New insight from the CALIPSO mission on the retrieval of dust surface concentration in Western Africa

Jean-François Léon[1], Nadège Martiny[2], Isabelle Chiapello[3], Béatrice Marticorena[4]

[1]Laboratoire d'Aérologie, Université Paul Sabatier, CNRS, Toulouse France.
[2]Centre de recherche en climatologie, Biogeosciences, Université Bourgogne, CNRS, Dijon, France
[3]Laboratoire d'optique atmosphérique, Université Lille 1, CNRS, Villeneuve d'Ascq, France
[4]Laboratoire inter-universitaire des systèmes atmosphériques, CNRS, Université Paris Est Créteil
Keywords: dust, remote sensing, Africa.
Presenting author email: jean-francois.leon@aero.obs-mip.fr

Northern Africa is the largest source of suspended mineral dust in the world with annual emission estimated between 400 and 2200 Tg. The Sahel is under the influence of the northeasterly Harmattan wind bringing dust over Southwestern Africa during the dry season that lies between October and April. Among adverse health effects, dust events are suspected to play a role in the meningitis outbreaks occurring in the so-called "Meningitis belt" (Lapayssonie, 1963) during the dry season (Martiny and Chiapello, 2013). A further analysis of the relationship between exposure to mineral dust and health impact requires long-term records of dust surface concentrations over large areas where however observations are scarce.

In this paper, we make use of the spaceborne lidar CALIOP (Cloud-Aerosol LIdar with Orthogonal Polarization) aboard the CALIPSO (Cloud Aerosol Lidar and Infrared Pathfinder Satellite Observations) mission (*Winker et al.*, 2009) to infer the surface dust concentration over the Sahel. CALIOP records atmospheric attenuated backscattering profiles at 532 and 1064 nm with an along-track resolution of 335 m. We have used the level 2 Aerosol layer products (namely 05kmALay) from 2006 to 2014. Version 3.01 is used from June 2006 to October 2011, version 3.02 from November 2011 to February 2013 and version 3.30 from March 2013 to December 2014.

An aerosol layer is characterized using the bottom and top altitude of the layer, its optical thickness and the aerosol type as identified by the scene classification algorithm (*Vaughan et al.*, 2009). The columnar dust optical depth (AOD) is computed by the adding the contribution of each layer classified as dust. The dust extinction coefficient is computed for the lowermost dust layer by dividing its optical thickness by the geometrical depth of the layer. The dust mass concentration is then estimated by dividing the dust extinction coefficient by a mass extinction efficiency of 1.0 m^2/g (Schepansky, 2009).

Both CALIOP total dust optical depth and estimations of the dust mass surface concentration are compared with in situ data available in the Sahel region. Since 2006, the Sahelien Dust Transect (Marticorena *et al.*, 2010) is providing continuous measurements of the PM10 (mass concentration of particles with an aerodynamic diameter less than 10 µm) at 3 locations in the Sahel, respectively in Niger, Senegal and Mali. PM10 are measured using a tapered element oscillating microbalance (TEOM 1400A from Thermo Scientific). A fourth TEOM have been installed in Burkina-Faso in 2012. The stations in Mali, Senegal and Niger are also equipped with an automatic sun photometer belonging to the Aerosol Robotic Network (AERONET) (*Holben et al.*, 1998) for aerosol optical depth measurements.

The CALIOP dust AOD is well correlated to the AERONET sun photometer AOD. The correlation coefficient ranges between R=0.6 for Niger to R=0.79 for Senegal. However the AOD is underestimated by roughly a factor of 2 whatever is the station. The CALIOP-derived surface mass dust concentrations are also well correlated with daily mean PM10 at the different stations in the Sahel, showing correlation coefficients between 0.70 and 0.82 for layers with a base altitude below 1.5 km. For higher base altitude, the correlation vanishes. The daily amplitude of the surface dust concentrations is also a parameter affecting the relation between satellite-derived and ground level dust concentrations. At a regional scale, CALIOP-derived dust surface mass concentration is able to reproduce the seasonal and interannual variability of dust surface concentration.

Holben, B. N. et al. (1998), AERONET—A federated instrument network and data archive for aerosol characterization, Remote sens. Environ., 66(1), 1–16.

Lapeyssonnie, L. (1963), La méningite cérébro-spinale en Afrique, Bull. World Health Org., 28(suppl. 1), 3–114.

Marticorena, B., et al. (2010), Temporal variability of mineral dust concentrations over West Africa: analyses of a pluriannual monitoring from the AMMA Sahelian Dust Transect, Atmos. Chem. Phys., 10(18), 8899–8915,

Martiny, N., and I. Chiapello (2013), Assessments for the impact of mineral dust on the meningitis incidence in West Africa, *Atmos. Environ.*, *70*, 245–253.

Schepanski, K., et al. (2009), Saharan dust transport and deposition towards the tropical northern Atlantic, Atmos. Chem. Phys., 9(4), 1173–1189.

Vaughan, M. A. et al. (2009), Fully Automated Detection of Cloud and Aerosol Layers in the CALIPSO Lidar Measurements, *J. Atmos. Ocean. Tech.*, *26*(10), 2034–2050.

Winker, D. M., et al. (2009), Overview of the CALIPSO Mission and CALIOP Data Processing Algorithms, *J. Atmos. Ocean. Tech.*,, *26*(11), 2310–2323.