EGU General Assembly 2020

Online | 4–8 May 2020

Multi-parametric observations of debris-flow initiation at the headwaters of the Gadria catchment (eastern Italian Alps)

Velio Coviello (velio.coviello@unibz.it), Matteo Berti, Lorenzo Marchi, Francesco Comiti, Giulia Marchetti, Ricardo Carrillo, Shusuke Miyata, Pierpaolo Macconi

unibz
Freie Universität Bozen
Libera Università di Bolzano
Università Liedia de Bulsan

irpi
Istituto di Ricerca per la Protezione Idrogeologica

ALMA MATER STUDIORUM
UNIVERSITÀ DI BOLOGNA

efre · fesr
Südtirol · Alto Adige
Europäischer Fonds für regionale Entwicklung
Fondo europeo di sviluppo regionale
EUROPEAN UNION
AUTONOME PROVINZ BOZEN SÜDTIROL
PROVINCIA AUTONOMA DI BOLZANO ALTO ADIGE

Intro

- Most models assume the saturation of the channel bed as an essential condition for debris-flow initiation but the water content in a natural debris-flow channel was never measured.
- Debris-flow initiation is commonly associated to the exceedance of critical rainfall thresholds, but it is also controlled by the availability of sediment in the source areas.

The understanding of the mechanisms controlling debris-flow initiation is still an open challenge in landslide research.

7th International Conference on Debris-Flow Hazards Mitigation

Valid debris-flow models must avoid hot starts

Richard M. Iverson[a,*], David L. George[a]

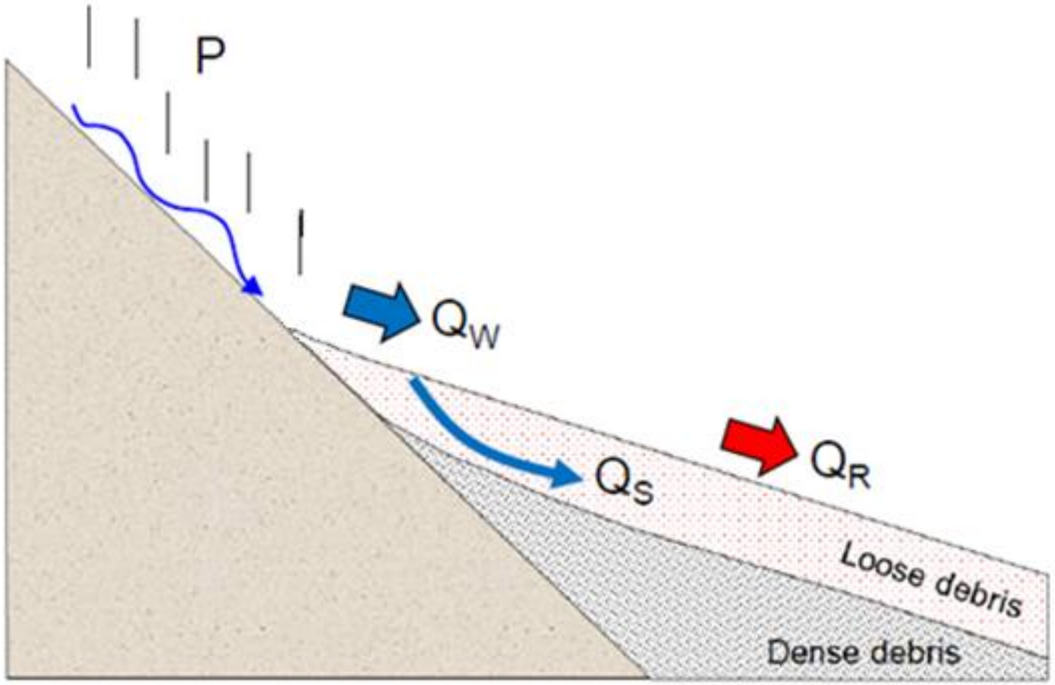
[a]*U.S. Geological Survey, 1300 SE Cardinal Ct., Vancouver, WA 98683 USA*

Abstract

Debris-flow experiments and models commonly use "hot-start" initial conditions in which downslope motion begins when a large force imbalance is abruptly imposed. By contrast, initiation of natural debris flows almost invariably results from small perturbations of static force balances that apply to debris masses poised in steep channels or on steep slopes. Models that neglect these static balances may violate physical law. Here we assess how the effects of hot starts are manifested in physical experiments, analytical dam-break models, and numerical models in which frictional resistance is too small to satisfy static force balances in debris-flow source areas. We then outline a numerical modeling framework that avoids use of hot starts. In this framework an initial static force balance is gradually perturbed by increasing pore-fluid pressure that may trigger the onset of debris motion. Subsequent increases in pore-fluid pressure, driven by debris motion, may then reduce the debris frictional strength, leading to high flow mobility.

Research objective: understanding of debris-flow initiation in steep channels

Gadria catchment (2200 m a.s.l.), Eastern Italian Alps



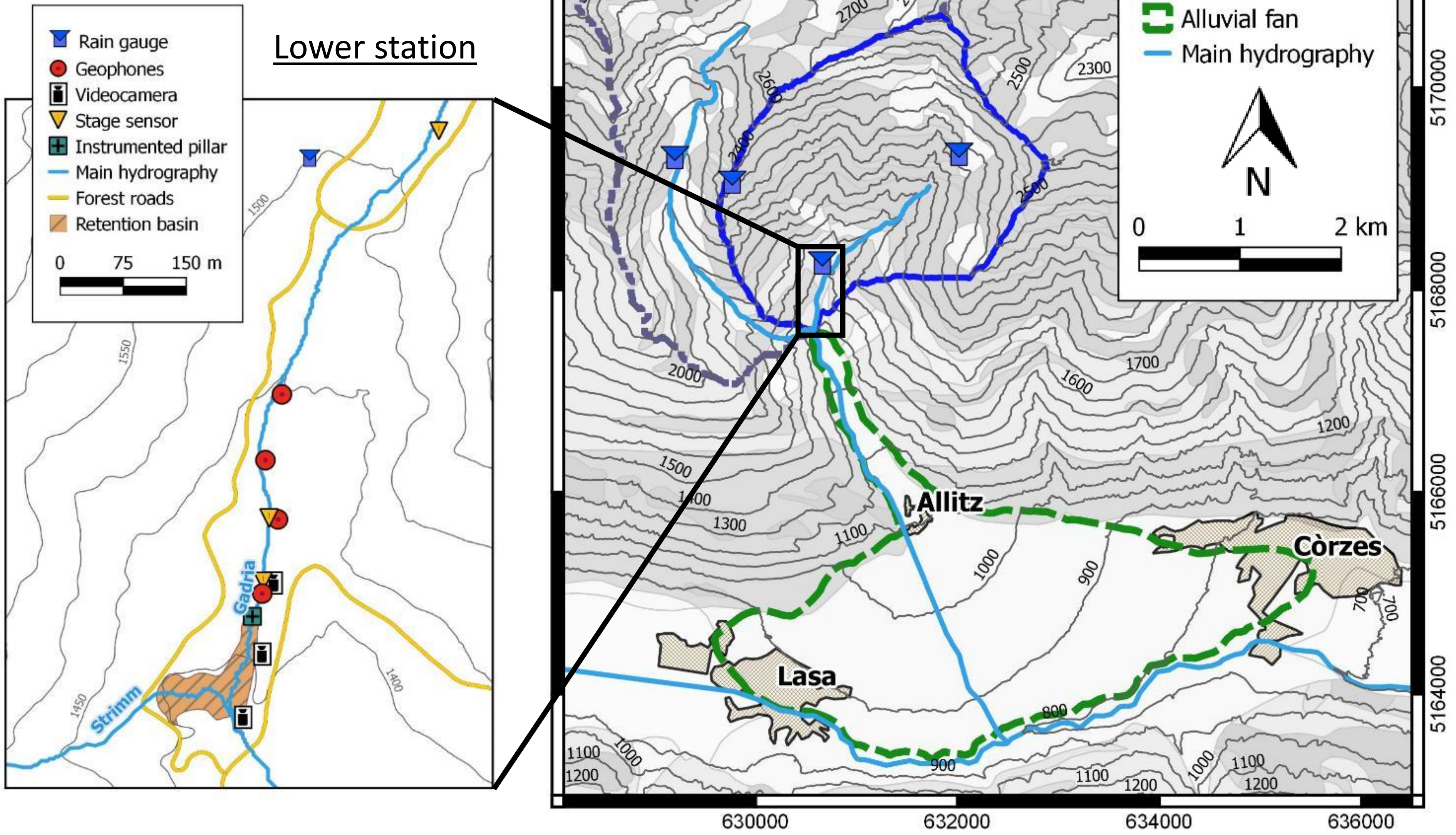
P = rainfall (mm)

Q_W = total water discharge
Q_S = groundwater discharge
Q_R = surface discharge

Study site: Gadria catchment

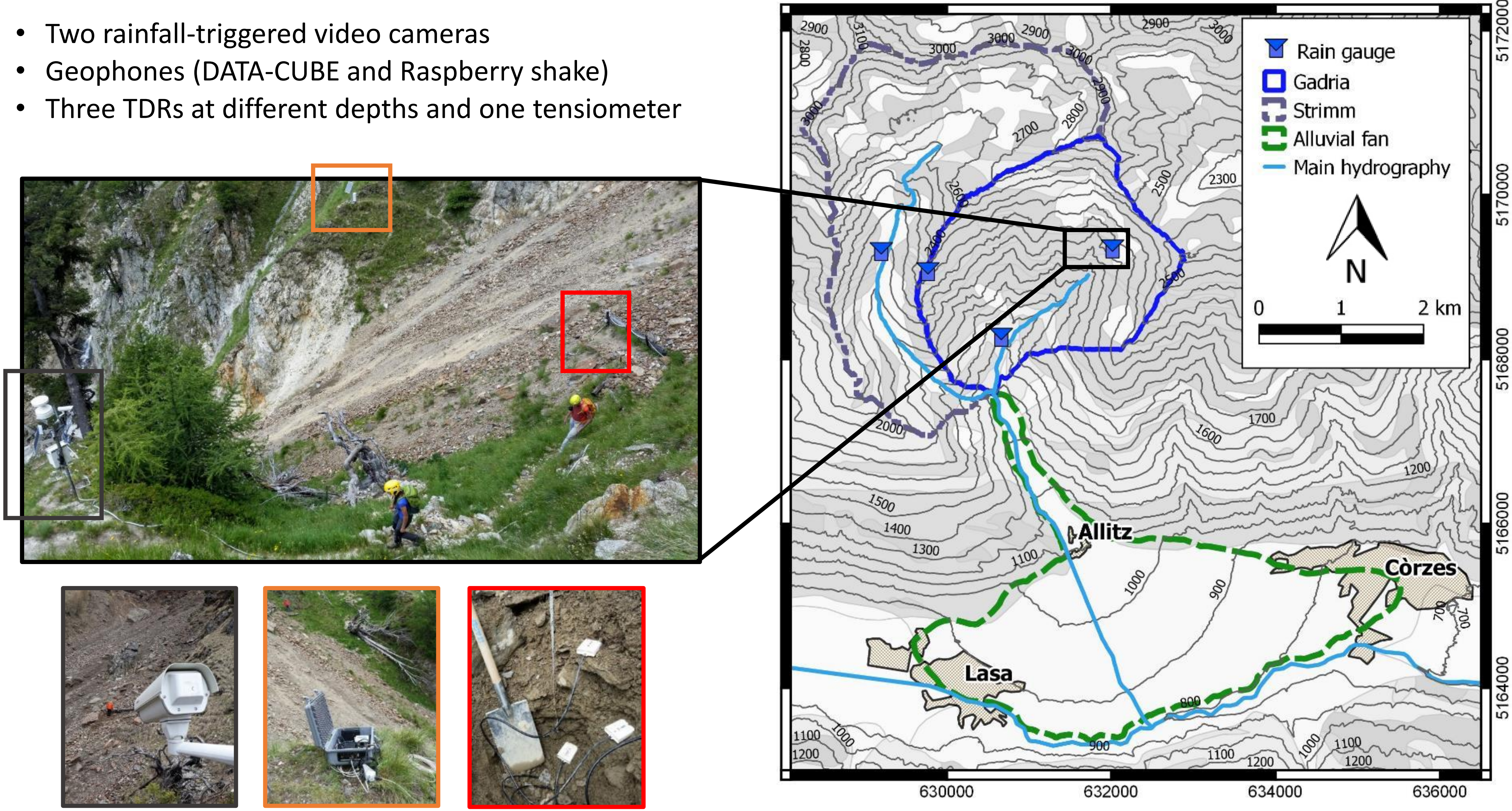
- Well-known debris-flow basin
- 2 debris-flow events per year on the average
- Monitoring performed since 2011
- Lower station: channelized debris flows
- Upper station: source area (this study)

(Comiti et al., 2014; Coviello et al., 2019; Hürlimann et al., 2019)

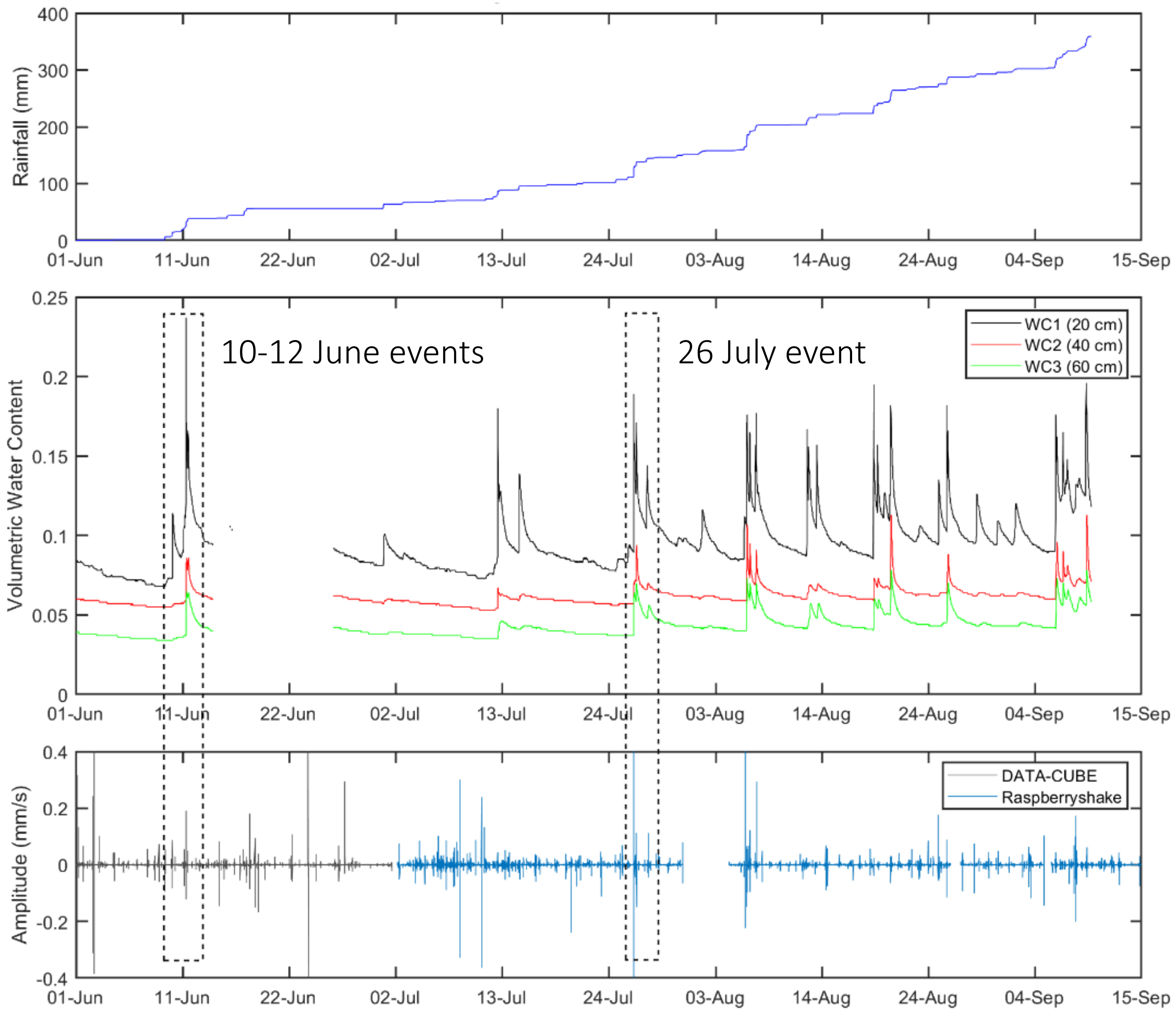


Upper station (this study):

- Two rainfall-triggered video cameras
- Geophones (DATA-CUBE and Raspberry shake)
- Three TDRs at different depths and one tensiometer

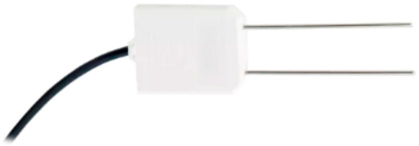


2019 monitoring season at upper Gadria



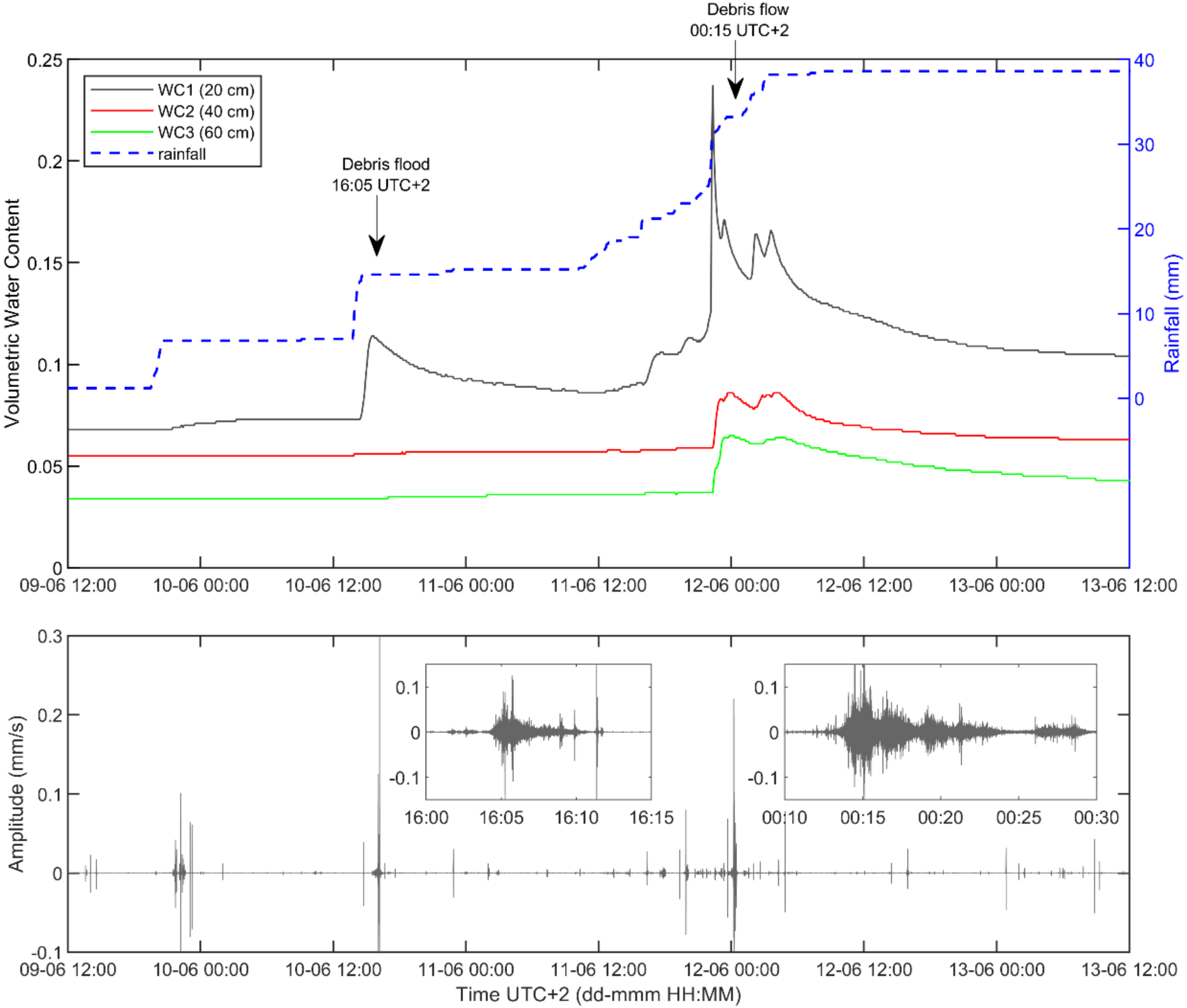
TDR sensors (Campbell CS655)

installed at three depths



10-12 June events

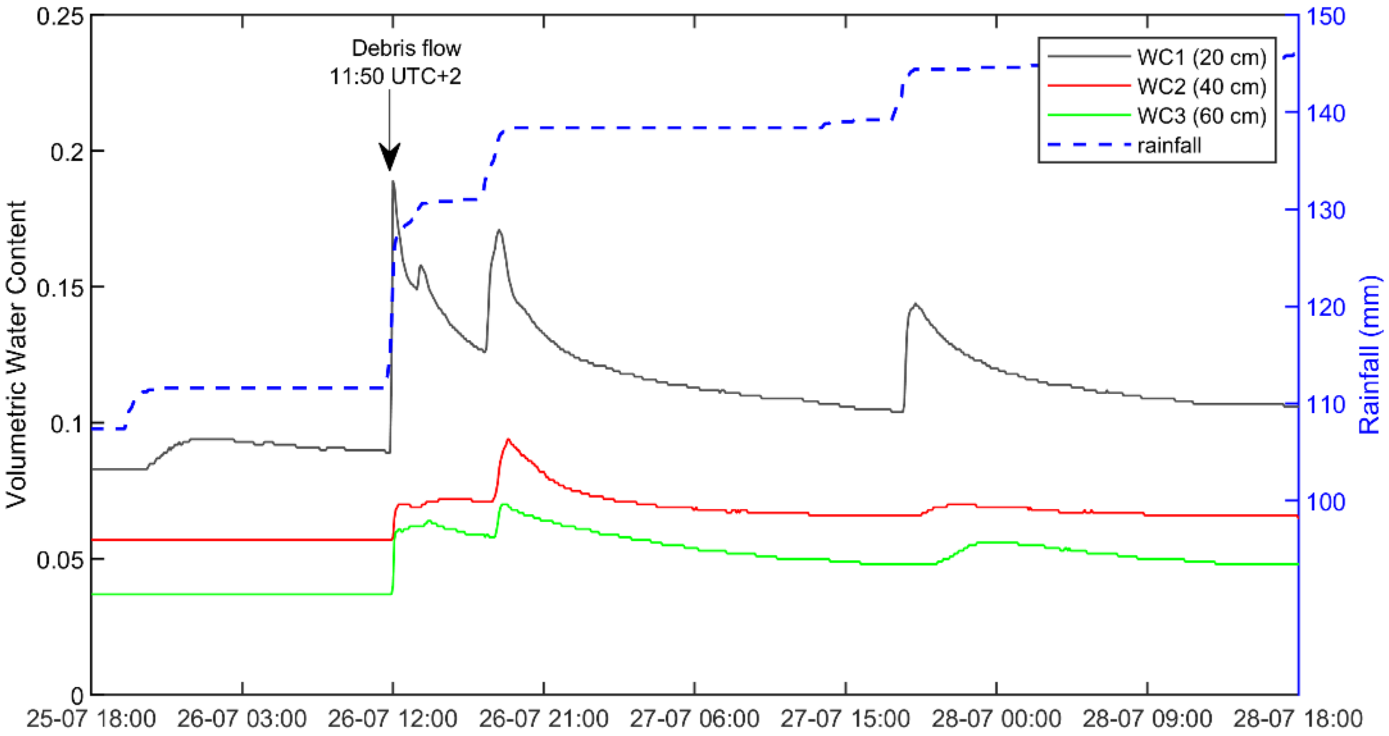
Post-event field survey (June 26)

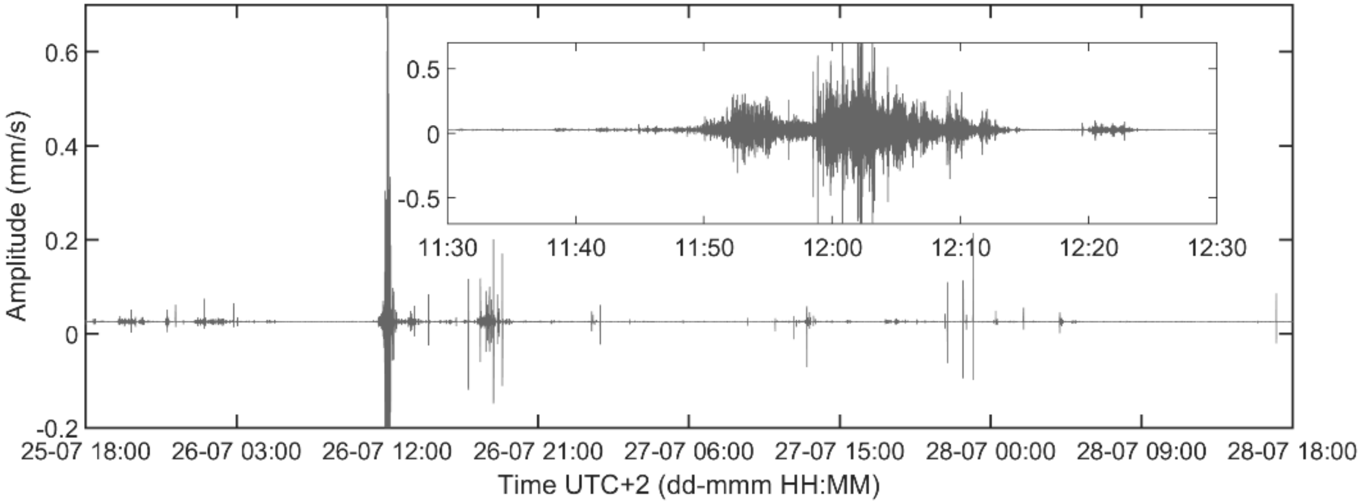


26 July event

Pre-event field survey (July 2)

Post-event field survey (July 31)





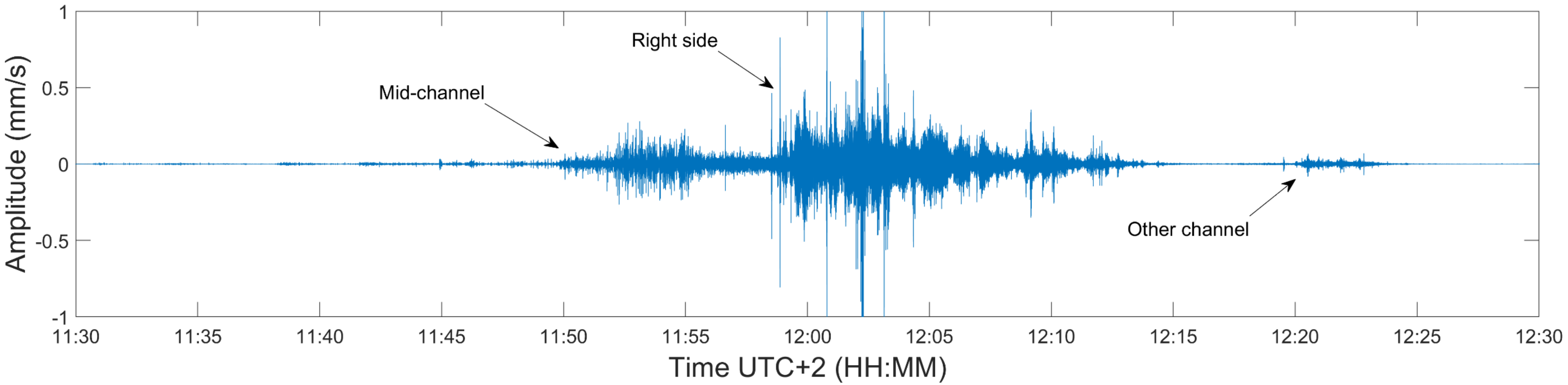
26 July 2019

Start (11:49:30)

Mid-channel (11:50)

Right channel (11:58)

End (12:12)



Key points

- During all debris flows, we measured peak values of soil water content that are far from saturation (<0.25 at -20 cm, <0.15 at -40 cm, <0.1 at -60 cm).
- In the seismic traces we recognize signals produced by different processes: high water discharge, debris flows, small rockfalls.
- We derived the exact time of occurrence and the duration of debris-flow events from the analysis of the seismic signals.
- The debris flow event that occurred on 26 July 2019 produced remarkable geomorphic changes in the monitored channel, with up to 1-m deep erosion of the channel bed.
- The starting time of the 26 July 2019 debris flow corresponds with a 20 mm rainfall event and with the subsequent peak of water content measured in the channel bed.

Recent papers presenting debris-flow observations at Gadria:

Coviello V., Arattano M., Marchi L., Comiti F., Macconi P. , 2019. Seismic characterization of debris flows: insights into energy radiation and implications for warning. Journal of Geophysical Research – Earth Surface, 124 (6), 1440-1463, https://doi.org/10.1029/2018JF004683.

Hürlimann M., Coviello V., Bel C., Guo X., Berti M., Graf C., Hübl J., Miyata S., Smith J.B. and Yin H.Y., 2019. Debris-flow monitoring and warning: review and examples. Earth-Science Reviews, p.102981, https://doi.org/10.1016/j.earscirev.2019.102981.