Impact of wild forest fires in Eastern Europe on aerosol composition and particle optical properties

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Climate change results from both natural and human-induced modifications of the Earth's energy balance. These climate related factors include variations in the amounts of greenhouse gases, aerosols, changes in land use, and the amount of energy Earth receives from the Sun.

Regional scale variations in radiative forcing have significant regional and global climatic implications, which cannot be addressed through the idea of global mean radiative forcing. Until now only a small number of studies has been dedicated to regional radiative forcing and response. It is still very difficult to describe a regional forcing and response in the observational record. Regional forcings may induce global climate responses, while global forcings can be connected with regional scale climate responses.

Wild fires have been modifying atmospheric composition for centuries. They have significant impact on the physical environment including modifications of land cover, land use, biodiversity or inducing climate changes and this impact is on both regional and global scales. Differences in aerosol composition on a regional scale as a result of advection of particulates from the regions of wild fires have been described before.

In order to describe and quantify the role of biomass burning as a source of atmospheric gases and aerosol particles to the atmosphere, information is required on the global magnitude of biomass burning. Biomass burning aerosols include two important chemical components: black carbon and organic carbon. The first component primarily absorbs solar radiation, and the second scatters solar radiation. Takemura et al. (2002) made 3-D model simulations of radiative forcing of various aerosol species. In their model they divided all the main tropospheric aerosols into the following groups - carbonaceous (organic and black carbons), sulfate, soil dust, and sea salt aerosols. They compared their model simulations of total aerosol optical thickness, Ångström exponent, and single-scattering albedo for mixtures of four aerosol species with the observed data from both optical ground-based measurements and satellite remote sensing retrievals at a great number of stations. They reported the mean difference between the simulation and observations to be less than 30% for the optical depth and less than 0.05 for the single-scattering albedo in most regions.

Year 2002 was unique in terms of air temperatures which were recorded in the region of central Europe and the Baltic area. Seven consecutive months were warm or very warm, and between February and September the multiannual average air temperature was higher than the normal temperature by over 1 degree centigrade. May and August 2002 were extraordinarily warm. Such conditions were very conducive to wild fire outbreaks in the areas of Eastern Europe, which are widely covered by forests and meadows.

Years 2007 and 2008 were also very hot in the discussed region, however, warm periods were shorter than in 2002 and lasted mostly 4 weeks. Then temperatures returned to the multiannual average for some time and warm periods returned. These years and 2010 were also fire abundant in the discussed region but the air mass trajectories were such that the smoke plume did not reach the area of the Baltic Sea. Thus these years have not been analyzed in this paper.

In this work the authors discuss the changes of aerosol optical depth (AOD) in the region of eastern Europe and the Baltic Sea due to wild fire episodes which occurred in the area of Belarus and Ukraine in 2002. The authors discuss how the biomass burning aerosols were advected over the Baltic area and changed the composition of aerosol ensemble for a period of several summer weeks. The air pressure situation and slow wind speeds also facilitated the development of such conditions. As a consequence very high AOD levels were recorded, by an order of 3-4 higher versus normal conditions and they significantly increased the annual averages. On particular days of August 2002 the AOD values reached a level of over 0.7! On these days fine particles fully dominated the entire ensemble of aerosol particles. They were either sulfates or smoke particles. Such situation was unique over a period of many years and it had its serious consequences for the region and especially for the Baltic Sea.

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