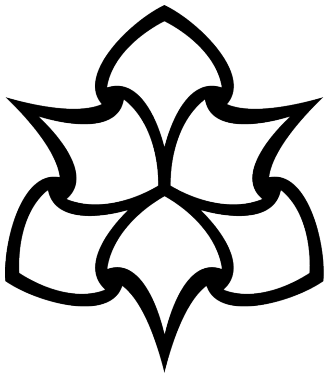

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Glacial lake outburst flood risk in the Bolivian Andes

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Glaciers of the Bolivian Andes have experienced areal shrinkage of $\sim$43% in the last three decades, which has been accompanied by the development of proglacial lakes, some of which could generate glacial lake outburst floods (GLOFs). We provide the first attempt to assess GLOF risk in Bolivia, and model potential GLOF inundation. There are $\sim$137 proglacial lakes in the Bolivian Andes, 25 of which have population and/or infrastructure downstream. We first developed a GLOF risk assessment strategy using Multi-Criteria Decision Analysis (MCDA) guidelines that could be used remotely and free-of-charge to identify glacial lakes that represent the greatest GLOF risk. This revealed that three lakes posed medium or high risk, and required further analysis. Secondly, we undertook a modelling study of potential GLOF inundation from these three lakes. This involved the generation of a 2m resolution Digital Elevation Model (DEM) from stereo and tri-stereo SPOT 6/7 satellite images; the 2D hydrodynamic model HEC-RAS 5.0.3 was used to model GLOF flow. The model was tested against field observations of a 2009 GLOF from Keara, in the Cordillera Apolobamba, and was shown to reproduce realistic flood depths and inundation. The model was then used to model GLOFs from Pelechuco lake (Cordillera Apolobamba), and Laguna Arkhata and Laguna Glaciar (Cordillera Real). In total, six villages could be affected by GLOFs if all three lakes were to burst. We ran the model for three scenarios (pessimistic, intermediate, optimistic) which give a range of 1589 and 2302 people affected by flooding; between 1107 and 2168 people would be exposed to damaging floods (flow depth $\geq$ 2m). We suggest that Laguna Arkhata and Pelechuco lake represent the greatest risk due to the higher numbers of people who live in the potential flood paths, and hence should be a priority for risk managers.