PhD Position – Stochastic Modeling of Emerging Arboviral Diseases

INRAE – PACA Center – BioSP Unit (Avignon)

Working Environment

The PhD will be carried out within the **BioSP unit (Biostatistics and Spatial Processes)**, a research unit of the MathNum department of INRAE, located at the Provence-Alpes-Côte d'Azur center in Avignon. BioSP develops approaches in probability theory, mathematical modeling, statistics, and numerical analysis for the study of complex dynamic systems, particularly in epidemiology, ecology, and plant health.

The PhD is part of the national project **Maths-ArboV**, led by Luis Almeida (Sorbonne Université), Benjamin Roche (IRD), and Raphaël Forien (INRAE). The project brings together a consortium of modelers (INRAE, IRD, Institut Pasteur, INSERM, and several mathematics laboratories) to better understand and anticipate health risks related to emerging arboviral diseases in mainland France.

The PhD candidate will be **jointly supervised by two mathematicians from BioSP and one epidemiologist from IRD**, ensuring both strong theoretical and applied guidance. The candidate will work in an interdisciplinary environment, with regular interactions with researchers in applied mathematics, modeling, statistics, and public health.

Scientific Objectives

Arboviral diseases transmitted by *Aedes albopictus* (dengue, chikungunya) represent a growing risk in mainland France. The recent increase in locally transmitted outbreaks highlights the need to develop mathematical tools capable of linking vector dynamics, environmental factors, and epidemic risk.

The main objective of the PhD is to develop a **stochastic spatio-temporal host–vector transmission model** integrating:

- Spatial and temporal heterogeneity in vector and host densities;
- Climatic and anthropogenic factors;
- Control measures implemented following case detection.

The research will combine:

- **Probabilistic modeling of host–vector systems**, accounting for stochastic effects associated with small transmission clusters;
- **Analysis of spatial stochastic processes**, limit theorems, and homogenization techniques to connect individual and regional scales;
- Development of **mechanistic-statistical approaches** within a Bayesian framework for parameter estimation from real epidemiological data;
- Numerical simulation of dynamic systems in realistic heterogeneous landscapes.

This PhD also offers the opportunity to produce **original theoretical results in applied probability and partial differential equations** (PDEs), while remaining strongly grounded in applied public health and epidemiological issues.

Education and Required Skills

Master's degree (M2) or equivalent with specialization in **applied mathematics**, probability, or PDE analysis.

Desired skills:

- Stochastic processes and advanced probability;
- Partial differential equations;
- Statistics;
- Scientific programming (Python).

Personal qualities:

- Strong interest in both theoretical and applied modeling;
- Interest in the mathematics–epidemiology interface;
- Ability to interact with scientists from other disciplines;
- Autonomy, scientific curiosity, and rigor.

The PhD candidate will be enrolled in the Doctoral School of Mathematics and Computer Science of Marseille.

Contact and Practical Information

Raphaël Forien – raphael.forien (at) inrae.fr
Lionel Roques – lionel.roques (at) inrae.fr

Expected starting date: Fall 2026.

To apply, please send a **CV**, **cover letter**, and **academic transcripts** to the supervisors (above).