Analysis of seasonal and diurnal variation in vegetation canopy water content using AVIRIS-derived liquid water products from ACORN

Tao Cheng[a], David Riaño[a, b], Susan L. Ustin[a]

[a]Center for Spatial Technologies and Remote Sensing, Department of Land, Air and Water Resources, University of California, Davis, CA, USA
[b]Instituto de Economía y Geografía, Centro de Ciencias Humanas y Sociales, Consejo Superior de Investigaciones Científicas, Madrid, Spain
Contact: gtcheng@ucdavis.edu (T. Cheng), driano@ucdavis.edu (D. Riano), slustin@ucdavis.edu (S. Ustin)

Introduction

The liquid water (equivalent water thickness, EWT) output from hyperspectral imagery, as a by-product of atmospheric correction from a popular software package ACORN, has been used to analyze the spatial and temporal variation in vegetation water status. However, the EWT product has rarely been evaluated against ground measurements. The water vapor absorption feature at 940 nm (as opposed to the liquid water feature at 970 nm) is popularly used in the community for EWT retrieval with ACORN, but little attention has been paid to the feature at 1140 nm.

Objectives:

- To evaluate the ACORN-produced EWT using field-measured seasonal and diurnal canopy water content (CWC) data
- Investigate the effect of absorption features at 940 nm and 1140 nm on EWT retrieval across seasons

Methods

Study site and field data:
Almond and pistachio orchards, Southern San Joaquin Valley, California

CWC: = EWT_{Leaf} × LAI (# of samples=174)

AVIRIS imagery acquired:

- 05/20/2011: green-up (12:00h PST ±2)
- 11/02/2011: senescence (12:00h PST ±2)
- Pixel size: 8 m
- Bidirectional Reflectance Distribution Function (BRDF) effect: applied empirical BRDF corrections to diurnal imagery by normalizing cross-track radiance to the nadir value

EWT retrieval: ACORN 5b (Imspec LLC)

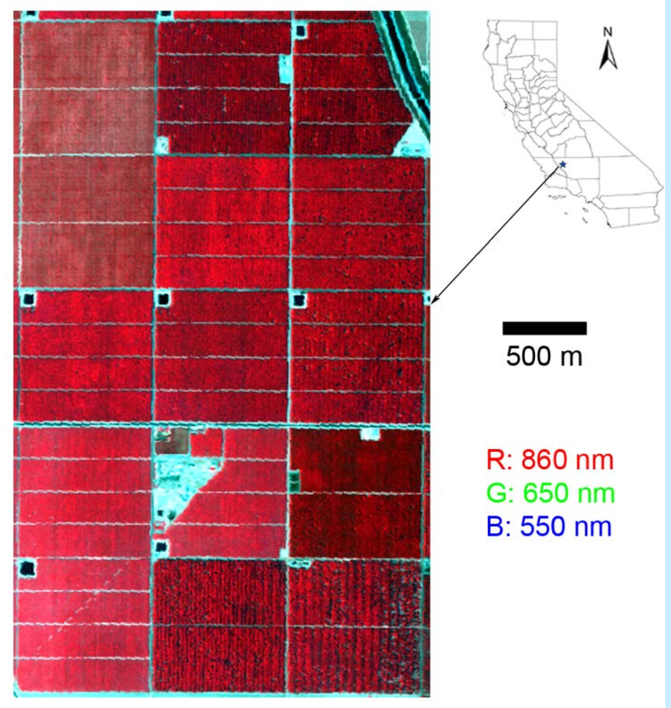

Fig. 1. The geographic location and an AVIRIS color infrared composite image of the study area

Results

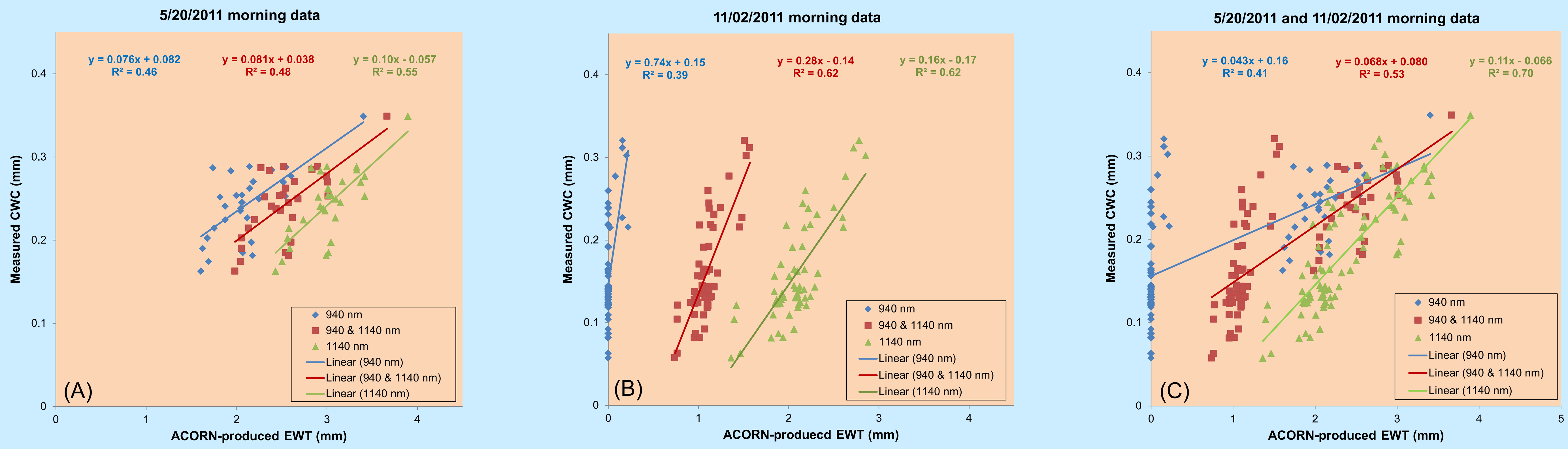

Fig. 2. Relationships of field-measured canopy water content (CWC) with ACORN-produced equivalent water thickness (EWT) obtained using different absorption features for (A) May data, (B) November data, and (C) May & November data. Note that the scatter plot in (C) has two clusters by season for the EWT data obtained using the 940 nm feature and both features.

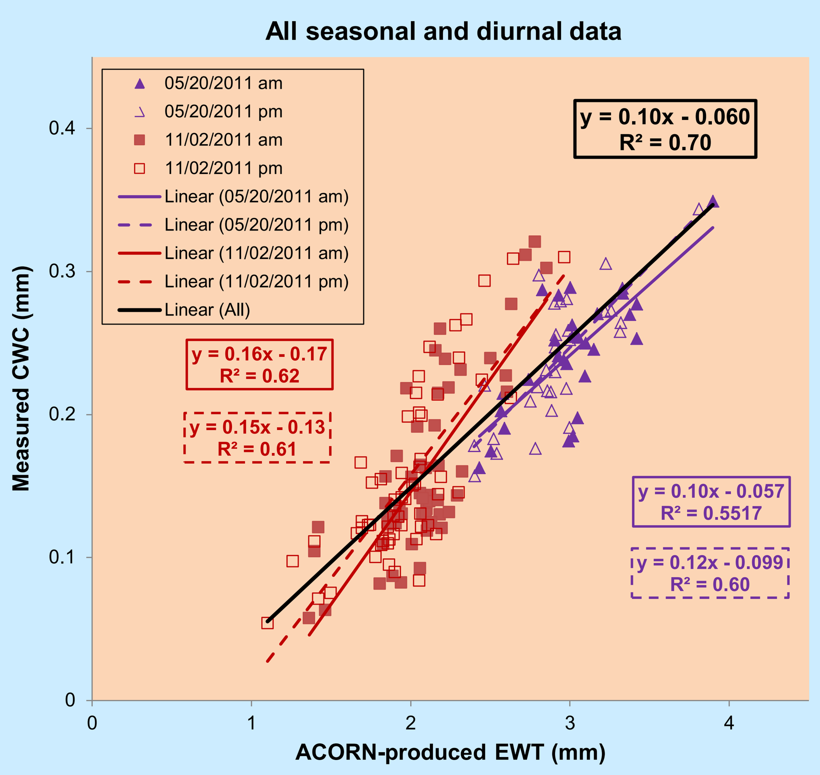

Fig. 3. Relationships of field-measured CWC with ACORN-produced EWT obtained using the 1140 nm feature for all seasonal and diurnal data.

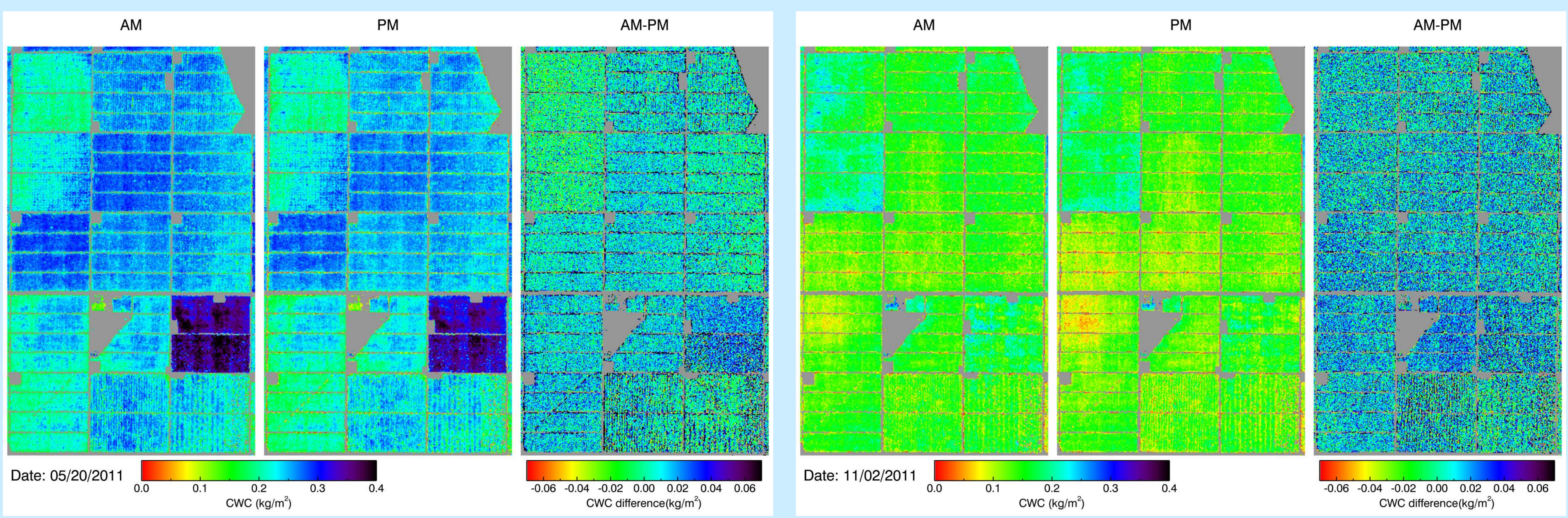

Fig. 4. CWC maps generated by applying the universal relationship (black line) in Fig. 3 to the morning and afternoon AVIRIS imagery acquired in May (left panel) and November (right panel).

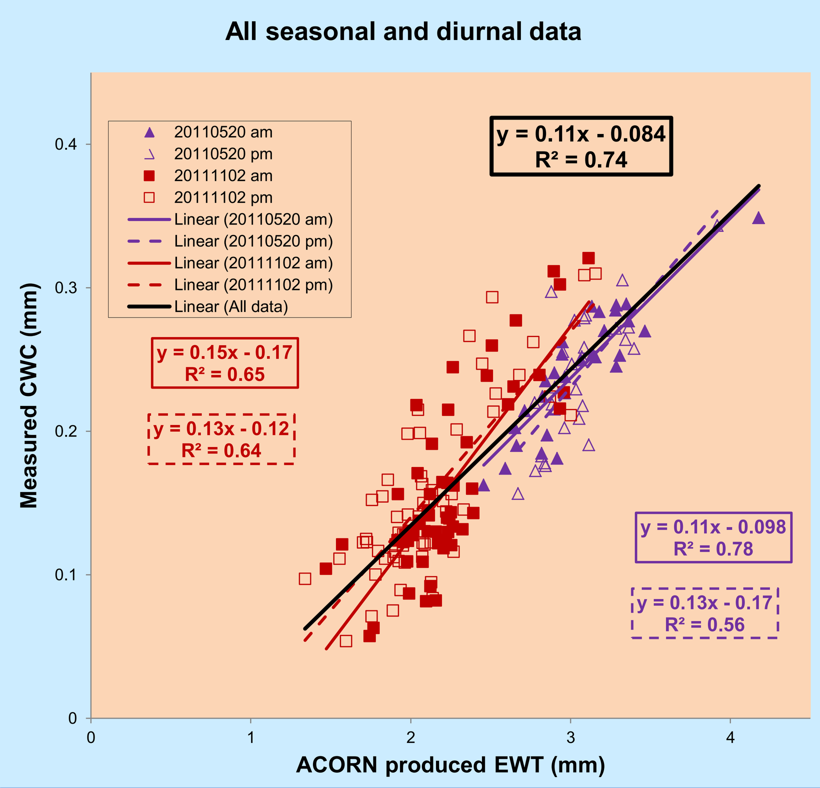

Fig. 5. The same as Fig. 3 except that the AVIRIS imagery was not corrected for the BRDF effect.

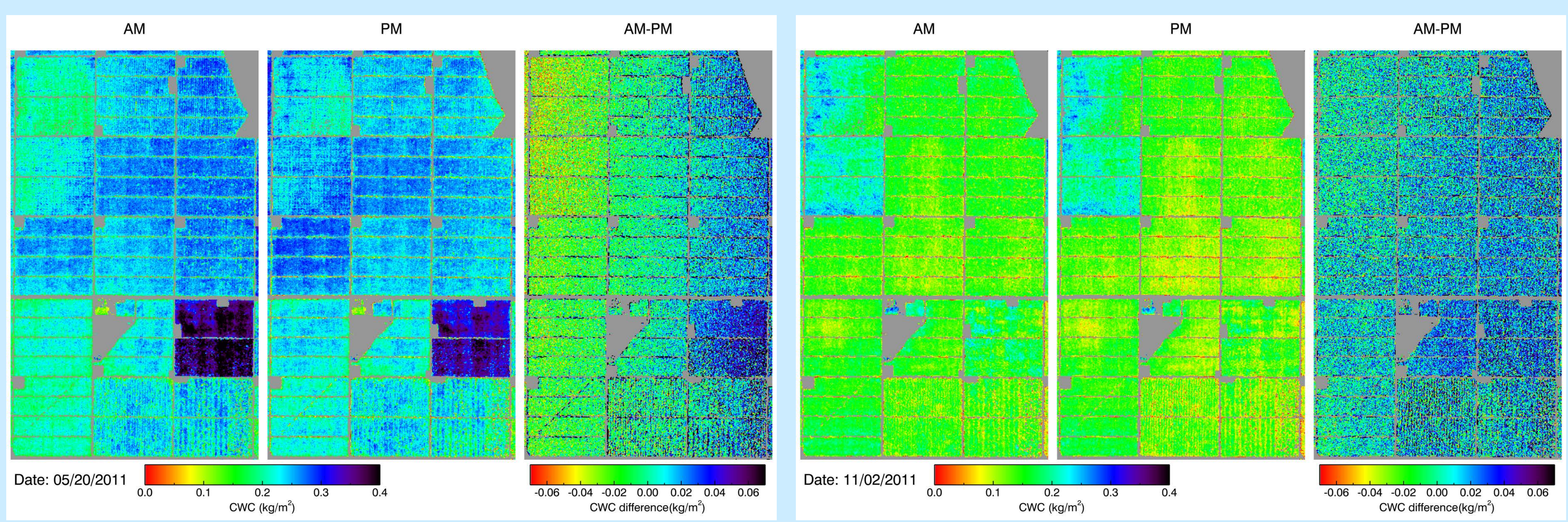

Fig. 6. CWC maps generated by applying the universal relationship (black line) in Fig. 5 to the morning and afternoon AVIRIS imagery acquired in May (left panel) and November (right panel). Note that the systematic spatial variation in horizontal direction most significant in the CWC difference maps was caused by the BRDF effect. A similar systematic variation was not seen in maps of Fig. 4 since the AVIRIS imagery had been corrected for the BRDF effect before the EWT retrieval with ACORN.

Conclusion

- ACORN-produced EWT is much greater than field-measured CWC by 10:1 in magnitude.
- Although the 940 nm feature is popularly used in the community, we found ACORN failed to retrieve EWT from the November imagery based on this feature. Instead, the 1140 nm feature alone led to a consistent relationship between retrieved EWT and field-measured CWC across seasons.
- The BRDF correction applied to AVIRIS radiance data did not change the EWT~CWC relationship but removed the systematic spatial patterns in CWC maps.
- Caution should be taken when using EWT retrievals from multi-temporal AVIRIS imagery to analyze seasonal variation in CWC.

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