METMA-LATAM II

Book Abstracts of the 2nd Latin American Conference on Spatio-Temporal Modelling

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Foreword

Over the past thirty years, spatial statistics has grown rapidly, becoming a key field in understanding complex data linked to location and space. Thanks to advances in computing power and software, researchers have been able to develop and apply increasingly sophisticated models to a wide range of disciplines—from environmental science and epidemiology to agriculture, public health, and even astronomy. One of the most exciting developments in recent years has been the rise of spatio-temporal statistics, which combines both spatial and temporal information to better understand how processes change over time and across regions. These methods are especially useful for addressing real-world problems such as tracking disease outbreaks, monitoring pollution, predicting weather events, and managing natural resources.

Recognizing the importance of this growing field, the METMA Congress (International Conference on Spatio-Temporal Modelling) has served as a major scientific gathering in Europe since 2001. Held every two years in countries like Spain, Italy, Portugal, France, and the United Kingdom, METMA has helped build a strong international community focused on advancing spatio-temporal modeling. As more and more Latin American researchers became involved, and as the need to address region-specific challenges grew, it became clear that a dedicated space was needed for the region. That's how METMA-LATAM was born—a version of the METMA conference adapted to the Latin American context.

The first edition of METMA-LATAM took place in 2023 in Quito, Ecuador, creating a unique platform to share knowledge and experiences among academics, professionals, and institutions working on regional challenges like climate change, land use, health systems, and public safety. In 2025, METMA-LATAM II, hosted from June 25 to 27 at Universidad del Norte in Barranquilla, Colombia, built on this success and brought together researchers from diverse fields to explore the latest developments in spatial, temporal, and spatio-temporal modeling. Through keynote talks, scientific

presentations, poster sessions, and networking activities, participants connected with international experts and discovered new opportunities for interdisciplinary collaboration.

What makes this congress so valuable is not just the scientific content—it's the way it connects advanced statistical tools to real-world problems that matter to people and communities across Latin America. Fields like spatial epidemiology, ecology, meteorology, criminology, and even seismology and astronomy all found a home at METMA-LATAM II. To further extend the impact of the event, a special issue of the journal Environmetrics will publish selected papers presented at the conference, giving global visibility to research from the region and encouraging international cooperation. METMA-LATAM II 2025 stands as a turning point for applied statistics in Latin America. By building collaborative networks and promoting joint research, the congress strengthens a growing community that is ready to tackle current and future challenges using powerful and innovative statistical methods.

Table of Contents

Keynotes 1

Cross-validation for dependent data
H. Rue 2

Machine learning for geospatial data with explicit modeling of spatial correlations
A. Datta 3

On spatio-temporal disease mapping: Univariate and multivariate models with applications
M. D. Ugarte 4

Basis representations for latent Gaussian random field models
M. Haran 5

Advancing Monte Carlo simulation with GANs, diffusion models, and normalizing flows
R. Assunção 6

Statistical challenges in environmental data sets
A. Fassò 7

Invited

8

Assessing the agreement between two continuous sequences
R. Vallejos 9

Modeling temporal dependence in a sequence of spatial random partitions driven by spanning tree: An application to mosquito-borne diseases
R. H. Loschi 10

Bayesian latent space modeling with spatial covariates for network community detection
J. C. Sosa M. 11

Composite likelihood inference for space-time point processes
F. Cuevas-Pacheco 12

A nonparametric test for SOIRS: Assessing second-order reweighted stationarity with covariates
J. A. Gonzalez 13

Accelerating AI in 2025
J. Merino 14

A decay-adjusted spatio-temporal model to account for the impact of mass drug administration on neglected tropical diseases prevalence
C. Fronterre 15

Fast mixture spatial regression: A mixture in the geographical and feature space applied to predict porosity in the post-salt
M. O. Prates 16

Guest session TIES 17

Statistical learning for spatio-temporal point processes
J. Mateu 18

Reconstructing latent spatial relationships throw lasso methods
Y. Cuvero 20

Contributed 21

Multiclass classification of skin diseases from mobile phone images
N. Serdyukova 22

Nonlinear distributed lag models with mixed effects for assessing climatic impact on respiratory health in Costa Rica
E. Parra-Rodríguez and S. W. Chou-Chen 23

Testing for equivalence on the spatial concordance correlation coefficient: An approach using satellite images of lake Villarrica, Chile, from Landsat 8 and Sentinel-2
G. Ferreira, J. Urrutia and R. Vallejos 24

Indirect estimation of the need for palliative care during the COVID-19 pandemic: A descriptive cross-sectional study using mortality data in the Biobío Region, Chile
C. Barría-Sandoval, M. Espinoza V. and G. Ferreira 25

On modeling discrete lattice data using the Potts model
M. P. Duenas-Herrera, S. Berg and M. Haran 26

Intimate partner violence in Colombia 2015-2023 from the ecological feminist model
M. J. Meisel and K. Florez 27

Kernel universal kriging
R. Giraldo, W. Caballero and F. J. Rodríguez-Cortés 28

Supervised classification for spatial functional multivariate data, based on the Mahalanobis distance
M. P. Bohorquez C. 29

Effective sample size for a Gaussian process under fixed domain asymptotics
J. Acosta and D. Velandia 30

Gaussian massive spatial datasets: A block with pairwise likelihood approach
J. Acosta, C. Caamaño-Carillo and B. Morales 31

Influencia del método de interpolación en la generación de Modelos digitales de elevación en zonas planas: Caso de estudio en el delta del río Ranchería, La Guajira
J. M. Fragozo A., J. R. Escobar V., J. I. Pérez-Montiel 32

Dinámicas espaciales de la desigualdad socioeconómica y su relación con los cultivos ilícitos en Nariño, Colombia
F. Sepúlveda, A. Tapia and A. Grajales 33

Statistical analysis of point processes on linear networks based on the box counting dimension
J. F. Díaz-Sepúlveda, R. Giraldo, J. Mateu and F. J. Rodríguez-Cortés 34

Inhomogeneous interacting marked point processes for studying morphostructures in paleobiological data
D. Astaburuaga, R-S Stoica, D. Gemmerlé and F. Cuevas-Pacheco 35

A statistical test for selecting a cluster model in homogeneous spatial point processes
Y. Y. Ocampo-Naranjo, T. Mrkvička, J. Mateu and F. J. Rodríguez-Cortés 36

Dinámica espacio-temporal de los índices VCI, TCI y VHI (2000-2022) en la región caribe norte de Colombia
C. Diaz M., R. Rodriguez F. and R. Melendez S. 37

Evaluación del modelo de pulsos rectangulares de Bartlett-Lewis para la desagregación de lluvia diaria en una cuenca semiárida del caribe Colombiano
Y. A. Movil F., J. Pérez M. and J. D. Giraldo-Osorio 38

Spatio-temporal approaches for traffic flow prediction: A comparative study
M. Flores, R. Mollineda, M. Quimbiulco 39

Topological data analysis of spatial point patterns in tropical forests
S. Madrid, F. Cuevas-Pacheco and P. Montero 40

Characterization of path loss in omni antennas: A geostatistical approach
H. Bahamondes, F. Cuevas-Pacheco and M. Diago 41

Nonparametric methods for the homogenization of functional data
R. Fernández-Casal, M. Oviedo de la Fuente and M. Flores 42

Bayesian spatiotemporal evaluation of air quality policies and health impacts in Mexico City. The ProAire program
P. Juan, C. Diaz-Avalos, S. Chauduri, D. S. Antonio, W. S. Garcia-Peñuela and M. Saenz 43

Spatiotemporal assessment of heat-related infant mortality in Catalonia, Spain (2012-2022)
D. Solano, M. Solans, X. Perafita, M. A. Moreno, P. Juan, M. Saenz and M. A. Barceló 44

Bayesian spatio-temporal modeling of gender-based violence: The case of Medellín, Colombia
A. E. Patiño H., V. Seguro V., J. Cardona-Jiménez, S. Ruíz M., T. Rodríguez T., X. Castañeda O., M Hernández G. 45

Urban heat island intensity in coastal cities of northern Colombia using Landsat data and WRF/UCM model
R. Melendez, L. Diaz and H. Arregoces 46

Bayesian modeling of fish spatial distribution in Antioquia's fluvial networks using spatially correlated effects
D. L Cruz R. 47

Modelization of geographical distribution of aposematic frogs in Ecuador using deep learning and weighted pseudo-absences
D. Reina and A. Uquillas 48

Separable modelization of the geographical distribution of aposematic frogs in Ecuador
A. Salazar, A. Uquillas 49

A bayesian spatially-adjusted Gini index using poverty rates for fine-grained inequality mapping
X. Perafita, A. Tarres, A. Vila, D. Solano, M. A. Moreno, D. S. Antonio, W. S. García-Peñuela, M. Solans, M. A. Barceló and M. Saez 50

Unequal lifespans in sparse regions: A spatiotemporal exploration of how sex, nationality, and age shape life expectancy (2000–2022)
X. Perafita, A. Tarres, A. Vila, D. Solano, M. A. Moreno, D. S. Antonio, W. S. García-Peñuela, M. Solans, M. A. Barceló and M. Saez 51

Análisis del patrón puntual de presencia de peces en el sistema del río Cauca, Antioquia, Colombia
N. F. Romero S. and N. E. Céspedes P. 52

Keynotes

Cross-validation for dependent data

H. Rue

Computer, Electrical and Mathematical Sciences and Engineering Division, King Abdullah University of Science and Technology, Saudi Arabia

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Abstract. *I will discuss our new take on cross-validation (CV) for dependent data, like the case for spatial or spatio-temporal data. Traditional use of CV, like leave-one-out CV, is justified using independence-like assumptions. With dependent data, then leave-one-out CV make less sense, as we are evaluating interpolation properties rather than prediction properties. We can adapt the CV idea to dependent data, by removing a set of "near-by" data-points (to be defined), before predicting, but the issue is then how to do this in practice, which is less evident for more involved models. I will discuss our approach in the context of Latent Gaussian Models (LGM) where we can automatically can select appropriate groups of data to remove before predicting one data point. The new group-CV approach is available in the R-INLA package.*

Machine learning for geospatial data with explicit modeling of spatial correlations

A. Datta

Department of Biostatistics, Johns Hopkins University, United State of America

Abstract. *Traditionally geospatial analysis has relied on statistical models that explicitly model spatial correlations in the data. Recently, machine learning algorithms, such as neural networks and random forests, are increasingly used in geospatial analysis. However, most machine learning algorithms do not possess the functionality to directly encode spatial correlations. There is limited understanding of the consequences of ignoring spatial correlations in machine learning algorithms applied to geospatial data, despite this practice becoming increasingly common. We show empirically and theoretically that ignoring spatial correlations reduces accuracy of machine learning algorithms for geospatial data.*

We then propose well-principled machine learning algorithms for geospatial data that explicitly model the spatial correlation as in traditional geostatistics. The basic principle is guided by how ordinary least squares (OLS) extends to generalized least squares (GLS) for linear models to explicitly account for data covariance. We demonstrate how the same extensions can be done for random forests and neural networks, presenting the RF-GLS and NN-GLS algorithms. We provide extensive theoretical and empirical support for the methods and show how they fare better than naïve or brute-force approaches to use machine learning algorithms for spatially correlated data. We present the software packages RandomForestsGLS and geospaNN implementing these methods.

On spatio-temporal disease mapping: Univariate and multivariate models with applications

M. D. Ugarte

Statistics, Computer Science, and Mathematics Department, Universidad Pública de Navarra, Spain

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Abstract. *In this presentation, we will explore one of the most compelling applications of areal data: disease mapping. Following a brief historical overview, we will introduce the most widely used univariate space-time models in this domain. Then, we'll shift our focus to recently developed multivariate models, with an interesting application on gender-based violence in India. Additionally, we will discuss a straightforward alternative for analyzing large datasets, encompassing both univariate and multivariate models.*

Basis representations for latent Gaussian random field models

M. Haran

Department of Statistics, Penn State University, United State of America

Abstract. *Basis representations are central to modern spatial statistics, providing a flexible and computationally efficient approach for modeling high-dimensional spatial data. Focusing on Moran's basis, I will explain how basis representations provide an alternative model to traditional latent Gaussian random field models for all three categories of spatial data — geostatistics, lattice data, and point processes. They are also valuable in the field of computer experiments. I will connect and compare basis representations to other approaches for handling high-dimensional spatial data. Finally, I will explain how hierarchical spatial models using basis representations are easily implementable in standard statistical software like Stan, NIMBLE, and PyMC, facilitating broad applicability.*

Advancing Monte Carlo simulation with GANs, diffusion models, and normalizing flows

R. Assunção

Department of Computer Science, Universidade Federal de Minas Gerais, Brazil

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Recent years have seen remarkable progress in Monte Carlo simulation methods, driven by the integration of cutting-edge machine learning techniques such as Generative Adversarial Networks (GANs), diffusion models, and normalizing flows. These innovations enable the generation of complex, high-dimensional data, from highly realistic human faces to artistic transformations, such as converting a landscape photo into a Van Gogh-style painting. These breakthroughs, which often make headlines, capture widespread interest but remain challenging to simulate using traditional Monte Carlo techniques.

GANs operate by training two networks in a competitive framework, yielding impressive results in high-dimensional sampling. Diffusion models offer a compelling alternative to Monte Carlo sampling by iteratively refining samples, reversing a noise-adding process, and producing smooth transitions critical for many applications. Normalizing flows map simple, tractable distributions (e.g., Gaussians) to complex target distributions through a sequence of invertible transformations, enabling efficient density estimation and sample generation.

These advancements significantly expand the scope of Monte Carlo simulations, allowing statisticians and researchers to model more complex and non-standard distributions with greater accuracy and computational efficiency. This talk will explore these transformative methods, highlighting their principles, applications, and potential to redefine simulation in modern statistics and data science.

Statistical challenges in environmental data sets

A. Fassò

Department of Economics Sciences, University of Bergamo, Italy

Abstract. *I will first introduce the concept of "Statistical democracy" and provide some examples related to official statistics, COVID-19, big data, and generative AI. With this in mind, I will describe some issues related to air quality data sets. As a first data set issue, I will consider the spatiotemporally resolved connection between intensive farming and fine particulate matter (PM2.5) in Lombardy, Italy. Since, the intensive farming of livestock, primarily bovine and swine, is recognised as being responsible for approximately 97% of NH3 emissions in this region, I will discuss statistical modelling relating PM2.5 to NH3 emissions. Unfortunately, the NH3 monitoring network has an anti-preferential sampling bias, and statistical modelling will have to deal with this issue.*

The AGRIMONIA dataset (https://agrimonia.net/) provides airborne pollutant concentrations, weather, agricultural emissions, livestock, and land and soil use in the years 2016–2021, harmonised at the daily scale for Lombardy, Fassò et al. (2023). Thanks to a heteroskedastic Hidden Dynamic Geostatistical Model, the AGRIMONIA datasets is used to show that a 50% reduction in NH3 emissions in the wintertime would imply a reduction of PM2.5 by 7.0% overall (rural and urban plain) and by 12.8% in rural provinces where farming is more intensive, Rodeschini et al. (2024).

As a second data set issue, I will discuss the platform "AMELIA" developed in the frame of the GRINS project (https://grins.it/). It will cover hundreds of variables harmonised to the same resolution, i.e. municipality and daily, covering the Italian territory and years 2016-2022. For municipal air quality indicators, data from in-situ networks, models, and satellites will be fused using advanced statistical models for large spatiotemporal data.

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Invited

Assessing the agreement between two continuous sequences

R. Vallejos

Department of Mathematics, Universidad Técnica Federico Santa Maria, Chile

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Abstract. *The assessment of agreement between two variables has become increasingly important across diverse scientific disciplines and remains a subject of active research. A typical scenario involves comparing two instruments or measurement methods applied to the same experimental units, with the aim of quantifying the degree of concordance between them. For data measured on a continuous scale, various statistical approaches have been developed to evaluate agreement (Lin, 1989). In this talk, we introduce a novel coefficient of concordance based on the L1 norm, offering an alternative to existing robust measures. This new coefficient is parameter-free, computationally simple, and interpretable. We derive explicit expressions for the coefficient in the context of bivariate normal distributions and more generally within the class of elliptically contoured distributions. Additionally, we address the estimation of the proposed measure and demonstrate its practical utility through an application to real data. Finally, we outline a natural extension of the L1-based coefficient to assess agreement between two images, broadening its scope and applicability.*

Modeling temporal dependence in a sequence of spatial random partitions driven by spanning tree: An application to mosquito-borne diseases

R. H. Loschi

Departamento de Estatística, Universidade Federal de Minas Gerais, Brazil

Abstract. *Time-dependent regionalization, or spatially restricted grouping, is a significant area of research focused on understanding the evolution of spatial clusters over time. In this study, we adopt a probabilistic approach to regionalization, conceptualizing it as a random partition of geographic space at each time point, with the sequence of spatial partitions exhibiting time dependency. This methodology facilitates inference regarding the temporal dynamics of clusters. We employ a product partition prior for the random partitions at each time point, introducing temporal correlation among partitions through the temporal structure associated with prior cohesions. To explore partition search space effectively and ensure spatially constrained clustering, we utilize random spanning trees. This research is motivated by a pertinent applied problem: the identification of spatial and temporal patterns associated with mosquito-borne diseases. Given the overdispersion inherent in this type of data, we propose a spatio-temporal Poisson mixture model in which both mean and dispersion parameters vary according to spatio-temporal covariates. We apply the proposed model to analyze weekly reported cases of dengue from 2018 to 2023 in the Southeast region of Brazil. Additionally, we assess modeling performance using simulated data. Results indicate that our model is competitive in analyzing the temporal evolution of spatial clustering.*

Bayesian latent space modeling with spatial covariates for network community detection

J. C. Sosa-Martínez

Departamento de Estadística, Universidad Nacional de Colombia, Colombia

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Abstract. *We propose a robust Bayesian mixture model for community detection in both single-layer and multi-layer networks, integrating nodal attributes as a spatial process over latent space. The model captures heterogeneous dependence across layers by combining latent positions with spatially structured covariates, where edge probabilities depend on both latent distances (modulated by layer-specific factors) and attribute differences. Latent positions follow a finite Gaussian mixture, enabling probabilistic clustering. Simulations demonstrate improved performance over benchmark models, particularly under missing data. We also illustrate the model's utility on a real-world three-layer network of law firm employees.*

Composite likelihood inference for space-time point processes

F. Cuevas Pacheco

Departament of Mathematics, Universidad Técnica Federico Santa María, Chile

Abstract. *The dynamics of a rain forest is extremely complex involving births, deaths and growth of trees with complex interactions between trees, animals, climate, and environment. We consider the patterns of recruits (new trees) and dead trees between rain forest censuses. For a current census we specify regression models for the conditional intensity of recruits and the conditional probabilities of death given the current trees and spatial covariates. We estimate regression parameters using conditional composite likelihood functions that only involve the conditional first order properties of the data. When constructing assumption lean estimators of covariance matrices of parameter estimates we only need mild assumptions of decaying conditional correlations in space while assumptions regarding correlations over time are avoided by exploiting conditional centering of composite likelihood score functions. Time series of point patterns from rain forest censuses are quite short while each point pattern covers a fairly big spatial region. To obtain asymptotic results we therefore use a central limit theorem for the fixed timespan - increasing spatial domain asymptotic setting. This also allows us to handle the challenge of using stochastic covariates constructed from past point patterns. Conveniently, it suffices to impose weak dependence assumptions on the innovations of the space-time process. We investigate the proposed methodology by simulation studies and an application to rain forest data.*

A nonparametric test for SOIRS: Assessing second-order reweighted stationarity with covariates

J. A. González

Department of Statistics, Mathematics and Computer Science, Universidad Miguel Hernández, Spain

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Abstract. *This talk presents a novel nonparametric method to test the hypothesis of second-order intensity reweighted stationarity (SOIRS) in spatial point patterns, in relation to external covariates. The approach is based on the use of local indicators of spatial association (LISA) functions. These functional marks allow us to probe potential dependencies between the second-order structure of a point pattern and covariate information. While SOIRS is a common assumption in spatial analysis, formal tests for it are not common. Through simulation experiments, we demonstrate that the proposed test exhibits good performance in terms of both size and power. An application involving fish location data in a reservoir, along with several environmental covariates, showcases the method's practical utility.*

Accelerating AI in 2025

J. Merino

HPC & AI Latam Leader - Solution Sales Director Lenovo

Abstract. *Este es el Año del Auge, y en ningún otro lugar la oportunidad de ascender es mayor que en el mundo de la IA. Pero escalar no se trata solo de velocidad: se trata de elegir la dirección, establecer disciplina y determinar el camino correcto en un panorama complejo.*

A decay-adjusted spatio-temporal model to account for the impact of mass drug administration on neglected tropical diseases prevalence

C. Fronterre

Lancaster Medical School, Lancaster University, England

Abstract. *Monitoring and evaluating the effectiveness of Mass Drug Administration (MDA) programmes for Neglected Tropical Diseases (NTDs) presents significant methodological challenges, particularly when prevalence data are collected through repeated cross-sectional surveys at spatially varying locations. Traditional analyses risk conflating the spatial heterogeneity of disease with the true impact of intervention. We propose a flexible spatio-temporal geostatistical model that explicitly accounts for both the spatial structure of disease prevalence and the cumulative, time-varying effect of MDA campaigns.*

Our framework models observed prevalence as a binomial process, conditional on a latent spatial Gaussian process. The effect of MDA is incorporated as a multiplicative term on the counterfactual prevalence surface, allowing for flexible, parameterized decay functions to describe treatment impact over time. We demonstrate how to estimate model parameters via Monte Carlo maximum likelihood, and discuss identifiability issues arising from typical data limitations. Through simulation studies and application to realistic scenarios, we show how failing to account for the sampling design and intervention timing can bias impact estimates and spatial predictions. Our approach supports robust, fine-scale evaluation of intervention programmes and highlights the importance of principled spatio-temporal modelling in the context of disease control.

Fast mixture spatial regression: A mixture in the geographical and feature space applied to predict porosity in the post-salt

M. O. Prates

Department of Statistics, Federal University of Minas Gerais, Brazil

Abstract. *Extracting geological resources like hydrocarbon fluids requires significant investments and precise decision-making processes. To optimize the efficiency of the extraction process, researchers and industry experts have explored innovative methodologies, including the prediction of optimal drilling locations. Porosity, a key attribute of reservoir rocks, plays a crucial role in determining fluid storage capacity. Geostatistical techniques, such as kriging, have been widely used for estimating porosity by capturing spatial dependence in sampled point-referenced data. However, the reliance on geographical coordinates for determining spatial distances may present challenges in scenarios with small and widely separated samples. In this paper, we develop a mixture model that combines the covariance generated by geographical space and the covariance generated in an appropriate feature space to enhance estimation accuracy. Developed within the Bayesian framework, our approach utilizes flexible Markov Chain Monte Carlo (MCMC) methods and leverages the Nearest-Neighbor Gaussian Process (NNGP) strategy for scalability. We present a controlled empirical comparison, considering various data generation configurations, to assess the performance of the mixture model in comparison to the marginal models. Applying our model to a three-dimensional reservoir demonstrates its practical applicability and scalability. This research presents a novel approach for improved porosity estimation by integrating spatial and covariate information, offering the potential for optimizing reservoir exploration and extraction activities. The paper was partially supported by FAPEMIG and CNPq.*

Guest session TIES

Statistical learning for spatio-temporal point processes

J. Mateu

Department of Mathematics, University Jaume I, Spain

Abstract. *This seminar is focussed on using neural network strategies when dealing with spatio-temporal point processes. First problem. Given two spatial point patterns, random similarities or differences between them provide no information about the underlying differences between their corresponding generative point processes, and only structural similarities or differences are of interest. To this end, major determinants of given point patterns that include the most relevant information about the underlying point processes that have generated the observed point patterns must be extracted by a suitable transformation. Such transformation is called feature extraction in machine learning and pattern recognition literature. Here we use neural network methods to distinguish between generative processes and provide a classification method for new arrivals.*

Second problem. We propose a framework of spatio-temporal-network point processes for modeling crime events observed within street networks in urban areas. The framework incorporates the city street network structure as the underlying space of the crime events' occurrences, and uses a street network-based distance to measure the distance between events living in the continuous geographic space. We extend the definition of the event mark by concatenating the crime category of the event and the type of its nearby city landmark. Temporal and street distance-based spatial kernel functions are adopted to characterize the event dependencies over time and the geographic space, and the interactions between crime events with different marks are modeled through a mark interaction network. The learning of the mark interaction network is achieved by incorporating graph neural networks (GNNs) in our influence kernel.

Third problem. While random permutations of point processes are useful for generating counterfactuals in bivariate interaction tests, such permutations require that the underlying intensity be separable. In many real-world datasets where clustering or inhibition is present, such an assumption does not hold. Here, we introduce a simple combinatorial optimization algorithm that generates second-order preserving (SOP) point process permutations, for example, permutations of the times of events such that the L-function of the permuted process matches the L-function of the data. We apply the algorithm to synthetic data generated by a self-exciting Hawkes process and a self-avoiding point process, along with data from Los Angeles on earthquakes and arsons and data from Indianapolis on law enforcement drug seizures and overdoses. In all cases, we are able to generate a diverse sample of permuted point processes where the distribution of the L-functions closely matches that of the data. Fourth problem. Previous research demonstrated that second order statistics such as the K-function could not reliably be used to distinguish between log Gaussian Cox (LGCP) and Hawkes processes.

However, recent work suggests that machine learning algorithms such as convolutional neural networks (CNN) may be able to differentiate spatial point patterns. The use of a CNN allows for higher level features to be used to distinguish between point patterns that perhaps are indistinguishable by the human eye or through conventional statistics, especially first or second order statistics. Here, we analyze whether convolutional neural networks can aid in distinguishing Hawkes processes from LGCPs and offer recommendations for model selection between these two types of spatio-temporal clustering processes.

Reconstructing latent spatial relationships throw lasso methods

Y. Cuvero

Department of Mathematics, University Jaume I, Spain

Abstract. *Optimal resource allocation under spatial constraints is a fundamental problem in spatial statistics and applied decision-making, particularly in settings with limited resources. A notable example is the spatial deployment of pest control interventions, where suboptimal trap placement can lead to ineffective management and increased public health risk. In this work, we introduce a data-driven stochastic algorithm designed to identify spatially optimal intervention sites through a dimensionality-reduction approach grounded in the spectral decomposition of spatial structures.*

The method leverages a subset of eigenvectors derived from a spatial weights matrix, selected based on their correlation with the response variable and conditional local covariates. These selected eigenvectors and their associated eigenvalues are used to iteratively reconstruct a parsimonious approximation of the original spatial configuration that retains the key features of the latent spatial process. On the resulting structure, we compute a centrality measure—derived from graph-theoretical principles—to produce a ranked list of spatial units prioritized by strategic importance.

We apply this framework to a georeferenced dataset of cockroach sightings in Madrid from 2010 to 2013, identifying yearly rankings of optimal trap locations. As part of the conference presentation, the methodology will also be applied to a new dataset to demonstrate the algorithm's robustness, generalizability, and practical utility in spatial decision-making contexts. The results underscore the method's capacity to support data-informed policy interventions in complex urban environments.

Contributed

Multiclass classification of skin diseases from mobile phone images

N. Serdyukova[1]

[1]*Departamento de Estadística, Universidad de Concepción, Chile*

Abstract. *Access to specialized dermatological care in remote regions remains limited, and the diagnosis of malignant skin lesions can be challenging. Developing a system for multiclass classification of skin diseases based on images taken with mobile phones could significantly simplify preliminary diagnostics. The goal of this project is to create and train a neural network capable of multiclass classifying skin images. The best performance was achieved with EfficientNet, leveraging Compound Scaling to improve accuracy while maintaining computational efficiency. The model achieved validation accuracy of 1.0 and test accuracy exceeding 94%. The developed methodology can also be adapted for aerial imagery analysis to identify areas of environmental damage.*

Nonlinear distributed lag models with mixed effects for assessing climatic impact on respiratory health in Costa Rica

E. Parra-Rodríguez[1] and S. W. Chou-Chen [2]

[1] *School of Mathematics, University of Costa Rica, Costa Rica*
[2] *School of Statistics, University of Costa Rica, Costa Rica*

Abstract. *An integrated approach based on Distributed Lag Nonlinear Models (DLNM) combined with Generalized Linear Mixed Models (GLMM) is proposed, to analyze weekly hospital discharges due to respiratory conditions in the Central Valley of Costa Rica. Subregion-specific nonlinear and lagged associations were specified, and a random intercept was included to represent unobserved heterogeneity across subregions within the framework of a generalized linear mixed model. The results demonstrate substantial improvements in predictive performance compared to traditional models, enabling the identification of more vulnerable subregions and providing valuable evidence for public health surveillance and early warning systems.*

Testing for equivalence on the spatial concordance correlation coefficient: An approach using satellite images of lake Villarrica, Chile, from Landsat 8 and Sentinel-2

G. Ferreira[1], J. Urrutia[1] and R. Vallejos[2]

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Abstract. *In satellite image analysis, various tools facilitate spatial information extraction; however, differences in methodologies and algorithms create uncertainty in comparability, complicating both interpretation and cross-platform analysis. This lack of standardization can impact the reliability of conclusions drawn from spatial data. This study evaluates the similarity between satellite images captured by the Landsat 8 and Sentinel-2 satellites, focusing on distinct observations of Lake Villarrica, Chile. To evaluate agreement, we employ bioequivalence techniques commonly used in pharmacology and ecology. Using Monte Carlo simulations, we estimate the coverage of bioequivalence intervals under different equivalence limits for finite sample sizes. Our findings indicate that the bioequivalence approach provides a robust alternative for computing the Spatial Concordance Correlation Coefficient.*

Indirect estimation of the need for palliative care during the COVID-19 pandemic: A descriptive cross-sectional study using mortality data in the Biobío Region, Chile

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Abstract. *People with chronic diseases in their advanced phase require palliative care. This is essential to ensure their quality of life as it ends. However, a very low percentage of patients receive the necessary palliative care. The COVID-19 pandemic has adversely affected the planning and provision of palliative care. Despite this, in Chile, palliative care coverage was extended by law to cover nononcological chronic diseases. Implementation of this law is expected to be a significant challenge in terms of material resources, as well as the need for the formation of specialized palliative care teams. Therefore, it is essential to estimate the need for palliative care for all chronic diseases to generate useful input for planning and decision-making in public health. Objectives To indirectly estimate the need for palliative care among people with Chronic Oncological Diseases (COD) and Chronic Non- Oncological Diseases (CNOD) during the prepandemic and pandemic context due to COVID-19 in the BiobÃo Region in Chile. Methods Cross-sectional study based on mortality data from chronic oncological and nononcological diseases during the prepandemic (2010-2018) and pandemic (2020-2021) contexts due to COVID-19 in a Region of Chile through indirect estimation using minimal estimate, standardized mortality rates and geographically weighted regression. Results It was estimated that 76.25% of deaths from chronic diseases in the BiobÃo Region would have required palliative care, which represents 77,618 people who should have been included in these health benefits. The pandemic had a significant effect on the average number of deaths from CNOD. People belonging to this group were more likely to die from COVID-19 than from their baseline disease, unlike the deaths of people from COD, where no significant changes were observed.Conclusion These estimates highlight the potential size of the population requiring palliative care and emphasize the importance of recognizing the rights of individuals with COD and CNOD conditions. It is evident that there is a significant demand for palliative care services, as well as a pressing need for adequate resources, effective management, and strategic planning to cater to the needs of this population. This is particularly crucial in the heavily impacted areas and communes of the BiobÃo Region, Chile.*

On modeling discrete lattice data using the Potts model

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Abstract. *The analysis of spatial data on a grid is a widely used tool in fields like demography, epidemiology, image analysis, and land management. The Ising and Potts models are often used for such data, for instance in studying protein structures in biology, reconstruction of social networks in social sciences, and image segmentation in computer vision. However, in high-correlation settings simulations from the fitted models are not able to reproduce the characteristics observed in the data. Furthermore, likelihood-based inference is challenging due to an intractable normalizing constant that is a function of the model parameters. We propose a novel tapered version of the Potts models that builds on work from Fellows and Handcock in the context of exponential family random graph models. We show that the tapered model is a valuable alternative to the Potts model and provide an algorithm to fit the model. Based on real and simulated data studies, we provide practical guidance on when to use the tapered model, along with a discussion of its potential limitations.*

Intimate partner violence in Colombia 2015-2023 from the ecological feminist model

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Abstract. *Intimate partner violence affects one in three women worldwide, affecting their physical and mental health. The study conducts an ecological longitudinal study to analyze the district's influence on the variation of the risk of intimate partner violence in Colombia over a period of nine years. The study implements four models, which include two random factors: spatial effects and no spatial effects. The first is the convolution model without covariates, and the other three follow the ecological feminist model: characteristics of the victims (age, education, and relationship status), characteristics of the event (where the event took place, the triggering factor of the event, the weapon used in the event, the relation with the aggressor, the time of day, and the day of the week), and state characteristics (poverty, overcrowding, and people with unsatisfied basic needs). The model that best explains behavior is the characteristics of the event. San Andres Islands, Amazonas, and Casanare have the highest risk of suffering intimate partner violence.*

Kernel universal kriging

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Abstract. *Spatial prediction by using Kriging methods is very common in many applied fields including among others, environmental sciences, agronomy or geology. Ordinary kriging (OK) and universal kriging (UK) and their several related versions are widely used for carrying out prediction of spatial data. Given a realization of a random field OK solves the problem of spatial prediction when the process is stationary. This method does not require any explicit identification of the mean. If the mean of the process is not constant two practical solutions commonly used are UK and regression Kriging (also known as residual kriging). Assuming a realization of a Gaussian process, both OK and UK are best linear unbiased predictors (BLUP) or estimated BLUP (EBLUP), whether the parameters of the underlying linear model and the spatial covariance matrix are estimated from data. The problem of geostatistical modelling with nonlinear trend has been also considered. Here we give an approach in this context. A method which combines universal kriging (UK) and multivariate kernel regression (MKR) is considered. It is assumed that the non linear trend can be modeled by using MKR. The restrictions based on the weights of MKR are included in the UK equations system. We apply the methodology to a real data set. A cross-validation analysis allows to show the performance of the proposed methodology.*

Supervised classification for spatial functional multivariate data, based on the Mahalanobis distance

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Abstract. *In this work, we propose the use of geostatistical functional data tools to harness the spatial information and achieve an improved supervised classification of these type of data. We present the univariate and multivariate functional Mahalanobis semidistance in presence of spatial autocorrelation (SFMD), and illustrate its use for exploratory functional data analysis and for supervised classification.*

Effective sample size for a Gaussian process under fixed domain asymptotics

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Abstract. *Effective sample size (ESS) indicates the number of equivalent "independent" samples in an autocorrelated sample. In the literature, there are different analytical definitions for ESS. However, they all have in common that it is a function of the covariance matrix. When the latter is obtained from a parametric covariance function that satisfies the regularity conditions established in Mardia & Marshall (1984), it has been studied that, for the definitions given by Griffith (2005) and Vallejos & Osorio (2014) under the increasing domain approach, the estimation of ESS is consistent and asymptotically Normal. In this paper, we study the properties of the ESS estimators under an asymptotic infill scheme, showing that none of the previous estimators is consistent. This last is directly related to the fact that the spatial range parameter cannot be estimated consistently under the infill asymptotic scheme. Moreover, we show that under the Matérn covariance function, the ESS is upper bounded even when the sample size tends to infinity, which explains the inconsistency in the estimation of the rank parameter. Finally, this article provides an alternative definition of ESS, which is a function of the micro-ergodic parameter when considering the maximum likelihood estimation with data from a Gaussian process with an exponential covariance model under the fixed-domain asymptotic approach, and thus obtaining a consistent estimator of ESS. Simulation experiments were developed to evaluate the approximations provided by the proposed ESS and its statistical properties.*

Gaussian massive spatial datasets: A block with pairwise likelihood approach

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Abstract. *In recent decades, technological advancements have facilitated the collection of large volumes of real-time data from diverse sources (big data), including a notable increase in georeferenced data. This trend has introduced new methodological challenges in spatial statistics, particularly in obtaining efficient estimators and accurately assessing their uncertainty. In geospatial models, using full likelihood is often impractical for large datasets due to its high computational costs; for example, in Gaussian random fields, calculating the inverse of the covariance or correlation matrix is complex and frequently infeasible. To address this issue, the literature has proposed alternative methods such as composite likelihood. Some studies have explored pairwise likelihood using weighting functions based on distances or nearest neighbors, while others have investigated blockwise likelihood approaches, aiming to balance statistical and computational efficiency. This work proposes a hybrid methodology that combines block likelihood with pairwise likelihood: first, the data are divided into k-independent blocks, followed by the application of pairwise likelihood within each block. This approach reduces computational costs as the sample size increases, while maintaining statistical efficiency. Using Monte Carlo simulations on Gaussian random fields under an exponential model and employing weighting functions based on distances and nearest neighbors, we present results that support the feasibility of this approach.*

Influencia del método de interpolación en la generación de modelos Digitales de Elevación en zonas planas: caso de estudio en el delta del río Ranchería, La Guajira

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Abstract. *Se presenta la evaluación de la influencia del método de interpolación en la generación de modelos digitales de elevación (DEM) a partir de una nube densa de puntos LIDAR en una zona plana como el delta del río Ranchería, en Riohacha, La Guajira (Colombia). Utilizando cinco métodos de interpolación espacial: inverso de la distancia (IDW), vecino más cercano (NN), Topo to Raster (TTR), Spline y Kriging ordinario. La validación de los modelos se realizó con 315 puntos de control obtenidos mediante levantamiento GNSSRTK, y se calcularon las métricas RMSE, MAE y BIAS. Los resultados evidencian que TTR presentó el mejor desempeño global, seguido por Kriging con modelo exponencial. El método Spline mostró los mayores errores y sesgos. Estos resultados destacan la relevancia de una adecuada selección del método de interpolación para mejorar la precisión altimétrica de los MDE, especialmente en áreas planas con aplicaciones en modelación hidrológica y gestión del riesgo por inundación.*

Dinámicas espaciales de la desigualdad socioeconómica y su relación con los cultivos ilícitos en Nariño, Colombia

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Abstract. *La desigualdad en la distribución de recursos, oportunidades y acceso a servicios básicos continúa siendo uno de los desafíos más persistentes y complejos a nivel global, alimentando profundas brechas socioeconómicas. Frente a este panorama, los Objetivos de Desarrollo Sostenible se han consolidado como un marco orientador para enfrentar los retos más apremiantes de nuestras sociedades. En el caso de Colombia, la situación es especialmente preocupante. El país figura entre los más desiguales de América Latina, con notorias disparidades territoriales que limitan el acceso equitativo a condiciones de vida digna y reflejan una fragmentación estructural en su desarrollo. Ante esta situación, este trabajo se propuso abordar dos objetivos principales: analizar la variación espacial de las condiciones socioeconómicas y explorar su relación con la producción de cultivos de coca en el departamento de Nariño (Colombia). Para el primer objetivo, se consideraron variables como la tasa de homicidios, la proporción de vías primarias y seis índices construidos mediante el algoritmo Distance-Learning a nivel municipal. Para el segundo, se aplicó un modelo de Regresión Geográficamente Ponderado, el cual permitió examinar la heterogeneidad espacial en los factores que inciden en el cultivo de coca. Los resultados evidencian que las condiciones socioeconómicas presentan una marcada variabilidad espacial en Nariño, y que tanto el desempeño educativo como la tasa de homicidios se relacionan de forma significativa con la producción de cultivos de coca, siendo estas relaciones sensibles al contexto territorial.*

Statistical analysis of point processes on linear networks based on the box counting dimension

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Abstract. *In spatial statistic, the CSR hypothesis involves testing whether a point process is completely random. In the purely spatial case, a previous study proposed a CSR statistical test based on the fractal dimension, calculated using the box-counting method. We extend this methodology to a more complex geometric context, where the classical properties of a point process change and data visualization becomes less intuitive. As a result, the method is suitable for testing CSR in homogeneous point processes on linear networks, and for distinguishing between clustered and inhibitory behavior in point patterns. We present simulations and examples to illustrate the method.*

Inhomogeneous interacting marked point processes for studying morphostructures in paleobiological data

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Abstract. *This paper presents inhomogeneous marked point processes with multiple interactions that are applied to analyse morphostructures exhibited by a paleo-biological data set presented in Kolesnikov (2018).*

More specifically and due to the nature of the dataset, we model the probability density function describing the models by considering three effects: the distance to the nearest edge, the distance to the bottom right corner, and the distance to a reference point. Furthermore, interactions between the points through the observed marks are introduced. This is done via the Strauss and Area-Interaction processes. Such models may have between three and five parameters that must be estimated.

The proposed workflow is as follows. First from the data, the sufficient statistics of the proposed model are computed. Then, posterior sampling of the parameters is performed using the ABC Shadow algorithm. Next, the quality of the estimation is assessed trough the computation of estimation errors and significance of the model parameters is evaluated. Finally, model verification via envelope tests is performed.

The C++ library DRLib was the principal programming tool to perform model simulations, and parametric statistical inference based on the ABC Shadow algorithm The package of `R`*: spatstat was used for the exploratory analysis, for the model verification analysis through envelope tests and for the graphical presentation of the results.*

A statistical test for selecting a cluster model in homogeneous spatial point processes

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Abstract. *Selecting an appropriate model to fit a data set to make parameter estimation inferences is a fundamental goal in statistics. This task is particularly challenging in spatial point processes, where the large heterogeneity of spatial configurations makes multiple candidate models a significant theoretical and computational challenge. While formal and graphical tests can help distinguish between random, cluster, or regular, the essence of characterizing a point pattern lies in fitting a particular model through a goodness-of-fit test. However, when two or more models pass this test, the question arises about which model is the most appropriate. In this work, a formal statistical test based on a Monte Carlo method is proposed for the selection of homogeneous clustering models for stationary aggregated spatial point patterns. The performance of the test is evaluated in terms of Type I error and the power of the test is assessed through an extensive simulation study. Finally, the proposed method is applied to a point pattern of Paleolithic lithic tools discovered in an archaeological excavation in Tanzania, determining the Thomas model as the most suitable model.*

Dinámica espacio-temporal de los índices VCI, TCI y VHI (2000-2022) en la región caribe norte de Colombia

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Abstract. *Agricultural drought has intensified in the northern Caribbean fringe of Colombia La Guajira, Cesar and Magdalena over the last two decades, jeopardising the food security of Indigenous, peasant and Afro descendant populations. Using MODIS derived Normalized Difference Vegetation Index (NDVI) and Land Surface Temperature (LST) data (1 km, 8 day composites) for 2000- 2022, we calculated Vegetation Condition Index (VCI), Temperature Condition Index (TCI), and Vegetation Health Index (VHI). Pixel wise Mann 1Kendall tests and Sen's slopes revealed a significant regional decline in VHI (-0.006/year);* $(p < 0.05)$*, with the sharpest drops in upper La Guajira. A Bayesian INLA–SPDE spatio temporal model captured spatial dependence and generated annual probability maps of severe drought (VHI ¡ 0.4); cross validation yielded RMSE = 0.085 and AUC* $= 0.85$*. Forecasts indicate* $> 70\%$ *probability of severe drought for 2025 in La Guajira and the Serranía del Perijá foothills. Hot spot analysis (Getis Ord Gi) showed chronically stressed clusters co locating with sandy soils, low elevation and intensive land-use change. These findings support targeted adaptation measures and demonstrate the value of high resolution remote sensing coupled with hierarchical Bayesian modelling for early warning systems in data scarce regions.*

Evaluación del modelo de pulsos rectangulares de Bartlett-Lewis para la desagregación de lluvia diaria en una cuenca semiárida del caribe Colombiano

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Abstract. *La representación precisa de la variabilidad intra-diaria de la precipitación es esencial para el diseño hidrológico y la gestión del riesgo climático, especialmente en regiones semiáridas con escasa instrumentación. Este estudio evalúa la capacidad del modelo estocástico de Pulsos Rectangulares de Bartlett–Lewis (BLRP) para desagregar series diarias de precipitación en intervalos subdiarios de 30, 60, 90 y 120 minutos, tomando como caso de estudio la cuenca del río Ranchería, en el Caribe colombiano. Se utilizaron series diarias de 13 estaciones meteorológicas con alta calidad de datos. Los trimestres con mayor representatividad hidrológica fueron seleccionados a partir de un índice compuesto de frecuencia, intensidad y variabilidad de la lluvia. El modelo fue calibrado mediante el paquete HyetosMinute, preservando la estructura estacional y los totales diarios. Los resultados muestran que el intervalo de 60 minutos ofreció el mejor desempeño general, permitiendo simular series subdiarias coherentes con los patrones climáticos locales. Esta metodología permite generar información hidrometeorológica de alta resolución en zonas con baja densidad de estaciones, facilitando la modelación de eventos extremos y el diseño de sistemas de alerta temprana.*

Spatio-temporal approaches for traffic flow prediction: A comparative study

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Abstract. *Traffic congestion plagues urban roads, causing significant losses in time, energy, and productivity while worsening air quality, public health, and climate conditions. Accurate traffic prediction is essential for mitigating these challenges and advancing intelligent transportation systems (ITS). Spatio-temporal traffic prediction focuses on forecasting traffic states—such as flow, speed, or congestion— across interconnected road networks over time. This task is complex due to intricate spatial dependencies (between road segments or intersections) and temporal dependencies (across sequential time steps). This survey traces the evolution of traffic prediction methods, covering classical statistical models, traditional machine learning, deep learning architectures, and modern Graph Neural Networks (GNNs). GNNs are highlighted for their ability to effectively model non-Euclidean spatial data. We provide a comprehensive resource for researchers and practitioners by cataloging publicly available traffic datasets, preprocessing pipelines, and predictive models. Datasets are categorized by sensor type, geographic scope, temporal resolution, and data quality. We benchmark model performance using standardized datasets, evaluating accuracy, computational efficiency, and scalability under diverse traffic scenarios. The survey identifies future research directions, including transfer learning for cross-city applications and advanced GNN-based models. This work is pioneering in its thorough analysis of spatio-temporal traffic prediction methods, offering a mathematical formalization of the task and emphasizing models that adeptly handle both spatial and temporal dimensions.*

Topological data analysis of spatial point patterns in tropical forests

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Abstract. *In recent years, topological methods have emerged as powerful tools for understanding complex structures in data. In this work, we apply Topological Data Analysis (TDA) to study spatial point patterns in tropical forests using ecological data from Barro Colorado Island, Panama. This dataset includes over 424,000 spatial observations from eight forest censuses conducted every five years, providing detailed information on the distribution of more than 500 tree species. To reduce computational complexity, we focus on species with fewer than 500 individuals, analyzing their spatial structure through persistent homology. This technique captures topological features such as connected components, loops, and voidsâacross multiple scales and summarizes them in persistence diagrams and landscapes. These summaries are then used as input for clustering, allowing us to identify ecological similarities and differences among species. Our results show that, for most species, the spatial distribution remains stable across censuses, suggesting persistent ecological patterns. We also demonstrate the effectiveness of combining TDA with clustering algorithms (such as k-medoids) to classify species based on their topological signatures. This framework offers a novel perspective on species-level spatial organization and opens new avenues for exploring ecological spatial structure. Future work includes extending the methodology to other ecosystems and exploring hybrid models that combine TDA with machine learning approaches to improve classification accuracy and ecological interpretation.*

Characterization of path loss in omni antennas: A geostatistical approach

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Abstract. *Path loss describes the attenuation of an electromagnetic signal as it propagates from a transmitter to a receiver. This phenomenon depends on factors such as distance, obstacles, and environmental characteristics, with the presence or absence of a direct line of sight (Line-of-Sight, LoS or Non-Line-of-Sight, NLoS) playing a particularly relevant role.*

In this poster, we study path loss from a geo-statistical perspective, explicitly considering the difference between LoS and NLoS signals, emphasizing spatial dependence modeling and planar estimation.

The analysis is based on signal loss measurements collected in a library in Mexico using an omnidirectional antenna, classified by LoS or NLoS conditions. A Gaussian likelihood model is fitted, incorporating this classification through distinct mean and variance structures depending on the signal type. This allows the statistical characteristics of each case to be properly captured.

The spatial structure is modeled using a Matérn covariance function, and model adequacy is validated through standardized residual analysis and empirical variogram behavior. This approach is implemented using Gaussian random fields and universal kriging.

Nonparametric methods for the homogenization of functional data

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Abstract. *Functional data analysis (FDA) enables the modeling of phenomena that evolve continuously over time and is widely used in fields such as climatology and environmental sciences. However, functional curves are often contaminated with outliers or are partially observed, which can distort inference if not addressed through a homogenization step. This work presents a nonparametric procedure consisting of four main stages: pointwise outlier detection and correction, reconstruction of incomplete curves, identification of outlying trajectories, and homogenization of the sample. This procedure has been implemented in the R package npfda and is illustrated using real-world air pollution data.*

Bayesian spatiotemporal evaluation of air quality policies and health impacts in Mexico City. The ProAire program

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Abstract. *The Mexico City Metropolitan Area (ZMVM), one of the most densely populated urban regions in the world, has faced severe air pollution challenges for decades. While regulatory measures such as fuel reformulations, industrial emission controls, and vehicle restriction programs have been implemented since the 1980s, their spatio-temporal effectiveness and public health impacts remain insufficiently quantified. This study employs a novel Bayesian Interrupted Spatio- Temporal Series Analysis to assess the long-term effects of air quality interventions, particularly the ProAire program (2002–2010), on particulate matter (PM2.5 and PM10) concentrations and respiratory health outcomes. Our methodology integrates high-resolution air quality monitoring data, geospatial covariates, socio-economic indicators, and respiratory disease records across Mexico City. Using the Integrated Nested Laplace Approximation (INLA) with Stochastic Partial Differential Equations (SPDE), we model both abrupt and gradual changes in pollution patterns while accounting for spatial autocorrelation and confounding factors. Our findings indicate significant temporal reductions in both, PM2.5 and respiratory hospital admissions, following key policy implementations, though with pronounced spatial heterogeneity. Areas with higher socio-economic vulnerability exhibited slower improvements, suggesting inequities in policy effectiveness. Furthermore, the analysis reveals complex relationships between localized air quality trends and respiratory health outcomes, providing insights for targeted environmental interventions. This study contributes to the advancement of spatiotemporal statistical methods in environmental epidemiology by offering a robust framework for evaluating the impact of public policies across both time and space. The results underscore the need for geographically tailored strategies to address air pollution and its health disparities in megacities..*

Spatiotemporal assessment of heat-related infant mortality in Catalonia, Spain (2012-2022)

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Abstract. *Infant vulnerability to extreme heat remains understudied, particularly in fine-scale geographic analyses. This study evaluates the association between heat exposure and infant mortality in Catalonia, Spain, from 2012 to 2022 using a novel spatiotemporal Bayesian approach. We analysed daily mortality data, meteorological variables, air pollution levels, and socioeconomic indicators across basic health areas (ABS) to quantify heat-attributable risk. The study period recorded 1,830 infant deaths, with distinct patterns across age groups: 858 early neonatal (0-6 days), 391 late neonatal (7-27 days), and 581 postneonatal (28-364 days) deaths. Leading causes included perinatal conditions, cardiovascular/respiratory disorders, and sudden infant death syndrome. The year 2022 proved particularly critical, with six intense heatwaves occurring earlier and lasting longer than in previous years, resulting in measurable excess mortality. Our analytical framework advances current methodologies by generating highresolution temperature predictions at the ABS level while accounting for humidity, air pollution, and area-level deprivation. The results demonstrate significant spatial variability in heat-related risk, with economically disadvantaged areas showing heightened vulnerability. The analysis reveals critical periods of infant susceptibility to thermal stress and provides evidence for targeted public health interventions. This study contributes to climate-health research by demonstrating the value of spatiotemporal statistical methods in assessing environmental health risks. The findings emphasize the need for localized heat adaptation strategies to protect vulnerable infant populations, particularly in the context of increasing climate variability.*

Bayesian spatio-temporal modeling of gender-based violence: The case of Medellín, Colombia

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Abstract. *Gender-based violence against women and girls remains a persistent issue in Colombia, with serious implications for public health, human rights, and social cohesion. Understanding its behavior over time and space is essential for advancing rigorous analysis and generating useful evidence to support prevention efforts. This work presents a case study focused on the spatio-temporal modeling of gender based violence using official data from the national public health surveillance system and population projections. The objective is to explore the application of Bayesian hierarchical models to estimate the relative risk of case occurrence and produce short-term forecasts across specific territorial divisions. The methodological approach aims to capture both the geographic variability and temporal dynamics of the phenomenon, while accounting for the particularities and limitations of the available data. This study is part of a research project funded by the Orquídeas: Women in Science 2024 call by the Ministry of Science, Technology, and Innovation of Colombia, which supports initiatives led by women in science, technology, and innovation. The adopted approach seeks to contribute to the quantitative understanding of gender-based violence from a territorial and statistical perspective, highlighting the potential of Bayesian modeling in the analysis of complex social phenomena. Through this applica tion, the project aims to generate tools that help characterize spatio-temporal patterns and advance analytical frameworks that connect statistical knowledge with the urgent social challenges faced by the country.*

Urban heat island intensity in coastal cities of northern Colombia using Landsat data and WRF/UCM model

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Abstract. *This study examines the evolution of urban heat islands (UHI) in northern Colombia from 2016 to 2021, focusing on the Barranquilla metropolitan area. It uses a multi-method approach, combining Landsat satellite imagery with numerical simulations from the WRF model coupled with the Urban Canopy Module (WRF/UCM) to assess UHI intensity and magnitude. Landsat data revealed an annual mean land surface temperature (LST) increase, rising from 27.78 °C in 2016 to 28.46 °C in 2021, particularly in central and southern built-up areas. LST changes by land use/land cover (LULC) class showed increases of 0.48°C in vegetated areas, 1.23 °C in built-up zones, 0.06 °C in water bodies, and 1.07 °C in barren lands. The temperature difference between urban and vegetated zones widened from 2.14 °C to 2.89 °C, indicating increasing UHI intensity due to urban expansion and densification. While UHI magnitude was higher during the day, WRF/UCM simulations for 2021 indicated a reversal, with greater nighttime intensity (3.49 °C) than the daytime peak in 2016 (1.60 °C). This shift is linked to increased surface radiation absorption and reduced evaporative cooling in impervious areas, which elevates near-surface air temperatures. Additionally, minimal variation in sensible heat flux between impervious and vegetated surfaces contributes to enhanced nighttime UHI intensity. Finally, these findings highlight the urgent need for sustainable urban planning and development strategies to mitigate and adapt to the growing impacts of UHI in rapidly urbanizing regions.*

Bayesian modeling of fish spatial distribution in Antioquia's fluvial networks using spatially correlated effects

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Abstract. *Statistical models predicting the spatial distribution of fish across stream networks can inform conservation planning and ecological restoration, especially in biodiverse regions such as Antioquia, Colombia. However, modeling ecological data in fluvial systems is challenged by spatial autocorrelation arising from the dendritic and hierarchical structure of drainage networks. In this study, we employ a Bayesian approach based on integrated nested Laplace approximation (INLA) to model the presence and relative abundance of native fish species across multiple basins in Antioquia. The model incorporates spatially correlated random effects to account for dependency between sampling locations connected through the stream network. Model performance was assessed using leave-one-out cross-validation, yielding satisfactory values of root mean square error (RMSE) and coefficient of determination (R^2). This work highlights the potential of Bayesian spatial models for ecological applications in tropical river systems. Open-access R scripts and example datasets are provided to support implementation by researchers and environmental agencies.*

Modelization of geographical distribution of aposematic frogs in Ecuador using deep learning and weighted pseudo-absences

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Abstract. *The escalating threats of deforestation, climate change, and human activities jeopardize the survival of Dendrobatid frogs in Ecuador. To address this, we developed a robust species distribution modeling (SDM) framework leveraging deep learning to predict suitable habitats for these aposematic amphibians. Our approach uniquely integrates presence-only data with two distinct types of pseudo-absences—random background and target-group background points—to mitigate sampling bias and enhance model generalization. We implemented a multi-layer perceptron for multi-species prediction, trained on a comprehensive dataset of environmental and topographic covariates. Crucially, the model incorporates a full weighted loss function, enabling differential weighting of presences, pseudo-absences, and species-level imbalances. Our results demonstrate that this methodology significantly improves model robustness, accurately identifying ecologically plausible habitats even in under-sampled regions. This work not only highlights the power of deep learning to overcome critical challenges in ecological modeling but also provides actionable intelligence for targeted conservation and biodiversity monitoring in a global hotspot of amphibian diversity.*

Separable modelization of the geographical distribution of aposematic frogs in Ecuador

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Abstract. *In continental Ecuador, aposematic frogs face increasing threats from climate change, habitat loss and human activity. This study evaluates the hypothesis of first-order spatio-temporal separability by applying point process models to historical records between 1950 and 2019. Statistical tests such as global envelopes, quadratic deviation and chi-square were used. The results show a significant interaction between space and time, suggesting that they cannot be analyzed independently. These findings are key to improving ecological analysis and generating more precise conservation strategies.*

A bayesian spatially-adjusted Gini index using poverty rates for fine-grained inequality mapping

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Abstract. *The Gini index is widely used to measure income inequality, yet as a single summary statistic it has limitations, especially for territorial comparisons. It tends to underrepresent disparities among the most disadvantaged populations and is overly sensitive to extreme upper incomes. To address these shortcomings, we propose a normalization of the Gini index using the poverty rate as an adjustment factor, thereby enhancing its ability to reflect territorial inequality across small areas.*

Unequal lifespans in sparse regions: A spatiotemporal exploration of how sex, nationality, and age shape life expectancy (2000–2022)

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Abstract. *Key demographic factors—sex, nationality, and age—interact to shape life expectancy, particularly in sparsely populated areas where demographic volatility and limited data complicate health monitoring. These challenges hinder the identification of health inequities and the design of place-based interventions. Our objective was to estimate life expectancy in small areas by accounting for intersecting sociodemographic dimensions and to explore their spatial and temporal variation over a 22-year period.*

Análisis del patrón puntual de presencia de peces en el sistema del río Cauca, Antioquia, Colombia

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Abstract. *Colombia es una potencia hídrica mundial con una rica diversidad de peces de agua dulce, vital para la cultura y la economía. Amenazada por la contaminación, la minería y la sobrepesca, su conservación depende del estudio de la distribución de los órdenes de peces en la red fluvial. Este proyecto trata a los peces como patrones puntuales, utilizando un kernel gaussiano para evaluar la intensidad a lo largo de las distancias fluviales, revelando puntos críticos, agrupaciones y patrones clave de biodiversidad.*
