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Estimating parameters of unusual regional explosions from seismo-acoustic observations in Israel

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Infrasound signals from a bolide, that exploded over Iran city Zanjan (July 30, 2015), were observed at Israel acoustic sensors, operated by GII, and infrasound array IMA, operated by NDC, Israel, at distances 1200-1350 km. This bolide was witnessed by thousands of people (time between 15:40 and 15:50 UTC), and reported widely in the mass-media. A farmer, who witnessed the fireball, reported 4 distinct bursts and sonic booms as it traveled across the sky. Soon afterwards, he described a strange thud and found a hole nearby with a meteorite inside (in the town of Moshampa, at 36.942N, 47.674E).

After band-pass filtering 0.2-5 Hz of IMA records, four consistent infrasound phases were found with the group velocity $\sim$303 m/s, presumably corresponding to the four reported sonic booms. The f-k analysis estimated the same azimuth 67.8° for the first 3 weak phases and a close azimuth value 65.2° for the maximal fourth phase; similar apparent velocities for all phases 343-349 m/s were obtained. The azimuth estimates correspond well to the actual value 65.3°.

We conducted a yield evaluation for the bolide explosion, based on the empirical relation between the yield W and the dominant period T_0 of the infrasound wave. The period (T_0= 1.105 s) was calculated from the averaged maximum of the amplitude spectra of the main phase recorded at 5 IMA elements. Then the TNT equivalent yield was roughly estimated as W$\sim$7.3 tons. There were many reports of broken glass and shaking houses suggesting a large event. Based on an estimate of between 15 and 25 km/s for the bolide velocity, its kinetic energy suggests that the pre-atmospheric size of the meteoroid was of the order 100-300 kg.

Seismic signals from an explosion in Syria (May 14, 2014) were observed at Israel stations. Internet websites reported that rebels blew up the government army base Wadi Deif by detonating 60 tons of explosives planted in a tunnel under the base. The EMSC bulletin presented this event as an earthquake with local magnitude M_L=2.8, location 35.74N, 36.64E, depth 10 km, OT 15:58:51.4 UTC.

We analyzed Israel seismic records and obtained location parameters, similar to EMSC data. The event moment magnitude was determined based on S-waves displacement spectra: M_W(S)=2.75 (average for 4 stations). Then we used a new empirical relation between M_L and M_W(S) (Ataev, 2013): $M_W(S)=0.9*M_L+0.11$, that provided estimation M_L=2.9.

The LLNL researchers estimated the explosion yield as $\sim$40 tons, using the regional amplitude envelope method applied to records of seismic stations in Turkey and Cyprus (Pasyanos and Ford, 2015). We used the new-developed magnitude-charge dependence, based on numerous calibration explosions, conducted by GII, placed few meters below the surface: $M_L=0.5489*W^{0.1643}$, that provided estimation W$\sim$25 tons.

We applied a new spectral discriminant developed recently in GII (Ataev et al., 2015): ratios of P- to S-wave corner frequencies (averaged over recorded stations), that were found higher for explosions, than for earthquakes, with the threshold 1.48. This seismic event showed a ratio 1.79, and was clearly identified as an underground explosion.