Linking field observations and satellite data to assess the impacts of environmental controls on water use efficiency, for the state of Kentucky

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Introduction

Water use efficiency (WUE), the ratio of carbon assimilation to water loss, is a key physiological parameter linking carbon and water cycles. Understanding changes in WUE is critical to quantify the terrestrial ecosystem response to climate change. In this study, we evaluated satellite data against data collected at an eddy covariance site at Kentucky State University for 5 years (2016-2020). We compared the site data to remotely sensed data obtained from ECOSTRESS and MODIS. Our goal is to determine how climate change might have affected water use efficiency. ECOSTRESS, on board the International Space Station, provided new opportunities to monitor plant WUE and water stress from space.

Study Site

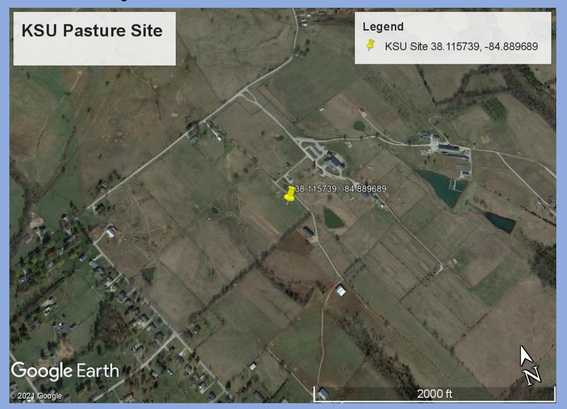

Figure 1: The pasture site is in north central Kentucky near Frankfort.

Methods

- We collected ET and GPP from ECOSTRESS, MODIS and an eddy covariance flux site at KSU for 2016-2018.
- We calculated WUE for the satellite and site data as WUE = GPP/ET
- We calculated the % error in WUE due to the use of MODIS GPP as: %errorGPP=|(WUEGPP-WUEsite)/WUEsite| x 100

Results

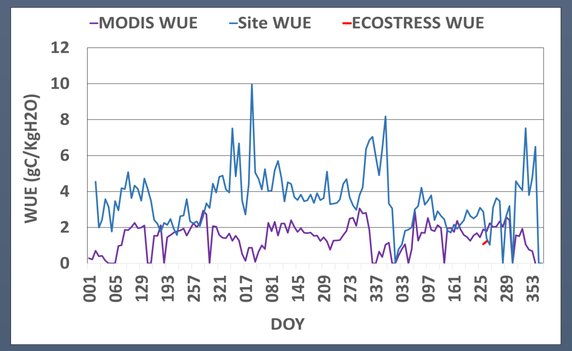

Figure 2. WUE time series plot for MODIS (purple), site (blue), and ECOSTRESS (red). Data is presented for 3 years (2016, 2017, and 2018)

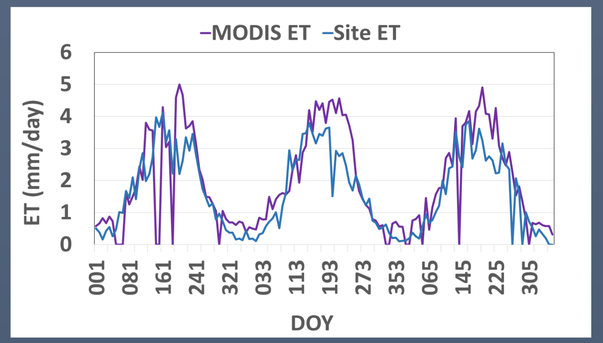

Figure 3: Evapotranspiration time series plot for MODIS (purple) and site (blue). Data is presented for 3 years (2016, 2017, and 2018)

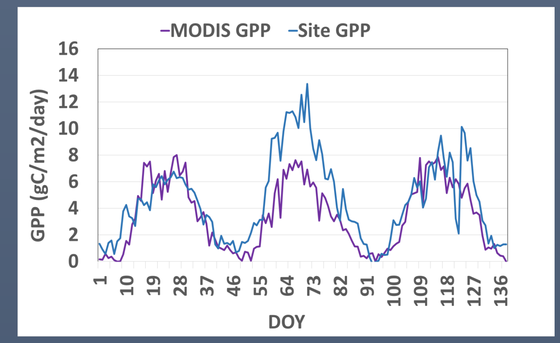

Figure 4: Time series of gross primary productivity MODIS (purple) and site (blue). Data is presented for 3 years (2016, 2017, and 2018.)

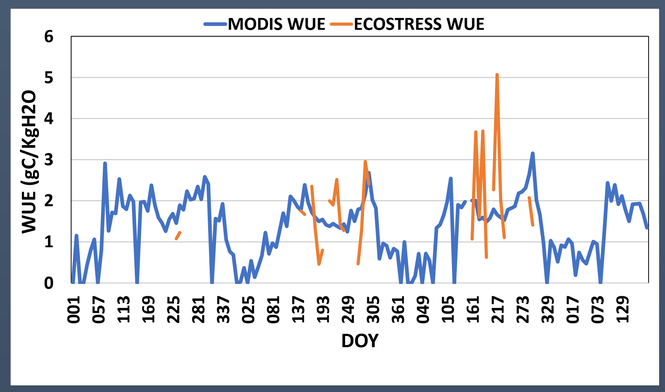

Figure 5: Time series of WUE for MODIS (blue) and ECOSTRESS (orange). Data is presented for 3 years (2018, 2019, and 2020).

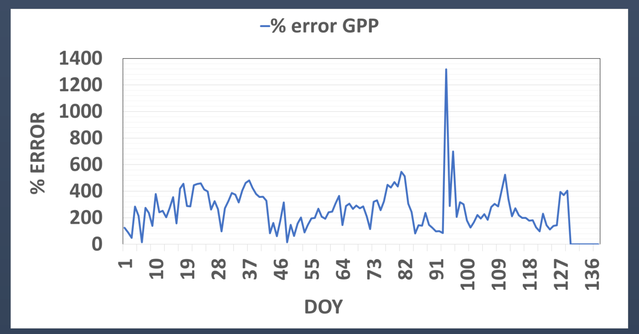

Figure 6: % error of in WUE due to the use of MODIS GPP data compared to the site data.

Conclusion

- Our results showed that MODIS slightly overestimated the site ET.
- MODIS underestimated the WUE compared to the site WUE.
- ECOSTRESS WUE showed higher values than MODIS WUE.
- MODIS overestimated GPP compared to the site data in 2016 and underestimated in 2017 and 2018.
- Results also showed that ET fluctuates with the seasons with little year to year variability.
- WUE was lower in 2016, had a huge spike in 2017, and dropped slightly in 2018. However, WUE was still higher in 2018 than in 2016. This could be related to the fact that GPP was higher in 2017 than both 2016 and 2018 and was lowest in 2016.

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