Atmos. Meas. Tech. Discuss.,
doi:10.5194/amt-2018-14-AC1, 2018

Atmospheric Measurement Techniques Discussions

Interactive comment on "A Singular Value Decomposition framework for retrievals with vertical distribution information from greenhouse gas column absorption spectroscopy measurements" *by* Anand K. Ramanathan et al.

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Received and published: 18 April 2018

Response to Anonymous Referee 1

- **P 4 line 22: "better representing" I don't know what is meant here, please restate.**

  Changed the sentence for more clarity from

  "Such simple methods have the advantage of better representing the instrument

  measurement, and enabling more feedback on instrument performance."

  to

  "Such simple methods have the advantage of enabling more feedback on instrument performance by virtue of forcing the retrieval to derive certain information strictly from the measurement even when non-optimal."

- **P 7: forward model definition. I find this section confusing. The measurement vector y is described as the deviation in the absorption from that corresponding to x_u, but that is not a measurable quantity and the statement is contradicted by Eq. (4). Near the bottom of page 8 it is claimed a valid choice for the reference profile is x_u = 0, so that y is a 'deviation' from zero. I believe this is correct in the end, and exploits the assumed linearity of the problem, but it is still not entirely clear to me, and I think the concepts should be better explained.**

  We agree with the reviewer. We have modified Eqn. 4 to include the noise term $\mathbf{epsilon}$

  The point of the equations at the bottom of page 8 were to use the offset and scale choices that we have at our disposal in setting how $\mathbf{x}$ relates to the CO_2 profile (in units of ppm). Our specific choice was made based on making the SVD equations least complicated. In the revised version, we will include an additional equation to explicitly show that relationship and include a sample calculation for clarity.

  In the examples we show, we set the uninformative prior to be a 400 ppm uniform column. With $\mathbf{x_u}$ being zero, $\hat{\mathbf{x}}$ having all elements 0 corresponds to a uniform column of 400 ppm. An element of $\hat{\mathbf{x}}$ having a value of 0.02 corresponds to that layer in the atmosphere having a mixing ratio of $(1 + 0.02) \times 400 = 408$ ppm. Similarly, an element of $\hat{\mathbf{x}}$ having a value of -0.02 corresponds to that layer in the atmosphere having a mixing ratio of 392 ppm.

The element in $\mathbf{x_u}$ corresponding to the surface reflectance or signal level (x_0) also has degrees of freedom for the offset and scale. Thus, one can set $\mathbf{x_u}$ to be zero with no loss in generality.

We have revised the text at the bottom of page 8 to

"In the above equations, we have carefully exercised our choice in linearly mapping the physical world to $\mathbf{x}$ by setting

$$\mathbf{x}_u = 0$$

for simplicity, and scaling $\mathbf{x}$ such that $x_i = -1$ corresponds to the GHG concentration of the i^{th} layer in the atmosphere being zero. As per Eqn. 3, $\mathbf{F}(\mathbf{x}_u)$ is a constant, which can also be set to zero with no loss in generality. These sorts of transformations are fairly standard in the literature and make the equations less complicated. "

We have also expanded our description of the numerical simulation methodology pertaining to the SVD method:

"For the SVD approach, we set the uninformative prior $\mathbf{x}_u$ to be a uniform 400 ppm CO_2 profile and anchor our definition of $\mathbf{x}$ to it. From this, $x = -0.02, 0, 0.02$ would correspond to mixing ratios of 392, 400 and 408 ppm respectively. "

- **P 21 line 7: "to the create"**

  We have corrected this to "to create"

- **P 28 line 11: "bias-free estimate" This is not true in general, as the authors have themselves noted on P 4 line 24. It should be qualified or its applicability defined**

  We have changed the sentence from

  "...confirms the notion that the retrieval of a column mean using least-squares line fitting of an absorption spectrum yields a bias-free estimate of the X_{GHG},

regardless of the shape of the profile used in the prior (which turns out to be uninformative)"

to

"...confirms the notion that the retrieval of a column mean using least-squares line fitting of an absorption spectrum yields an estimate of the X_{GHG} without incurring bias from the regularization or retrieval, regardless of the shape of the profile used in the prior (which turns out to be uninformative) "

Interactive comment on Atmos. Meas. Tech. Discuss., doi:10.5194/amt-2018-14, 2018.