Estimation of the Siberian fire in September 2016 on the concentration of ozone and BC in the Pan-Arctic region using a regional chemical transport model

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Black carbon (BC) particles strongly absorb sunlight, and it has recently emerged as a major contributor to the global climate change, possible second to CO2 and methane. BC is produced both naturally and by human activities as a result of the incomplete combustion of fossil fuels, biofuels, and biomass. It is also known as a component of PM2.5, and influences on the human health. BC also changes the Earth’s albedo by changing the color of ice and snow via deposition into the surface, and the impact of BC on the climate change seems to be larger at polar region than that at the rest of the world. To estimate the impact of biomass burning on the concentration of BC and other pollutants, we had conducted model simulations over the Pan-Arctic region using a regional chemical transport model (WRF-Chem version 3.8.1). The initial and lateral boundary conditions for the meteorology were taken from NCEP-GFS. RACM and GOCART modules were used for the gaseous and aerosol chemistry, respectively. Anthropogenic emissions were based on EDGAR 4.2, and the biomass burning were based on the near-real-time version of FINN for each day. A pyro-convection process was also considered for the estimation of vertical profiles of biomass burning emissions. In the aerosol module of the model, BC particles were assumed to be emitted as hydrophobic BC, and were converted into hydrophilic BC by the folding time of 2.5 days. Biogenic emissions of VOCs were estimated by MEGAN 2.1 which is included in the model to use the meteorology and radiation calculated in the model for each time step. 50-days calculation with 15-days spinup was conducted from August to October 2016, when the Siberian forest fire were estimated to be quite active in the NCAR FINN inventory. To estimate the impact of biomass burning, we have conducted two calculations; 1) full emissions (anthropogenic, biogenic, and biomass burning) and 2) without biomass burning emissions (anthropogenic and biogenic). Meteorological field was compared with the observational data from the ship-based observation on R/V Mirai at the Arctic Ocean and Bering Sea, and model succeeded to reproduce the general variations of meteorological field such as the passage of low pressure systems. BC concentration at the surface level was increased over the Bering Sea after 25 September, and the main cause of the increase was estimated to be the biomass burning at around the Lake Baikal in late September. Biomass burning emissions of NOx and VOCs also increased the concentration of ozone around the source region, and it reaches 40 ppbv as the maximum.

Keywords: Black Carbon, regional chemical transport model, Pan-Arctic, biomass burning

