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Global sensitivity analysis: a systematic approach to estimate regional effects of the astronomical forcing

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At the regional scale, climate change may often be interpreted as the response to a combination of factors, such as the astronomical forcing, sea-level and greenhouse gases. These effects are not always thought to be additive. In particular, the climate system is known to exhibit thersholds and hysteresis phenomenan. Hence, fully appreciating the combined effects of environmental factors on regional climate may appear as a daunting task, since the every factor has to be assessed independently, then combined with the others.

The problem is not specific to climate science and fortunately statisticians have developed a fairly complete framework to tackle the problem. It relies on three essential steps: design and perform experiments; design, calibrate and validate a "meta-model" (also known as an "emulator"); and perform the global sensitivity analysis. Here we show how this framework may be applied to palaeoclimate studies, with a focus on the effects of vegetation on the climates of the Sahel and the Arctic.

An important by-product of this effort is its consequences on our understanding and quantifying of the different sources of uncertainties associated with the experimental protocol : model internal variability; bias due to not fully reaching equilibrium; model structural uncertainties. Meta-models are also an important interface for carrying model-data comparisons.