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Atmospheric Chemistry and Physics Discussions

Interactive comment on "A self-adapting and altitude-dependent regularization method for atmospheric profile retrievals" *by* M. Ridolfi and L. Sgheri

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We thank the reviewer for pointing out three important issues that surely require a clarification.

1 Vertical oversampling is not the only cause of profile oscillations, these can be triggered also by specific altitude-dependent systematic errors. In the ORM implementation, however, the covariance matrix of the LS profile ($\mathbf{S}_x$ defined at page 18014, line 15) accounts only for the mapping of the measurement noise error. For this reason the VS method is able to smooth out also oscillations triggered by systematic errors, but only within the limit of a fraction w_e of the LS random error bars that are represented in $\mathbf{S}_x$.

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We will clarify this issue in the revised version of the paper.

2 The extension of the presented equations to the case of problematic or impossible inversion of the matrix $\mathbf{K}^T\mathbf{S}_y^{-1}\mathbf{K}$ may not be straightforward. Considering also the related comment from reviewer #1, in the revised paper we will modify the formulas to include the OE or LM modifications. The a-priori estimate $\mathbf{x}_{aoe}$ used in the OE for these difficult cases should be chosen with the largest error covariance $\mathbf{S}_a$ permitting the inversion of matrix $(\mathbf{K}^T\mathbf{S}_y^{-1}\mathbf{K} + \mathbf{S}_a^{-1})$ with negligibly small numerical errors. The estimate $\mathbf{x}_{aoe}$ should be taken from the initial guess profile of the retrieval.

3 The strong regularization achieved by the VS method removes from the retrieved profile oscillations and / or vertical structures that are not really determined by the actual measurements analyzed. The smoothing is operated using the regularization term $\mathbf{L}^T\mathbf{\Lambda}\mathbf{L}$ which introduces external information in the regularized profile. In case of large measurement errors the regularization term can also prevail over the contribution of the measurements (the term $\mathbf{K}^T\mathbf{S}_y^{-1}\mathbf{K}$). This external information that is fed in the profile through the regularization does not cause problems when profiles are visually inspected or analyzed on their own. However, as the reviewer points out, one must be careful when the regularized profiles are compared to other measured or modeled profiles with different vertical resolution. In this case we must make sure that the external information used to derive the regularized profile is not contrasting with the information already present in the other profile. For this reason, the use of large w_e and w_r parameters is not advisable in case of intercomparisons with profiles of finer vertical resolution. We plan to include in the revised version of the paper also recommendations for the strength of regularization to be used in different applications.

Specific comments

- *p.18014, Eq.7:* Normalization of the individual profile errors causes problems when a given profile point approaches zero. So far we did not notice the problem you mention

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in the water retrieval.

- *p.18014, l16:* Actually we extract the term $\mathbf{K}^T \mathbf{S}_y{}^{-1}(\mathbf{y} - \mathbf{f}(\mathbf{x_k}))$ from Eq.(3) with $\mathbf{\Lambda} = 0$ and plug into Eq.(10). We will reword this sentence in the revised version of the paper.
- *p.18016, l.9:* i is the order of the derivative, as defined at p.18010, l.21,22. However the definition is too far away, therefore it will be probably better not to recall the definition of l here.
- *p.18017, Sec.3:* Here we share the interests of the reviewer, however for length reasons this extension can not be included in this paper. We will consider this suggestion for future work.
- *p.18018, l.8-10:* In our tests we always used $\mathbf{x}_a = 0$ because we are convinced that in practical cases it is very difficult to find reliable estimates for $\mathbf{x}_a$. We will specify this choice in the revised version of the paper.
- *p.18020, l.27:* Here we mean that, due to the very large error bars, above 40 km the NO_2 profile can be transformed by the regularization into a straight line if the vertical resolution is not constrained. We will specify this issue in the revised version.
- *p.18023, Sec.5:* We will include the number of degrees of freedom of the retrieval in the revised version of the paper.

Interactive comment on Atmos. Chem. Phys. Discuss., 8, 18007, 2008.