Geosci. Model Dev. Discuss.,
https://doi.org/10.5194/gmd-2017-271-RC1, 2018

Geoscientific Model Development Discussions

Interactive comment on "Fast sensitivity analysis methods for computationally expensive models with multidimensional output" *by* Edmund Ryan et al.

Anonymous Referee #1

Received and published: 13 March 2018

This article provides a useful illustration of how PCA may be used to aid in sensitivity analysis for models with multidimensional outputs. Overall, the article is well written and identifies its objectives well. There are a few comments below highlighting items that would benefit from elaboration. The most novel contribution of the article, the connection of PCA with GSA, is not explained in great detail. I believe the article is worthy of publication, upon elaboration of this contribution.

-The authors present several estimators for the Sobol' indices. They may consider [1] where the "most efficient formulas available today..." for Sobol' index estimation is described.

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Discussion paper

-What is being plotted in figures 3 and 4? Based on the magnitudes, I assume this is the numerator of the Sobol' index, i.e. $Var(E[f(X)|X_i])$. Did you have to rescale anything to compare results from the different methods?

-How did you reconstruct the spatially distributed sensitivity indices in figures 3 and 4 from the PCA? Based on comparing the methods you clearly did it correctly; it would be nice to be a bit more explicit about this.

-As mentioned in [2], it is frequently useful to have a scalar sensitivity instead of a spatially distributed one as in figures 3 and 4. How can your results be "averaged" in space to provide one scalar sensitivity for each parameter?

-Two approaches are considered for constructing a meta-model for a spatial dependent output. One is based upon constructing a meta-model for each point in space, and the other is based upon constructing a meta model for each PCA mode. Would it be possible to construct a meta-model which is learned to predict all points in space simultaneously? In this case, it would be a function from $\mathbb{R}^n$ to $\mathbb{R}^m$ where n is the number of parameters and m is the number of model grid points. I could imaging training a neural network to learn this function. How would this approach compare with the methods of this article?

References

[1] Clementine Prieur and Stefano Tarantola. Variance-based sensitivity analysis: Theory and estimation algorithms. In Roger Ghanem, David Higdon, and Houman Owhadi, editors, Handbook of Uncertainty Quantification. Springer, 2017.

[2] Amandine Marrel, Nathalie Saint-Geours, and Matthias De Lozzo. Sensitivity analysis of spatial and/or temporal phenomena. In Roger Ghanem, David Higdon, and Houman Owhadi, editors, Handbook of Uncertainty Quantification. Springer, 2017.

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