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Spatio-temporal stochastic modelling of environmental hazards

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ABSTRACT

This is the editorial letter for the Special Issue dedicated to the joint VII International Workshop on Spatio-temporal Modelling (METMAVII) and the 2014 meeting of the research group for Statistical Applications to Environmental Problems (GRASPA14), which took place in Turin (Italy) from 10 to 12 September 2014. This SI summarises a selection of the main contributions presented at this workshop, related to spatial and spatio-temporal methodology, mainly based on point processes, and illustrated with environmental applications on earthquakes, tornadoes, and radioactive particles.

1. Introduction

In recent years, spatio-temporal modelling has become one of the most interesting and, at the same time, challenging research areas of natural sciences. This has been largely fuelled by the increased availability of inexpensive, high-speed computing. Such availability has enabled the collection of large spatial and spatio-temporal datasets across many fields, has facilitated the widespread usage of sophisticated geographic information systems (GIS) software to create attractive displays, and has endowed the ability to investigate challenging, evermore appropriate and realistic models (Gelfand et al., 2010). The relevant literature is growing fast and along directions that range from theoretical works to methodological developments to real world applications. Spatio-temporal systems modelling involves the synthesis of a rich interdisciplinary body of knowledge for which it

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is necessary to establish a solid theoretical foundation and a science-based methodology with both researchers and practitioners in mind.

This special issue is dedicated to the VII International Workshop on Spatio-temporal Modelling – METMAVII – and the 2014 meeting of the research group for Statistical Applications to Environmental Problems (www.graspa.org) – GRASPA14 – which took place in Turin (Italy) from 10 to 12 September 2014. The purpose of this workshop was to promote the development and application of spatial, temporal, and mainly spatio-temporal statistical methods to different fields related to the environment. The joint meeting METMAVII–GRASPA14 was an opportunity to bring together two communities with common research interests, such as the development and use of statistical methods in the environmental sciences. These research aims are at the cornerstone of *The International Environmetrics Society* (TIES), indeed the meeting was a TIES regional conference.

The conference topics included: (a) development and application of spatial and spatio-temporal statistical methods in different fields related to environmental and health sciences; (b) environmental quality; (c) safety and sustainability including air and water quality; (d) epidemiology; (e) earth science and ecology; (f) functional data analysis; (g) spatial and spatio-temporal sampling and extreme values.

The complete list of papers presented at the workshop and any particular information are posted at:

http://meetings.sis-statistica.org/index.php/graspametma14/metma7graspa14.

The proceedings can be found at:

https://aisberg.unibg.it/handle/10446/30963#.VcKS5_ntlHw.

In light of the above considerations, the articles of this special issue have been carefully selected to present a variety of conceptual frameworks, powerful methods and comprehensive techniques that address a number of interesting problems in environmental and health sciences. In particular, the selected papers present contributions related to spatial and spatio-temporal methodology, mainly based on point processes, and illustrated with environmental applications on earthquakes, tornadoes, and radioactive particles. For example, and as a direct connection between point process methodology and earthquakes, significant changes in the spatio-temporal dynamics of the seismic activity are observed previous to the volcanic eruption.

A spatial point process is a stochastic process each of whose realisations consists of a finite or countably infinite set of points in the plane. Spatio-temporal point processes are considered as being a hybrid of the spatial and temporal components, by extending the definition of spatial point processes to include time. Because the spatial location can always be considered as one component of a multi-dimensional mark, the evolution of spatial features with time is often of special interest. Despite such considerations, studies of spatio-temporal models have lagged well behind those of simple temporal models, and even those of purely spatial models. No doubt the reasons have been largely practical, notably the difficulty of compiling good spatio-temporal datasets and the heavy computations needed to analyse them. One way to observe these processes is to consider the spatial location itself viewed as a mark for a simple point process in time, thereby providing one route to likelihood analyses of spatio-temporal models. Further characteristics, such as magnitude, spatial extent, or even duration, can be added as additional marks. Thus, the study of spatio-temporal point processes leads almost inevitably to the more general study of evolving spatial fields, although practical modelling in this direction is still limited and very subject-specific. In this context, principled statistical modelling and residual analysis are at the core of many outstanding research works. Indeed, for gridded forecasts, deviance residuals seem ideally suited for model comparison. For replicated spatial or spatio-temporal point patterns, looking for methods of assessing whether all spatial point patterns share a common spatial distribution or there are specific features is of primary interest.

This special issue comprises papers mainly dealing with point processes and earthquake modelling (Adelfio and Chiodi, 2015; Gordon et al., 2015; Nicolis et al., 2015; Zhuang, 2015), one paper dealing with point processes and tornadoes (Gomez-Rubio et al., 2015), one paper dealing with point processes and radioactive particles (Altieri et al., 2015), and finally one paper dealing with entropy measures applied to earthquake modelling (Esquivel and Angulo, 2015).