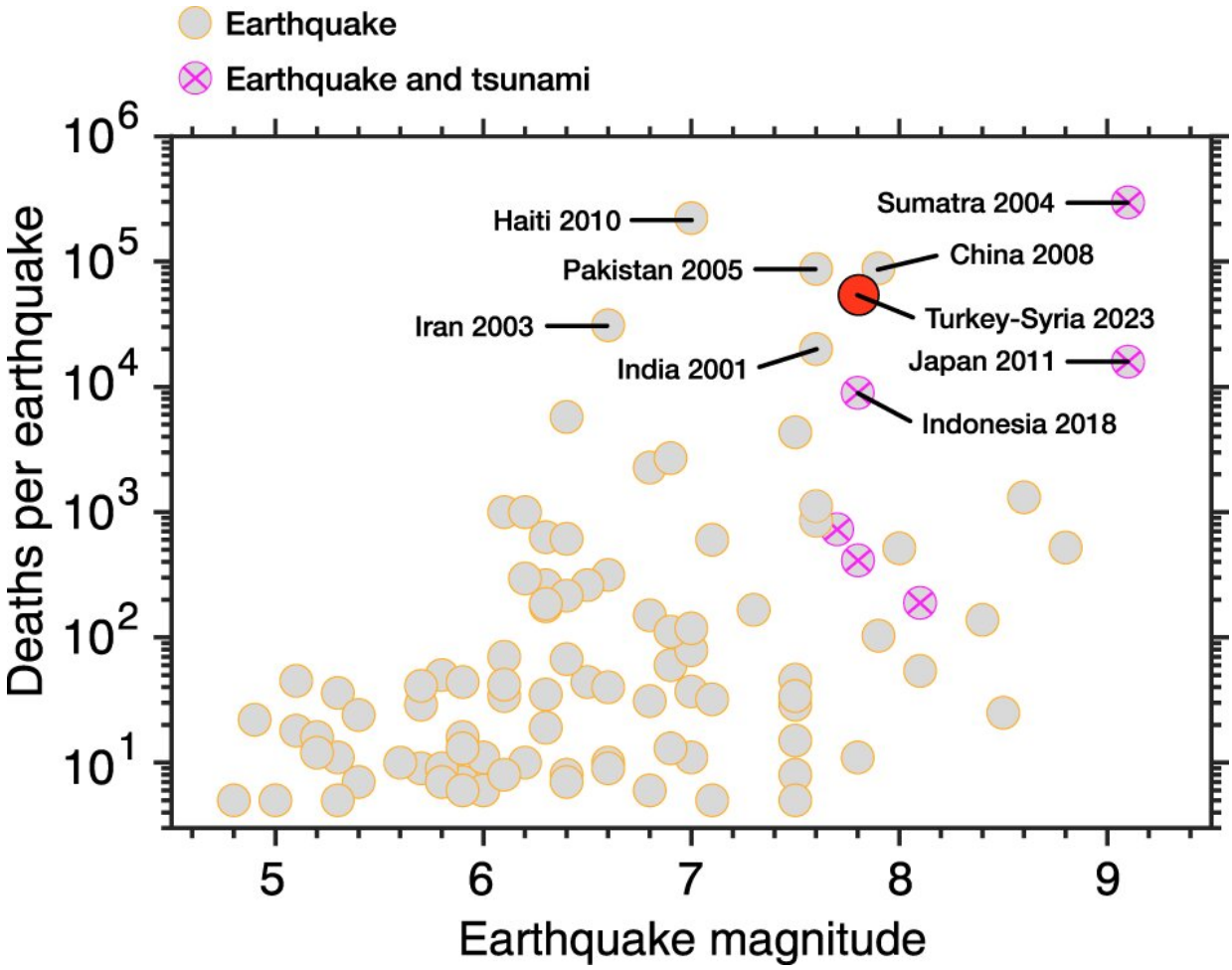
Earthquake in Turkey was a doublet: First quake triggered second in neighboring fault

March 30 2023, by Peter Rüegg



Deaths from earthquakes since 2000. The toll of the Turkey and Syria quakes is one of the highest of any previous magnitude-7.8 event, and the fifth worst earthquake since 2000. Credit: *Communications Earth & Environment* (2023). DOI: 10.1038/s43247-023-00747-z

ETH Zurich researcher Luca Dal Zilio offers an insightful summary of the recent earthquakes in Turkey and Syria, shedding light on the complex nature of this event. He discusses the lessons that can be drawn from it to better understand and prepare for future seismic occurrences in the region.

ETH News: You and your colleague Jean-Paul Ampuero from Geoazur have just published a commentary on the early February earthquakes in Turkey in the scientific journal *Communications Earth & Environment*. What's new?

Luca Dal Zilio: The two powerful earthquakes that hit Turkey and Syria on 6 February 2023 were of similar magnitude (7.8 and 7.6) and only nine hours apart. These events are referred to as an earthquake doublet because they are a pair of powerful earthquakes that have centroids closer than their rupture size and occur within a time frame that is shorter than the recurrence time inferred from the plate motion.

There was long talk of an exceptionally strong aftershock.

The second earthquake in this case wasn't a typical aftershock, as it was almost as strong as the first one and occurred on a different, nearby fault . According to Bath's Law, the largest aftershock is usually about 1.2 magnitudes smaller than the main earthquake. A series of earthquakes like the recent events in Turkey and Syria has its own unique features. Studying these events helps us learn more about earthquakes and improves our ability to predict them.

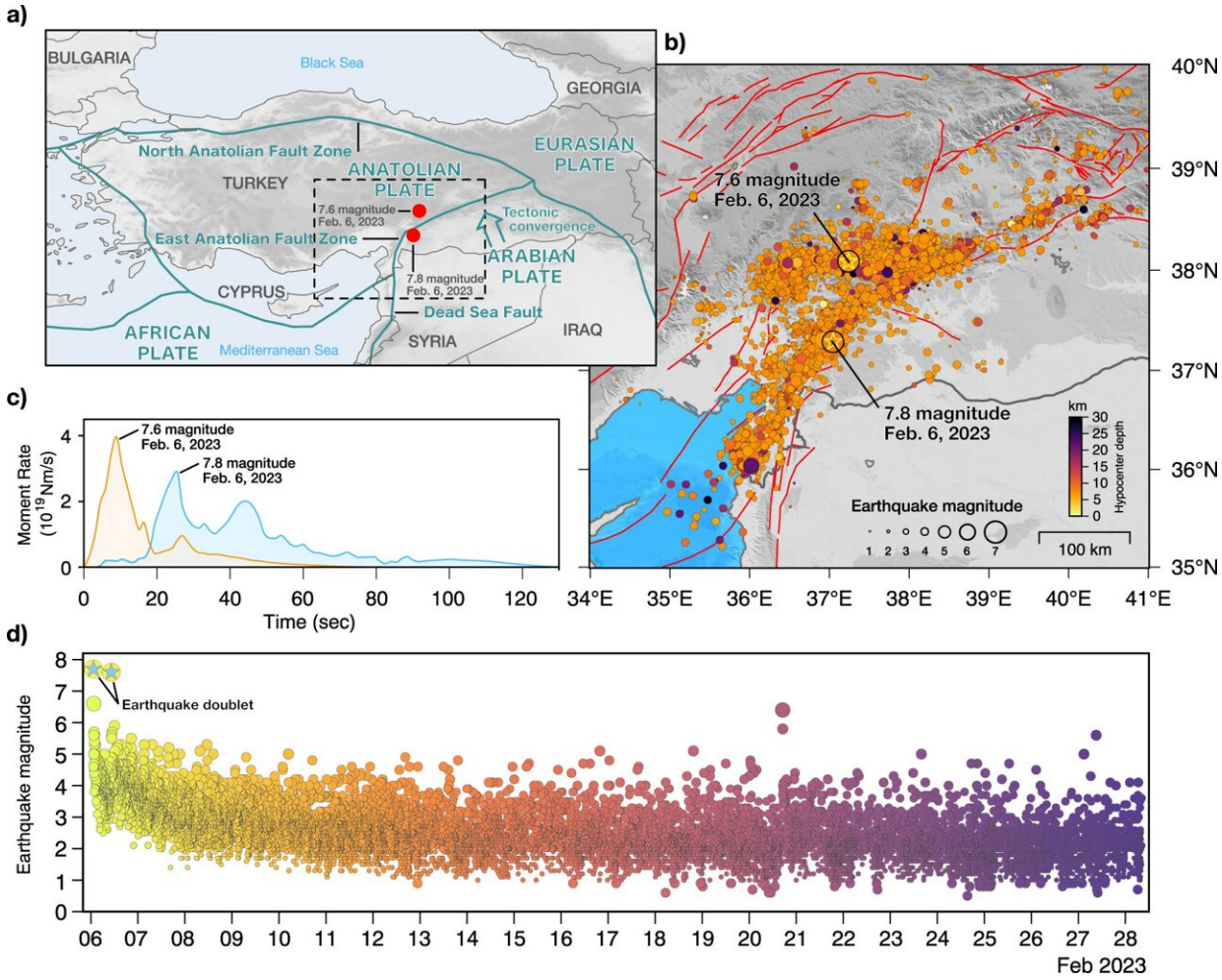
Why did an earthquake doublet occur?

The first earthquake probably contributed to an increase in static stress

in the area where the second event occurred. While this increase may not have been substantial, it could have been sufficient to set off the second event just hours later. This suggests that both faults were under critical stress. The first earthquake might have given a final nudge to the second fault zone, which had accumulated stress over decades and was already critically loaded. Further research will help us better understand this aspect of earthquake interaction.

What can be learned from your analysis for the reconstruction of towns and villages in the regions affected?

Significant damage cannot be avoided in earthquakes of this magnitude, especially when cities are located exactly on seismically active fault lines, causing large surface displacements of six to eight meters. This event underscores the need to better understand the strong ground motion near a fault and to update risk management practices—for instance, by calculating how stress transfer has changed the hazard probability in the region. Ideally, we should also find out to what extent strong mainshocks have changed the stability of buildings and increased their vulnerability to aftershocks.



Tectonic setting and seismicity caused by the 2023 Kahramanmaraş Earthquake Sequence. a The inset map shows the large-scale geodynamic context indicating the two main strike-slip faults that delineate the Anatolian block: the East Anatolian Fault and the North Anatolian Fault. Known and mapped surface traces of the main faults are shown as dark gray lines. b First month of relocated seismicity as a function of magnitude and depth, including the main two events and aftershocks. Fault lines are indicated in red. c Source time functions of both events of the main two events are provided by the US Geological Survey (USGS). d Temporal evolution of seismicity in the month of February 2023. The yellow-to-purple color scheme indicates the temporal evolution of seismicity. The two stars indicate the earthquake doublet. The seismic catalog is provided by the Disaster and Emergency Management Authority of Turkey (AFAD). Credit: *Communications Earth & Environment* (2023). DOI: 10.1038/s43247-023-00747-z

Haven't we long been aware of the high seismic hazard and the associated extreme risk for this region?

Yes, various European institutes—including ETH Zurich and the Swiss Seismological Service—have put a lot of effort into calculating the earthquake hazard across Europe in recent years. Thanks to these efforts, we now have an earthquake hazard map of Europe that everyone can access. This map shows that the North Anatolian Fault and the East Anatolian Fault—both of which run through Turkey—are two of the most active fault systems in Europe and the world and thus pose a major seismic hazard to the region.

The North Anatolian Fault, on which Istanbul is located, also poses a significant risk. There were several earthquakes along this fault in the last century. These events have now left a seismic gap south of Istanbul and beneath the Sea of Marmara, a gap that has not been filled for 250 years. Seismologists often refer to such regions as seismic gaps because they are sections of a fault system where little or no seismic activity has occurred over an extended period of time, even though neighboring sections have been affected by earthquakes. We assume that these are areas along a fault where stresses accumulate before releasing an enormous amount of energy all at once, which can result in powerful earthquakes.

How does the future look and what will happen next?

In summary, the current focus is on dealing with the tremendous loss of life and property. In the months and years ahead, several follow-up studies to our report will provide a further insight into this catastrophic event. We hope to be able to learn from this to make buildings safer and to better prepare for such events. As scientists, we hope that this event

can provide valuable insights into the mechanics of faults and the physics of earthquakes.

More information: Luca Dal Zilio et al, Earthquake doublet in Turkey and Syria, *Communications Earth & Environment* (2023). DOI: 10.1038/s43247-023-00747-z

Provided by ETH Zurich