THE EWIEM NIMDIE SUMMER SCHOOL SERIES IN GHANA

Capacity Building in Meteorological Education and Research—Lessons Learned and Future Prospects

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THE EWIEM NIMDIE SUMMER SCHOOL CONCEPT. The Ewiem Nimdie summer school is a biennial or triennial event that to date has been hosted in Ghana and focuses on the atmospheric sciences; "Ewiem Nimdie" means "atmospheric science" in the local Ashanti language. The first school was conducted in the summer of 2008, hosted by the Kwame Nkrumah University of Science and Technology (KNUST) located in Kumasi, with the second school taking place at the same institution two years later, in July 2010. The schools were designed to help launch the undergraduate meteorology program of KNUST and benefited from the significant increase in research activity regarding West African weather and climate that has arisen from the African Monsoon Multidisciplinary Analysis (AMMA) program. Both schools lasted two weeks and included a broad program of lectures, hands-on classes in regional forecasting and climate applications modeling, and a variety of field measurement activities with associated student projects that were presented at the culmination of each school.

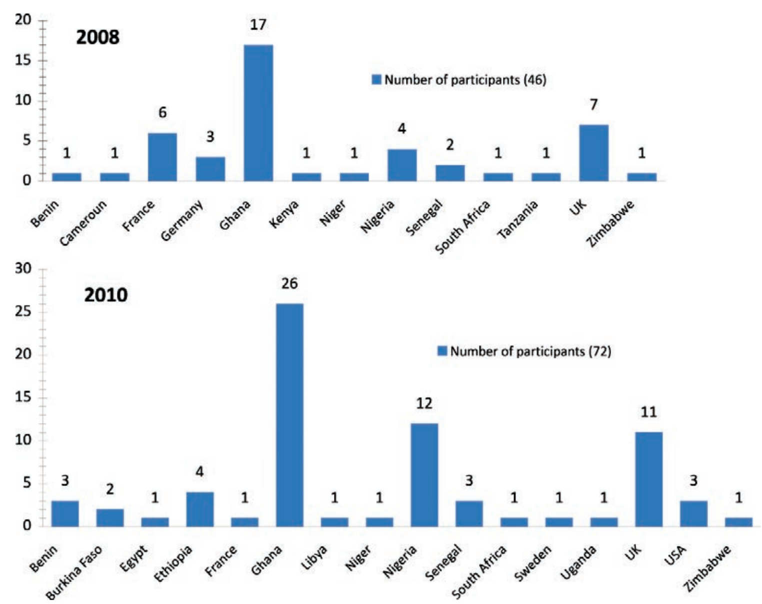

FIG. 1. Distribution of students by country of study/origin in the 2008 and 2010 summer schools.

From its inception, the summer school program was designed around the concept of integrating undergraduate and new Ph.D. students from all over the globe with research interests in African meteorology and climate. Figure 1 documents the country of study/origin of the students who participated in each school. The attendance of African students from across the continent was funded under the budget of each school, with about half originating

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DOI:10.1175/BAMS-D-11-00098.1

CROP-MODELING CLASSES

Students were introduced to the practical aspects of impacts modeling through an introductory lecture accompanied by two computer classes using a dynamical crop model called "GLAM." The model's relative simplicity makes it well suited to this kind of activity. First, a lecture outlined the processes simulated by GLAM, the input data requirements, model output, and the calibration procedure. During the computer classes, the students learned how to calibrate and run the model to simulate historic groundnut yields for a 1° x 1° latitude–longitude grid cell in Ghana (Fig. 2). A series of tasks—including changing the input data, method of calibration, and planting routine—helped the students gain a greater understanding of the modeling procedure. The students also acquired experience in using the Linux operating system and in comparing the skill of the simulations using basic statistics such as root-mean-square error and correlation. Future impacts-modeling classes could further complement the lecture content by demonstrating the use of seasonal or longer-term climate forecasts.

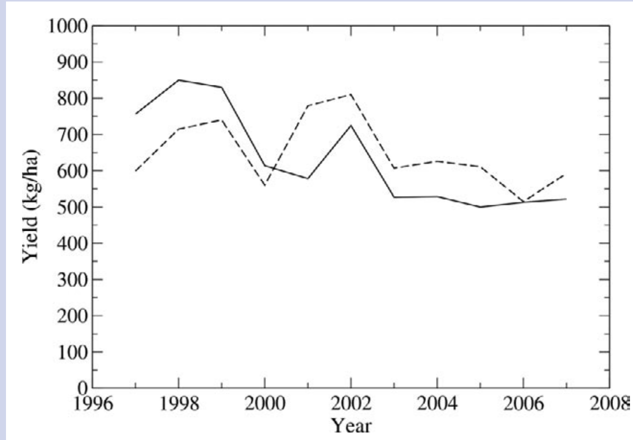

Fig. 2. Observed (solid) and simulated (dashed) groundnut yield for a 1° latitude by 1° longitude grid cell centered on 8.5°N,0.5°W in Ghana, produced by the students in the laboratory class. The students investigated the effects of changing planting dates, altering rainfall onsets and break cycles, and increasing/decreasing daily mean temperature.

from within Ghana. European students were mostly from France, Germany, and the United Kingdom, due to the involvement of lecturers from these countries in the school, in addition to a limited number of students from other European countries and North America. A table of the lecturers with their institutions and the years they contributed to the summer schools is in the electronic supplement to this article (http://dx.doi.org/10.1175/BAMS-D-11-00098.2). This broad engagement produced an environment in which African, European, and American students could not only have access to leading scientists in the field, but also could interact with their peers to form lasting working relationships. These links will serve well in the present highly competitive funding environment, in which an increasing proportion of European Union and North American research support is directed toward multicontinent cooperative actions. The multinational integration of the students and the wide range of activities gave the schools a unique and exciting atmosphere that we wish to maintain and foster in future similar projects here and elsewhere. In this paper, we report on the salient features of the summer school and its future prospects.

SCHOOL ACTIVITIES. School activities were multifaceted in both years. The foundation consisted of a series of lectures suitable for final-year undergraduate and beginning graduate (especially Ph.D.) students. The 2008 school concentrated initially on the fundamental components of West African meteorology and climate, with a broadening of the scope in the second week to include climate applications such as climate–health interactions. The 2010 school expanded this syllabus to add hydrology and agricultural modeling to the applications component, and covered seasonal climate forecasting issues in addition to short-range weather time scales. In both events, groups of three students were provided with a hands-on opportunity to make daily weather forecasts for the region. To inspire competition and motivation, points were awarded for forecast accuracy in a "weather game" over the duration of the schools.

There is a learning curve in exporting to Africa the teaching practices that work well in Europe and the United States. The experience of the first school demonstrated that slow (or nonexistent) Internet connections and disruptions to the local electrical power supply were facts of life that significantly impeded the learning process. In the second school, these problems were overcome by the following actions: use of Linux as a more efficient operating system; ensuring generators were available to replace grid power; designing scripts to download weather model output files overnight; and reducing reliance on Internet accessibility. The support of local technical staff was vital in providing quick fixes to unexpected problems so as to maintain the smooth running of practical sessions.

Afternoon laboratory classes included lessons in agricultural modeling (see Sidebar 1) and time allocated for work on student projects related to the field work. The field work was a unique part of both schools, providing students with the opportunity to have hands-on experience with a wide range of instrumentation (see Sidebar 2).

SUCCESSES, CHALLENGES, AND FUTURE OF THE SUMMER SCHOOL.

Successes. One of the major successes of each school was that for the majority of participants it was a unique event in their careers. For African students, it was their first taste of an international meeting with the opportunity to initiate professional acquaintances with peers from many countries that can be built into long-term collaborations. For the students from Europe and the United States, it was their introduction to the African environment and an initial opportunity to meet many African peers. The formal level of European engagement was heightened in both schools for the third-year undergraduate participants from the University of Leeds (environmental science and meteorology majors), who subsequently were awarded degree credit for an optional module titled "Meteorology and Climate of Africa: Summer School." To receive this credit, the Leeds students were required to undertake preliminary (preschool) exercises and, after returning to their home campus, produce additional practical reports based on their in-school fieldwork. There is considerable potential for the growth of awarding formal degree credit for participation in future schools, including by African universities.

The field measurement efforts were considered a great success of both schools. They were facilitated substantially by a combination of instrument contributions from Europe and North America with the ease of access to and use of the permanent field sites operated by KNUST. These endeavors provided surface and (to a lesser extent) upper-air data that were accessible for lectures and student projects at a high temporal resolution, for a region for which such data are very rare. Examples appear in Figs. 3 and 4. These highly informative measurements will continue to inspire both the lecturers and students and bring them together to investigate synoptic features of this understudied region. The first example of this inspiration, including use of Kumasi data, appears in a recently published paper on the summer stratus cloud over southern West Africa. This effort involved "north–south" collaboration and coauthorship between the University of Leeds, Ghana Meteorological Agency (GMet), and the University of Cologne, among other institutions.

Both the African and non-African students benefited from lecturing teams that possessed substantial and wide-ranging experience. Many of the lecturers had pioneered investigation of the globally unique aspects of West African weather systems, the resulting regional monsoon climate, and their relations with the larger climate system. All lecturers continue to be actively engaged in the scientific and societal challenges that result from this region experiencing the largest climate change on the planet during the last 60-plus years. The importance of this work is heightened by considerable uncertainty concerning the response of the West African monsoon system to ongoing global warming.

However, developing the opportunity to conduct the two summer schools held to date involved overcoming a number of challenges. Continuing the schools into the future will require similar persistence. We turn now to those challenges.

Logistics. Organizing a school program of this nature is a significant task, since it requires the availability and use of multiple accommodation options, lecture theaters, several field sites, meal choices, and computer laboratories. Fortunately, the KNUST campus was able to provide all of the necessary facilities and services for both schools. The significant distances between some of the venues required considerable transport coordination for more than 50 students and staff during a packed schedule, and therefore was a significant logistical challenge. Contingency plans for unforeseen circumstances—such as power and Internet outages and student health and safety—increased the preparation requirements.

Running a summer school is a learning process and always can be improved. To this end, both schools conducted student surveys and held debriefing meetings with the lecturers to assess which aspects had gone well and which elements could be improved for future schools. In general, both schools were well received by the students, and logistical problems that arose in the first school, such as with accommodation standards and inadequate facilities in the computer laboratories, were addressed satisfactorily in the second school.

Lecture content. A major challenge was setting the appropriate lecture content level for students with a wide range of backgrounds. The academic/scientific levels of the participants extended from the latter stages of undergraduate programs, to graduate students embarking on research careers, to (in a few cases) individuals with significant early-career research experience in closely related environmental sciences. Achieving the desired equilibrium learning level was pursued using several approaches. At one extreme and as described previously, some of the advanced undergraduates were assigned additional pre- and postschool activities for degree credit. At the other extreme, individual lecturers had one-on-one contact with early-career scientists from related disciplines to help bridge the disciplinary gaps. In between those extremes, graduate students also benefited from that type of engagement with lecturers concerning their developing thesis/dissertation topics.

The significant number (10–14) of lecturers present at each school led to challenges in coordinating the lecture program to achieve a smooth development of material without gaps or overlaps. This possibly resulted in some lecturers being underutilized. Also, since the second school extended the scope of the lecture material, it was found that some students were partially lacking the basics. Therefore, short (10-minute) briefing-style talks were inserted into each daily forecast laboratory class to introduce and develop a basic concept, such as potential temperature.

One suggested approach to addressing the above challenges is to extend the length of the program and make associated adjustments to its structure. The adjustments could include lecturers coming in shifts and possibly also separating the students into groups. The latter approach would require an additional preschool period for undergraduates that would cover basic lecture material. This would, of course, come at both financial and organizational expense and would require an even greater time commitment for the school organizers, both local and external. An alternative approach would be to take advantage of the significant lecturing team to divide students into more stratified and focused groups in parallel sessions, if sufficient facilities were available. Another option would be to target the summer school only at beginning graduate-level students. As research programs in the climate sciences grow in the region, more local students will be available to make this viable. This would be at the expense, naturally, of losing the potentially significant number of undergraduate students from Europe and North America that may take the school as an accredited course component, and whose involvement likely enriches the experience for the African students. All of these options remain under consideration for the next school, which likely will occur in 2013.

Local expertise and field equipment. A minority of the lecturers at the first two schools were from African universities and institutes. The school organizers feel there is a real need and potential to improve this ratio in the future, while retaining a mix of experts from across the globe to facilitate the exchange of ideas and methods. While the growth of local expertise in all the fields required will take time, there was a tendency to underutilize the existing African scientific expertise—even from within Ghana—which possibly was due to a lack of confidence. One way to improve this situation would be to develop and draw on a database of regional experts according to their field.

As previously indicated, the field measurement efforts were considered a great success of both schools. While they relied to a certain degree on the support of European and North American institutions to ship in instrumentation at considerable cost, the access to the KNUST permanent field sites will ensure that a core field program is possible in future schools at that institution, even without such a high level of external support. With the continuing commitment of GMet, an upper-air observing component will be sustainable along with vital surface observations. Forming a regional rather than local steering committee for the school program could also strengthen the possibility of securing funding to enhance the instrumentation network.

Location of future schools. Kumasi was chosen for the first two summer schools due to the recent establishment of a regional meteorological program at KNUST and the availability there of all necessary facilities. However, that location requires a minimum of four hours ground transport from the international airport at Accra, which increases the costs and logistics involved. This separation also

FIELD WORK

Field work was a central part of each school, and provided many of the students with their first opportunity to make meteorological measurements. Each school made significant use of the meteorological ground stations on the Kwame Nkrumah University of Science and Technology (KNUST) campus, located in Kumasi, which included rain gauges, anemometer systems, and dry- and wet-bulb thermometers in Stevenson screens. These routine KNUST measurements were supplemented in the two schools with mobile surface weather and energy flux stations from the University of Leeds and the University of Reading, respectively, and by a permanent donation of automatic, high-resolution rain gauges and a fully equipped automatic weather station from the University of Cologne.

The generous support of both schools by NOAA and the Ghana Meteorological Agency (known as GMET) meant upper-air observations were also possible, with students gaining experience in launching and tracking both pilot balloons (PIBALs) and radiosondes. A sequence of radiosonde soundings made during an all-night observing session (Fig. 3) clearly shows the distinct southwesterly monsoon layer, the tropical easterly jet and tropopause, and various other features that are common to all of the soundings. Both schools included an overnight session of upper-air measurements, using candle illumination to permit balloon tracking, in an attempt to record the evolution of the nocturnal boundary layer. This exercise had only mixed success, both in terms of the clear skies needed for PIBAL observations and the enthusiasm of the students for manning the 2 a.m. "graveyard" shift!

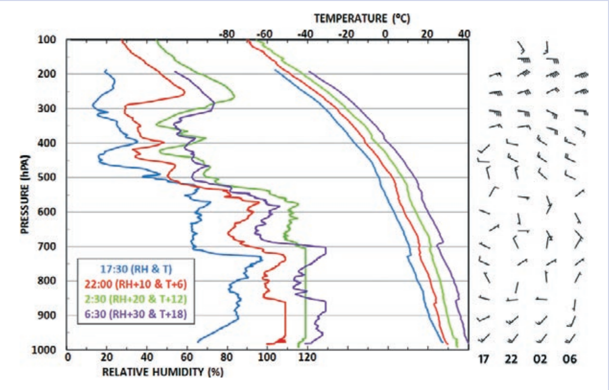

Fig. 3. Temperature (*T*), relative humidity (RH), and wind profiles as measured by four sequential radiosonde launches at the KNUST field site during the night of 23 Jul 2010 (times are local, with each successive *T* and RH profile offset by 6 K and 10%, respectively, for clarity). The wind plotting is conventional, with a full barb for 5 m s^{-1}. The *T* and RH plots reveal the time continuity of subtle stable layers and their associated RH changes over the 12-h period; the wind plots show that these wind shifts are associated with vertical shear. Saturated cloud layers (vertical parts of RH profiles below 700 hPA) are evident in three profiles. Common to all of the wind profiles is the southwesterly monsoonal flow from the surface to about 900 hPA, the strong tropical easterly jet near 200 hPA that is above a westerly wind layer from 500–400 hPA, and subtle variations in the meridional flow in the middle troposphere.

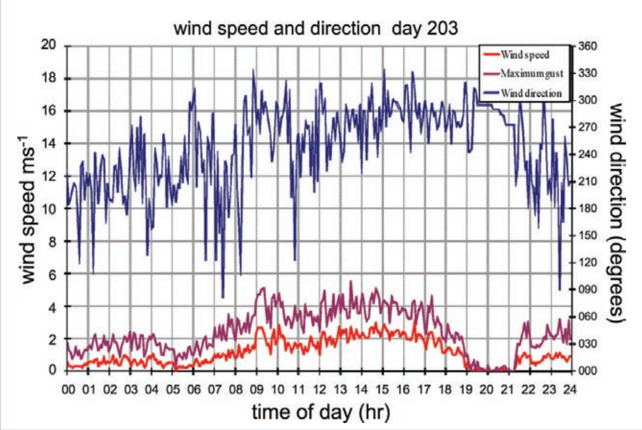

Fig. 4. Surface wind recordings at the KNUST field site during 22 Jul 2010. The very light surface wind strength associated with daytime boundary layer mixing remarkably drops to zero shortly after sunset (around 1900 LT). Around 2100 LT, the wind picks up again as the nocturnal jet strengthens and mixes down toward the surface.

The combination and variety of the available instruments meant that a wide range of phenomena could be studied by the students. For example, the portable weather mast provided by the University of Reading was operated at the KNUST field site to provide five-minute averages of various weather parameters during the entire two-week period. It yielded some beautiful examples of the development of nighttime surface winds associated with the overlying nocturnal jet (Fig. 4), which will be a valuable teaching resource in the future. Students conducted projects examining the temporal variability of rainfall, the boundary layer diurnal cycle, and the surface energy budget, and related their findings to knowledge of West African meteorology and the monsoon boundary layer gained in the lectures and forecast classes.

means that an individual's time commitment to the program is lengthened by two additional days, due to the transfer between Accra–Kumasi–Accra. Also, poor and expensive air transport links between French-speaking African countries and Ghana were an impediment to increasing the involvement in the first two schools of lecturers and students from the nonneighboring French-speaking African countries. However, despite these linguistic and logistical difficulties, the organizers consider it worthwhile to further pursue the development of a more truly pan-West African event.

Holding the summer school at KNUST every two or three years has several advantages. For example, the school can evolve and improve with time as the local organizers learn from previous experience, it will continue to have access to good facilities, and there will be an increasing number of local undergraduate and graduate students who can benefit from the program. On the other hand, rotating the location either within Ghana or possibly within West Africa would give the school wider African ownership, could reach a greater pool of students, and may encourage the involvement of more local and nonlocal organizers. If future schools were to remain in Ghana, for example, they could rotate between KNUST, the University of Cape Coast (at which a climate science program is being established), and possibly the University of Ghana campus in Legon near Accra. Both of the latter two universities also have excellent facilities for hosting such an event.

The school funding environment. The first school was funded by a British Council/Department for Education and Skills (DfES) grant and was organized by the University of Leeds in that country, while the second school was funded by the Italian Ministry of Education (MUIR) and administered by the Abdus Salam International Center for Theoretical Physics (ICTP) in Italy. This external funding paid for the local costs of the school, such as ground transport and rental of lecture room facilities, and for financing the attendance of African students. All non-African students and all lecturers were funded by their home institutes or governments, including the costs of shipping equipment used in the program.

The summer school could continue as a biennial or triennial event, with the necessary funding being solicited on a school-by-school basis. Many institutes worldwide include development and training in their mandates, allocating or obtaining funds for regular on-site courses with support for developing country candidates. Examples include ICTP (which organized the second school), the Cooperative Institute for Mesoscale Meteorological Studies (CIMMS) at The University of Oklahoma, the International Research Institute for Climate and Society (IRI) at Columbia University, and the Institut de Recherche pour le Développement (IRD) of France. These and similar institutes could be encouraged to link up with the Ewiem Nimdie event, running training courses offsite and thus cosponsoring an individual school. It is possible that each sponsoring institute would prefer to place emphasis on its own areas of research, which could widen the scope of individual summer schools.

Clearly, the summer school would be more sustainable if additional regular funding sources were established. Considering the extensive media attention within Ghana that the first two schools received, and the climate-related scope of the school program, the organizers feel that there is great potential for gaining sponsorship of the school from national or multinational companies operating in the region.

OUTLOOK. The first two Ewiem Nimdie summer schools were considered successful exercises by all those involved. They gave African students access to leading international specialists in African weather and climate research. Non-African students benefited from the chance to experience African weather firsthand, and students of all nationalities had the opportunity to mix and form lasting working relationships. Much was learned by both the local and nonlocal organizers in terms of staging an event of such a complex nature.

The summer schools should grow in stature and could act as a global blueprint for other similar regional events in developing nations. Priorities for the near future should include building networks of African expertise from both French-speaking and English-speaking African countries, as well as securing regular funding for the school from a wider spectrum of national and international organizations. If the school continues to include a strong emphasis on the advanced undergraduate level, efforts could be made to have the event accredited as a module in university programs both within and outside Africa, following the example set by the University of Leeds. This status would enhance the recruitment of participants. The possibility of rotating the location of the school within Ghana or between French-speaking and English-speaking West African countries also should be considered.

Above all, the Ewiem Nimdie Summer School Series involves helping Africa help itself. Therefore, institutes or individuals interested in contributing to future events should contact the corresponding author of this article.

ACKNOWLEDGMENTS. This article is dedicated to the memory of the late David Grimes, our dear friend, colleague, and co-author, who contributed so much to the understanding of precipitation in Africa and to educational outreach. The two summer schools were funded by grants from the United Kingdom's British Council/Department for Education and Skills and the Italian Government's Ministry of Education (grant award ICTP:241.FITU.11.G), respectively. The Kwame Nkrumah University of Science and Technology allowed the use of many university facilities at each school free of charge and acknowledges the efforts made by its local support team. The following institutes generously provided equipment and associated shipping costs: University of Cologne (Germany), NOAA National Severe Storms Laboratory (USA), GMet, and the Universities of Leeds and Reading (UK). Each school was supported by a large number of European and North American lecturers, who spent time to prepare teaching material and find travel funds; they are listed in the electronic supplement to this article (http://dx.doi.org/10.1175/BAMS-D-11-00098.2).

FOR FURTHER READING

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TECHNOLOGY

SMOS Satellite Improving Hurricane Forecasts

The amount of water in the soil and salinity in the oceans are both key variables linked to Earth's water cycle, affecting weather and climate. The European Space Agency's (ESA) Soil Moisture and Ocean Salinity (SMOS) satellite was designed to measure what it was named after, but it turns out it can do more. SMOS is proving it can also offer insight that could aid in improving hurricane forecasts.

The SMOS uses a microwave radiometer to measure Earth's brightness temperature, which corresponds to surface emissions of radiation. The sensor works in the "L-band" at frequencies that also can be used to track surface wind speeds over oceans, even in cloudy and rainy conditions. Because gale-force winds affect the microwave radiation emitted from the ocean surface, changes can be linked directly to the strength of the wind. The radiation detected by the satellite is also less disturbed by rain and atmospheric effects than higher microwave frequencies, making SMOS uniquely equipped for extreme conditions, such as those in a hurricane.

The researchers discovered this capability when analyzing

FREEZEPRUF YOUR GARDEN

Good news for gardeners in harsher climates. A new topical spray has been developed that is designed to protect foliage, flowers, and fruit from cold temperatures—an "antifreeze" for plants. According to researchers at The University of Alabama and Miami University of Ohio, who developed the spray, using FreezePruf is the equivalent of moving plants south about 200 miles. Tests revealed that the all-natural spray decreased plants' first damage temperature and mortality temperatures by 2° to 9°F, depending on the variety, improving their natural ability to tolerate freezing conditions. "We noted beneficial effects within hours of application," says David Francko, professor of biology at the University of Alabama. "Our results suggested that the spray formulation could add the equivalent of approximately 0.25 to almost 1.0 USDA Plant Hardiness Zone to the cold hardiness rating of the plants used in the experiments." The researchers note that the spray is not only friendly to plants, but the environment as well. It's made from a combination of cryoprotectants and other ingredients, all of which are biodegradable. FreezePruf is available online at freezeproof.com. (Source: American Society for Horticultural Science)