Estimating Large-scale Evapotranspiration in Arid and Semi-arid Systems

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1 Introduction

Large watershed scale estimates of evapotranspiration (ET) are necessary for management decisions, but scaling up local measurements has been problematic due to inherent temporal and spatial variability. Fortunately, satellite data provide spatially distributed remote sensing products (e.g. Enhanced Vegetation Index, EVI) that account for temporal and spatial variability in vegetation dynamics. These remote sensing products, in combination with micrometeorological data, can be used to create empirical models for improving ET estimates at larger scales.

2 Previous Models

Empirical models have been used to predict ET using a combination of vegetation indices and temperature variables. Using this approach, Scott et al. (2008) built a predictive equation that allowed for ET to be extrapolated to larger scales within the San Pedro watershed, AZ:

$$ET = a(1 - e^{-bEVI}) + (ce^{dT_s} + e)$$

where *a*, *b*, *c*, *d*, and *e* are regression parameters; EVI and T_s (nighttime land surface temperature, LST) are extracted from MODIS products.

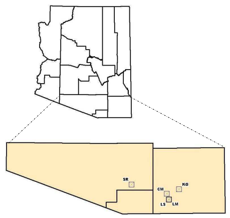
3 Objectives

Evaluate the ET model from Scott et al. (2008) with new 2007 datasets at five sites: 3 riparian sites (CM, LM, LS) adjacent to the San Pedro River and 2 upland sites (KG, SR) not influenced by shallow groundwater.

Specifically, compare the model's performance when combining all sites together and when keeping riparian and upland sites separate.

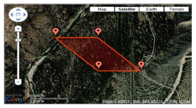
If necessary, create a new model to improve ET predictions for different landscapes.

4 Study Sites



Riparian Sites

Charleston – **(CM)** mesquite woodland
31.6636 -110.1778



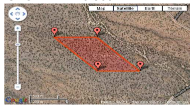
Lewis Springs – **(LM)** mesquite shrubland
31.5658 -110.1344

Lewis Springs – **(LS)** sacaton grassland
31.5615 -110.1403

Upland Sites

Kendall – **(KG)** grassland
31.7365 -109.9419

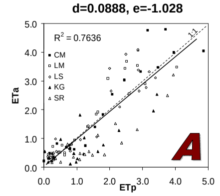
Santa Rita – **(SR)** mesquite shrubland
31.8214 -110.8661



5 Calibrating Empirical ET Models using 2003-2006 Remote Sensing and Micrometeorological Data

$ET = a(1 - e^{-bEVI}) + (ce^{dT_s} + e)$

a=-14.46, b=-0.6218, c=0.1975, d=0.0888, e=-1.028



- Trained model with data from all sites combined (CM, LM, LS, KG, & SR), spanning 2003-2006
- Lower R^2 than desired, prompted site-specific analyses to determine which variables are best to derive ET

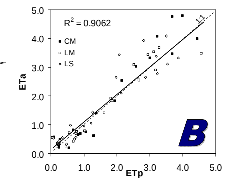
ET correlations: R^2

ET vs:	EVI	Ts	Precip
CM	*0.80*	*0.85*	0.26
LM	*0.71*	*0.81*	0.35
LS	*0.72*	*0.84*	0.21
KG	*0.56*	0.23	*0.44*
SR	*0.58*	0.29	*0.51*

- ET is strongly related to MODIS EVI and night-time land surface temperature (LST) at San Pedro sites
- ET has stronger relationships to EVI and precipitation at upland sites

$ET = a(1 - e^{-bEVI}) + (ce^{dT_s} + e)$

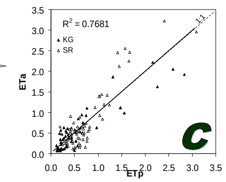
a=-0.5872, b=-3.942, c=0.4755, d=0.0876, e=-0.5737



- Trained model with data from San Pedro sites (CM, LM, & LS) only, spanning 2003-2006
- Removing upland sites (KG & SR) strengthened the model and improved San Pedro ET predictions

ET = *a* + *b*(EVI) + *c*(P)

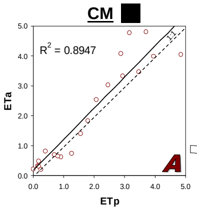
a=-0.5072, b=6.932, c=0.0174

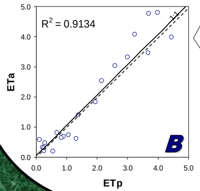


- Trained model with data from upland sites only (KG & SR) from 2004-2006
- A multiple linear regression approach adding precipitation and removing temperature improved ET predictions

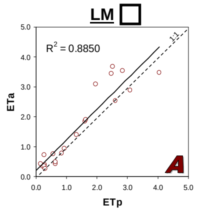
6 Evaluating Models A, B, and C with New 2007 Datasets – Testing Performance and Results

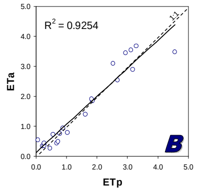
CM ■



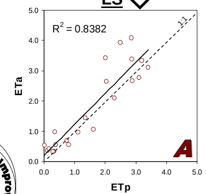


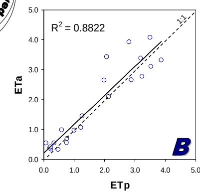
LM □





LS ◇

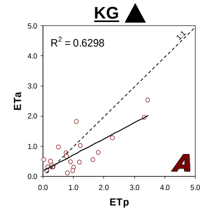


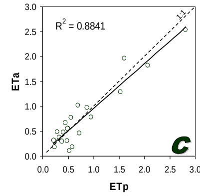


Improved

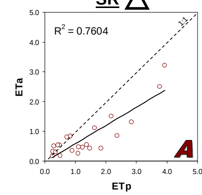
- Model A produces good predictions of ET, but Model B further improves estimations because the training set is specific to these sites
- LS (riparian) and KG (upland) are functionally similar grasslands, yet Model A predicts actual ET very well at LS and poorly at KG
- High R^2 values show that Model A and Model B explain the majority of the variability, thus transpiration appears to dominate ET at these riparian sites
- ET can be predicted very well entirely from MODIS products at these San Pedro riparian sites

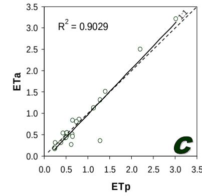
KG ▲





SR △





- Model A tends to over-predict actual ET at these upland sites
- Other factors or variables need to be incorporated, or a new model needs to be created to estimate ET
- Model C predicts actual ET very well using a simple multiple linear regression approach
- Model C validates the use of precipitation as a key component when estimating ET at these upland sites
- Precipitation data may be required to predict ET in upland sites where evaporation accounts for a large portion of total ET

7 Future Research

Future research will aim to: (1) refine and improve performance of current empirical ET models; and (2) create new models that can be used across landscape types. We will investigate when precipitation inputs are necessary because it is desired to use 100% remote sensing products to reduce data requirements. These models can then be used to estimate annual ET at river-reach or watershed scales provided that each region is classified appropriately and surface area is known.

ET (mm yr^{-1})		A	B	C
	ETa	ETp	ETp	ETp
CM	*688*	600	*665*	N/A
LM	*551*	466	*540*	N/A
LS	*637*	550	*581*	N/A
KG	*261*	355	486	*269*
SR	*282*	476	676	*294*

8 Acknowledgements

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