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SYNTHETIC EARTHQUAKE CATALOGS SIMULATING SEISMIC ACTIVITY IN THE CORYNTH GULF, GREECE, FAULT SYSTEM

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Introduction

The characteristic earthquake hypothesis is the basis of time-dependent modeling of earthquake recurrence on major faults, using the renewal process methodology. However, the characteristic earthquake hypothesis is not strongly supported by observational data. Few fault segments have long historical or paleoseismic records of individually dated ruptures, and when data and parameter uncertainties are allowed for, the form of the recurrence-distribution is difficult to establish. This is the case, for instance, of the Corinth gulf fault system, for which documents about strong earthquakes exist for at least two thousand years, but they can be considered complete for magnitudes $\geq$ 6.0 only for the latest 300 years, during which only few characteristic earthquakes are reported for single fault segments.

The seismicity of the Corinth Gulf Fault System (CGFS)

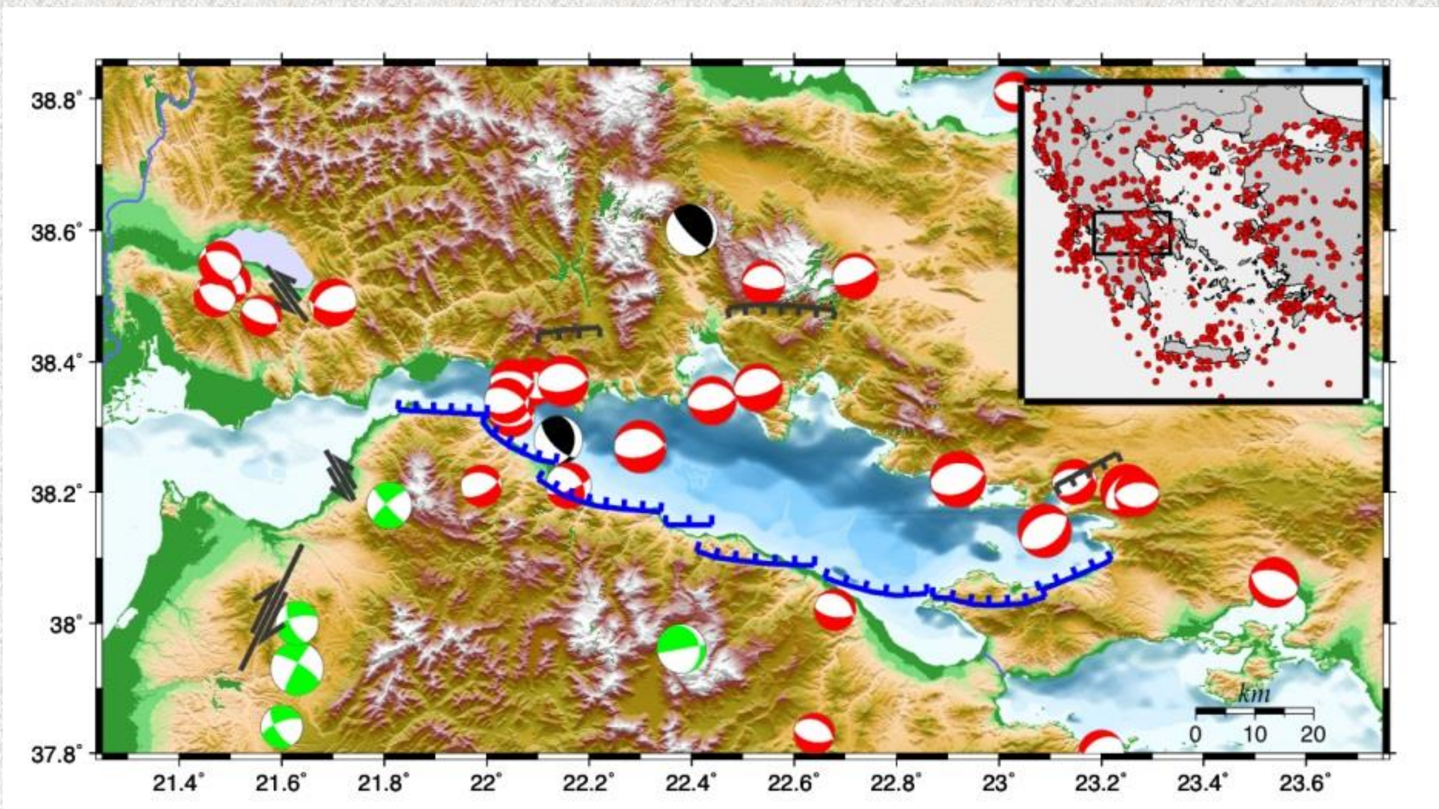


Fig. 1 – Seismotectonic setting of the Corinth gulf area with all known active faults. The fault segments bounding the southern coastline are traced in blue color. Fault plane solutions of M$\geq$5.0 that occurred in the last few decades are plotted as equal area lower hemisphere projections.

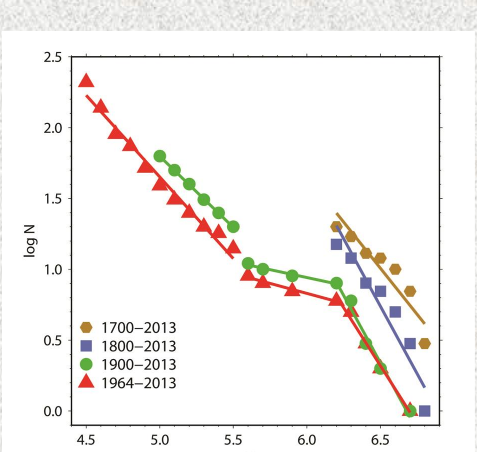


Fig. 2 – Cumulative frequency of the earthquakes observed in the Corinth gulf area in relation with their magnitudes for four different complete data sets.

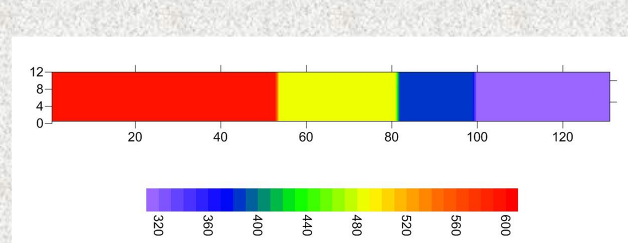


Fig. 4 – Map of the total slip released during a simulation of 100,000 years of seismic activity across the CGFS. The color scale gives the slip in m.

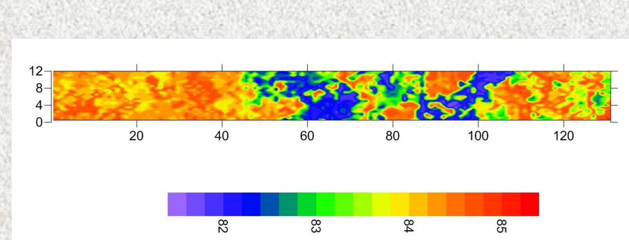


Fig. 5 – Map of the stress budget available after a simulation of 100,000 years of seismic activity across the CGFS. The color scale gives the stress in MPa.

Algorithm of the simulator code

The main features of our simulation algorithm are (1) the imposition of an average slip rate released by earthquakes to every single segment recognized in the investigated fault system, (2) the interaction between earthquake sources, (3) a self-organized earthquake magnitude distribution, and (4) the effect of minor earthquakes in redistributing stress.

The seismogenic source is approximated as a rectangle, divided into an arbitrary number of segments characterized by different slip rates, but without constituting any barrier to rupture growth.

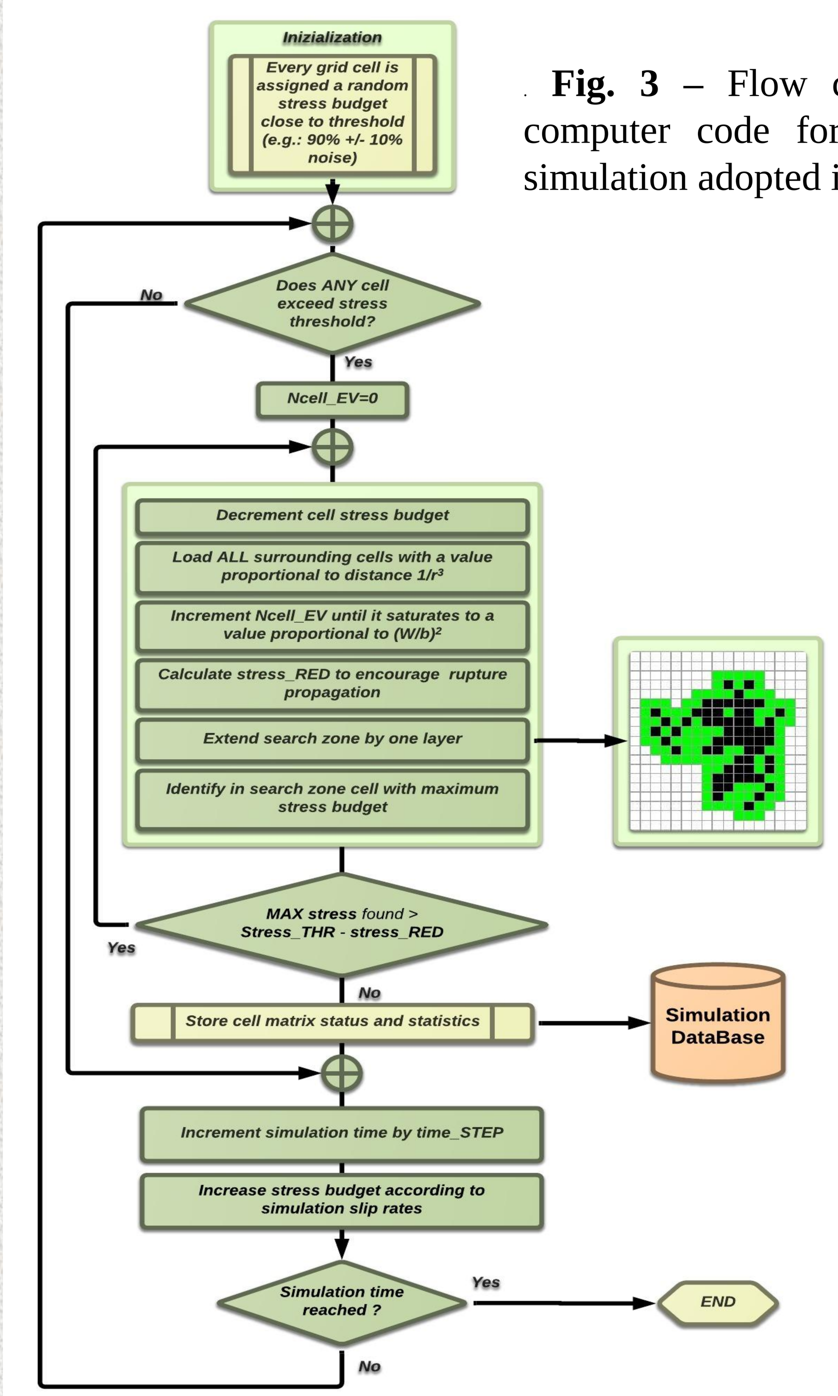
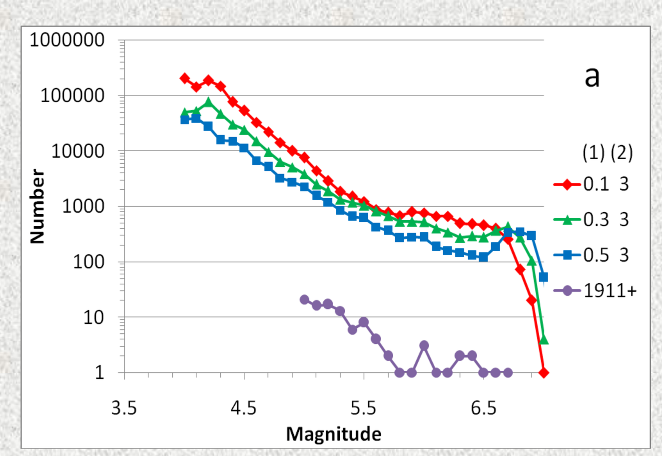


Fig. 3 – Flow chart of the computer code for earthquake simulation adopted in this study

The use of a physics-based earthquake simulator has allowed the production of catalogs lasting 100,000 years and containing more than 500,000 events of magnitudes $\geq$ 4.0.



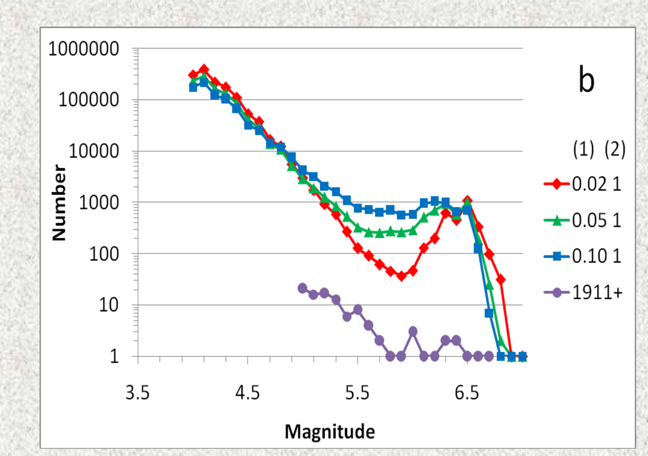


Fig. 6 – Frequency–magnitude distribution of the earthquakes in the synthetic catalogs obtained from the simulation algorithm with different combinations of two free parameters. Labels (1) and (2) refer to the values of parameters "strength reduction coefficient" and "fault aspect ratio" respectively. The total seismic moment released by the events in all the synthetic catalogs is the same. The bottom data refer to the earthquakes observed in the area starting in 1911. The combination adopted in this study is 0.10 (1) and 1.0 (2).

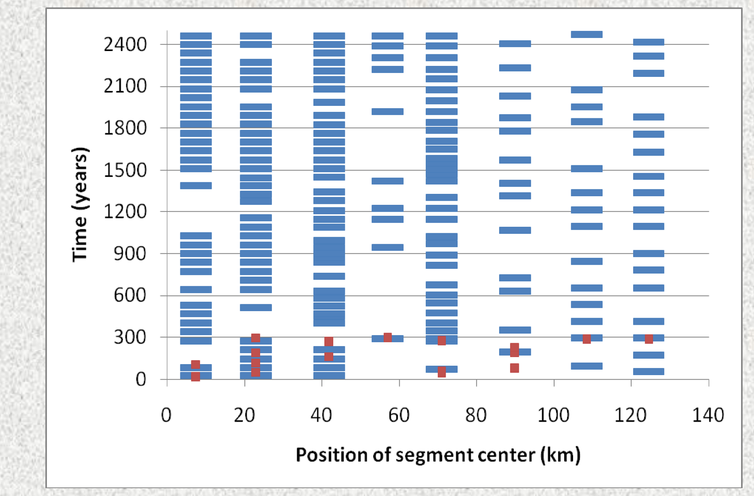


Fig. 7 – Space–time features of synthetic catalogs concerning earthquakes with M$\geq$6.0 for the first 2500 years (blue bars). Red squares show the occurrence time and location of the observed earthquakes.

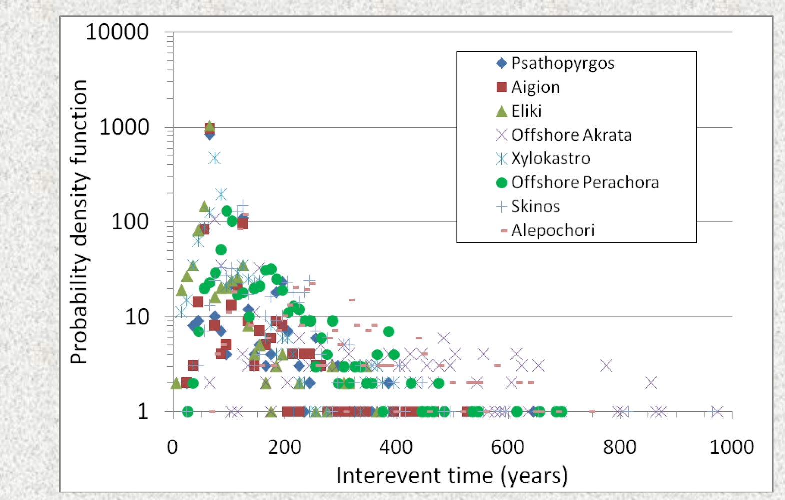


Fig. 8 – Inter-event time distribution from a simulation of 100,000 years of seismic activity across the CGFS.

Table 1. Number of simulated earthquakes rupturing a different number of segments

Number of segments	Number of events
1	3112
2	947
3	691
4	43
5	21
6	2
7	0
8	0

Table 2. Number of simulated earthquakes rupturing a single segment or with several segments associated to the same rupture

Segment number	Single segment rupture	Multi-segment rupture
1	266	944
2	175	1095
3	513	1000
4	32	326
5	845	371
6	604	77
7	412	232
8	265	211

Conclusions

1 - The magnitude-distribution of the simulated seismicity is consistent with observations, which support a characteristic earthquake hypothesis.

2 - The calculated average repeat times of strong earthquakes for each segment appear consistent with those inferred from the historical seismic catalog.

3 - The long period of simulations has allowed obtaining the statistical distribution of repeat time – an indispensable component for any seismic hazard analysis, which cannot be obtained from real observations, due to their short duration. The statistical distribution of earthquakes with M$\geq$6.0 on single segments exhibits a fairly clear pseudo-periodic behavior, with a coefficient of variation C_v of the order of 0.6.

4 - We have found clustering of the stronger events (multiplets) – a feature that can be inferred even from the limited time period covered by the observations.

5 - The synthetic catalog obtained from the simulations clearly shows the effect of smaller events clustering near to stronger ones (aftershocks). This effect appears to be very short in time – a peculiarity of the study area also observed in the evolution of real aftershock sequences.

6 - None of the above reported conclusions need a segmented rupture model, but they are all consistent with a fully unsegmented seismogenic fault model.

7 - The statistical features of the seismicity obtained from the simulation algorithm, easily computable from the long inter-event times series, can provide useful information for the seismic hazard assessment in the Corinth gulf area, in terms of occurrence probability of earthquakes exceeding a given magnitude for a given period of time in the future.