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UNIVERSITÄT  
BERN

OESCHGER CENTRE  
CLIMATE CHANGE RESEARCH



# Rivers do not only transport sediment: Monitoring and quantifying the **instream wood**, combining field, drone surveys, and AI

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# Flooding is not just about water



*The Ahr River, Germany, July 15, 2021*



*Saint-Martin-Vesubie, France, October 30, 2020*



*A13 Moesa River, Lostallo, June 22, 2024*



*Valencia, Spain, October 29, 2024*

# Bioecological effects



## Attachment and shelter

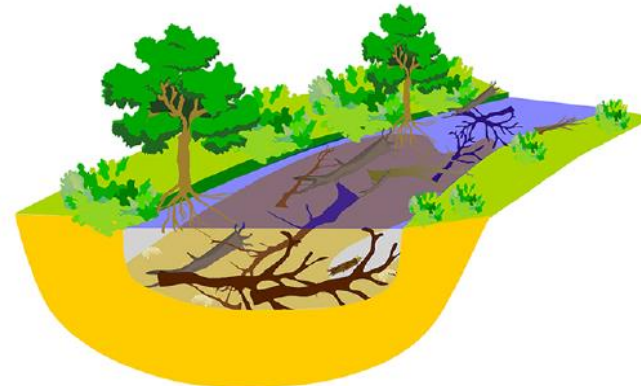
- Substrate for organisms (e.g., collectors, filter feeders, climbers, clingers)
- Residence for animals (e.g. beavers)
- Resting spots for invertebrates

## Food

- Resources for microbes (e.g. bacteria, fungi)
- Obligate and facultative xylophagous (e.g., burrowers, miners)
- Surface food provision for invertebrates (e.g., shredders, gatherers, grazers, scrapers, filter feeders, predators)

## Dispersal

- Passive and active transport of life organisms and propagules (e.g., seeds, cocoons)



## Survival

- Refuge during high flows
- Cover from predators
- Plantsuccession

## Reproduction

- Spawning & rearing (e.g., fish)
- Oviposition (invertebrates)
- Capture & germination of seeds

## Habitat enhancement

- Provision of hard substrate
- Habitat provision on the outer surface and inner matrix
- Habitat enrichment in the near surrounding (e.g. by erosion/sedimentation and flow alterations)
- Inducement of habitat dynamics in the stream bed

Verdonschot and Verdonschot, [2024](#)

See also [Lo et al., 2020](#)

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# Large wood transport during floods



Monitoring and including wood transport in flood hazard assessment is necessary

Bozkurt district of Kastamonu province (Turkey) August 2021

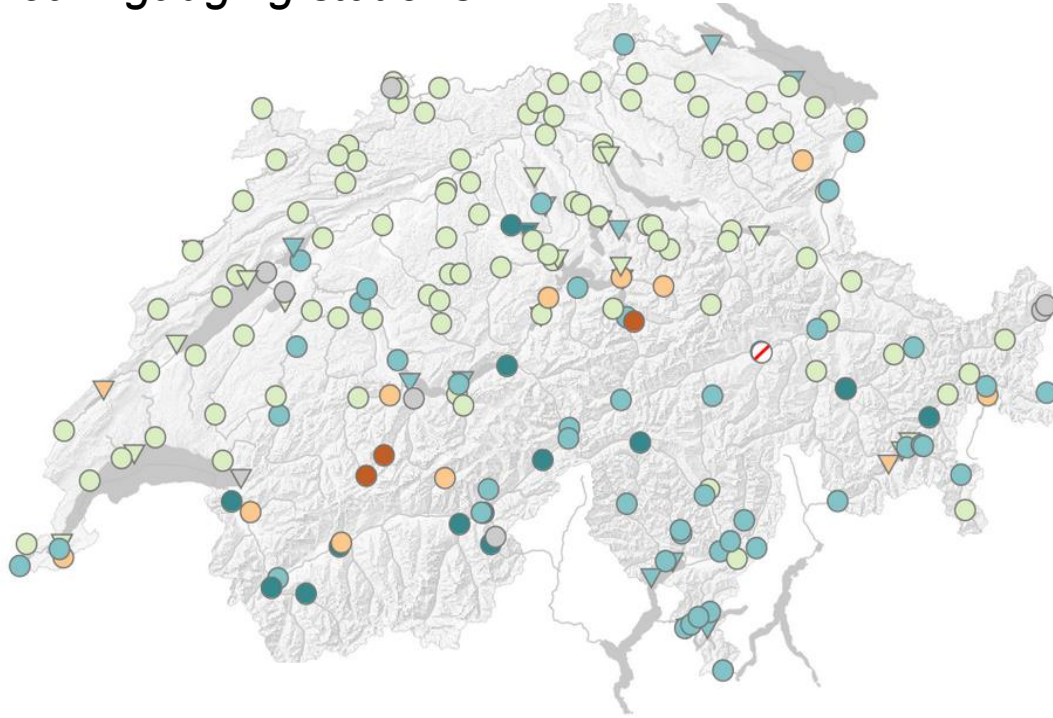
New Zealand, cyclone Gabrielle, 2022

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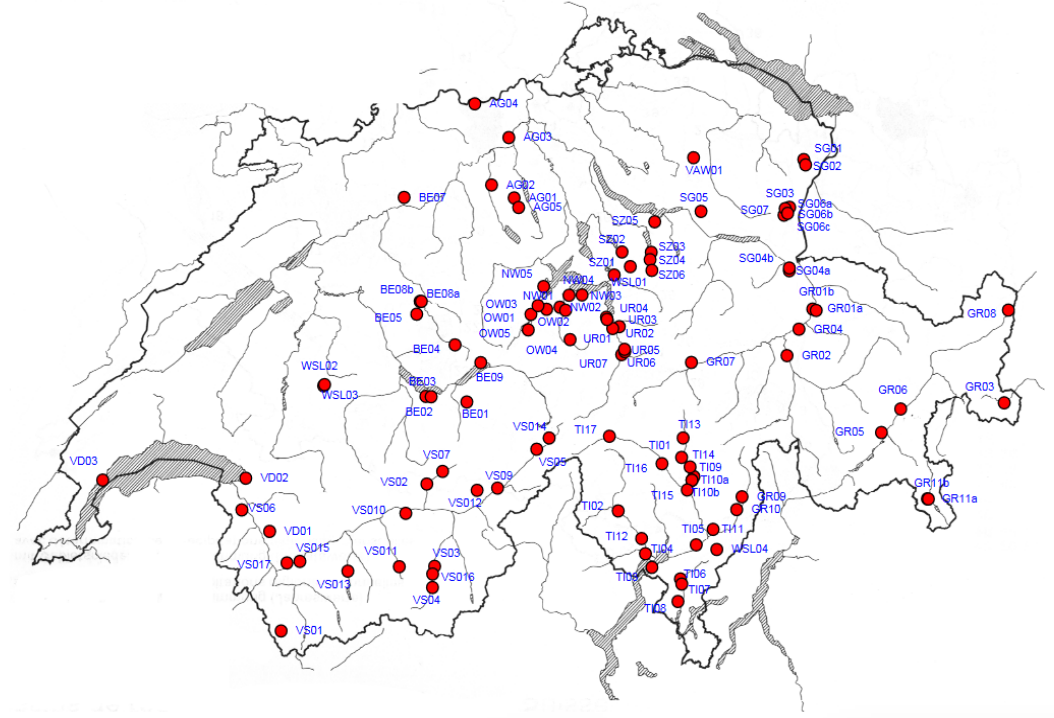
# Large wood transport during floods

Large instream wood: No monitoring stations, scarce and sparse data

Stream gauging stations



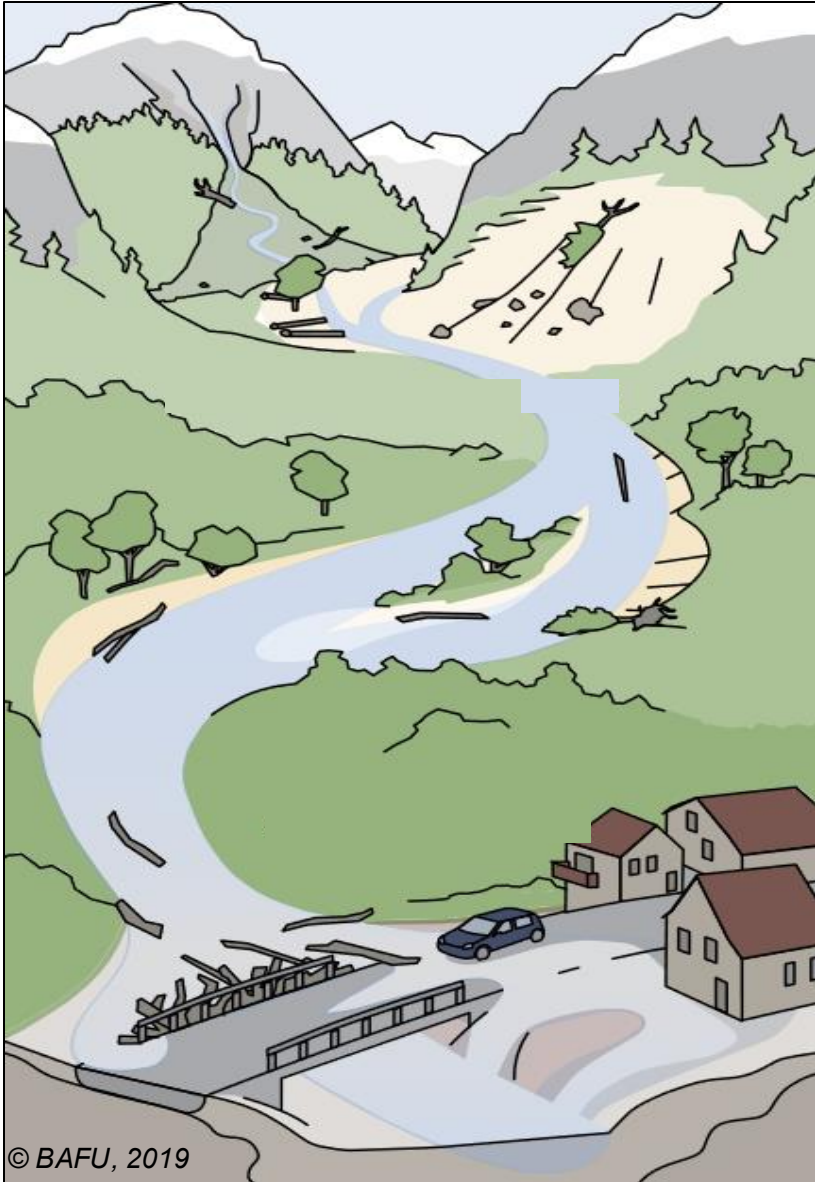
Sediment bedload monitoring stations GHO



Goal: Monitoring wood transport using cameras, drones and deep learning



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## Large wood transport

**How mobile** is the instream wood?

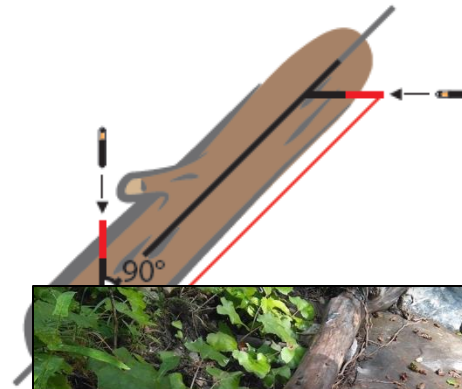
**How far** does it travel?

**How much** can be transported during a flood? **When** is it transported?

**What** are **critical sections** prone to wood trapping? and the **impacts**?

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# Tracking wood dynamics in the field

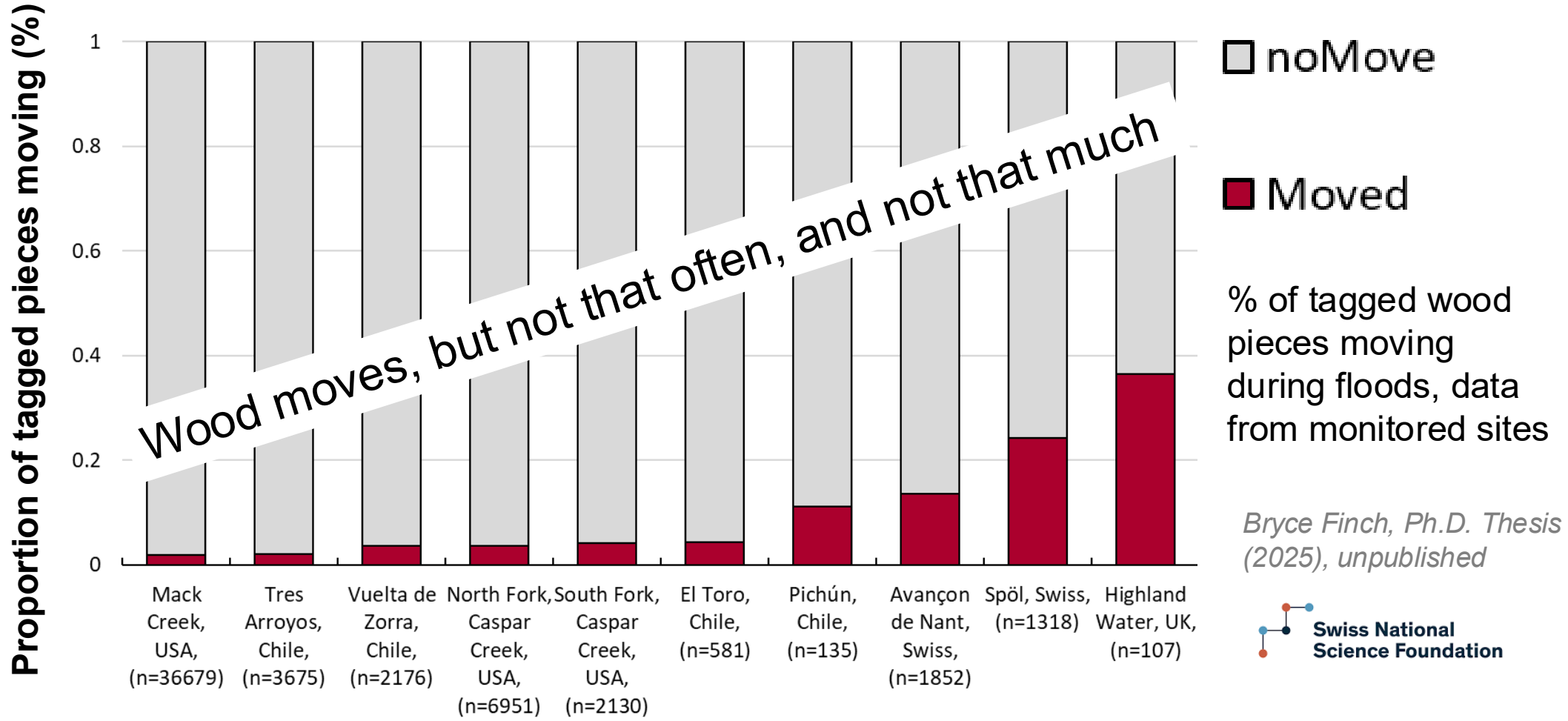


Metal and plastic tags, Radiofrequency transmitters (RFIDs)

Half Duplex (HDX) low frequency (LF)

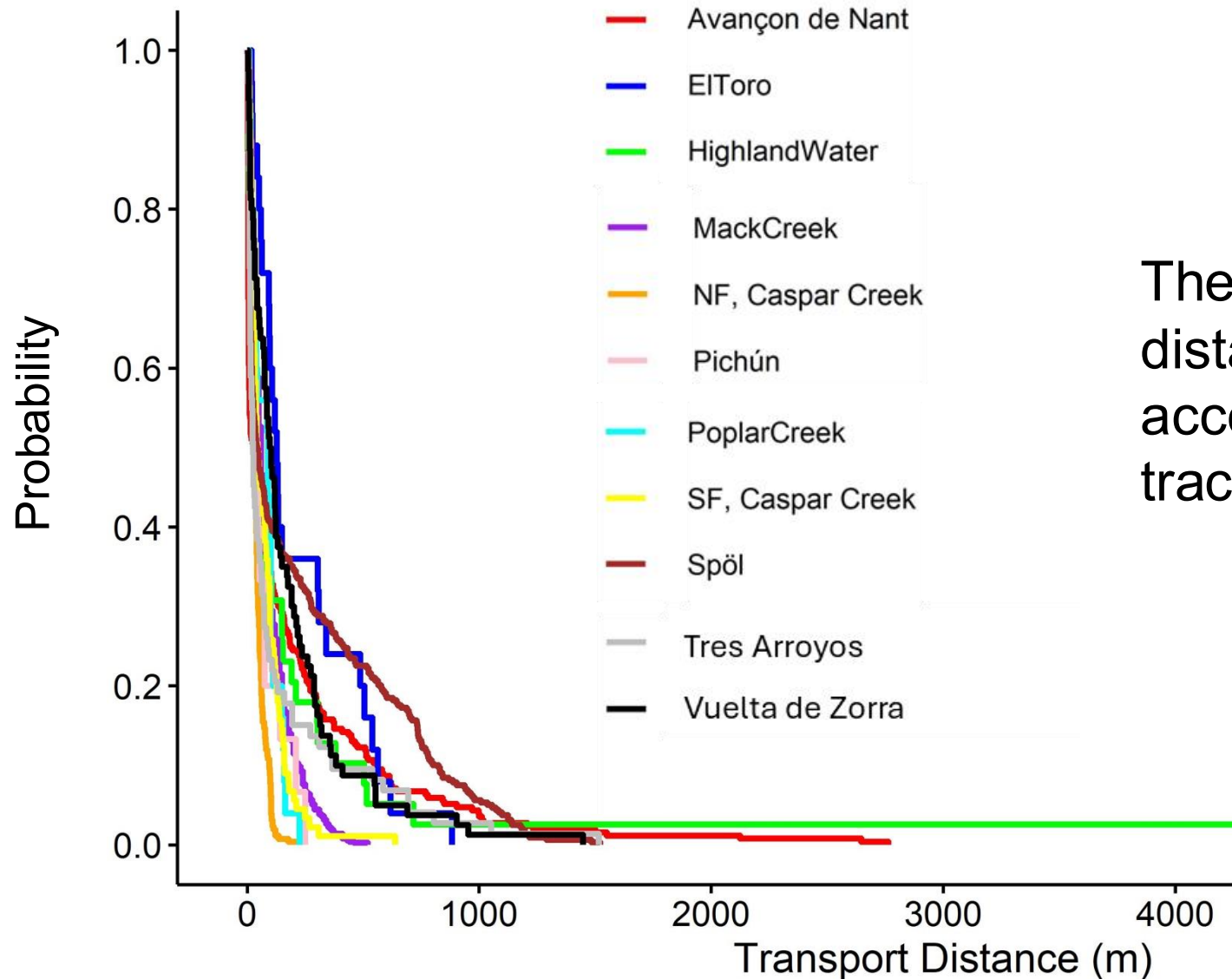
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# How much wood moves during a flood?



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# How far does wood travel?



The probability of traveling long distances is relatively low, according to observations from tracking studies



Bryce Finch, Ph.D. Thesis (2025), unpublished

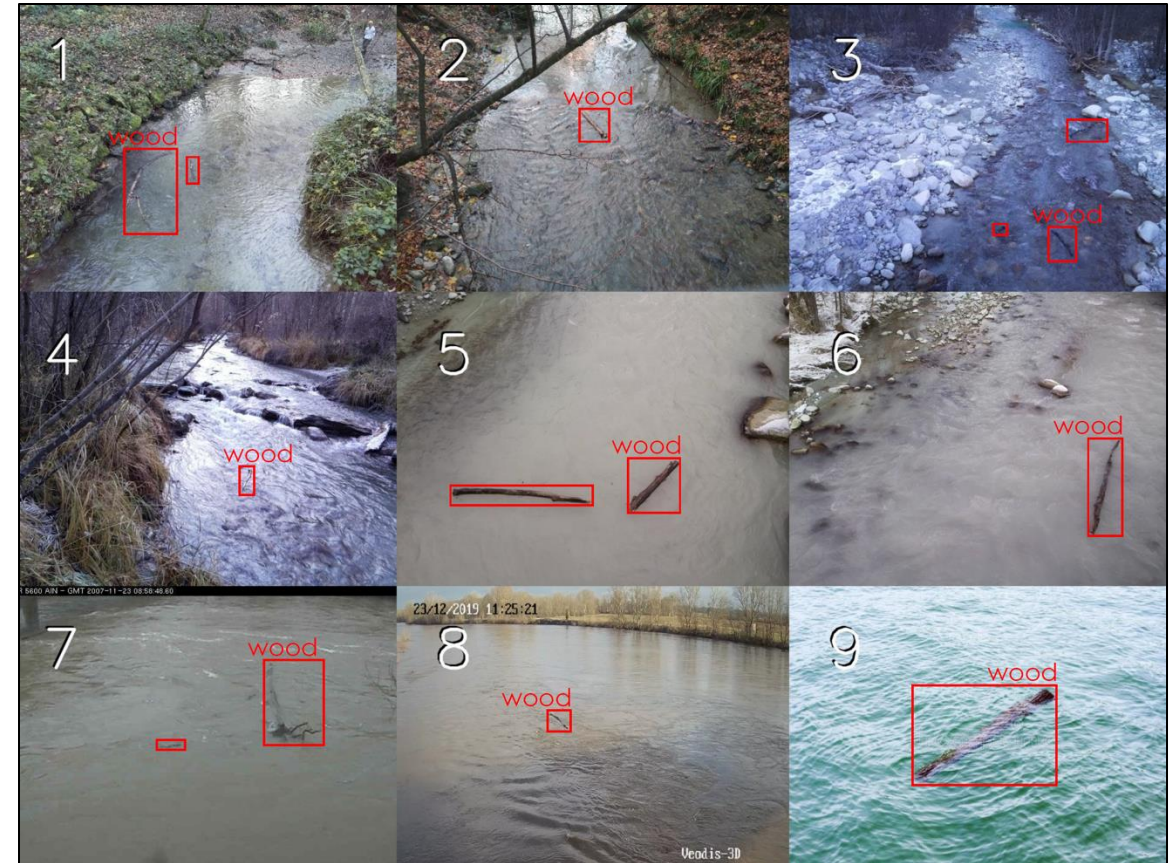
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# Data to train a CNN to detect wood in videos

Training (labelled) data



Automatic detection



 Swiss National Science Foundation

CNN Automatic tracking of wood in videos (YOLOv4)  
Janbert Aarnink, Ph.D. Thesis (2025)

Aarnink, ..., Ruiz-Villanueva, 2025 EarthSurf Dyn 10

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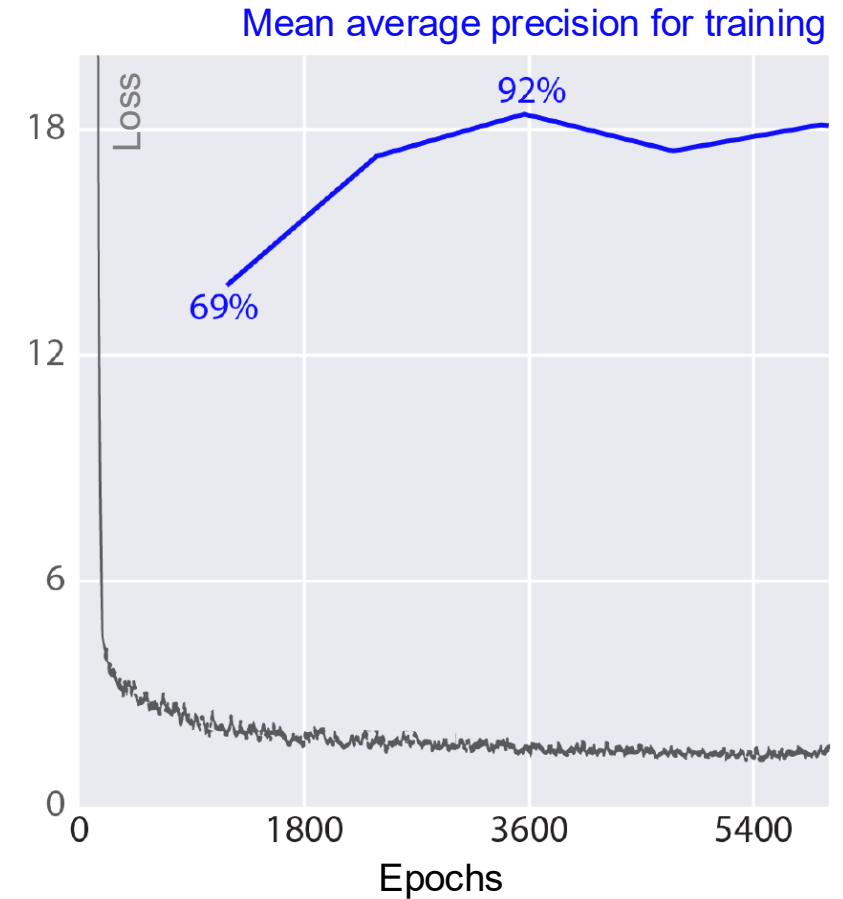
# CNN to automatically detect wood in videos



 Swiss National Science Foundation

*Aarnink, ..., Ruiz-Villanueva, 2025 EarthSurf Dyn*

*Code and data available on GitHub*



**Mean average precision for testing = 61%**

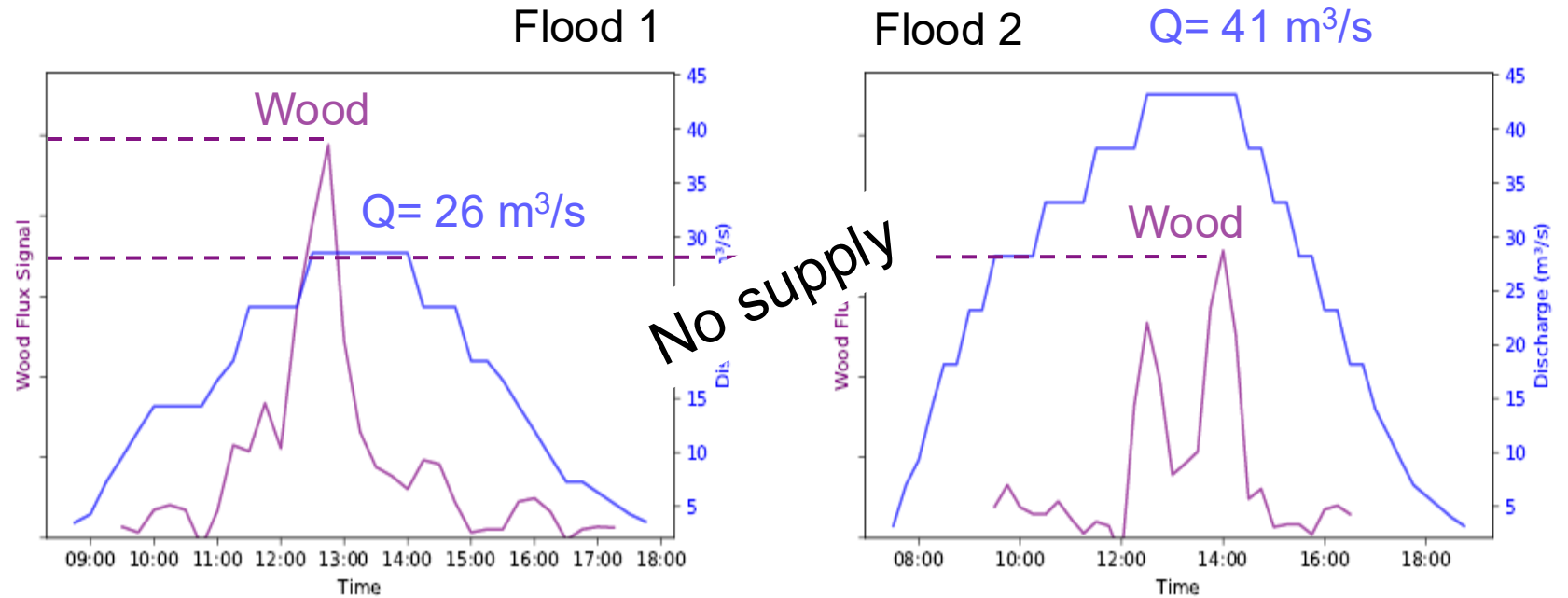
Loss= how much the model deviates from the ground truth  
Epoch = training the neural network with all the training data for one cycle

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# When does wood move during a flood?



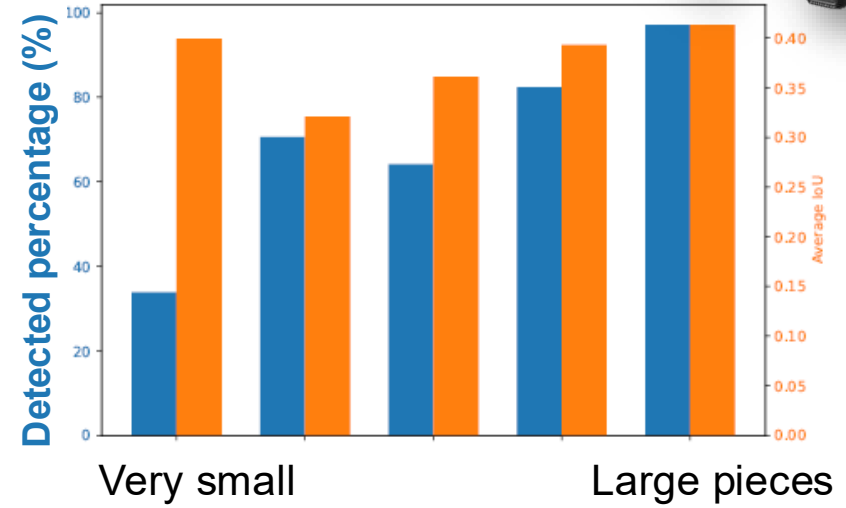
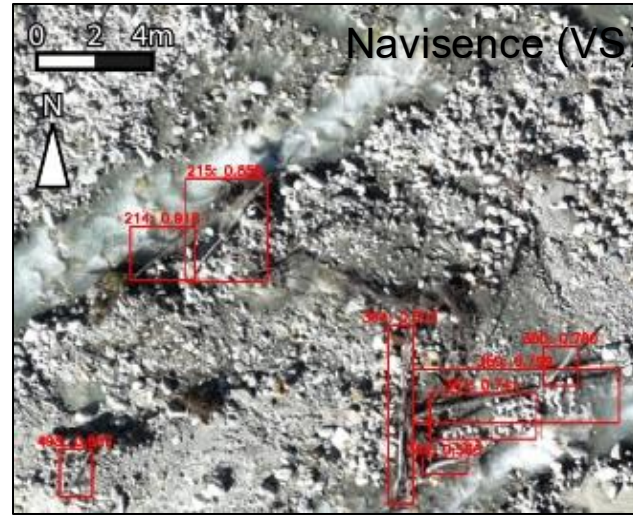
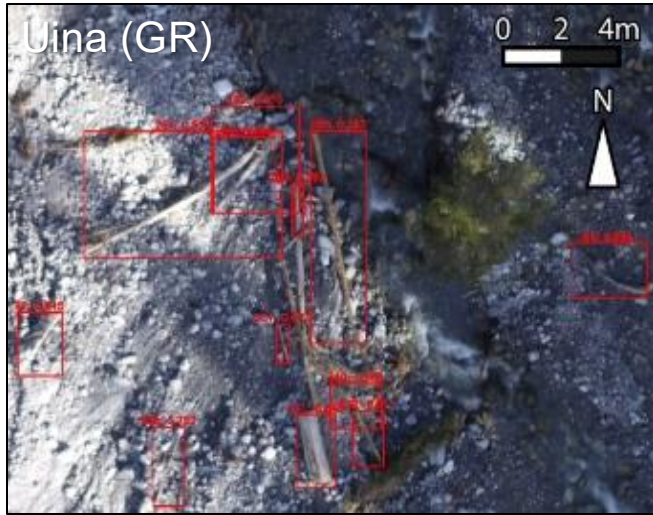
Wood transport monitoring during e-floods in the Spöl River (Graubünden)



Wood fluxes are governed not only by the forces of the water flow, but also by the river morphology, the availability of wood, and the flood history

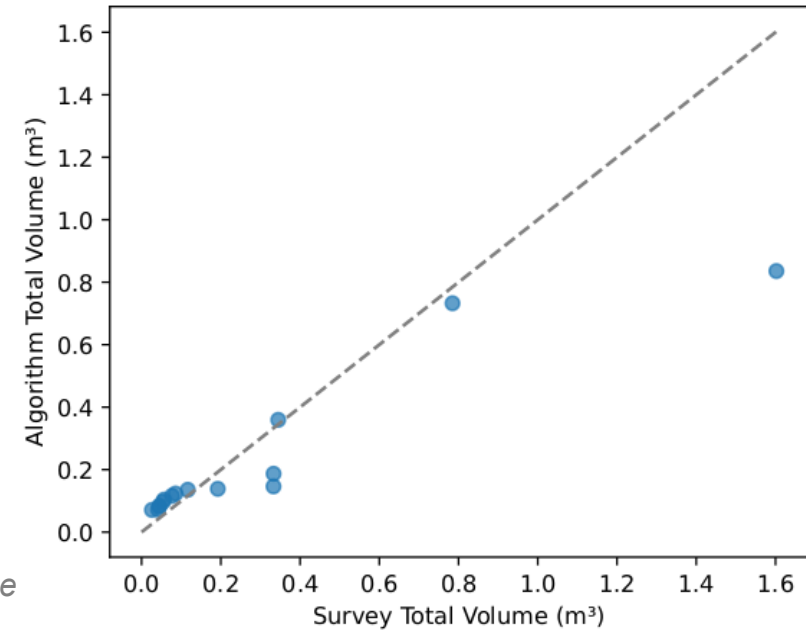
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# Wood storage automatic quantification



Very small

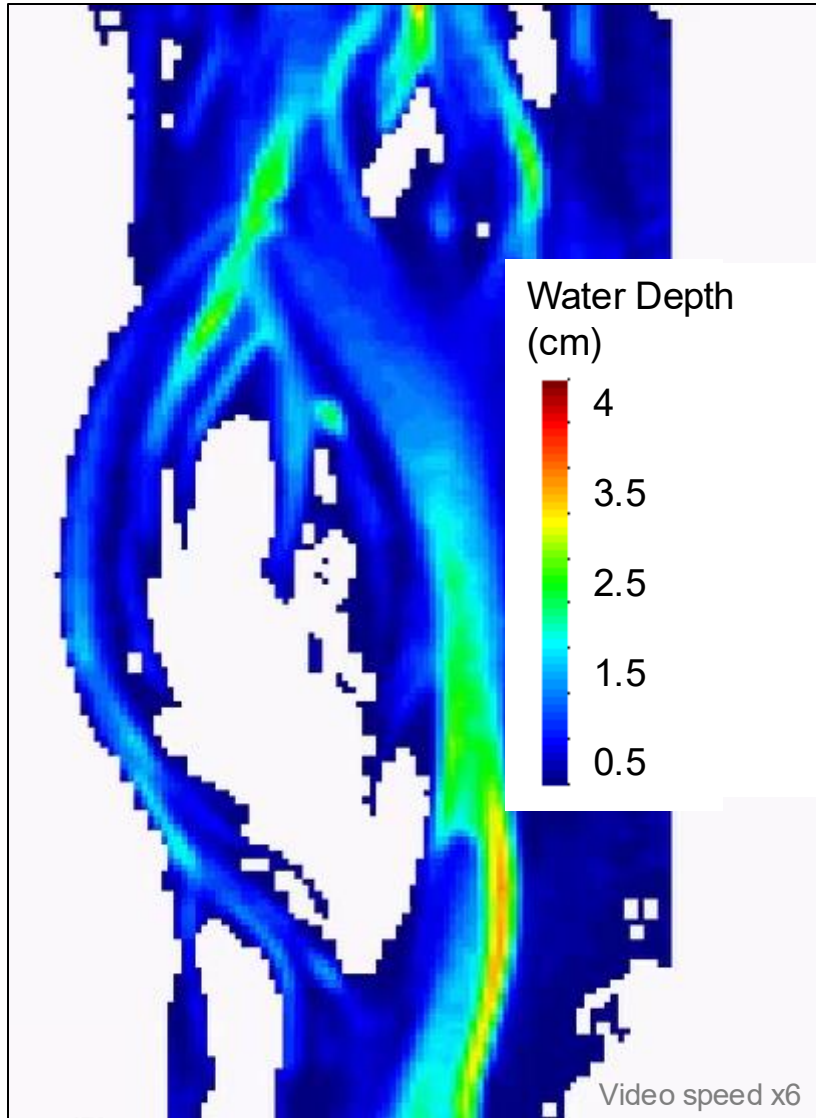
Large pieces



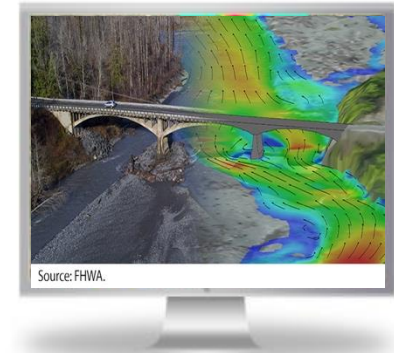
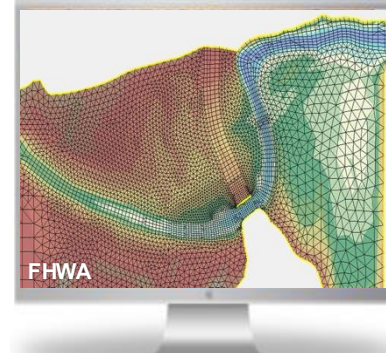
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# Numerical modelling of wood transport

Braided river (simulation of flume experiments)



Ruiz-Villanueva et al., 2020 WRR



## Hydrodynamics + sediment

depth averaged  
shallow water  
(2D- De St. Venant)  
equations

2D Exner +  
Meyer-Peter and Müller,  
Van Rijn,  
Engelund-Fredsoe, and others

## + wood transport

Lagrangian\*  
(discrete element)  
approach

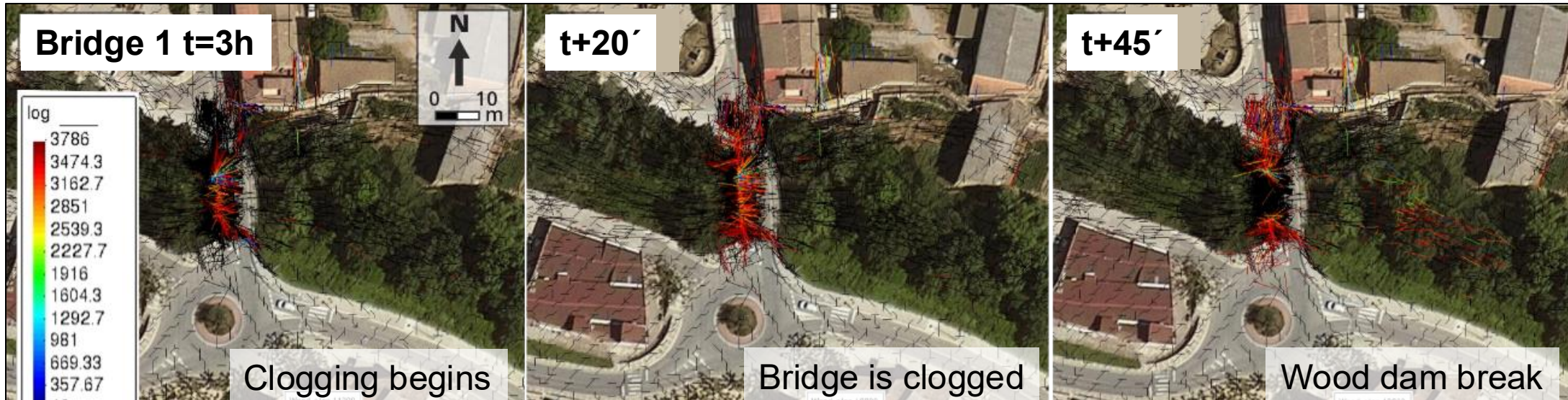
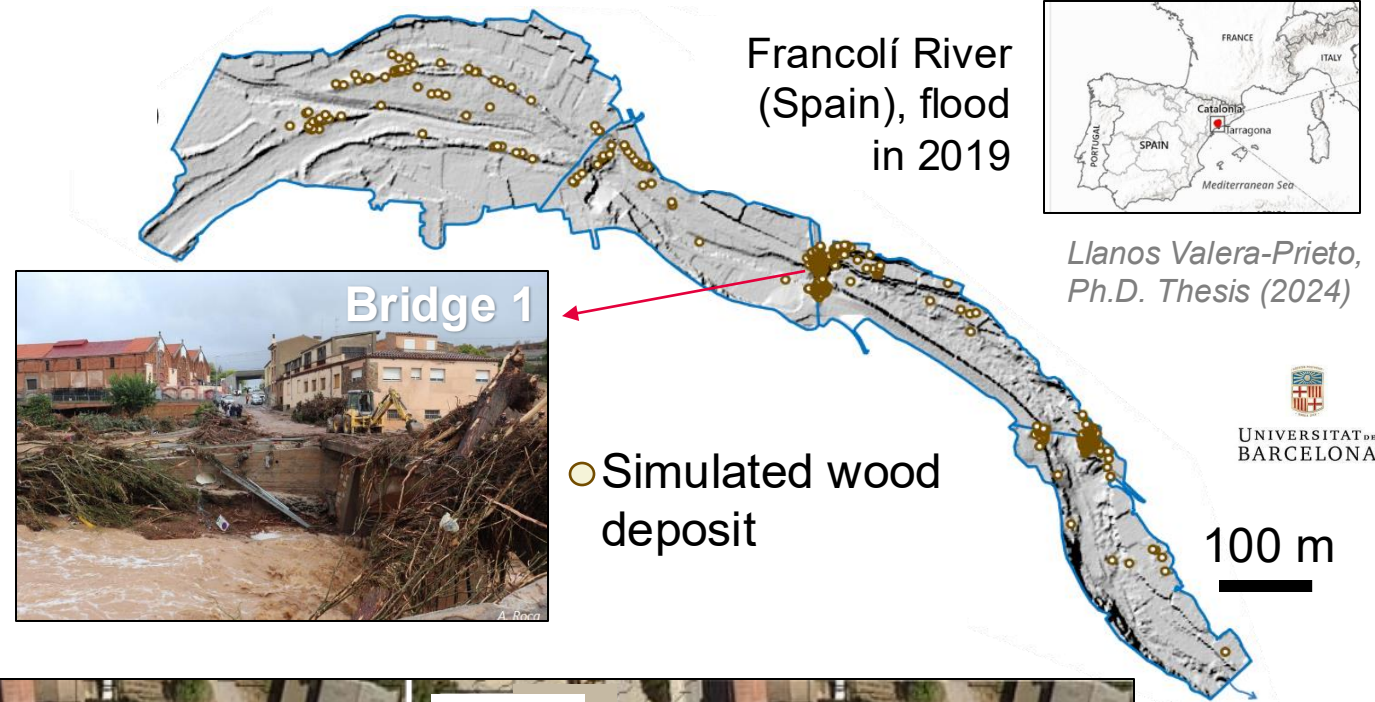
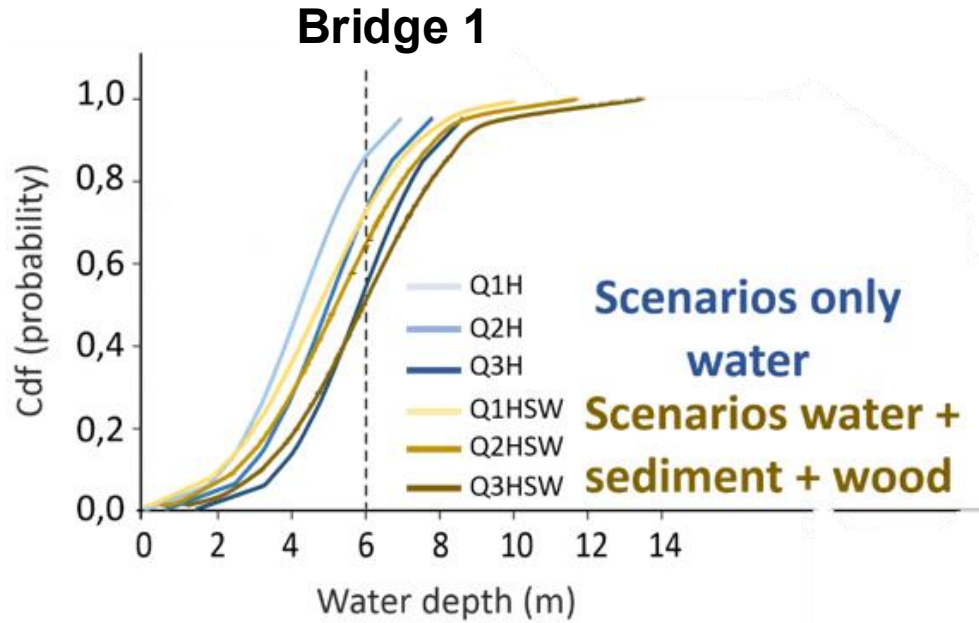


<https://iberaula.es/>

Ruiz-Villanueva et al., 2014 J. Hydroinformatics

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# Bridge clogging and dam breaching



Valera-Prieto et al., under review

# $u^b$ Take home messages

- ✓ Flooding is much **more than overbank water flow**; morphological changes, sediment, and **instream wood** transport, are key aspects but **still rarely considered in flood hazard and risk** assessment
- ✓ **Effective flood risk** management starts by **identifying** river reaches and bridges or **critical sections** prone to accumulating **wood**
- ✓ **Monitoring and modelling** wood dynamics must be **expanded**
- ✓ Field surveys, tracking, cameras and drones **combined with machine learning** offer powerful opportunities
- ✓ **Instream large wood** is a **functional component** of **healthy fluvial ecosystems**, as important as flow, sediment, and vegetation, **removal is not the solution!**



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***Thank you for your attention!***