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Towards a Seamless Framework for Drought Analysis and Prediction from Seasonal to Climate Change Time Scales (Plinius Medal Lecture)

Justin Sheffield
Department of Civil and Environmental Engineering, Princeton University. Princeton, NJ, USA, 08544 (justin@princeton.edu)

Droughts arguably cause the most impacts of all natural hazards in terms of the number of people affected and the long-term economic costs and ecosystem stresses. Recent droughts worldwide have caused humanitarian and economic problems such as food insecurity across the Horn of Africa, agricultural economic losses across the central US and loss of livelihoods in rural western India. The prospect of future increases in drought severity and duration driven by projected changes in precipitation patterns and increasing temperatures is worrisome. Some evidence for climate change impacts on drought is already being seen for some regions, such as the Mediterranean and east Africa.

Mitigation of the impacts of drought requires advance warning of developing conditions and enactment of drought plans to reduce vulnerability. A key element of this is a drought early warning system that at its heart is the capability to monitor evolving hydrological conditions and water resources storage, and provide reliable and robust predictions out to several months, as well as the capacity to act on this information. At longer time scales, planning and policy-making need to consider the potential impacts of climate change and its impact on drought risk, and do this within the context of natural climate variability, which is likely to dominate any climate change signal over the next few decades.

There are several challenges that need to be met to advance our capability to provide both early warning at seasonal time scales and risk assessment under climate change, regionally and globally. Advancing our understanding of drought predictability and risk requires knowledge of drought at all time scales. This includes understanding of past drought occurrence, from the paleoclimate record to the recent past, and understanding of drought mechanisms, from initiation, through persistence to recovery and translation of this understanding to predictive models. Current approaches to monitoring and predicting drought are limited in many parts of the world, and especially in developing countries where national capacity is limited. Evaluation of past droughts and their mechanisms is limited by data availability and especially before the instrumental period of the last 50-100 years, for which there is reliance on incomplete spatial proxy data, such as tree rings. Seasonal predictability is currently mainly limited to tropical and sub-tropical regions through connections with sea surface temperature variations such as ENSO. Predictability in mid-latitudes is low and especially for precipitation, although dynamical model predictions appear to be edging statistical models in many aspects of seasonal prediction.

This presentation describes ongoing research on evaluation of drought risk and drought mechanisms at regional to global scales with the eventual goal of developing a seamless monitoring and prediction framework at all time scales. Such a framework would allow consistent assessment of drought 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 drought 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 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 drought variability over the 20th century, which forms the background climatology to which current conditions can be assessed and drought mechanisms can be diagnosed. Future drought risk is quantified based on bias-corrected and downscaled climate model projections that are used to drive the land surface models. Current research is focused on several aspects, including: 1) quantifying the uncertainties in historic drought reconstructions; 2) analysis of drought propagation through the coupled hydrological/vegetation system; 3) the utility of new data sources such as on the ground sensors and new satellite products for terrestrial hydrology and vegetation, for improved monitoring and prediction, especially in poorly observed regions; 4) advancing predictive skill for all aspects of drought occurrence through diagnosis of the driving mechanisms and feedbacks of historic droughts; and 5) quantification and reduction of uncertainties in future projections of drought under climate change. The steps towards the development of a seamless framework for analysis and prediction in the context of this research

are discussed.