



California State University
MONTEREY BAY
Extraordinary Opportunity

Integrating Satellite and Surface Observations for Irrigation Management Decision Support

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Rachel Spellenberg, Isabel Zaragoza

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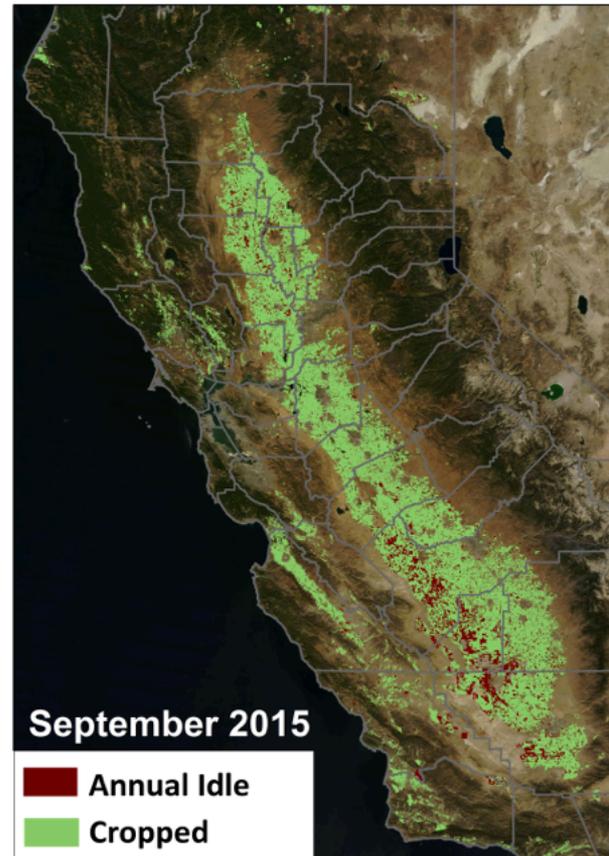
Michael Cahn, Richard Smith, UC Cooperative Extension

Bekele Temesgen, Kent Frame, Simon Eching, CA Dept. of Water Resources



Determining the Extent of Fallowed Land with Satellite Imagery

PROJECT TEAM: NASA Ames Research Center, USGS, USDA National Ag. Statistics Service, California Dept. of Water Resources, NOAA, California State University Monterey Bay



The maps above are based on data from the Landsat 5, Landsat 7, Landsat 8, and Terra and Aqua satellites and show patterns in crop cultivation and fallow agricultural lands in California during the 2015 summer season. Brown pixels depict farms and orchards that have been left fallow or "idled" since the start of the 2015 summer season. Green pixels are lands still being farmed during the summer growing season. During the summer of 2015, more than 1.9 million acres were fallow throughout the summer season, an increase of more than 522,000 acres since the start of the drought.



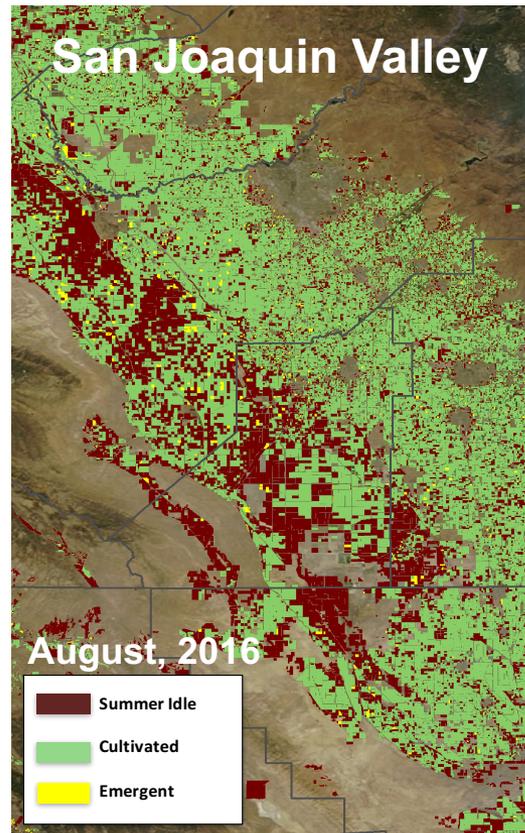
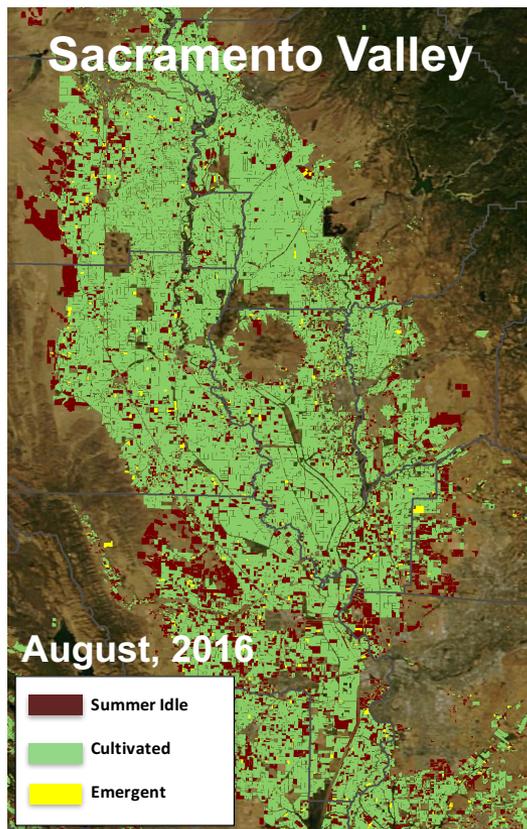
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Central Valley Fallow Acreage Summary

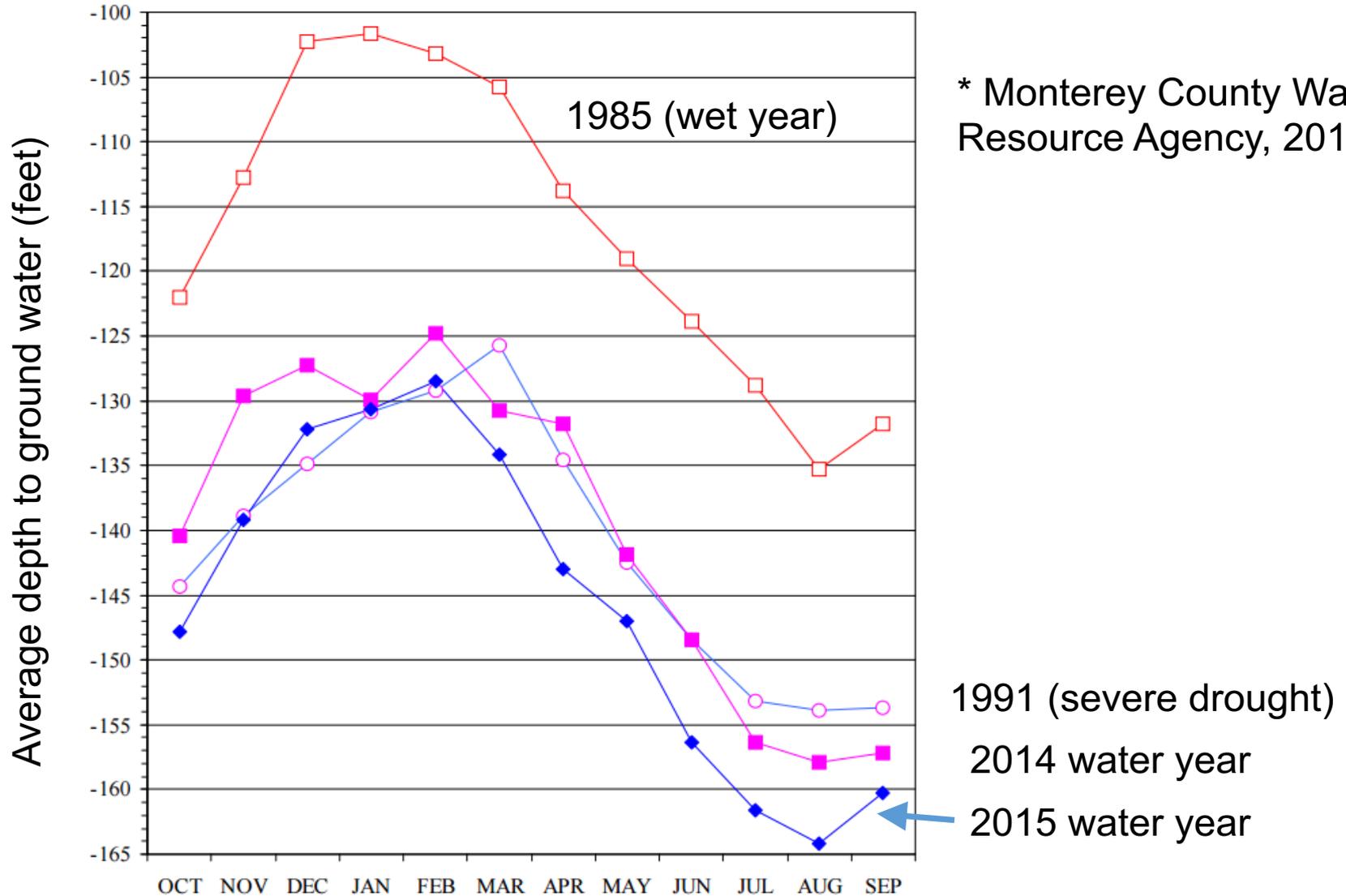
Central Valley, Total Fallow Acreage, Summary to Date (updated August 31)		
Year	Summer Idle (idle since June 1)	Annual Idle (year to date)
2016	1,891,359	1,001,140
2015	1,880,772	1,032,508
2014	1,848,890	1,310,099
2013	1,427,833	680,647
2011	1,383,669	405,996
2016-2011	507,691	595,144

Notes:

- Summer Idle: No crop detected since June 1
- Annual Idle: No crop detected since January 1
- “2016-2011” is the difference in winter idle acreage between 2016 and 2011
- Data source: NASA Ames Research Center / CSU Monterey Bay
- Accuracy for the estimates from NASA is +/- 10%, based on comparisons with monthly field observations collected across the Central Valley from February-August, 2016.

Average Ground Water Depths are Currently at Historically Low Levels*

* Monterey County Water Resource Agency, 2015



TIER 2/TIER 3 FARMS WITH HIGH NITRATE LOADING RISK TOTAL NITROGEN APPLIED REPORT - RANCH / RISK UNIT

Page 1 of 1 - June 5, 2014 Version

SUBMIT ELECTRONIC FORM: Click on "Submit Form" to send completed form directly to the Water Board

EMAIL FORM AS AN ATTACHMENT: Attach completed and saved form to an email and send to AgNOI@waterboards.ca.gov

CONDITIONAL WAIVER OF WASTE DISCHARGE REQUIREMENTS FOR DISCHARGES FROM IRRIGATED LANDS - REGIONAL BOARD ORDER R3-2012-0011

By October 1, 2014 and October 1 annually thereafter, Tier 2 and Tier 3 dischargers with High Nitrate Loading Risk must report total nitrogen applied and present in the soil. [Refer to instructions on reverse.](#)

SECTION I: GENERAL RANCH INFORMATION

AW#: Ranch Global ID: Ranch Name:
 High Risk Determination Name(s):

SECTION II: RECORDKEEPING AND REPORTING INFORMATION

Reporting Year: 2014 2016
 (select one) 2015 2017

Have nitrogen records been maintained for the required reporting period (September 1 - August 30)? YES NO

If NO, state the reporting period for which records have been maintained: to
MM/DD/YYYY MM/DD/YYYY

High Risk

SECTION III: TOTAL NITROGEN APPLIED REPORTING

Ranch / Risk Unit Reporting Name: Ranch / Risk Unit Acres:

	Crop Type(s) Grown and Harvested During Reporting Period	Crop Type Acres	Total Nitrogen Present in the Soil (lbs/acre)	Total N Applied in Fertilizers & Amendments (lbs/acre)	O / C	Average Nitrogen Concentration in Irrigation Water (mg/L as NO3-N)	Total Nitrogen Applied with Irrigation Water (lbs/acre)
1.	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
2.	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	Identify the Basis for the Amount of Total Nitrogen that was Applied (select all that apply)	
3.	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="checkbox"/> University Research Data <input type="checkbox"/> Yield Projection <input type="checkbox"/> Grower Experience	
4.	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="checkbox"/> UCCE Information <input type="checkbox"/> Commodity or Industry Group <input type="checkbox"/> Laboratory Recommendation	
5.	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="checkbox"/> UC Farm Advisor Consultation <input type="checkbox"/> Private Research Trials <input type="checkbox"/> Site Analysis Dry Biomass	
6.	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="checkbox"/> Water Coalition <input type="checkbox"/> On-Farm Research Trials <input type="checkbox"/> Scientific Literature	
7.	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="checkbox"/> Consultant (PCA, CCA, etc.) <input type="checkbox"/> Trade Publication	
8.	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="checkbox"/> Local Info/Neighbor <input type="checkbox"/> Fertilizer Distributor/Dealer	

SECTION IV: AUTHORIZATION AND CERTIFICATION

By submitting this Total Nitrogen Applied Report, in compliance with Water Code § 13267, I certify under penalty of perjury that this document was prepared by me, or under my direction or supervision, following a system designed to ensure that qualified personnel properly gathered and evaluated the information submitted. To the best of my knowledge and belief, this document is true, accurate, and complete. I am aware that there are significant penalties for submitting false information.

Does this form contain information related to trade secrets or secret processes? YES NO

Preparer Name: Preparer Title: Preparer Contact Info: Operator/RP Contact Info:

Nitrogen use reporting started October, 2014

Tools for Managing Water and Nitrogen Fertilizer in Vegetables & Berries

- Soil nitrate quick test
- Weather-based irrigation scheduling



Weather-based irrigation scheduling

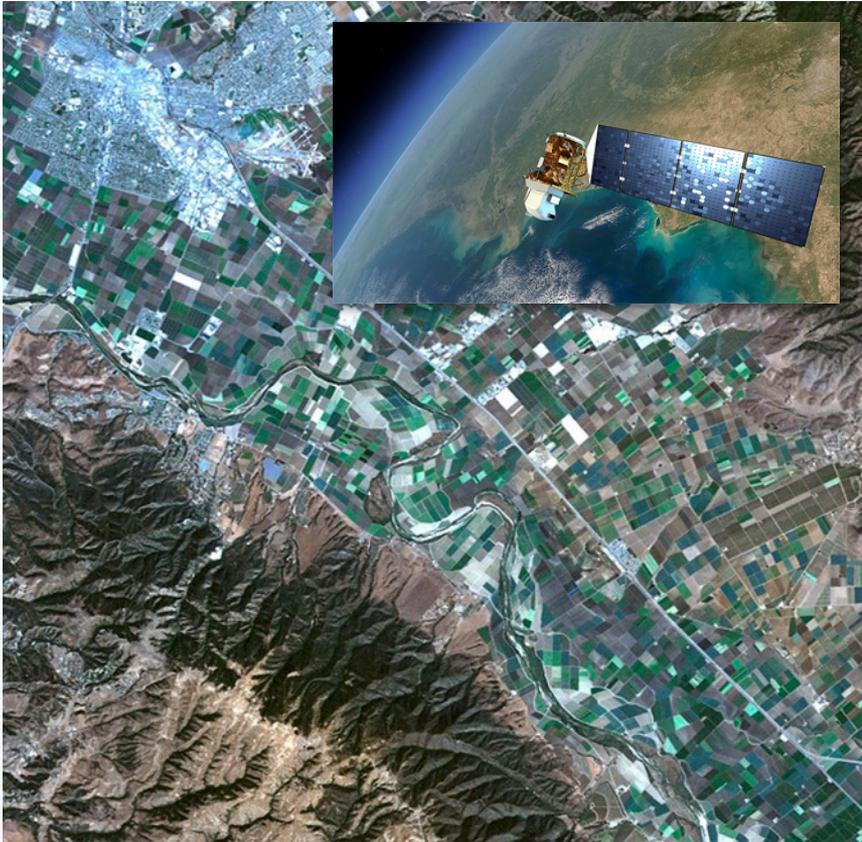


Converting Reference ET to
Crop ET:

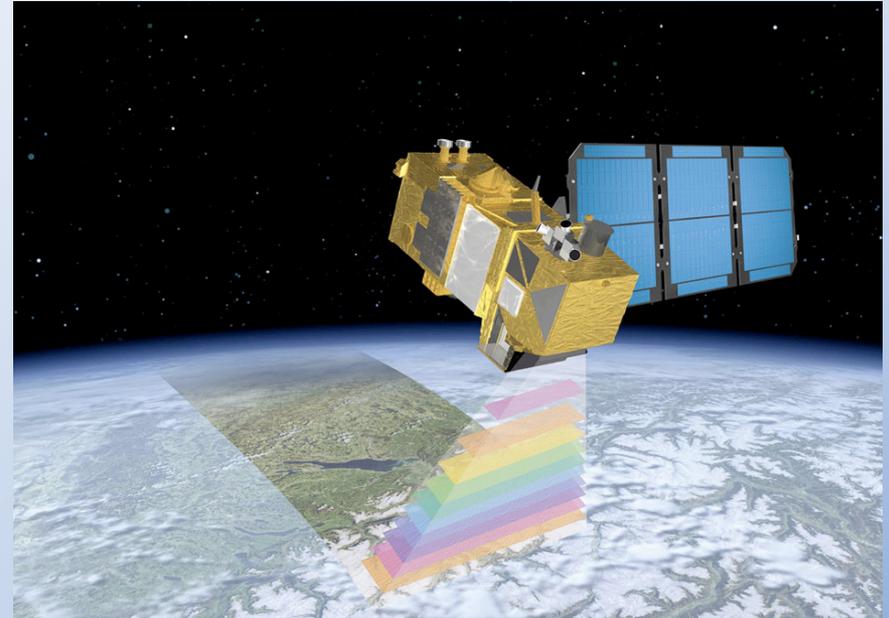
$$ET_{\text{crop}} = ET_{\text{ref}} \times K_{\text{crop}}$$

K_c can vary from 0.1 to 1.2

Satellite Data



Landsat (TM / ETM+ / OLI)
30m / 0.25 acres
Overpass every 8-16 days



Sentinel-2A
20m / 0.1 acres
Sentinel 2B launch in 2017

Monitoring Crop Canopy Development

Username:

Password:

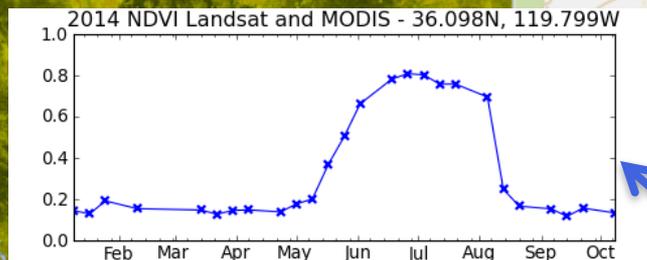
[Login](#)

TOPS Satellite Irrigation Management Support

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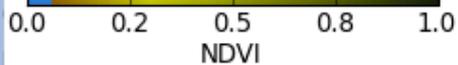
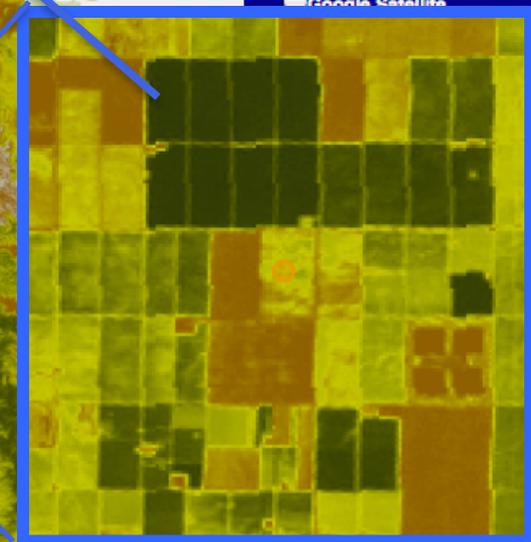
Select Date:



SIMS Data Layers

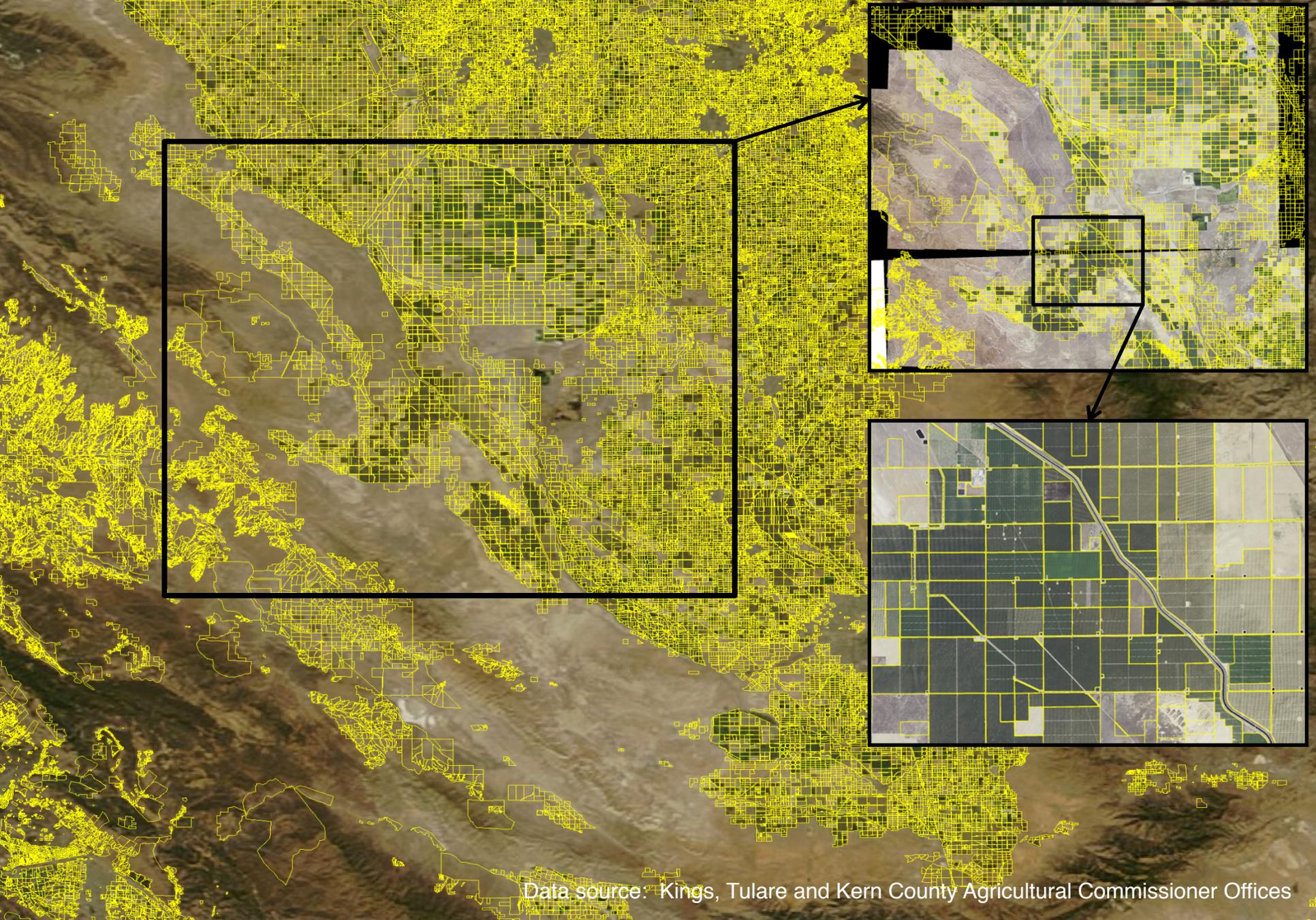
- ETcb
2011-07-07
 - Crop coefficient (Kcb)
2011-07-04 to 2011-07-11
 - Veg. Index (NDVI) gapfilled
2011-07-04 to 2011-07-11
 - Veg. Index (NDVI)
2011-07-04 to 2011-07-11
- Base Layer
- Google Satellite

Normalized Difference Vegetation Index (NDVI); 8-day composite from Landsat and MODIS



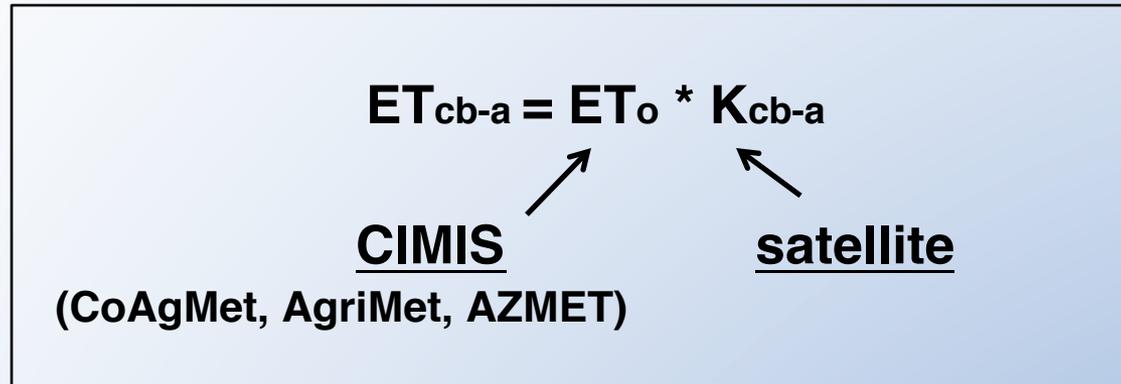
35.39402 N, -119.85320 W

Southern San Joaquin Valley, CA, Field Boundary Polygons



Data source: Kings, Tulare and Kern County Agricultural Commissioner Offices

Approach: Combining Surface and Satellite Data



Standard K_c Profile (manual)

Hypothetical Crop Coefficient (K_c) Curve for Typical Field and Row Crops Showing Growth Stages and Percentages of the Season from Planting to Critical Growth Dates

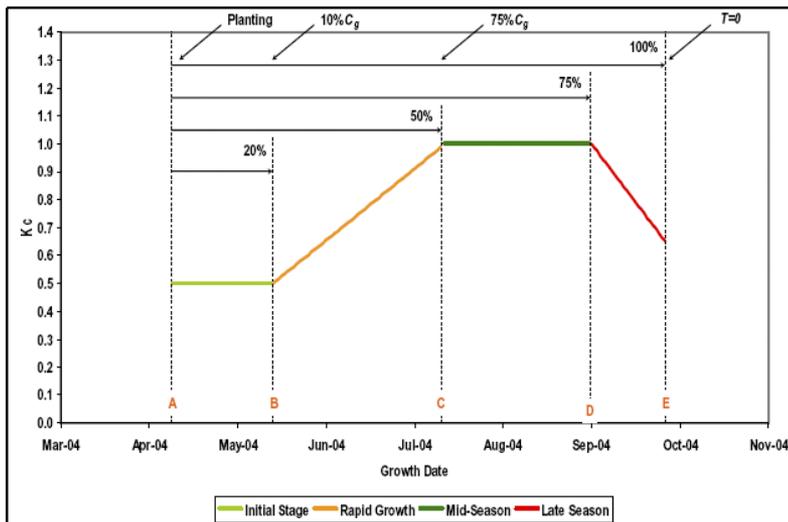
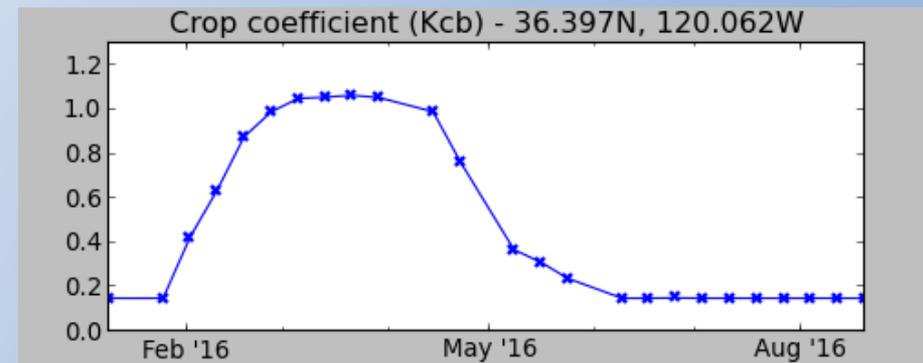


Figure credit: 2005 California Water Plan Update

SIMS K_{cb} Profile

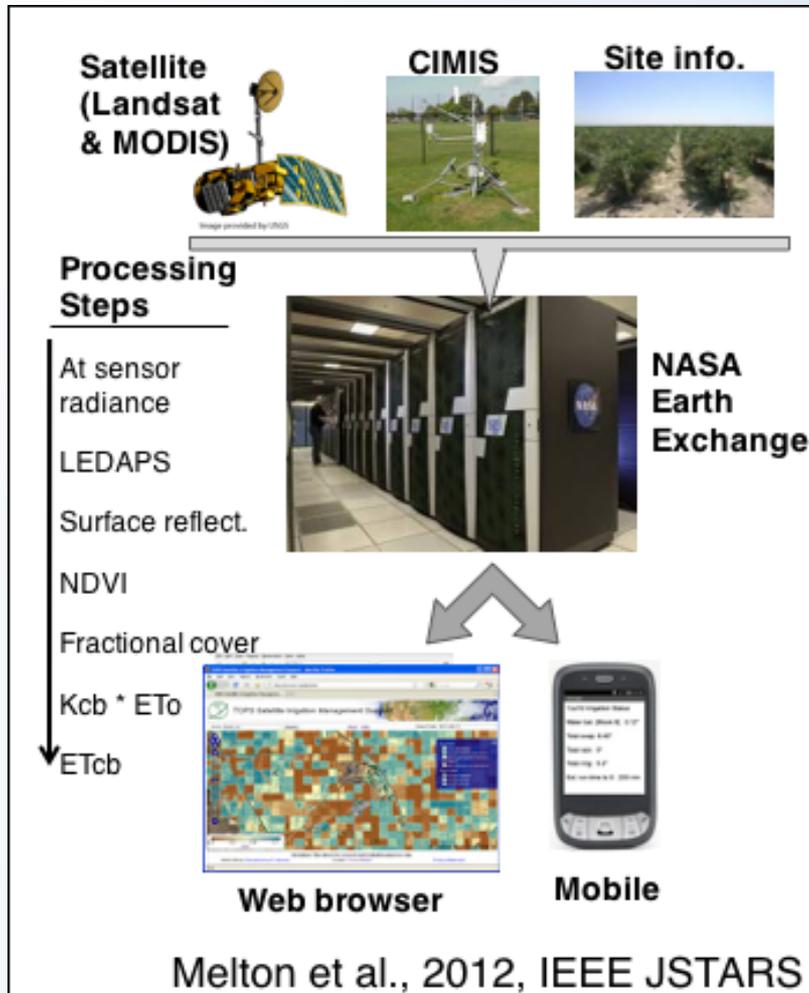
(Automated, Satellite-derived)



K_c profiles via 1) reflectance based algorithms (K_{cb}); and 2) METRIC surface energy balance (in development with DRI, J. Huntington)

Reflectance-based Approach: Mapping Actual Basal Crop Evapotranspiration

Satellite Irrigation Management Support (SIMS) Framework



Step 1:

NDVI \rightarrow Fractional Cover (F_c)

- Based on studies by Trout et al., 2008; Johnson et al., 2012

Step 2:

$F_c \rightarrow K_{cb-a}$

- Allen and Perreira, 2009; Bryla et al., 2010; Grattan et al., 1998; Hanson & May, 2006; Lopez-Urrea et al., 2009 . . .

Step 3:

$ET_{cb-a} = ET_0 * K_{cb-a}$

- Follows FAO-56 approach
- ET_0 from CIMIS
- Optional calculation of soil evaporation and crop stress via soil water balance at field scale

Satellite Irrigation Management Support (SIMS) Web Services



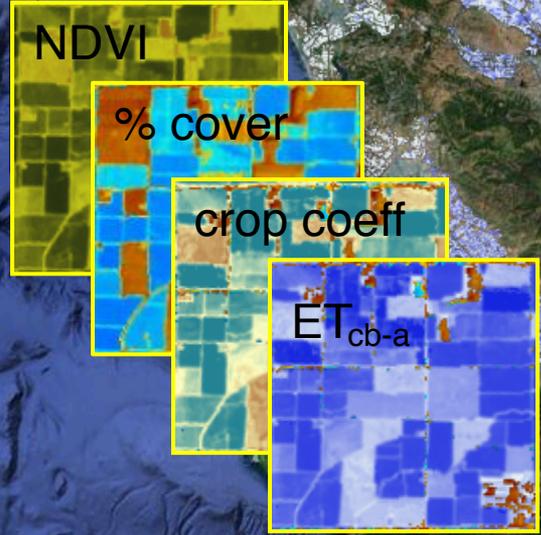
TOPS Satellite Irrigation Management Support

Username: Password:

Go to:

[About](#) [Help](#)

Select Date:

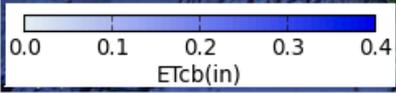


SIMS Data Layers

- ET_{cb}
2011-07-07
- Crop coefficient (Kcb)
2011-07-04 to 2011-07-11
- Fractional Cover (FC)
2012-07-27 to 2012-08-03
- Veg. Index (NDVI) gapfilled
2011-07-04 to 2011-07-11
- Veg. Index (NDVI)
2011-07-04 to 2011-07-11

Base Layer

- Google Satellite
- Google Terrain
- Google Streets



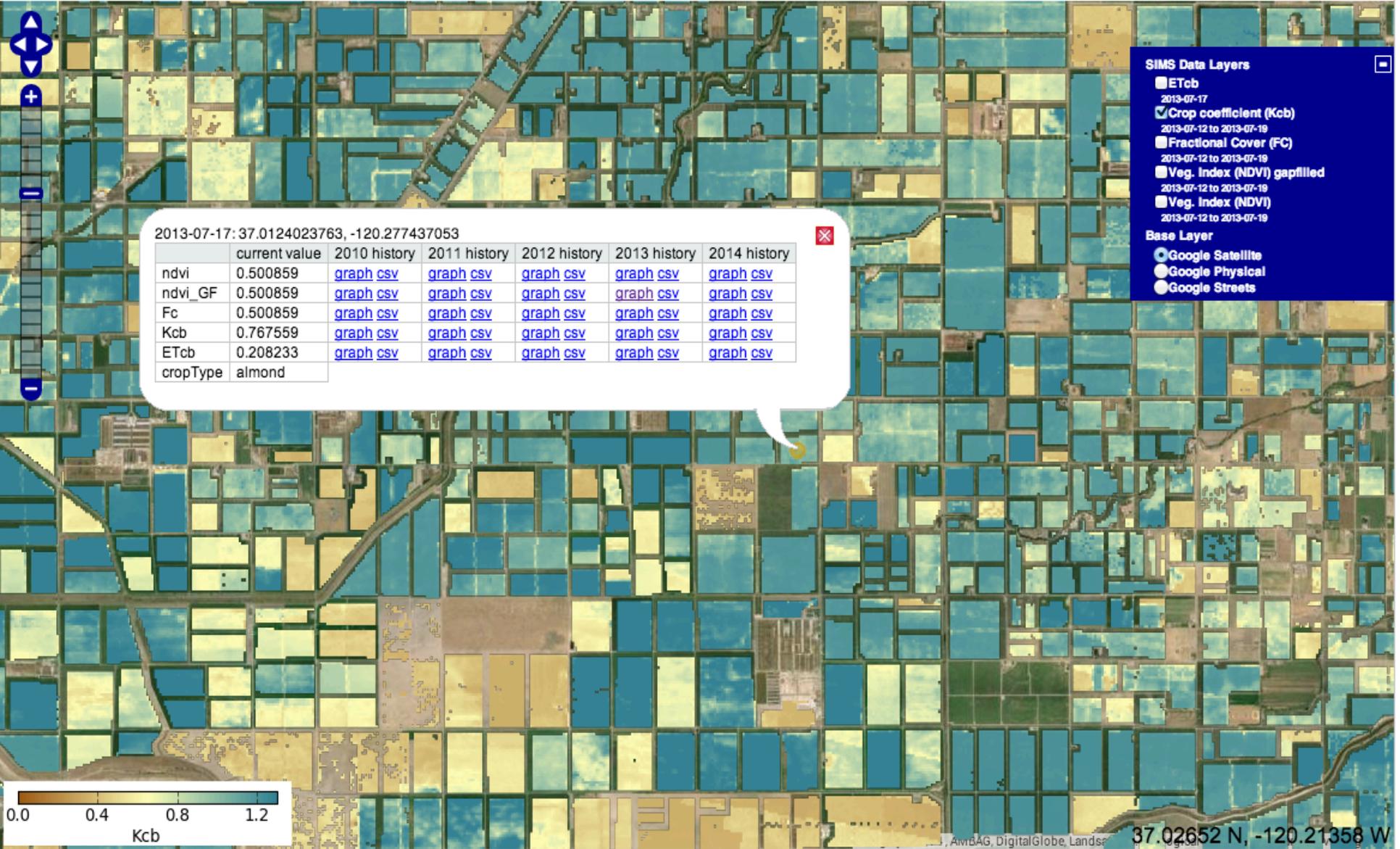
37.01591 N, -121.13824 W



Go to:

[About](#) [Help](#)

Select Date:



SIMS Data Layers

- ETcb
- 2013-07-17
- Crop coefficient (Kcb)
- 2013-07-12 to 2013-07-19
- Fractional Cover (FC)
- 2013-07-12 to 2013-07-19
- Veg. Index (NDVI) gapfilled
- 2013-07-12 to 2013-07-19
- Veg. Index (NDVI)
- 2013-07-12 to 2013-07-19

Base Layer

- Google Satellite
- Google Physical
- Google Streets

Disclaimer: This data is for research and evaluation purposes only.

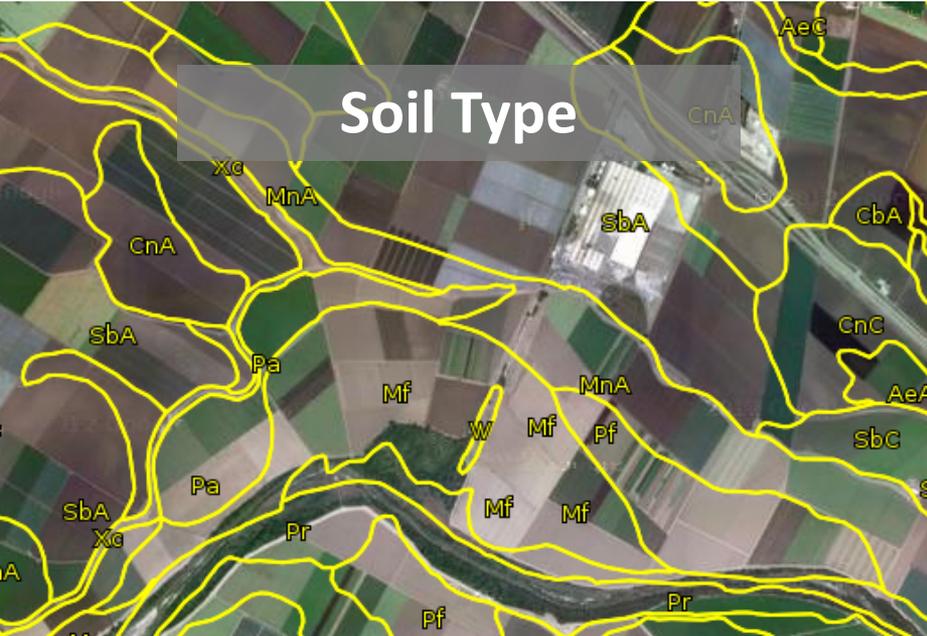
Other information needs to be considered



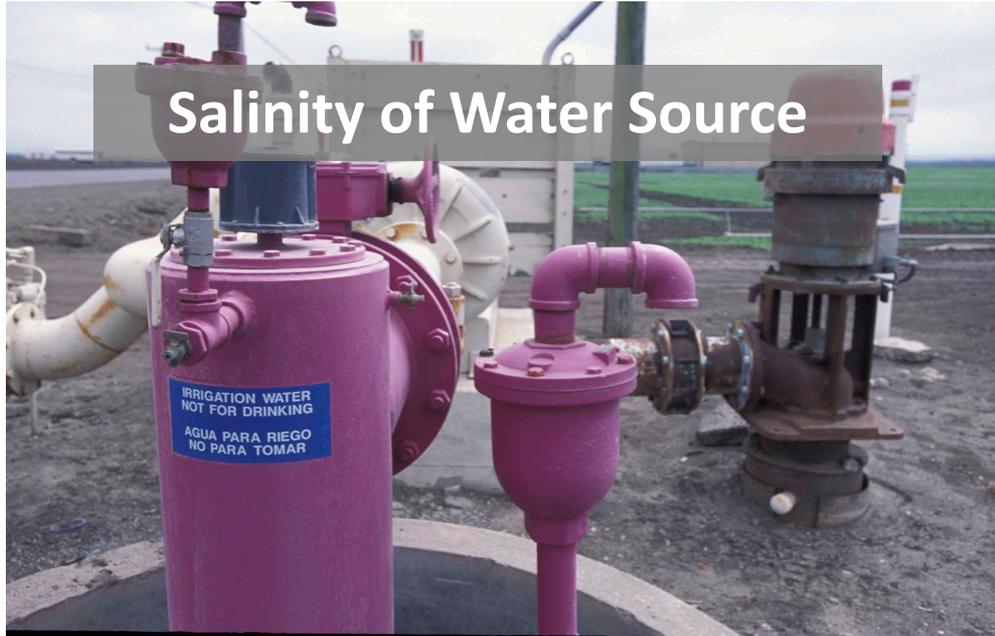
Rooting Depth



Irrigation System Uniformity and Application Rate



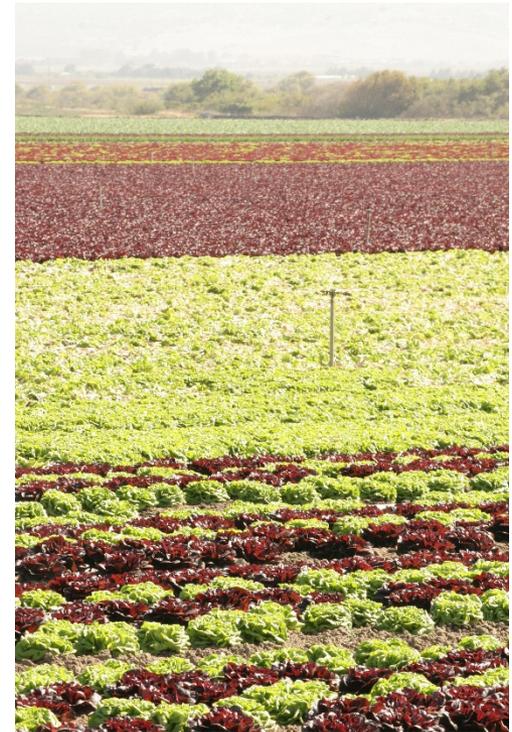
Soil Type



Salinity of Water Source

On-farm challenges in implementing tools for managing water and fertilizer:

- ✓ **Multiple fields to manage and track**
- ✓ **Other decisions and activities to coordinate**
- ✓ **Calculations involved in N and water management decisions are time consuming**
- ✓ **Collected data needs to be available to the decision maker(s)**

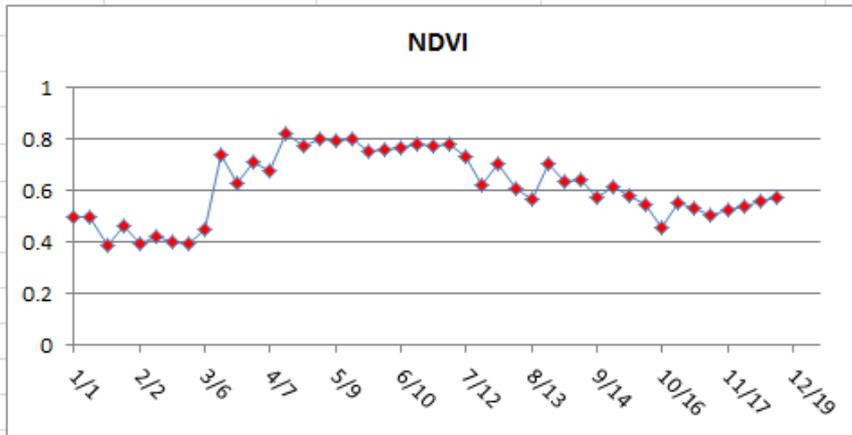


IrriQuest

On-farm Water Use Efficiency Calculator

Example for almond in San Joaquin Valley, 2013:

	A	B	C	D	E	F	G	H	I	J	K	L
1	sims update	[1.1] ndvi	goto SIMS	[1.2] crop type:	[1.3] region:	[1.4] mid-season period:		date	[1.5] precip (in.):	[1.6] ETo (in.):	view default ETo	
2	1-Jan	0.495388		almond	San Joaquin Valley	spring/summer		1-Jan	0.00	0.03	goto CIMIS	
3	9-Jan	0.493614						2-Jan	0.00	0.03		
4	17-Jan	0.388297						3-Jan	0.01	0.03		
5	25-Jan	0.463374						4-Jan	0.02	0.02		
6	2-Feb	0.391162						5-Jan	0.01	0.02		
7	10-Feb	0.42256						6-Jan	0.33	0.03		
8	18-Feb	0.397599						7-Jan	0.28	0.03		
9	26-Feb	0.391901						8-Jan	0.02	0.04		
10	6-Mar	0.448919						9-Jan	0.01	0.03		
11	14-Mar	0.737658						10-Jan	0.01	0.04		
12	22-Mar	0.628556						11-Jan	0.00	0.04		
13	30-Mar	0.713049						12-Jan	0.00	0.04		
14	7-Apr	0.675355						13-Jan	0.00	0.04		
15	15-Apr	0.822237						14-Jan	0.00	0.04		
16	23-Apr	0.770835						15-Jan	0.00	0.05		
17	1-May	0.797692						16-Jan	0.00	0.05		
18	9-May	0.704800						17-Jan	0.00	0.05		



Output:

- Crop ET (daily, seasonal)
- Consumptive Use Fraction
- Agronomic Use Fraction

CropManage: online irrigation and N management decision support tool

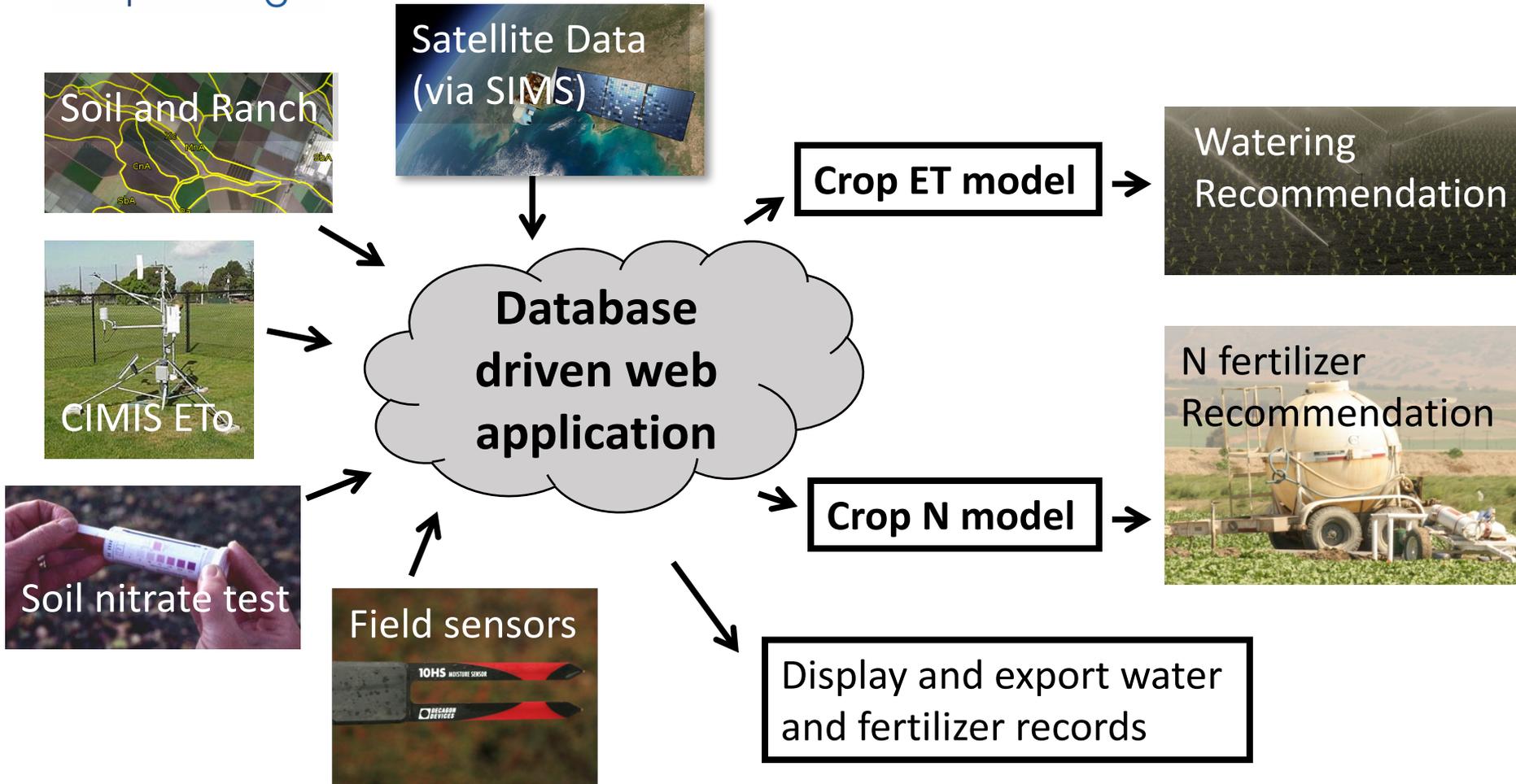
<https://cropmanage.ucanr.edu>

The screenshot shows the CropManage web application interface. At the top left is the CropManage logo. At the top right, there are links for 'Bondesen' (with a dropdown arrow), 'Español', and 'Log out'. A dark blue sidebar on the left contains a menu icon, the user's name 'Michael D Cahn' and title 'Ranch User', and navigation options: 'Home', 'Ranch', and 'Profile'. The main content area displays a 'Welcome to CropManage' message and a 'Ranch List' table. The table has columns for 'Ranch', 'Active Plantings', and 'Total Plantings'. It lists four ranches: Bondenson, Bondesen, Callaghan Ranch, and DaRosa, each with 0 active plantings and varying total plantings (17, 39, 82, and 1 respectively). Each row has a folder icon and a dropdown arrow.

Ranch	Active Plantings	Total Plantings
 Bondenson	0	17
 Bondesen	0	39
 Callaghan Ranch	0	82
 DaRosa	0	1

Michael Cahn, UCCE

Integrate information from multiple sources



Decision support using crop models

Crops currently supported by CropManage

Vegetables:

Romaine (40 and 80-inch wide beds)
Iceberg (40 and 80-inch wide beds)
Broccoli (summer and winter plantings)
Cauliflower (summer and winter plantings)
Cabbage (red and green)
Spinach (baby, teen, bunch)
Celery
Leaf lettuce*
Baby lettuce*
Mizuna*
Peppers*

Berries:

Strawberry
Raspberry*
Blackberry*

Replicated Irrigation Trial for Iceberg Lettuce



Treatment	head wt		carton yield		CFR ¹
	untrimmed	trimmed	untrimmed	trimmed	yield
	lbs/head		-----	lbs/acre	-----
Grower standard (150% ETc)	2.73	1.60	73903	43221	41070
CropManage (100% ETc)	2.76	1.61	75623	44109	39579
LSD _{0.05}	ns	ns	ns	ns	ns

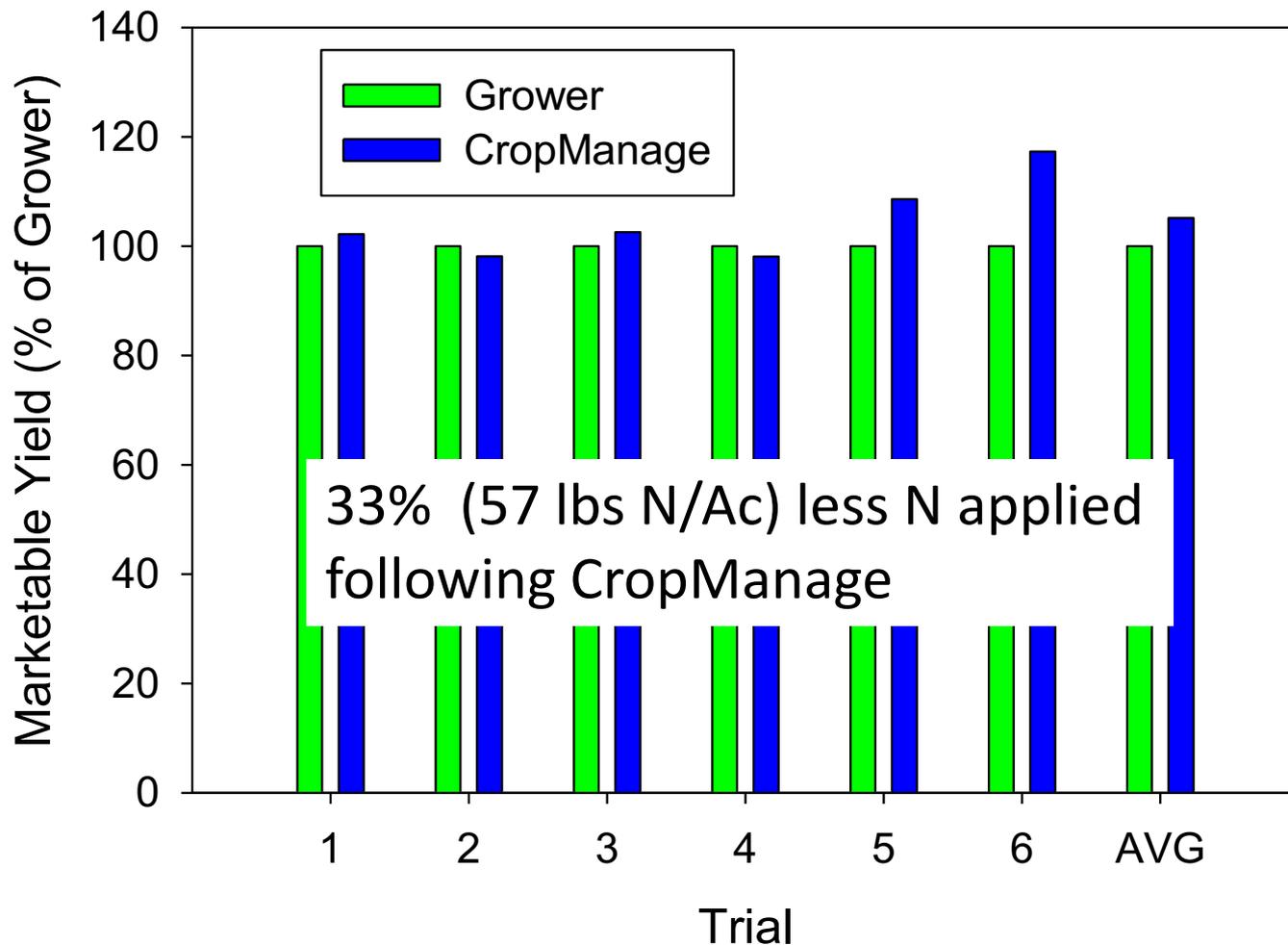
¹. Cored for region



Using weather-based irrigation scheduling for broccoli

Irrigation Treatment	Applied water inches	Marketable Yield		
		Crown ----- lbs/acre -----	Bunch	Total
Grower Standard (150% ET)	20.4	6797	8289	15086
CropManage (100% ET)	14.2	6747	9522	16269
LSD _{0.05}		NS	1052	1061

Summary of Commercial Lettuce Strip Trials (2012-2013)



Questions?



fmelton@csumb.edu