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Interactive comment on "Emulation of long-term changes in global climate: Application to the late Pliocene and future" *by* Natalie S. Lord et al.

M. Crucifix

michel.crucifix@uclouvain.be

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We would like to thank Andrey Ganopolsky for his thoughtful and constructive review. We will provide a full response once all reviews are in, but we found it useful to clarify a potential source of misunderstanding about the emulator response without waiting further.

The emulator is a meta-model, a "model" of the GCM. In that sense, it expresses a prior judgement about the GCM behaviour before we start running the experiments, and this prior judgement conditions among other things the way we organise our experiment design.

In our case, as in most applications we have seen so far, the most important judge-

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ment is that the GCM response is *smooth*, but it does not need to be linear. Another important judgement is that the GCM internal variability is Gaussian. To illustrate this point we consider here an ideal "GCM", with only one parameter, of which the response would be:

$$f(x) = \mathrm{atan}(2(x-5)), \tag{1}$$

with a Gaussian internal variability (that is, the deviation from $f(x)$ obtained when performing one run of limited length) of 0.2.

Suppose ten experiments sampling x, as shown on Figure 1. The "true" response $f(x)$ is in blue. Now, we apply the Gaussian process emulation following the methodology used in our article, and produce the black dashed curve, with a zone of 1-σ uncertainty represented by the gray zone.

In this case, the *meta-model* (Gaussian process) appears to be a good model of the true function, even though the latter is not linear. True, the prior mean of the Gaussian process is linear (term $h(x)\beta$ in equation (4)), but the *posterior* contains the term $t(x)A^{-1}(y - H\hat{\beta})$ (equation 7) which absorbs deviations from linearity.

We concede that the term "emulator" has been used by other authors to actually describe linear regression, but this is not the case here, as again shown by Figure 1.

It remains that, as in any model, a "meta-model" can be structurally wrong. The GCM response may not be smooth. This is what so-called validation diagnostics are supposed to detect. By inspecting the properties of leave-one-out experiments (Gaussianity of errors, independence with respect to explanatory variables...) you comfort yourself that the meta-model adequately captures the GCM behaviour. It also gives you the possibility to explore potential explanations of diagnostics that may appear problematic, and it is at this stage that the prior hypotheses, such as smoothness, can be called into question.

In summary, the emulator must also be seen as an exploratory tool, in addition to its role in retrospective or prospective time-series modelling.

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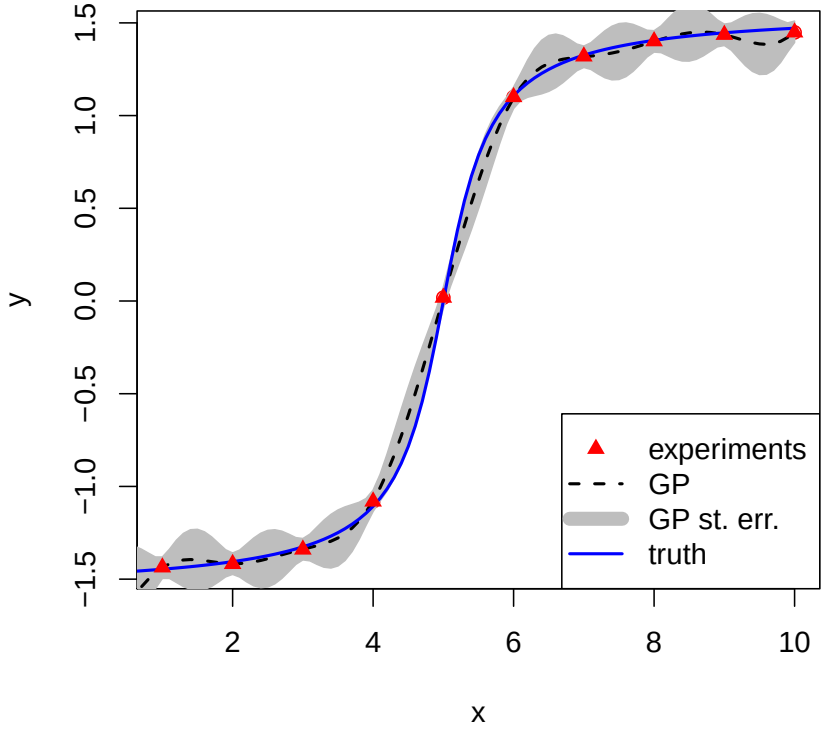

Fig. 1. Gaussian process fitting the function f(x) based on experiments represented by the red symbols.

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