Atmos. Meas. Tech. Discuss.,
doi:10.5194/amt-2019-232-RC2, 2019

Atmospheric Measurement Techniques Discussions

Interactive comment on "XCO_2 observations using satellite measurements with moderate spectral resolution: Investigation using GOSAT and OCO-2 measurements" *by* Lianghai Wu et al.

Anonymous Referee #3

Received and published: 22 October 2019

This manuscript analyses the impact of spectral resolution on the performance of a CO_2 satellite mission, which is relevant for future large-swath imaging instruments. To this end, satellite measurements from OCO-2 and GOSAT are spectrally degraded and the retrieval results are compared to corresponding results using the original spectral resolution. It is concluded from the spectrally degraded satellite measurements and from synthetic measurements that the lower resolution mainly induces a larger random error and has only little effect on the systematic error.

The manuscript covers an important topic, falls into the scope of AMT, and is well written. However, I think that a more detailed analysis is necessary to support the

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Discussion paper

conclusion that a degradation of the spectral resolution does not impact systematic errors significantly. Therefore, I recommend publication after major revisions have been incorporated.

General Comments

The main concern is the discussion of the systematic errors depending on the spectral resolution.

1) The validation with the TCCON shows that the station-to-station variability (standard deviation of the local biases) is similar for the retrievals based on the degraded and original spectral resolution. However, the local biases for the MSR and original instrument at a fixed site can differ considerably (see Figures 3 and 8). Hence, the good agreement of the standard deviations may become worse when adding or removing specific sites and is possibly not representative globally. This should be discussed in the manuscript. It would be helpful to harmonise and maximise the sites used in the OCO-2 and GOSAT comparison. Is it possible to add additional high latitude sites, e.g., East Trout Lake and Eureka?

2) Since the spatial representativity of the TCCON comparison is limited, the analysis of the synthetic spectra is particularly important to assess the impact of the spectral resolution on the systematic errors globally. Unfortunately, the corresponding discussion is rather short and the results are condensed to a single number "bias" in Table 3. How is this number defined? It would be very desirable to show the errors based on the global ensemble on seasonal global maps like in Butz et al. (2012) for OCO-2 and for all MSR concepts a-d to better track the impact of successive spectral degradation on the systematic error and to check if the decreased convergence rate clusters in certain regions.

See also specific comments for more details.

Specific Comments

OCO-2 synthetic spectra

More details are needed here. Please show and discuss the seasonal global maps of the errors obtained from the ensemble for the original OCO-2 spectral resolution and for MSR-d at least for test-1. If possible, it would be very helpful to also show maps for all MSR concepts a-d as proposed in the general comments. Moreover, it would be beneficial to show an additional map in each case for a 2-band retrieval without the 2.06 μm band (MSR-e) and to extent Table 3 accordingly to verify that the spectral resolution of 0.55 of MSR-d in this band is actually useful to reduce systematic errors.

TCCON validation

Please harmonise and maximise the sites used in the OCO-2 and GOSAT comparison, if possible. Additional high latitude sites would be particularly interesting. Please also harmonise the ordering of sites in Figure 2 (arbitrarily?), Figure 3 (by latitude), and Figures 7&8 (alphabetically); I would prefer to sort the sites by latitude in all Figures.

Please add and discuss bars to include all MSR concepts (a-d and ideally the proposed 2-band test MSR-e) in Figures 3 and 8 to better track the impact of successive spectral degradation.

OCO-2 hot spot and regional gradient detection

Why is MSR-c used in this section and not MSR-d as before?

Are the different averaging kernels considered in the comparisons of Figures 5 and 6? Is it possible that the 20-30% higher enhancement for the MSR-c concept in Figure 6 is due to the increased surface sensitivity of the spectrally degraded concept (see Figure 4)?

Conclusions and discussion

Please adjust the conclusions concerning systematic errors depending on the spectral resolution according to the new analyses or weaken the conclusions in terms of the

general comments above.

Is there a reference showing that the MAP instrument will actually characterise aerosol contributions in the CO_2 absorption bands well and that the XCO_2 retrieval accuracy "will benefit greatly" from its measurements? Otherwise, please weaken the conclusions by saying that the MAP instrument is aiming at reducing systematic errors.

Technical Corrections

P6, EQ7: Replace "$S_y =$" by "$S_y^{deg} =$"

P6, L153: 3.29 here, but 3.3 in Table 1

P8, L230: 1.37 ppm here, but 1.36 ppm in Figure 3

P23, Table 5: Replace "SD" by "σ_a"

References

Butz, A., Galli, A., Hasekamp, O., Landgraf, J., Tol, P., and Aben, I.: TROPOMI aboard Sentinel-5 Precursor: Prospective performance of CH_4 retrievals for aerosol and cirrus loaded atmospheres, Remote Sensing of Environment, 120, 267–276, 2012.

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