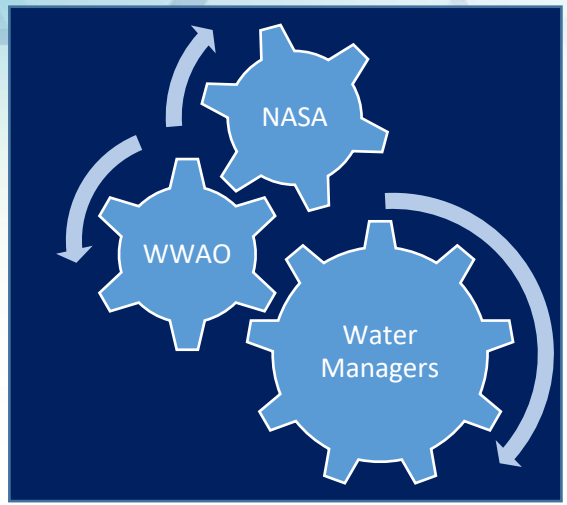
OPENET

Evapotranspiration Data for Water Management and Precision Agriculture

NASA · Google Earth Engine · EDF Environmental Defense Fund · DRI · USGS science for a changing world · USDA ARS

University of Idaho · Wisconsin University of Wisconsin-Madison · University of Maryland · University of Nebraska Lincoln · California State University Monterey Bay · HabitatSeven · UFRGS Universidade Federal do Rio Grande do Sul

NASA Applied Sciences Program: Western Water Applications Office (WWAO)



WWAO's Mission

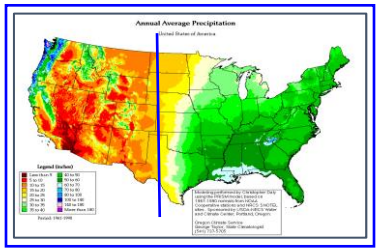
- **Improve how water is managed by applying NASA data, technology, tools in partnership with water managers and decision makers in the western U.S.**

WWAO does this by:

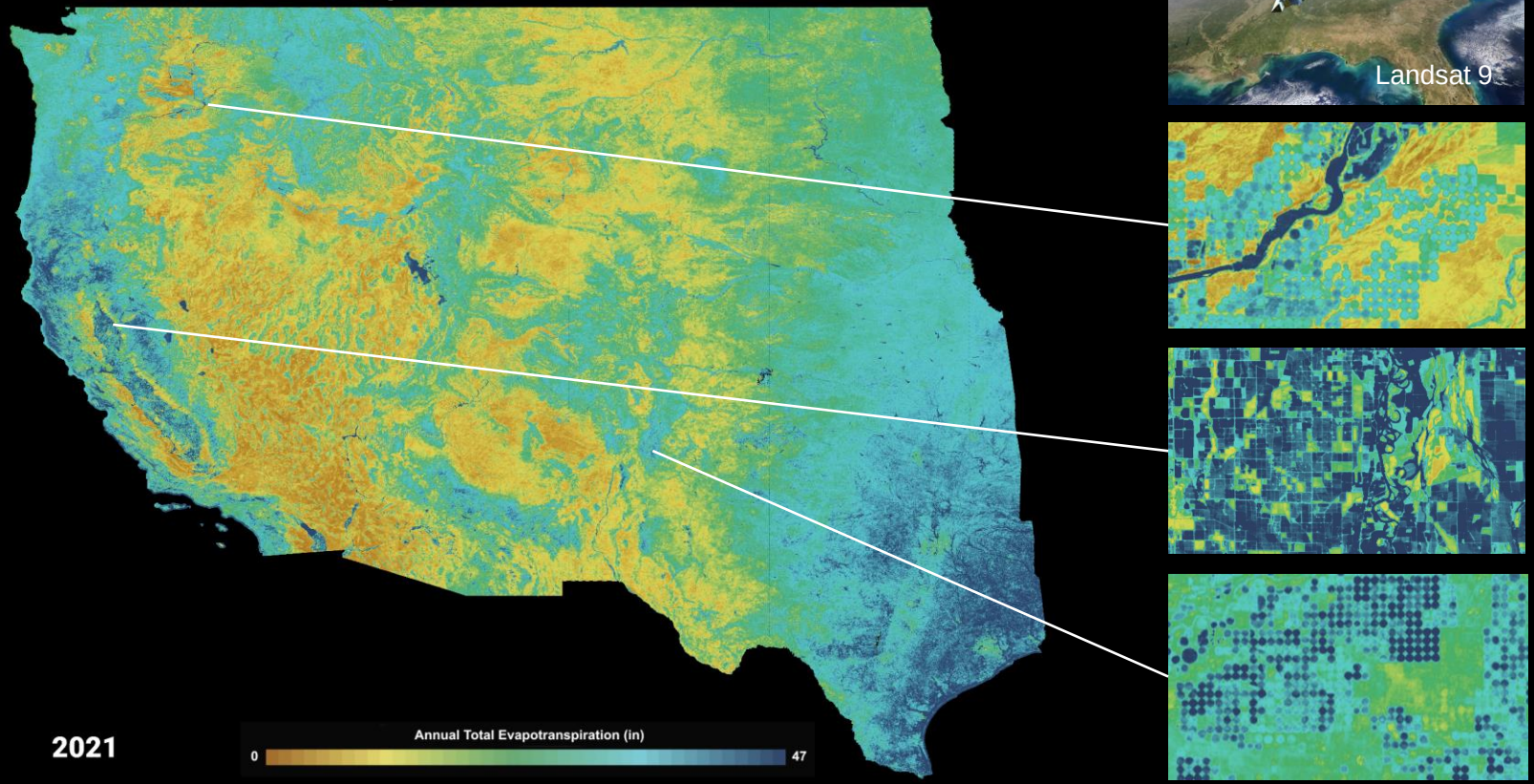
- **Identifying needs in western water management** for information and decision support
- **Making connections between stakeholders and NASA** scientists, technology, tools, and data
- **Supporting projects tailored to meet those needs**, engaging with partners from beginning to end
- **Transition of water applications** and technology into an operational, sustainable state for long-term impact

Why WWAO?

- NASA's science, remote-sensing data and expertise can bring a unique set of capabilities to address water management challenges
- Remote-sensing data can help fill critical data gaps in the West
- WWAO leverages decades of investment in science and technology, as well as deep relationships with partners and stakeholders



OpenET: Field-scale Evapotranspiration Data for Water Resources Management



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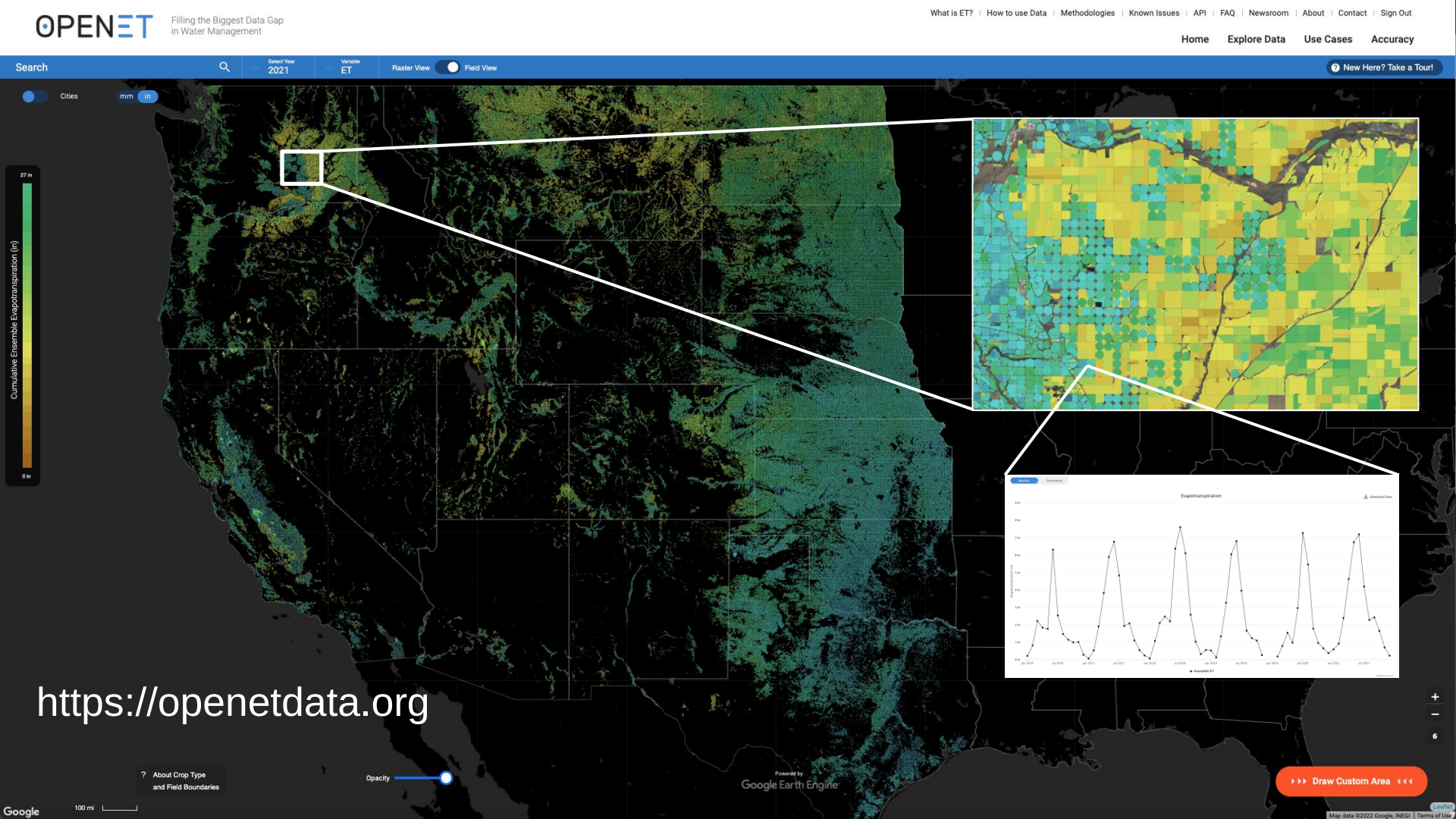
OpenETdata.org; Melton et al. (2021)
https://doi.org/10.1111/1752-1688.12956


OPENET
Filling the Biggest Data Gap in Water Management
What is ET? | How to use Data | Methodologies | Known Issues | API | FAQ | Newsroom | About | Contact | Sign Out
Home
Explore Data
Use Cases
Accuracy
Search
Select Year
2021
Variable
ET
Raster View
Field View
New Here? Take a Tour!
Cities
mm
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Cumulative Ensemble Evapotranspiration (in)
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Evapotranspiration
https://openetdata.org
About Crop Type and Field Boundaries
Opacity
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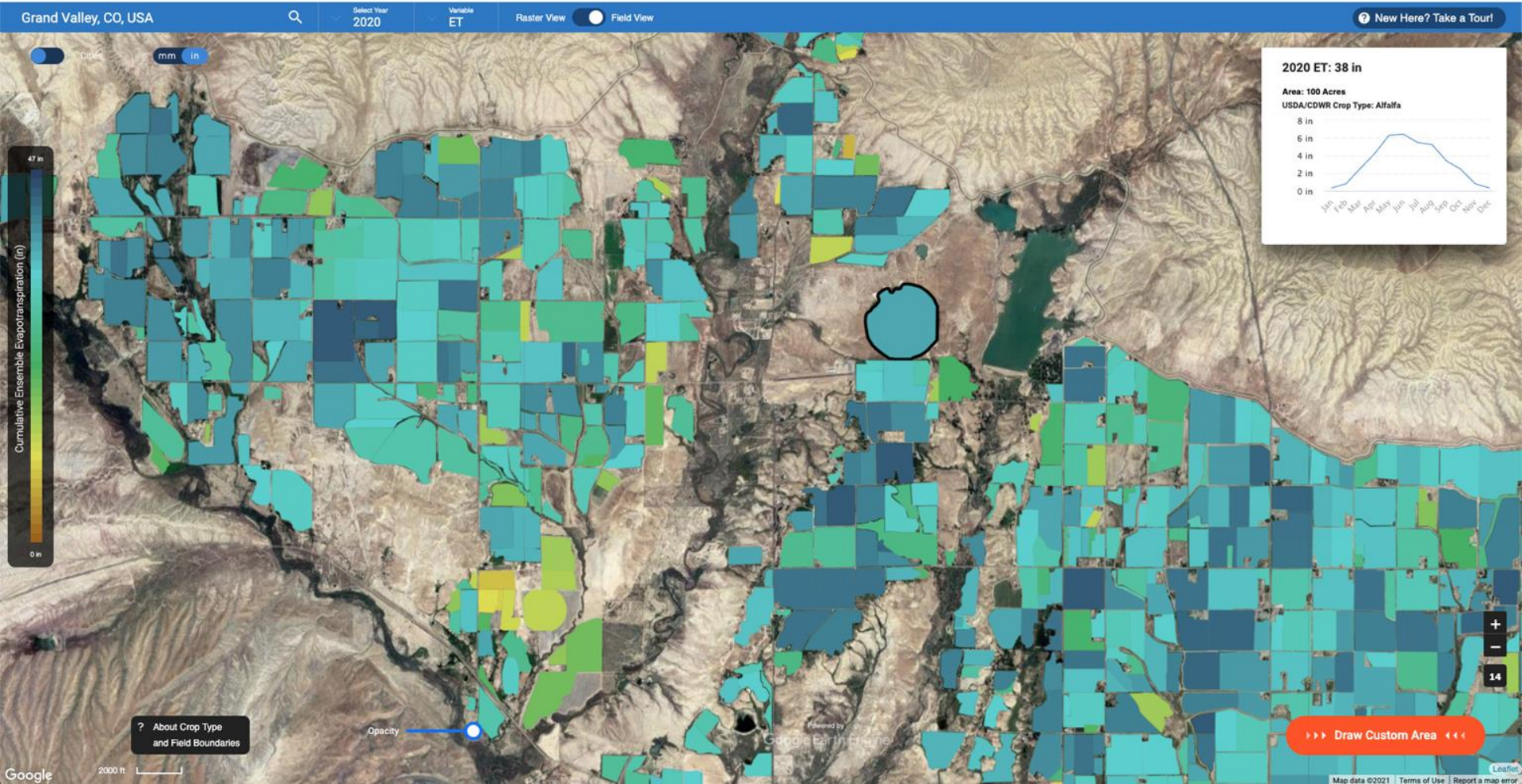
Grand Valley, CO, USA
Select Year
2020
Variable
ET
Raster View
Field View
New Here? Take a Tour!
Cities
mm
in
47 in
Cumulative Ensemble Evapotranspiration (in)
0 in
2020 ET: 38 in
Area: 100 Acres
USDA/CDWR Crop Type: Alfalfa
8 in
6 in
4 in
2 in
0 in
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
About Crop Type and Field Boundaries
Opacity
Powered by Google Earth Engine
Draw Custom Area
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Google
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Map data ©2021
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Report a map error

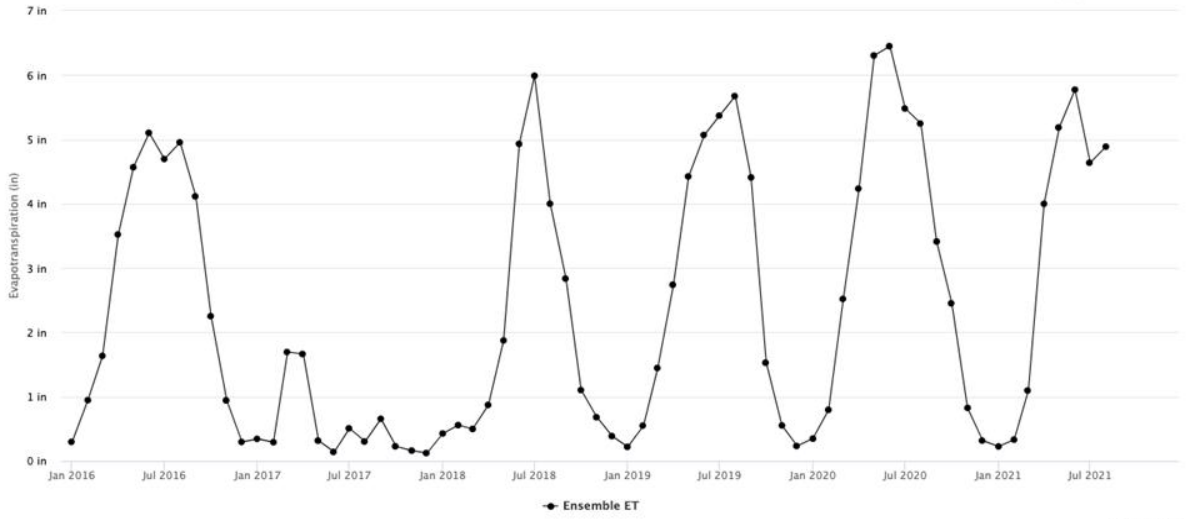
Grand Valley, CO, USA | Select Year 2020 | Variable ET | Raster View | Field View | New Here? Take a Tour!

USDA/CDWR Crop Type: Alfalfa | Area: 100 Acres | Field ID: 084171

Monthly | Cumulative

Evapotranspiration

Download Data



Data Options

ET

- Ensemble
- Range
- eeMETRIC
- SSEBop
- SIMS
- PT-JPL
- DisALEXI
- geeSEBAL

ET Fraction

Additional Variables

Cumulative Ensemble Evapotranspiration (in)

About Crop Type and Field Boundaries

Opacity

Draw Custom Area

Google

Grand Valley, CO, USA | Select Year 2020 | Variable ET | Raster View | Field View | New Here? Take a Tour!

mm | in

USDA/CDWR Crop Type: Alfalfa | Area: 100 Acres | Field ID: 084171

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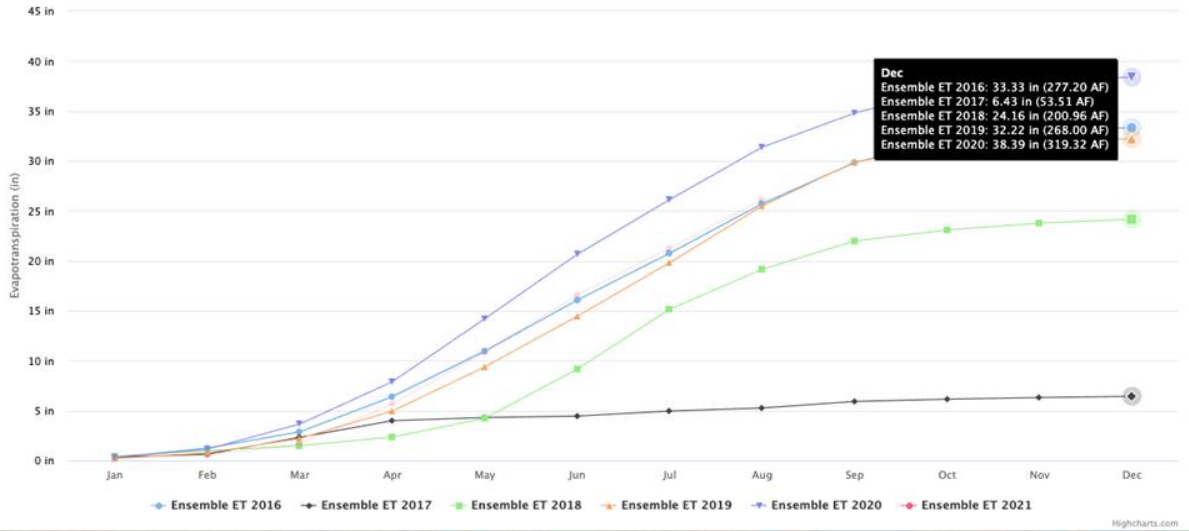
Cumulative Ensemble Evapotranspiration

Download Data



Data Options

ET

- (•) Ensemble
- ( ) eeMETRIC
- ( ) SSEBop
- ( ) SIMS
- ( ) PT-JPL
- ( ) DisALEXI
- ( ) geeSEBAL

Additional Variables

Cumulative Ensemble Evapotranspiration (in)

? About Crop Type and Field Boundaries

Opacity

Draw Custom Area

Google

Founded on Open Science

DRI, NASA Ames, Habitat Seven (Multimodel Development, Integration, API, UI) Forrest Melton, Justin Huntington Charles Morton, Will Carrara, Britta Daudert, Alberto Guzman, Jordan Harding, Matt Bromley, Jamie Herring

USDA, NASA Marshall Space Flight Center, U. Maryland, U. Wisconsin (ALEXI/DisALEXI) Martha Anderson, Yun Yang, Christopher Hain

U. of Nebraska, U. of Idaho, DRI (EE METRIC) Ayse Kilic, Rick Allen, Peter Revelle, Samuel Ortega

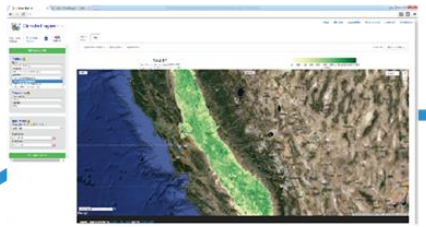
NASA JPL (PT JPL) Josh Fisher, Gregory Halverson

NASA Ames, CSUMB, Stanford University (SIMS) Forrest Melton, Alberto Guzman, Lee Johnson, Will Carrara, Conor Doherty, Ryan Solymar

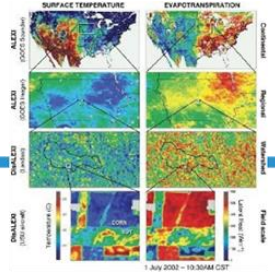
USGS (SSEBop) Gabriel Senay, MacKenzie Friedrichs, Gabe Parrish

Google Earth Engine

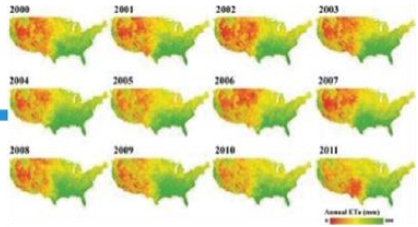
OpenET Uses Well-Established Methods



EE METRIC
University of Nebraska,
University of Idaho

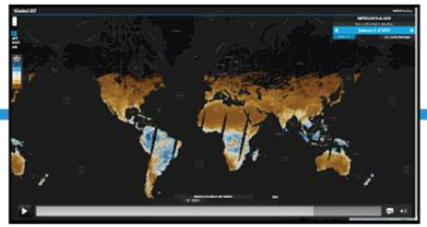


ALEXI/DisALEXI
USDA, NASA, University of Maryland,
University of Wisconsin

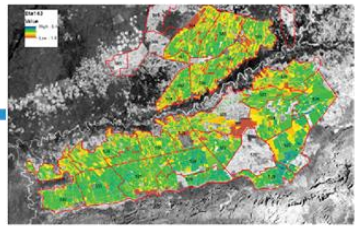


SSEBop
USGS

SIMS
NASA, CSUMB, Stanford University



PT-JPL
NASA



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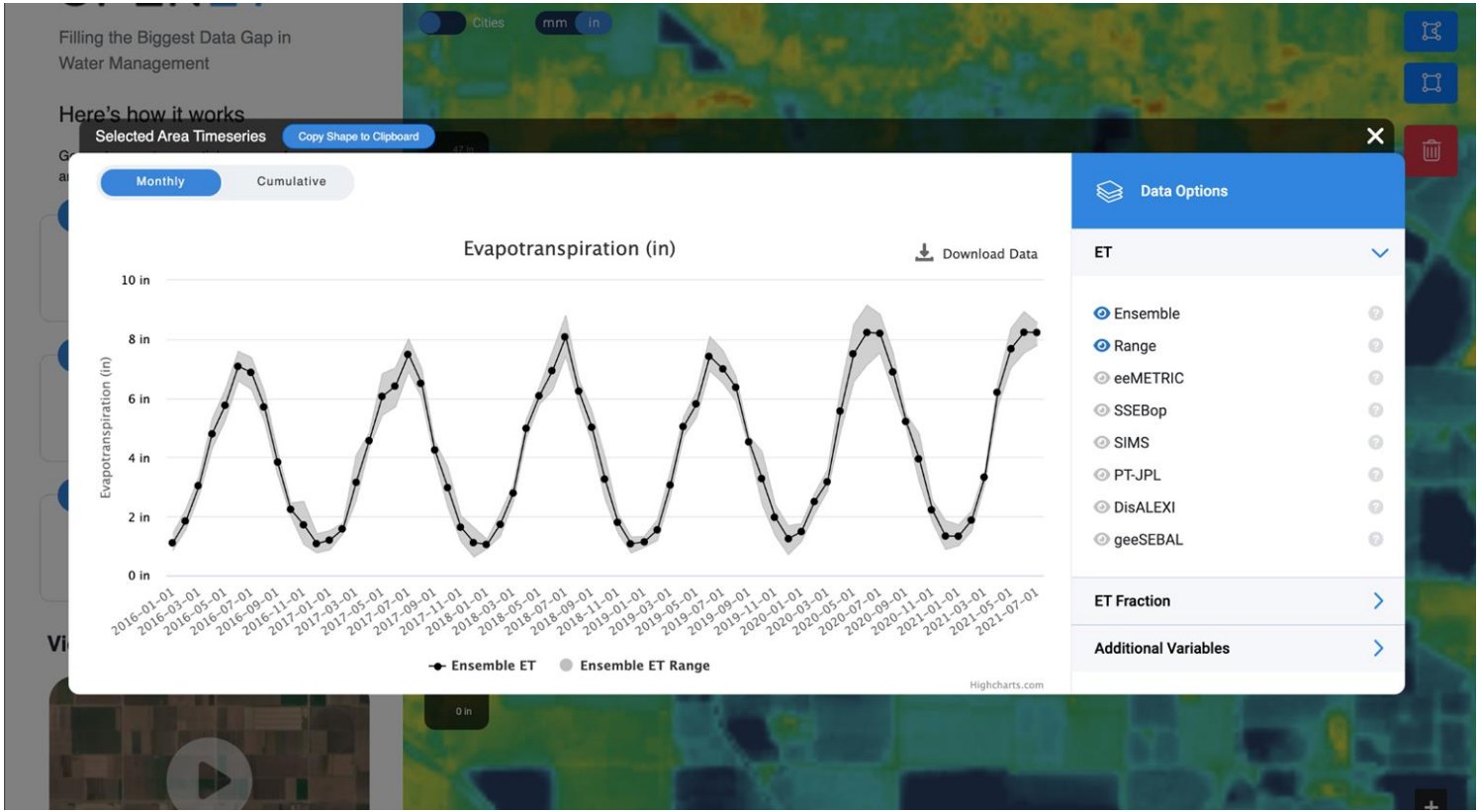
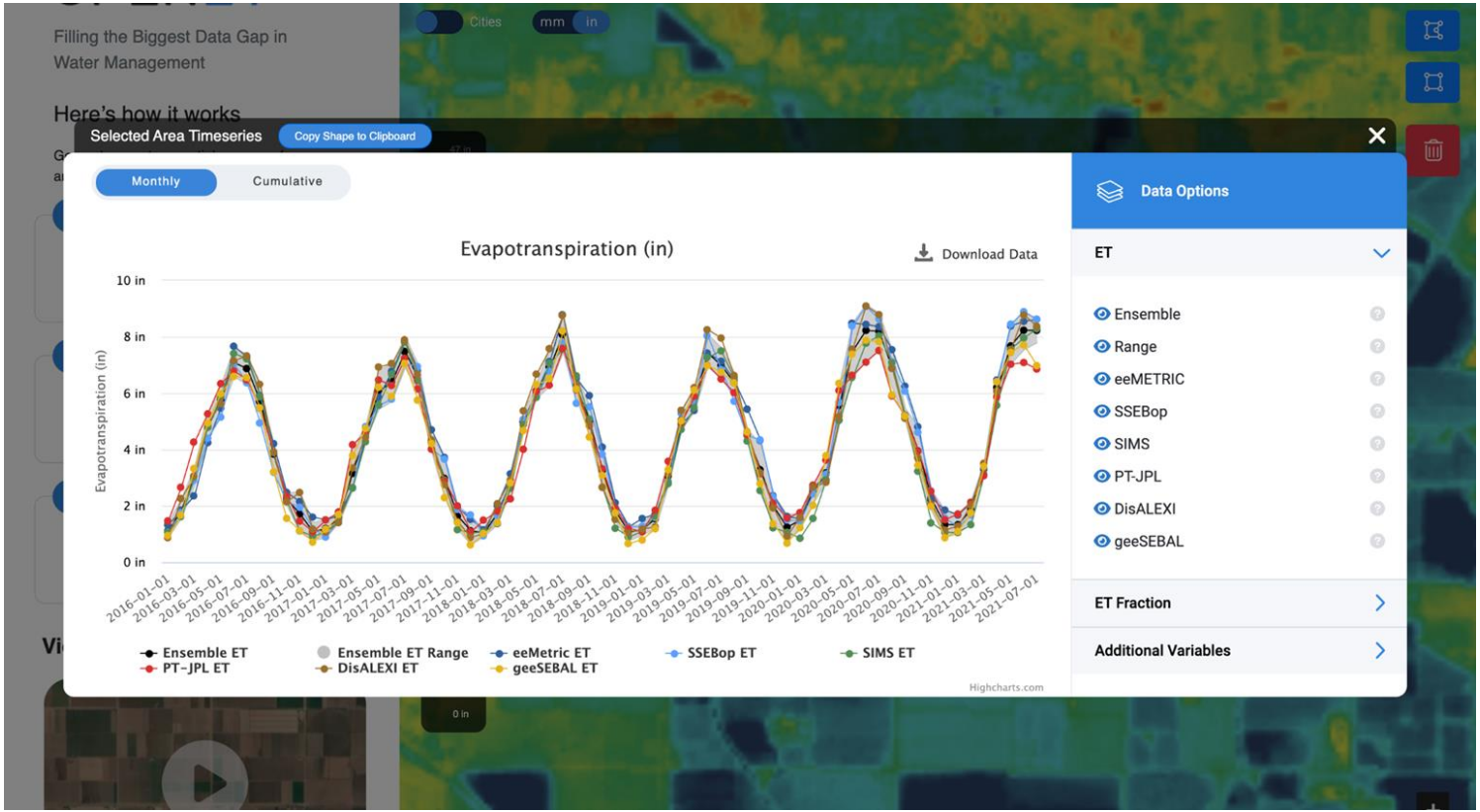
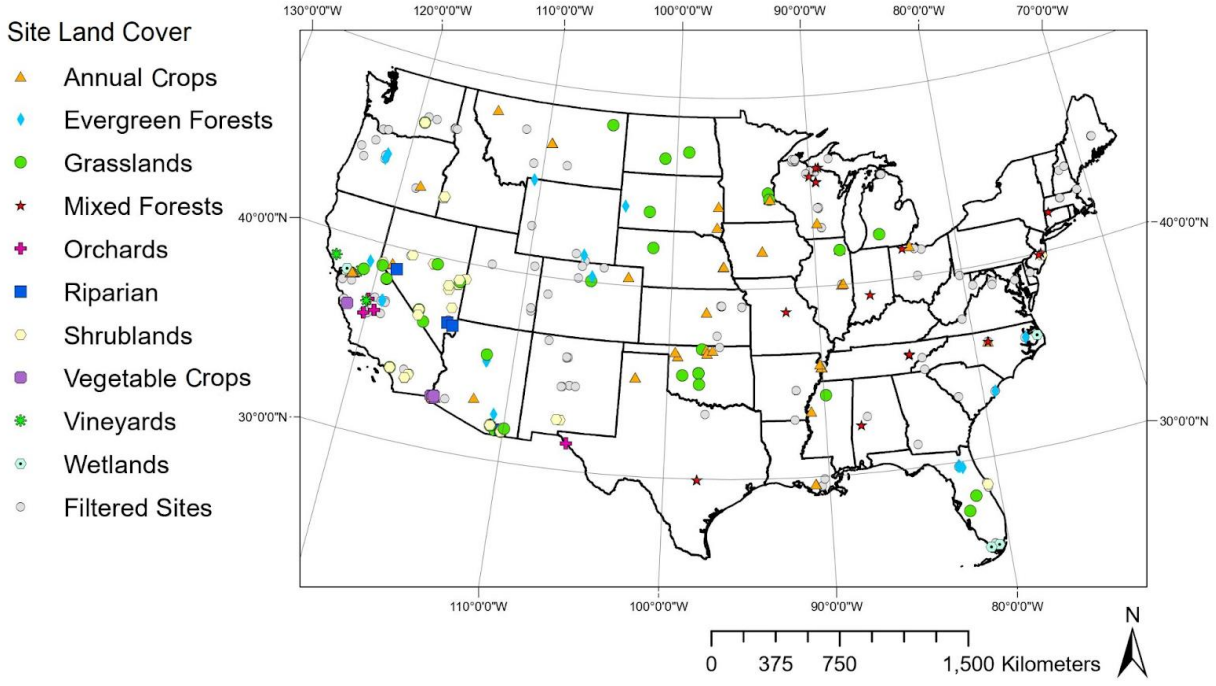
OpenET Ensemble Approach



OpenET Ensemble Approach



Intercomparison and Accuracy Assessment



- Phase I comparison complete (70 flux tower sites; 24 ag sites)
- Phase II comparison for 151 flux tower sites; 70 ag sites

Melton et al., JAWRA, 2022
Volk et al., 2023

OpenET Ensemble Value: Croplands

Accuracy Summary for Croplands for the OpenET Ensemble ET Value						
Time Period	**Slope**	**Mean Bias Error)**	**Mean Absolute Error**	**Root Mean Squared Error**	**r-squared**	**Mean flux tower ET**
Water Year: 14 sites / 48 total water years	0.93	-71.6 mm (-7.0%)	91.3 mm (8.9%)	100.5 mm (9.8%)	0.88	1024 mm
Growing Season: 38 sites / 151 growing seasons	1.0	-10.1 mm (-1.7%)	80.3 mm (13.2%)	92.7 mm (15.2%)	0.88	609.5 mm
Monthly: 45 sites / 1,682 months	0.95	-3.6 mm (-3.9%)	15.6 mm (16.6%)	20.0 mm (21.3%)	0.91	93.7 mm
Daily: 49 sites / 4,804 days	0.88	-0.3 mm (-7.4%)	0.8 mm (22.8%)	1. 1 mm (29.7%)	0.82	3.6 mm

Melton et al., JAWRA, 2022

Slope: Measure of overall bias; 1.0 is perfect
Mean Bias Error (MBE): Measure of bias; 0.0 is perfect
Mean Absolute Error (MAE): Measure of expected error; 0.0 is perfect
Root Mean Squared Error (RMSE): Measure of expect error with additional weight for outliers; 0.0 is perfect
r-squared: Measure of the ability of the model to reproduce observed variability; 1.0 is perfect

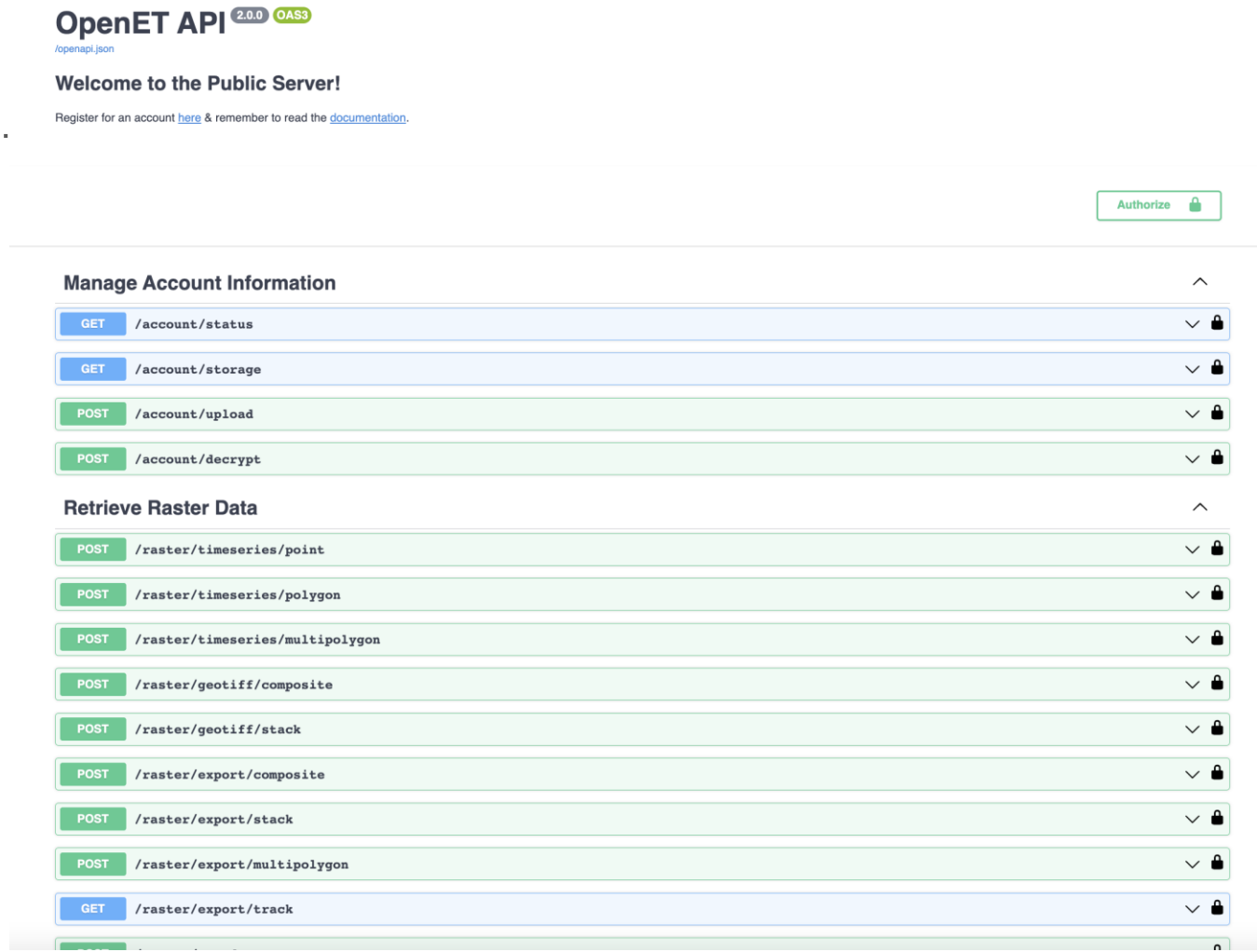
OpenET can help:

- Rural communities to design locally driven water conservation and trading programs.
- Water managers to develop more accurate water budgets, incentive programs and other innovative strategies.
- Policymakers to more accurately track water supplies, simplify regulatory compliance, and co-develop solutions with local communities.
- Farmers to expand use of data-driven irrigation practices to maximize “crop per drop” and reduce costs for fertilizer, water, and energy.

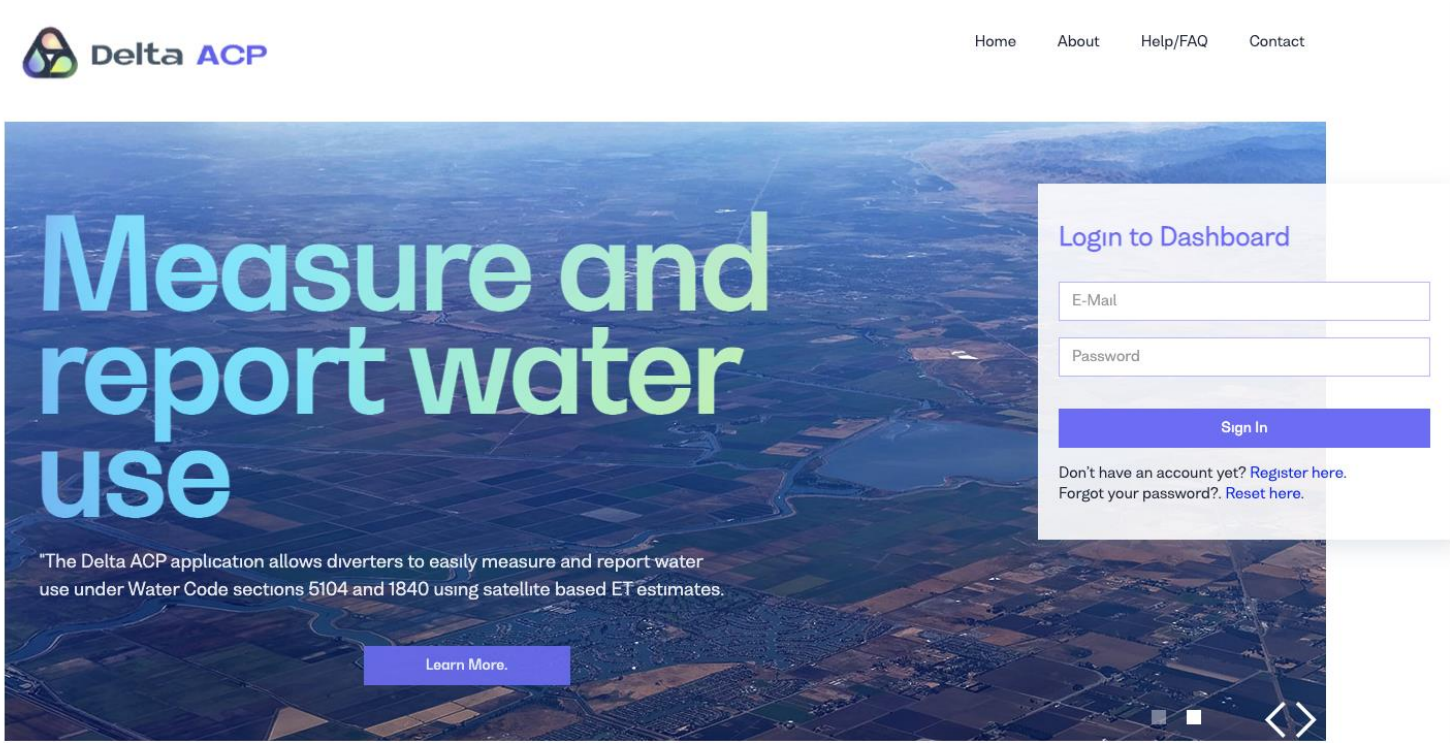
OpenET Use Cases

OpenET API

- Follows the OpenAPI standards
- Support for automated data retrieval
- Facilitates integration with other water data systems / water management applications



Streamlining Water Use Quantification and Reporting



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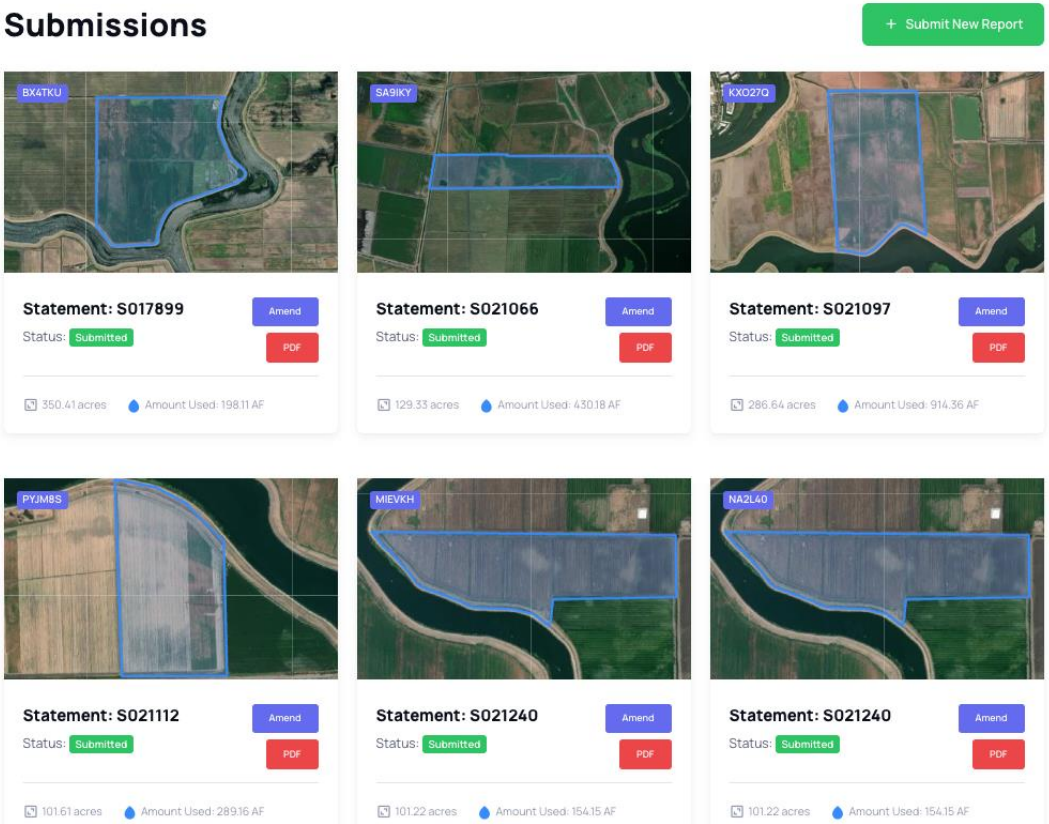

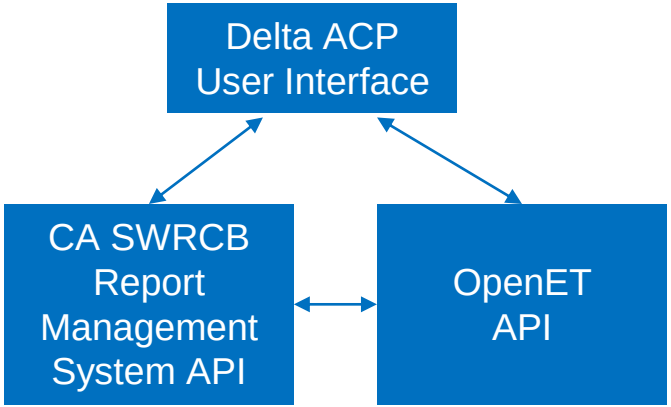

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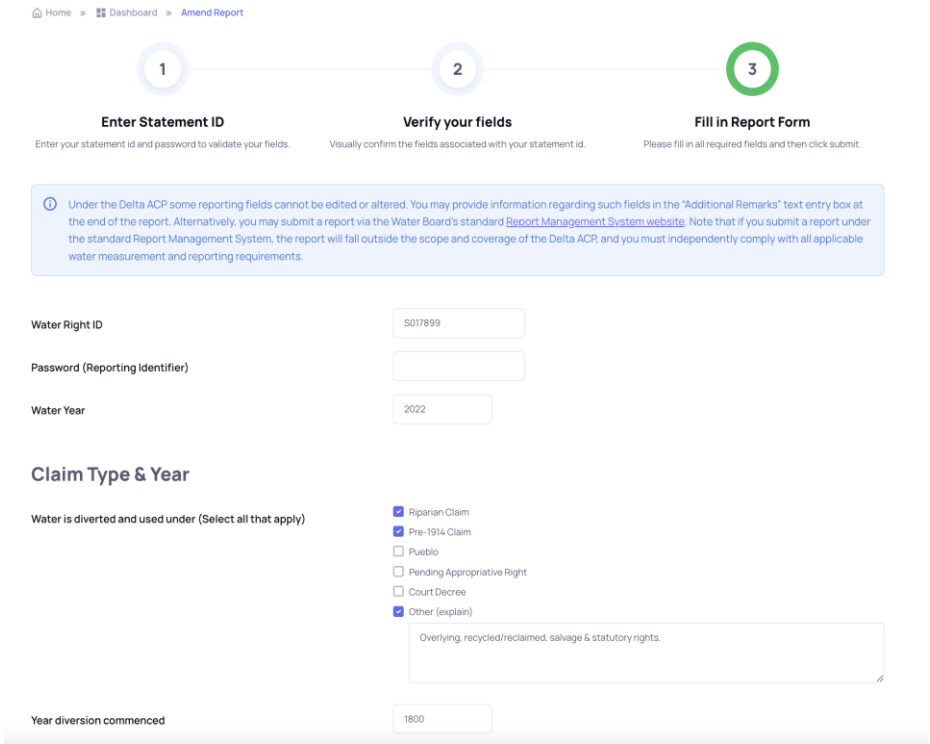

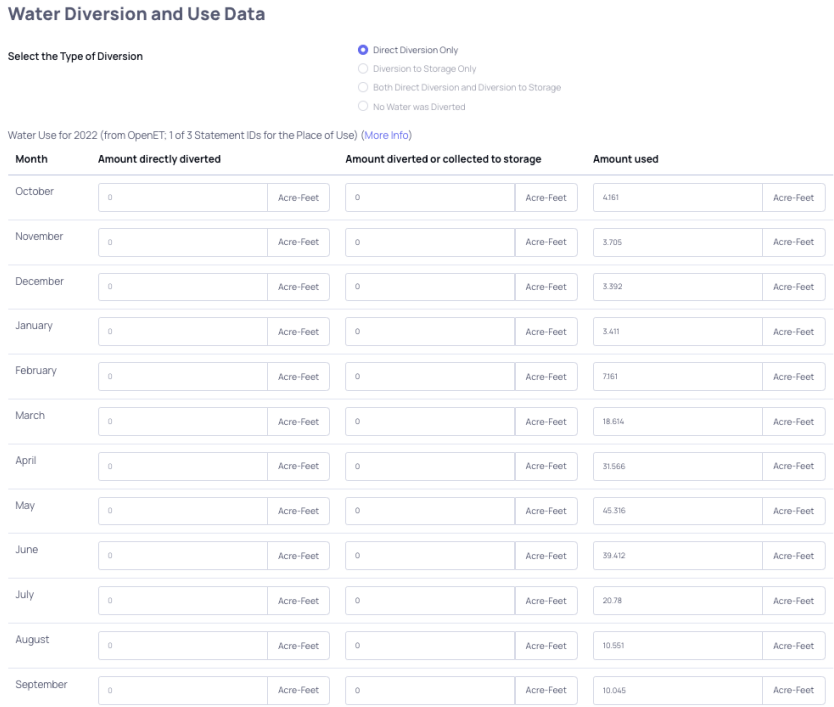

What’s next for OpenET?

- ✓ OpenET non-profit established
- ✓ Addition of OpenET Monthly Data to the Earth Engine Public Data Catalog
- ✓ Addition of daily data and integration with irrigation scheduling tools
- Public release of the OpenET API (Summer 2023)
- Completion of the custom reporting tools (Fall 2023)
- Best Practices Manual and updates to the ensemble ET value
- Automated calculation of effective precipitation and ET of applied water
- Historic data production and geographic expansion

OPENET


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USGS


EDF
ENVIRONMENTAL
DEFENSE FUND
Finding the ways that work


DRI


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MARYLAND


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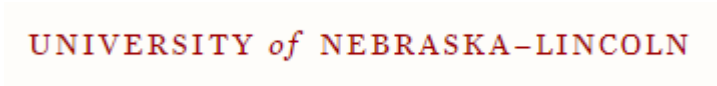
UNIVERSITY OF WISCONSIN-MADISON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DO RIO GRANDE DO SUL

Thank You!

OpenET gratefully acknowledges support from the Walton Family Foundation; the Gordon and Betty Moore Foundation; Lyda Hill Philanthropies; the S.D. Bechtel, Jr. Foundation; the Windward Fund; the Keith Campbell Foundation for the Environment; the North, Central, and South Delta Water Agencies; the NASA Applied Science Program and the NASA Western Water Applications Office; the USGS Landsat Science Team; and the California State University Agricultural Research Institute

Please visit https://openetdata.org for more information.

Questions?

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openetdata.org

wwao.jpl.nasa.gov

State Pilot Projects

- **California:** 1) Drought response and planning; 2) Production of 20+ year data archive; 3) Local and state agency support for implementation of the Sustainable Groundwater Management Act; 4) Water Use Reporting in the CA Delta; 5) CA Accuracy Assessment; 6) Ongoing data production and public data access

- **Utah:** 1) Intercomparison study and ensemble ET data refinement for Utah; 2) Calculation of effective precipitation and ET of applied water for Utah; 3) Production of 30+ year data archive; 4) Support for ongoing data production and public data access; 5) Comparison against crop coefficient methods; 6) Support for local and state agencies across a broad range of planning and water management applications

- **Oregon:** 1) Production of 30+ year data archive; 2) Support for additional accuracy assessments for the Pacific NW; 3) Support for calculation of data summaries for each HUC12

Federal Pilots Projects

- **USGS:** 1) Production of 20+ year archive of data for CONUS with SSEBop; 2) API enhancements and support for ongoing data updates and public data access; 3) SSEBop model evaluation and watershed-scale model intercomparisons; 4) Evaluation of CONUS404 data for calculation of ETo data for the U.S.

- **Reclamation:** 1) Production of 20+ year data archive for the Upper Colorado River Basin with the eeMETRIC model; 2) Production of data updates for the Upper Colorado River Basin in 2022 with the eeMETRIC model and additional accuracy assessments for eeMETRIC

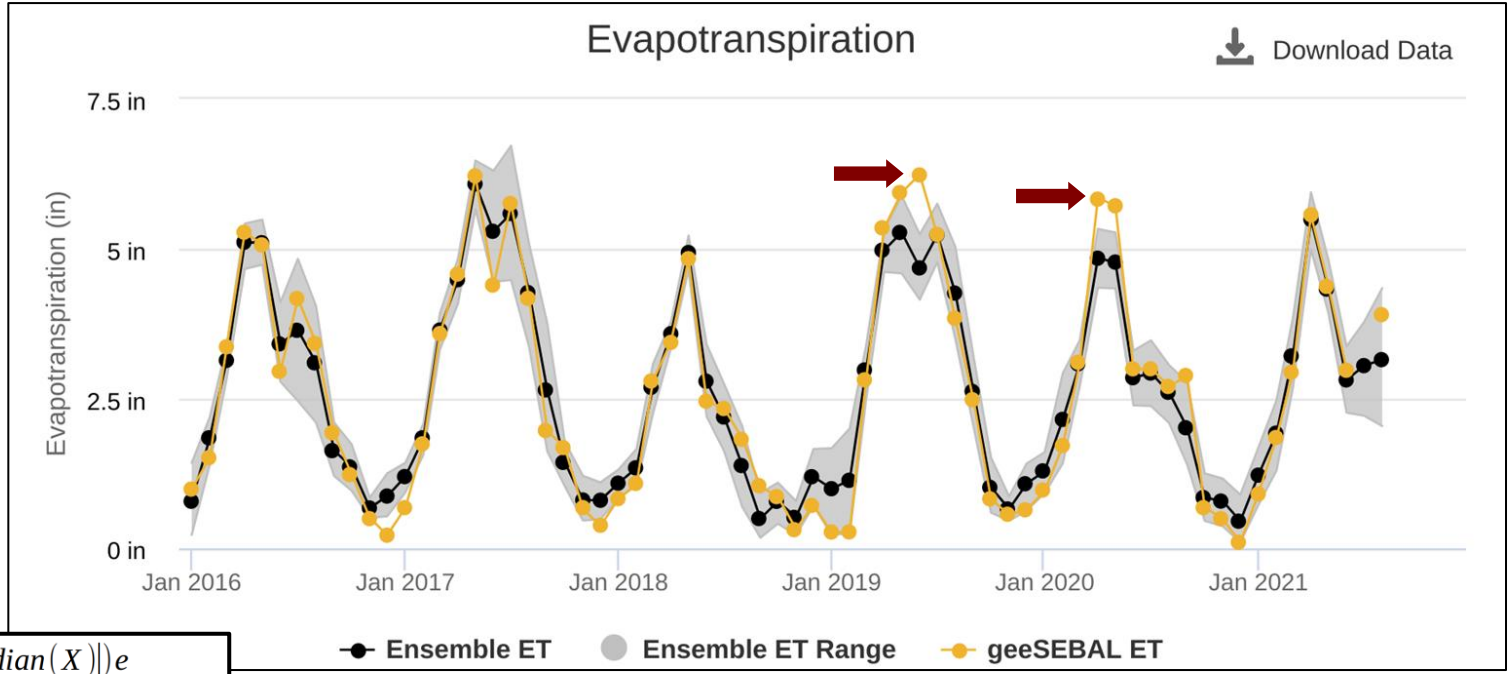
NASA Western Water Applications Office Supported Activities:

- **Reclamation:** Detailed model intercomparison study and explanation of model differences across the Upper Colorado River Basin

- **Columbia River Basin:** Production of HUC 12 data summaries for the Columbia River Basin; integration of HUC 12 summaries into state water data portals; and support for outreach and training workshops

- **Idaho Department of Water Resources:** Evaluation of OpenET data against Idaho Department of Water Resources METRIC ET data; deployment and collection of flux tower ET data in Magic Valley, Idaho

Model Ensemble: Median Absolute Deviation (MAD) Outlier Detection



$$MAD = 2 \cdot median(|X_i - median(X)|)e$$

Ensemble ET range:

$$median(X) + MAD > ET > median(X) - MAD$$

Average ET within range keeping at least 4 models.