WRITTEN TESTIMONY OF
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HEARING ON
DROUGHT FORECASTING, MONITORING AND DECISION-MAKING:
A REVIEW OF THE NATIONAL INTEGRATED DROUGHT INFORMATION SYSTEM
COMMITTEE ON SCIENCE, SPACE AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES
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Chaiman Hall, Ranking Member Johnson and other members of the committee: thank you for the opportunity to provide testimony on the National Integrated Drought Information System (NIDIS).

My name is James Famiglietti. I am a hydrologist and professor on the faculty at the University of California, Irvine, with appointments in the Department of Earth System Science and the Department of Civil and Environmental Engineering. I am also the Founding Director of the UC Center for Hydrologic Modeling. My research group uses satellite remote sensing and develops advanced computer models to track to water availability on land, including the occurrence of the hydrologic extremes of flooding and drought. It is on the strength of nearly 30 years of research, teaching and service to the water science and engineering community that I offer the following testimony.

INTRODUCTION

Drought is an insidious and patient killer – of food and fuel crops, of livestock, of other flora and fauna, and of humans. It causes billions of dollars of damage each year in the United States, and perhaps much more when its far reaching effects, for example, on water availability, on food and energy production and prices, or on the frequency of fires, are accounted for. Clearly, drought has emerged as a major threat to our nation's food, health, economic and water security. Unfortunately, these all may be at greater risk in the coming decades, as increasing temperatures are expected to result in more frequent and prolonged drought. In spite of its enormous emotional and financial toll, current investment in drought forecasting, monitoring and planning tools, such as those that we are discussing today, remains far too small to affect timely progress towards critical improvements.

The National Integrated Drought Information System (NIDIS), first proposed by the Western Governors' Association Report (2004) "Creating a Drought Early Warning System for the 21st Century: The National Integrated Drought Information System" made the case for a national-scale, coordinated drought monitoring and forecast system.

Among the goals listed in the NIDIS Implementation Plan (2007) are: 1) developing leadership and partnerships to successfully implement NIDIS; 2) fostering and supporting a research environment that focuses on risk assessment, forecasting and management; 3) the creation of a drought early warning system; 4) development of an internet portal for disseminating early warning system information; and 5) providing a framework for increasing public awareness and education of drought issues.

These goals are absolutely essential for a national-scale drought strategy and I fully support the continuation and proposed increase in NIDIS funding. For example, some key NIDIS successes are:

- Coordination of drought research in the U.S. Without NIDIS this work would be less organized and efficient.
- The NIDIS drought early warning system, which is in development but not yet implemented nationally, is a crucial step towards diminishing drought impacts and costs
- NIDIS funding has supported many innovative research projects that are yielding insights toward improved drought monitoring, prediction, and mitigation (Pulwarty, 2011).

One of the most widely used and visible drought awareness tools is the U. S. Drought Monitor (USDM), an important partner of the NIDIS program. The USDM, first developed around 2000 by a volunteer consortium, is now mandated by law, yet in my understanding, remains unfunded as a project (though individual researchers may receive funding).

IMPROVING NIDIS

The NIDIS Implementation Plan (2007) identifies several gaps in its longer-term development strategy. These gaps drastically limit the confidence of predictions and the accuracy of early warning systems. Of these, in my opinion, the most important are related to deficiencies in the nation's hydrological modeling assets, a lack of observations of the water environment, and their integration. It is important to recognize that these issues plague all aspects of water research, forecasting and planning. Our nation's ability to monitor and predict the state of its water environment is well behind where it needs to be, to address not only issues of drought, but also of water availability, flooding, groundwater depletion, of human versus ecological water requirements, and of the impacts of global change (Famiglietti et al., 2011). Moreover, we are falling behind the capabilities of other nations, while significantly constraining our domestic efforts to ensure sustainable water management (Famiglietti, 2012).

Critical Needs

More realistic computer simulation models. While the research community that develops our nation's computer models for hydrologic prediction has made great progress in the past few decades, enormous challenges lie ahead. Most of our regional and national models do not effectively the represent the coupling among snow, surface water and groundwater supplies. In some cases, the representation of rivers and groundwater is absent. The inclusion of human water management (groundwater pumping, reservoir storage, conveyance), a dominant control on water storage and movement, is effectively absent. A major acceleration in the development of advanced computer models for hydrology and water management, including an integrated national water model, is essential for effectively managing drought and range of critical water issues. It is critical that these advanced models readily integrate core satellite and ground-based measurements (see below), and that they evolve with advances in computing power and the structure of the internet.

Fill in fundamental knowledge gaps. Knowledge of Earth's water environment at the surface and shallow subsurface remains insufficient. Consequently, it is a major barrier to minimizing risk and maximizing resiliency to events like prolonged drought and extreme flooding. We know very little about the unseen topography beneath the water surface, for example, the bathymetry of thousands of river channels, floodplains, and lakes. An accurate, national-scale soil depth map does not exist, nor does a 3-dimensional map of the nation's hydrogeology. All are essential inputs into our computer models, yet without them, we are forced to guess at the values of these critical parameters. Major efforts at synthesizing existing information, and exploring and mapping what is as yet unknown, is an important frontier that can vastly improve drought preparedness and water management capabilities.

Support for key observations. Modern water observing systems include a dense network of ground-based measurements and satellite measurements to document status and changes over larger, regional areas. Key ground-based measurements include the U. S. Geological Survey stream gaging and groundwater monitoring programs, and the U. S. Department of Agriculture Soil Climate Analysis Network (SCAN; http://www.wcc.nrcs.gov/scan) sites for measuring soil wetness. The number of active stream gauges is in decline in the U.S., and in many states, reporting of groundwater pumping rates is not required. A reevaluation of this situation, including the number of active stream gauging stations, groundwater monitoring wells and reporting requirements would benefit all aspects of water availability, flood and drought management. The SCAN program is young and could be grown significantly to create a far better picture of water available for crops than is currently available.

Satellite observations, and in particular NASA missions, are providing new insights into rainfall rates (Tropical Rainfall Measurement Mission,TRMM), and areas of water stress and groundwater depletion (Gravity Recovery and Climate Experiment, GRACE). Upcoming NASA missions, such as the Surface Water and Ocean Topography (SWOT) mission, will map changes in surface water storage, including areas of high and low river flows, lake and reservoir levels. The Soil Moisture Active Passive (SMAP) mission will ultimately provide maps of the water content in surface soils that can be used to more effectively and efficiently schedule irrigation. The Global Precipitation Mission (GPM) will continue the success of the TRMM mission by expanding its coverage from tropical to global. The continued support of Congress for these core water missions is essential for effective and sustainable water management, including advancing our drought preparedness capabilities in the United States.

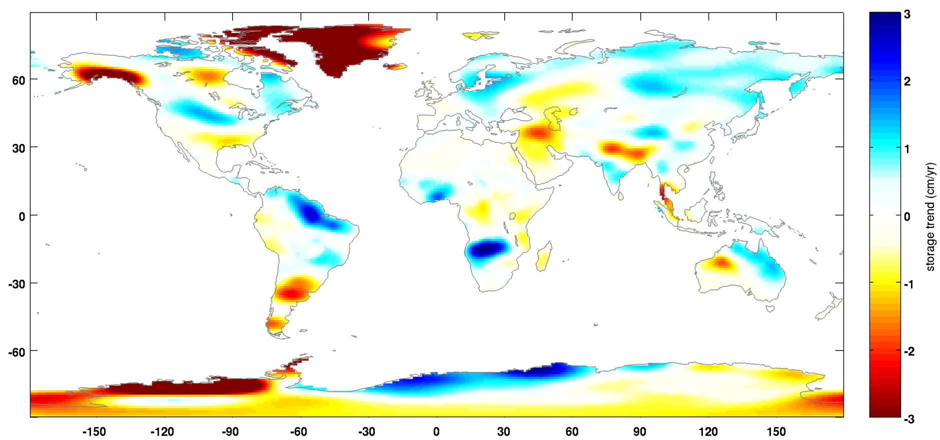


Figure 1. Trends in freshwater availability (cm/yr) from the NASA GRACE mission, 2002-2012. Red and yellow areas indicate losses of freshwater. Blue areas are gaining water. Note that the Southeastern US drought emerges as a long-term (10-yr) trend, implying predictive power when integrated into a forecasting system like NIDIS. Most of the red 'dots' correspond to regions of significant groundwater depletion. Paper in preparation by Famiglietti et al. Data courtesy of Sean Swenson, National Center for Atmospheric Research; and JT Reager, UC Irvine.

The foundation of a modern drought information system that NIDIS could become requires an advanced computer modeling system, such as that described above, that can ingest a range of ground and satellite observations to produce the best possible predictions. It is a daunting challenge and one on which we are making slow and steady progress. To move forward with predictive capabilities in a timely way, a significant increase in funding for 'model-data integration' or 'data assimilation' is required.

Integration with university researchers. The lack of significant university involvement in the NIDIS implementation plan and research report (Pulwarty, 2011) is noted. In particular, the efforts of the Consortium of Universities for the Advancement of Hydrologic Sciences, Inc. (CUAHSI, http://cuahsi.org) are consistent with the goals of NIDIS. In particular, CUAHSI's progress on Hydrologic Information Systems (HIS, http://his.cuahsi.org) could be leveraged. Its work with the Community Hydrologic Modeling Platform (CHyMP, http://www.cuahsi.org/chymp.html) on the development of a national-scale, integrated model with capabilities as describe above, could also help form an important connection to university researchers, and a pipeline for future employees. More generally, the pool of researchers contributing to drought studies and tool development could be greatly expanded by more effective connections to universities.

Pathways for translational science and communication. The time gap between research, for example, in drought forecasting tools, and operational implementation, for example, in NIDIS, is often several years to decades. New mechanisms and additional resources are required to shrink this gap, in particular given that human lives are at risk. In some cases, the case the technology for increasing forecasting lead times – for drought, for floods, for fires – is now available, but the pathway to operational implementation is unclear. Even with effective communication, the human resources at our government labs may not be available to modify current forecast systems.

Beyond the research to operations bridge, better communication of drought issues with the public and with environmental decision makers is also a key to heightened awareness and informed planning. Scientists and engineers are notoriously bad public communicators; nor does the current reward system offer any incentives for improving. A translational body, or a grant program for scientists wishing to engage in public communication, are potential options for raising awareness.

COMMENTS ON DRAFT LEGISLATION

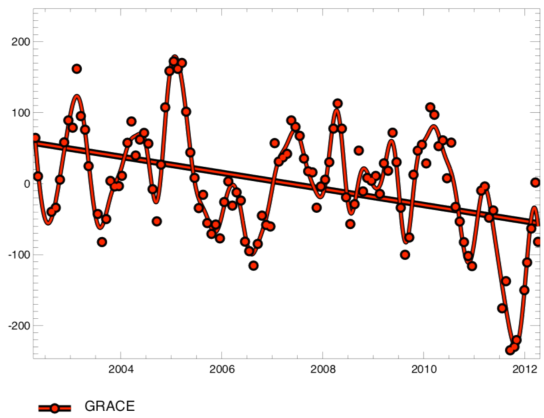
I recommend that language reflecting a commitment to advanced modeling tools be considered. For example, page 2, line 11, use of the term 'best available' information, or on page 2, line 13, 'best possible' and timely forecasts. The current models are good, but they are far from where they need to be. As described above, an acceleration in hydrological model development is required.

While I do not have access to the total amount of spending on drought research in the United States, the $13.5 million listed in the draft legislation strikes me as far too small to significantly advance our understanding, prediction and preparedness for drought in a timely manner. If NIDIS is only playing a coordinating role, then $13.5 million is likely sufficient. However, to address the range of challenges outlined above, a factor of 10 increase will be required to advance modeling capabilities.

CLOSING THOUGHTS

Water issues are rising to the forefront of the American consciousness. The current drought, previous floods, and falling groundwater levels in California, in the High Plains aquifer, and in the Southeastern U. S. have all heightened awareness. Our federal agencies, for example the USGS, the Army Corps, the Environmental Protection Agency, etc., are all working hard and maximizing their available resources. However, water is on trajectory to rival energy in its importance, yet the investment in observations, models, and exploration of the subsurface pales in comparison.

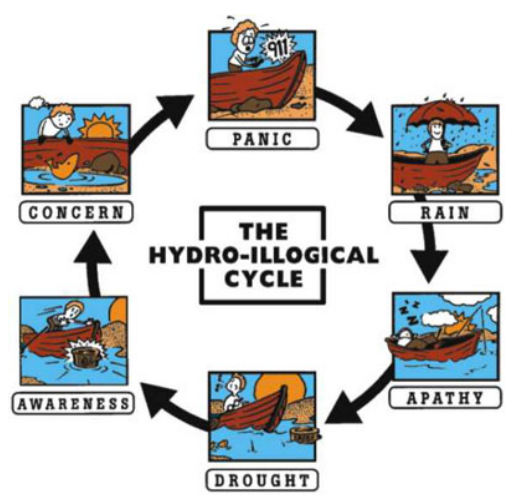
Could we have seen this drought coming? Consider the Texas drought, which has been characterized as having started about 18 months ago. However, data from the NASA GRACE mission shown here, which depict changes in all of the water stored in the central part of the Gulf Coast Drainage (USGS HUC2 region) suggest that the decline has been going on for much longer – three years or perhaps more. If such data had been integrated into NIDIS, could they have provided an earlier warning and better preparedness (data latency issues notwithstanding)? With the proper level of investment in monitoring and predictive tools, maybe, yes, we could have seen it coming. Note that a similar argument can be made about flooding.



Changes in total water storage (mm/mo) from GRACE for part of Texas. Red dots are monthly changes in water storage as differences from the mean of the 2002-2012 time period shown. Straight line shows decreasing trend for the time period. Data courtesy of Sean Swenson, National Center for Atmospheric Research

The technology for developing advanced models, observations, their integration and their dissemination through information systems currently exists in the United States and around the world. Arguably, our nation requires a technologically-advanced water modeling and information system consistent with our emerging technology-based economy. The vision is in place in the operational and university research communities. Leadership in Congress is what will make it a reality.   We have the potential to be world leaders in characterizing, monitoring and predicting all aspects of the water environment – from forecasting droughts and floods, to science-informed, technology-based long-term sustainable water management. Simultaneously, we can create jobs and protect the health and well-being of our population. The time is ripe and the technology is ready for an advanced, national-scale water modeling framework.

In closing, I suggest that we try to break the 'Hydro-Illogical Cycle' of human behavior (http://drought.unl.edu/Planning/HydroillogicalCycle.aspx), and become proactive, rather than reactive, about managing one of our nations most precious resources. Note of course, that an investment in drought is an investment in our greater water future.



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Additional Resources

Last Call at the Oasis, a new water documentary, http://lastcallattheoasis.com

Famiglietti, J., 2011, A Drought of Texas-Sized Proportions, http://blog.ucchm.org/2011/12/11/a-drought-of-texas-sized-proportions-when-praying-for-rain-just-wont-do-the-trick/