Jun 22nd, 10:40 AM - 10:55 AM

Session D1: Classification of Flow Patterns in a Nature-Oriented Fishway Based on 3D Hydraulic Simulation Results

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Classification of flow patterns in a nature-oriented fishway based on 3D hydraulic simulation results

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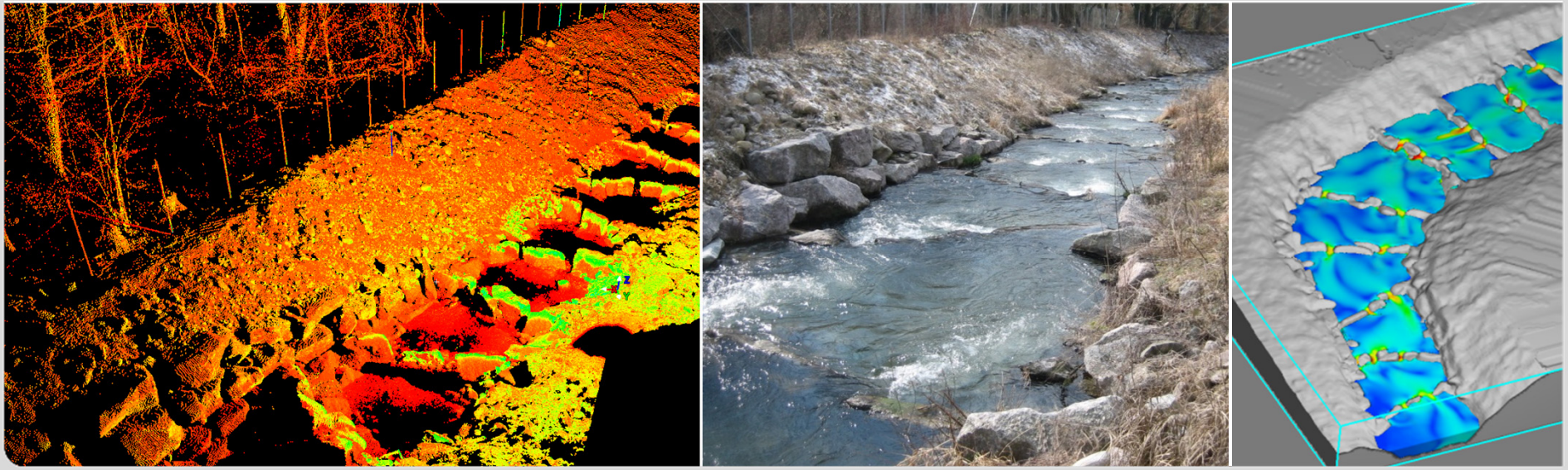
Institute for Water and River Basin Management



Hydraulics in fishways

Need for research

- Hydraulic values concerning passability (v_{min}, v_{max}, h_{min})
- Horizontal and vertical distribution of velocity, 3D flow pattern
- Nature-oriented fishways: lack of knowledge concerning hydraulics
  → special need for research

Numerical modeling

- Basis: topographical model
- Problem:
  complex topography and hydraulics

Technical fishway

+ Simple and reproducible geometry
+ Optimizeable

Nature-oriented fishway

+ High structural diversity
+ Irregular forms

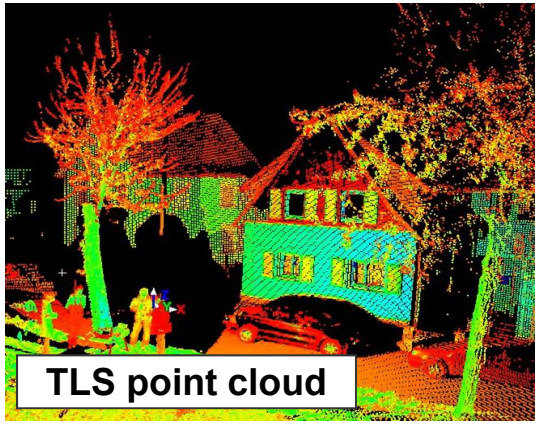
Hydraulic model has to be 2D or 3D and of a high resolution → High level of detail of the geodata necessary → Data acquisition using terrestrial laser scanning (TLS)

Acquiring high-resolution topographical data

Terrestrial laser scanning (TLS)

- Technique of optical 3D measurement
- Advantages / Disadvantages
  - \+ Highly detailed and exact data acquisition of the topography of the surroundings
  - \+ High measurement speed
  - \- Significant effort for data post processing
  - \- In general, no data acquisition of submerged structures
    - → If possible: data acquisition of dry stream bed, alternatively: data acquisition during low water period
    - → Completion of data set using tacheometry

Phase-based scanner „HDS6200“, Leica Geosystems



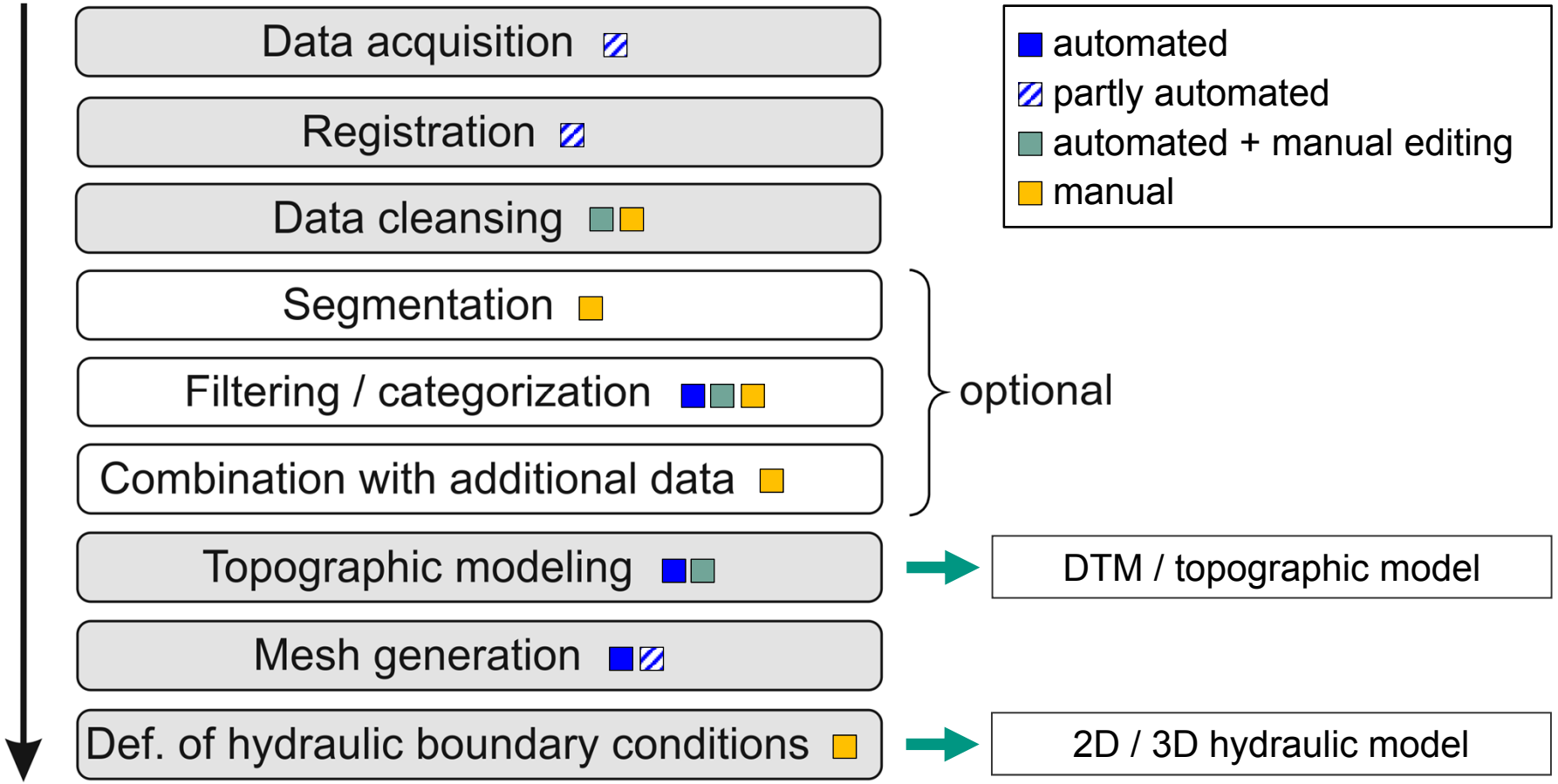
TLS point cloud

Cooperation

- Geodetic Institute (GIK), KIT
- Institute of Photogrammetry + Remote Sensing (IPF), KIT

From raw data set to the hydraulic model

Workflow



Source: Zippelt, Czerny, Nestmann 2011 (modified)

Project area and data acquisition

Project area

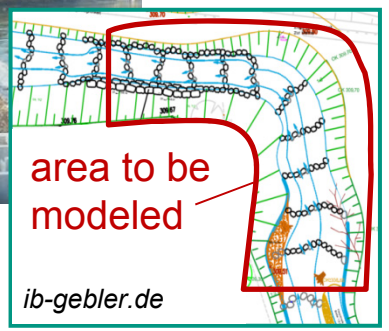
- Nature-oriented fishway at a diversion hydropower station at the High-Rhine
- Rock cascade pass

Data acquisition

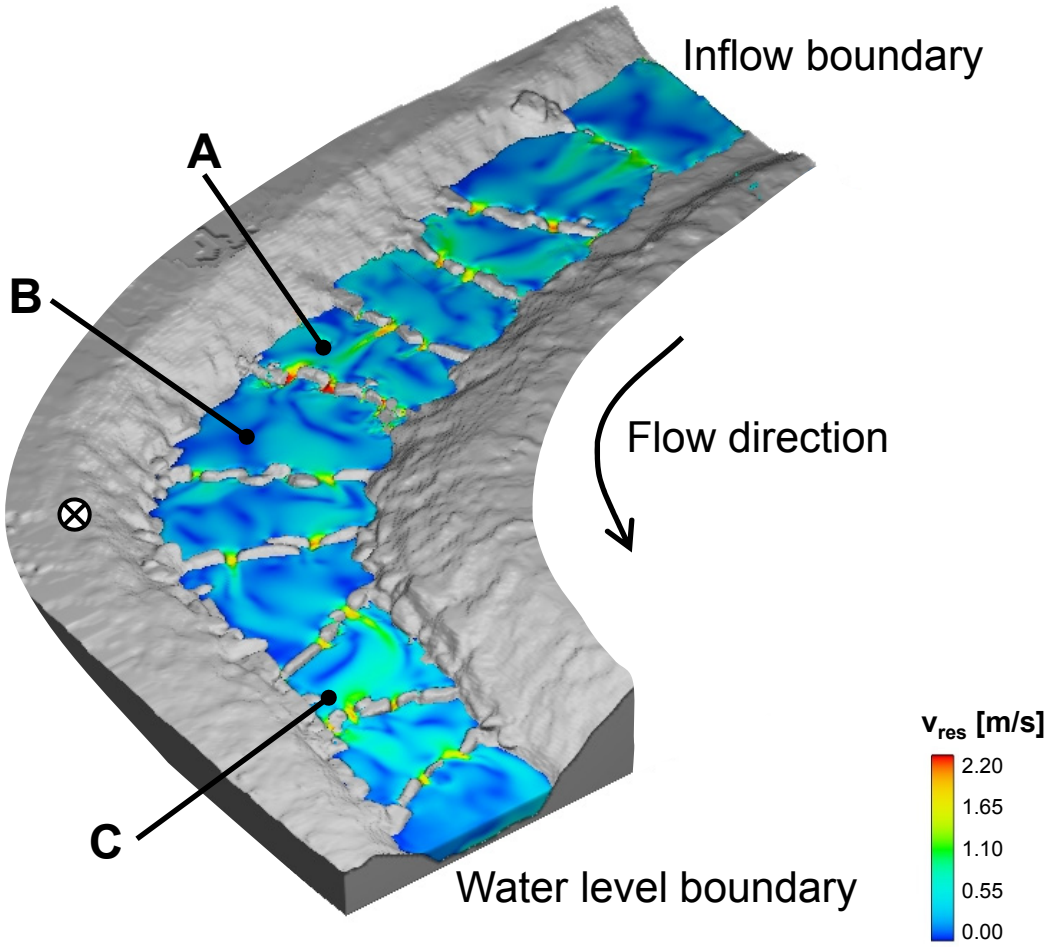
- TLS of dry stream bed prior to flooding

Model parameters

- Topography:
  3D polygon model
- 3D hydraulic simulation:
  FLOW-3D® (RANS)
- Block structured mesh:
  ≈ 4 million mesh elements
  (edge lengths: 5 cm, 10 cm)



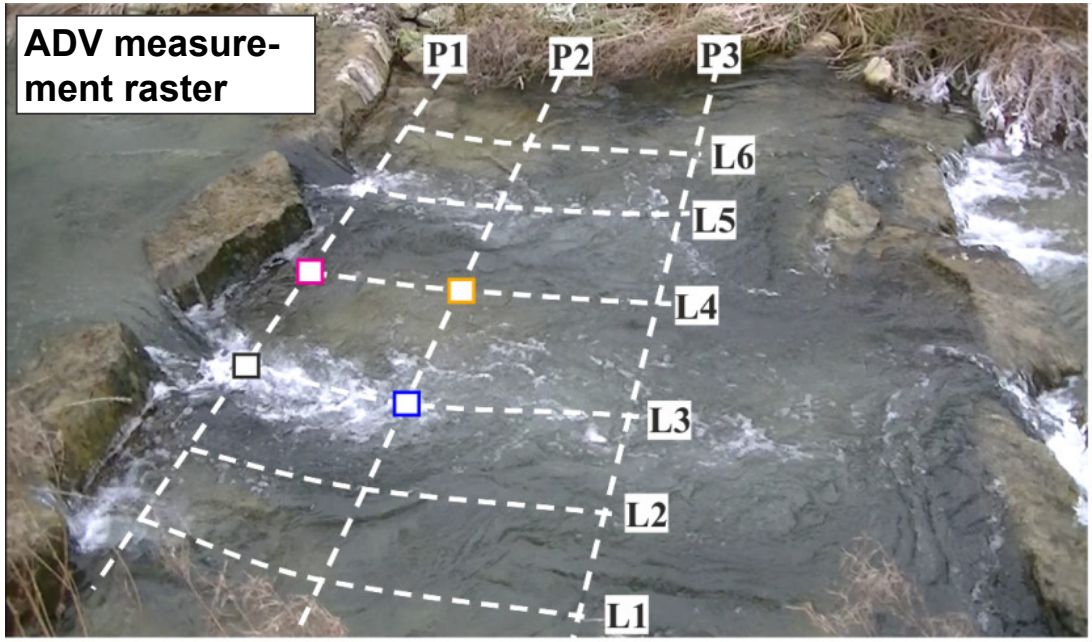
Topographic model

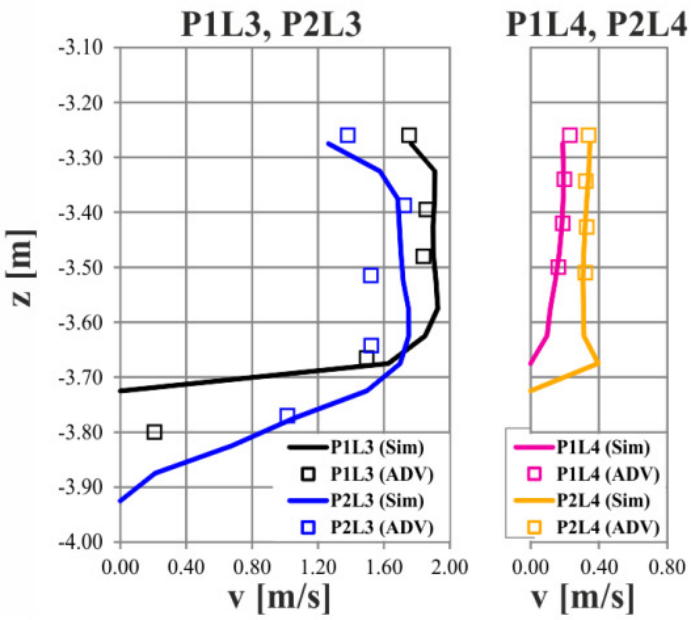


Validation

Field measurements

- Water level measurements (leveling)
- Determination of flow rate Q
- Flow velocities in the gaps of the cross-bars (magnetic inductive method / MID)
- Flow velocities in pool A (Acoustic Doppler Velocimetry / ADV)

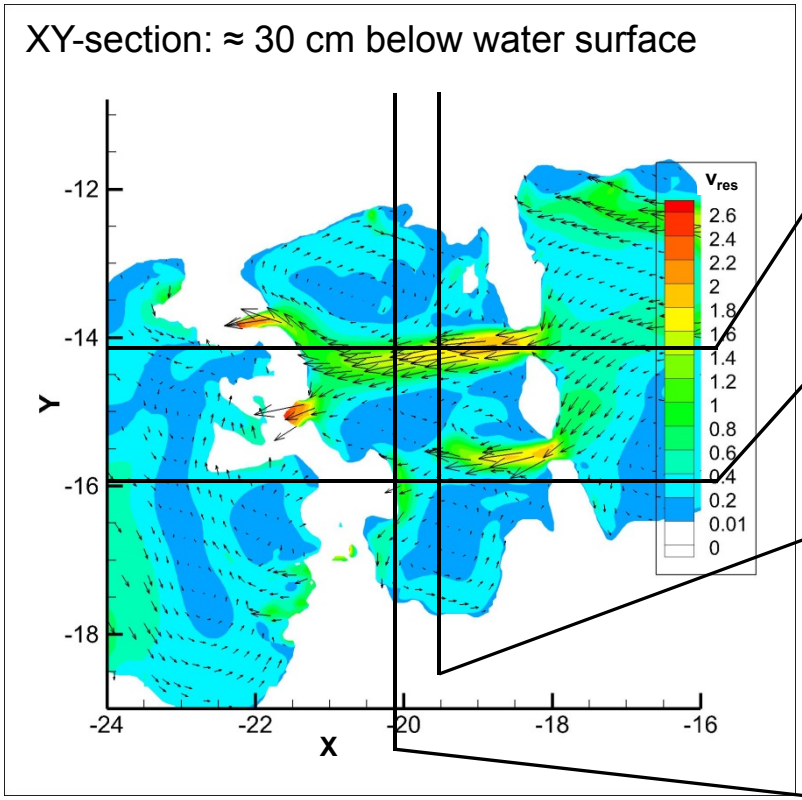


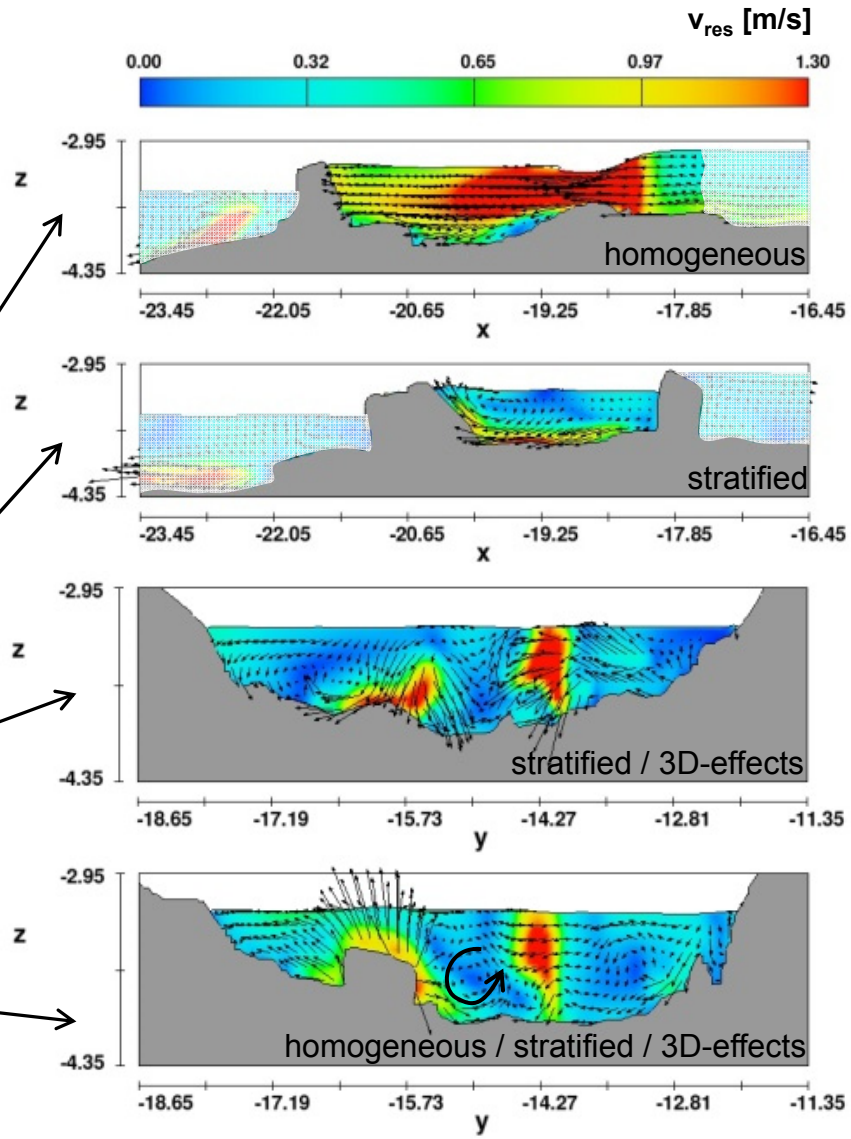


Typification of hydraulic pattern

Procedure

here: pool A





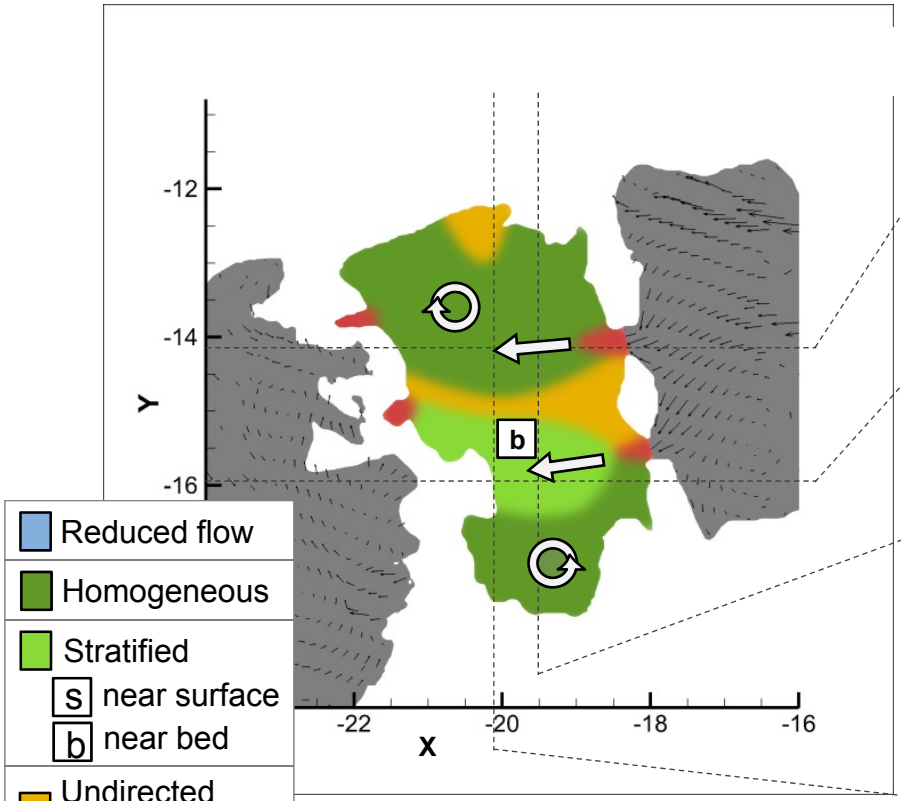
Typification scheme

	SYMBOL	DEFINITION	DESCRIPTION
FLOW DIRECTION		Distinctly directed flow path	Guiding flow path within the pool between two or more gaps of the cross-bars with velocity values within critical values
		Horizontal eddy	Distinctly identifiable horizontal rotational motion of the flow
		Vertical eddy	Distinctly identifiable vertical rotational motion of the flow
FLOW DISTRIBUTION		Area with reduced flow velocity	Area with velocities below the minimum velocity for rheotaxis (v_{min} < 0,30 m/s)
		Homogeneous flow distribution	Velocities are nearly constant for the entire flow depth
		Stratified flow distribution	Stratification of the flow and formation of zones of reduced velocity s v_{max} near the water surface b v_{max} near the stream bed
		Undirected flow	Zones without distinctly directed velocity distribution, which are characterized by a high degree of turbulence and 3D flow patterns
		Exceedance of critical values	Exceedance of critical values concerning flow velocity taken from standards

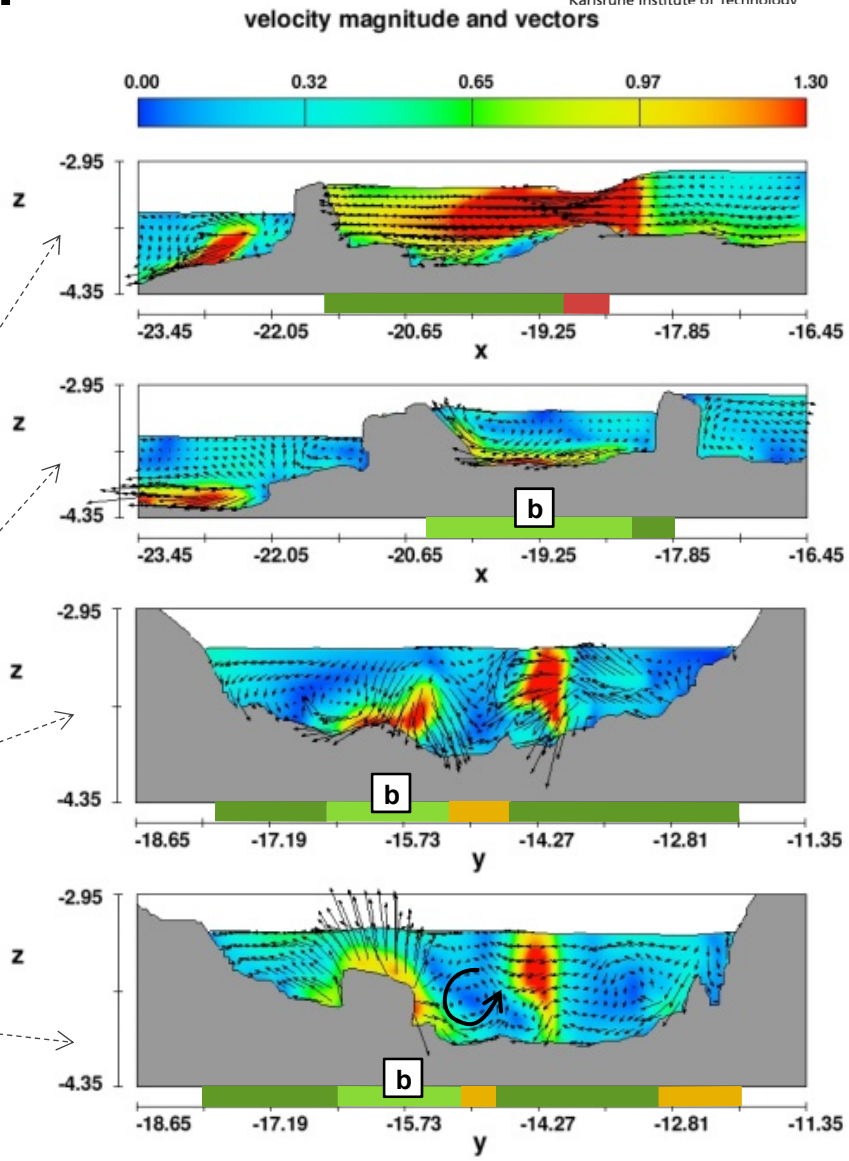
Typification of hydraulic pattern

Result

here: pool A

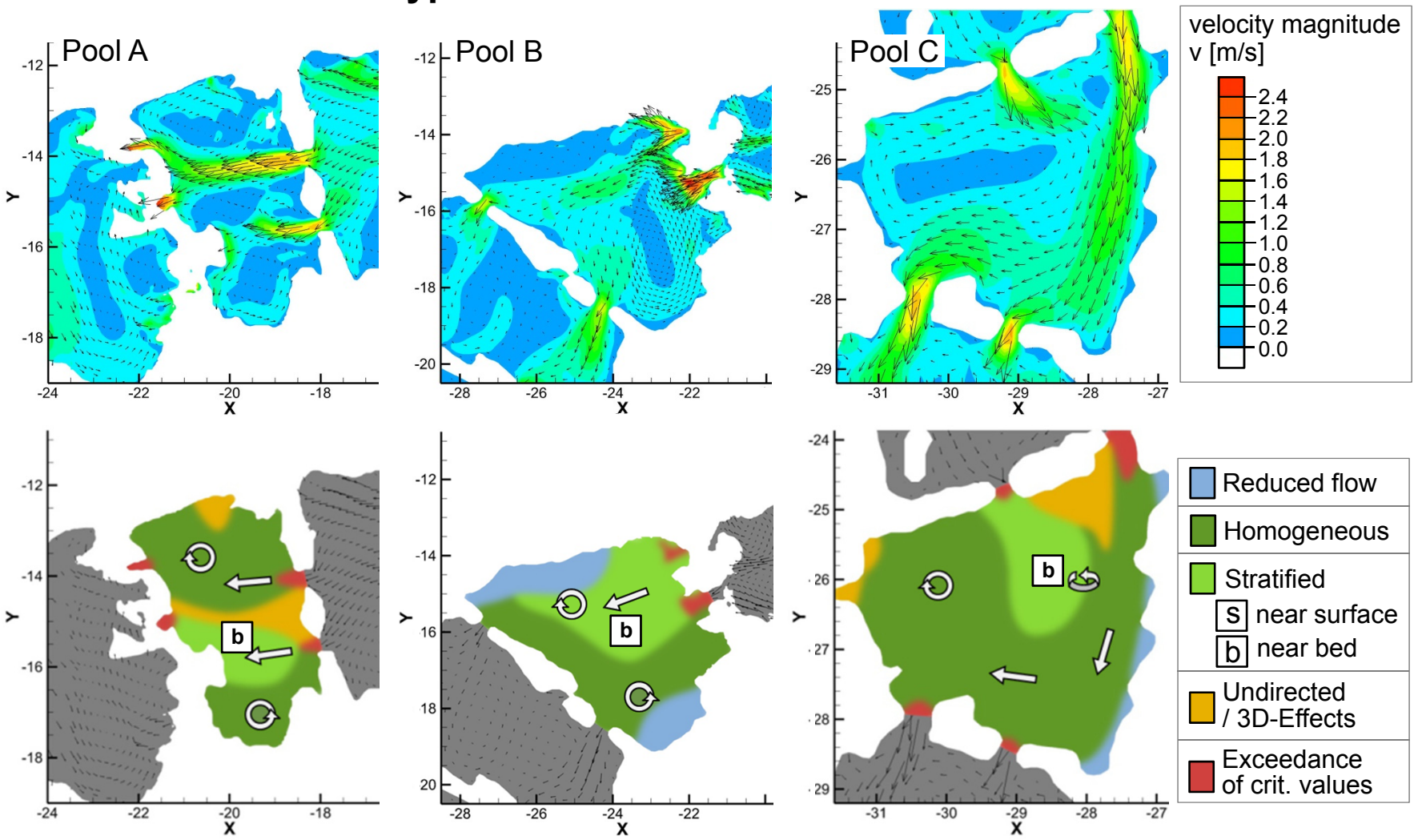


- Reduced flow
- Homogeneous
- Stratified
  - s near surface
  - b near bed
- Undirected / 3D-Effects
- Exceedance of crit. values



Analysis of simulation results

Simulation results and typification



Conclusion and outlook

Potential

- Combination of TLS data acquisition and high-resolution hydraulic modeling enables investigations of hydraulics in nature-oriented fishways
- Typification scheme enables a visual representation of complex simulation results
  - Simplifies interdisciplinary discussion
  - Basis for ecohydraulic assessment

Outlook

- Further development of typification scheme is possible
- Significant effort for manual post processing
  → Use of improved scan and filtering methods