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# *Interactive comment on* "Representing Model Uncertainty for Global Atmospheric $CO_2$ Flux Inversions Using ECMWF-IFS-46R1" *by* Joe McNorton et al.

**Anonymous Referee #2**

Received and published: 17 February 2020

Overview: The manuscript "Representing Model Uncertainty for Global Atmospheric CO2 Flux Inversions Using ECMWF-IFS-46R1" by McNorton et al. describes the quantification of various types of transport and emission errors when simulating atmospheric CO2 using an online earth system model. A number of experiments were carried out using an ensemble of 50 model simulations, which were perturbed in such a way as to be able to quantify various components of transport error, errors in the feedback to biogenic fluxes of CO2, and anthropogenic flux errors. This allowed for the estimation of a signal-to-noise ratio within the model. An attempt to account for spurious spatial error correlations was also included, through filtering of the model output in time. The paper suggests that model transport errors are a significant source of error for flux inversions,



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and should be more carefully accounted for in general.

Overall the manuscript is very well written, with few technical corrections necessary. Some details are skipped over without thorough explanation, however. The figures are generally quite clear and well chosen, although some further detail needs to be provided for some of them. The methods and models used within the manuscript are appropriate for such a study, and the study overall provides some idea of the size of model transport errors relative to emission errors for the two periods studied. The methods present a smart, if computationally-intensive, blueprint for other modellers to estimate model errors in a CCM setting.

I have few reservations regarding the publication of this manuscript in GMD, subject to some relatively minor changes, detailed below. Once these are fixed, I suggest that this paper is suitable for publication in this journal.

Comments:

Page 6, paragraph beginning at line 160: I gather that descriptions of the emission uncertainty experiments EXP, PEM and PEA are given in a forthcoming manuscript, and briefly here in Table 1. However, an extra sentence or two to briefly describe them, and the general differences between annual and monthly error, would be useful here. I later understood these experiments through context.

Page 8, line 199: To be clear, the two day spin-up is the 1st and 2nd of each month, included in some of the figures, and not the 30th and 31st of the previous month? Please make this clear in the text.

Figure 1: What do the numbers in these panels represent? If they represent model spread, what times do they represent?

Figure 2: Some comment on the fact that PEM is sometimes greater than EXP, and what this means, should be included in the main text.

Page 9, line 245: When discussing July, only one S/N ratio is provided. I assume this

is the monthly version? This should be stated. This is also true in Figure S2.

Page 10, line 263: The 24-hour period is January 1st (which should be stated). My understanding is that this date is discarded as spin-up when deriving monthly uncertainties. Would it be better to show a later date here and in Figure 3?

Page 10, line 283: In this section, the global (and monthly?) average error is often provided. I'm not sure whether this is a useful diagnostic since the error is very heterogeneous for the flux error cases. More helpful would be to provide values for a few of the affected regions, as is done for the transport error case from line 296. This would allow the reader to compare the biogenic and transport errors over the Amazon, for example.

Page 11, line 305: This exact sentence is already included earlier and I assume that it has been moved?

Page 13, line 324: What do you mean by 'as a first guess'?

Page 14, lines 346-351: I find these lines a little confusing, and they could be more clearly rewritten. I think you're saying that non-spurious error correlations can be found at varying - and surprising large - distances from a particular grid cell, and that using predefined localisation scales could remove error correlation information? It should be mentioned that this is difficult to account for in real inversions without thorough prior assessment of model output, isn't it? Also, how do you define whether correlations are 'part of the spatial extent of the plume'?

Page 15, line 355: How do you assess what is 'downwind'? Through analysis of the model winds? Or inspection of the plume? Is it instantaneous or averaged?

Abstract and line 431: You should clarify how your results can be used in future offline studies by the inversion community. Are you suggesting that modellers use the diagnosed transport errors derived here to drive their own offline inversions? Is the intention to produce these fields for periods other than January and July 2015?

Technical corrections:

Page 1, line 8: “prior flux, a forward model” rather than “prior flux, forward model”.

Page 5, line 146: Remove comma after ‘(TME)’.

Page 6, line 173: comma after ‘principle’.

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