# Assessing Evapotranspiration, Basal Crop Coefficient, and Irrigation Efficiency in Production Peach Orchard in California's San Joaquin Valley

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# Overview

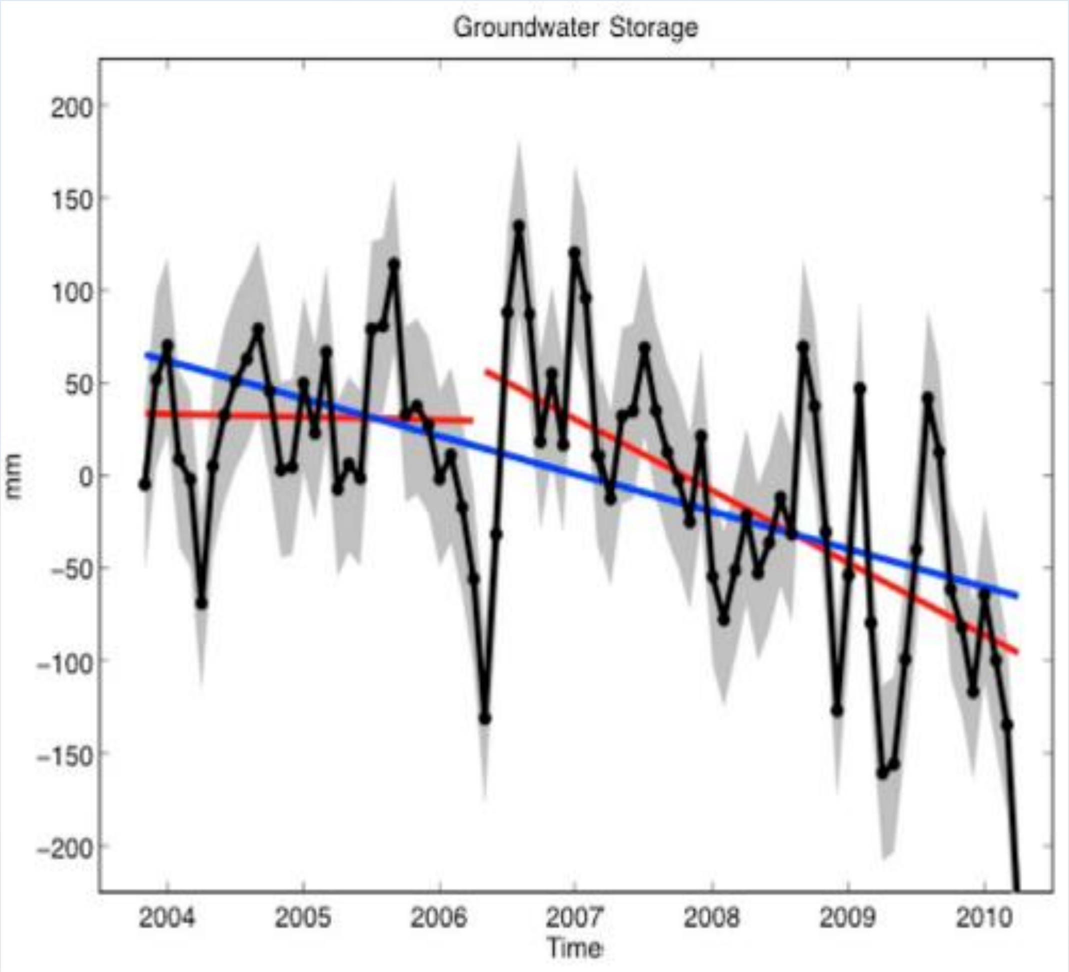
- Introduction, approach, and site
- Peach Evapotranspiration, controls, and partitioning
- Crop Coefficients and irrigation efficiency
- Future work

# Background and motivation

- Central Valley is a significantly water stressed region. Increasing need for efficient on farm use of applied irrigation water, particularly for important perennial crops like peach.

- Most studies of crop water use have been done in smaller experimental plots, not actual production systems (also limits upscaling with satellite remote sensing).

- Goals: (1) Assess how peach water use compares to previous experimental work, (2) assess on farm water use efficiency, and (3) improve satellite parameterizations of crop water use.




Monthly groundwater storage anomalies in Central Valley showing groundwater decrease due to pumping during 2007-10 drought [from *Famiglietti et al., 2011*].

# Approach

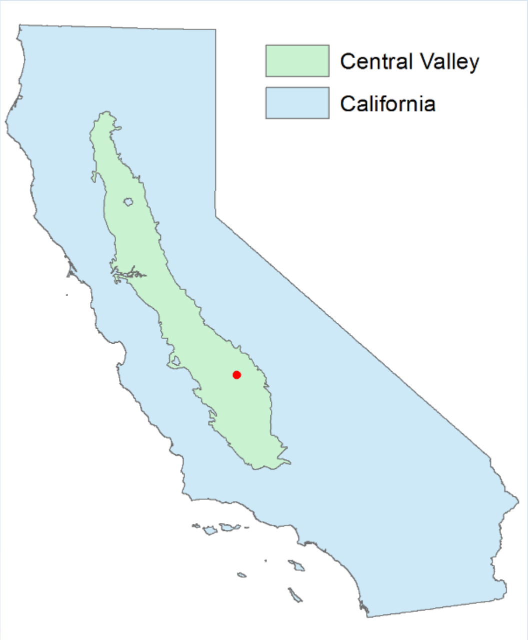
- Integrate multiple observation techniques (micrometeorology, field water balance, remote sensing, larger meteorological estimates of reference/potential ET) to observe water use and efficiencies in production peach orchard.

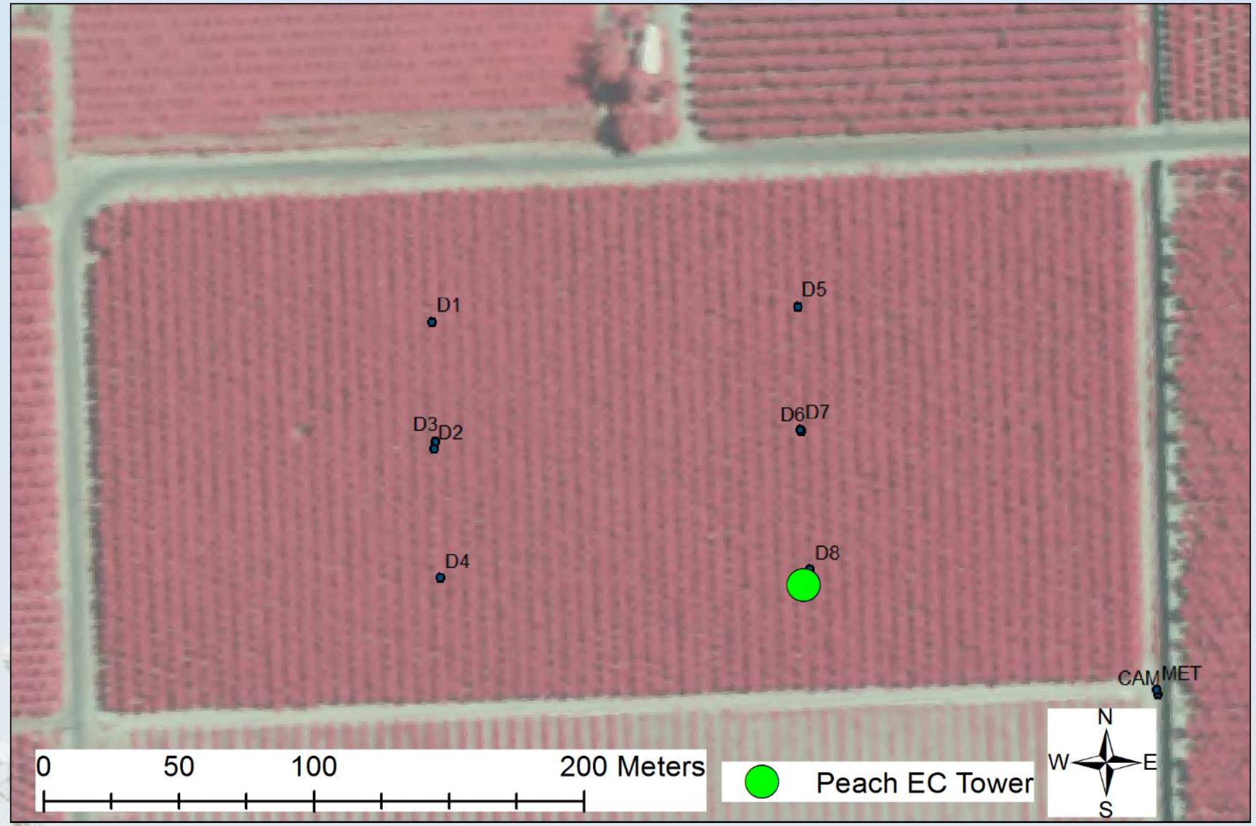
- Each techniques has particular advantages and drawbacks.  Integration of techniques enables mitigation of individual drawbacks.

- Ultimate goal of better parameterization for remote-sensing based models, particularly in relatively complex agricultural crop canopies like peach.

# Site

- 8.3 hectare mature canning (cling) Peach (Ross cultivar) field near Kingsburg, CA.




- Planted 1998.

- Furrow irrigated field with combination of surface water (junior rights) and groundwater sources.

- Alluvial sandy clay soils with no evidence (< 1.5 m) of hardpan.

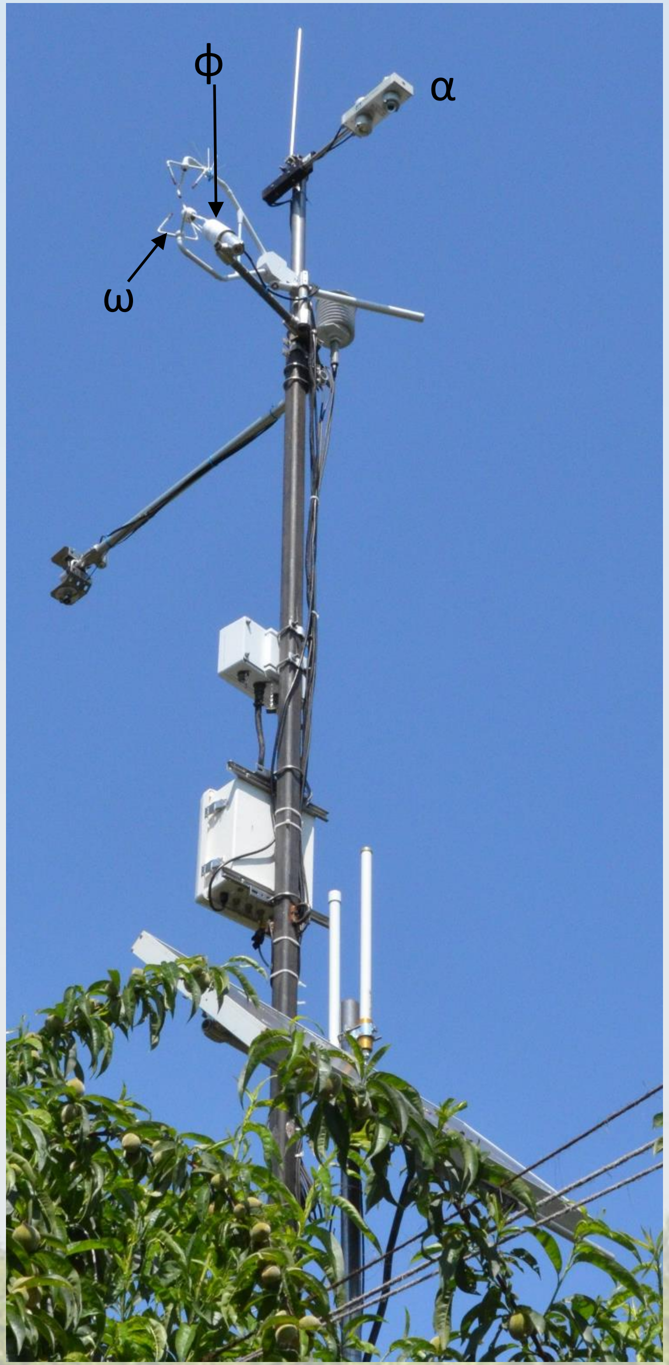
- Farmer does own irrigation scheduling. Attempts mild deficit irrigation after harvest (mid-August).

Top left: Field location (red dot) in relation to Central Valley and California.

Top right: Location of instrumentation in field. Black dots indicate CSUMB/NASA soil and met. instrumentation.

# Instrumentation and data – EC tower

- Eddy Covariance (EC) is micrometeorological technique that enables direct ET observation.  Key instruments include sonic anemometer (ω), IRGA (ϕ), and radiometer (α).
- Advantages include minimal interference with crop environment and much larger areal average than soil observations.  Also records meteorological information useful for upscaling with satellite data.
- Disadvantages include need to exclude and gap-fill (interpolate) data from time periods with insufficient turbulence or unsuitable wind direction.
- Tower established April 5, 2012



# Instrumentation and data–other locations

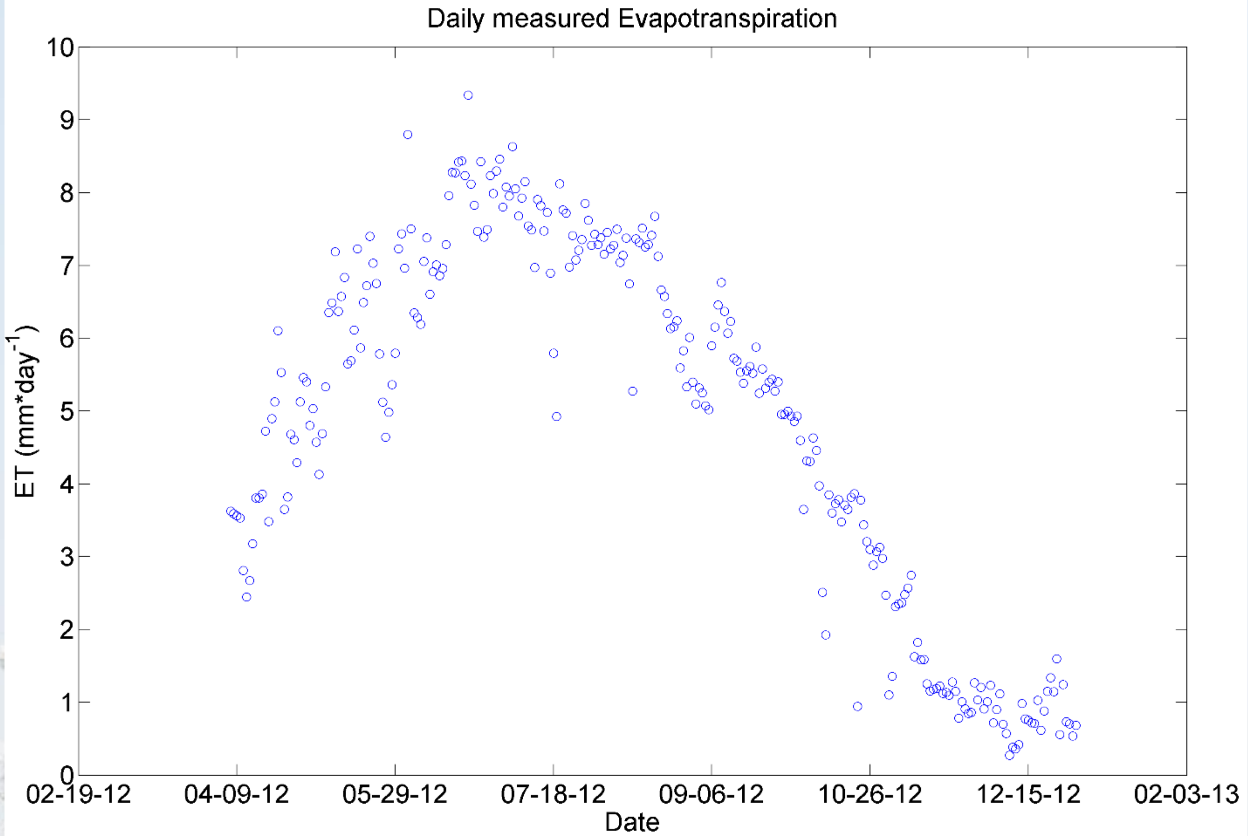
- Profile soil moisture observations from 0-40” (0-1.02 m) at 8 locations.
- Capillary drainage lysimeters installed to the same depth (top right) in furrow and mound.
- Flow meters on two rows (bottom right).  Soil, flow, and lysimeter data available for all 2012.
- Surface renewal station run by CA DWR.
- Meteorological data and below canopy radiation, IR, and wind observations.

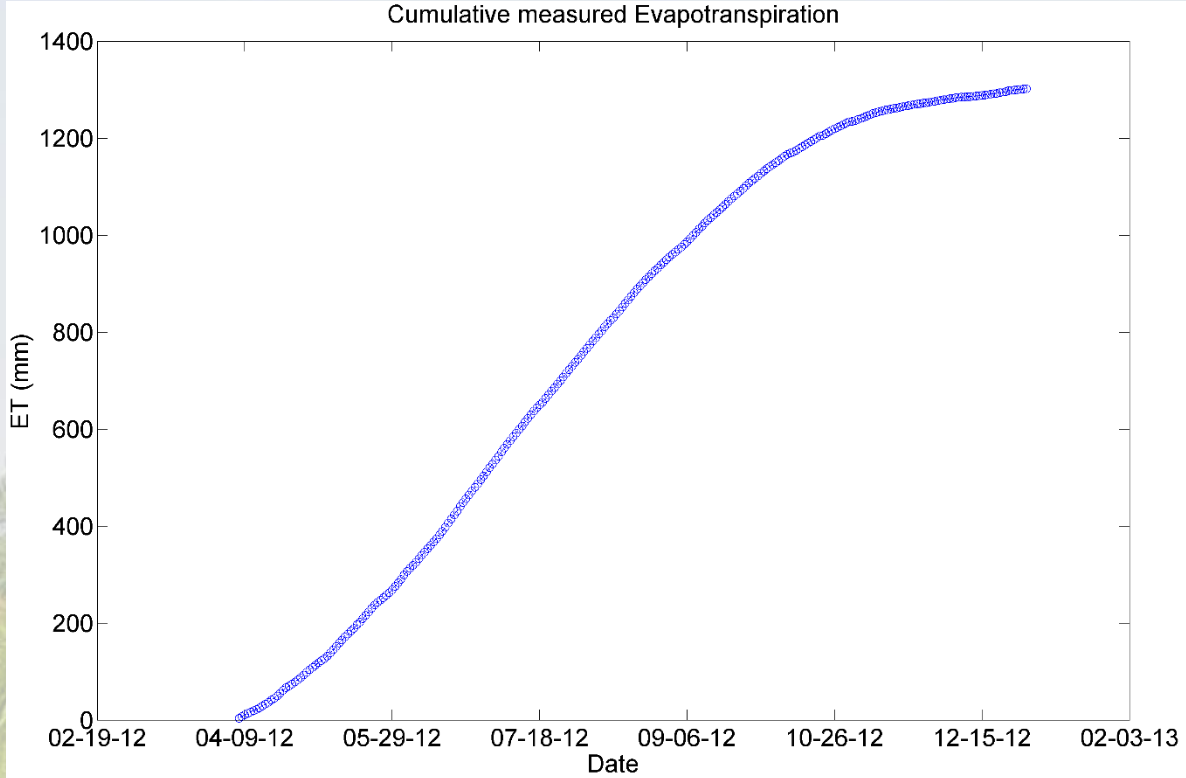
# Evapotranspiration

-Daily Evapotranspiration (ET) decreased from 9 mm/day to less than 1 mm/day after end of leaf senescence in November.

-Greatest variation in daily ET at beginning of season.

-Daily ET generally shows predictable seasonal patterns but daily outliers due to synoptic meteorology also appear.



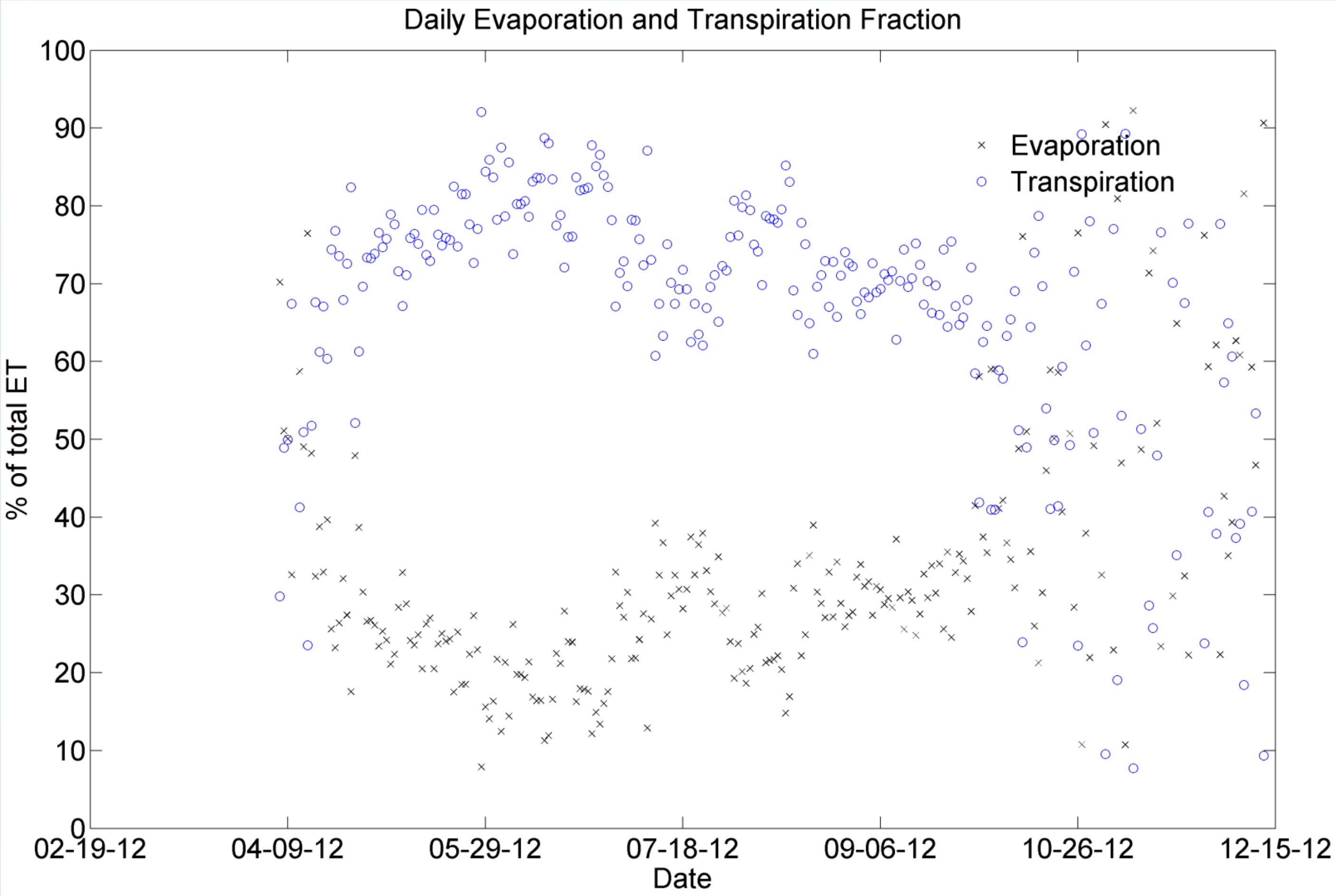




-Cumulative ET for tower period in 2012 (April 5-December 31) is 1309 mm.

-Compares to 1176 mm for CIMIS station (Parlier) reference $ET_0$ and 1221 for CIMIS Spatial reference $ET_0$.

# Flux Partitioning

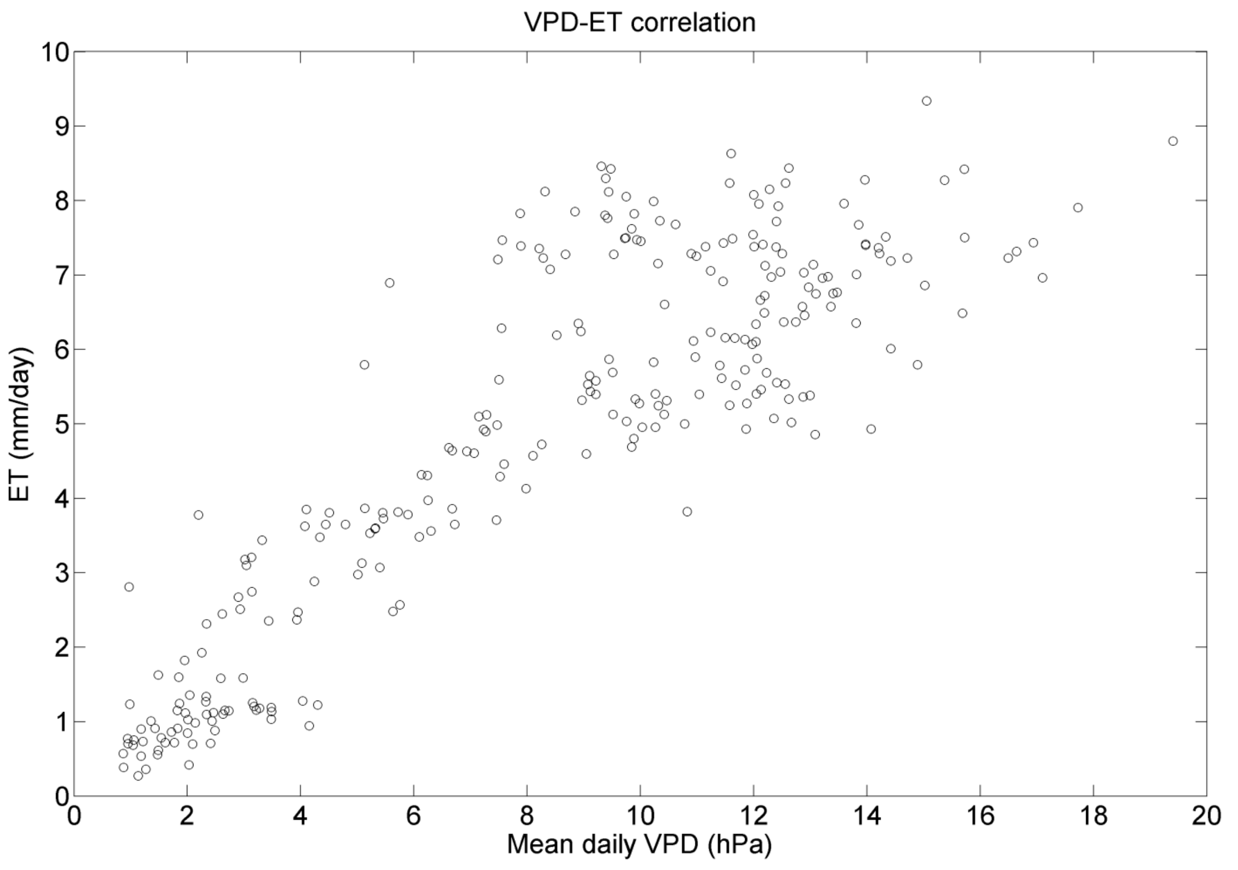
- Correlation between $H_2O$ and $CO_2$ concentrations can be used with plant physiological models to partition total ET into individual components [e.g. *Scanlon and Kustas*, 2010].
- Flux partitioning is significantly easier and less costly than other partitioning approaches (e.g. sap flux, isotopes).
- Can be used to assess more "productive" water use (transpiration) vs. evaporation of different systems.
- No clear increase in evaporation after irrigation events.

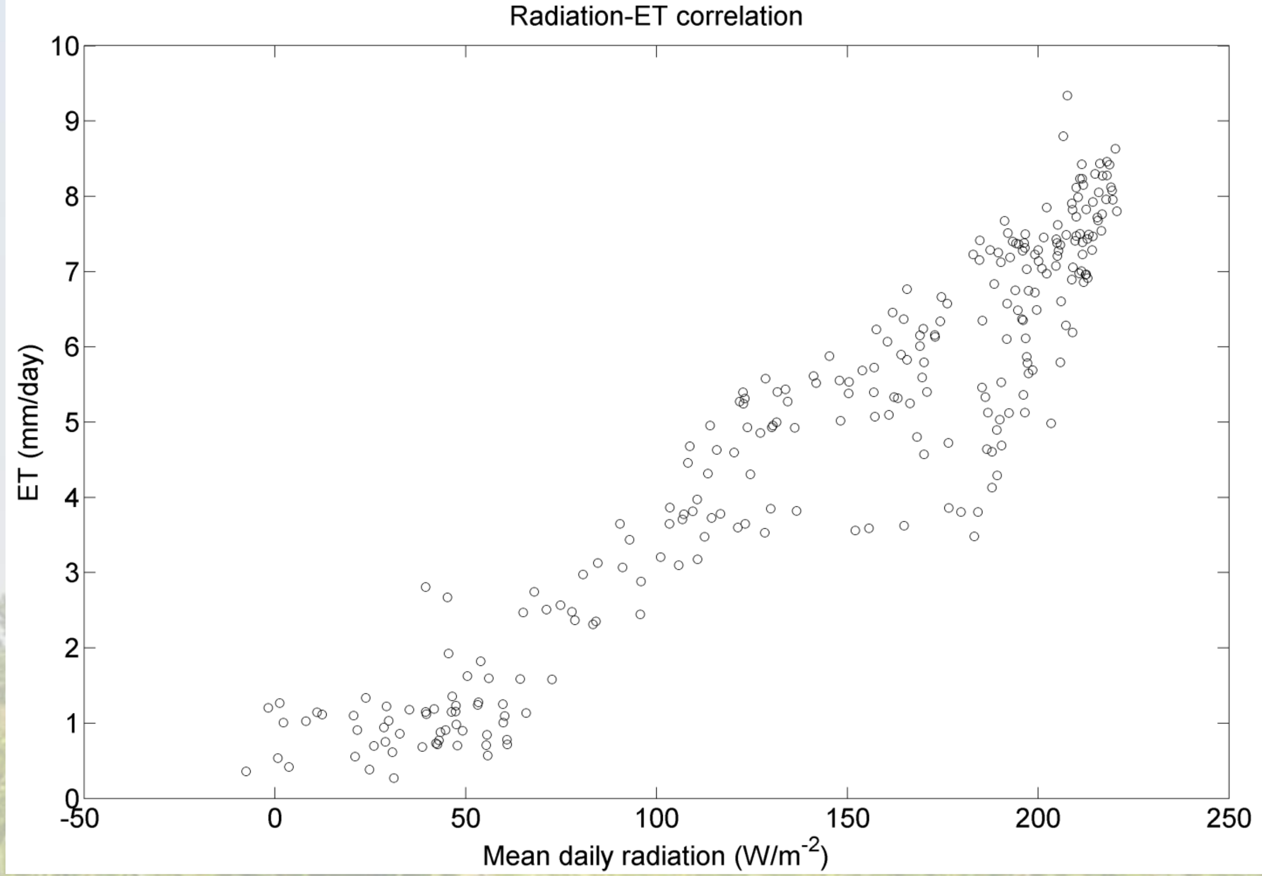



Daily proportion of daily ET as transpiration and evaporation. Evaporation is a much greater proportion before full leaf out (~1 May) and after leaves begin to senesce in October. Highest transpiration corresponds with highest ET (and highest air T) days when leaves need to shed excess energy.

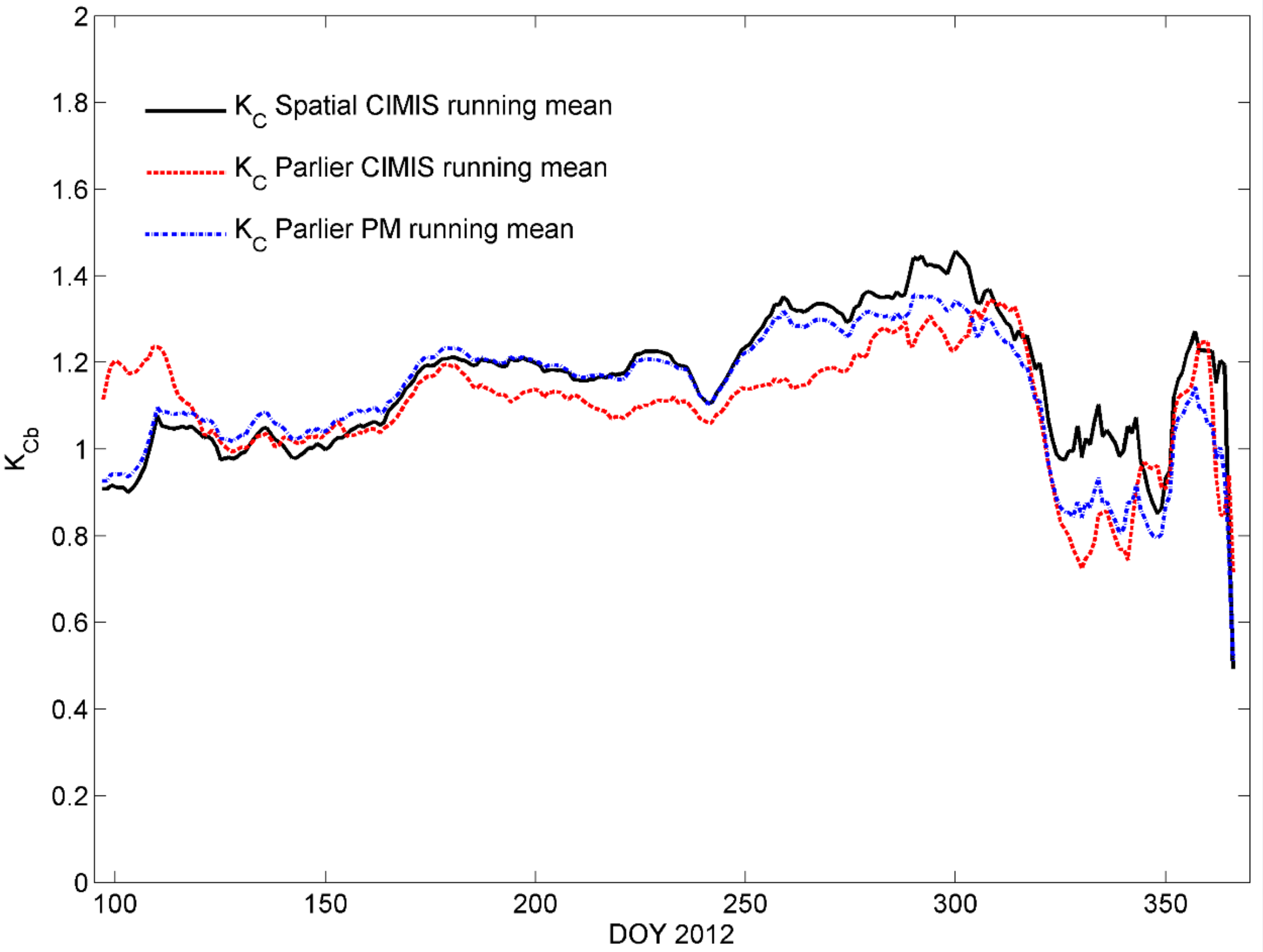
# Controls

Strong linear correlations between radiation and ET and vapor pressure deficit and ET.




Strong linear relationships and generally high soil moisture (not shown) indicates meteorological controls are primary controls on ET not water deficits/moisture availability.




Running mean (2 week averaging window) for basal crop coefficient using three ref. ET data sources: tower based Penman-Monteith $ET_0$ (PM) and CIMIS $ET_0$ come from Parlier CIMIS station (17 km from field); Spatial CIMIS $ET_0$ is extracted from 2 km pixel.

# Crop Coefficient

- Crop coefficient (Kc) for growing period ranged from 1 to ~1.3-1.4.
- Mean growing season Kc similar to reported values for peach based on lysimeter work in Fresno County [e.g. *Johnson et al.,* 2005].
- More variation in results at beginning and end of growing season.
- Similarities in Kc to reported values for peach gives confidence to EC ET numbers.

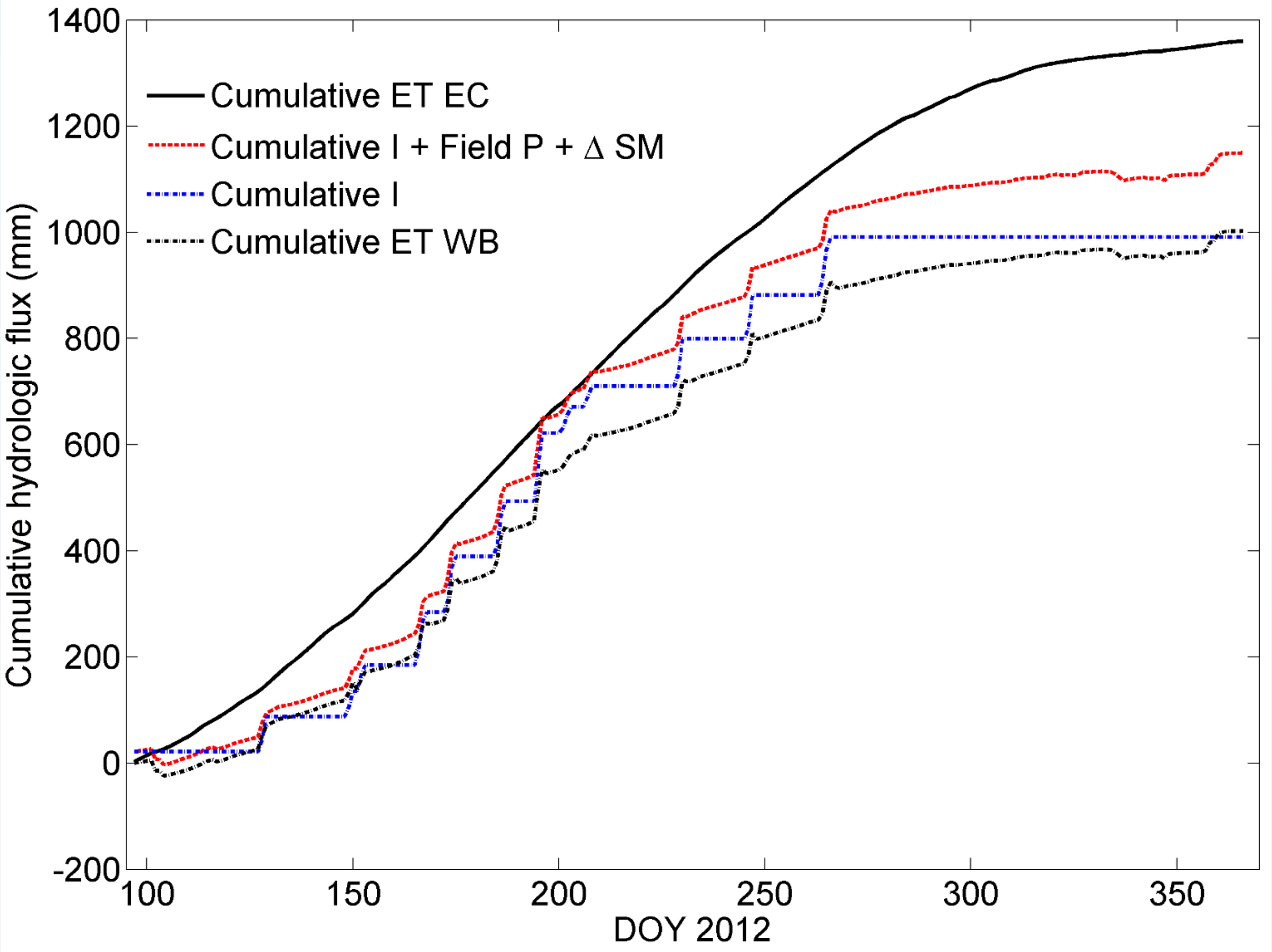
# Discrepancy

- Substantial discrepancy between cumulative water budget ET, water budget, and EC ET.

- Possible causes

1. Water extraction from below 40" (use of water applied early season before EC tower establishment). Johnson and others have found extraction from as deep as 3m in peach.
2. Errors in tower radiation, lysimeter drainage weighting, or flow metering.

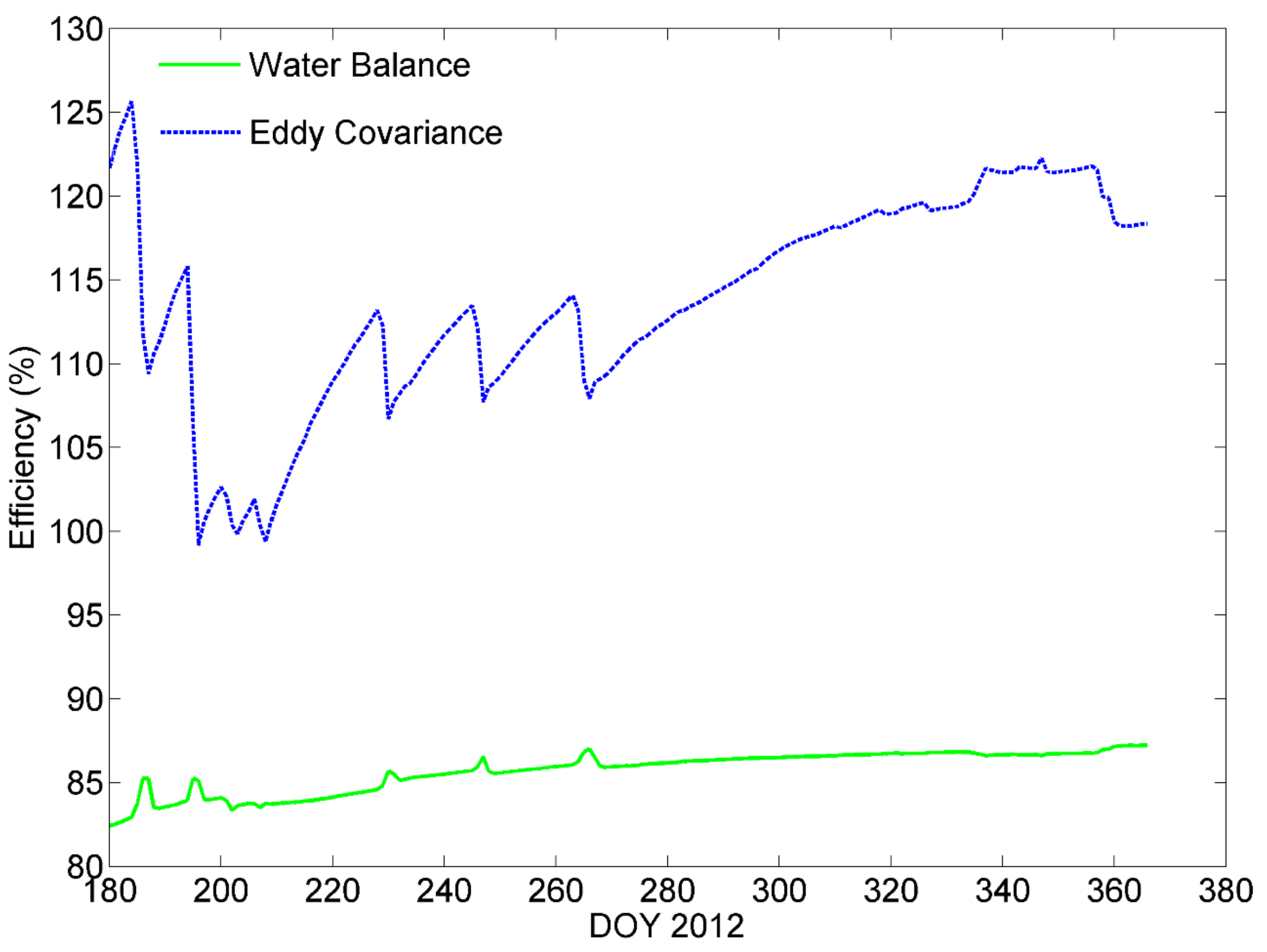
- Ongoing work should help identify possible issues




Cumulative ET from EC tower and from water balance (ET WB=I+P+ΔSM-lysimeter drainage). Cumulative fluxes do not consider P or I before April 5th. ET WB assumes that all lysimeter drainage is lost.

# Irrigation Efficiency

- Discrepancy between water balance and EC ET makes assessment of efficiency challenging.
- Even with conservative water budget approach, efficiency exceeds 85%.
- Values are significantly larger than frequently reported efficiencies for furrow irrigation. Approaches or exceeds values reported for drip irrigation.




Seasonal evolution of cumulative efficiency of peach orchard in using available water. Efficiency=ET/(P+I+ΔSM). Values would be higher if traditional metric (Efficiency=ET/I) was used.

# Summary and preliminary conclusions

- We observed peach evapotranspiration, irrigation efficiency, and basal crop coefficient in mature peach orchard.

- Initial data suggest crop coefficient similar to lysimeter derived values previously observed in San Joaquin Valley.

- Water use efficiency was high from both an irrigation design and plant physiology perspective.

- Data indicate that furrow irrigation can be highly efficient in suitable full canopy crop and soil.

# Future work

- Assessment of surface albedo and vegetation-Kc relationships with Landsat 8.
- Comparison of Eddy Covariance observations and full-year water budget with Surface Renewal station.
- Evaluation of interannual variation in growing seasons on water use.
- Aim to reconcile different approaches for assessing crop water use and better constrain estimates of ET and efficiency.

# Thank you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Questions?