The manuscript addresses an important topic which is relevant for all hyper-spectral near infrared satellite remote sensing techniques for the retrieval of atmospheric CO2 and which fits well to the aims and scopes of AMT. More specifically, the authors discuss the trade-off between computational efficiency and accuracy by comparing a version of the ACOS retrieval algorithm neglecting scattering with the full physics version of the same algorithm accounting for light scattering at clouds and aerosols. In this context the filtering method to identify the cloud and aerosol free scenes is discussed as critical part of the pre-processing. The manuscript is well structured and I recommend publication in AMT once my comments have been addressed.

1 Comments

Introduction: You only discuss full physics algorithms and their 0th order approximation, i.e., scattering is entirely neglected. What about the 1st order approximation using a light path proxy (e.g., O2 as used by Schneising et al. (2012)) to account for scattering. In principle, also a light path proxy method could be set up relying only on clear-sky RT simulations.

Section 4.2 and 4.3: As non-scattering retrievals are not per se inaccurate but only if they are confronted with aerosol and/or cloud contaminated scenes, I expect that the used pre-filtering and DOGO technique critically influence the results presented in this study. With this in view, I have the impression that the manuscript would benefit from more details in the description of the pre-filtering and DOGO technique. i) Which parameters have been used for pre-filtering and DOGO? ii) What is the throughput of the pre-filtering for GOSAT and OCO2? iii) Which are the most important parameters? iv) Why do you assume that DOGO filters out heavily contaminated scenes first (e.g., P13050 L25)? For ocean, Fig.5 may show this but Fig.6 shows that this is not so clear for land. Is this the reason why the FP (full physics) land algorithm outperforms the CS (clear-sky) land algorithm (with simulations)?

Fig.4: i) Please add an estimate for OCO2's RMS errors expected from noise (land and ocean). I expect that it is something in the order of 0.5ppm - 1.0ppm. This value can be used as lowermost estimate when DOGO starts removing "good" soundings. ii) Please indicate the DOGO throughput used by ACOS for OCO2 operationally. If these are smaller than 15%, CS should be considered as real option to be used in stead of FP, which is not the case for throughputs greater than about 50%. iii) I don't know how large the operationally used throughput values are but if they are larger than 15%, you should note that over land, the differences are quite substantial: if you would consider 1.5ppm as acceptable, FP gains 30% in terms of throughput; for a throughput of 90%, the variance roughly triples.

Fig.8: i) As for Fig.4, please add an estimate for GOSAT's RMS errors

expected from noise (land and ocean). ii) Please indicate the DOGO throughput used by ACOS for GOSAT operationally.

Fig.7, Fig.9: In contrast to the FP retrieval, the CS retrieval assumes that the surface pressure is perfectly known from ECMWF. Because of this and because of the additional state vector elements for the scattering properties in the FP retrieval, I would expect, that the FP retrieval diagnoses somewhat larger a posteriori noise for XCO2. If you find similar RMS values this could indicate that biases are larger for CS than for FP. For the application of surface flux inversion, regional biases are much more severe. Therefore, please add maps as Fig.7 and 9 but for scatter and bias.

P13040 L25,"RMS errors of less than 2.0ppm": i) Relative to which truth? Please specify. ii) Please add for comparison the corresponding RMS value for the full physics algorithm using the same sample. Is the difference significant?

P13040 L27,"These results imply that...": To my knowledge you primarily find in the literature conclusions on errors of "non-scattering" retrievals confronted with cloud/aerosol contaminated scenes (for clear sky scenes, you would not expect any problems). I.e., it is well known that issues of clear-sky algorithms arise from inabilities of the used filtering method. Therefore, I would suggest to reformulate the sentence to something like: "Our results imply that filtering methods can be found so that ...".

P13041 L3,"certain applications": Which are? Another potential application could be to use a FP (full physics) algorithm only for anchor points at nadir center pixels and use the fast CS (clear-sky) algorithm for the rest of the swath.

P13041 L18,"high accuracy": ... and precision

P13041 L24,"errors and biases": Do you mean "random errors and biases"?

P13042 L22,"non-linearity of the forward model": What is the problem with non-linearity of the forward model? As long as the non-linearity is moderate and the cost function does not have local minima, an iterative algorithm should be able to find the cost function's minimum. Please avoid citing not peer-reviewed literature or at least specify a web link.

P13042 L23,"full-physics retrievals may incur biases": In principle this is possible but it probably strongly depends on the specific retrieval set-up and likely on the used constraints for the a priori scattering information. For example, Reuter et al. (2010) have not found strong indications for issues with SCIAMACHY retrievals under cloud free conditions.

P13043 L18, "10 minutes": Is this for one CPU core?

P13043 L25, "our hypothesis": Please specify what exactly your hypothesis is.

P13043 L28, "Mandrake, 2015": Please avoid "grey" literature or at least provide a web link.

P13045 L24, "a priori surface pressure from ECMWF": OCO2 footprints are small compared to the ECMWF grid boxes. Do you inter/extrapolate the meteorological profiles to the OCO2 surface height?

P13045 L26, "We included Rayleigh scattering": Usually, this would mean that you account for multiple scattering in the RT so that you lose any gain in computational efficiency? How have you included Rayleigh without performing multiple scattering RT simulations?

P13046 L19, "Gaussian noise consistent with...": Please explain why you consider it useful to add Gaussian noise. It is well known how Gaussian noise propagates in retrieval noise. The drawback I see here is, that systematic errors (in which you are probably much more interested than in the noise) are potentially less visible because hidden in the noise.

P13049 L7, "Osterman et al., 2013": Please provide a web link in the references.

P13050 L25, "obviously contaminated": Please explain why you find it obvious that DOGO removes the (cloud/aerosol) contaminated scenes. If it is because of Fig.5, please add a reference to the figure. From section 4.3 (description of DOGO), I read that DOGO simply optimizes the RMS relative to an assumed truth by (smart) rejection of outlying soundings. DOGO does not care about the reason for the outliers. See also P13053 L13: "... DOGOs goal is ... not to remove scenes with high optical depths".

P13051 L5-L12, "The first 20% ...": i) Same as last point; please explain why you think that DOGO eliminates clouds at first. If it is because of Fig.5, please add a reference to the figure. ii) Which post-processing filters have been used for the FP and the CS algorithm? Reuter et al. (2010) found in simulations poor convergence for scenes with thick clouds. Is the convergence behaviour similar for the FP and the CS retrieval version for the first 20 %? Do you exclude non converging scenes?

P13051 L16-L18, "Below 30% throughput...": The same argument should hold for land observations but for land the FP performs better than the CS algorithm. Why?

P13052 L13,"Yellow corresponds ...": Move to figure caption.

P13053 L9, "as the RMS errors are nearly identical": RMS can be the same for totally different precisions σ and biases Δ: $\sigma = 2, \Delta = 0 \Rightarrow RMS = 2$; $\sigma = 0, \Delta = 2 \Rightarrow RMS = 2$. Recommendation: rephrase the sentence to something like "...performs about as well as the FP retrieval in terms of RMS. The same is true for precision and bias (not shown)."

Fig.5: DOGO does not remove the same data points for FP and CS maybe because DOGO uses retrieved quantities as input parameters. Which?

P13054 L9, "... has regional scatter and bias similar ...": Not shown here because you only show RMS comparisons.

P13054 L12, "We have shown that ...": i) Fig.4 shows that FP performs always better than CS for throughputs larger than only 15%. Additionally, Fig.7 shows that FP is superior in most regions of the world for a throughput of 30%. If the operationally used throughput is considerably larger than 15% I would recommend to rephrase the sentence in order to not "over-sell" the results. ii) You are not filtering for clouds. DOGO just optimizes the RMS. Fig.6 shows that by far not only cloudy scenes are rejected.

P13055 L9-L12, "At 100% throughput, it still ...": Another possible explanation could be better a priori CO2 profiles over ocean so that shielding by thick clouds has little effect.

P13057 L12, "...more measurements than OCO-2": CarbonSat would be such a mission. Please cite Bovensmann et al. (2010).

References

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