

CCRG EASTER MEETING, 1-2 APRIL 2008, UNIVERSITY OF READING
Abstracts

Plenary sessions, in order of presentation. Presenting author in italics.

PLENARY 1

Integrating seasonal forecasts for health impacts in Africa - the story so far...

Andy Morse

Seasonal forecast products with lead times of up to six months, especially those from ensemble prediction systems (EPS), are routinely produced within major operational forecasting centres and although these data are often disseminated, on the whole, there has been little connection between the needs of the impacts community and users, and the forecast centres. Recent (DEMETER) and current (ENSEMBLES and AMMA) research projects are undertaking collaborative research to allow the eventual operational use of these forecast products by health planners and decision makers in Africa. This paper will address many of challenges when integrating a user impacts model within an EPS and areas where there are still gaps within the integration process and the effective implementation of the results.

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PLENARY 2

Adaptation to climate change and variability in Southern Africa

Chasca Twyman

Research agendas that aim to improve understandings of people's potential to adapt to climate change require both appropriate frameworks for analysis and empirical data to interrogate questions about how adaptation occurs. These requirements can be met if research embodies the tools for climate data analysis, in order to identify the details of changes in climate parameters, and methods for identifying and then exploring response to the climate factors relevant to people's livelihoods. This paper attempts to show how these requirements can be met, through an analysis of responses to scientifically identified climate dynamics in South Africa.

PLENARY 3

African Regional Climate Information: Deliverables and Difficulties

Richard Washington

The Gleneagles G8 in 2005 did much to raise the political agenda of climate change in Africa. Not surprisingly, a variety of NGOs and government agencies have begun to examine the ways in which climate, both current and future, may influence their development efforts. Recent work has been commissioned by, amongst others, the UK DFID, World Bank and Oxfam to provide assessments of future climates in Africa. This presentation evaluates the extent to which the climate information needs of these organisations can be met by currently available (e.g. IPCC AR4 CMIP3) data. By way of some case studies, inadequacies in the available information are discussed.

PLENARY 4

Demographics and climate change: future trends and their implications for migration in Africa

Dominic Kniveton, Richard Black, Ronald Skeldon, Daniel Coppard, Akira Murata and Kerstin Schmidt-Verkerk

The consequences of climate change, including changes in the frequency and violence of extreme weather events and changing precipitation patterns are expected to have large impacts on people's livelihoods, especially in poor and vulnerable rural societies. In many of these societies migration has already been a livelihood strategy for generations. Shocks and stresses evoked by the consequences of a changing climate that threaten people's livelihoods are therefore also likely to have impacts on their migratory behaviour. Migration might increase as people need to search for a living elsewhere. But it might as well decrease as fewer people can afford to move. It is also conceivable that migrants choose different destinations that they perceive as more appropriate for their changing needs.

Despite the growing awareness of the nexus between climate change and migration the subject has not been explored empirically in a way that generates conclusive results. In this talk I will outline the key elements of demographical and climatic change of potential relevance to migration; as well discuss the current state of the debate about the relationship between climate change and describe approaches with which to further our understanding of climate change-related migration.

Session talks, in alphabetical order (by surname). Presenting author in italics.

Understanding the political economy of climate change is vital to tackling it

Diana Cammack

Climate change has reached the top of the international agenda even while debates about its causes, consequences, timing, trajectory and remedies continue. Technologists and planners are devising ways of mitigating and adapting to climate change in advance of its full impact. Financial experts are exploring the impact of climate change on trade and investment, the cost of climate change and the cost of addressing it. Development specialists are beginning to plan for the impact that climate change will have on social services and public goods. Meanwhile defence specialists are studying the security threat that climate change poses – labelled by the UK Chief Scientist as ‘more serious than even the threat of terrorism’. Post-conflict analysts are linking peacebuilding and adaptation to climate change.

Rainfall estimation over Africa using MSG

Robin Chadwick

Africa has a vital need for rainfall estimates, as many areas are extremely vulnerable to excesses and deficits of rain. Satellite rainfall estimates have the potential to be fed into crop yield and hydrological models, and can be used to predict flooding and drought in Africa. Due to financial and infrastructural constraints, rain-gauge and precipitation radar networks are currently extremely sparse over most of Africa. There is a particular shortage of rain-gauge data that is available in real time. Satellite-based rainfall monitoring provides a method of producing rainfall estimates for the entire continent, without the need for extensive real time surface observations.

The UK Met Office and the University of Reading are running a project to produce and validate rainfall estimates over Africa using Meteosat Second Generation (MSG) data, calibrated with precipitation radar data. This is based on a product already used operationally by the Met Office over Europe, calibrated with the European radar network.

The African rainfall estimates use a similar algorithm to the European estimates, and were initially calibrated in the same way using European radar data. These estimates were validated against African rain-gauge data in the Sahel region where there is a reasonably dense network of gauges. The MSG estimates were also compared with rainfall estimates produced by the University of Reading's TAMSAT African rainfall estimation algorithm, which has been shown to perform well in the Sahel region. The validation used historical MSG, European radar and rain-gauge data from May – Sept 2004.

The results of this show that the Met Office scheme performs less well than the TAMSAT scheme, so changes to the Met Office scheme will be necessary before the product can be disseminated to users in Africa. Work is ongoing to re-calibrate the Met office scheme using historical African radar data gathered as part of the 2006 AMMA campaign.

African climate change: assessing the vulnerability of food crop systems

Andrew Challinor

Agriculture plays a crucial role in supporting rural livelihoods and economic growth over most of Africa. The vulnerability of food crop systems depends upon the sensitivity of crops to variability in climate, the adaptive capacity of farmers, and the role of institutions in adapting to climate change. This presentation reviews each of these. The reasons for the wide variation in projected impacts of climate change on food crops in Africa are assessed, and future research needs in this area are identified. The ability of farmers to adapt to climate variability and change will depend on the level of access to relevant knowledge and information. Finally, we note the importance of policies that support and facilitate adaptation and resilience to climate change at local, national and transnational level.

Application of seasonal rainfall forecasting and satellite rainfall monitoring to crop yield forecasting for Africa

Helen Greatrex

Agricultural production is highly dependent on weather and climate. This is particularly the case in Sub-Saharan and Eastern Africa, where a lack of resources for irrigation and fertilisation can leave many communities vulnerable to crop failure. This can easily lead to famine, food insecurity and negative economic growth. Therefore for both economic and humanitarian reasons, the ability to accurately forecast crop yields on a timescale of months would be of enormous benefit. It would enable both governmental and non-governmental organisations to be alerted in advance to famine and it would facilitate national and regional economic planning. Individual farmers and communities could also benefit from a seasonal crop yield forecast, as it would enable them to take more informed decisions about their crop management and increase their resilience to climate change.

The aim of this project is to create a seasonal crop yield forecast for Ethiopia using the General Large Area Model for annual crops (GLAM). This is a process based model, designed to operate on scales similar to those of global and regional climate models. It also requires relatively few input parameters that need local calibration, making it ideal for regional seasonal forecasting. As the main determinant of crop yield in Eastern Africa is the quantity and distribution of rain, a model can be envisaged which runs GLAM using a seasonal rainfall forecast to provide an initial crop yield prediction. This prediction could then be continually updated by replacing the seasonal forecast with daily satellite rainfall observations as the growing season progresses. This should provide an increasingly accurate forecast. Satellite rainfall estimates are used rather than rain gauge data as real-time ground based measurements are too sparse to be useful over much of Africa. These have been shown to be accurate if locally calibrated; therefore work is ongoing to calibrate the TAMSAT African rainfall estimation algorithm for daily rainfall in Ethiopia using historical rain-gauge data.

In order to define the uncertainty associated with the yield forecast, an important feature of the proposed system is the generation of an ensemble of rainfall estimates from both the seasonal forecasts and the satellite information. This allows a range of possible yield outputs to be generated, thus describing the likely accuracy of the forecast.

Comparison of satellite based and raingauge based rainfall estimates for northern Africa

Ross Maidment & *David Grimes*

In the seasonally arid regions of Africa, rainfall is the most important meteorological parameter because of the strong dependence of the majority of the population on rain fed agriculture. It follows that measurement of rainfall should have a high priority so that agricultural yields can be predicted within the current season and so that climate variability and possible change in the longer term can be properly quantified.

Unfortunately, the current state of conventional monitoring is inadequate and getting worse. Raingauge networks fall well below the densities specified by WMO and operational radar is virtually nonexistent. Over the last 30 years a number of satellite methods for rainfall monitoring has become available. While these potentially provide a solution to the data shortage, there has been a lack of validation of the various methods against independent data. In this paper, we present a case study of comparison of TAMSAT satellite-based dekadal (~10 day) rainfall totals with an internationally available set of raingauge data and a dense network of raingauge data provided by the Agrhymet Centre in Niger. Although none of these data sets can be regarded as definitive, the comparison allows inferences to be drawn about their strengths and weaknesses and to delineate areas in which the TAMSAT data are likely to provide reliable estimates.

The UNDP Country Scale Climate Change Study

Mark New, *Carol McSweeney* and Gil Lizcano

Many developing countries have difficulty accessing the wealth of information on climate change available at various data centers around the world, yet require concise information on climate change at the national scale to inform international negotiations and national impacts assessments and adaptation plans. The UNDP Country Scale Climate Change Study provides summary information on past trends and future projections of key climate variables in an easily accessible format. For each country, we provide (1) A narrative describing key observed and projected climate changes, (2) area-average trends in mean and extreme climate, on annual and seasonal time-scales, from 1961 through to 2100, (3) spatial maps of multi-model ensemble mean climate changes and ensemble range for 10-year time-slices from 2010-2019 through to 2090-2099 and (4) easy to use text/EXCEL files containing the underlying data.

Nature and mechanisms of climate variability and change in east and central Africa and their impact on terrestrial hydrology in Uganda

Lucinda Mileham

Predicted future warming in equatorial Africa, accompanied by greater evaporation and more frequent heavy precipitation events, is expected to have substantial but uncertain impacts on terrestrial hydrology. Current low-resolution (~250 km) General Circulation Models (GCMs) are of limited use to regional and local-scale decision support systems for climate change impacts. Quantitative analyses of the impact of climate change at the local scale requires the improved representation of land-surface characteristics that is afforded by dynamical downscaling of GCM output (HadCM3) using a higher resolution (<50 km) Regional Climate Model (RCMs). In this study, precipitation simulated by the RCM, PRECIS (Providing Regional Climates for Impact Studies), is validated at regional (236,000 km²) and catchment scales (2,100 km²) and used to quantify the impacts of climate change on runoff and groundwater recharge in the River Mitano catchment of south-western Uganda using a semi-distributed soil moisture balance model (SMBM). PRECIS represents well the spatial and temporal distribution of precipitation but substantially overestimates its magnitude at regional and catchment-scales. SMBMs explicitly account for changes in soil moisture and enable assessments of climate change on groundwater by partitioning effective precipitation into groundwater recharge and runoff. The semi-distributed SMBM, calibrated with daily station data over a 15-year period (1965-1979), estimates a mean annual recharge of 104 mm·a⁻¹ and mean annual surface runoff of 144 mm·a⁻¹. PRECIS predicts a 14% increase in catchment precipitation accompanied by increased precipitation intensity and a 48% increase in potential evapotranspiration by 2070-2100, based on A2 SRES emission scenarios. Under these future conditions, an 80% reduction in mean annual recharge to 21 mm·a⁻¹ is predicted. This doctoral thesis presents one of the first catchment-scale, hydrological models driven by a RCM in East Africa and one of the first quantitative assessments of the catchment-scale impacts of climate change on groundwater in the humid tropics.

Use of large-ensemble GCM data in regional climate risk assessment

Mark New, Ana Lopez and Chak Fai Fung

Large-size climate model ensembles are becoming readily available, either through specific projects such as *climateprediction.net* (tens of thousands of ensemble members) or through multi-model ensembles such as those contributing to the IPCC 4th Assessment (several tens of ensemble members). Using data from such ensembles opens new possibilities for risk-based climate change assessments, but present considerable interpretation challenges, relating to both the sheer amount of model runs and differences in model skill over the region of interest. We present a likelihood-based methodology for assessing relative risk in key climatic and/or impacts thresholds at national and sub-continental scales.

Climate change, migration and agent based modelling

Christopher Smith

Climate change and migration share high profiles on political agendas around the world. This is particularly the case in the context of Sub-Saharan Africa, the region generally considered to be most vulnerable to the negative impacts of climate change. The population and economy of many of these Sub-Saharan countries rely heavily upon rain-fed agriculture and cattle-raising, making communities highly sensitive to changes in climate variables such as rainfall. However, the relationship between the issues of climate change and migration is poorly understood and largely contested. Considerable debate has occurred in the past 20+ years over the existence of 'environmental refugees' as those people forced to flee their native lands as a result of changing environmental conditions. Despite the debate regarding the actual existence of 'environmental refugees', it is generally accepted that environmental factors do play a part in forced migration, and, as a result of climate change, these factors may become more pertinent to the decision to migrate. Some estimates currently put the number of climate change induced migrants in the hundreds of millions while others suggest that this estimation is a gross exaggeration as a result of over-simplification. Methodologies which attempt to quantify climate-change related migration generally suffer at the hands of the complexity involved in determining the level of influence of climate as a contributory factor. The application of a well established cognitive modelling technique (that of agent-based modelling) to the migration and climate discourse is intended to assist in quantifying the impact of climate upon migration and provide a means to assess the contribution of climate to that decision. This presentation therefore aims to outline the potential relevance of climate change to migration and explore the opportunities for applying an agent-based modelling technique as a means to simulating the decision-making process of migrants in a Sub-Saharan context.

Impacts of climate change on groundwater resources in sub-Saharan Africa

Richard Taylor, Lucinda Mileham and Callist Tindimugaya

For decades, communities across much of sub-Saharan Africa have overcome intermittent and sustained water scarcity through the development of groundwater. Rising demand for freshwater due to population growth and projected rises in agricultural production in the coming decades will serve to heighten regional dependency upon groundwater resources. Changes in terrestrial hydrology as a result of climate change remain highly uncertain especially at scales (e.g. catchment, sub-national) where communities can develop and implement mitigation strategies. We report recent research from a case study in the inner tropics of Uganda seeking to address these knowledge gaps. Dynamical downscaling of output from General Circulation Models (HadCM3, A2 scenario) using the PRECIS Regional Climate Model reveals increases in the frequency of heavy rainfall events ($> 10 \text{ mm}\cdot\text{day}^{-1}$) for the period 2070-2100 relative to 1960-1990 in addition to rising air temperatures. Catchment-scale hydrological modelling of a medium-sized (2097 km^2) catchment shows, however, that these trends lead to an 85 % reduction in groundwater recharge due primarily to increased evapotranspiration. The forecasted reduction in contributions to groundwater storage due to climate change will provide a significant challenge to the sustainability of intensive groundwater abstraction for town water supplies and irrigation from the localised (discrete) aquifer systems that occur within weathered crystalline rocks underlying 40% of sub-Saharan Africa. The predicted rise in heavy rainfall events increases the risk of diarrhoeal disease through more frequent flushing of pathogenic microorganisms in faecal wastes to groundwater sources. The interruption of source – receptor pathways through improved community hygiene represents an effective intervention to mitigate the heightened risk to human health posed by climate change.

Teleconnections between East African summer rains and SST

Gulilat Tefera Diro, David Grimes and Emily Black

Rainfall is the most important climate parameter in many part of Africa since the economy is based mainly on rain fed agriculture. Understanding the mechanisms that lead to anomalous rainfall is therefore a great significant for the seasonal prediction. Previous studies have shown that warm/cold tropical central and eastern Pacific Sea Surface Temperature Anomalies (SSTAs) are linked to deficit/excess summer rains and excess/deficit spring rains over northeast Africa. In this study, the mechanisms for the link between tropical eastern and central Pacific and Ethiopian rains are studied using observational and modelling studies.

In the observational study, two sets of composites were analysed. The first set was composites of large scale atmospheric features based on excess and deficit rains to understand the large scale rainfall controls. The second set was also composites of large scale atmospheric features but based on warm and cold SSTs over equatorial Pacific. The observational study suggests that warm/cold equatorial Pacific SSTAs are linked to excess/deficit summer rainfall via the Tropical Easterly Jet (TEJ), the East African Low Level Jet (EALLJ) and westerly anomalies from Atlantic. In the modelling study, Atmosphere only General Circulation Model (HadAM3) forced with observed (HadISST) and idealised SSTA patterns was used to investigate whether there is a causal link between rainfall and SST and also to understand the mechanism of the link (if the link is causal). The HadISST forced HadAM3 run shows that the model captures the inter-annual variability of rainfall associated with ENSO. The idealised SST experiments suggest warm equatorial Pacific directly causes deficit summer rains and excess spring rains. Warm SSTA in the tropical Pacific triggers planetary waves (Kelvin and Rossby) in the equatorial Pacific and these waves transfer the anomalous energy over Africa and Asia and affect the large scale controls over Africa (the TEJ, EALLJ, moisture influx from Atlantic and Indian ocean, etc) and ultimately the rainfall.

Climate Change Impacts on Hydrology and Ecology of the Okavango River System, Southern Africa

Martin Todd, Wolski, Mackay, Davidson, Raghavan, Hughes, Kniveton

The Okavango river is one of the largest rivers in Africa and is best known for the Okavango Delta, an alluvial fan at the terminus of the river system, which is the worlds second largest inland wetland system (Maximum area $\sim 20,000\text{km}^2$). The wetland system, located in semi-arid Botswana, is sustained by an annual pulse flood which occurs 6 months out of phase with the local rainfall seasonal cycle. This characteristic and the lack of local development mean the Okavango delta is a rather unique hydro-ecological system characterised by high biodiversity. As a result it is the world's largest Ramsar site. Given the central role of hydro-climate in maintaining the system it may be sensitive to future climate change. Climate change impacts on the basin and delta have been quantified using a suite of hydrological models driven by climate change estimates from multiple GCMs and Regional climate models. There is considerable uncertainty in the sign and magnitude of future changes to the basin hydrology and therefore to the ecological impacts. The paper considers the relative magnitudes of the various sources of uncertainty and policy implications.

East-African rainfall variability in a high-resolution atmospheric GCM

Thomas Toniazzo, Len Shaffrey and Gulilat Tefera Diro

We present a first analysis of East-African rainfall distribution and its interannual variability as simulated by the high-resolution HiGAM model. An AMIPII integration is compared with gauge data and ERA40 reanalysis in terms of the spatial patterns, the seasonal cycle and the controls on interannual variability. A comparison is also carried out with the HadAM3 model to assess the impacts of resolution in the simulation of the regional climate.

Influence of Future Land Cover and Global Climate Change on the Climate of Central Africa

Esther White, Charles Williams, Emily Black, Dominic Kniveton and Julia Slingo

Although impacts of past land surface changes and increasing greenhouse gas (GHG) concentrations have been studied individually for Africa in the past, there is currently little research on how these processes may interact in the future. Human activity has both a direct effect on the local environment through land use changes, and an indirect effect through emission of GHGs. This PhD project considers Central Equatorial Africa, including the rainforest belt encompassing the region 7N-12S and 15-32E. This region is vulnerable to changes in land cover, such as deforestation, due to increasing socio-economic pressures. This project aims to assess the sensitivity of the regional climate to land cover changes and compare this with the sensitivity of the regional climate to global climate change, using a Hadley Centre climate model. In order to validate model simulation of the regional climate, particularly regarding precipitation, a number of data sources are considered. These include reanalysis, satellite and gauge where possible. Large scale and local mechanisms that influence precipitation temporally and spatially within Central Africa are considered.

Extreme rainfall events over southern Africa: influence of Atlantic sea surface temperatures on rainfall variability

Charles Williams, Dominic Kniveton and Russell Layberry

Rainfall variability and the identification of rainfall extremes is a function of scale, so high spatial and temporal resolution data are preferred to identify extreme events and accurately predict future variability. In this research, high resolution satellite derived rainfall data from the Microwave Infra-Red Algorithm (MIRA) are used as a basis for undertaking idealised model experiments using a state-of-the-art regional climate model. The MIRA dataset covers the period from 1993-2002 and the whole of southern Africa at a spatial resolution of 0.1 degree longitude/latitude. Once the model's ability to reproduce extremes has been assessed, idealised regions of sea surface temperature (SST) anomalies (associated with the identified extreme days) are used to force the model, with the overall aim of investigating the ways in which SST anomalies influence rainfall extremes over southern Africa.

In this paper, results from sensitivity testing of the UK Meteorological Office Hadley Centre's regional climate model's domain size are firstly presented. Secondly, simulations of current climate and rainfall extremes from the model are compared to the MIRA dataset at daily timescales. Finally, the results from the idealised SST experiments are presented, suggesting associations between rainfall extremes and both local and remote SST anomalies.