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Insights into predominant period as an early estimate of earthquake magnitude

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We introduce a variation of the original predominant period function, which we term Tp^M. We evaluate the relationship of Tp^M to magnitude in an aftershock dataset. We also compare its performance against previous estimators τ_p^{max} (Nakamura, 1988; Olson and Allen, 2005; Lockman and Allen, 2005) and τ_c (Kanamori, 2005). The Tp^M function, can be weighted not only by velocity, but by displacement and acceleration waveforms, and we examine the merits of each. We also use synthetic data to understand the causes of scatter evident in the predominant period vs magnitude relationship of observed data. In particular, we investigate the effect of different rupture properties on the predominant period, creating synthetic datasets from rupture models with varying rupture properties.

We find that:

- The variation Tp^M provides a more robust and accurate estimator of magnitude, than the original Tp function.
- Results for large magnitudes may lead to significant ambiguity. For example, in a 3 second window, waveforms from a M7 event may produce a smaller estimate than a M6 event. Such a result is critically important for understanding early warning.
- Filtering low frequencies is very important. It can resolve some of the ambiguity in predominant period for the large magnitudes. It can also extend the range of magnitudes over which the method can be applied.

- Basing the predominant period calculation on the displacement waveforms produces a more robust estimator of magnitudes for small magnitudes, (M1 to M5), than either velocity or acceleration. However, velocity can be superior for larger magnitudes ($>$ M5), while acceleration may have a useful application in the large magnitude range (M5 to M7). These conclusions depend on the choice of filtering. An algorithm for estimating magnitudes could combine results from all three forms.

- Variations in source properties such as stress drop, rupture velocity, rise-time, initiation point, aspect ratio, and dip or strike mechanisms, all lead to significant scatter in the predominant period vs magnitude relationship.

Many researchers have shown that the magnitude estimates from predominant period improve by simply averaging the results from different station positions. We extend our work from above to combine results from different station positions, examining which causes of scatter can be removed by such combination, and which cannot be resolved.