Pierrick Nicolet
Institut des Sciences de la Terre
Faculté des Géosciences et de l'Environnement
Université de Lausanne

# Abstract

## Quantitative risk analysis for natural hazards at local and regional scales

Natural hazards can have damaging consequences for human activities, causing death or economic losses. This PhD thesis concentrates on the risk of natural hazard, where risk is defined as the combination of the likelihood of a damaging event and its negative consequences. The types of hazards considered in this work are mostly geological hazards such as landslides and sinkholes, but hail is also investigated.

The first part of this work focuses on the local scale, where local stands for a small group of objects, typically a few houses or a road. First, in order to improve the characterisation of the hazard, the potential of the photogrammetric method, which consists in retrieving the 3D position of objects from a set of 2D pictures, is tested. Together with this promising method, Unmanned Aerial System (UAS) are presented, since they permit to carry a camera and thus to take pictures for a photogrammetric analysis. Then, a tool to calculate the risk at local scale is presented. This tool is designed in Microsoft Excel an aims at calculating rapidly the risk using hazard maps produced according to the Swiss guidelines. A particular aspect of this model is presented in the next chapter ; it reviews the methods used to calculate the conditional probability for a falling object, such as a rock block, to impact a moving vehicle, taking into account the dimensions of the block and of the vehicles. Then, prospective aspects of such a risk model are presented and deal with the addition of multiple risk scenarios and the inclusion of uncertainty in the risk analysis using a Monte-Carlo approach. To conclude this part, a method which aims at taking the protection measures into account in the hazard maps without losing the initial hazard level is presented.

The second part of this work presents risk analyses at regional scale, where the region varies from the size of a canton to the size of a (small) country. The first study concerns the risk induced by evaporite sinkholes on a building portfolio. An inventory of damaged buildings is built from different sources and projections are made to estimate the losses that the public building insurance company could face if this type of hazard was insured. Then, a stochastic model which aims at modelling shallow landslides with regard to a precipitation event, and at calculating the probability of impact with buildings is presented. It shows that the location of the landslides which occurred during the precipitation event considered in this study is positively correlated with the building location, suggesting a human influence in the landslides. To conclude this part, an analysis based on a hail event is presented and aims at relating the radar-derived maximum hailstone size reached during an event with the losses, at calculating the mean annual risk using this relation and at modelling random event to refine the risk analysis.

Although the basic principles of risk analysis are relatively simple, this work highlights the diversity of the risk analyses procedure and the need to adjust the procedure to the research question. In addition, it highlights the need for good inventories of events and consequences, since these inventories are crucial to perform a good risk analysis.