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Sensitivity study of the inverse problem on retrieval of the altitude profile of ozone from emission intensities of the molecular oxygen in the MLT

Kseniia Martyshenko and Valentine Yankovsky

Saint-Petersburg State University, Institute for Physics, Atmospheric physics, Saint-Petersburg, Russian Federation (vyankovsky@gmail.com)

Retrieval of the ozone density altitude profile is important problem for energetics of the upper atmosphere. For comparison of methods of retrieval of altitude profiles of ozone concentration from emissions of excited oxygen molecule and atom was used a modern model of electronic-vibrational kinetics of the products of O_3 and O_2 photolysis YM-2011 [1]. This study uses only a part of the complete model YM-2011 related to population of levels $O_2(b1\Sigma+g, v=0\text{-}2)$, $O_2(a1\Delta g, v=0\text{-}5)$ and metastable atom O(1D). Thereby, we obtained solutions of the inverse problem of $[O_3]$ retrieval from five proxies $O_2(a1\Delta g, v = 0)$, $O_2(b1\Sigma+g, v = 0, 1, 2)$ and O (1D). Theoretically, every proposed emission of excited component could be promising sources of information about $[O_3]$, because it depends on $[O_3]$ both in production and in quenching. Detailed analysis of the solutions of the inverse problem of $[O_3]$ retrieval were conducted by the sensitivity study of these levels for variations of all model parameters at altitudes of z=40-105 km.

The maximum values of sensitivity coefficient to $[O_3]$ variations have the following components: $O_2(b1\Sigma+g, v = 1)$, $O_2(a1\Delta g, v = 0)$ and O(1D). The sensitivity of all excited component to variations of ozone decreases sharply above 105 km due to a drastic fall of ozone concentration. $[O_2(b1\Sigma+g, v=2)]$ does not depend on ozone completely at the proposed altitudes, and $[O_2(b1\Sigma+g, v=0)]$ has the lowest sensitivity to variations of $[O_3]$ among rest components.

Based on the results of the sensitivity study authors investigated the ozone altitude profiles retrieval accuracy taking into account uncertainties of all input parameters (solar excitation and photodissociation rates, quantum yields of products and rate constants of aeronomical reactions). Uncertainties of retrieval of altitude profiles of $[O_3]$ from [O(1D)] don't exceed 10% in the interval 40-85 km were obtained. Profile of $[O_2(b1\Sigma+g, v=1]$ allows us to retrieval of $[O_3]$ with 21% uncertainty at z =40-95 km, and $[O_2(b1\Sigma+g, v=0]$ - 29% at altitudes up to 97 km. Uncertainties of retrieval of altitude profiles of ozone from $[O_2(a1\Delta g, v=0)]$ achieved 21% at altitudes of z=40-89 km, but it's not uniform in height and in the 77-85 km don't exceed 10%.

Overall, optimal methods of retrieval of altitude profiles of ozone concentration is the observation volume emission rate of the molecule $O_2(b1\Sigma+g, v=1)$ in the MLT region.

1. Yankovsky V. A., Manuilova R. O., Babaev A. S., Feofilov A. G., Kutepov A. A. 2011. Model of electronic-vibrational kinetics of the O_3 and O_2 photolysis products in the middle atmosphere: applications to water vapor retrievals from SABER/TIMED 6.3 μm radiance measurements. International Journal of Remote Sensing, V. 33, N. 12, P. 3065-3078.