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Interactive comment on "Global sensitivity and uncertainty analysis of an atmospheric chemistry transport model: the FRAME model (v. 9.15.0) as a case study" *by* Ksenia Aleksankina et al.

Anonymous Referee #2

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The paper seeks to estimate the uncertainty and sensitivity of multiple atmospheric chemistry transport model output with respect to three uncertain inputs. The authors use optimised Latin hypercube design to sample from the computationally expensive computer model and use three different methods to summarise the uncertainty and sensitivity of various outputs to the uncertain inputs.

In general I found the paper well written and easy to follow but I don't follow the reasoning of the two sensitivity measures and the difference between the two. My concerns lie in the choice of methods used to assess the uncertainty and sensitivity in the outputs and my comments are focussed in this direction.

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Method 1 - RC

The first method uses regression to estimate the coefficients of a linear model in order to assess output sensitivity to each model input.

Regression is not considered to be a particularly good way to estimate global sensitivity measures (since they are not very robust) and the 'main effects' that the authors refer to would normally be associated with a variance-based sensitivity analysis. Can the authors say more about why they feel this is a more appropriate method to use than variance-based sensitivity or what they are trying to capture that is different? In any case, I don't think the authors should use the term 'main effects' for regression coefficients due to their common use elsewhere.

A 100 point Latin hypercube design has been used to vary the parameters within +/- 40% for the regression. I don't understand the reasoning behind these ranges when this is way beyond those considered plausible by the UK Informative Inventory. Can the authors justify this better and say why the regression doesn't follow the emissions uncertainties?

It is recognised that the regression coefficients are only likely to be meaningful if the model is linear, as measured here by Rˆ2. Has Rˆ2 been calculated for all model gridboxes? It's not clear from the reporting of the value that it is calculated everywhere – I assume it must be as their needs to be a regression model at every grid box. How big does Rˆ2 need to be for the regression coefficients to be useful?

What happens to the regression coefficients when the intercept term is not included in the model?

In the text line 12 it is stated that the RC 'can be interpreted as the response of an output to a unit change in a particular input when all others are allowed to vary' but in line 25 'RC quantifies the effect of varying a model input X_i alone'. These are contradictory and line 25 is a better description of method 3 (although this section is

discussed later).

Method 2 – uncertainty propagation

The second method propagates the uncertainty in the emissions to the output using the estimated uncertainties from the UK Informative Inventory Report. Please make it clearer that a new sample has been created here.

On line 25 the authors state that the uncertainty is calculated as half the 95% CI relative to the mean value. Half the 95% CI gives 2\sigma – why is this used as opposed to \sigma? Can't \sigma be calculated directly from the data as I assume it is used to calculate the 95% CI in the first place? It would be helpful to see the emissions maps – even if just in the supplementary material.

Method 3 - SRC

I need some more convincing that the SRCs calculated here are the same as the measures from Saltelli 2008 – can you expand this? It is these measures that are normally be referred to as the main effects.

What is the Rˆ2 for these new regression fits and how were sigma_i and sigma_Y derived? sigma_i is stated as the standard deviation of the input – it should be the standard deviation of the output given uncertainty in the input.

I would also expect the measures here to follow the regression coefficients more closely given the linearity in the model. This measure is giving different information to the RC and I don't fully understand what that difference is and why the results are different.

I think the authors should consider using generalised additive modelling here to calculate the main effects following Strong M, Oakley JE, Brennan A. Estimating multiparameter partial Expected Value of Perfect Information from a probabilistic sensitivity analysis sample: a non-parametric regression approach. Medical Decision Making. 2014;34(3):311-26 particularly Eq 6 and 8.

The references should be expanded to include other uses of sensitivity analysis in earth science models. These tools are generally applicable across different types of models which is an important point to make.

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