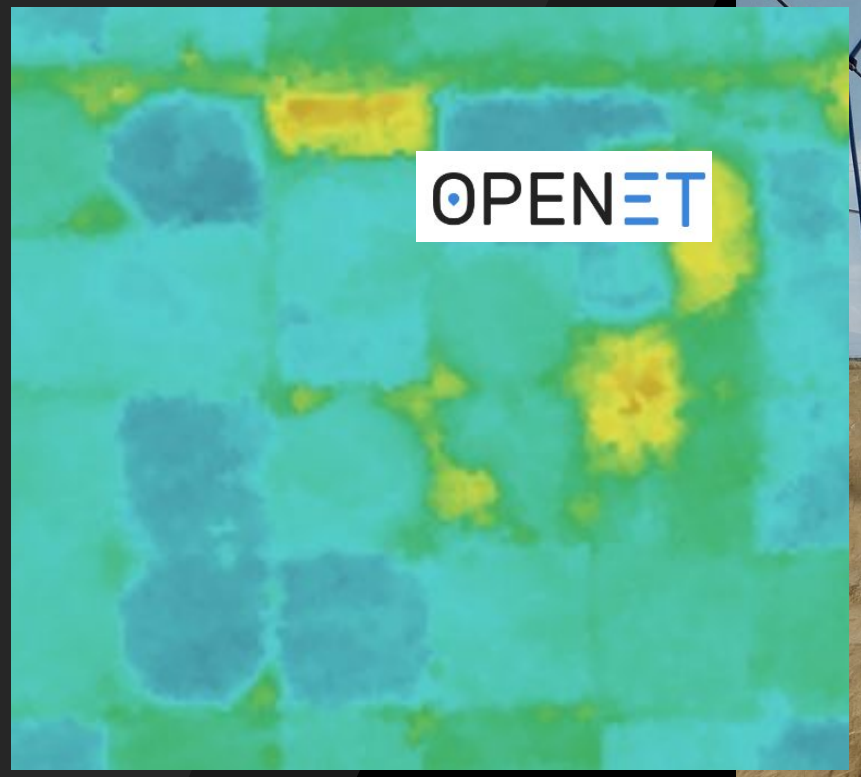
Satellite-based ET mapping for improved water and nutrient management in the Magic Valley



Erin Brooks
Jason Kelley
Dept Soil & Water Systems
University of Idaho

LESA Irrigation System at CAFE Research Dairy
Photo taken 8/3/2023

Project Team

Project title: Accuracy Assessment of Satellite-based ET mapping for improved water and nutrient management in the Magic Valley

Funded by WWAO-JPL in 2021

Field work 2022 & 2023

Project Completed 2024

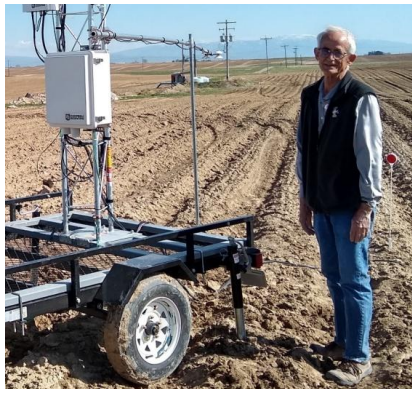
Dr. Erin Brooks

Dr. Chinmay Deval

Dr. Linda Schott

Arianna Hege

Dr. Jason Kelley



Clarence Robison

<u>Supporting Partners</u>

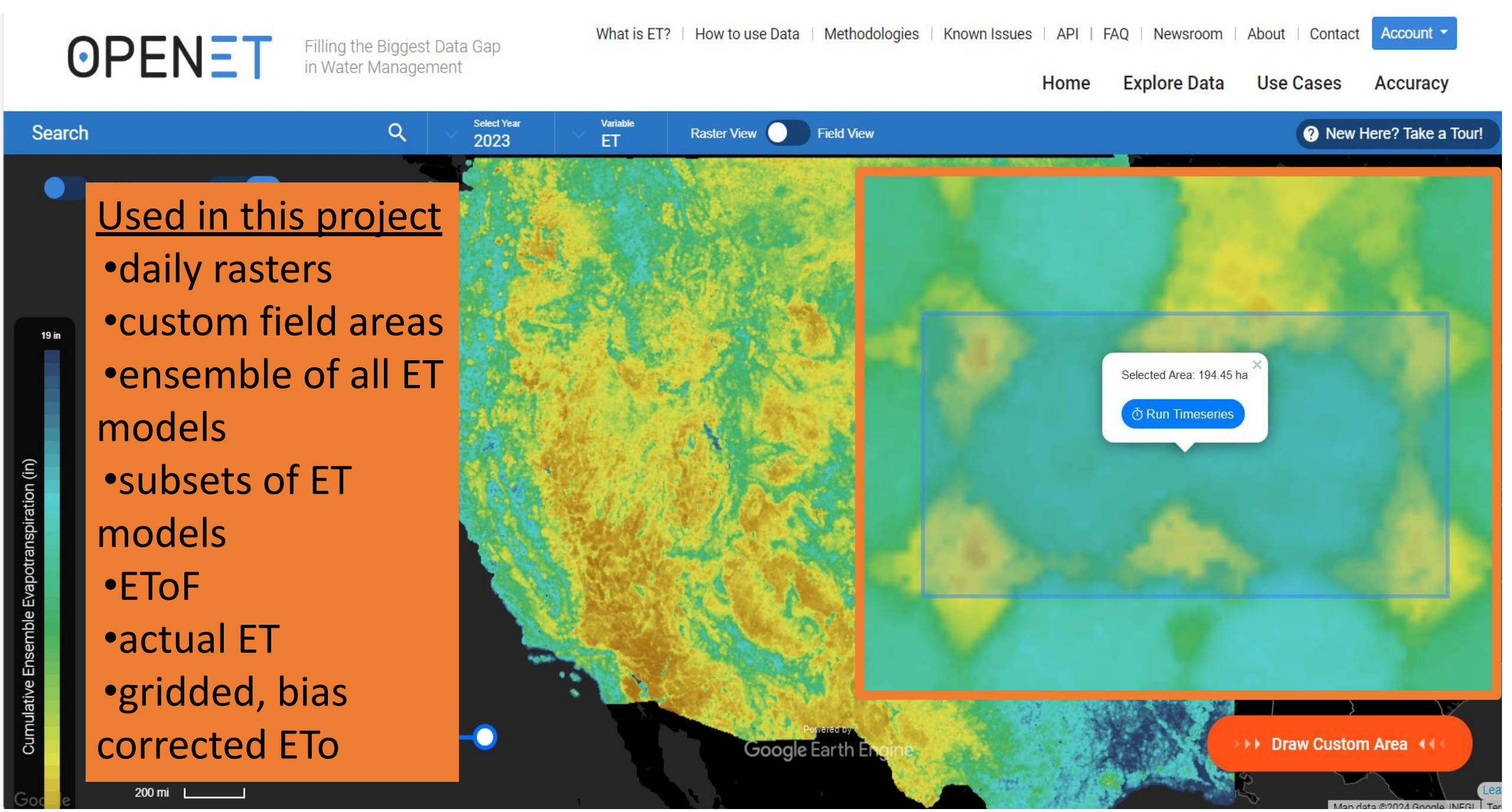
- **Dave Bjorneberg and Kossi Nouwakpo**, USDA-Agricultural Research Service (USDA-ARS), Northwest Irrigation and Soils Research Laboratory
- **Curtis F. Elke and Shawn Nield**, USDA-Natural Resources Conservation Service (NRCS)
- **Rick Naerebout**, Idaho Dairyman's Association (IDA)
- **Matt Weaver, Phil Blankenau, Bailey Liu**, Idaho Department of Water Resources (IDWR)

Stakeholder Identified Opportunities

- Regional Water Planning (groundwater models, reservoir storage)
- Water Rights Disputes (Legal finding-of-fact)
- Determining crop water requirements
- Assessing crop productivity and impacts of drought
- Prioritizing crop planting based in water limited years
- Guiding best practices in water, crop, and soil management

Project Goals

- Develop tools and assess NASA data products to refine information used in water and nutrient management in irrigated systems
- Assess water saving irrigation systems
- Assess the ability of satellite-based ET mapping approaches to quantify ET
- Use long-term ET maps to identify persistent patterns in consumptive water use


OPENET
Filling the Biggest Data Gap in Water Management
What is ET? | How to use Data | Methodologies | Known Issues | API | FAQ | Newsroom | About | Contact
Account
Home
Explore Data
Use Cases
Accuracy
Search
Select Year
2023
Variable
ET
Raster View
Field View
New Here? Take a Tour!
Used in this project
•daily rasters
•custom field areas
•ensemble of all ET models
•subsets of ET models
•EToF
•actual ET
•gridded, bias corrected ETo
19 in
Cumulative Ensemble Evapotranspiration (in)
200 mi
Selected Area: 194.45 ha
Run Timeseries
Powered by
Google Earth Engine
Draw Custom Area

OPENET

Filling the Biggest Data Gap in Water Management

Back to Data Explorer

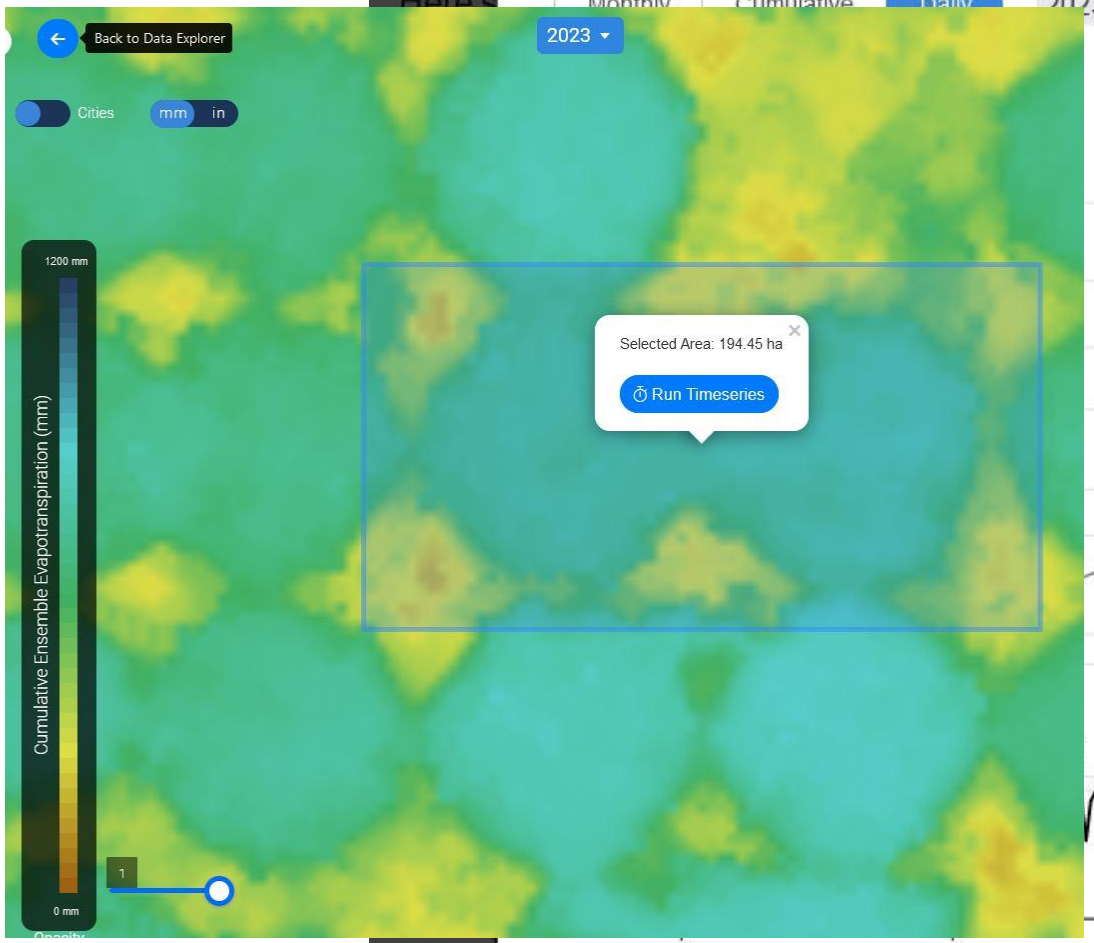
2023

Cities mm in

Selected Area Timeseries

Copy Shape to Clipboard

Monthly Cumulative Daily 2023



Daily Evapotranspiration in 2023 (mm)

Download Data

Jul 17 2023
Ensemble ET: 5.75
Ensemble ET Fraction: 0.80

1.25
1
0.75
0.5
0.25
0
ETo F, NDVI

Jan Mar May Jul Sep Nov

Ensemble ET Ensemble ET Fraction

Highcharts.com

IDAHO DEPARTMENT OF WATER RESOURCES

Water Rights ▾ Wells ▾ Streams/Dams/Floods ▾ Forms ▾ Water Data ▾ Maps/Spatial Data ▾ Legal ▾ Board ▾

About IDWR ▾

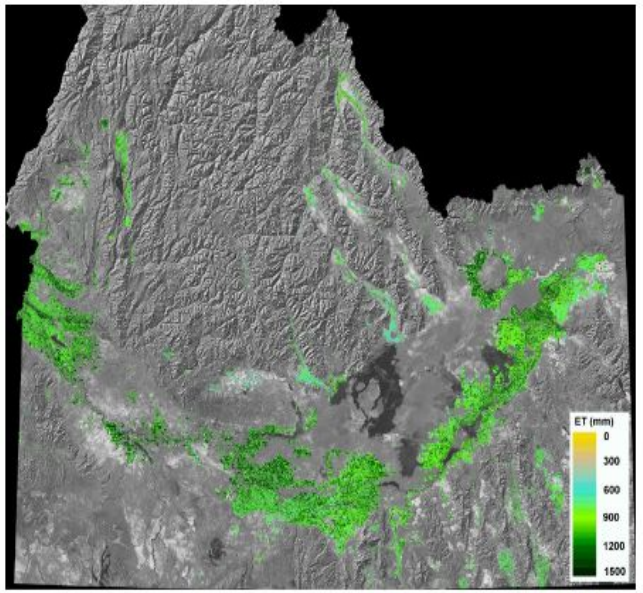
Home / Maps and Spatial Data / Mapping Evapotranspiration

- 22 Years of seasonal and monthly cumulative ET rasters (dating to 1985)
- readily combined in GIS with other data
- Used for managing water supply, verification in GW-surface water agreement, in groundwater model

Mapping Evapotranspiration

IDWR is responsible for the administration and management of Idaho waters which include the measurement and the accounting of consumptive and non-consumptive uses of water. Evapotranspiration (ET) from Idaho's 3.4 million acres of irrigated agriculture accounts for more than 95% of the consumptive use in the state.

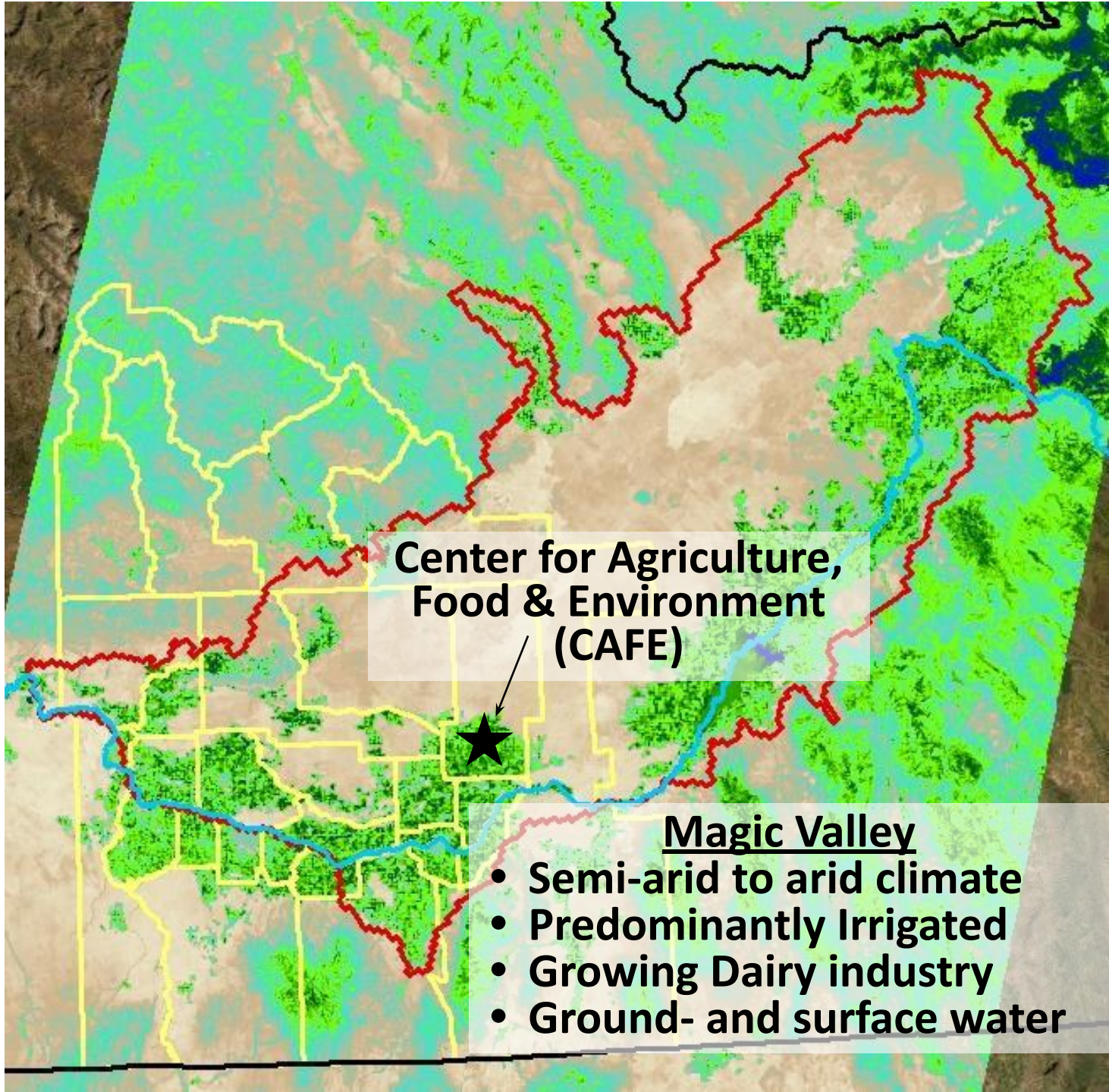
IDWR and the University of Idaho worked from 2000 to 2005 under a NASA grant to develop procedures to map ET from Landsat data and to apply the ET data to water resource problems. The Mapping EvapoTranspiration using high Resolution and Internalized Calibration (METRIC) energy balance model was developed to compute and map ET using Landsat images. Landsat is used because it is the only operational satellite that collects thermal data and has a pixel size small enough to map individual agricultural fields. Landsat thermal data are a critical part of the model and are needed to compute the surface temperature required in ET computations. IDWR uses Landsat-based evapotranspiration data in hydrology, water resources planning, and water administration.

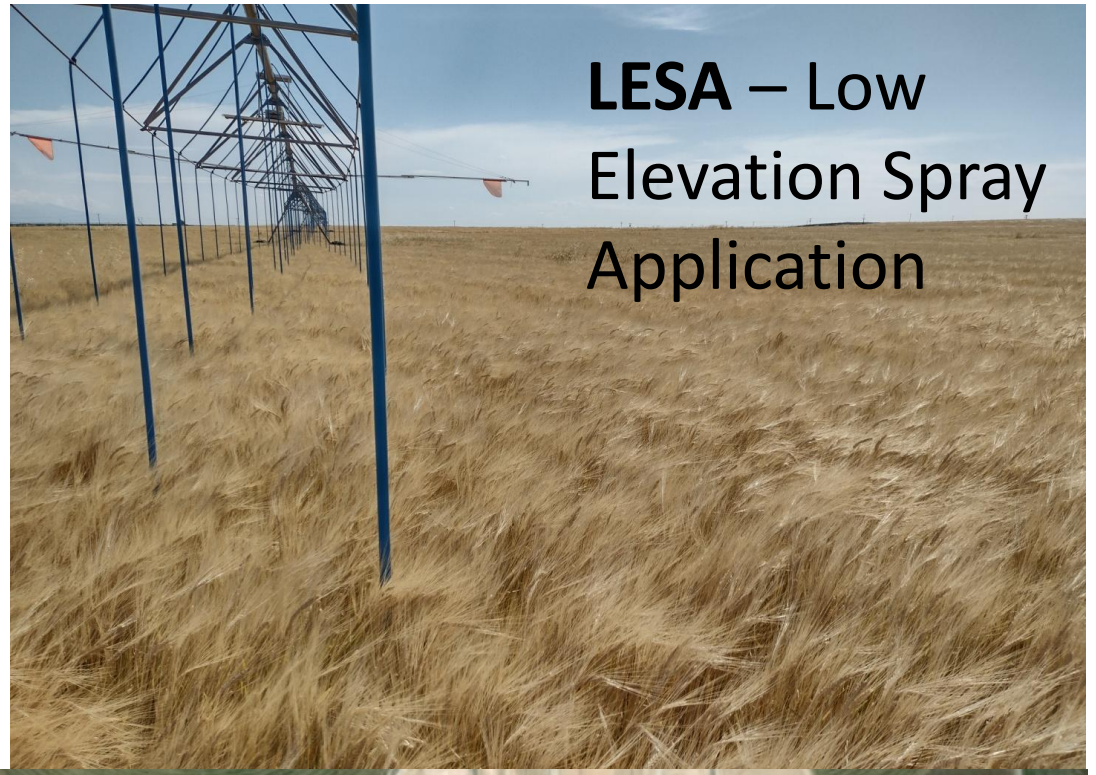


Seasonal ET for cropland 2000

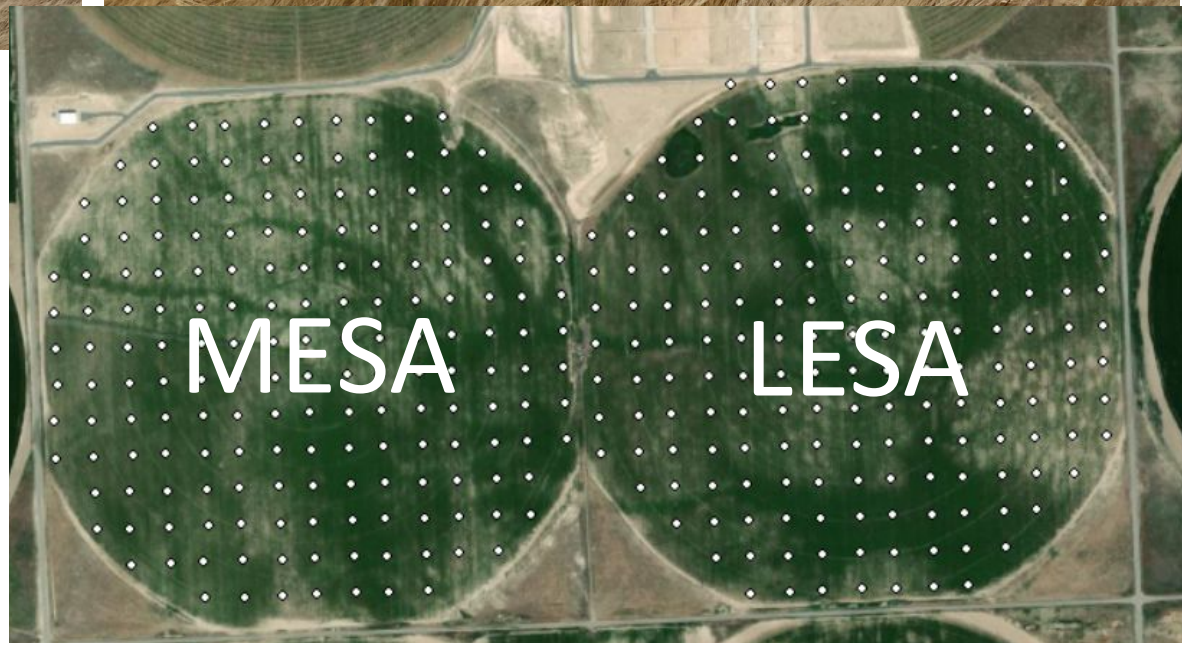
Manual analysis of single images as well as providing seasonal totals.
Thermal images sharpen down to 30 m resolution.


Study area
in southern Idaho
Snake
River
Eastern Snake
Plain Aquifer
Magic
Valley

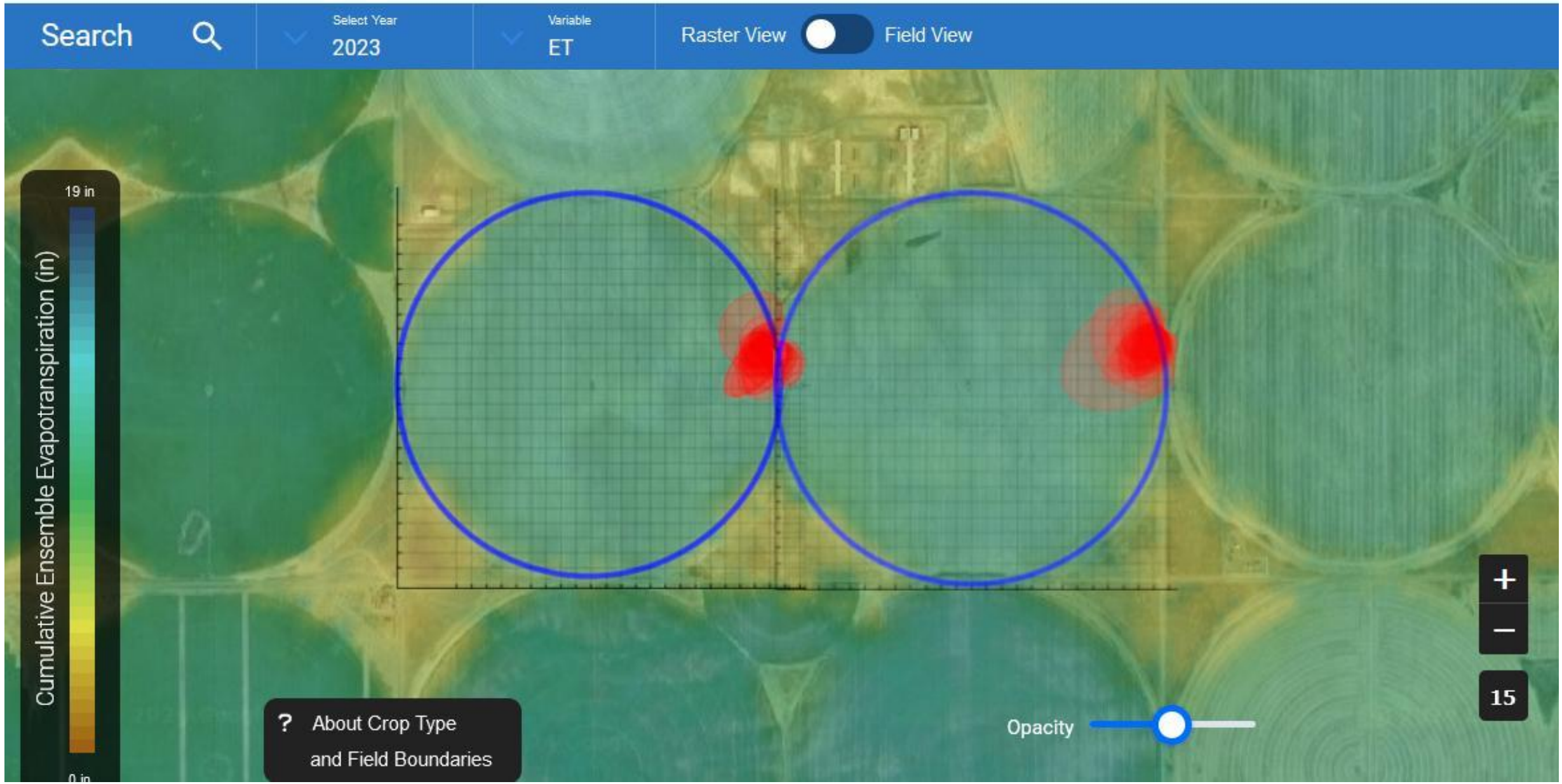

Center for Agriculture,
Food & Environment
(CAFE)
Magic Valley
• Semi-arid to arid climate
• Predominantly Irrigated
• Growing Dairy industry
• Ground- and surface water

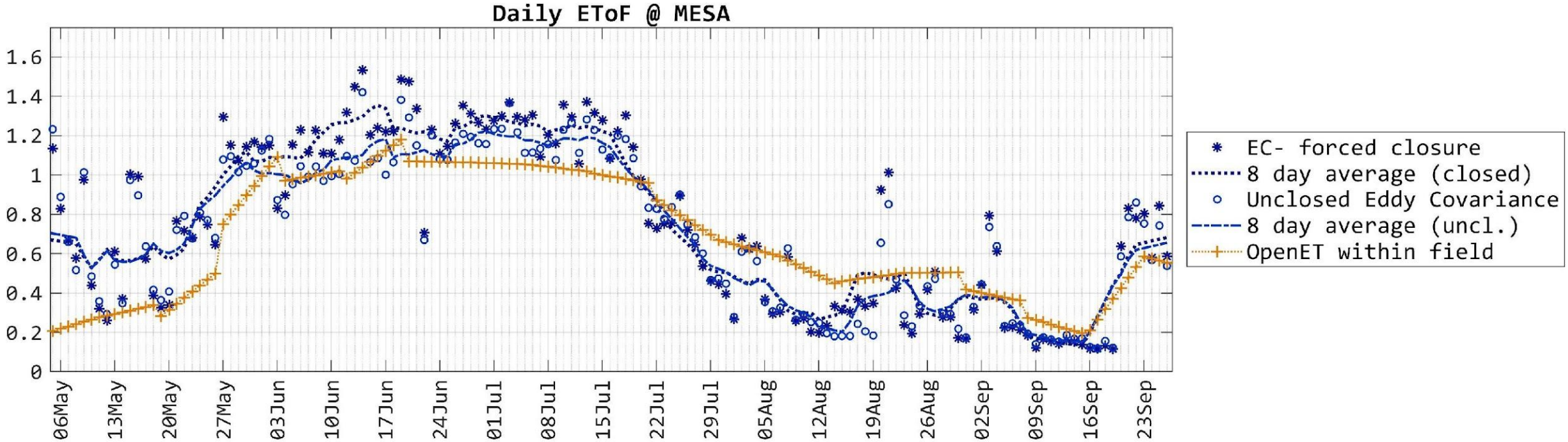


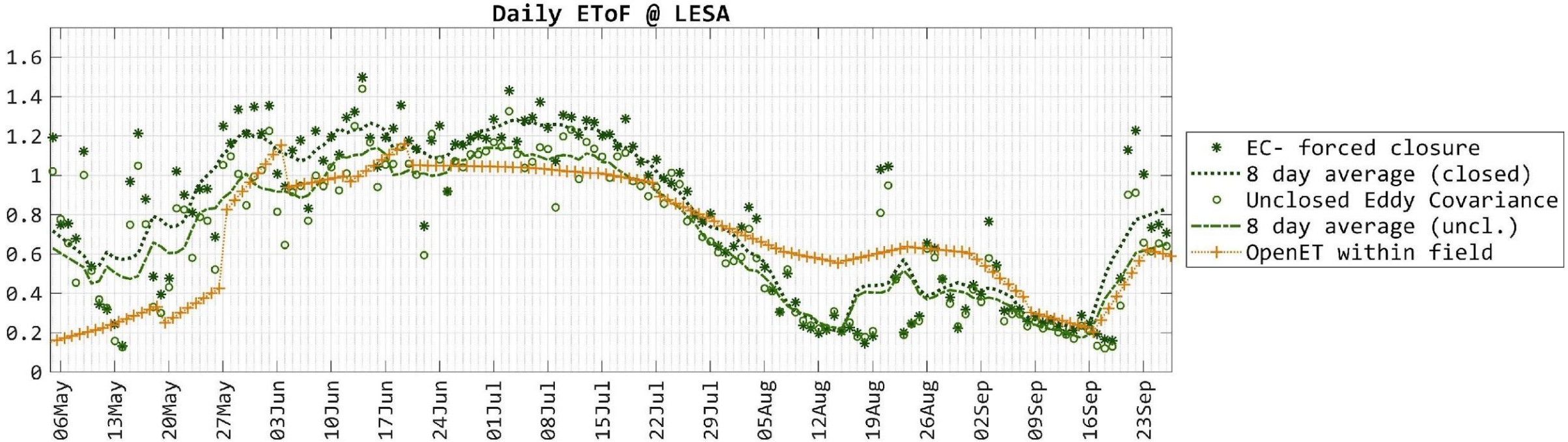
Study site-
Paired fields irrigated with center pivots at UI's CAFE Research Dairy

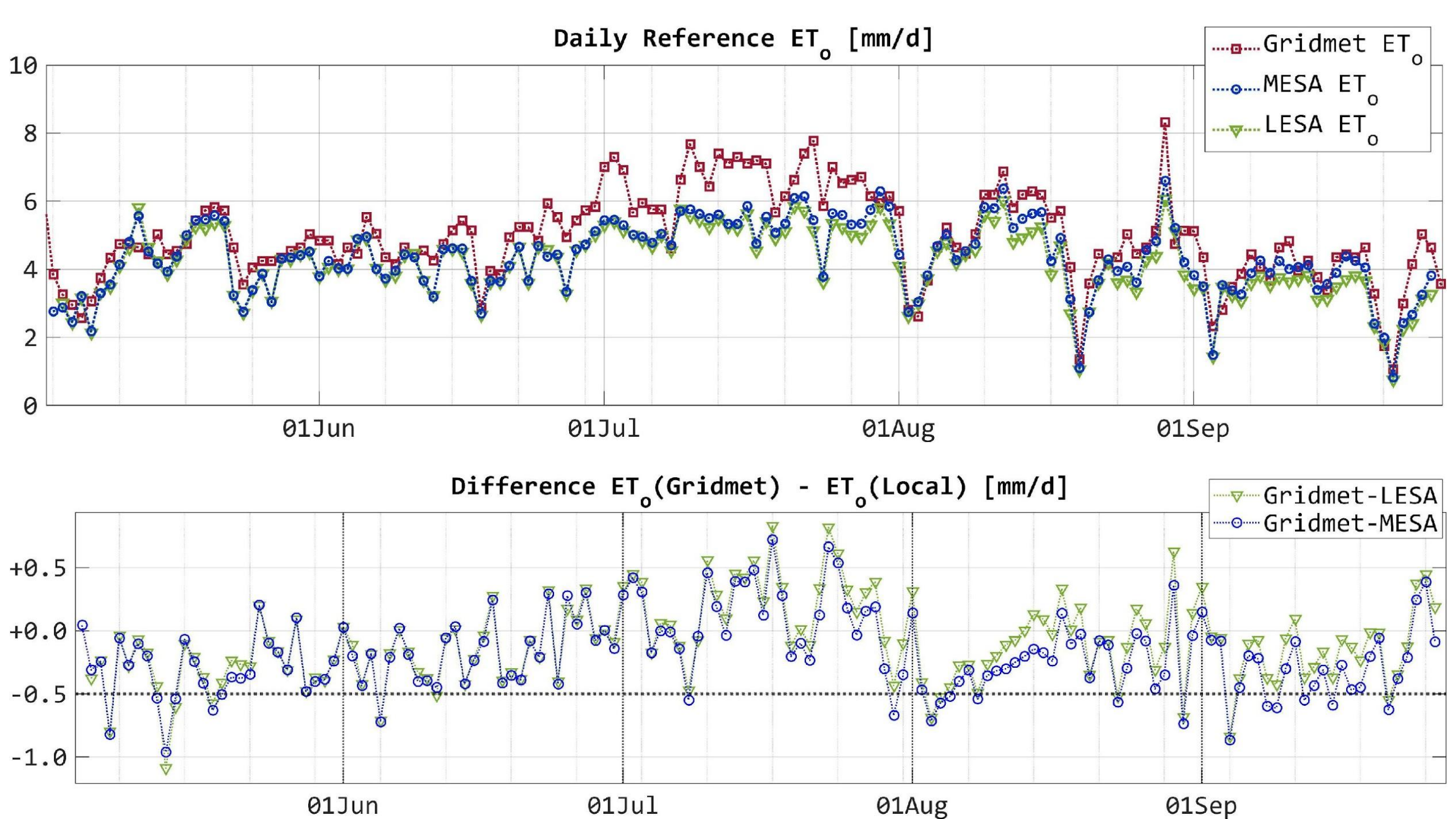



EC100

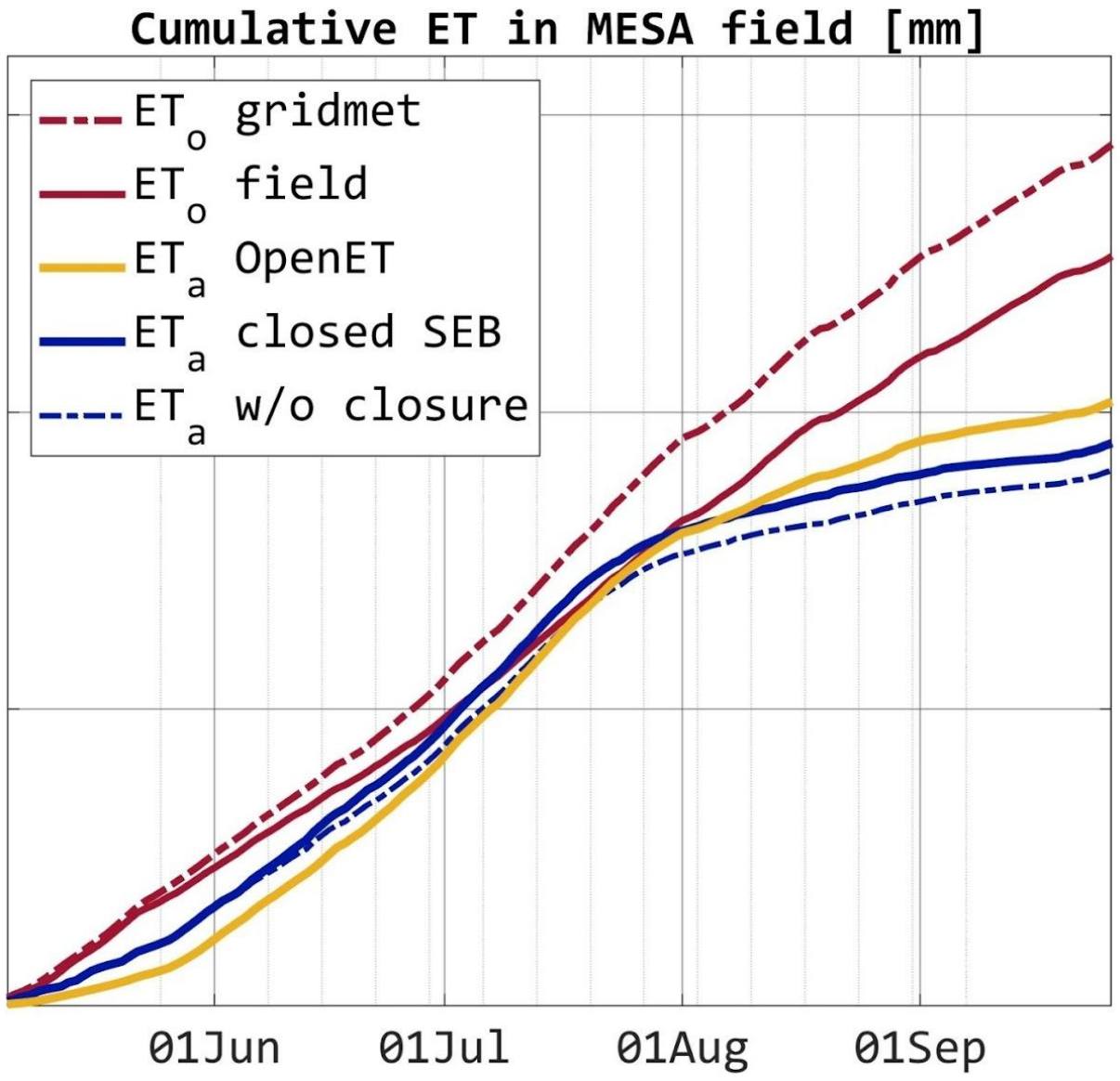

OPENET
Search
Select Year
2023
Variable
ET
Raster View
Field View
19 in
Cumulative Ensemble Evapotranspiration (in)
0 in
? About Crop Type and Field Boundaries
Opacity
+
−
15

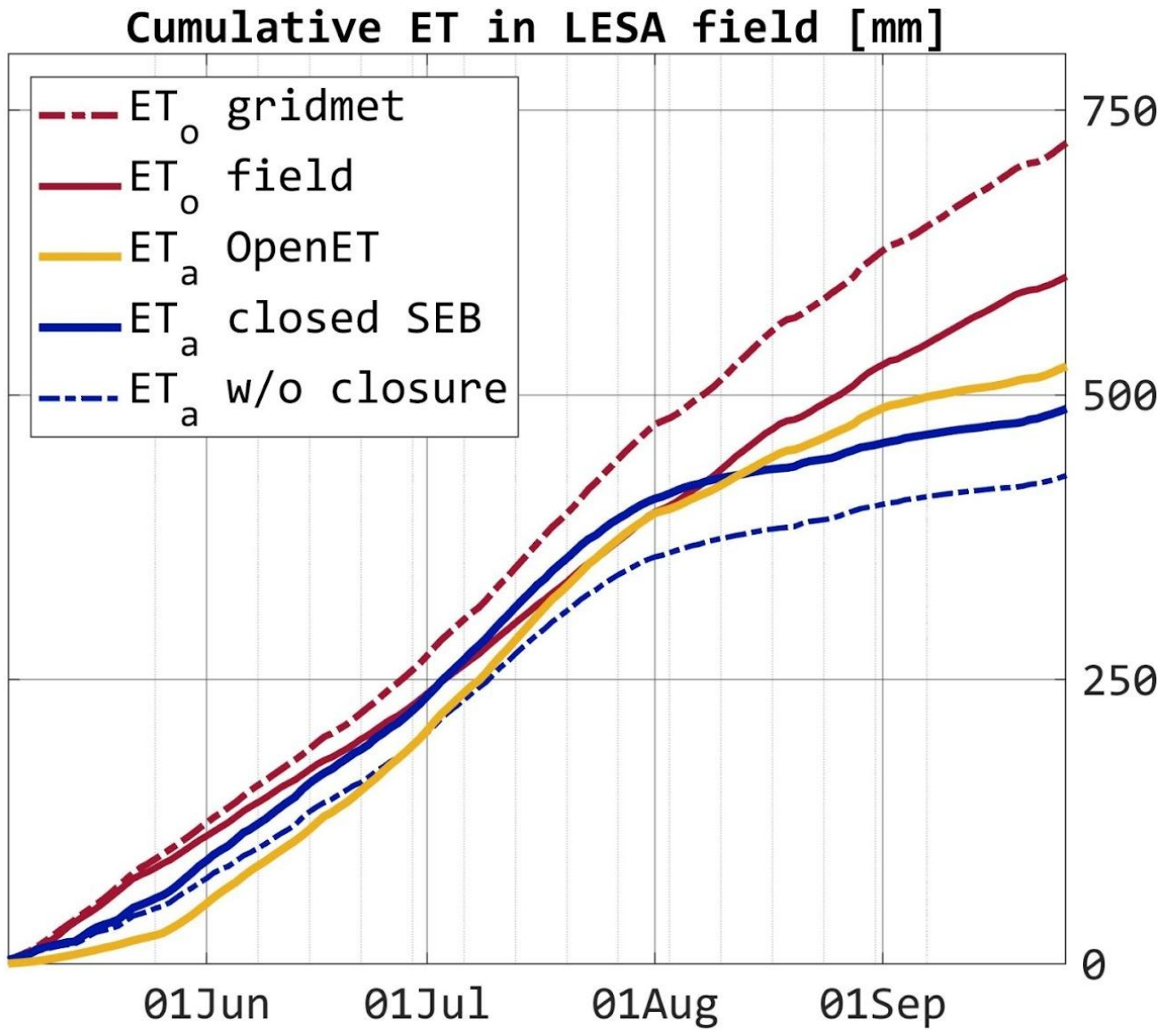

Daily EToF @ MESA
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
06May
13May
20May
27May
03Jun
10Jun
17Jun
24Jun
01Jul
08Jul
15Jul
22Jul
29Jul
05Aug
12Aug
19Aug
26Aug
02Sep
09Sep
16Sep
23Sep
EC- forced closure
8 day average (closed)
Unclosed Eddy Covariance
8 day average (uncl.)
OpenET within field


Daily EToF @ LESA
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
06May
13May
20May
27May
03Jun
10Jun
17Jun
24Jun
01Jul
08Jul
15Jul
22Jul
29Jul
05Aug
12Aug
19Aug
26Aug
02Sep
09Sep
16Sep
23Sep
EC- forced closure
8 day average (closed)
Unclosed Eddy Covariance
8 day average (uncl.)
OpenET within field


Daily Reference ET$_o$ [mm/d]
Gridmet ET$_o$
MESA ET$_o$
LESA ET$_o$
10
8
6
4
2
0
01Jun
01Jul
01Aug
01Sep
Difference ET$_o$(Gridmet) - ET$_o$(Local) [mm/d]
Gridmet-LESA
Gridmet-MESA
+0.5
+0.0
-0.5
-1.0
01Jun
01Jul
01Aug
01Sep

Total ET for entire season





Key results from field measurements

- Eddy covariance energy budget closed by 87%, with more consistency (higher R^2) observed at MESA field.
- After correcting measured ET, EToF values measured by eddy-covariance exceed OpenET ensemble during the irrigation season.
- After irrigation stopped, OpenET overpredicted field measured EToF.
- Gridmet overpredicted reference ETo compared to field measurement.
- Adjustments to actual ET (from corrections and calibration) exceed the observed differences between the two irrigation systems.

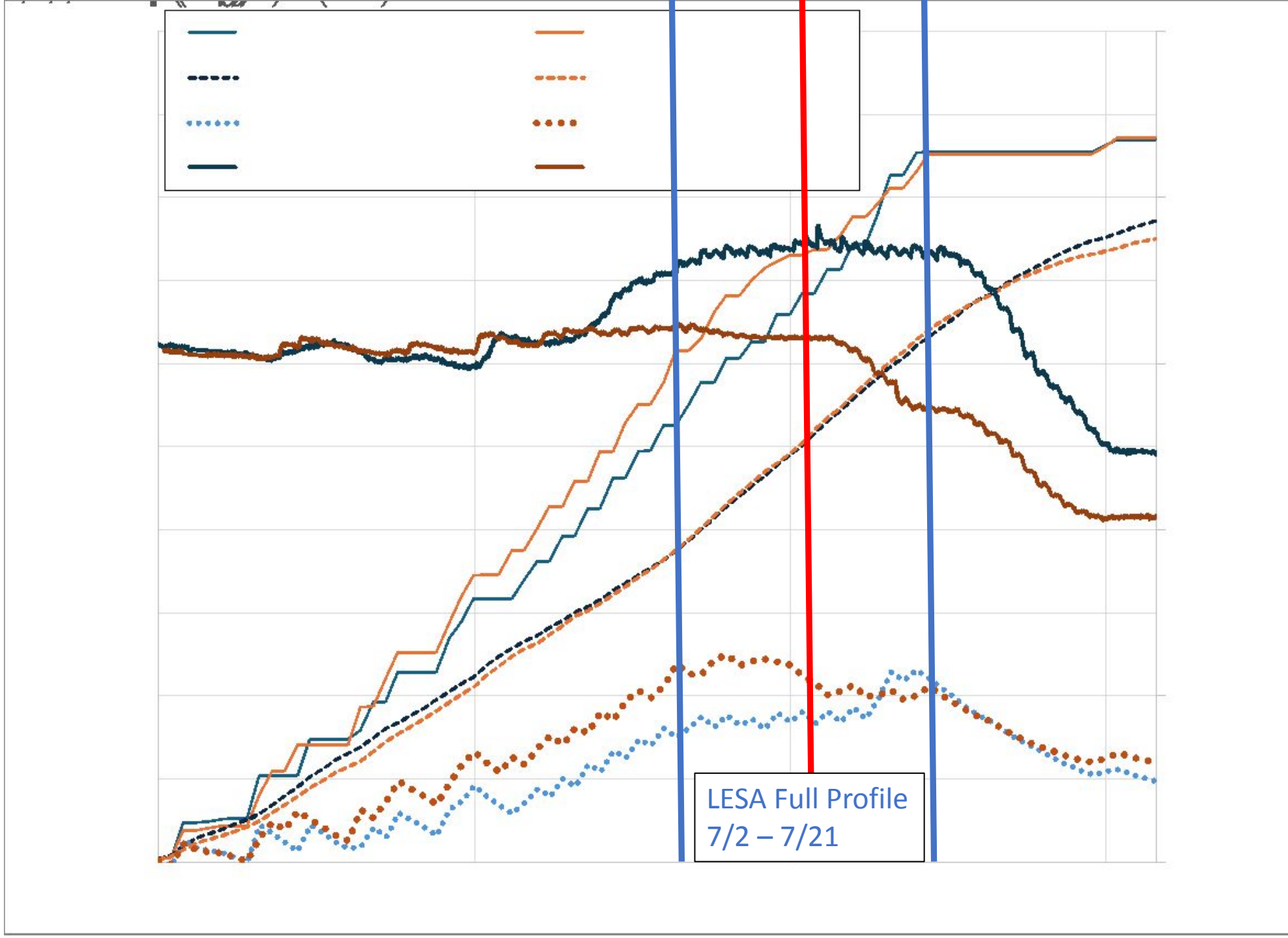
Water Budget

Nearly identical season total applied water

Minimal differences in actual ET

More water applied than ET consumed implies little to no water stress

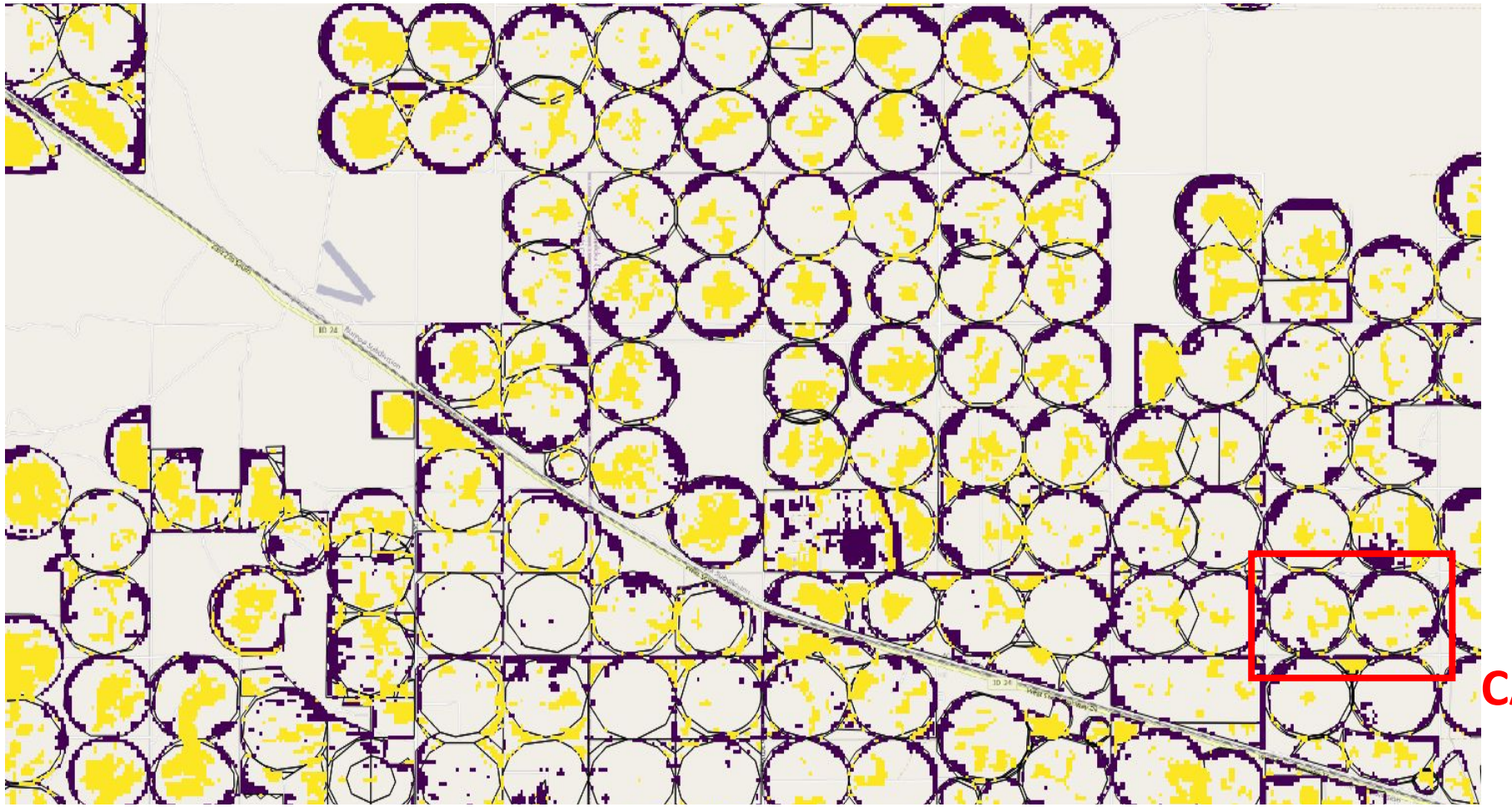
Greater soil moisture storage and wetter for a longer period of time in LESA vs MESA



Persistence patterns in ET

Open source tool for generating persistence pattern maps and guide variable rate management

- Shiny R (For just the CAFÉ Sites) https://cdeval.shinyapps.io/CAFE-ET-Persistence
- GeoServer (For entire Magic Valley): https://devalc.github.io/ETPersistence/



-Yellow regions: Statistically significant larger ET (> 5% difference)

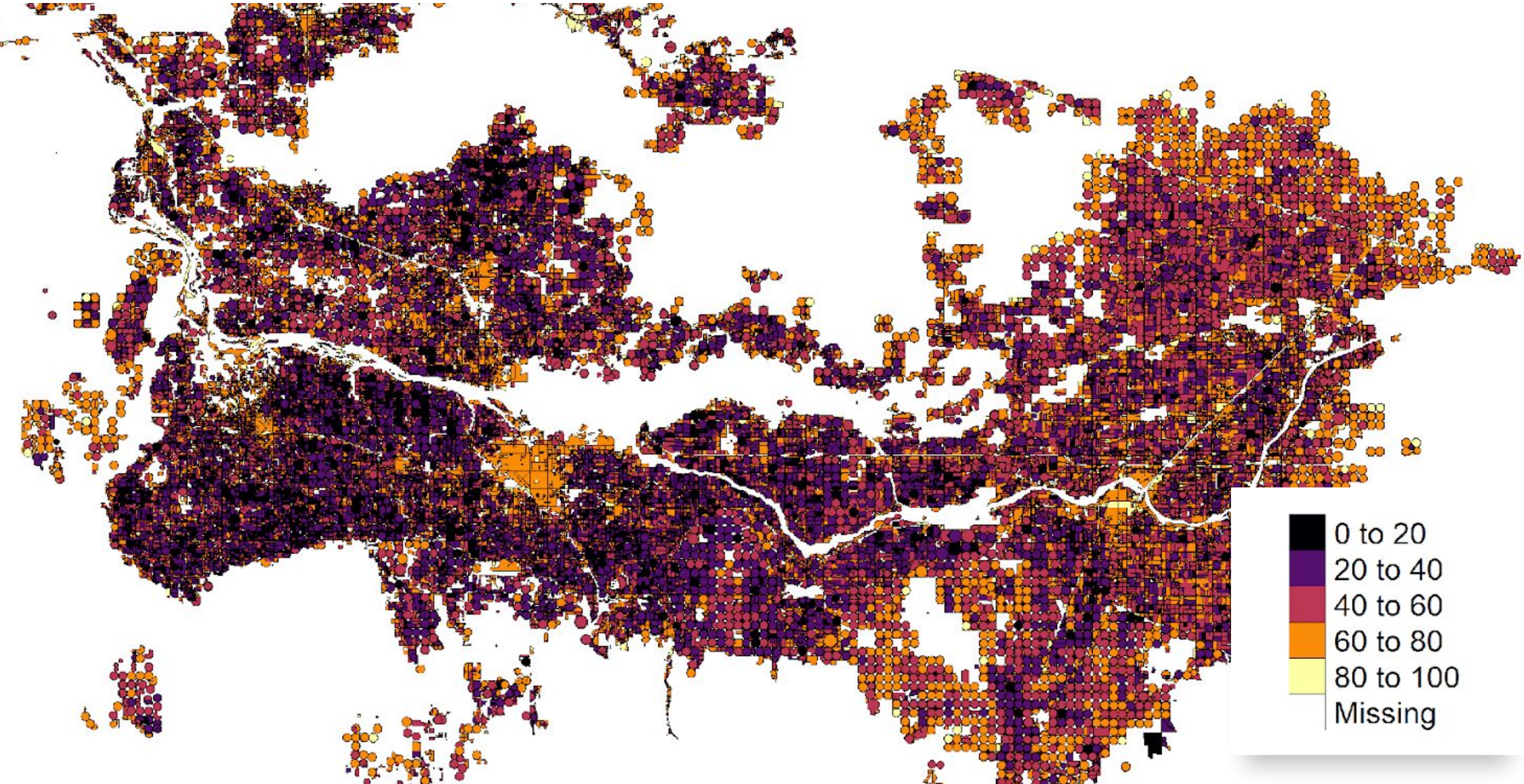
- Purple regions: Statistically significant smaller ET (> 5% difference)

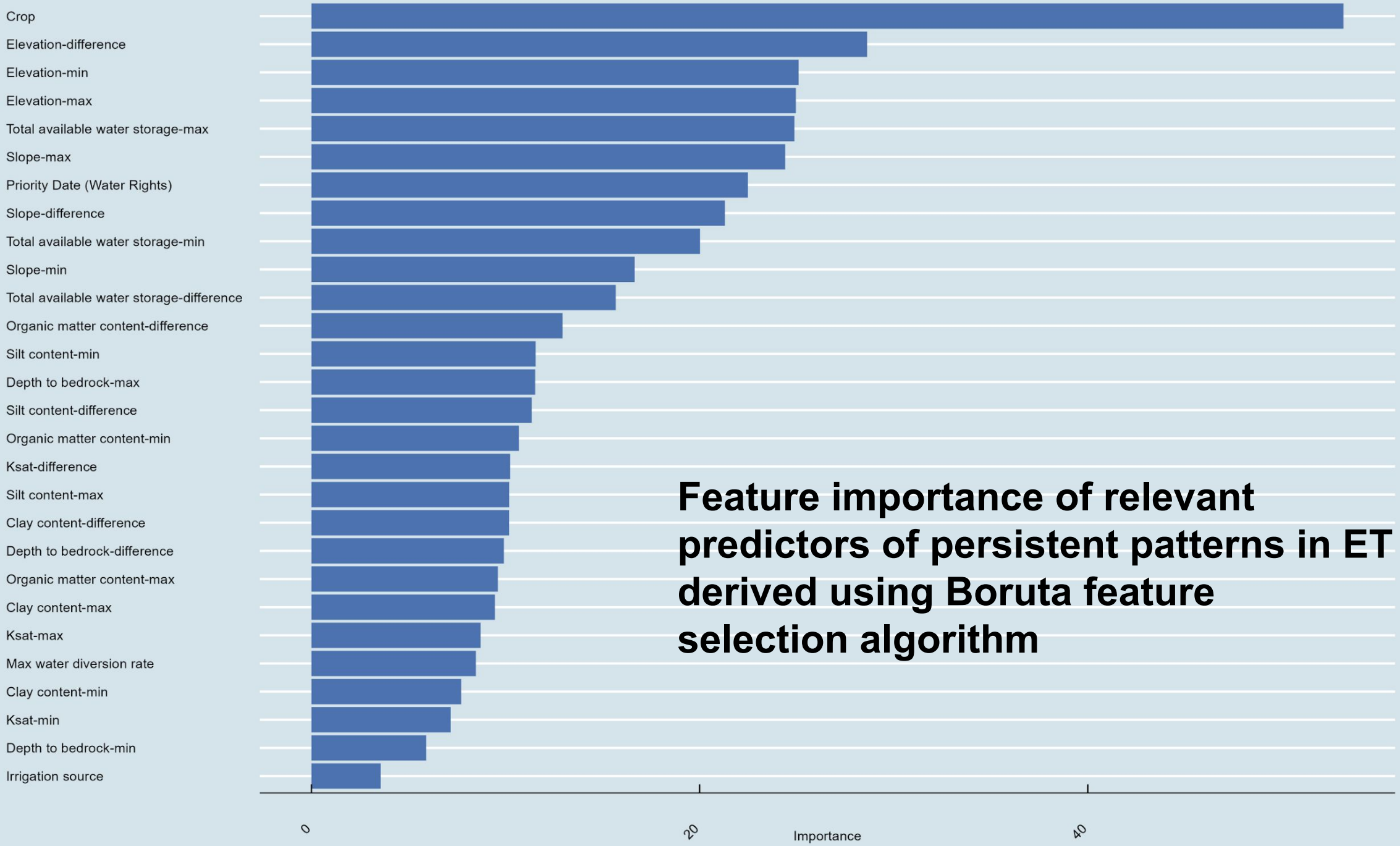
-0.05 P-value

-16 years of ET data 1984 to 2020

CAFE study site

Percent of field area exhibiting persistent ET patterns




Crop
Elevation-difference
Elevation-min
Elevation-max
Total available water storage-max
Slope-max
Priority Date (Water Rights)
Slope-difference
Total available water storage-min
Slope-min
Total available water storage-difference
Organic matter content-difference
Silt content-min
Depth to bedrock-max
Silt content-difference
Organic matter content-min
Ksat-difference
Silt content-max
Clay content-difference
Depth to bedrock-difference
Organic matter content-max
Clay content-max
Ksat-max
Max water diversion rate
Clay content-min
Ksat-min
Depth to bedrock-min
Irrigation source
0
20
40
Importance
Feature importance of relevant predictors of persistent patterns in ET derived using Boruta feature selection algorithm

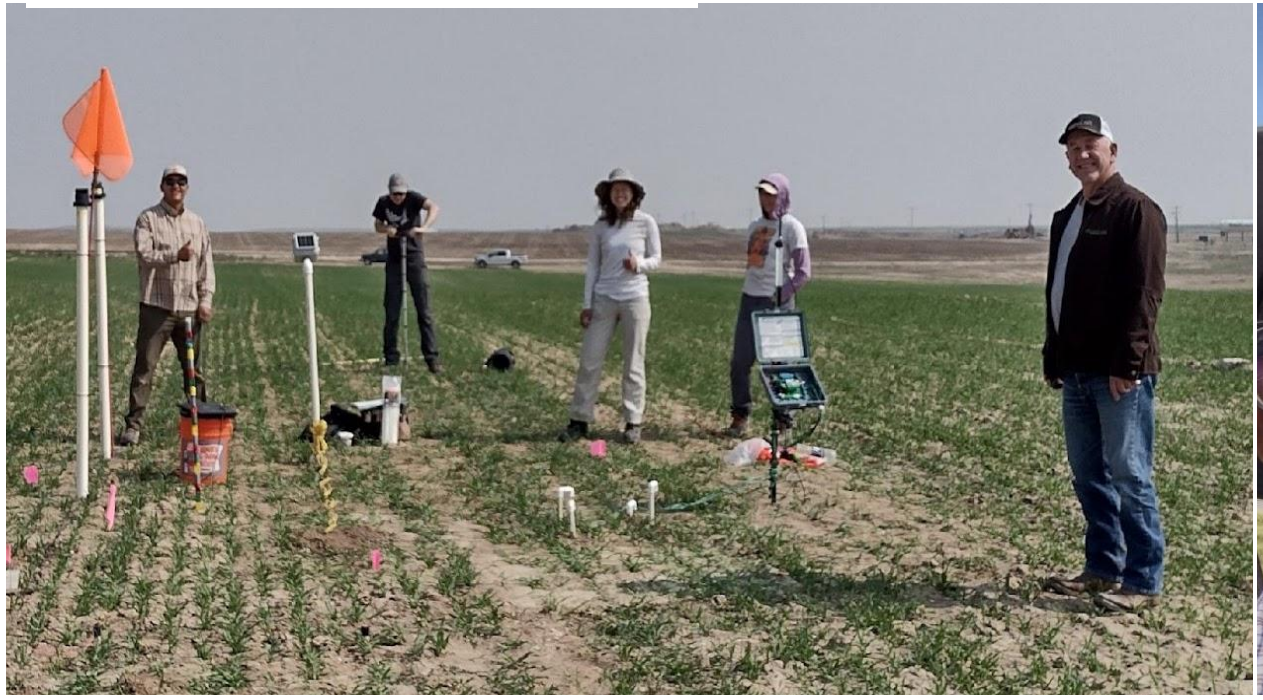
Partner Cooperation and Broader Impacts

- IDWR, Irrigation Districts, Water Resources Board, and Idaho Dairyman's Association are interested in continued use of mapping products and want more accuracy assessment of data products
- Idaho Water Resources Board funded a $1M follow-up project for ground-based validation of satellite ET mapping 2024-2027
- NRCS and Idaho Department of Environmental Quality has expressed interest in using persistence mapping tool to target and incentivize variable rate management practices
- USDA Funded $55M project "Climate-Smart Commodities for Idaho: A Public-Private-Tribal Partnership" at UI, providing incentive payments for producers to implement climate smart practices

Acknowledgements

- UI Field crews
- 4D Farms
- WWAO project funding and support
- Partners at USDA-ARS and NRCS, IDWR, IDA

Questions?



Summary

- Overall OpenET showed noticeable overprediction after irrigation stopped under dry canopy
- Observed bias when using GridMET data to estimate ETo
- Dynamic daily changes in ET were not captured by OpenET but seasonal totals were close to observed
- No noticeable impact of irrigation system on ET however both crops were well watered
  - LESA field showed greater and longer wetting
- Persistent pattern mapping tool may be useful for identifying opportunities for variable rate management
- LESA irrigated fields seem to be less sensitive to lodging