



NASA Western Water Applications Office (WWAO)

**WESTERN STATES WATER COUNCIL AND
THE WESTERN FEDERAL ADVISORY
SUPPORT TEAM**

**Bradley DOORN
Water Resources Program Manager**

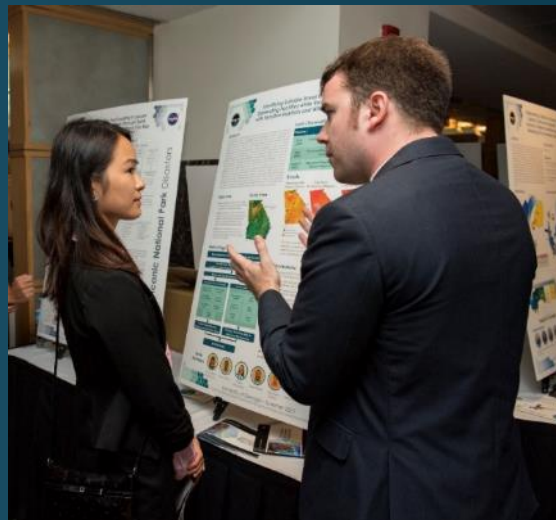
24 June 2020

NASA Earth Science

Measuring

Understanding

Delivering
Societal Benefit



Solar Radiation

CLIMATE VARIABILITY AND CHANGE

ATMOSPHERIC COMPOSITION
 H_2O , CO_2 , CH_4 , N_2O , O_3 , etc.
 Aerosols

Clouds

Volcanoes

WATER CYCLE

Evaporation
Precipitation

Atmosphere-Ice Interaction

Heat Exchange

Sea-Ice

Oceans

Ocean Circulation, Sea Level, Biogeochemistry

Industries

Cities

Transportation

Agriculture

Rivers

Terrestrial Radiation

HUMAN CONTRIBUTIONS AND RESPONSES

Glaciers

Ice Sheet

ECOSYSTEMS

Atmosphere-Biosphere Interaction

CARBON CYCLE

Vegetation

Vegetation-Soil interaction

Land Surface

LAND-USE/ LAND-COVER CHANGE

In parallel with research,
NASA pursues innovative and
practical uses of Earth
science data and results to
inform decisions and actions.

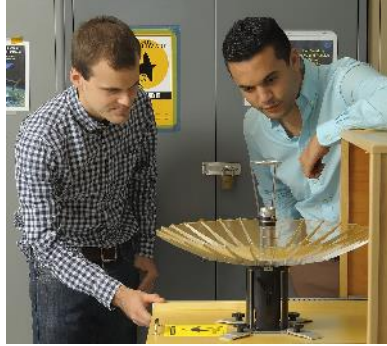
3

NASA's Earth Science Community Challenge

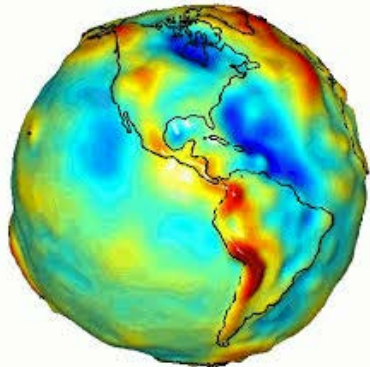
MISSIONS



TECHNOLOGY



RESEARCH



APPLICATIONS

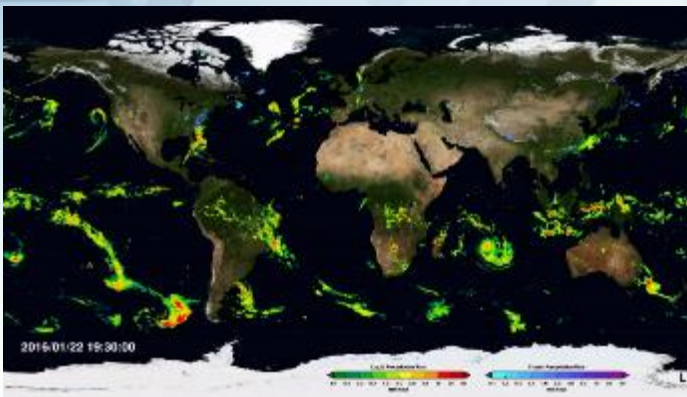


- *Pursue ambitious objectives and innovative solutions*
- *Enhance and accelerate the value of space-based Earth observations to the nation*
- *Deliver great value and ensure that further investment will pay substantial dividends.*

Information from NASA Earth Observing Satellites

Precipitation

The Integrated Multi-satellite Retrievals for GPM (IMERG) is the U.S. team's algorithm for producing fine-scale precipitation estimates from precipitation-relevant satellites.

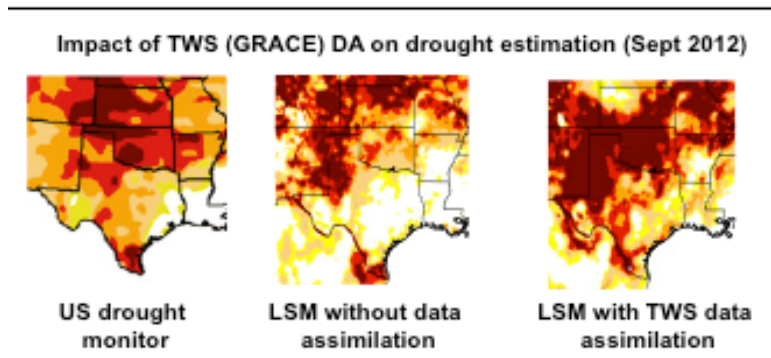


The GPM Core Observatory's observations are used to calibrate all other satellites. This map for 1930 UTC on 22 January 2016 shows both the beginning of the East Coast "Snowzilla" snow storm and Tropical Cyclone Corentin in the southern Indian Ocean.

Credit: NASA/GSFC

Ground Water

Estimates of terrestrial water storage changes can be estimated from GRACE/GRACE-FO measurements after removing the influence of atmospheric and oceanic circulations and impacts of major geophysical events.



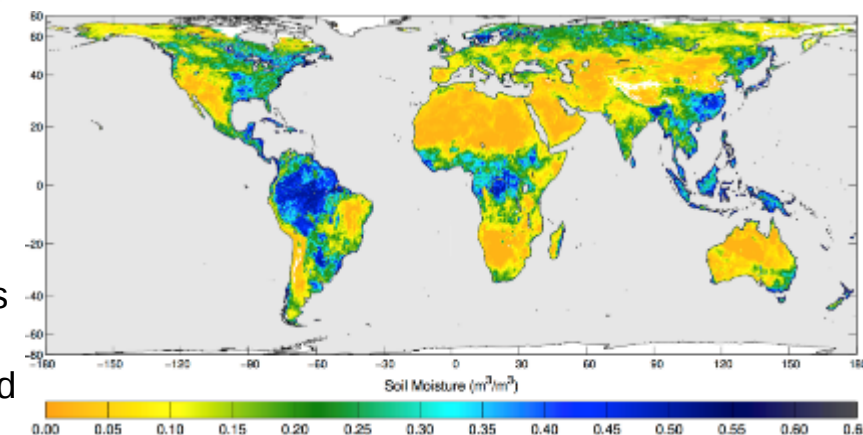
GRACE Terrestrial Water Storage data assimilation improve drought monitoring over US.

Credit: Kumar, S.V. (NASA GSFC) et al. (2016)

Soil Moisture

The SMAP Level 2, NISAR (launch 2022) passive soil moisture product demonstrates a retrieval accuracy that is better than $0.04 \text{ m}^3/\text{m}^3$, the project's established performance criteria.

This can enable further advances in hydrology science and applications.



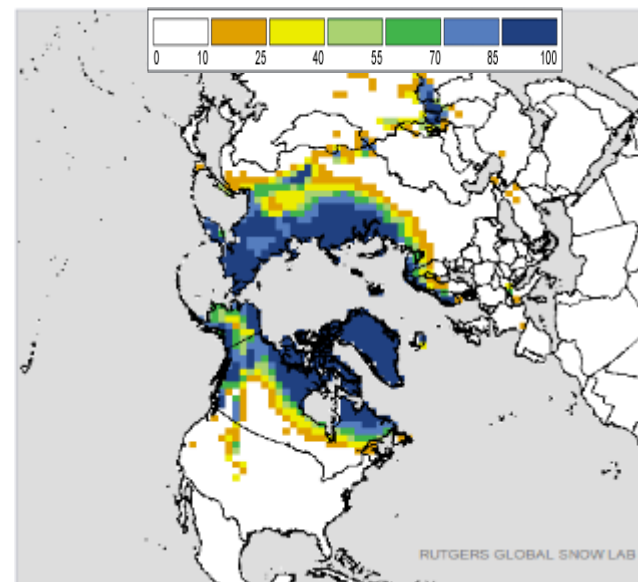
SMAP Level 2 soil moisture between June 1-7, 2015

Credit: Jackson (USDA) et al. (2016)

Snow Cover

MODIS, Percent of days snow covered climatology for the month of May (1981-2010) based on NOAA Climate Data Record (CDR) of Northern Hemisphere Snow Cover Extent (Robinson et al., 2012).

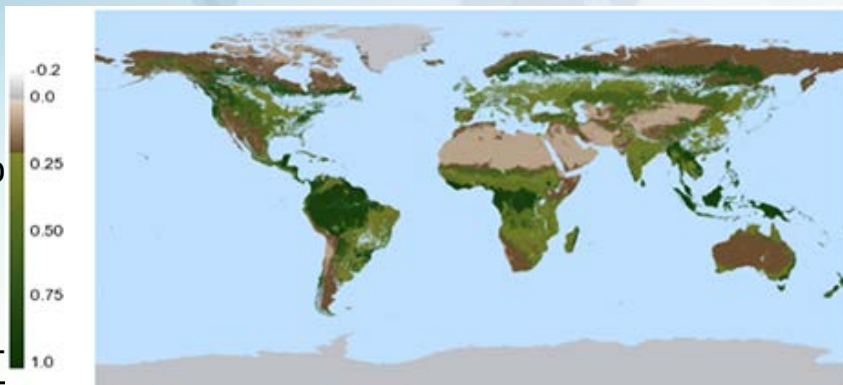
Credit: Rutgers University: Global Snow Lab



Information from NASA Earth Observing Satellites

Surface Water

VIIRS, Landsat, Harmonized Landsat Sentinel-2: High wavelength coverage of optical-SWIR bands provides surface-land boundaries. Laser altimetry from Sentinel-6 and upcoming SWOT data will provide precise river height information for lake/reservoir levels and river flow (SWOT)



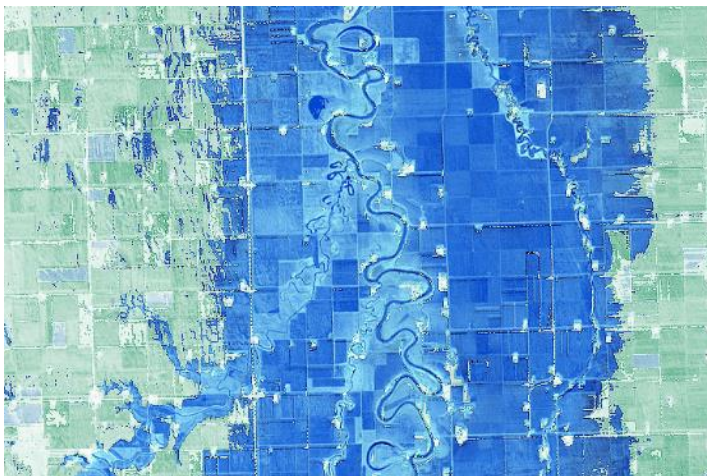
Global NDVI Average from VIIRS instrument –
NEO NASA/GSFC

Water Quality

MERIS, OLCI, Landsat, Harmonized Landsat Sentinel-2: Specific optical-SWIR bands provide indicators of potential water quality changes to include Harmful Algal Blooms



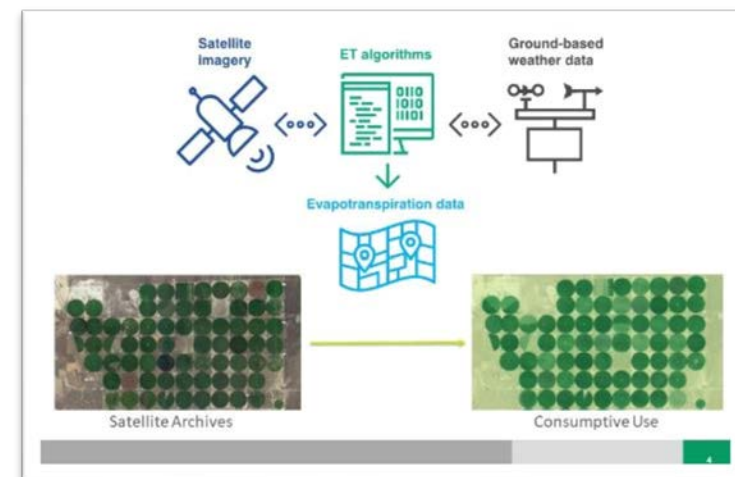
Source: MERIS/NASA; processed by
NOAA/NOS/NCCOS



Landsat 8 – Flood on the Red River
(ND/MN) - LPDAAC

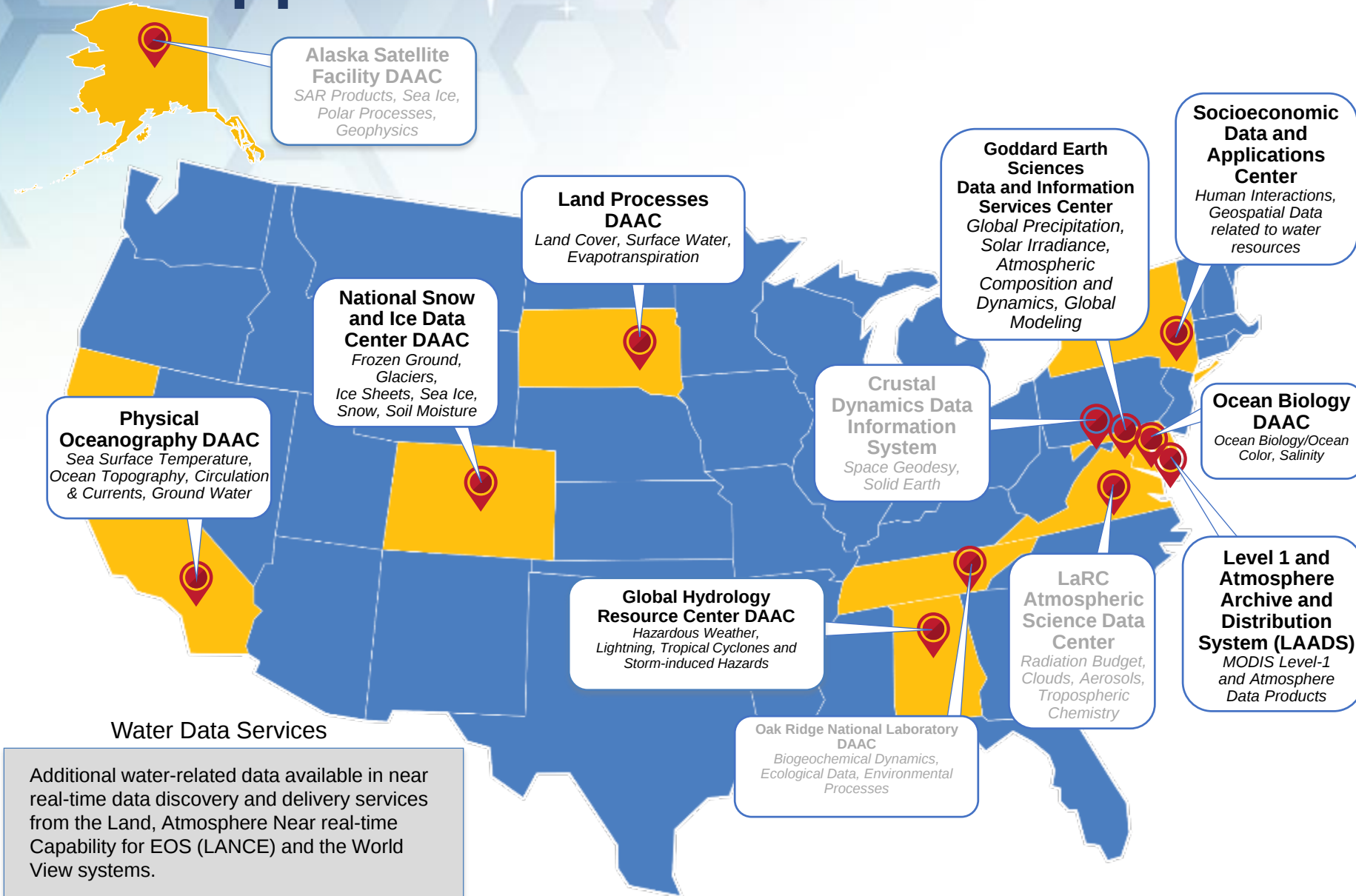
Agriculture Water Use

VIIRS, Landsat, and ECOSTRESS provide thermal observations for deriving Evapotranspiration and assessment of vegetation water use/demand.



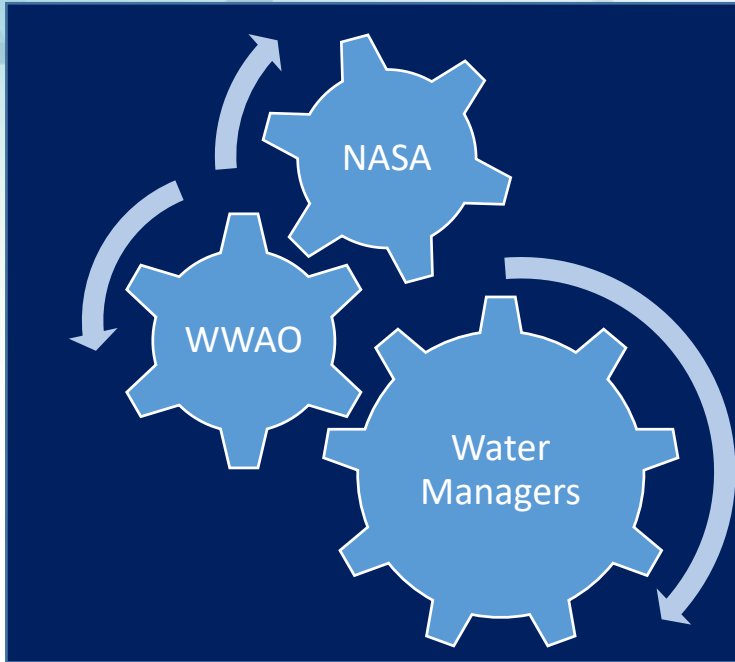
OpenET from Landsat – DRI –
Agriculture Water Use

NASA Supports Access to Water-Related Data



NASA's Western Water Applications Office

Tools for managing a scarce resource



WWAO's Mission

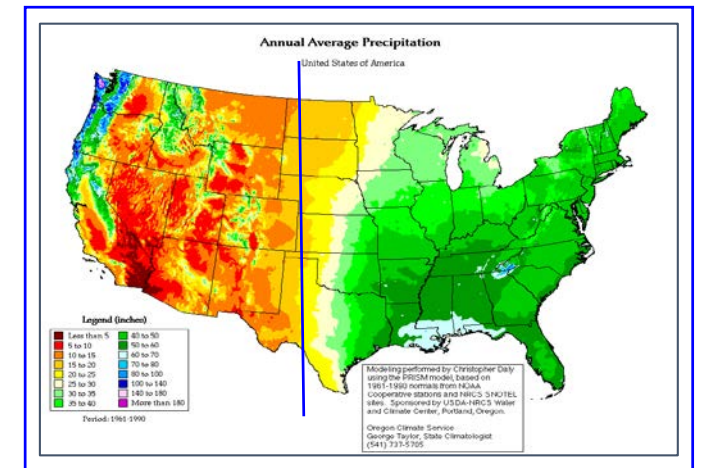
- Improve how water is managed by getting NASA data, technology, tools into the hands of western water managers

WWAO does this by:

- **Identifying Needs** in western water management for information and decision support that NASA can address
- **Making Connections** between stakeholders and NASA scientists, technology, tools, and data, and supporting projects to address needs
- **Transition** water applications into operations to achieve a sustainable and long-term impact

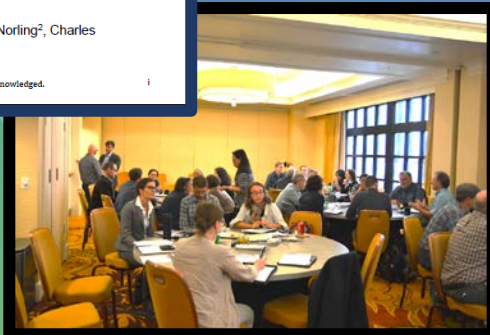
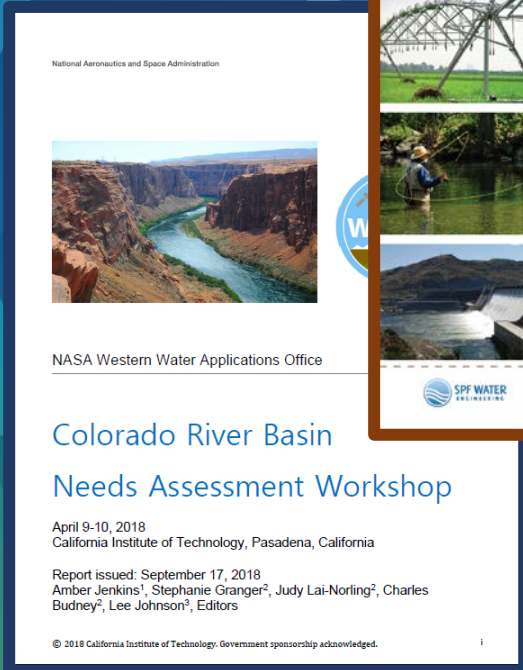
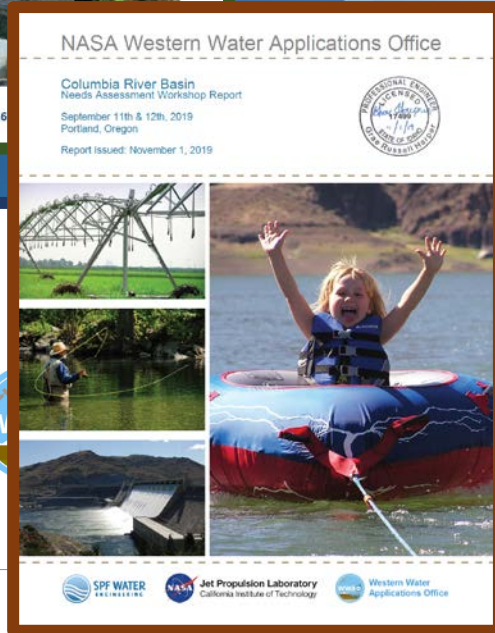
Why WWAO?

- Water is life. NASA's science, remote-sensing data and expertise can bring a unique set of eyes to solving water challenges
- Remote-sensing data can have a real impact on water issues
- WWAO leverages decades of investment in science and technology, as well as deep relationships with stakeholders



Understanding Needs

- WWAO has conducted Needs Assessment Workshops for Colorado and Columbia River Basin
- Identified dozens of needs spanning agriculture, water supply, water quality and watershed health
- Plans to conduct similar assessments of Rio Grande, Missouri and Arkansas-Red Basins to identify highest priority needs



Making Connections and Building Solutions



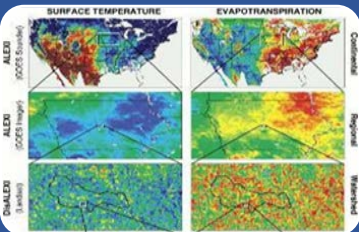
Drought

- Drought Severity Evaluation Tool for the Navajo Nation
- Drought Indicators for the State of Colorado



Agriculture

- Satellite-based Irrigation Management tools for California Farmers
- High Resolution Soil Moisture Products for the USDA



Water Use

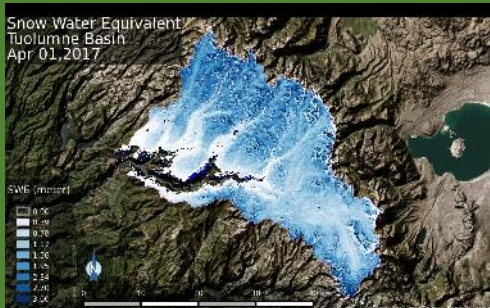
- Evapotranspiration Tools for the State of New Mexico
- Evapotranspiration Model Comparison for Upper Colorado River Basin

Transition to Operations

- Developing “Business Cases” for NASA applications in water management
- Building a “Research to Operations” community to facilitate transition of applications from NASA research to sustained operational use



NASA developed a technique to measure the available water snowpack using airborne LIDAR and Spectrometer. ASO, Inc. is a spinoff company that is now offering these surveys as a commercial service to water agencies



WWAO and the Western States Water Council, along with USGS and USBR plan to hold the 2nd Annual Research to Operations in Water Management Workshop” at the Beckman Center in Irvine, California on October 5-7

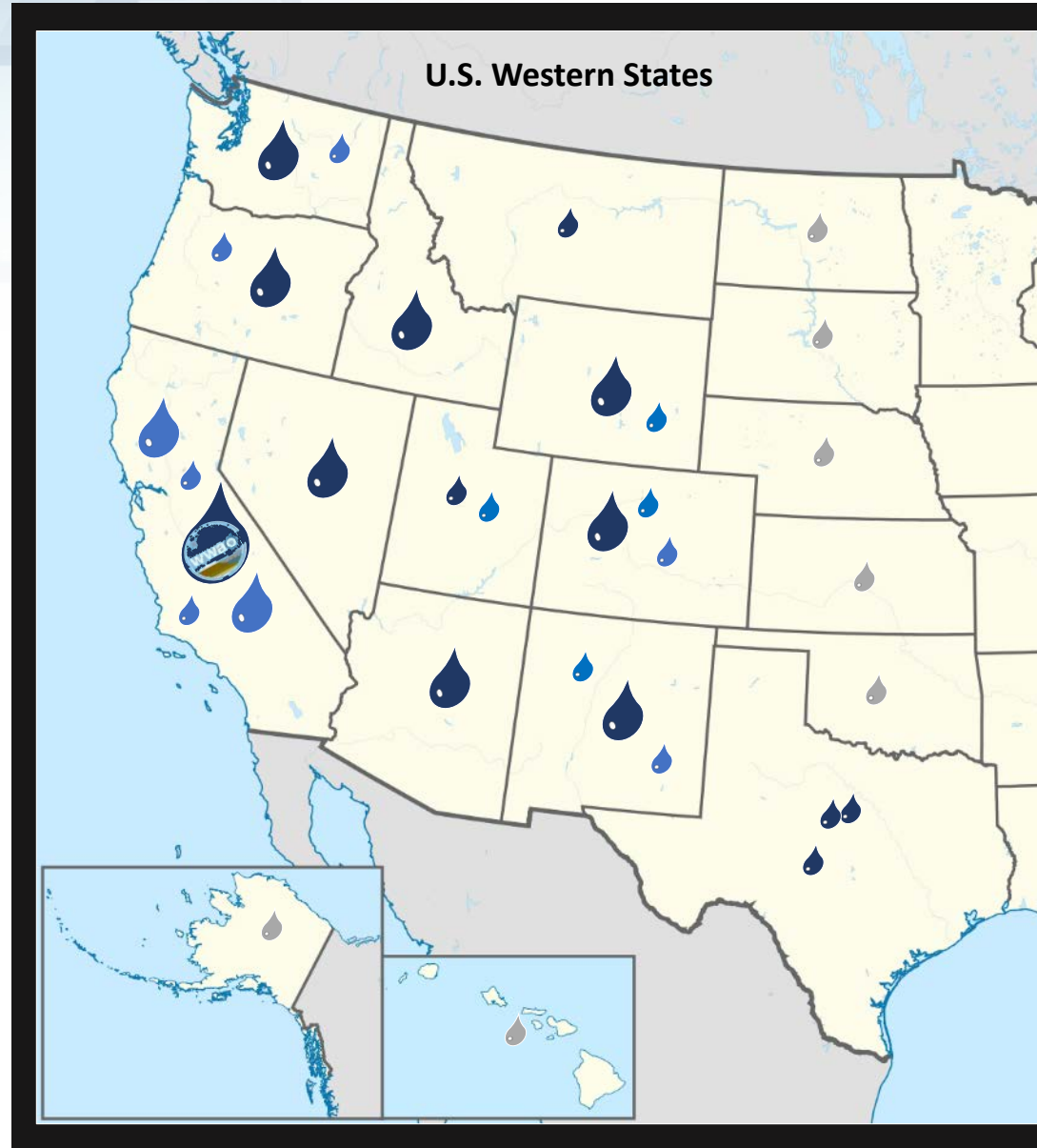


WWAO Dashboard

March 2020

Legend

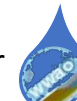
-  Planned engagement
-  Preliminary or higher level engagement;
Participation in conferences / workshops
-  Partner contributed to a Study or Assessment;
Needs entered into WWAO Needs Catalog
-  Strategic relationships established with
ongoing needs discussions and broader
engagement on NASA Earth Observations
-  Partner working with WWAO to advance an
application from WWAO Capabilities Catalog
-  Partner adopting a NASA application into water
management operations
-  Partner using a NASA application operationally
and/or NASA application transitioned to a
Partner to provide operational product/service

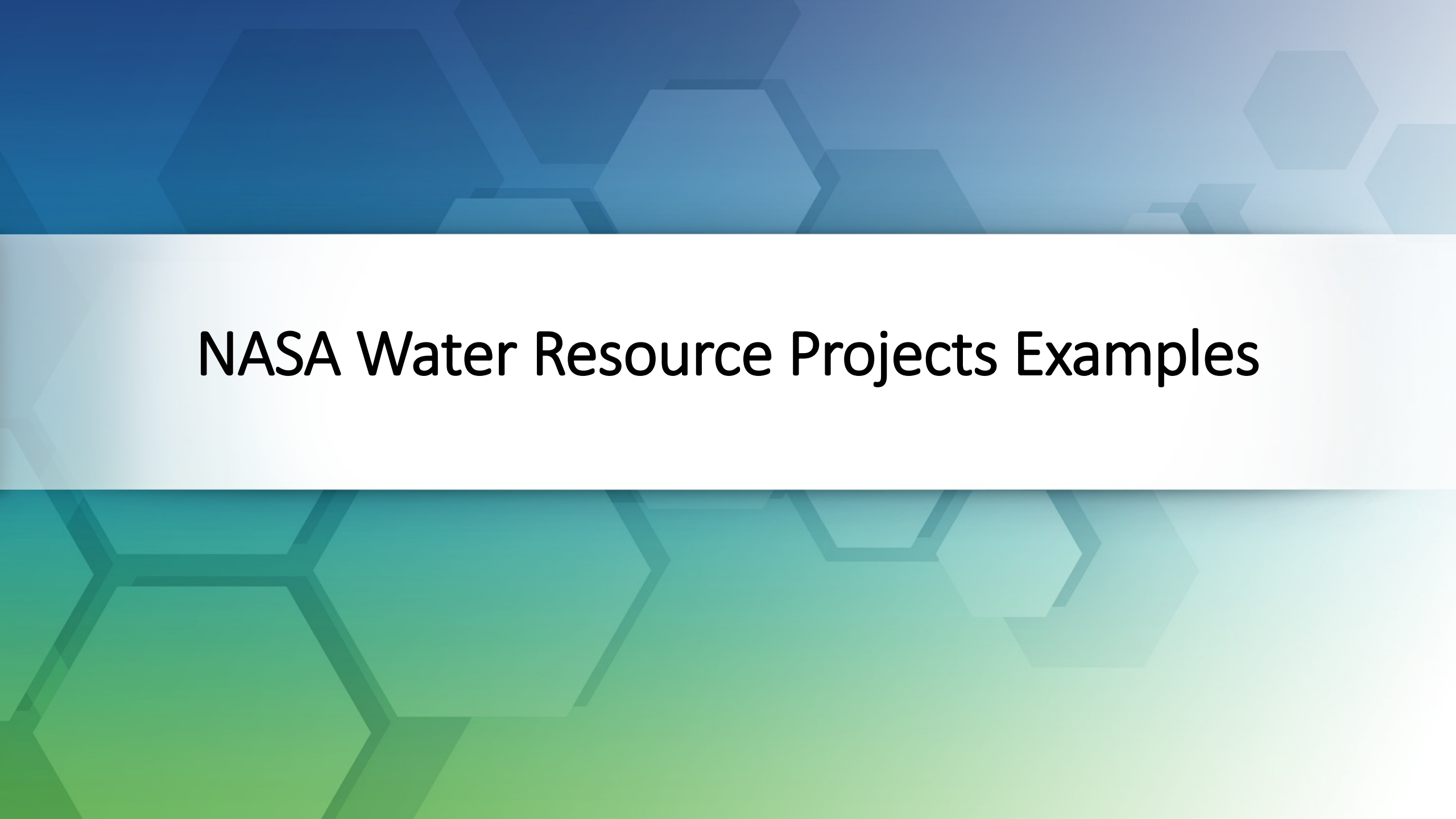


Federal / Regional

- NOAA 
- USBR 
- Army Corp 
- USDA 
- USGS 
- Tribal Nations 
- Other 

Private Sector

- Utilities 
- Data Services 
- Infrastructure 
- Other 

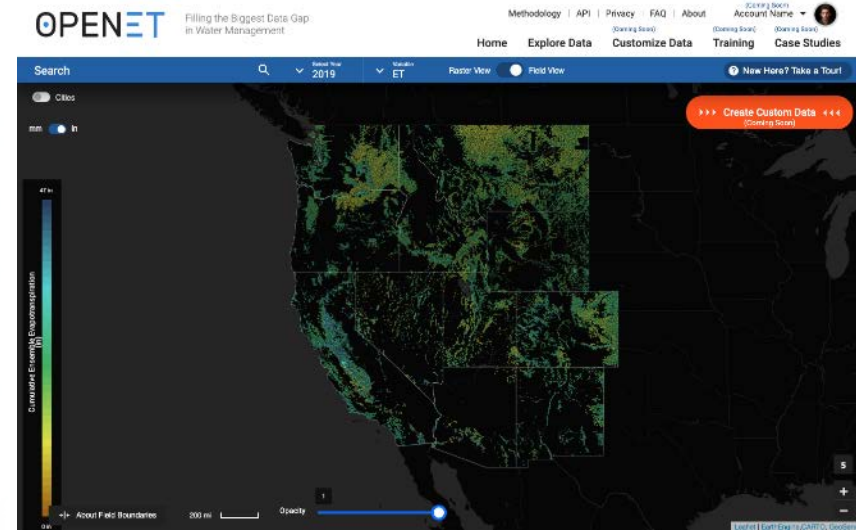
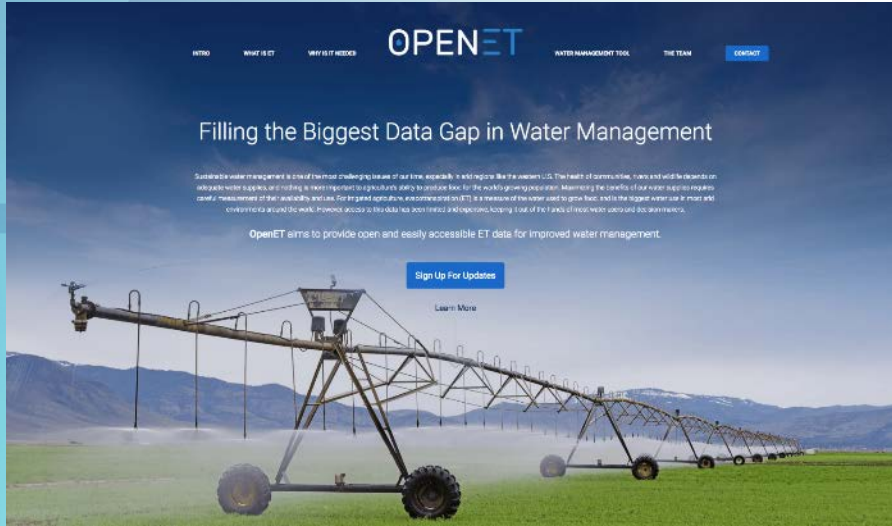
The background of the slide features a geometric pattern of overlapping hexagons. The top half is a dark blue gradient, and the bottom half is a green gradient. The hexagons are semi-transparent and vary in size and orientation, creating a modern, abstract look.

NASA Water Resource Projects Examples

Monitoring Water Demand and Use: OpenET

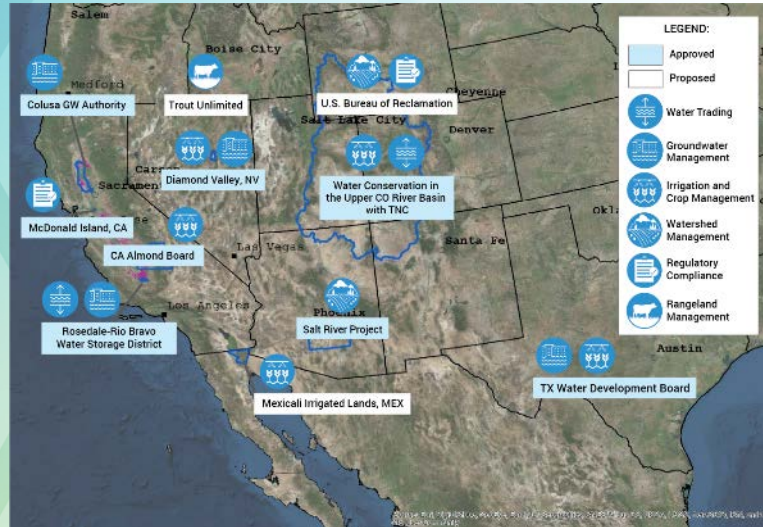
Information and data services on agricultural water needs and consumptive use for the western U.S.

Web UI
and data
services



Field-scale
(30m) ET
data for the
western
U.S.

Case studies
across the
West used to
define
requirements



Data review in
the field with
agricultural
partners

Monitoring Water Demand and Use: OpenET

Information and data services on agricultural water needs and consumptive use for the western U.S.

OPENET

Filling the Biggest Data Gap
in Water Management

Methodology | API | Privacy | FAQ | About

(Coming Soon)
Account Name

Home | Explore Data | Customize Data | Training | Case Studies

Search



Select Year
2019

Variable
ET

Raster View ☒ Field View

? New Here? Take a Tour!

☐ Cities

mm ☒ in

Cumulative Ensemble Evapotranspiration
(in)

47 in

0 in

About Field Boundaries

200 mi

Opacity

1



OPENET

Search



Select Year
2019

Variable
ET

Raster View ☒ Field View

? New Here? Take a Tour!

☐ Cities

mm ☒ in

Cumulative Ensemble Evapotranspiration
(in)

47 in

0 in

About Field Boundaries

1 mi

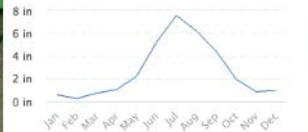
Opacity

1

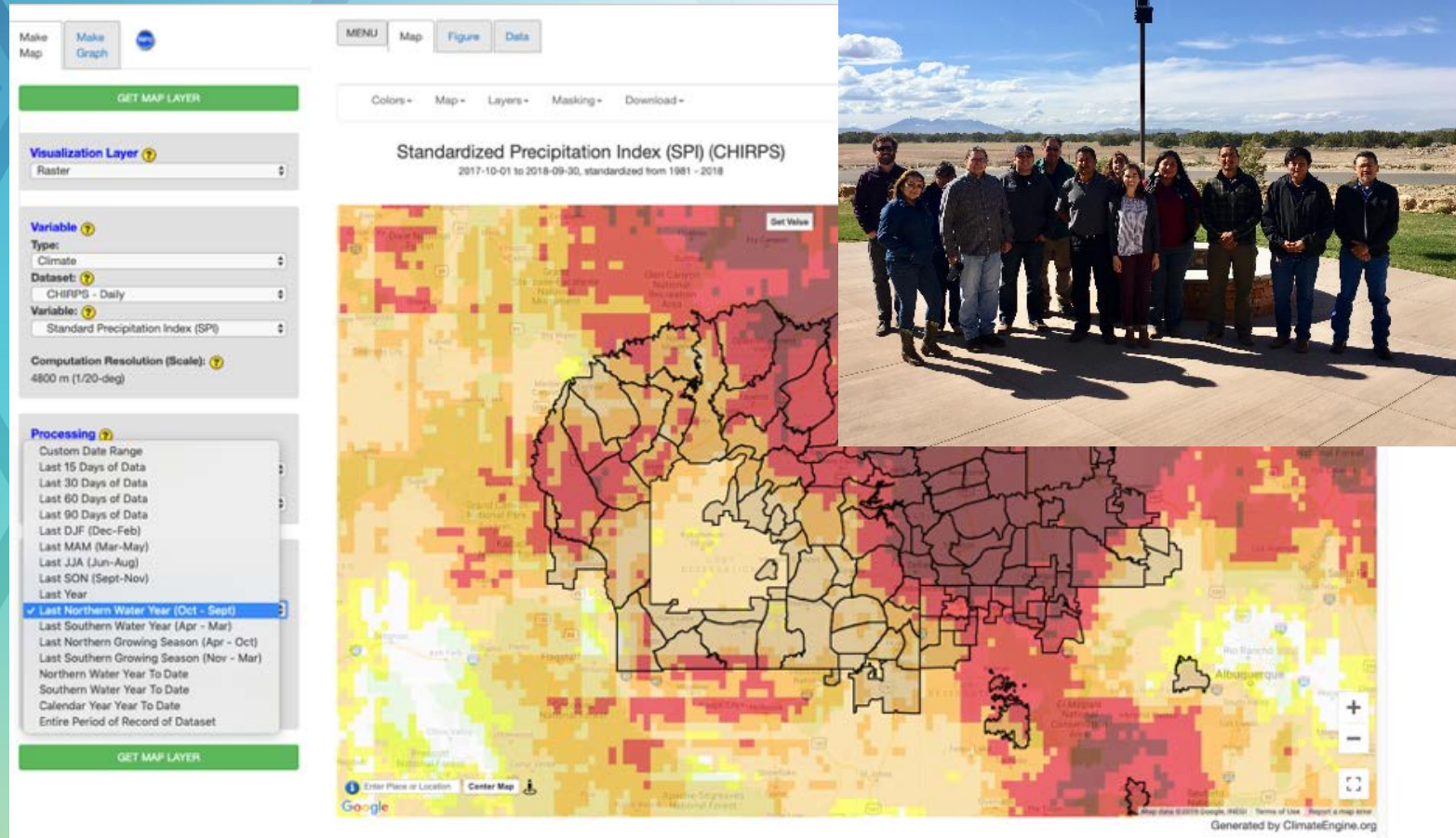
Create Custom Data

2019 ET: 30 in

Crop: Corn
Area: 128 Acres



Satellite-based Drought Reporting on the Navajo Nation



PI: Amber McCullum,
NASA ARC-CREST

Partner:
Navajo Nation DWR

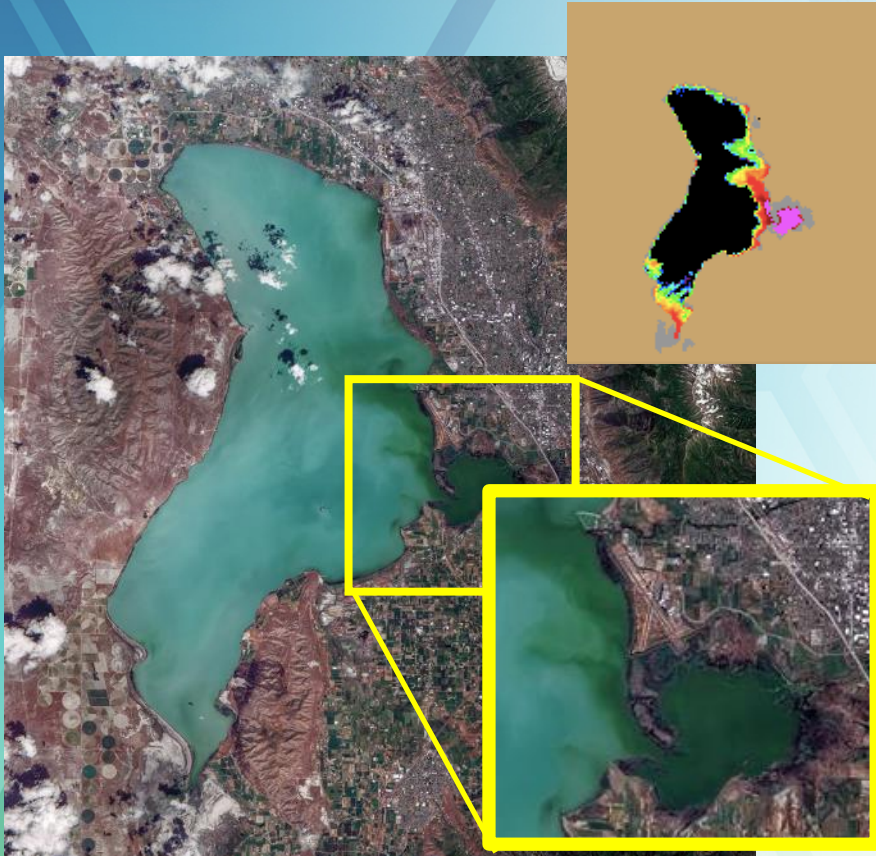
Capability:
Mapping of drought
indicators

Applications:

- Quantification of drought severity at local scales
- Allocation of drought emergency funds / resources for drought mitigation

Monitoring Water Quality

Cyanobacteria Assessment Network (CyAN)



Sentinel-2 image – June 27 2017 showing an algal bloom in Provo Bay. Utah Department of Environmental Quality used CyAN data products and imagery to monitor evolving algal blooms and deploy additional sampling resources.



CyAN image of bloom,
June 25, 2017

NEWS RELEASE
June 30, 2017

State of Utah
GARY R. EBERHART
Governor
SPENCER J. COX
Lieutenant Governor

Alan Swanson
Executive Director
Brad T. Johnson
Deputy Director
L. Scott Board
Deputy Director

CONTACT
Donna Kemp Spangler
Communications Director
Office: 801-536-4444
Cell: 801-554-4944
dspangler@utah.gov

Utah Lake Algal Bloom Spreading North Water Test Results Pending

SALT LAKE CITY—State environmental and health officials continue to closely monitor a blue-green algae bloom discovered in Utah Lake's Provo Bay that appears to be spreading north. If the bloom continues to spread northward, it may reach the Jordan River in coming days. Water quality tests outside the Provo Bay are pending to determine the risk to public health.

In the meantime, officials encourage people to enjoy Utah Lake, but avoid swimming in dark green water or areas of heavy scum.

Utah County Health Department (UCHD) and Utah State Parks have posted warning signs along Provo Bay Marina, which is the closest access point to where the algal bloom was identified via satellite imagery in Provo Bay, roughly a mile southeast of the marina. The warnings caution people from recreating in Provo Bay due to the potential health risk.

"We want people to enjoy Utah Lake during this holiday season, but we want them to be mindful of the presence of algae that have the potential to produce toxins," said Utah Department of Environmental Quality's Water Quality (DWQ) Director Erica Gaddis. "The bloom has the potential to shift with changes in wind patterns over the weekend and the public should watch for areas of scum."

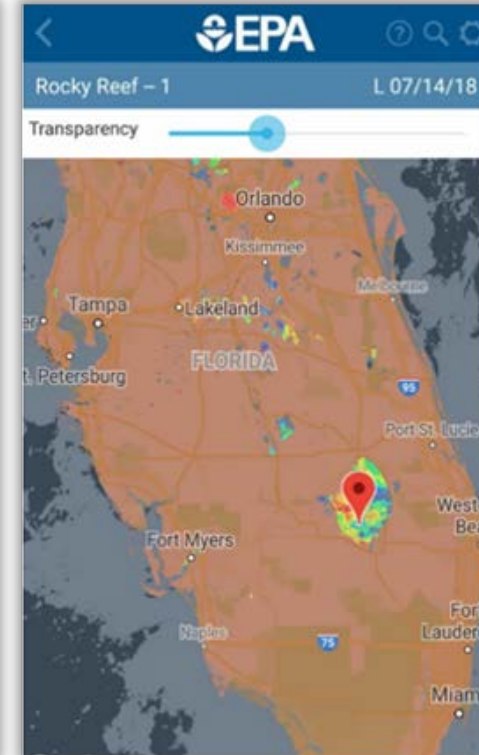
Satellite images show the bloom is expanding toward the northern shoreline of the lake, following a similar pattern as last year's massive algal bloom that shut down Utah Lake. However, preliminary information Friday from algal count samples suggest lower counts than were observed in last week's samples. The situation will be in flux for some time.

Salt Lake County Health Department (SLCHD) is monitoring the Jordan River and related canal systems for signs of potentially harmful algae, but officials had not observed algal blooms in those waterways as of Friday afternoon.

Water quality crews began collecting samples June 12, 2017, as part of routine monitoring. Follow-up water sampling detected cell counts above the threshold for recreational advisories at the mouth and open water of Provo Bay. The most recent test results indicate that the toxin microcystin is present, but at levels well below the Environmental Protection Agency's health-

-MORE-

190 North 1900 West • Salt Lake City, UT
Mailing Address: P.O. Box 160800 • Salt Lake City, UT 84116-0800
Telephone (801) 536-4000 • Fax (801) 536-0900 • TDD: (801) 963-3978
www.utah.gov
Printed on 100% recycled paper



Satellite monitoring of harmful algal blooms and threats to water quality across the U.S.



Integration of InSAR with Airborne Geophysical Data to Improve Groundwater Models



PI: Rosemary Knight,
Stanford University

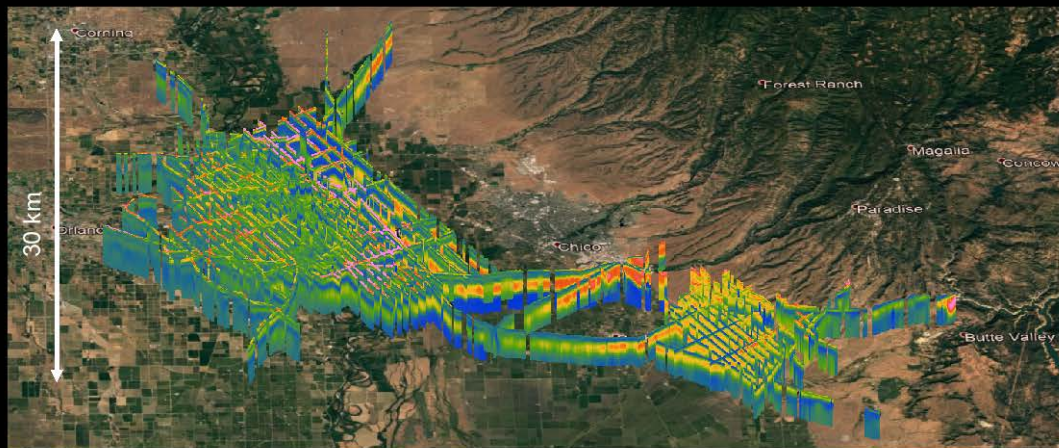
Partners:
CA DWR and USGS

Capability:
Use of airborne
electromagnetic surveys to
map aquifer connectivity /
structure

Applications:

- Groundwater monitoring
- Support for SGMA implementation

Butte County, December 2018
SkyTEM data – 800 line km
Processed/Inverted by Aqua Geo Frameworks



Depth of Investigation:
eastern area (SkyTEM 312): 236 m - 338 m
western area (SkyTEM 304): 196 m - 321 m

Resolution: horizontal, ~ 60 m along flight lines; vertical, meters to 10s of meter

Integration of Remotely Sensed Streamflow Data into Resource Management Agency Operations

Satellite-Derived Discharge for the Yukon River at Stevens Village, Alaska with Jason-2 Altimetry

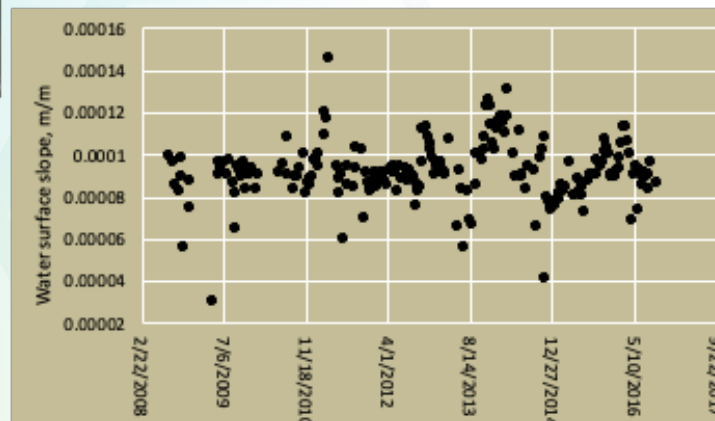
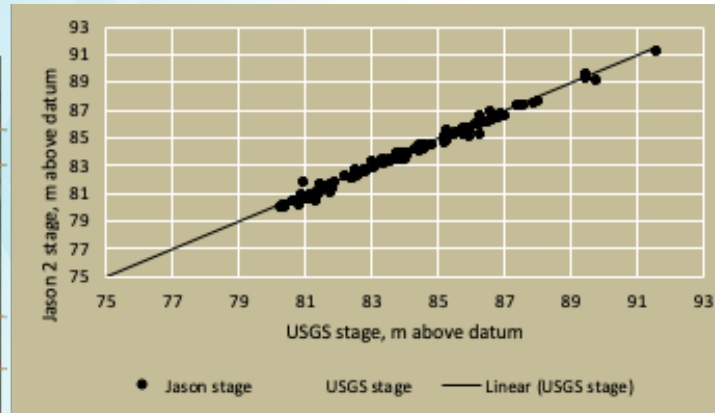
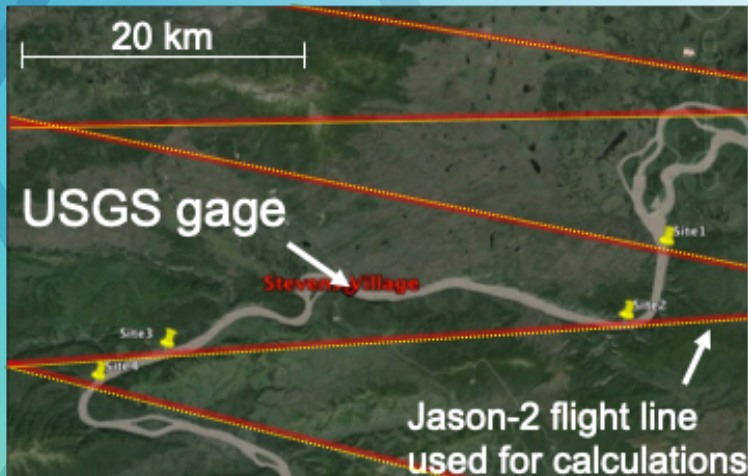
PI: Jack Eggleston, USGS

Partner:
USGS

Capability:
Remote sensing of stream elevation and streamflow in remote basins

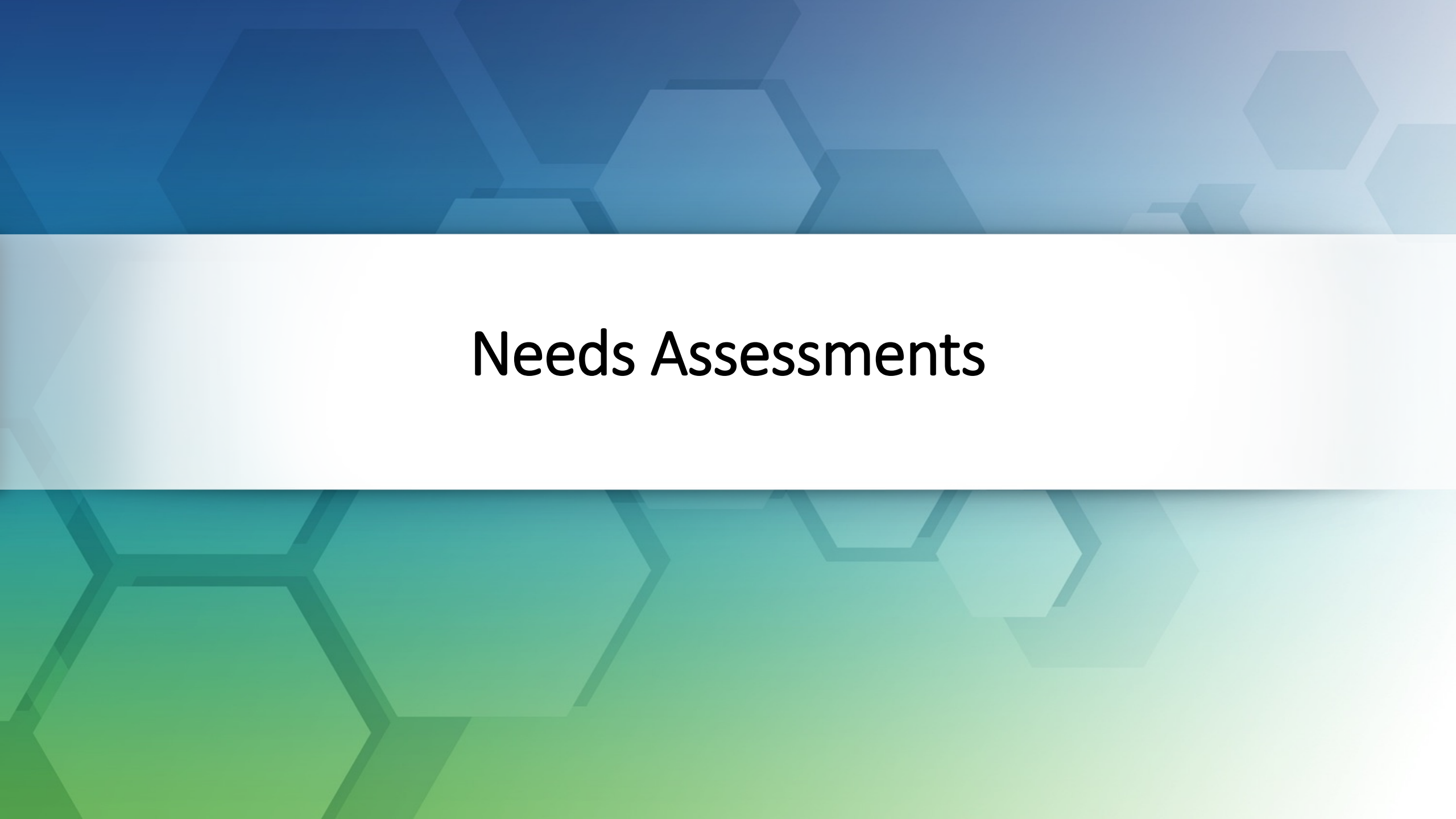
Applications:

- Streamflow monitoring
- Flood forecasting
- Greater safety for monitoring remote sites



$$\text{MAN : } Q = \frac{[W((h - B)(1 - (\frac{1}{1+b})))^{1.67} S^{0.5}]}{n}$$

$$\text{PVK : } Q = 2.5WY(gYS)^{0.5} \left(\ln \left(\frac{Y}{y_0} \right) - 1 \right)$$

The background of the slide is composed of two distinct hexagonal patterns. The top half features a blue gradient with darker blue hexagons of varying sizes and opacities. The bottom half features a green gradient with darker green hexagons. A white horizontal band separates the two patterns, serving as the background for the title text.

Needs Assessments

2019 Columbia River Basin Needs Assessment



*Portland, OR
September 10-12, 2019*

Agriculture

Evapotranspiration / Consumptive Use

Crop Mapping

Irrigation Management & Scheduling

Watershed Health

Habitat Management

Land Use and Land Cover

Surface & Groundwater Interaction

Stream Temperature

Water Quality

Turbidity

Cyanobacteria

Stream Temperature

Water Supply

Evapotranspiration

Streamflow Monitoring

Snow Water Equivalent

Groundwater recharge

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 (≥ 24-month period)	Predicting Changes in the Sierra Nevada or Rocky Mountain Snowline, Snowpack Distribution, and Streamflow Forecasts

Applied Science Program:

Partnerships are what make the Difference





Questions?

NASA Western Water Applications Office

Forrest Melton, WWAO Program Scientist

Forrest.S.Melton@nasa.gov

Stephanie Granger, WWAO Program Strategist

Stephanie.L.Granger@jpl.caltech.edu

Indrani Graczyk, WWAO Program Manager

Indrani.Graczyk@jpl.caltech.edu

NASA Applied Sciences Program

Brad Doorn, Program Mgr., Water Resources

Bradley.Doorn@nasa.gov

Lawrence Friedl, Director, NASA Applied Sciences

lfriedl@nasa.gov