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Towards early warning systems for ice/rock avalanches and glacier lake outburst floods: pilot experiences in Peru's Cordillera Blanca

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The Andes, as many other high mountain regions around the world, are strongly affected by climate change impacts, in particular in relation to accelerating glacier retreat that has been observed over the past decades and is projected to continue into the future. In the past, high mountain hazards have repeatedly threatened the Cordilleras of Peru, and large-scale disasters with thousands of people killed are on record. Ice/rock avalanches, debris flows, and glacier lake outburst floods (GLOF's) are among the most important hazards found.

In the face of climate change there is strong concern that warming has a destabilizing effect on perennially frozen bedrock and on steep glaciers in the steep flanks of high-mountain peaks, with potentially severe consequences to ice/rock avalanches, which may impact existing and new lakes, producing far-reaching outburst floods.

Related risks are changing and need to be recognized, assessed and managed using integrative approaches. As a first step, systematic spatiotemporal analyses of present and potential future high-risk zones must be carried out. Corresponding models of permafrost occurrence, glacier change, lake formation, flood waves and run-out paths of debris flows/rock-ice avalanches can help with this task but need further improvement. At recognized sites with critical conditions, early warning systems are promising to reduce related risks. However, early warning systems are highly complex systems that should include monitoring sensors, and data and voice communication, establish clear institutional responsibilities and response, and essentially involve local people to ensure that adequate action is taken according to different warning levels.

In Peru integrative assessments and fully operational early warning systems for high mountain hazards are not yet in place. Here we report on a pilot experience of a new early warning system for ice/rock avalanches and glacier lake outburst floods in the Cordillera Blanca of Peru. In April 2010, an ice avalanche from Hualcán impacted glacier lake 513 and triggered a flood wave that caused damage in downstream population centers, including the city of Carhuaz. In the framework of an international project an early warning system has been designed and implemented for this case. Automatic cameras, geophones, real-time discharge measurements, and a meteorological station are deployed, and data are transmitted to the civil defense center of Carhuaz. Dynamic, physically based modeling for (i) avalanche flow, (ii) lake displacement wave and (iii) lake outburst flood permitted to determine the characteristics of past events and future scenarios, and understand critical warning parameters such as flood travel time and flood inundation height. Redundancy of the system is ensured by different sensors, and local observers. Parallel to the technical implementation community based efforts are undertaken to ensure effective response and sustainability.

As for any other early warning system, a test and calibration phase must be scheduled which can last up to one year or more. The experience gained through this pilot early warning system is intended to be used for the implementation of further early warning systems across the country.