AEROSOLS DIRECT RADIATIVE FORCING ON DJOUGOU (NORTHERN BENIN) DURING THE AMMA DRY SEASON EXPERIMENT

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Abstract The purpose of this work is to investigate the direct radiative forcing of aerosols on the supersite of Djougou (Northern Benin) during the AMMA (African Monsoon Multidisciplinary Analyses) dry season experiment (January 2006). We focus our simulations on the Top Of Atmosphere (TOA), Bottom Of Atmosphere (BOA), and ATMosphere (ATM) radiative forcings. During the period, Sun-photometric measurements indicate a rather turbid atmosphere with a mean Aerosol Optical Depth (AOD), for the overall period, about 0.90 ± 0.01 at 440 nm. The aerosol absorption coefficient at the surface was comprised between 2 and 90 Mm⁻¹, with a mean value of 19.2 Mm⁻¹. In the same time, the scattering coefficient ranged between 50 and 400 Mm⁻¹, with an averaged of 160 Mm⁻¹. This leads to a Single Scattering Albedo (SSA) comprised between 0.75 and 0.95 with an average value of 0.90, indicating moderate absorbing aerosols.
Differential mobility analyser measurements indicate a monomodal (nucleation mode) number size distribution, with a mean geometric diameter of 96.5 nm, associated with a geometric standard deviation of 1.87. The characteristics of the size distribution, associated with the refractive index of aerosols, have been used in the Mie theory for computing aerosol optical properties at different wavelengths. Associated with ground-based observations, the micro pulse lidar indicates the presence of two distinct aerosol layers, with a first one located between the surface and 500 m and a second one, characterized by aged biomass burning particles, located above (1500-3500 m). Based on surface and aircraft observations, sunphotometer measurements, Lidar profiles and MODIS sensor, an estimation of the daily direct radiative forcing has been estimated for the 17th to 24th January 2006 period, by using a discrete ordinate radiative transfer model. Simulations indicate that aerosols reduce significantly the solar energy reaching the surface (mean $\Delta F_{BOA} = -61.3 \text{ Wm}^{-2}$) by reflection to space (mean $\Delta F_{TOA} = -19.0 \text{ Wm}^{-2}$) but predominantly by absorption of the solar radiation into the atmosphere (mean $\Delta F_{ATM} = +42.3 \text{ W.m}^{-2}$).

1. Introduction

Among all sources of atmospheric particles around the world, Western Africa is the world’s largest source of biomass burning aerosols and mineral dust. Long past satellite observations indicate that these aerosol plumes, characterizing by high aerosol optical depths (often superior than one in the visible range) are the most widespread, persistent and dense observed at global scale. The effect of such plumes of dust and smoke aerosols on climate change represents one of the largest uncertainties in the Earth radiative budget. In a first time, atmospheric aerosols emitted in Western Africa can modify the radiative budget directly by absorption or scattering of solar radiations. Secondly, they can modify clouds properties and/or lifetimes when particles act as Cloud Condensation Nuclei. Furthermore, as dust and smoke particles are able to absorb solar radiations, the radiative heating due to aerosol layers can modify the atmospheric dynamic and suppress convection, resulting in evaporation of clouds. This effect, named “semi-direct” effect, can lead to a positive forcing by reducing cloud fractional cover and counterbalances the aerosol indirect effect.

Hence, dust and smoke particles coming from the West Africa region could strongly modify the regional or global climate as they have the potential to be exported over great distances by prevailing winds and atmospheric waves. A better representation of their climatic effects needs, in addition with modeling exercises and satellite observations, ground based and integrated-column measurements of their physical, chemical and optical properties,