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Characterization of Atmospheric Aerosols and their Transport in West Africa Using Aeronet Data and Hysplit Model

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Abstract

In this study, we performed a back-trajectory analysis of atmospheric aerosols in West Africa during the period 2010 - 2019. For this purpose, we collected meteorological data from the Air Resource Laboratory (ARL) GDAS 1° distribution and archiving centre for the West African region. These data represent daily averages of geophysical parameters of the atmosphere. We also collected daily averages of aerosol optical thickness and size coefficient from six photometric stations of the AERONET network during the period 2010 - 2019 in order to characterize the aerosol types in West Africa. Using the HYSPLIT model we calculated the back-trajectory of air masses from the six AERONET sites which are: Banizoumbou, Cape Verde, Dakar, IER de Cinazana, Ilorin andZinder. The results obtained indicate that locally generated atmospheric aerosols in West Africa are a mixture of both fine and coarse modes with a predominance of coarse mode in May, June, July and August for the Cape Verde and Dakar sites, March, April, May and June for the IER sites of Cinzana, Banizoumbou, Zinder. On the other hand, in Ilorin, fine particles dominate the local atmospheric column in the months of June, July, August until November. The calculation of back-trajectories from the considered sites allowed to determine their spatial distribution across the continent and beyond. The air mass trajectories calculated with the HYSPLIT model reveal that these aerosols are dispersed throughout the West African region and go beyond to reach the northern and central regions of the African continent and even southern Europe.

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Atmospheric aerosols, AERONET, HYSPLIT, West Africa.

Introduction

It is well known that air mass trajectories are useful in the study of weather phenomena, meteorology, pollutant dispersion, the lifting and transport of atmospheric aerosols and even in health. Examples include the identification of desert dust trajectories, water vapour transport, the establishment of the source-receptor relationship of air pollutants, the pollen transport study (Korgo *et al.*, 2013). West Africa is close to three major aerosol emitting sources: the Sahara with mineral dust, the Sahel and forest regions with aerosols from biomass fires, and salts from the Atlantic Ocean (at the coast).is located in the central region of the country. Geographically, West Africa lies between 30° North latitude and 3° South latitude and 27° West longitude

and 17° East longitude (Stein *et al.,* 2015). In terms of climate, it is marked by four climatic zones as it moves across the latitudes from the Gulf of Guinea towards the interior of the continent (Stein *et al.,* 2015; Dubovik *et al.,* 2000).

A humid tropical zone extending from the Atlantic coast to below 10°N (Stein *et al.,* 2015). There is some equatorial forest and open forest. The average annual rainfall is 1500 mn. A dry tropical climate zone just above the humid zone between isohyets 1200mn and 400mn (Korgo *et al.,* 2013).

A semi-arid zone commonly known as the Sahel located in the band between isohyets 200 and 600mm. This zone is that of the savannah, a herbaceous steppe dotted with trees in its southern part and shrubs as one moves northwards (Korgo *et al.,* 2013).

An arid climate beyond 17°N, a zone covered by the Saharan desert where it almost never rains and characterised by the almost total absence of vegetation cover (Korgo *et al.,* 2013).

West Africa is characterised by a succession of two seasons that are closely linked to the West African monsoon: a dry season that runs from October to May and a winter season during which almost all the region's rain falls from June to September. West Africa is one of the three so-called monsoon zones (along with South Asia and Australia) where the seasonal variability and rainfall cycle depends on that of the monsoon (Dubovik *et al.,* 2000). From a dynamic point of view, the climate is subdivided into three important periods: a dry season from January to March, a wet season from July to September, and between the two seasons, an intermediate season considered as a transition period (Michael Weger *et al.,* 2018).

The seasonal cycle of the West African climate is modulated by a complex dynamic of flows and jets in the lower tropospheric layers, in the upper and middle layers as well as several convective systems (María José Granados-Muñoz *et al.,* 2016.a). This particularity has been extensively studied in the AMMA programme, whose aim was to provide a better understanding of the African monsoon and its climatic and socio-economic impact at all time and space scales (Korgo *et al.,* 2013; María José Granados-Muñoz *et al.,* 2019.c). The lower layers of the troposphere are driven by a harmattan flow and a monsoon flow. The upper and middle layers are the seat of jets and waves such as the African Easterly Jet (AEJ), Subtropical Jet (STJ) and Tropical Easterly Jet (TEJ). Studies have shown that these elements of the West African climate are responsible on varying scales for the lifting and transport of desert aerosols from this part of the continent (María José Granados-Muñoz *et al.,* 2016.b). This explains the aerosol contents detected by ground and satellite observations in this region, which are among the highest and most persistent on the planet (María José Granados-Muñoz *et al.,* 2016a). This makes the region a strategic area for the study of air mass trajectories[1]. Especially when one considers that the Sahara is the largest desert with an area of 8.5 million km² and the largest source of dust in the world (Korgo *et al.,* 2013; Stein *et al.,* 2015; Dubovik *et al.,* 2000). Annual emissions are estimated to be between 400 and 700 Mt (Dubovik *et al.,* 2000). The lifting and transport of such a large amount of aerosols into the atmosphere modifies the optical properties of the atmosphere, and affects the radiative forcing (Stein *et al.,* 2015; Dubovik *et al.,* 2000). The objective of this study is to perform a climatology of the return trajectories of 700-1000 hPa air masses over West Africa in relationship to the variability of aerosol optical parameters.

Materials and Methods

The data collected in this study are back trajectories computed with the single particle integrated trajectory model (HYSPLIT). These are the trajectories of air masses between heights of 700 and 1000 hPa at six AERONET sites in West Africa. These heights are chosen because they allow us to study air movement in the atmospheric boundary layer which is the seat of atmospheric turbulence that strongly influences meteorology and dispersion and also in the free troposphere where long-range transport of aerosols occurs (Korgo *et al.,* 2013). In addition, we used photometric data from AERONET (AErosolROboticNETwork), to study the variability of the optical thickness and Angstrom coefficient in order to determine periods of high aerosol activity in the region. The optical thickness at 440 nm and the Angström coefficient or particle size coefficient, measured by the CIMEL Sun-Sky photometers, were extracted from the level 2 data (quality assured data) and coupled to the analysed trajectories during 2010 – 2019.

HYSPLIT data

There are two ways of simulating the movement of air masses in time and space: the Eulerian model and the Lagrangianmodel (Korgo *et al.,* 2013; Thomas Popp *et*

al., 2016). The Eulerian model considers fixed points in space through which air masses flow; the Lagrangian model is based on the spatio-temporal movement of an air parcel (Thomas Popp *et al.*, 2016).

The HYSPLIT trajectory, as its name suggests, is a hybrid between the Eulerian and Lagrangian approaches (Thomas Popp *et al.*, 2016).

Advection and diffusion are done in the Lagrangian framework, while the concentration is calculated on a fixed grid (Draxler and Hess, 1998).The trajectory model provides a description of the concentrations are calculated on a fixed dependent function and its position x_0 at time t_0 as follows: (Korgo *et al.*, 2013; Thomas Popp *et al.*, 2016)

$$\boldsymbol{x(t) = x(x_0, t)} \quad \ldots(1)$$

All positions $x(t)$ describe the forward trajectory of the point x_0. The coordinates of the position x_0 at the initial time t are called Lagrangian coordinates (Dutton, 1986). The inverse transformation gives the expression of $x_0(t_0)$ as a function of $x(t)$ and t as follows:

$$\boldsymbol{x_0(t_0) = x_0(x, t)} \quad \ldots(2)$$

This transformation is used to describe the backward trajectory. The function $x(x_0,t)$ is the solution path defined by the equation:

$$\frac{dx}{dt} = v(x, t) \quad \ldots(3)$$

Where v(x,t) represents the velocity of the wind vector at time t. The analytical solution of the trajectory equation can be obtained by using the difference approximation of the expansion which gives x(t) as a Taylor series at time $t_1 = t_0 + \Delta t$. We then obtain:

$$x(t_1) = x(t_0) + (\Delta t)\frac{dx}{dt}\Big|_{t_0} + \frac{1}{2}(\Delta t)^2\frac{d^2x}{dt^2}\Big|_{t_0} + \cdots \quad \ldots(4)$$

The first approximation of this equation, a simple solution of zero acceleration, is:

$$\boldsymbol{x(t_1) = x(t_0) + (\Delta t)x(t_0)} \quad \ldots(5)$$

The Taylor series expansion of x at $t_0 = t_1 - \Delta t$ gives :

$$x(t_0) = x(t_1) - (\Delta t)\frac{dx}{dt}\Big|_{t_1} + \frac{1}{2}(\Delta t)^2\frac{d^2x}{dt^2}\Big|_{t_0} - \cdots \quad \ldots(6)$$

Combining the two developments above gives the following expression for x (t_1) :

$$x(t_1) = x(t_0) - (\Delta t)[\dot{x}(t_0) - \dot{x}(t_1)] + \frac{1}{4}(\Delta t)^2\left[\frac{d\dot{x}}{dt}\Big|_{t_0} - \frac{d\dot{x}}{dt}\Big|_{t_1}\right] + \cdots \quad \ldots(7)$$

The first approximation of the solution is:

$$\boldsymbol{x(t_1) \approx x(t_0) + \frac{1}{2}(\Delta t)[\dot{x}(t_0) + \dot{x}(t_1)]} \quad \ldots(8)$$

This solution corresponds exactly to that described by Draxler and Hess (1998) in the HYSLIT 4 modelling system for trajectories, dispersion and deposition, which is as follows:

$$P(t + \Delta t) = P(t) + 0{,}5[v(P, t) + v(P', t + \Delta t)]\Delta t \quad \ldots(9)$$

In this expression, P(t) is the three-dimensional position at reference time t, P(t + Δt) at time t + Δt, V(P, T) and V(P', t + Δt) respectively. (https://www.ready.noaa.gov.php)

The errors associated with trajectory modelling have been extensively studied by Stohl (1998), they are of five types:

Truncation errors related to the finite difference approximation which neglects the high order terms of the Taylor series (Korgo *et al.*, 2013).

Interpolation errors due to interpolations between gridded wind fields that are based on trajectory models and radio sonde measurements (Stohl *et al.*, 1996).

Errors resulting from vertical wind assumptions, because in contrast to the horizontal wind, the vertical wind component is obtained from meteorological models which are less accurate than the measurement results (Korgo *et al.*, 2013).

The wind field errors are in most cases either forecast errors or analysis errors. Numerous studies using different techniques by Stunder (1996) have shown

prediction errors ranging from 16 to 60% depending on the travel time, type of trajectory (isentropic, isobaric, three-dimensional).

Starting position errors. Starting position errors are often not precisely known. A small error in the initial position can cause large errors involving the convergence or divergence of the flow (Korgo *et al.*, 2013; Stein *et al.*, 2015; Thomas Popp *et al.*, 2016).

Despite these sources of error, trajectory models that have undergone several improvements over the decades have been used successfully in the study of transport, dispersion and deposition of particulate matter and air pollutants (Korgo *et al.*, 2013) and as specified by Draxler, the HYSPLIT model is designed to respond quickly to atmospheric emergence, diagnostic case studies and climatological analyses.

AERONET data

The AERONET network consists of CIMEL Sun-Sky radiometers which are installed all over the world. These radiometers measure direct and diffuse radiation from which the AERONET inversion code provides aerosol optical properties, radiative properties and microphysical properties in the total atmospheric column for different wavelengths. The inverted optical and are the aerosol optical thickness (AOT), the Angstrom exponent, the real and imaginary part of the radiative index. The microphysical properties are particle size distribution, sphericity ratio and radiative properties, single scattering albedo, phase function, asymmetry parameter, spectral fluxes, radiative forcing and radiative forcing efficiency.

The development of the AERONET inversion codes is described in the papers by Dubovik and King, 2000; Dubovik *et al.*, 2002. The aerosol optical thickness (AOT) is a dimensionless number that characterises the transparency of the atmosphere through sunlight.

It is defined by the fraction of electromagnetic radiation or the atmosphere at a given wavelength. If "I_0" is the intensity of the radiation emitted by the sun and "I" is the intensity of the radiation that reaches the earth's surface, the optical thickness of the atmospheric layer passed through is obtained by the following relation:

$$\frac{I}{I_0} = e^{-\tau} \quad \tau = -\ln\left(\frac{I}{I_0}\right)$$

or …(10)

In the atmosphere, where there is almost no energy loss, the optical thickness is close to zero. A high optical thickness indicates an atmosphere containing relatively localised aerosols and therefore not transparent. A large decrease in visibility is associated with a high optical thickness value.

The Angstrom coefficient α, also known as the particle size coefficient, is a parameter related to the size of the particles. For a wavelength other than 1 µm, the optical thickness is related to the turbidity coefficient βby :

$$\tau_{ext}(\lambda) = \beta.\lambda^{-\alpha} \quad \ldots(11)$$

The turbidity coefficient βvaries in the range 0 to 0.5. It is an coefficient that represents the amount of aerosol present in the atmosphere in a vertical direction (atmospheric loading), in some cases the β coefficient can exceed the value 0.5 for a highly loaded atmosphere (Korgo *et al.*, 2013). The Angstrom coefficient αdepends on the size distribution of the aerosol particles. The particle size coefficient varies between 4 and 0, when the aerosol particles are very small, on the order of air molecules, α approaches the value 4, and it approaches 0 for large particles (Korgo *et al.*, 2013).

The spectral dependence of the optical thickness $\tau_{ext}(\lambda)$ provides information on the size of the scattering particles as follows:

$$\frac{\tau_{ext}(\lambda_2)}{\tau_{ext}(\lambda_1)} = \left(\frac{\lambda_2}{\lambda_2}\right)^{-\alpha} \quad \ldots(12)$$

Where λ_1 and λ_2 are wavelengths chosen in general to be fairly close to each other; the Angstrom coefficient, α, is a rough indicator of particle size. The greater the spectral dependence of the aerosol optical thickness, the greater the angstrom coefficient and the smaller the particles (Korgo *et al.*, 2013; María José Granados-Muñoz *et al.*, 2016.a; Claudia Di Biagio *et al.*, 2016).

In the case of molecules (Rayleigh scattering), the optical thickness of aerosols follows approximately a λ^{-4} law and increases very rapidly as the wavelength decreases (Dubovick *et al.*, 2000). For aerosols, the Angström coefficient varies from 0 (very large particles, e.g. desert dust) to 3 (very fine particles, e.g. urban pollution). The population of large particles with a single mode distribution can have a slightly negative Angström coefficient (Korgo *et al.*, 2013; Dubovick *et al.*, 2000; Cheng Chen *et al.*, 2018).

Results and Discussion

Variation of monthly averages of optical thickness AOT and particle size coefficient

The monthly averages of the optical thickness and the Angstrom coefficient (or size coefficient) of the aerosols are shown in Figure 1, below. We note the following observations. For the Zinder station, the monthly averages of the optical thickness vary from 0.33 (November) to 0.73 (May) and the monthly averages of the size coefficient vary from 0.13 (May) to 0.52 (December). We observe that the low values of the particle size coefficient correspond to the high values of the optical thickness for the months of March, April, May and June during the period 2010-2019. This indicates that the atmospheric column of the locality is strongly dominated by coarse mode aerosols. From July to January, the mean values of the particle size coefficient correspond to the mean values of the optical thickness as well. This observation indicates a presence of fine and coarse mode aerosols in equal proportions in the atmospheric column. For the Ilorin station, the monthly averages of the optical parameters vary from 0.30 to 1.12 for the optical thickness and from 0.28 to 1.09 for the size coefficient. The high values of the Angstrom coefficient correspond to the low values of the optical thickness for the months of June to November during the study period 2010-2019.

This characterises a predominance of fine particles in the atmospheric column over the locality during these months. From December onwards the proportion of coarse mode aerosols increases rapidly and tends to predominate over fine mode aerosols in January, February, March and April. For the Banizoumbou station, the optical parameters derived in the atmospheric column vary from 0.34 to 0.70 for the optical thickness and from 0.12 to 0.50 for the particle size coefficient.

The low values of the particle size coefficient coincide with the high values of the optical thickness for the months of March, April, May and June, which indicates a predominance of coarse mode aerosols in the atmospheric column over the locality during these months. From of July to December and from January to February these months are marked by monthly average values of Angstrom coefficient coincide with monthly average values optical thickness values as well, indicating a mixture of fine and coarse mode aerosols in equal proportions in the atmospheric column. For the CinzanaIER station, the recovered optical thickness in the atmospheric column varies from 0.15 to 0.46 and the angstrom coefficient / particle size varies from 0.29 to 0.66. The months of March, April, May, June and July are marked by high values of optical thickness coinciding with low values of size coefficient, which indicate a predominance of coarse mode aerosols in the local atmospheric column. From August to December, then January and February, the local atmospheric column shows a mixture of fine and coarse mode aerosols in almost equal proportions over the locality.

For the Dakar station, the optical parameters of the aerosols recovered from the atmospheric column vary from 0.31 to 0.66 for the optical thickness and from 0.14 to 0.56 for the particle size coefficient. The low values of the size coefficient correspond to the high values of the optical thickness from March to July, mainly in June when the optical thickness is at its maximum value while the size coefficient is at its lowest value. These observations indicate a high abundance in the atmospheric column of the mineral large particles, originating from the soil and sea spray during these months. High values of the size particle / Angstrom coefficient coefficient correspond to low values of the optical thickness during the months of November and December, which indicates a trend of fine particles. This trend is balanced by that of coarse particles during the following months (January and February) marked by the presence of aerosols of both modes in equal proportions in the atmospheric column over the locality. For the Cape Verde station, the optical parameters of the atmospheric column vary from 0.20 to 0.51 for the optical thickness and from 0.12 to 0.43 for the size coefficient.

The months of May to September are characterized by high values of optical thickness which coincide with low values of size coefficient. This indicates a predominance of coarse mode aerosols in the atmospheric column over the locality.

The month of November is particularly marked by a high value of the particle size coefficient that corresponds to a low value of the optical thickness, which indicates a predominance of fine particles over mineral particles. In the months of January to April and in October and December, the monthly mean values of optical thickness and size particle coefficient / Angstrom coefficient coincide. This suggests the presence of a mixture of fine and coarse mode aerosols in considerable proportions in the atmospheric column over the locality.

Average aerosol back-trajectories at the six AERONET sites in West Africa

The trajectories of the air masses from the considered AERONET sites, calculated by the HYSPLIT model during the months of January to December, are shown in the figure below. The figure reveals the following information. At the Cape Verde station, during the months marked by the abundant presence of coarse mode aerosols in the local atmospheric column, which are the months of May, June, July, August and September, the air masses are transported towards the Western Sahara coast and the Mauritanian coast. The aerosols of mineral origin at the level of these coasts most probably come from Cape Verde during these months. The month of November, characterised by the predominance of fines in the atmospheric column, revealed by the values of the size coefficient and the optical thickness at the Cape Verde station, the masses move towards the coast of Western Sahara, revealing that in addition to the locally generated aerosols, the fine particles located at the coast of Western Sahara come from the Cape Verde site. At the Dakar site, during the months marked by the predominance of aerosols of mineral origin - which are March, April, May, June and July - the air mass movements are towards the north of Senegal and progressively deported towards the Mauritanian coast and the western region of Mauritania. This suggests that the coarse mode aerosols in these regions originate largely from Dakar. In November and December, where the aerosol parameter values reveal a predominance of fines in the atmospheric column of the Dakar station, the air masses are transported towards the Mauritanian coast (in November), then the trajectory is declined towards the west of Mauritania, in December, suggesting that the fine mode aerosols (natural and anthropogenic) locally generated in Dakar can reach these Mauritanian regions. For the CinzanaIER site, in the months of March, April, May, June and July, where the monthly averages of the optical parameters recovered from the atmospheric column reveal a clear predominance of aerosols of mineral origin, the air masses are transported towards northern Guinea, then towards northwestern Burkina, then towards the Timbuktu region, then in the direction of southern Mauritania, and finally towards northern Guinea-Conakry and northern Ivory Coast. These observations suggest that all these regions are affected by dust aerosols from the CinzanaIER. At the Banizoumbou station, during the months of March, April, May and June marked by the predominance of coarse mode aerosols, according to the optical parameter retrievals, the trajectories of the air masses are in the direction of northern Nigeria, then in the direction of the Mali-Niger-Algeria border and finally towards northern Togo. This information suggests that the aerosols from the locally generated dust at Banizoumbou can reach all the above-mentioned locations. As for the Ilorin station, the atmospheric column is marked by a predominance of fine particles during the months of June, July, August, September, October and November, with the transport of air masses towards the Gulf of Guinea. This observation assumes that the fine particles locally generated at Ilorin can reach the Gulf of Guinea. In addition, the atmospheric column at Ilorin station also experiences a very considerable presence of coarse mode aerosols during the months of January, February, March and April during which the air mass movements are towards central Nigeria with an abrupt change of direction towards southern Benin in April. This indicates that the large air masses transported from Ilorin may be located in the central regions of the country and in southern Benin. At Zinder station, during the months of March, April, May and June, which are marked by the predominance of coarse particles, the trajectories of the air masses are in the directions of the east to the north of Niger, passing by the centre of the country, then in the northwest of Nigeria. All these regions can be affected by aerosols of mineral origin from Ilorin. These results indicate that locally generated atmospheric aerosols in West Africa are spread throughout the region by the movement of air masses which is highly variable in time and space.

Overall aerosol trajectories at the six AERONET sites

The set of air mass trajectories over the course of a month for each of the concerning sites is shown in the following figure. The month considered is the one where the aerosol load in the atmosphere is very considerable for all the six AERONET sites, which is the month of March. For the Cape Verde site, the trajectories of the air masses during the month of March vary from the direction of the Mauritanian coast to the west coast of the Western Sahara. The atmospheric aerosols contained in these air masses coming from the Cape Verde site are likely to reach these coasts. For the Dakar site, the trajectories of the air masses are from the direction of northern Senegal to the direction of the Mauritanian coast during the month of March. During this month, the masses reach the southwest of Mauritania. Atmospheric aerosols of both modes, fine and coarse, contained in these air masses from the Dakar site, can be located in the southwestern regions of Mauritania and the Mauritanian coast.

Fig.1 Mean Optical Thickness and Angström Coefficient of Aerosols in West Africa

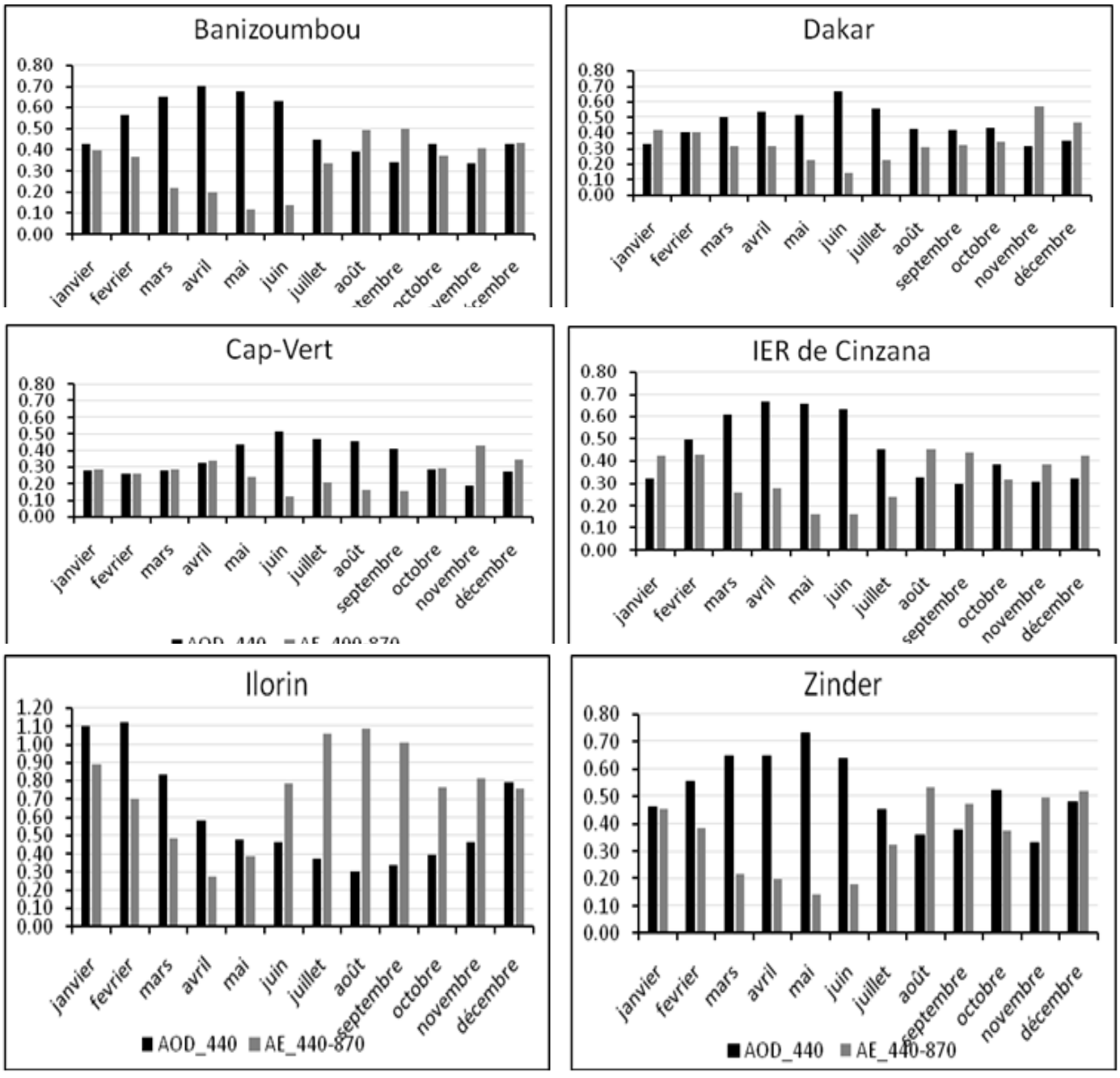
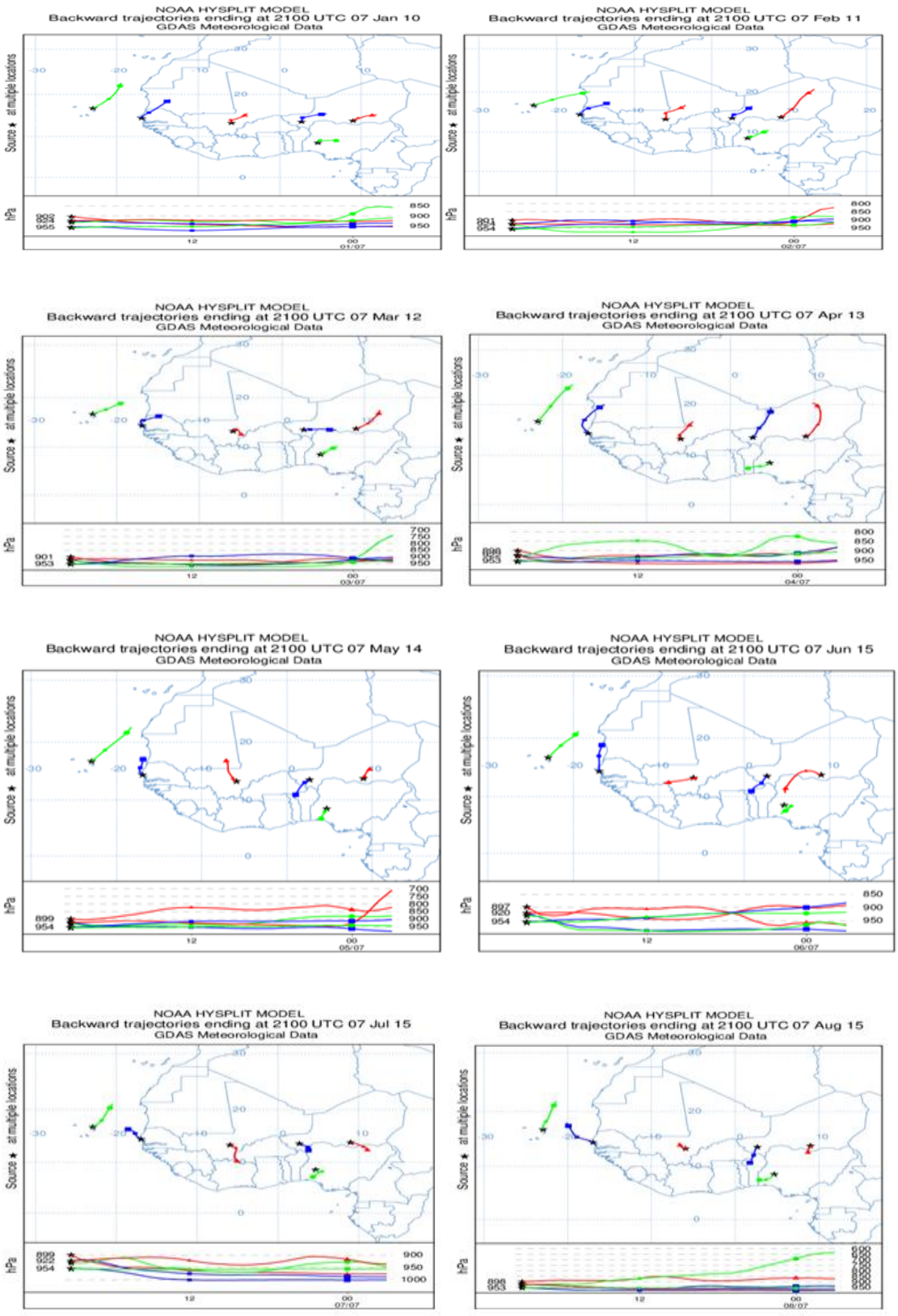


Fig.2 Monthly Average Aerosol Trajectory During The Period 2010 - 2019 In West Africa



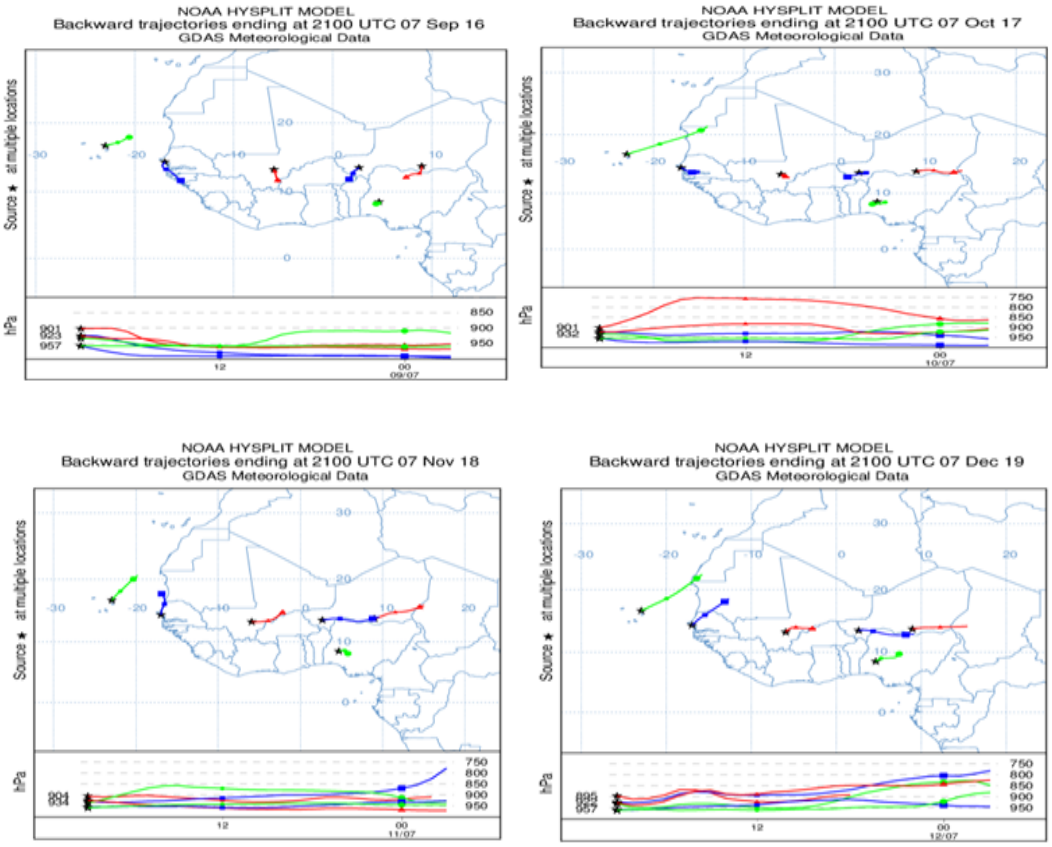
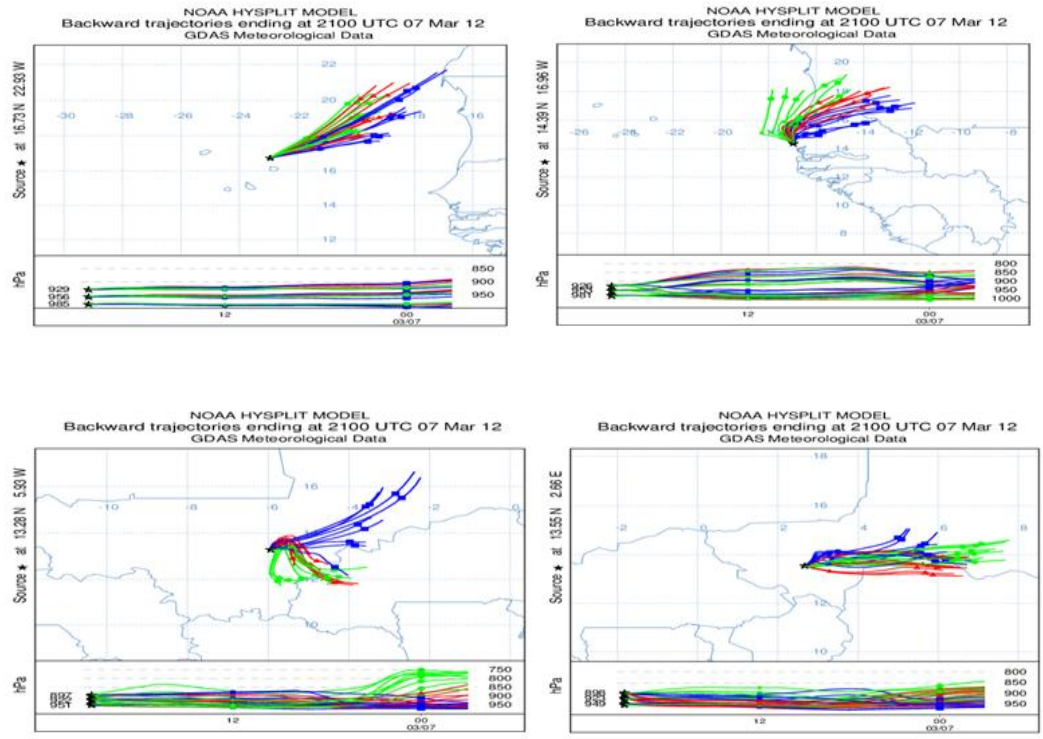
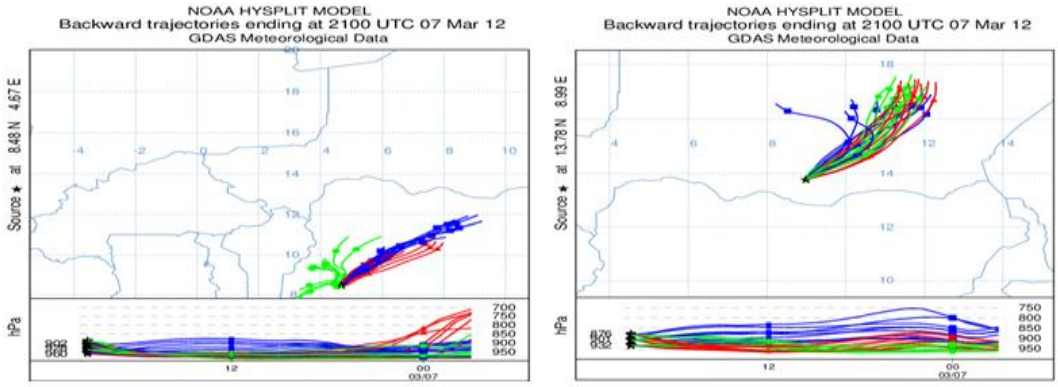


Fig.3 Overall Air Mass Trajectories By The Hysplit Model From The Six Aeronet Stations Considered In West Africa





At the CinzanaIER site, the aerosol-laden air masses are in very different directions. The trajectories take the initial direction of the south of Mali, towards the region of Sikasso, before changing direction towards the northwest of Burkina-Faso. Then, from the same source (CinzanaIER site), the air masses are transported towards the north of Burkina, and towards central Mali where they can reach the south of the Tombouctou and Gao regions. In addition to locally generated aerosols, aerosol particles in the atmospheric columns of the extended area between northwest Burkina and southern Gao and Timbuktu originate from the IER site in Cinzana. From the Banizoumbou station, aerosol-laden air masses, mainly consisting of dust, are transported along directed trajectories from northern Nigeria to central Niger during March. In this month when the aerosol subsidence time is quite long in this locality due to lack of precipitation, the aerosols are subjected to long range transport and can reach the whole area covering northern Nigeria and central Niger. At Ilorin station, the air masses are transported in various directions from northwest to northeast during the month under consideration. The coarse and fine aerosol particles they contain can be located in regions from northeast to northwest of the Nigeria. The optical parameters reveal in this month high aerosol loads consisting of coarse and fine mode aerosols which are of both natural and anthropogenic origin. From Zinder station, the trajectories are numerous but less varied during March when the aerosol load in the atmosphere is very considerable. The aerosols contained in the air masses coming from the Zinder site are mainly located in the center of Niger. These observations suggest that atmospheric aerosols from different sources in Africa are scattered, depending on the local wind regime, in the West African region in the lower middle layers of the atmosphere. These aerosols consist mainly of a mixture of fine and coarse mode aerosols originating from natural processes but also from socio-economic activities in different localities. West Africa region is a potential source of aerosols subject to long-range transport conditions that can bring them to regions of northern and central Africa.

The analysis of the air mass back trajectories from the six AERONET sites suggests the dispersion of coarse mode aerosols, fine mode aerosols and a mixture of both modes throughout the West African region and beyond. Aerosols from Zinder, Banizoumbou and IERCinzana sites are predominantly coarse mode during the months of March to June, while fine mode aerosols from Dakar and Cape Verde sites are predominantly in May, June and July. The other months, apart from those mentioned for these stations, are characterized by a mixture of aerosols with a considerable proportion of fine and coarse modes of aerosols from these sites. Aerosols with a high predominance of fine mode, which represents a significant share of anthropogenic aerosols, are estimated to be sourced in Ilorin from the months of July, August, September, October and November, and are transported in the lower and middle atmospheric layers and in the troposphere to various locations in West Africa and beyond. These observations indicate strong socio-economic activities in the city of Ilorin, such as transport, agriculture, industry and culinary needs. From December to June, the proportion of coarse particles increases considerably, resulting in a mixture of fine and coarse mode aerosols, similar to the other sites, which spread across the region. These results indicate that locally generated atmospheric aerosols in West Africa are subject to long-range transport according to atmospheric dynamics, which are found in other parts of Africa and beyond the african continent. The results of this study are in agreement with those of Korgo *et al.*, 2014, who reported that air masses in the city of Ouagadougou frequently originate from the Mediterranean, southern Libya and northern Chad from November to March, and the Gulf of Guinea from May to October. These trajectories are subject to alternating harmattan and

monsoon winds, which determine the different seasons in West Africa region.

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