technische universität dortmund

fakultät statistik

Juniorprofessur Environmetrics

Computationally efficient geostatistical models for describing time-scale-dependent climate variability

Masterthesis
Supervision: JProf. Dr. Nils Weitzel, Environmetrics group
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Short description

Climate varies on all spatial and temporal scales due to internal dynamics and changes in boundary conditions. Inferring the timescale-dependent spatial structure of climate variations from (potentially sparse) observations can help to understand drivers of climate variability and evaluate climate simulators used for future predictions. Standard geostatistical models to describe stochastic fields such as Gaussian processes suffer from high computational cost, making them unfeasible for large datasets and Bayesian inference with MCMC methods. Over the last couple of decades, several methods have been developed to approximate standard Gaussian process models as well as non-Gaussian and non-stationary extensions, in particular through sparse approximations of the covariance or precision matrices. This project aims at exploring to what extent these methods are suitable for describing climate variability as observed during the last couple of centuries and simulated by climate simulators. Potential thesis topics include

- Reviewing existing methods and implementations and their theoretical suitability for describing climate variability
- Comparing parameter and state estimates from existing implementations (mostly in R)
- Quantify the robustness of estimates as a function of the number and accuracy of climate observations

Key concepts/prerequisites

- Experience with geostatistical methods/stochastic processes (e.g. Gaussian random fields/Gaussian Markov random fields)
- Experience with spatial or spatio-temporal data
- Programming skills in R
- Interest in working with spatio-temporal climate data

Key references with example algorithms

- Heaton, M. J., Datta, A., Finley, A. O., Furrer, R., Guinness, J., Guhaniyogi, R., Gerber, F., Gramacy, R. B., Hammerling, D., Katzfuss, M., Lindgren, F., Nychka, D. W., Sun, F., and Zammit-Mangion, A.: A Case Study Competition Among Methods for Analyzing Large Spatial Data, JABES, 24, 398–425, https://doi.org/10.1007/s13253-018-00348-w, 2019.
- Hong, Y., Song, Y., Abdulah, S., Sun, Y., Ltaief, H., Keyes, D. E., and Genton, M. G.: The Third Competition on Spatial Statistics for Large Datasets, JABES, 28, 618–635, https://doi.org/10.1007/s13253-023-00584-9, 2023.