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RESEARCH ARTICLE

PRELIMINARY RESULTS OF ATMOSPHERIC AEROSOLS MEASUREMENTS OVER CHAD RAINFALL IMPACT ON PARTICLES QUANTITATIVE STUDY

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ABSTRACT

This paper studies the vertical distribution of atmospheric aerosols by concentrations and mid-volume diameters over three localities in a band of land situated likely inthe middle of Chad, namely N'djaména in the western, Abéché in the centre and Amdjarass in the eastern parts of the country. The measurements were made in the program OPEN with the use of aircraft and appropriate instruments presented in the text. This experiment took place from 2011 to 2012. It precised our knowledge on the vertical distribution of aerosols in the atmosphere. Notably, they are more concentrated near the earth surface and decrease with the height increasing. They are encountered till almost altitude 6000 m. With regard to their mid-volume diameters, various sizes particlesare observed in the troposphere till altitude around 5000 m. Their mid volume diameters vary from 0.2 to 0.8 µ m. Upper height 5000 m particles with mid diameters from 0.2 to0.5µm are most encountered, particularly during the rainy season. This vertical distribution is the consequence of the rainfall impact on the aerosols. The quantification of the washing effect of rain on atmospheric particles indicated that this phenomenon is intense near the desert.

INTRODUCTION

Aerosols are particles: liquid, solid, gas, including other components, in suspension in the atmosphere. They have various dimensions. Based on this criterion they are classified as follows:

- Aerosols of Aitken: their diameters are included between 0.001 and 0.1 µm.
- Big aerosols: their diameters vary from 0.1 to 1.0 µm.
- Giant aerosols: their diameters are between 1.0 and 10.0 µm.

Some former studies (Peter V. Hobbs and al., 1985) indicate that the concentrations of aerosols in the air are as follows:

- From 1000 to 5000 cm^{-3} for aerosols of type a).
- Around 100 and 1 cm^{-3} for aerosols of types b) and c) respectively.

Aerosols play a very important role in the cloud physic in general, and the formation of precipitations in particular.

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An atmosphere without aerosols cannot give rainfall as its relative humidity should be at last 500% above the normal value and this amount is unreachable in normal atmospheric conditions (Abdou, 2013). During these last years, some changes in the global climate are observed. Their impacts in local climate are noticed. Thus, some regions in the world are under constant influences of drought, others are facing frequent flogs. Their socio economic consequences are usually very considerable. This situation has forced governments and scientists of all over the world to search ways and means to prevent and even avoid such catastrophes. Today, one and the most encountered solutions to this problem is the cloud enhancement which consists of the modification of the structure of clouds by introducing new elements in the atmosphere. Thus, drought can be eliminated in an area, and inversely, depending on the structure of clouds and the introduced elements, (Abdou, 2013). It is clear that for the treatment to be successful, a better knowledge of the cloud structure over the considered region is required. Between other parameters to be known we have the followings: the type of aerosols, their concentrations and sizes. It is also obvious that aerosols carry a lot of diseases into the atmospheric air. When they are many in the air during the dry season, people suffers from various diseases such as ophthalmological, dermatological and cardio vascular ones, between others; inversely during the rainy season. Thus, it is clear that the rainfall impact on the distribution of these particles in the air cannot be neglected because of its cleaning effect on the atmosphere. This study concerns the vertical distribution of the concentrations and sizes of aerosols over N'djaména, Abéché, Amdjarass, and the quantification of the rainfall impact on this distribution. These cities are situated likely in a band of landnear the middle of the country, from west to east, as indicated in Figure 1.1.Except N'djaména, the capital of the country with many inhabitants, a lot of vehicles, big buildings and few small size factories, they are not industrial cities, small towns with few inhabitants. Thus, the aerosols over these localities are natural and are introduced in the air mainly by atmospheric turbulences.

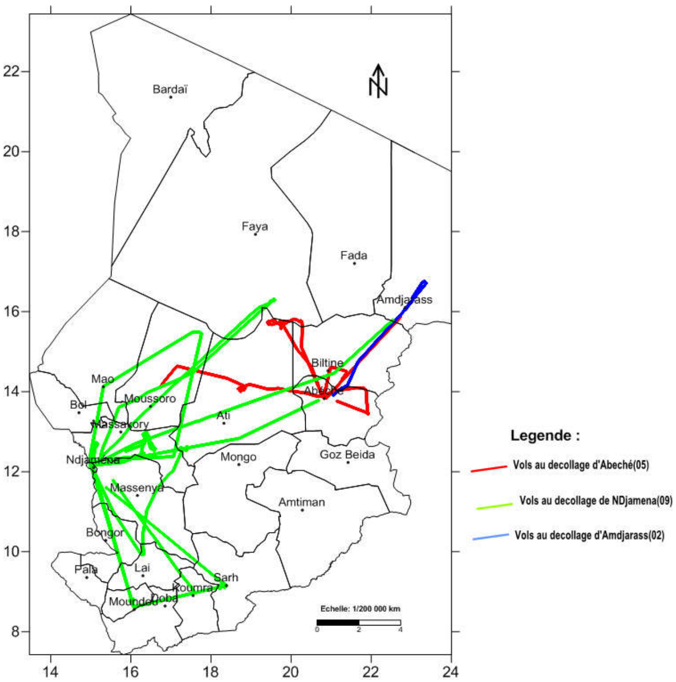

Figure 1.1. Localities of study. Directions of different flights: green – flights from N'djaména, red – flights from Abéché, blue – flights from Amdjarass

This paper contains five paragraphs. The first one is the introduction. The second gives some recalls about cloud enhancement program in Chad. The third presents the materials used during the experiment and the methodology applied. The results are analyzed in the fourth paragraph. The fifth is the conclusion. The bibliography ends the study.

Some recalls about the program "OPEN"

Chad is a sahelian country. As many others, ithas suffered a lotfrom a series of long and devastating droughts since late 1960's, (Nicholson, 1993; Le Barbe and al., 2002). In this series, droughts of years 1970 and 1980 can be recalled because of their more devastating effects. Again in year 2002 a severe rainfall deficit occurred in many countries of the area and forced the concerned governments as well as the international community to face a costly food supply to their inhabitants. This situation seems to continue nowadays. These frequent events prompted many authorities on the affected regions to put in place a rain enhancement program to help mitigate the devastating effects of its deficit in general, and to develop the operational capabilities to avoid it in particular.

This program was put in place under the French denomination "Opération Ensemencement de Nuages", in shorts "OPEN". Among these countries the next can be recalled: Morocco, Burkina Faso, Niger, Senegal and Chad. The program OPEN in Chad was executed during the period 2010 - 2015. The measurements were done in two different periods: by the ends of the dry and rainy seasons.

MATERIALS AND METHODOLOGY

Localities

Chad is a wide country of almost 1284000 km^2 situated between 7°-24°N and 13°-24°E. The experiment was carried out in N'djaména in the western part of the country near the boundary with Cameroon, in Abéché in the centre and Amdjarass in the eastern part of the country near the boundary with Sudan.

Instruments

During the experiment, many atmospheric parameters were observed, such as aerosols, cloud droplets and cloud condensation nuclei. Consequently, many instruments were used. As our paper concern only the aerosols, our attention is focused to the one used to measure the characteristics of aerosols, namely the "Passive Cavity Aerosol Spectrometer Probe 100X", in shorts "PCASP-100X". It has two main parts: a laser beam producer and an optical system. It works as follows. The intensity of the diffused light on aerosols passing through the laser beam permits to determine the number and size of particles with diameters from 0.1 to 3.0µm. This instrument was installed in an aircraft King 200 for flights in the atmosphere over the considered localities. Measurements wereoften made till a maximum altitude of 8000 meters above the earth surface.

METHODOLOGY

The aircraft flight paths were of two types. The first one was the straight line take-off of the plane. For the second type, the take-off path had a spiral form and at some levels the plane turned round many times and made many measurements before flying to the upper altitude. All this data are available at the Department of Physics of the above mentioned Faculty. The data treated in this paper come from the first type flight which took place the following dates.

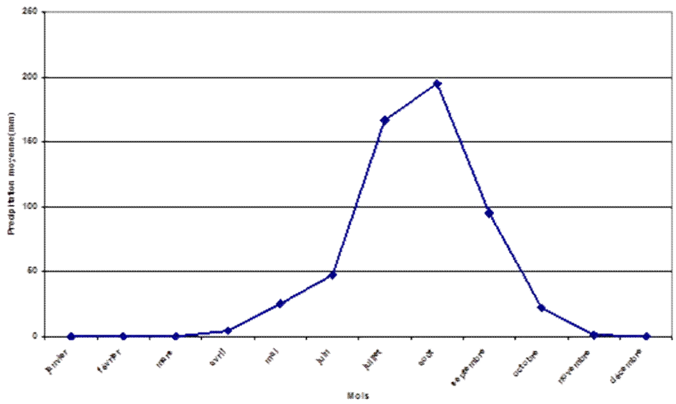

Figure 3.1. Monthly pluviometry in N'djaména Data from 1985 to 2015

For N'djaména: 20.08.2010a; 04.10.2010; 02.07.2011 and 19.06.2014.

For Abéché: 03.09.2010; 18.09.2012; 21.09.2012 and 28.07.2013.

For Amdjarass: 28.08.2010b and 31.07.2013.

As one can noticed, all the flights took place from June to October. The meteorological bulletins of Chad indicate that this period climatologically corresponds respectively to the ends of the dry and rainy seasons in the country. Figures 3.1 and 3.2 drawn for N'djaména and Abéché confirm this statement.

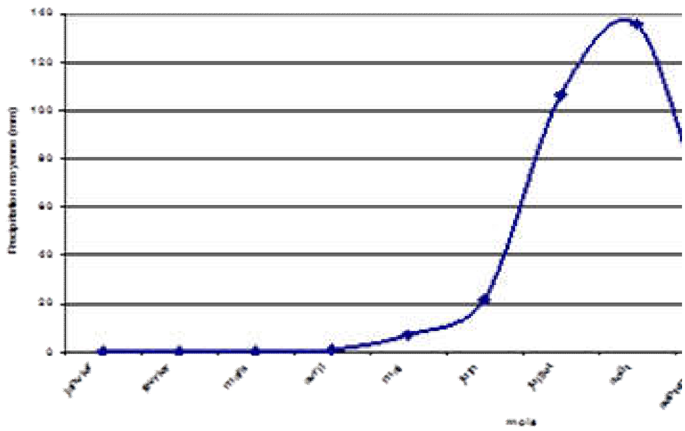

Figure 3.2. Monthly pluviometry in Abéché Data from 1985 to 2015

Thus, our data is divided into two groups: the first group concerns the end of the dry season (June and July), the second one– the end of the rainy season, (September and October). The data of each group is analyzed apart and the results are compared between themselves to highlight the rainfall impact on the aerosols in each locality. First the vertical distribution of particles by concentrations is analyzed, then their vertical distribution by mid volume diameters.

RESULTS AND ANALYSIS

Vertical distribution of the concentration of aerosols

Locality of N'djaména

The measurements done during the flights of02.07.2011 and 19.06.2014 are in Figures 4.1 and 4.2. They show that the vertical distributions of the concentrations of aerosols were high near the earth surface and deceased with the height increasing. Near the earth surface, the average concentrations were respectively 550 cm^{-3} and 325 cm^{-3}. These values fell to 250 cm^{-3} around altitude 3500m and 200 cm^{-3} around altitude 1000 m for the first and second flights respectively. Above these altitudes, the concentrations of aerosols increased with the height increasing to the average values of 500 cm^{-3} around altitude 6000 m and 350 cm^{-3} around altitude 2700 m, respectively. Upper these altitudes, these concentrations rapidly fell to 50 cm^{-3} around altitude 6500 m then it grew up to 175 cm^{-3} around altitude 7700 m, Figure 4.1. What concerns Figure 4.2, above altitude 2700 m and up, the concentrations of aerosols gradually decreased with the height increasing first rapidly till altitude 3000 m to the average value of 150 cm^{-3}, then slowly till altitude 5000 m to the average value of 140 cm^{-3}. Upper, it decreased faster till around altitude 6000 m to the average concentration of 20 cm^{-3}.

Results of the flights of 28.08.2010a and 04.10.2010,are presented in Figures 4.3 and 4.4. Theyalso indicate high concentrations of aerosols near the earth surface and its decrement with the high increasing. At different altitudes the following average values were registered: near the earth surface, 550 cm^{-3}; at 1000 m, 350 cm^{-3}; at 2700, 80 cm^{-3}; at 3000 m, 40 cm^{-3}; at 3500 m, 20 cm^{-3}; at 5000 m, 10 cm^{-3}; at 6000 m, 5 cm^{-3},(for the flight of 28.08.2010a)and 750 cm^{-3}; 1200 cm^{-3}; 175 cm^{-3}; 175 cm^{-3}; 100 cm^{-3}; 50 cm^{-3} and 5 cm^{-3}, (for the flight of 04.10.2010 and at the same altitudes).

Figures 4.1–4.2 and 4.3–4.4 permit us to estimate the average concentrations of aerosols at different altitudes and to quantify the cleaning effect of rainfall on these particles. These estimations are presented in Table 4.1 at heights: 1000, 2000, 3000, 4000, 5000 and 6000 m. It clearly indicates that aerosols are observed in the whole first half of the troposphere, that their concentrations in the atmosphere are higher in the dry season than in the rainy season and that they decrease with the height increasing. This distribution can be explained by many reasons. Between others, Chad is under a permanent influence of the inter-tropical zone of convergences, and thus, under constant intensive atmospheric turbulences. As its soil is sandy, turbulences easily carry a lot of giant and big particles deeply into the first half of the troposphere.

The washing effect of rainfall on aerosols is not perceptible at level 1000 m where it seems that particles are accumulated. At other levels, rainfall effect is remarkable. The result at level 1000 m is quiet unexplainable and is probably due to a wrong manipulation of the instruments. One may think that these instruments were not yet well-adjusted after the plane took-off. Table 4.1.Average concentrations of aerosols and rainfall impact on particles at N'djaména.

Altitudes (m)	Average concentration by the end of the dry season (cm^{-3})	Average concentration by the end of the rainy season (cm^{-3})	Balance between the first and second average values. (cm^{-3})
Near earth surface	550	325	225
1000	350	775	-425
2000	350	238	112
3000	250	113	137
4000	250	138	112
5000	275	100	175
6000	113	15	98

Locality of Abéché

Here only one flight took place by the end of the dry season on 28.07.2013. The results are presented in Figure 4.5. It indicates higher concentrations of particles near the earth surface with average values around 700 cm^{-3}and their decrement with the height increasing till altitude 1000 m where they fell to 90 cm^{-3}. Upper till 3000 m these concentrations increased with the height increasing to around 250 cm^{-3}. Above 3000 m, firstly the concentrations slowly decreased till altitude 4000 m to about 200 cm^{-3}, then rapidly till altitude 5000 m to about 40 cm^{-3}, and again slowly till 6000 m where they were tending to zero.

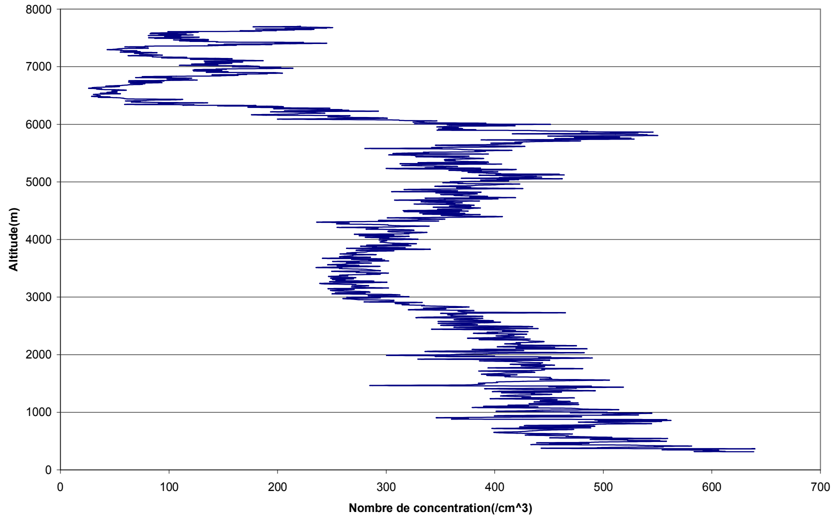

Figure 4.1. From the measurements of the fight of 02.07.2011 over N'djaména

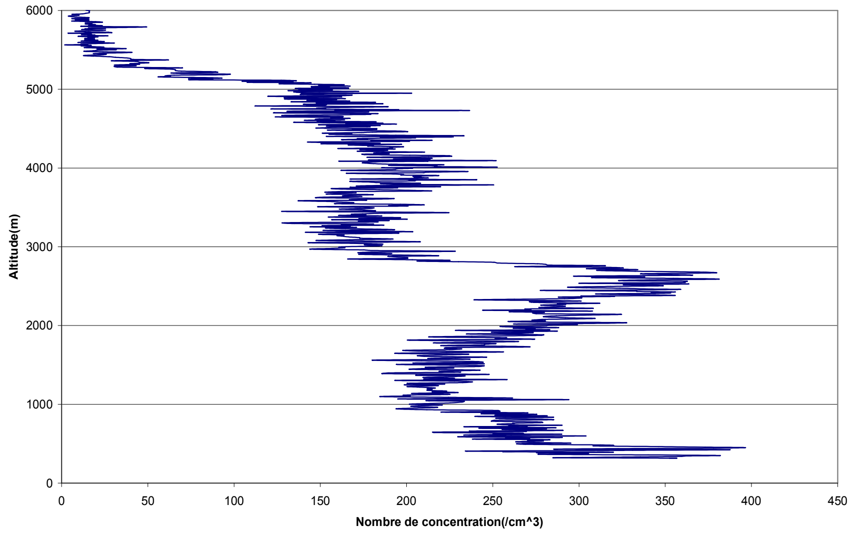

Figure 4.2. From the measurements of the fight of 19.06.2014 over N'djaména

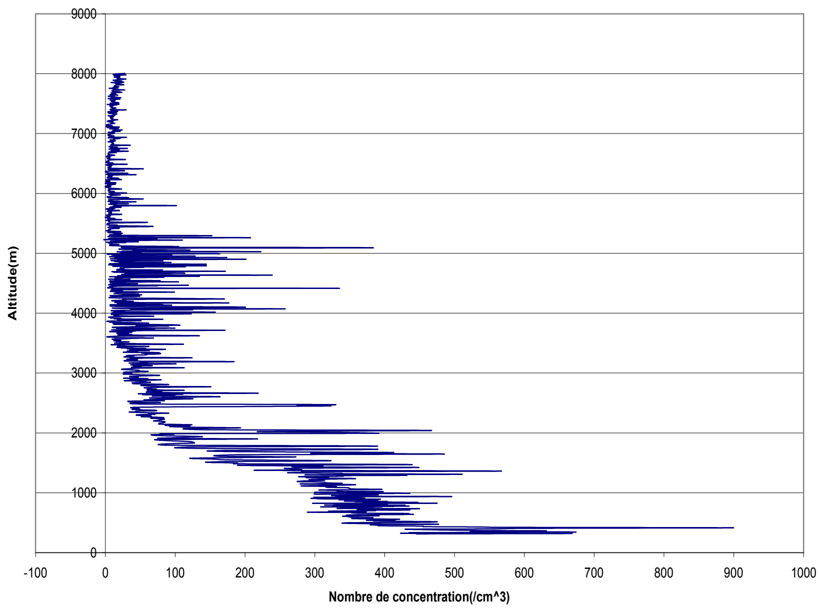

Figure 4.3. From the measurements of the fight of 28.08.2010over N'djaména

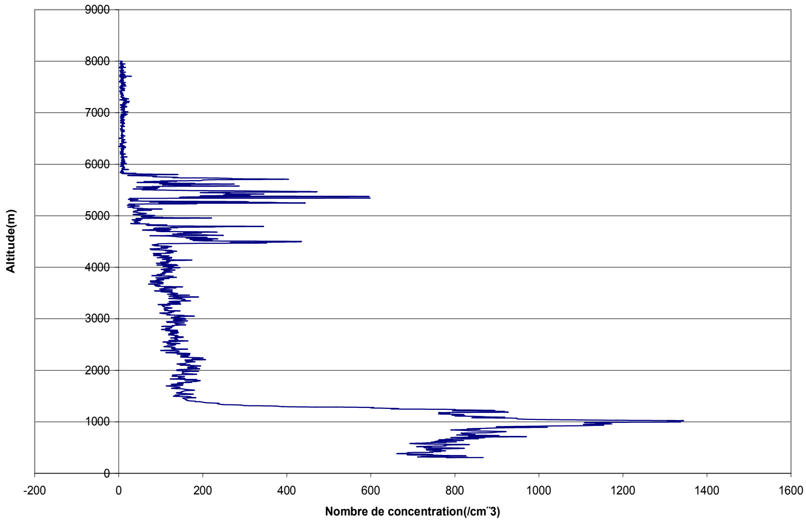

Figure 4.4. From the measurements of the fight of 04.10.2010 over N'djaména

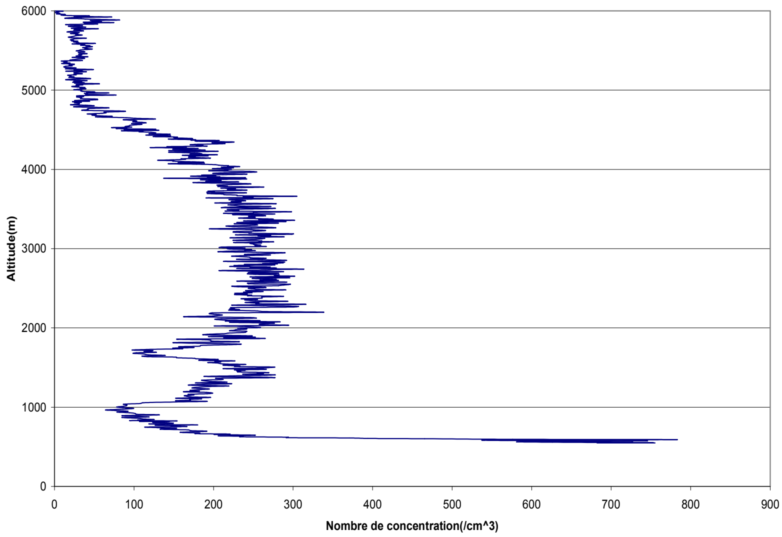

Figure 4.5.From the measurements of the fight of 28.07.2013over Abéché

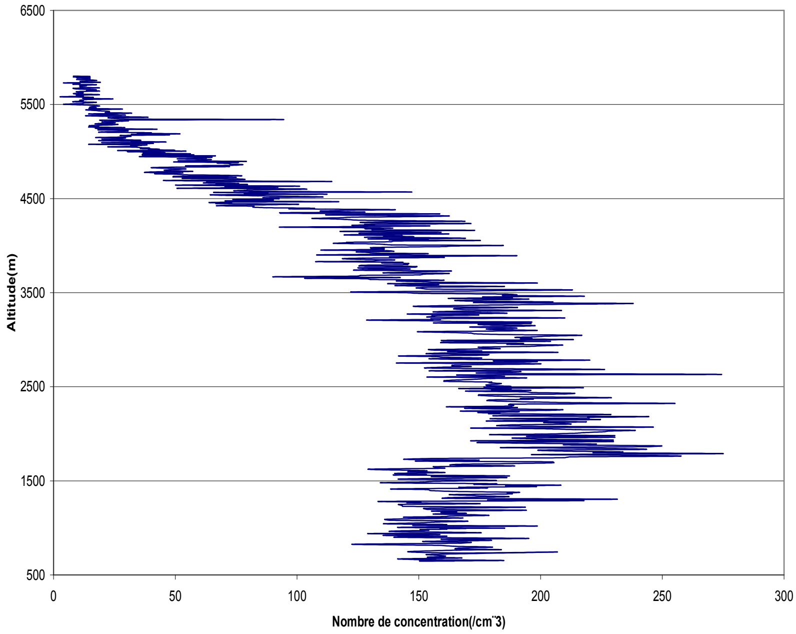

Figure 4.6. From the measurements of the fight of 18.09.2012 over Abéché

Three flights were executed by the end of the rainy season. The results of only two, i.e. the ones of 18.08.2012 and 21.09.2012, are presented in Figures 4.6 and 4.7. This is due to the fact that they have no significant difference between themselves. Both figures show high concentrations of aerosols near the earth surfaceand their decrement with the height increasing. They were used to estimate the concentrations at the next altitudes: near the earth surface, 175 and 225 cm^{-3}; at 1000 m, 180 and 200 cm^{-3}; at 2000 m, 225 and 200 cm^{-3}; at 3000 m, 180 and 180 cm^{-3}; at 4000 m, 140 and 150 cm^{-3}; at 5000 m, 40 and 10 cm^{-3}, respectively.

4.9, the concentrations were 250 cm^{-3} near the earth surface and decreased with the height increasing to values of about 100 cm^{-3} at altitude 3300 m from where they rapidly increased to the values of 350 cm^{-3} at altitude 3700 m. From here up, the average concentrations were decreasing with the height increasing. Comparison of the results of both flights enabled us to estimate the rainfall effect on the aerosols in the atmosphere. These estimations are contained in Table 4.3. Comparison of Tables 4.1-4.3 brings us to the next conclusions. In general, atmosphere in Amdjarass contains more aerosols than in N'djaména and Abéché, particularly during the dry season.

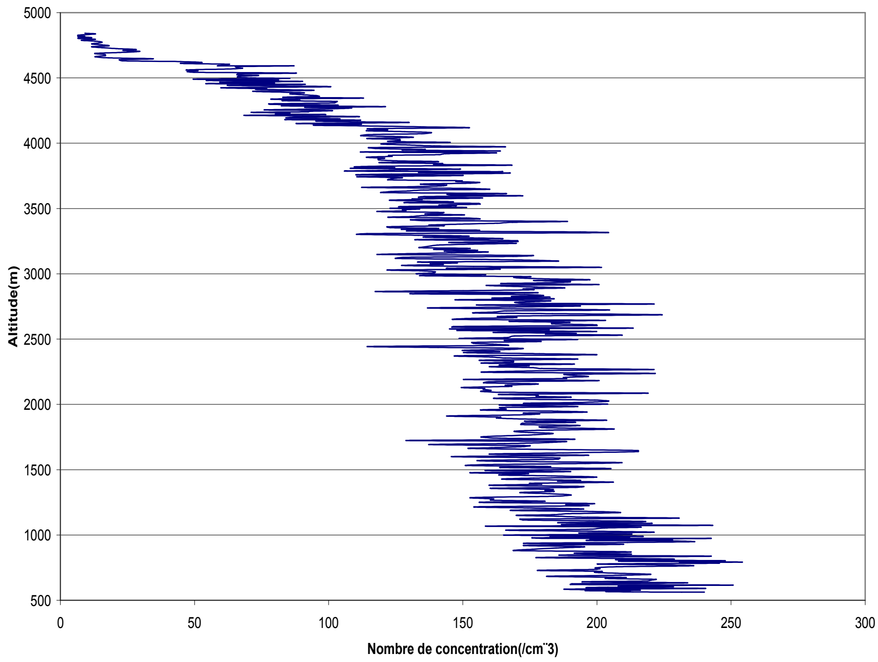

Figure 4.7. From the measurements of the fight of 21.09.2012 over Abéché

Taking into consideration the results of flights executed by the ends of dry and rainy seasons enabled us to highlight the rainfall impact on the vertical distribution of particles in the atmosphere and to build Table 4.2. Analysis of Tables 4.1 and 4.2 brings us to the following conclusions. In general, the atmosphere in N'djaména contains more particles than in Abéché particularly during the dry season, except in layers between 3000-4000 mduring the rainy season. The comparison of both tables indicates that the washing effect of the rain on aerosols is very important in N'djaména than in Abéché. This can be explained by the proximity of the rivers Logone and Chari in N'djaména while Abéché is closer to the Sahara desert.

Locality of Amdjarass

For this locality one flight was executed at the end of the dry season on 31.07.2013, and one - at the end of the rainy season on 28.08.2010b. The results are presented in Figures 4.8 and 4.9, respectively.

As in the two former localities, the concentrations of aerosols were high near the earth surface and generally decreased with the height increasing. In particular, the average concentrations were: near the earth surface 550 cm^{-3}, at levels 3500 and 4700 m - 450 $cm^{-3}$and 70 cm^{-3}, Figure 4.8. For what concerns Figure

Table 4.2. Average concentrations of aerosols and rainfall impact on particles at Abéché

Altitudes (m)	Average concentration by the end of the dry season (cm^{-3})	Average concentration by the end of the rainy season (cm^{-3})	Balance between the first and second average values. (cm^{-3})
Near earth surface	700	200	500
1000	90	190	-100
2000	220	213	7
3000	250	180	70
4000	200	145	55
5000	40	25	15
6000	5	-	-

Table 4.3. Average concentrations of aerosols and rainfall impact on particles at Amdjarass.

Altitudes (m)	Average concentration by the end of the dry season (cm^{-3})	Average concentration by the end of the rainy season (cm^{-3})	Balance between the first and second average values. (cm^{-3})
Near earth surface	550	250	300
1000	500	300	200
2000	480	220	260
3000	450	200	250
4000	300	280	20
5000	70	50	20

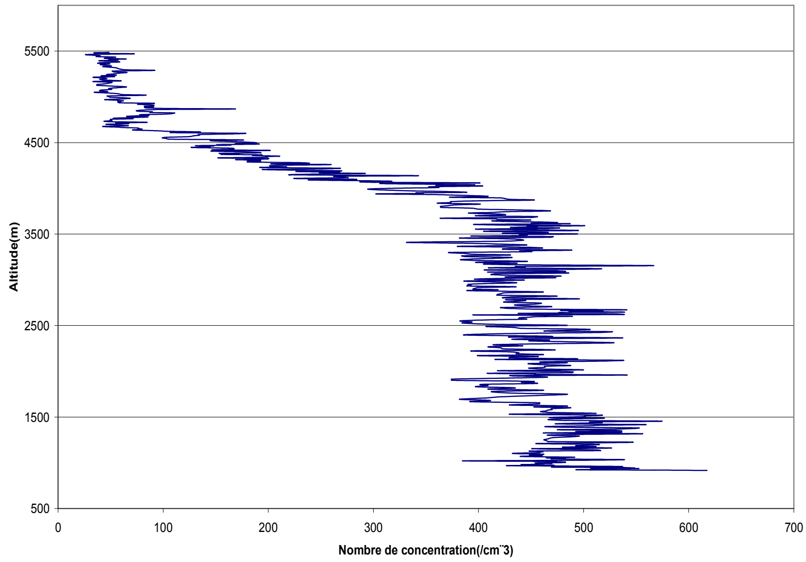

Figure 4.8. From the measurements of the fight of 31.07.2013over Amdjarass

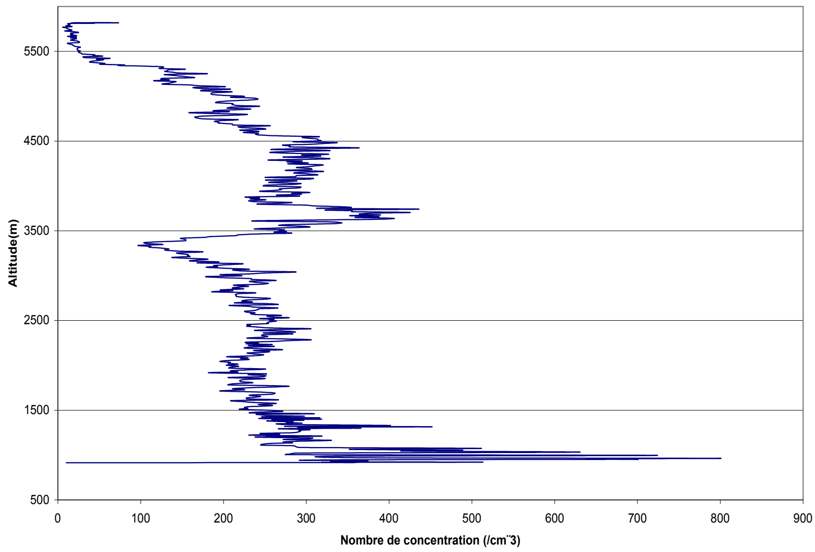

Figure 4.9. From the measurements of the fight of 28.08.2010b over Amdjarass

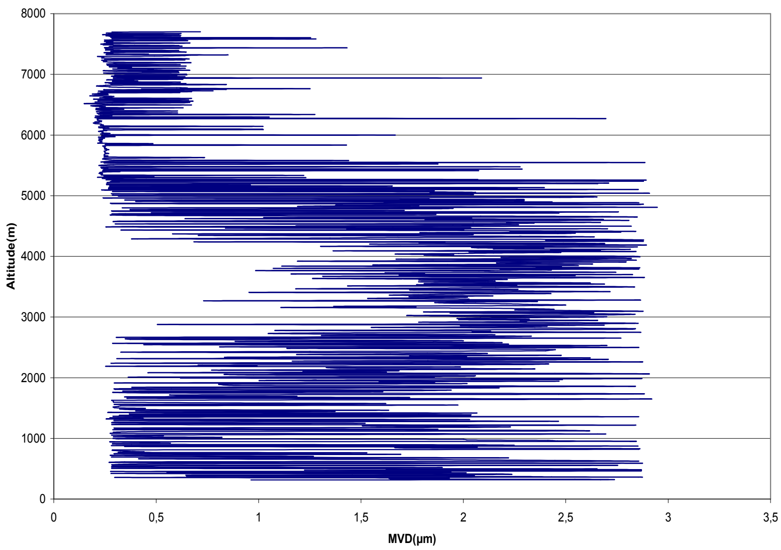

Figure 4.10. Vertical profile of the mid-volume diameters of aerosols over N'djaména on 02.07.2011

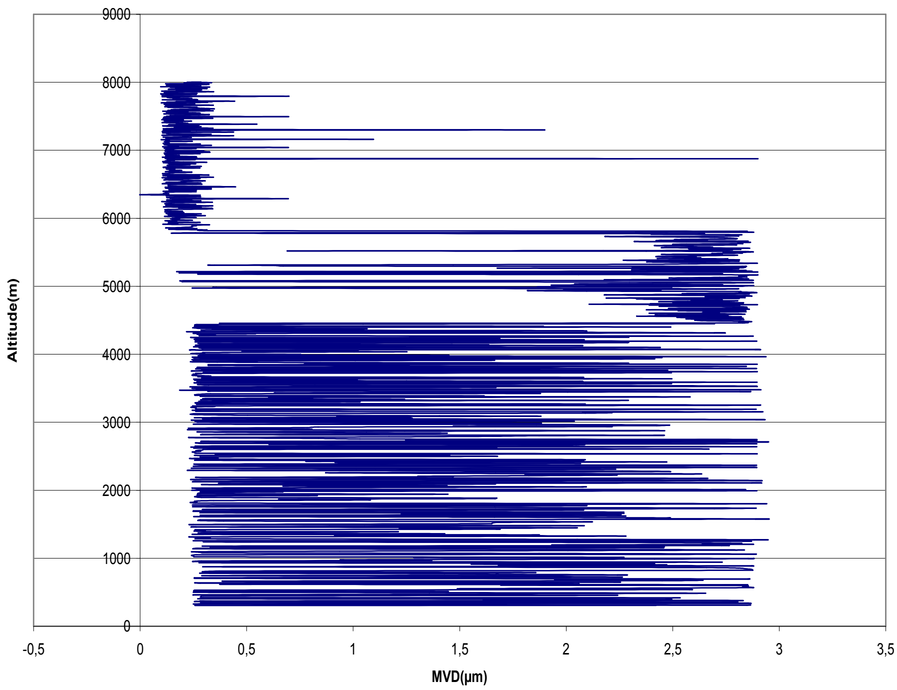

Figure 4.11. Vertical profile of the mid-volume diameters of aerosols over N'djaména on 04.10.2010

The rainfall impact on them is more important in Amdjarass near the earth surface till height 3000 m than in the two previous localities. This study shows that in general, the aerosols are more intense in the atmosphere near the earth surface and their quantities decrease with the height increasing. It indicates that the concentrations of aerosols in the atmosphere are higher during the dry season than the rainy season because of the washing effect of the rainfall on the particles. At last, quantitative estimations of the rainfall impacts on the vertical distribution of aerosols in the atmosphere over the concerned localities are given.

Vertical distribution of the mid-volume diameters of aerosols

These measurements enabled us to have a better idea on the sizes of aerosols and their vertical distributions in the atmosphere over the considered localities. Their analysis has shown many similarities, particularly in the lower troposphere till approximately altitude 5000 m. Thus, only the results of flights of 02.07.2011and 04.10.2010 respectively for the ends of the dry and rainy seasons in N'djaména are presented in Figures 4.10 and 4.1. In general from the earth surface till altitude roughly 5000 m were particles of various sizes. There mid volume diameters varied in the interval0.2-3.0 µm.Upper 5000 m, we have the predominance of particles with mid-volume diameters from 0.2 to 0.8µm, Figure 4.10, and 0.2 to 0.3µm, Figure 4.11. Thus, the number of big particles in the atmosphere is high in the dry season than in the rainy season. This distribution is the consequence of the rainfall effect on big aerosols.

Conclusion

This study gave us better information on the vertical distribution of aerosols in the atmosphere based on their concentrations and on their mid-volume diameters. The main results are the followings. Aerosols are more concentrated near the earth surface and they decrease with the height increasing. This decrement with the vertical is not homogeneous. With regard to their sizes, all dimensions are encountered in the atmosphere till altitude of about 5000 m. The washing effect of rainfall on aerosols is very intense on big particles on near the earth surface than on small ones. It permitted us to quantify the washing impact of the rainfall on the vertical distribution of these particles.

REFERENCES

Abdou Ganda Mahamadou 2013. Mise en evidence de l'effet de traitement par sels hygroscopiques des cumulus congestus en zone sahélienne. Mémoire de fin d'étude pour l'obtention d'un M.Sc. en Physique de l'Atmosphère et du Climat. Faculté des Sciences Techniques, Université Abdou Moumouni, Niger.

Le Barbé T., T. Lebel, D. Tapsoba 2002. Rainfall variability in West Africa. A hydrological perspective. *J. Climate*, 15(2), p. 187-202.

Nicholson S.E. 1993. *An overview of rainfall fluctuations of the last decade*. J. of Climate, 6, p. 1463-1466.

Peter V. Hobbs, David A. Bowdle, Lawrence F. Radke 1985. Particles in the lower troposphere over the High Plains of the United States. Part I: Size distributions, elemental compositions and morphologies. *J. of Climate and Applied Meteorology*, vol. 24, p. 1344-1356.

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