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Atmospheric Measurement Techniques Discussions

Interactive comment on "Tomographic airborne limb sounder retrievals on irregular grid with second order regularisation" *by* Lukas Krasauskas et al.

Anonymous Referee #1

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Review of: Tomographic airborne limb sounder retrievals on irregular grid with second order regularisation

by Krasauskas and colleagues.

High level comments:

This is a very nice, well-written paper that describes thorough work to develop and evaluate new approaches to the 3D-retrieval problem from airborne tomographic limb sounding observations. Although the paper is dense and mathematical, this is driven by the subject matter and, in my view, in line with what is required for completeness. I'm very happy to recommend that this paper be accepted with only minor revisions

detailed below.

My only high-level concern is that the end results, based on simulations for GLORIA, do not necessarily show the instrument or technique off at its best. In part, as I see it, this is because of the tight nature of the a priori constraints imposed, specifically the 0.645 K a priori precision estimate for temperature. As an aside, although the choice of the associated correlation lengths is well described in the manuscript, I was unable to find discussion of how the 0.645K number was arrived at (apologies if I missed it). A consequence of this very tight constraint is that the instrument has to "work very hard" to add useful information, as witness the similarity between the magnitude of the fields in figures 6 and 4 to those in the bottom row of figure 3. In other words, the instrument hasn't been "allowed" to tell you that much more than you already knew.

Some limb sounding teams opt to use very loose a priori constraints to enable the retrieved precision (Sx in the Rodgers notation) to be a clear marker of where information came from the instrument and what from the a priori (and/or use the averaging kernels to the same effect). While I recognize that this is not ideal, and that, indeed, having a more geophysically informed choice of a priori description is one of the cornerstones of your work, it would perhaps enable you to better quantify the strengths of your new technique compared to the prior state of the art. To be honest, 0.645 K feels tight even for a "geophysically informed" value of the a priori precision. It's possible I've understood some aspect of the work in this discussion, so apologies if so.

I'm not necessarily advocating a reappraisal or rerun of the work here, merely suggesting that the authors consider this in future work, and/or possibly include some brief discussion of the topic in the paper (certainly a description of how the numbers were chosen, unless I missed one that's already there). Finding a way to make the measurements appear as strong as they fundamentally are is important in advocating for future measurements.

My more detailed comments, below, mainly related to notation. For most of these my

aim has been to, where possible, avoid confusion for the more casual reader familiar with the notation of the Rodgers-like retrieval community. Obviously your discussion involves many more terms than are typical in the optimal estimation-based approaches, so some clash is perhaps inevitable. However, it would be prudent to avoid them where possible.

Another common thread in my more minor comments is the author's use of the word "accuracy" to describe quantities that I believe are more commonly referred to as "precision". In my experience, "accuracy" is used to described non-random (at least in physical origin if not geophysical-product consequence) terms that affect the measurement, such as errors in instrument calibration and spectroscopy. Precision relates to the uncertainty introduced by "noise" in the radiance observations, and is, I believe, the correct term for the errors the authors are aiming to characterize here.

Finally, the figures, while arguably numbered logically are not introduced in the text in that order. The current order has 3 first then, 6, 1a, 4, 5, then 2. I'm fine with keeping the figures in the order/numbers they currently have, but I would suggest that you arrange for the text to introduce them in that order for consistency. Just having a new sentence up font that introduces them in that order is probably simplest.

Specific comments:

—- Page 1

Line 18: "taken close from one another" -> "taken close to one another"

Line 23: "accuracy" -> "precision", see above.

—- Page 2

Line 3: "quality" is rather a loose term. Consider clarifying it further (e.g., information content, effective resolution, faithfulness to "true" atmosphere, etc.).

Line 4: Suggest you delete "given in equation (2)" as it's a forward reference. Instead

refer to Tikhonov paper?

Line 6: Is the "classic Tikhonov" approach necessarily first order? I know of some teams using second-order Tikhonov routinely.

Line 17: "air radiance" feels like odd wording to me, why not just "radiance"?

—- Page 3

Eq (2) and line 24: Surely if L_0 is a term in S_aˆ{-1} (as opposed to just S_a), then what it contains is more like reciprocal standard deviations is it not?

Line 27: I'm not sure that characterizing the alpha terms as "unphysical" is that fair. One could easily scale them with some suitable length term to cast them into constraints on spatial variability (which is more or less what you yourselves are doing). Also, such scaling would arguably render them less "grid dependent".

—- Page 4

Line 19: The term "covariance kernel" was new to me. Is it widely used? Is there some reference for it?

Equation 5: Doesn't Cˆ{-1} need a _k subscript?

—- Page 5

Equation 9: I suggest you split this in two and have ||\phi||ˆ2 = ... dU ** <comma> where <newline> ** \delta(\phi ..., and call these two separate equations.

Line 23 and 25: Not sure how, if L_h is constant (line 23) you can have "different correlation lengths...". Are you implying L_h only has to be horizontally homogeneous, not vertically constant?

—- Page 6

—- Page 7

Line 13: I don't understand why you're using y in the equation on this line rather than x, as in equation 1. I'd avoid using y for anything state-space related if possible to avoid confusion for the Rodgers-based reader.

Equation 15 and line 30: Why \phi(r_i) in one and \phi(x_i) in the other, why not have them both the same? Of the two, I'd pick r_i, as being less confused with the state vector.

Line 29: bold "a" subscript needed on D

—- Page 8

Line 29: I think that either x_i, x_j's here should either not be bold, as they are components of r_i or r_j, or you mean to actually use r_i and r_j themselves. Same applies for x_l and x_k in line 30.

—- Page 9

Line 26: Suggest "accuracy" -> "precision" as discussed above.

—- Page 10

Line 10: I'd suggest a different letter than y to again avoid confusing the Rodgers community (and those who remember your equation 1!).

Line 28: I like the term "Precision matrix" because, as with the word itself, "more" implies "better". However, is it in common use? Also, I believe it is often referred to as the "Fisher information matrix", but I'm not sure that in all cases Saˆ{-1} is indeed the same a the Fisher matrix (I'm stretching beyond my expertise here).

—- Page 11

Discussion starting around line 11, and through the remainder of the section: It's not clear to me how the matrix M in the lines 11-16 relates to the matrix A in equation 22 and beyond. Also, I don't believe A is the Rodgers-style "Averaging kernel" matrix in

this context is it (as Rodgers' A is not s.p.d.)? Again, I'd suggest using a different letter than A. If is intended to be a measure of S_a, as the discussion on Line 30 (page 11) seems to imply, then why not use S_a itself, perhaps with some suitable diacritic (a tilde, or hat or something)? Apologies if I'm missing a critical point here.

—- Page 12

—- Page 13

—- Page 14

Line 16: "my" -> "by" Line 18: Consider "longer" (or "greater") rather than "higher" for vertical correlation length.

—- Page 15

Line 16: Suggest "lower" -> "shorter"

—- Page 16

—- Page 16

—- Page 18

Line 17: Add "operator" after "Jacobian" (at first I'd thought it was meant to be a Jacobian matrix, and wondered why you'd not referred to it as K, as Rodgers does).

—- Figure 3

I suggest that, for the bottom row, as with figure 4, you use a red/blue (or other anti-symmetric) color scale. Also "smoothened" in caption should be "smoothed" I think.

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