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Atmospheric Measurement Techniques Discussions

Interactive comment on "The impact of surface reflectance variability on total column differential absorption LiDAR measurements of atmospheric CO_2" *by* J. P. Lawrence et al.

Anonymous Referee #1

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General Comments

The paper describes the investigation of the impact of surface reflectance variabilities on the precision of integrated path differential absorption lidars, which are candidates for future spaceborne instruments for the measurement of atmospheric carbon dioxide. The calculations base on a lidar simulation model using MODIS ground reflectance data.

The approach to use available ground reflectance data derived from satellite measurements seems to be feasible for this kind of investigation. Unfortunately in this paper many severe deficiencies occur. First, there are some errors in the fundamental lidar

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equations. Also the averaging procedure seems to be disputable. Biases are shown as the consequences from the reflectance variability due to the non-linearity of the lidar equation. This is a well known problem affecting all differential absorption lidar measurements and depends strongly on the applied averaging procedure. The latter is not explained sufficiently. The decreased measurement precision is another consequence of reflectance variations, if online and offline footprints does not overlap completely. The calculation of the given results regarding this issue is not explained. The important question, why the low-resolved MODIS data can be representative also for small scale variations that affect consecutive online and offline measurements on a 10-m spatial scale, is not discussed sufficiently.

In summary the approach is not described convincingly and so the reliability of the conclusions can not be followed. I do not recommend the publication in AMT.

Specific Comments

Introduction:

p. 150, 151: The derivation of the fundamental lidar quantities in this section is very confusing.

p. 150, eq. 1: This is not a correct expression of the number density measured by a hard target lidar. The vertical weighting function and the vertical integration are missing. In addition, the received intensities from the top of the atmosphere cannot be measured by a real instrument. Instead of that, the power reference measurement, which is needed in case of a hard target lidar, could be mentioned here.

p. 151, eq. 2: The integration limits have to be the ground and the top of the atmosphere.

p. 151, eq. 3: S_{on}/S_{off} is wrong: S_{off}/S_{on} is correct here.

p. 151, eq. 2-4: It should be mentioned, that ν corresponds to the vertical weighting function and τ to the optical depth.

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Section 2.1:

p. 152: The described modelling of the atmospheric Mie-scattering certainly is a key component of the Leicester LiDAR model, but there is no relation to the topic of the paper. Atmospheric scattering processes do not influence the problems that result from the surface reflectance variability.

Section 2.2:

p. 153, ll. 19-21: The hot spot effect is not a consequence of a nadir viewing lidar instrument, but a consequence of the lidar geometry itself: there is no angle between outgoing and incoming light. So, the lidar receiver does not 'see' any shadows on a complex surface structure, which leads to a reflectance enhancement compared to other geometries.

p. 155, eq. 17: The definition of S is confusing. It also should be mentioned, that S is a relative quantity, already normalized to the output power (a 'intensity' normally is defined as energy per time and per area).

Section 2.3:

p. 156, eq. 23: According to HITRAN the exponent of (T_{ref}/T) for the mentioned absorption lines is 0.74 and 0.82, respectively.

p. 157, ll. 8-10: The mentioned criteria are not clear.

Section 2.4:

p. 157, eq. 24: The averaging scheme is not clear. There is no reason to divide by $\sqrt{n}$.

Section 3.1:

p. 159: The bias introduced by strong signal variations is a well known problem of lidar systems and depends strongly on the applied averaging scheme, which is not explained in detail ('log-after-averaging' or 'averaging-after-log'...?).

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p. 166, table 1: Many parameters, such as pulse energy, telescope diameter and so on, are not essential for the purpose of the paper, since they do not have an impact on the calculated errors.

Interactive comment on Atmos. Meas. Tech. Discuss., 3, 147, 2010.

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