Evaluation of M_L-M_C as a Depth Discriminant in Yellowstone, USA and Italy

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Recent work has shown that the difference between two magnitude scales, ML (local Richter magnitude) and MC (coda/duration magnitude), acts as a depth discriminant in Utah. Shallow seismic sources, such as mining induced earthquakes and explosions, have strongly negative ML-MC values, while deeper tectonic earthquakes have ML-MC values near zero. These observations imply that ML-MC might be effective at discriminating small explosions from deeper natural earthquakes at local distances. In this work, we examine seismicity catalogs for the Yellowstone region and Italy to determine if ML-MCacts as a depth discriminant in these regions as well. We identified 4,780 earthquakes that occurred in the Yellowstone region between Sept. 24, 1994 and March 31, 2017 for which both ML and MC were calculated. The ML-MC distribution is well described by a Gaussian function with a mean of 0.102 and a standard deviation of 0.326. We selected a subset of these events with accurate depths and determined mean ML-MC values in various depth bins. An event depth was considered accurate if the formal depth error was less than 2 km and either (1) the nearest station was within one focal depth or (2) the distance to the nearest station was smaller than the bin size. We find that ML-MC decreases as event depths become shallower than about 10 km. Similar to the results for Utah, the decrease is statistically significant and is robust with respect to small changes in bin size and the criteria used to define accurate depths. We used a similar process to evaluate whether ML-MC was a function of source depth for 63,555 earthquakes that occurred between April 16, 2005 and April 30, 2012 in Italy. The ML-MC values in Italy are also well described by a normal distribution, with a mean of -0.477 and standard deviation of 0.315. We again find a statistically significant decrease in ML-MC for shallow earthquakes. In contrast to the Yellowstone results, for Italy ML-MC decreases at a nearly constant rate as focal depths change from 30 km to 4 km, and then it flattens out for the shallowest events. Our results reinforce the idea that ML-MC acts as a depth discriminant, but because it appears to behave slightly differently in the two regions, more areas need to be evaluated in the future.

Publication:	American Geophysical Union, Fall Meeting 2017, abstract #S21C-0758
Pub Date:	December 2017
Bibcode:	2017AGUFM.S21C0758L
Keywords:	7299 General or miscellaneous; SEISMOLOGY