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Radiative effects of smoke aerosol during the fires over European Russia in summer 2010

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We analysed radiative properties of smoke aerosol of the severe fires in summer 2010 over European Russia using aerosol measurements at two AERONET sites in Moscow (Meteorological observatory of Moscow State University - MSU MO) and at the Zvenigorod Scientific Station of the A.M. Obukhov Institute of Atmospheric Physics, radiative flux measurements in different spectral regions at the MSU MO and model RT simulations.

An extreme hot weather and the absence of precipitation in July and a first decade of August 2010 led to a large forest and peatbog fires over European Russia territory, which in turn influenced on the significant aerosol content increase and the dramatic attenuation of solar irradiance at ground. Extremely high daily average aerosol optical thickness at 500nm (AOT500) was observed in the first decade of August reaching the absolute maximum on August 7th in Moscow and Zvenigorod (AOT500=6.4 and AOT500=5.9 respectively). The detailed study of optical and microphysical aerosol properties has showed significantly smaller imaginary part of refractive index (REFI(675nm)=0.006) and the predominance of fine mode aerosol fraction in smoke aerosol conditions. These changes led to the increase in smoke aerosol single scattering albedo (SSA), which was higher than that in typical conditions (0.95 compared with 0.9 at 675 nm).

The presence of optically thick smoke aerosol cloud led to the dramatic attenuation of solar fluxes in different spectral regions. On average, the smoke aerosol in 2010 caused 33% loss of total shortwave radiation, 39% loss of visible radiation, 51% loss of ultraviolet radiation 300–380 nm, and 63% loss of erythemally weighted irradiance. However, the maximum irradiance losses comprise correspondingly 64%, 75%, 91%, and 97% on August 7th at relatively high solar elevation h=47. At the same time, there was an increase in downwelling longwave radiation up to 40–50 W/m2 under extremely high aerosol optical depths.

Special attention was paid to evaluating the reasons of much stronger radiative attenuation in UV spectral region. For this purpose the RT modelling with the help of modified TUV model with 8 stream DISORT code was fulfilled. The results have revealed that SSA UV should be in the range of 08-0.9 for matching measurements and model data, which is much lower than that in visible spectral region.

The assessments of radiative forcing effect (RFE) at the TOA indicated a significant cooling of the smoky atmosphere. Instant RFE reached -167 Wm-2 at AOT500=6.4 while climatological RFE calculated for monthly mean AOT in August 2010 was about -65 Wm-2 compared with -20 Wm-2 for typical aerosol conditions according to the 10 year period of measurements in Moscow.

Comparisons with other fire periods observed in 1972, 2002, and 2010 over European Russia have shown that the fire period observed in 2010 was characterized by a greater frequency of the highest class of Nesterov fire indices, a higher aerosol optical depths of the atmosphere, and a more significant attenuation of solar fluxes in different spectral regions.