NIDIS

DRY TIMES

NATIONAL INTEGRATED DROUGHT INFORMATION SYSTEM NEWSLETTER

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The significance of snowpack

What it means to the West. P.12

Julie Koeberle and Melissa Webb measure snow water content on Mt. Hood in Oregon, April 2013.

USDA PHOTO

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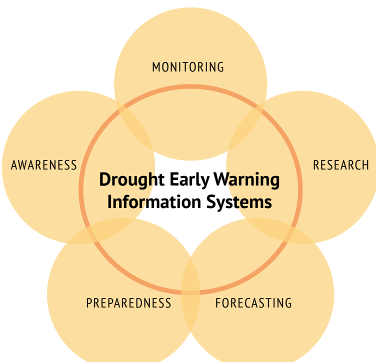


Inside this edition

NIDIS: WHO WE ARE

NIDIS introduces co-chairs of its six Working Groups

Leading the effort

Vital to the mission of NIDIS are its Working Groups (WG), each focused on a different aspect of drought information and preparedness. All the groups include members from multiple agencies and areas of expertise, chaired by a team of two or three people. Projects for the coming year are in development, including a revision of content relevant to each group on drought.gov. The chairs and their teams are:

PREDICTIONS AND FORECASTS

Siegfried Schubert

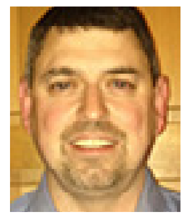
Dr. Schubert is a senior research scientist in NASA's Global Modeling and Assimilation Office (GMAO), where he leads the group on sub-seasonal to decadal climate. He received his Ph. D. in meteorology from the University of Wisconsin-Madison. His research interests include climate variability and predictability, droughts, the hydrological cycle, extreme weather and climate events, and reanalysis.

Dr. Schubert has authored or co-authored more than 100 research articles, serving as an editor of the *Journal of Climate*, and helping to organize two special collections of the *Journal of Climate* on drought. He is currently a member of the international CLIVAR scientific steering group, and as part of the leadership of the WCRP drought interest group, he helped organize two international workshops to assess current understanding of drought worldwide, with the goal of developing a global drought information system (GDIS).

As the lead of a NOAA drought task force, he is helping to coordinate and facilitate drought research projects nationally, including the development of a special collection of the *Journal of Hydrometeorology* on the topic of drought monitoring and prediction.

Jon Gottschalck

Jon Gottschalck has worked at the National Centers for Environmental Prediction (NCEP) Climate Prediction Center (CPC) since 2004 and was



recently named Acting Chief of the Operations Branch. Mr. Gottschalck previously served as CPC Head of Forecast Operations where he was responsible for overseeing day to day production and dissemination of CPC's operational forecast products. He also served as the MJO operational lead at CPC and was responsible for leading a team in monitoring, assessing, and predicting the MJO and its associated impacts. He coordinated the weekly production of the CPC Global Tropics Hazards and Benefits Outlook.

Mr. Gottschalck earned both B.S. and M.S. degrees in meteorology from the Pennsylvania State University in 1994 and 1996. After graduation, he was employed at the University of Miami Rosenstiel School of Marine and Atmospheric Science (RSMAS) from 1997-2001. In this capacity, he worked in the area of boundary layer meteorology, cloud remote sensing, MJO research, and was the university forecast meteorologist and tropical cyclone spokesman. From 2001-2004, Mr. Gottschalck was employed at NASA's Goddard Space Flight Center (GSFC) in Greenbelt, Md., where he worked in the area of land-atmosphere interaction.

OBSERVATIONS AND MONITORING

Dennis Todey

Dr. Dennis Todey is the state and extension climatologist

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for South Dakota. He has a background in climatology, meteorology and agricultural meteorology. He has been at SDSU since 2003.

Art DeGaetano

Art DeGaetano is professor in the Department of Earth and Atmospheric Sciences at Cornell. He is also the director of the federally-supported Northeast Regional Climate Center (NRCC). The NRCC's mission is to enhance the use and dissemination of climate information to a wide variety of sectors in the Northeast. Art serves as a climate specialty editor for the *Bulletin of the American Meteorological Society*.

Art has been at Cornell since 1991 serving as the center's research climatologist until 2001. He received an interdisciplinary Ph.D. focusing on climatology and horticulture from Rutgers University.

Hailan Wang

Hailan Wang is currently a senior research scientist at Science Systems and Applications, Inc., affiliated with both NASA Goddard Space Flight Center (GSFC) Global Modeling and Assimilation Office (GMAO) and NASA Langley Research Center. She holds a B.S. in Meteorology from Ocean University of China, and a Ph.D. in Atmospheric Sciences from the University of Illinois at Urbana-Champaign. Dr. Wang's research interests include climate variability and predictability, droughts, weather and climate extremes, global energy cycle, and GCM modeling of the Earth's climate. She has been involved in a number of NOAA and NASA research projects investigating North American drought drivers and physical mechanisms. Currently, as the PI of two NOAA projects, she is leading efforts at NASA GMAO of investigating the role of stationary Rossby waves for subseasonal development of North American droughts, as well as improving NASA GEOS-5 AGCM simulations of Madden-Julian Oscillation (MJO) using Dynamics of MJO (DYNAMO) field observations.

INTERDISCIPLINARY RESEARCH AND APPLICATIONS

Mark Shafer

Mark Shafer is Associate State Climatologist at the Oklahoma Climatological Survey, and established and leads the Southern Climate Impacts Planning Program (SCIPP), a NOAA Regional Integrated Sciences and Assessments (RISA) program based at the University of Oklahoma and Louisiana State University. SCIPP focuses on place-based applications of climate and weather information to improve community preparedness for a range of natural hazards, including drought. His research interests focus upon communication between the scientific community and policy makers, particularly in managing societal response to extreme events and climate change. Mark holds an M.S. in meteorology and a Ph.D. in political science from the University of Oklahoma and was a coordinating lead author on the Great Plains chapter in the 2014 National Climate Assessment.

Matt Rollins

Matt Rollins is the national program leader for U.S. Forest Service Wildland Fire and Fuels Research and Development in Washington D.C. In 2000 he got his start as a research ecologist with the Forest Service at the Missoula Fire Sciences Laboratory, working on evaluating how changes in wildland fire management strategies affected landscape composition, structure, and function over the 20th century; forecasting fire regimes and landscape change under a changing climate using ecological simulation models; and integrating landscape modeling and satellite imagery for national fire regime and fuel mapping applications. From 2009 to 2014 he worked with the USGS at the EROS data center as fire science team leader and at USGS headquarters as their National Wildland Fire Science Coordinator.

He earned a B.S. in Wildlife Biology in 1993 and an M.S. in Forestry in 1995 from the University of Montana in Missoula, Mont. His Ph.D. is from the University of Arizona in 2000, where he worked at the Laboratory of Tree-Ring Research.

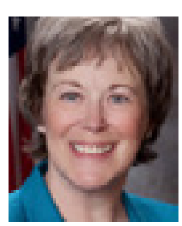
ENGAGING PREPAREDNESS COMMUNITIES

Deborah Bathke

Dr. Deborah Bathke is a climatologist with drought management experience, working with the National Drought Mitigation Center and the University of Nebraska-Lincoln's School of Natural Resources and Department of Earth & Atmospheric Sciences.

She was the assistant state climatologist in New Mexico, where she chaired the state's Drought Monitoring Working Group. She represented New Mexico in the Climate Assessment for the Southwest program (CLIMAS), one of NOAA's RISA programs. Among the projects she collaborated on were adapting the dynamic drought index for basins in the Carolinas to the Southwest; implementing a western version of the AgClimate tools developed by the Southeast Climate Consortium; and convening technical workshops on tree-ring reconstructions of streamflow. Bathke supervises ongoing student research on urban landscaping and drought.

She earned her B.S. and M.S. from the University of Nebraska-Lincoln, and her Ph.D. in atmospheric sciences from the Ohio State University.



Beth Freeman

Beth A. Freeman is the regional administrator for FEMA Region VII. She also served FEMA in the past as the director for Region VII in 2000. She gained

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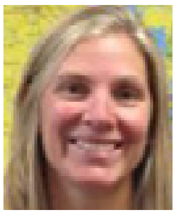
a deep understanding of Region VII in her 18 years working for U.S. Senator Tom Harkin of Iowa. During this time, she worked as the senator's regional director and managed operations for three eastern Iowa offices, and was also the statewide disaster recovery coordinator.

In addition to the strong relationships Freeman developed with state and local emergency managers while in Sen. Harkin's office, she has extensive experience working with important national partners in disaster response. Freeman holds an M.B.A from the University of Hawaii and a bachelor's degree from Drake University.



Kirsten Lackstrom

Kirsten Lackstrom is a research associate with the Carolinas Integrated Sciences and Assessments (CISA), based at the University of South Carolina. Kirsten's work includes research and applied projects to advance understanding of climate-related vulnerabilities and impacts in the Carolinas and to enhance the use of climate information in decision making and planning processes.

PUBLIC AWARENESS AND EDUCATION

Doug Kluck

Doug Kluck is the central region climate services director for the National Oceanic and Atmospheric Administration's (NOAA). He has worked for NOAA since 1992 with National Weather Service and National Centers for Environmental Information (NCEI). Doug's region covers 14 states from Colorado to Michigan. Doug's responsibilities include coordinating and informing on climate service activities among federal, state, tribal, academics and private interests in the region. Engagement with the above mentioned groups and interpretation of climate information, monitoring, directing research and education and outreach are all essential parts of his activities. During extreme climate events, such as drought and major flooding, Doug coordinates information response, attribution and assessment among core partners.

Jim Angel

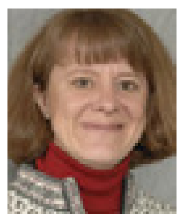
Dr. Jim Angel has been the Illinois State Climatologist since 1997 and began work at the Illinois State Water Survey in 1984. He has a broad interest in all things related to weather and climate, including droughts, floods, winter storms, heat waves, tornadoes, and long-term climate change (past, present, and future). He has worked on a number of research projects looking at drought, extreme rainfall events, Great Lakes storms, 19th and 20th century climate change, potential future climate change, as well as the impacts of weather and climate extremes.

Besides research, he works with a wide range of users and stakeholders, including students, teachers, homeowners, engineers, other scientists, farmers, as well as federal, state, and local officials on issues related to climate. He maintains a website, a blog, and Twitter feed for addressing a wide variety of climate topics as they pertain to Illinois.

DROUGHT PORTAL // DROUGHT.GOV

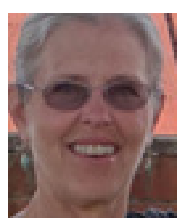
Mike Brewer

Mike Brewer is the manager of NIDIS's US Drought Portal (www.drought.gov). He works for NOAA at the National Centers for Environmental Information in Asheville, NC. Prior to NCEI, Mike worked at National Weather Service Headquarters, addressing climate data issues and the provision of climate services. He routinely authors the US, North American, and Global Drought Monitors and operates the Global Drought Information System. Prior to NOAA, Mike directed climate research programs at the University of Rhode Island and The George Washington University. Mike has a PhD in Climatology from the University of Delaware.



Kelly Smith

Kelly Helm Smith was one of the original employees of the National Drought Mitigation Center when it was established in 1995, contributing experience in journalism, PR and environmental communication. She helped launch the center's original award-winning website back when the web was new, worked with the Western Drought Coordination Council and climate scientists to develop drought monitoring updates for policymakers, and helped make the case for establishing the U.S. Drought Monitor. She took a leave of absence from the drought center in 2000 to earn a master's degree in Community and Regional Planning and to work with African refugees on behalf of various faith-based and non-profit organizations in Lincoln, Neb. Smith returned to the drought center in 2006. In addition to communication, she focuses on drought impacts and on drought planning.



Kathleen Bogan

Kathleen Bogan has been communications specialist at NIDIS since 2014, following a 32-year career in journalism. Her newsroom homes have included Nation Media in Nairobi, Kenya; the Rocky Mountain News in Denver, Colorado; the Casper Star-Tribune in Casper, Wyoming; and the High Country News in Lander, Wyoming.

Before that she worked as a freelance graphic designer, instructed at the National Outdoor Leadership School and Outward Bound, and taught English in Japan. She earned an M.F.A. in printmaking from the University of Montana and her B.A. is in art history and American studies from Williams College in Massachusetts.

Through MAPP, NOAA and NIDIS support projects that investigate whether models and prediction systems can simulate drought, then use the data to improve preparedness

Target: Understanding, predicting, monitoring drought

BY DAN BARRIE
NOAA Climate Program Office

Drought is among the costliest of climate hazards and has impacted the U.S. on many occasions. With accurate and timely information, actions can be taken to prepare for, mitigate, and adapt to the impacts of drought. Research to better understand how droughts evolve is critical to providing improved information, products, and services. In particular, improved monitoring and prediction capabilities are needed for timely water and emergency management decisions.

A list of funded projects appears on pages 6-7.

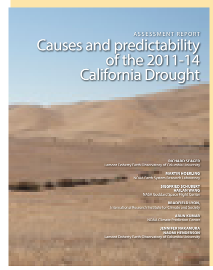
NOAA's Modeling, Analysis, Predictions, and Projections (MAPP) program awarded $6.6 million in 2014 to support 15 new multi-year projects in which university partners and federal researchers will work to improve our understanding of drought and advance NOAA's prediction and monitoring capabilities to better anticipate and respond to drought. MAPP is a part of the Climate Program Office (CPO), situated within NOAA's Office of Oceanic and Atmospheric Research (OAR). Extensive research is required to evolve our nation's drought monitoring system. Scientists and decision makers need a system that can effectively integrate an array of data and information about drought conditions from multiple sources and at spatial scales ranging from local to global to provide a clear picture of its origins and impacts. Predicting drought is a great challenge given the significant roles that multiple systems (atmosphere, ocean, and land surface) play in creating drought conditions.

MAPP funding will support research that deepens our understanding of past North American droughts to unlock the role that various factors played in their onset and recovery. Research projects will focus on whether models and prediction systems can accurately simulate these known droughts. These projects will help researchers improve models and prediction systems which in turn will enhance the nation's preparedness and ability to cope with and mitigate drought impacts.

NIDIS Director Dr. Roger Pulwarty noted, "scientifically robust drought early warnings are essential for effective early actions. These research projects will further our understanding of drought and move our information capability toward more accurate, longer-lead predictions and improved monitoring of drought conditions that impact the nation's economy, the environment, and our livelihoods."

MAPP Program funding strategically complements internal investments at NOAA's Geophysical Fluid Dynamics Laboratory (GFDL), the Earth System Research Laboratory (ESRL), and the National Centers for Environmental Prediction (NCEP) by investing in centers of research excellence across the U.S., engaging the community external to NOAA to help achieve NOAA's climate mission. Support for these projects comes from NIDIS, which partners with MAPP to advance drought research. These researchers will constitute a new NOAA Drought Task Force, organized by the MAPP program.

The Drought Task Force investigates the California Drought



"Causes and Predictability of the 2011-14 California Drought" is a recent project funded through MAPP. To read more about this report, see page 19, or visit https://www.drought.gov/drought/content/drought-task-force-report-causes-and-predictability-2011-2014-california-drought

What is MAPP?

The program's mission is to enhance the nation's capability to understand and predict natural variability and changes in Earth's climate system. MAPP supports development of advanced climate modeling technologies to improve simulation of climate variability, prediction of future climate variations from weeks to decades, and projection of long-term future climate conditions. To achieve its mission, the program supports research focused on the coupling, integration, and application of Earth system models and analyses across NOAA, among partner agencies, and with the external research community. For more information, go to the MAPP website at http://cpo.noaa.gov/ClimatePrograms/ModelingAnalysisPredictionsandProjections/AboutMAPP.aspx

New multi-year projects receiving funding through MAPP in 2014

Name of project	Goal	Investigators
"Advancing Drought Monitoring and Prediction Using a Multi-Index Multivariate Framework"	1) Expand, test and implement a multivariate drought analysis framework for combining multiple drought indicators (precipitation, soil moisture, runoff) probabalistically to improve the understanding of drought onset, development and termination. 2) Assess the proposed multi-index approach. 3) Diagnose physical underpinnings of variations in multivariate index performance for different droughts. 4) Use the proposed multivariate multi-index approach to assess one- to nine-month drought predictions using seasonal forecast datasets.	Amir AghaKouchak (University of California Irvine) Mark Svoboda (University of Nebraska-Lincoln) Andy Wood (National Center for Atmospheric Research)
"Advancing Predictive Understanding of North American Drought: The Role of the North Atlantic SST"	1) Conducting atmospheric GCM experiments to understand the dynamical linkages between sea surface temperatures (SST) and U.S. precipitation and temperature. 2) Examination of how predictability may be improved by knowing the state of the Atlantic Multidecadal Variability (AMV) while the rest of the oceans are varying seasonally and interannually.	Mingfang Ting (Lamont-Doherty Earth Observatory, Columbia University) Yochanan Kushnir (Lamont-Doherty Earth Observatory, Columbia University) Dong Eun Lee (Lamont-Doherty Earth Observatory, Columbia University) Anthony Barnston (International Research Institute for Climate and Society, Columbia University) Richard Seager (Lamont-Doherty Earth Observatory, Columbia University)
"Advancing Probabilistic Drought Monitoring with the North American Land Data Assimilation System (NLDAS) through Multisensor Ensemble Data Assimilation"	1) Adding improvements and capabilities to the NLDAS data production and drought monitoring system. 2) Assimilating GRACE terrestrial water storage and SMAP surface soil moisture products into NLDAS system for better diagnosis of drought and improvement of inital land conditions. 3) Performing a probabilistic historic drought analysis as well as real-time monitoring to both advance our understanding of drought and provide a measure of drought uncertainty.	Christa Peters-Lidard (NASA GFSC) David Mocko (SAIC at NASA/GSFC) Sujay Kumar (SAIC at NASA/GSFC) Shugong Wang (SAIC at NASA/GSFC) Michael Ek (NOAA/NCEP/EMC) Youlong Xia (IMSG at NOAA/NCEP/EMC) Jiarui Dong (IMSG at NOAA/NCEP/EMC)
"Collaborative Research: Towards Predicting Persistent Drought Conditions Associated with Consecutive La Niña Years"	Quantifying how predictable the duration of La Niña droughts is.	Pedro DiNezio (University of Hawaii) Yuko Okumura (University of Texas) Clara Deser (National Center for Atmospheric Research)
"Development of Probabilistic Drought Intensification Forecasts Using the GOES-BASED Evaporative Stress Index"	Develop a drought early warning system based on satellite-derived maps of evapotranspiration (ET) and forecast output from the National Multi Model Ensemble (NMME) that will provide probabalistic drought intensification forecasts over weekly to monthly time scales.	J.A. Otkin (University of Wisconsin Madison) M.C. Anderson M.D. Svoboda (University of Nebraska-Lincoln) C. Hain (University of Maryland) X. Zahn
"High-Resolution Integrated Drought Monitoring"	1) Using long-term bias correction methods to convert mulit-sensor precipitation estimates (MPE) into a reliable measure of long-term deficits and surpluses, then using this bias-corrected MPE to calculate drought indices, such as the standardized precipitation evapotrnspiration index (SPEI) and vrious Palme Drought indices (PDI.) 2) Develop and test the implementation of bias-corrected MPE as input inot the North American Land Data Assimilation System. (NLDAS).	John Nielsen-Gammon (Texas A&M University) Ryan Royles Michael Ek (NOAA EMC) Rebecca Cumbie Youlong Xia

New multi-year projects receiving funding through MAPP in 2014 (continued)

Name of project	Goal	Investigators
"Objective Monitoring and Prediction System for Drought Classification Over the Continental U.S."	To explore an objective scheme for drawing boundaries between D0-D4 classes used by the U.S. Drought Monitor.	Kingtse Mo (NOAA CPC) Dennis Lettenmaier (University of California Los Angeles)
"Precursor Conditions to Onset and Breakdown of Agricultural Drought Over the U.S. Corn Belt Region"	To broaden NOAA's drought monitoring and prediction systems by developing critical crop-specific algorithms for evaluation and prediction of intraseasonal drought development and termination events.	Paul Roundy (University at Albany)
"Subseasonal Development of Past North American Droughts: The role of Stationary Rossby Waves in a Changing Climate"	Examining the role of stationary Rossby waves in the development of North American droughts, the physical processes that initiate and sustain the stationary Rossby waves, and the predictability of these waves, in order to improve understanding of the predictability of the development of North American drought on subseasonal time scales.	Hailin Wang (SSAI) Siegfried Schubert (NASA GSFC) Randal Koster
"Subseasonal Predictability of U.S. Heat Waves/Droughts Associated with Planetary Wave Events"	Focusing on summertime droughts and associated heat waves that last for five days to about two weeks over the continental U.S., to investigate the prospects for predicting the likelihood of these events as a result of their connections with intraseasonal fluctuations in midlatitude planetary waves and the potential for predicting those fluctuations.	Grant Branstator (National Center for Atmospheric Research) Jospeh J. Tribbia (NCAR) Haiyan Teng (NCAR)
"The Dynamical Mechanisms and Potential Predictability of Indian and Pacific Ocean Influences on Seasonal North American Drought"	To allow a more comprehensive understanding than available to date of how tropical Pacific and Indian Ocean sea surface temperature (SST) anomalies can impact North American precipitation and drought; what matters in the SST anomalies; what the strength of the relations are; how this depends on season; and what the physical mechanisms are that couple the mean and transient atmospheric circulation and moisture budget.	Richard Seager (Lamont Doherty Earth Observatory, Columbia University) M. Ting (Lamont Doherty Earth Observatory, Columbia University) N. Henderson (Lamont Doherty Earth Observatory, Columbia University) D. Lee (Lamont Doherty Earth Observatory, Columbia University)
"Towards an Enhanced Probabilistic National Drought Forecasting"	To quantify and reduce the major uncertainties involved in drought forecasting by implementing state-of-the-art data assimilation methods and multivariate statistical drought forecasting by means of copula functions.	Hamid Moradkhani (Portland State University)
"Understanding Changes in the Regional Variability of U.S. Drought"	1) Advance the understanding of the physical mechanisms linking changes in North American lower level jet (NALLJ) fluctuations and regional precipitation variability. 2) Determine the ability of the current generation of global climate models to simulate and predict NALLJ variability and its related precipitation impacts. 3) Examine the roles of natural climate variability and anthropogenic climate change to recent changes in regional precipitation and NALLJ variability.	Scott Weaver (NOAA/NCEP/CPC)
"Understanding Predictability of Long-Lived North American Drought Regimes"	To understand why the contiguous U.S. experiences distinct decadal-scale modulations in drought.	Arun Kumar (NOAA CPC) Marty Hoerling (NOAA ESRL) Siegfried Schubert (NASA GSFC)
"Understanding the Role of Land-Atmospheric Coupling in Drought Forecast Skill for the 2011 and 2012 U.S. Droughts"	To understand land-atmospheric coupling processes in CFSv2 and their role in the predictability of drought development, intensification and termination; and to perform attribution and modeling studies for the improvement of drought predictions.	Eric Wood (Princeton University) Mike Ek (EMC/NCEP)

The observation: The strength of a second-year La Niña correlates with the depth of oceanic thermocline before onset

Predicting the return of La Niña to improve drought forecasting

BY PEDRO DINEZIO
University of Hawaii
YUKO OKUMURA
University of Texas
CLARA DESER
National Center for Atmospheric Research

Although they are often portrayed as a pair of opposites, El Niño and La Niña are not mirror images of each other. El Niño arrives at the beginning of northern winter and rarely lasts through spring as it leads the way to the arrival of La Niña the following winter. La Niña, in contrast, often returns for a second consecutive northern winter, making its worldwide influence linger. This was the case during the winters of 2010-11 and 2011-12, two consecutive La Niña years that were both associated with devastating U.S. droughts.

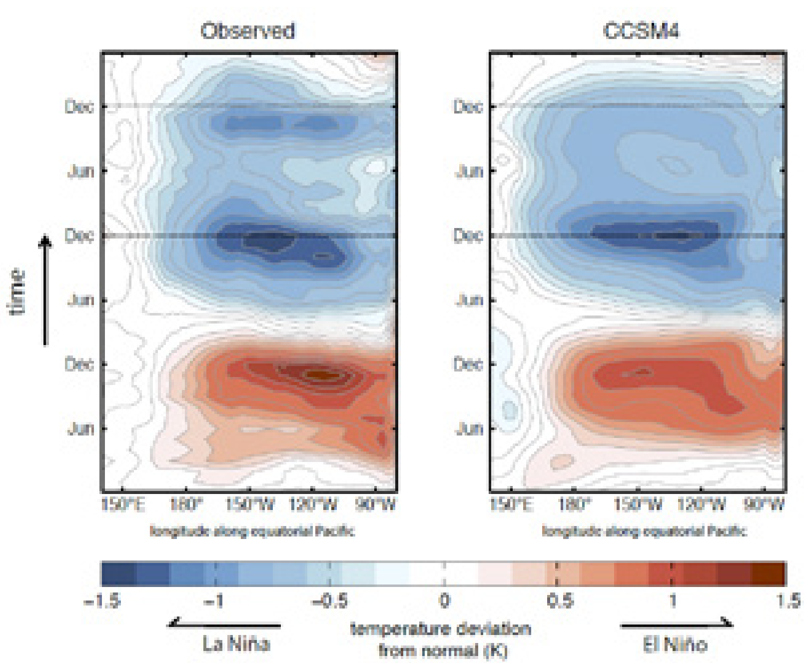
Predicting the onset of La Niña years is not difficult since they always occur after an El Niño. This is why the predictability of La Niña has not received much research attention. However, predicting the demise of La Niña has proven to be challenging. For instance, during the summer of 2011 climate prediction centers throughout the world speculated that La Niña would return the following winter. Their prediction systems, however, did not provide consistent results, leading to uncertain forecasts.

Our project aims to advance the capability to forecast the return of La Niña and the duration of associated drought in the U.S. We think that the key to making progress is having a computer model that can realistically simulate La Niña. Therefore we rely on the Community Climate System Model Version 4 (CCSM4), a computer model developed at the National Center for Atmospheric Research, which is capable of simulating the return of La Niña with great fidelity (see figure at lower left).

We are using this model to look for mechanisms that could help us do better forecasts. We are currently exploring one involving the thermocline, the boundary between frigid waters in the deep ocean and warmer waters on the surface. Longstanding theories predict that La Niña develops when the thermocline rises closer to the ocean's surface, allowing cold waters to be mixed upwards, and ends when the thermocline returns to deeper depths, allowing the surface to warm up. Our model and observations show that in many cases, this mechanism does not succeed in ending La Niña, and cold temperatures persist for an additional winter, prolonging its far-flung impacts for an additional year.

We have tracked the depth of the thermocline in the model and in the observations of La Niña. In both cases we found that the strength of the second year La Niña is correlated with the depth of thermocline before the onset. This could provide a year and half later window for predicting the return of La Niña.

We are currently exploring this idea on an actual forecasting system, hoping to tap this mechanism to improve the prediction of La Niña and its associated drought.



Evolution of La Niña events observed in nature (left) and simulated by the CCSM computer model (right). Time is shown along the vertical axis and longitude along the equatorial Pacific is shown along horizontal axis.

Blue colors indicate that ocean temperatures are colder than normal, and show La Niña and its return the following winter. Red colors correspond to the warmer temperatures associated with the preceding El Niño.

Note the striking similarity between the observed and simulated patterns.

NCAR team aims to predict probability of deadly phenomenon

The likelihood of heat waves

BY GRANT BRANSTATOR, HAIYAN TENG AND JOE TRIBBIA
National Center for Atmospheric Research

Heat waves and associated dry spells occur at short time scales, from several days to weeks. In spite of their short duration, heat waves are the most deadly meteorological phenomenon on Earth. In the U.S., heat waves are responsible for more deaths than floods, hurricanes, and tornadoes combined. The 1995 Chicago heat wave alone led to approximately 600 deaths over a period of five days.

Our team is investigating a new physical mechanism that may influence the likelihood of these events and lead to more accurate probability forecasts of heat wave/dry spells at the two- to three-week range than was previously thought possible.

Prior studies have mainly focused on accounting for the influence of persistent land- or sea-surface conditions, or slowly varying diabatic heating anomalies associated with tropical convection, for providing predictability of the atmospheric state beyond about two weeks. Midlatitude atmospheric dynamical processes were considered to be too chaotic to allow significant prediction skill at these extended ranges.

Based on a 12,000-year integration of a numerical model that simulates the atmosphere, we have

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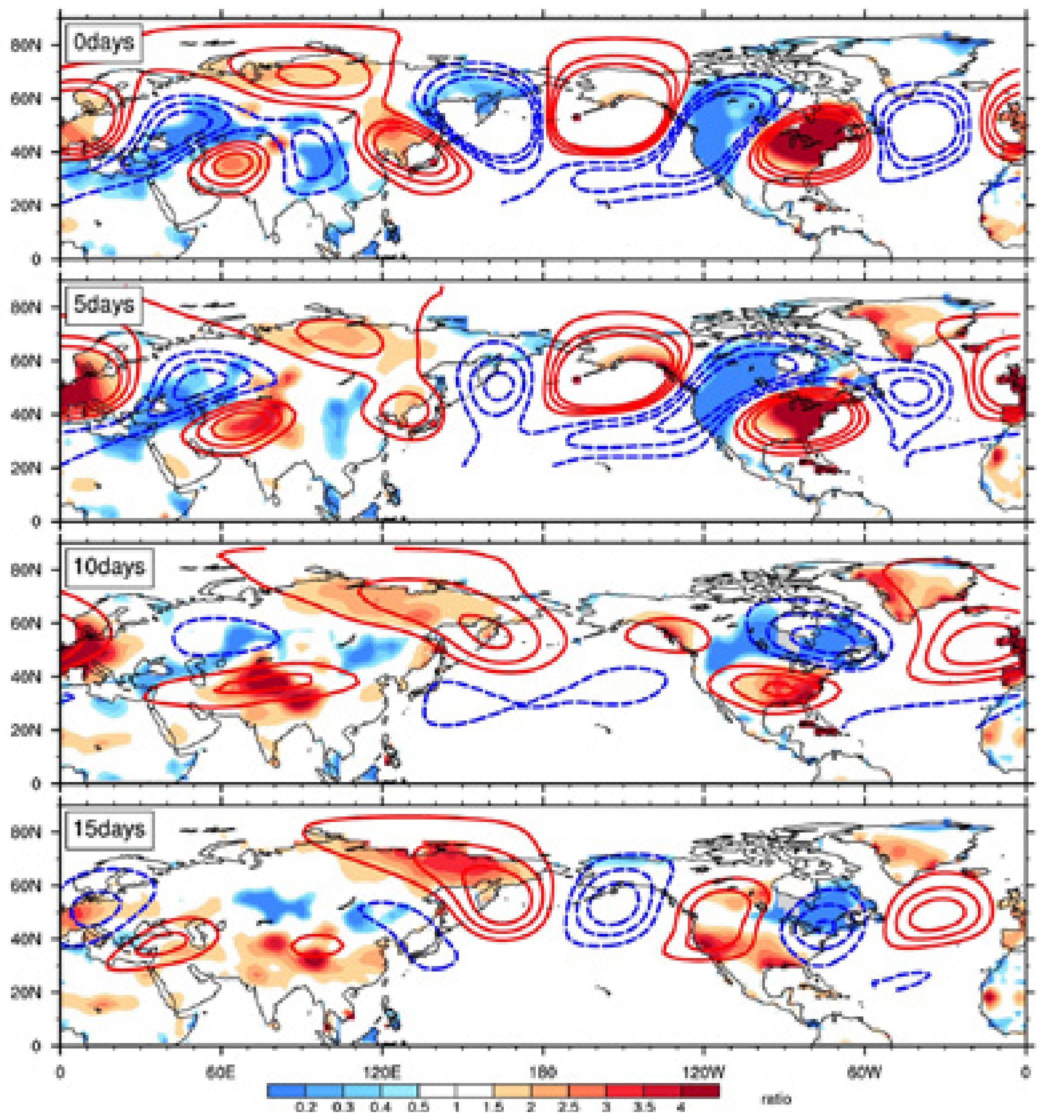

Fig.1

Impacts of the leading circumglobal teleconnection pattern (CGT) on the probability of heat waves based on a 12,000-year simulation with NCAR's Community Atmospheric Model, version 3.

Shading represents the ratio of the probability of a heat wave occurring 0 days (top), 5 days (second row), 10 days (third row) and 15 days (bottom) after an extreme CGT event relative to the probability of a heat wave without any precondition.

Contours represent a composite of 300 hPa streamfunction anomalies during those extreme CGT events on the corresponding days at ±1, 2,3 x$10^6 m^2 s^{-1}$ intervals.

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identified a circulation pattern that appears predictable at these longer ranges. Analysis of heat waves in this model indicates that their likelihood of occurrence over North America is influenced by this circulation pattern, so that there is some skill at predicting the probability of heat waves and dry spells more than two weeks in advance.

This special circulation pattern, which is also seen in nature, can arise as a result of midlatitude atmospheric processes. It does not rely on slowly varying surface or tropical conditions, and thus is distinct from the phenomena that have previous been relied on for two- to three-week predictions.

A noteworthy attribute of the pattern (sometimes referred to as a circumglobal teleconnection pattern, or CGT), is that it consists of a chain of five pairs of alternating high and low pressure features that encircle the Northern Hemisphere. Our team has expanded previous studies of the link between this pattern and U.S. heat waves so that we now recognize that this pattern and a second CGT impact the likelihood of heat waves and dry spells in the Northern Hemisphere. When strong circulation anomalies resemble one of these patterns, the probability of heat waves can be increased or reduced in key regions by a factor of 4, concurrently and in the following two weeks (Fig.1 on page 9.)

An extension of our effort concerns investigating how the structure and behavior of these circulation patterns may change as the climate changes. Using mechanistic models, we have found that the structure of these patterns changes if the mean circulation changes, in particular the strength and placement of the tropospheric jet.

Because of the impact that these patterns have on heat waves and dry spells, our work will provide a mechanism by which climate change can influence the likelihood and geographical distribution of these extreme events.

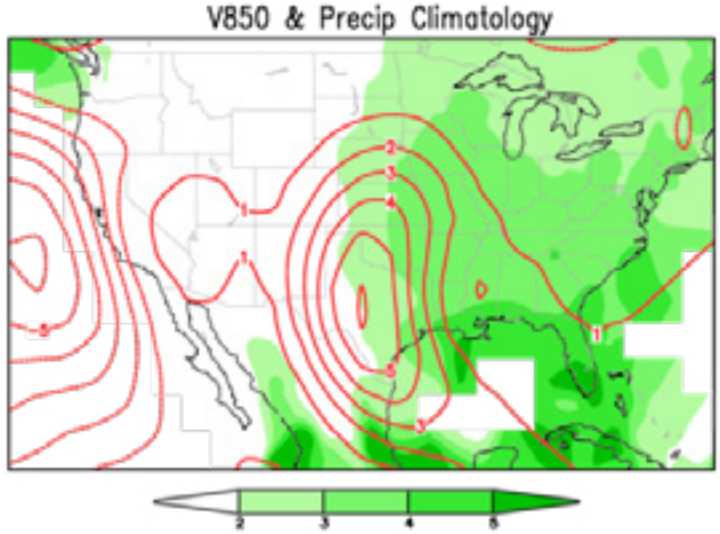
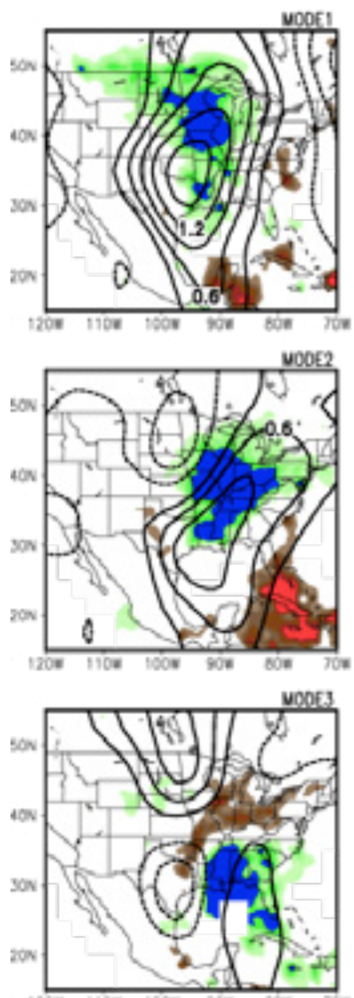


Fig. 1

Warm season climatology of precipitation (shaded) and the 850-hPa meridional winds (contoured). Winds > 1 m s^{-1} are contoured at 1 m s^{-1} intervals and precipitation > 2 mm day^{-1} is shaded.

The positive (negative) contours denote southerly (northerly) meridional wind components.

Understanding changes in the regional variability of U.S. drought



BY SCOTT WEAVER
NOAA/NCEP/CPC

Some recent studies suggest that during meteorological summer (June, July, August) the interannual variability of North American precipitation has been increasing over the last six decades. However, upon closer examination it is evident that trends in this variability are more nuanced than previously thought. During April, May and June both the Great Plains and Southeast showed an increasing trend in interannual variability of precipitation over 1950-2010; however, during July, August and September the changes in variability exhibit a more decadal appearance.

The North American low-level jet (NALLJ) is a dynamical feature of the atmosphere (Fig. 1, above) that is typically active over the Great Plains, effectively acting as a scale transfer mechanism between the large-scale forcing and regional climate. Variations of this pattern focus regional scale precipitation anomalies leading to the occurrence of drought and/or pluvial conditions (Fig. 2, at left).

This research project investigates the role of the NALLJ in promoting the multidecadal changes to the year-to-year (interannual) variability in regional precipitation and the interplay between natural variability and anthropogenic climate change using a suite of observations and climate model experiments.

Fig. 2
Recurrent patterns of springtime NALLJ variability (contours) and precipitation regressions (shaded) for 1980-2010. The EOF modes are contoured at 0.2 m s^{-1} and precipitation regressions are shaded at 0.1 mm day^{-1} intervals.

Combining short-range and long-range temperature and precipitation forecasts can help to boost skill of drought forecast

Toward more skillful prediction

BY LIFENG LUO
Michigan State University
PANG-NING TAN
Michigan State University
DAN BARRIE
NOAA Climate Program Office

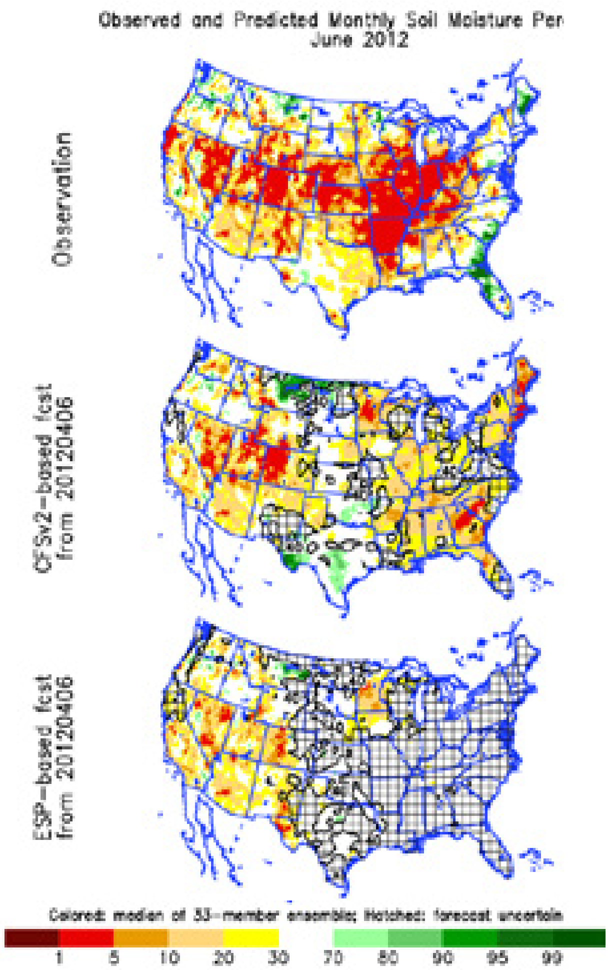


Fig. 1

Predicted drought conditions (with uncertainty) (middle and bottom) for June 2012 and the corresponding verification (top). Lower values indicate relatively drier soil moisture conditions. Forecasts were issued on April 6, 2012, and the lead time is about 2.5 months. The ESP forecast approach (bottom) is adopted by the River Forecast Centers at NWS, serving as a reference here.

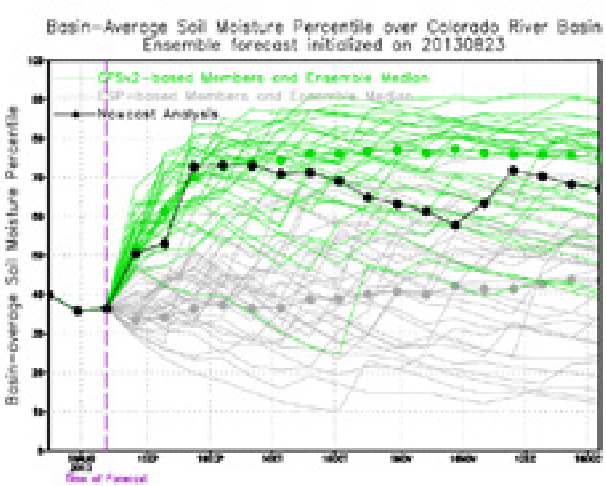


Fig.2

Ensemble prediction of basin-average drought conditions over the Colorado River Basin for a 4-month period since the time of forecast on August 23, 2013. The black curve is the analysis serving as the proxy for observations. The gray curves are from the ESP forecast serving as a reference.

Prior research has demonstrated the feasibility of using hydrological models to predict future drought in the U.S. via soil moisture and other hydrological variables at subseasonal to seasonal time scales. The key to a skillful prediction of such is the accuracy of the initial hydrological states at the time of the forecast, and the weather evolution weeks and months afterwards.

Since accurate weather prediction is impossible beyond about two weeks due to the chaotic nature of the climate system, how to best represent the possible weather sequences and the associated uncertainties in an ensemble framework is a major challenge.

An ongoing research project, supported by the NOAA Climate Program Office Modeling, Analysis, Prediction, and Projections (MAPP) program, tackles such a challenge by exploring methods to better utilize existing weather and climate forecasts to improve seasonal drought forecast.

In particular, we explore ways to combine short-range (e.g. seven-day quantitative precipitation forecasts, or QPF) and long-range (e.g., Climate Forecast System version 2 or CFSv2) forecasts of temperature and precipitation to better represent the likelihood of weather conditions at various lead times. The new approaches developed in this research are either based on Bayesian statistics or machine learning algorithms that are traditionally used in the field of data mining.

These methods have been implemented in a Drought Monitoring and Prediction System, and they have shown encouraging results in improving drought forecast skills. For example, the ability to predict the much drier than normal conditions over the Central Plains for June 2012 two months in advance (Fig. 1, above left) makes these forecasts useful for early drought warning.

The system has also shown the ability to predict wetter than normal conditions quite successfully. In August 2013, we predicted higher than normal rainfall, thus wetter than normal soil moisture conditions over the Colorado River Basin, which was verified nicely by subsequent observations (Fig. 2, lower left).

More information about the project, including past and real-time forecast can be found at http://drought.geo.msu.edu/research/forecast/ .

A conversation about snowpack and its significance to drought in the West

'Our biggest and most important reservoir'

Each week the author of the U.S. Drought Monitor map sifts through input from as many as 350 observers and contributors around the nation. The exchange of information from sources reporting on precipitation, soil moisture, stream flows and other factors, lays the foundation for the depiction of drought that week.

Snowpack is an element that goes into assessing and predicting drought, especially in the West. But what happens when it rains a lot instead of snowing? Can there be a "snow drought?"

A Drought Monitor author posed this question to the group in February, when much of what had typically fallen as snow in the winter was now taking liquid form.

Read on to follow the conversation and learn more abuot the role of snowpack and the nature of drought.

BY THE USDM COMMUNITY
Multiple Agencies

We had an interesting discussion during our U.S. weather briefing today at USDA, and it raised a question that I know there's no easy answer for, but whatever guidance we could get would be a big help.

In many areas of the West, in particular the Northwest, we see near- to above-normal rainfall but at the same time much below-normal snowpack. If you have a mild, wet winter (even wetter than normal), and you enter the spring with full reservoirs but meager snowpack, what role will the meager snowpack play moving forward?

More simply put, what percentage of total water use does the snowpack supply? I expect the answer is complex…

Eric

Eric D. Luebehusen, Meteorologist, USDA
Office of the Chief Economist, World Agricultural Outlook Board
Washington, D.C.

Good question. The main challenge lies in the type and use of the reservoirs we have in the West.

For reservoirs with no flood control capacity, it doesn't matter as much as for those which rely on snowmelt to fill the flood reserve space that is held through the winter.

The exception to that rule is for reservoirs that modulate the flow distribution of the snowmelt to accommodate water use through the summer. These reservoirs are usually small compared to the runoff volume of the watershed behind them. Mother Nature doesn't always provide a nice smooth distribution of snowmelt runoff through the spring and summer. In those cases the reservoir is managed more heavily to try to balance runoff and deliveries without "losing" too much runoff to flows over the spillway.

Each watershed is unique in its structure, and water management needs and input from the community are vital. For reservoirs that have a flood reserve space, the snowpack is like a secondary reservoir that is used to fill in that space through the spring and then can be used for deliveries through the summer and fall for a variety of purposes.

When the snowpack isn't there, there is a lot less water to work with to balance a bunch of competing needs. If there are a lot of winter flows, any water that goes into the flood reserve space in the reservoir must be released as soon as it is safe to do so, and is often "lost" for other purposes.

There's a lot of research on how to use forecasts to enable more dynamic consideration of how much flood reserve space to have on hand in reservoir operations.

Mike

Michael Anderson, State Climatologist
California Department of Water Resources
Sacramento, Calif.

I echo what Mike said regarding reservoirs. There are many papers on the importance of the snowpack to the Pacific Northwest (PNW); the Northwest chapter of the National Climate Assessment covers this in detail. Not all of our surface water supply is fed by a man-made reservoir. We rely on the snow to act as our biggest and most important reservoir.

Beyond hydrology, there are the factors of soil moisture and bare ground, which can exacerbate wildfires in the summer (though in-season conditions matter a lot as well), and impact a multi-million dollar winter recreation industry.

We haven't had much of a winter here and it is very apparent. Bend's annual WinterFest is this weekend (Feb. 14, 2015); it will be in the high 50s

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An NRCS worker measures the snowpack at the GRBC Meadows Snow Course, Utah in May 2005. Photo by Kendall Datrup, one of the winners in the 2012 NRCS photo contest.

HTTP://WWW.WCC.NRCS.USDA.GOV/PHOTO_CONTEST/2012/INDEX.HTML

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and there's not a lot of snow to be found. In good news, we've also heard stories of successful water conservation by irrigation districts in these recent snowpack-limited years.

Snow trumps rain here in the mountains in the PNW.

Kathie

Kathie Dello, Associate Director, Oregon Climate Change Research Institute
Deputy Director, Oregon Climate Service
College of Earth, Ocean, and Atmospheric Sciences
Oregon State University
Corvallis, Oregon

Another impact, at least for Washington State, is that there are minimum streamflow requirements on several waterways. Junior water rights holders may be cut off in late summer if streamflows drop below the minimum, which is more likely in low-snowpack years, especially in watersheds without reservoirs.

How about a new Drought Monitor category for plenty of rain and not enough snow?!

Katherine

Katherine Rowden, Service Hydrologist
National Weather Service / NOAA, Washington State

One add-on for the fisheries flows Katherine mentioned is that storage is needed in the reservoirs to maintain a cold pool of water to provide the right temperature of water for the fish in the late summer and fall. It might look like water is available, but it may be being held for a specific purpose that is not the traditional water supply.

Mike

I dug up a few articles mentioning snowpack, precipitation amounts and water supply, but none of these give any rule of thumb to go by, just some food for thought. Snowpack as percentage of total water supply varies considerably from place to place, with some reservoirs needing sufficient annual precipitation while others can hold enough water to last multiple years.

The low snowpack/above-normal precipitation issue has been bothering me. Can we consider areas to be in "drought" when average or more precipitation falls, even in the wrong form? Even if the water supply runs low later in the year? If an area getting normal precip or better, even falling at the wrong time of year, is it drought that causes the water shortages -- or isn't it?

Denise

Denise Gutzmer, Drought Impact Specialist
National Drought Mitigation Center,
University of Nebraska-Lincoln
Lincoln, Neb.

When I talk with Montana school groups, I explain the snowpack as our bank account of water that we need to get through the summer. If we don't

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Dan Kenney takes notes at the Skwentna snow course in Alaska in February 2009. Photo by Rick McClure, one of the winners in the 2012 NRCS photo contest.

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get enough snow, or we lose snowpack too early, we're going to see reduced stream flows earlier in the summer.

Climatologically, we receive less precipitation and fewer precipitation events in July and August compared to May and June. Spring and early summer bring more stratiform events which spread out a given amount of precipitation over time and space, compared to mid- and late summer which are more convective, with storms dropping that given amount of precipitation in limited time and space. The convective storms provide only a very short-term benefit to stream flows. The melt of the remaining higher mountain snowpack helps keep streams running through at least part of this period.

Problems from the lower stream flows include not only irrigation. Junior water rights holders could be cut off. And the recreation industry suffers. Fishing is huge here, a big part of tourism. Reduced stream flows mean increased water temperature and can lead to decreased water quality, both of which can stress fish, and lead to stream closures. Some are just 'hoot owl' closures, something like 2 p.m. to midnight; others are 24-hour closures.

While we do have reservoirs, we don't have them on every stream or river. And because reservoirs have to be managed for a variety of purposes, they can't always keep the downstream flows running at 'ideal' levels.

Gina
Gina Loss, Senior Service Hydrologist
Great Falls Weather Forecast Office, Great Falls, Montana

Yes, you can have a "snow drought". Mike Palecki and others have done research on these types of droughts, as they can and do have major impacts on recreation, increase fire risk, and lead to moisture stress on high elevation trees.

It makes our USDM depiction a lot more challenging, especially if the area has seen above-normal precipitation. I like to occasionally raise the issue of having a "Water Monitor" sister product, which would be focused a lot more on the "supply" side.

Then again, it would take quite some time to run down all the "rule curves" and managing entities for every storage body (thousands) in the U.S., and then knowing why or how they are managing the water during any given year, in order to tease out what is standard operating procedure vs. climate or drought-induced impacts.

The higher temperature trends are certainly a major contributing issue.

Mark
Mark Svoboda, Climatologist, Monitoring Program Area Leader
National Drought Mitigation Center,
University of Nebraska-Lincoln, Lincoln, Nebraska

This is the webcam from Hoodoo ski resort (above). I'd certainly call this a drought. Temperature can't be overlooked. You can't ski on rain.

Kathie

I'**ve read about plenty of snow droughts,** which have far-reaching consequences, and don't argue with that concept, but can we honestly term it a drought when there is above normal precip in the wrong form or at the wrong time to bolster the snowpack? It may lead to water shortages later, but it isn't a drought exactly. It's more of a timing and temperature issue. If warm temps melt the snowpack early, we don't call it drought. It's a temperature issue preventing or melting the snow.

Denise

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It is very different type of creature than is typically depicted in the Drought Monitor. Consider though, that for Washington, the statutory definition of drought conditions: "water supply conditions where a geographical area or a significant part of a geographical area is receiving, or is projected to receive, less than seventy-five percent of normal water supply as the result of natural conditions, and the deficiency causes, or is expected to cause, undue hardship to water users within that area."

Currently, there are many basins in Washington that will meet these criteria for the summer water supply forecast season unless snowpack suddenly improves or we get some really impressive spring rains. I know there are other criteria for state drought declaration, but the water supply forecasts are definitely a part of it.

Katherine

I agree with you when: 1) Precipitation is above normal at most time scales; 2) reservoirs and streams are at or above normal; 3) soil moisture is wet; 4) snow is less because of unseasonable warmth causing precipitation to fall as rain (or melt existing snow) while the snow season is still ongoing.

To me, it becomes more of a drought later in the spring, once snow season is over and normal spring snowmelt should be occurring, but isn't. By adding the category "abnormally dry" (D0) to the Drought Monitor now, it's like forecasting drought and/or reduced snowmelt runoff in the spring and summer. The Drought Monitor isn't supposed to be forecasting. I'd be more inclined to add D0 or drought a bit later in the season when impacts (such as reduced streamflows) are occurring, maybe April or May.

Dave Miskus

David Miskus, Meteorologist/Drought POC
Climate Prediction Center OPB
College Park, Md.

I think this discussion just reinforces what we already knew about drought: it is a complex, multidimensional system about which we are still learning.

Russell Martin

Keep in mind that several other "snow drought" cases (think east of the Rockies in the northern tier states) are due to actual precipitation deficits independent of temperature. The deficits can impact recreation and economies, expose trees, yards, land cover and wildlife to bitter cold temps, and can lead to more grass fires when dry grasses aren't buried in wet snow, in addition to the missing moisture not working its way into the soil profile in the spring when soils thaw.

So, not all "snow droughts" are created equally, and it certainly isn't just a western phenomenon.

Mark

At this time of year (February), the many reservoirs are kept fairly empty, or with at least enough space to make sure they can capture the majority of the peak snowmelt runoff when it occurs. Larger federal and state reservoirs are mandated to keep to a rule curve for refilling. This usually does not allow them to capture much rainfall in the winter, unless they are below where they should be, so most of this rain has probably passed through many of the reservoirs. Since the precipitation pattern in much of the West is highly winter dominant, the stored water in the snowpack and snowmelt make up a huge percentage of the annual water budget. That is why we are able to fairly accurately provide streamflow forecasts based on the snowpack. After April and May, only a very small percentage of the annual precipitation budget for most areas remains to fill out the water year (Oct. 1-Sept. 30).

Snowmelt provides the primary source of water for irrigation, municipal needs, power, fish and wildlife health, in-stream flow, etc. Winter rainfall across the region may be near average, serve to bolster the current soil moisture, and provide short term streamflow and reservoir water for those reservoirs that were down to minimum levels. But most of this water will be long gone before we get to the spring growing season, and for many other uses.

We still need to have water from snowmelt to fill streams for the April to July water supply for spring and summer use, when there is next to nothing falling from the sky. So in my view, "no snow" is a pretty serious drought for water use and management in many areas of the West.

It is also very true that the current and future impacts are easily mixed in this snow discussion, so it is very difficult for anyone to take everything into consideration and to decide what is providing an impact when! There is always future rain that is unknown.

Jolyne

Jolyne Lea, Hydrologist
USDA NRCS National Water and Climate Center
Portland, Ore.

I think we have tended to lump this all under "drought" as insufficient water to meet needs, and brought about largely by natural processes.

That's still my own inclination.

Kelly

Kelly Redmond, Research Professor Climatology
Desert Research Institute,
Reno, Nevada

Snow droughts do exist!

Being married to a ski coach for nearly 25 years and a race parent for more than 18 years, watching ski areas move or changes in ski races were my first signs of snow drought. This year numerous ski races in the intermountain division have been moved or canceled because of lack of snow or rain.

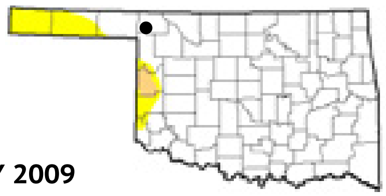
Impacts on the economy are felt through travel, lodging, lift tickets, and food for racers and parents.

We will be seeing all 3 conditions (drought, normal year and wet year) this summer. Your (our) question and challenge is how to drawn this on a single map…

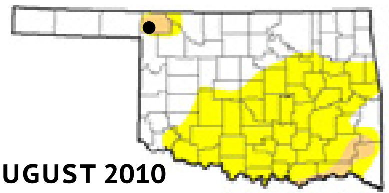
It is the snowpack that sustains the stream flows. Rain runoff events are flashy in nature and do not provide the volume of water that snowmelt does. Last year the Owyhee Basin irrigation water ran out of July 18.

Ron

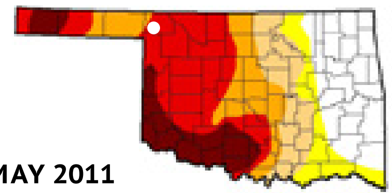
Ron Abramovich USDA NRCS Snow Survey
Water Supply Specialist, Boise , Ida.



MAY 2009
No drought



AUGUST 2010
D1: Moderate drought



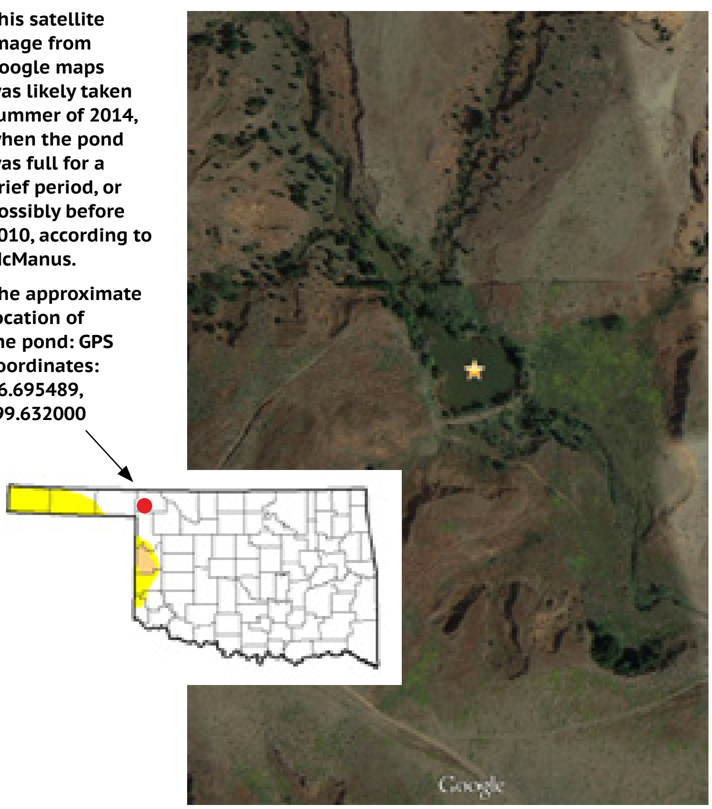
MAY 2011
D3: Extreme drought

Correlating the U.S. Drought Monitor with scenes on the ground over the years

The rise and fall (again) of the pond on the McVicker farm

This satellite image from Google maps was likely taken summer of 2014, when the pond was full for a brief period, or possibly before 2010, according to McManus.

The approximate location of the pond: GPS coordinates: 36.695489, -99.632000



PHOTOS BY GARY MCMANUS

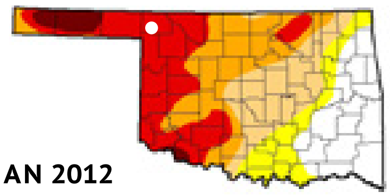
What does drought look like? Oklahoma State Climatologist Gary McManus has been tracking the state of a spring-fed pond south of Buffalo, Okla., where he fished as a kid. His photos show its journey from 2009 through early 2015.

The pond was looking flush in May 2009, about a month after a good 20-26 inch snowfall event in late March. As the drought advanced, the pond dried up for the first and only time since it was built more than 40 years ago.

When ten inches of rain fell last June, the McVicker farm appeared to have recovered. Then another eight months of drought commenced and the waters evaporated again, shrinking the shoreline back to where it had been in January 2014. With the warm, windy days typical of springtime around Buffalo ahead, its future appears grim.

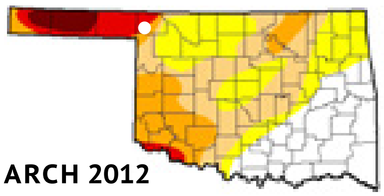
WHAT DOES DROUGHT LOOK LIKE WHERE YOU LIVE?

Drought in Maine looks different from drought in Arizona. NIDIS and the National Drought Mitigation Center (NDMC) would like to see what you see when you see drought in your part of the world. Help us out by being a citizen scientist! You can upload pictures to the Drought Impact Reporter ore-mail to nidis.program@noaa.gov. We'd like to feature the best shots in upcoming editions of Dry Times.



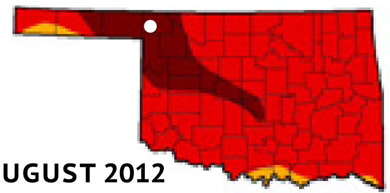
JAN 2012

D3: Extreme drought



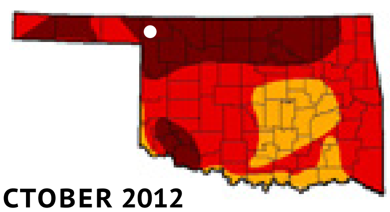
MARCH 2012

D2 Severe drought



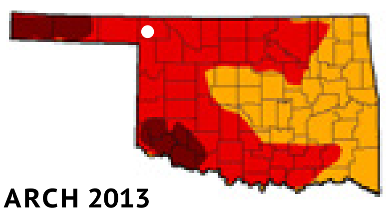
AUGUST 2012

D4: Exceptional drought



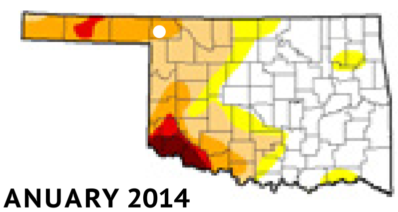
OCTOBER 2012

D4: Exceptional drought



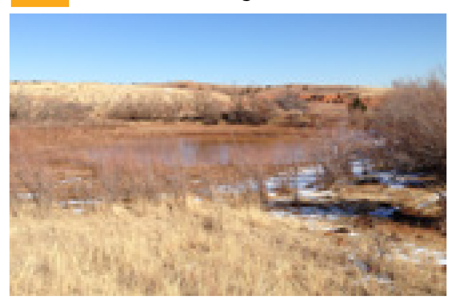
MARCH 2013

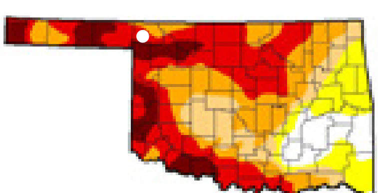
D3: Extreme drought



JANUARY 2014

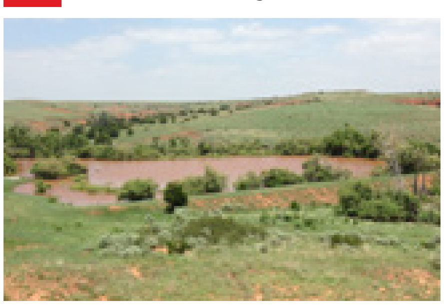
D2 Severe drought

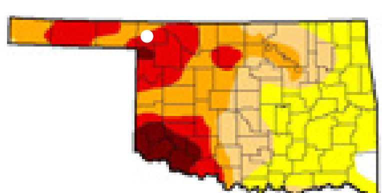




JUNE 2014

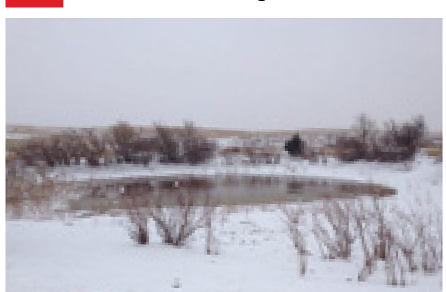
D3: Extreme drought





FEBRUARY 2015

D3: Extreme drought



Maps are from the U.S Drought Monitor archive http://droughtmonitor.unl.edu/Home/StateDroughtMonitor.aspx?OK

- D0: Abnormally dry
- D1: Moderate drought
- D2 Severe drought
- D3: Extreme drought
- D4: Exceptional drought

Like this site? DIY

Here's a team building exercise:

Tap into open data about the California drought. Create a data visualization that illustrates the drought's progression in several ways. Animate it. Make it understandable to all kinds of people, with links to the metadata for those who want to go deeper. Post it online.

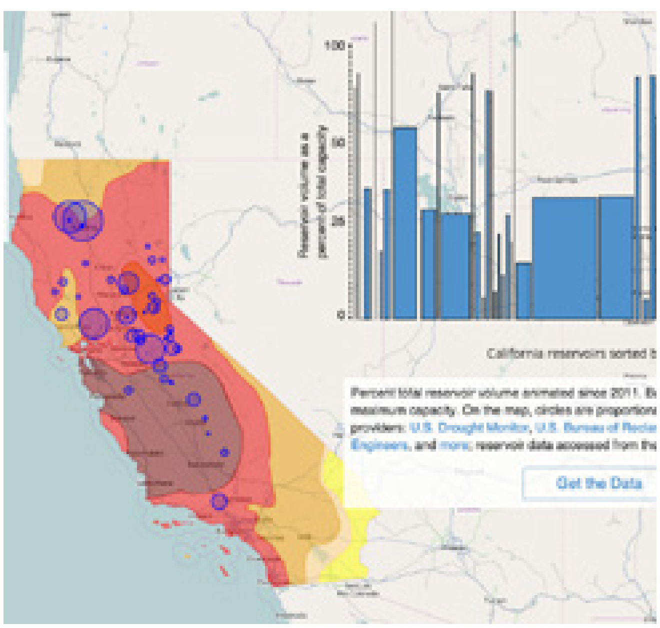
Sixteen developers at the USGS Center for Integrated Data Analytics (CIDA) did just that in 2014. Their presentation, "California drought, visualized with open data" (http://cida.usgs.gov/ca_drought/), lets users scroll through a collection of maps, animated graphics and charts. You can watch on your computer screen to see California reservoir volumes decline as drought grows. Or observe the shrinkage in water surface area from 2010 to 2014 at Trinity Lake and Shasta Reservoir. Or examine a pie chart breakdown of where California's water goes.

Much of the data displayed automatically updates, giving a current snapshot of drought conditions in the state, particularly as they relate to water storage and usage.

The data which form the building blocks of the site come from free and publicly accessible sources, including NOAA, the USGS, USDA, the California Department of Water Resources and the U.S. Drought Monitor. The analytical, graphical, and software tools used for the site are open-source as well, and available for public reuse.

So you could build this site yourself, though it might take a bit longer than it took the team of 16.

For more information, contact gs-cida_ca_drought_cida_app@usgs.gov.



This screen grab shows a still from an animated sequence on the site. In the animation, the U.S. Drought Monitor categories overlay the map, and change through time as you scroll. The bar chart and the bubbles on the map show the reservoir volumes corresponding to the dates and statuses on the map.

Introducing new CA DEWS coordinator Julie Kalansky

Julie Kalansky is joining the NIDIS team for the California Drought Early Warning System.

Kalansky's involvement with NIDIS began in the Russian River region in northern California, where drought and precipitation in general caught her imagination. She says about her research:

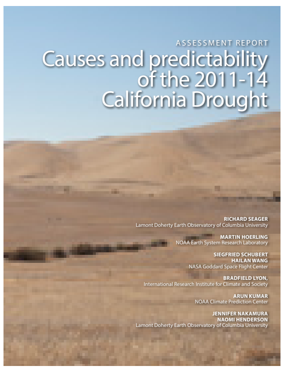
> *Very broadly my research interests stem from trying to understand weather and climate in order to better prepare for extreme events and future conditions. Currently my research focuses on understanding precipitation patterns and drought in California. In collaboration with Sonoma County Water Agency, I am developing drought indicators to help stakeholders make informed management decisions and mitigate the effects of drought. We are also trying to understand how different oscillations, such as ENSO and the Pacific Decadal Oscillation, affect the frequency, intensity and latitude of atmospheric rivers. Atmospheric rivers are relatively long, narrow regions of strong winds that transport large amounts of water vapor to the subtropics. When atmospheric rivers make landfall they can cause precipitation events. For example, in California atmospheric rivers are responsible for 25-50% of the precipitation.*
>
> *I'm also interested in studying climate variability for the last 2,000 years in order to understand natural modes of climate variability. By studying climate on this timescale we can examine low frequency forcings and connections in the climate system that might not be apparent in the relatively short observational record.*

Kalansky's goal for her work with NIDIS is to educate the public on the tools and information available, so they can easily see where conditions stand in their region. Furthermore, she wants to work on providing the information resource managers need in order to make appropriate decisions.

Kalansky grew up in Southern California and got her BA in Chemistry at Scripps College in 2003. She earned her Oceanography MS in 2010 and PhD in 2014 at the University of Rhode Island and Rutgers University, respectively. She is currently doing her postdoc at Scripps Institution of Oceanography.

2014 was driest of years since 2011, with exceptional (D4) drought covering more than half the state by December

California drought: Could it have been foreseen?



The report, "Causes and Predictability of the 2011-14 California Drought" is a project of the Narrative Team of the NOAA Drought Task Force, organized by the Modeling, Analysis, Predictions and Projections (MAPP) Program of the NOAA/OAR Climate Program Office.

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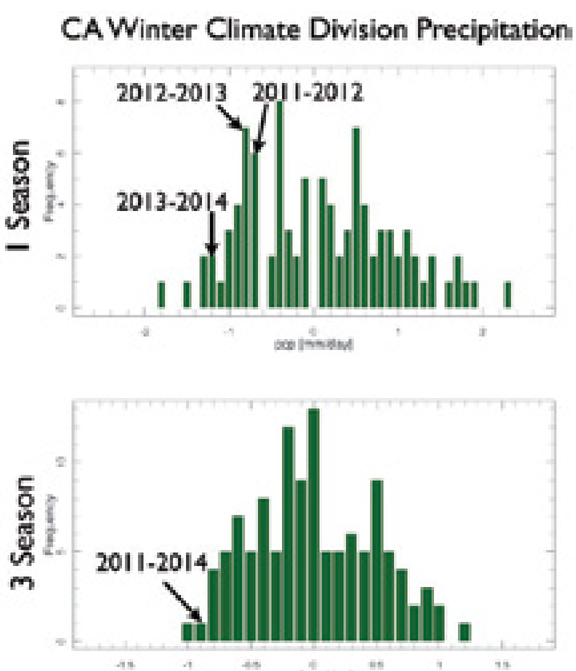
How severe has the California drought been?

Statewide precipitation during the last three winters (November-April 2011/2012 through 2013/2014) ranked the second lowest since official measurements began in 1895. Only the consecutive three-year period of 1974/75 through 1976/77 was drier. As one critical indication of the cumulative and growing impact of this drought, the September 2014 assessment of statewide water storage was only about 50% of average for that time of year, according to the California Department of Water Resources. Water supply depletion has not resulted from the lack of precipitation alone, but also from very high temperatures with the 2013/14 winter being the state's warmest on record when this report was written. 2014/15 has been even warmer.

As the 2014/2015 wet season commenced, the U.S. Drought Monitor indicated almost all of California to be experiencing extreme to exceptional drought. The situation had deteriorated greatly during 2014, the third consecutive year of low precipitation and the driest of 2011-14. Exceptional conditions (D4) covered more than half of the state in December, whereas one year earlier no regions in the state were considered to be under D4.



What factors caused the California drought?

Weather conditions were key. A high pressure ridge off the West Coast diverted the track of storms during all three winters, typical of historical droughts. West Coast high pressure was rendered more likely during 2011-14 by effects of sea surface temperature patterns.

The drought's first year (2011/12) was likely the most predictable, when La Niña effects largely explained high pressure off the West Coast, though simulations indicate that high pressure continued to be favored due to ocean effects in 2012-14.

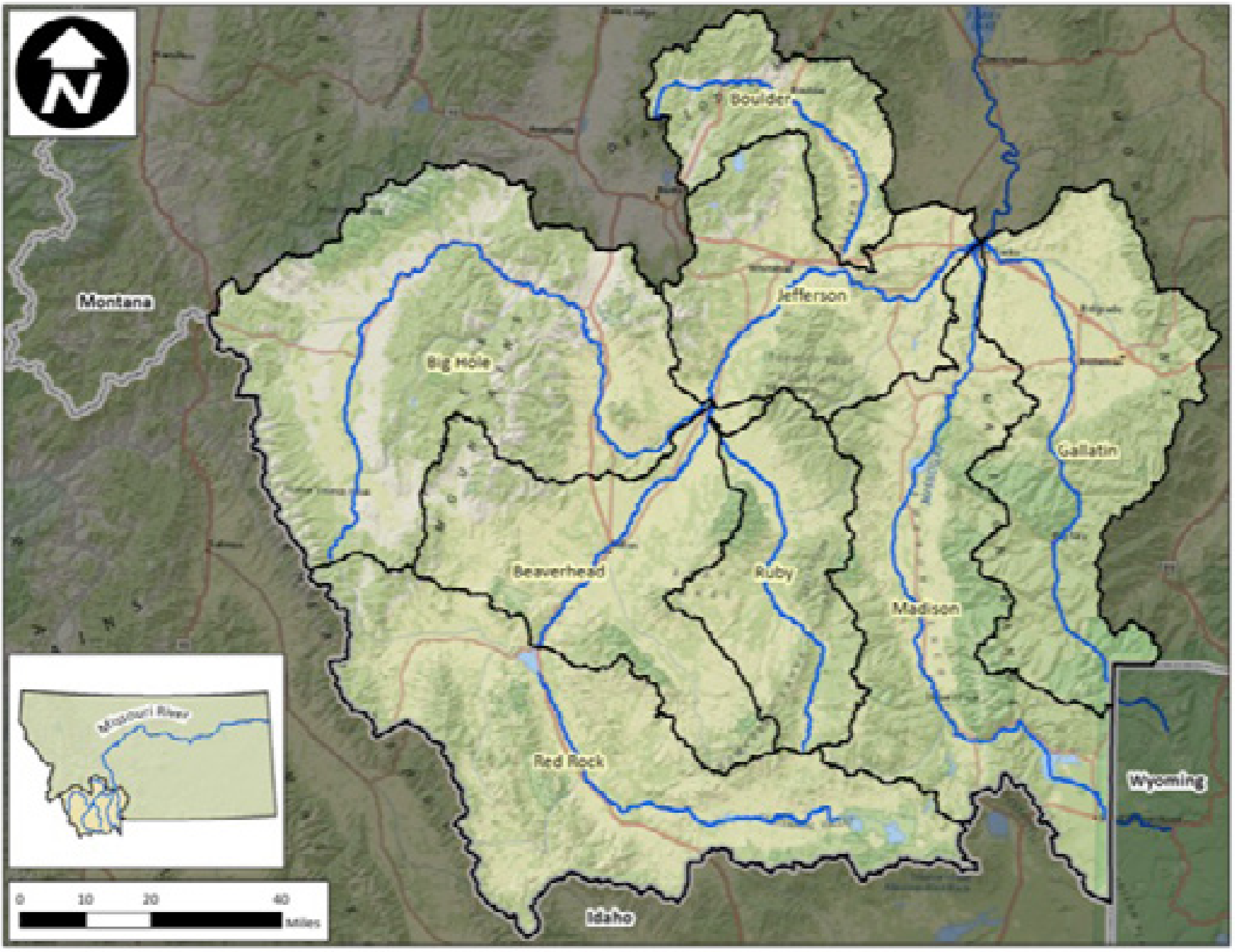
Is the California drought a symptom of long-term climate change?

The current drought is not part of a long-term change in California precipitation, which exhibits no appreciable trend since 1895. Key oceanic features that caused precipitation inhibiting atmospheric ridging off the West Coast during 2011-14 were symptomatic of natural internal atmosphere-ocean variability.

Model simulations indicate that human-induced climate change increases California precipitation in mid-winter, with a low-pressure circulation anomaly over the North Pacific, opposite to conditions of the last three winters. The same model simulations indicate a decrease in spring precipitation over California.

However, precipitation deficits observed during the past three years are an order of magnitude greater than the model-simulated changes related to human-induced forcing. Nonetheless, record-setting high temperatures that accompanied this drought were likely made more extreme due to human-induced global warming.

Watershed management groups and stakeholders in southwestern Montana share successes, plans for the future in a drought planning workshop



Working toward resilience, step by step

BY CHAD MCNUTT AND KATHLEEN BOGAN / NIDIS

On March 16-17, NIDIS, the National Drought Mitigation Center (NDMC) and Montana's Department of Natural Resources and Conservation (DNRC) hosted a workshop in Bozeman, Montana to bring together participants from the Upper Missouri Basin to discuss ways to improve drought early warning and drought resilience. The event,"Building Drought Early Warning Capacity," was part of a larger demonstration project for Montana announced by the National Drought Resilience Partnership (NDRP).

The workshop gathered watershed-based teams that could initiate a conversation with their communities on managing scarce water resources and preparing for future drought conditions.

Representatives of seven sub-watersheds attended (shown on the map above), including the Beaverhead, Ruby, Big Hole, Upper Gallatin, Lower Gallatin, Madison, and Jefferson Rivers. The diverse

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Sarah Washko, a Big Sky Watershed Corps member for the Big Hole watershed, points out issues of concern for her area during the workshop. Identifying potential impacts of drought and possible solutions helped lay the groundwork for establishing or expanding drought plans.
NIDIS PHOTO

Points of view: What about vulnerability?

Before the workshop, the facilitators asked the BSWC members to respond to some survey questions. Included among them was the following question, with some of their responses.

In your watershed, do you think vulnerability to droughts has been increasing, decreasing, or remaining the same and why?

• Increasing, because the land resources are experiencing a cumulative effect from past drought years. For instance, native bunch grasses are more susceptible to drought because their vigor is low, and with each additional drought year the plant begins to die off.

• Decreasing due to good land health management.

• Decreasing due to the development of our Drought Management Plan, but I'm nervous about the upcoming water year after this relatively dry winter.

• Increasing on public lands because the agencies have have difficulty acting in a timely manner; on private lands because of an inability to see the need for adaptability planning and prevention. We are fortunate to have active, effective voluntary drought management plans that have proven to work well, but I see that as a bandaid for temporary conditions, not long term planning for the future.

• Increasing. More people, more water-hungry crops, chasing greater yields and larger cattle, all require more water. A continuing decline in soil organic matter leads to less water retention capacity. More irrigation and well drilling reduce ground water supplies with no understanding of recharge rate/dynamics.

• Decreasing due to improved watershed coordination

• Increasing. The population in this watershed is expected to triple by the end of the century, creating tension between municipal and agricultural water users. Drought will only compound this issue.

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group included Big Sky Watershed Corps (BSWC) AmeriCorps members, watershed coordinators, state and local agencies, city planners, agricultural producers, land trusts, conservation districts, NGOs, hydrologists, and local federal partners.

Using tools to support step-by-step planning

Over the course of the workshop presenters showed a mix of new and existing data tools that could be used to develop or strengthen watershed-specific drought plans. Some of the headwaters groups already had plans in place; others were starting from scratch.

Facilitators from NIDIS and the NDMC led the group in a step-by-step drought planning process using such applications as the Drought Impact Reporter and the Drought Risk Atlas, to track conditions, identify triggers and work through potential conflicts between water users.

By assembling teams of relevant decision-makers and stakeholders, the groups had already accomplished the first step in any drought-planning effort. Then they began to work through key questions:

■ **How will drought affect us?** Looking at past drought impacts helps people understand their vulnerability to drought.

■ **How will we recognize the next drought in the early stages?** Understanding what data are available and collecting more, if necessary, are key. This is part of monitoring and early warning.

■ **How can we protect ourselves from the next drought?** The answer to this will vary tremendously depending on the enterprise. The NDMC maintains a searchable database (http://drought.unl.edu/droughtmanagement/Home.aspx) that includes drought plans, mitigation actions, and more.

After researching impacts, monitoring, and management options, the team will need to come up with a plan detailing how the organization will recognize and respond to drought. In many cases it may be appropriate to use triggers to phase in response actions according to the severity level of drought.

In addition to the overarching theme of drought, the workshop highlighted the opportunity to develop broader water management plans to reflect water shortages even in non-drought years.

Outcomes and next steps

Several ideas or themes emerged from the meeting: 1) What could be done in the watersheds

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Working toward resilience, step by step

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to recognize the work already underway; 2) How to leverage and build on the successes many of the watersheds have developed , such as the Lower Gallatin's Watershed Restoration Plan; 3) How to utilize the active NGO partners, state agencies, universities, and private citizen interest.

BSWC members identified some initiatives to take away from the workshop, in order to contue developing their drought plans:

Comments on the workshop

The Beaverhead Watershed Committee's Facebook page described the group's takeaways and future plans from the workshop as including "many new tools and ideas for addressing drought risk in Beaverhead County.

"Going forward we hope to work with the Beaverhead County Drought Task Force, the Clark Canyon Joint Board, and other community groups to enhance their access to hydrologic data such as precipitation, snowpack, stream flows, soil moisture, and more. We also intend to help Beaverhead County stakeholders understand where the data comes from and how it is used for decision making at the state and federal level.

"One creative and fun idea that we are also exploring is producing a video documentary in which we interview longtime Beaverhead County residents about their experiences with previous notable drought years."

■ Develop a Missouri Basin Headwaters Plan: Working through the BSWC members, develop a plan that integrates the watersheds to allow early warning and proactive planning for drought.

■ Assess way to integrate existing water planning concepts into the discussion of drought early warning and overall drought resilience. For example:

-- Use the process of Watershed Restoration Planning and 319 funding to get stakeholders (e.g. irrigators) in the watershed more involved in drought-related planning.

-- Assess models and or mechanisms that could support sub-watershed planning efforts like the West Gallatin plan

■ Conduct drought scenario workshops, to exchange perspectives and assess triggers, data gaps and coordination needs within as well as among watersheds.

■ Continue the dialogue with the NDMC, NIDIS, and DNRC through webinars and in-person meetings to exchange information on drought planning (such as NDMC's Managing Drought Risk on the Ranch), improve understanding of seasonal climate forecasts, and other topics of interest.

■ Apply water conservation efforts like those used by the City of Bozeman for watersheds with large resorts and developments.

WEBINARS: Keep up with current conditions in your area

Several of NIDIS' partner organizations offer regular live reports on drought conditions in their regions, through webinars. Upcoming and past webinar listings are at http://www.drought.gov/drought/content/regional-programs/regional-drought-webinars. How to sign up for future events, or view past sessions:

Managing Drought in the Southern Plains

The Southern Climate Impacts Planning Program (SCIPP) holds bi-weekly discussions of drought and its impacts on the second and fourth Thursdays of each month at 11:00 a.m. Central Time. States covered include Oklahoma, Texas, and New Mexico. To join in, please register at http://www.southernclimate.org/ . You can view past webinars on YouTube at https://www.youtube.com/user/SCIPP01 .

Upper Colorado River Basin Webinar

The Colorado Climate Center conducts Climate, Water and Drought Assessment briefings detailing events in the basin states of Colorado, Utah and Wyoming. To register, please visit: http://ccc.atmos.colostate.edu/drought_webinar_registration.php

Midwest and Great Plains Drought Update

The National Oceanic and Atmospheric Administration (NOAA), the American Association for State Climatologists (AASC) and the High Plains Regional Climate Center (HPRCC) have responded to drought across the Midwest and Great Plains by organizing, creating and presenting webinars since July 2012. These presentations are held monthly but can be more frequent when conditions warrant.

The webinars consist of a regional climate summary, impacts due to drought and climate outlooks.

The webinars are held on the third Thursday of every month at 1pm Central Time. A link to the webinar registration page, along with recordings and powerpoints from previous webinars, can be found here: http://www.drought.gov/drought/news/midwest-and-great-plains-drought-webinar-jan-15-2015 .

Apalachicola-Chattahoochee-Flint (ACF) River Basin Drought Assessment Webinar

The Southeast Climate Consortium (SECC) organizes a drought assessment webinar that includes current conditions and outlooks for the ACF basin.

Currently the webinars occur monthly, and will increase in frequency if drought conditions warrant. Webinar partners include the U.S. Army Corps of Engineers, National Weather Service and USGS. To receive webinar announcements, send a request to reuteem@auburn.edu to get on the email list. To view previous webinar summaries, visit http://www.drought.gov/drought/regional-programs/acfrb/acfrb-home and choose from the list on the right side of the page.

Scoring the accuracy of the Monthly Drought Outlook: An update

On target, much of the time

In the NIDIS November 2014 newsletter, we told you about the Monthly Drought Outlook verification, which assesses the accuracy of the Monthly Drought Outlook produced by NOAA's Climate Prediction Center (CPC). The results for the first part of winter are displayed on this page.

CPC is always looking for ways to refine and improve the product, and the verfication process is part of that process. You can track the scores for each month at http://www.cpc.ncep.noaa.gov/products/expert_assessment/mdo_archive/

In the first part of 2014, scores were showing that about 75% of each forecast is accurate.

The MDO forecasts tend to be more accurate concerning areas where drought is expected to persist or worsen. There is not yet enough data to assess how accurate monthly forecasts are for areas where drought is expected to develop, but in the seasonal (three-month) outlooks, areas where drought develops, or is expected to develop, are not forecast as successfully.

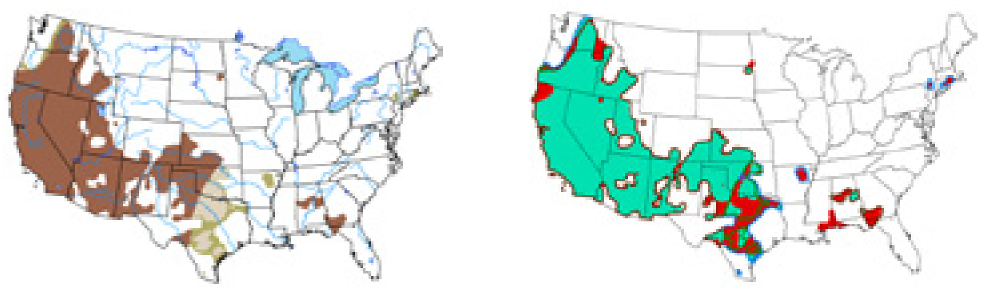
THE PREDICTION

- Drought persists or intensifies
- Drought remains but improves
- Drought removal likely
- Drought development likely

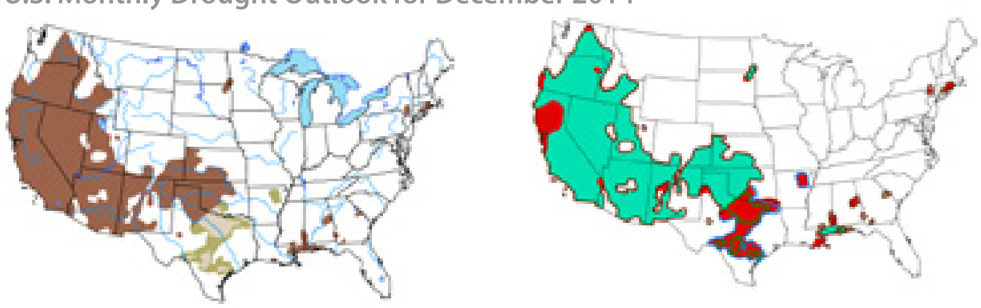
HOW ACCURATE WAS IT?

- Successful forecast
- Inaccurate forecast
- Development predicted
- Persistence predicted
- Removal predicted
- Improvement predicted

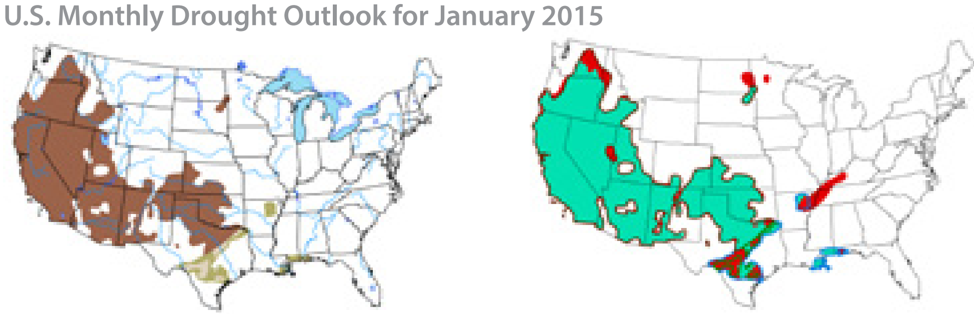
U.S. Monthly Drought Outlook for November 2014



U.S. Monthly Drought Outlook for December 2014



U.S. Monthly Drought Outlook for January 2015



About the Monthly Drought Outlook

The monthly outlook is designed to reflect changes in drought conditions that evolve more rapidly than seasonal timescales, such as the 2012 Midwest flash drought. This shorter-term information can more fully inform communities, in particular agricultural interests during the growing season, allowing them to become more resilient and prepared for short-term changes in drought.

The Western Governors' Association wraps up its year-long Drought Forum with a legacy site that includes best practices, case studies, webinars and meeting highlights

Eyes on drought in the West

Webinar series

As a followup to the live forum meetings, the WGA organized a series of webinars featuring panelists from the public and private sectors, researchers, nonprofit organizations and others. The webinars are available online for replay .

Once Marginal, Now Crucial: The Growing Demand for Re-used, Produced, and Brackish Water
Technological and regulatory obstacles to utilizing re-used, produced, and brackish water.

Community Outreach and Consumer Technology for Municipal Water Use
How utilities, technology developers, NGOs, and citizens team up to reduce municipal consumption of water.

Tip of the Spear: The Horizon for Drought Data and Technology
How scientists use data to understand drought and help policymakers anticipate dry conditions.

Managing Forest Health for Water Resources
The latest science on forest management practices that may increase water availability and add security to water portfolios.

Why Variation in Hydrology and Legal Structures means that Drought Looks Different across the West
How solutions tailored to the needs of specific communities could be utilized across the region.

Nevada Gov. Brian Sandoval's timing was impeccable. Since he launched the Western Governors' Association's Drought Forum initiative last June, drought in the West has become front-page headline news as it intensifies and spreads. And the outlook for relief is grim.

Conditions over the past year has made the need for addressing drought all the more urgent.

The forum, which the WGA sponsored in partnership with NIDIS, was designed to foster a regional dialogue in which states and industry could share case studies and best practices on drought policy, preparedness and management.

The meetings gathered experts from government, industry and other areas to discuss drought impacts in various sectors. Material from the events has populated an online library that features a collection of drought-related resources.

Along with the listings of case studies and best practices, there is a webinar series (see sidebar), meeting videos and highlights.

The meetings focused on impacts and solutions in the following areas:

The Energy Sector

Sept. 18-19, Norman, Okla: Roundtable discussions on the scope of and outlook for drought in the Southern Great Plains. Other sessions illustrated how the energy sector manages drought and ways the energy industry is using technology to prepare for, manage and recover from drought. Case study: Oklahoma Panhandle Water Plan.

Manufacturing, Mining and Industrial Sectors

Oct. 7-8, Tempe, Ariz.: Attendees discussed the outlook for drought in the region, innovations in industry and manufacturing that allow more efficient use of water, and other issues. Case study: Partnership between Gila River Indian Community & Salt River Project.

The Agricultural Sector

Nov. 13-14, Sacramento, Calif.: Roundtables on topics such as "What is Drought? A Slow-Moving Disaster through the Lenses of Agriculture, Water Management and Science" and "Drought Impacts in the Agricultural Sector." Case study: California's Approach to Addressing Record Drought.

Water Supply

Dec. 8-9, Las Vegas, Nev.: Panels such as "The Science of Drought," which included NIDIS Director Roger Pulwarty. Case study: Collaboration in Addressing Drought in Southern Nevada

Recreation and Tourism Sectors

Jan. 28-29, 2015, Santa Fe, N.M.: Among the panels was "Innovative Approaches to Drought," which included Gordon Briner, the CEO of Taos Ski Valley. Case study: The River Stewards Initiative.

More information

Find meeting summaries, presentations, case studies, video and media coverage at http://westgov.org/drought-forum

The National Integrated Drought Information System (NIDIS) is a nexus of drought information, policy and research. We promote collaboration among government agencies, communities and individuals at all levels to share information about drought, and provide resources for planning, forecasting, management and recovery. Together with our federal, state and local partners we pursue these goals:

- **Leadership and networking among all sectors to plan for and cope with the impacts of drought**
- **Supporting research on the science of drought, including indicators, risk assessment and resilience**
- **Creating regional early warning systems for drought management**
- **Developing resources, systems and tools to promote drought awareness and response**