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Bayesian analysis of temporal changes in the probability distribution of seismic parameters and links with the seismic cycle

E. Varini[1+], *R. Rotondi*[1++]

(1) CNR – National Research Council, IMATI – Institute for Applied Mathematics and Information Technologies, Milan, Italy, [+]*elisa.varini@mi.imati.cnr.it* [++]*renata.rotondi@mi.imati.cnr.it*

In the frame of nonextensive statistical mechanics, the q-exponential probability distribution arises from the maximization of the Tsallis entropy under appropriate constraints [1]. The Tsallis entropy, unlike the Boltzmann-Gibbs entropy, is non-additive and more suitable to describe complex systems far from equilibrium and with possible long-range interactions. These features have suggested several studies on earthquakes as complex system (e.g. [2] and references therein). In this study we assume the q-exponential probability distribution for the analysis of the temporal variations of some seismic parameters (e.g. magnitude, spatial location of the epicentres) in earthquake sequences of Italy. Bayesian inference is performed by processing data on sliding time windows, such that each window has a fixed number of events (100 in this study) and shifts at each new event [3]. Other distributions (e.g. tapered Pareto, generalized gamma) are also considered and the best fitting distribution in each time window is selected by comparing the estimated values of the posterior marginal likelihood (Fig. 1). We found that the best fitting distribution varies over time and can be a further indicator of the activation state of the systems [4].

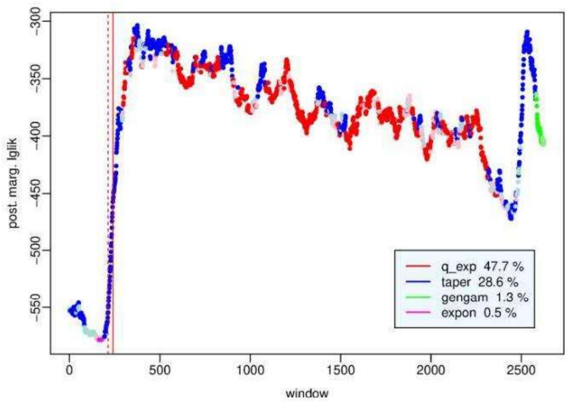

Figure 1: L'Aquila sequence - Posterior marginal log-likelihood of the probability distribution of Voronoi cell area that fits better than the other distributions to the dataset of each time window. The red vertical lines indicate the mainshock of Mw 6.1 occurred on April 6, 2009 (solid line) and the 30 March earthquake of Mw 4 (dashed line) respectively.

Acknowledgements

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References

[1] C. Tsallis, *J. Stat. Phys.* (1988) 52, 479–487.
[2] F. Vallianatos, G. Papadakis, G. Michas, *Proc. R. Soc. A* (2016) 472: 20160497.
[3] R. Rotondi, G. Bressan, E. Varini, *J. Geopys. Int.*, 230 (2022) 1318–1337.
[4] R. Rotondi, E. Varini, *Front. Earth Sci.* (2022) 10:928348.

Thursday, 8 June

9.00-10.00	**Plenary talk-Room: Crystal Hall** **Perspectives on Mortality Modelling - Gareth Peters** *Chair: Athanasios Kehagias*				
	Room: Crystal Hall	Room: Grand Pietra I	Room: Grand Pietra II	Room: Dock Six I	Room: Dock Six II
IS: Invited session CT: Contributed Talks	**CT: Markov Models**	**CT: Decision Theory- Part II - Stochastic control**	**CT: Probabilistic modeling in applied sciences**	**IS: Stochastic Modeling in Reliability and Resilience**	**CT: Applications of statistics to environmental and related topics**
10.00-11.00	Chair: *Andreas Georgiou*	Chair: *Alexander Gnedin*	Chair: *Serkan Eryılmaz*	Chair: *Bei Wu*	Chair: *Rodi Lykou*
	Analysis of a multi-level manpower model under different circumstances *Nikolas Tsantas*	A Stochastic Control Problem With Linearly Bounded Control Rates In A Brownian Model *Clarence CS Simard*	Structural reliability assessment of composite columns in steel and concrete *Pellumb Zogu*	System Reliability Modelling via Virtual Ages *Lirong Cui*	A Remote Sensing Application of Generalized Linear Mixed-Effects Models in Crop Phenology Prediction *Ioannis Oikonomidis*
	Functional Central Limit Theorem for Certain Markov Chains in Random Environment with Applications in Machine Learning *Attila Lovas*	Stochastic Maximum Principle For A Constraint Nonzero-Sum Game Application: Bancassurance *Emel Savku*	Acceptability Model of Risk in Italian Tunnels *Massimo Guarascio*	Reliability Modeling for Systems Degrading in Markovian Environments with Protective Auxiliary Components *Jingyuan Shen*	Modeling Rainfall Interarrival Times, Rainfall Depths and their dependence, using the Hurwitz Lerch Zeta family of distributions and Discrete Copulas *Tommaso Martini*
	Moments Computation for Markov-Modulated Fluid Models with Upward Jumps and Phase Transitions *Abdallah Itidel*	Optimal stopping zero-sum games in continuous hidden Markov models *Pavel V. Gapeev*	Investigation of the climate impact on WNV vectors abundance *Orfeas Karathanasopoulos*		Multivariate Fay-Herriot Models for Small Area Estimation in Forest Inventory *Aristeidis Georgakis*
11.00-11.30	Coffee Break				
	Room: Crystal Hall	Room: Grand Pietra I	Room: Grand Pietra II	Room: Dock Six I	Room: Dock Six II
IS: Invited session	**IS: Branching Processes and Related fields I**	**IS: Sequential Selection, Best Choice and Games Problems**	**IS: Probabilistic Modeling of Engineering Systems**	**IS: Stochastic Modeling in Reliability and Resilience**	**IS: Fractional long-range dependence processes: theory, applications and simulations**
11:30-13:30	Chair: *Miguel Gonzalez*	Chair: *Yaakov Malinovsky*	Chair: *Serkan Eryılmaz*	Chair: *Bei Wu*	Chair: *Enrica Pirozzi*
	Ancestral inference for age-dependent branching process with immigration *Anand N. Vidyashankar*	The Last-Success Optimal Stopping Problem with Random Observation Times *Alexander Gnedin*	Reliability evaluation of discrete time consecutive-k systems *Cihangir Kan*	Reliability of Three-dimensional Consecutive k-type System *He Yi*	Estimation of the Hirst Parameter from Continuous Noisy Data *Marina Kleptsyna*
	Scaling Limits of Critical Controlled Multi-type Branching Processes *Pedro Martín-Chávez*	On optimal stopping of a random sequence with unknown distribution *Alexander Goldenshluger*	Analyzing the Number of Failed Components in a series-parallel System *Murat Ozkut*	Reliability Modeling for Balanced System Considering Mission Aborted Policies *Chen Fang*	The Monte Carlo method for the fractional calculus *Igor Podlubny*
	Multi-type Sevastyanov Branching Processes and Application in Cancer Research *Maroussia Bojkova*	On Round-Robin Tournaments with a Unique Maximum Score and Some Related Results *Yaakov Malinovsky*	On the reliability structures with two common failure criteria and cold standby redundancy *Ioannis Triantafyllou*	Resilience Modeling for multi-component systems based on Markov process *Bei Wu*	Mittag-Leffler Single Server Queues *Nicos Georgiou*
	Large Deviation results for Controlled Branching Processes *Inés M. del Puerto*	Blotto Game with Testing (The Locks, Bombs and Testing Model) *Isaac Sonin*	Probabilistic modelling and assessment of a renewable hybrid energy system *Serkan Eryılmaz*	Mean Hitting Time Approximation for Rare Events *Nikolaos Limnios*	Coupling Plateaux and Jumps: the Undershooting of Subordinators and the Corresponding Semi-Markov Processes *Giacomo Ascione*
13:30-15:00	Lunch Break				
15.00-16.00	**Plenary talk-Room:Crystal Hall** **Repeated Significance Tests Based on Multiple Scan Statistics for One- and Two-Dimensional Data- Joseph Glaz** *Chair: Markos Koutras*				
	Room: Crystal Hall	Room: Grand Pietra I	Room: Grand Pietra II	Room: Dock Six I	Room: Dock Six II
CT: Contributed Talks	**CT: Stochastic Modelling in Epidemiology**	**CT: Bayesian methods**	**CT: Brownian and Gaussian Processes**	**CT: Stochastic processes- Part II**	**CT: Distribution theory and related topics- Part II**
16:00-17:00	Chair: *Dimitris Kugiumtzis*	Chair: *Apostolos Batsidis*	Chair: *Marina Kleptsyna*	Chair: *George Vasiliadis*	Chair: *George Afendras*
	Modeling and parameter estimation of a multi-hidden chain model of typhoid fever in Mayotte *Ibrahim Bouzalmat*	Parameter Estimation Issues on the Generalised Gamma Model for Complete and Interval Censored Observations *Samis Trevezas*	Estimates for Exponential Functionals of Real-Valued Continuous Gaussian Processes *Jose Alfredo Lopez-Mimbela*	Reliability Modeling and Evaluation of Continuous Degradation System under Dynamic Environments *Yamei Zhang*	Coverage and connectivity in stochastic geometry *Mathew D Penrose*
	SIR epidemics perturbed by Feller processes *Matthieu Simon*	Genetically modified mode jumping MCMC approach for Bayesian multivariate fractional polynomials *Aliaksandr Hubin*	Quickest change-point detection problems for multidimensional Wiener processes *Pavel V. Gapeev*	Windings Of Planar Stochastic Processes And Applications. *Stavros Vakeroudis*	Asymptotic results for sums and extremes *Claudio Macci*
	Modeling the Health Impact of COVID-19 using Mixed Interaction Models and Chain Graph Models *Konstantina Gourgoura*	Interval Bayesian method to sequential sampling problem *Masayuki Horiguchi*	The Inverse First-passage Time Problem as Hydrodynamic Limit of a Particle System *Alexander Klump*	On the growth rate of superadditive processes and the stability of functional GARCH models *Baye Matar Kandji*	Stochastic Comparisons of Mixtures Models: Review and Discussion *Bahaedin Khaledi*
17.00-17.30	Coffee Break				
	Room: Crystal Hall	Room: Grand Pietra I	Room: Grand Pietra II	Room: Dock Six I	Room: Dock Six II
IS: Invited session	**IS: Branching Processes and Related fields II**	**IS: Information and modeling in continuous-valued time series- Part II**	**IS: Inference and limit theorems for stochastic processes with applications**	**IS: Statistical seismology I**	**IS: Fractional and nonlocal operators in applied probability**
17.30-19.30	Chair: *Inés María del Puerto García*	Chair: *Dimitris Kugiumtzis*	Chair: *Salim Bouzebda*	Chairs: *Eleftheria Papadimitriou, Rodolfo Console and Jiancang Zhuang*	Chair: *Giacomo Ascione*
	Implicit multi-type branching processes with immigration and periodic integer-valued autoregressive models *Martón Ispany*	Inflation Dynamics in Greece and Asymmetric Causal Effects *Katerina Kyrtsou*	Empirical likelihood with censored data *Amor Keziou*	Bayesian analysis of temporal changes in the probability distribution of seismic parameters and links with the seismic cycle *Elisa Varini*	Volterra sandwiched volatility model: Markovian approximation and hedging *Anton Yurchenko-Tytarenko*
	On the absorption and limiting behaviour of defective branching processes in a varying environment *Carmen Minuesa*	Nonlinear connectivity as a driver of time-horizon heterogeneity *Angeliki Papana*	Markov-Switching State-Space Models with Applications to Neuroimaging *David Degras*	On extending the ETAS model *Jiancang Zhuang*	From Semi-Markov Evolutions to Scattering Transport and Superdiffusions *Bruno Toaldo*
	Statistical sequential analysis for Controlled Branching Processes *Miguel González*	Applications of an information-based causality networks in finance *Akylas Fotiadis*	Bayesian Nonparametric Hypothesis Testing with Applications *Mame Diarra Fall*	From simulated earthquakes a key to modelling the occurrence of a strong event *Rodolfo Console*	Gaussian and Non-Gaussian Processes Linked to Convolution-type Fractional Operators *Luisa Beghin*
	Multitype Branching Process with Nonhomogeneous Poisson and Contagious Poisson Immigration *Landy Rabehasaina*	Information measures for balancing redundancy and relevance in data analysis *Dimitris Kugiumtzis*	Shannon Entropy in Deep Learning: Applications and Benefits *Issam El Hattab*	Testing of the Seismic Gap Hypothesis in a model with realistic earthquake statistics *Eugenio Lippiello*	Time-Fractional Diffusion from Two Markovian Hopping-Trap Mechanisms *Gianni Pagnini*