Paper 1


Abstract

During the Cairo Aerosol Characterization Experiment an automated Sun photometer belonging to the NASA Aerosol Robotic Network has been implemented for the first time in the megacity of Cairo, Egypt. The inversion of the measurements performed by this instrument several times a day and over a duration of more than 1 year (from the end of October 2004 to the end of January 2006) provides a way of determining the temporal variability of aerosol characteristics such as size distribution, complex refractive index, single-scattering albedo, and asymmetry parameter. The analysis of the results reveals that Cairo’s aerosol is a mixture of three individual components produced by different mechanisms: “background pollution” aerosol produced by local urban activities, “pollution-like” aerosol resulting from biomass burning in the Nile delta, and “dust-like” aerosol released by wind erosion in the Sahara. It is also shown that the variations in the overall aerosol properties are in fact due to changes in the proportions of this mixture. In particular, short-duration dust storms and biomass-burning episodes explain the largest observed aerosol optical depths (AOD) (AOD > 0.7) through the extreme enhancements of concentrations in dust-like aerosols characterized by low Ångström’s exponent values ($\alpha < 0.5$) and in “biomass-burning” aerosols ($1.0 < \alpha < 1.5$). When averaged over longer (monthly and yearly) time periods, the effects of these high-frequency modifications are smoothed. In particular, an average “mixed aerosol” type is defined for the whole duration of the measurements period. The low single-scattering albedo (SSA) of this average aerosol and its marked spectral dependence clearly indicate that, at least on a yearly basis, the aerosol is dominated by its two light absorbing pollution components (background pollution and pollution-like) and to such an extent that it compares well with values obtained in other polluted megacities (e.g., Mexico City). This general dominance of the absorbing components can be challenged at shorter timescales. Indeed, the occurrence of several dust storms in springtime, and particularly in April, causes a significant increase in SSA and a parallel decrease in spectral dependence during this month. Conversely, the October biomass-burning events are not able to cause such important deviations from the yearly averaged mixed aerosol model that its optical properties can no longer be used for this month.
Paper 2

M. El-Metwally, S.C. Alfaro, M.M. Abdel Wahab, A.S. Zakey, B. Chatenet, 2010. Seasonal and inter-annual variability of the aerosol content in Cairo (Egypt) as deduced from the comparison of MODIS aerosol retrievals with direct AERONET measurements. *Atmospheric Research* 97, 14–25

Abstract
As this is the case in many megacities of the developing countries, the atmospheric aerosol load is usually particularly large over the Cairo (Egypt) conurbation. However, being the result of a combination of meteorological factors and of the activity of various particle sources, some of which are seasonal, this load is variable in time. The objective of this study is to document this variability at the intra- and inter-annual scales. For this we use the qualitative Aerosol Absorption Index (AAI) derived from Aura-OMI (the ultimate version of the Total Ozone Mapping Spectrometer, TOMS) and the Aerosol Optical Depth (AOD) derived from the radiance measurements performed between 2000 and 2008 by the Moderate Resolution Imaging Spectroradiometers (MODIS) implemented aboard either the Terra or the Aqua satellites. In the sense that AOD maxima are always obtained in April and in October at the peaks of the desert dust and biomass burning periods, respectively, the results yielded by these two methods are in good qualitative agreement with those of direct sunphotometer observations performed in Cairo for more than one year (from end of October 2004 to the end of March 2006). However, a quantitative comparison of the MODIS and AERONET products for their common period of measurements reveals that MODIS tends to overestimate systematically the AOD and underestimate the aerosol's Ångström exponent. We propose an empirical method for correcting the AOD retrieved by MODIS at 550 nm and match it with the sunphotometer values. When applied to the whole MODIS dataset, the effect of this correction is to smooth the inter-annual differences. As a result, the month-to-month variations of the AOD can be described by the same pattern independently of the year in the period of study (from 2000 to 2008). The monthly averaged AOD obtained by this method is minimal (0.24±0.04 at 550 nm) from December to February because of the washing out of airborne particles by rain events more frequent in winter. Conversely, the AOD increases in summer because particle accumulation is favored in this season by the absence of precipitations and by atmospheric stability. However, AOD maxima are obtained in April (0.38±0.02) and in October (0.36±0.03) when particles produced outside of the city by natural processes (wind-erosion of desert surfaces) or by human activities (burning of agricultural wastes in the Nile Delta) are transported by prevailing winds and contribute significantly to the enhancement of the city's aerosol burden.
Abstract
Cairo is one of the largest megacities in the World and the particle load of its atmosphere is known to be particularly important. In this work we aim at assessing the temporal variability of the aerosol's characteristics and the magnitude of its impacts on the transfer of solar radiation. For this we use the level 2 quality assured products obtained by inversion of the instantaneous AERONET sunphotometer measurements performed in Cairo during the Cairo Aerosol CHaracterization Experiment (CACHE), which lasted from the end of October 2004 to the end of March 2006. The analysis of the temporal variation of the aerosol's optical depth (AOD) and spectral dependence suggests that the aerosol is generally a mixture of at least 3 main components differing in composition and size. This is confirmed by the detailed analysis of the monthly-averaged size distributions and associated optical properties (single scattering albedo and asymmetry parameter). The components of the aerosol are found to be 1) a highly absorbing background aerosol produced by daily activities (traffic, industry), 2) an additional, 'pollution' component produced by the burning of agricultural wastes in the Nile delta, and 3) a coarse desert dust component. In July, an enhancement of the accumulation mode is observed due to the atmospheric stability favoring its building up and possibly to secondary aerosols being produced by active photochemistry. More generally, the time variability of the aerosol's characteristics is due to the combined effects of meteorological factors and seasonal production processes. Because of the large values of the AOD achieved during the desert dust and biomass burning episodes, the instantaneous aerosol radiative forcing (RF) at both the top (TOA) and bottom (BOA) of the atmosphere is maximal during these events. For instance, during the desert dust storm of April 8, 2005 $RF_{BOA}$, $RF_{TOA}$, and the corresponding atmospheric heating rate peaked at $-161.7\,\text{W/m}^2$, $-65.8\,\text{W/m}^2$, and $4.0\,\text{K/d}$, respectively. Outside these extreme events, the distributions of the radiative forcing values at BOA and TOA are Gaussian with means and standard deviations of $-58(\pm 27)$, and $-19(\pm 11)\,\text{W/m}^2$, respectively. These two negative values indicate a cooling effect at the 2 atmospheric levels but the largest absolute value at BOA corresponds to a trapping of solar radiation inside the atmosphere. The averages of the instantaneous forcing efficiencies (FE) derived from measurements performed at solar zenith angles between 50 and 76° are $-195(\pm 42)$ and $-62(\pm 17)\,\text{W/m}^2$.AOD$_{550}$ for BOA and TOA, respectively. The value at TOA is larger than in other urban environments, which could be due to the desert dust and biomass burning aerosols shows that fluctuations of their monthly-averaged concentrations explain the departures of the TOA and BOA radiative forcings from the background situation. In April, the contributions of DD to the month averages of the instantaneous radiative forcing are as high as 53% at BOA, and 66% at TOA. In October, the biomass burning mode contributes 33 and 27% of these forcings,
respectively. Noteworthy is that the contribution of DD to RF is never less than 17% (at BOA) and 27% (at TOA), emphasizing the importance of the mineral dust component on the transfer of solar radiation above Cairo, and this even in months when no major dust storm is observed.
Paper 4


Abstract

Two databases of solar surface irradiance (SSI) derived from satellites were compared to ground measurements in Algeria, Egypt, Libya and Tunisia. We found that it was possible to accurately derive the SSI from geostationary meteorological satellites, even with a coarse spatial resolution. The two databases HelioClim-1 (HC1) and SSE exhibited similar and good performances. The bias was generally lower for SSE than for HC1; however, HC1 exhibited a smaller scattering of data compared to ground measurements (smaller standard deviation) than the SSE, allowing better performance when mapping the long-term variations in SSI. The long-term variations in SSI from 1985 to 2005 show that these four countries as a whole experienced dimming. Detailed analyses of the range of dimming at sites with long-term records and of its spatial distribution were performed. We found that the analysis of SSI from HC1 supports the findings for the individual sites. Dimming may be explained by: (1) transportation of sand dust northwards from the Sahel, (2) an increase in urbanization, and (3) an increase in cloud cover and aerosol loading.
Paper 5


Abstract
Long-term data from diffuse and global irradiances were used to calculate direct beam irradiance which was used to determine three atmospheric turbidity coefficients (Linke $T_L$, Angstrom $\beta$ and Unsworth–Monteith $\delta_u$) at seven sites in Egypt in the period from 1981 to 2000. Seven study sites (Barrani, Matruh, Arish, Cairo, Asyut, Aswan and Kharga) have been divided into three categories: Mediterranean climate (MC), desert Nile climate (DNC) and urban climate (UC, Cairo). The indirect method (i.e., global irradiance minus diffuse irradiance) used here allows to estimate the turbidity coefficients with an RMSE% B20 % (for $\beta$, $\delta_u$ and $T_L$) and*30 % (for $\beta$) if compared with those estimated by direct beam irradiance and sunphotometric data, respectively. Monthly averages of $T_L$, $\beta$ and $\delta_u$ show seasonal variations with mainly maxima in spring at all stations, due to Khamsin depressions coming from Sahara. Secondary maxima is observed in summer and autumn at DNC and MC (Barrani and Arish) stations in summer due to dust haze which prevails during that season and at UC (Cairo) in autumn, due to the northern extension of the Sudan monsoon trough, which is accompanied by small-scale depressions with dust particles. The mean annual values of $\beta$, $\delta_u$, and $T_L$ (0.216, 0.314, and 4.6, respectively) are larger in Cairo than at MC stations (0.146, 0.216, and 3.8, respectively) and DNC stations (0.153, 0.227, and 3.8, respectively). Both El-Chichon and Mt. Pinatubo eruptions were examined for all records data at MC, UC and DNC stations. The overburden caused by Mt. Pinatubo’s eruption was larger than El-Chichon’s eruption and overburden for $b$, and $T_L$ at DNC stations (0.06, and 0.58 units, respectively) was more pronounced than that at MC (0.02, and 0.26, respectively) and UC (0.05 and 0.52 units, respectively) stations. The annual variations in wind speed and turbidity parameters show high values for both low and high wind speed at all stations. The wind directions have a clear effect on atmospheric turbidity, and consequently, largest turbidities occur when the wind carries aerosols from the main particle sources, such as industrial particle sources around Cairo or to some extent from the Sahara surrounding all study stations.