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Carbon dioxide vertical profile retrieving from proxy in MLT region: Monte Carlo uncertainty study

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In the framework of the YM2011 model of electronical-vibrational kinetics, we have demonstrated that collisional quenching with CO_2 is essential for the only one proxy, $O_2(b^1\Sigma_g^+, v = 0)$ [1]. The remaining proxies, $O(^1D)$, $O_2(b^1\Sigma_g^+, v= 2$ or 1), $O_2(a^1\Delta_g, v= 0$ or 1), do not depend on $[CO_2]$ as it was shown using the photochemical model YM2011. However, the population of the level $O_2(b^1\Sigma_g^+, v = 0)$ depends also on the overlying level $O_2(b^1\Sigma_g^+, v = 1)$ due to the fast E-V energy transfer in the reaction $O_2(b^1\Sigma_g^+, v= 1) + O_2(X^3\Sigma_g^-, v = 0) \rightarrow O_2(X^3\Sigma_g^-, v = 1) + O_2(b^1\Sigma_g^+, v= 0)$. Thus, to retrieve the altitude profile of $[CO_2]$ in the daytime mesosphere and lower thermosphere (MLT), we developed a method that uses the simultaneous measurement of the volume emission rates for the transitions from two excited levels of the oxygen molecule, $O_2(b^1\Sigma_g^+, v= 0)$ and $O_2(b^1\Sigma_g^+, v= 1)$.

The uncertainty of retrieval of the CO_2 concentration was estimated by the Monte Carlo method taking into account the errors of all the YM2011 model parameters without exception. The proposed algorithm allows to obtain the altitude profile of CO_2 concentration in the range of 50 – 85 km with an uncertainty of 10 –20% and in the range of 85 – 100 km with an uncertainty of 20 – 60%. The simultaneous retrieval of altitude profiles of ozone concentration (in the altitude range of 50–100 km) and atomic oxygen concentration (above 89 km) is also possible by using respective proxies. In addition, we compared the results obtained with the results of the sensitivity analysis [1].

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1. Yankovsky V. A., Manuilova R. O., “Possibility of simultaneous $[O_3]$ and $[CO_2]$ altitude distribution retrievals from the daytime emissions of electronically-vibrationally excited molecular oxygen in the mesosphere.” J. Atmospheric and Solar-Terrestrial Physics 2018; 179: 22–33, doi:10.1016/j.jastp.2018.06.008.