



Bayesian downscaling of building exposure models with remote sensing and ancillary information

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Residential building exposure models for risk and loss estimations related to natural hazards are usually defined in terms of specific schemas describing mutually exclusive, collectively exhaustive (MECE) classes of buildings. These models are derived from: (1) the analysis of census data or (2) by means of individual observations in the field. In the first case, expert elicitation has been conventionally used to classify the building inventory into particular schemas, usually aggregated over geographical administrative units whose size area and shape are country-specific. In the second case, especially for large urban areas, performing a visual inspection of every building in order to assign a class according to the specific schema used is a highly time- and resource intensive task, often simply unfeasible.

Remote sensing data based on the analysis of satellite imagery has proved successful in integrating large-scale information on the built environment and as such can provide valuable vulnerability-related information, although often lacking the level of spatial and thematic resolution requested by multi-hazard applications. Volunteered Geo Information (VGI) data can also prove useful in this context, although in most cases only geometric attributes (shape of the building footprint) and some occupancy information are recorded thus leaving out most of the building attributes controlling the vulnerability of the structures to the different hazards. An additional drawback of VGI is the incompleteness of the information, which is based on the unstructured efforts of voluntary mappers.

Former efforts have been proposing a top-down/bottom-up approach moving from regional scale to neighbourhood and per-building scale, based on the analysis and integration of different data sources at increasing spatial resolutions and thematic detail. Following the same principle, this work focuses on the downscaling of already existing building exposure models based on census data making use of a probabilistic approach based on Bayesian updating. Different aggregation models can be taken into account to increase the spatial resolution of the building exposure model, also including variable-resolution models based on geostatistical approaches. Land-use

masks are first generated after a supervised classification of Sentinel-2 images, in order to better relate the built-up area to meaningful geographical entities. Two independent statistical models are then created based on prior input information. Maximum likelihood estimations are obtained for each model. Two types of auxiliary data have been employed in order to constrain the downscaling via a specific likelihood term in the Bayesian updating: 1) building footprints area from the open-source-volunteered geo-information OpenStreetMaps and 2) built-up height and density estimators based on remote sensing developed by the DLR (the German Aerospace Agency).

This approach, developed within the scope of the RIESGOS, was tested in Valparaiso and Viña del Mar (Chile) where the residential building exposure model proposed by the GEM-SARA project has been downscaled. The performance of the different auxiliary data were separately tested and compared. An independent building survey has also been carried out by experts from CIGIDEN (Chile) using a Rapid Remote Visual Screening Survey and used for preliminary validation of the approach.