Numerical Application of the Threshold Conditions for Vegetation Removal during record flood in the Meuse River

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Equation for vegetation dynamics

$$\frac{\partial \phi}{\partial t} = \underbrace{\alpha_g \, \phi \, (\phi_m - \phi) \frac{t_g}{T}}_{\text{Growth}} - \underbrace{\alpha_d \, \phi \, Y \, V^2 \frac{t_d}{T}}_{\text{Decay}}$$

Threshold conditions for vegetation removal

$$V_c = \sqrt{\frac{\alpha_g \, t_g}{\alpha_d \, t_d} \frac{\phi_m}{Y}}$$

V_c = Threshold flow velocity [m / s]

ϕ = vegetation density

ϕ_m = Carrying capacity

α_g = growth coefficient

α_d = decay coefficient

t_g = growth duration

t_d = decay duration

Y = water depth

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Biomorphological scaling laws from convectively accelerated streams

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Geophysical Research Letters

Threshold Conditions for the Shift Between Vegetated and Barebed Rivers

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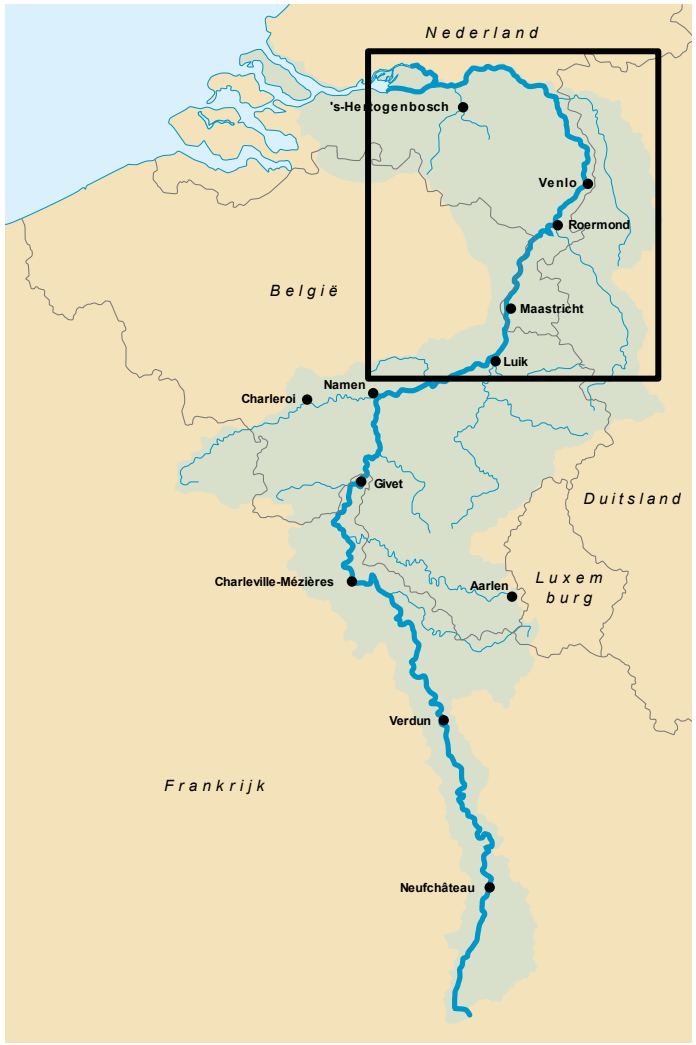
Ombrone River (Italy)
before and after November 2016 flood

The Dutch Meuse River



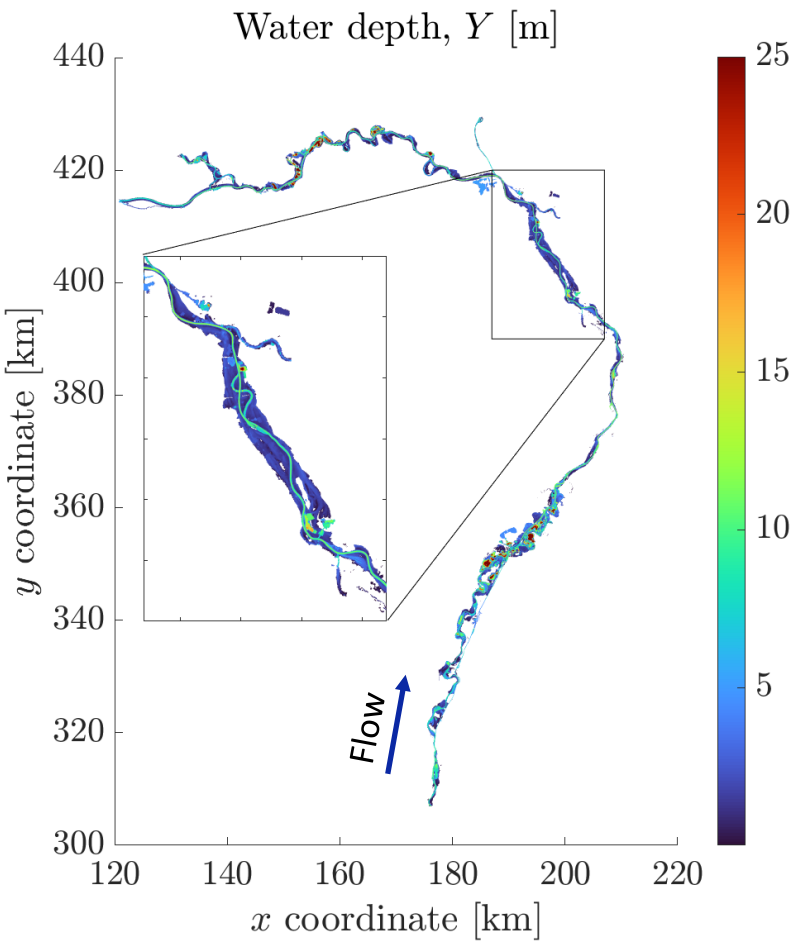
Riparian vegetation along the Meuse River (Netherlands).

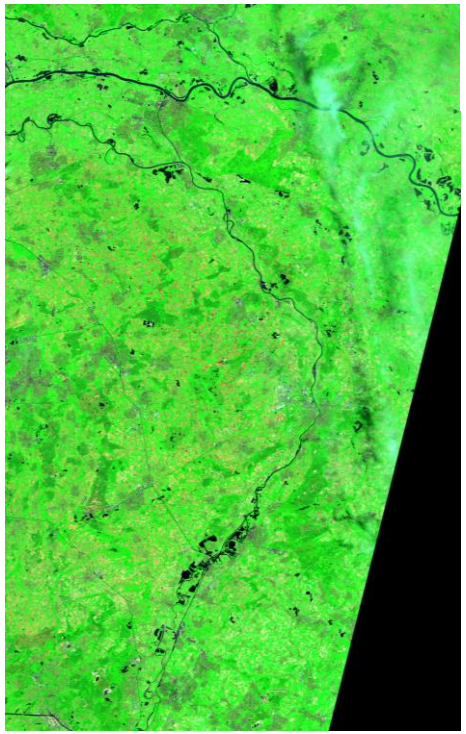
Courtesy of Hermjan Barneveld (@WUR)

The flood event in the Meuse River – 17 July 2021

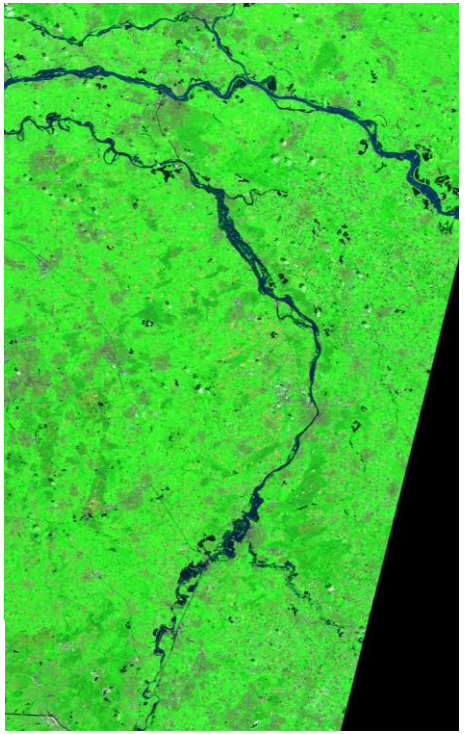
The flood event in the Meuse River – 17 July 2021

Numerical simulations with Delft3D





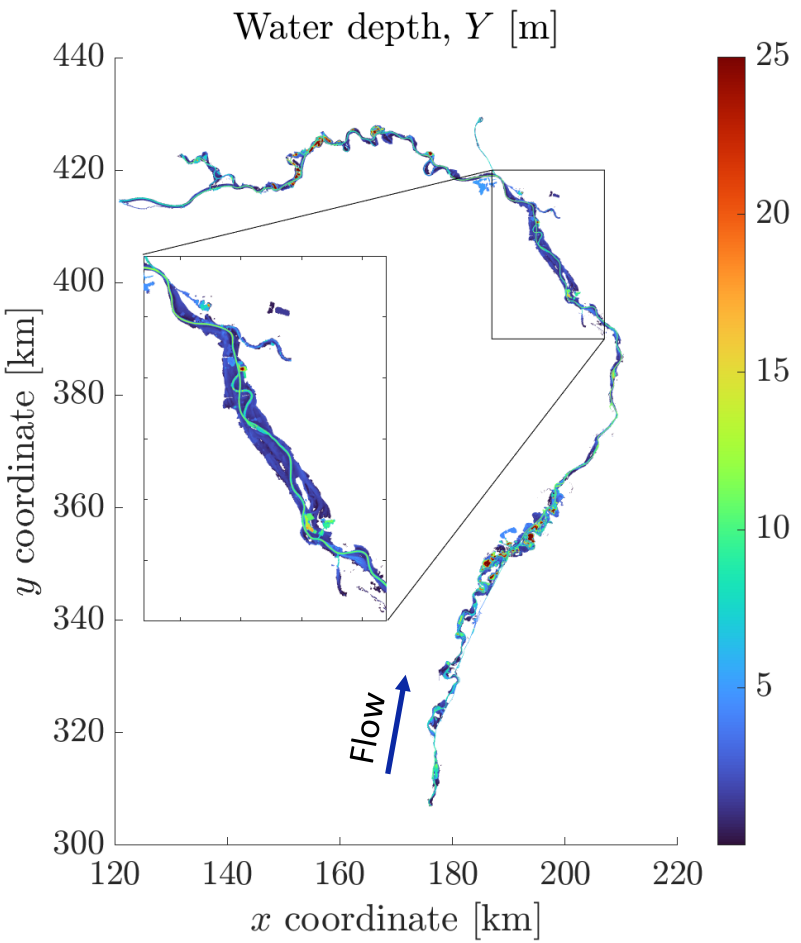
16 July 2021
before the flood event

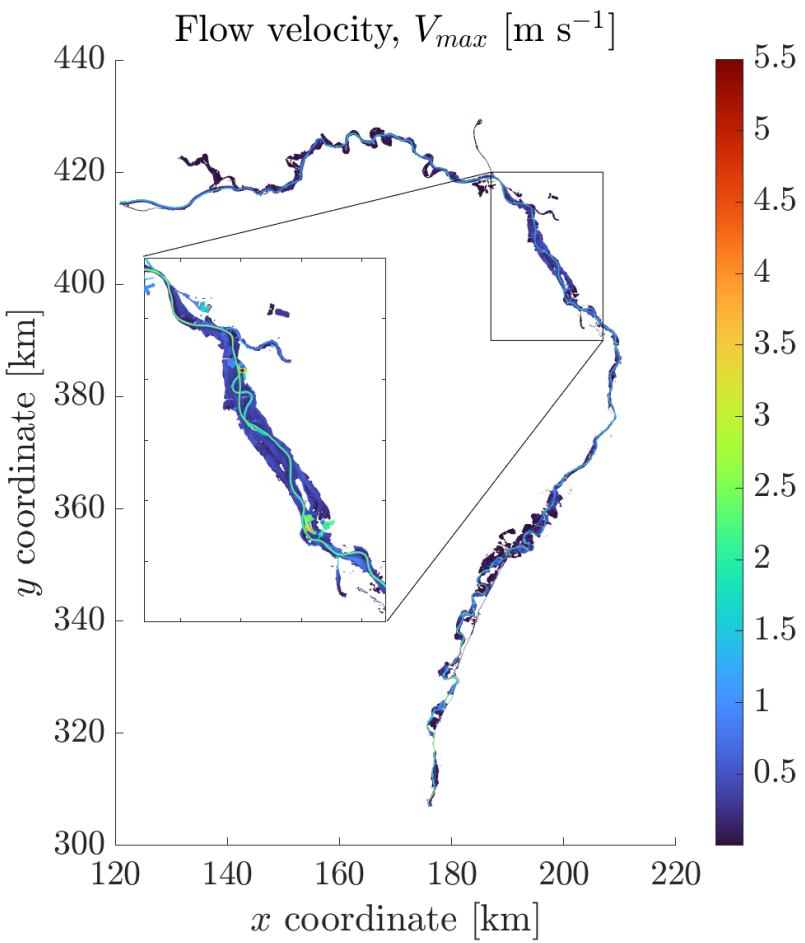


19 July 2021
after the flood event

The flood event in the Meuse River – 17 July 2021

Numerical simulations with Delft3D





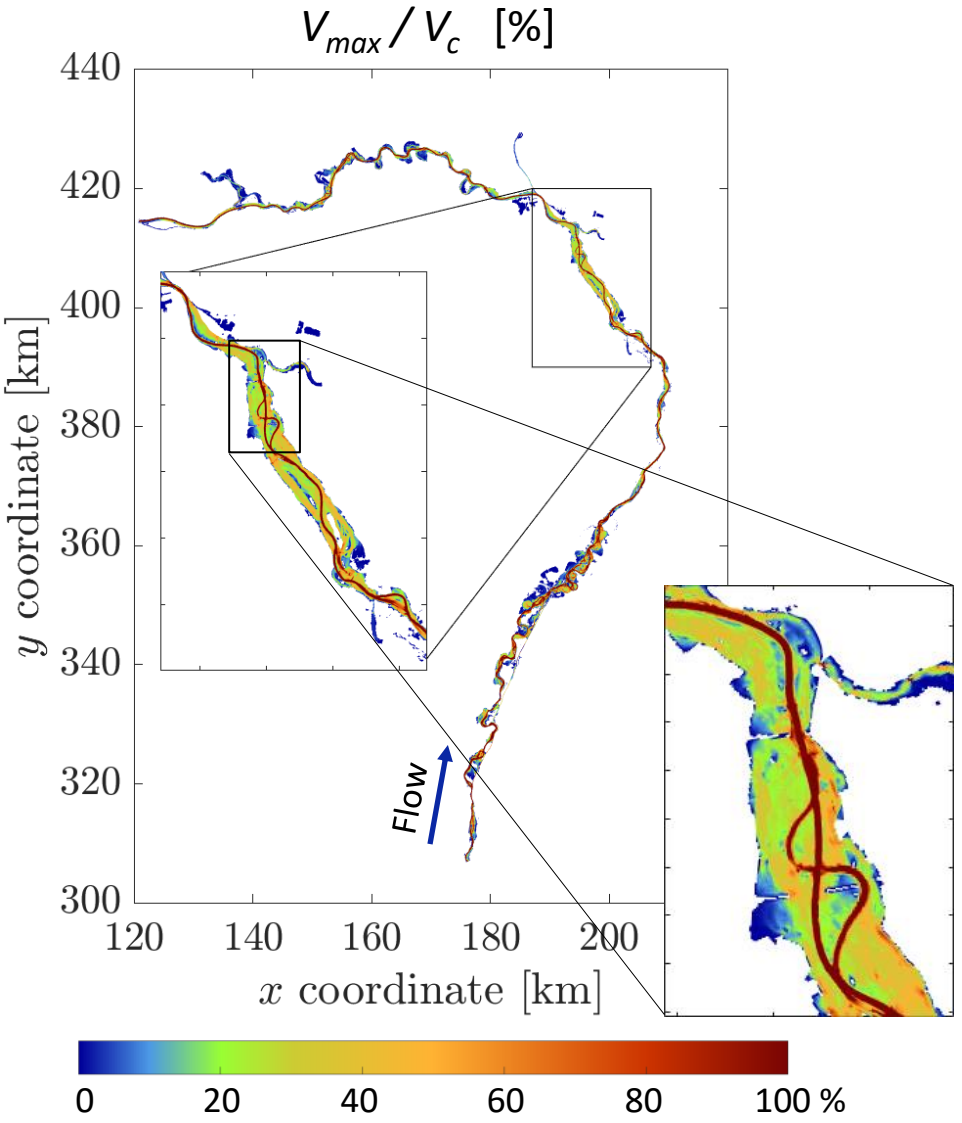
Maps of vegetation removal

Flow velocity-to-threshold ratio

Type of vegetation: willows

V_c = 1.1 m/s (area around Weir Sambeek)

V_c is point-by-point variable (depends on Y)



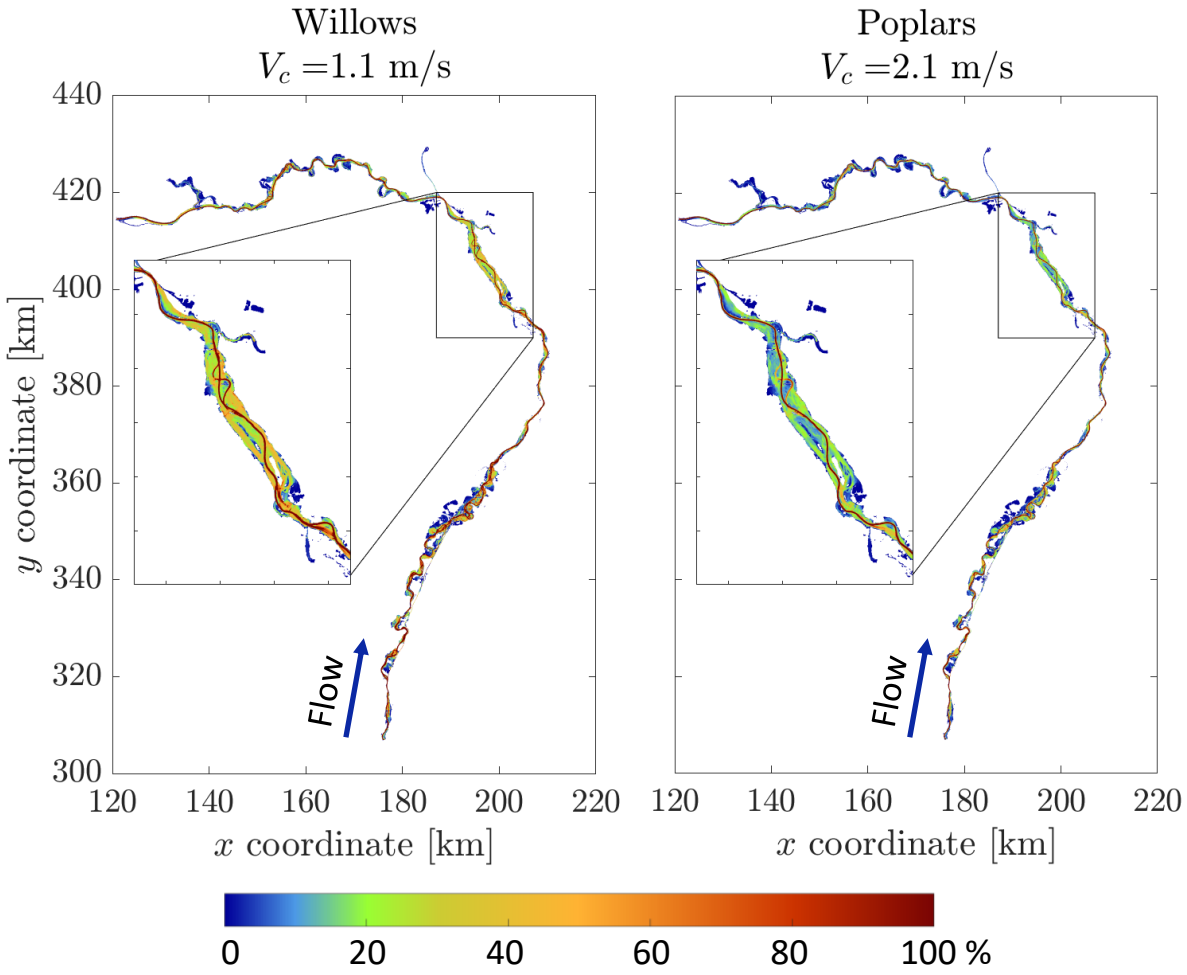
Maps of vegetation removal

Flow velocity-to-threshold ratio (V_{max} / V_c) [%]

Comparison among different types of plants

Willows are more prone to be uprooted than poplars

Important for the design of river restoration projects



Conclusion and future perspectives

- Vegetation characteristics are averagely quantified
- Regions susceptible to plant removal are clearly identifiable
- Plant removal may increase river dynamics and wood transport processes
- Comparison to field measurements and observations

References

- Calvani, G., Perona, P., Schick, C., & Solari, L. (2020). Biomorphological scaling laws from convectively accelerated streams. *Earth Surface Processes and Landforms*, 45(3), 723-735.
- Calvani, G., Carbonari, C., & Solari, L. (2022). Threshold conditions for the shift between vegetated and barebed rivers. *Geophysical Research Letters*, 49, e2021GL096393.
- Edmaier, K., Burlando, P., & Perona, P. (2011). Mechanisms of vegetation uprooting by flow in alluvial non-cohesive sediment. *Hydrology and Earth System Sciences*, 15(5), 1615-1627.

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