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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Retrieving global sources of aerosols from MODIS observations by inverting GOCART model" *by* O. Dubovik et al.

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1 General comments

This paper represents a novel application of aerosol remote sensing data combined with an evolved and ambitious implementation of geophysical retrieval techniques. I believe that with a little improvement it will serve as a basic reference for emissions inversion research activities for a number of years to come.

One criticism I have relates to the occasional lack of clarity which makes the reading of such a complex paper more than a little onerous in certain places (this lack of clarity is sometimes related to the level of written English which I discuss immediately below). Another criticism would be the lack of spatial sensitivity analysis in the emissions

estimates given the large uncertainties in MODIS data. The authors should consider adding a figure which shows the emissions retrieved for artificially noisy MODIS data (please see the detailed comments).

The text contains a lot grammar mistakes (missing definite articles, inappropriately placed definite and indefinite articles, missing verbs, missing prepositions, incorrect prepositions, prepositions abutting other prepositions, etc.) and examples of awkward style. I stopped correcting this after page 3638 unless the departure from acceptable written English was so severe that the message could not be understood. The authors would be well advised to get some help from a technical writer who received his or her formal education in English; in most cases one can decipher the meaning by filling in or correcting the grammar "on the fly" but in some cases the grammatical errors or awkward phrases are a real obstacle to understanding what is being said.

There are a lot of dimensions involved in the matrix equations (time, space, process, aerosol component, iteration index). It would have been helpful to me, and I suspect other readers, if the authors had added a thoughtful conceptual 3D diagram (maybe even a 4D diagram with two end-point cubes) which shows the main variables and their indices (even the iterative process could be represented in the conceptual diagram).

I'm not sure that the equations shouldn't be relegated to an appendix since, while they are certainly necessary if they haven't been published before, they tend to obscure the message of the paper (about being published before; I happen to know that a significant fraction of the equations were published in Dubovik et al., ÓPTICA PURA Y APLICADA – Vol. 37, núm. 3 - 2004 but I would agree with an argument about consolidating everthing in one more readily accessible paper . . . but again an appendix would be more appropriate).

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2 Detailed comments

Key;

- author's quotes in italics between quotation marks.

- my suggested replacement text between non-italicized text and specific changes in bold (with an arrow "->' from the author's text to my suggested revisions)

- my comments, in non-italicized text, preceeded by a hyphen

Abstract

"*Chemical transport models rely on archived meteorological fields, accounting for aerosol sources, transport and removal processes can simulate the global distribution of atmospheric aerosols.*"

-> "Chemical transport models **can simulate the global distribution of atmospheric aerosols by employing archived meteorological fields and by accounting for aerosol sources, transport and removal processes**."

Page 3631;

"*Such additional assumptions . . .*"

- assumptions which are in addition to what assumptions?

Page 3632;

" *. . . do not yet provide the required accuracy and details of time and space variability of aerosol properties.*"

-> " . . . do not yet provide the required accuracy **nor the level of detail needed to assess the** time and space variability of aerosol properties."

"*Tropospheric aerosol may have strong local variations and any single satellite needs*

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at least several days of observations to provide global nearly cloudless images."

-> "Tropospheric aerosols may **display** strong local variations and any single satellite needs at least several days of observations to provide **sufficiently cloud-free** images on a global scale."

" . . . that adopt the meterological data . . . "

-> " . . . that **incorporate** meterological data **into the model physics** . . . "

Page 3633;

"*Weaver et al. (2006) suggested a procedure for assimilating atmospheric radiances measured from satellite into the aerosol field produced by the GOCART global transport model.*"

-> "Weaver et al. (2006) suggested a procedure for assimilating **satellite-level** radiances into a **radiative transfer model driven by the aerosol field predictions generated** by the GOCART global transport model."

" *. . . and have been successfully applied for atmospheric gases inverse modeling applications . . .* "

-> " . . . and have been successfully applied **to inverse modeling analyses involving atmospheric gases**"

Page 3634;

"*Our paper explores the possibility of deriving the global distribution and strength of aerosol emission sources from satellite observations. We are employing the adjoint approach for implementing an inversion of an aerosol transport model.*"

-> "Our paper explores the possibility of deriving the global distribution and strength of aerosol emission sources from satellite observations **using the adjoint approach to invert an** aerosol transport model."

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EGU

" . . . in early sixties . . . " -> " . . . in **the** early sixties . . . "

"*Here, we discuss the possibility to constrain temporal and/or spatial aerosol variability by applying a priori limitations of the derivatives of aerosol mass with respect to time and space coordinates.*"

-> "Here, we discuss the possibility **of constraining** temporal and/or spatial aerosol variability by applying a priori limitations **to** the derivatives of aerosol mass with respect to time and space coordinates."

Page 3635;

" *where s(t, **x**) – mass emission, . . .* "

-> " where $s(t,$**x**) **represents the** mass emission, . . . "

" *. . . via matrix equation:*"

-> " . . . **in terms of the** matrix equation:"

- why does m(t', x) get reduced to the initial vector of M_0 in the matrix formulation (equation (5)) while s(t', x) which is identical in formulation does not get reduced to an analogous S_0 (rather than a time dependent S)?

Page 3636;

- using "n" for the time limit index and "n" for total number of processes as per equation (3) is confusing (its difficult enough to understand these phenomenogical mathematical arguments without having to deal with ambiguous nomenclature)

" *. . . each location **x** and time step t_k from all locations **x** and previous time steps $t_{i<n}$.*"

- is their a mixup of subscript symbols here? (if not, what is "i"?)

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"*Here, $\boldsymbol{M}_0$ – vector of measurements corrected by the effect of the aerosol mass $\boldsymbol{M}_0$ presented in the atmosphere prior observations i.e. $\boldsymbol{M}* = \boldsymbol{M}^{meas} - -\boldsymbol{TM}_0$.*"

- What does "presented in the atmosphere prior observations" mean? Is this what is mean't?;

"Here, $\boldsymbol{M}_0$ is the vector of mass measurements corrected for the background aerosol (M_0) present in the atmosphere prior to the observation period i.e. M*=M^{meas}–TM_0."

" . . . *and DS is vector of the errors that usually considered statistically independent*..."

-> " . . . and D$S$is vector of the errors that **are** usually considered statistically independent ..."

Page 3638;

"*Thus, in difference Eq. (8), utilizing a priori constraints requires simultaneous minimization both measurement term 2Ñm and a priori term 2ÑS*."

-> "Thus, in difference Eq. (8), utilizing a priori constraints requires simultaneous minimization **of** both **the** measurement term 2Ñ$m$and **the** a priori term 2ÑS."

Page 3665;

Equations 57a; - what does "i" refer to and why does "i" appear within the summation as well as outside of the summation?

Equations 57b; - why is there a summation over "i" where the only subscript associated with the summation terms is "k"? What does "k" refer to?

Equation 57 in general; - how about a bit more description of the equation?;

"where τ*$_i$ is the measured aerosol optical depth in column "i" and τ_i(S) is the computed optical depth generated by the retrieved emission sources. The summation is applied over all measurement columns and all times within the test period. The absolute standard deviation . . . "

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"*The values of the fitting residuals are: σ_{abs}≈0.006 and σ_{rel}≈12%.*"

- this is actually better than the case which was not sub-sampled as per MODIS sampling (σ_{abs} ≈0.01 and σ_{rel} ≈15%). Doesn't this merit a comment? (specifically about the effect of sampling strategies on the results)

"*Several numerical tests were performed to evaluate consequences of such limitation on global emission retrieval from* . . . " - was the MODIS sub-sampling used for these tests?

"*Then the modeled τ_{fine}(0.55) were inverted using simplified model of single fine mode aerosol.*"

- is the discussion in this paragraph about one run only? (i.e. a single fine mode aerosol composed of sulfate, BC and OC) . . . the use of "Then" and the discussion in the following paragraph is very confusing to me (the difference between the runs and how many runs there were is not clear to me).

"*As can be seen on Figs. 11–12 the results of the retrieval using simplified single fine mode aerosol look encouraging.*"

- as the authors state, the result for this fine mode test was inferior to the previous "generic" aerosol optical depth results. Why is this result "encouraging" when the reasonable residuals could be just due to the dominance of total aerosol optical depth by the fine mode? (I'm especially worried about the MODIS fine mode fraction which is known to be marginal over the oceans and largely untested over land)

Page 3668;

"*The numerical test shows that if "measured" τ_{gine}(0.55) was composed by BC and OC only the retrieval provides better fit than the retrieval based on single fine mode aerosol.*"

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-> "**New** numerical tests of the **under-constrained retrieval mode** show that if “measured” τ_{gine} (0.55) was composed **of** BC and OC only**,** the retrieval provides **a** better fit than the retrieval based on single fine mode aerosol."

- is this what is mean't? What's the difference between the retrieval constrained to BC and OC components and the retrieval based on a single fine mode aerosol? (and why is the retrieval based on a single fine mode aerosol different from the case discussed in the previous paragraph?)

"*The fitting errors were:* σ_{abs}*≈0.005 and* σ_{rel}*≈15%, while the retrieval with single fine mode aerosol in better fitting errors* σ_{abs}*≈0.01 and* σ_{rel}*≈20%.*"

-> "The fitting errors were: σ_{abs} ≈0.005 and σ_{rel} ≈15%, while the retrieval with single fine

mode aerosol **were** σ_{abs} ≈0.01 and σ_{rel} ≈20%."

- the "better fitting errors" part of the sentence is completely confusing

Page 3669;

"*The algorithm was applied to the actual measurements of* τ_{gine}*fine(0.55) and* $\tau_{goarse}(0.55)$ ..." - which algorithm; the underconstrained algorithm or the a priori algorithm?

Page 3671;

For example, standard output of GOCART model results into much higher residuals (σ_{abs}*≈0.12 and* σ_{rel}*≈170%) than those achieved by retrieval (*σ_{abs}*≈0.04 and* σ_{rel}*≈48%)*.

- this is a relevant example but it is rather blunted by the extreme amount of averaging that goes into these ensemble errors. It begs the question as to the spatial sensitivity of the emission retrievals with respect to the MODIS AOD errors (in a simple-minded

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sense, 0.12 is not that distant from 0.04 in terms of MODIS errors). The authors should consider evaluating some measure of spatial sensitivity in their emission estimates; for example, a randomn error with standard deviation = MODIS standard deviation being added to the MODIS image in the upper panel of of Figure 14 and then inverting that.

"*The desert dust and sea salt emission distribution used by GOCART for the same time period of August 2000 is shown in Fig. 15.*"

- the caption of Fig. 15 only mentions sulfates, BC and OC??

Page 3672;

"*Correspondingly, one can speculate that τ_{goarse}(0.55) observed over that area could be attributed to the coarse of mode of biomass burning aerosol.*"

-> "Correspondingly, one can speculate, **given the bulk mode treatment of biomass burning aerosols by GOCART,** that τ_{goarse}(0.55) observed over that area could be attributed to the coarse mode of **the** biomass burning aerosol."

- is this what is mean't?

"*However the accurate derivation of biomass coarse mode fraction of smoke is probably challenging because smoke is dominated by small particles. Therefore some inconsistency of MODIS retrieval would be surprising in this situation.*"

- The logic of the second sentence, given what was stated in the preceeding sentence, makes no sense to me. Does the "Therefore" refer to the last few words of the preceeding section rather than the whole sentence? (clarification is needed). And if it does what exactly is the point being made?

" *. . . (we attribute all coarse mode aerosol emissions over ocean) . . .* "

- this phrase makes no sense as written. Do the authors mean; -> " . . . **(we attribute all coarse mode aerosol emissions over the ocean to sea salt)** . . . "?

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Page 3681;

"*The optical thickness during high aerosol loading events of loading was reproduced with the standard deviation of* $\sim$ *48%.*" - this awkward sentence seems to imply that only high aerosol loading events were selected for the two week test period . . . is that the idea the authors wanted to convey?

Interactive comment on Atmos. Chem. Phys. Discuss., 7, 3629, 2007.