Automated Detection of Small Seismic Events using the Transportable Array

John D. West & Jeffrey S. Lockridge
Matthew J. Fouch
School of Earth and Space Exploration, Arizona State University, Tempe, AZ 85287
Department of Terrestrial Magnetism, Carnegie Institution of Washington, Washington, DC 2005

Introduction

Here we report preliminary results from a new method of detecting local small-magnitude seismic events using arrays of seismometers. Initial results are from the USArray Transportable Array (TA) [www.usarray.org] (Figure 1) recorded in Arizona during 2006-2008, and are compared with a published catalog of small seismic events [Lockridge et al., 2012] for verification. Our initial test spans 10 days in August 2007, during which the catalog contains 125 local seismic events or mine blasts. We can detect all cataloged events during the test period, but require further development on methods to avoid false detections.

Methods

We create new Integrated Ground Motion (IGM) time series by obtaining 40 sample/sec broadband seismic data from the IRIS Data Management Center (DMC) [www.iris.edu/dms/dmc], deconvolving the instrument response, filtering over 4 bands, and integrating the area under the absolute values of IGM for the previous 15 minutes (Figure 2). We further compute a short-term/long-term ratio of IGM values for regions containing multiple stations fewer than 3 successive 15-second windows [Magee, 2010].

Results: Example seismic event (Figure 4) and mine blast (Figure 5) show the location of the event or mine blast from the catalog, and the sequence of circular clusters detected for each. For these examples, the average of the cluster centers are approximately 40 and 20 km, respectively, from the epicenters listed in the catalog. At the current stage of development, this technique detects numerous false clusters from transient high values at separated and presumably unrelated stations (Figure 6). Future enhancements of the cluster detection algorithm will focus on reducing or eliminating these false detections.

Implications: This technique is potentially useful in a number of lines of scientific inquiry which include statistical analysis of catalogs of small seismic events, such as investigation into triggering of local seismicity by remote earthquakes. It may also prove useful as a labor-saving method for detecting seismic events, by identifying approximate times and locations of events for further analysis. We also anticipate that it will allow for automated detection of seismic signals which do not include a discernable P-wave arrival.

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References


Results and Conclusions

Figure 1: Map of the broadband stations used in this study.

Figure 2: Example of seismic waveforms from various steps in our processing methodology. (a) 40 sample/sec broadband seismic data, with the input earth signal filtered 1-8 Hz bandpass. (b) 15-second IGM time series deconvolved from the instrument response. (c) Short-term/long-term ratio of individual IGM samples to the average of the previous 15 minutes.

Figure 3: EMERALD (emerald.dtm.ciw.edu) is a visual web application for seismic data processing, currently in beta test with initial release planned for spring of 2013. We are actively recruiting new beta users: contact john.d.west@asu.edu.