

***Interactive comment on “Six years of mesospheric CO estimated from ground-based frequency-switched microwave radiometry at 57° N compared with satellite instruments” by P. Forkman et al.***

**Anonymous Referee #2**

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This paper discusses continuous observations of mesospheric CO (~58 – 88 km) from a ground-based station at 57°N from 2002 – 2008. A detailed error analysis is given for the observations, and they are also compared to a number of satellite observations of CO at the same time-period. CO is an interesting trace gas for investigations of the dynamics of the mesosphere, especially during polar winter, when CO is very long-lived and dynamical features like downwelling or major warmings are clearly observed in mesospheric CO measurements. Ground-based observations are especially inter-

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esting for this because they can provide observations at one geolocation with a very good temporal resolution. Insofar the paper is scientifically interesting and well within the scope of AMT; it is also clearly and well written.

I have a number of specific comments and technical corrections listed below.

There are two aspects it may be good to discuss:

One is the observed systematic overestimation of CO above ~70 km by OSO compared to satellite observations. A similar feature is discussed in a paper by Hoffmann et al. (2011) comparing ground-based MW observations of CO from Kiruna. Does that mean that the reason for the overestimation is a specific feature of (ground-based) microwave observations? What could be the reason for this?

Satellite observations are interpolated onto a fixed a 2 km vertical grid for the inter-comparison. Is it possible to interpolate them to a finer vertical grid (e.g., 0.5 km), and could this improve the accuracy of the intercomparison?

Specific comments

Page 3910, line 6: the data-set is uniquely long for ground-based observations. Some satellite time series cover a longer time, e.g., the Mipas data cover the period 2002 – early 2012.

Page 3910, line 23: The reaction  $\text{CO} + \text{OH}$  is also a major sink of CO in the mesosphere.

Page 3911, line 3: as far as I know, the global circulation brings down constituents from the upper mesosphere, but not directly from the lower thermosphere as the mesopause provides a transport barrier. Transport of species from the lower thermosphere into the upper mesosphere probably works by small-scale mixing (turbulent and diffusive) across the mesopause.

Page 3911, line 10 ff: There are several publications showing that mesospheric CO is

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observable by ground-based FTIR measurements as well (e.g., Kasai et al., *Adv Space Res*, 2005; Velazco et al., *ACP*, 2007; Hones et al., *JGR*, 2007)

Page 3921, line 19: as you don't scan horizontally, 'horizontal resolution' is not the correct term here. What you mean is probably that your beam has a horizontal width of 4 km in the mesosphere?

Page 3926, line 22 ff: I think it is possible that you lose information when you interpolate the satellite data to the fixed 2 km grid of OSO. E.g., if the satellite data show a pronounced maximum in between the OSO grid points, it will be reduced considerably already by the interpolation (before it gets even more degraded by the convolution to the lower vertical resolution of OSO), so the satellite data will be underestimated. (And the reverse for a pronounced minimum of course). I wonder whether this problem could be evaded; for example by interpolating the satellite data, not to the OSO grid, but to a much finer resolved vertical grid, for example 0.5 km or 0.1 km. This can be convolved with the OSO averaging kernels, which then also have to be interpolated to the finer grid (and probably re-normalized).

Page 3927, line 11; Page 3921, line 22 and 24: please make clear whether you used pressure or altitude as a vertical grid. This is not quite clear; from the description of the retrieval procedure (page 3919, line 10) I assumed that you use a fixed vertical altitude grid for the retrieval with a 2 km spacing. However, when reading the last paragraph on page 3921, I got the impression that you do the retrieval on pressure coordinates which are then related to altitudes. If this is not the case, you could make this more clear by writing (page 3921, line 21-22): 'The results . . . will be given as the mixing ratios at 55 km (~36 Pa), 63 km (~12 Pa), and columns above 71 km (~4 Pa)'. As pressure at a given altitude can vary quite a lot over the year, showing results on 55 km or on 36 Pa is not the same.

Page 3931, line 23: the satellite intercomparison shown here, and the results presented, are indeed quite similar to the results shown by Hoffmann et al., 2011. This

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seems to suggest that the overestimation of CO in the upper mesosphere and lower thermosphere shown both by OSO and by KIMRA compared to satellite instruments indeed are specific to the microwave observation, as suggested by Hoffmann et al. (2011). As your results seem to confirm this suggestion, it would be good to discuss this in more detail here.

Figure 3: I wonder about the choice of your a priori profile for winter; observations seem to be quite consistently higher than the a priori above ~70 km. Would it then not be better to use a higher a priori profile for winter (DJF)? Especially concerning the very high values you retrieve in the lower thermosphere; how would the retrieved mesospheric profiles change if your thermospheric a priori values were significantly higher, as the retrieved values suggest?

Technical corrections:

Page 3910, lines 8 – 10: a comparison . . . is carried out.

Page 3919, line 8: comma missing after the first GHz

Page 3922: line 18: start a new sentence after 'spectra'.

Figure 2: the range of the y-axis is too small in the right-hand figures

Figure 3: above 100 km, many of the retrieved profiles are out of the plot range. Considering that you don't have vertical information at these altitudes anyway, you could also cut the figures at 90 km; but if you want to keep the lower thermosphere because technically, profiles are retrieved up to 110 km, then the x-scale should cover the full range of profiles retrieved.

Figures: generally, lines and symbols are very thin and hard to read in your figures. All figures could be improved by using thicker lines and symbols. This is especially true for figure 9 and 10, which are also rather small.

Figure caption Figure 3, last sentence: this sentence contains too many commas.

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