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A new multi-disciplinary model for the assessment and reduction of volcanic risk: the example of the island of Vulcano, Italy

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Volcanic eruptions are accompanied by numerous hazards which pose short- and long-term threats to people and property. Recent experiences have shown that successful responses to hazard events correlate strongly with the degree to which proactive policies of risk reduction are already in place before an eruption occurs. Effective proactive risk-reduction strategies require contributions from numerous disciplines. A volcanic eruption is not a hazard, per se, but rather an event capable of producing a variety of hazards (e.g. earthquakes, pyroclastic density currents, lava flows, tephra fall, lahars, landslides, gas release, and tsunamis) that can affect the built environment in a variety of ways, over different time scales and with different degrees of intensity. Our proposed model for the assessment and mitigation of exposure-based volcanic risk is mainly based on the compilation of three types of maps: hazard maps, hazard-specific vulnerability maps and exposure-based risk maps. Hazard maps identify the spatial distribution of individual volcanic hazard and it includes both event analysis and impact analysis. Hazard-specific vulnerability maps represent the systematic evaluation of physical vulnerability of the built environment to a range of volcanic phenomena, i.e. spatial distribution of buildings vulnerable to a given hazard based on the analysis of selected building elements. Buildings are classified on the basis of their major components that are relevant for different volcanic hazards, their strength, their construction materials and are defined taking into account the potential damage that each group of building elements (e.g. walls, roof, load-bearing structure) will suffer under a volcanic hazard. All those factors are enumerated in a checklist and are used for the building survey. Hazard-specific vulnerability maps are then overlapped with hazard maps in order to compile exposure-based risk maps and so quantify the potential damage. Such quantification is the starting point of the identification of suitable mitigation measures which will be analyzed through a cost-benefit analysis to assess their financial feasibility. Information about public networks is also recorded in order to give an overall idea of the built environment condition of the island. The vulnerability assessment of the technical systems describes the potential damages that could stress systems like electricity supply, water distribution, communication networks or transport systems. These damages can also be described as function disruption of the system. The important aspect is not only the physical capacity of a system to resist, but also its capacity to continue functioning. The model will be tested on the island of Vulcano in southern Italy. Vulcano is characterized by clear signs of volcanic unrest and is the type locality for a deadly style of eruption. The main active system of Vulcano Island (La Fossa cone) is known to produce a variety of eruption styles and intensities, each posing their own hazards and threats. Six different hazard scenarios have been identified based on a detailed stratigraphic work. The urbanization on Vulcano took place in the 1980s with no real planning and its population mostly subsists on tourism. Our preliminary results show that Vulcano is not characterized by a great variability of architectural typologies and construction materials. Three main types of buildings are present (masonry with concrete frame, masonry with manufactured stone units, masonry with hollow clay bricks) and no statistically significant trends were found between physical and morphological characteristics. The recent signs of volcanic unrest combined with a complex vulnerability of the island due to an uncontrolled urban development and a significant seasonal variation of the exposed population in summer months result in a high volcanic risk. As a result, Vulcano represents the ideal environment to test a multi-hazard based risk model and to study the transition between micro (building) and macro (urban environment) scale of analysis, which is still an unexplored field in the study of volcanic risk. Different levels of vulnerability need to be analyzed in order to increase the level of preparedness, plan a potential evacuation, manage a potential volcanic crisis and assess the best mitigation measures to put in place and reduce the volcanic risk.