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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 #1 Received and published: 22 July 2008

The paper is coherently written and well organized. The results presented are important in understanding the variation of the chemical key constituent water vapour. The most important finding may be the phase change of the semi-annual variation of the water vapour mixing ratio between 75 and 80 km (Fig. 4). It helps in understanding some disagreements in calculations and observations. For this reason I recommend the paper for publication in ACP. Some historical remarks and minor comments could additionally be included in the paper.

Already in 1991 Smith and Brasseur (JGR, 96, 7553-7563) found a semi-annual variation of mesospheric water vapour in 2D-calculations for small Prandtl numbers. An

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indication of a semi-annual oscillation obtained by ground-based microwave observations was first given by Nedoluha et al. in 1996 (JGR, 101, 21,183-21,193). Chandra et al. (Geophys. Res. Lett., 24, 639-642, 1997) showed clear semi-annual variations at 80 km at 5 N and smaller peaks in middle latitudes using HALOE data. The maxima occurred around the solstices (see their Fig. 3) with the exception of one intermediate maximum in the northern spring in 1993. They compared the observations with 2D-calculations and found good agreement concerning the occurrence of the maxima.

Reply: It was not meant to disregard these ground-based measurements, however our focus was on a complete analysis of the MSAO in the tropics and subtropics. In this context we consider the analysis by Jackson et al. [1998] as the first, and to our knowledge the only, of its kind. The analysis of Nedoluha et al. [1996] included only data from one station at the edge of the subtropical area. Chandra et al. [1997] certainly show examples of the annual cycle in the equatorial region and mid-latitudes, but SAO as a term is not mentioned at all and their main focus is clearly on the solar cycle variation of mesospheric water vapour. Nevertheless, we have now implemented references to the ground-based measurements and Chandra et al. [1997] in the revised version of the manuscript.

In 2001 Körner and Sonnemann (JGR, 106, 9639-9651) showed a semi-annual oscillation at 89 km altitude in low latitudes calculated by means of a 3D-model. However, in contrast to the results presented in this paper, the maxima occurred during the equinoxes. Apparently, the model did not reproduce this phase step.

Reply: We have noted that before and now implemented a short statement in the discussion. There seems to be rather different results from the model simulations. WACCM shows the phase shift over the altitude range between 60 km and 80 km. COMMA-IAP as pointed out does not show such phase shift at all. This gets even more evident in Ulrich Körner’s Ph.D. thesis.

10159, line 28: Perhaps the term “ the rather precise solar occultation tech-

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nique” is a somewhat too optimistic view of the accuracy of this method, particularly at the upper domain, because the local density will be derived from an integral signal. Fig.1 displays differences in the water vapour profiles derived with two different instruments, which indicates that the precision of all measurements is limited.

Reply: We agree that the precision of all measurements discussed here is limited. However, from the point of view of emission-based measurements, solar occultation measurements tend to be more precise. These measurements have good signal-to-noise ratio due to the strong solar source term and they are self-calibrating.

10168, lines 10-15: The result that the amplitude of the semi-annual and annual variation above 90 km does not depend on latitude is surprising. One would expect that the annual amplitude increases with increasing latitude. Perhaps the relative amplitude is more important than the absolute one as the absolute water vapour mixing ratios are already very small. The QBO is a stratospheric phenomenon with an average period of longer than two years. Is the QBO found linked to that in the stratosphere?

Reply: There is certainly some latitude variation, but comprising very low concentrations. There might be also some indications that the situation above 85 km is different as the situation in the altitude range below, which needs to be studied more thoroughly.

We have not done any further studies regarding the QBO signal we found in the mesospheric water vapour distribution. However this is planned as noted in the discussion to investigate the inter-annual variation of the MSAO in water vapour.

10169, line7: “As noted before the summer maximum is stronger in the Northern hemisphere than its counterpart in the Southern hemisphere, while the winter maximum is stronger in the Southern Hemisphere.” Looking at Fig. 9 upper panel, evidently the annual amplitude is larger in the Northern Hemisphere than in its southern counterpart, whereas the semi-annual amplitude is larger in the Southern hemisphere as is also displayed in Fig. 7, upper panel.

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10172, lines 1-14: The discussion in the last paragraph is somewhat misleading. The function of Rossby waves for the formation of the hemispheric differences could be discussed and also the influence of the eccentricity of the Earth orbit (see e.g. the paper of Berger 2008, JASTP, 70, 1170-1200). A stronger circulation from the Northern to the Southern Hemisphere should entail smaller water vapour mixing ratios in, at least, middle to high latitudes of the wintry Southern Hemisphere than in its northern counterpart because the downward flux of dry air is also stronger. The behaviour in the subtropics cannot simply be explained with only a gravity wave driven meridional circulation.

Reply: We think that it is beyond the scope of the manuscript to discuss the inter-hemispheric differences we observe in detail. The upper panel of figure 7, which describes the situation above 80 km, might indicate that the semi-annual variation in water vapour we observe may be based on an additional component which arises from the meridional advection of water vapour from the polar region of the summer hemisphere across the equator. In that context inter-hemispheric differences in the subtropics might be anticipated. This conclusion is based on recent evidence of an inter-hemispheric coupling between the polar winter stratosphere and polar summer mesosphere using the mesospheric pole-to-pole circulation as the connecting link [Karlsson et al., 2007, GRL, 16806-+; Becker et al., 2004, GRL, 24-+; Becker and Fritts; Annales Geophysicae, 2006, 1175-1184]. These studies suggest a stronger flow from the northern hemisphere polar area to the southern hemisphere polar area as vice versa. That is the points we would like make and tried to make it more clear in the revised version of the manuscript.

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