STEEP STREAMS

Solid Transport Evaluation and Efficiency in Prevention: Sustainable Techniques of Rational Engineering and Advanced MethodS

Aronne Armanini
Giuliano Di Baldassarre
Antonio Heleno Cardoso

Water JPI
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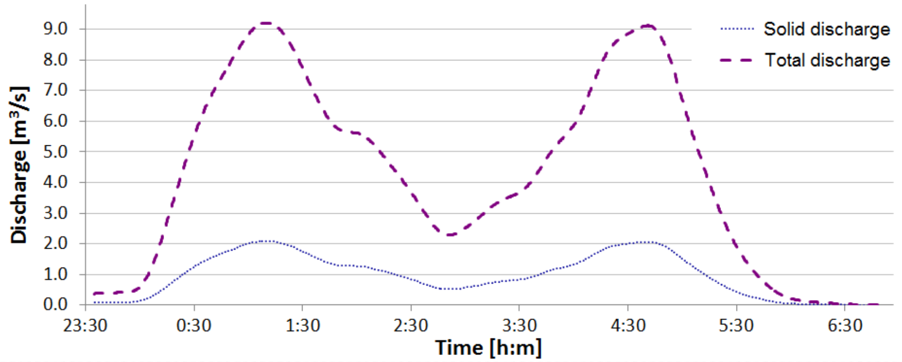
Why STEEP STREAMS?

Debris Flows:

- **catastrophic events** affecting **small mountain basins;**
- causing **loss of lives and properties damage**.
- **The total volumes** mobilized is **several times larger that that of the actual rainfall** volume

- **Uncertain triggering conditions.**
- often the **after a long rain saturating the soil,** followed by a **intense rain** that **induces the collapse.**

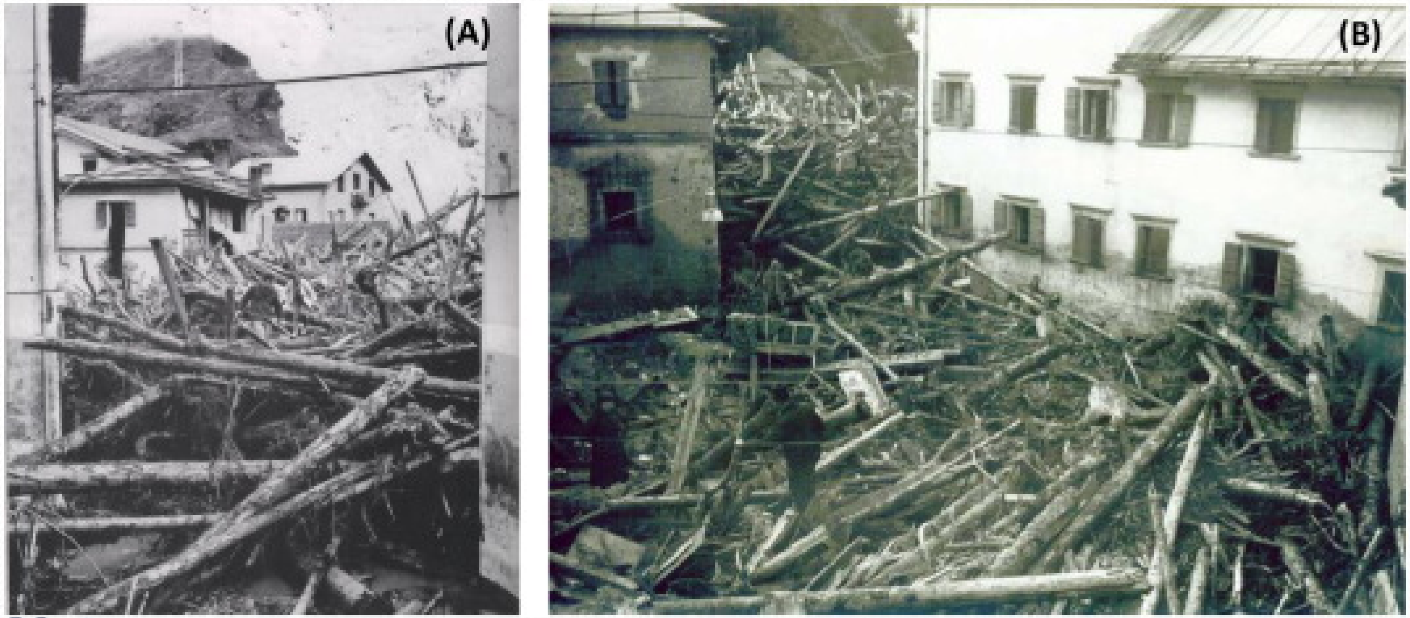


- Most **effective defense structure** is the **deposition basin** combined with the **<u>open check dam</u>**, which acts by reducing the peak of solid discharge during extreme events.

Why STEEP STREAMS?

An **<u>unresolved</u>** problem: the **presence of wood**:

- that enhances **clogging of the protection structures**;
- increases the **destructive power of the flow.**



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The Consortium of STEEP STREAMS

Coordination
University of Trento, Italy

Partners
Instito Superior Tecnico, Lisbon Portugal University of Uppsala, Sweden

Main targets of STEEP STREAMS

- Triggering condition in a scenario of climate change
- rational criteria for the design of defense structures against debris flows and driftwood able to manage separately sediments and wood.
- Design guidelines
- Dissemination of the results

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Scientific progresses

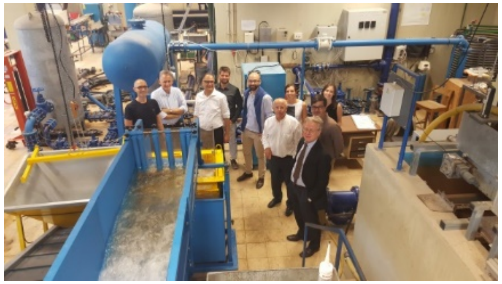
WP Number	*WP Title*	*OBJECTIVES*	*Trento*	*Uppsala*	*Lisboa*
WP1	*Project Coordination & Management*		*L*	*P*	*P*
WP2	*Climate change and hydrology*	*O1. definition of the return time of debris flows in a scenario of climate change*	*P*	*L*	*P*
WP3	*Mathematical models*	*O2. A new 2DH two-phase flow numerical model of debris flows, based on a well-founded rheology and the driftwood.*	*L*	*P*	*P*
WP4	*Defence structure against sediments*	*O3. Rational defence structure against bedload and driftwood*	*L*	*P*	*P*
WP5	*Defence structure against driftwood*	*O4. Design of new retention structures for debris flows and woodtransport*	*P*	*P*	*L*
WP6	*Design of the works in experimental basin*	*O5. New devices to trap vegetal material and wood without interfering with sediment transport control.*	*L*	*P*	*P*
WP7	*Dissemination*	*O.6 Dissemination.*	*L*	*P*	*P*

L=Leader, P=Partner

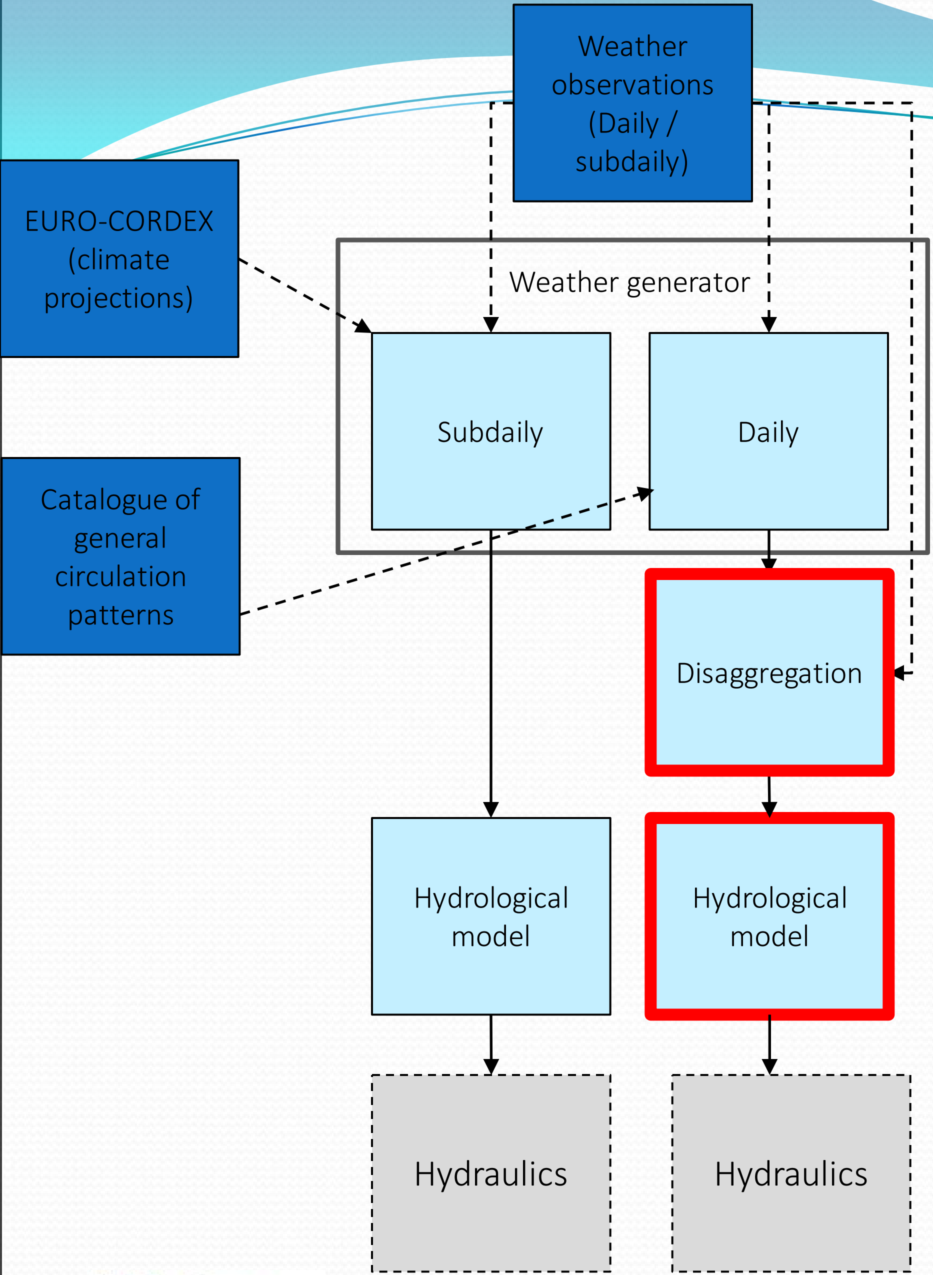
WP1

- subscription the Consortium Agreement (no DESCA model but which included all the required sections)
- Organization of the first meeting at Uppsala University on October 7th, 2016

- Organization of the second meeting at Lisbon University on October 6th , 2017.



- Organization of the third meeting at Trento University on 15th June 2018



WP2

G. Di Baldassarre & K. Brail (Uppsala)
R. Rigon: (Trento)

1. Development of a space time weather generator to simulate precipitation patterns and temperature fields and fill the observational gaps at daily time scale
2. Development of a space time algorithm to disaggregate **from daily into hourly values** (precipitation and temperature)
3. Tested at **small scale** (Trentino) and at **large scale** (Sweden)
4. Implementation of **weather forecast models**
5. Implementation of the existing model **JGrass-NewAGE**

A. Armanini (Trento)
S. Meninno: (Lisbon)

S.Sibilla & E. Persi University of Pavia (Italy) external partners

Eulerian description of driftwood

Methods: experiments and simulations

Experimental campaign in a bended channel: Three synchronized GoPro Cameras + 50 logs (wood cylinders) released individually for each configuration

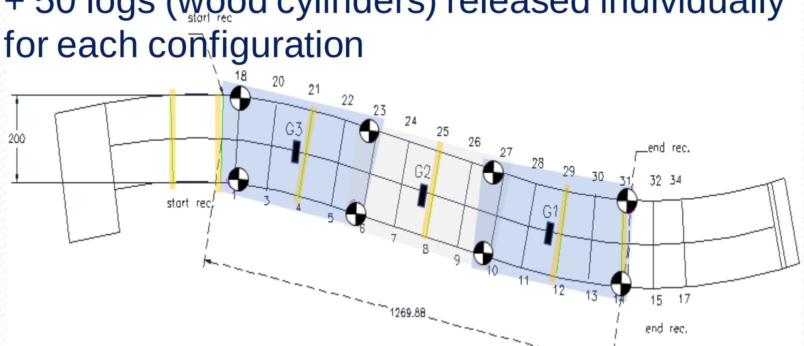


Figure 1: Channel subvided in three distinguished areas covered by three different cameras.

Numerical code: ORSA2D_WT: Eulerian solution of the Shallow Water Equation + dynamic Lagrangian module

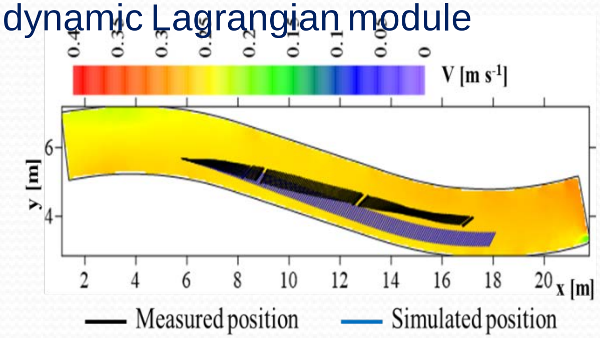


*Figure 2: S*imulated trajectories compared to the measured ones.

Preliminary Results

The analysis of the experimental data allows the determination of an Eulerian diffusion coefficient for driftwood and the Determination of a advection-diffusion equation for the wood volume fraction.

WP4+WP5

A. Armanini , G. Rossi (Trento)

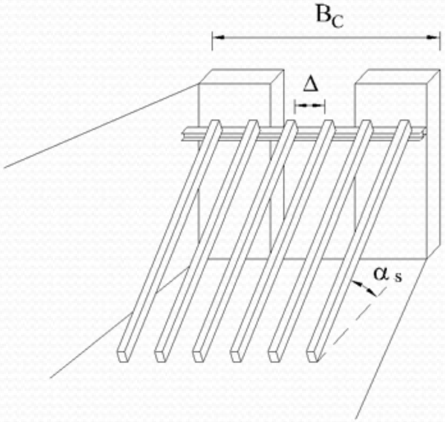
- The device analyzed in this study is a suitable inclined barrier located upstream the slit of the check;
- Firstly, the investigation allowed the **definition of objective parameters** to measure the **efficiency of wood restraining devices**, against the capacity of the check dam to laminate the solid volume; $Trapping\ efficiency\ [\%] = TE = \frac{N_{hold}}{N_{imp}}$

Controlled quantities: $T_{clog,solid}$ $Q_s = 0\ \mathrm{m^3/s}$

Aims: 1. *increase TE* 2. *increase $T_{clog,solid}$*

Parameters of devices

- $a_s = 30°, 60°$
- *Coefficient* $l = \frac{\Delta}{L}$) *L = length of logs)*
- *Coefficient of recover* = $\frac{(Nr+1)\Delta}{B_c}$



WP5

A.Cardoso; S. Meninno; R. Canelas; J. Matos (Lisbon)

Best strategy to intercept wood before a check dam

Research question

1. Analysis and performance of retaining structure for wood under clear water conditions
2. Performance of the devices with intense sediment transport

Methods

Experimental apparatus:

- Physical model under Froude similarity (λ=30); corresponding to a natural stream with nearly Width = 13 m; Slope = 0.01 Q_{200}= 100 m^3/s
- Width of the slit b= 9 cm (2.7 m)
- Grid with longitudinal bars before the check dam
- Different wood discharge and geometry

Slit check dam, and of the rack from the transparent side-wall

Preliminary results

Trapping efficiency versus bar inclination and distance for different wood discharge and characteristics.

WP6

Experimental basin: Torrente Meledrio

Basin located in the Province of Trento, in Val di Sole, North-West of Trento

Fig. 1 – Vista aerea 3D del bacino del Torrente Meledrio

Some data:

Parameter	Data
Area of the basin	52.8 km^2
Length	15.5 km
Minimum height	816 m a.s.l.
Average slope	56.3%
Average phi	-
Flood Discharge (Tr=100)	101m^3/s
d_{50}	0.15 m

Existing check dams on Meledrio torrent

New specific structures will be constructed according to the SteepStreams project

WEBSITE:

https://sites.google.com/a/g.unitn.it/steepstreams/home

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STEEP STREAMS

Solid Transport Evaluation and Efficiency in Prevention:
Suitable Techniques of Rational Engineering and Advanced Methods

Contents:

The recent increase in intensity and frequency of meteorological and hydrological events in mountainous areas is recognized as one of the effects of climate change. Extreme meteorological events endorse hydrological extreme events in steep channels, like flash floods, intense bed load transport, debris flows, and driftwood. Conventional defence works and their design criteria currently in use are erratic to ensure sufficient protection to human life and urban settlements.
For this reason, new approaches need to be studied.
STEEPS STREAMS project aims at researching structural innovative solutions and design criteria reliable to mitigate the impacts of flash floods and debris flows especially in presence of intense woody material transport, typical of mountain catchments.

Key words:

Climate change; mountain basins; debris flows; driftwood; torrent protection works; experimental basins.

UNIVERSITY OF TRENTO - Italy

UNIVERSITY OF TRENTO - Italy
CUDAM - Center for Advanced Studies on Hydrogeological Risks in Mountain Areas

UPPSALA UNIVERSITET

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Water 2014 Works

MIUR

formas
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FCT
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Dissemination of the results 1/2

7 Peer-reviewed journals

- Breinl, K., Di Baldassarre, G., Lopez, M. G., Hagenlocher, M., Vico, G., & Rutgersson, A. (2017). Can weather generation capture precipitation patterns across different climates, spatial scales and under data scarcity? *Scientific Reports,* 7(1), 5449. (WP2)
- Breinl, K, Di Baldassarre, G (2017, submitted). A new non-parametric method for the space-time disaggregation of rainfall and temperature. *Water Resources Research.* (WP2)
- Gravity-driven, dry granular flows over a loose bed in stationary and homogeneous conditions. S. Meninno, A. Armanini and M. Larcher. *Physical Review Fluids* 3, 024301 (2018). (WP4-WP5)
- Nucci, Armanini, Larcher, The interphase forces in submerged granular flows, *under review*, June 2017. (WP4)
- Dynamic impact of a water and sediments surge against a rigid wall. A. Armanini, G. Rossi and M. Larcher, under review of *J. Hydraulic Research* (WP4)
- R.B. Canelas, M. Brito, O. García-Feal, J.M. Domínguez, A.J.C. Crespo, 2018. Extending DualSPHysics with a Differential Variational Inequality: modeling fluid-mechanism interaction, *Applied Ocean Research,* under review (WP5)
- Abera, W; Formetta, G.; Borga, M.; Rigon, R.; Estimating the water budget components and their variability in a Pre-Alpine basin with NewAge-JGrass, *Advances in Water Resources*, 2017 (WP2)

Dissemination of the results 2/2

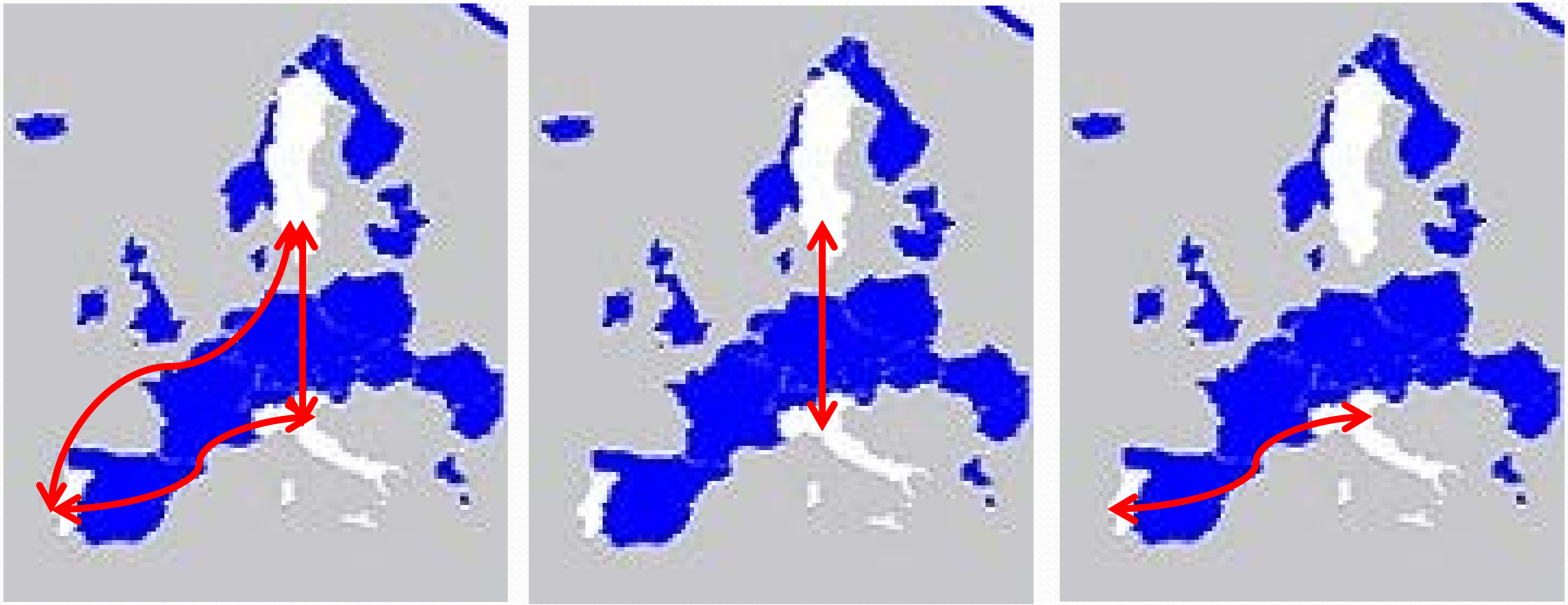
WP7

16 Proceedings paper, presentations, and posters

1. Armanini, A., et al. STEEP STREAMS-Solid Transport Evaluation and Efficiency in Prevention: Sustainable Techniques of Rational Engineering and Advanced MethodS. In: EGU General Assembly Conference Abstracts. 2017. p. 17261.
2. Armanini A., Larcher, M. (2017) “Slit-check dams for the control of debris flow”. EGU General Assembly 2017, Vienna, 08-13 April 2017.
3. Dry granular flows rheology: experimental investigation and particles simulations. G. Rossi and A. Armanini, Sorrento *AERC-European Society of Rheology* 2018. (WP4)
4. G. Rossi, A. Armanini and M. Larcher. Dynamic impact of granular material on a vertical obstacle. EGU General Assembly. Vienna, April 2017.
5. G. Rossi, A. Armanini A depth integrated model for dry geophysical granular flows. EGU General Assembly. Vienna, April 2017.
6. M. Larcher, A. Armanini, Schlitzsperren zur hydrodynamischen Kontrolle der Sedimente. Stand der Technik im Naturgefahren-Ingenieurwesen, Vienna, 21-23 February 2018.
7. Breinl, K., Di Baldassarre, G., Müller, H.. Extreme flows in small alpine catchments under current and future climate conditions: impact of temporal rainfall disaggregation In: López-Tarazón, J. A., Bronstert, A., Thieken, A., & Petrow, T. (2017). International symposium on the effects of global change on floods, fluvial geomorphology and related hazards in mountainous rivers.
8. Breinl, K. (2017, April). Single-site vs. multi-site rainfall generation and the role of parametric rainfall distributions in lumped hydrological modelling. In EGU General Assembly Conference Abstracts (Vol. 19, p. 4935).
9. Breinl, K., & Di Baldassarre, G. (2017, April). Flash floods in small Alpine catchments in a changing climate. In EGU General Assembly Conference Abstracts (Vol. 19, p. 5231).
10. Breinl, K., Di Baldassarre, G., & Girons Lopez, M. (2017, April). Reduced-complexity multi-site rainfall generation: one million years over night using the model TripleM. In EGU General Assembly Conference Abstracts (Vol. 19, p. 3065).
11. Gozzi, D, Breinl, K, Di Baldassarre, G. (2018, submitted) Hydro-meteorological extremes in the Adige river basin, Italy. 5th IAHR Europe Congress, Trento, June 2018.
12. Armanini Rossi 5th IAHR Europe Congress, Trento, June 2018.
13. Larcher M., Jenkins J.T., 5th IAHR Europe Congress, Trento, June 2018
14. R. B. Canelas, D. Conde, O. Garcia-Feal, M. J. Telhado, R. M.L. Ferreira, 2017. A 2D-3D strategy for resolving tsunami-generated debris flow in urban environments, European Geosciences Union, Vienna
15. R.B. Canelas, J.M. Domínguez, A.J.C. Crespo, M. Gómez-Gesteira, R.M.L. Ferreira, 2017. Resolved simulations of a granular-fluid flow through a check dam with a SPH-DCDEM model, European Geosciences Union, Vienna
16. D. Zugliani, M. Pasqualini, G. Rosatti, Dynamic transition between fixed- and mobile-bed: mathematical and numerical aspects.

Collaboration, coordination and mobility

WP1+WP6+WP7 **WP2** **WP3+WP4+WP5**



- Meetings (Uppsala, Lisbon, Trento)
- Several skype calls
- Dr. K. Brain (Sweden partner) stayed one month in Trento
- Dr. S. Mennino (Portuguese partner) is supervisor of a master student in Trento

Stakeholder/industry engagement

- The collaboration with the Torrent Control Authority of the Province of Trento **ASM** started immediately with the definition of the experimental basin for the field test.
- The Italian partner is collaborating with a private company, i.e. **M.I.C.** (**Maccaferri Innovation Center**) of Bozen Italy on an the extensive use of nets based on the use of iron nets, lighter and cheaper respect to the traditional solutions.
- Joint project between **ASM**, **M.I.C.** and the **University of Trento**.

Identified problems or specific risks

1. The idea behind the JPI project is **certainly positive**: the direct **involvement of the member states and the national agencies.**
2. However, the different **methodologies** adopted by the States members to **elect the funding** risked **jeopardising the success** of the project.
3. In particular, it has **compromised** the effective **collaboration** between **the partners.** In our case this collaboration has been **partially recovered** thanks to a work of substitution carried out by **the individual universities.**
4. However, an **extension of the deadline** of the project will be **necessary** to allow completion of **final reports** and to better enable the **transfer of the results to stakeholders.**

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