Introduction to the special issue on the October 30, 2020, M_w 7.0, Samos Island, Greece, earthquake

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On October 30, 2020, the eastern Aegean Sea and western Turkey areas were struck by the largest earthquake to occur in the region in the last decades. The M_w 7.0 earthquake occurred offshore and close to the north coastline of Samos Island, Greece, because of the Aegean and Anatolian portions of the crust being pulled apart by north–south extensional stresses, which has been suggested as resulting from slab rollback, at the region where the eastern Mediterranean oceanic plate is subducting northwards beneath Eurasia. The mainshock generated severe ground shaking in Samos and the greater Izmir area causing several deaths and serious injuries, with economic and social impacts on the local population bound to be long-lasting. In Samos Island, two young people, 16 and 17, a young couple, coming back from school and walking through a narrow street, lost their lives as they passed close to an old warehouse that collapsed. The coincidence was tragic. In Izmir, Turkey, even though this city is farther from the epicenter (~ 75 km), the damage was more prominent due to the urban population density and type of structures. In Izmir, everyday people and authorized teams looked for casualties and survivors in the damaged multistory buildings for several days after the mainshock. According to the media, 119 people died, 1053 injured, and 15,000 were left homeless in Izmir.

Unravelling the secrets of the sequence and the geodynamics of the area is the crucial point of this special issue of *Acta Geophysica* aimed at gathering a suite of articles on detailed investigations and syntheses in all phases of scientific and engineering work about the Samos earthquake, as

well as papers on post-earthquake response and public policy matters. This issue would not have been possible without the contribution of our fellow guest editors: Eleftheria Papadimitriou and Vassileios Karakostas, from the Aristotle University of Thessaloniki. Understanding the mechanism and recurrence of earthquakes such as the Samos event is extremely important for regional seismic hazard assessment, to help reduce the risk of people being subjected to another tragic event, and scientifically since little is known about the link between deep tectonic processes and upper crustal deformation in the region.

The article “Seismotectonic implications of the 2020 Samos, Greece, M_w 7.0 mainshock based on high-resolution aftershock relocation and source slip model” investigates the aftershock evolution and the properties of the activated fault network employing aftershock relocations using the double-difference and cross-correlation techniques. They show a well-defined E–W activated structure. A simultaneous inversion of teleseismic and strong motion waveforms indicated an N-dipping plane for the mainshock with a slip patch of $36 \text{ km} \times 22 \text{ km}$ and a maximum slip of 1 m at 12 km depth. The slip is mainly concentrated in a single asperity implying a rupture mode of asperities breaking in isolated earthquakes rather than a concatenation that produces a more significant rupture. Coulomb stress calculations highlight increased positive stress changes at the locations of most of the aftershocks and activation of minor fault segments by stress transfer.

In the article “Co-seismic and postseismic deformation, field observations and fault model of the October 30th, 2020, $M_w = 7.0$ Samos earthquake, Aegean Sea,” the authors report on the deformation field caused by the earthquake and its implications for regional tectonics. Using InSAR displacement data from Sentinel-1 interferograms, they invert for the fault parameters. Near the inferred fault, they measure a permanent uplift of the Island up to 10 cm. A postseismic signal with 22–33% of the coseismic displacement on the vertical component was observed at GNSS

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stations SAMO and SAMU. They also report effects of the earthquake, including liquefaction, rock falls, rock slides, road cracks, and deep-seated landslides, all due to the strong ground motion and associated downslope mobilization of soil cover and loose sediments.

In the article “On Rapid Multidisciplinary Response Aspects for Samos 2020 M7.0 Earthquake” the authors combine existing knowledge geodatabases concerning historical seismicity and rupture zones with seismological and geodetic measurements as well as with results of modeling and in situ observations to provide an assessment of rapid response to the seismic event. They propose that a multidisciplinary approach can efficiently address rapid response issues to allow effective preliminary interpretation of the earthquake activity, even within the first 24 h of the event. The study highlights the readiness level of the various domains that have been significantly improved over the past years, including rapid seismological solutions, systematic availability of free and open Earth Observation data, and on-demand online processing through dedicated platforms. The combination between routinely applied inversion modeling and timely in situ observations is proposed to improve operational response levels.

In the article “On the origin of upper crustal shear-wave anisotropy at Samos Island, Greece,” the authors associate shear wave splitting to different sources in the upper crust. They consider oriented minerals, stress-aligned microcracks, and tectonic structures as causes of seismic anisotropy. They employ data from the 2020 Samos Mw = 7.0 event and its associated aftershocks to study regional shear wave splitting characteristics. They searched for appropriate earthquakes in five years preceding the mainshock and performed an automatic analysis on over 200 event-station pairs obtaining high-quality splitting observations between January 2015 and November 2020. Results indicated a strong connection to local structures since fast S-polarization axes align with faults in the area. However, they also observed a period of increasing and decreasing time delays associated with an Mw = 6.3 earthquake that occurred in June 2017 near Lesbos Island. This behavior implies the possibility of stress-induced anisotropy in the area.

The article “Scaling properties of the Mw7.0 Samos (Greece), 2020 aftershock sequence” aims to provide a first analysis of the scaling properties observed in the aftershock sequence as reported until December 31, 2020. The analysis focused on the primary cluster observed in the eastern area of the activated fault zone strongly related to the main rupture. The aftershock sequence follows the Omori law with a value of $p \approx 1.01$ for the primary cluster, remarkably close to a logarithmic evolution. The analysis of interevent times distribution, based on non-extensive statistical physics, indicates a system in an anomalous equilibrium with a crossover from anomalous ($q > 1$) to normal ($q = 1$). The

obtained value $q \approx 1.67$ suggests a system with one degree of freedom.

The study “Short-term clustering modelling of seismicity in Eastern Aegean Sea (Greece): A retrospective forecast test of the 2017 Mw = 6.4 Lesbos, 2017 Mw = 6.6 Kos and 2020 Mw = 7.0 Samos Earthquake Sequences” investigates the short-term earthquake clustering properties in the Eastern Aegean Sea (Greece) area through the application of an epidemic type of stochastic model (Epidemic Type Earthquake Sequence; ETES). The authors employ a background sub-catalog from 2008/01/01 to 2016/12/31 for the learning period for the model’s parameters estimation. Then, a second sub-catalog from 2017/01/01 to 2020/11/10 in which the sequences of 2017 Mw = 6.4 Lesbos, 2017 Mw = 6.6 Kos, and 2020 Mw = 7.0 Samos mainshocks are included, is used for a retrospective forecast testing based on the constructed model. The estimated model parameters imply a swarm-like behavior, indicating the ability of earthquakes of small-to-moderate magnitude above M_c to produce their offsprings, along with the stronger earthquakes. The retrospective evaluation of the model is examined in the three aftershock sequences, where lack of foreshocks resulted in low predictability of the mainshocks, with estimated daily probabilities around 10–5. Immediately after the mainshock’s occurrence, the model adjusts well between the expected and observed aftershock rates, particularly for earthquakes with $M \geq 3.5$.

The authors of “Updating the macroseismic intensity database of 19th-century damaging earthquakes in Greece—A case study in Samos Island” analyze studies containing descriptive information on earthquake effects in Greece from the non-instrumental period 1800–1899 from which they assign EMS98 macroseismic intensities. Their goal was the enrichment of macroseismic datapoints (MDP) contained in the Hellenic Macroseismic Database (HMDb.UoA) and the Archive of Historical Earthquake Data (AHEAD). Compared to the MDPs presented in the 20 Hellenic Macroseismic database, the total number of MDPs from the present study is more than double. Based on the information provided by the analysis, intensities were re-assigned for all events. The macroseismic parameters of one of the newly incorporated earthquakes were determined, and the seismic picture of the Island showed that two earthquakes, similar to the October 30, 2020, Samos event, occurred in the nineteenth century. The additional earthquake intensities improve the seismic picture and allow for more accurate risk parameters assessment.

The study “Post-event field observations in the İzmir–Sığacık village for the tsunami of the October 30th 2020 Samos–Kuşadası earthquake (Mw 6.9)—Western Turkey” first focuses on details of the destruction in villages of Greece and Turkey, reporting intensity reaching a maximum of VII in İzmir–Bayraklı. Next, the authors discuss a tsunami that followed the mainshock and hit many

villages around Samos and the Kuşadası bay. They mention that Sığacık village of İzmir–Turkey suffered heavily from the tsunami. A post-event field survey in Sığacık conducted on October 31, 2020, reports low depth, run-up, and inundation limits. The authors attribute high run-up values to the elongated geometry of the Sığacık bay, the shallow seafloor, the low and morphology in Sığacık, and to the existence of four > 70-m-long E–W trending channels. The authors also discuss the difficulty of paleo-tsunami surveys in the Aegean Sea region.

In the article “First evidence of the non-extensive character of pre- and postseismic deformation of Samos (2020) Mw7.0 earthquake,” a study of surface displacements using continuous GNSS measurements in the vicinity of the 2020 Mw7.0 Samos (Greece) is presented. The GNSS time series before and after the mainshock in SAMO station (belonging to METRICA SA HexagonSmartNet commercial network) demonstrate significant surface deformation in the broader epicentral area. The authors also analyze the surface displacement increments a few days before and after the mainshock using the non-extensive statistical physics (NESP) framework to provide a basis to study the complexity of the earthquake process. The analysis results suggest that the statistical distribution of ground displacement increments presents asymptotic power-law behavior that deviates from the standard Gaussian function. The observed distributions are described by the q-Gaussian function, for q-values in the range of 1.10–1.15. The statistical pattern obtained from the analysis is discussed in terms of superstatistics, indicating

that the ground displacement increments a few days before and after the mainshock correspond to a system with high enough degrees of freedom of the order of 13–15. The results support the non-extensive character of displacement increments using 4 years of recordings suggesting long-range temporal correlations.

Finally, the authors of “Stress field estimation by the geoid undulation of the Samos–Kuşadası Bay and earthquake hazard implications” correlate the effective elastic thicknesses (EET) of the lithosphere seismogenic layer thickness to understand the nature of the earthquakes in the region. They determine that the seismogenic layer’s upper and lower depth limits are in a range of 5 to 15 km, meaning that the earthquakes in the study area are bound to the upper crust. They argue that the seismogenic layer and effective elastic thicknesses are close to each other, indicating that the earthquakes are tightly connected to the elastic–brittle portion of the crust. They further estimate the stress field from the geoid undulations as a proxy of gravitational potential energy. The results delineated edges of gravity anomalies that reveal some previously unknown features.

Declarations

Conflict of interest On behalf of all authors, the corresponding author states that there is no conflict of interest.