Assessing physical vulnerability and modeling flash floods and debris flows in the City of Arequipa, Perú

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The city of Arequipa, southern Peru is the largest Latin American center exposed to a large number of natural hazards from Misti volcano, earthquakes, flash floods and mass flows. A multidisciplinary project aims to address hazards, exposure, vulnerability of buildings and bridges, as well as hazard knowledge and risk perception of flash floods and debris flows along two ravines that cross the city. Based on simulations of real and potential mass flows, we aim to map scenario-based hazard zones and assess physical vulnerability.

Three scenarios for a variety of mass flows including flash floods, hyperconcentrated flows (HCF), and debris flows have been derived from recent disastrous 'small' events (c. 100,000 m^3 for the 8 February 2013 HCF) to simulate moderate to extreme events (c. 250,000 m^3 to 600,000 m^3) similar to historical lahar events. Simulations based on high-spatial resolution DEMs have used the average-depth thin layer model Titan 2F for biphasic gravity flows. The input (A) and output (B) parameters for simulating three different mass-flow scenarios are as follows:

Flow Scenario
Input parameters: 1 / 2 / 3
Volume (m^3): 256,000 / 350,000 / 600,000
Initial solid concentration (vol.%): 30 / 40 / 40
Simulation time (minutes): 20 / 25 / 45
Initial Velocity (m/s): 0 / 0 / 0
Outputp parameters
Inundation depth (range, in m): 0.3 - 3 / 0.7 - 4 / 1 - 4
Solid concentration range (vol.%): 10 - 30 / 10 - 40 / 10 - 40
Velocity range (m/s): 1 - 7 / 1 - 5.25 / 3 - 35
Dynamic pressure range (kPa): 7 - 30 / 3 - 35 / 3 - 35

Additional surveys were conducted to determine socio-economic characteristics, hazard knowledge and risk perception of people living along two ravines. Exposure and physical vulnerability of homes were investigated using surveys at the scale of city blocks, high-spatial resolution Pléiades images and drone images. Field observations have enabled us to characterize eight structural types of buildings based on construction material, structural support, openings and roof type, etc. This typology has yielded four vulnerability classes according to three hazard magnitudes and based on inventories of damage after real flow events. Maps of exposed buildings and inundated areas display probabilities of four damage states caused by destructive flash floods and mass flows. Finally, potential fatalities and loss of buildings and bridges will be estimated according to three scenarios, with the aim to contribute to planning emergency procedure and civil defense works.