Is hydraulic modelling parametrization the major source of variability in flood hazard assessment? Insight into hydrologic uncertainty and the role of design rainfall in probabilistic flood maps

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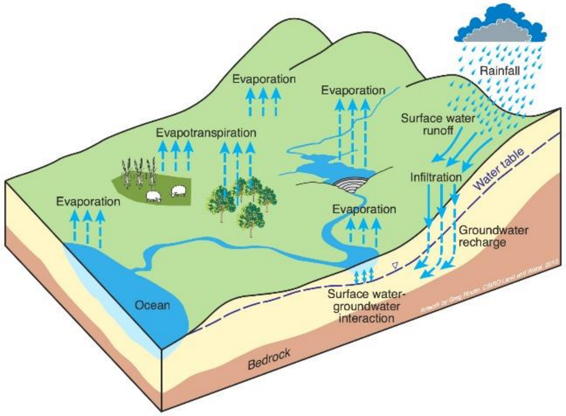
Flood hazard maps

- Lack of available flow time series for most of the secondary river networks worldwide
- Need for using rainfall-runoff modeling



Source: ewater.org.au

Research Question

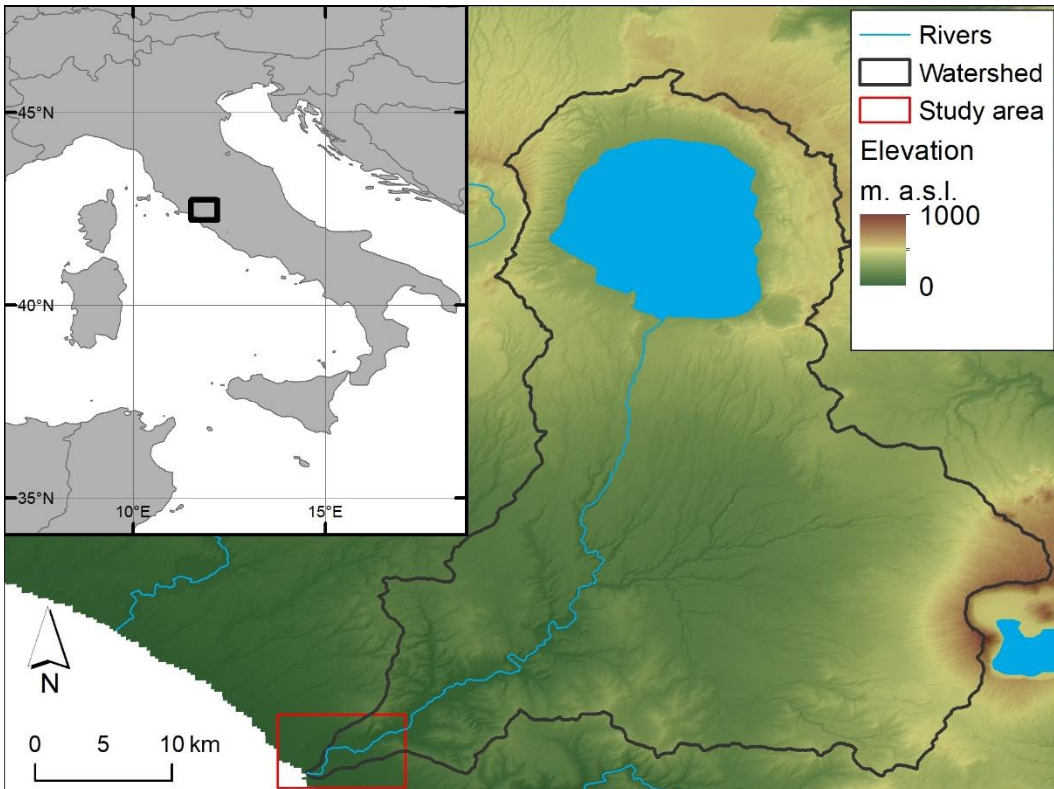
- How the uncertainty of the **hydrologic** component can impact the **inundation maps**, compared to the **hydraulic** uncertainty?

Uncertainties related to inundation maps

Macro areas	Main uncertainties	Components of each uncertainty
Hydrology	Extreme rainfall intensity values	Rainfall measurements
		Limited time series length
		Statistical inference
		Parameter estimation
	Infiltration coefficient	Initial soil moisture condition
		Soil type
		Infiltration model
		Numerical simplification
		Parameters calibration
	Flow hydrograph	Model simplifications
		Parameters calibration
Hydraulics	Topography	Changes of the channel/floodplain geometry over time
		DEMs/surveys inaccuracies
	Flood wave propagation	Numerical simplification
		Parameter estimation

Study area

Marta river basin (Downstream part)

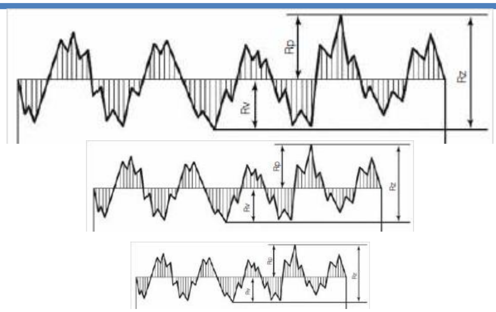


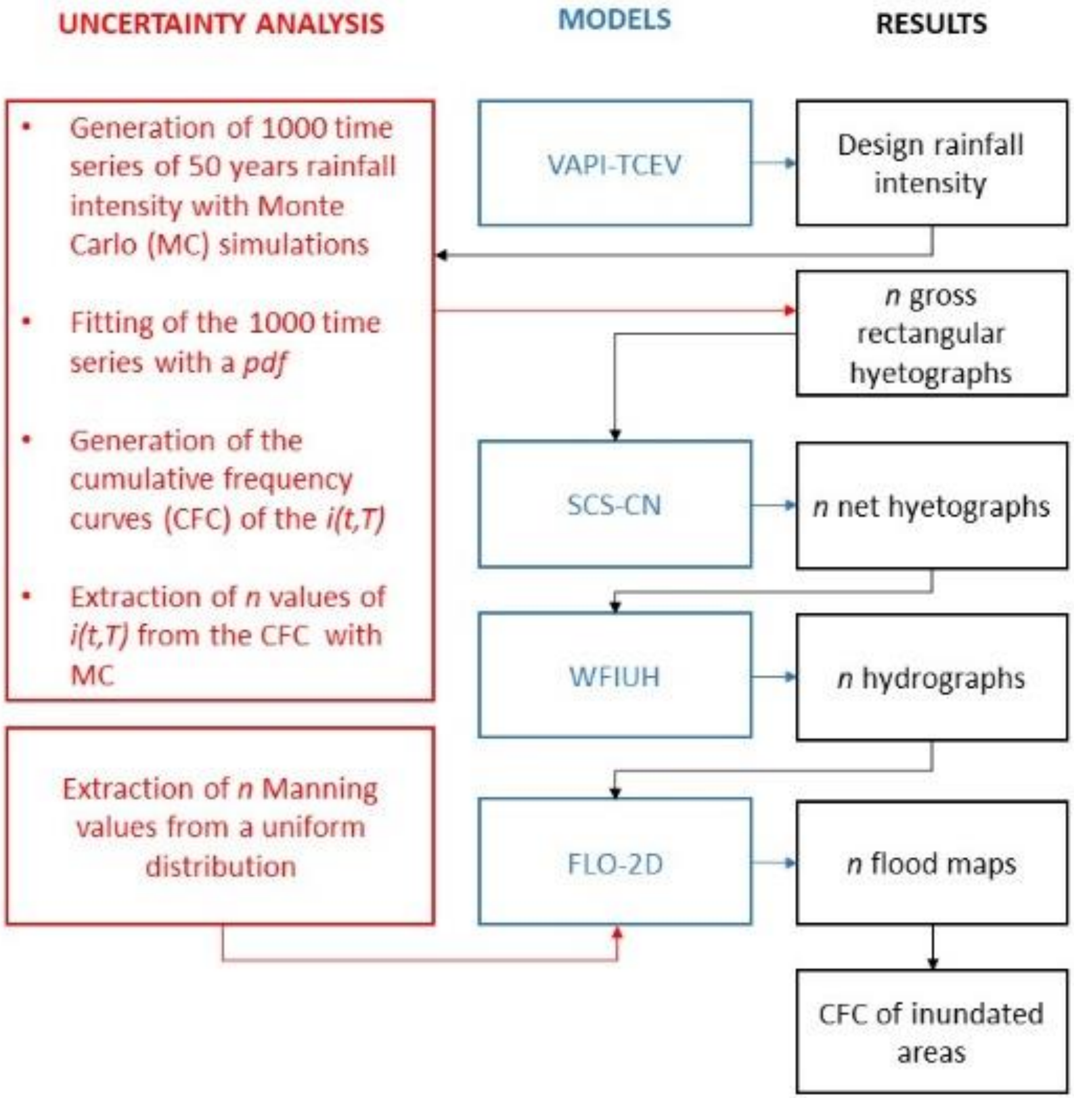
Methodology

Representation of hydrologic and hydraulic uncertainties with Monte Carlo simulations perturbing…

…Synthetic rainfall

…Roughness

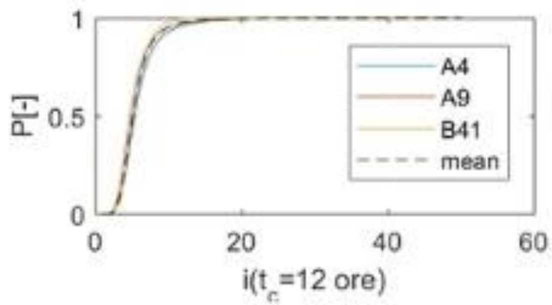




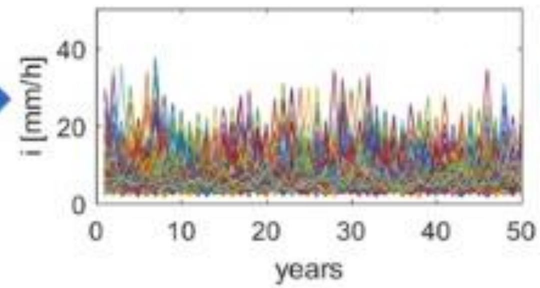
Flow diagram of the models and methods to generate the cumulative frequency curve (CFC) of the inundated areas considering the uncertainties related to the rainfall intensity and the floodplain roughness.

Methodology – rainfall uncertainty

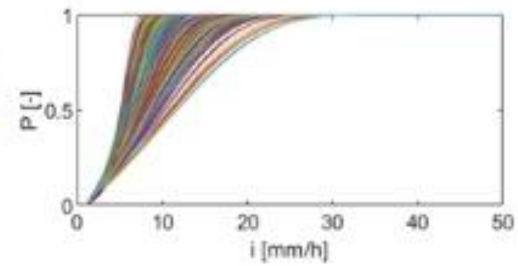
Starting point: rainfall distribution (TCEV-VAPI)



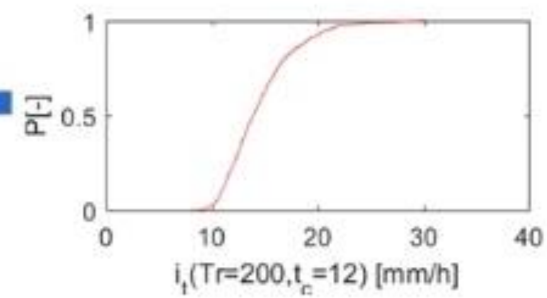
Monte Carlo generation of 1000 synthetic series



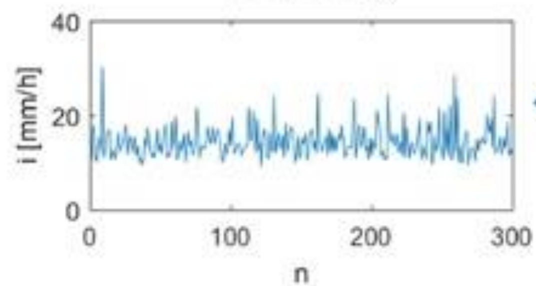
Fitting of the series by a TCEV distribution and extraction of i(T)



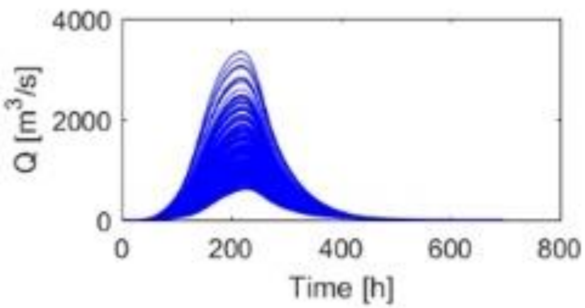
Extraction of the cumulative frequency for i(T)



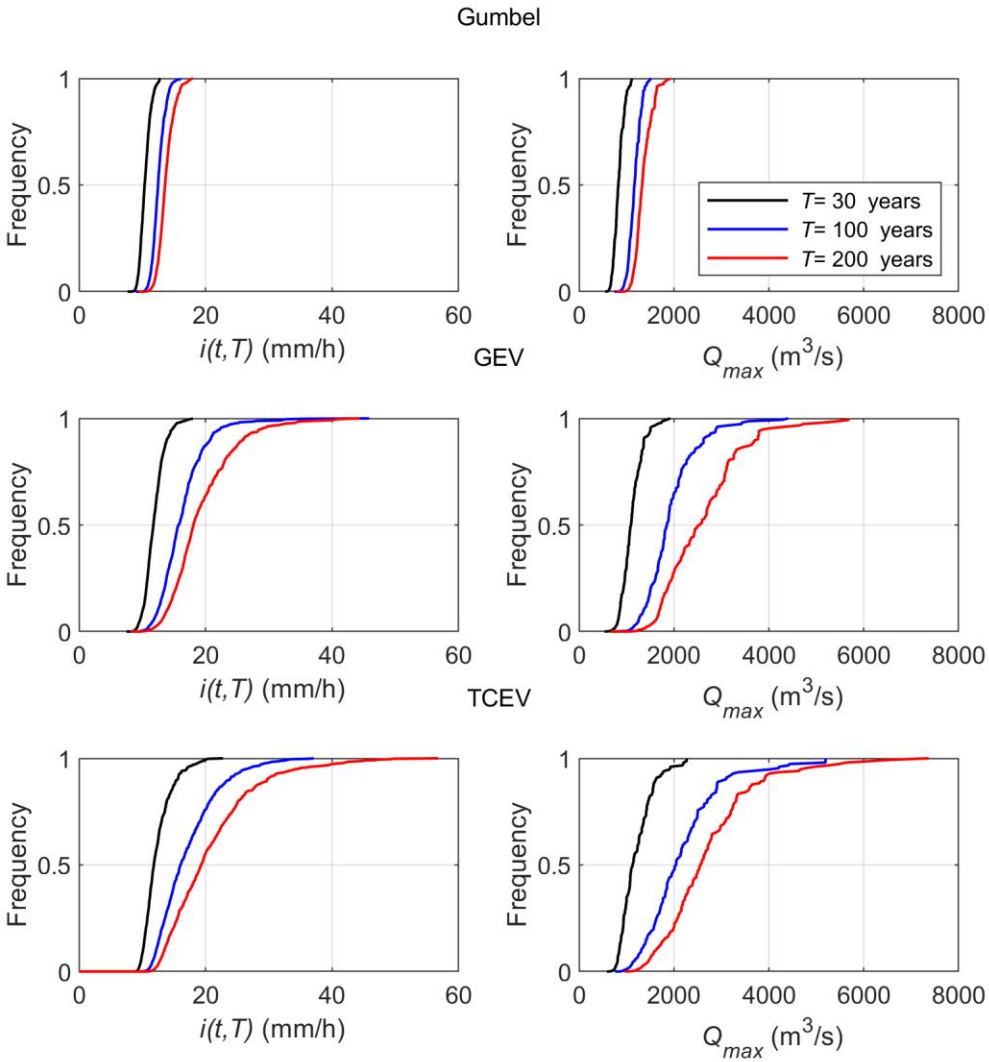
Monte Carlo generation of *n* i(T) from the cumulative frequency



Generation of *n* design hydrographs by WFIUH and SCS-CN methods

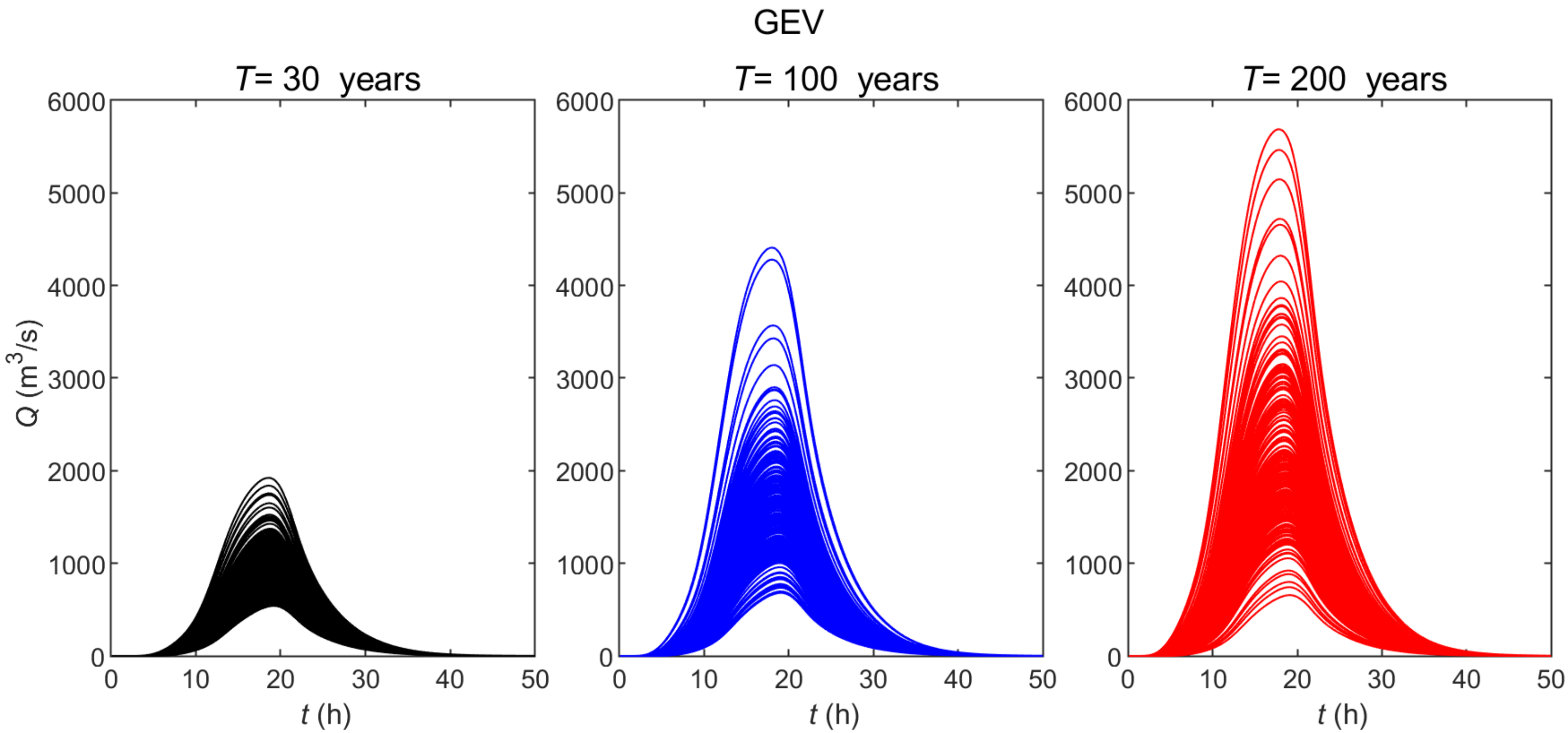


Methodology – rainfall uncertainty



Cumulative frequency distributions of rainfall intensity and the corresponding peak flow for each return period (T = 30, 100 and 200 years) and for each probability model considered in the analysis (Gumbel, GEV and TCEV).

Methodology – rainfall uncertainty



Design hydrographs derived adopting a Monte Carlo approach for return periods T = 30, 100 and 200 years using the GEV probability distribution to interpret the frequency behaviour of the rainfall synthetic time series

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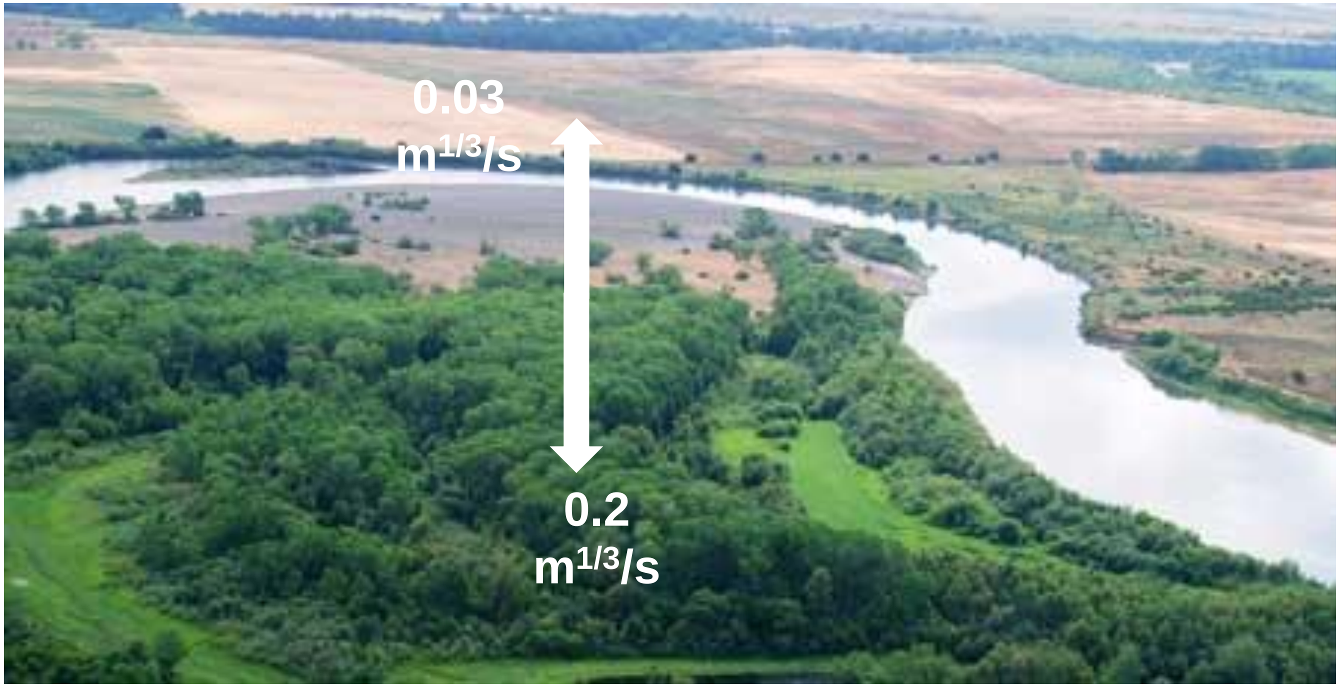
EGU European Geosciences Union

Methodology – roughness uncertainty

- Uniform distribution between literature values:



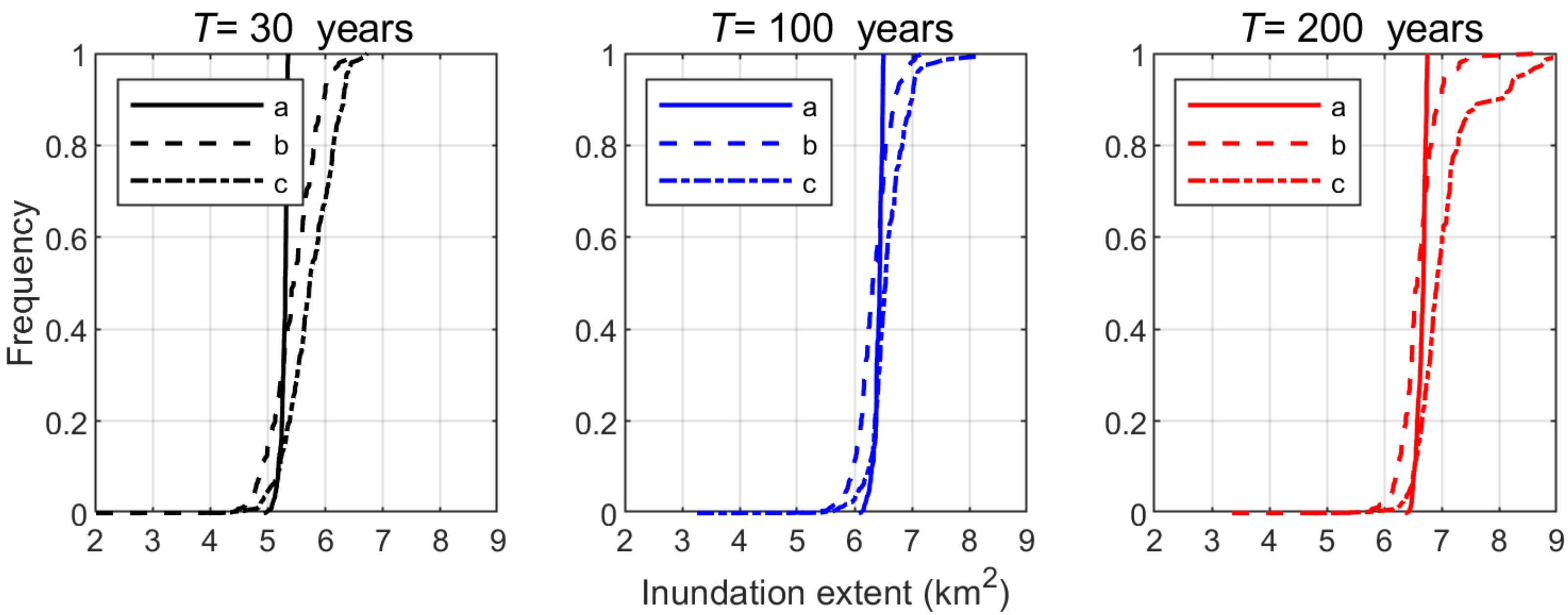
http://www.riverpartners.org/resources/riparian-ecology/veg-floodway/

Methodology

- Scenarios

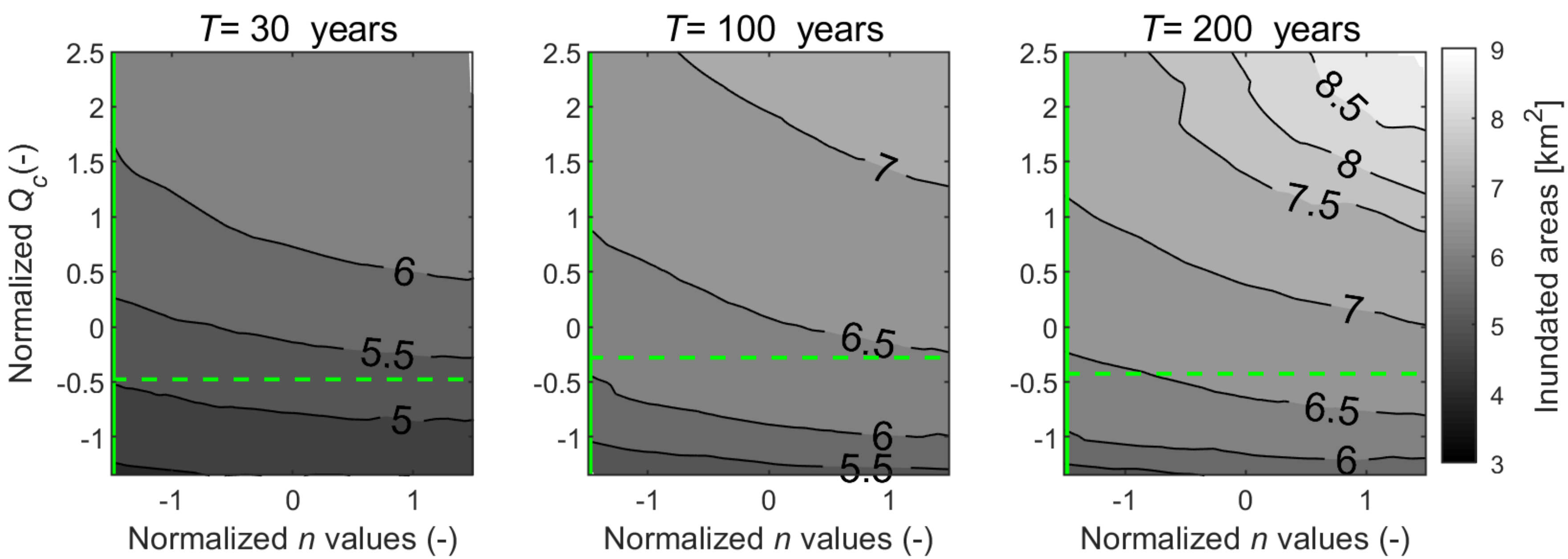
Scenario	Uncertainties of the simulations	
	Synthetic hydrology	Hydraulic parametrization
a		X
b	X	
c	X	X

Results



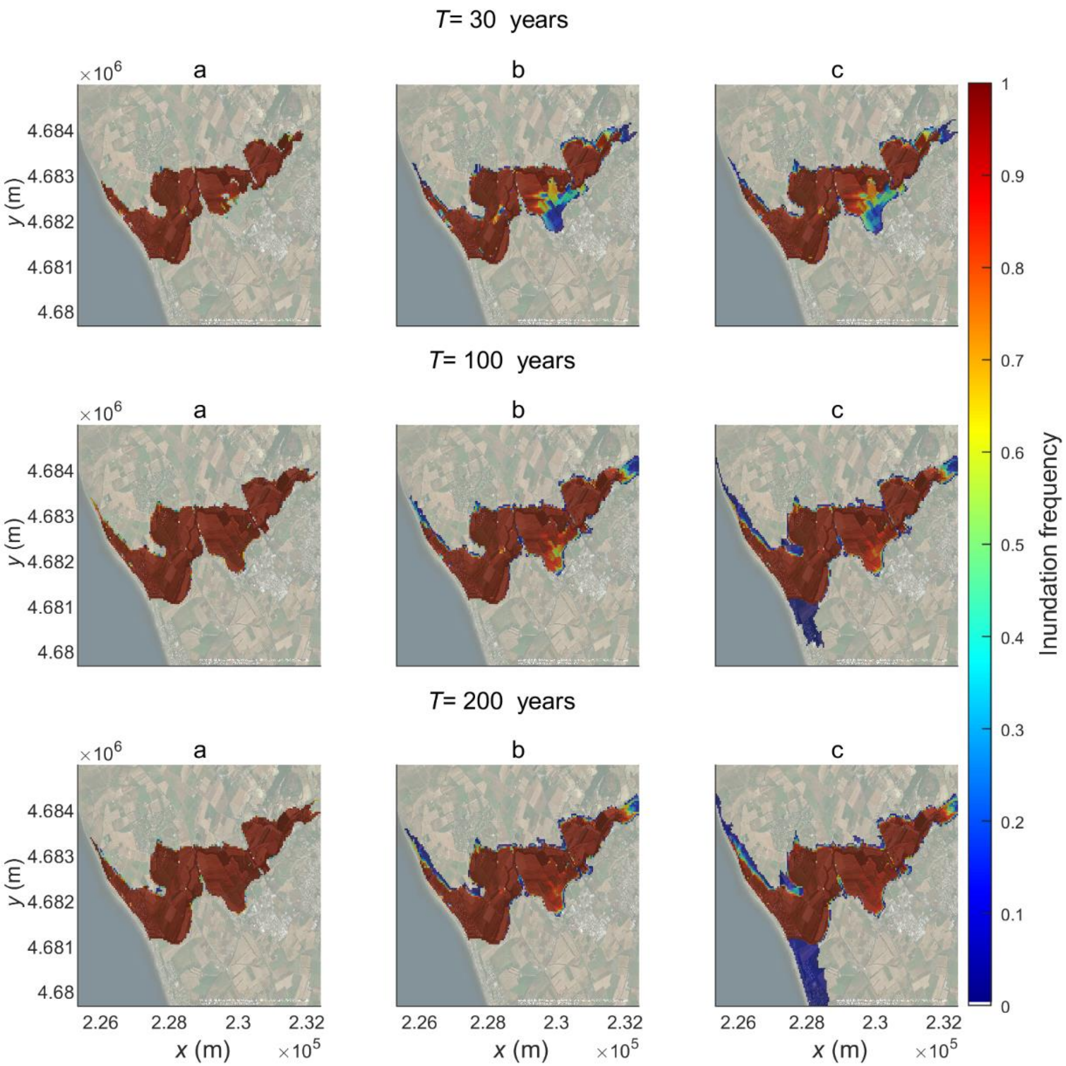
Cumulative frequency distributions of inundated area for scenarios a, b and c (solid, dashed and dot-dashed lines, respectively) and for return periods, T = 30 years (left), 100 years (middle) and 200 years (right).

Results



Contour plots of the inundated area as a function of the normalized peak flow and Manning's coefficient value for each return period (Scenario c) The horizontal and vertical (green) lines represent scenarios *a* (solid line) and *b* (dashed line), respectively.

Results



Maps of the inundation frequency for scenarios a, b and c (left, middle and right panels, respectively) and for return periods, T = 30 years (top), 100 years (middle) and 200 years (bottom).

Conclusions

- The hydrological uncertainty, mainly due to the limited sample size of the rainfall time series, represents the main source of estimation uncertainty of the extent of the inundated area with respect to hydraulic uncertainty.
- The uncertainty due to hydraulic modelling parameterization might still play a role, yet only under conditions characterized by low Manning's coefficient and high peak flow values;
- Locally, large uncertainty values can be observed in the proximity of urban features interacting with inundation flows such as levees and bridges.

For further information…

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Check for updates

Quantifying the relative impact of hydrological and hydraulic modelling parameterizations on uncertainty of inundation maps

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ABSTRACT
Flood risk management strongly relies on inundation models for river basin zoning in flood-prone and risk-free areas. Floodplain zoning is significantly affected by the diverse and concurrent uncertainties that characterize the modelling chain used for producing inundation maps. In order to quantify the relative impact of the uncertainties linked to a lumped hydrological (rainfall–runoff) model and a FLO-2D hydraulic model, a Monte Carlo procedure is proposed in this work. The hydrological uncertainty is associated with the design rainfall estimation method, while the hydraulic model uncertainty is associated with roughness parameterization. This uncertainty analysis is tested on the case study of the Marta coastal catchment in Italy, by comparing the different frequency, extent and depth of inundation simulations associated with varying rainfall forcing and/or hydraulic model roughness realizations. The results suggest a significant predominance of the hydrological uncertainty with respect to the hydraulic one on the overall uncertainty associated with the simulated inundation maps.

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