Sandro Martinelli Reia, PhD

Data Scientist | Computational Physicist | Urban Scientist

smreia@gmail.com • Google Scholar • sandroreia.github.io

Summary

Research Scientist with 10+ years of experience in applying computational modeling, statistics, and machine learning to analyze real-world complex systems and generate actionable insights. Expertise in high-performance computing (HPC), large-scale simulation, and scalable data pipelines, including metropolitan-scale agent-based models with 20M+ agents. Researcher with 33+ peer-reviewed publications (including in *Nature Communications* and *Nature Cities*), 400+ citations, and an h-index of 11. Proven ability to translate complex problems into rigorous analytical solutions, collaborate in interdisciplinary teams, and work under deadlines and mission-driven goals.

Experience

Postdoctoral Researcher, Geography & Geoinformation Science 2023 – Present
George Mason University Fairfax, VA

- Developed a large-scale agent-based model simulating mobility for 20M+ agents using `repast4py`/MPI; optimized high-performance computing (HPC) workflows to reduce simulation runtime from days to minutes.
- Architected end-to-end geospatial pipelines using `GeoPandas` and `OSMnx` to integrate social, infrastructure, and behavioral data for deployment in the HAYSTAC/IARPA program.
- Led research lifecycles for high-stakes deliverables, translating complex technical findings into actionable insights for L3Harris and ensuring on-time delivery of mission-critical outcomes.

Postdoctoral Researcher, Civil Engineering 2021 – 2023
Purdue University West Lafayette, IN

- Developed multi-scale stochastic systems models to characterize urban evolution, disaggregating domestic migration into inter-city and intra-city flows for 3,100+ U.S. counties.
- Engineered analytical workflows to synthesize 15 years of American Community Survey (ACS) data, utilizing Lévy stable distributions to identify "migration shocks" and quantify their impact on city rank volatility.
- Authored high-impact research (e.g., *Nature Communications*, *Nature Cities*) demonstrating how negative population density gradients drive urban sprawl and how spill-over effects temper local demographic shocks.

Postdoctoral Researcher, Institute of Physics 2016 – 2021
University of São Paulo São Paulo, Brazil

- Developed and analyzed parsimonious agent-based models in Fortran across 10^5 simulation runs, demonstrating that constrained information sharing optimizes search efficiency in complex collective systems.
- Used the SIR epidemic model to describe 15 years of empirical APS data, showing that state-of-the-art models for forecasting nonstationary time series are very likely to fail to predict the long-term citation counts of highly-cited papers.
- Evaluated the "wisdom of crowds" phenomenon by applying nonparametric statistical analysis to nearly 10,000 empirical forecast experiments from the FRBP database, demonstrating that collective predictions outperform the majority of individual experts less than 70% of the time and exposing the phenomenon as a selective attention fallacy.

Education

PhD in Physics (Statistical and Computational Physics) 2015
University of São Paulo (USP) São Paulo, Brazil
Dissertation: *Activity, Phase Transitions, and Media Effects in a Sociocultural Model*

MSc in Physics (Statistical and Computational Physics) 2011
University of São Paulo (USP) São Paulo, Brazil
Thesis: *Phase Transitions and Nucleation Processes in Cellular Automata Rule Space*

BSc in Physics (Theoretical Physics) 2008
University of São Paulo (USP) São Paulo, Brazil

Selected projects

IARPA HAYSTAC — Large-scale Urban Mobility Simulation (Lead Developer)

- Established models of "normal" human movement across times, locations, and people in order to characterize what makes an activity detectable as anomalous within the expanding corpus of global human trajectory data.
- Led the development of a high-performance urban microsimulator in `Repast4Py/MPI` to generate realistic trajectories for 20M+ agents, enabling the detection of subtle anomalous behaviors within massive mobility datasets.

NSF CRISP Type 2: Critical Transitions in the Resilience and Recovery of Interdependent Social and Physical Networks

- Investigated post-disaster recovery in interdependent social and physical networks, focusing on how network structure, household decision-making, and cascading failures influence resilience, tipping points, and community re-entry.
- Simulated recovery dynamics and evaluated policy scenarios; highlighted heterogeneous recovery pathways relevant to climate adaptation and community resilience.

FAPESP Diffusion of Innovations: a computational approach based on Axelrod's model

- Investigated how innovations spread in culturally heterogeneous populations using variants of Axelrod's model, with emphasis on social influence, homophily, media effects, demographic mobility, and phase transitions in collective behavior.
- Developed and analyzed computational extensions of Axelrod-type agent-based models, using large-scale simulations and statistical-physics methods to characterize how mobility, long-range interactions, and network structure affect innovation diffusion and cultural dynamics.

Core Skills

HPC	Fortran, OpenMP, MPI, Repast4Py.
Data Science & Machine Learning	Python (Pandas, SciPy, Scikit-learn, MySQL), data analysis, data visualization (Seaborn), supervised and unsupervised learning, classification, regression, k-means clustering, random forests, multilinear regression, feature engineering (embedding).
Geospatial & GIS	GeoPandas, Shapely, PyProj; geospatial data processing, spatial analysis.
Data Sources	OpenStreetMap (building footprints and road network), NHTS/AADT (mobility data), Safegraph/Veraset (POI foot-traffic volume), Census/ACS (demographic datasets), Web of Science/APS (citation network).
Leadership & Mgmt	Supervised PhD students and led day-to-day laboratory activities. Expert in project lifecycle management, interdisciplinary team coordination, and technical mentorship.
Communication	Scientific writing with 30+ publications and 400+ citations. Skilled at translating complex data insights for non-technical audiences.

Selected Publications

- **Reia**, S. M., et al. *Domestic migration and city rank dynamics*. **Nature Cities**, 2025.
- **Reia**, S. M., et al. *Spatial structure of city population growth*. **Nature Communications**, 2022.
- **Reia**, S. M., et al. *Modeling the dynamics and spatial heterogeneity of city growth*. **npj Urban Sustainability**, 2022.
- **Reia**, S. M., et al. *Function and form of U.S. cities*. **Computers, Environment and Urban Systems**, 2025.
- **Reia**, S. M., et al. *Agent-based models of collective intelligence*. **Physics of Life Reviews**, 2019.
- **Reia**, S. M., et al. *Opportunities and challenges of LLMs in urban science*. **Physics of Life Reviews**, 2025.

Academic service

- Academic Editor, PLOS One (Complexity and networks, Urban studies).
- Frontiers Topic Editor in the Research Topic "Science of Science: A Complex Network Perspective".
- Reviewer for journals including CEUS, IJGIS, Scientific Reports, Communications Physics, Physica A, and others.