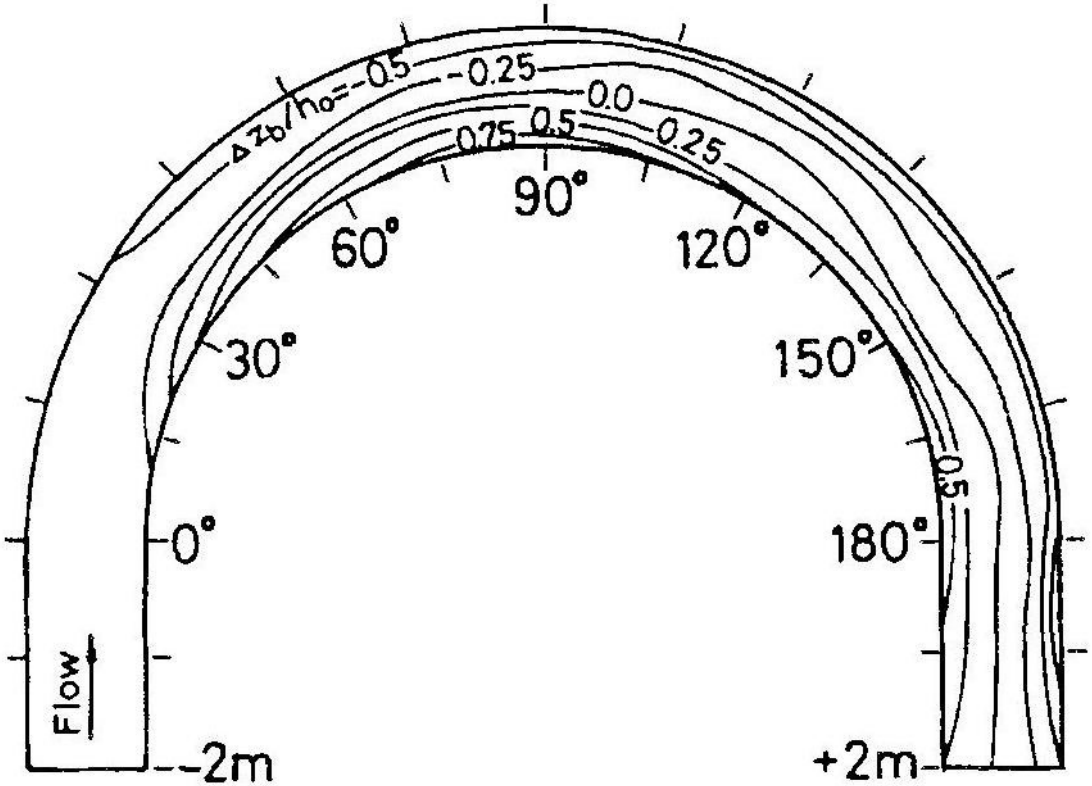
90° channel bend with non-erodable sides

Numerical model results



180° channel bend with non-erodable sides

Setup of the physical model



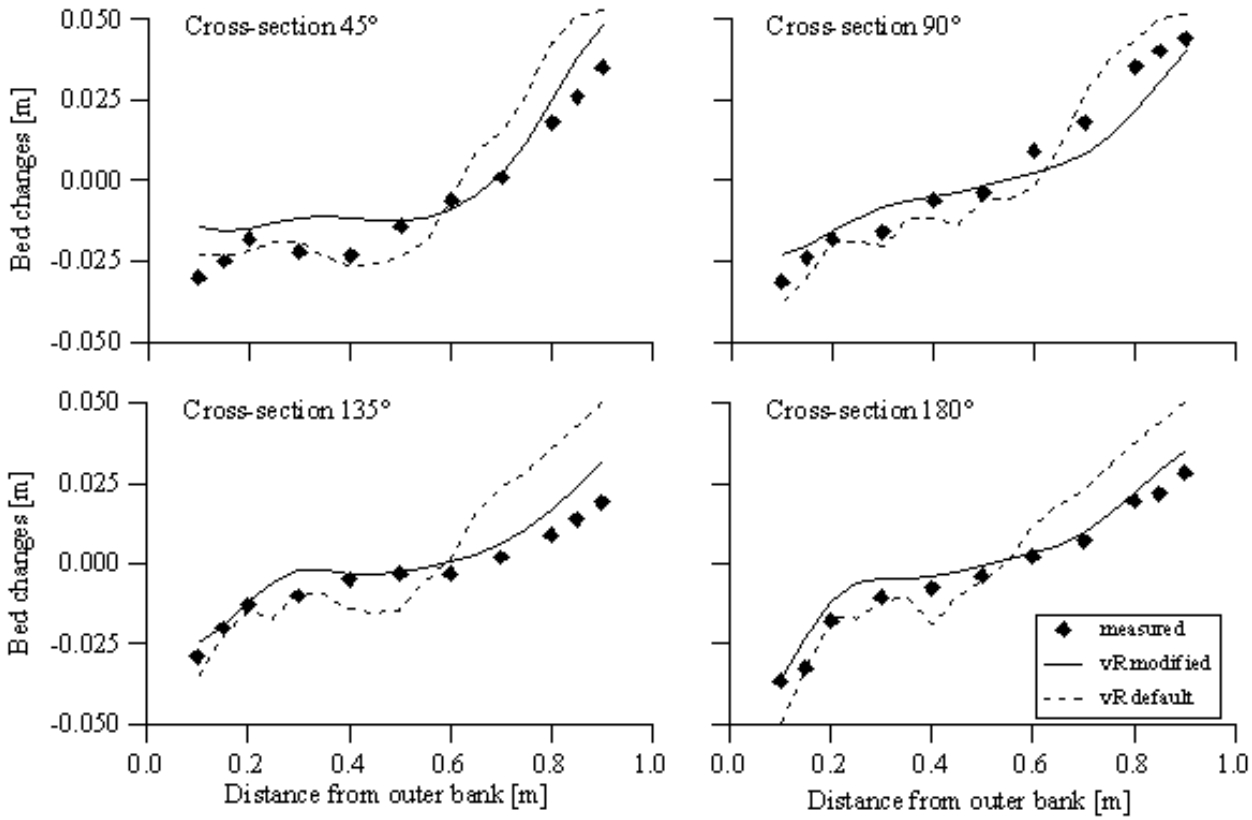
Geometry and hydraulic setup

Bend angle :	180°
Flume width *B*:	1.0m
Radius of curvature:	4.0m
Flume length *L*:	29.3m (6.3m)
Discharge *Q*:	20 – 56l/s
Width/ depth B/h_{av}:	9.7 – 18.9
Initial slope S:	0.002
Running time T:	300 min

Experimental setup by Yen & Lee, 1995

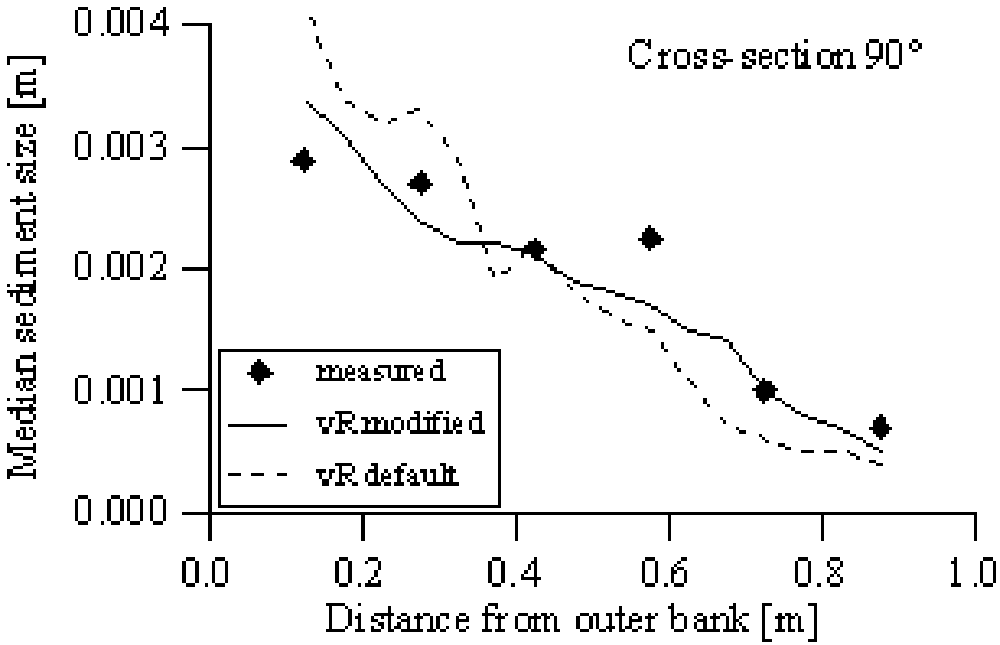
180° channel bend with non-erodable sides

Numerical model results



180° channel bend with non-erodable sides

Numerical model results



180° channel bend with non-erodable sides

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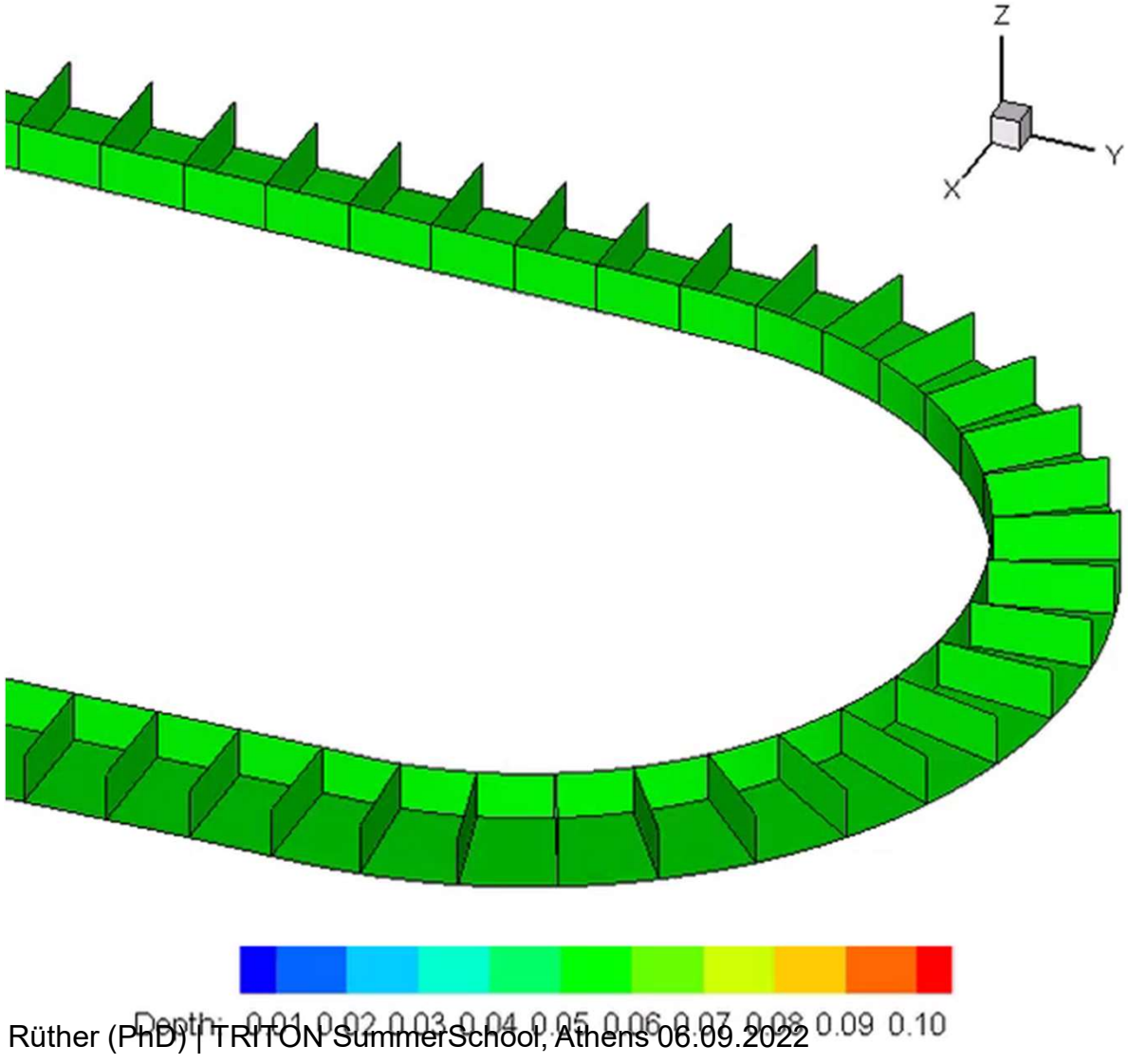

180° channel bend with non-erodable sides

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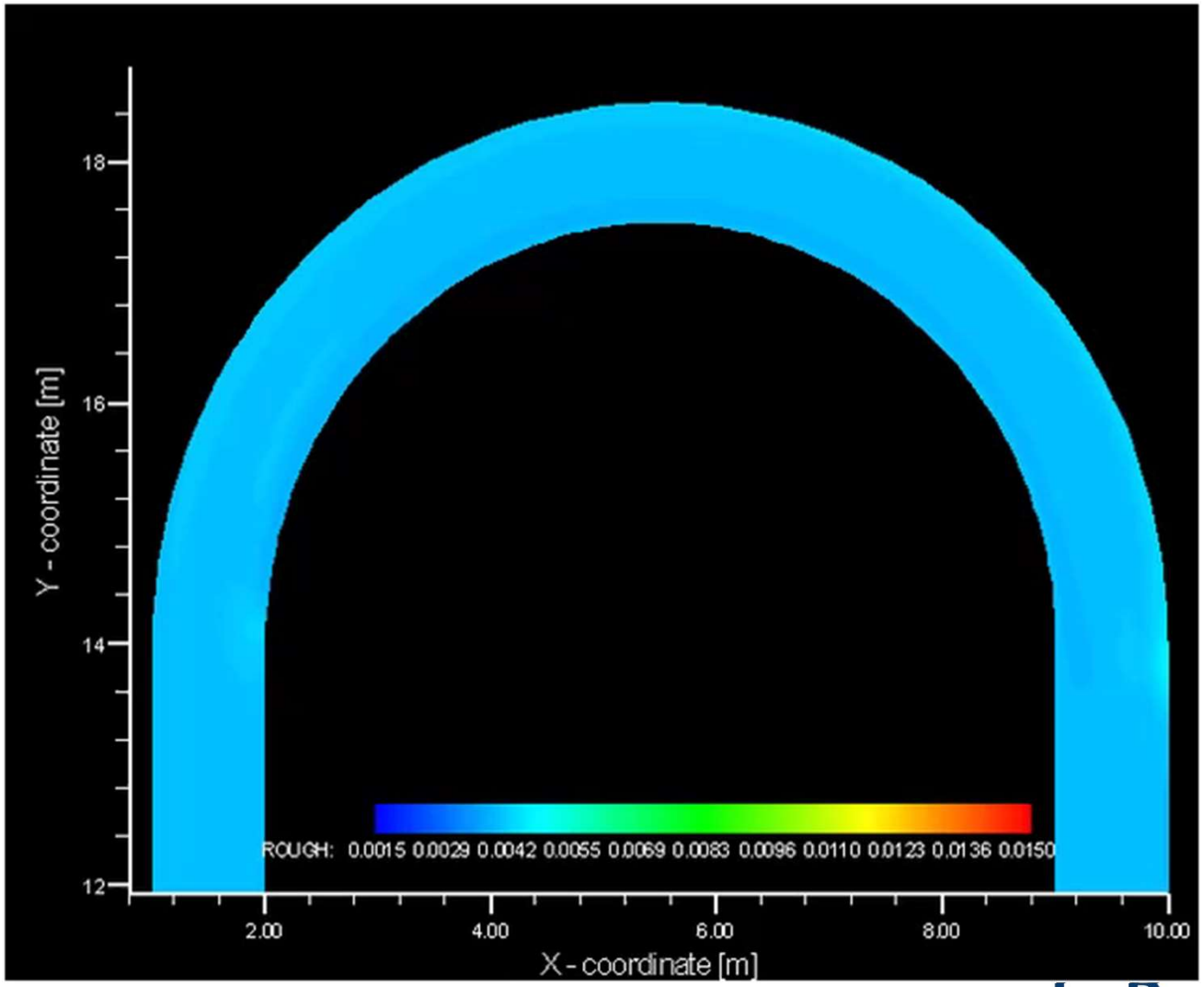
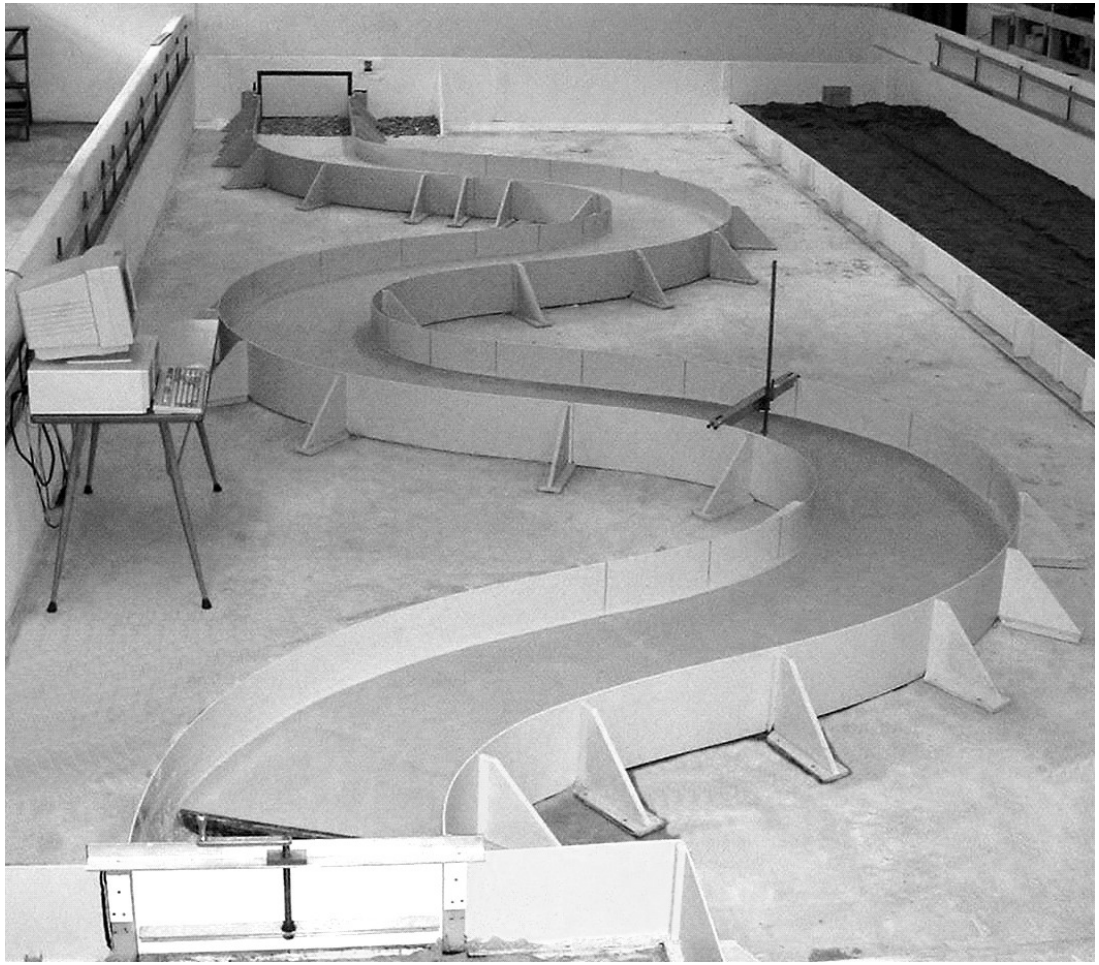


Meandering channel with non-erodable sides

Setup of the physical model



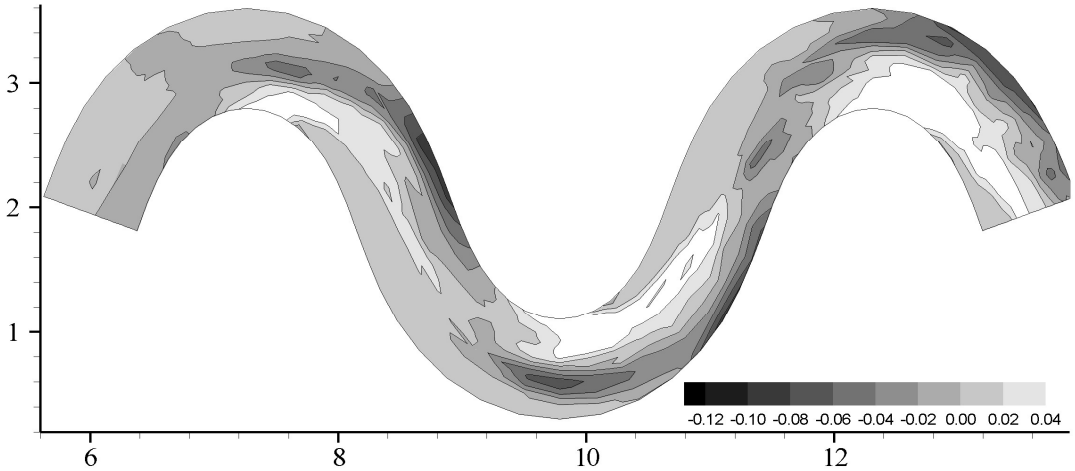
Geometry and hydraulic setup

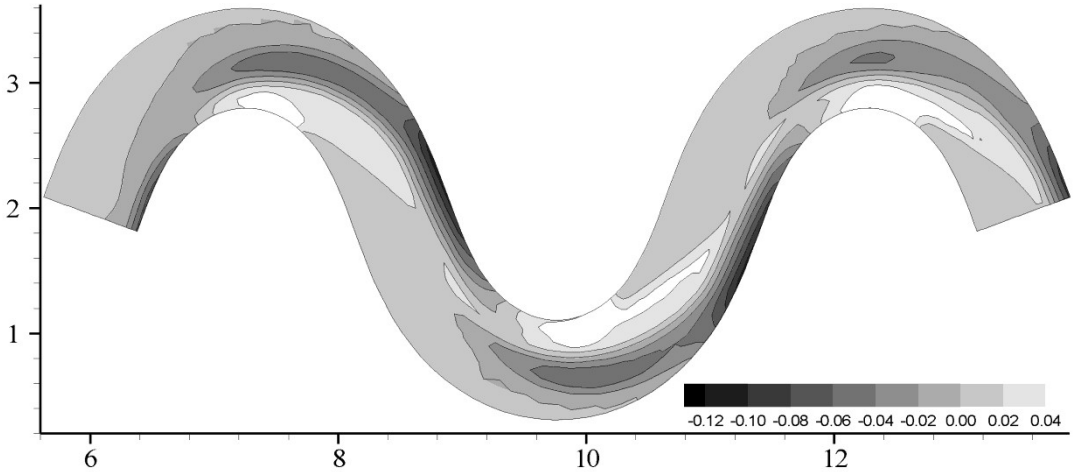
Deflection angle Θ:	70°
Flume width B:	0.8m
Wavelength Λ_M:	5.03m
Flume length L:	15.23m+2m
Discharge Q:	11 / 7.6l/s
Width/ depth B/h_{av}:	10.67/18.18
Slope S:	0.002/0.004
Shear velocity u^*:	0.04 / 0.042
Reynolds number Re:	13750/9475
Running time T:	60 / 170 min

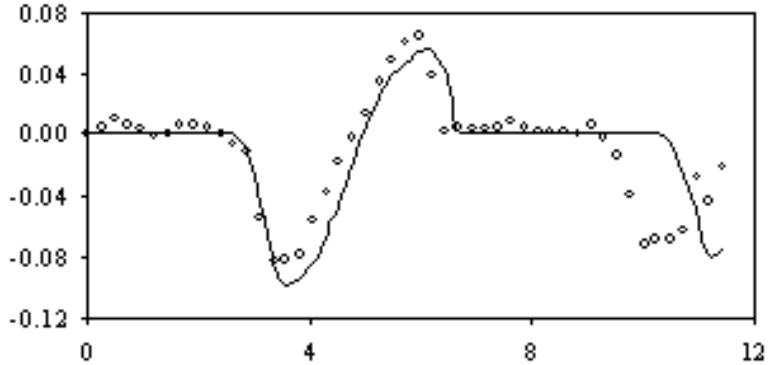
da Silva &Tarek, 2006

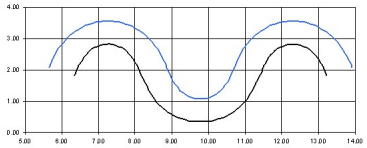
Meandering channel with non-erodable sides

Numerical model results









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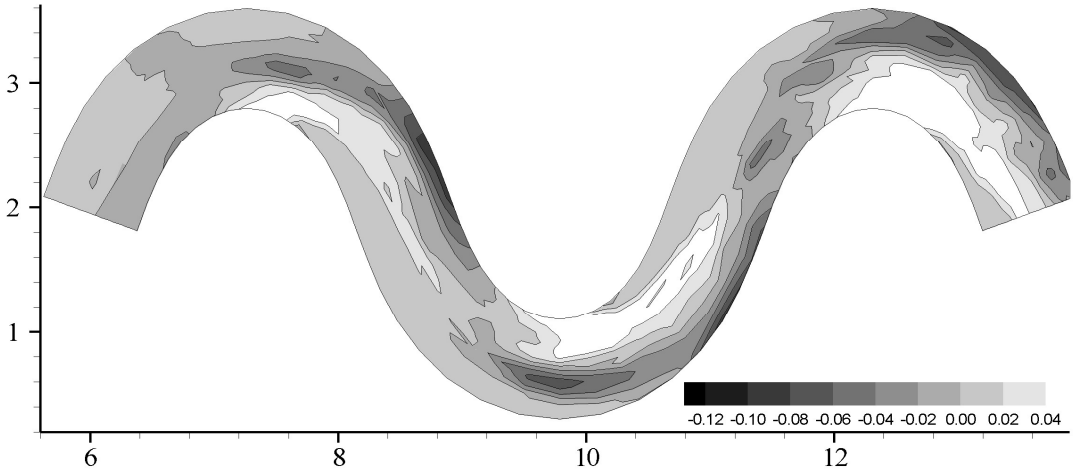

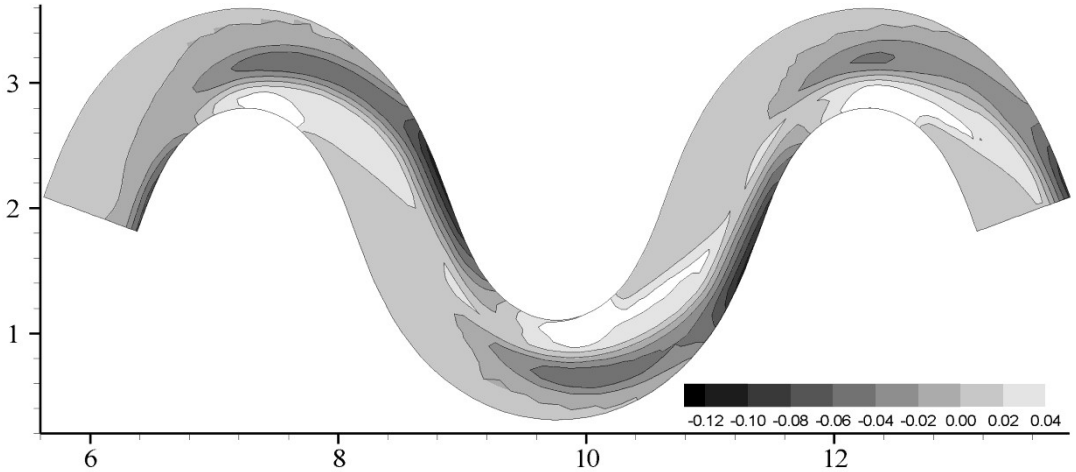

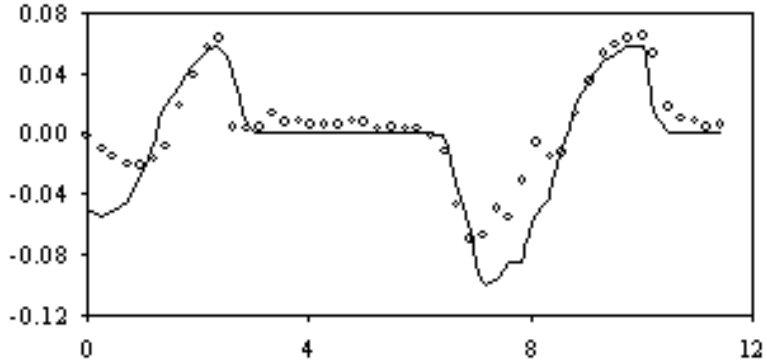

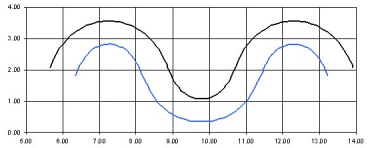

Meandering channel with non-erodable sides

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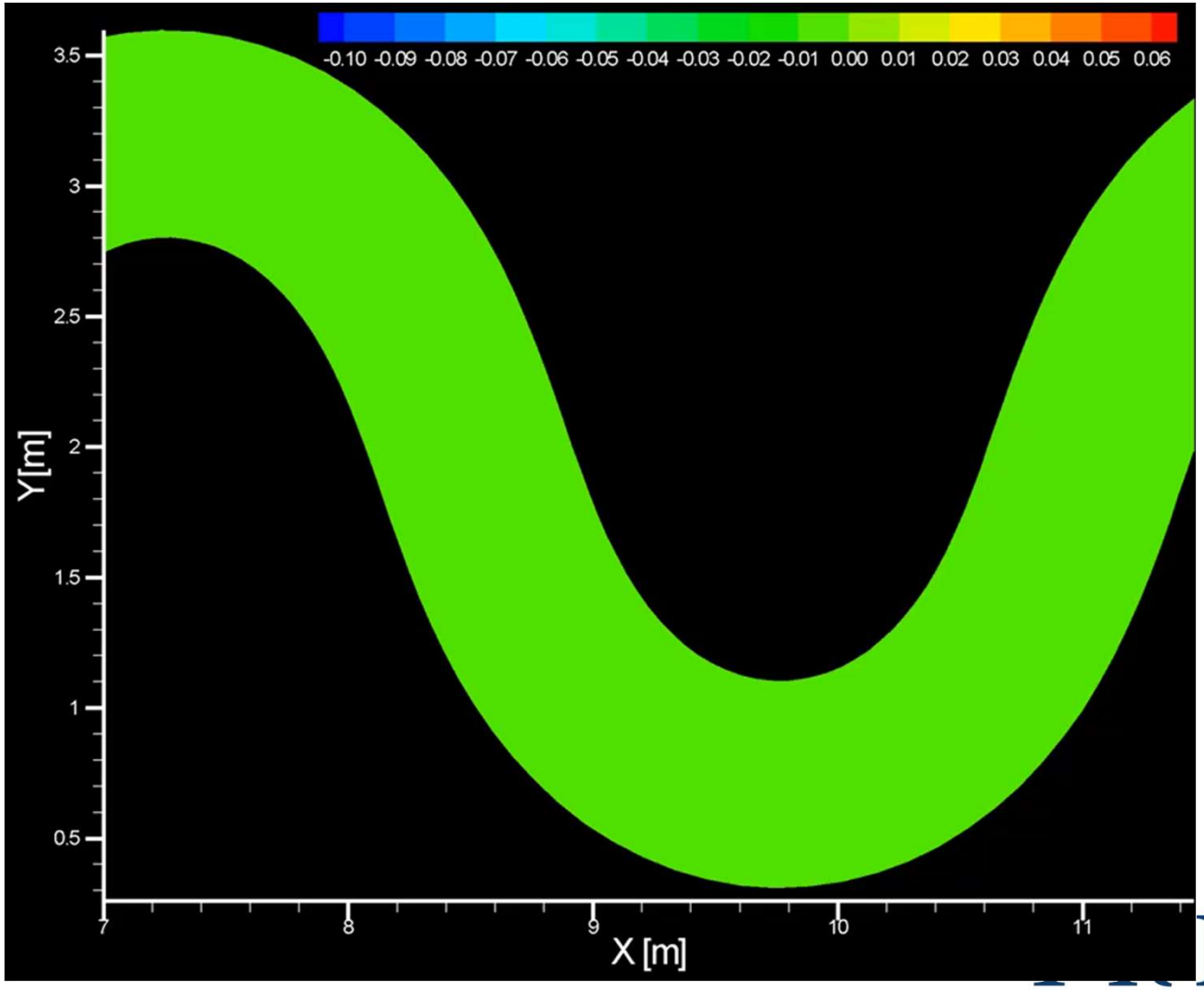
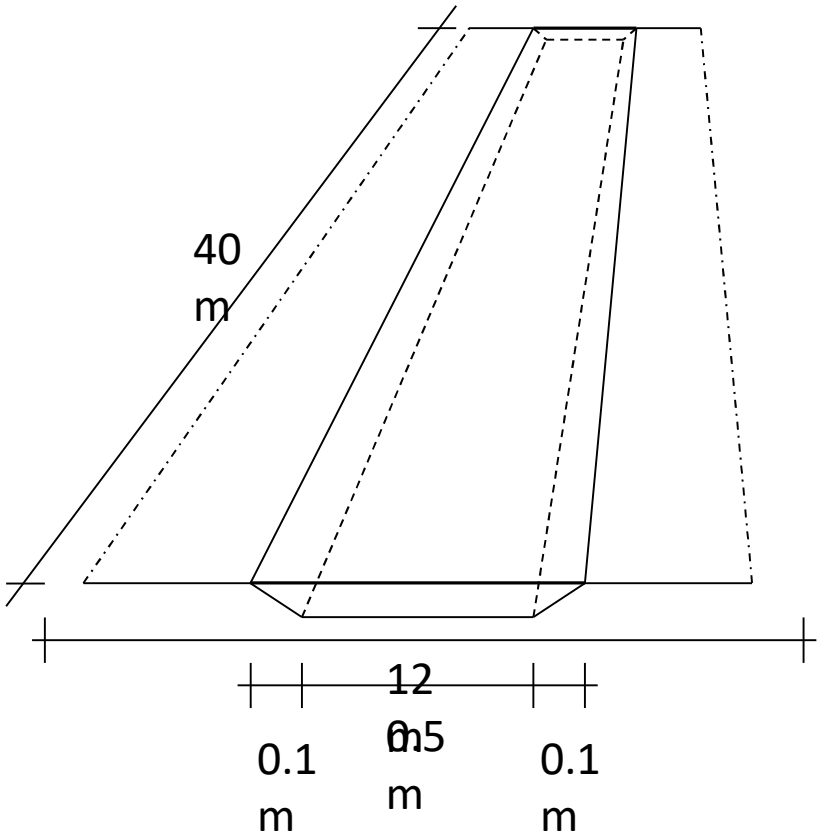


Free-forming meandering channel

Setup of the physical model



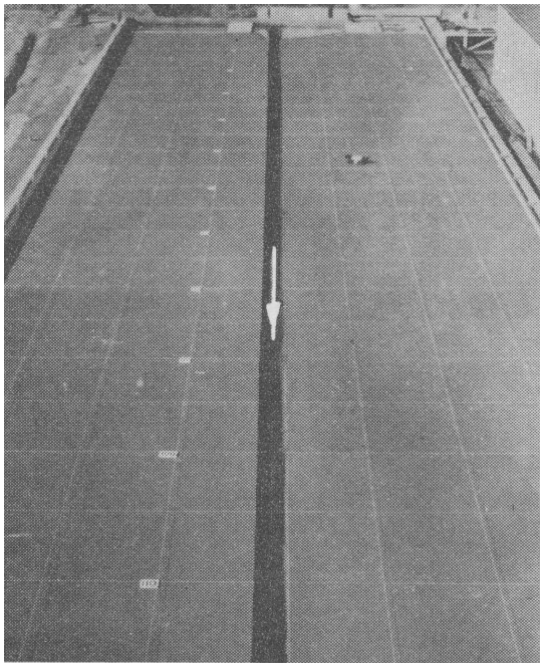
Geometry and hydraulic setup

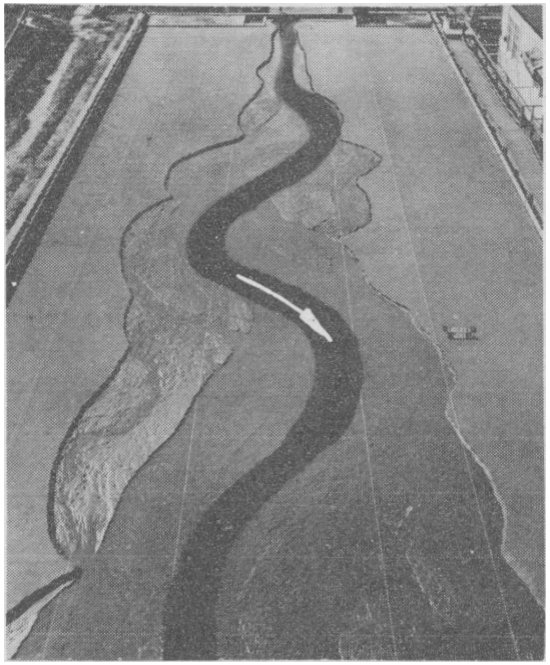
Discharge	8.5 l/s
Mean flow depth	50 mm
Mean bed slope	0.009
d_{50}	0.2 mm
Top width	0.7 m
Total length	40.0 m

Friedkin (1945)

Free-forming meandering channel

Setup of the physical model





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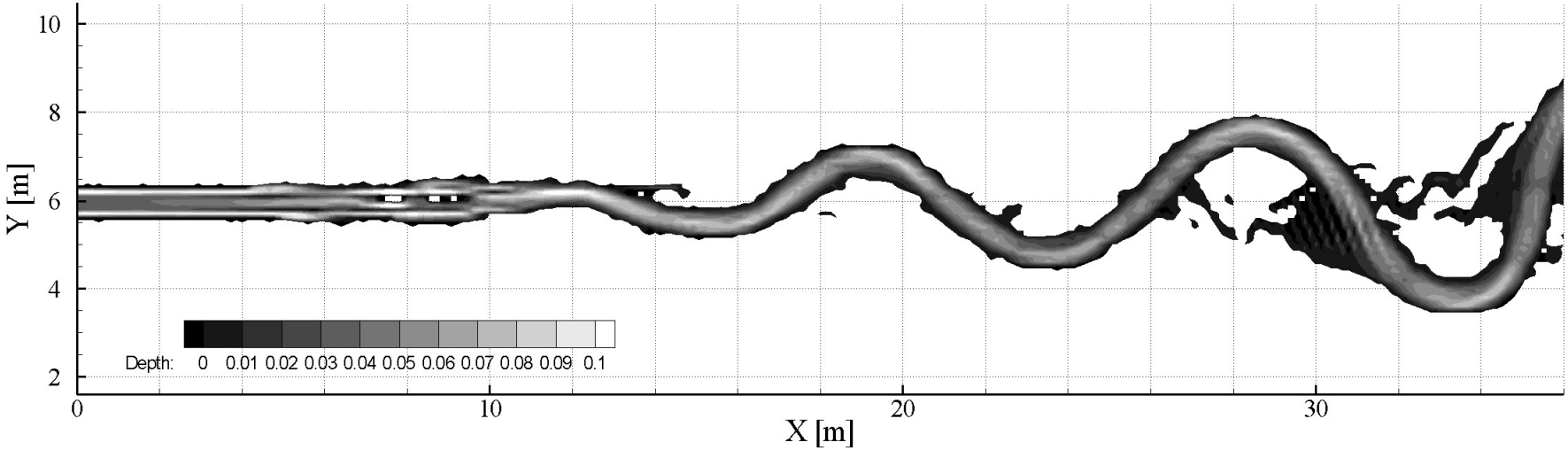

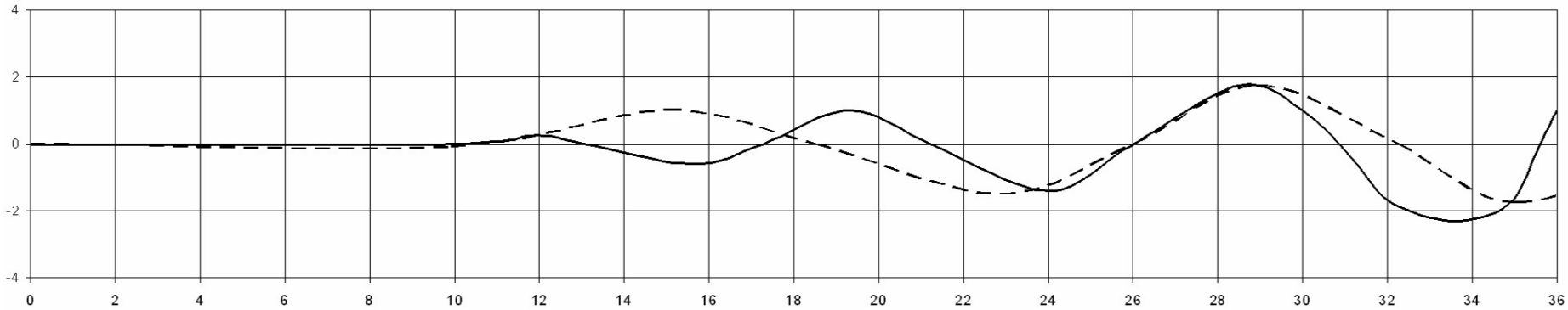

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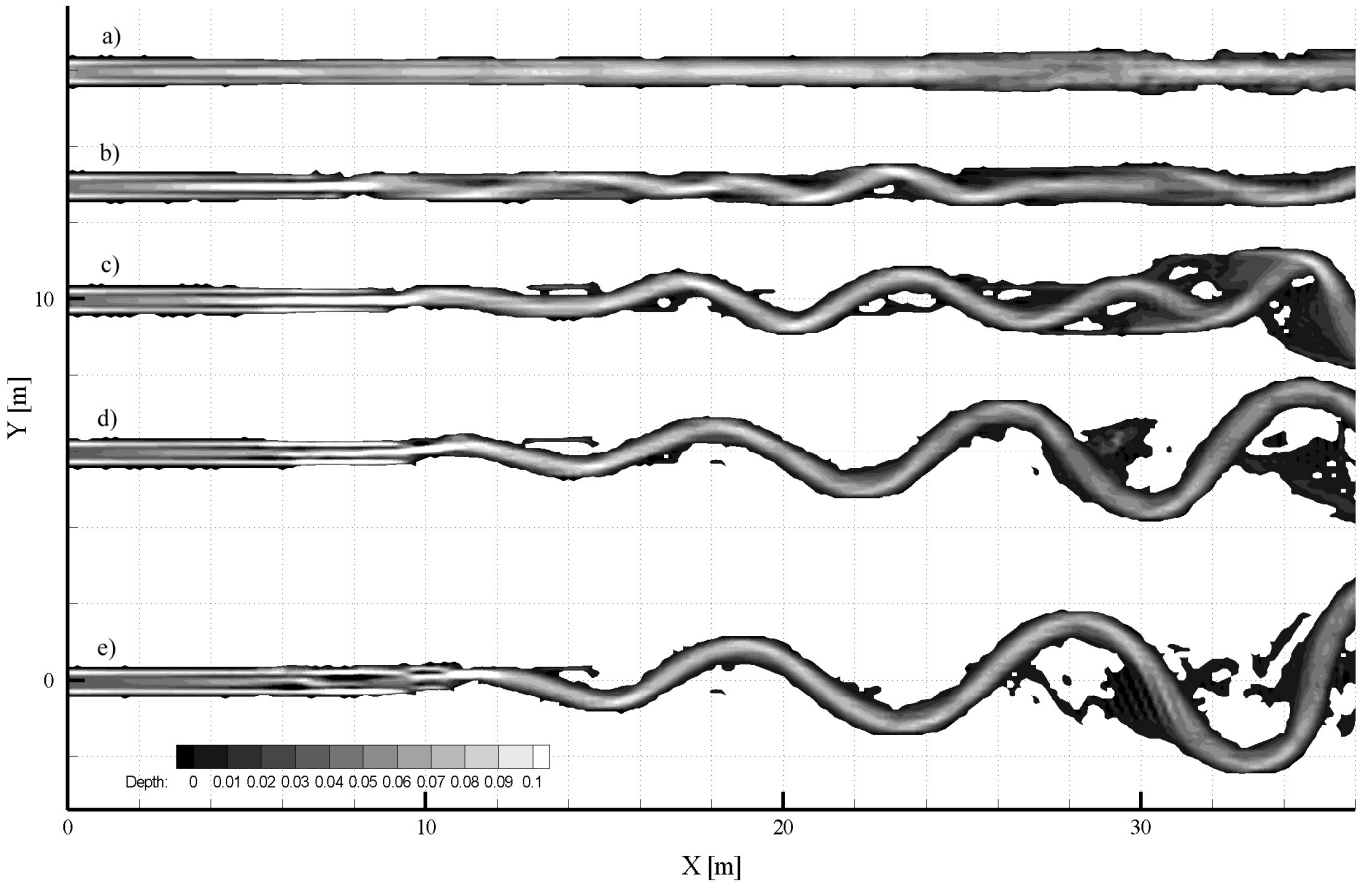
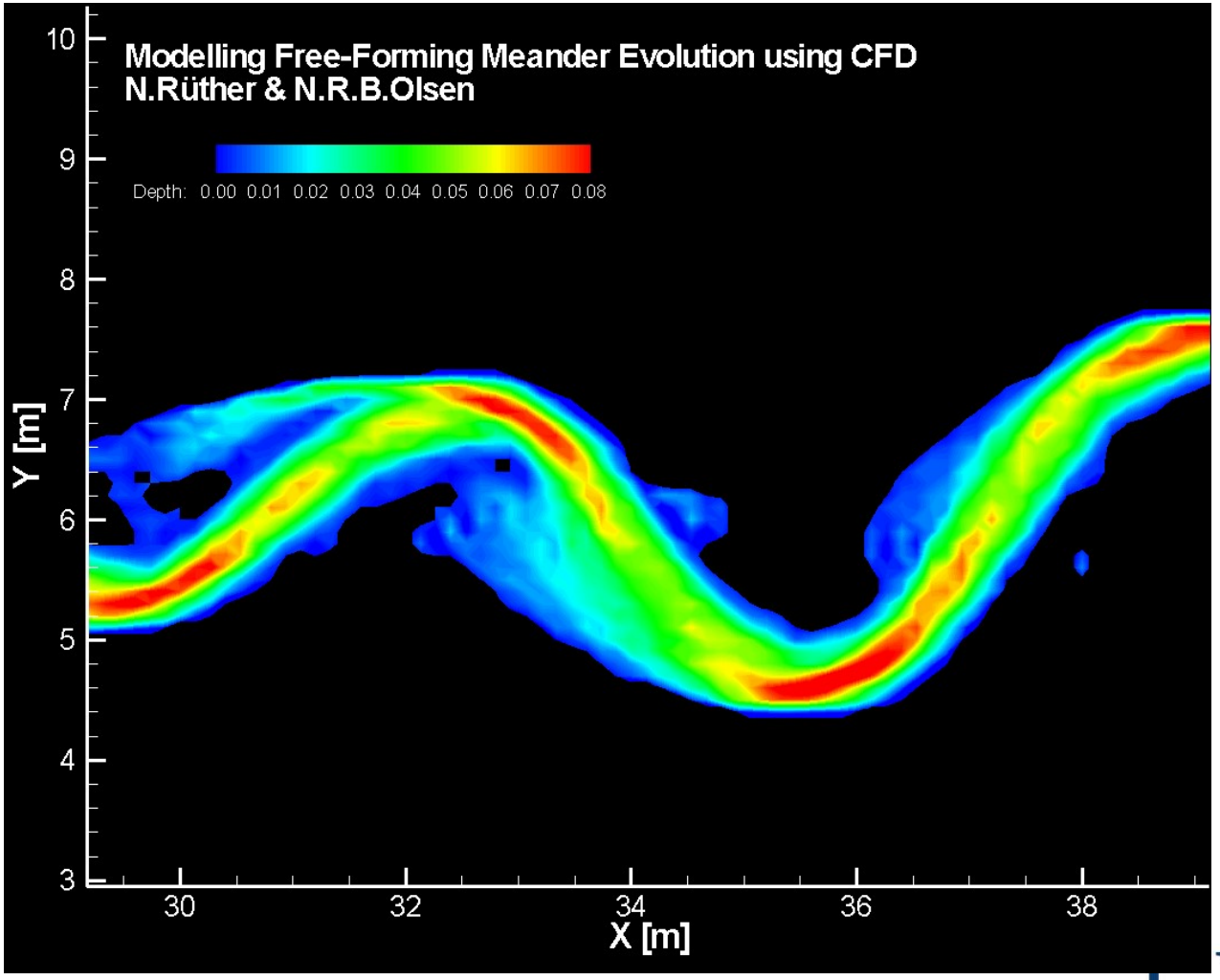


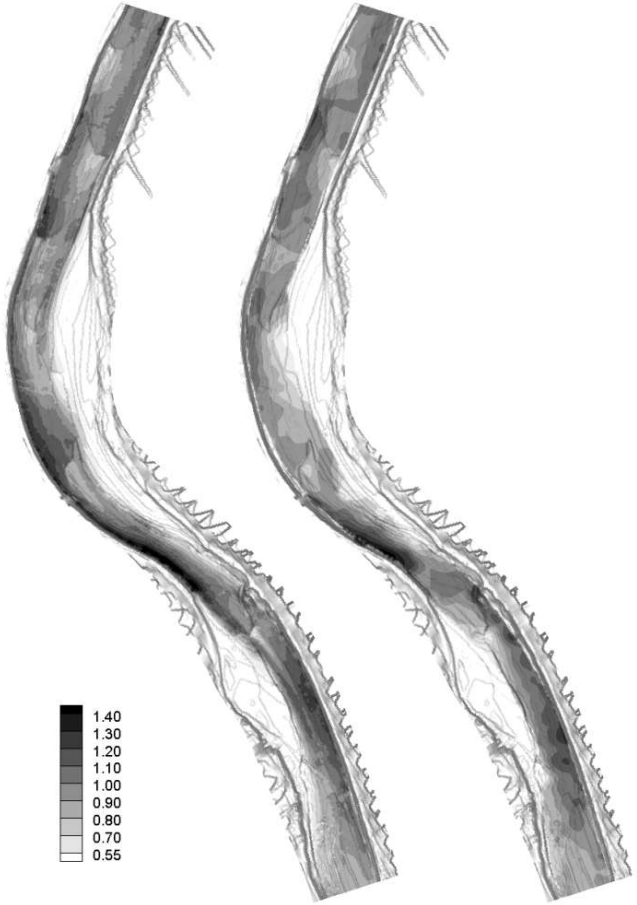
Free-forming meandering channel

Numerical model results



RIVER PO

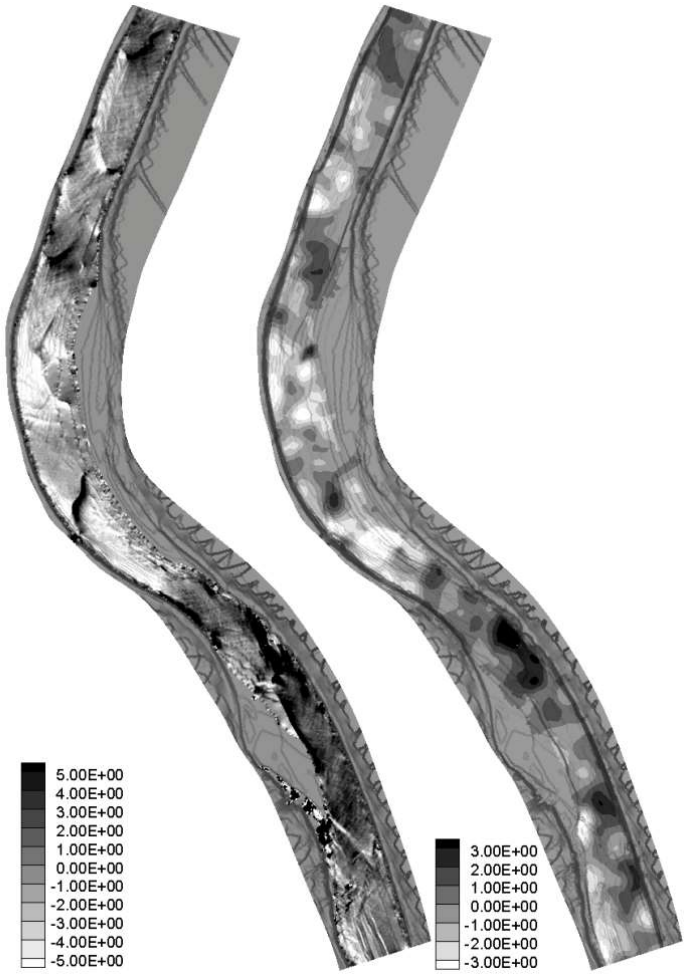
Depth-averaged velocities

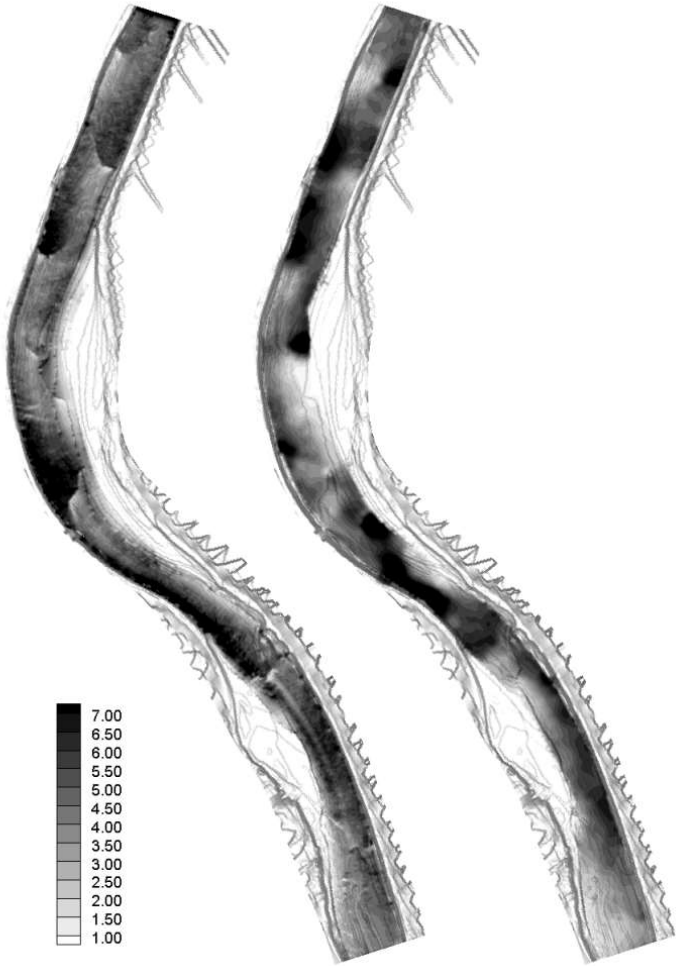


computed measured

RIVER PO

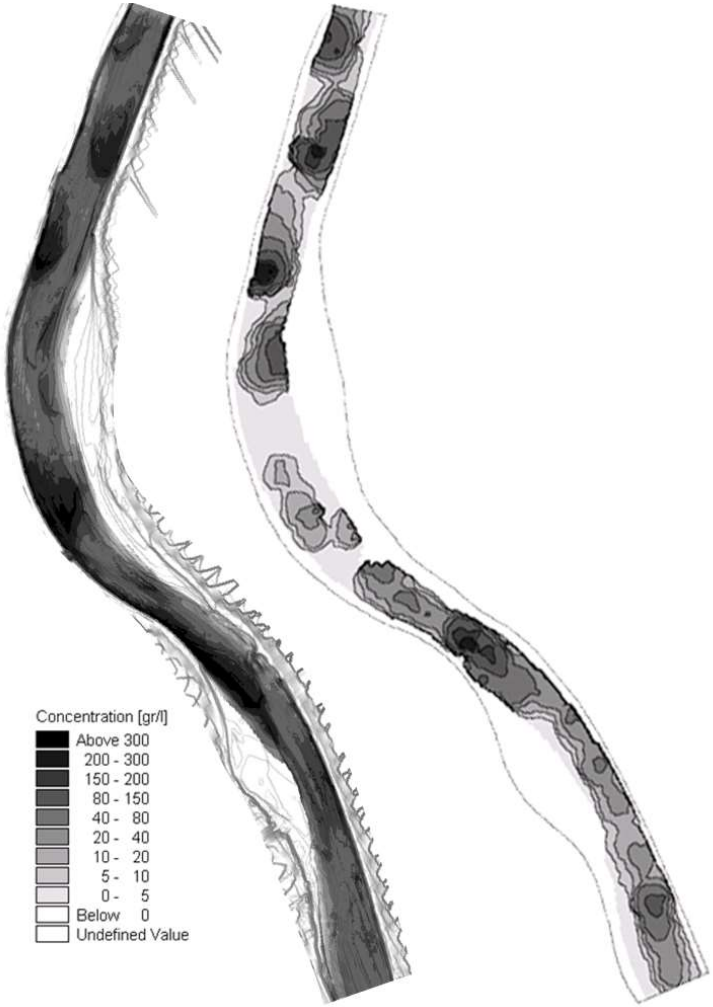
Helical flow and bed shear stress





RIVER PO

Sediment concentrations



INTERACTION: SEDIMENT TRANSPORT- VEGETATION

Foto: Fjellanger Widerøe AS ©

Delta of Lake Øyeren:

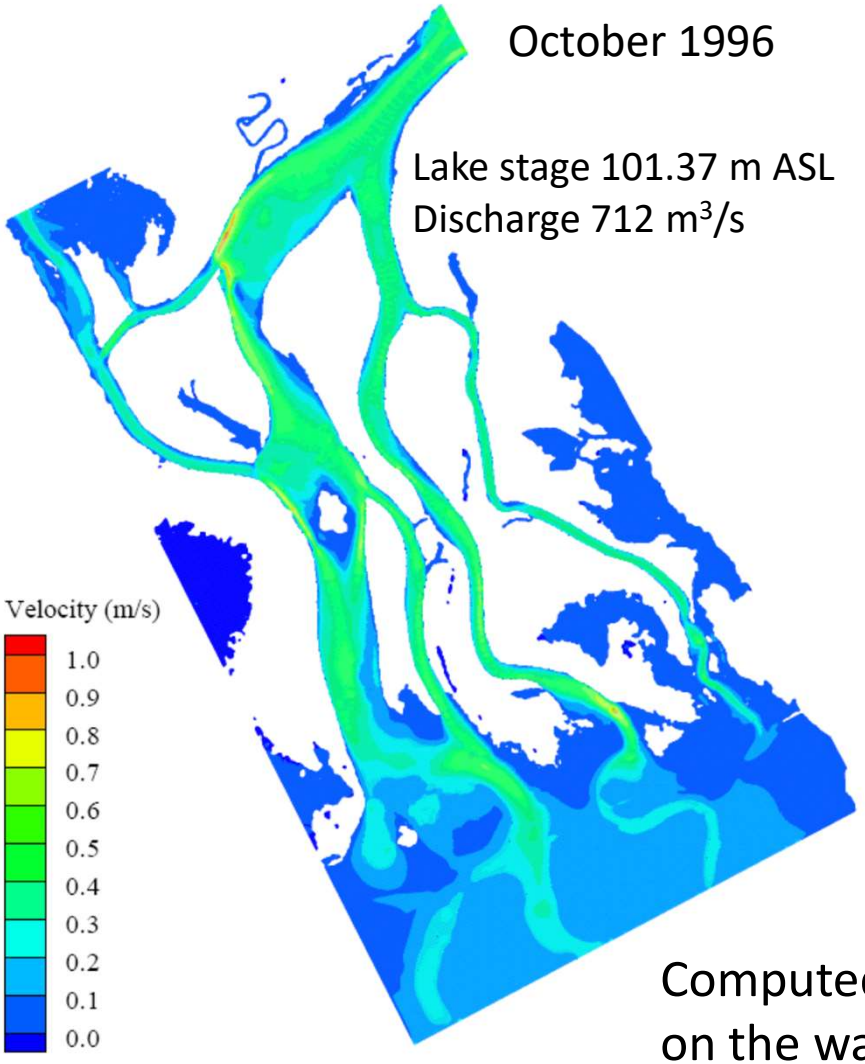
- Confluence of three rivers

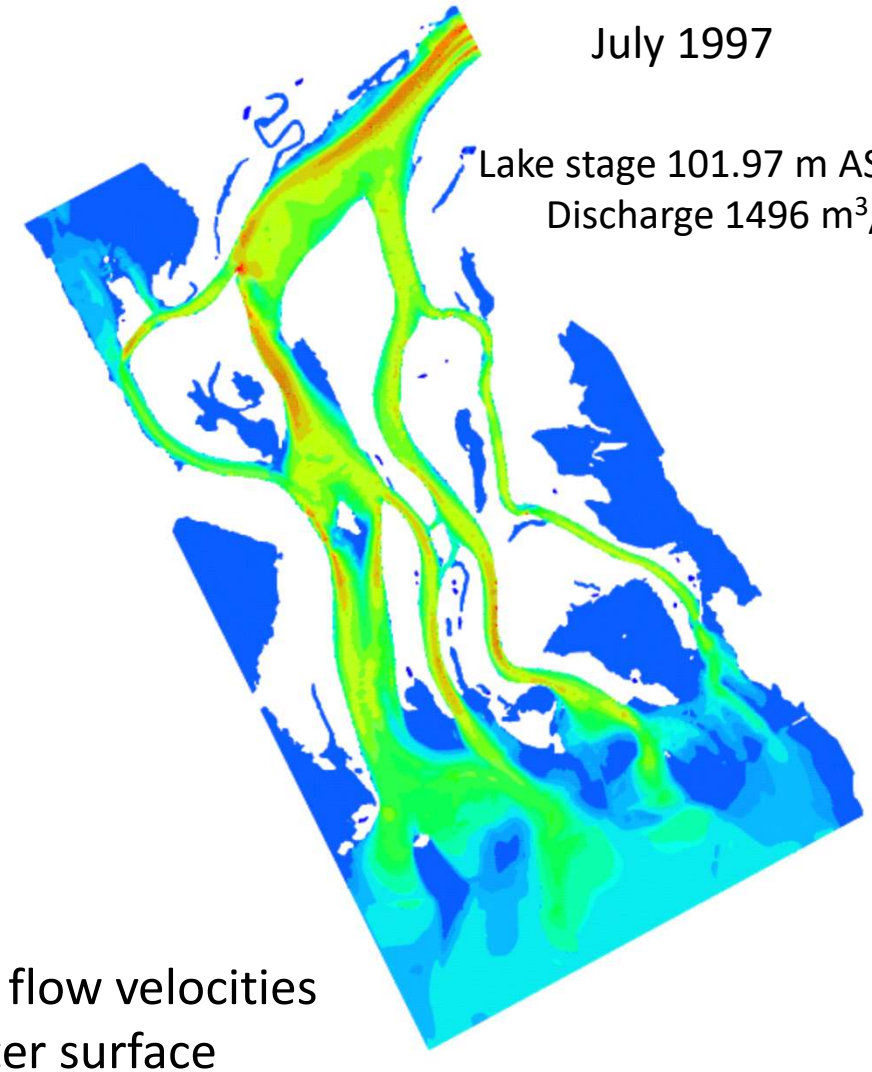
- the largest freshwater delta in Northern Europe (9 km^2)

- an important bird habitat and nature protection area,

- Located upstream of a hydro-power reservoir which influenced by water level regulations since 1860

INTERACTION: SEDIMENT TRANSPORT- VEGETATION





Computed flow velocities on the water surface

MODELLING OF ALLUVIAL ROUGHNESS

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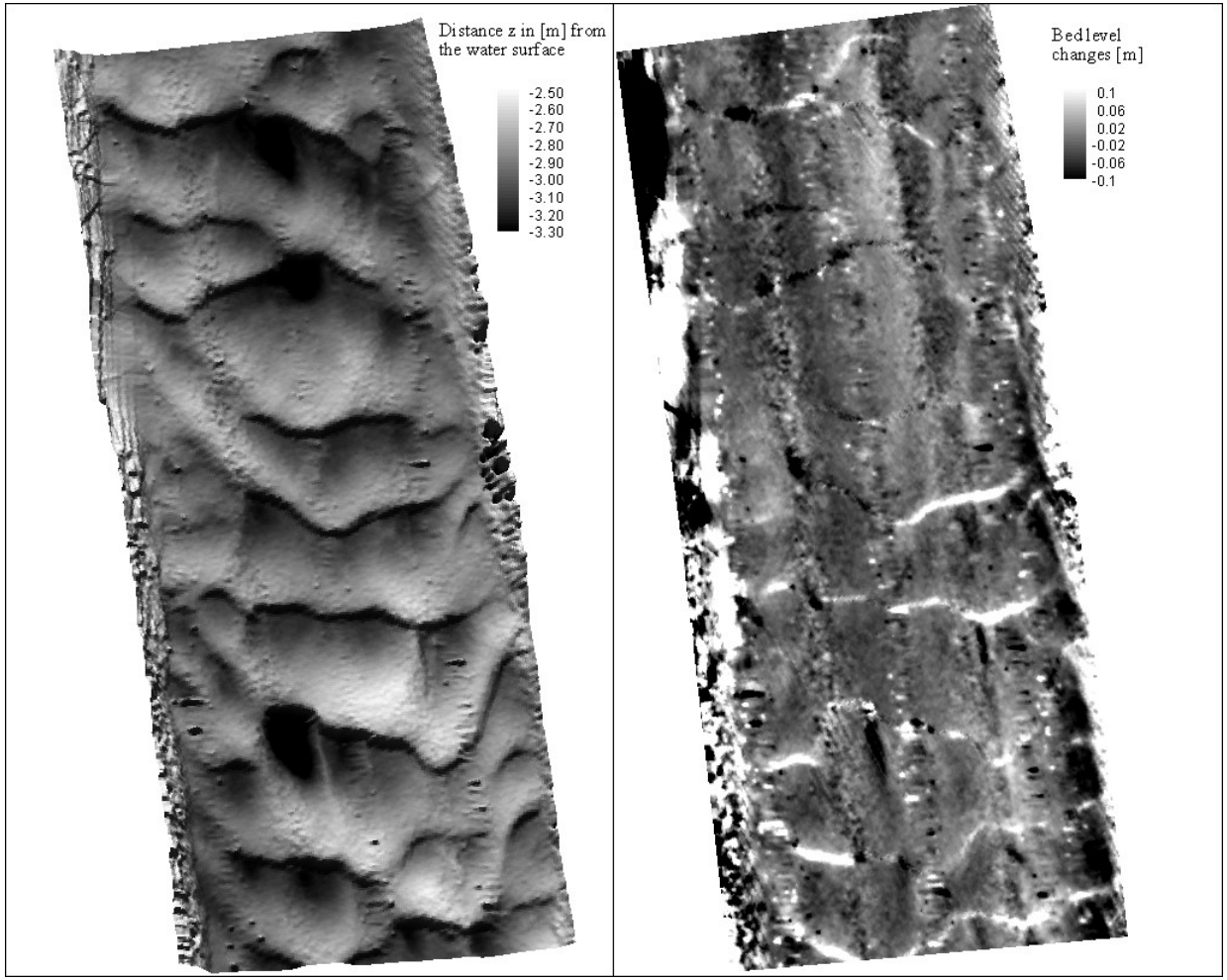


Depth measurements

Bed level changes after 24 hours

CHANNEL

Width = 40m

Length = 110m

DUNES

Height = 0.4m

Length = 9–13m

Lee angle = 9–13°

MODELLING OF ALLUVIAL ROUGHNESS

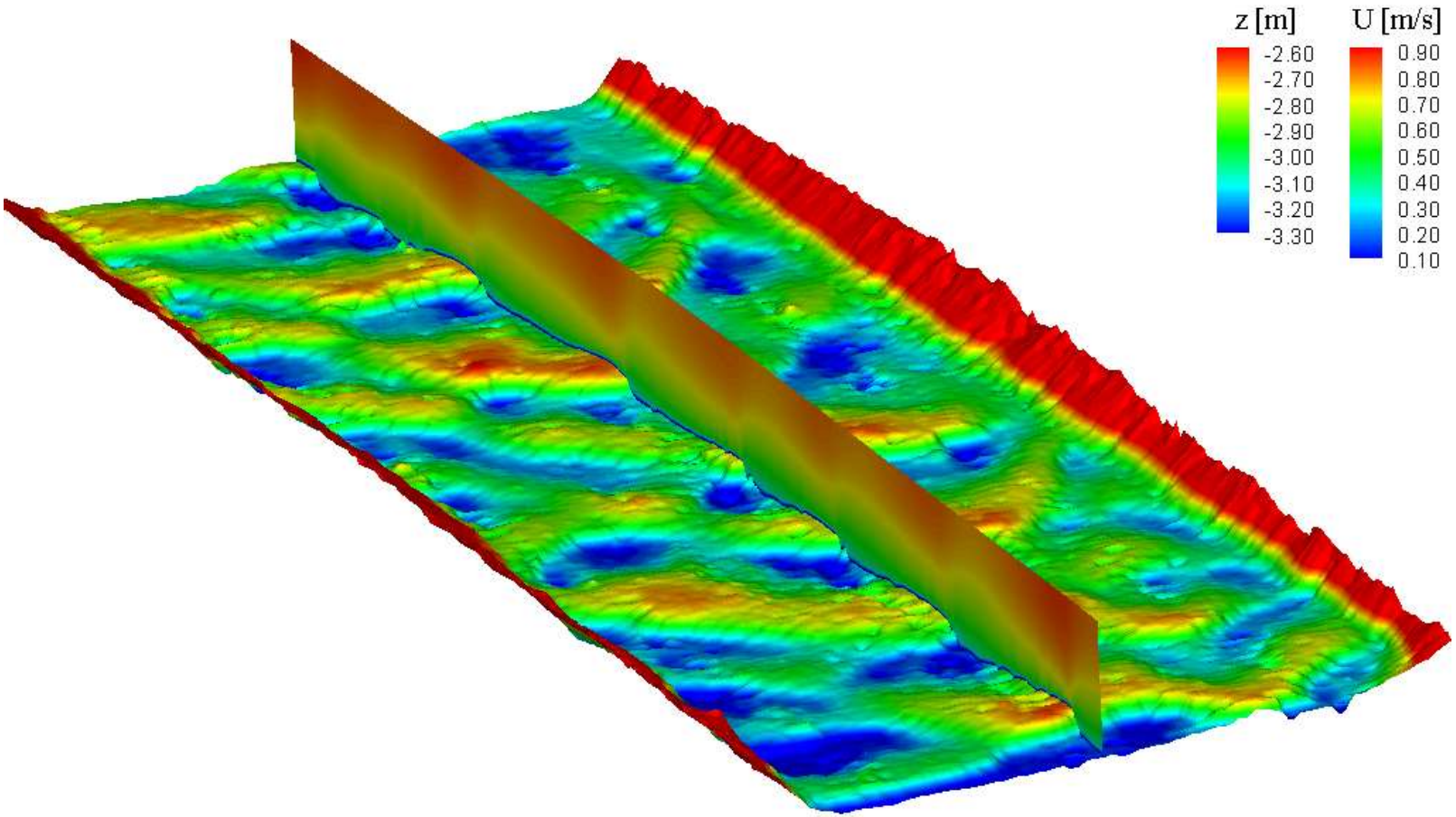
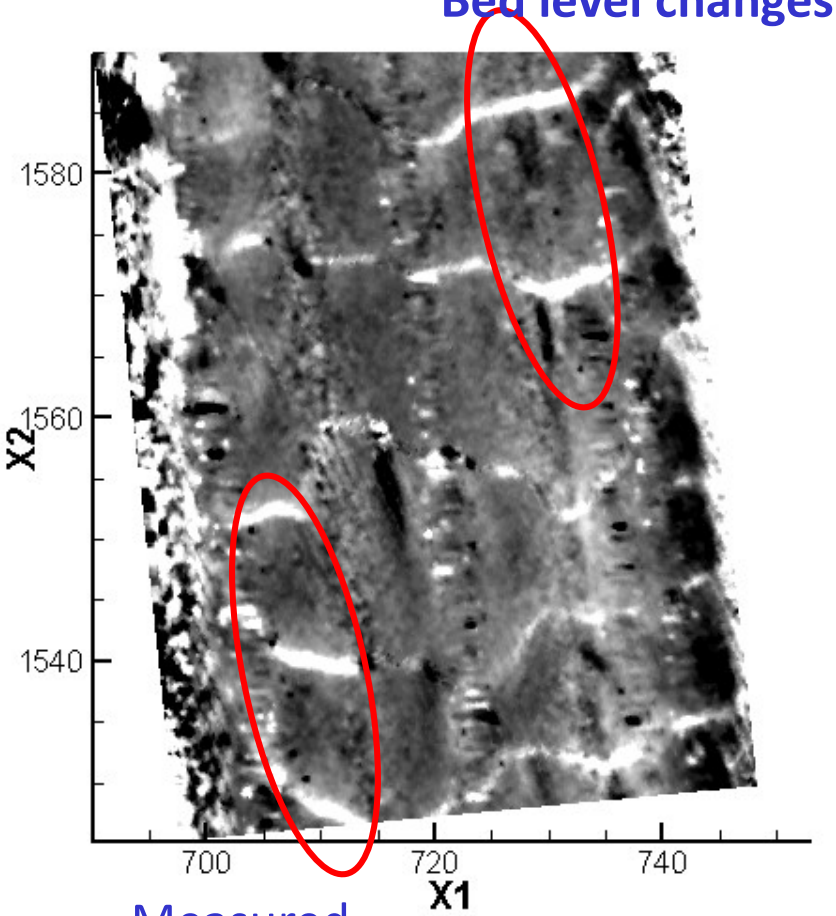


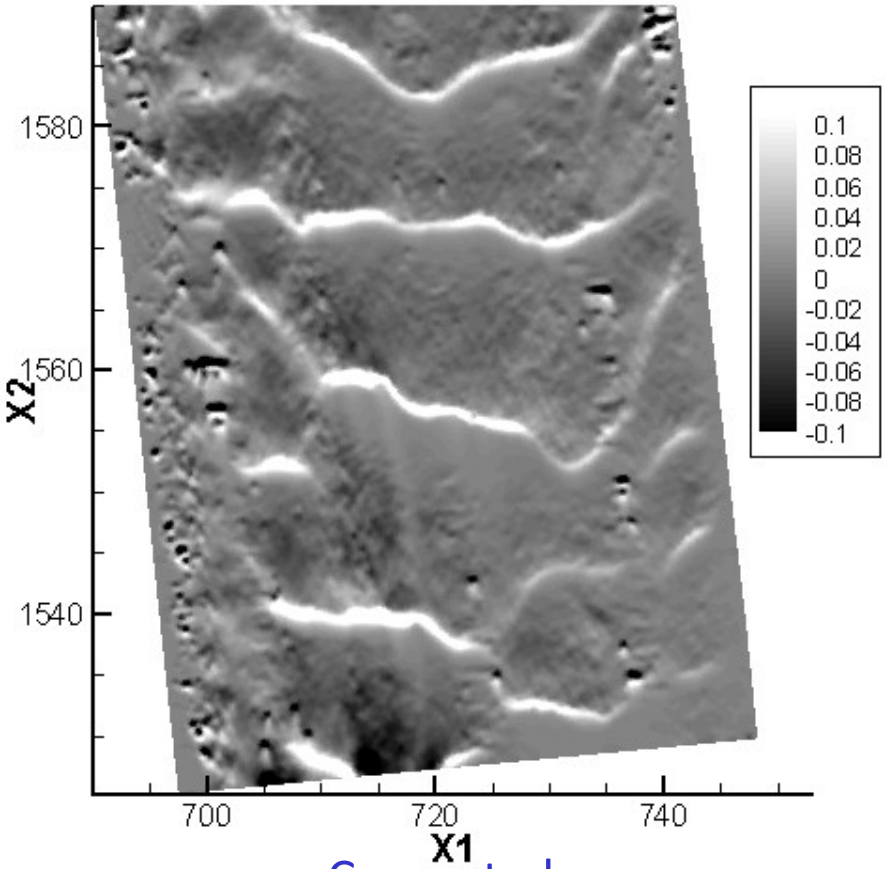
Figure 1: Bed levels z [m] of the initial geometry and a longitudinal cut of the computed velocities [m/s]

MODELLING OF ALLUVIAL ROUGHNESS

Bed level changes after 24 hours

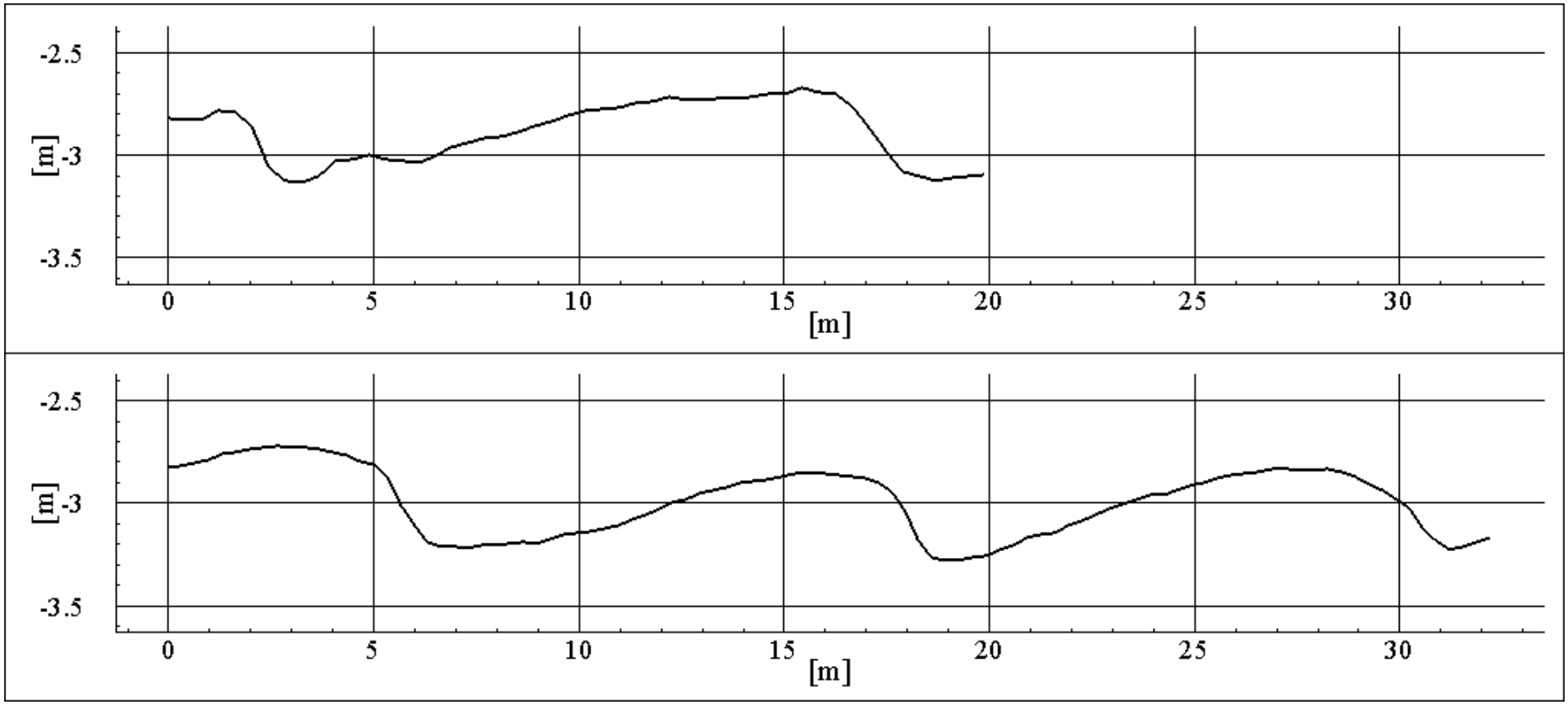


Measured



Computed

MODELLING OF ALLUVIAL ROUGHNESS



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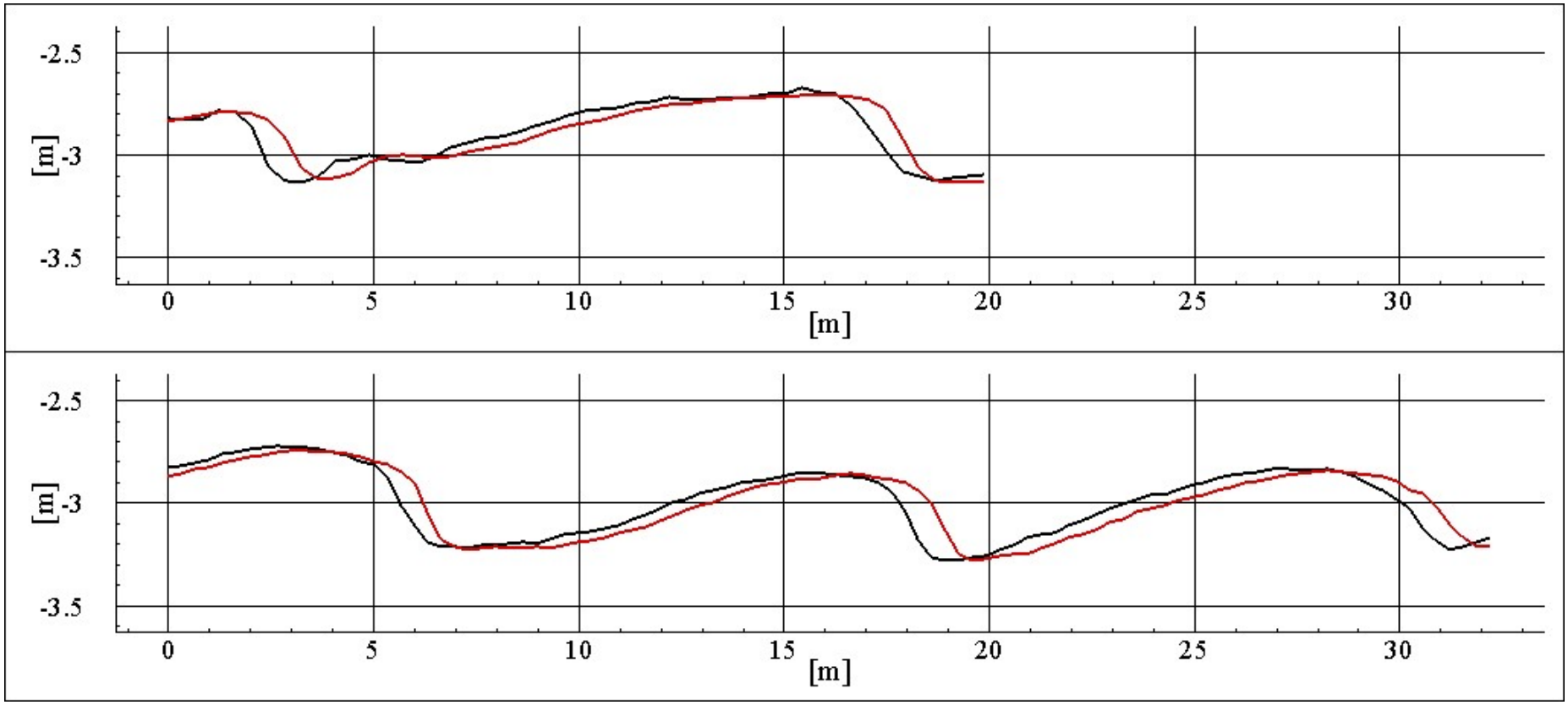

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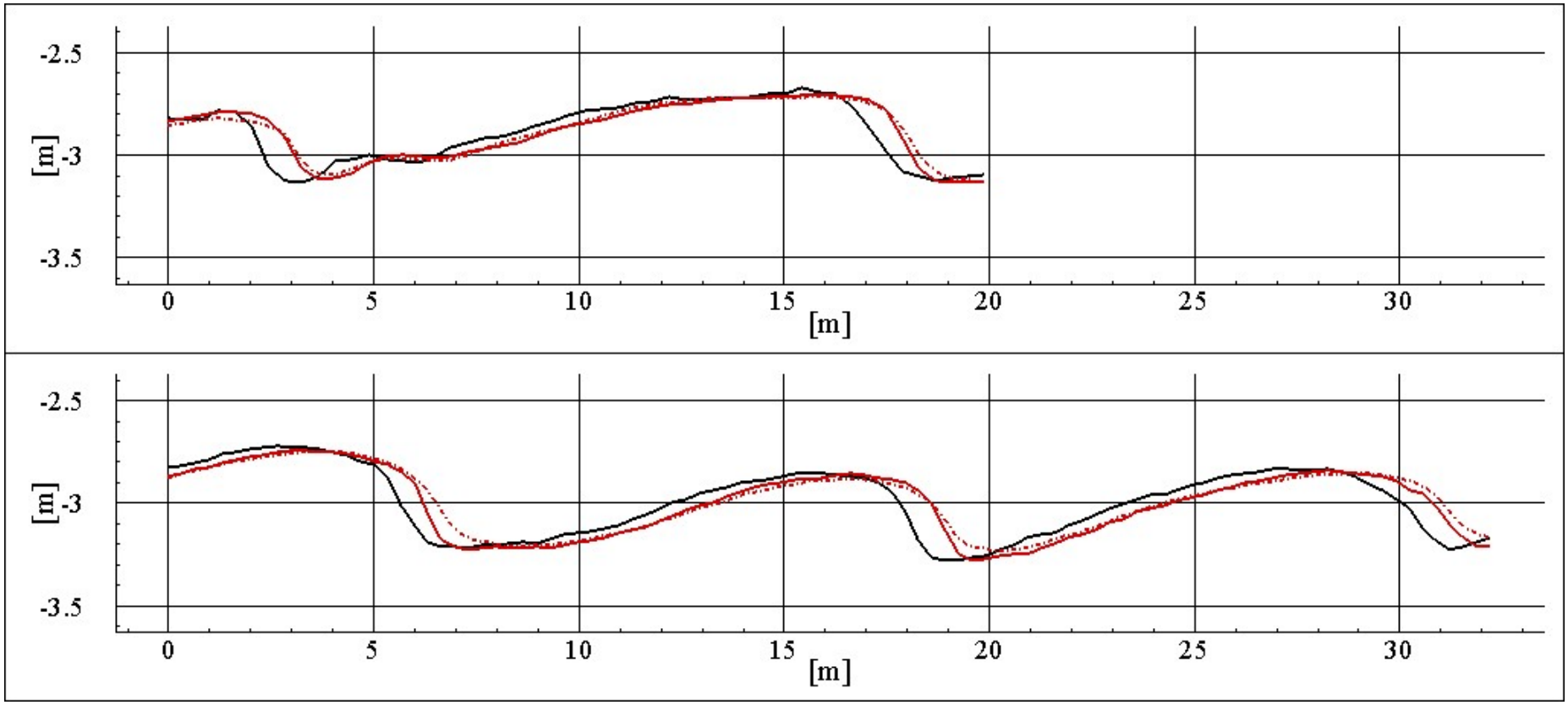
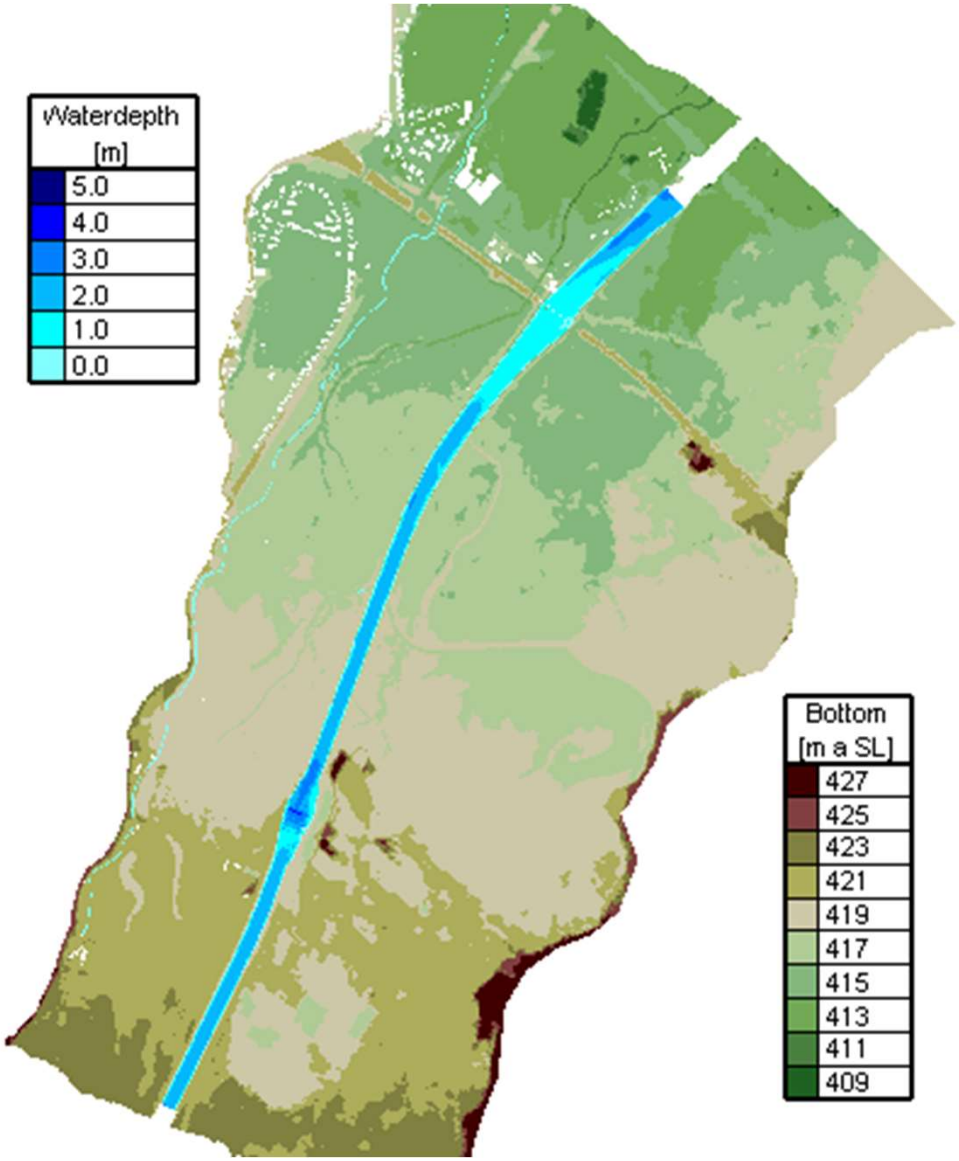
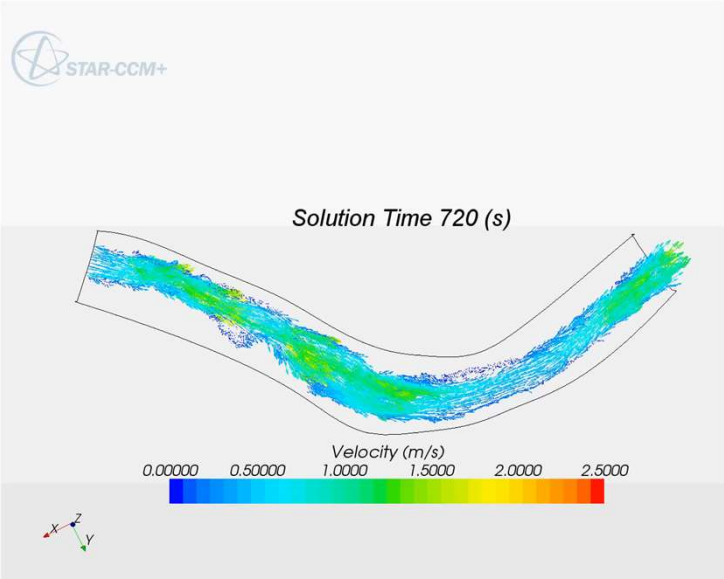


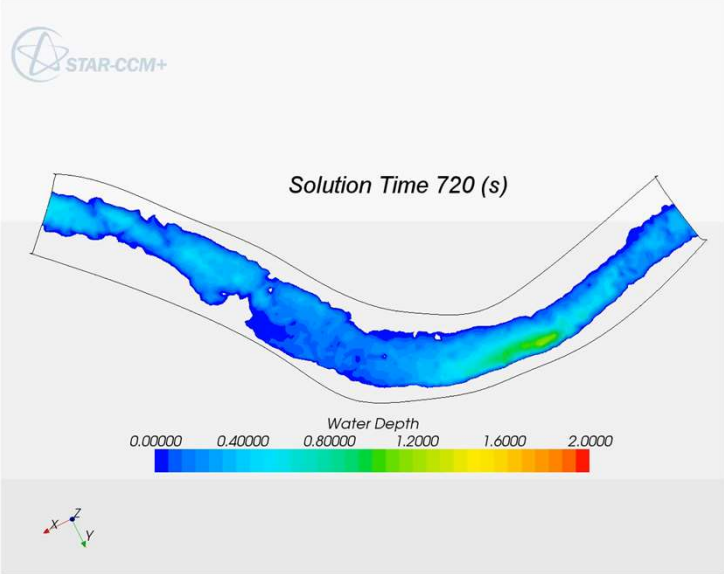
MODELLING MORPHODYNAMIC RESPONSE OF FLOOD EVENTS

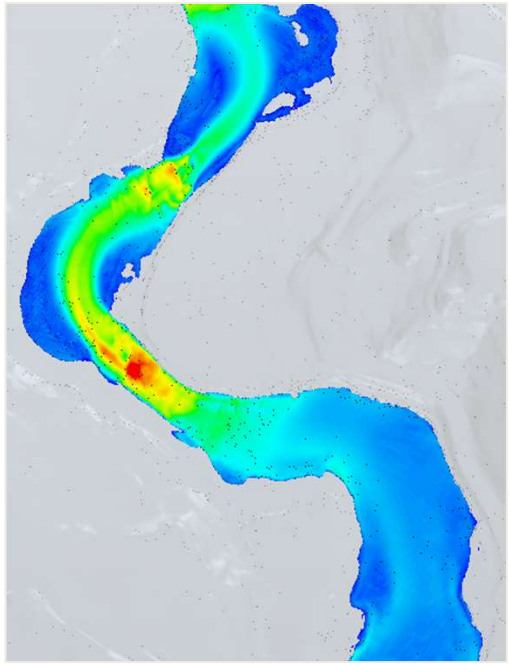


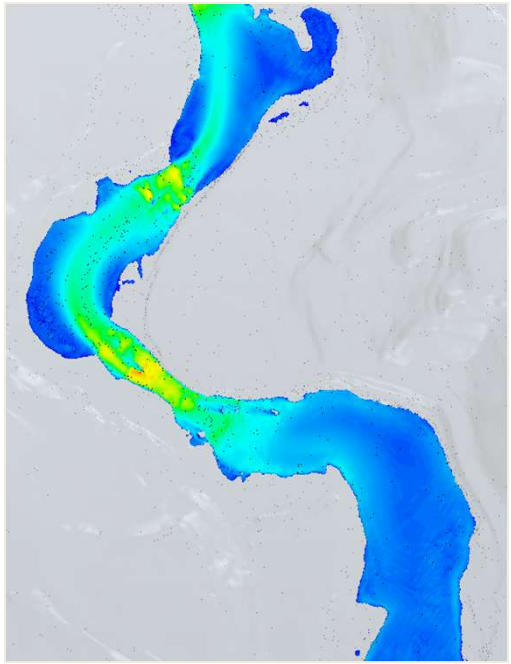
Water depth at the river Inn during a flood event. 2D-shallow water equation.

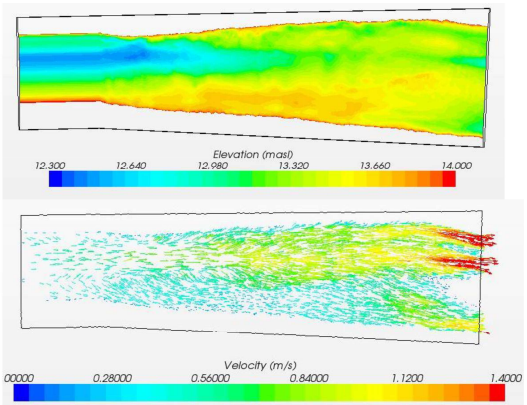
MODELLING OF HYDRO PEAKING





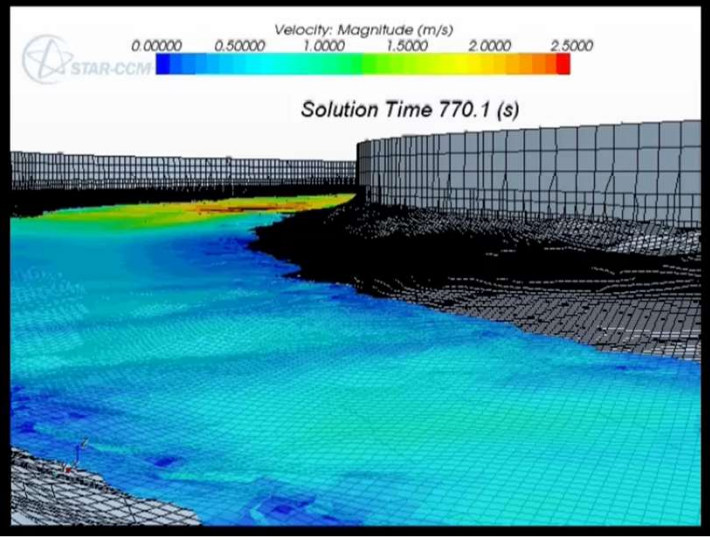




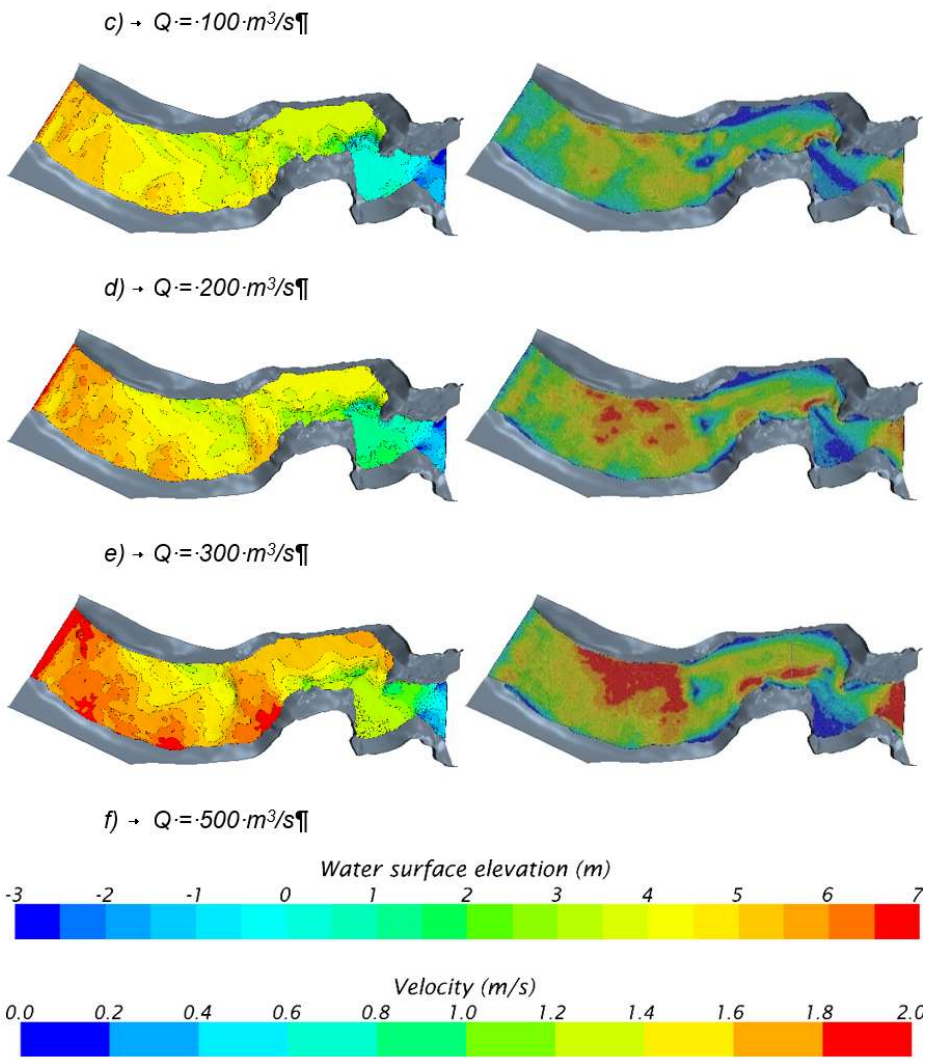


Hydro Peaking: Highly unsteady flow in river reaches with very few water else.

MODELLING OF HYDRO PEAKING

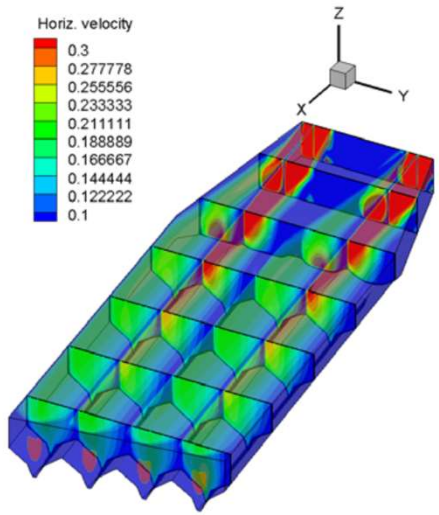


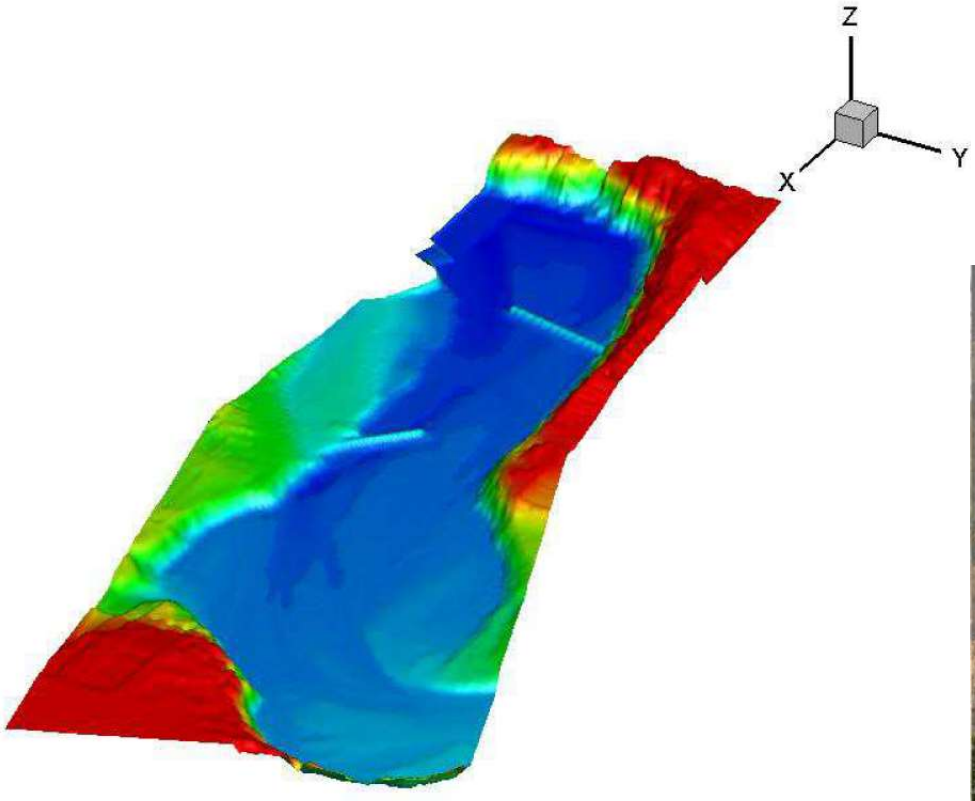
MODELLING OF GAUGING STATIONS



MODELLING OF HEAD WORKS

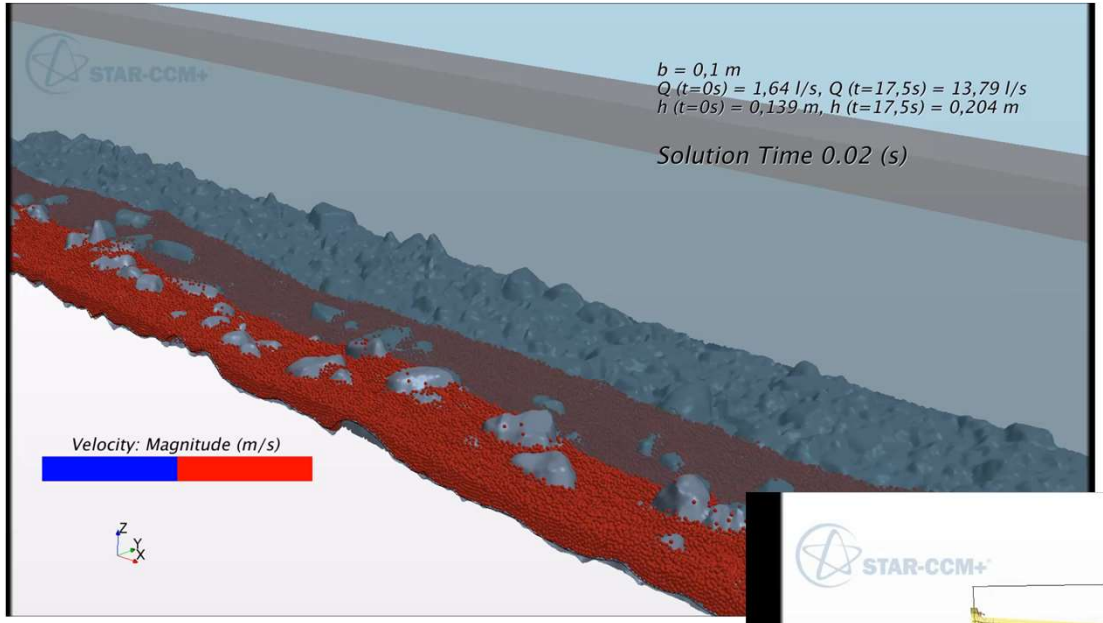
Mai Khola Hydro power intake

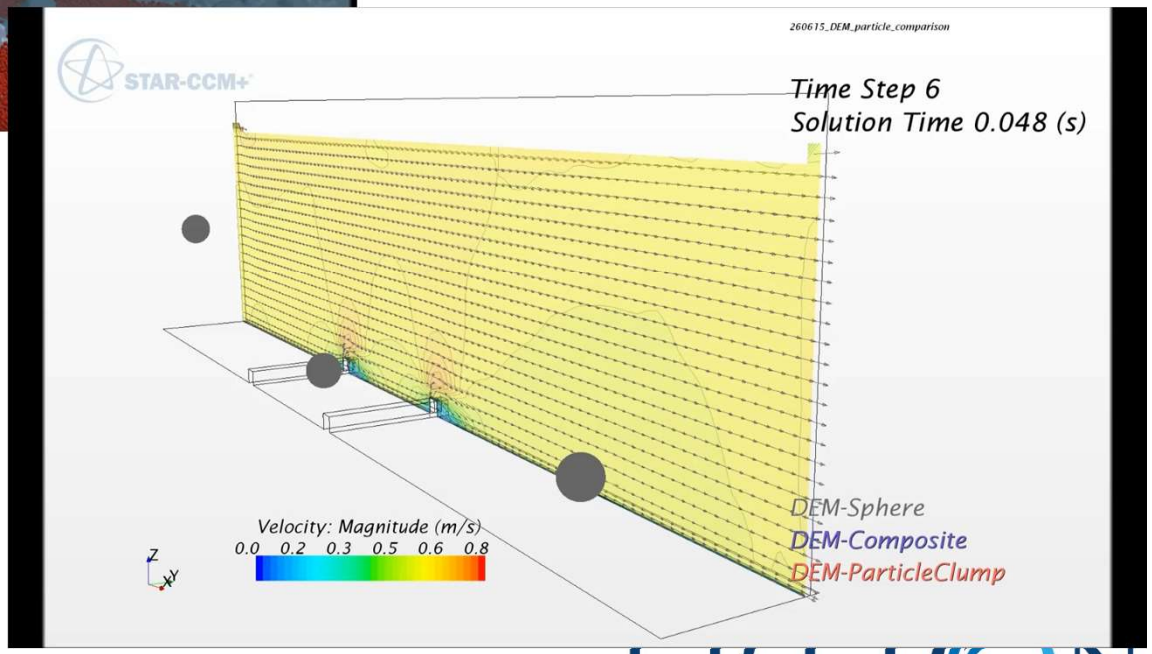




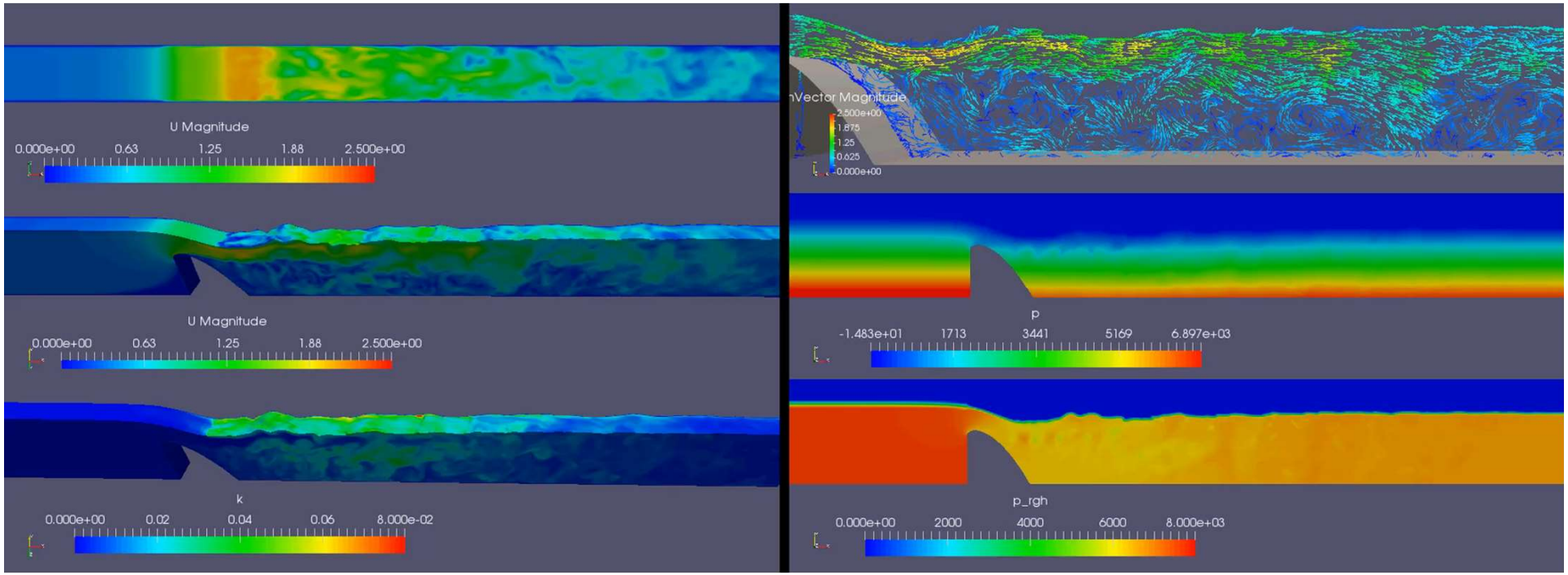
https://sanimaengineering.com/project/mai-hydropower-project/

MODELLING OF ROUGH SURFACE FLOWS





MODELLING OF WEIR FLOW



Binga Lake

THANK YOU VERY MUCH
FOR YOUR ATTENTION

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