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Smoke aerosol and its radiative effects during extreme fire event over Central Russia in summer 2010

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An extreme hot weather and the absence of precipitation in July-August 2010 led to a large forest and peatbog fires over Central Russia, which in turn caused the significant aerosol content increase. Simultaneous measurements by the collocated AERONET CIMEL sun/sky photometers at the Moscow State University Meteorological Observatory (MSU MO) and at the Zvenigorod Scientific Station (ZSS) of the A.M. Obukhov Institute of Atmospheric Physics provide us the data for the analysis of the aerosol properties as well as spatial and temporal features of the "fire cloud" distribution during the July-August period.

The fires over Central Russia began at the second part of July and gradually cover larger areas. There was a constant linear increase in aerosol optical thickness at 500nm (AOT500) in July up to the beginning of August at a rate of about 0.3 AOT500 per a decade due to the absence of the precipitation, significant air advection from the south-east and, as a result, aerosol accumulating process. Approaching the fires close to Moscow at the beginning of August has led to a significant growth of aerosol optical thickness. The maximum aerosol thickness was observed on August, 7th, both in Moscow and Zvenigorod, when AOT500 reached approximately 5! This was one and a half time larger than the absolute maximum observed during the previous mega-fire event in 2002. Due to the change in atmospheric circulation at the end of August and due to the advection of very clean air from the western regions, the AOT dropped to 0.06 on August 20, 2010. However, on average, in August monthly mean AOT was about 4 time higher than the similar climatic value. Comparisons with the previous fire-smoke events show that in 2010 we had the most severe fire-smoke episode with maximum aerosol loading for the whole period of measurements.

Volume aerosol size distributions retrieved by the method described in Dubovik and King (2000) were characterized by a distinct bimodal character with a significant increase in fine aerosol mode compared with typical Moscow and Zvenigorod conditions. Single scattering albedo of aerosol was higher than typical Moscow and Zvenigorod values, which is in accordance with optical properties of the smoke aerosol. The angular distribution of radiance in smoke conditions were also analyzed for different aerosol conditions.

A significant increase in AOT led to a large attenuation of shortwave irradiance. The loss in shortwave irradiance was calculated against model values in aerosol-free conditions. During the maximum aerosol loading observed on August 7, 2010, the loss of shortwave irradiance (0.3-4.5 um) was about 50-60%, while the loss in UV irradiance (0.3-0.38 um) – was about 75-90%, and erythemally-weighted irradiance – up to 95%. At the same time there was a noticeable increase in downward longwave irradiance with the increase in aerosol loading. Aerosol forcing efficiency at the TOA according to the estimates by the standard AERONET algorithm during the fire events was about -45 W/m2 and the maximum radiative forcing at the TOA could reach -190 W/m2 at maximum AOT. The work was partly supported by the RFBR grants #10-05-01019, #09-05-00582.