Seismoacoustic observation of surface explosions in Israel region.

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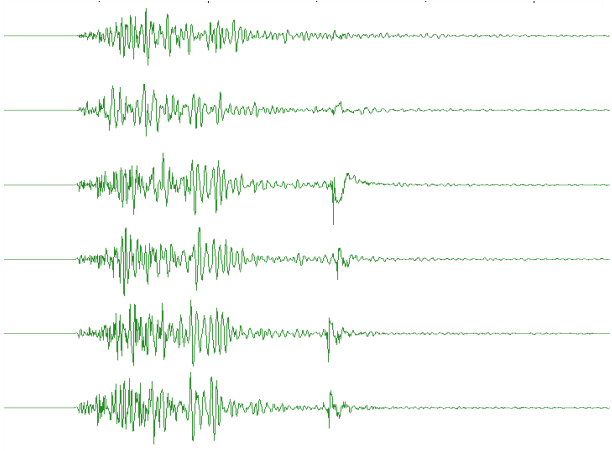
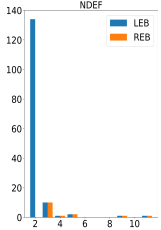
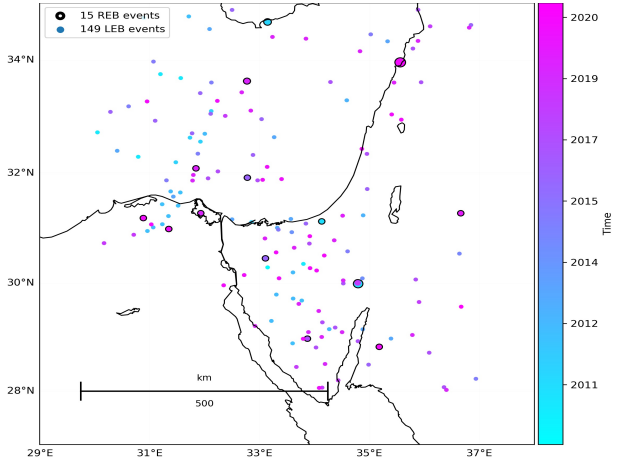
2021-July-1

Talk layout

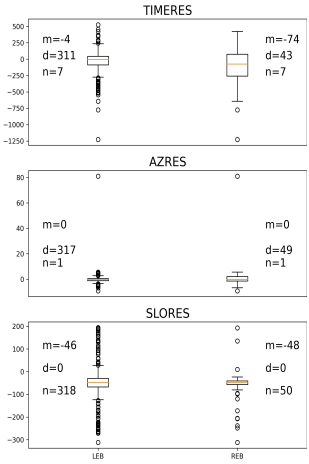


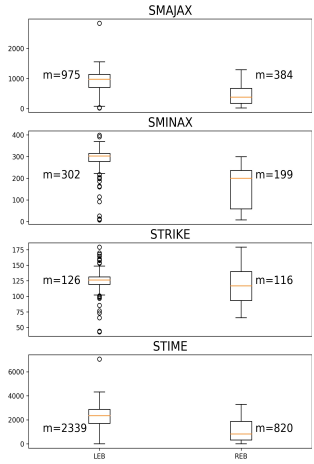
Motivation


NDEF
LEB
REB
140
120
100
80
60
40
20
0
2
4
6
8
10


15 REB events
149 LEB events
34°N
32°N
30°N
28°N
29°E
31°E
33°E
35°E
37°E
km
500
Time
2020
2019
2017
2015
2014
2012
2011

Motivation


TIMERES
m=-4
d=311
n=7
m=-74
d=43
n=7
AZRES
m=0
d=317
n=1
m=0
d=49
n=1
SLORES
m=-46
d=0
n=318
m=-48
d=0
n=50
LEB
REB


SMAJAX
m=975
m=384
SMINAX
m=302
m=199
STRIKE
m=126
m=116
STIME
m=2339
m=820
LEB
REB

Motivation

Several questions:

- LEB events based on two stations do they carry any information?
- How many of LEB/REB events are real events?
- What can be done in the absence of local network?
- Can the location accuracy be improved?

Historical Calibration Explosions

- Two sets of surface calibration explosions were executed in Sayarim range by the Geophysical Institute of Israel (GII) with international cooperation[1]:
  - August 26 2009 at 6:31 a 82 t $\Rightarrow$ 96 t TNT (ASMDC)[2].
  - January 24 2011 at 13:17 a 10.24 t $\Rightarrow$ 7.4 t TNT (CTBTO)
  - January 26 2011 at 07:17 a 102.08 t $\Rightarrow$ 76.8 t TNT (CTBTO)
- Summer Vs. Winter

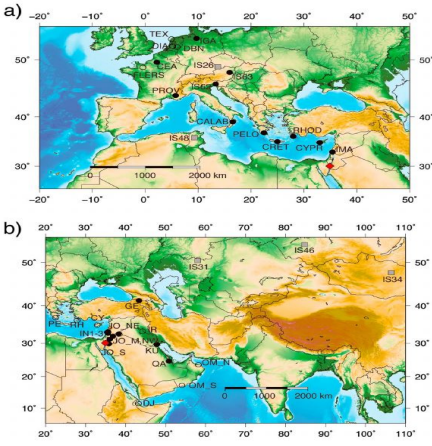
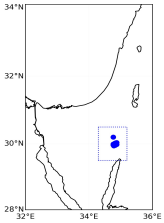
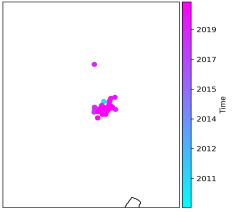


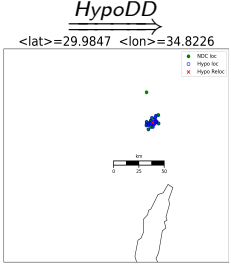
Figure is taken from David Fee et. al. [1]

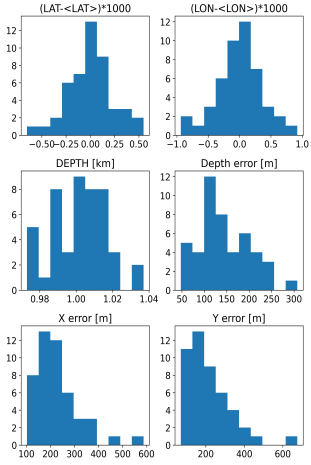
Candidate Calibration Explosions

- Sayarim range routine ammunition demolition.
- Same locations as the Calibration explosions locations.
- Winter and Summer
- Yield range from several tons up to 40 t.
- But not optimal.

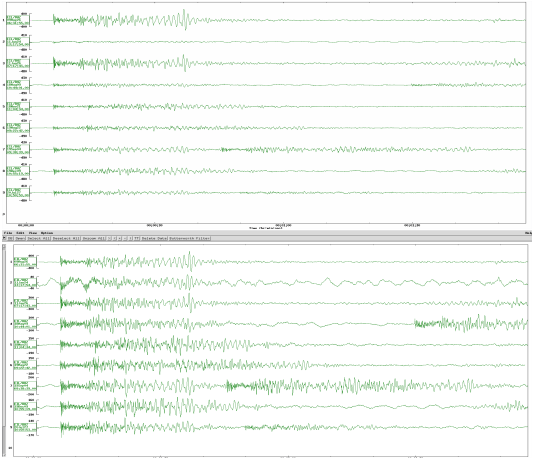








Event Similarity



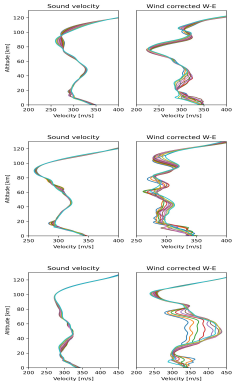
Geotool, PMCC, LocSAT,NDC in a BOX

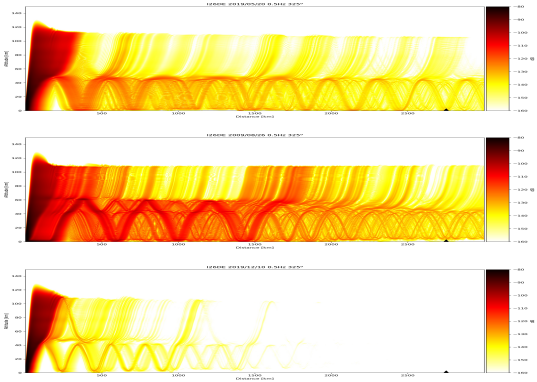
ATM GT→I26DE

May 20 2019

September 26 2009

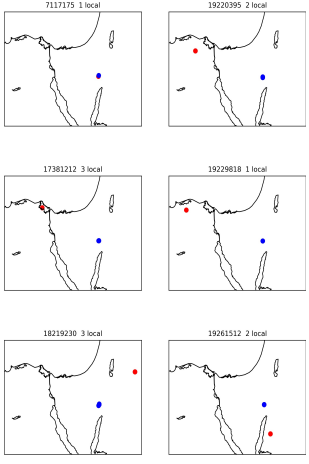
December 12 2019



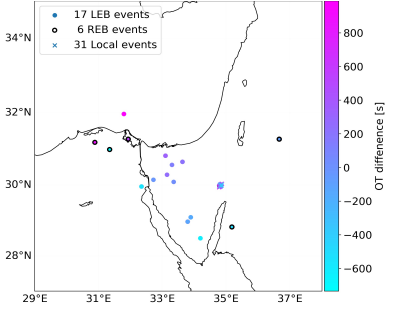


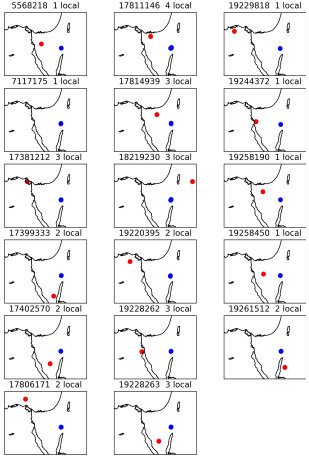
ATM data was downloaded from NCPA G2S Request System, calculation done with ncpaprop 2.0.0 [3]

Event matching

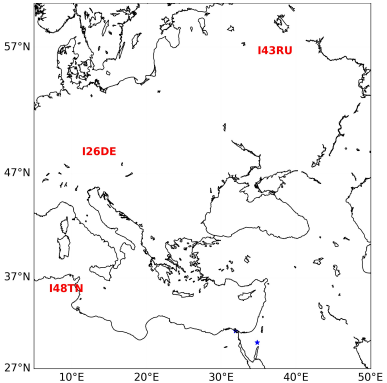


$$|OTdiff| \leq 1800$$





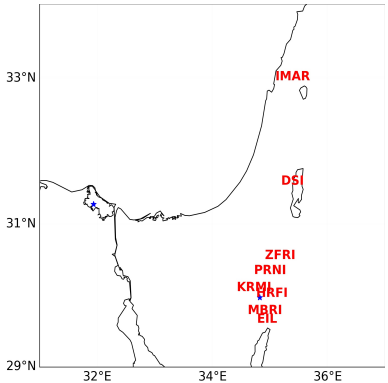
May 20 2019 event



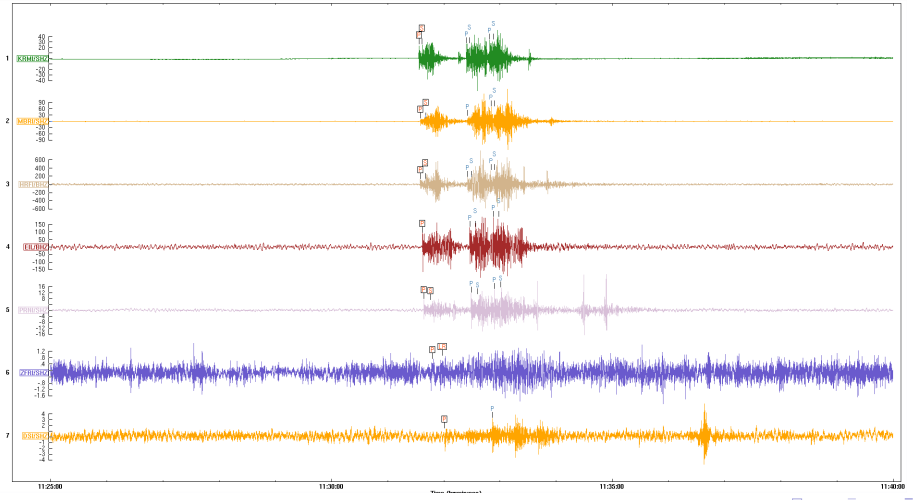
3 explosions between 11:31 to 11:33, approximate yields are 10t, 20t and 22t

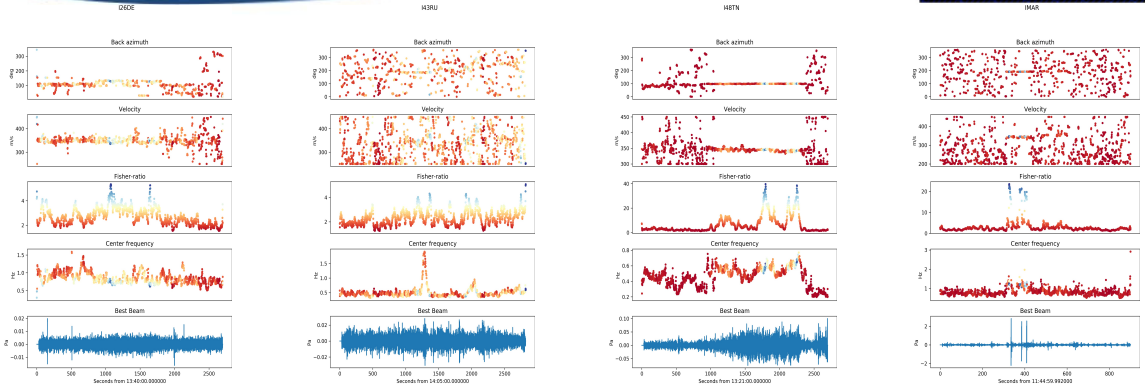
⇓

One REB/LEB event.



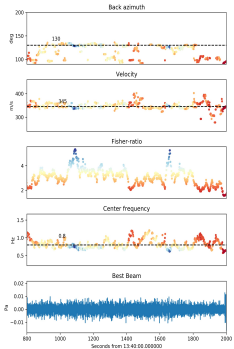
Seismic waves



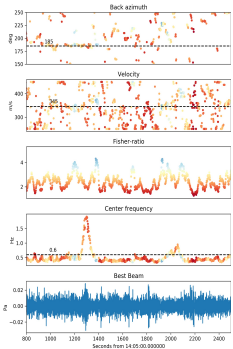


Time-Domain Fisher Detector program , Jelle D. Assink, KNMI

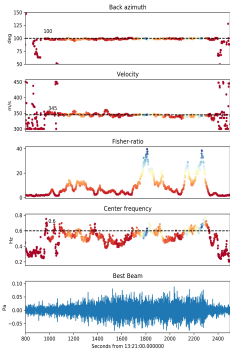
I26DE



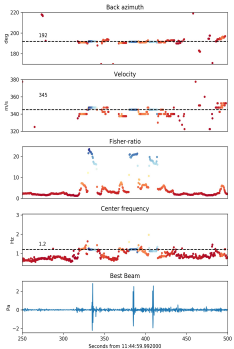
H3RU



H8TN



IMAR



SOREQ

SnT 2021

```
Location ran for  4 iterations ... Converged!

EvID: -7  In_OrID: -7  GRN: EGYPT

Final location estimate (+/- S.D.):
     Latitude:        29.980 deg. N +/-     3.824 km.
    Longitude:        34.825 deg. E +/-     5.718 km.
        Depth:         0.000  km.
Relative O.T.:        -2.764 sec.   +/-     0.457 sec.
Absolute O.T.: 1558351890.962 sec.   +/-     0.457 sec.
             : 2019/05/20 11:31:30.962

Confidence region at 0.90 level:
  Semi-major axis:    14.1  km. =  0.13 deg.
  Semi-minor axis:     4.4  km. =  0.04 deg.
Major-axis strike:    58.8 deg. clockwise from North
 Orig. time error:     0.8 sec.

Standard errors (sigma):
             Prior:  1.00 ( 99999 deg. of freedom)
         Posterior:  1.00 (100006 deg. of freedom)
         Posterior:  0.28 (Normalized sample S.D.)

  RMS travel-time residual: 0.272 sec.
     Maximum azimuthal GAP: 167.6 deg.
  Effective rank of matrix: 3.00
Condition number of matrix: 3.406
 - No damping required !
```

Ariv ID	Statn	Phase	Def		Residuals True	Residuals Normal	A Priori Error	Dist. (deg.)	Azimuth (deg.)	Data Import	Err
657603	KRMI	P	t	d	-0.483	-0.533	0.907	0.162	327.70	0.256	0
657604	KRMI	S	t	d	0.222	0.317	0.702	0.162	327.70	0.759	0
657607	HRFI	P	t	d	0.169	0.117	1.439	0.192	72.86	0.652	0
657608	HRFI	S	t	n	2.734	3.534	0.774	0.192	72.86	-1.000	0
657605	MBRI	P	t	d	0.102	0.120	0.848	0.200	157.25	0.737	0
657606	MBRI	S	t	n	3.028	4.294	0.705	0.200	157.25	-1.000	0
657609	EIL	P	t	d	-0.036	-0.023	1.550	0.325	160.14	0.231	0
657609	EIL	P	s	n	-15.755	-2.710	5.814			-1.000	0
657609	EIL	P	a	n	-18.046	-0.201	89.798			-1.000	0
657610	PRNI	P	t	d	-0.063	-0.037	1.719	0.403	22.76	0.301	0
657611	PRNI	S	t	n	1.217	0.584	2.083	0.403	22.76	-1.000	0
657612	DSI	P	t	d	-0.436	-0.148	2.938	1.681	16.74	0.059	0
141848746	I48TN	I	t	n	-286.231	-0.689	415.693	22.158	291.89	-1.000	0
141848746	I48TN	I	s	n	-28.877	-0.955	30.222			-1.000	0
141848746	I48TN	I	a	d	0.683	0.125	5.481			0.001	0
141849404	I26DE	I	t	n	-64.383	-0.155	415.693	24.781	325.42	-1.000	0
141849404	I26DE	I	s	n	-28.268	-2.953	9.573			-1.000	0
141849404	I26DE	I	a	d	-0.538	-0.271	1.984			0.005	0
141849604	I43RU	I	t	n	804.518	1.935	415.693	26.784	2.93	-1.000	0
141849604	I43RU	I	s	n	-25.527	-0.843	30.277			-1.000	0
141849604	I43RU	I	a	d	0.723	0.130	5.546			0.000	0

= 0, No problem, normal interpolation

Geotool LocSAT,NDC in a BOX

```
Location ran for  4 iterations ... Converged!

EvID: -5  In_OrID: -5  GRN: EGYPT

Final location estimate (+/- S.D.):
     Latitude:        29.979 deg. N +/-     7.163 km.
    Longitude:        34.825 deg. E +/-     9.695 km.
        Depth:         0.000  km.
Relative O.T.:        -2.808 sec.   +/-     1.085 sec.
Absolute O.T.: 1558351941.519 sec.   +/-     1.085 sec.
             : 2019/05/20 11:32:21.519
Confidence region at 0.90 level:
  Semi-major axis:    23.3  km. =  0.21 deg.
  Semi-minor axis:    11.1  km. =  0.10 deg.
Major-axis strike:    58.9 deg. clockwise from North
 Orig. time error:     1.8 sec.

Standard errors (sigma):
             Prior:  1.00 ( 99999 deg. of freedom)
         Posterior:  1.00 (100006 deg. of freedom)
         Posterior:  0.16 (Normalized sample S.D.)

  RMS travel-time residual: 0.234 sec.
     Maximum azimuthal GAP: 167.6 deg.
  Effective rank of matrix: 3.00
Condition number of matrix: 2.459
 - No damping required !
```

Ariv ID	Statn	Phase	Def		Residuals True	Residuals Normal	A Priori Error	Dist. (deg.)	Azimuth (deg.)	Data Import	Err
657615	KRMI	P	t	d	-0.452	-0.214	2.107	0.163	327.77	0.310	0
657620	KRMI	S	t	d	0.260	0.131	1.981	0.163	327.77	0.652	0
657616	HRFI	P	t	d	0.098	0.039	2.489	0.192	72.67	0.469	0
657621	HRFI	S	t	n	1.511	0.658	2.297	0.192	72.67	-1.000	0
657617	MBRI	P	t	d	0.101	0.036	2.829	0.200	157.23	0.386	0
657618	EIL	P	t	d	-0.015	-0.006	2.380	0.325	160.14	0.568	0
657618	EIL	P	s	n	-13.096	-2.193	5.972			-1.000	0
657618	EIL	P	a	n	4.292	0.081	53.009			-1.000	0
657622	EIL	S	t	n	1.121	0.464	2.414	0.325	160.14	-1.000	0
657622	EIL	S	s	n	-24.235	-4.058	5.972			-1.000	0
657622	EIL	S	a	n	121.572	3.335	36.448			-1.000	0
657619	PRNI	P	t	d	-0.147	-0.071	2.061	0.403	22.71	0.418	0
657623	PRNI	S	t	n	1.058	0.481	2.201	0.403	22.71	-1.000	0
657624	DSI	P	t	d	0.262	0.108	2.428	1.682	16.73	0.181	0
141848746	I48TN	I	t	n	-336.930	-0.811	415.693	22.158	291.89	-1.000	0
141848746	I48TN	I	s	n	-28.877	-0.955	30.222			-1.000	0
141848746	I48TN	I	a	d	0.682	0.124	5.481			0.002	0
141849404	I26DE	I	t	n	-115.158	-0.277	415.693	24.782	325.42	-1.000	0
141849404	I26DE	I	s	n	-28.268	-2.953	9.573			-1.000	0
141849404	I26DE	I	a	d	-0.538	-0.271	1.984			0.014	0
141849604	I43RU	I	t	n	753.744	1.813	415.693	26.785	2.93	-1.000	0
141849604	I43RU	I	s	n	-25.527	-0.843	30.277			-1.000	0
141849604	I43RU	I	a	d	0.724	0.131	5.546			0.001	0

= 0, No problem, normal interpolation

```
Location ran for  4 iterations ... Converged!

EvID: -3  In_OrID: -3  GRN: EGYPT

Final location estimate (+/- S.D.):
     Latitude:        29.968 deg. N +/-     3.639 km.
    Longitude:        34.734 deg. E +/-     4.853 km.
        Depth:         0.000  km.
Relative O.T.:        -3[redacted]290 sec.   +/-     0.968 sec.
Absolute O.T.: 1558351965.961 sec.   +/-     0.968 sec.
             : 2019/05/20 11:32:45.961

Confidence region at 0.90 level:
  Semi-major axis:    10.8  km. =  0.10 deg.
  Semi-minor axis:     7.2  km. =  0.06 deg.
Major-axis strike:    68.1 deg. clockwise from North
 Orig. time error:     1.6 sec.

Standard errors (sigma):
             Prior:  1.00 ( 99999 deg. of freedom)
         Posterior:  1.00 (100009 deg. of freedom)
         Posterior:  0.49 (Normalized sample S.D.)

  RMS travel-time residual: 0.899 sec.
     Maximum azimuthal GAP: 209.8 deg.
  Effective rank of matrix: 3.00
Condition number of matrix: 2.52
 - No damping required !
```

Ariv ID	Statn	Phase	Def		Residuals True	Residuals Normal	A Priori Error	Dist. (deg.)	Azimuth (deg.)	Data Import	Err
657625	KRMI	P	t	d	0.308	0.136	2.269	0.149	356.98	0.222	0
657632	KRMI	S	t	d	2.059	0.906	2.272	0.149	356.98	0.345	0
657629	MBRI	P	t	d	-0.026	-0.015	1.716	0.233	137.92	0.252	0
657633	MBRI	S	t	d	0.082	0.040	2.053	0.233	137.92	0.262	0
657628	HRFI	P	t	d	-0.914	-0.450	2.031	0.271	75.43	0.124	0
657630	HRFI	S	t	d	-1.180	-0.646	1.826	0.271	75.43	0.355	0
657626	EIL	P	t	d	-0.025	-0.011	2.324	0.350	147.22	0.163	0
657626	EIL	P	s	n	-14.907	-2.700	5.521			-1.000	0
657626	EIL	P	a	n	43.098	0.625	68.996			-1.000	0
657631	EIL	S	t	d	0.779	0.381	2.048	0.350	147.22	0.308	0
657631	EIL	S	s	-	-13.888	-1.922	7.225			-1.000	0
657631	EIL	S	a	-	-98.432	-4.685	21.010			-1.000	0
657627	PRNI	P	t	n	-0.612	-0.265	2.311	0.449	31.47	-1.000	0
657634	PRNI	S	t	d	-0.302	-0.153	1.971	0.449	31.47	0.348	0
610465	IMAR	I	t	n	-38.966	-0.162	240.008	3.094	10.38	-1.000	0
610466	IMAR	I	t	n	-6.966	-0.029	240.008	3.094	10.38	-1.000	0
610467	IMAR	I	t	n	52.034	0.217	240.008	3.094	10.38	-1.000	0
610468	IMAR	I	t	n	150.034	0.625	240.008	3.094	10.38	-1.000	0
610469	IMAR	I	t	n	218.034	0.908	240.008	3.094	10.38	-1.000	0
141848746	I48TN	I	t	n	-337.117	-0.811	415.693	22.089	291.94	-1.000	0
141848746	I48TN	I	s	n	-28.877	-0.955	30.222			-1.000	0
141848746	I48TN	I	a	d	0.577	0.105	5.481			0.000	0
141849404	I26DE	I	t	n	-127.028	-0.306	415.693	24.746	325.53	-1.000	0
141849404	I26DE	I	s	n	-28.268	-2.953	9.573			-1.000	0
141849404	I26DE	I	a	d	-0.708	-0.357	1.984			0.003	0
141849604	I43RU	I	t	n	724.096	1.742	415.693	26.800	3.04	-1.000	0
141849604	I43RU	I	s	n	-25.527	-0.843	30.277			-1.000	0
141849604	I43RU	I	a	d	0.550	0.099	5.546			0.000	0

= 0, No problem, normal interpolation

Summary and future work

- The verification regime creates many Infrasound events in the Israeli region.
- Event validation is not straightforward without a local network.
- Detection of low yield events by IMS stations opens the path to use these events as calibration events.
- The calibration event list will include:
  - Location and Yield relative to the historical calibration explosions.
  - The relevant ATM.
  - List of IMS and other stations detecting the event.
- In addition Mount Meiron and Dimona Infrasound arrays will be used in order to verify validity of all events.

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