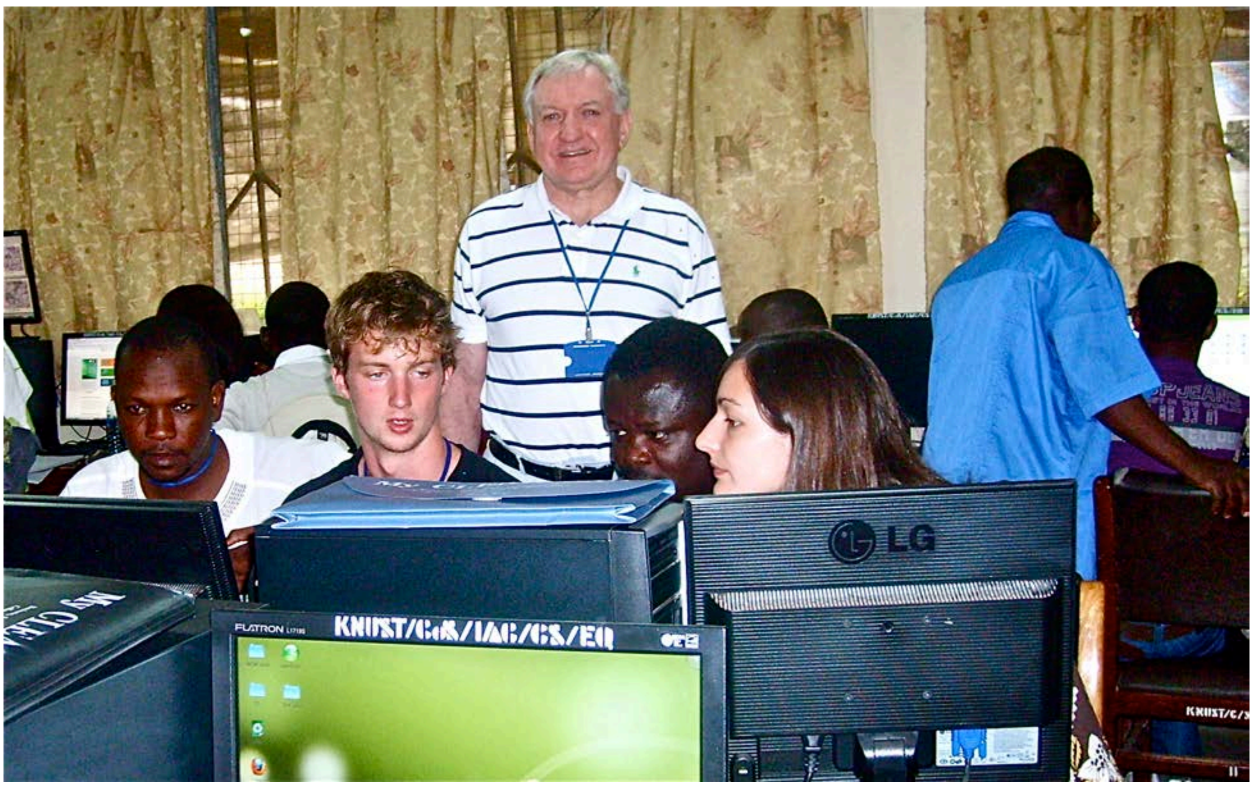
PETER J. LAMB SYMPOSIUM

HELPING AFRICA TO HELP ITSELF



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FOREWORD

This symposium honors Dr. Peter J. (Pete) Lamb, George Lynn Cross Research Professor of Meteorology at the University of Oklahoma, Director of the Cooperative Institute for Mesoscale Meteorological Studies (CIMMS), and long-time researcher in regional climate diagnostics and dynamics, including notably in Africa, and mentor to many students and colleagues around the world. Pete passed away quite unexpectedly on May 28, 2014 at the age of 66, with much left to do.

Pete was born in Nelson, New Zealand on June 21, 1947 and arrived in the United States in 1971. He received his Ph.D. in Meteorology from the University of Wisconsin in 1976. He conducted research at the University of Miami and led research programs at the University of Illinois before coming to the University of Oklahoma in 1991 to lead CIMMS. He was CIMMS Director for 23 of its 37 years of existence, and because of this, CIMMS was Pete. Over the years he was a strong leader of the consortium of NOAA Cooperative Institutes, where his loss is still felt.

The 2015 Annual Meeting of the American Meteorological Society in Phoenix, Arizona featured two sessions dedicated to Pete's work in climate variability in precipitation processes, part of the 27th Conference on Climate Variability and Change. This 2016 named symposium focuses on Pete's research and outreach record and legacy in Africa. As you can see in the symposium agenda included here, it features contributions from around the world.

I wish to acknowledge the organizing committee for this symposium: Professors Michael Richman, Lance Leslie, and Aondover Tarhule of the University of Oklahoma, Pete's recent Ph.D. graduates Dr. Mouhamadou Issa Lélé (Niger) and Dr. Zewdu Segele (Ethiopia) at the University of Oklahoma, Dean Berrien Moore of the University's College of Atmospheric and Geographic Sciences, and two special colleagues of Pete's from afar: Dr. Rosalind Cornforth, Director of the Walker Institute at the University of Reading and of the African Climate Exchange (AfClix), and Dr. Hassan Virji, Executive Director for Global Change System for Analysis, Research and Training (START).

Donations in Pete's memory can be made to the Ethembeni School, a boarding school serving 300 physically disabled or visually impaired students in the KwaZulu-Natal region of South Africa. http://ethembenischool.co.za/

Randy Peppler

Pete in his element on a bar stool, enthusing the Reading populace at Science Cafe with Ros Cornforth, September 2013

1.1

The Lamb Index from the Early Years Onward

Michael A.Bell, Columbia University, Palisades, NY

In the wake of very dry conditions in the West African Sahel from 1968 to 1974 and the accompanying famine, a number of researchers began investigating the causes of this drought and the mechanisms that control the climate of the region and its variability more generally. These efforts required finding ways of characterizing seasonal and annual precipitation in the region based upon the limited precipitation datasets that were generally available to the research community at the time. An index of standardized seasonal precipitation departures based upon data from about twenty rainfall stations scattered throughout West Africa, with long and largely complete monthly records from the 1940s onward, was maintained and updated by Peter Lamb and his associates and came to be commonly known as the Lamb Index. This index became a widely-recognized means of characterizing the precipitation variability of the region and documented the dramatic decline in precipitation that began during the 1960s and culminated in the extreme drought years of the early to mid-1980s. Here we discuss aspects of the efforts and challenges involved in maintaining and updating the Lamb Index in its early years. In the succeeding years great progress was made by a multitude of researchers to establish the teleconnections that linked ocean variability with seasonal precipitation variability in the Sahel. Dr. Lamb sought also to extend the teleconnection chain and to document how variations in daily precipitation characteristics contributed to the variability seen in the Lamb Index. Here we also discuss the development of indices based upon daily precipitation data from the Sahel that were used to characterize the extent and intensity of the daily disturbance lines that, in aggregate, produced the seasonal results seen in the Lamb Index.

1.2

Development of a Seasonally – Inclusive NAO Index

Diane H.Portis, CIMMS/Univ. of Oklahoma; Department of Atmospheric Sciences, Univ. of Illinois, New Bern, NC

In a 1987 paper, Lamb and Peppler presented evidence linking the NAO to the interannual variability of Moroccan rainfall. From this study emerged an extended scientific collaboration with several Moroccan scientists. One area of subsequent research with one of these Moroccan scientists, Mostafa El Hamly, was the construction of a seasonally and geographically varying “mobile” index of the North Atlantic Oscillation (NAOm). Monthly sea level pressure (SLP) data from the NCEP reanalysis for 1948-1999 were used to identify the locations of the maximum monthly out-of-phase signal between the subpolar and subtropical North Atlantic SLP (Portis et al. 2001, Fig. 1). There is a general migration of the subtropical node from southeast-northwest from winter to summer and return from summer to winter with exceptions in February-March and November. As a validation of the NAOm, we evaluated its ability to capture the North Atlantic surface westerly flow by correlating it with historical measures of westerly wind intensity across North Atlantic midlatitudes (Barry and Perry, 1973; Lamb, 1972). This seasonally inclusive NAO maintains a higher out-of-phase signal from winter to summer than traditional NAO indices based on fixed stations in the eastern North Atlantic (Azores, Lisbon, Iceland). When the NAOm index is extended back to 1873 using the UEA-Jones (1987) dataset, its annual values during the late 1800s are strongly negative relative to those of the winter-only indices due to negative contributions from all seasons. In contrast, after the mid–1950s, the values for different seasons sufficiently offset each other to make the annually averaged NAOm smaller than those of winter-only indices. Comparison of monthly hemispheric teleconnection maps of the NAOm and teleconnection maps of a more traditional fixed nodal index show the wider influence during the spring-summer-autumn when the NAOm is used -- particularly in the western North Atlantic, eastern North America, and Arctic. In a later study, the NAOm was used to analyze the timescale behavior of the seasonal signal of the NAO from 1873-2001. This was a first step in establishing a frame of reference to explore any seasonal coordination between the NAO and the ocean/cryosphere.

1.3

The Roles of Temperature and Precipitation in Drought: A Comparison of California and Ethiopia

Michael Richman, CIMMS/Univ. of Oklahoma, Norman, OK

Recent research indicates that the prolonged severe drought in California is characterized by both a precipitation deficit and abnormally warm temperatures. The latter has resulted in both higher evaporation rates and less snowpack in winter, providing positive feedback. Although previous multiyear droughts are present in a century long record in California, the present drought is the first one to combine a several consecutive years of abnormally warm climate with the precipitation deficit. The idea that droughts in the 21st century may be exacerbated by high temperatures is mentioned in the most recent IPCC AR5 report. In this research, we apply the ideas gleaned from the extratropical drought (California) to examine if and how temperature affects droughts in the tropics (Ethiopia). Monthly temperature and precipitation records for the period 1953 – 2013, for two regions in Ethiopia, are studied. One striking finding is a consistent large standard deviation rise in the temperatures across all calendar months from the 1950's to the present. The average increase is 4.59 standard deviations (representing a temperature increase of +3.2C), with a range of 3.86 standard deviations (September, +2.3C) to 5.67 standard deviations (January, +3.3C). All but one calendar month have an increase in temperature of >4 standard deviations from the 1950s to the 2010s. August, a month critical for agriculture, has the largest warming at +4.1C . Given these findings, drought years are then related to individual months of temperature and precipitation anomalies in a number of regression and regression tree approaches. Results suggest that there are significant monthly temperature precursors to drought in Ethiopia. Hence, combining temperature anomalies with those for precipitation, to produce a drought risk index, may prove useful for predictive purposes.

1.4

World Weather Attribution and Well-being

Roop K.Singh, Red Cross Red Crescent Climate Centre, New York, NY

The Red Cross Red Crescent Climate Centre is piloting a new project named World Weather and Well-being (W3) that will help assess the resilience of populations in Africa and Asia to climate extremes such as floods, droughts and tropical cyclones, as they occur. News articles and literature that follow extreme events typically report on casualties, and property damage, but miss the opportunity to talk about what coping mechanisms were actually effective during the event. W3 brings together all three areas of disaster risk: the hazard, exposure, and resilience of a population, to build case studies for learning about what coping mechanisms are most effective during actual floods and droughts. These case studies can help inform the work of adaptation practitioners as well as influence policy decisions. The hazards are monitored using near real-time tools, such as the University of Maryland's Global Flood Monitoring System which incorporates TRMM Multi-satellite Precipitation Analysis rainfall (TMPA) data into a hydrological runoff and routing model to highlight areas where flooding is likely taking place. Based on this objective information about the hazard, we notify our partners on the ground about areas that may be flooding. Our partners subsequently interview people on the ground about which coping mechanism were in place, and how effective they were during the event. This can include information about the services available before and after the event, whether or not there was an early warning of the event, and if people acted on that warning, as well as more difficult questions like “what could have gone wrong, but didn't?” These interviews are integrated into news stories, and blog posts for local and international media. In some cases, we may find that no one was impacted at all, despite the occurrence of climate extreme. By highlighting why this occurs, W3 will shed light on events that normally would

not have made the news as opportunities for learning. In conjunction with this work, another project called World Weather Attribution uses statistical methods and climate model projections to assess if some of the events identified by W3 can be attributed to climate change. The injection of both information about the current state of resilience, and whether or not an event was caused by climate change into local media will help people understand their risk to climate extremes in the context of a changing climate. In the cases where a disaster does occur, this information can be invaluable as decisions about rebuilding, relocation, and recovery are made at a local level.

For example, heavy rain on May 12, 2015 caused flooding that wreaked havoc on roads in Nairobi, Kenya. Many people were stuck overnight on the roads, while others used social media and the local radio to know which roads should be avoided due to flooding, a coping mechanism.

The government blamed the flooding on garbage and debris that blocked drains, and dispatched teams to unblock the drains. In the aftermath of the flooding, many Nairobians were critical of the lack of longterm solutions posed by the government, with some calling for the demolition of buildings that impede the flow of water along the riverbank. An analysis of the changing probabilities of extremes, as well as coping mechanics that are effective during flooding would prove useful for making investments in more resilient infrastructure and adaptation practices, highlighting the potential World Weather Attribution and, World Weather and Well-being have to influence policy around the world.

2.1

The Role of the Atlantic Ocean in Determining the Recent Multi-Decadal Drought of East Africa

Kara A.Smith, North Carolina State University, Raleigh, NC

East Africa has been experiencing persistent decline of the March-April-May Long Rains for multiple decades. Although the connection between the decline and the Indo-Pacific Ocean has received much attention the role of the Atlantic Ocean has not been recognized. Here we show the previously unrecognized role of stationary atmospheric wave forms which link the northern Atlantic Ocean basin source region and the East African Long Rains. The Atlantic Multi-decadal Oscillation (AMO) variability dominates the variability during the cessation of the Long Rains (CLR) in May. The negative phase of the AMO is associated with enhanced rainfall during the cessation. In contrast, reduced rainfall occurs during the positive phase of AMO and it has contributed to the ongoing multi-decadal decline. The projected continuation of the positive phase of AMO for several more decades by recent studies imply the likelihood of the Atlantic Ocean's potential contribution to prolong the ongoing drought conditions over East Africa.

2.2

Understanding the Role of Low and Mid-level Cloudiness for the West African Monsoon: The DACCIWA Project

Andreas H.Fink, Karlsruhe Institute of Technology, Karlsruhe, Germany

Recent research by the authors revealed that the southern parts of West Africa, from the coast to about 10°N, are frequently covered by an extensive deck of shallow, low (200 – 400 m above ground) stratus or stratocumulus clouds during the summer monsoon season. Climatologically, the ultra-low stratus deck forms after sunset along the Guinea coast, spreads inland and reaches its maximum northward extent of 10-11°N between 0900 and 1000 UTC of the following day. The maximum affected area is approximately 800,000 km2. After about 1000 UTC, the northern boundary gets fragmented due to the breakup of stratus decks into fair-weather cumuli. It has been shown that the night-time cloud formation is related to a subtle balance between ''stratogenic'' upward (downward) fluxes of latent (sensible) heat caused by shear-driven turbulence below the night-time low-level jet, cold advection, orographic lifting, and radiative cooling on one hand, and ''stratolytic'' dry advection and latent heating on the other hand. Up to one third of the nights unaffected by rainfall systems remained cloud free in central Benin (~9°N) during the 2006 AMMA campaign, the reason of which are not fully understood. A consequence of this subtle balance is that Coupled Model Intercomparison Project 3 (CMIP3) global climate models often failed to represent the ultralow clouds, leading to errors in surface solar radiation of up to 90 W m-2. New results using CMIP5 and YOTC (Years of Tropical Convection) GASS (GEWEX Atmosphere System Study) global climate models show that the representation of low-level cloudiness has not improved in the latest generation of global models. This may be related to problems in simulating the shallow meridional circulation. In general, validation of weather and climate models in terms of the representation of ultra-low clouds is problematic due to the misrepresentation of ultra-low cloud decks in most satellite products. These findings were one major motivation to create the DACCIWA (Dynamics–Aerosol–Chemistry–Cloud Interactions in West Africa) project (2013-2018) that is funded by the European Union with 16 partners in Africa and Europe. DACCIWA will carry out a large surface, upper-air and multi-aircraft campaign in southern West Africa in June-July 2016. The campaign data set will help to improve our understanding of the dynamics of the formation/dissipation of low-level stratus and mid-level altostratus in this region and beyond. From the beginning, Pete Lamb was very much interested in this research, got involved in the creation of the DACCIWA project and agreed to chair its scientific advisory board. Sadly, the DACCIWA project team lost a friend and an invaluable source of help and support. Not only have we dedicated a BAMS Inbox article to Pete Lamb, but his legacy is also a motivation to us to further our understanding of West African Meteorology and Climate and to train young, early-career African researchers.

2.3

Africa Monsoon Multidisciplinary Analysis: Legacy and Future Plans

Chris D.Thorncroft, SUNY, University at Albany, Albany, NY

Established in 2002, AMMA has both transformed our basic understanding of the physics of West African climate, and established programmes within Africa which are developing practical tools for decision-makers. AMMA is built around 3 objectives: (i) to improve our understanding of the West African monsoon and its predictability, (ii) to relate it to societal issues like food security, water resources and public health, and (iii) to integrate AMMA research with prediction and decision-making activities. We have created robust and long-standing research collaborations between African and international partners, spanning all of the physical and socio-economic questions, involving approximately 250 scientists and more than 100 PhD students from Africa. Illustrations of success in applying new knowledge and observations for the needs of African society include; (i) future crop yield projections based on temperature and rainfall changes (included in the latest IPCC chapter on Africa), (ii) the production of a monthly monitoring and forecasting bulletin of the cropping season by AGRHYMET (http://www.agrhymet.ne/bulletin.html), currently being tested in the context of climatic insurance products, (iii) climatically-based meningitis early warning bulletins disseminated by the national weather service of Burkina Faso and supported by the World Health Organization, and (iv) water resource scenarios developed for National Actions Plans for Adaptation to Climate Change in Burkina Faso, Benin, Mali, Niger and Senegal. While AMMA still recognizes the importance of continuing to improve our fundamental understanding and the need for field campaigns (e.g. PREFACE and DACCIWA are ongoing); phase 2 of AMMA is giving, through new projects such as "AMMA-2050", greater emphasis to the integration work (objective 3) and linking prediction to decision-making activity.

2.4

Transitioning Enhanced Land Surface Initialization and Model Verification Capabilities to the Kenya Meteorological Service

Jonathan L.Case, ENSCO, Inc., Huntsville, AL

Flooding, severe weather, and drought are key forecasting challenges for the Kenya Meteorological Service (KMS), based in Nairobi. Atmospheric processes leading to convection, excessive precipitation and/or prolonged drought can be strongly influenced by land cover, vegetation, and soil moisture content, especially during anomalous conditions. It is thus important to represent accurately land surface state variables (green vegetation fraction, soil moisture, and soil temperature) in Numerical Weather Prediction (NWP) models. The NASA SERVIR and the Short-term Prediction Research and Transition (SPoRT) programs at Huntsville, AL have established a working partnership with KMS to enhance its regional modeling capabilities. SPoRT and SERVIR are providing experimental land surface initialization datasets and model verification capabilities for capacity building through enhanced operations at KMS. To support its forecasting operations, KMS is running experimental configurations of the Weather Research and Forecasting (WRF) model on a 12-km/4-km nested regional domain over eastern Africa, incorporating the experimental datasets provided by NASA SPoRT and SERVIR. Enhanced regional modeling capabilities have the potential to improve guidance in support of daily operations and high-impact weather and climate outlooks over Eastern Africa. For enhanced land-surface initialization, the NASA Land Information System (LIS) is run over Eastern Africa at ~3-km resolution, providing real-time land surface initialization data in place of interpolated global model soil moisture and temperature data available at much coarser resolutions. A 10+ year LIS soil moisture climatology run has been made and will provide the basis for computing soil moisture percentiles to support drought and climate outlooks. Additionally, real-time green vegetation fraction data from the Suomi-NPP VIIRS instrument is being incorporated into the KMS-WRF runs, using the product generated by NOAA/NESDIS. Model verification capabilities are also being transitioned to KMS using NCAR's Model Evaluation Tools (MET) software in conjunction with a SPoRT-developed scripting package, in order to quantify and compare errors in simulated temperature, moisture and precipitation in the experimental WRF model simulations. Future enhancements shall include the assimilation of NASA Soil Moisture Active Passive (SMAP) retrievals into the Eastern Africa LIS simulations and incorporation of GPM/IMERG quantitative precipitation estimates to drive the LIS simulations and verify WRF model precipitation forecasts. This presentation will describe the collaboration between KMS, SERVIR, and SPoRT, discuss the transition and capacity development activities to date, and present selected model sensitivities using the enhanced land surface modeling datasets and verification capabilities.

2.5

Building Climate Resilient Society in the Sahel: The Rainwatch-AfClix Experience

Aondover, A.Tarhule, University of Oklahoma, Norman, OK

The Sahel-Soudano zone that spans North Africa from Senegal to Ethiopia has experienced pronounced climatic variability (and conflicts) for millennia. This home to 250 million people -- one quarter of Africa's population -- is a fragile transition zone in environmental and human terms. From south-to-north, rainfall decreases from around 30 inches per year on average to essentially nothing. Recent back-to-back contrasting rain years (deficits in 2011; floods in 2012) left over 18 million people in the West African Sahel threatened by food shortages between 2012 and 2013, highlighting yet again the strong dependence of livelihoods on rainfall in the region. Ironically (tragically, even), the stakeholders within the Sahel have less access to, and therefore use less, instrumental rainfall information for planning and management than almost anywhere else in the world. Furthermore, short-term weather and seasonal climate forecasting have limited skill for the region. Recognizing these constraints, Pete Lamb supported, financed, and promoted Rainwatch to demonstrate the value of near real-time rainfall monitoring and improved communication in this fragile region. It appealed greatly to Pete's vision of "helping Africa help itself" that Rainwatch, which automates and utilizes user-friendly interfaces to display, query, and visualize daily rainfall data was designed by an African graduate student and supervised by an African professor both at the University of Oklahoma. At core, Rainwatch affords a common platform that permits a regional visualization of seasonal rainfall dynamics. The platform provides all users a common format, common feel and common visuals, regardless of the country information they choose to interrogate.

Following several refinements and iterations, Rainwatch was coupled with a boundary organization, AfClix (Africa Climate Exchange, see http://www.afclix.org) and is now extending its reach across the African Sahel, through integrating the expertise and actions of relevant institutions, agencies, and stakeholders to broker ground-based dialogue and promote resilience in the face of recurring crisis. Whilst many of the National Hydrological and Meteorological agencies are making impressive efforts to produce tailored climate forecasts for their stakeholders, most appear to be country specific. Working in partnership with the National Hydrological and Meteorological Services (NHMSs) from Burkina Faso, Mali, Niger, Nigeria, Chad, Guinea, Sierra Leone, Liberia, and Ghana over the course of this year, RWX is supporting efforts by regional climate centers such as the African Center for Meteorological Applications for Development and the Agrometeorology, Hydrology and Meteorological center. Indeed, Rainwatch-AfClix (RWX) is emerging as an important partnership for 1) bridging the gap between those who do the science and those who use the science to make decisions; 2) increasing timely access to value-added rainfall information to stakeholders and decision makers; 3) identifying how climate science can play a consistent and substantive role in reducing people's vulnerabilities to weather-related hazards in Africa; 4) following this through with action on the ground to promote resilience, and 5) building an integrated community of climate information users that cuts across national boundaries and fostering regional perspectives. The RWX partnership has had to overcome several challenges, including the data policies of the participating countries. It also has raised important research questions about how to better integrate climate science-policy to develop locally relevant adaptive capacity and build resilient society. An important outcome is the co-production of understanding and the promotion of a more participatory decision-making process. This paper discusses on-going efforts to build upon Pete's vision. It outlines new initiatives to the RWX partnership, including efforts to loosely couple real time rainfall monitoring to crop yield prediction using process-based crop yield modeling. Additional on-going development includes extending the seasonal rainfall monitoring from representative points to larger areas through merging with satellite-based measurements. The experience of RWX suggests a keen desire on the part of African NHMSs for regional alliances and cooperation. The lessons learned further reinforce the necessity for climate information knowledge co-production and dissemination to assure content relevance and accuracy for intended purposes. For example, as has been found in other research, concepts like probability and percentiles while easily understandable to climate scientists proved immeasurably difficult to translate to stakeholders. Furthermore, to take maximum advantage of near real-time climate information, institutions must establish clear protocols and actions to be triggered once certain thresholds are met. Stakeholders also must establish practical innovations to anticipate impending crises and work collaboratively across the region to share information and strengthen supporting infrastructure. Within this framework, timely access to user-relevant climate information, access to relevant and reliable forecasts, and the ability of stakeholders to act on that information through effective strategic partnerships will prove the difference between coping proactively with emerging climate challenges and perpetuating the cycle of climate triggers and crisis. RWX is filling this very important niche.

2.6

The NCAR Colloquium on African Weather and Climate: Fulfilling Peter Lamb's Mission

ArleneLaing, Science Education and Research, Boulder, CO

“African Weather and Climate: Unique Challenges and Application of New Knowledge,” was the topic that brought together 23 graduate students and 26 instructors for 2011 NCAR Integrated Studies Program (ISP) summer colloquium. A first of its kind gathering, the colloquium grew out of discussions among US-based colleagues, including Peter Lamb, at the 3rd International Conference of the African Monsoon Multidisciplinary Analysis (AMMA). Our goal was to enhance interactions among students and to attract more graduate students and postdocs to research problems related to African weather and climate. Therefore a proposal was made to the ISP, whose mission was well suited to address the land-atmosphere-ocean interactions and societal impacts that are unique to Africa. The colloquium focused on (i) synthesizing knowledge of African weather and climate, and (ii) applying modern tools (remote sensing, numerical simulation and prediction, statistical data analysis, and visualization) to understand variability on synoptic, sub-seasonal, interannual, and climate timescales, making and interpreting their prediction, and optimizing their societal benefit in Africa. In the panel discussion on lessons learned for successful collaboration in Africa, Pete cited the importance of encouraging independence, forging personal relationships, and helping Africans to help themselves. He reminded the students that they were the future leaders of science in Africa and of their responsibility to use their science to benefit Africa and its development. Four years after the colloquium a survey is being conducted to learn about participants' current careers, research outcomes, the contribution of the colloquium to their professional development and capacity building in Africa, and to find out how/whether they have risen to the challenge presented by Pete Lamb. The results of the survey will be presented at the symposium.

J2.1

Synoptic Kelvin Type Perturbation Waves over Congo Basin During the Period 1979–2010

AndreLenouo, University of Douala, Douala, Cameroon

Water resources, agricultural and health on Central Africa depends on rainfall. What people really want to know is when and how much will it rain. The Congo basin region depends heavily on rainfall during spring and is characterized by high rainfall over the Cameroon Highlands. The associated precipitation over the Congo basin has unique characteristics compared to other continental regions in particular, a relatively small rainfall amount regarding to high cloudiness or lightning activity, attributed either to the abundance of aerosols or to relatively dry boundary layer that elevates the cloud base and decreases the amount of rain reaching the ground. The synoptic structure and inter-annual variability of Kelvin waves over the Congo basin from 1979 to 2010 are explored using outgoing longwave radiation (OLR) and National Centers for Environmental Prediction–National Center for Atmospheric Research (NCEP–NCAR) reanalysis data. Composite method shows that high values of synoptic Kelvin wave (SKW) index are located over Congo basin during March-June where the convective active phase favors the formation of convective synoptic systems. Mean composite SKWs structure shows that these waves propagate faster over land surface and dissipate with suppressed phase. Because convective instability is smaller, these waves cannot grow in Congo basin. High correlation between SKWs and precipitation time series occurs when the Kelvin waves lead the precipitation time series by about 4 days. The analysis of 32 years datasets (1979-2010) also shows that in some particular year, strong SKWs propagation exists with periods centered around 5 days. Otherwise, results show marked inter-annual variability of Kelvin wave activity over Congo basin associated with divergence and low level westerly trade winds.

J2.2

Projected Changes in Malawi's Growing Season: Connections with the Large-scale Circulation

Kerry H.Cook, University of Texas, Austin, TX

Rainfall and altitude play dominant roles in determining crop cycles and growing seasons in the three major agro-climatic zones defined for Malawi. These zones are characterized by elevation, and include semi-arid low altitudes (<600 m), semi-arid/sub-humid mid altitudes (600–1,300 m), and sub-humid high altitudes (>1,300 m). More than 90 % of Malawi's total annual precipitation occurs between November and April. The rainy season begins in the south in late October and progresses northward in association with the development and movement of the South Indian convergence zone. The demise of the rains also occurs first in the south in late March/April, and in late April/early May in the north. Rainfall and, as a result, growing seasons are highly variable, including on the decadal scale, and known to be sensitive to the large-scale circulation.

Regional model simulations with 30-km resolution are used to better resolve this narrow, mountainous country. Simulations of the late-20th century are compared with precipitation observations and reanalyses, and show that the high-resolution simulation is able to capture the regional climate dynamics well. Simulations of the mid- and late-21st c. under the RCP8.5 emissions scenario project precipitation reductions that are accompanied by significantly shorter growing seasons south of 13.5°S and an earlier demise of the rainy season. The changes in precipitation are related to amplified warming of the land surface compared with the ocean, resulting in the intensification of the Kalahari thermal low/ anticyclone system and an increase in the moisture flux divergence over Malawi that suppresses convective activity.

J2.3

Representation of African Easterly Waves in CMIP5 Models

ElinorMartin, University of Oklahoma, Norman, OK

African easterly waves (AEWs) can act as seed disturbances for tropical cyclones (TCs) in the Atlantic and changes in future AEW activity may have important consequences for development of TCs. The simulation of AEWs was investigated using output from the Coupled Model Intercomparison Project 5 (CMIP5) suite of experiments including coupled historical and future simulations and atmosphere only (AMIP) simulations. Large biases exist in the simulation of low- (850 hPa) and mid-level (700 hPa) eddy kinetic energy (EKE, a proxy for AEW activity) in AMIP and historical simulations. CMIP5 models simulate excessive EKE and deficient rainfall south of 17°N. The same biases exist in historical and AMIP models and are not a consequence of errors in sea surface temperatures. The models also struggle to accurately couple AEWs and rainfall, with little improvement from CMIP3 models. CMIP5 models are unable to propagate AEWs across the coast and into the Atlantic which is shown to be related to the resolution of the Guinea Highlands. Future projections of the annual cycle of AEW activity show a reduction in late spring and early summer and a large increase between July and October that is consistent with rainfall projections in the Sahel but large differences exists in future projections between high and low resolution models. The simulation of AEWs is challenging for CMIP5 models and must be further diagnosed in order to accurately predict future TC activity and rainfall in the Sahel.

J2.4

Comparison of Simulated and Reconstructed Variations in East African Hydroclimate over the Last Millennium

FrançoisKlein, Université catholique de Louvain, Louvain-la-Neuve, Belgium

Most of East Africa's agriculture depends on the amount and the seasonal occurrence of rainfall. This, with other factors such as rapid changes in land use associated to population growth, makes this region very sensitive to climate change. However, there is no consensus on future climate change for this region, the drivers responsible for East African precipitation variability being poorly understood. General Circulation Models (GCMs) generally predict a wetter climate over that region in the context of global warming, but these projections contrast with the recent decades-long decline in East African rainfall.

In this context, it is crucial to assess the performance of GCMs to determine whether they may represent realistically future changes in East African hydroclimate. The recent period, when direct measurements are available, is the first natural test but it is complemented here with analyses covering the last millennium in order to study also multidecadal to centennial variability. Specifically, we consider forced transient experiments simulated by six GCMs as well as lake-sediment records reconstructing hydroclimate conditions of four East African lakes: Lake Challa, Lake Naivasha, Lake Malawi and Lake Masoko.

While the unimodal seasonal cycle of precipitation characterizing the region including the lakes Masoko and Malawi is fairly well represented by GCMs, the magnitude of the two rainy seasons of Lake Challa and Lake Naivasha is less well captured. The comparison between model results and proxy-based reconstructions display very different time development over the last millennium. Additionally, there is no common signal among model time series. This suggests that simulated hydroclimate fluctuations are mostly driven by internal variability rather by a common forcing until 1850. After that, half of the models used simulate a relatively clear response to forcing, but this response is different between the models.

Overall, the link between precipitations and tropical sea surface temperature (SSTs) over the last millennium is stronger and more robust for the rainfall over the Challe/Naivasha region than over the Masoko/Malawi region. At interannual time scale, Challa/Naivasha precipitations are positively correlated with the western Indian Ocean and negatively with the eastern part of the basin, while the influence of the Pacific Ocean seems minimal and unclear. Although most of times not significant, the dipole in the Indian Ocean is still present using time series smoothed to highlight centennial variability, but only in unforced simulations. This means that, at the centennial time scale, the effect of forcing can overwhelm natural variability in large scale teleconnections.

J2.5

Horn of Africa Rainfall Sensitivity to Regional Sea Surface Temperature Forcing in the Indian and Atlantic Oceans

ZewduSegele, CIMMS/Univ. of Oklahoma, Norman, OK

Major features of the tropical atmospheric circulation, averaged over time-scales longer than a month or two, are largely determined by sea surface temperature (SST) variations. This study employs the Abdus Salam International Center for Theoretical Physics (ICTP) version 4.4 Regional Climate Model (RegCM4) to investigate the rainfall response over the Horn of Africa to SST forcing in the Indian and Atlantic Oceans. To isolate the effects of SST forcing and smooth out chaotic internal model variability, 10 individual simulations obtained from random perturbations of the initial and time-varying boundary conditions are analyzed. In these simulations, a constant or linearly zonally varying SST anomaly (SSTA) forcing is prescribed in individual basins while specifying the 1971–2000 monthly varying climatological SSTs across the remaining model domain. The nonlinear rainfall response to SST anomaly strength is also investigated by separately specifying +1K, +2K, and +4K SST anomaly forcing in the Atlantic and Indian Oceans. The model sensitivity experiments showed that the vertically integrated (1000–600 hPa) meridional moisture flux across the Ethiopian southern boundary generally is more than twice as large in magnitude as the zonal flux, and thus the southerlies from the Indian Ocean are the primary moisture driver for Ethiopian June–September rainfall season. The simulation results also show that warm SSTs over the entire Indian Ocean produce drier conditions across the larger Blue Nile catchment, whereas warming exceeding +2K generates large positive rainfall anomalies exceeding 10 mm·day-1 over drought prone regions of northeastern Ethiopia. However, the June–September rainy season tends to be wetter (drier) when the SST warming (cooling) is limited to either the Northern or Southern Indian Ocean. Wetter rainy seasons generally are characterized by deepening of the monsoon trough east of 40°E, intensification of the Mascarene high, strengthening of the Somali low level jet and the tropical easterly jet, enhanced zonal and meridional vertically integrated moisture fluxes, and steeply vertically decreasing moist static energy. The opposite conditions hold for drier monsoon seasons.

J2.6

Exploration of the ENSO-Sahel Relationship on Intraseasonal to Interannual Timescales and its Relevance to Local Climate Services

CatherinePomposi, Columbia University, Palisades, NY

Previous studies have identified and elucidated a relationship between the El Niño Southern Oscillation (ENSO) climate mode in the Eastern Tropical Pacific and rainfall in the West African Sahel, the semi-arid grassland which sits directly south of the Sahara desert and exhibits large variability on a number of timescales. In particular, during warm events (El Niño), the Sahel is expected to be anomalously dry while during cold events (La Niña), rainfall anomalies are of the opposite sign and the region tends to be wetter than normal. However, the seasonal total of rainfall that occurs in West Africa during an ENSO event cannot simply be understood in terms of thinking of the magnitude and warm or cold nature of the event itself. For example, during the extraordinary 1997 El Niño event, the Sahel was only modestly dry, and some of the strongest La Niña years (e.g. 1973 & 1975) were not the wettest seasons for the Sahel during the 20th Century. It is with inconsistencies such as these in mind that the Sahel's behavior during ENSO events is studied with a diagnostic framework, utilizing newly available high-resolution observations such as the CHIRPS dataset. Specifically, we complete this study with the following objectives,

to study whether the precipitation response in the Sahel is different when El Niño is growing versus when it is on the decline, and to understand whether the state of the Tropical Atlantic can modulate the ENSO teleconnection to the Sahel. Results from this work have particular relevance for informing seasonal forecasting applications as these forecasts are primarily made using the current state of ENSO to inform local experts on the probability of having a normal, above normal, or below normal rainfall season. An example of how the increased knowledge of ENSO's effects on Sahel rainfall may be used will be discussed by detailing current efforts of the Agence Nationale de l'Aviation Civile et de la Météorologie (ANACIM) du Sénégal, host to the lead author's visit in country to work on delivering climate information and build resilience to climate variability locally.

J5.1

Climate Monitoring and Forecasting for Humanitarian Response Planning

Wassila MamadouThiaw, NOAA, College Park, MD

Drought is one of the greatest challenges in Africa due to its impact on access to sanitary water and food. In response to this challenge, the international community has mobilized to develop famine early warning systems (FEWS) to bring safe food and water to populations in need. Over the past several decades, much attention has focused on advance risk planning in agriculture and water. This requires frequent updates of weather and climate outlooks. This paper describes the active role of NOAA's African Desk in FEWS and in enhancing the capacity of African institutions to improve forecasts. Emphasis is on the operational products from short and medium range weather forecasts to subseasonal and seasonal outlooks in support of humanitarian relief programs. Tools to provide access to real time weather and climate information to the public are described. These include the downscaling of the U.S. National Multi-model Ensemble (NMME) to improve seasonal forecasts in support of Regional Climate Outlook Forums (RCOFs). The subseasonal time scale has emerged as extremely important to many socio-economic sectors. Drawing from advances in numerical models that can now provide a better representation of the MJO, operational subseasonal forecasts are included in the African Desk product suite. These along with forecasts skill assessment and verifications are discussed. The presentation will also highlight regional hazards outlooks basis for FEWSNET food security outlooks. The preparation of the hazards outlooks requires the monitoring of the climate system and the forecasts. Beside meteorological fields, other products considered in the preparation of the hazards include crop conditions obtained from remote sensing data, hydrological information, and field reports. The information is blended using geographical information system (GIS) to draw polygons in areas that may experience drought or flooding during the outlook period. The outlooks are disseminated to the public and to FEWSNET, and are used in the preparation of regional food security outlooks. Finally, the African Desk residency training program, which is supported by this seamless approach to operational forecasting and aimed at enhancing the capacity of African institutions to improve forecasts, is discussed.

J5.2

Towards a Forecast Based Financing Framework to Trigger Humanitarian Action Before Floods

AndrewKruczkiewicz, Columbia Univ. /Red Cross Red Crescent Climate Centre, Palisades, NY

Forecast based financing is a novel approach to automatically trigger pre-established humanitarian actions based on forecasts and observations at various timescales (Coughlan de Perez et al., 2015). In Africa this system will be of particular interest to humanitarian and government disaster managers as preparedness actions prior to a hydro-meteorological disasters can be ad hoc.

In January 2015, extended periods of extreme rainfall caused a series of flood events throughout southern Africa. With little or no warning, the floods took communities by surprise, resulting in the displacement of over 230,000 residents and causing 276 fatalities (Government of Malawi, 2015). Parts of Malawi and Mozambique were amongst the hardest hit regions, with internally displaced people still residing in tented shelter camps as of August 2015. The meteorological situation was complex, with both riverine floods and flash floods occurring in various parts of the region within a narrow temporal frame.

In the days after the floods, humanitarian organizations and government level disaster mangers made decisions using information available to them, many time relying on satellite and flood model driven flood maps and anecdotal evidence from contacts in the field. Many maps were available, however, decision-making was hampered by uncertainty in the validity of the flood maps and challenging communication with the most impacted regions.

In partnership with the Malawi Red Cross National Society, we compared ground-truth data (locations of shelter site of internally displaced people (IDPs) and origins of IDPs) with the spatial distribution of remotely sensed and model driven flood products derived from NASA sensors, MODIS, SSM-I and AMSU-A and Landsat data from USGS. Furture, to explore the potential predictive capabilities of geophysical variables, we evaluated the relationship between soil moisture (data from the advanced scatterometer (ASCAT) provided by the European Space Agency and rainfall (data from the Tropical Rainfall Measuring Mission (TRMM) by provided by NASA).

A disaggregation of flood types in the context of monitoring and production of flood maps may aid in the development of a regional flood climatology in southern and eastern Africa, which in turn would contribute to the refinement of triggered actions fixed to levels of geophysical variables. In addition, project outputs suggest further exploration of the relationship of coupled variables, such as forecasted rainfall and antecedent soil moisture status, could be useful in developing thresholds to trigger humanitarian action in Mozambique.

In the same way that the geophysical characteristics of flood vary spatially and temporally by flood type, so too does the linked humanitarian action. The results of this study will increase the ability to forecast and monitor flood events in Mozambique, Malawi and across Africa, benefiting organizations involved with disaster preparedness and relief efforts, with a specific emphasis on providing analysis for the development of forecast based financing mechanisms to release funding before a disaster based on pre determined triggers and actions.

J5.3

Hydrological Modeling and Capacity Building in the Republic of Namibia

RaceClark, CIMMS/Univ. of Oklahoma, Norman, OK

Since 2012, scientists from the University of Oklahoma (OU) have partnered with the Government of Namibia's Ministry of Agriculture, Water, and Forestry (MAWF) to improve flood and drought forecasting and monitoring across Namibia. Namibia is the driest country in sub-Saharan Africa and is comprised almost entirely of arid and semi-arid climates that experience highly variable annual rainfall, making the country susceptible to economically devastating droughts and floods.

OU's hydrological modeling framework, EF5 (Ensemble Framework for Flash Flood Forecasting), uses satellite estimates of precipitation and/or forecast rainfall from weather models to monitor or predict stream water levels and soil moisture content, both of which are important in producing flood and drought forecasts. EF5 additionally has a hydraulic modeling component. Combined with observations of inundated areas from space borne instruments, this allows for forecasts of the spatial extent of flooding.

The National Aeronautics and Space Administration (NASA) and the Open Cloud Consortium run Project Matsu, a cloud computing service which hosts the Namibia Flood Dashboard. The Dashboard allows users to access water information related to Namibia and the surrounding area, including the weekly flood bulletin from the Namibian MAWF, OU/NASA hydrological model output over select river basins, observed stream flows on several important basins, geo-located satellite images from hydrologically interesting events, and more.

The aim of all these activities is to give Namibian hydrologists the technical expertise to set up, run, use, and interpret the hydrologic model on the Matsu cloud. This capacity building process is now entering its fourth year; several dozen hydrologists employed by the Namibian government, local universities, NGOs, and other stakeholders in the southern Africa community have been trained in the use of EF5. This presentation will trace the history of OU and NASA's activities in Namibia and explain where we plan taking these activities in the next few years. We hope the lessons we have learned from Namibia over the years will prove helpful to other hydrologists and meteorologists intending to pursue their own capacity building activities on the African continent.

J5.4

Linking Past, Present and Future Climate Change to Adaptation in the African Sahel

AlessandraGiannini, IRI/Columbia University, Palisades, NY

The semi-arid African Sahel has received unique attention in the climate science community and beyond since inception of persistent drought at the end of the 1960s. Initially, drought was attributed to rapid population growth leading to mismanagement of land resources. The hypothesis of a positive bio-geophysical feedback tied human-induced baring of the soils to a reduction of precipitation, which further exacerbated the loss in vegetation cover [Charney 1975, in Q J Roy Meteor Soc]. In contrast, the seminal work of Lamb dating back to the 1970s [e.g., 1978 in Mon Wea Rev, 1982 in Nature] tied Sahel drought to variations in the surface temperature of the tropical Atlantic, and attendant regional atmospheric circulation, paving the way for seasonal climate prediction.

In the more recent ~10 years the climate of the Sahel has again emerged as the focus of active research, this time as a possible "canary in the coal mine" for anthropogenic climate change. Advances in climate science have first conclusively tied persistent drought to subtle shifts in the surface temperature of the global oceans [Giannini et al. 2003], "freeing farmers of blame" in the drought, then partially attributed these shifts to the influence of greenhouse gases and aerosols [Held et al. 2005, in Proc Nat Acad Sci; Booth et al. 2012, in Nature]. In the meantime the region has partially recovered from drought, and is experiencing an increased frequency of flooding [Tall 2010, in Proc Env Sci], underlined, to the extent that it has been documented, by a subtle increase in the intensity of precipitation [Lodoun et al. 2013, in Env Develop; Alhassane et al. 2013, in Secheresse].

Here I present a novel interpretation for the role of the oceans in effecting precipitation change in this region, an interpretation that has benefited from collaborative research through sustained opportunities of engagement catalyzed by the regional Climate Outlook Fora organized by ACMAD, especially PRESAO, the West African COF. Sahel rainfall responds to the relative temperature of the North Atlantic, source of the moisture that converges in the region, with respect to the global tropical oceans. The temperature of the global tropical oceans, which is communicated first vertically through deep convection, then laterally by atmospheric waves [Chou and Neelin 2004, in J Climate; Held and Soden 2006, in J Climate; Sobel et al. 2001, in J Atmos Sci], broadly determines the threshold for convection. The temperature of the North Atlantic relative to that of the global tropical oceans measures the potential for the moist, but cool air that is converged onto the African continent from the adjacent ocean to trigger deep convection and precipitation.

This interpretation consistently explains past drought, partial recovery, and the current alternation of wet and dry states on time scales from daily to interannual [Lodoun et al. 2013, in Environmental Development; Salack et al. 2014, in Clim Dyn]. It also sheds light on the uncertainty in future projections, relating them to the uncertainty in patterns of sea surface temperature change [Giannini et al. 2013, in Env Res Lett]. This contribution aims to frame the physical context in which to discuss societal response to drought, and its applicability to adaptation to current variability and future change.

J5.5

Development of Innovative Technology to Provide Low-Cost Surface Atmospheric Observations in Africa

Paul A.Kucera, NCAR, Boulder, CO

Accurate and reliable real-time monitoring and dissemination of observations of surface weather conditions is critical for a variety of societal applications. Applications that provide local and regional information about temperature, precipitation, moisture, and winds, for example, are important for agriculture, water resource monitoring, health, and monitoring of hazard weather conditions. In many regions in Africa (and other global locations), surface weather stations are sparsely located and/or of poor quality. Existing stations have often been sited incorrectly, not well-maintained, and have limited communications established at the site for real-time monitoring. The US National Weather Service (NWS) International Activities Office (IAO) in partnership with University Corporation for Atmospheric Research (UCAR)/National Center for Atmospheric Research (NCAR) and funded by the United States Agency for International Development (USAID) Office of Foreign Disaster Assistance (OFDA) has started an initiative to develop and deploy low-cost weather instrumentation in sparsely observed regions of the world. The goal is to provide observations for environmental monitoring, and early warning alert systems that can be deployed at weather services in developing countries. Instrumentation is being designed using innovative new technologies such as 3D printers, Raspberry Pi computing systems, and wireless communications. The initial effort is focused on designing a surface network using GIS-based tools, deploying an initial network in Zambia, and providing training to Zambia Meteorological Department (ZMD) staff. The presentation will provide an overview of the project concepts, design of the low cost instrumentation, and initial experiences deploying a surface network deployment in Zambia.

J5.6

Tigge Ensemble Weather Forecasts to Help Manage Meningitis in the Sahel

Thomas M.Hopson, NCAR, Boulder, CO

Meningitis epidemics in the Sahel have historically occurred with regularity, leading to the deaths of hundreds. Until 2010, the protection provided by the only available vaccine was so limited and short-lived that the only practical strategy for vaccination was reactive: waiting until an epidemic occurred in the region and then vaccinating in that region to prevent the epidemic's further growth. While a new vaccine has been developed that is effective and inexpensive enough to be used more broadly and proactively, it is only effective against serogroup A which causes the most common kind of bacterial meningitis in the Sahel. As a result, other strains have been occurring in the Sahel with limited vaccine that have been impacting thousands, potentially continuing the need for for reactive vaccination strategies as these new serogroups continue to circulate. Because in the past, the reactive vaccine only provides protection for two to three years, does not prevent carriage, and does not induce herd immunity, retrospective analysis can estimate the impact of meningitis on a district with or without a reactive vaccination campaign and with or without advanced knowledge of weather conditions. This approach allows us to retrospectively assess how “perfect” weather information could have been used to allow public health officials to deploy vaccines sooner to areas in which the epidemics are likely to persist due to continued dryness and avoid vaccinating areas where the epidemics will end with higher humidity, mitigating the impact of the disease on human morbidity, mortality, and strained health-directed financial resources. However, in reality no forecast is perfect, and often ensemble approaches are the best option. In this context we investigated the application and skill of the Thorpex Tigge multi-center ensemble weather forecasts. In this talk we discuss our work to optimally blend the multi-model ensemble weather forecasts, and discuss the benefits of its application to more effectively allocate scare meningitis vaccine over single-model or climate forecasts. We also discuss ongoing efforts with the World Health Organization and ACMAD to test the utility of country-specific forecasts based on weather forecasts and current district-level disease incidence to help inform public health officials from several African countries during the vaccination decision-making process.

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Impact of land use and land cover on the local Climate of Lake Victoria Basin

MasilinGudoshava, North Carolina State University, Raleigh, NC

In the past centuries humans have modified the land use and land cover through different activities, such as urbanization. Although urbanization makes up a small percentage of the total land cover, the accelerated conversion of vegetated land to paved impervious land cover can have profound consequences on the socio-economic livelihoods of people and the ecosystem. Africa is expected to have a surge in urban expansion, with an estimated growth of approximately 590%. The shores of Lake Victoria are among the regions that are expected to have a high growth in urban extent. We hypothesize that the rapid urbanization over Lake Victoria shores will have an impact on the local and regional climate, altering the surface energy balance, temperature and precipitation. Simulations were conducted with the current land cover and the projected 2030 urbanization levels utilizing the Weather and Research Forecasting model (WRFV3.7). Both the control and sensitivity simulations were done with three nested domains. The outer domain which has a resolution of 36 km is over East Africa and parts of the Indian and Atlantic Oceans, the 12 km resolution domain is over East Africa and some parts of Congo, while the 4km domain is over the Lake Victoria Basin. Evaluation for the control simulation was conducted using the Tropical Rainfall Measuring Mission (TRMM) and the following statistics were calculated: root mean square error, mean bias, correlation and standard deviation. Evaluation of the control simulations show that the model has skill with only small biases in temperature and precipitation. Sensitivity simulations show that increasing the urban fraction over the northern part of the basin modifies physical parameters such as albedo, moisture and surface energy fluxes, aerodynamic roughness and surface emissivity, thereby altering the precipitation and temperature over the region. The change in the physical parameters increases temperature over the urbanized region in all of the domains. The increased temperature over the urbanized region alters the land-lake breeze circulation system and leads to a change in intensity, distribution, and frequency of precipitation. More specifically the results show pronounced increase in rainfall over the north-western crescent of Lake Victoria Basin coinciding with the region of largest urbanization growth. The relative differences between the sensitivity and control simulations are not statistical significantly impacted by domain resolution.

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Sunspot numbers: Implications on Eastern African Rainfall

FrancisGachari, Jomo Kenyatta University of Agriculture and Technology, Nairobi, Kenya

Following NASA's prediction of sunspot numbers for the current sunspot cycle, Cycle 24, we now include sunspot numbers as an explanatory variable in a statistical model. This model is based on fitting monthly rainfall values with factors and covariates obtained from solar–lunar geometry values and sunspot numbers. The model demonstrates high predictive skill in estimating monthly values by achieving a correlation coefficient of 0.9 between model estimates and the measurements. Estimates for monthly total rainfall for the period from 1901 to 2020 for Kenya indicate that the model can be used not only to estimate historical values of rainfall, but also to predict monthly total rainfall. We have found that the 11-year solar sunspot cycle has an influence on the frequency and timing of extreme hydrology events in Kenya, with these events occurring every 5±2 years after the turning points of sunspot cycles. While solar declination is the major driver of monthly variability, solar activity and the lunar declinations play a role in the annual variability and may have influenced the occurrence of the Sahelian drought of the mid-1980s that affected the Sahel region including the Greater Horn of Africa. Judging from the reflection symmetry, the trend of the current maximum and the turning point of the sunspot minimum at the end of the Modern Maximum, with a 95% level of confidence, drought conditions similar to those of the early 1920s may reoccur in the year 2020±2.

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Assessment of Soil Moisture Budget Using a Water Balance Model and Use of Model Results for Drought Early Warning. Case of a Moderate Semi Arid Watershed Northern Tunisia

ZoubeidaBargaoui, Université Tunis El Manar, Tunis, Tunisia

A water balance model presented by Kobayashi et al. (2001) modified in parameterisation by Bargaoui and Houcine (2010) is adopted to assess soil moisture content evolution through the hydrological year. This is the main model aim. The model is composed by a single soil layer reservoir, daily time scale and lumped. Three model parameters out of seven (Active soil layer, moisture retaining capacity and stomatal resistance of vegetation to evapotranspiration) are estimated using observed daily discharge data, the other being estimated out of the model through adopting pedotransfer functions and using basin soil texture information. The study analyzes the effect of adopting regional evapotranspiration a priori knowledge to constraint the set of parameters solutions obtained using runoff residual criteria. Effectively in a first step fitting criteria linked to model efficiency are adopted to select valuable parameters sets. These performance measures are: absolute annual relative error less than 20% associated to acceptable runoff Nash coefficients at monthly and decadal time scales. The case study is Wadi Oussafa (Tunisia), area 397 km², elevation between 508 m and 1294 m, intermittent river coming from Makthar elevations feeding the deep aquifer of Siliana underflow during winter season. Data division method for model testing is k-fold partitioning, with k=4. Thus, daily discharge series from 1928 to 1932 are used for training. Periods 1933 to 1938, 1960 to 1963 and 1966 to 1972 are used for testing. Before using data for model calibration and testing, data control process was undertaken identifying flood periods (minimum daily runoff volume = 0.5 Mm3 and separation time interval=2 days). Observed daily hydrographs were found coherent with observed daily hyetographs and resulting runoff coefficients. Parameters sets selected this way, result in good visual agreement between observed and predicted discharges in calibration and testing periods. They are then adopted to run the model. Subsequently, monthly predicted percolation fluxes, evapotranspiration fluxes and soil moisture contents are compared between solutions. Surprisingly, they do report a wide variability from one set of solutions to another. Moreover, they do display bimodal distributions. Using the Budyko model (1956) and its Hsuen Chen (1988) approximation to estimate regional evapotranspiration for this basin, as well as using ecological constraints dictated by the basin climatic conditions (semi arid area) (Eagleson 1994), the number of acceptable solutions is therefore reduced as well as the variance of model responses. Using the retaining solutions after this second step of model building, it is found that the average soil water content predicted by the model is a good proxy of the hydrological year dryness. Thus, a drought index is adopted (representing a defined soil moisture content quantile) to evaluate drought occurrence conditions and to help drought early warning.

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Interannual to Multidecadal Climatic Fluctuations Due to Volcanic Eruptions

Joanna MajaSlawinska, Rutgers University, New Brunswick, NJ

Low-frequency (decadal to centennial) modes of ocean variability are important components of climate variability. These modes are often inferred from long-term climate simulations after being preprocessed by low-pass filtering. Notably, the few modes that are consistently found in many climate models differ significantly, even in frequency, as every model has biases and model errors. At the same time, validation of the extracted signals against observations is limited by the time span of the observational record (e.g., sea surface temperature and sea ice extent observed during the satellite era), which is often shorter than the timescales of interest and also significantly altered by anthropogenic factors. More importantly, due to preprocessing as well as the subsequent data analysis techniques, such as empirical orthogonal functions (EOFs), the results have frequently ambiguous physical interpretation.

Here, we investigate interannual to multidecadal response of oceanic circulation to volcanic eruptions and their possible impact on climate (e.g., droughts, glaciations). We also study other modes of coupled atmosphere-ocean climate variability (e.g., North Atlantic Oscillation) and establish linkages between these patterns and low-frequency perturbations of climate triggered by volcanic eruptions. For that, we study the Last Millennium Ensemble (https://www2.cesm.ucar.edu/models/experiments/LME). We analyze individually over 70 eruptions of both tropical and extratropical origin, with a particular focus on their regional impact (e.g., Baffin Island, Sahel, Australia) on long-term perturbation of precipitation or ice cover. We capture patterns of coupled atmosphere-ocean response to volcanic eruptions through multi-component composites, providing physical mechanisms behind regional climatic response to volcanic eruptions. Moreover, we apply a recently introduced technique called Nonlinear Laplacian Spectral Analysis. Through this technique, drawbacks associated with ad-hoc filtering are avoided as the extracted signals span many temporal scales without preprocessing the input data, enabling detection of low-frequency, low-amplitude and intermittent modes otherwise not accessible with classical approaches.

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Helping Africa Help Itself

JimAnderson, Earth Networks, Germantown, MD

Over the last couple of decades international aid agencies and countries in Africa have invested heavily in modernizing and expanding their weather observing, forecasting and severe weather alerting infrastructure. Unfortunately, much of that investment has not had significant impact on the service provided to key government and enterprise users as well as the quality of information available to the general public. More work needs to be done. Modern cloud computing, mobile telecommunications and signal processing are enabling a new generation of weather intelligence solutions that operate more reliably in regions with limited infrastructure and capacity, cost less, and can have broader application.

In this presentation Earth Networks reviews a range of case studies and examples of how a new generation of technology is being used to benefit wide swaths of east and west Africa. Technical challenges and solutions are reviewed. Possibilities for technology enhancements are discussed.

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Influence of the Atlantic Ocean on the Interannual Variability of the Eastern Africa Rainfall

Rowan ElizabethArgent, North Carolina State University, Raleigh, NC

The rainfall in Eastern Africa is a lifeline to the millions of people living around and downstream of the large lakes scattered across the area. The rainfall in the region is highly variable on all timescales and is influenced by many factors and teleconnections. The interannual variability of the short rains (October to December, OND) has been extensively studied and has been shown to be primarily influenced by the El Nino Southern Oscillation (ENSO) and the Indian Ocean Dipole (IOD). However the variability of the long rains (March to April, MAM) is not well understood, and given that the short rains provide the greater rainfall, this is an area in need of improvement. Recently it has been shown that the Atlantic Multidecadal Oscillation (AMO) is influential on the decadal timescale for the long rains, in particular for the cessation in the month of May. The influence on the region is propagated through AMO-induced stationary Rossby Waves. The placement of the high and low pressures, as a result of the Rossby wave, influences the flow over the region and the corresponding rising and sinking motion influences the locations that receive the most rainfall. Variations in the positions determine which regions see more or less rainfall. It is proposed that this influence could also be important on an interannual basis. We hypothesize that the indices that produce the waves, such as the AMO, also influence the regional climate over shorter timescales. We envisage that the mechanisms responsible for the longer time-scale variability also acts on a day to day, month to month and year to year basis during which the index changes albeit on a much smaller scale. The interannual variation of AMO and rainfall for May are analysed for the period, 1950-2010. These results showed that the role of AMO-induced teleconnections may be more complex on the interannual time-scale than on the decadal time-scale. For example, the Rossby wave may not be treated as a stationary phenomena thus explaining why the simple correlation analysis, which we previously adopted in our multi-decadal study, cannot detect a significant relationship; however a visible wave pattern is still apparent over the region and appears to originate in the Atlantic Ocean. It is further hypothesized that the SST in the Atlantic Ocean still plays an important role in modulating the interannual variability of East African rainfall. Additionally, it is expected that the interactions of individual teleconnections on an interannual timescale are different to that of the decadal timescale and that these interactions are highly influential in determining the amount of rainfall East Africa experiences each year. Consequently this project identifies the indices which are responsible for the teleconnections that interact to either reinforce or counter influences in the East African region. This is done through the computations of correlations and combined EOFs. The mechanisms by which these indices influence the region are analysed using a regional model in order to gain an understanding of the physical processes at play over the region. A greater understanding of the interactions of teleconnections and their influence over the region should lead to a greater ability to understand what is likely to happen in the future.

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GPM Rainfall-based Streamflow Analyses for East Africa

Clay B.Blankenship, USRA, Huntsville, AL

Availability of reliable rainfall data has been a major challenge in Africa, which lacks extensive radar and precipitation gauge networks. Global Precipitation Mission (GPM) data products are meeting that need, with frequent, high-resolution rainfall available globally. SERVIR, a joint USAID-NASA project aimed at improving the environmental decision making capacity of developing countries, and the Regional Centre for Mapping of Resources for Development (RCMRD) in Nairobi, Kenya, are collaborating to produce nowcasts of regional streamflow. The streamflow analyses are produced by the Coupled Routing and Excess STorage (CREST) model, with forcing from Integrated Multi-satellitE Retrievals for GPM (IMERG), and routing from a high-resolution topographical database. The streamflow products are used to issue “wet” and “very wet” condition alerts to the Kenya Department of Water Resources (DWR) when they exceed historical thresholds at select locations. Output from SERVIR's model is also made available online using the CREST Viewer.

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Sensitivity of Wind Energy Potential Analysis over East Africa to Land Cover Change

MasilinGudoshava, North Carolina State University, Raleigh, NC

In the past few decades, the urban population over East Africa has been increasing steadily at a rate of approximately 4 to7%. This increase in population is expected to surge in the near future, with Lake Victoria Basin expected to have a population increase of approximately 300% over the year 2000 population in 2030. Most countries in this region depend on hydroelectric power however currently demand is greater than what can be supplied. Hence alternative sources of clean energy have to be sought. Wind power energy has been successfully implemented in Europe, with Denmark being able to generate approximately 40% of its demand. We therefore hypothesize that East Africa has the potential for wind energy expansion beyond the Turkana Wind Project and future land cover will likely alter the potential for wind energy in the region.

To assess the potential for wind energy over the region, we use the Weather and Research Forecasting model (WRFV3.7) coupled to a 1-Dimensional lake model. Seto et al.(2012) land cover projections for the year 2030 were used for the sensitivity. Simulations were conducted for different years, that is 2009, which was a climatological year, 2006 an extremely wet year and 2010 a dry year.

With the current land cover the wind speeds show that Kenya and Tanzania have a high potential in wind energy. Some parts of Uganda also show high potential in wind energy. Different resolutions show different wind speeds, with the coarser resolution missing some regions that have high wind speed. No major differences were obtained by looking at different years. The highest wind speeds occur in the early hours of the day and in the evening. The probability of getting wind speeds greater than 3.5 m/s, the typical cut-in speed for a small turbine to start generating power is greater than 60%. Using future projected land cover, we find that the wind speed over the urbanized region changes slightly with some urbanized regions having slightly higher wind speeds. Further analysis on why wind speeds increase will be done. In conclusion East Africa has the potential to expand their wind power energy and urbanization has an effect on the wind power energy production.

Nocturnal Low Level Jets in West Africa

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1 Introduction

West African monsoon (WAM) diurnal cycle has a major role in the monsoon water budget as well as those of aerosols and trace gases (Parker et al. (2005)). One of the main features of the diurnal cycle is the decrease of turbulence at night leading to the formation of a nocturnal low-level jet (NLLJ). The NLLJ has been described as the major responsible for moisture transport to the northern Sahel. A comparison between model and observations in the NBL showed that the Met Office Unified Model underestimates the wind speed (including the NLLJ) in the NBL as well as the moisture flux (Bain et al. (2010)). Surface energy balance is also poorly represented in current model (Milton et al. (2008), and Haywood et al. (2005)). This error is mainly due to cloud radiative forcing errors. Indeed, the formation of low-level clouds (200m-400m) (Schrage et al. (2007)) which reduce solar radiation are not taken into account by the model leading to this error. It could represent up to 90W m^{-2} in the mean daily surface solar radiance in this region in global climates models (Knippertz et al. (2011)). The formation of these clouds has been identified as a consequence of the wind shear turbulence underneath the NLLJ which mixes moist surface air upward generating clouds. The low level cloud layer could last the whole morning before being erode by the sun (Knippertz et al. (2011)). Further studies have been made to explain the parameters acting on the formation and the maintenance of these clouds. The low-level stratus layer is a consequence of turbulent vertical mixing, advection of cool air, and forced lifting from the mountain winds. Each parameter contribution in the cloud formation process depends with the distance to the coast. Small changes in turbulent fluxes and advected air masses lead to bias in the cloud cover, affecting SW radiation balance and temperature at the surface (Schuster et al. (2013) and Schrage and Fink (2012)).

Different mechanism where proposed to explain the formation of a LLJ. The oldest one was introduced by Blackadar in 1957 (Blackadar (1957)). It infers that a wind inertial oscillation induced by a disequilibrium between pressure gradient and Coriolis force is at the origin of the jet. This imbalance is the consequence of the decoupling of the residual boundary layer from the surface boundary layer. In regions where there is a change in surface characteristics such as coast lines the difference of sensible and latent heat flux produces strong low-level baroclinicity. In this situation the jets are parrallel to the low-level horizontal temperature gradient. These jets are considered as LLJs in region where fluxes have a diurnal component (Stensrud (1996)). It suggests that LLJs have different behaviour regarding to the distance to the coast and the sea breath strength. Aged convective cold pools can as well trigger NLLJ (Knippertz and Todd (2012)). Cold pools can glide over a stable boundary layer leading to local pressure gradients triggering the NLLJ (Heinold et al. (2013)).

2 NLLJ inertial oscillation conceptual models

To identify the origin of the jet, conceptual inertial oscillation models were run. Blackadar developed a model (named here B57) for the development of low level jets due to inertial oscillations assumes that the geostrophic winds perform an oscillation with a period $2\pi/f$ (where f is the Coriolis parameter) and the amplitude around the ageostrophic velocity component at sunset. However, friction being largest near to the ground causes the ageostrophic component to become too large to apply the B57 model at the NBL's bottom (Van de Wiel et al. (2010)). Van de Wiel et al. proposed a model extension of the B57 model where he includes an equilibrium friction (i.e the friction if the equilibrium between the geostrophic wind and the friction force was made and constant with time).

Comparison between these run and ceilometer results in the morning will show the consequences of the inertial oscillation on cloud formation.

3 Cold pool outflows Convective activity is chase through satellite imagery. Stability and speed profile Comparison between nights with and the one without cold pools will be used to describe the modification into the inertial oscillation induced by the cold pool. The understanding of the cold pool NLLJ and the inertial NLLJ will be used to produce a Low level clouds predictive model based on nocturnal condition.

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Investigating Key Climate Parameters over West Africa under RCP8.5 Scenario from RCA Multi Model Simulations

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Rainfed agriculture is dominant in West Africa, and therefore dependents highly on climate conditions. To better assess the impacts of climate change on this central sector, regional studies and in-depth analyses of key climate parameters and/or indicators were conducted. In this study, we used data from the Coordinated Regional Downscaling Experiment (CORDEX-AFRICA) simulations to assess climate paramters that affect agricultural activities over West Africa. The Swedish Meteorological and Hydrological SMHI-RCA3.5 regional climate model, run at a 50km horizontal resolution for a domain covering the whole Africa, was assessed over West Africa for an historical period and the future under the Representative Concentrations Pathway 8.5, (RCP8.5). The yearly variations in temperature and especially the drought of the early 1980s are not well simulated by most models. While the seasonal cycle is reasonably well captured by a few models, these generally fail to simulate the onset of the rainy season. Under RCP8.5, models generally project slightly wetter conditions for both intermediate and far terms over the whole West Africa. Another finding, in keeping with current trends, is the positive trend slope of precipitation, which has a high coefficient of variation suggesting a swing pattern mainly over the Sahel for both the IT and the FT.

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Impacts of Climate Variability and Agricultural Intensification on the Origin of Runoff: The Case Study of the Watershed Kolondieba in the South of Mali

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As part of the international research program RIPIECSA (Interdisciplinary and Participatory Research on Interactions between Ecosystems, Climate and Society in Africa), watershed Kolondieba (under Sudanese climate) was selected to understand the mechanism of runoff process in order to improve hydrological model in a context of strong climate variability and agricultural intensification (cotton culture is the main economic activity in the basin). The method used is based on rainfall, hydrometric, geochemical and piezometric data monitoring over the period 2009-2011. The results showed that 2009 and 2010 were normal rainfall years (1300 mm, in average), compared to the average of chronic 1960-1969 (wet period), while 2011 has emerged as a dry year compared to the chronic 1970-1992 (dry period). During the last contrasted two years, the runoff coefficient has decreased by half from 2010 to 2011 occasioned groundwater discharge deficit estimated at 33%. Monitoring the mineralization of targeted water compartments: rainfall, surface water, and groundwater with the integrator chemical parameter (Electrical Conductivity), showed a very little mineralization of rainfall with an average of 16.99 ± 8.53 μScm-1. Mineralization of surface water is closer to the rainfall's, but it's far from the groundwater's consist of shallow aquifers and deep ones with respectively 120.58 ± 90.07μScm-1 and 133.57 ± 85.68 μScm-1 in average. This chemical relationship between water compartments showed that deep aquifers don't contribute enough to the runoff. This allowed to deduct a double origin of the runoff on the watershed consists of stormflow and subsurface flow. The separation of the hydrograph in a normal year (2010) gave a contribution of stormflow about 77%. This contribution has increased by 3% in dry year (2011). In these conditions runoff doesn't depend only on rainfall variability, it can be assigned to the land use because cotton culture area is increasing on the basin since 1960.

A BRIEF BIOGRAPHY OF PETER J. LAMB

Pete J. (Pete) Lamb received B.A. (1969) and M. A. (1971, with Honors) degrees in Geography from the University of Canterbury (New Zealand), Ph.D. in Meteorology from the University of Wisconsin in 1976, and D.Sc. for published research in Climate Science from the University of Canterbury in 2002. His early appointments were at the University of Adelaide (Australia, 1976-1978), University of Miami (1978-1979) and Illinois State Water Survey/University of Illinois (1979-1991). In 1991, Pete joined The University of Oklahoma (OU) as Director of the NOAA-OU Cooperative Institute for Mesoscale Meteorological Studies (CIMMS), where he remained the rest of his career.

Pete's basic research focused on the physical and dynamical processes responsible for regional climate and its short-term fluctuations (intraseasonal, interannual, decadal), especially for Northern Hemisphere Africa and North America east of the Rocky Mountains. He authored or coauthored more than 100 peer-reviewed publications, which have received approximately 4,000 and 5,100 citations, respectively, according to the Web of Science and Google Scholar. He was the founding Chief Editor of the Journal of Climate (1989-1995). Pete was a member of the Council (2011-2014) and Executive Committee (2012-2014) of the American Meteorological Society.

Pete arrived in the United States in the fall of 1971 to study meteorology at the graduate level at the University of Wisconsin – Madison. He earned a PhD in Meteorology in 1976 under Professor Stefan L. Hastenrath. The subject matter in his dissertation, "Variations in General Circulation and Climate over the Tropical Atlantic and Africa: Weather Anomalies in the Subsaharan Region", continued on to be a major portion of his life's work, often in collaboration with Professor Hastenrath. His focus was on linking regional climate science with real world problems. He grew to love Africa and made many trips there to advise governments and hydrometeorological service providers.

Pete was an avid sportsman, having played rugby, basketball, and cricket for his school teams in New Zealand. He would persuade his friends to accompany him to Wisconsin rugby games and took great care to explain the rules and nuances of the game. His fellow graduate students presented him with the Southern Hemisphere Rotating Chair, which was an antique oak swivel chair appropriated from Old Science Hall. Even though he understood the humor involved, he used this chair as his desk chair throughout his time there. Pete was very proud of his Wisconsin heritage. It is appropriate then that Professor Hastenrath dedicated the last sentence in one of his books to Pete's memory.

"The study of climate is most important where it may serve the needs of mankind. In particular, the tropics are above all the lands and seas of the Third World, whose manifold social, economic, and political problems are intricately intertwined with climate."

Pete was a Post-Doctoral Research Associate at the Cooperative Institute for Marine and Atmospheric Studies (CIMAS) at the University of Miami during 1978-79 where he worked closely with Eric Kraus, who encouraged him to focus on North Atlantic climate and ocean processes. His work documented the annual march of the heat budget of the North and Tropical Atlantic Oceans. These included surface heat exchanges, net surface heat gain, subsurface heat storage change, and meridional oceanic heat transport. Pete had taken an early interest in the causes of the intense drought in the Subsaharan regions of North Africa, which had begun in the late 1960s and was particularly intense in the early 1970s. At CIMAS his research focused on understanding the factors that affected rainfall in the region. To this end, he began to compile statistics from stations in the Sahel region. This became the foundation of the long Sahel-Soudano rainfall time series, a record that serves as a vital data source for much of the research on West African climate to this day. In publications he showed that Sahel rainfall was linked to variations in the West African Monsoon. He posited that the drought of the early 1970s had continued into the 1980s, contrary to various scientific and media reports that had suggested that the drought had ameliorated. This paper alerted the community to the possibility of continued societal stress in the region, a warning that proved to be true. Indeed the height of the drought was not reached until the mid-1980s and drought continues to this day, albeit considerably weakened.

During Pete's residence at CIMAS, he had discussions with Dr. Joseph Prospero who was studying the transport of African dust across the Atlantic to the Caribbean based on aerosol measurements. These data showed large increases in dust transport in the 1970s and 1980s coincident with the two intense drought phases. In a joint paper, they showed that the year-to-year variability of dust transport over that time period had a strong negative correlation to rainfall in the Sahel as measured in Pete's network. Because dust itself is a climate-forcing agent, the linkage between dust and rainfall suggested the possibility of a feedback loop between rainfall and forcing. This has a number of implications, including the possible role that dust might play in affecting ocean sea-surface temperatures and in modulating Atlantic tropical cyclones.

Pete joined the Illinois State Water Survey (ISWS) at the University of Illinois in 1979. He was hired to augment the breadth and depth of the weather and climate research at ISWS, particularly the interface between the two, which affected the agricultural sector of the state economy. He began his tenure at ISWS as a Professional Scientist (1979-81) and was promoted to Principal Scientist (1982-91), owing to his prolific research record and the foresight to reach across several disciplines to provide a full assessment of weather and climate impacts, the underlying science, and policy implications. In 1984, Pete was promoted to head of the ISWS Climate and Meteorology Section and served in that capacity until 1990. In addition to his leadership role at ISWS, during the 1980's Pete was appointed an Adjunct Associate Professor of Meteorology in the Department of Atmospheric Sciences at the University of Illinois in 1983, and was promoted to Adjunct Professor in 1987. He also was appointed as an Affiliate of the Center for African Studies (1985) and as an Adjunct Professor of Geography (1988), all at Illinois.

While at ISWS, Pete's research interests included studying the physical and dynamical processes responsible for climate and its seasonal-to-interannual-to-decadal-scale variations, particularly for regions in North America and Africa where the vital growing season rainfall is delivered by mesoscale weather systems. Some of his earlier lines of inquiry (Subsaharan rainfall; oceanic heat budget) were expanded at Illinois. One of his key research efforts was directing extensive investigations of this type for the African Sahel and North America east of the Rocky Mountains, through a series of continuous National Science Foundation Grants in the 1980s through early 1990s. Pete had a keen interest in how physical-dynamical regional climate research can benefit society, particularly in the aforementioned regions. Many of the collaborations he formed in the 1980s and early 1990s continued to flourish after leaving Illinois. In particular, his applied research with economists on use of weather and climate information for U.S. agriculture provided the material for his 1991 Margary Lecture to the Royal Meteorological Society. His various papers on African climate have been referenced well over 2000 times and manuscripts he co-authored on the concept and application of the North Atlantic Oscillation have been cited over 400 times in the literature, as of this writing. During his tenure at Illinois, he was Chief Editor of the AMS *Journal of Climate* from 1989-95. His excellence at editing and persistence insuring the highest scientific standards for publication fostered the growth and stature of the *Journal of Climate*.

Pete loved to travel, visiting nearly every continent to present his research. He was particularly fond of joint endeavors with the Reading and East Anglia (UK) groups. During the 1980s and early 1990s, he was invited to each International Meeting on Statistical Climatology where he presented findings about applications of statistics to regional climate studies. His interest in weather processes made him a strong supporter of the University of CHicago and ILLinois State Water Survey (CHILL) radar program, a forerunner of the present-day national dual polarization Doppler radar network. Under his leadership CHILL was deployed around the country to link time and space scales ranging from cloud microphysics though climate. In the early 1990s, when the ISWS began to divest itself of such advanced sensor platforms and to diminish its scope of research, Pete realized this would make it difficult for him to accomplish cutting edge research and maintain his international collaborations, so he began a new phase of leadership in Oklahoma.

In 1991, Pete joined the University of Oklahoma as a tenured full Professor in its School of Meteorology, and as Director of its Cooperative Institute for Mesoscale Meteorological Studies that largely is funded by the National Oceanic and Atmospheric Administration (NOAA). During his 23 years as head of CIMMS, the number of staff and annual budget grew considerably. Pete also served as Director of the International Center for Disaster Research at OU from 1994-99, and was Associate Director of Oklahoma Weather Center Programs from 1996-2006. In 2001, Pete was honored with a George Lynn Cross Research Professorship, which is OU's highest research honor.

Pete's research topics expanded at OU, involving more than 20 graduate students, three of who have won AMS awards for their efforts. In addition, shortly after moving to Oklahoma in 1991, Pete was appointed Site Scientist for the Southern Great Plains component of the U.S. Department of Energy's Atmospheric Radiation Measurement (ARM) Program. The long-term effort he directed continued until 2012, and spanned scientific guidance for site operations, basic research, and educational outreach. Beginning in 1994, Pete led a multiyear program of collaborative research and development with the Moroccan National Weather Service that provided Morocco with an experimental long-range prediction capability for its crucial winter precipitation during 1996-2000. This program brought several long-term Moroccan visitors to OU, one of whom completed a Ph.D. and returned to his National Weather Service. In the mid-to-late-1990s, Pete also worked with Emeritus Professor Yoshi Sasaki to develop a substantial collaborative research program with Japan on small-scale weather phenomena and the resulting regional climate variability. This involved the Japan Science and Technology Agency, Kyoto, and Tokyo Universities, and the Hitachi Corporation. Pete coordinated Hitachi's donation of a supercomputer to OU for use in the collaborative program.

Starting in 1997, Pete led a program of collaboration and cooperation between CIMMS and the African Centre of Meteorological Applications for Development (ACMAD – Niamey, Niger) receiving significant funding from the International Activities Office of the U.S. National Weather Service and the U.S. Agency for International Development. This support facilitated the CIMMS research of graduate students from Kenya, Côte d'Ivoire, Morocco, Ethiopia, Chad, and Niger, most supervised by Pete. Almost all of the African graduates now are working back in their home countries. As part of this CIMMS–ACMAD linkage, Pete participated in several meetings of the ACMAD Governing Board. During the last decade, Pete collaborated closely with the Institute of Atmospheric Physics in the Chinese Academy of Sciences (Beijing), including serving as Principal Organizer of the First U.S.-China Symposium on Meteorology (University of Oklahoma, February 2008) and Co-Principal U.S. Organizer for the Second Symposium in this series (Qingdao, China, June 2013). Pete visited China in most years since 2005, where he gave invited presentations at the Chinese Academy of Sciences, Peking University, Lanzhou University, Nanjing University, and the City University of Hong Kong. Over the last decade, Pete's research had broadened to consider the monsoons of the Horn of Africa (especially Ethiopia) and North America (Mexico-Arizona-New Mexico), Australian dust and New Zealand sunshine variability, tropical cyclones in the western Pacific both north and south of the Equator, and the role of climate variability for Native American health. Pete was a key member of the science team for the first deployment of the ARM Mobile Facility in Africa for the RADAGAST field campaign, located in Niamey, Niger in 2006. Pete's research interest in North Africa's Subsaharan rainfall was notable in securing the field campaign, and he continued to foster that progress through collaborations with the University of Niamey. Shortly before the end of his life, Pete attended a kickoff meeting for a European Union project designed to compliment continuing scientific interests in West African climate research, and was planning a return to Niamey and nearby Burkina Faso in June 2014 to pursue these research possibilities. His participation in the Rainwatch and AfClix (African Climate Exchange) programs was instrumental to their continuing success.

Pete's passion for rugby was well known; he played it as an undergraduate, and was an avid supporter of the New Zealand All-Blacks team. For Pete, rugby was also a metaphor for pursuing one's life and career—with full-on enthusiasm and dedication, strength of purpose, and an overarching strategy. It was evident in his fearlessness in advocating for those in whom he felt a moral obligation to see succeed, and in showing his advisees and those he mentored how to successfully engage the rough-and-tumble that can sometimes be the Academy. As such, Pete embodied the ideal that the scientific enterprise is stronger when it is not the preserve of a self-selecting few, but when it is tackled by scholars from multiple disciplines possessing diverse perspectives.

Michael B. Richman, Lance M. Leslie, James F. Kimpel, Randy A. Peppler, Joseph M. Prospero, Andrew M. Carleton

PETER J. LAMB

I. PERSONAL

Born June 21, 1947, at Nelson, New Zealand
New Zealand and United States (naturalized) citizen
Father of two adult children (Dr. Karen D. Lockwood, Brett T. Lamb)

II. EDUCATION

B.A., Geography Major, University of Canterbury (New Zealand), 1969. Coursework included Climatology, Mathematics, and Physical Oceanography.

M.A. (Second Class Honours, Division I) in Geography, University of Canterbury, 1971. Specialization in Climatology/Meteorology, including thesis entitled: "An Investigation of the Canterbury Nor'-wester" (Supervisor: David E. Greenland). Other coursework in Geomorphology, Coastal Studies, and Urban Geography.

Ph.D. in Meteorology, The University of Wisconsin, 1976. Meteorology coursework in General Meteorology, Micrometeorology, Tropical Meteorology, Dynamic Climatology, Geophysical Fluid Dynamics, Advanced Dynamic Meteorology, Classical Problems. Other coursework in Mathematics and Computer Science. Ph.D. Minor in Geography. Dissertation entitled: "Variations in General Circulation and Climate over the Tropical Atlantic and Africa: Weather Anomalies in the Subsaharan Region." Major Professor: Stefan Hastenrath.

D.Sc. for published research in Climate Science, University of Canterbury, 2002. Document entitled: "Contributions to the 'Climate Revolution' -- Investigations of Regional Climate Variability, Predictability, and Applications".

III. EMPLOYMENT/POSITIONS HELD

Department of Geography, University of Canterbury (New Zealand): Demonstrator (i.e., Teaching Assistant), February 1969-June 1970; Assistant Lecturer (i.e., Instructor), February 1971-August 1971.

Department of Meteorology, The University of Wisconsin: Research Assistant, September 1971-January 1976; Post-Doctoral Research Associate, February 1976-August 1976.

Department of Geography, The University of Adelaide (Australia): Lecturer (i.e., Assistant Professor) in Meteorology, August 1976-June 1979.

Cooperative Institute for Marine and Atmospheric Studies, The University of Miami/NOAA: Visiting Post-Doctoral Research Associate, August 1978-May 1979.

Atmospheric Science Sections, Illinois State Water Survey: Professional Scientist, June 1979-August 1982; Principal Scientist, September 1982-July 1991; Assistant Section Head, December 1982-August 1984; Section Head (Climate and Meteorology), September 1984-June 1990.

Department of Atmospheric Sciences, The University of Illinois: Adjunct Associate Professor, January 1983-May 1987; Adjunct Professor, June 1987-August 1994.

Center for African Studies, The University of Illinois: Affiliate, July 1985-August 1994.

Department of Geography, The University of Illinois: Adjunct Professor, January 1988-August 1994.

School of Meteorology, The University of Oklahoma: Professor, August 1991-April 2001; George Lynn Cross Research Professor, April 2001-2014.

Cooperative Institute for Mesoscale Meteorological Studies, The University of Oklahoma/NOAA: Director, August 1991-2014.

International Center for Disaster Research, The University of Oklahoma: Director, November 1994-August 1999.

Weather Center Programs, The University of Oklahoma/NOAA: Associate Director, April 1996-December 2006.

IV. HONORS AND RECOGNITION

Fellow, American Meteorological Society, 1988

Associate Editor, *Journal of Climate*, American Meteorological Society, 1988

Chief Editor, *Journal of Climate*, American Meteorological Society, 1989-1995

Margary Lecturer, Royal Meteorological Society, 1991

Site Scientist, Atmospheric Radiation Measurement Program, U.S. Department of Energy, 1992-2012

Regents' Award for Superior Accomplishment in Research and Creative Activity, The University of Oklahoma, 1996

George Lynn Cross Research Professorship, The University of Oklahoma, 2001-2014

Outstanding Professor of the Year, The African Student Association, The University of Oklahoma, 2002

W. John and Gail M. Hussey Commemorative Lectureship in Meteorology, The Pennsylvania State University, 2003

Editor, *Atmospheric and Oceanic Science Letters,* Chinese Academy of Sciences, 2008-2014

Editor, *Meteorological Monographs,* American Meteorological Society, 2009-2014

Member, Council (2011-2014) and its Executive Committee (2012-2014), American Meteorological Society

Honorary Vice President for United States of America, Nelson College Old Boys' Association, New Zealand, 2013-2014

Guest Speaker, Senior Prizegiving (i.e., Commencement), Nelson College, New Zealand, 2013

Listed in *Who's Who in the World* (13th Edition, 1996), *Who's Who in the 21st Century* (1st Edition, 2001), *2000 Outstanding Intellectuals of the 21st Century* (2nd Edition, 2003), Who's *Who in America* (48th-59th Editions, 1994-2005; 62nd-68th Editions, 2008-2014), *Who's Who in Science and Engineering* (2nd-11th Editions, 1994-2012), *Who's Who in the South and Southwest* (24th Edition, 1995-96; 27th-37th Editions, 2000-2013), *The International Directory of Distinguished Leadership* (5th Edition, 1994), and *American Men and Women of Science (*19th Edition, 1995-1996*)*.

V. PUBLICATIONS

PEER-REVIEWED RESEARCH MONOGRAPHS

Hastenrath, S., and P. J. Lamb, 1977: *Climatic Atlas of the Tropical Atlantic and Eastern Pacific Oceans.* The University of Wisconsin Press, Madison, 112 pp.
Hastenrath, S., and P. J. Lamb, 1978: *Heat Budget Atlas of the Tropical Atlantic and Eastern Pacific Oceans*. The University of Wisconsin Press, Madison, 104 pp.
Hastenrath, S., and P. J. Lamb, 1979: *Climatic Atlas of the Indian Ocean, Part I: The Surface Circulation and Climate*. The University of Wisconsin Press, Madison , 117 pp. [Reprinted in 1989]
Hastenrath, S., and P. J. Lamb, 1979: *Climatic Atlas of the Indian Ocean, Part II: The Oceanic Heat Budget*. The University of Wisconsin Press, Madison, 111 pp. [Reprinted in 1989]
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Skinner, B.D., D. Changnon, M.B. Richman, and P.J. Lamb, 1999: Damaging weather conditions in the United States: A selection of data quality and monitoring issues. In *Weather and Climate Extremes: Changes, Variations, and a Perspective from the Insurance Industry* (T.R. Karl, N. Nicholls, and A. Ghazi, eds.), Kluwer Academic Publishers, Dordrecht, 69-87. [This chapter is a reprint of the Skinner *et al.* (1999) paper in *Climatic Change* cited below.]

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VI. GRADUATE STUDENTS – CHAIR AND COMMITTEE MEMBER (University of Oklahoma unless noted)

CHAIR

Andrew Carleton (1978 – Masters – University of Adelaide)
Michael Richman (1994 – Doctorate – University of Illinois at Urbana-Champaign)
Chia-Rong Chen (1996 – Doctorate)
Mikhail Ovtchinnikov (1997 – Doctorate)
Brian Skinner (1997 – Masters)
David Birmingham (1998 – Masters)
Jonathan Finch (1998 – Masters)
Gary McManus (1999 – Masters)
Michael Bell (2001 – Masters)
Mostafa El Hamly (2004 – Doctorate)
Pauline Dibi Kangah (2004 – Doctorate)
James Rogers (2005 – Masters)
David Montroy (2006 – Doctorate)
Zewdu Segele (2006 – Doctorate)
Mouhamadou Issa Lélé (2007 – Masters)
John Fredy Mejia Valencia (2008 – Doctorate)
Samuel Mbainayel (2010 – Masters)
Mouhamadou Issa Lélé (2014 – Doctorate)
Irenea Corporal Lodangco (2014 – Doctorate)
Esther Mullens (2014 – Doctorate) – Replaced as Chair by Lance Leslie
Reed Timmer (2015 – Doctorate) – Replaced as Chair by (Co-Chairs) Michael Richman and Lance Leslie

COMMITTEE MEMBER

Xiaofeng Gong (1998 – Doctorate)
Renee McPherson (2003 – Doctorate)
Jonathan Gourley (2003 – Doctorate)
John Esterheld (2004 – Masters)
Matthew Haugland (2006 – Doctorate)
Christopher Godfrey (2006 – Doctorate)
Alexandre Fierro (2007 – Doctorate)
Cynthia Whittier (2007 – Masters)
Hamish Ramsay (2008 – Doctorate)
Kimberly Klockow (2008 – Masters)
Brian Harms (2009 – Masters)
Elaine Godfrey (2010 – Doctorate)
Lindsay Tardif-Huber (2011 – Masters)
Jordan Guernsey (2012 – Masters)
Rahama Beida (2013 – Masters)
Robert Clark III (In Progress – Doctorate) – Replaced as Committee Member by Mark Morrissey

PHOTOS AND TRIBUTES

*Third WMO Symposium on Meteorological Aspects of Tropical Droughts – Niamey, Niger
30 April 30 – 4 May 1990. Pete is in the back row, fifth from left.*

At the University of Abdou Moumouni in Niamey, Niger (2009) for the establishment of a laboratory for graduate students. From left to right, Dr. Zewdu Segele (Ethiopia), Dr. Ibra (Niger), Pete, Professor Ben Mohamed (Niger), Mr. Hama (Niger), and Dr. M. Issa Lélé (Niger).

Pete in the bush during the Special Observing Period of the African Monsoon Multidisciplinary Analysis (AMMA) Project (2006) in Banizoumbou, Niger.

At the National Weather Center of Ethiopia (Addis-Ababa – 1998) with Mohamed Boulahya (former Director of the African Centre of Meteorological Applications for Development – ACMAD – in Niamey, Niger), and Zewdu Segele (Ethiopia).

A Letter from Professor Ben Mohamed, Long-Time ACMAD Colleague, Niamey (Niger)

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Family and Friends of late Professor Peter Lamb
George Lynn Cross Research Professor of Meteorology
Director, NOAA -CIMMS
The University of Oklahoma, USA

Niamey, 01 June 2014

Dear Madam/Sir,

I write to express my profound sadness after the tragic loss of Professor Peter Lamb.

I first met Prof. Lamb in 1996, at the African Centre of Meteorological Applications for Development (ACMAD) in Niamey (Niger) in my capacity of Chair of the Center's Scientific Advisory Committee (SACOM). He was kind enough to provide valuable guidance to allow ACMAD to become very quickly a Center of Excellence in Africa.

Prof. Lamb was infinitely aware of environmental issues in sub-Saharan Africa and their broader socio-economic context – the nexus of environmental degradation and extreme poverty – and eager to effect change. He showcased his disposition to engage "on the ground", to discuss state-of-the-art science and its practical/policy consequences with colleague scientists as well as with a broader audience of stakeholders and policymakers, particularly in contributing to initiate the West African Seasonal Climate Outlook process-PRESAO, which very first map elaborated in 1998 has been framed in his office at CIMMS. He made outstanding contributions to get products out of research findings that could be used by African Meteorological and Hydrological Services and authorities, among which, tools and applications such as RANET (using Radio and Internet to provide climate information to rural communities) and RAINWATCH (monitoring, visualization and tracking of critical rainfall attributes beneficial to farmers).

Within the framework of the International AMMA Program and the implementation of some of its field experiments, namely the ARM Mobile Facility at Niamey in 2006, Prof. Lamb visited University of Niamey in several occasions and facilitated the acquisition of the platform's data as well as the establishment of a small laboratory for graduating students. He also hosted a number of visiting scientists from our university at CIMMS.

Today, African scientists have lost their best friend ever within the international climate community. In addition to his professional qualities recognized all around the world, Prof. Peter Lamb was a very fine person who conducted himself with considerable dignity. So, I would like to express, on behalf of the University of Niamey, our most sincere condolences to his family and friends.

May his soul rest in peace. Amen!

Sincerely,

Abdelkrim BEN MOHAMED

A Personal Note from Mostafa El Hamly, Pete's First African Graduate Student (Morocco)

I really was deeply saddened by the news of Prof. Lamb's passing, and want you to know that our thoughts and prayers are with his friends/colleagues/students, and his family. Since I learned of Pete's death, it has been hard to focus on anything else. I have known Pete since Sep 1994. I had the honor and pleasure of working with him for 10 years (1994-2004). He tremendously marked my professional life. I was particularly impressed by his abilities, diligence, best morals and attitudes, and his love for the highest and perfect things that are reflecting highly on and around him.

In fact, Pete was the one who initiated a cooperative meteorological research and professional exchange between Moroccan Meteorological Office (DMN) and OU, especially the Al Moubarak (i.e., NAO) Program. At Agadir conference (Morocco, Nov 1985), Prof. Lamb announced the discovery of relatively strong control of the NAO on Moroccan precipitation. He laid the groundwork for this new investigation with the help of Randy A. Peppler (Cf. Lamb and Peppler, 1987, 1988, 1991).

I worked under the day-to-day guidance of Professor P. J. Lamb and with the continuous support and great assistance of particularly two of his associates (Diane H. Portis, Michael B. Richman). Later on, M. Neil Ward joined us to reinforce our team that had been engaged in a constructive and continued research work pertinent to Morocco. In particular, we were able to develop and issue several "Experimental Precipitation Prediction Statements (EPPS)" for Morocco, for each rainy season (using statistical and dynamical methods). Our main objective was to substantially increase the EPPS skill so as to yield results that would be of improved practical assistance to several critical Moroccan sectors (e.g., hydraulics, agriculture). This effort has exploited and enhanced the foundation of project experience within DMN of its engineers to the point that they are contributing nowadays to the further development of the project while being located at DMN. To date, DMN is still issuing improved EPPS. Pete is irreplaceable, but the fact that Moroccan DMN is currently issuing seasonal and long-range precipitation forecasts, would serve his memory well to aspire to more applied research. Indeed, Pete did contribute a lot on research in Africa. Many African friends of mine have confirmed this fact to me. Pete kept returning to Africa again and again, working with in-country scientists & engineers. In particular, Pete loved Morocco (Kingdom of Morocco is a country in the Maghreb region of North Africa); he visited this country ~10 times (or maybe more).

Dr. Lamb was an active leader in service to the national and international atmospheric sciences community and was especially interested in mentoring early career scientists from developing nations. Under the supervision of Pete, I was able to get a Ph.D. in Meteorology (University of Oklahoma (OU), Norman, OK). Thesis: "*North Atlantic Winter Surface Extratropical Cyclone Track Variability on Interannual-to-Decadal Time-Scales"*, May 2004. Without his supervision and continuous help, this dissertation would not have been possible. One simply could not wish for a better or friendlier supervisor. Pete had been a tremendous mentor for me. He was always encouraging my research, which allowed me to grow as a research scientist. I owe my deepest gratitude to him.

Furthermore, Pete's words of encouragement spurred me on to do even better. My final grade in each individual course taken at OU was "A", including the two graduate level Civil and Environmental Engineering courses (Environmental Modeling, Hydrology). My final GPA (cumulative grade point average) is a perfect 4.00 out of 4.00. As an honor, I got in 2000 the nomination for lifetime membership in the National (US) Society of Collegiate Scholars (NSCS) in recognition of "Outstanding, Scholarship, Leadership, and Service" (invited). Definitely, this special recognition would not have been possible without Pete's support and encouragement. Moreover, I learned a lot of things from Pete, in particular how to perform research, write papers (in English). It should be noticed that English is the 4th or 5th language I learned (thanks to Pete & his associates) after Berber, Moroccan dialect, Classical Arabic, and French.

Pete was very tolerant. By his great tolerance, I personally realized that I no longer had the luxury of not having a dialogue among the people of different faiths/cultures. In his work, Pete was dealing with many international people (students, researchers, etc.). He was very efficient in promoting tolerance and respect while building bridges of international understanding of social, religious, political, and other related issues between individuals of all faiths, cultures, and persuasions. In this regard I am delighted to report that Pete indeed succeeded in establishing an open and lucid dialogue between his students (from different backgrounds) to help instill harmonious relations and bridging gaps, before real learning and listening takes place. Even if it's "I don't agree with this" or "I have questions", what one would get out of any dialogue/discussion is a look at the same issue but from a different perspective; hence, yielding interaction, mutual learning, and better understanding.

Through my work for him, I have come to know him as a person of integrity and high moral character. Now, it would be very instructive and enlightening here to mention briefly some of the salient features of Pete's manners and morals. The first and foremost quality of his character, which attracted my attention, is his honesty and truthfulness. The next great trait of his noble qualities is trustworthiness. A radiant attribute of his high morals is kindness and generosity. He invited me with my family at his house and elsewhere many times. Modesty (i.e., humility) was another eminent quality of him. Further, rigid simplicity was another bright feature of his standards. He's distinguished from others by the way in which he builds his relationship with his friends on a basis of respect, kindness, sympathy, great self-control (self-restraint), patience, tolerance, gentleness of speech. In brief, in his relationships with others, he is a social being of the highest class, easy going, sincere and straightforward, wise, eloquent, humble. He offers sincere advice; he keeps his promises; he does not harbor resentment. He surely possesses other ethics and high moral qualities that I've left out or I am not aware of.

It is very sad that Pete left the meteorology community (at OU) to which he made certainly a strong contribution. For sure, CIMMS (and hence Africa) is losing one of his strong assets and, while we hold him in the highest regard, we will miss him, too. He will live on in our memories forever. Again, my heartfelt condolences particularly to his family.

With deepest sympathy,
Mostafa El Hamly
Casablanca (Morocco), June 1st, 2014

A Personal Note from Pauline Dibi Kangah, Pete's Second African Graduate Student (Cote d'Ivoire)

I'm speechless and very sorry for our great loss.

Our beloved Prof Lamb has left behind a thousand moments that will live in our heart forever...His dedication and commitment to African research are our inspiration more than ever.

May the wonderful and precious memories of Prof Lamb's love for an outstanding work be with us and comfort us at this difficult time.

RIP Prof Peter Lamb! Tu seras a jamais notre inspiration!!

Pauline Dibi Kangah, Université de Cocody, Abidjan (Cote d'Ivoire), June 2014

Resting at the terrace of the Grand Hotel in Niamey after a hard day's work under the Sahelian sun and at least 110° F temperature, with his then graduate student M. Issa Lélé, 2006.

Participants in the First Workshop on Regional Climate Prediction and Applications: Tropical Atlantic Basin, 11 October – 12 November 1999, University of Oklahoma.

A Humorous Anecdote from Tim Palmer

I hope you won't mind my recalling what in retrospect was a somewhat amusing episode when Pete and I were returning to the airport at Niamey, following a conference organised by Stefan Hastenrath. The taxi took us along the airport perimeter road and we passed the airport meteorological observation site. Pete asked the taxi driver to stop so that he could take a few photos – after all, he said, he had written countless papers based on data from this site. What he didn't realise was that some military aircraft were parked just behind the met site. Suddenly some officials arrived and Pete had to explain that he wasn't photoing the planes, he was photoing the weather station!! It took quite some persuading that we really were meteorologists and not spies!

Pete was a dear colleague whose warmth and sincerity I will sorely miss.

Tim Palmer
Royal Society Research Professor in Climate Physics at the University of Oxford, and
Principal Scientist with the European Centre for Medium-Range Weather Forecasts in Reading, UK
June 2014

A Remembrance from Michel Legrand (Cameroon)

A great man of science, an expert and committed climatologist, Prof Peter Lamb has gone. I remember the tears of happiness of this great man at the Golf Hotel in Abidjan just after the adoption of the first seasonal forecasting of precipitation in West Africa (PRESAO-1). It is really a great loss not only for the climate experts, but for those of us involve in the development of seasonal prediction in Africa and in the rest of the word. My sincere condolences to his family, and to those who knew him. May his soul rest in peace!

Michel Legrand
SAAH Expert Consultant en Climat et Développement, Douala (Cameroun)
June 2014

A Remembrance from Ousmane Ndiaye (Senegal)

We all knew Pete (as we use to call him) always available to help out in African climate sciences: training, meetings, projects, ideas...We should acknowledge his contribution as one of the scientists who set the basis of seasonal forecasting in West Africa (in two papers in 1978) as well as the PRESAO in 1998 (even 1996) and other things. I hope we will do something to remember him as contributor of African climate studies.

Ousmane Ndiaye
Agence Nationale de l'Aviation Civile et de la Météorologie (ANACIM), Dakar-Yoff Dakar (Sénégal)
June 2014

A Remembrance from Leonard Amekudzi (Ghana)

We in KNUST are very surprised with the sad news about the death of our senior colleague Peter Lamb. His contribution to teaching and learning of meteorology in our new program is still very fresh in our memories. Peter was one of the self sponsored lecturers for 2008 and 2010 summer schools in KNUST and has personally donated some of his teaching notes on atmospheric thermodynamics and tropical meteorology for teach in our new programme. Peter has carried out extensive field measurements and research in Africa in particular in the Sahel region of west and central Africa. His demise is therefore a great lost to Africa meteorology and climate science research.

Leonard K. Amekudzi
Kwame Nkrumah University of Science and Technology (KNUST), Kumasi (Ghana), June 2014

A Remembrance from Serge Janicot (France)

Pete initiated a new vision of the research on West African climate and its variability, in particular through his landmark papers in 1978. From that moment on he was a leader in this field of research and an inspiration to many young scientists and students. He actively contributed to the definition of the international AMMA program and the implementation of some of its field experiments. In particular he played a key role in the establishment of the ARM Mobile Facility at Niamey in 2006, which has provided pivotal data used in many research studies. He has always been present to share his wisdom with us to the benefit of Africans and African development. His fingerprint is present forever and his memory lives with us still.

Serge Janicot
AMMA West African Monsoon Program (France)
June 2014

A Remembrance from his Ph.D. Adviser Stefan Hastenrath (Wisconsin)

With shock and sadness I learned of the death of Peter Lamb, just some five months after we last met here at AOS in University of Wisconsin. It brings back memories. In 1971 PL came from New Zealand to Madison to complete his doctorate in 1976. This was an era of protracted and aggravating drought regime in Subsaharan West Africa, and PL studied the underlying circulation mechanisms. Along with that, we published our atlases of climate and oceanic heat budget of tropical Atlantic and eastern Pacific 1977, 1978; after he left to work in Australia we continued to work together on our atlases of Indian Ocean, l979. The dataset was TDF11 with a spatial resolution of one degree lat/lon. Here just two reminders. (A). We found in the cross-equatorial flow from the southern hemisphere a speed maximum just at the recurvature from southeasterly to southwesterly and along with that understood the dynamics of ITCZ and ITDZ, Intertropical DIVERGENCE Zone (which one journal editor tried to corrupt). (B). We found that the oceanic heat transport in the Atlantic is directed from the southern hemisphere northward across the Equator. The implications of that for the diverse cryosphere decay in Arctic versus Antarctica remains to be explored.

After returning from Australia to USA, PL worked in Florida, Illinois, then Oklahoma. He combined science research with organization of institution and observational network and human impact. Thanks to his continued compilation of his Sahel rainfall index we could explore the pertinent circulation mechanisms over a century, in a paper published last year. In his honor let me quote the last sentence from my l985 book: The study of climate is most important where it may serve the needs of mankind. In particular, the tropics are above all the lands and seas of the Third World, whose manifold social, economic, and political problems are intricately intertwined with climate.

Stefan Hastenrath
Department of Atmospheric and Oceanic Sciences, University of Wisconsin,
June 2014

A trip on the River Niger near Niamey (2006).

Lecturing during the opening of the RWX Workshop (June 2013) in Khartoum (Sudan).

A Remembrance from Arlene Laing (Jamaica)

The atmospheric science community has suffered a great loss. Peter's research provided critical information about physical and dynamical processes that influence climate variability. This work was most critical to understanding climate in Africa, whose societies are vulnerable to climate extremes. Peter will be greatly missed by the generations of African students that he mentored. He was not only an excellent scientist; he also focused on the application of that science to the good of society. He led by example in demonstrating how to use scientific knowledge to help society prepare for climate related impacts with projects such as Rainwatch, a system that provides an alert for rainfall extremes in the Sahel.

Others are better suited to speak of his contribution to international science programs and field projects. I will speak of my experiences with Peter in how he related to students. Peter was always willing to share his guidance and wisdom with students, e.g., advising and advocating for graduate students, teaching at the AMMA summer schools, and helping to organize and lecture at the NCAR colloquium on African weather and climate. Colloquium attendees appreciated not only his scientific lectures; they cited his panel discussion talk as outstanding. In that panel, on lessons learned for successful collaboration in Africa, he spoke of encouraging independence, forging personal relationships, and helping Africans to help themselves. He reminded the students that they were the future leaders of science in Africa and of their responsibility to use their science to benefit Africa and its development.

On a personal level, Peter was friendly and easy to talk with. Although he was from the southern midlatitudes and I am from the northern tropics, we had some similar high school experiences from having attended British-styled boarding schools. He was also involved in organizing old school friends to help their old school, further exemplifying his friendship and service. His legacy and memory remain with us.

Arlene Laing (on behalf of the 2011 NCAR ISP colloquium)
National Center for Atmospheric Research (Colorado)

Pete with his students (left to right) Akim (Benin), Essan (Egypt), and Mostafa El Hamly (Morocco) in 2002.

New Zealand All Blacks Rugby – Pete's favorite.

NEW ZEALAND
ALL BLACKS

Try not to be disconcerted by the unexpected and, above all, don't underestimate your own ability.

~David Pointer

Scientists are not dependent on the ideas of a single man, but on the combined wisdom of thousands of men, all thinking of the same problem and each doing his little bit to add to the great structure of knowledge which is gradually being erected.

~Ernest Rutherford

There is a universal respect and even admiration for those who are humble and simple by nature, and who have absolute confidence in all human beings irrespective of their social status.

~Nelson Mandela

Parliament Square, London – September 2013