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Global sensitivity analysis of GCMs to astronomical forcing, CO_2 and ice volume

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We propose a global sensitivity analysis of the climate simulated by General Circulation Models of the Atmosphere and Ocean (AOGCM), to the astronomical forcing, CO_2 and ice sheet topography and volume. Our purpose is to determine the structural properties of the models response, and in particular identify, in a systematic fashion, non-linear behaviours resulting from the combination of different components of the forcing.

In principle, exploring fully the input space would require thousands of simulations. The solution adopted here relies on the construction of a statistical surrogate, called emulator. This emulator is calibrated on a moderate number of experiments (typically 20 to 50), chosen using a MaxiMinLatin hypercube design. The emulator provides both an estimate of the model at untried, arbitrary inputs, and quantifies uncertainty associated with the fact this is an emulator instead of the full simulator. The emulator chosen here is a Gaussian process.

The emulator is here is expressed in a reduced output space made of the principal modes of the climate variability, extracted using a principal component analysis on seasonal mean surface temperature and seasonal mean precipitation. The methodology is applied to two simulators : LOVECLIM and HadCM3.