# Adopting New Technologies and Earth Observations for Improved Natural Resource Management and Early Warning

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Desert Research Institute

Presentation to the Western States Water Council

May 23, 2023

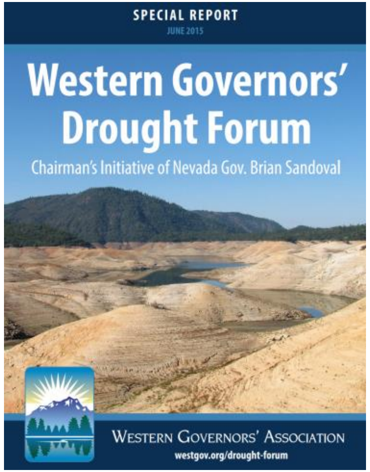
DRI Desert Research Institute

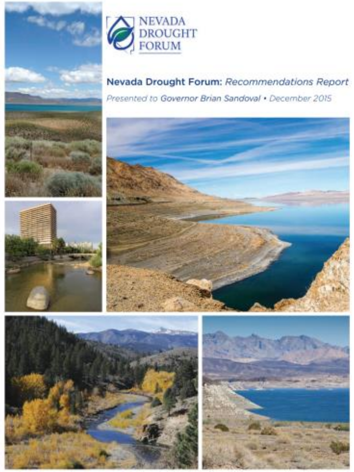
ClimateEngine.org

THE UNIVERSITY OF CALIFORNIA MERCED · LET THERE BE LIGHT · 2005

# Background

- Beginning of stakeholder engagements
  - 2015 Western Governors' Drought Summit (Las Vegas, NV)
  - 2015 - Nevada Drought Forum
  - 2015-2016 - Creation of NIDIS CA-NV Drought Early Warning System (DEWS)




- Common Theme Across DOI, USDA, and DEWS stakeholders:
  - Consider both vegetative and hydrologic drought
  - Develop and integrate new datasets and tools for place-based drought monitoring and forecasting
    - Satellite observations
    - Place-based climate and vegetation data
    - New data storage, computing, and visualization technologies (cloud)
    - Subseasonal forecasts for early warning

- CA-NV DEWS Strategic Plan - "Develop and deliver new state-of-the-art cloud computing tools that provide user-friendly drought monitoring data to decision-makers"

# Background

Use of new technologies, observations, computing to address “One Size Doesn’t Fit All” drought issues


Place-based assessments is needed - “Drought Due Diligence”

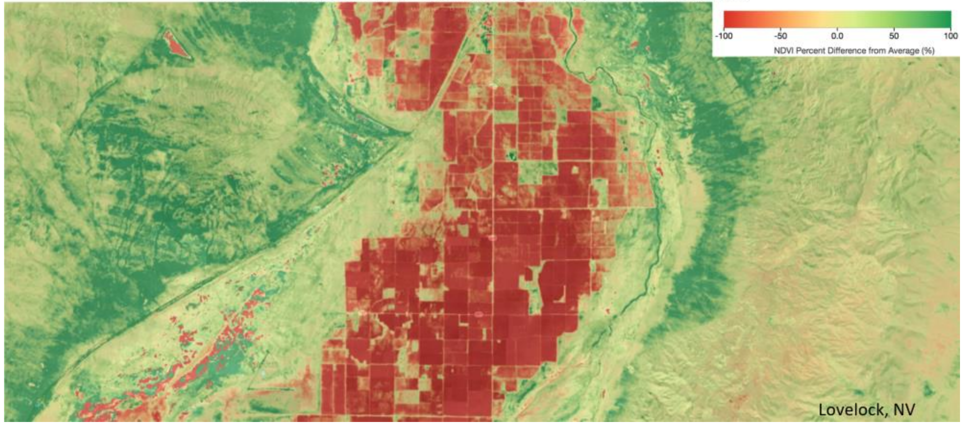
Drought regional in nature, but impacts are place-based and dependent on

- Water source (reservoir, small stream, or groundwater)
- Rangeland vegetation, rainfed agriculture, irrigated agriculture
- Time scale (e.g. 3-month - vegetative vs. multi-year - hydrologic)

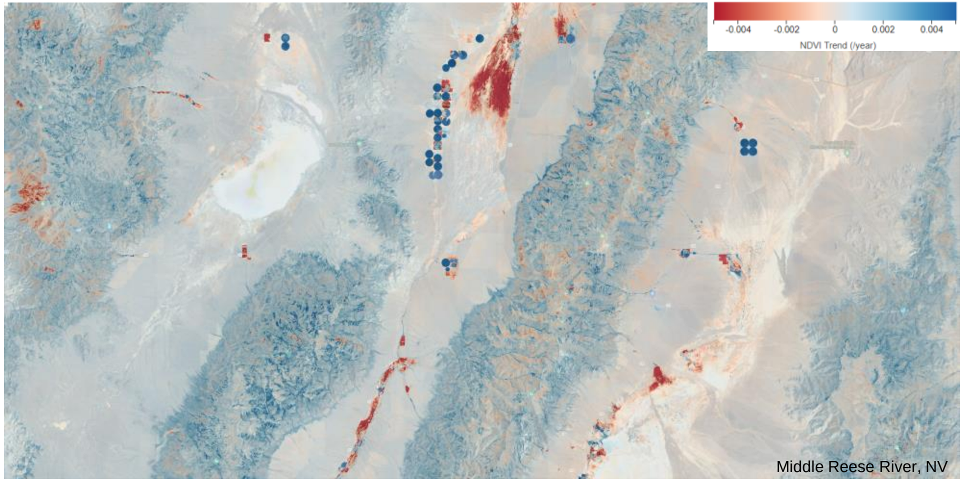
Place-based impact assessments require local scale data

- In-situ and satellite observations at field-scale
- Gridded climate data at high spatial (<4 km pixels) and temporal resolution (daily to bi-weekly, low latency)

Landsat Percent Difference from Average for April – October, 2015




Landsat Summer NDVI Trend, 1985-2022



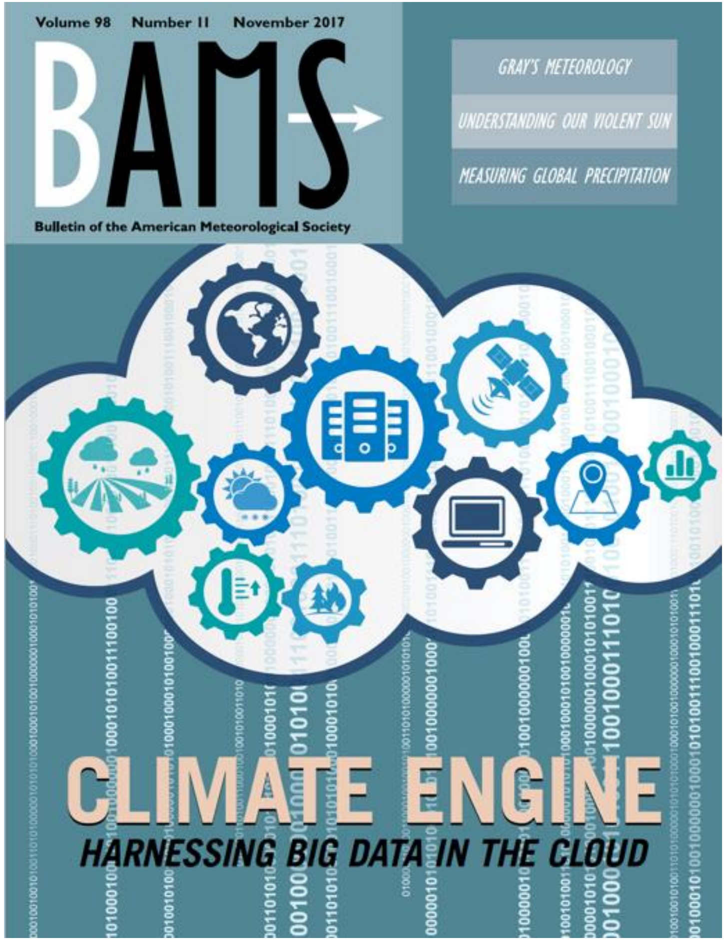
# Background

- ClimateEngine.org began in 2014 as “Google Drought” with a grant from the Google Earth Engine Faculty Research Award Program and offically launched in 2016 at the White House Water Summit

- Since, it has been primarily supported by NOAA-NIDIS and BLM

  * *Public <> Private Partnership* *

- ClimateEngine.org is a DRI led project that helps academic, public, and non-commercial users develop and deliver satellite remote sensing and climate data for actionable insights around natural resources and early warning




Huntington, J.L., Hegewisch, K.C., Daudert, B., Morton, C.G., Abatzoglou, J.T., McEvoy, D.J. and Erickson, T., 2017. Climate engine: Cloud computing and visualization of climate and remote sensing data for advanced natural resource monitoring and process understanding. *Bulletin of the American Meteorological Society*, *98*(11), pp.2397-2410.

DRI Desert Research Institute | ClimateEngine.org | U.S. DEPARTMENT OF THE INTERIOR BUREAU OF LAND MANAGEMENT | NIDIS

# Core Data Catalog and Compute

### Earth Engine Data Library

- World's largest archive of open Earth data (700+ native datasets)

### Google Cloud Processing

- Dedicated cloud computing with 800+ algorithms

### Open and Commercial Data Integration

- Access to open and commercial data and models to leverage the best available science for decision-making

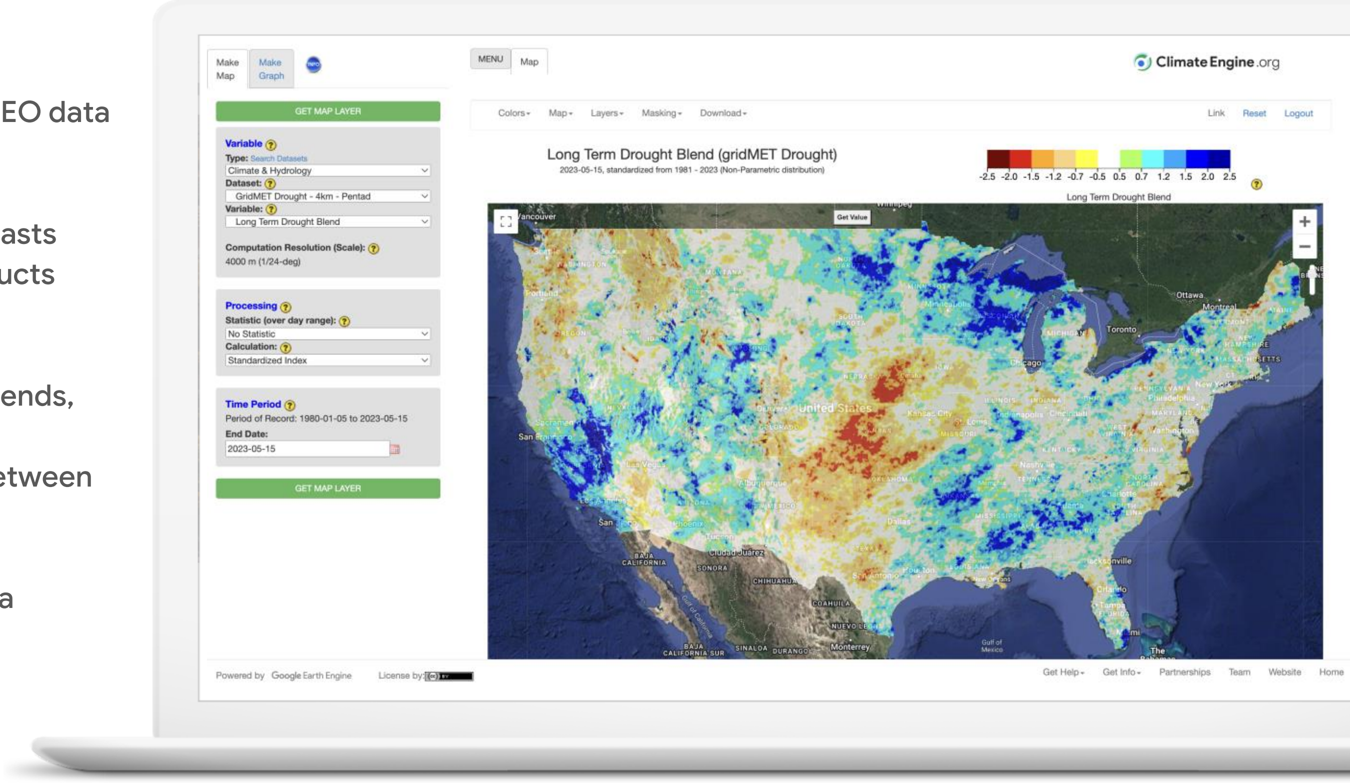
- Bring algorithms to data, not data to algorithms
- Efficient data to decision making requires scale, and minimal or no-code solutions
- The challenge is not the lack of data. The challenge is converting these data into **actionable insights**


Google Earth Engine

# Research & Visualize

## Climate Engine UI

- Access to petabytes of climate and EO data
    - Google, NOAA, custom data catalogues
    - Historical, current, and forecasts
    - Multi-platform satellite products
- On-demand data Processing
    - Values, anomalies, indices, trends, probabilities, zonal statistics
    - Interoperable calculations between climate and satellite data
- Download maps and time series data




https://app.climateengine.org

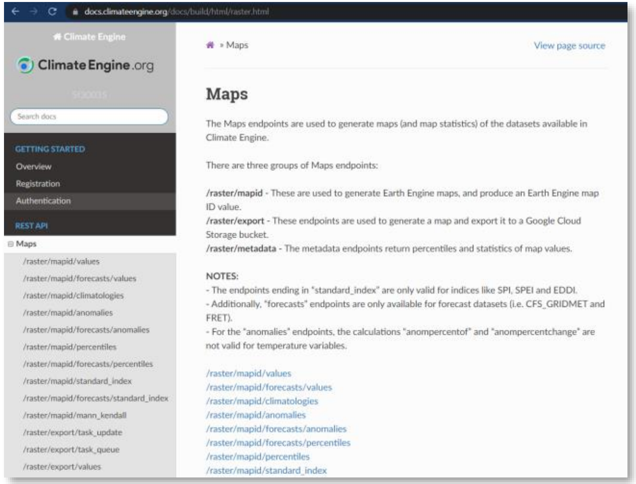
# Research to Operations

## Drought.gov

- Research and operational use of the Climate Engine Application Programming Interface (API) (docs.climateengine.org) to efficiently access, compute, and export raster and time series data

- Operational batch API calls and export to NOAA Google Buckets

https://www.drought.gov/current-conditions


docs.climateengine.org/docs/build/html/raster.html

Climate Engine

Climate Engine.org

Search docs

GETTING STARTED

Overview

Registration

Authentication

REST API

Maps

/raster/mapid/values

/raster/mapid/forecasts/values

/raster/mapid/climatologies

/raster/mapid/anomalies

/raster/mapid/forecasts/anomalies

/raster/mapid/percentiles

/raster/mapid/forecasts/percentiles

/raster/mapid/standard_index

/raster/mapid/forecasts/standard_index

/raster/mapid/mann_kendall

/raster/export/task_update

/raster/export/task_queue

/raster/export/values

» Maps

View page source

**Maps**

The Maps endpoints are used to generate maps (and map statistics) of the datasets available in Climate Engine.

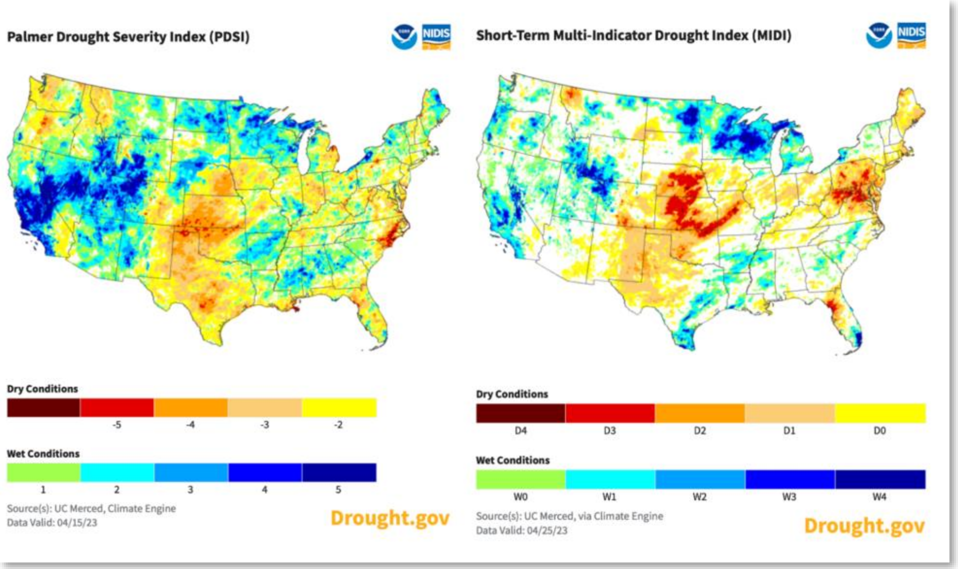
There are three groups of Maps endpoints:

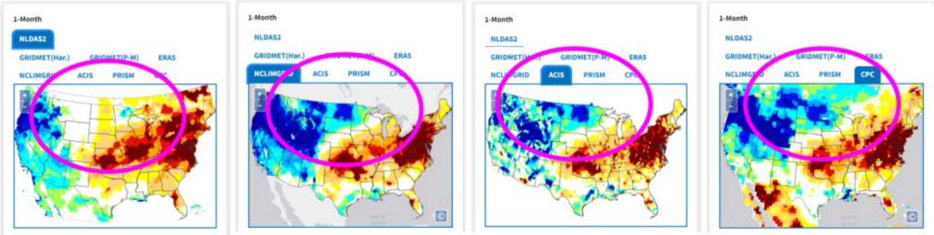
**/raster/mapid** - These are used to generate Earth Engine maps, and produce an Earth Engine map ID value.
**/raster/export** - These endpoints are used to generate a map and export it to a Google Cloud Storage bucket.
**/raster/metadata** - The metadata endpoints return percentiles and statistics of map values.

NOTES:
- The endpoints ending in "standard_index" are only valid for indices like SPI, SPEI and EDDI.
- Additionally, "forecasts" endpoints are only available for forecast datasets (i.e. CFS_GRIDMET and FRET).
- For the "anomalies" endpoints, the calculations "anompercentof" and "anompercentchange" are not valid for temperature variables.

/raster/mapid/values
/raster/mapid/forecasts/values
/raster/mapid/climatologies
/raster/mapid/anomalies
/raster/mapid/forecasts/anomalies
/raster/mapid/forecasts/percentiles
/raster/mapid/percentiles
/raster/mapid/standard_index

Computing and downloading 400+ daily indices and indicators derived from foundational datasets, processed each night in under an hour

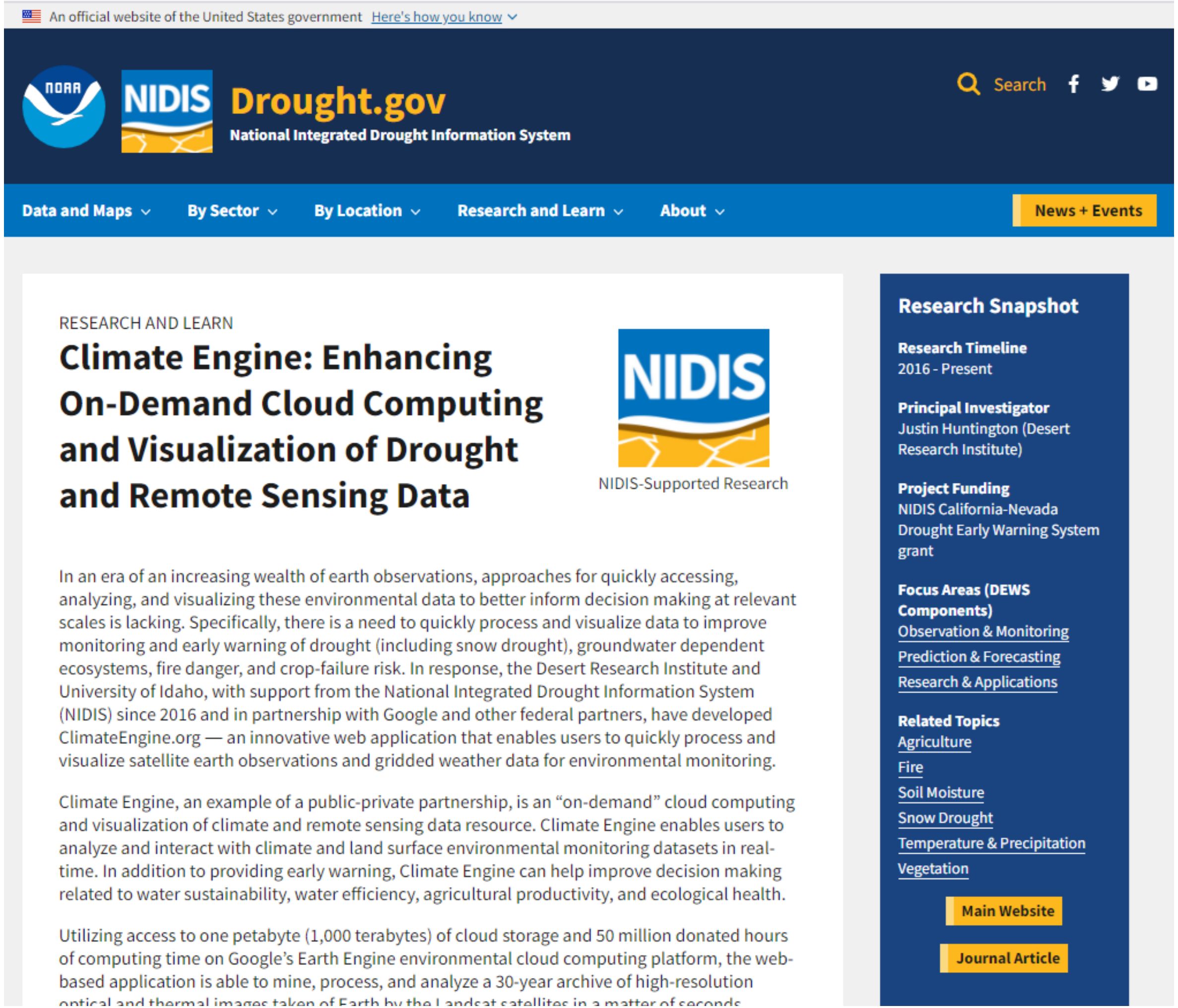


# Drought.gov

*“Climate Engine is a powerful cloud solution that has enabled NOAA to rapidly create and disseminate critical climate and drought information in ways previously not possible.”*

*-Steve Ansari, NOAA*



An official website of the United States government Here's how you know

NIDIS Drought.gov
National Integrated Drought Information System

Search

Data and Maps | By Sector | By Location | Research and Learn | About | News + Events

RESEARCH AND LEARN

## Climate Engine: Enhancing On-Demand Cloud Computing and Visualization of Drought and Remote Sensing Data

NIDIS-Supported Research

In an era of an increasing wealth of earth observations, approaches for quickly accessing, analyzing, and visualizing these environmental data to better inform decision making at relevant scales is lacking. Specifically, there is a need to quickly process and visualize data to improve monitoring and early warning of drought (including snow drought), groundwater dependent ecosystems, fire danger, and crop-failure risk. In response, the Desert Research Institute and University of Idaho, with support from the National Integrated Drought Information System (NIDIS) since 2016 and in partnership with Google and other federal partners, have developed ClimateEngine.org — an innovative web application that enables users to quickly process and visualize satellite earth observations and gridded weather data for environmental monitoring.

Climate Engine, an example of a public-private partnership, is an “on-demand” cloud computing and visualization of climate and remote sensing data resource. Climate Engine enables users to analyze and interact with climate and land surface environmental monitoring datasets in real-time. In addition to providing early warning, Climate Engine can help improve decision making related to water sustainability, water efficiency, agricultural productivity, and ecological health.

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.

### Research Snapshot

**Research Timeline**
2016 - Present

**Principal Investigator**
Justin Huntington (Desert Research Institute)

**Project Funding**
NIDIS California-Nevada Drought Early Warning System grant

**Focus Areas (DEWS Components)**
Observation & Monitoring
Prediction & Forecasting
Research & Applications

**Related Topics**
Agriculture
Fire
Soil Moisture
Snow Drought
Temperature & Precipitation
Vegetation

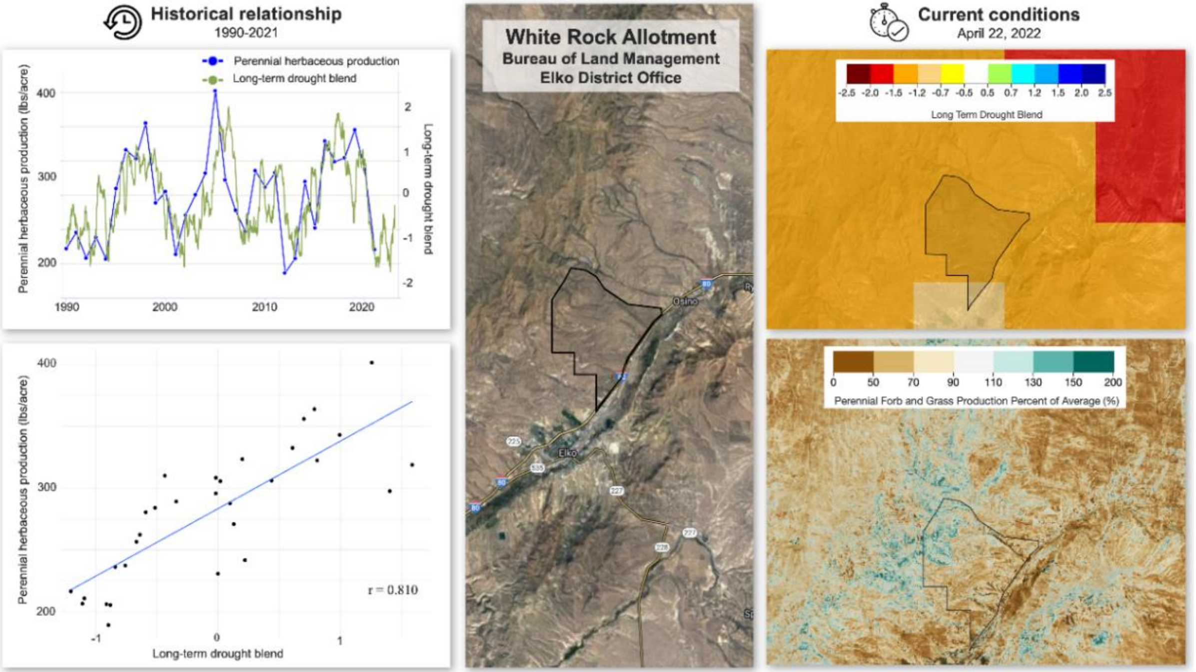
Main Website

Journal Article

# Research to Decisions

## How can BLM reduce drought risk and build resilience on public lands?

- Improve awareness and assessment of drought conditions and impacts
- Incorporate drought science into land use planning and NEPA processes
- Combine in-situ and remote monitoring
- Prioritize restoration of riverscape connectivity
- Protect instream and in-situ uses of water

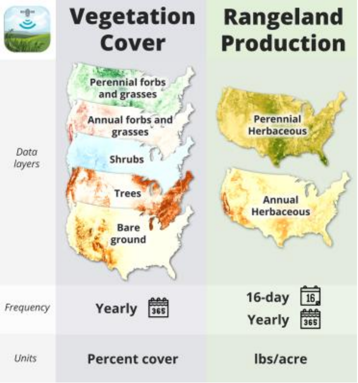



- ➔ Freely available web-based satellite and climate data and tools such as Climate Engine are important to achieving these objectives
- ➔ Trainings and videos to scale up the use of tools like Climate Engine within the BLM and other agencies

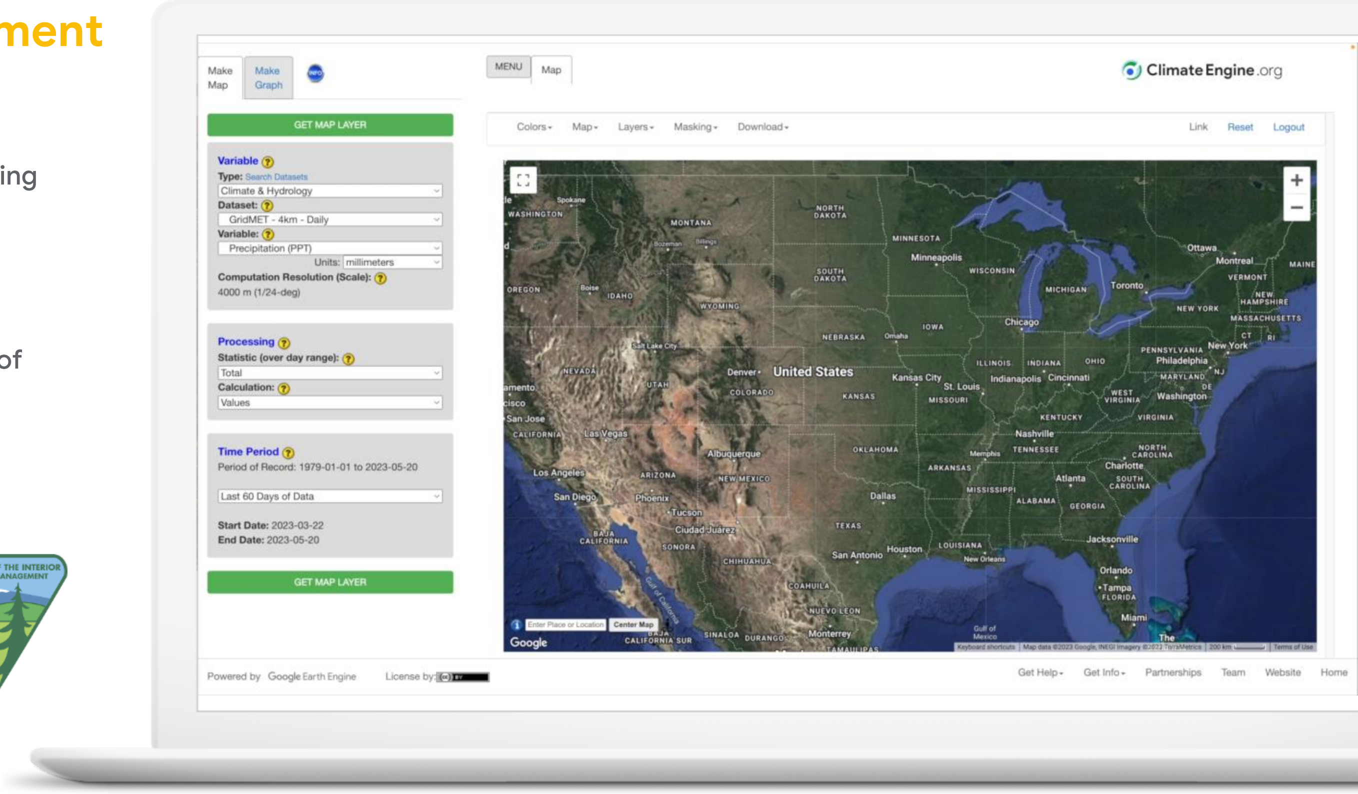
# Research to Decisions

## Bureau of Land Management

- Rangeland vegetation and climate monitoring
- Supporting decisions related to grazing permit renewals
- Baseline assessment and trends in vegetation
- Assessing target areas for riparian restoration, and success (or failure) of riparian restoration projects




U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT



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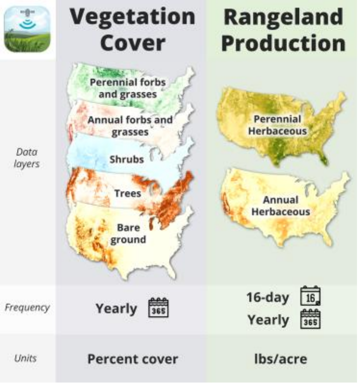
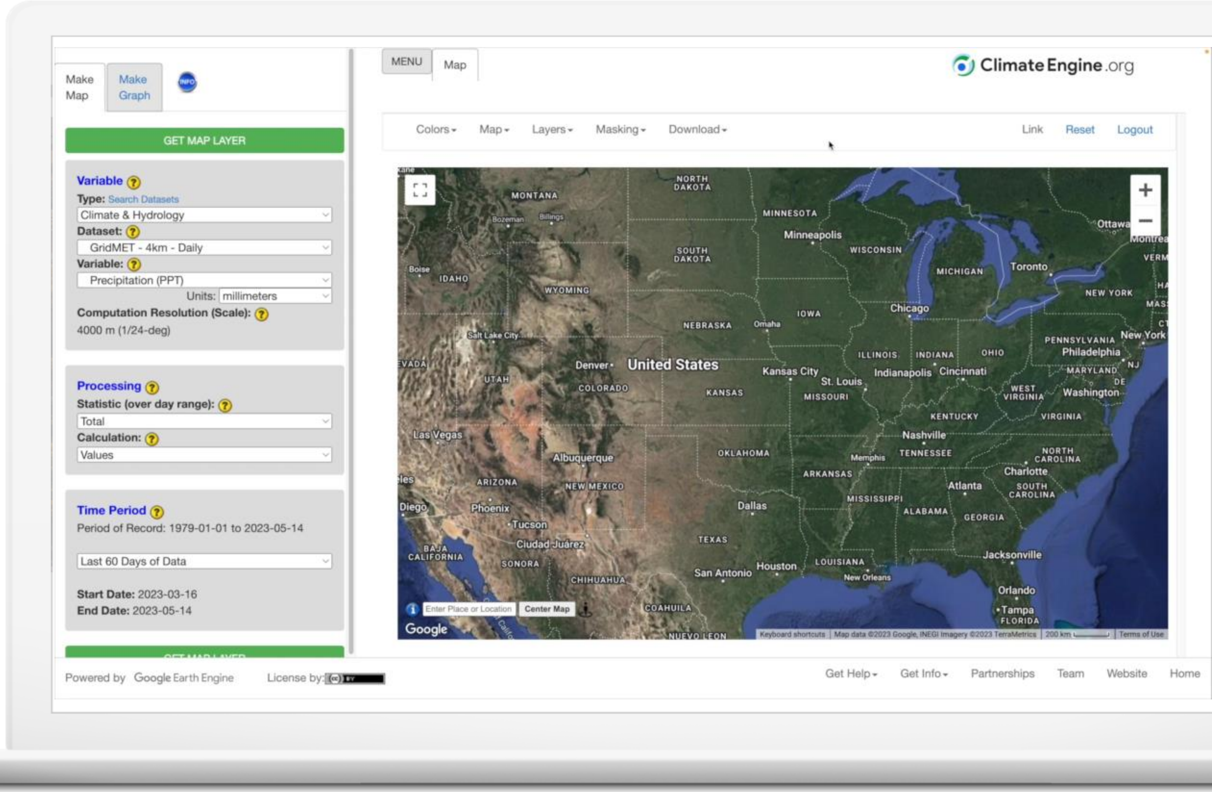
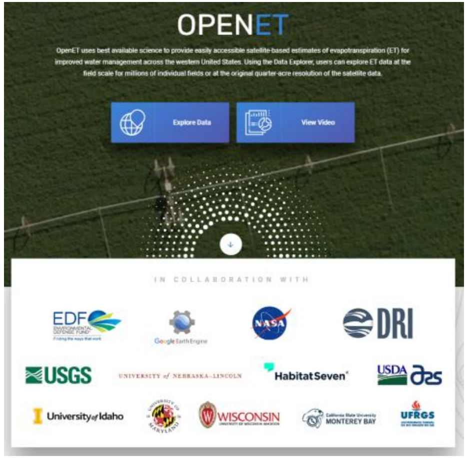


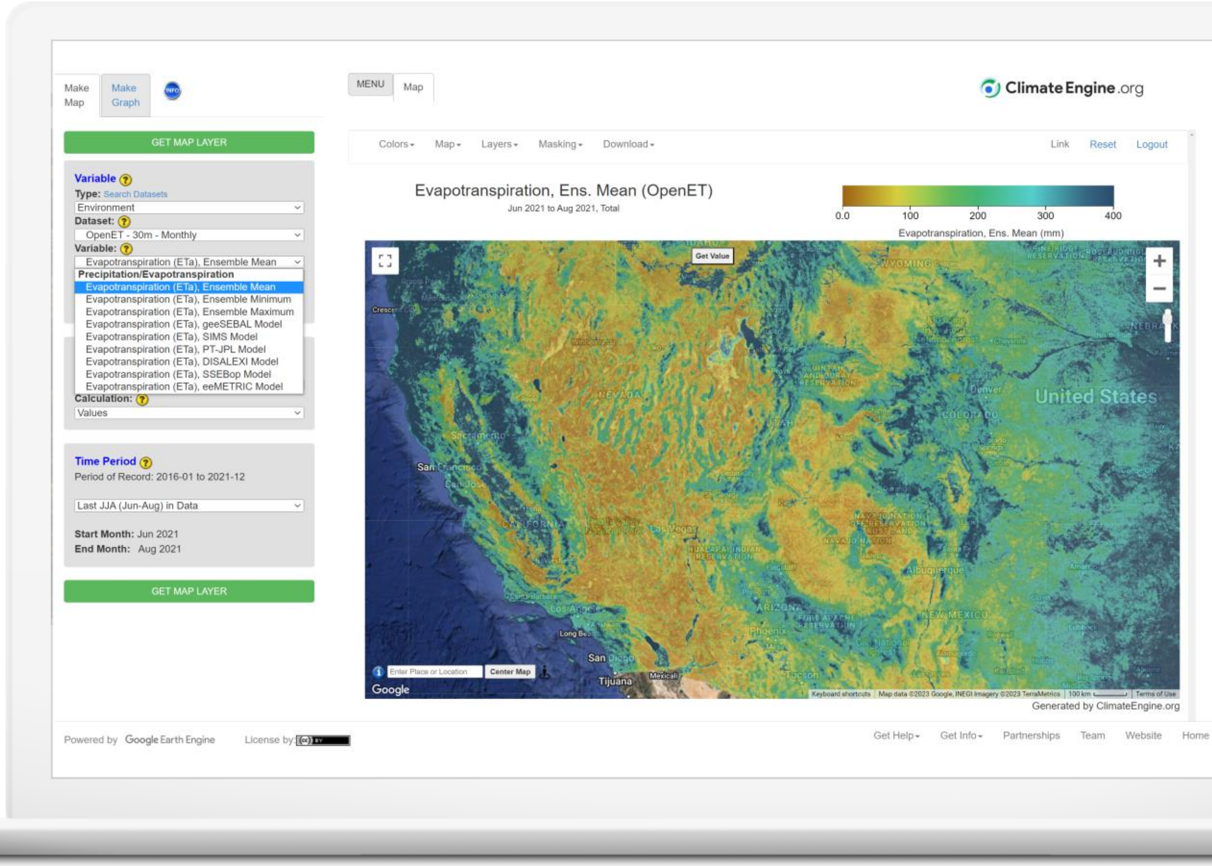
# Consumptive Water Use

## Water use accounting

- OpenET data recently added to ClimateEngine.org
- Differences in ET with respect to climate and management over time provides insights into model performance, and potential water use and conserved consumptive use




[https://openetdata.org/](https://openetdata.org/)



U.S. Department of the Interior

Bureau of Land Management

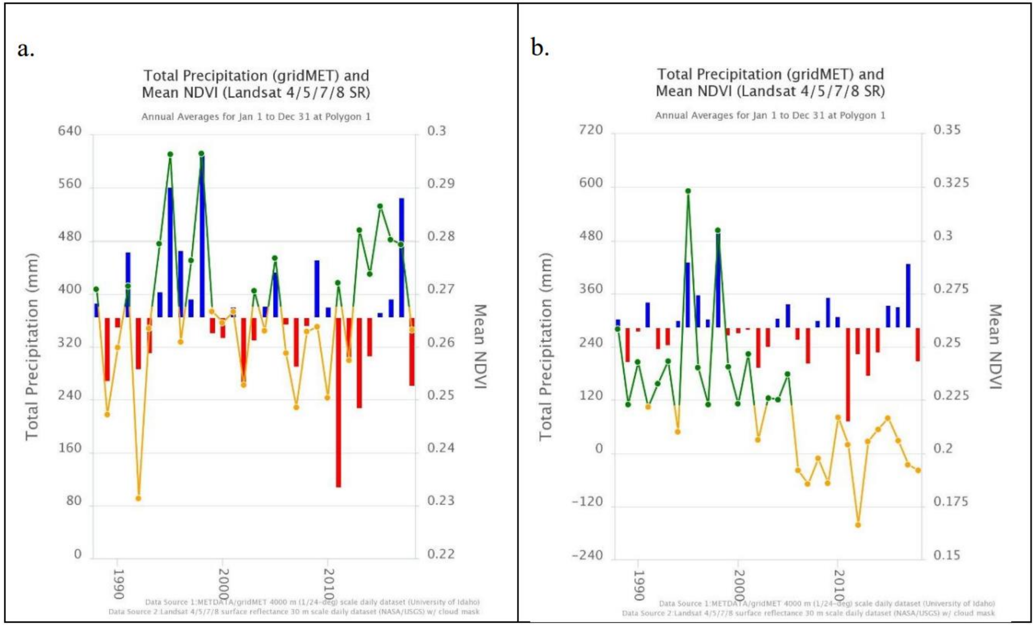
# Rangeland Health Assessment and Evaluation Report

## Pilot-Table Mountain Allotment

PREPARING OFFICE

U.S. Department of the Interior
Bureau of Land Management
Carson City District
Stillwater Field Office
5665 Morgan Mill Road
Carson City, NV 89701

*Figure 13: NDVI Data Correlated to Precipitation for (a) Cornelius Spring and (b) Upper Summit Spring*




"Specifically, Upper Summit Spring appeared to have higher utilization rates and overall use of the spring, as indicated by the contributing factors for not meeting PFC listed in table 14. This included poor water quality and the lack of functional and structural plant groups due to overgrazing, which was not reported as a contributing factor at Cornelius Spring."

NDWR
Water Rights Ruling

Ruling
Page 13

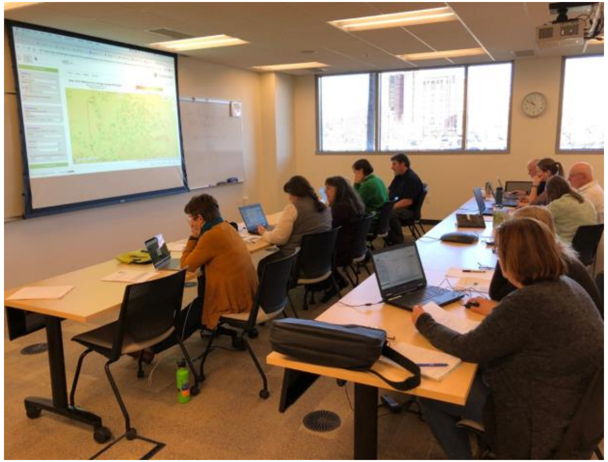
The use of aerial or satellite imagery and of commonly accepted tools such as the Climate Engine calculation and display of NDVI to determine the use of water is a common, regular, and ordinary practice of the State Engineer, and the State Engineer finds that the evidence presented in the report based on these images and tools are (with one exception detailed below) clear and convincing evidence of where the water was placed to beneficial use by the Applicant.

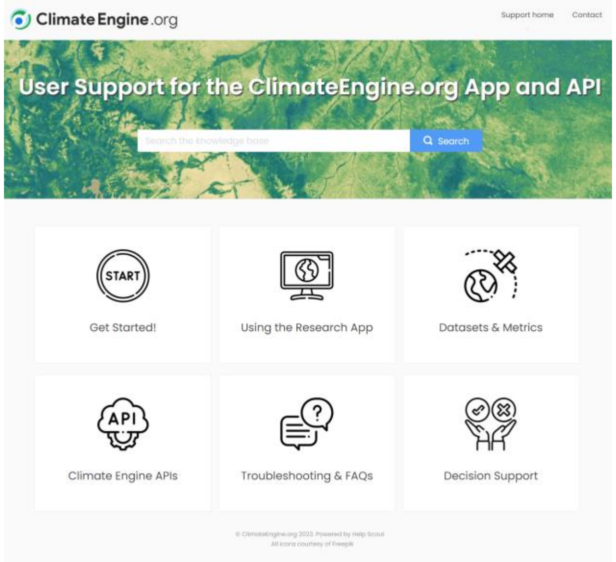
http://images.water.nv.gov/images/rulings/6396r.pdf

# Outreach, Trainings, & Support

*“Climate Engine analyzed massive amounts of Landsat and climate data for a recent water right dispute in a few minutes that would have taken weeks without.”*

William J Kramber, Senior Remote Sensing Analyst, Idaho Dept. of Water Resources






NIDIS

IDWR

https://support.climateengine.org/

https://www.youtube.com/@ClimateEngineOrg

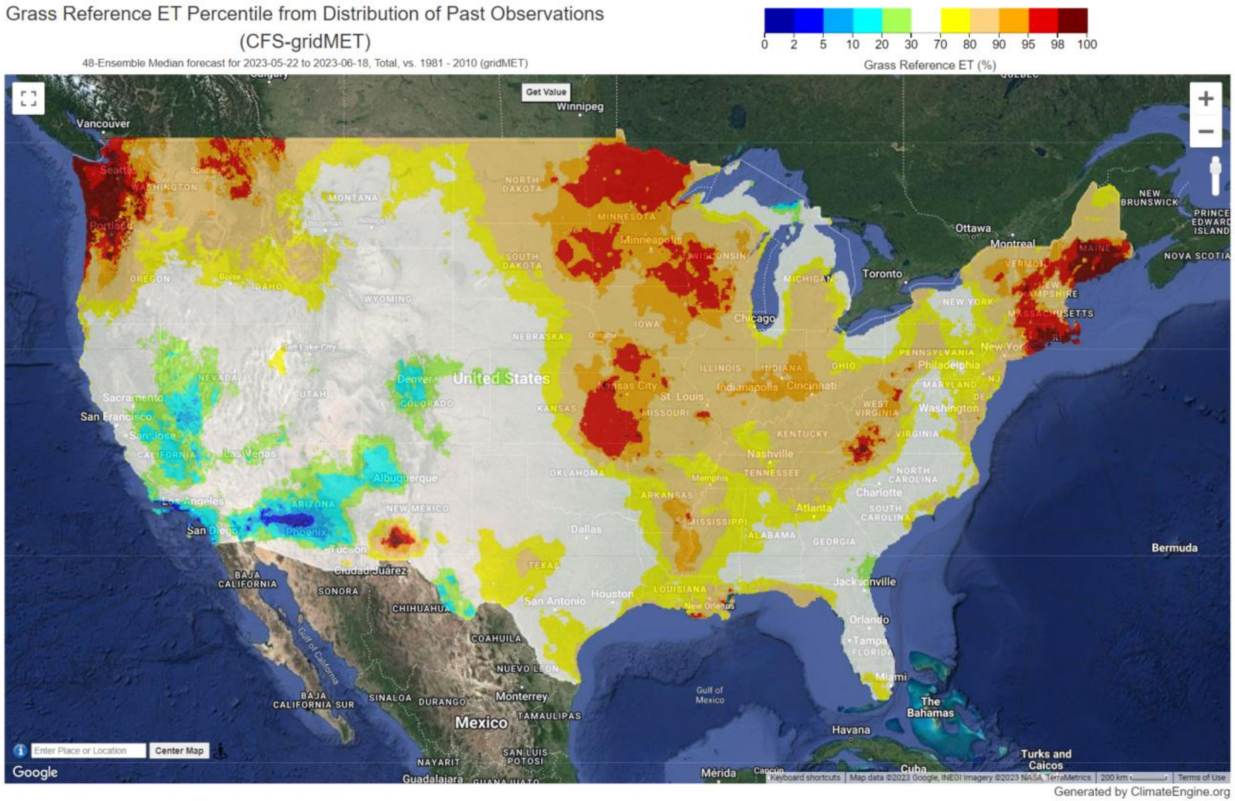
# Summary

- ClimateEngine.org and platforms like it provide new and advanced opportunities for assessing place-based insights related to natural resource management

- The recent explosion of EO data and integration into operations and decision making is just starting…

- Adequate support for adoption from agencies will be key… especially Admin and IT support for in-house use of new technologies (e.g. trainings, cloud, security, time for research and special projects)

- Landsat is key for water and natural reousrce monitoring and planning. Please support the Landsat program!




Reference ET forecast through June 18

# Thankyou!

Contact
Justin.Huntington@dri.edu

ClimateEngine.org

# Research to Operations

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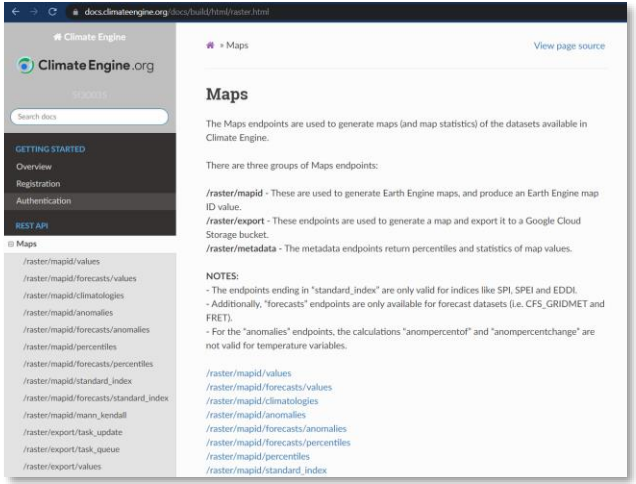



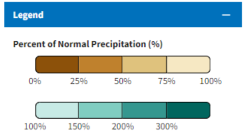


**GeoTIFF Download:**

| Dataset | Precipitation | Percent of Normal Precip. | Temperature Departure from Normal | SPI | SPEI | EDDI | Coverage and Resolution | Latency |
|---|---|---|---|---|---|---|---|---|
| nClimGrid-Daily | 1-Month, 2M, 3M, 6M, 9M, 12M | 1-Month, 2M, 3M, 6M, 9M, 12M | 1-Week, 2W, 1-Month, 2M, 3M, 6M, 9M, 12M | 1-Month, 2M, 3M, 6M, 9M, 12M | 1-Month, 2M, 3M, 6M, 9M, 12M | 1-Week, 2W, 1-Month, 2M, 3M, 6M, 9M, 12M | ConUS 4km | 4-6 days |
| ACIS "Grid 1" | 1-Month, 2M, 3M, 6M, 9M, 12M | 1-Month, 2M, 3M, 6M, 9M, 12M | 1-Week, 2W, 1-Month, 2M, 3M, 6M, 9M, 12M | 1-Month, 2M, 3M, 6M, 9M, 12M | 1-Month, 2M, 3M, 6M, 9M, 12M | 1-Week, 2W, 1-Month, 2M, 3M, 6M, 9M, 12M | ConUS 4km | 3-5 days |
| CPC Daily ConUS Precip. | 1-Month, 2M, 3M, 6M, 9M, 12M | 1-Month, 2M, 3M, 6M, 9M, 12M | Not Available | 1-Month, 2M, 3M, 6M, 9M, 12M | Not Available | Not Available | ConUS 25km | 3-5 days |
| PRISM | 1-Month, 2M, 3M, 6M, 9M, 12M | 1-Month, 2M, 3M, 6M, 9M, 12M | 1-Week, 2W, 1-Month, 2M, 3M, 6M, 9M, 12M | 1-Month, 2M, 3M, 6M, 9M, 12M | 1-Month, 2M, 3M, 6M, 9M, 12M | 1-Week, 2W, 1-Month, 2M, 3M, 6M, 9M, 12M | ConUS 4km | 3-5 days |
| GridMET | 1-Month, 2M, 3M, 6M, 9M, 12M | 1-Month, 2M, 3M, 6M, 9M, 12M | 1-Week, 2W, 1-Month, 2M, 3M, 6M, 9M, 12M | 1-Month, 2M, 3M, 6M, 9M, 12M | 1-Month, 2M, 3M, 6M, 9M, 12M | 1-Week, 2W, 1-Month, 2M, 3M, 6M, 9M, 12M | ConUS 4km | 3-5 days |
| ERA5 (ConUS Subset) | 1-Month, 2M, 3M, 6M, 9M, 12M | 1-Month, 2M, 3M, 6M, 9M, 12M | 1-Week, 2W, 1-Month, 2M, 3M, 6M, 9M, 12M | 1-Month, 2M, 3M, 6M, 9M, 12M | 1-Month, 2M, 3M, 6M, 9M, 12M | 1-Week, 2W, 1-Month, 2M, 3M, 6M, 9M, 12M | ConUS 30km | 7-10 days |
| CPC Daily Unified | 1-Month, 2M, 3M, 6M, 9M, 12M | 1-Month, 2M, 3M, 6M, 9M, 12M | 1-Week, 2W, 1-Month, 2M, 3M, 6M, 9M, 12M | 1-Month, 2M, 3M, 6M, 9M, 12M | 1-Month, 2M, 3M, 6M, 9M, 12M | 1-Week, 2W, 1-Month, 2M, 3M, 6M, 9M, 12M | Global 0.5 deg | 4-6 days |
| ERA5 (Global) | 1-Month, 2M, 3M, 6M, 9M, 12M | 1-Month, 2M, 3M, 6M, 9M, 12M | 1-Week, 2W, 1-Month, 2M, 3M, 6M, 9M, 12M | 1-Month, 2M, 3M, 6M, 9M, 12M | 1-Month, 2M, 3M, 6M, 9M, 12M | 1-Week, 2W, 1-Month, 2M, 3M, 6M, 9M, 12M | Global 50km | 7-10 days |
| CMORPH | 1-Month, 2M, 3M, 6M, 9M, 12M | 1-Month, 2M, 3M, 6M, 9M, 12M | Not Available | 1-Month, 2M, 3M, 6M, 9M, 12M | Not Available | Not Available | Global 8km | 2-4 days |
| GPM IMERG | 1-Month, 2M, 3M, 6M, 9M, 12M | 1-Month, 2M, 3M, 6M, 9M, 12M | Not Available | 1-Month, 2M, 3M, 6M, 9M, 12M | Not Available | Not Available | Global 10km | 2-4 days |

400+ daily indices and indicators derived from foundational datasets, processed each night in under an hour

# Background

The Big Data Problem.....

- Dramatic increase in the use of Earth Observation (EO) datasets is happening
- Combining multi-source EO is challenging for scientists and practitioners alike
- Best practices should follow Findable, Accessible, Interoperable, and Reusable (FAIR) data principles

*"If the data can't work together, the scientists can't either"*


CREATING DATA TOOL KITS THAT EVERYONE CAN USE

BY ZHONG LIU, VASCO MANTAS, JENNIFER WEI, MENGLIN JIN, AND DAVID MEYER

Earth scientists need to make the growing wealth of data more accessible and build data services meant for interdisciplinary use.

As Earth science and the technologies it uses evolve and improve, the data and services that support the science also change and become more complex, often spanning multiple disciplines. The ability to easily find and seamlessly access these data and services in an open and integrated environment is essential to facilitating interdisciplinary research and applications and to broadening data user communities.

The sheer amount of available data is growing rapidly as the science community adopts the Findable, Accessible, Interoperable, and Reusable (FAIR) data principles [*Wilkinson et al.*, 2016] and emerging technologies such as cloud computing. Even with recent advances in data archiving and services (e.g., more data sets and related information are available online with customized data services and multiple data access methods), accessing heterogeneous inter-

*Multiple special or discipline-oriented tools, often with steep learning curves, are required to handle heterogeneous, complex, and evolving Earth science data sets in interdisciplinary research and applications. Credit: Pixabay/Deborah Breen Whiting*

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