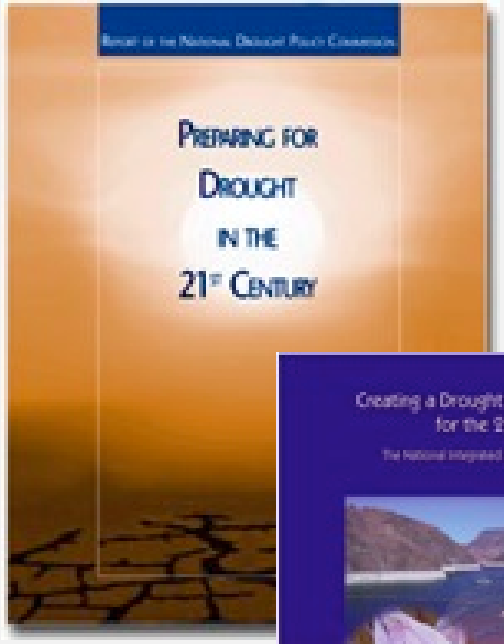
Coordinating research and networks to advance understanding, monitoring, prediction of droughts and society's preparedness

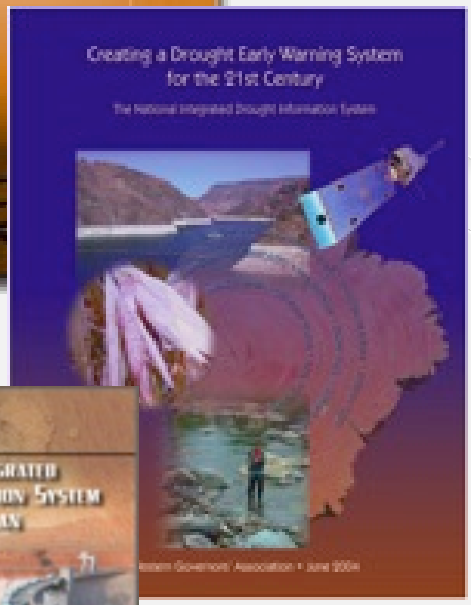
Annarita Mariotti and Claudia Nierenberg

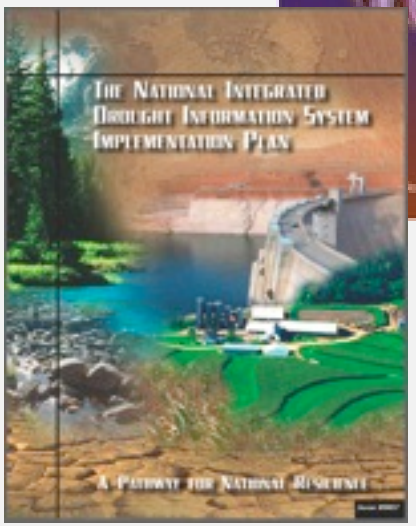
NOAA Climate Program Office

Public Law 109-430
(The NIDIS Act 2006, 2014)

- "Enable the Nation to move from a reactive to a more proactive approach to managing drought risks and impacts"
- "Better informed and more timely drought-related decisions leading to reduced impacts and costs"







***Initial NIDIS-2006 Mandate**: To establish a National Integrated Drought Information System within the National Oceanic and Atmospheric Administration to improve drought monitoring and forecasting capabilities...*

Tasks under the 2014 NIDIS Act:

(I) Provide an effective drought early warning system..

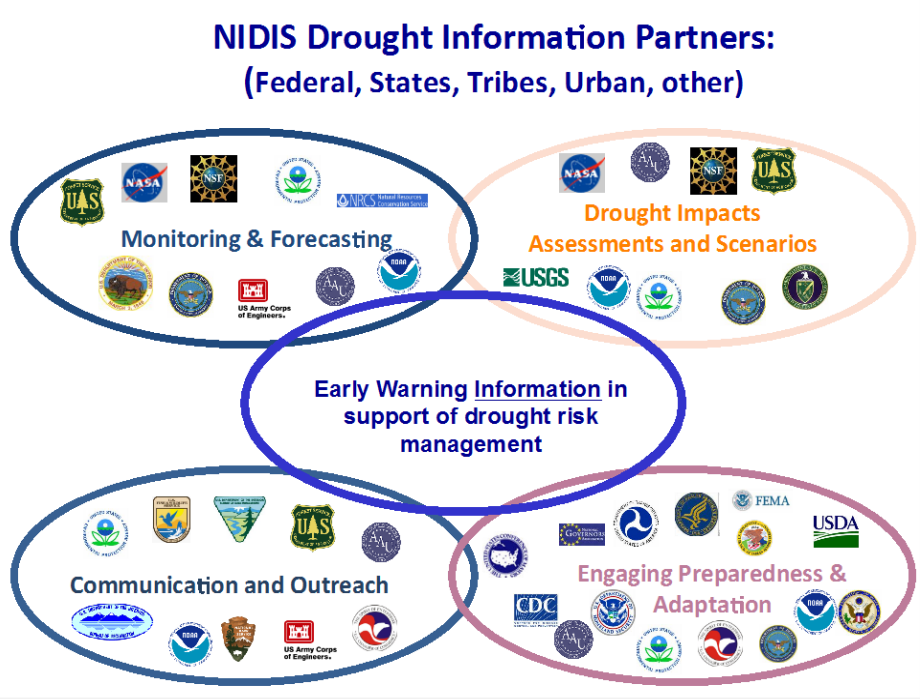
(II) Communicate drought forecasts, drought conditions, and drought impacts…

(III) …reflect local, regional and state differences in drought conditions;

(IV) **Coordinate and integrate as practicable, Federal research in support of a drought early warning system**

(V) Build upon existing forecasting and assessment programs and partnerships

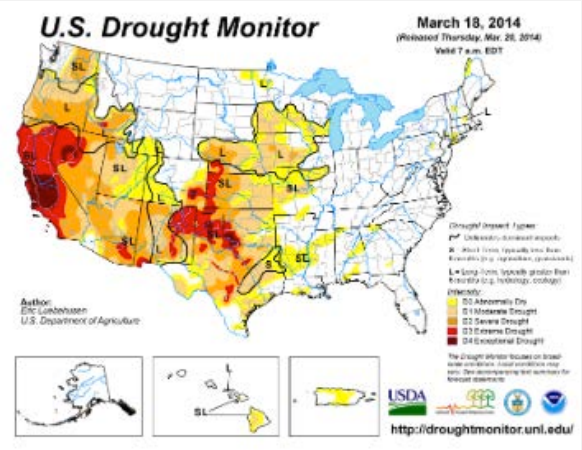
(VI) Continue research and monitoring activities…



National Integrated Drought Early Warning System (NIDIS)

A National Drought Information System:

- informs the development of strategic responses to anticipate crisis
- provides capabilities for generating problem-specific risk assessments and scenarios
- effectively communicates options to critical actors for the purposes of decision making, preparedness and mitigation



Drought understanding, monitoring and prediction research drivers

User-requirements from the NIDIS network

More accurate and reliable forecasts of drought evolution, severity..

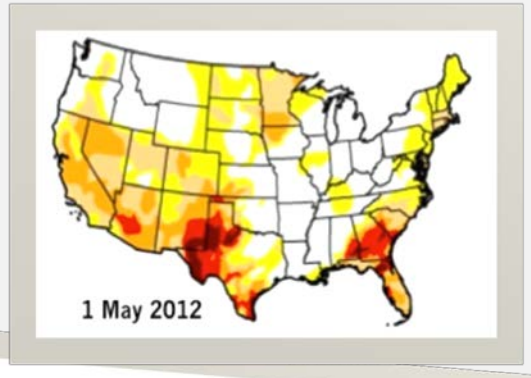
Longer-lead forecasts..

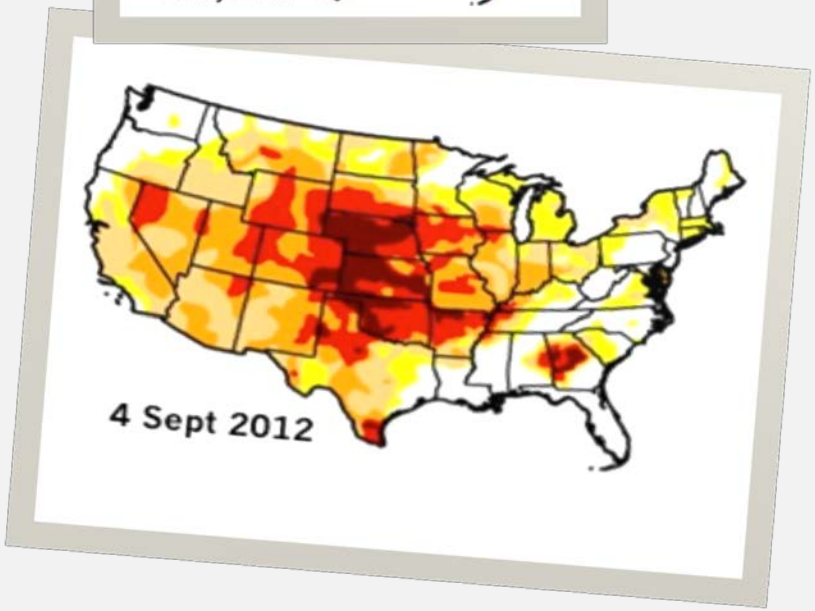
Higher resolution, more timely drought monitoring..

Address meteorological, agricultural and hydrological droughts..

Drought understanding, monitoring and prediction research questions: an example

2012 Central Great Plains Drought: A major recent drought to hit the U.S. with important socio-economic consequences





Research questions:

- *When did the drought become apparent?*
- *Which systems first/best detected it and why?*
- *What caused the 2012 Central Great Plains Drought?*
- Was it predictable and on which timescales?
- Which prediction systems forecasted the event?
- Are we making progress in our capability to monitor/predict such events?
- …

The Approach

- Sustained foundational research investments
- Coordination & collaboration among relevant research efforts
- Strong coordinated connections with the user community through the NIDIS network

Drought Task Force

An initiative of NOAA Climate Program Office Modeling, Analysis, Predictions and Projections (MAPP) Program in partnership with NIDIS; involves 30-plus scientists from academia, other agencies and across NOAA

Underpinning Science

Basic scientific advances that support progress

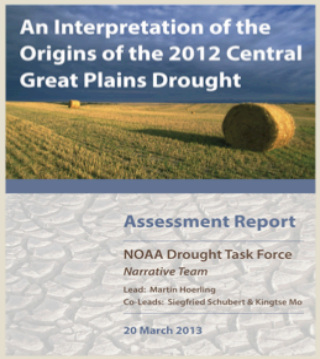
A J of Hydrometeorology special collection

Basic Science

Testing New Capabilities

Retrospective Drought Analyses

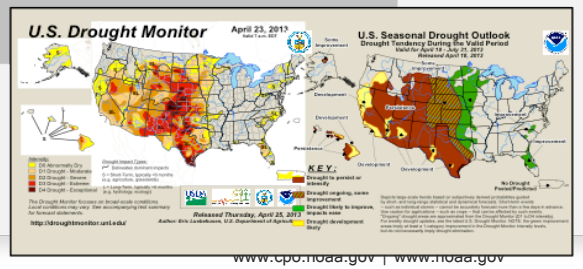
Assessments to improve understanding of U.S. drought



A spectrum of coordinated research activities to advance drought understanding, monitoring and prediction

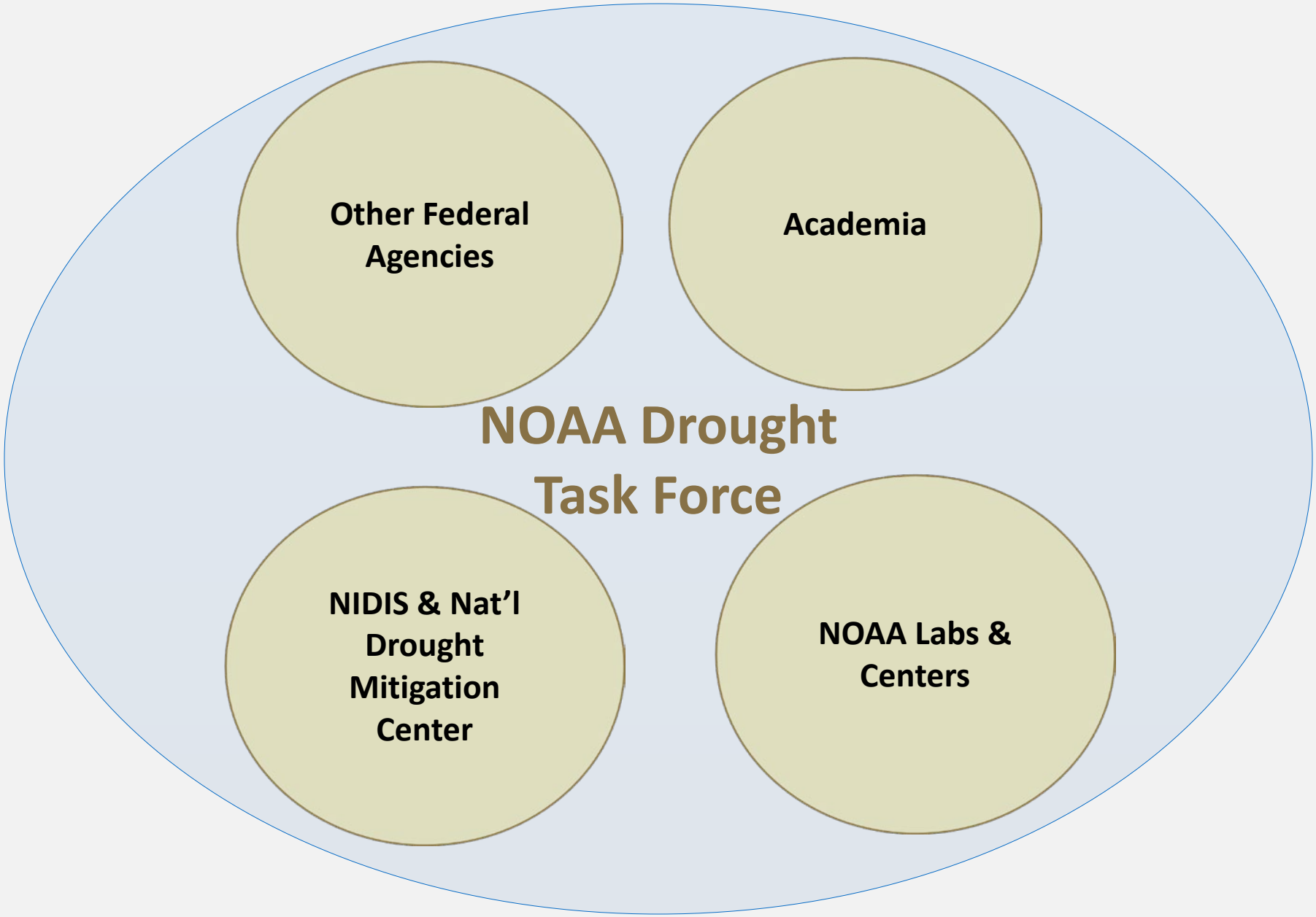
Assessing and Improving Drought Capabilities

A testbed framework to advance drought systems



cpo.noaa.gov/MAPP/DTF

DTF People


Other Federal Agencies
Academia
NOAA Drought Task Force
NIDIS & Nat'l Drought Mitigation Center
NOAA Labs & Centers

The Bigger Picture

Other U.S. research
e.g. NASA NEWS

WCRP research
GEWEX, CLIVAR

NOAA DTF

National Drought Information System

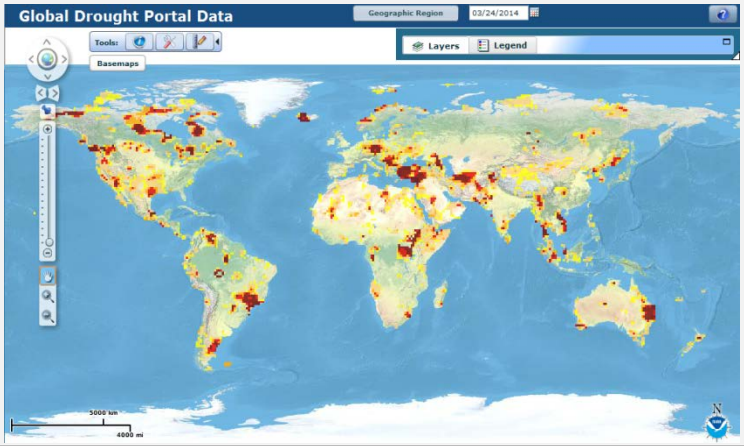
Global Drought Information System
Emerging

The Global Drought Information System (GDIS)

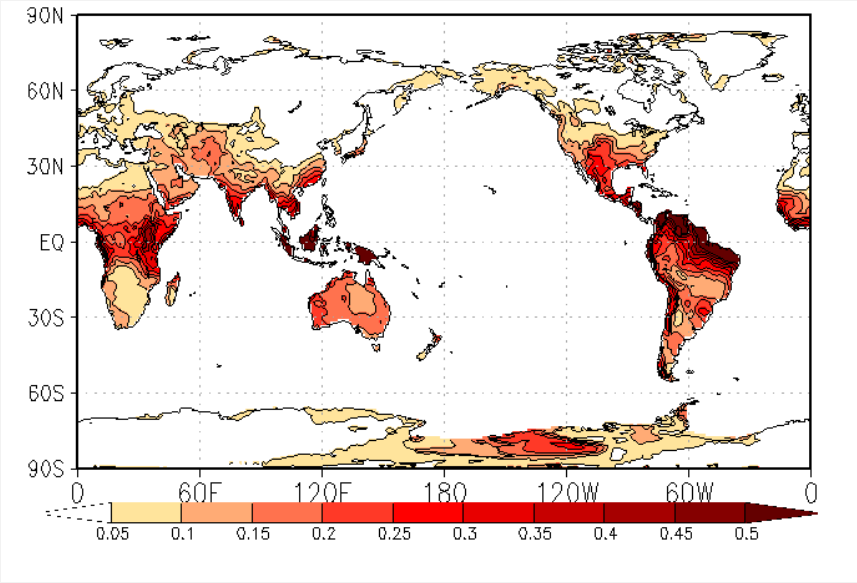
An initiative of the international WCRP Drought Interest Group

- Advance understanding of drought mechanisms and predictability
- Advance regional climate information and decision support
- Develop an experimental global real time monitoring and prediction

NIDIS & DTF research can be key to advance GDIS



Precipitation Signal/Total Variance



Courtesy of S. Schubert

The DTF Foundations

DTF builds on competitively selected research projects

Advanced meteorological and hydrological prediction systems

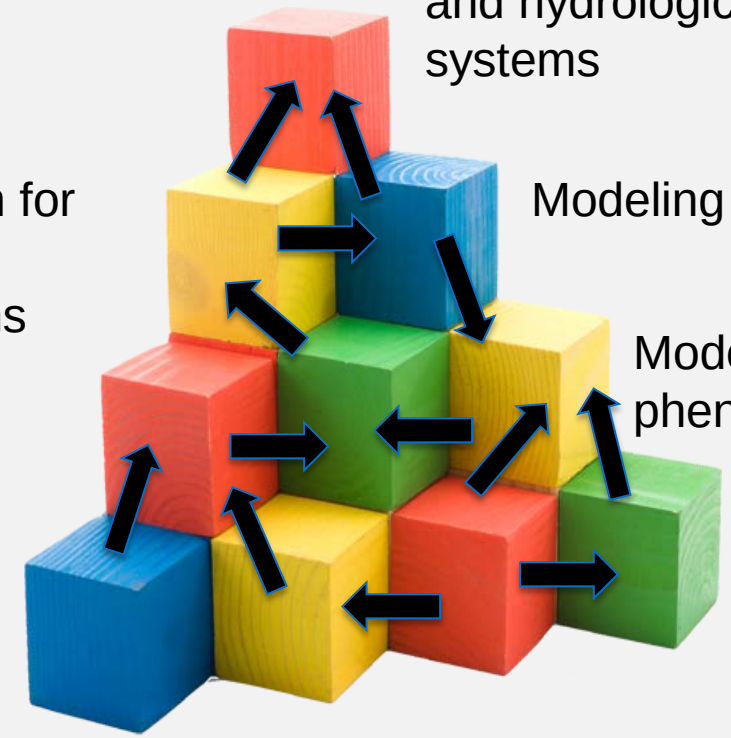
Data assimilation for advanced land-surface depictions

Modeling of hydrologic processes

Modeling of drought phenomena

Land-atmosphere interactions

Understanding Predictability



Cross-cutting Integrative Community Activities

AMS Drought Special Collection
Advancing Drought Monitoring and Prediction

- JHM Special Collection organized by the DTF
- Over 15 individual papers when completed
- A synthesis paper

http://journals.ametsoc.org/page/droughtMonitoring

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Advancing Drought Monitoring and Prediction

Description:

This special collection of the Journal of Hydrometeorology focuses on scientific research to advance the U.S.'s capability to monitor and predict drought, including the development of new data and methodologies. The results presented in this issue represent the outcomes of research in large part funded by NOAA's Modeling, Analysis, Predictions and Projections (MAPP) program, also leveraging other U.S. agencies' investments, and coordinated within the framework of the MAPP Drought Task Force. The collection includes a Synthesis paper that motivates the research, highlights the main results of the various investigations, and summarizes the remaining challenges and research gaps as well as the prospects for new global scale drought monitoring and prediction systems. The collection is divided broadly into papers addressing monitoring and those addressing the prediction problem, but also includes an important focus on improving our understanding of past droughts. The papers provide a state-of-the-practice / state-of-the-science assessment of the modern drought challenge and efforts to understand and manage it.

MAPP
Modeling, Analysis, Predictions, and Projections

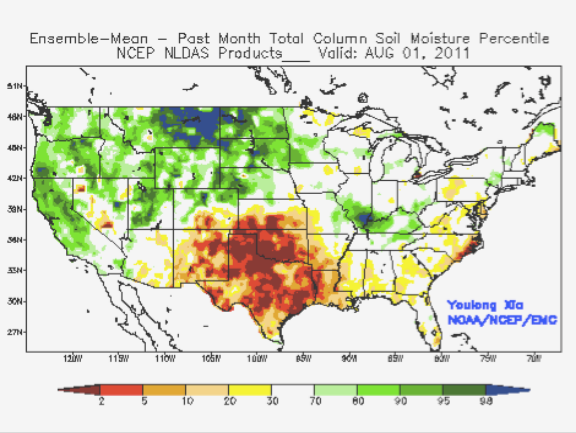
Collection Organizers:

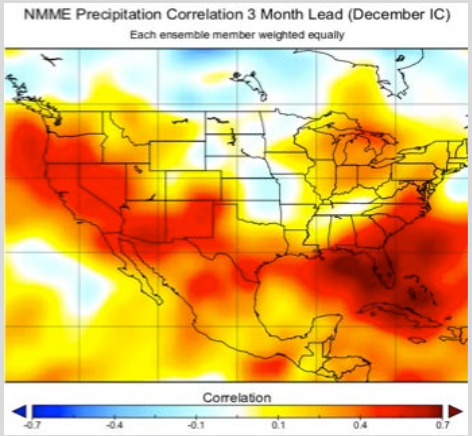
Siegfried Schubert and Kingtse Mo, NASA Goddard Space Flight Center; and Annarita Mariotti, NOAA Climate Program Office

Abstracts for all AMS articles are available to everyone, as is the full text of Bulletin articles. Access to full-text HTML and PDF articles in the technical journals is limited to paid subscribers.

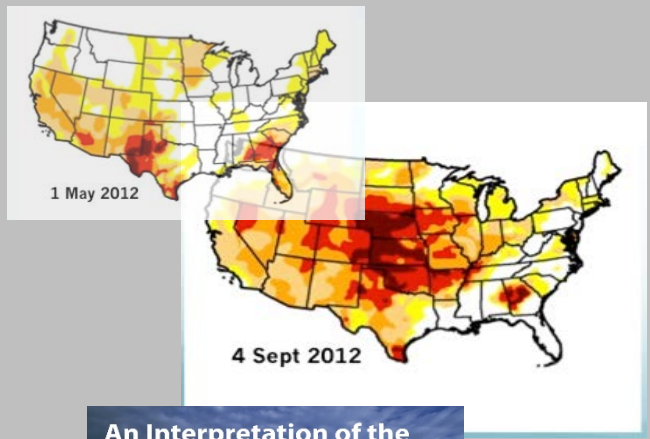
Retrospective Drought Analyses

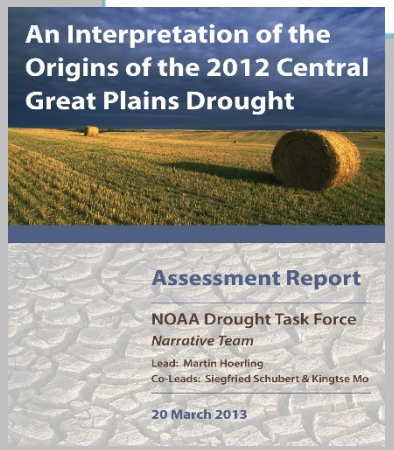
The 2010/2011 Tex-Mex Drought





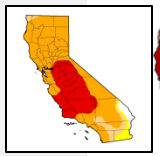
2012 Central Great Plains Drought

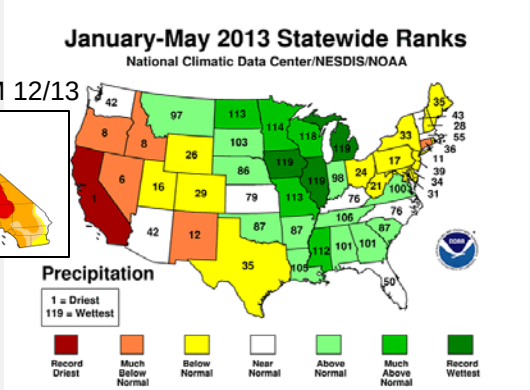




Investigating the 2013 California drought

USDM 12/13

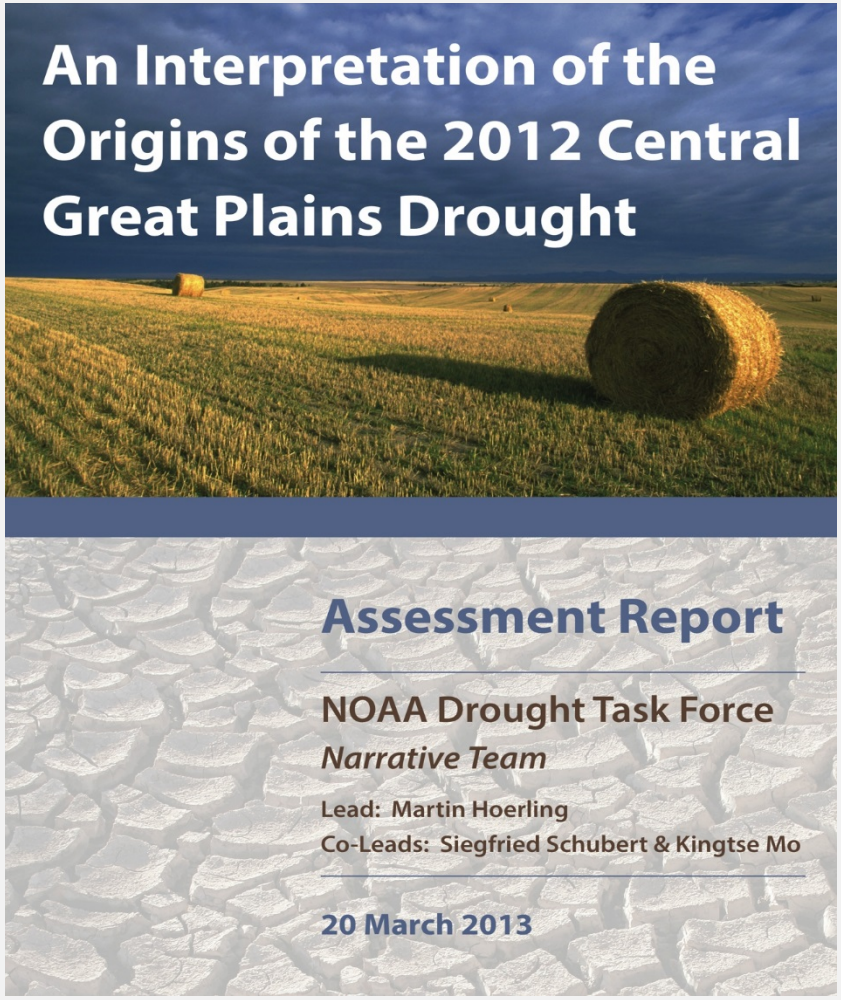




These studies matter to science, they matter to society.

2012 Central Great Plains Drought

A report to explain causes of the drought with the particular goal to better understand the event's predictability.



Who was involved?

Prepared by the **Narrative Team** of NOAA's Drought Task Force in partnership with NIDIS

What caused the 2012 Central Great Plains Drought?

Mostly natural weather variations.

- Moist Gulf of Mexico air failed to stream northward in late spring as cyclone and frontal activity were shunted unusually northward.
- Summertime thunderstorms were infrequent and when they did occur produced little rainfall.

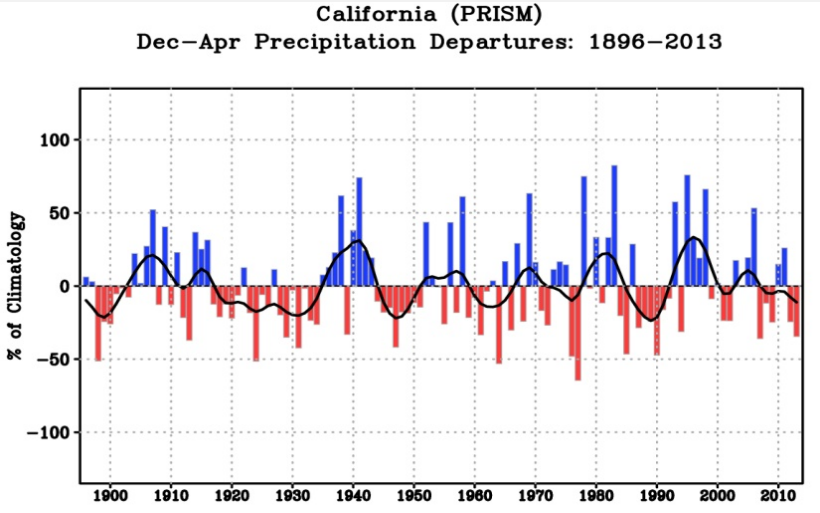
Was it Predictable?

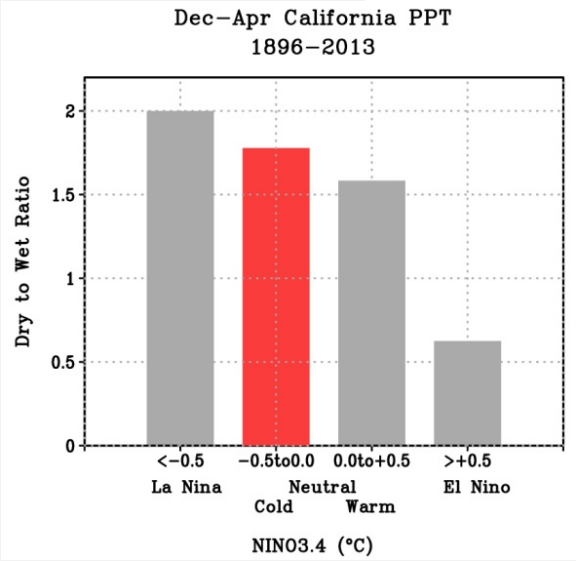
Neither ocean states nor human-induced climate change appeared to play significant roles in severe rainfall deficits, **hence little predictability** (at least in rainfall)

Historical Characteristics of California Rainy Season Variability

How anomalous was the 2012-2013 rainy season in the instrumental record?

What is the typical effect of ENSO on California Precipitation?





Courtesy of M. Hoerling

DTF Work in Progress: 2013 California Drought

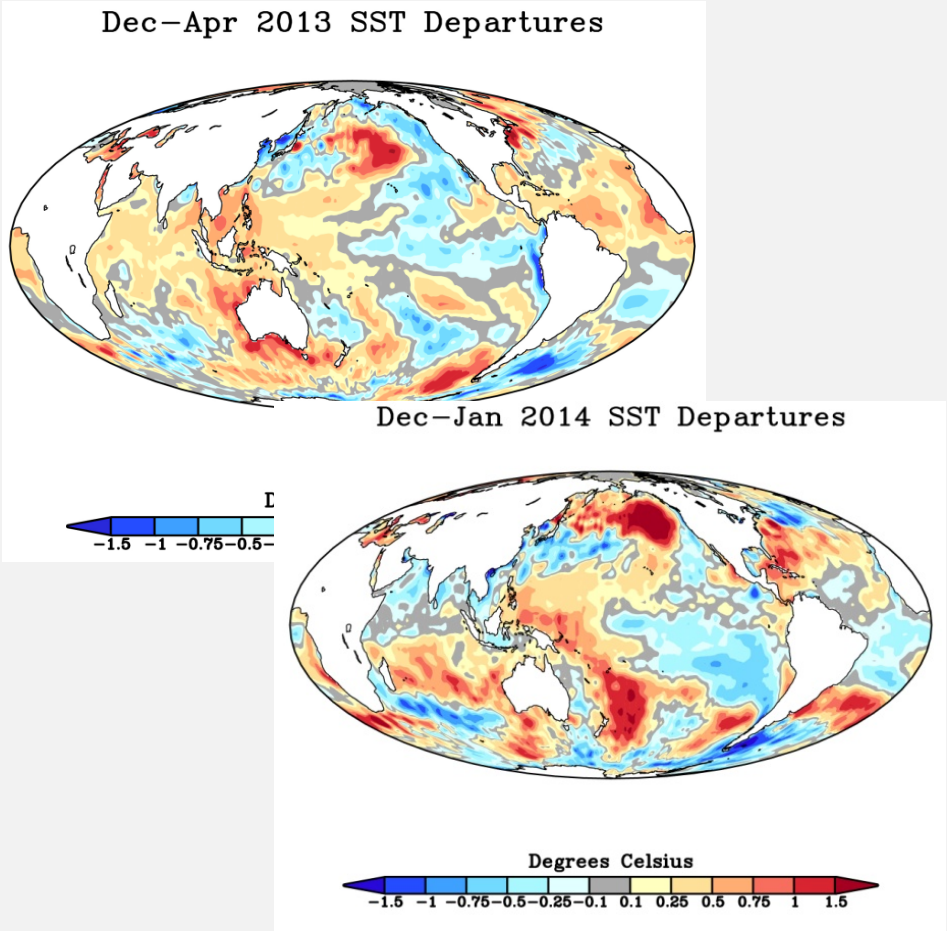
Current Scientific Understanding on Drivers for the Current California Drought

Were global SST anomalies a driver of this drought?

What was the effect of atmospheric variability on the drought?

What are the implications for predictability?

What are the open research questions?

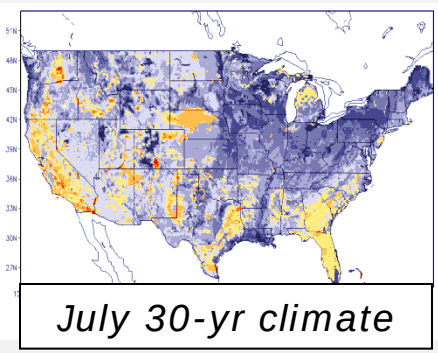


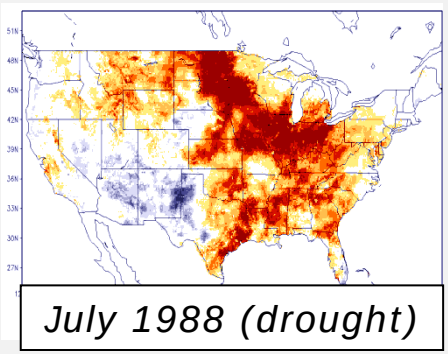
A report and peer reviewed publications in preparation..

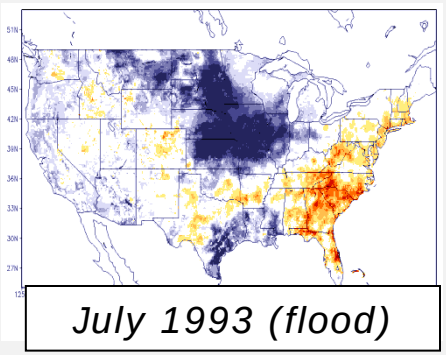
Advancing Drought Monitoring

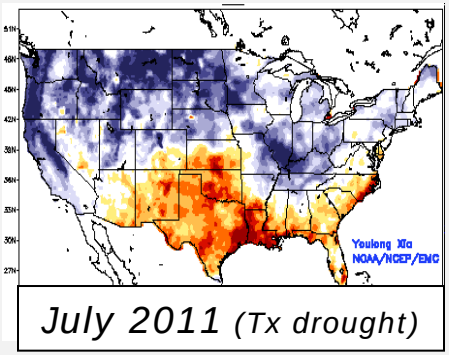
Objective Drought Monitoring with the North American Land Data Assimilation System (NLDAS)

- NLDAS objective anomalies used for drought monitoring
- An input to the USDM
- Current research: higher resolution, land model upgrades, improved precipitation and temperature inputs, snow and soil moisture assimilation, converting to US Drought Monitor drought categories



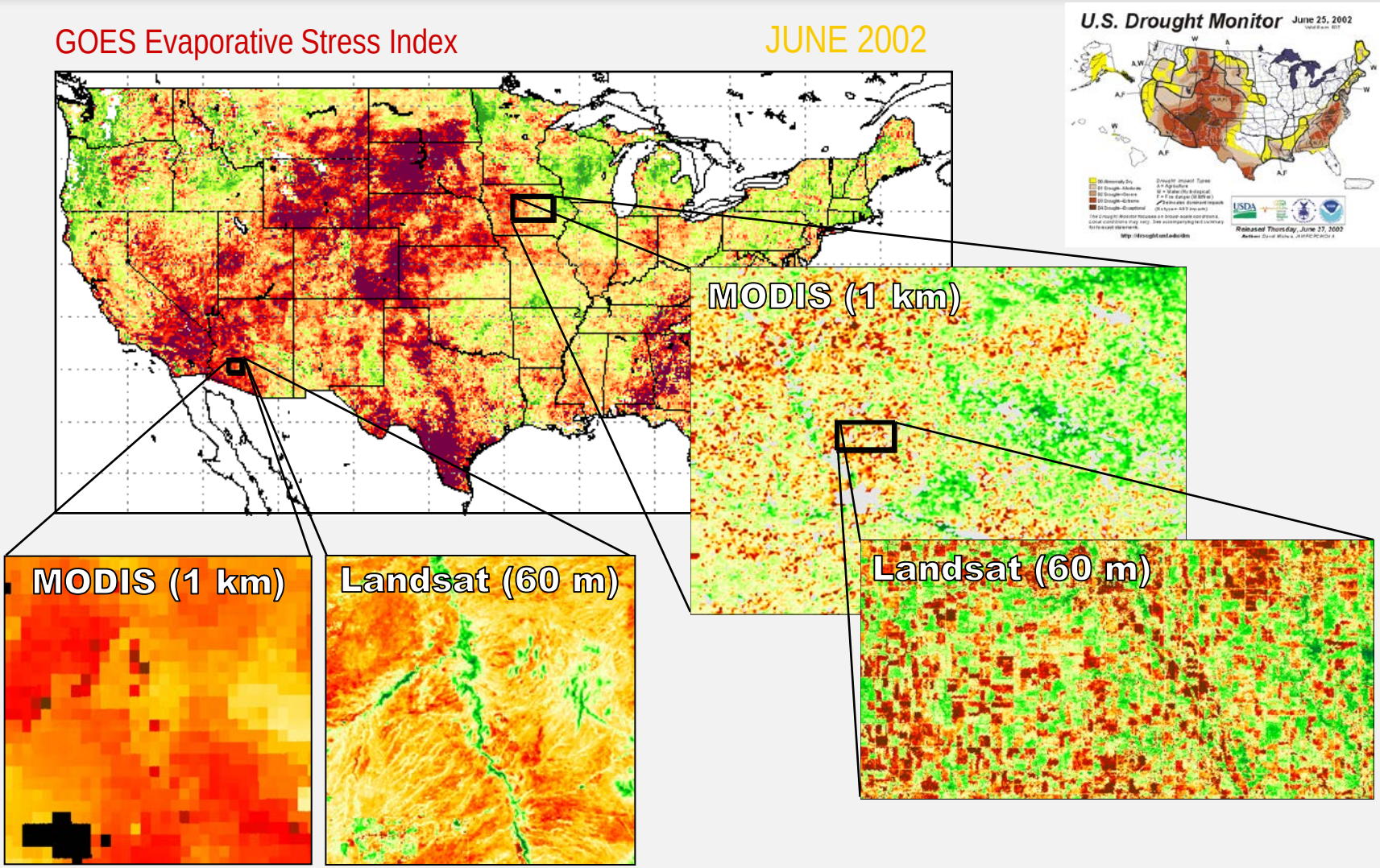






NLDAS four-model ensemble monthly soil moisture anomaly.
Courtesy of Mike Ek, info at www.emc.ncep.noaa.gov/mmb/nldas

Drought Monitoring Using Remote Sensed Data



High resolution drought mapping

With higher resolution thermal IR imagery from e.g. MODIS and Landsat, we can potentially determine how the GOES-scale stress signal is distributed over subpixel land-classes.

Courtesy of M. Anderson

Experimental Drought Prediction

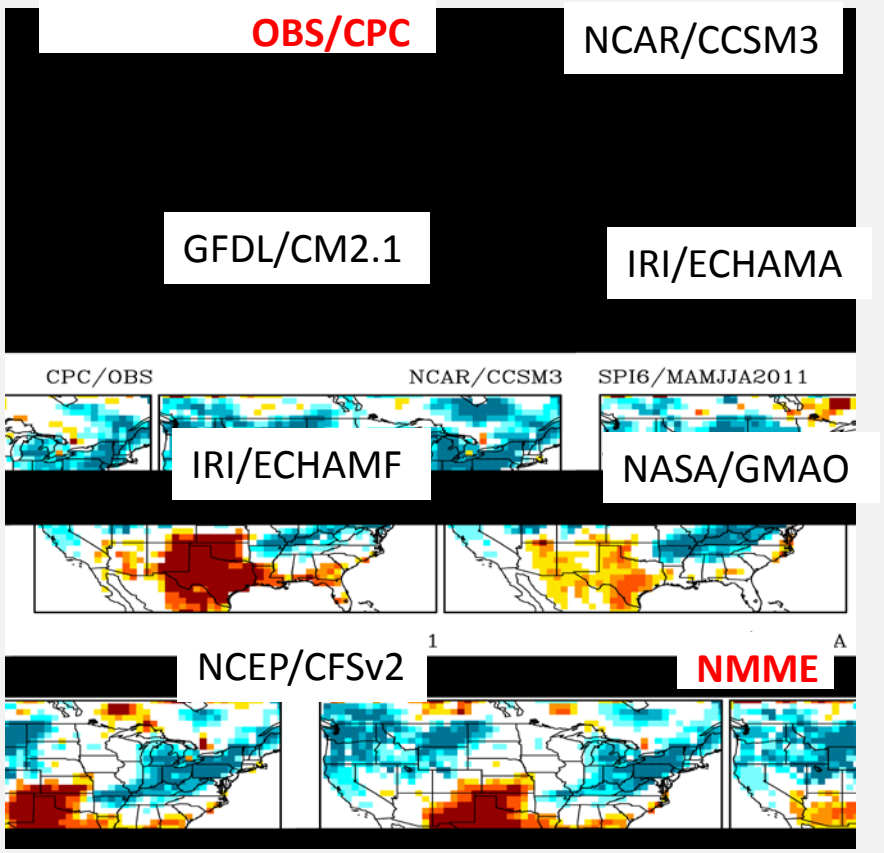
Drought Prediction using the National Multi-Model Ensemble (NMME) System

NMME is broad NOAA-led multi-institutional interagency-funded Climate Test Bed research project

- Running experimentally in an operational mode;
- Used for research, including experimental SPI prediction

NMME allows better sampling of uncertainties in forecasts

SPI6 for 2011 MAMJJA

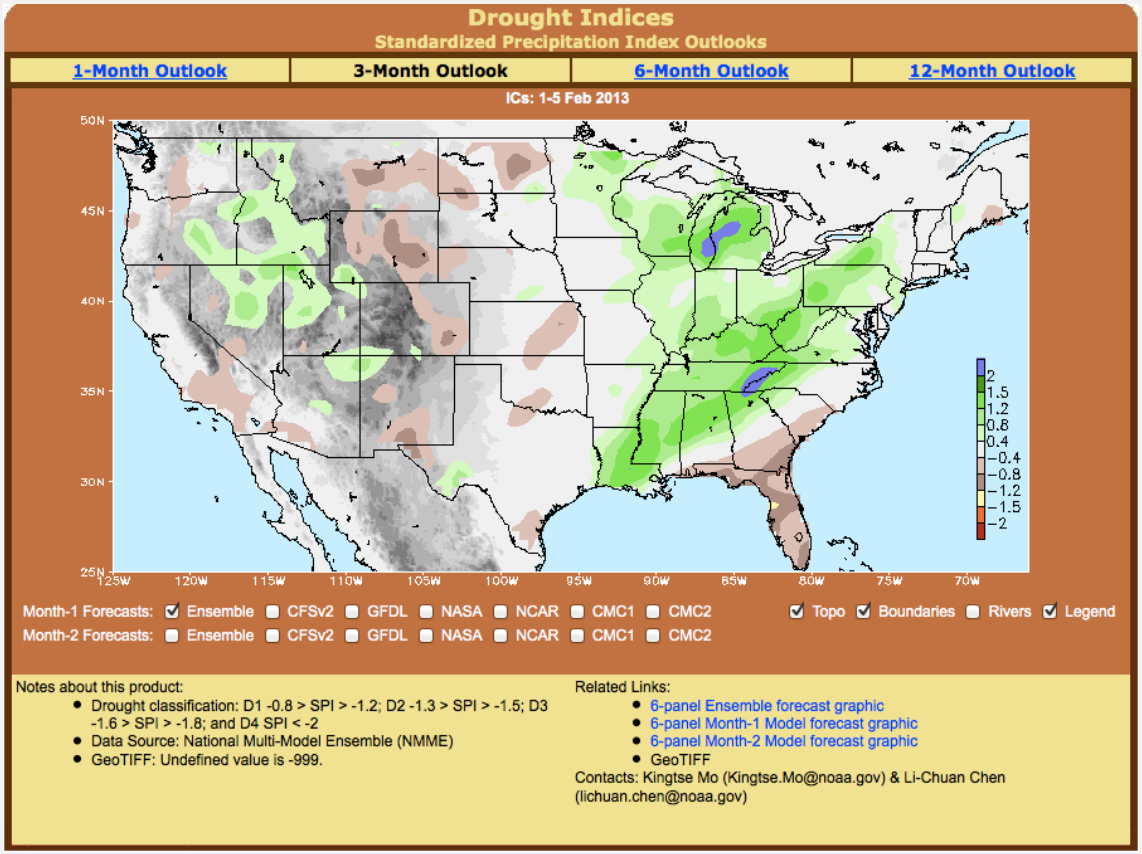


Prior 3-month (MAM) observation with current (JJA) 3-month forecast. Courtesy of E. Wood.

NMME-based Drought Products at NCEP

- Experimental NMME forecasts already used as part of NOAA's drought forecasts
- An input for the US Drought Outlook

Courtesy of Kingtse Mo and Lichuan Chen

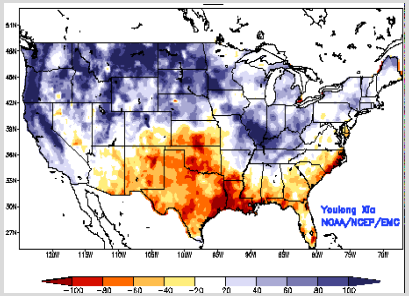


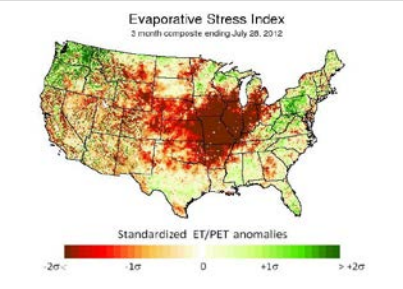
www.cpc.ncep.noaa.gov/products/Drought/Monitoring/spi_outlooks.shtml

DTF Evaluations

A DTF Drought Assessment Protocol—Need a community to agree on standards

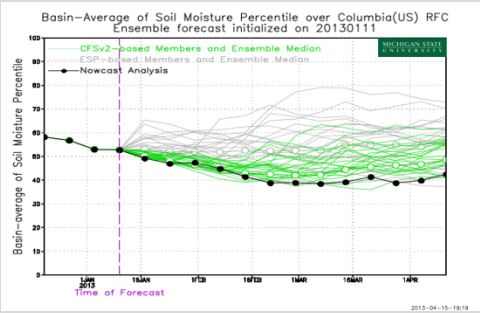
Drought Monitoring





A report in preparation on experimental systems and their evaluation

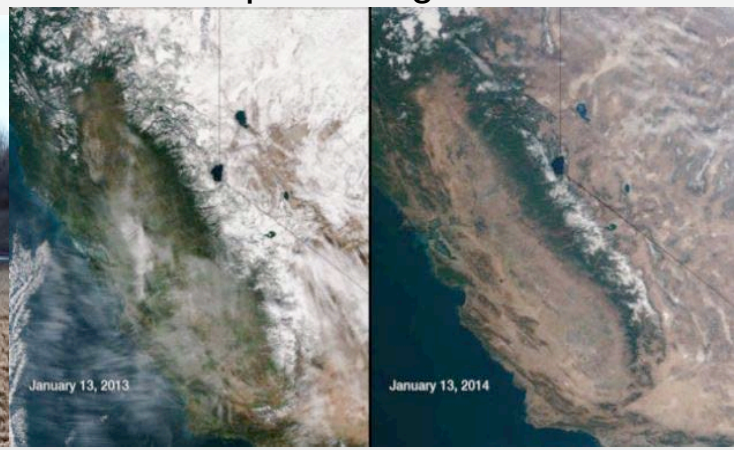
Dynamical predictions



Opportunities for Further Progress

- Improving understanding of drought processes and predictability
- Developing objective monitoring systems that leverage on assimilation of new/improved data and different methodologies to deliver higher resolution/more accurate land depictions.
- Developing probabilistic drought predictions that better exploit predictability, better represent drought evolution
- Continue to work collaboratively as part of the NOAA DTF

www.cpo.noaa.gov/MAPP/DTF



National Integrated Drought Early Warning System (NIDIS)

"An early warning system is much more than a forecast - it is a linked risk information …and communication system that actively engages communities involved in preparedness. "

Pulwarty and Sivakumar, 2014

NIDIS

NATIONAL INTEGRATED DROUGHT INFORMATION SYSTEM

The Approach

- Sustained foundational research investments
- Coordination & collaboration among relevant research efforts
- Strong coordinated connections with the user community through the NIDIS network

The Approach

…to be effective, new knowledge and information has to be undertaken in context, tied to institutional realities and resources and accessible to the public.

- Interdisciplinary
- Actionable
- Adaptive

Photos. NPR, climate.gov

If environment is changing:

Government/community:

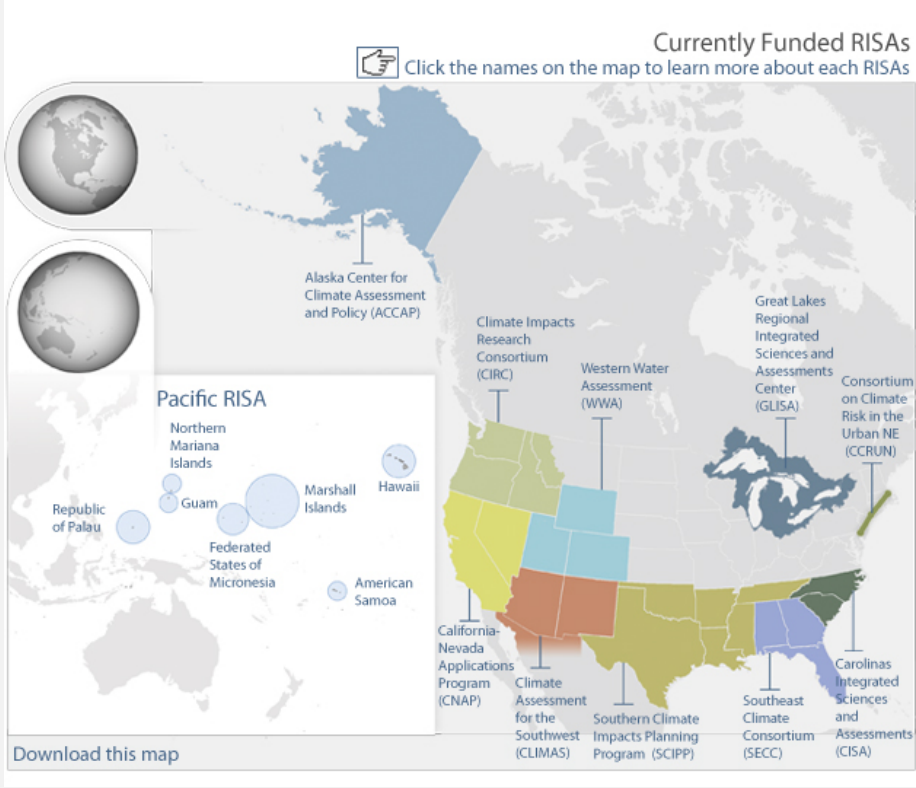
Research Program	KEEPS GOAL SAME	CHANGES GOAL
REMAINS THE SAME	Degradation	Symbolic gesture, Passive acceptance
CHANGES	*Post-event Adjustment*	***Adaptation & Innovation***

Coping with Drought Research -- RISA

Regional Integrated Sciences and Assessment (RISA) teams

1. Understand context

2. Develop knowledge on impacts, vulnerabilities, and response options;



1. Innovate products, tools, services

2. Test diverse governance structures for managing scientific research

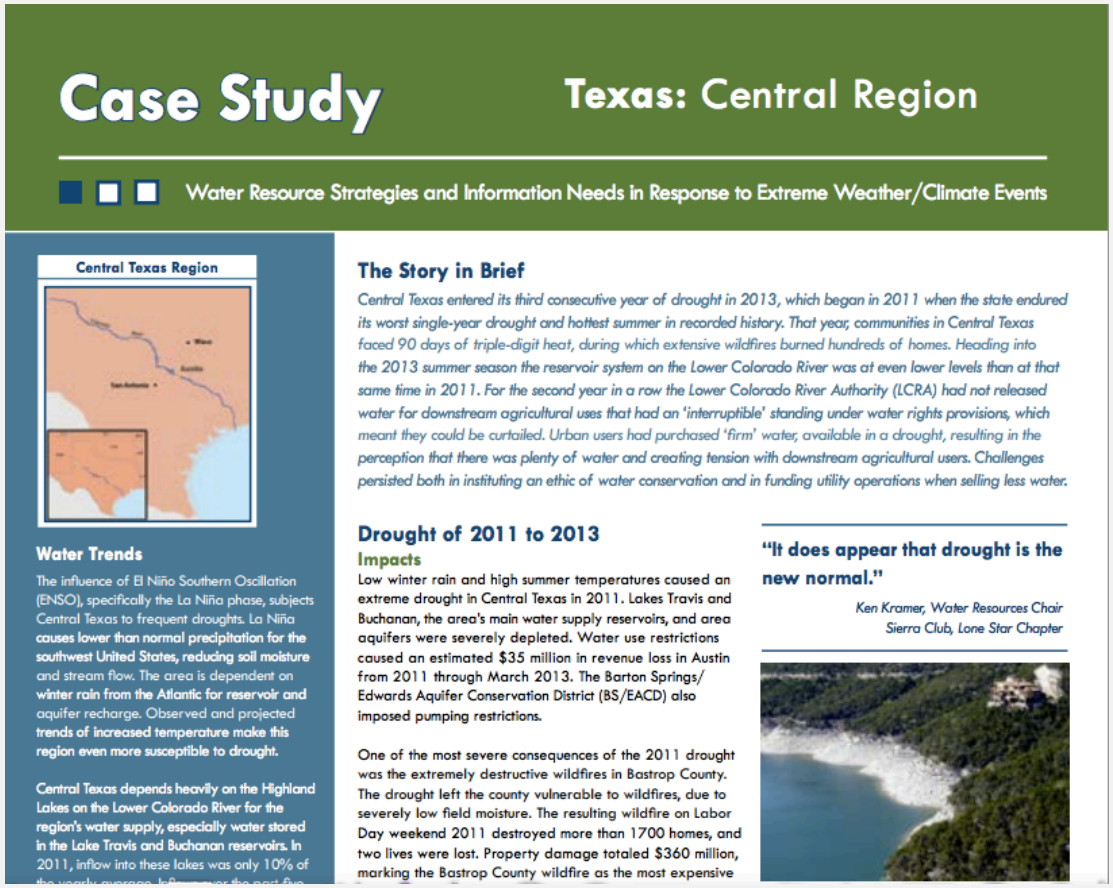
Coping with Drought Research- RISA

- What accounts for vulnerability?
- Who feels the impacts and what will we learn by improving monitoring and documentation of impacts?
- How might risks shift as the climate changes?
- What are the sources of data that are reliable, available, trusted?

Sectoral Applications Research Program (SARP): Project-based

- Characterizing **risk perceptions**;
- assessing **drought's economic impacts** and building tools for producing drought **risk scenarios** (e.g., water supply analysis); and
- Identifying how to **increase adaptive capacity** (e.g., building water treatment plants on higher ground as water levels will rise with rising sea levels).

Workshops and case studies on community planning for managing through extremes



Case Study

Texas: Central Region

Water Resource Strategies and Information Needs in Response to Extreme Weather/Climate Events

Central Texas Region

Water Trends

The influence of El Niño Southern Oscillation (ENSO), specifically the La Niña phase, subjects Central Texas to frequent droughts. La Niña causes lower than normal precipitation for the southwest United States, reducing soil moisture and stream flow. The area is dependent on winter rain from the Atlantic for reservoir and aquifer recharge. Observed and projected trends of increased temperature make this region even more susceptible to drought.

Central Texas depends heavily on the Highland Lakes on the Lower Colorado River for the region's water supply, especially water stored in the Lake Travis and Buchanan reservoirs. In 2011, inflow into these lakes was only 10% of

The Story in Brief

Central Texas entered its third consecutive year of drought in 2013, which began in 2011 when the state endured its worst single-year drought and hottest summer in recorded history. That year, communities in Central Texas faced 90 days of triple-digit heat, during which extensive wildfires burned hundreds of homes. Heading into the 2013 summer season the reservoir system on the Lower Colorado River was at even lower levels than at that same time in 2011. For the second year in a row the Lower Colorado River Authority (LCRA) had not released water for downstream agricultural uses that had an 'interruptible' standing under water rights provisions, which meant they could be curtailed. Urban users had purchased 'firm' water, available in a drought, resulting in the perception that there was plenty of water and creating tension with downstream agricultural users. Challenges persisted both in instituting an ethic of water conservation and in funding utility operations when selling less water.

Drought of 2011 to 2013

Impacts

Low winter rain and high summer temperatures caused an extreme drought in Central Texas in 2011. Lakes Travis and Buchanan, the area's main water supply reservoirs, and area aquifers were severely depleted. Water use restrictions caused an estimated $35 million in revenue loss in Austin from 2011 through March 2013. The Barton Springs/Edwards Aquifer Conservation District (BS/EACD) also imposed pumping restrictions.

One of the most severe consequences of the 2011 drought was the extremely destructive wildfires in Bastrop County. The drought left the county vulnerable to wildfires, due to severely low field moisture. The resulting wildfire on Labor Day weekend 2011 destroyed more than 1700 homes, and two lives were lost. Property damage totaled $360 million, marking the Bastrop County wildfire as the most expensive

"It does appear that drought is the new normal."

Ken Kramer, Water Resources Chair
Sierra Club, Lone Star Chapter

Sponsored by:

- NOAA
- EPA
- Water Research Foundation
- Water Environment Research Foundation (WERF)
- Concurrent Technologies Corp. (CTC)
- Noblis

Central Texas: 2011- 2013:

Lessons learned:

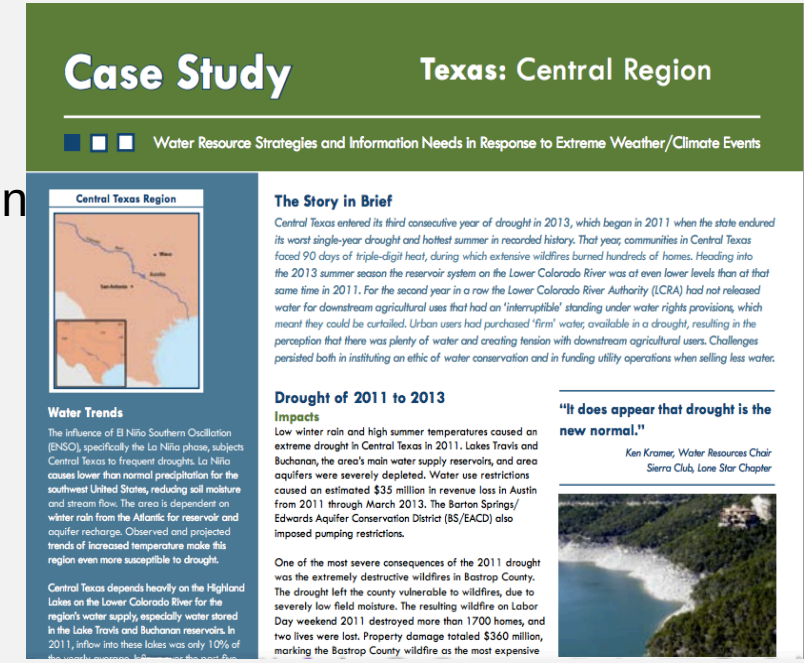
- Acquifer storage and recovery
- Addressing secondary and tertiary effects of drought requires collaboration
- Water conservation is often confused with drought management….

Tools and Resources:

- US EPA Climate Ready Water Utilities
- TX WARN – www.txwarn.org
- LCRA – www.lcra.org
- USGS Water Resources Home Page…

Information Needs:

- Studies evaluating socio-econ impact
- Analysis of reservoirs
- Guidance for structuring water rates
- Monitoring to support adaptive management



Case Study

Texas: Central Region

Water Resource Strategies and Information Needs in Response to Extreme Weather/Climate Events

Central Texas Region

Water Trends

The influence of El Niño Southern Oscillation (ENSO), specifically the La Niña phase, subjects Central Texas to frequent droughts. La Niña causes lower than normal precipitation for the southwest United States, reducing soil moisture and stream flow. The area is dependent on winter rain from the Atlantic for reservoir and aquifer recharge. Observed and projected trends of increased temperature make this region even more susceptible to drought.

Central Texas depends heavily on the Highland Lakes on the Lower Colorado River for the region's water supply, especially water stored in the Lake Travis and Buchanan reservoirs. In 2011, inflow into these lakes was only 10% of

The Story in Brief

Central Texas entered its third consecutive year of drought in 2013, which began in 2011 when the state endured its worst single-year drought and hottest summer in recorded history. That year, communities in Central Texas faced 90 days of triple-digit heat, during which extensive wildfires burned hundreds of homes. Heading into the 2013 summer season the reservoir system on the Lower Colorado River was at even lower levels than at that same time in 2011. For the second year in a row the Lower Colorado River Authority (LCRA) had not released water for downstream agricultural uses that had an 'interruptible' standing under water rights provisions, which meant they could be curtailed. Urban users had purchased 'firm' water, available in a drought, resulting in the perception that there was plenty of water and creating tension with downstream agricultural users. Challenges persisted both in instituting an ethic of water conservation and in funding utility operations when selling less water.

Drought of 2011 to 2013

Impacts

Low winter rain and high summer temperatures caused an extreme drought in Central Texas in 2011. Lakes Travis and Buchanan, the area's main water supply reservoirs, and area aquifers were severely depleted. Water use restrictions caused an estimated $35 million in revenue loss in Austin from 2011 through March 2013. The Barton Springs/Edwards Aquifer Conservation District (BS/EACD) also imposed pumping restrictions.

One of the most severe consequences of the 2011 drought was the extremely destructive wildfires in Bastrop County. The drought left the county vulnerable to wildfires, due to severely low field moisture. The resulting wildfire on Labor Day weekend 2011 destroyed more than 1700 homes, and two lives were lost. Property damage totaled $360 million, marking the Bastrop County wildfire as the most expensive

"It does appear that drought is the new normal."

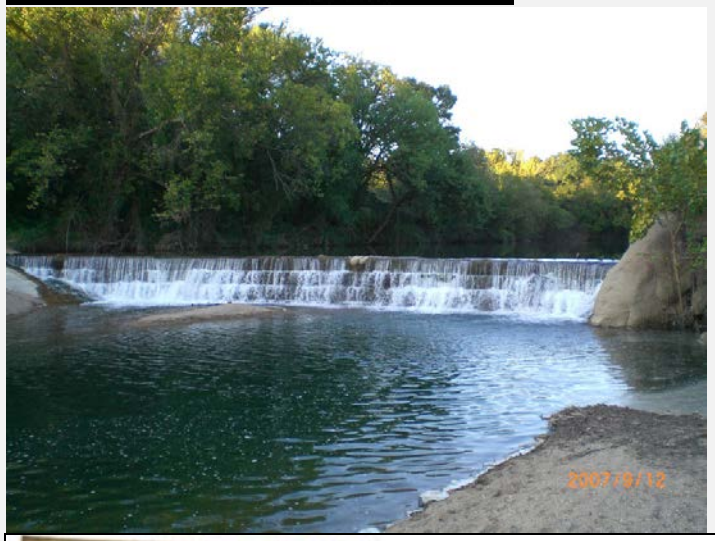
Ken Kramer, Water Resources Chair Sierra Club, Lone Star Chapter

Arbuckle-Simpson Aquifer: Water Decisions- SARP Project/

How much groundwater can be extracted to "*not reduce the natural streamflow?*"

- How do stakeholders **perceive drought risks across weather and climate scales**, and how do these perceptions guide water management decisions (preferences)
- Taking research results to the development of **early warning**

(Heather Lazarus, et al, NCAR)



A slice of the drought research network…

Managing participation, sustain information; stimulating innovation; building tools for evaluation – foundations for regional drought early warning

National Climate Assessment – 2014

Key Findings – Great Plains:

Rising temperatures are leading to increased demand for water and energy. In parts of the region, this will constrain development, stress natural resources, and increase competition for water among communities, agriculture, energy production, and ecological needs.

- Aligning federal drought policies across the federal government…..
- Build on existing efforts across the federal government with states, Tribes, and communities
- Linking information to drought preparedness strategies in critical sectors (agriculture, municipal water, energy, recreation, tourism, transportation

Summary

Climate interacts with existing social and environmental stresses

How we can do better at connecting early warning with early action?

- What is the quality of information available to decision-makers at all levels?
- What factors influence whether or not such information will be used?
- What governance structures may facilitate better decision-making practice?
- How to adapt the decision-making systems to the different levels of decision makers?

Are We Better Off?

- The number of states and institutions with improved capacity to inform risk management and reduce exposure to drought and flood risks
- The number of staff in or working with those institutions trained to develop and communicate local drought information and help reduce impacts
- The number of research projects that conduct and update drought impacts and user needs assessments in drought-sensitive parts of the US and
- The percentage of the U.S. population covered by adequate drought risk and early warning information systems

Take away messages

- Research to support knowledge and action with respect to climate variability and change is a long-term, iterative process that requires coordination and collaboration across networks.

- Integration, assessment, communication are critical throughout

- The benefits of participation in design, implementation and communication are substantial

- ….Better risk management strategies are essential for adaptation as climate changes over the long term