Influence of the concentration of minor neutral (NO, O_3, and O) constituents on the structure of the lower ionosphere during solar proton events.

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Solar energetic proton events (SPE) produce extra ionization and change the neutral composition of the lower high-latitude ionosphere. One important aspect of SPE is the enhancement of concentration of the nitric oxide, NO, and odd hydrogen constituents, H and OH which leads to changes in ozone, O_3, and atomic oxygen, O. Theoretical estimates show that during the SPE event the NO concentration can increase by 1-2 orders of magnitude and the concentration of O_3 and O is decreased during daytime by a factor of 2 or 2-10, respectively. In this study, based on a theoretical model of the D region, we investigate the influence of the NO, O_3, and O concentrations on the following parameters of the lower ionosphere: the f^+ parameter which describes the ratio of the positive cluster ions to positive molecular ions O^+_2 and NO^+; the λ parameter which represents the ratio of the total negative ion density N^- to the electron density Ne; the transition heights $h_{f+=1}$ and $h_{\lambda=1}$; the electron density defined as $Ne = N^+ - N^-$; and effective recombination coefficient α_{eff}.

We use the SPE on 17 January 2005 as a case study and show that each minor neutral component has its unique input into ionization balance which depends on altitude. Increasing [NO] inside the height range 55-90 km up to [NO] $\approx 10^8$ cm^{-3} does not effect the negative ion chemistry and does not change the transition height $h_{\lambda=1}$. The $f^+(h)$-profile depends on [NO] in the height range 67-85 km and the transition height $h_{f+=1}$ is decreased by 3 km compared to low concentration of the [NO]. Enhancement of the [NO] up to $\approx 10^9$ cm^{-3} leads to increasing of the transition height $h_{\lambda=1}$ by ~1 km and decreasing the $h_{f+=1}$ by ~6 km compared to low concentration of the [NO]. This results in a decrease of the effective recombination coefficient in the height range 67-82 km and an increase of the electron density by about 1.5 times.

Variations in the ozone concentration at the altitudes below 70 km affect the negative ion chemistry. However, as it is known, depletion of the [O_3] due to SPE

does not exceed 50%. The effect of such a decrease in ozone on the ion composition and electron density is very small.

The biggest changes are caused by variations in [O]. With decreasing of the [O] concentration in the height range 55-75 km from [O] ≈ 2×10^{10} -5×10^{9} cm^{-3} till [O^-]≈10^9 cm^{-3}, the transition heights $h_{f+=1}$ and $h_{\lambda=1}$ rise, the effective recombination coefficient below 70 km is increased and variations in the electron density can be as much as a factor of 2-5.

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