Effectiveness of statistical method for estimation of water use efficiency in temperate and boreal forests of North America exclusively using MODIS data

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Motivation

Water use efficiency (WUE) is a critical index indicating the couple of water and carbon cycling in ecosystems. To acquire spatially continuous WUE, upscaling methods are essential. Previous methods usually require field measurements (e.g. soil moisture), which cannot be obtained at large scales. Moreover, Different types of WUE were developed: (1) ecosystem WUE; (2) inherent WUE. We know little about their different responses to the environmental variables.

OBJECTIVES:

- Evaluate the effectiveness of remote sensing for estimating WUE by using statistical method.
- Examine the responses of eWUE and iWUE to the environmental variables

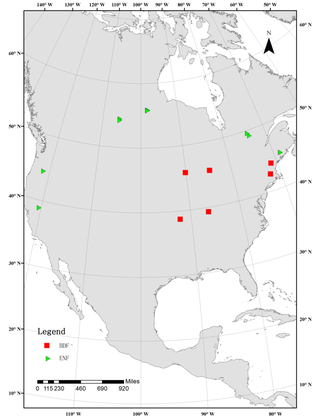
Data and Method

Flux measurements

free fair-use' Public FLUXNET Dataset (a subset of the LaThuile dataset 2007, http://www.fluxdata.org/default.aspx)

MODIS products

Name	Product
Enhanced vegetation index	MOD13Q1
Land surface temperature	MOD11A2
Leaf area index	MOD15A2
Fraction of absorbed photosynthetically active radiation	MOD15A2
Nadir reflectance	MCD43A2

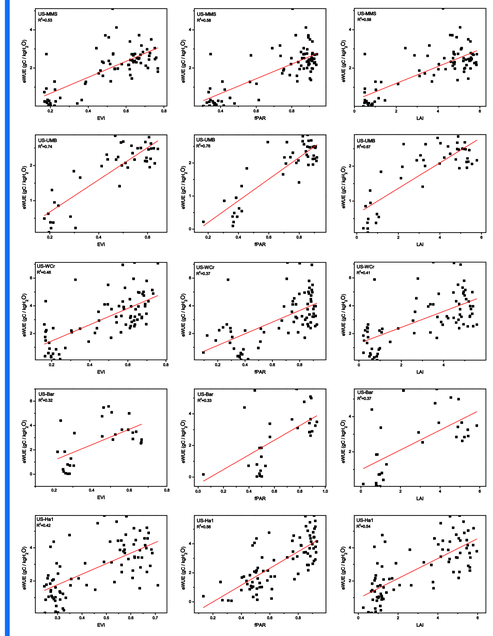


The distribution of flux sites used in this study, which include six broad deciduous forest (BDF) sites and nine evergreen needle forest (ENF) sites across North America.

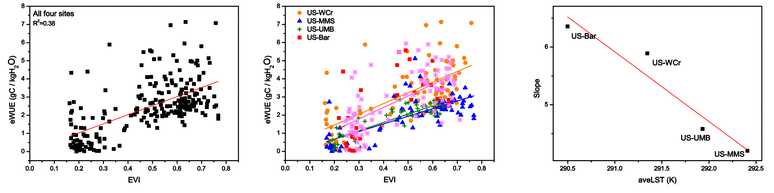
Statistical method

Simple regression method is used to examine the relation between WUE, which are derived from flux measurements and environmental variables from 16-day MODIS data. The variables include EVI, LAI, fPAR, LST and NDWI.

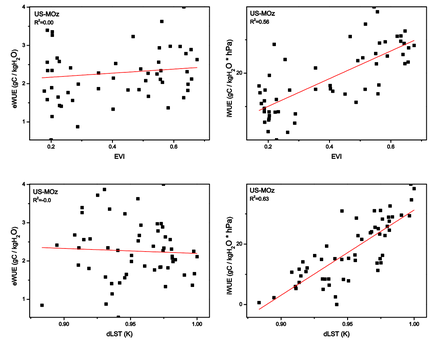
Result and Discussion



- At all evergreen sites, the correlations between WUE and MODIS variables are not significant, especially for biophysical variables.
- For each BDF site, the correlation coefficients between eWUE and EVI, fPAR and LAI are higher than others', which ranges 0.32-0.74, 0.33-0.76, and 0.37-0.67, respectively. (Figures on the left)
- But no significant improvement is obtained by usinig multiple linear regressions.



- The slopes of linear equations vary from site to site (two figures on the left), indicating spatial variables could influence the relations merely dependent on temporal evolutions.
- We use the average annual land surface temperature (remove the values less than 5 ° C) of each site during the experimental periods to calibrate the slope, i.e. *slope = -1.2*aveLST + 356.69.* (The figure on the right)



- The US-MOz site suffered drought during the experimental period (Sims et al., 2014). We compared the responses to the EVI and daytime LST between the eWUE and iWUE. (Figures on the left)
- It supposes that the relation between iWUE and environmental variables be more 'inherent' despite the climate disturbance.

Conclusion and Perspective

- 16-day MODIS optical and thermal observations are able to capture the variations of WUE at most deciduous forests although the impacts of evergreen forests need more explorations.
- iWUE is much more effective to reflect the inherence of vegetation variations in the forest ecosystem specially under environmental disturbance (e.g. drought).

This study will be useful for future development of WUE models using remote sensing across different land cover types and climates.

Key References

Beer, C., Ciais, P., Reichstein, M., Baldocchi, D., Law, B.E., Papale, D., Soussana, J.F., Ammann, C., Buchmann, N., Frank, D., Gianelle, D., Janssens, I.A., Knohl, A., Köstner, B., Moors, E., Roupsard, O., Verbeeck, H., Vesala, T., Williams, C.A., & Wohlfahrt, G. (2009). Temporal and among-site variability of inherent water use efficiency at the ecosystem level. *Global Biogeochemical Cycles, 23*, GB2018

Wu, C., Chen, J.M., Desai, A.R., Hollinger, D.Y., Arain, M.A., Margolis, H.A., Gough, C.M., & Staebler, R.M. (2012). Remote sensing of canopy light use efficiency in temperate and boreal forests of North America using MODIS imagery. *Remote Sensing of Environment, 118*, 60-72

Sims, D.A., Brzostek, E.R., Rahman, A.F., Dragoni, D., & Phillips, R.P. (2014). An improved approach for remotely sensing water stress impacts on forest C uptake. *Global Change Biology, 20*, 2856-2866