Atmos. Meas. Tech. Discuss.,
doi:10.5194/amt-2018-265-RC3, 2018

Atmospheric Measurement Techniques Discussions

AMTD

Interactive comment

Interactive comment on "Joint retrieval of surface reflectance and aerosol properties with continuous variation of the state variables in the solution space: Part 2: Application to geostationary and polar orbiting satellite observations" *by* Marta Luffarelli and Yves Govaerts

Anonymous Referee #2

Received and published: 30 August 2018

This paper evaluates a retrieval of surface reflectance and aerosol optical properties proposed in its accompanying paper. A quality control system is outlined and the sensitivity of the retrieval discussed. Retrievals from SEVIRI and PROBA-V data during 2015 are compared to AERONET, showing a disappointing AOD retrieval, and the MODIS Land Product, which are rather more satisfying.

Printer-friendly version

Discussion paper

I wish to clearly state that I quite like the idea behind this algorithm. Single-scattering albedo and the asymmetry parameter provide a theoretically superior state space in which to evaluate aerosol retrievals and I would love to see (and do) more research around this idea. I am always pleased to see a discussion of information theory in an atmospheric science paper and more validation papers should discuss uncertainty. I want to see this pair of papers eventually published.

My issue is that I see no evidence that this algorithm currently produces acceptable results. Fig. 14 is not good. It's not bad enough to imply your technique is without merit, but if that's the only plot you're going to provide, you will struggle to attract interest in this algorithm as your correlation, bias and RMSE are worse than most products I've encountered. At the very least, you need to find some circumstances where your retrieval's ability to mix aerosol types produces a better retrieval than a more developed product (e.g. MODIS collection 6.1 or the Swansea University product from Aerosol CCI). Maybe biomass burning emissions from Africa or the industrial regions of China?

Also, the heritage of the algorithm and the plots in the supplement imply this method is a much better retrieval of the surface than of aerosol. I would warm to the paper more if it was arguing that you made a slightly better aerosol retrieval without harming the surface product rather than the current structure, which implies you were trying to make an aerosol retrieval and skims over the significant limitations in your current results.

A list of my more major concerns follows, attempting to only repeat points I made in my reviews of Part 1 and the comments of Reviewer #1 for emphasis.

§4 Though I'm pleased to see a discussion of information content in an atmospheric science paper, yours is rather unusual. You're using the magnitude of the Jacobian to argue which terms are the most important. However, the Jacobian has units and so the magnitude of different terms isn't direct comparable.

To illustrate, consider Fig. 5, which you use to argue that ρ_0 is a more dominant driver of changes in TOA radiance than θ. A small change in surface reflectance could be of order 10^{-3}, which would produce a change of about 10^{-3} in $\mathbf{y}$ (as the Jacobian is approximately unity). A small change in viewing angle could be 1° and, if the Jacobian shown was in units of degrees, that would imply a change of -0.2 in $\mathbf{y}$, which is much larger than that for ρ_0. (The change is still larger if the units are radians.) The value of the Jacobian must be scaled by an appropriately small change to be compared to other values.

Optimal estimation already has a mechanism to evaluate this. It's called the averaging kernel and Eq. 2.78 of Rodgers (2000) defines it as,

$$\mathbf{A} = \left(\mathbf{K}^T \mathbf{S}_\epsilon^{-1} \mathbf{K} + \mathbf{S}_a^{-1}\right)^{-1} \mathbf{K}^T \mathbf{S}_\epsilon^{-1} \mathbf{K}.$$

You likely already calculate this when determining the entropy (see Eq. 2.80). A row of the averaging kernel summarises the contributions of each state vector element to the retrieval of each other variable while the diagonal elements quantify the reliance on the prior. (Things are slightly complicated by the addition of smoothing, $\mathbf{H}$, terms to your cost function. The difference is subtle; ask Oleg Dubovik about it.) For your retrieval, I would expect the diagonal of $\mathbf{A}$ for ρ_0 to be close to one and k to be closer to zero. It would also illustrate the interdependence of the different terms.

I don't know if the average reader would find such an analysis easier to understand. Averaging kernels, though very powerful, are confusing. I tend to put them in supplementary material for people that care to find.

If you don't switch to averaging kernels, label your plot axes as derivatives rather than Jacobians (e.g. the x-axes on Fig. 6 is $\frac{\mathrm{d}y}{\mathrm{d}\tau}$) so readers have some chance of understanding what's being plotted.

More practically, I'd say a superior test to use in §5.2.4 would be the number of degrees of freedom for noise (e.g. $n - \mathrm{tr}\,\mathbf{A}$).

§4 More generally, I'm not sure why this section is so long. It's worthwhile to point out that the retrieval's sensitivity is a function of what is observed, but there must be a more efficient way to show that the retrieval has minimal sensitivity at some times of day/year.

Tab.2 This is a substantial problem. You should be more upfront about the current limitations of your method and outline in more detail what you intend to do about them. There's nothing wrong with incremental progress. This also affects L568.

Fig.4 I agree with the other reviewer in wondering why you selected vertices that exclude a significant population of observed aerosols.

L280 I partially disagree with the other reviewer. For aerosol, there is less information content in the backscattering direction. This is why the orientation of the second view was flipped from AATSR to SLSTR. The instrument now views backscattering in the Northern Hemisphere, reducing the influence of aerosol on the signal and improving the quality of surface products in the region of the world that contains most of the humans.

L299 I strongly suspect that there is less information content in the polar data because you ascribed more uncertainty to it (σ_c and σ_θ), not because of anything intrinsically advantageous to the geostationary view. This affects your conclusions on L555 and L561. (My opinion is that geostationary data is superior when you need temporal resolution and polar data superior when you need global coverage.)

L321 Do you mean that the magnitude of the cost increases with the number of observations because there are, well, more observations?

- L297 of Part 1 addressed something similar by putting a scaling into the cost function; you could do that.
- The cost function is (theoretically) a χ^2 distribution with a number of degrees of freedom equal to the number of observations. Using that model, the cost can be converted into a probability that the fit is coincidental and a

threshold for retrieval quality defined in terms of that (for example, keeping only retrievals with less than a 5 % probability of being the result of chance).

- Regardless, I agree that filtering by cost alone will not identify retrievals with minimal sensitivity.

§5.2 This section is very difficult to follow and needs redrafting with help from someone unfamiliar with the method. Switching between p, q, and QI doesn't help, especially when 1 is a good value for one while 0 is a good value for the other. It would be substantially easier to follow if you provided a decision tree.

§5.2.3 Though I understand the motivation behind this test, I should point out that $\frac{y_m - y_0}{\sigma_0}$ is normally distributed. As such, 31.8 % of observations would be expected to fail your test by simple chance.

L360 I agree with the other reviewer that the lack of discussion of a cloud masking is surprising. PROBA-V lacks thermal channels, making it difficult, but you have no problems on SEVIRI.

L425 This extra test should have been mentioned back in §5.2.5. More justification of this work around is necessary.

L453 A factor of two is not a 'slight' overestimation and the fact that your retrieval was this bad eight years ago does not forgive it's failure now.

L478 That isn't good agreement. A good agreement can be seen between the red and green lines in Fig. 18(a).

§6.2 These comparison look good! Why not give us a version of Fig. 14 for SSA and g? Considering they're what you retrieve, I wouldn't be surprised if you could estimate them better than you could AOT. Wouldn't make me think the product was any better as most users want AOT, but they aren't many global SSA datasets and if you could provide one, even if it's very uncertain, that would be something worth writing about.

Some more minor comments,

L116 There are many potential calibration methods for SEVIRI. If you're using IMPF or GSICS, could that be mentioned explicitly? If you're using something in-house, a citation would be appreciated.

L145 Why make this approximation? Is the calculation of the other terms computationally expensive?

Eq.6 This seems a strange choice. Why not the standard deviation or interquartile range or a constant value based on climatology?

§2.4(1) What's the value of N_{min}? Why increase the uncertainty by 5 % per day rather than any other amount?

§2.5 I'd actually prefer to see a thorough sensitivity study of bias as a function of the various parameters rather than the simple 1 - 3 % uncertainty you've added, but that can be in a third paper.

P12L2 In my experience, the first guess is set to reduce the number of iterations needed to reach a solution. Avoiding local minima involves checking the shape of state space around the final solution or annealing (i.e. running multiple retrievals on the same data).

Eq.8 So you're using a different first guess for even and odd numbered time steps? That's peculiar and, on its own, I don't see how it avoids local minima.

§4 The third paragraph covers four pages. Perhaps split it up.

P17L1 As the sensitivity drops through the day, I would expect the uncertainty to increase.

L351 What is the maximum number of iterations?

L352 Could you clearly state that $p_0 = 1$ in all other circumstances. I wasn't certain of that till I got to Eq. 15.

§5.2.2 Did you ever explore using the a priori cost for this test (i.e. the difference between the retrieval and the prior)?

Eq.11 Aren't the y terms vectors? If so, wouldn't this require some sort of sum?

L371 Didn't you have to calculate the full Jacobian to perform your inversion? I see your point, but this is a lot of explanation for why you don't use something you should already have.

L379 I assume that if I ask for a justification of this statement, I will be told to go look at your papers from 2010 so I will make this sarcastic remark instead.

Eq.15 For the sake of future readers' comprehension, please restrict q_i to the range $[0, 1]$ and make QI a simple product rather than use the difficult to comprehend $1 - \max(q, 1)$ construction.

L409 Please specify this sigmoid function (or at least give it's width).

Fig.14 Can we please have a version of this plot as a 2D histogram in the supplement, similar to the ones already there for the BRF?

- The y-axis of Figs. 5, 6, 9, 10, 15, 17, 18, 19 should probably be 'Fractional counts' considering they clearly have non-integer steps.

Fig.16 (b) and (c) aren't that interesting or helpful. Perhaps make (c) an inset in (a).

Printer-friendly version

Discussion paper

The English is easily understood but I agree with Reviewer #1 that it reads more like speech than text. There are too many interrupting statements and initial qualifiers. As the other reviewer provided extensive technical corrections, I list here only those issues that I noticed in the course of reading.

L1 Move 'simultaneous retrieval' to before 'Aerosol'.

L4 demonstrate CISAR's applicability (Similar corrections on L24, 464, 474, 583.) This correction isn't universally preferred and an alternative would be 'demonstrate the applicability of CISAR applicability to'.

L32 with a revisit time in the range of several tenth tens of minutes

L33 limited field of regard view (similar corrections in Fig. 1 and on L67).

L33 that many different instruments with different sub satellite locations are needed

L34 Earth. The poles cannot

L66 applied on to observations

L81 in Eq. 17 in of Part 1

L82 composed by of the radiometric

L87 observation in the near-real time

L90 with a 15 minutes minute repeat

L137 The reference to Dee et al. lacks a year; it's 2011.

L142 strongly affect affects the CISAR

L152 is not supposed expected to undergo

L170 FASTRE requires to must know

Fig.3 during a 5 days

L210 For a polar

P12L7 computational performances performance, the

L245 latter consists in fact in of the minimisation

L253 reflectance shape results is more

L261 When the magnitude of AOT

L305 smaller value values than

L307 polar orbiting one ones, the

L340 to defined define a QI

L345 been defined trough through an analysis

L365 For the inversion being to be successful

L370 Performing a test over on the Jacobians

L373 state variables, for which

L382 applied on to the AOT

L391 parameters, compute computed as follows

L415 been chosen by observing

L456 the algorithm to fit from fitting rapidly

L458 of AOT which normally results is normally smaller

L464 Some example examples of

L465 overestimation for of low AOT

L466 observed even a few kilometres distant from

L472 measurement, being applied to pixels of observing areas of a few kilometres . . . to be affect affected by

L484 correctly characterise characterised by

L488 for both satellite satellites. The

L498 linear combination combinations of

L521 plots of the CISAR BHR

L539 consists in of the

L540 step of the CISAR

L541 evaluation consists thus in of the

L549 Despite Though the PROVA-V

L552 The CISAR retrieval is finally evaluated

L553 suspicious retrieval retrievals and

L559 is applied on to geostationary observation observations

L565 with the MODIS

L576 applied on to sensors

L577 algorithm on to data

Interactive comment on Atmos. Meas. Tech. Discuss., doi:10.5194/amt-2018-265, 2018.