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Experimental studies of aerosol and its radiative effects during AeroRadCity-2018 experiment and corresponding COSMO-ART modelling over Moscow megalopolis

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During the Moscow AeroRadCity-2018 spring aerosol experiment at the Moscow State University Meteorological Observatory (Moscow MSU MO) the aerosol properties of the atmosphere and radiative aerosol effects were analyzed using AERONET datasets and PM10 measurements including black carbon (BC) concentrations under different meteorological conditions. Special quantitative indicators were used for characterizing the air dispersion intensity. During this period the prevailing conditions with low values of the Angstrom absorption coefficient were observed, which indicated the BC dominance as a result of high-temperature combustion of natural fuel in transport engines. At the same time, especially during the May holidays the increased values of the Angstrom absorption coefficient were recorded probably due to the intensive burning of agricultural garbage at the Moscow suburbs. The BC/PM10 average ratio was about 4% with a maximum of 34%. We analyzed the empirical relationships between different gaseous species and aerosol including AOT500 fine and coarse fractions taking into account for the quantitative air dispersion intensity indicators and paying special attention for the BC contribution and its effects on radiative properties of aerosols. Especially high correlations were found between BC and nitrous oxides, which possibly indicates common sources of air pollution.
The analysis of aerosol radiative effects in Moscow showed that their smallest values at the top of the atmosphere were about -3 Wm-2 under the north air advection conditions. In other cases aerosol radiative effect could reach -13-16 Wm-2. Model aerosol experiments using COSMO-ART chemical-transport model with various emissions rates of aerosol precursor gases according to TNO for 2010 and TNO 2003-2007 allowed us to estimate the sensitivity of the modelled AOT550 urban component (dAOT550) to their values. The TNO 2010 emissions were shown to be of a better quality for urban aerosol modelling. The comparisons of the modelled dAOT550 using COSMO-ART with the measurements were made over the Moscow MSU MO AERONET site and in background conditions over the Zvenigorod AERONET site. The modelled dAOT550 values showed a satisfactory agreement with the experimental data.
In addition, during the AeroRadCity experiment in rainy conditions we obtained significant negative trends in PM10 concentrations, whereas for black carbon, this trend was not evident. The analysis of AOT500 changes, as well as its fine and coarse fraction before and after precipitation revealed more complex multidirectional trends in variations of these characteristics. During the period of the experiment we also analyzed the aerosol sedimentation in dissolved and suspended forms. A high correlation between these components was obtained (r=0.94). The mineralization value of the deposited suspended matter in the insoluble form was almost always about twice as large compared with those in the dissolved form. This suggests more effective removal mechanism of the insoluble form of aerosol particles from the atmosphere. The work was supported by the Russian Science Foundation, grant # 18-17-00149.