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The Challenges of Developing a Framework for Global Water Cycle Monitoring and Prediction (Alfred Wegener Medal Lecture)

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The Global Earth Observation System of Systems (GEOSS) Water Strategy ("From Observations to Decisions") recognizes that "water is essential for ensuring food and energy security, for facilitating poverty reduction and health security, and for the maintenance of ecosystems and biodiversity", and that water cycle data and observations are critical for improved water management and water security – especially in less developed regions. The GEOSS Water Strategy has articulated a number of goals for improved water management, including flood and drought preparedness, that include: (i) facilitating the use of Earth Observations for water cycle observations; (ii) facilitating the acquisition, processing, and distribution of data products needed for effective management; (iii) providing expertise, information systems, and datasets to the global, regional, and national water communities.

There are several challenges that must be met to advance our capability to provide near real-time water cycle monitoring, early warning of hydrological hazards (floods and droughts) and risk assessment under climate change, regionally and globally. Current approaches to monitoring and predicting hydrological hazards are limited in many parts of the world, and especially in developing countries where national capacity is limited and monitoring networks are inadequate.

This presentation describes the developments at Princeton University towards a seamless monitoring and prediction framework at all time scales that allows for consistent assessment of water variability from historic to current conditions, and from seasonal and decadal predictions to climate change projections. At the center of the framework is an experimental, global water cycle monitoring and seasonal forecast system that has evolved out of regional and continental systems for the US and Africa. The system is based on land surface hydrological modeling that is driven by satellite remote sensing precipitation to predict current hydrological conditions, flood potential and the state of drought. Seasonal climate model forecasts are downscaled and bias-corrected to drive the land surface model to provide hydrological forecasts and drought products out 6-9 months. The system relies on historic reconstructions of water variability over the 20th century, which forms the background climatology to which current conditions can be assessed. Future changes in water availability and drought risk are quantified based on bias-corrected and downscaled climate model projections that are used to drive the land surface models. For regions with lack of on-the-ground data we are field-testing low-cost environmental sensors and along with new satellite products for terrestrial hydrology and vegetation, integrating these into the system for improved monitoring and prediction.

At every step there are scientific challenges whose solutions are only partially being solved. In addition there are challenges in delivering such systems as "climate services", especially to societies with low technical capacity such as rural agriculturalists in sub-Saharan Africa, but whose needs for such information are great. We provide an overview of the system and some examples of real-world applications to flood and drought events, with a focus on Africa.