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Atmospheric Chemistry and Physics Discussions



# *Interactive comment on* "First direct observation of the atmospheric $CO_2$ year-to-year increase from space" *by* M. Buchwitz et al.

**Anonymous Referee #2**

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This manuscript describes CO2 observations from SCIAMACHY in the northern hemisphere for a 3 year period with a focus on the seasonal cycle and the atmospheric increase in CO2. Special emphasize is given to the comparison of space based CO2 with CarbonTacker for 2 broad latitude bands and the assessment of the error of the zonally-averaged CO2. The authors conclude that the annual increase of 1-3 ppm/year can be observed from space with an error of 1 ppm. The manuscript is well written and clearly structured and I recommend publishing it in ACP after my comments are appropriately addressed.

Major comments 1) To infer the annual increase and the seasonal cycle from space is certainly of interest to the science community and the conclusion of this study is that the annual increase is between 1-3 ppm/year and that it can be measured with a precision of 1 ppm/year. However, the ground-based in-situ network allows inferring the annual increase of CO2 much more accurately. In my opinion, the authors should discuss the pros and cons of the reported space-based observations and the implication of these measurements for our understanding of the carbon cycle. Furthermore, it is unclear how the 1ppm/year precision has been inferred. Is it based on the error analysis or on the comparison with CarbonTracker as shown in Figure 2?

2) The authors present 2 approaches to assess the error of the monthly mean anomaly in XCO2. The first one is based on theoretical error analysis and they conclude that this error should be less than 0.8%. However, important parameters such as aerosols and spectroscopy are not included in their assessment. Both can result in significant seasonal and temporal varying retrieval biases. Furthermore, due to the large footprint size of SCIAMACHY, a significant number of soundings will pass the cloud filtering that still include some cloud perturbations, so that an average over many soundings might be biased. The impact of aerosols, clouds and spectroscopy should be included in this error discussion otherwise the error will be largely underestimated. The second approach is based on a fit of a linear function in airmass factor to the difference between SCIAMACHY observations and CarbonTracker. I have several concerns here. First, the fact that the results of this fit for the northern and southern hemisphere are significantly different suggests that this empirical model to describe the difference is not valid and that other factors have to be considered as well. Also from the theoretical error analysis, they should be able to identify which retrieval assumptions or effects have the potential to introduce these biases. I believe that it is necessary to include such a discussion in the paper and also to show the described differences and their fits in a figure. Second, the authors infer the error of their CO2 retrieval from a comparison to the model-based system Carbon-Tracker. This implies the assumption that the Carbon-Tracker calculations are a good representation of truth. This might be true for certain regions, in particular close to a site that has been assimilated into CarbonTracker, but many other regions could be significantly wrong. A discussion about the accuracy of the CarbonTracker should be included in the manuscript. Third, the authors argue



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that the error inferred by comparison to CarbonTracker is similar to the ~2 ppm error obtained by the error analysis. However, the error inferred from the comparison with CarbonTracker is between 1.5 ppm and 4.5 ppm (using the AMF given in the paper) for the Northern hemisphere and 4.6 ppm and 11.8 ppm for the Southern hemisphere, which is significantly larger than the 2 ppm estimated from the error analysis. From my point of view, both error estimates are rather inconsistent (which might be simply due to the fact that aerosols, clouds and spectroscopy have not been considered in the error analysis).

Minor comments

p. 6720 By using the precise but sparse in-situ CO2 measurements 25 of the surface network -> the in-situ measurements are not only precise, but also very accurate. -> it might be good to name such a network, e.g. NOAA CMDL CCGG cooperative air sampling network

p. 6721 Inverse modelling studies... -> Synthetic Inverse modelling studies...

p. 6721 ...satellite measurements of the column-averaged CO2 dry air mole fraction, XCO2, have the potential to significantly improve the determination of source sink distributions of CO2... -> this is only true for NIR observations. Thermal-IR observations are typically of minor value for source/sink inversion

p. 6721 Currently no study exists where the acceptable bias between regions, or the relative accuracy, of the satellite XCO2 measurements, has been specified without major assumptions. -> The recently published study of Chevallier at al. (JGR, 2007) gives some estimates of biases

p. 6722 ...most notably OCO (Crisp et al., 2004) and GOSAT (Hamazaki et al., 2004), which will perform similar measurements as SCIAMACHY... ->Only the spectral range is similar. Most other features are fairly different.

p. 6724 ...ideally multiplicative, low frequency radiance modulations... -> this is only true for very weak absorption lines. Most lines in the O2 A-band region and to a minor degree in the CO2 bands are strong.

p. 6724 The results shown here are therefore free of any influence of a priori information about the spatio-temporal behaviour of CO2... -> It is true that a scaling fit typically does not depend on prioir information. However, the use of a constant CO2 profile (for the scaling fit) will result in a spatio-temporal varation in smoothing errors and subsequently in a spatio-temporal bias.

p. 6725 For cloud detection, the measured oxygen columns and the sub-scene information provided by the SCIAMACHY Polarization Measurement Devices (PMDs) are used. This approach (Buchwitz et al., 2005a) does not discriminate between clouds and snow or ice covered surfaces -> The oxygen column should allow distinguishing snow from clouds

p. 6726 A quantitative analysis of the satellite retrievals with reference data such as the global assimilation system Carbon-Tracker (see below) suggests that the satellite data have a quite systematic low bias of approximately 1% -> I don't understand how and why you separate this bias from the bias discussed later in the same section (which is $>$ 1.5 ppm)

Figure 1 and 2: The SCIAMACHY retrievals show different data gaps for considered years and seasons (e.g. over Sahara region or Sibiria). Consequently, the zonal, seasonal averages will be bases on somewhat different areas and I wonder if this could bias the results shown in Figure 1 and 2.

Technical comments:

p. 6720 to retrieved information -> to retrieve information

p. 6724 different algorithms to retrieved CO2 columns -> different algorithms to retrieve CO2 columns

p. 6734/Fig1 Clearyl visible is the seasonal cylcle -> Clearly visible is the seasonal



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cycle

p. 6735/Fig2 Increase size of figure

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Interactive comment on Atmos. Chem. Phys. Discuss., 7, 6719, 2007.