Welcome to the First WCRP Africa Newsletter

We are very pleased to introduce the first issue of the WCRP Africa Newsletter. The CLIVAR and GEWEX African Climate Panel, sponsored by the World Climate Research Programme (WCRP), decided to launch the Newsletter for the African climate research community to share new research results, funding, training opportunities and events, and to share programmatic news. We wish to make the newsletter relatively informal so that the content is not restricted to completed work, but also can include on-going and planned studies. The aim of such an informal publication is that the contributions will reach an international audience, both within and outside Africa, in a timely manner.

The Newsletter is intended to help generate ideas for new collaborative links by strengthening the network of scientists within Africa and by familiarizing scientists working outside Africa with the activities of African research groups. We anticipate that the projects and activities presented in the Newsletter will be of interest to the climate science community and funding agencies, as well as users of science-based climate information.

This first issue is dedicated to short notes from the fellows of the fellowship scheme of the DFID-Met Office Climate Science Research Partnership (CSRP) for Africa. We invited the CSRP fellows to contribute short articles outlining their work, regardless whether they are just starting out or reaching completion, as an opportunity to publicize their work. The release of the first issue has been timed to coincide with the CLIVAR Exchanges Special Issue on Africa (Exchanges No. 60, September 2012 - http://www.clivar.org/publications/exchanges) that gives an overview of key on-going African climate science coordinated research programs. The Newsletter will be produced quarterly and we welcome articles from individual scientists to share their own work as well as collections of articles from research groups or projects that wish to share with the community their activities. Please email the International CLIVAR Project Office (icpo@noc.ac.uk) if you are interested or would like more information.

The fellowship scheme of the DFID-Met Office Climate Science Research Partnership for Africa

R.J. Graham

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The papers collected in this newsletter summarise research being conducted by African climate scientists as part of the Climate Science Research Partnership (CSRP) between the Department for International Development (DFID) of the UK Government and the Met Office Hadley Centre (MOHC). The research is being done in close collaboration with the MOHC and is supported by a fellowship scheme coordinated as part of the CSRP programme.

The key aims of the CSRP are to advance understanding of African climate processes and their representation in climate models; to develop, with users, new climate monitoring and experimental monthly-to-decadal prediction products and to strengthen climate science in Africa. The reader is referred to Graham et al. 2012 and to www.metoffice.gov.uk/csrp for a summary of the programme and its results so far. By aligning the fellowship projects to the CSRP's research themes, the fellowship scheme is advancing the science objectives of the programme, enhancing the professional development of the fellows and increasing understanding between climate model developers at the MOHC and climate researchers and climate forecasters in Africa

Eleven fellowships were awarded following a call for applications in December 2010. Applicants were required to be resident African nationals and to conduct their fellowships at an African institute - either their home institute or as a visiting scientist at a hosting African institute. Three types of fellowship were offered: postdoctoral and postgraduate research fellowships, both of one year duration (four and five fellowships awarded, respectively), and applications project fellowships of 6 months duration (two awarded). A range of regional interests are covered with four fellowships in each of East and West Africa, two in southern Africa and one in Central Africa.

The fellowship research themes are: 1) climate model evaluation, 2) climate process understanding, 3) seasonal forecasting, 4) decadal prediction, 5) observational data development and recovery and 6) regional downscaling. The papers provide extracts of work done within this framework and cover the following topics:

- model representation of the West African monsoon and its intraseasonal characteristics;
- investigation of the drivers of the low-level westerly flow over western equatorial Africa – of prime importance to the water cycle;
- teleconnections of East African rainfall to global sea surface temperature;
- assessment of regional climate model simulations and global model decadal predictions for East Africa;
- development of methodologies for improving the use of dynamical seasonal prediction models in seasonal outlooks for East, West and southern Africa;
- recovery of climate observations – leading to longer and more useful historical national climate datasets.

For model-based studies, the MOHC's HadGEM3 model (global and regional versions) and the seasonal forecast system (GloSea4) are used primarily – but studies also include models of other international centres.

All fellows are working with a collaborator at the Met Office (co-authors of the papers) and have completed a visit to the UK (typically of one month duration) to interact with their collaborators and other scientists from the MOHC, as well as with other UK climate scientists – notably at the Universities of Reading, Leeds and Oxford – and to collect data for the research. Some fellows were sponsored to present results of their fellowship work at the 4th international conference of the African Monsoon Multidisciplinary Analyses (AMMA) programme (July 2012, Toulouse). Second visits to the MOHC are planned for some fellows as well as participation in the second Climate Change and Adaptation for Africa (CCDA-II) conference organised by the African Climate Policy Centre (ACPC). In its vision for the Global Framework for Climate Services the World Meteorological Organization has recognised the need to strengthen collaboration between Global Climate Centres such as the MOHC and regional and national organisations conducting climate research and providing climate services. With a focus on the African continent, the research and interactions developing through the CSRP fellowship scheme are contributing to this goal. We hope you find the papers stimulating and encourage you to make contact for further information.

Assessment of GloSea4 representation of intra-seasonal rainfall statistics over northern and southern Senegal

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This study is investigating the ability of the UK Met Office's global seasonal prediction system, GloSea4 (Arribas et al., 2011) to represent and predict, over Senegal, intra-seasonal rainfall variability such as the number of rain days during the rainy season, the frequency spectrum of daily rainfall amounts and the season onset timing.

Two distinct climatological regions in Senegal are used, the North and the South. In both regions almost all the annual rainfall occurs within a single season encompassing May to September. The South records higher rainfall totals than the North, an earlier onset to the season (May-June, compared to July in the North) and less intra-seasonal variability. The figure (see inset) shows how the regions are represented in this study. For observed climate in the North we have selected four stations (solid squares) located between 15.5°N and 17°N. Quantities averaged over these stations are compared with corresponding averages over the four nearest adjacent GloSea4 grid points (along 16.5°N - open squares). For the South, five stations (solid circles) between 12.5°N and 13°N and GloSea4 output at four adjacent grid points along 12.5°N are used. We do not undertake assessment for the central part of Senegal.

GloSea4 hindcasts are initialised on the 1st, 9th, 17th and 25th days of each month. Three ensemble members are run from each initialisation, with perturbations generated by a stochastic physics scheme. Here we use 7 consecutive initialisation dates over the period 25 April to 17 June which ends just prior to typical onset timing in the North. The forecast target period for our assessment is 17 June to 24 September (a common period to all the 7 hindcasts). Hindcasts for each of 14 years 1992 to 2005 are used.

We examine skill after aggregating 3 hindcast dates (to enhance ensemble size to 9, and obtain an improved representation of forecast uncertainties), but also for the individual 3-member hindcasts themselves. This allows some investigation of sensitivity of skill to lead time, which may be important for capturing intra-seasonal characteristics such as onset.

Preliminary results suggest that forecast skill for both the seasonal rainfall total and the number of rain days (number of days in the season with more than 1mm of rainfall) is low in the South (correlations no better than order 0.2) but more promising in the North where correlations for both quantities reach 0.4. For the North there is some evidence that forecast skill may increase substantially in later initialisations and the significance of this is being investigated.

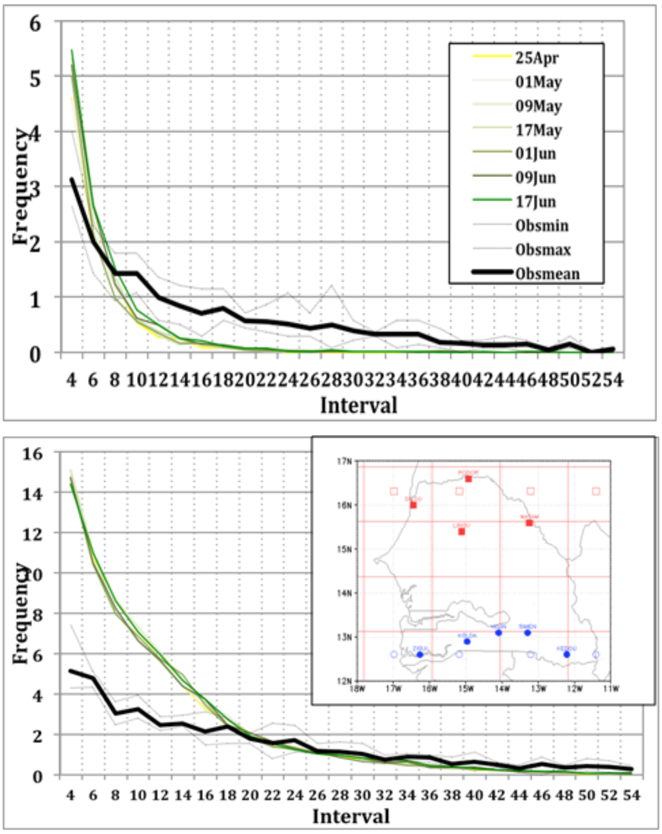

Figure 1: Average observed (black) and GloSea4 (coloured - see key) frequencies of daily rainfall amounts over the period 17 June to 24 September 1992-2005 in the North (top) and South (bottom) regions of Senegal. For definition of the regions see text and the inset. Frequencies are calculated for 2mm bins. Thin black lines are the observed maximum and minimum regional averages over the 14 year period. To help plot clarity at the higher rainfall end, the 0-2mm bin (which has largest frequencies) has been removed.

In addition to considering predictability we also examine the GloSea4 climatology in terms of the statistics of daily weather. Over the southern part of Senegal (bottom panel) GloSea4 represents well the frequencies of daily rainfall amounts greater than 18mm, but overestimates the frequencies of lower amounts. In the North the frequencies of lower rainfall amounts are overestimated while the frequencies of higher amounts are underestimated. As might be expected, there is strong coherency between the 7 GloSea4 hindcast climatologies.

Future work will investigate GloSea4 forecasts of season onset date and the longest dry spell during the critical period of crop development (August-September) both of which are very important for agriculture and other sectors in Senegal.

Simulation of West African summer monsoon rainfall in Met Office models

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West Africa is among the regions across the world where economy and food supply depend essentially on agriculture, which also is highly dependent on climate, particularly on seasonal rainfall. West African rainfall depends on the West African Monsoon (WAM) system which is associated with the northward migration of the Intertropical Convergence Zone (ITCZ) during northern summer and consists of many atmospheric features such as monsoon flow, African Easterly Jet, Tropical Easterly Jet, African Easterly Waves and Mesoscale Convective Systems interacting in a complex way to provide summer monsoon rainfall over the region. The ITCZ over West Africa is quasi-stationary around 5°N in May-June and shifts abruptly northward to hold another quasi-stationary position near 10°N for the period July-August (Sultan and Janicot, 2003). The shift corresponds to monsoon onset in the Sahel. Sylla et al. 2010 showed that the RegCM3 Regional Climate Model (RCM) reasonably captures the monsoon onset. Vellinga et al. (2012) analysed representation of the WAM in the Met Office Hadley Centre's coupled global climate model, HadGEM3. Here we present a comparison of global and regional versions of HadGEM3 (in both cases the GA3 development cycle was used), both forced with prescribed sea surface temperature (SST).

The aim of this study is twofold. First we assess the ability of the global (HadGEM3) and regional (HadGEM3-RA) models to simulate the climatology of West Africa. Second, we investigate the dynamics of the monsoon onset and possible causes of model errors.

The horizontal resolution of HadGEM3 and HadGEM3-RA are ~120km and ~50km respectively. HadGEM3-RA is run over the African Coordinated Regional climate Downscaling Experiment (CORDEX) domain and forced by ERA-Interim. Both models use Reynolds SST as ocean boundary forcing. Simulations are compared to GPCP (Adler et al. 2003) rainfall.

Both models reasonably represent the main features of June-September rainfall totals over the region including the observed rainfall maxima centred on Guinea and Cameroon, with the rainfall intensity generally better in HadGEM3-RA (not shown). The intraseasonal variability is also well captured with quite good accuracy on the mean timing of different phases of the WAM (see Figure). From April to early June, both models show the maximum of rainfall between 0°-6°N followed by an abrupt shift of the latitude of maximum rainfall into the Sahel region. Average onset timings over the 1998-2007 period (using a standard index) of 38th pentad (HadGEM3) and 36th pentad (HadGEM3-RA) both compare well with the observed (GPCP) timing of 37th pentad. After the shift, a peak in rainfall intensity in the Sahel during August is simulated by both models. The rainfall intensity is well captured by HadGEM3-RA but underestimated by HadGEM3. This underestimation of rainfall is dynamically consistent with insufficient vertical velocity in HadGEM3 between 10N-15°N. This in turn may be associated with errors in the positioning of the Saharan heat low and associated low-level circulation which are too far south in HadGEM3, but relatively well captured in HadGEM3-RA. The dynamical and physical factors influencing onset timing will be investigated in future work.

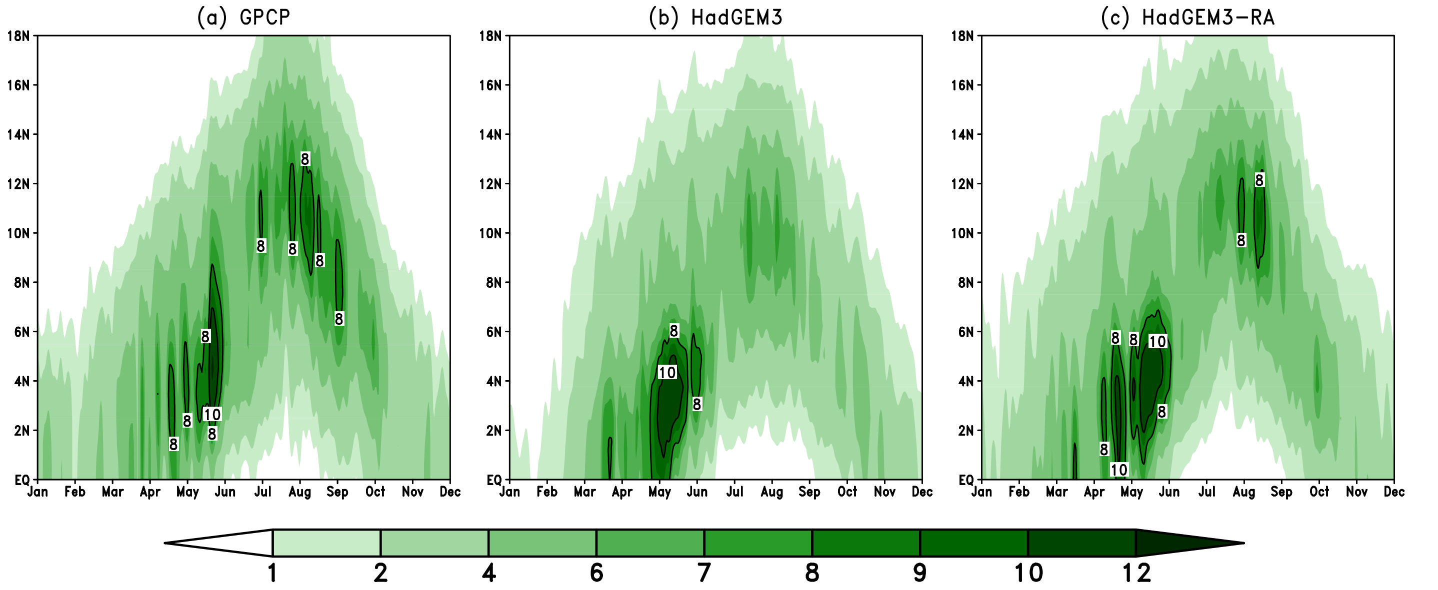

Figure 1: Time-latitude diagram of daily precipitation (mm/day) averaged between 10°E and 10°W for 10 years (1998-2007 period) from GPCP (a), HadGEM3 (b) and HadGEM3-RA (c).

Assessment of the GloSea4 system as a seasonal forecasting and research tool for southern African climate variability

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The main objective of the project is to investigate the skill of the Met Office's global seasonal forecasting system (GloSea4 – Arribas et al. 2011) for seasonal rainfall totals over the Southern African Development Community (SADC) region and for global ocean sea surface temperature indices. In addition, the model's ability to simulate SADC's intra-seasonal rainfall characteristics is investigated. GloSea4 forecasts are being considered for inclusion in the operational multi-model seasonal forecasting systems being developed for southern Africa.

Here we examine the skill of GloSea4 predictions of seasonal rainfall totals during spring (September to November – SON), mid-summer (December to February – DJF) and autumn (March to May – MAM) for the southern African region south of 15°S. In particular, the model's ability to discriminate between wet seasons and the rest, as well as between dry seasons and the rest, is assessed through the calculation of relative operating characteristic (ROC; Wilks 2006) scores for probabilistic forecasts of the three seasons at lead times of 1 month and of 4 months respectively.

Analysis is performed using retrospective forecasts (hindcasts) from GloSea4 over the 14 year period 1996 to 2009. Skill assessment is performed over the last 7 years, 2003 to 2009 with all years preceeding the predicted year being used – in cross-validated mode – to develop post-processing models. Thus the number of years used in post-processing progressively increases by one with each forecast year (e.g. Landman and Beraki 2012). The skill of forecasts generated with three forms of post-processing are compared: 1) no post processing (i.e. raw GloSea4 ensemble mean precipitation); 2) use of Canonical Correlation Analysis (CCA) to calibrate GloSea4 precipitation ensemble mean hindcasts with observed precipitation; 3) use of CCA to calibrate GloSea4 hindcasts of 850hPa geopotential height with observed precipitation. The CCA analysis is performed using the IRI's Climate Predictability Tool (http://iri.columbia.edu). Observed precipitation for the region is taken from the UEA CRU TS3.1 gridded 0.5°x0.5° resolution rainfall dataset (Mitchell and Jones 2005). Calibration is performed at the same resolution, and thus the procedure implicitly includes downscaling of the model predictions. Probabilistic forecasts are generated by constructing a probability distribution function around the ensemble mean, based on its error variance over the calibration period used.

The figure shows ROC scores for the SON, DJF and MAM seasons at 1- and at 4-month lead-times for each of the 3 post-processing methods. The three categories considered are the equi-probable categories of above-normal, near-normal and below-normal, but ROC scores for only the outer two categories are presented. Note that ROC scores may be interpreted as the proportion of events that are correctly discriminated by the forecasts.

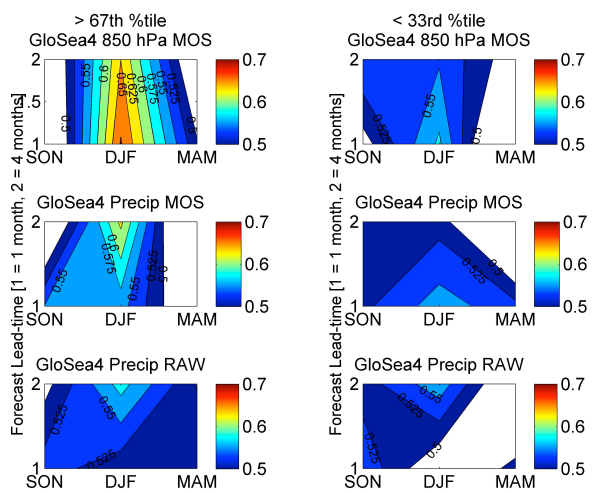

Figure 1: ROC scores obtained by retro-actively predicting for wet and for dry seasons over SADC for a 7 year test period. The x-axis shows the seasons considered, and the y-axis the lead-times (1 = 1-month lead; 2 = 4-month lead). The GloSea4 variables calibrated are, top: 850hPa geopotential height; middle: precipitation, bottom: no calibration (raw GloSea4 precipitation output).

A key result is that the ability of GloSea4 to discriminate wet seasons from the rest of the seasons during mid-summer is best accomplished through calibration/downscaling of the low level circulation (850 hPa geopotential heights between 10°S and 40°S, and between 5°E and 45°E) to rainfall (top row, left). ROC scores in this case are of order 0.65 (suggesting 65% of events are correctly discriminated). In fact, GloSea4 appears generally better able to predict for wet seasons as opposed to dry seasons. Although the test period of 7 years is rather short to determine if this is a robust result, a similar conclusion has been drawn for southern Africa using a different set of global forecast models and over a longer test period (Landman et al. 2012).

Teleconnections between Ethiopian Rainfall Variability and Global SSTs: Model Evaluation

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The small scale rain-fed agricultural systems and socioeconomic development of Ethiopia are strongly affected by seasonal rainfall variability - which is marked, both in terms of spatial and temporal distribution. Although, the annual and seasonal rainfall totals do not show substantial trends when analysed at the country level, large increasing and decreasing changes are observed when analysed at regional and station levels, for the last 5 decades. However, the reason behind this spatial variation in the trends of rainfall variability, and the trends themselves is not yet well understood. In addition to this, the details of daily rainfall characteristics and extreme rainfall variability and trends, which have significant implication for rain-fed agricultural and water management practices, have not been studied.

To help understand the drivers of such variability we take a fresh look at teleconnections between Ethiopian rainfall and global Sea Surface Temperature (SST) anomalies, with particular focus on the seasonality and spatial variations of the teleconnection patterns. The modes of SST variability examined are ENSO (Niño3.4); the Indian Ocean Dipole (IOD), a central Indian Ocean Index and an Atlantic Dipole Index that all have potential impacts on Ethiopian rainfall. In addition, we also investigate the ability of the new Met Office Hadley Centre climate model (HadGEM3 – Hewitt et al., 2010)) and one experiment from the previous model (HadGEM2 – Gordon et al., 2000) to represent both the observed seasonal cycles of regional rainfall and the observed teleconnection patterns. The models are assessed both in coupled ocean-atmosphere configuration and in atmosphere-only configuration (forced with observed SST). Monthly mean rainfall and SST data were used. For observed rainfall, the Climate Research Unit (CRU3.0) gridded global monthly rainfall product was used due to its advantage in showing the complex spatial variation in rainfall distribution, its use of elevation as a factor in the interpolation of the climatologically values over the highland regions of the world, like East Africa, and the presence of strong agreement with rain-gauge data in Ethiopia.

Using the observed monthly mean data, correlations between gridded rainfall and the above SST indices were analysed to help us define rainfall seasons and sub-regions of Ethiopia based on consistency of their teleconnection patterns across these seasons and regions. As an example, the figure presents the correlation between the Ethiopian Kiremt (June-September) season's rainfall, which is the main rainy season in the country and Niño3.4. It shows significant correlation (at 0.05 level) between Kiremt rainfall and Niño3.4, but limited to central/northern parts of the country. The ability of the models to reproduce the observed teleconnections is also being investigated. In addition the long-term climatology of model rainfall is being evaluated against observed rainfall over Ethiopia.

Further work will study the variability and trends of daily and extreme rainfall events for the three rainy seasons (March-May, June-September and October-December) over Ethiopia. In addition to remote influences on rainfall we also study the local climate drivers that cause significant variations in rainfall variability and trends between nearby recording station over Ethiopia. This will enable the government to formulate policy and strategies at local and regional levels for climate change adaptation intervention.

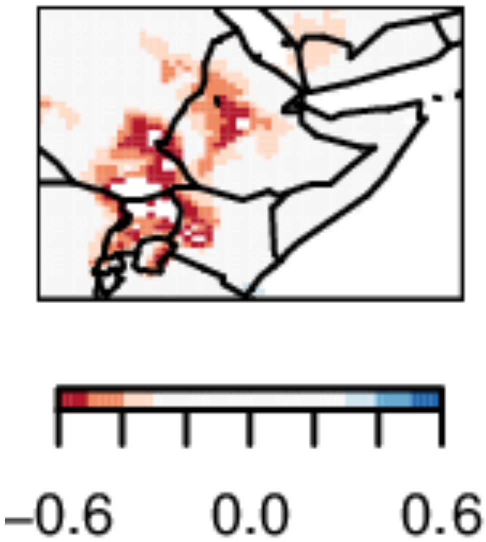

Figure 1: The teleconnection between rainfall variability in Ethiopia during Kiremt (June-September) season and Niño3.4 for the period 1955-1995. Only correlations estimated as significant at 0.05 level are shown.

Identification of processes driving low level westerlies in West Equatorial Africa

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Recent studies have underlined the importance of low level westerlies (LLW) in determining the water cycle over West Equatorial Africa (WEA), mainly during the big rainy season September-November. The crucial role of the water cycle for both climate variability and climate change underlines the importance of investigating its driving processes. Understanding the processes driving westerlies could contribute to modeling efforts and the interpretation of existing discrepancies in the regional response to climate change. This is necessary for efficient strategies to respond to the expected future changes.

This study has two main objectives. First to investigate and characterize the low level tropospheric circulation over WEA (10°S-10°N; 9°W-30°W), with a focus on the zonal flow. To achieve this, the processes which control the height and strength of the LLW are examined. Their seasonal and interannual variability are evaluated. Secondly, a diagnostic analysis of the regional climate model simulations from the Met Office Hadley Centre PRECIS system will be done to evaluate the representation of all the above processes and interactions.

For the characterization of the processes which control LLW variability, focus is made on the contribution of divergent and non-divergent circulation to the total flow. To achieve that, we partitioned the horizontal wind field into divergent and rotational (non-divergent) circulation. Through such an approach, predominance of a circulation type would allow the identification of the controlling mechanisms. We used monthly mean meridional, zonal and vertical wind from 40-yr European Centre for Medium-Range Weather Forecasts Re-Analysis (ERA-40), NCEP/NCAR reanalysis (NCEP) and Modern-Era Retrospective Analysis for Research and Applications (MERRA) for the period January 1980 to December 2001.

The first results show that from February to October, the spatial pattern of westerlies exhibits two wind maxima, in the North of WEA and around the Equator. The maximum cell in the North, poleward of 5^0N, appears around 10^0E in March. It moves north in April and reaches the northernmost position during June-August when it is strongest. It disappears from November to January. This cell is primarily driven by the rotational circulation in the West African Monsoon system. A second cell of westerlies is centered at the equator all year round. It is most defined from August to October, being strongest in September. During this period, mean core speed reaches $4 m.s^{-1}$ as opposed to only $1-2 m.s^{-1}$ in the others months. It weakens in November.

Further analysis of the equatorial cell shows that during both the small (March to May) and big (September-November) rainy seasons, the divergent flow drives a Walker type circulation with ascent over the continent. This circulation is strongest in the big rainy season (Figure): the maritime subsidence is reinforced, and the related strengthening of low level descent leads to deep and strong westerlies which peak at 925hPa. There is good agreement between reanalyses on this seasonal variability of the Walker circulation driven by the divergent circulation, and the induced strength of LLW. Although, winds are weaker in the MERRA than ERA40 and NCEP.

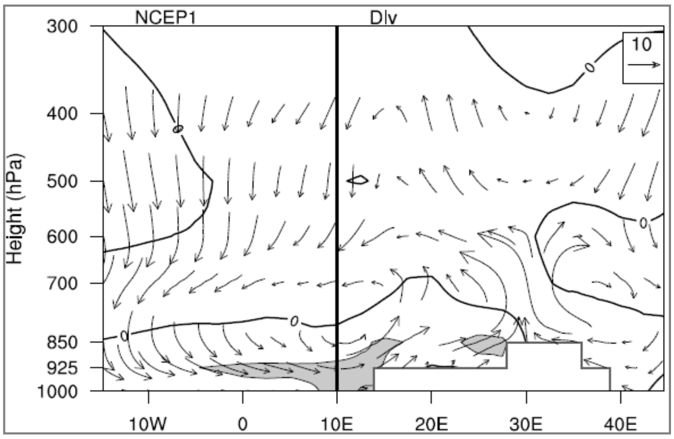

Figure 1: Difference between SON and MAM of the mean zonal divergent circulation in longtitude-pressure section, averaged between 0^0S and 10^0S for NCEP1. The vertical line at 10^0E indicates the boundary between ocean (on the left) and continent (on the right). The vertical velocity w is significantly smaller than the divergent zonal wind u_D, thus for clarity in the plot w has been scaled up by a factor 600. Shaded areas indicate u_D, greater than 1 $m.s^{-1}$. White 'boxed' areas east of 10^0E below 850hPa indicates grid points under the topography. Units: $u_D(m.s^{-1})$, $w(10^1 Pa.min^{-1})$.

At interannual time scales, the divergent circulation shows low variability compared to the rotational flow, which is dominated by easterlies. Results indicate that the rotational wind component has a damping effect on the strength of LLW. As a consequence the strength of LLW shows increase (decrease) during years of weak (strong) rotational flow.

Evaluation of the GloSea4 Seasonal Forecast system over Mozambique: Rainfall Climatology and predictability

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We assess the performance of the Met Office Hadley Centre's global seasonal forecast system (GloSea4, Arribas et al., 2011) in predicting seasonal rainfall over Mozambique at one-month lead. Retrospective forecasts (hindcasts) from the GloSea4 system covering a period of 21 years (1989-2009) are used with particular attention paid to forecasts initialized in August for the September to November (SON) period and in November for the December to February (DJF) period. Onset of the rainy season in Mozambique occurs in the period SON, while the DJF period corresponds to the core of the rainy season. For both periods the hindcasts used consist of nine ensemble members.

We analyzed first the biases in the model climatology and second the skill of probabilistic seasonal forecasts. Forecast skill was measured using the Relative Operating Characteristic (ROC) diagnostic (Wilks, 2011). The observed precipitation data used for results shown here are from the Global Precipitation Climatology Project (GPCP, Adler et al. 2003). Additional analysis also uses the CRU3.0 gridded dataset (Mitchell and Jones, 2005) and station data for Mozambique kindly provided by the Mozambique National Institute of Meteorology (INAM).

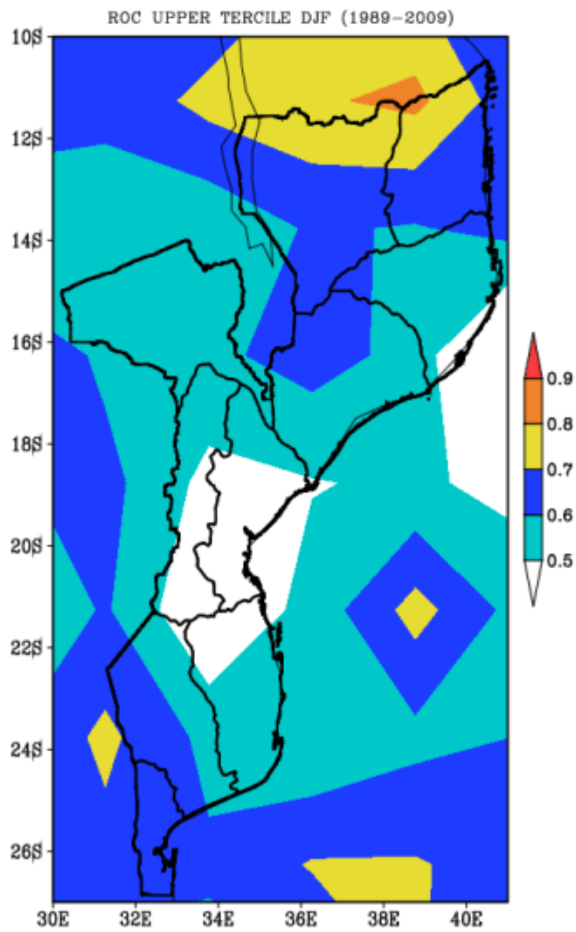

Figure 1: Difference between SON and MAM of the mean zonal divergent circulation in longtitude-pressure section, averaged between 0^0S and 10^0S for NCEP1. The vertical line at 10^0E indicates the boundary between ocean (on the left) and continent (on the right). The vertical velocity *w* is significantly smaller than the divergent zonal wind u_D, thus for clarity in the plot *w* has been scaled up by a factor 600. Shaded areas indicate u_D, greater than 1 m.s^{-1}. White 'boxed' areas east of 10^0E below 850hPa indicates grid points under the topography. Units: u_D(m.s^{-1}), *w*(10^1Pa.min^{-1}).

We find that, when compared to the observed climatology, the GloSea4 system seems to capture well the mean rainfall patterns over the country during the SON period. However, on average, the system generates excessive rainfall in northeastern Mozambique. During the DJF period, the GloSea4 system captures the general south-to-north gradient of rainfall with the largest accumulation in the north, however, the observed regional maximum, located over northern Mozambique, is displaced westward to a position over northern Zambia An observed minimum in rainfall occurs between 20° to 25°S (the 'drought corridor' – Usman and Reason, 2004). Despite positive rainfall biases there is some evidence that GloSea4 reproduces this climatological feature at least on the western side of the country.

The area underneath the ROC curve (the ROC score) is a measure of the ability of probabilistic predictions to discriminate below-normal and above-normal precipitation events and has been calculated for the SON and DJF periods. For the SON period ROC scores are generally close to 0.5 over much of the country for both above and below normal events - indicating that forecasts are little better than guess work - correctly discriminating these events only about half the time, however higher scores are found in the far south of the country. Better skill is present for the DJF period (see the figure) for which scores for the above-normal events exceed 0.6 in southern and northern regions (and approach 0.8 in the north). Skill for the below normal events follows a similar pattern, though with less skill in the central and northern districts and greater skill in the far south. Thus overall, the GloSea4 system is more skilful in predicting rainfall during the DJF period than for SON. In the far north, where highest DJF rainfall accumulations occur, the system has relative good skill in discriminating above normal rainfall events, and similarly good levels of skill are found for prediction of below normal events in the far south, in a region approximately coincident with the drought corridor.

In further work we will assess the enhancement to skill that can be obtained through use of statistical post-processing of other GloSea4 predicted fields (e.g. 850 hPa geopotential height) to infer seasonal rainfall over the region.
Institute of Meteorology (INAM).

Integration of statistical and dynamical methods in seasonal forecasting: an example for Kenya

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Seasonal rainfall forecasts for Kenya, issued by the Kenya Meteorological Department, are at present generated predominantly using guidance from statistical prediction methods, which invoke historical associations between rainfall and a variety of predictors including precursive indices of SST and atmospheric circulation (Ogallo, 1980, 1989 and Ogallo et al. (1994)). Forecasts are issued for 12 climatic zones. In recent years there has been growing use of output from climate-model-based seasonal prediction systems (dynamical systems) made available by WMO Global Producing Centers (Graham et al., 2011). However, to date, incorporation of such dynamical model forecasts has been achieved using largely subjective methods. The main objective of this study is to investigate improvements to forecast performance that can be obtained by combining, objectively, both statistical and dynamical forecasts.

Combining is achieved by using, as predictors in linear regression models for each zone, indices of dynamical model output as well as the precursor SST and atmospheric circulation indices already employed. The dynamical model indices used have potential to capture regional to large scale influences on the 12 zones and are 1) predicted precipitation averaged over a rectangular area approximately covering Kenya; 2) Principle Components (PCs) of model precipitation and 850 hPa wind field for an extended domain covering most of Africa, the tropical Atlantic and Indian Ocean. Results were assessed from various combinations of these indices calculated using output from dynamical systems of the following centres: the Met Office Hadley Centre (MOHC), the European Centre for Medium Range Weather Forecasting (ECMWF), the NOAA NCEP Climate Prediction Centre (CPC) and Météo-France (MF).

The benefit of the above procedure has been assessed for predictions of both Kenya's two main rainy seasons: the "long-rains" in March-May (MAM) and the "short-rains" in October-December (OND). Rainfall during OND is known to be correlated with the El Niño Southern Oscillation (ENSO) and other large scale indices (Mutai et al, 1998, Indeje et al, 2000) and this leads to relatively good predictability with statistical methods: Relative Operating Characteristic (ROC) scores (Wilks, 2011) for both categories, calculated over the period 1961-2006, exceed 0.65 in 8 out of 12 zones, suggesting that more than 65% of forecasts discriminate the correct category. Predictability for the MAM season is lower with statistical methods achieving ROC scores greater than 0.65 in only 4 zones. On average, the dynamical systems assessed are also more skillful during the OND season than in the MAM season.

Initial results with the combined statistical and dynamical methods show mixed impacts. There are encouraging results, with some notable improvements to forecast skill found in several zones indicating that the dynamical models are adding useful predictive potential on the scale of the climate zones. However, overall, over both seasons and with methodology employed, skill is raised and lowered in about an equal number of regions. Further research will look at case studies to gain an understanding of the causes of raised or lowered skill with the aim of improving the combining methodology. Sample results from one of the more successful combinations ('GRAND', see below) are shown in the figure for predictions

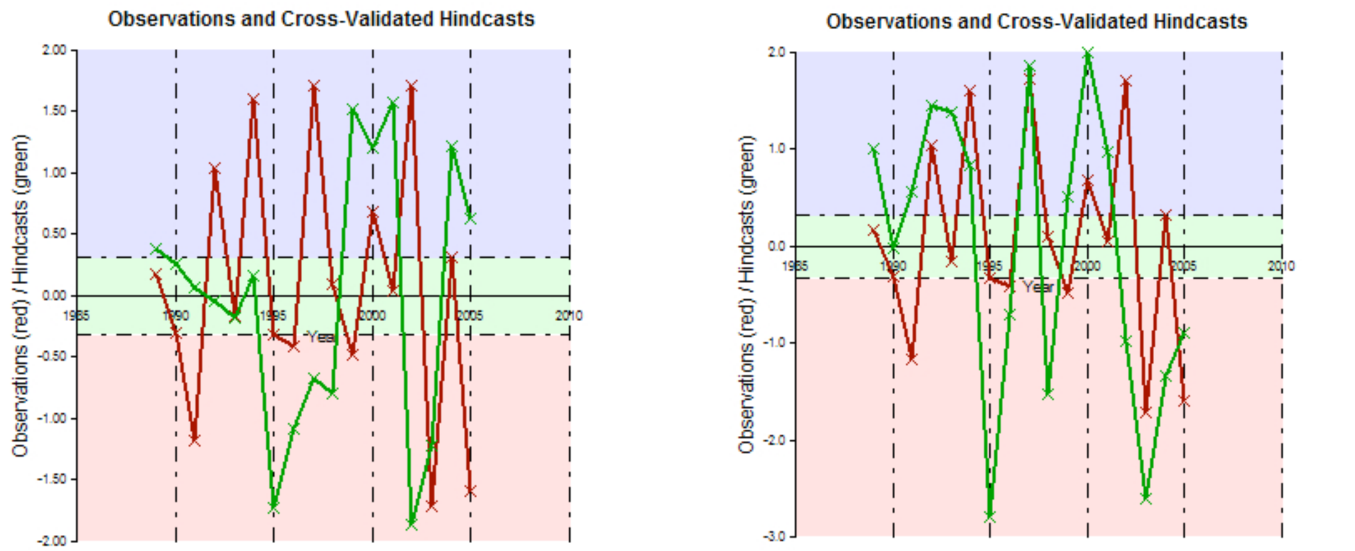

Figure 1: Observed (red) and predicted (green) OND precipitation 1989-2005. (a) Statistical predictors only; b) GRAND combination of statistical + dynamical predictors (see text).

of the OND season for Zone 4 (in the southeast of the country). The correlation of the predicted and observed time series is improved from -0.09 to 0.45, with forecasts for the wet 1997 season and dry 2005 season showing particular improvement. For this region ROC scores for the above and below tercile categories respectively are improved from 0.40 to 0.82 and 0.38 to 0.67.

The GRAND combination was defined as:
Statistical predictors + multi-model ensemble mean precipitation forecast for Kenya from the MOHC, ECMWF, CPC and MF systems + PCs of predicted precipitation and 850 hPa wind field (over extended domain) from the ECMWF and MF systems.

The use of seasonal rainfall forecasts by farmers in Sengal: a survey of the Fatick and Kaffrine districts

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The economy of Senegal, like in most Sahelian countries, is based on rain-fed agriculture and thus can be strongly impacted by inter-annual and intra-seasonal variability in the West African Monsoon (WAM) – the primary rain-bringing system to the region. Seasonal forecast services for the region have been developed to assist adaptation to such variability and can provide a basis for farmers to incorporate likely rainfall variability into their operational farming decisions. For 15 years a consensus seasonal rainfall outlook for July-September, the peak period of the WAM, has been generated through the Regional Climate Outlook Forum for West Africa (PRESAO). The consensus is coordinated by the

African Centre for Meteorological Applications for Development (ACMAD) in collaboration with the National Meteorological Services (NMSs) of West and Central Africa and various international research and prediction centres. The PRESAO consensus is issued in late May, giving 1-2 months lead before the start of the rainy season. The outlook is expressed in terms of probabilities for below, near and above average seasonal rainfall totals and provides broad-scale information for the whole of sub-Saharan West and Central Africa. Spatial detail in the forecast is addressed by delineating (typically) 4-5 forecast zones, and thus is generally coarser than national scale. This broad consensus provides NMSs with a regional framework that can assist in developing more detailed national outlooks. For Senegal, the National Agency of Civil Aviation and Meteorology (ANACIM) produces a national seasonal rainfall forecast and disseminates it to different users including to farmers.

This paper gives a brief summary of a survey conducted to improve understanding of the awareness among farmers of the forecast products, the usefulness of the information for farming decisions, and farmers' priorities for enhancing the forecast information. A total of 120 farmers, all heads of families responsible for decisions on agricultural operations, were surveyed over two regions, Kaffrine and Fatick (see figure) within the 'groundnut basin' of Senegal. The main crops produced in this area are peanut (a cash crop), millet, maize and sorghum. Key results of the survey are summarised below.

- Nearly half of farmers interviewed (47%) were unaware of the existence of seasonal rainfall forecasts;

Of the remaining 53% who were aware of the forecasts:

- 72% understand and use the forecast information: uses cover selection of crops and cultivars (56%), investment choices on agricultural inputs (22%), general planning decisions including crop planting (22%). The majority of farmers hear the forecast information over the radio and attribute the source to ANACIM.
- Most farmers (74%) felt the format of the forecast (described above) is informative. However, 65% indicate that the current release time of the forecast (late May) is not useful, with a majority preferring release in the first half of May. The level of spatial detail was also deemed insufficient.

Highest priorities for new types of forecast information are for season onset and cessation timing and the frequency and likely timing/duration of dry spells within the season.

- Forecasts of onset timing would be most useful if issued 1-2 months ahead of normal onset even if the forecast precision were relatively low – this lead time would allow for strategic choices on cultivar selection and investment in agricultural inputs. Forecasts of onset issued at 1-2 week lead were not very considered useful.
- One-week-lead forecasts of cessation timing were considered useful for planning harvesting

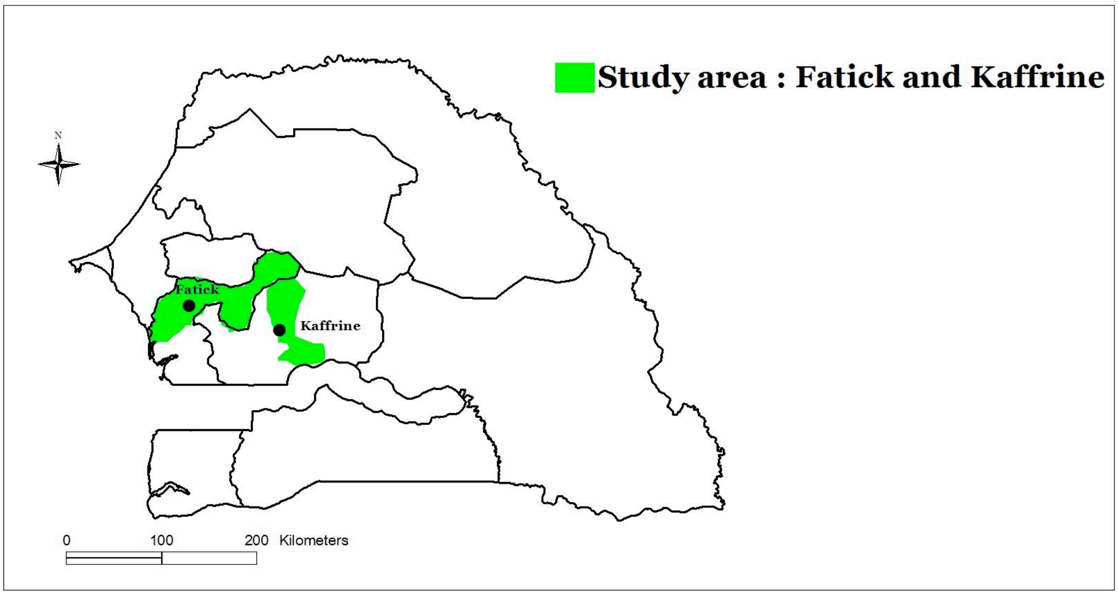

Figure 1: Map of Senegal showing the location of the Fatick and Kaffrine districts where the survey was conducted.

operations, though a lead time of 1-2 months was preferred.

- A dry spell of 15 days was considered the typical threshold for dangerous impact. The frequency of such spells predicted 1-2 months ahead of normal onset was indicated as very useful by 80% of farmers. Shorter-lead forecasts (1-2 weeks) of the timing and duration of dry spells were also viewed as very important to allow preparation of plant protection strategies.

The above information, together with details available from the survey, is being used by ANACIM to help direct seasonal forecasting research and strategies for engaging with agricultural users.

Prediction of decadal climate over Eastern Africa region using Hadley Centre Decadal Climate Prediction System (DePreSys)

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The East Africa Region, like many regions of the continent, is prone to recurrent drought and flood - with serious implications on water resources, agriculture, food security, health and other socio-economic sectors. Reliable predictions of climate variability on seasonal, multi-annual and 10-year (decadal) timescales are needed to strengthen resilience to such events.

Methodology and infrastructure for predicting variability at the seasonal range has been in operation in the region for around 15 years through the interaction of the National Meteorological Services of the region and the IGAD Climate Prediction and Applications Centre (ICPAC) in the Greater Horn of Africa Climate Outlook Forums (GHACOFs). The GHACOF process, supported by dynamical seasonal forecasts from Global Producing Centres (Graham et al. 2011), generates and disseminates consensus rainfall forecasts for the season ahead, issued in the month before the typical season start. To date, no similar coordination to exploit developing potential for multi-annual-to-decadal predictions has been initiated. Such forecasts might provide information on prospects for individual seasons up to 1 or 2 years ahead, with more general information on likely trends in rainfall and temperature up to 10 years ahead. The science of decadal prediction is still developing, but there is encouraging evidence of prediction skill at these longer ranges, including at regional scales (e.g. Eade et al., 2012). This project is evaluating decadal predictions for East Africa from the Met Office Hadley Centre (MOHC) Decadal Prediction System (DePreSys – Smith et al. 2007). The main objectives are to: i) assess the predictive skill of the DePreSys; ii) improve understanding of mechanisms driving decadal climate variability in the region and iii) develop experimental decadal prediction products for the region.

A set of retrospective forecasts (hindcasts) with DePreSys are used for the evaluation. The hindcasts comprise 46 10-year predictions started in November of each year in the period 1960-2005. Each prediction is initialised with the observed ocean and land-surface state, to allow potential for predicting natural variability, and configured with projected concentrations of CO_2 and aerosols – to account for the influence of human-induced climate change (volcanic aerosol concentrations are left to decay exponentially from those at the start date so effects of future volcanic eruptions are left unknown). Predictions are also configured with a projected solar activity cycle (repetition of the previous eleven-year cycle). The DePreSys system is run in a 9-member ensemble comprising 1 unperturbed member and 8 perturbed members in which model physics parameters are perturbed in a controlled way that reflects uncertainty in the model formulation.

The figure provides an example of the forecast data being evaluated: specifically, the predicted near-surface air temperature anomalies (relative to 1958-2006) for June-July-August 1961 as predicted from November 1960. Collectively, the 9 ensemble members provide an estimate of the forecast uncertainty: for example, in member 5 negative (cold) anomalies are widespread, and typically of order -1.0°C, while positive anomalies of similar magnitude are widespread in member 6. The ensemble mean (bottom, right) acts to highlight commonalities over the ensemble members and shows a signal for positive anomalies aligned along 10° N, and negative anomalies in most other regions

Forecast output of the type shown is being synthesized over all years and all for ecast ranges and prediction skill measured for both temperature and precipitation using Root Mean Square Error and other performance measures.

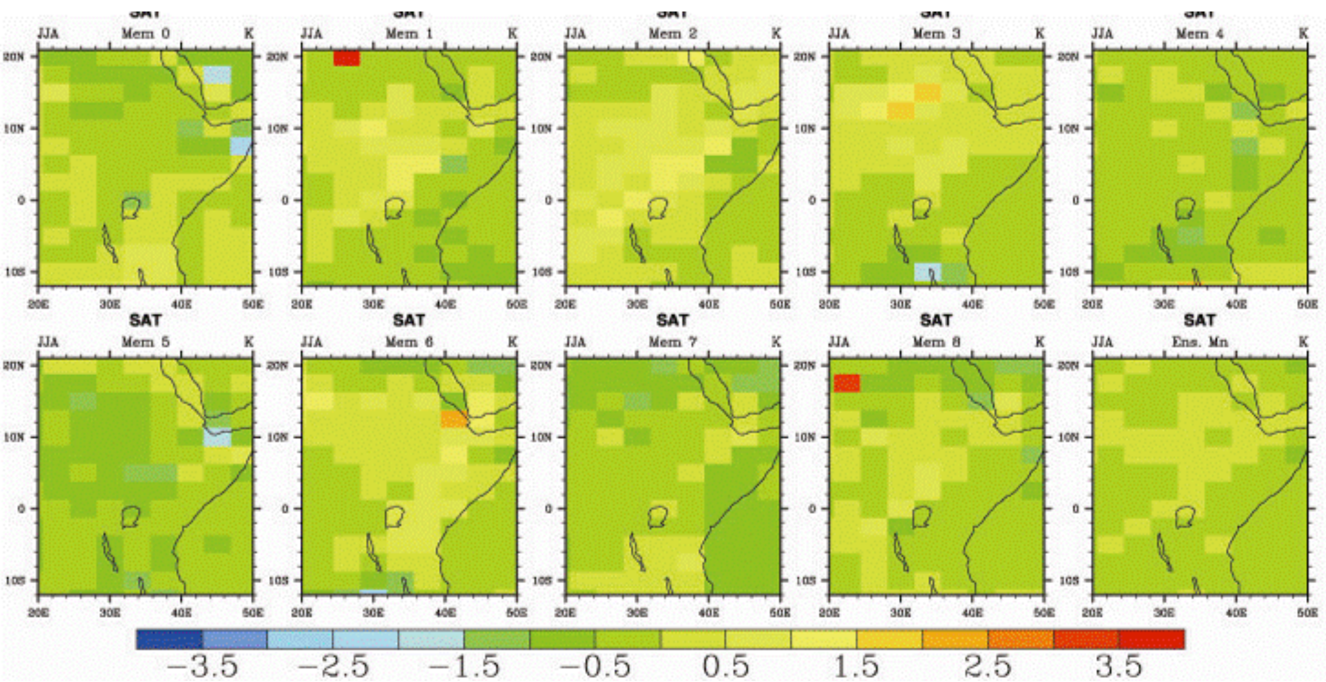

Figure 1: Example near-surface spatial temperature forecast for June-July-August 1961 over the Greater Horn of Africa region from a DePreSys hindcast starting in November 1960. All 9 ensemble members are shown with the ensemble mean (bottom right).

Development of historical meteorological data records for Ghana

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Models, tools and technologies have been developed that use climatic data to conduct research in order to address the problem of climate change, a pressing scientific challenge which cuts across regional and societal boundaries. But a significant challenge for many African countries is the lack of observed climate data that is complete over a long historical period and is digitized. For example, lack of long observed historical time series makes robust detection of climate change trends difficult. National meteorological services are the designated authorities and advisers to governments on matters relating to meteorology and climatology, so we describe a project underway at the Ghana Meteorological Agency to improve Ghana's historical climate records.

Three of Ghana's climatological stations were reportedly established in 1886, and by 1937 there were a modest spread of stations across the country, but the earliest data available in digital form in the Ghana Meteorological Agency were, until recently, only from 1961. So this project is compiling an improved historical observational dataset for Ghana with a focus on data completeness, quality control and homogeneity. We have scanned daily temperature and rainfall observations registers held in the archives of the United Kingdom Met Office covering 1891-1942, along with some monthly summaries back to 1888 which have now been digitized. The figure shows how the project has extended the digitized monthly precipitation record for Accra back to 1888. Daily rainfall records of 16 stations between 1928 and 1960 have also been digitized. We plan to progressively digitize the remaining scanned daily data. Documentation of metadata specifying how, when and where the observations were made will be made as complete as possible. This documentation will include photographs of each station. Provision will be made for open access to the data for research.

The mission of the Agency is to provide cost effective weather and climate services by collecting, processing, archiving and disseminating meteorological information to support the sustainable socio-economic development of Ghana with special regard to the protection of life and property and safe-guarding the environment. The Agency has a vision to be a leading meteorological institution in the subregion, which will provide cutting edge climate research and reliable, timely and relevant weather and climate information to all weather-sensitive sectors of the country. The Agency has currently deployed automatic weather observation systems at seven synoptic stations including the five airport stations at Accra, Kumasi, Tamale, Sunyani and Takoradi. The other two automatic observation systems are installed at Navrongo and Wa. These seven stations run this automatic equipment, concurrently with the normal manual equipment as the other synoptic stations. The Agency has also acquired a weather-radar, which has been installed and commissioned.

This project will contribute to the fulfillment of the Agency's vision. The data will also contribute to climate applications, research and other services in Africa and beyond. Ghana's national meteorological datasets will provide a good example to guide other West African nations in the development of complete, high-quality homogeneous datasets.
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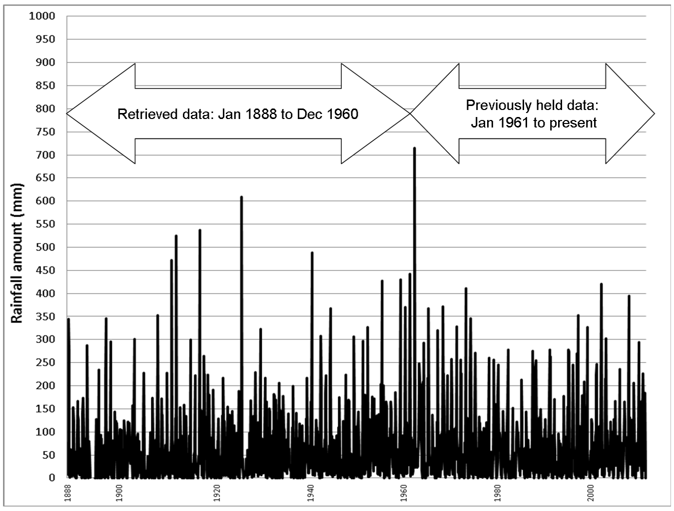

Figure 1: Accra monthly rainfall, 1888-2010 – showing the period of data retrieved by the project , Jan 1888 to Dec 1960 and that previously held by the Ghana Meteorological Agency, Jan 1961 to present (shown to Dec 2010)

Evaluation of regional climate models over the Greater Horn of Africa (GHA)

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Climate is typically variable over national and regional scales that are generally not well represented by relatively coarse resolution global climate models. Practical use of climate prediction from global-scale models is therefore facilitated by 'downscaling' the information to finer geographical scales. The need for downscaling is particularly evident for the GHA region where high and complex orography, large lakes and coastal effects contribute to strong geographical variations in climate. Downscaling can be accomplished using statistical or dynamical methods based on Regional Climate Models (RCMs). In this study we focus on dynamical methods and evaluate the performance of 5 RCM systems in simulations of historical (1989-2008) climate for 20 subregions of the GHA region.

The RCMs evaluated are:

- HadGEM3-RA: a regional version of HadGEM3, the newly developed Met Office Hadley Centre (MOHC) climate model (the GA3 development cycle was used);
- PRECIS-M1: based on the earlier MOHC HadCM3 model with version 1 of the Met Office Surface Exchange Schemes (MOSES1);
- PRECIS-M2: as above but with version 2 of MOSES;
- PRECIS-UCT: an implementation of PRECIS maintained by the University of Cape Town;
- RegCM3: A regional model based on the NCAR-Penn State University mesoscale model, maintained by the International Centre for Theoretical Physics (ICTP).

All experiments were run at 50 km resolution, used the ERA-INTERIM dataset for lateral boundary conditions and Reynolds SST and sea ice for lower boundary forcing. The HadGEM3-RA, RegCM3 and PRECIS-UCT simulations are contributions to the WCRP CORDEX (Coordinated Regional Downscaling Experiments) programme (Nikulin et al. 2012).

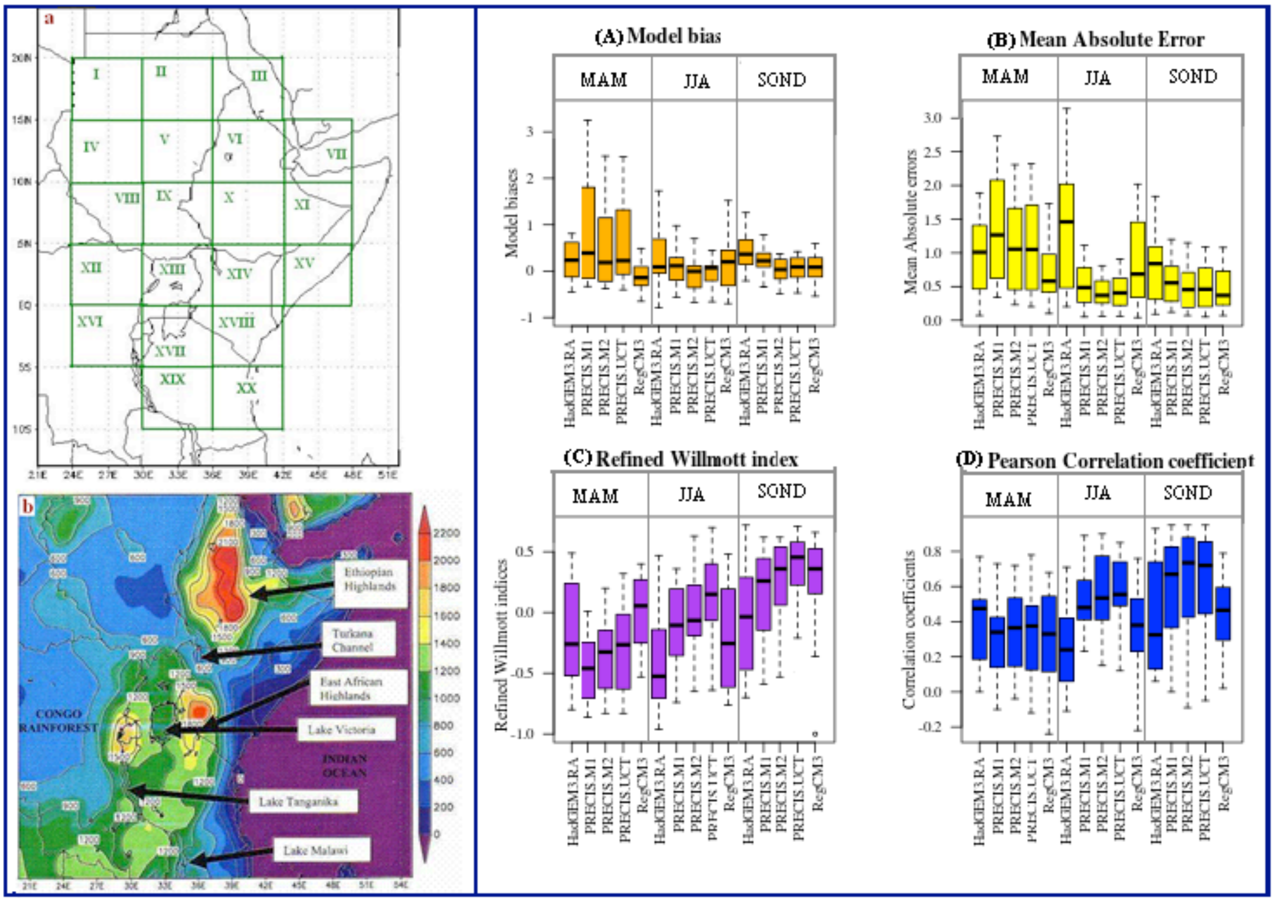

Figure 1: Performance of 5 Regional Climate Models (see text) for simulations of MAM, JJA and SOND rainfall for 20 subregions (top left panel) of the GHA over the period 1990-2008. Performance measures are described in the text. The box and whisker representations show the spread of results over the 20 subregions (right panel) – with 'boxes' showing the median and the inter-quartile range and

Simulated seasonal rainfall accumulations were compared against average observed rainfall from four widely available gridded datasets. Here we focus on results with the following 4 assessment measures: the model bias (B); the Mean Absolute Error (MAE); the refined Willmott index (RWI – Willmott et al. 2011); and the Pearson correlation coefficient (PCC). The RWI is a dimensionless measure of agreement between model and observed fields bounded by -1.0 and +1.0 (with positive values indicating better agreement).

A summary of results for the three GHA seasons of March-May (MAM), June-August (JJA) and September-December (SOND) is presented in the figure.

Model biases lie generally between -1mm/day and +3mm/day for all seasons and all models except for the MAM season for which the three PRECIS-based models have larger positive biases over a substantial proportion of the subregions.

Median values of MAE/RWI/PCC indicate better performance for all models for SOND relative to MAM – with the exception of HadGEM3-RA median PCC, though even for this case SOND scores are higher for many of the subregions (note the large spread of values). The better performance for SOND may be a result of the stronger large-scale forcing (e.g. ENSO) often present in this season relative to MAM. For SOND the best performing models are the PRECIS-based systems and RegCM3 (though RegCM3 performs less well against the PCC measure). For MAM the RegCM3 and HadGEM3-RA systems perform best, with RegCM3 scoring notably better on MAE and RWI. In general performance for JJA is intermediate between that for MAM and SOND. The PRECIS-based systems outperform both HadGEM3-RA and RegCM3 in this season.

In future studies, this work will be linked to a parallel project assessing the value of RCM simulations and future climate scenarios for estimating impacts of climate variability and change on banana production in Uganda.

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Conference Announcement

Africa Climate Conference
October 2013
African Union Hall
Addis Abeba, Ethiopia

Setting the priorities for climate research in Africa and delivering climate information into the hands of users.

The Africa Climate Conference 2013 will bring together decision-makers and climate researchers, scientists and practitioners from Africa and around the world, to jointly: 1) identify the state of knowledge on the African climate system, recognizing current gaps in climate knowledge; 2) define and drive an African agenda for future climate research that will inform adaptation decisions out to the mid- to end 21st Century.; 3) develop a framework for mainstreaming climate information into decision making, as well as a network of experts who evaluate and interpret this knowledge for practical applications in areas such as agriculture ad food production, water resources management, climate risk management and adaptation planning, etc.

The expected outcome from the Conference is a set of concrete research proposals to address the critical gaps in our knowledge of the African climate system, led by regional and national institutions and experts, to provide science-based climate knowledge that will inform decision-making out to the mid- to end 21st Century in Africa in the many sectors affected by climate variability and change.

<u>Objectives</u>
1) Provide a wide international forum to exchange understanding on the current state of knowledge of the African climate and the drivers of African climate variability and change.
2) Deepen and broaden the consensus, begun at CCDA-II, on the priority knowledge gaps/climate science frontiers that need to be addressed.
3) Review and assess the state of knowledge on each climate science frontier identified (from the mapping of knowledge gaps in 1), through presentations by leading researchers in each field.
4) Identify missing links and obstacles that will need to be overcome in order to bridge African climate science and applications.
5) Develop pan-African climate research program proposals for each critical climate science frontier, for funding submission.
6) Leverage national, regional and international sources of funding to advance climate research for sustainable development in Africa.
7) Develop and strengthen the network of climate researchers and practioners working on the African climate system, building on existing national/regional/continental climate research institutions and knowledge hubs.
8) Create a platform for knowledge sharing, advocacy and consensus building for climate research in Africa to serve sustainable development needs.

The overall goal of the Africa Climate Conference 2013 is to set an Africa wide agenda on climate research for sustainable development, linked to existing continental policy processes, partners and institutions (regional, national and sub-national) to deliver an Africa agenda on climate research, while addressing global research needs.

The call for abstracts will be opened in January 2013 and will close end of March 2013. More information will be widely advertised in the coming months. For more information email anna.pirani@noc.soton.ac.uk

ACPC African Climate Policy Centre

WCRP World Climate Research Programme

UNECA

CALENDAR

ICTP Capacity Building Workshop on Modeling of Regional Climate and Air Quality for West Africa
12-16 November 2012
Abidjan - Cote d'Ivoire
Contact: smr2392@ictp.it

Workshop of the CDKN/CCAFS/Red Cross/ANACIM Project "Demonstrating the Value of Climate Services" Kaffrine 2011-2012
21-22 November 2012
Dakar - Senegal

CCAFS/WMO/USAID/CSP International workshop on "Scaling Up climate services for Farmers in Africa and South Asia"
10-12 December 2012
Dakar - Senegal
Contact: a.tall@cgiar.org

Energy, Water and Climate Change - Building Bridges between Europe and Middle East/North Africa
10-12 December 2012
Dakar - Senegal

HYVIC Planning Workshop at Speak Hotel, Munyonyo
March 2013
Kampala, Uganda

ICTP School on Modelling Tools and Capacity Building in Climate and Public Health
15 April – 01 May 2013
Trieste, Italy
Contact: smr2453@ictp.it

ICTP Workshop on Mathematical Models of Climate Variability, Environmental Change and Infectious Diseases (smr2450)
29 April – 10 May 2013
Trieste, Italy
Contact: smr2450@ictp.it

ICTP 2nd Workshop on Water Resources in Developing Countries: Planning and Management in a Climate Change Scenario (smr2457)
06-16 May 2013
Trieste, Italy
Contact: smr2457@ictp.it

4th DBCP Africa/Western Indian Ocean Capacity Building Workshop
May 2013
Zanzibar, Tanzania
Contact: sidney.thurston@noaa.gov

Joint ICTP-IAEA Advancing Modelling of Climate, Land-use, Energy and Water (CLEW) Interactions
07-11 Oct 2013
Trieste, Italy
Contact: smr2490@ictp.it

ICTP Climate and Impact Modeling for Eastern Africa: Climate, Water, Agriculture, and Health
October 2013
Addis Abeba, Ethiopia
Contact: smr2514@ictp.it

WCRP-ACPC Africa Climate Conference
October 2013
Addis Abeba, Ethiopia
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A big thank you to Richard Graham for the excellent editorial work on all articles.

The WCRP Africa Newsletter was produced by the International CLIVAR Project Office. WCRP activities in Africa are jointly organized by CLIVAR and GEWEX.