Debris-flow data collected in the Moscardo Torrent (eastern Italian Alps) between 1990 and 2019

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Outline of this work

Debris-flow monitoring in the Moscardo Torrent (eastern Italian Alps) began in 1990 and still keeps on.
26 debris flows were recorded by the monitoring instrumentation, 4 were documented through post-event field surveys.

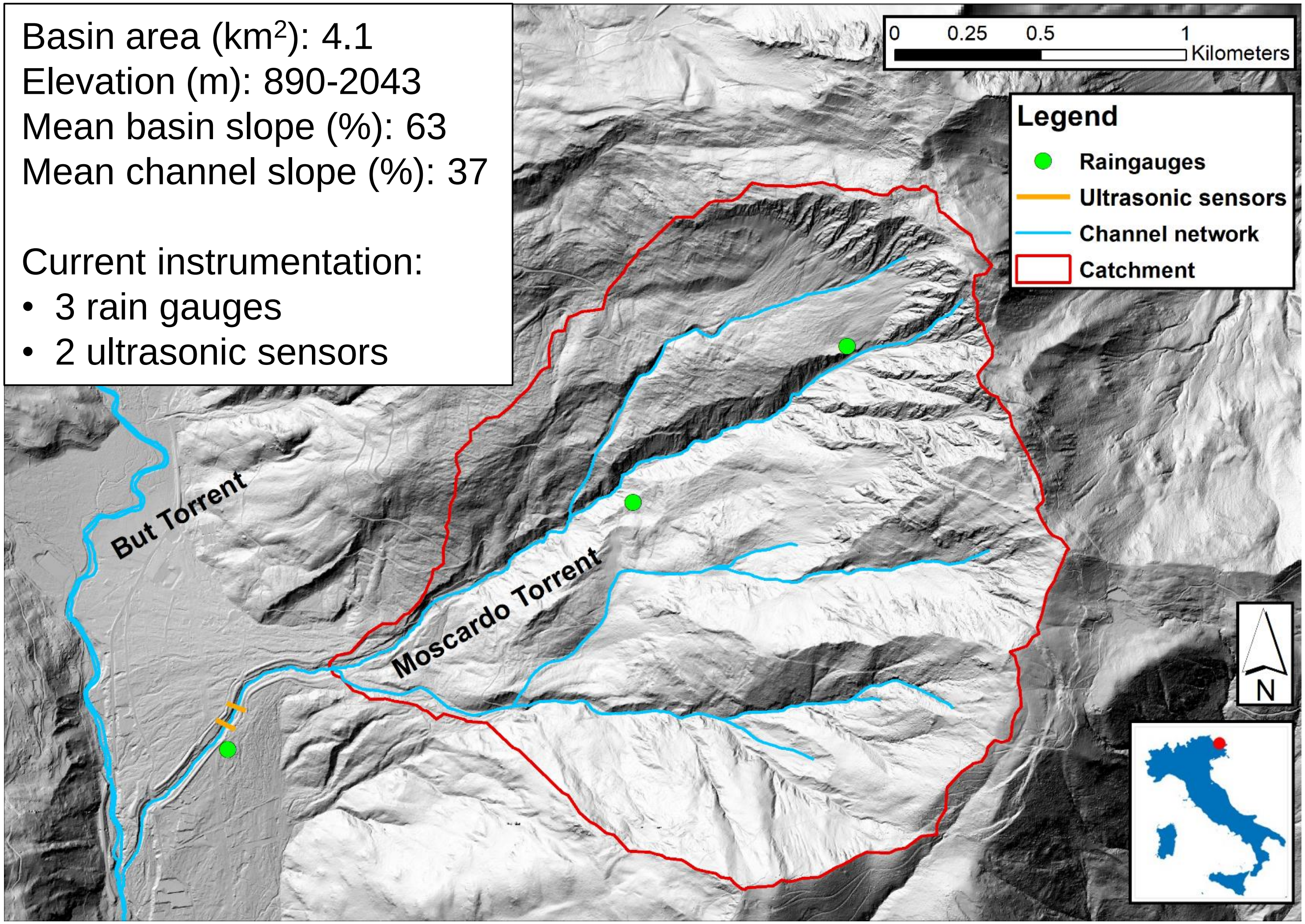
<u>Objectives:</u>

- Gathering data so far unpublished or reported in various sources.
- Summarizing the basic characteristics of the debris flows in the Moscardo Torrent (seasonal distribution, frequency, triggering rainfall, flow depth, hydrographs shape, etc.).
- A step toward the implementation of a freely accessible dataset.

The Moscardo Torrent basin

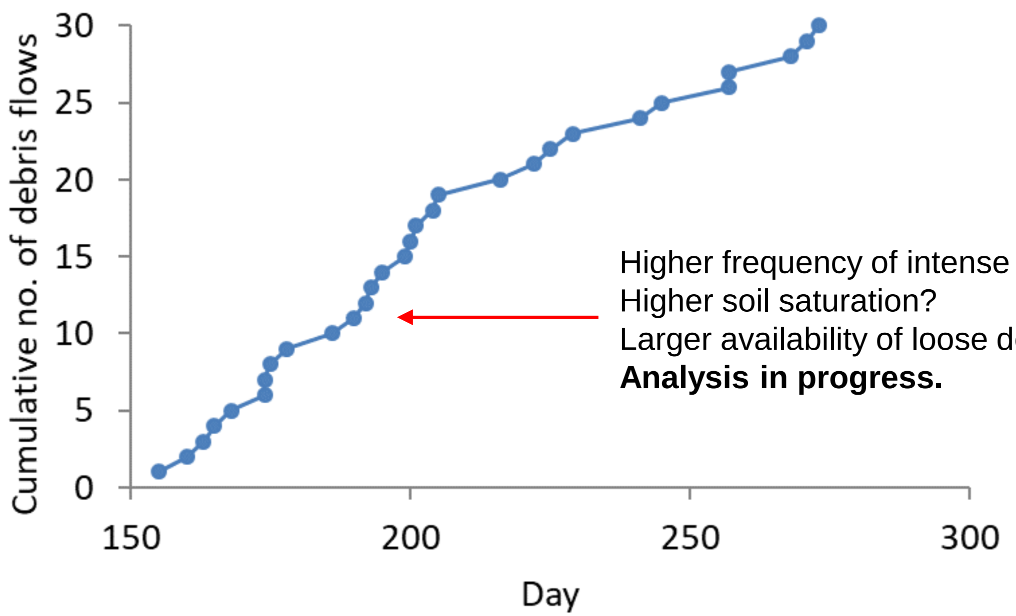
Basin area (km^2): 4.1
Elevation (m): 890-2043
Mean basin slope (%): 63
Mean channel slope (%): 37

Current instrumentation:
- 3 rain gauges
- 2 ultrasonic sensors



Geology	Carboniferous Flysch
Mean annual precipitation (mm)	1820

Days of debris-flow occurrence in the 30 years of observation

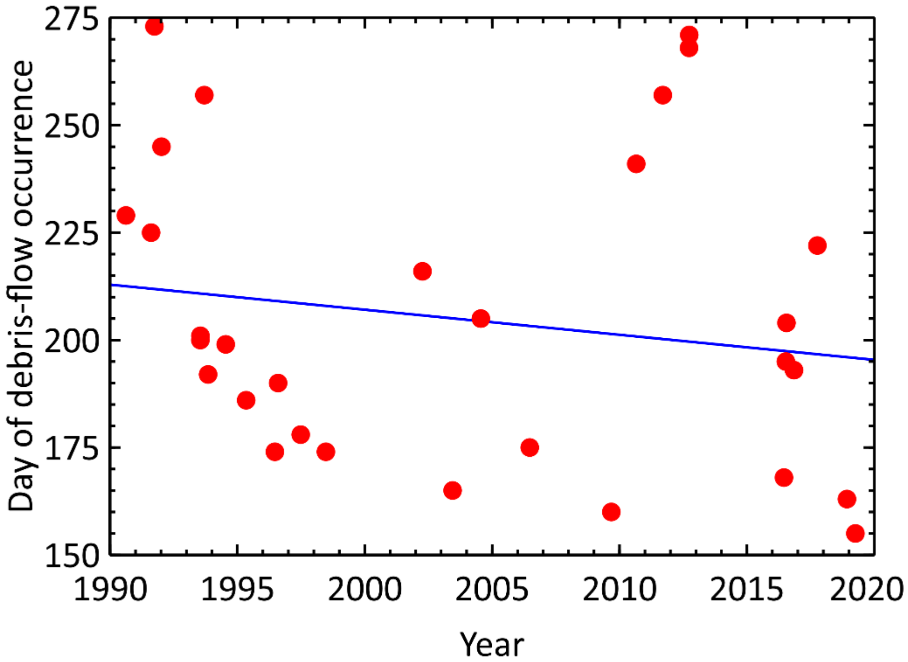


Higher frequency of intense rainstorms?
Higher soil saturation?
Larger availability of loose debris?
Analysis in progress.

The debris flows in the Moscardo Torrent occurred from the beginning of summer (4 June 2019) to early autumn (30 September 1991), with 18 out of 30 events occurring in the first 50 days.

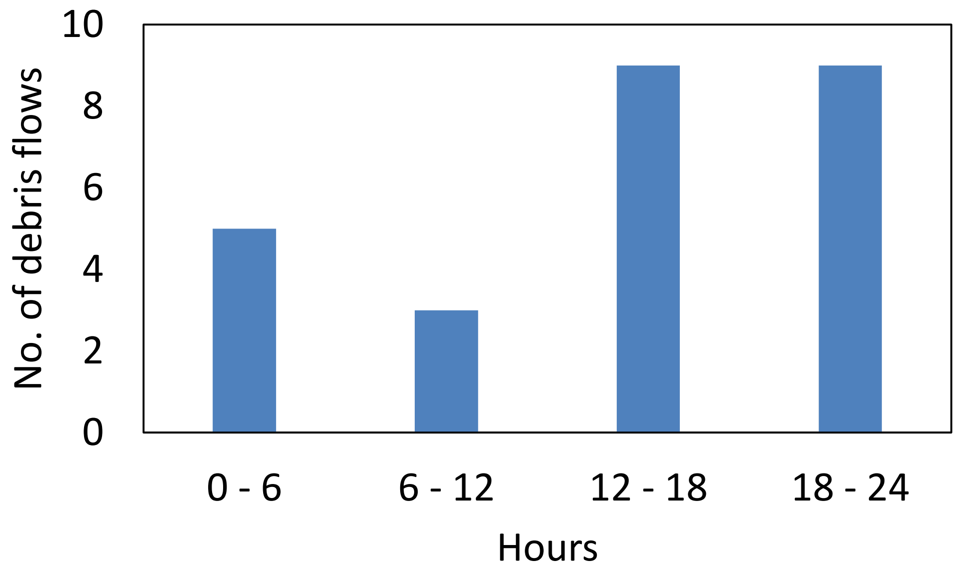
No debris flows were triggered by snowmelt, which takes place in April-May in the Moscardo Torrent.

Days of debris-flow occurrence in the 30 years of observation



The tendency toward the earlier occurrence of debris flows is weak (linear regression coefficient *r* = - 0.17) and not significant (*p-value* = 0.363)

Time of debris-flow occurrence

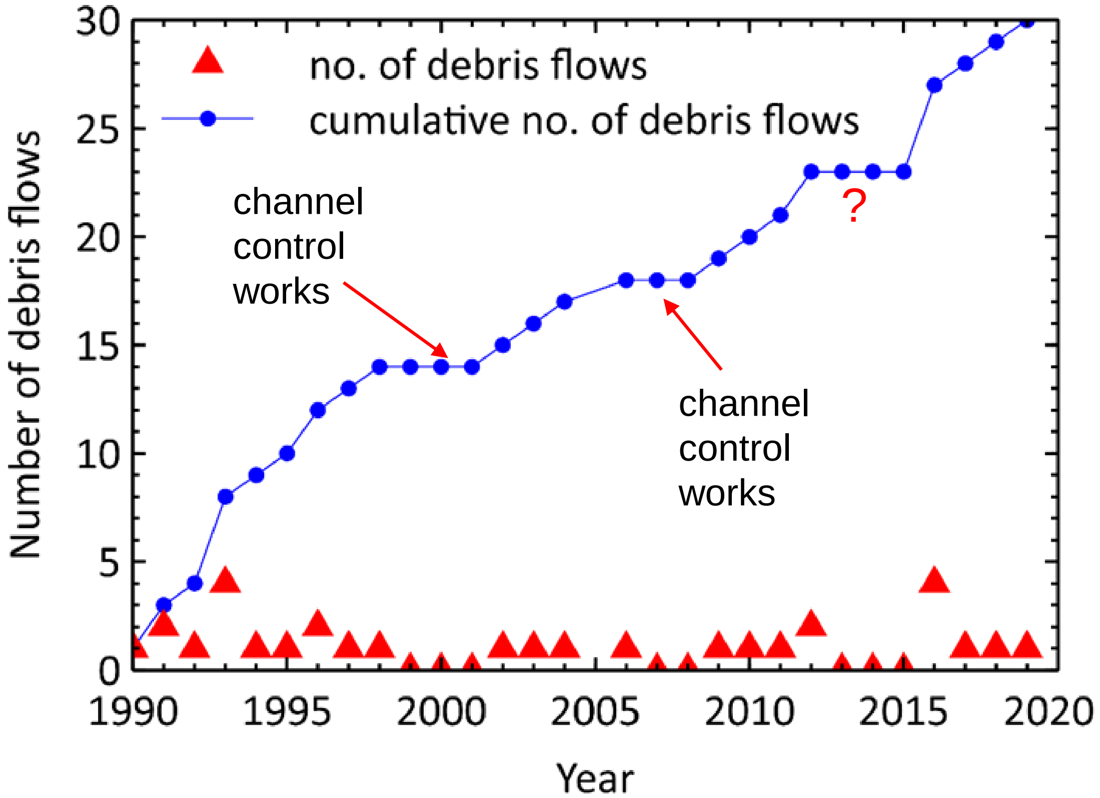


Most debris flows (69%) occurred in the second half of the day, with 9 events from 12 to 18 hours and 9 from 18 to 24 hours.

This is consistent with the triggering mostly caused by summer convective rainstorms, which mostly take place in the afternoon or the evening.

Time series of debris-flows

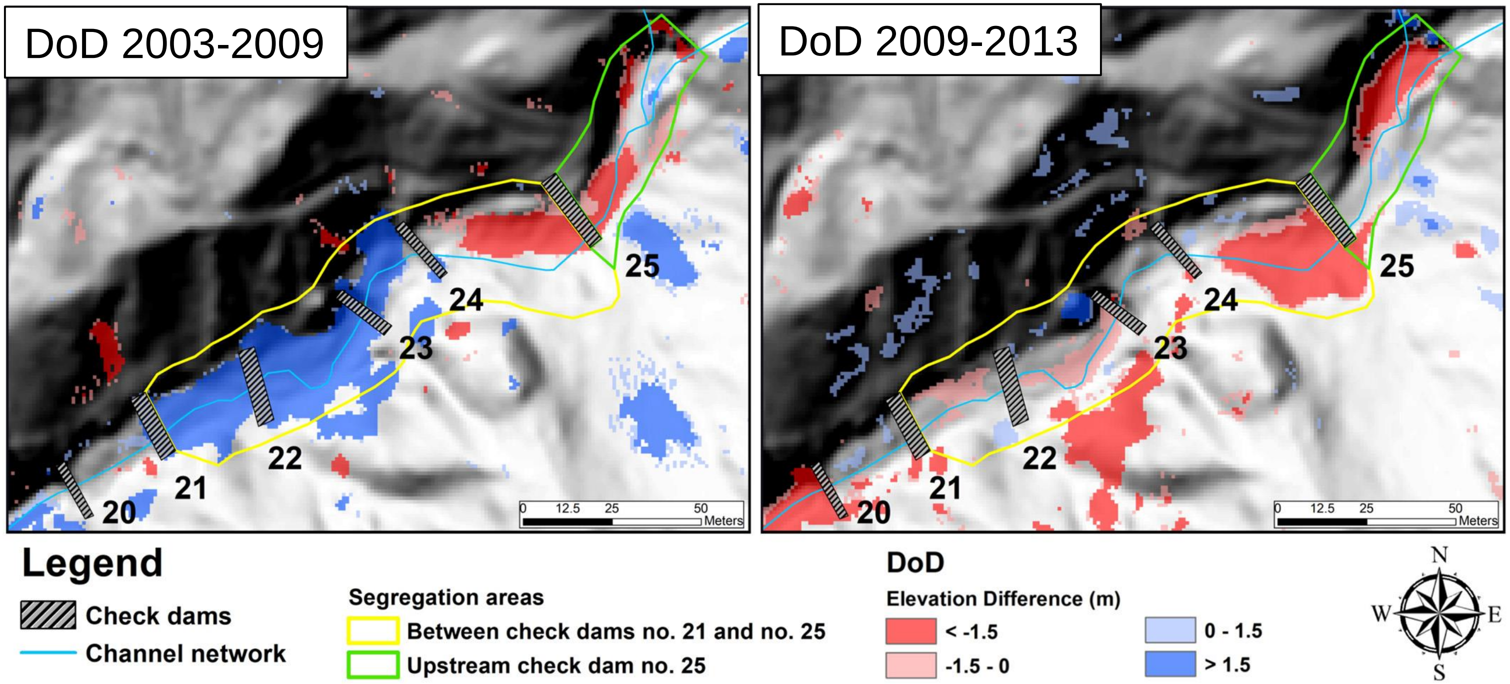
Mean debris-flow frequency: 1 event/year



The absence of debris flows in 1999-2001 and 2007-2008 can be referred to the temporary effect of new check dams.

No debris flows in 2013-2015: scarcity of available debris after two large debris flows in 2012?

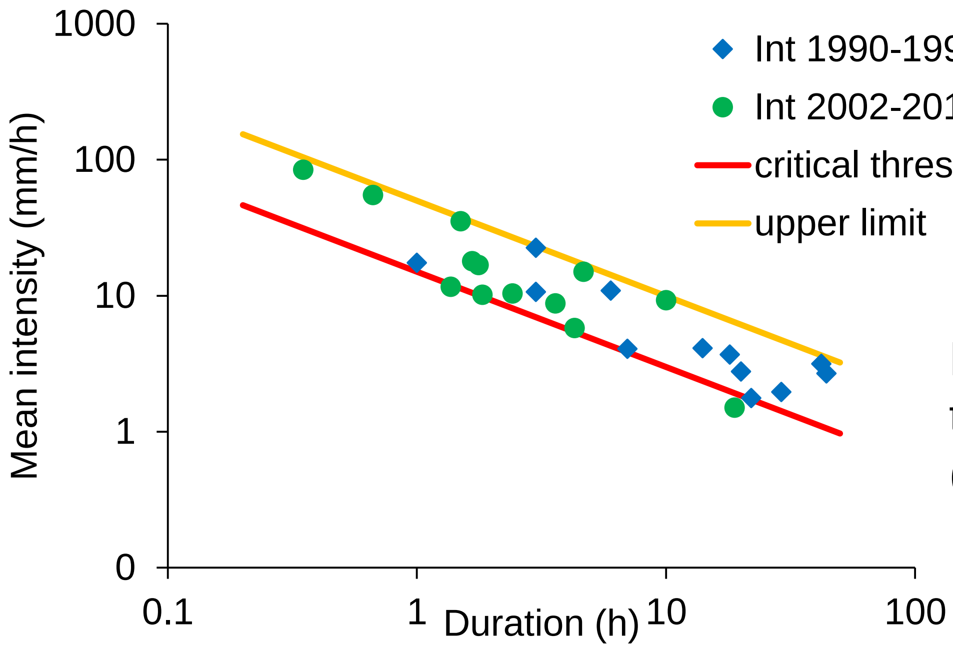
Check dams in the middle and lower part of the channel: a temporary effect on debris-flow propagation to the catchment outlet.



The check dams built in the middle part of the catchment in 2005-2006 had only a temporary effect on sediment retention and debris-flow control.

Cucchiaro, S., Cazorzi,F., Marchi, L., Crema, S., Beinat, A., Cavalli, M. Multi-temporal analysis of the role of check dams in a debris-flow channel: Linking structural and functional connectivity. Geomorphology, 345, 1-12, https://doi.org/10.1016/j.geomorph.2019.106844

Triggering rainfall



Empirical rainfall thresholds (graphically fitted)

The critical rainfall intensity threshold for debris flow occurrence (Deganutti et al., 1990) after the first years of observations (1990-1998), is confirmed by the more recent data. It is possible to identify an upper limit, with the same exponent, for the rainstorms that triggered debris flows. The two rainfall thresholds have the form:

$$I = a \cdot D^{-0.7}$$

where *a* is 15 for the lower threshold and 50 for the upper limit.

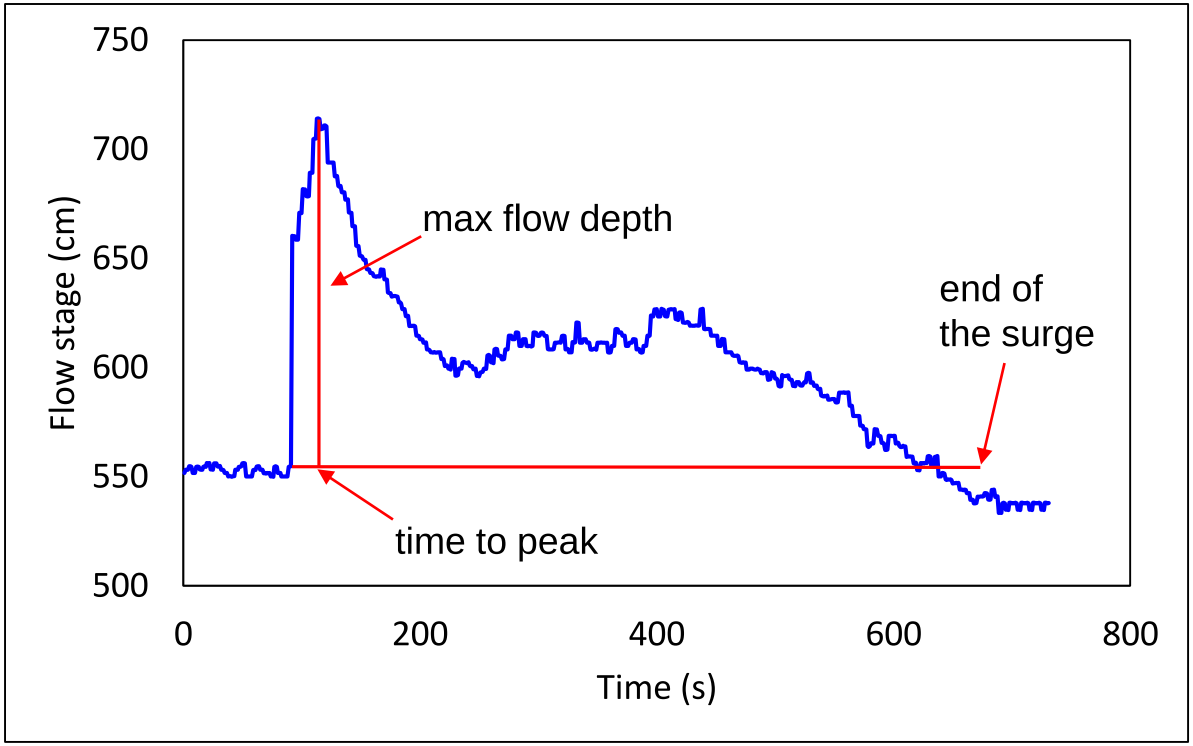
Analysis of 62 individual debris-flow surges

The availability of several debris-flow hydrographs permitted to analyze them to define their basic characteristics, such as maximum flow depth, time to peak, surges duration.

The maximum flow depth is computed as the difference between the surge's peak and the level before the start of the flow rise.

A minimum rise of 0.5 m has been adopted to include a surge among those to analyze.

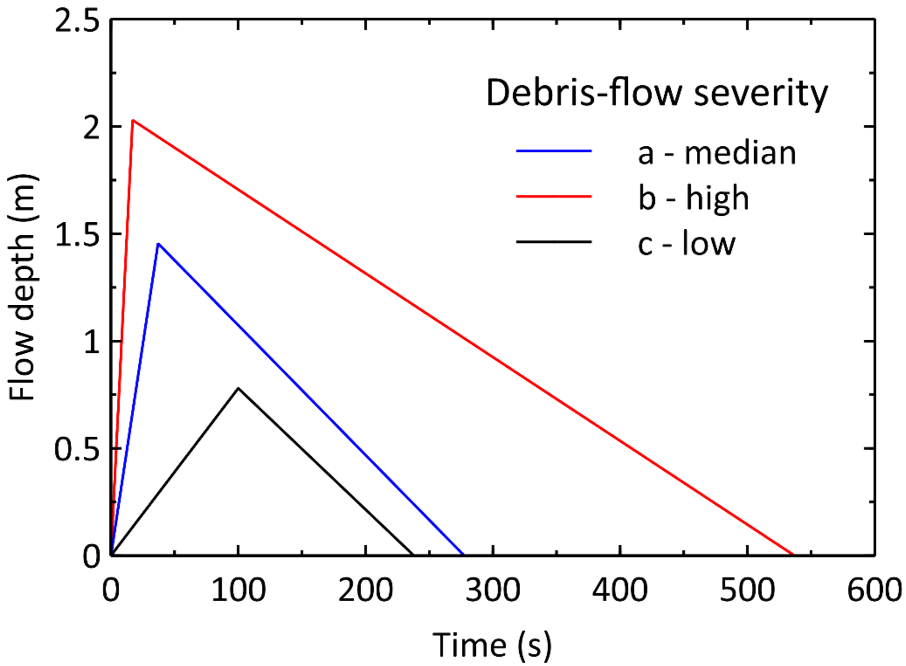
The end of the surge corresponds to the time when flow level reaches an almost constant value.



A simplified representation of the debris-flow hydrographs in the downstream reach of the Moscardo Torrent

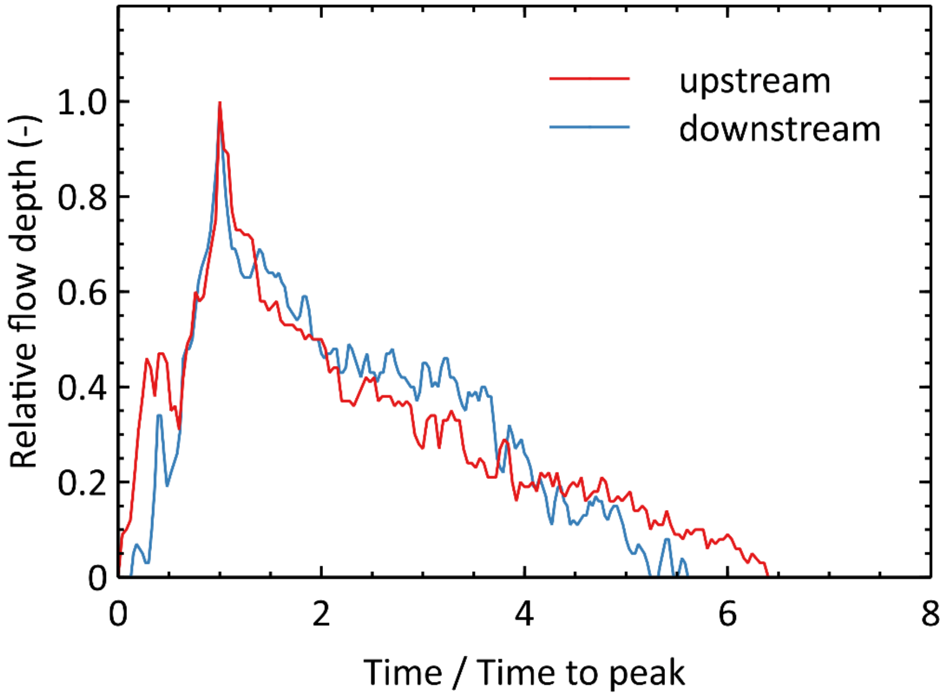
Basic statistics on debris-flow surges duration and flow depth

	Valid N	Mean	Std. Dev.	Median	Lower quartile	Upper quartile
Time to peak (s)	62	68	76	44	17	100
Recession duration (s)	56	397	412	234	138	520
Max flow depth (m)	62	1.48	0.76	1.46	0.78	2.03



a) hydrograph characterized by the median value of the time to peak, flow depth and recession duration;
b) severe event, coupling a short time to peak, high flow depth and long duration (25th percentile for the time to peak and 75th percentile for flow depth and recession duration);
c) low-severity event, featuring a relatively long time to peak low flow depth and short recession (75th percentile for the time to peak and 25th percentile for flow depth and recession duration).

Recognizing the shape of debris-flow hydrographs in the Moscardo Torrent



- Debris flows recorded between 2002 and 2019: data for 12 surges for both the upstream and downstream measuring stations
- The flow peaks were aligned to preserve the sharp shape that is a distinctive feature of debris-flow hydrographs.
- Mean debris-flow hydrographs were obtained by averaging the ordinates.
- Dimensionless hydrographs may enable comparison with other instrumented catchments and could also permit the study of the hydrograph deformation along a channel.

Concluding remarks

- Data recorded by the monitoring system are available for 26 out of the 30 debris flows that occurred between 1990 and 2019.
- Data collection has been conditioned by variability in available financial resources (obsolescence of the instrumentation 2007-2010), and by the implementation of hydraulic works, which caused temporary disruption of data recording (1999-2001).
- Debris flows in the Moscardo Torrent occur between early June and the end of September, with higher frequency in June and July. No significant changes in the day of occurrence have been observed in the 30 years of observation.
- The empirical rainfall threshold for debris flows established after the first years of monitoring (1990-1998) has been confirmed by rainfall data collected in the following 20 years.
- The recorded hydrographs have been analyzed to derive simplified triangular hydrographs corresponding to events of different severity and dimensionless hydrographs that outline the typical shape of debris-flow surges in the Moscardo Torrent.
- The Moscardo Torrent dataset enables the comparison of triggering rainfall and basic flow variables (depth, velocity, volumes) with other basins instrumented for debris-flows monitoring under different climate and geolithological conditions.