CFD modelling of the Po River hydro-morphodynamics affected by bridge piers

HS9.1/GM4.9/SSS12.22

Michael Nones [1], Massimo Guerrero [2], Nils Ruther [3], Sándor Baranya [4]

[1] Interdepartmental Centre for Industrial Research in Building and Construction - Fluid Dynamics Unit, University of Bologna, Italy - michael.nones@unibo.it
[2] Department of Civil, Chemical, Environmental, and Materials Engineering, University of Bologna, Bologna, Italy - massimo.guerrero@unibo.it
[3] Department of Hydraulic and Environmental Engineering,Norwegian University of Science and Technology, Trondheim, Norway - nils.ruther@ntnu.no
[4] Faculty of Civil Engineering, Budapest University of Technology and Economics, Budapest, Hungary - baranya.sandor@epito.bme.hu

INFRASAFE project

Intelligent Monitoring for Safe Infrastructures
POR FESR 2014-2020 - ASSE 1 - AZIONE 1.2.2

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.

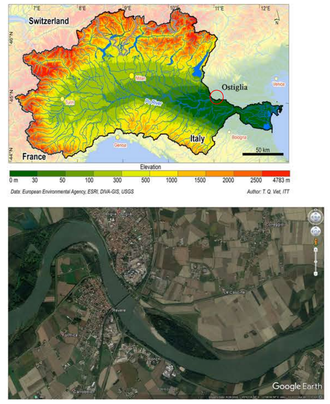
Duration: 1.04.2016 - 31.03.2018 public-private partnership

info: *www.infrasafe-project.com*

Proposed approach

As a part of the INFRASAFE project, the present work is focused on the modelling of hydro-morphological changes of a small reach affected by the presence of two bridges.

The freeware code SSIIM, developed by the NTNU, is implemented to reproduce the nowadays situation, in terms of hydraulics (water discharge, current velocities) and morphodynamics (bathymetry, sediment transport). In the future, the model will be used to evalute the impact of natural (climate change) or anthropogenic (reshapening, embankments construction) activities, by means of additional data taken during the project.



Po River

L = 7000 m
B = 250 - 350 m
Q_{50} = 800 m^3/s
S = 2.5 ‰
d_{50} = 25 mm

Ostiglia bridges

Modelling

The numerical model SSIIM is applied to study the hydro-morphodynamics of a 7-km reach of the Po River, affected by the presence of two bridges.

SSIIM permits to reproduce the behaviour of the reach in terms of hydraulics (water discharge and flow velocities), morphodynamics (erosion/deposition) and sediment transport.

First results show the model capability in reproducing the data, measured in the last years, but also the necessity of a thorough calibration of the model in terms of initial and boundary conditions, especially regarding the solid phase (sediment grainsize and bottom composition).

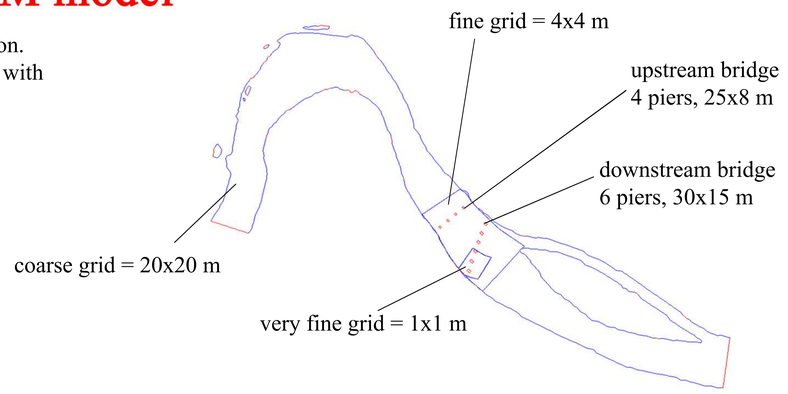
Up-to-date data will be measured within the INFRASAFE project, aiming to improve the overall modelling.

SSIIM model

SSIIM is an abbreviation for Sediment Simulation In Intakes with Multiblock option.
The program solves the Navier-Stokes equations using the control volume method with the SIMPLE algorithm and the k-epsilon turbulence model.
Sediment transport is handled with the van Rijn's formula.

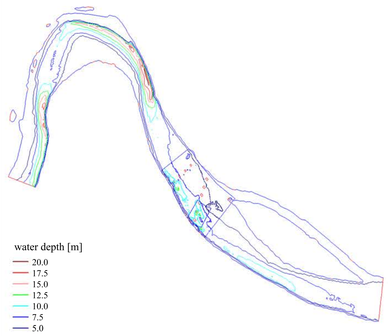
SSIIM 1 is used to create the structured grids (coarse/fine) .
SSIIM 2 combine these grids in a single unstructured grid, necessary to simulate the river hydro-morphodynamics with a wet-dry algorithm. This code handles nested grids having a different resolution.

http://folk.ntnu.no/nilsol/ssiim/

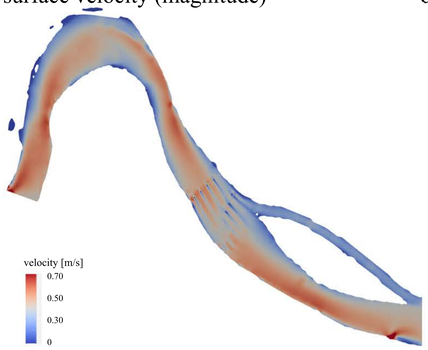


Preliminary results

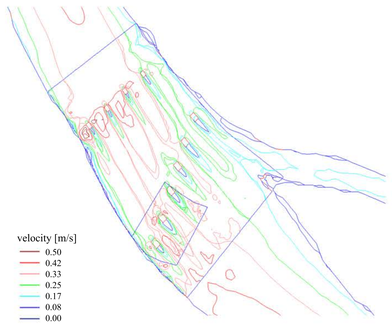
water depths



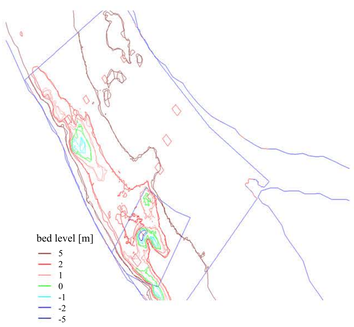
surface velocity (magnitude)



depth-averaged velocity



bed levels



Future steps

1. Make a sensitivity analysis of the model based on the current data (initial and boundary conditions).

2. Monitor the reach to acquire up-to-date data (bathymetry, hydrology, sediment samples, suspended sediment transport etc.).

3. Consider additional processes in the model (riparian vegetation, temperature, macrozoobenthos, fishes, etc.).

4. Compare the modelling results with the monitoring data.

5. Simulate future scenarios, pointing out possible failures of the piers because of a changing hydrology (climate change or human activities).

INFRASAFE Project

www.infrasafe-project.com