In a 2006 BAMS article, Washington et al. identified two key constraints to development of African climate (and weather) science: a scarcity of both African observations and African scientists. The University Corporation for Atmospheric Research (UCAR) Africa Initiative (AI) is addressing these overarching needs by developing sustained partnerships with African researchers and operational meteorologists.

The AI has contributed to three recent projects focused on West Africa and the Sahel: 1) a modest radar network and data distribution system within and between Burkina Faso and Mali; 2) a partnership among UCAR, the Ghana Meteorological Agency, and the Ghana university community to develop an operational Weather Research and Forecasting (WRF) model for West Africa; and 3) a recent workshop titled “Sahel 2007: Improving Lives by Understanding Weather.” In addition to these pilot projects, a number of other UCAR programs are active in Africa. The AI’s key benefit to UCAR has been to provide a connection among these various programs and develop collaborations in Africa.

These AI efforts are meant to provide a springboard for broader participation. We recognize that universities and government agencies are undertaking a number of other efforts, including atmospheric science capacity building, in various forms, in Africa. However, given the substantial needs, UCAR is augmenting these activities. We hope that this report about the UCAR AI will initiate further opportunities for collaboration and coordination toward improving the atmospheric sciences infrastructure in Africa. Those wishing to coordinate with the UCAR AI should contact Raj Pandya (pandya@ucar.edu).

**A WEATHER RADAR NETWORK IN WEST AFRICA.** Currently, there is no reliable way to follow a convective system’s evolution as it crosses the western part of Africa. This makes nowcasting hazardous weather and precipitation difficult and negatively affects aviation safety and agriculture. To address this need, initial steps are underway to develop an operational network of weather radars in West Africa, beginning with Burkina Faso, Mali, and Senegal. In all three countries, existing (and sometimes nonoperational) radars are being rehabilitated and upgraded with simple personal-computer-based software systems that allow the radars to be controlled and maintained with only minimal engineering support. Figure 1 shows the coverage of the radars. Currently, the radars in Burkina Faso (Ouagadougou and Bobo Dilasso) and Mali (Bamako, Mopti, and Mononlali) are operational. The Senegal radar located at Liguere will soon be operational, and the Niger radars are not yet operational. More information about the radar project in West Africa can be found at [www.ral.ucar.edu/projects/westafrica/radar.php](http://www.ral.ucar.edu/projects/westafrica/radar.php).

In addition, Mali and Burkina Faso have agreed to share their radar data with each other and the international community, using software and networking tools developed by the UCAR Unidata program. Unidata provides data in real time and at no cost to over 160 operational and research communities, and shares tools to access and visualize those data. Real-time data include operational forecast-model output, satellite imagery and derived products, radar products,
and global positioning system perceptible-water-vapor observations. Mali and Burkina Faso’s participation in Unidata could be a model for connecting African universities and meteorological services with each other and with global partners. For example, Kwame Nkrumah University of Science and Technology, in Ghana, is launching a new atmospheric science program and plans to join the Unidata Community.

**OPERATIONAL MODELING.** Forecasters in Africa rely primarily on global models or a handful of mesoscale models, neither of which is ideal to meet their needs. The global models widely used in Africa are known to have difficulty realistically representing the tropical atmosphere because of the models’ inability to resolve local high-impact weather systems, inaccurate parameterizations of subgrid phenomena, and the lack of observations for defining initial conditions. Currently, only a few African countries are running mesoscale models operationally. Most of these models, however, were developed for research or have not been adapted for African weather. Also, many of the mesoscale models are not easily modifiable—either because the models are proprietary and the operators don’t have access to source code or because the operators lack human and capital resources to invest in model development. This makes it difficult to “tune” the models to accurately represent local phenomena or to customize the model output according to local users’ needs.

The modeling component of the AI uses the WRF model. This model offers a variety of advantages: it is available free of charge over the Web; it can be used for weather and climate research as well as operational forecasting; it can be run at very high resolutions; it possesses numerous physics options; it has a vigorous community of users whose members share ideas and solutions to problems; it is technically supported at the National Center for Atmospheric Research (NCAR); and formal training is available for new users. Most importantly, it is customizable and adaptable, and so provides an ideal platform with which to develop a mesoscale model for Africa. The long-range goal is to develop capacity in numerical weather prediction in Africa, such that WRF is running operationally in Africa, is maintained by African weather services, and is being adapted by African researchers to meet specific regional needs. A preliminary step is already done—a WRF-based operational forecasting system, with the highest resolution focused on West Africa (see Fig. 2), has been run in an operational mode at NCAR for a period of months. For more information, see [www.ral.ucar.edu/technology/model/rtfdda.php](http://www.ral.ucar.edu/technology/model/rtfdda.php). Regular forecasts were made available via the Web, and operational forecasters in Ghana and surrounding countries were asked to use the forecasts and comment on their strengths and weaknesses. This didn’t produce much usable information, and the next step is to move the model to a host facility in Ghana. Until a host facility is identified, and while funding allows, the model and the associated Web site that provides products will continue to operate at NCAR under the cosponsorship of NCAR and the Ghana Meteorological Agency. The interface to the real-time modeling system is available at [www.ral.ucar.edu/cgi-bin/ugui?range=wafrica/rtfdda](http://www.ral.ucar.edu/cgi-bin/ugui?range=wafrica/rtfdda).

In order for this forecasting system to have the maximum impact on food security, public safety, water-resources management, and public health, it should be coupled with relevant special-application models. The UCAR AI participants are actively seeking partnerships, particularly outside of the atmospheric sciences, to develop application models that can be coupled to the WRF modeling in Africa. Toward that
end, the newest UCAR AI project, funded by Google.org, involves a partnership with African and international health and weather communities to explore how 2–14-day weather forecasts can be used to better manage the spread of the disease meningitis.

In the aforementioned BAMS article, Washington et al. identified credibility and scale as the two most important limits on the usefulness of existing numerical forecasts. The modeling system just discussed addresses the issue of scale by allowing high-resolution forecasting over Africa. While its ultimate credibility will be established with time and in partnership with local users, the ability to easily customize the model offers the opportunity to adapt WRF to outperform proprietary models run as black boxes.

SAHEL CONFERENCE. This conference, held in Ouagadougou, Burkina Faso, on 2–6 April 2007 and sponsored by Programme Saaga in Burkina Faso, the Meteorological Services in Mali and Burkina Faso, and the UCAR AI, was attended by over 80 participants from 18 countries. “Sahel Conference 2007: Improving Lives by Understanding Weather” explored ways to increase the value and use of meteorological data and models in the Sahel. The participants—researchers, government ministers, operational forecasters, and university professors from across the Sahel—worked together to outline common problems and identify potential projects. The conference helped UCAR to begin to fulfill the AI’s ideal of “African solutions to African

Fig. 2. WRF forecast domains for the operational modeling system, with example forecast products on the two inner grids. The grid increments on D1, D2, and D3 are 40.5, 13.5, and 4.5 km, respectively. The forecasts are 48 h in duration on D1 and D2, and 36 h on D3.
problems” by learning about the context of African meteorological activity.

Four working groups discussed 1) data collection, sharing, and distribution in the Sahel; 2) better models and observations for improved forecasting of precipitation and dust; 3) cloud-seeding operations in the Sahel and their connection to other meteorological operations and infrastructure; and 4) improved numerical models for predicting African weather. In addition to working-group reports, conference outcomes included next steps to guide long-term collaborations among the African meteorological and hydrological services, African universities, and UCAR and UCAR-member universities. A summary of the conference can be found at www.africa.ucar.edu/sahelconference.html.

EDUCATION AND TRAINING. Other UCAR programs with projects in Africa include the Global Learning and Observations to Benefit the Environment (GLOBE) program, the Cooperative Program for Operational Meteorology, Education and Training (COMET), and the Digital Library for Earth System Education (DLESE). GLOBE (www.globe.gov) has 26 partner countries in Africa, and it is holding discussions with additional potential partner countries. Through GLOBE, students measure and report physical, chemical, and biological properties of the atmosphere, the hydrologic system, soil, land cover, and biota. GLOBE students take environmental measurements at or near their schools and report their observations to the GLOBE database via the GLOBE Web site or e-mail. Students use tools on the GLOBE Web site to analyze GLOBE datasets, share their data with other schools around the world, and conduct research in collaboration with scientists and other GLOBE students worldwide.

COMET (www.comet.ucar.edu) provides professional development for operational weather forecasters and the research community. An example of an African project started by COMET and now handled by DLESE (www.dlese.org/library) is the African Satellite Meteorology Education and Training (ASMET) program, which trains forecasters to make better use of satellite data. The training is done via self-paced, interactive learning modules that are produced by the ASMET team and are available on CDs and/or online. At the outset of the project, four meteorology instructors from the Regional Meteorological Training Centers in Niamey, Niger, and Nairobi, Kenya, attended a nine-month training program on the instructional design process at COMET. Since then, the team has produced a series of modules, including ASMET 1—Satellite Meteorology in Africa; ASMET 2—Integrating Satellite Imagery of the Inter-Tropical Convergence Zone Into Analyses; ASMET 3—Combining Satellite Imagery and Model Output in Weather Forecasting; and ASMET 4—Tropical Cyclones over the Southwest Indian Ocean. The team is currently working on ASMET 5, a series of case studies that use Meteosat second-generation data to depict weather phenomena over Africa, including dust storms, cloud clusters, and secondary lows behind frontal systems. The modules are in English and French and are distributed to all forecast offices and higher-education programs in Africa. The initial training program was funded by several organizations, notably the European Organization for the Exploitation of Meteorological Satellites and the Deutsche Gesellschaft für Technische Zusammenarbeit in Germany. Since then, the European Meteorological Satellite program known as EUMETSAT has funded all module development activities.

SUMMARY. The overarching goal of the UCAR AI is to enhance opportunities for African scientists to perform research on problems relevant to their continent. The initiative is motivated by the fact that Africa has been underrepresented in international efforts to improve research capabilities, observing facilities, operational forecasting, and meteorological education. This is in spite of the fact that sub-Saharan countries are especially vulnerable to weather and climate variations, and that Sahelian weather directly impacts the United States in the form of hurricanes and dust clouds. Thus far, we have focused on UCAR’s own capacity for enhancing and providing access to African observations, especially radar data and high-resolution models. The radar data and the final analyses and forecasts from the operational WRF model, as well as the availability of other data through UNIDATA, are designed to provide much needed data and infrastructure for African researchers.

We hope that this paper demonstrates UCAR’s capacity to contribute to atmospheric science research in Africa, and we hope the outlined pilot efforts will provide a springboard for collaboration with universities and other organizations. In the future, we will focus on facilitating informal and formal collaborations between U.S. and African atmospheric scientists, including facilitating visitor exchanges and fostering productive mentoring and training for early and pre-career scientists in Africa. While UCAR would participate in these efforts, we see our
primary role as enabling partnerships between universities and programs in Africa that seek to develop new research capacity and universities with relevant research programs. We offer this paper, in part, to initiate a dialogue about these possibilities.

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**FOR FURTHER READING**
