

Interactive comment on “Retrieval of water vapor profile in the mesosphere from satellite ozone and hydroxyl measurements by the basic dynamic model of mesospheric photochemical system” by M. Yu. Kulikov et al.

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The authors of the paper appreciate the Referee's merit rating of our work, its significance and novelty, as well as the valuable comments.

Below we give our response to all the Referee's comments and recommendations (bold face italicized text) and indicate the changes introduced in the revised manuscript.

(1) This paper addresses relevant scientific questions within the scope of ACP and will be ready for publication in ACP once the authors have considered the following minor points. Page 5756 line 20 "From the table 1 it is clear that, first,

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reaction with participation of the members of the families of ClOx and NOx as well as with participation CH₄, H₂,H₂O₂ and some mesospheric MGCs weakly influence the constituents of interest to us"; This sentence should be more justified. There is only list of reaction in the Table 1 and explanation is not sufficient for reader.

We agree with this Referee's comment. The paragraph was changed and supplemented with the corresponding justification of the secondary nature of the chemical reactions that are neglected in this work (please see the first paragraph of Section 2):

"A complete MPCS usually includes about a hundred chemical reactions with participation of more than twenty chemical constituents of the mesosphere (see, e.g., Brasseur and Solomon, 1986; Fichtelmann and Sonnemann, 1989). These constituents have different lifetimes, and chemical reactions running with their participation generally make different contributions to the evolution of this photochemical system. The main goal of this research is determination of the relationship between the concentrations of O₃, OH and H₂O that would allow us to retrieve vertical distribution of the latter species by vertical distribution of the two first species measured during the CRISTA-MAHRSI campaign. So, the complete MPCS may be reduced substantially for solution of this problem. We are going to consider the most important chemical reactions (see Table 1) only that determine evolution of the constituents of the family of odd oxygen Ox (O, O(¹D), and O₃) and odd hydrogen HOx (H, OH, and HO₂) at the heights of 50-90 km in the time interval with a duration of approximately one day (daylight hours). Note, first of all, that the presented list of reactions does not include the reactions that are of minor importance, such as destruction of Ox constituents due to catalytic cycles of reactions with participation of the families of ClOx and NOx. Brasseur and Solomon (1986) showed that the rate of the destruction, in the first approximation, is proportional to ClO₂ and NO₂ concentrations, respectively. The concentration of these constituents in the mesosphere during daylight hours is known to decrease dramatically with increasing height, so that already at the height of 50 km the cumulative sink of Ox provided

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by the above mentioned catalytic cycles is approximately 10 times less than the sink of Ox due to the reactions specified in Table 1. The reactions with participation of the constituents of the family of even hydrogen (CH₄, H₂, H₂O₂) were not considered for the same reason. In Sec. 3 of the current work we assess maximum error of retrieval of water vapour concentration as a result of this approximation. Besides, in our earlier work (Kulikov et al., 2006) where we used the COMMA-IAP model (Sonnemann et al., 1998) that includes a complete set of constituents and reactions of the mesospheric photochemical system we also demonstrated that the reactions in Table 1 determine well (to an accuracy not worse than 1-3%) daytime concentrations of fast constituents of the families of Ox and HOx.”

(2) Specific Comment: The results on water vapour distribution obtained on the base on proposed retrieval are discussed in the Section 5. Figures 4-6 show modeled profiles of water vapor and the text discusses the origins of height maxima. At that, the discrepancies between experimental and modeled profiles are partly attributed to the possible errors in the initial data on OH concentration. It would be very useful to show also the experimental data in Fig. 4-6, against which the modeled profiles are compared. The proposed retrieval is applied to a mesospheric system describing day evolution of key minor constituents at this heights. It is not clear what kind of experimental data were used for comparisons (data version, averaging for what period and geographical domain ect)? Did these experimental data reflect also diurnal variation of mesospheric water vapour or was H₂O considered as a dynamical tracer?

The data compared with the retrieved distributions of water vapour concentrations are averaged (over 10 years) HALOE data borrowed from the works by McHugh et al. (2003) and Hervig et al. (2003). For a more comprehensive response to the Referee’s comment we included in the revised manuscript (see Fig. 4) instantaneous vertical profiles for the concentrations of this constituent in the mesosphere measured by the same instrument on August 3 and August 22, 1997 at the points with the horizontal

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coordinates close to the model profiles. In addition, we specified all characteristics of the data as requested by the Referee. Note that of all the data available to us these experimental data have spatio-temporal characteristics that are most close to the CRISTA-MAHRSI data. The corresponding paragraph of the paper was corrected appropriately (please see the first paragraph of Section 5):

“Note that the presence of two maxima in the distribution of H₂O concentration at 73 and 81 km shown by the heavy solid curve and dark circles in Fig. 4 agrees well, both quantitatively and qualitatively, with results of direct measurements. In particular, in Fig. 4 we present for comparison three vertical profiles of water vapour concentration in mesosphere measured by HALOE (v. 19) on August 3 and 22, 1997. Moreover, these maxima are also observed in the HALOE data measured in July-August at 65-70°N (McHugh et al. (2003), Hervig et al. (2003)) averaged over 10 years.”

(3) Specific Comment: Unique in situ rocket measurements of water vapour were presented in the following papers Khaplanov et al. A direct measurements of water vapour in the stratosphere and mesosphere, Geophys.Res.Lett., 23, 1645-1648, 1996 Lossow et al. Middle atmospheric water vapour and dynamics in the vicinity of the polar vortex during Hygrosonde-2 campaign, ACP,2008 In these papers the combined measurements yielded a high resolution water vapour profile up to an altitude of 75 km. Using water vapour as a dynamical tracer it was possible to directly relate the water data to the position of the polar vortex. Systematic difference in the water vapour concentration between the inside and outside the polar vortex conditions was observed in the mesosphere and is consistent with efficient downward transport of air inside the vortex. Comparisons with the mentioned direct water vapour measurements could be useful for understanding the role of mesospheric dynamics and for verifying the results of the proposed retrieval.

It is a very valuable comment. Unfortunately, the CRISTA-MAHRSI data used in our paper were measured in August 1997 that is before the polar vortex event and before

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than the rocket measurements referred to by the Referee. Besides, all known to us satellite data (including CRISTA-MAHRSI data) seem to have insufficient time resolution (several hours) for retrieving small-scale variability of mesospheric water vapour concentration in the conditions of polar vortex. Recently, we modified the discussed method. Vertical distribution of water vapour concentration may now be retrieved within the framework of the basic dynamic model of mesospheric photochemical system by results of measurements of mesospheric ozone only, without data on hydroxyle profile. When using the modified method one needs to know ozone profile variations at a given coordinate point with temporal resolution of about 0.5 hours. This resolution may be attained with the use of data of ground-based microwave probing. Therefore, ground-based measurements of the mesospheric ozone profile together with in situ measurements of water vapour concentration would indeed, as mentioned by the Referee, be useful for understanding the role of mesospheric dynamics and for verifying the results of the proposed retrieval.

The discussion was, accordingly, supplemented as follows (please see the last paragraph of Section 5):

“To conclude, we note that the proposed method of water vapour retrieval in mesosphere implies that the magnitude of this parameter at specific altitude weakly changes within several hours (4-7 hours). This supposition may be violated in some cases, for example, near the boundary of a polar vortex where water vapour concentration has an appreciable meridional gradient and gravity waves impact the boundary (Lossow et al., 2009). In such nontrivial situations experimental data with high temporal resolution are required for retrieving water vapour concentration using the basic dynamic model of mesospheric photochemical system.”

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