THE UNIVERSITY OF ARIZONA

2021 ECOSTRESS Science and Applications Team Meeting

Diurnal Vegetation Water Stress Over a Semiarid Mixed Conifer Forest

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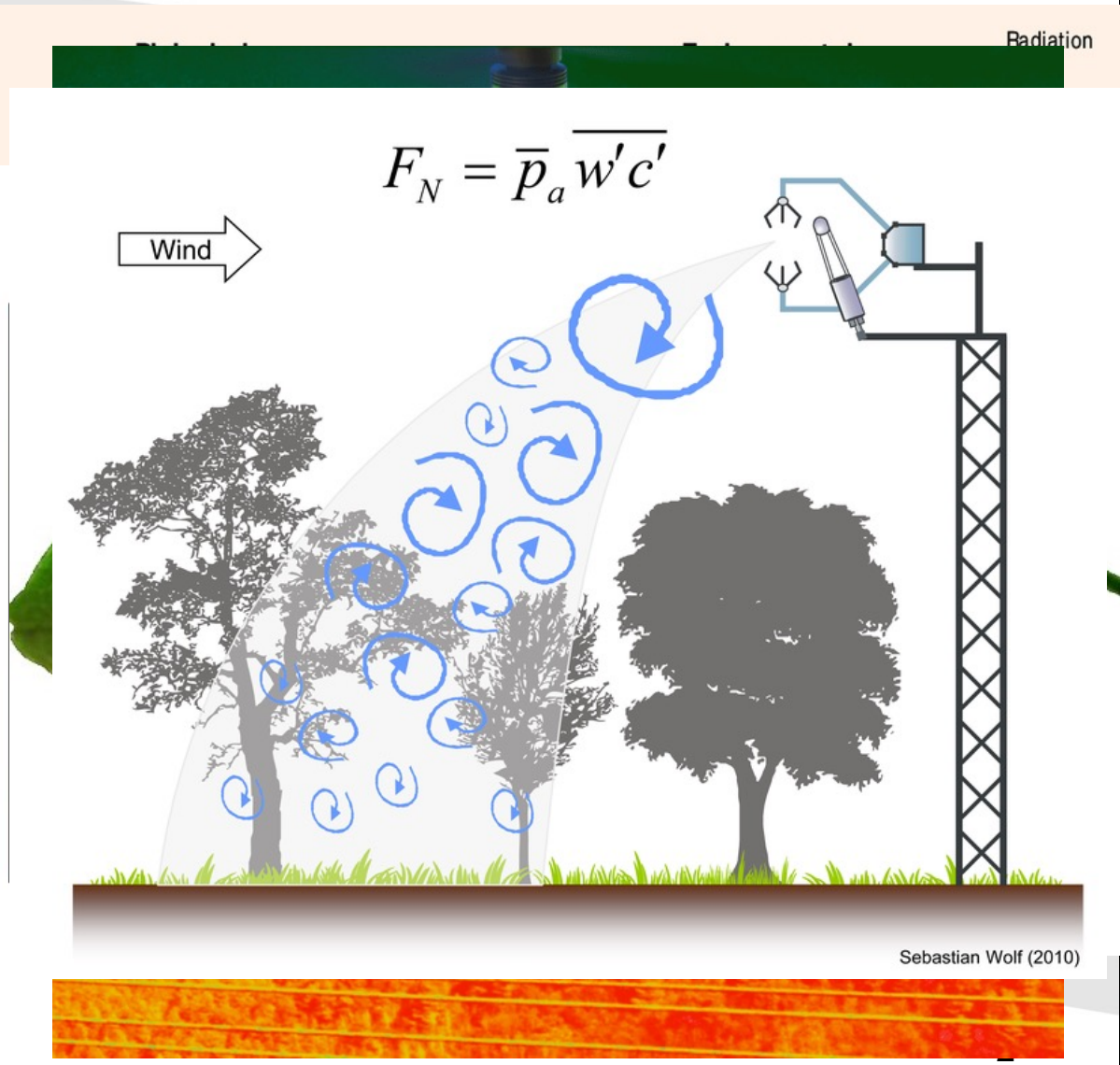
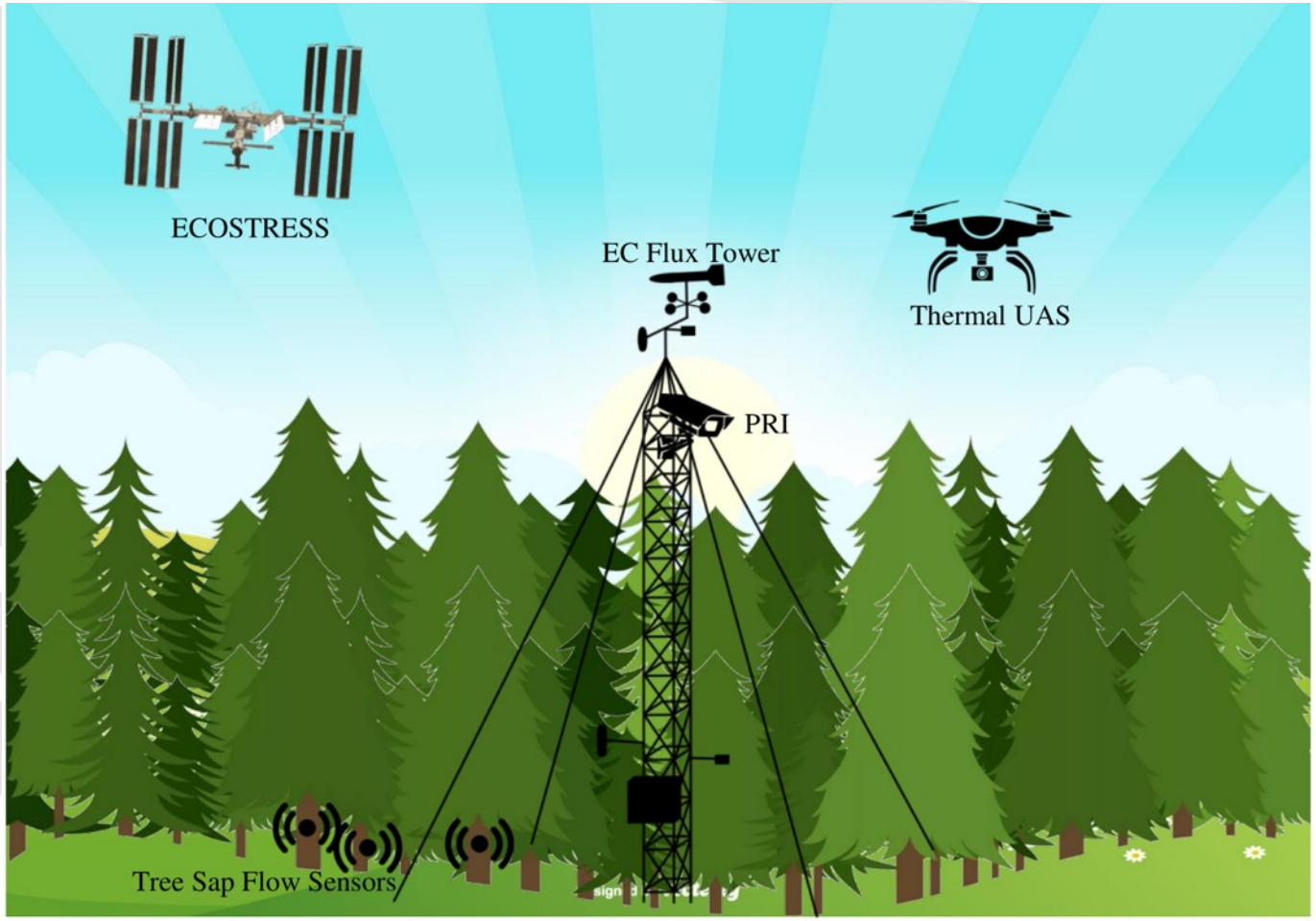
Background

- Plant canopy temperature (T_c) is partly regulated by evaporation and transpiration from the canopy surface and can be used to infer changes in stomatal regulation and vegetation water stress
- Over Southwest US, Air temperature differences between day and night often exceed 30°C
- Plants have adapted to regulate their leaf temperatures through transpiration, or the loss of water through tiny pores on their leaves called stomata
- ECOSTRESS mission is the first satellite capable of detecting sub-daily vegetation water stress
- Thermal sensors placed on Unmanned Aircraft Systems (UAS) have higher spatial and temporal resolution
- The eddy covariance technique, Tree sap flow and Photochemical Reflectance Index (PRI) can give us diurnal dynamics of the plants
- In this study, we combined thermal UAS, eddy covariance, sap flow, PRI, and ECOSTRESS data to assess diurnal vegetation water stress over a semiarid mixed conifer forest in southern Arizona



Instruments

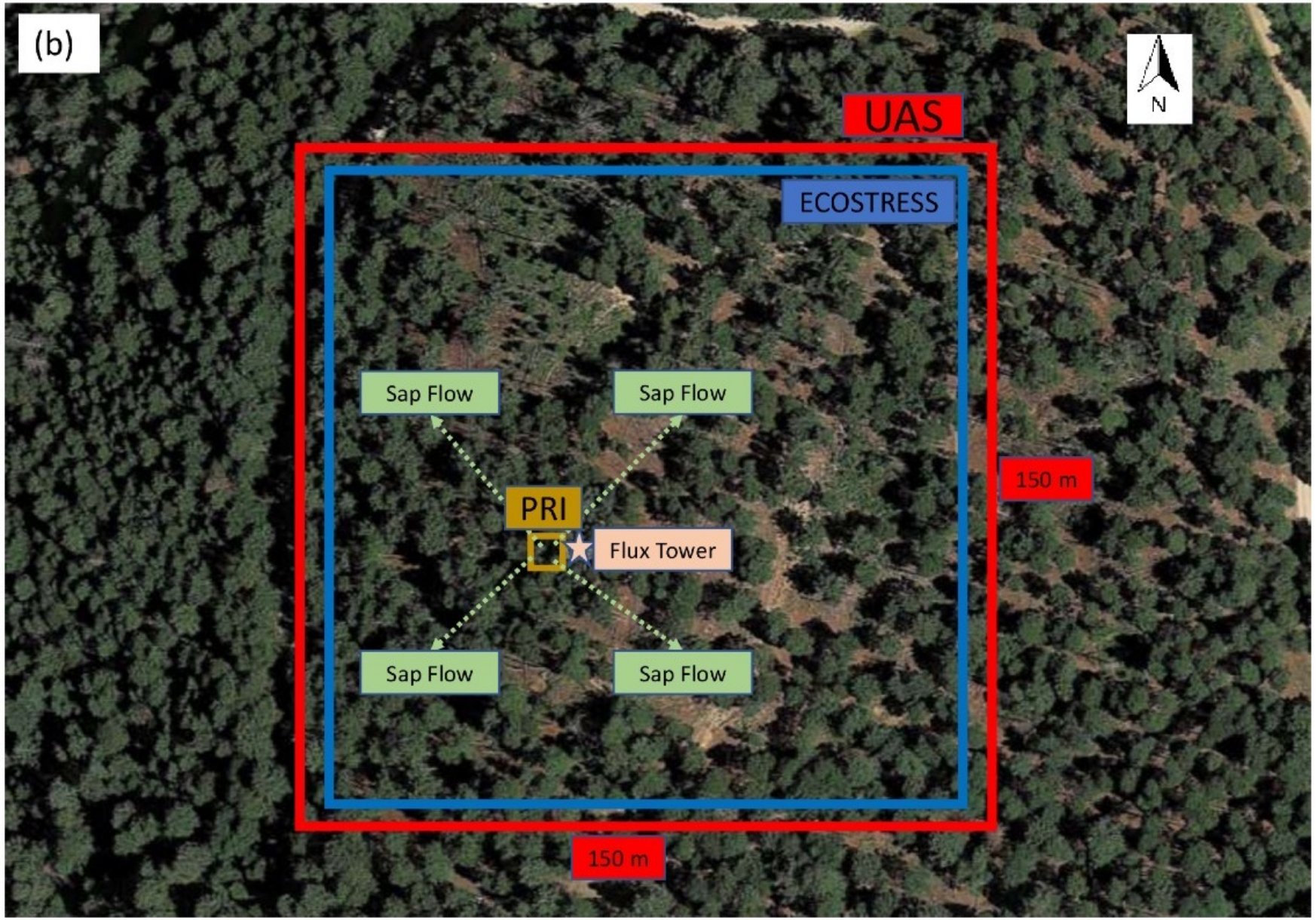
US-MtB Flux tower



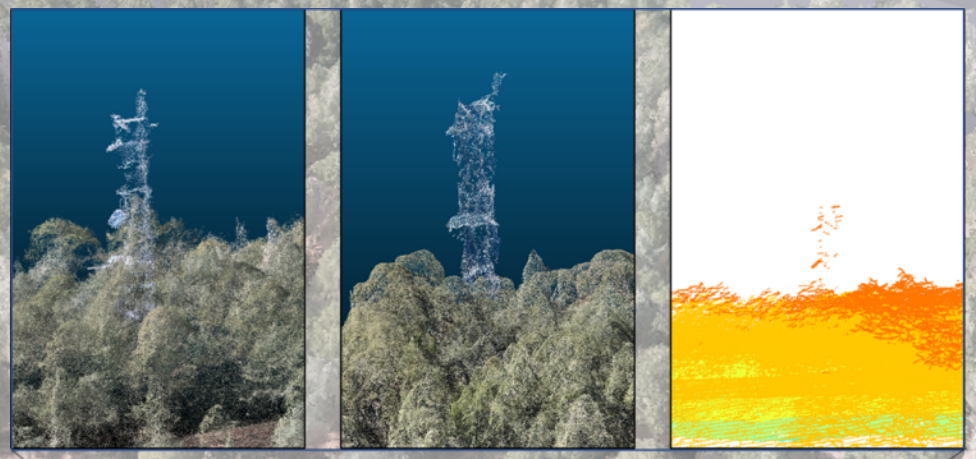
MAVIC 2 Thermal UAS

Tree Sap Flow

Footprint of the various instruments

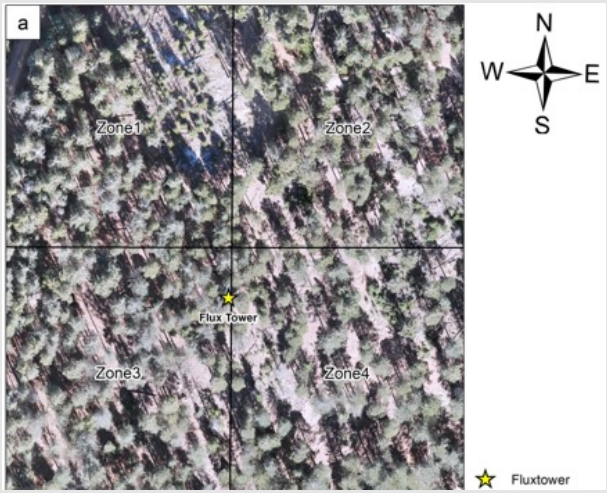


UAS 3D Outputs

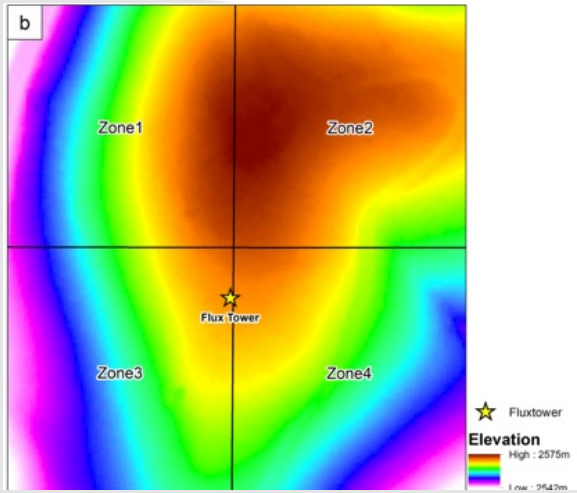


Site Description

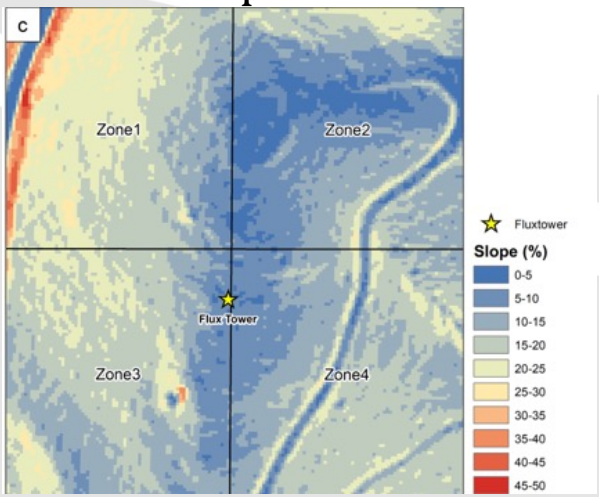
RGB



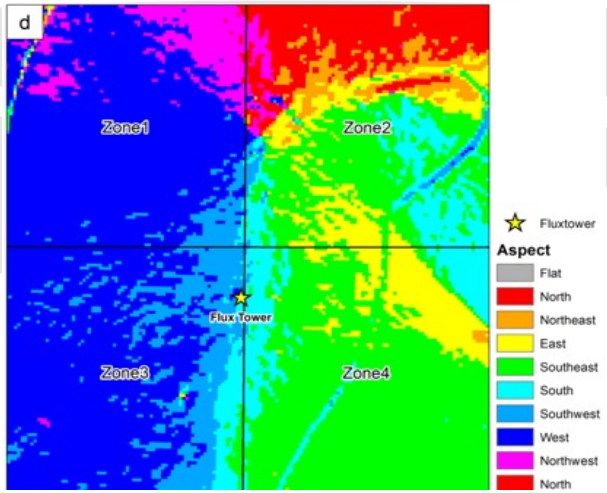
Elevation



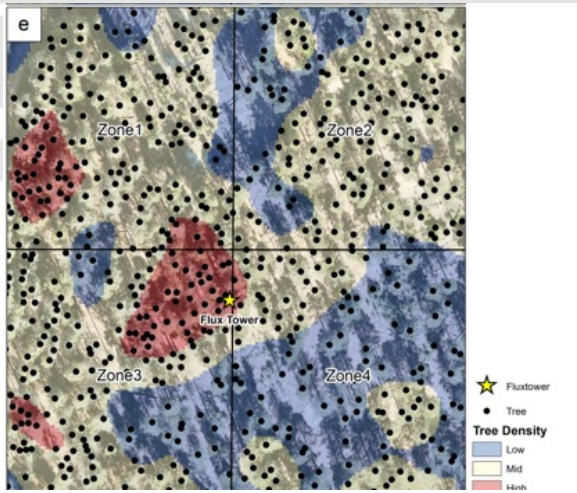
Slope



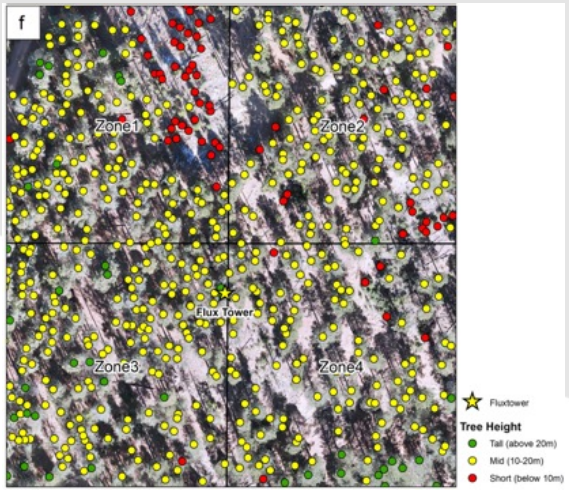
Aspect



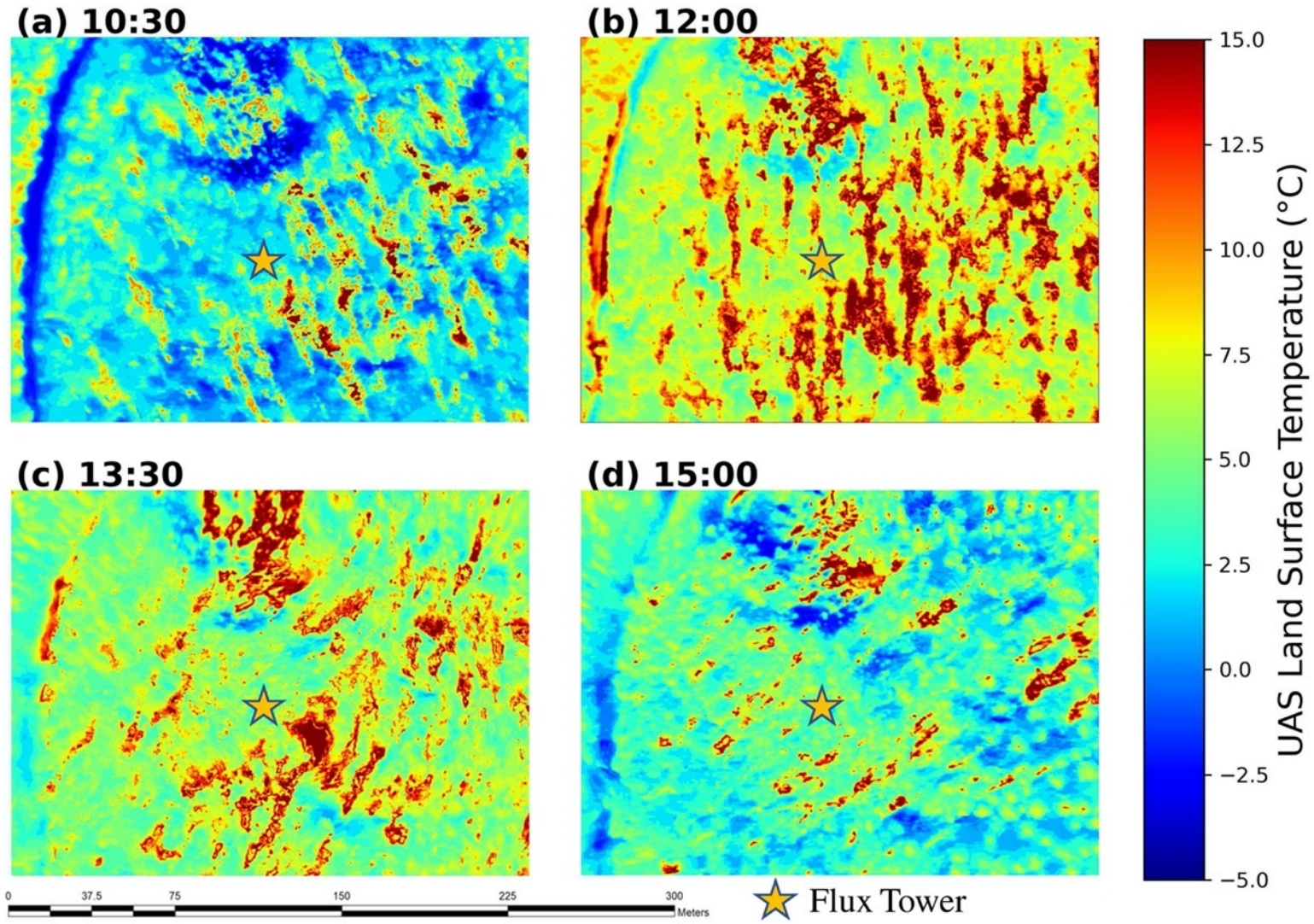
Tree Density



Tree Height



UAS thermal images on Nov 14, 2020

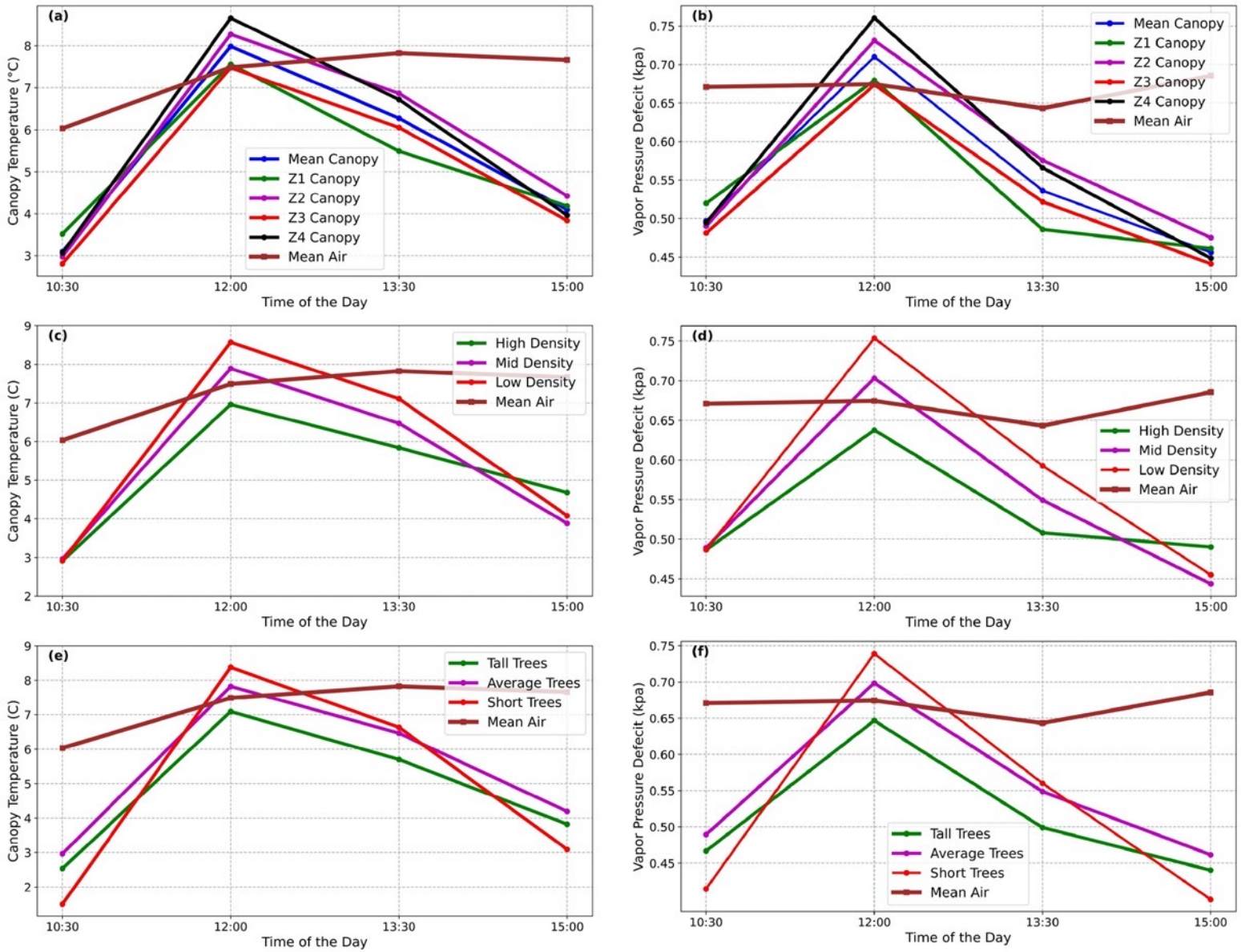


Diurnal variation of canopy temperature and VPD

- On average, T_c was 1.8 °C lower than air temperature
- Relationship between Tc and Ta varied significantly according to tree density and tree height classes
- Taller / denser tree, stands exhibiting relatively low Tc-Ta (2.4 and 2.1 °C cooler respectively)
- Shorter / lower density stands (1.7 and 1.5 °C cooler respectively)
- 2 °C difference between Taller / denser tree and Shorter / less-dense at noon

Canopy Temperature

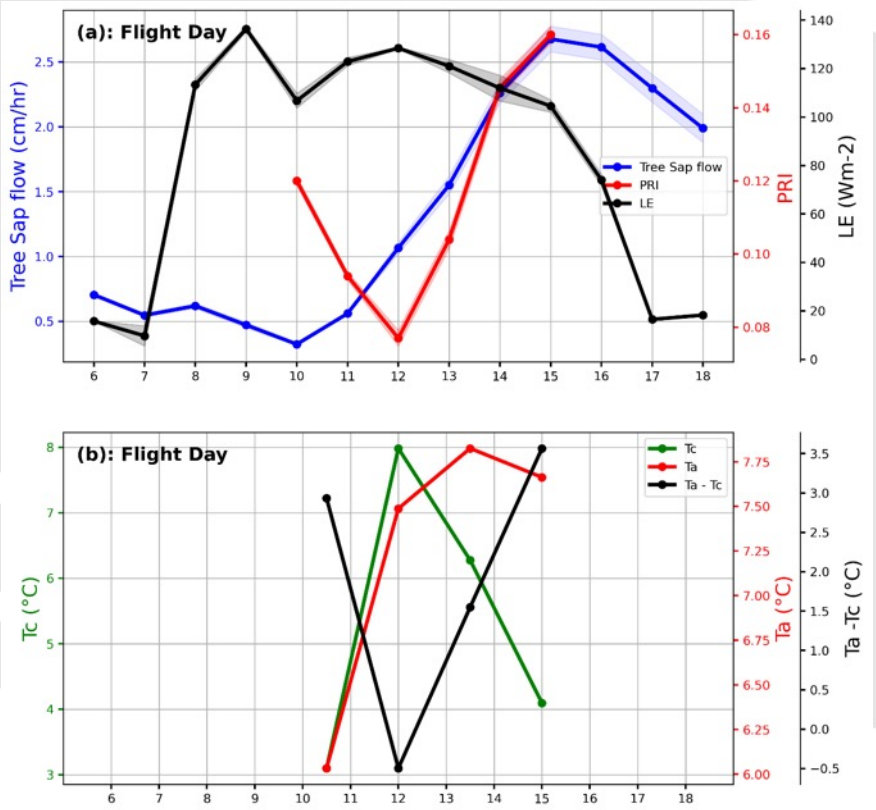
Canopy VPD



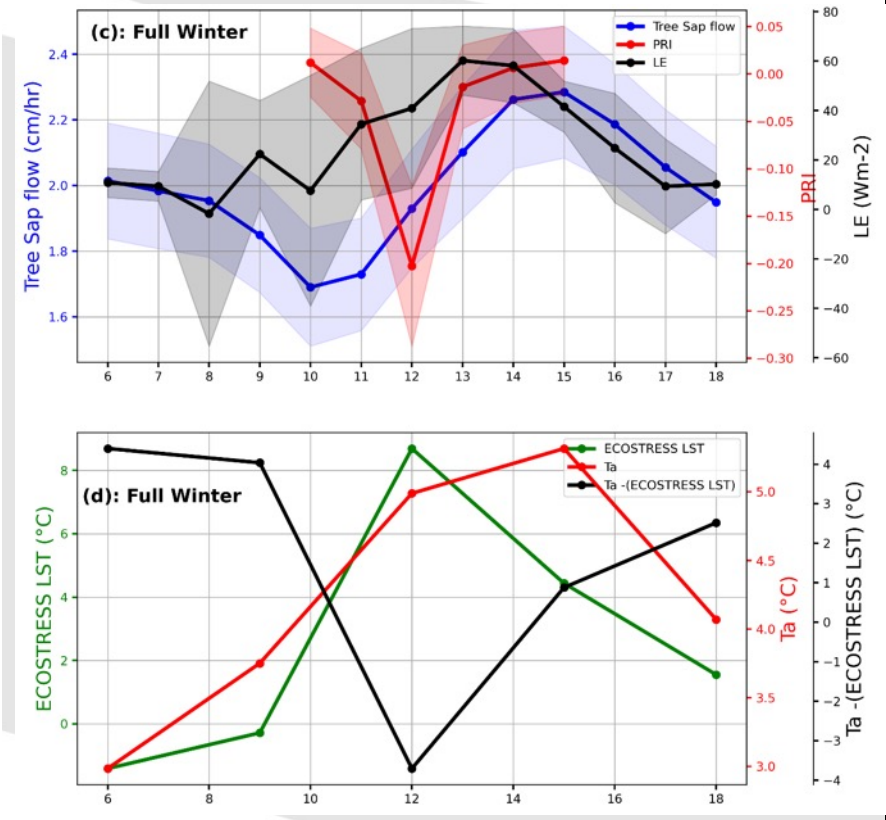
Comparison between datasets

- Thermal data from ECOSTRESS and UAS are in high agreement with PRI and sap flow data
- There is a lag between sap flow peak and LE peak
- Soil evaporation is dominant in the morning, but transpiration is more significant in afternoon
- Towers cannot partition evaporation and transpiration but spatial thermal data including thermal UAS and ECOSTRESS are able to capture this difference and are consistent with sap flow.

Flight Day



Winter

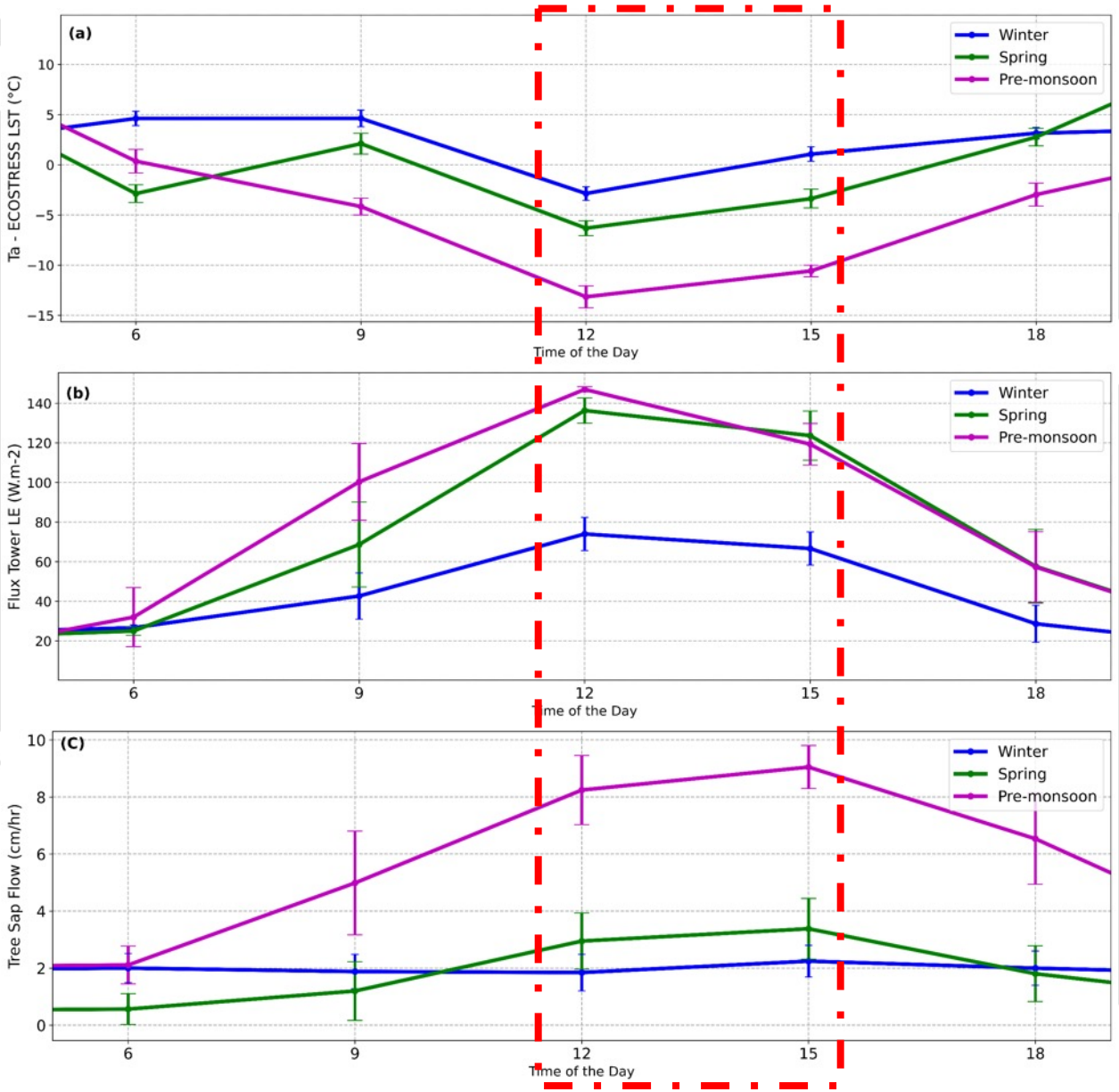


ECOSTRESS capability to capture diurnal dynamics

- ECOSTRESS LST as an index of T_c was 1.2 °C cooler than T_a which is comparable by UAS T_a-T_c that was 1.8 °C considering the soil impact on ECOSTRESS LST

- LE peaks about 12 pm in all seasons

- However, sap flow as an index of transpiration peaks at 3 pm in all seasons because of time-dependent redistribution of water within the trees



Conclusion

- Canopy temperature and VPD differed significantly among different tree density and height classes for a semiarid mixed conifer forest site
- Diurnal canopy temperature dynamics were closely related to canopy PRI and plant hydraulic traits
- Satellite observations from ECOSTRESS captured aspects of diurnal canopy temperature dynamics that were consistent with site-level measurements

Thank you for Your Attention!

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