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Atmospheric Measurement Techniques Discussions

Interactive comment on "Airborne lidar reflectance measurements at 1.57 μm in support of the A-SCOPE mission for atmospheric CO_2" *by* A. Amediek et al.

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Comment 1: Abstract: Please include some quantitative results in the abstract, e.g. that the estimated A-SCOPE XCO2 error due to reflectance variability is well below 1 ppm.

We agree. It will be added to the abstract.

Comment 2: Abstract: Utilization of MODIS data should be mentioned in the abstract.

We agree. It will be added to the abstract.

Comment 3: p. 1490, l. 1-3: Are ambiguities due to the fact that the detector does not

separate between different wavelengths?

Yes. The separation between online and offline is only performed via a temporal separation. This is better described in the manuscript now.

Comment 4: section 2: To assist readers not familiar with the IPDA measurement technique it would be good to add at the begin of this section a short paragraph introducing the basic principles rather than starting directly discussing the retrieval error.

We agree. A more detailled derivation is added to the manuscript.

Comment 5: p. 1492, l. 19-21: I got confused since it was stated in the introduction that 'on-line' and 'off-line' refer to different wavelengths rather than consecutive values?

Yes, both is correct. This fact is now described more clearly in the text.

Comment 6: p. 1494, l. 4-5: Add a sentence like 'B being normalized, i.e. ...'.

We suggest to replace the existing text with: "... and an averaging function B(x,y) that describes the spatial distribution of laser light within the beam: [here equation (7)] B(x,y) is normalized as follows [here integral of B(x,y) equal to one]."

Comment 7: p. 1494, l. 14-15: Should be $\delta\rho_2$ rather than δ_2 in Eq. (10) in line 14 and 15, I guess?

Yes, these are typos, which are corrected now.

Comment 8: p. 1495, l. 21: Point out in the text that B no longer is assumed to be normalized.

We suggest to remove all occurrence of the integral of B(x,y) in the denominators of right-hand sides of equations (13), (14) and (18). We also suggest to add, after equation (13) : "where B(x,y) is assumed to be still normalized according to equation [and then cite the equation that gives the normalization of B(x,y)]"

Comment 9: p. 1496, l. 1: Please explain 'Using the property...

We suggest to replace the existing sentence ("Using the property... can be calculated") with:

"As $\rho(x, y)$ is spatially uncorrelated, its variance over the area $dS + dS'$ is equal to its variance over dS plus its variance over dS'.

Extending this property to a finite area S gives

$$\mathrm{Var}\left[\iint \rho(x,y)dxdy\right] = \iint \mathrm{Var}\left[\rho(x,y)\right] dxdy \tag{1}$$

It is now also assumed that Var$[\rho(x, y)]$ does not depend on x and y. Then

$$\mathrm{Var}\left[\iint \rho(x,y)dxdy\right] = kS \tag{2}$$

where k denotes the constant variance and S is the surface of the finite area. This reasoning can be repeated with the product $\rho(x, y)B(x - x_i, y)$, by considering that dS and dS' are infinitesimal areas where $B(x - x_i, y)$ is constant. Then

$$\mathrm{Var}(\rho_{B,i}) = \mathrm{Var}\left[\iint \rho(x,y)B(x-x_i,y)dxdy\right] = \iint \mathrm{Var}\left[\rho(x,y)B(x-x_i,y)\right] dxdy \tag{3}$$

Using equation 2, the following result is obtained

$$\mathrm{Var}(\rho_{B,i}) = k \iint B^2(x-x_i,y)dxdy \tag{4}$$

In practice the reflectivity will not be uncorrelated, and will have a finite, even if quite small, correlation length. It is assumed in the paper that the areas dS and dS' where

$B(x, y)$ is constant are significantly larger than the correlation length. Then the result of equation 4 is still applicable for real cases."

We ackowledge that the assumption of a constant variance for $\rho(x, y)$ was not explicit.

Comment 10: p. 1500, l. 3-6: Please provide a reference or quantitative statement.

It is mentioned now, that the influence is in the order of the instrumental noise that is given in table 2.

Comment 11: p. 1500, l. 9-10: What about clouds?

The occurrence of clouds is detected by the analysis algorithm, except their backscatter signal is too weak. In general we tried to avoid conditions with low altitude clouds. The downlooking onboard cameras help to identify doubtful cases.

Comment 12: p. 1500, l. 22-23: This sentence is a bit unclear. Data analysis of what?

Now: "The values given here are calculated using the same routines as used for the analysis of the airborne measurements."

Comment 13: p. 1503, l. 14: 'best possible matching' is too vague. Least square fit? Visual inspection?

Yes, here, the best matching was evaluated by eye.

Comment 14: p. 1503, l. 19-20: 'a certain deviation' is too vague. Can this be quantified, e.g. by applying the upscaling methods presented before?

It is added now, that a higher variability is expected for the TROPOLEX measurements compared to the MODIS data. I agree, the upscaling of the TROPOLEX measurements to a MODIS pixel should be possible using the autocorrelation method. Then, the reflectivity variances should be in the same range, but I do not think, that such a calculation is needed with regard to the context here.

Comment 15: p. 1503, l. 23: 'ASTER' not introduced before.

See p. 1500 l. 24.

Comment 16: p. 1503, l. 25: Please expand on the MODIS measurement geometry.

Done.

Comment 17: p. 1503, l. 26-27: 'could also lead to deviations' is too vague. Please quantify or provide a reference.

The results of a numerical simulation using the ESA Reference Model of the Atmosphere are given now.

Comment 18: p. 1507, l. 10-15: Even though the 1D unweighted upscaling approach provides a conservative estimate in the error analysis, the autocorrelation methods provide clearly better results (Fig. 9). Why don't you use these methods for the subsequent studies?

We agree, a proper explanation for the choice of the method used in the shown studies was missing. Now, it is added at the end of section 6, that the autocorrelation approach is very precise, but only allows calculations regarding the absolut differences of upscaled ground reflectivities. However, for the calculation of the IPDA retrieval error the relative differences of consecutive ground spots are required. This information is provided by the 1-D upscaling.

Comment 19: p. 1509, l. 1-8: There seems to be a large constant offset in the autocorrelations plotted in Fig. 12. Please explain.

The shown correlation length is quite short. The curves drop down for larger distances (up to the kilometer range).

Comment 20: p. 1512, l. 14: '(ESA, personal communication, 2009)' is too vague for a reference.

Ok. Changed.

Comment 21: p. 1525, Fig. 4: The red curve does not really allow to identify unreliable outliers in the measurement data. Better remove them completely from the plot?

The outliers are removed from the plot already. They are not taken into account for the statistical calculations. The red curve shall maintain the information about their occurrence, indicating the reason for the removal (low signal, overload signal, also cloud hits) to provide the possibility of searching for the reason of this irregular signal. The outliers itself are not unreliable in the sense of a wrong measurement. They only cannot be related to a ground reflectivity, because of the signal acquisition limits. Almost all of these cases can be related to hits of water surfaces or man-made objects.

Comment 22: section 2: unify use of '2-D' or '2D' in text and equations

Done.

Comment 23: p. 1494, l. 9-17: align equations properly, e.g. by use of eqnarray-environment in LaTeX

The shifts were introduced during the typesetting of the online version.

Comment 24: p. 1495, l. 6-8: align equations properly, e.g. by use of eqnarray-environment in LaTeX

See above. I will take care of this at the final typesetting.

Comment 25: p. 1519, Tab. 2: aver -> over

Corrected.

Comment 26: p. 1525, Fig. 4: font size in the plots is rather small

I agree. This depends on the typesetting on the respective page. I will pay attention to it at the final typesetting.

Interactive comment on Atmos. Meas. Tech. Discuss., 2, 1487, 2009.