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Contribution of wildfire emissions to ambient air quality in Europe during summer 2003: meso-scale modeling of smoke emissions, transport and radiative effects.

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The present study investigates the effects of wildfire emissions on air quality in Europe during an intense fire season that occurred in summer 2003. The meso-scale chemistry transport model CHIMERE is used, together with ground based and satellite aerosol optical measurements, to asses the dispersion of fire emissions and to quantify the associated radiative effects. The model has been improved to include the MODIS daily smoke emission inventory and to account for the altitude transport of smoke particles. The simulated aerosol optical properties are used as input to a radiative transfer model to estimate the effects of smoke particles on photolysis rates and atmospheric radiative forcing. The wildfire emissions were estimated from acreage burned, fuel loading information and fuel emission factors. During summer 2003, the fires resulted in 220 and 322 kTons of primary PM2.5 and PM10 (particles smaller than 2.5 and 10 microns in diameter) emissions, respectively, which represent almost half of aerosol anthropogenic emissions in Occidental Europe (14W:25E, 35N:58N) for the same period. The major wildfire events occurred on 3-4 and 11-14 August, and 12-13 September over Portugal and were associated with relatively high aerosol optical thicknesses

(AOT>0.4 at 532nm) and large Angstrom exponents (in range 1.3-1.6) characteristic of soot particles. Significant changes in aerosol optical properties were observed not only close to the fire source regions, but also over a large part of Europe as a result of the long-range transport of smoke. Model performance in simulating aerosol concentrations and optical properties are significantly improved when wildfire emissions are considered. Quantitative analysis of modeling results show the ability of the model to reproduce the main spatial features observed in MODIS and POLDER data, with a general agreement within a factor 2. High AOT values observed over the Northern Europe after the 3-4 August fire event are correctly reproduced by the model and attest of the occurrence of high altitude transport of smoke plume from Portugal source region across Northern Europe. The average increase in PM10 ground concentrations caused by the wildfire emissions varies from 2 to 15 μg/m3 (5 to 50%) during the first half of August over a large part of Europe. The largest enhancement in PM10 concentrations stay however confined within 200 km area around the fire source locations and reaches up to 15 μg/m3 in Portugal and 3-5 μg/m3 over Southern Mediterranean basin. The presence of elevated smoke layers over Europe during summer 2003 plays also an important role in altering atmospheric radiative properties. The model results imply that during the period of strong fire influence 10 to 30% decrease in photolysis rates throughout a large part of Europe is caused by wildfires. Furthermore, the fire emissions resulted in an increase in atmospheric radiative forcing estimated to 10-35 Wm-2 during major fire events. The study suggests that sporadic wildfire events may have significant effects on regional photochemistry and atmospheric stability, and need to be considered in current chemistry-transport models.