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Interactive comment on "Global sensitivity analysis of GEOS-Chem modeled ozone and hydrogen oxides during the INTEX campaigns" *by* Kenneth E. Christian et al.

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The focus of this paper is on an analysis of the causes of discrepancies between modeled and measured O3, OH, and HO2 vertical profiles during the INTEX-A and INTEX-B field campaigns. The analysis is based on a global sensitivity analysis approach, in which an ensemble of model runs (in which multiple variables are simultaneously perturbed) is used to construct sensitivity factors to delineate the relative importance of the various variables considered on modeled tracer fields. This is potentially an interesting approach to understand observation-model differences, but the paper seems to fall short in fully exploiting the power of this approach and in terms of the analysis

presented. I discuss my specific concerns below:

1) Section 2.2 presents a relatively technical description of the global sensitivity analysis approach and gives the impression that the advantage of the approach (relative to a local sensitivity analysis) is to examine the uncertainty in model results due to the joint uncertainty in multiple model inputs. However, the paper focuses solely on the calculation and analysis of first order sensitivity indices, because of the computational burden associated with number of model runs needed to estimate higher order sensitivity indices. This raises the question as to whether the calculated first order sensitivity indices are in fact meaningful, or whether they themselves could be uncertain owing to the truncation of the polynomial function (eqn 1) that is being fit. It also raises the question as whether there is any advantage of using the global sensitivity analysis approach itself. Given that only first order sensitivity indices are estimated, wouldn't it have been more straightforward to use a local sensitivity analysis approach?

2) Another potentially important issue pertains to the treatment of uncertainty of individual variables. Let me illustrate by focusing on the assumed uncertainty for biomass burning emissions. Presumably, the authors assume that this is a systematic (as opposed to random) uncertainty so that in any given model run, the sampled uncertainty factor is applied uniformly in each and every grid cell of the model. Is this in fact appropriate? Or would it more appropriate to assume that some portion of the uncertainty is random? Also unclear is how inter-species uncertainty correlations are handled. For example, are CO and NOx biomass burning emissions perturbed by the same scaling factor in every grid cell in a given run (which would occur if the uncertainty was solely due to uncertainty in burned area for example) or are the perturbation factors completely independent (which would occur if the uncertainty was solely due to uncertainty in emission factors for examples)? As another example, are the perturbation factors for the photolysis rates correlated or uncorrelated? The authors should describe more clearly their approach in selecting perturbation factors and the justification for the approach they use – and discuss how their choice might impact their conclusions.

3) There also seems to be a bit of a disconnect between the sensitivity indices shown in Figures 6-9, and the discussion of results in Section 3.3. For example, on page 13, line 1 the authors say that '. . .suggests that ..'. Why 'suggests'? Doesn't Figure 7 in fact make the case that uncertainty in lightning NOx cannot solely explain the discrepancy in modeled O3? More importantly, I am somewhat puzzled by the authors approach of using a subset of ensemble members to illustrate some of their points. Wouldn't it be more straightforward to make an additional set of model runs in which all the important identified parameters were appropriately perturbed (based on Figures 6-9) and to demonstrate that the the final configuration results in better statistical agreement with observations?

4) A minor comment - I think some thought needs to be put into making the presentation more appealing. Much of Section 3 describes in detail various aspects of the figures that are obvious by simply looking at the figures, rather than highlighting the most important aspects of the results.

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