
Forrest Melton
forrest.s.melton@nasa.gov

Forrest Melton, Lee Johnson, Alberto Guzman, Isabel Zaragoza, Jason Dexter, Kirk Post, Carolyn Rosevelt, Carlos Wang, Andy Michaelis
NASA ARC-CREST / CSU Monterey Bay

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

Michael Cahn, Richard Smith, UC Cooperative Extension
Motivation

Threats to Water Supplies and Water Quality in California

Source: UC Davis

Source: CDWR

Source: CDWR

Community Public and State Small Water Systems, Raw Water Nitrate Levels, 2006-2010 (mg/L)
- up to 1.0
- 1.1 - 15
- 15.1 - 22.6
- 22.6 - 45
- 45.1 - 90
- over 90
Objective: Increase the utility of satellite data for irrigation scheduling and evaluation of on-farm water use efficiency by growers/irrigators.

Requirements:
- Field scale
- Cost effective
- 10+ year baseline
- Known accuracy
- Timely
- Open data
- Data continuity is critical

Melton et al., 2012, IEEE JSTARS
**Objective:** Increase the utility of satellite data for irrigation scheduling and evaluation of on-farm water use efficiency by growers/irrigators.

**Applications:**
- Irrigation scheduling and management
- Calculation of water use efficiency metrics
- Compliance monitoring for water transfer agreements
- ET mapping

**Processing Steps**
- Surface reflect.
- Cloud masking
- Gap-filling
- NDVI
- Fractional cover
- $K_{cb} \times E_T$
- $ET_{cb}$

Melton et al., 2012, IEEE JSTARS
Project Partners and Stakeholders

**Water Management**
California Department of Water Resources (CDWR), CA State Water Resources Control Board

**Agriculture**
Western Growers Association, Booth Ranches, Chiquita, Constellation Brands, D’Arrigo Bros., Del Monte Produce, Driscoll’s, Dole, Inc., E & J. Gallo, Farming D, Fresh Express, Pereira Farms, Ryan Palm Farms, Tanimura & Antle, CDFA, Vineyard Management Group

**Research and Extension**
Univ. of California Cooperative Extension / UC Davis, Desert Research Institute, Center for Irrigation Technology / CSU Fresno, USDA ARS / NRCS, USGS
Future Project Partners and Stakeholders

Water Management
Nevada State Engineer’s Office
Oklahoma Water Resources Board
Central Asia Regional Water Network
USAID

Research and Extension
University of Colorado, Boulder
University of Oklahoma
American University of Central Asia, Kyrgyz Republic
Key Datasets and Decision Support Systems: California Irrigation Management Information System

Landsat 5/7/8

MODIS, Terra & Aqua

Sentinel-2A/2B

Spatial CIMIS ET₀ (mm)

SIMS ETₑ (mm)
SIMS Approach

Step 1:
NDVI → Fractional Cover (F_c)
- Based on studies by Trout et al., 2008; Johnson et al., 2012

Step 2:
F_c → K_d → Kcb
- Allen and Pereira, 2009 / ASCE Manual 70; (also Bryla et al., 2010; Grattan et al., 1998; Hanson & May, 2006; Lopez-Urrea et al., 2009 . . .)

Step 3:
ET_{cb} = ET_0 * Kcb
- Follows FAO-56 approach
- ET_0 from CIMIS
- Calculation of soil evaporation and crop stress via soil water balance

\[ K_d = \min(1, M_L \cdot Fc_{eff}, Fc_{eff}^{1/(1+h)}) \]

\[ M_L : \text{effect of canopy density on shading} \]
\[ \text{max relative ET} \]
\[ K_d : \text{density coefficient} \]
\[ Fc_{eff} : \text{effective fractional cover} \]
\[ h : \text{crop height} \]
Approach: Combining CIMIS and Satellite Data

\[ \text{ET}_{cb-a} = \text{ETO} \times K_{cb} \]

- CIMIS
- Satellite
  
  (NICE Net, CoAgMet, AgriMet . . .)

**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

**SIMS \( K_{cb-a} \) Profile**

(Automated, Satellite-derived)

Crop coefficient (\( K_{cb} \)) - 36.397N, 120.062W

\( K_c \) profiles via reflectance based algorithms (\( K_{cb-a} \))

Figure credit: 2005 California Water Plan Update
Highlights: SIMS Web Interface

http://ecocast.arc.nasa.gov/dgw/sims/
Highlights: SIMS API

SIMS Application Programming Interface

Data Service:
http://ecocast.arc.nasa.gov/cgi/ncpoint
https://ecocast.arc.nasa.gov/cgi/ncpolygon

Query example for a single day:
https://ecocast.arc.nasa.gov/cgi/ncpoint?apikey=userkey&date=2016-04-14&lon=-120.46428&lat=36.69523&croptype=75

Query example for a timeseries for full year or current year-to-date:
https://ecocast.arc.nasa.gov/cgi/ncpoint?apikey=userkey&year=2016&lon=-120.46428&lat=36.69523&croptype=75

https://ecocast.arc.nasa.gov/cgi/ncpolygon?varname=Fc&apikey=userkey&year=2016&croptype=75&geom=POLYGON+((-120.9710708296299941+37.4955228156940024, -120.9765639936899930+37.4573781184929970, -120.9133926069799969+37.4475663354349990, -120.9216323530699952+37.4955228156940024, -120.9710708296299941+37.4955228156940024))
Highlights: Crop Manage Integration

Crop Canopy

- Canopy Data Imported

About NASA Sims and canopy data.

NASA Sims

Crop Canopy Adjustment

<table>
<thead>
<tr>
<th>Maximum Canopy</th>
<th>0.85</th>
<th>0.85</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum Fraction</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>Canopy B</td>
<td>-11.9760</td>
<td>-11.9760</td>
</tr>
</tbody>
</table>

Graph showing crop canopy adjustment over time.

- Save
- Save & Recalculate
- Reset

Date | CropManage Canopy | Measured Canopy

No data available in table

Root Mean Square Difference:

Repopulate All Removed Canopy Values

https://cropmanage.ucanr.edu/
Impacts: Field Demonstrations of SIMS / CropManage

Results to Date for Reductions in Applied Water

- Lettuce (Iceberg & Romaine): 21-29%
- Broccoli: 30-40%
- Cabbage: 21-22%
- Strawberries (ongoing)
- Tomatoes (2018)
- No statistically significant differences in yield/quality

Johnson et al., 2016, Hort Sci 51.7
**Outputs:**
- Crop ET (daily, seasonal)
- Crop Consumptive Use Fraction
- Agronomic Water Use Fraction

Lee Johnson, NASA Ames / CSUMB
https://ecocast.arc.nasa.gov/simsi/irriquest/

Soil water balance model:
- Derives stress & evaporation coefficients: $K_s$, $K_e$
- Calculates adjusted ET as:
  \[ ET_c = (K_s \cdot K_{cb} + K_e) \cdot ET_o \]
Transition Strategy: SIMS 2.0

• Report evaluating transition strategy options presented to CDWR

• Option 1: Algorithms / processing workflows to be transferred to CDWR IT Infrastructure

• Option 2: Algorithms / processing workflows transferred to Google Earth Engine / Amazon EC2

• Prototypes implemented on both Earth Engine and Amazon EC2

• CDWR formed working group to evaluate and advise on final transition

• With support from CA DWR, work beginning to implement IrriQuest prototype as a desktop application
Lessons Learned

1) Field validation and quantification of accuracy is critical, but also challenging in commercial agriculture settings.

2) Partnership with growers / ag community is key, but requires sustained investment of time.

3) For agricultural applications, data continuity is essential → Landsat 8 TIRS data interruptions have been challenging.

4) Needs for APIs to integrate with other tools → Collaboration creates success; competition creates confusion for stakeholders.

5) Changes in California water policy creating new opportunities for applications of satellite data for ET mapping.


Questions?

For more information:
https://c3.nasa.gov/water/projects/1/
forrest.s.melton@nasa.gov

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