



# ***Interactive comment on “High dimensional decision dilemmas in climate models” by A. Bracco et al.***

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Response to referee # 1' comments

In the following we provide a response to the following comments:

1) First, the manuscript contains about 70 figure panels, hampering the readability of the manuscript. Please move a considerable fraction of the panels to supplementary material. At the same time, please synthesize the main findings more clearly from examples and illustrations into generic results and conclusions.

Response: We agree with the referee that we show many panels, and we removed three in the last figure (Figure 13) to improve its readability. However, we prefer to have a single connected text and set of figures as here, than follow the format of general-

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audience articles where most of the technical presentation is left as supplemental information, given the scope and audience of the Geoscientific Model Development. We also considered removing more panels, but it is our opinion that the discussion of the different, often contradicting dilemmas encountered when tuning general circulation models will not be delivered as effectively. We hope that once the figures will be introduced in the text, instead of collapsed at the end of it, the overall readability will improve. Overall, the number of figures and panels is not outside what considered standard in climate science. In the revision we will modify abstract, introduction, and conclusions to address the second part of the referee' comment, and we will make sure that the presentation of the main findings in those three sections is more appealing to a general-audience reader. Additionally, we will modify the titles of the movies showing the reconstructed model error evaluated against CMAP for clarity, and we will remove the movies showing the error evaluated against the standard case, that could confuse the readers.

2) Second, smoothness of error metric vs. parameter value is assumed. Evidence contradicting this assumption is not presented. It is argued, for instance in doi:10.5194/npg-19-127-2012 that the response is not smooth, and that use of summary statistics (as in this manuscript) can lead to biased parameter estimates. Please discuss the validity of the basic assumption behind the research.

Response: Our approach is based on a series of experimental GCM results (both with the ICTP-AGCM , shown here, and with the Community Atmospheric Model version 4 - CAM4 - and 5 - CAM 5 – still in progress ) indicating smoothness for certain metrics and parameters. Such smoothness has been confirmed in an independent exploration performed by Bellprat et al. using the non-hydrostatic regional climate model COSMO-CLM (hereafter CCLM) version 4.8. A theoretical argument possibly justifying the framework of linear response theory in climate science has been proposed by Hairer and Majda (2010) – we will add such reference to the revision, as it suggests that smoothness could be generic in some circumstances. We will emphasize, nonetheless,

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that one does not know a priori and fundamentally that all parameter dependencies will be smooth in general circulation models. This is a quantitative result that needs to be verified for each variable and parameter of interest in a particular model. For those situations where it applies, it can be very useful. The metamodel methodology proposed is based on the outcome of our exploration so far, but we are aware – and we will remark it in the revision in the abstract, introduction and conclusions- that we may discover situations (variables, parameters, geographical areas) where this is not apt. We are aware that simpler models, as the Lorenz 95 system employed by Hakkarainen et al. in their exploration of parameter sensitivity, can provide responses that are not smooth. To our knowledge, however, conclusions on smoothness from simpler idealized models have not been proven (yet) to hold for more complex GCM. We will comment on results from idealized models as well.

3) Third, model response to parameter variations is only covered from the point-of-view of performance metrics. Please elaborate how parameter variation in a trade-off situation changes the model response in terms of model physical processes, and what is the physical reason behind the improvements in error metrics. Without this information it is hard to judge whether a dilemma in trade-off situation can be resolved by a physically justified manner.

Response: We will add a more detailed discussion of the physical reason behind improvements in the error metrics for given parameter changes. We recognize that while such discussion is present in reference to some parameter / variable (for example in the discussion of Figure 7), it is lacking in others, and we will correct this in the revision. In particular we will add a discussion of changes in the atmospheric circulation and precipitation patterns in relation to figures 5, 6, and 13 (left and central columns). To aid the physical interpretation of the curves showing the root mean square global or regional errors, on the other hand, we will add error bars quantifying the spread between ensemble members for each given parameter configuration, providing a measure of the internal variability of the system.

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4) Fourth, tuning a global model for regional details is questionable since model physics and parameters therein are designed as global representations of sub-grid scale processes. Guidance on varying parameter values based on regional details should come from physical justification by model developers rather than from estimation procedures. Please discuss the justification of tuning the model to regional details.

Response: We agree with the referee that tuning at regional scales is effectively implemented in zoomed models or regional models and we are not advocating to tune global models to regional details. We will clarify this point in the revision, according to the following. When tuning a general circulation model, including global ones, there are multiple potential weightings in evaluating improvements that will depend on assessments at regional scales. It is not uncommon, for example, to verify separately the model representation of the Asian monsoon, or of precipitation patterns over land, or of the variability associated with the North Atlantic Oscillation over Europe. We present regional investigations with the proposed metamodel to assess the tuning dilemmas that arise in a given set of parameterizations. If a single set of parameter updates improves everything of interest to all users, then there is no dilemma. We show, however, that this is not the generic situation, and that by analyzing regional patterns it is possible to gain information that can be useful in revising parameterizations or making choices.

5) Finally, Conclusions state that a strategy (p. 2747, l. 13) is presented. Such a strategy does not explicitly appear in the text. Please present the strategy Conclusions refer to.

Response: We will explicitly state in the conclusions that the strategy consists in identifying the parameters and metrics, followed by fitting the metamodel after performing few GCM runs, exploring the decision dilemmas encountered by varying the parameters, and finally choosing the best, or least unsatisfactory, parameter set.

Response to referee # 2' comment

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To address the following comment: “More discussion can be give to identify limits of their methods, such as is the case when using polynomial models for highly dynamic even discontinuous fields.”, we will expand in the abstract, introduction and conclusions on the appropriateness of using the proposed polynomial "methods" (metamodel functions).

Our approach is based on a series of experimental GCM results (both with the ICTP-AGCM , shown here, and with the Community Atmospheric Model version 4 - CAM4 - and 5 - CAM 5 – still in progress ) indicating smoothness for certain metrics and parameters. We do not know a priori and fundamentally that all parameter dependencies will be smooth. The metamodel methodology proposed is based on the outcome of our exploration so far, but we are aware – and we will remark it in the revision - that we may discover situations (variables, parameters, geographical areas) where this is not apt.

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