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Reducing uncertainties in earth system sciences by optimizing model parameters and measurements

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The aim of my work is to optimize parameters and conditions for measurements for different models of parts of the Earth system. Models play a key role in describing and studying the Earth system. Often these models contain parameters which are only vaguely known. If these parameters are insufficiently determined, this leads to inaccurate models. Therefore, the parameters are adjusted so that the model describes the reality sufficiently accurate. Using mathematical optimization method parameters can be computed, so that the model reproduces the reality as closely as possible.

For this purpose, usually measurements of the modeled entities are performed. However, these measurements may require a considerable amount of resources, such as time or money. Therefore only necessary measurements should be carried out and these should provide a maximum information gain.

Using statistics, it can be determined how many measurements are needed to achieve a given accuracy for the model parameters. Further, the conditions under which the measurements are carried out can be optimized so that the obtained measurement results contain as much information about the model parameters as possible. Examples of optimizable measurement conditions are where and when measurements are performed for spatial and temporal models.

In my work I have developed a Matlab toolbox which allows to optimize measurement conditions in a simple way. I recently optimized parameters and measurement conditions for a model which describes sediment concentration in seawater which floods salt marshes. It had to be determined at which high water levels of the tidal inundation and what time the laborious measurements have to be performed at the best. Currently I am working with a global model of phosphate and dissolved organic matter in the ocean and have to determine where and when the costly measurements for its parameter optimization have to be performed.

Uncertainties is the central topic in my work. As models of the Earth system play an important role in its investigation, it is important that they are reliable. The uncertainty associated with a model can be minimized by optimizing their model parameters. Furthermore, by optimizing the corresponding necessary measurements the available resources are used in an optimal way. This makes it possible to accurately determine the parameters with minimal resource cost.