Response to Reviewer T. Chelidze

We would like to thank the Reviewer for his valuable comments, which gave us the opportunity to provide a more detailed explanation about our work through our answers as well as to improve the quality of our paper.

In the following we present a detailed report, containing all answers / actions to be taken and references to the intended manuscript changes. Each one of our replies is given in blue-colored fonts, following the corresponding Reviewer's comment (in `black colored fonts`). In the replies text, **bold fonts** indicate text to be inserted / changed in the manuscript.

Comment:
"The standard approach to earthquake (EQ) prediction (both pro-active and retrospective) is to investigate, whether the physical quantity accepted as a precursor (here signatures of critical, as well as tricritical, dynamics) is statistically significant, namely, it should be estimated how often the anomaly considered as a precursor is observed in seismically quiet periods (false alarms), really preceded EQ (hits) and was absent before strong EQ (misses). As it is very difficult to meet all these criteria it would be sufficient at this stage to estimate probability of false alarms, i.e. to show that critical dynamics features are absent in quiet periods."

Reply:

Our up to now research efforts, through the application of the method of critical dynamics (MCF) and, lately, of the natural time (NT) method on MHz fracture-induced electromagnetic emissions (EME), has led us to the conclusion that a few days (approximately during the last week) before a strong, on-land or near coast-line, earthquake (EQ) takes place, critical characteristics are identified in the recorded MHz time-series (usually referred to as "critical window", CW). Note that these kind of EQs (M>6, with an epicenter on land or near coast-line) are not often in the area of Greece, where our measurement network is deployed. Prior to all such EQ events MHz EME have been recorded, however not all of them could be analyzed either due to short data lengths or due to low amplitude (the recorded radiation is not always clearly emerging from the EM background) (see remark in page 016104-4 of Karamanos et al., 2006). The above mentioned conclusion has been verified for a number of such EQ events which have taken during the last years and for which data of adequate length and amplitude, so that reliable time-series analysis was possible, were available (e.g., Contoyiannis et al., 2010, Potirakis et al., 2015; Contoyiannis et al., 2015, the present article about the Cephalonia EQs). The naturally arising question is whether after each time that criticality characteristics are identified in the MHz time-series a strong EQ event definitely follows. Before replying to this question we have to remind that in the frame of our proposed four-stage model, the appearance of a valid MHz anomaly (CW) is not a "necessary and sufficient" condition for a main EQ event to happen (e.g., Eftaxias et al., 2013, and references therein; Eftaxias and Potirakis, 2013, and references therein; Contoyiannis et al., 2015, and references therein; Donner et al., 2015). Indeed, there has been a very small number of cases for which critical MHz EME signals were recorded but no strong EQ took place after that. However, for these cases, a significant increase of seismicity (with events of M approximately <5) followed the identified MHz critical signal without an EQ event with (M>6) to happen. According to our proposed model, this means that the organization in the studied area reaches a critical condition during which the long-range correlation of fracture events expands over the wider activated area. During this phase the family of asperities sustaining the fault are sieged by the developed stresses, however in the specific cases the process did not developed to the direction of fracturing the asperities themselves. We emphasize that we have never found a critical MHz signal during a time period of seismic quiescence. In conclusion, according to our view, there is no meaning of studying the probability of false alarms for the MHz EME, since it is a candidate electromagnetic precursor of which appearance is not a "necessary and sufficient" condition for a main EQ event to happen.

Comment:
"One of the first papers devoted to criticality as a precursory sign are: T.Chelidze. Percolation and fracture. Physics of the Earth and Planetary Interiors. 1982, 28, 93- 101. T.Chelidze, Yu. M. Kolesnikov. Percolation Modell des Bruchprozesses. Gerlands Beitr. Geophysik. Leipzig. 1982, 91, 35 – 44. more recents are: T.Chelidze, Yu. Kolesnikov, T.Matcharashvili. Seismological criticality concept and percolation model of fracture // Geophysical Journal International. 2006,164,125-136. J. Wanliss, V. Muñoz, D. Pastén, B. Toledo, and J. A. Valdivia. Critical behavior in earthquake energy dissipation. Nonlin. Processes Geophys. Discuss., 2, 619–645, 2015 John B. Rundle, James R. Holliday, William R. Graves, Donald L. Turcotte, Kristy F. Tiampo, and William Klein. Probabilities for large events in driven threshold systems. PHYSICAL REVIEW E 86, 021106 (2012) Inclusion of some of these papers into references seems to be desirable."

Reply:
The reviewer is right, the suggested papers will be added to the references list of the revised version of our article. Specifically, we will add one sentence as the first sentence of Section 2. In the first version of our manuscript it was: "Critical phenomena have been proposed as the likely model to study the origins of EQ related EM fluctuations,…" and in the revised version it will be: "**Criticality has early been suggested as an EQ precursory sign (Chelidze, 1982; Chelidze and Kolesnikov, 1982; Chelidze et al., 2006; Rundle et al., 2012; Wanliss et al., 2015)**. Critical phenomena have been proposed as the likely **framework** to study the origins of EQ related EM fluctuations,…"

Comment:
"Authors' belief that the natural time approach extracts maximum possible information from a given time series seems to be a bit exaggerated: for example I am not sure that NTM permits proper analysis of scaling in waiting times' distribution between events in a given time series as in NTM the time scale is homogenized."

Reply:
The Reviewer is right about the exaggeration. We will rephrase the specific part to be more accurate. The specific part of the text was originally "…and has been shown to extract the maximum information possible from a given time series (Abe et al., 2005)", it will be changed to "…and has been shown **to be optimal for enhancing the signals in the time-frequency space** (Abe et al., 2005)."
Concerning the part of the Reviewer's comment about waiting times distribution, we have to note that in natural time analysis, as published by the proponents: "*For a time series comprised of N events, we define the natural time for the occurrence of the kth event by $\chi_k=k/N$ (1), which means that we ignore the time intervals between consecutive events, but preserve their order.*" (Sarlis et al., Minimum of the order parameter fluctuations of seismicity before major earthquakes in Japan, PNAS (2013) vol.110 pp.13734–13738.). In other words, natural time analysis does not consider at all the waiting times' distribution.