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On trends and climatic effects of multi-type and cascading hazards in the Andes of Peru

C. Huggel (1), A. Raissig (1), G. Romero (2), M. Rohrer (3), N. Salzmann (1), A. Díaz (2), and D. Acuña (4)

(1) Department of Geography, University of Zurich, Zurich, Switzerland (christian.huggel@geo.uzh.ch), (2) Centro de Estudios y Prevenión de Desastres PREDES, Lima, Peru, (3) Meteodat, Zurich, Switzerland, (4) Servicio Nacional de Meteorología e Hidrología del Perú SENAMHI, Lima, Peru

Multi-type hydrometeorological hazards such as landslides, debris flows and floods are recurring all over the Andes region and cause death to local people and widespread damage to population centers and infrastructure. Such disastrous events are also a threat to development because they often destroy livelihood conditions of the most poor and vulnerable people.

The southern Peruvian Andes are formed by steep and complex terrain, with many remote settlements. A distinctly dry, cold, and a wet, warmer season characterize the climate. Heavy precipitation events have observed to cause landslides and debris flows with volumes of 104 up to as much as 107 m3. The climatic conditions causing the landslides are often poorly understood which is an drawback for more effective risk management. Furthermore, it is unclear whether the frequency of these events has increased over the past decades and whether there is a relation to climate change.

Here we systematically analyze existing multi-type disaster inventories over the period 1970-2010 and their spatio-temporal patterns. To better understand the climatic effects we compiled a record of available meteorological stations. However, these stations are relatively sparse and therefore we included satellite data such as from the Tropical Rainfall Measurement Mission (TRMM) in the analysis.

The results show that no clear trend can be detected in the disaster series, but important insight into spatio-temporal patterns reveal that some regions have experienced an increase over some periods of the past 40 years. Heavy precipitation events have generally increased since the mid-1960s but the effect on landslide and flooding activity cannot yet be clearly observed. Improved understanding of multi-type hydrometerological hazards is likely to come from more detailed investigations of selected case studies. We could show, for instance, that both rainfall intensity and antecedent rainfall are important factors for landslide generation in the southern Peruvian Andes. Furthermore, sediment availability is an important driver in some cases, and temperature can have an effect in high mountain regions due water input from snow and ice melting. Particularly important in terms of hazard and risk assessment are geomorphological and hydrological processes that result in cascading multi-type hazards, with interactions between landslides, debris flows and floods.

We conclude that it is not trivial to detect any significant and reliable trend in hydrometeorological disaster series in the Andes and caution should be applied when relating these disasters to any climatic change. Nevertheless, risk managements should consider short-term and long-term climate impacts, and poorly recognized cascading effects. Early warning systems, based on information such as generated in this study, should be designed and implemented as effective risk reduction measures.