Machine Learning Techniques for Global Sensitivity Analysis in Earth System Models

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Abstract

Studies dealing with Earth system models are not only challenged by the compute intensive nature of these models but also by the high-dimensionality of the input parameter space. In our previous work with the land model components (Sargsyan et al., 2014, Ricciuto et al., 2018) we identified subsets of 10 to 20 parameters relevant for each output quantity of interest (QoI) via Bayesian compressive sensing and variance-based decomposition. Nevertheless the algorithms were challenged by the nonlinear input-output dependencies for some of the relevant QoIs.

In this work we explore a set of machine learning techniques to build computationally inexpensive surrogate models tailored to land model predictions at several Fluxnet sites (www.fluxdata.org). We compare the skill of machine-learning models, e.g. neural networks, to identify the optimal number of classes in selected QoIs and construct robust multi-class classifiers that partition the parameter space into regions with smooth input-output dependencies. These classifiers are then coupled with sparse learning techniques to build sparse or low-rank surrogate models tailored to each class. The multiclass surrogates are then used for global sensitivity analysis (GSA) via variance-based decomposition, identifying parameters that are important for each QoI. Besides confidence in GSA results, the error associated with the surrogate can subsequently be used for likelihood construction in surrogate-enhanced calibration studies.

References

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