Federal University of Technology, Minna

*"METEOROLOGY
A Cornerpiece for Nation Building"*

Weather events, Climate Variability and CHANGE in relation to NEEDS and MDGS. 'Problems and Prospects of the Nigerian Economy'

INAUGURAL LECTURE

BY

Daniel Oladele Adefolalu, B.Sc, M.Sc, Ph.D; FNMS

(Professor of Applied Meteorology).

Inaugural Lecture Series 9

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'A People without Information.........

...........is dead'

(Afghan-farmer CNN, 2000)

Typeset by

2A BUSINESS CENTRE

Bosso Road, Opp. Means Petrol Station

Minna, Niger State

Printed by:

BAROCER PRINTS MINNA

08033512678

"METEOROLOGY
A Cornerpiece Environmental Science For Nation Building"

PROLOGUE

Since World War II the meteorology of West Africa has continued to receive attention for many reasons. The War turned Africa into a "recruitment-ground" for support commands and necessitated airlifting of men and materials which required weather briefs for pilots. The weather of the sub-region was closely monitored resulting in the first and (up-to-date) most comprehensive treatise by Hamilton and Archbold (1945). Thus and unfortunately, the importance of meteorology to aviation led to partial efforts in bringing out the -full benefits of meteorological service to countries in West Africa and for many years, most (if not all) national weather services offered no other useful contributions to nation building. It is however to be observed that 'de-emphasis' of Aviation is perhaps contributory to the demise of the Industry in Africa which has only 4% of Aircrafts but accounts for over 25% of global air crashes. Nigeria has had more than her quota of this misfortune in the last 12months with the commercial planes, one private and one military crashes with incredible high profile losses. As AVIATION EXPERT under the Medium Term Sector Strategy (MTSS) by the new Reform Agenda, it was clear from the shopping list from all sub-section in Aviation that a lot need to be done.

The severe drought of 1969 to 1973 which came to a climax in 1972 /1973 seemed to have posed a challenging question in relation to the relative weighting of the different aspects of services that meteorological Departments can and should offer. Meetings of Heads of Governments, especially in the Sahel since that catastrophic episode (which still linger on) have culminated in a call for better understanding of the Weather and Climate and its variabilities as they affect the livelihood of the people in the sub-region in particular and Africa in general. That Drought caused hundreds of thousands of death of man and livestock but perhaps did not 'draw' as much attention as one or two plane crashes.

It is an important turn-around by Governments which, hitherto, had been very lukewarm when it comes to meteorology. In 1991 the African Centre for Meteorological Applications for Development (ACMAD) was established in Niamey-Niger by the World meteorological Organisation (WMO) and the Economic Commission for Africa (ECA) at the instance of the Ministerial Council of the Organisation of African Unity (OAU).

Having realized, howbeit belatedly, the potentials of meteorological research in national development, the various Governments would wish to see a continuity in the diverse efforts in various places and at varying levels of sophistication in order to ensure a rapid rejuvenation of economic development in the era of Climate Change. Prior to this, the West African Monsoon Experiment (WAMEX) during the first GARP Global Experiment (FGGE) was conducted in 1979 to bridge the gap between observational and climatological approaches during Pre- Global Atlantic Tropical Experiment (GATE) and the synoptic dynamic and Numerical Modelling research efforts since GATE-1974. Anew 'Experiment' is now being developed by the WMO known as THORPEX to rise to the challenges of severe weather episodic events. We have been invited to take part in THORPEX Africa.

In this Lecture, a brief review of the "State of the art" prior to WAMEX is first given. Then the scientific breakthroughs emanating from research in comparison to other findings are highlighted in Sections Three and Four. The next section of the paper deals with major observational studies, diagnostic results and numerical modeling, respectively. What next? This is sketched out as the concluding remarks.

1.0 METEOROLOGY

1.1 Definitions and Explanations

> **"Then God commanded, "Let lights appear in the sky to separate day from night and to show the time when days, years and season begins" (Genesis 1[14])**

METEOROLOGY is the physical and chemical science of the atmosphere (Gr. meteora and logos, the science of things above of the things in the air). The subject, which is a branch of geophysics, comprises the study of the whole atmosphere but, for practical and observational reasons, weather and climate have been largely concentrated, on the processes in the lowest 10-15 km, which give rise to weather. By creation of lights (sun and moon) and the energy released by the sun to the atmosphere is characteristically in motion at all points, and its properties are always changing. This sequence of change constitutes WEATHER a term often but not necessarily referring to the atmospheric changes directly apprehensible be man. The quantitative study of the sequence of change is the subject matter of physical, dynamic and synoptic meteorology.

The observations on which synoptic charts are based are made by standardized procedures of Instrument meteorology. Subjecting the data to rigorous mathematical manipulations based on the physical laws of motion and thermodynamic principles call for assumptions and approximations for them to be applicable to other branches including:

- Atmospheric acoustics dealing with propagation of sound through t he atmosphere
- Atmospheric electricity the study of electric field, currents (lighting), space charge and charge separation.
- Atmospheric optics covering optical reflections, refractions, in addition to scattering phenomena: mirages, rainbows, halos, sky colours, etc.
- Radio meteorology which, apart from being a tool, is concerned with the effect of the troposphere as the propagation of radio waves or pulses. In his doctoral work, Oyedum (2005) demonstrated the poor information technology performance in Nigeria and related it to lack of adaptation of measures to neutralize the effects of degrading and attenuation of signals by thunderstorms and rain, respectively.

This lecture deals with physical, dynamic and synoptic meteorology including aspects that are responsible for weather events and climate variability and change which are current issues of national and international concerns.

1.2 Historical Background

> ***"Who is wise enough to count the clouds and tilt them over to pour out the rain----?" (Job 38[37])***

Weather has been of primary concern to mankind for all times. Biblical stories of NOAH's flood, Drought and famine in Pharaoh's Egypt and others during King Solomon's reign while the life and times of Elijah, Ezekiel and the rest prophets 'told' vividly 'established' the Quasi regular famine episodes.

Aristotle and his student Theophrustus (380-300 BC) were the first to document treatises in meteorology. But for another 2000 years, no breakthroughs were recorded due to lack of instruments to make sustained observations and meteorology did not become a systematic science until Galileo invented the Thermometer in 1607, Evangelist Torricelli the Barometer in 1639 through which Lavoisier (1783) and Dalton (1800) made observations to explain the behaviour of atmospheric air and variations of water vapour, respectively-thus marking the beginning of physical basis of modem meteorology.

The 'arrival' of synoptic charts signaled the beginning of weather forecasting and by 1853 through 1990, during which the International Meteorological Organisation (IMO) came into being, the understanding of atmospheric behaviour had became clearer through analyses of pressure level charts of winds, temperature and geopotential heights by the famous Norwegian scholars. Establishment of upper air networks after World War II in 1945 and rockets, aircrafts and weather Satellites in the 50s into the 60s hastened the evolution of Forecasting.

Since those early achievements (only 130 odd years ago) improved Information Technology has moved the world from synoptic to Numerical Weather Prediction and with the advent of super computers, Global General Circulation (Prediction) models have enabled Climate models which could not have come at a better time for 'modelling' of Climate Change and current world-wide disasters associated with its impact.

1.3 <u>*21st Century Meteorology And Future*</u>

> ***"Now then; these are all one people and they speak one language: this is just the beginning of what they are going to do (of men who built the tower of Babel).***
> ***Soon they will be doing anything they want!***
> ***Let us go down and mix up their***
> ***language so that they will not***

understand one another"
(Genesis **11**$^{6-7}$**)**.

1.3.1 Climate Change Defined

Climate Change, as defined in the United Nations Framework Convention on Climate Change (UNFCCC), is

> *"a change of climate which is attributed directly or indirectly to human activity that alters the composition of global atmosphere and, which is, in addition to natural climate variability observed over comparable time periods"*

Man woke up to Climate Change in the new Millennium not knowing what to make of Global Warming and its Consequences. Decades of research notwithstanding, there was (and still are) misgivings as to the definition of Climate Change and who should do what to ameliorate a dangerous trend on impacts of effects of the Change. Nations are still divided on the Instrument- the Kyoto Protocol-to implement the United Nations Convention on Climate Change although they are in agreement on the most Vulnerable Countries (or areas) which in accordance with Article 4.8 and 4.9 of the Convention, include

a. Small Island Countries.
b. Countries with low-lying coastal areas.
c. Countries with arid and semi-arid areas liable to forest decay.
d. Countries with areas prone to natural disasters.
e. Countries with areas liable to drought and desertification.
f. Countries with areas of high urban atmospheric pollution.
g. Countries with fragile ecosystem, including mountainous ecosystem.
h. Countries whose economics are highly dependent on income generated from oil production processing and export, and/or consumption of fossil fuels and associated energy-intensive product.
i. Land-locked and transit countries.

Article 4.9 States where Response measures will adversely affect the economies of Countries, especially dependent on Fossil Fuels, assistance to the KYOTO PROTOCOL.

While the United States of America remains unyielding (until perhaps the 2005 Hurricane season when Katrina dealt the worst blow to damage her invincibility) on acceding to the Protocol, despite spending about US $5Billion (about N675 Billion) annually since 2000 on studies to ascertain the reality of Climate Change, the rest of the civilized World has commenced intervention strategies to control or 'contain' the impact of Climate Change. The USA is of the view that conventional scientific findings have failed to demonstrate the 'whole weight' of impacts on a country like USA over and above the vagaries of Weather and Climate. It was felt that Hurricanes, Tornadoes (of Spring/Summer months) cannot break the 'will' of the people just like they not only nurse but believe in their ability to contain winter blizzards from snowfalls accompanied by extremely strong winds. Not only has Nature showed that they 'know not what they are contending with' through the likes of Katrina that the level key southern cities, especially New Orleans, and drought-induced forest fires in the southwest, in-depth studies on Climate Change impact on plants, animals, insects and birds (see below) have proved conclusively the almost irreversible losses (in the short term, at least) of plant and animal species that are becoming extinct.

1.3.2 Coherent Signals Of Global Climate Change.
(Convincing the Doubting - Thomas Nations - BIOTA REDISTRIBUTION)

Even though President George Bush (Snr) initiated the global conference that gave birth to Kyoto Protocol as implementation instrument of United Nations Framework Convention on Climate Change his son and current president of U.S.A, unconvinced that Climate Change is taking place has blocked all efforts to actualize Kyoto To convince him beyond reasonable doubt American Scientists have delivered the 'KILLER PUNCH' through a holistic survey of IMPACT of Climate Change on the EARTH'S BIOTA. Excerpts from a 2005 study covering global flora and conducted by at least 36 experts as documented by PEW (2005) are highlighted here.

Global results provide convincing evidence that 20^{th} century anthropogenic global warming has already affected the Earth's biota.

These changes have been reviewed in several recent scientific publications by the Inter-Governmental Panel on Climate Change (IPCC) One study which synthesized the results of many independent studies that described long-term observations of almost 1,600 species across the global was by Parmesan and Yohe (2003). In these surveys and synthesis of findings, species that have not responded, to recent Climate Change were documented along with those that have responded allowing for an estimation of the overall impact of Climate Change. The analysis showed that about half of the species studied exhibited significant changes in their phenologies and/or distribution over the past 20 to 140 years. The species responses have been occurring in diverse ecosystems (from temperate terrestrial grasslands to marine intertidal Zones to tropical rain forests, and in a wide variety of organisms including birds, butterflies, sea urchins, trees, and mountain flowers (Table 1.1)

Table 1.1: Global Summary of Observed Change

Climate Change Prediction	Change as predicted	Change opposite to prediction	Statistical likelihood of obtaining patterns by chance[1]
Earlier timing of spring event	87%	13 %	Less than one in billion
Extension of species range poleward or upward shift in elevation	81%	19%	Less than one in billion
Community abundance: cold adapted species declining and warm-adapted species increasing	85%	15%	Less than one in billion

NOTE: Data available for 1, 5 and 6 individual fauna species show that (59%) detectably change, mainly 80-90% in the direction predicted to regional Climate Change:

1: Binomial Test ($P<0.1\times10^{[illegible]}$)

SOURCE: Parmesan & Yohe (2003).

1.3.3 Results Of Diagnostic Studies

Important diagnostic patterns specific to Climate Change impacts helped to confirm that global warming is the driver of the observed changes in natural systems. These patterns include differential responses of cold-adapted and warm-adapted species at the same location, and species tracking of decadal temperature swings, such as shifting southward during cool periods and northwards during warm periods. Such diagnostic "sign-switching" responses were observed in 294 species spread across the globe ranging from oceanic fish to tropical birds and European butterflies. The present Environmental Heat Stress complicated by Aeolian dust pollution with pathogenic substrates in Hot/Humid conditions experienced by poultry in Nigeria has been termed AVIAN FLU (speculated as the ASIAN TYPE H5N1) is not unconnected with present trend in Climate Change to which we have been calling attention since 2000/2001 when it resulted in high mortality of poultry (layers, cockerels of Agric hybrids and locals in Ekiti, and Osun States). There was little or no response measures by Governments until the sudden reports of late attacks in 2005/2006 Harmattan season on which the Country was ALERTED during the 2004/2005 season (Adefolalu 2004).

At the global level, Climate scientists have attributed the majority of warming in the past 50 years to the human-caused increase in greenhouse gases such as carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_20) and certain industrial chlorofluoro carbon gases. The warming influence of these green-house gases has been estimated by the IPCC to be more than six times as powerful as solar influences. At the global scale, then, it is possible to relate greenhouse gas-driven Climate Change to biological change (see figures 1.1a-c on methane CO_2 and 1.2a-c on CH_4).

Linking global trends to regional or local changes is not entirely straightforward, however. The larger the study area, the smoother the Climate signal and the greater the case in detecting all anthropogenic effects. As one focuses on smaller geographic areas yearly Climate variation becomes strong enough to mask the types of anthropogenic signals that Climate scientists use to link recent warming to human-induced increases in atmospheric CO_2. Thus, no single weather event, or even long-term trends in a single location, can be unambiguously linked to anthropogenic Climate Change. However, over large regions with homogeneous conditions (terrain, water bodies, etc) some signals of all anthropogenic greenhouse gas influence have been detected. Some of these include:

- Average yearly precipitation with drier arid / semi-arid areas getting hotter but not water wetter with fewer but highly extreme Climate episodic events giving unusually heavy precipitation resulting in floods.

- Higher average temperature in rural areas, mainly due to warmer nighttime temperature.
- Very dramatic Day-time temperature maxima (not only prevalent in Sahelian West Africa but in the Guinea-Sudan to forest mosaic down to the coast)

Warming in Sea Surface Temperature (SST) at lower latitude

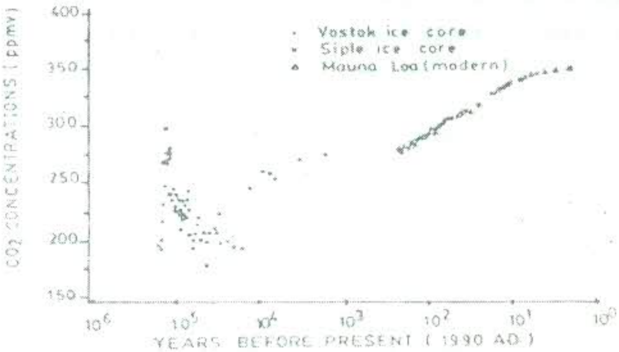


Figure 1.1a: Annual atmospheric CO_2 Concentration during the Past 100,000 years (derived from the Vostok and Simple Ice Cores and Keeling's Mauna Loa Record)

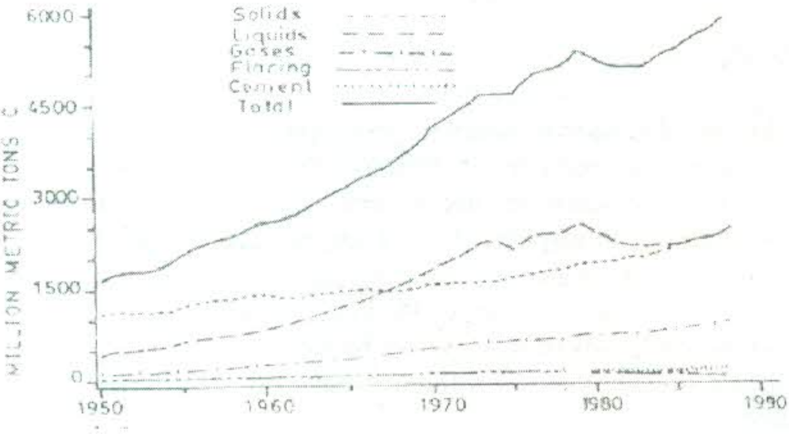


Figure 1.1b: Global CO_2 Emissions

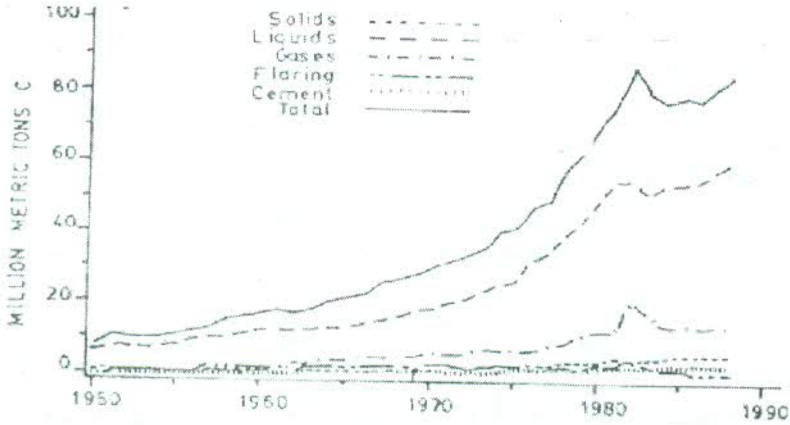


Figure 1.1c: CO_2 Emissions from Mexico
[Figures 1.1a 1.1c adapted from Keeling (1975) and Kelling et al, 1989]

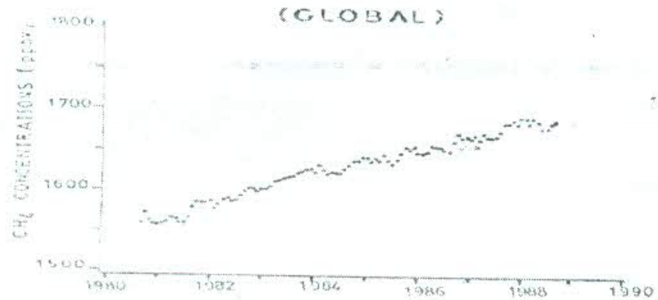


Figure 1.2a: Monthly Concentrations of Atmospheric Ch_4

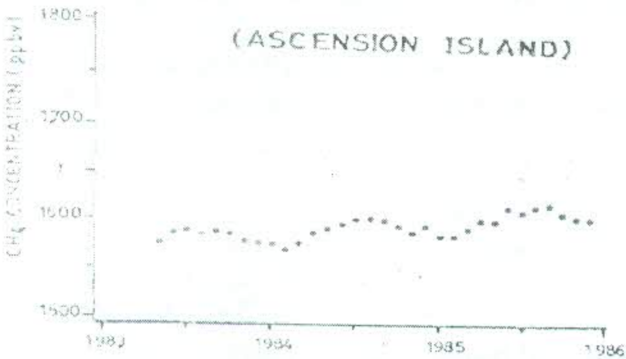


Figure 1.2b: Monthly Concentrations of Atmospheric CH_4

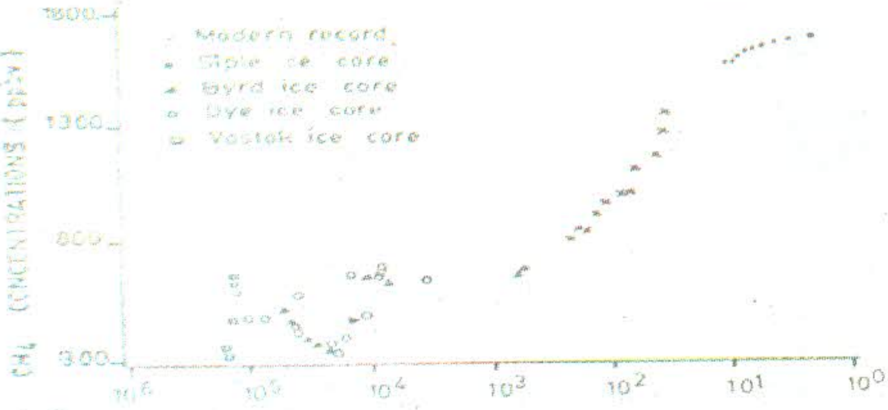


Figure 1.2c: Annual atmospheric CH4 concentrations during the past 160,000 years (derived from ice cores and the NOAA/CMDL flask sampling network). Adapted from Kalil and Rasmaseen, 1990)

1.3.4 Impacts

Shift in Tress Lines as Indicator of impact

Given the complex nature of the interacting factors determining tree line, interpretation of 20th century trends has typically not been so straightforward. The explanation for different responses may lie in differences in rainfall. In Nigeria, recent decades have had dry spells and wild-fires which may have prevented trees from responding to current warming as they did before. In contrast, the mangroves (and marshy, swamps) in the south, where floral meadows around springs exist, have increased tree species in areas now experiencing not only warmer temperatures but also increased rainfall. The new Vegetation (Tree) line in 2005 has shifted equatorward to about 27.75 km south of its position in 1970-75 (see figure 1.3a) which has affected the northern limits of groundnut producing areas (Ogunwale and Owonubi 1998) as illustrated in figure 1.3b.

Sea-Level Rise and Coastal Marine Life

Sea-level Rise (SLR) has caused some contraction in the coastal species. Globally, an 18-22cm rise in sea level has been observed since 1901, due primarily to thermal expansion as the oceans have warmed by 0.6^{0}C. There are fewer Bamboo and Raffia-Palm mangroves in the lowest-lying areas possibly due to increased ground water salinity caused by sea-level rise. In Nigeria they are now restricted further inland which has resulted in habitat loss for aquatic life species that depend on their shoots along the 850km coastline of the Country. Cane products which earned substantial revenue for fishing communities are now a rarity. This suggests a rapid transformation if the marine ecosystem that has undergone large changes in its vegetation community composition, with increases in spatial cover of low-marsh species such as smooth grasses, at the expense of the high-marsh communities (dominated by water hyacinths).

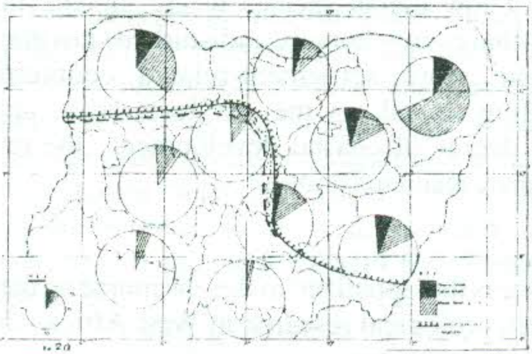


Figure 1.3a: Percentages of Sahel-Type vegetation in the Sudan-Sahel Belt of Nigeria (Adapted from Adefolalu, 1990). Hashed line is vegetation line or transition from Sahel-type dry grassland to wooded Savana.

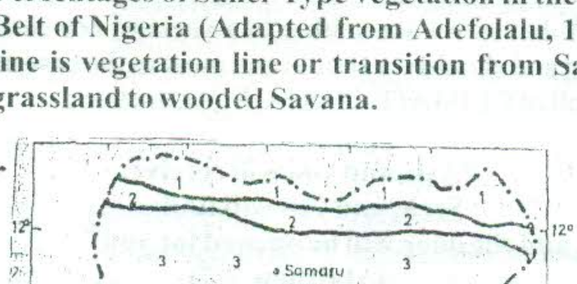


Figure 1.3b: Change in the northern limit of groundnut producing area since 1970 (from Ogunwale & Owonubi, 1998)

This example indicates that responses to rising sea level are not likely to be simple landward shifts of individual species. Studies also suggest that sea-level rise had been faster than the rate of new accumulation of marsh substrate, leading to fewer habitats for high-marsh species. In some areas with the most vegetation changes this may be linked to excessive human manipulations. However, in recent years other marshes in the same system have been showing (less-pronounced) vegetation changes in the same directions. Loss of low marsh species where human impact has been minimal indicates that even relatively undisturbed sites may suffer similar problems to their more settlement-related counterparts. Simple, translational shifting inland, as the sea level rises, appears unlikely regardless of the degree of coastal development the rates of changes differ, but the ultimate result may not.

1.4 Summary

The narration above is the 'appetizer' to this discourse on meteorology and specifically on meteorological research in West Africa with a bias to the dilemma of Nigeria as a country.

It must be told that as we are neither in a vacuum nor isolated in a cave, Nigerians must and should (or should and must as the case may be) react to the wake-up call of CLIMATE CHANGE. We are told:

"Ask, and you will receive;
Seek, and you will find;
Knock and the door will be opened for you"
(Matthew 7:7)

Let me 'ask' on your behalf 'Where are we in Meteorological Research?'

2.0 METEOROLOGICAL RESEARCH IN WEST AFRICA

2.1 Mean State Forcing

To answer the above question, the following is an understatement in West Africa (including Nigeria)

> ***"Albert Einstein once said that next to the human being, the climate system was one of the most complex systems he could think of"[Obasi, 1996].***

This statement is as true as 'Day and Night' in West Africa which, in itself, experiences mild severe weather events but acts as breeding ground for Atlantic Hurricanes. For the West African sub-region (and prior to public enlightenment on Climate Change) the scientific Community has been soldiers in arms to effectively control two climate episodic events FLOOD AND DROUGHT that have ravaged the sub-region since about 1960. But like the Biblical passage quoted earlier "can we understand one another?" Not that one is in want of evidence on Flood and Drought as the major scourge that will test human will in the sub-region (Obasi, 2000), but the common denominator is lack of consensus on the Causative factors of severe weather events to the extent that about 14 indicators of Climate FORCING have been put forward and vigorously contested as if Weather and Climate are distant 'relations' whereas a mother foetus child (complex to explain) intimacy is involved. No wonder the physics genius (Albert Eistein) called it the most COMPLEX. These are illustrated in figure 2.1 which show:

i General Circulation Features (F-1 TO F-3):

- F-1 Sub-Tropical of sub Antarctic forcing in the southern Hemisphere
- F-2 MildAtlantic Trough of the American warm Aguulhas Drift
- F-3 Sub-Tropical forcing

ii Interaction Forcing (I-1 TO I-5)

- I-1 Inter-hemispheric interaction (Southern Atlantic)
- I-2 Counter Equatorial [Upwelling] ocean current
- I-3 - latitude Westerly Trough/Waves
- I-4 Asian Monsoon
- I-5 Heat Low over Sahara Desert

iii. Regional Features (CR-1 TO R-3)

- R-1 Inter-Tropical Discontinuity
- R-2 Tropical Easterly Jet [TEJ]
- R-3 African Easterly Jet [AEJ]

iv Sub-Regional System (C-1 TO C-3)

- C-1 Squall Mesosystem
- C-2 African Easterly Wave

C-3 Monsoon Trough (MT-)

So far, these the 'known' to play integrated evolutionary roles in the weather while climate change features have not been incorporated. Clearly, a very complex modulating weather producing system will evolve when signatures of either regional or sub-regional higher hinterland or Sea Surface Temperatures resulting in exacerbation of extreme weather producing systems. One such regional climatic feature is the upper level EAST-WEST circulation first discovered by Professor Krishnamurti and his Group at the Florida State University, Tallahassee, USA in 1982.

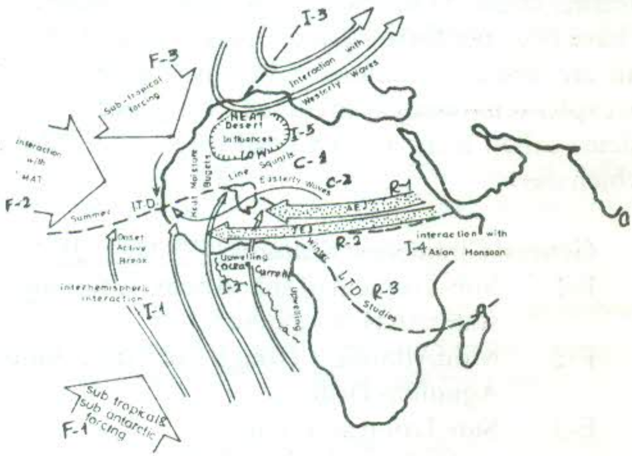


Figure 2.1 Schematic illustration of the overall distribution of the main components of scale interaction in West Africa. (Adapted from Dhonneur et al, 1987; WMO-Tech 41, 1978).

It is to be observed from figures 2.2 on the EAST-WEST circulation causes an outflow from the Tibetan High (over northern Himalayas in India) into Africa which results in intensification of the sub-tropical Anticyclone over the Sahara. This suggests that the strong easterly flow at higher levels (300-200 hPa levels) in figure 2.3 is a response to the E-W outflow in figure 2.2. These have not been included in the 14 FORCING above but implied by the TEJ without which the summer in West Africa will be devoid of a strong southerly Monsoon flow and consequently shallow convection will dominate to result in DROUGHT.

It is therefore informative to know that scale interaction and its consequence are the most important features in meteorological forecasting in West Africa [Adefolalu, 1983a]. But can all these be modelled to produce a prediction for long-term CLIMATE CHANGE indicators? This is what we 'SEEK' next!

Thus, if we 'seek' the cause(s) of a good monsoon over the Indian Sub-Peninsula, we will find a 'GOOD KEY' to indicators of SAHELIAN DROUGHT in West Africa the consequences (or impact of which we narrate below.

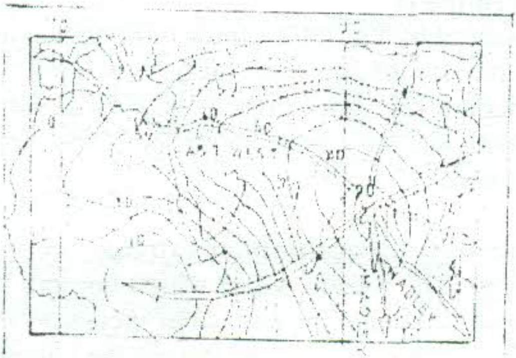


Fig 2.2: Hadley and East West circulation on emanating from the Tibetan high

(adapted from Krishramurti, 1982)

Fig 2.3: Resulting Streamline outflow from Figure 2.2 over Africa (adapted from Krishnamurti, 1982)

A good and early India Monson year cyclone season starting in May is synonymous with strong The E-W circulation resulting in the most intense upper level anti-cyclones shown in figures 2.2. The Easterlies (of over 60 msec^{-1}) are the celebrated Tropical Easterly Jet (JET) indicated by the strong arrows over Africa illustrated in figure 2.3. Without this special upper level outflow will be the consequence resulting in a poor summer rainy season over the Sahelian Belt of West Africa. 'Climate Change' is affecting the flow regime in the Asian and African regions resulting in alternating years of drought and flood with associated impacts.

2.2 Regional Impacts

So far, as monitored by the IPCC, three generalized impacts of climate change (among others) arising from global warming by the greenhouse gases are of immediate relevance to the West African sub-region in general and Nigeria in particular have been identified. These are highlighted (and expatiated upon) here.

i. Deserts are likely to become more extreme becoming hotter but not significantly wetter. The Sahara desert which borders West Africa to the north has been noted to be making persistent 'incursion' into the Sahel (Lat. 14-20^{o}N) resulting in drier conditions during the summer monsoon. The recurring drought spells in the sub-region have been associated with anomalous circulation such as declining monsoon in-flow, monsoon Trough interphasing with sub-Tropical Anticylone; poor AEJ/TEJ orientation over the Sahara (Flohn etal, 1974; Laseur & Adefolalu 1975; Adefolalu 1999).

ii. Global hydrologic cycle will be intensified with changes in precipitation, its total amount, frequency and intensity. In relation to these expectations, global concern expressed on water scarcity during UNCED-92 re-echoed in R10+$_{10}$ (2002). It is established that, total estimated runoff from World's rivers amounted to 7,600m^3 per capita per year constitutes a drop of about 80% from the 1970 value of 12.700m^3 while the declining trend will continue such that by the year 2025, water per capita would be about 40% of the value in 1970 or 5,200m^3. In reality, the amount of water per person may appear high globally; the situation in arid and semi-arid regions is far below these expectations resulting in experiences of severe water scarcity at the time of maximum need. Countries in these regions record withdrawal of runoff in excess of 20% which is synonymous with ACUTE SHORTAGE thus requiring considerable investments in both supply and management in order to increase water availability to assure sustainability.

In West Africa, the literature is full of various attempts [diagnostic studies] made within the past three to four decades to explain such phenomena as the SAHELIAN DROUGHT of 1969-72 without any concrete forecast of future re-occurrence(s). Ayoade, 1970; Obasi et al, 1978; Olaniran, 1983; Adefolalu, 1990, Oladipo, 1990). None of the classical treatises have proffered reliable projections for future changes of rainfall pattern due to climatic aberrations while elements of 'predictiveness' of effective precipitation are yet to be refined. However, derived parameters such as onset and cessation dates, length of the rainy season, degree of wetness or dryness etc. from which estimates of specific water consumption have been properly defined and documented.

In order to address the issue of available water as a consequence of effective precipitation in West Africa it is expedient to evolve a new approach. From past experiences in West Africa, water is a natural resource requiring a 'BUDGET'. Aspects relating to human ability to adapt to climate variability as it affects water availability in West Africa are considered to be critical for mitigation against spatio-temporal vulnerabilities in the development process.

iii. Agricultural production (including forestry) will increase in some areas and decrease in others taking into account the beneficial effects of $C0_2$ concentrations.

Evidently, West Africa cannot be categorized among countries where agricultural production will be high. None of the countries is presently self-sufficient in native crops and many depend on relief aids. Such countries as Senegal, Mali, Niger, Nigeria, Chad, and Sudan have had very poor returns from agricultural investments since the 1969-73 Drought the respite from persistent drought as evidenced from a periodic annual rainfall increases late in the seventies and eighties notwithstanding.

Agriculture, which is the most important sector of the economy in West

Africa NOW requires baseline information far beyond the scope of hitherto information on indices of drought as quantified by various author (Landsberg, 1986;). What needs to be exploited are the inter-play between rainfall and soil moisture; rainfall seasonality and specific water consumption or water equivalent to avert drought; rainfall intensity and soil erodibility/flood or water logging condition(among others)

All assessment indicate that developing countries (Africa in particular) will be 'more seriously affected than developed countries; not necessarily due to the 'actual' consequences of these impacts but their inability to readily adapt (contest) by not having coherent and integrated mitigation strategies to contain drought catastrophe (Odingo, 1976; Oladipo, 1986).

3. IDENTIFYING THE 'POSSIBLES'

3.1 The Forcing Functions

In 1979, the First Global Experiment (FGGE) of the Global Atmospheric Research Programme (GARP) was conducted with about $66 ***Billion***. The case for a West African Monsoon Experiment (WAMEX), which was brought to the fore by Adefolaluin 1995 at the Inter-Governmental' Committee in FGGE in Geneva, became part of the Global Monsoon Experiment (MONEX). With 4 months intensive observation period from MAY TO AUGUST 1979, it set out to establish the hierarchal order among the 14 'Forcings' in Figure 2.1. It was not only a success but one which revealed the following:

1. Atlantic Hurricanes form from incipient waves off the coast of West Africa [-a conclusion which was discountenanced about three years earlier that cost me WMO young scientist's award for a breakthrough].
2. The TEJ and AEJ form the southern and northern boundaries of weather producing systems in West Africa (figure 3.1). Thus, they ensure that the band of clouds within the West Africa sub-region constitute the incipient storm-producing system that are to be associated with 'TYPE'-A Monsoon- Cyclone) that can traverse the whole of West Africa depositing over 60-80% of the summer rains. Again, we discovered that the 'TYPE A' Wave (major discovery among many from my Ph. D works, Adefolalu 1974) is the Incipient 'Monsoon - Cyclone Wave'.

What is most intriguing is the favorite 20⁰ longitude wave length of the waves with a '3 day cycle (periodicity) while a hitherto unknown mean current synoptic oscillation <u>Monsoon Trough</u> (MT) has a periodicity of 5 days. These two distinct features were previously 'Combined' as one.

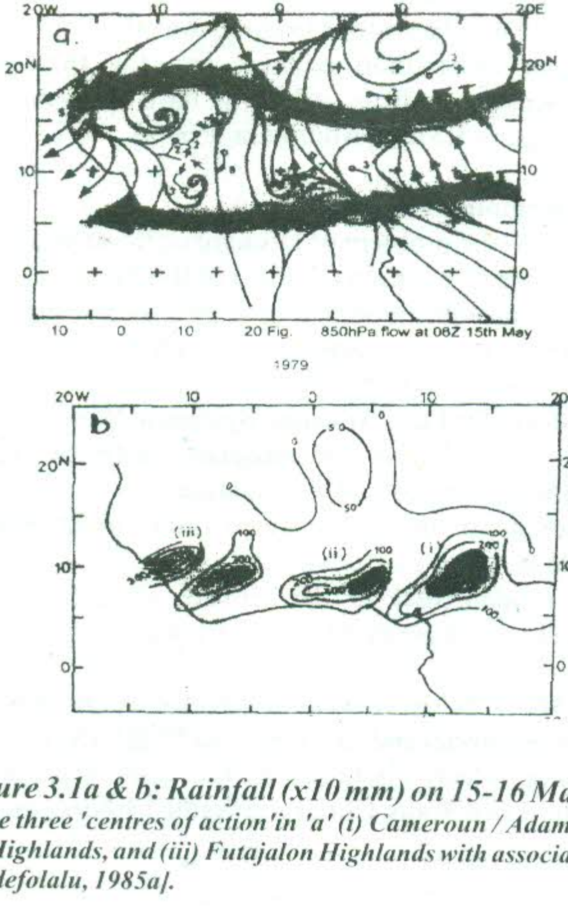


Figure 3.1a & b: Rainfall (x10 mm) on 15-16 May 1979

Notice the three 'centres of action'in 'a' (i) Cameroun / Adamawa mountains, (ii) Nigeria Highlands, and (iii) Futajalon Highlands with associated rain areas in 'b'. [From Adefolalu, 1985a].

With their separation by Spectral methods, Figures 3.2 a & b show them as two distinctly different phenomena. While the wave traverses E - W, the MT has a meridional oscillatory/ vacillatory movement through which it invigorates the wave during its northward excursion and downgrades it to Type B inverted - V' wave on its equatorward retreat.

Unique rainfall regime results from the above in- phase and out- of- phase relationship of the wave and MT. Again it took the scientific Community over 10 years to believe that the two systems are different but compliment each other. In fact, the main antagonist and a renowed Professor in UK later joined forces with me on WAMEX to project the finding. We were joint authors of the FINAL WAMEX Report published by the WMO. Part of our findings was the Spatio - temporal rainfall anomalous distribution patterns in May through August represented by departures from the long term 40 year (1941-80) averages 'shown' figure 3.3 a-d.[Adefolalu, 1984a]

3.2 *Major* **Regional Teleconnection**

Another dimension to the problem of Drought or flood years is the role of the EL-Nino Southern Oscillation (ENSO) of the Pacific Ocean. It is our conviction that a thorough understanding of this phenomenon and its Dynamics in suppressing (or otherwise) convective Hadley system in the tropics will not only lead to a better forecast/prediction 'Tool' but will also be a veritable platform for Early Warning System in West Africa Monsoon which, as highlighted above, is also associated with the GOOD YEAR INDIAN MONSOON induced E-W Circulation.

We can no longer doubt the influence of hither-to 'remote' causes of changing weather patterns and seasonality including cyclic tendencies which are now fundamental to the climate aberrations (variability) observed on shorter term scale than Climate Change.

In fact, for any EARLY WARNING to be effective we must seek to use the appropriate GCM, Regional and sub-Regional FORCING that is relevant. It is similar to acting selectively to make exact deductions and inferences (as advised by the Lord Jesus Christ). Afterall El Nino means 'Christ's Child'.

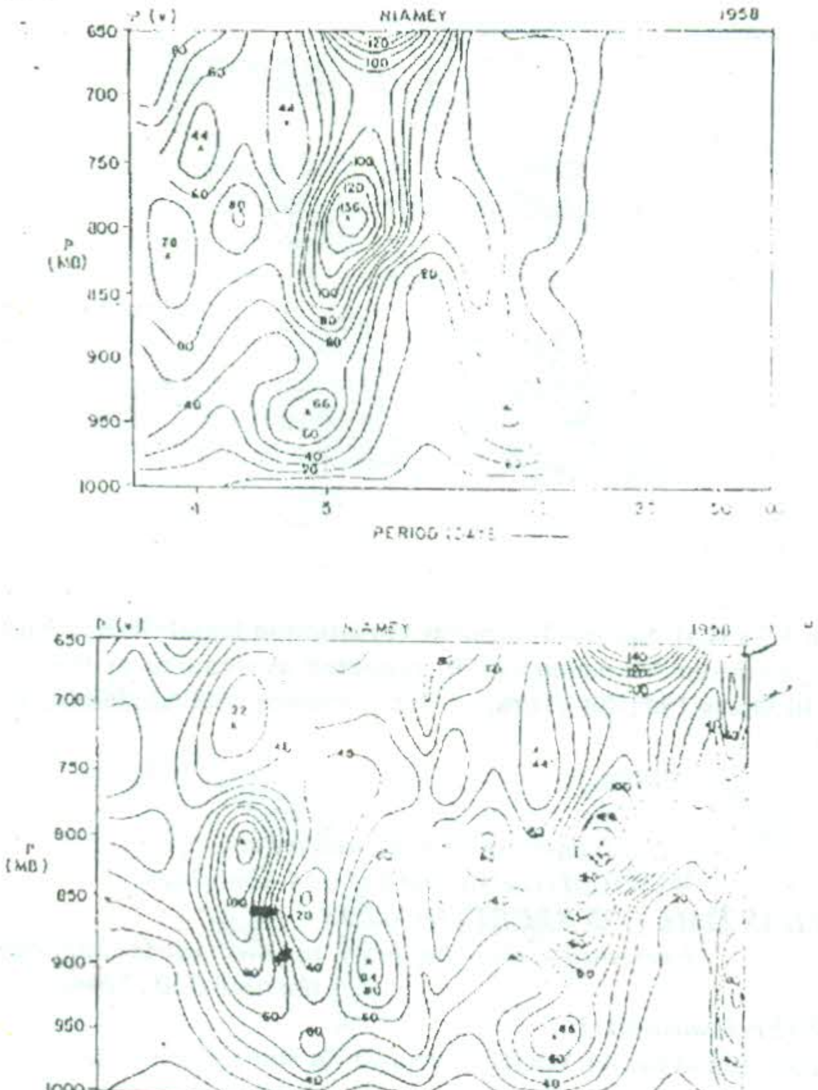


Figure 3.2 a & b: Smoothed power spectra of filtering seasonal (June to October) time series of meridional (v) wind component at Niamey in 1958 (from Adefolalu, 1974).

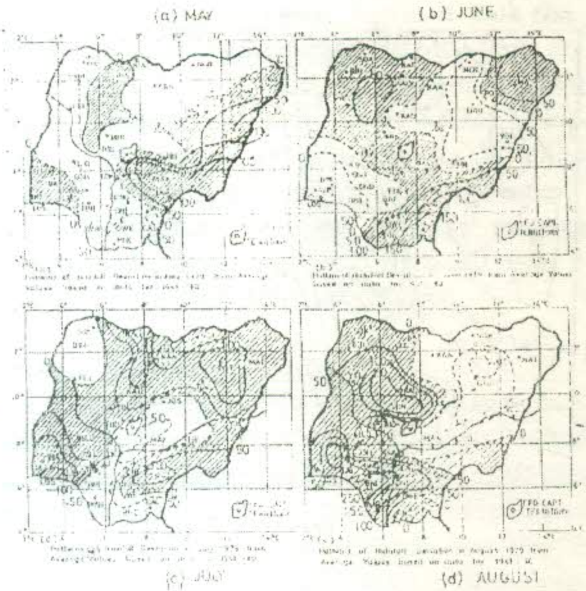


Figure 3.3 a & d: Spatio-Temporal Variation in Rainfall over Nigeria during Summer Monsoon (1979) reported as departures from long term 40 years 1941-80 averages (from Pearce and Adefolalu, 1983; 1984a)

It goes to prove the statement:
"WISDOM is in the hand of God Almighty"
WHO HAS TIME FOR EVERYTHING AS
"Everything that happens in this world happens at the time God chooses -------

-------" (Ecclesiastes 3:1)

We all must hold the ALMIGHTY in awe for some global incidents such as:

Hurricane in England in 1988 (at least 44^0N far removed from the northern limit of such warm water severe weather events) or Tidal Waves that accompanied the Tsunami of Boxing Day 2004 which took with it hundreds of thousands of lives or 2005 Hurricane Katrina in Southern Coast of the New Orleans USA which brought the country to her knees!

Note he(God Almighty) asked Job:

"Have you ever in all your life commanded a day to dawn --------.

Who is wise enough to count the clouds and tilt them over to pour out the rain"? (Job 38: 12, 37)

3.3 The El-Nino Teleconnection

This short but precise update by the WMO (1998) on El Nino (figure 3.3a & b) is presented in order to ensure that the most effective or accurate information is made available.

It is a summary of:

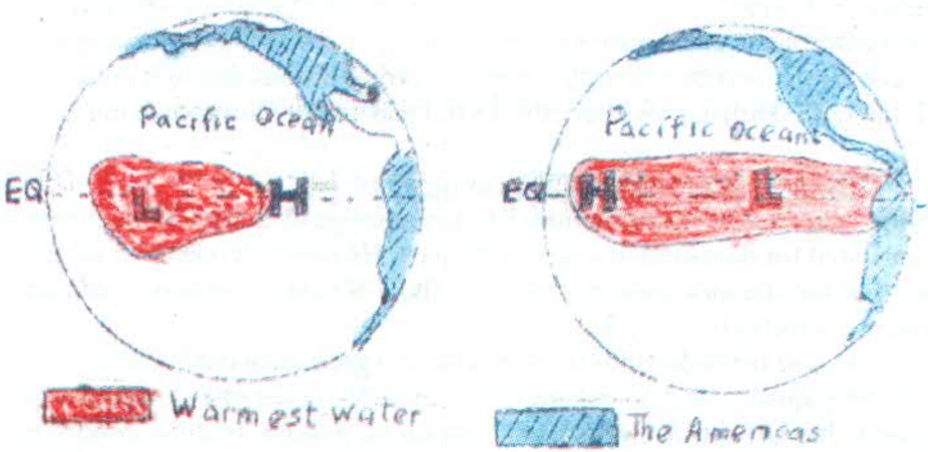
(i) Current knowledge of El - Nino phenomenon

(ii) Its associated impacts on global scale, and

(iii) Forecast information (indicators).

This update is complied from a variety of scientific sources including several major climate prediction centers, and is intended to address the questions and concerns of an audience that ranges from the general public to the policy makers. Key aspects are highlighted below:

THE USUAL SITUATION *EL NINO YEARS*



Warmest water *The Americas*

Figure 3.3a & b: Normal and El Nino years (adapted from WMO, 1998).

i. El Nino, ENSO and La Nina

"El Nino" is the term that is used for an oceanographic phenomenon; an extensive warming of the upper ocean in the tropical eastern Pacific lasting three or more seasons. The negative or cooling phase of El Nino is called La Nina. El Nino events are linked with a change in atmospheric pressure known as the southern Oscillation (SO). This is characterized by a see-saw in the atmospheric pressure between the western and central regions of the Pacific Ocean, with the centre of action located in the vicinity of Indonesia and the other centre located over the central Pacific Ocean. The index that measures the magnitude of the SO is known as the Southern Oscillation Index (SOI) and it is obtained by calculating the difference in atmospheric surface pressure between Tahiti and Darwin, Australia. Because the SO and El Nino are so closely linked with each other, they are collectively known as El Nino-Southern Oscillation, or "ENSO".

ii. Cause(s) of El Nino

El Nino results from interaction between the surface layers of the Ocean and the overlying atmosphere in the tropical Pacific. It is the very complex interaction between the ocean and the atmosphere that determines the onset and termination of El Nino events. The system oscillates between warm (El Nino) to neutral (or cold) conditions with a natural periodicity of roughly 3-4 years between El Nino events. Although a connection between the occurrence of El Nino events and possible global warming has not been confirmed by research but with warmer oceans due to increasing SST, the ENSO impact may become 'LOUDER' under Climate Change.

iii. El Nino as an old recurring Phenomenon

El Nino is not a new phenomenon. Evidence suggests that El Nino events have existed for thousand of years in the past. However, it is only in recent times that satisfactory understanding of the 3-4 year cycle of occurrence has been quantified (see fig 3.5).

During the last three decades there has been a great deal of investment in monitoring and research to enhance the capacity to predict El Nino, it was not until the advent of high-speed computers, though, that the complex interactions and massive amounts of data could be put together to provide a relatively clear picture of the phenomenon. Even so, the 1982-83 El Nino widely recognized as perhaps the most severe of the 20^{th} century, caught scientists by surprise. Unlike the El Nino events of the previous three decades, it was not preceded by a period of stronger than normal easterlies on the Equator, and it took place later in the calendar year than usual, even though it was not recognized as an El Nino until it was half over, it was responsible for extreme impacts on the global climate. North America experienced highly unusual weather throughout 1983; Australia experienced massive drought and devastating bushfires; it was one of the worst periods for drought in the sub-Sahelian countries; and the monsoons failed in the Indian Ocean. Total damages were estimated at somewhere between \$8 billion and \$13 billion (US dollars), and approximately 2,000 lives were lost.

iv. Tropical Pacific Ocean Temperature and Global Weather Pattern

During El Nino, the tremendous concentration of excess heat in the eastern tropical Pacific Ocean modifies the atmosphere immediately above it, and the effect are carried around the global by the modified circulations to the atmosphere, resulting in changes in the normal weather patterns in many regions. The sea-surface temperature deviated even further. The result is climatic response that is truly global. At higher latitudes the effects are more variable from one El Nino to another and the long-range climate forecasts are generally not as reliable as in the tropics.

> ***Our Lord Jesus Christ one more time opened our hindsights but we won't learn;***
> ***"When you see a cloud coming up in from the west, at once you say that it is going to rain ------ and it does.***
> ***And when you feel the south wind blowing, you say that it is going to get hot ---------and it does -----------"***
> ***You can look at the earth and the sky and predict the weather. But how is IT THAT YE CANNOT KNOW THE MEANING of the present time?***
> ***(Luke 12: 54 56)***

v. Predictability of Global Impacts of El Nino Events

By studying past warm and cold episodes[figure 3.4], scientists have discovered precipitation and temperature anomaly patterns that are highly consistent from one episode to another. Within the tropics, the eastward shift of thunderstorm activity from Indonesia into the central Pacific during warm episodes usually results in abnormally dry conditions over northern Australia, Indonesia and the Philippines in both seasons. Drier than normal conditions are also usually observed over south-eastern Africa and northern Brazil. During the northern season, the Indian monsoon rainfall tends to be less than normal, especially in the northwest. Wetter than normal conditions during warm episodes are usually observed along the west coast of tropical South America (Gulf Coast) and South America (SOUTHERN Brazil to central Argentina).

Southern Part of West Africa:

During the 1997-98 El Nino season the sub-region of West Africa, known as the Sahel, received abnormally low rainfall. The same region also received an extended period of suppressed rainfall during 1982-83 El Nino.

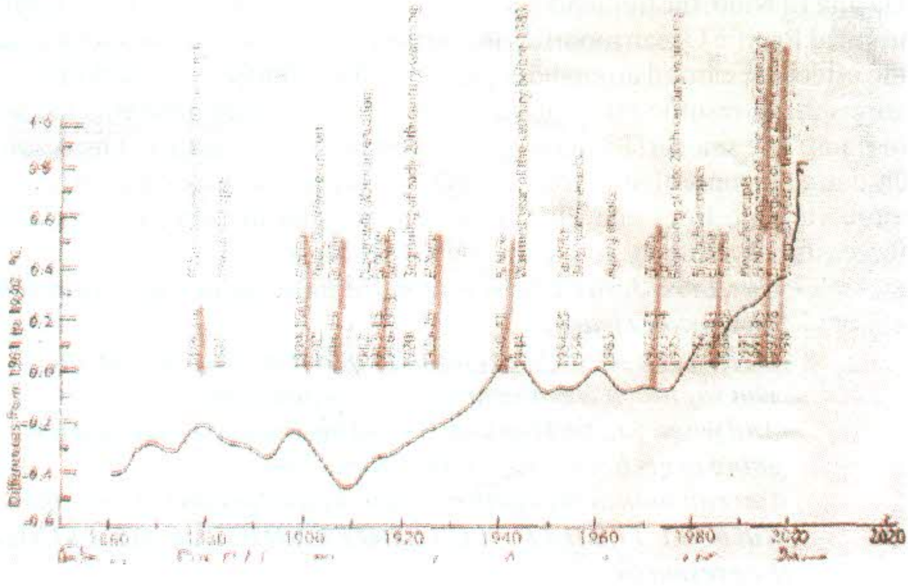


Figure 3.4: Global Temperature Anomalies 1860-2000 (adapted from WMO/WCRP-123, 2005)

There is no doubt that future El Nino events will create so much impact that all Nations will come together to carry out operational research because as noted in January 2005 (at the wake of the Tsunami) Brazil recorded its first ever TORNADO. But the impact was 'drowned' by that Asian catastrophe. With our warming SST in the Gulf of Guinea (Figure 3.5) which reached 31°C during the last 1997-98 El Nino, the worst is to be 'expected' and it is for this reason that so much time was spent on the El

Nino phenomenon as we continue to 'SEEK' for indicators of Failed or VIGOROUS Monsoon Season.

3.4 Role of Mid Atlantic Troughs (MATs)

Research initiatives using WAMEX data confirmed the role of westerly Troughs in enhancing the ONSET dates of the rainy season in West Africa and hence Thundery showers. Figures 3.6 show the upper level trough as it translates eastwards at the wake of which the ONSET outbreak took place in 1979 while Figure 7 depicts the same phenomenon during the Winter Monsoon Season.

Illustrated in figure 3.8a-d are Satellite Cloud pictures associated with the translating trough between 13^{th} and 18^{th} May 1979. The arrival of the MATs over West Africa marks the northward thrust of the MT and the more intense the particular MAT the **'deeper'** the low level moist layer 'underneath' the MT. It is the sudden surge of moisture which feeds the pseudo-waves turning them into on the Monsoon 'Cyclone's' releasing spontaneous outburst of convective clouds known as the 'HOT TOWERS' that form travelling squalls accompanied by strong winds (the squall), lighting and thunder.

The unique lessons from the Winter MATs is that as 'Forcing' function, MAT during the Harmattan is to strong convection in the Gulf of Guinea which, as observed in December 1960, results in outbursts of Thundery activity similar to what obtains during the summer but in the absence of transient invigorated by the MT. This makes it mandatory to understand the dynamics of the MT as <u>**WHAT WE MUST 'SEEK'**</u>. The implications of intensifying STH after the passage of the MAT, including raising and advection of Dust (Adebayo, 1986; Anuforom et al, 2005) that not only paralises aviation (poor visibility) but is known to be associated with respiratory ailments in both man and livestock, require better **'DIGESTION'** [Adefolalu 1984b]

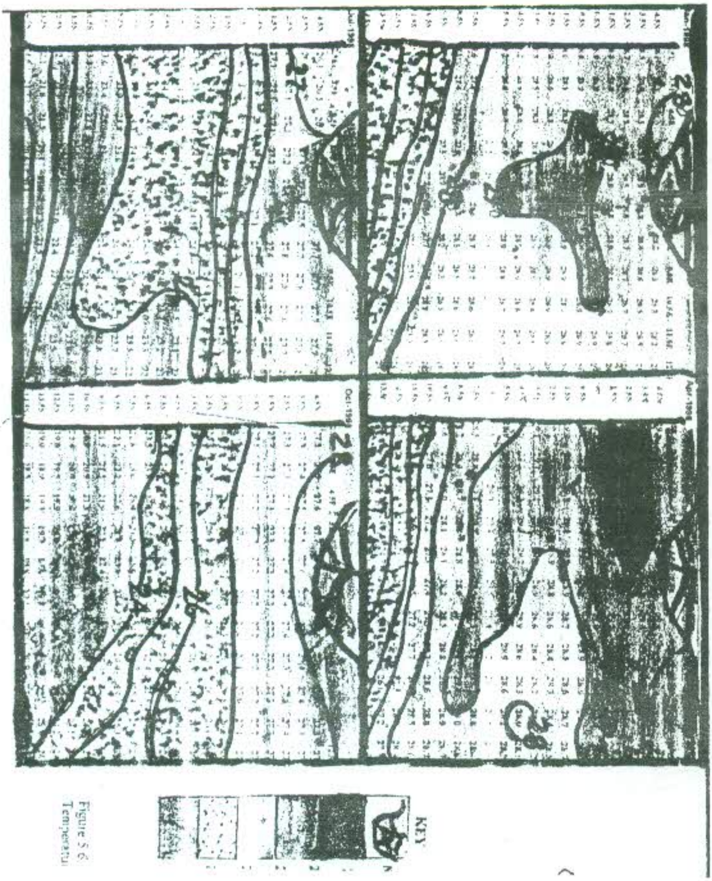


Figure 3.5: Sea Surface Temperature (°C) (From Eco-Proj. Rep. No.3, 2005]

Unstable Monsoon Basic Current and Precipitation

The above differences in precipitation patterns with respect to each wave suggest that the Monsoon basic current is conditionally unstable. Garstang et. al. (1967) defined this kind of instability in terms of change in sign of the vertical gradient of the mean static energy Qt written as:

$Qt = Cpt + gz + Lq$ -- (1)

Where

CpT = dry enthalpy gz = geopotential Lq

= Latent enthalpy

Pettersen (1964) had earlier shown that

$$Cp\theta e = CpT + Lq\,(1000/p)^{k} \text{ -------------------------------------- } (2)$$
$$\text{But } Cp\theta = CpT + gz \text{ -- } (3)$$
$$\text{i.e. } Cp\theta e = CpT + gz + Lq\,(1000/p)^{k} \text{ -------------------------- } (4)$$

It has been established that the coefficient $(1000/p)^{k}$ is nearly unity at lower levels where q is large but is large at higher levels where q is zero (Garstang et. al, 1967). Hence, for all practical purposes.

$$Cp\theta e = Qt = CpT + gz + Lq \text{ -------------------------------------- } (5)$$

Thus, the criterion for conditional instability is usually written in the form

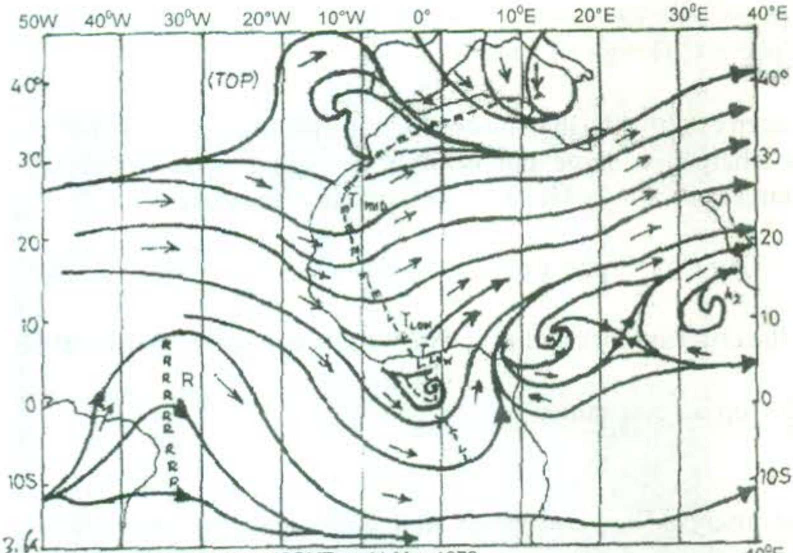
$Cp\frac{\delta\hat{\theta}_e}{\delta P}$<; cp is a constant & P

Further analysis has confirmed that the troposphere over West Africa fulfils the above criterion as illustrated in Figure 9 on latitude height cross-section of mean Qe values in which, at lower levels (below 700 hPa approximately) and south of latitude 12.5^{0}N

Since changes in the vertical profile of mean e is indicative $\frac{\delta\theta e}{\delta P}$ of potential

Convective processes, bad weather should be associated with large vertical gradients while fair weather may be linked with weaker gradients. Indeed, for mean seasonal rainfall, drought conditions during northern summer in West Africa appear to be associated with the above characteristic feature of the mean θe structure.

It is therefore possible to explain droughts in West Africa through the mean state characteristics of the monsoon basic current especially since $(\delta\theta e/\delta P)$ at lower levels (which determines conditional instability) is very much dependent on 'Lq' the latent heat component with 'q' representing the moisture content.



3.6 Figure ~~1~~a: 200hPa Streamlines at 12GMT on 11 May 1979

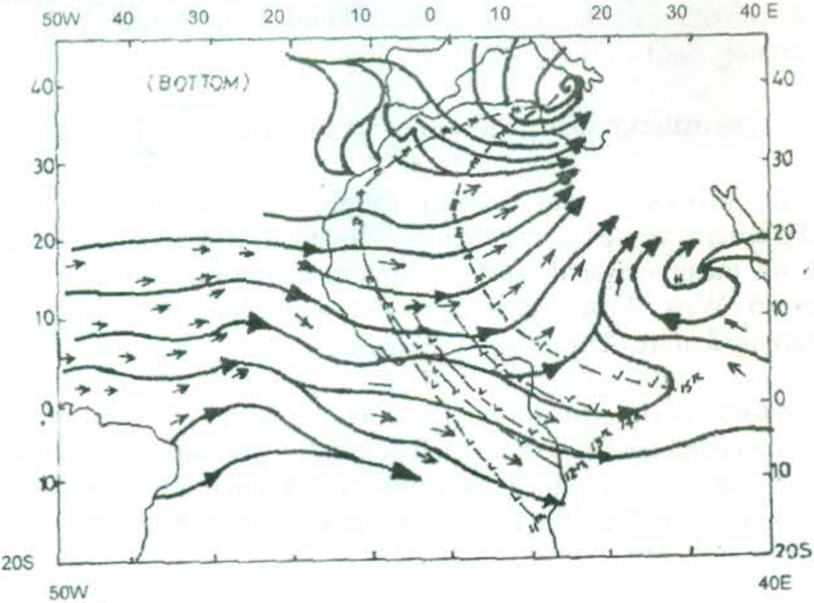


Figure 3.6a &b; 200hPa Streamline at 12GMT on 13May 1979 Positions of the Trough Axis (TLOW) are marked from 11 15 May. (From Adefolalu 1983c)

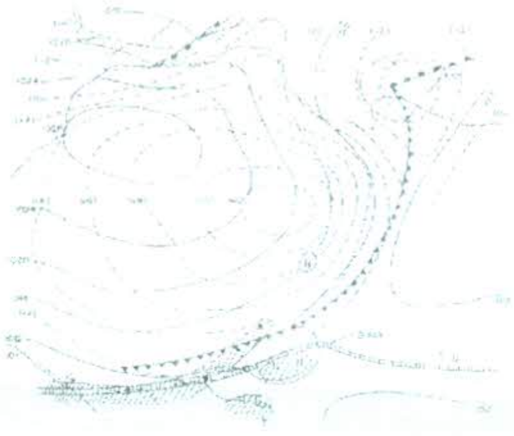


Figure 3.7; Surface chart showing passage of deep frontal system over Africa on December 26, 1960. Hatched areas were affected by thunder and / or rain on that day (after Mathews and Gilchrist 1962)

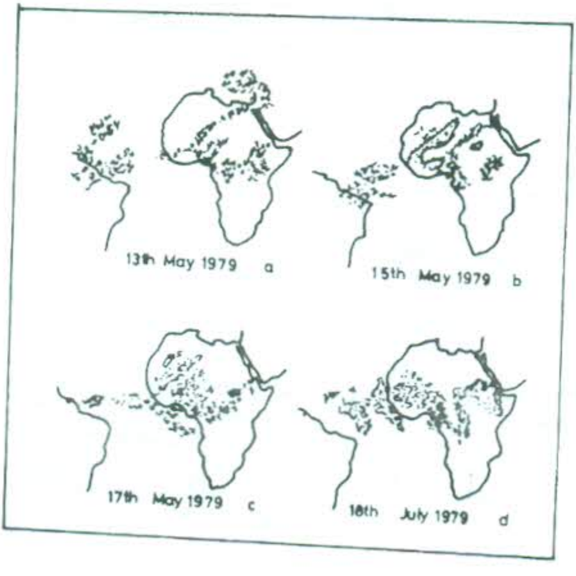


Figure 3.8a d: Satellite Cloud Pictures at 11.30 GMT on 13th, 15th, 17th May, and 18th July 1979 (from Adefolalu, 1983b)

An accepted theory of monsoon onset based on the super-position of the

MATS on MT which enhances pseudo easterly waves that trigger Convection and hence the beginning of the rainy season proper is anchored on

'RELEASE OF CONDITIONAL INSTABILITY'
which translates into $\delta Cp\varnothing e/\delta p < 0$
where $\Theta_e = C_{pT} + gz + Lq$

This is explained graphically in figure 3.9

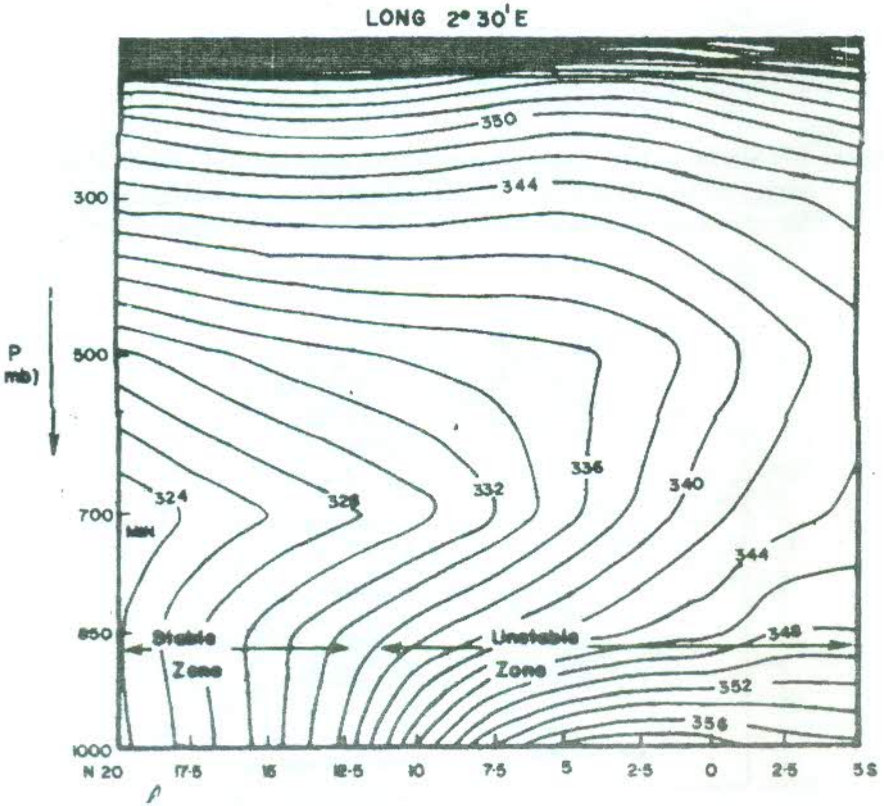


Figure 3.9 Latitude Height Cross-Section of Mean Equivalent Potential Temperature (δe) along Longitude $2^0 3)^1 E$ in West Africa. (Adefolalu, 1990)

At the surface up to about 850hPa level, we are to note the vertical lines north of Latitude $12^0\ 30^1$N [stable zone] while straight horizontal lines dominant south of that latitude. It is in the latter zone that the conditional Instability criterion is fulfilled

$$i.e.:\delta/\delta p\ Cp\varnothing e < 0$$

In the layer between 850 and 500hPa levels are the 'absorbers' of convective instability for tall (cumulonimbus) towers to shoot to higher levels. In numerical models, this is known as 'Convective 'adjustment'.

Once this is achieved, the Monsoon rainy season has commenced and seasonal variation in received rainfall is a function of how well these dynamics have been established. Understanding of Monsoon Dynamics is the beginning stage of grasping the DRY or WET YEAR Cycles [Adedokun, 1978; Adefolalu 1983c]. For a good monsoon Summer Season, there must be low-level southerly inflow into doublet vortex to the eastern flank of the Gulf of Guinea (see figure 3.10). All other things being equal, steady streams of waves will provide the impetus for enhanced convective activity and hence copious rain.

Figure 3.10: Schematic representation of line-squall generating low-level synoptic-scale system over Nigeria, West Africa

4.0 THE MODERATORS

4.1 African Easterly Jet (AEJ) and Dynamic (Baroclinic) Instability

The monsoon wave is embedded in the shallow layer of moisture south of the Belt where temperature increases rather than decreases with latitude from about Latitude 4^{0}N to 25^{0}N in the Heart of the Sahara.

Actual patterns are shown for May through August 1979 in figure 4.1 a-d, respectively. While in the Gulf of Guinea, temperature was generally 26^{0}C (or less), at the heart of the Sahara. it rose from 40^{0}C in Mav / June to 44^{0}C in July / Aug

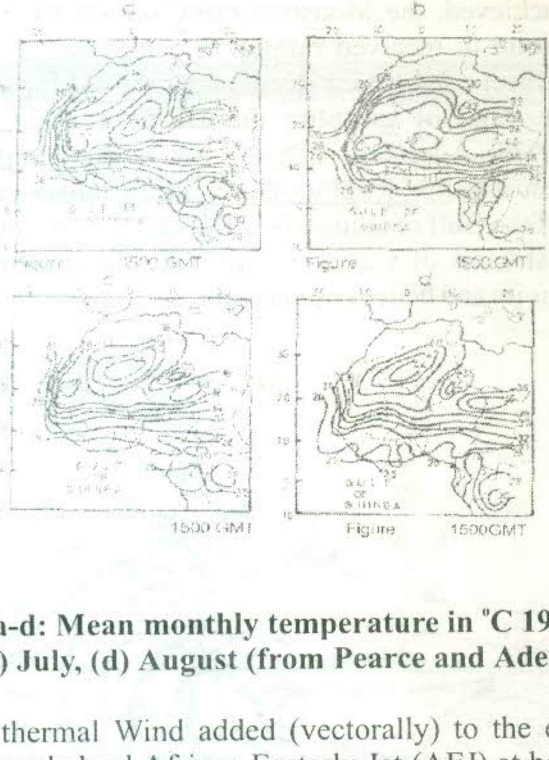


Figure 4.1 a-d: Mean monthly temperature in ^{0}C 1979 (a) May, (b) June, (c) July, (d) August (from Pearce and Adefolalu, 1983)

The resultant thermal Wind added (vectorally) to the easterly current forms the acknowledged African Easterly Jet (AEJ) at between 700 and 600hPa levels thus $\longrightarrow \quad \longrightarrow \quad \longrightarrow$

$$\text{Veasterly} + \text{Vthermal} = \text{Vjet.}$$

During Peak Monsoon months AEJ could rise to 40 msec^{-1} thus creating both barotropic and Baroclinic (Dynamic) Instabilities in the layers below and to the immediate south of the Jet axis between $\underline{12\text{-}20^0N}$ lat. As modulator of the summer monsoon, the stronger the Jet axis, the more intense is the monsoon cyclonicity and hence the WETTER the monsoon season.

West Africa is the only tropical sub-region where both the AEJ AND TEJ exhibit such Modulating influence that can result in flood as Drought years.

The spatio-temporal variation in rainfall in Nigeria in May through August 1979 has been discussed earlier. Massive in-flow of southerly moist air in figures 4.2c & d for July and August. The rainfall charts speak for themselves.

4.2 AEJ-TEJ and Surface Weather

As previously alluded to, many investigators have speculated on the importance of tropospheric jets in West Africa in relation to surface weather, especially deriving from wave-scale cloud clusters, resulting in line-squall propagation.

In studies based on WAMEX Data, definite empirical relationships were formulated. Using 65 cases of upper level TEJ trajectories at 200mb and latitude of thunderstorm maxima, Arikpo (1983) established an empirical (positive) linear relationship between the latitude of TEJ and latitude of maximum thunderstorm occurrences for May-August 1979. With the same techniques but using the latitude differences (Lat.) between the AEJ and TEJ and the extreme north and south limits of thunderstorms (Lat.B) Alkhalil (1983) also found a similar linear (but negative) relationship between Lat. (AEJ-TEJ) and Lat. of Thunderstorms.

On the relationship between the TEJ and precipitation, Atikpo found that the east-west axis of the latitude of maximum observed rainfall is related to the TEJ latitude by the expression:

$$\phi_{R_{max}} = 3.6 + 0.8\,\phi_{TEJ}$$

where is latitude at longitude 10^0E

On the latitude band between the TEJ and AEJ in relation to surface weather Alkhali (1983) found a very interesting inverse but linear relationship. The empirical expression relates to the latitude band of the thunderstorm (R,) to the latitude band between the TEJ and AEJ in the form:

$$\phi_R = 1.1 - 0.8\,(AEJ\text{-}TEJ)$$

n a later study which made use of the raw data from the two studies highlighted above, Adefolalu (1984) found further linkages which are illustrated in figure 4.3a-d. Also, the inverse but linear relationship between the latitude band of thunderstorm and the latitudinal distance between the east-west axis of the AEJ and TEJ which was highlighted by Alkhali is very realistic i.e. the smaller the latitude difference, the higher the intensity of tall cumulus convection .

Other interesting features are contained in figures 4.3 a c which may be summarized as follows:-

(i) In relation to the TEJ, when it is between 6°- 8° north, there are 24 occurrences of maximum precipitation at about 8° to 10° north. This implies that the location of intense convection begins generally 2° north of TEJ axis. This represents 73% of all cases studied.

(ii) The preferred location of the AEJ on the other hand is 15° to 16° north for maximum precipitation to occur at 8° to 10° north. This also accounts for 72 % of all cases. This means that maximum convective clouds may be triggered at about 6° south of AEJ position.

(iii) For the latitude difference between the AEJ and TEJ, lat. (AEJ - TEJ), it is observed that the optimum latitude band (6° to 8°) of thunderstorm is to be expected when lat. (AEJ - TEJ) is 8° to 9°. This represents 60% of total occurrences.

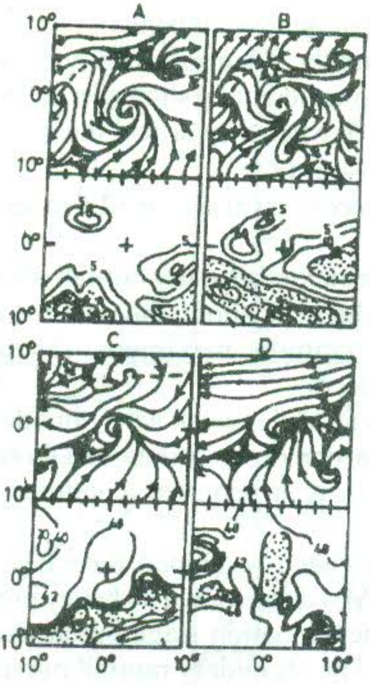


Figure 4.2: Composite of waves at 850hPa observed precipitation for

A. 11 17 May 1979 B. 11 17 June 1979
C 16 23 July 1979 D. 21 27 August 1979

(Adopted from Pearce and Adefolalu, 1983)

These three findings suggest that the zone of maximum convection is usually very narrow at the formative stage of thunderstorm occurrence. It may be no more than 2° or about 200km. This agrees well with earlier delineation of the active weather zone C for West Africa (see Hamilton and Arcbold, 1945) which has been corroborated by later studies that fixed the axis of maximum large - scale related convection at about 8° to 10°N (Dean, 1972; Dean and LaSeur, 1974 and Adefolalu, 1974).

On the actual amount of precipitation or band of thunderstorms in relation to the strength of both Jets, the relationship is non-linear. Nevertheless, there are two peaks each conspicuously shown in the curves occurring for precipitation (Max) where or when the vertical shear;

U|TEJ/max - U|AEJ/max = $\pm$5m sec^{-1}

and U| TEJ/max - U|AEJ/max = -10 m sec^{-1}or +2.5 m sec^{-1}

For precipitation, the mean maximum daily rainfall observed at wind shear of -5m sec^{-1} is 80mm which is about the same amount when mean thunderstorm band is 4°latitude maximum. There are two basic interpretations to these patterns:

(i) TEJ is very strong and AEJ is weak when thunderstorm is expected. This agrees with earlier observations of Dhonneur (1981) that a rupture of the AEJ is a required condition for Cb - cluster development.

(ii) Once the cloud clusters have developed, the AEJ is re-established and U between TEJ and AEJ decreases. The heavy precipitation received need not occur at the formation stage but at mature as parent line squall moves away. The secondary rainfall maxima of about 65mm per day are associated with a shear of +5m sec^{-1} while the thunderstorm band is 3.5° latitude. The shear for the latter is + 2.5m sec. These are situations which could be associated with thundery activity which may be widespread but are not likely to be the squall-type.

Although these results hold promise, especially for operational forecasting, there are definite problems which further research may help to solve. For example, it is not enough to identify locations of possible thunderstorm occurrence. The intensity in terms of precipitation amount and duration of fall are critical in say, agricultural activities. This latter part as observed above suggests that it is not a linear relationship to say the least.

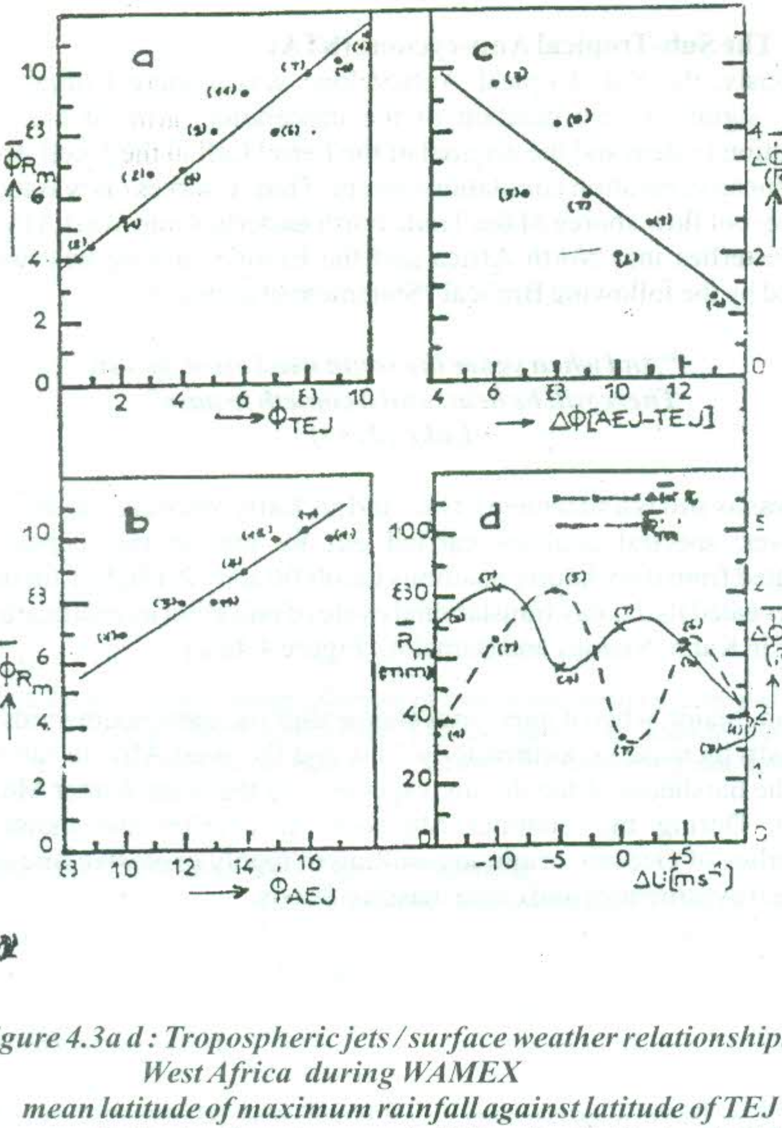


Figure 4.3a d : Tropospheric jets / surface weather relationships in West Africa during WAMEX

a- mean latitude of maximum rainfall against latitude of TEJ

b - mean latitude of maximum rainfall against latitude of AEJ

c- mean latitudinal width of thunderstorm band against latitude difference of the AEJ and TEJ

d- vertical shear (U^{TEJ}_{Max} U^{AEJ}_{Max}) against latitudinal width of thunderstorm band and maximum rainfall R_{max} (from Adefolalu, 1984)

4.3 The Sub-Tropical Anti-cyclone (STA)

Previously, the Sub-Tropical Anticyclone was a mere Climatological 'entity' signifying the position of the descending 'arm' of the Hadley circulation system and the original of the Ferrel Cell in the 3-cell structure of the mean generation circulation system. Thus, it serves (as was thought) as mean out flow source of the Trade north easterlies into West Africa and the Westerlies into North Africa and the Europe causing heat wave as implied by the following Biblical "Statement of authority".

> ***"And when ye see the south wind blow; ye say,***
> ***There will be heat; and it cometh to pass"***
> ***(Luke 12: 55)***

That was as still is a statement of fact and an 'Early Warning' model.
However, spectral analysis carried out by me on the Times series generated from it six hourly positions for 00/06 and 12/18GMT for one full year revealed its 7.5 day translational cycle of pulsating intensification and 'decay' in Kano, Niamey and Bamako. (Figure 4.4a-c).

As a modulator, when it intensities and/or shift its centre southwards, there is a sharp increase in northeasterly flow and the West African sub region feels the harshness of the dry air, especially in the drier Winter Monsoon season. During the Summer Monsoon, it overlies the moist/warm southerlies of Oceanic origin in resulting in highly explosive line squalls that destroy structures and cause massive floods.

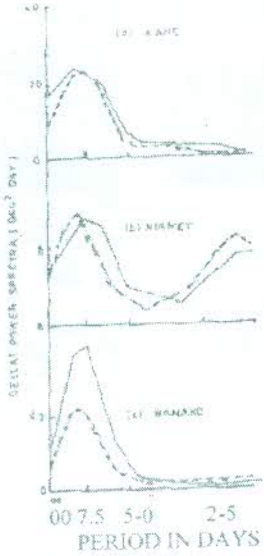


Figure 4.4 a-c: Smooth Power Spectra of time series derived from position of the The-W axis of the STA at 700hPa as latitude departures relative to (a) Kano, (b) Niamey, (c) Bamako (from Adefolalu, 1974; 1983c)

4.4 The Harmattan and DRY Summer months

During winter Monsoon, the Harmattan (Dry Northeast Trades) normally reach about 6^{0}N latitude and vacillate around 5 7^{0}N for most of the dry season. But since about 1970, the intensity of the sub-TROPICAL High (STH) during the Harmattan has intensified leading to severe dust haze spells (Adebayo, 1980)

Harmattan (dry winds) now reach the coastal areas with effortless ease (see figure 4.5a & b for Calabar, southeastern coastal town in 1982 and 1983). This have been supported by recent studies of Anuform et al (2005). A dust spell of the 1982 type is often a fore-runner of poor rainy season during the following summer monsoon months which are coincident with intense ENSO years. This needs to be further explored for seasonal forecasts and food Early Warming.

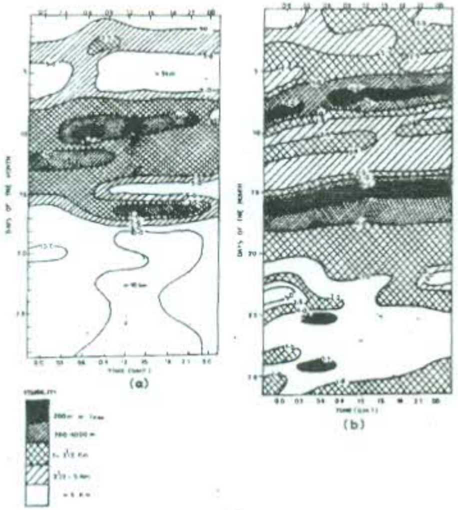


Figure 4.5 a & b: Visibility (km) showing the influence of Harmattan dust haze in Calabar 1982-83 (a) February 1982, (b) January 1983 [from Adefolalu, 1984]

4.5 THE SST/SLR FACTOR

Although work is just beginning on the elaborate 'plot' of Climate Change to destablise Nigeria through coastal inundation by Sea level Rise (SLR) and tornadic severe Weather events, it suffice to state with illustration that we need to pray that our Good Lord keeps his promise:

> ***"I will remember my Covenant, which is between me and you and every living creature of all flesh; and the water shall NO MORE BECOME A FLOOD TO DESTROY" (Genesis 9: 15)***

Mark the word Destroy it did not say damage!!!

However, figure 3.1 shows the current trend of Sea Surface Temperature (SST).

5.0 IMPLICATION FOR FUTURE RESEARCH

The presentations in Section 4 have been limited to observational, synoptic and climatological studies based on past and WAMEX data sets especially the latter. This has been deliberate in view of the fact that the WAMEX Atlas has been reproduced from actual charts and the summary is to highlight such aspects of climate episodic events that the maps can corroborate. To this end, certain aspects of the monsoon meteorology which appear to require close scrutiny are highlighted below.

5.1 Mean State

WAMEX results on the mean state of the tropics have confirmed previous findings and results of diagnostic studies in relation to the existence and role of planetary scale features including the oceanic trough, sub-tropical anticyclones (STA), the Tropical Easterly Jet (TEJ) and, over Africa, the Easterly Jet (AEJ) and the heat low at about 20°N.

Further studies of the Mean state of the tropical atmosphere over West Africa should include the:

The most important and fundamental question on the maintenance of the mean state. This will entail studying the interaction of:
The mean state with the mean state (for example the interaction of the south and north sub-tropical high pressure belts and the evolution of the monsoon flow over West Africa (See figure 5.1 a& b for Winter and Summer Monsoons).

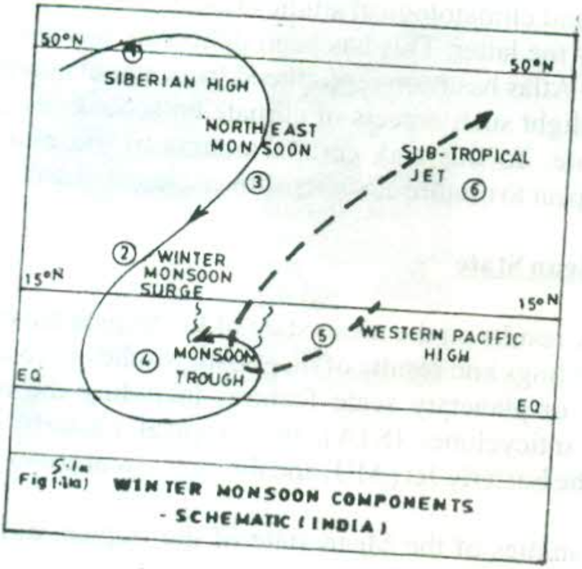
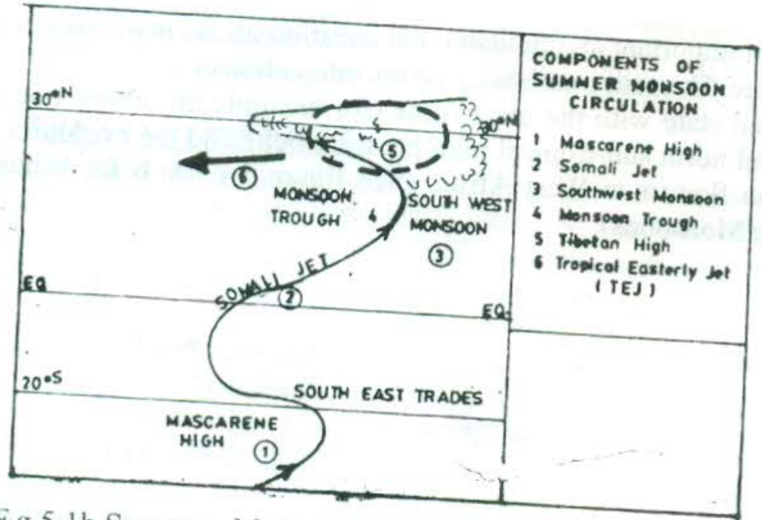


Fig 5.1a WINTER MONSOON COMPONENTS - SCHEMATIC (INDIA)



F.g 5.1b Summer Monsoon Components Schematic (India)

5.2 Synoptic- Scale Disturbances

The problem of transient waves in West Africa appear to have over-flogged within the last three decades at least while oscillation of the monsoon on the synoptic scale was held with skepticism. Modelling, which have emerged from other regional studies, including the American Pacific, have confirmed the role of the monsoon trough in formation and life cycles of weather disturbances in that part of the tropics. Coming from a region where the Easterly wave was first discovered (Riehl, 1954) the West African monsoon cannot be different. Its place in the evolution of tropical weather is not in doubt. However, models of the easterly wave in the Pacific show that it is a 'decaying' phenomenon with only barotropic energy sources. Thus it is easier to predict.

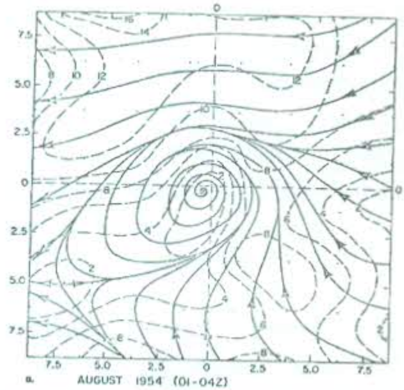
But the African wave, embedded in deep southerly flow with maximum cyclogenesis at the MT axis, the modelling have to incorporate all the modulators and the other forcings already discussed. It is no wonder that after 30years of active research, the resolve has been to describe the resultant weather and climate in relation to their impacts. Observational models were first used to identify the Type A wave cyclone in phase with northward surge of the MT and type B wave associated with retreating MT (Figure 5.1a&b)

Suffice it to state that results of observational and synoptic/climatological studies have survived the test of time and both theoretical and analytical studies have also reaffirmed the basic characteristics of the African wave determined in the early 'sixties'. The interaction between monsoon Trough oscillation and wave have been confirmed by WAMEX results.

However, research into the following areas necessary but expedient:

(a) The relative importance of the horizontal shear resulting from upper influence which lies above the ITCZ cloud clusters;

(b) The transfer of westerly momentum away from the tropical easterlies by the anticyclones circulation with axis extending from the Venezuelan coast (5°N) to the Tibetan High (30°N) and the consequence of this on the dynamics of the African wave and other disturbances;



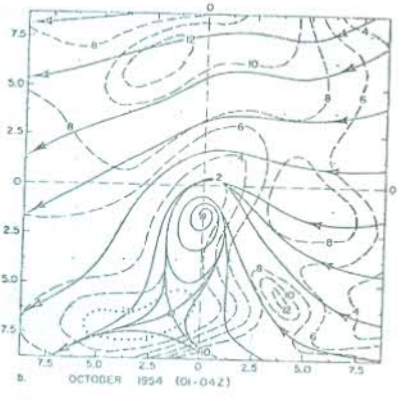


Figure 5.2a & b: Type A and B Waves Composite Model of all waves in (a) August for Type A and (b) October for Type B (From Adefolalu, 1972).

(c) The dynamics of the north-south excursions of the monsoon trough as a 5-day synoptic-scale meridional oscillation and, more importantly, the consequences of its interaction with the wave disturbances which, in part, has been suggested as being responsible for the evolution of synoptic wave types A and B and intensification of Type A monsoon cyclone into Atlantic Tropical Depressions/Hurricanes. The interest of Americans in this type of wave has heightened since the 1979 FGGE Experiment and today they have come to recognize that understanding its dynamics hold the key to prediction of Hurricanes in the Atlantic Lessons of the 2004 and 2005 Hurricanes seasons are responsible for new initiatives by the WMO (GARP 2005). 'THORPEX Africa' is already gaining momentum and we have been invited to participate.

(d) With respect to the monsoon itself, the onset, active, break and cessation periods and the critical factors responsible for inter and intra-seasonal changes. For instance, regional scale ENSO features that can be associated with the Indian monsoon have been highlighted. Since the ultimate goal of sub-regional research in West Africa is to make weather forecasting and prediction an objective operational Programme for EARLY WARNING AND FOOD SECURITY there is an urgent need for numerical experimentation on the monsoon and regional scale interactions and teleconnections.

6. CONCLUSION

6.1 Many 'unknowns'

We have so far confirmed the complex nature of tropical weather and whatever we do, using the conventional techniques 'known to meteorology' to predict future state of the atmosphere, will remain an 'attempt' and not the solution.

There are Theories and Models like the Energy cycle over West Africa illustrated in Figure 6.1 All the 14 'elements' of figure 2.1 constitute the 'Control' to predict we must quantify the 'FeedBack'. But just like the case of the Scientist who carried out Laboratory experiment on the Bee and concluded that the weight of the bee is too 'heavy' for the tiny 'singing' wings to keep it flying. The Scientist says that but the bee doesn't know it and so it keeps flying. The inference from this is that we must accept and respect 'NATURE'. This is on only too true in meteorology. On September 30, 2006 it rained all nigh and morning. I took special interest because one of our respected men of God was to give her daughter hand in marriage. It was bound to happen and we are to be reminded that there is "A Time for everything".

"Everything that happen in this World happen

What we need to do is note the signals relating to the occurrence of an event, diagnose its major impact and store up for future recurrence this is called 'ANALOGY'. The Chinese have carried to the greatest heights by establishing botanical gardens, aquariums and specialized zoos for animals whose behavioural patterns ahead of a severe weather are 'connected' to conventional weather observations.

In essence they have married weather fore-casting with nature. There are known characteristics of plant like those that shut their petals at the approach of a heatwave; special fishes dive down to the bottom of aquarium before 'cold weather' starts while goats run-amok at the approach of thunderstorms. We have a lot to LEARN from natural elements. But we have GOOD interpreters. Pharoah's JOSEPH is needed now more than ever before.

The Meteorologist has tools that go beyond the conventional to monitor and forecast weather. Remote sensing is one of the very best in the provision of information to cover all places. But it will seem as if the more we try to 'cage' nature by devising special platforms, the more the surprise we get about the ingenuity of Nature.

That the level of 'unknown' will continue to rise (mount), as our attempts improve, is told in these two short stories. In 1973, the Global Atlantic Tropical Experiment (GATE) was carried out to monitor closely the character of African wave systems that develop into Hurricanes. Hard as the Scientists tried for three months to 'FOLLOW' EACH TRANSIENT WAVE, NOT ONE DEVELOPED INTO Hurricane. The experiment had hardly been closed down, all Aircrafts, ships and special plat-forms dismantled and left the 'ARRAY' area than the very next wave developed into the hardest hitting Hurricane seven days later.

In 1974, a full blown Hurricane that had just passed the Honduras was to make a direct hit at the USA. Many (up to seven) models predicted its trajectory. Not one was corect. Why, the hurricane lost steam and died where it was when the 'predictors made their predictions'.

CONTROL

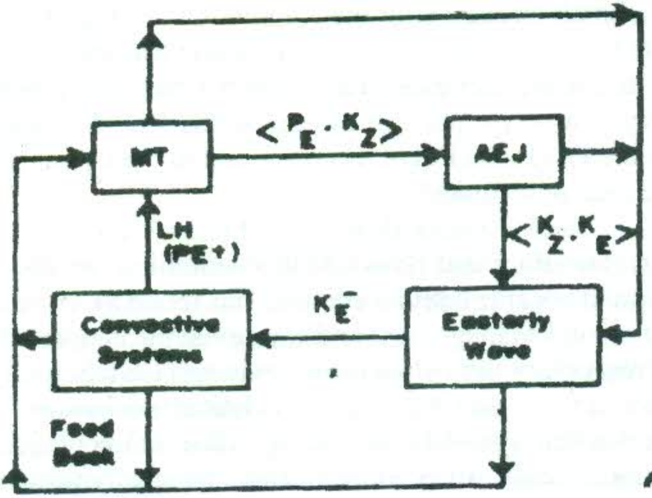


Figure 6.1: Energy Cycle over West Africa (adapted from Adefolalu 1985a)

Of our incompetence to contest with God, He says (talking to Job)
"Look at the monster Benemoth (Hippopotamus)
I created him and I created you
He eats grass like a cow____
But what strength is there in his body
And what power there is in his muscles" (Job 40:15 16).

6.2 FROM 'KNOWN' TO 'PREDICTABLES'

Nigeria is yet to get to grips with implications to Climate Change. The National Meteorological Agency (NIMET) can testify to that Challenges of reequipping up Air stations without which weather Short Time forecasting for economic activities will remain a day dream.

Rather than take 'sit-down-look' attitude, Government Institutions should embark on Mean State studies for EARLY WARNING going from "KNOWN' TO THE 'UNKNOWN'. At the Federal University of Technology, Minna we have in the past 20years embarked on doing the 'possible'. Some illustrations of products of our Research are shown in figures 6.2 to 6.16 with captions on associated episodic event.

We made a break through after the completion of mean State Mapping of Niger State for Land Use Planning. The study was sponsored by the Col. Gwadabe led Administration at a cost of N1.8Million (1988 value). The products were used (in part) in designing the EU Funded Middle Belt Project by the FAO which sent its consultant to the University to obtain a copy of the final phase maps.

The African Development Bank (ADB) "stumbled" on the Atlas sets for Niger State and became convinced that it has found a Centre at Excellence on Environmental Management and appointed the University to carry out a similar Project for Ondo State (now Ondo and Ekiti States) in 1991. The outcome was a three-part Atlas series on State level mean climate, Local Government level Agro-Climatological Atlas and ecological zones and soil mapping at cost of US $1.26million. The study took three years to complete.

The success of both projects inspired the University to put up a N99.88 Million Project proposal to the ecological Fund Office for the 36 States and the Federal Capital Territory (FCT) in 2001. The Project scaled all hurdles and was executed in 2004 2006. Hajiya (Dr) Mrs. Safiya Muhammad was the Permanent Secretary of Federal Government Agency now with yet another elegant lady (Mrs. Umoren) as Permanent Secretary-In-Charge was so impressed by the Products that she has now promised to recommend the Project annually subvention thus turning it into a Programme.

6.3 Human Resources Development

With these encouragements, the Department of Geography, in collaboration with the Centre for Climate Change and Freshwater Resources have in the past 10 15years jointly trained:

17 Ph. Ds in Meteorology and Remote Sensing Applications. In fact, we humbly submit that not only has our Programmes lifted the standard of staff 10 Senior Teaching Staff have Ph.Ds) seven trained at FUT, Minna Six of whom have attained Professorial status. We have also been providing training to staff of other Universities, (at home and abroad, two are FULL FLIGHT PROFESSORS) Agencies of States and the Federal Government.

6.4 **Salt and Light**

Finally, permit me Mr. Chairman to close this presentation with this famous advice:

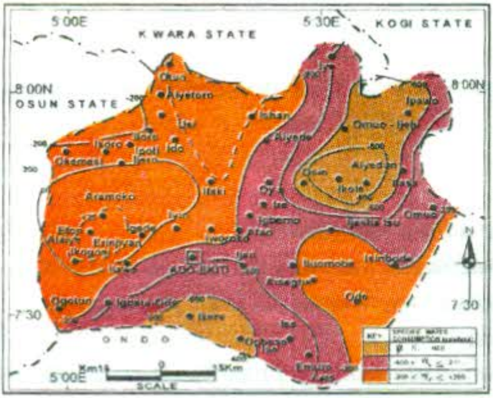
> ***"You are the salt for the whole human race.***
> ***But if the salt loses its saltiness, there is no way to make it salty again. It has become worthless' so it is thrown out and people trample on it.***
> ***You are the light for the whole world. A city built on a hill cannot be hidden.................................... light must shine before people, so that they will see the good things you do and praise your father in heaven"***
> ***(Matthew 5:13 16)***

6.5 Thanksgiving

All Glory to Almighty God for making today a reality. My appreciation goes to all the Leaders of Management of University to date, colleagues, associates and students who have made my 20years of toil, pain and stress more like 200years of Bliss.

All support Staff of the CCCFR and Mrs. F. F. Bankole of 2A Business Centre, Bosso Minna did the Word Processing while original figures were drafted by Mr. J. O. Omotayo.

EKITI STATE
SPECIFIC WATER CONSUMPTION



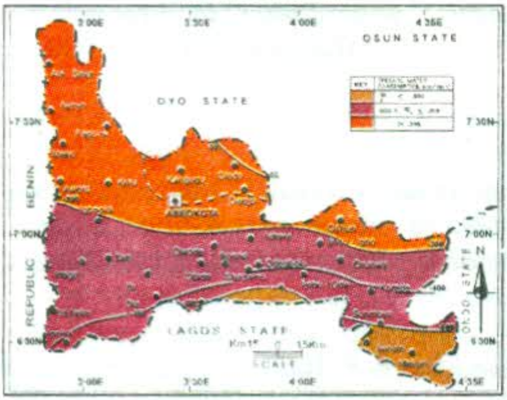
Moderate rainfall intensity *of 30 40 mmhr⁻¹*

Moderate rainfall*: 1100 1900mm*

Low to Hydro Neutral *: - value is 0.5 to 1.0*

Deficit to Moderate specific water consumption *- 25 to 800mm.*
Southwest / Efon Plateau in Danger of severe forest degeneration. Axis of LGAs highly prone to forest degradation bisecting State into two with 50% of eastern half prone to erosion

OGUN STATE
SPECIFIC WATER CONSUMPTION



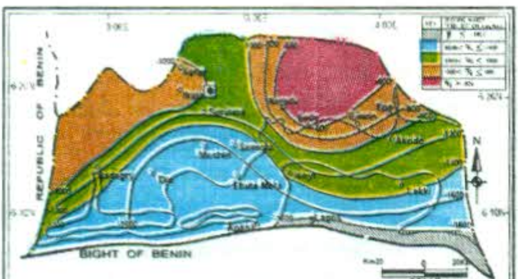
Moderate rainfall intensity *of 30 45 mmhr⁻¹*

Moderate Annual rainfall *of 1000 1800mm*

Below Hydro-Neutral *with - value of 0.5 0.9*

Zero to moderate specific water consumption *: Riverine areas prone to flood and upland location susceptible to drought due SWC 00 to 600mm*

LAGOS STATE
SPECIFIC WATER CONSUMPTION



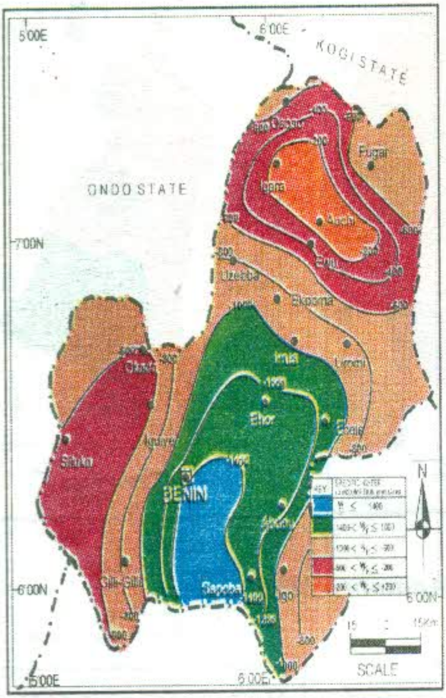
Moderate rainfall intensity *of 30 40mm hr⁻¹*
Annual rainfall *1000 1900mm*
Nearly Hydro Neutral *with - value of =1.0*
Moderate to High EXCESS *specific water consumption of 500 1800mm FLOOD is perennial due low lying flat terrain*

Map6.2a c : Ekiti, Ogun, Lagos StateS with Indicators of Disasters

SS 1 - EDO [10]

EDO STATE

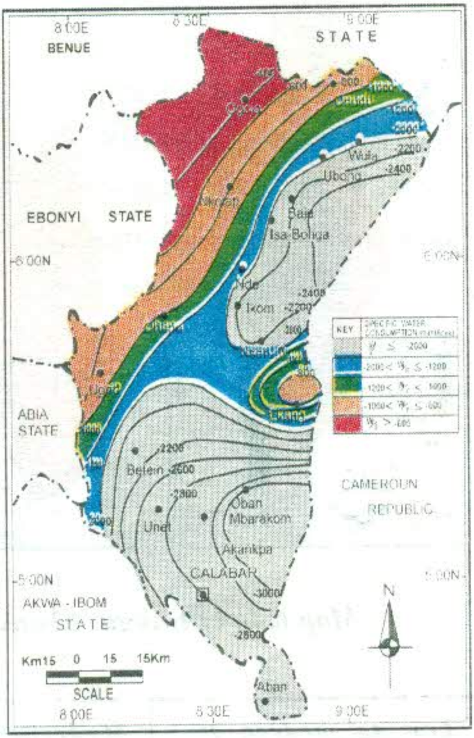
SPECIFIC WATER CONSUMPTION



SS 6 - CROS [10]

CROSS RIVER STATE

SPECIFIC WATER CONSUMPTION



Map 6.3 a&b : Edo, Cross River States with Indicators of Disasters

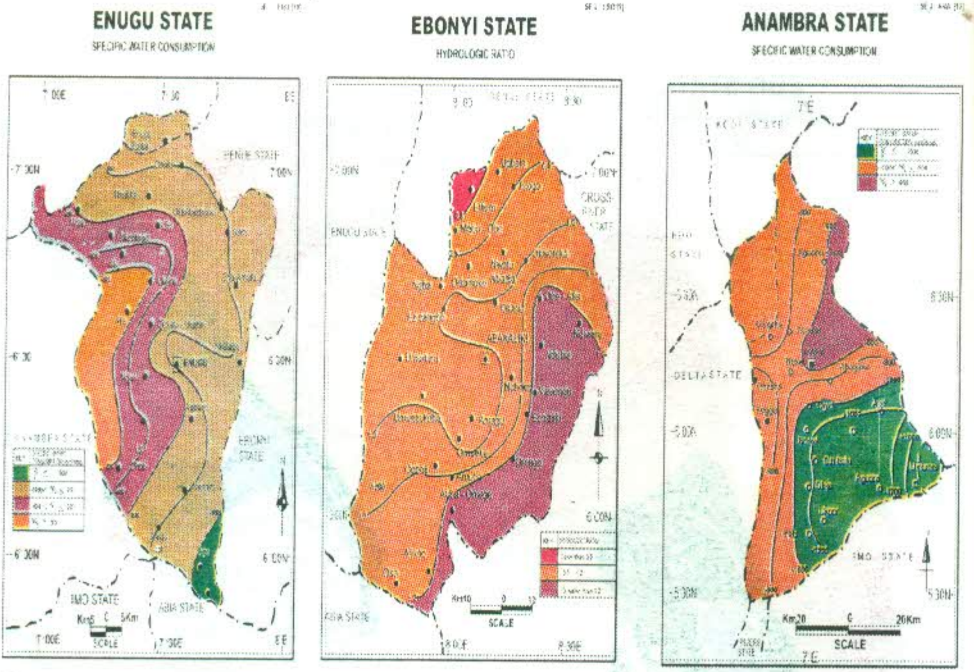
Low to moderate rainfall intensity *of 25 45 mm h⁻¹*

Moderate to very high annual Rainfall *ranging From 1200mm in the NE to 2500mm in South / Central areas.*

Hydro Neutral *with - values of 0.7(NE) to 1.3 (south / central)*

Low to High Specific Water Consumption
Prone to Flood / sheet flow and Annual flood in South / Central areas. North of Benin requires water supplementation in upland parts

Moderate rainfall Intensity *30 -46mmhr⁻¹*
Moderate to very High Annual Rainfall *of 1500 4600mm*
Hydro Neutral to Super Water Logging
with - values of 0.8 to 2.4 severe water logging in cross River Basin. Northern highland plains - north of Ikon have low water surplus (400mm or less) but water shed perennially water logged



Map 6.4a c: Enugu, Ebonyi, Anambra States

Low to modern to Rainfall intensity: *24 49mm hr^{-1}*

Moderate to High Annual Rainfall: *1200 2000mm*

Hydro Neutral *with - values of 0.8 to 1.3*

Low to high SWC *(200 to 1000mm) excess rainfall equivalent resulting in high erosion and soil loss due* *Terrain* *and* *loose* *soil structure which is ferrugenoues*

Moderate rainfall Intensity *(40 44mm hr^{-1}*

Moderate to High Annual Rainfall *(1400 2000mm)*

Hydro Neutral with - values *of 0.8 to 1.2*

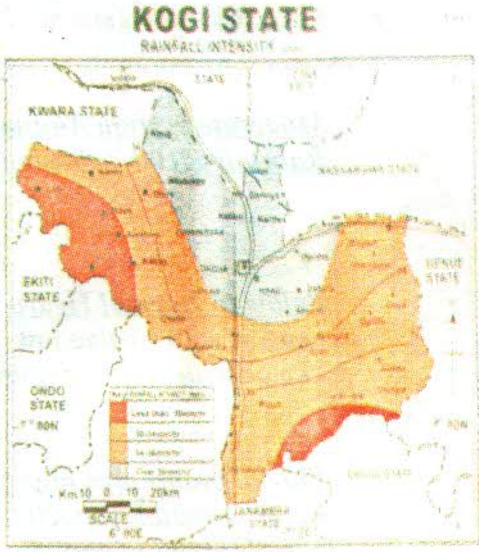
Moderate to High *excess water (400 1200mm)> erosion high in loose ferruginous soils in High gradient sites. Water sheds prone to flooding.*

Moderate rainfall Intensity *(32 42mm hr^{-1})*

Moderate to High Annual Rainfall *(1400 2000mm).*

Hydro Neutral *- values of 0.8 1.3*

Moderate to High *excess water in strong to severe slope wash and failures usually reduced to Erosion. Soil structure is loose ferruginous resulting in massive slope failures in highly denuded areas of Onitsha/ Nnewi axis.*

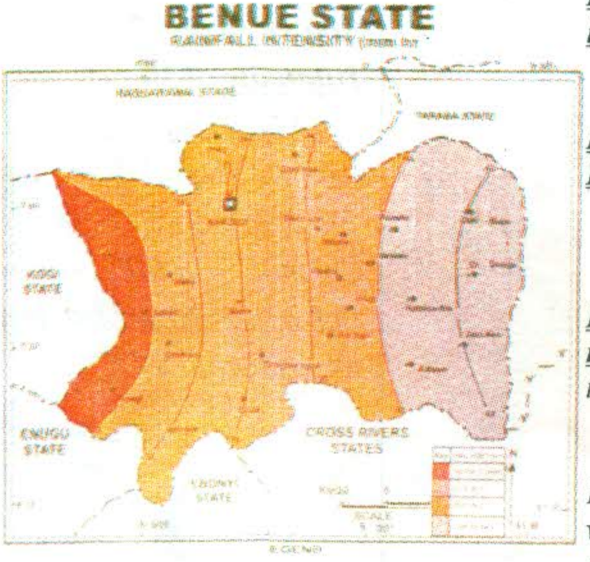


Moderate Rainfall

Intensity *of 30 '30 mmhr $^{-1}$. Moderate to High Annual Rainfall (1200 1900mm) below to normal (-values range between 0.6 and 1.0 low to moderate SWC*

Catchement Basins of river Niger and Benue susceptible to flooding especially in the Niger Water shed from Jebba to Niger / Benue Confluence in Lokoja

Maps 6.5a&b : Kogi State

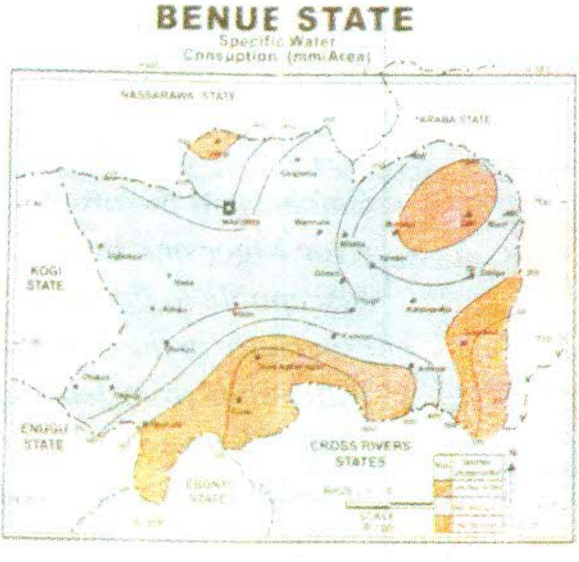


Moderate rainfall intensity *(32 -42mm hr^{-1})*

Moderate to High Annual Rainfall *(1100 1900mm)*

Below to Normal Hydro neutral *with - value low to moderate excess water.*

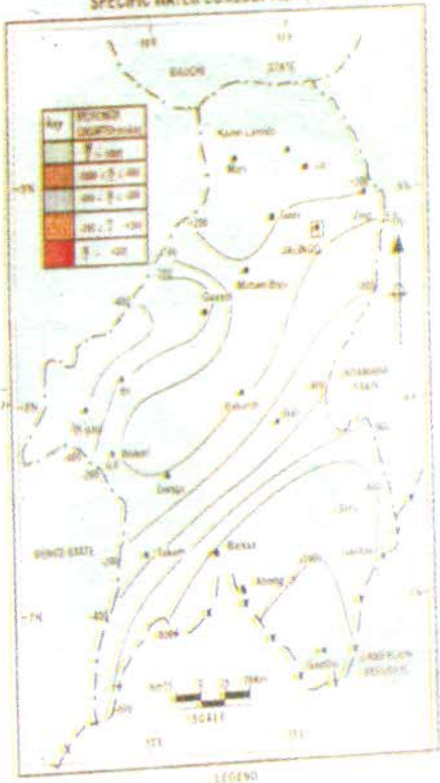
Fluvial plains plus high water retention capacity of soils result in surface water surplus.



Map 6.6a & b : Benue State

TARABA STATE

SPECIFIC WATER CONSUMPTION



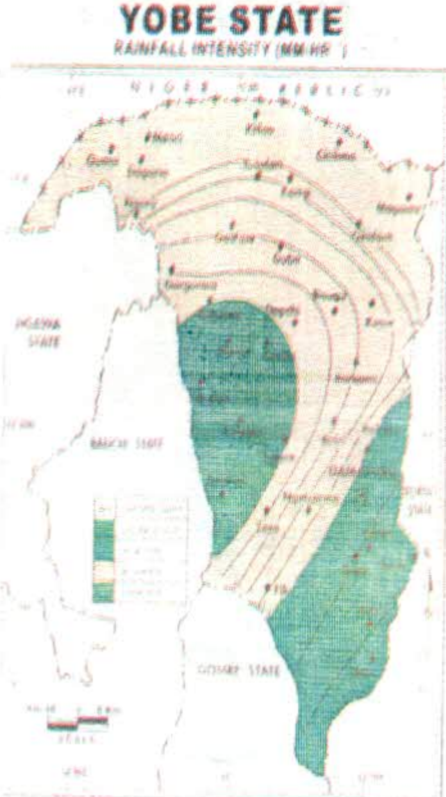
TARABA STATE

RAINFALL INTENSITY

Moderate to High Rainfall Intensity *(38 54 mm hr^{-1}) Central parts of Taraba receive worst storms hence severe flash floods, as closely packed Isopicnic lines (rainfall intensity lines), are to be expected in highly degraded farmlands.*

Moderate to Heavy rainfall *(1000 2000mm) high for its latitude.*

Low to High *erosivity reduces soil water retention in the North while highest λ -values increase from 0.8 to 1.8 in the southest (low lying) pene plains. The Highland area have excess surface water to the SE (High SWC) while areas of lower rainstorms to the northwest belong to Dry semi arid zone.*



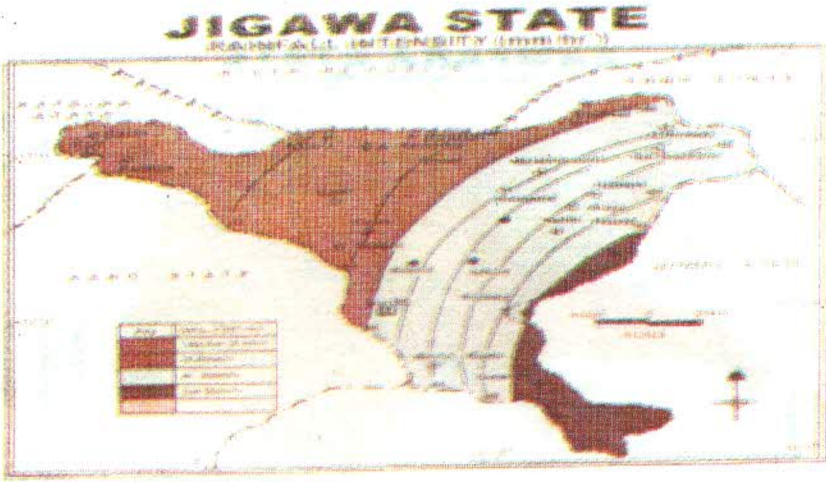
Map 6.8a b: Yobe State

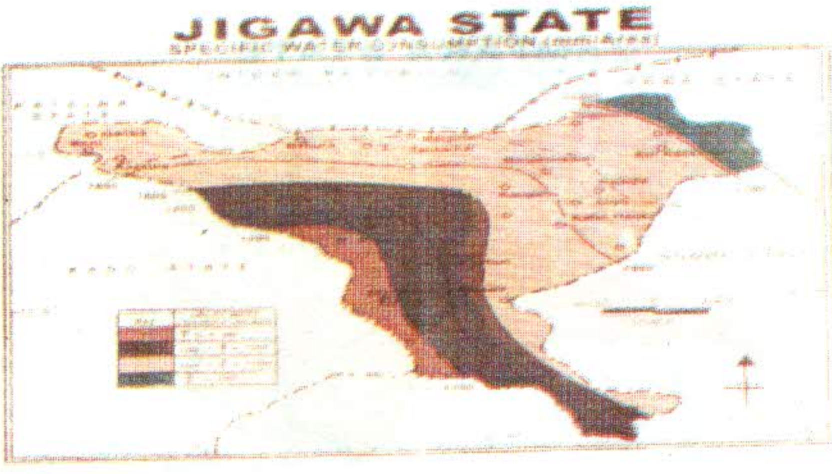
*<u>**Moderate to High Rainfall Intensity**</u> (36 50mm hr^{-1})*

*<u>**Moderate to Low Annual Rainfall**</u> (400 800mm)*

*<u>**Very low - values**</u> or 0.0 to 0.3 confirm pure sahel (Dry grassland) Ecological zone.*

*<u>**Moderate to High**</u> deficit SWC (700 1000mm) suggest desertification process can only be alleviated through massive Dam and Reservoir Construction as Drought will be persistently severe. Irrigation is a <u>MUST</u> for viable agriculture in very rich soils.*





Map 6.9 a & b: Jigawa State

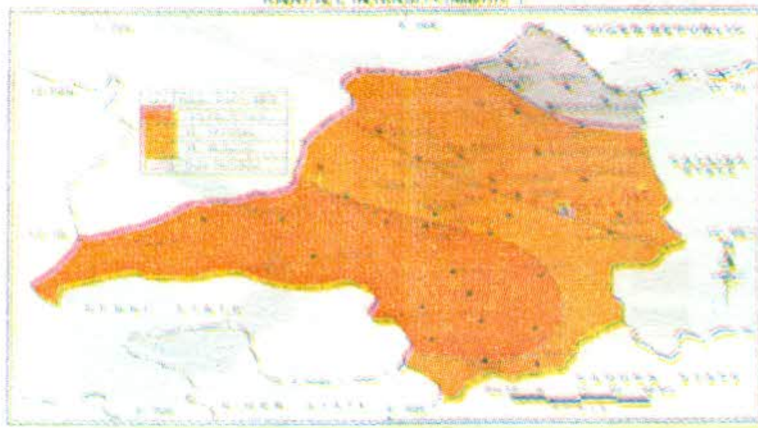
Rainfall Intensity *is moderate to High (34 50mm hr^{-1}) resulting in flooding under severe Rainstorms.*

Low to Moderate Annual Rainfall *insufficient to cause sheet flow but high RI will cause flash flood (400 900mm Annual rainfall)*

Low Soil moisture *(0.2 to 0.4 - values)*
High deficit water content*: (200 1000mm) suggests droughts will be severe especially in the east.*

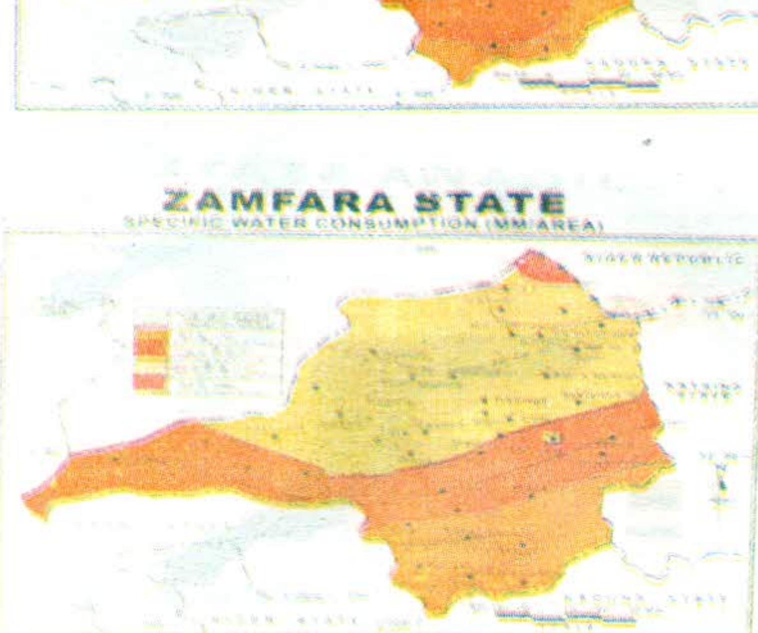
ZAMFARA STATE

RAINFALL INTENSITY (MM/HR)



ZAMFARA STATE

SPECIFIC WATER CONSUMPTION (MM/AREA)



Map 6.10: Zamfara State

Moderate Rainfall Intensity *(30 36 mm* hr^{-1}*) storm to be expected in the Zamfara river basin*

Low to High Annual Rainfall *(500 1400mm)*

Degree of wetness or dryness *is very low in the north and near vegetation line value of 0.6 in the south.*

Low to High Specific Water Consumption*: of 0 to 1000mm combines with - value of 0.5 in the south to put the southern borders on the edge of the viable vegetation line.*

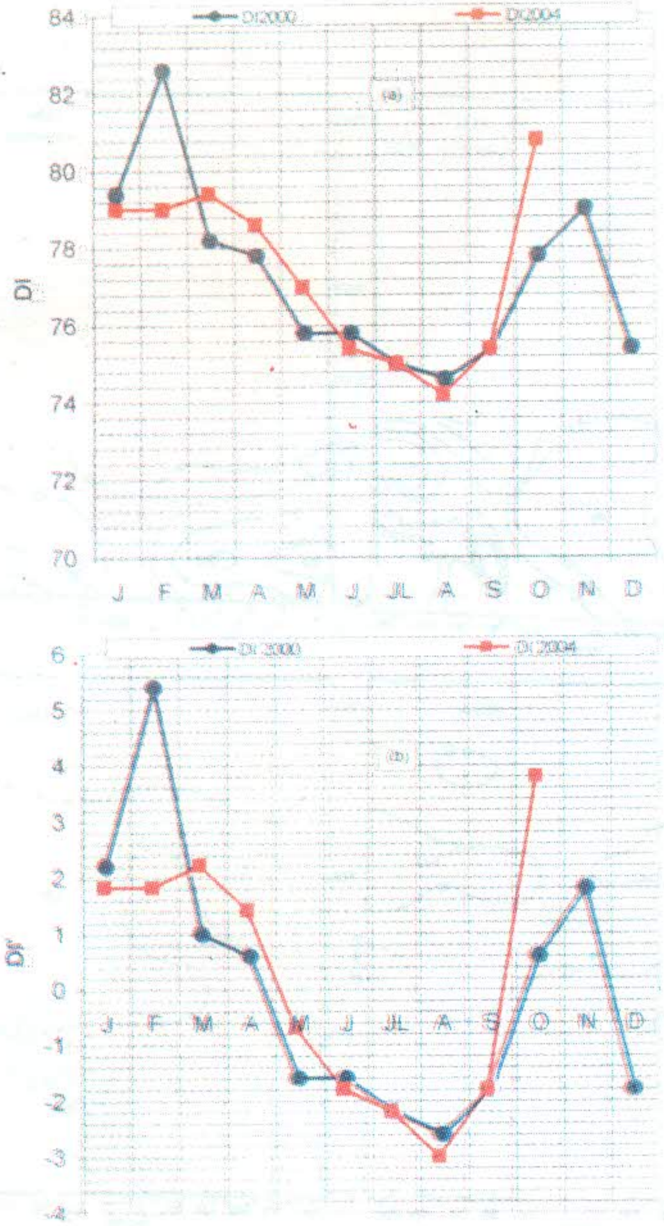


Fig.6.11a&b : DI and DI' for 2000/2004 for Ikere, Ekiti State (from Adefolalu, 2005)

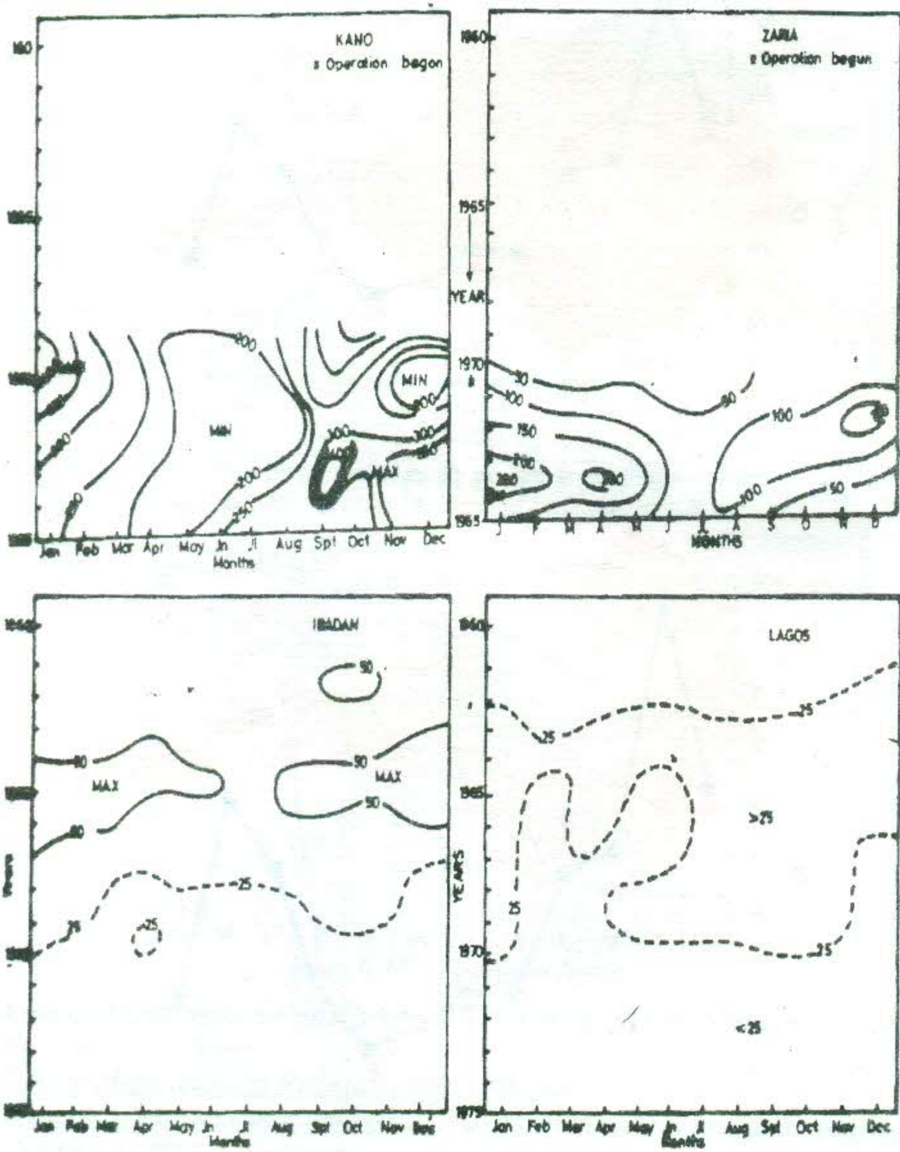


Figure 6.12a d: Number of cases of in patient treated for respiratory problem in four key locations in Nigeria (From Adefolalu, 1984a)

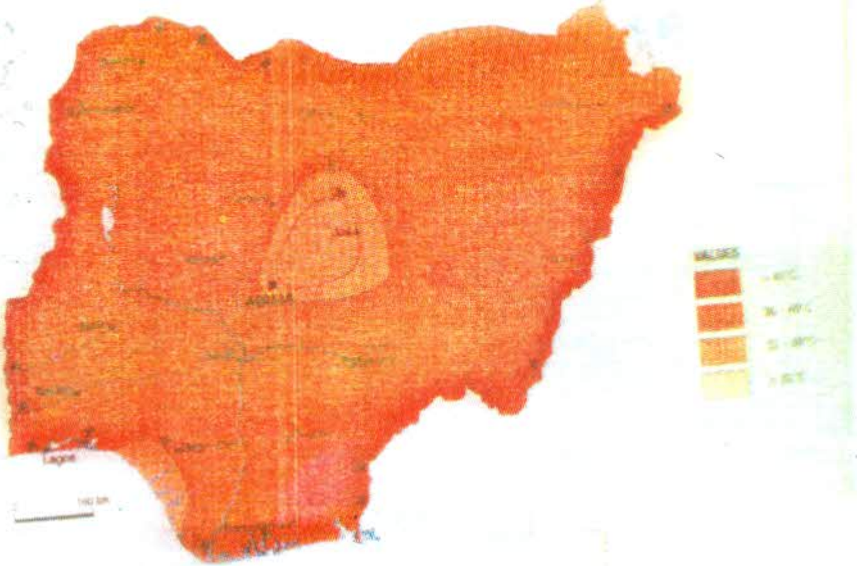


Figure 6.13: Mean Effective temperature (°C) in March at 15GMT (from Adefolalu, 2002b)

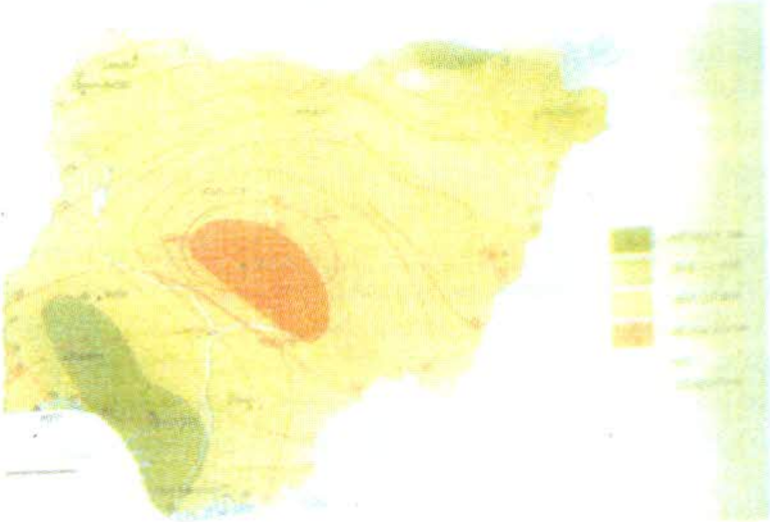


Figure 6.14: Shortest Length of the Rainy Season (LRS) and LRS departures in 1983 drought year. (from Adefolalu, 200b)

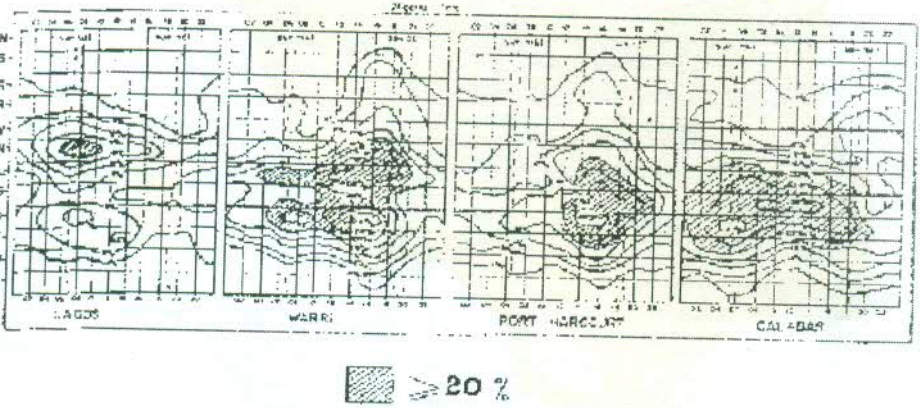


Figure 6.15a d: Percentage Occurrence of Rain-Hours
A Rain Hour is an Hour during which a measurable amount of rain falls.

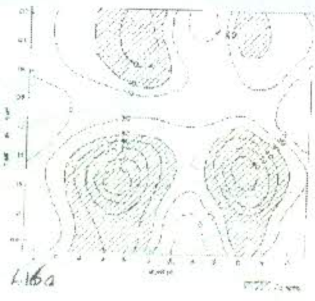


Fig.6.16a: Frequency of Occurrence of thunderstorms in Calabar (1951 80)

Fig.6.16b: Percentage frequency of rain occurrence in Calabar (1951 80) (From Adefolalu, 1984b)

EPILOGUE

When I was still an 'infant, I used to nurse the ambition of flying the BIG BIRD carrying messages to the great BEYOND'(my father's reason for Aircraft over-flying our farm every Saturday afternoon in the late forties). The chance came in 1962 when I was one of the aptitude ready survival of a more than 9 month exercise to weed over 1500 candidates down to 32 out of which 9 were admitted to the flying school, Ikeja Lagos.

The first day in 1962 (16^{th} August) in the air as a Trainee Pilot was eventful as we crash landed in Kirikiri Apapa Lagos. The second one in 1966 29 September was less dramatic but ended my dream of being a Pilot and opened the window to the sky of weather. Cloud bubbled and on that maiden flight had tried to dodge them even inside the cockpit of which my captain snapped, "you will be training and twisting forever for you'll have to fly through many a cloud. The rock and-roll will be like singing soft melodies to a baby in a crib but when it become violent pray hard".

When on getting to the village after the nine of us had been selected. My father was as unnerved as a boy asleep on the mother's lap while I had thought he would be 'trilled' as my dream had come through. Instead, he asked how the six-weeks had gone. I did not have to go beyond 16 August 1962 when we crash-landed as he retorted (mildy), "Let us wait and get Divine "WORD". That was to come in two accidents involving aircrafts in Turkey and the other in the Far East (somewhere). My father said "it is not for you!" quite affirmatively. All my dreams of being a pilot ended there. Perhaps it was just as well because 5 years later the Air Force was recruiting Pilots to fight in the Civil War. My intuition would have driven me into that adventure.

And this lecture would not have been (who knows) there would have bee no Civil "MAY-DAY-MAY-DAT" but WHAM! DEAD!! (not stuck in flooded marsh at Kirikiri but much worse since Late Professor Lambo had prophesied my being prone (susceptible is *more appropriate) to accidents. My best friend student pilot died on the other side during that Civil War.*

The Rock and Roll in dome-shaped cotton wool Cumulus became an obsession and in 2nd September 1963 I joined forces with the Nigerian Meteorological Services in another adventure weather forecasting. The course of 3 years lasted 12months in my case and after 6 years of practice got into Florida State University USA where I was equipped to probe the atmosphere in all ramifications since graduation at the Doctor level in December, 1974. The report of the journey so far reads like that of Biblical Daniel. Pray it has something in common BEYOND the Name.

THANK YOU FOR LISTENING.

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ANNEX A

Ph. D Thesis Supervised by Professor D. O. ADEFOLALU (1987 2005)

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