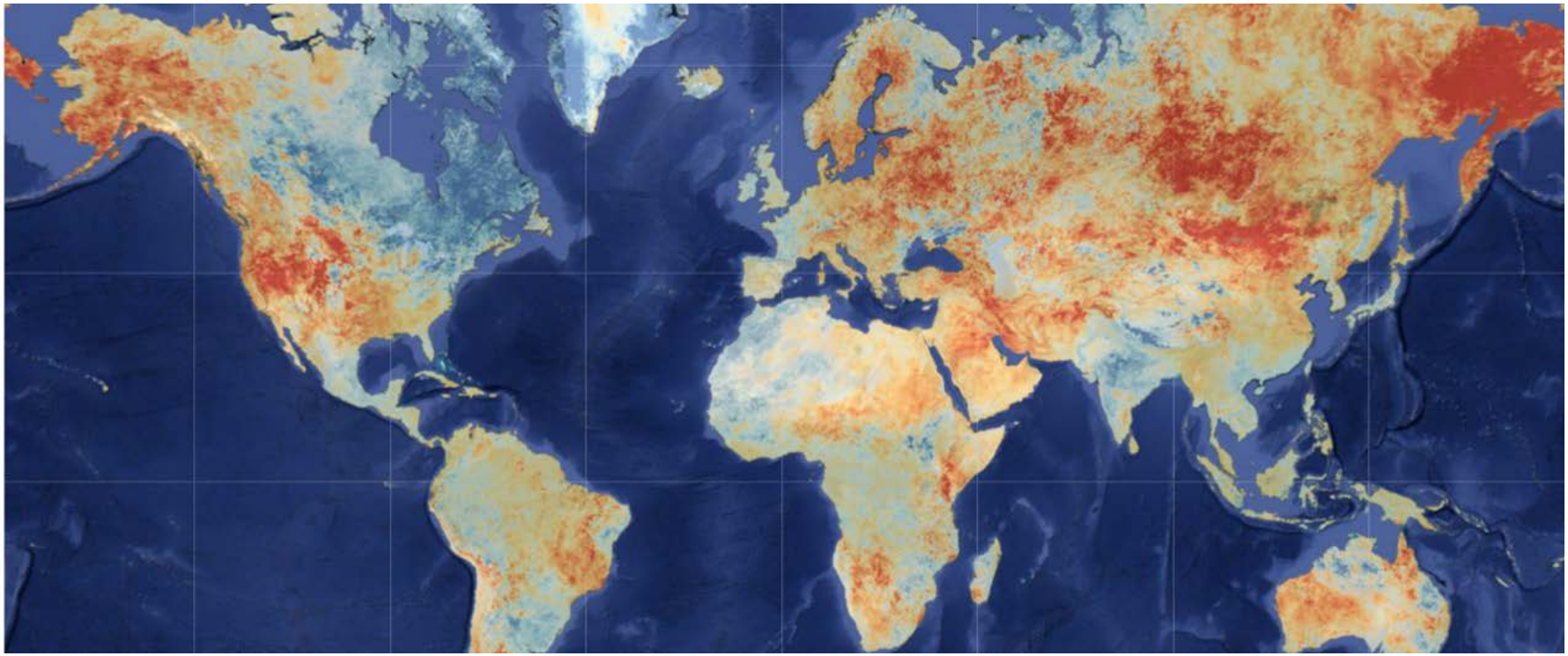
Monitoring Drought with Climate Engine: From Archives to Answers



Justin Huntington, DRI
Britta Daudert, DRI
Charles Morton, DRI
Dan McEvoy, DRI

John Abatzoglou, UI
Katherine Hegewisch, UI
Donny VanSant, UI
Rick Allen,

Earth Engine Team

Martin Landsfeld, UCSB
Greg Husak, UCSB
Jim Verdin, UGSG
Mac Friedrichs, USGS

Desert Research Institute

University of Idaho

Google

FEWS NET
FAMINE EARLY WARNING SYSTEMS NETWORK

Outline

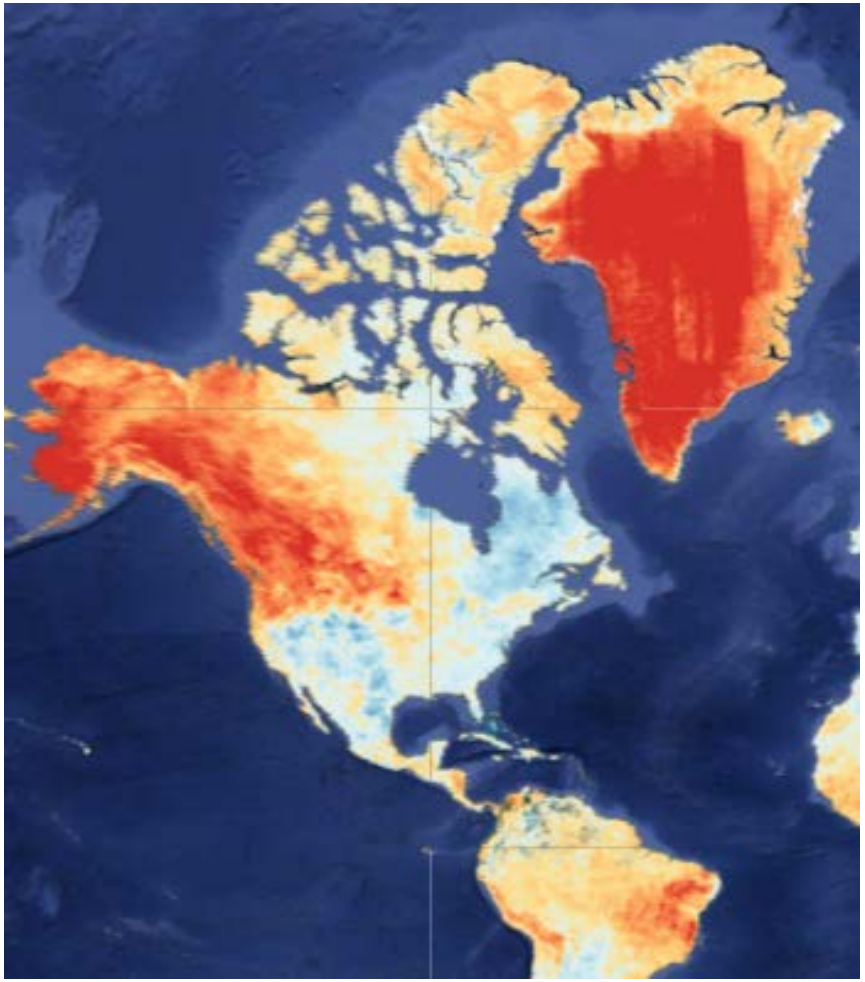
- The need for place-based information
- Different types of place-based drought impacts
- Cloud computing with climate and remote sensing data for drought/climate/water use monitoring
- Bottle neck – bringing this technology to natural resource management
- Climate Engine web application
- Future directions – water use mapping

Introduction – From Archives to Answers

- In an era of increasing wealth of earth observations and environmental data, approaches for quickly accessing, analyzing and visualizing these data to better inform decision making at relevant and place-based scales is lacking

- Great need to be able to quickly process and visualize data to improve monitoring and early warning of drought, wildfire, and crop-failure risk

- Instead of focusing on processing entire archives, focus on results and answers for efficient decision making



March 15 - May 15, 2016 MODIS Land Surface Temperature Difference from Average (2000-2016) (+/- 6 degC)

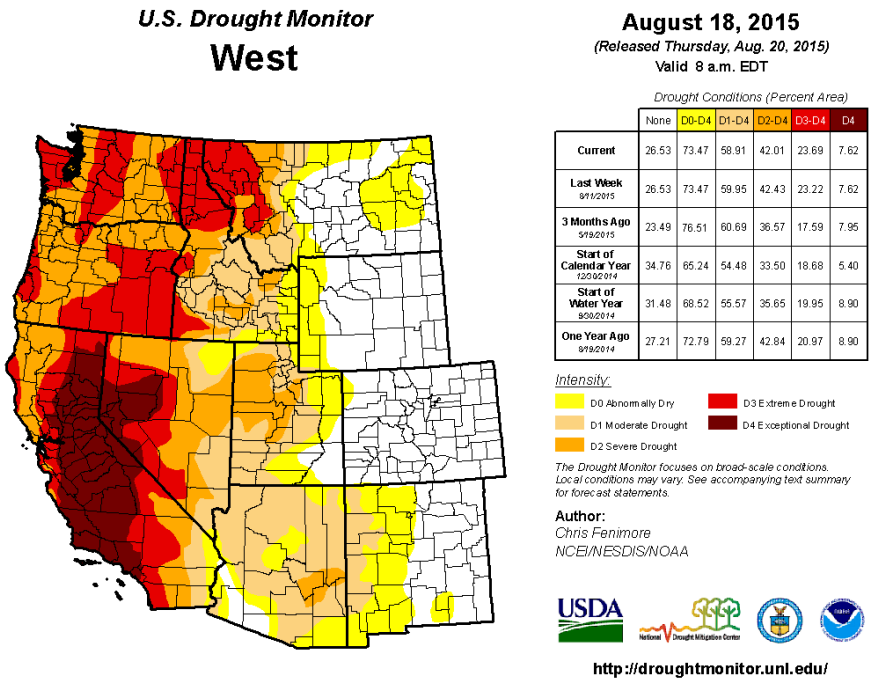
Introduction - Drought Information Needs at All Scales

- Drought information is needed at global, regional, and local scales

- Local “place-based” information has traditionally been hard to obtain due to the lack of observations and data access and processing limitations

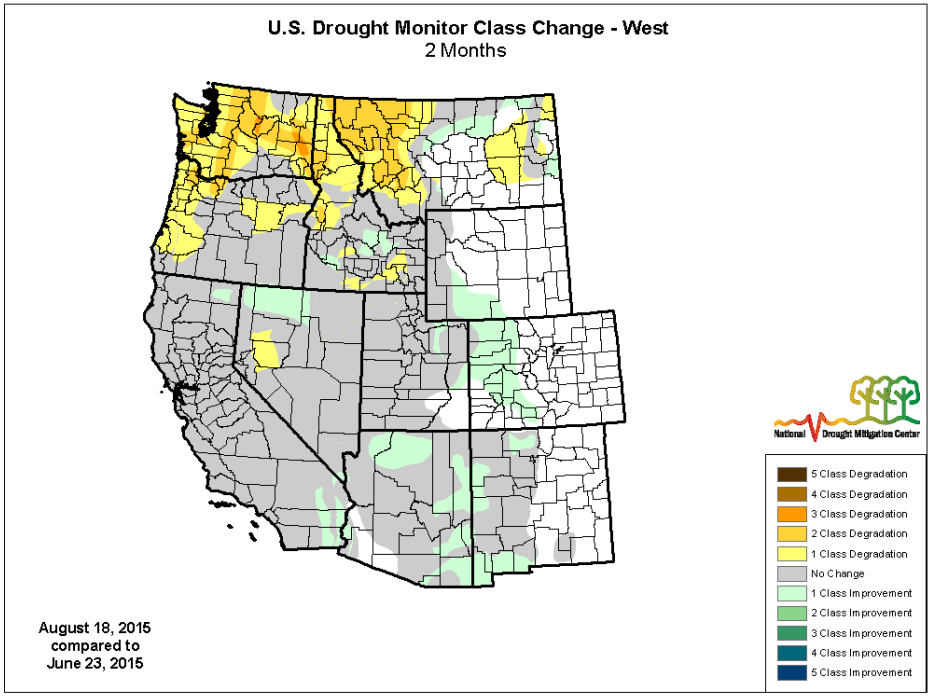
- With new and easy access to remote sensing, gridded weather data, and cloud computing platforms, place-based, regional, and global drought monitoring needs can be met

Regional & Large Temporal Scale
-US Drought Monitor-



- USDM reflects hydrologic drought more than rangeland drought conditions
- No one map can capture all types of drought

- Minimal changes in USDM over the summer of 2015

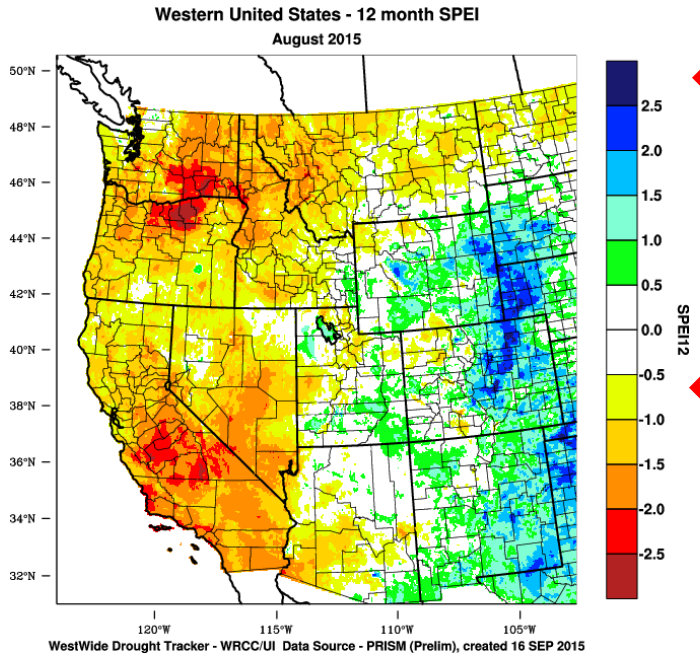


http://droughtmonitor.unl.edu

Different Types of Drought at the Same Time

Drought is complex: it has multiple drivers and develops and recovers at different time scales

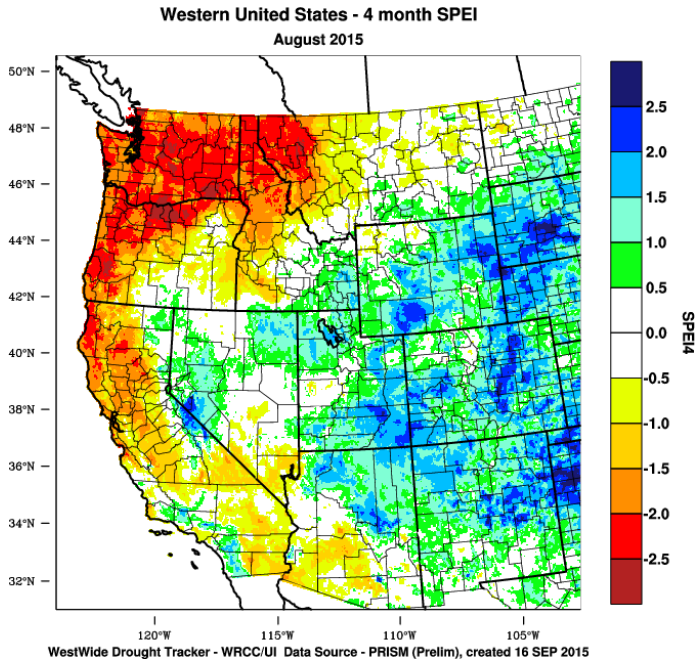
12 Month SPEI Ending in August, 2015



Long Term vs. Short Term Drought

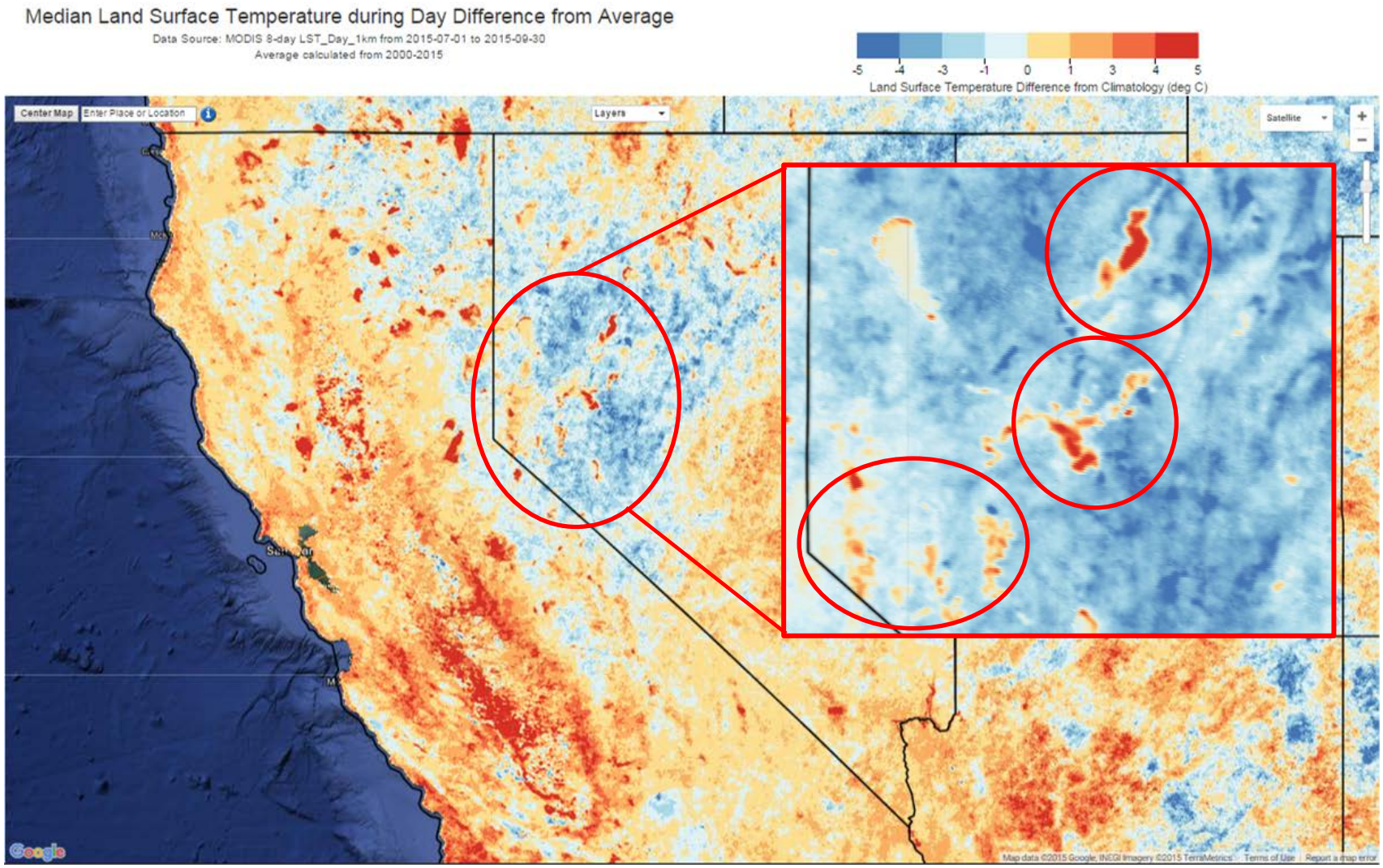
Hydrologic vs. Soil Moisture/ Rangeland Drought

4 Month SPEI Ending in August, 2015



Blue = Wet,Cool : Red = Dry,Hot

Different Types of Drought at the Same Time - Summer 2015

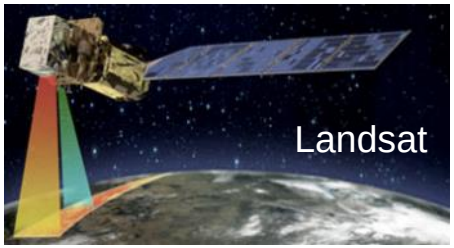


MODIS Surface Temperature Anomaly for July – Sept, 2015

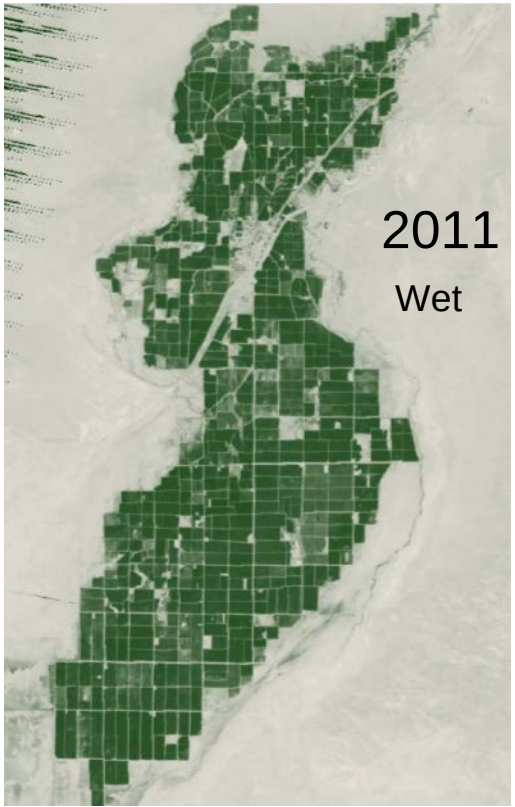
Place-Based Hydrologic and Rangeland Drought Assessments

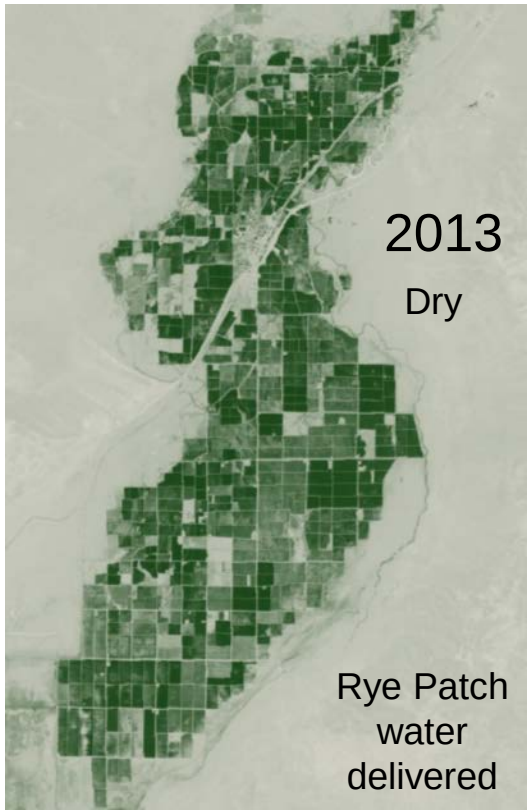
Lovelock, Nevada – Humboldt River Basin

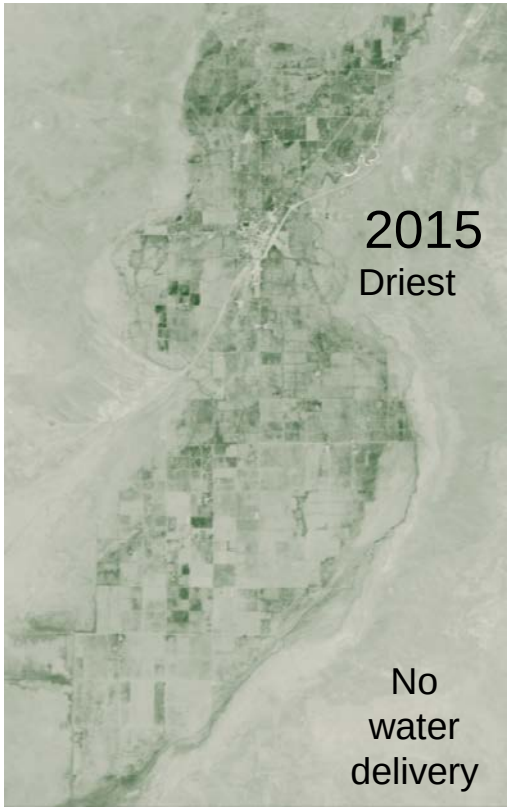
- No groundwater pumping for irrigation (too salty)
- Very little storage upstream
- Extremely sensitive to persistent hydrologic drought



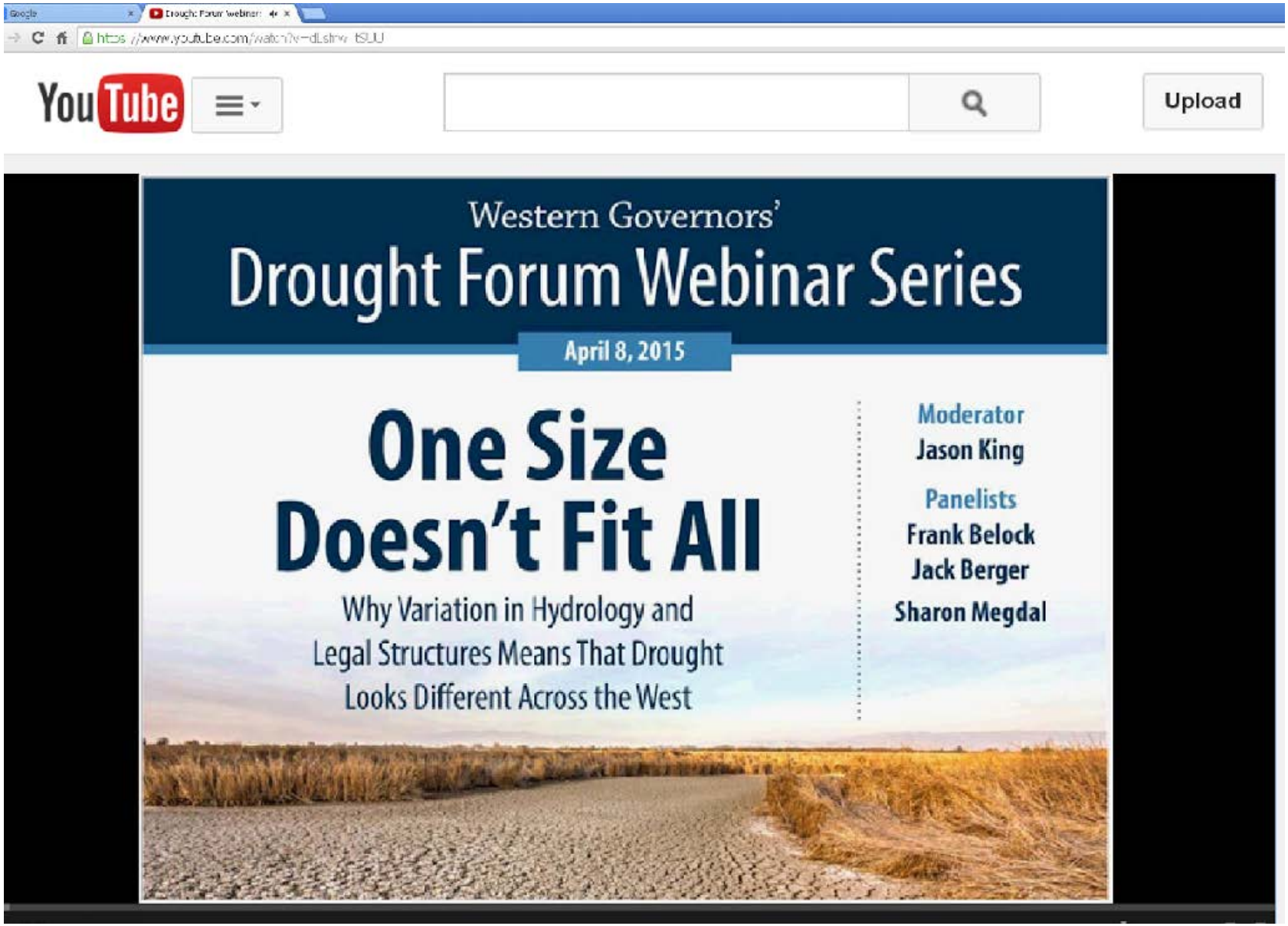
-Growing Season Max NDVI (30m Pixels)







Western Governors' Drought Forum

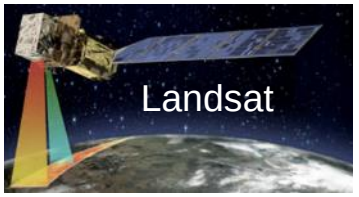


Place-Based Hydrologic and Rangeland Drought Assessments

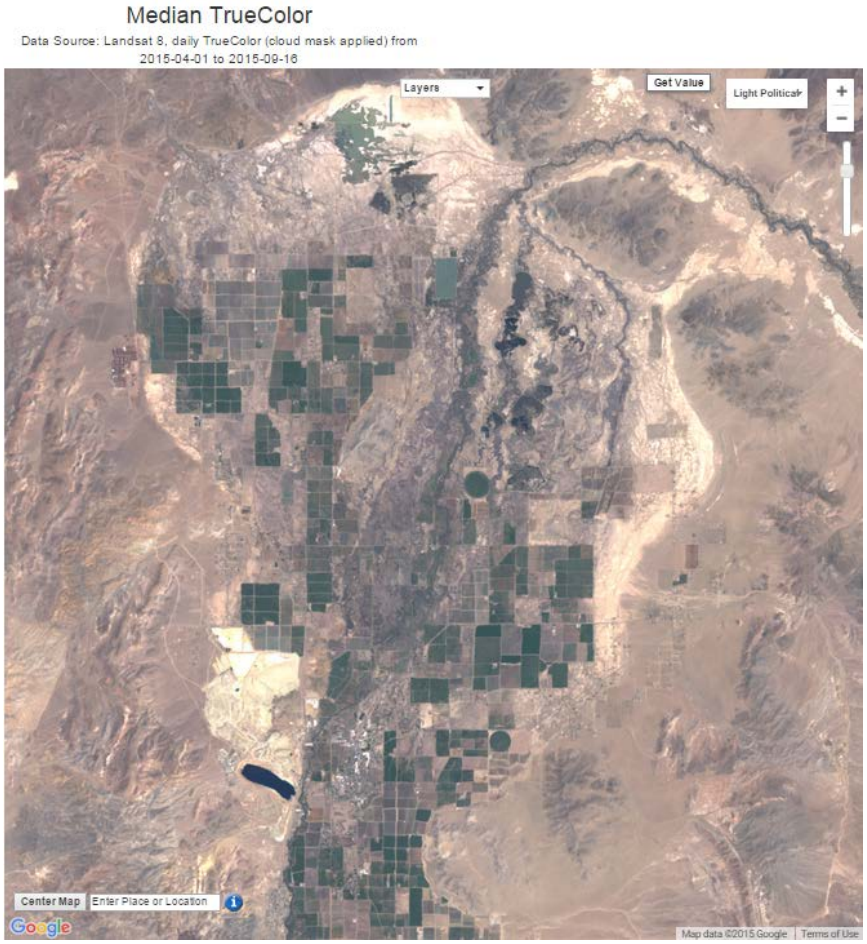
- Landsat Median Vegetation Greenness (NDVI)

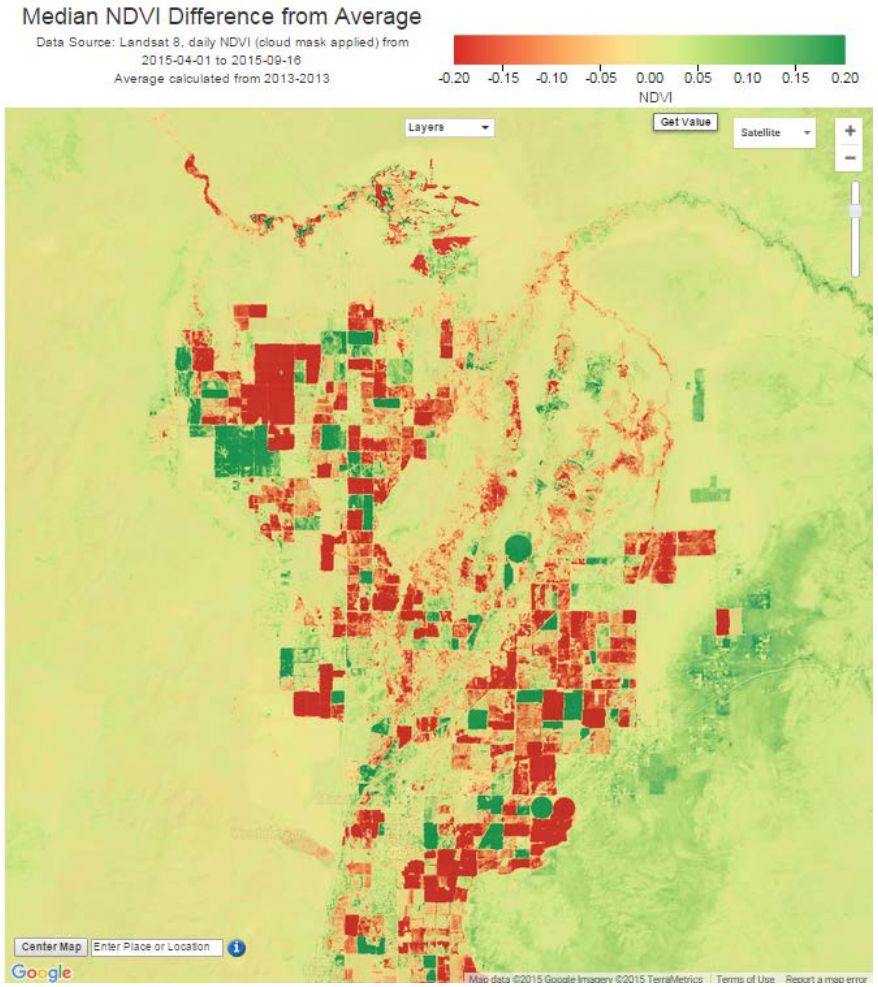
	4/1 – 8/16, 2013	4/1 – 8/16, 2015	2013 minus 2015
Fallon			
Carson Smith Mason			
Lovelock			

Place-Based Hydrologic and Rangeland Drought Assessments

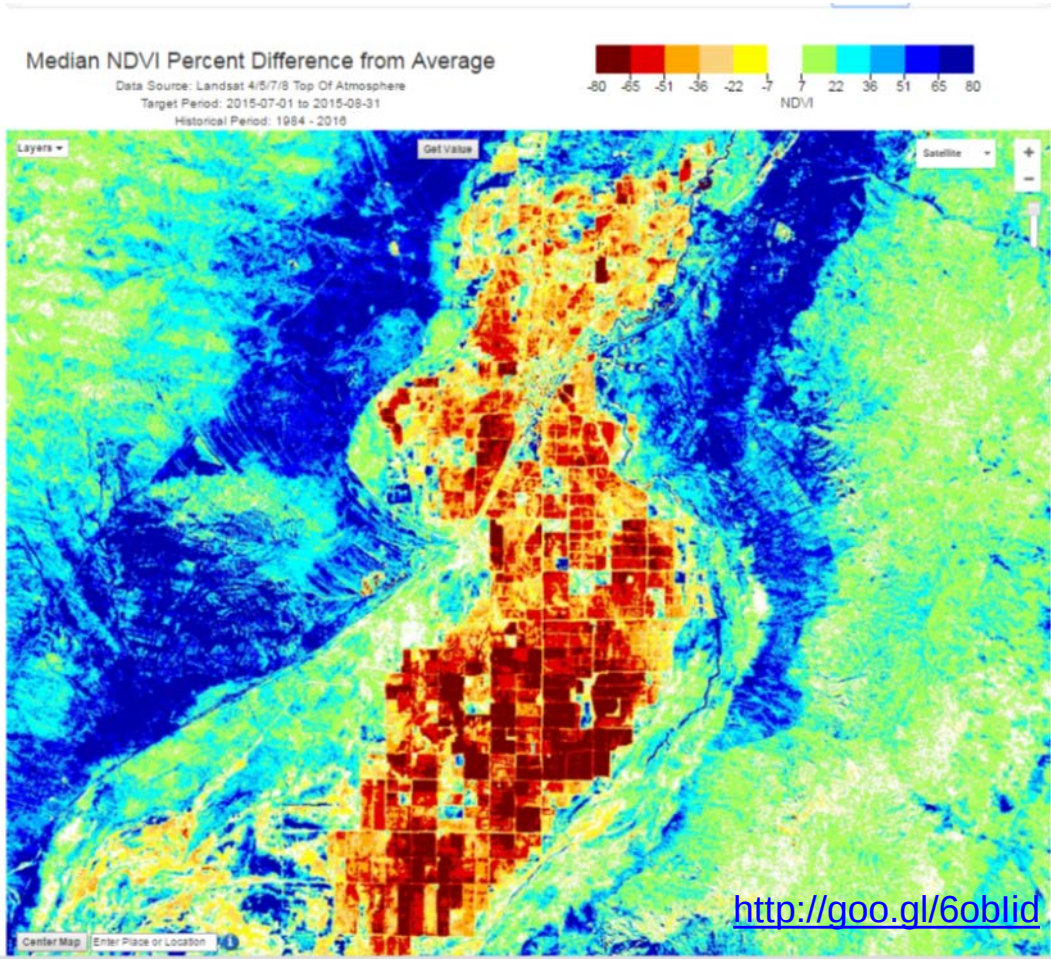


- Mason Valley 2015 difference from 2013 Greenness (April – Sept of 2015)





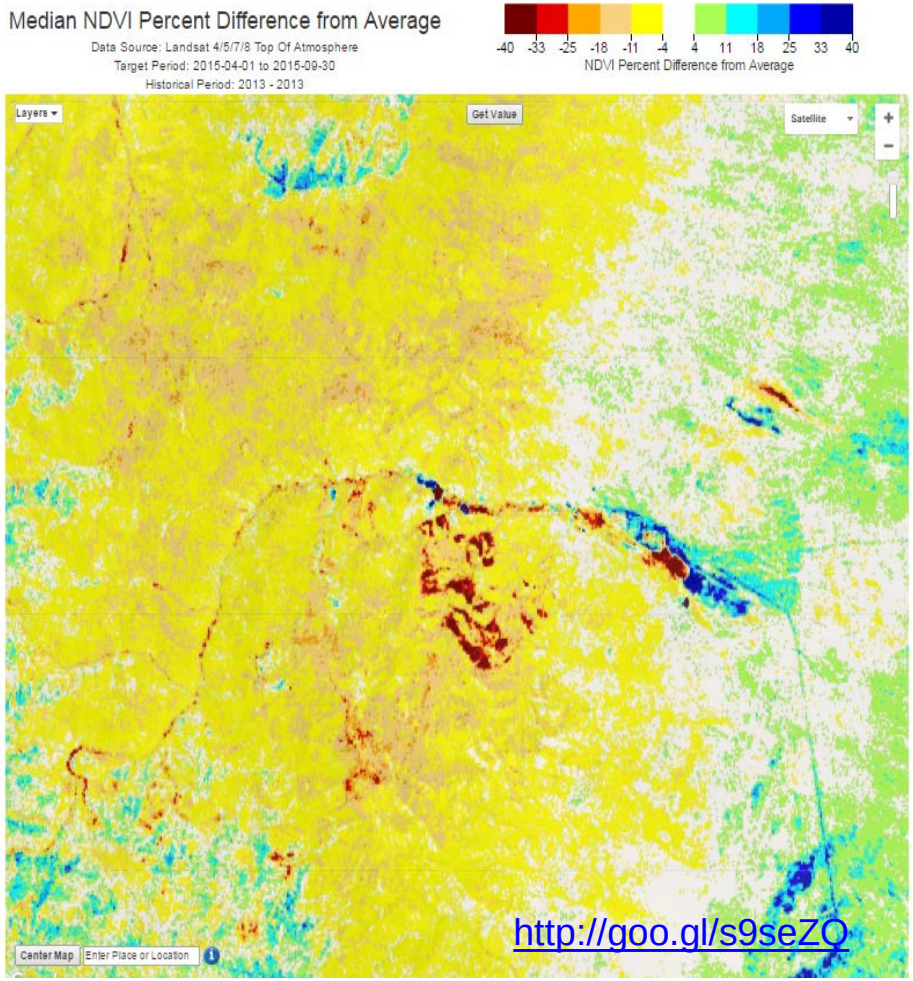
Place-Based Hydrologic and Rangeland Drought Assessments



Landsat Percent Difference from Average (30yr) for July – August, 2015

Place-Based Hydrologic and Rangeland Drought Assessments

- Smith Creek Ranch (Desatoyas) 2015 difference from 2013 Greenness (April – Sept of 2015)



Place-Based Ecological Drought Assessments

2013 July-Aug
Max NDVI

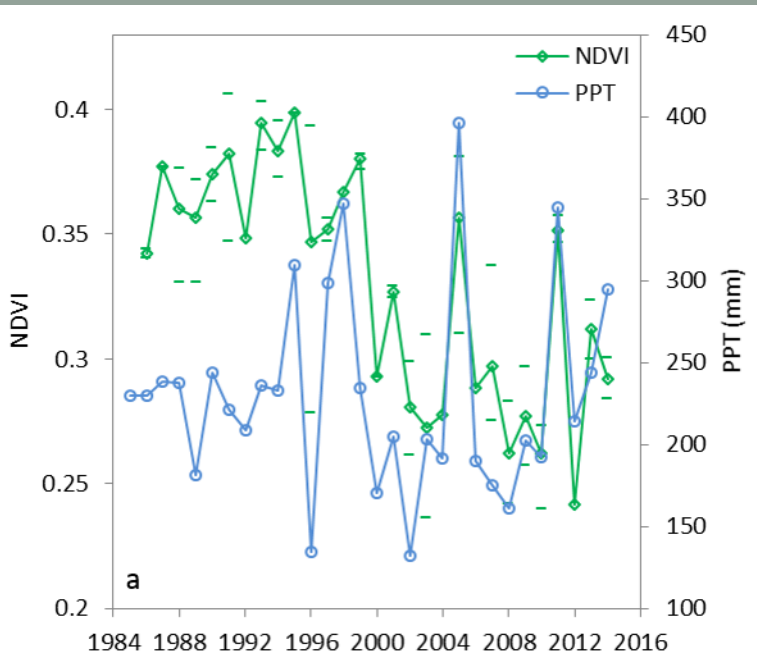
2014 July-Aug
Max NDVI

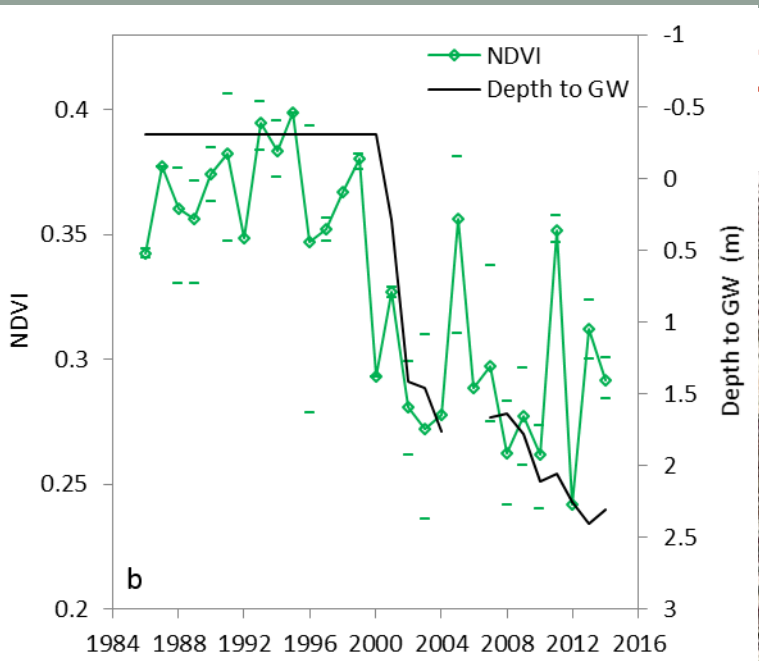
2015 July-Aug
Max NDVI

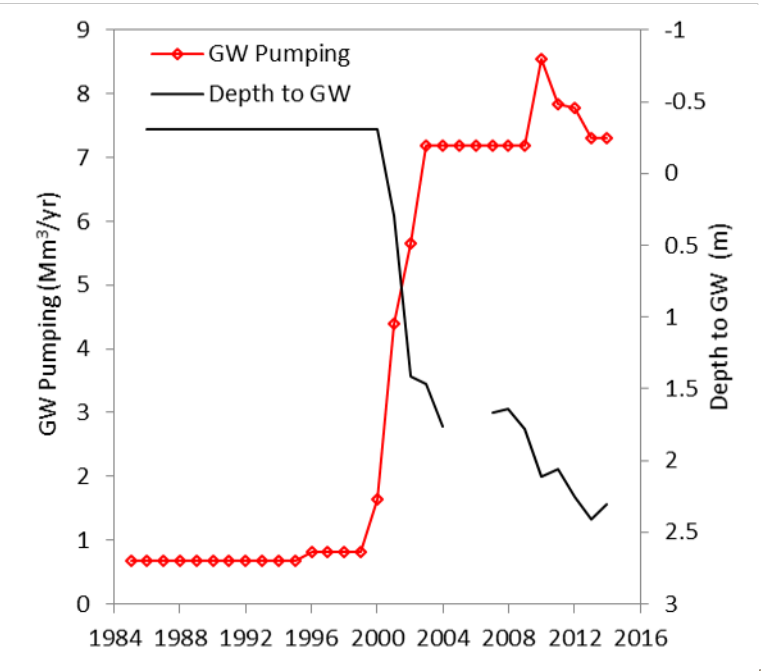
Indian Valley, NV (Upper Reese River) supports the largest sage-grouse lek counts (i.e. dance floors) in NV

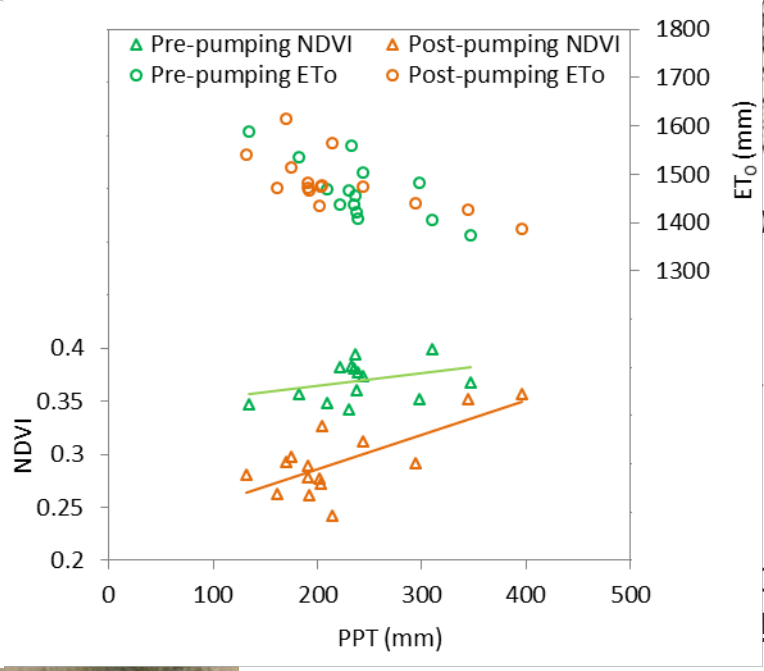
Which areas are resilient to extended droughts?

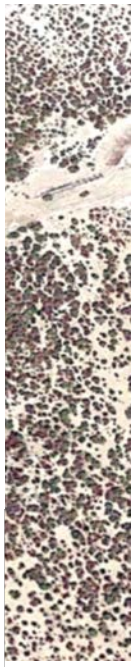
Plac
Asse











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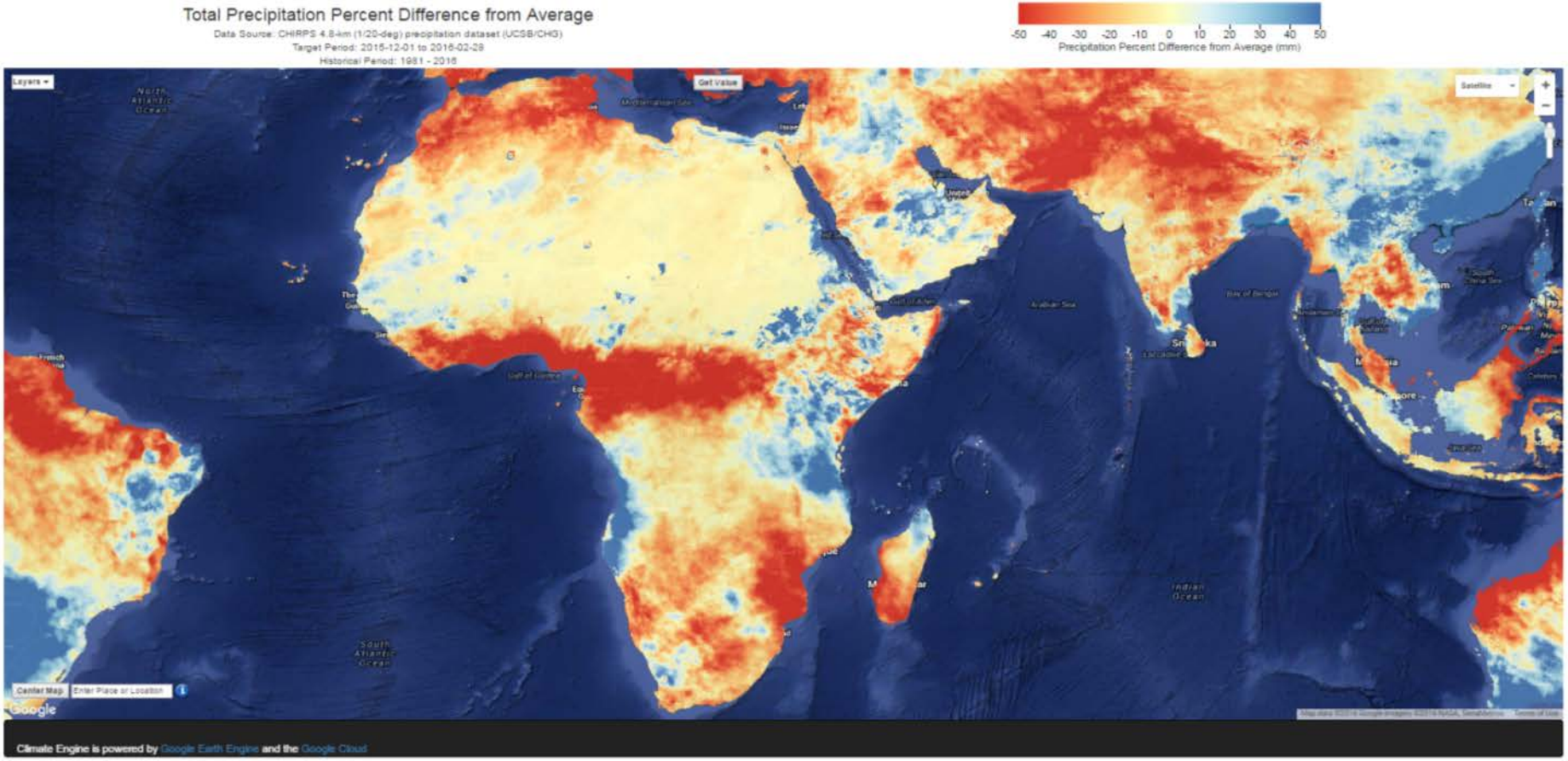
Global Scale – Drought and Famine Watch

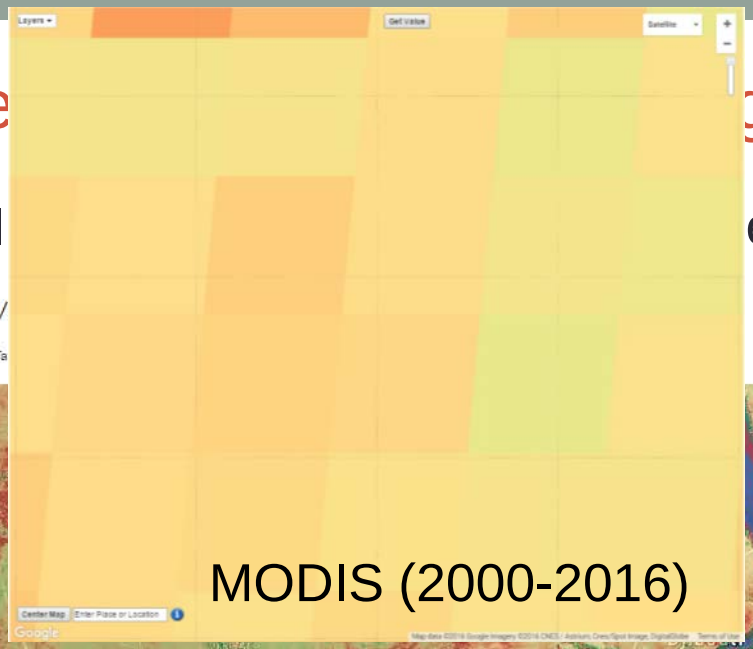
CHIRPS December-February 2015/2016 percent difference from average precipitation

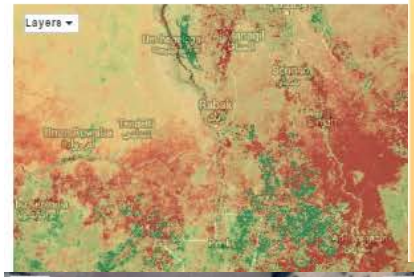


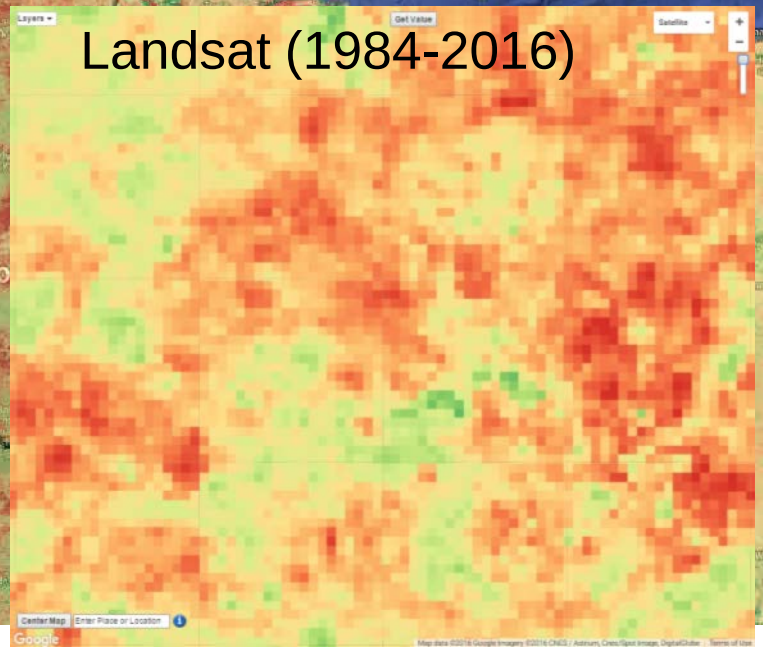
Example shows the impact of El Nino on Africa and Asia where crop failure was extreme due to low PPT

Global Scale ght and Famine Watch

MODIS NDVI e from May – October, 2015







Example shows the impact of El Nino on Ethiopia crop failure

From Archives to Answers that Programmers *and* Non-programmers can obtain…

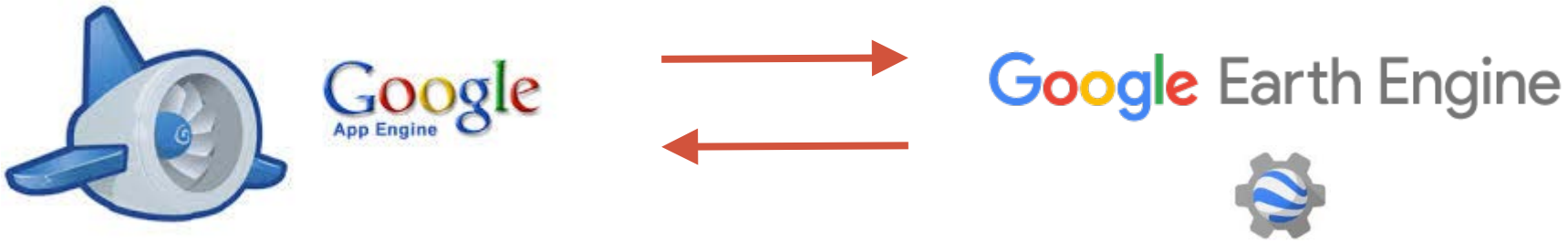
- Having Landsat, MODIS, and gridded climate and weather archives combined with cloud computing is super!!

- But the bottleneck is providing the ability for anyone to perform data analysis on their own
  - BLM staff, State water agencies, African field scientists, etc..

- Solution? – Link Google Earth Engine to a web-based frontend where coding by users is not needed to provide commonly needed drought/climate/water maps, metrics, and time series

Earth Engine Based Web Application for Drought Monitoring - *ClimateEngine.org*

- Everything shown so far was created with Earth Engine
- ClimateEngine.org relies on Google App Engine and Google Maps linked and Google Earth Engine through the Python API
- Users input collection and time parameters -> Google App Engine passes these parameters to Google Earth Engine -> results return to Google App Engine



How We Started, Motivation, Our Team

How We Started

- Our project was funded through a Google Earth Engine Faculty Research Award in Summer of 2014

Motivation

- Develop a web application that allows the public to visualize global and place based maps and time series of climate and remote sensing archives together and in near real-time, for drought, climate, and vegetation monitoring and post processing and, ***data discovery***

DRI Desert Research Institute

University of Idaho

Justin Huntington

Associate Research Professor, Hydrology
Desert Research Institute
University of Nevada,Reno
Justin.Huntington [at] dri.edu

Britta Daudert

Research Scientist
Desert Research Institute
University of Nevada,Reno
Britta.Daudert [at] dri.edu

Charles Morton

Research Scientist
Desert Research Institute
University of Nevada,Reno
Charles.Morton [at] dri.edu

Dan McEvoy

Graduate Student
Desert Research Institute
University of Nevada,Reno
Daniel.McEvoy [at] dri.edu

John Abatzoglou

Associate Professor, Geography
University of Idaho, Moscow
jabatzoglou [at] uidaho.edu

Katherine Hegewisch

Postdoctoral Fellow
University of Idaho, Moscow
khegewisch [at] uidaho.edu

Donovan VanSant

Graduate Student
University of Idaho, Moscow
vans1746 [at] vandals.uidaho.edu

Now collaborating with:

FEWS NET FAMINE EARLY WARNING SYSTEMS NETWORK

UC Santa Barbara

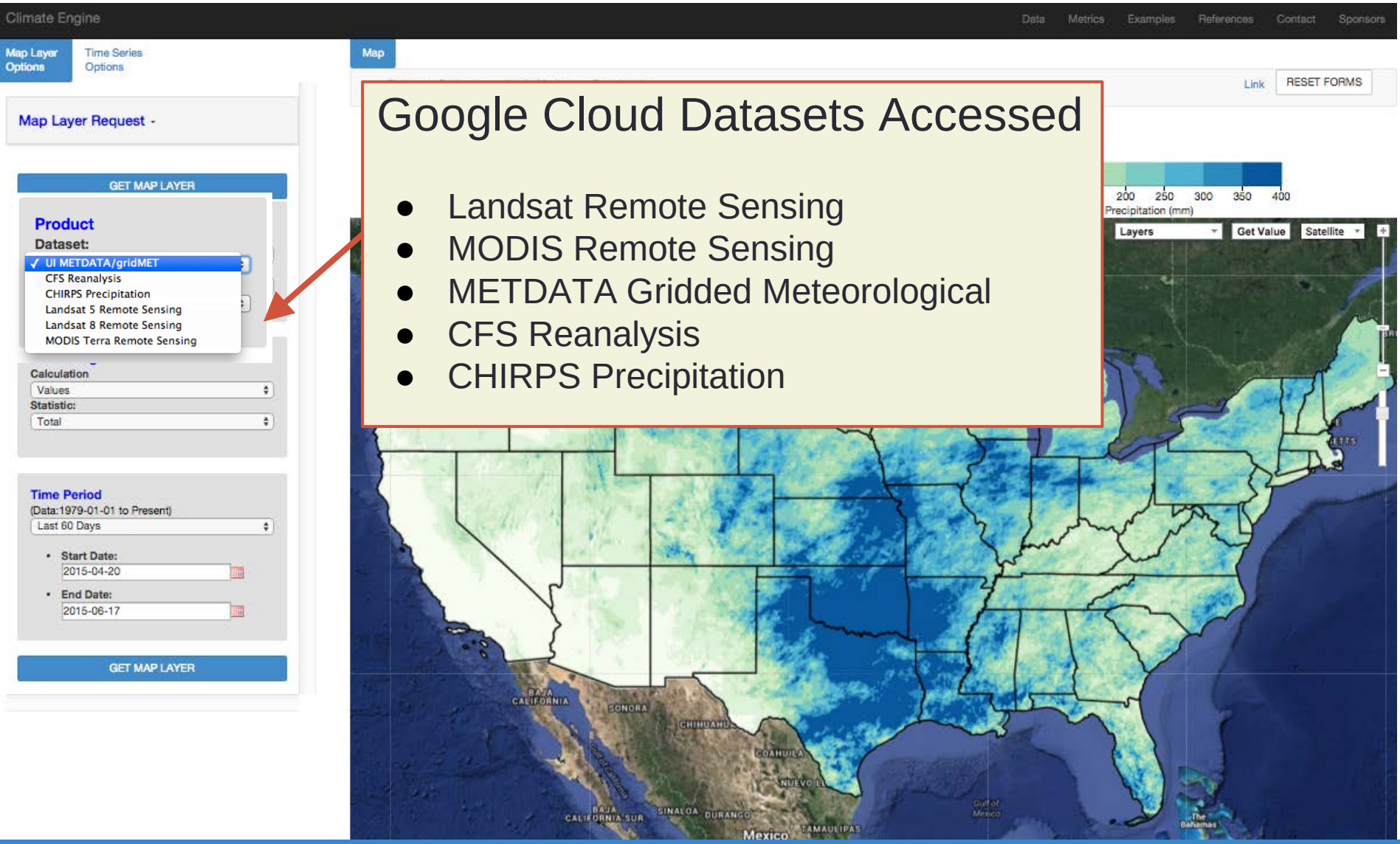
NIDIS

NASA

USGS

Recently Unveiled at the White House Water Summit

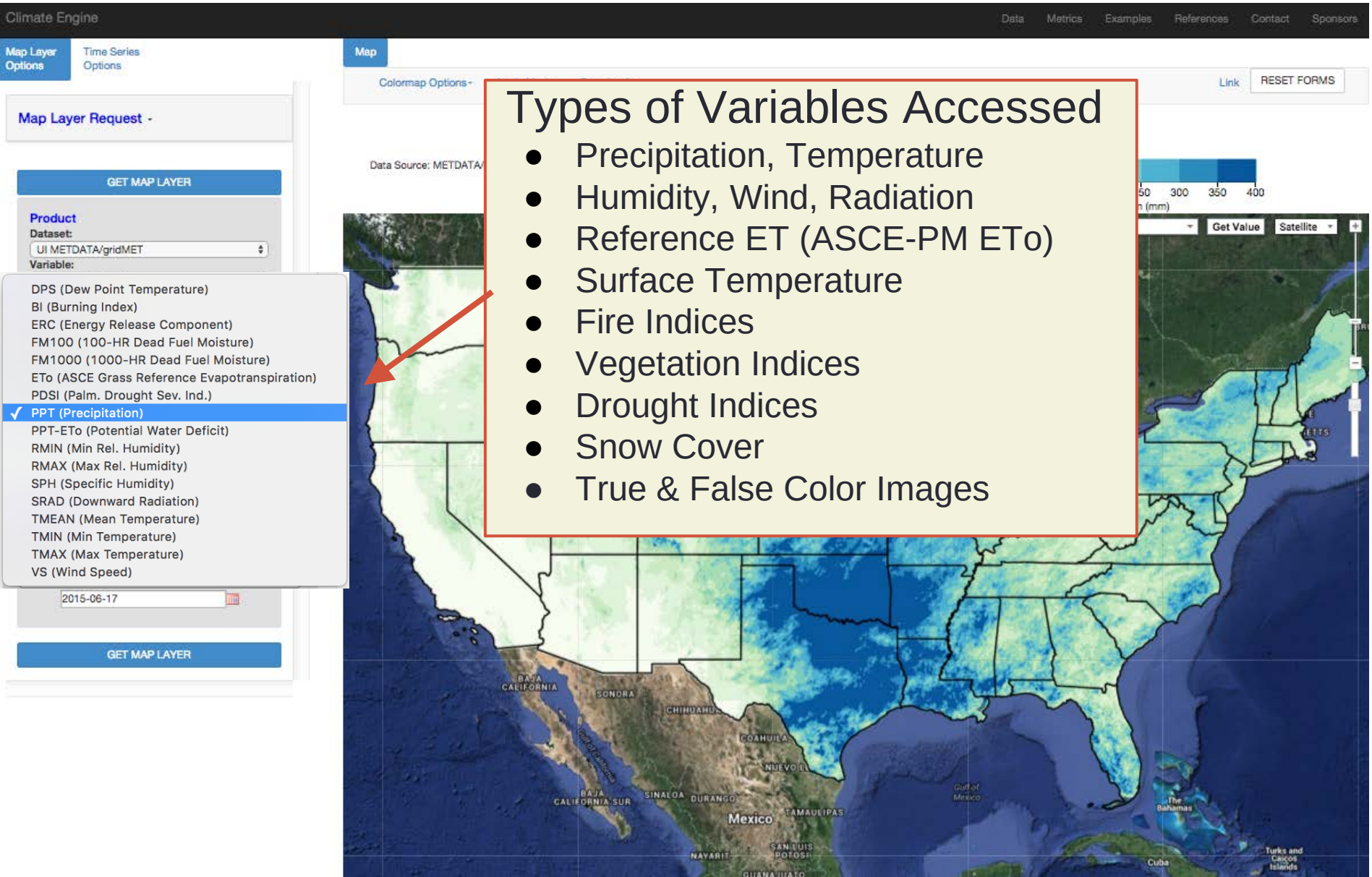
Google Cloud Assets



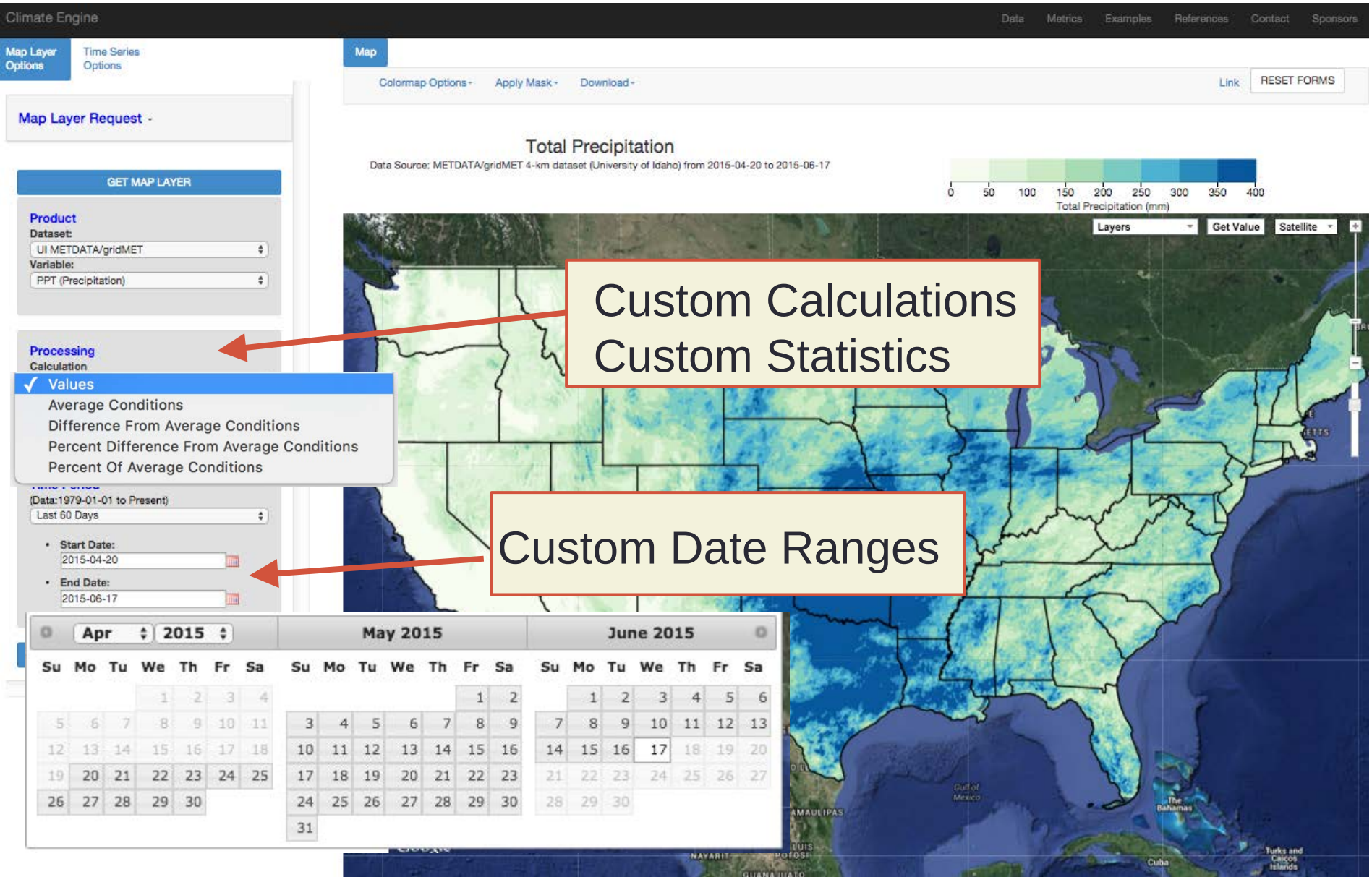
Google Cloud Datasets Accessed

- Landsat Remote Sensing
- MODIS Remote Sensing
- METDATA Gridded Meteorological
- CFS Reanalysis
- CHIRPS Precipitation

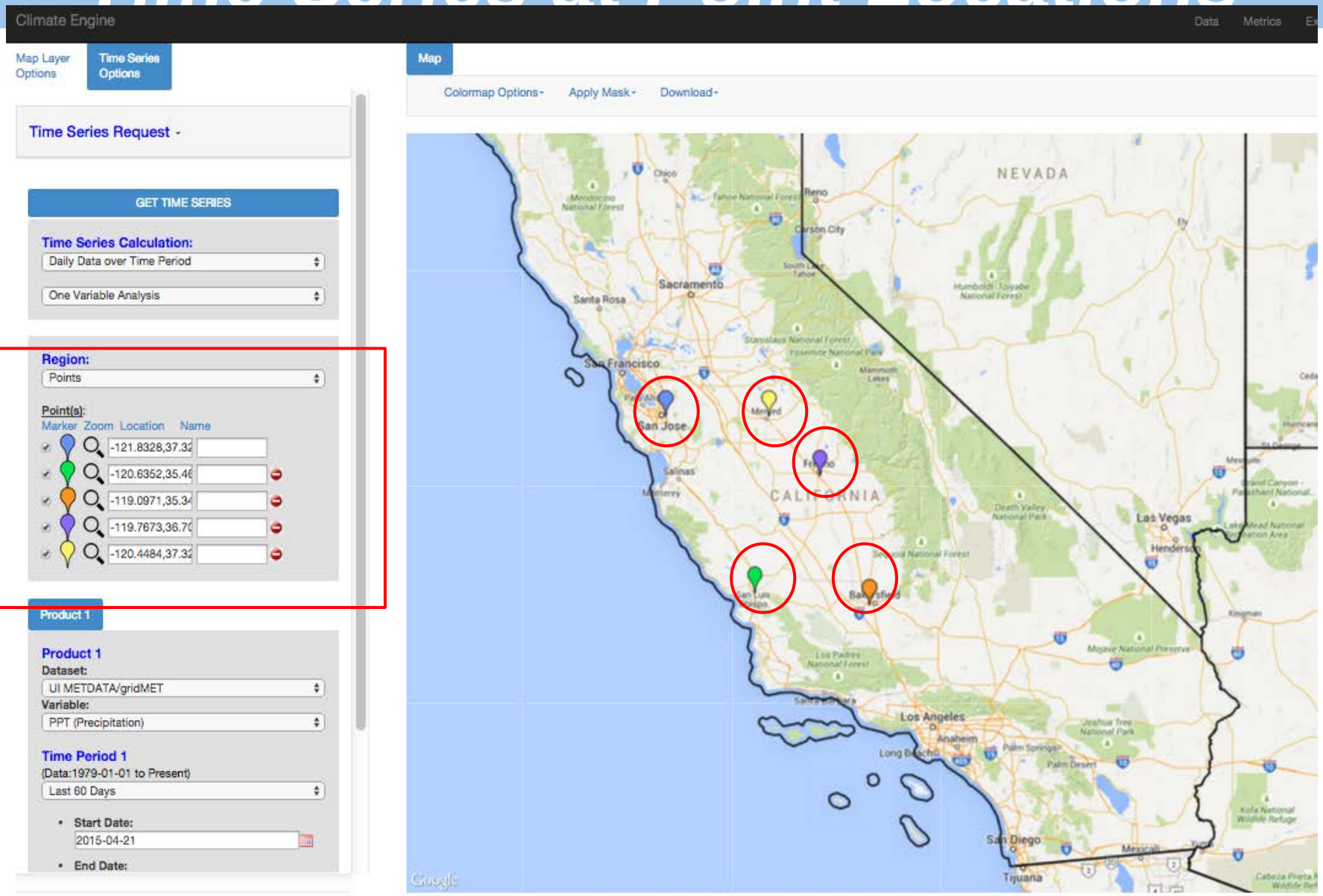
Variables Computed or Accessed



Custom Interface

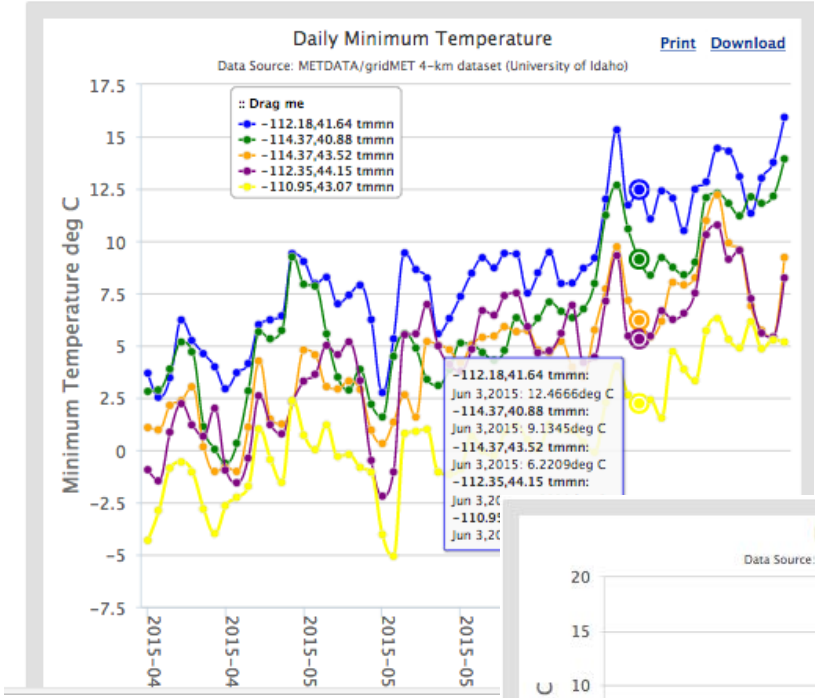


Time Series at Point Locations

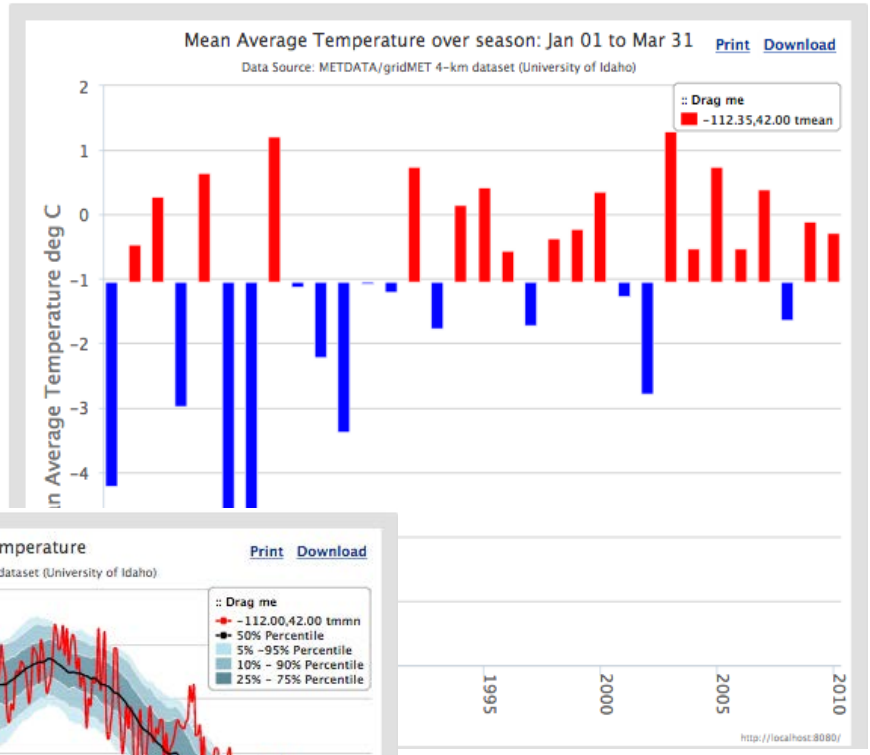


Time Series Summaries

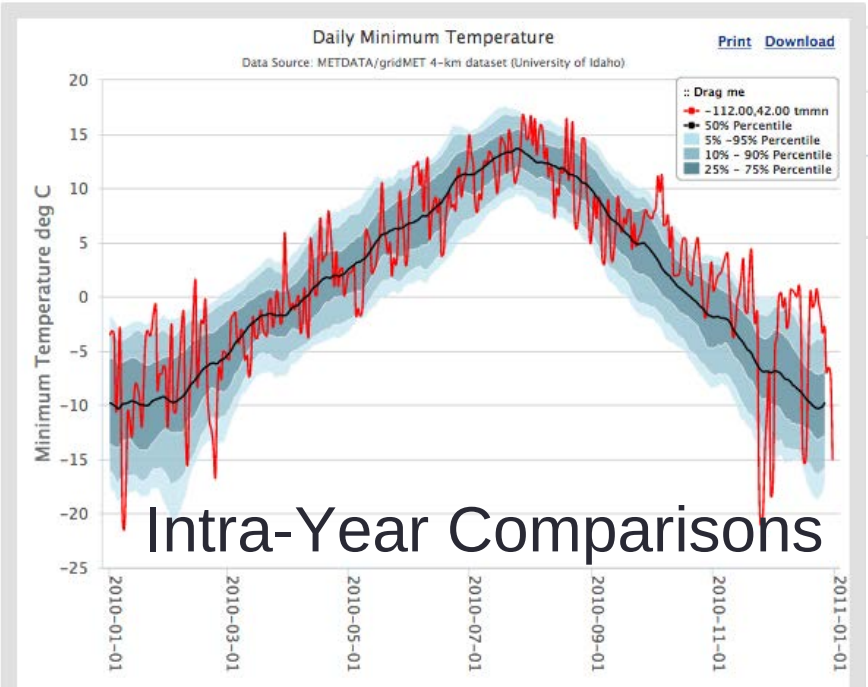
Multiple-Region Comparisons



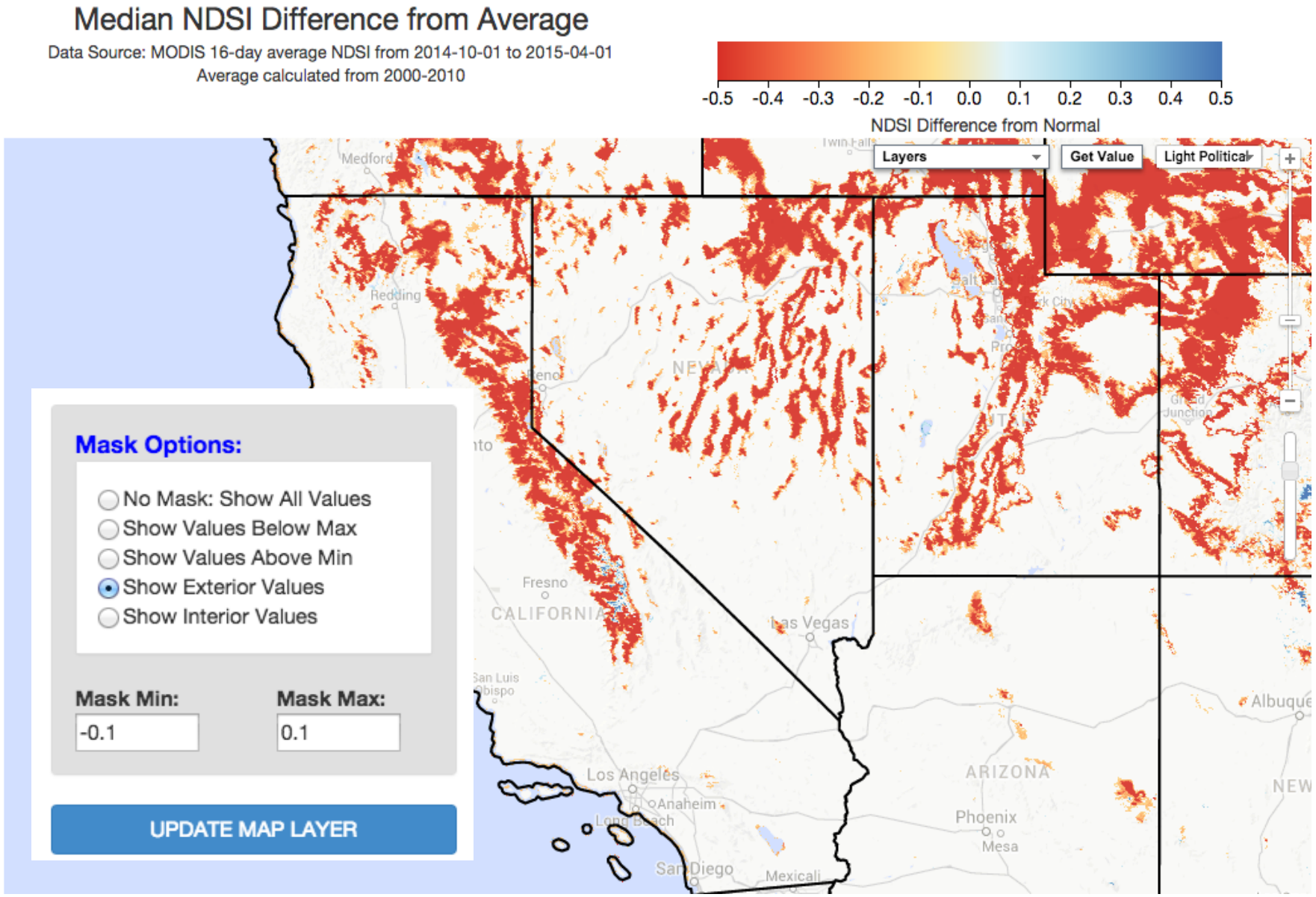
Multiple-Year Comparisons



Intra-Year Comparisons



Custom Masking



Spatial Averaging in Time

Climate Engine Beta

Map Layer Options | Time Series Options | HIDE MENU

GET TIME SERIES

Time Series Calculation:
Raw Data over Time Period
One Variable Analysis

Region:
Area Averages

Area of Interest:
Polygon

Variable 1

Variable 1
Type: Remote Sensing
Dataset: Landsat 4/5/7/8 Surface Reflectance
Variable: NDVI (Vegetation Index)

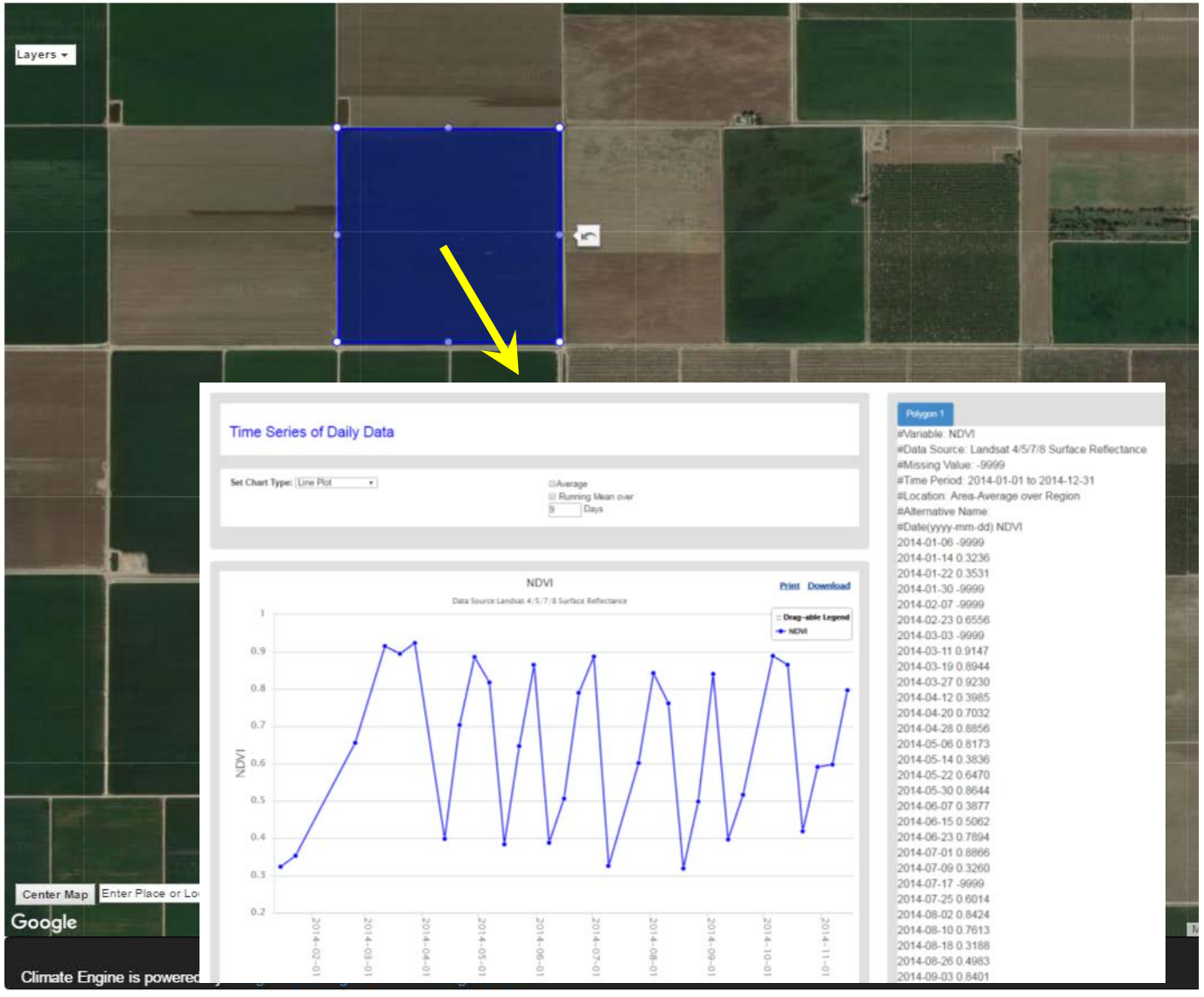
Time Period
(Data: 1982-01-01 to 2016-06-07)
Custom

Start Date: 2014-01-01
End Date: 2014-12-31

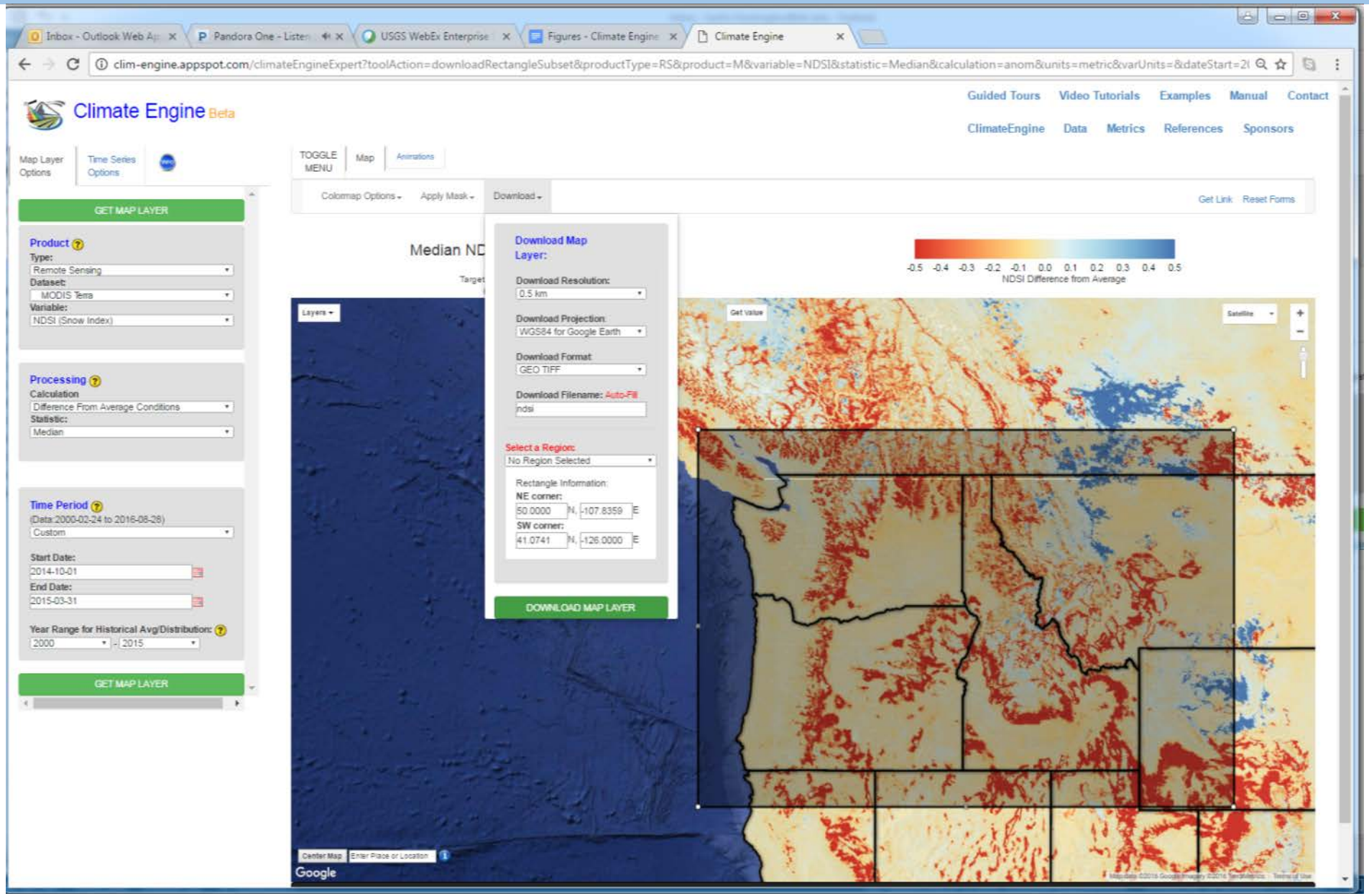
GET TIME SERIES

Plot Options

Landsat 7 and 8 NDVI Time Series for 2014 – Alfalfa Field



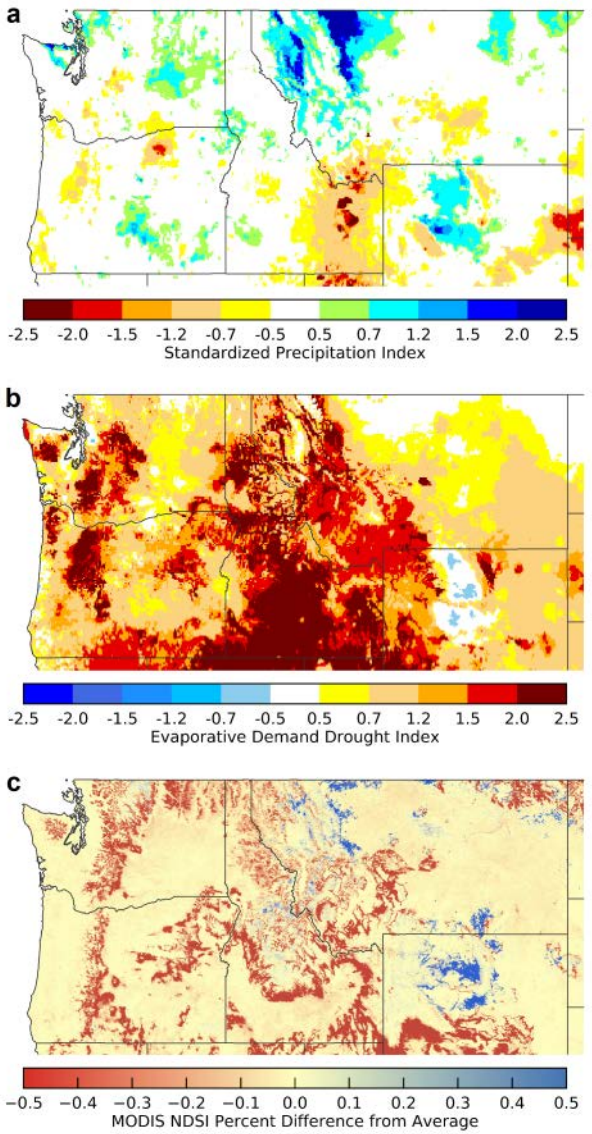
Download Maps



Bring Maps into GIS for Publication

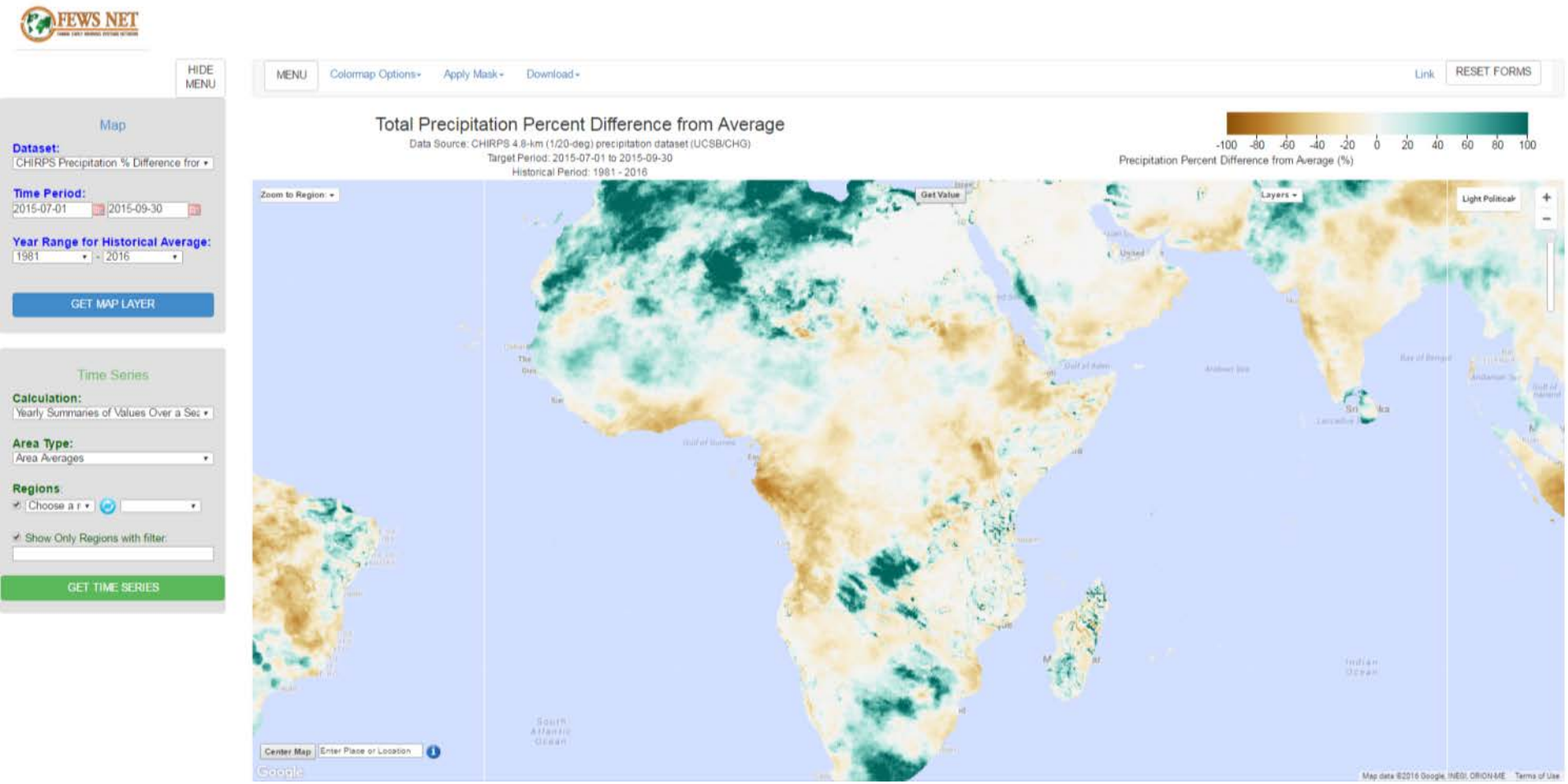
Pacific Northwest Snow Drought

- SPI from Oct. 2014 to March 2015 is largely normal in Cascades N. Rockies
- Evaporative Demand High (high temp and solar radiation)
- Let to high snow line, high snow melt, and “snow drought”
- Download answers instead of archives!!



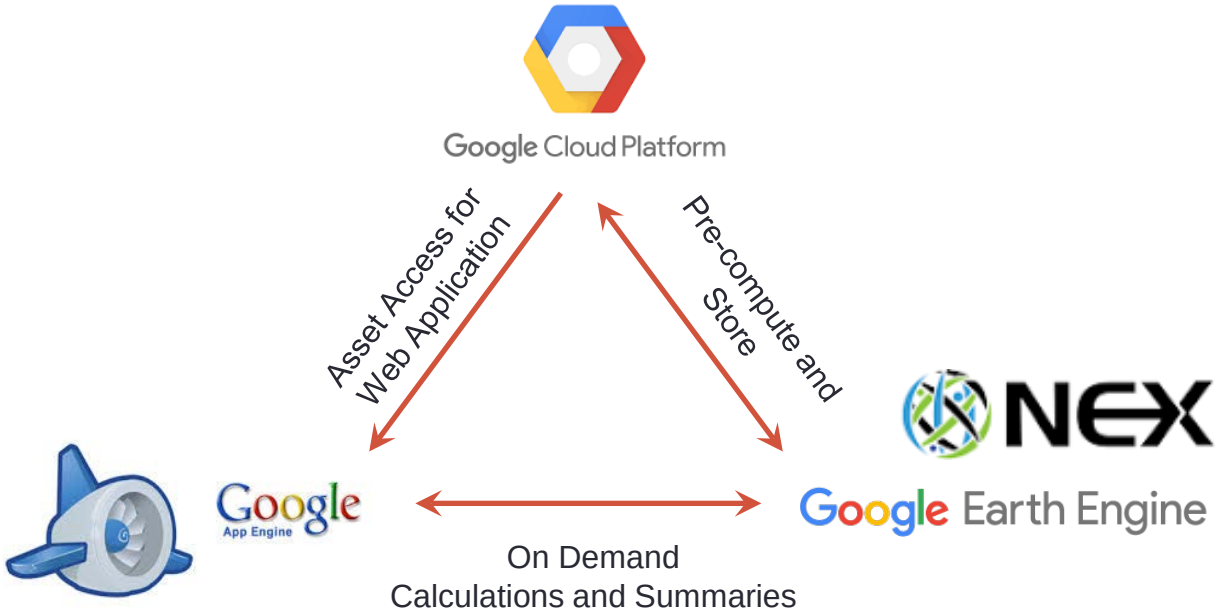
Created Spin-off App. For Famine Early Warning System

- Took all the core assets and functions of ClimateEngine.org and made it FEWS NET focused
- Collaboration with UC Santa Barbara, USGS, and USAID



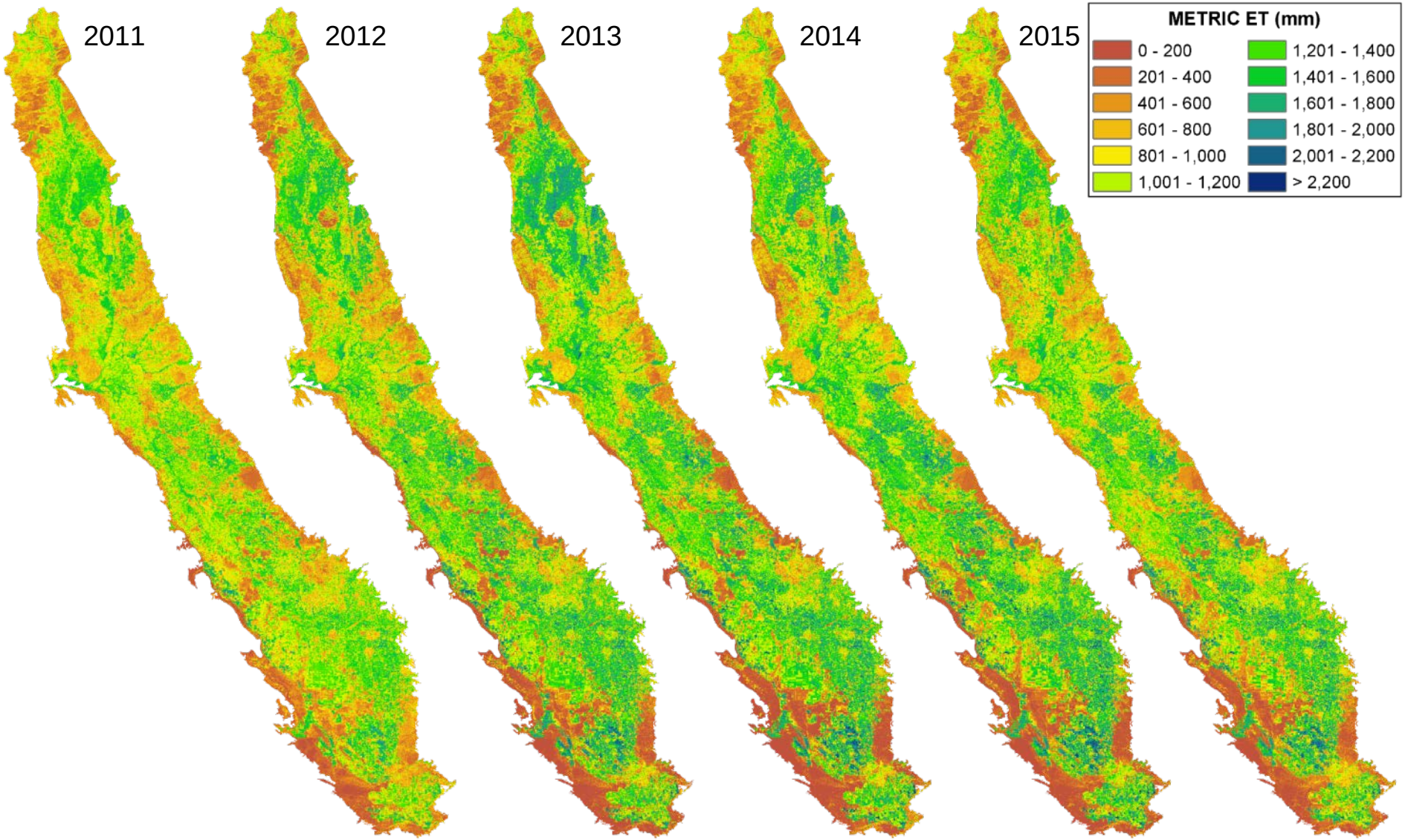
Future Directions – Export.image.toAsset

- New Earth Engine asset manager allows users to create data and export “assets” to the cloud
- Assets can then be accessed through a web application like ClimateEngine.org
  - New ability to programmatically and operationally compute, store, and access data in the cloud is really powerful and exciting..game changer!!



ET for the last 5 years generated on NEX

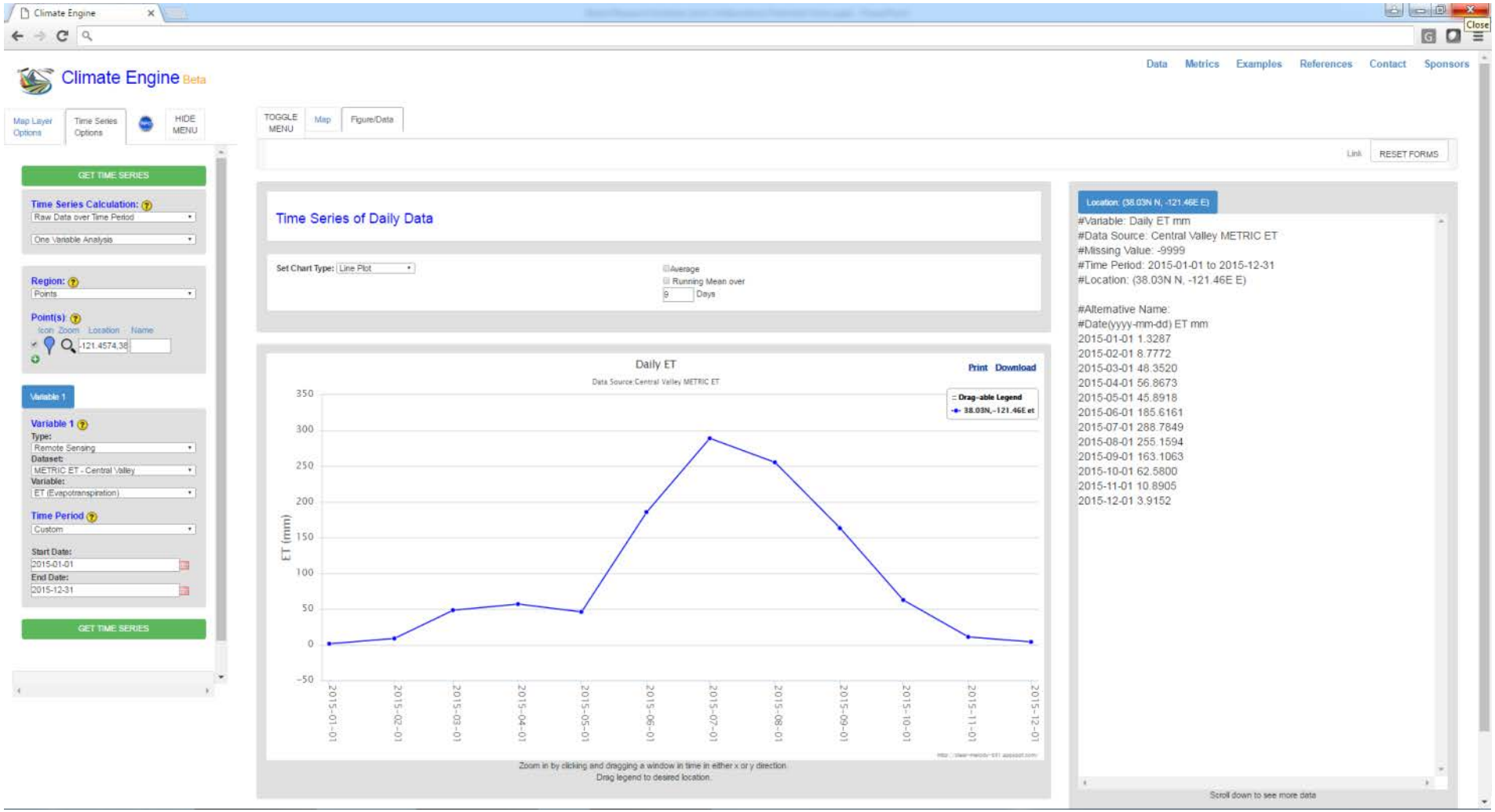
- Lower ET during drought in water limited areas
- Higher ET during drought in well-watered areas

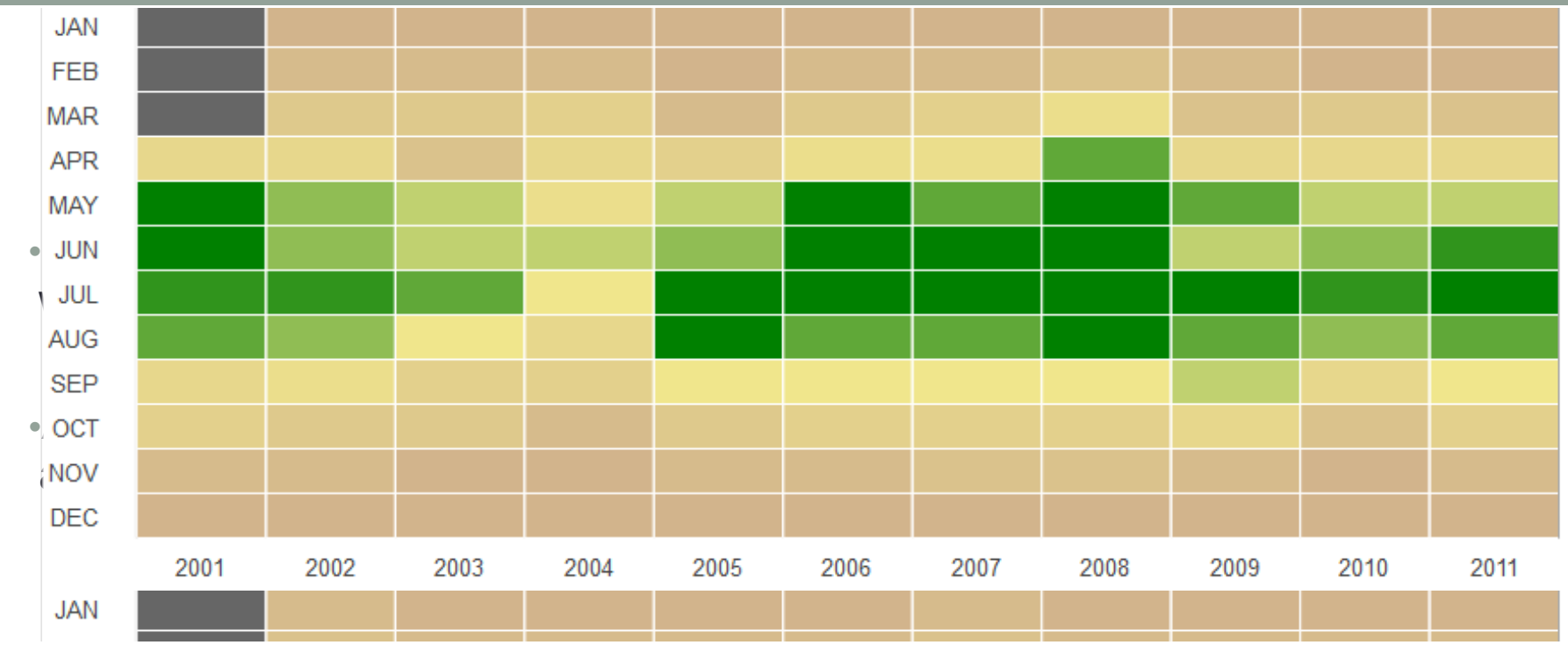


Our First Test

Uploaded NEX pre-computed Landsat monthly METRIC ET (2011-2015) to asset manager, and accessed in the Earth Engine Playground and ClimateEngine.org

ClimateEngine.org to host and post-post Process ET Data




JAN
FEB
MAR
APR
MAY
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SEP
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2001
2002
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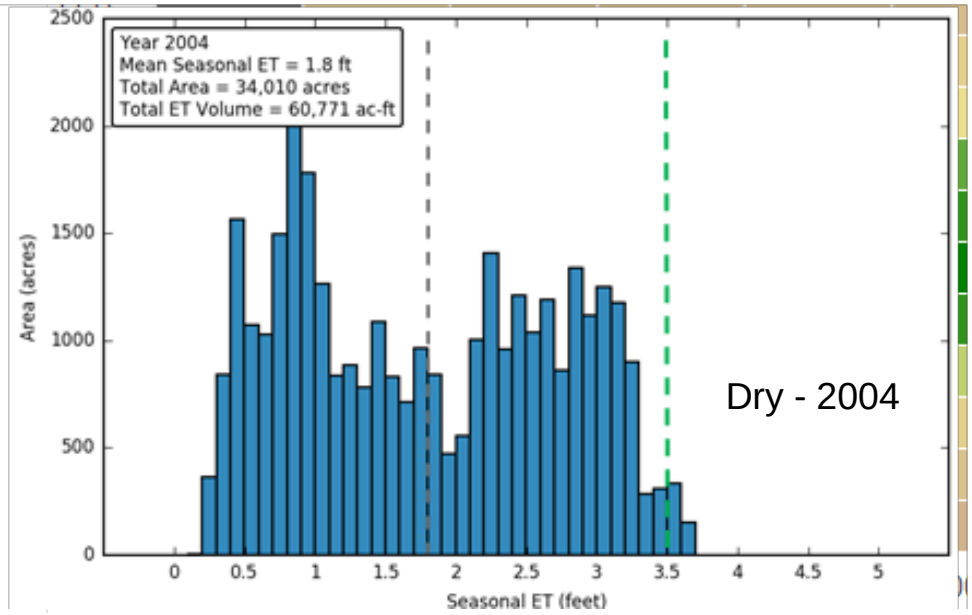
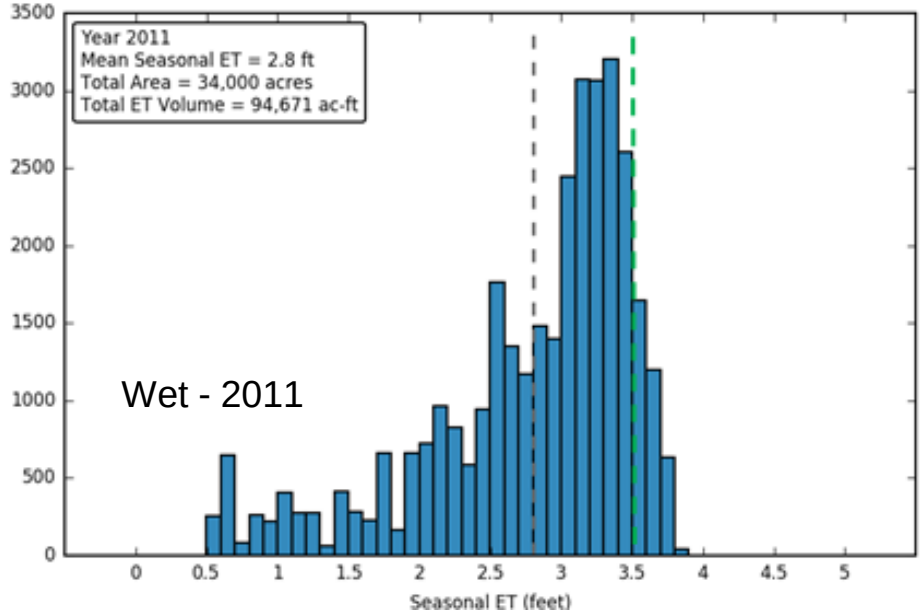
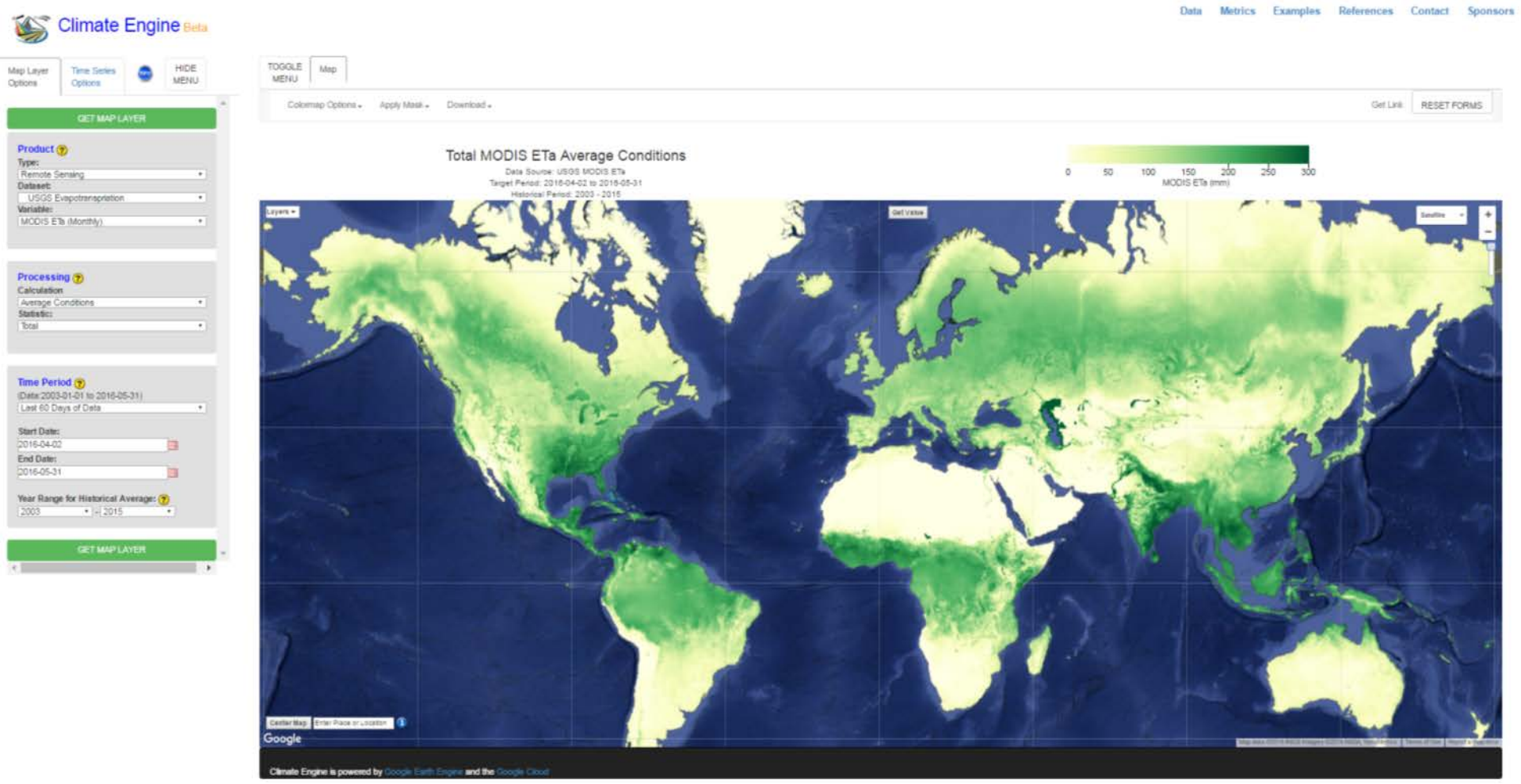
2011


Year 2004
Mean Seasonal ET = 1.8 ft
Total Area = 34,010 acres
Total ET Volume = 60,771 ac-ft
Area (acres)
Seasonal ET (feet)
Dry - 2004


Year 2011
Mean Seasonal ET = 2.8 ft
Total Area = 34,000 acres
Total ET Volume = 94,671 ac-ft
Area (acres)
Seasonal ET (feet)
Wet - 2011

Larger Scale ET Mapping – Coming Soon..

MODIS based USGS ET products loaded to asset manager and accessed through ClimateEngine.org to perform statistical calculations and summaries (i.e. ET and % Difference From Average mapping and time series).. More ET models/products hopefully on the way.. pending funding



A few impacts of ClimateEngine.org and FEWS NET Apps.

- National Integrated Drought Information System (NIDIS) supporting application and will soon host ClimateEngine.org on Drought.gov for regional and place-based drought monitoring
- Bureau of Land Management and Forest Service supporting application for baseline assessments and operational monitoring of rangelands and groundwater dependent ecosystems
- USAID and FEWS NET African field scintists starting to use FEWS NET app. for crop failure monitoring
- Water resource agencies using ClimateEngine.org for drought, groundwater dependent ecosystem, and water right abandonment
- Being used by several NGOs to perform water resource and ecosystem monitoring related to climate and water development

NIDIS

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

FOREST SERVICE U.S. DEPARTMENT OF AGRICULTURE

FEWS NET
FAMINE EARLY WARNING SYSTEMS NETWORK

NEVADA DROUGHT FORUM
drought.nv.gov

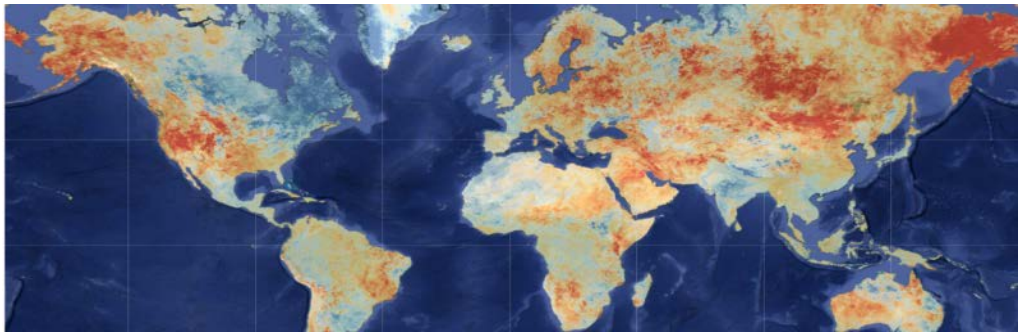
SOUTHERN NEVADA WATER AUTHORITY

STATE ENGINEER STATE OF NEVADA

The Nature Conservancy
Protecting nature. Preserving life.™

BARRICK

Summary



- Cloud computing with remote sensing and climate data is amazing!
- Creating never imagined opportunities for advanced drought monitoring with climate and remote sensing data at all scales
- ClimateEngine.org allows for on-demand processing of common climate/drought/vegetation metrics with a simple web connection
- Allows for scientists and non-scientists to perform advanced monitoring
- Download answers instead of archives!

Contact Information:
Justin Huntington (DRI) - justinh@dri.edu
John Abatzoglou (U Idaho) jabatzoglou@uidaho.edu

Demo of ClimateEngine.org