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SPOTPY: A Python library for the calibration, sensitivity- and uncertainty analysis of Earth System Models

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Earth and Environmental System Models need appropriate settings of their parameters. These parameters are often neither measureable nor based on physical constants. They are rather applicable in a certain range, which introduces inevitably uncertainty. However, there are many tools around, helping modelers to deal with the parameterization. Firstly, the sensitivity analysis (SA) techniques, which can give information how important the parameters are for a specific research question. Secondly, uncertainty analysis (UA) techniques. They help to quantify the confidence in model output with the given parameters. Finally, calibration techniques, which help to find a good parameter setting to achieve the best model results. For each of different methods there is a comprehensive set of algorithms available. While new methods are coming up. All methods differ in their underlying philosophy, how parameters are threated and model performances are propagated. Unfortunately, there is overall little guidance about the benefits of a specific method. Consequently, the users' choice for a specific parameter estimation method becomes more dependent on its availability than its performance.

We developed SPOTPY (Statistical Parameter Optimization Tool), a free open source Python package containing a comprehensive set of methods typically used to calibrate, analyze and optimize parameters for almost any parameter driven model. SPOTPY currently contains 15 widely used algorithms for SA and UA, 17 objective functions, 17 likelihood functions, 23 hydrological signature functions and can sample from 11 parameter distributions. SPOTPY has a model-independent structure and can be run efficiently in parallel from a workstation using multiprocessing, to large computation clusters using the Message Passing Interface (MPI) for single and multi-objective calibration.

SPOTPY is already widely used for a variety of models. It comprises contributions from different working groups. We will give an overview about latest advancements and included algorithms. The use of SPOTPY will be demonstrated with simple hydrological open source models (HYMOD, CMF). Finally, a recently developed Graphical User Interface will be used to show that the choice of different parameter optimization methods as well as objective functions can lead to conflicting results.