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# ***Interactive comment on “Ability of the 4-D-Var analysis of the GOSAT BESD XCO<sub>2</sub> retrievals to characterize atmospheric CO<sub>2</sub> at large and synoptic scales” by S. Massart et al.***

**Anonymous Referee #2**

Received and published: 26 October 2015

In their paper, Massart et al. show the benefits of assimilating satellite-retrieved, column-averaged CO<sub>2</sub> (XCO<sub>2</sub>) data in ECMWF's CAMS carbon dioxide analysis system. They use a 4-D-Var approach on the assimilation of the GOSAT BESD XCO<sub>2</sub> retrievals provided by the University of Bremen. This assimilated CO<sub>2</sub> product that they refer to as “the analysis” is a near-real time product and, therefore, could be of major interest, for example, for validating retrievals from the Orbiting Carbon Observatory OCO-2. Through several well-designed comparisons that support each other, the authors show that the analysis has a reduced bias and scatter with respect to the retrieved XCO<sub>2</sub> from the TCCON stations that are here considered as the truth, as

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compared to either the free run or the retrieval product (MACC) GOSAT BESD XCO<sub>2</sub>. I found the results for the cold front case study particularly interesting as the value of satellite data in this kind of synoptic scales can easily be questioned and has not been studied much. Moreover, the analysis is also shown to have some forecast value for up to 10 days.

I think the paper is well merited and suited for publication in ACP, and I recommend that it will be accepted for publication after having dealt with the minor revisions suggested in this report, in addition to those in Referee #1's report. I try not to repeat their comments in this report.

#### General comments:

In Sect. 2.2 the authors write that they have included in their comparisons all TCCON sites except JPL 2011/Caltech, Dryden, and Eureka, and give good reasons for excluding these sites. However, also Bremen, Ny Ålesund and Tsukuba TCCON sites have been excluded although they were (to my knowledge) operational during year 2013. I would like to know if there is a particular reason for excluding these sites, and if not, I suggest that the authors consider adding them to the revised paper.

GOSAT BESD XCO<sub>2</sub> retrievals are only one of several independent GOSAT XCO<sub>2</sub> retrievals by different teams and retrieval algorithms, and each of these retrievals have their characteristic biases. Even though it is outside the scope of the paper to repeat the assimilation and comparisons for another GOSAT retrieval, I suggest the authors add a brief description and/or a literature review about how the GOSAT BESD XCO<sub>2</sub> retrievals compare to the other retrievals from GOSAT measurements; at least to the official NIES retrieval product. I think this would be valuable information to the reader because the authors propose that the product of this forecasting system can be considered as an alternative to the satellite XCO<sub>2</sub> retrievals.

Are GOSAT BESD XCO<sub>2</sub> retrievals not made above the ocean (in the GOSAT glint mode) or were these just excluded in the paper (if so, why)? Some other retrieval

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algorithms retrieve XCO<sub>2</sub> over oceans from the GOSAT glint mode measurements. How would inclusion of ocean retrievals affect the assimilation results?

Specific comments:

Page 26276, lines 22-23. “NIR/SWIR measurements based on backscattered solar radiation.” The GOSAT measurements are made from scattered solar radiation, not necessarily backscattered; it depends on the observational geometry.

Page 26276, line 25. Add “and a low aerosol optical depth” after “cloud-free conditions” because aerosols can affect the retrieval quality in addition to clouds.

Page 26279, lines 13-18. About thinning: was the one data point in 1deg x 1deg grid cell in target mode retrievals chosen randomly? Why not average all soundings within one grid cell?

Page 26279, lines 24-27. Does “quality filtering” refer only to SZA filtering, or did you use other criteria in the filtering as well? Please specify.

Sect. 2.1. Did you apply any bias correction to GOSAT BESD XCO<sub>2</sub> data? If so, please add a description of that in the text.

Sect. 2.1. Did you include both medium and high-gain (M-gain and H-gain) nadir mode GOSAT retrievals in your study? Please specify.

Sect. 2.2. I think a brief description of the TCCON measurements, instrumentation and accuracy together with references would be appropriate.

Page 26283, line 21. The range is even larger: according to Table 2, Ascension has 2.32 ppm. Suggest replacing results for Darwin with the results for Ascension.

Sect. 4.1. The bias in the high Northern latitudes is mostly dictated by the comparison to the Sodankylä TCCON. Adding Ny Ålesund TCCON data might change this dramatically.

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Page 26287, line 5. I think “a correction” probably refers to the averaging kernel correction, right? Please specify.

Page 26287, lines 6-8. Which TCCON sites were excluded based on this criterion? Please specify in the text.

Page 26287, lines 23-28. I find this part difficult to read and follow. Where does the value of 1 ppm refer to? I suggest clarifying these sentences a little.

Page 26288, lines 4-5. I disagree with the sentence that states that the analysis provides a more accurate and precise representation of the global atmospheric XCO<sub>2</sub> field as compared to the satellite data. Based on the results, this is true at the TCCON sites but elsewhere too? We simply do not know.

Page 26288, line 18. Should the reference to “(Fig. 7e and b)” be to some other panels (maybe a and b)?

Figure 4 in the paper and Supplement, Figs. 1-5. I would suggest adding the co-located GOSAT BESD XCO<sub>2</sub> data in the figures as well (in addition to the analysis), using the same geolocation and temporal criteria for the data selection that were mentioned in Sect. 4.4.

Technical corrections:

Page 26275, line 11. Change “GOSAT data” to “GOSAT BESD data”.

Page 26276, line 13. Add a word after “four-dimensional variational (4-D-Var)”. Suggestions: “data assimilation”, “approach”?

Page 26278, line 2. Change “obtained” to “produced” or “provided” or something similar.

Page 26279, line 1. Remove “strong” in front of the “O<sub>2</sub>-A band”.

Page 26281, line 3. Change “used to compared a simulation with the TCCON” to “used

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in comparisons of simulations and the TCCON".

Page 26283, line 6. Change "As" to "A".

Page 26285, line 21. Remove "for".

Page 26285, line 22. I find the word "evident" a little confusing here.

Page 26287, line 4. Change "criteria" to "criterion".

Page 26287, line 24. Change "curently" to "currently".

Page 26289, lines 24-25. Change "climatology, the higher the better" to "climatology: the higher the ACC, the better".

Figure 1 caption. Change "about 3400 data" to "about 3400 data points" or "soundings", "measurements", "retrievals". 1270 similarly. Also please change "GOSAT XCO2" to "GOSAT BESD XCO2".

Supplement, Table 1 caption. Change "faction" to "fraction".

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