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The dependence of the formation of ground-level ozone on humidity

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Despite the numerous long-term studies of the ozone dynamics, some of the mechanisms of its formation in the atmosphere still remain unclear. In particular, the matter concerns a role of meteorological variables in ozone formation in the troposphere. We have previously shown that there is an exponential dependence of the ozone formation rate on the surface air temperature (Belan et al., 2018a). This dependence is also manifested in the presence of snow cover that prevents the emission of ozone precursors from the underlying surface during the winter period (Belan et al., 2018b). Here, we analyze a relationship between surface ozone and absolute humidity.

The study of the relationship between ground-level ozone concentration and meteorological variables was based on the observational data obtained at the so-called TOR-station (56˚28'41"N, 85˚03'15"E, West Siberia). Isolation of the absolute humidity contribution to the ozone formation was carried out according to the following approach. After synoptic selection performed to exclude events of frontal passages and wildfire plumes, the entire dataset was divided into subarrays with equal values of air temperature. It was done to eliminate the dependence of the ozone formation rate on air temperature (Belan et al., 2018a). Thus we obtained eight subarrays: -40±1; -30±1; -20±1; -10±1; 0±1; 10±1; 20±1; 30±1 ˚C. Then, we compared values of ozone concentration and the absolute humidity within each subarray for the same point of time.

It was revealed that there is a steady trend of decreasing ozone concentration with increasing water vapor content in the range of air temperatures from +30 to -10 ˚C. The trend line becomes neutral at a temperature of -30 ˚C. And at the temperature of -40 ˚C, an increase in the concentration of water vapor leads to one in the ozone production.

Since the range of changes in absolute humidity differs significantly in each subarray, the differences in the ozone concentration were normalized to ones in absolute humidity in order to derive the dependence of O_3 concentration change on the water vapor content. The derived functional dependence showed that at positive air temperatures (0 – + 30 ˚C) the change in ozone concentration depending on the absolute humidity is insignificant and close to zero.

The most significant decrease in ozone concentration with increasing absolute humidity (reaching 17.3 μg m^{-3}/g m^{-3}) is observed in the range from -20˚C to -10 ˚C. At the temperature of -40 ˚C, a convergence takes place and a growth in absolute humidity leads to an increase in the concentration of ozone at a relative rate of 77.5 μg m^{-3}/g m^{-3}.

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