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Identification of quarry blasts near BRMAR seismic array: An application of Multichannel Cross-Correlation detector

T2.1-P15

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Figure 2: *A zoom-in to the stone quarry near the site BR235. The nearest point to the BR235 is about 500m.*

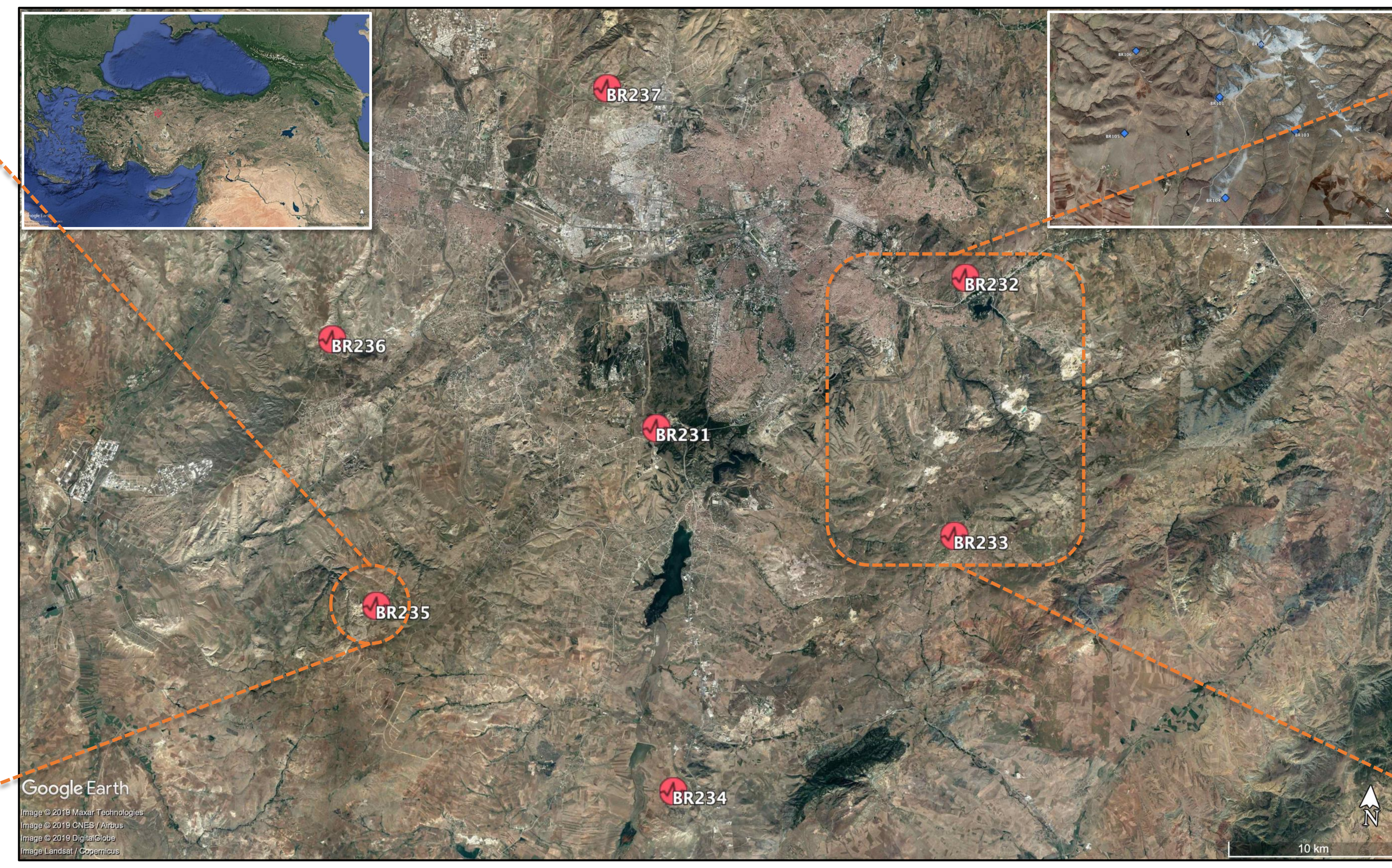

Figure 1: *Map showing the circular configuration of the BRMAR array. On the top left, array's location within Turkey and on the top right BRTR array located 80 km south-east of BRMAR are shown.*

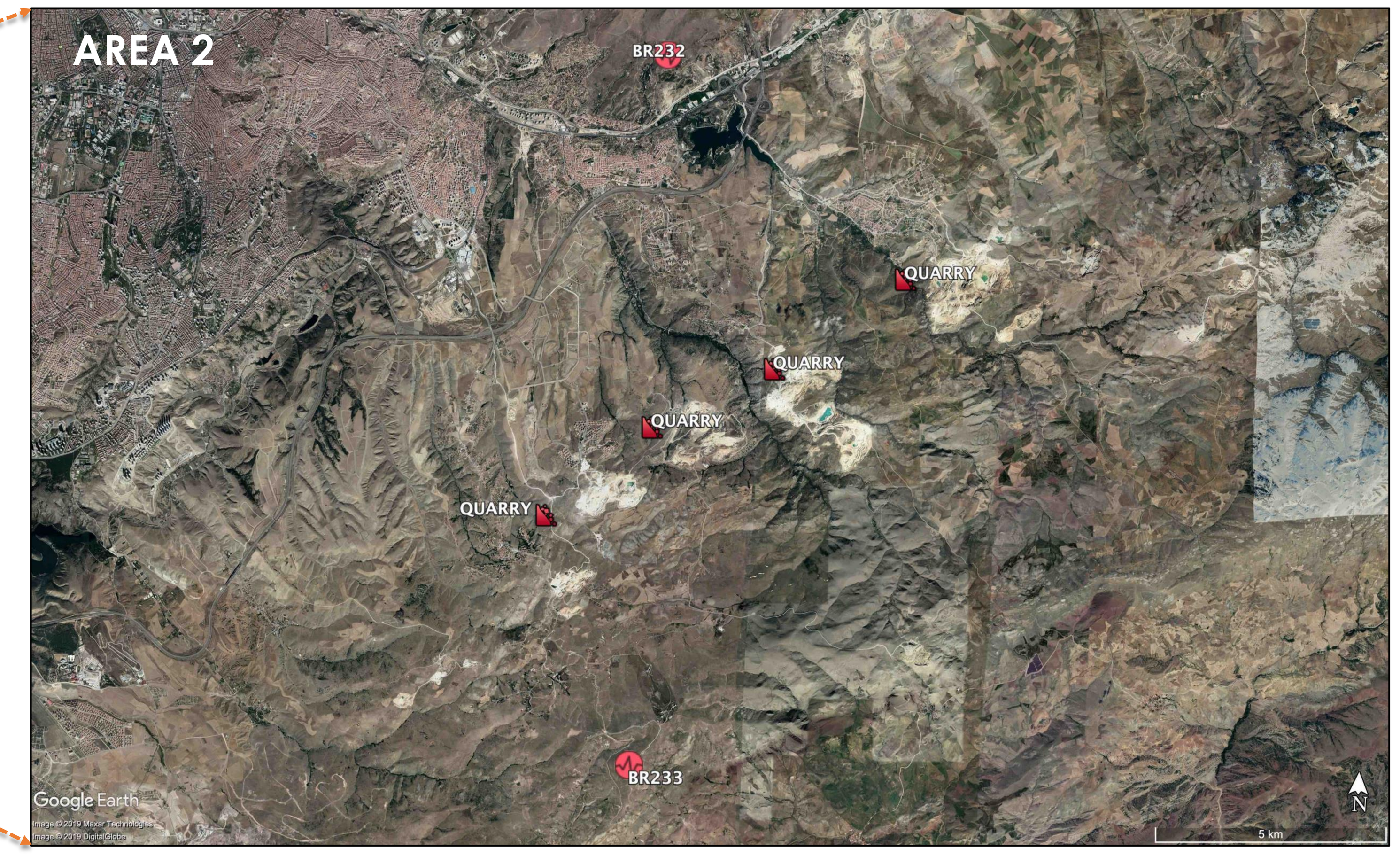

Figure 3: *Map showing the many stone quarries located between BRMAR array sites BR232 and BR233*

INTRODUCTION

With the increasing population of many quarries around the BRMAR array, the data quality of the stations is polluted by the blasts. There are more than 10 operational quarries spread across the city and some of them very close in proximity to the array. BRMAR is a circular shaped 7 elements array with a diameter of approximately 40 km located in the city of Ankara. The array consists of borehole type medium period instruments (4 sps) installed at 60 to 40 m depth from the surface. Long period array data is important for nuclear explosion monitoring, especially for measuring the mb/MS discriminant. Therefore, monitoring of the quarry activities has become an important task for the Turkish NDC. Multichannel waveform cross-correlation method accurately detects and classify the quarry blasts using a repository of template events.

MULTI-CHANNEL WAVEFORM CORRELATION

In the MCWC method, basic principle is cross-correlating the incoming data stream with a known waveform template. To quantify the level of waveform similarity for each pair of events, we calculate a fully-normalized correlation coefficient by sliding a waveform template over a selected time-window for the second event and recording the estimated maximum correlation coefficient. We utilized ***eqcorrscan*** (Chamberlain et. al, 2017) python package for the waveform correlation method. Waveform correlation has many advantages over standard energy detectors, since its performance is independent of array geometry; waveform coherency over the array elements is replaced with waveform similarity between a signal template and the incoming data. Therefore, correlation method works really well especially for monitoring explosion type signals since they are repeating from the same location and have high-waveform similarity.

MCWC Template Selection and Data Preperation

We have used several templates belonging to different quarry locations in terms of location and time. A total of 16 templates is selected for 2017 and two more for the year 2016. We have also selected two templates from the BRTR SP array since the biggest explosion signals (~ML2.8) reaches the BRTR.

Table 1: *Template Processing Parameters*

Array Site	Filter (HZ)	Sampling R.	Temp. Length (s)	Pre-pick (s)
BRMAR	0.65 - 1.6	4	12	1.5
BRTR	1.0 - 5.0	20	8	0.5

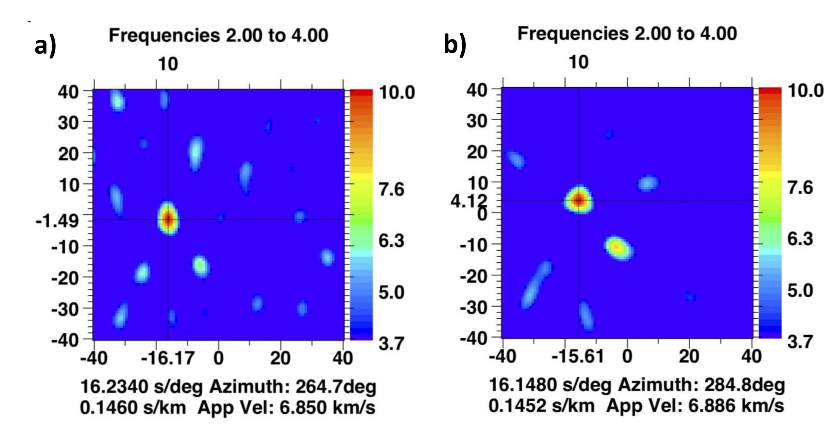

Figure 6: *F/K analysis of one of the blasts from Area 1(a) and Area 2(b) at BRTR Array. F/K Analysis was used to verify the correlation results. Back azimuth and slowness values for each event are shown below the figures.*

AREA 1 RESULTS

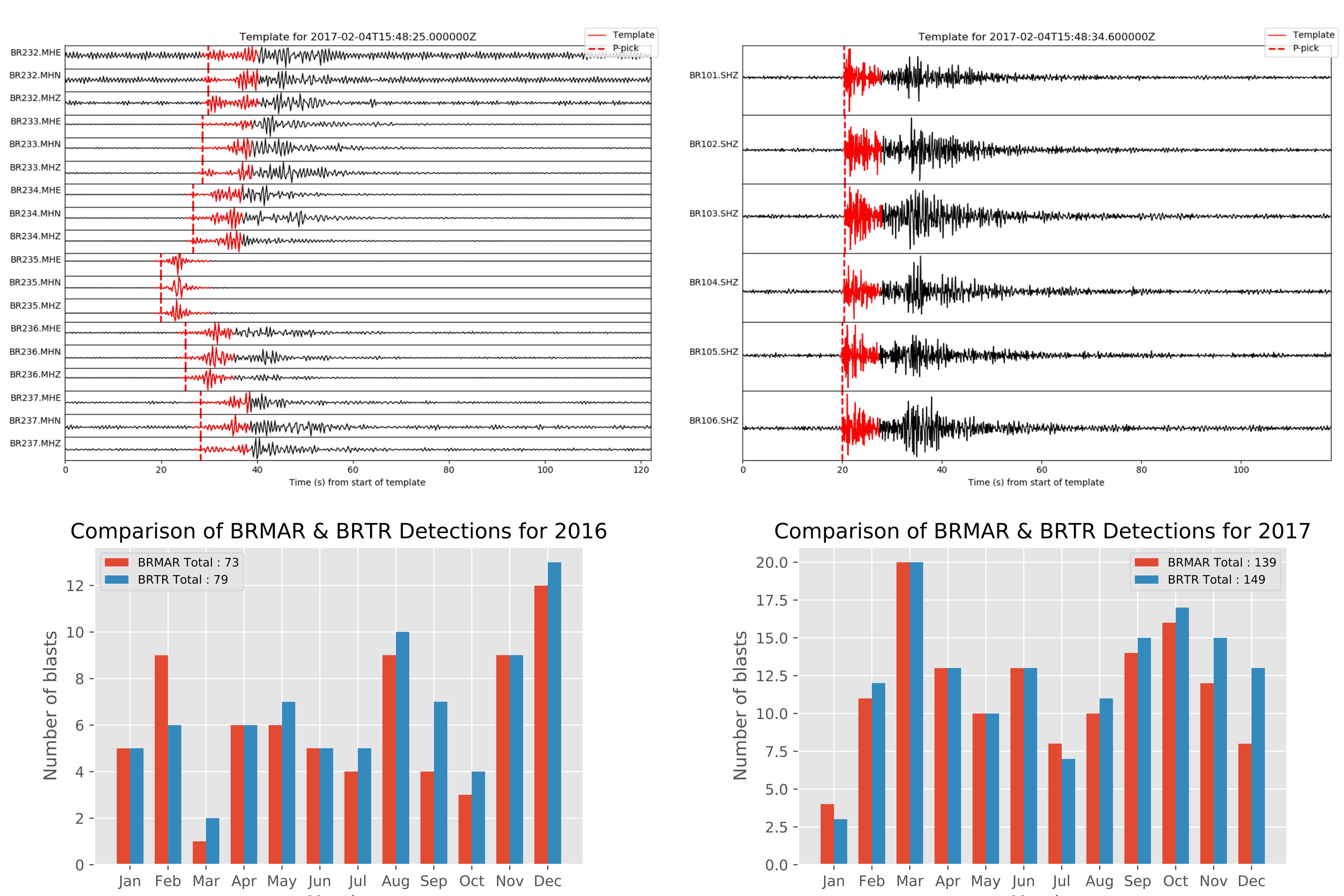

Figure 4: *Top_left: Template for the quarry near BR235 using BRMAR Array data. Top right: Template for the quarry near BR235 using BRTR Array data. Bottom left: Comparison of total number of blasts detected by both arrays for 2016. Bottom right: Comparison of total number of blasts detected by both arrays for 2017.*

Table 2: *Total number of blasts detected by BRMAR & BRTR for Area 1*

2017-02-04T15:48	2016	2017
BRMAR	73	139
BRTR	79	149

AREA 2 RESULTS

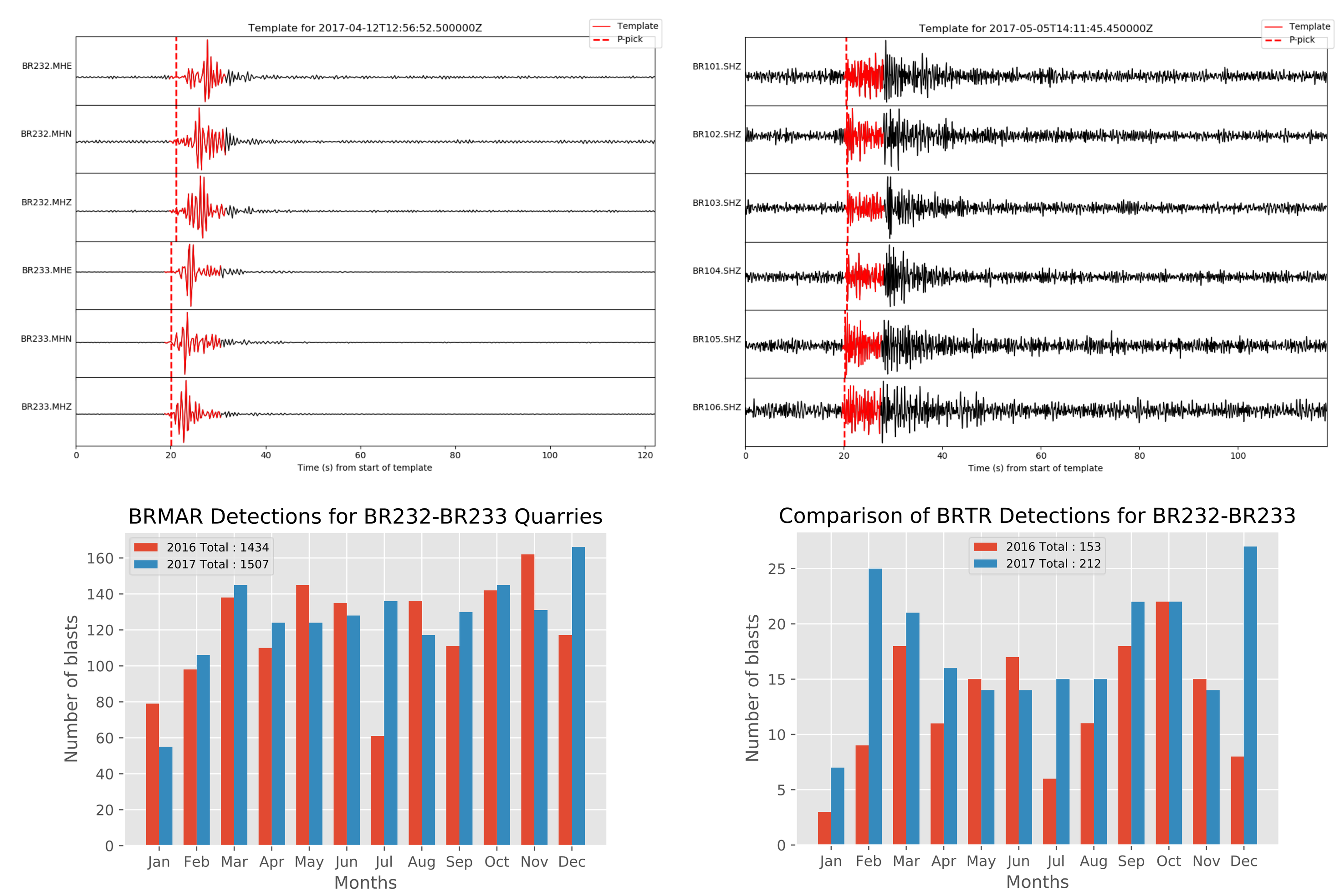

Figure 5: *Top_left: Example template for the quarry near BR232-BR233 using BRMAR Array data. Top right: Template for the quarry near BR232-BR233 using BRTR Array data. Bottom left: Comparison of total number of blasts detected by both arrays for 2016. Bottom right: Comparison of total number of blasts detected by both arrays for 2017.*

Table 3: *Total number of blasts detected by BRMAR & BRTR for Area 2*

2017-05-05T14:11/ Many Templates	2016	2017
BRMAR	1434	1507
BRTR	153	212

CONCLUSION & DISCUSSION

- Using same template (2017-02-04T15:48) from AREA 1 for both arrays, we estimated very similar count of blast detected in the area (Figure 4). For AREA 1 both BRMAR and BRTR show similar results. Interestingly, BRTR seems to be achieving slightly better detection rate which can be attributed to the fact that greater waveform similarity between array elements due to short aperture. The 4 sps sampling rate of BRMAR combined with its large aperture makes it hard to get a good similarity between BRMAR array elements.
- Both arrays show higher blast detection rate for AREA 2 since the area is crowded with stone quarries as seen in Figure 5. BRMAR detects around 1500 blasts whereas BRTR catches around 200 blast events. The reason for that is the smaller magnitude of the blasts in AREA 2 compared to AREA 1. We have used only one template event that is good enough (good SNR) for BRTR representing the events in AREA 2. However, 7 templates were used for BRMAR array to detect the events in AREA 2 which is the main reason of detection rate difference between the two arrays.
- Using a MAD threshold of 7.5 for the events in AREA 1 and 2, we get near %90 accuracy in detections for BRMAR. BRTR depicts %92 accuracy with a MAD threshold of 8.0. Another fact that is observed is that the events rate is increasing within both areas.

References:
Chamberlain, C. J., Hopp, C. J., Boese, C. M., Warren-Smith, E., Chambers, D., Chu, S. X., Michailos, K., Townend, J., EQcorrscan: Repeating and near-repeating earthquake detection and analysis in Python. Seismological Research Letters, 2017

Disclaimer: The views expressed on this poster are those of the author and do not necessarily reflect the view of the CTBTO

PUTTING AN END TO NUCLEAR EXPLOSIONS