Reply to RC2

The reviewer's comments are reported in italic; our answers follow each comment. A copy of the revised paper was not requested by the editor at this stage of the reviewing process. Therefore we report within square brackets the page and line numbers [P*x*L*y*] where the AMTD text will be modified. The modified text is then reported in red.

Specific points

***Introduction**:*
What is the need and use for such measurements?

The role and the importance of atmospheric CO_2 are well established concepts. We concisely recall them in the first lines of the "introduction" section and we cite a literature (in the lines that follow) where the argument is discussed. We consider unnecessary to include further details in our text.

What are the requirements for determining the accuracy of the stratospheric distribution of CO2? Is an accuracy of 1 ppmv a useful constraint?

Please note that, in the revised paper, 1 ppmv will be indicated as the target precision of the retrieved CO_2 VMRs. The reference adopted to set this constraint is the rate of CO_2 VMR increase in the troposphere that is ~ 2.5 ppmv per year. On the other hand, considering the present lack of measurements of stratospheric CO_2 distributions, 1 ppmv would represent a major step.

P. 4
line 10: Please give the low temperatures that are required.

In the revised paper the period starting at [P4L7] will be reassembled as:
The NESR requirement assumed for this study can be obtained with a detector-noise limited spectrometer with an optical layout, similar to the one used in SAFIRE, with an optical throughput of 0.015 cm^2 sr, and using 4.2 K cooled detectors.

l. 18: Indicate that these are the O3 v2 band transitions
l. 20: are these transitions rotational, continuum, or both?

In the revised paper we will specify: "the main interference to the CO_2 spectral features is due to the O_3 ν_2 band rovibrational transitions"

l. 25ff- Does this procedure for determining MW's lead to a unique result? Do the results depend on the order of the seeds chosen?

The algorithm for the definition of seeds is based on the derivative of spectral points with respect to target parameters (Jacobian matrix) within the considered spectral interval. The derivative is a measure of the information content that provides an objective criterion which is not driven by the user. Therefore the order of the seeds (and the result) is unique for this procedure.

P. 5 ll. s11ff: How much information was lost by reducing the number of MWs? How would the later results have been different if these MW's were included?

We did not carry out the test with all the MWs generated by the selection algorithm. However, we verified that the inclusion of two additional MWs led to minor changes in the results. This behavior is expected if the previous selection has been operated by choosing the highest IL values that cover at best the altitude range. In this case the inclusion of further MWs corresponds to introduce further terms in a quadratic summation (see the matrix algebra in appendix A) where the largest terms, that dominate, are already present.

P.6
l. 5: Could the horizontal gradients be treated just as well by using a shorter orbital segment, and moving the segment around the orbit? Would this save computer resources?

The strategy to break the 2-D retrieval of the full orbit into a set of retrievals over segments moving around the orbit requires less computer memory but probably not less CPU time. Actually, the orbit segments cannot be adjacent but overlapping because the results close to the edges of an orbit segment must be discarded. This implies that a number of limb-scans must be processed twice. On the other hand, the problems linked to the computer resources can be overcome with an ad-hoc matrix compression algorithm and the corresponding matrix algebra (see Carlotti et al., 2001a, Carlotti et al., 2006).

l. 6: Clarify that target here refers to the different gases.

We did not catch the point. Any geophysical parameter can be a target. In our case we have two gases (CO_2 and H_2O), pressure, temperature and atmospheric continuum at the frequency of the analyzed MWs. The state vector is specified in the first two lines of Sect 4.2.

l. 24: Please say something more about the 2-D averaging kernel- how wide is it? A plot or reference would be nice.

The 2-D averaging kernel is a square matrix whose dimension is the number of retrieval parameters that, as specified at [P8L29], is 24840. A map of such a huge matrix does not provide useful information especially if it refers to a MTR where several targets are merged together. More meaningful are the maps of the spatial resolution for specific targets as those reported in Fig. 7. The reference for this subject is Carlotti et al., (2007).

l. 25: Have you tried doing 1-D retrievals to get the first guess field, then go to 2-D as a correction, or refinement?

Not in this study. However our experience indicates that the additional 1-D step could lead to save one (or two) 2-D retrieval iteration but does not improve the results.

P.7: ll. 5,7 These could be stated more clearly by "For each perturbation profile a random value of A is assigned", and " For each perturbation profile a random value of φ between 0 and 2π is assigned"

In the revised paper we will reassemble the statement at [P7L9] as indicated by the reviewer.

P. 8

l. 19: Apparently 401 limb scans are included in a "full orbit". If overlap to the next orbit is done, it should be stated and if necessary described.

Please note that, in Table 1, the horizontal sampling of ~110 km was a typo. We have now corrected to 100 km this value.
In our orbit the average OC of the first limb scan is about 0.24 deg. The separation between limb scans is about 0.9 deg. The limb scan 401 has OC of about 359.26 deg. So there is no overlap.

l. 31: Spell out VCM first mentioned here (and refer to appendix)

Done.

l. 31: B values seem very large, especially 80% for CO2. Are there any model results on the variations of CO2 in the stratosphere?

The *B* values have not been chosen on the basis of climatological or model variability but with the purpose to test the robustness of the retrieval system even in "extreme" conditions. This concept is already expressed at [P9L7]. As specified at [P5L21], we use the model described in Remedios et al., (2007).

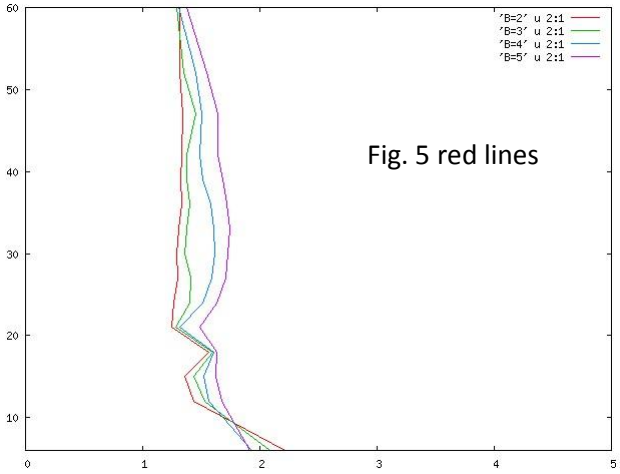
P. 9

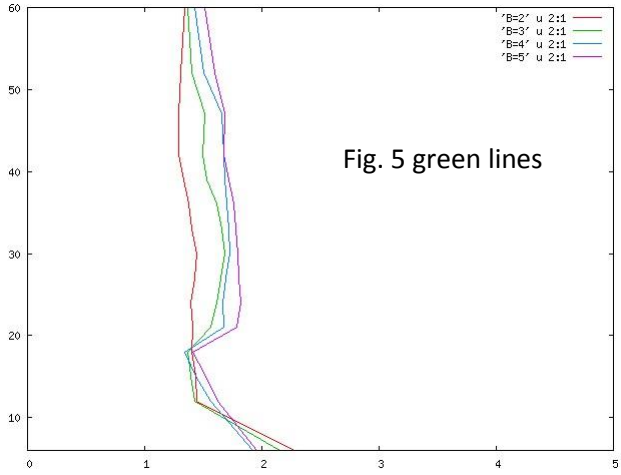
l. 14: Discussion of Fig. 4- what is the reason for the vertical pattern of larger differences? Does this undercut the ability to get a geographic pattern of differences?

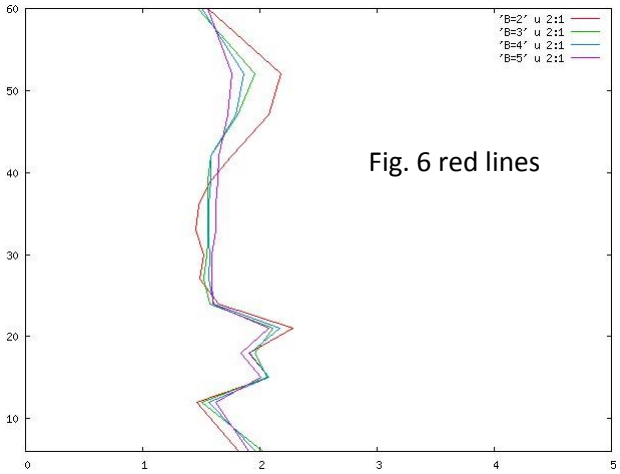
In Fig. 4 the largest differences occur in the troposphere (that can be identified by looking at the temperature distribution in the lower-right map of Fig. 2) and are explained by the known opacity of this region at the considered wavelengths. The vertical pattern of the differences represents the statistical fluctuation deriving from the 20 random perturbations applied to the initial guess profiles at each OC. We hope to have correctly interpreted the reviewer's point.

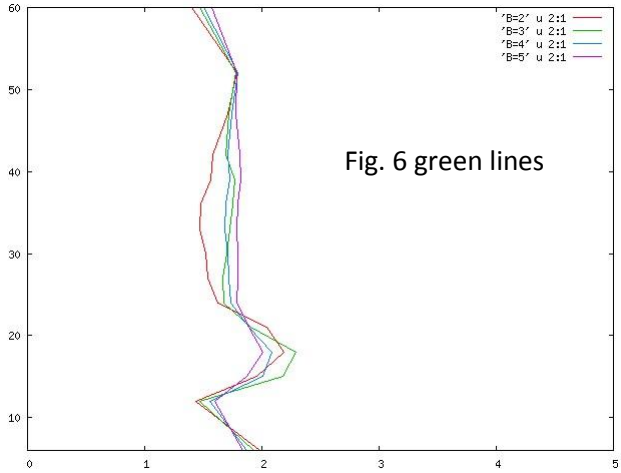
l. 20: Figs. 5 & 6 need standard deviations as well as mean values.

We have calculated the standard deviation and the uncertainty for each of the curves reported in Figs. 5 and 6 (the figures below show the % uncertainties as a function of altitude). However, including further curves sensibly worsen the clarity of Figs. 5 and 6 so that we prefer not to show them. In the revised paper, after the period at [P10L2], we will add:
The uncertainty of the average differences plotted in Figs. 5 and 6 ranges between 1.2% and 2.3%.









My understanding of Figs. 5 & 6 is that for B=2 the perturbation is ~0.65%, or about 2.6 ppmv, so that the retrieval has reduced the uncertainty to ~ 1ppmv- is that right?

Yes. However it is not fully correct to refer to 2.6 ppmv as an "uncertainty"; it is the average error made when assuming the initial guess as "true" value.

l. 32: The green lines are very interesting, in that they could be implemented by a much simpler instrument than OXYCO2.

Yes. It depends on the importance attributed to the factor of about two around 30 km.

How much could the bulge around 30 km be reduced by averaging more orbits?

We focused the paper on the performance of individual retrieved profiles. We omitted to discuss the issue of averaging strategies that, of course, can be used to increase the precision. Averaging can be done over more orbits (taking care of averaging profiles with common geo-location); in this case there is a loss in time resolution. Averaging can also be implemented within the single orbit over geographical regions; in this case the loss is in space resolution.

Why is the bulge smaller in Fig. 6 for B=2?

By considering the complexity of the retrieval scenario we don't have a unique explanation for this statistical behavior.

Again, if a shorter segment of the orbit were used, could more MW's and more spectral points be used, and would this allow better retrievals of CO2?
Would this improve results with only TIR channels?

The answer provided above (relative to the question for P5) is valid also for orbit segments.

P. 10 l. 25ff: If the ozone interference even with OXYCO2 high resolution leads to a systematic error of ~ 1 ppmv, what is the plan for dealing with this?

With the exception of ACE measurements, the present knowledge of stratospheric CO_2 distribution comes from model calculations. On the light of this we consider the precision of 1 ppmv a result that, if achieved by an operational experiment, would represent a major improvement. The impact of ozone interference could be reduced by including its VMR in the state vector (not tested) and with a better knowledge of ozone climatology (that can be exploited to reduce its a-priori error in the optimal-estimation process).

P. 12 ll. 8-11: This is unclear; it seems to say that at the end of an orbit part of the next orbit is added to allow the same views of all scans. If this is right, please say more clearly.

(We identified the part of the paper this comment refers to even if the reviewer seems to have indicated the wrong lines of the AMTD text). In the geo-fit analysis a full orbit of measurements is built by starting from the limb-scan whose tangent heights (TH) directly follows the North (or South) Pole having OC=0. Limb-scans are then added until the OC of its THs does not overpass OC=360. At this point the loop of overlap between nearby sequences closes with the atmospheric parcel sounded by the first limb-scans observed again by the last limb-scans even if after the orbit period (101 min) and from a different point of view (angular difference of about 20 deg).

All but one of the **suggestions for changes in wording** will be implemented in the revised text. The exception is the use of "connection" instead of "correlation" at [P2L23]. The reason is that "correlation" has a specific meaning in the mathematics of the inversion algorithm.