Journal de la Société Française de Statistique
Vol. 158 No. 3 (2017)

Editorial of the special issue: Statistics for spatial and spatio-temporal data and RESSTE Network

Titre: Éditorial du numéro spécial :
Statistique pour les données spatiales et spatio-temporelles et réseau RESSTE

Delphine Blanke[1] and Denis Allard[2]

As indicated by its name, spatio-temporal statistics is about analyzing data with spatial and temporal structure. Typical domain of applications include (but are not limited to) environmental and climate sciences. Often, data have been recorded at regular time interval by sensors located at several georeferenced locations but more complex sampling designs exist, such as measurements recorded along trajectories. Spatio-temporal data are often complex to analyze due to the intricate relationship between space and time and due to the interactions between the (often numerous) recorded variables. Characterizing these dependencies is one of the scientific challenge in this very active research domain in statistics. Research is needed for many aspects of the analysis and the modeling of spatio-temporal data, in particular for their visualization, the definition of valid and relevant models, the estimation of the parameters of those models and the design of efficient algorithm able to cope with the usually rather large size of the datasets. The aim of this Special Issue is to present recent methods, their application to large datasets and their implementation with up-to-date *R* packages.

Several contributions to this Special Issue are authored by research teams participating to the RESSTE network created in 2014. RESSTE (RESeau Statistiques pour données Spatio-TEmporelles) is funded by the Applied Mathematics and Informatics division of INRA, the French National Institute for Agricultural Research. It gathers around 60 academics and researchers from 19 research teams belonging to national and international universities and research institutes. Its objective is to build a spatio-temporal statistics community in France by organizing scientific meetings and workshops, to open new research fronts in space-time statistics, to *transfer/diffuse* recent advances to scientists for the analysis and the modeling of spatio-temporal data, and to foster new collaborations between these researchers and statisticians. More details can be found on the RESSTE web page, where many presentations can be freely downloaded, at http://informatique-mia.inra.fr/resste/.

[1] LMA EA2151, Université d'Avignon, Campus Jean-Henri Fabre, 301 rue Baruch de Spinoza, BP 21239, 84916 Avignon Cedex 9.
E-mail: delphine.blanke@univ-avignon.fr
[2] BioSP, INRA, 84914 Avignon.
E-mail: denis.allard@inra.fr

This Special Issue starts with a paper by M. Valera-López, A. Pineda and J.R. León "*Application of satellite image to the implementation of two stochastic models for modeling the transport of chlorophyll-a on Lake Valencia (Venezuela)*". Two statistical methods of diffusion of particles are proposed for modeling the transport of pollutants in Lake Valencia (Venezuela). A deterministic hydrodynamical model is used to model the surface current and a stochastic diffusion model is used to model the transport of pollutants. In particular, this paper proposes a new and original algorithm that randomly generates the position of the particles of pollutant using satellite image information. This simulates contaminant dispersion from a true initial distribution into the lake since the time when the images were captured by the satellite. This method accurately approximates the actual density of organic waste into the lake. It ensures that the simulation of contaminant transport is not only determined by the initial position of the particles but also by the density of pollution in the area determined by these positions.

The paper by T. Opitz "*Latent Gaussian modeling and INLA: A review with focus on space-time applications*" deals with Bayesian hierarchical models with latent Gaussian layers. These models have proven very flexible in capturing complex stochastic behavior and hierarchical structures in high-dimensional spatial and spatio-temporal data. The inferential framework of Integrated Nested Laplace Approximation (INLA) is capable to provide accurate and relatively fast analytical approximations to posterior quantities of interest. It heavily relies on the use of Gauss-Markov dependence structures to avoid the numerical bottleneck of high-dimensional nonsparse matrix computations. With a view towards space-time applications, this contribution reviews the principal theoretical concepts, model classes and inference tools within the INLA framework. To showcase the practical use of `R-INLA` and to illustrate its principal commands and syntax, a comprehensive simulation experiment is presented using simulated non Gaussian space-time count data with a first-order autoregressive dependence structure in time.

In the paper "*Detecting and modeling multi-scale space-time structures: the case of wildfire occurrences*", É. Gabriel, T. Opitz and F. Bonneu analyze daily records of fire events and burnt surfaces in the Bouches-du-Rhôn county (French Département), in Provence, France. They start with an exploratory analysis of the dataset that allows to select relevant land use and climatic covariates. They then fit a log-Gaussian Cox process including covariate information and nonparametric spatial and temporal effects. Estimation is carried out within an INLA formulation of the model. The residual space-time interaction structure is analyzed thanks to the use of non homogeneous spatio-temporal K-functions. This work evidences the inhibition effect, in space and time, of large burnt surfaces.

In the paper by F. Lavancier and P. Rochet, "*A tutorial on estimator averaging in spatial point process models*", the authors present a clear overview of a general methodology for averaging estimators. They investigate the efficiency of averaging in some common spatial point process models. Specifically, they consider the estimation of the intensity of an inhomogeneous spatial Poisson point process, the estimation of the parameters of a determinantal point process (a model for regular point patterns), of a Thomas process (a model for clustered point patterns), and of a Boolean model with inhomogeneous intensity. For each of these models, several competing estimators are possible and it is not always clear which one performs best due to the lack, in most cases, of a universal single best estimation method. The objective of averaging is to produce a single final efficient estimator constructed from an estimation of the mean-square error matrix of the initial estimators. The methodology is illustrated on simulations demonstrating that, in most cases, the average estimator improves on the best estimator in the collection. For each example, the full implementation of the averaging procedure is described in the software *R*. The code takes only few lines of scripts that mainly rely on routines available in the package `spatstat`.

The last contribution, "*Analyzing spatio-temporal data with R: Everything you always wanted to know – but were afraid to ask*", is a collaborative paper written by 12 members of the RESSTE Network. It intends to open new developments in the analysis and modeling of spatio-temporal data with *R*. The paper starts by presenting the models, methods and techniques for the analysis and the prediction of spatio-temporal processes. Based on a real case study of PM_{10} data with daily records at 507 air quality stations in France, the authors provide a critical review of the most complete *R* packages for spatio-temporal data available today. They show how to perform the analysis of spatio-temporal data, from visual exploration of the data set to the estimation of the space-time covariance function and to the prediction. Extensive *R* code examples are provided through supplementary material in the `R Markdown` format that can be freely downloaded.

We wish to thank all authors that have contributed to this Special Issue. We are grateful to the reviewers for their careful reading and their relevant comments. We warmly thank Gilles Celeux, Editor-in-Chief for his trust and his continuous support when preparing this Special Issue. As a final word, for any question or request regarding the RESSTE network, feel free to browse through its web page and/or to contact one of its coordinators.