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Atmospheric Measurement Techniques Discussions

Interactive comment on "Correcting for trace gas absorption when retrieving aerosol optical depth from satellite observations of reflected shortwave radiation" *by* F. Patadia et al.

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This paper outlines a revision of the Dark Target algorithm to better account for the absorption of common atmospheric gases. The radiative transfer code and spectral database have been updated since Collection 5, but the essence of the method is unchanged. A gas's optical path is modelled as a linear (or, in the case of water, quadratic) function of gas path length. Ten gases were evaluated, and the regression coefficients are reported for both the MODIS and VIIRS sensors. It concludes with a brief reminder that ignoring the difference in spectral response between two instruments can produce non-trivial errors.

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Discussion paper

Though this paper has a rather small audience, it is well within the remit of this journal and is the sort of work that is often overlooked. Other than a few minor corrections, I recommend it for publication.

Thank you very much for a thorough review and for suggestions that have improved the paper. We have incorporated all of them.

A few matters that warrant consideration: L28 Though I appreciate the simplicity of the language, aerosols aren't necessarily 'tiny'. Hinds described them as 'fine' but I find 'Aerosols are particles in the atmosphere' is usually sufficient.

We have replaced 'tiny' with 'fine'.

L285 It is true that these gases are usually well mixed. However, a not-insignificant number of users of aerosol data study emissions from volcanoes and fires. As those emit many of the gases you are studying in significant quantities, do you have any estimate of the magnitude of errors that will result from using climatological concentrations there? A back-of-the-envelope calculation could be quite informative.

We agree that the climatological concentration of gases is not representative of their concentrations at sources such as volcanoes, fires, industries etc. We are using climatological optical depth for CO2, N2 O, O2 and CH4. Some of these gases are emitted by fires (CO2, N2 O, and CH4) and volcanoes (CO2, SO2). These gases are transparent to solar radiation in the shortwave channels used for aerosol retrieval. Tables 2.1, 2.2 show that these gases absorb in the 1.6 μm and the 2.1 μm channels.

CO2 concentrations (AIRS Maps) indicate $\sim$2% [400 ppm to 408 ppm] increase in fire locations compared to background. In the 2.1 μm channel, used by DT algorithm, 2% increase in CO2 concentration would translate to $\sim$0.001 CO2 optical depth, which would not change the total gas optical depth in 2.1 μm channel by a lot.

Similarly, from CH4 maps from volcano events, there seems to range by $\pm$65 ppbv ($\sim$3.5%). For VIIRS, CH4 optical depth in 2.1 μm channel (0.04914) will change by

$\sim$0.002.

So, using climatology for gases other than H2O and O3, will impact the atmospheric gas corrections near source regions. However, since these gases absorb in IR, where signal is low, the errors will be small.

L304-9 Could you please provide some quantitative indication of the quality and uncertainty of these fits (e.g. root-mean-square deviation and the maximum error)? To-Do

This would be particularly instructive for water vapour, where I would appreciate a more scientific justification for using a quadratic fit (or, vise versa, a justification for using linear fits with everything else).

Thank you for this comment. We have revised the text with additional information :

Water vapor absorbs over a wide range of electromagnetic spectrum through different mechanisms (rotational, vibrational, electronic transitions etc). The spectra are also all different for isotopic variants of water (e.g. HDO, D2O, H218O). Laboratory measurements show a broad absorption at 405 μm with quadratic dependence on water monomer concentration and similar absorption with a linear component at 532 nm. With greater levels of water vapor the increase in water dimer will be nearly quadratic, and increase the direct absorption of sunlight to a greater extent than water monomer absorption and line broadening.

L336-8 While I appreciate that in normal operations you can't use the MODIS water vapour product, you've presumably tried using it offline. Could you quantify approximately how much difference it makes to the final product?

We haven't used the MODIS water vapor product. However, we have estimated the uncertainty in the retrieved AOD due to error in the water vapor data used by the DT algorithm. A 20% error in water vapor content results in AOD uncertainty of $\sim$0.002 (median) , $\sim$0.003 (mean). The uncertainty magnitude was similar for different months of global data we looked at.

L441-3 This final paragraph begs the obvious question to any algorithm paper: You've proposed something that sounds sensible, but is it actually better than what you did before? Fig. 7 implies you've processed at least a month of data with the new corrections. For that data, does the RMS difference against AERONET collocations improve (or at least not significantly degrade)?

We had tested to ensure that our empirical relations (Eqs 5, 6) can reproduce the transmission calculated from LBLRTM for different water vapor and ozone profiles. At the time of doing this work, few other changes were made in the retrieval algorithm. The

Printer-friendly version Discussion paper Fig.1 The axes labels are far too small to be legible. Corrected

Figs.3-4 The axes labels aren't meaningful to someone that hasn't read the text exhaustively. Also, is the y-axis of 3(a) really the log of the log of the transmission factor?

Thank you. Added more description. Yes, y-axis label is correct

Fig.6(a) Could this be the same size as 6(b) to facilitate comparison? Done

Fig.7 There might be a good reason why not, but could the fractional difference be plotted rather than (or in addition to) the absolute difference? Over the central Pacific changes appear to be 0.01, which is rather significant there. Done. Additional figure added

The English quality is in the upper quartile of paper's I've reviewed. Though I found the language rather repetitive, it is not my place to nitpick style. However, I do have some grammatical recommendations:

All edits suggested here have been incorporated in the paper. Thank you for the suggestions.

âĂć "the" should proceed the following words: L12 underlying, L14 Moderate, L18

High-resolution, L21 MODIS, L25 gas, L34 characterization, L40 solar, L53 accuracy, L98 context, L106 Earth's, L126 spectral reflectance, L211 coefficients, L311 gas, L326 largest, L381 HITRAN, L395 subsequent, L400 MODIS, L470 nadir. L17 There should be a comma after 'paper'. L23 AOD biases of up to L24 studies are attempting have attempted to create L35 'over broad regions' seems redundant to 'global'. L41 from the solar radiation interacting interaction with suspended aerosol particles aerosols from the L51 to apply in to new situations. These latter includepaper L55 suggested that for reducing to reduce uncertainties L67 magnitude as to pristine AOD, and is equal L76 (well-mixed) throughout across the globe L77 their absorption would also would lead to L82 gases to be too small to bother with negligible [MISR ATBD] L105 from blue through to the shortwave L116 'observed' seems redundant to 'as measured by the satellite'. L123 been made for about the surface L141 each gas were was calculated L195 The expression for G should be typeset as math not text. L252 This heading should be bold. L256 database [] for calculating to calculate transmittance L267 This heading should be bold. L323 accordance to with absorption L329 w should be typeset as math not text. L347 SO2, and other trace L348 day-to-day should be hyphenated. L355 different gases is differentper L357 case of with a small amount L371 'match' seems to be the wrong word. I think you mean 'be consistent with' or 'can be used with'. Fig.1 are overlaid for visualizing to visualize their positioning in atmospheric 'window' region regions where

All above edits have been incorporated in the paper. Thank you for the suggestions.

There are also a few thoughts I would like the authors to be aware of but which are unreasonable to expect a revision: L86 Though aerosol retrievals don't often discuss gas correction, sea surface temperature studies do because of their more stringent accuracy requirements, such as doi:10.1016/j.rse.2010.10.016. For aerosol in particular, §2.3.3.3 of the thesis of Haiyan Huang (http://eodg.atm.ox.ac.uk/eodg/theses/Huang.pdf and https://ora.ox.ac.uk/objects/uuid:16e444e6-5da9-43da-a122-c50c7e6a2412) presents a

sensitivity study of TOA brightness temperature from AATSR to a variety of gases. I am curious if the authors have ever considered the importance of species such as F12 and CFCs, which Dr. Huang found to be rather important?

Dr Huang found these gases to be important in the Infrared channels. The DT algorithm doesn't use these channels for aerosol retrievals. For the channels used in DT algorithm, we have looked at all those gases (in HITRAN database) that might have some absorption in these channels. Only the ones listed in the paper are the important ones.

L257 I agree with Dr. Gordon that you should have used a more recent version of HITRAN.

We agree. The only reason for using the earlier version of HITRAN was because at the time when modifications were made to our gas tables (2012 – 2013), HITRAN2008 was the latest version. In the next version of DT algorithm, we will update our calculations with latest HITRAN version.

L281 Many studies desire a representative set of atmospheric profiles. I appreciate that you've cited someone for making that decision. However, researchers have done statistically robust selections for the minimally representative set. For example, §3 of https://www.ecmwf.int/sites/default/files/elibrary/2008/ 11040-generation-rttov-regression-coefficients-iasi-and-airs-using-new-profile-training-set-and-new. pdf.

Thank you for pointing to this reference. We have added the relevant reference to the paper.

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