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Methods of atomic oxygen and ozone retrieval from observations of the O_2 dayglow emissions in the MLT region

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The problem of creating the new methods of remote sensing of altitude profile of the [O(3P)] and [O_3] in the daytime is actual for the mesosphere and lower thermosphere range. Currently there is no reliable method for remote sensing of altitude profile of the [O(3P)], but atomic oxygen is a key component in the mechanism of the atmosphere cooling by quenching of vibrationally excited CO_2 molecules and also one of basic quencher of excited components in MLT region.
The airglow emission in 1.27 μm IR Atm(0 - 0) band from [O_2(a1Δg, v=0)] has been used as a proxy for [O_3] in MLT for over a decade. However, lifetime of O_2(a1Δg, v=0) is more than 1 hour, therefore this method is not suitable for detecting of relatively rapid [O_3] variations which occur due to the variability of the solar spectrum in the UV range (120 - 320 nm) and other space factors. The aim of this study is revealing of proxies for retrievals of [O(3P)] and [O_3]. In the framework of developed model of electronic vibrational kinetics of excited products of O_3 and O_2 photolysis in MLT of the Earth (model YM-2011) [1] we consider the photolysis of O_2 in the Schumann–Runge continuum and Lyaman-A H atom and of O_3 in Hartley band and for excited products of photolysis (O_2(a1Δg, v=0 - 5), O_2(b1Σ+g, v=0, 1, 2) and excited oxygen atom O(1D)) we took into account more than 60 aeronomical reactions of photoexcitation and deexcitation by energy transfer between the excited levels and of quenching of the levels in collisions with O(3P) O_2, N2, O(3P), O_3, CO_2. We tested 5 excited components, namely, O_2(b1Σ+g, v=0, 1, 2), O_2(a1Δg, v=0 – 5) and O(1D) as the O(3P) and O_3 proxies. The total system of kinetic equations for 10 components has been solved and altitude profiles of concentrations of O(1D), O_2(b1Σ+g, v=0, 1, 2), and O_2(a1Δg, v=0 – 5) have been calculated.
To compare characteristics of assumed proxies we used sensitivity analysis of the proxy concentrations altitude profiles to variations of [O_3] and [O(3P)] and have calculated the altitude profiles of: 1) photochemical lifetimes of excited states; 2) volume emission rates (VER) of these excited components; 3) the relative uncertainties values of [O(3P)] and [O_3] retrieved from intensities of emissions formed by the corresponding radiative transitions. Based on this complex analysis we concluded that the optimal proxy for [O(3P)] retrieval are O_2(b1Σ+g, v=0) and/or O_2(b1Σ+g, v=2) at 90-150 km, and for [O_3] retrieval are O_2(b1Σ+g, v=1) and/or O_2(a1Δg, v=0) at 40-97 km. It should be noted, that lifetimes of O_2(b1Σ+g, v=0, 1, 2) are not more than 10 s in MLT, what gave the opportunity to register the short-period [O(3P)] and [O_3] variations

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.