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Integration of Ground Motions into Induced Seismicity Risk Management in the Kiskatinaw Area, Northeast B.C.

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Summary

The project will investigate the incorporation of ground motions into traffic-light protocols (TLPs) for induced seismicity oversight with a focus on applications in the Kiskatinaw area. The objectives of the study are twofold:

1. The development of regional ground motion models for induced events, which can be used for the assessment of associated hazard in future, and

2. the review of the existing magnitude thresholds of traffic-light protocols (TLPs) on the basis of ground motions for effective induced seismicity risk management.

The project is conducted in three phases: ground motion prediction, definition of perception and potential damage thresholds, and review of traffic light protocol (TLP) magnitude thresholds on the basis of ground motions.

Workflow

During phase 1, a ground motion prediction equation (GMPE) and site amplification for the Kiskatinaw area is developed by examining regional source and attenuation attributes of compiled public and private ground motion data from the region. Ground motion simulations are then leveraged to investigate the scaling of ground motions for significant events where empirical data is sparse. An inversion is carried out in order to empirically determine attenuation effects as well as empirical site amplification factors at each instrumented location. The empirical site amplification factors are correlated with available geological and geotechnical information such as depth to bedrock or topographic slope based Vs30 in order to estimate the amplification level for instrumented locations throughout the region. This will allow for the localized variations in site conditions to be accounted for when evaluating the GMPE for the development of shaking intensity maps. The variability in observed ground motions about the model prediction is captured in order to evaluate the GMPE for different motion percentiles. Figure 1 shows the model performance, the evaluated model against ground motion observations, and the empirical site amplification effects relative to the average site response throughout the region.

A literature review is performed in Phase 2 to determine typical perception and damage threshold levels in terms of PGA and PGV. It is found that PGV of 0.07 cm/s and PGA of 2.5 cm/s^2 correspond to the perception level (equivalent of Modified Mercalli Index Intensities as calculated by Caprio et al., 2015, of II – III). The lower boundary of non-structural damage levels (superficial damage such as cracks in plaster) are found to begin at PGA of 84.3 cm/s^2 and PGV of 5.52 cm/s (MMI VI), where structural damage potential is found to begin at PGA of 154.0 cm/s^2 and PGV of 13.9 cm/s (MMI VII). Felt reports from significant events in the Ft. St John area are correlated with station locations or ground motions are estimated via the derived

GMPE and site amplification map. It is found that the description provided in the felt report correlates well both with the associated MMI and recorded/estimated peak ground motion.

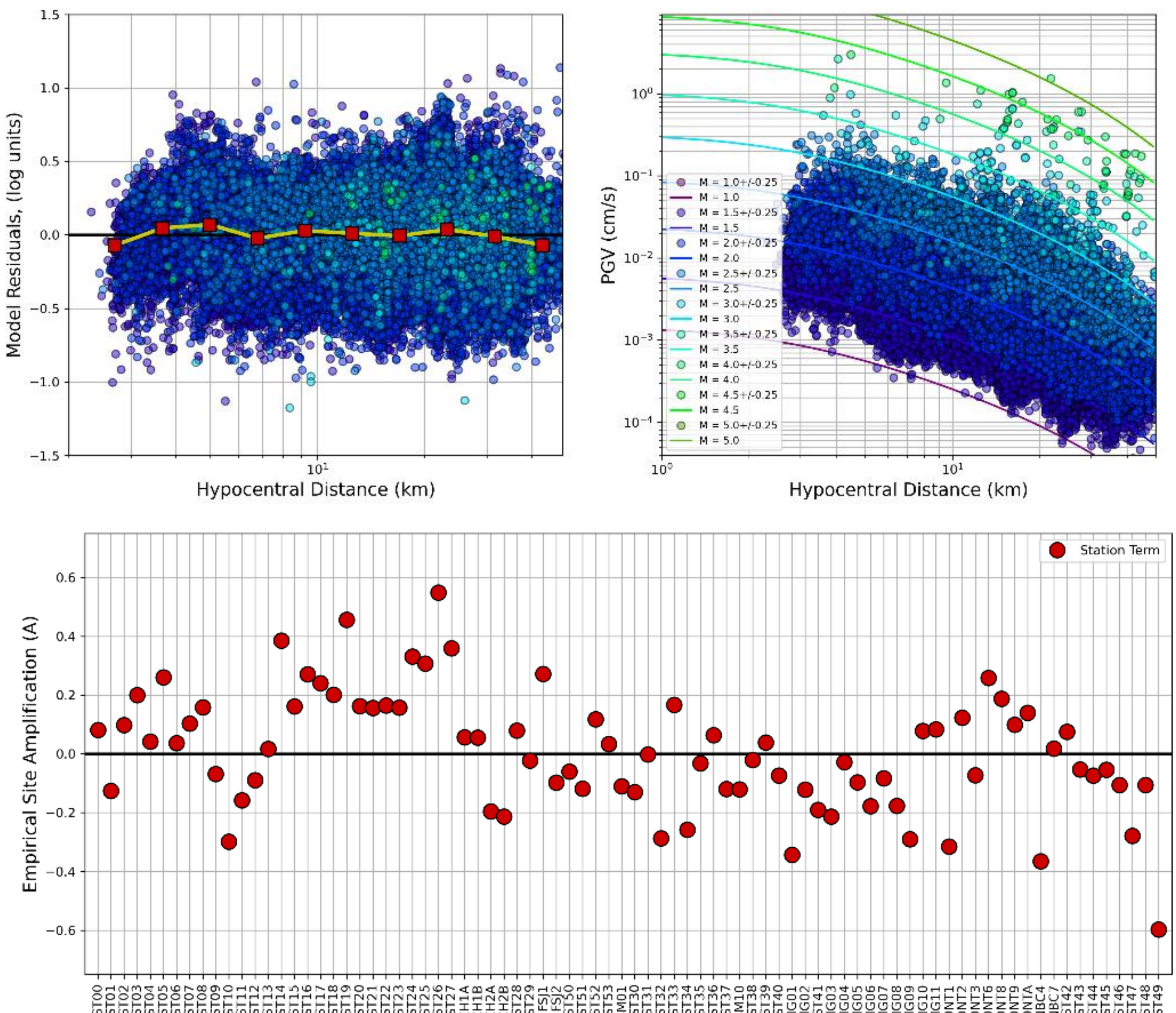

Figure 1. (left) shows model residuals (observation – prediction) as a function of hypocentral distance, (center) shows the evaluated GMPE against observed ground motions, and (right) shows the empirical site amplification values derived for each station relative to the average response of the region.

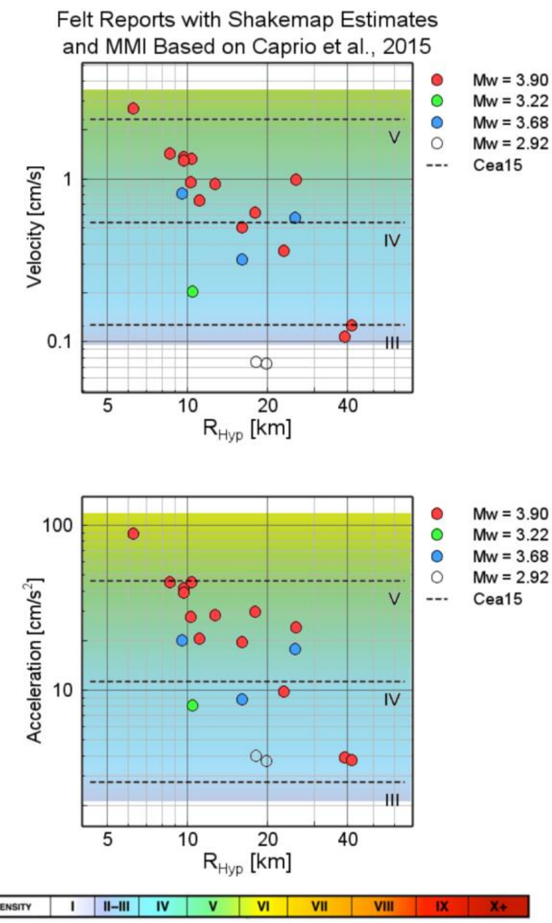

Figure 2. Peak ground motions associated with felt reports are shown in circles. The background is colored to reflect the equivalent MMI based on Caprio et al., (2015) where the center of the MMI range for each intensity level is plotted as dashed horizontal line.

In the final phase, the magnitudes of earthquakes which are unlikely to exceed the perception or non-structural damage threshold within the Kiskatinaw region are determined. To this end, shaking intensity maps are generated by simulating earthquakes on a 500m grid at several depth levels. The resulting ground motions from each scenario across the region are compared against the thresholds defined in Phase 2. The magnitude of event at each grid point which is unlikely to exceed the thresholds is recorded in order to generate magnitude-threshold maps. These maps will be used to inform decisions within the BCOGC for appropriate traffic light levels across the region.

References

Caprio, M., Tarigan, B., Worden, B., Wiemer, S., and Wald, D. J., 2015, Ground motion to intensity conversion equations (GMICEs): a global relationship and evaluation of regional dependency: Bull. Seis. Soc. Am. Early Edition 105, 3.