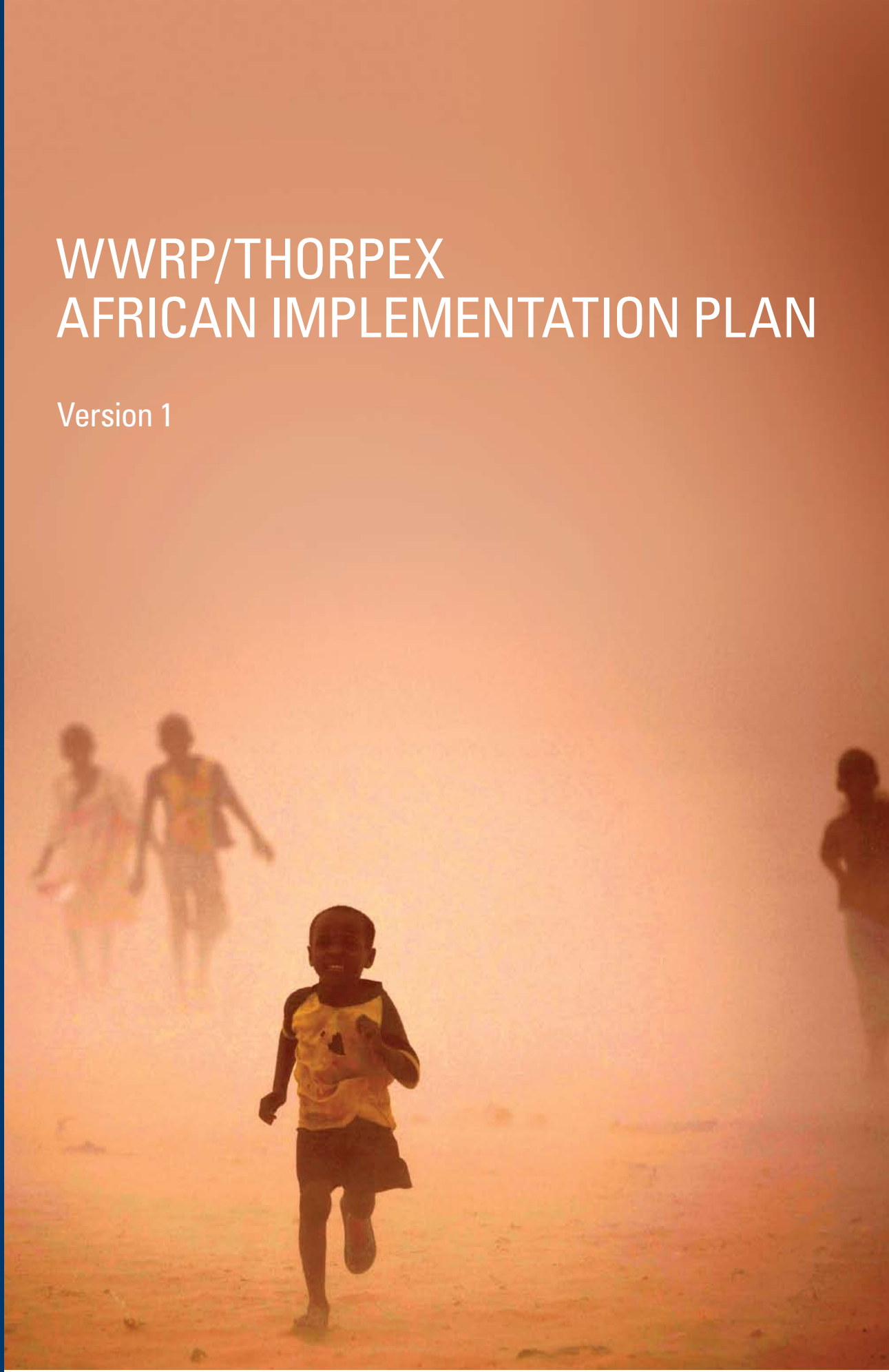
WWRP/THORPEX AFRICAN IMPLEMENTATION PLAN

Version 1



World Meteorological Organization
Weather • Climate • Water

WMO/TD - No. 1461
WWRP/THORPEX - No. 11

WWRP WORLD WEATHER RESEARCH PROGRAMME

THORPEX A World Weather Research Programme

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WORLD METEOROLOGICAL ORGANIZATION

WWRP/THORPEX

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EXECUTIVE SUMMARY

Introduction

WWRP/THORPEX Africa is the African regional contribution to the international THORPEX programme. The implementation of the WWRP/THORPEX programme for Africa is expected to start in 2009 following a 3 year planning period (2006-2008). WWRP/THORPEX Africa will contribute to better development and operation of African observing, data exchange, forecasting and application systems.

Overall goal of WWRP/THORPEX Africa

WWRP/THORPEX Africa aims at providing the research to reduce the adverse effects of meteorological and climate related natural disasters in Africa and to promote multidisciplinary collaboration between research, operations and user communities to deliver the benefits of improved earth observations, advanced communications and improved forecast systems. Priority sectors of application include disaster and water management, agriculture including food security, health (e.g. meningitis) and transportation (e.g. aviation).

Major actions

To show evidence of the impacts of advances in forecasting and observing systems on vital socio-economic sectors in Africa, Forecast Demonstration Projects (FDPs) will be conducted in the framework of WWRP/THORPEX Africa. At the initial phase, the FDPs will be built on existing projects to improve them or provide added-value (e.g. USAID's-Famine Early Warning System – FEWS for food security in Africa, the International Federation of Red Cross and Red Crescent Societies' disaster preparedness and response activities, integrated water management for major African river basins (Nile, Congo, Niger), Meningitis Environmental Risk Information Technology – MERIT, the Sand and Dust Storm-Warning, Advisory and Assessment System -SDS-WAS).

To facilitate integrated and multidisciplinary studies, WWRP/THORPEX Africa will develop an African high impact weather (HIW hereafter) information system providing a common platform to collect, store, and exchange data, methods and tools. The information system will gather not only climate/meteorological data for particular events but also document the impact of these events on society, the economy and the environment.

Societal and Economic Research and Applications (SERA) activities are planned to develop user-oriented forecast verification and assess the cost of damage due to HIW events and the benefit of improved HIW forecasts. Socio-economic research networks (e.g. the African Economic Research Consortium -AERC- http://www.aercafrica.org/home/index.asp) will be contributing to developing appropriate verification measures for each priority sector and cost/benefit assessments. WWRP/THORPEX Africa will collaborate also with the WWRP SERA working group for these activities. Through this collaboration between the meteorological and socio-economic communities, WWRP/THORPEX Africa will contribute to improving the visibility and the profile of African NMHSs.

The generally declining observation network in Africa and the rather poor transmission of data to weather and climate centres poses a challenge in weather and climate monitoring, forecasting and early warning systems in the continent. As improvements of forecasts rely partly on improvements of observation network and real time date transmission, WWRP/THORPEX Africa will:

- Contribute to the design of an optimum conventional observing network in Africa by promoting radiosonde data impact studies and monitoring, following-up the studies being undertaken in West Africa in the framework of the African Monsoon Multidisciplinary Analyses (AMMA) programme
- Promote the use of non conventional observing technologies such as AMDAR or other new sensors, particularly in remote areas by liaising with the WMO AMDAR panel to expand AMDAR profiles of temperature and humidity in Africa. Impacts of data from AMDAR and other new sensors on high impact weather monitoring, forecasting and application will be investigated

- Liaise with the WMO Information System (WIS) management. As WIS is designed to meet the information exchange requirements of all WMO programmes including THORPEX, it is worthwhile to make WWRP/THORPEX Africa data and products WIS compliant.

The data impact studies have been included in THORPEX/Data Assimilation and Observing Systems Working Group plans and will be followed by recommendations to WMO/CBS on the optimal low cost observing and telecommunication network to improve forecasts of HIW and so help reduce weather impacts in African countries.

Some basic research activities will be conducted in the framework of WWRP/THORPEX Africa to explore the predictive skill of HIW events in each African sub-region. These activities include actions to improve our understanding of HIW events in Africa, assess their predictability and improve prediction capabilities. A catalogue of typical high-impact weather events in Africa describing weather phenomena and statistics, conceptual models and limits of predictability will be produced from diagnostic and modelling studies. This activity will be conducted in liaison with the forecasters' handbook project in the framework of AMMA and will help to feed the information systems mentioned earlier.

It is recognized now that forecasts at sub-seasonal timescales are of high importance for each key priority sector in Africa such as agriculture, disaster and water management and health. WWRP/THORPEX Africa will undertake activities to improve our knowledge and understanding of the nature and causes of intra-seasonal variability and to improve ensemble predictions in Africa, to provide seamless forecasts from daily to seasonal timescales.

The THORPEX/Predictability and Dynamical Processes Working group will support studies on model diagnostics, predictability, ensemble forecasting and dynamical processes in Africa.

Resources

WWRP/THORPEX Africa will require research, development and transition to operations activities. To the maximum extent possible WWRP/THORPEX Africa will build and leverage on existing infrastructure by coordinating and augmenting on-going activities at African NMHSs and participating global and regional Centres. The AMMA Programme, the Africa programme at NOAA/NWS/NCEP and UCAR, the South African Ministry of Science and technology's High performance computing programme, and relevant WMO programmes (e.g. THORPEX/GIFS, WIS, AMDAR, GDPFS/SWFDPs) are examples of initiatives that WWRP/THORPEX Africa activities will contribute to and build upon. WWRP/THORPEX Africa will collaborate with existing programmes such as International Council of Science African Office (ICSU-ROA) programmes, GCOS/CLIMDEV, African Monitoring of Environment for Sustainable Development (AMESD), WCP/CLIPS, Kopernikus-GMES (Global Monitoring for Environment and Security) for complementary actions. WWRP/THORPEX Africa will use the concept of a Global Interactive end-to-end forecasting system and then will explore the potential of existing observing systems and new tools in forecasting to provide appropriate decision support tools and assessments for social, economic and environmental decisions. In that sense, WWRP/THORPEX Africa is unique in bringing a multidisciplinary approach between weather/climate scientists and socio-economic experts on one hand and between research, operational and user communities.

The network of expertise at NMHSs, regional Centres, universities and research institutes, UNESCO/ICTP and AERC will provide the manpower at the initial stage. WWRP/THORPEX Africa also recognizes the necessity for international cooperation with the international scientific community given the limited available capability in Africa in terms of modelling and data assimilation.

Voluntary support and/or endorsement of WWRP/THORPEX Africa activities are expected from NMHSs and international partners. Specific proposals and requests for support will be prepared as opportunities identified from development funding agencies, interested foundations and European Commission research and development directorates.

Deliverables
The major expected deliverables are:

- An information system for African HIW including related losses, damage and other socio-economic or environmental impact data
- A catalogue describing typical HIW in Africa
- Optimal and realistic observing and communication strategies for Africa
- Reports on the use and impacts of probabilistic forecast information for decision making in identified priority sectors
- Guidelines and success stories on Forecasts Demonstration Projects and communication of forecast uncertainties
- Reports on new knowledge and understanding of African HIW and related processes or phenomena.

These deliverables are expected to provide better tools for decision and policy making such as better early warnings including estimates of expected impacts, advisories for food security, agriculture, energy production, water and disaster management. Overall, WWRP/THORPEX Africa is expected to help reduce deaths, infrastructure and property damage, poverty, and environmental degradation, due to high-impact weather.

Monitoring
The success of WWRP/THORPEX Africa will be measured by the observed improvement in indicators of advances in high impact weather knowledge, agriculture productivity, food security, water and disaster management and energy supply due to meteorological information in the continent. Collaboration with relevant programmes or projects mentioned above will be initiated or strengthened to ensure complementarity and subsidiarity.

ACKNOWLEDGEMENTS

WMO is acknowledged for supporting the WWRP/THORPEX Africa planning meetings and contributing to the review of the document. We wish to gratefully acknowledge the support of the Meteorological Services of Burkina Faso and Senegal, the South African Weather Service and the University of Karlsruhe (Germany) by hosting the WWRP/THORPEX Africa planning meetings. Other institutions, programmes and individual experts worldwide provided comments and inputs during the planning meetings that helped in the preparation of the present Implementation Plan. Dr Raj PANDYA (UCAR African Initiative), Dr Yong Seong KANG (GEO Secretariat), Dr Achuo EOW (ICSU-ROA), Prof. Chris THORNCROFT (University at Albany, AMMA-THORPEX working group) contributed to the revision of the Plan. We thank all experts for their significant contributions and helpful advice.

1. INTRODUCTION

THORPEX is a ten year international research and development programme under the WMO World Weather Research Programme (WWRP) to accelerate improvements in accuracy of 1 day to 2 weeks high-impact weather forecasts and realize related benefits for society, the economy and the environment.

A WWRP/THORPEX African science plan with a regional focus was developed in 2006 and 2007 by scientists interested in African meteorology. Two planning meetings held in Ouagadougou (Burkina Faso) and Karlsruhe (Germany) in February and November 2007 respectively discussed and revised the science plan which is available via the WMO THORPEX web page at http://www.wmo.int/pages/prog/arep/wwrp/new/african_regional.html.

The science plan contains four components: Observing Systems/Data Assimilation and Observing Strategy, Predictability and Dynamical Processes, Societal and Economic Research and Applications, Cross-cutting activities. Each component of the science plan provides a set of scientific questions and briefly describes related tasks.

The WWRP/THORPEX African Implementation Plan is developed following a foundation provided by the science plan. This implementation document defines the outcomes, approaches, resources (human and infrastructure), partnerships and time required for completion of each activity. It describes with more details the priorities identified by WWRP/THORPEX Africa community, establishes roles and responsibilities of partners, integrates activities with those of other relevant programmes, and proposes needed commitments and a road map.

The WMO/AREP/WWRP/THORPEX has supported meetings that brought the scientific community and partners together to exchange ideas and build plans at international and regional levels. Meteorological services, user organizations, research institutes and University laboratories are gradually working together to meet WWRP/THORPEX objectives.

This document is designed to capitalize and improve upon existing and planned research and development programmes that contribute to WWRP/THORPEX objectives for Africa.

2. OVERVIEW OF WWRP/THORPEX AFRICA AND CORE OBJECTIVES

The main goal of WWRP/THORPEX Africa is to provide better forecasts and realize benefits for society, the economy and the environment. The outcomes of WWRP/THORPEX Africa will include skilful forecasting techniques or procedures, high resolution deterministic and probabilistic forecasts with uncertainty information, estimates of cost and benefits of African high impact weather, forecast skill assessments, estimates of societal and economic loss reduction due to improved high impact weather forecasts, exploitation of advances in observation and communication technology. More importantly, to build a sustainable WWRP/THORPEX for Africa, enhancement of African capacity in observations, communications, assimilation, forecasting and development of societal/economic assessments and decision systems is critical.

THORPEX Africa core objectives are to:

1) Increase knowledge and understanding of the nature and variability of high-impact weather systems over Africa and explore the limits of predictability.
2) Identify the needs for an optimal design of observing and communication systems over Africa.
3) Encourage and facilitate exchange of ideas through workshops and newsletters for THORPEX-related forecasting and research activities in Africa.
4) Develop and promote socio-economic applications and the use of weather forecast and climate information amongst social, policy and decision-making communities.

The THORPEX programme provides the basis on which WWRP/THORPEX Africa will contribute to reducing the vulnerability of socio-economic systems to the potential increase of high impact weather events within a changing climate.

The THORPEX Africa Implementation Plan has been developed by the WWRP/THORPEX African Regional Committee with guidance and oversight from the international WWRP/THORPEX community.

3. SOCIETAL AND ECONOMIC RESEARCH AND APPLICATION TASKS

Summary of projects and major goals

Projects	**Goals/Actions**		
	Duration in years		
	2	**4**	**8**
SERA1: High impact weather information system	Discuss the architecture and content of the information system	Collect data, develop and test the Information system	Maintain and update the information system and consider its transfer to an African Centre
SERA2: Forecast verification and cost/benefit assessments. .	Prepare forecast verification systems. Prepare metrics for cost/benefit assessments.	Tailor metrics to each priority sector	Prepare and publish reports on: - quality/value of high impact weather forecasts from the user perspective - Cost of high impact weather - Benefits of forecast improvements for policy and decision making.
	Applications tools and demonstration of weather information system		

The second WWRP/THORPEX African planning meeting led to the identification of a set of priority sectors for applications. These sectors are:

- Disaster and water management
- Agriculture including food security
- Health
- Energy production and distribution
- Transportation (Aviation)

3.1 SERA 1: High impact weather information system for Africa

Research activities in Africa are usually difficult because of limited data, tools, computing and storage capacity in African centres. When global databases are available at international centres, scientists based in Africa do not always have the facilities for easy access and extraction of needed data. To facilitate integrated and multidisciplinary studies, WWRP/THORPEX promotes development of weather, economic and societal impact databases with analysis/processing tools. Then, it is important to set up a high-impact weather information system compiling key high-impact weather events in each sub-region in Africa. This database will gather not only observations and model output but also event documentation, particularly impacts on society, the economy and the environment. The information system will provide a common platform to collect, store and exchange data, and to promote methods and tools for integrated and multidisciplinary activities.

3.1.1 Approach

During the coming two years, networking of institutions and organizations having relevant data and expertise for design of the information system architecture will be the main activity. A

data server for weather and impacts, an application server with processing/ visualization software including GIS, a web server as interface with the user are the main components of the information system. This information system will be first based at UNESCO/ICTP and will be transferred to Africa before the end of the THORPEX programme.

With the latest available communication and information technology including possibly artificial intelligence, high impact weather information will be collected, processed, archived, exchanged and regularly updated. Ranking and classification will help to synthesize data facilitating identification of valuable information for a country, a sub-region and the continent.

Having a user-friendly system available for use by the scientific, forecasting and user communities is the ultimate output at the end of the programme.

Documents will come from relief organizations, national and regional meteorological centres, emergency management agencies, sensitive businesses, Red Cross and Red Crescent societies, UNISDR, etc. Scientists and experts from these organizations will provide references or materials during the information collection phase via workshops and e-meetings.

Some of the model data will be provided by the TIGGE sub-programme. Creating subsets of TIGGE data related to high-impact weather events will facilitate research in Africa. The processing, archiving, updating, training and exchange will be accomplished progressively during the lifetime of the programme.

MEDEX and Southern Hemisphere (SH) THORPEX have started to document high impact weather over Northern and Southern Africa. NMHSs have additional weather data for national high impact events. Relief and emergency management organizations have information on the impacts of weather on society, the economy and the environment. This activity is designed to facilitate collection, processing and exchange of weather and impact data. This resource will integrate existing information and make it accessible to research, operations and users for decision and policy making. In the framework of WWRP/THORPEX Africa, these data will be the foundation for an all-Africa information system. Northern and Southern Africa will contribute with MEDEX and SH THORPEX respectively. In the framework of WWRP/THORPEX Africa in collaboration with AMMA and other relevant programmes (e.g. UCAR/Africa Initiative, ICSU-ROA, GCOS/ClimDev, RIPIECSA, CLIVAR/VACS, AMESD) development of data and information for West, Central and Eastern Africa will be made to complement the effort underway over Northern and Southern Africa. Workshops (the first expected in 2009 at UNESCO/ICTP-Italy) will help to organize existing high impact weather information, discuss and document current understanding and prediction of high impact weather for each sub-region, review weather events with high economic (e.g. GDP), societal (e.g. displaced people) or environmental (e.g. pollution level) value. In addition to meteorological observations and forecasts associated with high impact weather, the following data will be collected, processed, exchanged and archived:

- Loss of life and transportation infrastructure
- Damage to commercial and residential buildings
- Damage to critical infrastructure and resources (energy and water supply, health and emergency facilities, ecosystems)
- Repair and reconstruction costs
- Shelter, food and medical aid costs
- Forecasting/application methodologies, procedures, success stories, training and communication materials on high impact weather.

This activity will particularly identify weather events and related forecasts that have major impacts over different African sub-regions. A list of past African high impact weather events ranked according to their documented impacts will be prepared and published. Forecasting systems verification information specific to these events will be collected and disseminated. The ultimate goal of this activity is to provide a three level information system for: all Africa, each sub-region and each country respectively by the end of WWRP/THORPEX lifetime.

3.1.2 Expected outcomes

- Data base (with meteorological and impact data) on all African high impact weather events of the past two decades. (Link with Predictability and Dynamical Processes –PDP-sub-programme and WWRP SERA activities)
- Statistical Information on the recent past evolution of African high impact weather (Link with PDP)
- High impact weather risks maps for each priority sector
- Documented success stories on preparedness and responses in case of high impact weather in Africa
- Better decision systems, manuals, expert systems and tools to support forecasts and use of high impact weather information exchanged.

Estimated reduction in the impact of disasters and increased economic and environmental efficiency related to improved high impact weather forecasts.

3.1.3 Timescale

This activity has already started in Southern and Northern Africa and will be expanded over other sub-regions. The coming two years will be devoted to architecture development in close partnership with UNESCO/ICTP and other partners. The preparation of the information system architecture and collection of initial materials will be completed within approximately four years.

Content development, maintenance and update, training and transfer of the information system in Africa are activities for the remaining years of WWRP/THORPEX.

3.1.4 Level of international cooperation

A high level of international cooperation will be needed with:

- The WMO Disaster Prevention and Mitigation Programme (DPM), WMO Information System (WIS), GEONETCAST, the International Federation of Red Cross and Red Crescent societies, other international disaster relief and recovery organizations
- Excellence centres in computing with experience and networks in Africa (i.e. UNESCO/ICTP).

3.1.5 Key players

International Federation of Red Cross and Crescent Societies and other emergency management organizations for impact data:

- TIGGE, global forecasting centres (NCEP, ECMWF, UK Met Office, Météo-France, IRI, etc) and NMHSs for weather data
- UNESCO/ICTP and its network of African associates and affiliated institutes to facilitate architecture and content development, maintenance, updates, training and transfer to a centre based in Africa.

3.1.6 Infrastructure required

Websites and servers, data storage capacity, data base management systems, high speed Internet facilities, etc.

3.1.7 Links with other programmes

- UNISDR, WMO/DPM, WIS, GEONETCAST for data collection and dissemination
- GEO and UNESCO/ICTP Earth System Science and computing programmes for training, transfer, architecture design, information system development, update and maintenance
- The MERIT project under the UCAR Africa initiative will contribute to the development of the information system with focus on health throughout the project period.

3.1.8 Initial actions

Actions	Focal points	Target period
Workshop in 2009 on "high-impact weather predictability and information system for Africa" to discuss the architecture and procedures for data collection, archiving and processing.	UNESCO/ICTP Weather and Climate group will host the workshop in Trieste (Italy) that will be organized with the co-chairs (Aïda Diongue-Niang, André Kamga) and an ICTP scientist (Adrian Tompkins).	2009
The system architecture development with a Web server as interface, an application server with processing tools and a data server with weather and impact data.	UNESCO/ICTP computing science group with the support of Andre Kamga (co-chair) will be responsible for this action.	December 2011

3.2 SERA 2: User forecast verifications, cost and benefits assessments

Most of the currently used verification systems are developed to answer modellers' verification questions. National forecasters need verification on specific high impact weather events of interest to the countries (e.g. the performance of a given forecasting system for the onset of rainfall). They need tools that can help towards better interpretation of models outputs, assessment and communication of confidence information on the timing, location and severity of events. Users are more interested in the value of the forecast via its ability to improve their decisions and policies. This research will develop appropriate verification measures for each priority sector. As an example, an emergency manager needs the forecasts of timing and location of heavy rainfall that may lead to flooding, the duration of heavy rains, droughts, very high or low temperatures, strong winds. Verification for these needs will be developed and tested. Observing and predictability activities are expected to benefit from the measures developed here to assess observing and forecasting systems improvements. Interactions with pilot users for each priority sector will facilitate understanding of decisions, policy systems and verification requirements. THORPEX forecast demonstrations are possible platforms for these interactions in real time.

- *Cost/benefit analysis of high impact weather forecasts*

A better identification and classification of high impact weather relies on precise estimation of its cost when it occurs for a given application sector. Benefits of forecasting high impact weather is another piece of information needed to sustain investments for WWRP/THORPEX activities. Cost/benefit analysis for high impact weather of each specific sector is expected. This research will be carried out in close partnership with the social and economic scientists as well as development experts.

3.2.1 Approach

This endeavour will document the value of high impact weather forecasts for sustainable societal and economic development in Africa. Training tools for business decisions and policy makers, metrics for quality, value, cost and benefit assessment will be developed. Weather information benefits will be progressively demonstrated on weather sensitive activities and improved definition of high impact events made possible. Given the estimated cost and benefits of an event and associated forecast, informed decisions can then be made about investments for better forecasting systems and tailored verification methods or procedures. It is expected that results from a given sector can be used for others. A mechanism to ensure that findings are shared between sectors benefiting all partners will be put in place. Substantial involvement of the social and economic science community will be crucial for this research.

3.2.2 Expected outcomes

- In collaboration with weather sensitive businesses, tailored verification schemes for each priority application sector will be developed and tested
- Socio-economic value assessment systems will complement existing forecast verification systems in African meteorological organizations

- Trained decision and policy makers with documented cost/benefit assessments of forecasts will help to optimise investment decisions and plans to set up better forecasting and application systems for the African society and economy.

3.2.3 Timescale

After a review of available verification methods during the first two years, a selection, development, testing and tailoring phase will follow for the remaining period.

Cost/benefit assessments involving preparation of metrics, identification of pilot user groups, tailoring and application of metrics will be carried out throughout the period.

Verification schemes will be developed and tested with users.

Socio-economic experts' support will be highly sought throughout the project to better estimate the cost/benefit of high impact weather and related forecast for each sector.

3.2.4 Level of international cooperation

High level participation of WMO verification working groups will facilitate the review of current metrics and developments.

3.2.5 Key partners

- Aid or relief organizations, development banks, government and private organizations involved in the identified priority sectors, physical, societal and economic scientists, insurance businesses
- The SERA WG which has the responsibility for the entire societal and economic research issues associated with the whole of the WWRP
- Global and regional meteorological centres, NMHSs
- WMO verification working groups, WMO Public weather services programme
- AMMA-THORPEX Working group.

3.2.6 Infrastructure

- Facilities to access developed user-oriented diagnostics and to exchange with decision and policy system makers
- Data and information on weather and impacts to test assessment tools.

3.2.7 Links with other programmes

- IRI
- International Strategy for Disaster Reduction
- WMO Disaster Prevention and Mitigation Programme
- Related national and regional initiatives to be determined.

3.2.8 Initial actions

Actions	Focal points	Target period
Identification of the sector specific needs for potential verification schemes and cost/benefit assessment tools through surveys, meetings, climate outlook forums, etc…	André Kamga, Franklin Opijah, Eugene Poolman	December 2009

4. OBSERVING SYSTEMS/DATA ASSIMILATION AND OBSERVING STRATEGIES

Summary of projects and major goals

<table>
<tr><th rowspan="3">Projects</th><th colspan="3">Goals/Actions</th></tr>
<tr><th colspan="3">Time Scale (Years)</th></tr>
<tr><th>2</th><th>4</th><th>8</th></tr>
<tr><td>OS1: Design an optimum network</td><td>- Assess the current state of observing system
- Define areas critical for forecast skill
- Determine targeting observing strategies using OSEs and OSSEs</td><td>- Promote data impact studies in Africa for an optimal design of observing network
- Test and evaluate network design</td><td>- Determine strategies to maintain and sustain observing network</td></tr>
<tr><td rowspan="2">OS2: Enhance the use of non conventional observing technologies</td><td>- Evaluate potential use of new technologies</td><td>- Develop and maintain skill for meeting up with technological developments</td><td rowspan="2">- Encourage and enhance R&D facilities and capacity at regional and subregional level</td></tr>
<tr><td colspan="2">- Conduct Demonstration projects to assess the impact of non conventional observing technologies on predictability of High Impact Weather</td></tr>
<tr><td rowspan="2">OS3: Improvement of telecommunication facilities in Africa (WIS-Africa) towards improved forecasts of high-impact weather events</td><td>- Help assess current state of telecommunication network, data exchange capacities</td><td>- Help design optimal telecommunication network for weather forecasting</td><td rowspan="2">- Determine, in collaboration with WMO/CBS, strategies to maintain and sustain a stable telecom. network and data processing and management capacities</td></tr>
<tr><td colspan="2">- Conduct pilot projects to test or build core components of WIS-Africa that meet THORPEX requirements</td></tr>
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4.1 OS1: Design of an optimum observing network

The Observing System in Africa has been deteriorating over many years. However, in West Africa, the recent AMMA field campaign increased the number of stations, particularly the upper air stations. The generally declining observation network in Africa poses a challenge for weather and climate monitoring, prediction and early warning systems in the continent. These realities create key gaps in our understanding of and ability to predict high impact weather events. The ECMWF has been playing a key role in carrying out radiosonde performance monitoring over West Africa in the framework of the AMMA project. WWRP/THORPEX Africa will promote this activity and support its extension to other African projects over the next decade.

These needed improvements in observing systems performance monitoring fundamentally underpin effective meteorological services in support of agriculture, water resources, health, natural disaster reduction and other sectorial strategies for the reduction of poverty, hunger, disease and environmental degradation. The impacts of field campaign data on the forecasts (e.g. AMMA-SOP data) will be promoted to provide essential information on the network needed to improve predictions of high impact weather in Africa. In the framework of AMMA, radiosonde data denial experiments to assess their impact on analyses and forecasts are underway at ECMWF, Metéo-France and NCEP GFS and other OSEs are also being carried out (e.g. University of Albany, Naval Research Laboratory). The ultimate aim is to make recommendations about what the future observing system should be in the continent that will lead to better high impact weather predictions.

4.1.1 Approach

Discussions with global centres (e.g. ECMWF, NCEP) will be undertaken to extend observing system performance monitoring activities initiated with AMMA to more sub-regions of Africa.

Given the relatively low budgets of African NMHSs, it is a major priority across the continent to rationalize and justify the costs of observations. Assessments of field campaign data impacts on weather prediction in the framework of AMMA, RIPIECSA and other Observing System Experiments (OSEs) projects with NWP centres and research institutes around the world (e.g., ECMWF, Météo-France, etc) will be supported. It is recommended that data impact studies currently underway over the AMMA region be conducted for other sub-regions of Africa. Also, opportunities available with the GEO framework will be explored to improve the observing system.

The observing system monitoring will provide documentation on what data is available, what is indeed transmitted on the GTS and the quality of the collected information. There will also be an assessment of priority observing stations (surface, upper-air and marine monitoring stations). These priority stations will be determined according to 1) the spatial situation of the station, 2) its current state, 3) its associated expected costs and benefits, and 4) the presence or not of ongoing or future OSEs or demonstration projects.

4.1.2 Expected outcomes

- Reduced forecast errors due to shortcomings in observing systems and networks
- Recommendations to WMO/CBS for the design of an optimal (in space and time) African observing network
- Observing systems over Africa regularly monitored.

4.1.3 Timescale/dependencies

The first part of this activity, i.e. the assessment of the current observational network will probably take up to 2 years capitalizing on the results of AMMA at ECMWF on radiosonde stations monitoring. Ongoing data impact studies for AMMA will be extended for other sub-regions. Then, throughout the THORPEX programme, an optimal observing system will be developed via OSEs and OSSEs.

4.1.4 Level of cooperation, links to other programmes and key players

The deficiencies of the African observation system do not only affect African Meteorological Services but the entire globe as well. Therefore, these activities will require international cooperation. Strategies and policies will have to be defined at national, regional and international levels. For instance, weather systems (eg. Easterly waves) from West Africa that move over the Atlantic are important for Africa and America. Cooperation between these two regions will define and organize efficient, optimal and coordinated monitoring and sharing of resources. The THORPEX International Working Group on Data Assimilation and Observing Systems has included in its plans at the last meeting of the working group (September 2008, Geneva) data denial studies in Africa to assess the impact of African upper-air data on high-impact weather forecasts in Africa and also in tropical areas and mid-latitudes.

- NWP centres and academic institutions, with data assimilation capabilities will be collaborating on carrying out OSEs and OSSEs
- African National Meteorological and Hydrological Services (NMHSs) and regional or sub-regional organizations such as ACMAD, ASECNA, ICPAC and DMCH which control and support the deployment of the African observing system.

4.1.5 Infrastructure requirements

- Access to NWP forecast systems including observational databases, data assimilation and forecast models will be essential, as well as computer time for OSEs and OSSEs
- High Performance Computing facilities.

4.1.6 Initial actions

Actions	Focal points	Target period
Check the existing reports on Observing systems in Africa	Ernest Afiesimama	February 2009
Inventory of observing network of stations	Arona Diedhiou	February 2009
Report on the progress of AMMA field campaign data impact studies at ECMWF	André Kamga	Throughout year 2009

4.2 OS 2: Enhance the use of non conventional observing technologies

Africa is one of the regions where despite the tremendous advances in observing systems (particularly air and space based systems), it has been difficult to achieve a better coverage in observations. More corrections, calibration/validation sites and experiments are needed to facilitate the use of available data from advanced platforms over Africa.

This activity is aimed at exploring the potential for these new observing technologies to provide additional observations that improve the skill of high-impact weather forecasts. The activity will explore better use of new observing technologies (MSG, SSMI, TRMM, AMDAR, GPS, new radiosonde sensors, dropsondes etc) for nowcasting and NWP in Africa.

4.2.1 Approach

To improve the spatial and temporal observational coverage, technologies providing non conventional observations will have to be explored, in particular for remote areas. AMDAR, MSG, GPS-Observation, and associated data are examples of possible resources to fill in the gaps in observations. The deployment of such technologies will be assessed in the next few years (e.g. AMDAR). The AMMA field campaign has been an opportunity to test a set of new observing platforms particularly during the Special Observing Period of the summer 2006. Following the field experiment, a moisture bias correction scheme has been developed for radiosonde humidity and tested in data assimilation at ECMWF with encouraging results. Development of such correction schemes targeting high impact weather events over all Africa, with additional new observing platforms will be promoted.

Training of African experts to operate and maintain existing observing platforms will be promoted. New technologies and algorithms for correction, calibration and validation for AMDAR, GPS-Observations or new satellite sensors will be evaluated for Africa. The THORPEX Data Assimilation and Observing Systems Working Group has included in its plans the assessment of AMDAR data on predictability over Africa (Meeting of the Working Groups, September 2008, Geneva).

Demonstration projects to explore the impact of available observing technologies will be proposed to NWP centres with data assimilation capacities. AMDAR data impact in Africa will be the first of these demonstration projects. The partnership for deployment of AMDAR sensors will be built between sensor manufacturers, carriers (e.g. air transportation companies for AMDAR) and users from the meteorological community.

4.2.2 Expected outcomes

- Increased use of new sensors and observing platforms
- Multisource data to analyze and forecast high-impact weather events
- More NMHSs with capacity to operate and maintain new sensors and observing systems.

4.2.3 Timescale/dependencies

This activity will be conducted throughout the period of the THORPEX programme.

The AMDAR data impact demonstration project should be conducted in the next three years.

4.2.4 Level of cooperation, link to other programmes and key players

There will be coordination with programmes such as EUMETNET, Southern Hemisphere THORPEX programme, MEDEX, WMO's World Weather Watch (WWW) Programme, and strategies developed by WMO's Commission for Basic Systems (CBS), would be considered. Also, providers of satellite systems and airline managers could help while NMHSs provide an enabling environment.

4.2.5 Infrastructure requirements

- NMHSs satellite receivers and platforms
- Pilot briefing offices
- Aircraft and land based AMDAR capability
- Voluntary aircraft.

4.2.6 Initial actions

Actions	Focal points	Target periods
Check for available aircraft with AMDAR activities in Africa	André Kamga	February 2009
Report on the status of AMDAR project in ASECNA countries	Aïda Diongue-Niang	February 2009
Investigate the requirements for the installation of AMDAR software and equipment	Ernest Afiesimama	February 2009

4.3 OS 3: Improvement of telecommunication facilities in Africa (WIS-Africa) towards improved forecasts of high-impact weather events

Many African Meteorological Services have difficulties overcoming the weaknesses of public telecommunication infrastructure. The obsolescence of telecommunication facilities currently used by the NMHSs, and the difficulties of obtaining associated supplies such as spares and power shortages have been a major constraint for data collection and dissemination. This has been a contributor to the limited quality of weather forecasts in parts of Africa.

The continent suffers from deficiencies in the organization and management of national and regional meteorological and hydrological databases. Successful implementation of improved telecommunication facilities would improve access to model outputs or observational data by NMHSs, the academic research community and other users. This would be in particular a key point for other THORPEX implementation sub-programmes.

On the other hand, the current GTS does not facilitate access to high impact weather data several days to weeks or months after it occurs. The WMO information system (WIS)[1] is an infrastructure designed to meet information exchange requirements of all WMO programmes including THORPEX. It will integrate diverse datasets of different data types in real and non-real time. WIS will be built on the Global Telecommunication System and will utilize international industry standards for protocols, hardware and software (e.g. Internet).

In the framework of WWRP/THORPEX Africa, it is important to know what are the CBS plans to implement WIS in Africa and whether the plans meet the requirements of WWRP/THORPEX Africa (e.g. getting large datasets).

[1] (http://www.wmo.int/pages/prog/www/WIS-Web/home.html)

4.3.1 Approach

The first task will be in conjunction with the expert team on telecommunication for Regional Association I (RAI i.e. Africa) to assess the current state of the telecommunication network over Africa to define priority recommendations to WIS-Africa. Understanding of: 1) critical position in the entire network (regional or subregional node for instance), 2) the data needed from sensitive areas, and 3) the presence or not of ongoing projects related to meteorological telecommunications will be important.

To ensure stability in the telecommunication network, a breakdown of a transmission node should not prevent collected data to be broadcast via alternative systems promoted by WIS. Stability and sustainability will also require training on computing, communication, operation and maintenance. In this framework, WIS-Africa will consider new telecommunication systems currently available in remote locations over the continent (e.g., internet, cell phone, etc). On the other hand, WIS-Africa should enable large transfers of data throughout Africa (e.g. TIGGE data).

THORPEX Africa will work with the R A I WIS task team to conduct pilot projects to test or build in African core components of WIS that meet requirements of high-impact weather data exchanges in the framework of THOPRPEX.

4.3.2 Expected outcomes

- Recommendations to WMO/CBS on actions to facilitate exchange and management of high impact weather data and information in Africa using the latest advances in information technology.
- Design of a stable and sustainable telecommunication network in Africa that can effectively be used for data collection and exchange to improve high impact weather data and information dissemination in the continent
- Improved transmission of observed data to NWP centres to improve high-impact weather prediction.

4.3.3 Timescale/dependencies

The assessment of the current state of telecommunication networks over Africa and of WIS implementation in Africa will be provided during next year.

Pilot projects to test or build core components of WIS that meet THORPEX requirements will be conducted at national and regional levels during the next 4 years.

Recommendations and design for an optimum telecommunication network using WIS will be provided throughout the project.

4.3.4 Level of cooperation, link to other programmes and key players

International expertise will be helpful to the support of WIS in Africa. Collaboration with major NWP centres, WMO/CBS, GEONETCAST will be needed to implement recommendations for Africa.

The key players will include:

- NMHSs in charge of national meteorological telecommunication networks, data processing and data management facilities at national level
- Subregional and regional centres such as ACMAD, ASECNA, ICPAC, DMCH and AGRHYMET, in particular for the coordination of resource deployment and training
- NWP Centres such as ECMWF, Météo-France, UK Met Office, and NCAR for connection with the global network and support for data management
- WMO's Space Programme for the promotion of satellite based dissemination systems
- GEONETCAST for development of multi satellite broadcasting capabilities
- WMO/CBS for implementation of recommendations.

4.3.5 Infrastructure requirements

- Equipment (telecommunication equipment, Internet capacities, workstations for data processing, servers for databases, software or tools for data management)
- Training to use and maintain telecommunication systems.

4.3.6 Initial actions

Actions	Focal points	Target period
Meet WIS project manager at WMO to discuss WIS implementation in Africa	Aïda Diongue Niang & André Kamga	September 2008
Report on the status on WIS implementation in Africa with RA 1 experts	Aïda Diongue Niang	February 2009
Report on the current telecommunication network in Africa	Ernest Afiesimama	February 2009

5. PREDICTABILITY AND DYNAMICAL PROCESSES TASKS

Summary of projects and major goals

<table>
<tr><th rowspan="3">Projects</th><th colspan="3">Goals/Actions</th></tr>
<tr><th colspan="3">Time Scale (Years)</th></tr>
<tr><th>2</th><th>4</th><th>8</th></tr>
<tr><td rowspan="4">PDP1: Predictive skill of high-impact weather events in Africa</td><td>- List of high-impact weather events (HIWE) from 1990 to date

- Statistics on high-impact weather events</td><td></td><td rowspan="3">Case studies of high-impact weather with mesoscale models implemented in Africa and collaborating international centres: EPS-LAM for Africa</td></tr>
<tr><td colspan="2">Catalogue describing high-impact weather events in Africa</td></tr>
<tr><td colspan="2">Evaluate the predictive skill of HIWE in global NWP systems for deterministic and ensemble predictions</td></tr>
<tr><td colspan="3">Contribute to the forecaster’s handbook project in the framework of AMMA</td></tr>
<tr><td rowspan="2">PDP2: Development of a seamless forecasting system</td><td>Define and get access to deterministic and EPS forecast products necessary to build a seamless forecast from short range to seasonal timescale in Africa</td><td>- Evaluation of EPS in Africa

- Evaluation of weekly, biweekly and monthly forecasts in Africa

- Feedback to modelling centres

- Explore statistical methods for intra-seasonal prediction</td><td>- Development of improved EPS in Africa

- Provide seamless skilful weather and climate products for applications in relation with SERA sub-programme</td></tr>
<tr><td colspan="3">Improve our knowledge and understanding of the nature and causes of intraseasonal to seasonal variability and its impacts on weather statistics</td></tr>
</table>

5.1 PDP1: Predictive skill of high-impact weather events in Africa

The main goal of this task is to improve our understanding of HIWE, assess their predictability and improve our ability to predict these events, particularly their timing, intensity and track. The range considered in this task is the range targeted in the WWRP/THORPEX international programme (from1 day to 14 days). The high-impact weather events that are the focus in this task include:

- Heavy rainfall and floods due to severe storms, embedded or not in easterly waves
- Tropical cyclones
- Severe extra tropical events
- Dry/wet spells
- Sand and Dust episodes
- Severe winds due to topical cyclones, severe storms, cyclogenesis
- Early or late onset and withdrawal of the seasonal rainfall
- Extreme temperatures.

5.1.1 Approach

First, the definition of HIWE will be revisited in relation with Disaster/Emergency managers and for each priority sector, experts and users. Then, a simple list of HIWE of interest will be provided in each sub-region in Africa from 1990 to date using a designed template. This template will consider meteorological criteria on the one hand and social, economical and environmental criteria on the other hand. Then, a climatological analysis of the events will be performed using for example similar methods as in the MEDEX and South Hemisphere THORPEX initiatives. This will be followed by a description of HIWE over the different sub-regions in Africa using available data. Data collection will be based on existing records from National Weather Services, NOAA/African Desk, ACMAD, AMMA, Southern Hemisphere THORPEX and MEDEX and also from emergency/disasters organizations and specialized organizations for each priority sector. The ECMWF and NCEP reanalysis data will be used to complete observations gathered about these high-impact weather systems. A framework for analysis (i.e. methods, strategies, etc) of key features in each sub-region is to be established through workshops (the first expected in 2009 at UNESCO/ICTP-Italy). These events will help to improve our understanding of high-impact weather events, assess their predictability, and agree on methods and metrics that will be used to build a catalogue describing the relevant high impact weather events in each African sub-region. The activities described here are complementary to the “high-impact weather information system” project (see SERA projects) and will help to feed the associated database.

Secondly, as part of assessing the predictive skill, there will be an evaluation of the representativeness of African HIWE in global NWP models using case studies from the catalogue. The limit of predictability of African high-impact weather events will be assessed, using both deterministic and probabilistic forecasts. Evaluation will be conducted at International centres (e.g. NCEP, ECMWF), regional centres, Regional Specialized Meteorological Centres (RSMCs) and advanced national meteorological services. Feedback will be provided to NWP modelling teams. The AMMA initiative at ECMWF in this regard provides the impetus for future activities.

Training workshops will be held on tools and methods in order to conduct this activity.

Finally, mesoscale models (and if possible cloud resolving models) will be used to explore further predictability of African high-impact weather systems. Limited Area Models (LAMs) will be used for deterministic and ensemble predictions with commonly agreed case studies from the established catalogue. These studies aim i) to capture the range of uncertainty in the initial conditions, time varying lateral boundary conditions and ii) to investigate model physics for better representation of processes associated with high impact events.

The TIGGE-LAM working group will be a key partner for reception of initial and boundary conditions from global EPS. Furthermore, WWRP/THORPEX-Africa will take advantage of the

outcomes of the working group about outputs and formats of the EPS-LAM data, archiving and verification methods.

Investigations of model physics will be centred on convection. Assimilation of convection in initial fields, assimilation of humidity profile and its impacts on convection and impacts of surface processes on convection are topics to focus on.

To undertake EPS-LAM in Africa, a large number of ensemble members is desirable to quantify the uncertainty associated with nonlinearities in the atmosphere. Then the amount of computing time required is huge and computing facilities are a key issue. Over Africa, Numerical Weather and Climate Prediction research has been hampered partly by the lack of computational resources. The South African Government's Department of Science and Technology has initiated a national Centre for High Performance Computing (CHPC) (http://www.chpc.ac.za). The aim of the centre is to provide High Performance Computing facilities and expertise for research in South Africa. The International Business Machines (IBM) Corporation recently established a partnership with the CHPC through the provision of a Blue Gene supercomputer as a platform to accelerate world-class research in Africa. South African climatologists and oceanographers have started reaping the benefits of the availability of the HPC facilities in the country. These scientists have been able to run dynamical models producing many ensemble members and multi-model studies are being conducted with GCMs running in the country. The CHCP presents a real opportunity for WWRP/THORPEX Africa to undertake an EPS LAM project research for Africa.

The findings of the activities described in this project will form part of the handbook project initiated in the framework of AMMA.

The THORPEX international working group on Predictability and Dynamical Processes (the THORPEX/Predictability and Dynamical Processes Working Group) will support studies on model diagnostics, predictability and ensemble forecasting and dynamical processes in Africa; In particular, the working group will support studies to build a catalogue representing typical high-impact weather events in Africa and to improve EPS in Africa.

5.1.2 Expected outcomes

- A catalogue describing high-impact weather events in Africa
- Climatology of high impact weather events
- Better understanding of HIWE and their predictability
- Better interactions with Emergency/Disaster management organizations, decision/policy makers and users
- Conceptual models of African high impact weather events
- Common metrics and strategies for analysis and evaluation
- Assessment of the skill of global NWP models in predicting African high-impact weather events
- Assessments of model deficiencies
- Development of local modelling expertise.

5.1.3 Timescale/dependencies

The "High-impact Weather Predictability and Information System for Africa" workshop to be held in 2009 at the UNESCO/Abdus Salam ICTP will be an opportunity to present case studies of HIWE and discuss templates to collect events, methods and metrics to undertake studies. Then the climatological analysis is expected to be available in 2010.

The description of the HIWE in each sub-region with some conceptual models, as well as model evaluation of HIWE in global models, will be delivered by 2013.

Parallel to these activities, efforts will be made to build modelling capabilities in a few African countries/regional centres to conduct mesoscale modelling studies to follow-up the model

assessment studies. Case studies on modelling African high-impact weather events are expected to deliver final reports/papers in 2016.

The findings on these activities will be incorporated into the handbook project noted earlier.

5.1.4 Infrastructure requirements

- Telecommunications
- Accessibility to data, both observations and model products
- Tools (hardware and software)
- Training for data processing and use of EPS
- Regional modelling capabilities: model software, training
- Computing facilities.

5.1.5 Level of international cooperation

There is a great need for international cooperation for this work given the current lack of infrastructure and modelling capabilities in most parts of Africa. The support of NWP global centres (ECMWF, NCEP, Météo-France, UKMO, and DWD) and research institutes (e.g. UCAR, UNESCO/ICTP, CIMMS, University at Albany) is necessary for data access, tools, modelling and training.

This requires collaboration between the NMHSs, universities and regional centres within Africa.

5.1.6 Link to other programmes

The THORPEX Interactive Grand Global Ensemble (TIGGE) programme is a key component for data access and use. WWRP/THORPEX Africa will benefit from the infrastructure and access facilities being set up and from the multi-model multi-analysis ensemble prediction system and the proposed Global Interactive Forecast System (GIFS).

The AMMA programme will be a key partner. Strong linkages will be made with the joint AMMA-THORPEX working group, particularly on activities related to model evaluation, and the forecaster's handbook, in addition to research activities associated with predictability and process studies.

There is also an opportunity to cooperate with the University Corporation for Atmospheric Research (UCAR) Africa Initiative.

Linkages will be made with initiatives to build LAM modelling capabilities in some African countries, for example, pilot activities with the University of Oklahoma/Cooperative Institute for Mesoscale Meteorological Studies (CIMMS), UCAR African Initiative using the WRF hierarchy model simulations of real time weather, University at Albany using WRF model for research purpose over Africa and model implementation in a few African countries (e.g. ALADIN, Met Office model, HRM, Eta).

ICSU-ROA, which is implementing the programme "Natural and Human-Induced Hazards and Disasters", is a key partner for promoting the THORPEX Africa initiative.

5.1.7 Key players

- National Meteorological Services in Africa
- Research institutes and universities focused on weather and climate in Africa
- Centre for High Performance Computing (CHPC), South Africa
- TIGGE LAM
- Operational NWP global centres
- International research institutes and universities
- AREP/WWRP/Mesoscale Forecasting working group
- AREP/WWRP/Tropical Meteorology working group

- AREP/WWRP/Verification working group
- WWW/Global Data-processing and Forecasting Systems (GDPFS) programme.

5.1.8 Initial actions

Actions	Focal points	Target period
Provide a primary list of events (from 1990 to date) associated with high impact weather in each sub-region of Africa	André Kamga	May 2009
Define framework for analysis and evaluation of key features	Benjamin Lamptey	May 2009
Collect fundamental data to perform climatological analyses	Aïda Diongue Niang and Arona Diedhiou	December 2009

5.2 PDP2: Development of a seamless forecasting system in Africa

Both the weather and climate communities have recognized the necessity to work together in order to improve climate and weather models and build a "seamless" weather prediction system (World Modelling Summit, ECMWF, May 2008). The WCRP Strategic Framework for 2005-20015 on Coordinated Observation & Prediction of the Earth System (COPES) aims to facilitate the evolution towards a unified framework for the prediction of weather, climate variability and climate change. The necessity to build a "seamless" weather prediction system has also been developed in the green Paper of WCRP, IGBP and WWRP/THORPEX in 2007 entitled: "The socio-economic benefits of a revolution in climate & weather prediction" and in the white Paper of WRCP, WWRP/CAS and THORPEX in 2008 entitled: "Towards a seamless process for the prediction of weather & climate".

Moreover, the users generally need comprehensive weather/climate information from daily to seasonal and decadal timescales spanning short-to-medium range, extended range and long-range forecasting.

Short range forecasts and seasonal outlooks are widely provided to users across Africa whereas there is the gap concerning weekly, biweekly and monthly forecasts. However, key socio-economic sectors (e.g. agriculture, health, water resources) may need intra-seasonal weather information. This task under THORPEX Africa/PDP sub-programme aims i) to improve our knowledge and understanding of the nature and causes of intraseasonal to seasonal variability and its impacts on weather statistics and ii) to provide a continuum of skilful weather/climate prediction systems from daily to seasonal timescales that meet societal and economic needs in Africa.

5.2.1 Approach

For each priority sector of interest (agriculture and food security, health, water resources, aviation and energy) there will be interactions with users via the SERA sub-programme to assess their real needs.

Improvement of our understanding of the nature and causes of intraseasonal variability and its impact on weather statistics will be carried out by building on the work currently being done in AMMA. The successes gained in West Africa will be replicated in other sub-regions.

We will identify in global/regional NWP centres, and climate research institutes, existing products that are necessary to build a forecasting system that can provide a continuum of weather forecast and climate information from daily to seasonal timescales. Accessibility to these products and tools to process the data, in continental/regional centres, RSMCs and advanced NMHSs and universities in Africa, will be facilitated through THORPEX/TIGGE. WWRP/THORPEX Africa will be connected to the developments on ensemble prediction systems and seamless prediction systems

that are being conducted and/or discussed in weather and climate communities in order to take advantages of the new opportunities for Africa.

Seamless Forecasting systems will be assessed with a focus on intraseasonal timescales (weekly, biweekly and monthly) and particularly EPS products. While in mid-latitudes, the skill in medium-range forecasts has been greatly improved and the EPS have subsequently contributed to increasing the range of forecasts from short-to-medium to extended range, the monitoring of global NWP performance in the tropical regions has not been regular leading to limited predictability in forecasting systems over Africa. At the same time, statistical methods developed in other tropical regions for intra-seasonal prediction will be explored for Africa.

A framework for model assessments will be established and the activity will be conducted by researchers and forecasters. Feedback on the use and assessment of subseasonal forecasts will be provided to modelling and research centres. Training in using the model data and software/tools will be arranged for the organizations that will conduct this task.

Contrary to the PDP1 project which focuses on model evaluation with the range 1-14 days from case studies of high-impact weather, the PDP2 project will evaluate the whole routine forecasting system from seasonal to daily timescales with a focus on subseasonal forecasts.

WWRP/THORPEX Africa will encourage NWP centres and research institutes to develop improved EPS forecasts for Africa.

The WWRP/THOPRPEX Africa PDP sub-programme will work closely with the WWRP/THORPEX Africa SERA sub-programme to provide the continuum of weather/climate products that could be used in application models (e.g. agriculture, health, water resources) and decision systems. This would also help to build an information system for better decision making throughout the programme.

5.2.2 Expected outcomes

- Assessment of EPS value in Africa
- Evaluation of medium range, weekly, biweekly and monthly forecasts in Africa
- Feedback on forecast errors to modelling centres for possible improvement
- Interactions researcher-forecaster-user
- A continuum of weather /climate information from daily to seasonal timescales
- Reduced adverse effects of HIWE.

5.2.3 Timescale/dependencies

The identification of required products to build a continuum of weather/climate information and the setting up to get access of these products and necessary tools needs to be done within the next two years i.e. by 2010.

Evaluation of sub seasonal forecasts and provision of feedback is to be completed within 4 years (i.e. 2012). By the end of the THORPEX programme, it is the aim to have improved EPS forecasts and improved sub seasonal forecasts in Africa. Throughout the programme, PDP and SERA sub-programmes will work closely together to provide the continuum of weather/climate information for applications. Some basic research will be conducted to improve understanding of subseasonal variability throughout the project.

5.2.4 Infrastructure requirements

As 5.1.4

5.2.5 Level of cooperation

As 5.1.5

5.2.6 Link to other programmes

The THORPEX Interactive Grand Global Ensemble (TIGGE) programme is a key component for data access and use. THORPEX Africa will benefit from the infrastructure and access facilities being set up and from multi-model multi-analysis ensemble prediction systems within TIGGE and the potential Global Interactive Forecast System (GIFS).

The THORPEX Year Of Tropical Convection (YOTC) which is a joint international initiative of WCRP-WWRP/THORPEX of coordinated observing, modelling, and forecasting with a focus on organized tropical convection, its prediction, and predictability.

The WCRP Coordinated Observation and Prediction of the Earth System has an aim to integrate and synthesize the activities of *all* the components of WCRP and facilitate the evolution of a unified framework for the prediction of weather, climate variability and climate change.

The GCOS Climate for Development in Africa (ClimDev Africa) which is an integrated, multi-partner programme is designed to mainstream climate information into development practices throughout Africa, while promoting sustainable development and helping to achieve the Millennium Development Goals (MDGs). This programme will support the climate activities of the seamless prediction experiments.

The AMMA programme will be a key partner. Strong linkages will be made with the AMMA modelling group which works on short to annual timescales.

VarESP-Monthly and Coupled Forecast System (CFS) projects at ECMWF and NCEP respectively are ongoing initiatives to capitalize on.

5.2.7 Key players

- National Meteorological Services in Africa
- Research institutes and universities focused on weather and climate in Africa
- Operational global Centres
- International research institutes and universities
- AREP/Commission for Atmospheric Science (CAS)
- WCRP/Joint Scientific Committee (JSC).

5.2.8 Initial actions

Actions	Focal points	Target period
Identify available subseasonal forecasts at NCEP, ECMWF and other research institutes and their ease of access	Benjamin Lamptey	February 2009
Report on data access within TIGGE (ease, resources required)	Aïda Diongue Niang	February 2009
Review of use and evaluation of EPS in Africa	André Kamga Foamouhoue	March 2009
Define a framework to provide seamless forecasts	Aïda Diongue Niang, André Kamga, Benjamin Lamptey	June 2009

6. CROSS-CUTTING ACTIVITIES

Projects	Goals/Actions		
	Duration in years		
	2	4	8
Capacity building and Infrastructure development	Prepare a report on capacity building, networking opportunities and infrastructure needs to better tackle WWRP/THORPEX Africa challenges.	Develop training programmes on cross-cutting themes for all sub-programmes as needed including for users.	- Evaluate the effectiveness of training and infrastructure - Advice on possible low cost solutions for infrastructure development
THORPEX Demonstration Projects	FDP projects implemented as they are identified throughout the WWRP/THORPEX lifetime		
Monitoring and Evaluation of THORPEX Activities	Prepare a framework for monitoring THORPEX activities in each sub-region in Africa	Report on THORPEX Implementation	Update the THORPEX Implementation Activities

6.1 Capacity building and infrastructure development

Capacity building and infrastructure development with capitalization on advances in information and communication technology in Africa are considered very important for the sustainability of WWRP/THORPEX AFRICA.

This activity will assess capacity building needs of Africa to effectively contribute to and sustain WWRP/THORPEX activities. Capacity building will encompass training for all sub-programmes for effective implementation of WWRP/THORPEX related activities, transfer of communication and information technology. Local and remote computing and communication facilities will be at the heart of the infrastructure development.

6.1.1 Approach

Using the existing networks of NMHSs, regional centres and research institutes (e.g. UNESCO/ICTP) and feedback from relevant programmes (e.g. AMMA, RIPIECSA), a dedicated working group will provide a report on the status and needs for Africa to improve the forecasting system and its use for decision and policy making. This report will recommend and suggest opportunities and priorities for capacity building, infrastructure and communication upgrade. E-learning or training, targeted workshops, conferences and symposia, summer schools, intensive courses and hands-on training will be strengthened. Development and use of training materials related to WWRP/THORPEX themes will be promoted in existing national and international centres.

6.1.2 Expected outcomes

- Increased trained human resources to strengthen more active research on Limited Area Modelling, Data Assimilation, Forecast and applications in Africa
- Enhanced Infrastructure for observing, forecasting and communicating high-impact weather forecasts
- Strengthened forecasting science, operation and user networks for exchanges at national and regional levels with up to date communication technology.

6.1.3 Timescale

Throughout the THORPEX lifetime, with a first phase focused more on training, infrastructure status and needs and the second phase on prioritization and implementation.

6.1.4 Level of international cooperation

International collaboration will be needed to build and exchange training materials, mobilize additional resources to buy and set up infrastructure, run training programmes, improve institutional governance, workshops, courses and summer schools.

The Group on Earth Observations (GEO) is coordinating efforts to build a Global Earth Observation System of Systems (GEOSS). In this process the development of capacity is an important and necessary component. Infrastructure development, individual and institutions capacity building, resource mobilization are essential elements of GEOSS capacity building activities. The WWRP/THORPEX African Initiative is seen as a project in the weather and climate societal benefit areas that addresses capacity development for GEOSS.

6.1.5 Key partners

- Global weather and climate centres
- Universities and institutes (e.g. University of Oklahoma/CIMMS Africa programme, UNESCO/ICTP, TWAS, UCAR)
- WMO training, infrastructure development and governance programmes
- GEO, ICSU.

6.1.6 Links with other programmes

- International training and infrastructure development programmes
- UNESCO/ICTP computing and earth sciences programmes
- UCAR Africa initiative
- AMMA programme, RIPIECSA Project
  ICSU-ROA/Natural and Human-induced Hazards and Disasters
- And other collaborative projects to be determined.

6.1.7 Initial actions

Activities	Responsibility
Preparation of a report on capacity and infrastructure needs	All committee members coordinated by the co-chairs Target period: end of 2010
Development and implementation of training events	All committee members coordinated by the co-chairs Target: Throughout WWRP/THORPEX lifetime

6.2 Forecast Demonstration Projects (FDPs)

Recent advances in numerical weather and climate forecasting systems achieved by a combination of better high resolution models, improved data assimilation and air or space based observing platforms, ensemble techniques and coupled land-ocean-atmosphere models have paved the way for progress in many developed and developing regions of the world. Given the existing unused potential of new forecasting tools and techniques in Africa, FDPs will be developed to assess the social and economic benefits that would result from the operational use of these recent tools and techniques. Moreover, Demonstration Projects will improve trust in user communities and facilitate translation of meteorological information to quantities required as inputs to decision systems particularly in cases of high impact weather. This activity is important to improve the visibility of NMHSs in Africa.

The successful implementation of the Severe Weather Forecast Demonstration Project (SWFDP) over Southern Africa has provided impetus for extension of forecast demonstrations over all sub-regions of Africa. This activity will be part of the African contribution to the international THORPEX demonstration projects. Over West and central Africa, forecast demonstrations related to water management projects, using ECMWF and NCEP deterministic and EPS products have already started in June 2008.

6.2.1 Approach

Global, regional and national operational and research centres must be involved. The activity should comply with the typical requirement of WWRP's Developing countries FDPs.

Forecasts Demonstrations from daily to seasonal timescales applied to all priority applications sectors will be promoted for different sub-regions of Africa. A typical demonstration project will involve:

- A research and development component on systems and technologies to be demonstrated (for example high resolution LAMs, new nowcasting tools using MSG or the use of Mesoscale Limited Area Ensemble prediction systems, AMDAR data impact in Africa)
- A training component for forecasters and users on new diagnostics, EPS and high resolution deterministic products, communication of uncertainties, guidelines for forecaster/user interactions
- A production component with experimental forecasts, advisories , warnings and expected impacts at daily to seasonal timescales for the application sectors of interest
- A verification component with reports on the quality and value of the forecasts and related information
- A training material development component using high impact weather events observed during the demonstration period.

The FDP will involve development and implementation of new or enhanced technologies/techniques in an operational environment and dissemination of forecast information to users in real time. End users should be engaged via workshops and forums (e.g. COFs in Africa). Successes of FDPs will help to promote operational use of new methods, tools, procedures and techniques.

6.2.2 Expected outcomes

- Demonstrated improvements in high impact weather forecasting and use in Africa.
- Demonstrated usefulness of existing forecasting tools in key sectors (health, food security, water resources…)
- Enhanced collaboration between research, forecasting and user communities
- New forecasting methods for example EPS forecasts for each of the priority sectors
- New training materials
- New decision support and assessment tools that better handle forecasts for example probabilistic information from ensemble prediction systems
- Reduction in disaster impacts and increased economic and environmental efficiency through with new tools and technology
- More testing of new forecasting and diagnostics tools in Africa
- Improved benefits from weather information in Africa.

6.2.3 Timescale

Advanced forecasting techniques and application tools available will be tested and related benefits demonstrated during WWRP/THORPEX lifetime.

6.2.4 Level of international cooperation

To foster forecasting research and development, international partnerships will be needed between research institutes and operational programmes to test high resolution global models and LAMs. International collaboration will be required for the operational component of an FDP. For example global NWP centres that provide model products, coordinate forecasts and evaluation, businesses and organizations from the priority applications sectors that use forecasts and feedback to the forecasting community, regional centres and NMHSs to provide services.

International collaboration on EPS training, additional diagnostics, and communication of uncertainties will benefit from existing initiatives at global centres (e.g. NCEP, ECMWF) and the

WMO's Public Weather Service Programme. Typically GCOS/CLIMDEV will be needed to provide climate information and services as complementary contribution to the user needs.

6.2.5 Key players

- African Desks at global centres and Regional application centres that lead forecast demonstrations and provide guidance and advice at national level
- Research and development partnerships involving research institutes, university laboratories etc. to develop new techniques to be demonstrated
- Global forecasting centres (NCEP, ECMWF, UK Met Office, Météo-France, IRI) that supply EPS, high resolution global forecasts, new diagnostics, have data assimilation capabilities and support forecasts assessments
- NMHSs that provide services to key application sectors stakeholders or businesses and collect feedback
- Organizations and agencies that take weather sensitive decisions and policies (e.g. Disaster/water management, agriculture, energy production and distribution, health, aviation, etc). These users will provide feedback on the use of information to the meteorological community and contribute to developing forecast tailoring tools.

6.2.6 Infrastructure required

- Access to deterministic and EPS products from operational centres
- Access to application sector data and/or records
- High speed internet facilities at regional centres and pilot NMHSs
- Staff (forecasters and coordinators) at African desks, regional and national pilot centres
- Better communication facilities between stakeholders.

6.2.7 Links with other programmes

- CBS Expert team on EPS
- CBS/SWDFP
- WMO /WCRP/COPES
- WMO PWSP, GDPFS, DRR
- GCOS/ClimDev Africa
- NOAA/NCEP and ECMWF Africa programmes
- UCAR Africa Programme, CIMMS at University of Oklahoma and University of New York at Albany
- Red Cross and Red Crescent societies, relief and recovery programmes.

Potential FDPs could be: MERIT health initiative, Hydrological Forecasts for the Niger River Basin, Extension of SWFDP with R&D components.

6.2.8 Initial actions

Actions	Focal points	Target period
Get International THORPEX working groups interested in FDPs in Africa	The co-chairs	Working Group meeting September 2008, Geneva
-Contact global forecasting centres to discuss and define their involvement on different components of FDPs - Discuss the links with existing initiatives	The co-chairs	June 2009
Develop detailed proposals and seek funding and other support for FDPs.	The co-chairs	December 2009

6.3 Monitoring and evaluation of WWRP/THORPEX Africa activities

6.3.1 Approach

A framework for monitoring and evaluation will be prepared and discussed. Every year, the Regional committee will prepare documents on the achievements and next year activities of WWRP/THORPEX Africa. Inputs for these documents should come from leaders of activities, focal points in countries, regional centres and contributing organizations.

The co-chairs will prepare initial draft reports and submit to other committee members for review at least three months before the target date for publication.

Members will provide comments/inputs on the draft over a period of one month and documents will be finalized and submitted during the following two months.

6.3.2 Expected outcomes

- Document describing the achievements, gaps, challenges, and next year activities of WWRP/THORPEX Africa produced every year
- Regular reviews or summaries to monitor and evaluate new research findings in the framework of WWRP/THORPEX Africa.

6.3.3 Timescale/dependencies

First report published by the end of 2009 and first review paper in 2010 followed by yearly reports and a review paper every two years.

6.3.4 Level of cooperation, link to other programmes and key players

The Co-Chairs are responsible for this activity. Inputs from committee members and identified experts will be sought.

6.3.5 Infrastructure requirements

The staff time to work on the reports and reviews or any specific preparation task.

6.3.6 Initial actions

The co-chairs will submit to the Regional Committee a first draft monitoring and evaluation framework by June 2009.

7. OPERATION OF THE WWRP/THORPEX AFRICA REGIONAL COMMITTEE STRUCTURE AND TERMS OF REFERENCE

7.1 Committee composition

The Committee membership will be scientists in Africa representing as far as possible the main geographic regions of Africa and expertise needed by the programme. The committee Members should be involved in scientific activities directly related to the WWRP/THORPEX mission, and have the ability to further the aims of WWRP/THORPEX Africa. The possibility to have a person from social/economic background has been discussed and an expert on methods to assess the benefits of meteorological information and services has joined the committee.

7.2 Committee chairmanship

The current two Committee Co-chairs were elected from among the Committee by the members of the Committee. One Co-chair will step down in December 2012 and another Co-chair will be selected. From then on each second year a committee Co-chair will stand down and another selected.

7.3 Committee communication

The WMO web page established for the WWRP/THORPEX Africa Regional Committee will be used to provide a forum for communication amongst members and scientists working on activities.

7.4 Committee meetings

Meetings of the Committee should take place annually to review progress made, discuss annual report to IPO and prepare the plan for the following year.

7.5 Committee Terms of Reference

The following Terms of Reference will apply to the WWRP/THORPEX Africa Regional Committee:

- To steer the WWRP/THORPEX Africa programme in line with the principles and directions of the WWRP/THORPEX Programme and International Project Office
- To facilitate, monitor and guide the implementation of the WWRP/THORPEX Africa Plan according to the agreed activities and timelines
- To promote the principles and programme of WWRP/THORPEX Africa among all African countries and international partners
- To promote WWRP/THORPEX Africa plan to secure the necessary human and financial resources for its implementation
- To evaluate, endorse and promote potential projects and Forecasts Demonstration Projects under the WWRP/THORPEX Africa programme
- To report on the progress of the WWRP/THORPEX Africa activities to the WMO and the WWRP/THORPEX International Project Office
- To ensure that the priorities of WWRP/THORPEX Africa are reflected in the overall WWRP/THORPEX programme
- To identify the necessary capacity building needs and implementation strategies for the African scientists to take maximum benefit from WWRP/THORPEX programme
- To identify the appropriate collaboration, partnership and communication mechanism for linking the African scientific institutions with other relevant institutions undertaking WWRP/THORPEX related activities
- To prepare, with support from WWRP/THORPEX programme office and other relevant organizations, meetings of the WWRP/THORPEX Africa programme.

8. ENDORSEMENT OF THE SCIENCE AND IMPLEMENTATION PLANS

Endorsement of WWRP/THORPEX for Africa by AU, UNECA, African Development Bank and sub regional economic groupings in Africa will be promoted. Presentations of the plans during meetings of these bodies will be supported. WMO will take the lead in the promotion of the plans with the members of RA1.

The Science and Implementation Plans documents will be distributed to:

- Potential agencies/organizations that can support or fund the WWRP/THORPEX African Initiative via WMO
- All Met Services, meteorological /climate related regional and sub regional institutes via WMO. A cover letter requesting nomination of country focal points and description of the needed profile will accompany planning documents
- Some research institutes or organizations via WMO to engage the academic community. ICSU-ROA offers an opportunity for large distribution. Other organizations or programmes such ICTP, TWAS, GEO, African Science Academy, AMMA are additional opportunites to reach research community
- All participants to WWRP/THORPEX Africa Planning meetings by the co-Chairs.

9. RESOURCE MOBILIZATION

Human resources and funds are recognized as basic requirements for effective implementation. In and outside Africa a set of institutions or organizations (e.g. UNESCO/ICTP, UCAR, GEO, ICSU, CIMMS, and CHCP) are available and have expressed their willingness to

develop activities in line with WWRP/THORPEX Africa objectives and/or help to enhance capacity building. Under the responsibility of the co-chairs with the support of WMO, a document on existing funding opportunities and adjustments if needed in projects to facilitate support of WWRP/THORPEX Africa activities will be prepared by the end of 2009. This document is expected to strengthen and complement organisations working on WWRP/THORPEX Africa activities.

The implementation of WWRP/THORPEX Africa will involve three levels of networking:

- The network of expertise composed of scientists, forecasters and end-users effectively committed to WWRP/THORPEX objectives. This network will help to develop detailed proposals when needed for different funding agencies. The AMMA, UNESCO/ICTP and ICSU regional office for Africa networks provide a foundation
- The network or consortium of institutions bound by formal working arrangements (e.g. MoUs) or consortium agreements that facilitate consideration of WWRP/THORPEX projects in institutions work plans and their effective execution. The WMO and major players in each project will promote this network
- The policy network with policy and strategic planning organizations to facilitate institutional and policy reforms that creates an enabling environment for R&D in Africa, modern management systems and cooperation on WWRP/THORPEX Africa activities. AU with the support of UN development programmes and African development Bank will be contacted to lead this network.

With the support of the WMO, the regional committee will lead development of detailed project proposals for different funding bodies including the European Commission, International cooperation programmes in developed (*e.g.* USA, UK, France, Spain …) and some emerging countries *(e.g*. India, China, …), African development Bank and UN Programmes for sustainable development. The GEO Secretariat will help to connect WWRP/THORPEX Africa to funding bodies for aspects of the programme that contribute to the tasks identified in GEO work plan. Funding from African countries will be mobilized with the support of NMHSs.

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ACRONYMS

ACMAD	African Centre for Meteorological Applications to Development
AGRHYMET	Regional Centre of the Interstate Committee for Drought Control in the Sahel
AMDAR	Aircraft Meteorological DAta Reporting
AMESD	African Monitoring of Environment for Sustainable Development
AMMA	African Monsoon Multidisciplinary Analysis
ASECNA	Agence pour la Sécurité de la Navigation Aérienne en Afrique et à Madagascar
AREP	Atmospheric Research and Environment Programme
CAS	Commission for Atmospheric Sciences
CBS	Commission for Basic Systems
CFS	Coupled Forecast System
CHPC	Centre for High Performance Computing
CIMMS	Cooperative institute for Mesoscale Meteorological Studies
CLIMDEV	CLIMate for DEVelopment
CLIVAR-VACS	CLImate VARiability - Variability of the African Climate System
COF	Climate Outlook For a
COPES	Coordinated Observation and Prediction of the Earth System
DAOS	Data Assimilatiuon and Observing Strategies
DRR	Disaster Risk Reduction
DMCH	Drought Monitoring Centre Harrare
DWD	Deutscher WetterDienst
ECMWF	European Centre for Medium range Weather Forecasts
EPS	Ensemble Prediction Systems
ETA	Mesoscale model of NCEP
EUMETNET	EUropean METeorological services NETwork
EUMETSAT	European organization for exploitation of METeorological SATellites
FDPs	Forecasts Demonstration Projects
GCOS	Global Climate Observing System
GDP	Gross Domestic Product
GDPFS	Global Data-Processing Forecasting System
GEO	Group on Earth Observation
GEONETCAST	Data Dissemination system for GEO
GEOSS	Global Earth Observation System of Systems
GIFS	Global Interactive Forecast System
GIS	Geographical Information System
GPS	Global Positioning System

GTS	Global telecommunication System
HIW	High-Impact Weather
HIWE	High Impact Weather Events
ICPAC	IGAD Climate Prediction and Applications Centre
ICSU	International Council for Science
ICSU-ROA	International Council for Science-Regional Office for Africa
ICTP	International Centre for Theoretical Physics
IGAD	InterGovernmental Authority for Development
IGBP	International Geosphere Biosphere Programme
IPO	International Project Office
IRI	International Research Institute for climate and society
JSC	Joint Steering Committee
LAM	Limited Area Model
MEDEX	MEDiteranean Experiment on cyclones
MDGs	Millenium Development Goals
MoU	Memorandum of Understanding
MSG	Meteosat Second Generation
NASA	National Aeronautic and Space Administration
NCAR	National Centre for Atmospheric Science
NCEP	National Centres for Environmental Prediction
NMHSs	National Meteorological and Hydrological Services
NOAA	National Oceanic and Atmospheric Administration
NRL	Naval Research Laboratory
NWP	Numerical Weather Prediction
OS	Observing Systems
OSE	Observing System Experiment
OSSE	Observing System Simulation Experiment
PDP	Predictability and Dynamical Processes
PWSP	Public Weather Services programmes
RA1	Regional Association 1
RIPIECSA	Recherche Interdisciplinaire et Participative sur les Interactions entre les ECosystèmes et Sociétés d'Afrique
RSMCs	Regional Specialized Meteorological Centres
SERA	Societal and Economic Research Applications
SOP	Specific Observing System
SSM/I	Special Sensor Microwave/Imager
SWFDPs	Severe Weather Forecast Demonstration Projects
THORPEX	THe Observing system Research and Predictability Experiment

TIGGE	THORPEX Interactive Grand Global Ensemble
TRMM	Tropical Rainfall Measuring Mission
TWAS	Third World Academy of Sciences
UCAR	University Corporation for Atmospheric Research
UKMO	United Kingdom Meteorological Office
UNESCO	United Nations. Education, Science and Culture Organization
UNISDR	United Nations. International Strategy for Disaster Reduction
VarEPS	Variable Resolution Ensemble Prediction System
WCRP	World Climate Research Programme
WMO	World Meteorological Organization
WWRP	World Weather Research Programme
WWW	World Weather Watch programme
YOTC	Year Of Tropical Convection

ANNEX

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