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Geoscientific Model Development Discussions

Interactive comment on "The degree of freedom for signal assessment of measurement networks for joint chemical state and emission analysis" *by* Xueran Wu et al.

Anonymous Referee #2

Received and published: 22 August 2018

This paper discusses an approach to calculate the degrees of freedom for signal given by observation networks in joint state-emission data assimilation. The problem is important, and therefore deserves a careful treatment. The paper is not particularly well written, and I would like to encourage the authors to revise the language and the spelling. Also, the presentation is somewhat repetitive and can be shortened for an easier read. While the title says "chemical", there is no discussion of nonlinear dynamics in either the theory or the numerical experiments.

Major comments: 1. Please explain in detail how the methodology proposed in Section 5 is different than the following work (if it is not, explain similarities and

cite appropriately): https://rmets.onlinelibrary.wiley.com/doi/pdf/10.1002/qj.123
https://www.sciencedirect.com/science/article/pii/S1877050912002347
http://www.met.rdg.ac.uk/phdtheses/Information%20content%20of%20observations%20in%

2. Please explain the computational cost of the methodology. How does the cost scale with the number of ensembles? With the data set? With the model size? With the assimilation window length?

3. There is no comparison between the results obtained with the authors' approach and other existing approaches in the literature, e.g., Zupanski 2007. The numerical experiments would be more convincing if such a comparison was included.

4. There is no discussion on how this can be applied to nonlinear systems. Adding some nonlinear chemistry to one of the test problems may help argue that this methodology, while developed under linear assumptions, can be in fact useful for nonlinear systems as well.

Minor comments:

Eqn. (25) does not seem to be the traditional 1-norm of a matrix. Please clarify the notation. Also, clarify what matrix square root is used, as there are infinitely many possibilities. Eqn. (38), for example, does not seem to follow from the current (25) unless we are more specific.

Equation (20), /*we* define a matrix P. . ./ This matrix is the standard starting point in the definition of DFS, cf. Fisher 2003, Singh 2013. The discussion of Eqn (28) is confusing. The well accepted meaning of Ptilde(j) in the literature is: how much have we learned about variable xj from the data: from 0 (nothing) to 1 (everything). This is the amount learned about one degree of freedom (xj) out of n; the total number of degrees of freedom informed by the data/signal is the sum over all variables.

Editorial comments: Please carefully revise the writing of the manuscript (English correctness) as well as the spelling. There are hard to read (in English) formulations such

as /aspiring a means/ (?). There are also typos in the manuscript. For example: /to what extend/ should be /to what extent/ in the Abstract, or /anfd Wu/ should be /and Wu/ in the Introduction, etc. Please avoid embedding URLs in text, they are best deferred as citations referring to web pages.

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