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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Observations of the mesospheric semi-annual oscillation (MSAO) in water vapour by Odin/SMR" *by* S. Lossow et al.

S. Lossow et al.

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Anonymous Referee #2 Received and published: 30 June 2008

This is a very interesting paper showing ODIN/SMR mesospheric and even lower thermospheric water vapor variations in the tropics and mid-latitudes. This is a region where diurnal variations can confuse the seasonal signatures, and the authors seem to have done a good job in taking these into account. The paper presents and interesting comparison with a previous study of this region with HALOE, which necessarily provided much sparser sampling.

My only serious worry with this paper is that the annual cycle shown at northern mid-latitudes in the upper mesosphere goes ’off the scale’ at over 1 ppmv. Even if the color doesn’t change here, the authors should show the contour

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lines here. As is, the authors merely state in the text ’At 35 N the amplitude exceeds 1 ppmv in that altitude range.’ What is that number? Is it unrealistic? Is it an indication of a problem with the data? In this, as for various other amplitudes, the authors argue that the variations in HALOE are smaller because of an undersampling problem in the HALOE data. This argument is fine to start with, but the authors should also directly compare their coincidences with HALOE in the subtropics and see if the seasonal variation is the same. If not, then it's not a sampling problem.

Reply: The typical amplitude of the annual component at 35°N is about 1.1 ppmv to 1.2 ppmv. In accordance we implemented contour lines up to 1.2 ppmv in the revised version of the manuscript. To use 1 ppmv as uppermost contour level was simply an arbitrary choice.

The remaining comments mostly just reflect minor requests for additional information.

’The mesospheric SAO in water vapour has so far only been addressed by Jackson et al. (1998), based on HALOE measurements between the end of 1991 and the beginning of 1996.’ The Mesospheric SAO in water vapor was reported with ground-based radiometers well before Jackson et al. (1998). References include: Bevilacqua et al., JGR 95, 883-893, 1990. Nedoluha et al., JGR, 101, 21183-21193, 1996. The latter reference even shows the hemispheric asymmetry using 2 ground-based stations.

Reply: Our focus has been on a complete analysis of the MSAO in the tropics and subtropics. In that way we have considered the Jackson et al. [1998] as the first analysis of its kind. The measurements reported by Bevilacqua are in the mid-latitudes, while only the measurements at Table Mountain reported by Nedoluha et al. [1996] can be counted to be performed in the subtropical region. Anyhow we have implemented now references to earlier ground-based measurements.

’The water vapour emission line covered by the measurements is centred at 556.936 GHz.’ This sentence shouldn't be a paragraph by itself.

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Reply: Changed according to the recommendation.

’Above 90 km the retrieval precision can easily exceed 50%.’ I don’t think you can say ’retrieval precision exceeds ...’. Perhaps ’random error’ or ’random uncertainty’ would be a better word than ’precision’ here.

Reply: The retrieval precision describes a statistical error of the retrieved profiles, so we used “statistical error” instead. The error combines several aspects, such as the measurement noise, errors in the forward model and its parameters and a retrieval smoothing error.

Figure 1 - A 1000 km difference in these comparisons could lead to a large bias if there is a difference in the average latitude offset between the satellites. It would be comforting to hear in the text that results with 500 km differences were similar.

Reply: We have checked the average latitudes of the respective coincidence data sets which exhibit not an offset at all. In addition we have performed a new comparison using only a 500 km distance as coincidence criteria. This comparison resulted in 31 events of coincident measurements with ACE/FTS (instead of 118 events using allowing a 1000 km distance) and 240 events with UARS/HALOE (instead of 771 events using allowing a 1000 km distance). There are small changes in the observed water vapour differences between Odin/SMR and ACE/FTS respective UARS/HALOE when applying a stricter spatial coincidence criterion. However the overall characteristics of the comparisons do not change. We added the information regarding the comparisons using only a 500 km coincidence criteria in the revised version of the manuscript.

The authors have clearly worked hard to get a good tidal correction, and I think their estimates of the correction would be of interest to anyone else trying to perform a similar study with other instruments. The authors either need to quantify what they mean by the phrase ’tidal contributions are rather small’, (i.e. give some upper limit), or perhaps present their correction factors in a table.

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Reply: The tidal correction is a four-dimensional field (day of year x local time x latitude x altitude), which makes it difficult to implement it a simple way. We simply followed the example given by Shepherd et al. [2004, JGR, D24117], which also only provided the maximum amplitudes. Nonetheless, we feel that there is a need for a detailed description of the tidal signatures in water vapour as derived from model simulations. As discussed the measurement database of tidal signatures in water vapour is extremely limited and other satellite missions measuring water vapour in the upper mesosphere/lower thermosphere will encounter the same problem as we do, needing to remove tidal signatures. Hence, we are planning an extra publication on this topic, using more models and a global coverage. It is obvious that such a reference is needed for future investigations and as comparison when, hopefully soon, measurements of the diurnal variation in water vapour in the altitude range of interest become available (like from SABER, ground-based radiometers with low measurement noise or maybe from the SHIMMER instrument via OH measurements).

While the authors have worked out the tidal issues, they seem to have ignored diurnal variations due to photodissociation. This is probably important at 85-90 km, especially in the tropics. If it’s not important, please at least give an approximate estimate as to its effect.

Reply: This should be a problem in the polar regions but not here. The water vapour lifetime in this altitude region is still in the order of days and rather constant between solar zenith angles of 0° and 80°.

Is an annual variation term included in the calculation of Fig. 5?

Reply: The amplitude results are based on a wavelet analysis instead of a least square solution.

’In addition to semi-annual and annual variations described here we also found a small QBO and a 90 day time variation.’ Where the QBO and 90-day terms generally included in the fitting routine, or was this just an additional check?

ACPD

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Reply: This is also the outcome of the wavelet analysis.

’Furthermore, the minimum between the two maxima is not statistically significant in the UARS/HALOE evaluation.’ Is this statement made in Jackson et al. (in which case it should be specifically referenced) or did the authors do this calculation themselves.

Reply: This can be seen in figure 5 of the Jackson et al. [1998] paper. We added a reference to it.

Interactive comment on Atmos. Chem. Phys. Discuss., 8, 10153, 2008.