Response to Referee 2 - Anonymous

Informative description of the monitoring situation of the Moscardo torrent.
We wish to thank the reviewer for his/her comments. Below we present our responses.

Comments: It would be fine to get some background information about the instrumentation before chapter 3 (debris flow data). The main recordings are along the cannel are flow height and seismic amplitude. How these data are observed, recorded and treated? Within the sampling interval (measuring interval?) is the record averaged, or is it the maximum etc.? How to start and end a debris flow surge with a Zero value in order to calculate a discharge? How to define the real flow section of a debris flow, if there is only a punctual measurement? How big are possible uncertainties within the dataset? Are there any suggestions?
Seismic amplitude is not considered in this paper: we focus on rainfall data and flow stage data because, as we remind in the Introduction, other data are available only for a part of the monitoring period.
The systems for flow stage data recording varied during the monitoring period: in the present installation, data are recorded by a Campbell CR1000 data logger. We would prefer not to provide details about present and past recording systems because we think they would be of limited interest to possible users of debris-flow data.
Stage data are averaged over the recording period: the resulting approximations are negligible for the debris flows recorded since 1996 (recording intervals of 1 or 2 s), whereas they could be more relevant for the debris flows recorded in the first years (recording interval 10 s).
The start of a surge is easily identified at the first rise of the hydrograph; larger uncertainties can arise regarding the end of the recession phase, which occurs when the flow level becomes almost stable or a new surge begins. The process of surge identification is similar to hydrograph separation for water floods, although the sudden variations in the stage of debris flows make it somewhat more complicated. In the Moscardo the water level before the occurrence of a debris flow is negligible if compared to the maximum depth of debris-flow surges: as a consequence, there is no need to subtract a “baseflow” from the recordings of the debris-flow stage.
Although the surface of a debris flow is not perfectly planar, video recordings do not show remarkable differences in flow stage along a cross-section: one stage sensor at each instrumented cross-section is considered adequate to monitor debris-flow hydrographs.
Several factors influence the uncertainties of debris-flow measurements. Among the variables considered in this study, the debris-flow volumes are affected by the largest uncertainties because the assessment of volumes includes errors in flow depth measurement, approximations in the identification of the end of the surge(s), and possible variations in the geometry of the cross-section. A systematic analysis of uncertainties has not been carried out in the Moscardo. The experience from another instrumented catchment (Coviello et al., 2020), in which debris-flow volumes computed from the analysis of the hydrographs can be compared with debris

volumes accumulated in a sediment trap, shows that uncertainty in debris-flow volume can reach ± 50% for small events, i.e. debris flows with low flow depth.

Line 83... (surge) velocity, mean velocity (see table 2): How is mean velocity calculated, which difference is calculated to (surge) velocity? How is the peak discharge really estimated?
The methods for the computation of surge velocity, peak discharge, and volume are described in the submitted manuscript (section 3):

> *"The mean debris-flow velocity was calculated as the ratio of the distance between two instrumented cross-sections to the time difference between the occurrence of the peak of the debris flow in the two recorded hydrographs. The debris-flow volume was computed by summing up, over the entire duration of the event, the product of mean flow velocity and cross-section area occupied by the flow at each time increment. The assumptions underlying this approach to volume computation, and the possible associated errors are discussed in Marchi et al. (2002) and Arattano et al. (2015)."*

Ch 4 (Line 100) ...beginning of summer (2019) to early autumn (1991). What does this mean? Are the triggering rainstorms independent from the gauging station?
The earliest debris flow occurred at the beginning of summer (4 June 2019), the latest at the beginning of autumn (30 September 1991).

Fig. 4 Legend is missing Are the data shown for all stations? What does 150 and 275present? Give the information about the day.
Thank you for noticing the missing legend. When multiple rain gauges were working, only the one with the longest time series was selected for this figure. 150 and 275 are the day number of the year.

Fig. 5: There is no significant regression! Why to present a regression? It is better to show the scattered data.
We agree with this comment. We will modify the figure accordingly if we will be invited to submit a revised paper.

L135 ...evacuation of sediment.. better: mobilization of sediment
The terms "evacuation of sediment" or "sediment evacuation" are widely used to describe the export of sediment from a geomorphic system.

Ch 4.2: For the reader it would be better to combine this Chapter with Ch 4.1 (Ocurrence). Well, Ch 4.1 shows the distributiion of df ocurrence during the year and Ch4.2 is focused on the precipitation thresholds, but there should be a link between the chapters to come out with some new findings. How is the duration of triggering rainfall defined? Is it the time before the debris flow arrives at the station or less?
We will take these comments into account to modify the structure of section 4.
Possible revision:
4.1 Rainfall thresholds
4.2 Debris-flow occurrence

4.3 Debris-flow hydrographs
Duration and mean intensity of triggering rainstorms were computed from the onset of precipitation to the passage of the debris flows at the stage measurement stations. We plan to take into account also non-triggering rainstorm and to plot them in a duration-intensity plot. We wish to stress, however, that the automatic extraction of rainstorm events leads to the identification of duration and rainfall quantities that can hardly be compared to the expert-driven event identification. While the expert-based event definition can leverage the availability of debris-flow timing information and unravel the role and importance of rain and hiatuses, the automatic procedure relies only on thresholds of rainfall amount and intensity, showers separation. As such, on average the automatically-extracted rainfall events tend to be longer than the expert-identified ones as they include rainstorm tails.

Table 1: Just a question: How do we define a catchment (area)? It seems that this area is calculated as the area of the drainage basin (which is hydrological defined). Usually a catchment area includes the are of the fan, too. (see Fig.1) How is mean basin slope and mean channel slope calculated?
We respectfully disagree with the Reviewer about the computation of the catchment area. A drainage basin is the entire area providing runoff to a stream. A fan does not provide runoff to the stream, rather it is an area where flow (and sediment) divergence occurs.
Mean basin slope and mean channel slope were originally computed on a contour lines topographic map at the scale of 1:10,000: the resulting values are consistent with the computation on a catchment DEM.

Table 2: mean velocity ???? (see above)
See the answer to previous comments.

Fig. 6: Please include the years of missing data in a different way, not only showing a Zero-value.
There are no years with missing data on debris-flow occurrence. Even when the monitoring instrumentation was not working, the debris-flow occurrence was documented through field observations.

Fig. 7: Legend is missing
Thank you for this comment. We will add the legend if we will be invited to submit a revised paper.

Reference in this response

Coviello, V., Theule, J.I., Crema, S., Arattano, M., Comiti, F., Cavalli, M., Lucía, A., Macconi, P., Marchi, L., 2020. Combining Instrumental Monitoring and High-Resolution Topography for Estimating Sediment Yield in a Debris-Flow Catchment. Environmental & Engineering Geoscience, Vol. XXVI, No. 4, in press.