An ordered probit model for seismic intensity data

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We consider the intensity of seismic events, which is the measure of earthquake effects on buildings, structures and people. The intensity, measured through the Mercalli, Cancani, Sieberg (MCS) scale, provides an assessment of ground shaking deduced from building damages, from any natural environment changes and from any observed effects or feelings. Generally, moving away from the earthquake epicentre the effects are lower but intensities may vary in space, as there could be areas that amplify or reduce the shaking depending on the earthquake source, geological features and local factors. Currently, the Istituto Nazionale di Geofisica e Vulcanologia (INGV) analyses, for each seismic event, data collected through the macroseismic questionnaire available at the web site www.haisentitoilterremoto.it. In particular, questionnaire responses are elaborated obtaining local estimates of the earthquake intensity and then intensities are aggregated at the municipality scale. In this work we employ an ordered probit model for intensities at the municipality scale. In particular, we assume that the intensity response variable is related through the link probit function to some predictors, such as the distance from the epicentre, the earthquake magnitude and depth. Differently from what it is commonly done in the macroseismic literature, this approach properly takes into account the qualitative and ordinal nature of the macroseismic intensity as defined on the MCS scale. Using Markov chain Monte Carlo methods, we estimate the posterior probability for each intensity. We are able to predict the intensity posterior probability distribution (IPPD) for any value of distance and magnitude. It is thus possible to map the whole area interested by an earthquake with a given magnitude, by computing the IPPD for each municipality, moreover we can detect, by local comparison with observed data, areas of possible effects amplification/attenuation. The obtained results can be compared with the existing attenuation laws.

Key words: earthquakes, attenuation law, Mercalli scale, Bayesian modeling.