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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Emergence of a linear tracer source from air concentration measurements" *by* J.-P. Issartel

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This manuscript presents an original and thorough mathematical investigation of a novel inversion method for estimating surface sources from atmospheric measurements. Recently, inverse modeling of sources and sinks of atmospheric trace gases is receiving increasing interest. Several mathematical procedures have been proposed. So far, however, there is no consensus on the most efficient/realistic method. This manuscript presents yet another approach that seems worth further investigation. Unfortunately, as will be explained below, the relation between the current and other methods remains unclear. Some attempt in direction has been made, but, as will be explained, it remains difficult to assess the added value of this approach. Generally, for somebody who is not a dedicated mathematician, this manuscript is rather difficult to read. Because of this, it may only reach a limit audience in its present form. This report provides suggestions to make this work more accessible. Overall I advise that this manuscript can only be accepted for publication in ACP after major revisions that should satisfactorily address the following:

GENERAL COMMENTS

The need for a renormalization function:
As explained in section 2 a renormalization function is introduced to reduce the influence of the illumination hotspots centered over the measurement locations. Although the results indicate that the proposed procedure improves the solution, it seems to lack a physical basis. Therefore it remains unclear if the procedure only improves the results of this specific experiment or that it may be expected to improve inversion results in general. The reason that IŠm skeptical about the latter is that one might think of a different source configuration for which the method probably wouldnŠt work. Suppose for example that the true sources were actually at the measurement locations. In this case the solution without renormalization would likely have performed better. Of course this is an unlikely scenario, as measurement location are typically away from the source areas. As an alternative Ű and more physically motivated - approach one might take advantage of this information by adding some prior constraint in the inversion. In that case the underlying assumption would be made much more explicit (and physically interpretable), and would probably be implemented differently. For example, the present approach probably effectively smoothens the solution, which, for a point source like the ETEX experiment, doesnŠt seem to be a justified assumption. In summary: The physical implication and justification of the mathematical assumptions should be made clearer. If it turns out that under physically justifiable assumptions the solution is still poor and unsatisfactory, the conclusion would be that the inverse problem is poorly constrained by the available observational evidence.

Comparison with other techniques:
It remains unclear how this method performs in comparison with more conventional and widely used techniques. An attempt is made in this direction by the use of Gaussian

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basis functions, but, in my view, this doesnŠt quite resemble any of the approaches that are generally applied. In addition, it would be highly valuable to know how this method compares with other methods that follow similar principles. As it seems to me, this method bears a lot of resemblance to the representer method (Bennett, 1992), but the renormalization issue is probably treated differently. This study should give the reader a better sense of the added value of this approach to with is being used already.

Redundant mathematics:
Judging the scope of ACP, mathematical derivations should serve the physical and chemical principles that are under investigation. Some paragraphs in this study, even though probably highly interesting to some specialized readers, seem to divert from the principle research questions. This applies in particular to the parallels with quantum mechanics discussed in sections 7 and 8. I would propose to delete these sections. This has also the advantage that a single notation can be used in section 9 and 10, which would probably make it more transparent. The derivation in section 9 could move to an appendix. Any equation that isnŠt strictly necessary to explain the method might put the reader on the wrong track, which is why I advise to reevaluate every equation for its relevance.

References to ŚweŠ throughout the manuscript suggest there is more than one author (?).

SPECIFIC COMMENTS

Equation 12: The purpose of this equation is not clear. I didnŠt find a reference to this equation elsewhere in the paper and therefore assume if was not used?

Page 4: There should be a clear definition of the quality of the inversion results and how this is measured. The last sentence of section 3 mentions that Śthe quality of the estimate is not investigated yet in terms of measurement errors but in terms of the geometry of the physical system.Š Please clarify what is meant by the geometry of the physical system and how this is measured.

Page 4: ŚB is generally addressed in terms of indirect observations of the error $\delta\sigma$ = σ - σ_{est}Š Since B would generally correspond with the prior covariance matrix, Śσ_{est}Ś should in my opinion be replaced by Śσ_{pri}Š (if not then please clarify). Also the subsequent sentences suggest that prior and posterior covariance matrices are confused.

Page 5 ŚAs stressed in Sec. 3 this relation cannot be demonstrated and must be admitted as a definition or as an assumptionŠ The section title indicates that it is considered an assumption. On the other hand the relation seems to follow readily from equations 10 and 11, without any further assumption. Therefore, at most the notation of equation 22 can be considered a definition. If it is, then it is not clear to me what exactly is the assumption of this section. This should be clarified.

Figure 1: The right panels are unclear. Please indicate the meaning of the axes., and provide additional labels.

Figure 2: c3 the triangles and circle are not in the same place as in the other panels.

Page 5 Replace Śalgorithm 35Š by Śequation 35Š

Page 7 What happened to the minus sign going from eq. 36 to 37?

Page 8 Replace Śis Sec. 5Š by Śin Sec. 5Š.

Page 10, ŚIn this expression the left and right bars have totally different meaningsŠ What expression is referred to? If this is equation 61 than a clarification is needed.

Page 13 Śfor which we received the help of Geoffray Adde and Fabien Lejeune as indicated in the comments of Fig. 8.Š Please move this sentence and the additional information in the figure caption to the acknowledgements.

Page 13 Śto require then ...?Š Should probably be replaced by Śto require less thanŠ

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