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Interactive Comment

Interactive comment on "Greenhouse gas network design using backward Lagrangian particle dispersion modelling – Part 2: Sensitivity analyses and South African test case" *by* A. Nickless et al.

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The authors would like to thank the reviewer for considering the paper, for constructive criticism and guidance on improvement of the paper. The points below have been identified from the review, and each is addressed.

In general, concerns were raised concerning the structure of the paper, the justification for the different sensitivity tests, the manner in which the networks from the different sensitivity tests were assessed, and the generalisation in the conclusions. After considering the comments from both reviewers, we have decided to completely restructure

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the paper. Particularly the methods have been condensed into one section, where unnecessary repetition from Part 1 (Ziehn et al., 2014) has been removed and only those equations which pertain to the sensitivity tests have been included, such as the Bayesian solution for the posterior flux covariance matrix and the final solution for the elements of the sensitivity matrix. We also explain in more detail the parameters that we considered for the sensitivity tests, and reordered these tests in a more logical format.

Our justification for the need for these sensitivity tests is that this type of analysis is important because, as shown by Rayner (1996), certain changes to the optimisation problem, such as changing the quantity to be optimised even if very similar in nature to the original, can result in drastically different placement of stations. This would ultimately impact on the final network design used for deployment. Particularly for a network design for such a new network such as that for South Africa, having alternative network solutions based on parameterisation changes, can help us to assess how important certain stations are. We would expect stations which resolve sources with large uncertainties to remain constant despite parameter changes. The sensitivity analyses should also provide insight into parameter specifications which will be important for the estimation of fluxes through inverse methodology from the new network of measurement sites. Those parameter changes which significantly alter the network are likely to be important parameters for other network designs as well.

The results section has been improved by focusing more on the results from the sensitivity analysis, and in particular, changing the way the results for the different network solutions are compared. We have implemented statistical spatial metrics which provide a more objective approach to the network comparison. In addition, the results section now includes an assessment of the aggregation error, which is an important consideration particularly related to the high resolution case.

The following specific points were extracted from the review:

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The layout of the paper is disorganized and confusing to the reader.

Response: The paper has been re-written with focus towards the sensitivity analysis, which is the main emphasis of the paper, and we have tighten up the writing and organisation of the paper so that it is clearer to the reader, following a more logical format.

Redundancies and inconsistencies in terminology occur.

Response: In re-writing the paper we have ensured that all unnecessary repetition has been removed from the paper. We have also ensured that the terminology has been consistently and correctly used throughout the paper. For example, we have been very explicit in the new manuscript when referring to the "prior flux covariance matrix" and when referring to the "observation covariance matrix".

The structure of the paper needs to better reflect the sensitivity tests conducted and better justification is required for the variables which were controlled. The sensitivity tests appear to be random.

Response: The methodology section has been restructured from two sections into one section, where much more emphasis has been placed on the sensitivity analysis, and the reasons for the choices of the variables which were controlled have been clearly outlined. The choices of the sensitivity tests were determined through the process of setting up the inversion and optimisation procedure for Part 1, under the Australian test case. At junctions where choices needed to be made, and these choices were not apparent from the literature or ambiguous, these parameters were selected for sensitivity tests. The value for the parameter most commonly used in the literature was selected for the standard case, and alternatives were considered for the sensitivity analysis. The sensitivity tests have been broken up into those which relate to the formulation of the sensitivity matrix, those which relate to the specification of the observation covariance matrix (where we have included aggregation error), those that relate to the prior flux covariance matrix, and those that relate to the optimisation procedure.

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The emphasis of Part 2 on detailing the inversion system which has already been described in Part 1 of the paper needs to be reduced.

Response: All unnecessary explanation and detailing of the inversion system has been removed, with more reference to Part 1 of the paper included. The authors had originally placed some of the inversion system detail into the manuscript so that the reader would not need to constantly refer to the Part 1 to follow the methodology of Part 2. Only those equations which pertain to the sensitivity analysis have been included in the new manuscript.

Analysis of the results needs improvement and needs to be more scientifically defensible.

Response: To compare between solutions, we have determined which spatial statistical measures can be used to assess the clustering of stations and similarity between network solutions. This includes the test statistic from the Complete Spatial Randomness test and a test statistic for dissimilarity, where the statistic increases as the optimal network solutions from two different sensitivity test runs become more different.

Aggregation errors need to be considered.

Response: The authors have included an assessment of the aggregation error, and accounted for this in the analysis, adopting an approach based on Kaminski et al. (2001) to determine the size of the aggregation error. To do this more easily, the spatial resolution of the high resolution test case was changed to divide the domain into 100 by 50 grid blocks.

Authors need to avoid interpreting results in view of preconceived ideas of what the network should look like, and avoid judging the merit of the network on this notion.

Response: The discussion of the results has been improved, and the authors have avoided interpreting the results based on what was previously expected for the network design. Instead, more emphasis has been placed on the reduction of error that a network can achieve, and the similarity between networks which is statistically based.

Avoid drawing general conclusions where they are unfounded.

Response: We have re-written the discussion and conclusions of the paper, and particularly ensured that conclusions are only drawn where appropriate, generalisations are only made where logical to do so, and that more emphasis is placed on the test case under consideration and made this clear in the manuscript.

Explain how this network design will be used to facilitate the placement of the five new measurement sites.

Response: The discussion in the new manuscript includes detail on the optimal locations determined from the analysis, and practical details on the implementation and the potential for placing instruments at or near these locations.

Part 2 should be merged with Part 1.

Response: The authors disagree with this assessment. We believe that the sensitivity tests on their own are an interesting enough topic, as stated by both Referee 1 and Referee 2. If the sensitivity tests were merged with the Australian test case, we feel that there would be too many thinking points contained within one paper, and a single paper would be unnecessarily large. Having a Part 1, emphasizing the inversion setup and the use of the Lagrangian particle dispersion model, and Part 2, emphasizing the sensitivity analyses, with each considering a different test case, also allows us to present practical results for different, but important regions in the Southern Hemisphere, which we know to be under-sampled. To justify Part 2 as its own paper, we have ensured that the sensitivity analyses are better motivated, as explained under the general comments, the analyses expanded and better assessed, and their discussion improved.

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