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

Daniel P.Bunting[1], Edward Glenn[2], Shirley A. Kurc[1,2], Russell L. Scott[3], Pamela Nagler[4]

1 School of Natural Resources and the Environment, University of Arizona, Tucson, AZ, USA. 2 Soil, Water, and Environmental Science, University of Arizona, Tucson, AZ, USA.

3 Southwest Watershed Research Center, USDA-ARS, Tucson, AZ, USA. 4 US Geological Survey, Southwest Biological Science Center, Sonoran Desert Research Station, University of Arizona, Tucson, AZ, USA.

1 Introduction

Large watershed scale estimates of evapotranspiration (ET) are necessary for decision making, but scaling up local measurements has been problematic due to variation in temporal and spatial variability. Fortunately, satellite data are now available and provide spatially distributed remote sensing products (e.g. Normalized Difference Vegetation Index NDVI, 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 EVI and temperature variables. Using this approach, Nagler et al. 2005 and Scott et al. 2008 built predictive equations that allow for ET to be extrapolated to larger scales. Their equations are found below, (1) & (2).

Nagler et al. 2005

$$ET = a(1 - e^{-bEVI*})(c/(1 + e^{(-T_a-d)/e}) + f) \quad (1)$$

where *a*, *b*, *c*, *d*, *e*, and *f* are regression parameters;
T_a is maximum daily air temperature from flux tower sites;
EVI* is scaled EVI where $EVI^* = 1 - (EVI_{max} - EVI)/(EVI_{max} - EVI_{min})$
where $EVI = 2.6(\rho_{NIR} - \rho_{Red})/(\rho_{NIR} + 6\rho_{Red} + 7.5\rho_{Blue} + 1)$

Scott et al. 2008

$$ET = a(1 - e^{-bEVI}) + (ce^{dT_s} + e) \quad (2)$$

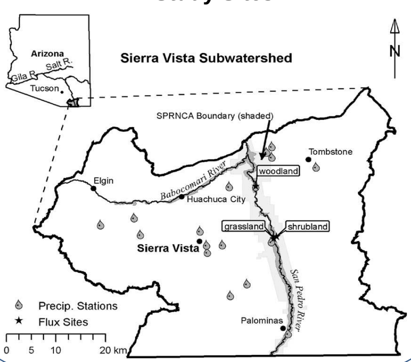
where *a*, *b*, *c*, *d*, and *e* are regression parameters;
T_s is nighttime land surface temperature from MODIS

3 Objectives

The above research referenced was calibrated with data spanning from 2000-2005. Here, I test these two models to see how they perform with new 2006 and 2007 datasets from three study sites near the San Pedro River, AZ.

If necessary, a new ET model will be created incorporating new data from upland sites with the aim to refine past models and continue to improve large scale ET estimates.

4 Study Sites



5 Testing the Models

Nagler et al. 2005

$$ET = 11.5(1 - e^{-1.63EVI*}) \times (0.883/(1 + e^{(-Ta-27.9)/2.57}) + 1.07)$$

Scott et al. 2008

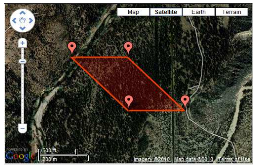
$$ET = 11.96(1 - e^{-0.52EVI}) + (0.56e^{0.09Ts} - 0.87)$$

Bunting et al. 2010

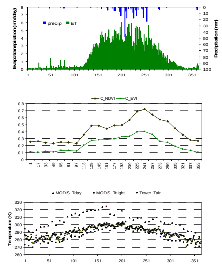
$$ET = 3.76(1 - e^{-5.48EVI}) + (0.09e^{0.15Ts} - 1.44)$$

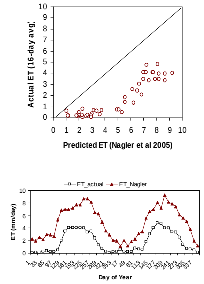
Data Variables

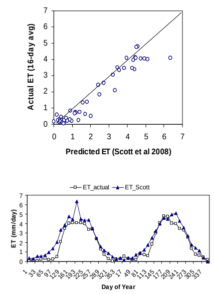
Charleston – mesquite woodland

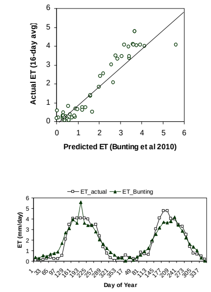


31.6636 -110.1778



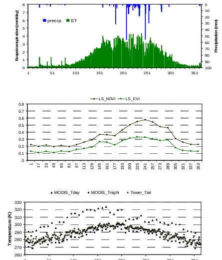


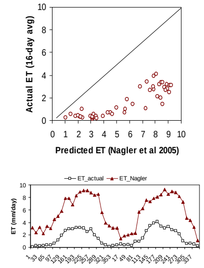


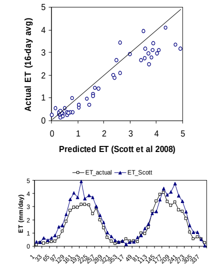


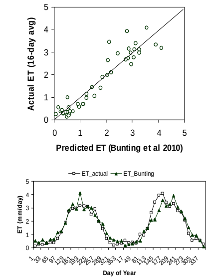
Lewis Springs – sacaton grassland

31.5615 -110.1403



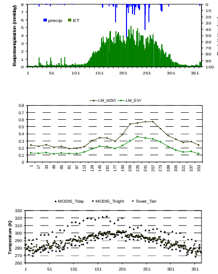


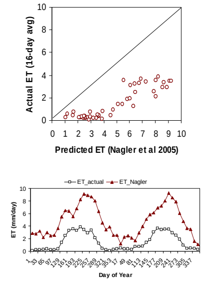


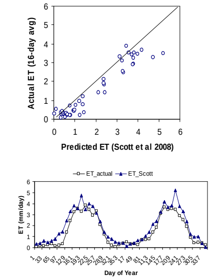


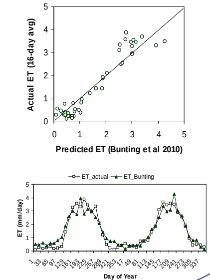
Lewis Springs – mesquite shrubland

31.5658 -110.1344









6 Preliminary Results

Both models produced by Nagler and Scott overpredict actual ET measurements made from flux tower sites from 2006-2007. It is apparent that these current models can be refined or recalibrated to improve ET estimates. An analysis of independent variables from 2003-2007 supports the use of EVI over NDVI and MODIS nighttime land surface temperatures over local daily maximum temperatures when predicting ET.

7 Future Research

Future research includes the addition of two upland study sites which will: (1) refine and increase the performance of current empirical ET models; or (2) be used to create a new model with new parameters. The inputs to this model will be derived entirely from MODIS products. 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.

8 Acknowledgements

This research is a collaborative effort between the University of Arizona and the U. S. Geological Survey and I would like to thank all faculty involved in the generation and sharing of data. I also gratefully acknowledge the National Science Foundation for their monetary support.

College of Agriculture and Life Sciences
Soil, Water and Environmental Science

USGS science for a changing world

ARIZONA

NSF