INFRASAFE Project

CIRI EDILIZIA E COSTRUZIONI
UNIVERSITÀ DI BOLOGNA

Numerical simulations of 12-years evolution of the Po River morphodynamics

EGU General Assembly

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CIRI • EDILIZIA E COSTRUZIONI
CENTRO INTERDIPARTIMENTALE PER LA RICERCA INDUSTRIALE
UNIVERSITÀ DI BOLOGNA

INFRASAFE Project

Intelligent Monitoring for Safer Infrastructures

POR FESR 2014-2020 - ASSE 1 - AZIONE 1.2.2

General objective

- creation of an integrated monitoring and diagnosis system, based on available technologies, to be used in channels, floodplains, riverbanks, embankments and road infrastructures to enhance their safety by allowing timely interventions.

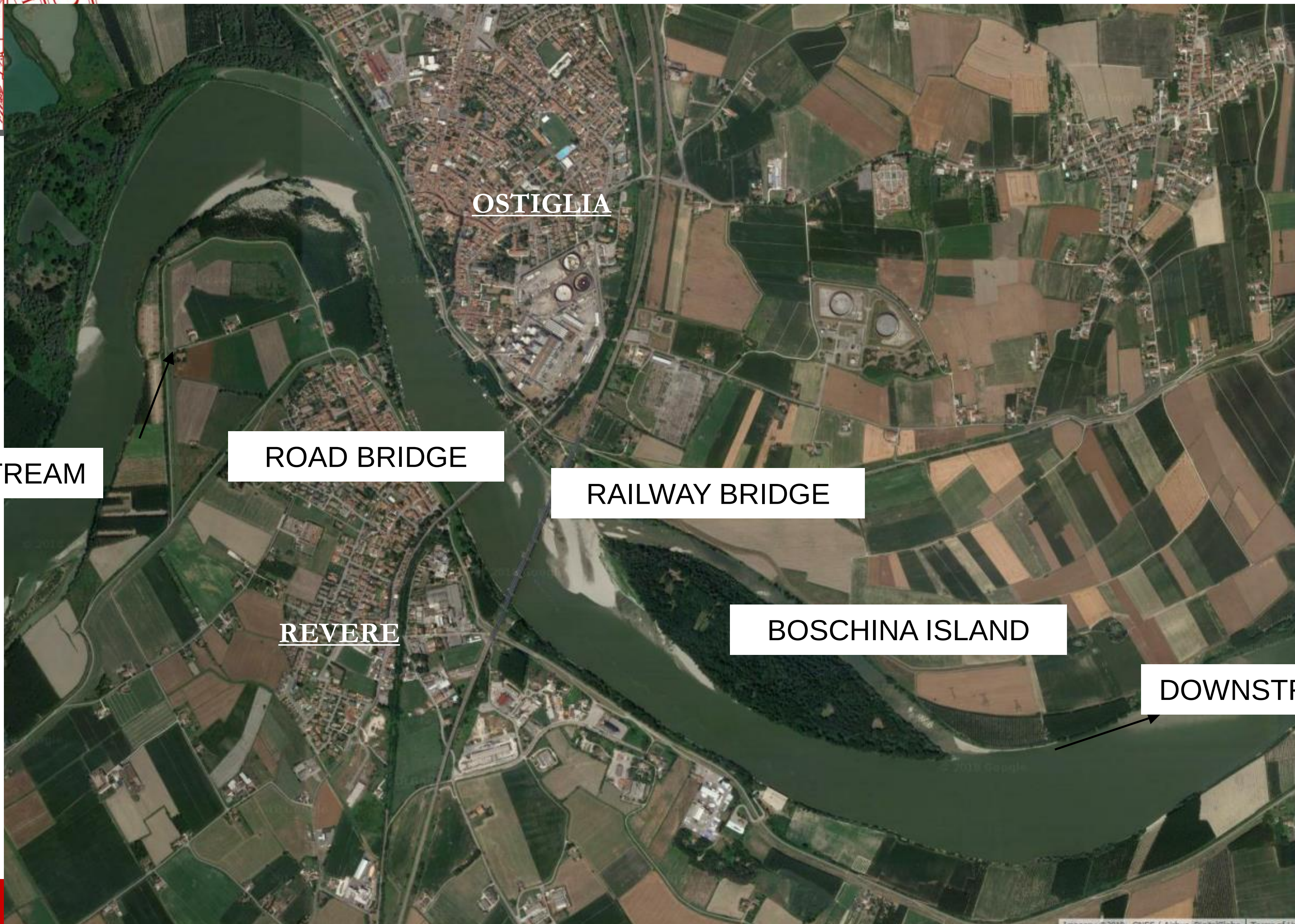
Duration 01.04.2016 - 31.03.2018

www.infrasafe-project.com

POR FESR EMILIA-ROMAGNA 2014/2020
UNIONE EUROPEA
Fondo europeo di sviluppo regionale
Regione Emilia-Romagna

Po River at Revere, Italy

Po River at Revere, Italy



ADCP campaign - October 2017

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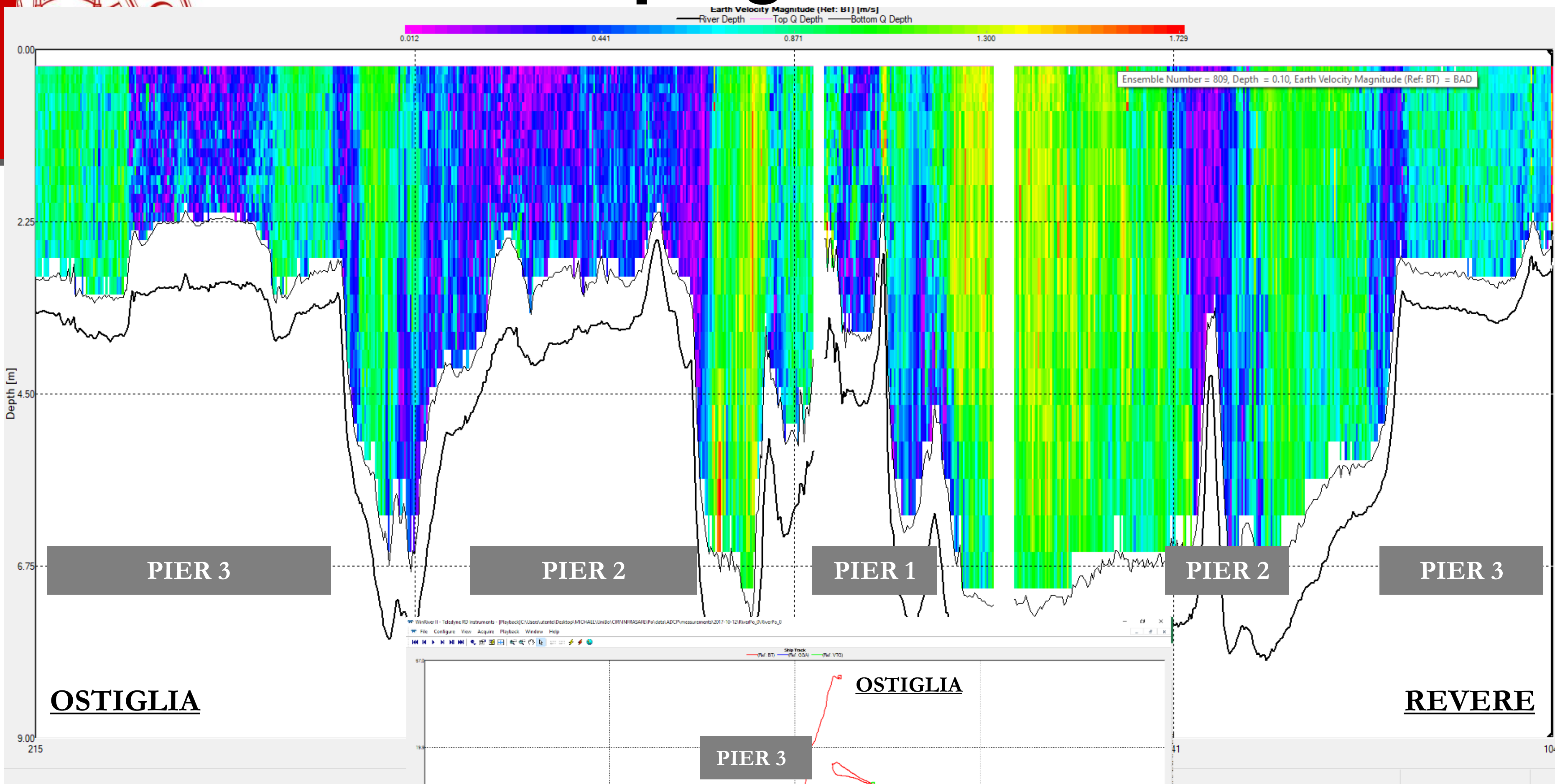
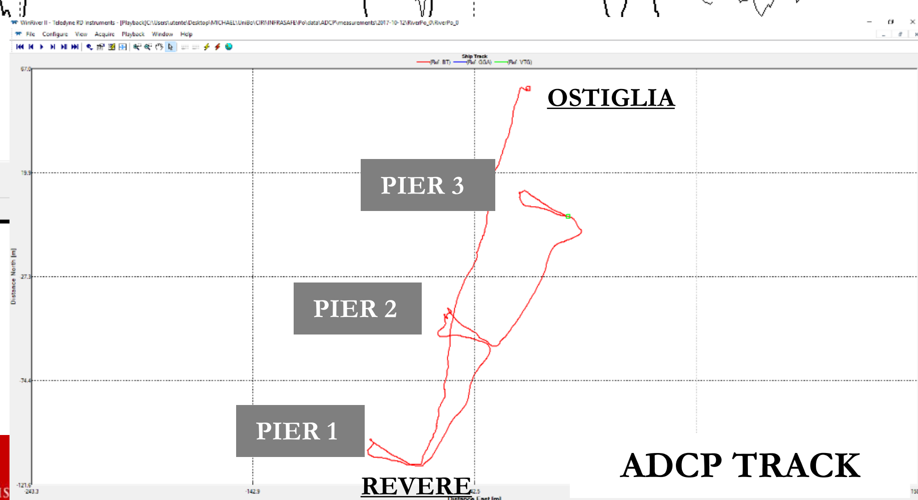
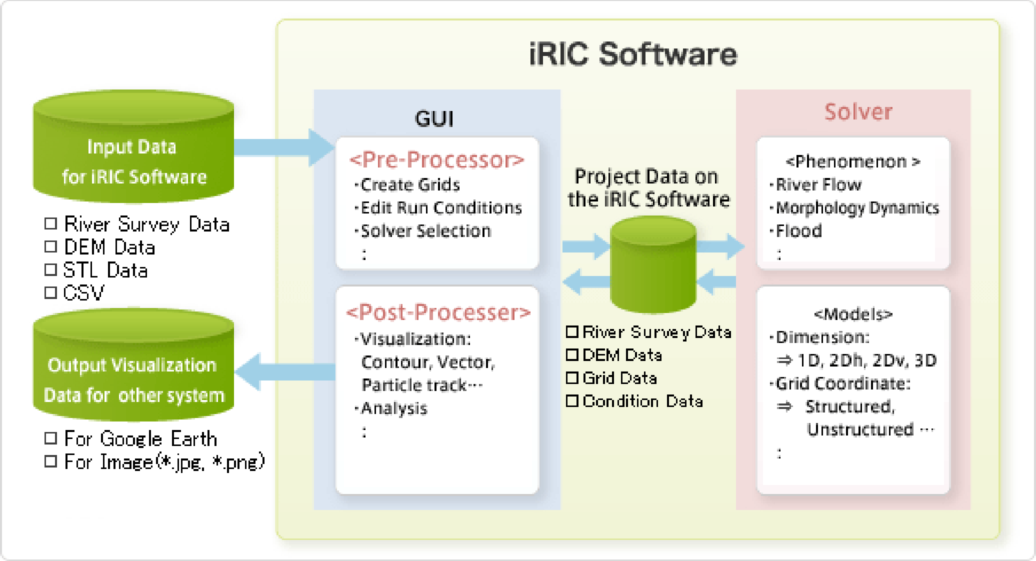




iRIC model

i-ric.org

iRIC Software
Changing River Science



iRIC (International River Interface Cooperative) is a river flow and riverbed variation analysis software package combining the functionality of MD_SWMS, developed by the USGS (U.S. Geological Survey) and RIC-Nays, developed by the Foundation of Hokkaido River Disaster Prevention Research Center.

The software consists of three parts: pre-processor, post-processor, and solvers.

The pre-processor creates calculation conditions (hydrologic conditions, calculation methods, etc.) from survey data such as river survey data, DEM or geometric configurations.

The postprocessor permits to visualise the results in terms of vector, contour, maps and graphs, easily exportable.

The user can select one of 15 solvers (continuously updated), depending on the problem under study (1D-3D), riverine and coastal environments, etc.

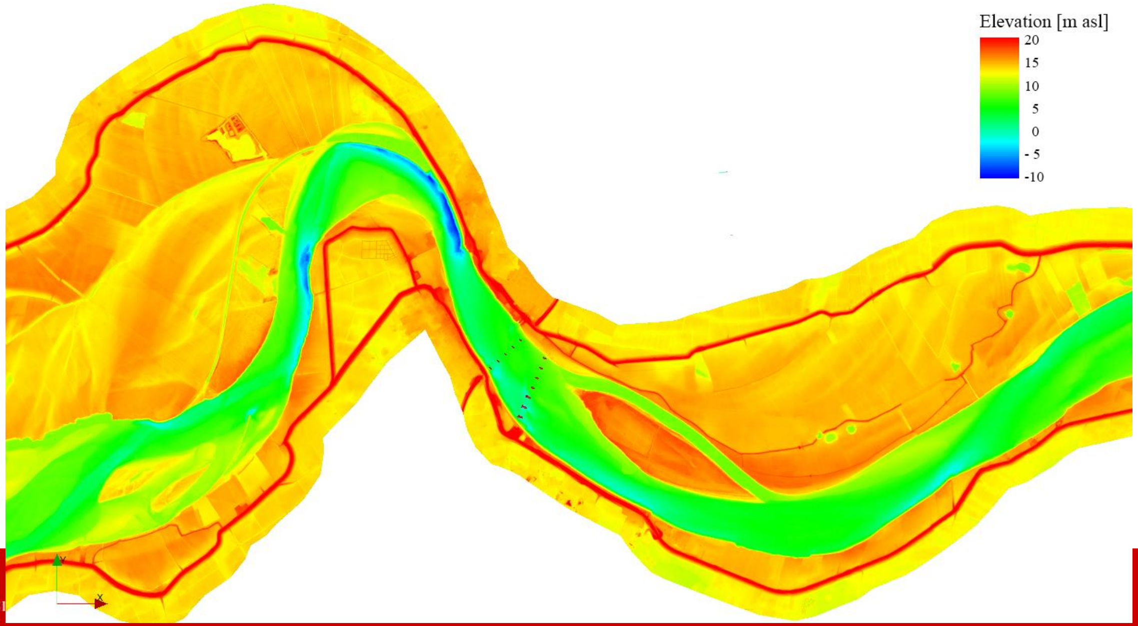
iRIC model: Mflow_02 solver

i-ric.org/en/software/19

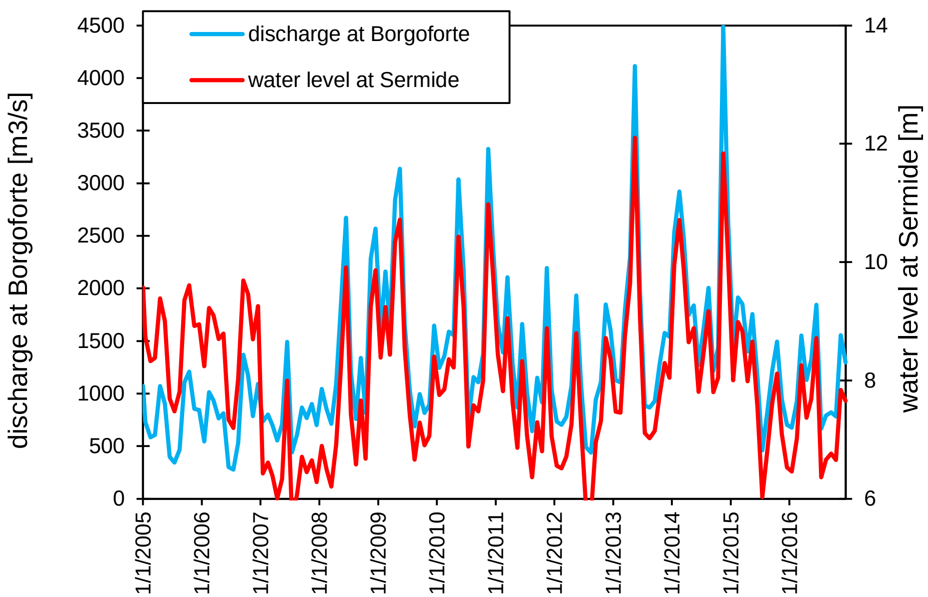
Mflow_02 is an analysis solver to calculate 2D plane unsteady flow and riverbed variation by unstructured grid, using the FEM in orthogonal coordinate system.

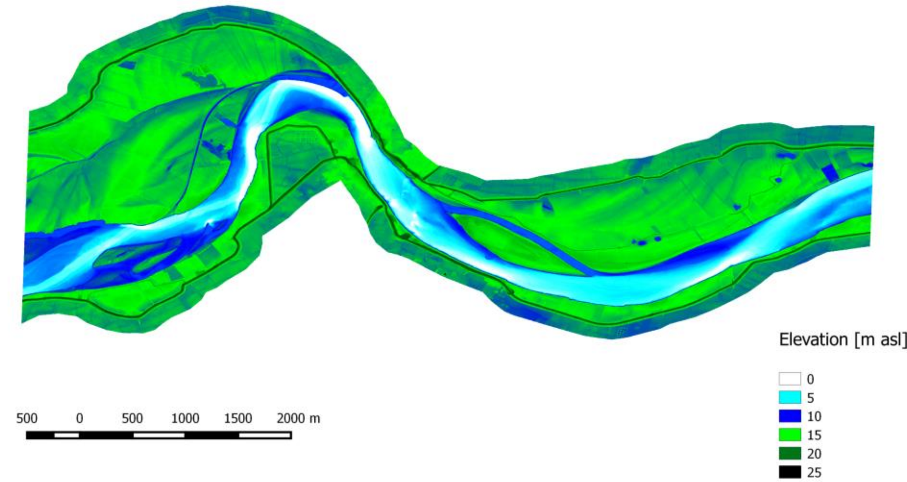
Unsteady flow conditions are computed given the boundary conditions in terms of discharge (upstream) and water level (downstream).
Sediment transport is calculated assuming a movable bed composed by non-uniform material.

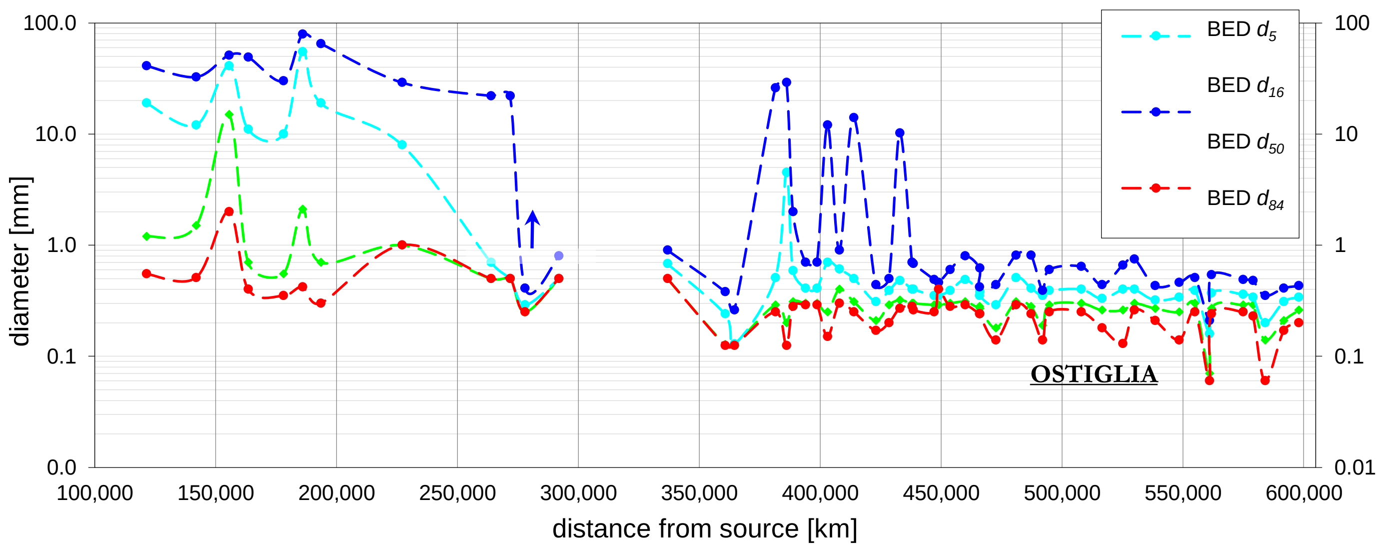
Aiming to produce boundary conditions for detailed 3D models, simulations of the large scale morphodynamics were performed using the version 3β, released in March 2018.



Input data


discharge at Borgoforte
water level at Sermide
discharge at Borgoforte [m3/s]
water level at Sermide [m]
4500
4000
3500
3000
2500
2000
1500
1000
500
0
14
12
10
8
6
1/1/2005
1/1/2006
1/1/2007
1/1/2008
1/1/2009
1/1/2010
1/1/2011
1/1/2012
1/1/2013
1/1/2014
1/1/2015
1/1/2016


Elevation [m asl]
0
5
10
15
20
25
500 0 500 1000 1500 2000 m


BED d_5
BED d_{16}
BED d_{50}
BED d_{84}
diameter [mm]
100.0
10.0
1.0
0.1
0.0
100
10
1
0.1
0.01
OSTIGLIA
100,000
150,000
200,000
250,000
300,000
350,000
400,000
450,000
500,000
550,000
600,000
distance from source [km]

Modelling parameters

grid ==> nested grids with triangular cells, area range from 3000 m^2/element to 50 m^2/element

boundary conditions ==> **upstream** flow discharge, **downstream** water elevation, monthly values

sediment transport ==> M.P.M (bedload) + Garcia-Parker (suspended load) eqs., exchange layer 2 m

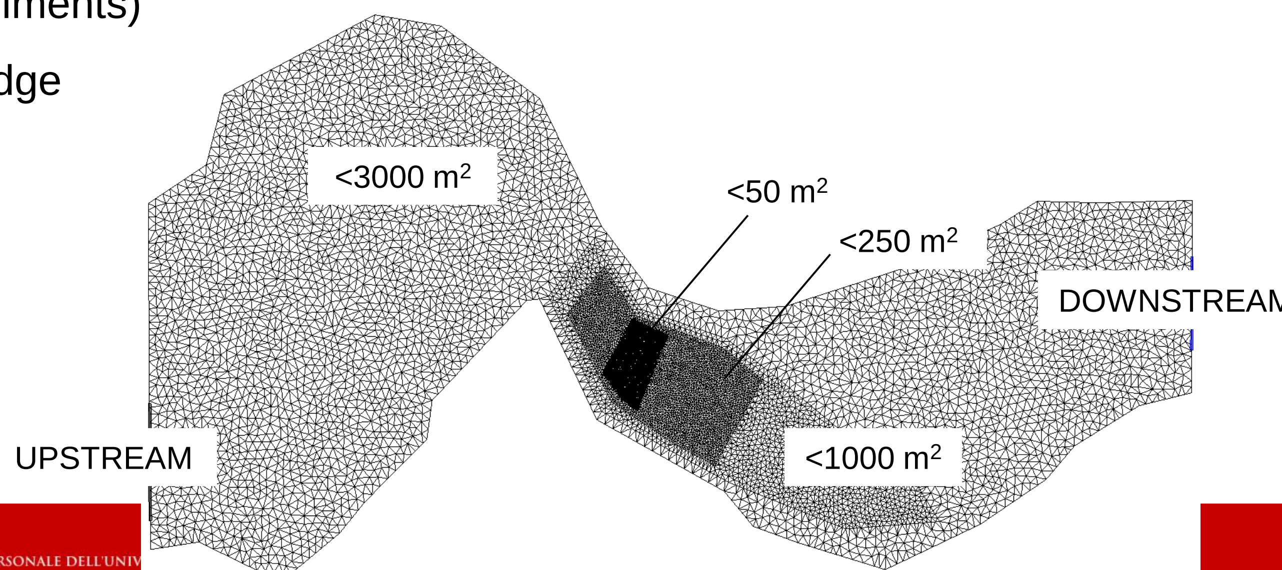
turbulence ==> k-ε model

bed roughness ==> 0.035 $m^{1/3}$/s for channel, 0.06 $m^{1/3}$/s for floodplains

time step ==> 0.2 s (water/sediments)

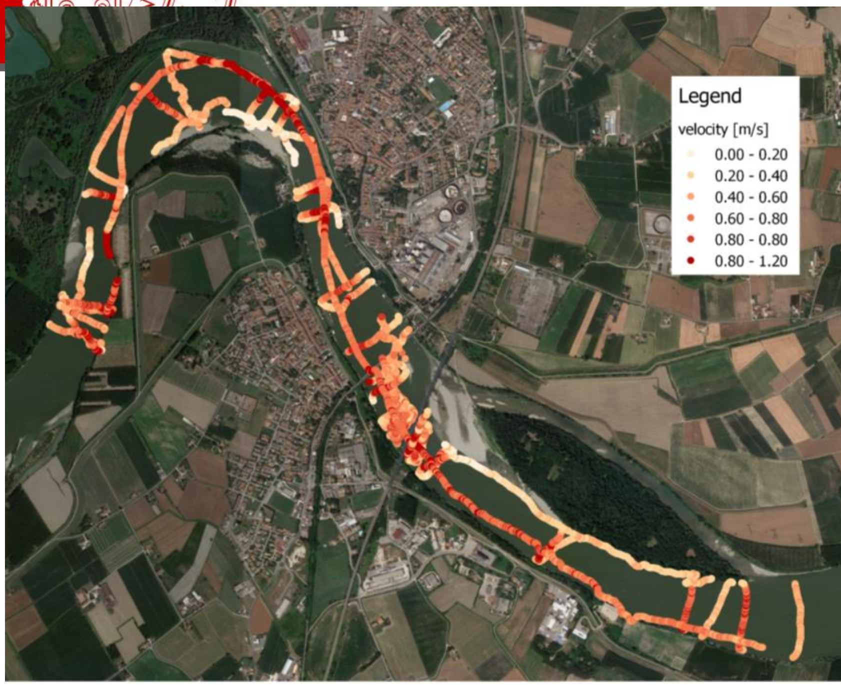
bridges ==> road + railway bridge

simulation time ==> 14 days

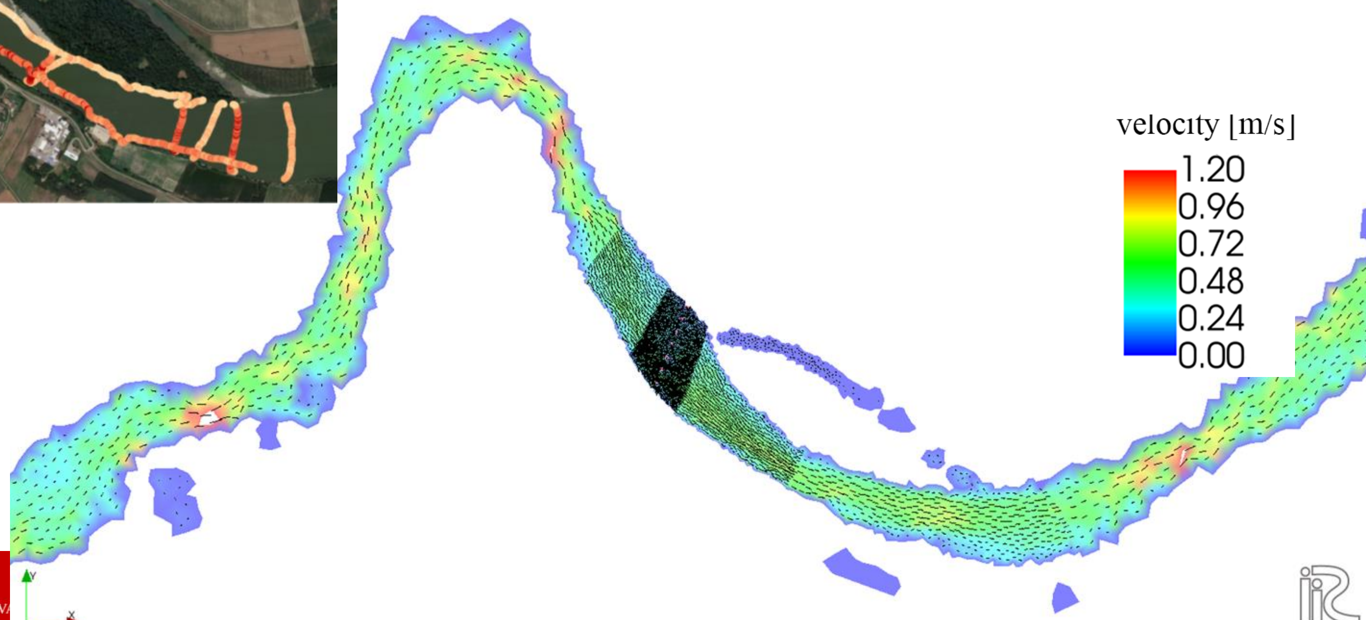


Calibration: 2017 data

water flow velocity ==> **hydrodynamics**

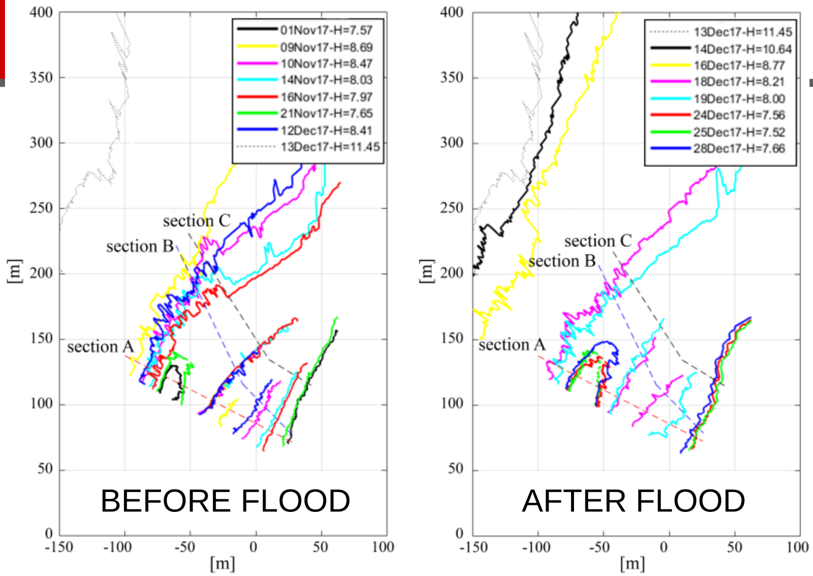


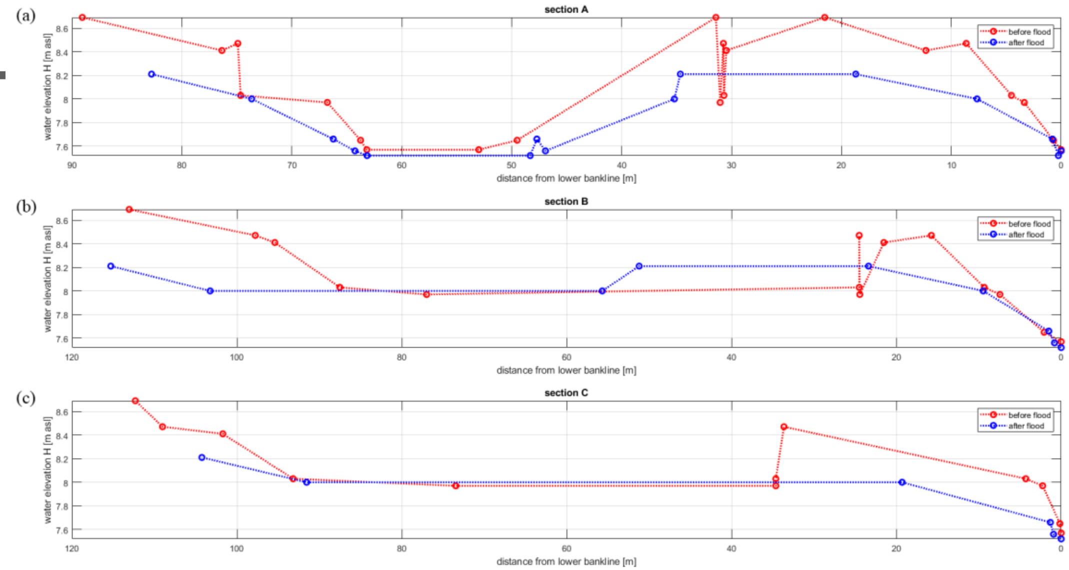
Mean velocities in the order of 1.00-1.20 m/s in low-mean flow conditions.

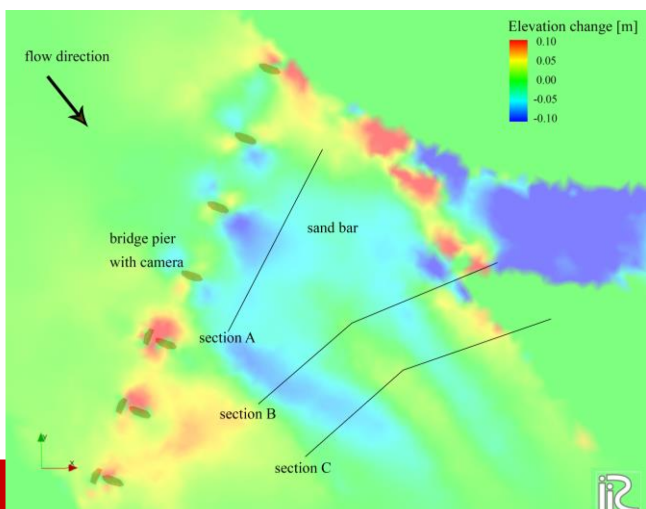


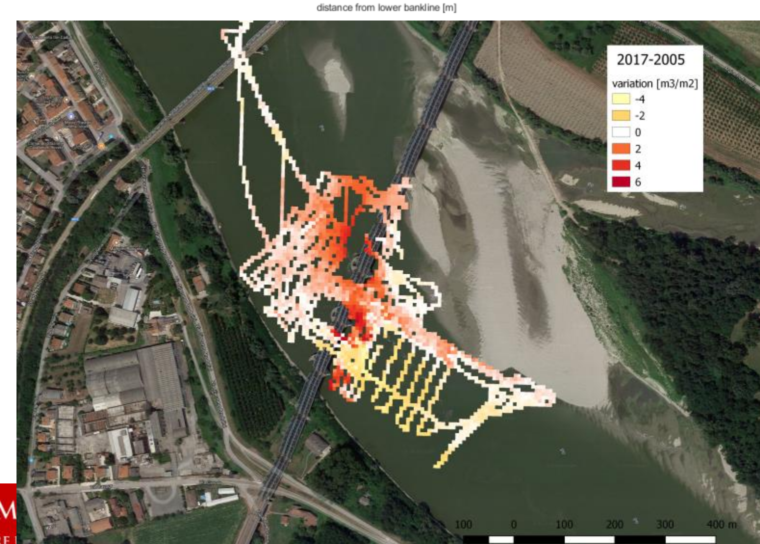
Calibration: 2017 data

bankline displacements + DEM ==> **morphodynamics/morphology**

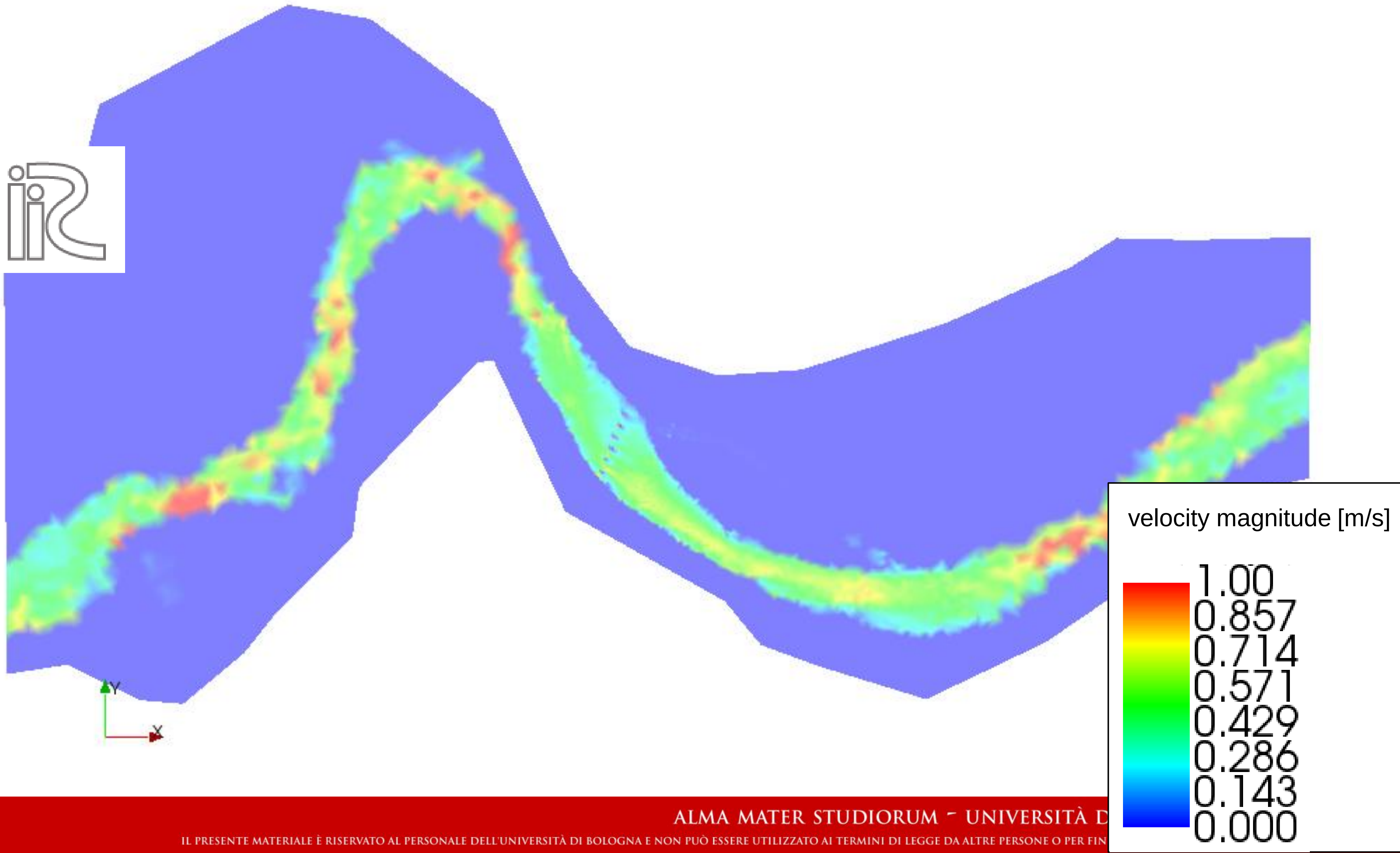




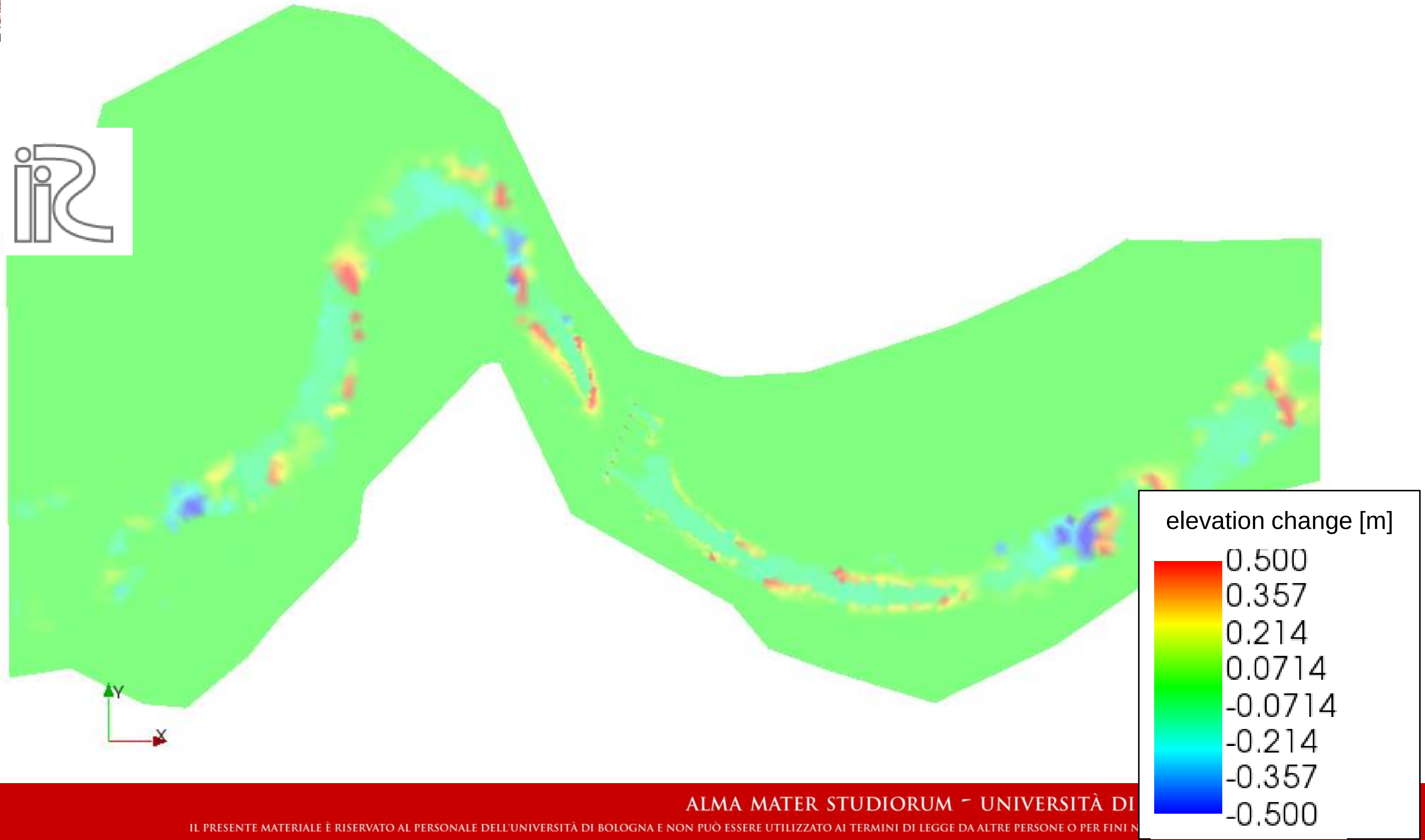




Results: velocity



Results: elevation change



Conclusions

Preliminary applications show that:

- iRIC suite is a powerful tool in multi-scale analysis

- hydro-morphodynamics are quite well represented

- flow velocities of around 1 m/s and bed erosion of 5-10 cm/y are plausible compared with field data and literature information

- high and low flow conditions operate in a counteracting way: for *low discharges*, sediments are deposited on bars and the main channel eroded; for *high discharges*, sediments are redistributed across the channel reducing the erosive trend

- migrating bars are moved by flooding waves, which are rare in the last years

- 2D solvers can be applied to produce boundary conditions for 3D simulations

Future steps

Future research is necessary on:

- **domain discretization**, giving a higher detail close to the bridge piers and where significant morphological changes are forecasted/measured

- **modelling approach**, changing the simulation parameters (grid dimension, time step) and the forcing terms (initial and boundary conditions, spatially-varying bed roughness, etc.) to simulate wet and dry regions

- **input data**, measuring local quantities with traditional and innovative techniques (remote videography, hADCP, SAR satellite, etc.)

Thank you for your attention

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