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THREE YEARS AND COUNTING: WHAT'S NEW WITH THE DROUGHT MONITOR

Mark D. Svoboda*, Michael J. Hayes
National Drought Mitigation Center
University of Nebraska-Lincoln
Lincoln, Nebraska

Rich J. Tinker
NOAA/Climate Prediction Center
Camp Springs, MD

1. INTRODUCTION

Operational since late summer 1999, the Drought Monitor (http://drought.unl.edu/monitor/) has refused to remain static. This unique weekly product attempts to make an assessment of current drought conditions in the contiguous United States, Hawaii, Alaska, and Puerto Rico. Four entities now share in authoring the map: the National Drought Mitigation Center (NDMC), Climate Prediction Center (CPC), United States Department of Agriculture (USDA), and National Climatic Data Center (NCDC).

The Drought Monitor effort has led to the development of new products and has reinforced the need for improvement and support of existing climate networks critical to monitoring our nation's climate. One of the new products recognizes that drought has different short- and long-term characteristics. This product combines indicators representing the semi-independent nature of short- and long-term characteristics to improve drought monitoring. We are calling this family of products the experimental Objective Blends of Drought Indicators (OBDI).

2. BACKGROUND

Intensity, duration, and spatial extent are the key parameters we can use to help us differentiate one drought from another. Understanding these characteristics is the first step in determining a drought's magnitude and potential impacts.

Given the typically slow evolution of drought, perennial monitoring and early warning are essential to preparedness and proactive response measures. The development of an integrated drought monitoring system in the United States has been recommended for some time. The relatively recent development of the Internet has provided the technology to improve information sharing about those critical elements of the hydrologic cycle required to monitor drought and water supplies.

Corresponding author address: Mark D. Svoboda
National Drought Mitigation Center, 107 LW Chase Hall, Univ. of Nebraska-Lincoln, Lincoln, NE 68583-0749; email: msvoboda2@unl.edu

3. THE DROUGHT MONITOR

The Drought Monitor is not a forecast but rather an attempt to objectively determine and categorize the characteristics of a drought's onset, duration, spatial extent, and intensity, along with the impacts being felt. One of the strengths of the product lies in its use of multiple indicators and indices.

The Drought Monitor classifies drought into four categories (D1-D4), with a fifth category (D0) indicating an area to watch for emerging drought conditions (or an area that is recovering from drought but may still be seeing lingering impacts). The D1-D4 categories reflect increasing drought intensity levels, with D1 representing areas experiencing moderate drought and D4 depicting a region experiencing an exceptional drought event (likened to a "drought of record") (Svoboda et al. 2002).

The six key indicators are: streamflow, the Modified Palmer Drought Severity Index (PMDI) (Heddinghaus and Sabol 1991), Standardized Precipitation Index (SPI) (McKee et al. 1993), percent normal rainfall, the Satellite Vegetation Health Index (VHI) (Kogan 1995), and the CPC Soil Moisture model (SM) (Huang 1996).

In addition, the Palmer Drought Severity Index (PDSI), long-term Hydrologic-index (PHDI), and related short-term Z-index (Palmer 1965), Crop Moisture Index (CMI) (Palmer 1968), Surface Water Supply Index (SWSI) (Shafer and Dezman 1982), the water equivalent content of mountain snowpack (SWE), reservoir information, groundwater measurements, soil moisture observations, and many other ancillary inputs are used depending on the region and time of year. As a result, the Drought Monitor has the ability to remain flexible and evolve as our climate monitoring technology and capabilities expand. The classification scheme and key variables used in the Drought Monitor analysis are shown in Table 1.

We know that no single definition of drought is appropriate in all situations. Likewise, no single indicator can completely assess a drought and all of its impacts. The fact that the Drought Monitor is a blend of multiple indicators is indeed an essential strength. The flexibility to change is there when technological improvements warrant it.

It should be emphasized as well that the fundamental success of the Drought Monitor is dependent on input from a network of more than 150 local experts in the areas of climate, water, and agriculture. Through both a web-based and an email forum, the Drought Monitor product is reviewed and critiqued each week in an informal peer-review process. Anyone interested in joining the Drought Monitor discussion/review group can sign up at: http://ndmc.unl.edu/mailman/listinfo/Drought

4. OBJECTIVE BLENDS

A suite of new and exciting products that are now created as a result of the Drought Monitor effort are called the experimental Objective Blends of Drought Indicators (OBDI). These experimental products are a first attempt by the authors of the Drought Monitor to blend a variety of relevant indices into objective long-term, short-term, and "unified" (combined short- and long-term) drought indicators. The parameters and weighting factors chosen were initially discussed by the authors and other scientists at a forum for Drought Monitor issues held in Lincoln, Nebraska in November, 2000. Since that time, they have been adjusted, tested, and compared to an operational drought objective blend indicator developed by CPC as well as reported ground conditions and related impacts (http://www.cpc.ncep.noaa.gov/soilmst/drought.html).

All of the blends are generated using CPC's real-time daily and weekly climate division data and NCDC's monthly archive of indices for 1932-2000. Following is a summary of how the blends are generated and important points to know when using these products. Tables 2 and 3 show the indicators used in calculating the raw versions of both the short- and long-term blends, along with their weighting factors. The “raw” unified blend product is simply the average of the short- and long-term blends. The “finished” unified product actually plots the percentile of the current raw values relative to the 1932-2000 distribution of values generated from NCDC’s monthly climate division data archive.

More details about the methodology and all of the products and their archives can be found on a web site set up for the experimental blends at CPC: http://www.cpc.ncep.noaa.gov/products/predictions/experimental/edb/access.html.

The first step in this methodology is to express all parameters as percentiles with respect to 1932-2000 data using a percent rank method. Most parameters are ranked relative to NCDC’s historic data for the current month, except for the Z-Index, which is rendered relative to all months on record.

For both blends, the averages of the percentile inputs are calculated, with each input weighted as defined in the formulae. This yields a "weighted raw average" of the individual component percentiles for each blend. Then, each raw average is compared to its historic distribution (1932-2000), generated from the NCDC and CPC archives. The real-time data are then expressed as a percentile relative to all retrospective months, not just the current month, since the raw blended percentile inputs were each generated (for all but the Z-Index) based on the current month only. This has the effect of expanding our sample size, rendering more accurate percentile assessments, and of making extremes more possible during the wetter times of the year.

The multi-month precipitation percentile inputs are generated in a somewhat unusual way, combining month-to-date numbers from CPC with NCDC's preliminary monthly totals for prior months. This ensures that the most accurate data are incorporated into the multi-month precipitation percentiles, since they will be updated as NCDC converts recent-past preliminary data to near-final and final data.

However, this introduces a problem. An x-month precipitation total ending in the middle of the current month stretches back to some other mid-month point. To accommodate this problem, the multi-month precipitation totals are generated by decreasing the precipitation input for the first month in a period by the proportion of the current month that has already passed. For example, a 3-month total for a period ending August 12 would be generated using CPC's real-time data for August 1-12, NCDC's monthly total for June and July, and NCDC's monthly total for May reduced by the proportion of August included in the total. Since we have 12 August days included, the May amount is reduced by a factor of (12/31) [about 38.7%].

The multi-month precipitation percentile generation method described above has an additional significant benefit besides the incorporation of the most recent and accurate data available -- it allows the “earliest” precipitation in a period to be slowly and steadily removed from the x-month total as time progresses. Water is added to the hydrologic cycle as it falls, but it is not eliminated in that way; it is eliminated slowly and steadily with time. For example, Tropical Storm Allison dumped huge rainfall totals on parts of the Southeast in late June 2001. As September progressed, the large June totals were removed steadily, rather than plummeting as soon as the days of Allison's rains were no longer a part of the 3-month-to-date period. This simulates the appropriate environmental response to such heavy rains.

In addition to the maps, a table is generated describing the proportion of the country currently below or above selected percentile thresholds. The areal extent of conditions, the anomaly (relative to the 1932-2000 mean areal extent of similar conditions for the current month), and the percentile (relative to the array of 1932-2000 areal extents for the current month) are each generated for the short-term, long-term, and "unified" blend index percentiles. This allows for a quick summary of how much area is being affected each week, how that extent compares to historical occurrences, and whether things are getting better or worse nationally. Table 4 provides an example of the weekly update for the short- and long-term blends.

Other potential tools we are looking at developing, or incorporating, are focused on better assessing water resources both above and below ground. Efforts are underway on a prototype interface that allows the user to calculate a weekly SPI and PDSI (http://nadss.unl.edu) value on a station-by-station basis using real-time data obtained from the Unified Climate Access Network (UCAN) (Pasteris et al. 1997). Work is currently underway on the development of a regional tool for the High Plains. The next step is to take this interface to the national level.

On a national level, a comprehensive water supply tracking tool does not exist. Currently, a few states in the West calculate SWSI values, which are customized to their specific needs and are not always readily available (or comparable from basin to basin or state to state) or standardized for use in the Drought Monitor. A regional Surface Water Supply Index Application using the “Garen method” (Garen 1993) (SWSIA) (Pasteris 2002) is being looked at as a potential tool to better address the complicated nature of drought in the western United States. This tool will incorporate precipitation, snowpack (snow water equivalent), streamflow, reservoir storage, and seasonal streamflow forecasts on a more general level in order to be utilized in the making of the Drought Monitor. Finally, the Drought Monitor group is finding ways to tap into existing national, regional, and state soil moisture monitoring networks. The soil moisture component is one of the most neglected components in our country’s ability to monitor drought.

5. SUMMARY

A comprehensive, integrated drought monitoring approach was once considered unfeasible but is now possible through the advent of the Internet and availability of data on a near-real time basis. The development of the U.S. Drought Monitor would not have been possible otherwise. Launched in 1999 as an experimental product by the NDMC, USDA, and NOAA, it quickly became an operational product and has gained widespread acceptance by the media, scientists, resource managers, policy makers, the business community, and the public.

We can credit the success of the Drought Monitor in large part to a combination of: 1) the collaboration between the principal partners, other organizations, and experts in the field; 2) the integration of several climate and water supply indicators into a timely assessment of drought severity, spatial extent, and impacts; 3) the use of the Internet in both the making and timely dissemination of the product; and 4) feedback from the user community. There is a strong commitment by the principal partners toward continuing this effort and bettering the product.

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Table 1. Drought Monitor Drought Severity Classification System.

Drought Monitor Classification							
Drought Type		**Associated Ranges of Objective Indicators**					
Category	**Description**	**Palmer Drought Index**	**CPC Soil Moisture Model (Percentiles)**	**USGS Weekly Streamflow (Percentiles)**	**Percent of Normal Precipitation**	**Standardized Precipitation Index (SPI)**	**Satellite Vegetation Health Index**
D0	Abnormally Dry	-1.0 to -1.9	21-30	21-30	<75% for 3 months	-0.5 to -0.7	36-45
D1	Moderate Drought	-2.0 to -2.9	11-20	11-20	<70% for 3 months	-0.8 to -1.2	26-35
D2	Severe Drought	-3.0 to -3.9	6-10	6-10	<65% for 6 months	-1.3 to -1.5	16-25
D3	Extreme Drought	-4.0 to -4.9	3-5	3-5	<60% for 6 months	-1.6 to -1.9	6-15
D4	Exceptional Drought	-5.0 or less	0-2	0-2	<65% for 12 months	-2.0 or less	1-5

Table 2. Experimental Short-term Objective Blend Indicators and Weighting Factors.

Short-term Objective Blend	
Indicator	**Weighting**
Palmer Z-index	35%
3-Month Precipitation	25%
1-Month Precipitation	20%
CPC Soil Moisture Model	13%
Palmer (Modified) Drought Index	7%

Table 3. Experimental Long-term Objective Blend Indicators and Weighting Factors.

Long-term Objective Blend	
Indicator	**Weighting**
Palmer Hydrologic Drought Index	30%
12-Month Precipitation	20%
6-Month Precipitation	15%
Palmer (Modified) Drought Index	10%
24-Month Precipitation	10%
60-Month Precipitation	10%
CPC Soil Model	5%

Table 4. Percent of U.S. Mainland in Selected Drought Blend Percentile Ranges, and Change from Previous Week—February 17, 2002.

Percentile Range	Short					Long				
	Current	Anomaly*	Percentile*	Change	% Change	Current	Anomaly*	Percentile*	Change	% Change
98-100 (W4)	0.37	-0.81	50.8	+0.00	+ 0.0	0.00	-1.98	0.0	+0.00	+ 0.0
95-100 (W3)	0.40	-3.07	21.2	+0.00	+ 0.0	0.66	-4.34	19.7	-0.71	-51.7
90-100 (W2)	0.75	-7.06	9.2	-0.50	-40.0	2.91	-7.53	27.1	-1.51	-34.1
80-100 (W1)	3.51	-14.48	4.8	-5.59	-61.4	8.74	-11.80	21.8	-1.47	-14.4
70-100 (W0)	17.55	-11.04	23.9	-5.02	-22.2	14.64	-15.82	19.8	-2.58	-15.0
30-70	46.48	+3.28	67.1	-1.20	- 2.5	46.01	+6.65	77.3	+0.51	+ 1.1
0-30 (D0)	35.97	+7.76	70.5	+6.21	+20.9	39.35	+9.17	72.1	+2.06	+ 5.5
0-20 (D1)	24.61	+6.78	71.3	+7.39	+42.9	25.33	+4.89	66.8	+1.24	+ 5.1
0-10 (D2)	7.79	-0.15	56.6	+1.46	+23.0	16.59	+6.37	77.7	+2.74	+19.8
0-5 (D3)	4.88	+1.33	75.2	+1.27	+35.1	8.89	+3.28	79.1	+0.74	+ 9.1
0-2 (D4)	0.94	-0.35	66.3	+0.75	+41.3	4.21	+1.90	83.6	+0.72	+20.5

*Anomalies and percentiles based on end-of-month 1932 - 2000 data closest to valid date, from National Climatic Data Center.