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Discussions

Interactive comment on "Factors controlling erosion-deposition phenomena related to lahars at Volcán de Colima, Mexico" *by* R. Vázquez et al.

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First we like to thank to R. Cioni, for his objective observations and suggestions to improve the content of our manuscript. According to the observation that the FLO-2D simulation is not fully satisfactory for the objective of our paper, we decided to leave these results out of the paper. Instead we improve the discussion by comparing our results with the works of Berger et al. (2011) and Schürch et al. (2011). They found that the depth of the flow front is strictly related to the erosion or deposition regime developed by the flow. These findings are in agreement with our results, and hence we focus on the description of the observed morphological changes in this manner: This cyclic behavior of E/D regimes controlled by the channel morphological changes has been previously observed and quantified by Doyle et al. (2009), Berger et al. (2011), and Schürch et al., (2011). In particular, Schürch et al. (2011) supported this remark by studying the scouring effects of debris flows at Illgraben, in the Swiss Alps. According to their measurements, a substantial erosion is more likely when flow depth increases. Events with front heights >2.3 m were all erosive, meanwhile the events with front heights <2.7 m were mainly depositional. A similar behavior was observed in the Montegrande ravine, where the flows that occurred during the 2013 season had front heights of more than 2 m and up to 3.5 m„ presenting a regime mainly erosive, especially considering the 11 June lahar alone. During the 2014 season, the flows presented mean front heights of ∼1.5 m, being mainly depositional. These values clearly correlated with the annual E/D rate observed during the 2013-2014 season. We also improve the discussion about the relation between rainfall and lahar occurrence along the studied period, by complementing the data reported on Fig. 9 (according to the submitted manuscript), with data of past rainfall events that did not triggered lahars (attached figure). In particular, rainfall data here presented are based only on one raingauge and, as observed before, rainfalls can be locally concentrated. Hence, the estimation of rainfall thresholds triggering a lahar cannot be very accurate at least for the events at the beginning of the season, which are strongly related to orographic rainfalls (high intensities – low rain accumulation) (Capra et al., 2010). At Volcán de Colima, after the last significant eruptive phase (i.e. 2004-2005 years), on the succeeding years (i.e. 2007-2012), the rain episodes needed to trigger lahars were of short duration and low accumulated rainfall values as reported by Capra et al. (2010). But from 2013, the precipitations required to detonate a lahar were of higher values of accumulated rainfall and/or longer duration). For example, rainfall episodes with characteristics similar to those that triggered lahars during the 2007-2012 period, did not induce any lahars during the 2014 season, which confirms the gradual increase in slope stability of the volcano (attached figure). Finally, about the sediment balance, it is worth mentioning that an active volcano has a natural slope where sediment supply is regulated by the frequency and magnitude of the explosive activity. After a main eruption, lahar frequency increases due to the immediate reworking of pyroclastic material (Manville et al., 2009), even in correspondence of low accumulated rains (Capra et al., 2010), until it progressively decreases in the following years, as observed at Volcán de Colima (Davila et al., 2007; Capra et al., 2010) and other volcanoes (Lavigne, 2004; Thouret et al., 2014; Major et al., 2016). These factors, along with the physical features of the flows (i.e. sediment load, depth, volume, discharge, etc.) will control the morphological evolution of the ravine, until the landscape response to the volcanic perturbation returns to background conditions (Manville et al., 2009; Thouret et al., 2014). This dynamic is evident in Montegrande ravine, where the sediment availability has been decreasing in the last years. The eruptive phase occurred in 2004-2005 is the last significant phase of sediment supply that occurred along the volcano flanks. Block-and-ash flows (BAFs) were emplaced on main ravines up to 6.5 km from the crater (Macías et al., 2006; Sulpizio et al., 2010), due to the repetitive growing and collapse of the summit dome. Then, a new period of slowly dome growing begin in 2007 and stopped in 2010, after reaching the crater rim and spilling over on 2011 (Capra et al., 2015). Finally, a phase of low activity characterized the 2013-2014 years. Consequently, a period of eight years (during the intra-eruptive period from 2007 to July 2015, Capra et al., 2016), was needed to recover the hydrological and sedimentary-yield balance to background conditions. This dynamic is in agreement with the recovering times observed after a minor eruption (Manville et al., 2009). This means that as the volcano recovery its slope stability, more extreme rainfall events are needed to trigger a lahars.

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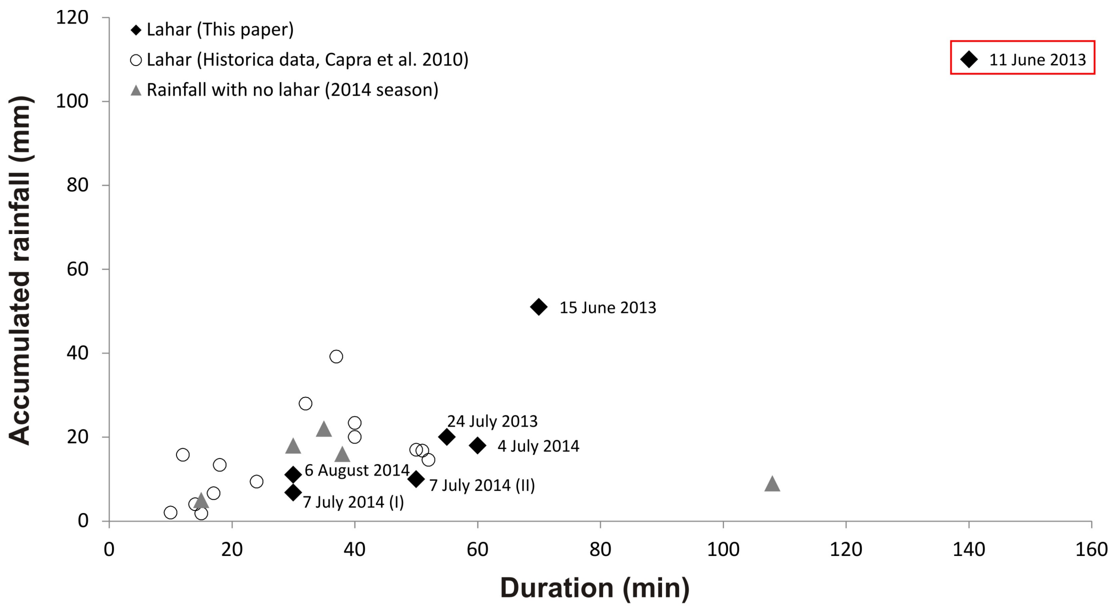

Fig. 1.

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