



InSAR based terrain motion mapping in support of landslide hazard assessment in high mountainous areas:

Integrating EO information for cascading landslide and flood hazard monitoring and early warning, Cordillera Blanca, Peru

Executive Summary

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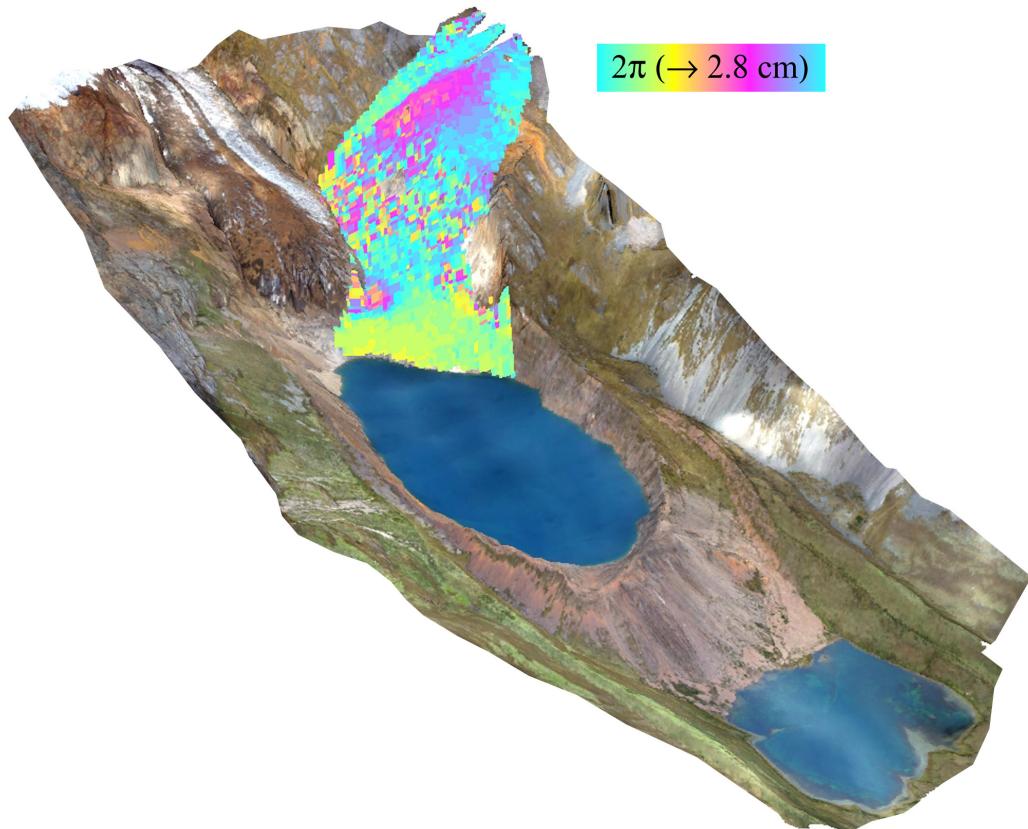
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Picture



Oblique view of terrain displacements at a landslide above the Safuna Alta Lake, Cordillera Blanca, Peru, as indicated by a interferogram of Sentinel-1 from November 2015 to September 2016. In the centre of the landslide, movements of ~2 cm/yr are observed. Background: Orthophoto acquired by a drone in May 2017, draped over a DEM derived from the same drone imagery.

Motivation

Landslides are a well-known but so far less-investigated hazard and risk in the Cordillera Blanca. In this pilot study, EO information in combination with in-situ measurements and modelling was applied for investigating and monitoring landslide processes in this mountain region.

Methodology

Landslides pose significant hazards and risks to the densely populated mountain region of the Cordillera Blanca in Peru, with a series of catastrophic events in

the past. In this Alcantara pilot study, value-added information was generated by combining DInSAR-based products with optical EO data, aerial and terrestrial surveys, structure-from-motion applications, as well as different types of slope stability models. This information was applied to investigate landslide processes at selected study sites, design and implement terrestrial survey strategies and a multi-source landslide monitoring system at one of the sites. InSAR analyses in combination with field investigations and historical aerial photographs was further used to inform numerical models for simulations of glacier lake outburst processes. Finally, the potential of EO contribution to landslide Early Warning Systems, a prevailing topic, was analysed and presented in a white paper, considering both conceptual considerations as well as practical implementation aspects.

Results

- Multi-source landslide monitoring System designed and implemented at the Safuna Alta study site, a priority field site of the local research partner ANA/UGRH. Will be continued by the local partner institution and outlast the project.
- Factors of Safety derived from geotechnical slope stability models at different scales (large-scale to single slope). Reconstruction and evaluation of a past and potential future glacier lake outburst event, obtained by numerical modelling of involved process chains.
- White paper on the 'Contribution of Earth Observation to landslide early warning', combining conceptual considerations and practical implementation aspects.
- Promotion of InSAR as a promising and capable technology within research institutions and political organizations on a regional and national level.

Publications

- Cochachin, A., Frey, H., Huggel, C., Strozzi, T., Büechi, E., Cui, F., Flores, A., Saito, C., "Integrated satellite InSAR and slope stability modelling to support hazard assessment at the Safuna Alta glacial lake, Peru", Geophysical Research Abstracts, Vol.19, EGU2017-14505, 2017.

- Frey, H., Strozzi, T., Caduff, R., Wiesmann, A., Huggel, C., Büechi, E., Cochachin, A., “*An InSAR based landslide inventory for the Cordillera Blanca, Peru: Compilation and validation*”, Abstract book of the Fringe 2017 Workshop, 5-9 July, Helsinki, Finland, 276-277, 2017.
- Huggel, C., Caduff, R., Strozzi, T., Frey, H., Cochachin, A., Klimeš, J., “*Contribution of Earth Observation to landslide early warning*”, White paper, University of Zurich, Gamma Remote Sensing, National Water Authority of Peru, 2017.
- Klimeš, J., Vargas, R., Ocaña, D., Strozzi, T., Frey, H., “*Evaluación de peligros de los deslizamientos en las montañas altas, el ejemplo de la población del Rímac Grande, Carhuaz, Ancash*”, Nota técnica, INAIEM, Huaraz, Perú, in preparation.
- Salazar, C., Cochachin, A., Frey, H., Huggel, C., Portocarrero, C., “*History and current safety measures at Laguna Palcacocha, Huaraz, Peru*”, Geophysical Research Abstracts, Vol.19, EGU2017-14740, 2017.
- Strozzi, T., Klimeš, J., Frey, H., Caduff, R., Huggel, C., Wegmüller, U., Cochachin, A., “*Satellite SAR Interferometry for the Improved Assessment of the State of Activity of Landslides: A Case Study from the Cordilleras of Peru*”, in preparation.

Highlights

The white paper on EO contributions to landslide EWS is the first publication on this topic, at least at this extent and detail. It addresses a prominent gap in scientific literature, which has focused so far only on monitoring applications. The document is directed to both the scientific community dealing with landslide hazards and risks and organizations funding related research. Considering the potential of EWSs as efficient non-structural disaster risk mitigation measures and their high priority on the international policy level, integrating EO in such systems is a promising innovation with a high potential to offer a valuable contribution for operational implementation.