Fractal analysis of the spatial distribution of earthquakes along the Hellenic Subduction Zone

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The Hellenic Subduction Zone (HSZ) is the most seismically active region in Europe. Many destructive earthquakes have taken place along the HSZ in the past. The evolution of such active regions is expressed through seismicity and is characterized by complex phenomenology. The understanding of the tectonic evolution process and the physical state of subducting regimes is crucial in earthquake prediction. In recent years, there is a growing interest concerning an approach to seismicity based on the science of complex systems (Papadakis et al., 2013; Vallianatos et al., 2012). In this study we calculate the fractal dimension of the spatial distribution of earthquakes along the HSZ and we aim to understand the significance of the obtained values to the tectonic and geodynamic evolution of this area. We use the external seismic sources provided by Papaioannou and Papazachos (2000) to create a dataset regarding the subduction zone. According to the aforementioned authors, we define five seismic zones. Then, we structure an earthquake dataset which is based on the updated and extended earthquake catalogue for Greece and the adjacent areas by Makropoulos et al. (2012), covering the period 1976-2009. The fractal dimension of the spatial distribution of earthquakes is calculated for each seismic zone and for the HSZ as a unified system using the box-counting method (Turcotte, 1997; Robertson et al., 1995; Caneva and Smirnov, 2004). Moreover, the variation of the fractal dimension is demonstrated in different time windows. These spatiotemporal variations could be used as an additional index to inform us about the physical state of each seismic zone. As a precursor in earthquake forecasting, the use of the fractal dimension appears to be a very interesting future work.

References
Caneva, A., Smirnov, V., 2004. Using the fractal dimension of earthquake distributions and the slope of the recurrence curve to forecast earthquakes in Colombia. Earth Sci. Res. J., 8, 3-9.
Makropoulos, K., Kaviris, G., Kouskouna, V., 2012. An updated and extended earthquake catalogue for Greece and adjacent areas since 1900. Nat. Hazards Earth Syst. Sci., 12, 1425-1430.
Papadakis, G., Vallianatos, F., Sammonds, P., 2013. Evidence of non extensive statistical physics behavior of the Hellenic Subduction Zone seismicity. Tectonophysics, 608, 1037-1048.
Papaioannou, C.A., Papazachos, B.C., 2000. Time-independent and time-dependent seismic hazard in Greece based on seismogenic sources. Bull. Seismol. Soc. Am., 90, 22-33.
Robertson, M.C., Sammis, C.G., Sahimi, M., Martin, A.J., 1995. Fractal analysis of three-dimensional spatial distributions of earthquakes with a percolation interpretation. J. Geophys. Res., 100, 609-620.
Turcotte, D.L., 1997. Fractals and chaos in geology and geophysics. Second Edition, Cambridge University Press.
Vallianatos, F., Michas, G., Papadakis, G., Sammonds, P., 2012. A non-extensive statistical physics view to the spatiotemporal properties of the June 1995, Aigion earthquake (M6.2) aftershock sequence (West Corinth rift, Greece). Acta Geophys., 60, 758-768.