Alaskan Ground Motion Versus Intensity-Empirical Relationships between Ground-Motion Parameters and "Did you Feel It?" Intensity

Roshan Raj Bhattarai[1], Roshan R Bhattarai[2,3], and Chris H Cramer[2]

[1]Affiliation not available
[2]CERI, The University of Memphis
[3]Terracon Consultants Inc

December 27, 2023

Alaskan Ground Motion Versus Intensity—Empirical Relationships between Ground-Motion Parameters and "Did you Feel It?" Intensity

Roshan R. Bhattarai[*1,2] and Chris H. Cramer[1]

[1]CERI, The University of Memphis, TN, USA; [2]Terracon Consultants Inc., TX, USA

* Correspondence: rrbhttri@memphis.edu

INTRODUCTION

The relationship between the quantitative ground motion and intensity, known as the ground motion intensity correlation equation (GMICE), is an important topic in seismic hazard analysis. Although numerous such studies have been conducted in the United States, they often focus on the eastern, central and California regions. An Alaskan GMICE does not currently exist, but the existence of sufficient data due to improved seismograph coverage since 2010 and the implementation of "Did you feel it?" in Alaska provides the opportunity for developing an Alaskan relation. In particular, the occurrence of the 2018 Anchorage **M**7.1 earthquake with intensities up to VIII in the Anchorage area provides a dataset with needed higher intensities.

METHODOLOGY

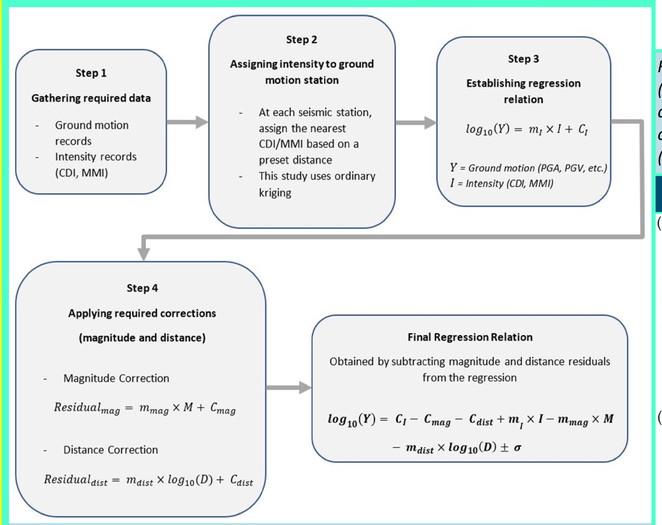

Fig.1: Flow diagram explaining a general approach used in establishing ground motion intensity correlation equations (GMICE).

DATA

- PGA, PGV and Spectral Acceleration (SA) at 29 different periods (0.01, 0.02, 0.03, 0.04, 0.07, 0.1, 0.15, 0.2, 0.25, 0.3, 0.4, 0.5, 0.6, 0.7, 0.75, 0.8, 0.9, 1.0, 1.5, 2.0, 3.0, 4.0, 5.0, 6.0, 7.0, 7.5, 8.0, 9.0, 10s) for five distinct earthquakes .
- Geocoded Community Decimal Intensity (CDI) reported through the USGS "Did You Feel It?" (DYFI).

Magnitude (M)	Depth (km)	CDI		Number of stations	
		Available	Used	Available	Used
7.1	127.8	112	26	149	26
7.1	44.1	419	94	433	94
7.6	33.3	158	133	170	133
7.8	28	181	88	277	88
8.2	35	181	87	285	87

ASSIGNING INTENSITY

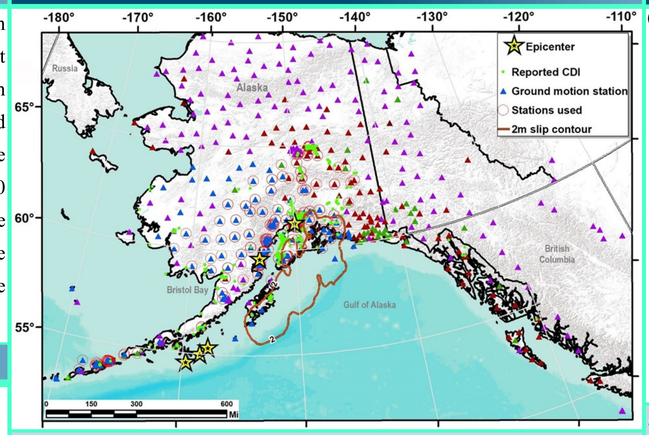

Fig. 2: Map of Alaska showing the location of the epicenter of earthquake used (yellow star), ground motion stations (triangle), CDI reported in the area (green dots) and the ground motion stations used (triangles in red circles). The 2m slip contour of the 1964 co-seismic slip, projected and redrawn from Ichinose et al. (2007), is depicted in bold red.

ESTABLISHING THE RELATIONSHIP

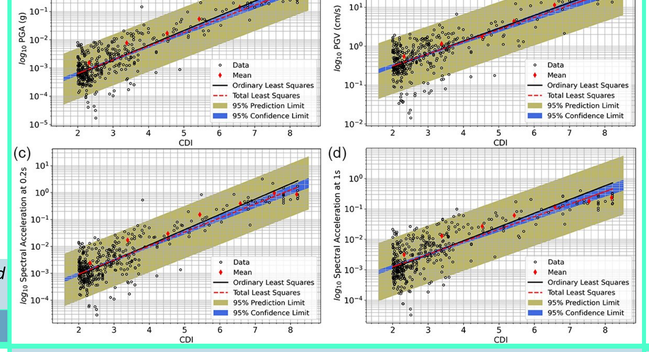

Fig. 3: Regression between CDI and GMPs (a) log_{10}PGA, (b) log_{10}PGV, (c) log_{10} SA at 0.2s and (d) log_{10} SA at 1s. Regression fits are established for both OLS (black line) and TLS (dashed red line). Red diamonds are the mean of the GMPs between each CDI interval (2-3, 3-4 and so on). The shaded region in dark blue is the 95% confidence limit and the shaded region in dark khaki green is the 95% prediction limit of the established relationships using TLS.

REFERENCES

Atkinson, G. M., & Kaka, S. I. (2007). Relationships between felt intensity and instrumental ground motion in the central United States and California. *Bulletin of the Seismological Society of America, 97*(2), 497–510.

Atkinson, G. M., & Sonley, E. (2000). Empirical relationships between modified Mercalli intensity and response spectra. *Bulletin of the Seismological Society of America, 90*(2), 537–544.

Ichinose, G., Somerville, P., Thio, H. K., Graves, R., & O'Connell, D. (2007). Rupture process of the 1964 Prince William Sound, Alaska, earthquake from the combined inversion of seismic, tsunami, and geodetic data. *Journal of Geophysical Research: Solid Earth, 112*(B7).

Kaka, S. I., & Atkinson, G. M. (2004). Relationships between instrumental ground-motion parameters and modified Mercalli intensity in eastern North America. *Bulletin of the Seismological Society of America, 94*(5), 1728–1736.

Ogweno, L. P., & Cramer, C. H. (2017). Improved CENA regression relationships between modified Mercalli intensities and ground-motion parameters. *Bulletin of the Seismological Society of America, 107*(1), 180–197.

Tselentis, G.-A., & Danciu, L. (2008). Empirical relationships between modified Mercalli intensity and engineering ground-motion parameters in Greece. *Bulletin of the Seismological Society of America, 98*(4), 1863–1875.

Wald, D. J., Quitoriano, V., Worden, C. B., Hopper, M., & Dewey, J. W. (2012). USGS "Did You Feel It?" internet-based macroseismic intensity maps. *Annals of Geophysics, 54*(6).

Worden, C., Gerstenberger, M., Rhoades, D., & Wald, D. (2012). Probabilistic relationships between ground-motion parameters and modified Mercalli intensity in California. *Bulletin of the Seismological Society of America, 102*(1), 204–221.

ACKNOWLEDGEMENT

U.S. Geological Survey (USGS), Department of Interior, for funding this research under USGS award number G21AP10027.
Center for Earthquake Research and Information (CERI) at the University of Memphis.
Terracon Consultants Inc. for providing the logistic support

DISTANCE DEPENDANCE OF RESIDUALS

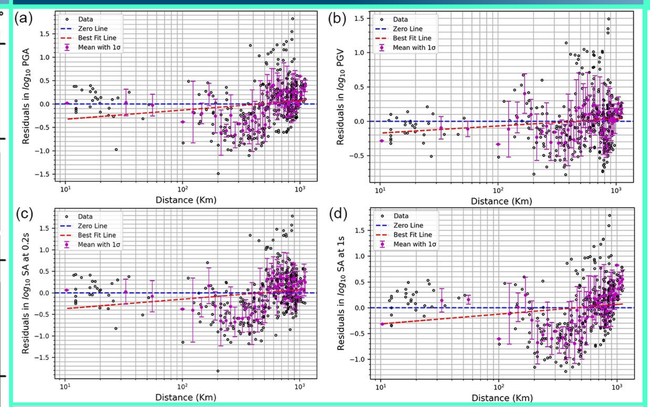

Fig. 4: Residuals observed in GMPs (observed minus predicted ground motion at the period of interest), (a) PGA, (b) PGV, (c) SA at 0.2s and (d) SA at 1s plotted as a function of log_{10} (Distance). Dashed red line is the best fit to the residuals and dashed blue is the zero line. The error bars in magenta represent mean ± 1σ for the binned mean residuals obtained by dividing the distance into fifty equally spaced bins.

MAGNITUDE DEPENDANCE OF RESIDUALS

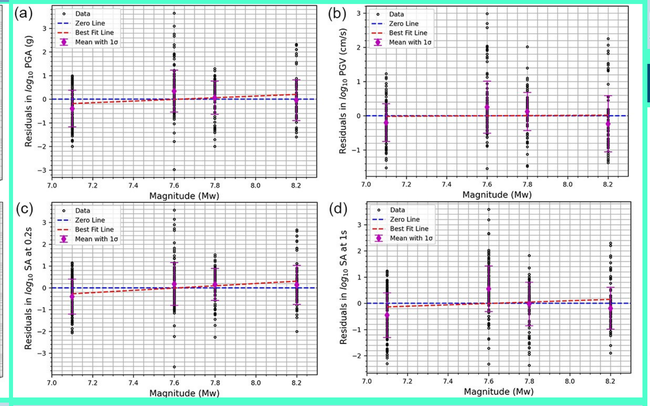

Fig. 5: Distance term corrected residuals plotted as a function of magnitude for some selected GMPs, (a) PGA, (b) PGV, (c) SA at 0.2s and (d) SA at 1s. Dashed red is the best fit line to the residuals and dashed blue is the zero line. The error bars in magenta represents mean ± 1σ for the binned mean residuals for each earthquake.

CONCLUSIONS

- Established a novel correlation between observed ground motion and CDI in Alaska.
- Interpolation technique better justify the assigned intensity rather than using the average value across a specified radius.
- Distance and magnitude correction factors did not significantly improve our relationships.
- Comparing the 1964 **M**9.2 Great Alaska earthquake's ground motion observations and estimates with current ground motion models reveal some deficiencies (significant over and under predictions) in the current GMMs, indicating the need for Alaska-specific corrections for Alaska seismic hazard estimation.

COMPARISON WITH PREVIOUS STUDIES

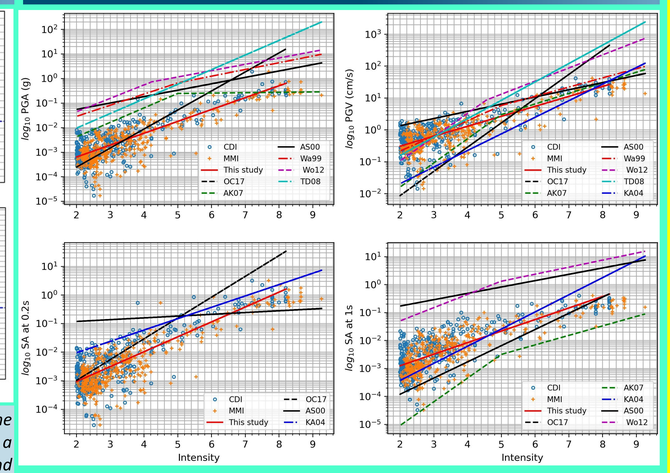

Fig. 6: Comparing our relationships between some selected GMPs [(a) PGA, (b) PGV, (c) SA at 0.2s and (d) SA at 1s)] with GMICE from previous studies. Blue circle is the reported Alaskan CDI and orange '+' sign is the MMI obtained using the OC17 conversion equation. In the figure, OC17 = Ogweno & Cramer, (2017); AK07 = Atkinson & Kaka, (2007); AS00 = Atkinson & Sonley, (2000); Wa99 = Wald et al., (1999); Wo12 = Worden et al., (2012); TD08 = Tselentis & Danciu (2008); KA04 = Kaka & Atkinson, (2004).

EVALUATING ALASKAN SUBDUCTION GMM

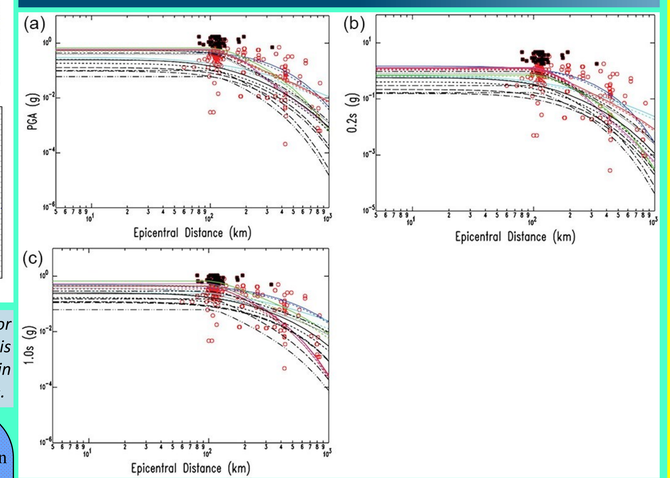

*Fig. 7: Comparison of **M**9.2 Alaska CDI intensities converted to ground motions (red circles) for PGA (a), 0.2 s spectral acceleration (b), and 1.0 s spectral acceleration (c). Black asterisk data points are for ground motion values from CDIs exceeding 8.2, the upper limit of CDI observations of our dataset. GMMs for rock (dashed) and NEHRP B/C boundary (solid) are red – A16 forearc; magenta – A16 backarc; green – Z06, blue – AB03; and cyan – Y97. NGA-Sub GMMs in black are solid – K20 B/C, short dashed – K20 rock, long dashed – P20 B/C, long dash dot – P20 rock, long dash short dash – S20 B/C, long dash double dot – S20 rock, long dash double short dash – A20 B/C, and dotted – A20 rock.*