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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Diagnostic methods for atmospheric inversions of long-lived greenhouse gases" *by* Anna M. Michalak et al.

Anonymous Referee #1

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The manuscript provides an interesting overview of the existing diagnostics to evaluate atmospheric inversions of long-lived tracers. The paper doesn't introduce any novelty in the field, but rather, it establishes a list of the existing tools. It is well written, and there is no obvious "wrong" point to comment on. I was quite pleased with Sections 1 and 2, which are a nice introduction to the topic, for non-specialists. I was unfortunately less convinced by Sections 3 and 4: although they are well written as well, I wonder what kind of reader would actually learn from it. Inverse modeling specialists are already familiar with the concepts that are presented; Non-specialists will get an idea of the diagnostics tools available, but since the paper often doesn't go much beyond listing them, they will have to read the (many) references to actually understand them.

As an example, in Section 3.1.1 (the first in which some diagnostic tools are actually presented and discussed), in 19 lines, the authors talk about: evaluation inversions

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against observations left out of the inversions; evaluation inversions against observations from aircraft profiles (and as a one-line example, against vertical concentration profiles); evaluation of satellite observations constrained inversions using in-situ measurements; evaluation of in-situ observations constrained inversions using satellite measurements; evaluation against "all types of independent atmospheric observations". Each of these in less than three lines.

This is not useful to the experienced inverse modelers who are already very familiar with all this. This is not very interesting for newcomers to inverse modeling (it can be summarized in one sentence: "evaluate your results against independent data", the rest is case-specific). Finally, for specialists from other disciplines who would like to get a glimpse at how inverse models are evaluated, it quickly gets boring. Meanwhile, there are important questions that could be discussed here, but that are, in the best case, left to Section 4: comparing observations with their model counterpart is not always trivial (case of satellite observations which may require an important work of data selection, bias correction, and the application of an averaging kernel to the model fields), not always wise (comparing low-resolution model CO2 fields with CO2 observations in an urban environment is not so smart), and not always that useful (the implications of a bias vs. independent observations in the upper stratosphere are not the same than that of a bias in the continental boundary layer). On the other hand, not doing it is sometimes catastrophic (incorrect interpretation of inversions constrained by biased satellite data).

Some subsections of Section 3 are better, but overall, the paper would read much nicer with less references, less examples, but more detailed ones (given the pedigree of the authors, I am certain that they can easily find some from their own work, and illustrate them with a few figures). Once again, the key is to define the target readers, and what they should retain: Non specialists don't need to know of tens of examples (they won't remember them all anyway), but they need to understand correctly and completely those that are presented. Specialists might be interested in the many references, but

most of them could be moved out of the main text, perhaps to one or several tables (perhaps one for each Section 3.1, 3.2 and 3.3), as it is often done in literature reviews.

Before final publication in ACP, I would therefore recommend that the authors consider revising Section 3 and 4, keeping in mind that readers should be able to learn from it without having to read the references and/or the other papers from the special issue.

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