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## Fusing Damage Proxy Maps with Geospatial Models for Bayesian Updating of Seismic Ground Failure Estimations: A Case Study in Central Italy

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On August 24, 2016, a magnitude-6.2 earthquake in Central Italy resulted in at least 290 deaths, significant ground failure (including landslides and liquefaction), and building damage. After the event, the NASA Advanced Rapid Imaging and Analysis team produced Damage Proxy Maps (DPM) that reflect earthquake-induced surficial changes using synthetic aperture data from the COSMO-SkyMed satellite. However, exact causes of these surface changes, e.g., ground failure, building damage, or other environmental changes, are difficult to directly differentiate from the satellite images alone. For example, changes could reflect building damage, landslides, the co-occurrence of both, or numerous other processes that are not related to the earthquake. Alternatively, existing ground failures models are useful in locating areas of higher likelihoods but suffer from high false alarm rates due to inaccurate or incomplete geospatial proxies and complex physical interdependencies between shaking and specific sites of ground failure. In this work, we present a joint Bayesian updating framework using a causal graph strategy. The Bayesian causal graph models physical interdependencies among ground shaking, ground failures, building damage, and remote sensing observations. Based on the graph, a variational inference approach is designed to jointly update the estimates of ground failure and building damage through fusing traditional geospatial models and the remotely sensed data. As a case study, the DPMs in Central Italy are input to the model for jointly calibrating and updating the probability of ground failure estimations as well as for estimating building damage probabilities. The results showed that by incorporating high-resolution imagery, our model significantly reduces the false alarm rate of ground failure estimates and improves the spatial accuracy and resolution of ground failure and building damage inferences.