

# Supporting Information for ” Array-based convolutional neural networks for automatic earthquake detection and 4D localization”

Heather Shen<sup>1</sup> \* and Yang Shen<sup>1</sup>

<sup>1</sup>Graduate School of Oceanography, University of Rhode Island, Narragansett, RI, United States

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1. Figures S1 to S7

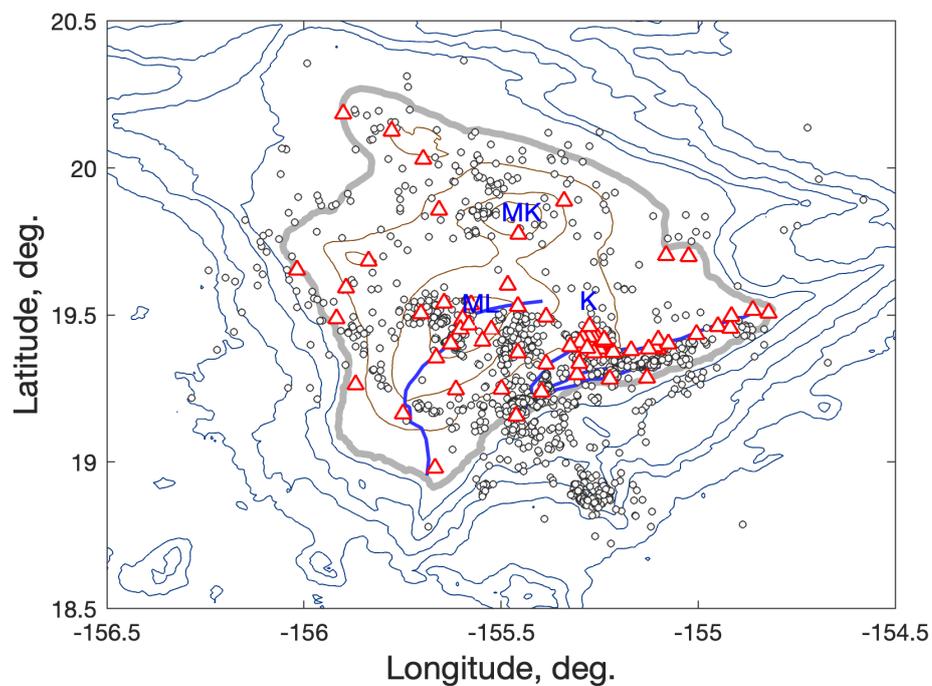
## Introduction

This file contains seven supplementary figures referred to in the main text.

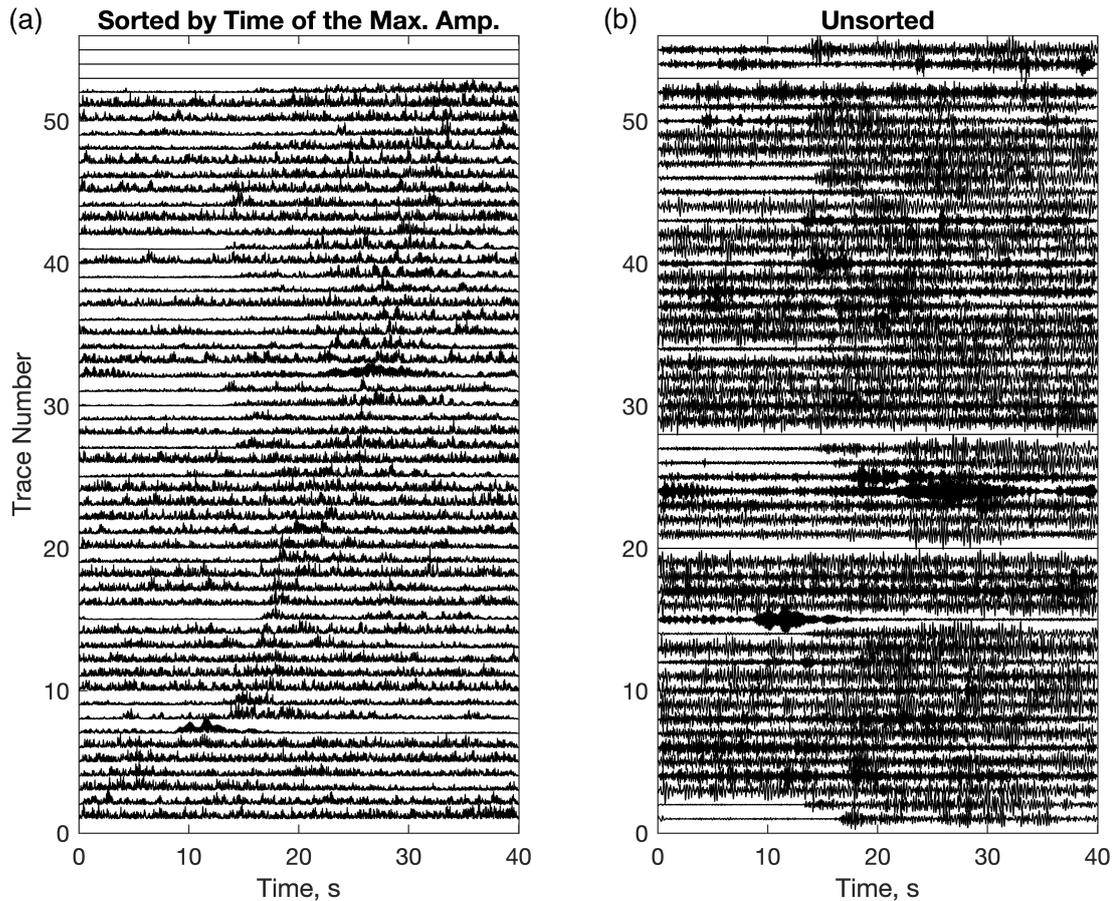
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\* As a volunteer research assistant

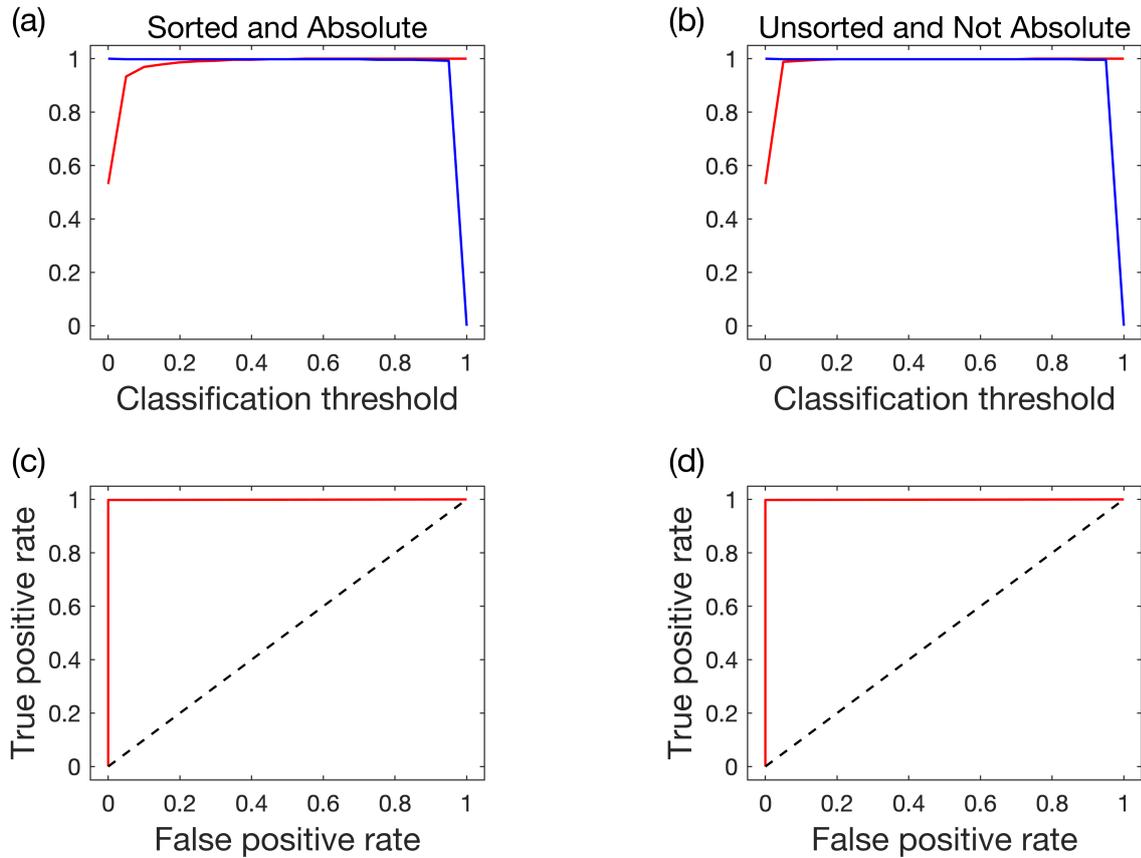
October 13, 2020, 10:19pm



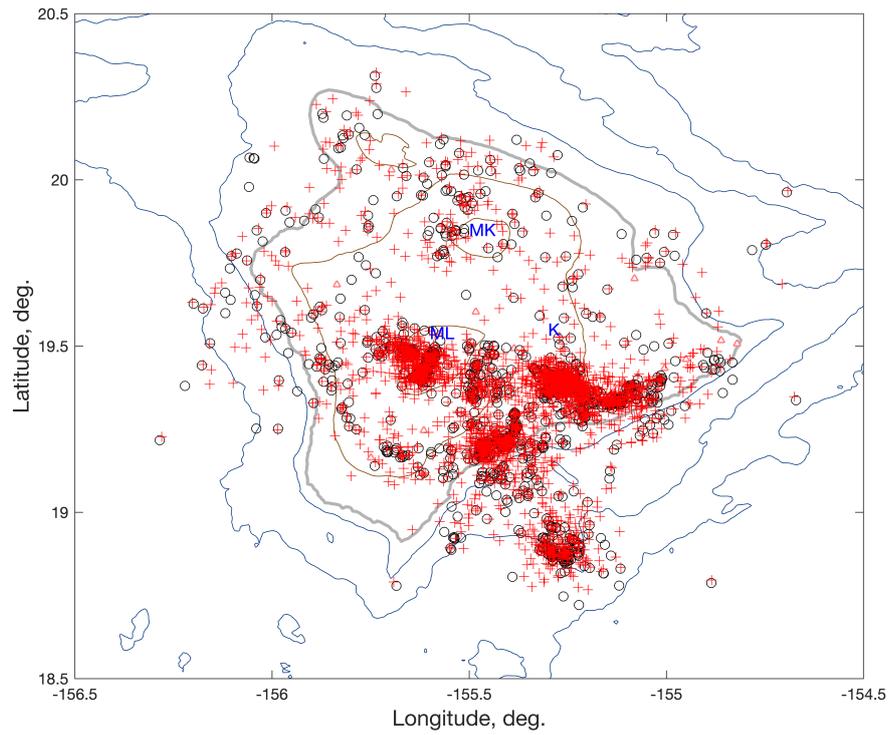
**Figure S1.** Map of the seismic stations (red triangles) and earthquakes (small circles) used in the study. The coast of Hawai'i Island is outlined by the grey contour, while topography and bathymetry are contoured in 1000-m intervals. Blue lines represent the major Quaternary faults and fault systems. ML, K and MK stand for Mauna Loa, Kilauea and Mauna Kea Volcanoes, respectively.



**Figure S2.** An example of earthquake waveforms sorted by (a) the time of the maximum amplitude and (b) the unsorted waveforms arranged by station names alphabetically. The earthquake occurred at time 2017-01-06T01:28:50 according to the USGS catalog. Only the vertical-component traces are shown. Each trace is normalized by its maximum amplitude and the sorted traces are taken as absolute values. The missing channels are zero-filled and placed towards the high-trace-number end in the sorted version. The traces have been bandpass filtered between 3 to 20 Hz.

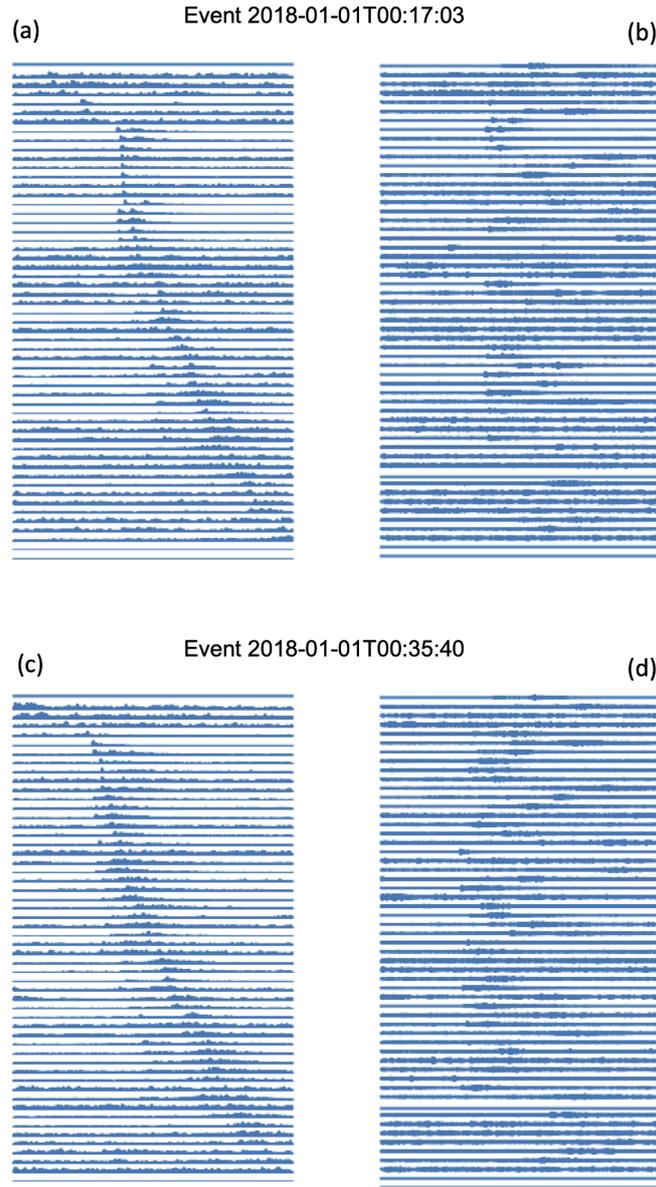


**Figure S3.** Precision (red) and recall (blue) as a function of the classification threshold for the CNN model using the maximum-amplitude-sorted waveforms (a) and that with unsorted, alphabetically arranged waveforms (b). Receiver operating characteristics (ROC) curve (red line) for the model with the sorted (c) and unsorted (d) waveforms. The dashed line is for a model with no predicting skill. The precision, recall, and ROC curves of the resulting models of the two waveform inputs are nearly identical and almost completely overlap if they are plotted together.

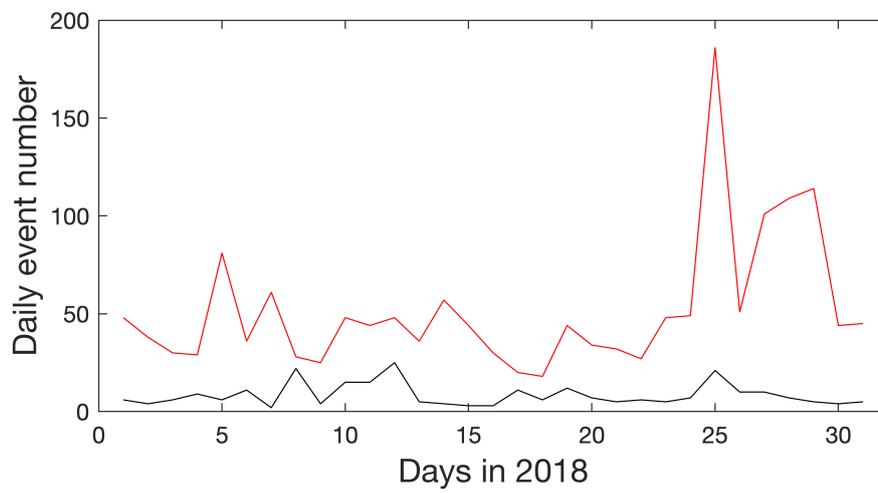


**Figure S4.** Epicenter locations of earthquakes from the USGS catalog (circles) and ArrayCon- vNet model predictions (red crosses) for the test data.

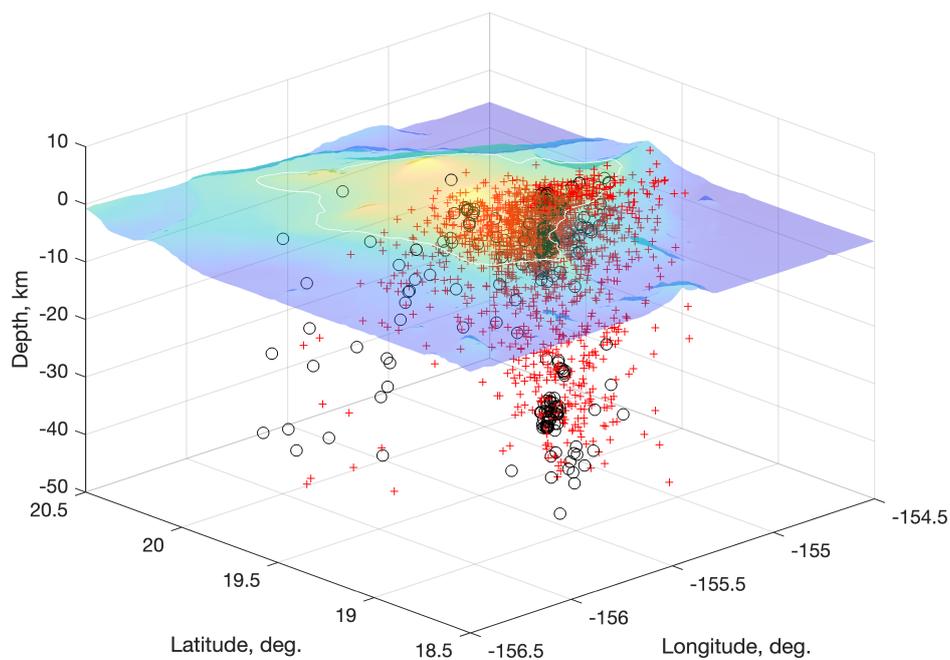
October 13, 2020, 10:19pm



**Figure S5.** Two examples of uncovered earthquakes in the first hour of 2018, which are not in the published USGS catalog. The maximum-amplitude-sorted (a) and unsorted vertical-component waveforms (b) for an event occurred a few seconds after 2018-01-01T00:17:03 (the trace start time). The sorted traces are arranged from the top to bottom and taken as absolute values. The total window length is 50 seconds. (c) and (d) are the same as (a) and (b) for an event shortly after 2018-01-01T00:35:40.



**Figure S6.** Comparison of daily number of earthquakes reported by USGS (black line) and that detected and located by our model (red line).



**Figure S7.** Hypocenter locations of 261 earthquakes from the USGS catalog during January 2018 (circles) and 1605 events detected and localized by our ArrayConvNet model (red crosses) in a three-dimensional view looking from the southwest direction. The topography and bathymetry of the Island are shown as a semi-transparent surface.