Space Based Observation Systems for Enhanced Climate Change Mitigation and Adaptation Policies in Nigeria

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Abstract— **Climate monitoring, prediction and research have become a core pillar of the global response to climate change mitigation and adaptation. Improved accuracy about the pace of change and better definition of uncertainty levels improves policy definition and may accelerate a global consensus. The United Nations Environment Programme (UNEP) and the World Meteorological Organization (WMO), along other international organizations, sponsor the Global Climate Observation System (GCOS). GCOS supports the United Nations Framework Convention on Climate Change (UNFCCC). Operationally, the GCOS has identified 44 Essential Climate Variables (ECV) as being essential to understanding the climate change process and developing the appropriate mitigation and adaptation policies. They are needed to determine the prevailing climate of any given region and to measure rates of change of variables, such as temperature and rainfall (monitoring), to assess the future state of the climate system, years and decades ahead (prediction), supported by continued developments in the collection, archiving, analysis and application of climate data (research). A considerable number of the identified ECVs can be obtained through or at least with significant input from space-based observations. All space-based observations, including ECVs, can be and are already used for a multiplicity of policy applications across policy areas such as climate change, biodiversity, disaster response or monitoring etc. This paper reviews the status of earth observing satellites within the framework of the GCOS, the basic requirements for generating ECVs are identified. Finally the status of space based data for climate change mitigation and adaptation in Nigeria is appraised and suggestions are put forward for an optimal utilisation of space based data within GCOS specification in the country; particularly with the launching of the Nigerian earth observing satellite (Nigeria Sat-2) and the ample number of GNSS-CORS in the country.**

Index Terms— **Climate change, Adaptation, Mitigation, Global Climate Observation System (GCOS), Essential Climate Variables (ECV), Earth observation. Global Navigation Satellite System (GNSS), Continuously Operating Reference Station (CORS).**

I. INTRODUCTION

Satellite-based remote-sensing technologies are an integral part of the United Nations Framework Convention on Climate Change (UNFCCC) work, through the Global Climate Observing System (GCOS). GCOS, whose mandate is to determine what data are needed for the monitoring of climate impacts, has identified 44 so-called Essential Climate Variables (ECVs) **[1]**, **[2]**. Thirty-one of these ECVs use space-based remote sensing outputs **[3]**. According to GCOS, progress in producing the 44 ECVs has been lethargic to date. Nonetheless, the increasing importance of adaptation in terms of both costs and needs has heightened the interest in space-based operations **[4]**.

Space-based observation is ever-increasing in importance due to the need to appropriately understand and model climate impacts and to the rising demand for reliable emissions reductions monitoring systems. Where adaptation is concerned, information on climate change and vulnerability to those changes will drive policy making in general, and the negotiations on allocation of financial assistance in particular. Without appropriate data, the effectiveness of the international effort will be undermined. Furthermore, it is recognised that satellite-based tools can and will play an increasingly important role in the monitoring of greenhouse gas emissions **[4]**.

The United States and Europe through the European Space Agency (ESA) are playing a leading role in enhancing space based technologies for Earth monitoring. Other industrialised countries, such as Japan, have already put in place space-based monitoring systems. And such activities do not limit themselves to industrialised countries. The government of India, for example, intends to have its first such satellite in operation by 2012 and its second in 2013, with the objective to monitor GHG emissions across India and the globe. Nigeria is not left out in this regard; NigeriaSat-2 and NigeriaSat-X satellites were successfully launched on 17th day of August, 2011(www.narsda.ng.org). NigeriaSat-2, one of the most advanced Earth observation small satellites will significantly boost Nigeria and African capabilities for natural resource management, as well as aid disaster relief through the disaster monitoring constellation.

The major objective of the present study is to appraise Nigeria's prospective of generating ECVs from space based sources as required by the GCOS, ECVs are fundamental data sets for climate change mitigation and adaptation policies. The paper presents in first section the elements of climate change and consequence of it. The next section contains an overview of global effort toward mitigating and adapting to climate change, the requirements for ECVs generation were

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also identified. Finally, the Nigerian scenario in addressing climate change and in contributing to global efforts was appraised and suggestions were proffered for optimal use and benefit of space observations in climate mitigation and adaptation policies.

II. ELEMENTS OF CLIMATE CHANGE

In 2007, the Intergovernmental Panel on Climate Change, or IPCC, a scientific group created by the United Nations in 1988 to evaluate climate change, released its Fourth Assessment Report on climate change. The report reflected scientific consensus that climate change is the result of increased levels of greenhouse gases in Earth's atmosphere and that these increased emissions are primarily the product of the burning of fossil fuels for energy (coal, oil, and natural gas) and practices in agriculture, land use, and forestry. Roughly three quarters of emissions come from burning fossil fuels for energy and the rest from deforestation and land use **[5]**.

Some of the observed effects of a warming Earth over the last century include more rainfall over land masses as well as increased drought as we are witnessing in the horn of Africa presently, shorter winters and melting glaciers, stronger storms, and rising sea levels and washing away of coastal areas (as seen in parts of Lagos, Nigeria recently).

The IPCC suggested that by dramatically reducing greenhouse gas emissions, society can avoid the most dramatic effects of a changing climate. An effective strategy for dealing with climate change involves three pillars: mitigation to avoid the worst projected outcomes of a changing climate, adaptation to cope with the unavoidable effects, and a commitment to science and observation to bolster our ability to understand, mitigate and adapt **[6]**.

Mitigation includes any purposeful efforts to reduce greenhouse gas emission or enhance greenhouse gas "capture." While no global goal has been agreed upon, the general consensus is to reach agreement on policies that will reduce the overall accumulation of greenhouse gases in the Earth's atmosphere in time to slow the pace and magnitude of changes in the global climate and avoid irreversible changes to the Earth's natural systems. Climate change mitigation involves application of modern technologies to reduce its impact such as Clean Development Mechanism (CDM), Reducing Emission from Deforestation and forest Degradation (REDD), renewable energy development, carbon capturing and storage.

Adaptation refers to the social and economic changes taken in response to climate effects. In the broadest terms, adaptation can be planned (purposely set in motion to deal with expected or observed changes) or autonomous (happen in a less coordinated fashion in reaction to climate changes). Adaptation efforts generally reduce vulnerabilities or increase resilience. Adaptation is often thought of as an alternative to mitigation (i.e., if climate change cannot be slowed or avoided then society must adapt). In reality, adaptation and mitigation are both vitally important elements of a successful climate strategy. Climate models that forecast the potential effects of unabated climate change suggest that human capacity to adjust to a changing natural environment can be overcome by the pace and magnitude of those changes. At the same time, even the most aggressive mitigation strategy cannot shield society from the ongoing and expected climate changes due to historical emissions accumulated in the atmosphere. For many parts of the world, particularly lesser-developed countries, adaptation strategies are crucial for survival and continued stability. According to Anuforom **[7]** adaptation remains the only option for most societies to cope with the projected changes and impact over the next 100yrs. However, in order to develop effective adaptation strategies that will both reduce vulnerability and cope with unavoidable consequences as well as exploit opportunities, a sound scientific knowledge of a nation's climate as well as the possible impacts of its variability and change on the various socio-economic sectors is necessary.

Like mitigation, adaptation requires time, money, and planning. It also requires communities to weigh the benefits and the costs of specific adaptation measures, a difficult task made even more complicated by uncertainty regarding the timing and magnitude of climate change. Communities must balance planning for high impact, low probability events with planning for low impact, high probability trends. In addition, economic, technological, cultural, and information barriers to adaptation often challenge even the most conscientious efforts to improve resiliency and lower vulnerability **[6]**.

There are significant challenges in going from predictions of how the climate may change to the effects these changes may have on water, resources, or human health. Meeting this challenge requires boosting adaptation research; bolstering capacity to monitor change and its effects; producing the sorts of integrated assessment on the pace, patterns, and regional effects of climate change that will be needed by decision makers and providing metrics and goals for both mitigation and adaptation; and making climate data and information accessible to those who need it. However, the task of generating mitigation and adaptation polices is heavily dependent on ECVs obtained from emerging space technologies. The next section looks into the essential space based observation requirements within the framework GCOS.

III. ESSENTIAL SPACE BASED OBSERVATION REQUIREMENTS

Space-based observation can provide vital data about the impacts of climate change, as well as provide essential tools for monitoring the progress of actions implemented to reduce greenhouse gas emissions. More concretely, space-based observation can reduce the present level of uncertainty in climate prediction linked to the lack of quality observations, as has been recognised by the UNFCCC.

The GCOS was established in parallel to the UNFCCC and is itself made up of the national meteorological, hydrological, oceanographic, space, environmental, research and other Earth observing agencies of more than 190 member countries from the World Meteorological Organization (WMO), the Intergovernmental Oceanographic Commission

(IOC), the United Nations Environment Programme (UNEP), the International Council for Science (ICSU) and the Food and Agriculture Organization (FAO), with the support of other national, regional and international coordination and capacity building organisations and mechanisms, such as national meteorological organisations.

In 2004, the GCOS published the *Implementation Plan for the Global Observing System for Climate in Support of the UNFCCC,* which catalogues the needs for global monitoring of climate change, and in which space-based observations are presented as an important element of the monitoring process. The space component has been led by ESA. According to the Implementation Plan, there are 44 Essential Climate Variables (ECVs) required to support the work of the UNFCCC and the IPCC (see Table 1). ECVs are a set of atmospheric, oceanic and terrestrial variables needed to understand the physics of climate change (including the measurements of greenhouse gas emissions and their sources), formatted to specific standards to make them available internationally. They are the essential variables that need to be monitored by parties to the UNFCCC in order to meet their commitments under Articles 4 and 5 of the Convention. (These articles specify the obligations of the parties to provide the necessary information on emission inventories, national programmes for mitigation, research, and physical data on climate impacts). According to (Wilson et al. **[3]**, 31 out of these 44 ECVs are at least partly to be provided by satellite-based observation (in *italics* in Table 1).

Table 1: GCOS Essential Climate Variables (After GCOS [8])

Domain	Essential Climate Variables(ECV)
Atmospheric (over land, sea and ice)	**Surface:** air temperature, wind speed and direction, water vapour, pressure, precipitation, surface radiation budget **Upper-air:** temperature, wind speed and direction, water vapour, cloud properties, earth radiation budget (including solar irradiance) **Composition:** carbon dioxide, methane, and other long-lived greenhouse gases, ozone and aerosol, supported by their precursors.
Oceanic	**Surface:** sea-surface temperature, sea-surface salinity, sea level, sea state, sea ice, surface current, ocean colour, carbon dioxide partial pressure, ocean acidity, phytoplankton. **Sub-surface:** temperature, salinity, current, nutrients, carbon dioxide partial pressure, ocean acidity, oxygen, tracers.
Terrestrial	River discharge, water use, groundwater, lakes, snow cover, glaciers and ice caps, ice sheets, permafrost, albedo, land cover (including vegetation type), fraction of absorbed photosynthetically active radiation (fAPAR), leaf area index (LAI), above-ground biomass, soil carbon, fire disturbance, soil moisture.

According to Wilson et al. **[3]**, the ECVs data can assist in areas of *climate monitoring, prediction and research.* These are required to determine the prevailing climate of any given region and to measure rates of change of variables such as temperature and rainfall; to determine the future state of the climate system years and decades ahead.

From the perspective of policy formation, climate information is needed in the policy cycle at four key points **[3]**:

- *policy definition*: improved accuracy about the pace of change and better definition of uncertainty levels;
- *management and scenario building*: improved accuracy of assessments, with implications on funding allocation and prioritisation, as well as on post-project audit to measure the success of given projects;
- *reporting requirements, i.e. MRV (Measurement, Reporting and Verification)*: improved verification of data provided by countries on elements such as greenhouse gas emissions, carbon sinks, biodiversity protection, etc.;
- *alarm function*: forest fires, flood and droughts etc., with implications for security of food supply, access to water, etc.

In its latest progress report on the Implementation Plan, published in April 2009, GCOS expresses concern about the lack of progress in the systematic analysis of ECVs and calls on all members to undertake efforts in this respect, including on weaknesses in data processing from satellite observations (despite the availability of such data), and on the lack of operational structures to do so. The GCOS ECV requirements can only be fulfilled through the collection of observations from several sources (i.e. atmospheric, oceanic, and terrestrial variables collected through combined observation from different satellites and *in situ* measurements): "Since no single technology or source can provide all the needed observations, the ECVs will be provided by a composite system of *in situ* instruments on the ground and on ships, buoys, floats, ocean profilers, balloons, samplers, and aircraft, as well as from all forms of remote sensing, including satellites" **[9]**. The data obtained requires subsequent processing to supply the finished ECV products, through analysis and integration in both time and space.

IV. Nigeria's Potential To Provide Space-Based ECVs

The quality of earth monitoring systems and geodetic data on the African continent remains an issue of great concern and fall far short from what is applicable in other regions of the world. Some of the problems of the geodetic and meteorological community on the continent includes question of the accuracy of various global data sets on the African continent in view of the poor data contributions from Africa in their realization. There are several initiatives to improve the state of geodetic infrastructure and monitoring system on the continent which includes: The Africa Reference Frame (AFREF) an initiative to unify the many national coordinate reference systems in Africa using GNSS as the primary tool;

AfricaArray is an initiative to promote coupled training and research programs for building and maintaining a scientific workforce for Africa's natural resource sector. AfricaArray's initial focus is on geophysics to maintain and develop geophysical training programs in Africa; Although a global project, the International Heliophysical Year (IHY) has strong interest in densifying its observing capability in the equatorial regions of Africa; Also is the African Monsoon Multidisciplinary Analysis (AMMA) GPS project which is primarily a meteorological project aimed at West Africa using GPS as a supporting observing technique; The SERVIR-Africa initiative is a regional visualization and monitoring system. There is also the proposed Africa Sat1 which is planned for obtaining satellite image mosaics of Africa by radar and optical satellite systems. Some countries like Nigeria and South Africa have contributed to the geodetic monitoring of the continent through their respective space research programs.

The Nigerian National Space Research and Development Agency (NARSDA) steers the country space program. Recently, NigeriaSat-2 and NigeriaSat-X satellites were successfully launched (www.narsda.ng.org). NigeriaSat-2, one of the most advanced Earth observation small satellites will significantly boost Nigeria and African capabilities for natural resource management, as well as aid disaster relief through the disaster monitoring constellation. It will also contribute to the generation of ECVs in Nigeria and the world at large

A superb approach for generation of ECVs in many countries in the developed world is brought through the concept referred to as GNSS meteorology. GNSS meteorology is the remote sensing of the atmosphere using GNSS. The term GNSS meteorology relates to the utilization of the Global Navigation Satellite System's (GNSS) radio signals to deliver information about the state of the troposphere. Continuous observations from GNSS receivers provide an excellent tool for studying the earth atmosphere. OSGoF (Office of the Surveyor General of the Federation), which is the National Mapping Agency of Nigeria, initiated in 2008 a project to establish NIGNET (NIGerian GNSS Reference NETwork). This network, formed by state-of-the-art CORS (Continuously Operating Reference Station) GNSS (Global Navigation Satellite Systems) equipments, intends to implement the new fiducial geodetic network of Nigeria. NIGNET will serve many different applications at national and continental levels. In fact, the first motivation to implement NIGNET was to contribute for the AFREF (African Reference France) project in line with the recommendation of the United Nation Economic commission of Africa (UNECA) through its Committee on Development, Information Science and Technology (CODIST). At national level, NIGNET will serve primarily as the fiducial network that will define and materialize a new reference frame based on space-geodetic techniques and linked to AFREF. Currently, NIGNET is formed by nine CORS stations covering the entire country (see figure 1). The selection of the locations was carried out considering different theoretical and practical criteria.The new Nigerian GNSS network (NIGNET) provides an ample of opportunities for Nigerian climate change modelling through the concept of GNSS meteorology.

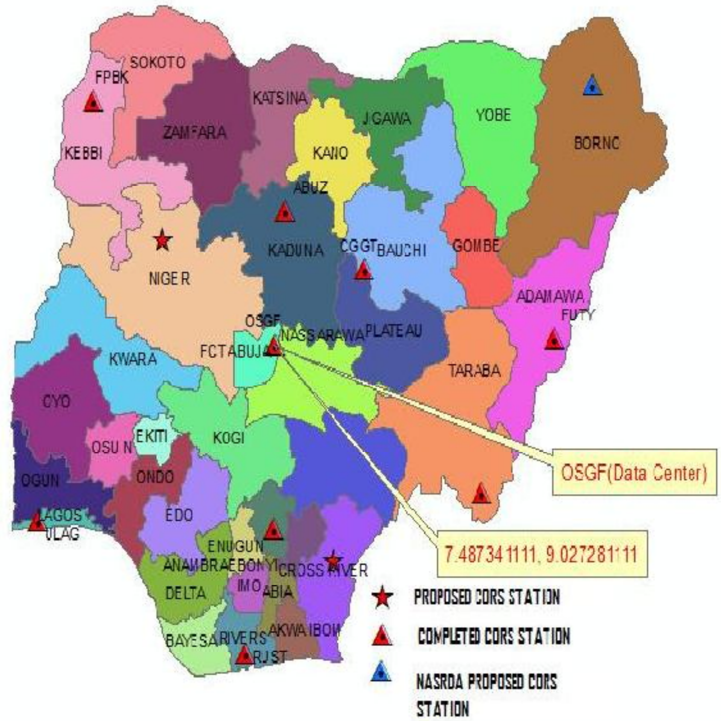

Figure 1 – Distribution of the NIGNET stations (After Jatau et al. [10]).

Clearly, GNSS meteorology promises to be a real boost to atmospheric studies with expected improvements on weather forecasting and climatic change monitoring, which directly impact on our day to day lives. In **[11]**, the possible use of IPWV for flood prediction is proposed, while **[12]** have outlined the potential of water vapour for meteorological forecasting. For environmental monitoring, GPS meteorology will further play the following roles:

1. Precisely derive vertical temperature and pressure profiles: These will be useful in the following ways **[13]**:

- By combining them with other observations of ozone densities and dynamic models, our understanding of conditions which lead to the formation of polar stratosphere clouds will be improved. We will also be able to understand how particles in which heterogeneous chemical reactions lead to ozone loss are believed to occur.
- The precise measured temperature will enable the monitoring of global warming and the effect of greenhouse gases. This is made possible as the change in surface temperatures caused by an increase in the greenhouse gas densities is generally predicted to be the largest and therefore most apparent at high latitudes. Precise temperature can be used to map the structure of the stratosphere,

particularly in the polar region where temperature is believed to be an important factor in the minimum levels of ozone observed in spring.

- Accurate high vertical resolution temperature reconstruction in the upper troposphere will increase our understanding on the conditions which cirrus clouds form. The cirrus clouds will generate for instance a positive feedback effect if global warming displaces a given cloud layer to a higher and colder region. The colder cloud will then emit less radiation forcing the troposphere to warm in-order to compensate for the decrease.
- Accurate temperature retrievals from GPS meteorological measurements combined with high horizontal resolution temperatures derived from the nadir-viewing microwave radiometers will provide a powerful data set for climate studies of the Earth's lower atmosphere. This can be achieved by using the derived profiles to monitor trends in the upper troposphere and lower stratosphere where the GPS meteorological techniques yield its most accurate results.
- The measured pressure is expected to contribute to the monitoring of global warming. This is because pressure versus geometrical height is potentially an interesting diagnostic of troposphere's climatic change since the height of any pressure surface is a function of the integrated temperature below.
- The temperature in the upper troposphere/tropopause influences the amount of energy radiated to space. Accurate measurements of temperature in this region over a long period of time will provide data for global warming and climatologic studies.

2. Derive water vapour: Precise analysis of the water vapour will contribute o the data required by hydrologists to enhance the prediction of local torrential rain that normally cause damage and havoc (see e.g., **[11]**). Besides, the knowledge of water vapour density in the lower troposphere will be useful in; providing data that will be directly assimilated into meteorological models to enhance predictability and forecasting of weather, applicable for creation of distribution of water vapour via tomographic techniques **[14]**, applied to correct the wet delay component in both Synthetic Aperture Radar (SAR) and GPS positioning thus benefiting applications requiring precise positioning such as deformation monitoring,
3. Contribute towards climatic studies: By comparing the observed temperatures against the predicted model values, a method for detecting and characterizing stratospheric climatic variations as well as a means for evaluating the performance of model behaviour at stratospheric altitudes will be developed and the existing ones tested.
4. Enhance disaster mitigation measures: Its information will contribute to the much-needed information required to improve forecasting of catastrophic weather around the world.

In-order to fully realize the potential of the GPS atmospheric remote sensing listed above; estimated profiles have to be of high quality. Already, comparative results with the existing models such as European Centre for Medium Weather Forecast (ECMWF) and National Centre for Environmental Prediction (NCEP) are promising as seen from the works of **[15]**with respect to GPS/MET and CHAMP missions, respectively. Detailed exposition of the application of GNSS remote sensing to environment is presented in **[16]**.

In addition to the potentials of ECVs generation already discuss under this section, the Nigerian Meteorological Agency (NIMET) has long historical climate data, some of which span over 100 year coupled with its unlimited access to the WMO's enormous global database constitute an invaluable tool **[7]**. Already, NIMET provide a wide range of services and information through it climate information services/products for adaptation strategies which includes information against (1**) Desertification** (Wind direction & speed/max gust to guide the choice of strength and alignment of the wind breakers; Temperature data to ensure that the chosen tree types can withstand the dryness & heat of the area). (2) **Drought impact on Agriculture/Food Security** (Seasonal Rainfall Prediction on rain onset, cessation & rainfall amount, Issuing advisories against crop failures and famine in the event of droughts, as well as guide farmers in the selection of the best seed varieties, and crop protection measures to adopt against pests and diseases). (3)) **Development and updating of the in-house seasonal climate** prediction model for effective monitoring of drought, desertification, erosion, crop failure, etc., and (4) **Dissemination of critical weather/climate alerts** using specialized weather dissemination system for rural areas, namely the Radio-Internet (RANET) system, which does not require electricity to function.

From the foregoing it can be seen that the vast potential of the country to collect the space-based Fundamental Climate Development Records (FCDRs) needed to generate the ECVs, remains largely untapped to this day. ECVs are essentially needed to improve knowledge of climate and underpins many other "societal benefit areas" (as defined by the GEOSS 10-year implementation plan11), such as Weather, Water, Agriculture, Health and Energy. In the same vein, if the satellite data records and products identified in this document were indeed obtained in conjunction with real-time and near-real-time applications, as largely the case with meteorology today, the resulting observing system would cover a major part of the satellite needs of all GEOSS societal benefit areas. For example, the value of a validated, routinely-produced global precipitation product would not be limited to weather and climate forecasts, but would also have a considerable impact on agricultural planning, forestry and water management. For this reason, concerned agencies need to follow a coordinated, systematic mission strategy in which particular instruments are cost effective and meet as many application needs as possible.

The next section of this report identifies some fundamental step that would enhance the acquisition of FCDRs to develop ECVs for the country from available satellites systems.

V. Steps To improve Nigeria's Capabilities to Generating Spaced based ECVs

The GCOS calls for the creation of international data centres (IDC) which actively collect data and organise it for international use. NIMET and NARSDA have the potential to supply satellite data (FCDR) to develop a number of ECVs. The recommendations to develop Nigeria's space based capabilities to produce the necessary FCDRs to GCOS standards are the following:

1. Providing to the existing satellite and observatory operators, i.e. NARSDA and NIMET, the necessary resources to process the data.
2. Ensuring that NARSDA's Earth observation programme is adapted to develop the FCDRs to support climate research and other programmes. This will require an expansion of human and material resources to guarantee the necessary level of operational capacity on a long-term basis, including the maintenance of the satellite infrastructure.
3. Creating a Climate Change Initiative for the country which will help to ensure that its existing capabilities are used to develop the necessary capacity to produce the FCDR for ECVs, excluding those data sets that NIMET can already produce itself. This should include; gathering, collating and preserving the long term time archives, ensuring and facilitating its access and exploitation.
4. Integrating the data sets derived from individual contributing EO mission and sensors to constitute the most comprehensive and well-characterised global long-term records possible for each ECV; and assessing the trends and consistency of the ECV records in the context of climate models and assimilation schemes. This should also involve developing improved models and algorithms for production of the required variables.
5. Data from GNSS CORS in the country should be integrated into the proposed initiative, there are about 20 GNSS-CORS in the country and provide climate data in addition to their designated assignments. GNSS radio occultation technique offers the unique advantage of modelling and producing numerical weather components.
6. Expanding extent of data captures, which should include the scope of the Global Ocean Observing System (GOOS), Satellite Altimetry and the processing of Gravity Recovery And Climate Experiment (GRACE) and Gravity field and steady state Ocean Circulation Explorer (GOCE) data.

VI. Conclusions

In this paper the prospective of generating ECVs form available space based technology in Nigeria were appraised and steps to improve the generation ECVs were outlined. Space-based observation and the development of the ECVs identified by the GCOS are important elements for a number of Nigeria`s policies, and essential in the promotion of the Nigeria's interests in international climate negotiations. NARSDA's space based capabilities can enhance the understanding of climate change and significantly contribute to Africa's ability to influence international negotiations on climate change, as well as assisting in developing more targeted adaptation actions in Africa and globally.

Through NARSDA`s Earth Observation (EO) and NIMET climate product programmes, Nigeria can assist and support policies for domestic adaptation and for international aid, as well as use the information for a number of other policies. The present work, coupled with additional resources and some targeted reorganisation, can add to the number of fundamental data records for the creation of ECVs.

Given the importance of space-based research for the UNFCCC negotiations and to support a policy initiative on climate change for Nigeria, both domestically and internationally, NIMET and NARSDA should ensure that it has the necessary capacity in place to produce the data. The infrastructure already exists and considerable quantities of data are being collected but not used. It is recommended that NIMET, NARSDA and other related agencies consider expanding their operational capabilities, and ensure that data generated are formatted according to GCOS specifications.

To better serve the national interest, NIMET and NARSDA should increase their Earth observation capabilities especially space-based sensors for carbon monitoring to improve our ability to understand the carbon cycle and to inform any future international agreement. This means that until these capabilities are adequate for monitoring climate change, investment in Earth observation satellites should take precedence over other space programs. Increased spending on earth observation satellites specifically designed for climate change should be maintained until the current capability shortfall is eliminated.

A climate change policy for the country should be that inform decision makers and planners in both government and the private sector by providing understandable metrics and analyses of the effectiveness of, and compliance with, mitigation programs and adaption plans. The customers for this should include federal agencies, state and local governments, private sector users, and other nations. Such task is better handle by a body specifically mandated to do such, this light it is finally recommended that the Nigerian government and legislatures should accelerate, expand, and reinforce a National Climate Commission to improve climate information management and decision making. In a related effort, Nigeria should support the World Meteorological Organization in its efforts to create a World Climate Service System.

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