SnT 2025
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# Earthquake Early Warning alert in Israel due to a 370 T explosion in southern Lebanon, October 26, 2024

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## INTRODUCTION AND MAIN RESULTS

On October 26, 2024 at 4:02 UTC (7:02 IDT), the destruction of a Hezbollah tunnel by the Israeli Defense Forces (IDF) using 370 T of explosives was detected ~2 km west of Misgav Am in northern Israel. Israel's Earthquake Early Warning (EEW) system, *Truaa*, operated by the Geological Survey of Israel's (GSI) Seismological Division, created an initial M5.25 solution 22 km away from and ~4 s after the explosion. The final solutions for this event were closer to the M3.63 catalogue (GSI) magnitude. Public EEW alerts were sent for the first time in Israel by the IDF's Home Front Command (HFC).

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## Event Timeline at the GSI 24/7 Emergency Operations Center (EOC)

07:02: **EEW alert for an M5.2 event received** on HFC application, internal Telegram bot and through sirens in northern Israel

07:08: EOC verifies **EEW alert follows a controlled explosion**

07:12: EOC issues a message to stakeholders that **this is a scheduled explosion and not an earthquake**

07:17 Initial **analysis of *Truaa* performance** by EOC

07:38: Ministry of Energy issues a statement explaining **the *Truaa* EEW system sent an alert for an explosion**;

08:04: Director of GSI is updated

08:50: Starting to formulate a **public clarification message** to be published on GSI Facebook page

09:36: **Discussion about the clarification message** between Ministry of Energy spokesperson, Directors of Seismological Division and GSI

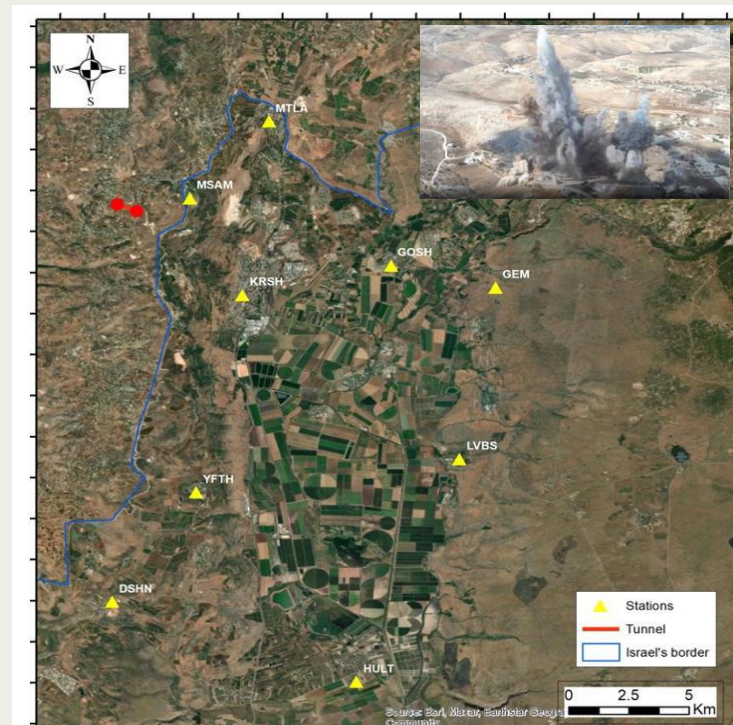10:07: **Publication of the clarification message** on Facebook.

## Settings



***Figure 1:*** *Map view of the tunnel (red line), nearby* Truaa *stations (yellow triangles) and Israeli border with Lebanon (blue line). The top inset view shows a picture of the explosion (IDF).*

## Alert parameters

| Update | # | Time (s) | Mag | D (km) |
|---|---|---|---|---|
| Preliminary | 0 | 3.3 | 5.13 ± 0.5 | 13.8 |
| 1st alert | 1 | 3.9 | 5.25 ± 0.4 | 22.0 |
| Max magnitude | 7 | 4.7 | 5.38 ± 0.3 | 26.2 |
| Last update | 125 | 48.5 | 3.85 ± 0.2 | 4.4 |

***Table 1:*** *Selected* Truaa *EEW updates with corresponding parameters: update number, delay time (in s), magnitude with error and distance from the real location (in km).*

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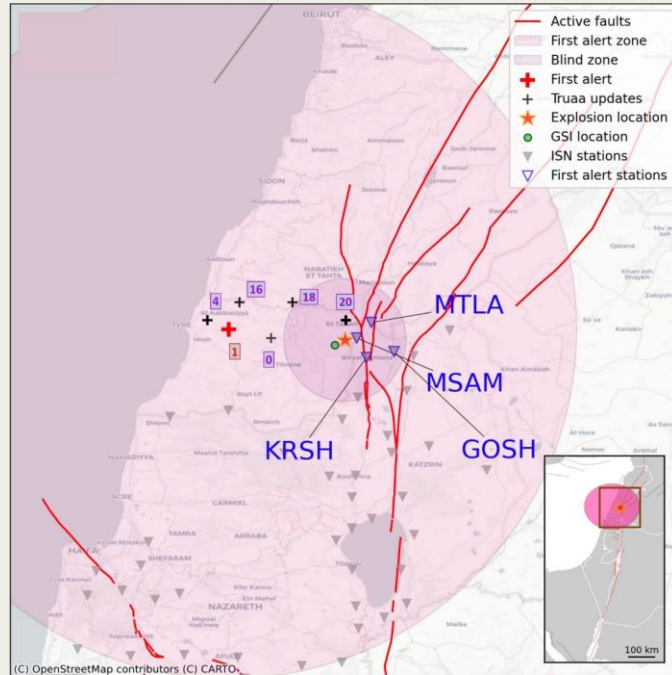## Data analysis: mislocation and magnitude overestimation



**Figure 2:** *Location map for all of* Truaa's *alerts (crosses) for this event, corresponding catalogue (GSI) solution (green circle), actual (IDF) location of the explosion (star), as well as* Truaa *stations (triangles) in the area. The extents of the magnitude-dependent alert zone (pink circle) and blind zone (purple circle) are also shown. Local (red lines) and regional (grey lines) active faults are displayed.* **Red** *and* **purple** *numbers refer to the various* Truaa *solutions in all related tables and figures.*
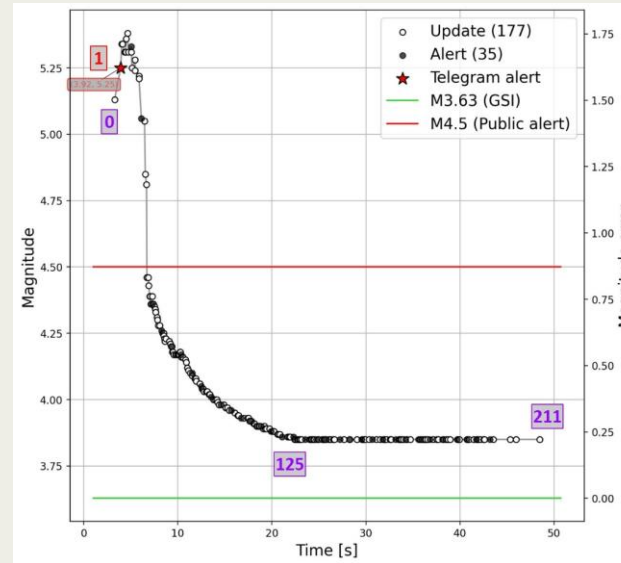


**Figures 3:** *Changes in* Truaa *absolute magnitude (left axis) and relative to GSI value (right axis), as a function of time (in seconds after origin time). Each circle represents a* Truaa *update; the red star represents the EEW alert.*



**Figure 4:** *Changes in* Truaa *location error (left axis) and number of stations (right axis), as a function of time (in seconds after origin time). Each circle represents a* Truaa *update; the red star represents the EEW alert.*

**Figure 5:** *Waveforms for the first stations to record the event (see Table 2 for parameters)*



| Station | Available data (s) | Distance to *Truaa* (km) | Distance to explosion (km) | PGA (cm/s²) | *Truaa* Magnitude | Distance corrected Magnitude |
|---------|--------------------|--------------------------|----------------------------|-------------|-------------------|------------------------------|
| MSAM | 2.20 | 24.1 | 2.2 | 30.0 | 5.87 | 4.9 |
| KRSH | 1.53 | 26.6 | 5.6 | 3.8 | 4.86 | 4.21 |
| MTLA | 1.22 | 26.8 | 6.3 | 3.8 | 5.17 | 4.25 |
| GOSH | 0.49 | 31.4 | 9.6 | 2.4 | 4.66 | 4.16 |

**Table 2:** *Parameters for the first stations to record the event: signal duration (in s), distances to Truaa solution and to real explosion location (in km), peak ground acceleration (PGA; in cm/s2), Truaa station magnitude and distance-corrected station magnitude (see Figure 5 for waveforms).*
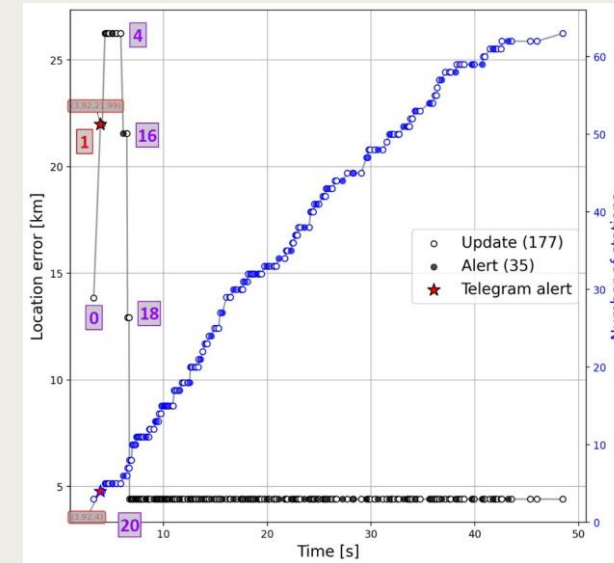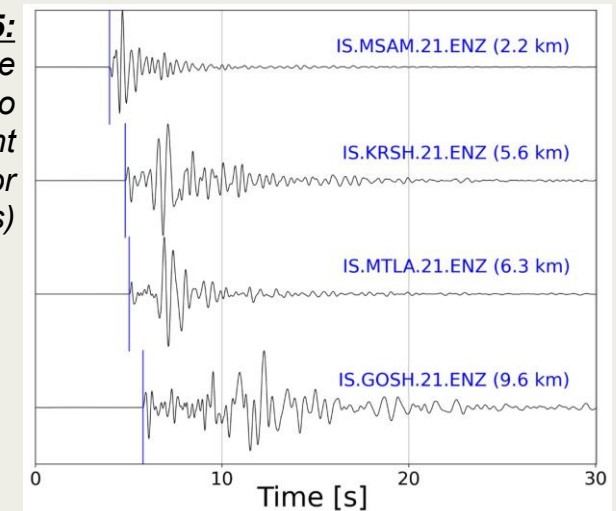
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## Explosion relocation

Relocating using a fixed 0-km depth results in:
- location much closer to reality (< 1.5 km error)
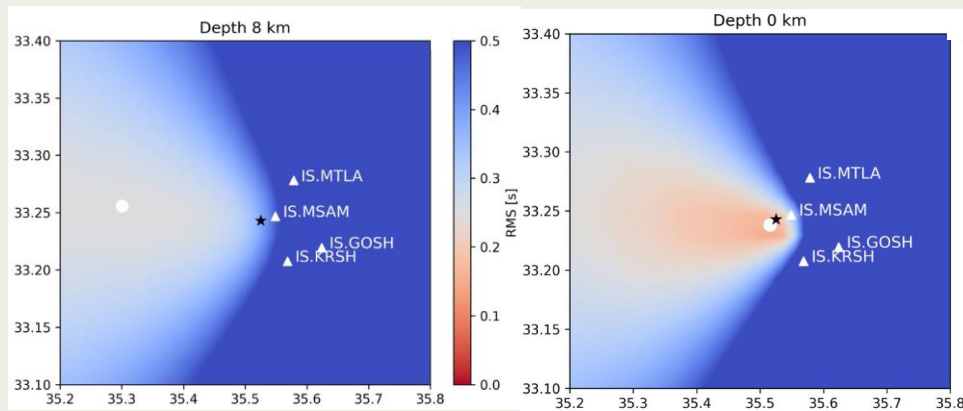- correct distances, and therefore more accurate station magnitudes.



***Figure 6:*** *Comparison of* Truaa *location (white dot) accuracy resulting from using a 8-km fixed depth (left) or 0-km fixed depth (right). Background colours show RMS values (see colour bar). The four first stations (white triangles) and actual location of the explosion (star) are also shown.*

## Summary: First EEW in Israel

- **Accurate *P*-wave picking** (not causing location errors)

- Mislocation due to **fixed 8-km depth** in algorithm

- Location error < 1.5 km when using **fixed 0-km depth**

- **Mislocation** contributes to magnitude overestimation

- **Extreme explosion** (370 T) and **close proximity** to the station (~2 km) leading to **high PGA** (30 cm/s$^2$)

- High PGA and **more available data** (higher weights) at close stations lead to **magnitude overestimation**

- Magnitude formula designed for **more energy in *S* waves (earthquakes) than *P* waves (explosions)**

- **Combination** of location error, high amplitudes and mechanism leads to **magnitude overestimation**

- Public alert is disseminated **according to alert policy**

- Previous, smaller explosions did not issue alerts

## Conclusions

- **First public EEW** in Israel

- *Truaa* system worked **as designed**

- **Other dedicated systems** produced an alert

- Opportunity to test **end-to-end workflow**

- Appropriate response by **GSI 24/7 EOC**

- Scheduled explosions will be mitigated by temporarily **disabling the closest stations** (though it requires the sharing of potentially sensitive information by the IDF)

- Highlights the unique challenges of dealing with **anthropogenic sources**

- Research ongoing to **discriminate between explosions and earthquakes** in real time, and to understand **public reaction to the alerts**

- **No need to redesign the** *Truaa* **EEW system**