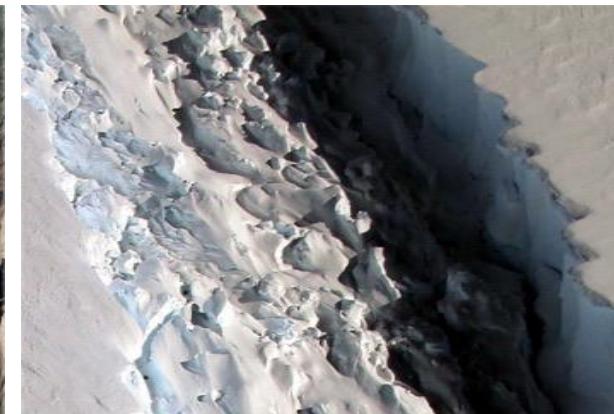


SCIENCE

National Aeronautics and
Space Administration



NASA WESTERN WATER
APPLICATIONS OFFICE

Forrest Melton, Program Scientist

NASA ARC-CREST
Earth Science Division
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forrest.s.melton@nasa.gov



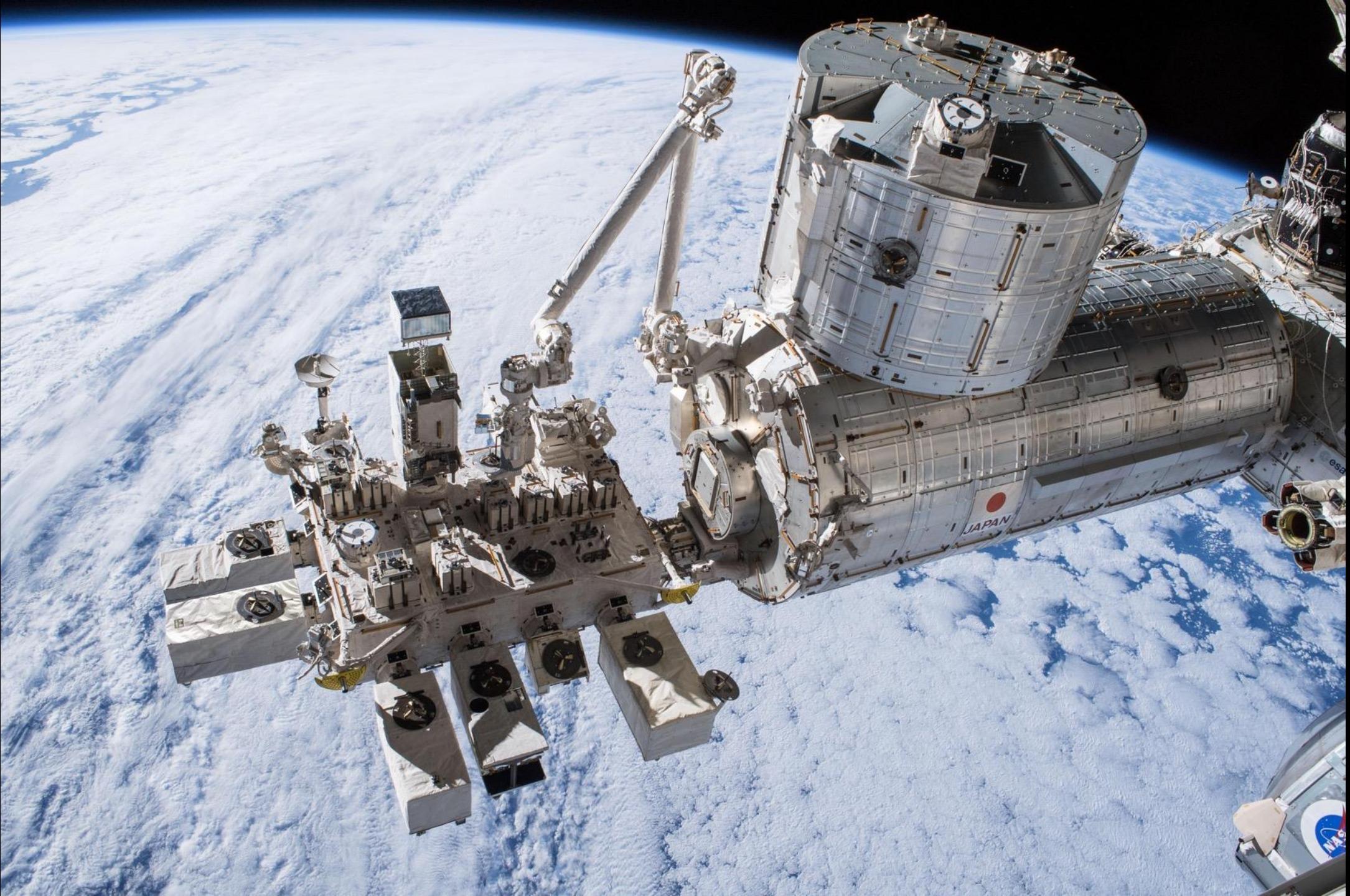
ECOSTRESS Launch
June 29, 2018, Cape Canaveral AFS

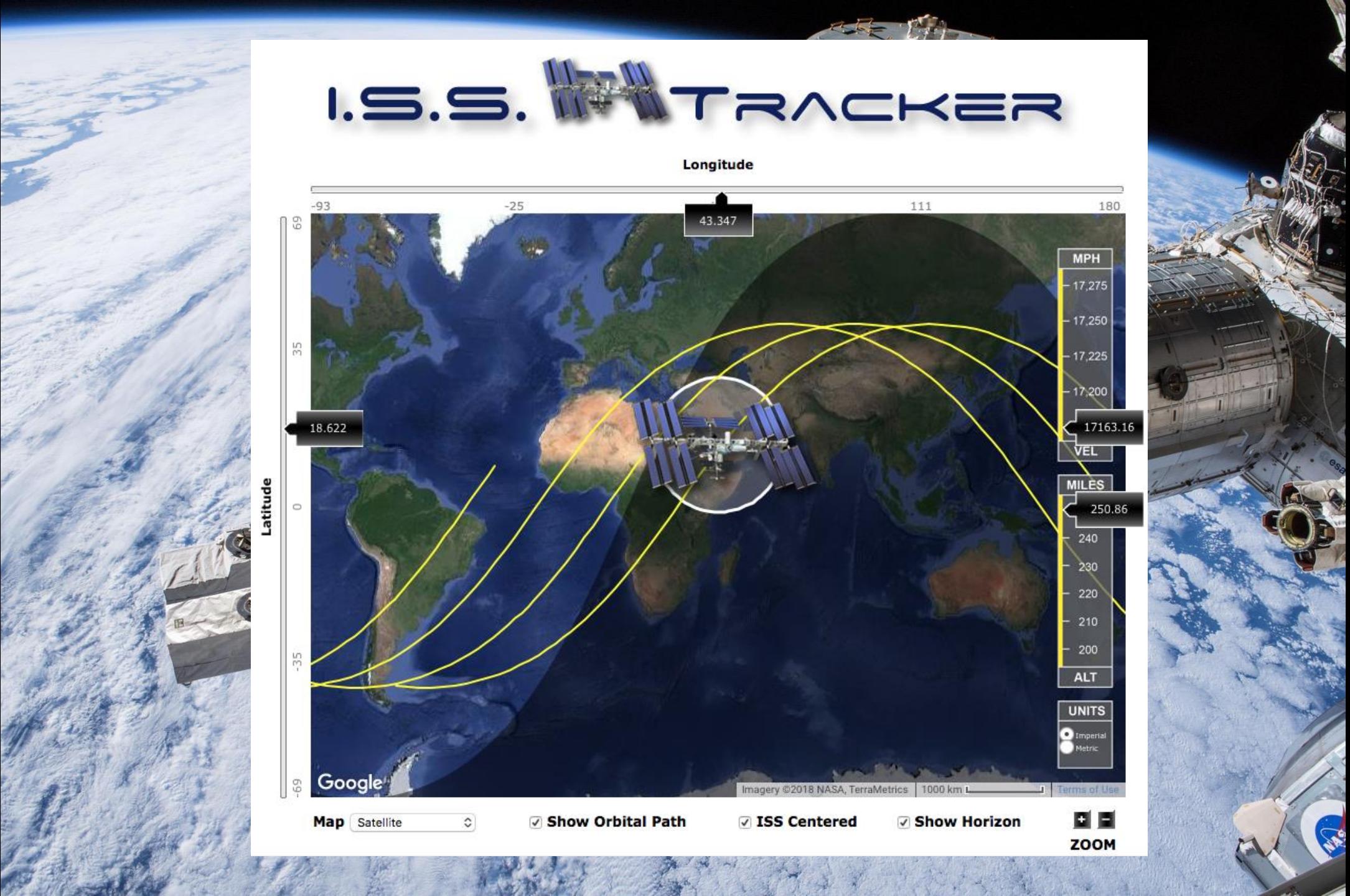
ECOSTRESS

Launch



June 29, 2018, Cape Canaveral AFS



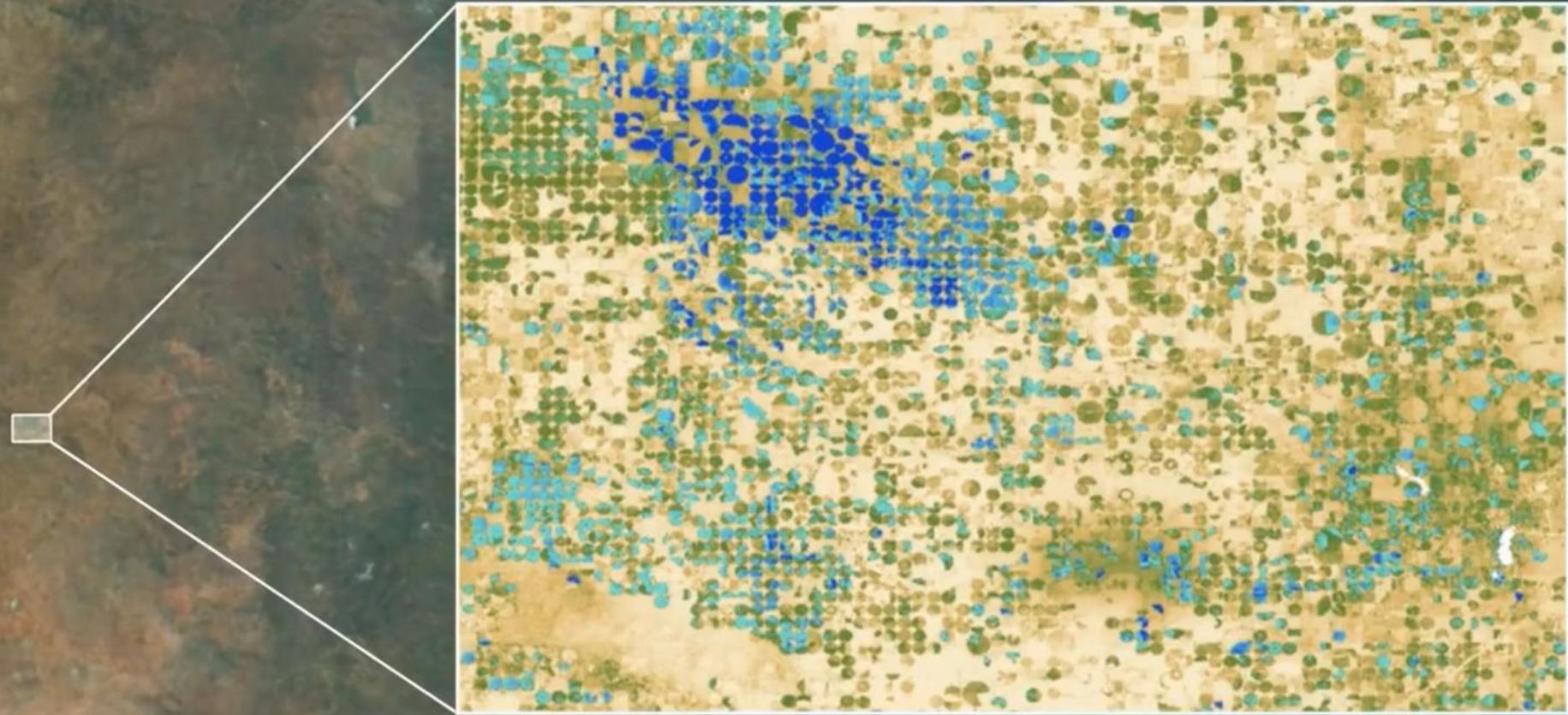


ECOSTRESS - Evapotranspiration

science @  NASA

Crop Water Use

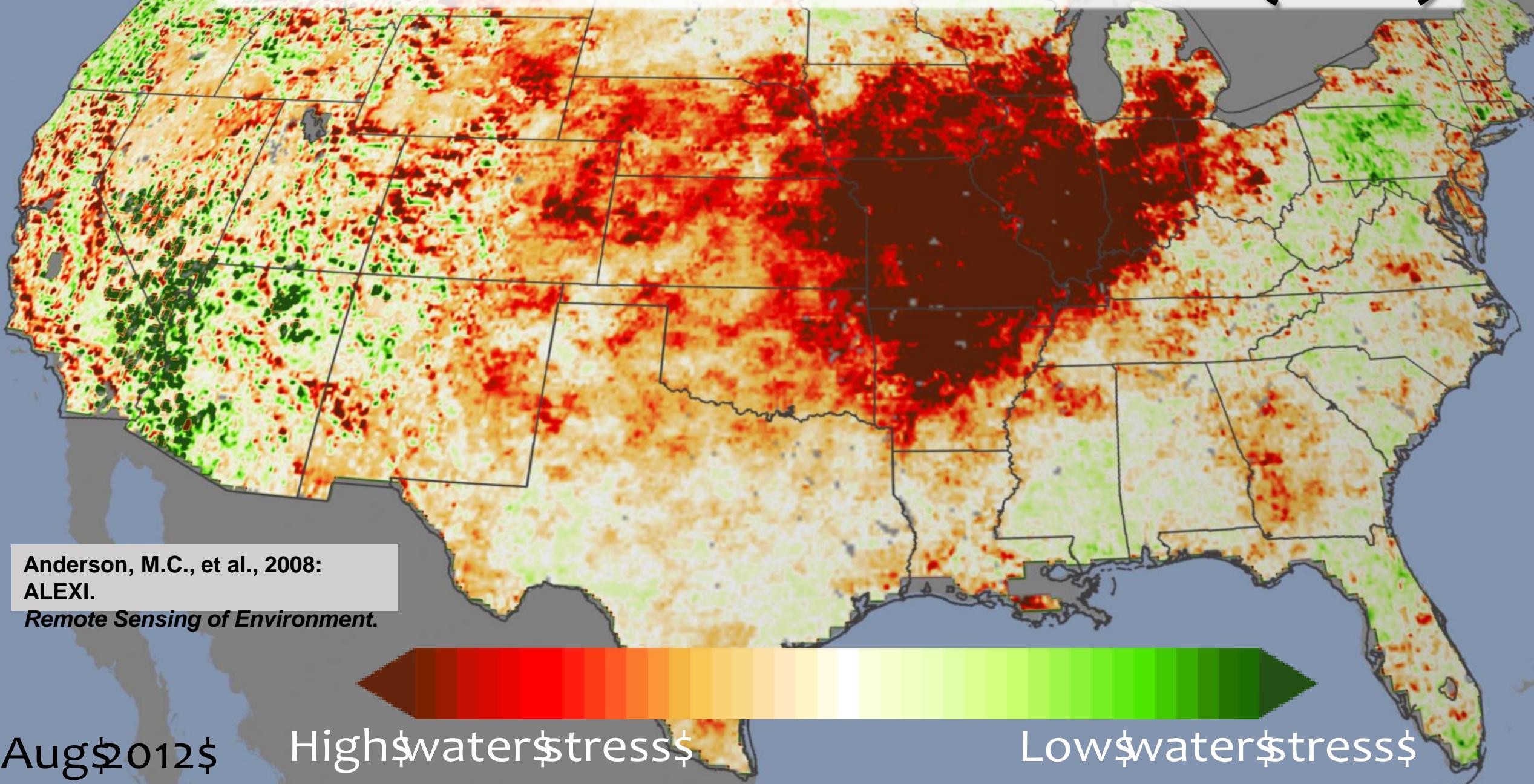
Combined release of water from crops and soil



Less active water release

Adequate water for cooling

EVAPORATIVE STRESS INDEX (ESI)





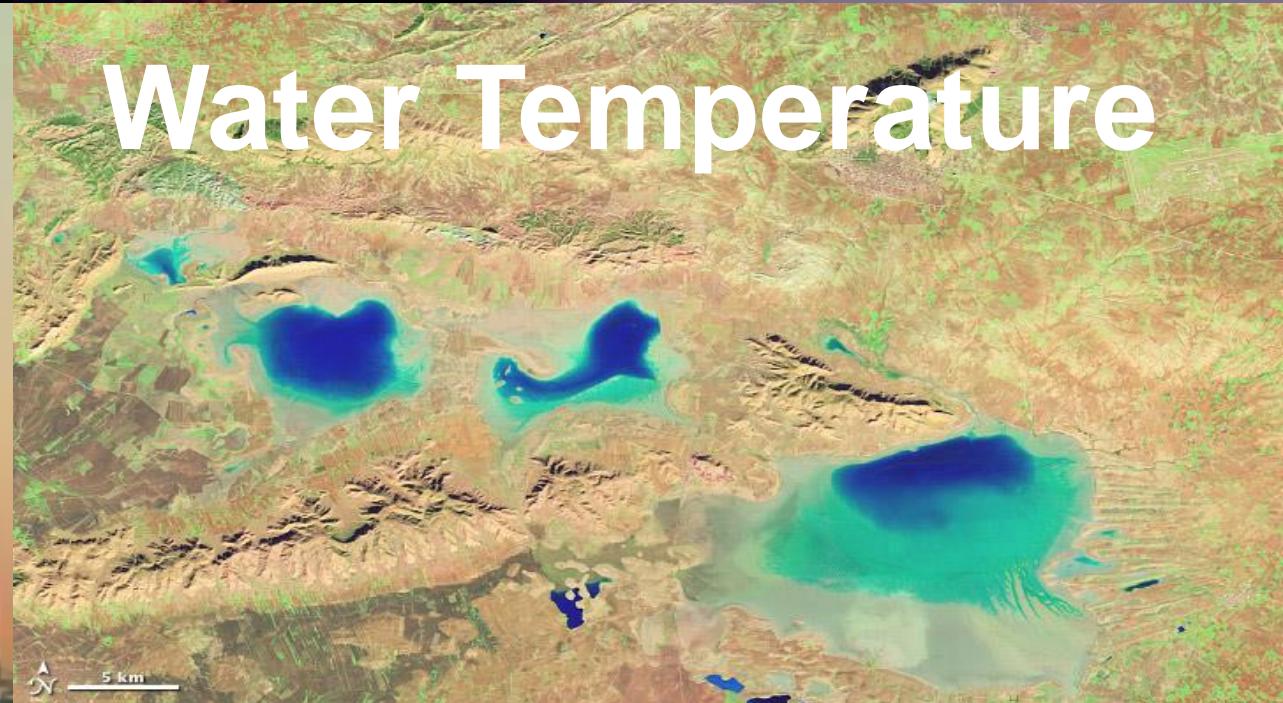
Wildfire Risk



Urban Heat Islands



Volcanoes



Water Temperature

New Water-Related Missions

- **GRACE-FO** successfully launched May 22, 2018
- Measures speed/distance between two satellites to map gravitational pull and measure total water storage (among other variables)
- Extends 15 year GRACE record



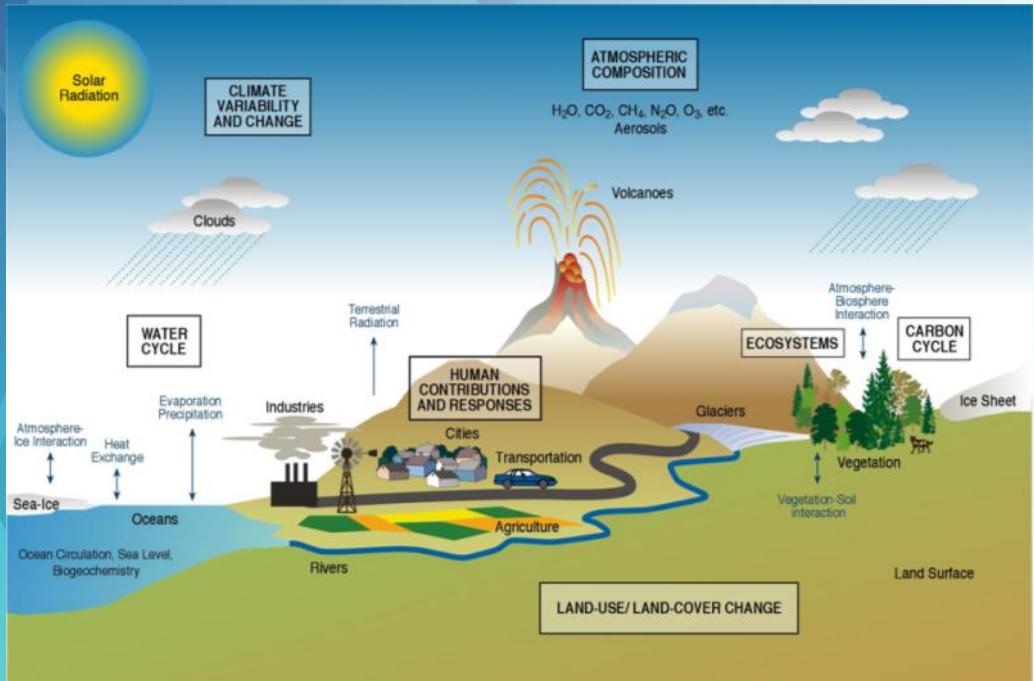
- **ICESat-2** launched Sept 15, 2018
- The Advanced Topographic Laser Altimeter System (ATLAS) will collect a more detailed, precise picture of the heights of the planet's ice, vegetation, land surface, water and clouds
- Extends and improves the ICESat data record to improve mapping of ice extent and height

NASA Earth Science Missions

September, 2018



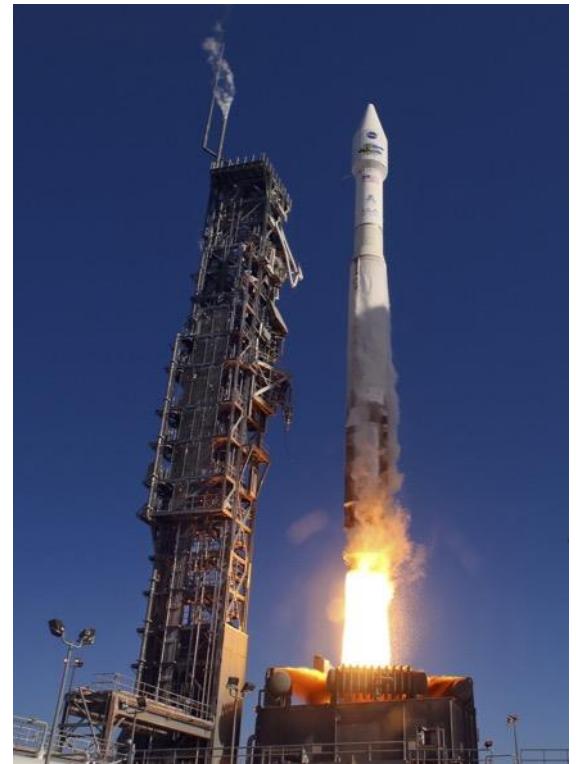
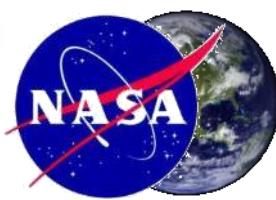
NASA Earth Science



NASA Earth Science supports basic and applied research on the Earth system and its processes.

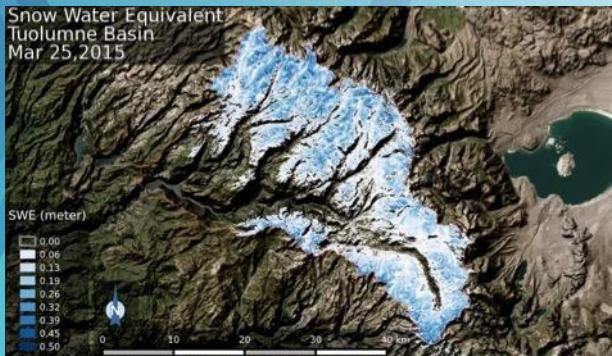
Characterize, understand, and improve predictions of the Earth system to advance knowledge and benefit society.

*Technology
Flight Missions
Research
Data Systems
Education
Applications*

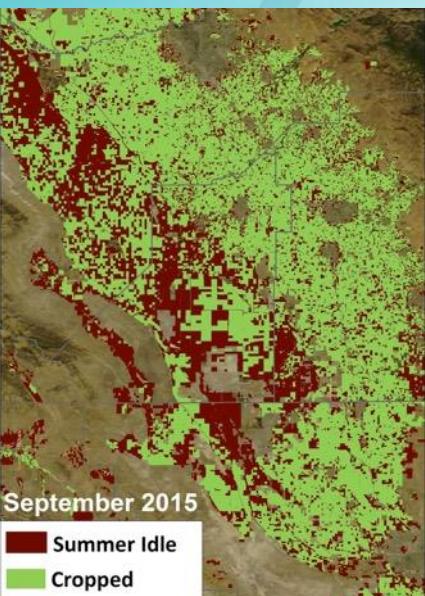


NASA Applied Sciences Program: Water Resources

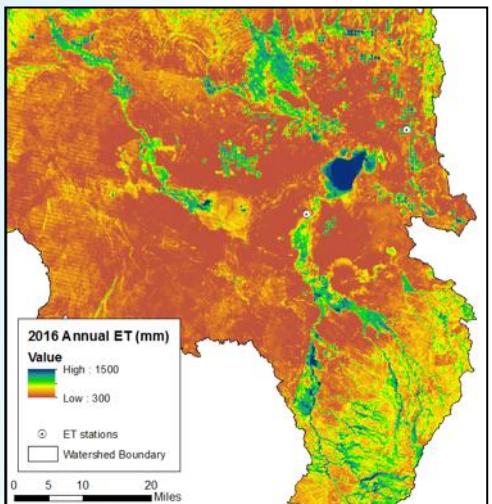
Snow Water Equivalent
Airborne Snow Observatory



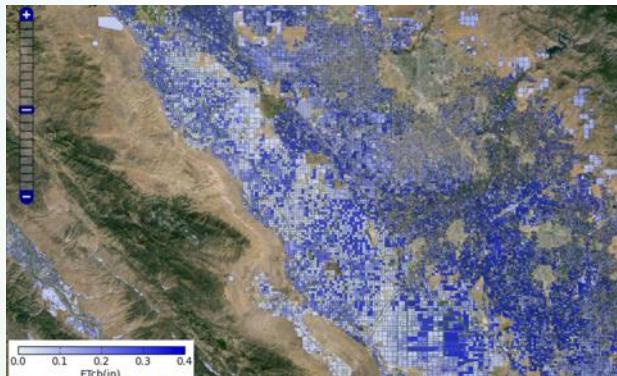
Land Fallowing



ET Mapping in Impacted
Basins with Western States



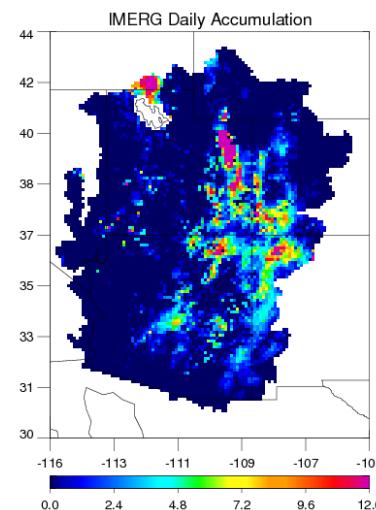
Evapotranspiration Mapping
for Irrigation Mgmt. & SGMA



Evaporative Stress / Drought Intensity



Seasonal Forecasting of Snow Water
Resources and Runoff



WWAO: NASA's Western Water Applications Office

A local western office helping to inform water decisions with NASA data



What is NASA WWAO?

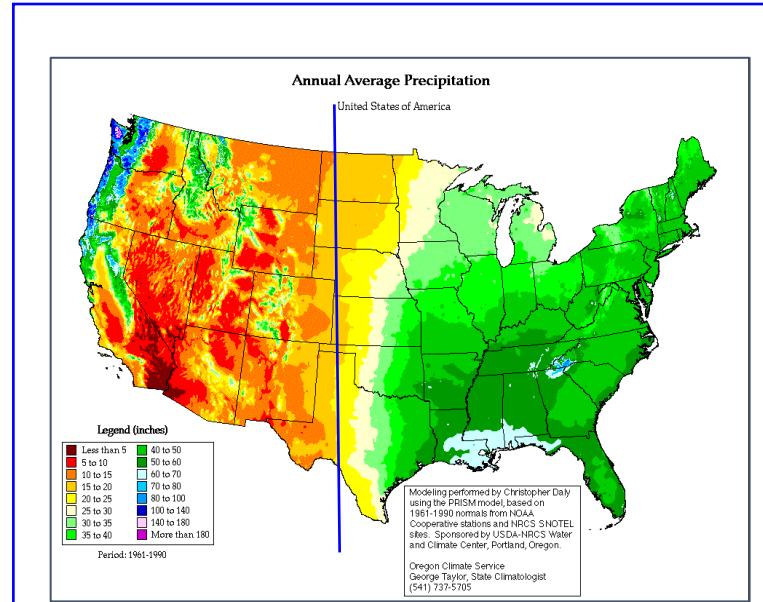
An initiative from NASA's Applied Sciences Program to put NASA research, observations and technology to work in support of Western US water management challenges.

What Does WWAO Do?

- Develop and maintain relationships with partners in western states to identify water resources needs.
- Develop and implement needs-driven applications projects.
- Assist with application transition from NASA to operational partner.

Why WWAO?

- Innovate approaches to project development and meeting water data and information needs.
- Apply NASA science, remote sensing data and expertise.
- Local western office to serve western U. S. water resources needs.



30-year climatology of annual U. S. Precipitation. The red line denotes the 100th meridian. (Source: C. Daly, Oregon State University)

The Western United States is defined by the Department of Interior (DoI) as those states that are on or west of the 100th meridian and encompasses the states represented by the Western Governor's Association (WGA). It is roughly the divide between the "wet" east and the "dry" west

Water Variables Observed by NASA



WSWC / WWAO

Water Information Management Systems Workshop

- January 2018 workshop co-hosted by the Western States Water Council & WWAO
- Assess the needs of WSWC members and their highest priorities regarding water information data systems:
 - Water use reporting/permitting systems
 - Use of cloud computing and big data
 - Open water data platforms and trends
- Key findings on transitioning research projects to operations
 - Frequent communication and partner engagement
 - Easy to use tools for data access and processing
 - High resolution datasets in widely adopted data standards
 - Reduce the difficulty in working with federal partners
- Summary & presentations available:
<http://www.westernstateswater.org/upcoming-meetings/2018-water-information-management-systems-wims-workshop/>

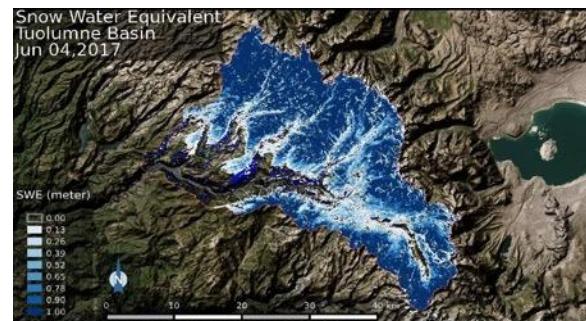


Current WWAO Projects

Operational Analysis & Modeling with ASO

T. Painter, NASA-JPL

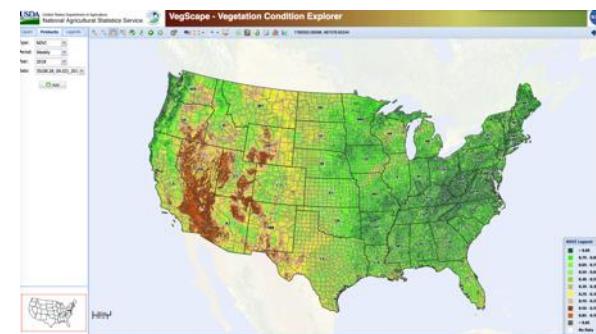
- Enable 1-10 day streamflow forecasting with USDA ARS Automated Water Supply Model (AWSM) + ASO data
- Work with CDWR and local agencies to include ASO and AWSM products in calculation of seasonal hydro-forecasts



Higher Resolution Soil Moisture for USDA NASS

R. Bindlish, NASA-GSFC

- Integrated SMAP and SMOS data to attain 1 km resolution with accuracy of 0.06 m³/m³ and daily revisit
- Results to be integrated with USDA NASS VegScape tool



Operational Evapotranspiration for the State of New Mexico

J. Fisher, NASA-JPL

- Daily, 1 km resolution, spatially consistent, statewide coverage of ET and other drought indices (evaporative stress index, land surface temperature, NDVI, albedo)

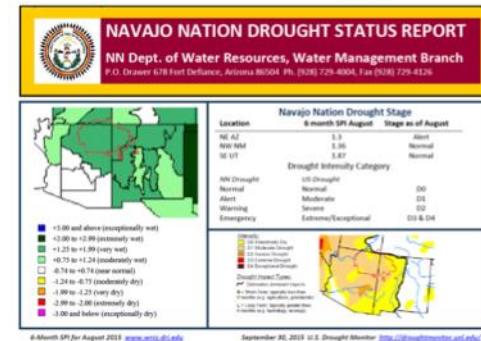
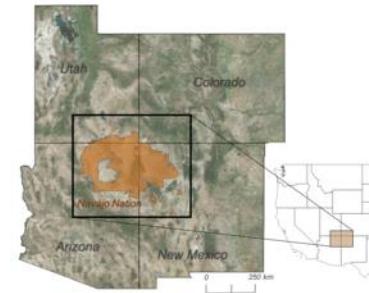


Current WWAO Projects

Navajo Nation Water Resources and Drought Monitoring

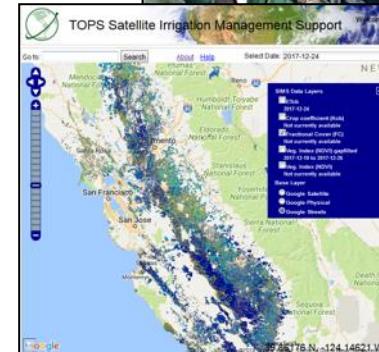
A. McCullum, NASA-ARC

- Assist the NNDWR in drought reporting through improved precipitation maps and data generation processes
- Supplement NN rain gauge data with remote sensing data
- Build on Drought Severity Evaluation Tool (DSET) originally prototyped through NASA DEVELOP program



SIMS-Crop Manage – A. Guzman, NASA-ARC

- Integration of NASA Satellite Irrigation Management System (SIMS) into CropManage
 - CropManage (Univ of CA Cooperative Extension) provides decision support for on-farm irrigation and fertilizer management
 - NASA Satellite Irrigation Management Support (SIMS) system provides NDVI, fractional cover, Kcb, and ETcb mapping at daily, 30 meter resolution
 - Integrating SIMS and CropManage to extend CropManage to other crops and incorporate satellite observations to maximize accuracy



WWAO Projects Driven by Partner Requirements



Workshop to Understand Information Needs in the Colorado River Basin

- April 9-10, 2018 at Caltech Campus, Pasadena, CA
- 15 Colorado River Basin agency partners participated in WWAO workshop
- Facilitated approach generated:
 - 79 ideas on using NASA data for Western Water Management, and;
 - 13 use cases developed to inform requirements for potential future WWAO projects.

2018 Colorado River Basin Needs Assessment Priority Needs

Water Resources Category	Use Case
Snow Properties and Processes	Improved Forecasts of Snowpack, Runoff, Water Demand, Evapotranspiration
Water Supply Forecasting (< 1 year period)	Streamflow Predictions at Sub-Basin Scales
Evapotranspiration (ET) over Land and Water	Consumptive Use for Calculating Water Budgets Reservoir Evaporation
Crops and Agriculture Properties and Processes	Crop Mapping Crop Monitoring
Irrigation Types and Methods	Irrigation Management Irrigation Mapping
Groundwater Characterization	Augmenting Groundwater Quantification
Extreme Event Prediction and Impact Assessment	Mitigation of Wildfire Impacts on Watershed Supply Augmentation of State-Level Drought Planning and Response Drought Planning and Response at the State Level
Water Supply Forecasting (\geq 24-month period)	Predicting Changes in the Sierra Nevada or Rocky Mountain Snowline, Snowpack Distribution, and Streamflow Forecasts



Thank you!

WWAO Contact Information

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Judy Lai-Norling, Stakeholder Engagement Manager
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ECOSTRESS

Christine Lee, Applied Science Lead
Christine.M.Lee@jpl.caltech.edu

ECOSTRESS Early Adopters Program
& Data Access:

https://ecostress.jpl.nasa.gov/applications/app_request

ECOSTRESS:

<https://ecostress.jpl.nasa.gov/>

Back-up Slides

Evapotranspiration (ET) is the greatest remaining data gap in water resources management, and the largest component of water use by agriculture.

Across the western U.S., between 59% and 97% of water diverted for human use is consumed by agriculture for food production.

Supported by \$4.8M in funding from the S.D. Bechtel, Jr. Foundation, the Moore Foundation, and the Walton Family Fund.



OpenET

Filling the biggest data gap in water management: Evapotranspiration

Benefits for water resources management:

- Expansion of ET-based irrigation practices that maximize “crop per drop” and reduction of costs for fertilizer and water inputs;
- Support for water trading programs that protect the financial viability of farms during droughts, while ensuring that water is also available for other beneficial uses; and
- Development of more accurate water budgets and innovative management programs that ensure adequate water deliveries for agriculture, people, and ecosystems over the coming decades.

OpenET brings together six ET models developed with NASA support and leverages Google's Earth Engine platform to integrate data from eleven NASA, USGS, NOAA and ESA satellites to map ET across the western U.S. at user-defined scales and timeframes. The project is a public-private partnership supported by NASA and private foundations to increase access to ET data to improve sustainability of water resources in the western U.S.

Principal Investigator: Robyn Grimm, Environmental Defense Fund

Project Scientists: Forrest Melton, NASAARC-CREST; Justin Huntington, Desert Research Institute
<http://www.etdata.org>



Development of a Multi-Scale Remote-Sensing Based Framework for Mapping Drought over North America

PI: Christopher Hain (University of Maryland)

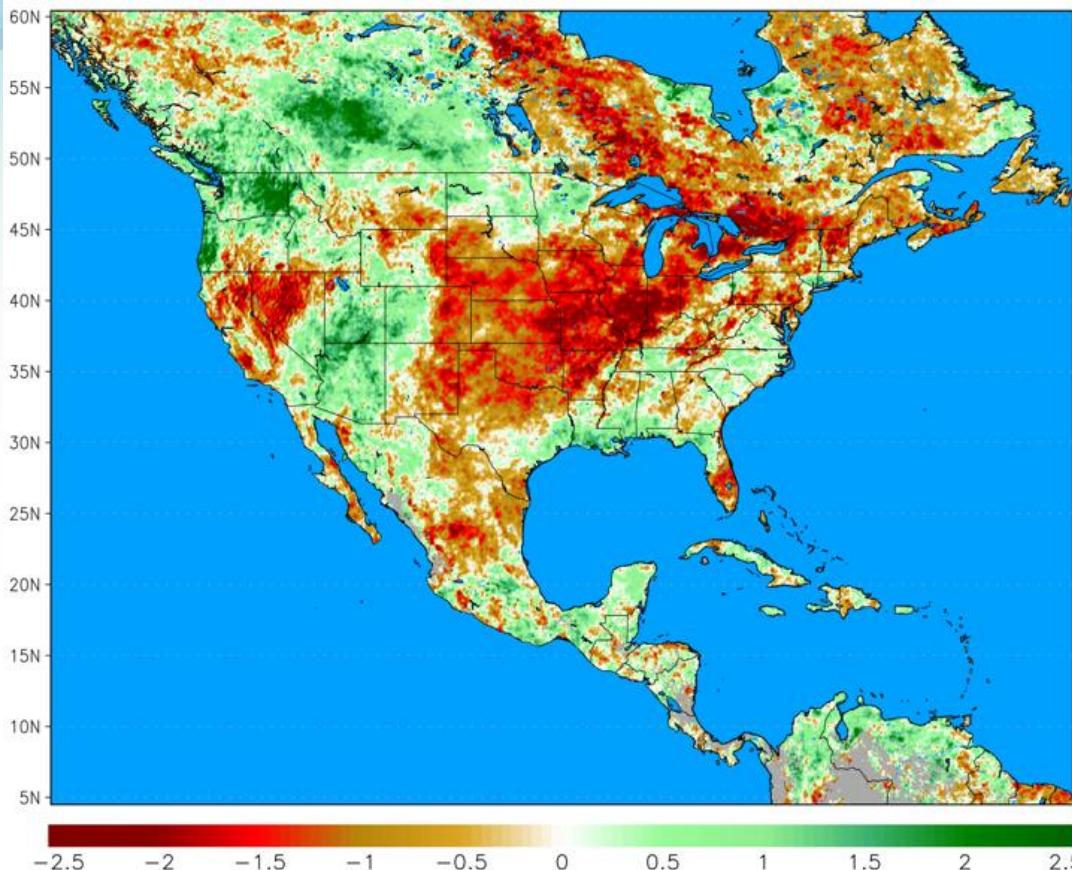


Figure 1. Evaporative Stress Index 4-week composite for 1 August 2012. Red (green) shading indicates lower (higher) than average evapotranspiration rates. The “flash” drought of 2012 highlighted the ability of ESI as a drought early warning indicator, as ESI showed significant degradation in ET rates two to four weeks before other indicators showed drought conditions.

Impact:

- The Evaporative Stress Index (ESI) provides information to end-users which aids in the detection and early warning for drought events.
- ESI supports decision making for drought mitigation, *adaptation and mitigation in support of food security* yield estimation, plant health, and water use.



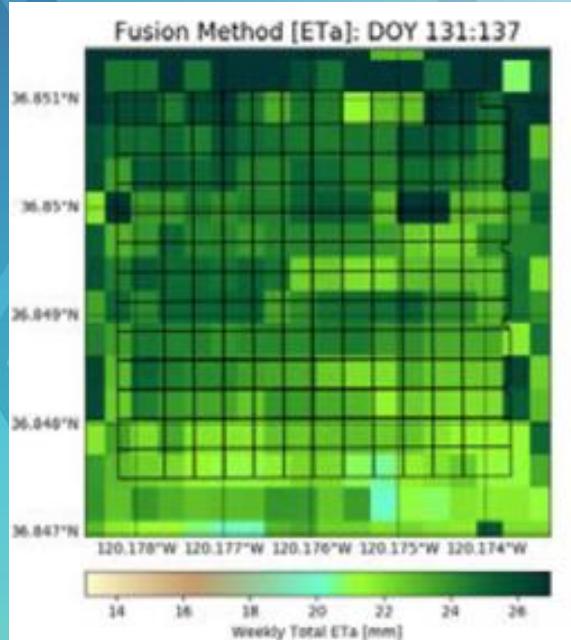
Suomi NPP



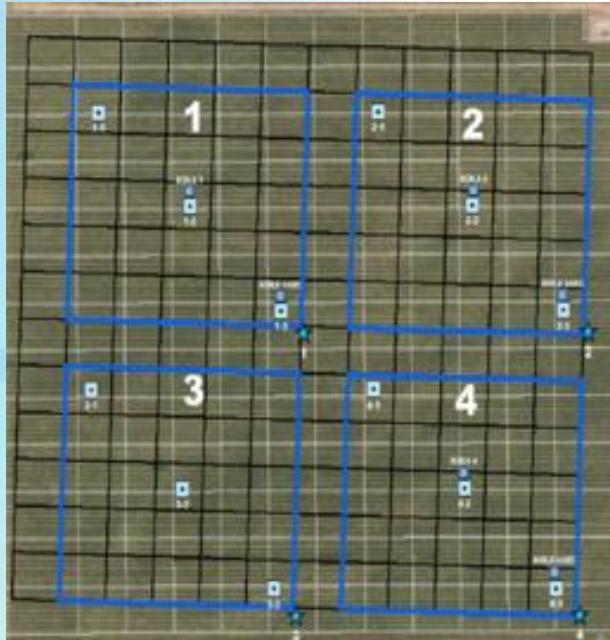
GOES

Monitoring Vineyard Water Use and Vine Water Status with Land Surface Temperature for Improved and Sustainable Water Management from Field to Regional Scales

PI: William Kustas, USDA ARS
Partner: E & J Gallo Winery



Sample daily ET map



VRDI grid at field site



Impact:

- High resolution mapping of crop water requirements (via crop evapotranspiration) and plant stress for precision irrigation
- Partnership with E & J Gallo Winery to develop new irrigation technologies (variable rate drip irrigation) to optimize both irrigation and crop quality and value
- Joint development of software toolkit for integration of satellite data into irrigation scheduling workflow

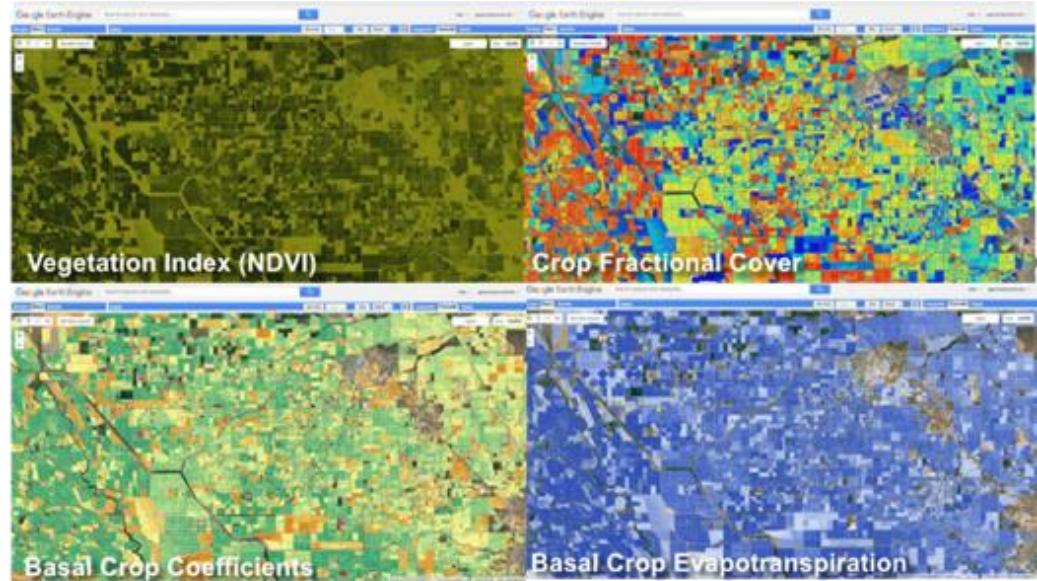
Satellite Irrigation Management Support (SIMS) System

Advances towards Operations in California

PI: Forrest Melton, NASA Ames Research Center

Impact:

- Satellite mapping of daily crop water requirements at field scale across 3.2 million hectares of irrigated ag lands in partnership with CA water and ag agencies
- Integrated with mobile-based irrigation and nutrient management software → 20-40% gains in on-farm water use efficiency demonstrated
- Data processing moved to Earth Engine to facilitate sharing with other regions



Landsat 8

Sentinel-2A

The Quick Drought Response Index (QuickDRI)

PI: Brian Wardlow, University of Nebraska, Lincoln

Background:

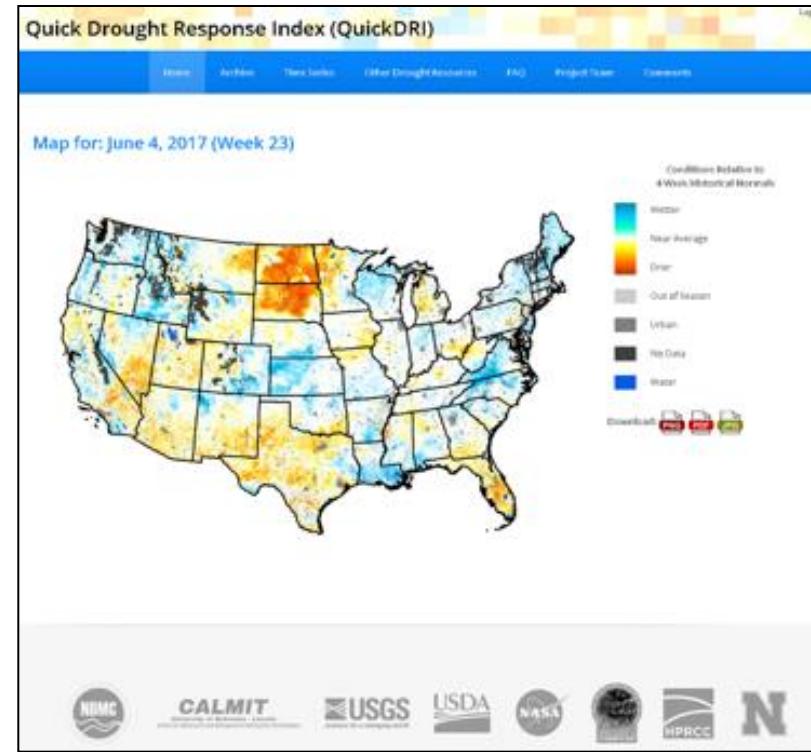
- QuickDRI is drought indicator that integrates data from MODIS, GOES, NLDAS, surface weather information and ancillary data to produce weekly drought maps for the U.S. Drought Monitor.
- It was developed through a multi-agency collaboration to provide improved data for decision making for drought response at the state level. Developed with support from NASA, it is currently hosted operationally by the National Drought Mitigation Center and USGS.

Highlight:

The QuickDRI drought monitoring tool transitioned to operational status (ARL 9) and became publicly available on July 12, 2017 for sustained operations, improving the ability of U.S. Drought Monitor (USDM) authors to identify and delineate flash drought events.

Impact Examples:

- QuickDRI was used to identify areas of analysis for expansion and intensification of a flash drought over **eastern MT, the Dakotas and eastern MN.**
- During summer 2017, the state drought task force in Montana used QuickDRI as a key information source to establish a drought declaration for eastern Montana. A drought emergency declaration was issued by the Governor of Montana on June 23, 2017, triggering eligibility for crop insurance payments for farmers impacted by the developing flash drought in eastern Montana. The recommendation to the Governor's office specifically referenced the the QuickDRI tool.



quickdri.unl.edu



vegdri.cr.usgs.gov/viewer/

Fallowed Area Mapping for Drought Impact Reporting and Decision Making

PI: James Verdin, USGS (currently USAID)

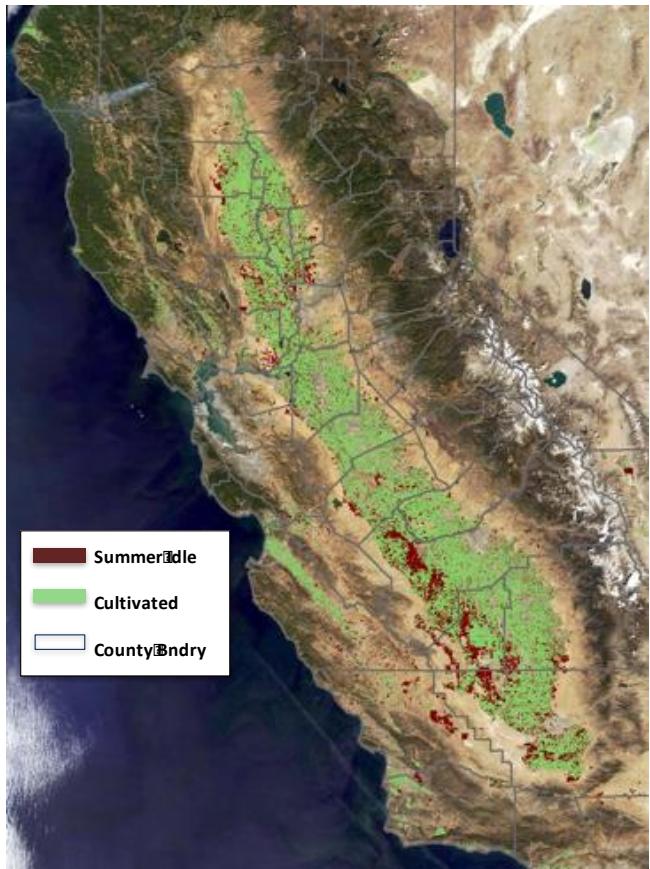
Challenge:

Fallowing of agriculture land is one of the primary impacts of drought. **Prior to this project, western states have not had an ability to monitor increases in land fallowing on a monthly basis during drought events.**

Highlight:

The data processing system developed for the Fallowed Area Mapping project has been fully ported from the NASA Earth Exchange to Google Earth Engine (ARL 8).

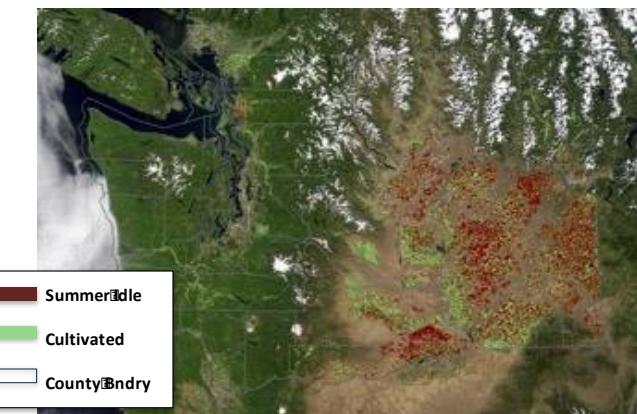
- By moving the satellite data processing capability to a publicly accessible cloud-based computing resource, this advance prepares this new capability for transition to full operations at the California Department of Water Resources (CDWR).



2017 California Summer Fallowed Acreage (June 1 to Sept 30)

Impact:

- During 2017, the project observed a decline in fallowed acreage as the drought ended. Total fallowed acreage in 2017 was only slightly higher than in 2011, prior to the start of the drought.
- Data from the project has previously been used by the California Governor's Office to inform allocation of drought emergency funds to food banks and social service agencies in heavily impacted counties.



2015 Washington Annual Fallowed Acreage (Mar 1 – Sept 30)



2016 Nevada Annual Fallowed Acreage (Mar 1 – Sept 30)



Agriculture & Food Security

- NASA's **Food Security Initiative** is a program of activities to advance sustained uses of Earth observations by **international** and **domestic** organizations to increase food security and improve agricultural practices for economic and societal benefits.
- **University of Maryland**, College Park was selected to develop, lead, and manage a multi-sectoral **Consortium** of over 40 organizations to achieve the objectives of the program
- **Agility** in choosing private and public sector partners
- **Engagement** with end users:
 - Strategic targeting of new, non-traditional end users
 - Regional and national level food security
 - Crop monitoring and forecasting
 - Markets and trade
 - Early warning

