**Atmospheric
Measurement
Techniques
Discussions**

Interactive comment on "Observation of strato-mesospheric CO above Kiruna with ground-based microwave radiometry – retrieval and satellite comparison" *by* C. G. Hoffmann et al.

Anonymous Referee #2

Received and published: 7 August 2011

General comments

This study presents profile measurements of strato-mesospheric CO above Kiruna derived from ground-based microwave radiometry. The retrieval method is presented, the vertical profile sensitivity is discussed, the error contribution to the retrieval is analyzed, and the retrieved profiles are compared with satellite measurements.

The paper addresses relevant scientific questions within the scope of AMT. Such profile measurements of strato-mesospheric CO are very rare and furthermore required to gain a better knowledge of the atmospheric transport in the middle atmosphere. The

location of the station in the high latitudes and the measurement technic are well suited to study strato-mesospheric CO. The presented time series is from scientific interest. I highly recommend publishing this paper in AMT after the following requirements are fulfilled to improve the quality of the paper.

- the structure of the paper must be improved

- details of the retrieval method are missing and the discussion must be extended

- some discrepancies in the error analysis must be corrected

Specific comments

1) A discussion about which retrieval approach was used and which vertical sensitivity was achieved by former ground-based microwave radiometry studies is missing in the retrieval section. For example Bevilacqua et al. (1985) reports a quite similar sensitivity range from 50 to 85km with a vertical resolution of 12 to 15. Please extend your retrieval section by an extensive discussion about:

a.) retrieval and regularization method suggested by former studies.

b.) vertical sensitivity achieved.

2) It is not clear how the used regularization matrix looks like and how it is used in the retrieval:

a) How and from which data is the regularization matrix calculated?

b) In the case that the regularization matrix is based on the standard deviations given in figure 3 you should describe in detail how this VMR values are transformed to be applied to profiles in fraction VMR?

3) Figure 5 clearly shows that your retrieval is optimized to measure profiles in fractional VMR but not profiles in VMR. This can be seen by the strong oscillations of the VMR AVK's that you already mentioned in the text. This could be due to the chosen

regularization. Please include an analysis how the vertical sensitivity depends on the chosen regularization approach. The results should then be included in figure 4. I would suggest trying a first order Tikhonov regularization (first derivation of the vertical profile) a) on VMR profiles and b) on the fractional VMR profiles. The scaling factor of the Tikhonov matrix can be chosen in a way that the mean dofs of all your retrievals is between two and three. Please also add your optimal estimation approach applied on profiles in VMR and additional also on profiles in fractional VMR. Please scale these regularization matrixes that the resulting retrievals shows the same mean dof as all the other cases.

4) The complete section 3.4 about the performance and the profile sensitivity of the retrieval is based on the averaging kernel matrix in fraction VMR (A_frac) but this is incorrect. Section 3.4 must be based on the averaging kernel matrix in VMR (A_VMR) because only this matrix is describing how good a VMR profiles is measured. Please change that.

5) It is right that for the later comparison with satellite data the smoothing error could be from minor relevance. But at least this error is highly important to characterize your retrieval. Therefore please calculate an estimation of the smoothing error and include this into figure 7:

a.) The required profile covariance can be derived from the WACCM VMR profiles which were used to calculate your CO a priori profile.

b.) The full WACCM profiles from 0 to 130 km and also all columns of your averaging Kernel Matrix (A_VMR) should be used.

c.) By calculation the smoothing error please also take into account the off diagonal elements of the covariance matrix.

6) For many years measurements of strato-mesospheric CO above Kiruna by FTIR are done (see, Velazco et al. 2007, figure 3). You should find a lot of time and spatial

coincident measurements with these observations. Therefore It would be very useful to include these FTIR measurements in your study.

Major technical corrections

a) It is confusing for a reader that the paper consists of multiple summary and results sections. Please remove the following subsections:

3.4.5 Summary of retrieval performance

3.5.3 Results

5.5 Discussion of satellite comparison

Of course the essential findings of these parts must be included in the remaining sections but without producing repetitions. However the text of these three sections should be reduced at least to one third of its current size.

b) The paper consists of two many subsections. Together with the itemization it reaches a depth of four. Sections 4 only consist of 25 lines and therefore don't need further subsections. Please remove the following subsections:

4.1 Descent of air masses

4.2 Sudden stratospheric warmings

4.3 Breakup of the vortex

I would like to suggest changing the whole paper to the following flat structure with a maximum depth of two:

1.) Abstract

2.) Introduction

3.) Measurement

a. Location

b. Instrument

4.) Retrieval

a. Method

b. Sensitivity

c. Error analysis

5.) Satellite comparison

a. Influence of the collocation criteria

b. Influence of the measurement period

6.) Summary and Conclusions

c) I suggest combining figure 13, 14, 15, 16 into one single figure, the very short discussion is not justifying so many figures.

Minor technical corrections

page 4248, table 1: please rename the caption in "Characteristics of the measurements" and include the row "mean number of measurements per day"

page 4248, table 2: please extend the table by the column "References"

page 4252, table 5: please include the column "number of coincident measurements" that where used in the calculation

page 4213, line 21: "using the a new optimal . . ." -> "using a new optimal . . ." .

page 4216, line 3: please use for this equation the notation of Rodgers (2000).

page 4211, line 5: please delete "(as shown later in Fig. 3)".

page 4211, line 11: "The meridional circulation is directed from the equator to the winter pole" -> "... directed from the summer pole to the winter pole" (see, Solomon et

al., 1985).

Page 4262, figure 11: please extend the legend by the radii used (1000 km?).

Interactive comment on Atmos. Meas. Tech. Discuss., 4, 4209, 2011.