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Natural Hazards and Earth System Sciences
Discussions

Interactive comment on "Measuring the seismic risk along the Nazca-Southamerican subduction front: Shannon entropy and mutability" *by* Eugenio E. Vogel et al.

Anonymous Referee #1

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General Comments: In this manuscript (ms), Vogel et al. apply Shannon entropy and mutability for the estimation of the seismic risk along the Nazca-Southamerican subduction front. Four geographical zones are selected along the trench formed by the subduction of the Nazca Plate under the South American plate. The authors study the sequence of intervals between consecutive earthquakes (EQs) in each of the four geographical zones by using Shannon entropy and mutability. The obtained results are interesting but the presentation does not conform to the existing literature although it uses ideas earlier published by other researchers.

Specific Comments: For example, in both methods, see, e.g., Eqs. (1), (4) and (5),

the number of events (or event windows) is used in the sense it is used in natural time analysis that has appeared almost two decades ago, see, e.g.

[P. Varotsos, N. Sarlis, and E. Skordas, Spatiotemporal complexity aspects on the interrelation between Seismic Electric Signals and seismicity, Practica of Athens Academy, 76, 294-321, 2001. Available from http://physlab.phys.uoa.gr/org/pdf/p3.pdf]

[P.A. Varotsos, N.V. Sarlis, and E.S. Skordas, Long-range correlations in the electric signals that precede rupture, Phys. Rev. E, 66, 011902 (7), 2002.]

[Varotsos P.A., Sarlis N.V. and Skordas E.S., Natural Time Analysis: The new view of time. Precursory Seismic Electric Signals, Earthquakes and other Complex Time-Series (Springer-Verlag, Berlin Heidelberg) 2011]

but the original works are not mentioned. The importance of natural time in the study of seismicity has been recently stressed by

[Rundle, J. B., D. L. Turcotte, A. Donnellan, L. Grant Ludwig, M. Luginbuhl, and G.Gong (2016), Nowcasting earthquakes, Earth and Space Science, 3, 480–486, doi:10.1002/2016EA000185],

I quote "Event counts as a measure of "time," rather than the clock time, is known as "natural" time [Varotsos et al., 2002, 2005, 2011; Holliday et al., 2006]. We will show that the use of natural time has at least two advantages when applied to earthquake seismicity. . .".

Thus, the authors should accommodate their present findings within the pre-existing literature by inserting in the Introduction section in page 2 a paragraph concerning the findings of natural time analysis related to seismicity. Indicative results can be found in the references mentioned in the above quotation as well as the more recent:

[P.A. Varotsos, N. V. Sarlis, E. S. Skordas, Seiya Uyeda and Masashi Kamogawa, "Natural time analysis of critical phenomena", Proceedings of the National Academy of Sciences of the United States of America, Vol.108 (2011), 11361-11364.]

[N. V. Sarlis, E. S. Skordas, P. A. Varotsos, T. Nagao, M. Kamogawa, H. Tanaka, and S. Uyeda, "Minimum of the order parameter fluctuations of seismicity before major earthquakes in Japan", Proceedings of the National Academy of Sciences of the United States of America, Vol.110 (2013), 13734–13738.]

[N. V. Sarlis, E. S. Skordas, P. A. Varotsos, T. Nagao, M. Kamogawa, and S. Uyeda, "Spatiotemporal variations of seismicity before major earthquakes in the Japanese area and their relation with the epicentral locations", Proceedings of the National Academy of Sciences of the United States of America, Vol.112 (2015), 986–989.]

[N.V. Sarlis, E.S. Skordas, A. Mintzelas, and K.A. Papadopoulou, "Micro-scale, mid-scale, and macro-scale in global seismicity identified by empirical mode decomposition and their multifractal characteristics", Scientific Reports, Vol. 8 (2018), 9206, DOI 10.1038/s41598-018-27567-y]

[N. V. Sarlis, E. S. Skordas, and P. A. Varotsos, "A remarkable change of the entropy of seismicity in natural time under time reversal before the super-giant M9 Tohoku earthquake on 11 March 2011", EPL, Vol. 124 (2018), 29001(7), DOI 10.1209/0295-5075/124/29001.]

[J. B. Rundle, M. Luginbuhl, A. Giguere, D. L. Turcotte, Natural Time, Nowcasting and the Physics of Earthquakes: Estimation of Seismic Risk to Global Megacities, Pure and Applied Geophysics 175 (2018) 647-660. doi:10.1007/s00024-017-1720-x.]

[J. B. Rundle, A. Giguere, D. L. Turcotte, J. P. Crutchfield, A. Donnellan, Global Seismic Nowcasting With Shannon Information Entropy, Earth and Space Science 6 (1) (2019) 191-197. doi:10.1029/2018EA000464.]

Appropriate changes should be also made in line 334 where it is written "while the latter considers the order in which the registers entered in the distribution" but natural time is not mentioned, and in lines 359-360 in the Conclusions. What the authors state here is one of the major applications of natural time analysis and in particular for the

entropy change under time reversal, see, e.g.,

[P. Varotsos, N. Sarlis, E. Skordas, and M. Lazaridou, "Identifying sudden cardiac death risk and specifying its occurrence time by analyzing electrocardiograms in natural time", Applied Physics Letters, Vol. 91 (2007), 064106]

Additionally, on Page 1, lines 43 to 46 the Authors write: "Data may come from a variety of techniques used to record variations in some earth parameters like infrared spectrum recorded by satellites (Zhang et al., 2019), earth surface displacements measured by Global Positioning System (GPS) (Klein et al., 2018), variations of the earth magnetic field (Cordaro et al., 2018; Venegas-Aravena et al., 2019), among others." I cannot understand completely the meaning of the sentence, hence it needs rewording. If it refers to precursory changes before EQs there is an obvious omission of the Seismic Electric Signals that precede EQs, see, e.g.,

[P. Varotsos and K. Alexopoulos, Physical properties of the variations of the electric field of the earth preceding earthquakes, I. Tectonophysics 110, 73-98, 1984.]

[P. Varotsos and K. Alexopoulos, Physical properties of the variations of the electric field of the earth preceding earthquakes, II. Determination of epicenter and magnitude, Tectonophysics 110, 99-125, 1984.]

[P. Varotsos, K. Alexopoulos, K. Nomicos and M. Lazaridou, Earthquake prediction and electric signals, Nature 322, 120, 1986.]

[P. Varotsos and M. Lazaridou, Latest aspects of earthquake Prediction in Greece based on Seismic Electric Signals. I, Tectonophysics 188, 321-347, 1991.]

[P. Varotsos, K. Alexopoulos and M. Lazaridou, Latest aspects of earthquake prediction in Greece based on Seismic Electric Signals II, Tectonophysics 224, 1-37 1993.]

[P. Varotsos, The Physics of Seismic Electric Signals, TerraPub, Tokyo (2005) 338 pages.]

[N.V. Sarlis, P.A. Varotsos, E. S. Skordas, S. Uyeda, J. Zlotnicki, T. Nagao, A. Rybin, M.S. Lazaridou-Varotsos, and K.A. Papadopoulou, "Seismic Electric Signals in seismic prone areas", Earthquake Science, Vol. 31 (2018), 44-51, DOI 10.29382/eqs-2018-0005-5.]

[P.A. Varotsos, N.V. Sarlis and E.S. Skordas," Phenomena preceding major earthquakes interconnected through a physical model", Annales Geophysicae 37 (2019), 315–324.]

Technical Corrections: I am now turning to other problems with the presentation:

Page 2, lines 145 and 146 two different symbols appear for G_{k,Z}, G_{Z,k} also in Figure Caption 2.

Page 2, line 152: "data base" -> "database"

Page 4, line 162: why \nu was selected 24?

Page 5, line 166: Please give an explicit definition of what is meant by "w(t_i, \nu) bytes"?

Page 5, line 167: Also provide an explicit definition of wˆ* because I cannot comprehend the term "wˆ* is the size in bytes of the compressed dataset associated to the time intervals \Delta_j within the time window." What is a compressed dataset for a time interval? and how time written when uncompressed?

Page 5, line 176: Figure 3 is missing, also in many lines in the paper e.g. line 213 on page 6.

Page 5, lines 183-184: It should be clarified here that the figure depicting t_i uses natural time.

Page 5, at the end: lines 189-190 are missing.

Page 6, line 217: "Figure." -> "Figure"

Page 7, Table II, first row, fourth column: "(yr)" -> "(y)"

Page 9, line 285: For the readers' convenience please mention the EQ to which you are referring to.

Page 9, line 297: Please explain how the error bars were found.

Page 10, Figure 9: The error bars drawn in the figure reach even negative values of the interoccurrence interval

Page 11, line 334: I cannot understand the term "the registers entered in the distribution", please explain.

In summary, I suggest that the authors make a major revision along the lines suggested above.

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