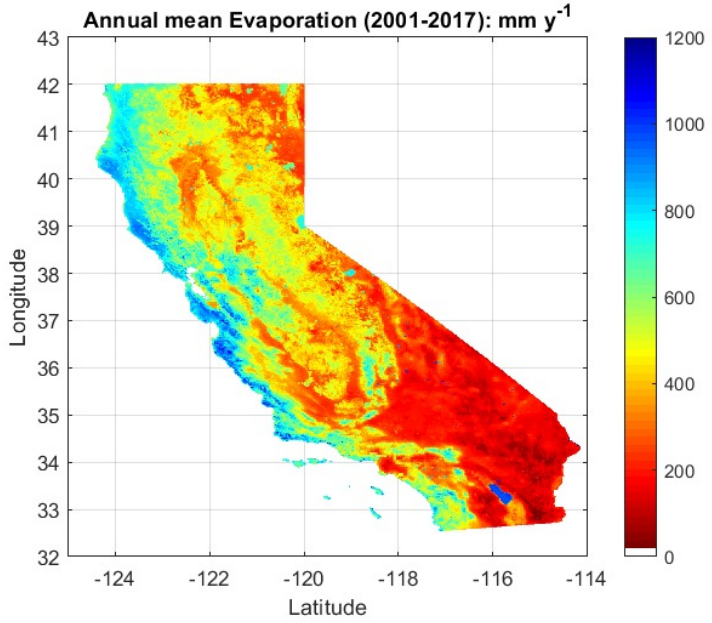
How Much Water is Evaporated Across California?: An Assessment Using a Meso Network of Eddy Covariance Sites, Biophysical Model Forced with Satellite Remote Sensing and ECOSTRESS Data

Dennis Baldocchi, Camilo Rey-Sanchez, Tianxin Wang, Nicole Keeney

UC Berkeley….

Kaniska Mallick, Josh Fisher



ECOSTRESS 2021 PI Team Meeting

August, 2021

Topics

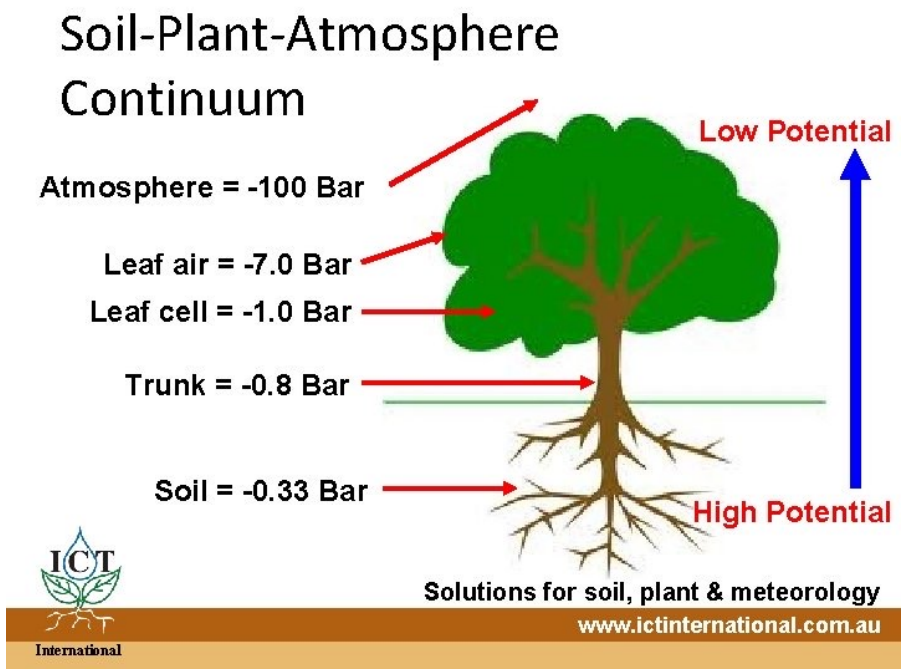
- Parameterizing and Diagnosing Evaporation Fraction as f(Soil Moisture Stress Index)
- Sub-Grid Variability
- Hand shaking Flux Footprints and Remote Sensing Pixels

- Future
  - Advection study on Sub Grid Variability

Hypothesis 1

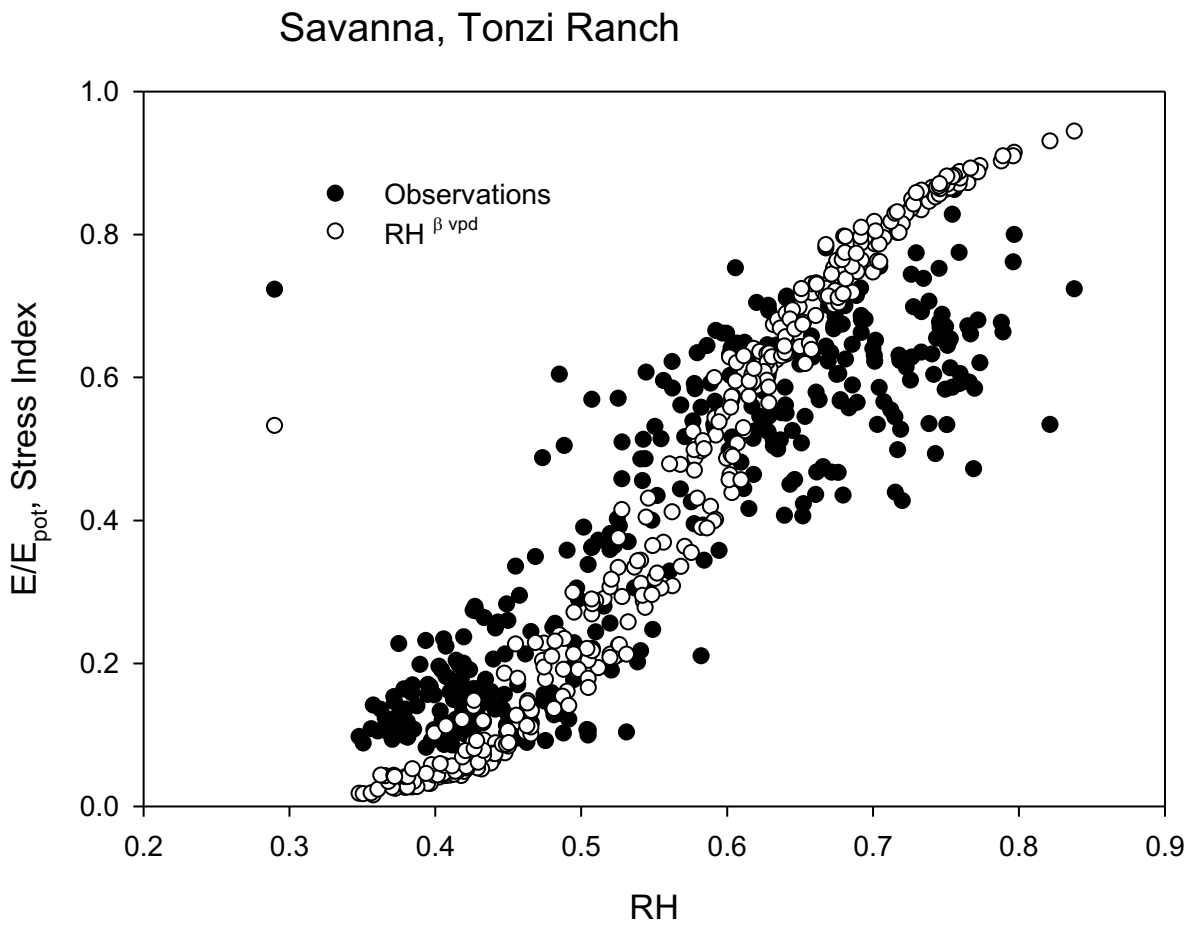
- Can We Sense Soil Moisture by Using Plants as a Sensor?

$$\frac{E_a}{E_{pot}} = RH^{\beta \cdot VPD}$$



Soil Moisture Deficits Reduce Evaporative Fraction (E_a/E_{pot}).
which are Revealed by Humidification of the Planetary Boundary Layer

Test With Data from Tonzi Ranch, a Savanna in a Californian Mediterranean Climate
It Experiences Distinct and Prolonged Wet and Dry Periods

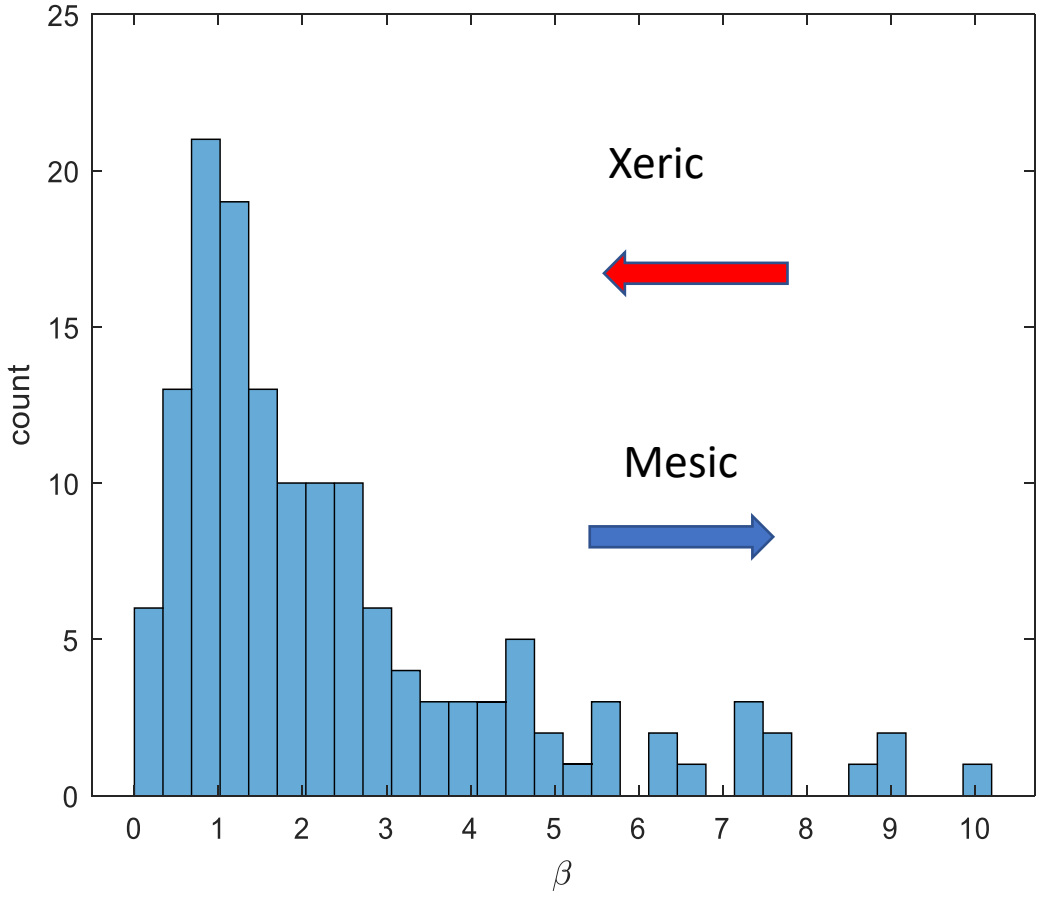


$$\frac{E_a}{E_{pot}} = RH^{\beta \cdot VPD}$$

Baldocchi, Dennis, Siyan Ma, and Joe Verfaillie. 2021. 'On the inter- and intra-annual variability of ecosystem evapotranspiration and water use efficiency of an oak savanna and annual grassland subjected to booms and busts in rainfall', *Global Change Biology, 27: 359-75.*

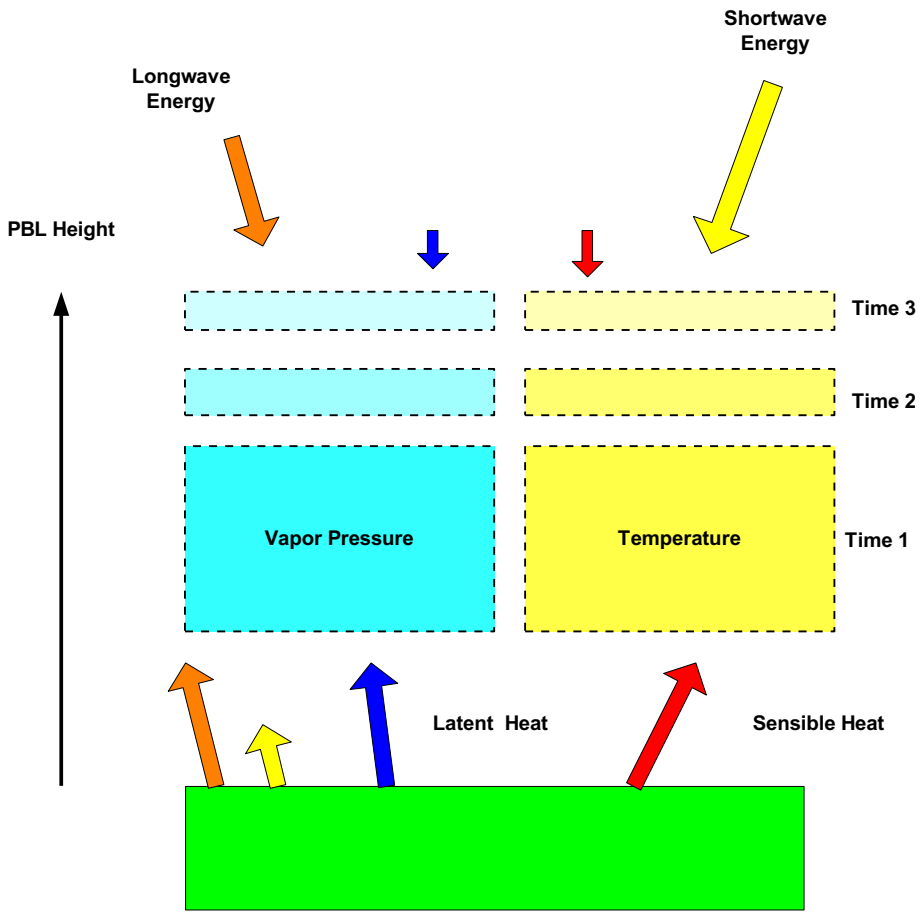
Histogram of Beta for 140+ Fluxnet Sites

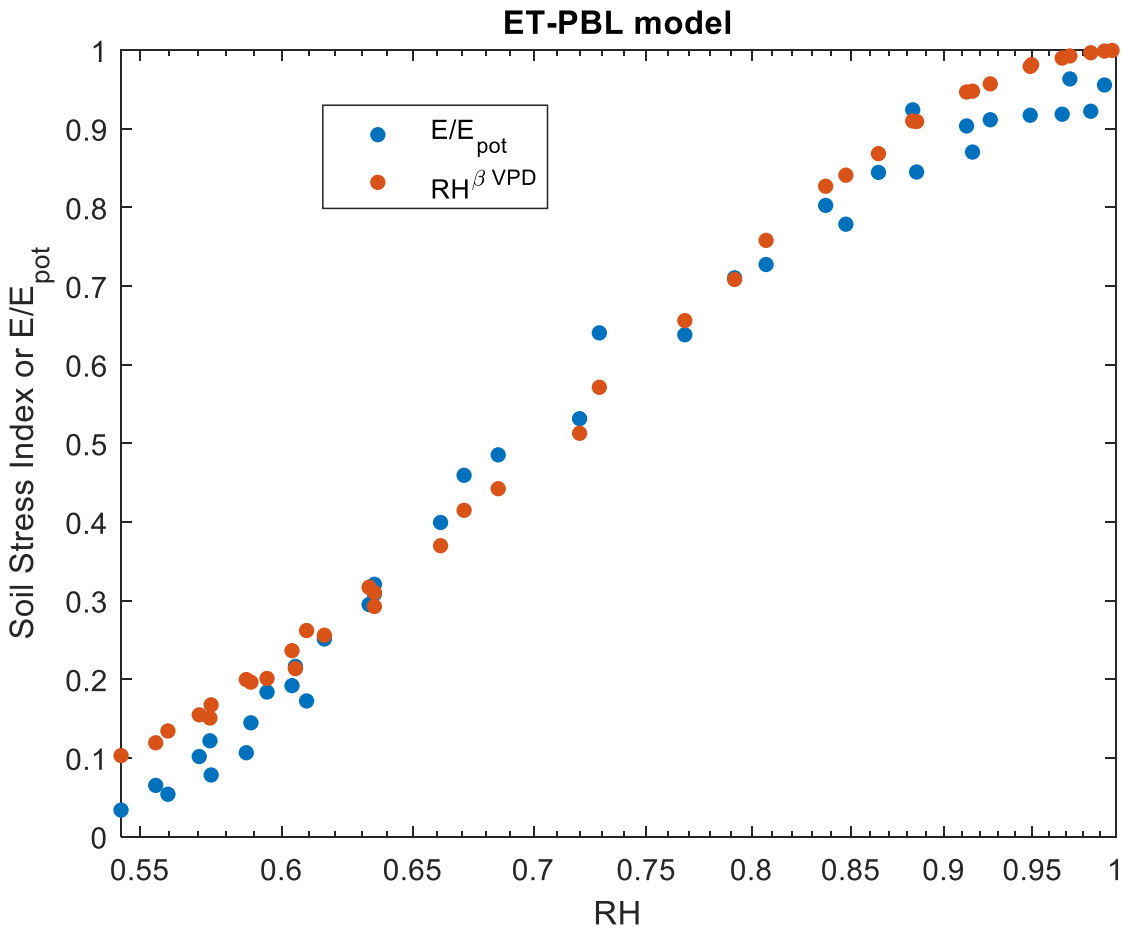
CC by 4.0 Dataset



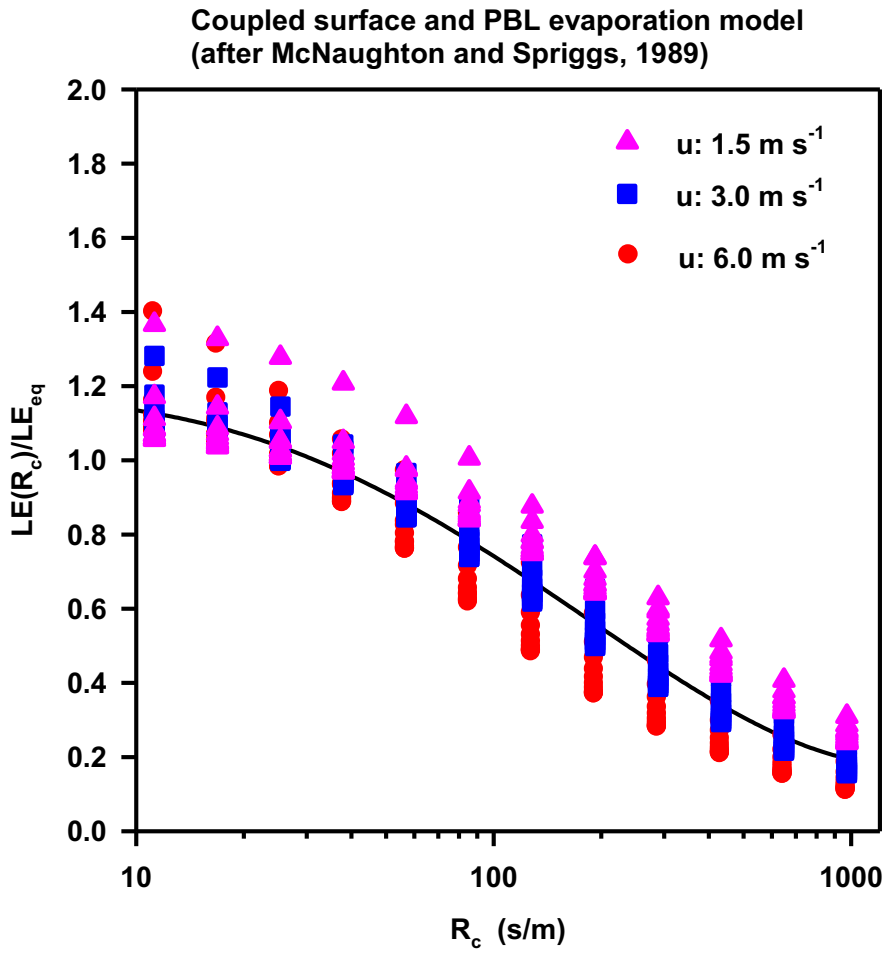
Median of 1.710

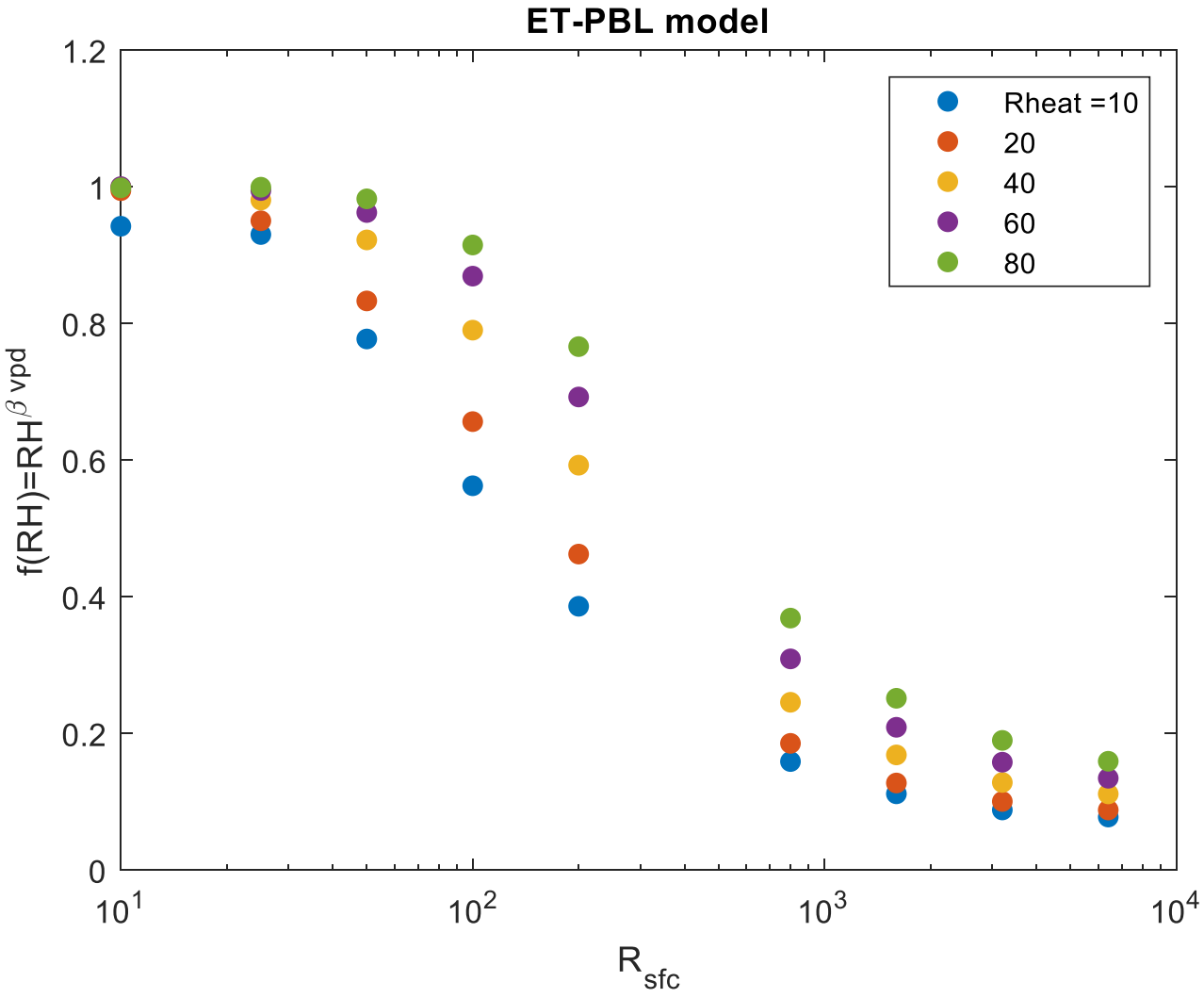
Diagnose How and Why the Soil Moisture Stress Index Works:
Test with coupled Penman Monteith, PBL model Runs with a variety of Surface Resistance, R_{sfc}





The Soil Moisture Stress Index is an Effective Proxy for Canopy Surface Resistance





Rsfc=f(LAI, Soil Moisture, V_{cmax}, C_3/C_4)

Takeaway

- Soil Moisture Stress Index Works Well
- Works Best at Monthly Timescales, at Landscape Scales and for Semi-Arid and Arid Climates

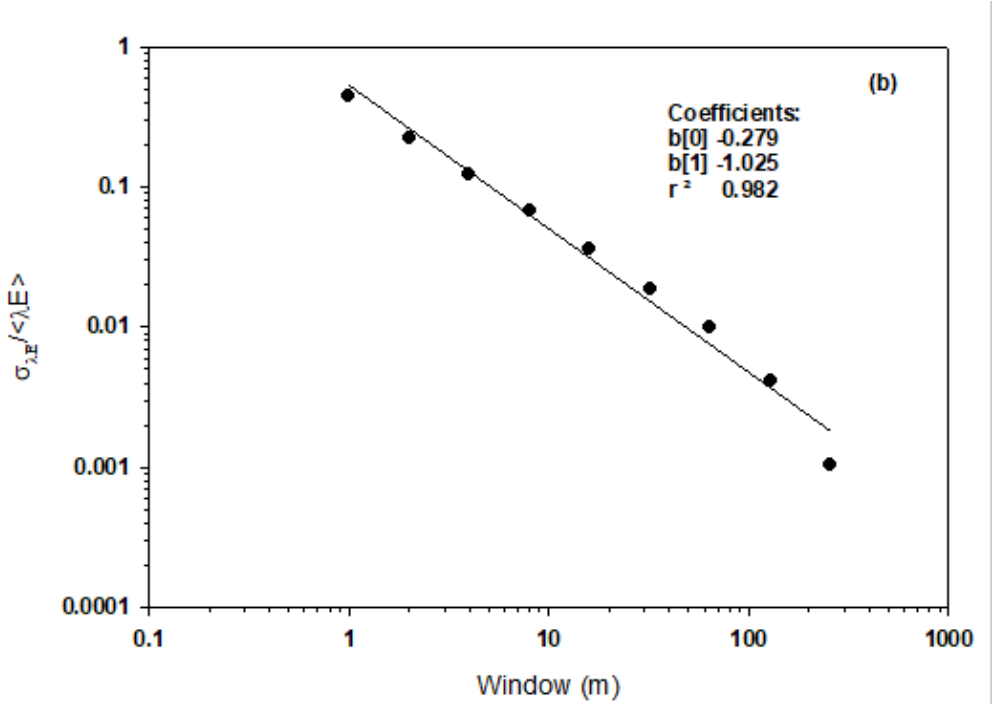
Hypothesis 2
The 70 m Pixel Scale of ECOSTRESS Is/Is Not Fine Enough?

$$E[F(a)] \approx F(<a>) + \frac{1}{2}\frac{\partial^2 F(<a>)}{\partial a^2}\sigma_a^{\ 2}$$

The Expected Value of a Non-Linear Function
Is NOT a Function of the Mean

Is Flux Information Degraded at 'Coarse' Scales?

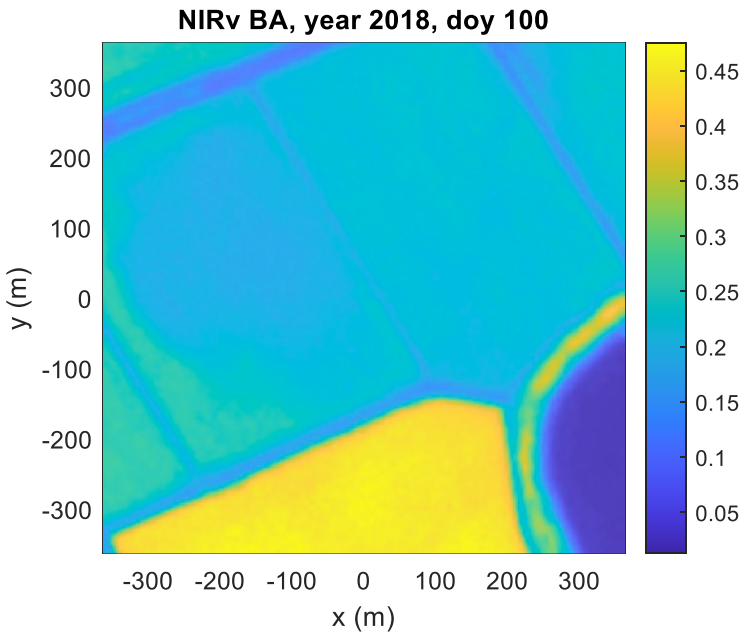
How Coarse is Coarse?

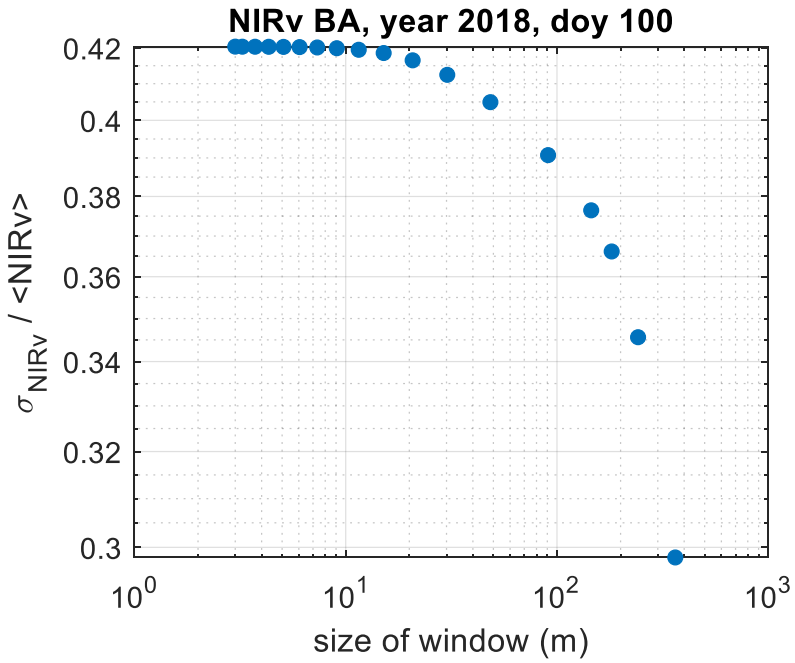


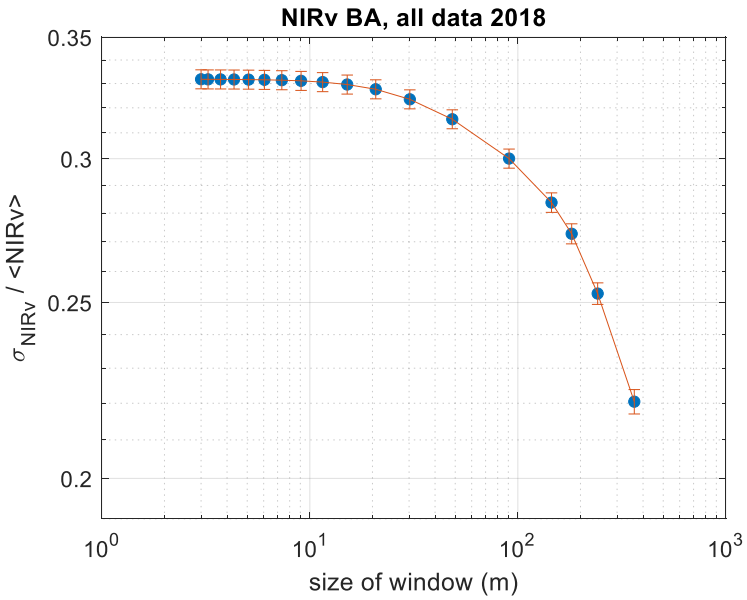
Hypothetical Scaling with Wet-Dry Daisy World

Baldocchi, D.D., T. Krebs, and M. Y. Leclerc. 2005. ''Wet/Dry Daisyworld': A Conceptual Tool for Quantifying Sub-Grid Variability of Energy Fluxes over Heterogeneous Landscapes.', *Tellus, 57: 175-88.*

Inspecting Sub-Grid ECOSTRESS Scaling with Planet Lab, 3 m, Data



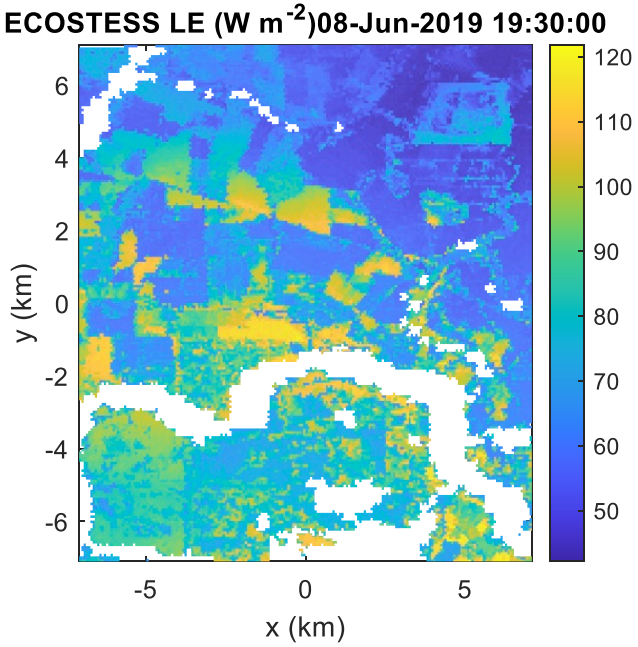


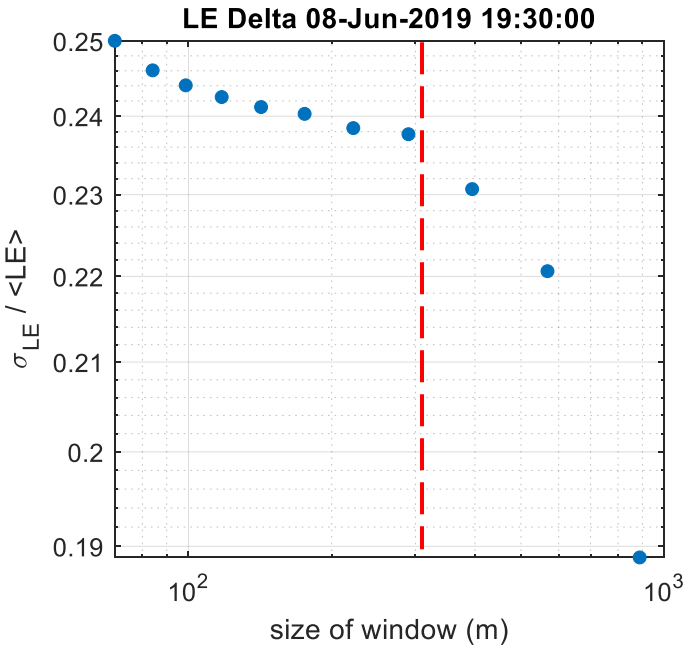


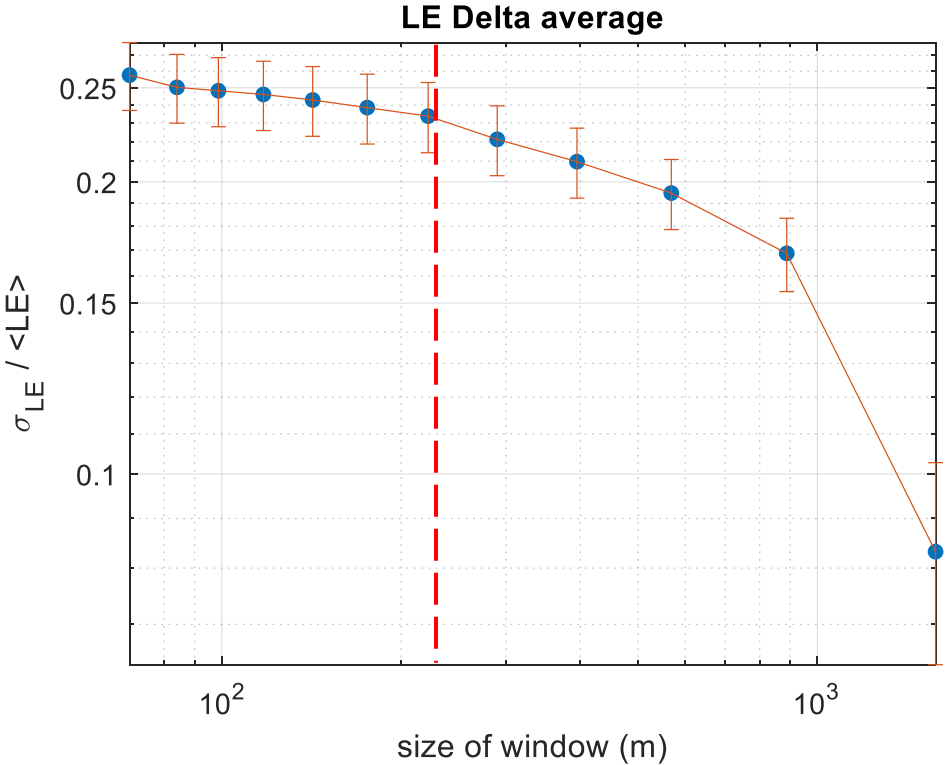
Scale Invariance of Drivers Below 40 m; Modest Invariance at 70 m

ECOSTRESS Scaling

Drop in coefficient of variation at about 250 m







Error bars are the standard error

Takeaway

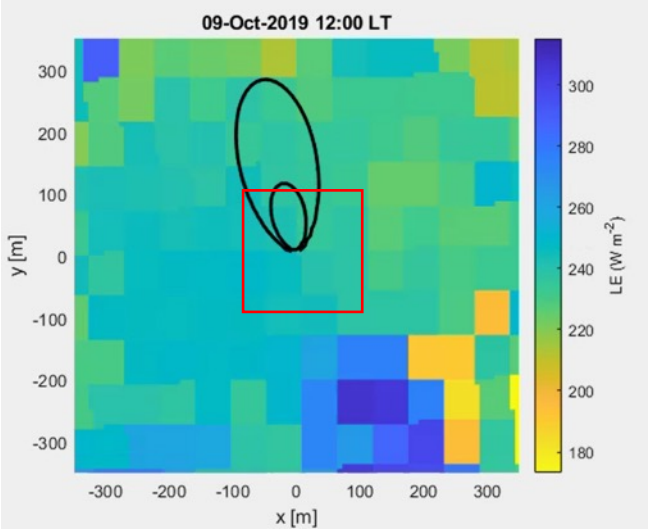
- ECOSTRESS Pixels are at a Sufficient Resolution to Capture Spatial Heterogeneity in Agricultural Landscapes
- MODIS was Too Coarse and Averages and Smooths Hot/Dry and Cold/Wet Spots

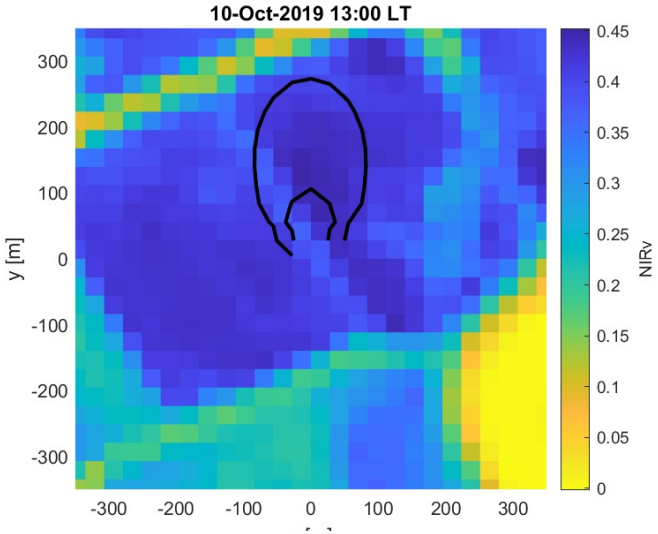
Hypothesis 3

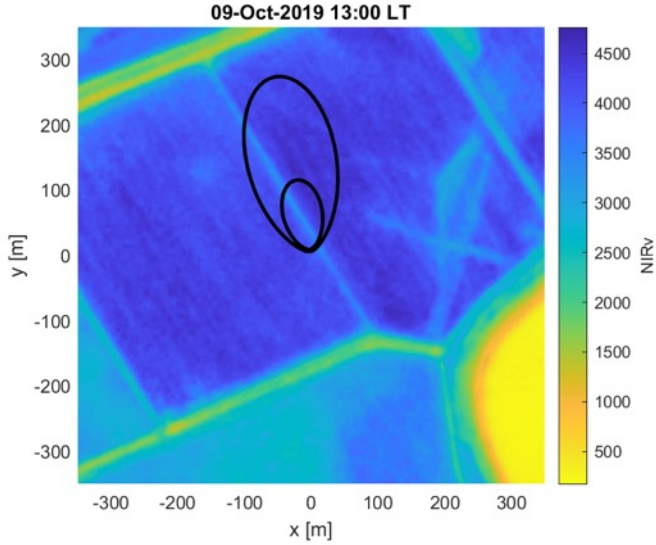
- Intra- and Inter-Field Advection May or May Not be Occurring
- It May or May Not Affect ECOSTRESS Validation

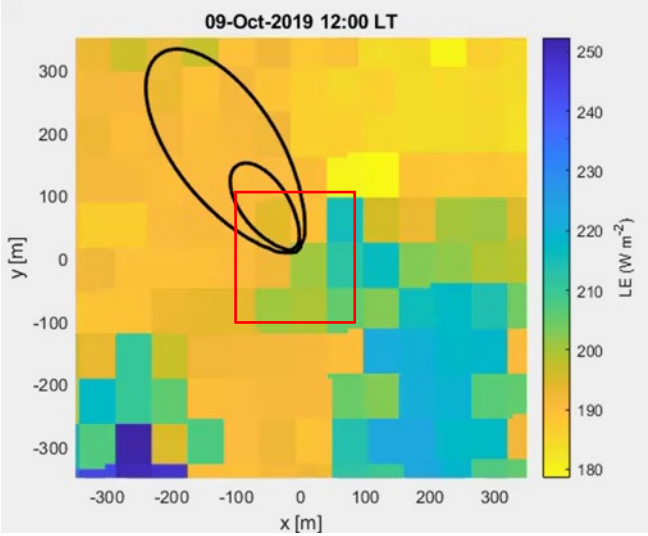
Sentinel-2A: 2020-06-01 to 2020-11-01

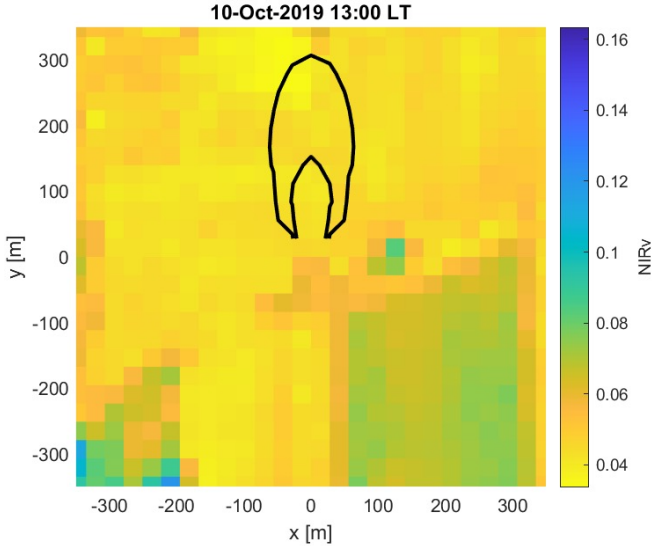
Satellite | ECOSTRESS E (W m^2) | Landsat NIRv | Planet NIRv

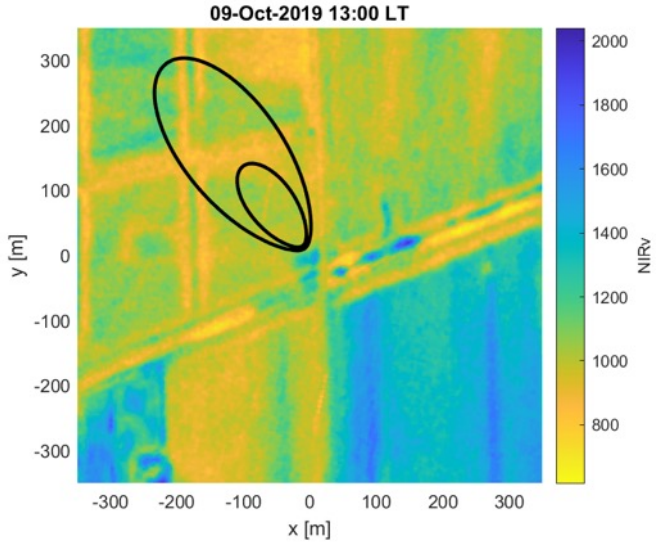






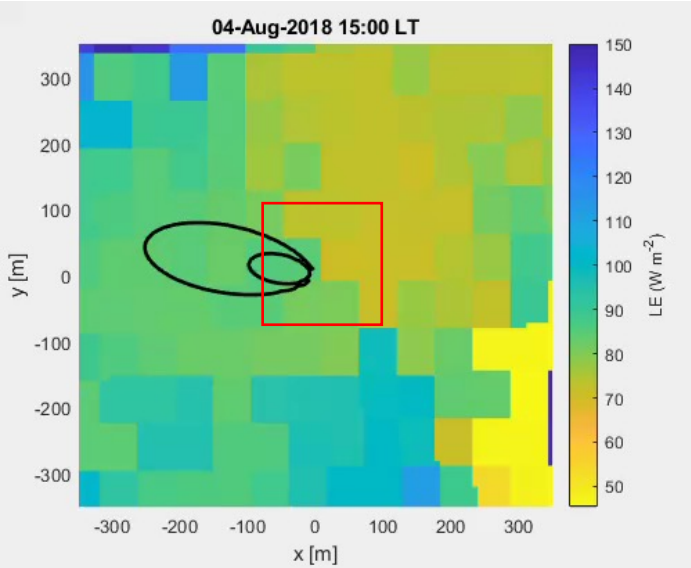




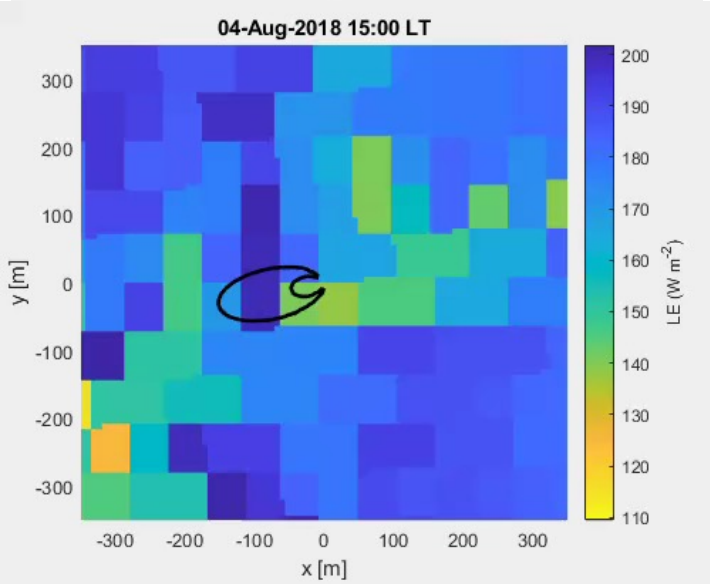


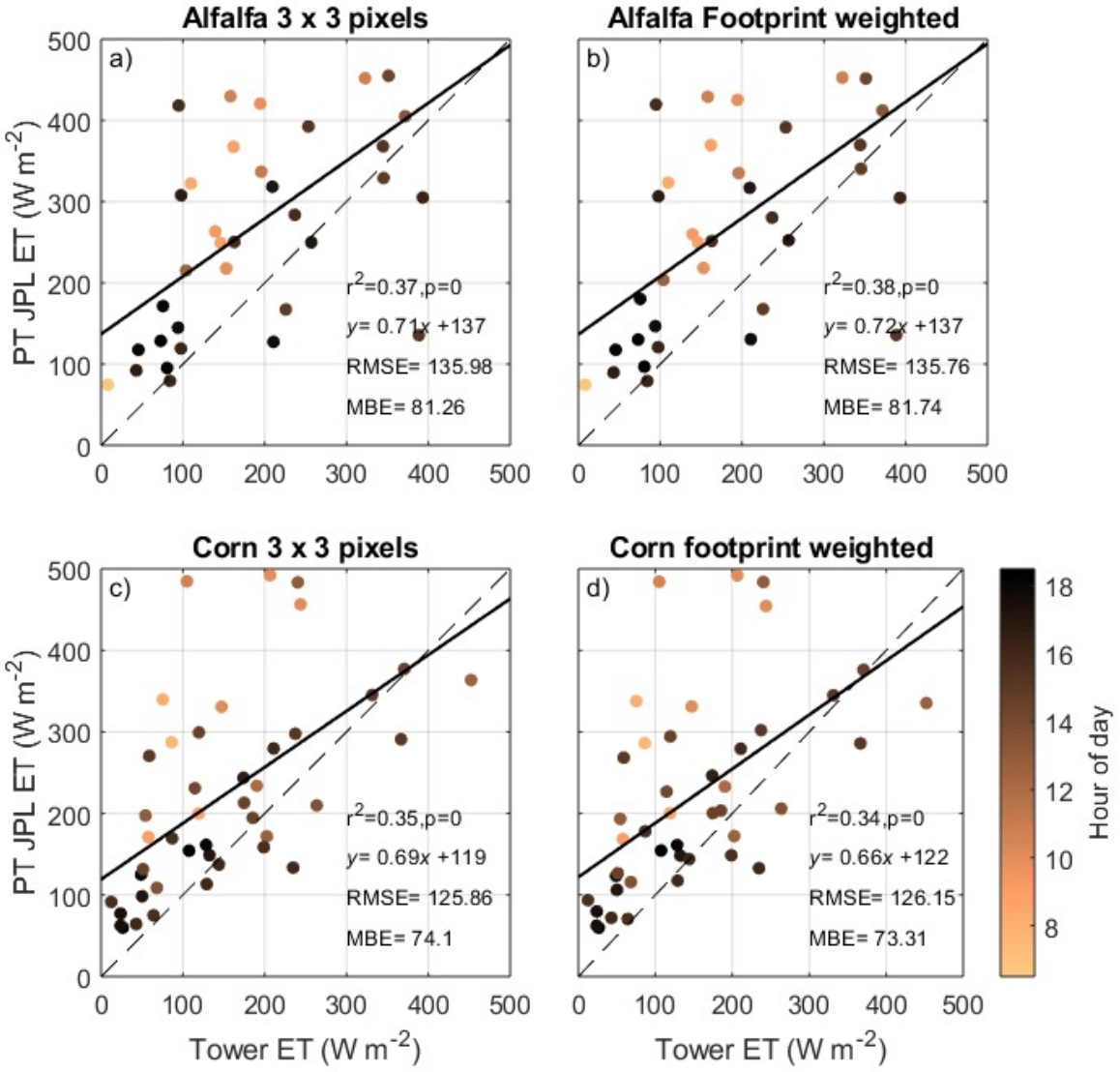
Validation Instantaneous Evaporation

Alfalfa

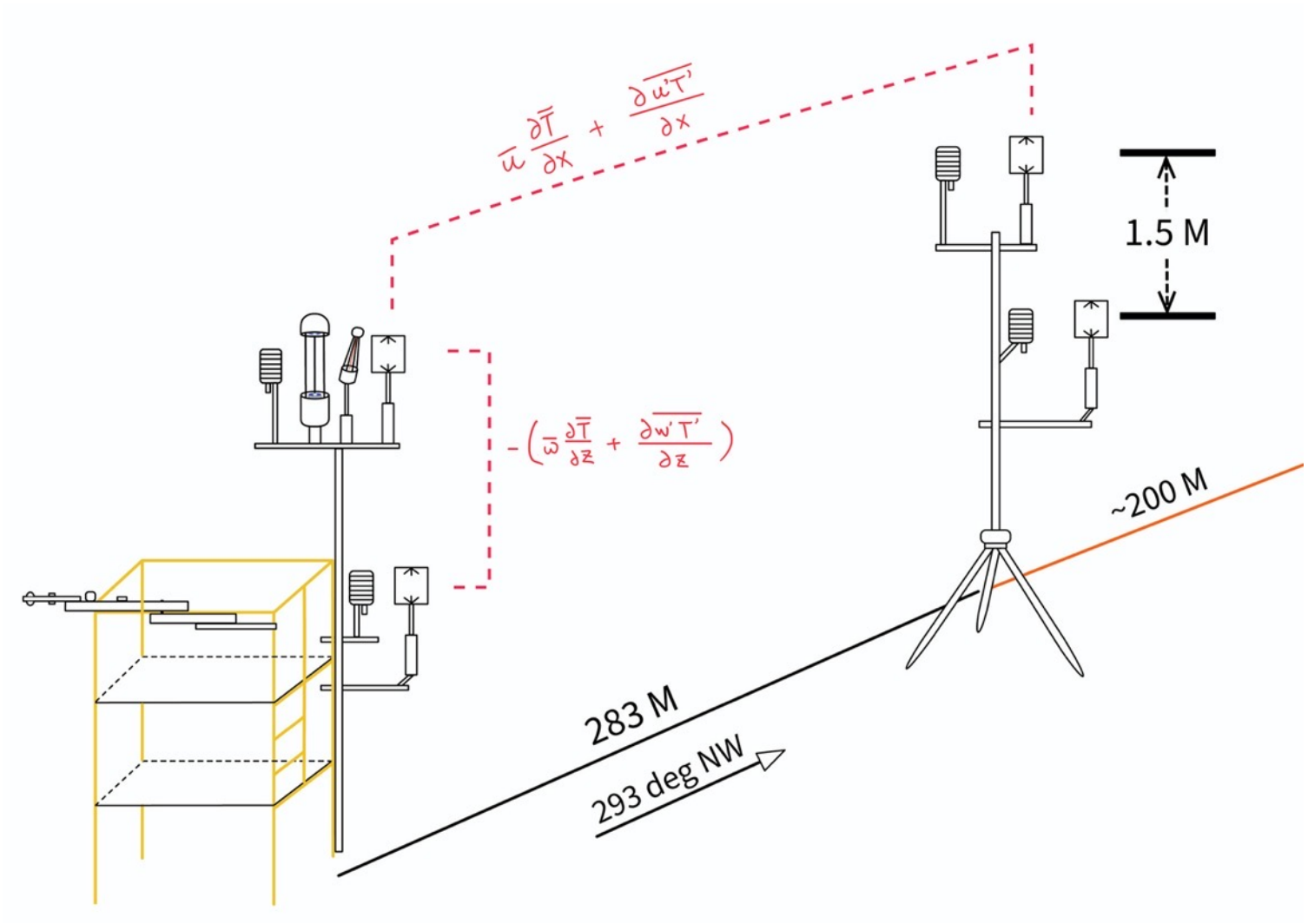


Corn





Quo Vadis?: On To Quantifying Advection



Tianxin ‘Carlos’ Wang

Takeaway

- If Advection is Occurring, We cannot Treat Pixels as Isolated Silos.
- There Will Be Lateral Transfer of Heat and Moisture that will Affect Eddy Covariance Flux Measurements and Model Interpretations

Lesson: Leaning Silos Will Fall