RPC 2020

ECOSTRESS evapotranspiration over Garden City, Kansas

Virtual Research Presentation Conference

Linking the Texas Water Observatory with ECOSTRESS

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Program: SURP

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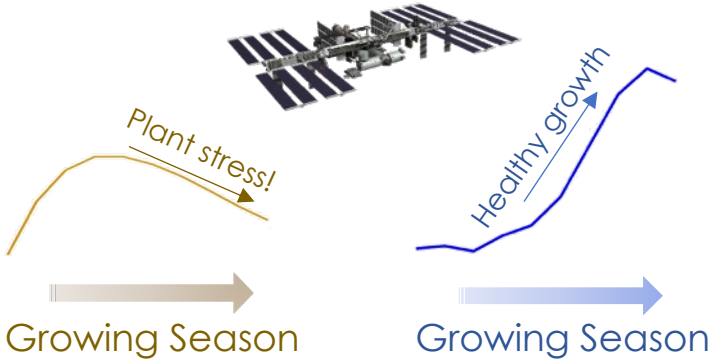
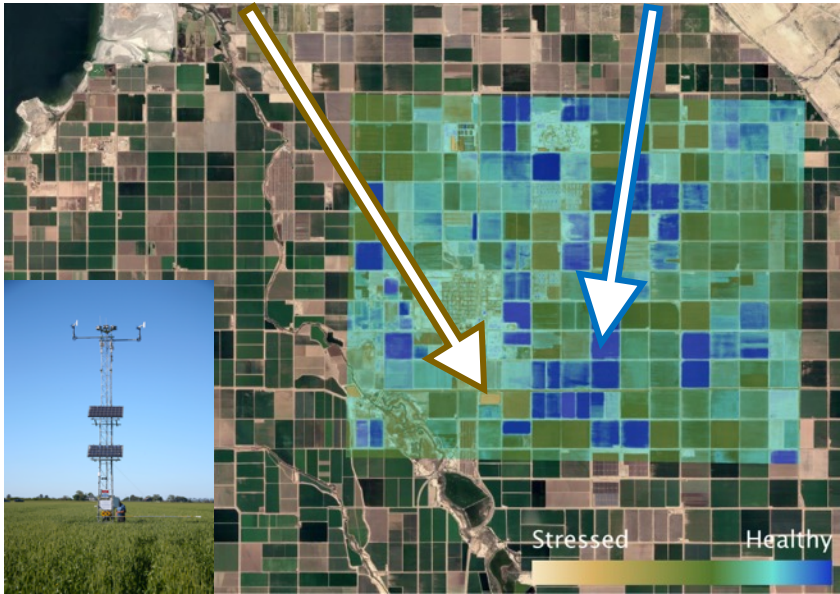
Tutorial Introduction

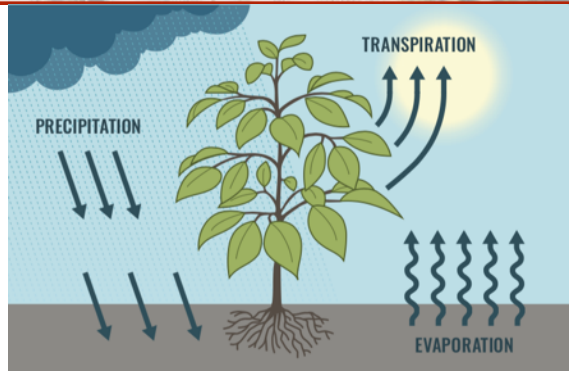
Abstract

- Agricultural and water resource managers need to understand plant stress in fine detail, both
  - In space, to resolve each farmer's fields, and
  - In time, since plant health can change rapidly over critical periods of the growing season
- Remote sensing instruments (such as ECOSTRESS) provide a snapshot of plant stress over wide regions, but only every ~5 days
- Measurements made by towers on the ground measure plant stress half-hourly throughout the day, but this represents only a single point
- By merging the two, we can exploit the benefits of each of these datasets to provide measures of plant stress every day and at fine spatial resolution over the entire region





Problem Description



a) Evapotranspiration (ET) is a measure of plant water loss, which can be used to identify plant stress. For impactful agriculture and water resource management, ET needs to be known at the resolution of an individual farmer's field, at regular time intervals, especially during the growing season or at drought onset.

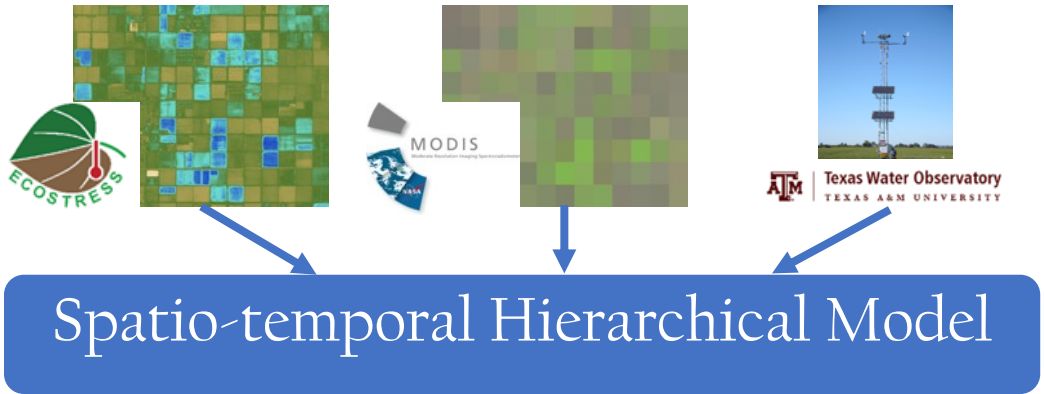
b) ECOSTRESS acquires data every 1-5 days (depending on ISS orbit) at varying times of day, at 70 m spatial resolution. The spatial information allows for fine-scale evaluation of stress at a resolution finer than a small farmer's field. But more regular measurements are needed to capture critical periods of plant growth or stress. Other satellites, such as MODIS, have a daily overpass, but at 500 m resolution, which is too coarse. Field measurements are made by flux towers (in this case the Texas Water Observatory) frequently throughout the day, but these represent a single point location. By fusing all of these datasets, we create a high spatial and temporal resolution ET product for improved decision making.

c) There is high value in producing ET at a combination of both high spatial and high temporal resolutions for better incorporation into irrigation scheduling and hydrological water management tools. In addition, a better understanding of ET changes at small time steps will enable an improved understanding of acquisition schedules for future mission design. The Texas Water Observatory is a network that will prove to be beneficial to NASA for the validation of ET products derived from current (e.g. ECOSTRESS), and future missions (e.g. the Surface Biology and Geology Designated Observable).

Methodology

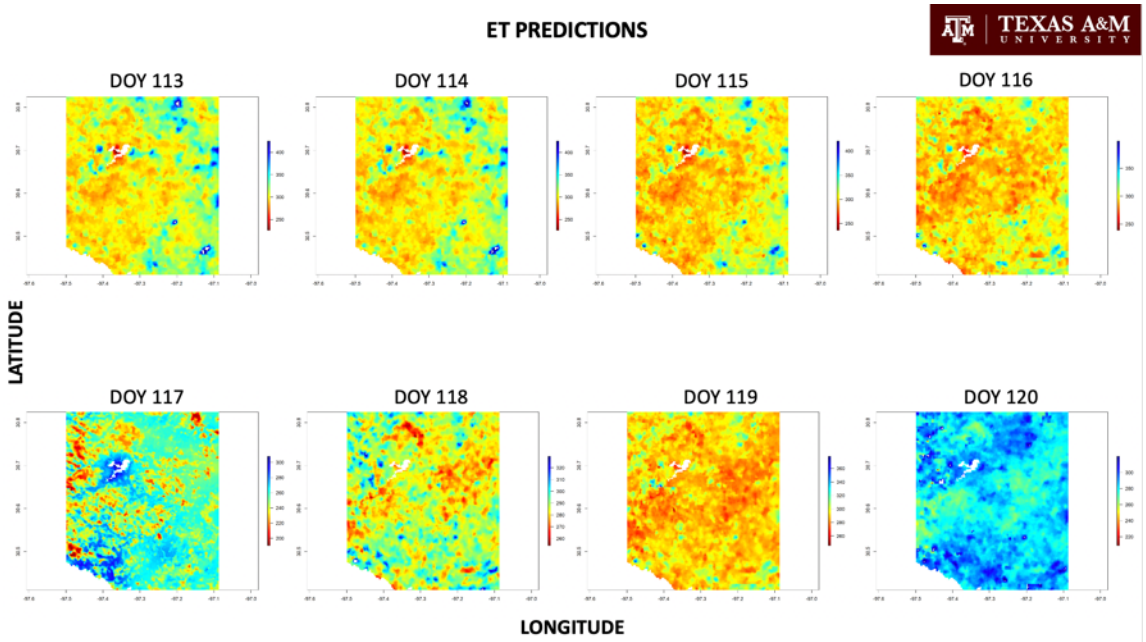
a) We propose a spatio-temporal Gaussian Process Model (GPM) for fusion of ECOSTRESS, MODIS, and field data. We model the covariance of ET as a product of separable spatial and temporal covariance functions; the former is determined from ECOSTRESS and MODIS, and the latter from eddy covariance field data (from the Texas Water Observatory).

b) Current methods for combining datasets include: data assimilation, which assumes an underlying physical model but is highly sensitive to poorly defined priors; or machine learning, which is computationally efficient, but is seen to be a “black box”. Statistical data fusion is data driven yet also allows physical interpretability. Applying this technique to ET estimation is an innovation in the field that will lead to improved understanding of the carbon and water cycles, as well as optimized agricultural decision making.



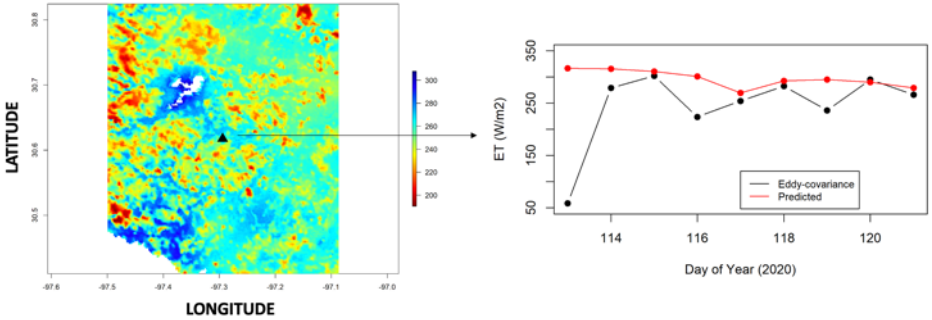
Results

We were able to develop and apply a fusion prototype which produces daily ET at 70 m resolution.



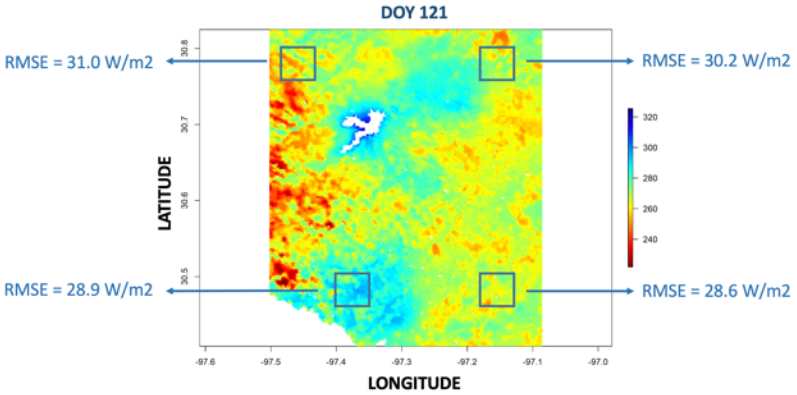
Results

These results were validated both temporally, using flux tower data, and spatially, by leaving a subset of ECOSTRESS pixels out of the model and attempting to predict them. Both tests showed an bias less than 10%, which is within the expected accuracy of ECOSTRESS ET!



Temporal validation

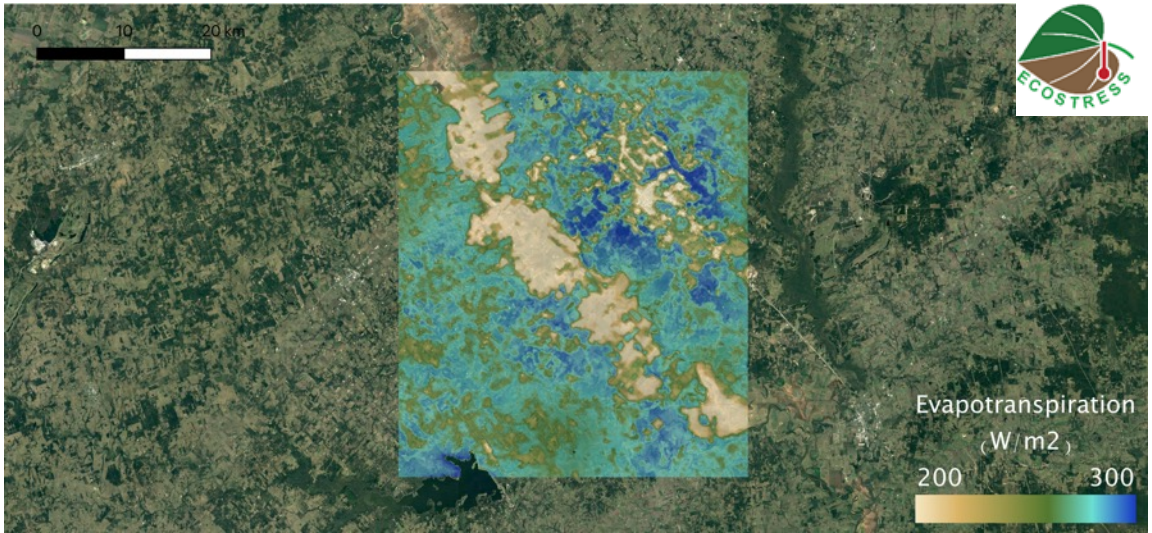
Spatial validation



Results

a) This model is significant in that it demonstrates the power of data fusion for creating ET products at high spatial and temporal resolution. This can then be used to inform precision agriculture and other water resource management decisions.

b) Should we receive further funding, we will apply this model to a wider region and determine the impact of landcover type on model accuracy.



Publications and References

PUBLICATIONS

[A] Kathuria, D., Mohanty, B., Katzfuss, M., Cawse-Nicholson, K., Johnson, M., “Multiscale Big Data Fusion from Point to Satellite scales: Application to Evapotranspiration,” *in progress*.

REFERENCES

[1] Gelfand, A. E., Zhu, L., & Carlin, B. P. (2001). On the change of support problem for spatio-temporal data. *Biostatistics*, **2**(1), 31-45.

[2] Kathuria, D., Mohanty, B. P., & Katzfuss, M. (2019). Multiscale data fusion for surface soil moisture estimation: a spatial hierarchical approach. *Water Resources Research*, **55**(12), 10443-10465.