# EFFECTS OF WEATHER ELEMENTS ON FLIGHT OPERATIONS AT THE NNAMDI AZIKIWE INTERNATIONAL AIRPORT, ABUJA – F.C.T.

BY


**HYELNI HARUNA BASSI**

***M. TECH/SSSE/773/2001/2002***


***SUBMITTED TO THE DEPARTMENT OF GEOGRAPHY***

***FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA***

***IN PARTIAL FULFILLMENT OF REQUIREMENT FOR THE AWARD OF***

***MASTER OF TECHNOLOGY DEGREE IN METEOROLOGY***

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## *ABSTRACT*

Cancellation of flights, diversions, delays and even crash-landing of air crafts are common experience in our airport, as a result of bad weather, which ranges from mere clouds, strong winds, to simply visibility restrictions.

Therefore the effect of weather elements can never be overemphasized on flight operations. The data used for this study was collected at the Metrelogical Department and Air traffic services Department of the Nnamdi Azikwe International Airport, Abuja, (NAIA) FCT. In general, climatologically summaries for the period 1991-2000 (10 years) form the main set of data used in specific analysis on the climatic element (Atmospheric pressure, winds, air temperature, precipitation, cloud types and visibility) and related weather hazards (thunderstorm and harmattan dust haze).

The work showed that sourtherly wind conditions dominates both the seasons, thus, favouring the use of run-way22 during the most part of the year. Low clouds are predominant during the wet season and the total amount of cloud cover is also greater during the wet season. Pressures is generally lower during the wet season and higher during the dry season. Visibility is generally fair, the difficult periods for flight operations are the early hours (0000 – 0600z) for the months of October to February. Thunderstorm affects Abuja

Airport during the afternoons from (1200 – 1800z). in the month of April to October. Optimal temperature conditions for flight operations is between the month of May and October. Precipitation is more frequent in the month of April to October every year.

In order to ensure that the conduct of flight operations remains safe and efficient, the nation must invest resources and effort in the existing and evolving infrastructure in the Nigerian Metrological Agency (NIMET). The individuals and organizations engage in the business of flying must have access to the most accurate, timely, reliable weather information

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***Chapter Five***

## *MEANINGS OF SOME ACRONYMS*

| | | |
|---|---|---|
| MFCT | - | Ministry Of Federal Capital Territory |
| N.A.I.A. | - | Nnamdi Azikwe International Airport |
| Ft | - | Foot |
| AMSL | - | Above Mean Sea Level |
| WAMEX | - | West African Mosoon Experiment |
| IATA | - | International Air Transport Association |
| AOPA | - | Aircraft Owners Pilot Association |
| NTSB | - | National Transport Safety Board |
| PAN MET | - | Procedure For Air Navigation For Meteorology |
| ILS | - | Instrument Landing System |
| ICAO | - | International Civil Aviation Organization |
| WMO | - | World Meteorological Organization |
| NAMA | - | Nigerian Airspace Management Agency |
| NIMET | - | Nigeria Meteorological Agency |

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# *CHAPTER ONE*

## *1.0 INTRODUCTION*

## *1.1 BACKGROUND*

While the ordinary task of daily life may be affected significantly the occurrence of single adverse weather event, modern agricultural business and industrial activities may even be paralyzed by relatively small changes in the weather.

In West Africa, the harmattan phenomena which are becoming a major sub-tropical anticyclone are the dry hot air by the day, cold air by the night, dust laden north east wind (harmattan) and early morning fog in the coastal areas which reduces visibility (Adefolalu, 1984). Hence air pollution and incidence of smog (smoke-dust-fog mixture) are to be expected during the dry season. The rainy season have various climatic events relating to thunderstorm occurrence, heavy precipitation and thick cloudiness.

On the whole, harmattan dust haze and fog during the dry season result to poor visibility, while severe thunderstorms and rains during the wet months causing flash flood and contamination of runway. The latter leads to the slippery runway. What is lacking among most airlines, especially in the developing countries of the third world like Africa, and which no national

meteorological service may be expected to provide, is a complete set of meteorological data in appropriate formats which can be used for long-term operational planning for both economic and "passenger comforts" reasons.

However, recent experiences relating to atmospheric electricity and power failures, disruption of transportation due to early morning fog and intense dust haze spells and the over increasing expenditure on road maintenance in all major urban settings due to erosion and flood should convince one of the need for weather related planning and decision making. The distribution and time (periods) of the most important weather events which affect flight operations over a period often years (1991-2000) are described in subsequent chapters. The occurrence of any phenomenon at a particular time of the year is a response to the variations in the circulation pattern of the atmosphere. For instance, formation of clouds and precipitation could be due to frontal or convective activity over a region.

From the above, therefore, it is obvious that a study of some of the weather elements of Nnamdi Azikiwe International Airport will be stimulating from aspects of its location within highlands and hills. The seasonal variability of any phenomenon associated with weather elements can be determined by mapping out the means monthly data for a specific number of years (10 years

in this case). This is carried out for those weather phenomena considered hazardous to flight operations in general .thereby ascertaining space-time distribution, frequency-intensity relationship and the trends of occurrence.

Whereas in a few hours line-squall and thunderstorms can be tracked in space when encountered enroute by aircraft or waited out in time, if sufficient warning is received before take-off, wide spread thick dust haze or persistent down pour on the other hand can render flight operations and hence substantial portions of the economy of the nation to a stand still. This was the situation during the severe spell of March 1977 during which many aircrafts were grounded for several days as visibilities were reduced below the critical landing and taking off values for most aircrafts in some local and international airports for example Adebayo (1977) indicated that 1,500 m is the critical take off or landing visibility for Boeing 707.

## *1.2 STUDY AREA*

Abuja is located in the middle belt region in the Guinea Savanna region of Nigeria. It is located geographically between latitudes 08° 25' and 09' 26' north of the equator and longitudes 06° 45' and 07' 45' east of the equator. Out of the 36 states, that make up the Federation, Abuja shares its boundaries

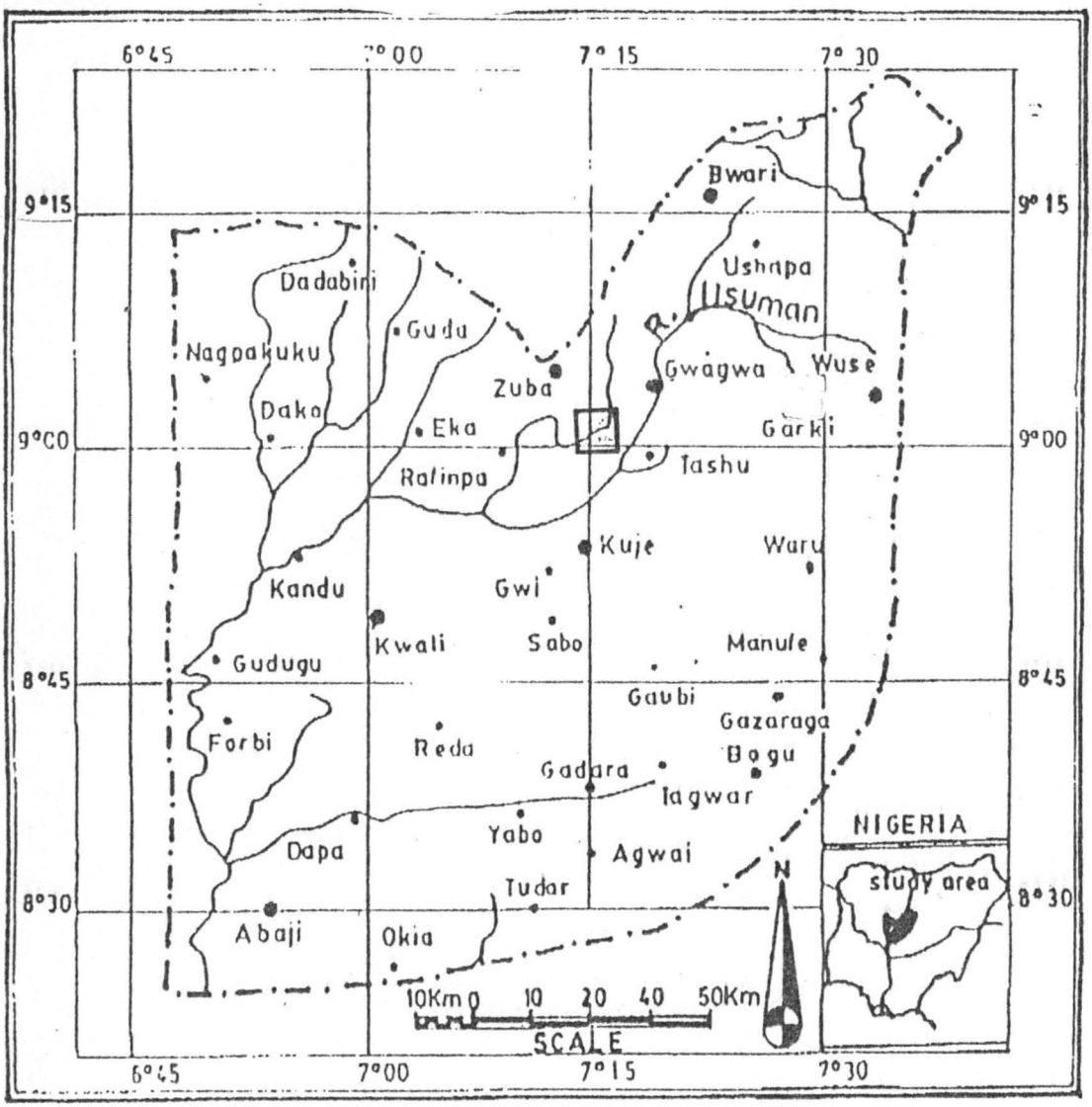
with four: Kaduna State to the north, Nassarawa to the east and south east, Kogi to the south west and Niger to the west.

Being in the tropical region, Abuja experiences two major weather changes in a year. The two seasons are: the rainy season and the dry season and are both of moderate levels. The dry season lasts from October through March while the rainy lasts from March through October. The harmattan season spans from November through March, with occasional dust haze, which sometimes could reduce atmospheric visibility to about 3 km. During harmattan, the weather is usually cold with low temperatures at night and early hours of the morning (MFCT, 1992).

The high altitude and undulating topography of Abuja has a moderating influence on me weather conditions (MFCT, 1992).

The Nnamdi Azikiwe International Airport, Abuja (N.A.I.A) (Study Area) is located on latitude 09 00 15'N and longitude 07° 15' 30''E situated about 40km west of the Federal Capital city. The airfield elevation is 342m above mean sea level (AMSL) and the reference temperature of maximum 35.6°C. The airport is the only air inlet and outlet for both domestic and international flights.

Some of the elements that are of interest are pressure variation, wind direction, rainfall, visibility etc., and the associated hazards which result from these and other elements are the dust haze, fog, thunderstorm, icing, just but to mention a few. These elements have direct and indirect effects on flight operations, the focal point of this study.




LEGEND

Boundaries of the Federal Capital Territory
The study area
Major Towns — Garki
Minor Towns and Villages — Kandu
Rivers

Fig.1 : ABUJA SHOWING THE STUDY AREA

## *1.3 PROBLEM STATEMENT*

Aviation is central to the world's way of life because it permeates nearly every facet of business, industry and recreation The Federal Aviation Administration estimates that commercial aircraft logged nearly 10 million hours airborne m 2000, while general aviation logged over 20 million hours. The United States Commercial carrier was reported to have carried over 100 billion passengers miles in 2000. All these projections, indicates an increase in aviation usage in coming decades (IATA,2000).

Aviation, perhaps more than any other mode of transportation today, is strongly impacted by weather conditions. Weather is a leading cause of aviation weather accidents. The atmosphere is continually adjusting to the forces operating on it from within and without. A patch of sky that may be quite benign to aircraft one moment can, within hours, or even minutes, become an extremely hazardous place to fly an aircraft. Weather conditions, whether good or bad, play a major role in the safe and efficient flight operations of every aircraft. The timely, precise, and accurate identification and localization of what are termed aviation impact variables that is weather-related conditions, such as wind shear, icing which may or may not be directly observable but which can significantly threaten flight operations safety and efficiency is of crucial importance.

Since civil aviation today is very much an international activity. The fastest and usually most comfortable means of international-continental travel is by air. In recent times, air transportation has gained so much over the other two "less expensive" but "time consuming" principal means of transportation sea and land - that one may easily conclude, that "with the globalization tendencies the world is in a hurry". It is appropriate therefore, to infer that airfare by itself which used to be far beyond the reach of many is being rapidly relegated to the background as more and more people take to air.

In 1976, for example, me Nigerian Airways alone carried a total of 654, 384 passengers on its three major service routes (Nigeria Handbook 1982). This has since greatly increased tremendously with time and as a result of the social, political and economic development has prompted a sudden increase in the number of airlines acquired by governments, private companies and international airliners.

Therefore, in order to serve the public properly, fight operations must be safe-economical and comfortable. To ensure this, the use of best aircraft and ground navigational facilities must not only be of greater concern to airline operators, but efforts must also be made to develop a high degree of

forecasting model that will relate the weather events (not changes) to the airline operators for smooth flight operations and to save lives and properties mat are being transported from time to time and from one place to the other. The effect of theses weather elements and the hazards they cause are also noticed in the area of reduced range 'of vertical and/or horizontal visibility on flight operations which can lead to cancellations of flights or diversions as well as losses in money and time to airliners and passengers alike. Crash landing and/or overshooting of runways by planes as a result of bad weather like presence of low clouds, gusty multi-directional winds flooding and consequent slippery runway to mention but a few, as well as lack availability of weather right-in-time information are also common in most airports.

## *1.4 AIMS AND OBJECTIVES*

This work is aimed at:

- Accessing the weather elements that can impact on flight operations.
- Evaluate the impact of the weather elements and its related hazards on flight operations.
- Proffer recommendation aimed at reducing and possibly eliminating the weather – related hazards on flight operations.

## *1.5 JUSTIFICATION*

Reduction and possibly, a total eradication of aircraft accident during flight operation in the airspace and airport in the very near future will depend, to a large extent, on the ability to understand the atmospheric weather events and the hazards that result, so as to be able to forewarn airline operators of the time of day/month and year that are non hazardous or dangerous to flight operations (air transportation).

Since this is related to weather elements effects, especially in their distribution in space and time, an understanding of their trend over the past years will over an opportunity for knowing what to be expected and how to go about avoiding them or at least reduce the extent of damages that may arise. Nothing could make this understanding possible other than a detailed study and analysis of some of these important weather elements like (pressure level, win direction, precipitation (rainfall), humidity etc. and the resulting hazards like (thunderstorm, dust haze, fog, drizzle, flood etc.) over time and space.

Similarly, mapping and analysis as stated above could be done using mean data for different periods of the day. After knowing the months or seasons of the year, weather phenomenon is considered to be hazardous to flight

operations- the periodicities of the phenomenon could be communicated to airline operators for their planning.

For this study, Nnamdi Azikiwe International Airport was chosen by the virtue of its importance as the country's gateway by air to the new Federal Capital Territory, which serves as the only airport for Diplomatic flights, International flights and Local flights on a 24 hours basis. And also being one of the fastest growing airports in Nigeria, second only to Murtala Mohammed International Airport, in Lagos it is justified to subject it to this type of study.

## *1.6 SCOPE OF THE STUDY*

The scope of this study is confined within the limit of the available data and information at the Nnamdi Azikiwe International Airport Meteorological/Forecast Office, Airline operators. Air Traffic Controllers, Meteorologist and other stakeholders in the aviation industry. Data collected for this study spanned a period often years (1991 - 2000). However, the reliability of the result obtained from the study depends on the accuracy and genuineness, of the data collected. Where there is vital information was found missing, attempts were made to infer certain values but in accordance with the previous and proceeding available information, so as to have a uniform

data organisation. These problems notwithstanding, efforts and care were made to achieve a very reliable data.

## *CHAPTER TWO*

### *LITERATURE REVIEW*

The past few decades have witnessed a number of developments in the study, analysis, estimation and prediction that have direct relevance and applicability in organizational forecasting. These advances in both theory and practice have been necessitated by the increasing complexity, competitiveness, and rates of change in the environment (McGee 1982). Organisation of all sizes find it essential to make future forecasts aimed at reducing the uncertainty of the environment and taking full advantage of the opportunities available to the organization.

Frequently, there is a time lag between awareness of an impending event or need and occurrence of that event. This lag time is the main reason for planning and forecasting. In this situation, forecasting is needed to determine when an event will occur or a need arises, so that appropriate actions can be taken (McGee, 1982). The ability to predict many types of evens seems as natural today as will the accurate forecasting of weather conditions in a few decades. The trend in being able to accurately predict more events, particularly, those of an economic nature will continue to provide a better base from which to plan. During the past decades, meteorology has undergone a number of important advances. This study thus provides an up-

to-date information for pilots and others whose interest in meteorology is primarily in its application to flight operations. It is therefore quite obvious that an international organization is needed to standardize operational practices such as rules of the air, air traffic control, personal licensing, aerodrome design, meteorological services etcetera. Thus in 1910, the first attempts to International - Co-operation was made by some European Countries (PANS-MET NCAT Zaria 1997).

The First World War gave a boost to the aviation industry, and the need was felt for a larger organization. During the peace conference following the war, the International Convention for air navigation was created (PAN-Met, 1987). It was soon followed by the International Commission for air navigation. The second world war was of greatest importance to the aviation industry. The speed, capacity, range and number aeroplanes increased tremendously and experience in world wide air transport increased rapidly. It was found that the operational, legal and economic aspect of aviation had to be coordinated unless there would be chaos. This led to a meeting in Chicago in 1944 between 52 nations from which the convention on international Civil Aviation (The Chicago Convention) emerged. The International Civil Aviation Organisation (ICAO) was officially formed on 4h April, 1947. Its headquarters is in Montreal, Canada with seven regional offices.

However, the Nigerian Airways was created in 1959 when it took over the operation of domestic air services in Nigeria from the disbanded West African Airways Corporation (WAAC) (Nigerian Handbook 1982).

Scheduled domestic and International air services within Nigeria were exclusively operated by the Nigeria Airways as well as scheduled Intercontinental services to various major airports over the world. Today the aviation industry has grown tremendously Nigeria with over 20 airports, thousand of flights daily recorded (Aviation Digest, 2002) with a domination of private participation.

Because of these functions coupled with the fact that different types of aircrafts are being handled, there is the need for proper documentation of associated weather elements that directly or indirectly hamper the smooth and safe operations of these aircrafts. Materials published on weather hazards over West Africa in general and Nigeria in particular have concentrated on involving forecasting techniques for the onset and dispersion of hazards primarily for civil aviation purposes.

If airline authorities realize these problems and the futility of addressing them from purely on economists financial angle, the question is: are there still other

"parasites" eating away the meager resources of the "not so" profit-making airlines? (Adefolalu, 1977). This brings the focus on natural phenomena which may be so influential as to negate the advantages of money and man-power "savings" which could be embarked upon to counteract the biting effects of operational cost. These natural phenomena are categorized as atmospheric weather patterns and systems whose study constitute the science of meteorology.

Anticipating the rapid growth and development of commercial aircraft operations, the World Meteorological Organization (WMO) working with the International Civil Aviation Organization (ICAO) has pioneered efforts to make dissemination of meteorological information available to operators of all Airlines. However, most of these are basically for day-to-day operations involving route and station weather forecasts and warnings.

Such approaches have been unreliable since they were dependent upon the first visible evidence of say dust emission in the desert source region. Recent works on weather related hazards problems discussed among others: Low-level jet techniques for the forecasting of the emission and subsequent southward advection of the dust (Adefolalu, 1968; Aina 1972). In the tropics, climatological, synoptic, meso-scale and divernal features have been observed

to play important roles on the distribution of precipitation to which most efforts in forecasting have been concentrated up to the present time (Palmer, 1952). As (he ultimate goal of any Airline is to operate its flight operations more safely and efficiently in order to satisfy that economic objective to make moneys, it is necessary to examine some of the ways in meteorology may be applied in achieving these goals through careful planning.

To do away with or reduce to a minimum daily flight operational "headaches", there is no substitute for a most thorough study and application of long-term variability of weather elements like: fog, rain, snow, severe thunderstorm, thick dust haze storms, frontal and other low stratiform clouds directly affect visibility (horizontal and slant) which is most crucial for landings or take off.

Therefore, in planning to establish new routes as called for by expansion, it is of primary importance to ascertain the variabilities of climatological, variables such as those listed above. It is not sufficient to base expansion programmes on the economic viability of certain sectors alone because planning which do not reflect the recognized and specific variability of mean weather patterns will not only result in the attendant failures of not operating to schedule but loss of revenue which will aggravate flight operational costs (Adefolalu, 1977).

In the broadest sense, there are meteorological elements or weather phenomena that does not affect one or more branches of aviation. The spectrum ranges from take-off and recovery of spacecraft, operation of all conventional aircrafts, to flight of hot air balloons. Weather forecast used in support of flights increase in time scale as endurance mounts (Beckworth, 1961). This increase also compromises the forecast accuracy, which usually deteriorates with time.

The important aspect of these studies is the fact that in West Africa, the variable nature of the basic climatic pattern from one year to the next is due also to the variability in seasonal synoptic features and scales of motion of the tropical atmosphere (Hassan, 1973). It is obvious from here that previous studies have emphasized climalological and synoptic scale of motion and their influences. There are climatological features like the sub-tropical anticyclone, monsoon trough or ITD trades and the monsoon which are well known.

West Africa is unique in, forms of the relative magnitude and roles of these features. However, lack of recognition of their influences on synoptic scale such easterly perturbations has resulted in attendant short-comings of routine weather forecasting in the region (Adefolalu, 1974). For examples, for a period of up to four months or more (November-February) spells of

harmattan dust haze affect the Sahalian region in the northern zone, while the early morning occurrence of fog and/or mist patches is rule rather than the exception in the southern zone. During the spreading and dispersal stages of the harmattan haze in the north, and under favourable conditions, harmattan haze is frequently observed in the southern zone (Kalu, 1978).

Although fog at the coast and harmattan haze in the hinterland characterize the dry season, cool season in West Africa, isolated local thunderstorms activity along the coastal belt is often reported. It is obvious that understanding the weather during dry cool months is a function of less number of variables than in summer. The interaction among these variables in summer is therefore more important.

Operational forecasting methods in West Africa is up till now qualitative, thereby making prediction very subjective. Forecasting the generation or formation and development of the African wave has become an obsession to the meteorologist not-withstanding the lack of a thorough knowledge of the role of the monsoon basic current as it relates to variabilities in intensity of the waves.

The question is not whether airlines require meteorological information to solve day-to-day flight operational problems and achieve maximum returns for investments. The attempt here has been to focus on these problems and treat them as being chiefly dependent on basic long-term planning which in the long-run is shown to be one of the primary causes.

The future of better forecasting therefore lies in incorporating the synoptic scale characteristics in short range weather prediction models. If forecasting is to become objective, numerical models should be developed as a matter of expediency. Most other countries within the tropics have already put to operational use numerical forecasting methods.

Events within the last decades, Sahelian droughts of 1983-84, flash flooding in Chad, Sudan in 1985 and adverse or severe harmattan haze every dry cool months even in the coastal areas of Nigeria have amply demonstrated the need for accurate weather prediction, if only to give an outlook for agriculture and allied activities such as aforestation and water resources management-aviation and surface transport industries. General Aviation accidents from 1982-1998 shows that about 27% were weather related (fig. 2.1).

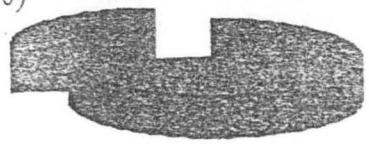
From the foregoing, it is evident that no single synoptic or climatological feature can be employed for a thorough understanding of weather in West Africa.

In order to improve on the mediocre level of efficiency in day-to-day short term forecasting, and incorporation of the interaction, between the basic current and perturbation is expedient. The objective has been to highlight the urgency of taking into consideration inevitable variabilities of the weather in long-term operational planning and it is hoped that some measure of success, no matter how small, has been achieved in satisfying this objective.

# Weather Safety Benefits Needed

41% during cruise

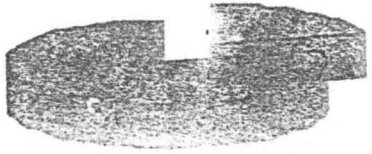
27% due to visual flight operation in instrument flight conditions




**GA Aviation Accidents 1982-1993**
**(22,053 total accidents)**
Source: AOPA Air Safety Foundation

Non-Turbulence-related Injuries (67%)

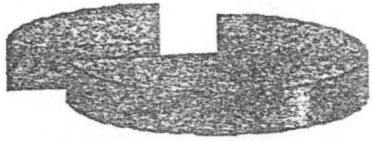
Turbulence Injuries (33%)
*Ranked #1 for Injuries*



**Commercial Transport Serious Injuries 1990-1996**
Fatal/Non-fatal Accidents
Source: NTSB Data

Weather-related (33%)

Non-weather-related (67%)



Commercial Carrier
**Accidents 1983-1995**
Source:NTSB

Fig 2.1 Flight - RelatedFHazards and Accidents

## *CHAPTER THREE*

## *3.0 METHODOLOGY*

### *3.1 DATA AND DATA SOURCE*

The data used for this study was collected at the meteorological department and air traffic services department of the Nnamdi Azikiwe International Airport, Abuja (N.A.I.A.) F.C.T. In general, climatological summaries for the period 1991-2000 (ten years) form the main set of data used in specific analysis on climatic elements at the Abuja Airport.

These elements are pressure, visibility, cloud types, precipitation, winds and temperature (maximum and minimum). Weather hazards on which data are available include harmattan dust haze and thunderstorms, with respect to the general data used for circulation and evolution of weather in tropical West Africa, a variety of weather information was employed for analysis and discussion.

Where possible, data were directly photocopied from records at the station, while others had been manually extracted before processing. Where daily mean values were omitted for some days correction were made by estimating the missing value using the general trend of the parameters involved.

## 3.2 COMPUTATIONAL METHODS

For the computation of mean, deviations -from the mean, conventional statistical methods were applied. These include:

### 3.2.1 Mean

If X (b, t) is a variable which is a function of month (b) and time of day (t), then, the mean X(t) and deviations $X^1$ (b, t) arc expressed for alt months. These are given below:

1. $$\overline{X}(t) = \frac{1}{N}\sum_{b=1}^{N} x(b,t)$$

2. $X^1$ (b, t) = X(b, t) -

   where b = 1, 2, 3, 4, 5

### 3.2.2 Probability of Occurrence of Cloud

Ordinarily: Given an event occurring "X" times during a certain period "Y". The general probability expression may be written as:

$$\Pr = \frac{X}{Y}$$

This is employed in showing probability of the occurrence of either, low cloud, medium or high clouds of each month of the year.

### *3.2.3 Conversion Table*

For the conversion of Imperial units of metric system, the formula are used:

$$^{o}C = \frac{5(^{o}F - 32)}{9}$$

$$F = \frac{9}{5(C + 32)}$$

Inch = 25.4mm

1000m = 1 km

### *3.2.4 Graph Plotted*

Graphical method was used to buttress the extent and distribution of the occurrences of certain parameters. There are:

i. Frequencies of occurrences of calm and south westerlies wind at main synoptic hours (0,000,000,1200,1800Z).

ii. Mean monthly sea level pressure

iii. Mean monthly surface temperature (maximum and minimum)

iv. Diurnal variation of mean annual sea level pressure

v. Trend in the frequency of occurrence of the hazards resulting from the weather elements e.g. thunderstorm, dust haze, fog and precipitation.

vi. Percentage frequency of occurrence of cloud types.

vii. Line graphs constructed to show the frequency of occurrence of the different hazards visibility & thunderstorm.

# *CHAPTER FOUR*

## *4.0 PRESENTATION AND DISCUSSION OF RESULTS*

## *4.1 WEATHER PHENOMENA*

### *4.1.1 WIND*

Pressure and temperature variations result in two kinds of motions in the atmosphere; the movement of air in ascending and descending currents (vertical motions) and the horizontal flow of air known as wind. Both of these motions are of primary interest to the pilot because they affect flight operations. For instance lift off and climb out during strong, gusty and variable wind conditions and in super cooled clouds that might produce aircraft icing too often result in incidents or accidents.

In this study, more emphasis is paid to horizontal flow of air. The wind system in the tropical region, is more as reponse to the general circulation which results in the primary wind system. The mean wind direction at the NAIA, Abuja is illustrated in Table 4.1.

During the dry season (northern Harmattan), the north – east trades usually known as harmattan invade the entire sub- region of West Africa, South to the coast.

Table: 4.1

***MEAN DIRECTION OF SURFACE WIND IN NAUTICAL MILES PER***

HOUR (KT) 1991-2000.

| | J | A | N | | | F | E | B | | | M | A | R | | | A | P | R | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| s | 00 | 06 | 12 | 18 | Hrs | 00 | 06 | 12 | 18 | Hrs | 00 | 06 | 12 | 18 | Hrs | 00 | 06 | 12 | 18 |
| r | | | | | Dir | | | | | Dir | | | | | Dir | | | | |
| | 1 | 1 | 2.5 | 1 | S | 1.5 | 2 | 3 | 2 | S | 3.5 | 2.5 | 3.5 | 5.5 | S | 9 | 4.5 | 8.5 | 9 |
| | 1 | 1 | 2 | 8.5 | N | 1.5 | 1 | 6 | 8 | N | 1 | 1 | 3 | 3.5 | N | - | 2 | 1.5 | - |
| | 3.5 | 2.5 | 7.5 | - | E | 1 | 1 | 1 | 2 | E | 3.5 | 2 | 2.5 | - | E | 15 | 1 | 1 | 2 |
| | 1 | 1 | 3 | 13.5 | W | - | 1 | 2 | 1 | W | 1 | 3 | 2.5 | 1.5 | W | 2 | 2 | 9 | 7.5 |
| L | 11.5 | 14.5 | - | 1.5 | CALM | 7 | 18 | 1 | 5 | CALM | 9.5 | 13 | 1 | 2.5 | CALM | 5 | 12.5 | 1 | 3 |
| | | M | A | Y | | | J | U | N | | J | U | L | | | A | U | G | |
| S | 00 | 06 | 12 | 18 | DIR | | | | | DIR | | | | | DIR | | | | |
| | 8 | 4.5 | 12 | 10 | S | 5.5 | 7.5 | 9 | 6 | S | 6 | 4.5 | 11.5 | 7 | S | 3.5 | 3 | 6.5 | 6 |
| | - | - | 1 | 1 | N | - | - | 1 | - | N | - | - | - | - | N | - | - | - | - |
| | 3 | 4 | 1 | 1 | E | 1 | - | 1 | 1 | E | 1 | - | - | 1 | E | - | - | 1 | - |
| | 3 | 3.5 | 3.5 | 4.5 | W | 2 | 2 | 7.5 | 4 | W | 2 | - | 4 | 7 | W | 1 | 1.5 | 8 | 5 |
| L | 8.5 | 12.0 | 3 | 3.8 | CALM | 14.5 | 13 | 2 | 5 | CALM | 18 | 19 | - | 5 | CALM | 22 | 11.5 | 15 | 9 |
| | S | E | P | | | O | C | T | | | N | O | V | | | D | E | C | |
| S | | | | | HRS | | | | | HRS | | | | | HRS | | | | |
| | 6.5 | 3.5 | 10.5 | 4.5 | S | 2.5 | 2 | 9 | 5 | S | - | - | 3 | - | S | - | - | 6 | - |
| | - | - | 1 | - | N | 1 | - | 1 | 1.5 | N | 3 | 3 | 2 | 9 | N | 3 | 1.5 | 2 | - |
| | 1 | 3 | - | - | E | - | 1 | 1 | - | E | 1 | 25 | 8 | - | E | 1.5 | 4 | 6 | - |
| | 6.5 | 1 | 3.5 | 8 | W | - | - | 6 | 5 | W | - | - | 1.5 | 1.5 | W | 1 | - | 3 | 2.5 |
| L | 12.5 | 16.5 | 2 | 7 | CALM | 24.5 | 24.5 | 4 | 9 | CALM | 21 | 19.5 | 1 | 19.5 | CALM | 16 | 15 | - | 14 |

*Source*: **Nigeria meteorological Agency (NIMET), Abuja International Airport.**

Table: 4.1 contains mean directions of the surface wind as a function of time of the day for the period 1991-2000. These show wind pattern for calm condition and four main directions of cardinal points ($0^0$ - $360^0$) observed four times per day thereby illustrating the behaviour of the atmosphere near ground at Abuja International Airport.

As earlier mentioned, emphasis is rightly on wind direction because it is common, knowledge that wind speed is generally low in the equatorial latitude (La Seur, 1960). It will also be noticed from table 4.1 that "calm" conditions are most prominent between late evening and early morning hours, the afternoon are dominated by southern winds in both season thus favouring the use of runway 22 in most part of the year. Figs. 4.1, 4.2, 4.3 4.4, 4.5. Show the graphs of wind in southerly, northerly, easterly, westerly and calm for the main synoptic. hours only (0000/ 0600, 1200 & 1800z).

These different directional motions of the winds at different times and months of the year are usually considered by air line operations in that headwinds will reduce aircraft speed landing and aid smooth and fast climb out during take off, whereas tailwind increase landing speed which could some times cause aircraft to over shoot the run way (Adefolalu, 1977).

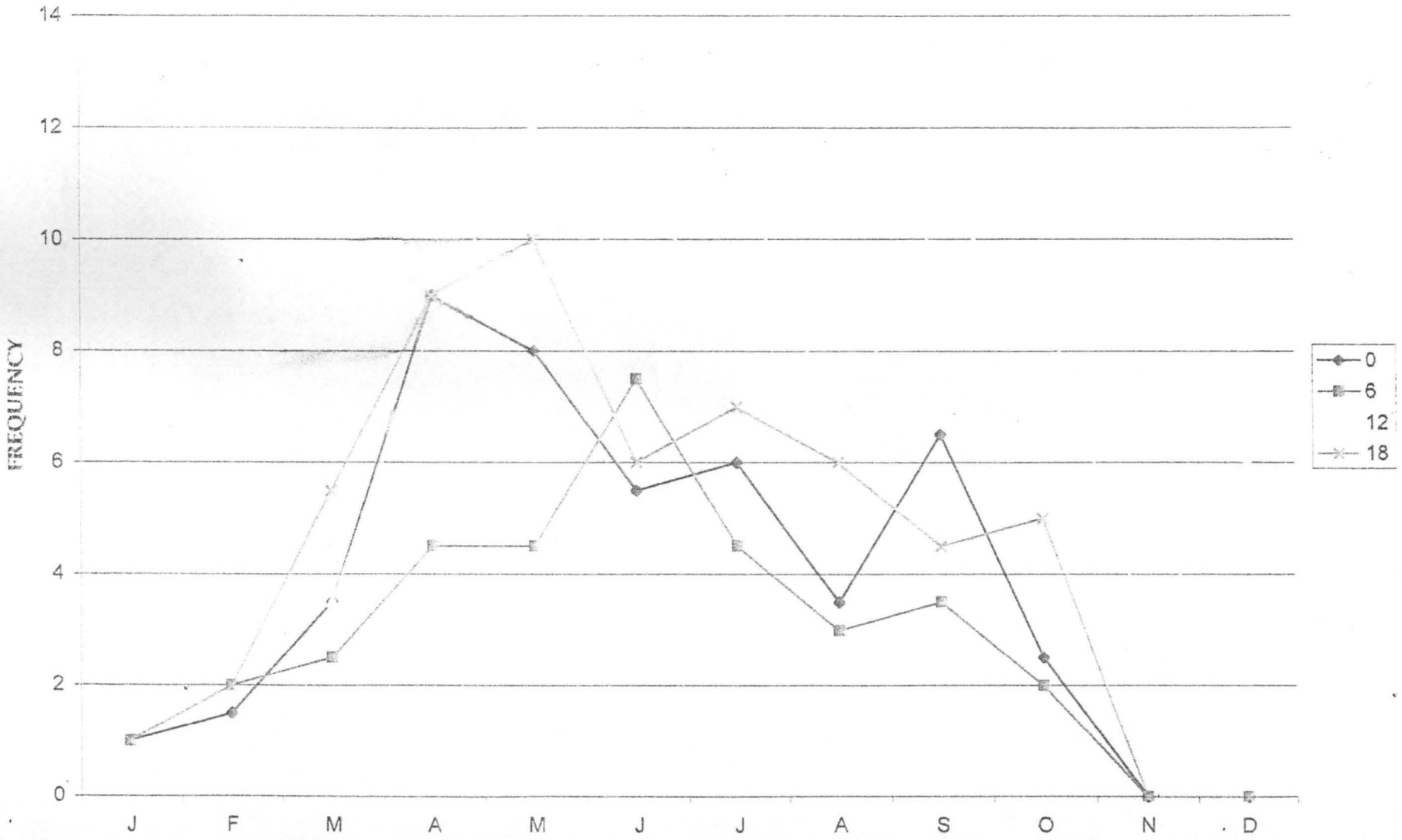



Fig 4.1 MEAN DIRECTION OF SOUTHERLY

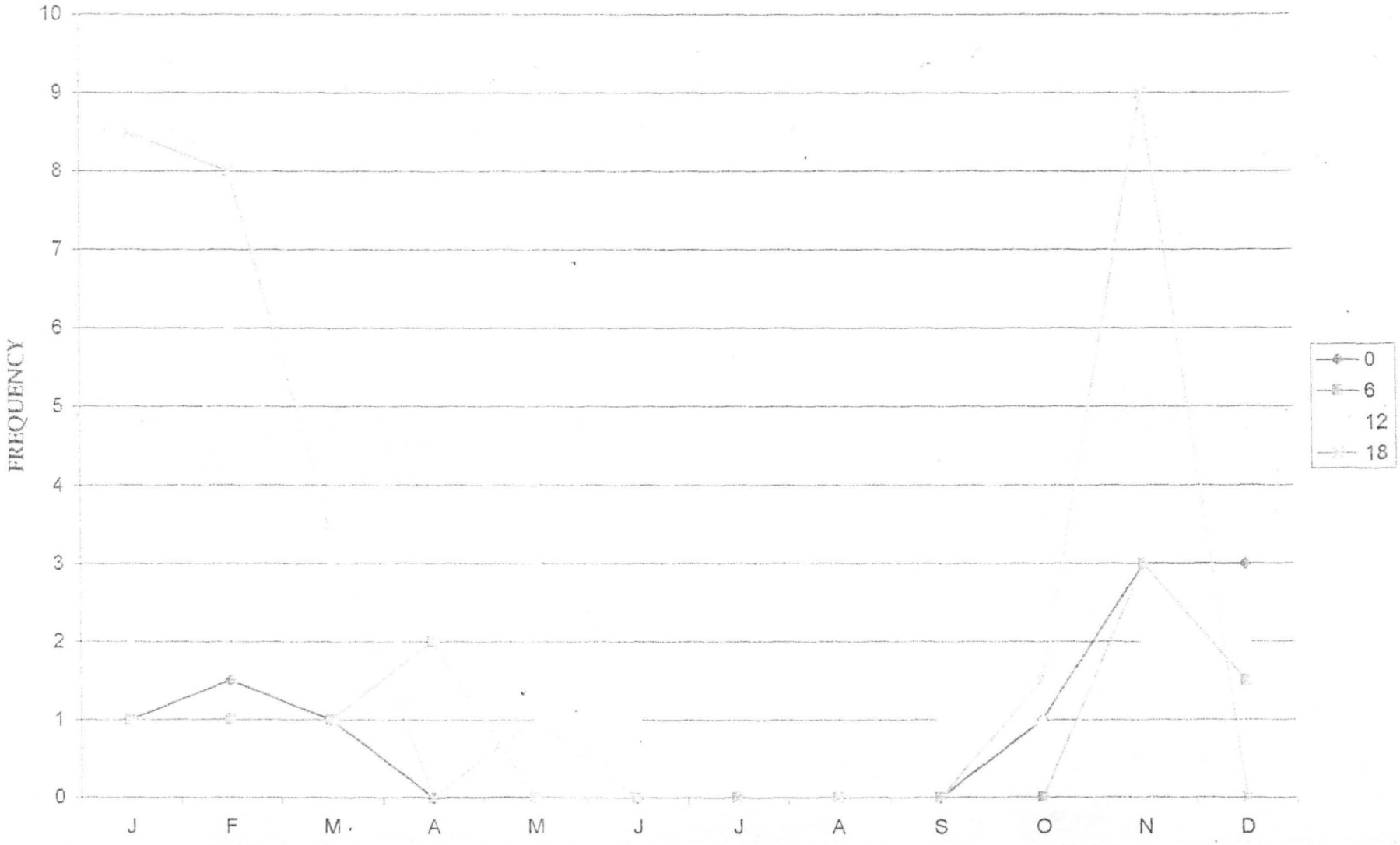



Fig 4.2 MEAN DIRECTION OF NORTHERLY WIND IN KNOTS

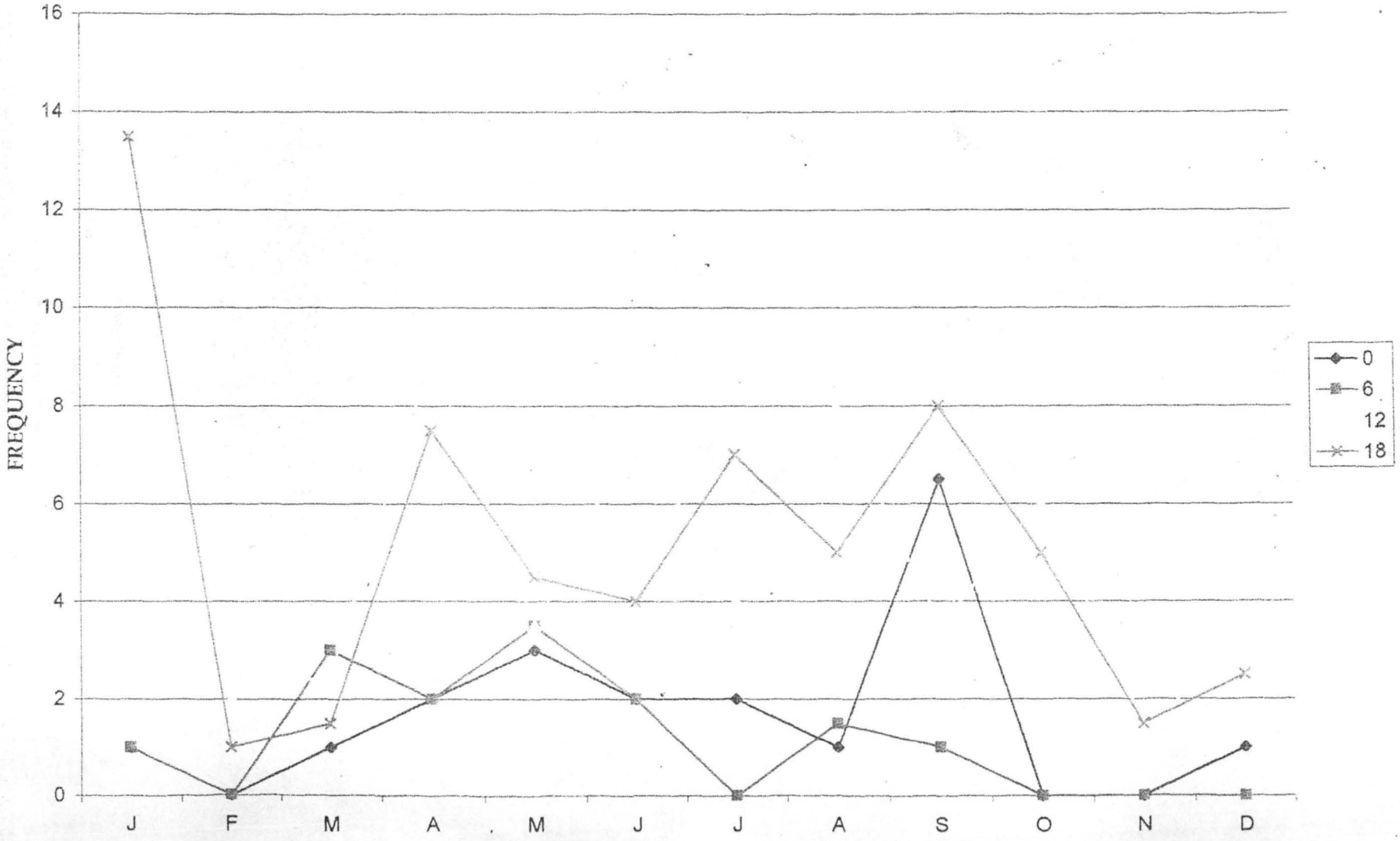



Fig 4.3 MEAN DIRECTION OF EASTERLY WIND IN NAUTICAL MILES PE

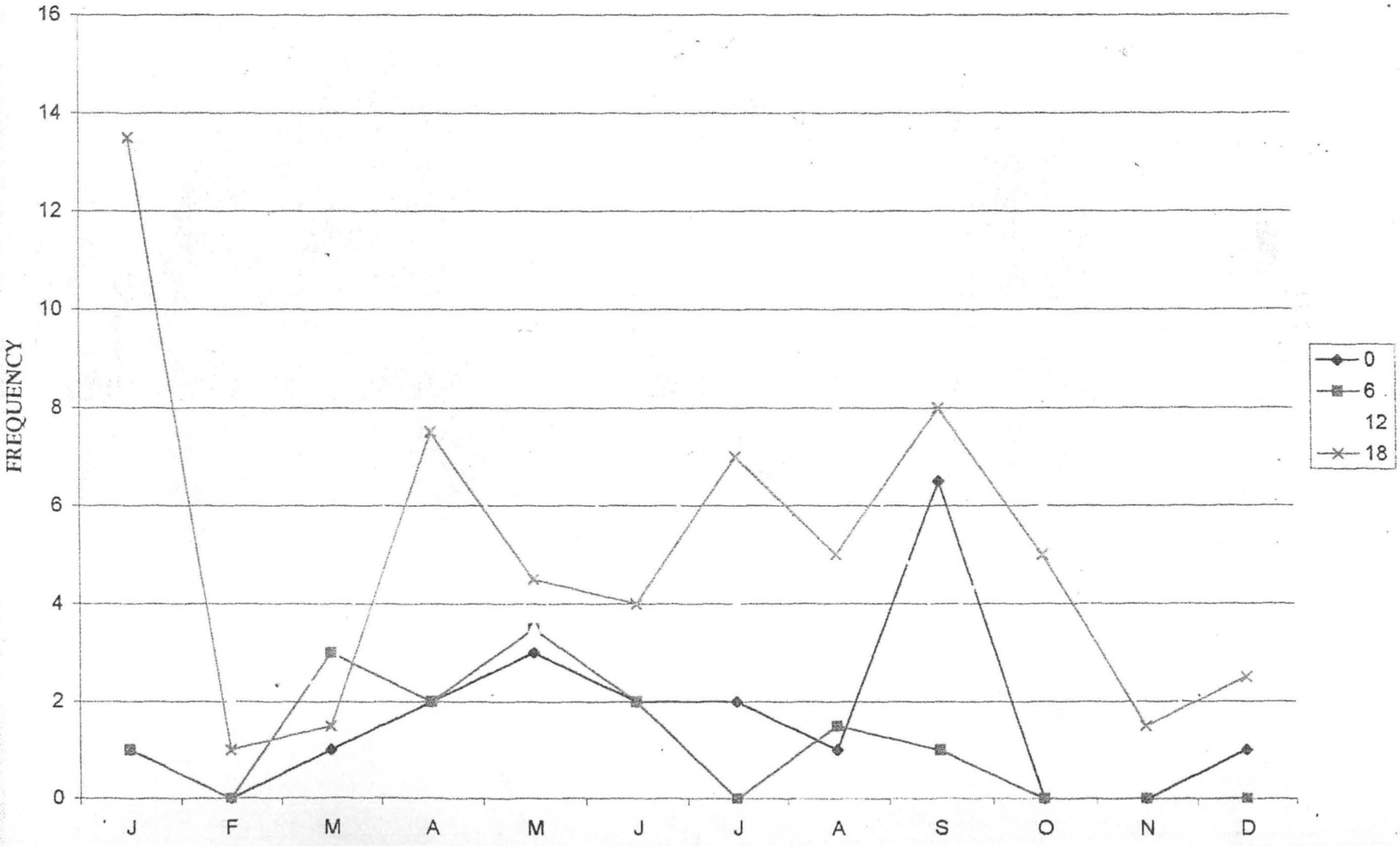



Fig 4.4 MEAN DIRECTION OF WESTERLY WIND [illegible] NAUTICAL MILES

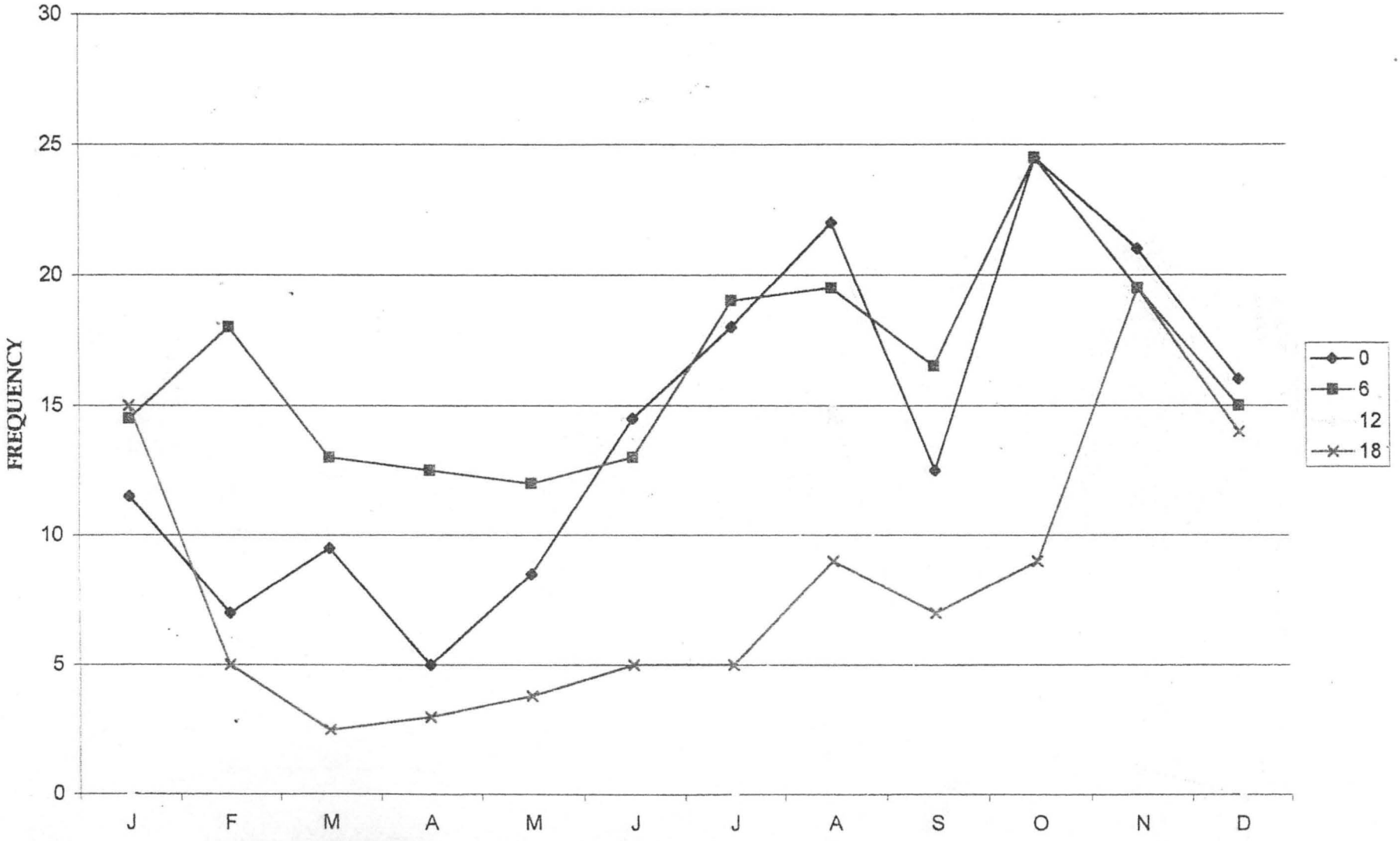



Fig 4.5 MEAN DIRECTION OF CALM WIND IN NAUTICAL MILES PER HOUR (KT) 1991-2000 SOURCE:-DATA

## *41.2 CLOUD AMOUNT AND TYPES*

Clouds are also important to flight operations planning in that they indicate what the atmosphere's is doing, giving visible evidence of the atmospheres motion, water content and degree of stability.

In this sense, clouds are a friend to the pilot. They become the enemy, however, when they become too numerous or wide spread, form at a low levels, or show extensive vertical development. The knowledge of cloud formation helps in making the recognition of potential weather hazards possible when flying.

Information include types and amounts of cloud received at frequent intervals. Cloud information is very important in the early analysis and prediction of weather for safe operation of flights.

Tables 4.2 show the amount of cloud forms at different levels and occurrence probability of such clouds. The table reveals that high cloud forms are more associated with the dry season at Abuja with little medium cloud occurrence, whereas higher frequency of low clouds are prominent

during the wet season. The total amount of cloud cover is also greater during the wet season.

Therefore, the departure from or arrival of an aircraft in the terminal area may be adversely affected by the presence of low clouds thereby reducing visibility conditions. Figure 4.6 shows the frequency of occurrence of each cloud type base on the table.

The periods of the different cloud occurrence should be watched by airline operators. This stems from the view that operation of flight in the low clouds is risky in that buffeting and strong down thrust (bumps) are observed when aircraft enters cumulus and cumulonimbus (cb). This implies that the sudden down thrust of aircraft may be due to the presence of a narrow belt of powerful downdraft which form as a result of the dissipation of cumulus clouds. Low clouds most especially cumulonimbus is associated with strong turbulence, updrafts resulting from atmospheric instability and the heating of the cloud mass by the energy released during condensation of water vapour. Hence, care must be taken in the schedule of flights during this period to avoid these cloud forms in flight operations.

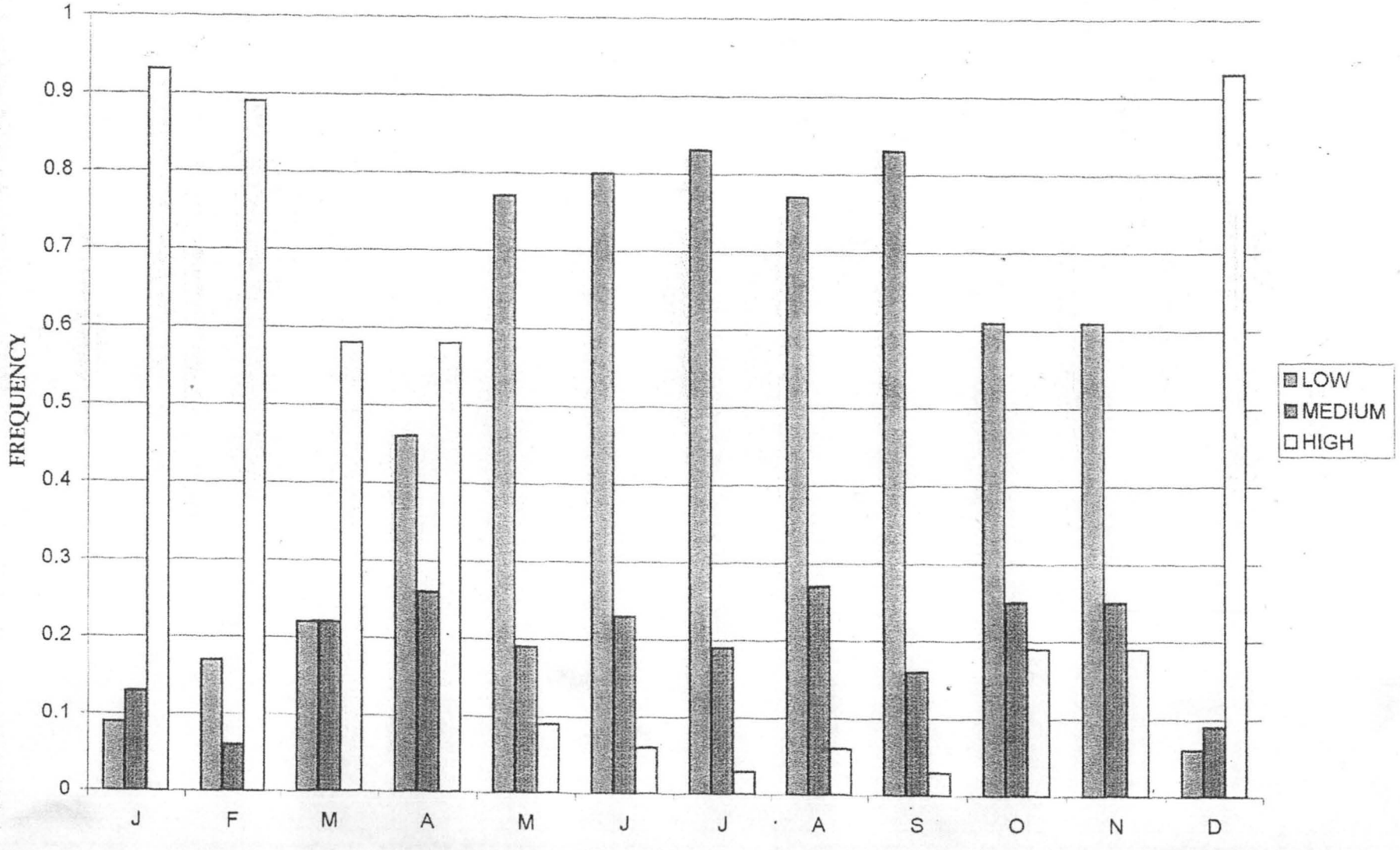



Fig 4.6 PROBABILITY OF CLOUD OCCURENCE SOURCE:-DATA

Table:4.2 ***SUMMARY OF MEAN CLOUD FORM 1991-2000***

| ***MONTHS*** | ***J*** | ***F*** | ***M*** | ***A*** | ***M*** | ***J*** | ***J*** | ***A*** | ***S*** | ***O*** | ***N*** | ***D*** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CLOUD TYPES | | | | | | | | | | | | |
| LOW CLOUD | 3 | 5 | $7^{2}$ | $14^{4}$ | $25^{8}$ | $28^{8}$ | $24^{8}$ | $28^{8}$ | $24^{3}$ | $19^{8}$ | $8^{3}$ | $2^{1}$ |
| MEDIUM CLOUD | 4 | 2 | 7 | 8 | 6 | 7 | 6 | 8.5 | 5 | 8 | 4 | 3 |
| HIGH CLOUD | 29 | 26 | 18 | 8 | 3 | 2 | 1 | 2 | 1 | 6 | 28 | 29 |

*Source:* ***Nigeria Meteorological agency (NIMET), Abuja International Airport***

***NB***

Power number indicates amount of cumulonimbus cloud (cb) along with low cloud.

### *4.1.3 ATMOSPHERIC PRESSURE*

Atmospheric pressure at any level is equal to the weight of a column of air cross sectional area extending from that level throughout the entire atmosphere above. The actual atmospheric pressure at a station is called "station" pressure. This pressure at a given place and time is dependant on

the altitude of the station, the effect of gravity, and amount of air above the station. Pressure variations definitely affect flights.

The effect of pressure on flight operation can be better explained in terms of air density, that is, lower pressure, higher temperature and increased humidity results in lower air density, which decreases aircraft performance. Thus on a warm day more fuel will be required for take off and longer runway than on a cool day.

The most noticeable effect of decrease in pressure due to increased elevation is that are the higher requires true airspeed for taking off and landing of aircraft, lower rate of climb and higher stalling speeds.

The surface pressure of Abuja is generally low throughout the year. The mean annual value is about 1011.2 Hpa representing average conditions with the mean monthly value ranging from 1006.6 Hpa in April to 1013.8 Hpa in January.

From the mean monthly sea level pressure (Table 4.3), it can be seen that pressure is lower during the wet season, while the highest values are synonymous with dry season as shown in Figure 4.7.

The differences in pressure values at Abuja during different seasons of the year has significant effects on flight operations. During the wet season when the pressure is generally low, more power is needed for aircraft take off.

The variation in pressure is also important. Indeed this is the most predictable feature of the pressure pattern (fig 4.7). The maximum value is around 0900 and 2100z hours and minimum at 0300 and 1500z hours. From the above, it is obvious that: the variation of daily pressure is the same as the seasonal variation, when insolation is high, seasonally in February to April, the pressure is low just as during day time with highest insolation at 1500 – 1800 hours, corresponding to the lowest daily pressure value.

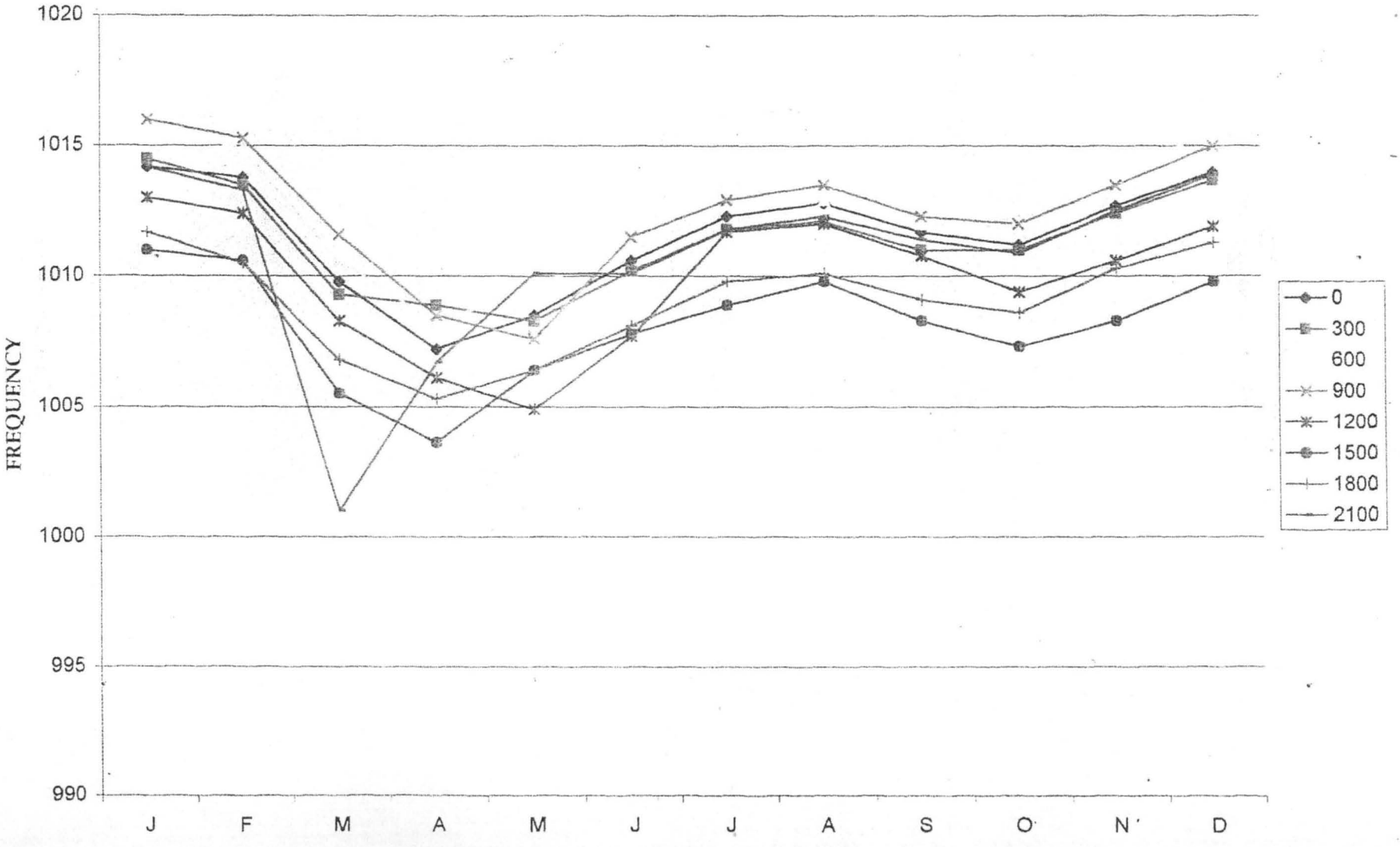
Higher airspeed is required during take off and landing at these periods of the day by aircraft.

*TABLE 4.3* ***MONTH MEAN OF SEA-PRESSURE IN HECTO PASCAL (hpa)***

***(1991-2000)***

| MONTH | J | F | M | A | M | J | J | A | S | O | N | D |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0000 | 1014.2 | 1013.2 | 1013.8 | 1009.8 | 1007.2 | 1010.6 | 1012.3 | 1012.8 | 1011.7 | 1011.2 | 1012.7 | 1014.0 |
| 0300 | 1014.5 | 1013.5 | 1009.3 | 1008.9 | 1008.3 | 1010.2 | 1011.8 | 1012.1 | 1011.0 | 1011.0 | 1012.4 | 1013.7 |
| 0600 | 1015.5 | 1014.9 | 1010.6 | 1008.2 | 1009.6 | 1011.2 | 1012.8 | 1012.9 | 1012.0 | 1012.2 | 1013.8 | 1015.6 |
| 0900 | 1016.0 | 1015.3 | 1011.6 | 1008.5 | 1007.6 | 1011.5 | 1012.9 | 1013.5 | 1012.3 | 1012.0 | 1013.5 | 1015.1 |
| 1200 | 1013.0 | 1012.4 | 1008.5 | 1006.1 | 1004.9 | 1007.7 | 1011.7 | 1012.0 | 1010.8 | 1009.4 | 1010.6 | 1011.9 |
| 1500 | 1011.0 | 1010.6 | 1005.5 | 1003.6 | 1006.4 | 1007.8 | 1008.9 | 1009.8 | 1008.3 | 1007.3 | 1008.3 | 1009.8 |
| 1800 | 1011.7 | 1010.5 | 1006.8 | 1005.3 | 1006.4 | 1008.1 | 1009.8 | 1010.1 | 1009.1 | 1008.6 | 1010.3 | 1011.3 |
| 2100 | 1014.2 | 1013.3 | 1001.0 | 1006.7 | 1010.1 | 1010.1 | 1011.8 | 1012.3 | 1011.4 | 1010.9 | 1012.5 | 1013.9 |

Source: ***Nigeria Meteorological agency (NIMET), Abuja International Airport***




MEAN

Fig 4.7 MONTHLY AT MOSPHERIC PRESURE IN HECTO[illegible]

### *4.1.4 AIR TEMPERATURE*

In aviation, air temperature has an important effect on aircraft performance. At a given pressure, high temperature implies low density. This has an adverse effect upon both piston engine and jet aircraft, and is usually greatest on take off.

***Table 4.4 MONTHLY OF MAXIMUM TEMPERATURE IN O°***

***1991 - 2000***

| Months | J | F | M | A | M | J | J | A | S | O | N | D |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Years | | | | | | | | | | | | |
| 1991 | 33.3 | 37.4 | 37.6 | 35.6 | 31.8 | 31.4 | 29.7 | 29.0 | 30.8 | 31.1 | 35.4 | 44.1 |
| 1992 | 33.5 | 36.6 | 37.3 | 34.0 | 33.2 | 30.3 | 29.3 | 28.7 | 29.4 | 32.2 | 34.2 | 35.3 |
| 1993 | 34.3 | 32.0 | 36.6 | 33.0 | 34.9 | 31.3 | 29.7 | 29.4 | 30.7 | 32.5 | 34.5 | 35.3 |
| 1994 | 34.2 | 37.1 | 34.2 | 34.1 | 34.6 | 31.9 | 30.1 | 28.7 | 29.0 | 31.2 | 35.0 | 34.2 |
| 1995 | 36.2 | 37.0 | 38.9 | 37.2 | 33.6 | 30.5 | 30.3 | 29.0 | 30.6 | 32.0 | 34.4 | 34.7 |
| 1996 | 35.8 | 37.6 | 38.3 | 35.4 | 33.4 | 30.8 | 29.2 | 29.5 | 30.9 | 31.5 | 35.0 | 35.8 |
| 1997 | 34.7 | 35.8 | 37.1 | 38.4 | 33.2 | 30.4 | 30.2 | 30.8 | 31.7 | 34.7 | 34.9 | 35.0 |
| 1998 | 35.4 | 38.8 | 38.5 | 37.0 | 33.7 | 29.4 | 30.5 | 29.6 | 29.9 | 31.7 | 36.3 | 35.0 |
| 1999 | 35.5 | 39.0 | 38.3 | 37.3 | 30.2 | 30.6 | 30.1 | 28.6 | 29.5 | 31.3 | 35.7 | 35.5 |
| 2000 | 35.7 | 34.8 | 38.1 | 37.5 | 35.1 | 30.4 | 30.9 | 30.9 | 30.2 | 31.5 | 35.8 | 34.8 |

SOURCE: ***Nigeria Meteorological Agency (NIMET), Abuja International Airport***

***Table 4.5 MONTHLY MEAN OF MINIMUM TEMPERATURE IN Oc 1991-2000***

| *Months* | *J* | *F* | *M* | *A* | *M* | *J* | *J* | *A* | *S* | *O* | *N* | *D* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Years* | | | | | | | | | | | | |
| ***1991*** | 21.5 | 22.6 | 25.9 | 24.4 | 23.0 | 22.8 | 22.1 | 22.2 | 21.2 | 21.6 | 19.5 | 19.6 |
| ***1992*** | 22.8 | 22.2 | 25.0 | 24.0 | 24.2 | 23.3 | 22.0 | 21.9 | 21.6 | 22.1 | 20.4 | 19.5 |
| ***1993*** | 22.8 | 22.6 | 24.2 | 25.4 | 23.9 | 22.4 | 21.7 | 21.7 | 21.3 | 22.0 | 34.5 | 20.0 |
| ***1994*** | 20.2 | 22.7 | 25.4 | 24.9 | 23.3 | 32.0 | 22.0 | 21.8 | 21.8 | 21.2 | 18.9 | 19.0 |
| ***1995*** | 19.6 | 21.8 | 24.9 | 25.4 | 23.2 | 22.3 | 21.9 | 21.8 | 21.6 | 21.9 | 19.9 | 18.7 |
| ***1996*** | 19.3 | 22.9 | 25.4 | 25.0 | 22.7 | 21.5 | 21.3 | 20.9 | 21.0 | 20.4 | 19.5 | 18.8 |
| ***1997*** | 20.6 | 21.4 | 25.0 | 24.2 | 22.8 | 22.4 | 22.1 | 22.4 | 21.6 | 22.0 | 19.5 | 17.6 |
| ***1998*** | 20.0 | 23.5 | 24.2 | 26.3 | 22.7 | 22.8 | 22.7 | 22.1 | 22.0 | 22.0 | 19.3 | 18.8 |
| ***1999*** | 20.7 | 22.8 | 26.3 | 23.7 | 23.2 | 22.7 | 22.3 | 22.1 | 21.9 | 22.0 | 20.1 | 19.8 |
| ***2000*** | 21.7 | 22.4 | 25.3 | 25.9 | 23.9 | 23.9 | 22.0 | 21.5 | 21.7 | 21.6 | 18.8 | 19.9 |

***SOURCE**: Nigeria Meteorological Agency (NIMET), Abuja International Airport*

Thus on a hot day aircraft requires more fuel and longer runway to take off. Table 4.4 and 4.75 show the monthly mean of maximum and minimum temperatures. It can be observed that the maximum temperature occurred in the months of November to April, whereas the lowest minimum temperature occurred in August and September. It can be deduced from the table that optimal condition that aircraft can land and take off easily is between the months of May and October. Less fuel consumption and maximum take-off load can be carried in these months.

### *4.1.5 PRECIPITATION*

Rain (slight, moderate and heavy) drizzle falls in stable air and therefore is usually accompanied by fog, haze or smoke. Visibility is usually very poor during precipitation which can affect flight operations. Also rainfall can cause flooding around the runway and thus makes runway to be slippery for flight operations. The frequency of precipitation is shown in figure 4.10

Table 4.6 ***MONTHLY PERCENTAGE IF OCCURRENCE OF PRECIPITATION (MM) 1991 – 2000***

| Months | J | F | M | A | M | J | J | A | S | O | N | D |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hours | | | | | | | | | | | | |
| 00-03 | - | - | - | - | 04 | 08 | 10 | 36 | 33 | 30 | - | 01 |
| 03-06 | - | - | - | 02 | 06 | 12 | 26 | 40 | 35 | 23 | 01 | - |
| 06-09 | - | - | - | 04 | 08 | 13 | 30 | 49 | 49 | 20 | 03 | - |
| 09-12 | - | - | - | 01 | 04 | 13 | 20 | 55 | 33 | 15 | - | 03 |
| 12-15 | - | - | 02 | - | 09 | 20 | 22 | 49 | 58 | 33 | 03 | - |
| 15-18 | - | - | 01 | 03 | 12 | 18 | 30 | 45 | 40 | 20 | 08 | 07 |
| 18-21 | - | - | - | 04 | 08 | 22 | 22 | 40 | 33 | 15 | 03 | 01 |
| 21-00 | - | - | 03 | 08 | 09 | 26 | 40 | 35 | 35 | 09 | 04 | 01 |
| Total | - | - | 06 | 22 | 60 | 132 | 201 | 349 | 316 | 176 | 22 | 16 |

SOURCE: ***Nigeria Meteorological Agency (NIMET), Abuja International Airport***

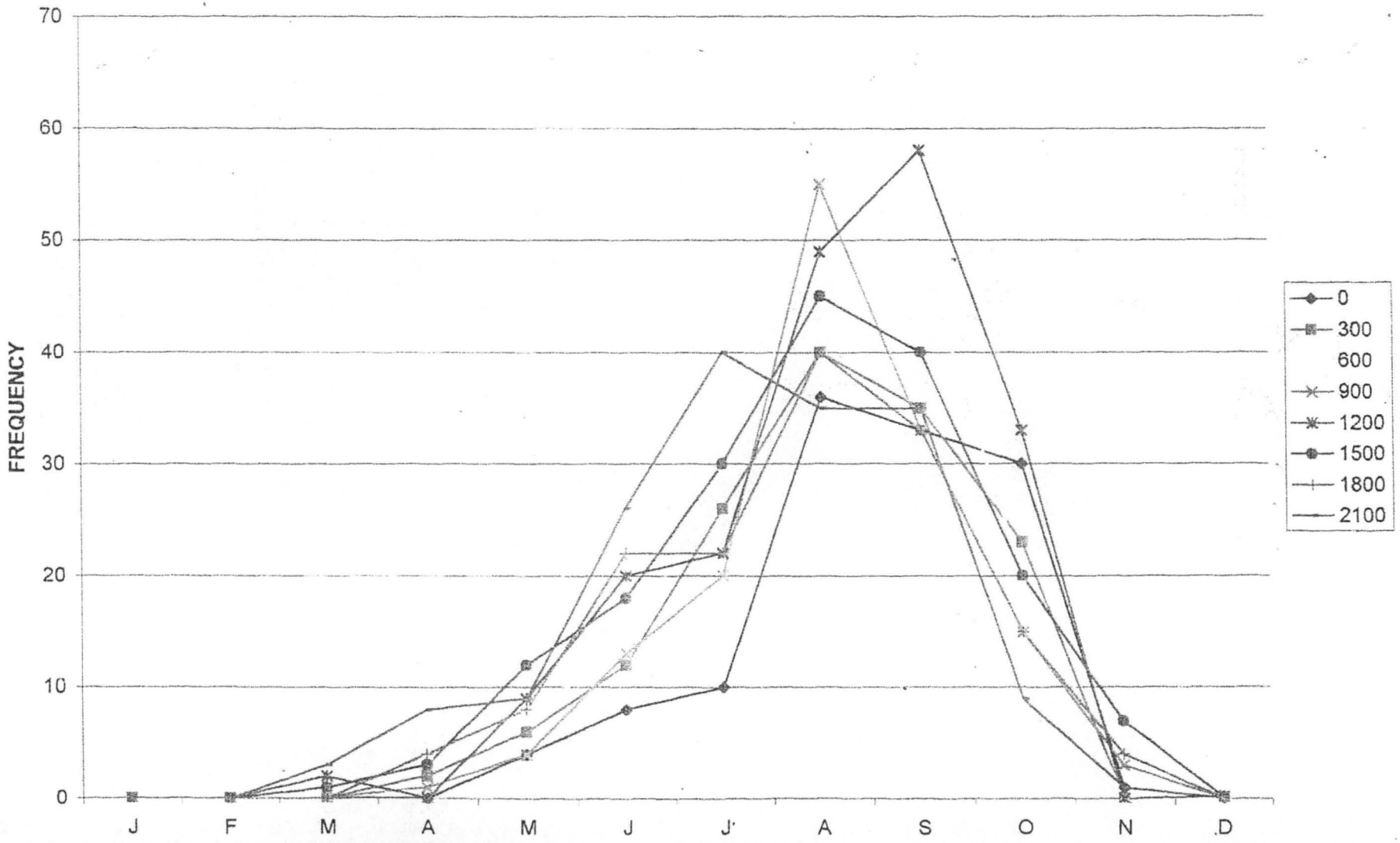



Fig 4.10 MONTHLY PERCENTAGE OF OCCURENCE OF PRECIPITATION (mm) 1991-2000 SOURCE:-DATA

Precipitation is more frequent in the month of April to October every year in Abuja. Heavy precipitation is associated with poor visibility.

## 4.2 *WEATHER EVENTS AND HAZARDS*

Statistics show that low cloud ceiling and visibilities contribute toward many aircraft accidents both fatal and non-fatal. Low clouds (as earlier discussed) prevent navigation by visual reference more often than any other weather situation. Thus, they have an extremely important effect on aircraft operations, particularly during landing and taking off. However low cloud and fog are not the only hazards, others which are also rather common occurrences in this study include: thunderstorm, dust haze and precipitation.

### *4.2.1 VISIBILITY*

Visibility which is defined generally as the greatest distance from which prominent objects can be seen and identified, by normal eyes unaided. Pilots are concerned with the visibility that can be expected in flight

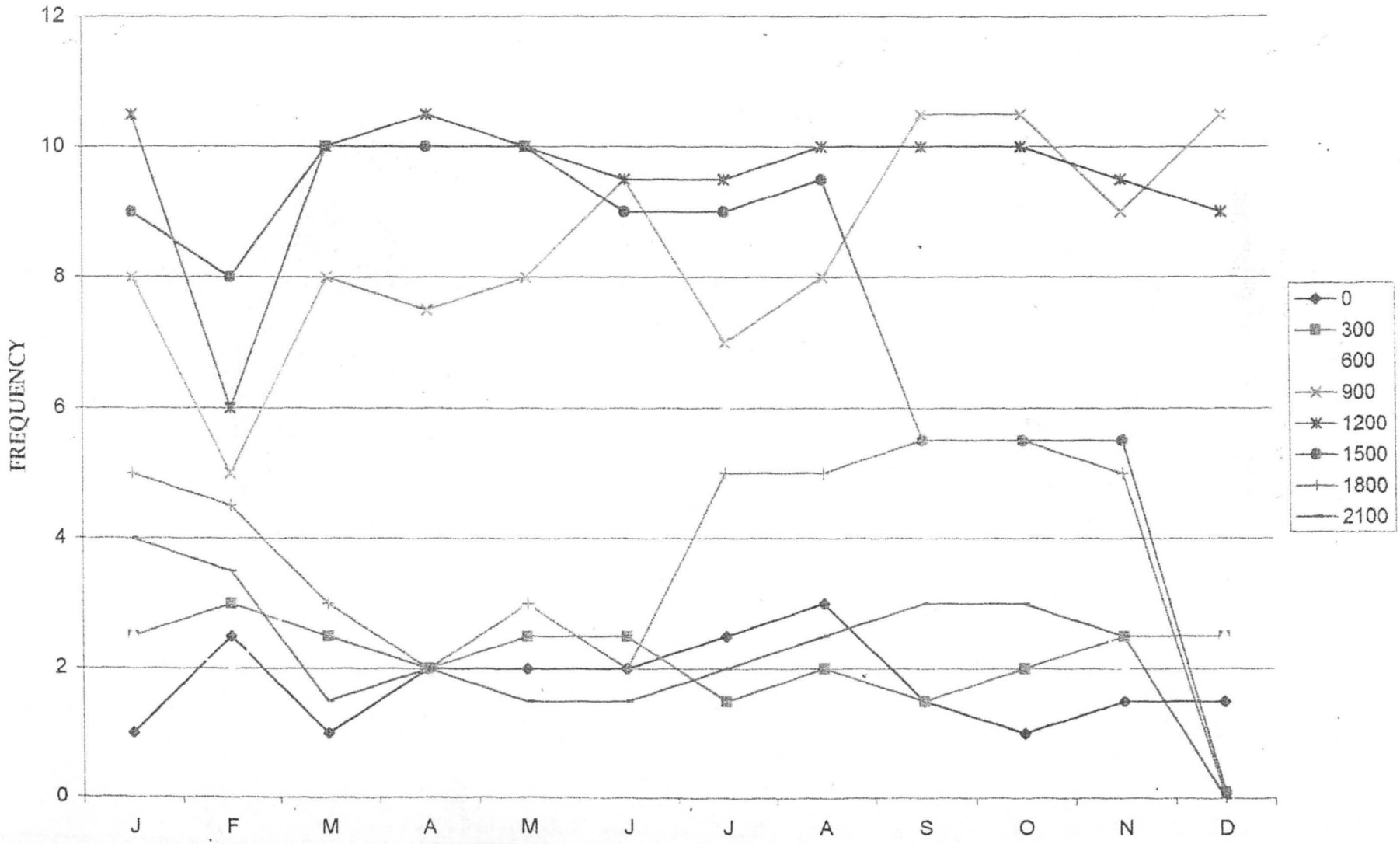
## *Table 4.7 MONTHLY MEAN OF VISIBILITY IN KILOMETRES*

## *1991-2000*

| Months | J | F | M | A | M | J | J | A | S | O | N | D |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hours | | | | | | | | | | | | |
| 0000 | 1.0 | 2.5 | 1.0 | 2.0 | 2.0 | 2.0 | 2.5 | 3.0 | 1.5 | 1.0 | 1.5 | 1.5 |
| 0300 | 2.5 | 3.0 | 2.5 | 2.0 | 2.5 | 2.5 | 1.5 | 2.0 | 1.5 | 2.0 | 2.5 | 2.5 |
| 0600 | 2.5 | 2.0 | 3.5 | 2.5 | 3.0 | 3.0 | 6.0 | 5.5 | 4.5 | 5.0 | 2.0 | 2.5 |
| 0900 | 8.0 | 5.0 | 8.0 | 7.5 | 8.0 | 9.5 | 7.0 | 8.0 | 10.5 | 10.5 | 9.5 | 9.0 |
| 1200 | 10.5 | 6.0 | 10.0 | 10.5 | 10.0 | 9.5 | 9.5 | 10.0 | 10.0 | 10.0 | 9.5 | 9.0 |
| 1500 | 9.0 | 8.0 | 10.0 | 10.0 | 10.0 | 9.0 | 9.0 | 9.5 | 9.0 | 5.5 | 5.5 | 5.0 |
| 1800 | 5.0 | 4.5 | 3.0 | 2.0 | 30 | 2.0 | 5.0 | 5.0 | 5.5 | 5.5 | 5.0 | 5.5 |
| 2100 | 4.0 | 3.5 | 1.5 | 2.0 | 1.5 | 1.5 | 2.0 | 2.5 | 5.0 | 3.0 | 2.5 | 2.5 |

Source: ***Nigeria Meteorological Agency (NIMET), Abuja International Airport.***

Between take off and landing, the surface visibility observed at most weather stations is that greatest horizontal visibility which is surpassed throughout half of the horizon circle. It is this visibility that determines whether flights are permissible under instruments or visual condition. Also important here is the flight visibility that determines air to air visibility. Another type of visibility of importance to pilot is the distance from which the pilot on the instrument approach glide path can see landing aids (this type is called slant visibility) (Pans Met 1997)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1800
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Table 4.7 and Fig. 4.8 show the mean monthly frequency distribution of visibility of Abuja International Airport which is generally fair for flight operations except occasional flight period of bad weather events like heavy precipitation or early morning fog which can lead to severe visibility reduction. The difficult times for flight operation at Abuja Airport is the early hours (0000-0600z) for the months of October to February.

### *4.2.2 THUNDERSTORMS*

This is one of the major weather events during the raining season of West Africa. The thunderstorm is a local storm, which invariably is produced

***Table 4.8 MONTHLY MEAN OF THUNDERSTORM 1991-2000***

| Months | J | F | M | A | M | J | J | A | S | O | N | D |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hours | | | | | | | | | | | | |
| 0000 | - | - | - | 1.6 | 2.6 | 2.3 | 2.5 | 1.4 | 1.8 | 1.5 | 0.1 | - |
| 0300 | - | - | 0.3 | 0.9 | 1.9 | 2.0 | 2.0 | 1.9 | 1.2 | 0.9 | - | 0.1 |
| 0600 | - | - | 0.1 | 0.2 | 2.1 | 1.0 | 2.0 | 1.6 | 1.4 | 0.3 | - | 0.1 |
| 0900 | - | - | - | 0.4 | 1.1 | 0.8 | 1.0 | 1.2 | 1.3 | 0.8 | 0 | 0 |
| 1200 | - | 0.1 | 0.3 | 0.5 | 3.1 | 2.7 | 3.0 | 3.1 | 5.9 | 5.8 | 0.2 | 0.2 |
| 1500 | - | 0.1 | 1.9 | 3.5 | 6.9 | 7.2 | 4.8 | 5.9 | 9.7 | 10.0 | 0.7 | 01 |
| 1800 | - | 0.1 | 0.3 | 1.4 | 2.9 | 4.4 | 4.2 | 2.4 | 5.5 | 5.5 | 0.2 | - |
| 2100 | - | - | 0.2 | 1.1 | 1.8 | 2.1 | 1.8 | 0.9 | 2.3 | 1.1 | - | - |

SOURCE: ***Nigeria meteorological Agency (NIMET), Abuja International Airport.***

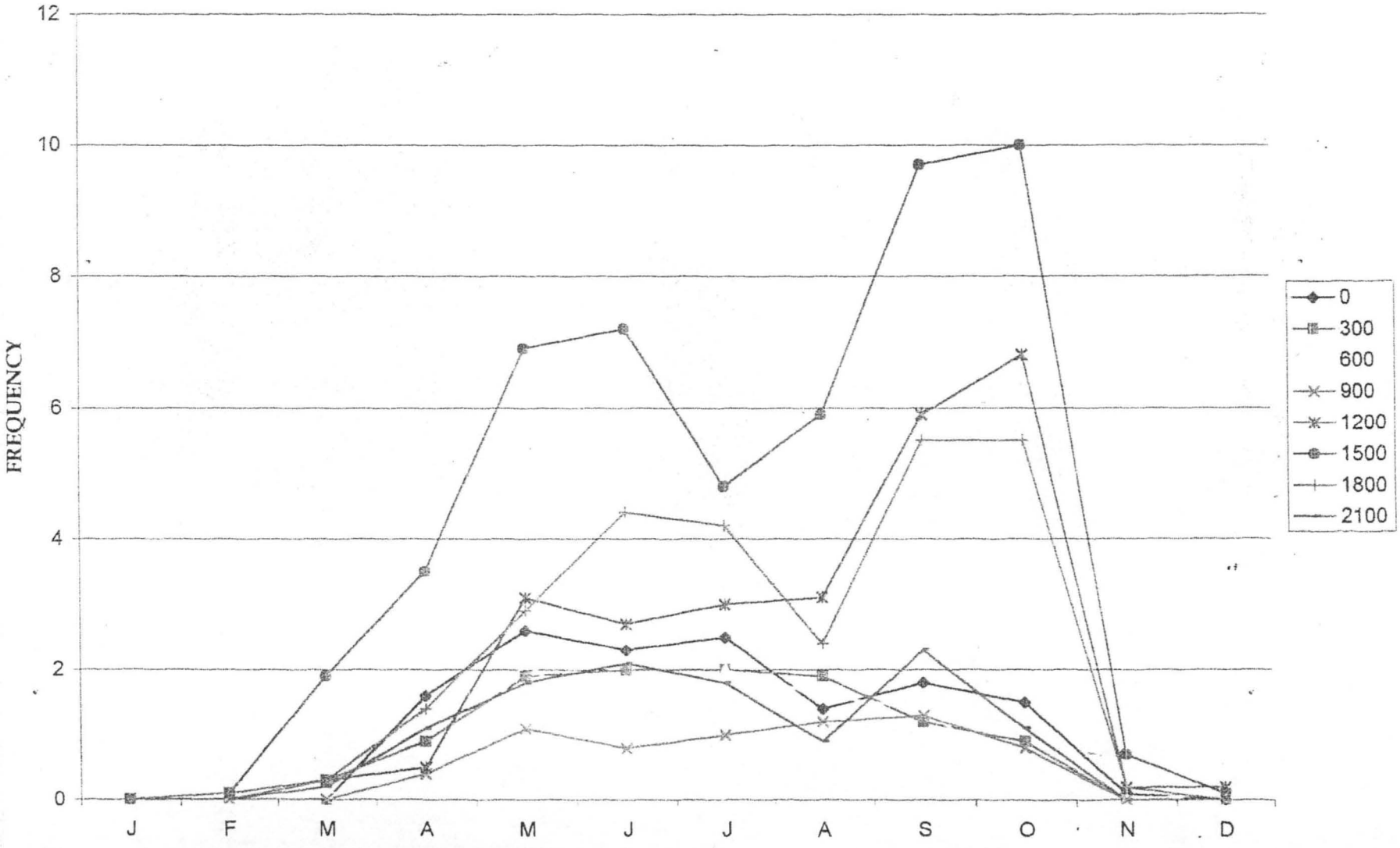


Fig 4.9 MONTHLY MEAN OF THUNDERSTORM 1991-2000 SOURCE:- DATA

by cumulonimbus cloud and is always accompanied by lightening and thunder. It could be defined as the ultimate manifestation of the growth of a cumulus cloud. Thunderstorms are particularly dangerous for pilots because many of the most severe atmospheric hazards are found within them. They are always accompanied by strong gust of wind and severe turbulence. Obviously, thunderstorms should be avoided if possible. From table 4.8 and figure 4.9 thunderstorms affect the Abuja Airport during the afternoons (1200 – 1800z) in the months of April to October.

So far as flying is concerned no thunderstorms should be considered as "light" and since there is on first class means of measuring the extent of thunderstorms in the developing world, therefore, flying should be avoided at the slightest warning.

# *CHAPTER FIVE*

## *5.0 CONCLUSION AND RECOMMENDATION*

### *5.1 CONCLUSION*

The connection between safe and efficient aviation and weather element is readily apparent. Weather alone is a significant cause of aircraft accident and contributing cause in many accidents with other main causes. Weather alone is also the single most important cause of delays.

This work has demonstrated the importance of weather phenomena and associated hazards to air flight operations. The analysis shows that the southerly wind condition dominates both the seasons thus favouriung the usage of runway 22 throughout the year. Low cloud and the total cloud amount of cloud cover are predominantly during the wet season. Atmospheric pressure during the wet season and higer during the dry season. The visibility is generally fair, but the difficult times for flight operations were the early hours (0000 – 0600z) for the months of October to February. Thunderstorm affects Abuja Airport during the afternoons (1200 – 1800z) in the month of April to October. Optimal temperature condition for flight operation is between the months of May and October. And precipitation is more frequent in the months of April to July.

The weather events and hazards studied and analyzed in this project show that with proper planning of flight operations at the Nnamdi Azikiwe International Airport, the problems of flight cancellations, diversions, delays and plane crash resulting from weather events can be prevented (or at least be reduced).

The effort to keep aircraft flying safely within the national airspace requires the complex interplay of an incredible number of system. Weather is just one of the factors that must be dealt with, but it is an unrelenting factors. Day after day the weather is present, continually changing and challenging.

## *5.2 RECOMMENDATION*

In order to ensure that the conduct of flight operations, remains safe and efficient, the nation must invest resources and effort in the existing and evolving infrastructure in the Nigeria meteorological Agency (NIMET).

The individuals and organizations engaged in the business of flying must have access to the most accurate, timely and reliable weather information available.

The following are recommended to improve flight operation at the Nnamdi Azikiwe International airport.

a. The Meteorological station at the Abuja airport should be equipped with the state of art weather equipment like weather radar, automatic weather system, satellite receiving station for satellite data and upper air monitoring devices, being the gateway to the Nigerian Nation.
b. All aircraft operating into the station should be equipped with weather radar on board.
c. Training and re-training of staff of the meteorological agency on computers and various application software should be adopted.
d. For early morning flight to continue during the cool dry months that are associated with poor visibility, the runways should be installed with Instrument Landing Systems (ILS) category III.
e. Runways 22 should be maintained for landing and taking off as the wind remain southerly for most for most of the year.
f. The original master plan of Abuja specifying Gwagwalada as industrial area should be looked into because smokes from the industries may constitute visibility problem to the airport.
g. More research into technologies that will reduce weather related accidents should be encouraged.

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Appendix I

# Passenger Movement

| AIRPORTS | 1999 | 2000 | 2001 | 2002 |
|---|---|---|---|---|
| MMA (DOM) | 1,205,487 | 1,404,527 | 1,563,483 | 1,879,164 |
| INT | 944,968 | 1,053,572 | 1,234,160 | 1,263,326 |
| TOTAL | 2,150,455 | 2,458,099 | 2,797,643 | 3,142,490 |
| ABJ (DOM) | 673,535 | 892,748 | 1,082,981 | 1,334,873 |
| INT | 13,931 | 55,100 | 68,234 | 106,861 |
| TOTAL | 687,466 | 947,848 | 1,151,215 | 1,441,734 |
| PHG (DOM) | 444,007 | 219,938 | 294,420 | 667,422 |
| INT | 39,230 | 37,834 | 42,908 | 52,769 |
| TOTAL | 483,237 | 257,772 | 337,328 | 720,191 |
| KANO (DOM) | 236,224 | 132,647 | 112,238 | 103,346 |
| INT | 208,276 | 163,272 | 154,984 | 123,940 |
| TOTAL | 444,500 | 295,919 | 267,222 | 227,286 |
| KAD (DOM) | 127,120 | 114,967 | 141,827 | 146,050 |
| ENUGU | 46,696 | 68,405 | 103,107 | 140,247 |
| MAID (DOM) | 28,660 | 55,438 | 80,312 | 73,802 |
| INT | 0 | 4,298 | 16,912 | 5,304 |
| TOTAL | 28,660 | 59,736 | 97,224 | 79,106 |
| CAL (DOM) | 45,567 | 60,017 | 71,939 | 83,613 |
| INT | 1,960 | 3,992 | 5,832 | 9,357 |
| TOTAL | 47,527 | 64,009 | 77,771 | 92,970 |
| SOK (DOM) | 11,495 | 11,589 | 12,947 | 9,053 |
| INT | 0 | 9,585 | 21,096 | 21,983 |
| TOTAL | 11,495 | 21,174 | 34,043 | 31,036 |
| YOLA | 16,388 | 34,893 | 27,769 | 45,660 |
| JOS | 41,227 | 47,278 | 58,000 | 35,978 |
| BENIN | 2,385 | 1,4246 | 19,953 | 36,317 |
| OWERRI | 3,374 | 6,149 | 7,979 | 24,640 |
| IBADAN | 461 | 637 | 3,467 | 6,988 |
| ILO (DOM) | 2,969 | 759 | 4,429 | 5,164 |
| INT | 0 | 2,843 | 4,469 | 0 |
| TOTAL | 2,969 | 3,602 | 8,898 | 5,164 |
| MAKURDI | 856 | 670 | 543 | 466 |
| MINNA | 1,664 | 711 | 313 | 1,062 |
| KATSINA | 700 | 325 | 941 | 911 |
| AKURE | 288 | 242 | 298 | 1,224 |
| TOTAL | 4,097,468 | 4,396,682 | 5,135,541 | 6,270,416 |