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Did the summer 2003 forest fires in Portugal affect air quality over Europe?

AI Miranda, V Martins, E Sá, A Carvalho, JH Amorim, and C Borrego
University of Aveiro, CESAM, Department of Environment and Planning, Aveiro, Portugal

A forest fire is a large-scale natural combustion process consuming various types, sizes and ages of botanical specimen growing outdoors in a defined geographical area. Although wildland fires are an integral part of ecosystems management and are essential to maintain functional ecosystems their dimensions can give rise to disastrous results. Due to the frequency of occurrence and the magnitude of effects on the environment, health, economy and security, forest fires have increasingly become a major subject of concern for decision-makers, firefighters, researchers and citizens in general. Among their consequences, is the emission of various environmentally significant gases and solid particulate matter to the atmosphere that interfere with local, regional and global phenomena in the biosphere.
Smoke from forest fires contains important amounts of carbon dioxide (CO2), carbon monoxide (CO), methane (CH4), nitrogen oxides (NOx), ammonia (NH3), particulate matter (PM) (that is usually referred in terms of particles with a mean diameter less than 2.5 μm, or PM2.5, and particles with a mean diameter less than 10 μm, or PM10), non-methane hydrocarbons (NMHC) and other chemical compounds. These air pollutants can cause serious consequences to local and regional air quality by reducing visibility, contributing to smog and impairing air quality in general, thus threatening human health and ecosystems.
Pollutants emitted from forest fires are transported, chemically transformed, and dispersed in the atmosphere. Although major wildfires are limited to some hundreds of hectares, their impacts, with no natural or political boundaries, can be felt and reported far beyond the physical limits of the fire spread. Depending on meteorological conditions, smoke plumes and haze layers can persist in the atmosphere for long periods of time and prevailing conditions will influence the chemical and optical characteristics of the plume.
The extreme fire events occurred in the summer of 2003 in Portugal highlighted the need to better analyze the link between forest fires and air quality. Portugal faced in 2003, the worst fire season ever recorded and this is clearly reflected in the values measured by the air quality-monitoring networks. There were 4,645 fires burning 8.6% of the total Portuguese forest area.
The main purpose of this paper is to evaluate the contribution of summer 2003 Portuguese fires to air quality impairment in Europe.
Portuguese forest fire emissions, namely CO2, CO, CH4, PM10, PM2.5, NMHC, NOx, SO2 and NH3, were estimated throughout the summer of 2003, based on specific southern European emissions factors, on type of vegetation and area burned. LOTOS-EUROS, which is an operational 3D chemistry transport model aimed to simulate air pollution in the lower troposphere, was specifically adapted to simulate forest fire emissions. The modelling system was applied first at a continental scale (with 0.5° x 0.25°, approximately 35 km x 25 km) and then to mainland Portugal domain, using the same physics and a simple one-way nesting technique, with 17.5 km x 12.5 km horizontal resolution. The simulation period covered the entire summer, aiming to estimate hourly concentration values of gaseous and particulate pollutants levels in the air. A baseline simulation (BS) was carried out, only including the “conventional” anthropogenic and biogenic emissions, and a forest fire simulation (FS), which also considered emissions from large forest fires (area burned higher than 100 ha). Hence, forest fire emissions values were added to the anthropogenic and biogenic grid emissions, according to the fire location and assuming a uniform fire spread and a constant injection altitude in the dynamic mixing layer.
The modelling system indicates a severe degradation of particulate matter and ozone (O3) concentrations due to forest fires, not only in Portugal, but also in United Kingdom, France and Spain. Modelling results were compared to background monitoring data from the European Air quality dataBase (AIRBASE). A statistical analysis was

performed to evaluate the simulations results, using some statistical parameters such as the root mean square error (RMSE), the systematic error (BIAS) and the Pearson correlation coefficient (r). The model performance increased substantially when forest fire emissions were included.