DYNAMIC SPACE-TIME MODELLING FOR ENVIRONMENTAL AND ECOLOGICAL APPLICATIONS

Ph. D. Joshua S. Nort
Ph. D. Likun Zhang

This course provides a practical introduction to hierarchical dynamic spatio-temporal models (DSTMs) for analyzing environmental and ecological data. We will explore a powerful framework for understanding how natural processes evolve across both space and time while rigorously accounting for uncertainty.

The curriculum will first establish the core principles of hierarchical modeling, including specifications for data models (how observations relate to the true process), process models (the latent dynamics governing the system), and parameter models. We will cover both linear and nonlinear dynamical systems, with a focus on parsimonious parameterizations, dimension reduction techniques (e.g., basis functions, EOFs), and process models motivated by scientific knowledge (e.g., PDEs and integro-difference equations).

To bridge theory and practice, the course features hands-on analyses using real-world datasets. Participants will apply these models to:
- Sea Surface Temperature (SST) Data: Forecast El Niño and La Niña events using both linear and nonlinear DSTMs in a Bayesian hierarchical framework.
- Animal Migration Data: Model the spread of an invasive species (e.g., Eurasian Collared Dove) using a nonlinear, ecologically motivated process model that accounts for imperfect detection and spatially varying dispersal.

Implementation and inference will be a major focus. By the end of the course, students will be equipped to build, fit, and critique their own dynamic spatio-temporal models for a wide range of scientific applications.

ABOUT THE SPEAKERS

Joshua S. North is a Research Scientist in the Earth Systems Sciences Division at Lawrence Berkeley National Laboratory. He received his Ph.D. in Statistics from the University of Missouri Columbia, where his dissertation focused on Bayesian approaches to data-driven discovery of nonlinear dynamic equations. His research develops statistical methods for dynamic processes, probability distributions for dependent basis functions, methods for understanding weather and climate events, and statistical modeling of ecosystems.

Likun Zhang is currently an Assistant Professor in the Department of Statistics at the University of Missouri. He obtained his PhD from the Department of Statistics at the Pennsylvania State University and did postdoctoral research under the DOE-funded CASCADE project at the Lawrence Berkeley National Laboratory. His research focuses on extreme value theory and flexible spatial extremes modeling, which has been used to study a variety of weather processes and to detect changes in their long-term climatology. He works closely with deep learning techniques in the modeling of spatial extremes.