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Long term monitoring of river bedload flux in representative sandbed rivers of the Emilia-Romagna region, Italy

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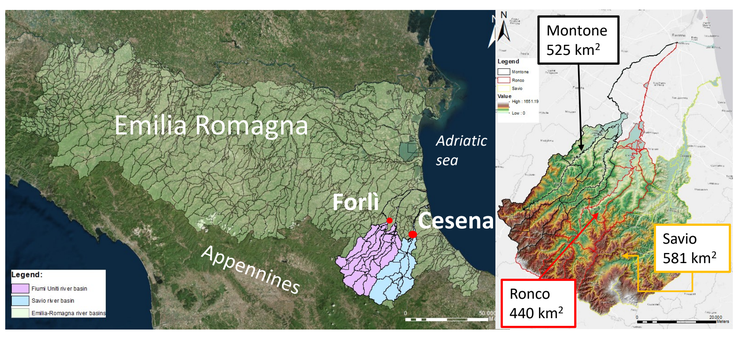
Introduction

Over the last decades, most of the Emilia-Romagna (Italy) beaches have been affected by marked erosion that is still progressing, which is primarily due to the reduction of sediment supply by the local rivers. Since the role of small rivers has been recognized as important in contributing to both beach stability and changes, some studies on bed-load sediment transport in the Emilia-Romagna region were carried out, but unfortunately referred to a limited number of rivers (Billi & Salemi 2004, Ciavola et al. 2005, Ciavola et al. 2010; Billi et al., 2017). In order to widen the data set of river sediment supply in the whole region, bedload measurement campaigns in representative rivers are in progress by the authors of the current paper. The research focuses on the Fiumi Uniti and Savio rivers that are paradigmatic in terms of mouth morphodynamics. The research activities include hydrological investigations and bed load transport measurements. Moreover, representative annual discharge duration curves were calculated from data-sets of registered rainfall and flow levels at several gauge stations in the catchments.

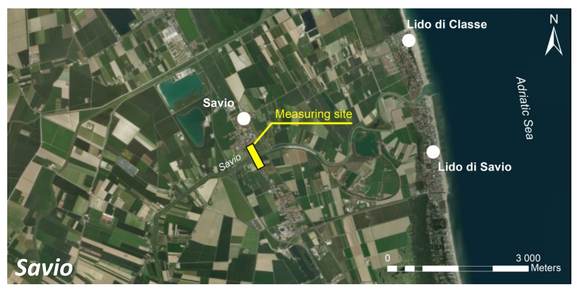
Objectives

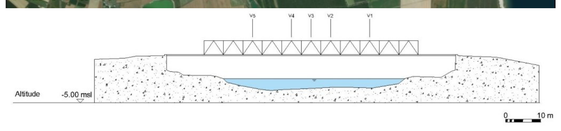
- Definition of a regional approach to analyze the sediment supply of the local rivers
- **Bed load transport estimation of sandy bed rivers**
- Prediction of the threshold bed shear stress value for bed particle entrainment

Study area

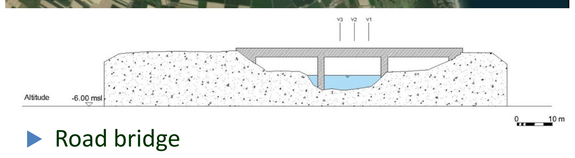


The lowermost reach of the Fiumi Uniti is an artificial river 9.3 km long that was realized around the 18th century. The Savio river officially originates in the Apennines at an elevation of 1100 m asl and flows for 126 km north-eastwards to the Adriatic Sea. From Cesena to the sea it is an artificially dammed river.





- Pedestrian bridge
- Distance to the sea: 8 km
- Cross- section: trapezoidal
- Maximum channel width: 60 m
- Stream bed gradient: 0.29 m/km
- Bed material: D_{50} = 0.55 mm
- Aspect ratio W/D ~ 9 < 11 (narrow)



- Road bridge
- Distance to the sea: 6 km
- Cross- section: trapezoidal
- Maximum channel width: 25 m
- Stream bed gradient: 0.3 m/km
- Bed material: D_{50} = 0.50 mm
- Aspect ratio W/D ~ 5 < 11 (narrow)

Methodology

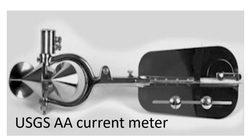
1. Bedload transport measurements :

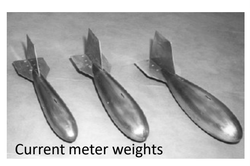
2005/2006 and 2017/ongoing

- Flow depth and flow velocity measurements at fixed verticals of the active cross-section
- Bedload transport measurements at the same locations
- Standard Helley-Smith bedload sampler with a 76x76 mm intake and sample bag with 0.1 mm mesh

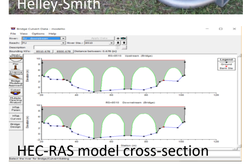
2. Hydrodynamic modeling :

- Acquisition of cross-section data from the River Basin Authority
- Creation of a geo-referenced HEC-RAS model
- Model calibration
- Energy Gradient Slope calculation

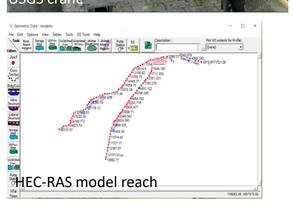

USGS AA current meter


Current meter weights

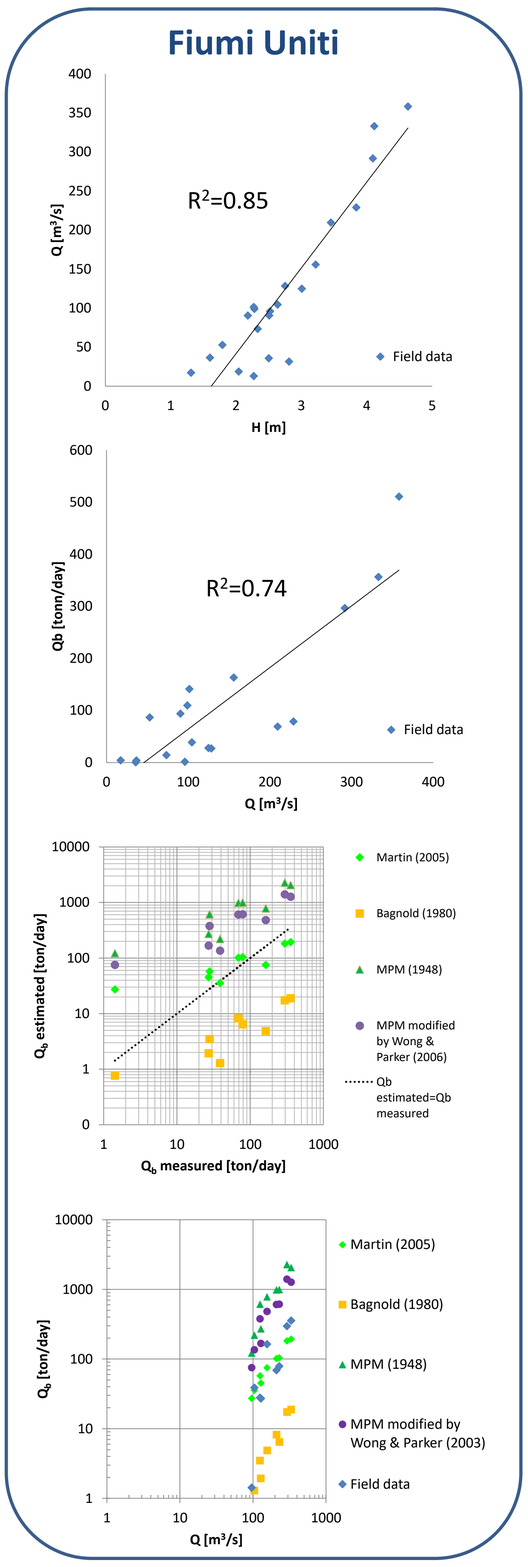

Helley-Smith

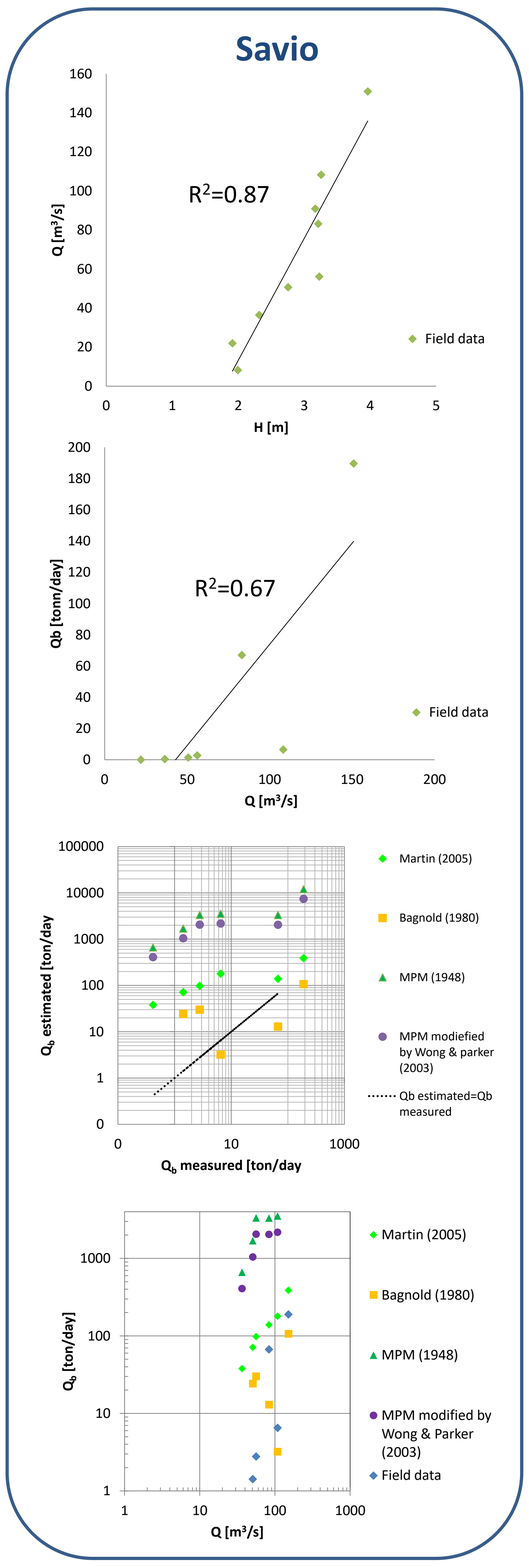

HEC-RAS model cross-section


USGS crane


HEC-RAS model reach

Results





Discussion

Twenty-three floods for the Fiumi Uniti and nine for the Savio river have been monitored. Starting from 2005 for the Fiumi Uniti case, the monitoring activities have been carried out until March 2018 and are still ongoing. All floods monitored are reported in the graphs which show rating curves and relationship between liquid and solid discharge. It is important to notice that **both rivers are effectively transporting less material than expected**. In fact, especially for the Savio case, the bed load transport is really low even with high water discharges values.

In order to estimate bed load transport capacity, several formulae such as Mayer Peter and Muller (1948), MPM revised by Parker (2003) followed by Martin (2005) and Bagnold (1981) equations have been tested. MPM formula is one of the oldest equations which have been used for its simple applicability. It is based on the bed shear stress excess of the threshold one. Martin and Bagnold equation are both based on unit stream power. In Martin's (2005) equation is i_b=0.0505ω where ω is unit stream power expresses in kg/ms. This approach does not include a threshold condition for particle entrainment, unlike Bagnold's equation which considers also a critical stream power value.

The comparison between measured and calculated bedload rates demonstrate that some approaches overestimate bed load transport with at least list one order of magnitude, especially for MPM (1948) and MPM modified by Parker (2003).

Conclusions

- Reliable predictions of sediment transport in natural streams with human induced variations are necessary both for fluvial and coastal management, especially to face the Emilia-Romagna coastal erosion;
- Results show probable effects of **sediment supply limited condition** since bed load material championed during floods is way lower than expected;
- At the moment, **Martin (2005) and Bagnold (1981) approaches seem to be the most suitable for our study rivers**, though Bagnold's equation lightly underestimates sediment transport.

References

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