Italy-Florida collaboration on Water Science, Culture and Security

Perugia, Italy

November 9, 2017

Fernando Nardi
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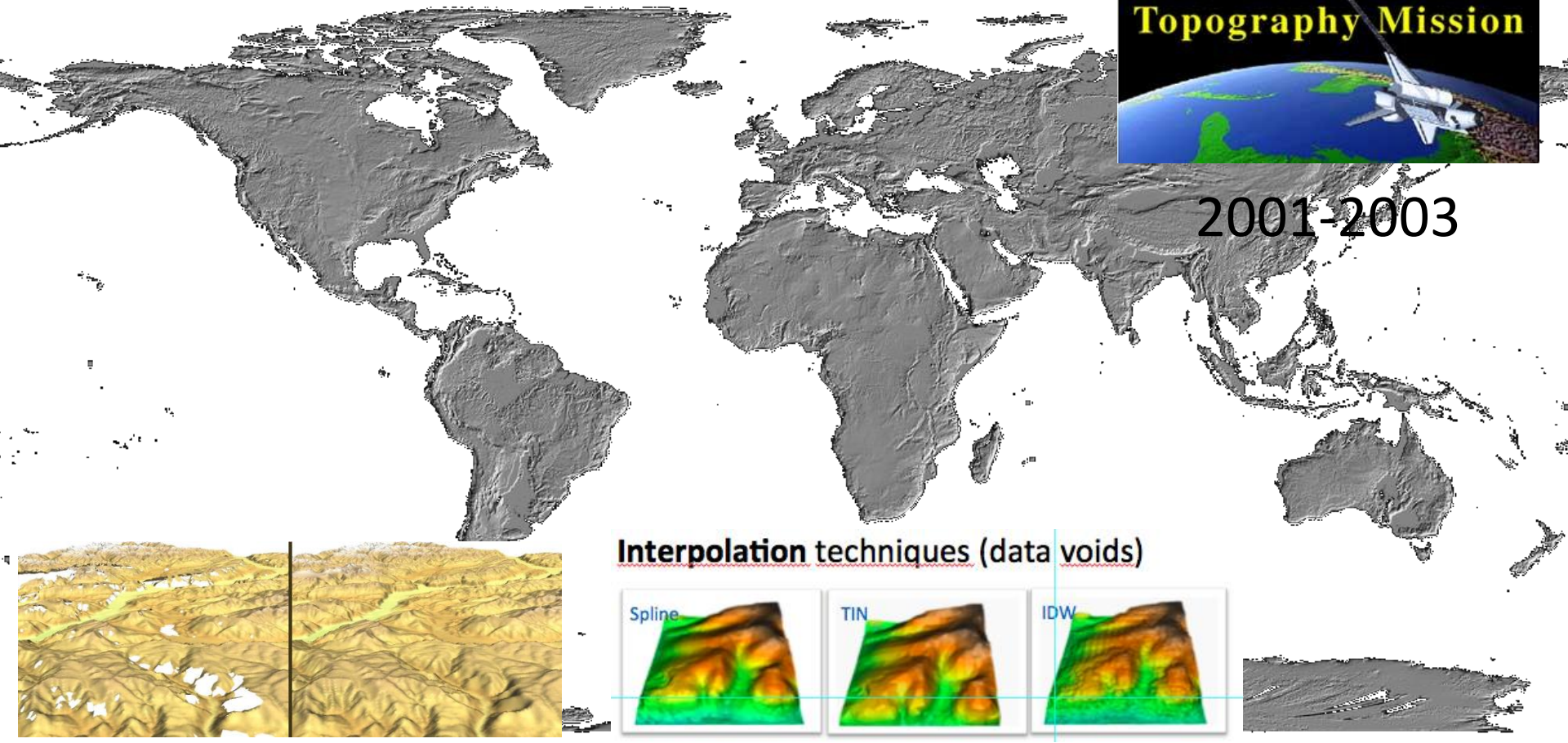
Outlines

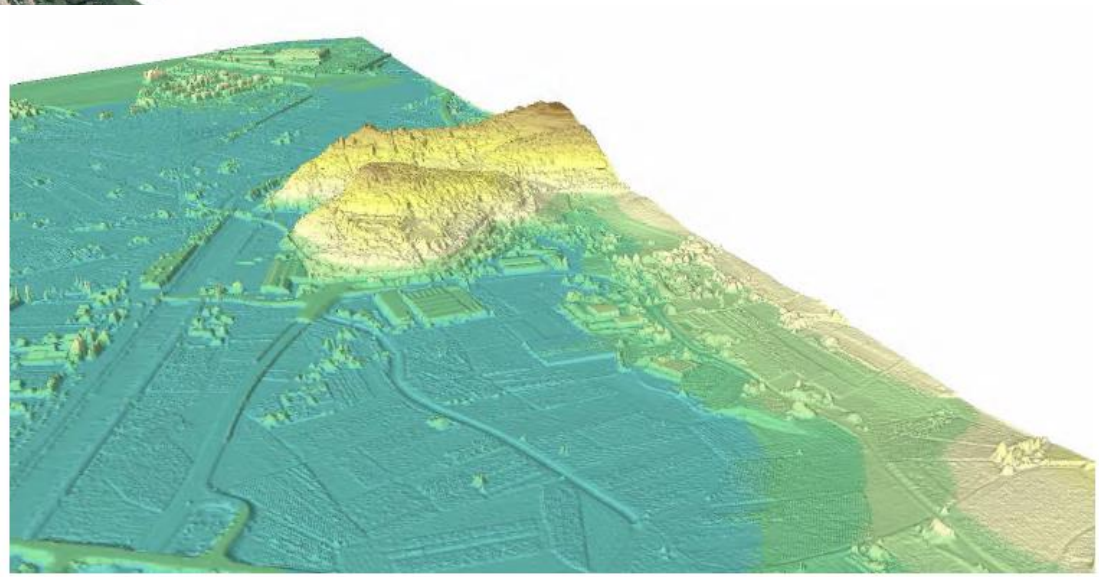
- ***Research background and solutions***
- *Rome flood risk management project*
- *Floodplains (water geomorphic footprint) and human dynamics/perception*

DTMs and EO data

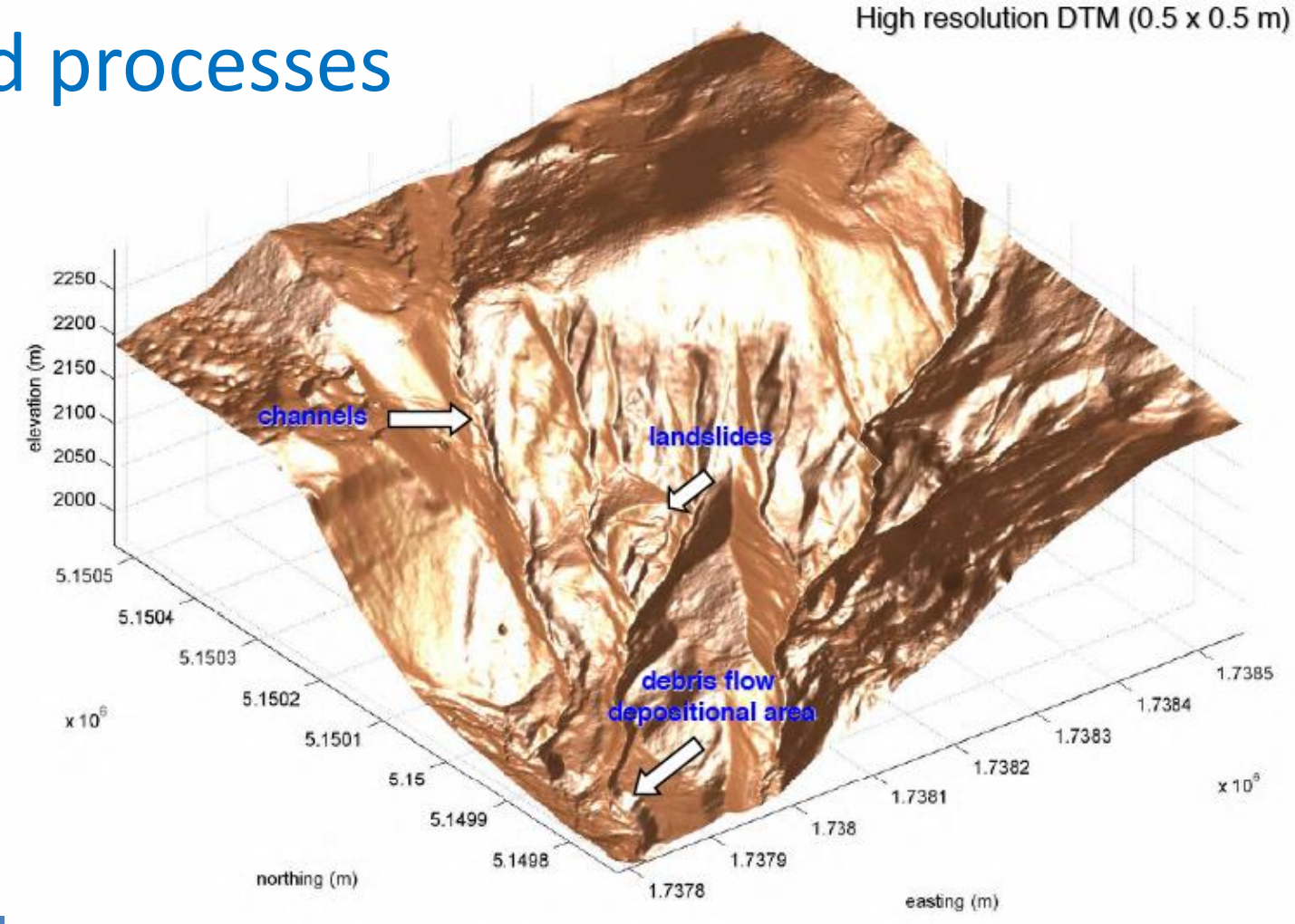


Terrain analysis

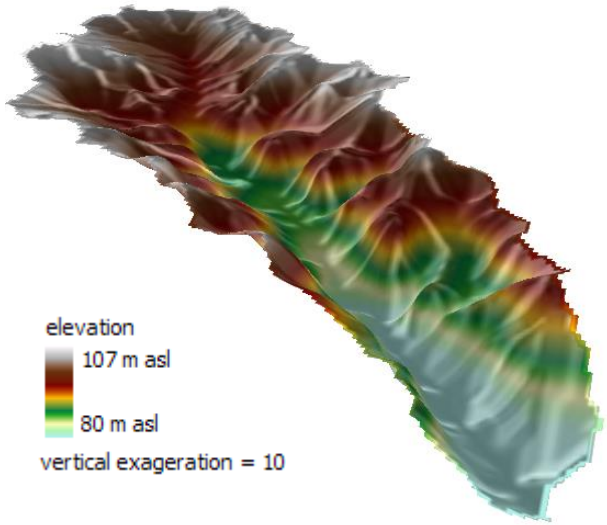
Observing urban and natural features…

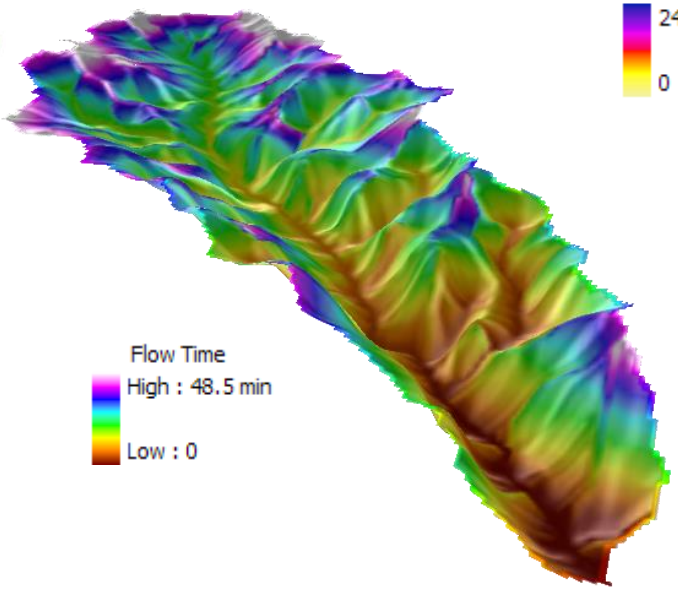


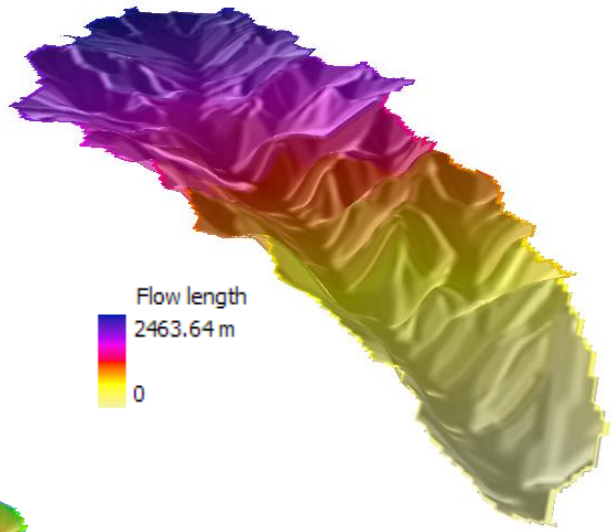
...and processes



Hydrologic modelling enforcing geomorphic principles



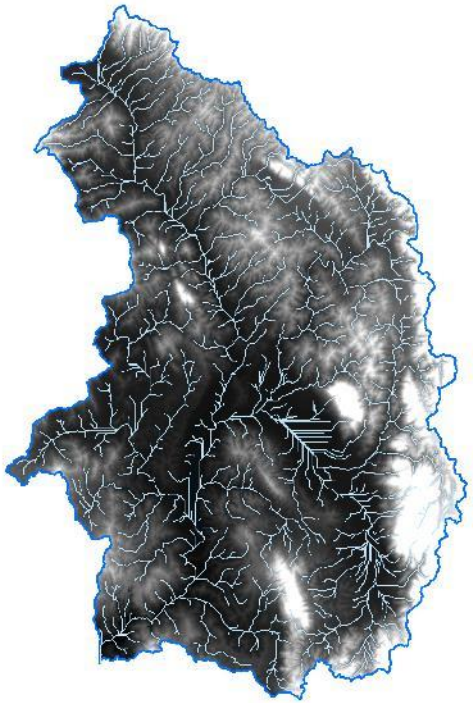


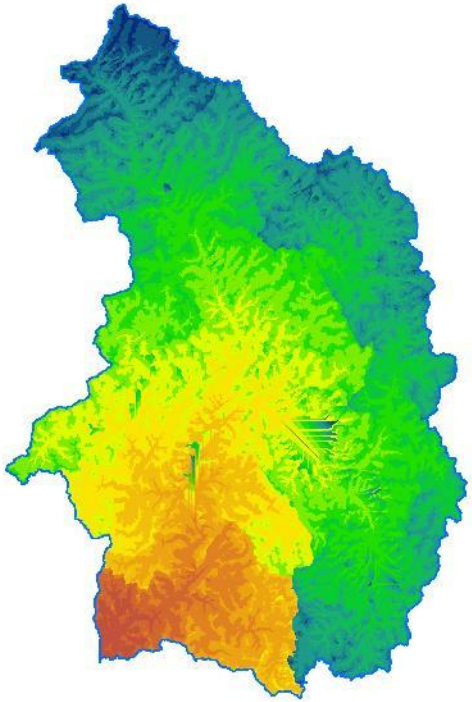


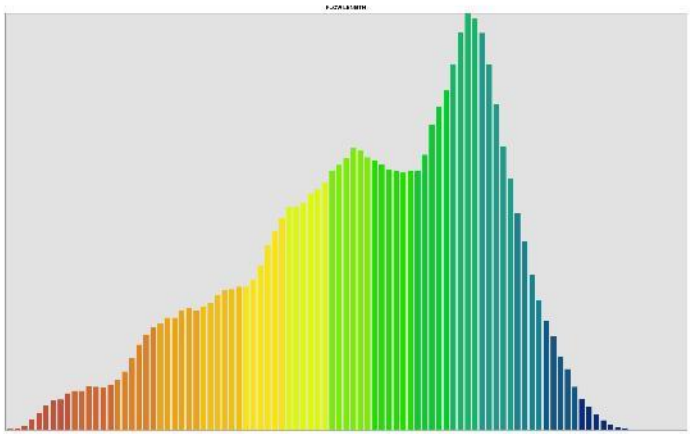
Spatially Variable Velocity (channel/hillslope)

$$T_i = \frac{L_h(i)}{V_h} + \frac{L_c(j)}{V_c}$$

Hydrologic modelling enforcing geomorphic principles







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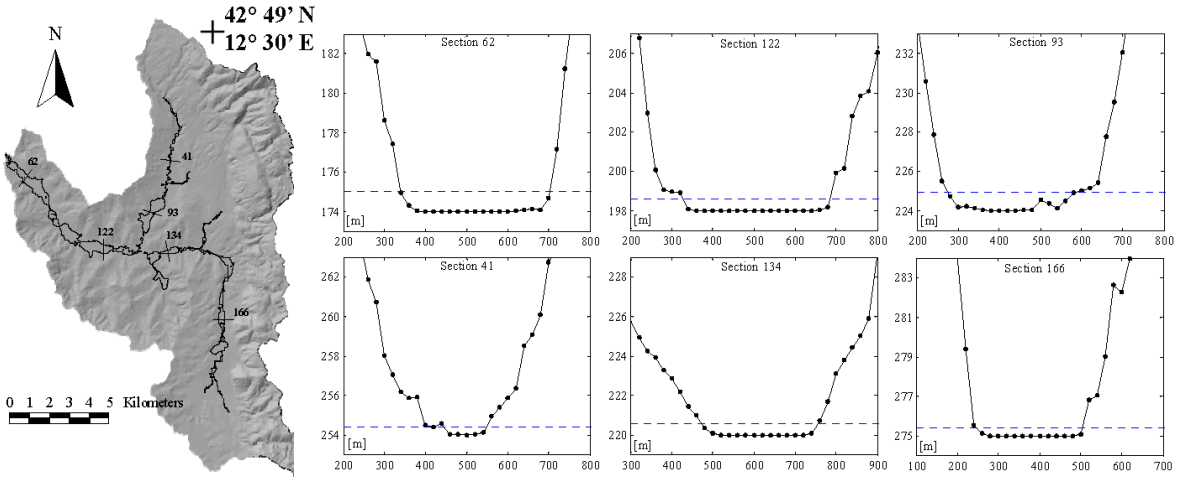
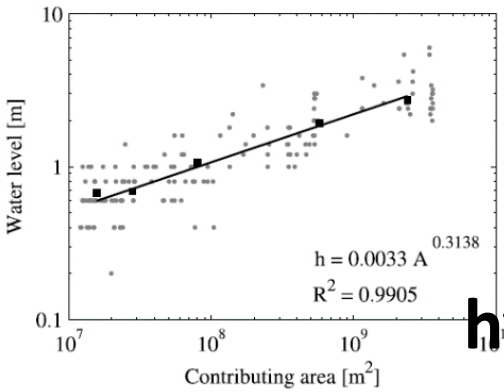
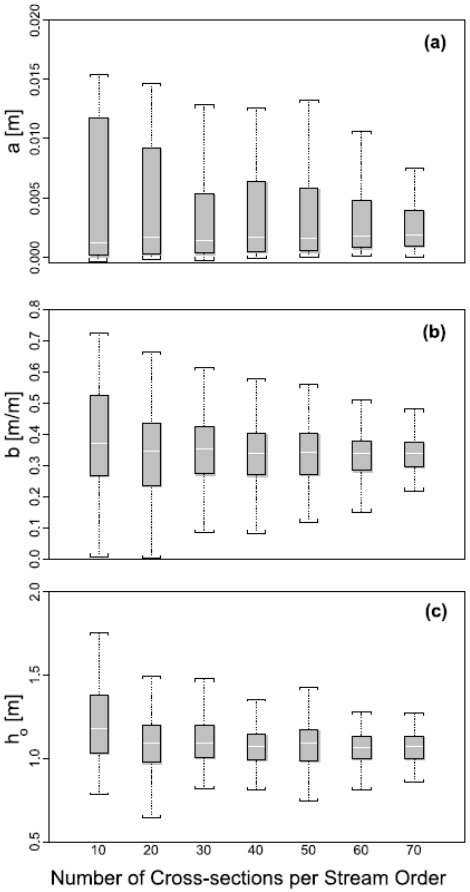
Scaling laws for hydrogeomorphic applications



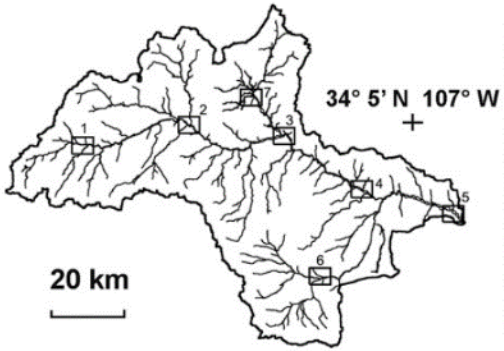


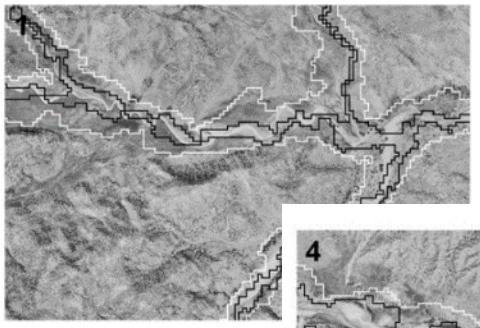
Manning Roughness n	Intercept a, m	Slope b, m/m
0.03	0.0032 (0.0010)	0.311 (0.017)
0.04	0.0033 (0.0009)	0.315 (0.013)
0.05	0.0034 (0.0009)	0.319 (0.014)
0.07	0.0035 (0.0006)	0.322 (0.010)

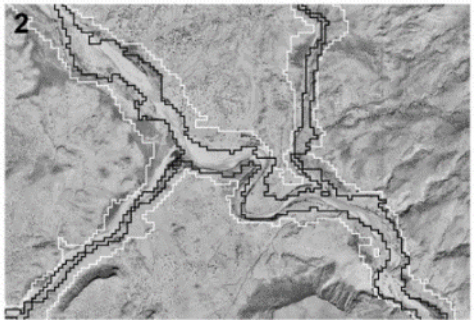


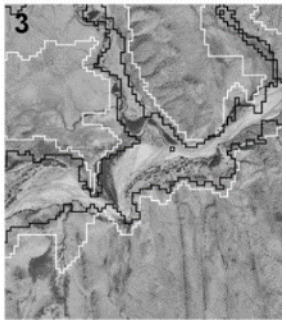
hydrogeomorphic watershed analysis

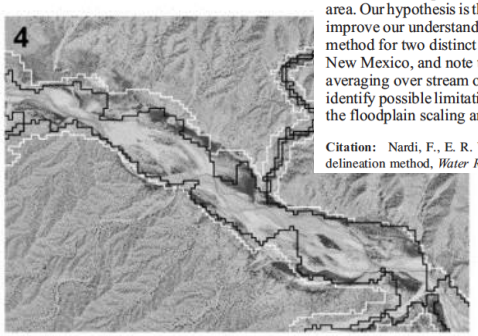
Floodplain modelling and mapping

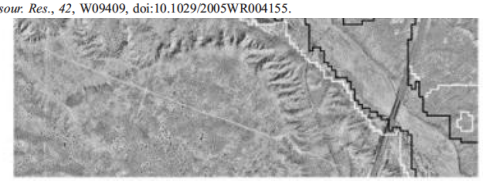


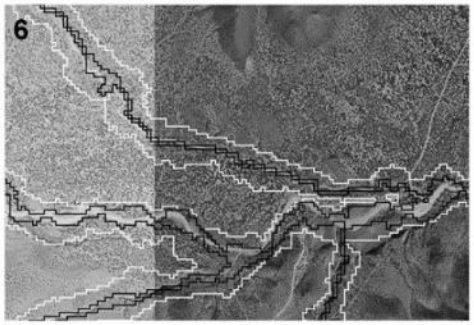


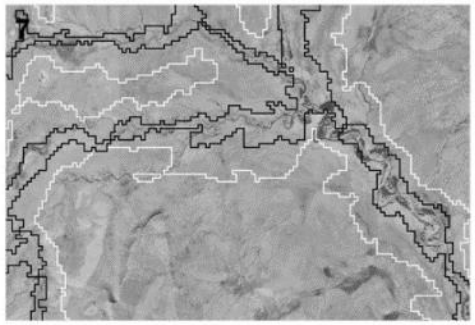












WATER RESOURCES RESEARCH, VOL. 42, W09409, doi:10.1029/2005WR004155, 2006

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Investigating a floodplain scaling relation using a hydrogeomorphic delineation method

Fernando Nardi,[1,2] Enrique R. Vivoni,[3] and Salvatore Grimaldi[2,4]

Received 30 March 2005; revised 24 April 2006; accepted 26 May 2006; published 14 September 2006.

[1] Floodplains are critical landscape features that are highly distinguished from neighboring uplands in terms of their hydrologic, geomorphologic, biogeochemical, and ecological processes. Thus an essential step in floodplain studies is the determination of the lateral floodplain extent and its variability within a basin. Recent advances in topographic mapping and GIS-based analysis provide a means for developing automated techniques to determine floodplain extent. In this study, we propose a hydrogeomorphic floodplain delineation which links a simplified inundation algorithm with the river basin properties. We utilize the method to investigate the physical controls on floodplain formation, as captured by scaling relations between floodplain width and contributing area. Our hypothesis is that an efficient delineation grounded in hydrogeomorphic theory can improve our understanding of floodplain geometry across a range of conditions. We test the method for two distinct watersheds, a humid catchment in Italy and an ephemeral basin in New Mexico, and note the existence of power law scaling of the floodplain width after averaging over stream orders. An analysis of the algorithm parameters is conducted to identify possible limitations. Further systematic tests are needed to establish the generality of the floodplain scaling and its control on floodplain processes.

Citation: Nardi, F., E. R. Vivoni, and S. Grimaldi (2006), Investigating a floodplain scaling relation using a hydrogeomorphic delineation method, *Water Resour. Res.*, *42*, W09409, doi:10.1029/2005WR004155.

Nardi et al. ***Water Resources Research***, **(2006)**

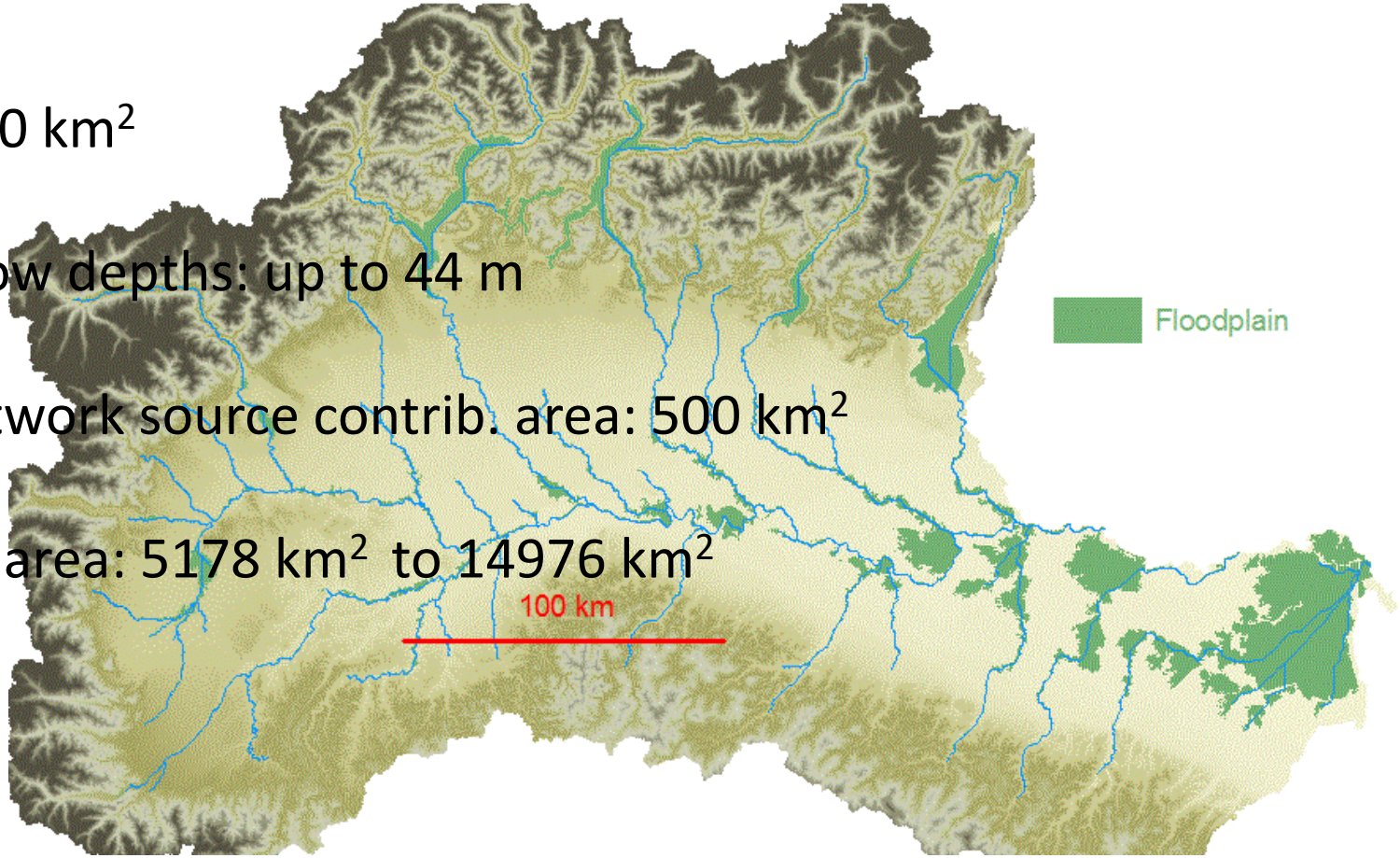
Po river basin (North Italy)

Area 75,000 km^2

Channel flow depths: up to 44 m

Stream network source contrib. area: 500 km^2

Floodplain area: 5178 km^2 to 14976 km^2

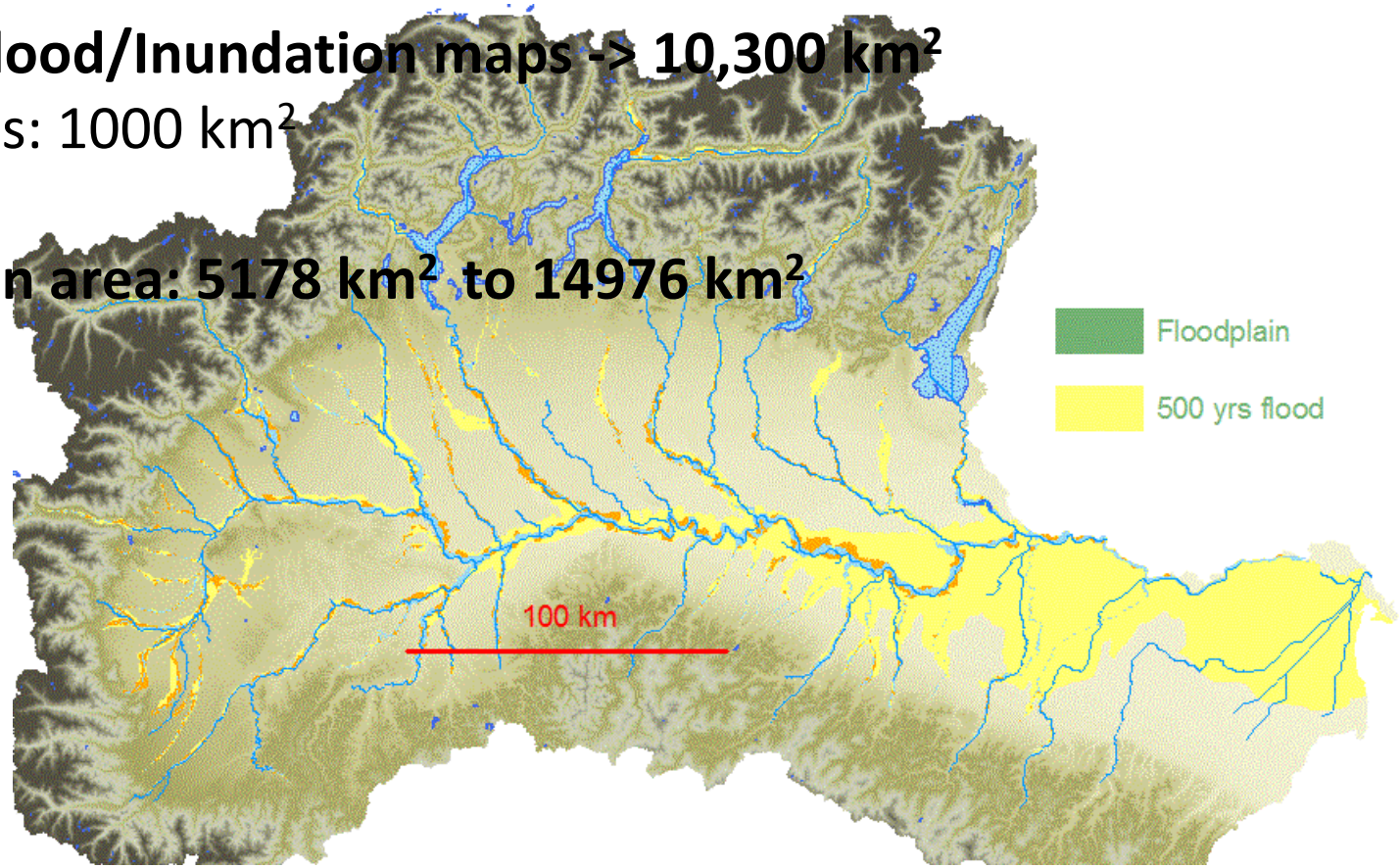


Po river basin (North Italy)

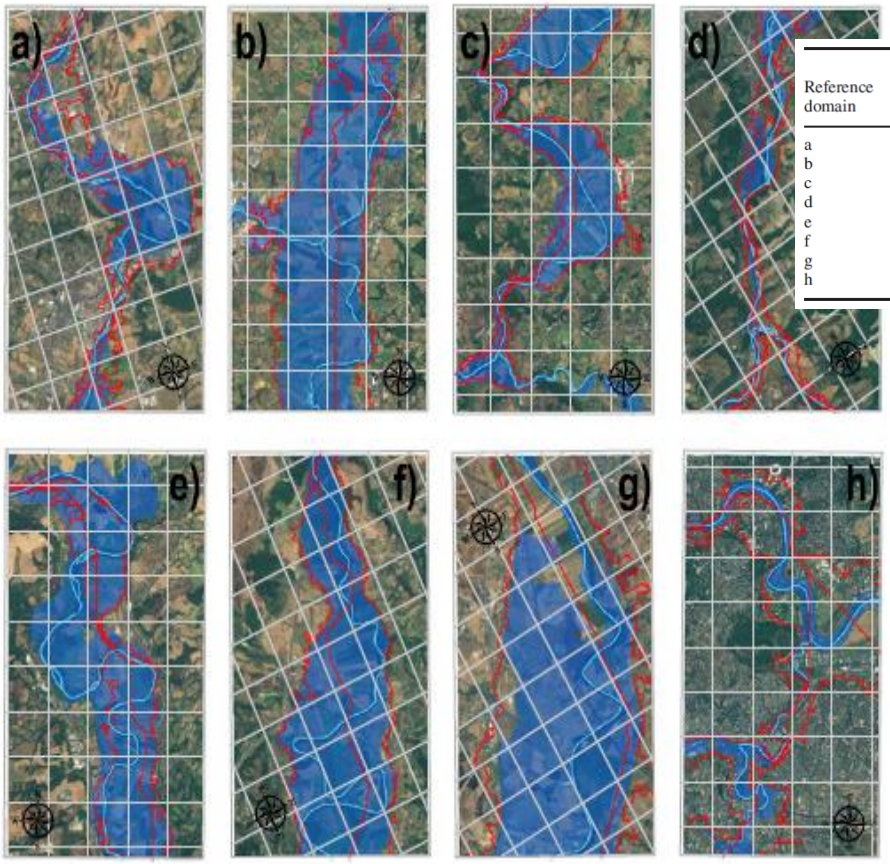
500 yrs Flood/Inundation maps -> 10,300 km²

Lake areas: 1000 km²

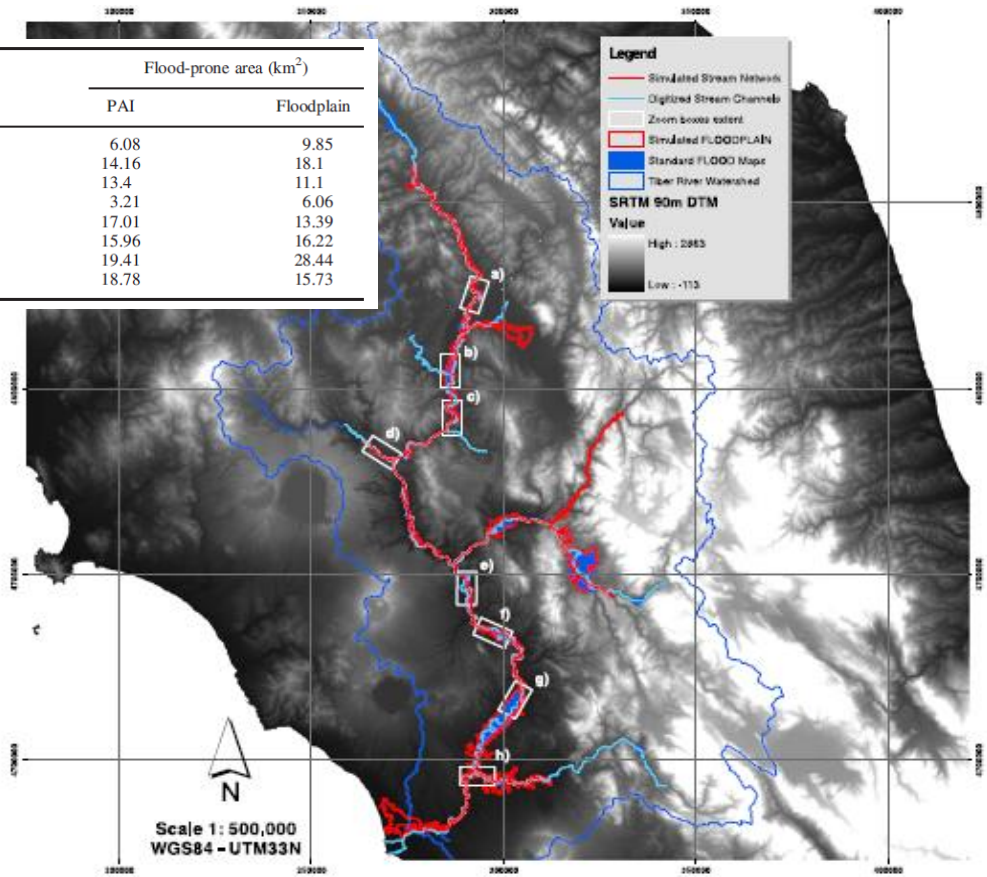
Floodplain area: 5178 km² to 14976 km²



How do the hydrogeomorphic floodplain behave as respect to standard flood/inundation maps?

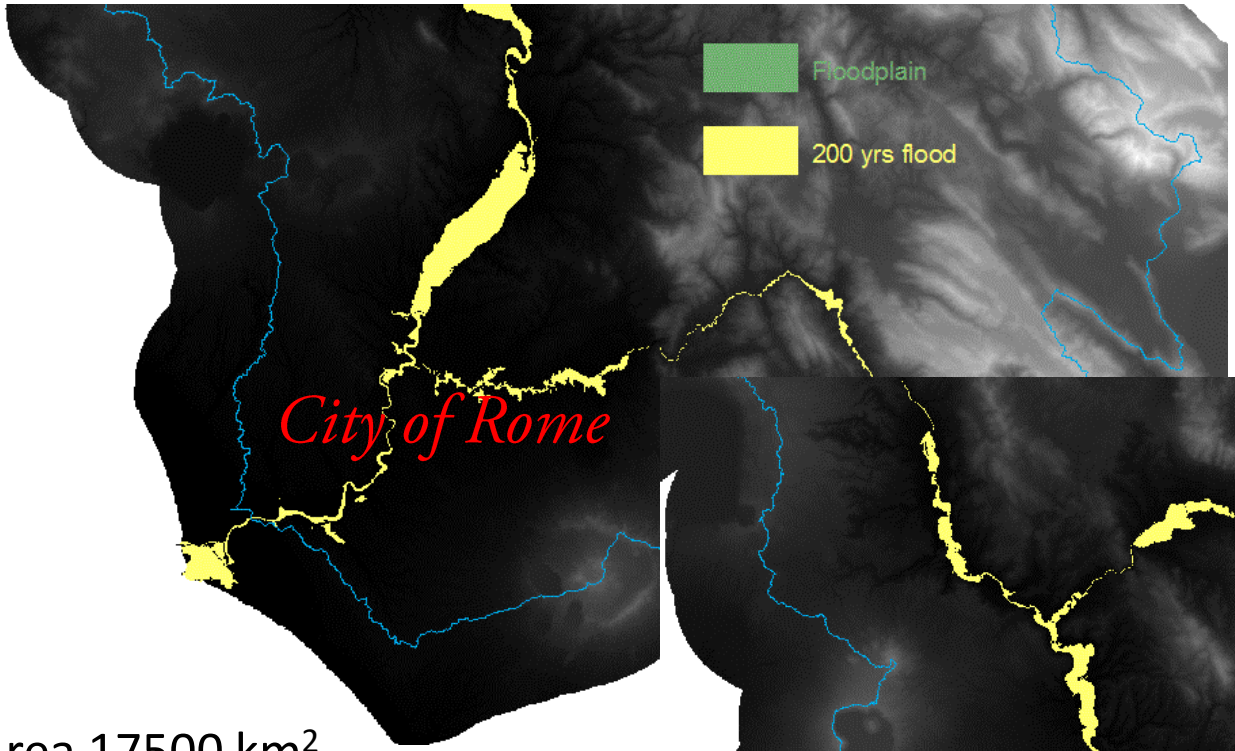


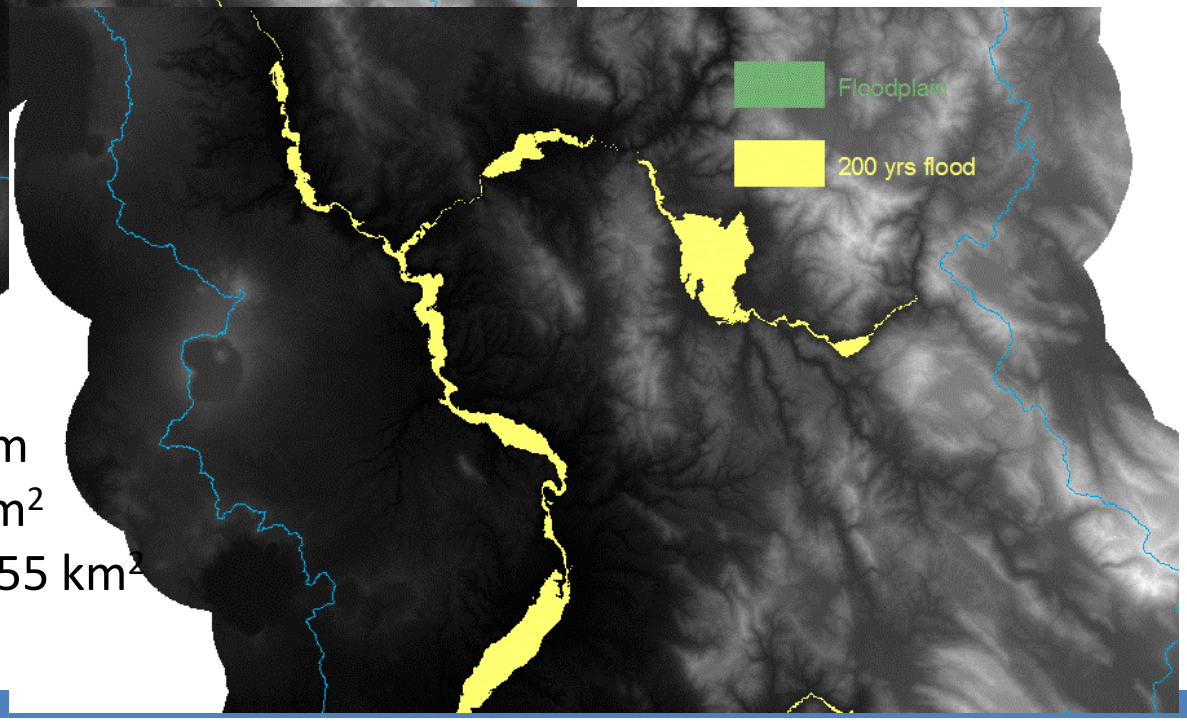
Reference domain	Flood-prone area (km^2)	
	PAI	Floodplain
a	6.08	9.85
b	14.16	18.1
c	13.4	11.1
d	3.21	6.06
e	17.01	13.39
f	15.96	16.22
g	19.41	28.44
h	18.78	15.73



Nardi et al. ***Journal of Irrigation and Drainage*, (2013)**

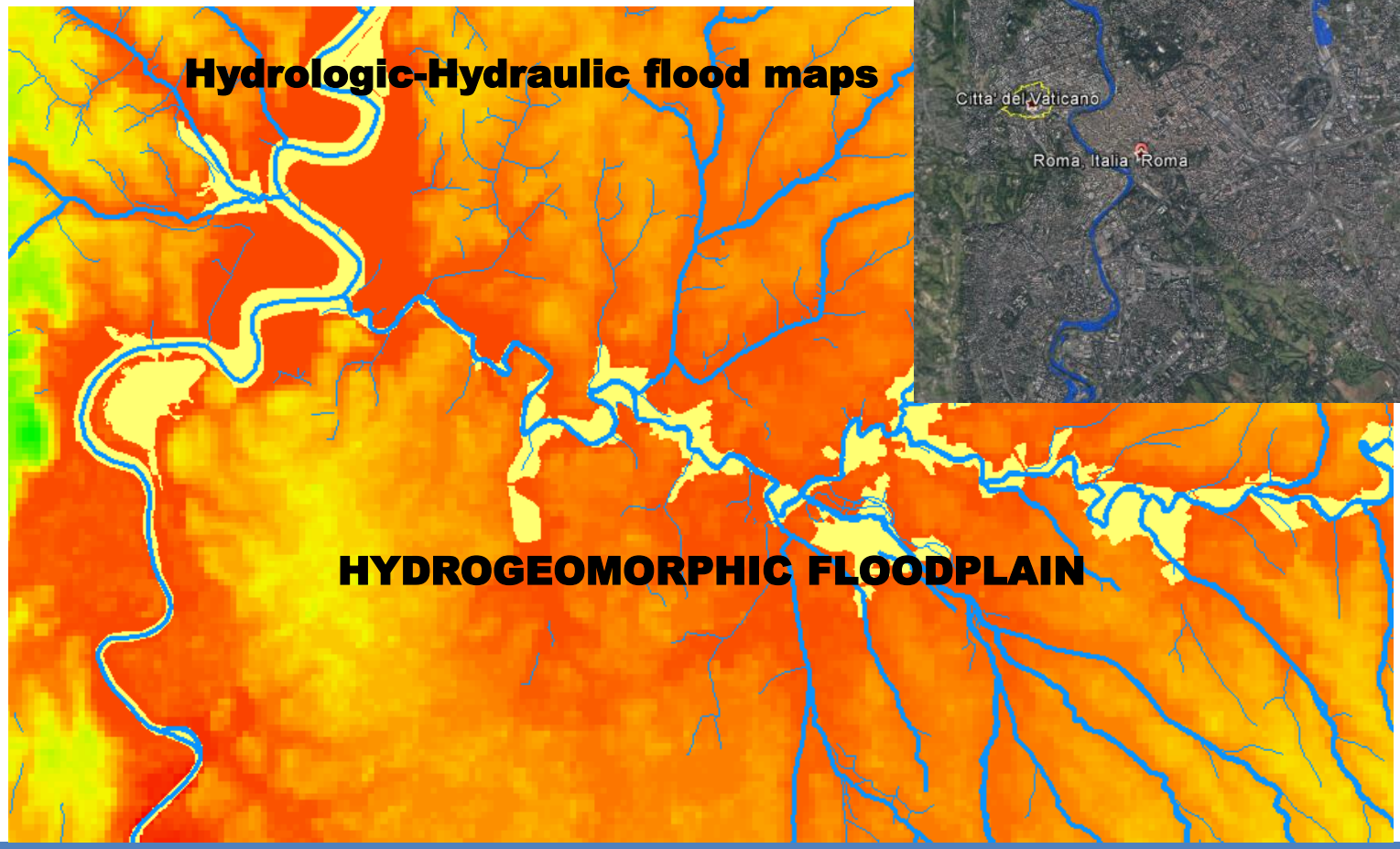
Tiber river basin
(Central Italy)

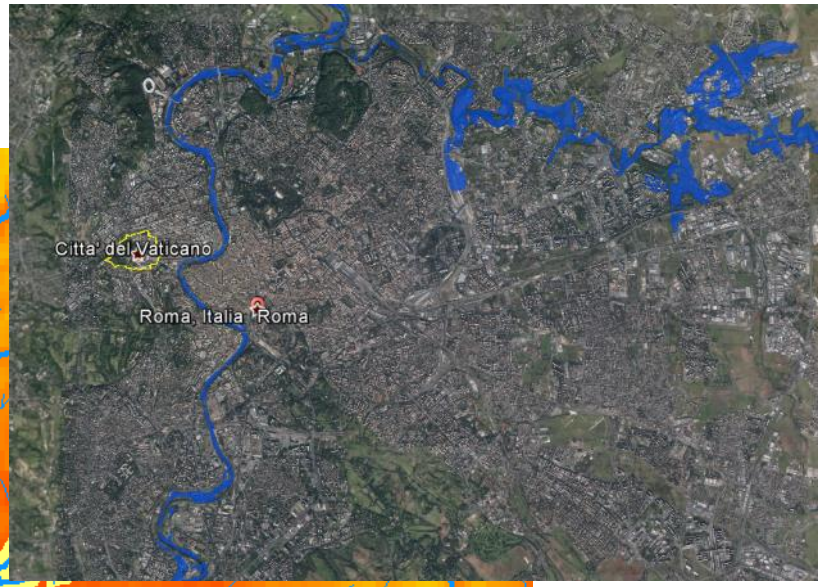




Area 17500 km^2
Channel flow depths: up to 25 m
Stream network source : 500 km^2
Floodplain area: 760 km^2 to 1455 km^2
200 yrs flood maps: 436 km^2

Tiber river basin (Central Italy)





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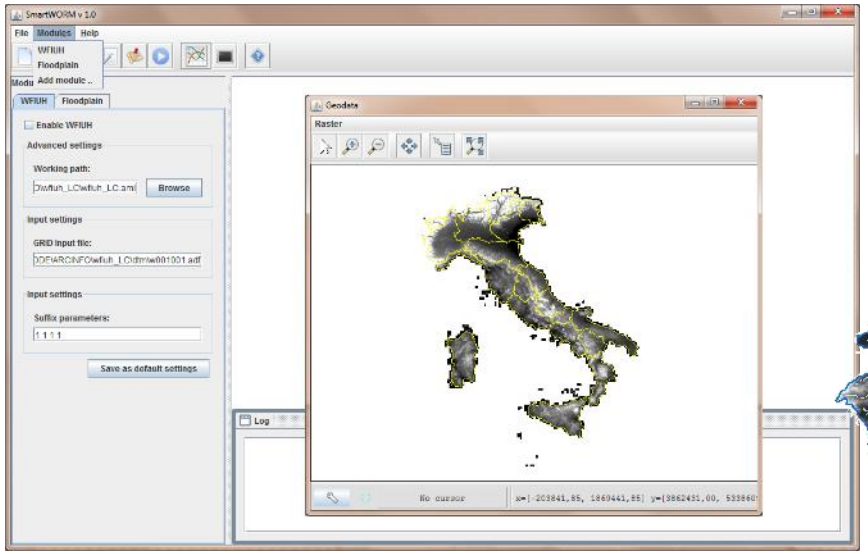
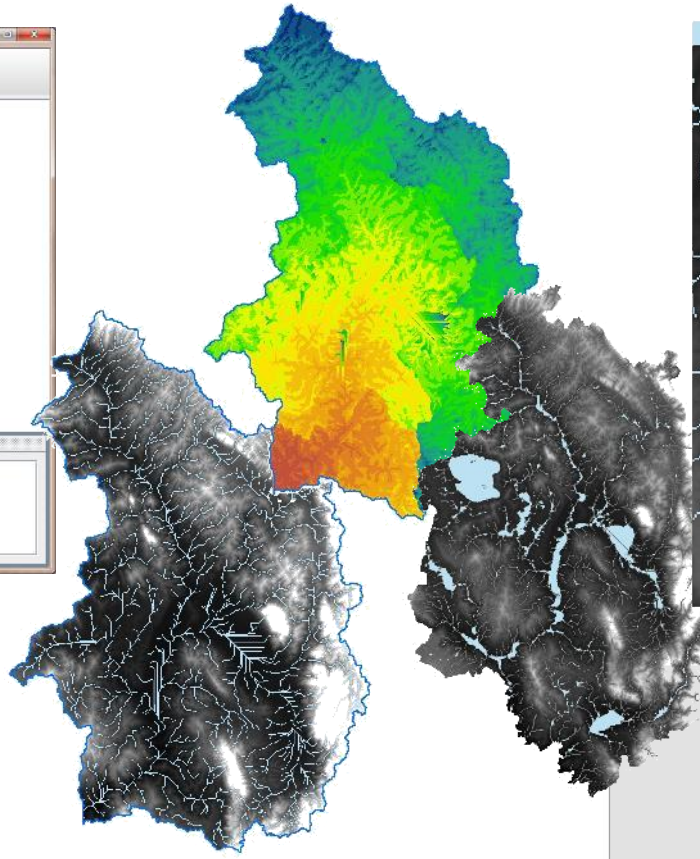
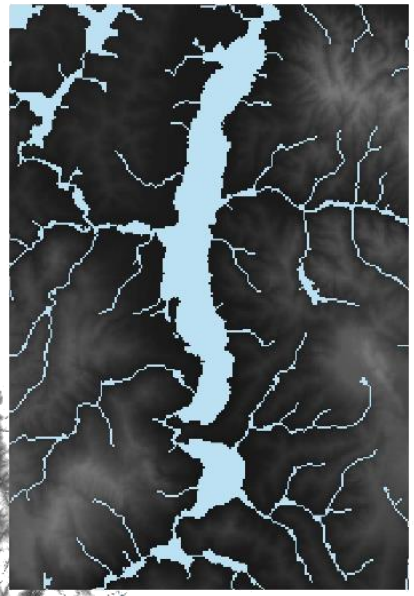
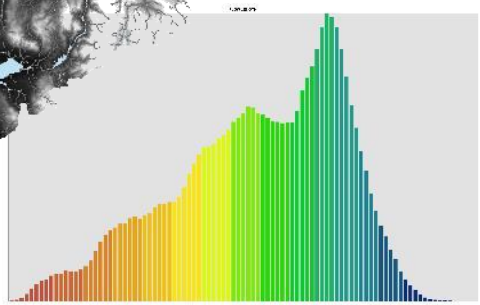








Applications:

Water res. Management

DSS for water risk

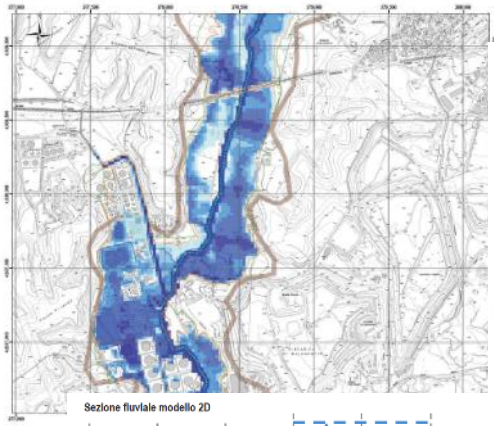
Large scale Culvert conveyance analysis

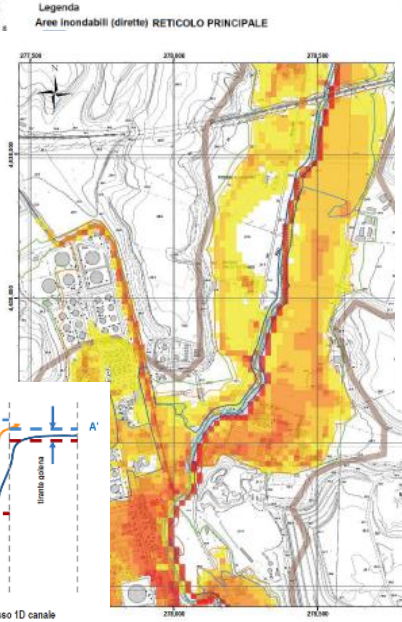
Hydrologic analysis for mini-hydro potential production

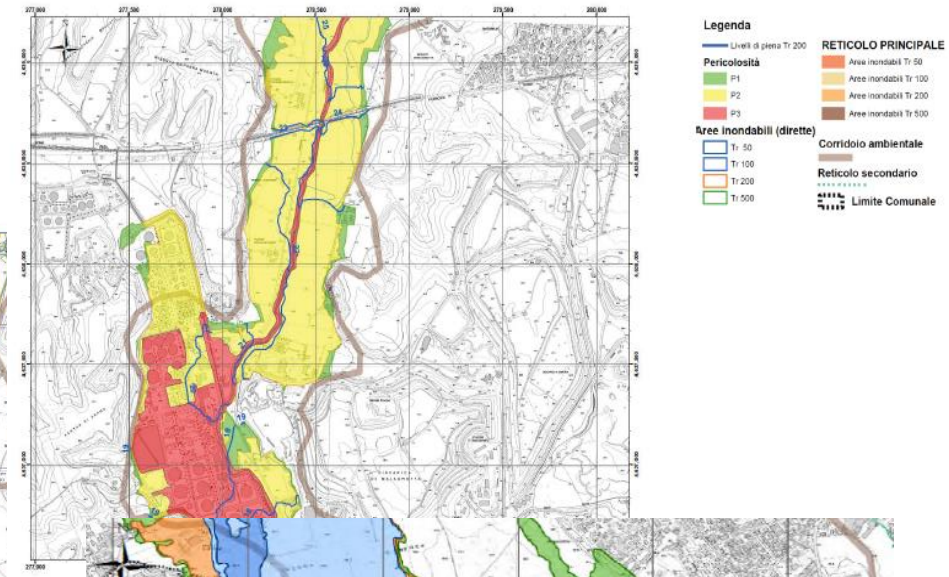
Outlines

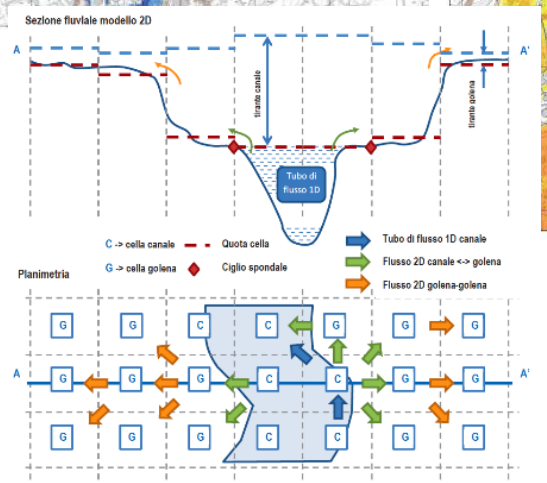
- *Research background and solutions*
- ***Rome flood risk management project***
- *Floodplains (water geomorphic footprint) and human dynamics/perception*

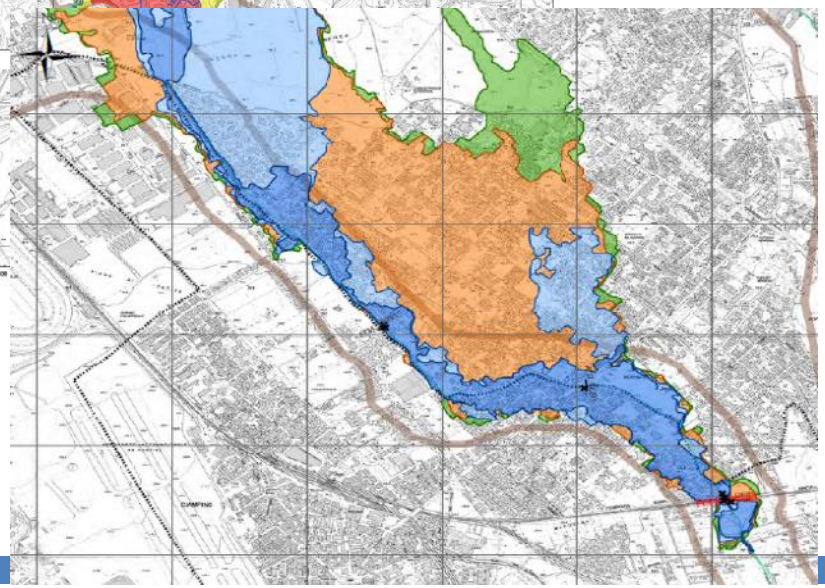
2D hydraulic routing and flood hazard/risk mapping











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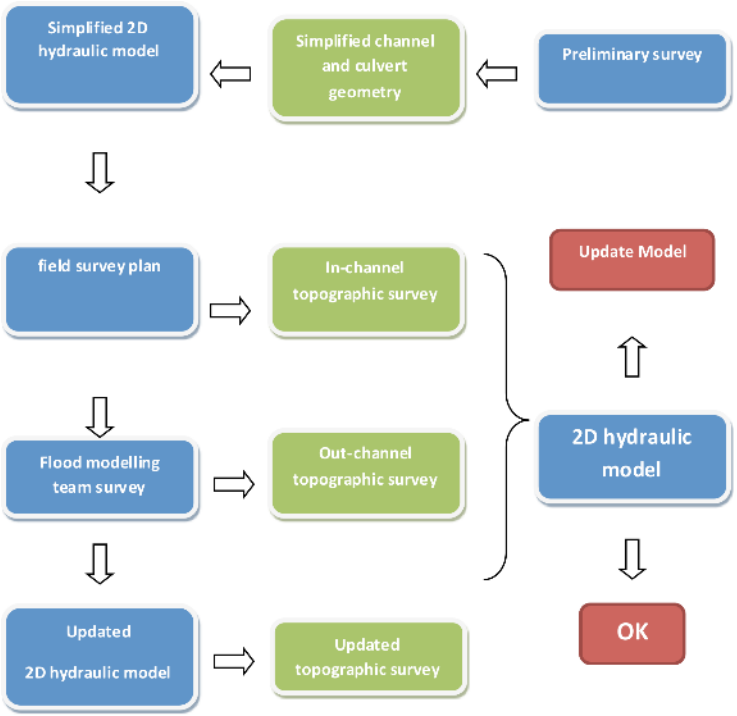
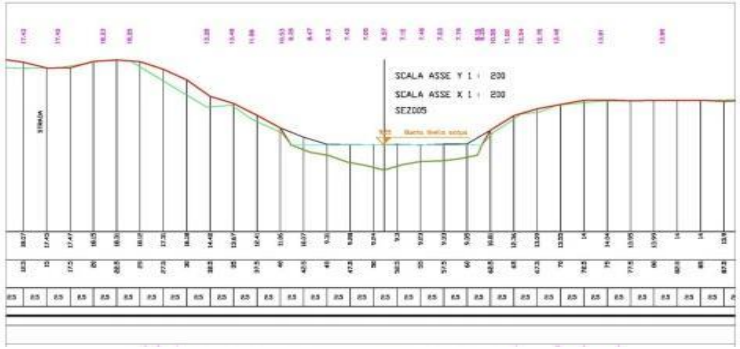
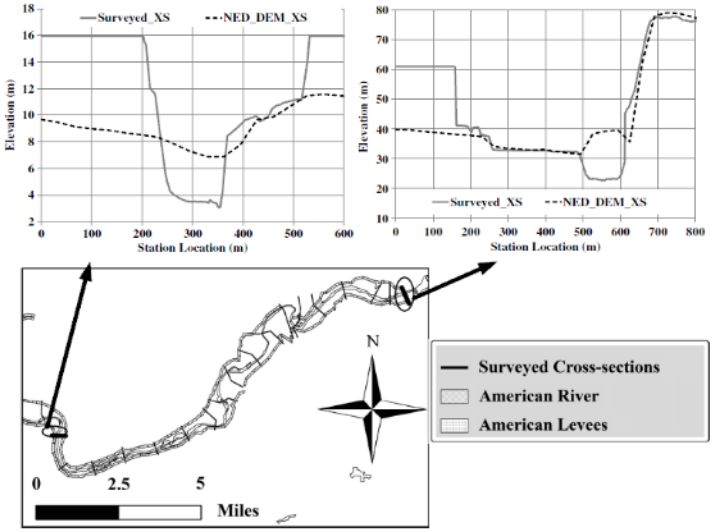
GIS for topographic surveying and digital mapping of fluvial corridors

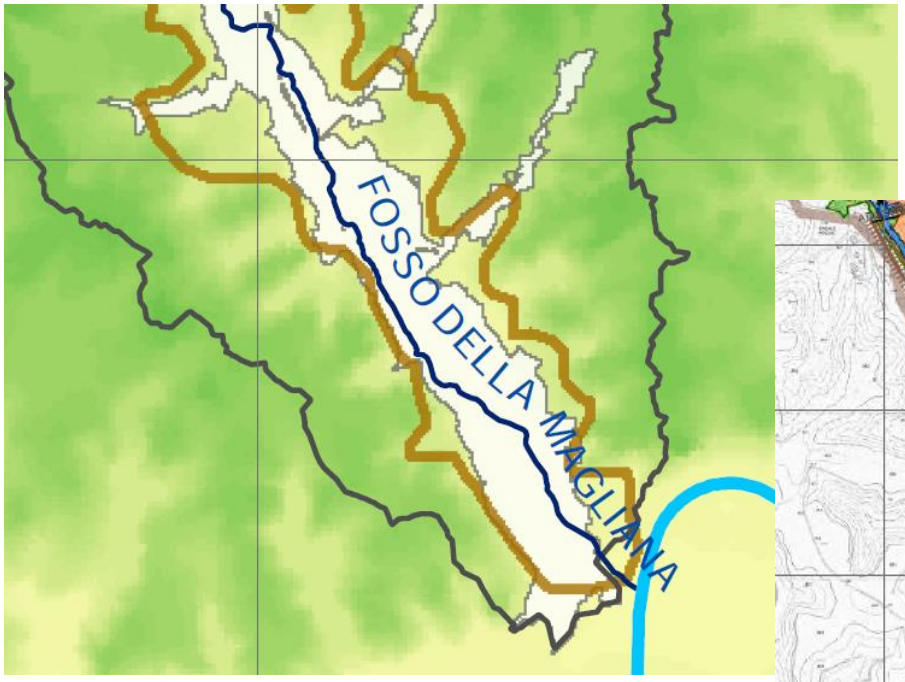


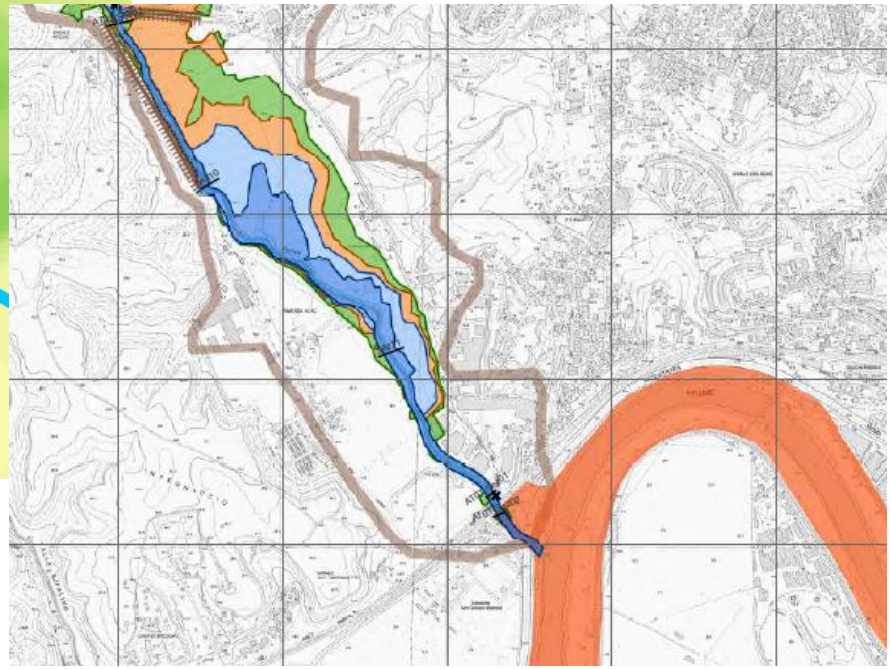




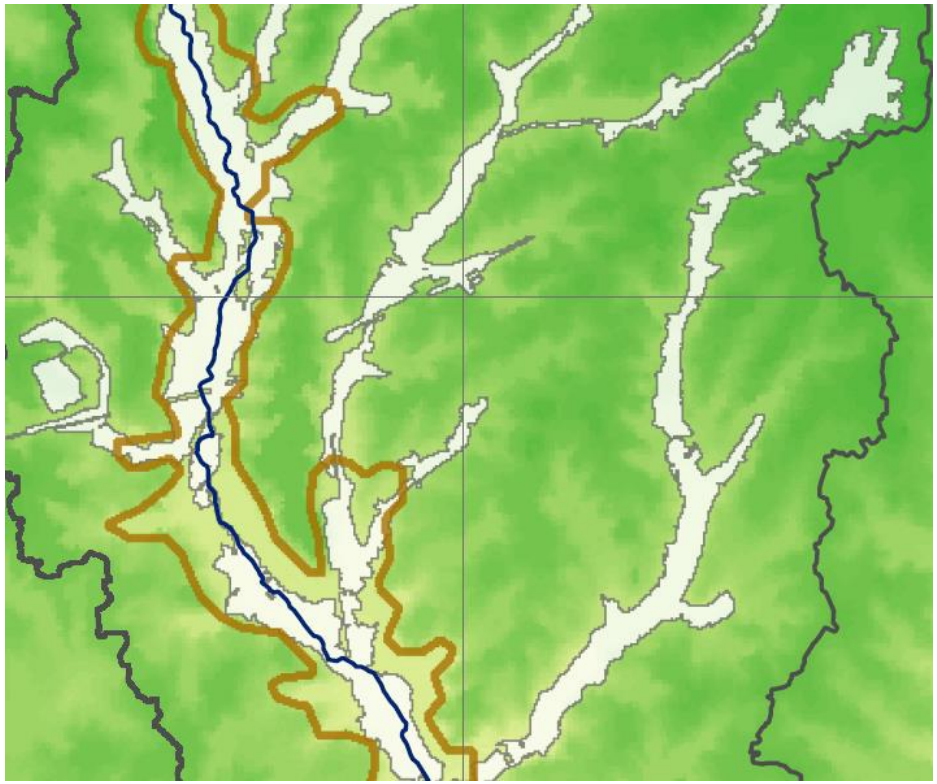
Bhuyian, Md. N. M., Kalyanapu, A. J., and Nardi F. An Approach for Digital Elevation Models (DEM) Correction by Improving Channel Conveyance, ***Journal of Hydrologic Engineering***, **(2014)**

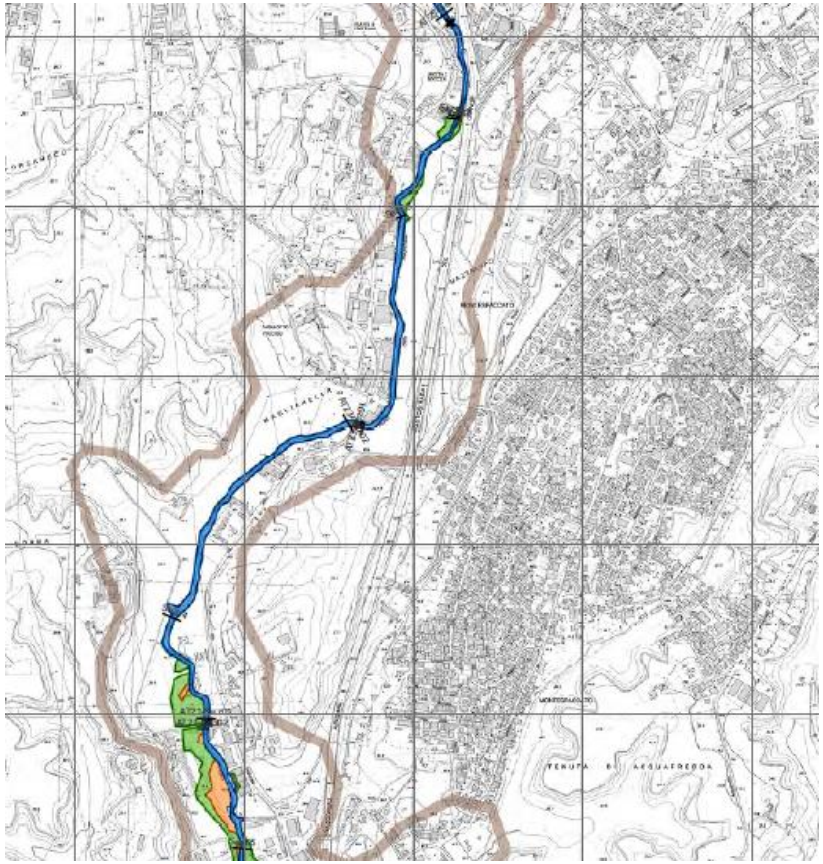
Floodplain vs flood map



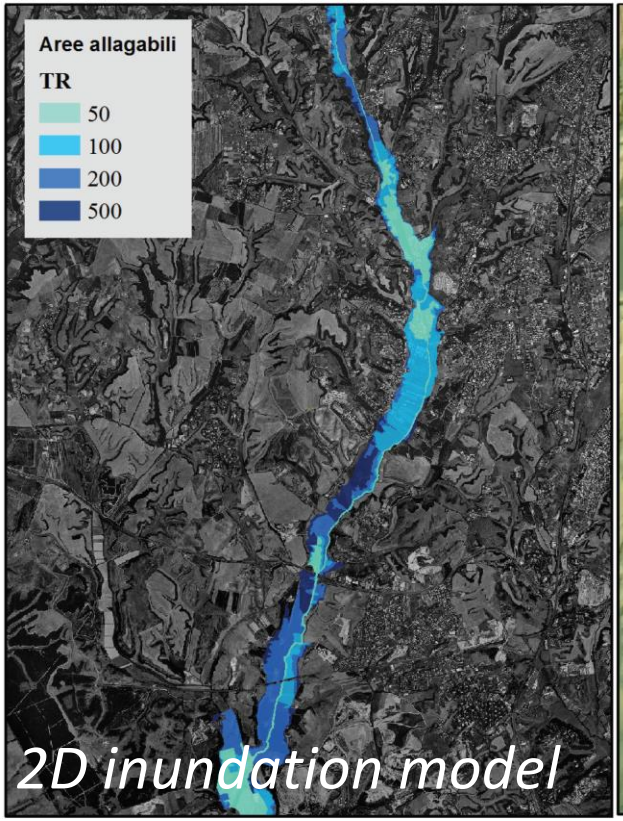


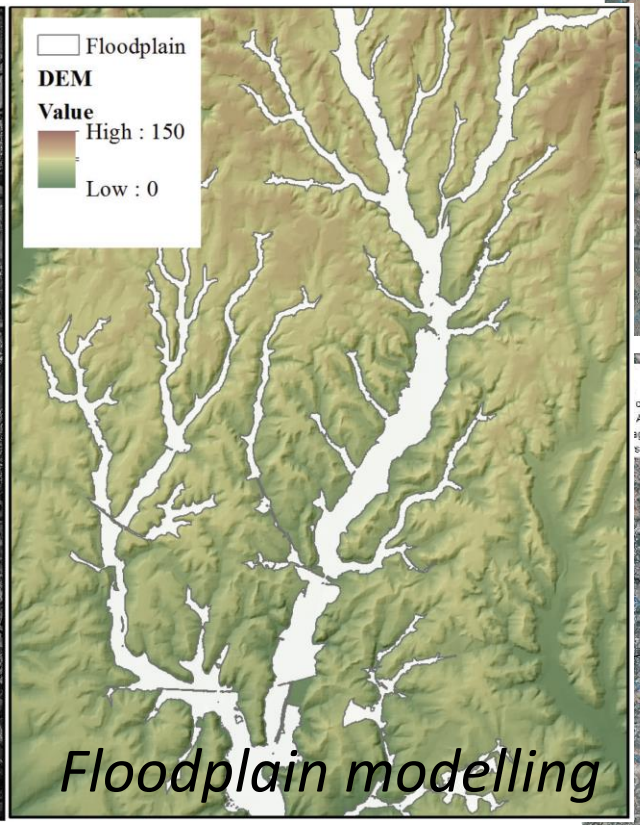
Floodplain vs flood map

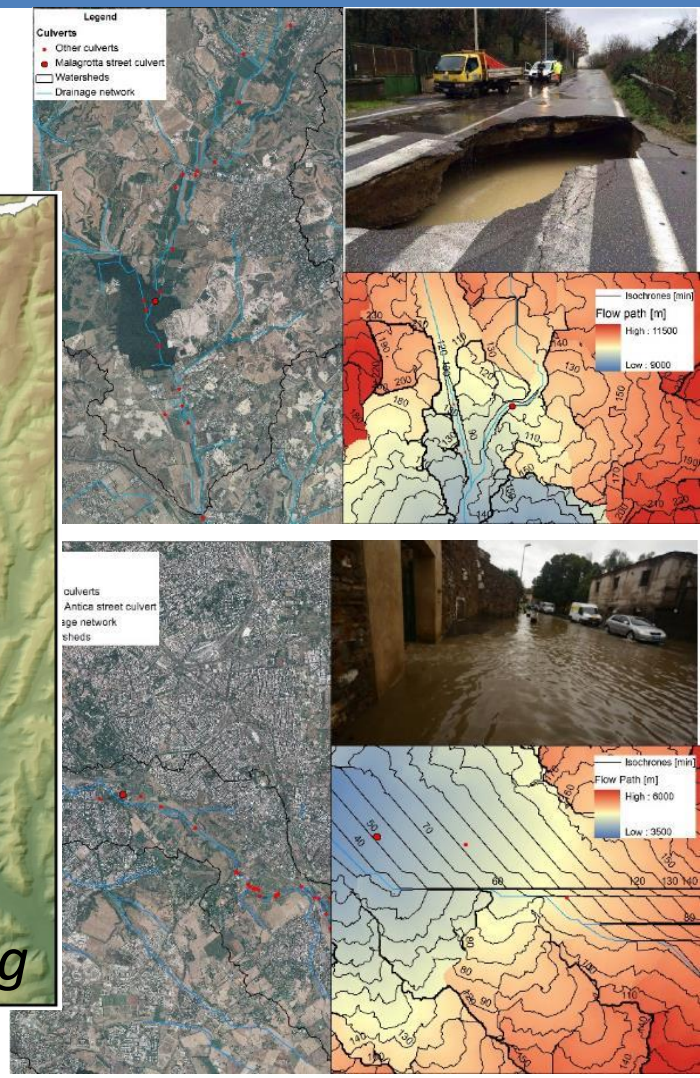




Large scale hydro-geomorphic modelling for remediation strategy

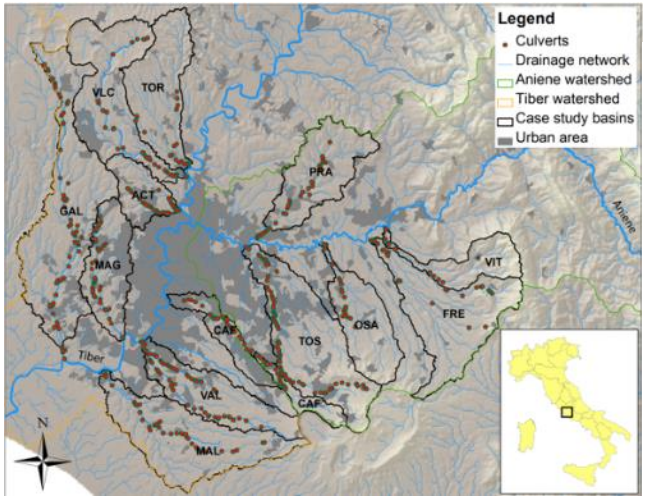






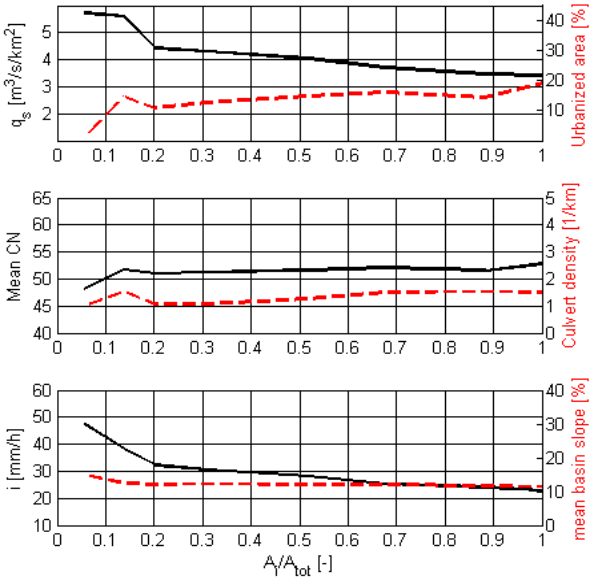
Nardi et al. ***Journal of Flood Risk Management*** **(2015)**

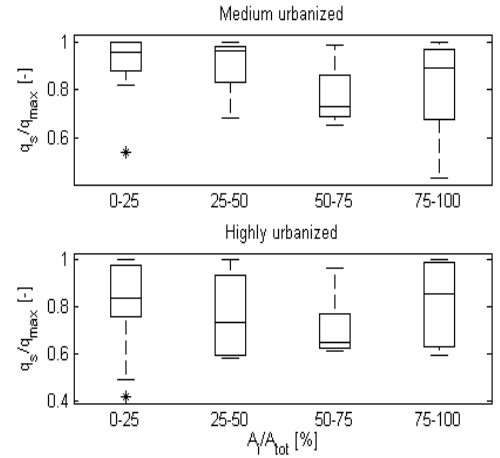
Man-made impact on flood hydrology/hydraulics

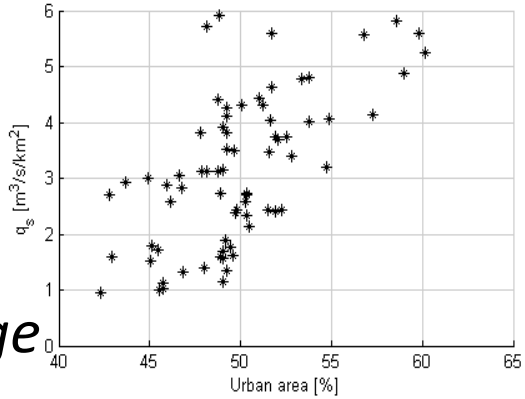


City of Rome: Tributary network of 220 km with an average culvert inter-distance of 300-400m

1000 km^2 of ungauged basins in highly urbanized area





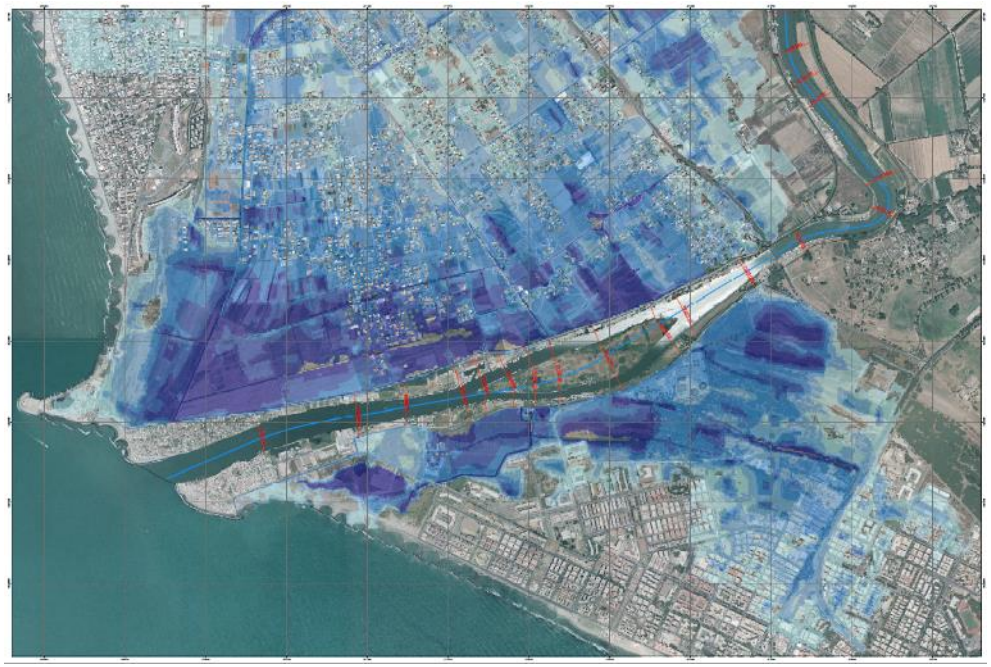


Hydrologic change

Runoff ratio/CN and Unit discharge

Nardi et al., ***Journal of Flood Risk Management*** **(2015)**

Large to local scale hydraulic engineering



Large to local scale hydraulic engineering

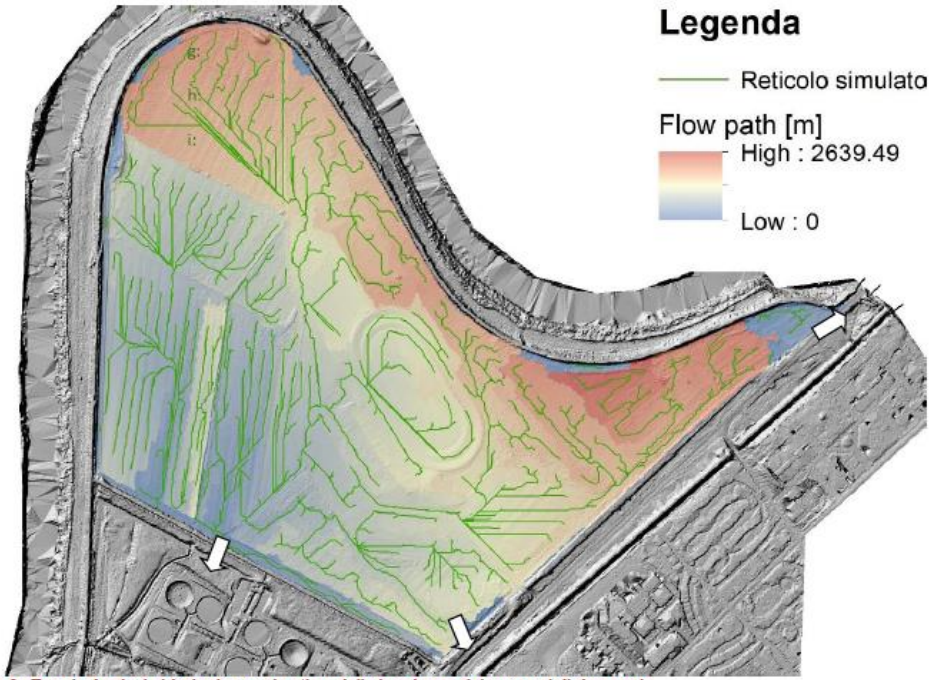


Figura 8 –Terrain Analysis idrologico per la stima della lunghezza dei percorsi di drenaggio

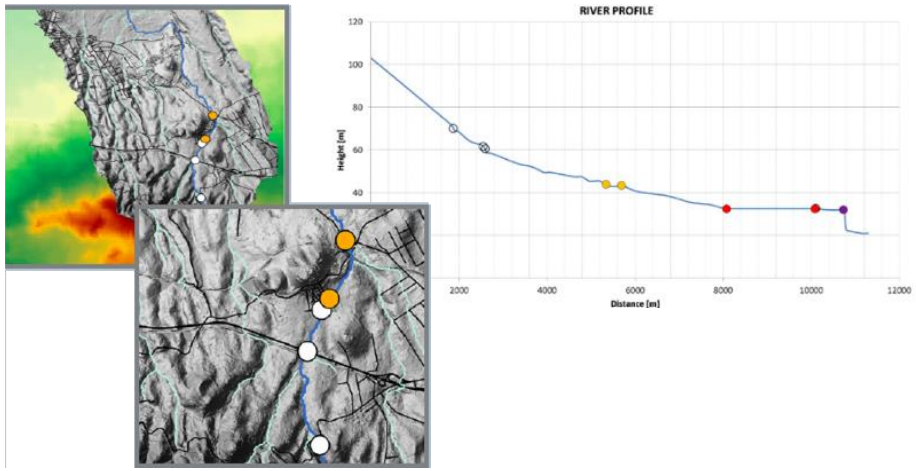
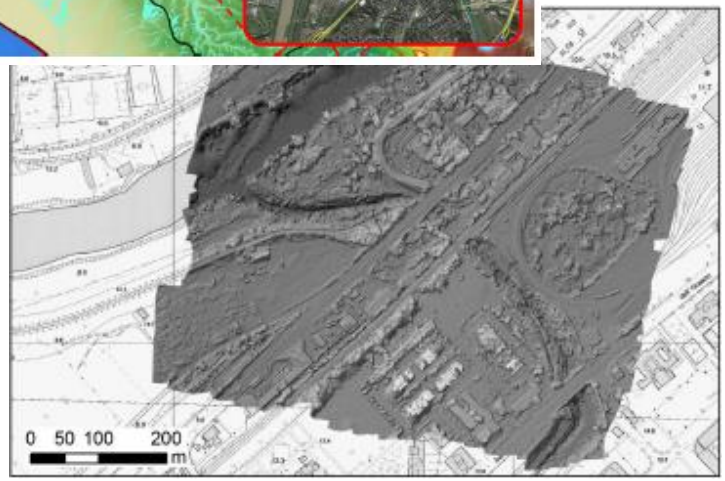
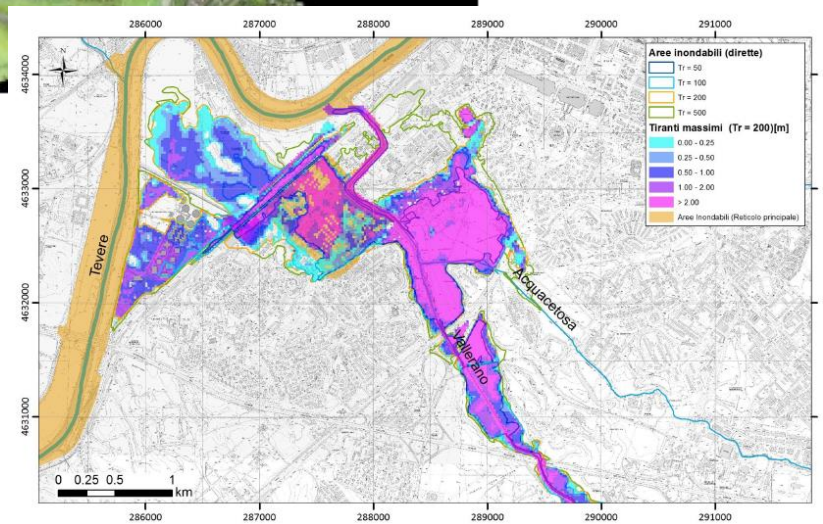


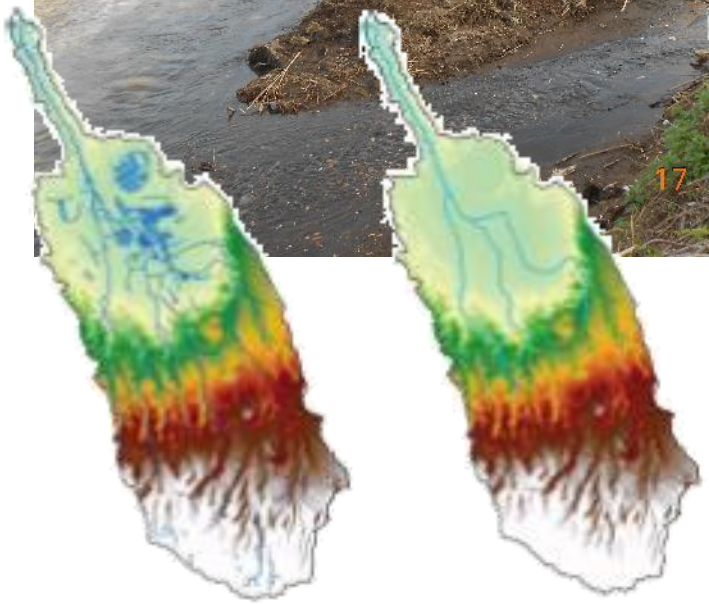
Figura 26 - F01: Vista da monte del ponte romano di via Ostiense (Sezione V03)

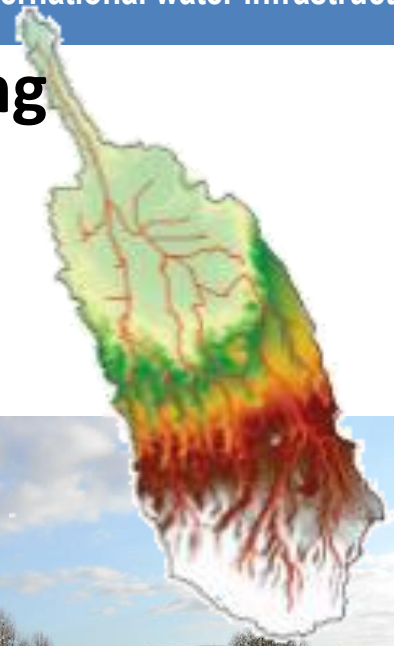
Large to local scale hydraulic engineering





Large to local scale hydraulic engineering

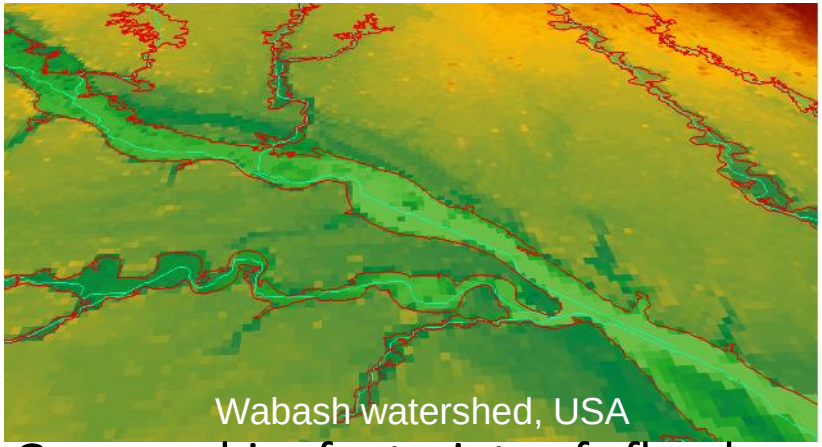




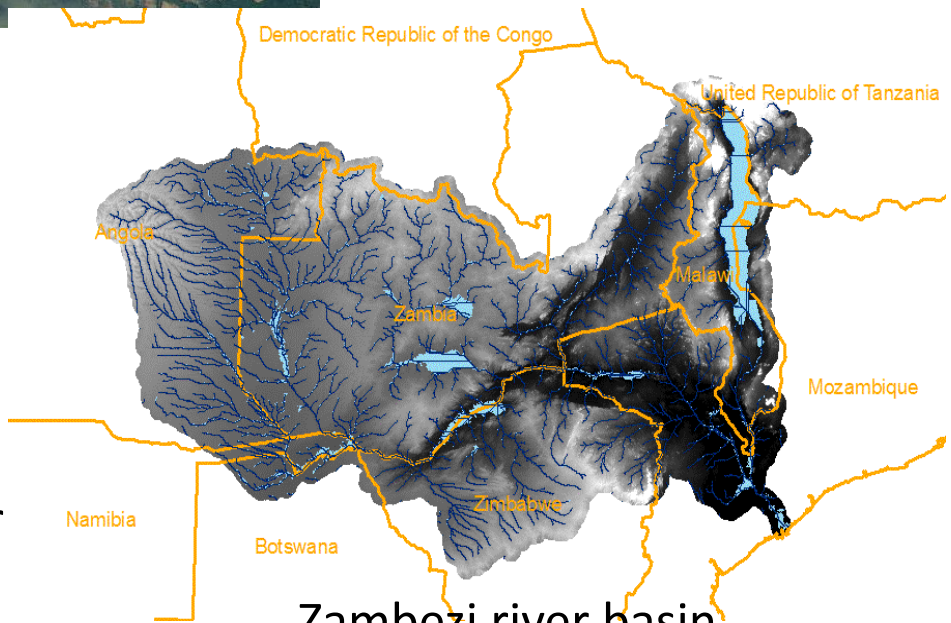
Outlines

- *Research background and solutions*
- *Rome flood risk management project*
- ***Floodplains (water geomorphic footprint) and human dynamics/perception***

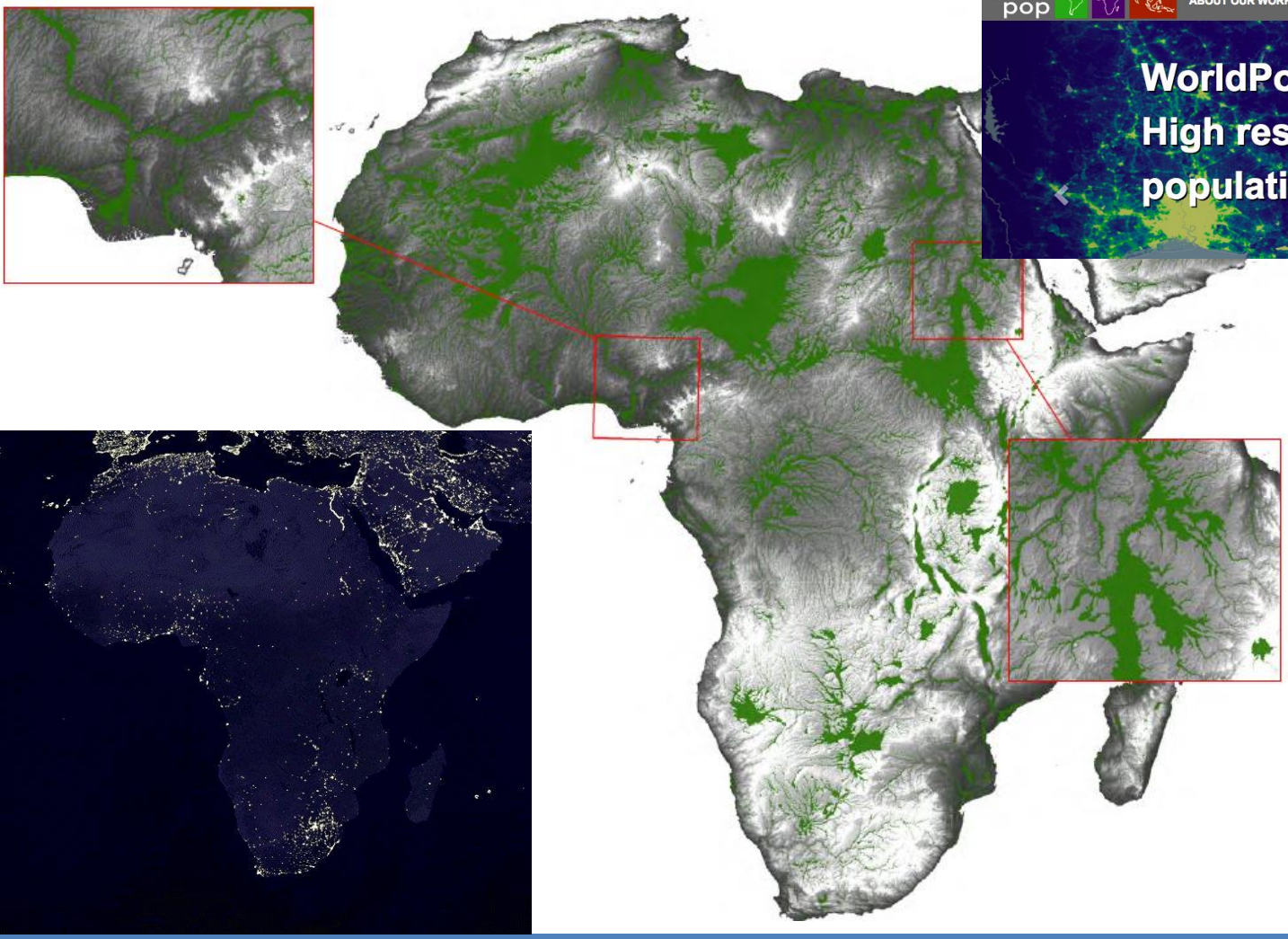
Floodplain mapping



Geomorphic footprint of floods under historical or varying climatic and hydrologic conditions



Zambezi river basin

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Thanks for your attention

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