Do Low-Cost Seismographs Perform Well Enough for Your Network? An Overview of Laboratory Tests and Field Observations of the Raspberry Shake 4D

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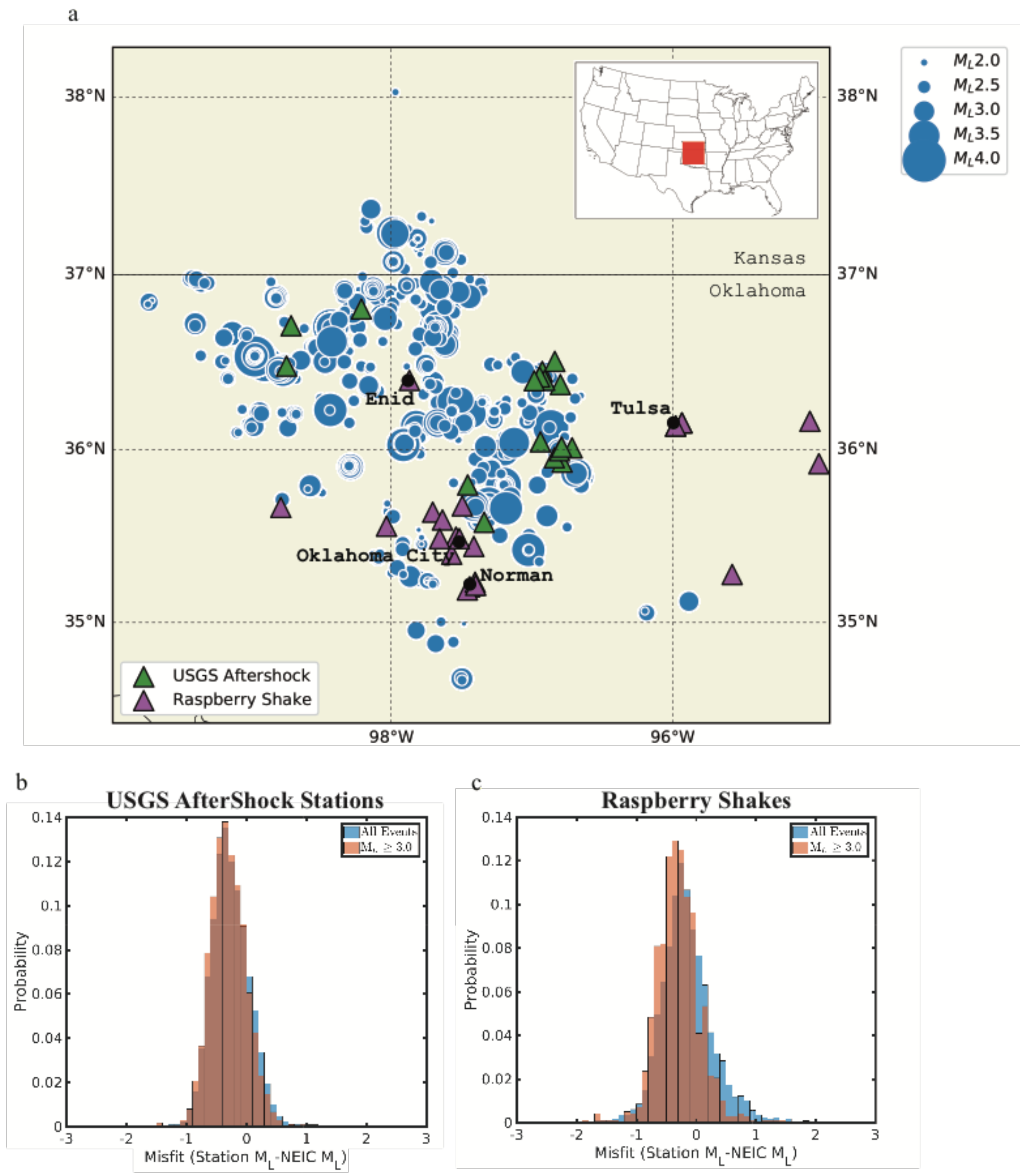
Abstract

Recently, seismologists have begun utilizing low-cost nodal sensors in dense deployments to sample the seismic wavefield at unprecedented spatial resolution. Earthquake Early Warning Systems (EEWS) and other monitoring networks (e.g. wastewater injection) would additionally benefit from network densification; however, current nodal systems lack power systems and/or real-time data transmission required for these applications. A candidate sensor for these networks may instead be the Raspberry Shake 4D. The Raspberry Shake 4D is an all-in-one package which includes a vertical component geophone, 3-component accelerometer, digitizer, and near real-time miniSEED data transmission only costing a few hundred dollars per unit. Here, we step through instrument testing of this sensor at Albuquerque Seismological Laboratory. We find that the self-noise levels of these sensors are suitable for local event detection, but are likely too high to attain robust estimates of ambient background noise or surface waves from teleseismic events of intermediate magnitude. To demonstrate the impact of relatively high self-noise levels on the Raspberry Shakes compared to broadband sensors, we estimate local magnitudes of earthquakes in Oklahoma using Trillium Compact broadband sensor data from U.S. Geological Survey (USGS) aftershock deployments as well as 23 Raspberry Shakes operated by hobbyists and private owners within Oklahoma. We found that the Raspberry Shakes require events of magnitude ~0.3 larger than the broadband sensors in order to reliably estimate M_L at a given distance from the epicenter. Recent field testing in Myanmar provides additional evidence that supplementing a sparse broadband network with a handful of Raspberry Shakes could lower a network's detection threshold to M~3. We thus believe that network operators may find the Raspberry Shake 4D beneficial for densifying sparser networks of high-quality broadband installations designed to detect local earthquakes.



a) United States Geological Survey (USGS) aftershock seismic stations (green triangles) and Raspberry Shakes (magenta triangles) which recorded local Oklahoma and Kansas earthquakes (blue circles) between 1 January 2017 and 1 April 2018 of at least local magnitude (M_L) 2.0. Histograms of the misfit between individual, vertical component station local magnitude (M_L) estimates compared to the reported National Earthquake Information Center M_L are shown for both the USGS aftershock deployment stations (b) and Raspberry Shakes (c).