Dynamic sediment connectivity in Alpine catchments as a tool for sediment management at the river basin scale

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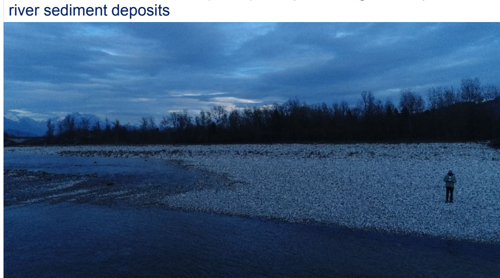
MAJOR QUESTIONS REGARDING SEDIMENTS IN WATER INFRASTRUCTURES PLANNING AND OPERATION

Were should water infrastructures be built?
How should water infrastructures be managed?

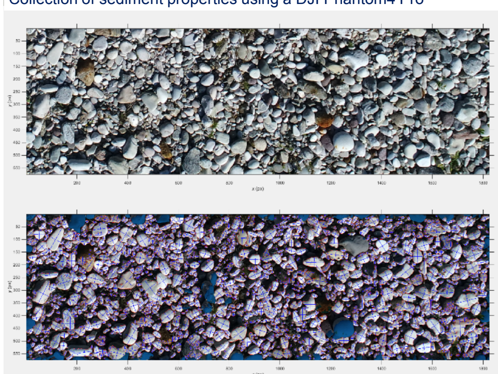
2

WHAT CAN WE MEASURE IN THE FIELD?

Unmanned Aircraft Vehicles (UAVs) to capture images of exposed river sediment deposits

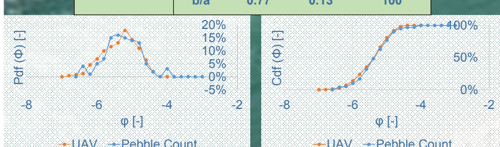


Collection of sediment properties using a DJI Phantom4 Pro



Application of the object recognition software BASEGRAIN to estimate grain size

		Average	St. Dev.	# Samples
UAV	Φ	-5.44	0.48	482
	b/a	0.69	0.14	482
Pebble Count	Φ	-5.37	0.51	100
	b/a	0.77	0.13	100



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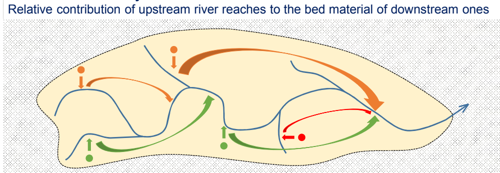
WHICH METRICS OF MORPHOLOGICAL CHANGES CAN BE ASSESSED AT BASIN SCALE TO INFER IMPACTS OF WATER INFRASTRUCTURES?

Sediment Connectivity
Relative contribution of upstream river reaches to the bed material of downstream ones



References

T. Szabó, G. Domokos, J. P. Grotzinger, & D. J. Jerolmack, Reconstructing the transport history of pebbles on Mars. Nature Communications, 6 (2015) 8366

Phillips, Colin B., and Douglas J. Jerolmack. 2016. "Self-Organization of River Channels as a Critical Filter on Climate Signals." Science 352 (6286)

R. J. P. Schmitt, S. Bizzi, & A. Castelletti, Tracking multiple sediment cascades at the river network scale identifies controls and emerging patterns of sediment connectivity. Water Resources Research, 52 (2016) 3941–3965.

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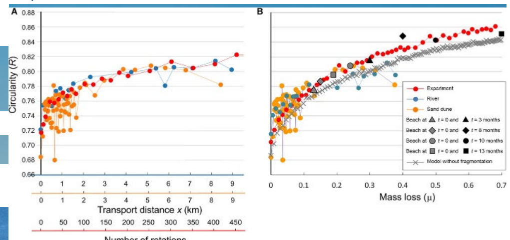
Hypothesis 1
Sediment shape, roundness, texture and lithology allow the estimation of particles distance travelled and of their sources



Data showing the "universal" evolution of circularity with (A) transport distance and (B) mass loss (after Novák-Szabó et. al. 2018)

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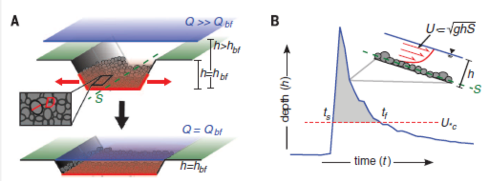
Morphological changes
Rivers change their cross-section and slope due to changes in the sediment transport rate: they "adjust" to the flow conditions (after Philipps and Jerolmack 2016).



Rivers adapt their geometry so that, during floods, the shear velocity slightly surpasses the critical valued for the given bed material

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Hypothesis 2
Sediment connectivity is an emerging property of the river network. Meaning that a 'natural' system, tends towards an 'equilibrium' as a consequence of its 'adaptation' to the sediment transport that it has been facing over time

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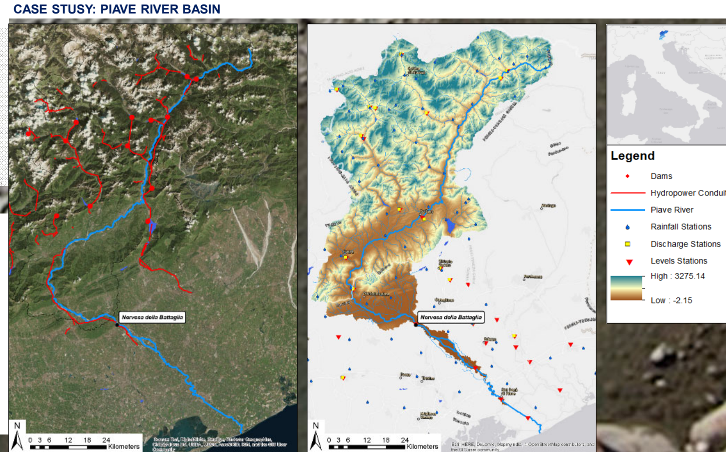
RESEARCH QUESTIONS

1. What is the accuracy of travel distances inferred from sediment shape and roundness parameters remotely sensed from images of bed sediment? (HP1)
2. Is sediment connectivity an emerging property of sediment transport processes at basin scale? (HP2)
3. What are the effects of water infrastructures (reservoirs and diversions) on sediment connectivity in a river network?
4. What is the resilience of sediment connectivity to perturbations due to localised sediment inputs in a river network?
5. What is the resilience of sediment connectivity to changes in climatic forcings in a river network?

CASE STUSY: PIAVE RIVER BASIN



The Piave River basin, location of the hydrological monitoring stations managed by ARPAV and schematic representation of major reservoirs and diversion pipelines

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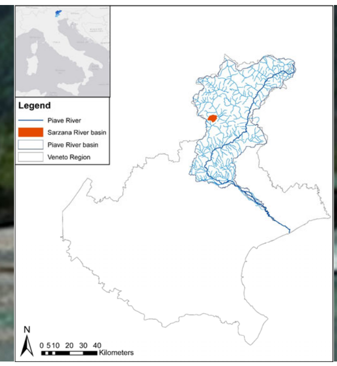
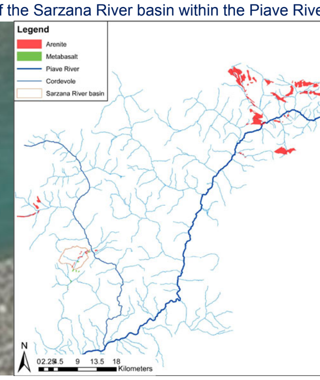
Methods

1. Identification of sediment tracers for testing hypothesis 1
    1. Sarzana River basin, localized outcrops of metabasalts and arenite
2. Sampling of sediment tracers' properties along the river network;
3. Assessment of the influence of different hydro/geo/morphological properties on abrasion rates;
4. Assessment of the validity of hypothesis 1 and of its applicability to estimate travel distances;
5. Development of a new sediment connectivity framework;
6. Application of the sediment connectivity framework to investigate hypothesis 2
    1. Assess the response of the system to instantaneous localized injections
    2. Assess the resilience of the system to reservoir development and localized water diversions
    3. Assess the resilience of the system to changes in the forcings: climatic and anthropogenic



Location of the Sarzana River basin within the Piave River catchment



Location of the arenite and metabasalt sediment sources used as tracers to test hypothesis 1