“Monitoring daily evapotranspiration over two California vineyards using Landsat 8 in a multi-sensor data fusion approach”

Presenter
Erhan Eroğlu

GGIT 561
13 May 2020

Paper Information

Paper Tittle: Monitoring daily evapotranspiration over two California vineyards using Landsat 8 in a multi-sensor data fusion approach

Author: Kathryn A. Semmens,Martha C. Anderson,William P. Kustas,Feng Gao,Joseph G. Alfieri,Lynn McKee,John H. Prueger,Christopher R. Hain,Carmelo Cammalleri,Yun Yang,Ting Xia,Luis Sanchez,Maria Mar Alsina,Mónica Vélez

Citation Indexes: 43
Publication: Remote Sensing of Environment
Publisher: Elsevier
Date: November 2016

Outline

Purpose of the paper

Experimental site and datasets

Methods

Results

Critisism

References

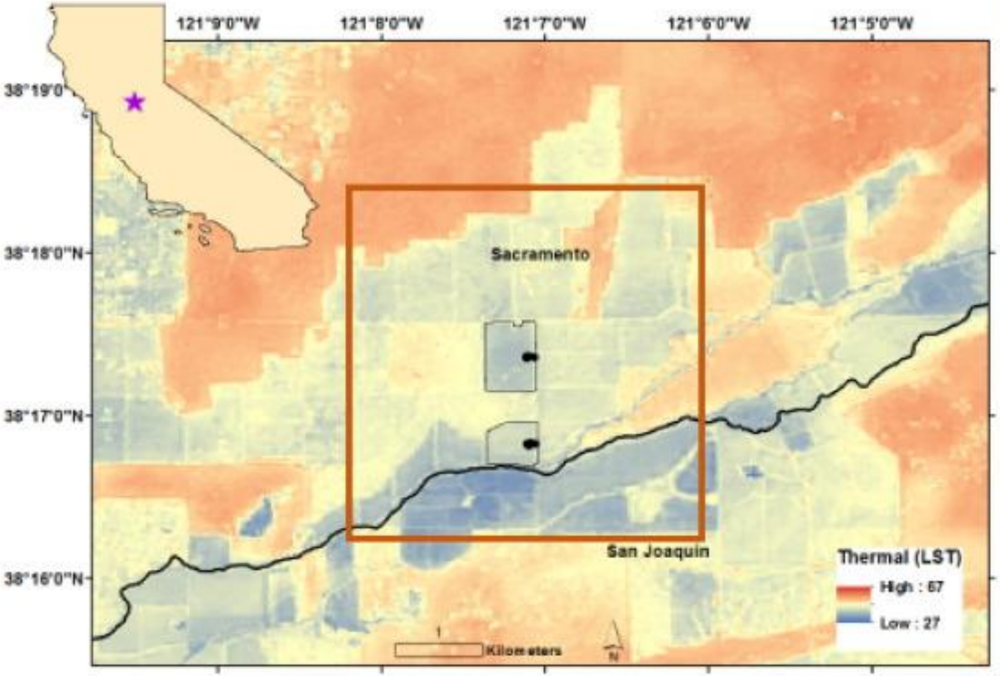
Purpose of the paper

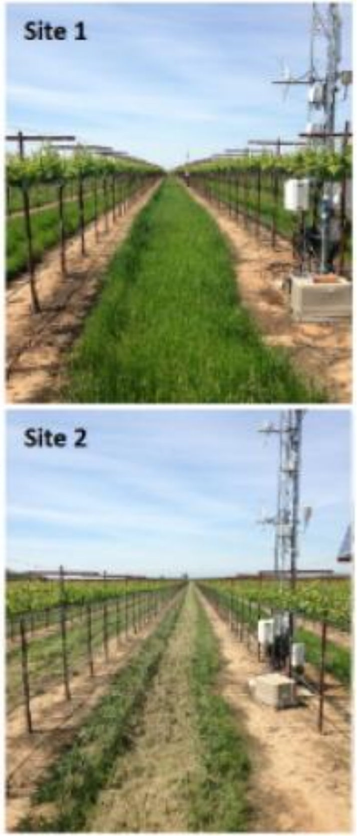
Given the high value of this crop commodity, the continued growth in production, and limited water availability in the state, there is significant interest in developing efficient water management strategies for California vineyards.

Complete field-scale maps of ET can be of significant value in managing vineyards and efficiently planning irrigation schemes, particularly when implemented over extensive acreages.

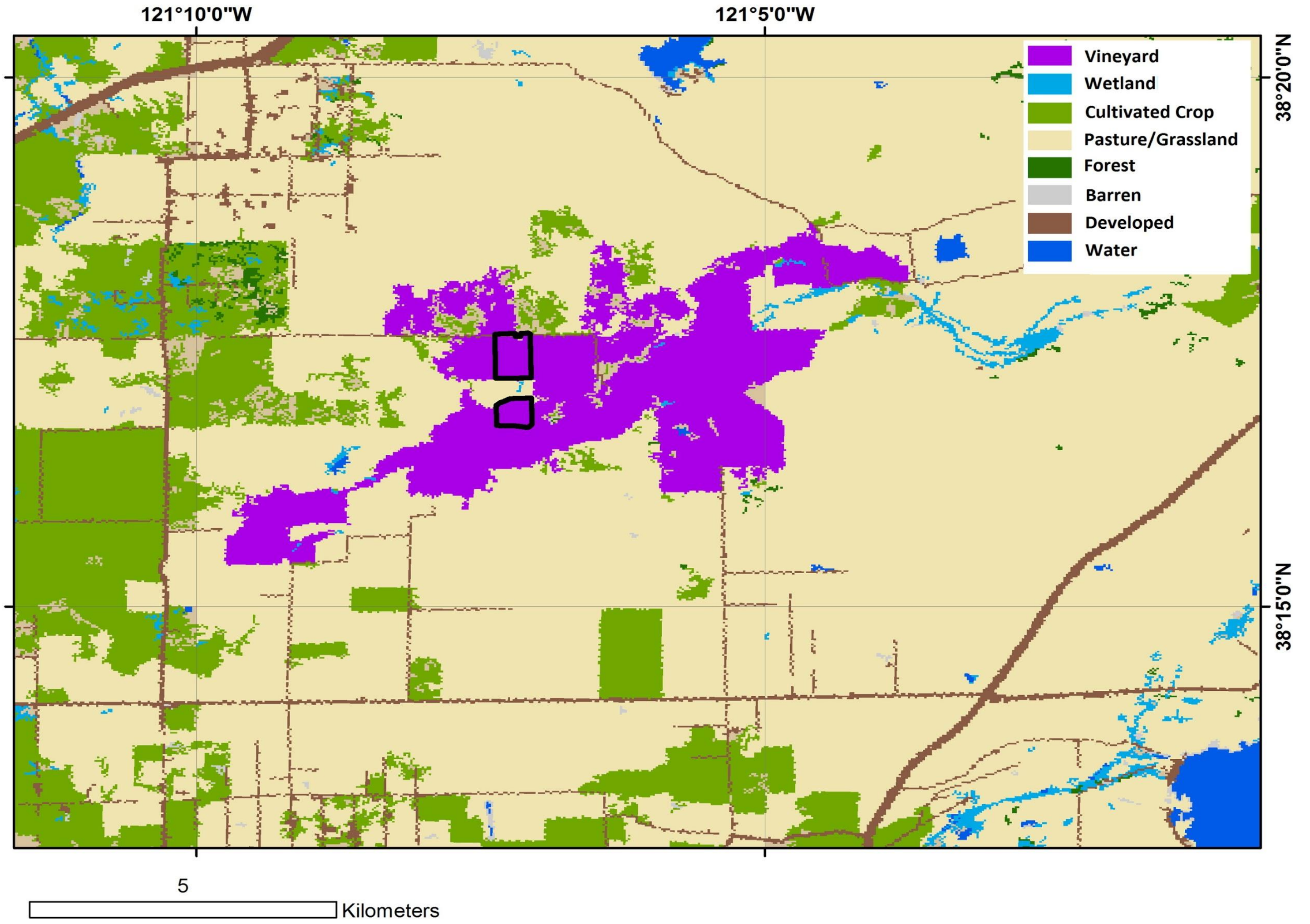
Study area

Wine grape production is expanding in the Central Valley region of California





Soil moisture is carefully controlled throughout the growing season to regulate vine water availability at different phenological stages. A grass cover crop between vine rows germinates in the late winter/early spring and is used to deplete soil moisture that accumulates from winter rains. This inter-row grass canopy remains green until late May/early June when temperatures rise and the dry season commences. In some years, the cover crop may be mowed prior to senescence to further control soil moisture evolution in a given field (see photograph of Site 2 in Fig. 2 from the 2014 growing season). Drip irrigation typically commences sometime later in June and is continued until harvest if necessary. Decisions to begin irrigation in a field for a season are triggered by various factors, including visual assessment of canopy water stress, spot measurements of leaf water potential with pressure chambers, soil moisture and upcoming weather conditions. Harvest for Pinot noir in the Central Valley typically occurs in early September. In 2013, the average yield in the northern field was 25.76 t ha^{-1} (metric tons per hectare), while in the southern field it was 16.93 t ha^{-1}.


121°10'0"W
121°5'0"W
38°20'0"N
38°15'0"N
Vineyard
Wetland
Cultivated Crop
Pasture/Grassland
Forest
Barren
Developed
Water
5
Kilometers

Experimental site and datasets

Micrometeorological and biological field measurements

Remote sensing data **(DisALEXI-Landsat, DisALEXI-MODIS, ALEXI-GOES, High resolution aircraft imagery)**

High resolution aircraft imagery

Regional meteorological inputs

Landcover

Methods

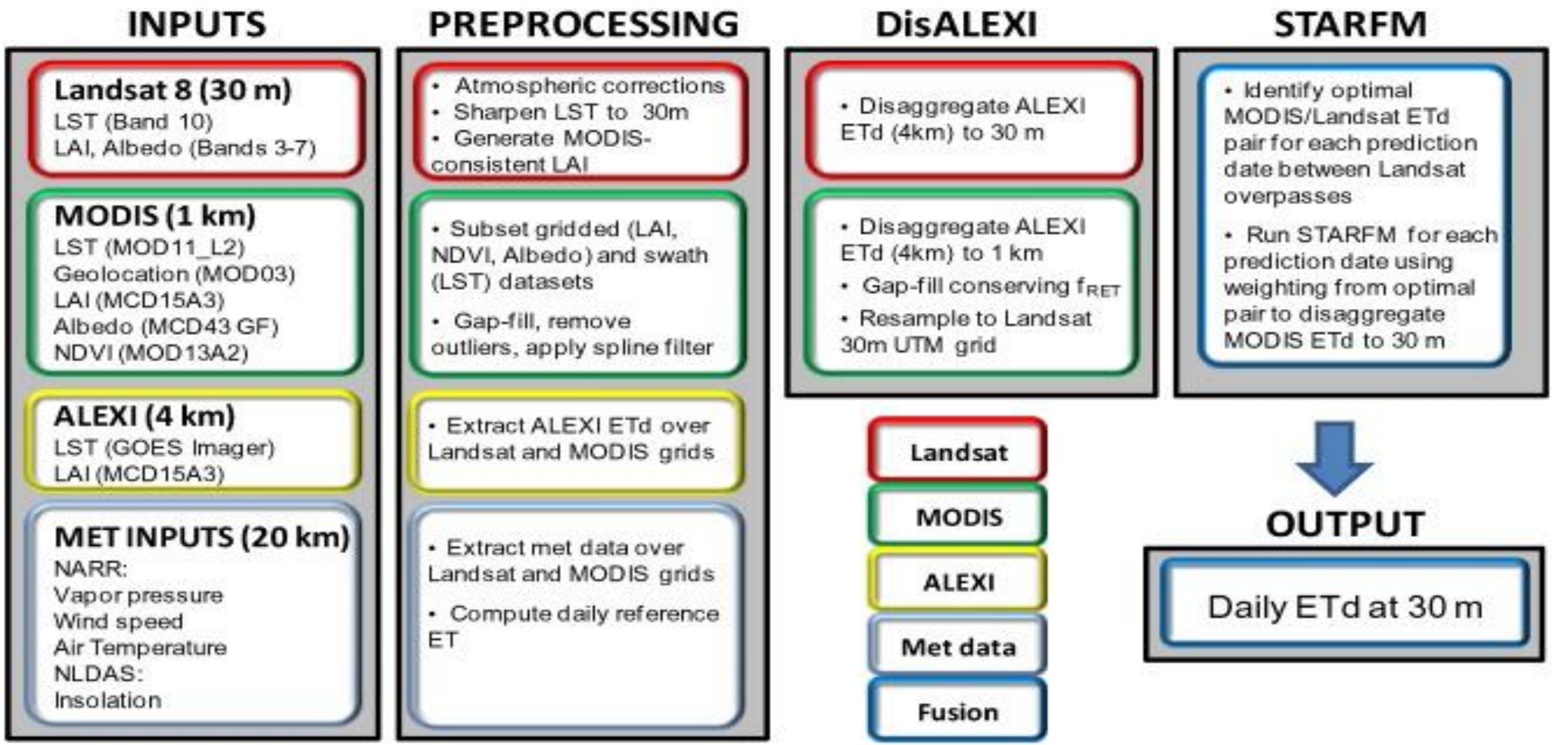


Fig. 1. Schematic overview of the inputs and processing steps in the ET data fusion system.

A schematic overview of the data fusion processing package, including inputs and image processing steps, is shown in Fig. 1. The main diagnostic input, the land surface temperature (LST), can be retrieved from various thermal imaging sensors over a range of different spatial and temporal resolutions. Remotely sensed LST inputs drive a multi-scale surface energy balance algorithm as described below.

STARFM: Spatial and Temporal Adaptive Reflective Fusion Model

combined with a multi-scale ET retrieval algorithm based on the Two-Source Energy Balance (TSEB) land-surface representation to compute daily ET at 30 m resolution.

In this system, TSEB is run using thermal band imagery from the Geostationary Environmental Operational Satellites (GOES; 4-km spatial resolution, hourly temporal sampling), the Moderate Resolution Imaging Spectroradiometer (MODIS) data (1 km resolution, daily acquisition) and the new Landsat 8 satellite (sharpened to 30 m resolution, ~ 16 day acquisition).

ALEXI, the multi-scale energy balance modeling scheme has its foundation on coarse-scale regional flux estimates from the Atmosphere–Land Exchange Inverse (ALEXI) model, driven primarily by a diagnostic measurement of the morning rate of surface temperature rise, which can be acquired from geostationary satellites.

Results

Model evaluation

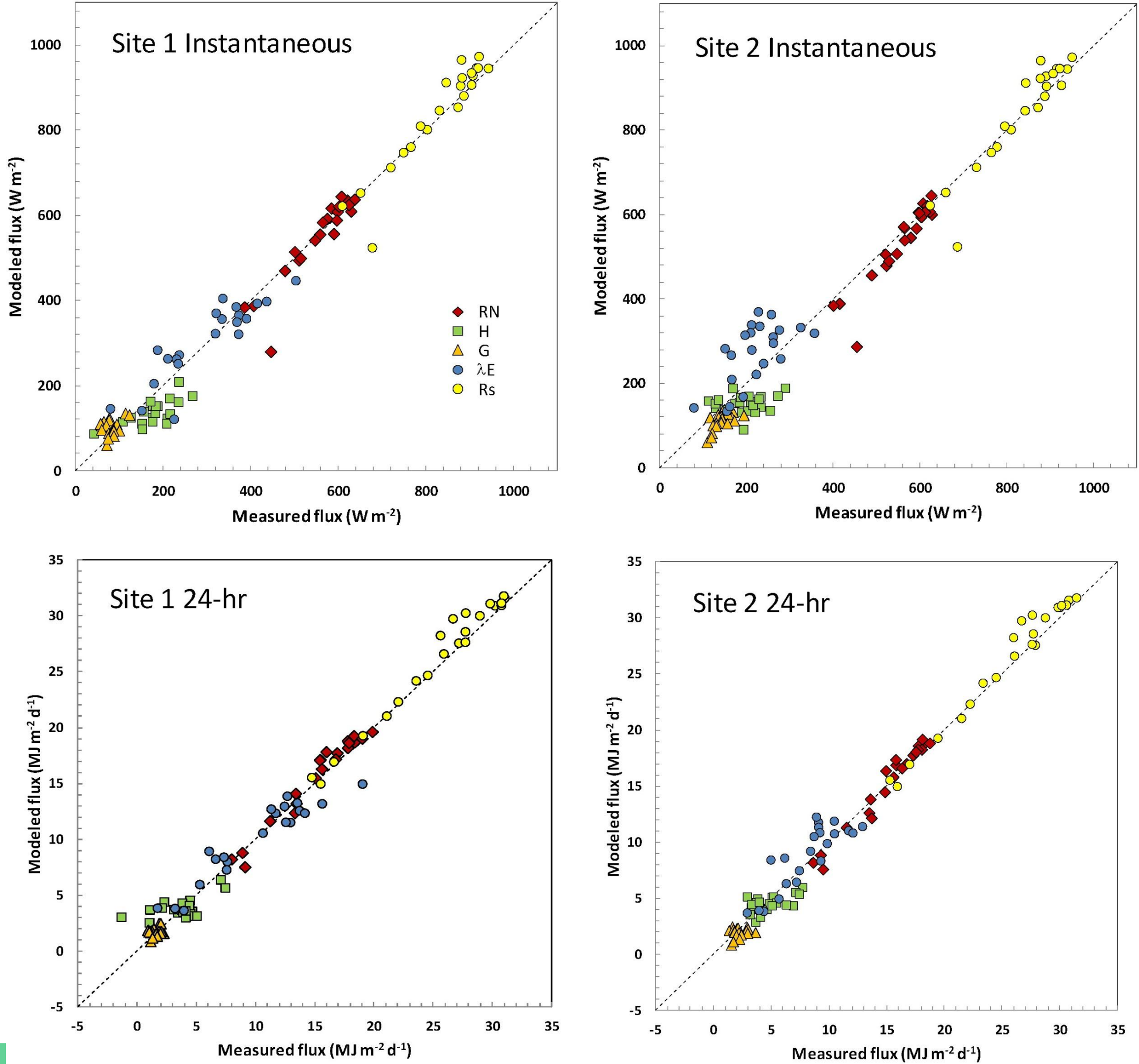


Fig. 4. (Top panels) Scatterplots comparing observed fluxes and estimates obtained with DisALEXI-Landsat on Landsat overpass dates for instantaneous fluxes (*Rs* — solar radiation, *Rn* — net radiation, λ*E* — latent heat, *H* — sensible heat, *G* — soil flux) for the two flux tower sites. (Bottom panels) Scatterplots comparing observed and Landsat-retrieved 24-h fluxes for two flux tower sites in the vineyards.

Temporal patterns in evapotranspiration (ET)

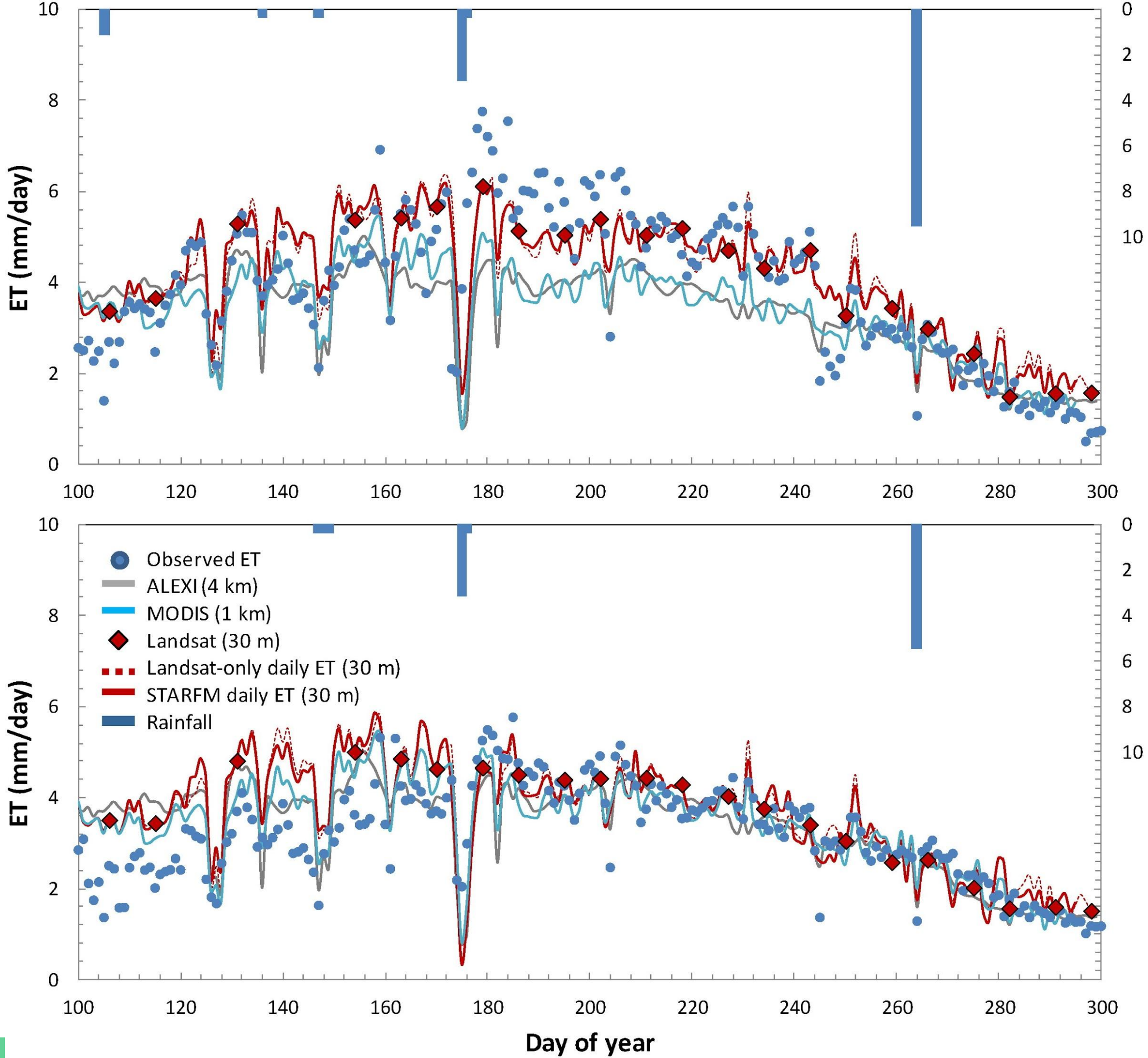


Fig. 5. Time series of observed daily ET (blue dots), ET retrievals from ALEXI (gray line), DisALEXI-MODIS (aqua line) and DisALEXI-Landsat (red diamonds), along with 30 m daily ET estimates from STARFM (solid red line) and Landsat-only interpolation (dotted red line) for Site 1 (top panel) and Site 2 (bottom panel). Rainfall events are shown as blue bars.

Fig. 6. Comparison of Landsat-retrieved and measured leaf area index (LAI, top panel) and land surface temperature (LST, middle panel) at the time of overpass (~ 1840 UTC) for each Landsat overpass date at Sites 1 and 2. Bottom panel shows difference in ET between Sites 1 and 2 as inferred from EC observations and the STARFM retrievals, smoothed with a 10-day moving average. The period prior to DOY 160 when the early season model bias at Site 2 is significant has been highlighted.

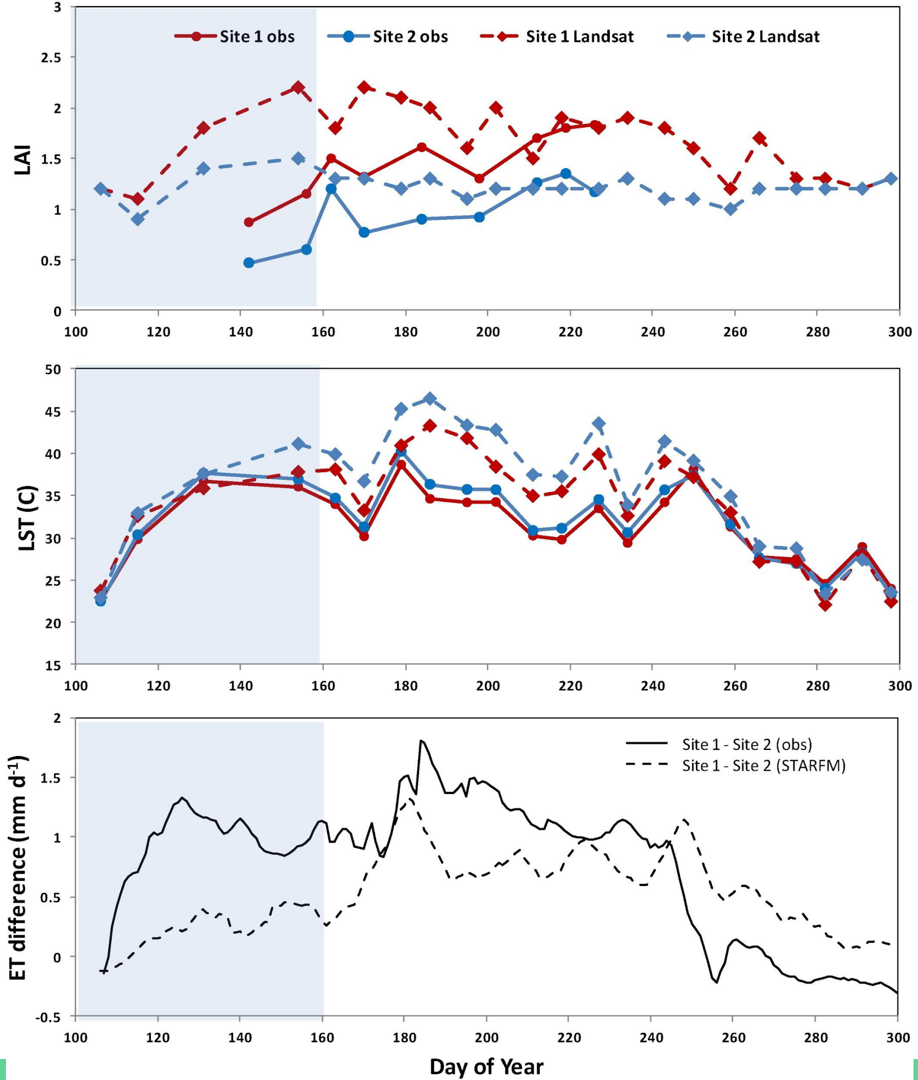
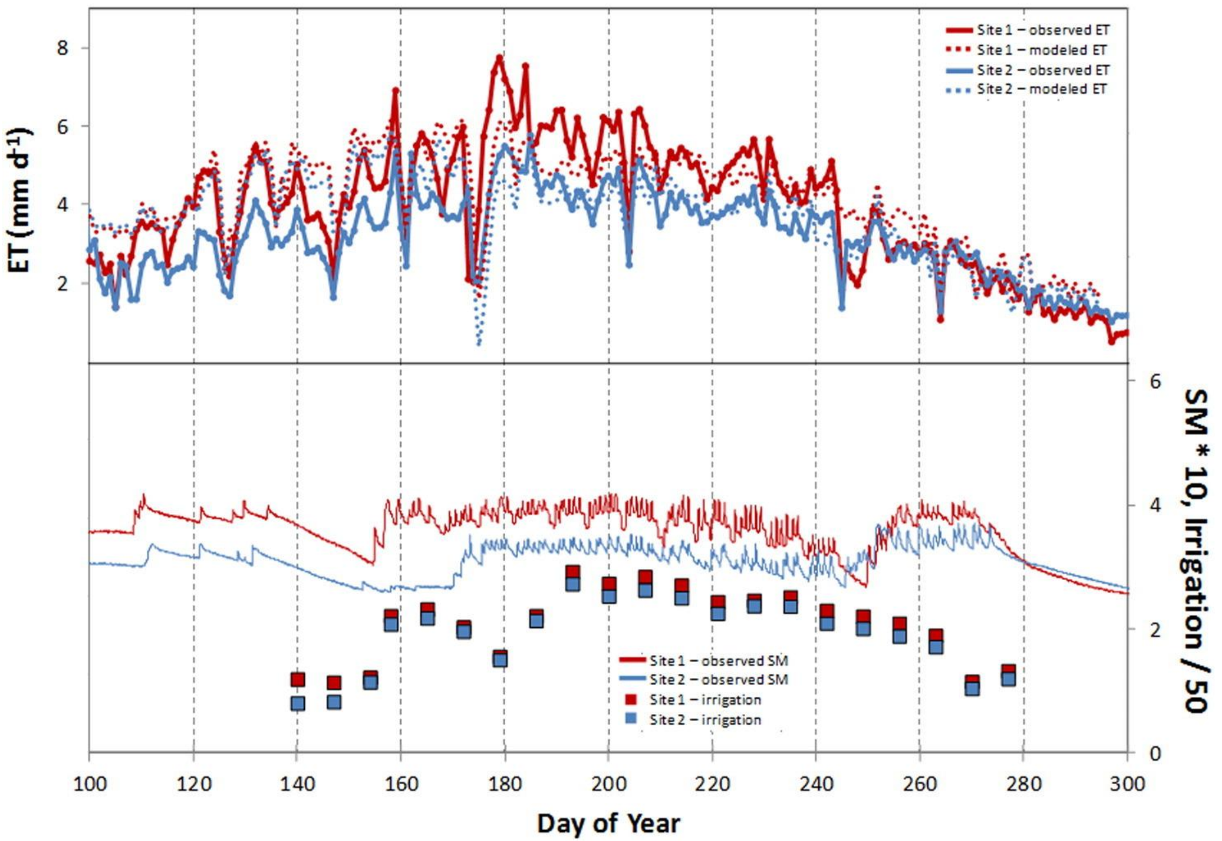


Fig. 7. Time series of observed (solid lines) and fusion modeled (dotted lines) ET for Sites 1 (red) and 2 (blue) are shown in top panel. Average soil moisture (SM; volumetric water content ∗ 10) shown as solid lines in bottom panel is plotted with values on the right axis, as well as approximate weekly irrigation rates shown with squares (liters per vine/50).



Spatial patterns in evapotranspiration (ET)

Fig. 8. Spatial timeseries (every 30 days) of 24-h ET (left column) and cumulative ET (right column) over a 4 × 4 km area including the two vineyard sites instrumented for GRAPEX. Individual fields are easily distinguishable as are times of higher ET (and possible irrigation).

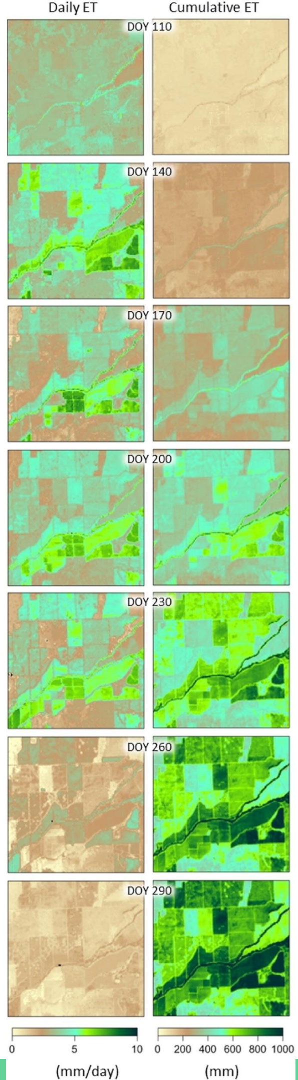


Fig. 9. Two up close snapshots of Site 1 and Site 2, as well as the alfalfa field just south of these fields. The four alfalfa fields have very high ET on day 202, but just a few days later are essentially bare due to harvesting.

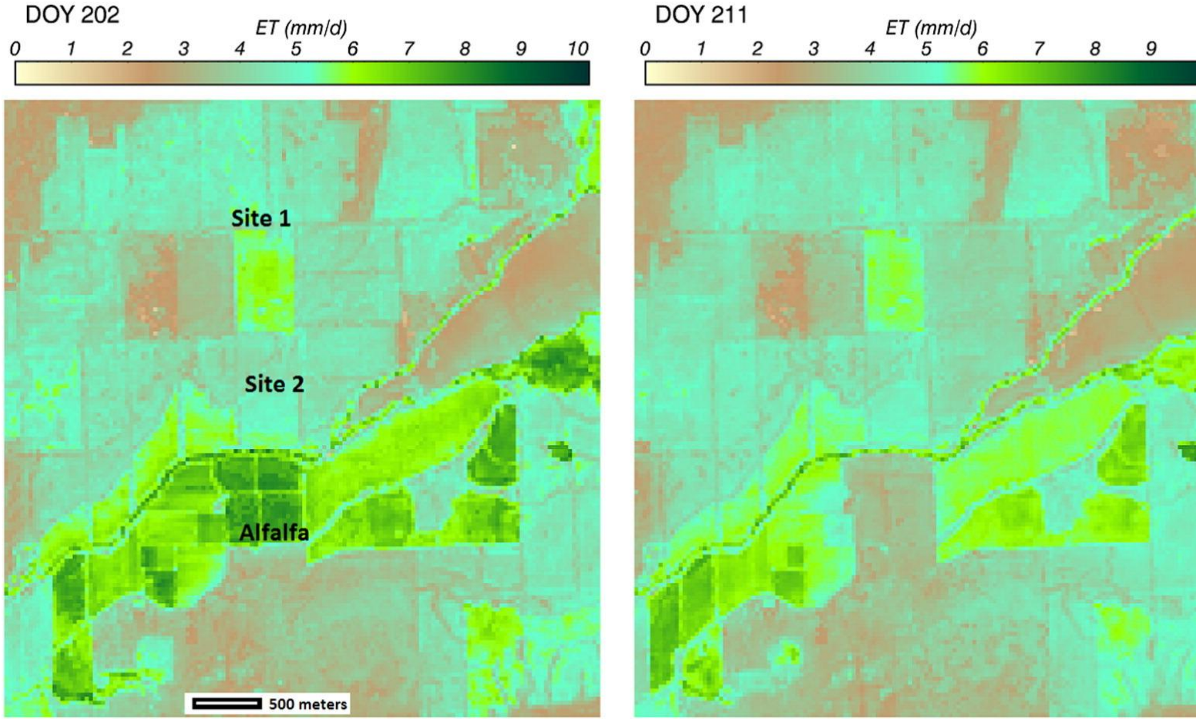
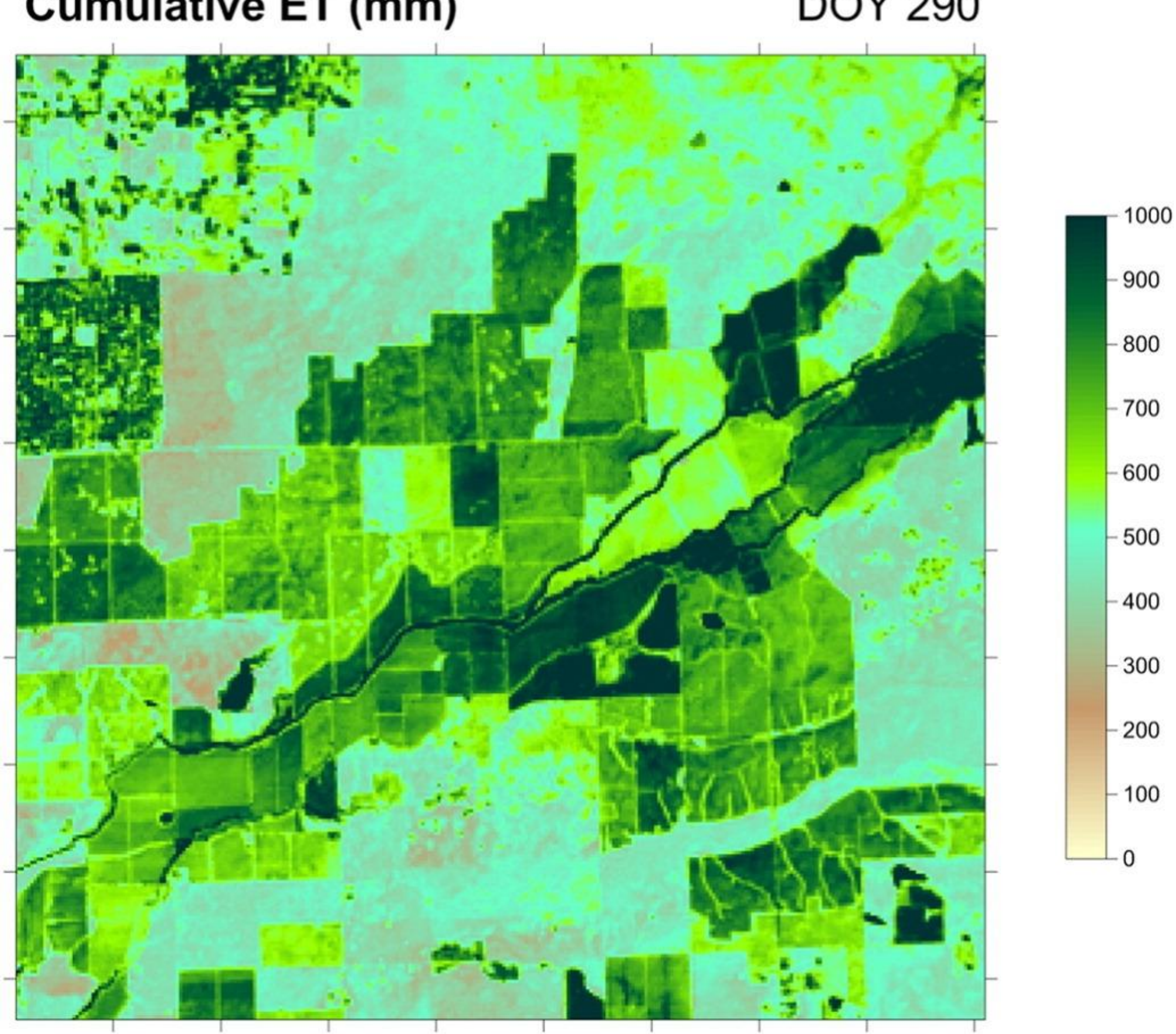


Fig. 10. Cumulative seasonal ET (mm) map (9 × 9 km) on DOY 290 surrounding the GRAPEX study.



Subfield variability

in water use and yield

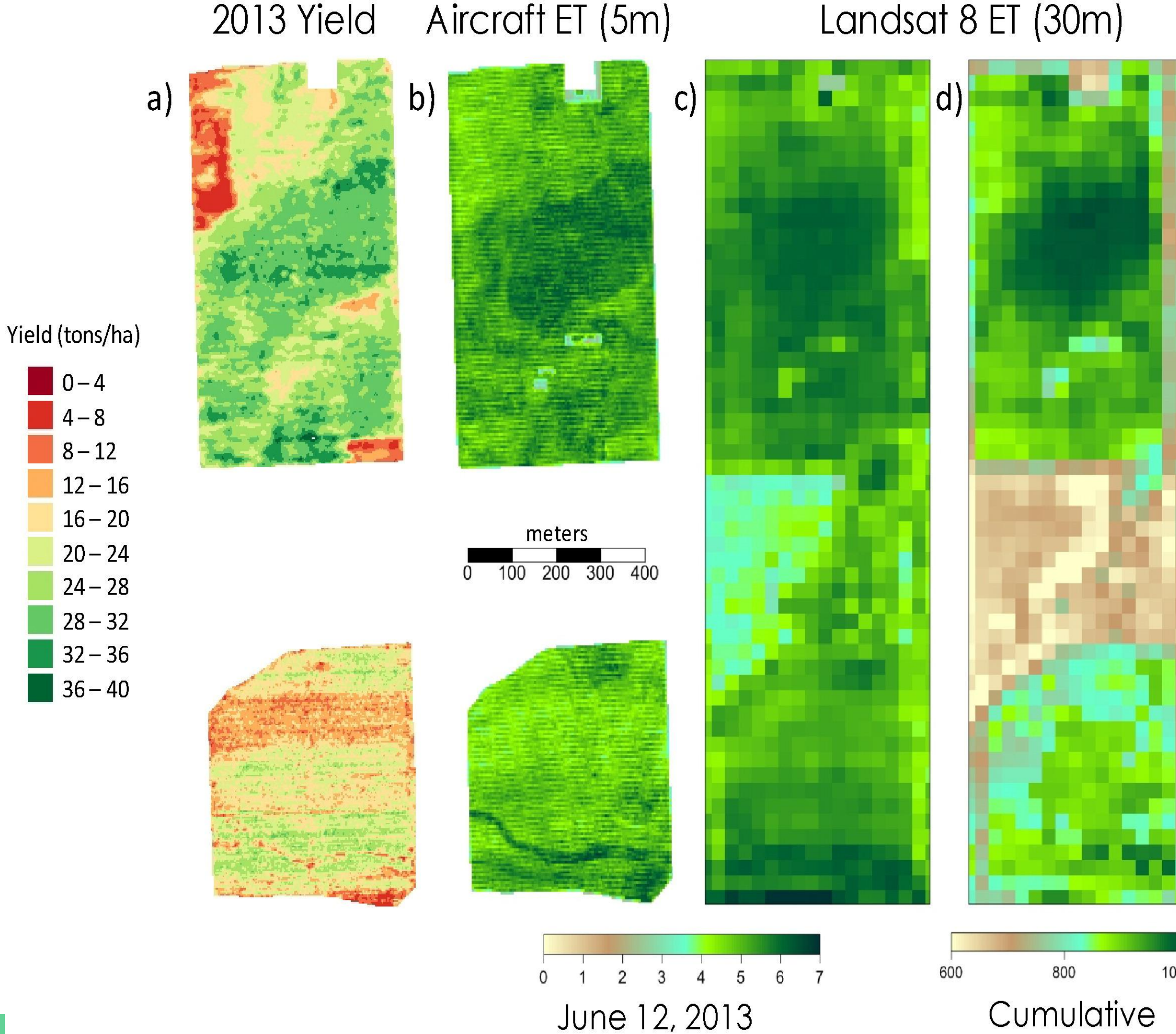


Fig. 11. Spatial distribution of a) yield (metric tons per ha) at the end of the 2013 season; b) 24-h evapotranspiration (ETd) at 5 m resolution from DisALEXI applied to aircraft imagery for DOY 163; c) 24-h evapotranspiration (ETd) at 30 m resolution from DisALEXI applied to Landsat LST for DOY 163; d) cumulative evapotranspiration (DOY 106-245) at the end of season at 30 m resolution derived from STARFM daily ET output.

Critisism

Performance of multi-sensor and scale data fusion approach to mapping ET using GOES, MODIS and Landsat TIR and shortwave imagery was assessed in an application over two vineyard sites in central California using data products from the new Landsat 8 satellite. Both temporal and spatial timeseries of ET show interesting details in water use variability within the individual fields as well as in contrast with the surrounding area.

General spatial correspondence of fused daily and cumulative ET maps with within-field variability in at-harvest yield maps suggest potential utility for adaptive precision management of irrigation applications to homogenize grape production across fields.

Cumulative ET maps from DOY 106 to 245 (date of first Landsat 8 scene to harvest) demonstrate strong variability in seasonal water use in relationship to crop type and water management strategy. Cumulative ET was predicted to within 2% for the more mature vineyard (Site 1), while in the younger vineyard site, cumulative ET was overestimated by 16% due to an early season wet bias.

This overestimation may have an instrumental component, or may in part relate to issues with model parameterizations of canopy architecture relating to a between-row grass cover crop used to consume excess springtime moisture. This bias will be further investigated using data collected between the 2013, 2014 and 2015 growing seasons.

References

Monitoring daily evapotranspiration over two California vineyards using Landsat 8 in a multi-sensor data fusion approach

Author:
Kathryn A. Semmens,Martha C. Anderson,William P. Kustas,Feng Gao,Joseph G. Alfieri,Lynn McKee,John H. Prueger,Christopher R. Hain,Carmelo Cammalleri,Yun Yang,Ting Xia,Luis Sanchez,Maria Mar Alsina,Mónica Vélez

Publication: Remote Sensing of Environment

Publisher: Elsevier

Date: November 2016

Published by Elsevier Inc.

https://doi.org/10.1016/j.rse.2015.10.025

Thank you for your attention.