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Urban aerosol in Moscow megacity and its radiative effects according to the AeroRadCity experiment and COSMO-ART modelling

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The AeroRadCity urban aerosol experiment over Moscow megacity have been carried out during spring 2018 and 2019. The experiment included measurement campaign at the Moscow MSU MO and numerical experiments using COSMO-ART model (Vogel et al., 2010, Vilfand et al., 2017). We examined the dynamic of aerosol properties and their radiative effects under various meteorological conditions using both columnar and surface aerosol measurements (AERONET dataset, mass concentration of PM10, black carbon (BC), different aerosol gas-precursors, etc.). For qualifying urban pollution special attention was given to the analysis of columnar and surface Angstrom absorption coefficients, low values of which indicated the BC dominance as a result of high-temperature combustion of natural fuel in transport engines. We obtained a positive statistically significant dependence of AOD on PM and BC concentrations with a pronounced bifurcation point around PM10=0.04 mgm^{-3}. Model and experimental data demonstrated positive BC relationships with PM10, NO_2 and SO_2 at Moscow megacity (Chubarova et al., 2019). The analysis of radiative effects of aerosol in clear sky conditions has revealed up to 30% loss for UV irradiance and 15% - for shortwave irradiance at high AOD. Much intensive radiation attenuation is observed in the afternoon, when remote pollution sources affected solar fluxes at elevated boundary layer conditions. Negative (cooling) RF effect at TOA varied from -20 Wm^{-2} to -1 Wm^{-2} with average of -8 Wm^{-}2. The minimum (absolute) RF effect corresponded to the lowest AOT and single scattering albedo. A statistically significant regression dependence of the single scattering albedo on BC/PM10 fraction was obtained at high level of particle dispersion intensity.

The urban AOT550 calculations in COSMO-ART model were compared with the results of measurements in Moscow and Zvenigorod at the A. M. Oboukhov IFA RAS institute. They showed a satisfactory agreement between model and measured values of city aerosol pollution (respectively, dAOT= 0.017 and dAOT= 0.013). In some days the difference increased up to 0.05 in conditions with low intensity of pollutant dispersion.

During the experiment a high correlation (R^2=0.95) was revealed between the insoluble

component and the total mineralization of rain precipitation, which indicates that 70% of aerosol deposition occurs as the insoluble fraction. We show that at the initial concentration of C_0(PM)>10 μgm^{-3} exponential washout coefficients are significant for PM (alfa (PM)=0.17+-0.09 $hour^{-1}$) and insignificant for BC (alfa (BC) =0.07+-0.10 $hour^{-1}$). At C_0(PM) <10 μgm^{-3}, the alfa values both for PM and BC are close to zero. According to the numerical experiments with and without account of wet deposition the alfa value was estimated to be 0.08 $hour^{-1}$, which fits the confidence interval obtained from the measurements. The work was supported by the Russian Science Foundation, grant # 18-17-00149.

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