An initiative for improving modeling, observing systems, data access, and training related to precipitation in Africa

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Introduction

The U.S. University Corporation for Atmospheric Research (UCAR) has established an Africa Initiative (AI) whose aim is to further develop infrastructure in Africa related to operational numerical prediction of precipitation and other variables, the observation of precipitation through improved radar and gage networks, the sharing of radar and other data among African scientists, and the education and training of scientists related to the atmospheric component of the hydrologic cycle.

Initial efforts include the establishment, in collaboration with the Ghana Meteorological Agency, of an operational atmospheric modeling system for Africa that is based on the community Weather Research and Forecast (WRF) model. This model has been operational since December 2006, and forecast products are being made available over the web to all forecasters in Africa. Precipitation forecasts will be especially useful for assessment of the threat of floods and for agricultural applications. In addition, weather radars, that provide high spatial- and temporal- resolution estimates of current precipitation, are being rehabilitated and upgraded in West Africa. These new precipitation-rate data that are placed on a network and made available over the web will serve a variety of needs.

This paper will describe continuing activities, by UCAR and its U.S. Member Universities and International Affiliate Universities, that involve the development of infrastructure in Africa related to the numerical prediction of precipitation and other variables, the continued enhancement and networking of the radar-based system for precipitation estimation, and the education of local scientists and managers in the effective use of rainfall estimates and forecasts for applications in water resources and agriculture.

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, negatively affecting 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 non-operational) 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. In addition, two of the radars are using Unidata software, developed at UCAR, to deliver operational data through a web interface. Finally, Mali and Burkina Faso have singed an MOU pledging to share radar data with each other, using the same Unidata software. Figure 1 shows the coverage of some of the radars. More information about the radar project in West Africa can be found at http://www.rap.ucar.edu/projects/westafrica/radar.html.

OPERATIONAL MODELING

Forecasters in Africa rely primarily on global models or a few proprietary mesoscale models, none of which are ideal to meet their needs. The global models whose products are 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 sub-grid 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 proprietary, and this makes it difficult to "tune" them to accurately represent local phenomena or customize their output according to local users' needs.

The modeling component of this initiative 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 (Skamarock et al. 2005); 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 designed to be customized and adapted, 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 Africans, and is being adapted by Africans to meet their specific needs. The first step is already done: a WRF-based operational forecasting system, with the highest resolution focused on West Africa (see Fig. 2), has been established using the model described in Liu et al. (2007).
(http://www.ral.ucar.edu/projects/4dwx/technology/modeling/rtfdda.html). As a second step, operational forecasters in Ghana and surrounding countries are providing input about forecast strengths and weaknesses, and improvements are being made. For about the next 12 months, until a host facility is identified, the model and the associated web site that provides products will continue to operate at NCAR, under the co-sponsorship of NCAR and the Ghana Meteorological Agency. The interface to the real-time modeling system is available at 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 special-application models (e.g., agricultural, water-resource management, health, energy, and economic models). Special-applications-oriented output will be developed in consultation with end-users, as needs arise.

In summary, Washington et al. (2006) identified credibility and scale as the two most-important limits on the usefulness of existing numerical forecasts for Africa. 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 more credibility than do proprietary models run as black-boxes.

SAHEL CONFERENCE 2007: IMPROVING LIVES BY UNDERSTANDING WEATHER

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. The main purpose of the conference was to explore ways to increase the value and use of meteorological data and models for the economic and societal benefit of countries in the Sahel. A second purpose was to bring together researchers, government ministers, operational forecasters, and university professors from across the Sahel to outline common problems and potential projects. Finally, the conference provided a means for UCAR to begin to fulfill the AI's ideal of "African solutions to African 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 models for prediction of African weather. In addition to working group reports, conference outcomes included further 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 http://www.africa.ucar.edu/sahelconference.html.

IMPROVED METEOROLOGICAL DATA-ACCESS AND DATA-ANALYSIS TOOLS AT AFRICAN UNIVERSITIES

Unidata is one of the groups in the UCAR Office of Programs (UOP). The UOP creates, conducts, and coordinates projects that strengthen education and research in the atmospheric, oceanic and Earth sciences. Unidata activities include the provision of different types of data in real-time and at no cost to both operational and research communities, and the sharing of tools to access and visualize those data. The real-time data include operational forecast-model output, satellite imagery and derived products, radar products, global positioning system precipitable-water-vapor observations, etc. Other functions of the Unidata Program can be found at http://www.unidata.ucar.edu/publications/directorspage/UnidataOverview.html. An example of Unidata software that is used globally is the Network Common Data format (netcdf). Unidata could be a model for connecting African universities with each other, and with global partners. Plans are underway to establish a Unidata node at a university in Ghana, as a first step toward providing service for the rest of the continent. As already noted, connections have been established between Unidata and the radar pilot project, making the radar data available to some countries in the Sahel.

EDUCATION AND TRAINING

Three other units of the UOP that have projects in Africa are the Global Learning and Observations to Benefit the Environment (GLOBE) program, the Cooperative Program for Operational Meteorology, Education and Training (COMET) program and the Digital Library for Earth System Education (DLESE). The GLOBE program is a hands-on, school- and community-based science and education program that brings together students, teachers, and scientists to study and research the dynamics of Earth's environment. More information can be found at (http://www.globe.gov/). The GLOBE program has twenty-six partners 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 and climate, the hydrologic system, soil, land-cover, and biota. The GLOBE students take environmental measurements at or near their schools, and report their observations to the GLOBE database via the GLOBE web site or email. Students use tools on the GLOBE web site to analyze GLOBE data sets, share their data with other schools around the world, and conduct research in collaboration with scientists and other GLOBE students worldwide.

The COMET program (http://www.comet.ucar.edu/) provides professional-development opportunities for operational weather forecasters and the geosciences research community. This program partners with international organizations such as the World Meteorological Organization (WMO), the Kenya and Niger WMO Regional Meteorological Training Centers, and the European Meteorological Satellite (EUMETSAT) program, among others. An example of an African project started by COMET and now handled by DLESE (http://www.dlese.org/library/) is the African Satellite Meteorology Education and Training (ASMET) program. The goal of this project is to improve the quality of weather forecasts in Africa by training 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.

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Figure 1. West Africa weather-radar coverage (circles). See text for details.

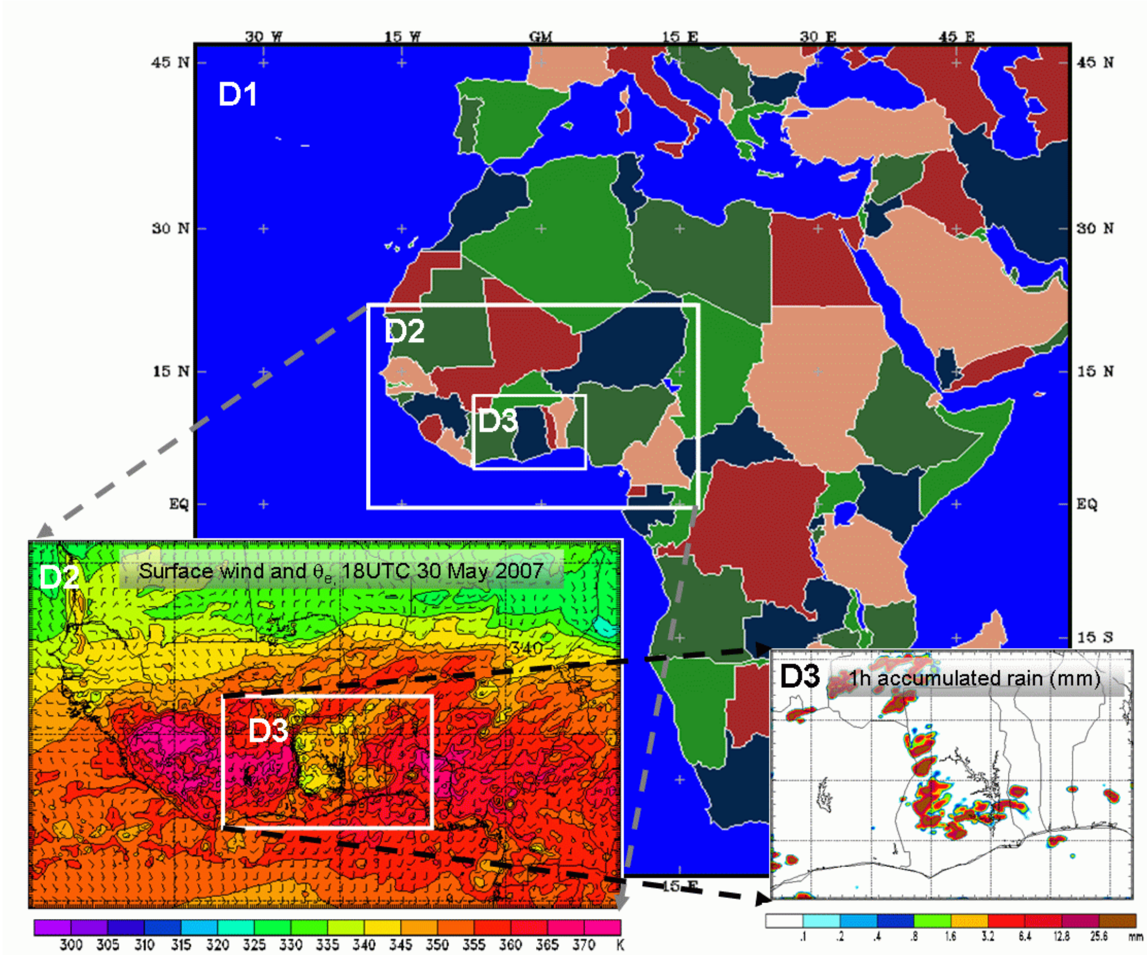

Figure 2. WRF forecast domains for the operational modeling system, with example forecast products on the two inner grids. The grid increments on D1, D2, and D3 are 40.5, 13.5 and 4.5 km, respectively. The forecasts are 48 h in duration on D1 and D2, and 36 h on D3.