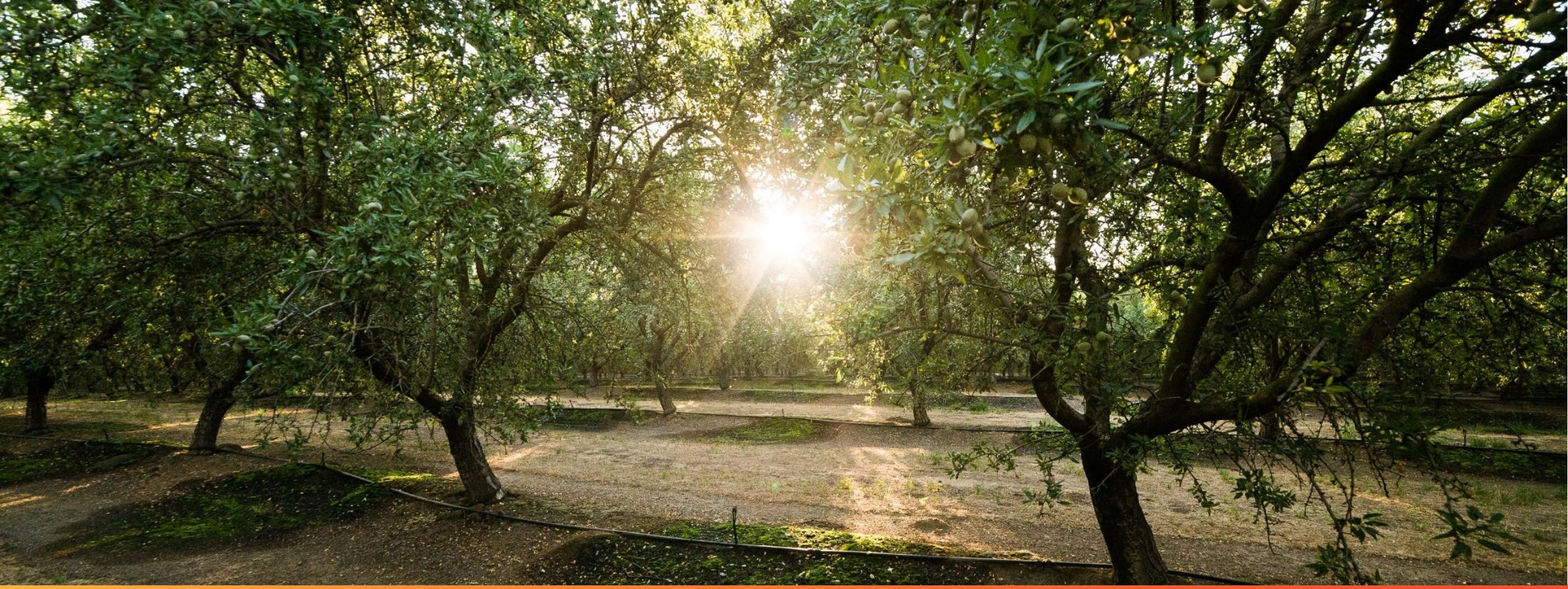


2018 | THE ALMOND CONFERENCE

IRRIGATION TECHNOLOGY EVOLUTION: DOWN TO EARTH, DOWN TO THE ROOTS

ROOM 308-309 | DECEMBER 5, 2018

california almonds
Almond Board of California

growing ADVANTAGE
The Almond Conference

Continuing Education Units (CEU's)

- **What type of CEU's are offered at conference?**
  - Tuesday – Certified Crop Advisor (CCA)
  - Wednesday – Certified Crop Advisor (CCA)
  - Thursday – Certified Crop Advisor (CCA) and Department of Pesticide Regulations (DPR)

- **Where are the CEU sign in sheets?**
  - CEU sign in sheets will be in the back of each session
  - There are separate forms on Thursday for the CCA and DPR credits

- **Special instructions for Thursday**
  - PCA's will need to pick up their scantrons in the morning before the first session of the day. They will also need to return the scantron at the end of the day to the CEU booth. This is in addition to signing in and out of each session.

AGENDA

- **Spencer Cooper**, Almond Board of California, moderator
- **Zac Ellis**, Olam Farms
- **Alex Bergwerff**, Winters Farming
- **Forrest Melton**, NASA AMES
- **Andrew McElrone**, UC Davis

OpenET

Filling the Biggest Data Gap in Water Management

Forrest Melton, Sr. Research Scientist
NASA ARC-CREST

December 5, 2018

California Almond Conference

OPENET

EDF ENVIRONMENTAL DEFENSE FUND
Finding the ways that work

NASA

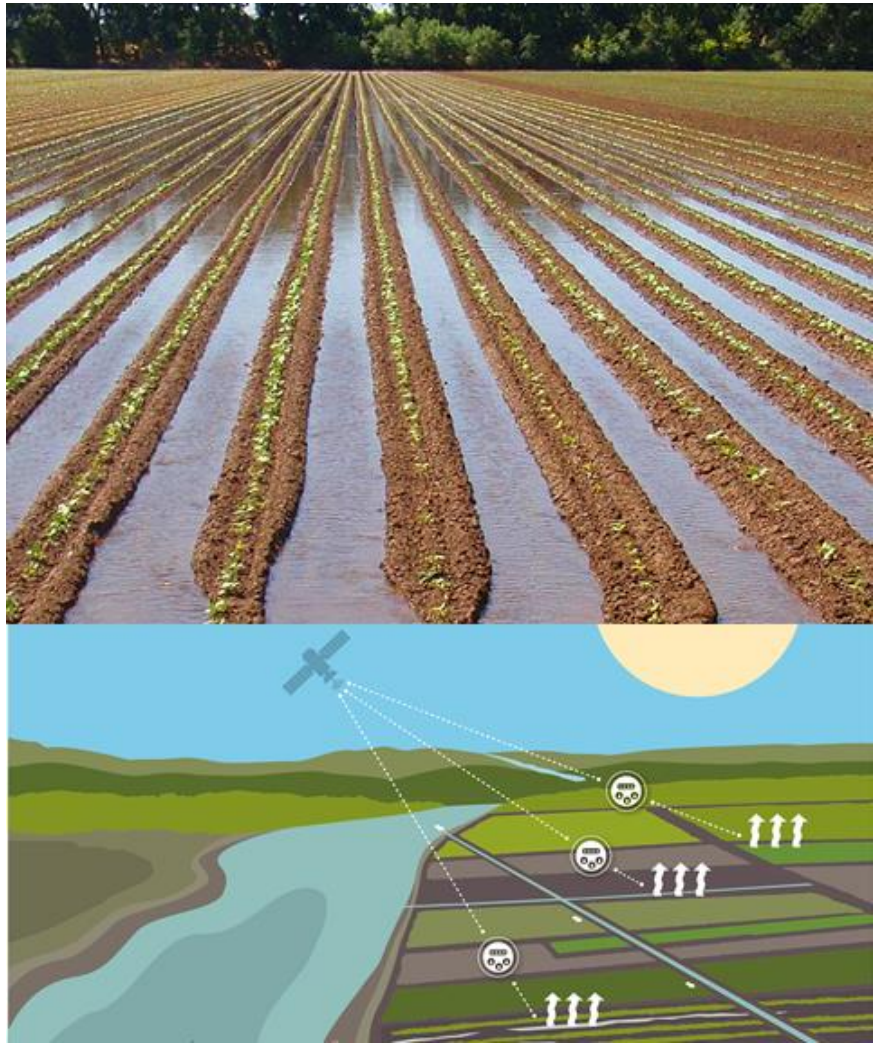
Google Earth Engine

DRI Desert Research Institute

Why is ET important for irrigated agriculture?

Measurement of evapotranspiration (ET) enables us to…

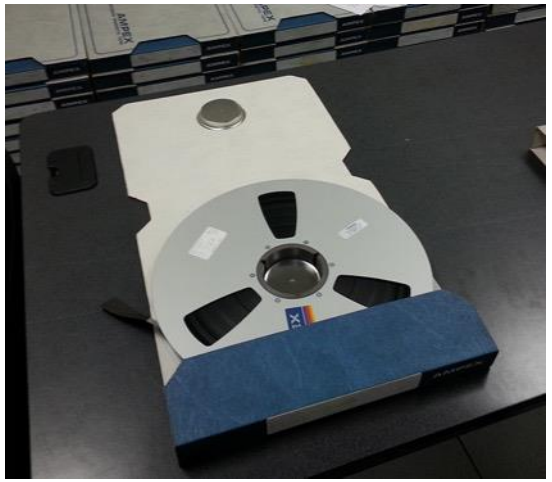
- Match irrigation to plant water requirements
- Establish realistic water budgets
- Incentivize conservation and innovation
- Give proper credit for reduced use
- Reduce the transaction costs for water trading programs
- Increase urban and on-farm efficiencies



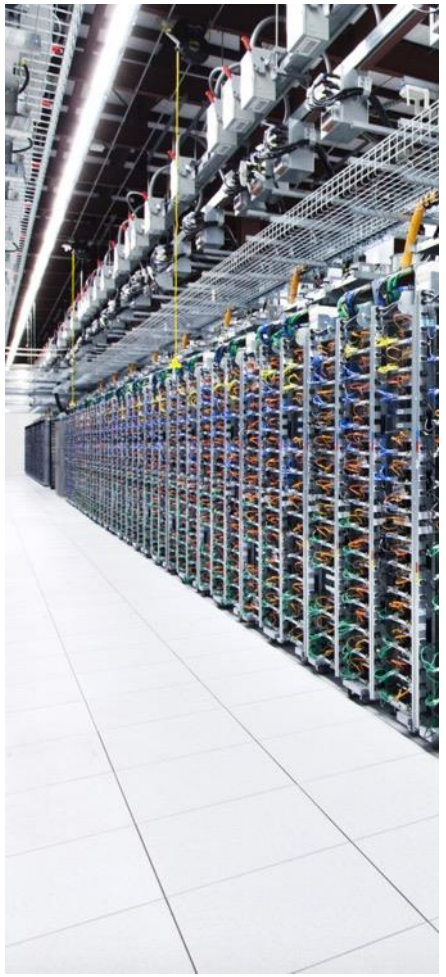
OPENET

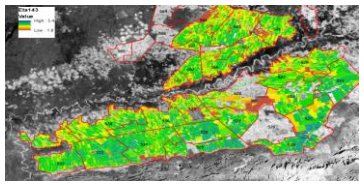
Remote sensing of evapotranspiration (ET)

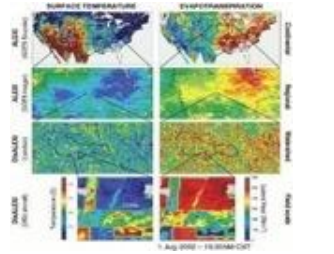
1988

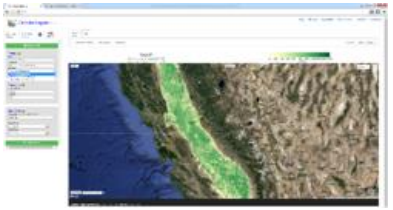


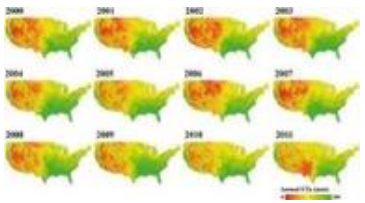
2018



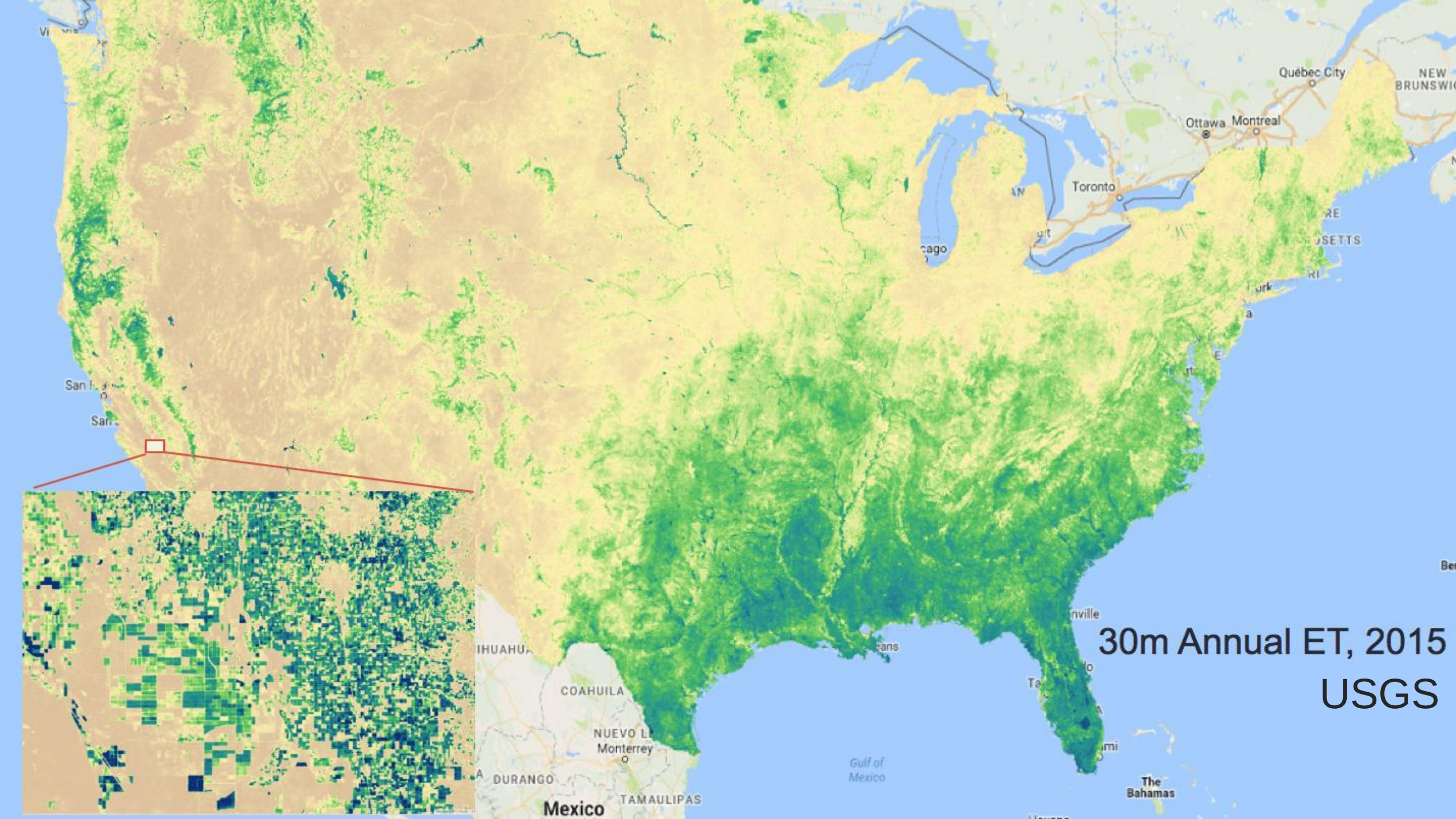








OPENET

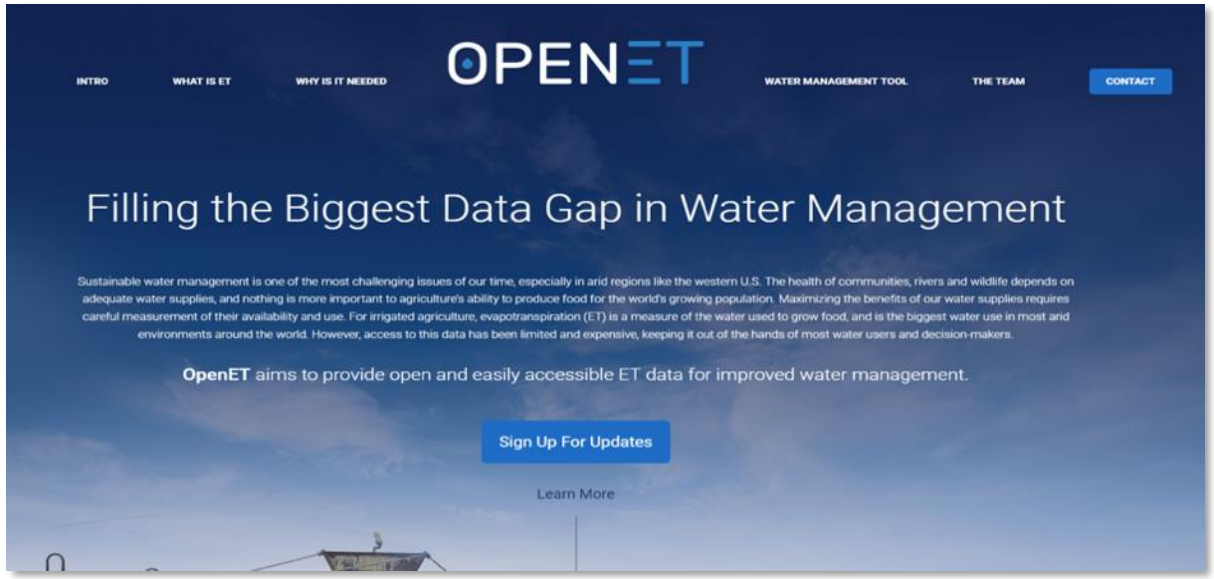

Québec City
Ottawa
Montreal
Toronto
COAHUILA
Monterrey
DURANGO
TAMAULIPAS
Mexico
Gulf of Mexico
The Bahamas
30m Annual ET, 2015
USGS

Why is OpenET needed?

Access to ET Information	Today	With OpenET
Cost	High	Low
Comparability and Trust	Variable	High
Scope	Limited	Broad
Accessibility	Low	High

OPENET

Project Goals: OpenET envisions a future in which...



Reliable ET data are produced and available at low cost, and **easily accessible via etdata.org** for any area within the Western US.

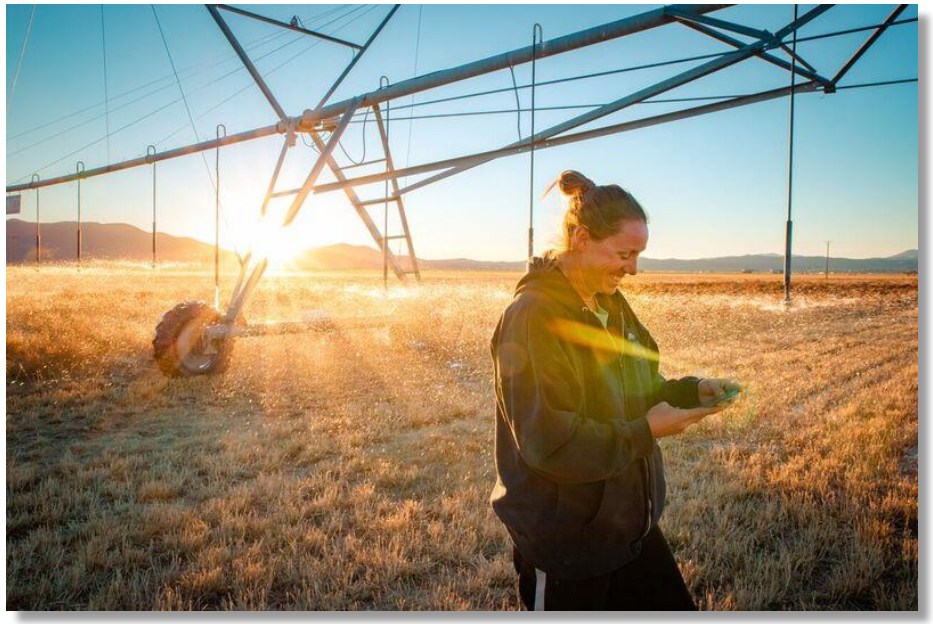
Project Goals: OpenET envisions a future in which...

There is trust in the validity of the data and information provided by the platform, and it is utilized by private and public resource managers at the local, state and federal levels.

Project Goals: OpenET envisions a future in which...

A variety of **sustainable resource management practices are enabled** at a much larger scale than is currently possible.

OpenET: User-driven design



Partnering with experts to guide development

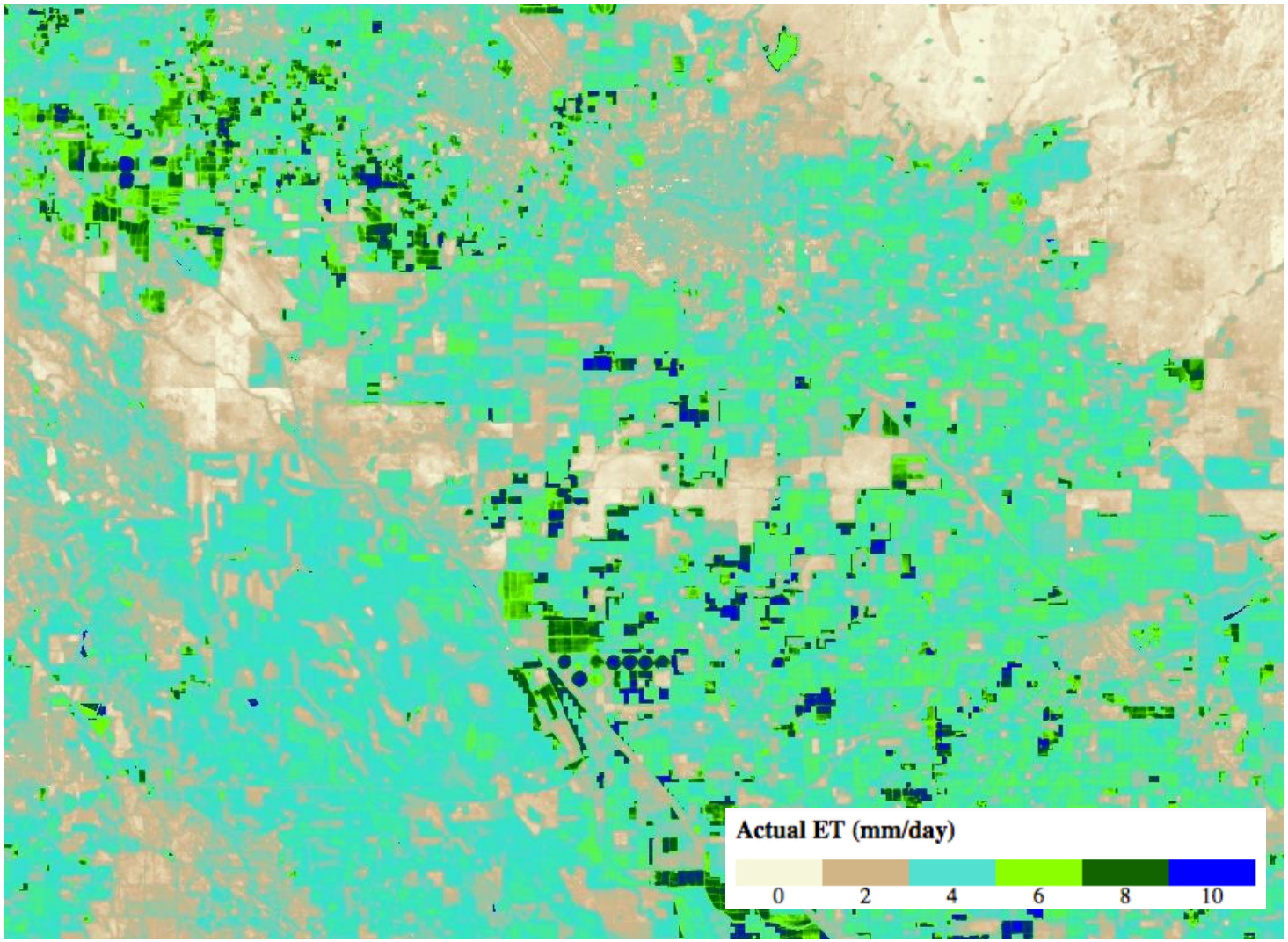
California Working Group - Organizations Represented

1. CA Farm Bureau Federation
2. CA Dept of Food and Ag
3. Sustainable Conservation
4. Gallo
5. CA State Water Resources Control Board
6. UC Ag Issues Center
7. David's Engineering
8. Governor's Office of Planning and Research
9. CA Dept of Water Resources

Colorado River Basin Working Group - Organizations Represented

1. Audubon
2. Wyoming Office of Engineers
3. Metropolitan Water District
4. Arizona Dept of Water Resources
5. Wilson Water Group
6. Utah State Univ.
7. Nevada Division of Water Resources
8. New Mexico Office of the State Engineer
9. US Bureau of Reclamation
10. Utah Division of Water Resources

How do we measure ET with satellites?

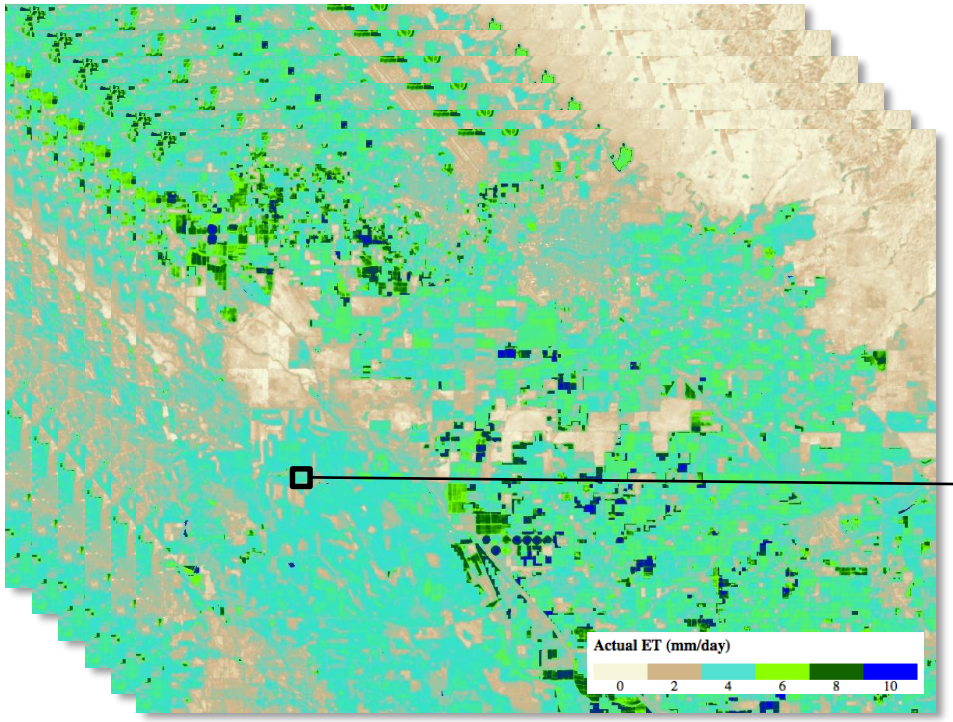


Images courtesy of eeFlux

OPENET

How do we measure ET with satellites?

Timeseries of Satellite Data



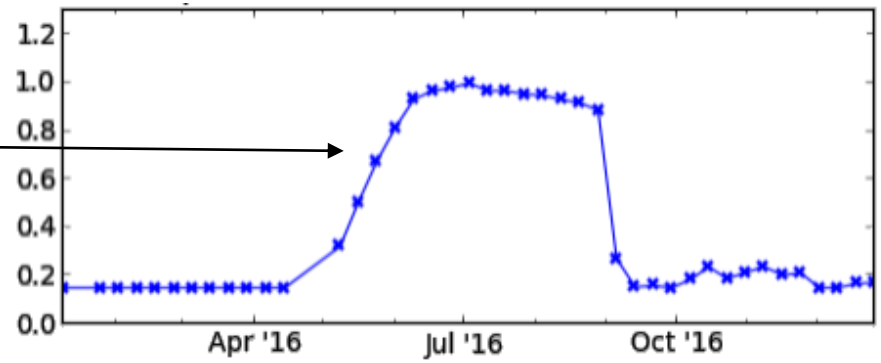
ETrf = ETsat / ETo

ET = ETo * ETrf

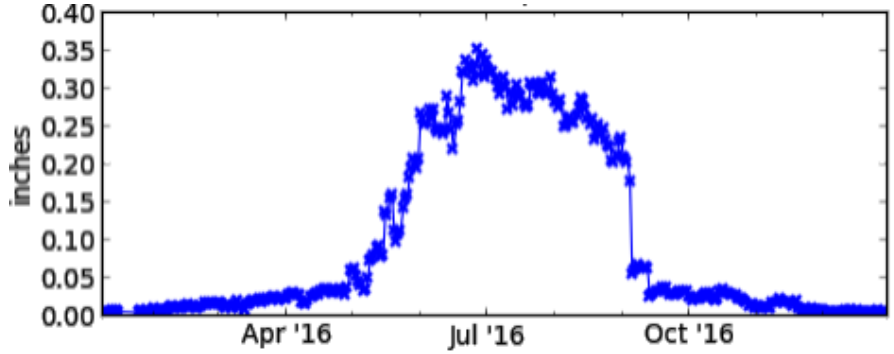
CIMIS

Satellite data

ETrf

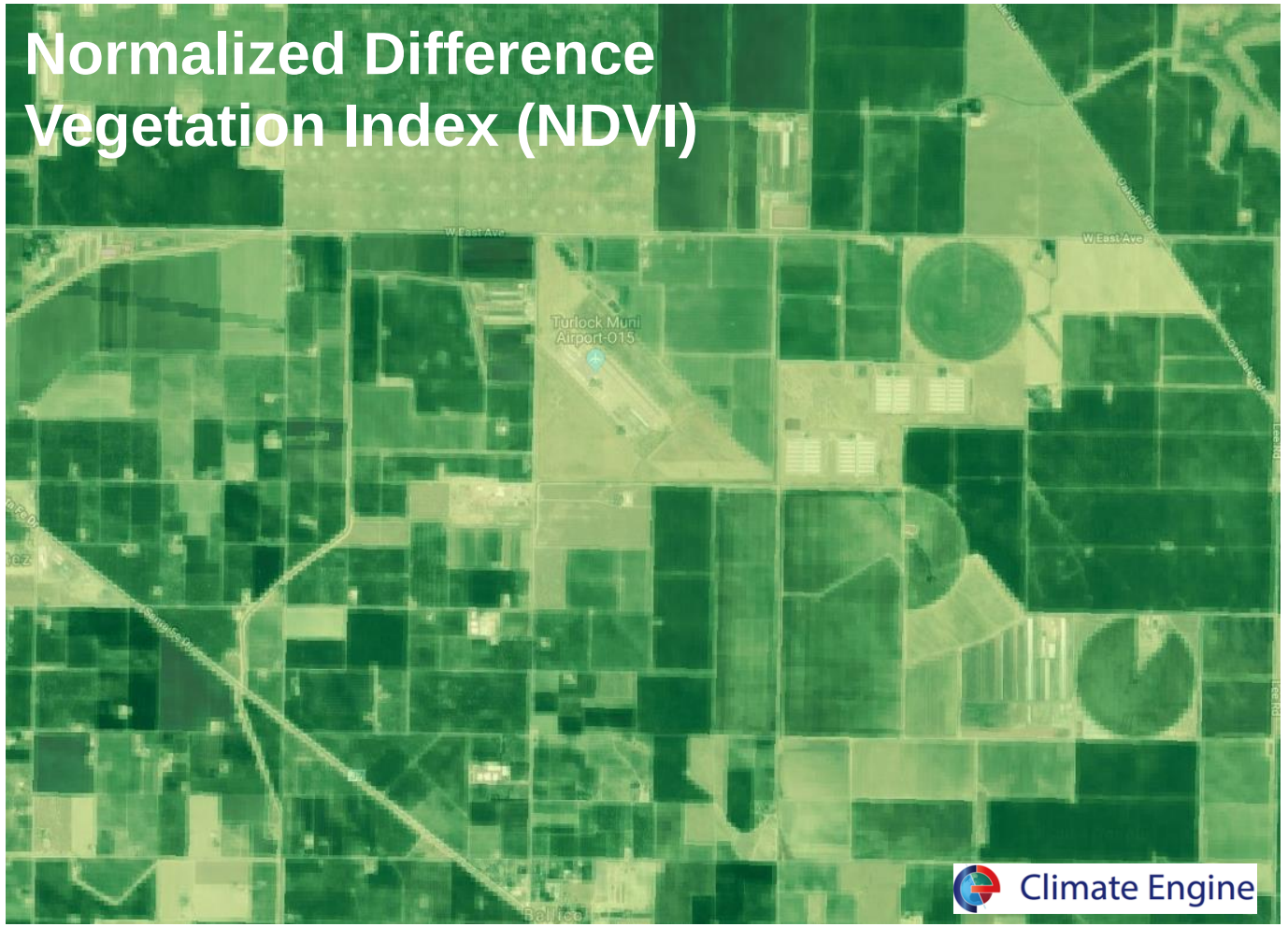


Daily ET



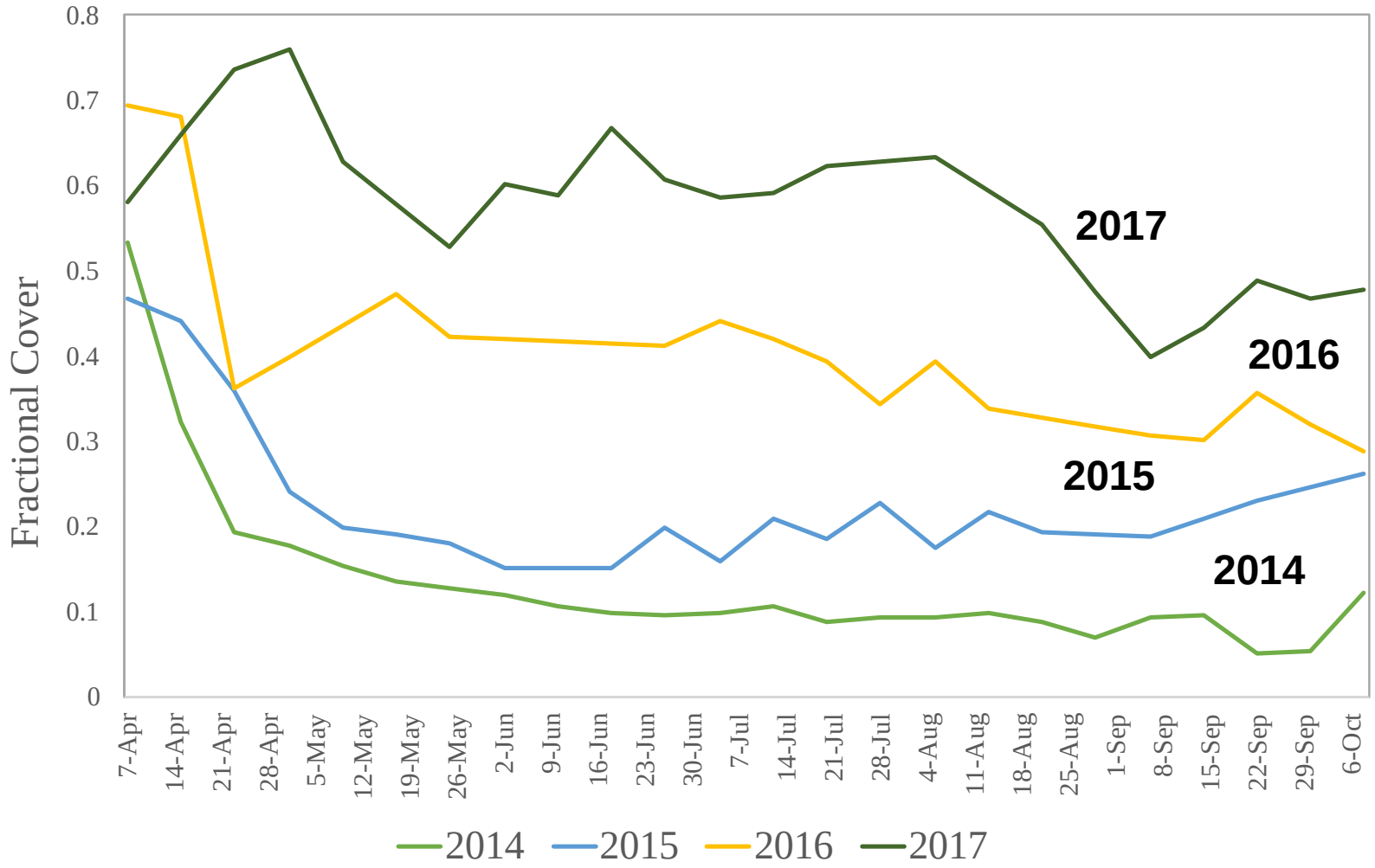
OPENET

More than ET: Vegetation Indices, Kc, Fractional Cover



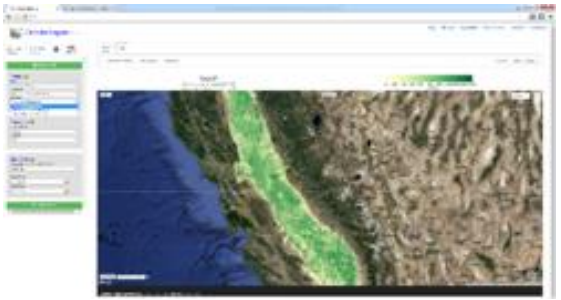
OPENET

More than ET: Vegetation Indices, Kc, Fractional Cover

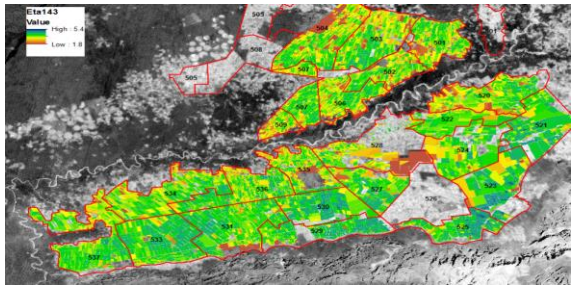


OPENET

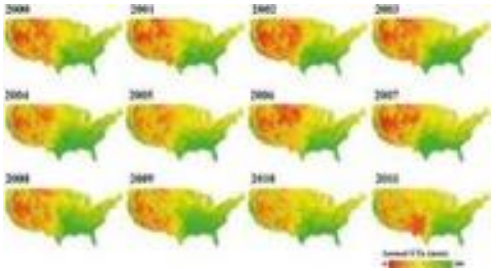
OpenET uses well-established models



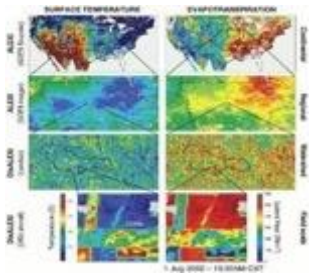
METRIC, 30m, 20+ state water mgmt agencies



SEBAL, 30-300m, World Bank, UN FAO, eLeaf

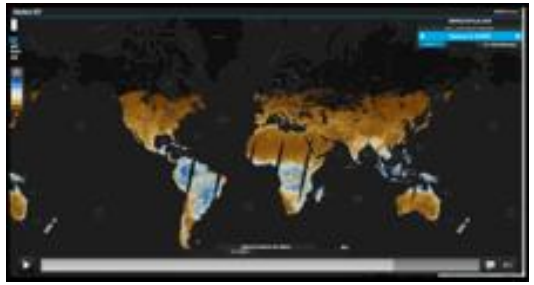


SSEBop, 30m-1km, USGS National Water Census



ALEXI/DisALeXI, 500m-5km, NOAA, USDA, NASA, U.S. Drought Monitor

SIMS, 30m, CA Dept. of Water Resources, UCCE, +5 western states, NASA



JPL-PT, 30m-1km, New Mexico State Eng. Office, NASA

OPENET

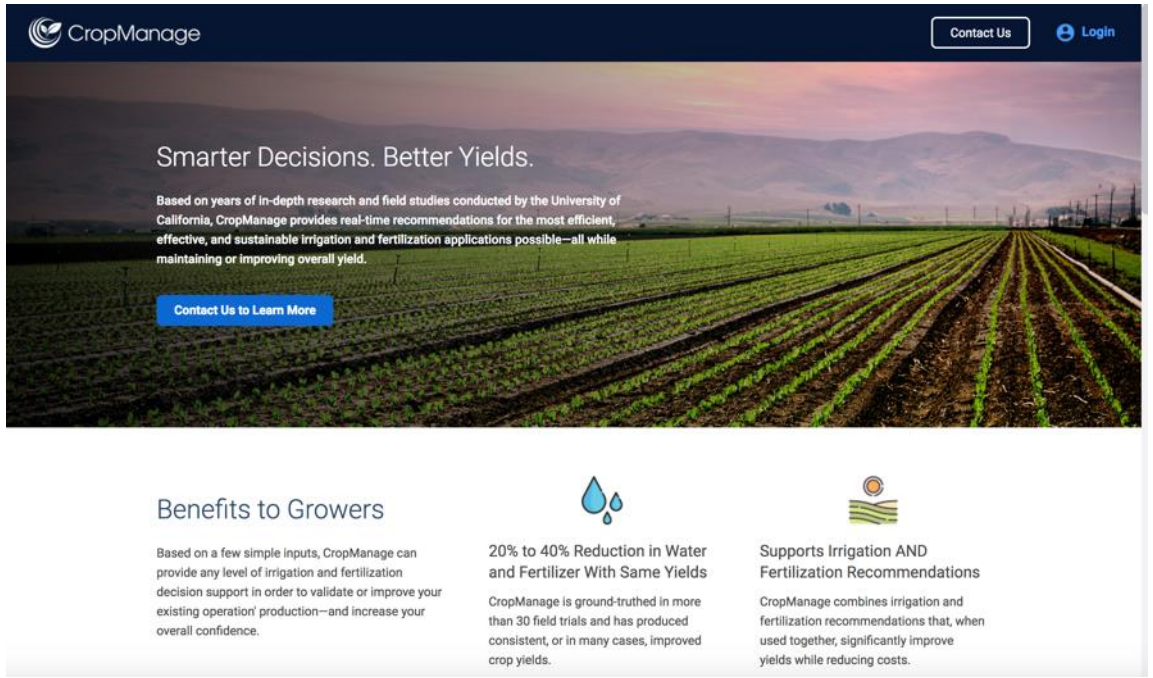
How will OpenET assess accuracy?

OPENET

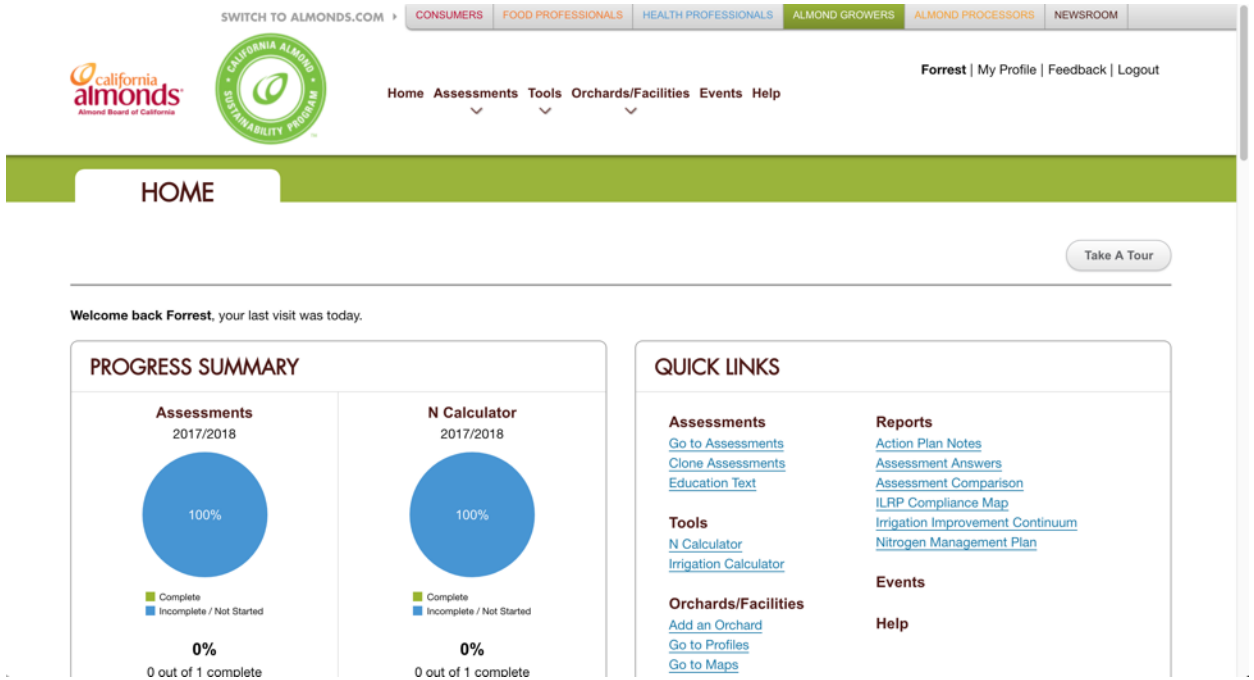
Images courtesy of Ray Anderson, USDA ARS

How will OpenET help growers?

Reliable data services for existing tools: vegetation indices, fractional cover, Kc, ET



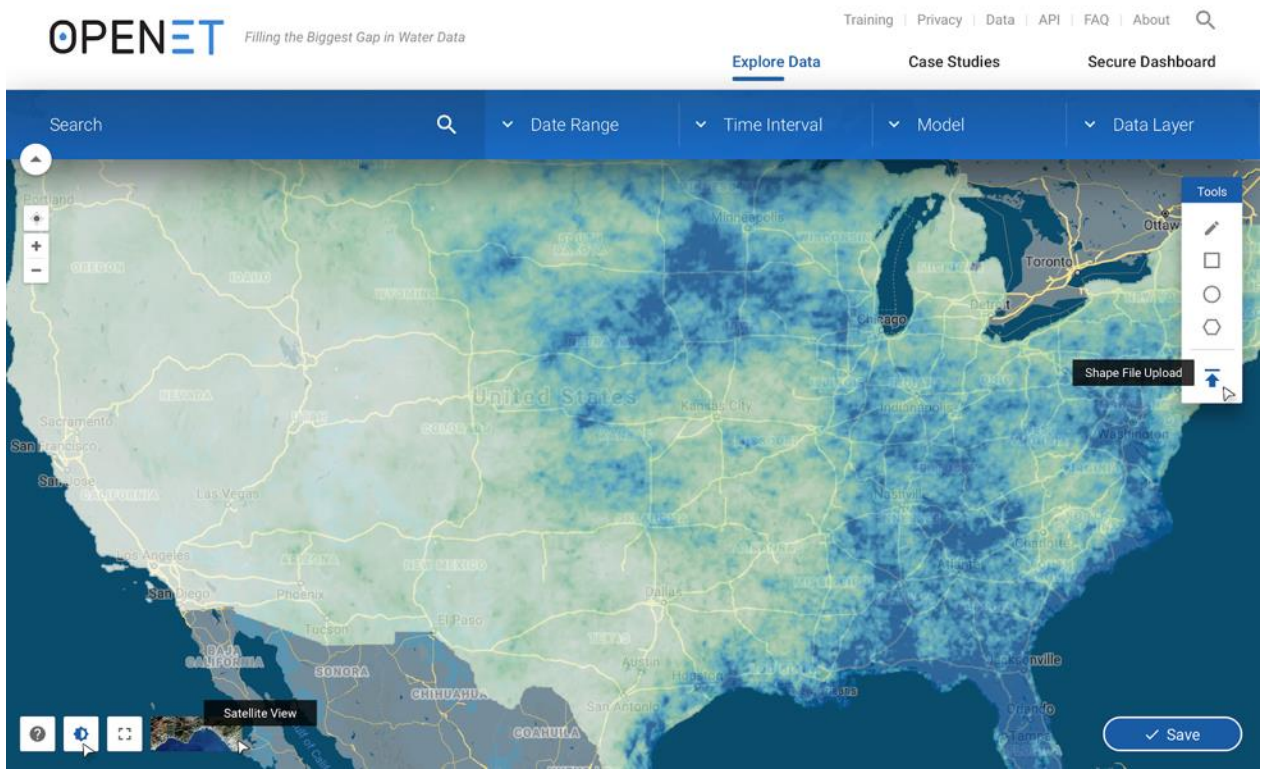
UCANR CropManage



California Almond Sustainability Program

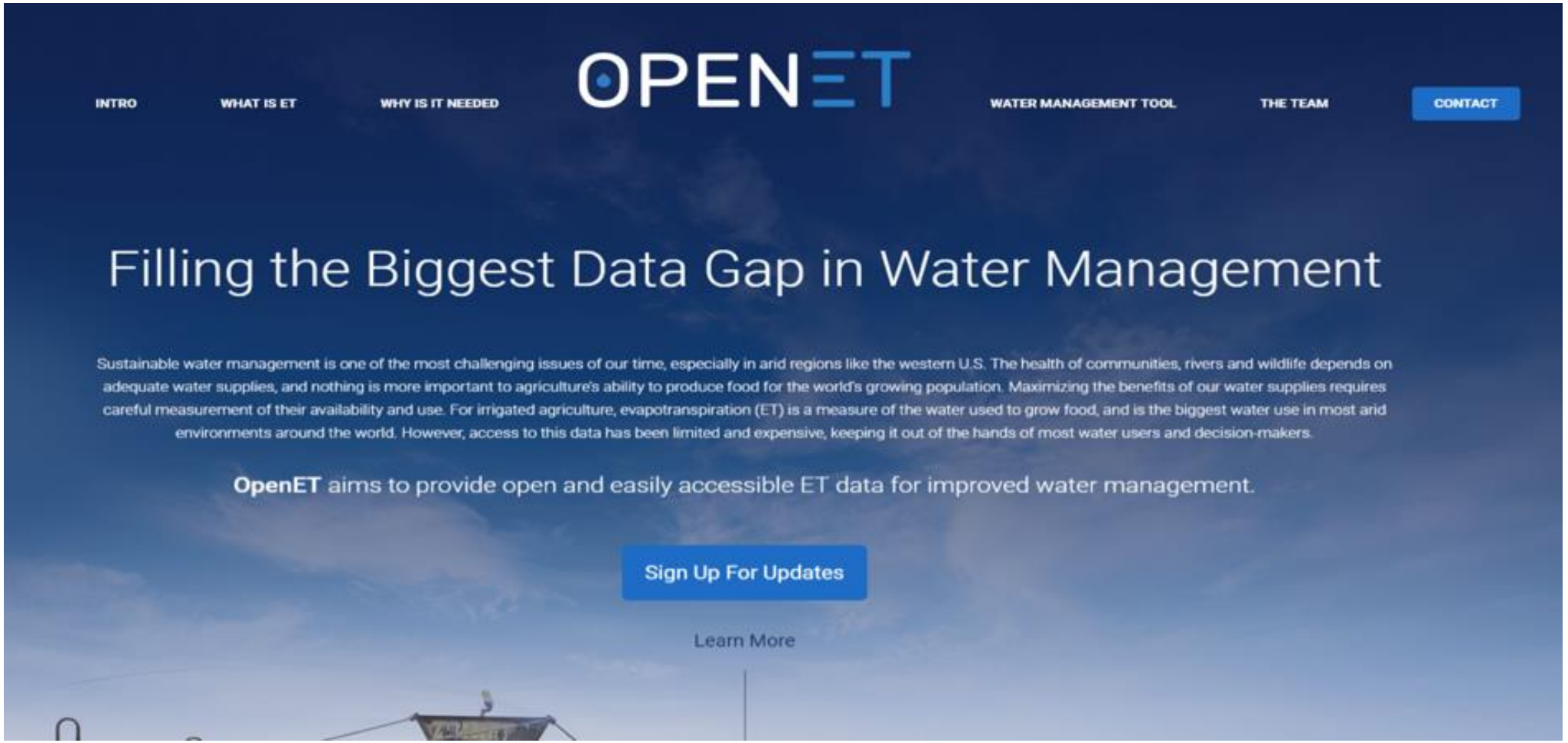
OPENET

How will OpenET help growers?



- Documentation and reporting
- Incentive-driven conservation programs
- Water trading
- Evaluation of commercial data products
- Improve public understanding of the value of water for agriculture and water use by natural ecosystems

etdata.org


INTRO
WHAT IS ET
WHY IS IT NEEDED
OPENET
WATER MANAGEMENT TOOL
THE TEAM
CONTACT
Filling the Biggest Data Gap in Water Management
Sustainable water management is one of the most challenging issues of our time, especially in arid regions like the western U.S. The health of communities, rivers and wildlife depends on adequate water supplies, and nothing is more important to agriculture's ability to produce food for the world's growing population. Maximizing the benefits of our water supplies requires careful measurement of their availability and use. For irrigated agriculture, evapotranspiration (ET) is a measure of the water used to grow food, and is the biggest water use in most arid environments around the world. However, 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 provide open and easily accessible ET data for improved water management.
Sign Up For Updates
Learn More

OpenET Team

Environmental Defense Fund: Robyn Grimm, Maurice Hall, Dana Rollinson

Google Earth Engine: Tyler Erickson

SIMS Team (NASA, CSUMB): Forrest Melton, Alberto Guzman and Lee Johnson

METRIC / EE Flux (The Desert Research Institute and U. Nebraska): Justin Huntington, Rick Allen, Charles Morton, Ayse Kilic

ALEXI / disALEXI Team (USDA, NASA, U. Maryland, U.Wisconsin): Christopher Hain, Martha Anderson, Mitch Scull, Yun Yang, Mutlu Ozdogan

SSEBop Team (USGS): Gabriel Senay, Mac Friedrichs

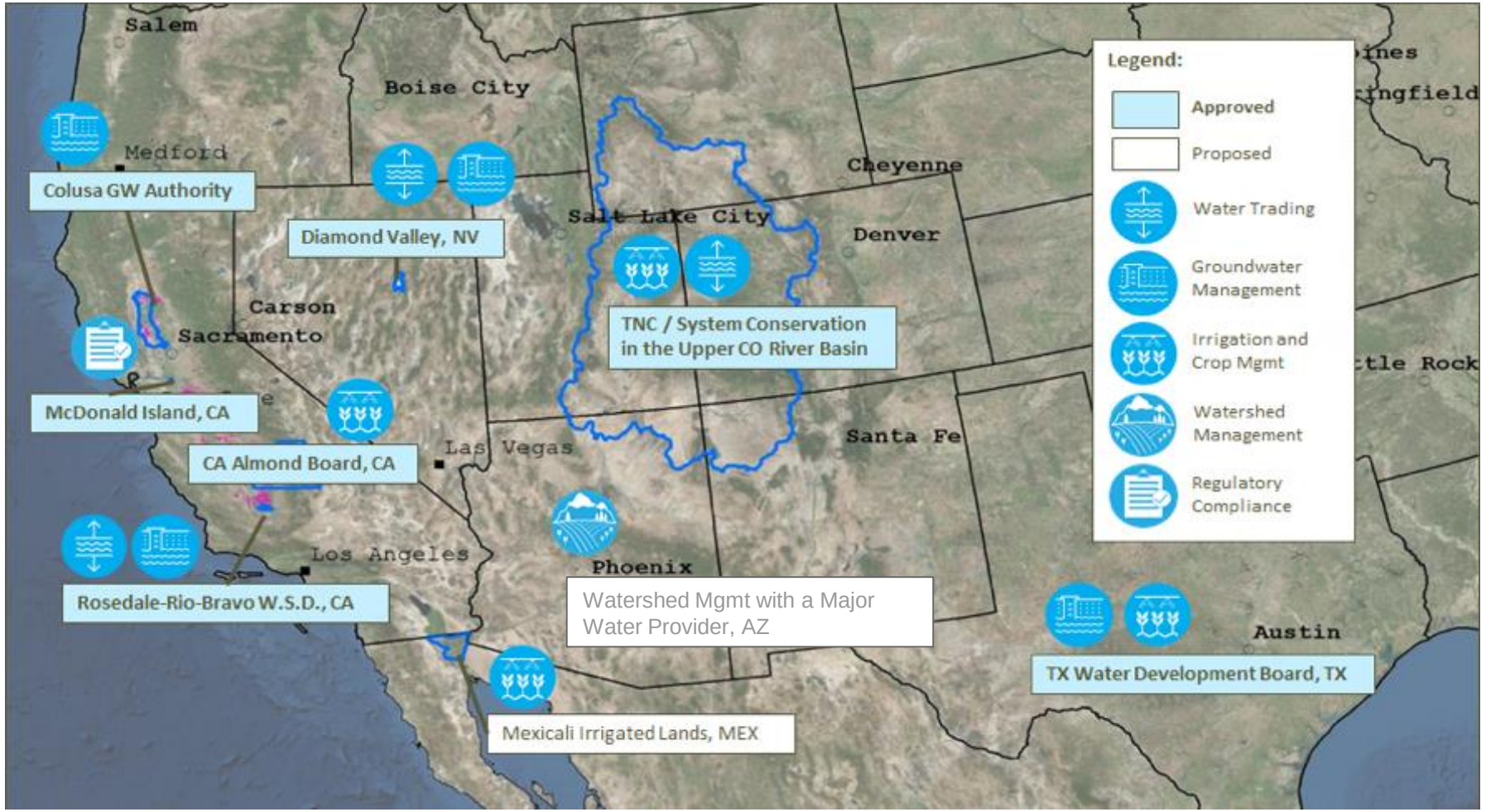
Priestley-Taylor JPL Team (NASA JPL Team): Josh Fisher, Greg Halverson

SEBAL Team (UNESCO IHE): Wim Bastiaanssen, Tim Hessels, Janna von Opstal

Multimodel Development, Integration, API, WebDev: Charles Morton (DRI), Britta Daudert (DRI), Jordan Harding (HabitatSeven), Jamie Herring (HabitatSeven)

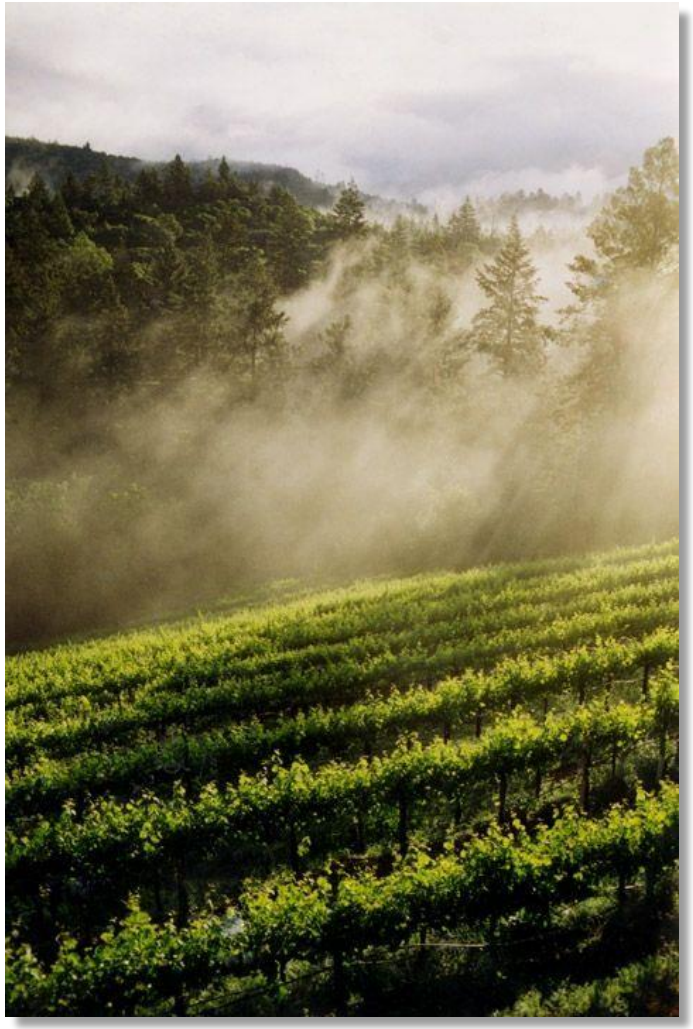
Back-up

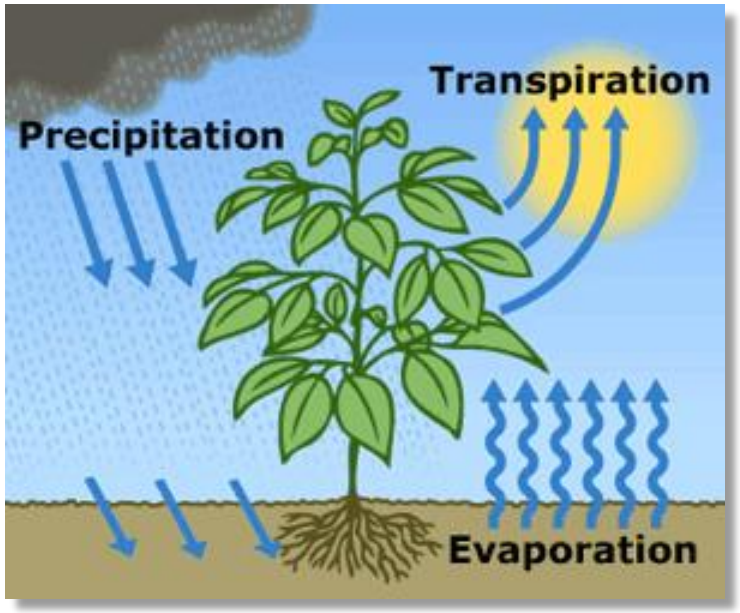
OpenET Use Cases will Guide Development

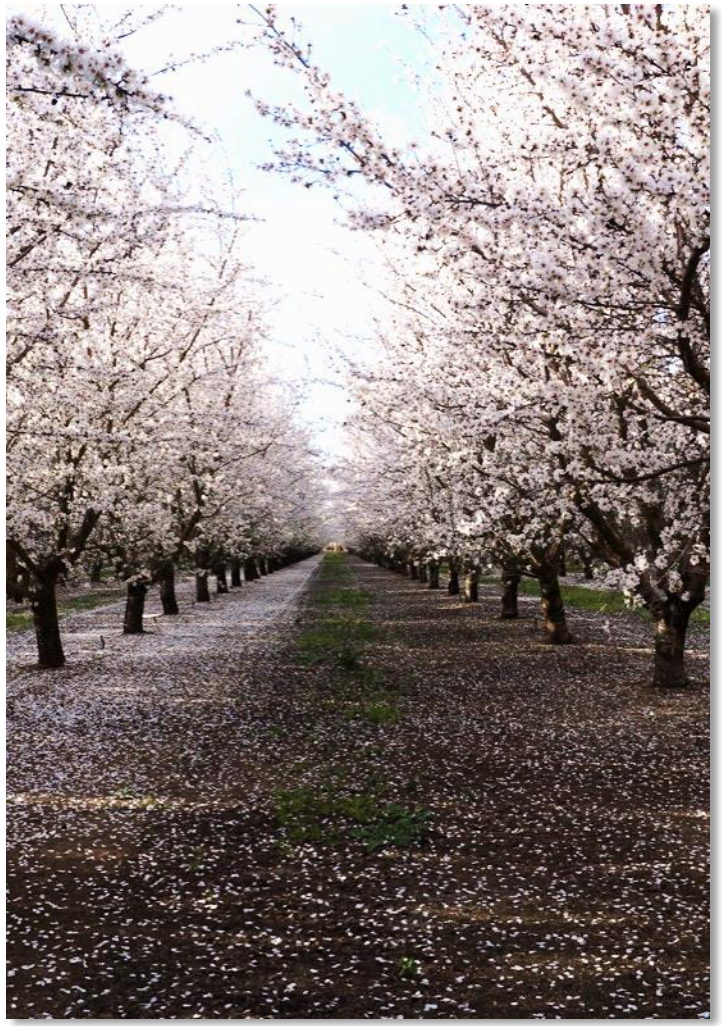


OPENET

Evapotranspiration (ET)

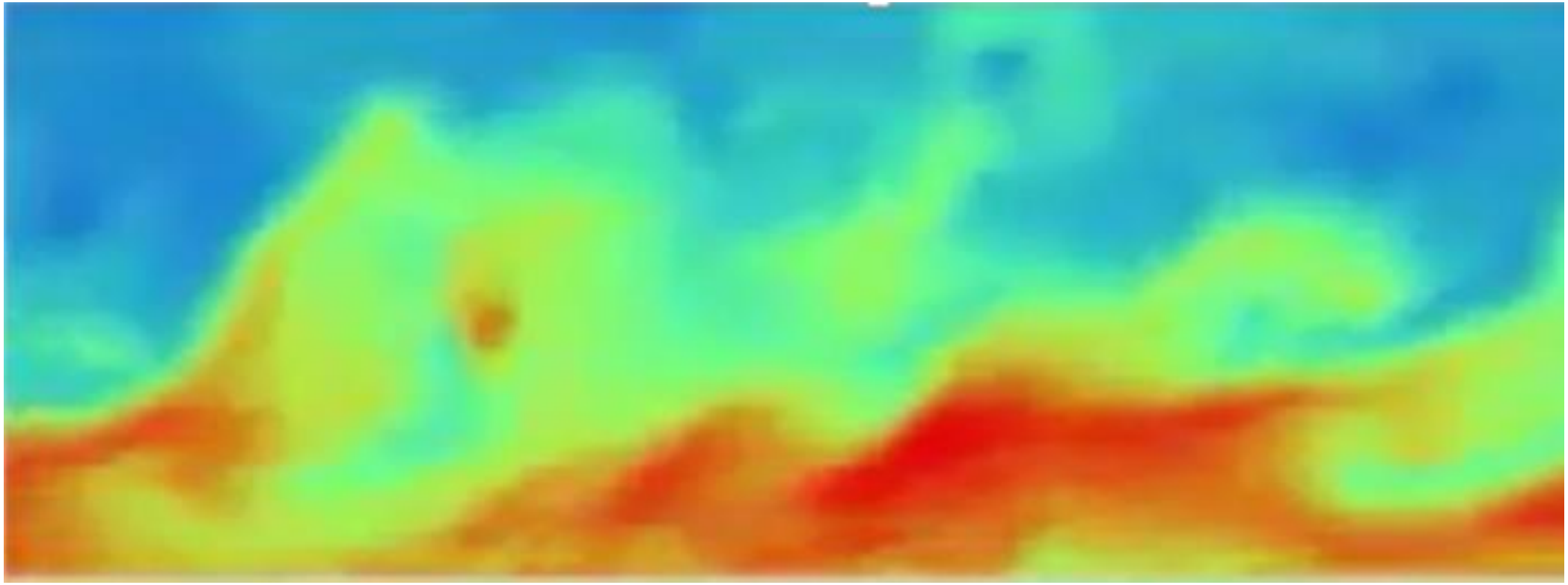






OPENET

The answer is blowin’ in the wind: evaluating how well surface renewal measures almond ET



Andrew J. McElrone; ajmcelrone@ucdavis.edu

USDA UC DAVIS UNIVERSITY OF CALIFORNIA

Evapotranspiration (ET): Evaporation + Transpiration

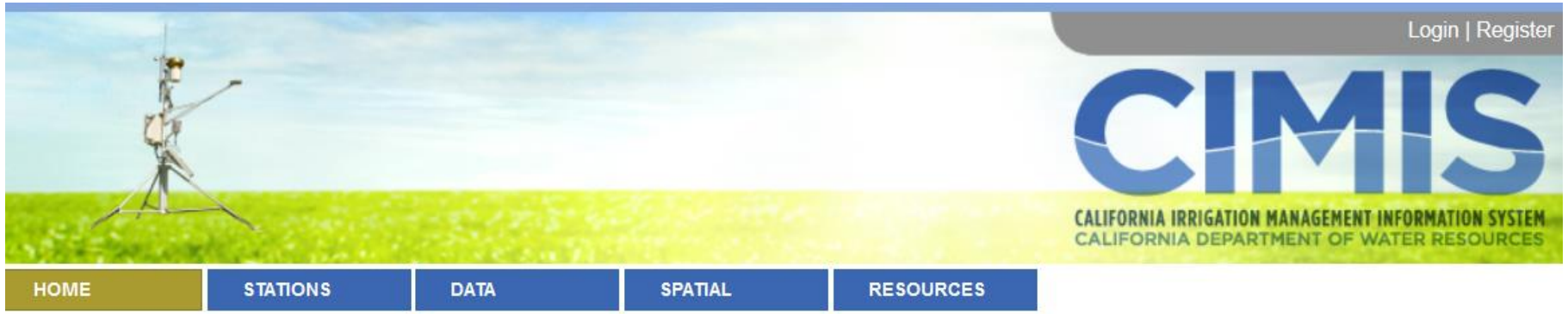
Integrates soil, plant and atmosphere

Irrigation management→ how much & when?

Water lost: replacement needs

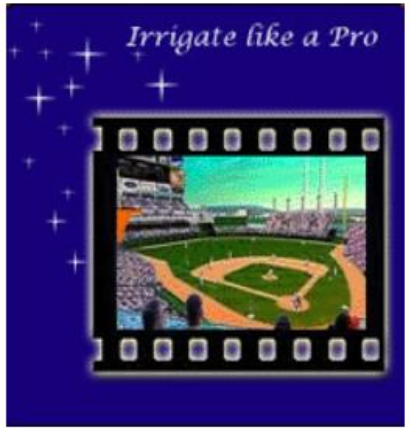
Detect crop stress: push thresholds to achieve water savings and other outcomes

California Irrigation Management Information System



NOTICES

Dropdown menu not working? Please add this website to your browser's Compatibility View settings.



Overview | Getting Started | CIMIS Staff | System News | FAQs

printer friendly version

CIMIS Overview

The following sections give a brief overview of CIMIS. Sections include the following: Introduction; Data Collection, Transmission, and Processing; Data Retrieval by Users; ETo Maps (Spatial CIMIS); and Trends in CIMIS Data Use. Please click on the arrow to the right of each title below to access the section.

Introduction

The California Irrigation Management Information System (CIMIS) is a program unit in the Water Use and Efficiency Branch, Division of Statewide Integrated Water Management, California Department of Water Resources (DWR) that manages a network of over 145 automated weather stations in California. CIMIS was developed in 1982 by DWR and the University of California, Davis (UC Davis). It was designed to assist irrigators in managing their water resources more efficiently. Efficient use of water resources benefits Californians by saving water, energy, and money.

Data Collection, Transmission, and Processing

Data Retrieval by Users

ETo Maps (Spatial CIMIS)

Trends in CIMIS Data Users

California Irrigation Management Information System

$$ET_c = K_c * ET_o$$

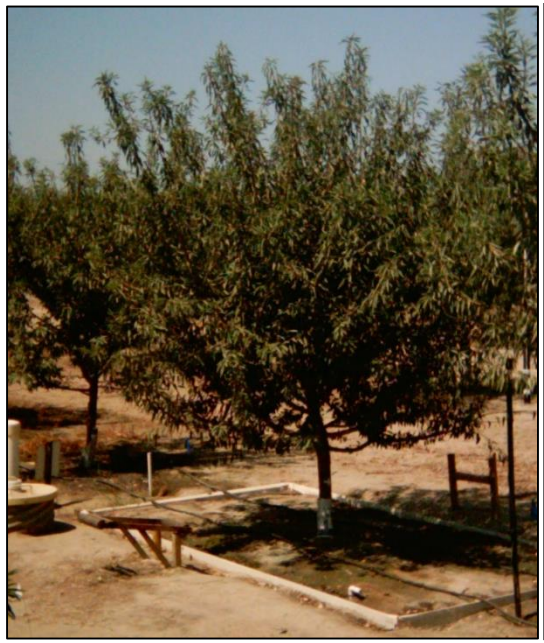
Tree/Vine evapotranspiration

Crop coefficient

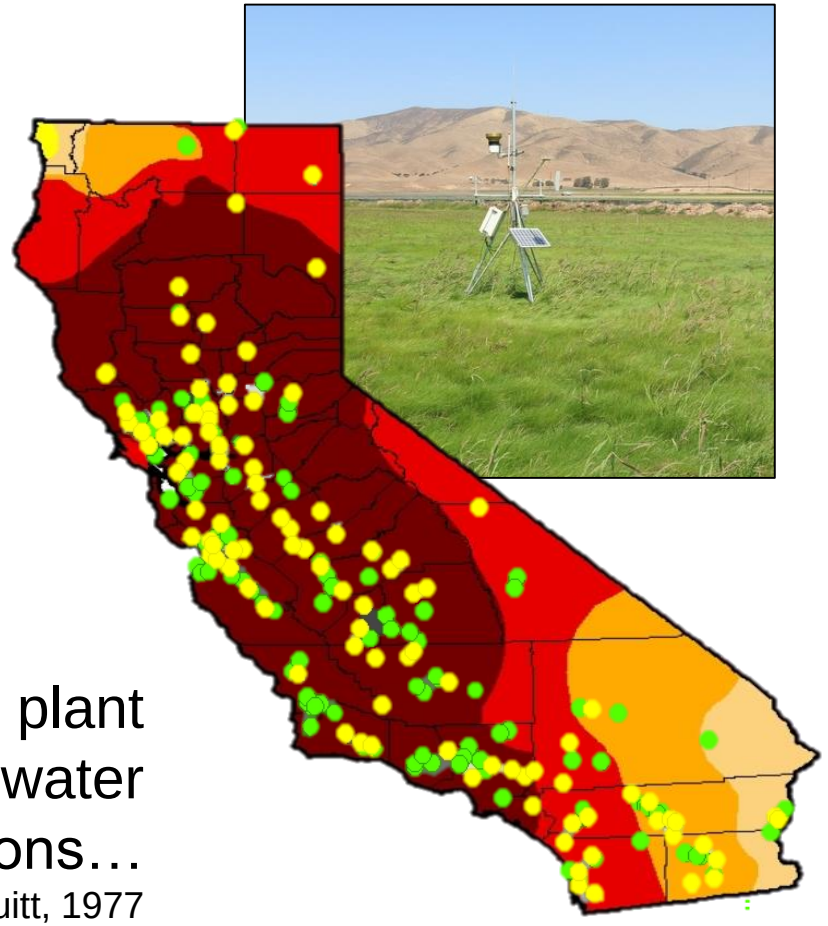
Reference ET (well-watered model grass)

$$K_c = ET_c / ET_o$$

Obtained from plants in weighing lysimeter



Kearney Agricultural Center
Univ. of California- Parlier CA



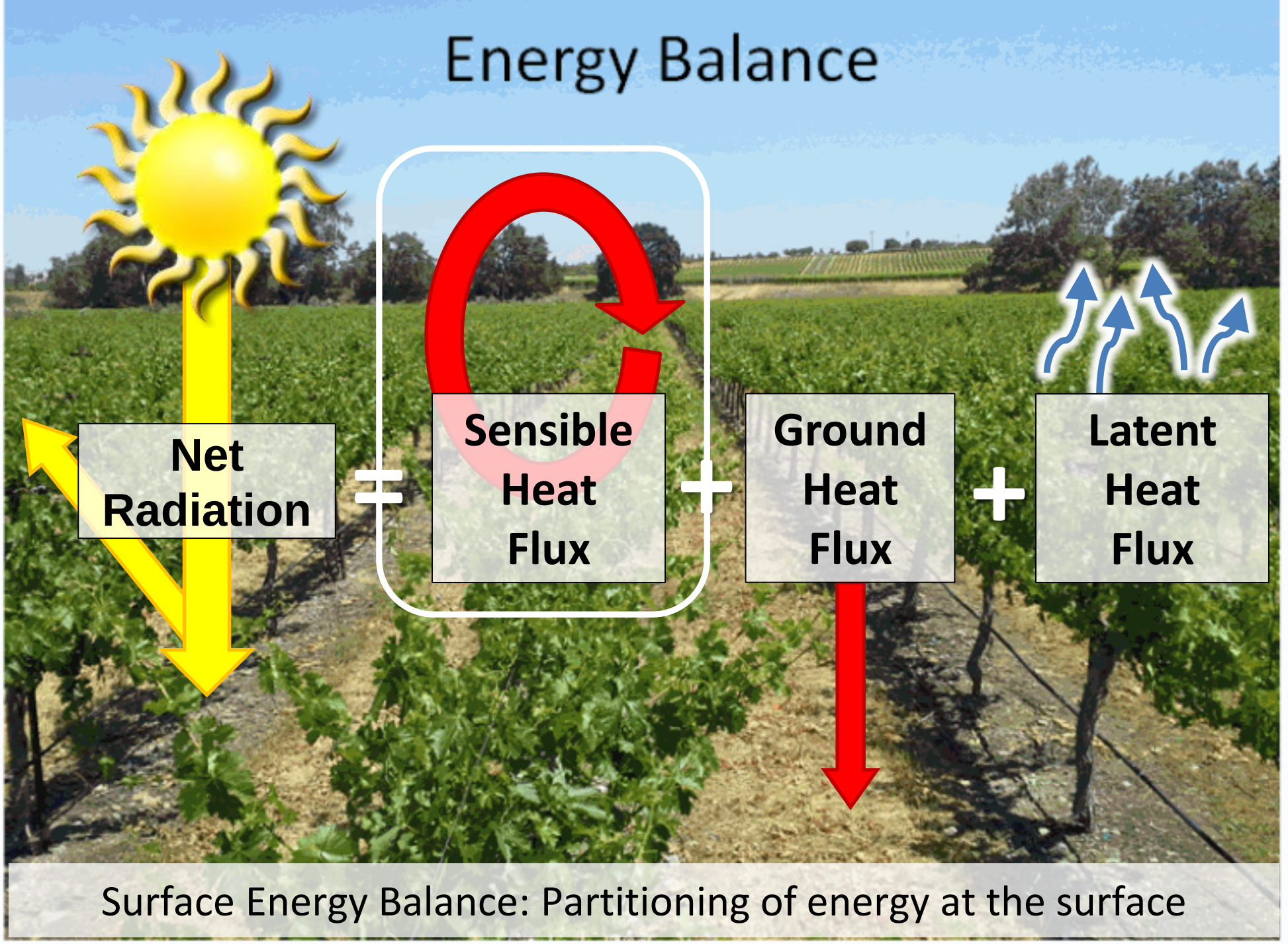
…assumes a disease-free plant grown under optimum soil water and nutrient conditions…

Doorenbos and Pruitt, 1977

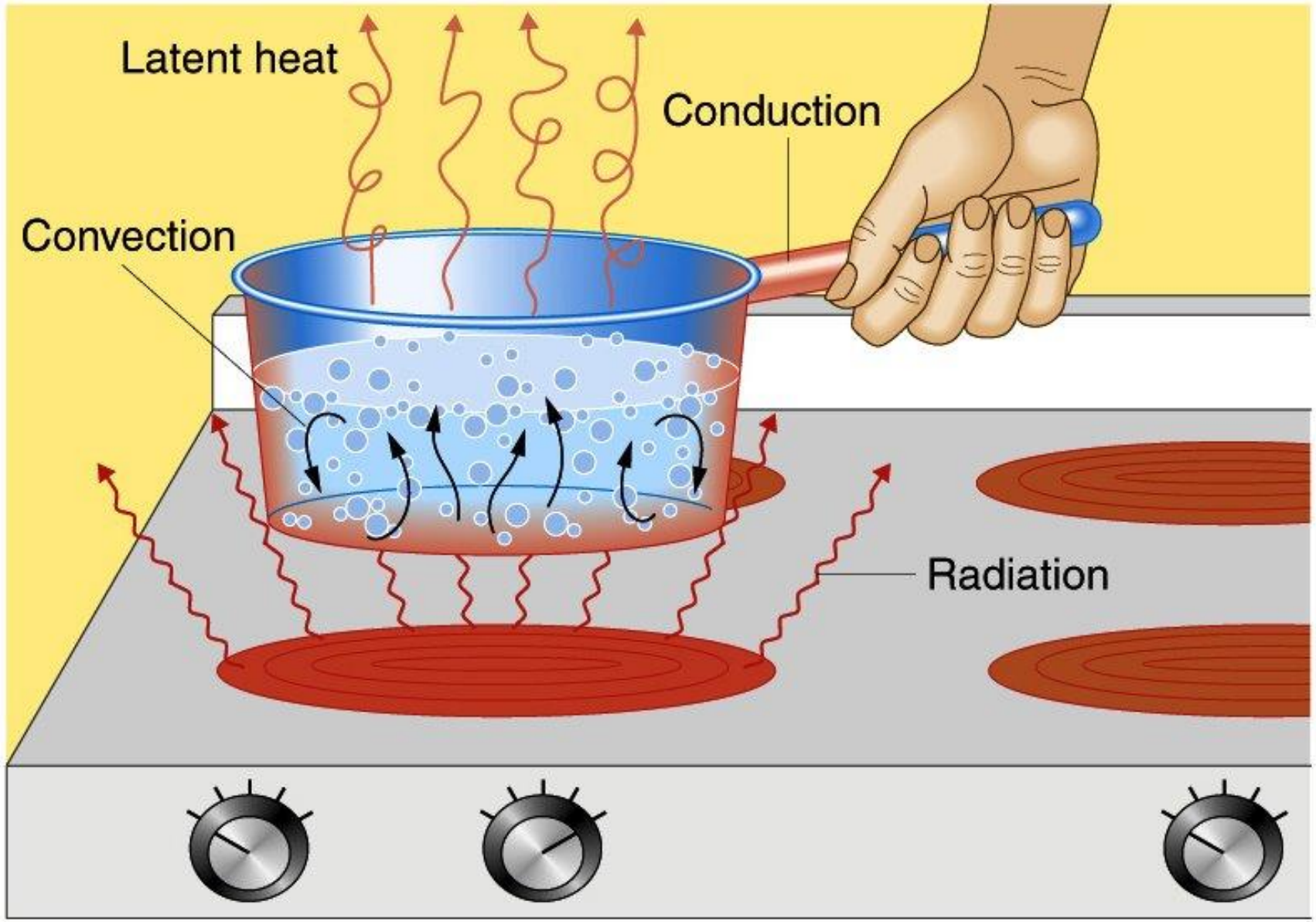
Goal: inexpensive, site-specific measurement of actual crop water use (replace CIMIS)

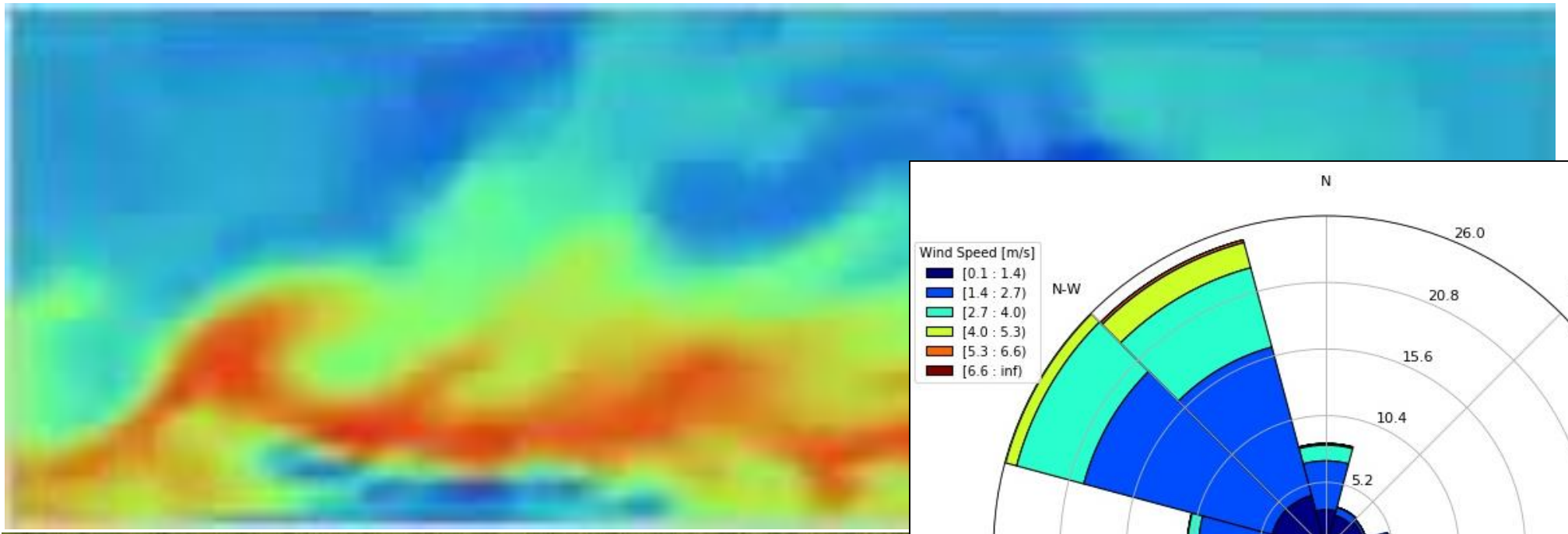
Surface Renewal

Paw U & collaborators 1989, 1991, 1995


Energy Balance
Net Radiation
=
Sensible Heat Flux
+
Ground Heat Flux
+
Latent Heat Flux
Surface Energy Balance: Partitioning of energy at the surface

Energy cannot be created nor destroyed





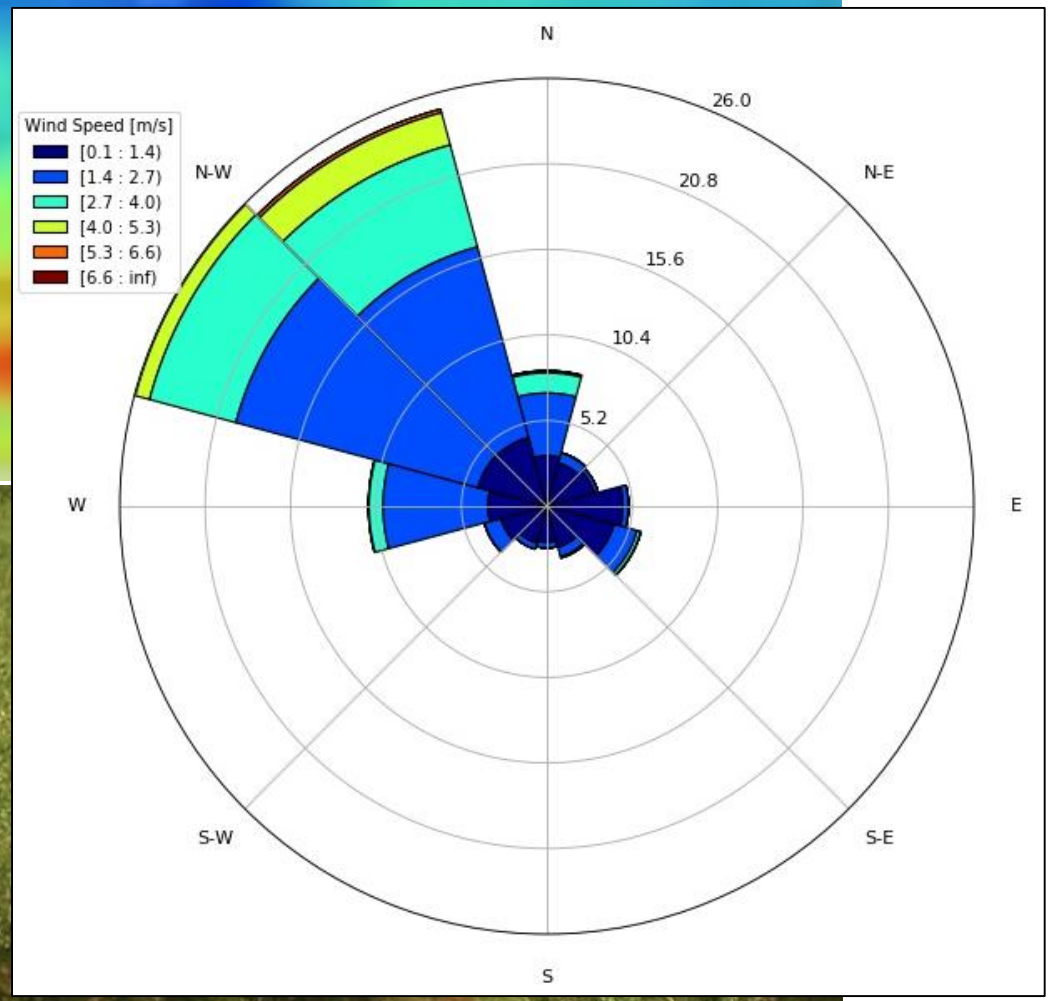
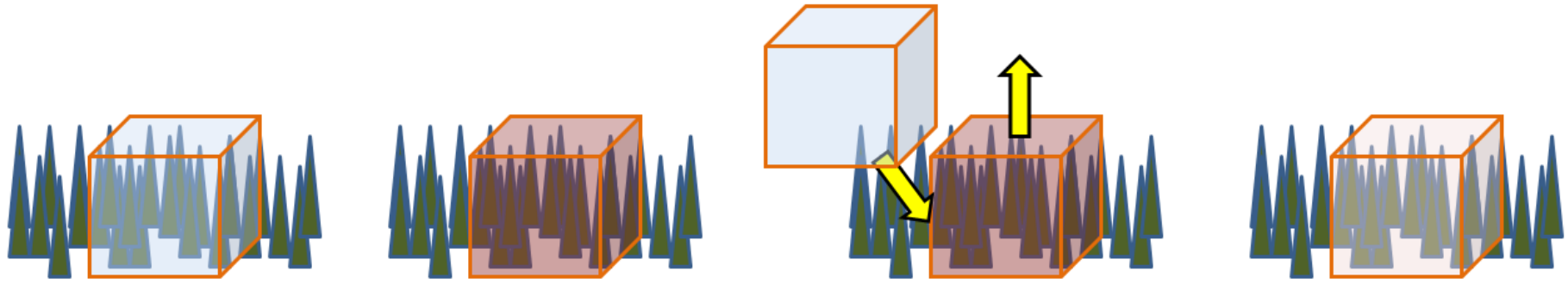
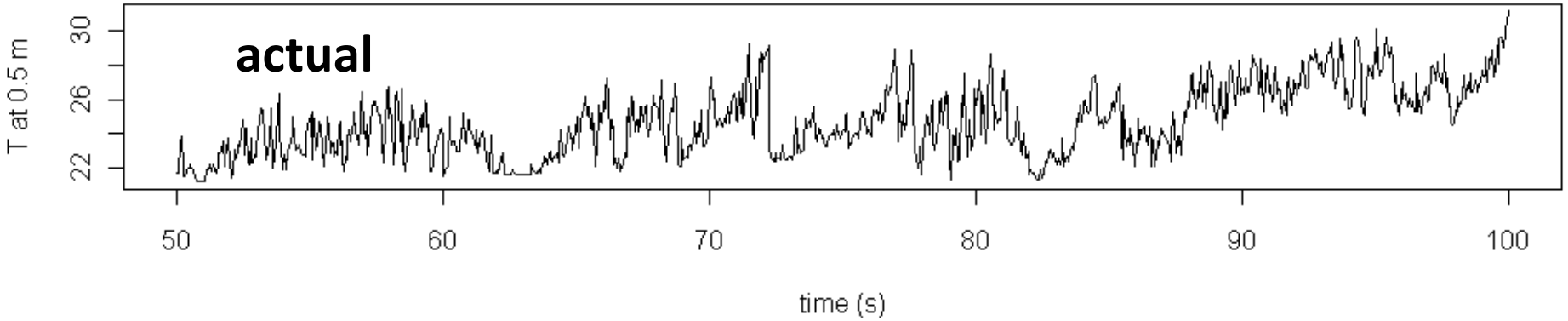

N
N-E
E
S-E
S
S-W
W
N-W
26.0
20.8
15.6
10.4
5.2
Wind Speed [m/s]
[0.1 : 1.4)
[1.4 : 2.7)
[2.7 : 4.0)
[4.0 : 5.3)
[5.3 : 6.6)
[6.6 : inf)


Image from Irribiz

Surface Renewal- Theory vs. Reality

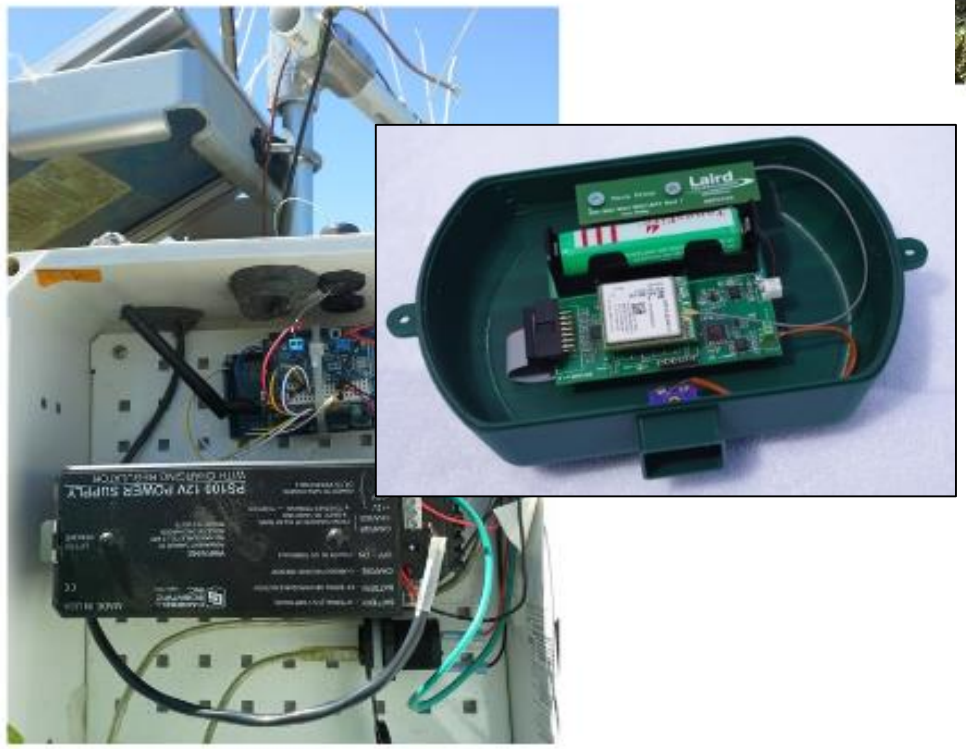




Successfully removed the need to calibrate against expensive research grade system (Shapland et al. 2012a,b, 2014)

Hardware & Software

Expensive
Net Radiometer
vs.
Modelling Net
Radiation

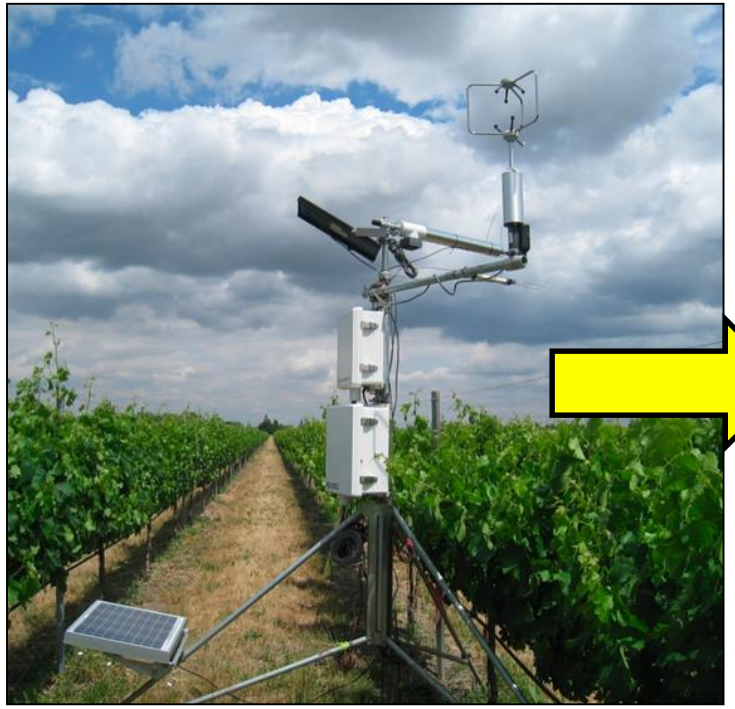


Expensive Dataloggers vs. Arduinos

Expensive Sonic Anemometer
vs. Thermocouple

vs.

New Surface Renewal System:
A reliable & automated ET measurement system



Research Grade System
~$10,000

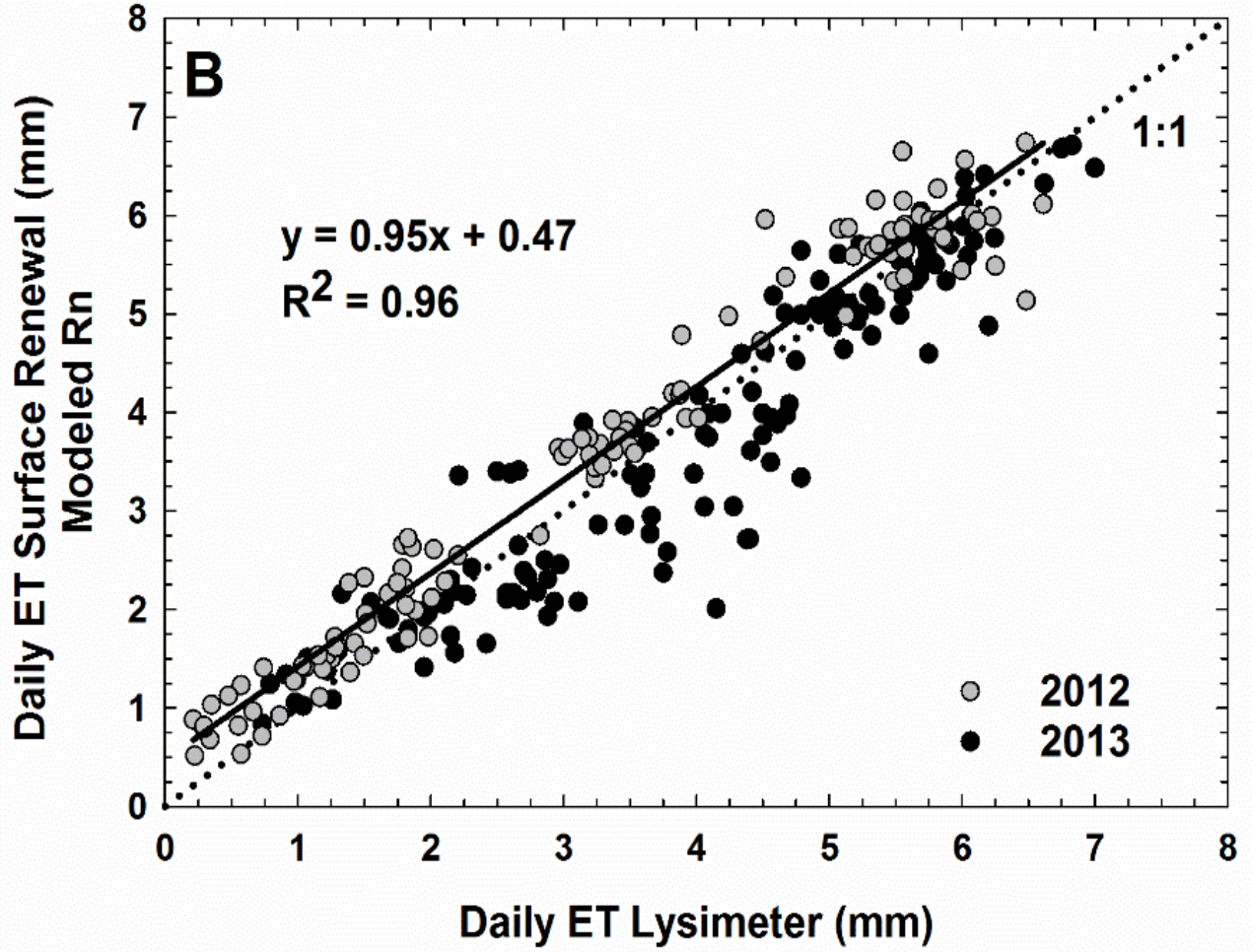
New Commercial System

- **Joint patent between USDA & UC Davis**
- **In 2018, ~2000 stations across varied crops**

Proof of concept (Grapevines):

New Surface Renewal Method vs. Weighing Lysimeter

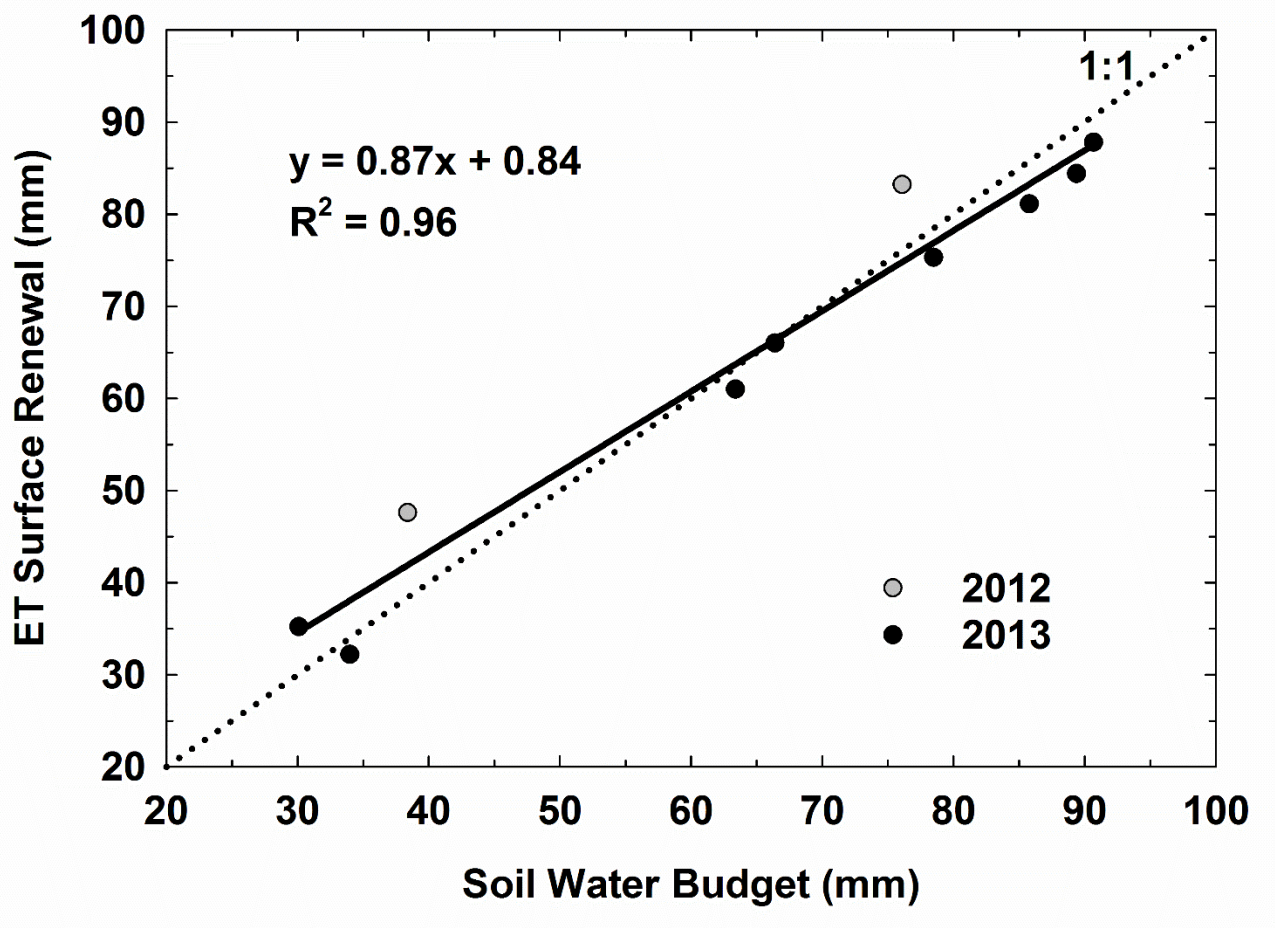
Kearney Agricultural Center
Univ. of California- Parlier CA



Proof of concept (Grapevines):

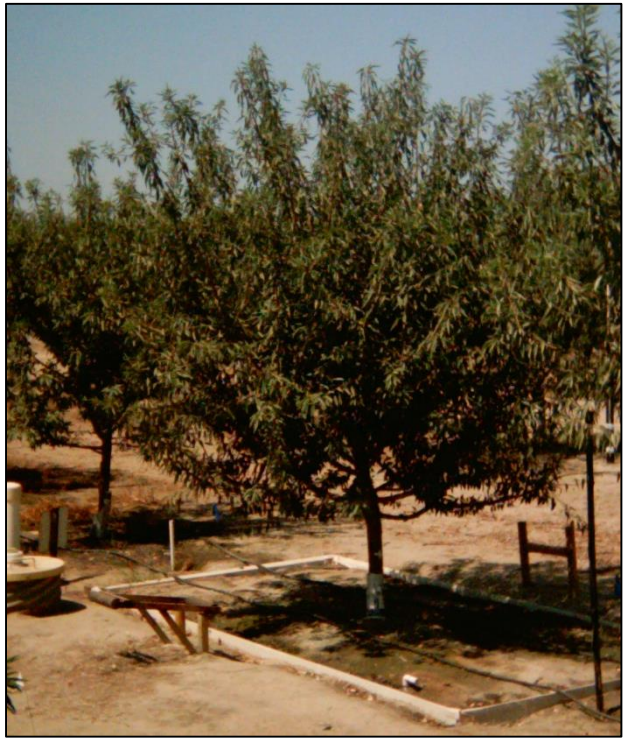
New Surface Renewal Method vs. Soil Water Budget

Kearney Agricultural Center
Univ. of California- Parlier CA

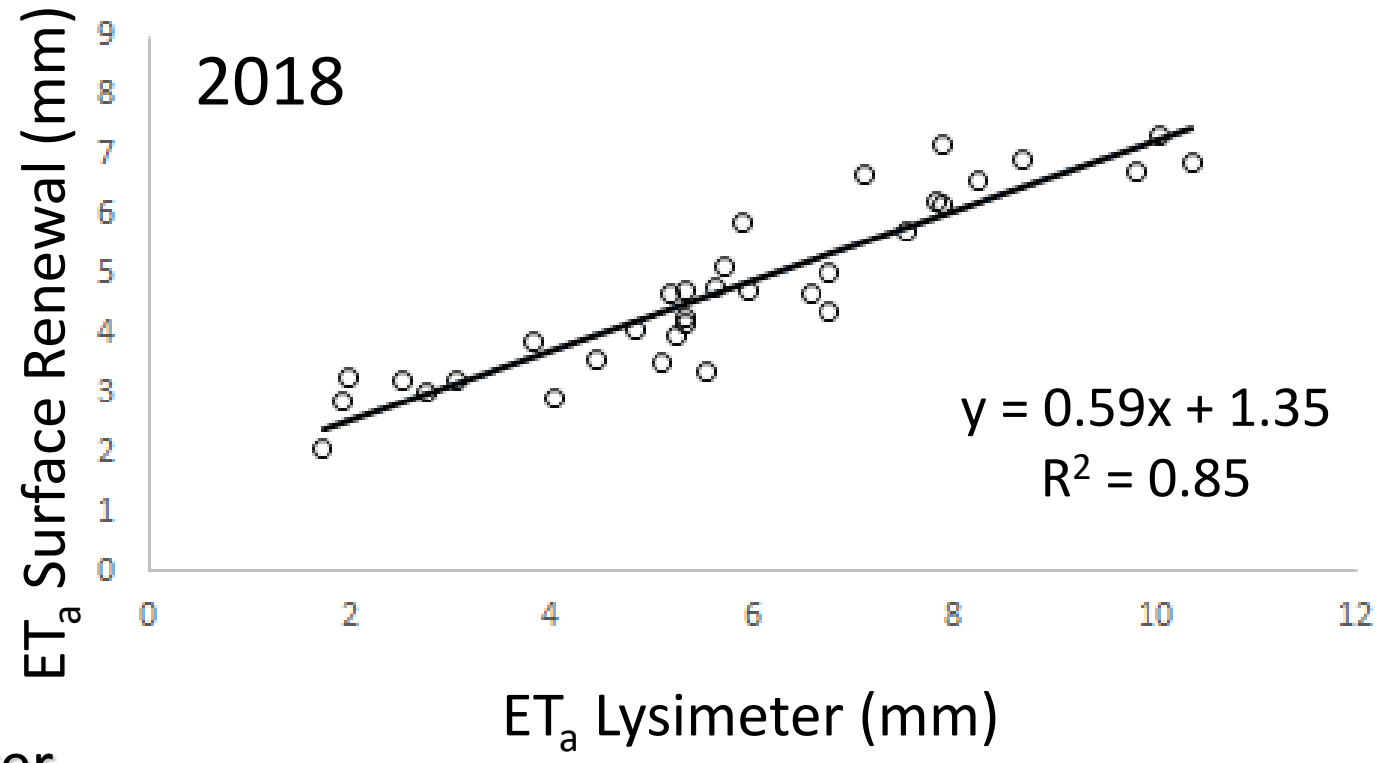


Proof of concept (Almonds):

New Surface Renewal Method vs. Weighing Lysimeter

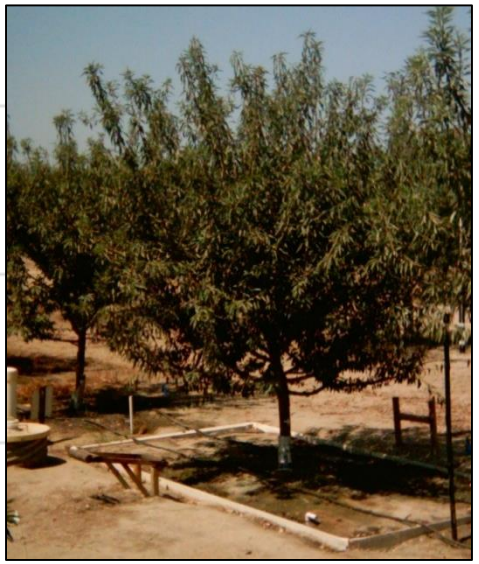


Kearney Agricultural Center
Univ. of California- Parlier CA



New Surface Renewal Method vs. Almond Weighing Lysimeter

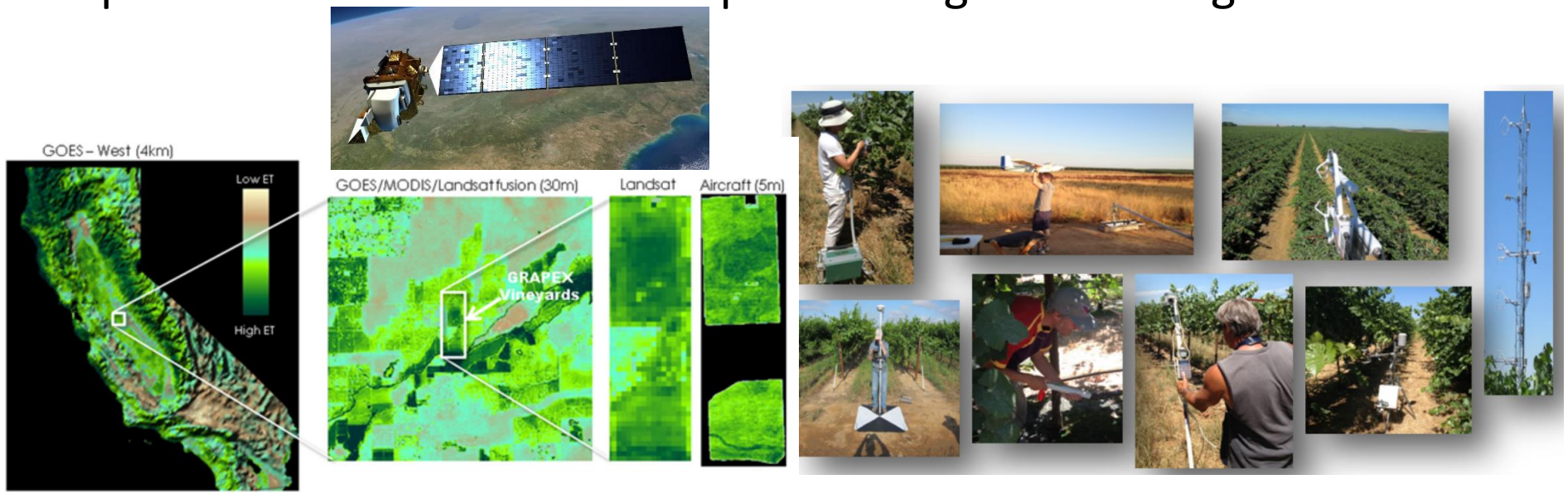
Kearney Agricultural Center, Univ. of California- Parlier CA

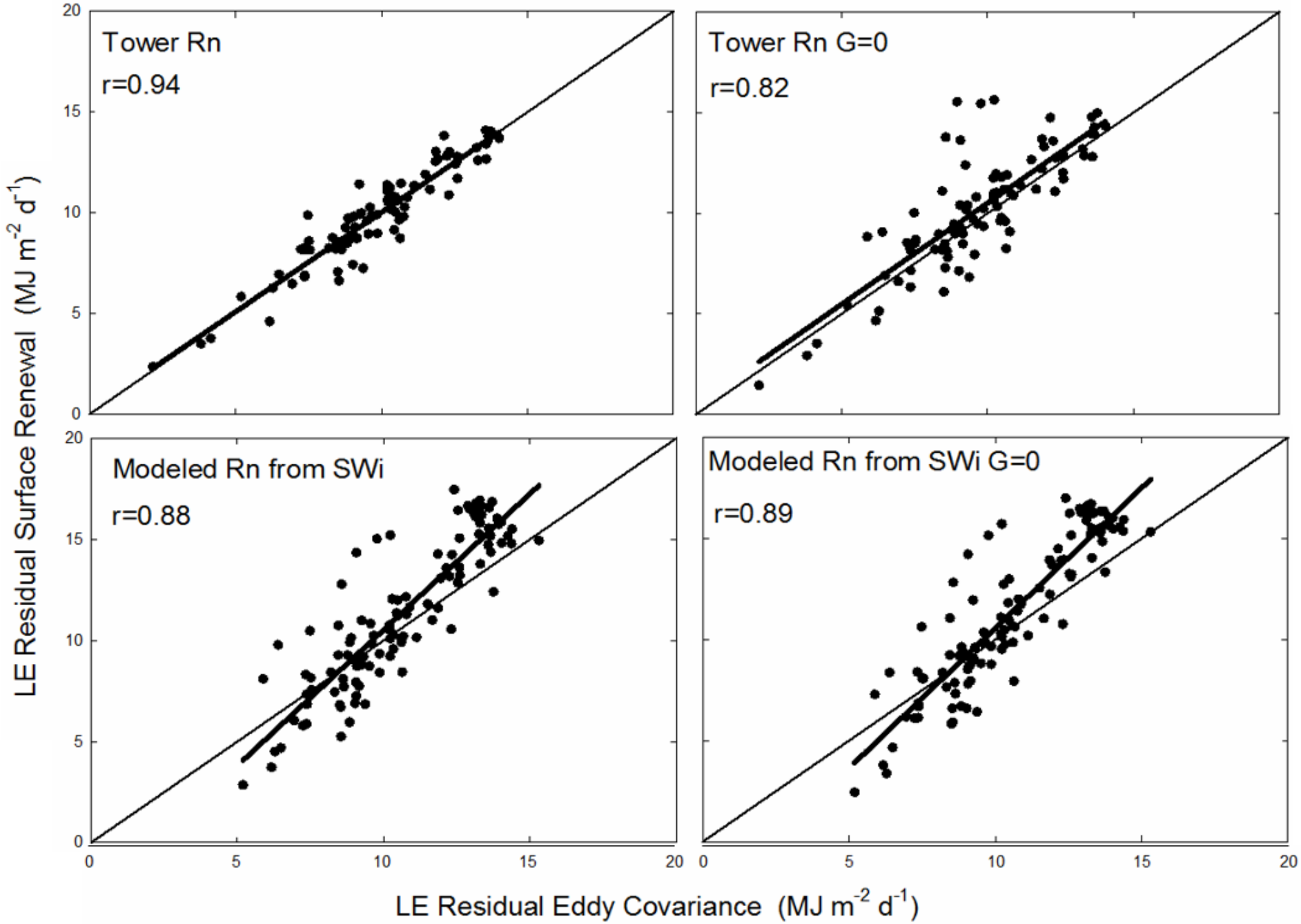


Grape Remote sensing Atmospheric Profile & Evapotranspiration eXperiment

grapex

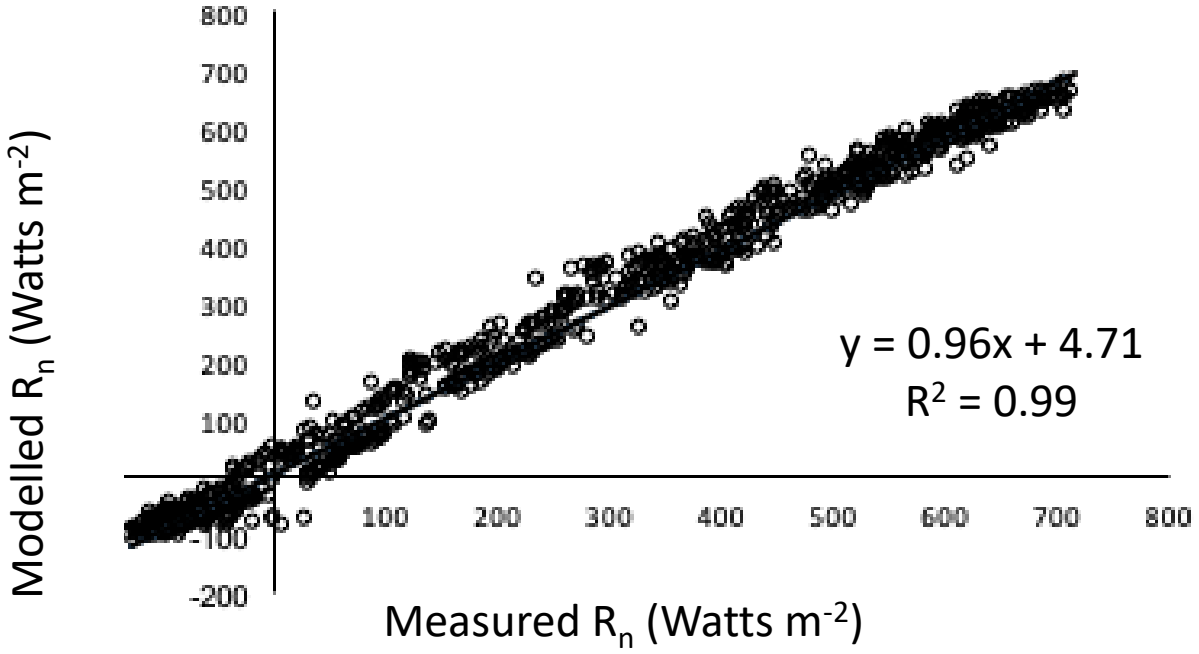
Refine and apply a multi-scale remote sensing ET toolkit for mapping crop water use and stress for improved irrigation management in CA

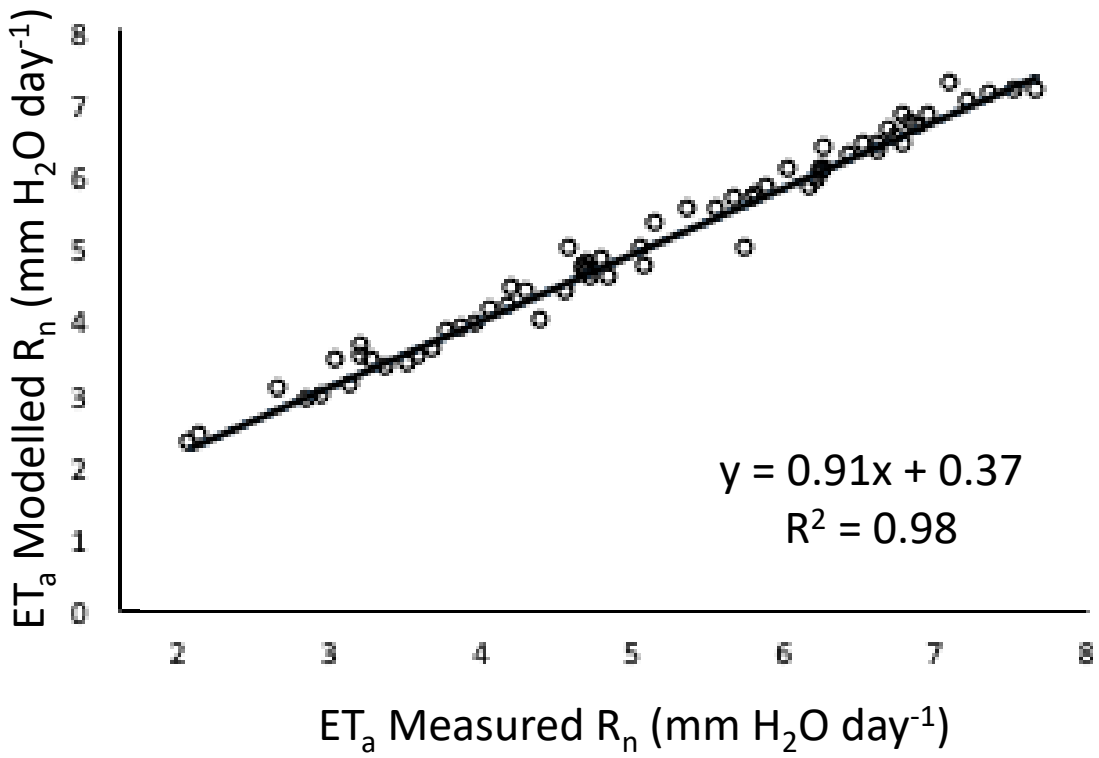



Tower Rn
r=0.94
Tower Rn G=0
r=0.82
Modeled Rn from SWi
r=0.88
Modeled Rn from SWi G=0
r=0.89
LE Residual Surface Renewal (MJ m-2 d-1)
LE Residual Eddy Covariance (MJ m-2 d-1)
0
5
10
15
20

2018 Field Season

Kearney Agricultural Center
Univ. of California- Parlier CA

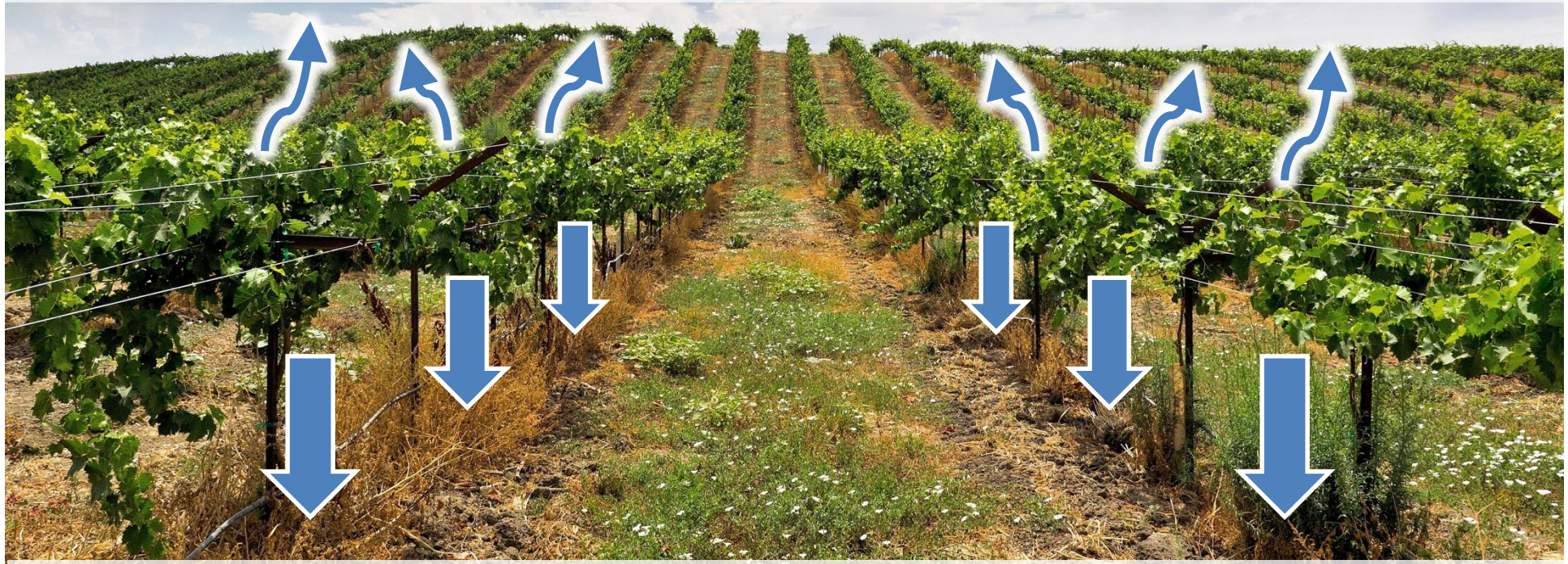




How to use the technology?

Amount lost = amount applied

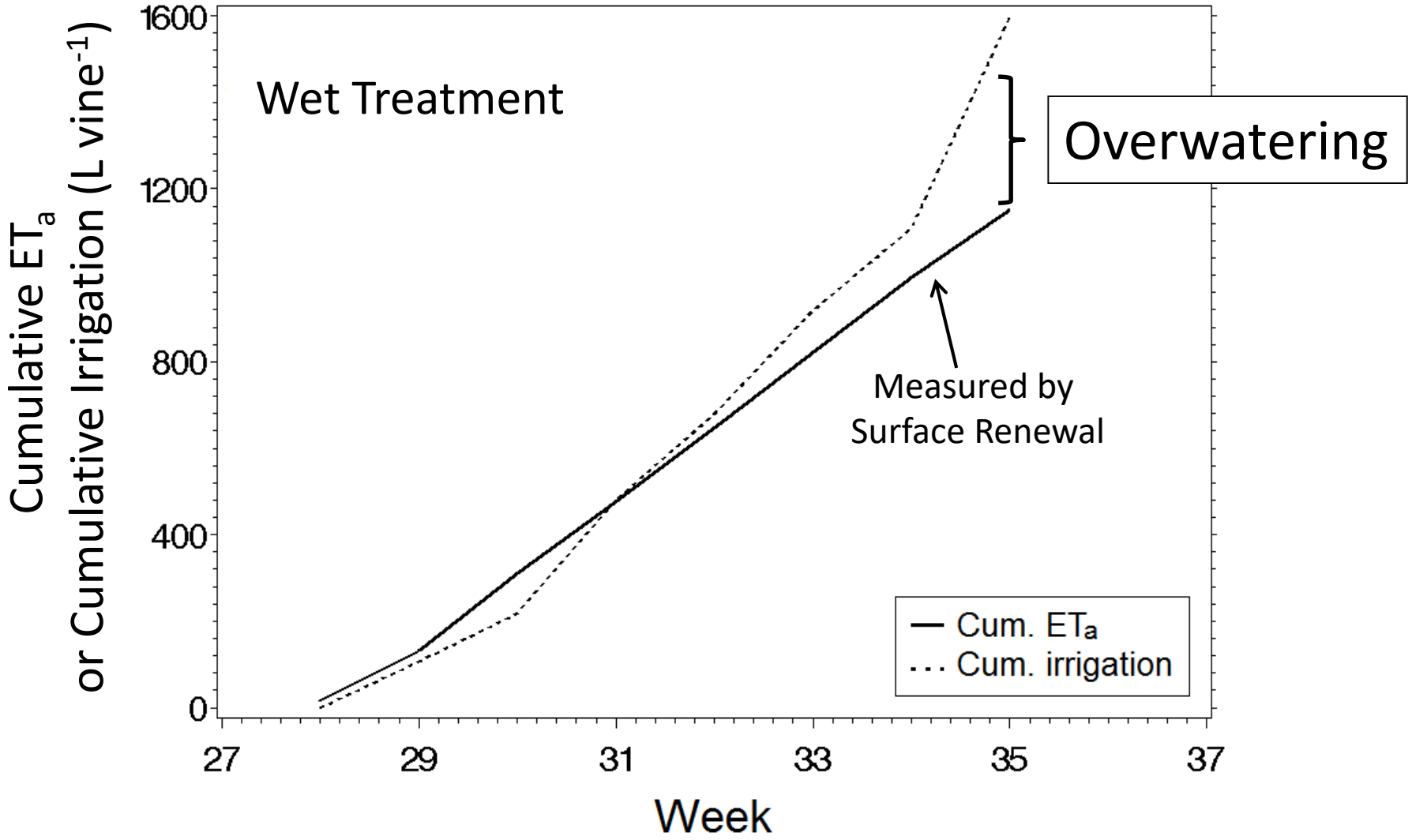
- Not possible previously on a site by site basis
- As if there is a weighing lysimeter at each site



- Automated reports to users– layered approach
- One, simple actionable number: Pump run time

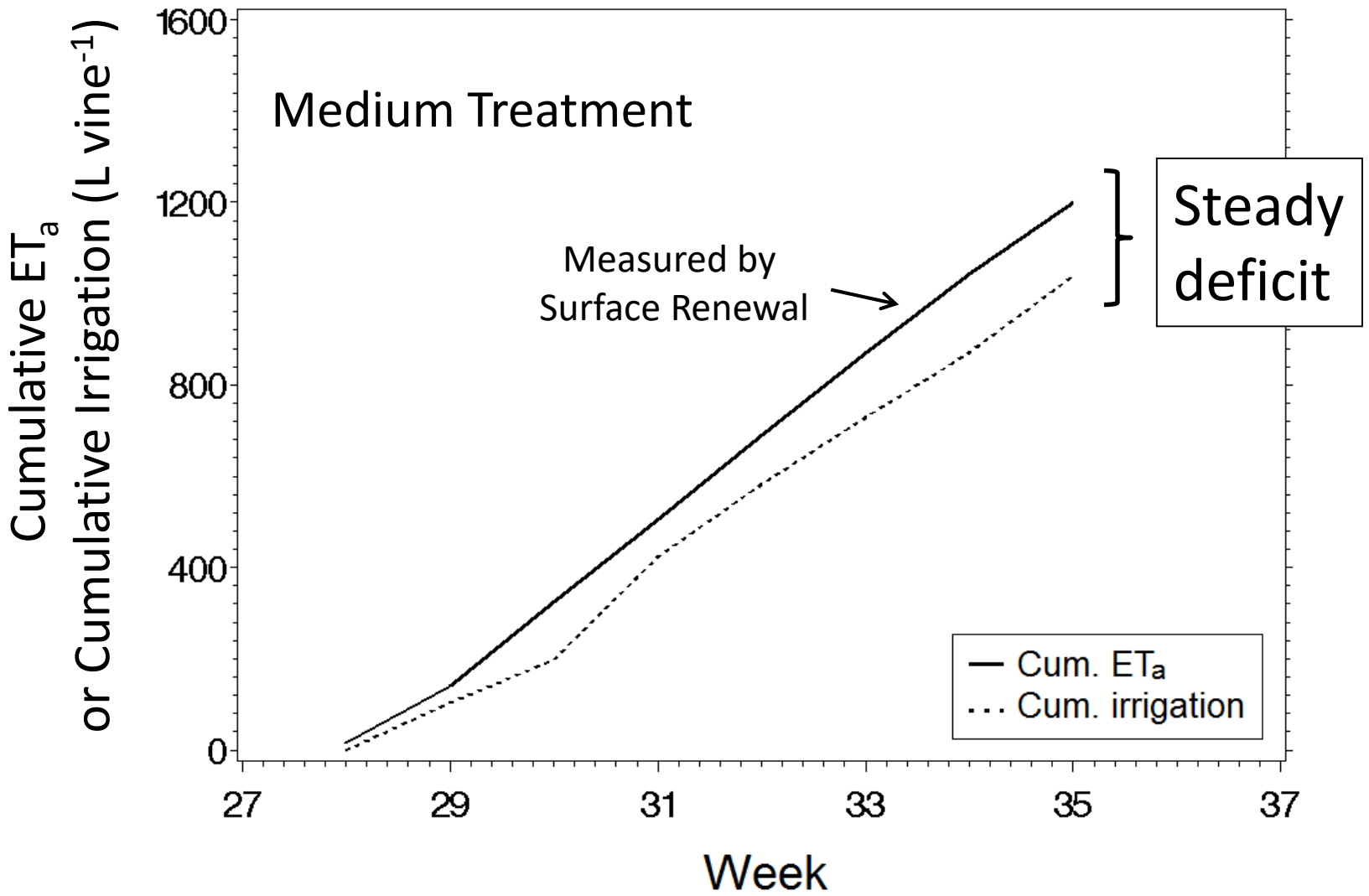
How to use the technology?

Targeted deficit based on actual water use



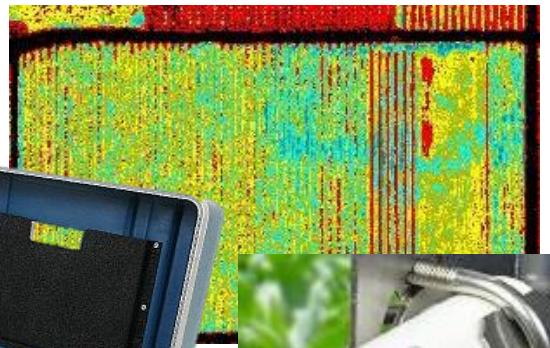
How to use the technology?

Targeted deficit based on actual water use



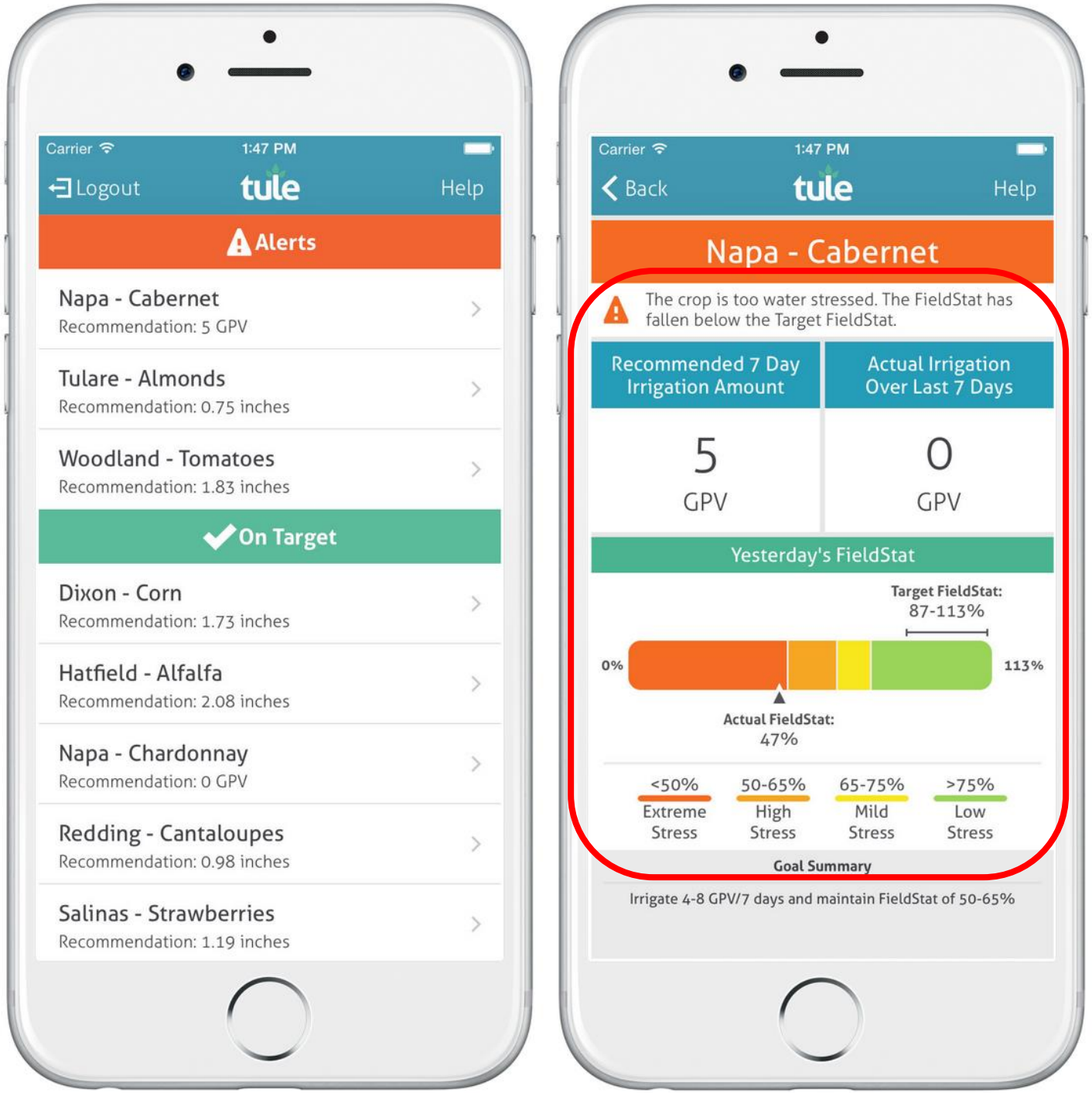
Irrigation management→ how much & when?

Image from Irribiz

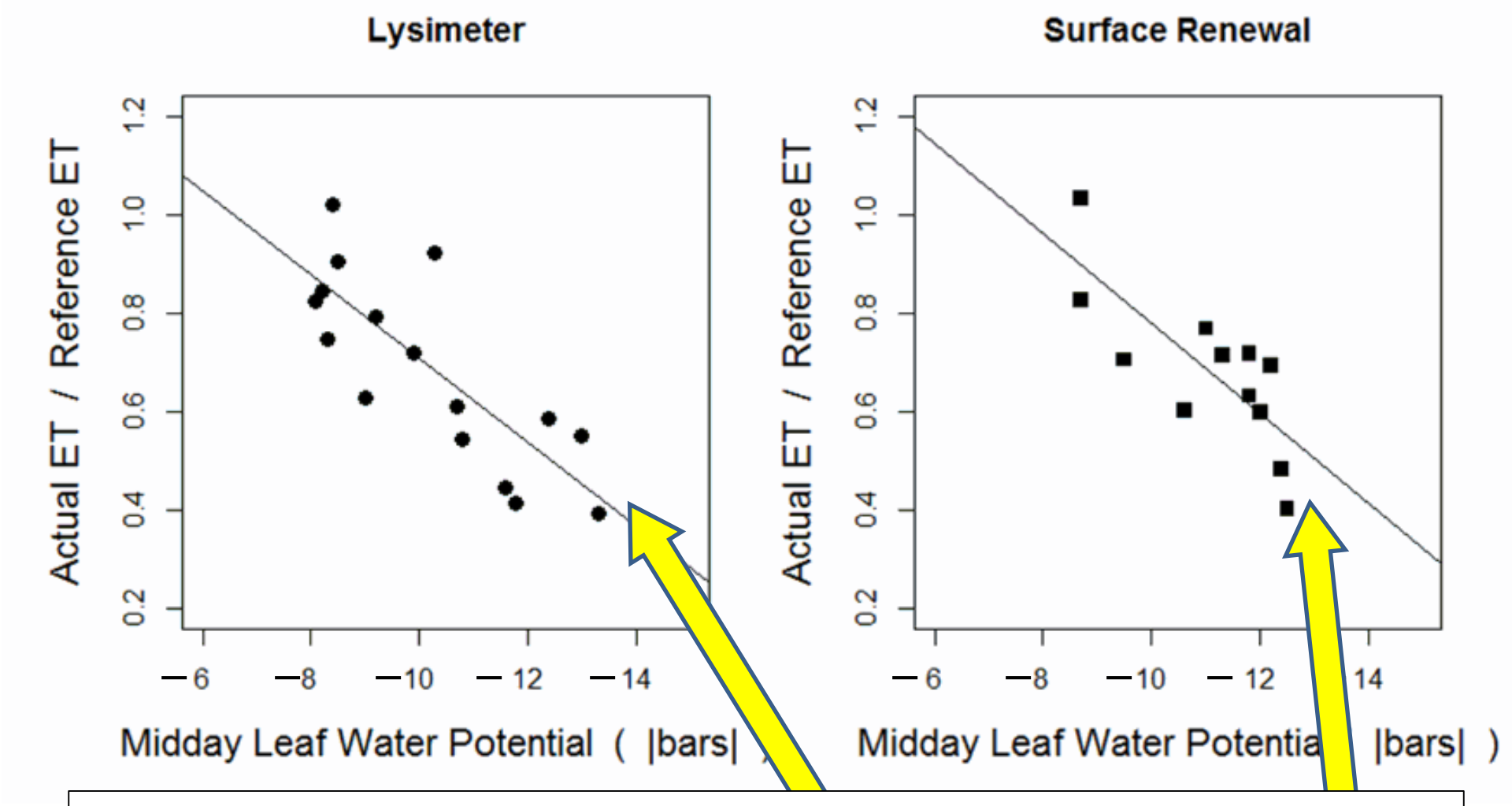


Can SR be used to measure water use AND detect crop stress?

$$\frac{\text{Actual ET}}{\text{Reference ET}_O}$$


Carrier
1:47 PM
Logout
tule
Help
Alerts
Napa - Cabernet
Recommendation: 5 GPV
Tulare - Almonds
Recommendation: 0.75 inches
Woodland - Tomatoes
Recommendation: 1.83 inches
On Target
Dixon - Corn
Recommendation: 1.73 inches
Hatfield - Alfalfa
Recommendation: 2.08 inches
Napa - Chardonnay
Recommendation: 0 GPV
Redding - Cantaloupes
Recommendation: 0.98 inches
Salinas - Strawberries
Recommendation: 1.19 inches
Carrier
1:47 PM
Back
tule
Help
Napa - Cabernet
The crop is too water stressed. The FieldStat has fallen below the Target FieldStat.
Recommended 7 Day Irrigation Amount
Actual Irrigation Over Last 7 Days
5
GPV
0
GPV
Yesterday's FieldStat
Target FieldStat:
87-113%
0%
113%
Actual FieldStat:
47%
<50%
Extreme Stress
50-65%
High Stress
65-75%
Mild Stress
>75%
Low Stress
Goal Summary
Irrigate 4-8 GPV/7 days and maintain FieldStat of 50-65%

Lysimeter Vineyard-Kearney Ag Center



During stress, plants can’t keep up with demand from atmosphere

-1.65 MPa

-1.63 MPa

-1.36 MPa

-1.61 MPa

-1.35 MPa

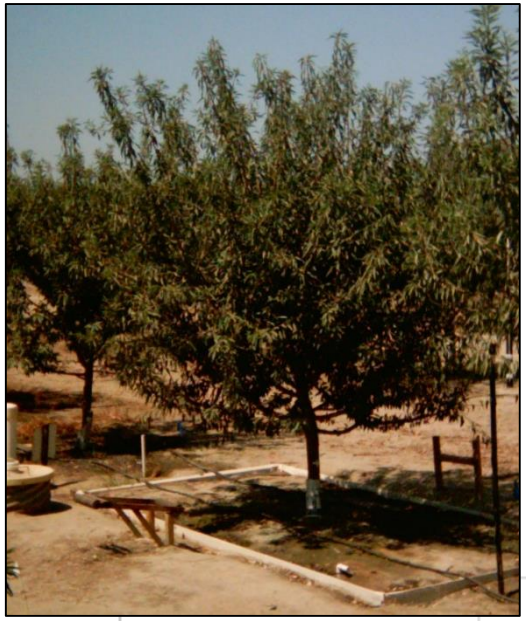
ETa (gallons/vine)

Irrigation (gallons/vine)

July 9

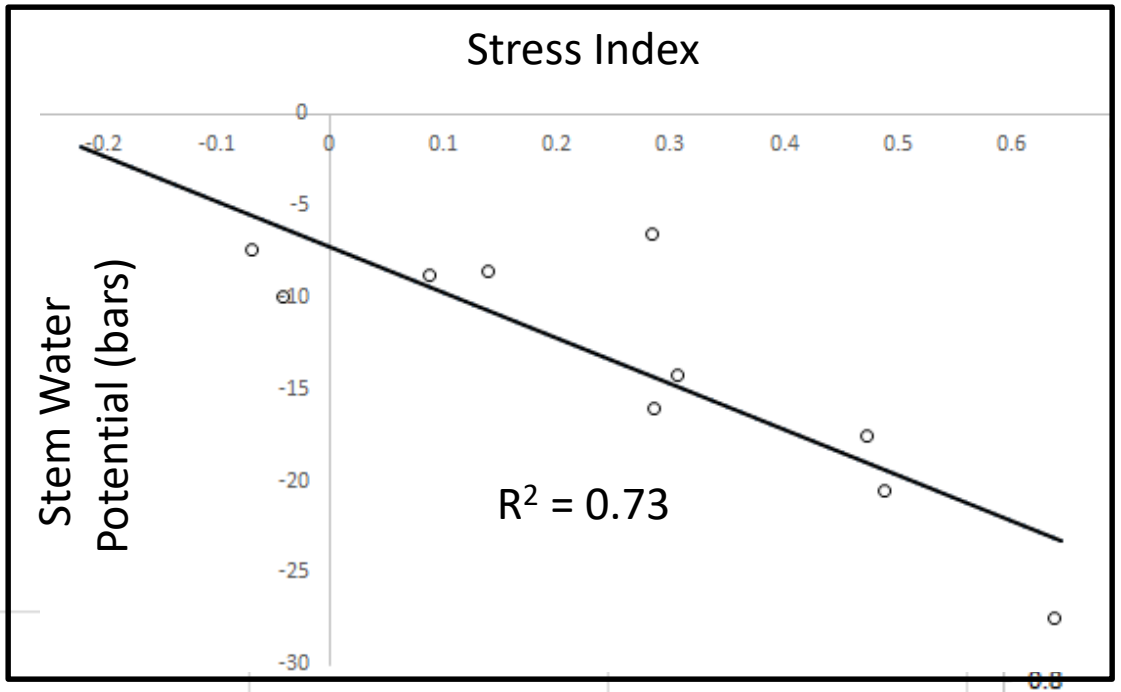
Sept 7

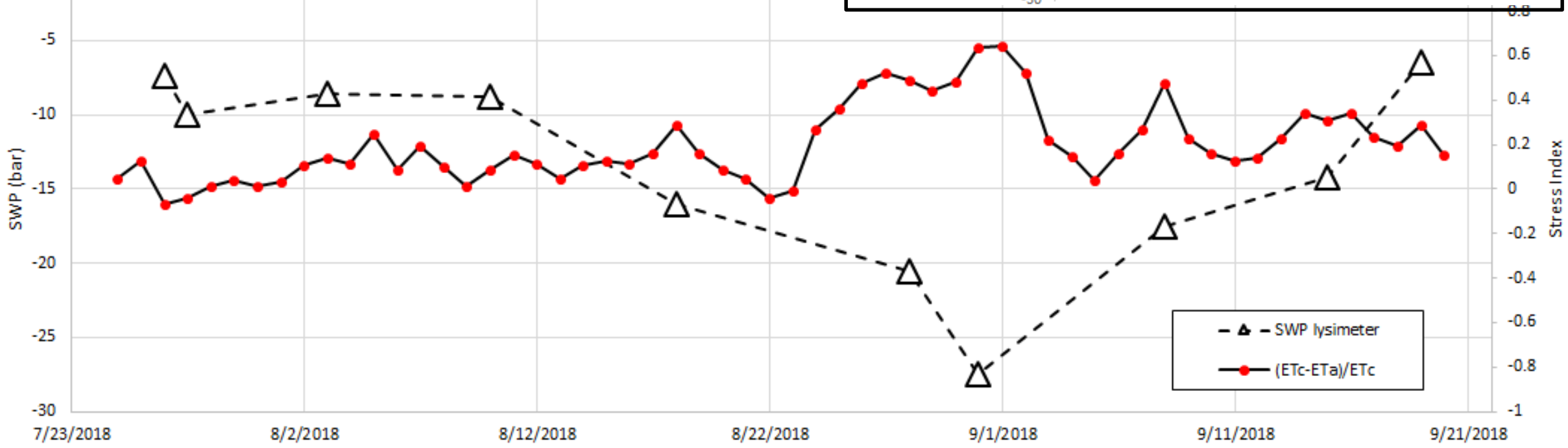
Paso Robles- J Lohr Cabernet Sauvignon



2018 Field Season

Kearney Agricultural Center
Univ. of California- Parlier CA





Conclusions

- How much?
  - SR accurately measures vineyard water loss
  - Modelled R_n works well
  - Still more work on G
- When?
  - More work to resolve how well it measures stress
  - Continuing work on infrared sensors

Acknowledgements

- **Funding Sources:**
  - Almond Board of California
  - J. Lohr Vineyards and Wines
  - American Vineyard Foundation
  - National Grape and Wine Initiative
  - NIFA-Specialty Crops Research Initiative
  - USDA-ARS Sustainable Vit CRIS

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- Kyaw Tha Paw U- UC Davis
- Chris Parry- USDA-ARS
- Anji Perry- J Lohr V&W
- Ken Shackel- UC Davis
- Tom Shapland- UC Davis
- Rick Snyder- UC Davis
- Larry Williams- UC Davis

Thank you!


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Almond Board of California


growing
ADVANTAGE
The Almond Conference

What's Next

Research Poster Session at 3:00 p.m.

Almond Stage Presentation at 3:00 p.m.

- Electronic Sensing of Larvae and Adult Insect Moths, presented by Sensor Development Corporation

3:30 p.m. – 5:30 p.m. Social Hour is sponsored by Mulch Master

Sensor Development Corporation

MulchMaster
Conserving Water Beautifully

What's Next

Almond Stage Presentation at 3:30 p.m.

- Best Practices in Nut Butter Milling, presented by AC Horn

Almond Stage Presentation at 4:00 p.m.

- In-Canopy Sensors & Micro-Climate Models for Navel Orangeworm Management, presented by Semios

Almond Stage Presentation at 4:30 p.m.

- Smart Pest and Disease Scouting for Almond Trees, presented by Aerobotics