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Coupling SWAT with In-stream Models for an Integrated Assessment of Sediment Transport

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Outline

1. Background and scope of the project
2. Model coupling
3. Modeling water fluxes on three scales
4. Modeling sediment fluxes on three scales
5. Discussion

Integrated ecohydrological river basin assessment

Reality

Modelling

Catchment processes

In-stream processes (1D, 2D)

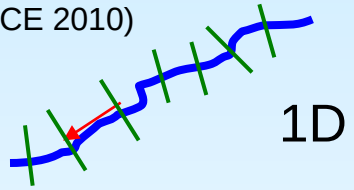
Habitat

Kirchweddelbek (SH), Foto: U. Holm

The in-stream models

HEC-RAS

(USACE 2010)

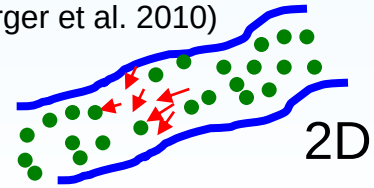


Widely used hydraulic model for simulating open channel flow and sediment processes in river networks

ArcGIS interface available

ADH

(Berger et al. 2010)



Adaptive Hydraulics model for simulating 2D-shallow water problems with sediment transport on a triangular finite element mesh

Dynamic adaption of mesh resolution during simulation

ArcGIS interface had to be programmed

Why additional in-stream models?

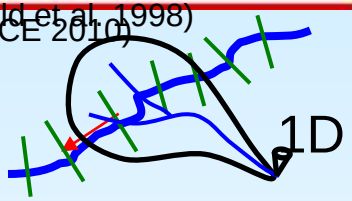
SWAT

(Arnold et al. 1998)

supplies spatially distributed results from the catchment

no differentiation of stream properties beyond subbasin

(USACE 2010)



supplies spatially distributed results at cross sections

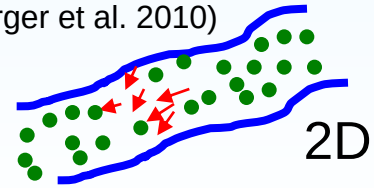
too coarse to model in-stream morphodynamics for habitat assessments

ADH

(Berger et al. 2010)

supplies spatially distributed results on points

very high resolution in the stream possible



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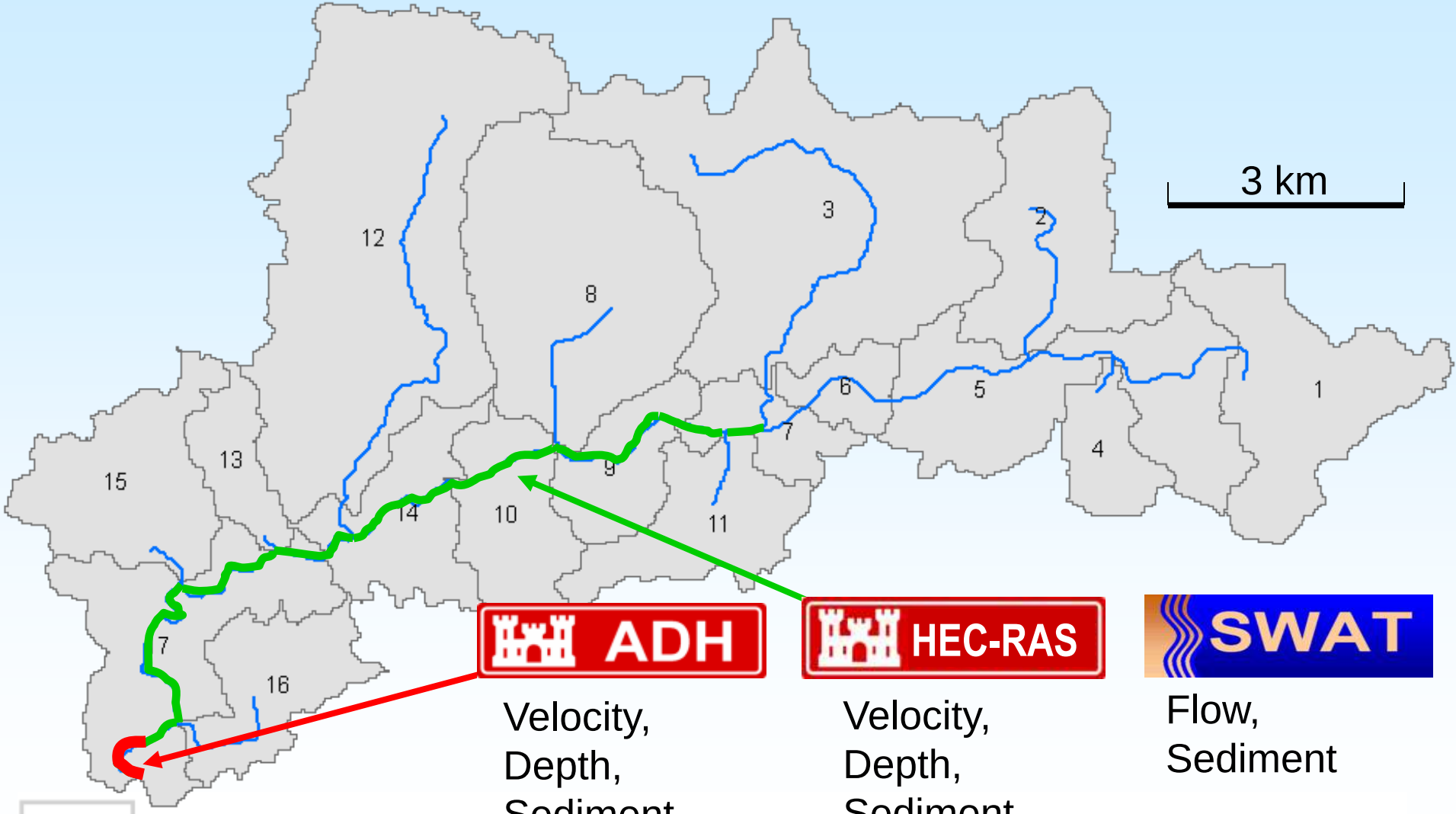
Kielstau catchment, UNESCO demosite for Ecohydrology

- 50km²
- 8.2°C
- 870mm/a
- Low hydraulic gradients, near-surface groundwater
- Agricultural land use
- Urban influence

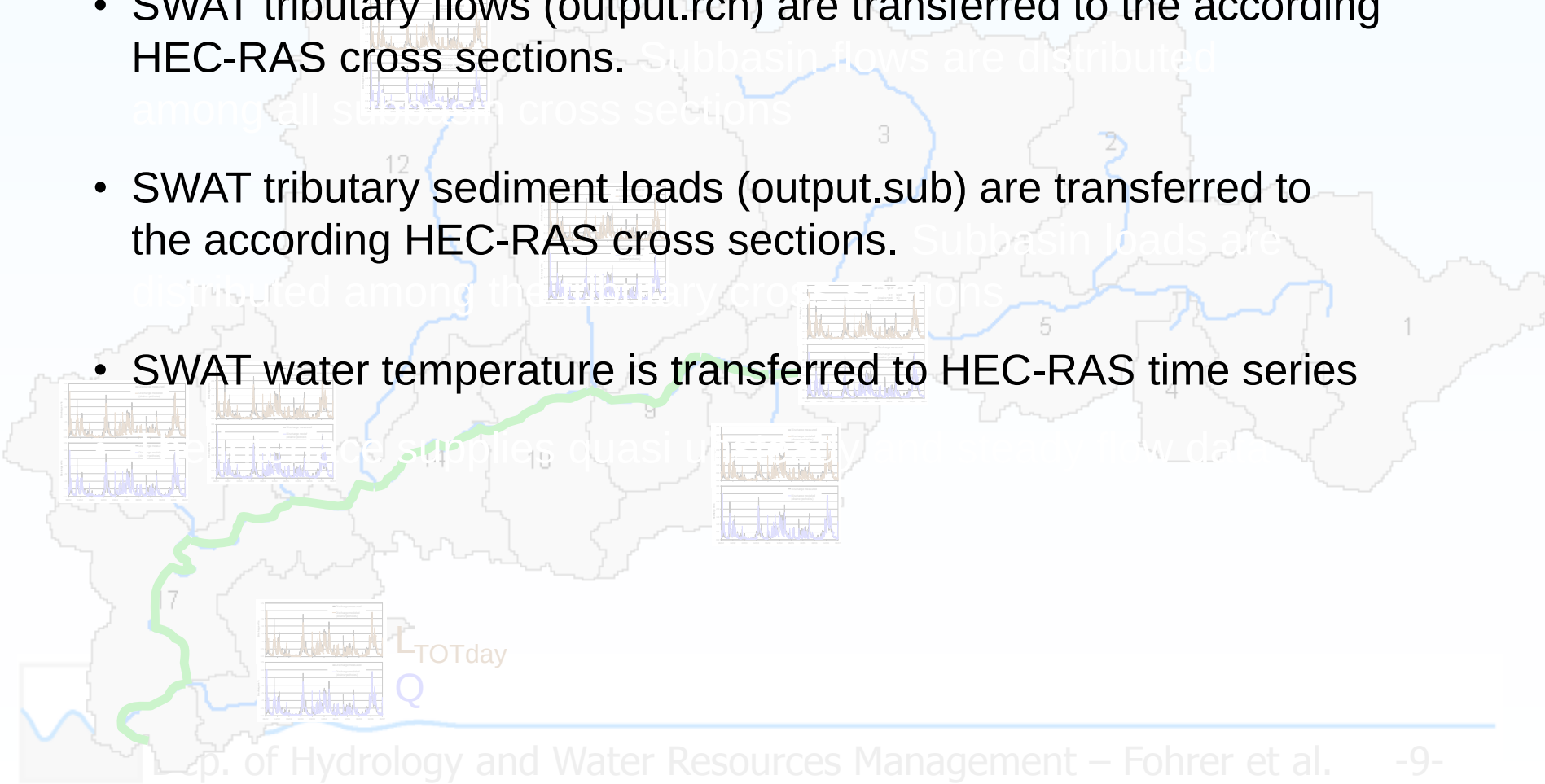
Process depiction on three scales



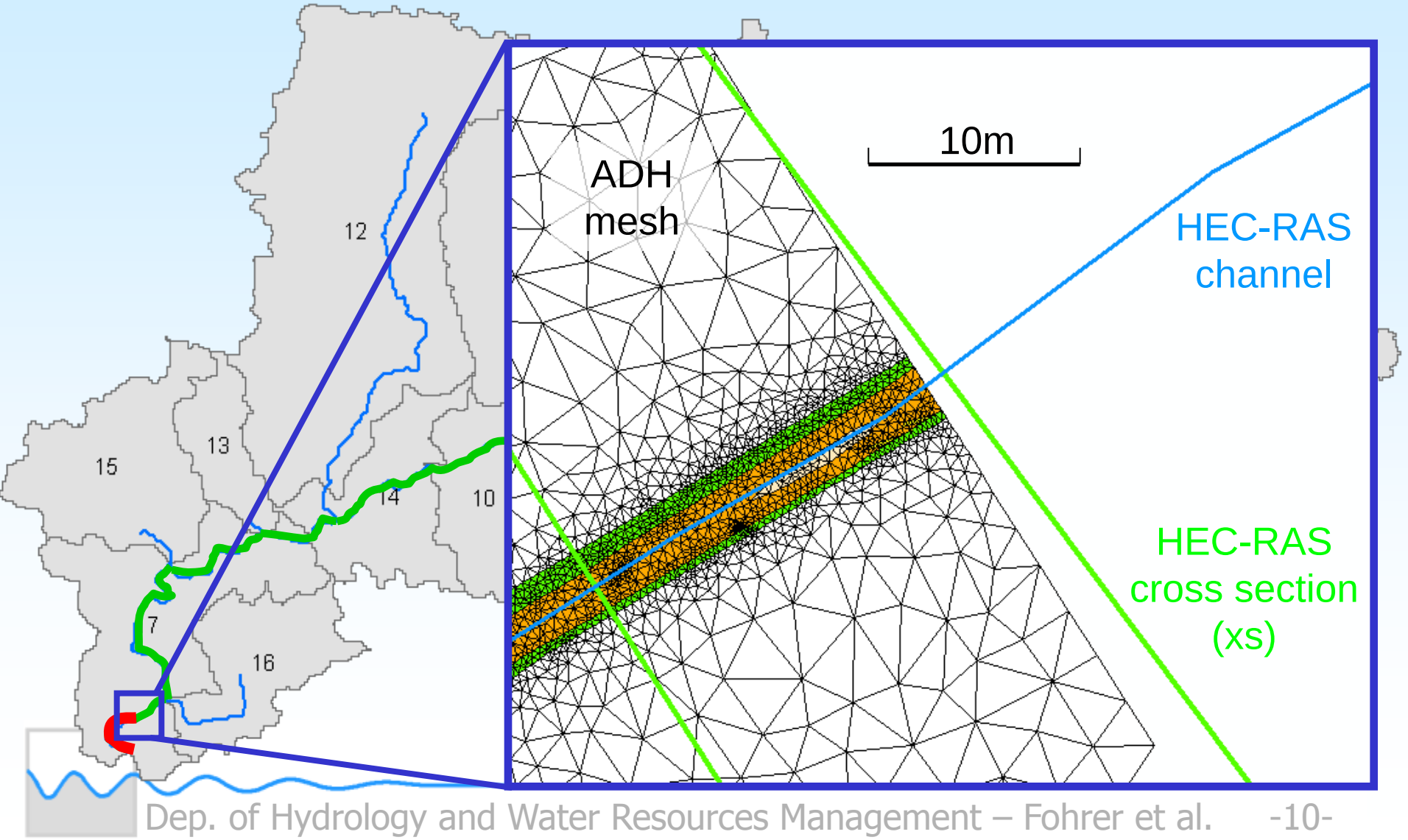
Model coupling

ArcGIS 9.2 PYTHON script:

- SWAT tributary flows (output.rch) are transferred to the according HEC-RAS cross sections.
- SWAT tributary sediment loads (output.sub) are transferred to the according HEC-RAS cross sections.
- SWAT water temperature is transferred to HEC-RAS time series



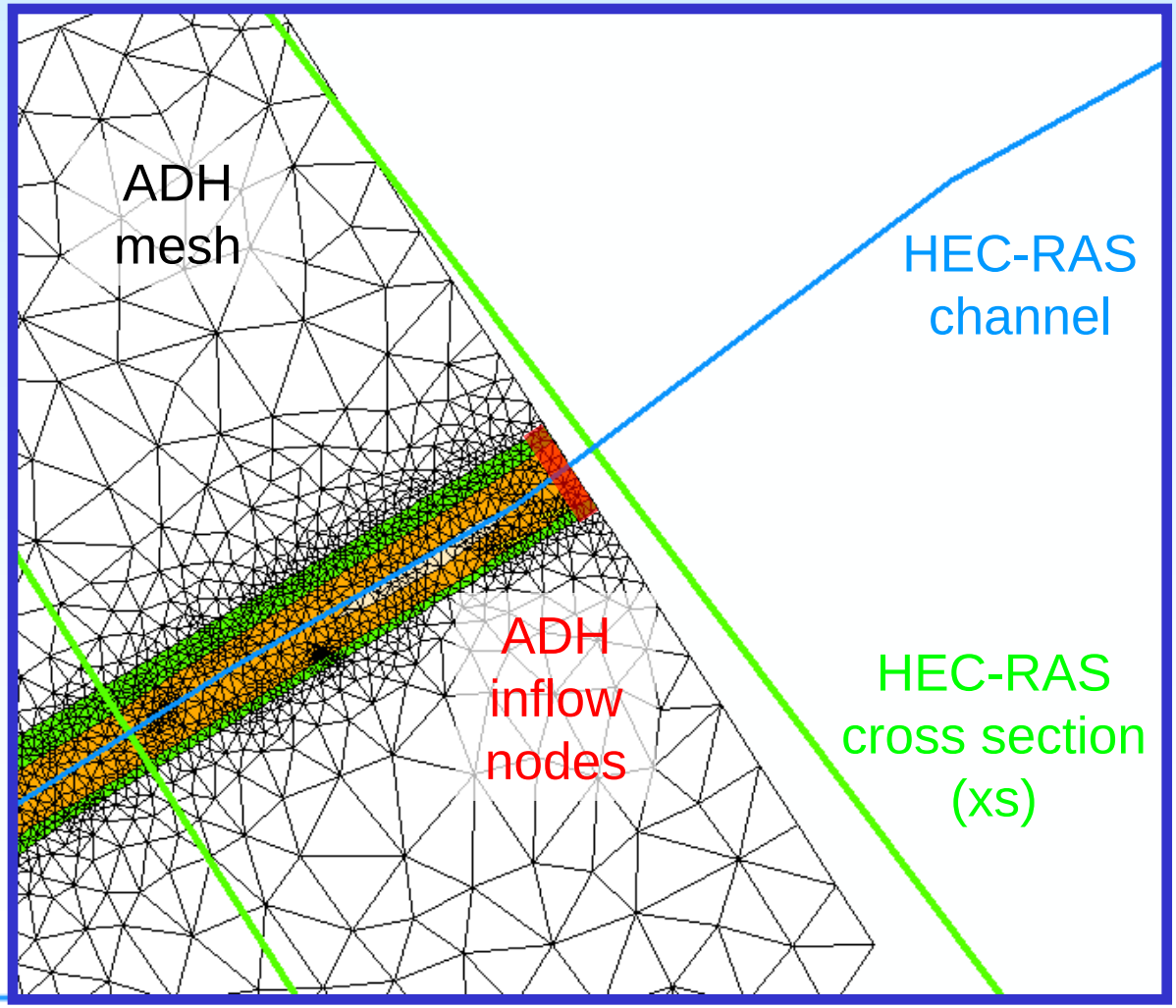
Model coupling



Model coupling

HEC-RAS → ADH

HEC-RAS flow values and loads of each grain fraction are transferred from the cross section to the ADH inflow mesh nodes for each daily time step



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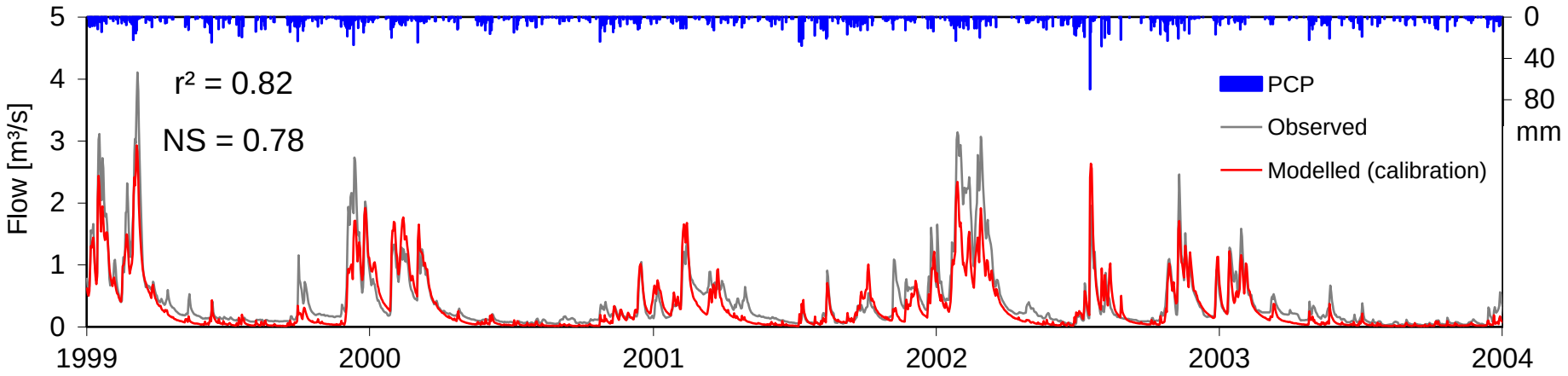
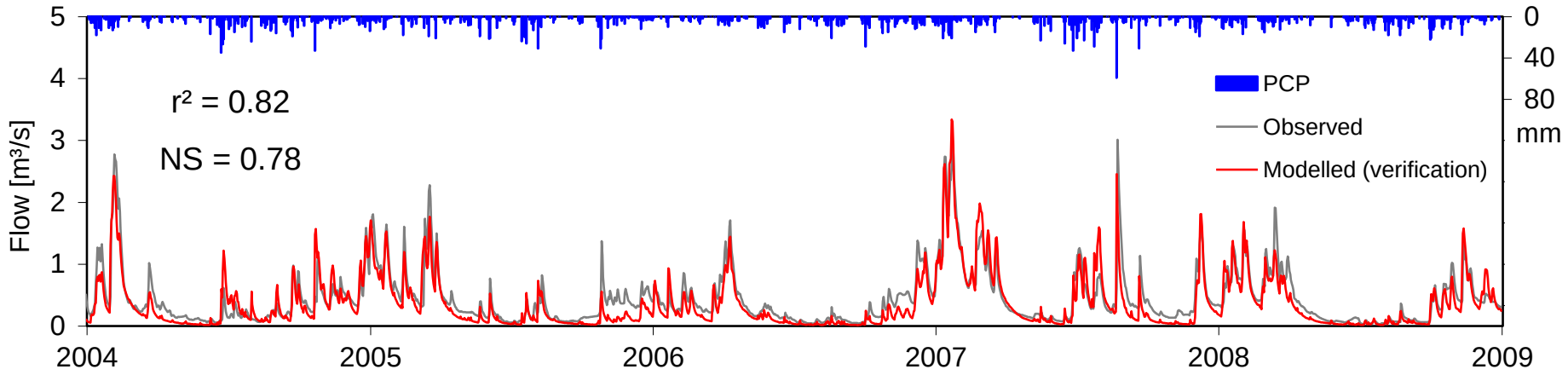
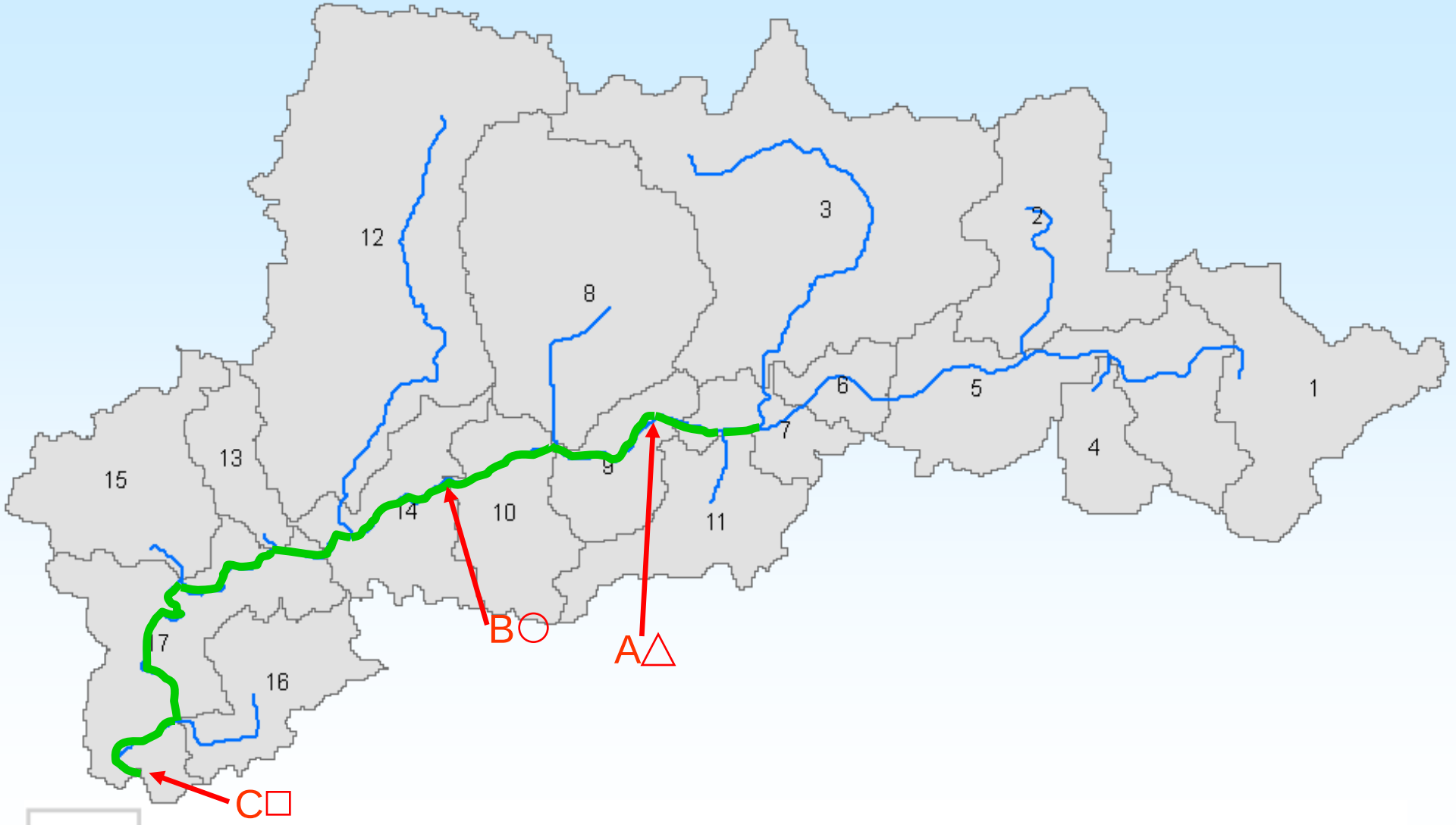
Catchment hydrology





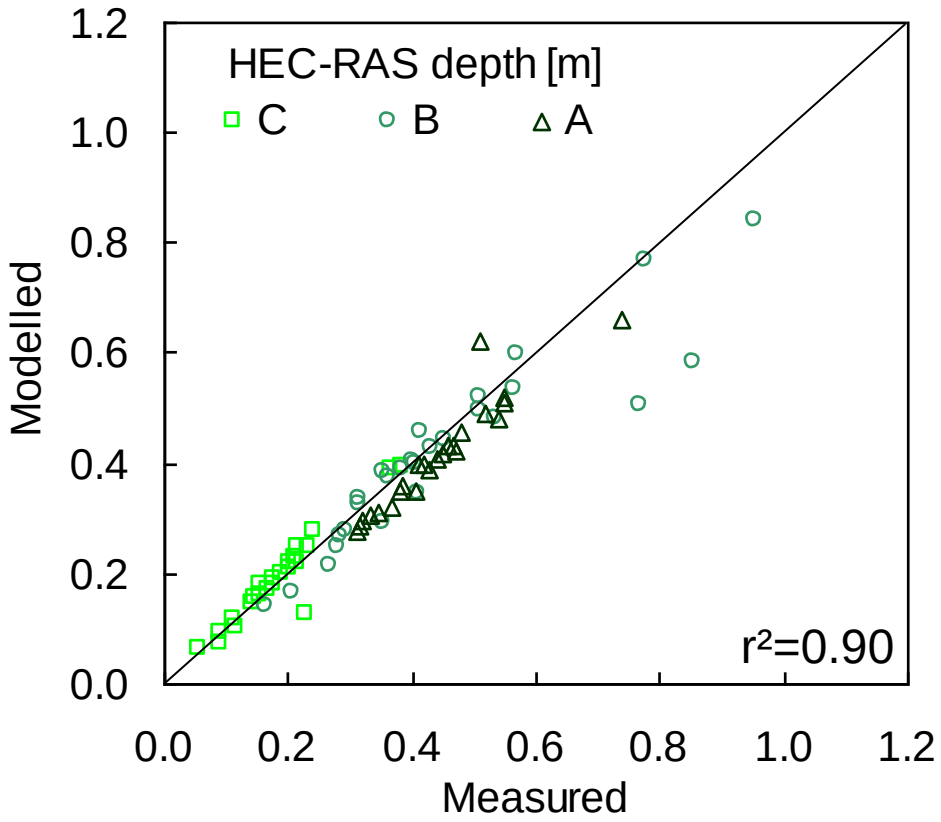
1D stream hydraulics



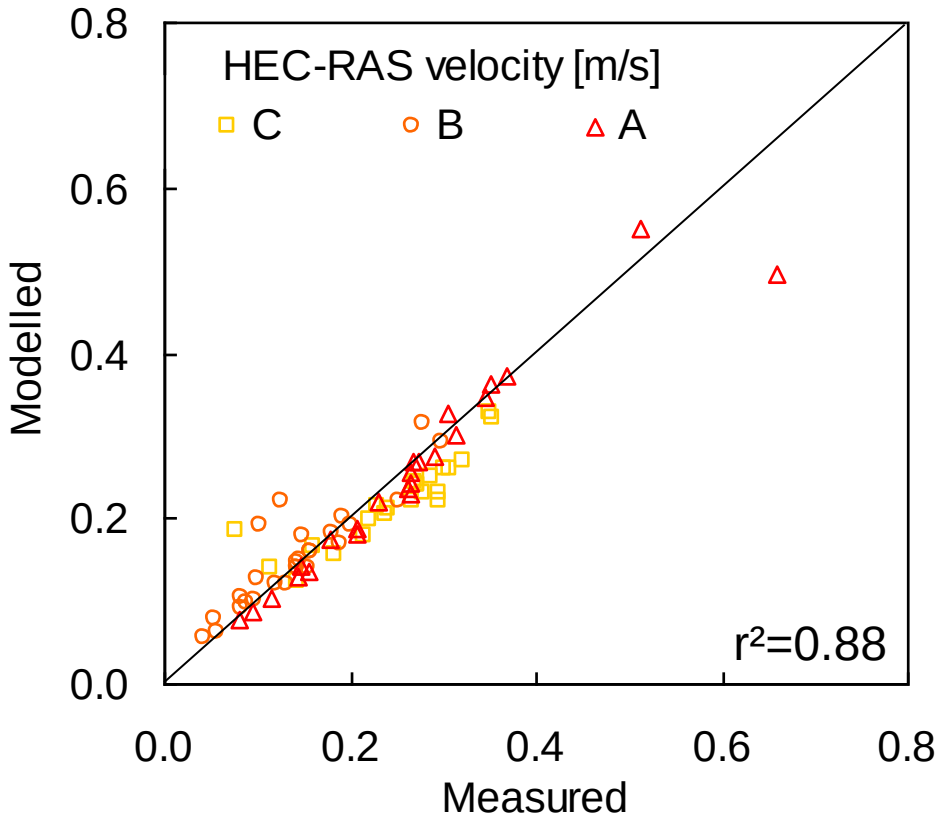
1D stream hydraulics

HEC-RAS

Water depth

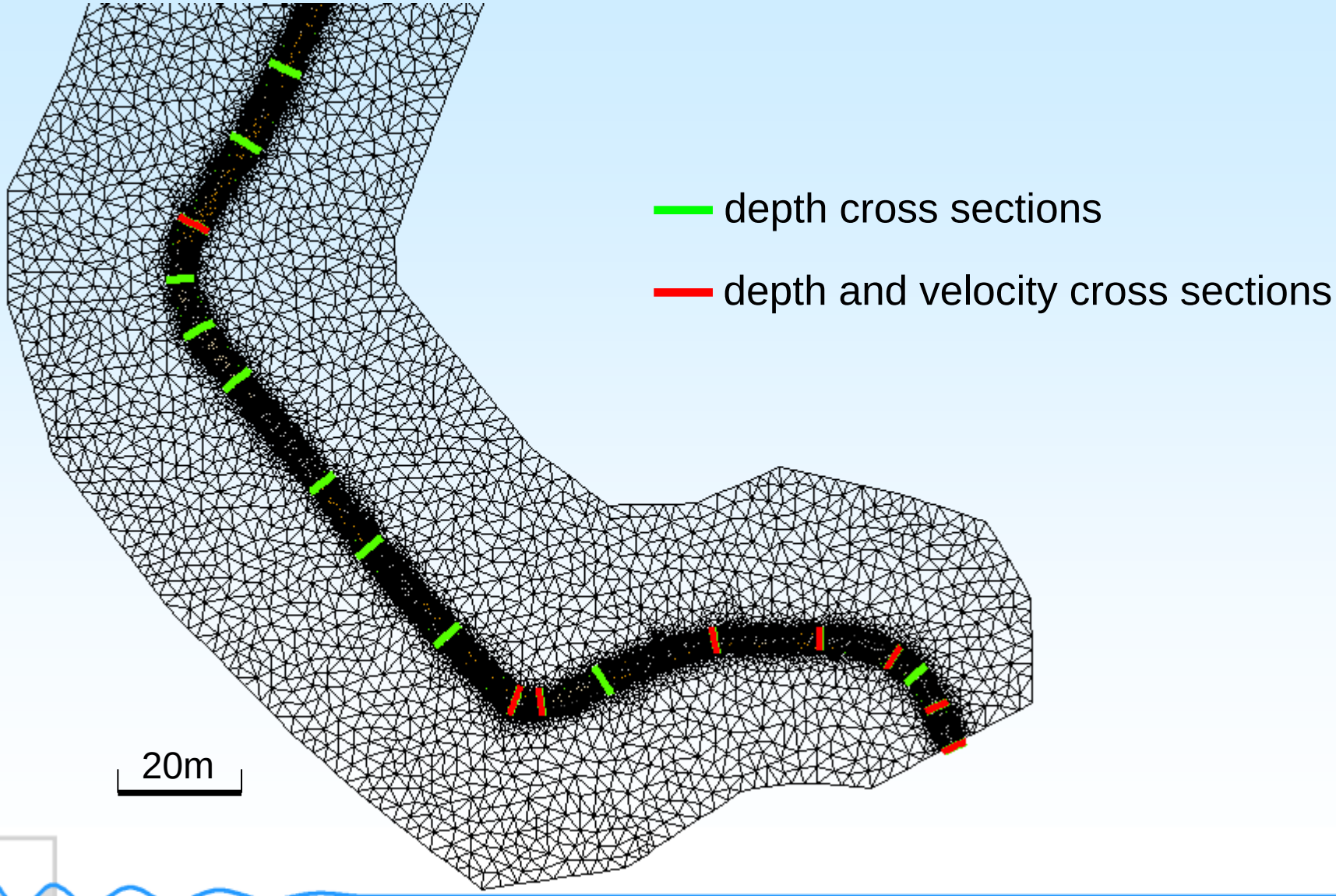


Flow velocity



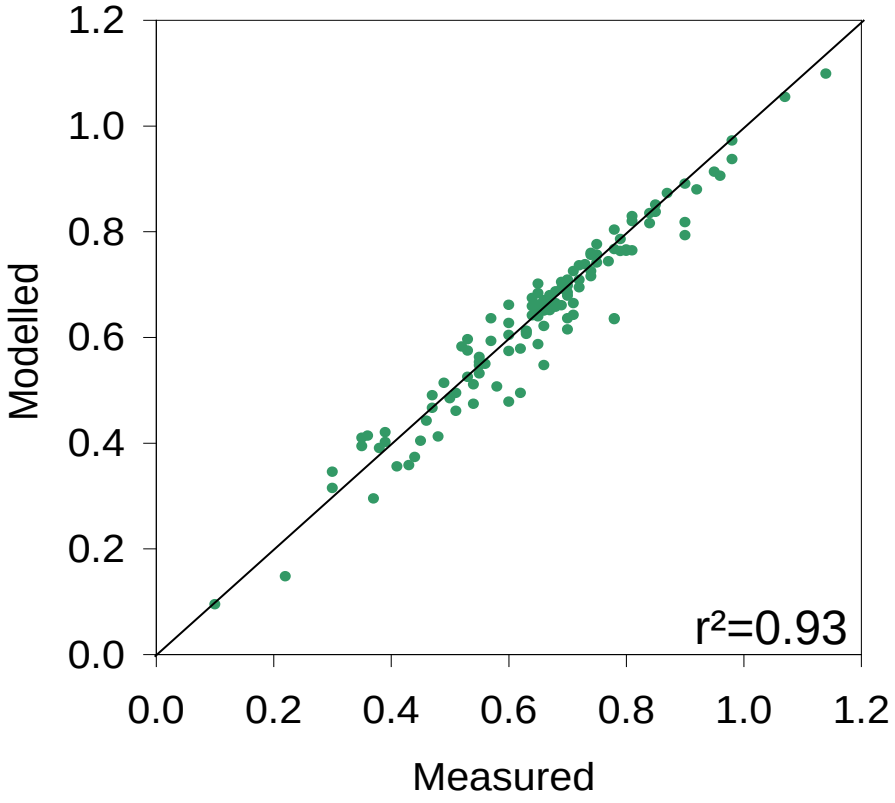
24 flow scenarios: Q_{min} = 0.06m³/s Q_{max} = 1.26m³/s

2D stream hydraulics

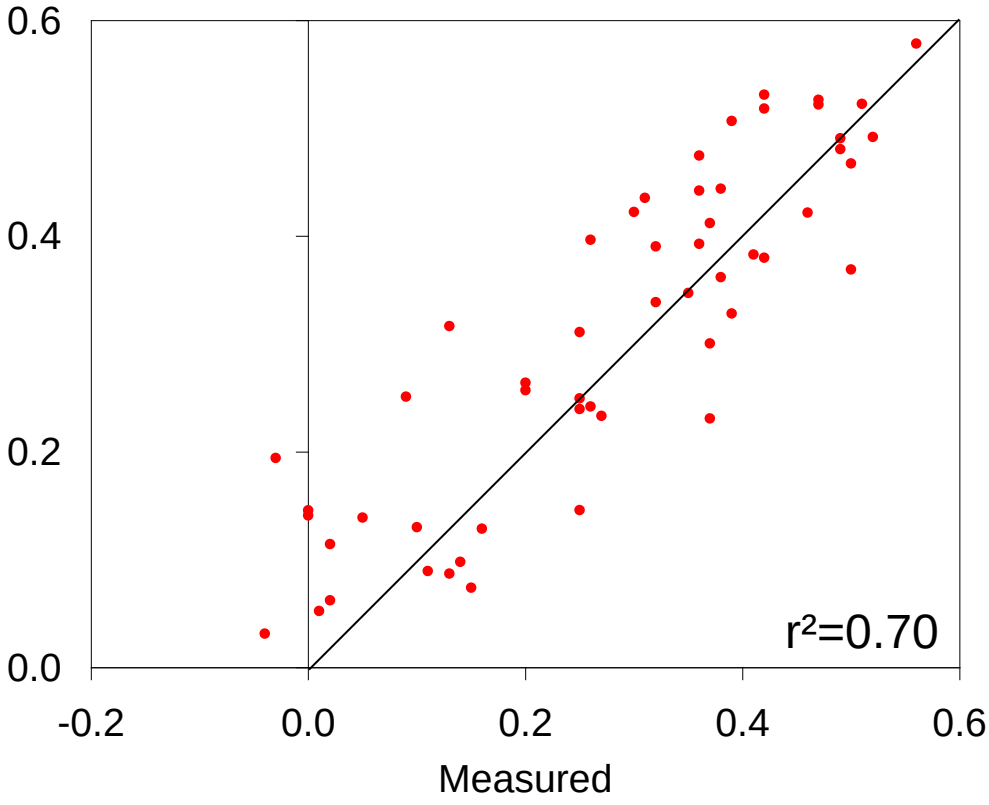


2D stream hydraulics

Water depth

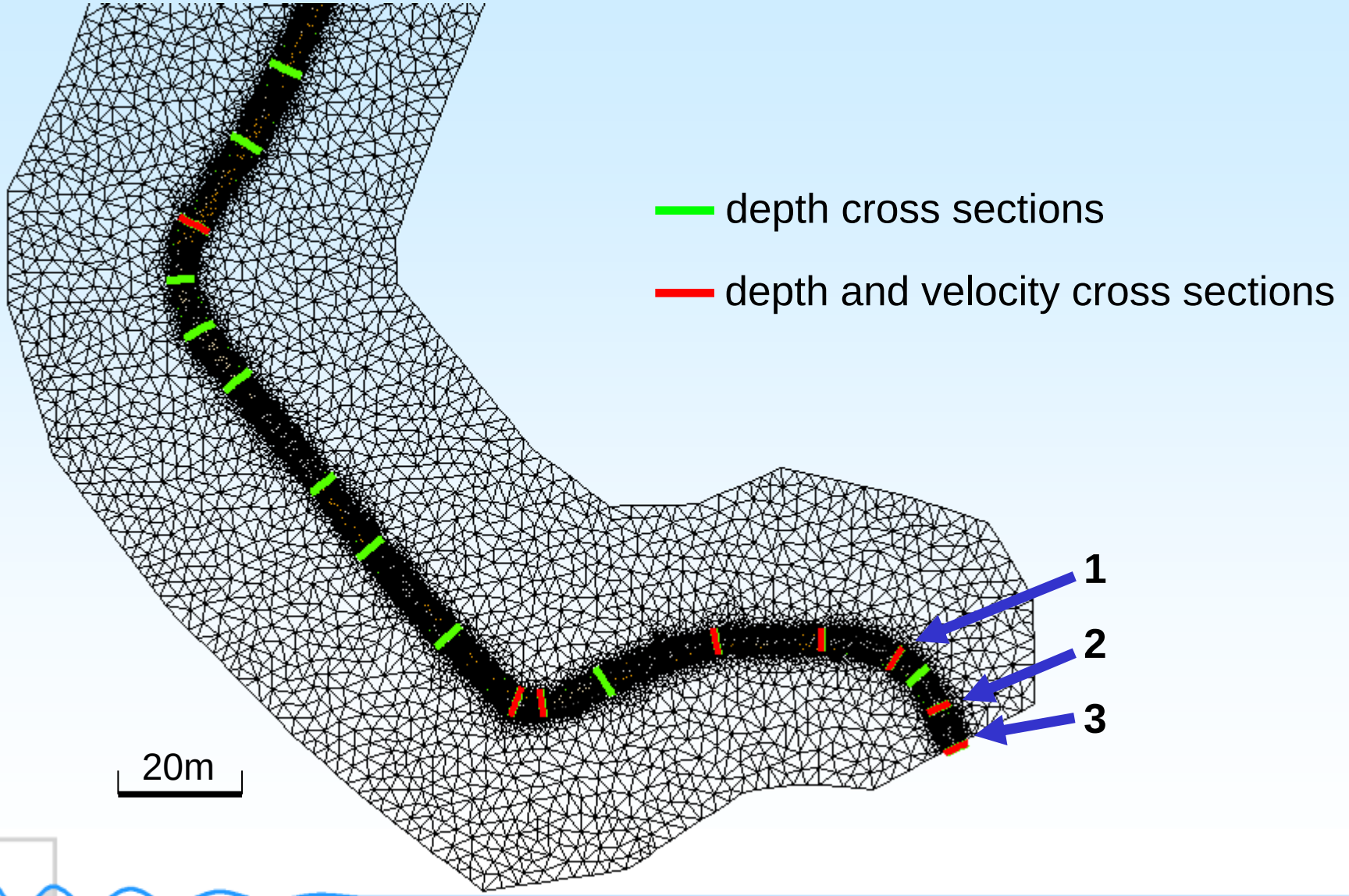


Flow velocity

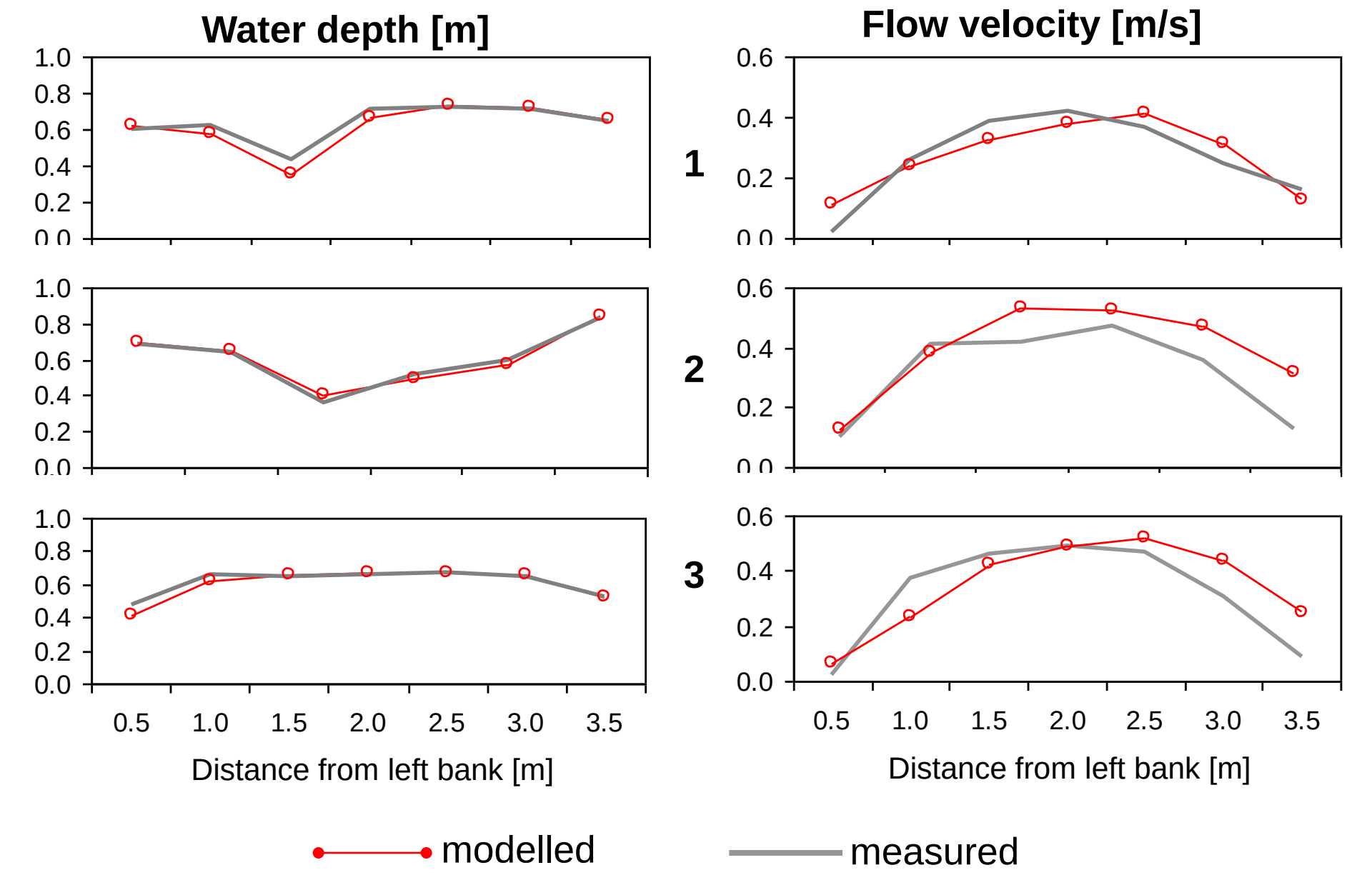


1 flow scenario: Q = 0.73m³/s

2D stream hydraulics



2D hydraulics – cross sections



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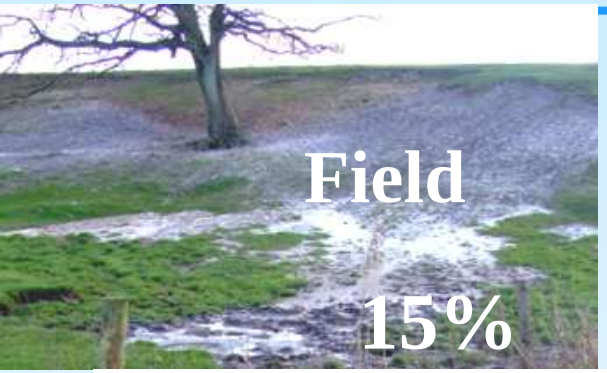
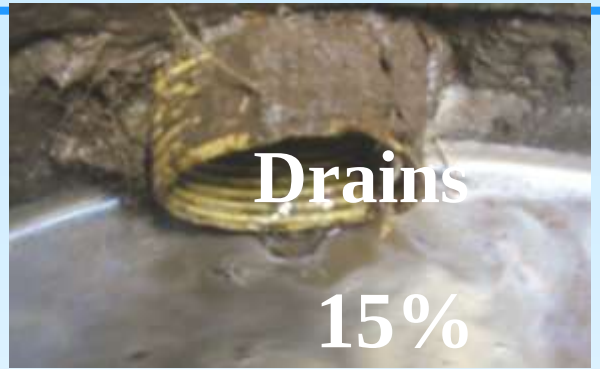
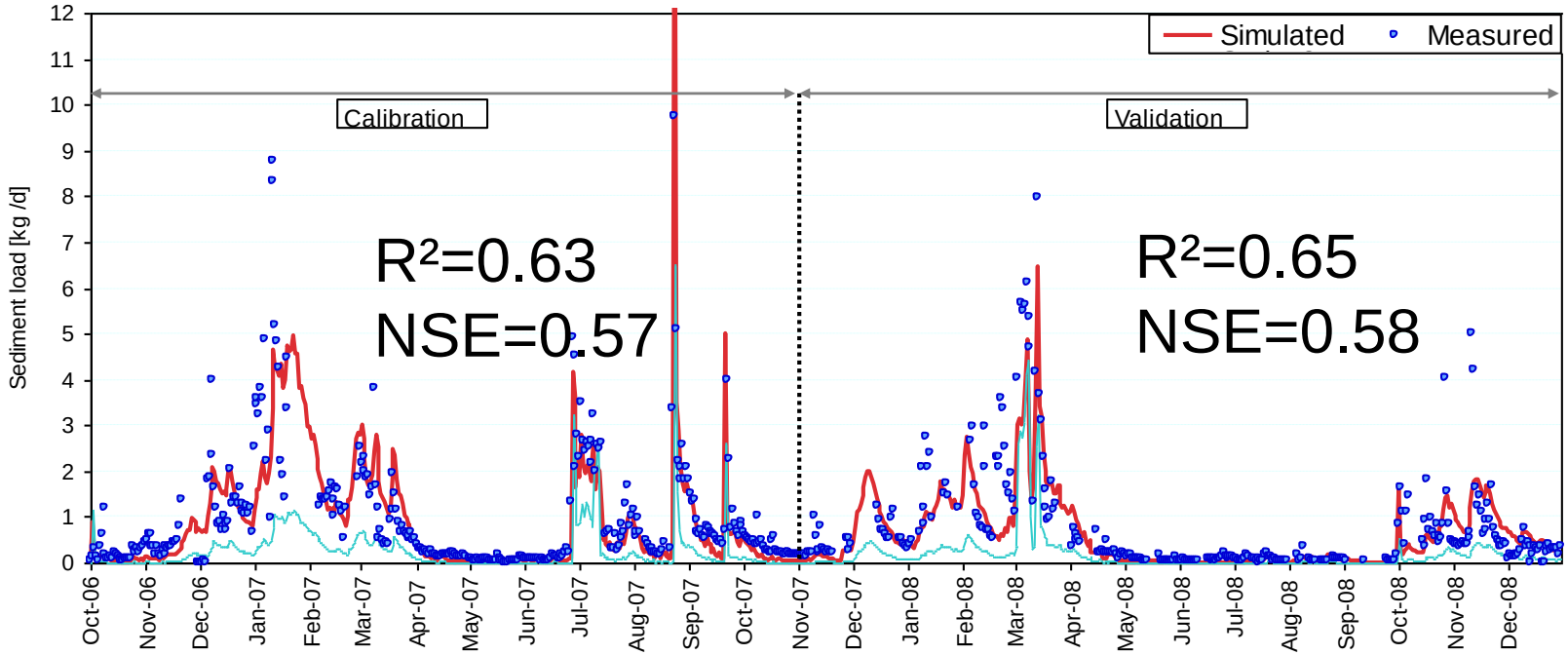
Daily sediment loads in lowland catchments



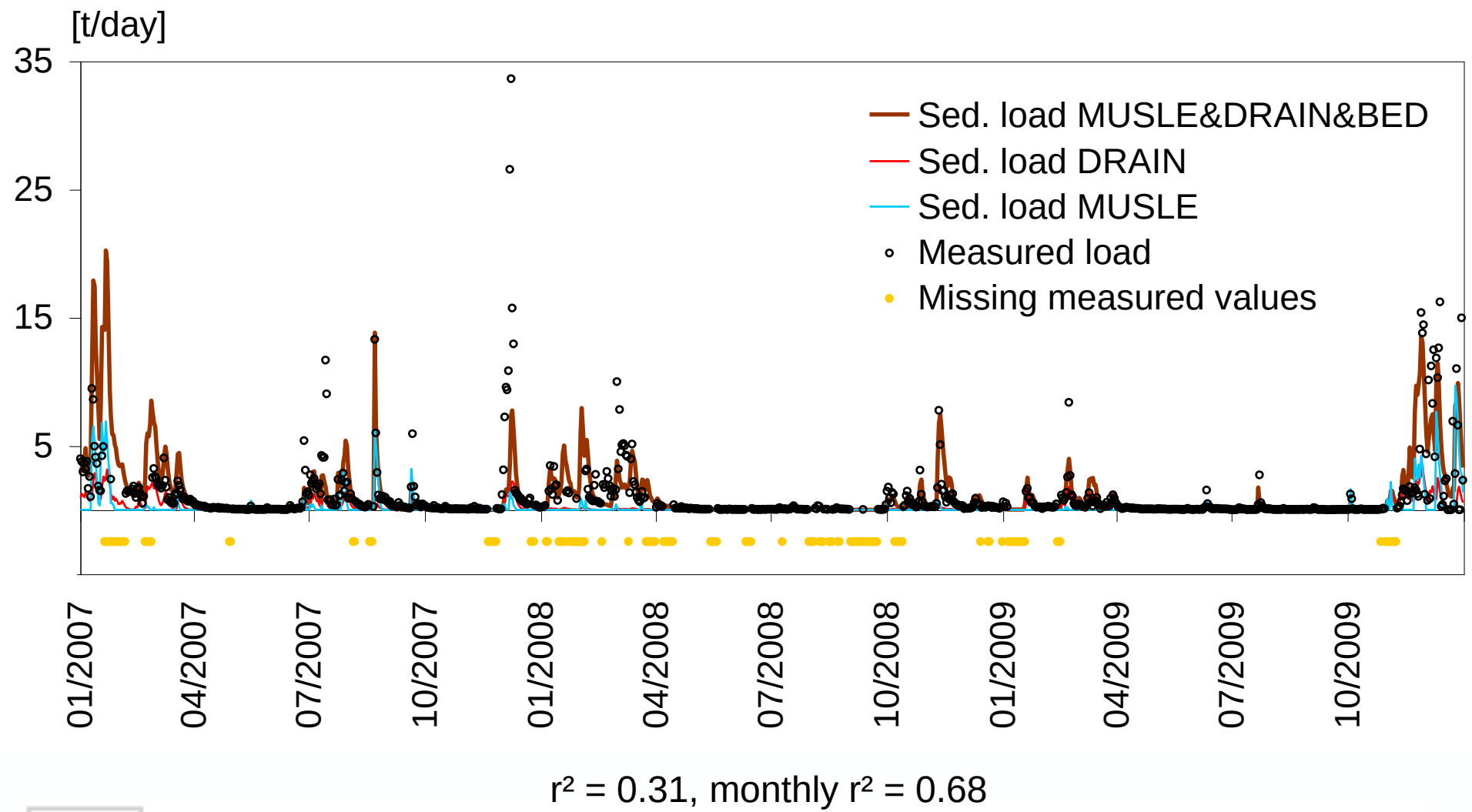




Loading from HRUs/Subbasins

Loading from Subbasins + channel degradation/deposition

1D stream sediment - temporal

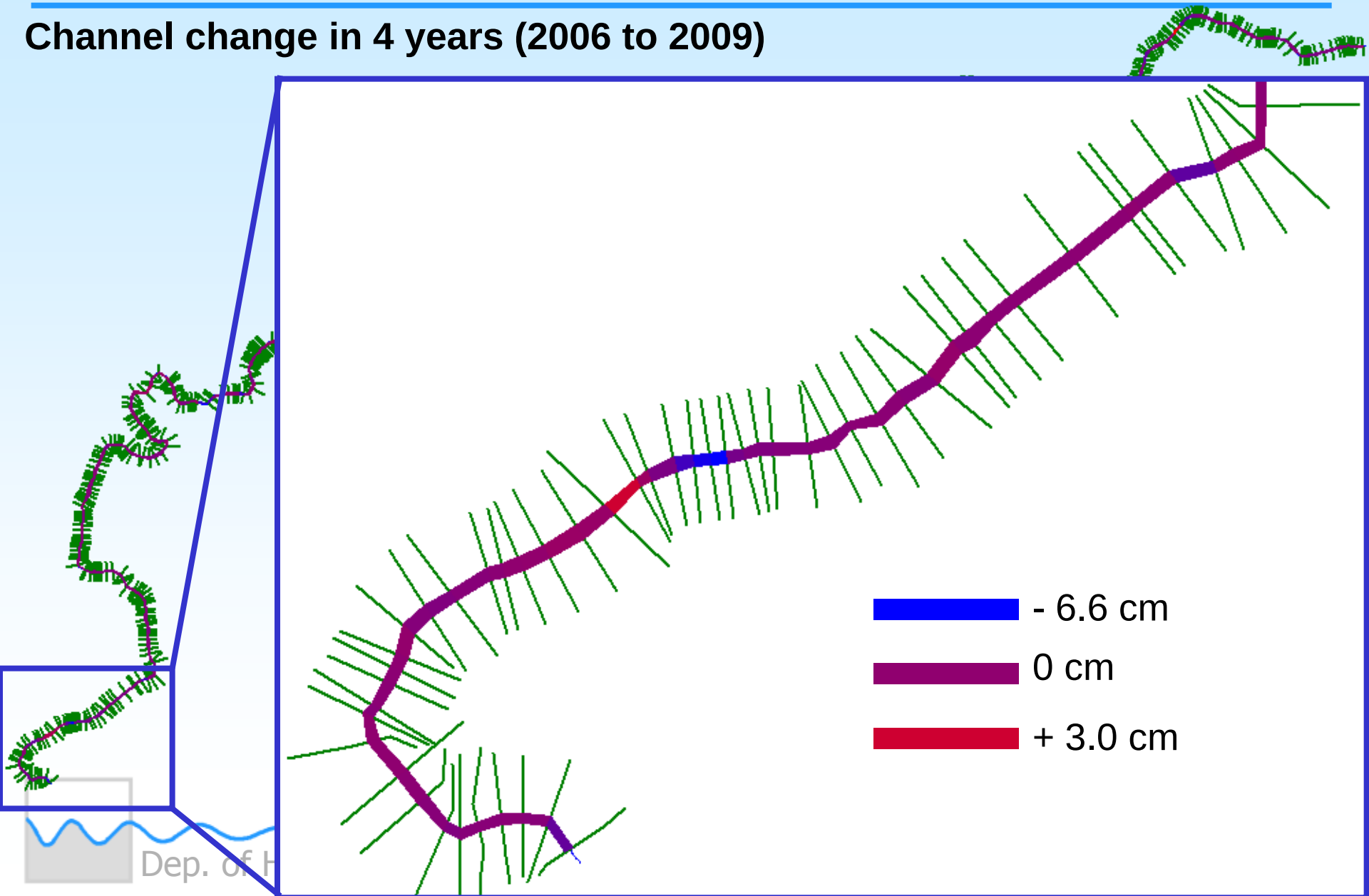


$r^2 = 0.31$, monthly $r^2 = 0.68$

1D stream sediment - spatial

HEC-RAS

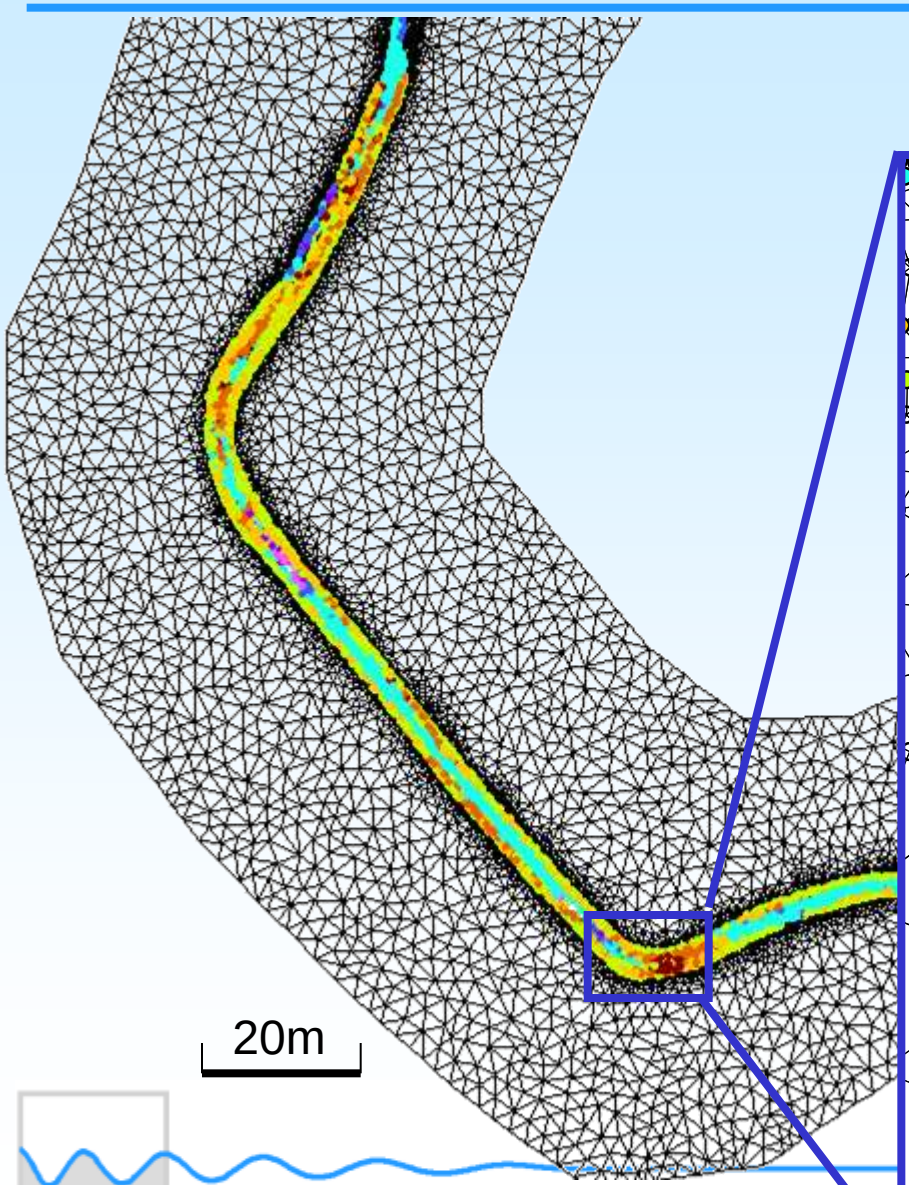
Channel change in 4 years (2006 to 2009)

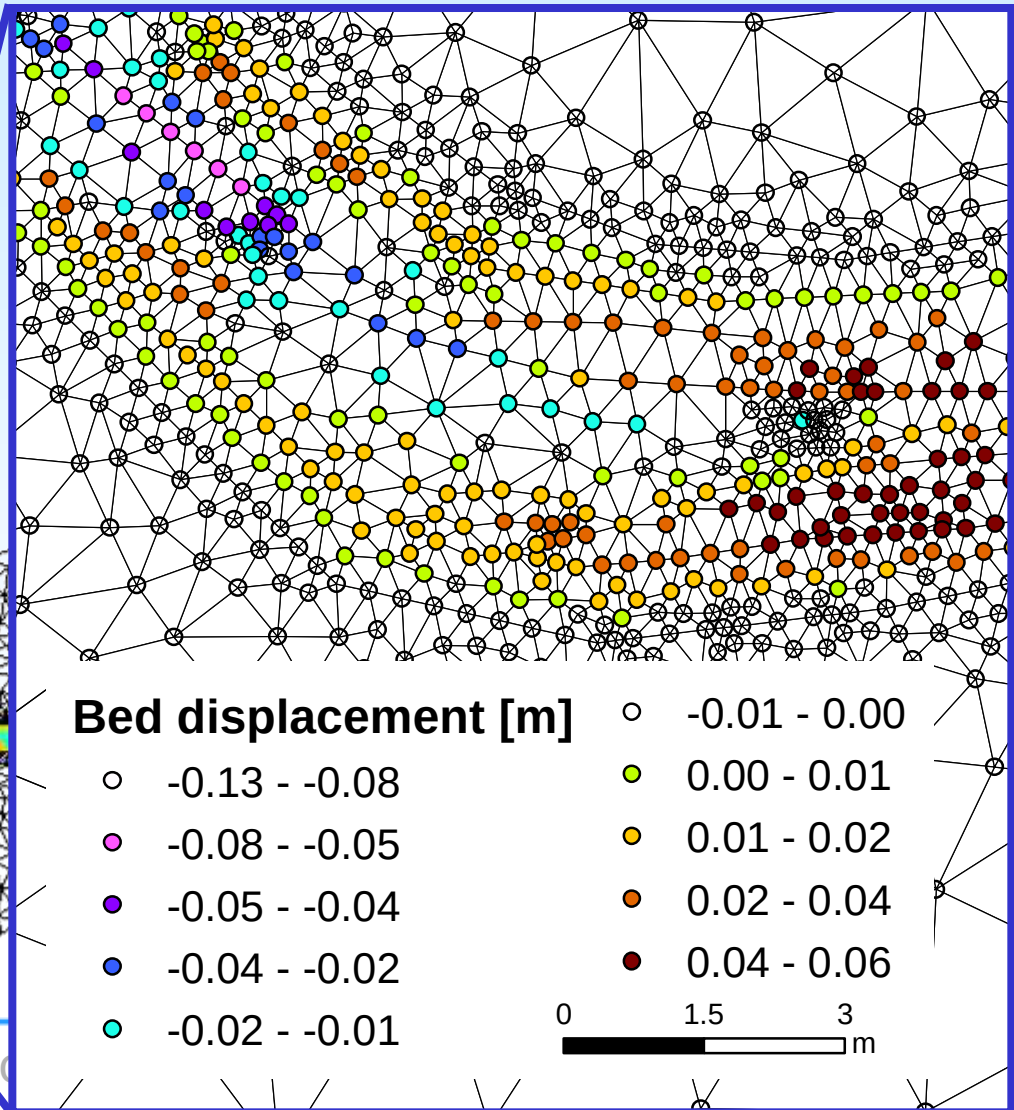


2D stream sediment

ADH

Bed displacement 01.-30. April 2008





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Discussion

- The combined SWAT – HEC-RAS model is a feasible way to model different sediment pathways over yearly periods in a reasonable resolution
- The shown temporal and spatial 1D sediment results are plausible and can be used to identify erosion and deposition sections
- The combined HEC-RAS – ADH model can simulate detailed substrate conditions, but with a high computational demand
- The shown spatial 2D sediment results need further calibration, as current displacement rates are too high
- The capability of the model system to depict hydraulic- and substrate conditions on different scales based on catchment and in-stream properties is valuable for habitat assessments

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Thank you for your attention