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A coordinate EU project on defence structures for debris flow and driftwood accounting the effects of climate change.

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ABSTRACT

STEEP STREAMS (**S**olid **T**ransport **E**valuation and **E**fficiency in **P**revention: **S**ustainable **T**echniques of **R**ational **E**ngineering and **A**dvanced Method**S**) is a collaborative project between the Universities of Trento, Uppsala and Lisbon, who joined in a consortium within the ERANET Water JPI call WaterWorks2014. The aim of the project is to produce new rational criteria for the design of protection works against debris flows, a phenomenon consisting in hyper-concentrated flows of water and sediments, classified as catastrophic events typical of small mountainous basins (area <10 km^2) and triggered by intense rainstorms [1].

INTRODUCTION

Debris flows are non-stationary phenomena that arise in a very short time, and their recurrence is rather difficult to determine. Compared to water floods, they are more difficult to anticipate, mostly since they are triggered by convective precipitation events, posing a higher risk of damage and even loss of human lives. These extreme events occur almost annually across Europe, though the formal return period in an exposed site is much larger. Recently, the increase in intensity and frequency of small-scale storm events, leading to extreme solid transport in steep channels, are recognized as one of the effects of climate change. In this context, one of the key challenges of this project is the use of comparatively coarse RCM projections to the small catchments examined in STEEP STREAMS.

Given these changes, conventional protection works and their design criteria may not suffice to provide adequate levels of protection to human life and urban settlements. The most effective intervention against these phenomena consists in the realization of suitable deposition basins of the solid material, placed at the closure of alluvial fans and before the settlements areas with the aim of reducing the solid flow rates.

In this way the dimensions of the canalization works can be significantly reduced in area of high landscape and historical value, often constrained by rather restrictive urban regulations.

To optimize the peak reduction of solid mass flux, it is necessary that the deposition basin is controlled by a slit check dam, capable of inducing a controlled sedimentation of the solid volume. In order to achieve that, reliable design tools are needed [3].

Figure 1: The problem of driftwood in mountain basin affected also by debris flows

However, one of the unresolved problems of these devices is the wood and vegetal material transported during the flood events, this material represents another important factor increasing the risk, as clogging induced by the vegetal material represents a major problem for the operational reliability of slit check dams. Current procedures in compiling hazardous maps do not account for such effects. The STEEPS STREAMS project aims at developing 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.

RESULTS

Several results are achieved. In particular, with respect to each work packages of the project:

WP2 Climate change and hydrology:
- Development of a space-time weather generator to simulate precipitation patterns and temperature fields and fill observational gaps at daily time-scale [2];
- Development of a space-time algorithm to disaggregate the daily weather fields into hourly time resolution;
- Statistical analysis of hydro-meteorological extremes (flood peaks, precipitation) in the Adige river basin;
- Progress has been made in implementation of weather forecast models to obtain future projections of climate to feed the GEOframe-NewAGE (GN) system;
- Development of the GEOframe infrastructure (http://geoframe.blogspot.com) and its model components that forms the GN system.

WP3 Mathematical models:
- Revision of the existing single-phase and two-phase approaches for intense bed load and debris flow over fixed and mobile bed. In this regard, it is worth mentioning that, due to the delay in the founding of the project, SteepStreams will adopt a recent new model based on a web service approach has been developed before and outside the present project;
- Development of a theoretical numerical approach to deal with the transition from fixed- to mobile-bed conditions (and vice versa);
- In order to set up a module for the modelling the vegetal material and driftwood in a Eulerian framework, i.e. a suitable advection-diffusion equation with proper coefficients, a Lagrangian approach is currently being developed and used in collaboration with an institution outside the project;

WP4 Defence structure against sediments:
- Theoretical and experimental analysis of the relation between the dimension of slit-check-dams and the retention capacity of solid volumes of debris flows [4];
- Theoretical and experimental analysis of the dynamic impact of a debris flow on a vertical wall;
- Theoretical and experimental analysis of the hydraulic functioning of net check dams for debris flows (ongoing).

WP5 Defence structure against driftwood:
- A review of existing defense structures;
- A tilting flume was adapted, with the inclusion of an automatic conveyor belt to ensure the recirculation of solid material. Initial data was collected regarding the dynamics of driftwood in the absence of sediments and near a slit-check dam. Novel computer vision based data treatment routines were developed in order to capitalize on the three available high-resolution cameras, allowing for the tracking of individual dowels in stream. Low cost ultrasonic level probes were assembled and implemented on the flume, requiring the manipulation of sensitive electronics and associated control software. A high-resolution 3D numerical model was further adapted in order to reproduce the detailed interactions between the fluid and solid phase of the flow, with the aim of complementing the experimental work in characterizing the flow;
- The initial literature review suggested a lack of characterization of driftwood dynamics associated with steady flow, prompting the design of experiments to measure drag forces under varying conditions, also serving as an initial validation test for the developed numerical model;
- An additional campaign has been started in collaboration with the University of Trento to characterize the dynamics of large wood in fluvial conditions, investigating the effect of the flow conditions on the distribution of wood elements across the channel as well as on their orientation;
- WP6 Design of the works in experimental basin;
- Collections of data from catchments, especially from the experimental basin (Rio Meledrio, Trentino, Italy).

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