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
Earth as a Complex Inter-related System

NASA Earth Science advances knowledge of Earth as a system to meet the challenges of environmental change and to improve life on our planet.

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

Earth System Science: Requires quantitative understanding of interactions between processes in order to define the Earth system – nonlinearities link spatial and temporal scales.
NASA’s Earth Science Community Challenge

- 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.

Source: “Thriving on Our Changing Planet: A Decadal Strategy for Earth Observations from Space” A Consensus Study report of National Academies of Science
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.

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.

Soil Moisture
The SMAP Level 2, NISAR (launch 2022) passive soil moisture product demonstrates a retrieval accuracy that is better than 0.04 m$^3$/m$^3$, the project’s established performance criteria. This can enable further advances in hydrology science and applications.

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).
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

Agriculture Water Use

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

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

OpenET from Landsat – DRI – Agriculture Water Use
NASA Supports Access to Water-Related Data

Additional water-related data available in near real-time data discovery and delivery services from the Land, Atmosphere Near real-time Capability for EOS (LANCE) and the World View systems.
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.
**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

**WWAO Dashboard March 2020**

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<th>Federal / Regional</th>
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<tr>
<td>NOAA</td>
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<td>USBR</td>
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<td>Tribal Nations</td>
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<th>Private Sector</th>
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<td>Utilities</td>
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<td>Data Services</td>
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<td>Infrastructure</td>
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<td>Other</td>
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(U.S. Western States map with icons representing various engagements and partnerships)
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.

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

Web UI and data services

Data review in the field with agricultural partners

Case studies across the West used to define requirements
Monitoring Water Demand and Use: OpenET

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

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
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

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\text{MAN} : Q = \frac{W ((H - B)(1 - \left( \frac{1}{1+8a} \right))^1.675^{0.5}}{n}
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\text{PVK} : Q = 2.5WY(gYS)^{0.5} \left( \ln \left( \frac{Y}{Y_0} \right) - 1 \right)
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Needs Assessments
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

2019 Columbia River Basin Needs Assessment

Portland, OR
September 10-12, 2019
## 2018 Colorado River Basin Needs Assessment Priority Needs

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<tr>
<th>Water Resources Category</th>
<th>Use Case</th>
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<tr>
<td><strong>Snow Properties and Processes</strong></td>
<td>Improved Forecasts of Snowpack, Runoff, Water Demand, Evapotranspiration</td>
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<td><strong>Water Supply Forecasting (&lt; 1 year period)</strong></td>
<td>Streamflow Predictions at Sub-Basin Scales</td>
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<td><strong>Evapotranspiration (ET) over Land and Water</strong></td>
<td>Consumptive Use for Calculating Water Budgets</td>
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<td><strong>Crops and Agriculture Properties and Processes</strong></td>
<td>Reservoir Evaporation</td>
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<td>Crop Mapping</td>
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<td>Crop Monitoring</td>
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<td><strong>Irrigation Types and Methods</strong></td>
<td>Irrigation Management</td>
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<td><strong>Groundwater Characterization</strong></td>
<td>Augmenting Groundwater Quantification</td>
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<td><strong>Extreme Event Prediction and Impact Assessment</strong></td>
<td>Mitigation of Wildfire Impacts on Watershed Supply</td>
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<td>Augmentation of State-Level Drought Planning and Response</td>
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<td>Drought Planning and Response at the State Level</td>
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<tr>
<td><strong>Water Supply Forecasting (≥ 24-month period)</strong></td>
<td>Predicting Changes in the Sierra Nevada or Rocky Mountain Snowline, Snowpack Distribution, and Streamflow Forecasts</td>
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Applied Science Program:
Partnerships are what make the Difference
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<th>NASA Western Water Applications Office</th>
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<tr>
<td>Forrest Melton, WWAO Program Scientist</td>
<td>Brad Doorn, Program Mgr., Water Resources</td>
</tr>
<tr>
<td><a href="mailto:Forrest.S.Melton@nasa.gov">Forrest.S.Melton@nasa.gov</a></td>
<td><a href="mailto:Bradley.Doorn@nasa.gov">Bradley.Doorn@nasa.gov</a></td>
</tr>
<tr>
<td>Stephanie Granger, WWAO Program Strategist</td>
<td>Lawrence Friedl, Director, NASA Applied Sciences</td>
</tr>
<tr>
<td><a href="mailto:Stephanie.L.Granger@jpl.caltech.edu">Stephanie.L.Granger@jpl.caltech.edu</a></td>
<td><a href="mailto:lfriedl@nasa.gov">lfriedl@nasa.gov</a></td>
</tr>
<tr>
<td>Indrani Graczyk, WWAO Program Manager</td>
<td></td>
</tr>
<tr>
<td><a href="mailto:Indrani.Graczyk@jpl.caltech.edu">Indrani.Graczyk@jpl.caltech.edu</a></td>
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