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Atmospheric Measurement Techniques Discussions



# *Interactive comment on* "Improving retrieval quality for airborne limb-sounders by horizontal regularisation" *by* J. Ungermann

**Anonymous Referee #2**

Received and published: 12 November 2012

Review of manuscript: Atmos. Meas. Tech. Discuss., 5, 6577-6626, 2012 "Improving retrieval quality for airborne limb-sounders by horizontal regularisation" Manuscript author: J. Ungermann

General Comments

The manuscript describes a data processing algorithm for atmospheric remote sensing instruments, specifically those using a limb-sounding observation geometry. The technique is illustrated by using a flight worth of data from the CRISTA-NF instrument, an air-borne infrared limb-sounder operated on board the M55 Geophysica stratospheric aircraft. A comprehensive theoretical section describing the algorithm(s) used is followed by a case study, where the impact of algorithm configurations (aka. different

retrieval settings) are shown using data from a flight that took place at Kiruna on 2nd March 2011.

The fundamental claim of this work is that for fast scanning limb-sounders, the proximity of neighboring measurements is close enough in space/time so that individual scans become horizontally correlated, and a horizontal regularisation can therefore be introduced to either increase the spatial resolution of the retrieved cross-section, or reduce the retrieval errors. The principle is similar to the one of tomographic retrievals, but different enough to merit separate publication.

The retrieval of individual profiles of the same instrument has been published by the same author in the past. The results published in this case study are new to the peer reviewed literature though, and the retrieval algorithm is significantly modified from the one used in individual profile retrievals.

No indication had been found that this work had been previously published as a whole or in parts in the peer reviewed literature.

As far as we can tell the author of the manuscript displays a thorough understanding of the problems posed by the retrieval of remote sensing data and the mathematical background of optimal estimation theory, the use of regularisation in handling ill-posed inversion problems and the extraction of retrieval diagnostics.

The algorithm described in this work can be applied to improve the retrieval results from the CHRISTA-NF instrument from past campaigns, and might also be used on other existing air-borne limb-sounders. The technique is also claimed to be applicable for future satellite-borne instrument, although we have some questions about that in the specific comments.

To conclude the authors compare the results of their retrieval approach with an alternative vertical smoothing method using filter convolution. Overall this is a comprehensive and well written publication which, if some minor corrections are met, should be pub-



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lished in Atmospheric Measurement Techniques.

Specific Comments

Section 1 - Introduction:

Page 2 line 25: Points out that filaments of a lesser extent than the measured vertical resolution are not resolvable, but in the context implies that this algorithm could do so. Surely if the measurement density is lower than the atmospheric feature then that information is lost?

Section 2 - Cross Section Retrievals:

Page 9 line 16: Here a part of the elaboration of the algorithm is omitted due to the complexity of the notation. In the other parts of the manuscript the author is very explicit in describing the mathematics of the algorithm. A choice should be made if a full formalism is desired to allow third parties to recreate every single step of the work, or if only novel steps need to be described. In the first case the missing steps should be included; in the second case the author could simplify the whole of section 2 and refer to the literature for well established aspects of the optimal estimation algorithm.

Section 3 - Case Study:

Page 13 line 9: Would this study have worked for another flight date as well? Is some date better suited than others? If yes which ones, and why. Page 14 line 6: A tangent point uncertainty of 100m is calculated from a given pointing angle uncertainty, but due to the limb-viewing geometry this number will vary as a function of the current scan angle. What is the absolute tangent altitude at which a 0.02 deg pointing error results in a 100m tangent point error? Page 15 line 20 (also, page 20 line 23): "The choice of CFC-11 is disadvantageous for cross-section retrievals." Why chose this gas then in the first place? Page 16 lien 3: Is there any evidence to back this up? Page 16 line 19: Based on what data sets is 200 the typical scale difference between horizontal and vertical structures in the atmosphere? Page 16 line 24 (also, page 20 line 11):



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"not very pleasing to the eye..." This is not a very scientific statement. Could this be further quantified/classified? Page 17 line 6: The author mention that they have left out a plot of the stronger HNO3 distribution, which they claim confirms the structures they managed to extract from the weaker gases thanks to the improved algorithm. This plot would be a strong evidence of their conclusions. The scenario with factor-20'000 regularisation strength seems a bit extreme. Its results in this case study indicate that this would not be a viable choice for a real application. Is it worthwhile including it in the case study? Page 26 line 15: If this technique can indeed improve the retrieval of instrument parameters this would be a major strengths in its books, but this is only given as a side note here. It seems worthwhile to expand on this claim.

Conclusions:

It's somewhat unclear how much this analysis is specifically suited to the instrument under test (i.e. CRISTA-NF), and how much it would benefit other techniques. The original premise of the study is that due to the high sampling rate of CRISTA the individual scans are horizontally correlated, a fact which is exploited with this retrieval technique. However, other limb-sounding instruments have lower sampling rates. I.e. just looking at instruments on the same air-borne platform, the other infra-red limb-sounder MIPAS-Str takes a slightly longer time to complete a full atmospheric scan, and the microwave instrument MARSCHALS even takes a significantly longer time to do so. We guess at one point the benefit of this approach becomes marginal, but it's not quite clear what this threshold is. On a similar note, the application of this techniques to future air-borne or satellite missions is not completely clear. The GLORIA-AB infra-red limb-imager is using a truly tomographicR:\MARSCHALS\ESSENCE\CorrelativeData\Gloria\flight2_filaments scanning mode, so 'neighboring' profiles are directly correlated, not just indirectly. The satellite missions will mostly be forward or rearward looking (i.e. PREMIER), so a directly tomographic retrieval approach might be more applicable in these cases. The author mentions that for pushbroom imagers the retrieval would be split up in



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swaths and each, in which case we presume that each swath would be subject to a tomographic retrieval, and that horizontal correlation could then be used to improve the 3D fields. We believe to understand that the technique described here could be used in a single step to retrieve 3D datasets, but this is only mentioned in a side note and it's not quite clear that this indeed the case, nor what additional steps would be necessary to implement such an algorithm to a full 3D scenario, as compared to simpler example case of this study. Overall we perceive a certain ambiguity as to whether this is a paper documenting the next stage in the analysis of CRISTA-NF data, on which it clearly delivers, or if it's meant to be a general paper on a new data processing algorithm, in which case more evidence to underline the relevance to other measurement techniques would be welcome. We also missed a statement whether the analysis of additional campaign data of CRISTA-NF is planned in the near future.

Technical Corrections

Page 3 line 17: Spelling: "no or no unique solution" should be "no unique solution"

Page 8 line 5: Punctuation: "...sparse storing techniques, nor straightforward..."

Page 8 line 15: Punctuation: "...calculate the i-th row of G, the i-th row of..."

Page 15 line 14: Orthography: "rations" should be "ratios"

Page 16 line 8: Orthography: "ration" should be "ratio"

Page 16 line 9: Grammar: "smaller" should be "lower"

Page 16 line 16: Punctuation: "much less noisy, mostly because"

Page 16 line 27: Grammar: "Some such outliers" should be "Some of these outliers"

Page 16 line 28: Wording: "has become quieter" should be "has become more uniform"

Page 17 line 20: Rephrase: "some structures appear also vertical more smoothed"

Page 19 line 1: Please specify plots labels, i.e. "the baseline retrieval setup (a), and



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factor 2000 regularisation (b)."

Page 18 line 14: Missing word: "down to 30% of the original level"

Page 18 line 18: Spelling: "not notably" should be "not notable" (in fact, I would replace by "insignificant")

Page 19 line 1: Phrasing: "including linear interpolation in between data points" should be "by linear interpolation between data points"

Page 19 line 2: "stemming from" should be "due to"

Page 21 line 13: Rephrase: "which is of very small extent" could simply be "which is very narrow"

Page 24 lines 4-6: Whole sentence is unclear, please rephrase.

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