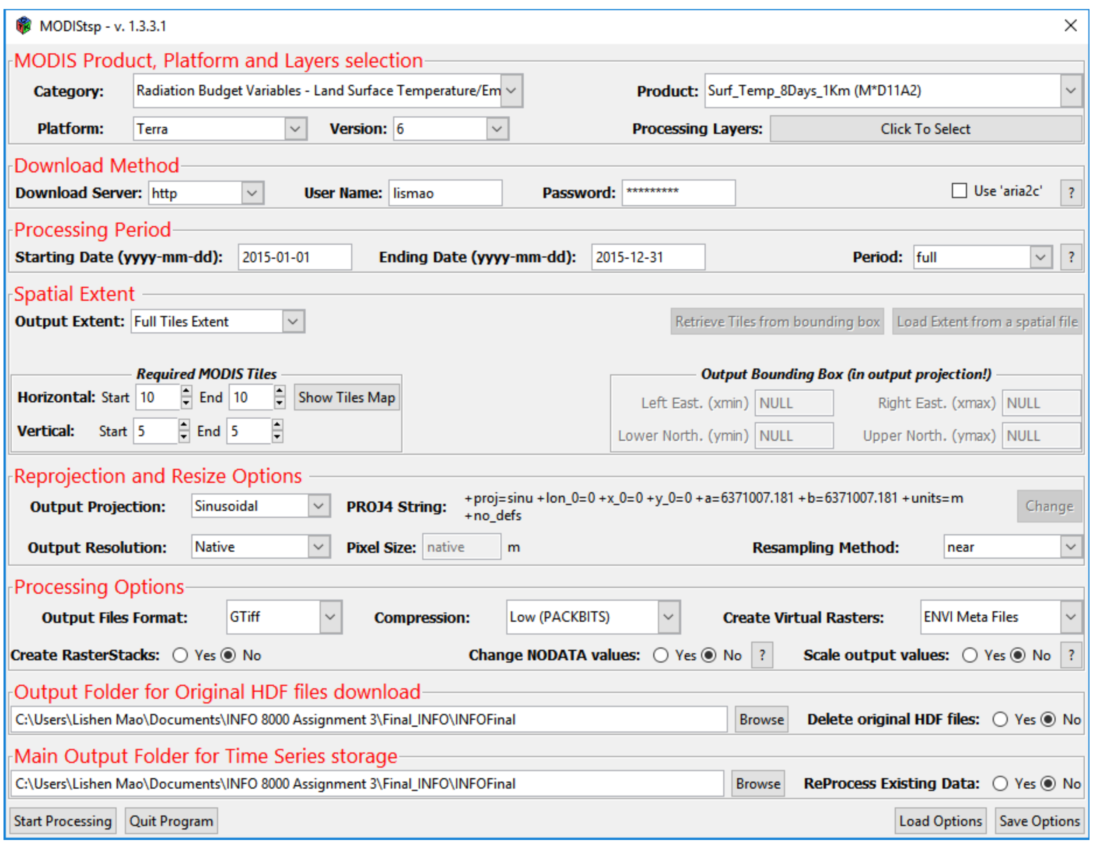
INFO 8000 Final project report Lishen Mao

12/8/2017 Geography

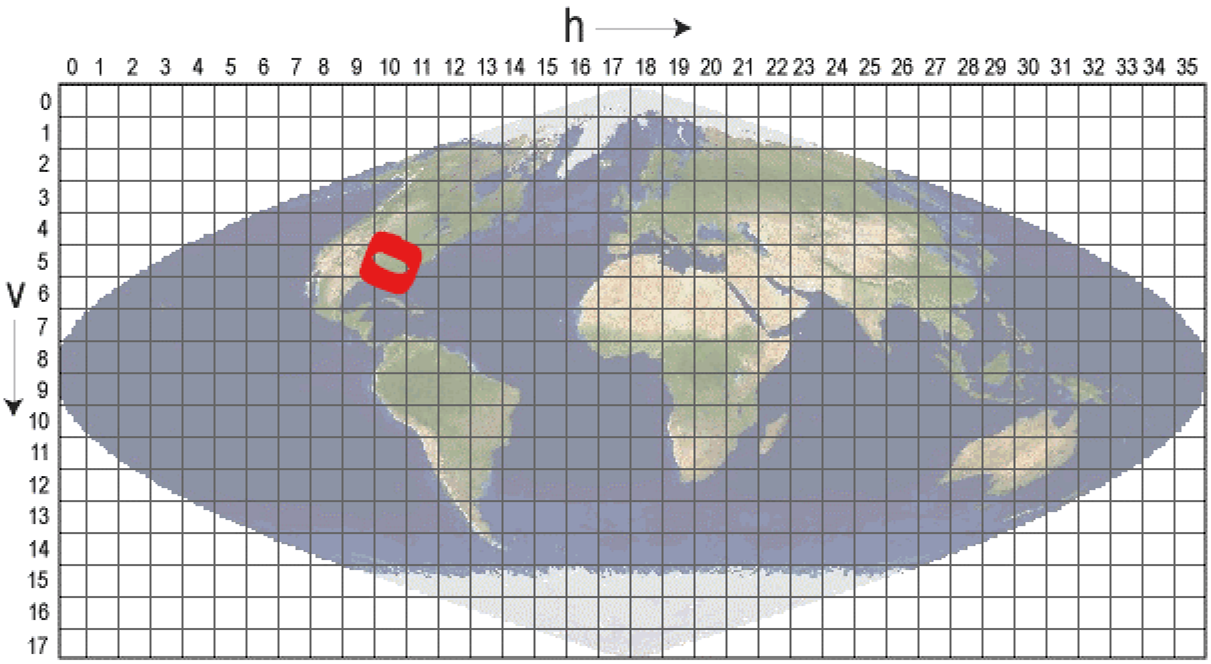
Data acquisition:

Four datasets are used to implement this project, including MODIS 17A2 8-day Gross Primary productivity (GPP) dataset, MODIS 11A2 8-day Surface Temperature dataset, MOD09GA daily Land Surface Reflectance (LST) dataset, 30 minutes daily Eddy covariance dataset by flux tower at Grand Bay National Estuarine Research Reserve, Mississippi. MODIS 17A2 8 day GPP dataset, MODIS 11A2 8-day Surface Temperature dataset and MOD09GA daily surface reflectance dataset was downloaded and preprocessed by MODIStsp, it allows automating the creation of time series of rasters derived from MODIS Satellite Land Products data. It performs several typical preprocessing steps such as download, mosaicking, reprojection and resize of data acquired on a specified time period. All processing parameters can be set using a user-friendly GUI (Figure1). Users can select which layers of the original MODIS HDF files they want to process, which additional Quality Indicators should be extracted from aggregated MODIS Quality Assurance layers and, in the case of Surface Reflectance products, which Spectral Indexes should be computed from the original reflectance bands. For each output layer, outputs are saved as single-band raster files corresponding to each available acquisition date. Virtual files allowing access to the entire time series as a single file are also created. Command-line execution exploiting a previously saved processing options file is also possible, allowing to automatically update time series related to a MODIS product whenever a new image is available (Busetto & Ranghetti , 2016).



(Figure 1, MODISstp GUI)

The MODIS land products are produced at 4 resolutions (250m, 500m, 1km, and 0.05 degree) In order to maintain reasonable file sizes for the other higher resolution MODIS land data products, each projection is divided up into a tiled grid. The land products are thus produced and distributed in adjacent non-overlapping tiles that are approximately 10 degrees square (at the equator). Most of MODIS land products are produced in the Sinusoidal tile grid (Nickeson, 2017). My study site located in the red circled grid with horizontal tile 10; vertical tile 5



Eddy covariance flux tower was set up by previous graduate student and project investigator. It locates at latitude 30.369073° longitude -88.417211° in Sinusoidal projection system and GCS_WGS_1984 Geographic Coordinate System. Eddy covariance data comes with a lot of missing value due to instrument running problem and calculation error, for example (figure 2). Therefore I first deleted GPP value equals to -9999 and then picked the exact day that matches 8-day interval MODIS GPP and Land surface temperature datasets and calculate mean value of each day. My dataset includes 46 rows (attributes) from day 1 to day 361 of 2015, including days of 1, 9 , 17, 25, 33, 41, 49, 57, 65, 73, 81, 89, 97, 105, 113, 121, 129, 137, 145, 153, 161, 169, 177, 185, 193, 201, 209, 217, 225, 233, 241, 249, 257, 265, 273, 281, 289, 297, 305, 313, 321, 329, 337, 345, 353, 361. However due to missed data in EC measurement dataset, I eventually only have 36 rows(attributes), which are days of 25, 33, 41, 49, 57, 65, 73, 81, 145, 153, 161, 169, 177, 185, 193, 201, 209, 217, 225, 233, 241, 249, 257, 265, 273, 281, 289, 297, 305, 313, 321, 329, 337, 345, 353, 361. Remote sensed GPP and LST data was extracted by using "Extract multi values to points" spatial analyst tool in ArcGIS. I also exercised using R to extract values for flux tower site pixel from GPP and LST dataset. EVI was calculated by formula: 2.5 * (RNir – RRed/1+RNir + 6*RRed-7.5*RBlue), while near inferred (RNir) is band 2, Red (RRed) is band 1 and Blue (RBlue) in MOD09GA surface reflectance dataset. I also used the similar strategy to select specific EVI value of date out to match 8-day MODIS GPP and LST data. I also changed unit from $\mu mol/(s*m^2)$ in eddy covariance dataset to match G/cm^2 in remote sensing GPP dataset. The formula is g/cm^2 = µmol/(s*m^2) / 1000000 / 0.022722366761722 * 1000000.

SOUTH_Date	wind_dir	ustar	fco2	moving_avg_Re	nee	gpp	FCO2_qc	air_t	humidity	PAR	footprint_S	footprint_peak
#LT	degrees	m/s	µmol/(s*m	µmol/(s*m2)	µmol/(s*m	µmol/(s*m	none	degrees	percent	µmol/(s*m	m	m
1/1/2015 0:00	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999
1/1/2015 0:30	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999
1/1/2015 1:00	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999
1/1/2015 1:30	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999
1/1/2015 2:00	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999
1/1/2015 2:30	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999
1/1/2015 3:00	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999	-9999

Figure 2: missing data in EC measurement dataset

<u>Temperature & Greenness model</u>:

The Temperature and Greenness (TG) model was developed by Sims et al. (2008) that based on the Enhanced Vegetation Index (EVI) and the Land Surface Temperature (LST) products from MODIS. The TG model equals GPP ∝ ScaledEVI * ScaledLST, where ScaledEVI = EVI – 0.1 because previous studies by Sims et al (2016) suggested that GPP drops to zero when an EVI value of 0.1. ScaledLST is defined as Min [(LST/30 :(2.5-(0.05*LST)].

<u>Result</u>

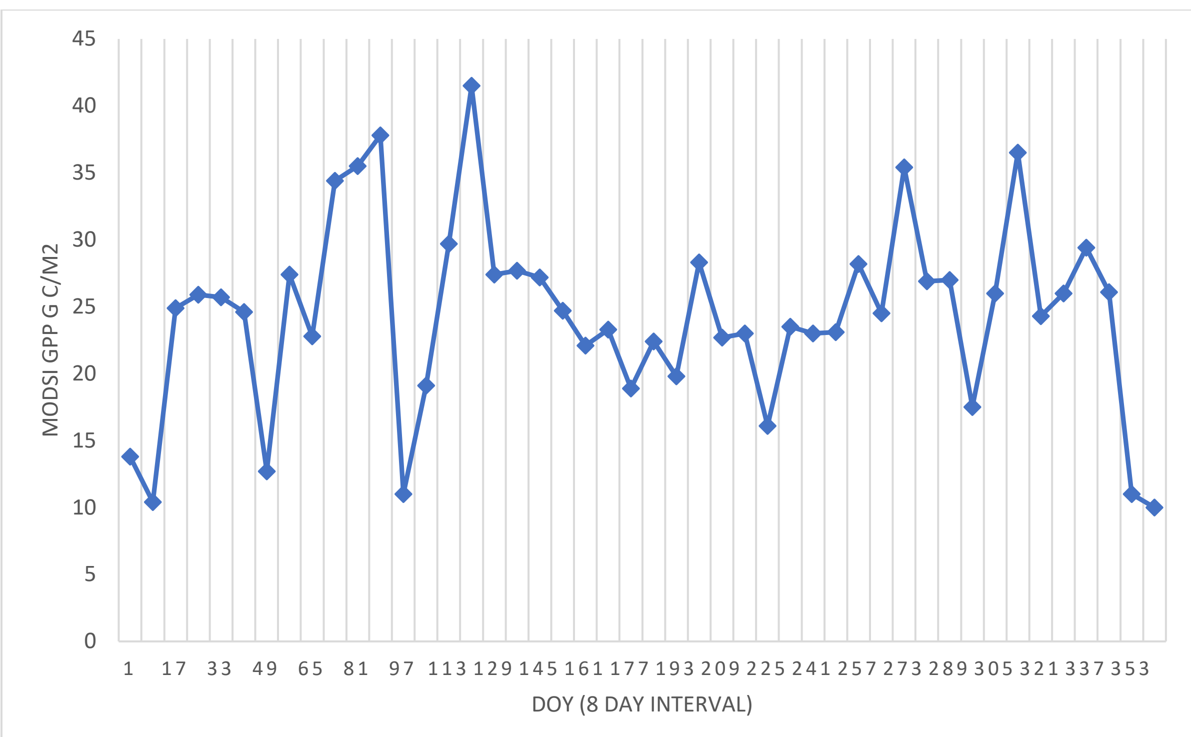


Figure 3 the 8-day composites of GPP from MODIS GPP product

Seasonal MODIS GPP in 8-day interval of flux tower at Grand Bay National Estuarine Research Reserve showed no patterns for year 2015(Figure. 3). Seasonal variations of GPP ranged from 10 gC/m2/(8-day)occurred January, (DOY≈15), March (DOY≈ 105) and December (DOY≈360) to 43 gC/m2/8-day during the spring (DOY≈120). With seasonal growth and senescence of vegetation, GPP should be highest at summer season and decreasing to approximately zero after DOY≈300. However, our flux dataset (figure. 4) shows relatively strong seasonal pattern with higher GPP value took place during summer period from May (DOY≈ 150) to Early September (DOY ≈ 281) except a few extremely low records.

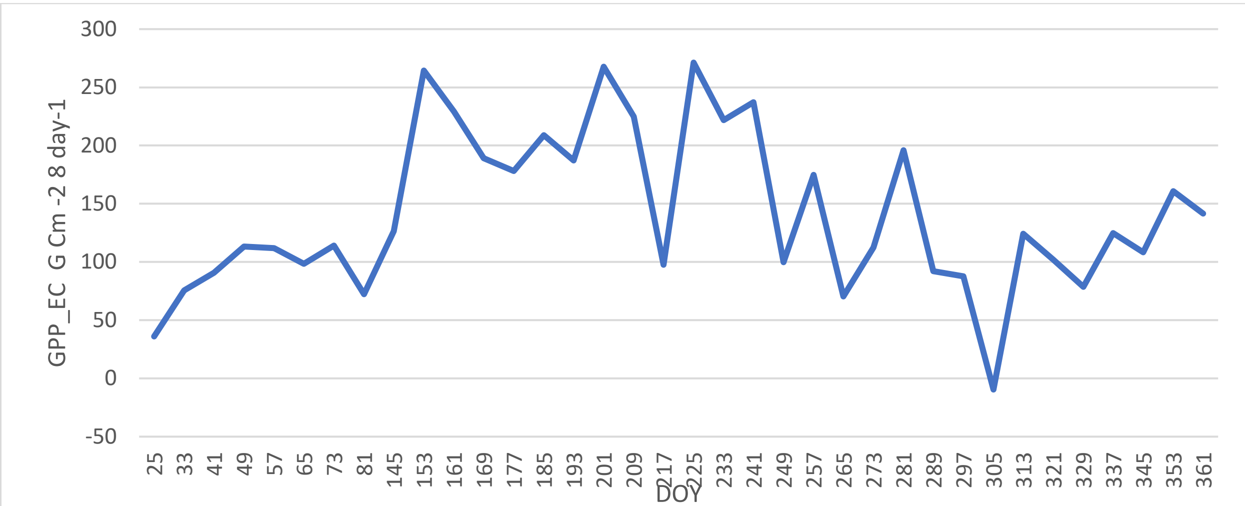


Figure 4. The 8-day composites of GPP from covariance flux measurements in Grand Bay

Land surface temperature showed common seasonal patterns during a year which is consistent with variation in EC GPP. The higher range of values of LST occur between approximately DOY 145 and DOY 290. The light independent reactions of photosynthesis are dependent on temperature (Mackey et al., 2013), therefore TG model should able to predict better GPP value than MODIS GPP

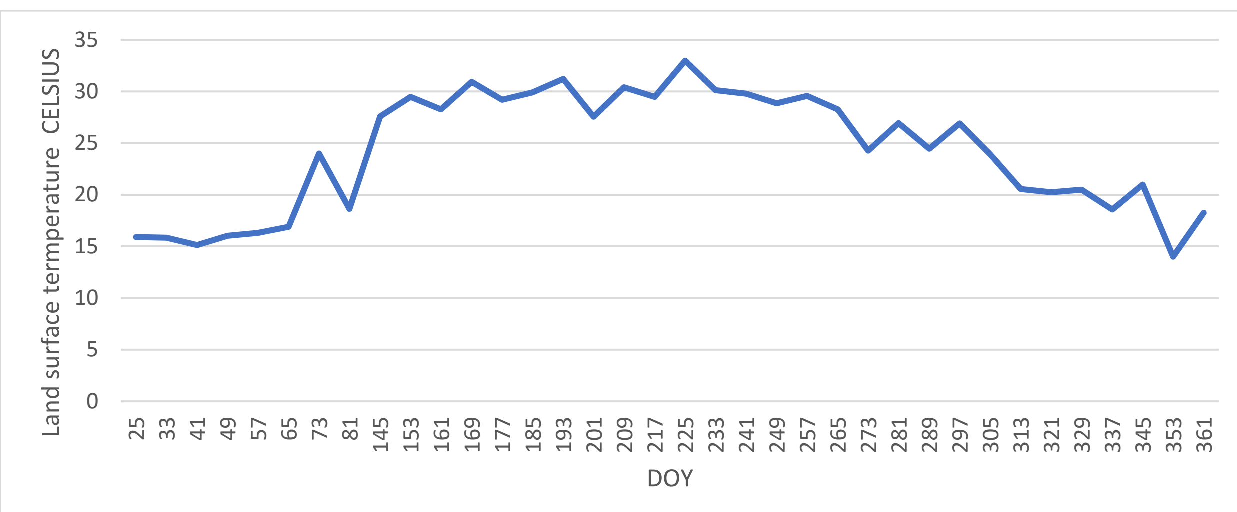


Figure 5. The 8- day composites of LST from MODIS surface temperature dataset

A correlation coefficient (r) value equal to 0.0531 for the overall data were observed between the GPP_EC and MODIS GPP (Figure 6), in addition it seems that the GPP_EC values tend to be much higher than that of the MODIS GPP. Similar results were also observed in Sims et al. (2006), while the MODIS GPP was found significantly underestimated GPP values of flux measurements.

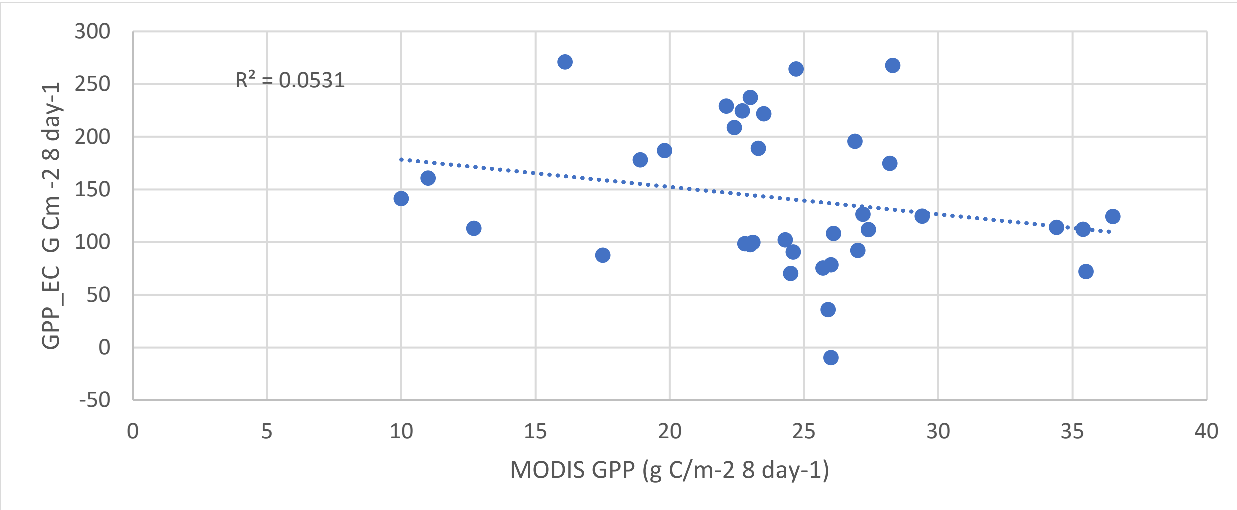


Figure 6. Relationship of GPP_EC/MODIS GPP

The estimated GPP values from TG model verse Eddy variance measured GPP showed 0.192 correlation coefficient in Grand Bay National Estuarine Research Reserve (Figure 7). It is a slightly better GPP estimate than the MODIS GPP product on wetland ecosystem. Ideally, TG based GPP will be a good tool to estimate GPP in large scale because it based completely on remote sensed variables such as land surface temperature and enhanced vegetation index without any in-situ meteorological input (such as wind speed and humidity). However poor correlation between TG GPP product and the flux measured GPP may result from less correlated relationship between vapor pressure deficit (VPD) and Land surface temperature (LST) over costal marsh ecosystem. The poor correlation between photosynthesis active radiation (PAR) and LST may be the other reason that causes very low correlation coefficient between TG GPP and EC GPP. Theoretically, GPP should be largely affected by the leaf and canopy biochemical components (for photosynthesis and intercept of energy) (Wu et al., 2010), it may be worth of reviewing our EC measured dataset, using more complicated and advanced data composition methods for both EC and TG GPP dataset would be able to improve correlation coefficient.

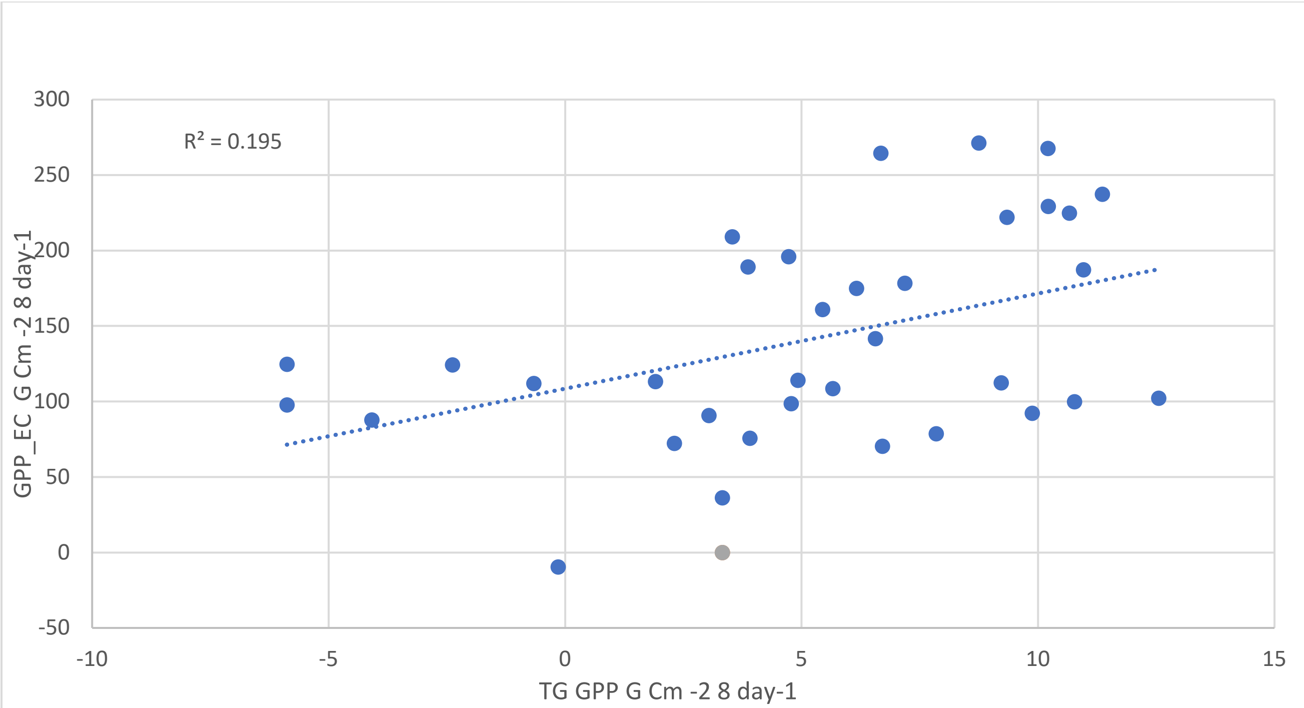


Figure 7. Relationship of GPP_EC/TG GPP

Reference

L. Busetto, L. Ranghetti (2016) MODIStsp: An R package for automatic preprocessing of MODIS Land Products time series, Computers & Geosciences, Volume 97, Pages 40 48, ISSN 0098-3004, http://dx.doi.org/10.1016/j.cageo.2016.08.020. URL https://github.com/lbusett/MODIStsp/.

Mackey, K. R., Paytan, A., Caldeira, K., Grossman, A. R., Moran, D., McIlvin, M., & Saito, M.A. (2013). Effect of temperature on photosynthesis and growth in marine Synechococcus spp. Plant physiology, 163(2), 815-829.

Nickeson, Jaime. "MODIS Land." [https://modisland.gsfc.nasa.gov/MODLAND_grid.html]. November 2017.

Sims, D. A., Rahman, A. F., Cordova, V. D., El-Masri, B. Z., Baldocchi, D. D., Flanagan, L. B., et al. (2006).On the use of MODISEVI to assess gross primary productivity of North American ecosystems. Journal of Geophysical Research, 111, G04015. doi:10.1029/2006JG000162.

Wu, C., Munger, J. W., Niu, Z., & Kuang, D. (2010). Comparison of multiple models for estimating gross primary production using MODIS and eddy covariance data in Harvard Forest. Remote Sensing of Environment, 114(12), 2925-2939.