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Atmospheric Chemistry and Physics Discussions

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Interactive Comment

# *Interactive comment on* "Interference errors in infrared remote sounding of the atmosphere" *by* R. Sussmann and T. Borsdorff

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Final Response to Anonymous Referee #1

We like to thank Referee #1 for carefully reading this manuscript and making very helpful suggestions for improvements to this paper. In final response, we thereafter provide positive point-to-point replies to all referee comments (given in italics).

Ad: General Comments

*"However, in its current form, I find the manuscript too long and lacking focus. ..."*

We accept this comment which is, however, interfering a little bit with the opinion of Anonymous Referee #2 who stated

*"The paper is well written and structured."*



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Therefore, we performed the following compromise (preferring not to separate theory and illustration into separate papers):

- we shortened the text where we could
- we moved Sections 2 and 3.3 to appendices
- we reorganized the paper, so that the general formulation became self consistent including *i*) the formulation for quantification of interference errors (for the cases of fine-grid retrievals, coarse-grid retrievals, and non-retrieval of the interfering species), *ii*) the minimization of interference errors, and *iii*) the impact of microwindows; the illustration part (using the real FTIR sounding) was revised to match the structure of the general part.

We feel that these measures have in fact improved readability of the paper. On the other hand, we could not achieve an overall shortening because additional issues have been risen (also by Referee #2, and within the open discussion), that had to be included to the paper:

- deepened discussion of microwindow dependency
- discussion of the case of unretrieved interfering species
- clarification of the reasons for use of ad hoc constraints (for the interfering species) versus climatological constraints (for the target species)

Ad: Specific Comments

*"1. Introduction states that optimal estimation methods have been applied solely to microwave observations. This is untrue."*

Our original sentence was slightly different ("... have been applied solely to microwave observations for a long time"). Anyway, we corrected the sentence for the revised manuscript that way: " ... has been applied to microwave soundings in the beginning."

*"... on page 13030 is not actually a complete sentence: "For example, temperature profiles retrieved at the same time as the target species, which may be used in order to*



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*minimize errors from insufficient knowledge of the true temperature profile at the time of observation."*

We thank for this hint and corrected this sentence.

*"3. Strictly speaking, what authors call 'interference errors' should be considered as a subclass of 'forward model parameter errors' (as defined by Rodgers) rather than an entirely 'new class of errors' (p. 13033). By definition, forward model parameters include all those parameters which 'influence the measurement, are known to some accuracy, but are not intended as quantities to be retrieved' (from p. 44 of Rodgers book 'Inverse Methods for Atmospheric Sounding'). Profiles of non-retrieved trace gases are clearly such parameters."*

We agree that unretrieved trace gases can be treated by the well known concept of model parameter errors, but we had stated that we do not treat this case (page 13030, line 10). Our paper is about the interference effect from retrieved trace gases, which can neither be treated by model parameter errors, nor by any of the other three terms of classical error analysis (equation 3.16 of Rodgers, 2000).

To avoid this misunderstanding, we decided to add a brief discussion of unretrieved interfering species to the revised manuscript, and explain the difference to the treatment of retrieved interfering species.

*"4. In Section 3.3, the authors use an optimal estimation-based constraint matrix for the target gas, but use an ad-hoc Tikhonov constraint matrix for the interfering species. This inconsistency is never fully explained."*

We use ad-hoc Tikhonov constraint matrices for the interfering species for two different purposes and due to two different reasons, in detail as follows (we added a similar text within Sections 2.2.2 and 2.4.2 of the revised paper):

1. Use for emulation of coarse-grid retrievals on a fine retrieval grid

Many operational algorithms are using coarse-grid retrievals for the interfering species



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due to computation power limitations. Fro instance, in ground-based FTIR spectrometry, it is still a widely used practice to retrieve the interfering species only via one VMR-profile scaling factor per species. However, in the case of a coarse-grid retrieval of the interfering species, there is no appropriate interface to link the true atmospheric (high-resolution) profile covariance of the interfering species into the interference error analysis. In consequence, the calculation of interference errors on a coarse grid leads to erroneous results, i.e., significant underestimations of the true interference errors. In order to overcome this difficulty, we have to implement a sufficiently fine retrieval grid for the interfering species and emulate their coarse-grid retrieval (namely that of the operational algorithm to be characterized). This can be achieved by using an appropriate block-Tikhonov-type soft constraint with a high regularization strength.

2. Use for being able to tune the regularization strength of profile retrievals via only one parameter

There is a trade-off between minimizing interference errors and the smoothing error. This is because both errors are depending on the regularization strength applied to the retrieval of the interfering species. I.e., a total minimum of the combined error (from interference and smoothing) can be found. In order to perform this minimization of regularization of the interfering species in a systematic way, we implement a Tikhonov-type first-order regularization for the interfering species, since this allows the regularization strength to be easily tunned using only one parameter $\alpha$. We suggest Tikhonov regularization for retrieval of the interfering species, because of this practical advantage. Details of the retrieved interfering profiles are not of interest. They will casually suffer from oscillations for the optimum $\alpha$, which may be found to be a very small number. This is because the optimization is at the cost of increasing model parameter errors, forward model errors, and retrieval noise errors for the profiles of the interfering species. But this does not matter, i.e., it does not impact the target species retrieval. Note, that we have to take leave here of the idea of optimal estimation for retrieval of the interfering species: application of optimal estimation in the strict sense for retrieval



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of the interfering species, i.e., use of a climatological constraint would in general lead to larger interference errors compared to our optimized Tikhonov approach, and never to smaller interference errors. This is because our approach uses a systematically minimized constraint for the interfering species, which will always be softer than any fixed climatological constraint, if the optimization requires this - leading to smaller residuals from the interfering species. This being said, the target species can still be retrieved via optimal estimation, if preferred.

*"5. Section 4.1 seems much longer than necessary."*

We agree and shortened this section.

End of response.

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Interactive comment on Atmos. Chem. Phys. Discuss., 6, 13027, 2006.



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