# NIDIS ANNUAL REPORT





### **THE DROUGHT CRISIS**

From New Hampshire to New Mexico, drought's impacts can be diverse and devastating, made worse by a changing climate.

Water users, agricultural producers, natural resource managers, planners, and others must be able to assess the risks of drought before its onset to make informed decisions and implement effective mitigation measures.

We're on a mission to make that happen.

Drought conditions set the stage for the Alameda Wildfire in Phoenix, Oregon, which destroyed more than 2,600 homes, September 2020. Credit: arboursabroad

Cover: Looking north up at the start of the foothills in front of the Flatirons in summer. Boulder, Colorado. Credit: Charles Goudy

### **OUR MISSION**

NIDIS's mission is to maximize the nation's ability to proactively manage drought-related risks, by providing those affected with the best available information and resources to assess the potential for drought and to better prepare for, mitigate, and respond to the effects of drought.

Toward that end, NIDIS is creating a drought early warning system for the nation.

Boulder, Colorado is the home of NIDIS and NOAA's Earth System Research Laboratories. Credit: Takahashi Outdoors



#### LETTER FROM THE DIRECTOR

Each year, NIDIS makes its impact through critical investments in drought forecasting, monitoring, planning, interdisciplinary research, and public awareness to build an effective drought early warning system for the country.

In 2021, during another difficult year for drought across the West, the results of these investments were on display, bringing vital response resources to drought impacted communities. We relaunched the U.S. Drought Portal in January, kicking off a year marked by enhanced access to localized, action-

able drought information. In February, NIDIS released findings from the successful Flash Drought Workshop and identified several near-term priorities for researchers and decision-makers in flash drought-prone areas. With partners across NOAA's National Weather Service and National Centers for Environmental Information, as well as the USDA Climate Hubs, Regional Climate Centers, State Climatologists, and others, we released timely early warning announcements including alerts that were sent to 40,000 water rights holders across California. These regionally coordinated drought messages throughout the year helped decision makers, the media, and the public understand local conditions, forecasts, impacts, and relevant research and resources.

In June, we proudly released a Strategy for the National Coordinated Soil Moisture Monitoring Network, a multi-agency effort that will strengthen extreme weather early warning systems, improve flood and drought forecasts, and strengthen climate models. In July, NIDIS joined with our federal, state, tribal, and local partners to host a drought webinar specifically for western communities and featuring perspectives from those on the ground responding to worsening drought conditions. And in September, we hosted a 4-day Southwest Drought Forum, focused on long-term implications of drought in the Southwestern United States. We rounded out the year with the launch of an ACF River Basin Drought and Water Dashboard, delivering upon our 2019 reauthorization mandate to deliver localized and watershed scale drought information. The year ahead does not appear to offer respite from the need for these services, but NIDIS and our partners are well positioned to meet the challenges ahead.

I want to end on a personal note. As 2021 came to a close, the most destructive wildfire in Colorado history tore through the Boulder suburbs of Louisville and Superior where many of our staff and colleagues live. While we still don't know what caused the fire, a warm and dry summer contributed to ideal conditions for wildfire. We are still grappling with the after effects of this terrible event in our own backyard, but we are built up each day by our work to deliver earlier warnings of drought and to raise awareness of its impacts. This work gives us resolve and strength. Thank you to our incredible network of partners for making this mission possible.

Sincerely,

Veva Deheza Executive Director NOAA NIDIS



### OUR PARTNERS & THE PUBLIC MADE THIS POSSIBLE IN 2021...



Our Regional Drought Early Warning Systems (DEWS) served 38 states and 13,920 stakeholders through webinars, workshops, and email communications.



We funded and managed 47 research projects and resources to advance drought science and preparedness across the nation.

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Our award-winning website, *drought.gov*, served 1.25 million users who viewed over 3.45 million pages seeking to get the latest drought conditions, outlooks, and impacts.

*Drought.gov* was used by 127 local and national media outlets in their reporting.

More than **3,000** people signed up to receive drought email alerts

NIDIS Twitter impressions numbered 8.8 million, and our Twitter community grew to more than 10,000 followers.

Our Facebook community passed **2,000** friends.

We held 88 webinars and virtual workshops, delivering the latest drought updates and research to thousands of viewers.

The Western Drought Crisis Webinar in July was viewed by 1,439 people, including 745 who watched it live and another 694 who viewed the recorded version on YouTube.

More than 4,000 subscribers received each issue of Dry Times, our bi-weekly newsletter.



### **BUILDING A NATIONAL DROUGHT EARLY WARNING SYSTEM**

The 2006 NIDIS Public Law prescribed a comprehensive, interagency approach for drought monitoring, forecasting, and early warning planning and preparedness to help states and local communities cope with the impacts of drought.

It called on NIDIS to develop and provide a national drought early warning system (DEWS). Given the diversity of drought impacts, predictability, and stakeholder needs across the Nation, and the need to leverage the capabilities of partner agencies on the ground, NIDIS has, since its inception, taken a regional approach. Around the country, eight regional DEWS:

- Support rich networks of researchers, academics, resource managers, and decision-makers who share information and actions that help communities cope with drought;
- Integrate five key components of a drought early warning information system: interdisciplinary

research and applications; predictions and forecasting; observations and monitoring; planning and preparedness; and communication and outreach;

• Advance the provision of drought early warning information and science-based drought decision support tailored to the region's unique characteristics and needs.

Today, each regional DEWS has been supported by a multi-year strategic plan that identifies how it can further facilitate not only drought information delivery but also action to reduce the impacts of drought.



▲ Map of regional Drought Early Warning Systems (DEWS). Credit: NOAA NIDIS, Fiona Martin As these 8 regional networks have grown and trusted partnerships have deepened, common stakeholder priorities and best practices across the regional DEWS have emerged, which have informed the launching

of several national-level initiatives that cross boundaries, hazards, and disciplines. These programs and key activities have been designed to build out the national DEWS, including:

- The NIDIS Drought and Wildland Fire Nexus Strategy
- The National Coordinated Soil Moisture Monitoring
   Network Strategy

- The NIDIS Tribal Drought Engagement Strategy
- Flash Drought Initiative: 2017 Northern Plains Drought Assessment, 2020 Flash Drought Workshop
- Megadrought: 2021 Southwest Drought Forum, 2021 NOAA Modeling, Analysis, Predictions, and Projections (MAPP) Drought Task Force
- Drought and Private Sector Engagement: 2019 National Drought Forum, Climate Engine
- Drought and Human and Public Health Initiative
- The Coping with Drought Grant Applied Research Competitions
- A Redesigned U.S. Drought Portal (*drought.gov*)



The implementation of these national-level initiatives and many other recent milestones mark a new phase in the growth of NIDIS; what started as a small program with burgeoning regional pilots in 2006 is now maturing into a fully national drought early warning information system. Achieving national coverage will require additional resources to build out new regional DEWS and tailor exist-**Observations** and Monitoring ing tools and products to the unique decision contexts of those regions. But today, NIDIS imple-Planning and Drought Preparedness ments national-level Early initiatives within eight Warning successful regional DEWS. System Today, anywhere across the country, any individual can visit **Prediction and** Communication *drought.gov* to find actionable, and Outreach Forecasting shareable drought early warning information by city, county,

state, and zip code, as well as sign up to receive regular, up-to-date local drought information alerts. The completion of a fully operational national drought early warning system is fundamental to creating a more drought-ready and resilient nation. Through continued investment, transformational improvements in drought monitoring, forecasting, planning, and research will help reduce drought's catastrophic economic, wildfire, health, and environmental impacts across the country.

> ◄ Components of the Drought Early Warning System (DEWS). Credit: NOAA NIDIS

#### **Early Warnings in Action**

#### **Drought Alert Emails**

NIDIS drought email alerts provide up-to-date local drought information right to your inbox. Since the launch of the new *drought.gov* at the beginning of 2021, NIDIS has partnered with NOAA's National Centers for Environmental Information (NCEI) to deliver these alerts with the latest changes to local U.S. Drought Monitor conditions. NIDIS and NCEI also expanded this climate service in 2021 by providing information on the latest drought outlooks from the National Weather Service Climate Prediction Center.





#### **Drought Outlook Products**

NIDIS and the National Weather Service Climate Prediction Center (CPC) are teaming up to improve CPC drought outlook products and services by improving the current deterministic drought outlooks and developing new probabilistic drought outlooks. Improved drought outlooks will provide national and regional users with authoritative official operational forecasts for drought conditions at the lead times of up to 6 months. They will also inform and enhance the existing NIDIS DEWS by facilitating more timely decision making to prepare for and mitigate drought related impacts and costs.

#### **Drought Status Updates and Webinars**

NIDIS works with state climatologists and federal partners to issue Drought Early Warning Updates sent to thousands of stakeholders in each regional DEWS facing drought. These updates communicate potential areas of concern for drought development and/or expansion based on recent conditions and the upcoming forecast. NIDIS and partners also host a very popular regional webinar program to provide stakeholders with timely information on current and

developing drought conditions, as well as discussions on drought impacts on wildfires, water supplies, ecosystems, and high precipitation events as well as impacts to sectors like agriculture, tourism, and public health.

#### **Drought Indicators**

NIDIS works with state climatologists and federal partners to issue Drought Early Warning Updates sent to thousands of stakeholders in each regional DEWS facing drought. These updates communicate potential areas of concern for drought development and/or expansion based on recent conditions and the upcoming forecast. NIDIS and partners also host a very popular regional webinar program to provide stakeholders with timely information on current and developing drought conditions, as well as discussions on drought impacts on wildfires, water supplies, ecosystems, and high precipitation events as well as impacts to sectors like agriculture, tourism, and public health.



# NIDIS LAUNCHES A NEW DROUGHT.GOV

NIDIS launched the redesigned U.S. Drought Portal (*www.drought.gov*) in 2021 to better serve stakeholders, decision makers, the media, and the public.

The new website, developed in collaboration with NOAA's National Centers for Environmental Information, features updated content and new interactive architecture designed to provide actionable, shareable information and easy-to-understand graphics describing current drought conditions and forecasts by city, county, state, zip code, and at watershed to global scales. The Drought Portal also aggregates and presents drought impact data for economic sectors such as agriculture, energy, water utilities, and recreation using interactive maps and data that don't exist anywhere else.

"The new state-of-the-art U.S. Drought Portal provides numerous decision support resources to enable communities and economies across the United States in efforts to strengthen their resilience to drought," said Veva Deheza, Executive Director of NIDIS. "Whether you are looking for current drought conditions in your county or needing to make water management decisions during a drought, the new U.S. Drought Portal is designed to be a one-stop shop for data, decision-support products, resources and information on drought."

Need to find the latest drought status? Head over to the Data and Maps section, where you can get the latest drought conditions, impacts, and outlooks and as well as drought-related maps for temperature and precipitation, wildfire updates, and soil moisture conditions, and more.

The Portal also has the following four major new features:

• City and county level conditions: Explore current conditions, key indicators of drought, outlooks, forecasts, and historical drought conditions. Local drought data can assist with monitoring drought conditions at greater levels of granularity and evaluating local mitigation measures.

#### Screenshot of drought.gov. Credit: NOAA NIDIS

- Historical data and maps: View
   U.S. Drought Monitor data going back 20 years, standardized precipitation index (SPI) data going back 125 years, and paleoclimate data (e.g., from tree-ring analysis) going back 2,000 years. These data sets allow you to compare historical and current conditions even at the county level. By looking back at historical data, communities can get a better understanding of the drought and extreme weather threats to plan for and to be prepared for.
- Sector impacts: Explore drought impacts in a new comprehensive resource of economic sector data, such as agriculture, energy, water utilities, and tourism and recreation. For example, reductions in snowpack and stream flows directly affect outdoor recreation and tourism snow sports like skiing and snowmobiling, and water sports like boating, rafting, canoeing, fishing, and swimming. The maps in this section display U.S. recreation and tourism attractions currently in drought, including ski areas, national parks, and reservoirs. Additionally, *drought.gov* now provides updated snow drought information, streamflows, information on active wildfires, wildfire outlooks, and more.
- Research and Learn: Go "back to the basics," learn about *flash drought, snow drought*, new NOAA drought research tools like *EDDI* and *LERI*, and initiatives like the *National Coordinated Soil Moisture Monitoring Network*. This section also includes links to ongoing and published NIDIS research designed to help build resilience to drought across the United States.

Many of the maps and data on the new *drought.gov* are pulled from *Climate Engine*. Climate Engine enables users to quickly process and visualize satellite earth observations and gridded weather data for environmental monitoring and to improve early warning of drought, wildfire, and crop-failure risk. Climate Engine is a partnership between the Desert Research Institute, the University of Idaho, and Google, with support from NIDIS and other federal partners. NIDIS is continuing to support the advancement of Climate Engine including exploring the future of cloud computing and data storage for drought decision making and for utilization.



#### Types of Snow Drought

There are two types of snow drought based on the AMS Glossary of Meteorolo

Dry snow drought Below-normal cold-: Warm snow drought A lack of snow accumulation despite nearnormal precipitation, caused by warm temperatures and precipitation falling as rain rather than snow or unusually early snowmel

#### Data, Maps, and Tools

Few drought metrics include storage and release of snow water. Several years of low snowpack, especially across the western U.S., have led to studies examining the causes and impacts of reduced snow storage and seeking a new definition for snow drought.



#### "The new *drought.gov* site is truly transformational."

KYLE BOCINSKY, CROW CANYON ARCHAEOLOGICAL CENTER, DESERT RESEARCH INSTITUTE, MONTANA CLIMATE OFFICE



### CLIMATE-DRIVEN MEGADROUGHT IN THE SOUTHWEST

In February 2022, a study found that the 22-year-long southwest North American megadrought is the region's driest in at least 1,200 years.

Studying the area from southern Montana to northern Mexico, and from the Pacific Ocean to the Rocky Mountains, a *UCLA-led study* discovered that humancaused climate change is responsible for about 42% of the soil moisture deficit since 2000, the paper found. One of the primary reasons climate change is causing more severe droughts is that warmer temperatures are increasing evaporation, which dries out soil and vegetation.

This study builds on previous research on the southwestern megadrought. *A study published in 2020* in the journal *Science* considered data only up to 2018, missing the exceptional dry years of 2020 and 2021. NIDIS is taking a leadership role in alerting the nation to this megadrought as well as delivering the information and resources needed for communities to respond.

#### WESTERN DROUGHT CRISIS WEBINAR

Historic drought conditions across the western U.S. worsened and expanded in 2021 with over 80% of the West in drought by mid-summer, according to the U.S. Drought Monitor. To provide the latest information on drought conditions across the Southwest, California, Pacific Northwest, and the Missouri River Basin, as well as the serious impacts on diverse sectors of the economy, NIDIS joined with federal, state, tribal, and local partners to host a drought webinar in July specifically for western communities.



The webinar featured remarks by senior-level officials from the NOAA, U.S. Department of Interior (DOI), and U.S. Department of Agriculture (USDA), as well as stakeholders, decision makers, and drought experts to provide the latest information on drought conditions, impacts, and response efforts in the Western United States.

The webinar was viewed by 1,439 people, including 745 who watched it live and another 694 who viewed the recorded version on YouTube.

#### SOUTHWEST DROUGHT FORUM

NIDIS hosted a four-day Southwest Drought Virtual Forum in September. The Forum assembled stakeholders, decision makers, and drought experts for a cross-cutting dialogue on worsening drought conditions in the Southwestern United States, and response and relief efforts across levels of government and sectors, with the goal of supporting communities impacted by ongoing water scarcity and building long-term drought resilience in the region.

Key highlights of the Forum agenda included introductory remarks by Dr. Richard Spinrad, NOAA Administrator and keynote addresses from Eric Kuhn, former General Manager for the Colorado River District, and Will Sarni, an internationally recognized thought leader on water strategy and innovation.

On the second day of the Forum, a Federal panel of leaders from NOAA, U.S. Department of the Interior, U.S. Department of Agriculture, U.S. Environmental Protection Agency, and Federal Emergency Management Agency discussed how "New and Innovative Federal Government Initiatives Can Help Decision Making Within the New Paradigm in the Southwest." The panel provided an overview of the Interagency Drought Relief Working Group, established by President Biden to address worsening drought conditions in the West and support farmers, Tribes, and communities impacted by ongoing water shortages, as well as the National Drought Resilience Partnership (NDRP).

Finally, a closing panel offered paths forward for a sustainable and healthy West included perspectives from leaders, including: David Hayes from the Executive Office of the President; Alice Hill from the Council on Foreign Relations; John Fleck from the University of New Mexico; and Bidtah Becker from the Navajo Nation.

#### **MEGADROUGHT WEBINAR SERIES**

NIDIS hosted two webinars in 2020 focusing on the megadrought:

- Impact of Anthropogenic Warming on an Emerging North American Megadrought explored the severe and persistent 21st-century drought in southwestern North America, compared it to medieval megadroughts, and discussed the role of anthropogenic climate change.
- Coping With Megadrought in the Colorado River Basin discussed how water managers are working on ways to adapt to a long-term dry pattern on the Colorado River that looks increasingly like one of the region's millennial megadroughts.

A third NIDS-hosted webinar focused on *a potential megadrought in Texas*. A study, published in *Earth's Future*, found that climate models are robust in projecting drying of summer season soil moisture and decreasing reservoir supplies for both the eastern and western portions of Texas during the 21st century.

#### NIDIS RESEARCH AND RESOURCES ON CLIMATE CHANGE AND THE SOUTHWEST DROUGHT

#### **Study:** *Exceptional Southwest Drought Exacerbated by Human-Caused Warming*

This report by the NOAA *Drought Task Force* found that while precipitation was exceptionally low in the Southwest from 2020–2021, temperatures over the same period were exceptionally warm. These warm temperatures caused both a shortened snow season and the record high vapor pressure deficit (VPD), a measure of how thirsty the atmosphere is, observed between January 2020 to August 2021. Additional increases in VPD from human-caused warming helped make drought more likely. This study was part of NOAA Drought Task Force research, funded by NIDIS through NOAA's Climate Program Office Modeling, Analysis, Predictions, and Projections Program (MAPP). The NIDIS/MAPP long standing partnership is a key part of the NIDIS research agenda.

### **Study:** Climate Change is the Main Driver of Increasing Fire Weather in the Western U.S.

The leading cause of the rapid increase of wildfires over the western U.S. is the rapid increase of surface air vapor pressure deficit, or VPD. This study found that 68% of the increase in VPD is explained by human-caused global



▲ Webinar. Credit: NOAA NIDIS

NOAA Drought Task
 Force Report on the
 2020-2021 Southwestern
 U.S. Drought. Credit:
 NOAA NIDIS

warming. This study was part of NOAA's *Drought Task Force* research.

#### Study: Dry Future Likely Unavoidable for Southwest, But Reducing Greenhouse Gases Can Still Help

This study found that regardless of future levels of greenhouse gas emissions, the warming climate has locked in an elevated risk of intense megadroughts for the Southwest. However, greenhouse gas mitigation measures can still help. The study was sponsored by NIDIS and NOAA's Climate Program Office, and led by NASA's Goddard Institute for Space Studies.

NOAA DROUGHT TASK FORCE

**REPORT ON THE 2020-2021** 

SOUTHWESTERN U.S. DROUGHT

### **Video:** *Living With Drought and Increasing Aridification in the Southwest*

This video includes interviews with people whose livelihoods are impacted by the Southwest drought and how rising temperatures are bringing aridification and a "new normal" to the region. The video was produced by NIDIS and S&D Marketing, with footage provided by Sonya Doctorian.

For more on climate-driven megadrought, visit https://www.drought.gov/ research-spotlight-climate-driven-megadrought



Very heavy smoke and fire glow over Highway 22 in Oregon. Credit: Victoria Ditkovsky

### NIDIS DROUGHT & WILDLAND FIRE NEXUS (NDAWN) STRATEGY

NIDIS, the Western Regional Climate Center, and the Desert Research Institute partnered to form the NIDIS Drought and Wildland Fire Nexus (NDAWN) to identify priorities and actions to improve products and communication in the drought and fire communities.

NDAWN is both a strategy and a network. As a strategy, it defines the needs and challenges of fire managers to effectively utilize drought information and aims to meet those needs and to establish a robust drought and wildland fire decision-support information network. This strategy presents a logical framework to guide how NIDIS investment over the next five years could benefit both wildland firefighters and public health and safety in fire-prone areas of the United States. NDAWN also functions as a network at multiple scales, from sub-regional to national. This multi-tiered approach of direct engagement enables NIDIS and its partners to better understand drought impacts for on-the-ground fire management and identify how drought impacts could be mitigated.

Since 2015, NDAWN has convened 8 regional and subregional workshops, presented to fire practitioners at 8 conferences, and interviewed 15 fire weather forecasters on the impacts of drought on wildfire planning, behavior, and post-wildfire response. Fire managers and planners emphasized a need for increased engagement across agencies and the public on the topic of drought and wildfire. Many of the impacts identified are already present in the absence of drought. However, drought amplifies



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these impacts, and some can transmute into entirely new impacts, both in intensity and consequences.

Below are just a few of the ways that NDAWN is helping to improve products and communication in the drought and fire communities.



#### TOOL DEVELOPMENT: FORECASTS OF NATIONAL FIRE DANGER RATING SYSTEM (NFDRS) FIRE DANGER INDICES

The objectives of this NIDISfunded project are to develop an automated system for subseasonal forecasts for fire danger

indices and relative fire risk metrics that are directly applicable to fire business decision makers and support early warning efforts in wildland fire operations. These forecasts will complement existing outlooks developed by Predictive Services and other outlets. Specifically, these forecasts will help inform geographic areas of heightened fire potential that may warrant additional suppression personnel and fire prevention efforts, as well as other areas where fire risk might be limited that could allow for the use of more managed fire and/or prescribed fire where warranted.

#### SCIENCE & RESEARCH: DROUGHTS, FIRES, AND SNOWPACK IN THE WESTERN U.S.

Our current understanding of the interactions and feedbacks among droughts, fires, and snowpack is still very limited, which hinders accurate predictions and projections of U.S. droughts and related hydroclimatic and socio-economic effects. This project is examining quantitative characteristics and relationships of droughts, fires, and snowpack evolution in the western U.S. based on observations, state-of-the-art models, and mechanisms for drought-fire-snowpack interactions and feedback. The study is part of NOAA Drought Task Force research, funded by NIDIS through NOAA's Climate Program Office Modeling, Analysis, Predictions, and Projections Program (MAPP).

#### SCIENCE & RESEARCH: POST-FIRE RECOVERY

After the wildland fires have been extinguished, the threat of post-fire debris flows and shallow landslides may be of concern for years. Drought conditions inhibiting recovery of soils and vegetation contribute to the potential of post-fire debris flows and landslides. Drought may also



#### Burned cars rest near a destroyed home after the Caldor Fire impacted the community of Grizzly Flats in El Dorado County, California. August 17, 2021. Credit: Jaden Schaul

#### Drought Influences on Post-Wildfire Flooding and Debris Flow Hazard

2 months post-fire



Fig.1: Vegetation recovery following the 2015 Fub.Fire near too Angers's the left was taken two menths after the fire. The right photo shows vegetation necovery 45 months after the fire. For comparison, an unburnt landscape (partially covered in red fire retardand) is seen on the right side of the prominent ridge. Photos by L. McGuire.

45 months post-fire



While there is a strong connection between drought and wildfire in the western United States, how drought influences the post-wildfire environment is less well-understood, especially at shorter (1-3 year) timescales. The hazards posed by post-fire flooding and debris flows in burned landscapes depends on burn severity, underlying geology and topography, and vegetation recovery following the fire. Because vegetation recovery depends on weather and climate conditions, drought may play an important role in controlling the likelihood and magnitude of debris-flow hazards during the recovery process.

impact the success of restoration projects. These impacts need to be understood and incorporated into planning to avoid bad investments and adjust techniques ▲Post-wildfire project: Drought Influences on Post-Wildfire Flooding and Debris Flow Hazard. Credit: NOAA NIDIS

and approaches to improve success rates. To address these issues, NIDIS has funded a project with the Western Regional Climate Center, Desert Research Institute, University of Arizona, and Climate Engine to identify relevant drought and vegetation recovery metrics that can be monitored remotely using data derived from satellites (e.g., Google Climate Engine), to inform how post-fire hazards change with time. single quantitative definition of a RFW, NWS also issues a Fire Weather Watch that can be confused with RFWs, and RFWs are issued so frequently that agencies and the public are becoming numb to the product. As a result of these issues and questions, NIDIS is part of a collaboration to assess the RFW forecast product and improve both consistency and messaging, including improving communication and identifying actions for public and firefighter safety across fire prone areas of the United States. NIDIS is working on this project with California Nevada Applications Program (CNAP), a NOAA RISA team, NOAA NWS Fire

Weather, and the National Wildfire Coordinating Group,

Fire Environment Committee.

#### COMMUNICATING FIRE RISK: RED FLAG WARNINGS

A Red Flag Warning (RFW) is a term that has been used since the 1960s by NOAA NWS fire weather forecasters to alert forecast users to an ongoing or imminent critical fire weather pattern. However, several issues with this system have evolved. There is no single quantitative definition of



# NATIONAL SOIL MOISTURE STRATEGY

NIDIS has released A Strategy for the National Coordinated Soil Moisture Monitoring Network: Coordinated, High-Quality, Nationwide Soil Moisture Information.

Developed in part to fulfill the requirements of the NIDIS Reauthorization Act of 2018 (*P.L. 115-423*), this Strategy is the result of a 2-year multi-agency effort that included broad community engagement.

#### BACKGROUND

*Soil moisture* is a critical land surface variable, impacting a wide variety of climatological, agricultural, and hydrological processes. As a result, soil moisture measurements are needed for applications ranging from agricultural monitoring, to weather prediction, to drought and flood forecasting. At the same time, the means and methods of monitoring soil moisture are undergoing rapid growth and innovation with the advent of new *in situ* and proximal sensors, new remote sensing technologies, and enhanced modeling capabilities. Despite these opportunities, there has been no coordinated national strategy for the deployment and maintenance of soil moisture

networks, or for the development of nationally-integrated soil moisture data products. Until now.

Sponsored by NIDIS, the *National Coordinated Soil Moisture Monitoring Network* (NCSMMN) is an ongoing collaborative initiative by federal agencies, soil moisture scientists, state mesonet operators, and others to plan for and support nationally coordinated soil moisture monitoring, data assimilation, and product development. The newly released NCSMMN Strategy represents a significant milestone for this initiative, and documents a roadmap forward and the resources needed to build a national network to provide coordinated, high-quality, nationwide soil moisture information for the public good.

#### THE NCSMMN STRATEGY

The NCSMMN Strategy includes: a summary of current in situ networks, a review of remote sensing and modeling





data resources; a discussion of network design considerations; guidance for *in situ* network installation and quality assurance/control; and considerations and recommendations for strategy implementation. The following nine recommendations are detailed as a part of the strategy:

- 1. Determine a home agency and management structure for the NCSMMN.
- 2. Establish a web presence and formalize communication and outreach planning for the NCSMMN.
- 3. Formalize partnerships with the National Mesonet Program and existing monitoring networks.
- 4. Develop a set of criteria for high-quality data sources.
- 5. Support research necessary to develop or improve NCSMMN methodologies.
- 6. Increase in situ soil moisture monitoring nationwide.
- 7. Explore increasing partnerships with the private sector.

A selection of different soil moisturesensors. Credit: Tyson Ochsner

► The NCSMMN Strategy. Credit: NOAA NIDIS

- 8. Engage with the Citizen Science community.
- 9. Develop, release, and promote NCSMMN products.

Implementing these recommendations will provide a unifying structure for national soil moisture efforts and will position the broader NCSMMN community to deliver transformative soil moisture products to the nation. *Read the NCSMMN Strategy* to learn more.

For more on the National Soil Moisture Strategy, visit https://www.drought.gov/drought-in-action/ national-coordinated-soil-moisture-monitoring-network.



# **CLIMATE ENGINE**

*Climate Engine®*, a valuable example of a public-private partnership, is an "on-demand" cloud computing and visualization resource for climate and remote sensing data.

*Climate Engine* is a partnership between the Desert Research Institute, University of Idaho, and Google, with support from NIDIS since 2016. Climate Engine allows users to analyze and interact with climate and earth observations for decision support related to drought, water use, agriculture, wildfire, and ecology.

Utilizing access to one petabyte (1,000 terabytes) of cloud storage and 50 million donated hours of computing time on Google's Earth Engine environmental cloud computing platform, the web-based application is able to mine, process, and analyze a 30-year archive of high-resolution optical and thermal images taken of Earth by the Landsat satellites in a matter of seconds, compared to hours and even days with traditional computing systems.

Climate Engine is the backbone of many of the drought indicator maps on *drought.gov*. Drought.gov uses the cloud-based Climate Engine tool to produce drought indices and statistics from both NOAA and partner datasets residing in the NOAA Big Data Project and Google Earth Engine storage platforms. This approach allows Drought.gov to leverage the massive parallel computing available from the cloud to process large high-resolution gridded datasets with substantially lower costs and effort than previous on-premises solutions. In addition to displaying maps and other visualizations, drought. gov facilitates reuse of these maps, statistics, and raw data to all users.

Climate Engine is being used by public agencies and private companies for science-based decision-making. For instance, the BLM Nevada office uses Climate Engine maps to better understand how vegetation greenness pairs with precipitation levels, in order to make land management decisions. For example, if an area has received ample precipitation and yet the vegetation is stressed, the cause isn't lack of precipitation; it could



▲ Vapor pressure deficit percent difference from average for June-August 2021. Screenshot from Climate Engine.

be overgrazing by livestock. Climate Engine maps and time series are also providing BLM staff new placebased information for assessing grazing permits.

Going forward, NIDIS will continue to partner with Climate Engine to expand the high-resolution gridded datasets available through Climate Engine—enabling the US Drought Portal to preprocess large climate datasets and display new data visualizations on Drought.gov with fast load times. This will also provide a key resource for applied drought research, for example, making it easier to compare key drought indicators at different timescales and with different underlying datasets. NIDIS will also continue to connect these efforts to the NOAA Big Data Project and leverage NOAA's agreements with Google while exploring the value Climate Engine brings to NOAA.

In addition, NIDIS is partnering with the Climate Engine team to create improved drought monitoring maps that blend several key drought monitoring products

◀ Screenshot of an interactive graphic on the *Climate Engine* homepage. Credit: Climate Engine and indices into a single short-term or long-term product. With the Climate Engine platform, we can apply the results of innovative drought indicators research to existing

drought blended products, adjusting weighting ratios for different indicators and indices as well as underlying data sources. This will help pave the way for new objective drought blends customized by region and season.



### **MAKING SENSE OF FLASH DROUGHT**

Some droughts occur with such rapid onset that it seems as if they appear in a "flash," rendering them and their consequences hard to predict and prepare for. These flash droughts can have substantial agricultural and economic consequences, including billions of dollars in losses.

Notable recent flash droughts have included the Central U.S. in 2012, Northern Plains in 2017, and Southeast U.S. in 2016 and 2019. Clear conceptualization of flash drought is important as there are differing understandings and confusion on what flash drought is and how it differs from other droughts. To address this need, NIDIS is working with partners to develop a shared understanding/definition of flash drought, and to identify research and tools needed to improve flash drought early warning.

#### WORKSHOP AND REPORT ON FLASH DROUGHT: CURRENT UNDERSTANDING & FUTURE PRIORITIES

NIDIS held a virtual workshop in December 2020 to explore characteristics and definitions of flash drought, and to coordinate and co-develop a research agenda to address its associated management challenges. In total, around 120 people attended the workshop, representing academia, government (foreign, federal, state, local), nonprofit organizations, and other interested stakeholders.

There was strong consensus that the key feature of flash drought is rapid onset/rapid intensification of drought conditions, although more remains to be settled about how those two concepts differ and how exactly to standardize terms like "rapid." Another strong consensus view was that regionality, seasonality, and impacts are essential attributes for characterizing flash drought, implying a need for an integrated set of indicators.

The report, *Flash Drought: Current Understanding & Future Priorities*, published in July 2021 provides a list of



Agricultural field on which, due to drought, the green leaves of sugar beets have wilted. Credit: rsooll

#### Evaporation/ evapotranspiration Soil moisture Precipitation Temperature US Drought Monitor NDVI 0 2 4 6 8 10 12 Frequency of use to define "flash drought" in literature (through August 2020)

priority actions to advance flash drought research activities and tool development

#### LITERATURE REVIEW EXAMINES DEFINITIONS, INDICATORS, AND WHERE WE GO FROM HERE

In the study, "*Making sense of flash drought: definitions, indicators, and where we go from here*," published in the *Journal of Applied and Service Climatology*, NIDIS researchers took a deep dive into the flash drought literature to provide the first synthesis of the research to date. Specifically, this review focused on documenting the range of definitions of flash drought being proposed ► Flash Drought: Current Under-

standing and Future Priorities. Credit: NOAA NIDIS

✓ Frequency of drought indicator terms used to define "flash drought" in the literature through August 2020. Credit: NOAA NIDIS, Fiona Martin

### LASH DROUGHT

CURRENT UNDERSTANDING & FUTURE PRIORITIES

in the research community. It was found that the term first appeared in the peer-reviewed literature in 2002, and by 2020 has become an area of active research. Within that 18-year span, "flash drought" has been given 29 general descriptions,

and 20 papers have provided measurable, defining criteria used to distinguish a flash drought from other drought.

NIDIS is also partnering with the Midwestern Regional Climate Center at Purdue University to develop an experimental Flash Drought Risk Tool. This tool shows the risk of rapid intensification of drought conditions (i.e., flash drought) over the next two weeks based on the incorporation of forecasted data over that 14-day period. This tool was developed by utilizing machine learning, which trained on historical flash drought events and several atmospheric variable datasets. The Colorado River flows on Navajo Lands under the Navajo Bridge in Grand Canyon National Park, Arizona. Credit: Norm Lane

# NIDIS TRIBAL DROUGHT ENGAGEMENT STRATEGY

In order to ensure the inclusion of indigenous perspectives in the implementation of our DEWS, NIDIS launched a Tribal Drought Engagement initiative in January 2019 in collaboration with the Masters of the Environment Program at University of Colorado-Boulder. 2021–2025 **NDDS TRIBAL DROUGHST** MURSDURF IRVER BASIN AND MISSES MURSDURF BASIN A

The project aimed to strengthen relationships with tribal resource managers across the Missouri River Basin and Midwest DEWS regions in order to effectively deliver timely and relevant drought information.

The inaugural *NIDIS Tribal Drought Engagement Strategy: 2021–2025* was developed following this project, which included a year of consultations with tribal resource managers across the two regions. These consultations helped identify critical engagement gaps and the actions that could be taken to address them. The engagement in these two DEWS will inform consultations with tribal nations as a foundation for scaling the Strategy to other regions. ▲ The NIDIS Tribal Drought Engagement Strategy: 2021–2025. Credit: NOAA NIDIS

Two types of information are encompassed in the *Strategy*. The first are a set of "Guiding Principles of Engagement" that capture important approaches that NIDIS wants to embody in partnerships with tribal nations. Following these principles are "Key Outcomes and Activities" that are organized around the five components of a DEWS



(interdisciplinary research and applications; predictions and forecasting; observations and monitoring; planning and preparedness; and communications and outreach). The *Strategy* also provides a framework for integrating indigenous perspectives into the DEWS. Ultimately, implementation of the *Strategy* will lead to improved drought monitoring, forecasting, and resilience for tribal nations.

#### NIDIS WELCOMES CRYSTAL STILES, TRIBAL ENGAGEMENT COORDINATOR

In 2021, NIDIS welcomed Crystal Stiles to NIDIS as the Tribal Engagement Coordinator. Crystal is working to implement NIDIS's *Tribal Drought Engagement Strategy* across our network of 8 regional drought early warning systems. For the past 7 years, Crystal was an Applied Climatologist with the High Plains Regional Climate Center at the University of Nebraska-Lincoln (UNL), where she directed both the stakeholder and tribal engagement programs.

### COPING WITH DROUGHT COMPETITION ON BUILDING TRIBAL DROUGHT RESILIENCE

Since 2007, NIDIS has funded more than 60 innovative drought research projects through the Coping with

Drought research competition. For FY22, NIDIS held an FY22 Coping with Drought Competition on Building Tribal Drought Resilience. This competition focused on the implementation of actions—together with research on those actions—to build tribal drought resilience contained A Navajo sheep graze in front of the red buttes and spires of Monument Valley. Navajo Tribal Park, Southern Utah, near Arizona border. Credit: Joseph Sohm

in existing plans and strategies. Plans could include, but were not limited to, drought contingency plans; drought, water, or natural resource plans; agricultural resource management plans; or climate adaptation plans. Decisions will be announced in the summer of 2022.

For more on NIDIS and Tribal Engagement, visit https://www.drought.gov/about/tribal-engagement.



### ACF BASIN DROUGHT & WATER DASHBOARD & STORY MAP

The Apalachicola, Chattahoochee, and Flint (ACF) Rivers, along with the Apalachicola Bay, link the people and natural systems of Alabama, Florida, and Georgia.

Balancing the water needs between three states and various sectors creates complex water management challenges, which are further intensified during times of drought.

In response to a request by regional stakeholders, and in close partnerships with state and regional partners, NIDIS has launched the new *ACF River Basin Drought and Water Dashboard* and *ACF Drought Story Map*. These web resources will improve the public's ability to view real-time information with interactive, shareable, and easy-to-understand graphics on current and predicted drought conditions, and assist decision-making at the basin and local level. This *ACF Dashboard* reflects a partnership of federal, state, and regional stakeholders, and was developed in close collaboration with the states of Alabama, Florida, Georgia, and the U.S. Army Corps of Engineers. The content of this new Dashboard was user-driven from the start, created following extensive iterative feedback from over 100 diverse stakeholders in the basin, and intentionally designed to meet the diverse drought information needs across the region.

This new Dashboard will help the public, decision makers, and the media answer these questions:

• Why does drought matter to the ACF River Basin?



- What are the current drought and water conditions across the basin, but also in my county?
- What should we expect over the next 3 months?
- How does this drought compare to previous droughts in the basin?
- Where can I get additional information?

The Dashboard was developed as part of a *NIDIS-supported project* implemented by Albany State University Water Planning and Policy Center, Auburn University Water Resources Center, and NOAA's National Centers for Environmental Information (NCEI).

Following the success of the launch of the ACF Basin Dashboard, the U.S. Army Corps of Engineers and NIDIS are developing an Alabama-Coosa-Tallapoosa River Basin (ACT) Drought & Water Dashboard in 2022.





▲ (*Top*) Screenshot of ACF Dashboard. (*Bottom*) Screenshot of ACF Story Map. Credit: NOAA NIDIS

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