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Proposals on methods for the simultaneous retrievals of [O_3] and [CO_2] altitude profiles in the mesosphere

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The small components O_3 and CO_2 are responsible for the thermal regime of the daytime mesosphere and lower thermosphere (MLT) of the Earth. The CO_2 concentration in the MLT region is usually retrieved indirectly by solving the complicated problem of radiative transfer at conditions of the breaking of local thermodynamic equilibrium (LTE). The analogous difficulties of [O_3] retrieval from the observation of emission in 9.6 μm band are explained by complexity of vibrational kinetics of the O_3 molecule.
The problem of independent and simultaneous retrieval of [O_3] and [CO_2] can be solved by using individual proxy for each of the target component. In this study we present the method of simultaneously retrieval of [O_3] and [CO_2] worked out on the base of the model of electronic-vibrational kinetics of the products of O_2 and O_3 photodissociation in the MLT, YM2011 [1]. We use the altitude dependence of the concentration of the excited component O_2(b1, v = 0) (where v is vibrational quantum number) as a proxy to retrieve [CO_2] and of the O_2(b1, v = 1) concentration as a proxy for retrieval of [O_3] altitude profile. The concentration indicator for the O_2(b1, v = 0) is emission from this level in the O_2 bands Atm (0, 0) at 762 nm, O_2 Atm (0, 1) at 865 nm and for the O_2(b1, v = 1) is emission from this level in the O_2 bands Atm (1, 1) at 771 nm, O_2 Atm (1, 0) at 688 nm or Atm (1, 2) at 874 nm [1]. The method of retrieving the altitude dependence of the volume mixing ratio of the CO_2, Cv,CO_2, in the mesosphere (nearly 50 – 85 km) is based on measurement of the ratio of concentrations of two excited components: [O_2(b1, v = 1)]/[O_2(b1, v = 0)]. In this study we have showed, that to determine Cv,CO_2, it is necessary to measure the absolute value of volume emission rate (VER) of the radiation produced by transitions from the level O_2(b1, v=0), as well as VER of the radiation generated by the transitions from the level O_2(b1, v=1). For the O_3 volume mixing ratio, Cv,O_3, we have showed, that the error of the Cv,O_3 retrieval mainly depends not on all reactions included in the model YM2011, but on the following parameters: on the accuracy of the measurements of VER of the radiation generated by the transitions from the level O_2(b1, v=1) and also on errors in the rate coefficients of reactions O_2(b1, v=1) + O_2 $\rightarrow$ O_2(X3, v=1) + O_2(b1, v=0) and O_2(b1, v=0) + O_3 $\rightarrow$ products. The funding of the study was provided by RFBR, grant N 17-05-00532-a.

1.Yankovsky V. A., Martyshenko K. V., Manuilova R. O., Feofilov A. G., “Oxygen dayglow emissions as proxies for atomic oxygen and ozone in the mesosphere and lower thermosphere,” Journal of Molecular Spectroscopy, 327, 209-231 doi:10.1016/j.jms.2016. (2016).