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The extreme air pollution episodes in the Moscow megacity region during the 2010 Russian wildfires: modelling and analysis

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One of the serious problems associated with growing urbanization is air pollution which is harmful for population and is also an important issue in the context of the climate change. The air pollution problems in a densely populated region may dangerously aggravate if this region is affected by air pollutant emissions from wildfires. We address a remarkable example of such a situation which took place in the Moscow megacity region during anomalous heat wave in summer 2010. Specifically, the extreme air pollution level (e.g., up to 20 mg/m3 and 1 mg/m3 of daily mean concentrations of CO and PM10, respectively) and strongly reduced visibility were observed in Moscow during this period as a result of combined emissions from anthropogenic sources and wild fires under stagnant meteorological conditions.

The goal of our study is to analyze the chemical evolution of the atmosphere over the Moscow megacity region during the 2010 heat wave by integrating available ground based and satellite measurements with results of meso-scale modeling. We use the state-of-the-art CHIMERE CTM which was earlier validated for the European part of Russia under “normal” atmospheric conditions. However, the standard version of CHIMERE is not directly applicable to the considered episode. Specifically, it was necessary to specify air pollutant emissions from wildfires and to modify the parameterization of photodissociation. Taking into account that available methods for evaluation of wildfire emissions give rather uncertain results, we follow the inverse modeling approach. A key idea of our method is to optimize major uncertain parameters of an algorithm which derives fire emission estimates from satellite measurements of fire radiative power by assimilating data of ground measurements of atmospheric composition into the model. We found that the optimized simulations reproduce independent ground and satellite observations (e.g., the MOPITT CO measurements not used in the optimization procedure) quite adequately (specifically, the correlation coefficient of daily time series of CO and PM10 exceeds 0.8) and that inclusion of fire emissions into the model significantly improves its performance.

The modified model is used for investigation of different aspects of the observed air pollution episodes in the considered megacity region. In particular, our analysis shows that the observed high concentrations of CO and PM10 in Moscow were indeed caused mainly by advection of pollutants from wildfires, but, at the same time, the attenuation of photolysis rates caused by smoke inhibited the formation of ozone favored by anomalous meteorological conditions. Several issues requiring further investigations (e.g., the potential role of heterogeneous reactions on surface of aerosol particles) will be discussed.