GLOBAL CLIMATE OBSERVING SYSTEM

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REPORT OF THE GCOS REGIONAL WORKSHOP FOR EASTERN AND SOUTHERN AFRICA ON IMPROVING OBSERVING SYSTEMS FOR CLIMATE

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EXECUTIVE SUMMARY

The Global Climate Observing System (GCOS) was established in 1992 to ensure that the observations and information needed to address climate-related issues are obtained and made available to all potential users. The Parties to the United Nations Framework Convention on Climate Change (UNFCCC) have recognized the importance of improving climate-related observations to meet Convention needs, and, in a series of decisions, have urged Parties to take actions to improve all types of observations including atmospheric, oceanographic, and terrestrial components of the climate system. Decision 5/CP.5, of the 5th Conference of the Parties (COP-5), in particular, invited the GCOS Secretariat, in consultation with relevant regional and international bodies, to organize regional workshops that could develop specific GCOS Regional Action Plans to set out a framework and implementation timetable for improving climate monitoring in a region, both within the immediate context of country commitments to the UNFCCC and with respect to specific national and regional systematic monitoring priorities.

GCOS and its regional partners in Eastern and Southern Africa, the Drought Monitoring Centres in Nairobi (DMCN) and Harare (DMCH), organized a GCOS Regional Workshop for Eastern and Southern Africa (ESA) in Kisumu, Kenya from 3 to 5 October 2001. This Workshop was the second in a series of ten regional workshops that GCOS has planned in response to the concern of the Conference of the Parties to the UNFCCC regarding declining climate observation networks for climate change monitoring, detection, attribution, and assessment of the associated socio-economic implications.

The GCOS Workshop was supported by the Global Environment Facility (GEF), the United Nations Development Programme (UNDP), the United Nations Environment Programme (UNEP), and the World Meteorological Organization (WMO). This support enabled the participation of 25 Directors of the National Meteorological and Hydrological Services (NMHSs) (or their representatives) and national climate change coordinators from some 22 countries of the Eastern and Southern African region. (The list of the participants is given in Annex I.)

The key goals of the GCOS Regional Workshop Programme are to identify deficiencies and needs in meteorological and atmospheric, oceanographic, and terrestrial observing systems for climate monitoring and to guide participants in the process of developing plans and proposals to address the identified priority needs.

The Workshop was divided into four major sessions (see the Workshop agenda in Annex II). The first session addressed data requirements for an integrated monitoring of the global and regional climate system. The set of presentations in this session reviewed the status and needs of observing systems in the region. The session also addressed the question of why improved observations are important for both the region and the globe at large and with the deficiencies and needs of key meteorological and atmospheric, oceanographic, and terrestrial observing systems.

Key presentations made in this session included:

- The importance of improved regional and global climate observations: an Eastern and Southern Africa regional perspective;

- A review of the historical development, present status, and strategy for addressing the deterioration of the GCOS Surface and Upper-Air Networks in the sub-region;

- Limitations of data for climate change modelling in Africa;
- Satellite observational needs for regional climate change studies;
- Terrestrial observation challenges in Africa, with special reference to carbon cycle observations;
- A review of regional hydrology networks;
- A review of ClimDex software for climate change studies;
- A review of deteriorating regional Voluntary Observing Systems;
- The role of historical data in climate change monitoring, detection and attribution; and
- A review of the Regional Data Archive.

An overview of GCOS and its mission was also presented to familiarize participants with GCOS to help them understand the linkages between GCOS and the UNFCCC, and to inform them about the possibilities, especially through GEF, for funding of improvements in observing systems.

The second session was devoted to the climate extremes of the region. The Eastern and Southern Africa sub-region is currently facing significant challenges associated with climate extremes, especially droughts, tropical cyclones, frost, and floods. The more recent cases include floods and droughts associated with the 1997/98 El Niño and 1999-2001 La Niña events, as well as the Mozambique floods caused by the gigantic tropical cyclone Eline in 2000. The climate extremes have been associated with anomalies in oceanic and atmospheric circulation patterns, ocean-atmosphere interactions, sea-surface temperatures, and the El Niño/Southern Oscillation, among other regional climate elements. The recent occurrences of severe droughts, floods and tropical cyclones over the region have raised serious concerns about whether such extremes could be linked to regional climate change. The two key presentations that laid foundation for the discussions in this session were:

- A review of regional climate change and extreme weather/climate events, with special reference to data needs for monitoring of land and atmospheric extremes; and
- A review of the Global Ocean Observing System (GOOS) for monitoring of oceanographic-related extreme events, with special reference to the Indian Ocean.

The third session addressed the relationship between GCOS and the UNFCCC and the emergence of a GCOS programme of regional workshops in response to UNFCCC mandates. Guidelines for national reporting on observations were also presented.

The climax of the three-day Workshop was session four, which was devoted to the development and adoption of the Workshop Resolution (Annex III). Discussions during the Workshop identified the following issues as important and justified the need for improved observing systems for climate in the Eastern and Southern African Region:

1. The ESA sub-region is considered among the most vulnerable to the impacts and consequences of human-induced climate change, in particular, global warming and the potential threats associated with extreme weather and climate events and sea-level rise;

2. Improved observations of climate will enable provision of information and forecasts which will greatly assist the governments and national communities of countries in the region to prepare for the season-to-season and year-to-year variations of climate extremes associated with sea-surface temperatures, the El Niño/Southern Oscillation, and other natural phenomenon, as well as to detect and better prepare for long-term, human-induced climate change;

3. The region currently faces significant challenges associated with natural climate variability, especially droughts, tropical cyclones, floods, sea-level variations, and changes in ocean temperature;

4. Oceanic and atmospheric circulation patterns and ocean-atmosphere interactions in Eastern and Southern Africa play significant roles in determining global patterns of climate change and climate variability;

5. Measurements of meteorological/atmospheric, oceanographic, and terrestrial variables in the region provide essential data for detecting and attributing climate change; for monitoring, understanding and predicting climate change and climate variability; for developing strategies to ameliorate the potential harmful effects of climate change and climate variability; and for advancing sustainable development regionally;

6. The basic observation networks of the NMHSs provide the foundation on which the strengthening of GCOS must be built;

7. Enhanced cooperation among stakeholders with responsibilities to deal with climate change issues, including national climate change coordinators and NMHSs, is essential;

8. The observations from the GCOS Surface Network (GSN), GCOS Upper-Air Network (GUAN), GOOS, and the Global Terrestrial Observing System (GTOS) are currently inadequate, and these networks have been deteriorating in recent years;

9. Substantial historical data exists that have not been made available;

10. Urban activities have significant impacts on the global climate;

11. The Drought Monitoring Centres (DMCs) play an important role in climate monitoring and applications; and

12. An opportunity exists to use the development and implementation of an Eastern and Southern African GCOS Action Plan to enhance cooperation and communication among partners at all levels.

A major outcome of the Workshop was the Workshop Resolution, which calls for a Regional Action Plan (RAP) to be prepared. The RAP will specify priority actions to be undertaken in order to improve observing systems and chart a strategy for implementing these actions. The DMCs, in collaboration with the NMHSs in the region and national climate change coordinators, were mandated to take the lead in developing the Action Plan. It was recommended that the Action Plan be drafted by a balanced team of experts representing the three observing system domains and the climate change coordinators. It will then be circulated to all countries in the region for comments and approval.

1. INTRODUCTION AND BACKGROUND

The United Nations Framework Convention on Climate Change (UNFCCC), adopted on 9 May 1992, in New York, and signed at the 1992 Earth Summit in Rio de Janeiro by more than 150 countries and the European community, called for the stabilization of the concentrations of the greenhouse gases in the atmosphere at levels that would prevent dangerous anthropogenic interference with the climate system. The Parties to the UNFCCC have recognized the importance of high-quality data for climate-related purposes and have noted that, in many instances, either the geographic coverage, quantity or quality of the data produced by current global and regional observing systems are inadequate. Most of the problems occur in developing countries, where lack of funds for modern equipment and infrastructure, inadequate training of staff, and continuing operational expenses are often major constraints. The Global Climate Observing System (GCOS) was established in 1992 to ensure that the observations and information needed to address climate-related issues are obtained and made available to all potential users.

In response to several pertinent decisions of the Conference of the Parties (COP) to the UNFCCC, in particular, Decision 5/CP.5, the GCOS Secretariat, in consultation with relevant regional and international bodies, was invited to organize regional workshops designed to address the capacity-building needs and funding required to overcome deficiencies in meteorological and atmospheric, oceanographic, and terrestrial observing systems for climate in developing countries. The central goals of the GCOS Regional Workshop Programme are to:

- Assist participants in identifying regional deficiencies in global observing systems for climate;
- Assess priority observing system needs and funding required to enable countries to overcome deficiencies in observing systems and to allow them to collect, exchange, and utilise data on a continuing basis;
- Identify capacity-building needs in the region;
- Facilitate improved communication among stakeholders; and
- Initiate the development of regional action plans and proposals to fund improvements in observing systems.

As a follow-up to each regional workshop, GCOS facilitates the development of Regional Action Plans (RAPs) and related proposals that can be submitted to donor countries and international organizations to fund improvements in observing systems for climate. The regional partners are, however, expected to take the lead in developing the plans and proposals.

The Pilot Project for the GCOS Regional Workshop Programme (a programme of ten regional workshops to be held between 2000 and 2005) was initiated in 2000 with a Workshop for the Pacific Islands' sub-region. The second in the series was the Workshop for the Eastern and Southern African (ESA) region.

The ESA region currently faces significant challenges associated with natural climate variability, especially droughts, tropical cyclones, floods, sea-level variations, and changes in ocean temperature. The season-to-season and year-to-year variations of climate extremes are associated with anomalies in the oceanic and atmospheric circulation patterns and ocean-atmosphere interactions, sea-surface temperatures, the El Niño/Southern Oscillation, and other natural phenomenon. The region also plays a significant role in determining global patterns of climate change and climate variability. It is considered among the most vulnerable to the impacts and consequences of human-induced climate change, in particular, global warming and the potential threats associated with extreme weather and climate events and sea-level rise.

The GCOS Regional Workshop for Eastern and Southern Africa on Improving Observing Systems for Climate was held from 3-5 October 2001 in Kisumu, Kenya, by the Drought Monitoring Centres (DMCs) and the GCOS Secretariat, with additional support from the World Meteorological Organization (WMO), the United Nations Environment Programme (UNEP), the Global Environment Facility (GEF), and the United Nations Development Programme (UNDP).

The Workshop brought together the Permanent Representatives with WMO of 25 countries in the region, national climate change coordinators from some 22 countries, scientific and educational institutions, non-governmental organizations (NGOs), and relevant national, regional and international programmes and organizations active in climate change issues (a list of participants is included as Annex I).

2. SUMMARY OF THE WORKSHOP DELIBERATIONS

The deliberations of the Workshop can be grouped into six major categories, namely: The official opening session; data requirements for integrated monitoring of the global and regional climate system; extreme climate events in the region; the United Nations Framework Convention on Climate Change and guidelines for reporting on systematic observations; development of a Workshop Resolution and Regional Action Plan; and the official closing of the Workshop.

2.1 Official Opening of the Workshop

The Workshop was officially opened by the Honorable Musalia Mudavadi, Kenyan Minister for Transport and Communications. In his address the Honorable Musalia Mudavadi highlighted the importance of monitoring weather and climate conditions and of lessening the impacts of weather and climate extremes through advanced warning and guidance. The Minister made a special reference to the importance of the timely availability of weather and climate information in an understandable format that the public, governments, and businesses find useful and usable. Using specific examples of the Kenyan experience during the 1997/98 El Niño-related floods and the 1999-2001 La Niña-related droughts, the Minister highlighted how most of the socio-economic systems in Kenya were affected. He also provided some statistics regarding migration of people and animals; loss of life; impacts on water, energy, and agriculture/foods sectors; destruction to infrastructure and settlements; and other basic needs of society.

The Minister noted that some impacts could have been avoided if accurate and timely sector-specific tailored climate information were available to various socio-economic sectors. The Minister further noted that the impacts of climate change leading to frequent and/or more severe climate events would be catastrophic to humankind.

The Minister recognized the important role played by the Kenya Meteorological Department that falls within his Ministry. He concluded by noting the value of weather and climate observations in the planning and management of all climate-sensitive sectors, along with related analysis, forecasting, risk zoning, education and public outreach, and practical applications.

In his address on behalf of the Executive Director of UNEP, Mr R. Hepworth, UNEP Deputy Director (Division of Environmental Conventions) provided a review of UNEP activities with special reference to UNEP contributions to UNFCCC and other Environmental Conventions. He highlighted the support that UNEP has provided to the UNFCCC, IPCC, GTOS, GCOS and many other environmental organizations.

Dr A.R. Thomas, Director of the GCOS Secretariat, provided workshop participants with an overview of GCOS including its history, objectives, and component networks. Dr Thomas further highlighted the theme of the regional workshops with special reference to the outcomes expected from the ESA Workshop.

Dr M.S. Mhita, President of WMO Regional Association I - Africa, informed the participants that the declining observation network and communications problems in Africa are two of the major challenges for weather and climate monitoring and for prediction and early warning systems in Africa. These issues, therefore, have been in most programmes and meeting agendas of the WMO and the National Meteorological and Hydrological Services (NMHSs). He informed the meeting that in order to help in addressing the regional observational needs and challenges, WMO recently commissioned some experts to visit all the NMHSs in the sub-region and assess the specific national observational and communication problems. Dr Mhita informed the meeting that the experts' recommendations had been submitted to WMO for consideration. Dr Mhita informed the meeting that since the GCOS network for climate change monitoring and detection is the same as that used by the NMHSs for the daily weather forecasts, it is critical that the GCOS RAP adequately addresses the specific problems that have led to the deterioration of data and communication systems in the region. The RAP must consider the on-going and planned activities in the region in order to avoid duplication of efforts and resources. He promised that as the President of RA I and as Director of the United Republic of Tanzania NMHSs he would do all he can to ensure that the recommendations from the Workshop are adequately addressed in all relevant national, regional and international fora. He wished the meeting fruitful deliberations.

In his address, The Permanent Representative of Kenya with WMO, Dr J.R. Mukabana, noted that the Kenyan Meteorological Department (KMD), through the Government of Kenya, puts a lot of significance on climate change issues and has worked closely with the National Environment Secretariat (NES) for the coordination of Intergovernmental Panel on Climate Change (IPCC) and UNFCCC issues. He noted that KMD is hosting the WMO Subregional Office for Eastern and Southern Africa, the DMC-Nairobi, the Task Team on the Preparation for the Use of Meteosat Second Generation in Africa (PUMA), and the Intergovernmental Authority in Development (IGAD) Remote Sensing Project (RSP), among many regional and international programmes, indicating the importance it attaches to climate issues. Dr Mukabana also informed the meeting that Kenya is hosting a Global Atmosphere Watch (GAW) station that was being formally opened the same week by the Honorable Musalia Mudavadi, Kenyan Minister for Transport and Communications, on behalf of the President of Kenya. Professor G.O.P. Obasi, Secretary-General of WMO, attended this event and, as a result, could not attend the GCOS Workshop.

After the Workshop, however, Professor Obasi met with Permanent Representatives from the region in Nairobi. Dr Mukabana concluded his remarks by reassuring the participants that the KMD was committed to supporting any follow-up initiatives to the Workshop.

Prof. L. Ogallo of DMC-Nairobi thanked GCOS, WMO, UNEP, and UNDP for giving the Drought Monitoring Centres a chance to host such an important Regional Workshop. Prof. Ogallo also thanked the KMD and NES for the important role they played in providing most local logistics for the Workshop. He paid special tribute to the local organizing committee that included himself, Dr J. Mukabana, Ms O. Massawa (NES), Mr S. Njoroge (WMO Subregional Office for Eastern and Southern Africa), Dr R. Okoola (University of Nairobi), and Ms M. Seki (UNEP) for the enormous effort they had put in to ensure the success of the Workshop. He also indicated the willingness of the DMCs to coordinate any follow-up activities related to the GCOS Regional Action Plan for the ESA region.

2.2 Data Requirements for an Integrated Monitoring of the Global and Regional Climate System

The discussion papers presented in this session were:

- Review of the GCOS Surface and Upper-Air Networks in the sub region;
- The importance of improved regional and global climate observations: Eastern and Southern Africa regional perspective;
- Limitations of data for climate change modelling in Africa;
- Regional satellite observational needs for climate change studies;
- Carbon cycle observations;
- Regional hydrological observation networks;
- ClimDex software for climate change analyses;
- Voluntary Observing Systems;
- Role of historical data in climate change monitoring, detection and attribution; and
- Status of the regional data archive.

2.2.1 Overview of the Global Climate Observing System and its mission

An overview of GCOS and its mission was presented by Dr A.R. Thomas. Dr Thomas highlighted the relationship between GCOS and the UNFCCC and the emergence of a GCOS programme of regional workshops in response to UNFCCC mandates. He indicated that key elements of the GCOS strategy include:

- Implementation of an integrated observing system that builds on existing operational and research observing and data systems, including the GCOS Surface Network (GSN), the GCOS Upper-Air Network (GUAN), the Global Atmosphere Watch (GAW), ocean observing systems that comprise the climate component of the Global Ocean Observing System (GOOS) and the Global Terrestrial Observing System (GTOS);

- Obtaining and sustaining national commitments to support elements of the Global Climate Observing System;
- Addressing deficiencies at a regional level; and
- Keeping an integrated observing system for climate focused, relevant to users, and responsive to new scientific insights.

2.2.2 The regional perspective: Why improved observations are important for the region and the globe

Dr R. Okoola presented a regional perspective on why improved observations in the ESA are important for the region and the globe (Annex IV). The main points highlighted in Dr Okoola's presentation were that:

- The ESA experiences patterns of climate variability and change that are significant on both global and regional scales;
- The ESA is dominated by monsoon circulation, and the anomalies associated with monsoon flows are depicted by climate elements, such as rainfall, that tend to show a dipole pattern;
- Monsoons are associated with heat sources/sinks in the African convective centre over the Congo Basin/arid region and over the Greater Horn of Africa, respectively;
- Sea-surface temperature anomalies tend to control the patterns of rainfall and temperature over the region;
- The observational network has been sufficient during some periods, such as in the 1970s, but stations have significantly deteriorated in the recent past; and
- Satellite data are now available over the region, but they require surface observational data for validation.

2.2.3 Review of the current status and needs of the GCOS Surface and Upper-Air Networks in Africa

The current status and needs of the GCOS Surface and Upper-Air Networks in Africa was presented by Mr M. Saloum (Annex V). Mr Saloum stressed that in Africa data have mainly been collected for aviation purposes and not climate studies. The problems that Mr Saloum highlighted regarding the insufficient level of GUAN and GSN data for climate studies in Africa were:

- Lack of equipment;
- Lack of staff;
- Lack of consumables;
- Reporting using old format;

- Lack of appropriate telecommunications systems for the exchange of data and information (often obsolete equipment are used); and

- Lack of awareness on the part of the governments and other stakeholders regarding the value of climate information in socio-economic development.

2.2.4 Data limitations for climate modelling in Africa

Dr Mukabana reviewed data limitations for climate modelling over Africa. Dr Mukabana highlighted the data sources that are necessary for climate modelling as:

- Daily (6-hourly) and monthly analysis data from 2 or 3 state-of-the-art reanalysis projects;

- Monthly and annual means of some station observations;

- Global observations of gridded data from conventional observations including monthly temperature; precipitation based on land measurements, satellite microwave, satellite brightness temperatures, etc;

- More gridded data from reanalysis and other sources;

- Data sets from the main climate indices such as El Niño and Southern Oscillation Index; and

- Paleoclimate data.

Most of these data sets are not readily available to many African countries, and this poses a big handicap for modelling purposes.

2.2.5 Satellite observational needs for the region: The PUMA initiative

The potential role of satellite-derived data in climate change studies was noted in this paper. Mr E. Mukolwe further highlighted the need for satellite observations for the region with emphasis on the PUMA initiative (Annex VI). He stressed that satellite observations were meant to complement ground based observations, especially in data-sparse areas. He noted that a number of factors contributed to the need to have the Meteosat Second Generation launched. These included:

- Aging of the current generation of Meteosat satellites; and

- Inability of the current generation of satellites to provide detailed information for use in socio-economic development.

In order to overcome these difficulties, a continental project, Preparation for the Use of Meteosat Second Generation in Africa (PUMA), was initiated to assist African countries acquire ground-receiving equipment for the new generation satellites that will become operational by 2003. The Project has several components, including outlook activities, hardware and software management, and training. It was stated that the success of the project would depend on the individual efforts of NMHSs as well as on the community as a whole.

2.2.6 Carbon cycle observations

An overview of needed carbon cycle observations was presented by Dr R. Scholes (Annex VII). The presentation highlighted the importance of carbon observations, the current status of the observations, and how the gaps could be filled to ensure continuous data sets. Carbon dioxide observations are desirable because it is the principal greenhouse gas. The Kyoto protocol established a set of commitments for reducing CO_2 emissions by the developed countries and a mechanism for carbon trading. Methods exist for measuring pools and fluxes of carbon. It was noted, however, that there were as yet no flux measurements in Africa. Needs for carbon measurements in Africa include:

- 2 continental high precision sampling stations;
- 5 flux towers to cover the main bloom type;
- 50 collaborating sites measuring NPP by simple methods;
- 500 well-documented calibration locations; and
- An effective data and information system.

2.2.7 Review of hydrology networks

Dr D. Rutashobya gave an overview of hydrology networks (Annex VIII). His presentation covered the World Hydrological Cycle Observing System (WHYCOS), international sources of hydrological data, and the status of hydrological cycle observing systems in Eastern and Southern Africa. The main purpose of the WHYCOS is to assist countries in improving their hydrological services. International sources of hydrological data were enumerated as;

- The Global Precipitation Climatology Centre (GPCC);
- The Global Runoff Data Centre (GRDC);
- Flow Regimes from International and Experimental Network Data (FRIEND);
- The Global Environmental Monitoring System (GEMS)/Water Collaborating Centre;
- Hydrology for Environment, Life and Policy (HELP);
- The Global Network of Isotopes in Precipitation (GNIP); and
- The Global Energy and Water Cycle Experiment (GEWEX).

Regarding the current status of the hydrological observing systems in Eastern and Southern Africa, highlights were given concerning the Southern Africa Hydrological Cycle Observing System (SADC-HYCOS), Eastern Africa Hydrological Cycle Observing System (IGAD-HYCOS), and the Nile HYCOS. The hydrological cycle observing needs in Eastern and Southern Africa were grouped into two main components, namely:

- Hydrological data needs for climate (precipitation, evapotranspiration, soil moisture etc.); and

- Needs related to the development of observing systems (e.g., related to poor coverage, outdated equipment, lack of qualified staff, etc.).

Dr Rutashobya provided a way forward to address the hydrological observation challenges of the region (Annex VIII).

2.2.8 Review of the ClimDex Software

Dr T. Peterson presented a review of ClimDex Software (Annex IX), which has been developed for detecting climate change signals in extreme climate events. Version 1.3 of the software has been developed and is available on CD-ROM. No licensing is required. The software has in-built quality control and homogeneity test procedures. It also supports analysis and map displays. Some of the climate change indices that the software generates include:

- Heat wave duration;
- Percentiles of daily maximum and minimum temperatures;
- Number of precipitation days exceeding chosen thresholds like 10mm; and
- Maximum number of consecutive dry days (precipitation< 1mm).

Dr Peterson indicated that the software has also been developed to enable analysis of monthly data using some basic approaches.

2.2.9 Voluntary observing system: Experience of a voluntary observer

Professor D. Wasawo narrated the experience of a voluntary observer. Professor Wasawo highlighted the rituals that the old generation followed in their agricultural practices. Land preparation was a responsibility of the clan elder to declare. Nobody was allowed to plant before the clan elder conducted the ceremony of planting the first seed. The elders used to predict rainfall by observing the behaviour of animals and insects as well as the cloud developments and the phases of the moon. Traditional rainfall makers were regarded as having the competence of making rain. The introduction of conventional meteorological instruments significantly improved the available traditional knowledge. Professor Wasawo indicated that his interest to install a rain gauge was prompted by the large spatial variation of rainfall on his farm caused by a rain shadow on one side. The rain gauge has been managed by the farm manager, and the maid has also been trained to read it. The rain gauge has improved the capability to evaluate the monthly and annual variability of rainfall at the farm level for planning purposes. Professor Wasawo made the following recommendations:

- Publication of agricultural bulletins containing rainfall and crop conditions should be revived by the Kenya Meteorological Department and made available to farmers;
- The observation network should be enhanced to facilitate proper decision-making. This could be achieved through recruiting and training more voluntary observers;
- Adequate funding should be provided to the Meteorological Department to enable it to meet its needs and those of the users of climate information; and

- Consideration should be given to the diversification of the volunteer services to cover other meteorological parameters.

2.2.10 The RANET multimedia project

The RANET (Radio and Internet) multimedia project, was presented by the African Centre of Meteorological Applications for Development (ACMAD). The project responds to ACMAD's strategy for capacity building, which includes:

- Increased meteorological applications for sustainable development; and
- Development of application needs and techniques for poverty alleviation, food security, and disaster mitigation.

RANET is propelled by the need for timeliness and reliability in the dissemination of data and products. The main items highlighted in the presentation included:

- The assistance offered by RANET in the dissemination of local language products from meteorological services to end users;
- The access given by World Space to ACMAD to deliver weather and forecast information;
- The need for meteorological services to take advantage of developments in technology by using relay radios to improve the dissemination of products; and
- Encouragement of the use of rewinding radios for rural communities who cannot afford cell phones.

2.2.11 Role of historical data

The role of historical data in climate studies was presented by Dr T. Peterson (Annex X). Dr Peterson recapitulated the role of GCOS and the importance of high-quality, well-spaced data. A good network of stations is a prerequisite for calibration and digitization of data useful for climate studies. It has been observed that any analysis based on the Global Historical Climatological Network has always left out Africa due to unavailability of sufficient data. A search through old records has revealed some good historical data sets generated, for example, for German East Africa. The importance of historical data cannot be over emphasized. It could be used for:

- Evaluating the relationship between weather/climate and certain diseases; and for
- Investigating climate change signals at the regional level.

2.2.12 Status of the Regional Data Archive

Mr B. Garanganga discussed the status of the Regional Data Archive with reference to the Drought Monitoring Centres in Nairobi (DMCN) and Harare (DMCH). Mr Garanganga reviewed the data that were available at the centres, including rainfall data, temperature, global SSTs, and ENSO indices. The data sets are used to generate risk maps for vulnerability assessment as well as timely monitoring of climate conditions. There are problems encountered by the DMCs regarding data and information exchange with the participating countries. These include:

- Unavailability of historical data in electronic media in some of the participating countries;
- Lack of long continuous data for some locations;
- Use of old equipment for processing historical data; and
- Unavailability of appropriate communication facilities.

To overcome these impediments, the DMCs have made proposals to try to rescue climate data in some of the participating countries. The rescue process will involve:

- Making inventories of the data sets that exist on paper or in computer media that are obsolete and cannot be read by the modern data processing systems;
- Building capacity of NMHSs in areas of data management;
- Providing appropriate data processing facilities at the national level;
- "Migrating" data already in electronic form to modern archiving media; and
- Digitizing data still in paper form to avoid further deterioration.

2.2.13 Discussion and recommendations from the session

A number of questions and recommendations emerged from the presentations in Session 2. The main recommendations were:

- To enhance communication equipment and harmonize communication software to ensure that data transmitted from the NMHSs is not lost;
- To explore alternative methods of communication at the national level, e.g., use of cell phones;
- To install stations in critical regions where information is required;
- To have reporting stations use appropriate formats for data exchange;
- To identify the critical stations in the ESA sub region that should contribute to the GCOS;
- To generate long-term quality-controlled observations, which address climate issues such as variability and change;
- To sensitize governments to the value of climate information in decision-making;
- To create awareness on the part of the public of the importance of meteorological equipment and of the resulting data;
- To enhance the use of remotely sensed data, especially in data-sparse areas;

- To store historical climate data in appropriate media that conform with modern processing systems;

- To consider providing automatic rain gauges to voluntary observers and then to encourage feedback;

- To establish inter-institutional linkages in matters related to climate;

- To enhance capacities of personnel in data management at the national level;

- To seriously address the issue of cost and alternative methodologies for upper air measurements (because of the high cost of consumables) by regional and international institutions; and

- To develop a strategy for urban observations.

2.3 Extreme Climate Events in the Region

The discussion papers presented in this session were:

- Climate change and extreme weather/climate events: data needs for monitoring of land and atmospheric extremes, and

- Deficiencies and needs of ocean data in the Western Indian Ocean for climate activities.

2.3.1 Climate change and **extreme** *weather/climate events: Data needs for monitoring of land and atmospheric extremes*

Mr P. Ambenje provided Workshop participants with information on extreme weather/climate events (Annex XI) and their impact on climate change. He noted that one of the critical issues regarding climate change relates to extreme events, which often have far-reaching socio-economic impacts. A number of studies have suggested that there may be significant changes in the frequency and intensity of extreme events with only small changes in climate. The impacts of these extreme events have not been well simulated due to the limited amount of knowledge regarding the past space-time climate patterns in many parts of the continent, and particularly in the ESA.

One of the major problems contributing to this lack of knowledge is the scarcity of relevant high-quality data on the appropriate time scales (e.g., daily time scales for some extreme events). Global climate change scenarios are assembled from regional detection of climate change signals. The published scenarios therefore have a limitation because of non-existent signals from the Africa region. The certainty of conclusions that can be drawn about climate from observations depends critically on the availability of accurate, complete and consistent observations. For many variables, which are essential for documenting, detecting and attributing climate change, the data are still not good enough. There is therefore a need to establish the appropriate data sets necessary for studies related to temporal changes in extreme climate events.

2.3.2 Deficiencies and needs of ocean data in the Western Indian Ocean for climate activities

Extreme weather events often cause havoc on infrastructure and agriculture, crippling for years the economies of many countries in Southern and Eastern Africa, including the Small Island States. The floods at the beginning of 2001 in Mozambique and Malawi are vivid illustrations. Such extreme events, as well as droughts, may become more frequent with climate change. Studies have shown that there is strong correlation between the climate pattern in countries of Southern and Eastern Africa and ocean parameters such as sea-surface temperature in the Indian Ocean. However, though ocean observations have increased substantially in the Pacific and Atlantic Oceans with the deployment of moored and drifting buoys and an enhancement of the sub-surface ocean monitoring programme, the Indian Ocean remains poorly sampled. An overview of the deficiencies and needs of ocean data in the western Indian Ocean for Climate activities were presented by Mr S. Ragoonaden (Annex XII). He highlighted the need to build capacity in the region in order to develop a regional strategy for overcoming these deficiencies. The current ocean observing networks in the Indian Ocean include:

- Coastal Marine Stations;
- Sea-level stations;
- Wave-rider buoys;
- Deep-sea weather and moored buoys; and the
- Ships of Opportunity Programme (SOOP).

It was noted that all these observing networks had serious deficiencies. However, a number of programmes have been put in place to enhance observations in the near future. These include the Argo and Topex-Poseidon/JASON programmes.

2.3.3 Major recommendations from the session

The presentations in this session led to discussions and recommendations. The main recommendations were:

- To enhance the Western Indian Ocean observations and make them an integral part of an Indian Ocean observation strategy;
- To improve observations of climate to enable detection and better preparation for long-term, human-induced climate change; and
- To enhance cooperation among stakeholders with responsibilities for climate change issues, including national climate change coordinators and national meteorological and hydrological services.

2.4 United Nations Framework Convention on Climate Change (UNFCCC)

2.4.1 UNFCCC guidelines for reporting on systematic observations of climate

Dr W. Westermeyer provided background information on the guidelines for reporting to the Conference of the Parties (COP) of the UNFCCC on the national status of meteorological and atmospheric, oceanographic, and terrestrial observing systems. The highlights of his presentation included the following points:

- Baseline meteorological networks for characterizing global climate consist of the GSN, GUAN, and GAW. These networks define the minimum data requirements for climate-related purposes. Reporting on the status of these networks will help the COP understand problems and is a first step toward finding the means to ensure stations in these networks are fully operational. COP and GCOS would also like to know about the status of oceanographic and terrestrial networks measuring climate-related variables;

- Regarding space-based observing programmes, GCOS would like to know the types of data accessed, mechanisms for accessing data and products, prospects of long-term continuity of access to data, and current and planned future contributions to satellite-based observations; and

- Reports will provide essential information that can be used in making the case to upgrade climate observing systems - especially in developing countries.

2.4.2 Data needs for vulnerability and impact studies

Many countries are interested in vulnerability and adaptation (V&A) to climate change. Professor Ng'ang'a gave an overview of the climate data needs for vulnerability studies and impact assessment. The presentation highlighted some of the questions frequently asked regarding how climate change may affect different sectors. Some of the sample questions include:

How will any changes in precipitation, temperature, humidity, winds, etc. affect our country?

What can we do to moderate any bad effects?

How will economic growth, needs for energy, and population changes affect our country?

What data describe weather and climate changes for the past 50 years?

What data describe climate changes for longer periods?

What do climate models say about how the climate may change?

What effect will sea level change have on us?

The presentation proposed possible sources of data that could be used in V&A studies. It was noted that much data have been gathered by international organizations for every country that is not readily available to people in the countries. Since V&A studies are best done at the national level, Professor Ng'ang'a suggested that:

- Selected international data should be put onto CD-ROMs so that the information can be readily used; and

- Individual countries should acquire more data for their own needs.

National data needed for assessment, vulnerability, and adaptation projects include monthly and daily data for many precipitation stations in the country. Some data for radiation, sunshine, clouds, winds, turbidity, etc. are desirable. In addition, water resources are very important. Data for water runoff, irrigation use, etc. need to be available over long periods. Data on population, where people live, health, droughts, floods, etc. are also needed.

2.4.3 UNEP worldwide study of vulnerability and adaptation

Dr Y. Adebayo presented the UNEP study on vulnerability and adaptation at the Workshop. He discussed the following potential impacts of climate variability and climate change:

- Worsening food security;
- Risk of sea-level rise;
- Increased frequency and intensity of extreme weather/climate events; and
- Warming of the order of 0.7ºC during the 20th Century.

In view of the above threats, the study notes that adaptation is a necessity. For instance, warmer and wetter conditions could have impacts on diseases endemic to the region. Adaptation can generally be successful through understanding climate and socio-economic linkages.

Details of this presentation may be obtained from UNEP at their website: www.unep.org.

2.5 Development of Workshop Resolution and Regional Action Plan

On the third day, Dr M.S. Mhita of the United Republic of Tanzania, President of Regional Association I, led a plenary discussion on a Workshop Resolution. After extensive deliberations the Kisumu Resolution was adopted (Annex III).

The Kisumu Resolution called for a Regional Action Plan (RAP) to be prepared that specifies priority actions to be undertaken in order to improve observing systems and that charts a strategy for implementing these actions.

The Drought Monitoring Centres, in collaboration with national meteorological and hydrological services in the region and national climate change coordinators, were mandated to take the lead in developing the Action Plan. It was recommended that the Regional Action Plan be drafted by a balanced team of experts representing the three observing system domains, the climate change coordinators, and relevant stakeholders. It will then be circulated to all countries in the region for comments and approval. The detailed framework for the preparation of the RAP is available as Annex XIII.

2.6. Official Closing

The Honorable Noah Katana Ngala, Kenyan Minister for the Environment, performed the official closing. In his address, the Honorable Ngala pointed out the importance of monitoring the environment for sustainable national development. He informed the meeting that the National Environment Secretariat (NES) was established by the Government to coordinate environmental issues and is currently the focal point for activities related to the UNFCCC, the UN Convention on Biodiversity, and the UN Desertification Convention. Regarding climate change, NES is currently coordinating the preparation of a National Communication to the UNFCCC. NES is also working closely with the Kenya Meteorological Department (KMD) on all Intergovernmental Panel on Climate Change (IPCC) issues. He informed the meeting that NES, under the auspices of the Ministry of Environment, would continue to support any follow-up activities that may result from this important GCOS Workshop.

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Annex I

LIST OF PARTICIPANTS AT THE GCOS REGIONAL WORKSHOP FOR EASTERN AND SOUTHERN AFRICA ON IMPROVING OBSERVING SYSTEMS FOR CLIMATE
3 - 5 OCTOBER 2001, KISUMU, KENYA

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Annex II

GCOS REGIONAL WORKSHOP FOR EASTERN AND SOUTHERN AFRICA ON IMPROVING OBSERVING SYSTEMS FOR CLIMATE

(3-5 October 2001, Kisumu, Kenya)

Agenda

Day 1, Wednesday, 3 October 2001

08:00 - 09:00	**Registration**
09:00 - 10:00	**Opening Ceremony** *(Opening by Minister for Transport & Communications; Statement by SG WMO; Statement by Executive Director UNEP)*
10:00 - 10:30	***Coffee Break***
Session I:	**Data Requirements for Integrated Monitoring of the Global and Regional Climate System** *Chairperson: Dr J.R. Mukabana Rapporteur: P. Ambenje/ H.Dandaila*
10:30 - 11:00	**Overview of the Global Climate Observing System and Its Mission** ***Alan Thomas (GCOS Secretariat)***
11:00 - 11:30	**The Importance of Improved Regional and Global Climate Observations: Eastern and Southern Africa Region Perspective** **Raphael Okoola (UoN)**
11:30 - 12:00	**Historical development, present status, and strategy for addressing the deterioration of the GCOS Surface and Upper Air Networks** *Mahaman Saloum (ACMAD)*
12:00 - 12:20	**Data Limitations for Climate Modelling in Africa** *Joseph R Mukabana (KMD)*
12:20 - 12:40	**African Climate products and Challenges: Experiences from the National Centre for Medium Range Weather Forecasts, India.** *S V Singh (NCMRWF)*
12:40 - 13:00	**Discussion**
13:00 - 14:00	***Lunch Break***
	Chairperson: *S.O. Saad* Rapporteur: S. Marigi/T. Abebe
14:00 - 14:30	**Satellite Observational Needs for the Region; The PUMA Initiative** *Evans Mukolwe* (WMO)

14:30 - 15:30 **Discussion**

15:30 - 16:00 ***Coffee Break***

16:00 - 16:30 **Carbon Cycle Observations**
Robert Scholes (CSIR)

16:30 - 16:45 **Discussion**

16:45 - 17:15 **Review of Hydrology Networks**
Datius Rutashobya (MoW-TANZANIA)

17:15 - 17:30 **Review of ClimDex Software**
Thomas Peterson (NCDC)

17:30 - 18:00 **Discussion**

Day 2, Thursday, 4 October 2001

Chairperson: *S.O. Saad* *Rapporteur: W. Nyakwada/D. Masisi*

08:30 - 08:45 **Voluntary Observing Systems--Experiences of a Volunteer Observer**
Prof. Wasawo - a small-scale farmer

08:45 - 09:00 **Voluntary Observing Systems: RANET MULTIMEDIA Project**
ACMAD

09:15 - 09:45 **Discussion**

09:45 - 10:15 **Role of Historical Data**
Thomas Peterson

10:15 - 10:30 *Discussion*

10:30 - 11:00 ***Coffee Break***

11:00 - 11:30 *Regional Data Archive: Demonstration by DMC Harare*

11:30 - 11:45 **Discussion**

Session II: **Extreme Climate Events**

Chairperson: S.N. Sok Appadu *Rapporteur: T. Tseghe/B. Elasha*

11:45 - 12:15 **Climate Change and Extreme Weather/Climate Events: Data Needs For Monitoring of Land and Atmospheric Extremes**

Peter Ambenje (DMCN)

12:15 - 12:45 **Global Ocean Observing System for Monitoring of Oceanographic Related Extreme Events**
Sachooda Ragoonaden (MAURITIUS)

12:45 - 13:00 **Discussion**

13:00 - 14:00 ***Lunch Break***

Session III: **United Nations Framework Convention on Climate Change (UNFCCC)**

Chairperson: S.N. Sok Appadu *Rapporteur T. Tseghe/B. Elasha*

14:00 - 14:30 **UNFCCC and Guidelines for National Reporting on Global Climate Systematic Observations**
William Westermeyer (GCOS)

14:30 - 15:00 **Discussion**

15:00 - 15:30 **Data Needed to Address Vulnerability and Adaptation to Climate Change**
J. Ng'ang'a (UoN)

15:30 - 16:00 ***Coffee Break***

16:00 - 16:30 **UNEP: Worldwide Study of Vulnerability and Adaptation**
Y. Adebayo (UNEP)

16:30 - 17:00 Discussion

17:00 - 17:15 **A Brief Introduction to the Way Forward (Goals of Day 3)**
Alan Thomas (GCOS)

Day 3, Friday, 5 October 2001

Session IV: **Development of the Workshop Resolution**

Chairperson: Dr M. Mhita *Rapporteur R. Okoola/G. Obua/P.Ambenje*

08:30 - 10:30 **Discussion of Priorities for Improving Observing Systems and the Way forward**

Potential topics: 1. Getting partially working stations fully working, 2. Ensuring that observations that are made will be available, e.g., by improving the communication system, 3. Funding for consumables, 4. Training and Staffing, 5. Data Management.
- Mohamed Mhita *- Alan Thomas*

	- Prof R Odingo	*- UNDP*
	- Joseph Mukabana	*- UNEP*
	- Buruhani Nyenzi	

10:30 - 11:00 ***Coffee Break***

11:00 - 12:30 **Continue with the above discussions**

13:00 - 14:00 ***Lunch Break***

14:00 - 15:30 **Recommendations and Adoption of workshop resolutions**
(Adoption of the relevant resolutions for follow-up actions within the region)

15:30 - 16:30 **Closing Ceremony**

Note: **Details in separate Agenda**

16:30 - 17:00 ***Coffee Break***

Annex III

GEF
Global Environment Facility

G GLOBAL
C CLIMATE
O OBSERVING
S SYSTEM

Of UNESCO WMO UNEP ICSU

DMCN DMCH

RESOLUTION CONCERNING THE IMPROVEMENT OF GLOBAL CLIMATE OBSERVING SYSTEMS IN EASTERN AND SOUTHERN AFRICA, KISUMU, KENYA

The participants in the GCOS Regional Workshop for Eastern and Southern Africa on Improving Observing Systems for Climate

Welcome:

The opportunity provided by the GCOS Secretariat in partnership with the National Meteorological and Hydrological Services (NMHSs), the international climate change community, and Drought Monitoring Centers of Nairobi and Harare, and with the support of GEF/UNDP, UNEP, and WMO to identify ways to improve observing systems for climate in the region.

A *Recalling*:

(1) That the Conference of the Parties (COP) to the UN Framework Convention on Climate Change (UNFCCC) has encouraged Parties to actively support capacity-building in developing countries to enable them to collect, exchange, and utilize data to meet local, national, regional, and international needs (Decision 14/CP.4), and has recognized the need to identify priority capacity-building needs related to participation in systematic observation (Decision 5/CP.5);

(2) That Decision 5/CP.5 urges Parties to address deficiencies in the climate observing networks and to bring forward specific proposals for that purpose and to identify the capacity-building needs and funding required in developing countries to enable them to collect, exchange, and utilize data on a continuing basis in pursuance of the UNFCCC; and

(3) The role and importance of GCOS to facilitate, with other stakeholders, systematic observation regionally.

B. Recognizing:

(1) That Eastern and Southern African countries are considered among the most vulnerable to the impacts and consequences of human-induced climate change, in particular, global warming and the potential threats associated with extreme weather and climate events and sea level rise;

(2) That improved observations of climate will enable provision of information and forecasts which will greatly assist the governments and national communities of countries in the region to prepare for the season-to-season and year-to-year variations of climate associated with sea surface temperatures, El Niño/Southern Oscillation, and other natural phenomenon, as well as to detect and better prepare for long-term, human-induced climate change;

(3) That Eastern and Southern African countries currently face significant challenges associated with natural climate variability, especially droughts, tropical cyclones, floods, snowfall, sea level variations, and changes in ocean temperature;

(4) That oceanic and atmospheric circulation patterns and ocean-atmosphere interactions in Eastern and Southern Africa play significant roles in determining global patterns of climate change and climate variability;

(5) That measurements of meteorological/atmospheric, oceanographic, and terrestrial variables in the region provide essential data for detecting and attributing climate change; for monitoring, understanding and predicting climate change and climate variability; for developing strategies to ameliorate the potential harmful effects of climate change and climate variability; and for advancing sustainable development regionally; and

(6) That the basic observation networks of NMHSs provide the foundation on which the strengthening of GCOS must be built.

(7) That enhanced cooperation among stakeholders with responsibilities to deal with climate change issues, including national climate change coordinators and national meteorological and hydrological services, is essential

(8) That the observations from the GCOS surface network and GCOS upper air network are currently inadequate and that these important networks have been deteriorating in recent years;

(9) That substantial historical data exists that has not been made available;

(10) That urban climate has significant impacts on the global climate;

(11) That the DMCs play an important role in climate monitoring and applications.

C. Urge:

(1) That a Regional Action Plan be prepared to illuminate priorities within the region and to form the basis for the preparation of a proposal(s) for funding improvements in observing systems for climate and in other activities related to climate observing systems in Eastern and Southern Africa;

(2) That the Action Plan be prepared in accordance with the following programme:

a) The DMCs, in collaboration with the NMHSs and the national climate change coordinators, will facilitate the development of a Regional Action Plan that will incorporate the priorities raised in the workshop and initial country reports. In order to take advantage of opportunities to report to the UNFCCC, this regional Action Plan should be completed no later than May 2002. To facilitate this process, the Workshop participants recommend the creation of a core drafting team comprised of 10 people from among the region, to include representatives from the 3 observing system domains and from the climate change coordinator group. The DMCs should seek support of agencies such as UNEP, WMO, ACMAD, and GEF/UNDP in this endeavor.

b) Once the Plan is developed, it will be circulated to the members of IGAD, SADC, and IOC for approval; and

c) The DMCs, in collaboration with the NMHSs, the national climate change coordinators, GCOS, concerned international agencies, and regional organizations in Africa should develop a strategy for implementing the actions within the report.

(3) The countries of the region to prepare national reports on observing systems for climate. These reports should be developed through coordination between NMHSs and climate change country teams. All countries should strive to develop these reports pursuant to the UNFCCC guidelines;

(4) That the African community should take advantage of both communication and observation facilities offered by Meteosat Second Generation (MSG) and other relevant technologies to enhance availability of data and information over Africa;

(5) That additional effort be made to provide historical data in line with the request by the WMO Secretary General;

(6) That closer interaction and coordination between NMHSs and national climate change coordinators be undertaken to define country observing system needs for vulnerability and adaptation;

(7) That the region address the need for capacity building in a number of areas, including awareness raising and specialized training needs;

(8) That Western Indian Ocean observations be enhanced and become an integral part of an Indian Ocean observation strategy;

(9) That hydrology observations become an integral part of the observational strategy in line with programmes discussed at the GCOS Regional Workshop;

(10) That carbon cycle observations, essential for the full participation by African countries in the UNFCCC, should be promoted by working at the national level with partners in the agriculture, forestry, land use, and ecological sectors and by co-locating carbon cycle observation sites with GSN sites;

(11) That because of the high cost of consumables for upper air measurements, the issue of cost and alternative methodologies needs to be seriously addressed by regional and international institutions; and

(12) That because of the growing population of urban areas in the region, a strategy for urban observations be developed.

D. Requests that:

(1) The NMHSs and the climate change coordinators, with the assistance of the DMCs ensure that this resolution is widely distributed within the region and with appropriate collaborating partners;

(2) DMCs, working with the countries of the region, and in consultation with other organizations, including NMHSs and climate change coordinators, use the information developed in the Action Plan to prepare one or more specific proposals to potential donors to fund improvements in observing systems for climate;

(3) Development partners consider financing appropriate elements of the Action Plan;

(4) Parties to the UNFCCC in the region and the GCOS Secretariat bring this resolution to the attention of COP and its Subsidiary Bodies; and

(5) NMHSs become actively involved in the preparation of their national reports on activities related to systematic observation, as invited by the parties to the UNFCCC in Decision 5/CP.5.

E. Resolve:

To work relentlessly on improving observing systems for climate to ensure enhanced availability of climate data and information over Africa, including meteorological, atmospheric, oceanographic, and terrestrial (especially carbon and water) data that meets the regional climate needs and addresses the aims of the Convention.

Annex IV

THE IMPORTANCE OF IMPROVED REGIONAL AND GLOBAL CLIMATE OBSERVATIONS: THE EASTERN AND SOUTHERN AFRICA REGIONAL PERSPECTIVE

Raphael E. Okoola
University of Nairobi, Kenya

Climate is one of the most important natural resources since it determines not only the survival of the life on the planet earth, but also dictates the space-time patterns of all other natural resources. Any change in the space-time patterns of climate would, therefore, have far-reaching biological, environmental and socio-economic impacts. Such changes have for many generations been driven by natural processes. In the recent years, human activities such as environmental pollution, desertification and over utilization of natural resources, have been noted to have had some impacts on natural climate variability and changes at global, regional and local levels. Many scientific and political efforts have also been undertaken to address the climate change issues. For example the UN Resolution 44/228 adopted by the General Assembly at its forty-fourth session in 1989, affirmed that the protection and the enhancement of the environment are major issues that affect the well being of peoples and economic development throughout the world

Rainfall and temperature, both over land and ocean surface, are the most important climatic factors to the Eastern and Southern Africa countries. This is because the economy of the region is dependent on rain-fed agriculture. Extreme rainfall anomalies result into droughts and floods, which are often associated with food, energy, water shortages; loss of life and property and many other socio-economic disruptions. As regards temperature, it conditions growth rates of various crops allowing for one or more crops per year.

The inter-annual variability of the Eastern and Southern Africa seasonal rains results from a complex interaction between Sea Surface Temperature (SST) forcing, large-scale atmospheric patterns and synoptic-scale weather disturbances, including monsoons and trade winds especially in the adjacent oceans, sub-tropical anti-cyclones, tropical cyclones, easterly/westerly wave perturbations and extra-tropical weather systems. The extent to which SSTs influence the seasonal rainfall totals in the region has been widely studied. The short rains period showed substantially stronger relationships with SSTs and the SOI. Hence the seasonal forecasts in the region, especially for the October to December season, are based on global ocean Sea Surface Temperature Anomalies.

Africa plays a major role in the heat balance of the global atmosphere. It acts as a sink of heat over the expansive Sahara and the Kalahari deserts. It also acts as a heat source in the convective towers within the African Convective Centre located over the Congo basin. These sources and sinks of energy are associated with strong circulation systems both on the global, regional and local scales. For example, on the global scale it is reflected in form of the East - West Walker Circulation. The Walker circulation exhibits substantial variability on intraseasonal to decadal time scales. These time scales have been observed in the regional rainfall patterns as well.

Rainfall over the Eastern and Southern Africa region has demonstrated dipole behaviour (patterns) such that when the equatorial Eastern Africa region is dry, then the Southern Africa region is wet. But this dipole pattern in rainfall does not occur with all extreme rainfall anomalies, for example, the 1997 El Niño and 1999 La Niña year. Similar dipole (gradients) have been observed in the SST patterns over the Indian Ocean showing gradients in the SST between central Indian Ocean and Indonesia.

In view of the above it is acknowledged that understanding of the heat balance and the associated variability in the circulation over Africa is beneficial to both the global and regional communities.

The major problem that is inherent in all attempts to address climate change issues including the detection and attribution of climate change of global, regional, and national levels is the non-availability of long period high quality climate records with good area coverage. Several decisions have been undertaken by World Meteorological Organization and the UNFCC Conference of Parties to address how to reverse the decline in the existing observational networks, and how to support the regional and global observational systems in developing countries under the Global Climate Observing System (GCOS), the Global Ocean Observing System (GOOS) and the Global Terrestrial Observing System (GTOS), through appropriate funding mechanisms. It is in this regard that the UNFCCC Conference of Parties (COF 5) passed a resolution for the enhancement of Global Climate Observing Systems. It also called on GCOS to identify regional deficiencies, assess priority needs and also initiate a process to improve climate-observing systems.

Some extreme rainfall anomalies in East Africa (EA) have been associated with ENSO. A number of studies of the relationships between the global rainfall and southern oscillation Index

(SOI) have concluded that although the statistical association between the rainfall over East Africa and the SOI was weak, there was high probability of wet conditions in the region during El Nino years. The recent catastrophic disruption of socio-economic infrastructures and loss of life in East Africa has been associated with the 1997/98 ENSO event that further supports this notion. Significant teleconnections have been observed between the ENSO and seasonal rainfall over parts of EA, especially during the northern hemisphere autumn and summer seasons, with the strongest relationship being observed along the Equatorial Eastern Africa coast during the autumn season. The high skill of predicting ENSO phases up to a year in advance suggests the high prospects of successful applications of ENSO forecasts to seasonal climate prediction in EA especially for the October to December rainy period. It has however been noted that there is a relationship between ENSO occurrence over the central Pacific and the SSTs anomalies over the Indian and Atlantic Oceans.

SST is the oceanic variable that most influences the atmosphere and it is a sensitive indicator of climate variability. GCOS will require weekly and monthly global SST analyses for the development and verification of coupled-model forecast systems. Satellite observations provide global coverage at high spatial and temporal resolution. But these estimates need continuous calibration by in situ observations.

A particular problem in SST retrieval is the need to relate the skin temperature, estimated directly from satellite observations to the bulk temperature, obtained from in situ measurements. The in situ network consists of both ship observation and measurements form drifting and moored buoys. The buoy observations are needed because of the relatively poor quality of the ship based observations and because ship observations are only adequate along the shipping lanes. The drifting buoys therefore provide high quality SST observations. A strong in situ measurement program will always be needed to guarantee the validity of the analyses.

The Global Climate Observing System (GCOS) aims to address all aspects of the physical climate system and to provide the data for documenting climate changes and supporting applications of climate information such as seasonal to inter-annual prediction.

Climate prediction will increasingly depend on coupled models of the atmosphere/ocean/land surface system. Such models will require the best possible initial data describing the three-dimensional state of the atmosphere and upper ocean layers. As well, they will require a comprehensive description of land surface conditions of soil, state of the vegetation, river runoff among others and the description of the coverage, volume and state of sea ice. These data must be collected and distributed in real-time in order to make possible systematic data control and assimilation into operational or quasi-operational forecasting systems. While real-time data collection is a fact for meteorological observations, this is still not the case for oceanographic and hydrological data or for data characterizing the state of the land surfaces.

All climate data streams require longer records of climate with reliable data. All the three streams, for instance, depend crucially on good SST data. There is a need to promote the development of improved historical climate databases.

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Annex V

CURRENT STATUS AND NEEDS OF THE GCOS SURFACE AND UPPER-AIR NETWORKS IN AFRICA

Mahaman Saloum

Service météorologique du Niger

The global observing system (GOS) is one of the three essential components of the World Weather Watch (WWW) programmes. It consists of facilities and arrangements for making measurements and observations at stations on land, at sea and from aircraft, meteorological satellites and other platforms.

CURRENT OPERATIONAL STATUS OF OBSERVING SYSTEMS IN AFRICA

NATIONAL COMPONENT OF THE RBSN

The results of monitoring exercises on the reception and availability of African meteorological and climate data showed that the availability of these data is very poor. Only very few stations have a good rate of reports, while the availability of reports from the bulk of the stations is either unsatisfactory or completely absent. The situation is worse in those countries undergoing civil war or experiencing social unrest. The latest monitoring results of SYNOP reception are shown in the figure contained in the Annex.

However, the overall implementation of the surface stations in the Regional Basic Synoptic Network (RBSN) has shown an increasing positive stability; for instance, the percentage of synoptic stations with a fairly complete programme is 32% (1999), 17% (1998), 18% (1997), 13% (1996) and 17% (1997).

In view of the poor performance of the African Observing System, and in order to improve the availability of climatological data, the last session of the Commission for Basic Systems (CBS) held in Geneva from 11-15 September 2000 recommended several actions related to its area of responsibility. Thus, the meeting felt that, it seemed better to define the network of CLIMAT and CLIMAT TEMP reporting stations separately and call such a network a Regional Basic Climatological Network (RBCN). It also noted that the list of stations for RBCN could be prepared by the Rapporteur on Regional Aspects of GOS.

THE GLOBAL CLIMATE OBSERVING SYSTEM (GCOS)

The mission of GCOS is to ensure the availability and quality of the atmospheric, oceanographic, and terrestrial data critical to a wide variety of climate users. Such data, obtained through the RBSN and the RBCN from both in situ and space measurements, are needed for:

- Detecting and attributing climate change;
- Monitoring the climate system;
- Modelling, understanding and predicting climate change and its impacts;
- Developing strategies to mitigate potential harmful effects of climate variability (such as response to El Nino conditions) and to adopt human activities to climate change;
- Assessing the potential impacts on natural and man-made systems; and
- Advancing sustainable development.

As integrated parts of the GCOS Initial Operational System, the GCOS Upper-Air Network (GUAN) and the GCOS Surface Network (GSN) have been established to accommodate observed data from most land and areas, including many mid-oceanic islands.

The list of the stations in the next RBCN should include GSN and GUAN stations within the Region and be supplemented by other CLIMAT and CLIMAT TEMP reporting stations needed for the description of regional climate features and selected through the same criteria that were used for the selection of GSN stations. Non-RBSN stations, which are reporting CLIMAT messages, should be taken into consideration

THE GCOS UPPER-AIR NETWORK (GUAN)

STATUS OF THE GUAN IMPLEMENTATION IN SOUTHERN AND EASTERN AFRICA

A GUAN station is supposed to carry best practices of observation of upper air variables and the provision of TEMP and CLIMAT TEMP data.

Analysis on the implementation of the GUAN in Eastern and Southern Africa was based on the monitoring results from GUAN monitoring centres. The results of the analysis are presented in Table 1 below.

Table 1: Availability of CLIMAT TEMP reports from GUAN stations in Southern and Eastern Africa in contrast to the availability from the whole of Africa.

N° of stations	Percentage providing at least 90% of reports	Percentage providing from 50-89% of reports	Percentage providing from 1-49% of reports	Percentage Silent stations
10	50	20	10	20 *
23	9	57	17	17 **

* Results in Southern and Eastern Africa as at July 2000
** Results in the whole of Africa, monitoring period: January-June 1999

Table 1 shows that about 80% of GUAN stations in Eastern and Southern Africa transmitted at least 1% of CLIMAT TEMP reports while about 20% are silent. The latter does not necessarily mean that all the stations in the silent category are not operational, but for different reasons their CLIMAT TEMP reports have not been received. The percentage of unsatisfactory stations from which between 1 to 49% were received is about 10% and that of satisfactory stations from which 50 to 89% were received is about 20%. The operation of about half of the GUAN stations in Eastern and Southern Africa are good, i.e. the CLIMAT TEMP reception from these stations is at least 90%. However, there exist a big reception gap between GUAN stations in Southern Africa and those in Eastern Africa. While stations in the former are generally good or satisfactory, stations in the latter are generally silent or unsatisfactory.

THE GCOS SURFACE NETWORK (GSN)

STATUS OF IMPLEMENTATION OF THE GSN IN SOUTHERN AND EASTERN AFRICA

A GSN station is supposed to carry best practices in the observation of surface variables and the provision of SYNOP and CLIMAT data.

As in the case of GUAN, analysis on the implementation of the GSN in Eastern and Southern Africa, which results are presented in table 2, was based on the monitoring results from on WMO July 2000 volume A.

Table 2: Availability of CLIMAT reports from GSN stations in Southern and Eastern Africa in Africa in contrast to the availability from the whole of Africa.

N° of stations	Percentage providing at least 90% of reports	Percentage providing from 50-89% of reports	Percentage providing from 1-49% of reports	Percentage of silent stations
53	10%	35%	29%	26 *
155	8	33	12	47 **

* Results in Southern and Eastern Africa as at July 2000

** Results in the whole of Africa, monitoring period: January-June 1999

Table 2 shows that about 75% of GSN stations provide reports during the monitoring period. Among these stations, while about 25% were silent. The latter does not mean that all the stations were not operational; they may be making SYNOP observations, but for one reason or the other their CLIMAT reports were not received. The percentage of unsatisfactory stations from which between 1 to 49% were received is about 29% and that of satisfactory stations from which 50 to 89% were received is about 35%. The operation of about one tenth of the GSN stations in Eastern and Southern Africa are good, i.e. the CLIMAT reception from these stations is at least 90%. Here also, there is big gap between countries. For example while stations from South Africa are “good” or “satisfactory”, GSN stations from the Democratic Republic of Congo are silent.

PROBLEMS OF CLIMATE OBSERVING SYSTEMS IN AFRICA

The inadequacies of the present Climate Observing Systems can, in part, be attributed to the lack of priority given to the gathering, processing and dissemination of climate data. This has led to a number of key deficiencies. The main problems reside in the following areas: i) satisfactory global coverage for many of the essential climate variables has not been archived; ii) regional coverage is not adequate in many areas; iii) observations of selected variables often do not have adequate accuracy or precision to be reliably used as indicators of climate change; and iv) key data sets, although collected are often not effectively exchanged.

REASONS FOR AN INSUFFICIENT LEVEL OF GUAN AND GSN IMPLEMENTATION

There are several reasons for the low/non availability of CLIMAT and CLIMAT TEMP reports from GSN and GUAN stations from Africa. Many African stations have problems maintaining stations because of available funds are insufficient to buy new, modern equipment or to carry out day-to-day operations due to lack of consumables, spare parts and qualified staff. Other problems include reports that are generated but are not properly communicated to the related Regional Telecommunication Hub (RTH); reports that are communicated but not according to formatting and prescription; reports that are submitted too late in the month to be included and reports that are otherwise in good order but that are not properly transmitted between RTHs.

NEEDS FOR IMPROVING THE GUAN AND GSN PROGRAMMES OF OBSERVATION

There is a critical need to develop and or improve the African climate observing system to better understand the role of Africa in the global climate system and the African climate variability and change. This will also enable a better climate monitoring in the continent and thus a better mitigation of the effects of extreme climate events.
The recent strategic plan for the improvement of the GOS in Africa recommended the following actions:

The redesign of observing systems in Africa is essentially important because in many areas the system simply does not exist, whereas in other areas it is satisfactory or could be improved. The issues to be addressed have been identified; they essentially fall into three categories:

- Lack of public infrastructure (electricity, telecommunication, transport facilities, etc.);
- Lack of expertise (lack of staff, lack of training, etc.); and
- Lack of funding (equipment, consumables, spare parts, manpower, etc.).

To enable Africa's full participation in the Observing Programmes, due consideration must be given to these three issues. Attention must specially be given to improving current telecommunication facilities in those countries with poor telecommunication infrastructure. The needs for improvement may call for upgrading, restoring, substitution and capacity building.

It is also expected that many of the problems of the GCOS stations will be overcome as feedback from network monitoring is provided to the stations concerned.

The information received also makes it possible for some African countries to receive assistance to maintain their GUAN and GSN stations through appropriate channels, such as through the Voluntary Co-operation Programme.

However, the improvement and full implementation of the GCOS in Africa pass necessarily by the formulation and implementation of national programmes for:

- The reinforcement of the upper air network;
- The implementation of GUAN and GSN stations,
- The reception satellite and aircraft data;
- The measurement of mid-level temperature;
- The reinforcement of the network for cloud and precipitation observations;
- The creation of a national centre of climate analysis and prediction.

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Annex VI

PREPARATION FOR THE USE OF METEOSAT **SECOND GENERATION IN AFRICA (PUMA)**

Evans A. Mukolwe

World Meteorological Organization, Switzerland

STRATEGIES AND EXPERIENCES

1. Introduction

1.1 In 1977, or thereabouts, the present generation of METEOSAT Satellites was launched by the European Organization for the Exploitation of Meteorological Satellites (EUMETSAT). Since that time, data and information provided by these satellites has greatly contributed to the Integrated Global Observing System (IGOS) of the World Meteorological Organization (WMO) and, thereby, helped to enhance the operational activities of many National Meteorological and Hydrological Services (NMHSs), particularly in Africa. Primarily, satellite data and information on cloud cover (both in visible and infrared channels), water vapour, and wind vectors derived from cloud movement is used by NMHSs to locate areas of convergence, divergence, storm development, progress and movement. Dust and sand storms are also easily located using satellite imagery. These help to increase the accuracy of weather forecasts. In addition, the data and information is used in various remote sensing activities of institutions other than NMHSs.

1.2 The METEOSAT Satellites are providing a platform for the collection of some raw meteorological data and a mission for the distribution of some meteorological data and products. These are referred to as the Data Collection Platform (DCP) and the Meteorological Data Distribution (MDD) mission respectively and also contribute to the efficient functioning of the Global Telecommunication System (GTS) of WMO, at both the national and international levels.

1.3 However, after close to 24 years in orbit, these METEOSAT Satellites are coming to the end of their useful lives. Besides, technological changes dictate that these satellites be replaced. This will have negative implications on the operational activities of NMHSs as their present satellite ground receiving systems for these satellites will become obsolete.

2. METEOSAT Second Generation (MSG)

2.1 In 1996, EUMETSAT announced its decision to develop a new generation of METEOSAT Satellites, scheduled for launch in early 2002. These are the satellites now referred to as MSG and are meant, not only to replace the ageing present generation of satellites but, to respond to the needs and requirements of users for more and good quality data and information. Broadly, users will receive satellite imagery at twice the rate at which they are receiving it now and with a much better resolution. There will also be data and information for additional applications beyond the present operational activities of NMHSs. It is planned to have a significant increase in the capacity of the DCP/missions and MDD.

2.2 Specifically, the MSG will be characterised by a temporal resolution of 15 minutes, instead of the present 30 minutes, which will provide satellite imagery at double the present rate. The spatial sampling at sub-satellite point will be 3km (1km high rate (HR) visible) instead of the present 5km (2.5km visible). MSG will have 12 channels instead of the present 3 channels: 1 HR visible (VIS), 2 VIS, 1 near infrared (IR), 4 IR windows, 2 water vapour (WV) channels, 1 ozone and 2 CO_2 channels. As already mentioned, there will be a significant increase in the capacity of the DCP and MDD missions. There will also be an exploitation of data separated into general processing centrally by EUMETSAT and specialised processing by specific centres referred to as Satellite Application Facilities (SAFs). Data will be disseminated in both the High Rate Information Transmission (HRIT) and Low Rate Information Transmission (LRIT) modes.

2.3 While the MSG is primarily intended for European Weather Services, EUMETSAT will, as in the case with current satellites, provide free and unrestricted access to data to virtually all weather services in Africa. All MSG data will be provided, without charge, to all NMHSs of countries with a Gross National product for Capita (GNP/C) below United Sates Dollar (US $) 2000. It will also be provided free of per charge to NMHSs of countries affected by tropical cyclones. For monitoring of disasters and emergencies in accordance with relevant United Nations (UN) Resolutions, all MSG data will be provided free of charge and so will it be for scientific research and educational institutions.

2.4 EUMETSAT MSG coverage will remain the same as the present coverage of current satellites except for the Indian Ocean, which is currently covered by METEOSAT-5 (M-5) located at 63° East. The M-5 service is currently scheduled to continue until the end of 2001 due to fuel limitations. There is a possibility that the present METEOSAT-6 (M-6) could be moved to cover the Indian Ocean.

3. PUMA Task Team

3.1 When the African EUMETSAT User Community was informed of the consequences of the transition from Meteosat satellites to MSG, it decided to establish a task team to work out modalities to avoid interruption of services. During the Second EUMETSAT User Forum in Africa, in Harare, Zimbabwe in 1996, on the initiative of the African NMHSs, the PUMA – Preparation for the Use of Meteosat Second Generation in Africa – Task Team was created.

3.2 PUMA Task Team was created to ensure that African NMHSs and Regional and/or Subregional Centres maintain their primary access to global weather information consequent on the change of satellites. The two main missions of the PUMA Task Team were to come up with a strategy for the transition from the current METEOSAT Satellites to MSG for the African User Community and to support the resource mobilization efforts necessary to fund the replacement of ground receiving and processing equipment for the use of MSG in Africa. The idea was to have a continental approach covering all the African countries in order to avoid the errors of the past, when, after the launch of the current satellites, it took more than 15 years to equip most of the African NMHSs with receiving capacities. Further, it was felt necessary to create a sustainable project by providing similar equipment, developing local capacities and integrating training activities. The previous proliferation of equipment on the African Continent was not conducive to sustainable maintenance of the equipment.

3.3 From the beginning, it was decided that the composition of the Task Team was to be such that it allowed for active involvement and multi-disciplinary approach. The best mix was, therefore, counterparts of donors, users, and representatives of regional/subregional institutions. Thus, the composition of the PUMA Task Team includes 5 representatives of the African Regional Intergovernmental Organizations, designated by their respective Subregional Groupings, and 5 representatives of the meteorological communities from the same regions, designated by the NMHSs directors. Institutions/organizations represented on the Task Team were the African Centre for Meteorological Applications for Development (ACMAD), the World Meteorological Organization (WMO) and EUMETSAT acting as the Secretariat. Mr Evans Mukolwe, from the Kenya Meteorological Department (KMD), was designated Chairman of the Team.

4. The PUMA Task Team Project

4.1 After the creation of the PUMA Task Team in 1996, the Team's first key activities were to draft a plan of action and make a first approach to would-be donors. Several donors including the United Nations Development Programme (UNDP), the World Bank, United Sates Aid for International Development (USAID) and the Turner Foundation were approached before the European Union (EU) was identified as the donor. To justify the funding of such a project, it was necessary to assess the requirements of the users and to this end, the Task Team prepared and circulated a questionnaire, the results of which were analysed by a consultant contracted by the EU.

4.2 It was then upon the Task Team to draft project profiles from outlines that had been provided by the WMO Technical Cooperation Programme. They were revised on the basis of the recommendations contained in the report of the consultant. There was very strong support for these activities from the WMO and its constituent bodies like the Executive Council (EC) and Regional Association I (RA-I) (Africa) by way of resolutions. The team also undertook missions to the 5 Subregional Economic Groupings and drafted the necessary documents to originate from these groupings. Several meetings between the European Union and the Task Team were also organised in an effort to avoid any delays in the realisation of the project.

4.3 The project has been approved by the EU and a Financing Agreement between the Commission of the European Communities and Sub-Sahara African Countries and Regional Centres has been signed. The project covers 47 African Countries and has five (5) components: provision of hardware (HW) and software (SW); training on use of the SW and maintenance of the HW; training on the use of the data; outlook activities and Project Management Unit. It is anticipated that the project will last for close to 4 years.

4.4 There are six African countries that are not included in the financing agreement. These are the five North African (Maghreb) countries – Algeria, Egypt, Libya, Morocco and Tunisia – and South Africa. However, bilateral and WMO Trust Fund arrangements are underway to facilitate the participation of these countries in the PUMA Task Team Project.

4.5 The overall Project Management Structure will be at three levels: the Project Steering Committee (PSC), the Delegated Regional Authorising Officer (DRAO) and a Project Management Unit (PMU).

The PSC will be composed of the PUMA Task Team members and the European Union while the PMU will have a Project Manager, an engineer, Training Expert and/or an officer responsible for outlook activities. The DRAO will be the Director of the Meteorological Service hosting the project.

5. Observations and Recommendations

5.1 The Africa Meteorological Community should take advantage of the DCP communication offered by MSG to enhance availability of meteorological data over Africa – establishment of a network of Automatic Weather Observation Stations (AWOSs) with DCPs.

5.2 The NMHSs in Africa should make use of the MDD mission available on MSG to enhance reception of data and products for operational purposes, from other meteorological centres.

5.3 Both the DCP and MDD missions of MSG will improve both national data collections and communication between National Meteorological Centres (NMCs) and Regional Telecommunication Hubs (RTHs).

5.4 NMHSs in Africa should develop new applications using increased and additional data and information from the new and technologically advanced satellites.

5.5 NMHSs in Africa should enhance their visibility by inter-linking with other national and international institutions that would benefit from the use of data and information from MSG.

5.6 There should be a concerted effort to develop continent-wide project proposals aimed at the implementation and/or improvement of the WWW components (observations, telecommunications, and data processing) in Africa – a lesson from the PUMA Task Team Project.

Annex VII

CARBON OBSERVATION SYSTEMS IN AFRICA

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The methods used to estimate the pools and fluxes of carbon in terrestrial ecosystems depend on the scale at which the study is being conducted. All are valid and useful for particular purposes. The ideal system has a nested set of observations at different scales. The Global Terrestrial Observations System (GTOS) scale hierarchy is a useful framework for this discussion. GTOS Tier 1 consists of global or continental-scale estimates, usually strongly model-based. Tier 2 consists of sophisticated, instrumented sites monitoring continuously at a 'landscape' scale (1-10 km^2). Tier 3 consists of less equipment intensive, but sometimes more labour intensive sites where regular measurements are made on a specific type of vegetation or land use. Tier 4 consists of sites that are only visited once, or irregularly, and thus the carbon pools are characterised, rather than the fluxes. Tier 5 consists of remote sensing, an indirect measure of variables related to the carbon cycle.

Estimates of the net carbon balance of the whole of Africa, or a large part of it, can be made on an approximately annual basis by 'inversion' of very precise measurements (<0.5 ppm) of the atmospheric concentration of CO_2. Supplemental measurements of the O_2:N_2 ratio, ^{14}C and ^{13}C assist in the analysis. There is a global network of locations that draw a 'flask sample' of air once a month and send it to two advanced analysis laboratories. It is necessary to know the atmospheric and oceanic circulation to perform the inversion. Such estimates are routinely made for Africa by a number of centres, but the error range is very large. This is partly because there are few 'constraining' observation sites around Africa, and none within the continent itself. Continental measurements with this precision are technically challenging because they need to sample the 'free troposphere', uncontaminated by local effects. One method is to sample the 'profile' using a light aircraft – such measurements are taking place at Maun in Botswana. Maintaining and calibrating the analysers is expensive and difficult, but new technical developments such as low-flow analysers may make it easier in future.

At the landscape scale, the technology of choice for flux measurement is eddy correlation, either in its open path or closed path form. Other micrometeorological techniques, such as profile methods (typically applied on towers >200 m tall) or Bowen ratio methods can also be applied. Eddy correlation requires the measurement, about 10 times per second and at about 1.6 times the canopy height, of the vertical velocity of an air parcel and simultaneously its concentration of water and CO_2. This requires a sonic anemomenter (3-D, preferably) and a sophisticated infrared gas analyser, along with the control, analysis and data logging instruments. All the standard weather parameters, plus net radiation and soil heat flux are required, at least half-hourly intervals. Typically a large amount of effort also goes into site monitoring and characterisation: plant biomass and composition, soil maps and analyses, weekly to monthly soil respiration and leaf area index measurements, documentation of land use etc. Such sites cost around $100 000 to set up, and around $50 000 per year to operate.

They require at least one PhD -level investigator and two technically advanced technicians, not necessarily on a full-time basis. There are currently at least two permanent eddy correlation flux towers in Africa (Skukuza in South Africa and Maun in Botswana). This number will probably grow, so attention needs to be given to optimal location, and site networking.

Carbon flux and pool measurement in a homogeneous *patch* of vegetation (i.e., consistent soil, plant community, climate and land use) can be made using much less sophisticated and expensive methods, by using the classical manual approaches, which remain the 'reference method'. There are in fact no other reliable ways of measuring carbon 'pools'. This requires little more than tape measures, clippers, paper bags, drying ovens and balances accurate to 0.1g and 100 g, a very basic laboratory, and a large team of semi-skilled labour (5 people, plus a qualified supervisor). Very many sites in Africa – ecological, agricultural and forestry research stations – are capable of making such measurements, and many do, though perhaps only partially, or for other reasons. The site also needs to have a standard weather station, recording daily at least rainfall, maximum and minimum temperature. Additional climate information, such as solar radiation (or cloudiness), humidity, and 2 m wind run, are very useful.

The main carbon pools are the aboveground biomass, the litter, and soil carbon. Aboveground herbaceous layer biomass (grasses and forbs) is measured at least twice a year – near the end of the wet season, and near the end of the dry by clipping, drying and weighing all the material in about 20 'quadrats' 0.5 x 0.5 m square. Aboveground woody biomass is estimated using 'allometry', an initially tedious, but eventually quick way of calculating the biomass of the stems from their diameter and height. Tree leaf biomass can be measured either when it falls, by capturing it in litter traps (about 20 0.5 x 0.5 m per site), or by measuring the leaf area using an optical device, and then dividing by the specific leaf area (m^2/kg). Leaf litter mass is measured by collecting it from the quadrats in which the herbaceous layer was clipped, drying weighing and correcting for mineral soil contamination. Dead wood mass is determined by counting the number if interceptions along about 100 m of transect lines, and measuring the log diameter at each intercept.

Soil carbon is collected using a combination of a large number (40) of core or auger samples and a few pits (1-2 pits, one sample from each wall). The pits are used to determine the soil depth, depth distribution of carbon and the undisturbed bulk density per horizon, while the cores are used to determine the spatial variability of topsoil carbon. Carbon analysis is done in the lab, after drying, removing particles > 2mm, crushing and sub sampling. 'Wet oxidation' is cheap and adequate if proper blanks and controls are used, but dry oxidation using a CN analyser is preferable – most national soils institutes will have access to one. Soil organic carbon analysis captures some of the belowground biomass, but not the large roots. These are either estimated using belowground allometry, or by sorting out, drying and weighing all the large roots recovered from the soil pits and cores. Soil carbon only needs to be estimate once a year, or even less frequently.

Carbon fluxes within a patch are more onerous to estimate accurately. Net primary production is estimated by summing the growth of trees and herbs. Tree growth is estimated from the mean annual increment, determined by measuring the girth of a large sample of trees annually at the peak of the dry season. Tree leaf, twig and fruit production is estimated from litterfall captured in the litter traps. Grass production is by clipping grass from 0.5x0.5 m quadrats every few weeks, and sorting it into live and dead, drying it and weighing it and then applying a 'balanced transfer' calculation. Belowground fine root production follows a similar protocol.

In order to satisfy the data needs of CDM projects, it is likely that Africa eventually needs in the order of hundreds of such 'patch' measurements of carbon pools and fluxes.

'Site characterisation', i.e. a tier 4 measurement not requiring a permanent staff presence at a site, can be done by a pair of trained researchers in about a day per site, plus another few days back at their headquarters analysing the data and the soil samples. The major cost is the cost of getting the team to the site, which usually requires four-wheel drive vehicles. A GPS, compass and camera are also useful. The measurements are basically the same as for pool characterisation at level 3, except that specific allometry is not developed (generic equations are used) and soil pits are not dug. The sampling intensity may be about half of that required at tier 3. Literally thousands of such site measurements have probably already been made in the course of forest, range and agriculture surveys in Africa, but the data are often hard to find. They are particularly important in calibrating remotely-sensed data, which are then used to make regional extrapolations. It is important that the sites be located in an unbiased fashion – either by systematic or stratified random sampling.

Remotely sensed data is becoming cheaper, more accessible and better, but is still hard to obtain and analyse for researchers based in many African countries. The newer satellites generate maps of leaf area index, tree cover and net primary production, but these are still experimental products, and should be used with caution. Direct measurements of biomass and atmospheric CO_2 may be available within the next decade.

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Annex VIII

REVIEW OF HYDROLOGICAL NETWORKS

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1. INTRODUCTION

The climate community, scientists involved in research and modelling, and policy analysts frequently cite the need for improved access to hydrological data and information in order to understand key environmental change processes, identify significant trends, assess variability, and develop informed responses. Besides their role in climate-related considerations hydrological variables are important for other subject areas including water resources monitoring and assessment, monitoring of the global water cycle, biodiversity issues, land-based sources of pollution, as well as coastal and agricultural applications. It follows therefore that the climatological, meteorological and hydrological/water resources management communities will need to work in close collaboration in order to enhance the capability to understand and predict climate variability and possible climate change.

Despite the fact that substantial hydrological data are generated by national and regional hydrological services, such data are funded mainly for purposes of water resources assessment, not for climate or research needs. Also, such data come from a variety of sources and vary greatly in quality. Significantly, the global availability of hydrological data is diminishing. This calls for concerted efforts at regional and global levels to provide accurate and reliable hydrological data to the users.

2. THE WORLD HYDROLOGICAL CYCLE OBSERVING SYSTEM (WHYCOS)

In an effort to assist countries in improving their hydrological services and at the same time respond to a call from the United Nations Commission on Sustainable Development for improved knowledge of the world's freshwater resources, the World Meteorological Organization (WMO) has developed the concept of the World Hydrological Cycle Observing System - WHYCOS. The system was launched in 1993 in collaboration with the World Bank. The System is modelled on the World Weather Watch and uses current technology for the observation and transmission of hydrological and hydrometeorological data. Observations are made at agreed time intervals using Data Collection Platforms (DCPs) and are transmitted in real time or near real-time via satellite to a regional and to national centres.

WHYCOS is being developed and implemented in the form of a number of regional

components, referred to as "HYCOS projects", each being designed to meet specific regional and national needs. A component is launched when the countries concerned have expressed their collective desire for such a development, and their commitment to making it a success.

Implementation at a regional scale enables each HYCOS project to select objectives, agree on working procedures and select activities which are specific to the water resources context of the region and which best meet the needs of the participating National Hydrological Services and of the end-users. It also allows each HYCOS to establish institutional and financial arrangements, which are appropriate to the region.

At present there are fifteen projects, three of which, MED-HYCOS, SADC-HYCOS and the Pilot Phase of AOC-HYCOS are due to be completed in 2001. Other projects that are at varying stages of development are IGAD-HYCOS, Congo-HYCOS, CARIB-HYCOS, Baltic-HYCOS, Aral-HYCOS, Pacific-HYCOS, Black Sea-HYCOS and Danube-HYCOS. Draft proposals are available for Amazon-HYCOS and Nile-HYCOS, and discussions are ongoing concerning the development of La Plata-HYCOS, Arctic-HYCOS and Hindu-Kush Himalayan-HYCOS. Also, there are plans for development of a Caspian-HYCOS.

There is a two-tier coordination mechanism of WHYCOS. Internal coordination links the inputs of the various Departments concerned within the WMO Secretariat and External coordination links the various HYCOS components through the WHYCOS International Advisory Group (WIAG).

3. THE GLOBAL TERRESTRIAL NETWORK – HYDROLOGY (GTN-H)

The Global Terrestrial Network – Hydrology (GTN-H) is an evolving international effort to develop and implement a global hydrological observing network for climate. This network would be a component of the Global Terrestrial Networks under development by the Global Climate Observing System (GCOS) and the Global Terrestrial Observing System (GTOS).

The Terrestrial Observation Panel for Climate (TOPC), sponsored by GCOS and GTOS identified ten hydrologic variables of importance to climate change monitoring. These variables are surface water discharge, surface water storage fluxes, groundwater storage fluxes, precipitation, evapotranspiration, relative humidity, and transport of biogeochemical materials from land to ocean. Others are soil moisture, snow water equivalent and water use. TOPC also observed that there is no single entity that serves as a global or regional data centre for the above variables. In response, the WMO Hydrology and Water Resources Department (HWRD), GCOS, GTOS and TOPC organized two expert meetings, the first in June 2000, held in Geisenheim, Germany, and the second in June 2001 in Koblenz, Germany. The first meeting came up with a proposal for a Global Terrestrial Network – Hydrology (GTN-H) which will consist of existing networks, global databases and global data product centres, whereas the second one developed an implementation strategy for the GTN-H. The main objective of the network would be to:

- respond to urgent information requirements with regard to climate prediction, impacts and adaptation, including the characterization of hydrological variability to detect climate change;
- Assess water sustainability as a function of water use versus water availability; and
- Improve understanding of hydrological processes.

4. OTHER INTERNATIONAL SOURCES OF HYDROLOGIC DATA

4.1 Global Runoff Data Centre (GRDC)

The GRDC has been established at the Federal Institute of Hydrology in Koblenz, Germany in 1988. Operating under the auspices of WMO, the principal objective of the GRDC is to collect and disseminate hydrological data to support projects within the World Climate Programme (WCP) and the World Climate Research Programme (WCRP) of WMO as well as for other programmes.

4.2 Global Precipitation Climatology Centre (GPCC)

The GPCC is operated by the Deutscher Wetterdienst (DWD, National Meteorological Service), located in Offenbach, Germany, under the auspices of the World Meteorological Organisation (WMO). The Centre was established in 1989 and contributes to the World Climate Research Programme's (WCRP) Global Precipitation Climatology Project (GPCP) and the Global Climate Observing System (GCOS).

4.3 Flow Regimes from International and Experimental Network Data (FRIEND)

The FRIEND programme is an international collaborative study in regional hydrology. Its primary aim is to develop, through a mutual exchange of data, knowledge and techniques, a better understanding of hydrological variability and similarity across time and space.

4.4 GEMS/Water Collaborating Centre

The GEMS/Water Programme, which operates as the global water quality-monitoring arm of the United Nations Environment Programme (UNEP), can bring the needed water quality information to a global hydrological network. The GEMS/Water Collaborating Centre in Burlington, Canada has for many years collaborated with GRDC on areas of common interest.

4.5 Hydrology for Environment, Life and Policy (HELP)

HELP is a joint UNESCO/WMO programme that is designed to establish a global network of catchments to improve the links between hydrology and the needs of society. It is a crosscutting programme of the UNESCO International Hydrological Programme, and will contribute to the World Freshwater Assessment Programme as well as the Hydrology and Water Resources Programme of WMO.

4.6 Global Network for Isotopes in Precipitation (GNIP)

The GNIP is operated by the Isotope Hydrology Section of the International Atomic Energy Agency (IAEA) in Vienna, Austria. This world-wide survey of the isotopic composition of monthly precipitation started as early as 1961 in co-operation with WMO to study the raising Tritium levels in the atmosphere caused by nuclear weapon tests. The programme also aimed to provide systematic data on the global stable isotope content of precipitation as a basis for the use of environmental isotopes in hydrological investigations.

4.7 Global Energy and Water Cycle Experiment (GEWEX)

A major goal of GEWEX is better understanding of the global hydrological cycle so as to enable an improved prediction of weather and climate, climate variability, and the availability of water resources.

5. STATUS OF HYDROLOGICAL CYCLE OBSERVING SYSTEMS IN EASTERN AND SOUTHERN AFRICA

5.1 SADC-HYCOS

The project, funded by the European Union and implemented through the SADC Water Sector Coordination Unit (WSCU), involves 14 countries of the Southern African Development Community – SADC. The regional coordination of the project is the responsibility of the Directorate of Hydrology, Department of Water Affairs and Forestry (DWAF), Pretoria, South Africa.

By the end of April 2001, a total of 41 Data Collection Platforms (DCPs) had been installed. The target for the installation of 50 DCPs according to the project document, had been modified to a target of 47 DCPs. The current phase of SADC-HYCOS, initially planned to terminate in June 2000, was extended in agreement with all the parties concerned until August 2001. Under the umbrella of SADC/WSCU, GWP and WMO, plans are underway for the development of a Phase II of the project. Several bilateral donors have shown interest in participating substantially in these future developments.

During the extreme floods in February 2000, some stations located in South Africa and Zimbabwe transmitted valuable data to downstream Mozambique for use in forecasting and warning and management of the floods.

IGAD-HYCOS

This HYCOS component, involving seven countries, aims at strengthening the regional capacity to provide hydrological data and information and at developing regional cooperation for water resources assessment, monitoring and management. The project document, prepared with inputs from local experts and the IGAD Secretariat, has been reviewed and endorsed during the seventh annual meeting of the IGAD directors of Meteorology, Hydrological and Early Warning Systems held in Nairobi, Kenya, from 27 to 28 January 2000 and subsequently submitted to the European Commission.

To ensure the project's sustainability and long-term capacity to respond to the regional needs, EC suggested the preparation of a detailed design document, which would eventually lead to the implementation phase. The IGAD Secretariat requested WMO to assist them in drafting terms of reference in line with the EC recommendations for the preparation of such a document. It is expected that funding will soon be available to start work on this project.

5.2 Nile-HYCOS

Over the past two years the Nile riparian states have been engaged in preparation of a portfolio of cooperative projects. The portfolio was unanimously endorsed by the Council of Ministers of Water Affairs of the Nile Basin States (Nile-COM) for presentation to the international donor community. Financial support is being sought for the implementation of a suite of basin-wide cooperative projects, under the Shared Vision Programme (SVP).

At the request of the Nile-COM, the World Bank organized the first meeting of the International Consortium for Cooperation on the Nile (ICCON), which was held in Geneva from 26-28 June 2001. The ICCON meeting supported the Nile Basin Initiative (NBI) and launched ICCON, which is envisaged as a broad partnership between and among the Nile riparian states and the international community.

6. NEEDS OF HYDROLOGICAL CYCLE OBSERVING SYSTEMS IN EASTERN AND SOUTHERN AFRICA

6.1 Hydrological Data Needs for Climate

The key hydrological variables necessary for improved climate and weather prediction, detection and quantification of climate change, assessment of the impacts of climate change, assessment of fresh water sustainability, and understanding the global water cycle are:

- Surface water discharge
- Surface water storage fluxes
- Groundwater fluxes
- Water use
- Precipitation
- Evapotranspiration
- Atmospheric vapour pressure
- Soil moisture

6.2 Other needs

Many problems related to the development of observing systems for regional needs include:

- Reduction in coverage and in efficiency of hydrological networks
- Outdated equipment
- Insufficient qualified staff
- High dependence on short term assistance projects
- Lack of an adequate and regular budget to sustain a large network of stations for operating the networks and the data management systems

- Lack of regional integration in providing water resources information
- Security problems in some countries
- The depleted state of the hydrological information systems and of the National Hydrological Services (NHSs) in charge of these systems
- Use of non-standard procedures for collecting data
- Variations in quality assurance procedures among different national agencies and/or among different countries in a region
- Unreliable telecommunications systems
- Long observation gaps in time series, particularly during sensitive events such as floods and droughts

7. SUMMARY AND CONCLUSIONS

Developing countries and countries in transition have had difficulty maintaining hydrological cycle observing stations for national needs, much less doing so for the needs of global climate research. A principal motivation for the establishment of WHYCOS and of related regional hydrological cycle observing systems (HYCOSs) has been to improve the inadequate, and in many cases, deteriorating status of these systems. The most common difficulty has been the lack of funds to operate a large network of stations in individual countries. Hydrological observing systems are typically far down the list of funding priorities in developing countries, resulting in inadequate allocation of funds for continuing operations. There is, therefore, an urgent need to arrest the deteriorating situation by addressing the problems identified above in order to have the Eastern and Southern Africa covered with reliable and efficient hydrological networks.

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Annex IX

SUMMARY REPORT OF THE ACTIVITIES OF THE WMO CCl/CLIVAR WORKING GROUP ON CLIMATE CHANGE DETECTION

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Combining the interests of CLIVAR and the Commission for Climatology (CCl), the Working Group on Climate Change Detection sits at the intersection of observational data and models, though with more of a foot in the observational camp. Together with many collaborators around the world, we are trying to address questions such as: What observational data are needed for climate change detection and attribution? What analyses of these data can provide information useful for climate change detection and attribution? And what international coordination on data issues would improve climate change detection and attribution? We are putting particular emphasis on indices derived from daily data for the analysis of climate extremes. Extremes often have the most impact on society, and creating these indices is difficult as the data are less readily available. We have also put an emphasis on delivering a range of other indices to the IPCC.

Towards that end, our activities started with a workshop in Bracknell in 1998. This workshop particularly sought to identify and refine appropriate climate change indices which could be derived from daily data and provide insights into changes in extremes. However, it also sought to identify indices of mean quantities, as these are important for the IPCC. Out of this meeting grew a Task Group on Priority Indices that created a multinational assessment of changes in extremes and also created a draft Data Dictionary of a vast range of possible Indices, some of which are now incorporated in the IPCC Third Assessment (TAR). As a result, the TAR contains a markedly wider range of indices than did the Second Assessment. The work on changing extremes has been accepted for publication by *Climate Research* and contributed new kinds of results to the IPCC TAR. In this process, we have found that those countries, which are very reluctant to release daily data, are often willing to share climate change indices derived from these data. Accordingly, key tasks for the Working Group have been to plan and start to execute a series of regional international meetings that can deliver such indices. These have broadly followed a pattern developed by the Asia-Pacific Network in 1998 and 1999. The 1998 Bracknell meeting recognized this and contributed to the subsequent Asia Pacific Network extremes meetings along with our own regional extremes meetings later.

Planning for the new extremes initiative took place at a full meeting of the Working Group in Geneva in late 1999. By this time, it was clear that nearly half of the global land surface was not going to be represented in the *Climate Research* article. Locations not analyzed include southwest Asia, Africa, and the Americas south of the United States. At the 1999 Working Group meeting, we decided that the most beneficial thing this small working group could do to enhance climate change detection work was to try to extend the analyses to the blank areas on the map. To achieve this, we have created a regional climate change workshop “recipe” modeled on the successful Asia-Pacific Network meetings, which have already delivered results to the TAR. The workshops are “hands-on” with internationally recognized climate change experts assisting participants in quality controlling and analyzing their data in standard ways. The results have been to create new insights about changing extremes in previously unanalyzed areas and to build the capacity for further analysis in these regions. To date, two regional workshops have been held, one for the Caribbean in January 2001 and one for parts of

Africa in February 2001. Representatives from 40 different meteorological services attended these workshops and returned to their institutions with our specially developed but relatively simple climate change indices analysis software. We intend to host additional regional climate change workshops in the next period of Working Group activity.

During at least three days of a workshop, the participants engaged in hands-on exercises related to the data issues discussed. Participants had previously been asked to carry daily temperature and precipitation data of appreciable length (40 or more years) from their respective territories. Utilizing computers provided by the host institution and ClimDex software developed and provided by Byron Gleason of NCDC, participants initially logged many hours processing the data, which they had brought to determine their suitability for the climate change analysis, which was to be subsequently performed. The ClimDex software is comprised of four steps:

Quality control of the data (check precip > 0, Tmin < Tmax, etc.).
Homogeneity testing (t-tests using 5-year adjacent time periods).
Calculating derived climate indices (ten from Frich et al. (2001) and a further 5 regionally dependant threshold indicators) and time series.
Visualizing the data spatially.

This software is not designed to do in-depth quality control or homogeneity testing. But it can highlight any major data problem such as 28 degrees mis-entered as 82 degrees or a station times series that have undergone large discontinuities that would greatly impact indices analyses. The software uses a Microsoft Excel spread sheet which the majority of the computers in the world already have available. ClimDex is provided by the U.S. National Climatic Data Center/NOAA with no restrictions. But users are advised to remember that this is a research tool. It can facilitate standard analyses of certain widely reported indices of extremes. But it is continually being improved and updated and therefore should be used with caution as there might be unknown problems with it.

Reference

Frich, P., L. V. Alexander, P. Della-Marta, B. Gleason, M. Haylock, A Klein Tank and T. Peterson, 2001: Global changes in climatic extremes during the 2nd half of the 20th century, *Climate Research*, in press.

Annex X

THE ROLE OF HISTORICAL DATA

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Introduction

The Spanish-American philosopher George Santayana (1863-1952) wrote that "those who do not remember the past are condemned to repeat it." Chaos theory, however, makes it clear that historical weather will never be exactly repeated. But still the primary value of historical data is the prediction of the future climate so we don't make the same mistakes we did before we knew what to expect. Clearly we look to the past in order to see the future. Take for example, Normals, the smoothed 30 year averages we all use. Fundamentally, Normals are a prediction of the future, an indication of what we should expect ("climate is what we expect, weather is what we get"). Agronomists considering introducing a new crop variety to a region would look at the Normals to see if the plant was suitable for the area. And since the climate changes, we update Normals periodically to enhance their predictive value.

Normals tell us the means but don't say much about the variability. To answer some questions, we need to know the variability. For example, during a drought in Florida, a small town which was running low on water asked us whether they were in an extremely rare drought or whether they needed to build an additional reservoir to be prepared for another drought like this in a few years. In this particular case, it was not a very severe drought so spending the money on an additional reservoir was justified. A body of statistical literature exists that guides return period calculations. The general guidelines are that you can reliably calculate a return period up to about twice the length of data. Therefore, if you have 30 years of historical data, you can describe a 60 year flood or drought, but your accuracies on 100 year or 500 year events are much lower. Planners building flood levies may use 100-year floods as their guides. Therefore, the more data you have the better able you are to "predict" the magnitude of the largest flood they should expect in the next 100 years. Longer periods of record also allow better analyses of, for example, connections with ENSO events. So again, historical data can provide predictive value.

Now, the entire world is concerned about global climate change. More than just means and variability, can we detect trends (linear and non-linear) in local, regional and global values? This is perhaps the most difficult use to which we can put weather and climate data. It often stretches the fidelity of the data far beyond the uses that the original observers intended. For example, a dedicated observer may keep the shelter in the middle of his or her yard clean and white so that it accurately measures the temperature in the yard. But the shade tree the observer planted on the west side of the yard is slowly growing over the last 4 decades and its shade is increasingly cooling the yard in the afternoon. This change is not sudden or large and doesn't do any serious damage to calculations of Normals or variability. But it can impact long-term climate change analyses.

The Global Historical Climatology Network Example

In order to derive robust estimates of climate change, problems due to changes in observation environments need to be addressed. The Global Historical Climatology Network (GHCN; Peterson and Vose, 1997) has had to address these problems. Since there are many ways to address such problems, the GHCN example is but one approach. But most research quality data sets go through similar steps.

The most beneficial approach to addressing problems associated with individual stations is to include the data of many stations. GHCN has over 30 source data sets and over 20,000 stations. Some are global and some are regional. One or two, in fact, may only have a few stations from special locations. Still there were regions of the world or times within certain regions when data was quite sparse. Some regions, such as China before 1950, have such serious problems with their data that nothing can be done. But there are other regions of the world where data exist in hard copy form that can be digitized. We had a very selective digitization effort designed to add early historical data to the GHCN data set. This effort focused primarily on European colonial era archives stored in Europe or America (Peterson and Griffiths, 1997). In addition to the data, a carefully documented guide to what data these archives have for Africa was created (Griffiths and Peterson, 1997).

Once sufficient data have been digitized to reflect the climate of a region, the data needs to be quality controlled. The GHCN QC uses a suite of tests (Peterson et al., 1998a). The first series evaluates the source data sets to make certain there are no systematic problems in the database. The second series of tests look at station means and time series asking questions such as: Is the station reflecting the climate at this part of the world (e.g., is it mislocated or miskeyed 6 months out of phase)? Do the metadata agree with the physical world (e.g., does the elevation of 2000 meters mean it is floating far above the ground)? Are there major changes in the mean values (e.g., did units change)? And it performs numeric checks such as looking for identical values 3 months in a row or one year identical to the next, which can indicate problems with keying of the data. Only the last series of tests is what people normally consider QC: checking for outliers from time series perspectives and then checking these outliers to see if neighbors indicate it is a valid extreme value.

After the physically unreasonable data have been removed from the database, the data are ready to be assessed for homogeneity purposes. A time series is considered to be homogeneous if all changes in it are due to changes in weather and climate. If there are changes in the time series due to switching to a new instrument or moving the station to a new location, these changes can induce biases into the results of any long-term climate analyses. Many different approaches to inhomogeneity analyses are described in a review paper by 21 authors from 11 countries (Peterson et al., 1998b). In the case of monthly data, most approaches adjust the data to make early observations homogeneous with recent observations. However, in the case of daily data--which are much harder to adjust accurately--many researchers simply remove the most inhomogeneous time series from the analyses (e.g., Frich et. al, 2001).

> ***Only after the data have been subjected to homogeneity testing and adjusting are they ready for long-term climate change analyses. Most approaches to analyzing long-term trends "area-average" anomalies to a base period, though that is not the only analysis option (Peterson et al., 1998c). The final stage quality assurance is to use the data in a variety of analyses (e.g., Peterson et al., 1999). During the course of making the analyses, the researcher is often able to see whether any of the stations seem to be behaving strangely. So using the data should definitely be looked upon as post-production quality control as well as means to answer important climate change questions. This is perhaps especially true of stations whose data are going into the GCOS Surface Network (GSN; Peterson et al., 1997)***

as these stations--1000 of the best long-term stations the world has to offer--will form the core of many future observational climate change analyses.

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Annex XI

CLIMATE CHANGE AND EXTREME WEATHER/CLIMATE EVENTS: DATA NEEDS FOR MONITORING OF LAND AND ATMOSPHERIC EXTREMES

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Climate plays a very important role in the socio-economic activities of many countries. It dictates processes in sectors like agriculture, water resources, energy, health and industry etc. It is known to determine the space-time distribution of many natural resources. From a climatological point of view, the term Climate Change generally refers to ***"permanent shifts in the traditional space-time patterns of climate*"** regardless of the causes. In the past, such changes have been associated with changes in the natural systems which control climate. Recent studies have however, shown that human activities such as deforestation and urbanization have the potential to alter the space-time patterns of climate. The human activities are mainly a result of sharp increases in human and animal population among others.

According to the Third Assessment Report (TAR) (IPCC 2001) and on a global scale, average temperature has increased by approximately 0.6°C since the late 19^{th}. There has been a general reduction in the diurnal temperature range arising from steeper increases in minimum temperature and more moderate increases in maximum temperature. There is quite a large spatial disparity in the precipitation changes over the globe. An increase of 0.5 – 1% per decade has been observed over the Northern Hemisphere and mid latitudes. A decrease of about 0.3% per decade has occurred over the sub tropical land areas. The tropical land surfaces have recorded an increase of 2.4% per century.

One of the critical issues regarding climate change is with respect to the extreme events, which often have far, reaching socio-economic impacts. Some of the extreme events include floods, droughts, heat waves, cold spells, strong winds, hurricanes, cyclones etc. It is estimated that over 70% of the impacts of natural disasters are associated with such extreme climate events. It has for example been estimated that tropical cyclones alone account for an annual average of about 20,000 deaths and about US $ 6 billion in damages globally (WMO, 1996). More recent examples of the potential hazards of the extreme climate events have been demonstrated by the impacts of the 1997/98 El-Niño related floods in some parts of Eastern Africa. These floods led to loss of life and property, destruction of infrastructure and large losses to the economy. In Kenya alone, 17 billion USA dollars is required to rehabilitate the roads destroyed by those floods. The floods were immediately followed by one of the longest and severest droughts in the history of the sub region associated with the 1998-2000 La Niña episode. The drought had very harsh negative impacts on agriculture, livestock, wildlife, Tourism, Water resources and hydroelectric power generation. It is estimated that over 80% of the livestock in the marginal areas perished due to the drought. The need to have good knowledge of the extreme climate events have been highlighted by the IPCC Working Group I. A number of studies have suggested that there are significant changes in the frequency and intensity of extreme events with only small changes in climate. The temporal and spatial characteristics of trends in the occurrence of extreme/heavy precipitation events have been studied recently (Iwashima and Yamamoto, 1993; Yu and Neil, 1993; Karl et al., 1995; Karl and Knight, 1998; Suppiah and Hennessy, 1998; Plummer et al., 1999; Groisman et al. 1999a,b). Several of the above listed studies reported a general increase of "heavy" precipitation during the past several decades and/or the entire century over significant parts of North America, Eurasia, and Australia. In most cases this increase has accompanied changes in the mean precipitation of the same sign but was disproportionately larger (Karl et al., 1995; Karl and Knight, 1998; Suppiah and Hennessy, 1998; Groisman et al., 1999a,b). Groisman et al. (1999a,b) argue that due to specifics of the form of precipitation distribution that are practically universal over the globe, except desert areas, a disproportionate change in heavy precipitation will always occur when there is a significant change in mean precipitation. In this respect, there is growing consensus that detection efforts for climate changes should focus not only on linear climate change signals like changes in the climate means (averages) but also on non linear climate change signals like changes in the frequency and variance of extreme (heavy) events which are often more important. In some other cases, extreme precipitation events have increased despite the fact that the total precipitation remained constant or decreased. Mason et al., (1999) found this striking feature over Natal where an increase in heavy precipitation events has occurred even in seasons where the seasonal precipitation and precipitation frequency depict negative trends.

Some of the potential impacts of climate change in Africa have been highlighted by IPCC (1998). The impacts may, however, not be well simulated due the limited amount of knowledge regarding the past space-time climate patterns in many parts of the continent (Vincent et al., 1979). Among the few documented climate variability/change studies in Africa include those of Hulme (1992), Sivakumar (1992), Mason and Joubert (1997), Mason and Jury (1997), Nicholson (1979, 1980, 1986, 1989), Ogallo et al. (1999), King'uyu et al. (1999), Taljaard (1986), Tyson (1986), Mason (1996), Mason et al. (1999), Eldredge et al. (1988), Bunting et al (1976), and Dennet et al. (1985). Most of these have used longer time scale data sets (monthly, seasonal or annual) to investigate the space-time variations of rainfall. Most results have pointed to the fact that there are geographical differences in the temporal characteristics of the climate variability/change signals. This is, however, not a unique characteristic of the African environment alone as similar characteristics have been observed elsewhere on the globe. In general, most of the studies that have utilized shorter time scale data have mainly been over South Africa. For example, using daily rainfall data, Mason (1996) found evidence of general significant increase in the intensity of extreme rainfall between 1931-60 and 1961-90 in the east coastal parts of South Africa. He also established that the frequency of rainy days had increased between 1931 and 1995 and that the intensity of 10 - year high rainfall events had increased by over 50% over the same region.

In general, therefore, scant knowledge exists regarding the space-time patterns of climate change signals based on shorter time scales of weather events over most of the African continent. One of the major problems contributing to this scarcity is the lack of relevant high quality data on the appropriate time scales. This problem needs to be addressed to help piece together global climate change patterns from regional/national scenarios. Many global climate models have suggested an increase in the probability of intense precipitation with increased greenhouse gas concentrations. In order to validate such model projections, an assessment of instrumental records at short time intervals (≤ 1 day) is required at a regional level. Tyson (1980b) stressed the significance of generating climate change signals at regional and national scales that can then be used to fill in the existing gaps in the understanding of global climate change. IPCC (1992) also reiterated the importance of evaluating the potential impacts of climate change on society and natural ecosystems at the regional scale rather than as global or continental averages.

The certainty of conclusions that can be drawn about climate from observations depends critically on the availability of accurate, complete and consistent series of observations. For many variables, which are essential for documenting, detecting and attributing climate change, Karl et al (1995a) has demonstrated that the data are still not good enough. There is therefore the need to establish the appropriate data sets necessary for studies related temporal changes in the extreme climate events.

Annex XII

DEFICIENCIES AND NEEDS OF OCEAN DATA IN THE WESTERN INDIAN OCEAN FOR CLIMATE ACTIVITIES

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The atmospheric and ocean circulations in the Indian Ocean are unique. Unlike the Pacific and Atlantic Oceans, there is an annual reversal of wind direction and ocean currents. This monsoon regime and its embedded disturbances exert a profound influence on the climate pattern in the region. Extreme weather events often cause havoc on infrastructure and agriculture crippling for years the economy of many countries in the southern and Eastern Africa including the Small Island States. Most of them are developing countries where the main concern is food and housing security. The recent flooding in Mozambique and Malawi, at the beginning of this year, which caused widespread damage to property, and loss of life is a vivid illustration. Such extreme events as well as drought are becoming more frequent with climate change.

Studies have shown that there is strong correlation between climate pattern in countries of the Southern and Eastern Africa and ocean parameters such as sea surface temperature in the Indian Ocean. Abnormal ocean processes occurring in remote regions have also been found to have some impacts by teleconnection on climate regime in the region. The linkage between EL-NINO and drought in Southern Africa is now well established. However, though ocean observations have increased substantially in the Pacific and Atlantic Oceans with, inter-alia, the deployment of moored and drifting buoys and an enhancement of the sub-surface ocean monitoring programme, yet the Indian Ocean remain poorly sampled. This imposes marked constraint on climate forecast, to the detriment of countries in the region, for short and long term weather and climate based socio-economic planning.

The lack of ocean data in the Western Indian Ocean has long been realised. In May 1997, the World Meteorological Organisation and the Intergovernmental Oceanographic Commission of UNESCO organised a meeting for the benefits of the Meteorological Services and Oceanographic Institutions in the region to discuss the issue and other shortcomings. A project document entitled the Western Indian Ocean Marine Application Project (WIOMAP) was subsequently prepared. This document is currently being circulated to all stakeholders for comments and suggestions before finalisation for submission to donors/funding agencies. WIOMAP, which will be a regional contribution to GOOS, will address the problem of lack of human resources, with recommendations on how to enhance the ocean observational network, improve the communication system for data collection and product distribution and encourage the establishment of Processing and Assimilation Regional Centres.

In order to develop a regional strategy for overcoming deficiencies that can lead to significant improvements in observing systems including in-situ ocean observations for climate, it is essential that capacity building of countries in the region be enhanced. It is recommended, within the framework of WIOMAP, that a 9-month Post Graduate Diploma

Course in Marine Meteorology and Oceanography be organised at a well-established Institution in the region. For rapid and efficient exchange of data and products, advantage will be taken of modern communication technology such as the Internet and World Wide Web. It is also proposed that Specialised Marine Centres be established to prepare regional ocean products for distribution to participating Meteorological and Oceanographic Institutions for national adaptation.

Ocean Observing System in the Western Indian Ocean

A network of 12 moored buoys have already been deployed in the EEZ of India in the Arabian sea and Bay of Bangal to, inter-alia, collect met-ocean parameters in Indian seas, improve the weather and ocean state prediction, monitor the marine environment and validate satellite data. Some moored buoys are being planned in the Eastern tropical Indian Ocean by the Japanese. WIOMAP will address the deficiencies of ocean observation in the Western Indian Ocean.

Coastal Marine Stations

The number of coastal marine stations in the region is few and not ideally distributed. In many cases, they are too far inland to be representative of the marine environment. Some countries have established Port Meteorological Offices to provide services to Voluntary Observing Ships (VOS). However, lack of funds and equipment has led to stagnation in their development. Consequently besides South Africa and, to a lesser extent Reunion (France), very few ships have so far been recruited. First class coastal marine stations should be established in the vicinity of Port premises with well-equipped Port Meteorological Offices, for meteorological and ocean related observations such as coastal sea-surface temperature and salinity.

Sea-level stations

A network of sea-level stations was established in the Mid-1980s to monitor sea-level variation and rise within the framework of the Tropical Ocean and Global Atmospheric Programme (TOGA). They now form part of the Global sea level station (GLOSS) network. However, most of them have become almost obsolete and unavailability of spare parts is making it difficult to maintain them. The network should be upgraded to ensure a long-term series of continuous sea-level data for monitoring of sea-level variation and identify trend in sea-level as a consequence of Global Warming.

More stations in addition to the GLOSS network to study local and regional ocean processes should also be envisaged.

Wave-rider buoys

Measurement of offshore waves is important to forecast storm-surge which cause coastal flooding. It also provides valuable data for coastal development and management. Some countries have already deployed wave-rider buoys near their coast. The network of wave-rider buoys should be improved.

Deep-sea weather moored buoys

The technology to deploy deep-sea weather buoys has improved considerably and mooring system to depth greater than 2000m can now easily be handled. These buoys can be equipped to measure basic meteorological and surface and sub-surface oceanographic parameters including currents, salinity, wave and sea-surface temperature. The observations can usually be transmitted to national and regional centres in real time using the Argos System or via Meteosat for operational purposes. A network of 12 buoys is already in place in the Arabian Sea and Bay of Bengal. An extension of this network down to the South would increase the Ocean data coverage over the whole Indian Ocean. It is considered that three buoys in strategic position east of Madagascar and four buoys in the Mozambique Channel in the Exclusive Economic zone of countries in the region would initially be sufficient to obtain a good coverage with possibility of extension later. Such a network would substantially increase the number of routine, systematic and reliable ocean observations for various operational and research activities including cyclone monitoring for timely warning to save life and property. Moreover, beside providing valuable in-situ observations to calibrate satellite data, and input in numerical weather and climate models, such a network would enable long-time series of data to be obtained at specific sites for climate change monitoring over the ocean.

Ships of Opportunity Programme (SOOP)

With regard to sub-surface monitoring of sea-surface temperature with the SOOP, the Indian Ocean is the least observed of the three oceans. Very few countries are operating XBT lines. Though active participation is not expected, PMO could play a catalytic role in providing some assistance to ship of opportunity calling at Ports.

Concluding remarks

Several ocean programmes, which will revolutionise ocean observations in the coming years, are currently in the planning stage. Among these are the ARGO and Topex-Poseidon/JASON programmes. The ARGO involves the deployment of 3000 floats by the year 2003 which will provide temperature and salinity profile down to a depth of 2000m every 10 days. The Topex -Posiedon/Jason satellite programme will monitor sea-level topography at regular intervals to study changes in ocean circulation, which will lead to more reliable climate forecast and seasonal outlook. It is imperative that the capacity of countries in the region be built to enhance their participation within their capabilities in those programmes by, for example, providing platforms for the deployment of floats within the ARGO programme and take advantage of the wealth of data which will be generated for application in their socio-economic development to increase agricultural production and mitigate loss of life and damage to property during flood and drought-events.

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Annex XIII

GCOS FRAMEWORK FOR DEVELOPING A REGIONAL ACTION PLAN FOR IMPROVING CLIMATE OBSERVATIONS

The objective of a Regional Action Plan is to set out a framework and implementation timetable for improving climate monitoring in a region, both within the immediate context of country commitments to the UNFCCC and with respect to specific national and regional systematic monitoring priorities.

A principal outcome following implementation of an Action Plan should be an accessible database of climate data from a comprehensive network of stations, supported by access to externally collected data and products relevant to the region. The regional data would be available for a range of applications at the national and regional levels, including climate applications, climate change assessment, modelling and impact studies, and the development of national and regional response strategies to climate change.

Why is a Regional Plan important?

Several compelling reasons exist for a group of countries to develop a Regional Action Plan in addition to developing individual national plans:

- The global nature of climate and climate change requires ongoing cooperation among all nations to freely exchange and share weather and climate data in order to understand, monitor, and predict climate phenomena. Weather and climate transcend national boundaries, and accordingly, provision of climate services by NMHSs, as well as daily national weather forecasts and warnings, cannot be achieved without regional and international data. Consequently, observations throughout, and even beyond, a region are of considerable interest to individual countries within the region, as are products based on such observations. The benefits of regional cooperation and integration of observation activities are significant. A Regional Action Plan could focus attention on actions to improve observing systems that can benefit the region as a whole.

- It is seldom necessary or cost-effective for every country in a region to acquire the same facilities or capabilities, e.g., for managing climate data or producing climate products. Some facilities can, and should be, shared in order to avoid duplication and redundant costs. Also, given potential budget restrictions and/or lack of trained personnel, it is often not possible for some countries to undertake a full suite of climate-related activities. What is important is that high quality regional observations and climate products be available to legitimate users throughout a region.

- Potential donor countries and organizations are also likely to have limited resources available for improving observing systems and may find it more efficient to address needs at the regional level. Thus, such donors may be more inclined to fund elements of a well-thought-out regional plan to improve observations than to fund individual countries in a region. In such cases, the needs and priorities of the region as a whole can be taken into consideration.

- A regional plan is one way in which commitments and obligations under regional and international agreements and conventions can be addressed.

Who should be involved in the development of a Regional Plan?

An Action Plan could be developed by a small number of people, but to be broadly acceptable, important stakeholders and/or users of climate data would have to be consulted, and the Plan would need to be approved by the principal stakeholders.

- One set of important stakeholders includes the National Meteorological and Hydrological Services of the region. From GCOS's perspective, it is critically important that gaps and deficiencies in the baseline GSN and GUAN stations operated by the NMHSs be addressed in a Regional Plan.

- While the NMHSs are unquestionably important (perhaps even the most important set of stakeholders to consider), it is essential to recognize that other types of climate observations are important that are not typically the concern of NMHSs. Thus, it may also be important to consider the priority needs of those responsible for relevant terrestrial and/or oceanographic networks.

- In addition to addressing the needs of those responsible for operating observing system networks, a Regional Action Plan should also consider the users of climate observations and of the products based on those observations. Those responsible for preparing for or managing extreme events such as floods and droughts may have relevant views about the climate observing priorities that an Action Plan should consider. Likewise, those who think about observational needs related to vulnerability or adaptation to climate change may have relevant inputs to the development of an Action Plan.

What elements could be addressed in a Regional Action Plan?

A principal goal of a Regional Action Plan is to address the highest priority needs that would benefit the region as a whole. A Regional Action Plan would not be effective if it tried to address *all* of the individual needs of the countries in a region and should not just reflect the sum of individual country needs. However, by focusing on priority needs and/or needs common to the countries of the region, all countries will be able to benefit (though not necessarily to the same extent). Identifying priorities is a prerequisite to developing a Plan. Since not every potential element of an Action Plan can be a priority (or be equally important) some selection process is required. GCOS makes no recommendations about what should be in an Action Plan, but regions may wish to consider the following broad categories in developing the Plan:

- ♦ *Strengthen the GCOS Surface and Upper Air networks*. This category could include upgrading and restoring existing equipment, purchasing and installing new equipment as necessary, providing training to staff in the operation of equipment, etc. The overall objective would be to ensure that these networks operate function as planned to provide long-term high-quality data.

- ♦ *Strengthen other GCOS networks.* Depending on the region, improvements in other observing system networks, may need to be considered. For example, in many regions hydrological networks need upgrading. In selected regions, upgrading permafrost or glacier monitoring networks may be a priority.

- ♦ *Improve telecommunication networks*. The means of timely collection of raw and processed climate data and products are a necessary prerequisite for a provision of climate services. Modern communications technology has made possible the rapid exchange of high quality data and graphical information. However, in many developing countries problems still exist in transmitting meteorological and climate data to telecommunications hubs and world data centers. Some telecommunications systems are outdated, fragile, and subject to frequent failure, resulting in unacceptable breaks in transfer of data and products.

- ♦ *Improve climate data management, analysis, and applications*. All aspects of climate data management, including collection, archival, and utilisation for national, regional, and global purposes need to be improved. Routine reporting of CLIMAT messages from designated GSN stations is a requirement. Regions might also want to consider training in the provision of climate information and services, climatology training, and expanding and enhancing the prudent use of climate predictions.

- *Improved recovery of historical data.* A substantial amount of historical climate data exists in most regions that has not been retrieved and made available for climate studies. Such data provide a valuable but unused resource and should not be lost. Recovery of this data could also help improve weather forecasting, disaster mitigation, vulnerability and adaptation studies, etc.

- *Establishment or further development of networks that could be valuable for vulnerability studies and/or for adaptation to climate change.* Many human and natural systems are affected by climate variability and will be affected by climate change, including agriculture, wetlands, forests, water resources, human health, the coastal zone. An Action Plan may wish to consider what steps to take to improve monitoring of how these systems are affected by climate change and variability.

- *Consideration of the long-term operation of the national and regional monitoring infrastructure.* Countries need to consider their own capabilities to fund important monitoring systems. In addition, they should explore all available options for funding, such as traditional and new partnerships, on a regional and national basis. For example, potential access to funds through the UNFCCC Clean Development Mechanism, as well as possible linkages to other elements of the global environmental agenda might be considered.

How could a Regional Action Plan be developed?

The first steps in the development of a Regional Action Plan can be taken at the GCOS Regional Workshop. GCOS anticipates that the Plan itself would be developed after the workshop through a consultative process with GCOS's partners in the region taking the lead role. A principal goal of GCOS Regional Workshops is to identify and assess deficiencies in the climate monitoring capabilities of the region, with a particular focus on the designated GCOS networks. The activities assessed could include:

- the adequacy of the designated network for regional climate purposes,
- the operational status of designated GCOS stations,
- other potential GCOS stations,
- the compliance of procedures and practices at the stations with WMO and other appropriate standards,
- facilities for recording and archiving observations,
- technical capability of staff at stations,
- access to the data, and routine transmission of monthly reports (eg, CLIMAT messages) to World Data Centres.

Also at the workshop, participants can discuss a strategy for a coordinated approach to developing the Action Plan. In most cases, GCOS's regional partners would take the lead in developing the Plan

Following the workshop, GCOS proposes that its regional partner establish a small working group to draft the plan. If the process of developing the Plan is a consultative one, many months will be required to draft and approve the Action Plan.

An Option: A Cooperative Regional Centre for Climate

A possible approach to developing a regional framework for national monitoring plans and to ensuring effective climate data management might involve a cooperative regional centre to coordinate climate data management and provide a focus for technical assistance in the operation and maintenance of national observing systems. *GCOS does not necessarily recommend this approach, but notes that it may be of interest in certain regions.*

A cooperative regional centre for climate, established primarily for regional climate data management, could provide oversight to regional climate activities and observations and provide a focus for scientific and technical expertise. To be most effective and to operate most efficiently, the cooperative regional centre for climate should be closely aligned with existing WMO regional facilities including Global Telecommunication System (GTS) infrastructure.

Such an arrangement would in no way diminish the authority and responsibility of NMHSs to maintain observing networks at the highest possible standards for their own national purposes. Countries with existing meteorological observing stations, data collection and data archival systems would continue to maintain them and provide a range of local services. However, if a regional climate centre is established, some smaller countries may find it more efficient to

forward their climate data to the regional centre rather than duplicate the data management and archival facility.

In order to carry out its data management functions it would be necessary for the regional climate centre to establish an archive for the storage of collected climate information. Electronic storage of the data in an on-line database that was accessible by each participating NMHS would be a valuable resource for the region. Routine analysis of the data and the distribution of climate anomaly tables and maps would contribute to regional climate monitoring and assist with assessment of the strength and spatial impact of monthly and longer period climate anomalies and climate trends.

A regional approach to better management and use of existing data would provide the basis for future improvement to the regional GCOS network. Once the infrastructure for regional collection, archival and analysis of GSN data has been established, then expansion of the regional reporting networks is straightforward. If further review identifies suitable sites that would improve the regional density, then these could be added to the GSN with relative ease. The regional centre could also provide support to those designated GSN stations that are currently not functioning adequately or at all.

Currently, there is limited communication on operational performance between the World Data Centres and the more than 150 countries contributing data. If a country fails to make a routine CLIMAT report, there is no direct follow-up to implement corrective action. A cooperative regional approach to overall management of network performance, including monitoring the exchange of CLIMAT and other routine climate data, could identify non-reporting stations, facilitate technical support to the responsible NMHS, and recommend on corrective action.

A regional climate centre could also facilitate information flow from the various global centres and provide a range of integrated products for regional use. Such products would have applications for climate monitoring and the provision of early warning of such phenomena as El Niño and La Niña. A wide range of monitoring products that, for reasons of cost, expertise and opportunity, are beyond the active participation of many developing countries could be effectively accessed through the regional centre. These might include oceanographic data and products such as those derived from the Argo program. The regional focus may in some cases enhance opportunities for regional participation in international programs. The regional centre could act both as a shared central resource for regional climate data management and as a conduit for distributing regional data to world centres and integrating global products for regional use.

A fundamental decision for each NMHS will be the extent to which it would maintain independent climate data management infrastructure and capability or utilise the facilities of the regional cooperative facility for its climate data management requirements.

The Ultimate Aim of the Action Plan: Securing Funding for Needed Improvements

Although national socio-economic development has been the primary goal of development assistance in meteorology, it is widely recognised that assistance for the upgrading of national meteorological infrastructure provides significant additional regional and global benefits.

National meteorological data have global applications and benefits, and it is likely that traditional developed country donors will continue to participate in specific bilateral development projects and in regional projects coordinated through regional partners because of the wider benefits that flow.

To a certain extent, the Global Environment Facility and other international organizations are also potential sources of funding. The decisions of COP4 and COP5 provide new guidance to GEF in providing support to developing countries, particularly on a regional basis. Decision 5/CP.5 invites Parties to bring forward proposals to address deficiencies in climate observing networks, especially as they relate to systematic observations, collection, exchange and utilisation of data on a continuing basis in pursuance of the Convention. However, it is yet to be established how the Decisions of COP4 and COP5 will be interpreted and acted upon by the GEF. Nevertheless, a regionally coordinated project fits well within the guidelines advised by the COP.

Given the probable limitations of GEF funding, it is most likely that full implementation of an Action Plan will require the financial support of both national and international donors. GCOS does not suggest that securing funding for needed improvements in observing systems will be easy. However, we are convinced that the regional approach can yield substantial, cost-effective results for addressing the high priority observing system needs of a region. We are prepared to assist regions to attain these mutual goals.

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Annex XIV

LIST OF ACRONYMS

ACMAD: African Centre for Meteorological Applications and Development

AMDAR: Aircraft Meteorological Data Relay

ASDAR: Aircraft to Satellite Data Relay

CCl: Commission for Climatology (of WMO)

CLICOM Computers for Climate

CLIMAT: Monthly surface climate summary report

CLIVAR: Climate Variability (study of WCRP)

COP: Conference of the Parties (to UNFCCC)

DARE: Data Rescue

DMCH: Drought Monitoring Centre, Harare

DMCN: Drought Monitoring Centre, Nairobi

ESA: Eastern and Southern Africa

EUMETSAT: European Organisation for the Exploitation of Meteorological Satellites

FAO: Food and Agriculture Organization

GAW: Global Atmosphere Watch

GCOS: Global Climate Observing System

GEF: Global Environment Facility

GEMS: Global Environmental Monitoring System

GEWEX: Global Energy and Water Cycle Experiment

GLOSS: Global Sea Level Observing System

GOOS: Global Ocean Observing System

GOS: Global Observing System

GSN: GCOS Surface Network

GTN-G: Global Terrestrial Network for Glaciers

GTN-H: Global Terrestrial Network for Hydrology

GTN-E: Global Terrestrial Network for Ecology

GTOS: Global Terrestrial Observing System

GTS: Global Telecommunication System

GUAN: GCOS Upper-Air Network

ICSU: International Council for Science

IGAD: Intergovernmental Authority in Development

IGOSS: Integrated Global Ocean Services System

IOC: Intergovernmental Oceanographic Commission (of UNESCO)

IPCC: Intergovernmental Panel on Climate Change

LVEMP: Lake Victoria Environment management Programme
NMHS: National Meteorological and Hydrological Service
PUMA: Preparation for the Use of METEOSAT Second Generation in Africa
RBSN: Regional Basic Synoptic Network
RSMC: Regional Specialised Meteorological Centre
SBSTA: Subsidiary Body for Scientific and Technological Advice (of UNFCCC/COP)
SOOP: Ships of Opportunity Programme
SST: Sea Surface Temperature
UN: United Nations
TOPEX: Ocean Surface Topography Experiment
UNCED: United Nations Conference on Environment and Development
UNDP: United Nations Development Programme
UNEP: United Nations Environment Programme
UNESCO: United Nations Educational Scientific and Cultural Organization
UNFCCC: United Nations Framework Convention on Climate Change
WB: World Bank
WCASP: World Climate Applications and Services Programme
WCDMP: World Climate Data and Monitoring Programme
WCIRP: World Climate Impacts and Response Strategies Programme
WCP: World Climate Programme
WCRP: World Climate Research Programme
WMO: World Meteorological Organization
WHYCOS: World Hydrological Cycle Observing System
WWW: World Weather Watch