

## ***Interactive comment on “Using ocean-glint scattered sunlight as a diagnostic tool for satellite remote sensing of greenhouse gases” by A. Butz et al.***

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We thank the reviewer for the positive view on our work and thoughtful comments. Find our reply below.

*<<I definitely recommend the manuscript publication provided some minor comments would be considered (at least in the interactive comments).*

*1. Authors proposed special treatment for the observations of low-altitude optically thick particle layer (e.g. cumulus) which is overlaid by optically thin elevated*

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*layer (e.g. cirrus). What are the author estimates of the percentage of such situations for actual GOSAT observations? Could such observations be revealed by standard screening procedures (e.g. by CAI)?>>*

The filter criterion which we suggest in the manuscript is based on a threshold of the Lambertian albedo term retrieved as a correction to the glint reflectance. A filter threshold of 0.05 corresponds to rejecting 4.3% of the ‘upper edge’ data ie. 4.3% of the ‘upper edge’ data would have been contaminated by an unnoticed double-layer of scattering particles if the filter was not applied.

Other screening procedures based on reflectance ratios at visible and near-infrared wavelengths such as accessible through a cloud and aerosol imager should work from a conceptual point-of-view. Comparing the cloud flags derived from the CAI onboard GOSAT with our cloud screening measures (for the standard ‘RemoTeC’ products), however, showed that the CAI cloud flags seem to reject too many scenes. We decided not to use CAI products here (and not to use anymore for standard ‘RemoTeC’ processing), all the more since using CAI products requires considerable logistic efforts due to large data volume and due to the required geolocation matching with the TANSO-FTS.

*<<2. The authors operate with vast set of sun-glnt observations. Some of these observations were taken near TCCON sites (e.g., Wollongong TCCON site). Did author consider the possibility to extract ‘near-TCCON’ observations in order to retrieve XCO<sub>2</sub> under ‘non-scattering’ conditions and to compare with ground-based observations? These results might be serious argument in support of proposed technique to select observations that are free of ‘light-scattering’ errors.>>*

In fact, our standard ‘RemoTeC’ XCO<sub>2</sub> and XCH<sub>4</sub> products for GOSAT ocean-glnt soundings rely on the ‘upper edge’ ensemble ie. our standard XCO<sub>2</sub> retrievals are

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very similar to the XCO<sub>2</sub> dataset presented here. Subtle differences in the retrieval setup are discussed below in reviewer comment 3. We decided to make the 'upper edge' ensemble the standard product for ocean-glint since we consider it the most robust approach with respect scattering induced errors.

For the standard products, we perform extensive comparisons to ground-based measurements by the TCCON spectrometers. For our land-nadir retrievals, XCO<sub>2</sub> validation has been discussed recently by Guerlet et al., 2013. For the ocean-glint cases, we conduct similar comparison studies which are, however, hindered by the low number of coincidences with coastal/island TCCON sites and by the fact that islands often show considerable topographic relief. Keeping in mind that the statistical significance of the comparison is limited, we find that the ocean-glint XCO<sub>2</sub> is of similar quality as the land-nadir retrievals. When using ocean-glint together with the land-nadir retrievals for inverse modeling of CO<sub>2</sub> surface fluxes, Basu et al., 2013, suggest that our ocean-glint XCO<sub>2</sub> might be systematically higher than the land-nadir retrievals by roughly 1 ppm.

<<3. When describing the retrieval method, it is mentioned that (line 189) "Retrieval parameters are the 4-layer partial column profiles of the target absorbers O<sub>2</sub> and CO<sub>2</sub>". Next, it is stated that "The regularization parameter weighting the side-constraint against the least-squares term is chosen such that each absorber vertical profile gets one degree of freedom. Thus, the inverse method yields absorber profiles with the same shape as the a priori profiles..." Does it mean that in fact the algorithm retrieves scaling factors to a priori profiles and "target gas profiles" are kept in the state vector for the sake of algorithm flexibility? Is it the option for this study or general approach?>>

In general, the standard 'RemoTeC' algorithm retrieves absorber concentration profiles in 12 atmospheric layers with a regularization constraint that yields degrees of

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freedom up to 1.5.

For the sake of computational speed and simplicity, we decided to use a simplified variant of RemoTeC in the present study, in particular since we had to reprocess the entire GOSAT dataset several times for sensitivity studies. For the simplified variant, the number of atmospheric layers is reduced to 4 and the side constraint is weighted such that degrees of freedom for vertical absorber profiles are unity. As the reviewer correctly noted, this is equivalent to scaling the prior absorber profile. Simply increasing the weight of the side-constraint and keeping profiles in the state vector has the advantage that the method delivers all the retrieval diagnostics such as averaging kernels (Figure 7) without any further programming required.

#### References

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