

Interactive comment on “The ACOS CO₂ retrieval algorithm – Part 1: Description and validation against synthetic observations” by C. W. O’Dell et al.

Anonymous Referee #1

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The paper by O’Dell et al. evaluates performance of the ACOS CO₂ retrieval algorithm for simulated GOSAT observations. In contrast to previous studies on performance of the algorithm, the present study considers forward model errors due to various approximations in the setup of the method. Uncertain knowledge about aerosols and clouds turns out to be the error source that largely dominates over noise errors and errors due to imperfect meteorology and radiative transfer modeling. Unfortunately, the study does not address spectroscopic and instrument related effects which have been shown to limit current retrieval accuracy for real GOSAT measurements.

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The paper is a thorough and honest attempt to quantify residual errors in the ACOS CO₂ retrieval algorithm as far as simulations allow for. This study is overdue since other algorithms have been evaluated already in the past, since GOSAT is in orbit for more than 2 years, and since ACOS routinely delivers CO₂ retrievals from real GOSAT measurements. Nevertheless, the paper is of interest for algorithm developers and data users since it covers new aspects such as the effect of imperfect cloud screening and an evaluation of the actual a posteriori error in comparison to the noise error. The paper further forms a basis document for the upcoming OCO-2 mission.

I recommend publication in AMT after considering some minor comments and questions. Overall, I recommend refining the discussion of the algorithm performance such that it becomes clear to the reader which residual errors relate to which forward model approximations. Some comments below pick up on this issue.

Comments

p.6106,l.8: While fitting the logarithm of the aerosol parameters avoids negative values, it makes the forward model significantly nonlinear. Did you check if this trick deteriorates convergence behavior or makes the retrieval get stuck in local minima of the cost function?

p.6114,l.22: Section 3.1 and the discussion of the retrieval performance in section 3.3 would benefit from a more detailed summary of the differences between simulation and retrieval method. How do the radiative transfer methods differ? How do the aerosol models differ (height distributions, sizes, refractive indices, non-spherical particles)?

p.6118,l.25: What are the sources of the non-vanishing XCO₂ and surface pressure error for retrieval test 1, “which is to be expected on simple theoretical grounds”?

p.6121,l.10: The authors claim that there is a strong correlation between retrieved and true AOD for values <0.3. Fig. 8c does not support this and might hint at the retrieved aerosol parameters actually being pure correction parameters. Consider to use less

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strong wording eg. by replacing “strong correlation” by “some correlation”.

p.6121,l.26: The residual errors detected for test 5 come from the differences between the “true” and the “retrieved” scattering scenario. Positive bias over dark surfaces could for example be explained by the retrieval finding cirrus at higher altitudes than in the simulation. The paragraph reads like an explanation for test 4 errors ie. for a retrieval that entirely neglects aerosol and cloud scattering. Consider to refine the reasoning here.

p.6124,l.16: The study finds that more than 10% of the accurate XCO₂ retrievals correspond to scenes with true AOD>0.3. One of the quality filters screens all retrievals with retrieved AOD > 0.15 ie. retrieved and true aerosol scenario differ a lot. I would conclude that in these cases some lucky combination of surface albedo and mismatch between retrieved and true aerosol parameters yields small XCO₂ errors. Thus, I suggest not to highlight this as a peculiar achievement of the retrieval method.

Technical comments

p.6099,l.25 (or at a more appropriate place): I suggest to refer to other retrieval algorithms that already demonstrated highly accurate CO₂ (and/or CH₄) retrievals from GOSAT, in particular since results from SCIAMACHY are actually cited. Consider Morino et al., 2011, Butz et al., 2011, Oshchepkov et al., 2011, and potentially Parker et al., 2011.

p.6102,l.9: This rest -> The rest

p.6105,l.29: Could you classify aerosol types “2b” and “3b” by some descriptive wording eg, industrial, soot, marine, absorbing?

p.6107,l.16: been -> has been

p.6113,l.22: chi²R ,>2.3 -> chi²R >2.3

p.6115,l.23: ranged ranged -> ranged

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p.6118,l.9: Raleigh -> Rayleigh

p.6121,l.22: with with -> with

p.6127,l.4: variance! -> variance.

p.6128,l.16: filter than -> filter that

p.6129,l.3: by solely by -> solely by

p.6129,l.20: Define quantities q, g, Mdry.

Fig.8. Ordinate scale in panels (a) and (b) is too large and might cause masking of important detail in the most important parameter space AOD<0.3.

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