



JRC TECHNICAL REPORT

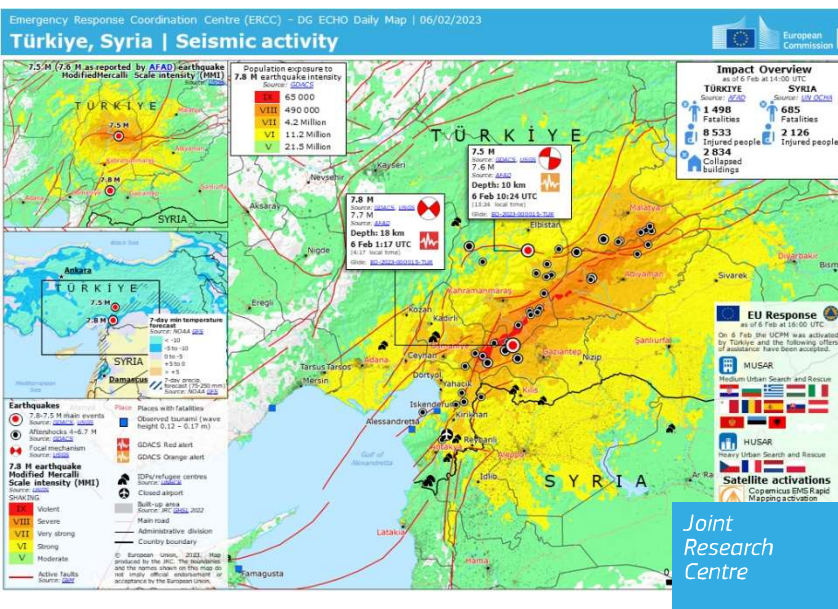
M7.8 and M7.5 Earthquakes in Türkiye and Syria

*JRC Scientific Analysis:
Update#1*

6 Feb 2023 19:00 UTC

Santini M., Necmioglu O., Abad Perez J., Proietti C., Lentini A., Krausmann E., Gkoktsi K., Joubert-Boitat, I., De Girolamo L., Duta A.M., Caravaggi I., Salvitti V., Mastronunzio M., Kamberaj J., Lorini V., Mari Rivero I., Spruyt P., Ceccato P., Spagnolo, L

2023



GDACS RED ALERT

M 7.8 in Türkiye on 06 Feb 2023
01:17 UTC – 04:17 local time



GDACS ORANGE ALERT

M 7.5 in Türkiye on 06 Feb 2023
10:24 UTC – 13:24 local time

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Research
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Abstract

This the first update of the JRC scientific analysis of the ongoing earthquake crisis in Türkiye and Syria, which started 6 Feb 2023 at 01:17 UTC – 04:17 local time (previous reports published on 6, 7 and 8 February, respectively).

Acknowledgements

The authors wish to thank the many colleagues who contributed to this report in record time.

Executive summary

- A strong earthquake of **7.8 M** (7.7 as reported by Disaster and Emergency Management Presidency of Türkiye-AFAD) at a depth of 18 km occurred on 6 February at 1.17 UTC (4.17 local time) **in southern Türkiye, close to the border with northern Syria**. The epicenter was located in Atalar town (Gaziantep Province, Southeastern Anatolia Region), and about 45 km north of the northern border of Aleppo Governorate in Syria. **Severe aftershocks are occurring** along the fault system, reaching magnitude up to 6.7 M. **A second event with a M 7.5 and 10 km depth occurred at 10:24 UTC**. The **Global Disaster Alert and Coordination System (GDACS) issued a Red Alert** for the severe humanitarian consequences.
- The earthquakes are occurring on the **East Anatolian Fault (EAF)**, which is a major transform type tectonic boundary between the Anatolian Plate and the northward-moving Arabian Plate.
- **Tsunami warnings** were issued followed by bulletins related to tsunami observations in Türkiye and Cyprus with less than 20cm wave height. No significant tsunami inundation or impact occurred.
- The Disaster and Emergency Management Presidency of Türkiye (AFAD) reports at least **1498 fatalities, 8533 injured, and 2834 collapsed buildings**. **In Syria, at least 685 people died and more than 2,126 others were injured**, as reported by Syria's Health Ministry. According to the White Helmets authorities, **over 380 people died in rebel-held north-western Syria**.
- In Syria the **humanitarian access is hampered by conflict and military operations**. UN OCHA classifies 203 out of 270 sub-districts of Syria under severe, extreme or catastrophic conditions. At the end of January 2023, 4.7 million people were in need of humanitarian assistance in Aleppo, Ar-Raqqa and Al-Hasakeh alone. Syria is also facing a cholera outbreak with 19 438 cases being registered in Aleppo (23% of the total) and 16 366 cases being registered in Ar-Raqqa (19% of the total), as at 31 January 2023.
- Severe damage to the critical infrastructures has been recorded, in particular **two hospitals collapsed and Hatay airport is out of service**. In addition, the earthquake has damaged **critical energy infrastructure** in Turkey. There is damage to both power transmission lines and natural gas transmission and distribution lines.
- The **European Commission's Copernicus emergency satellite mapping system was activated** by the ERCC on 6 February at 04:43 UTC to support damage assessment. The JRC Copernicus Mapping Team is providing technical support to the activity. Optical satellite imagery of very high resolution (less than 1 meter) will be acquired **on 07 February over 20 areas of interest** (AOIs) located close the epicenters of the earthquakes. The satellite Charter was activated as well.
- **International assistance** was requested by the Republic of Türkiye shortly after the event. The DG ECHO Emergency Response Coordination Centre-ERCC is coordinating the mobilization of the EUCPM. UN OCHA activated the United Nations Disaster Assessment and Coordination (UNDAC) team. Teams from other countries are also mobilizing.

Executive Summary

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1. Situation Overview

1.1. Situation

A series of earthquakes started on the 06 February 2023 with a strong earthquake of 7.8 M (7.7 M as reported by Disaster and Emergency Management Presidency of Türkiye-AFAD) at a depth of 18 km occurred at 1.17 UTC (4.17 local time) in southern Türkiye (epicentral coordinates: 37.174°N 37.032°E), close to the border with northern Syria. The epicenter was located in Atalar town (Gaziantep Province, Southeastern Anatolia Region), and about 45 km north of the northern border of Aleppo Governorate in Syria.

Following the main shock, 46 aftershocks occurred along the fault system with a $M > 2.5$.

A second event with a $M 7.5$ and 10 km depth occurred at 10:24 UTC at a distance of about 100 km from the first event (epicentral coordinates: 38.024°N 37.203°E), likely worsening the impact and the ongoing Search & Rescue operations.

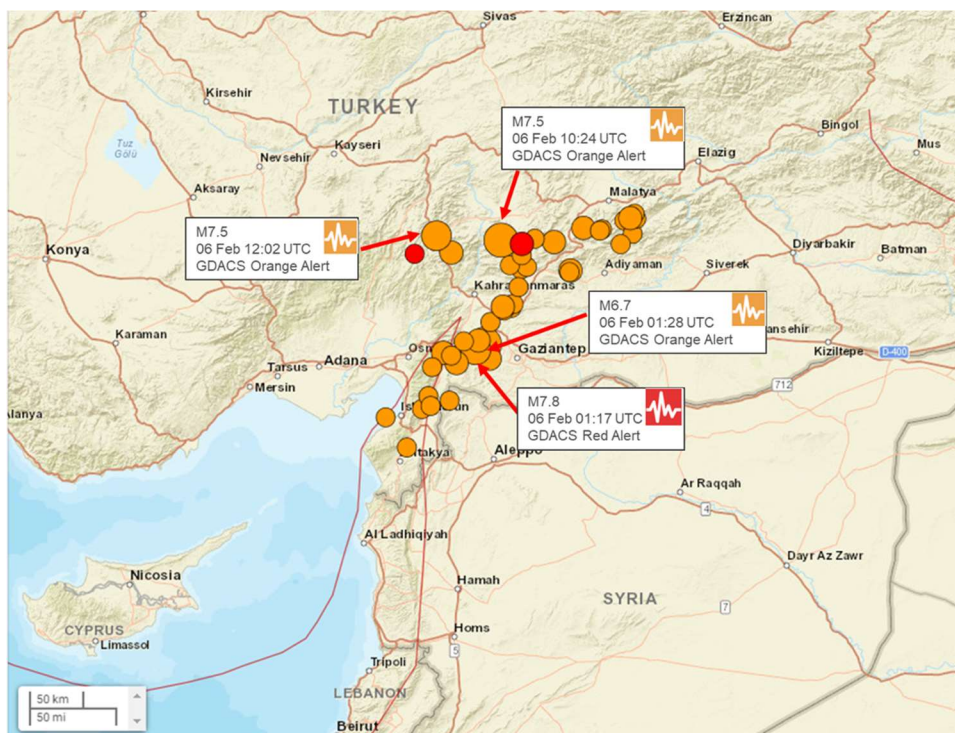


Figure 2 – Main shock and aftershocks on the 06 February 2023 (source: USGS, modified). Red dots are the most recent earthquakes.

1.2. Humanitarian impact

1.2.1. Earthquake impact

The preliminary humanitarian impact (as of 06 February at 17:00 UTC) is:

- Disaster and Emergency Management Presidency of Türkiye-AFAD reports at least 1,498 fatalities, while more than 8,533 individuals sustained injuries. 2824 buildings have been reported as collapsed. Casualties and damage have been recorded as well in Istanbul. (source: <https://www.afad.gov.tr/kahramanmaraş-pazarcıkta-meydana-gelen-deprem-hk-basin-bulteni7>)
- In Syria, at least 685 people died and nearly 2,126 sustained injuries, as reported by the Syrian Ministry of Health and the Syrian Arab News Agency (SANA) . A State of Emergency has been issued in north-western Syria by the White Helmets authorities. (source: White Helmets Syria <https://www.syriacivildefence.org/en/latest/media-releases/northwestern-syria-declared-state-emergency-after-catastrophic-earthquake/>). According to the White Helmets, over 380 people died in rebel-held north-western Syria and over 1000 were injured .

1.2.2. Pre-existing humanitarian crisis in North Western Syria due to the Syrian conflict

Since 2011, Syria has been the stage of a decade-long civil war between the Syrian regime and rebel forces, which caused extensive urban damage and population displacement. Infrastructure across the country is still in a fragile state due to years of airstrikes and shelling, as the post-war reconstruction effort is still underway.

According to INFORM Severity (latest update as at January 2023), the conflict in Syria still causes an humanitarian crisis of very high severity (Score 4.6 out of 5). All three dimensions of crisis severity, that is, impact, humanitarian conditions and complexity are scoring very high. The whole country's population is exposed to the crisis. The situation is seemingly unchanged over the last few months. There are estimated 14.56 million of people in need (more than 75% of the current population) and 16.58 million people displaced. (Due to Syrian Refugees in Turkiye there is another existing crisis area on Turkish side (Adana, Adiyaman, Gaziantep, Hatay, Istanbul, K. Maras, Kilis, Osmaniye, Sanliurfa) with highly severe humanitarian crisis (Score 3.2 out of 5). There are estimated 2 million of people in need and 3.56 million people displaced.)

In rebel-controlled North West Syria, there is an especially high number of Internally Displaced People (IDPs), with nearly 1.7 million IDPs living in more than 1 400 camps under difficult living conditions. The conditions worsened in the past week due to severe weather. In Aleppo governorate, in A'zaz, Jandairis, Afrin and Al Bab, more than 50% of the population is internally displaced.

There are severe disruptions to services and infrastructure including severe electricity shortages, the situation in Aleppo being the worst in the country. The humanitarian access is hampered by conflict and military operations. UN OCHA classifies 203 out of 270 sub-districts of Syria under severe, extreme or catastrophic conditions. At the end of January 2023, 4.7 million people were in need of humanitarian assistance in Aleppo, Ar-Raqqa and Al-Hasakeh alone.

Syria is also facing a cholera outbreak with 19 438 cases being registered in Aleppo (23% of the total) and 16 366 cases being registered in Ar-Raqqa (19% of the total), as at 31 January 2023.

1.3. Overview of the seismotectonic setting and historical seismicity

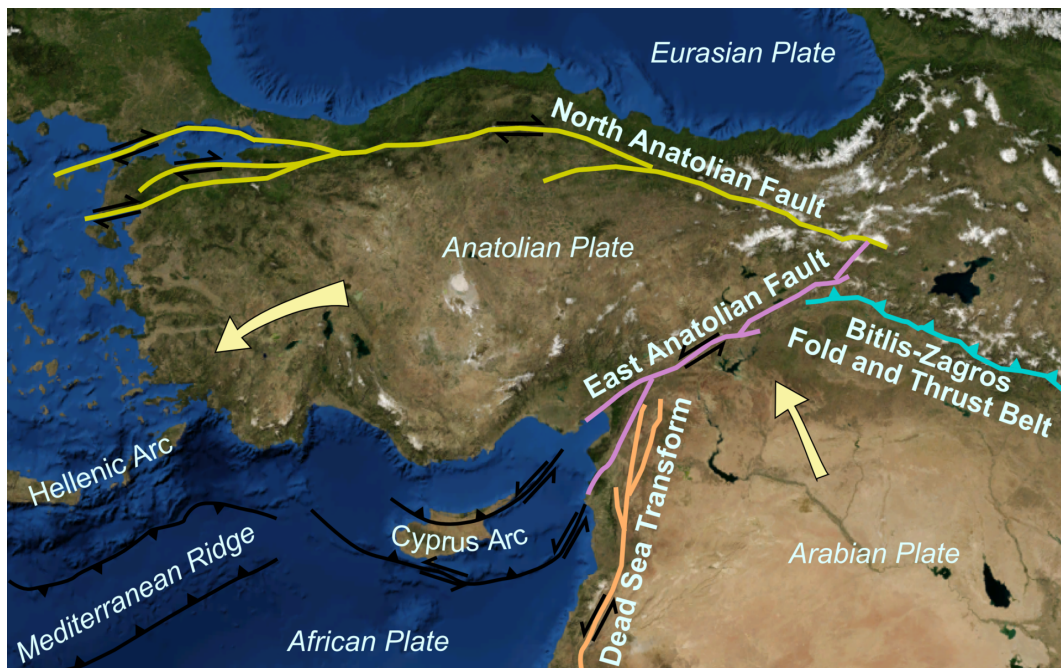


Figure 3 - Main tectonic structures of Anatolia and Middle East. North Anatolian Fault (NAF), East Anatolian Fault (EAF), Dead Sea Transform (DST), Bitlis-Zagros Fold and Thrust Belt (BZFTB)

(source: https://en.wikipedia.org/wiki/East_Anatolian_Fault#/media/File:Anatolian_Plate.png)

The earthquakes in Türkiye on 6 February 2023 occurred on the East Anatolian Fault (EAF), which is a major transform type tectonic boundary between the Anatolian Plate and the northward-moving Arabian Plate accommodated mainly by strike-slip faults, starting from the Maras Triple Junction (MTJ) at the northern end of the Dead Sea Transform (DST) and ending at the Karlova Triple Junction (KTJ) where it meets the North Anatolian Fault (NAF) (Figure 4). Aftershocks of the first earthquake with M7.8 extended also into the northern section of the DST to the southern parts of Antakya region. While the EAF has no history of earthquakes with $M > 7$, both NAF and DST experienced catastrophic events in their past, such as 1939 M7.7 Erzincan, 1943 M7.6 Ladik-Tosya, 1999 M7.6 Izmit on the NAF and 525-528 M7 and 1872 M7.3 earthquakes in Antakya, 1202 M7.6 in Damascus.

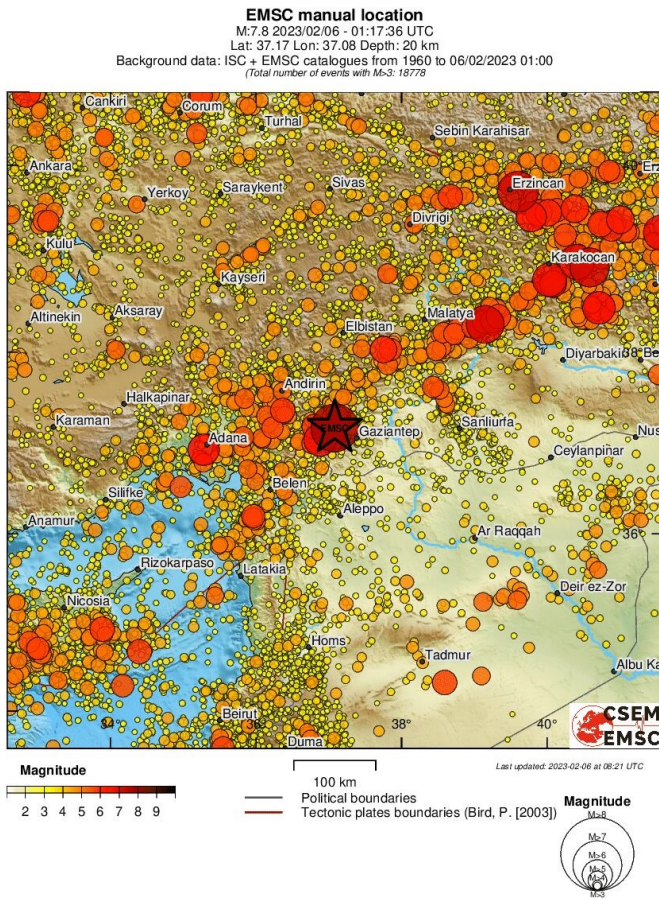


Figure 4 - Seismicity of the region since 1960 (EMSC)

Hatay Province has experienced large earthquakes in history, such as in the years 860, 1822 and 1872. A strong earthquake with Ms 7.4 occurred on the coast of Antiochia to Akko in January 860, which caused heavy damage to the coastal towns of Latakia and Jeble that were almost totally destroyed. Damage extended to the north, in Antakya, where about 1500 houses collapsed. The earthquake caused large rockfalls and landslides, where, in the region of Samandagı (Suaidiya), the sea receded and then flooded the coast (Soloviev et al., 2000). According to Altınok et al. (2011), the tsunami source is the partial sinking of Mt. Casius into the sea.

A destructive earthquake, with Ms 7.0, took place on the 13th of August 1822 in Aleppo, the largest to occur at the junction of the DSFZ with the EAFZ during the last five centuries, in particular in Antiochia, where two thirds of the towns were destroyed and thousands of the inhabitants were killed. The earthquake was felt from the coast of the Black Sea to Gaza, and it was followed by a long aftershock sequence. Aleppo, with about 40.000 houses containing a population of 200.000, including suburbs, was ruined, leading to an estimated number of 7.000 casualties. A tsunami was observed in Beirut, Iskenderun and on the Island of Cyprus (Soloviev et al., 2000 and Altınok et al., 2011, based on Kárník, 1971).

A large earthquake occurred on the 3rd of April, 1872 with Ms 7.2, where the shocks almost totally ruined Antakya (Antioch), and was felt throughout the Eastern Mediterranean, from Rhodes to Diyarbakir and from Konya to Gaza. Ambraseys (2009) reported that out of 3000 houses in Antakya, 1960 were destroyed and 894 so damaged as to become uninhabitable, leaving only 149 houses in good condition. In Antakya, the earthquake killed 500-1600 people and injured 400- 800. In Suaidiya (Samandağ), 2150-2425 houses were destroyed and 140-180 people were killed or seriously injured. As a result of the earthquake, the sea rose to a great height, flooding the coast in the vicinity of Jedida and Kabussi, with flood wave reaching as far as Samandağ (Suaidiya), nearly 2 km inland (Ambraseys, 2009; Altınok et al., 2011). Tsunami sediment deposits discovered in Suaidiya, are attributed to the 1872 event (Fokaefs and Papadopoulos, 2007).

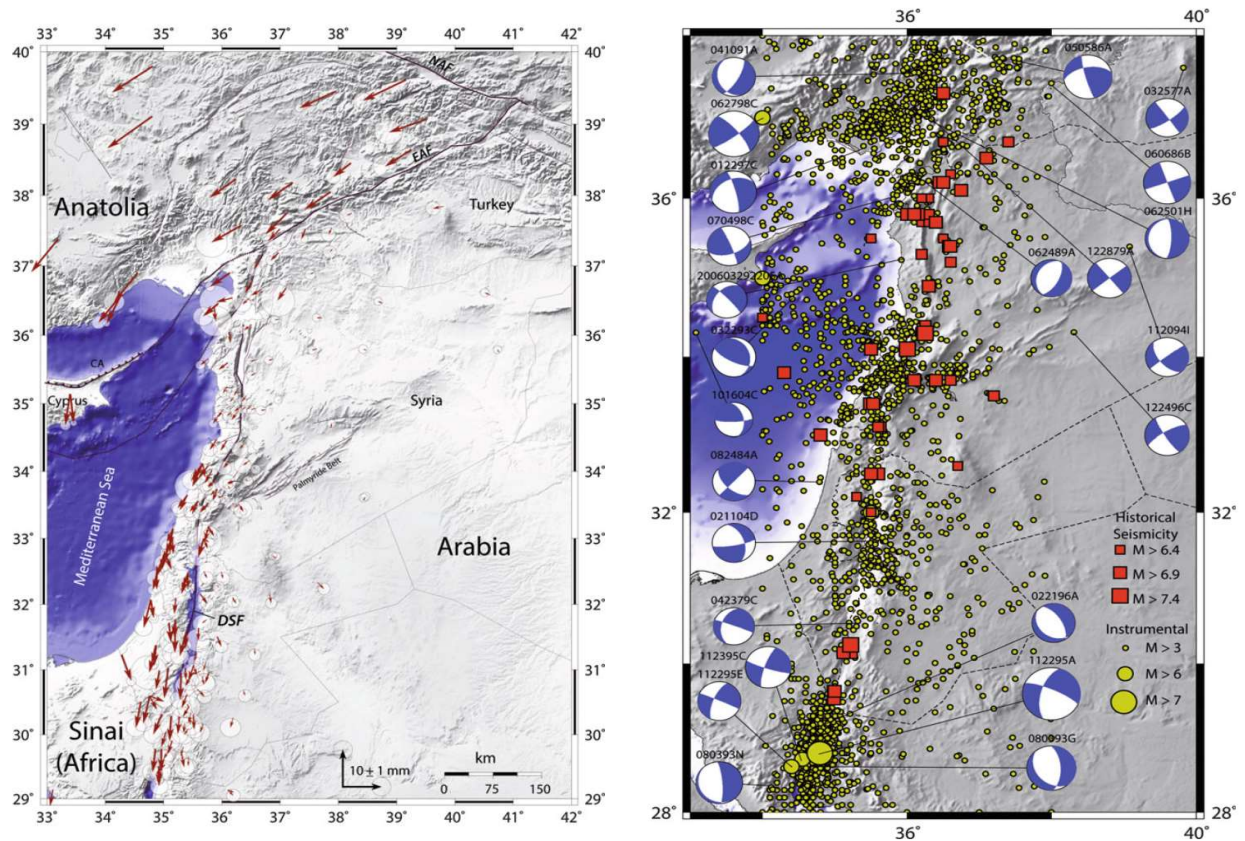


Figure 5 - (left) Plate boundaries (thick black lines) in the eastern Mediterranean pointing out the Dead Sea Fault (Transform) (DSF), East Anatolian Fault (EAF), North Anatolian Fault (NAF), and GPS data. (right): Last-century instrumental seismicity (1900–2012, yellow circle) and historical seismicity (1365 B.C.–1900, red box) along the Dead Sea fault (Meghraoui, 2015).

The instrumental seismicity (younger than 1900 A.D.) of the continental Dead Sea Fault is of a relatively low level compared to other major faults, such as the nearby East Anatolian Fault or North Anatolian Fault. Indeed, the largest earthquake that took place in the last century occurred on the 13th of July, 1927, with a local magnitude (ML) 6.2 that caused severe damage in Jericho and Jerusalem. More recently, the Mw 7.3 Nuweiba earthquake that took place offshore, further south in the Gulf of Aqaba and northern Red Sea, occurred as a reminder that large seismic events may be generated further north along the Dead Sea Fault. The apparent quiescence and the lack of major seismic events with Mw > 6.0 on most fault segments in the last centuries are in contradiction with the historical catalogue and related report of faulting events over the last 3,000 years or so along the continental Dead Sea Fault (Meghraoui, 2015; Guidoboni et al. 1994; Ambraseys and Jackson 1998; Sbeinati et al. 2005). The earthquakes of 6 February 2023 in Türkiye may very well be indicators of the “awakening” of the Dead Sea Fault.

1.4. Impact assessment

1.4.1 Overall impact by the earthquakes

Two major earthquakes with magnitudes above M7 at shallow depth have taken place within 9 hours of each other.

The first event, a M7.8 at 18 km depth according to the USGS, is expected to have caused widespread damage, with some locations having been exposed to intensities of IX on the MMI scale. An event of these characteristics is likely to cause between 1000 and 10000 victims, and billions of dollars in economic losses, according to the PAGER methodology, which further estimates that economic losses could total up to 2% of Türkiye's GDP.

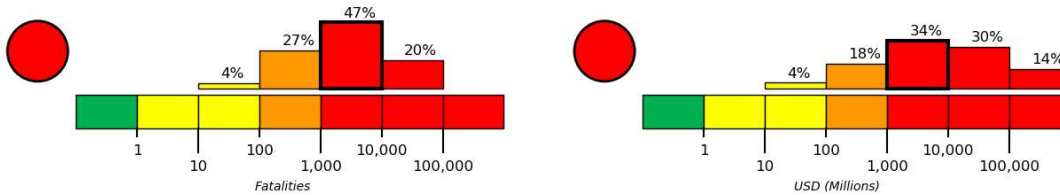


Figure 6 – PAGER estimates for human losses (left) and economic losses (right). Source: USGS

Furthermore, this damage is now compounded with the additional damage of a M7.5 at 10 km depth (also according to the USGS), with an epicenter about 100 km resulting in largely overlapping areas of strong shaking (see figures below). By itself, this second event could have generated tens to hundreds of fatalities. Current loss estimation techniques are not yet able to reliably account for the cumulative damage of several earthquakes striking the same location in short succession, making estimations difficult. However, it can be expected that this second event will have exacerbated the consequences of the first one: buildings that had remained standing have now likely collapsed after being fragilized by the first event.

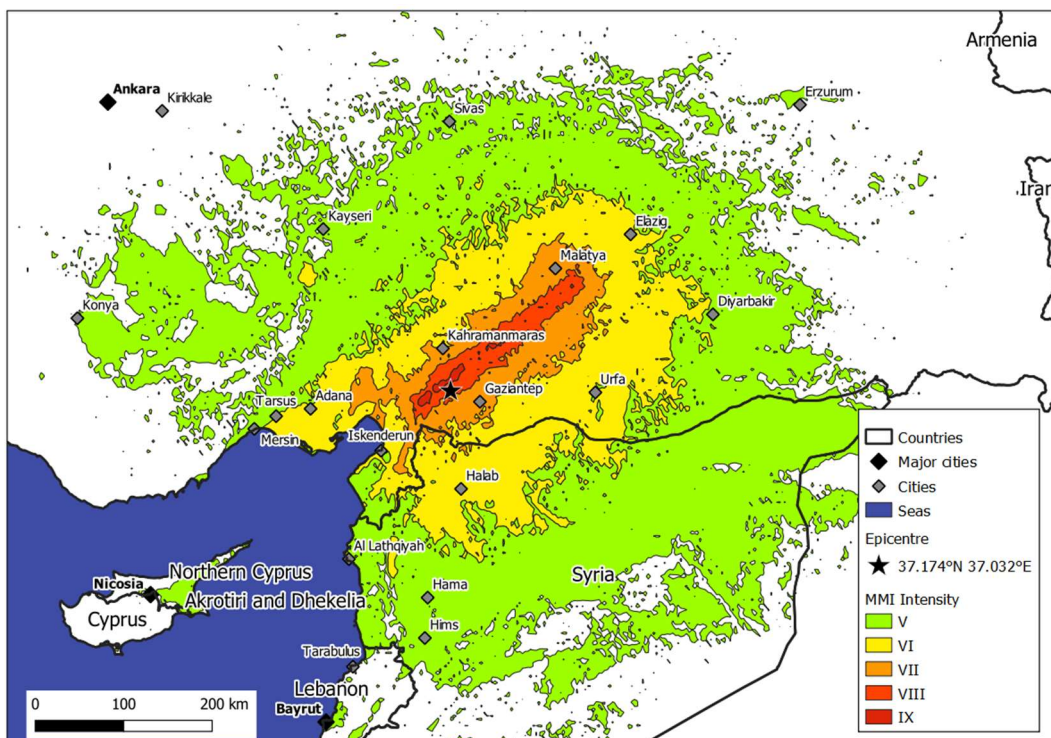


Figure 7 – Shakemap intensity of the M7.8 event.

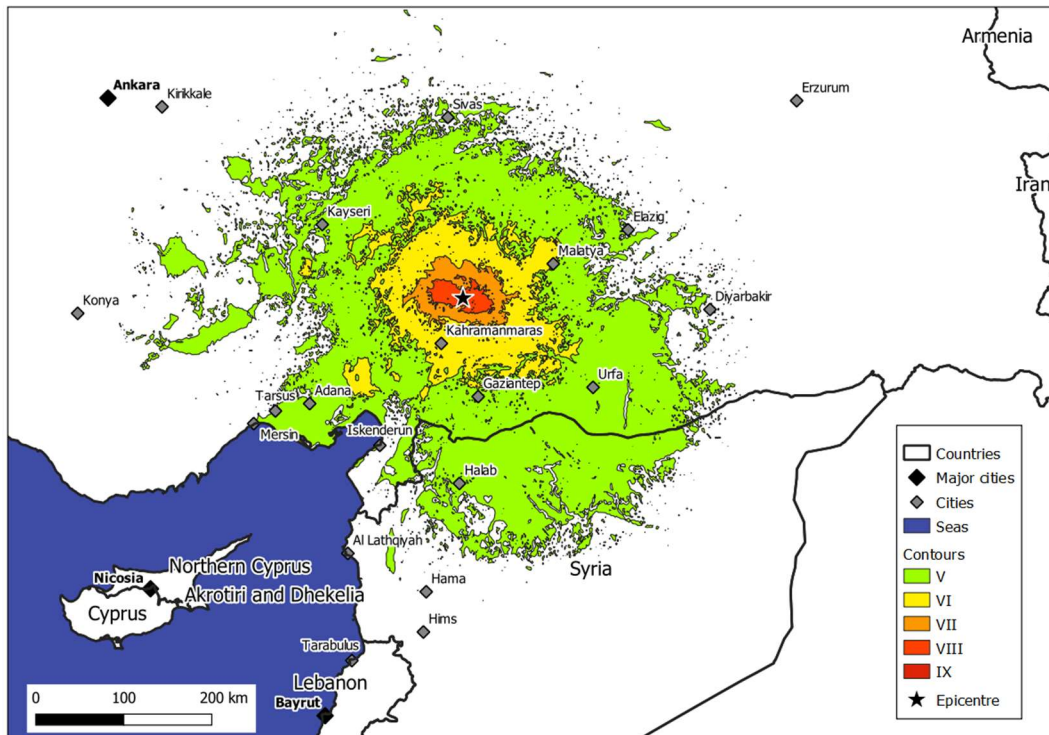


Figure 8 – Shakemap intensity of the M7.5 event.

1.4.2 Damage to critical energy infrastructures

Overall, the earthquake has damaged critical energy infrastructure in Turkey. There is damage to both power transmission lines and natural gas transmission and distribution lines. Approximately 30 substations belonging to Türkiye's Electricity Transmission Corporation (TEİAŞ) suffered varying degrees of damage. In addition, a major port in the Mediterranean coastal city of Iskenderun was partially damaged by the earthquake, with dozens of containers being toppled.

Gas pipeline rupture

Main event:

Due to the earthquake shaking, the state-owned **natural gas transmission pipeline** (operated by BOTAS), found at the southernmost Hatay Province in Turkey, was apparently **ruptured** in two sections (see Figure 7). The distance between the pipeline ruptures is roughly 3 km.

The biggest damage pertains to the rupture of the natural gas line in the Turkoglu district, which is close to the epicentre. This line is part of the main transportation line that carries natural gas to Marash, Gaziantep, Hatay and Kilis. The affected natural gas line in Kilis province continues to be fed from the gas inside the line. The affected areas may experience power outages.



Figure 9: Excerpt from the BOTAS pipeline network in Turkey showing the affected gas transmission pipeline influence area.

Consequences:

Explosion and fires in the two rupture points. It was estimated that the height of the flames was around 30 meters (100ft).

Precautionary measures:

- **Natural gas flows on the Kahramanmaraş-Gaziantep gas transmission line were halted** to Gaziantep, Hatay and Kahramanmaraş provinces and some other districts (Pazarcık, Narlı, Besni, Gölbaşı, Nurdağı, Islahiye, Reyhanlı, Kırıkhan and Hassa districts) near the epicentre as a result of the pipeline damage.
- BOTAŞ technical teams are carrying out the necessary controls and interventions in the field. In coordination with the natural gas distribution companies in the region, necessary studies are carried out to ensure safe gas flow to the citizens.
- All teams were immediately put on alert by BOTAŞ, and damage assessment studies were started by taking the necessary security measures.
- By establishing the necessary coordination with the natural gas distribution companies in the region, gas supply will continue to be provided by supplying CNG and LNG to critical facilities (such as hospitals, bakeries, etc.) through mobile power plants/ generators.

Ceyhan oil terminal

- Operations were suspended at the **Ceyhan oil terminal** (southern Turkey, 150 km from the epicentre) and an emergency meeting was being held on the issue. Ceyhan – a major oil export terminal on Turkey's Mediterranean – receives crude from two major cross-border pipelines: (i) the **Baku-Tbilisi-Ceyhan (BTC) pipeline** carries oil from fields offshore Azerbaijan across Georgia to Turkey's Mediterranean coast, (ii) the **Kirkuk-Ceyhan pipeline** transports oil from northern Iraq. Neither pipeline was damaged (according to Turkish pipeline operator Botas). Inspections are carried out and operations at Ceyhan will resume once an inspection has been finalised.
- Operations at the **port of Dörtöyl** (which sits across the Bay of Iskenderun from Ceyhan) are also suspended until further notice.

Oil pipelines

No damage to oil transmission pipelines has been reported to date. Oil exports through the pipeline connecting the Kurdistan region to Türkiye have been suspended to ensure the safety of oil exports and prevent any undesirable incidents.

Outlook

JRC will keep monitoring events over the next couple of days. Turkey keeps experiencing a series of shallow earthquakes with high magnitude; this may also mean that **industrial structures and equipment that were damaged during the first earthquake shock but did not have any release so far, might start releasing with the aftershocks if further damage happens.**

2.4.3 Overview of satellite mapping activations

The European Commission's Copernicus emergency satellite mapping system was activated by the ERCC on 6 February at 04:43 UTC to support damage assessment. The JRC Copernicus Mapping Team is providing technical support to the activity. All information and maps related to this activation (EMSR648) are available here:

<https://emergency.copernicus.eu/mapping/list-of-components/EMSR648>

Optical satellite imagery of very high resolution (less than 1 meter) will be acquired on 07 February over 20 areas of interest (AOIs) located close the epicenters of the earthquakes.

AOI n.	AOI name	area (km2)	Estimated population (source: GHSL via GDACS)	Status
1	Gaziantep	125.95	1.270.718	Planned / Waiting for satellite imagery
2	Adiyaman	62.47	220.725	
3	Diyarbakir	52.45	455.140	
4	Kahramanmaras	55.86	384.404	
5	Malatya	86.74	421.268	
6	Osmaniye	33.54	221.512	
7	Sanliurfa	60.23	410.832	
8	Pazarcik	7.21	22.978	
9	Cumhuriyet	12.44	25.260	
10	Islahiye	6.52	32.059	
11	Antiochia	84.62	383.809	
12	Erdemoglu	5.78	30.742	
13	Golbasi	5.93	27.283	
14	Duzici	9.96	52.238	
15	Bahce	3.52	13.558	

16	Nurdagi	3.55	10.644
17	Turkoglu	4.24	28.582
18	Kirikhan	11.86	65.212
19	Afsin	13.02	44.298
20	Elbistan	18.36	88.646
		664.25	4.209.908

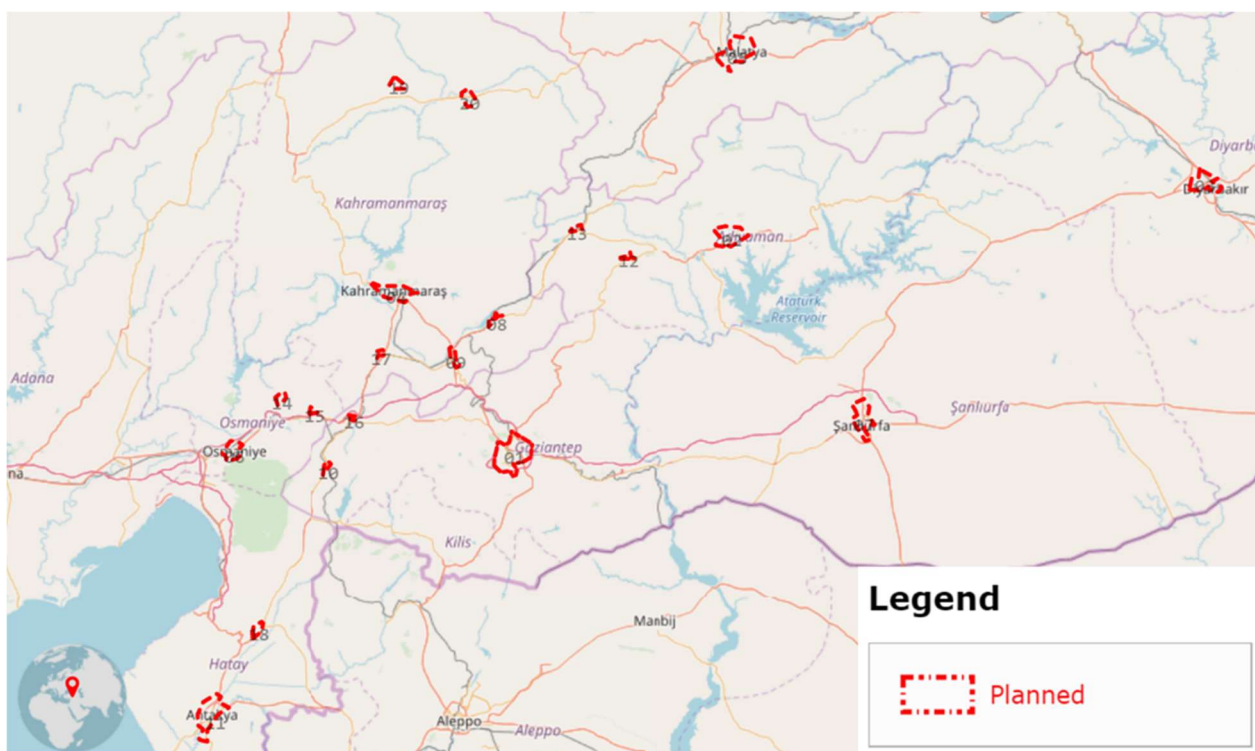


Figure 10 - Activation Extent Map, overview of the areas of interest and map production. Latest update [here](#)

The International Charter for Space and Major Disasters has been activated as well (available [here](#)).

1.4.4 Media coverage and social media activity

The Social media for Disaster Risk Management (SMDRM) platform has been triggered by GDACS system for 2 data collections. The main one refers to the event with GLIDE : [EQ-2023-000015-TUR](#).

This section aims to show a representative selection of Tweets of what is happening in Türkiye in real time. The JRC developed an artificial intelligence deep learning model for the automated multilingual classification of messages and images from social media in terms of impacts on population/infrastructure/services with the scope of supporting humanitarian aid (see methodology section below). We set up an automated processing pipeline for filtering impact related tweets. In few hours our tool aggregates and present relevant information as well as some meaningful message and images that can help depicting the situation among population. We favour information with statement from authoritative sources.

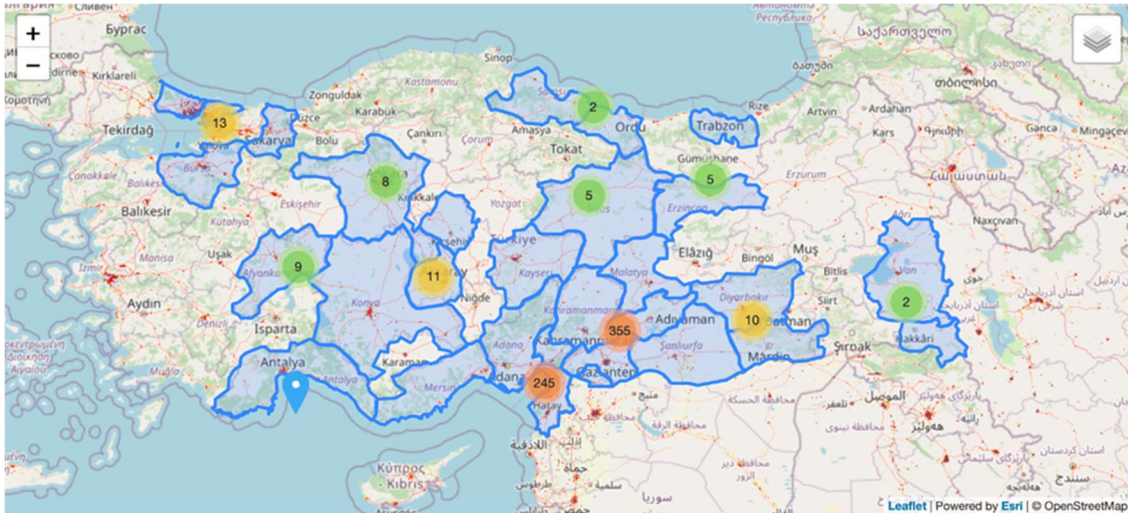


Figure 11 - Country-wide image of non-duplicated georeferenced posts relevant to impacts aggregated by Administrative regions.

A heatmap of the most mentioned locations in media (source EMM data via EIOS – Epidemic Intelligence from Open Sources) indicates that most mentions are referring to South-Western Syria.

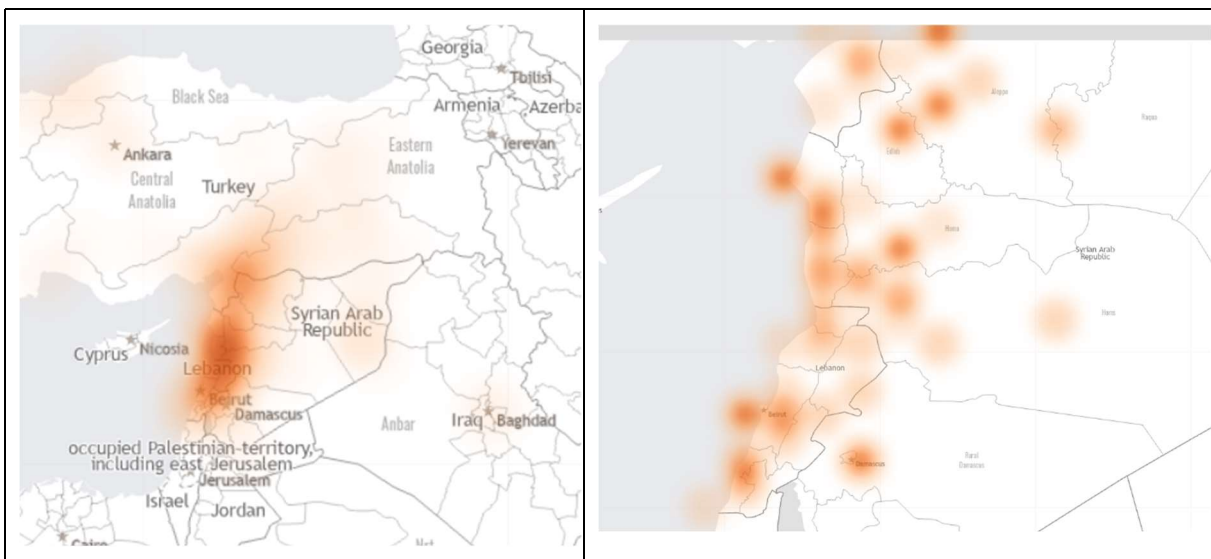


Figure 12 - Heatmap of most mentioned locations in media (source EMM data via EIOS – Epidemic Intelligence from Open Sources). Most mentions are referring to South-Western Syria.

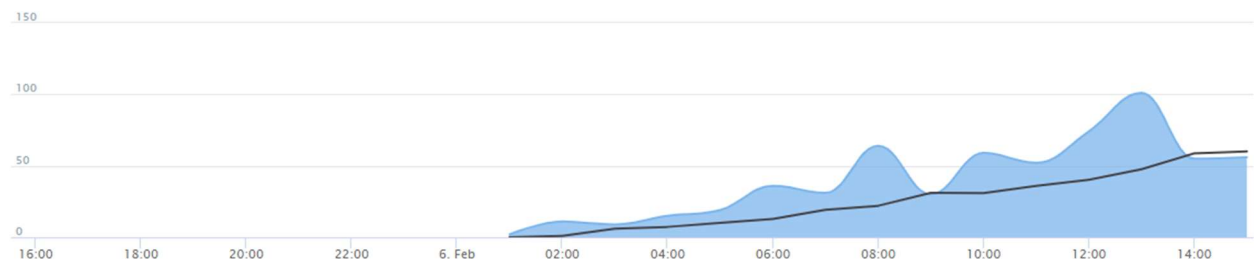


Figure 13 – Volume of media reports over time covering the event (source EMM data via EIOS – Epidemic Intelligence from Open Sources).

1.4. International Assistance

International assistance was requested by the Republic of Türkiye shortly after the event.

The Emergency Response Coordination Centre-ERCC is coordinating the mobilization of the EUCPM. The following modules are being deployed:

- Medium urban search and rescue teams (MUSAR): Croatia, Bulgaria (x 2 teams), Greece, Hungary, Italy, Malta, Romania, Spain (x 2 teams), Slovakia and Austria
- Heavy urban search and rescue teams (HUSAR): Czech Republic, France (x 2 teams), Netherlands, Poland

UN OCHA activated the United Nations Disaster Assessment and Coordination (UNDAC) team. Teams from other countries including Algeria, Georgia, Japan, Jordan, Malaysia, Qatar, Russian Federation, Switzerland and USA are also mobilizing.

Some Search & Rescue Teams already managed to reach the affected area. Other specialized teams are being made ready for deployment.

All teams are getting ready to work in severe weather conditions.

A dedicated emergency was opened in the GDACS session of the Virtual On Site Operational Coordination Centre (VOSOCC) managed by UN OCHA. The teams already deployed or ready to be deployed in the area for Search& Rescue activities are exchanging information.

1.5. Meteorological situation

The **Turkish State Meteorological Service** is reporting high risk of snow. No further meteorological alerts are in place for the Gaziantep region, where the highest intensities are expected, however the nearby Adana and Kahramanmaraş regions are under orange alert for low temperatures.

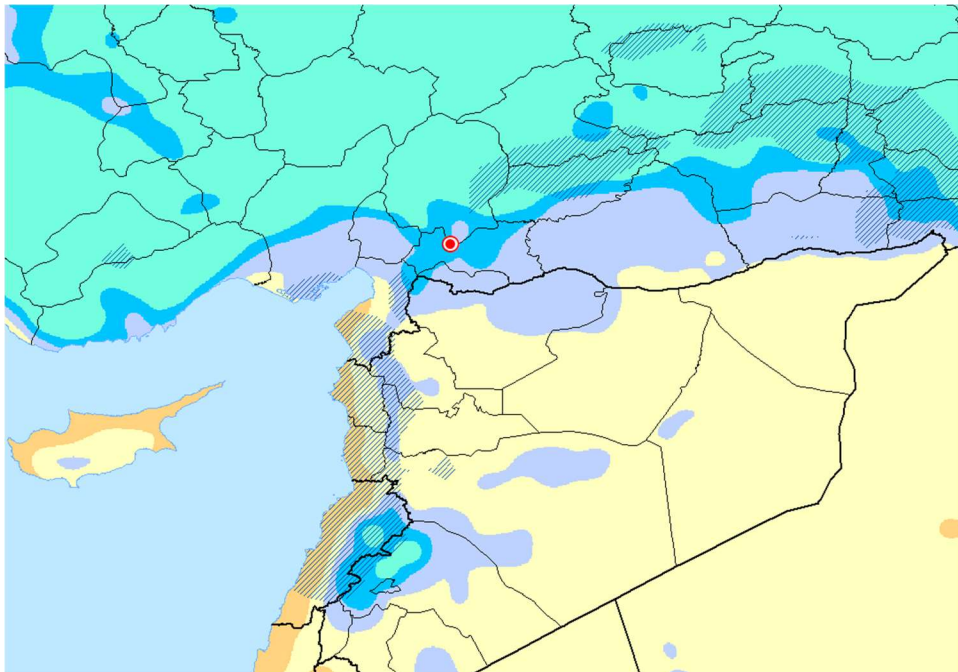


Figure 14 - Minimum temperature forecast NOAA GFS (cyan under -10°C , blue -5°C to -10°C). Dashed lines are 7 days precipitation forecast of 75-250 mm.

2. Activities performed by JRC

GDACS Alerts

The Global Disaster Alert and Coordination System (GDACS) emitted a **Red** alert for the M7.8 event:

<https://gdacs.org/report.aspx?eventid=1357372&episodeid=1487096&eventtype=EQ>

Daily Flash and Daily Maps

The JRC European Crisis management laboratory Team (ECML) provided DG ECHO/ERCC with a summary of the event, and will keep providing frequent updates in the following days to monitor the situation.

DG ECHO/ERCC requested the following ECHO Daily Map to be released this afternoon to inform the whole DG ECHO community on the impact and the response to the events:

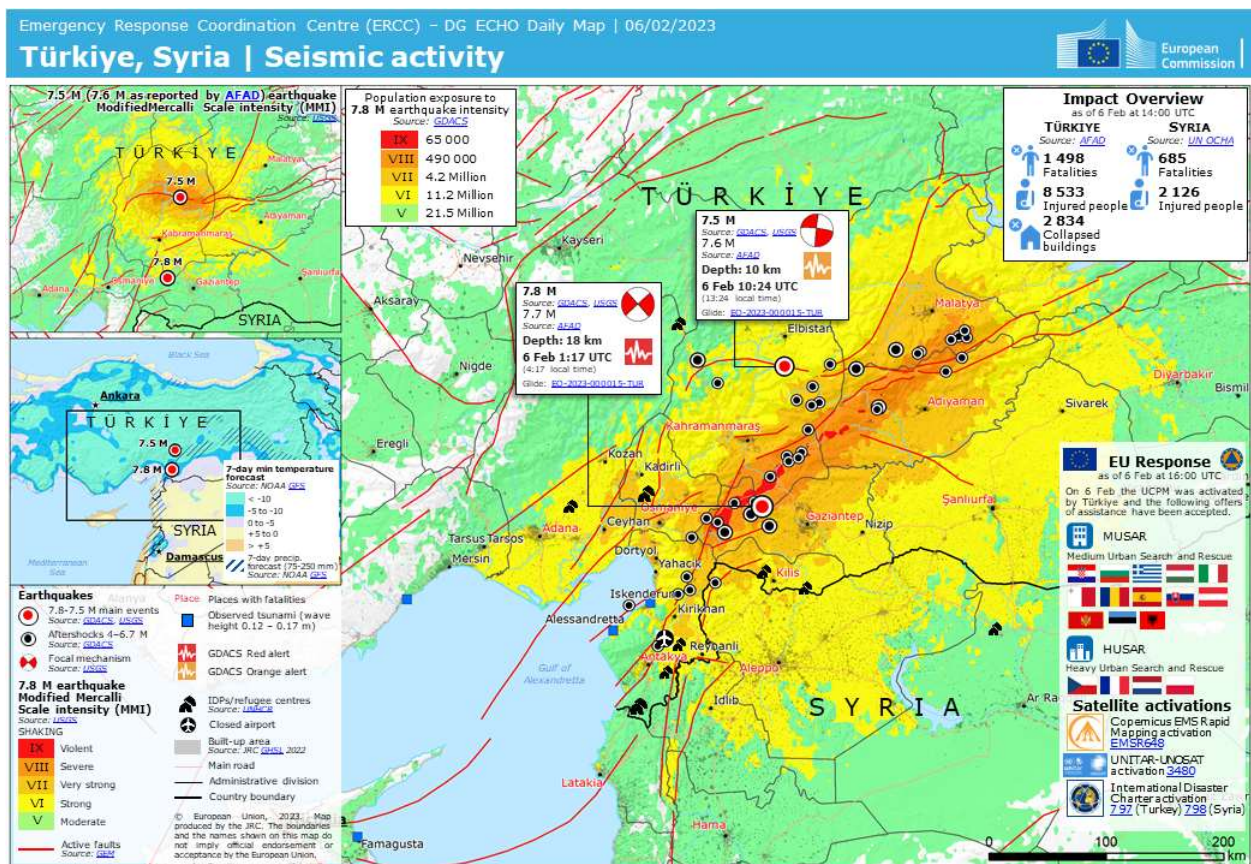


Figure 15 – Daily Map of the events.

3. Expected Updates

The report will be updated upon need to monitor the event and the response activities.

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For updated information on the disaster, please consult the following web sites:

- GDACS: <https://www.gdacs.org>
- ERCC portal: <http://erccportal.jrc.ec.europa.eu/>
- National Meteorological service:
 - Türkiye: <https://www.mgm.gov.tr/eng/forecast-cities.aspx>
 - Syria: <http://www.meteo.sy/> (NOT ACCESSIBLE)

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