The Second Roundtable on Colorado River Basin Data and Modeling

May 27-28, 2020

Via Webinar

The Western States Water Council (WSWC), in cooperation with the Internet of Water (IOW) and OpenET, is hosting a second roundtable as a follow-up to the first "Internet of Water Roundtable: Colorado River Basin," organized by the Aspen Institute and Nicholas Institute for Environmental Policy Solutions in January 2019 held in Salt Lake City, Utah. The Aspen Institute's Dialogue Series on water data led to its report, "*Internet of Water: Sharing and Integrating Water Data for Sustainability*," which presented a vision for a national policy framework to address institutional barriers to scaling and integrating water data and information to support sustainable water management. The first roundtable recommended continuing discussions and coordination among three ongoing projects: the **Internet of Water (IoW)**; the **OpenET** project, and the WSWC's **Water Data Exchange (WaDE)** program.

This second roundtable will bring IoW, OpenET and WaDE together with groups from Colorado River Basin federal and state agencies to present progress over the last year and discuss the next steps on modeling and data sharing. The projects' teams are working toward laying a foundation of open and interoperable water data and all have significant applications for water management in the Colorado River basin. Due to COVID-19 travel restrictions and concerns, the roundtable was adapted to a 2-day webinar.

Roundtable Goals:

- Serve as a forum for the Colorado River Basin States, federal agencies, and others to discuss efforts in mapping and reconciling differences in water use estimates and data sharing
- Highlight what has been accomplished across the OpenET, IOW, and WaDE projects to estimate water use, reconcile water glossaries and water budget models, and demonstrate WaDE 2.0 platform
- Report progress on water data initiatives and laws in state and federal agencies
- Identify areas of mutual interest, ways to collaborate, case studies, and some practical, on-the-ground next steps for how IoW, OpenET, and WaDE projects can further help Colorado River Basin States.

Agenda

Wednesday, May 27th (Mountain Daylight Saving Time)

9:45 AM	**Getting everyone connected to the Webinar**
10:00 – 10:30 AM	**Welcome** Tony Willardson, Executive Director -Western States Water Council (WSWC) Mike Myatt, Program Officer - Water Foundation (WF) Ted Kowalski, Senior Program Officer - Walton Family Foundation (WFF) Peter Colohan, Executive Director - Internet of Water (IOW) Robyn Grimm, Senior Manager, Water Information Systems - Environmental Defense Fund
10:30 – 11:00 AM	**First Aspen Institute Roundtable Recommendations** • Greg Gershuny, Executive Director - Aspen Institute Energy and Environment Program (EEP) • Sara Larsen, Deputy Director - Upper Colorado River Commission (UCRC)
11:00 – 12:00 PM	**Progress on Water Data Initiatives Update** • Internet of Water Update Ashley Ward, Senior Policy Associate and Kyle Onda, Data Architect – Internet of Water • OpenET Project Update Robyn Grimm, Senior Manager- Water Information Systems - Environmental Defense Fund Justin Huntington, Research Professor - Desert Research Institute Forrest Melton, Program Scientist - NASA Western Water Application Office (WWAO)
12:00 – 1:00 PM	**Lunch**
1:00 – 1:30 PM	**Progress on Water Data Initiatives Update** • Water Data Exchange (WaDE) Program Update Adel Abdallah, Program Manager and Ryan James, Data Analyst – Western States Water Council
1:30 – 3:00 PM	**Colorado River Basin: State Water Data Initiatives - Progress on Modeling Water Use and Sharing Data**
1:30 - 2:00 PM	• Wyoming: Jodee Pring, Supervisor, River Basin Planning - Wyoming Water Development Office and Charlie Ferrantelli, River Basin Coordinator - Wyoming State Engineer's Office
2:00 - 2:30 PM	• California AB1755: Streamlining Water Data Submissions to the State Joaquin Esquivel, Board Chair - California Control Board and Kamyar Guivetchi, Manager, Division of Planning - California Department of Water Resources
2:30 - 3:00 PM	• Colorado River Basin Consumptive Use and Loss Reporting James Prairie, Hydrologic Engineer - Bureau of Reclamation
3:00 PM	**Concluding Remark / Adjourn**

Thursday, May 28, 2020 (Mountain Daylight Saving Time)

8:45 AM	**Getting everyone connected to the Webinar**
9:00 – 9:20 AM	**Recap of Day 1** A brief re-orientation and synthesis of the previous day's discussions. Ashley Ward, Senior Policy Associate - Internet of Water
9:20 –10:20 AM	**Colorado River Basin: State Water Data Initiatives - Progress on Modeling Water Use and Sharing Data**
9:20 - 9:40 AM	• Arizona: Kyle Miller, Planning Manager - Arizona Department of Water Resources and Marcus Shapiro, Water Systems Supervisor - Central Arizona Project
9:50 - 10:20 AM	• Colorado: Rebecca Mitchell, Director and Brian Macpherson, Decision Support System Specialist - Colorado Water Conservation Board
	Break (10 min)
10:30 –12:00 AM	**Colorado River Basin: State Water Data Initiatives - Progress on Modeling Water Use and Sharing Data (Continue)**
10:30 - 11:00 AM	• Nevada: Seth Shanahan, Colorado River Programs Manager - Southern Nevada Water Authority
11:00 - 11:30 AM	• Utah: Todd Stonely, Assistant Director, Utah Division of Water Resources
11:30 - 12:00 PM	• New Mexico: Stacy Timmons - Associate Director, Hydrogeology – New Mexico Bureau of Geology and Mineral Resources, and Rolf Schmidt-Petersen, Director - New Mexico Interstate Stream Commission
12:00– 1:00 PM	**Lunch**
1:00 – 2:00 PM	**How the OpenET, WaDE, and IOW can Help the Colorado Basin States?** Panelists: Tony Willardson, Adel Abdallah, Peter Colohan, Justin Huntington Reflecting on the challenges related to data initiatives in the basin, panel participants and attendees will discuss how the IoW, WaDE, and Open ET can move forward effectively and quickly, and how they can make use of, and benefit from, ongoing water data projects.
2:00 – 3:00 PM	**Wrap-up and Next Steps** Panelists: Forrest Melton, Ashley Ward, Adel Abdallah, Tony Willardson The panel will synthesize the discussions, identify common barriers to progress, opportunities to develop synergies between the various projects, and identify case studies that best demonstrate the proposed approaches.
3:00 PM	**Adjourn**

Colorado River Basin Virtual Roundtable
Speakers' / Registrants' List
May 27-28, 2020

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Colorado River Basin Virtual Roundtable

Speakers' / Registrants' List

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Key Takeaways from the Colorado River Basin Roundtable

January 28-29, 2019

BACKGROUND

The Aspen Institute, in partnership with the Nicholas Institute for Environmental Policy Solutions at Duke University and Redstone Strategy Group, convened a ***Dialogue Series on Sharing and Integrating Water Data for Sustainability*** in 2016 and 2017. Water experts, managers, academia, and other representatives from the private and social sectors developed a series of recommendations for improving our water data infrastructure so that we can answer fundamental questions about our water systems in a timely way: *How much water is there? What is its quality? How is it used?* Because the data have been collected by different agencies, for different purposes, with different methods, across different platforms, and with different standards, they are rarely used to support real-time decision making or to develop an in-depth understanding of entire watersheds. The Dialogue series culminated in the publication of the *Internet of Water* report.

The Internet of Water (IoW) is a bold vision for how to improve water data infrastructure and fundamentally transform water management. The IoW describes a federation of disconnected data producers, hubs, and users, currently, which without direction is less likely to become interconnected in a reasonable amount of time into a form or function that would support and increase water sustainability. The components of the IoW already exist (data producers, hubs, and users); however, these entities operate in silos with their primary focus on meeting their respective missions.

The IoW is about building networks and improving connections and communication between and within existing water-focused communities. This process began with a series of regional and sector-specific roundtable discussions. The first roundtable took place in Palo Alto, California, and centered on the regulatory framework that has been created for opening and sharing water data with the passing of the *Open Water Data Transparency Act* (AB 1755) and the *Sustainable Groundwater Management Act* (SGMA). The second roundtable was held in Detroit, Michigan, and focused on how sharing data can help address the water quality issues plaguing industrial, lake-side towns and upstream agricultural communities in the Great Lakes region. The third roundtable took place in St. Louis, Missouri and focused on the agricultural community and conversations around data privacy and future regulations. The fourth roundtable took place in Austin, Texas in parallel with ongoing Texas Water Data efforts where much of the conversation centered on the tension between "if we build it, they will come" (open all water data) approaches and prioritizing opening water data linked to well-defined use cases.

COLORADO RIVER BASIN DATA ROUNDTABLE

The Aspen Institute and Nicholas Institute convened its fifth and final roundtable in Salt Lake City, Utah. This roundtable expanded the conversation to three open water data initiatives: the Western States Water Council's Water Data Exchange (WaDE) Program, NASA-Desert Research Institute's (DRI) OpenET project, and the IoW. This discussion brought together thought leaders and experts from different stakeholder groups within the Colorado River Basin to explore synergies between these three projects and address the water data needs of states within the basin. The roundtable had three priorities*: (1) to raise awareness of ongoing water data efforts, (2) to identify water data needs specific to the Colorado River Basin, and (3) to explore opportunities to leverage water data efforts to collectively meet needs.*

(1) Ongoing water data efforts

The group discussed three water data initiatives:

- **Water Data Exchange (WaDE)** – Making state administrative water data more discoverable and accessible, with a future goal of standardizing terms, data standards, metadata, etc. to improve interoperability.
- **OpenET** – Building an open platform that provides spatially explicit evapotranspiration (ET) data in a format that meets the needs of their user communities and their use cases.
- **Internet of Water (IoW)** – Providing a coordinating and convening role to build connections between data producers, hubs, and users to federate water data and demonstrate the value of those data to ensure long-term sustainable funding of water data communities.

The group also explored current approaches to water data in Arizona, California, and Nevada.

- **Arizona** – created an Office of Data Management in 2017 that takes a non-invasive data governance approach to improve their water data. Data producers must provide definitions and metadata for their data to be included in Arizona's data warehouse, and used by the State in water planning efforts.
- **California** – is developing a federated, interoperable open data platform to meet the requirements of AB 1755. The state is collaborating with others to (1) develop governance and funding options, (2) identify use cases, (3) adopt technical standards, and (4) create data challenges to test and improve the platform.
- **Nevada** – the Southern Nevada Water Agency collects data for operational and broad decision-making purposes that are available upon request. They are collaborating with state, federal, and NGOs to pull all water quality data for Lake Mead into a single, password protected database.

(2) Identify water data needs in the Colorado River Basin

The conversation focused on the challenges related to consumptive water use data. First, states and agencies have different definitions of consumptive water use. Second, measuring consumptive water use, particularly from ET is difficult, resulting in the development of multiple methods that produce different ET estimates that are used by different states and agencies. Third, any attempt to standardize a definition and method will have legal and administrative implications and challenges. The development of a standardized definition and method for consumptive water use must occur alongside legal and administrative conversations to create trust and buy-in by states and communities. Four approaches were proposed to further standardizing water use data.

(1) **Short-term, voluntary pilot studies (use cases)** that apply standardized consumptive water use to a watershed or region could implement these new approaches without litigation or the threat of losing water rights.

(2) **Safe harbors** could be developed that protect entities from the legal ramifications of adopting a standardized consumptive water use method. Safe harbors can create smoother transitions when new data or methods are anticipated to be disruptive.

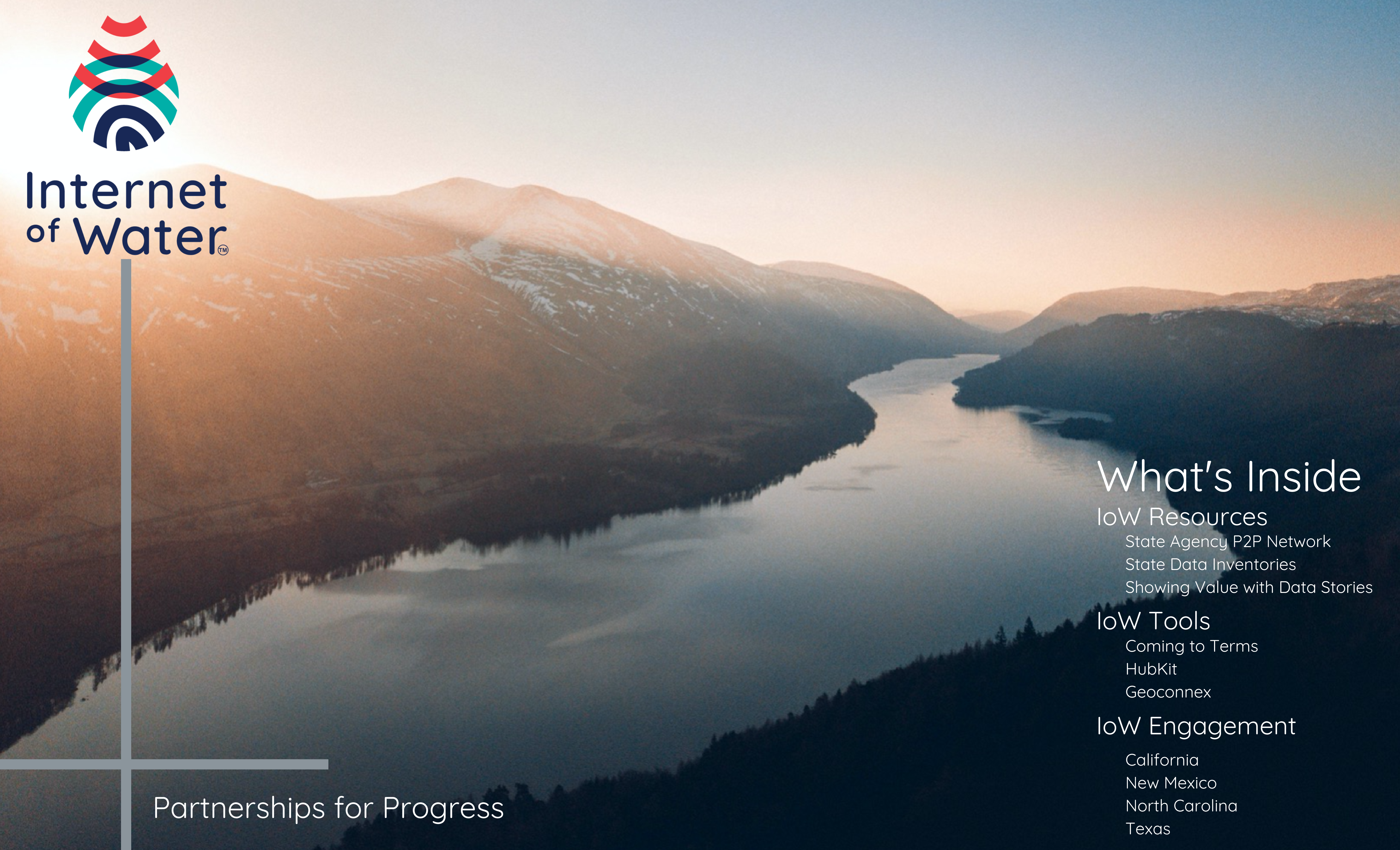
(3) **Identify win-win situations** where data build trust and creating mutually beneficial solutions instead of winners and losers.

(4) **Convene regular meetings and working groups** to continue building communities and relationships between the same set of stakeholders to progress from identifying terms and standards to reconciling and advocating for standardized definitions to their respective communities.

Additionally, developing sustainable, financial resources for local and state governments is essential to ensure they can continue collecting public water data and invest in their water data infrastructure. This can be achieved by building water data communities and technical capacity. **Water data communities** can (1) create trust around open data and mitigate against misuse, (2) share human resources and technical knowledge, and (3) participate in use cases that build agreement around data, standards, and methods to demonstrate the value of integrating water data. **Technical capacity** refers to the development of catalogs of data, definitions standards, metadata, and exchange standards, as well as creating crosswalks between different types of data. The catalogs would at first describe the data, and communities engaged in certain types of data (such as OpenET with consumptive water use and WaDE with administrative water data could begin working towards standardization.

(3) Leverage Water Data Efforts

All three data initiatives, and many of the initiatives described by federal and state agencies in the Colorado River Basin, are collaborative efforts within their respective communities. However, there is not much collaboration across communities. To that end, perhaps the greatest need is for a head librarian that facilitates and coordinates ongoing conversations across the water data community and provides a clearinghouse for data efforts, catalogs, definitions, standards, etc. The "head librarian" can provide guidance on agreed-upon minimum standards to ensure data are correctly placed on the shelf (cataloged) and discoverable by end users, and is the go-to resource for new data providers and hubs. Such an organization person could also provide a place for groups to convene and communicate with one another about ongoing efforts. This is a primary role for the IoW. The IoW would catalog existing efforts and build awareness so each state, hub, and project are learning from each other's novel solutions and experiences. IoW could provide resources for OpenET and WaDE (and others) to act as library branches that convene meetings and working groups for their particular communities. The regular convening of the same set of stakeholders could build relationships that move from identifying terms and standards to reconciling and advocating for standardized definitions to their respective communities. OpenET, WaDE, states, and other efforts are developing the platforms, tools, processes, and use cases that demonstrate the value of water data for different communities. These efforts are critical to ensure the long-term financial sustainability of open water data initiatives that could transform how we manage our water resources.



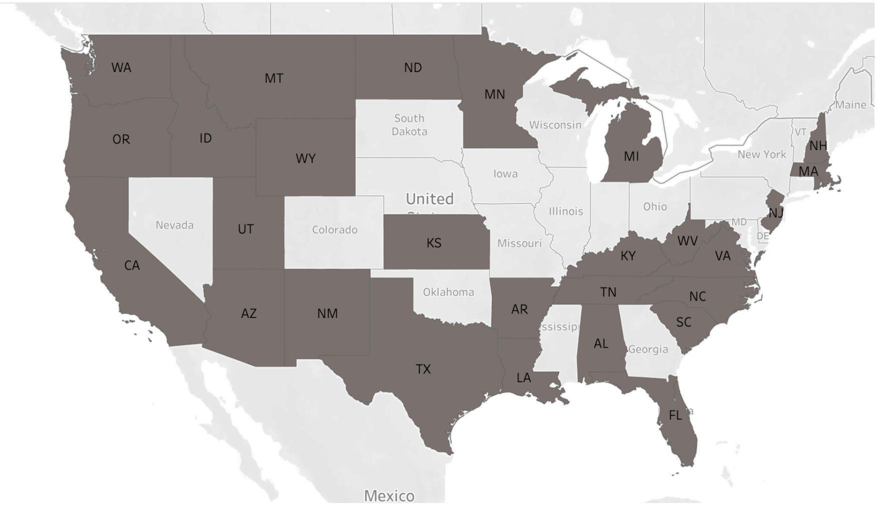
Internet of Water

Partnerships for Progress

What's Inside

P2P State Agency Peer-to-Peer Network

The Internet of Water's State Agency Peer-to-Peer (P2P) Network is a community of practice designed to connect members from across the nation who are working on modernizing their agency's water data infrastructure. Active employees of state, local, or tribal agencies are encouraged to register and participate. The Network will provide opportunities for members to share challenges, solutions, and lessons learned in the work to modernize their water data infrastructure. Members will also be invited to participate in quarterly webinars and a Network forum. The State Agency P2P launched on April 1, 2020.



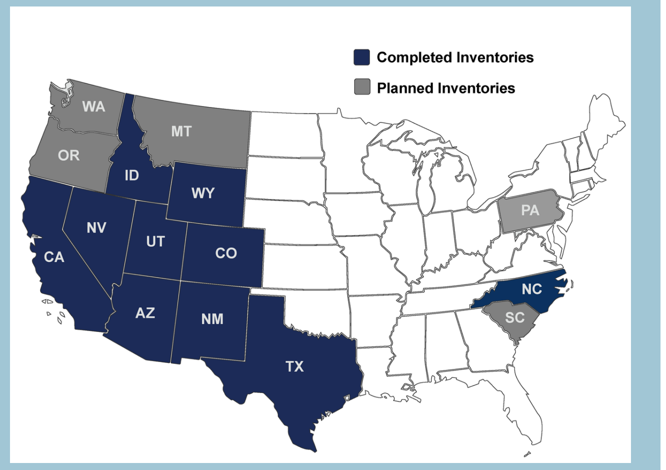
63 members 28 states

[Register Here](#)

State Water Data Inventories

Assessing the water data landscape

The Internet of Water is conducting water data inventories for each state in the U.S. Water data inventories tell us: **WHO** Is collecting water data; **WHAT** data Is being collected; and **HOW** discoverable, accessible, and Interoperable the data. To date, across only 4 states and the federal government we have found: 326 agencies Involved with water data and 279 platforms to find water data. **These results indicate high data fragmentation for water data.**



Inventory metrics generate an "Openess Score" that allow users to compare data openess with other, similar entities and identify where they can make improvements. DISCOVERABILITY measures how difficult data are to find. ACCESSIBILITY measures how difficult the data are to obtain. USABILITY measures the machine readability of the data, the quality of metadata, and presence of a data dictionary. Discoverability and Usability receive the overall lowest score.

Valuing Data

Without clear value propositions demonstrating how water data improves outcomes, investment in water data will remain minimal. The Internet of Water features a diverse set of data stories, meant to demonstrate the value of Integrated data and to provide guidance on methods for valuing water data.

[Read our data stories and learn how to assess value.](#)

Internet of Water

The Internet of Water is developing educational materials and tools as well as a shared, flexible, adaptable technical framework of established, agreed upon methods and approaches for creating data that is more discoverable, accessible, and interoperable. Because U.S. water data are so difficult to find, access, and use, the water sector is routinely unable to benefit from new technologies that have transformed other sectors. Our technological approach bridges this gap.

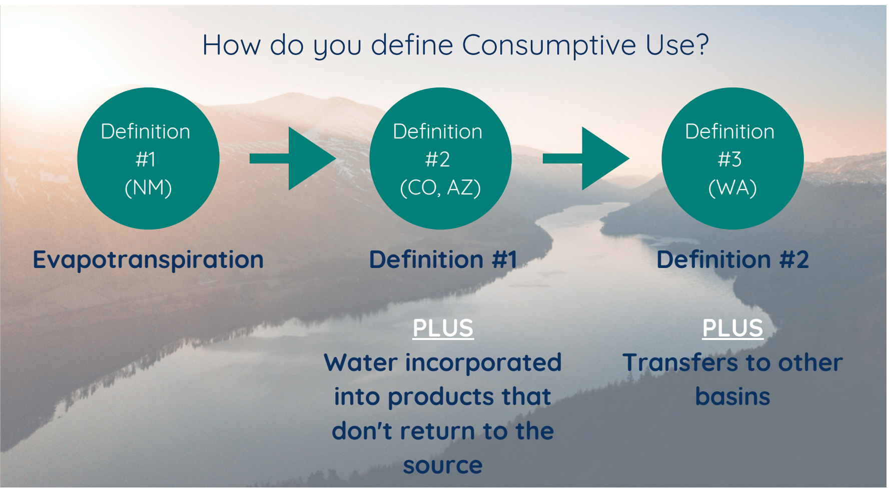
Coming to Terms

A Water Terminology Collection

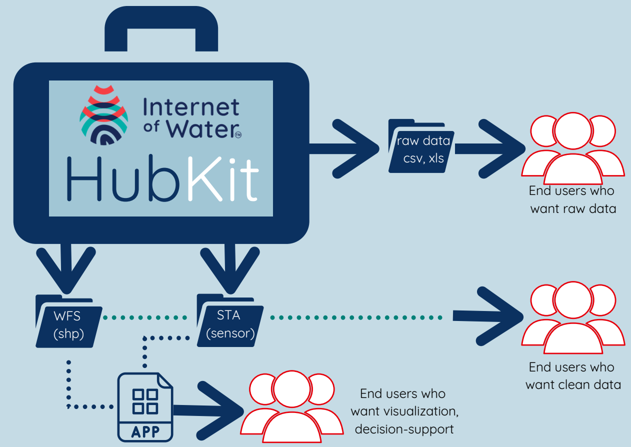
Integrated data requires shared vocabulary. Coming to Terms is an open source tool that tracks definitions, synonyms, and homonyms of water-related terms, provides access to vocabularies used by federal, state, tribal, local, and private entitites engaged In water management, science, and use.

The Vocabulary Challenge: The Tower of Babel

The Colorado River supplies water to **40 million people in 7 states and 21 tribes.** These entities share water based on an inter-state treaty first signed in 1922, and allocations depend upon how much water each state "consumptively uses." However, each state defines **"consumptive use"** differently.



It is impossible to share information and data between states if data don't have the same meaning. This is a universally acknowledged problem, but there is no one entity charged with addressing this problem. **The IoW is designed to address this problem.**



A collection of modular software components that enable storage, metadata documentation, and publication of time series, spatial, and tabular data using OGC Standard web services.

With a user-friendly interface, HubKit can be easily configured with other data sources and includes a data translation feature. HubKit Integrates different data sources, such as geoJSON, shp, kml, xls, or csv and convert that for:

- End users who want raw data
- End users who want clean data
- End users who want visualization, decision-support

Geoconnex

Hydrologic Linked Data Index

The Geoconnex project is a suite of activities designed to enable a federated, decentralized linked data system for water in the United States. We envision this system to encompass all types of water data, including hydrography, hydrometric observations, hydrologic model results, and administrative water data hosted by many organizations. This would enable developers to query geographic locations within the United States for every precipitation, streamflow, water quality, and water use observation or estimate in the stream reach, watershed, and aquifer relevant to that location. The Internet of Water, along with collaborators at the USGS and other public, academic, and nonprofit water data providers, is iterating on four key components of a nationwide linked water data system.

- Standard methods for representing environmental features and (meta)data sources about those features
- A Persistent Identifier (PID) Service for environmental features and data
- A service for hosting linked-data content for "reference" resources that don't have an authoritative data steward
- A community contribution process for curating the data within the system

Integrated water management requires integrated data

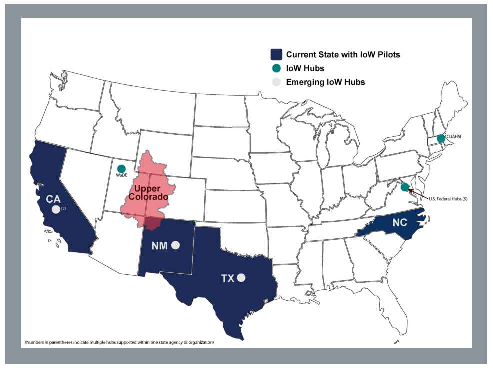
Internet of Water

Engagement

No single bureaucracy approach can be deployed to meet the diversity of the water data problem. Our partnerships are close collaborations with stakeholders designed to demonstrate the power of integrated water data. **A broad movement to change cultural norms and behavior across public sector agencies and utilities is an essential element to the development of the Internet of Water, which will complement and enable the needed technical transmforation.**

The Internet of Water is focused on changing minds and behaviors in ways that are sustainable. This means engaging stakeholders in a way that fosters ownership and respects stakeholder capacity. To acheive this, our approach to engagement focuses on pilot partners' needs and the context In which they work.

Because each state has different needs, moving at different paces and in different contexts, there isn't a single bureaucracy approach that can be deployed to meet this diversity. Instead, we have to meet them where they are, enable them where they are.



The IoW seeks to develop these projects in a manner that is transferable and scaleable. We don't want a network of place-specific solutions. We want a national network in which entities talk to one another.

The IoW currently has partnerships In California, New Mexico, North Carolina, Upper Colorado, and Texas

CA

In California we are working with stakeholders to enable the work of the Open and Transparent Water Data Act of 2016. Because of this act, California's data infrastructure is largely in place. Our role in this context is as a trusted, outside partner who can act as an intermediary between state agencies. In this context we are enabling projects around water demand, drinking water quality, and harmful algal blooms.

NM

Members of the IoW team worked with partners in New Mexico, who were developing the New Mexico Water Data Act of 2019, and continued to work with directing agency partners to carry out the requirements of that legislation and build the framework for the New Mexico Water Data Initiative. This successful initiative continues to develop to refine the New Mexico Water Data Hub and carry out a use case on water quantity with stakeholders from the Pecos River water districts.

NC

Our partnership in North Carolina is centered on drought resilience for water utilities. As such we are focused on supporting local governments with their efforts to incorporate data into their resilience planning and decision-making. Additionally, there are emerging equity issues to our work in North Carolina as we focus on building the capacity of medium to small utilities to meet growing demands which require modern data infrastructure.

TX

While there is no legislation to guide the work in Texas as in other states, Texas water agencies have voluntarily partnered and identified three key areas that need attention: flood, drought, and surface to groundwater interactions. Progress in these important areas require a centralized water data hub; therefore, our work with Texas partners supports the development of the Texas Water Data Hub and the integration of water data from agencies throughout Texas.

Internet of Water

OPENET

FILLING THE BIGGEST DATA GAP IN WATER MANAGEMENT

Frequently Asked Questions

This FAQ may be revised as the OpenET project develops. Please anticipate changes as we work toward a launch in 2021.

Table of Contents

Overview

What is OpenET?
OpenET is a collaborative effort to develop an operational system for mapping evapotranspiration (ET) at the scale of individual fields. The OpenET team is building a new web-based platform with data visualization and access tools to fill a critical data gap in water management across the western U.S. OpenET leverages publicly available information to provide accurate and trusted satellite-based data on ET and consumptive water use at a low cost to farmers and water managers.

What does the ET in OpenET stand for?
ET, short for evapotranspiration, is the process by which water is transferred from the land to the atmosphere. It includes both evaporation from soil and transpiration from plant leaves. ET is a core driver of the Earth's water cycle, returning water to the atmosphere to fall again as precipitation.

For irrigated agriculture, ET is a measure of the water used to grow food and is the biggest share of water use in most arid environments around the world. In most agricultural regions, ET is also an accurate measure of consumptive use of water by agriculture.

What is consumptive water use?
Consumptive water use is water that is removed from available supplies as a result of its use. It does not return back to the local system.

Why is OpenET being developed?
Sustainable water management is one of the most challenging issues of our time, especially in the arid western U.S. Maximizing the benefits of water supplies requires careful measurement of availability and use. However, one critical information gap is compounding this challenge: the lack of accurate, trusted consumptive water use data for irrigated agriculture, which accounts for the majority of water use in the western U.S. To date, access to this data has been limited and expensive, keeping it out of the hands of most water users and decision-makers. OpenET aims to change this and support sustainable water management and innovation in water conservation.

Who is developing OpenET?
The project is being led by NASA, the Desert Research Institute (DRI), and Environmental Defense Fund (EDF), with in-kind support from Google Earth Engine. The technical team brings expertise in satellite-based estimation of ET, cloud computing, and user-driven website design. It includes approximately 30 researchers and practitioners from NASA, DRI, U.S. Department of Agriculture (USDA), U.S. Geological Survey (USGS), University of Nebraska, University of Idaho, University of Wisconsin, University of Maryland, California State University Monterey Bay, University of Montana, Google Earth Engine, and web development firm HabitatSeven.

Who are the OpenET partners and early adopters?
The project has been user-driven from the start to ensure it best serves the needs of a broad range of water users and decision-makers. Since its inception, OpenET has been dedicated to demonstrating value in providing benefits to agriculture and supporting sustainable land and water management practices. The OpenET community includes partnerships with more than 45 stakeholder entities and organizations. This includes growers and agricultural groups making irrigation scheduling and other decisions at the field scale, water district managers building water accounting and trading platforms, and state and federal agencies making drought and water budget assessments at large

scales. The insights learned through these partnerships are integral to the success of OpenET, including defining user requirements, providing feedback on the website design, and testing the beta versions of the user interface.

What is the role of Google Earth Engine?
The models used in OpenET ingest hundreds of terabytes of satellite and meteorological data, which is computationally expensive. Google Earth Engine provides a common computing platform where all of the satellite-based ET models used in OpenET can be implemented and run using consistent inputs. This allows the scientific community to collaborate on software development and produce the most accurate and consistent ET data possible. In addition, Google Earth Engine allows the OpenET team to store, rapidly compare, and analyze results from the ET models, enabling expedited progress on evaluation of model results and identification of opportunities to improve the ET estimates from both individual models and the full ensemble of models. OpenET uses Google Earth Engine to efficiently produce daily and monthly ET images across the western U.S. and to calculate data summaries for millions of agricultural fields or other regions of interest. These data are then exported to the OpenET web-based platform for data visualization and distribution. The Google Earth Engine team is supporting implementation of the ET models and providing the cloud computing resources as an in-kind contribution to the effort.

What will OpenET cost?
Providing ET data to farmers and local water managers at no to low cost is a core objective of the OpenET project. At a minimum, any visitor to the site will be able to freely view field-scale estimates of monthly ET data across the western U.S. for the last five years. Users will also be able to download limited quantities of data directly from the OpenET site at no cost. Additional pricing details for access to the Application Programming Interface, custom reporting, and larger or more frequent downloads will be announced when the OpenET platform launches in 2021.

Geographic and Temporal Scale

What geography is covered by OpenET?
OpenET will cover 17 western U.S. states: Arizona, California, Colorado, Idaho, Kansas, Montana, Nebraska, Nevada, New Mexico, North Dakota, Oklahoma, Oregon, South Dakota, Texas, Utah, Washington, and Wyoming. Over time, the intent is to expand OpenET to also include coverage of other regions in the U.S. and across the globe.

At what spatial scale will the data be available?
OpenET is produced at a spatial resolution of 30m x 30m (0.22 acres). OpenET data can also be aggregated for individual fields or other locations of interest by calculating the average data value for the field at each timestep.

At what time intervals will you be able to provide data (daily, monthly, yearly)?
OpenET will provide data at daily, monthly, and yearly timesteps. Since production and storage of daily datasets can be expensive, it is likely that daily data will only be available for irrigated agricultural regions for recent time periods.

What is the expected data latency?
Our goal is to provide monthly ET data across the western U.S. with a data latency of six weeks or less. For daily data, we recognize the importance of providing data within two days of satellite overpass for irrigation management applications, and we are working hard to come as close as possible to achieving this target for daily data products.

How did you generate the field boundaries?
Publicly available field boundary datasets were collected from academic research teams, state and federal agencies, and the 2008 USDA Common Land Unit (CLU) database. These datasets have been filtered to remove redundant polygons, as well as very small slivers (<0.25 acres) and very large polygons associated with grazing on non-irrigated rangelands and shrublands. Priority was given to more recent field boundary datasets produced by each state, and the CLU data were used only in cases where no state or local level datasets are publicly available.

Applications of the Data

How can OpenET data be used?
Reliable and widely available ET data at the field scale can be used to:

- Expand ET-based irrigation practices that maximize “crop per drop” and reduce costs for fertilizer and water.
- Develop more accurate water budgets and innovative management programs that ensure adequate supplies of water for agriculture, people and ecosystems.
- Support water trading programs that protect the financial viability of farms during droughts, while ensuring that water is also available for other beneficial uses.

OpenET is *not* intended to be a new irrigation scheduling tool. Our goal is to provide transparent, credible, and easily accessible ET data only. OpenET does not take the next steps of integrating that data with soil moisture, nutrient content, and other information critical for making decisions or recommendations about when to turn an irrigation system on or off. However, OpenET *will* make the ET estimates used by such tools much more cost-effective to retrieve, and in many cases more accurate.

Why can't farmers just use meters to track their water use?
OpenET is not intended to replace meters where they are desired or preferred. However, there are two reasons that OpenET may be a complementary and/or alternative source of information:

1. Meters are expensive, both to purchase and to maintain, and do not necessarily lead to more accurate estimates of water use. OpenET can provide a cost-effective alternative to meters for tracking *changes in water use over time* at a geographic scale that is not possible with solely on-the-ground approaches to measurement. In addition, OpenET can provide historic data as far back as 1984, which can be valuable in locations where meters have only been installed recently.
2. Meters measure the volume of water pumped or diverted, but they do not necessarily measure the amount of water actually lost to the local system. Some water that is pumped or diverted may re-enter the local water supply as runoff or groundwater recharge. Water managers and growers will often need both sources of data – applied water as measured by meters and estimates of ET – to best understand their water budgets over time.

Ensemble of Models

Why are you using multiple models to measure ET, rather than narrowing down to the "best" model?
OpenET will provide data from multiple models that are used to calculate ET and also provide a single ET value, or "ensemble value," from those models for each location. The models currently included are listed in the table at right. Each model has its own strengths and limitations for different geographies, crops, and conditions.

Some models were developed for global monitoring applications and others focus on local-scale irrigation management. Several models leverage gridded meteorological reference ET data for time integration between Landsat satellite overpass dates, and other models utilize coarser resolution data from geostationary satellites.

Currently, a key challenge for practitioners in working with ET data is that there are multiple methods and sources of information, leading to confusion about the "correct" number. By working with an ensemble of ET models, the OpenET team can identify consistent biases within different models and work to explain and resolve those differences. We will include many models in an intercomparison study to determine which provide the highest accuracy for different crops, land cover types, regions, or seasons. We will use the results from the intercomparison study to calculate a single value from the ensemble of models, taking advantage of the strengths of each.

In some cases, the ensemble value might be drawn from a single model. In others, it might be a weighted average of just a few models or of the full suite of models. Most importantly, it will represent a single value from the ensemble that is endorsed by many of the leading national experts in remote sensing of ET.

Another advantage of using an ensemble of models is that, in most cases, we expect to see a range of ET values across the ensemble. This can provide a useful measure of uncertainty or measurement error of the remotely sensed ET data in regions where no ground-based measurements exist. In addition, the range across the ensemble can allow OpenET users to evaluate estimates of ET data against the range of values from OpenET.

Initial Ensemble of ET Models

Acronym	Name	Primary References
ALEXI/ DisALEXI	**A**tmosphere-**L**and **Ex**change **I**nverse model/ALEXI **dis**aggregation	Anderson et al., 2007; Anderson et al., 2018
METRIC	**M**apping **E**vapo**t**ranspiration at high **R**esolution with **I**nternalized **C**alibration model	Allen et al., 2005; Allen et al., 2007
PT-JPL	**P**riestley-**T**aylor **J**et **P**ropulsion **L**aboratory	Fisher et al., 2008
SEBAL	**S**urface **E**nergy **B**alance **A**lgorithm for **L**and	Bastiaanssen et al., 1998
SIMS	**S**atellite **I**rrigation **M**anagement **S**upport	Melton et al., 2012; Pereira et al., 2020
SSEBOP	**Op**erational **S**implified **S**urface **E**nergy **B**alance	Senay et al., 2014; Senay et al., 2018

How is the ensemble value generated?
At present, the ensemble value is calculated as the average of all models. This approach is likely to change once the intercomparison study is complete.

How do I know when it is better to use the ensemble value versus choosing one model?
We encourage you to use your own discretion and knowledge in accessing and applying this data. However, the OpenET team is undertaking two efforts to provide additional guidance when desired:

1. We will be developing a best practices manual, based in large part on the intercomparison and validation effort, to help answer this question.
2. The calculation of the ensemble value may also vary across different geographies and landscapes based on the team's best understanding of how to reduce the range of results down to what is likely to be the most accurate number.

What limitations should I keep in mind about the models and the ensemble?
It is important to keep in mind that the data from OpenET do not represent a direct measurement of ET but rather an estimate, or calculation, of ET based on the measurement of other variables in the environment. Our goal is to be as transparent as possible about the quality of satellite images and other data sets, methodologies, and equations used in the calculations. The results from the intercomparison study will be used to inform the overall accuracy for the data from OpenET.

Satellite-based Measurements

How do satellites provide data about water on the ground?
The majority of the models included in the OpenET platform are based on the energy balance approach. This approach relies on satellite measurements of spectral reflectance (the amount of light energy reflected off the land surface measured in specific wavelengths) and surface temperature combined with ground-based measurements of other key variables that govern the surface energy exchange. The only component of the surface energy balance that is not directly or indirectly measured by satellites and weather stations is ET, leaving it as the "residual" variable to solve for by applying a model or algorithm such as the ones available through the OpenET platform. For a brief overview of how the approach works, please see this NASA video: https://youtu.be/c6OmfYEgzA0.

The discrepancy between the various energy balance approaches primarily relates to different methods for correcting for atmospheric instability, interpolation between satellite images, and pre-processing of satellite and meteorological inputs to the models. A key strength of satellite-driven energy balance approaches is that they provide a measurement of actual ET from each field and have been shown to be almost as accurate as ground-based measurements in many studies. One key limitation for many of these models is that, traditionally, they have typically required supervised operation and calibration by an expert to achieve maximum accuracy. The OpenET team is currently working hard to overcome this limitation and fully automate these approaches.

SIMS, or the Satellite Irrigation Management Support system, relies instead on a reflectance-based approach. SIMS converts the normalized difference vegetation index (NDVI), a satellite-based measure of the density and health of vegetation, to crop fractional cover, the fraction of the ground that is covered by vegetation. It then combines this with estimated canopy height and a stomatal control factor (to account for physiological differences between crops) to calculate a crop coefficient for every 0.22-acre pixel in each satellite scene. Combining crop-coefficient data with California Irrigation Management Information System (CIMIS) data (or other ground-based estimates of reference ET) facilitates daily estimation of actual ET following approaches recommended by the Food and Agriculture Organization of the United Nations (FAO). Strengths of this approach include estimation of irrigation requirements under well-watered conditions, full automation, and the ability to integrate data from multiple satellites to increase the number of available observations. Limitations include underestimation of soil evaporation and a limited ability to detect short-term or intermittent deficit irrigation or stressed rainfed crop conditions.

How many satellites are involved in providing the data?
OpenET builds upon decades of investment by NASA, USGS, the National Oceanic and Atmospheric Administration (NOAA) and the European Space Agency (ESA) to develop, launch, and operate a constellation of Earth-observing satellites, and to establish the ground data systems required to capture, process, store, and distribute satellite data. All of the models in the initial OpenET ensemble leverage data from Landsat satellites to produce field-scale ET estimates, which is the primary satellite dataset used by the OpenET platform. However, multiple models implemented within the OpenET framework also integrate data from other satellites, including GOES, Sentinel-2, Suomi NPP, Terra, and Aqua, to produce ET data at a range of spatial and temporal scales.

Will you validate the data from satellites? How?
The OpenET team is currently initiating one of the largest intercomparison and accuracy assessments of ET models conducted to date. We are comparing the satellite-derived ET data against three ground-based approaches that quantify ET, or track changes in consumptive water use over time, including:

1. ET measurements collected by flux tower stations throughout the continental U.S.
2. Groundwater pumping records.
3. Water balances at the watershed scale.

The primary dataset for the intercomparison has been collected from a network of flux towers that use eddy covariance methods to measure the exchanges of carbon dioxide, water vapor, and energy between the land surface terrestrial ecosystems and the atmosphere. These tower stations are critical because they provide ground measurements of ET for comparison against a very specific set of locations with known land use types and characteristics. These estimates are derived directly from micrometeorological measurements used to calculate water and energy fluxes from the land surface. The ground measurements used in the OpenET analysis are from more than 120 flux tower sites across the U.S., including Ameriflux sites and additional locations within agricultural fields from collaborators at USDA, USGS, University of California Cooperative Extension, and other university partners. We have developed an extensive, automated screening process to identify any outliers or gaps in the instrument measurement record, and we have reviewed the sites using aerial imagery as well as wind speed and direction data from the towers to ensure that the location is representative of the surrounding field or land cover type.

Comparisons against groundwater pumping records also provide an additional check on the satellite-based ET data for more agricultural fields than can be covered with eddy covariance station measurements alone. This analysis can offer insight into differences between the volume of water that is pumped for irrigation and the consumptive use of water through ET.

Finally, contrasting satellite measurements against watershed-scale water balances is a useful tool to test the hypothesis that random errors will cancel one another out and model agreement across the ensemble will improve when data is aggregated over larger areas. Although watershed-scale water balances can have higher uncertainty than some of our other comparison approaches, they are useful additional data points to include in the broader intercomparison effort.

While this validation effort is an important step for OpenET because the models are being applied across a broader set of geographies and land cover types than ever before, it is worth noting that the individual models have been previously validated in more narrowly defined contexts.

Funding

How is OpenET being funded?
Development of the OpenET platform is supported by the S.D. Bechtel, Jr. Foundation, the Gordon and Betty Moore Foundation, the Walton Family Foundation, the Water Funder Initiative, the Windward Fund, the North, Central, and South Delta Water Agencies, and the NASA Applied Sciences Program. In-kind support is provided by partners in the agricultural and water management communities, Google Earth Engine, and the Water Funder Initiative. OpenET will need to secure additional funding to cover the transition of OpenET to its long-term home and to allow the team sufficient time to test funding models, licensing contracts, and other aspects critical to supporting the platform long term.

Why does OpenET need ongoing funding and support once the platform has been built?
One goal of OpenET is to continually provide the best available science-based estimates of ET. This requires a team of researchers and programmers to update the code as the science and underlying input data improves and as cloud computing and the Google Earth Engine platform evolve. We also expect ongoing computing and data charges and administrative and management needs associated with initiating and maintaining contracts and coordinating efforts between OpenET's scientific community and its users. OpenET also anticipates the need to provide user support and the development of training resources for the OpenET user community.

Who owns OpenET?
Currently, OpenET is "owned" by the project's fiscal sponsor, the Windward Fund. We are in the process of scoping a transition plan for OpenET, to be implemented in 2021 or 2022.

Western States Water Council

Water Data Exchange (WaDE) Program

Spring 2020

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Ryan James: Data Analyst / Hydroinformatics Specialist, MSc

Background

The Water Data Exchange (WaDE) Program was launched in 2011 as a cooperative effort between the Western States Water Council (WSWC), representing the 18 Western states, the Western Governors' Association (WGA), the Department of Energy (DOE), and Western Federal Agency Support Team (WestFAST). The focus of WaDE is to enable the states to share important water data (water availability estimates, water use by sector, and water allocation data) with each other, federal agencies, and the public. It also seeks to improve the sharing of federal water datasets that support state water planning efforts. By fall of 2018, WaDE was providing streamlined access to a mix of water rights, regulatory overlay, aggregate water budget, and site-specific data for 16 separate states.

Since its launch, the overall financial assistance that WaDE has brought towards its member states is about $660,000 so far. Most of the WaDE funding has been through Environmental Information Exchange Network grants from the U.S. Environmental Protection Agency (EPA). Since 2018, WaDE has received more funding from the Water Foundation, the Mitchell Foundation, and recently the Moore Foundation under a contract with Duke University with the Internet of Water organization. Funding from these different groups has allowed the WSWC to sustain the WaDE program with its two full-time positions and fund its assistance contracts to our member states, hiring many interns, and an information technology (IT) contractor.

WaDE 2.0

In 2019, WaDE underwent a major update to its architecture, database, portal, and documentation. The WSWC hired Don't Panic Labs (DPL), an independent IT contractor based in Nebraska, to upgrade WaDE using the latest technology standards and a cloud-based system (Figure 1). The system provides industry-standard data access API protocols that support the diverse needs of users and applications to inform policy decisions and data analysis across the West. The new system is significantly increasing the WSWC staff's ability to monitor usage and update the database system. The WaDE 2.0 system also significantly reduces the amount of effort needed by the member states to participate, reducing the amount of needed maintenance on data sharing protocols required by the member states' own staff. WaDE 2.0 data and its metadata schema have been designed to address the data's interoperability needs related to sharing time series data according to the use standards set by the Consortium of Universities for the Advancement of Hydrologic Science, Inc. (CUAHSI). In addition, the new schema complies with the United States Geological Survey (USGS) data and metadata indexing needs to enable data queries based on the national hydrography dataset fabric.

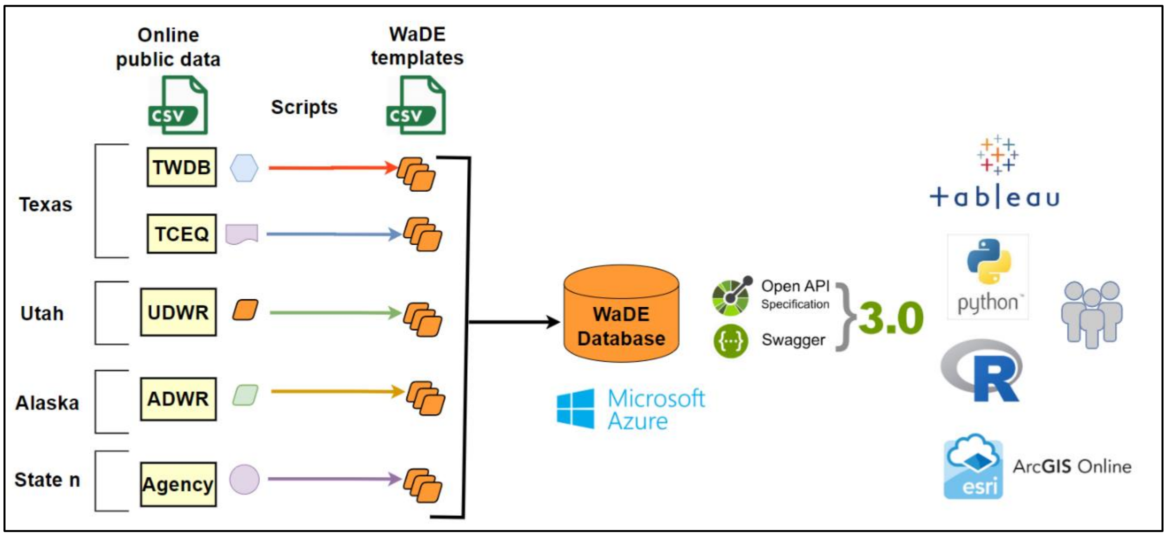

Figure 1: WaDE 2.0 system architecture including a cloud-hosted SQL database supporting the diverse data sharing protocols and structures by the member states.

As of January 2020, the WaDE 2.0 data system including its schema, the SQL Server database in Azure, the generalized data loader, and an Application Programming Interface (API) have been completed and deployed in a quality assurance stage. All schema, ongoing code development, and software deployment instructions are available through an online open-source at [https://github.com/WSWCWaterDataExchange/WaDE2.0.](https://github.com/WSWCWaterDataExchange/WaDE2.0) Along with the development of the WaDE 2.0 system, WaDE staff and interns have been working on connecting publicly available water rights and water use datasets as published by our member state agencies into the WaDE SQL Server database. So far, nine states have imported water rights data into the database, with efforts ongoing to connect four more states. Later in the Summer of 2020, we plan to connect the remaining member states (Figure 2- Left). WSWC has also imported aggregate (summary) water use data for five member states, with plans to import data for three more states this summer, and the last 10 states by the end of this year (Figure 2-Right). We also have plans to begin working on importing site-specific water diversions and use data for the member states either by the end of this year or early next year in 2021.

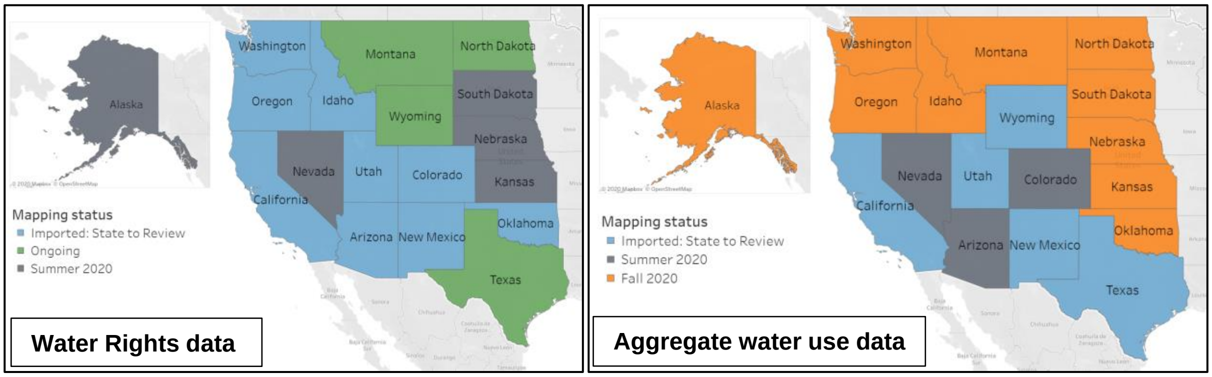

Figure 2: Progress of connecting WSWC member state agencies data into WaDE 2.0 system.

The WaDE team has also been working on developing a user-friendly portal to allow users from member states and the public to access, filter, and analyze water rights and water use data. We have been experimenting with different technical solutions to develop the portal to improve the user experience in querying water rights and water use data consistently within and across state boundaries. We plan to release a beta WaDE portal for water rights data by the end of the Summer 2020.

Outreach and Collaboration

Along with the active development of WaDE 2.0, the WSWC team has been collaborating with USGS, the Internet of Water, and the Consortium of Universities for the Advancement of Hydrologic Science, Inc. (CUAHSI). Below are two examples of our collaborative work.

The Water Management Information Systems (WIMS) / National Water Use Data Collaboration Workshop Report

In September 2019, the WSWC and USGS Water Use Mission Area staff co-hosted the Water Management Information Systems (WIMS) / USGS National Water Use Data Collaboration Workshop in Fort Collins Colorado. The workshop was held at the USGS Science Center in Fort Collins, Colorado. It focused on the status of water use data science, state agency strategies for getting high-quality water use information including online reporting, automated data checking, and remote-sensing tools. The WIMS and USGS workshop also served as a forum for states and other attendees to exchange information on highly specialized and important water data topics. Overall, fifty-four representatives attended the workshop from eighteen states, including five eastern states, as well as different federal agencies, universities, organizations, and the private sector. The workshop's thirty presentations and a summary report are available on the webpage http://www.westernstateswater.org/2019-wims/.

Coming to Terms: Internet of Water Collaboration

The WSWC has been collaborating with the Internet of Water team on their project "*Coming to Terms*." WSWC staff have been locating, scrapping definitions, synonyms, and homonyms of water-related terms use by public agencies. We have harvested and organized water glossary terms from 21 separate state agencies within 13 states. We are currently working to collect glossaries from two more states we plan to include by the end of summer 2020 (Figure 3). The Python code and documentation on harvesting each state's water glossary terms are available on GitHub at https://github.com/internetofwater/Glossary/tree/master/Vocabularies. Further information is available at their website at: https://internetofwater.org/resources/coming-to-terms/.

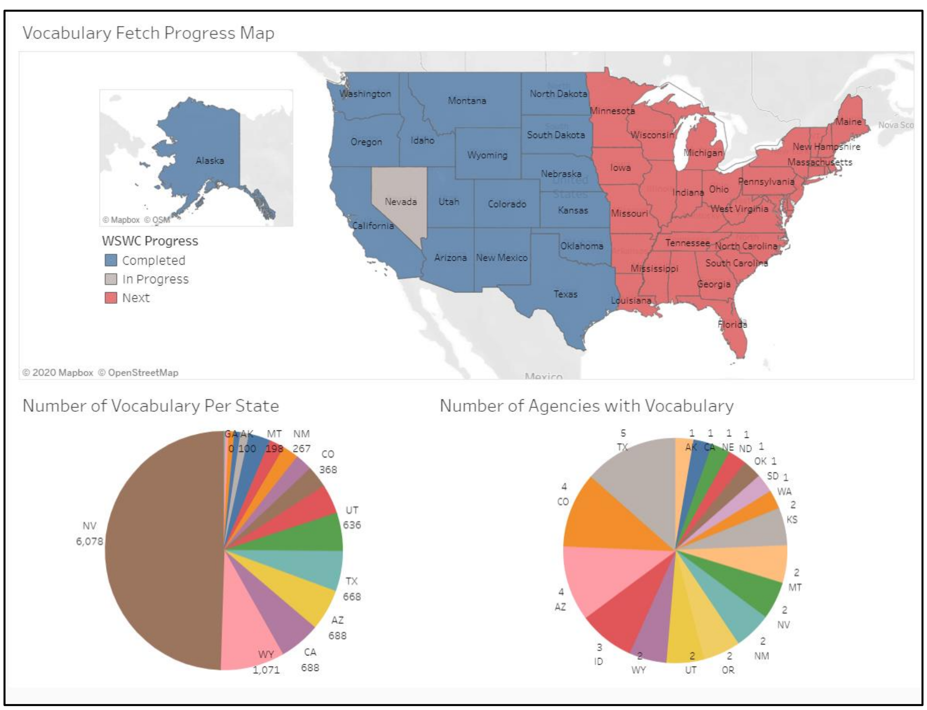

Figure 3: Progress of harvesting water glossary terms per WSWC member state agencies. The glossary terms are harvested from multiple agencies' websites within each state.