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Supplementary Materials for

Crowdsourcing triggers rapid, reliable earthquake locations

Robert J. Steed*, Amaya Fuenzalida, Rémy Bossu*, István Bondár, Andres Heinloo, Aurelien Dupont, Joachim Saul, Angelo Strollo

*Corresponding author. Email: bossu@emsc-csem.org (R.B.); robert.steed@emsc-csem.org (R.J.S.)

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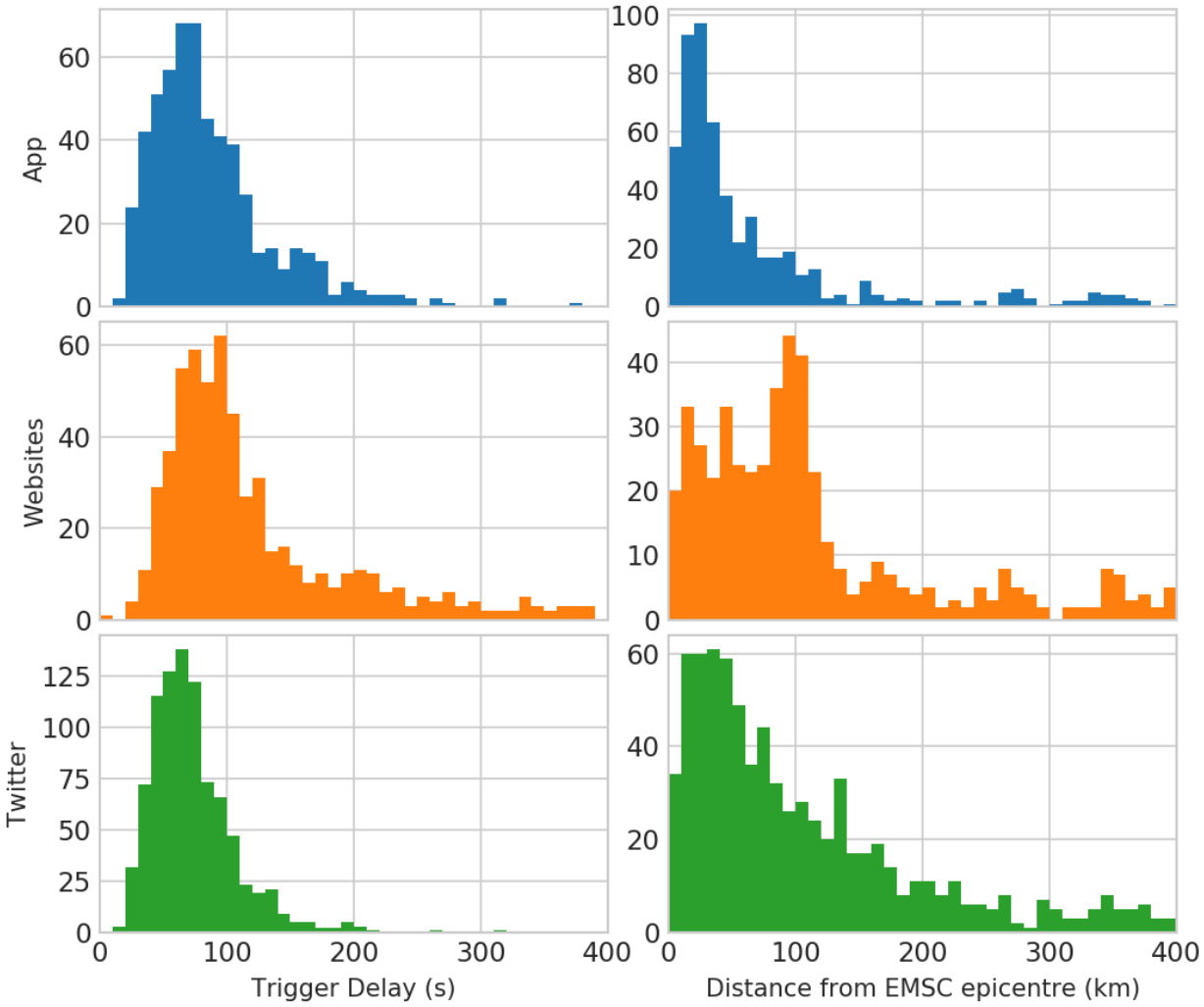

Fig. S1. Analysis of the crowdsourced detections during 2016–2017 that could be associated with EMSC-published epicenters, considering each detection method individually. Any duplicate detections made by a given system have been removed, keeping only the earliest. (A,B,C) distribution of trigger delays for each system. (D-F) histograms of location accuracy. It can be seen that the app detection system yields the most accurate barycenters.

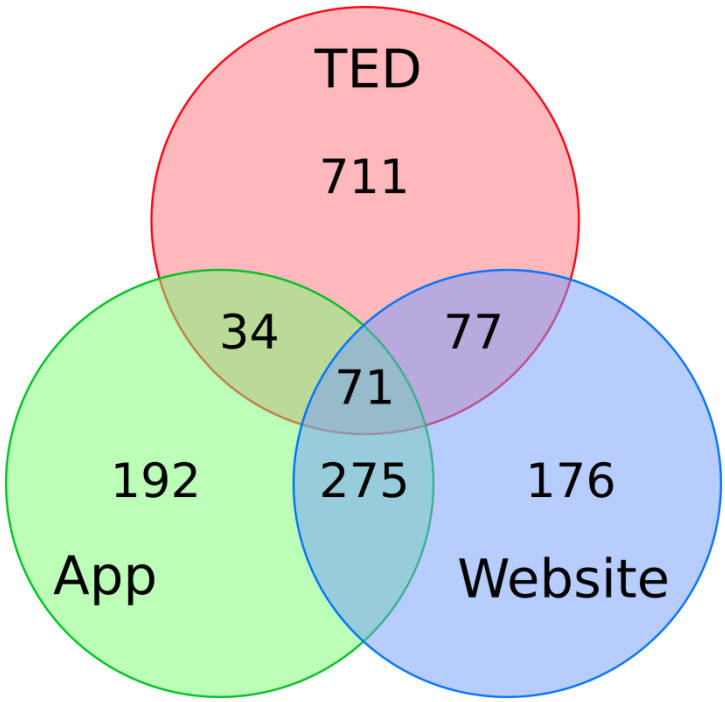

Fig. S2. A Venn diagram of the earthquakes detected by each crowdsourced system during 2016–2017. This shows that the systems are complementary since different earthquakes were detected by each method, despite there being some overlap in detections.

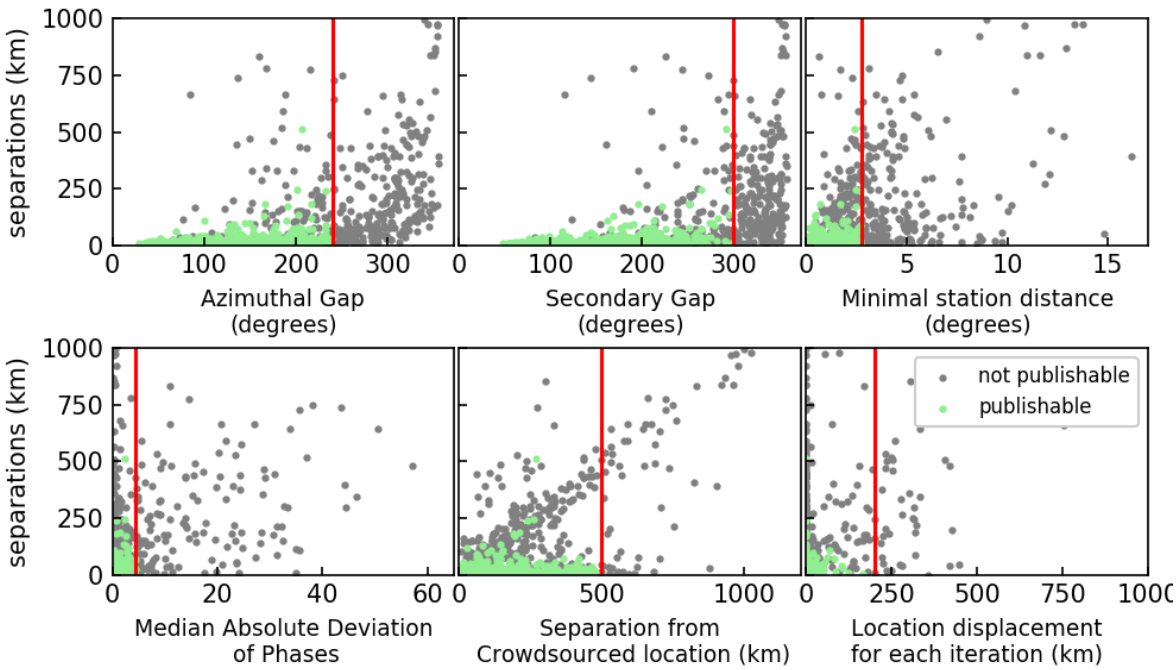

Fig. S3. Scatter graphs showing all obtained locations for the 10th iteration of the CsLoc analyses for all 2200 detections that were associated with an EMSC epicenter. The distance between the location found and the EMSC epicenter is plotted with respect to the parameters used for the publication criteria. The red lines show the threshold for each parameter and marker color shows whether a result met the criteria.

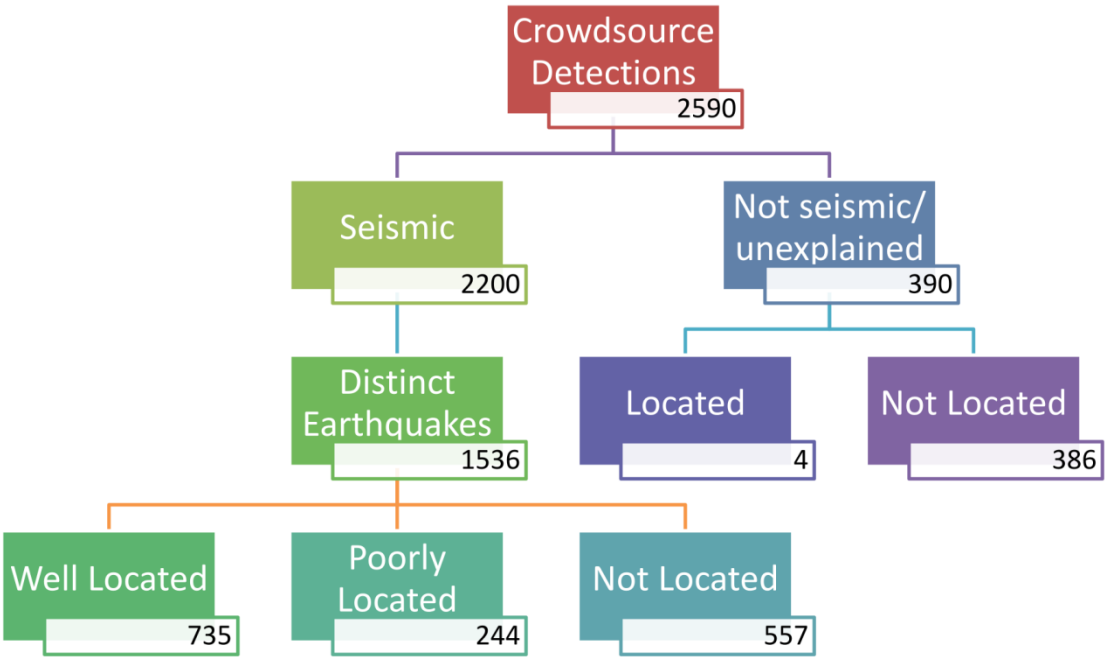

Fig. S4. Summary of the test dataset and its results starting from the 2590 crowdsourced detections; the transition from "seismic" to "distinct earthquakes" corresponds to the deduplication of detections from the multiple crowdsourced detection methods. 'Well Located' corresponds to earthquakes with at least one location that fulfilled the publication criteria while 'Poorly Located' results are those that did not.

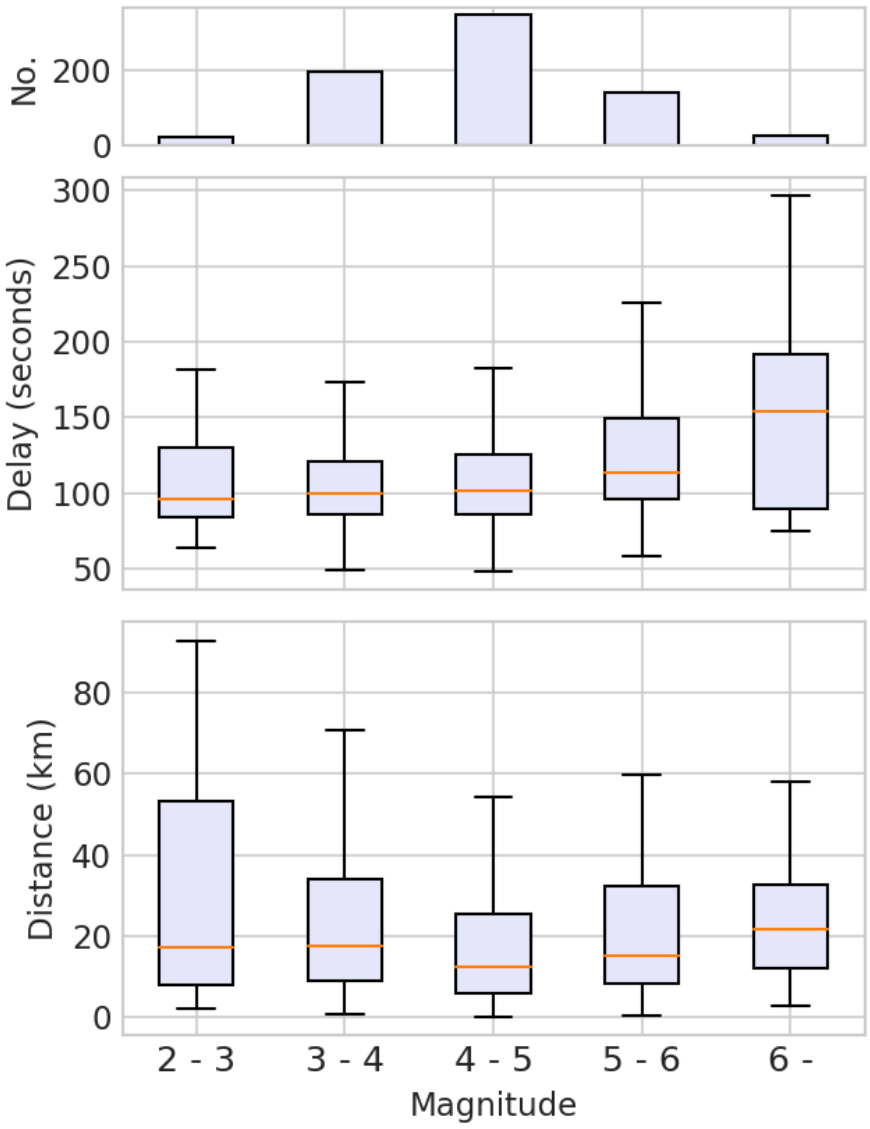

Fig. S5. An analysis of the 735 earthquakes located by CsLoc with respect to earthquake magnitude. The outlying categories contain a small number of events and hence show larger variance and less confidence is placed in their values. The inner categories show that CsLoc is largely magnitude independent between M2 – M6.

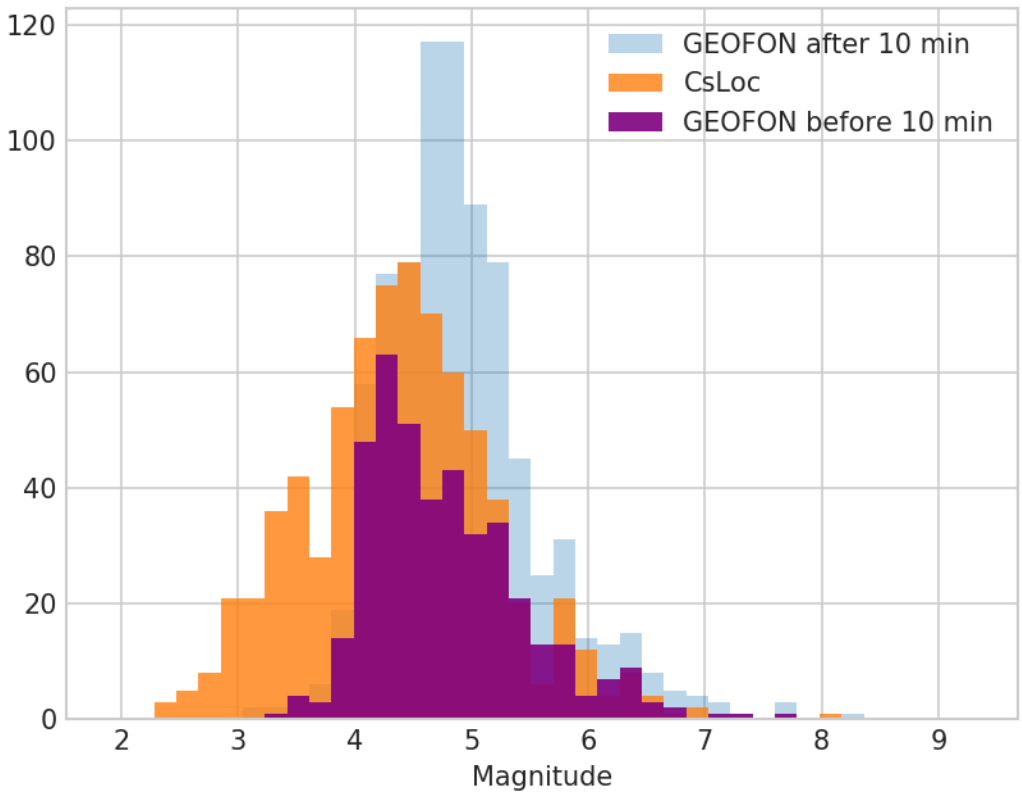

Fig. S6. The earthquakes located by CsLoc and GEOFON by earthquake magnitude; CsLoc had a wider spectrum of magnitudes, locating a larger number of events of magnitude lower than M5 with respect to GEOFON in the first 10 min. However GEOFON located a large number of big events after 10 minutes via teleseismic inversion. CsLoc works at multiscale; it can detect and locate events of different magnitudes worldwide, depending only on the regional station coverage. As long as an earthquake is felt and triggers a crowdsourced detection, there is no minimum threshold on the magnitude preventing it to be located.

Table S1. Summary statistics for crowdsourced detections at the EMSC during 2016–2017. For the website and app detections, the dataset contains duplicate detections for some earthquakes due to detections in neighboring countries. There were also detections of the same earthquake by the multiple systems, as seen in the final row.

system	detections	duplications (within each system)	false or unexplained	distinct earthquakes (for each system)
app	803	67	164	572
website	723	69	55	599
Twitter (TED)	1064	0	171	893

	detections	duplications (across all systems)	false or unexplained	distinct earthquakes (across all systems)
overall	2590	664	390	1536

Table S2. Summary statistics for the earthquakes detected by each crowdsourced detection. The detection delay and location accuracy compare the crowdsourced values to the EMSC epicenter values.

system	earthquakes	detection delay (s)			location accuracy (km)		
		percentiles			percentiles		
		10%	50%	90%	10%	50%	90%
app	572	37	76	158	10	36	269
website	599	55	98	273	23	103	459
Twitter (TED)	893	38	67	113	19	94	530
overall	1536	38	70	134	15	72	431

Table S3. Summary of the 735 earthquakes located by CsLoc that met the publication criteria. For each system, the earliest publishable analysis for each earthquake is used for calculating the statistics. This is done likewise for the global result which removes some duplicated detections made by the systems. Delays and separations are calculated w.r.t. EMSC published epicenter values.

system	earth-quakes	detection delay (s)			phase collection delay (s)			CsLoc analysis finished (s)			EMSC publication delay (s)			CsLoc Location accuracy (km)		
		percentiles			percentiles			percentiles			percentiles			percentiles		
		10%	50%	90%	10%	50%	90%	10%	50%	90%	10%	50%	90%	10%	50%	90%
app	331	43	76	121	74	98	163	77	102	365	133	272	676	4	14	48
website	324	56	93	182	79	115	205	81	119	210	136	267	669	3	11	46
Twitter	335	44	68	103	75	104	168	78	108	172	233	488	1427	4	15	49
overall	735	46	73	120	74	100	171	77	103	174	148	384	1131	4	15	54

Table S4. Statistics for the 429 earthquakes located by both GEOFON and CsLoc within 10 min of the origin time. Delays and separations are calculated with respect to the published EMSC epicenter values.

System	publication delays (s)			location accuracy (km)		
	percentiles			percentiles		
	10%	50%	90%	10%	50%	90%
CsLoc	76	103	173	3	14	46
GEOFON	126	179	393	3	10	22
EMSC	144	374	518	-	-	-