Geophysical Research Abstracts
Vol. 13, EGU2011-2556, 2011
EGU General Assembly 2011

Towards a rapid, integrated, multi-scale assessment of earthquake risk: a case study in Central Asia

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Earthquake risk models usually integrate hazard components, which encompass both seismicity and ground-motion information, and vulnerability models. The vulnerability model identifies the inventory of buildings and other assets exposed to seismic risk and quantifies their expected damage when subject to different level of ground-motion. In particular the quality and completeness of building stock inventory is vital both for a more realistic loss estimation and for post-event response purposes, and in principle it could be estimated with great accuracy.

In 2008 the urban population of the world exceeded, for the first time in history, the rural population. The process of rapid urbanisation is increasingly gathering millions of people into a few cities, challenging social and environmental planners which often lack the financial resources necessary to keep up with the fast pace of the urban sprawls. Many of this rapidly-changing cities are prone to natural disasters, among which earthquakes are of particular interest, due to their potential damaging capability.

Rapid urban growth, often accompanied by unplanned settlements, dynamically changes the vulnerability scenario over a short/medium time-scale (a few years). The short time-scale on which the modifications occur represents a great challenge for local governments, which are often unable to continuously update the exposed building stock. Therefore an efficient vulnerability model should be able to cope with these issues in order to successfully contribute to the main seismic risk model.

In the context of a rapid update of the vulnerability scenario, a thorough assessment of the buildings inventory, based on a building-by-building evaluation and repeated upon changing of the urban environment would yield the best results, but this approach cannot be realistically applied to a large scale systematic survey. On the other side an approximate evaluation computed on a much broader scale, for instance based on census data, provides only a rough estimate of the average vulnerability.

We propose an integrated approach to multi-scale seismic risk which can be easily applied to different urban environments and efficiently scaled based on the desired detail level.

The proposed approach is focused on a novel multi-source evaluation of the vulnerability model based on satellite remote sensing and ground-based omnidirectional imaging. A first analysis of the urban area is performed based on the processing of medium-resolution, multi-spectral satellite images. The urban area is automatically divided into homogeneous clusters that will be described by a single vulnerability class. The resulting clusters are then further aggregated based on estimated buildings age and land-cover/land-use. A ground-based, rapid survey of representative samples for each homogeneous cluster is then performed using a omnidirectional imaging system driven around with a car. The automatic processing of the acquired images provides an estimate of the building stock composition, as well as the most likely vulnerability class, following EMS-98 scale, for each building successfully located. The dominant vulnerability class is then associated to each cluster. The vulnerability model is based on a simple combination of damage probability matrices and empirical equations, which can be easily tuned according to the specific urban environment. This approach is quick and provides both a multi-scale estimate of earthquake vulnerability, and an extensive set of georeferenced visual information which can be also used for rapid post-event damage assessment.

The proposed approach has been applied to the town of Bishkek, Kyrgyzstan. Following a medium-scale analysis of satellite images, a ground-based survey with omnidirectional camera in the automatically selected sample areas has been carried out. Preliminary results from the automatic analysis of the captured omnidirectional video stream will be discussed.