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ALTERNATIVE WATER USE MODELING FOR COTTON, CORN, & SOYBEAN

Paul Colaizzi, Gary Marek, Steven Evett, Karen Copeland, Brice Ruthardt

USDA-ARS Conservation and Production Research Laboratory, Bushland, Texas, USA

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OUTLINE

- Bushland Large Weighing Lysimeter Facility
- USDA National Agricultural Library (NAL) Ag Data Commons (ADC)
- Bushland Two Source Energy Balance Penman Monteith (TSEB-PM) Model to Estimate ET
- Eddy Covariance to Estimate ET
- Conclusions and Future Work

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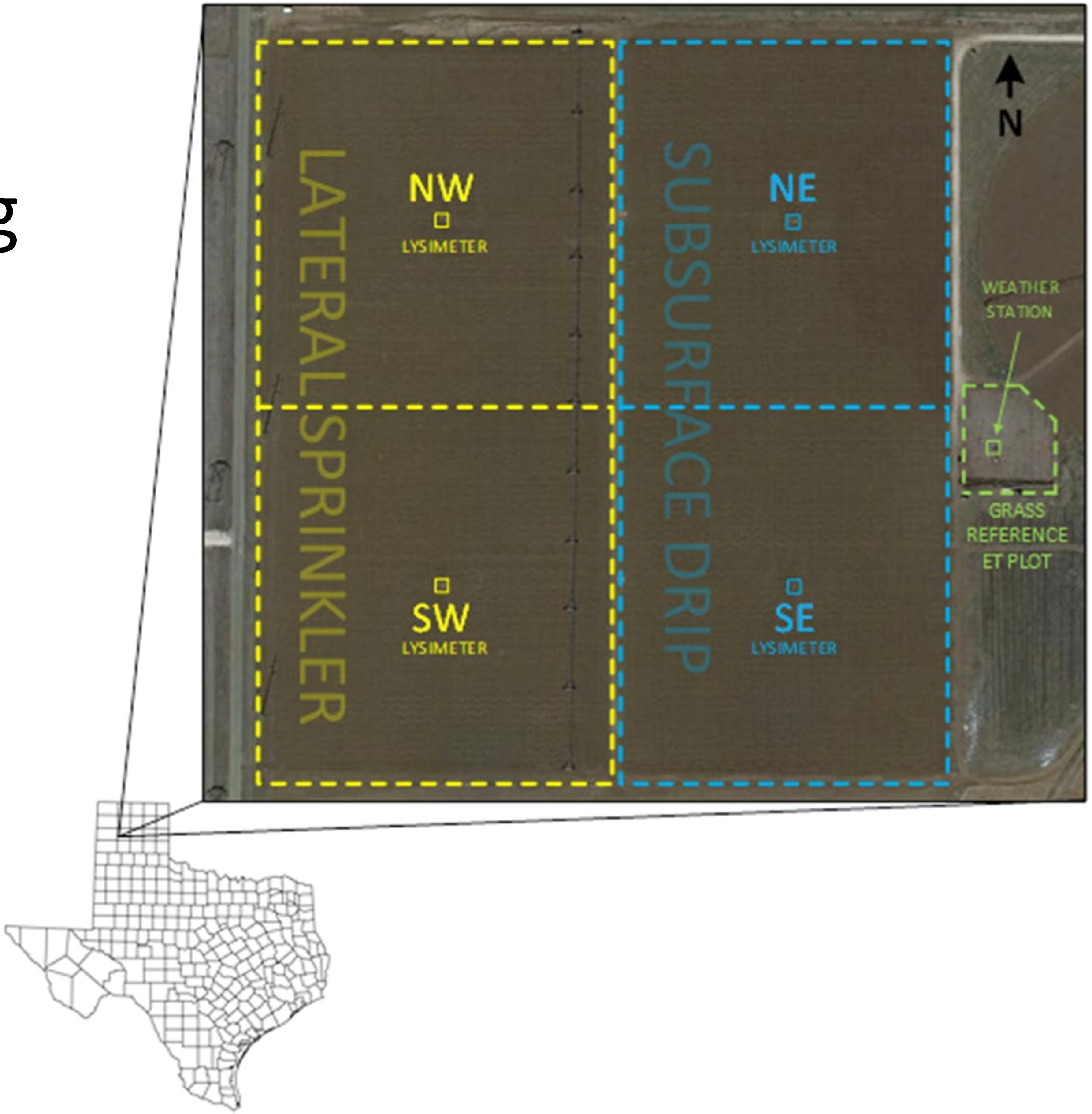
The Bushland Large Weighing Lysimeter Facilities

- Four ~4.4-ha fields with a weighing lysimeter centered in each field
- West two fields have lateral move sprinkler
- East two fields have subsurface drip irrigation (SDI)
- Research weather station with well-watered fescue to East of lysimeter fields



The Lysimeters

- Soil monolith – Pullman clay loam (calcic horizon)
- Dimensions (3m x 3m x 2.3m)
- Cantilever with load cell can obtain ≤ 0.05 mm accuracy.
- Base mass (ET) data files are 5 min avg.
- Direct measurement of ET

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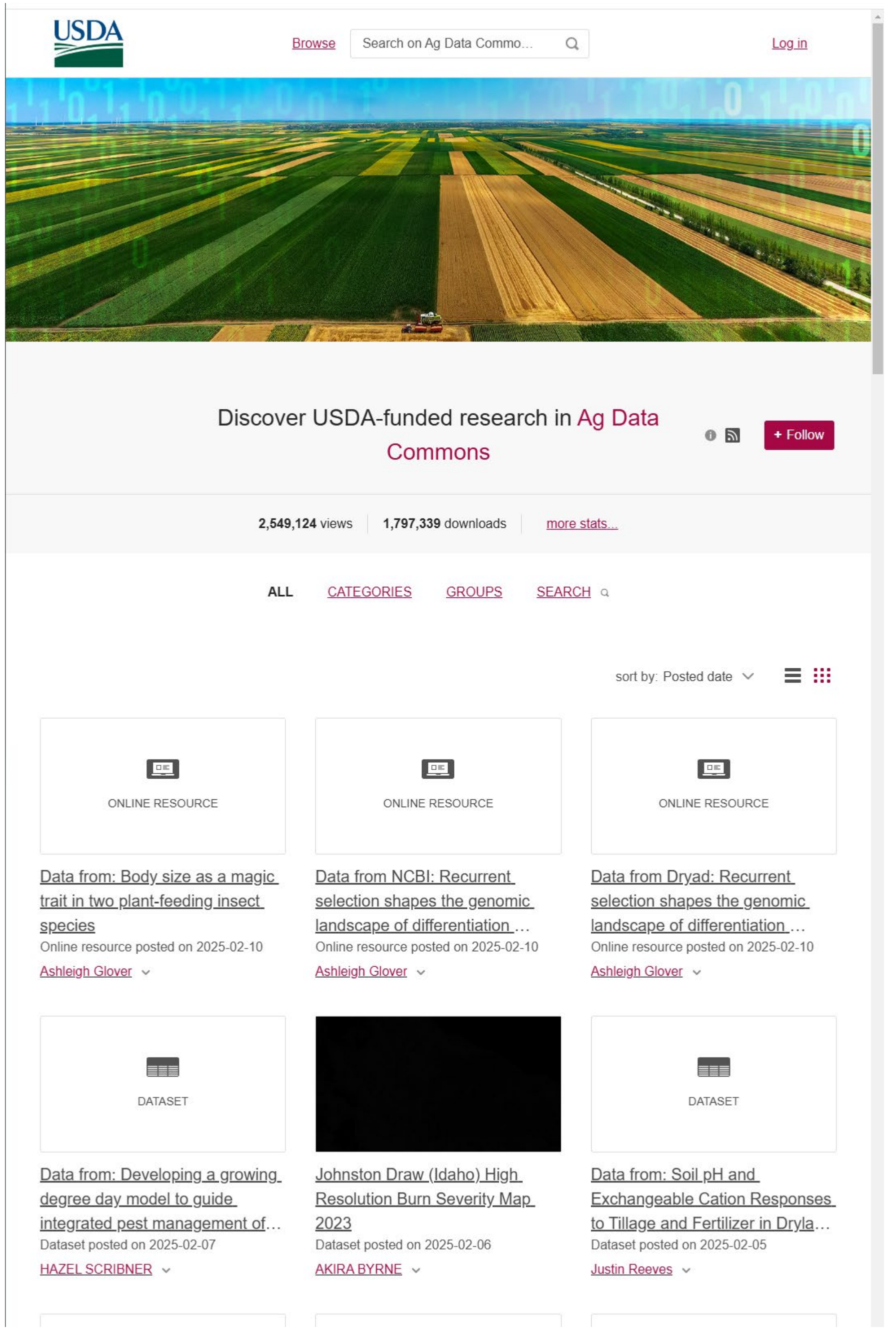
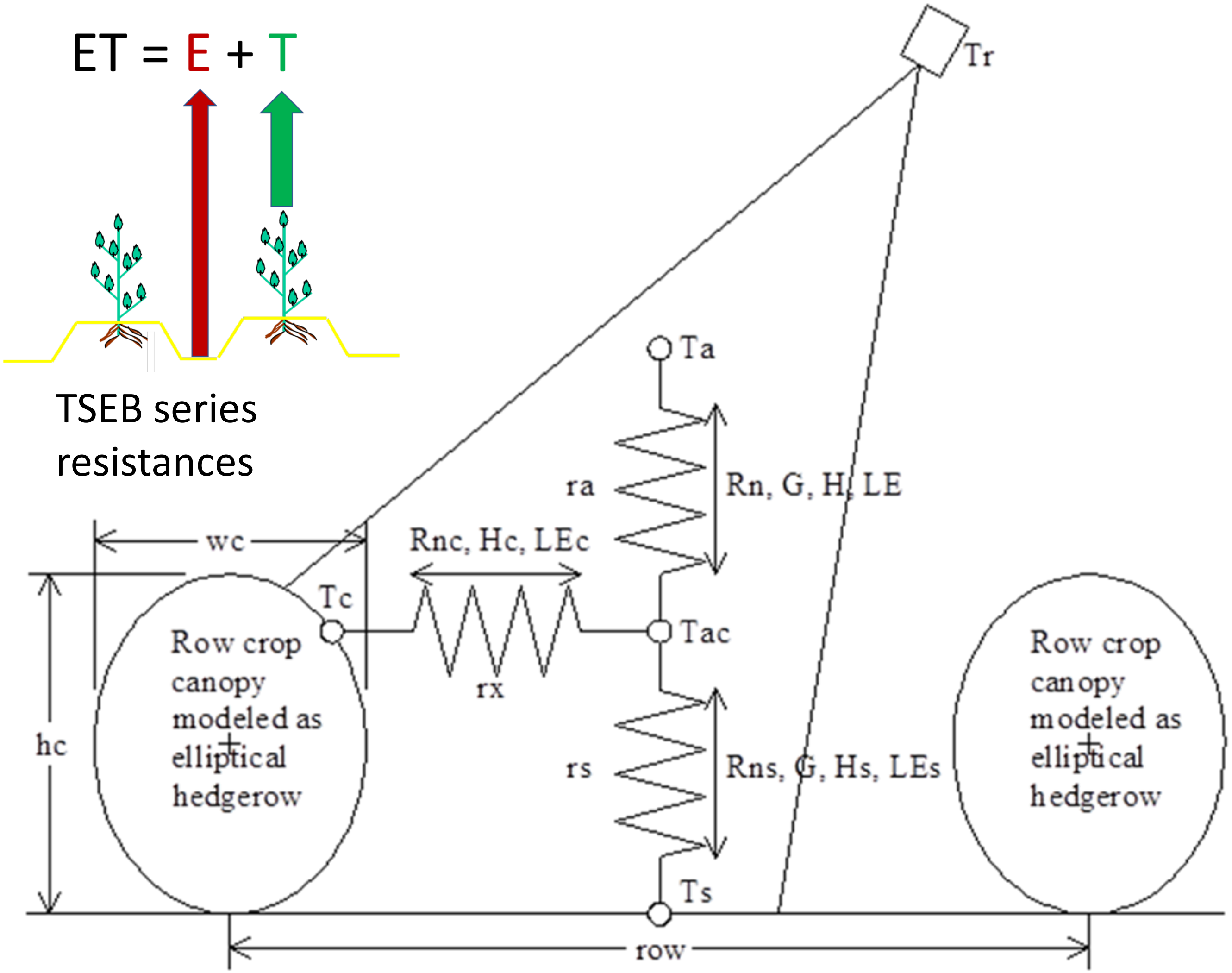
USDA National Agricultural Library (NAL) Ag Data Commons (ADC)

https://agdatacommons.nal.usda.gov/

- Includes historic and current Bushland lysimeter and weather data
- All USDA-funded research require data to be posted on ADC within one year of publication

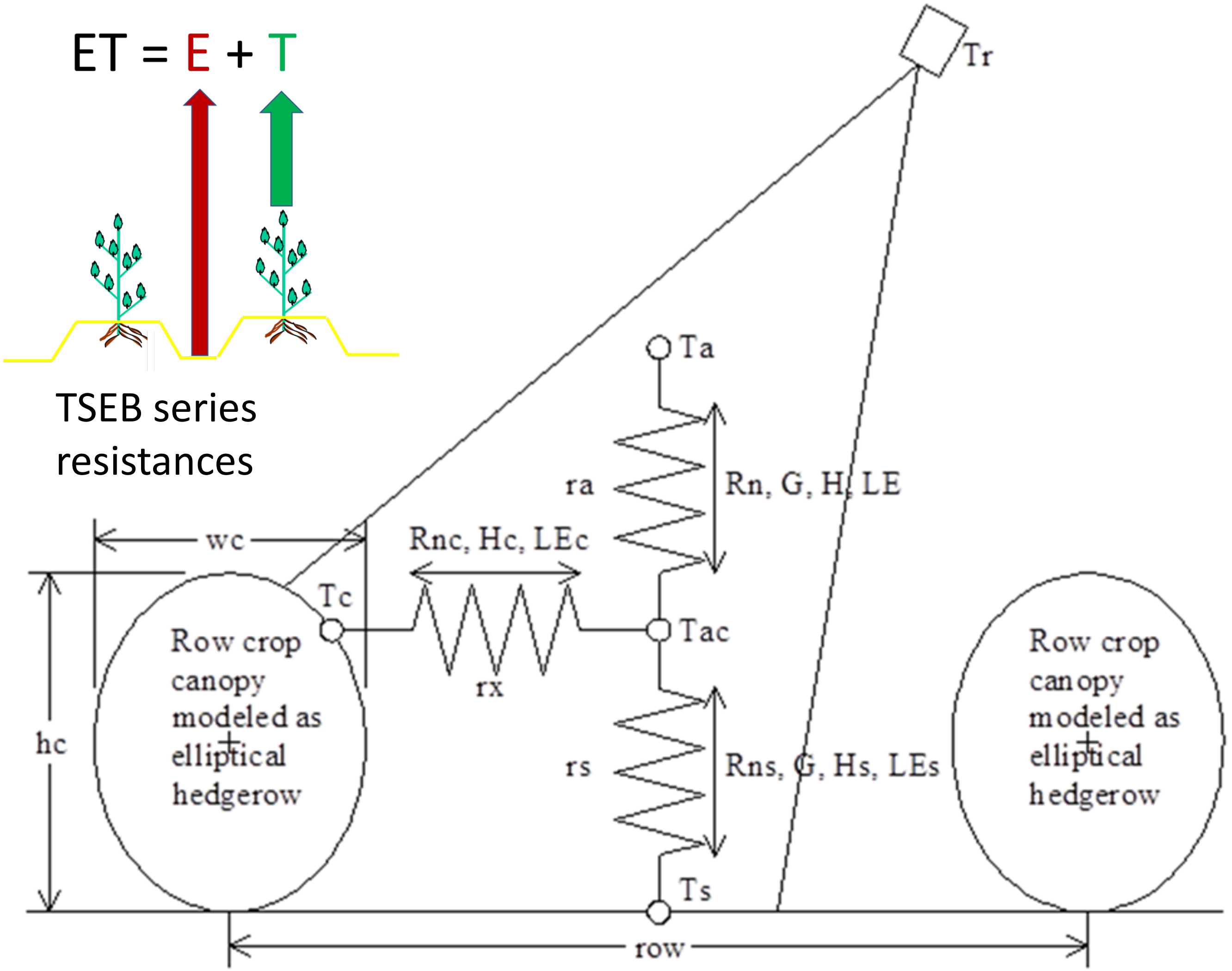


Two-Source Energy Balance (TSEB) Model



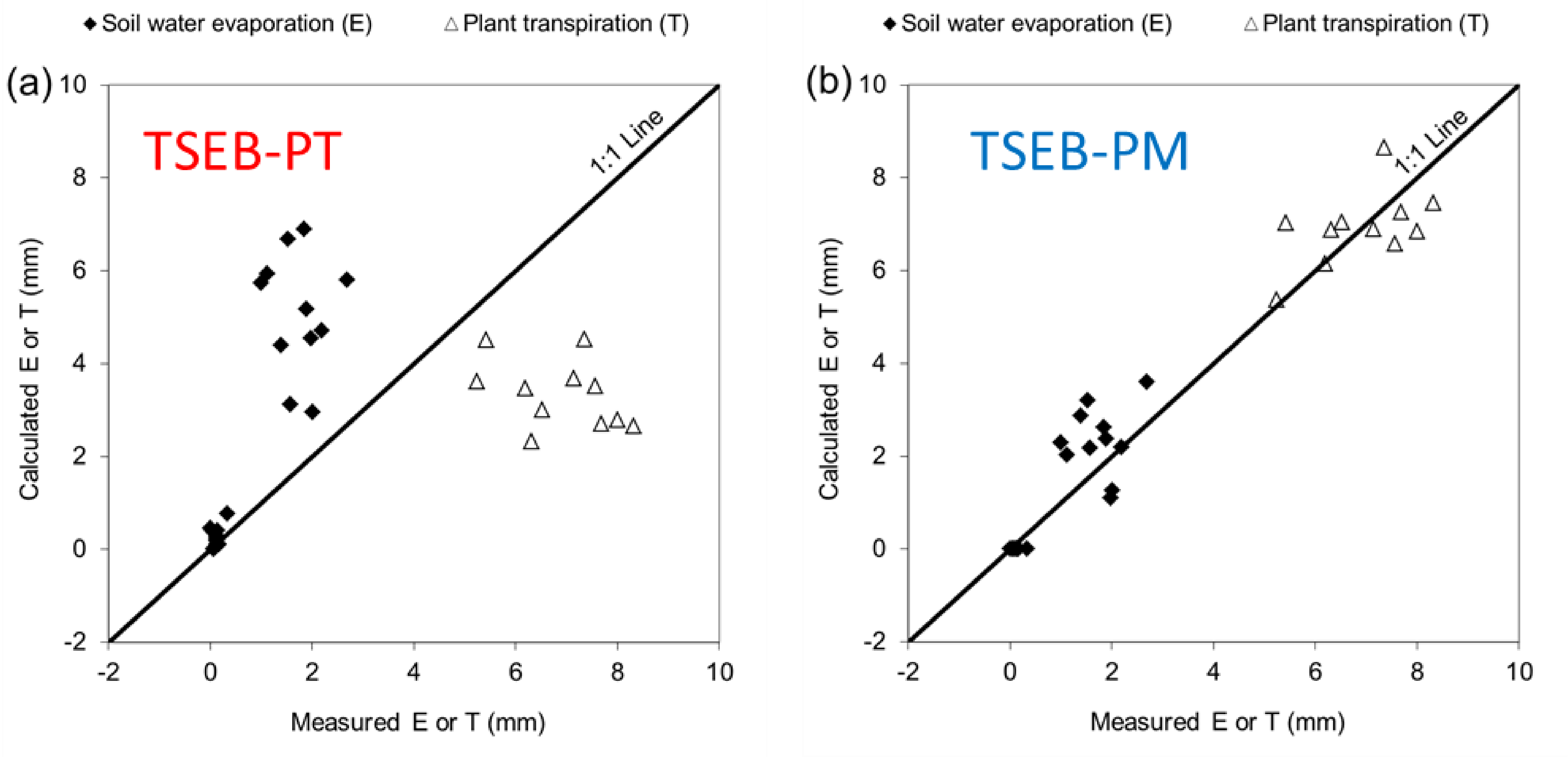
- Solves energy balance of canopy (T) and soil (E) separately, then combines E and T to ET
- Resistance-gradient network of energy components
- Requires weather data, crop width, height, LAI, radiometric surface temperature
- Scales can be small (< 1 m, IRTs) to large (> 5 km, GOES satellite)
- Can be series or parallel resistance

Two-Source Energy Balance (TSEB) Model



- Originally developed by John Norman (UW-Madison) and Bill Kustas (ARS-Beltsville)
- Based on Priestley-Taylor (**TSEB-PT**)
- Modified at ARS Bushland based on Penman-Monteith (**TSEB-PM**)
- **TSEB-PM** improved E and T partitioning compared with microlysimeters (E) and sap flow (T)

Two-Source Energy Balance (TSEB) Model



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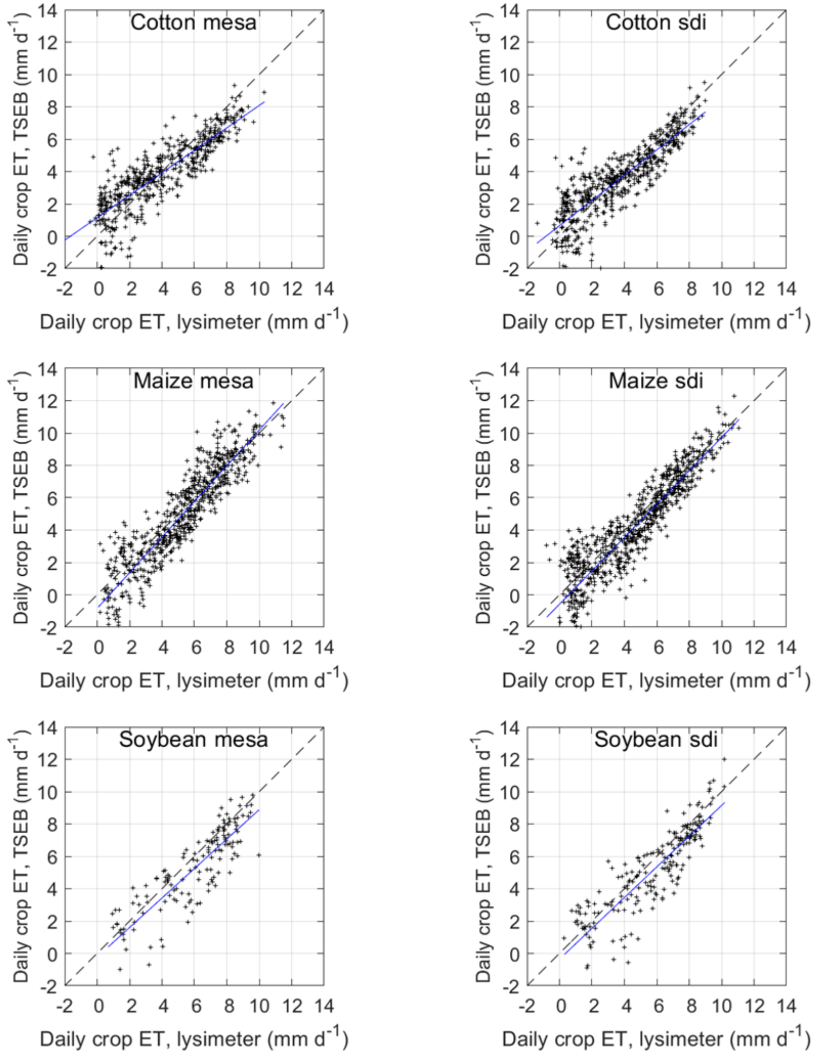
Two-Source Energy Balance (TSEB) Model



<u>Recent study comparing ET by TSEB-PM vs. Lysimeters</u>

- Cotton, Corn, Soybean
- MESA (sprinkler) and SDI
- TSEB-PM model performance was consistent for three crops and two irrigation methods
- r^2 was 0.73 to 0.83 ($p < 0.05$)
- RMSE was 1.3 to 1.5 mm d^{-1} (25 to 36%)
- MBE was -0.04 to -0.75 mm d^{-1} (-1.0 to -13%)

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Eddy Covariance Systems

Core System Equipment

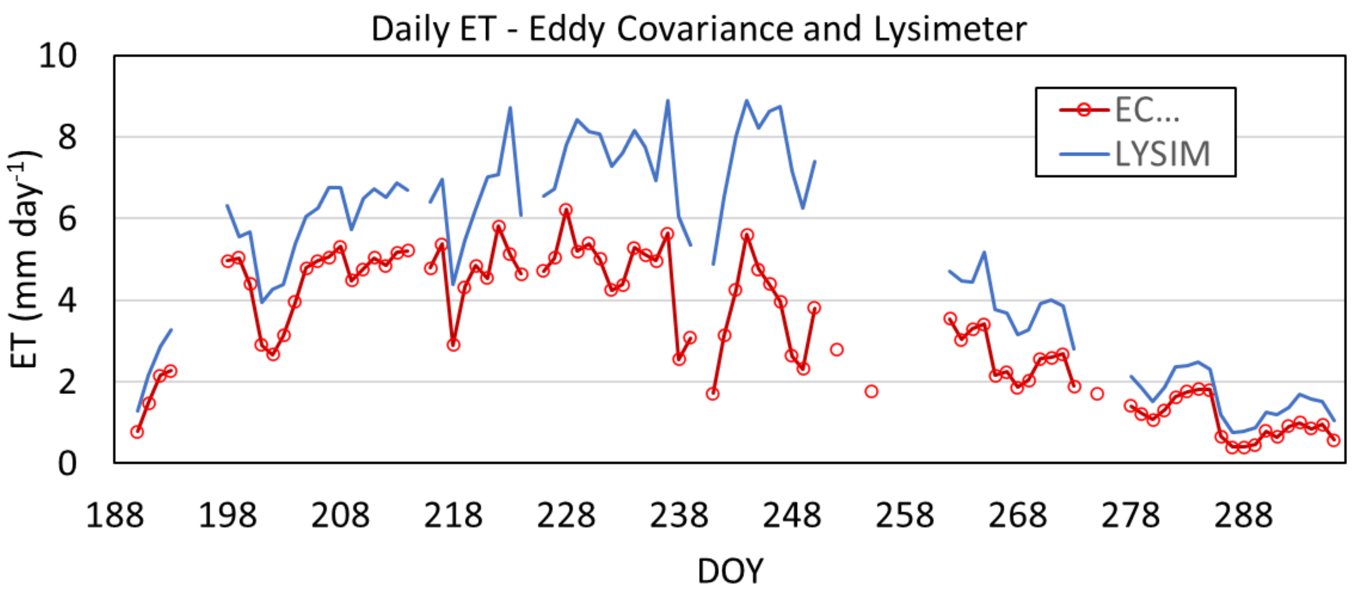
- Campbell Scientific (CS) IRGASON open-path analyzer and sonic anemometer
- CS CR3000 datalogger w/ EC100 Electronics module – 10 Hz measurements to 15-min values

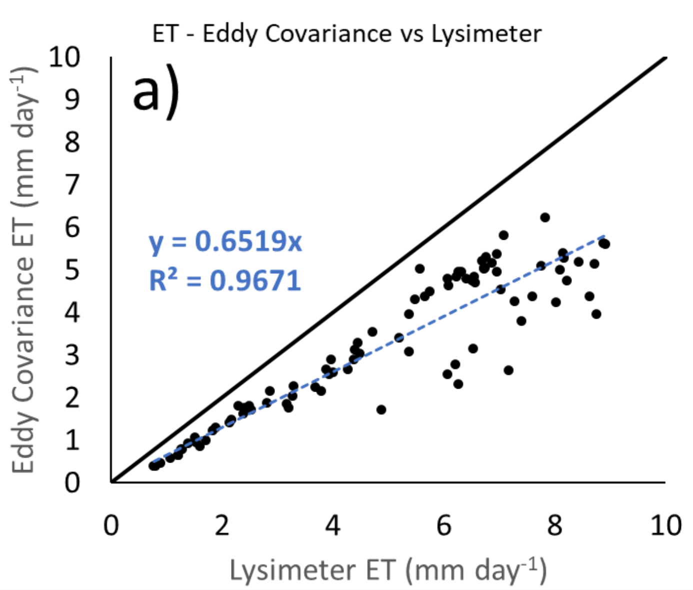
Supplemental Energy Balance Sensors

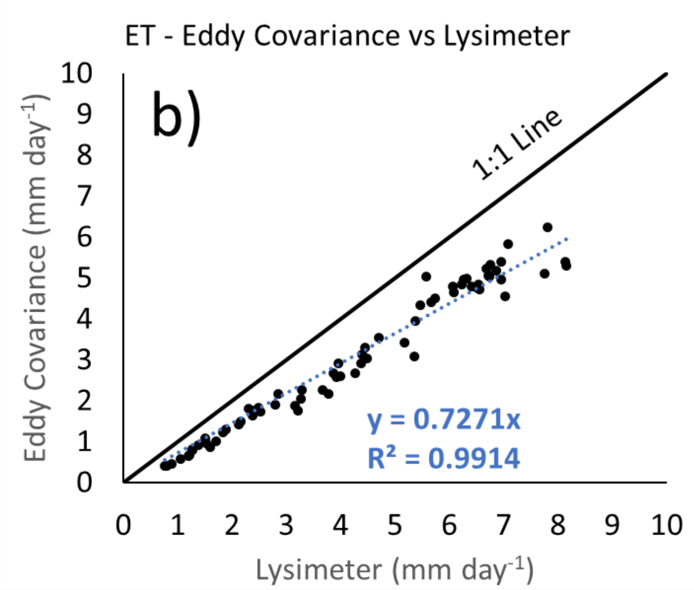
- Kip & Zonen NR-LITE2 Net radiometer (x1)
- Hukseflux HFPO1 soil heat flux plate (x4)
- Acclima TDR-315N (x4)
- (15 min values)

Data Analysis – NE Lys.

- Daily ET from the EC system and the lysimeter were plotted - days receiving appreciable precipitation were omitted
- Results showed chronic underestimation by the EC system throughout the growing season
- The largest discrepancies occurred during the early and mid-season period when crop water use was greatest
- The greatest agreement occurred in late season following reduced leaf area following the hail event
- Underestimation for all days was ~35% (fig a.)
- A subset of the data with larger ET values removed resulted in underestimation of ~27% (fig. b)

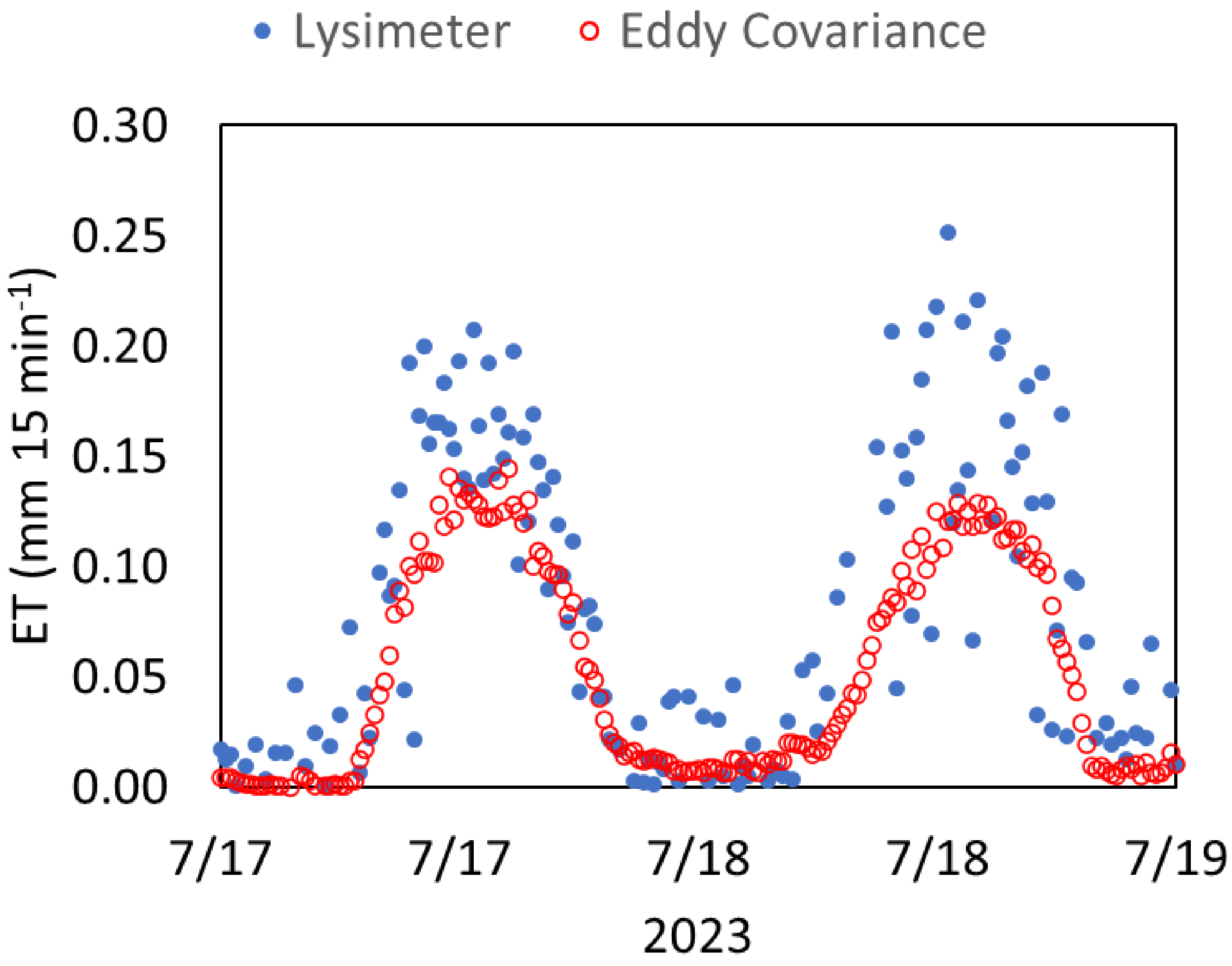






Data Analysis – NE Lys.

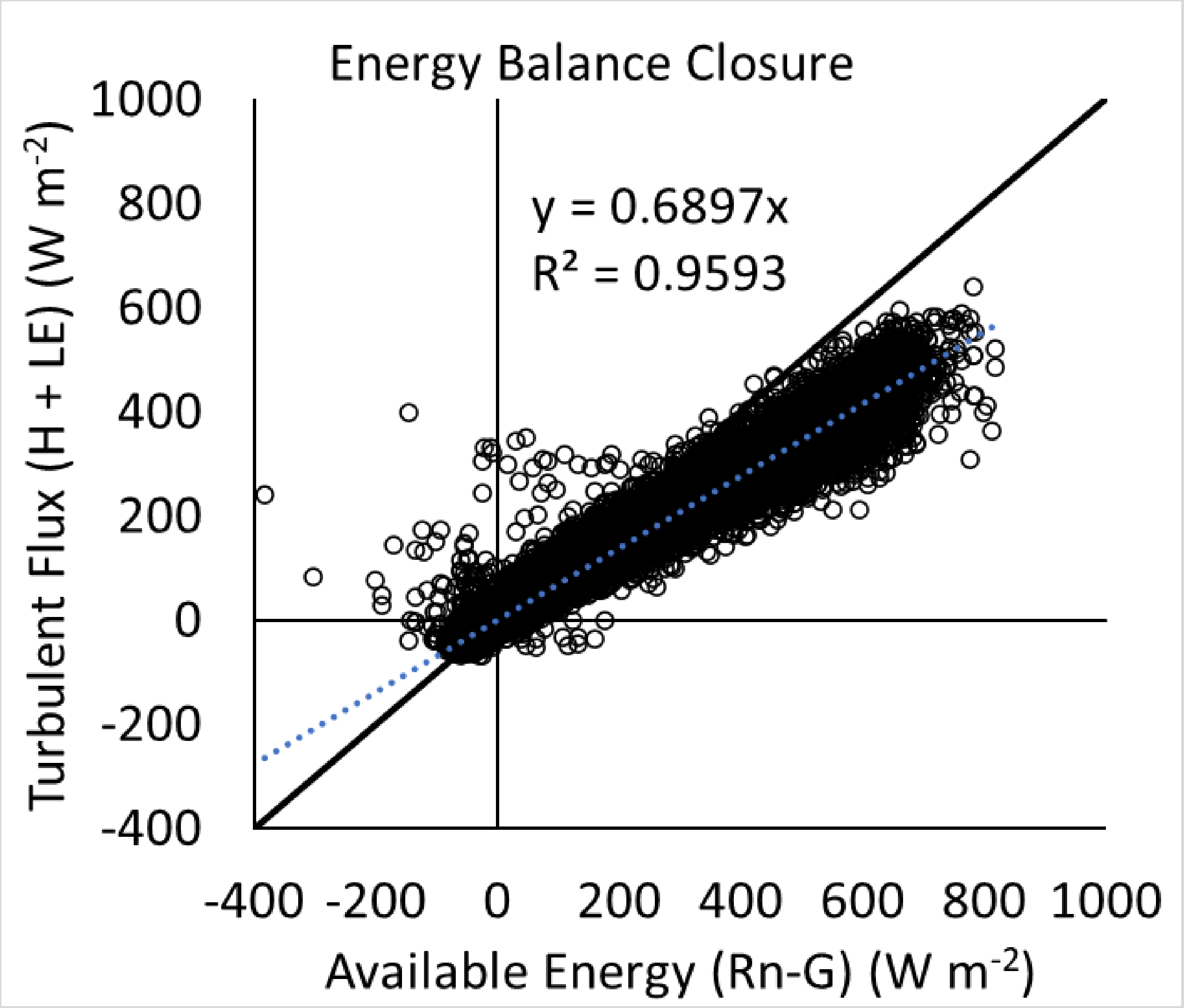
- 15-min ET data – Lysimeter raw vs. EC
- Distinct diurnal pattern
- EC clearly underestimates ET, particularly during mid day
- No negative ET values for EC system



Data Analysis – NE (SDI)

- 1:1 comparison of Available Energy (AE), (RN-G) to turbulent fluxes (H + LE) for all 15 min periods

- EB closure was 69% based on the slope of the regression lines



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Conclusions (TSEB-PM)

- TSEB-PM model performance was consistent for three crops (cotton, corn, soybean) and two irrigation methods (MESA and SDI).
  - r^2 was 0.73 to 0.83 ($p < 0.05$)
  - RMSE was 1.3 to 1.5 mm d^{-1} (25 to 36%)
  - MBE was -0.04 to -0.75 mm d^{-1} (-1.0 to -13%)
- It is important to account for surface emissivity, especially during leaf senescence, to avoid overestimating ET.
- TSEB-PM is recommended over TSEB-PT for improved E and T partitioning.

Conclusions (Eddy Covariance)

- Chronic underestimation of ET by > 25% was observed by an EC system positioned in a weighing lysimeter field
- Incorporation of an integrated gas analyzer and routine sensor cleaning did not appear to help with estimation of ET
- Season-long measurements did provide insight into discrepancies between daily ET values
- These findings should serve to caution researchers and producers for use of EC systems as a standard or reference method of estimating ET, at least in semiarid environments

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Future Work (TSEB-PM)

- Apply machine learning to estimate resistances
- Test new prototype infrared thermometer being developed by UT-Arlington
- Expand analysis to include forage crops (alfalfa) and grain crops (winter wheat, grain sorghum)

Future Work (Eddy Covariance)

- Further sub-hourly analyses are planned to assess underestimation of ET
- Future plans include replicating this study over deficit-irrigated alfalfa starting in the Spring of 2025, possibly with all four lysimeters

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Contact:
paul.colaizzi
@usda.gov

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