# Statistical emulation of vegetation-climate-CO2 relationships

Bachelor or Masterthesis
Supervision: JProf. Dr. Nils Weitzel, Environmetrics group
12.01.2026

## Short description

Earth system simulators (ESSs) are process-based numerical models of the atmosphere, ocean, and land surface. They are increasingly used to model past, present, and future changes of the climate and biosphere. However, their computational complexity limits the ability to perform sensitivity studies, that disentangle drivers of environmental changes, and quantify uncertainties. Statistical emulation of ESS submodules can replace computationally expensive simulations by fast statistical predictions, thereby helping to overcome these issues. This project aims at emulating the climate-CO2-vegetation relationship of ESSs to improve our understanding of past vegetation changes and calibrate ESSs that are used to predict the next decades and centuries. Building on emulations of tree cover with generalized additive models (GAMs), potential thesis topics include

- Comparing GAM-based emulations with other non-parametric estimation techniques (e.g., Gaussian processes, random forests)
- Optimizing predictor selection
- Comprehensive evaluation of emulator skill
- Extending emulations to multivariate response variables
- Uncertainty quantification and spatial modeling of residuals

## Key concepts/prerequisites

- Experience with non-parametric estimation/statistical learning methods
- Experience with model selection methods
- Programming skills in R or python
- Interest in working with large spatial datasets

## Key reference

- Sect. 2.5 in Dallmeyer, A., Weitzel, N., Schild, L., Herzschuh, U., Kleinen, T., and Claussen, M.: Unravelling the tree cover dynamics over the last 20,000 years on the Northern Hemisphere, EGUsphere [preprint], https://doi.org/10.5194/egusphere-2025-6393, 2025.