New Earthquake Classification System for the NGA-Subduction Project

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Motivation

- Previous studies have shown systematic differences between median ground motions from mainshocks and aftershocks by as much as 20 to 40 percent.

- Earthquakes that re-rupture the mainshock rupture plane and surrounding damage zones are likely to have lower stress drops and therefore lower short period ground motions.

- Our goal is to identify the subset of aftershocks that are believed to have certain ground motion characteristics.
Definitions

- **Class 1 Earthquake**: Mainshocks or aftershocks that are far from the mainshock in either space or time (triggered events)

- **Class 2 Earthquake**: The subset of aftershocks that occur sufficiently close to the mainshock rupture plane in space and time to have the property of lower stress drops (ground motions)
Classification Methodology

Dependent events must fall within both a time and distance window determined by the magnitude of the mainshock.

- **Problem:** Dependent events are misclassified as mainshocks when the rupture plane is long.
- **Solution:** Add rupture plane geometry.
Figure 1. Geographical locations of 70 subduction-zone earthquakes. (The index numbers indicated in the figure correspond to the event indexes shown in Table 1.) The color version of this figure is available only in the electronic edition.
Classification Methodology: Time Window

- Subduction zone magnitudes are generally large.
- Subduction zone catalog is short.
- Gardner Knopoff (1974) time window is adopted without modification
Method 1: $R_{\text{CLOSEST_P2H}}$

- Closest distance from C1 rupture plane to potential C2 hypocenter
- If the potential C2 event is within the GK time window and has a hypocenter within a predetermined cutoff distance, it is a C2 event.
Method 2: $R_{\text{CLOSEST\_P2P}}$

- Closest distance from C1 rupture plane to potential C2 rupture plane
- If the potential C2 event is within the GK time window and has a $R_{\text{CLOSEST\_P2P}}$ distance within a predetermined cutoff distance, it is a C2 event.
- The percentage of the C2 rupture place within the cutoff distance is computed.
Why alternative distance metrics?

- Motivated by a different ideas about what part of the rupture process has the greater effect on the resulting ground motion.

- \( R_{CLOSEST\_P2H} \) suggests that the closeness of the C1 event to the center of the moment release for the C2 event will have the larger effect.

- \( R_{CLOSEST\_P2P} \) suggests that the more important factor is the closeness of the two rupture planes and the percentage of the C2 event within the defined distance window from the C1 event.
Application

- Each developer team will select both the classification approach and distance window they deem most appropriate.

- The results will either be the creation of separate GMPEs to handle C1 and C2 events, or a single GMPE with some sort of filter to internally handle the difference.

- For consistency between GMPEs and Source Characterization, declustering by C1 and C2 is needed or assign a fraction of C1 and C2 by magnitude.

- Consensus mode is the default (all events are assume to be C1).