4-2011

THE LINCOLN DECLARATION ON DROUGHT INDICES: Universal Meteorological Drought Index Recommended

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Improved drought monitoring and early warning systems are urgently needed to cope with current and potentially changing drought patterns as we move into the future. Drought is a slow-moving natural hazard that can affect virtually all climatic regimes. Generally defined, drought is a deficiency of precipitation relative to what is expected (i.e., "normal") that, when extended over a season or a longer period of time, results in the inability to meet the demands of human activities and the environment. As countries around the world begin to establish national drought strategies, one critical component should be the development of a comprehensive drought monitoring system that has the ability to provide an early warning of the drought's onset, determine drought severity and spatial extent, and convey that information to decision-making groups in a timely manner. This information can then be used to either reduce or avoid the impacts of drought.

With this in mind, drought experts from nearly two dozen nations,[1] including from all six regions of the World Meteorological Organization (WMO), were brought together for the Inter-Regional Workshop on Indices and Early Warning Systems for Drought, which was a four-day workshop focused on developing standards for drought indices and guidelines for drought early warning systems (DEWS). The motivation behind this workshop came out of the primary recommendations from the February 2009 International Workshop on Drought and Extreme Temperatures in Beijing, China, where one of the main recommendations was for the WMO to identify

INTERREGIONAL WORKSHOP ON INDICES AND EARLY WARNING SYSTEMS FOR DROUGHT

WHAT: Fifty-four participants from 22 countries, including drought experts from each of the six WMO regions, met to discuss the development of standards for drought indices and guidelines for drought early warning systems

WHEN: 8–11 December 2009

WHERE: Lincoln, Nebraska

SPONSORS: WMO; National Drought Mitigation Center (NDMC) and the School of Natural Resources (SNR), both at the University of Nebraska–Lincoln; NOAA/National Integrated Drought Information System; U.S. Department of Agriculture; and the United Nations Convention to Combat Desertification Secretariat

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DOI:10.1175/2010BAMS3103.1

In final form 2 November 2010

[1] Argentina, Australia, Barbados, Botswana, Brazil, Canada, Costa Rica, Germany, India, Indonesia, Italy, Mexico, Nairobi, Niger, Peru, Philippines, Romania, Slovenia, Spain, Switzerland, United States, Uzbekistan.

methods and marshal resources to develop standards for agricultural drought indices.

The recent Lincoln, Nebraska, workshop had the following four specific objectives: 1) to review and assess drought indices that are currently used around the world for the three types of drought (meteorological, agricultural, and hydrological); 2) to review and assess the strengths, weaknesses, and limitations of existing drought indices and early warning systems; 3) to develop a consensus standard index for each of the three types of drought; and 4) to develop guidelines for WMO members in implementing and improving drought early warning systems.

The workshop was organized into multiple sessions that covered topics on early warning systems, the current use of drought indices by region, the impacts of drought, and current and emerging technologies in drought monitoring. Three breakout sessions utilized public participation techniques to develop a consensus on which index to use for each of the three types of drought. Finally, participants developed the Lincoln Declaration on Drought Indices, a document summarizing the workshop findings and principal recommendations.

For additional information about this workshop, including background materials, the agenda, presentations, participant list, and the Lincoln Declaration on Drought Indices, please visit the workshop Web page (available online at www.wmo.int/pages/prog/wcp/agm/meetings/wies09/index_en.html).

DROUGHT INDICES AND EARLY WARNING SYSTEMS FOR DROUGHT. A major portion of the Lincoln workshop focused on DEWS, regional perspectives on monitoring, and current and emerging drought monitoring issues. DEWS are important in that they 1) allow for early drought detection (either by observation or forecast), 2) improve response time, 3) trigger actions within a drought plan, 4) serve as a critical mitigation action, and 5) are the foundation of any sound, comprehensive drought mitigation plan. The United Nations (UN) has hazarded a generic definition for an early warning system (EWS): "the provision of timely and effective information, through identifying institutions, that allow individuals exposed to a hazard to take action to avoid or reduce their risk and prepare for effective response" (International Strategy for Disaster Reduction 2004).

It is important to distinguish between drought prediction and drought early warning. A DEWS will ideally contain both a forecast component and a suite of early detection tools and monitoring products. Once the onset of drought is detected (or strongly predicted), this can lead to the triggering of actions within a drought plan. An established DEWS can help authorities enact mitigation efforts, coordinate activity, provide accountability between various governmental agencies and local entities, direct emergency relief, and disseminate information to the general public.

The Lincoln workshop highlighted that a DEWS can contain the following components:

- data-monitoring networks (for the multiple and varied collection of climate, hydrological, and environmental observations, remote sensing, impacts, etc.);
- data retrieval and storage [quality assurance (QA) and quality control (QC)];
- derivative interpretation and value-added deliverables (products/tools);
- integration and application of various models, such as Land Data Assimilation Systems (LDAS), potential evapotranspiration, soil moisture, groundwater, etc.;
- translation from data to information, which is critical; and
- dissemination (accounting for user needs, mediums of delivery, timely information, and data sharing) of the information and status of conditions.

The Lincoln workshop also highlighted many of the indicators and indices used regionally around the world in monitoring drought. Emerging drought monitoring issues were also discussed, focusing on the transferability of the U.S. Drought Monitor and the North American Drought Monitor products to other regions. These discussions stressed that, individually, many nations will be unable to improve their drought coping capacities. Collectively, through global, regional, and national partnerships and networks, however, information and experiences can be shared to reduce drought through a global drought early warning system (GDEWS).

SECTORAL IMPACTS OF DROUGHT: INDICATORS FOR EARLY WARNING AND ASSESSMENT. This portion of the Lincoln workshop emphasized drought impact assessment and its importance. It is recognized that one component of a DEWS must focus on drought impacts. Often impact assessment is forgotten, or is not included, within the discussion of various drought monitoring tools and how they all fit into a DEWS. However, by understanding the impacts the severity of the drought is connected with decision making and appropriate drought-related responses. Impacts are also important clues for understanding vulnerabilities, which is important for targeting drought mitigation strategies.

The workshop session emphasized that identifying baseline impact information has been difficult at the national, state, and local levels because of the nature of drought impacts and impact reporting. This is true in most locations around the world and is why the Drought Impact Reporter tool (online at http://droughtreporter.unl.edu) was developed to collect, archive, and display drought impacts for the United States. Several other states and organizations are now also participating in the drought impact collection process. Overall, there appears to be a fundamental lack of knowledge or understanding about 1) the importance of monitoring impacts, 2) the usefulness of impact information, and 3) the type of information that is worthwhile to collect. These limitations need to be addressed to make the drought impact component successful within a DEWS.

Panelists for this workshop session also discussed distinguishing between agricultural and hydrological drought impacts, the difficulties of estimating economic impacts, and the need for additional tools for impact assessment.

BREAKOUT SESSIONS—METEOROLOGICAL, HYDROLOGICAL, AND AGRICULTURAL DROUGHT. One of the features of the Lincoln Workshop was that attendees were able to participate in one of three facilitated breakout sessions covering the topics of meteorological, hydrological, or agricultural drought. These breakout sessions were unique because of the various public participation techniques that were used to help participants develop a consensus standard index for each of the three types of drought.

The WMO organizing committee developed some general guidelines to help explore drought indices that may have global applications. Specifically, participants were asked to list all of the relevant indices and evaluate the following: region(s) where indices are used, the type of drought being monitored (agricultural, meteorological, and hydrological), how indices are being used, their advantages and disadvantages, and overall general usefulness.

Each breakout session followed a similar process. First, participants used a card writing, sorting, and consensus technique that was facilitated by a public participation "sticky wall" (Chambers 2002; exercise 1) based on the above guidelines. Then, participants used a decision grid (Chambers 2002; exercise 2) to quantitatively rank each index based on six evaluation criteria outlined by Keyantash and Dracup (2002). The purpose of this secondary activity was for the groups to achieve some level of consensus building.

METEOROLOGICAL DROUGHT BREAKOUT SESSION RESULTS. The following indices were identified during exercise 1: the standardized precipitation index (SPI), percent of normal precipitation, a soil moisture index, percentile ranking methods (deciles and quartiles), Palmer drought severity index (PDSI), and the K index. Using exercise 2, participants reached a consensus that the WMO should recommend the SPI for widespread use in countries wanting to track meteorological drought. Participants noted that the SPI should not replace any local meteorological drought indices currently being used; rather, the SPI should be the standard index available worldwide in addition to unique local indices and indicators.

HYDROLOGICAL DROUGHT BREAKOUT SESSION RESULTS. The following indices were identified during exercise 1: reservoir levels, percent of normal precipitation, SPI, surface water supply index (SWSI), aggregate dryness index (ADI), normalized ADI (NADI), and the low flow index. Participants also discussed the potential for the utility of the streamflow drought index (SDI) and for using artificial neural networks to monitor and predict global hydrological drought conditions. Rather than producing a consensus, exercise 2 led participants to recommend creating a new "composite index" that would ideally be based on streamflow, precipitation, reservoir levels, snowpack, and groundwater levels.

AGRICULTURAL DROUGHT BREAKOUT SESSION RESULTS. Exercise 1 yielded a list of 17 indices. This list was refined and limited to include a soil moisture index, percent of normal precipitation, normalized difference vegetation index (NDVI), water balance, and heat stress. Similar to the hydrological drought session, exercise 2 did not produce a consensus. Instead, participants recommended holding a follow-up discussion or workshop to specifically address agricultural drought indices.

PRINCIPAL RECOMMENDATIONS. The principal recommendations as outlined in the Lincoln Declaration on Drought Indices are as follows:

- Drought indices and early warning systems must be implemented with end users in mind. To accomplish this goal, a multidisciplinary approach incorporating user involvement is absolutely necessary.
- The National Meteorological and Hydrological Services (NMHSs) around the world are encouraged to use the SPI to characterize meteorological droughts and provide this information on their Web sites, in addition to the indices currently in use. WMO was requested to take the necessary steps to implement this recommendation.
- A comprehensive user manual for the SPI should be developed that will provide a description of the index, the computation methods, specific examples of where it is currently being used, the strengths and limitations, mapping capabilities, and how it can be used.
- Two working groups with representatives from different regions around the world and observers from UN agencies and research institutions (and water resource management agencies for hydrological droughts) were to be established by the end of 2010[2] to further discuss and recommend the most comprehensive indices to characterize the agricultural and hydrological droughts.
- Recognizing the need to develop a framework for an integrated approach for drought monitoring to address all sectoral needs, a comprehensive study of consensus drought indicators is needed for potential global application.
- A simple, systematic analysis of drought impacts in different sectors should be initiated in all affected countries to provide useful decision-making information for policymakers.

[2] The WMO International Strategy for Disaster Reduction (UNISDR) Expert Meeting on agricultural drought indices took place on 2–4 June 2010 in Murcia, Spain, and the WMO UNISDR Expert Meeting on hydrological drought indices took place in November 2010 in New Delhi, India. The outcomes from all of the workshops on drought indices will be presented in the 2011 UN Global Assessment Report on Disaster Risk Reduction.

The Lincoln Declaration on Drought Indices can be viewed in its entirety at (online at www.wmo.int/pages/prog/wcp/agm/meetings/wies09/documents/Lincoln_Declaration_Drought_Indices.pdf.)

ACKNOWLEDGMENTS. Special thanks to Mannava Sivakumar and Robert Stefanski at the WMO and Donald Wilhite at the University of Nebraska–Lincoln for their contributions to this article and for their effort in organizing the event.

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