

DFID - Met Office Hadley Centre Climate Science Research Partnership (CSRP)

WORKPLAN

1. Background

1a) Meeting the Science Requirements for Early Warning Systems and Adaptation Planning

Climate variability and change have huge impacts on food security, water availability, human health and social and economic infrastructures, particularly in Africa where vulnerability to hazardous weather and the natural vagaries of the climate is already high. The IPCC AR4 assessment has demonstrated that Africa is one of the areas where a better understanding of the drivers of climate variability and change is urgently required. The current generation of climate models do not provide a consistent picture of the expected future changes in rainfall over much of Africa. A clear research priority is to understand the drivers of African climate variability and change, and to improve the representation of the key relevant processes in the current generation of climate models.

The climate is already changing and past historical data can no longer be used to estimate the risk of even near-future climate extremes. Seasonal forecasts provide the basis for the systematic prediction of climate risk out to 6-months ahead and they have the capability to take into account both climate variability and change. These seasonal forecasting systems can also form the basis for early warning systems that will enable the better planning of relief activities. The improvements to the understanding and modelling of climate over Africa can be pulled through into the seasonal forecasting systems and thereby improve the skill and usefulness of these forecasts for Africa.

On the longer decadal timescale, the climate change and variability signals are typically of the same magnitude. The forecasts out to a few decades ahead are largely independent of the global greenhouse gas emission scenarios and these predictions can provide essential input for adaptation planning. A starting point in adaptation planning is to build resilience to current climate variability, whilst recognising that climate change means the current climate conditions will substantially change in the future. Decadal prediction systems enable both current variability and future climate change to be systematically accounted for.

An issue of increasing importance is the danger of mis-attribution of the changes that are observed. There is a growing tendency to attribute all climate related changes to anthropogenic increases in greenhouse gases whereas, in fact, other drivers such as natural climate variability and land use changes (e.g. deforestation) can be of first order importance. The development of near real time systems that can attribute the causes of observed changes is a high priority if mis-attribution and erroneous and expensive adaptation measures are to be avoided.

Information about the future climate is needed on a scale that is directly usable by in-country stakeholders. This requires downscaling of global climate information to the local level. The products currently available (e.g. seasonal forecasting products) are of limited use on the ground because they do not address key stakeholder requirements. There is an urgent need, therefore, to establish the priority variables and regions of interest for long range (monthly-to-decadal) forecast information,, through discussions with relevant projects and institutions operating in Africa.

The usefulness of climate science products to assist decision makers in disaster risk reduction and adaptation planning is further hampered by limited climate science capability in Africa. There exists a significant capacity gap in Africa, which developed countries have repeatedly committed to help narrow in climate negotiations.

The DFID-Hadley Centre Climate Science Research Partnership (CSRP) will complement other DFID research initiatives such as ‘Climate Change Adaptation in Africa’ (CCAA) and ‘Ecosystem Services for Poverty Alleviation’ (ESPA), with a view to addressing the above problems. It will also seek to liaise closely with the ‘Climate for Development’ (CLIMDEV) project which aims to improve the collection and provision of climate observations across Africa. The project will operate through two components: a science and a knowledge management component.

1b) The Science Component

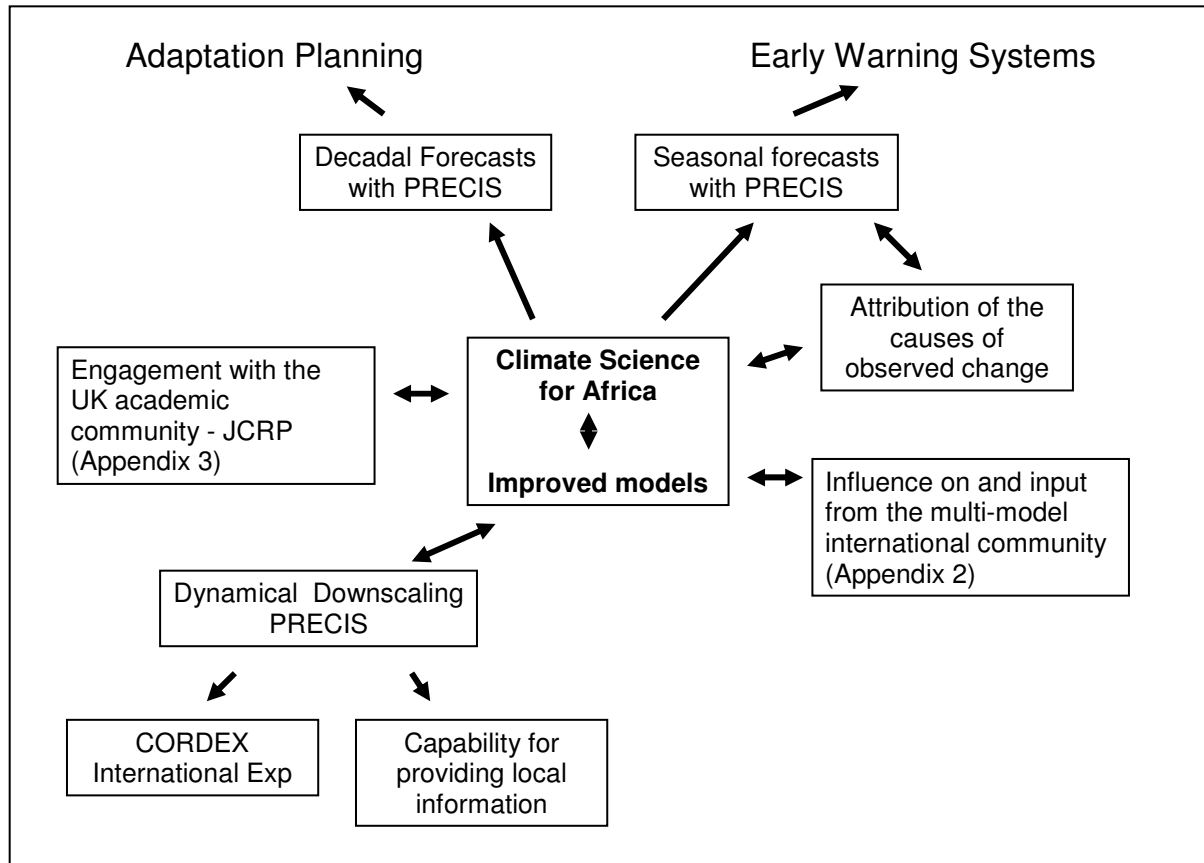
Figure 1 illustrates the approach that is being proposed for the science programme of the CSRP. At the core of the approach is the improved scientific understanding of climate related processes over Africa and the better representation of these in climate models. The work will focus on the latest version of the Met Office Hadley Centre’s model (HadGEM3)¹ and results will be openly published in the peer reviewed literature enabling the benefits of the research to be taken up by other groups. Appendix B describes in some detail how the work undertaken in this programme can be influential in the development of improved prediction systems for Africa in the wider international research community. UK wide research collaborations will also be essential to pull through the wider UK academic expertise into this programme. The Met Office/NERC Joint Climate Research Programme (JCRP - see Appendix C) provides a mechanism to do this and a UK African Climate Working Group will be established at an early stage.

This core science/modelling activity is the ‘engine’ of the research programme (Output 1). It will form the foundation for improved seasonal and decadal forecasting systems and for a near real time capability to attribute observed climate changes (Output 2). These forecasts will be downscaled using the PRECIS system and thereby provide information at the local scale (Output 3). PRECIS will also enable African institutions to engage in the WMO CORDEX (Coordinated Regional Downscaling Experiment) programme that will initially focus on Africa and provide results to IPCC AR5.

¹ See Appendix A for a full list of Climate Model versions referred to in this document

It is essential that the results of the science programme are informed from the outset by the African user requirement and that the research programme is aligned to meet these. The project will therefore conduct an initial stakeholder consultation to identify specific user needs and potential partnerships. Further details for each project output are provided in the next section.

FIGURE 1: SCHEMATIC OF THE DIFFERENT SCIENCE COMPONENTS



1c) The Knowledge Management Component

The approach to Knowledge Management is based on:

- enhancing the capability of southern institutions to undertake climate science and to use science outputs for climate risk management (Output 4) and.
- developing and delivering tailored climate products that meet the demand from African stakeholders and that are communicated in a way that is accessible to them (Output 5).

Central to this approach is the core-science component of this programme, which will enhance and provide access to the improved climate prediction tools. The involvement of African scientists in the core-science component will be achieved through a visitor and PhD fellowship programme. Effective southern partnerships will be developed that can play a key role in disseminating and assessing the climate

products developed in the outputs 1,2 and 3 to African stakeholders. Further details for each project output are provided in the next section.

1d) Met Office capability

The Met Office already provides state-of-the-art weather services across many sectors, and specifically supports a world-class programme in climate change prediction and research. It is arguably the only organisation that is world leading in both operational weather and seasonal forecasting, and in climate change prediction. It has the breadth of science necessary to tackle major issues of interest to DFID, such as tropical precipitation patterns, weather systems, monsoons and El Nino.

The Met Office is a WMO Global Producing Centre (GPC) for seasonal forecasts and, following the recommendations from World Climate Conference-3, the Met Office will be one of the GPCs able to extend its remit to include decadal climate forecasts. The Met Office also already has a project with DFID to exploit the seasonal forecast for Africa by engagement with users through the Regional Climate Outlook Forums. The Met Office is therefore well placed to both better exploit existing forecast systems and to develop the next generation of systems with a focus on Africa. Current forecast systems show some skill on the seasonal timescale and there is little doubt that considerably greater levels of skill are possible if the modelling systems are further developed.

2. Outputs and Deliverables

2a) The Science Component

Output 1: Improved understanding of drivers of African climate and their representation in climate models

Staff resources: 3 FTE

Met Office forecast tools are already acknowledged as state-of-the-art, but nevertheless there are still significant limitations in the ability of climate science to support decision making in the developing world. In what follows we have highlighted areas of underpinning science that are specifically relevant to improving climate predictions for Africa. We will use the consultation process with African scientists and stakeholders to help prioritise our work to deliver the maximum benefit to decision makers.

Improved forecasting capability for regional climate is required for timescales from months to the next decade. A key focus will be on delivering improved predictions of climate for vulnerable regions of Africa, including predictions of extremes for critical variables such as precipitation. Key modes of tropical variability and local physics will be targeted for improvement through a better understanding and modelling of the driving mechanisms and through higher global model resolution. While predictability in the tropics is higher than for the extra-tropics on seasonal timescales, very detailed simulation of tropical regions is particularly challenging due to complex local processes and a lack of observations. However, we have successfully delivered improvements in simulations of the Asian monsoon and ENSO prediction with our latest model (HadGEM2) through a ‘seamless’ modelling approach, where knowledge of sources of errors at particular time or space scales can benefit predictions at all timescales. The Met Office has a unified forecast and climate modelling system (MetUM) that runs a single physical modelling system across time and space scales. This means that, for example, we can use new data sources over key regions, such as the intensive observations made as part of the AMMA² project for evaluation of our models in real-time leading to improvements in models across timescales. In addition, we have evidence from our collaborative work on high resolution modelling, that increased atmosphere and ocean resolution in our global models will give further improvement in some modes of tropical variability (e.g. ENSO) and on the simulation of local physics and extremes - notably tropical cyclones. Again we can benefit from the unified modelling system using modelling studies of local processes (e.g. associated with convection or the land surface) at extremely high resolution (e.g. Cascade³) to improve our regional predictions from global and regional models on seasonal to decadal timescales.

² AMMA is the African Monsoon Multidisciplinary Analysis

³ Cascade is a NERC funded consortium project to study organized convection in the tropical atmosphere using large domain cloud system resolving model simulations. Africa is a key focus region

Workplan for Output 1

Evaluation of African Climate in the Hadley Centre's latest model (HadGEM3). We will set up a working group on African climate to evaluate model performance across space and timescales. We will develop and utilise a suite of diagnostics (or 'metrics') to look for similarities in errors at different temporal and spatial scales in comparison with all available observational data to understand errors at the process level and work to improve the representation of these processes in the HadGEM3 modelling framework through higher resolution and new or improved physical representation (see 2,3,4 below). We will engage UK university and African scientists in our working group and link to the wider International research community through initiatives such as AMMA¹ as part of the WCRP CLIVAR VACS (Variability of the African Climate System) and IPCC/CMIP5 to ensure use of proven diagnostic techniques and metrics are developed in the multi-model community.

2) Improved understanding of remote influences driving African climate in models. Specific focus will be on the role of key modes of tropical variability such as ENSO, NAO, IOD and their representation in the current generation of climate models. This will include improved understanding of the mechanisms by which these climate drivers affect regional African climate and improved understanding of the sources of errors in models.

3) Evaluation of key local processes of African Climate. Following a consultation process with African stakeholders, we will focus work on the highest priority processes/phenomena. An example might be analysis of the West African Monsoon (WAM) in the global HadGEM3 model and in the regional HadGEM3 model (when available). We will work in collaboration with the AMMA¹ project and scientists in the UK and Africa to understand the drivers of e.g. the WAM and their simulation in the HadGEM3 modelling family. We will build on our methodology applied to understand processes driving the Indian Monsoon.

4) Land atmosphere coupling. The role of land-atmosphere coupling on the water cycle (possible examples are the simulation of the diurnal cycle and initialisation and modelling of soil moisture). This will feed into the capability for detailed investigations of local forcing in Output 3.

5) Investigation of other influences on key African rainfall systems. We will use our development of higher resolution climate models, study of processes across model resolution and involvement in the Cascade² project to investigate the importance of high resolution modelling of mesoscale convective systems. Also, we will use our involvement in AMMA-UK to look at the importance of aerosol forcing.

6) Capacity building: African scientists could potentially be associated with this core science component through a PhD fellowship programme. Involvement in model development would probably not be practicable but diagnostic analysis of model simulations could be done through a combination of visits to the UK and remote working.

Deliverables for Output 1

Year 1: Measuring current capability

D1.1: Following the user consultation and prioritisation of processes and variables, diagnostics and measures will be developed to quantify the ability of HadGEM3 to simulate African regional climate.

D1.2: Evaluation of the simulation of key local processes e.g. the West African Monsoon (WAM) in HadGEM3.

Year 2: Understanding drivers

D1.3: Evaluation of the impact of tropical variability (e.g. ENSO) on the variability of African climate.

D1.4: Improved understanding of the land-atmosphere coupling and the water cycle influence on key African rainfall systems.

D1.5: Understanding of the role of resolution on the simulation of key processes driving African Climate.

Year 3: Delivering Improvement

D1.6: Delivery of an improved HadGEM3 model for monthly-to-decadal forecasting for Africa.

Output 2: Improved application of science and climate models for early warning systems and adaptation planning

Staff resources: 3 FTE

Climate forecasts from months to a decade ahead need to account for the current phase of natural climate variability and increases in greenhouse gases as both play a role in near term climate. Tropical climates are also generally more predictable than climate in extra-tropical regions and forecast systems skilfully predict major tropical climate drivers such as El Nino and anthropogenic change months and years ahead. This leads to skill in forecasts in potentially vulnerable regions of Africa but the regions and quantities for which skill is present are still unknown and are not being utilised by African decision makers. By using monthly-to-decadal predictions we can better inform adaptation to climate change in Africa and there are many user-focused applications that could be developed in consultation with DFID.

While it is tempting in some quarters to blame every extreme weather event on climate change, inappropriate adaptation responses could follow if based on incorrectly assuming that every event is attributable to increased greenhouse gas concentrations in the atmosphere. While the evidence for human influence on global climate is clear, extreme weather events also occurred in pre-industrial climate, and other drivers in addition to greenhouse gases, such as aerosols and land use changes can have major effects on climate. By considering how external drivers of climate and modes of variability have changed the probability of particular weather events we can improve the evidence basis to better inform adaptation.

2.1 Monthly-to-seasonal Prediction

Through the initial consultation process we will determine high priority climate variables for vulnerable regions. This will focus initial attention on specific areas and diagnostics to analyse in our existing seasonal forecast system. We will assess current skill, determine what climate drivers are responsible and focus our development work on improving forecast skill for these regions and variables. We expect this to include estimates of the likelihood of extreme events, estimates of exceeding thresholds and some monthly forecast information such as onset or duration of rains.

2.2 Decadal predictions

These longer range predictions will be more heavily influenced by climate change signals and bridge the gap between initialised seasonal forecasts and uninitialized centennial climate projections. They will provide experimental forecasts for adaptation to climate change on decadal timescales. Decadal predictions need to be “seamless” with monthly and seasonal forecasts from 2.1 to avoid providing conflicting information.

2.3 Attribution

We will develop the capability to provide updates in near-real time of the causes of extreme events. This will include an assessment of the probability of extreme events and how they have changed and will investigate the effects of external forcings and variability on regional climate changes and extremes. Examples include: links between aerosol forcing, shifts in the ITCZ and Sahel drought, the effects of biomass burning on African climate, the effects of land use changes on extreme temperatures. Based on the

understanding developed, and an analysis of the relevant driving processes in the prediction models, a near-real time attribution capability will be developed that will sit alongside the forecasting system. This will provide regularly updated appraisals of evolving climate conditions and extreme weather events in Africa, assessing the extent to which modes of variability and external forcings of climate have altered the probability of their occurrence.

Workplan for Output 2

1) Forecast skill in variables relevant to DFID stakeholders:

This will consider monthly-to-seasonal forecasts of mean climate and the likelihood of variables identified in the user consultation such as heatwaves, heavy rain, tropical storms and the onset and cessation of seasonal rains. It will eventually merge with Output 3 (i.e. downscaling of global model outputs using PRECIS) for regions where skill is present.

2) Provision of experimental monthly to seasonal forecasts and alerts for African regions where skill is present to DFID and its stakeholders. Details to be informed by (1).

3) Underpinning research on sources of African monthly-to-decadal predictability.

This work will consider the predictability of climate drivers in Africa and their assessment in forecast models (builds on Output 1 work on ‘remote influences driving African climate’).

4) Development of decadal prediction capability for Africa. This will assess what could usefully be provided from first year and multiyear forecasts for Africa and work towards a seamless monthly-to-decadal prediction system for all African regions.

5) Development of an observational monitoring and forecast evaluation capability for Africa. This will provide continuously updated monitoring of temperature and precipitation over Africa for evaluation of current climate conditions and for verification of monthly-to-seasonal forecasts. This will include an initial review of what data is currently available and it will link closely to CLIMDEV and related activities.

6) Attribution of observed changes This will provide a near-real time experimental attribution capability. Such a capability could inform regular updates of current climate conditions and the extent to which the most important natural and anthropogenic drivers of such events have altered the probability of their occurrence.

7) Capacity building: Involvement in this output can be fairly wide ranging and be developed as the programme proceeds. There is a clear role here for visitors and PhD fellowships in the development of new monitoring, forecasting and attribution products, and the assessment of their usefulness. This activity would need to involve strong links with the partner organisations in Africa.

Deliverables for Output 2

Year 1:

D2.1: Assessment of monthly-to-seasonal prediction skill for African regions based on existing capability, including monthly forecasts and extreme events where possible.

D2.2: Begin development of a monthly-to-decadal forecast system for Africa that will provide a consistent set of forecast products on all timescales.

D2.3: Development of observational dataset provision for forecast evaluation and for future attribution.

Year 2:

D2.4: Delivery of experimental monthly-to-seasonal forecasts of key quantities where skill is present to DFID stakeholders.

D2.5: Improved understanding of the drivers of predictability in African climate and their representation in monthly-to-decadal forecasts (see output 1).

D2.6: Assessment of the potential for robust attribution of extreme climate conditions and weather events in Africa.

Year 3:

D2.7: Experimental monthly-to-decadal forecasts for Africa using the new HadGEM3 system and estimates of prediction skill based on the existing and new systems.

D2.8: Provision of monthly-to-decadal forecast information from the new system for selected skilful regions for conversion to use in the PRECIS system (see output 3)

D2.9: Provision of near-real time experimental attribution system to run alongside forecast information system.

Output 3: Enhance technical/scientific capacity (PRECIS) for simulation of national/regional climates

Staff resources: 2 FTE

Deriving useful regional climate information from available climate forecast and long term climate projection data requires a good understanding of the quality of the data sources. Having confidence in and the ability to apply this information is significantly enhanced by: (a) having access to the models and data from which it is derived: and (b) being involved in generating it. There is a significant lack of this information and capability within Africa which is an important issue given the many developing countries there whose economies are heavily dependent on agriculture and natural resources that are vulnerable to fluctuations in climate.

PRECIS (Providing Regional Climates for Impacts Studies) is a regional climate modelling system developed at the Met Office Hadley Centre which incorporates Hadley Centre RCMs, boundary conditions from a range of GCMs, data processing, analysis and display tools backed up by a flexible and in-depth training programme. PRECIS can thus be used for:

- (1) scientific analysis of drivers of local and regional climate variability;
- (2) developing and analysing high resolution regional climate scenarios;
- (3) supporting the application and dissemination of regional climate information.

In this Output, in collaboration with African scientists, an in depth analysis will be undertaken of the capability of PRECIS to simulate and help research African climate variability. New capability will be added to incorporate multi-model boundary conditions and incorporate regional forcing scenarios. New capability will also be added to enable it to provide detailed seasonal-to-decadal predictions.

Work for this output will contribute to upgrading PRECIS-V2 to PRECIS-V3 by including the RCM version of HadGEM3. For further information on PRECIS-versions and their relationship with Hadley global and regional climate models, please refer to Appendix A.

Research conducted for this output will also contribute to the Coordinated Downscaling Experiment (CORDEX) of the World Climate Research Programme (WCRP), which aims to provide downscaled climate scenarios for Africa in the context of the 5th Climate Models Intercomparison Project (CMIP5) run to assist in the development of the IPCC's 5th assessment report (AR5)⁴.

⁴ see http://wcrp.ipsl.jussieu.fr/RCD_Projects/CORDEX/CORDEX.html for more details

Workplan for Output 3

- 1) Evaluating PRECIS over Africa and comparing with other RCMs: Run, in collaboration with African partners, simulations of 1989–2008 using RCMs with physics perturbations from PRECIS V2 driven by the ERA–Interim reanalysis. Run parallel simulations with a prototype HadGEM3 RCM contained in PRECIS V3. Devise and apply metrics to establish the quality of these simulations and parallel simulations run by other climate centres within the WCRP CORDEX programme.
- 2) Enabling PRECIS to be driven by global monthly-to-decadal predictions: Develop systems to enable PRECIS to be driven by the Met Office Hadley Centre seasonal and decadal predictions (using the new model) and make these available to regional centres. Maintain and enhance current IT systems and develop PRECIS functionality to support the application and dissemination of these data and/or systems.
- 3) Enabling PRECIS to incorporate regional forcing scenarios including aerosols (dust), tropical deforestation and other land use changes: Ensure functionality developed to model the relevant processes in the global Earth System version of HadGEM3 is implemented in PRECIS V3. Run and validate simulations of PRECIS V3 over Africa incorporating important regional forcings including mineral dust, black carbon, deforestation and other land use changes.
- 4) Capacity building: There will be extensive scope here for direct involvement of African scientists. The focus of this output is to develop capability that will be used in Africa and the partnerships, visitors and fellowships will be central to the use of this capability.

Deliverables for Output 3

Year 1:

D3.1: Assessment of the climatological skill over Africa of RCMs from the PRECIS V2 ensemble and comparison with available RCMs run for CORDEX.

D3.2 Comparison of the above results with HadGEM3-RA (the regional model version of HadGEM3).

Year 2:

D3.3: Development and validation of HadGEM3-RA incorporating important regional climate forcing factors for Africa including aerosols and land-use changes.

Year 3:

D3.4: PRECIS V3 incorporating the latest Hadley Centre RCM HadGEM3-RA including all developments relevant to Africa.

D3.5: Provision of an experimental downscaling capability to run in-country of monthly-to-decadal predictions from the new HadGEM3 system.

2b) Knowledge Management Component

Staff resources: 0.5 FTE⁵

Initial consultation: The addition of a knowledge management component represents a unique feature of this partnership, which aims to ensure maximum usefulness and uptake of research results through ‘capacity building’ (output 4) and ‘research into use’ (output 5). The project will initiate with a consultation process, which will inform and shape all outputs in both the science and knowledge management components of the CSRP. The results of this consultations will guide the definition of the main output variables to be considered under the “core-science” outputs of the programme and help identify specific science partnerships, communication channels and capacity building activities to be considered under the knowledge management component. Some specific opportunities for capacity building have already been identified under the science component outputs.

Partnerships: Both capacity building and research into use activities will target existing African climate institutions, with whom the project will aim to develop specific partnerships. An initial list includes ACMAD, IGAD/ICPAC, CILSS/AGRYMET, DMC-GABORONE and OSS, which represent regional climate information intermediary organisations in Africa. The project will also liaise closely with the Regional Climate Outlook Forums (RCOF) for Africa, which provide consensus seasonal forecasts for specific African regions where such forecast can be provided with a minimum amount of skill.

The project will also work closely with the DFID/IDRC funded Climate Change Adaptation for Africa (CCAA), the DFID/NERC/ESRC funded Environmental Services for Poverty Alleviation (ESPA) and the AU/UNECA/AfDB managed Climate for Development⁶ (CLIMDEV) projects to identify capacity building needs and opportunities and pursue joint activities to test the usefulness of climate prediction products. This will concentrate on two specific research products: (i) the provision of enhanced seasonal forecast information to underpin early warning systems, which is an essential component in mitigating the effects of current climate variability and change and (ii) the provision of improved decadal prediction information, and the new regional PRECIS scenarios that will be enabled by this programme, which will provide highly relevant inputs to adaptation planning. A priority in the early part of this programme will be an in-depth consultation with ClimDev, CCAA and ESPA to ensure full use can be made of the science outputs developed here. The project will also consult with the Humanitarian Futures Programme⁷ (HFP) to explore avenues for improved climate science – humanitarian assistance linkages.

⁵ In addition to staff resources provided under outputs 1, 2 and 3 who will be responsible for supervising specific capacity building activities under those outputs

⁶ and related CLIMDEV ‘offshoots’, such as the AfDB’s recently approved ‘Institutional Support to African Climate Institutions Project’

⁷ <http://www.humanitarianfutures.org/mainsite/>

Output 4: Capability of southern institutions to do and use climate science

This output will aim to contribute to the continuous development of African climate science research capacity and strengthen the activities of regional climate centres. This will be achieved through a combination of fellowships, training workshops and collaborative working with African scientists and regional centres.

The specific activities that will be supported to develop African research capacity will be determined during the initial on-site consultation mentioned above. They are likely to comprise activities to meet short term requirements as well as specific actions aimed at creating new capabilities with long term requirements in mind. The former will focus on enhancing the capacity of existing meteorological and climate information network to transfer climate information to ‘boundary agents and agencies’⁸. The latter will likely involve fellowships to African graduate students to pursue research on African climate issues⁹. Subjects will be chosen to contribute to core science outputs 1, 2 and 3, and fellows will be attached to the science teams developing those components.

A number of options will be considered to strengthen the activities of regional centres. One option will be to append tailored training workshops to targeted RCOF meetings. Another involves establishing a new learning platform through an alternative network, such as CCAA. The full costs and benefits of each option will be evaluated during the initial consultation and detailed plans drawn up during the project’s inception phase.

The scoping study (See CSRP Programme Memorandum - Annex 1) identified several potential partners for capacity building, including START, the global change SysTem for Analysis, Research and Training, IRI, The International Research Institute for Climate Prediction and ACCFP, African Climate Change Fellowship Program. Special efforts will be made to ensure capacity building activities promoted under the CSRP add value to these existing programmes.

Workplan for Output 4

1) Initial consultation: The starting point for Output 4 is the initial consultation process which will aim to understand the current capabilities and requirements of the main African institutions (see above for details). The subsequent capacity building exercise will have a two pronged approach: strengthening institutional capacity and strengthening individual technical capacity.

2) Strengthening the existing capacity to better use climate forecast information: This output will enable the better use of existing forecast information and the development of new forecast products that are identified through the consultation process. In addition, it will be important to develop improved and ‘user-friendly’ guidance on the use and interpretation of information from climate forecasts systems. A further aim will be to enable a better understanding and use of climate scenario information (from

⁸ Ie: professionals and organisations that interpret technical information for development purposes

⁹ These could include PhD fellowships, attached to African Universities, and with technical inputs from the Hadley research team, to strengthen the pool of in-country climate science researchers.

PRECIS) to underpin adaptation policy and planning. The project will attempt to identify suitably qualified experts in relevant boundary agencies (see list above) to enhance the climate science and forecasting contribution to existing early warning and adaptation/development projects in their organizations, as well as providing valuable feedback on the usefulness of existing climate forecast information. Thus capacity will be strengthened through the supply chain from national/regional forecast providers through to boundary agencies and onto vulnerable sector of African society.

3) Longer term capacity building: A mechanism will be developed to award fellowships to African graduate students to pursue research on African climate issues, potentially leading to a PhD or other post-graduate degree, as a way of strengthening the pool of in-country climate science researchers. The students would register for their degree in African universities and visit the Met Office regularly as a part of their PhD project. The content of the projects will be integral to the science workplans link to outputs 1, 2 and 3. The initial consultation process will explore how this may be taken forward with African regional partners and national universities. Consideration will also be given to post-doctoral level visiting scientist to work at the Hadley Centre as an integral part of the team working on the science outputs 1, 2 and 3.

4) Training Workshops: The project will also consider running technical workshops in Africa that will be designed and jointly led by Hadley Centre staff and African partners. The workshops will focus on improving the usage of climate forecast and scenario information, and specifically the new information emerging from this programme. Two options for the provision of training in Africa will be considered as part of the initial consultation:

- 1) to use the existing RCOF structure - there is a strong advantage to this option as it links into existing mechanisms for training and to the community directly engaged in constructing regional/national seasonal forecasts;
- 2) to establish a new platform through existing climate networks (e.g. ClimDev and/or CCAA) and invite the representatives of the *Boundary Agencies* to the workshop. This could be more productive as it will not be constrained by other training providers and therefore able to tailor the training more effectively to the outcome of this programme.

Deliverables for Output 4

Specific deliverables under output 4 will be defined during the project's inception phase and agreed with DFID at through a discussion of the inception report.

Output 5: Research products that target demand and are accessible to users

The primary objective of the CSRP is to increase the knowledge pool on African climate drivers with a view to improving their representation in climate models and thereby enhancing the skill of climate predictions. The main research output will consist of articles in peer reviewed journals and a prototype set of tailored climate products that will be evaluated as part of the research collaboration with African stakeholders. The delivery of operational products is outside of the scope of this programme. In addition, targeted policy briefs and technical reports will be written to inform strategic policy forums (e.g. Nairobi Work Programme, RCOF's, ...) and decision makers.

The project will aim to maximise the potential use of research outputs by decision makers in Africa. The training workshops proposed in output 4 will be used to disseminate the climate products to partners. PhD topics suggested for the long-term capacity building plan (in output 4) will be used as case studies to test and demonstrate the usefulness of climate information to humanitarian, development and climate adaptation processes.

The project will start with a consultation to identify the climate variables that are most useful to African stakeholders and to tailor products and services that are most relevant to the most vulnerable groups in Africa prior to initiating the science activities outlined in outputs 1, 2 and 3. The feasibility will be tested of supporting 'Research Into Use Champions' as part of the capacity building exercise under output-4, to promote the use of climate products in the existing development projects.

Workplan for Output 5

1) Initial Consultation: as explained above, the project will initiate with a consultation with African stakeholders, which will aim to i) understand and identify the climate forecast variables that are most useful to African stakeholders, ii) identify how climate information can best be communicated (e.g. web delivery, timeliness, scale and range of products), iii) identify the African requirements for the PRECIS modelling capability, iv) scope and prioritise options for training, both content and format and v) identify potential African university partners that will engage in the fellowship scheme.

2) Targeted 'Research into Use activities': Use will be made of the communication channels and forums established under output 4 to extend research results to potential information users. In addition, an attempt will be made to identify and nurture 'Research Into Use Champions' in African boundary agencies to promote the appropriate use of climate products in existing development projects – see above notes on partnerships for more details.

3) Publishing of research results: In addition to publishing climate science articles in peer reviewed journals, targeted policy briefs and technical reports will be written to inform specific policy forums (e.g. Nairobi Work Programme) and decision makers.

Deliverables for Output 5

Specific deliverables under output 4 will be defined during the project's inception phase and agreed with DFID at through a discussion of the inception report.

3. Timeline

The project's timeline is outlined in table 1.

Table 1 : Project timeline

OUTPUT	Jan-Jun 2010	Jul-Dec 2010	Jan-Jun 2011	Jul-Dec 2011	Jan-Jun 2012	Jul-Dec 2102
Output 1						
D1.1: Following the user consultation and prioritisation of processes and variables, diagnostics and measures to quantify the ability of HadGEM3 to simulate African regional climate will be developed..						
D1.2: Evaluation of the simulation of key local processes e.g. the WAM in HadGEM3.						
D1.3: Evaluation of the impact of tropical variability (e.g. ENSO) on the variability of African climate.						
D1.4: Improved understanding of the land-atmosphere coupling and the water cycle influence on key African rainfall systems.						
D1.5: Understanding of the role of resolution on the simulation of key processes driving African Climate.						
D1.6: Delivery of an improved HadGEM3 model for monthly-to-decadal forecasting for Africa						
Output 2						
D2.1: Assessment of monthly-to-seasonal prediction skill for African regions based on existing capability, including monthly forecasts and extreme events where possible.						
D2.2: Begin development of a monthly-to-decadal forecast system for Africa that will provide a consistent set of forecast products on all timescales.						
D2.3: Development of observational dataset provision for forecast evaluation and for future attribution.						
D2.4: Delivery of experimental monthly-to-seasonal forecasts of key quantities where skill is present to DFID stakeholders.						
D2.5: Improved understanding of the drivers of predictability in African climate and their representation in monthly-decadal forecasts (see output 1)						
D2.6: Assessment of the potential for robust attribution of extreme climate conditions and weather events in Africa						

	Jan-Jun 2010	Jul-Dec 2010	Jan-Jun 2011	Jul-Dec 2011	Jan-Jun 2012	Jul-Dec 2102
D2.7: Experimental monthly-to-decadal forecasts for Africa using the new HadGEM3 system and estimates of prediction skill based on the existing and new systems.						
D2.8: Provision of monthly-to-decadal forecast information from the new system for selected skilful regions for conversion to use in the PRECIS system (see output 3).						
D2.9: Provision of near-real time experimental attribution system to run alongside forecast information system.						
Output 3						
D3.1: Assessment of the climatological skill over Africa of RCMs from the PRECIS V2 ensemble and comparison with available RCMs run for CORDEX.						
D3.2: Comparison of the above results with HadGEM3-RA (the regional model version of HadGEM3).						
D3.3: Development and validation of HadGEM3-RA incorporating important regional climate forcing factors for Africa including aerosols and land-use changes						
D3.4: PRECIS V3 incorporating the latest Hadley Centre RCM HadGEM3-RA including all developments relevant to Africa.						
D3.5: Provision of an experimental downscaling capability to run in-country of monthly-to-decadal predictions from the new HadGEM3 system.						
Output 4						
D4.1: Develop the Capacity Building Strategy expanding on the workplan suggested above and identifying appropriate individuals and organizations. This will also include the procurement process (for example, open competition process to identify students and researchers).						
D4.2: Provide feedback and summary report to inform activities for the subsequent years i) Three 3-month visits by African scientists attached to relevant science themes under outputs 1, 2 and 3. ii) One training workshop in Africa at an identified institution by 3-4 Hadley scientists, followed by one scientist staying longer to provide follow-up support. iii) Provide support to three African scientists to attend conferences.						

	Jan-Jun 2010	Jul-Dec 2010	Jan-Jun 2011	Jul-Dec 2011	Jan-Jun 2012	Jul-Dec 2012
D4.2: Same as year 1, except that the number of exchange visits, training workshops, and conference participants will be decided in consultation with DFID and other African stakeholders.						
D4.3: Same as year 1, except that the number of exchange visits, training workshops, and conference participants will be decided in consultation with DFID and other African stakeholders.						
Output 5						
D5.1: Develop a communication strategy. Provide details of the channels of communications (e.g., web, networks, newsletters, peer reviewed articles, policy briefs). Host a project website either at the Met Office as a part of the communication strategy to promote networking.						
D5.2: Report assessing the user requirements following the initial consultation visit to Africa to inform climate science outputs, such as scale and extent of deliverables, target sectors.						
D5.3: Prepare “success indicators” to measure the effectiveness of climate information dissemination.						
D5.4: Evaluate the performance of success indicators. We need in-country evidence to evaluate the indicators, which could be obtained through the in-country communication champions. Contribute to interim review reports to DFID. Inform and shape workplans for science themes.						
D5.5: Assess the case studies carried under PhD programmes. Submit a “Lessons Learned” report to inform future initiatives.						

Appendix A: Climate Model Versions

	Seasonal (GloSea4)	Decadal (DePreSys)	Centennial	Regional Climate
Horizontal Resolution	Atm: 135km – N96 Ocean: 1.25°, 1/3° tropics	250km – N48 Ocean: 1.25°	135km – N96 Ocean: 1°, 1/3° tropics)	50km or 25km
Vertical Resolution	Atm: 38L Ocean: 42L	Atm: 19L Ocean: 20L	Atm: 38L Ocean: 40L	Atm: 19L
Atmosphere Physics	HadGAM2 + (relative to HadGAM2 some new physics towards HadGEM3 notably a new cloud scheme)	HadAM3 (Climate model vintage from 1997: Gordon et al, 2000)	HadGAM2 (Relative to HadCM3 changes include semi-lagrangian dynamics, much upgraded physics notably new boundary layer, gravity wave drag, microphysics, and sea ice schemes; major changes to the convection, land surface and cloud schemes and an interactive aerosol scheme)	HadAM3 (Climate model vintage from 1997: Gordon et al, 2000) PRECIS 2 uses this version of the atmospheric model and includes multiple perturbed parameter versions.
Ocean Physics	NEMO (Nucleus for European Modelling of the Ocean: Relative to HadGOM1 completely new ocean model (ORCA) with tripolar grid and new sea-ice model (CICE))	HadCM3 (Climate model vintage from 1997: Gordon et al, 2000)	HadGOM1 (relative to HadCM3 ocean changes include 4 th order advection, changes to vertical mixing and new thermodynamics and dynamics of sea-ice)	Driven by HadCM3 (coupled model) SSTs
ES Physics			HadGEM-ES including terrestrial and oceanic ecosystems (land and ocean carbon cycle) and tropospheric chemistry (including mineral dust, methane, ozone)	
Ensembles	40 member/month	16 member	HadCM3 Perturbed physics ensemble	
Initialisation	Atm: Reanalysis Ocean: Met Office global ocean data assimilation (FOAM)	Atm: Reanalysis Ocean: 4D multivariate initialisation of temperature and salinity		

Table 1: Operational Met Office Hadley Centre Model 2009

	Seasonal 2 Decadal	Centennial	Regional Climate
Horizontal Resolution	Atm: – 60km – N216 Ocean: 0.25°	135km – N96 to 60km – N216 Ocean: 1°; 1/3° tropics to 0.25°	50km to 12km
Vertical Resolution	Atm: 85L Ocean: 70L	Atm: 63L, 85L Ocean: 70L	Atm: 63L, 85L Ocean: 70L
Atmosphere Physics	HadGEM3-A + upgrades (Relative to HadGEM2 changes include new cloud scheme improved physics of convection, boundary layer and hydrology + possible upgrades developed since HadGEM3-A version fixed for centennial runs)	HadGEM3-A (Relative to HadGEM2 changes include new cloud scheme improved physics of convection, boundary layer and hydrology)	HadGEM3-A (Relative to HadGEM2 changes include new cloud scheme improved physics of convection, boundary layer and hydrology)
Ocean Physics	NEMO (Nucleus for European Modelling of the Ocean: Relative to HadGOM1 completely new ocean model (ORCA) with tripolar grid and new sea-ice model (CICE))	NEMO (Nucleus for European Modelling of the Ocean: Relative to HadGOM1 completely new ocean model (ORCA) with tripolar grid and new sea-ice model (CICE))	Driven by HadGEM3-AO (coupled model) SSTs PRECIS 3 is based on this version.
ES Physics		HadGEM3-ES (Relative to HadGEM2-ES will include more detailed tropospheric and stratospheric chemistry (UKCA) and more detailed land surface (JULES) both developed jointly with UK universities)	
Ensembles	40 member	HadCM3 Perturbed physics ensemble	N/A
Initialisation	Atm: Reanalysis Ocean: Either 3D or 4D multivariate initialisation of temperature and salinity Working towards fully coupled atmosphere and ocean initialisation		

Table 2: Aspirational operational Met Office Hadley Centre Models

