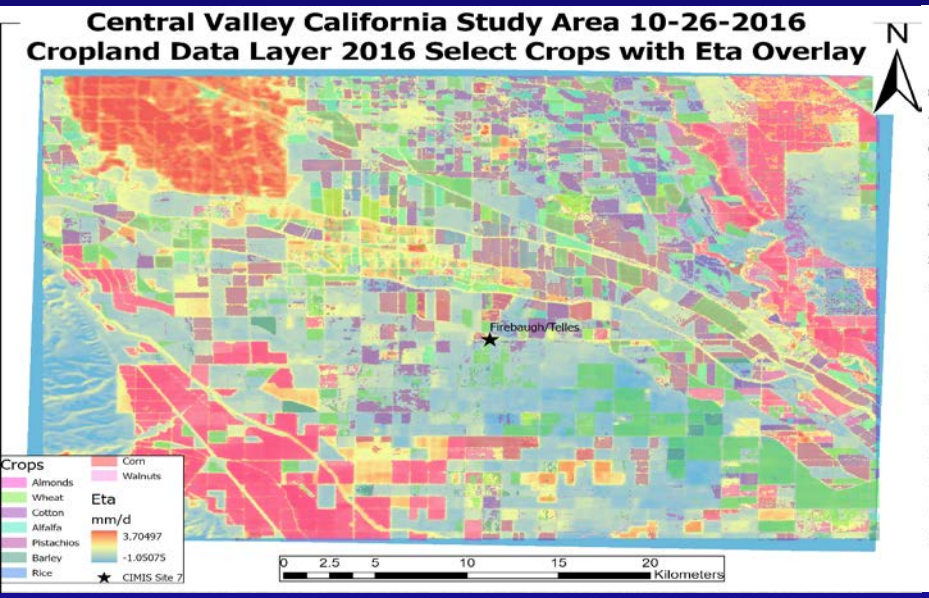
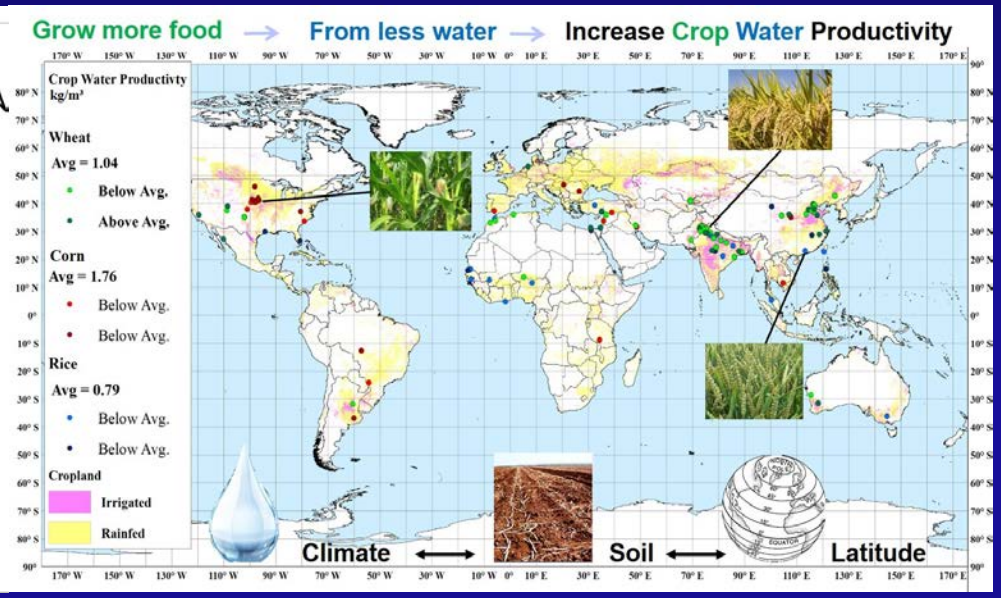
Crop Water Productivity Mapping with Remote Sensing and Google Earth Engine for Food and Water Security:
A Central Valley of California Case Study





waterSMART (Sustain and Manage America's Resources for Tomorrow) Project

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Western Geographic Science Center (WGSC)
United States Geological Survey (USGS)
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Crop Water Productivity ("crop per drop") Studies

Overarching Goal and Questions Answered

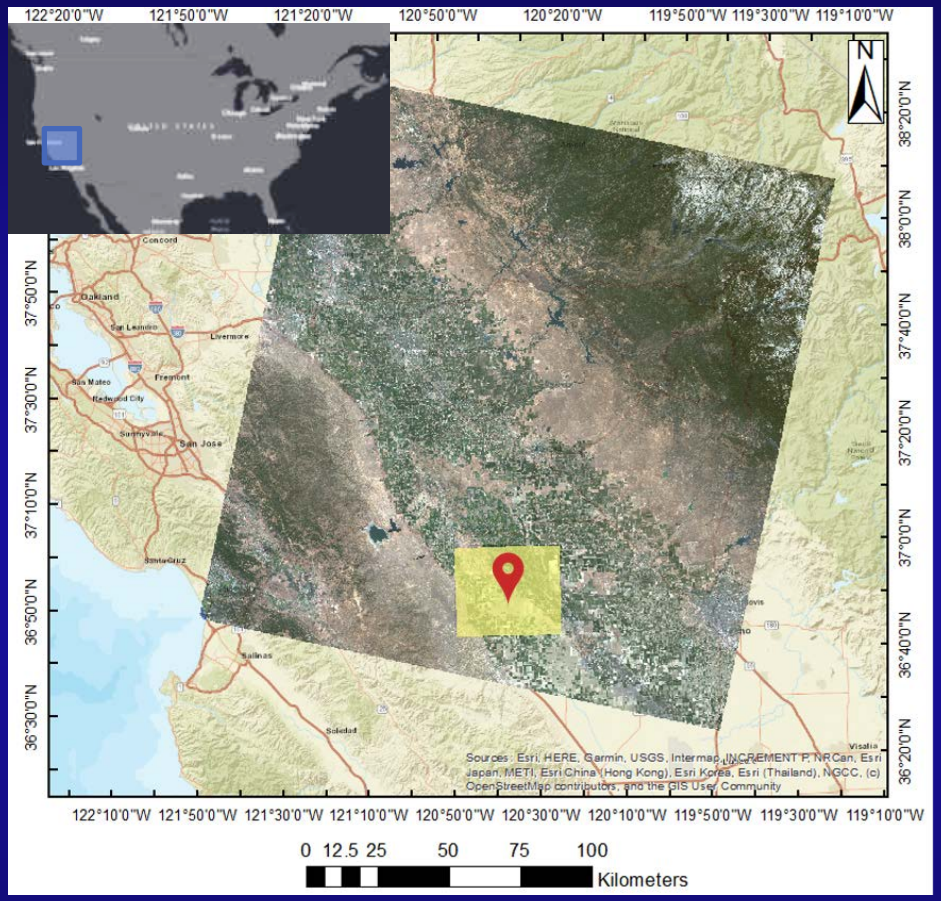
The **overarching goal** is to understand, model, map, & monitor **agricultural crop water productivity (CWP**) of leading world crops using multi-sensor remote sensing leading to answering questions such as:

1. **What is the CWP of various crops;**
2. **How does CWP vary within and between farm fields;**
3. **How much water can we save by increasing various incremental magnitudes of CWP?**

Study Area

San Joaquin Basin, California USA

- 1,136 km^2 area in southern San Joaquin Valley, CA USA
- Centered at California Irrigation Management Information System (CIMIS) Firebaugh/Telles station 7 Lat: 36.85, Lon: -120.59)
- Significant irrigated row crop & nut orchard cultivation
- In Fresno County, CA, on west side of the San Joaquin River 61 km west of Fresno



Central Valley of California study area map indicated by yellow square within greater Landsat image. CIMIS Site 7 represented by red pin.

Objectives

Study Crops

- Determine CWP of world's leading agricultural & water consuming crops
- Locate an agriculturally diverse study area in California Central Valley containing:
  - Almonds
  - Cotton
  - Wheat
  - Pistachios
  - Grapes
  - Barley
  - Rice
  - Corn
  - Walnuts

Table of crops analyzed within Study area by area

n	Crop	Percent of Study Area 2016	Area (ha) Study Area 2016
1	Almonds	8.70%	13601.79
2	Cotton	5.94%	9282.06
3	Winter Wheat	4.66%	7288.29
4	Pistachios	2.06%	3224.52
5	Grapes	1.60%	2508.57
6	Barley	0.47%	732.51
7	Rice	0.29%	450.18
8	Corn	0.08%	128.43
9	Walnuts	0.03%	43.74
	All select crop	23.83%	37260.09
	All Other	76.17%	60186.51
	Total	100.00%	97446.6

Image: USDA Cropland Data Layer produced covering California Central Valley. Map produced via Google Earth Engine

Data used in the Study

Type of Data used in the Study

Meteorological (CIMIS)

- Meteorological data provided by California Irrigation Management Information System (CIMIS) weather station network

Landsat 8 image selection spanning the Central Valley.

Remote sensing (Landsat & Google Earth Engine)

- Landsat 8 Surface Reflectance
- Acquire spectral information & process in Google Earth Engine (GEE)

Crop Type (USDA Crop Data Layer, CDL)

- US annual crop-specific land cover layer using moderate resolution satellite imagery & extensive agricultural ground data

cropland Class Table

Value	Color	Description
1	ffd300	Corn
2	ff2626	Cotton
3	00a8e2	Rice
4	ff9e0a	Sorghum
5	267000	Soybeans
6	ffff00	Sunflower
10	70a500	Peanuts
11	00af49	Tobacco
12	dda50a	Sweet Corn
13	dda50a	Pop or Orn Corn
14	7cd3ff	Mint
21	e2007c	Barley
22	896054	Durum Wheat
23	d8b56b	Spring Wheat
24	a57000	Winter Wheat

Cropland Data Layer selection.

Methods

Outline

1. **Crop type Mapping**
   - Select crops from USDA Cropland Data Layer

2. **Crop Water Use modeling**, CWU ($m^3\backslash m^2$)
   - Calculate Evapotranspiration mm/d (Et_a) as a measure of water use

3. **Crop productivity Modeling**, CP
   - Crop yield per area ($kg\backslash m^2$)

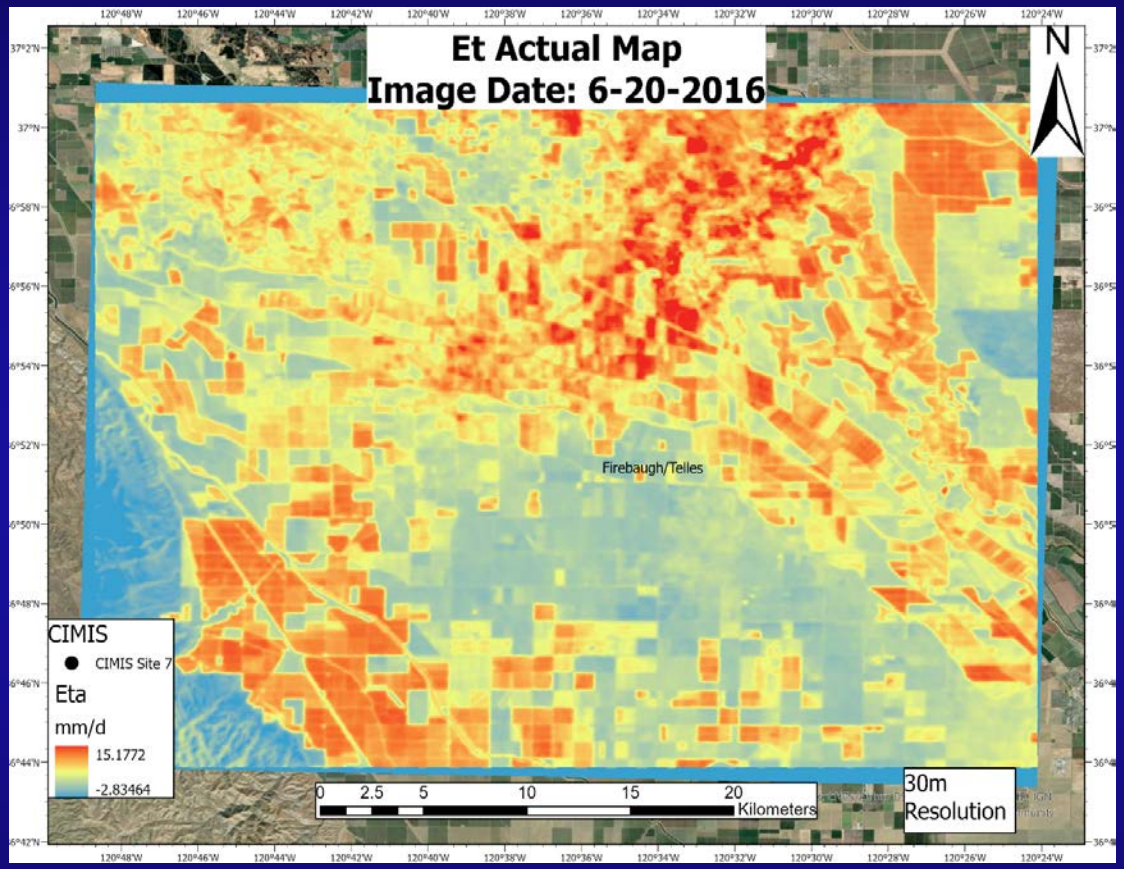
4. **Crop Water Productivity** modeling and Mapping (CWP, $kg\backslash m^3$)
   - CWP = Crop Yield (kg) / Et_a (m^3)

Image: USDA Cropland Data Layer produced map USA depicting major agricultural regions. Produced via Google Earth Engine

Results

Et_a (Actual Evapotranspiration)Map

- Water use Et_a (mm/d) study area raster maps produced monthly at 30 m resolution
- Produced from Et_o map made via CIMIS site Kriging Et_o resolution
- Et_a (30m) = Et_f (30m) x Et_o (30m)



Example of derived Actual Evapotranspiration (Et_a) map for image date 6-20-2016

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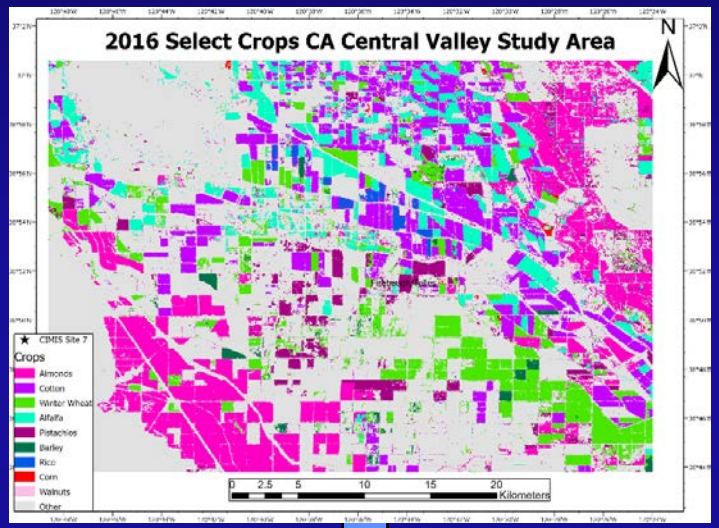
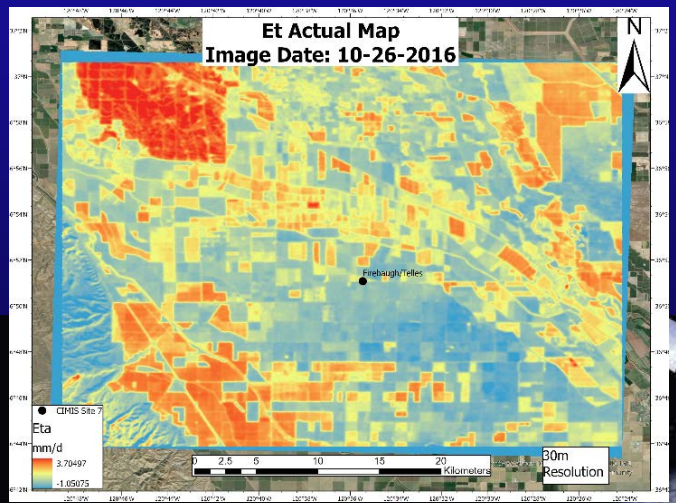
Results

Crop Type Overlay with Et_a

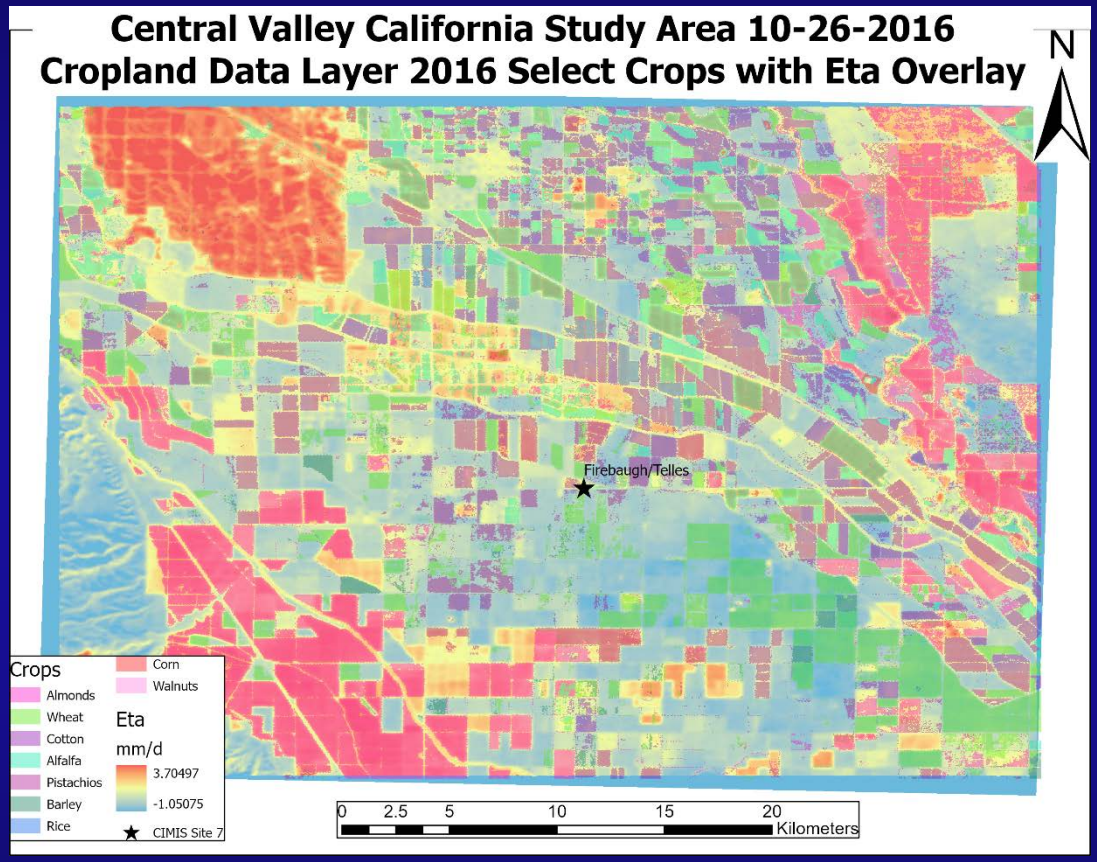
Crop Type Map - CDL 2016



Et_a Map



- Overlay map of select crop types & Et_a



Study area map showing leading world crops & high-water consuming crops in the Central Valley of California from CDL overlay with Eta. Image 10-26-2016.

Conclusions

Crop Water Productivity (kg/m^3)

- **Example: Almonds** grown in CA study site in 2016

- Estimated **164,680,880 m^3 of water** used **to grow 34,759,180 kg** of almonds in 13,602 ha or ~136 million **m^2** area
  - **Crop water use = 1.21 m^3/m^2**
  - **CWP = 0.21 kg/m^3**

- At .0012 kg per almond, estimated **1.5 gallons of water** to **produce 1 almond**
- This amount of water is equivalent to 65,872 Olympic Swimming Pools
  - Olympic swimming pool = 50 m x 25 m with a depth of at least 2 m

The Olympic swimming pool within the Olympic stadium in Montreal, Quebec, 2017.
Image: Wikicommons

Thank you: Questions?

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