The authors would like to thank Anonymous Referee #1 for their comments on our manuscript entitled "The potential of clear-sky carbon dioxide satellite retrievals." Below, we have addressed their comments and made the necessary changes in the manuscript.

1. While it is just to draw the optimistic conclusion that the clear-sky retrievals perform unexpectedly well compared to the full-physics retrievals, the pessimistic conclusion could be that the full-physics retrievals perform quite badly in accounting for particle scattering effects. Figure 1 might even support the pessimistic view that the full-physics method needs improvement. That thought should make its way into the discussion and conclusion section.

We agree and have added the following to section 6:

> "An alternative way to view this result is that the full-physics cloud and aerosol parameterization benefits GOSAT measurements over both land and ocean, but the improvement is more substantial over ocean."

In that context, I would tend to criticize the following statement (abstract): "These results imply that non-scattering XCO2 retrievals are potentially much more accurate than previous literature suggests, when employing filtering methods to remove measurements in which scattering can cause significant errors." It is not the method "nonscattering" which is much more accurate. It will go wrong when there is scattering induced lightpath modification. It is rather the occurrence of clear-sky cases or the ability to filter for clear-sky which is unexpected.

We agree and have modified the abstract:

> "These results imply that non-scattering $X_{\chem{CO_2}}$ retrievals are potentially more useful than previous literature suggests, as the filtering methods we employ are able to remove measurements in which scattering can cause significant errors."

2. Is there a particular reason why the clear-sky retrievals use both CO2 bands, 1.6 and 2 micron? Conceptually, using a single band could be beneficial for clear-sky retrievals if residual scattering is present. If there is residual particle scattering, its effect would be different in the 1.6 and 2 micron bands since particle scattering properties, surface reflection properties, and absorption optical depth are different for the two bands. Thus, using the two bands comes with the additional source of error that lightpath modification depends on wavelength. Previous studies preferred using the 1.6 micron band alone since aerosol effects are less pronounced (due to smaller CO2

absorption optical thickness) and since the surface is typically brighter than at 2 micron favoring the weight of the geometric lightpath. Probably, the IDP filter is efficient in removing the critical cases but, maybe, screening for clear-sky could be relaxed when using just one band.

Many configurations could have been explored, but we chose to limit our investigation to a dual-band clear-sky retrieval. Additionally, the 2.06 μm band is more sensitive to the surface, where sources and sinks are located, relative to the 1.61 μm band (Dufour and Bréon, 2003). Dependencies on wavelength are taken into account by allowing DOGO to filter on the CO_2 ratio and H_2O ratio products from the IMAP-DOAS algorithm.

3. Why is the XCO2 RMS for the OCO-2 simulations (Fig. 4) typically a factor 2 larger over land than over the ocean? Could there be a non-vanishing influence of the prior?

In both our real and simulated results, retrievals over land are typically worse than over ocean. Generally, this can be attributed to more complex light path modifications due to interaction with the surface and cloud/aerosol layers. Over ocean, the dark surface away from the glint spot typically prevents multiple scattering from occurring between the surface and cloud/aerosol layers.

4. The dry air column used for calculating XCO2 comes from different sources for the clear-sky and the full-physics method: for clear-sky, the meteorological (= true for the simulations) surface pressure is used, while retrieved surface pressure informs the fullphysics XCO2. So, the full-physics XCO2 retrieval faces the additional complication that the surface pressure retrieval could go wrong. What is the assumed prior variance for the surface pressure retrieval? Does it make a difference (eg. in Fig. 4 and 8) whether full-physics XCO2 uses meteorological or retrieved surface pressure?

The simulated data was created using ECMWF meteorology (e.g., surface pressure). Both the full-physics and clear-sky OCO-2 retrievals performed on those simulations used NCEP surface pressure as the prior to mimic real-world inaccuracies. For real GOSAT measurements, however, the "true" surface pressure was obviously unknown. For the clear-sky retrievals, we used ECMWF surface pressure as the prior and did not allow it to change (because ECMWF has been shown to be accurate to within 1-2 hPa) while for the full-physics retrievals we again used ECMWF surface pressure as the prior but allowed the retrieval to modestly adjust its value (prior uncertainty of 1 hPa at 1σ). This is because the full-physics retrieval included the O_2 A-band, which contains information about the dry air column. Additionally, we tested allowing the clear-sky retrieval to retrieve surface pressure using the O_2 A-band and found similar results. We have improved the organization and clarified the discussion of surface pressure in sections 2 and 3:

“Instead of using the \chem{O_2} A-band at 0.76\,\unit{{\mu}m} to retrieve information about surface pressure, which is used to estimate N_{d}, the clear-sky retrieval simply uses the a~priori surface pressure value.”

“For both the full-physics and clear-sky retrievals performed on simulated measurements, the a~priori surface pressure was taken from the NCEP reanalysis data. As discussed in Sect.~\ref{sec:Full-Physicsvs.Clear-SkyXCO2Retrievals}, the full-physics retrieval then used the \chem{O_2} A-band to fine-tune the surface pressure estimate while the clear-sky retrieval assumed the a~priori to be correct.”

“Surface pressure a~priori values were taken from the ECMWF IFS model, which has been shown to be accurate to within 1--2\,\unit{hPa} under most conditions \citep{salstein_2008,crowell_2015}. As the clear-sky retrieval did not retrieve surface pressure, it was necessary to have an accurate a~priori surface pressure estimate. To ensure this methodology was valid, we tested a~version of the clear-sky retrieval that was allowed to retrieve surface pressure from the \chem{O_2} A-band and found the results to be consistent.

5. The evaluation for GOSAT is hindered by the fact that the true XCO2 is unkown. The manuscript uses two sources for true XCO2: TCCON and model data. Would the evaluation be different if the validation sources were considered separately? In other words, does figure 8 vary substantially if it was drawn for land-TCCON, land-model, ocean-TCCON, ocean-model separately?

We analyzed the GOSAT retrievals using only TCCON-validated data and only model-validated data and found that the resulting RMS errors were mostly insensitive the method of validation. We have added the following to section 4.1:

“Additionally, the results of this study were found to be largely insensitive to the method of validation used.”

6. The DOGO filtration minimizes the RMS of the XCO2 difference between retrieval and validation. Thus, the same level of throughput contains different individual soundings for the clear-sky and full-physics retrievals. Fig. 5 and 6 suggest that the sounding ensembles cannot be so different after all, at least for the OCO-2 simulations. How would performance evaluation turn out if the exact same sounding ensemble was compared (in particular for GOSAT)?

We didn’t think it was fair to compare the exact same soundings because DOGO can and does filter on different variables for full-physics vs. clear-sky. For example, filtering the full-physics data to a threshold of 30% then examining the clear-sky version of those exact soundings would be unfair because those clear-sky soundings would not have been optimally filtered by DOGO. However, as you noted, there is considerable overlap in the soundings selected. For example, 74% of OCO-2 soundings and 65% of GOSAT soundings in the 30% throughput full-physics ensemble are present in the 30% throughput clear-sky ensemble. Thus, we would not expect the results to change significantly if we were able to fairly compare identical sounding ensembles.

Technical comments:

P13042,L20 and P13043,L8: "These clear-sky retrievals are simple and highly linear". Since Beer-Lambert's law is exponential in the absorber concentration (and it cannot be linearized in a DOAS-like way due to large absorption optical thickness in the infrared), the forward model is non-linear even in the clear-sky case. Even if the retrieval used the logarithm of the measured radiance (instead of radiance itself), linearity (in absorber concentration) would require that the convolution (by the instrument function) and Beer-Lambert's exponential commute. They do not. If I get things right here, I would not call the forward model linear. But I would agree that aerosol fitting makes the forward model "more" non-linear.

We agree that the clear-sky retrieval is more linear relative to the full-physics retrieval, rather than entirely linear. For example, the number of diverging steps that our retrieval takes when trying to find the minimum of the cost function is, on average, 0.37 for full-physics but a mere 0.001 for clear-sky. This indicates that the clear-sky algorithm nearly always takes steps towards a minimum in the cost function. The number of iterations needed for the retrieval to converge is also lower for the clear-sky retrieval (i.e. ~3 compared to ~4 for GOSAT) but they are artificially large because of the way our Levenberg-Marquardt solver works.

P13045, L3 "molecular number density with respect to dry air" I guess, one can remove "with respect to dry air", number density is per volume.

We agree and have made the appropriate change in section 2:

> "where $N_{\chem{CO_2}}(z)$ is the molecular number density of \chem{CO_2} at altitude z..."

P13048,L24: "used in the preprocessor" Do you mean "in the *GOSAT* preprocessor"?

While addressing the reviewer responses, we decided to only pre-filter the GOSAT measurements using the ABP and to incorporate the IDP results (i.e. the CO_2 and H_2O ratios) into the post-filtering process. This was the methodology we had used for the OCO-2 data and decided it made more sense to let the genetic algorithm choose how to apply the IDP parameters to the GOSAT data than to manually pre-filter with them.

We have moved the discussion of the IDP variables from section 4.2 to section 5.1:

> “Specifically, the \chem{CO_2} and \chem{H_2O} ratios were frequently selected by DOGO to filter the OCO-2 retrievals. The the \chem{CO_2} and \chem{H_2O} ratios were taken from the Iterative Maximum A-Posteriori Differential Optical Absorption Spectroscopy (IMAP-DOAS) algorithm \citep{frankenberg_2005,taylor_2015} and are calculated using estimates of \chem{CO_2} and \chem{H_2O} from both the 1.6\,\unit{{\mu}m} and 2.0\,\unit{{\mu}m} \chem{CO_2} bands independently using a~fast, non-scattering algorithm. Deviations from unity in the ratio of the 1.6\,\unit{{\mu}m} to 2.0\,\unit{{\mu}m} band values, caused by the wavelength dependence of clouds and aerosols, allows for the identification of many contaminated scenes.”

Section 5: “Throughput” refers to the pre-filtered dataset (section 4.2), right? It might be obvious, but for me it would have been useful to read it stated at the beginning of section 5.

Starting with the pre-filtered dataset, throughput is the percentage of data kept after post-filtering (section 4.3). We have clarified the language in section 4.3:

> “Filtering was done for different ``throughputs'', which equal the percent of data retained after post-filtering with DOGO at a~given filtration level.”

Figure 1: Please add information on coincidence criteria and the AERONET data type and source.

We have added the following to section 1 and a link to the data in the Holben et al. (1998) citation:

> “from the highly accurate AErosol RObotic NETwork (AERONET; \citealp{holben_1998}), using a~coincidence criteria of $\pm$30 minutes and 0.1 degrees.”

> “available at: \url{http://aeronet.gsfc.nasa.gov/new_web/aerosols.html}”

References:

Dufour, E., and Bréon, F.-M.: Spaceborne estimate of atmospheric CO 2 column by use of the differential absorption method: error analysis., Appl. Optics, 42, 3595-3609, doi: 10.1364/AO.42.003595, 2003.