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Criticality analysis of VLF subionospheric propagation data prior to recent (2021-2022), strong (M ≥ 5.5), earthquakes occurred in the southeastern Mediterranean

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In this work we focus on eight strong (M ≥ 5.5) earthquakes (EQs) that happened very recently (2021-2022) in southeastern Mediterranean by analyzing the very low frequency (VLF) subionospheric propagation data, acquired from three receivers installed at the prefecture of Attica in Greece. We used the VLF data received from many transmitters, mainly located in Europe and western Asia. For each one of these EQs, only the paths enclosing its epicenter in their 5th Fresnel zone were studied. In our analysis, we first applied the nighttime fluctuation method (NFM) to the nighttime amplitude recordings of the VLF signals to calculate the non-normalized VLF subionospheric daily-valued quantities trend (TR), dispersion (DP) and nighttime fluctuation (NF) [1]. Then, we applied the criticality analysis method known as natural time (NT) analysis [2] to the TR, DP and NF time series. NT analysis is known for its ability to identify the dynamic approach of a complex system towards the critical state, by co-evaluating the temporal evolution of four important quantities: the entropy in NT (S_{nt}), the entropy under time reversal (S_{nt-}), the variance (κ_1) and the "average" NT spectral distance ($\langle D \rangle$) [2]. The critical state is reached when κ_1 takes the value $\kappa_1 = 0.07$ by approaching "from above", while at the same time $S_{nt}, S_{nt-} < (\ln 2/2) - 1/4$ and $\langle D \rangle < 10^{-2}$ [2]. Our results show that criticality was reached for all studied EQs within a range of 15 days before the EQ occurrence. Figure 1 shows an example of the obtained results for the $M_W = 6.3$ EQ that happened on 3 March 2021, 10:16:09 (UTC), with epicenter at (39.755°N, 22.176°E) and 8.0 km depth.

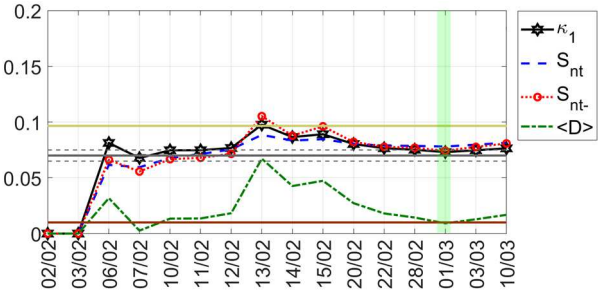

Figure 1: NT analysis of the NF quantity of the propagation path DHO-UWA for the period 2 Febr. 2021 to 18 March 2021. Criticality (marked by green background) was reached on 1 March 2021, 2 days before the EQ.

References

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