"Interdisciplinary Remote Sensing, Modeling, and Validation of Environmental Processes" COSPAR Capacity Building Workshop, 12-23 June 2017, Kumasi, Ghana

The COSPAR Capacity Building Workshop on "Interdisciplinary Remote Sensing, Modeling, and Validation of Environmental Processes" (https://feer.gsfc.nasa.gov/meetings/COSPAR2017/) took place at the Kwame Nkrumah University of Science and Technology (KNUST, https://www.knust.edu.gh/), Kumasi, Ghana, during 12-23 June 2017. The Workshop was primarily funded by COSPAR, with additional support from the African Development Bank (https://www.afdb.org/en/) and the West African Science Service Centre on Climate Change and Adapted Land Use (WASCAL, http://www.wascal.org), which also provided the necessary administrative and logistic support for the Workshop. The Workshop brought together a team of experts – with a combined experience of several decades of involvement in an extensive suite of major international research initiatives – who kindly accepted to contribute their expertise, knowledge, time and other resources, to convey a coherent knowledge base and best practices in scientific research to young professionals and graduate students in West Africa. Major American and European space missions were addressed, including: Landsat, Terra, Aqua, Aura, Meteosat, CALIPSO, and the Sentinel series. This capacity building initiative provided an excellent avenue to discuss topics that would lead to effective application of space science and technology to the development/advancement of research projects that can maximize societal benefits in vital areas of human and environmental services in West Africa such as agriculture, fire prediction and assessment, air quality, water resources management, and climate mitigation and adaptation. At such a time as this, when space-based interdisciplinary research needs a strong boost in West Africa, these two weeks with experienced professionals have hopefully equipped these young scientists to pursue similar collaborative scientific research paradigms within their region.

1. Workshop Rationale and Primary Objectives

West and Central African regions have, over the years, experienced repeated occurrences of a variety of disastrous events such as drought, epidemics, famine, and flooding. The region is also undergoing rapid population growth and industrial development that contribute to degradation of air quality. Although scientific data are necessary to facilitate proper assessment and early warning of these conditions, the region has only a limited number of ground-based monitoring stations that can collect scientific data. On the other hand, there are abundant space-based Earth observations and associated modeling products that are freely available from the United States National Aeronautics and Space Administration (NASA), the European Space Agency (ESA), the European Commission (EC) Copernicus program, and other science agencies/programs. Therefore, it is believed that with appropriate high-level in-region scientific

and technical capacity, these observations can be properly harnessed to fill persistent knowledge gaps to inform environmental and agricultural policies that can greatly improve the monitoring, forecasting, and mitigation of the above disastrous phenomena in West and Central Africa. The current capacity building workshop was focused on West Africa, but the same principles and intensive training can be easily applied to Central Africa as well.

2. Participants

Thirty participants attended the workshop from nine of the fifteen countries of West Africa, namely: Benin, Burkina Faso, Gambia, Ghana, Mali, Niger, Nigeria, Senegal, and Togo (Figure 1). Although most of these participants are current Ph.D students from various universities in these different countries of West Africa, there were a few other participants who were at various levels in their professional careers (academic or other), of whom three were actually professors at one university. According to these professors, they attended this workshop in order to leverage the good professional networking and interaction opportunities provided by it to synthesize ideas for creating a climate center of excellence within their university. Eight of the 30 participants were women, while the rest were men. It should be mentioned that the different countries of West Africa have either English or French as their official national language. Therefore, both language groups were well represented, although since it was announced that the Workshop would be conducted in English, all of the participants from the French-speaking countries were found to be appreciably fluent in English as well.

Figure 1: Google Map of West Africa on which the location of Kumasi where the workshop was held can be seen in the interior of Ghana, as well as the various countries where the participants and three of the Lecturers came from.

3. Lecturers

The lecturers were drawn from the United States, Europe, and West Africa, in order to cover as broad a range of expertise and perspectives as possible. These lecturers included: Prof. Anne Thompson (NASA Goddard Space Flight Center, Greenbelt, Maryland, USA), Dr. Richard Damoah (NASA Goddard Space Flight Center, Greenbelt, Maryland, USA), Dr. Susanne Bauer (NASA Goddard Institute for Space Studies, Columbia University, New York City, USA), Prof. Dr. Francis Okeke (University of Nigeria, Enugu Campus, Nigeria), Prof. Jean-Paul Rudant (Universite de Paris-Est-Marne-La-Vallee, Paris, France), Dr. Arona Diedhiou (IRD, Joseph Fourier University of Grenoble, France), Dr. Eloïse Marais (University of Birmingham, Birmingham, United Kingdom), Dr. Seyni Salack (WASCAL Competence Center, Ouagadougou, Burkina Faso), Dr. Gerald Forkuor (WASCAL Competence Center, Ouagadougou, Burkina Faso), and Dr. Charles Ichoku (NASA Goddard Space Flight Center, Greenbelt, Maryland, USA). These lecturers together cover the full range of topics that constitute the workshop theme with adequate overlap to ensure that the full objectives of the workshop were realized successfully.

4. Topics and Workshop Implementation

The workshop topics encompassed a variety of scientific research and professional skills that were designed to build adequate confidence in developing space-technology-powered careers in the Earth sciences. These topics were assigned course numbers to mimic graduate (600-level) courses in form, but not necessarily in content or delivery approach. These courses included the following [Lecturers in brackets]:
(601) Passive Remote Sensing and Geographic Information System [Gerald Forkuor]; (602) Active (Radar, Lidar) Remote Sensing and Image Analysis [Jean-Paul Rudant]; (603) Satellite Products and Interdisciplinary Research in West Africa [Charles Ichoku]; (604) Satellite Climatology and Climate Projections for West Africa [Susanne Bauer]; (605) West African Atmospheric Composition and Regional Climate Modeling [Richard Damoah]; (606) West African Monsoon and Precipitation Variability [Arona Diedhiou]; (607) Digital Mapping and Agricultural Applications of Remote Sensing [Francis Okeke]; (608) Field Campaigns and Air Quality Monitoring [Anne Thompson]; (609) Observation, Modeling, and Impacts of Emissions in West Africa [Eloïse Marais]; (610) Observation Networks and Ground-truthing in West Africa [Seyni Salack].

Each of the topics had both a lecture and a practical component. Both the lectures and the practical work were allotted an equal time of 90 min each, which we later found to be probably not optimal based on the evaluations we received at the end of the workshop, as will be discussed under the "Workshop Evaluation" section below. However, we had provided several additional 90-min periods for discussions and questions, as well as group and individual practical work not completed during regular practical periods.

In addition to the above science topics, we also covered a few peripheral topics that we considered useful for success in scientific careers. These were: (611) Preparation and Delivery of Presentations [Anne Thompson]; (612) Preparation and Submission of Articles for Publication [Eloïse Marais]; (613) Writing Proposals Successfully [Ichoku & Bauer]. To complement this last lecture, we introduced the participants to funding opportunities that are potentially available for researchers and research students in West Africa. Furthermore, toward the end of the workshop, we considered it also appropriate to discuss some tips and best practices on preparing

good curriculum vitae and resumes, even though this had not been planned prior to the workshop. The participants seemed to appreciate this additional component. Finally, we provided all of the presentations and materials used for the lectures and practical work to the participants for future reference when needed.

5. Organization and Venue

The venue of the Workshop, KNUST, Kumasi Ghana, houses one of WASCAL's Doctoral Programs, namely, that of "Climate Change and Land Use (CCLU)". Collaboration with WASCAL in this Workshop tremendously facilitated its planning and implementation, as we were allowed to conduct the workshop free of charge at the WASCAL-CCLU facilities. The opening ceremony was addressed by the top leadership of KNUST. Both the management and staff of the WASCAL Headquarters in Accra, Ghana, and the WASCAL-CCLU program at KNUST provided all of the necessary assistance that made this workshop so successful. We would like to acknowledge the key roles played by specific leadership team members of WASCAL, namely: Professors Jimmy Adegoke and Janet Adelegan, who are respectively, WASCAL's Executive Director and Capacity Building Director, as well as Professors Samuel Odai and Wilson Agyare, who are respectively, Director and Deputy Director of the WASCAL-CCLU program. The WASCAL-CCLU building where the Workshop was held was perfect for this event. We used the main lecture room with a capacity of ~50 people, which was just adequate for a group like ours to have a very meaningful interaction, for all lecturers, demonstrations, and practical work. The room was neither tight nor too large, and everyone could hear every speaker very clearly. In addition, we were allowed the use of the main executive conference room that could accommodate up to 30 people, and we used it for strategic planning meetings by the lecturers when needed to enhance the effectiveness of the lectures and practical work. We also had access to a third work/study room that can sit a few people at a time, and used it when anyone or a few people needed to work privately or have more focused discussion for a short time. Other than the foregoing occasional situations, all of the participants and all of the lecturers were always together in the lecture room all the time, to maximize interaction, in accordance with the intent of COSPAR Capacity Building workshops such as this one. Finally, we had our lunches and tea/coffee breaks together in a nice large outdoor party tent/canopy, which was perfect for the climate of the region where the workshop was held. In a few cases, when heavy/windy rain made it somewhat inconvenient to dine in the tent, our meals were served in another classroom that was just the right size and was temporarily converted to a lunch room for our purposes.

The KNUST Campus is overall very well laid out and beautiful, with very well designed buildings and open spaces. Some of us enjoyed taking leisurely walks in the evenings and played some sports during the weekend. As a group, we undertook a day bus tour organized by our WASCAL-CCLU hosts during which we visited Lake Bosomtwe, which is situated in an ancient impact crater, and believed to be the only natural lake in Ghana. On that same day trip, we also visited the Ashanti Kingdom Palace, as well as the place where the well-known Ghanaian kente cloths are weaved locally. It was a fun day outing that we all (lecturers and participants alike) enjoyed very much.

Figure 2: Most of the Participants and Lecturers of the Workshop in front of the WASCAL-CCLU building where the Workshop was held, together with the current Executive Director of WASCAL (Professor Jimmy Adegoke – front row far right), who was one of the original organizers of the Workshop.

6. Datasets and Software

The participants were provided a thorough introduction or reinforcement to the use of valuable imagery, products, and datasets from a variety of satellite missions. These included the active (RADAR) and passive remote sensing imagery and data products from ESA's Sentinels 1, 2, and 3 missions; imagery and datasets from the US Geological Survey's (USGS) Landsat series of missions; imagery and results from NigeriaSat 1 and 2; and imagery, products, and results from a wide variety of NASA and partner missions, including: Terra, Aqua, Aura, Suomi-NPP, CALIPSO, TRMM, and GPM. Great emphasis was placed, not only on data availability and utility, but also on accessibility. We demonstrated to the participants how to access and download these imagery and datasets in an efficient way. Some of the main data access portals introduced to the participants include: NASA Worldview (https://worldview.earthdata.nasa.gov); NASA Giovanni (https://giovanni.gsfc.nasa.gov/giovanni/); Sentinel (https://sentinel.esa.int/web/sentinel/home); and Landsat (https://landsat.usgs.gov) portals.

Regarding analysis software, the emphasis was on robust and reliable public domain or otherwise free software that anyone can either use online or download and install on their computer and use freely. This was meant to eliminate limitations imposed by cost of commercial software, which are generally not affordable by typical researchers and students from developing countries, such as those of West Africa. Therefore, we made sure that we taught and guided the participants to install and use at least the following analysis software: (1) SNAP for analysis of Sentinel 1, 2, and 3 data; (2) Quantum GIS (QGIS) for generic image processing and Geographic

Information System analysis; and (3) R statistical environment for various types of statistical analyses.

In addition to satellite observational data and their accessibility and analysis, we introduced the participants to various other types of datasets and products. These included ground-based networks, such as the NASA-Federated globally distributed AERONET network (https://aeronet.gsfc.nasa.gov) for ground-based remote sensing of atmospheric aerosols; the NASA SHADOZ network (https://tropo.gsfc.nasa.gov/shadoz/) for ground-based Ozone sounding profiles; and the WASCAL Data Infrastructure (WADI) system (https://wascal-dataportal.org/wascal_searchportal2/) for various types of ground observations in West Africa. These networks and ground-based observations are important both for satellite validation and focused scientific analyses. Furthermore, the participants were introduced to climate projection tools and datasets such as that provided by the NASA Goddard Institute for Space Studies (https://data.giss.nasa.gov/gistemp/), from which the participants were able to generate plots of projected climate variables for various parts of their region, based on different climate scenarios.

7. Workshop Evaluation

Toward the end of the workshop, we designed an evaluation form to get some feedback from the participants regarding their overall impressions about the Workshop. The form simply requested the following:

> Please respond to the following questions (not to exceed a total of 2 pages). Bearing in mind the theme and objectives of this specific COSPAR Workshop:
> (1) What did you like about this workshop?
> (2) What didn't you like about it? (Please suggest alternatives, if applicable)
> (3) What did you learn that you did not really know previously?
> (4) What (if anything) can the knowledge you gained help you improve in your studies/research/career/professional activity?
> (5) Would you recommend this type of workshop to others if there is opportunity?
> (6) What aspects of the workshop would you have liked to see handled differently?
> (7) On a scale of 0 to 10 (with 0=useless and 10=excellent), how much would you grade this workshop relative to your expectations?
> (8) Any other comments or suggestions?

This evaluation form was distributed to the participants at the end of the day on the eve of the last day, and they were asked to complete it overnight if they chose to, and were informed that the first 90-min period of the last day would be dedicated to completing the form. Twenty-three of the thirty participants submitted their responses. Essentially, all of the respondents indicated that they liked the workshop, mostly because of its interdisciplinary content and the broad spectrum of data and tools that were introduced to them. However, many of them thought that the workshop was quite intense and lasted long hours, and that the time devoted to practical work was insufficient. They would have liked to see more time devoted to practical work than was done in this workshop, with some suggesting that the 90-min time periods we gave for both lectures and practical work should have been allotted differently, perhaps with 60-min for each lecture and twice that time-length for the corresponding practical work. Nevertheless, they all indicated that they gained a significant amount of new knowledge that would be very beneficial

for advancing their studies/research/career/professional activities, and would recommend similar workshops to others. The overall grades given by the participants to the workshop were: five 7s, one 7.5, six 8s, three 9s, one 9.5, and seven 10s, which produces an average grade of 8.56/10.

8. Summary and Expected Longer-Term Outcomes

The workshop was extremely crucial and timely, as it provided the unique opportunity to reinforce a regional scientific collaboration culture among young Earth-observation-powered scientists in West Africa, and provided participants with the opportunity to build their regional networks. Furthermore, the close interactions these regional scientists had with the international group of Lecturers, which is expected to continue to an appreciable extent, will probably lead to enhanced active participation of West African scientists in international space-based Earth-science research community meetings and activities. This initial step can then kindle a process that can influence the regional/national/local operational agencies and policy makers to embrace the use of scientific data for decision-making, thereby elevating the position and value of space-based science/technology and the scientists themselves in the West African society. By making sound decisions based on appropriate scientific data and creating public awareness and knowledge of the basis of the decision making at the regional scale, the society will likely fare much better, and prepare for climate mitigation and adaptation with a united purpose as a region, since West Africa is arguably one of the most susceptible regions to potential disasters related to climate change. This is important because threats of climate-change effects do not respect local or even national political/administrative boundaries.