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Dealing with unquantifiable uncertainties in landslide modelling for urban risk reduction in developing countries

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Landslides have many negative economic and societal impacts, including the potential for significant loss of life and damage to infrastructure. Slope stability assessment can be used to guide decisions about the management of landslide risk, but its usefulness can be challenged by high levels of uncertainty in predicting landslide occurrence. Prediction uncertainty may be associated with the choice of model that is used to assess slope stability, the quality of the available input data, or a lack of knowledge of how future climatic and socio-economic changes may affect future landslide risk. While some of these uncertainties can be characterised by relatively well-defined probability distributions, for other uncertainties, such as those linked to climate change, no probability distribution is available to characterise them. This latter type of uncertainty, often referred to as deep uncertainty, means that robust policies need to be developed that are expected to perform acceptably well over a wide range of future conditions. In our study the impact of deep uncertainty on slope stability predictions is assessed in a quantitative and structured manner using Global Sensitivity Analysis (GSA) and the Combined Hydrology and Stability Model (CHASM). In particular, we use several GSA methods including the Method of Morris, Regional Sensitivity Analysis and Classification and Regression Trees (CART), as well as advanced visualization tools, to assess the combination of conditions that may lead to slope failure. Our example application is a slope in the Caribbean, an area that is naturally susceptible to landslides due to a combination of high rainfall rates during the hurricane season, steep slopes, and highly weathered residual soils. Rapid unplanned urbanisation and changing climate may further exacerbate landslide risk in the future. Our example shows how we can gain useful information in the presence of deep uncertainty by combining physically based models with GSA in a scenario discovery framework.