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Studying and analyzing the formation and dynamics of the black cloud over Cairo, Egypt, using a multi sensor approach

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In the past decade, episodes of severe air pollution from biomass burning and/or industrial activities, known as the "black cloud" have occurred over Cairo, and the Nile Delta region situated on the eastern side of the Sahara desert in Egypt, during the autumn season. Previous studies have attributed the increased pollution levels during the black cloud season only to the biomass or open burning of agricultural waste, vehicular, industrial emissions, and secondary aerosols. However, new multi-sensor observations (column and vertical profiles) from satellites, dust transport models and associated meteorology present a different picture of the autumn pollution. It was found that the same region receives as well numerous dust storms along with the anthropogenic aerosols during same season. Such complex combination of these aerosols results in poor air quality and poses significant health hazards for the population in this region. In this study, data from the Moderate Resolution Imaging Spectrometer (MODIS) along with the Multiangle Imaging Spectroradiometer (MISR) are used with meteorological data and trajectory analyses to determine the cause of these events. MODIS fire counts highlighted the anthropogenic component of the dense cloud resulting from the burning of agricultural waste after harvest season. Synchronous MISR data show that these fires create low altitude (<500 m) plumes of smoke and aerosols which flow over Cairo in a few hours, as confirmed by Hybrid Single Particle Lagrangian Integrated Trajectory (HYSPLIT) forward trajectory analysis. Much of the burning occurs at night, when a thermal inversion constrains the plumes to remain in the boundary layer (BL). Convection during the day raises the BL, dispersing these smoke particles until the next night. However, we have found a dust transport pathway along the Mauritania/Mali/Algeria/Libya/Egypt axis that significantly affects NE Africa, especially the Nile Delta region, during the biomass burning season. The increase in aerosol loading (A0D>0.9) along with corresponding decrease in the Angstrom Exponent, a typical feature of desert dust, point towards the presence of desert dust over the Delta region. Hence, the high aerosol concentration episodes cannot be solely attributed to biomass burning or local pollution. Our results show that high altitude long range transported dust is a major contributing factor to the black cloud pollution during the biomass burning season. Our new findings may create a new outlook to investigate the chemical and physical nature of air pollution by scientists and informed decisions by policymakers. The complexity of aerosol transport and different sources of origin is a most challenging issue, not just for pollution control in densely populated areas, but also for effects on the overall climate system. We have found that current models such as DREAM that forecasts dust aerosols require revision in estimates during the autumn season since they could show some events observed by satellites. The satellite data such as MODIS provide useful complementary information to validate and constrain forecast from dust models. Our results indicate that hastily assigning origin to aerosols (such as black cloud which implies anthropogenic pollution), may mask the more complex origin of aerosol loadings.