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Handling Uncertainty in Palaeo-Climate Models and Data

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The study of palaeoclimates can provide data on the behaviour of the Earth system with boundary conditions different from the ones we observe in the present. One of the main challenges in this approach is that data on past climates comes with large uncertainties, since quantities of interest cannot be observed directly, but must be derived from proxies instead.

We consider proxy-derived data from the Pliocene (around 3 millions years ago; the last interval in Earth history when CO_2 was at modern or near future levels) and contrast this data to the output of complex climate models. In order to perform a meaningful data-model comparison, uncertainties must be taken into account.

In this context, we discuss two examples of complex data-model comparison problems. Both examples have in common that they involve fitting a statistical model to describe how the output of the climate simulations depends on various model parameters, including atmospheric CO_2 concentration and orbital parameters. This introduces additional uncertainties, but allows to explore a much larger range of model parameters than would be feasible by only relying on simulation runs.

The first example shows how Gaussian process emulators can be used to perform data-model comparison when simulation runs only differ in the choice of orbital parameters, but temperature data is given in the (somewhat inconvenient) form of "warm peak averages". The second example shows how a simpler approach, based on linear regression, can be used to analyse a more complex problem where we use a larger and more varied ensemble of climate simulations with the aim to estimate Earth System Sensitivity.