Basic Water Science Seminar

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Quantification of water fluxes and irrigation use through remote sensing

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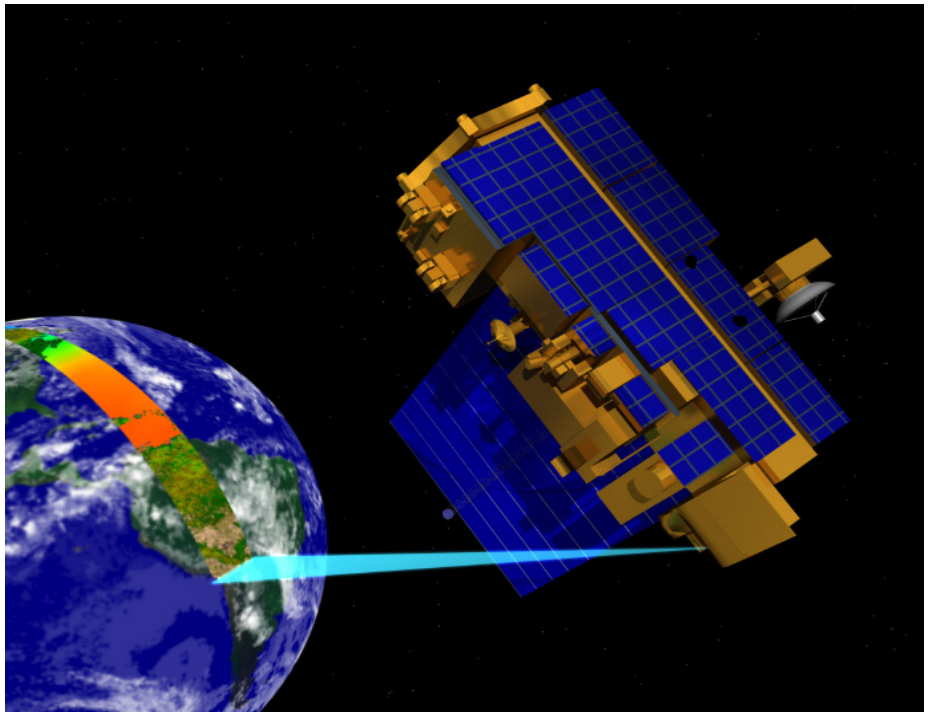
Overview

1) Quantification of water used (P – aET) in the Lugert-Altus irrigation district and detailed evaluation in Texas County according to crops grown
2) Extend validation of actual ET using eddy flux measurements, lake evaporation, river basin water balance, and the Oklahoma Mesonet
3) Assessment of water use (P – aET) in urban and rural areas in Oklahoma

Project Overview

- Accounting for water use and availability can benefit from knowing how much water is transported to the atmosphere from land surfaces.
- Water flux comes from irrigation water application, water bodies, available soil moisture, groundwater, and precipitation.



Can we measure actual evapo-transpiration using from remotely sensed images from the MODIS NASA satellite?

Remote Sensing-based Surface Energy Balance Methods

- Approaches for deriving ET using remote sensing data have been developed:

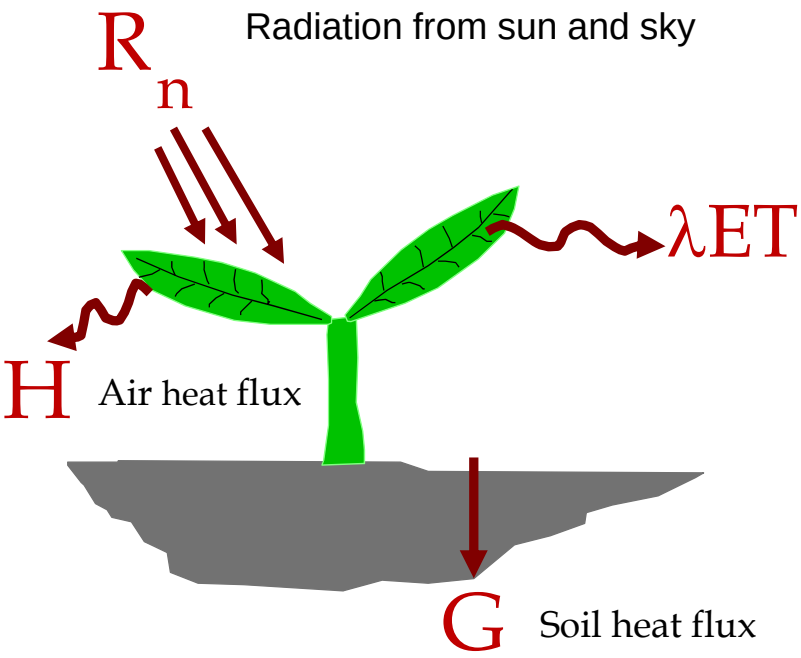
- *SEBAL (Surface Energy Balances Algorithm for Land) (Bastiaanssen et al., 1998; 2000; 2002; 2005)*

- *METRIC (Mapping EvapoTranspiration at high Resolution with Internalized Calibration) (Allen et al. 2005)*

- *SEBS (Surface Energy Balance System) (Su, 2002)*

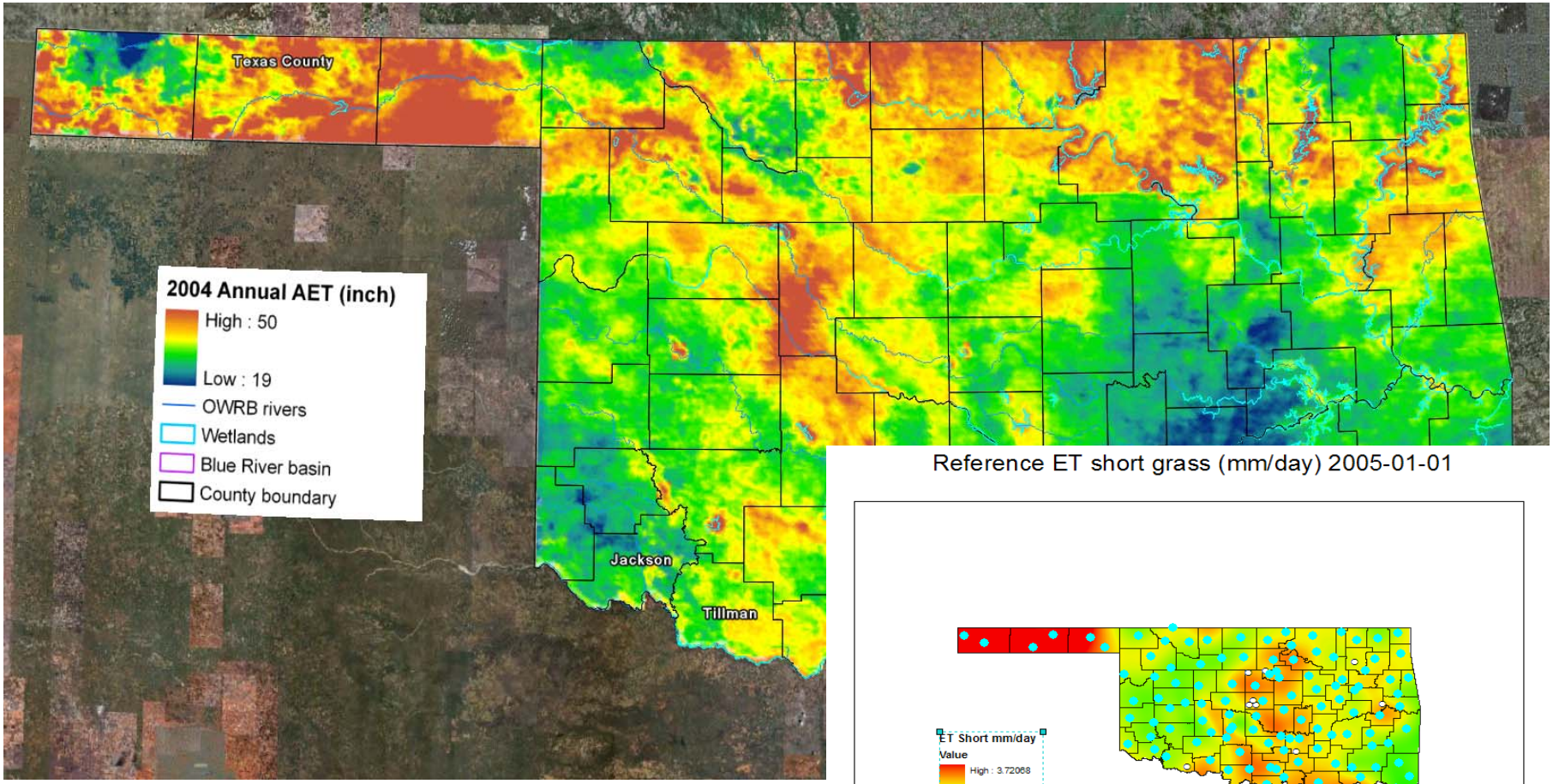
- *TSEB (Two-Source Energy Balances) (Norman, et al., 1995)*

- *S-SEBI (Simplified Surface Energy Balances Index) (Roerink et al., 2000).*



$$\lambda ET = R_n - G - H$$

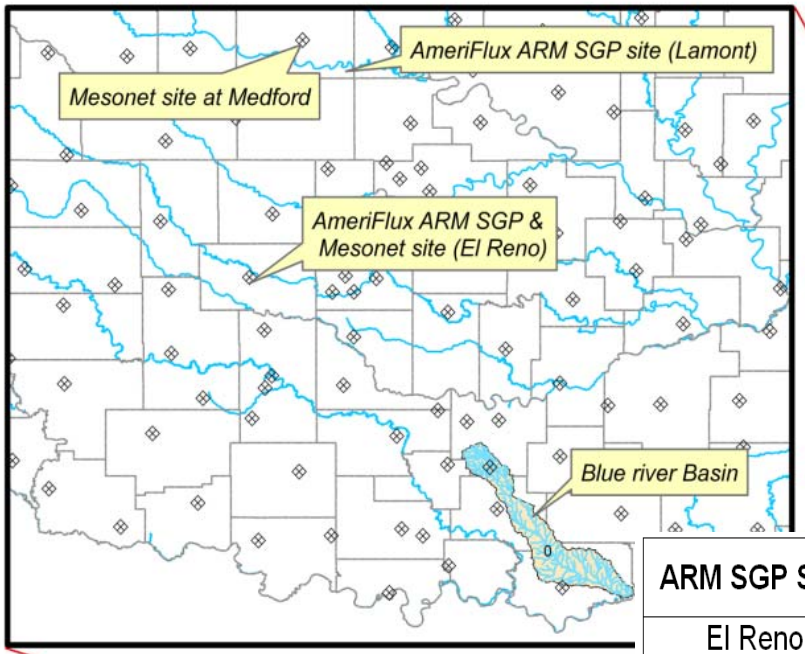
Annual aET (2004)



Reference ET short grass (mm/day) 2005-01-01

Evaluation

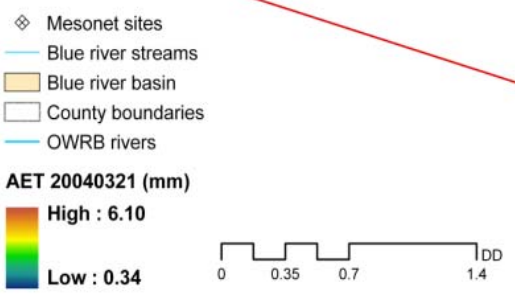
Study Area with Ameriflux towers, Mesonet sites and Blue River Basin

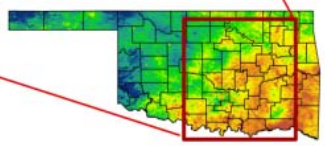


Evaluation Data:

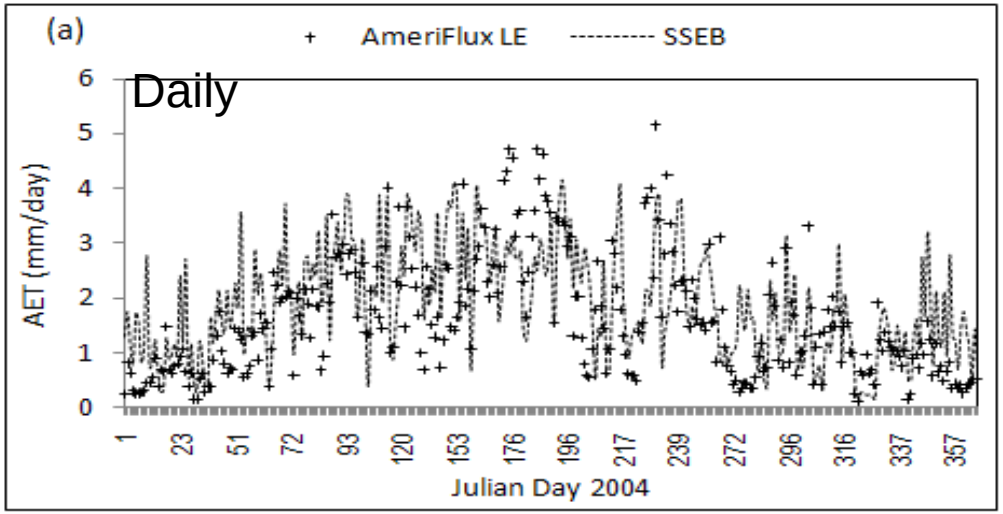
1. Ameriflux Towers (Lamont and El-Reno)
2. Crop ET (Mesonet sites)
3. Water Balance Modeled ET over the Blue River, OK

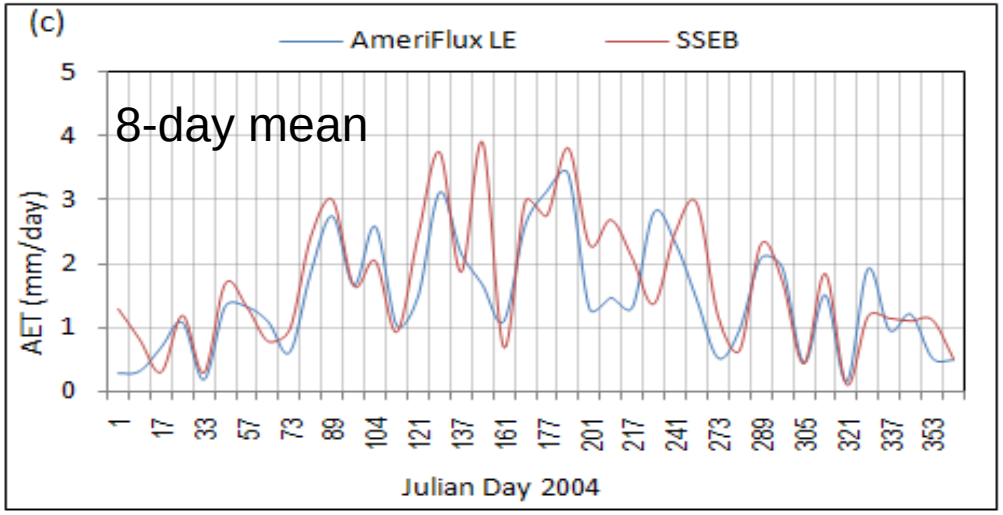
ARM SGP Site	Lat/ Long	Elevation (m)	County	Crop Type
El Reno	35.557 N98.017 W	421	Canadian	Pasture
Lamont	36.607 N 97.488 W	315	Grant	Wheat & Pasture
Mesonet Sites	**Lat/ Long**	**Elevation (m)**	**County**	**Crop Type**
Medford	36.473 N 97.444 W	332	Grant	Wheat & Pasture
El Reno	35.325 N98. 211 W	419	Canadian	Pasture





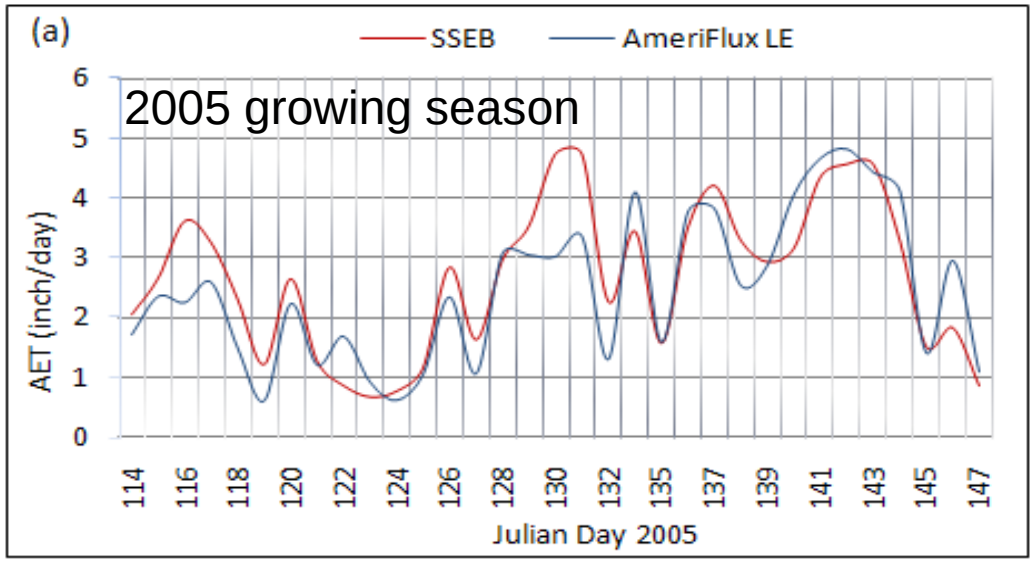
Validation by AmeriFlux Latent heat Flux: SGP Lamont Site

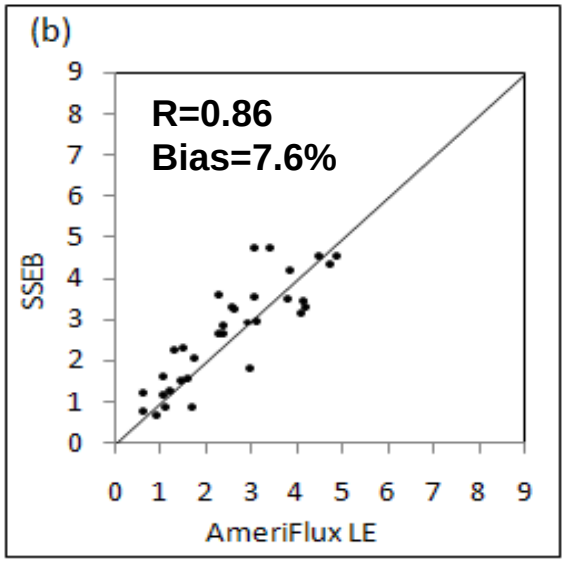


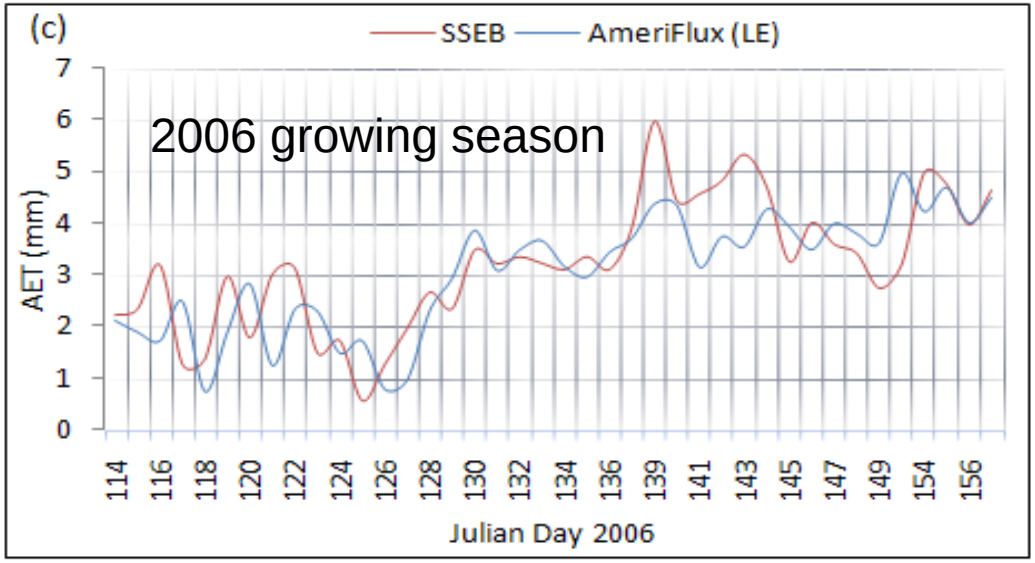


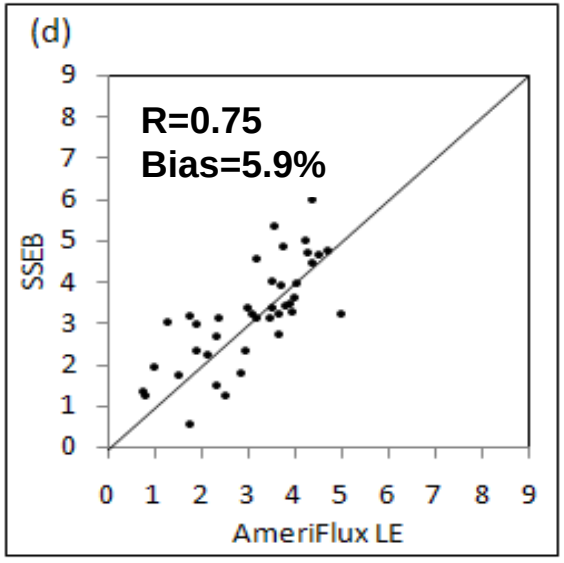
Lamont site	AmeriFlux mean (mm)	SSEB mean (mm)	Bias (mm)	Bias ratio
Summer	**2.46**	**2.62**	**0.16**	**6.5**
Fall	**1.70**	**1.83**	**0.13**	**8.0**

Comparisons of AET with AmeriFlux at ARM SGP El-Reno site (when available)

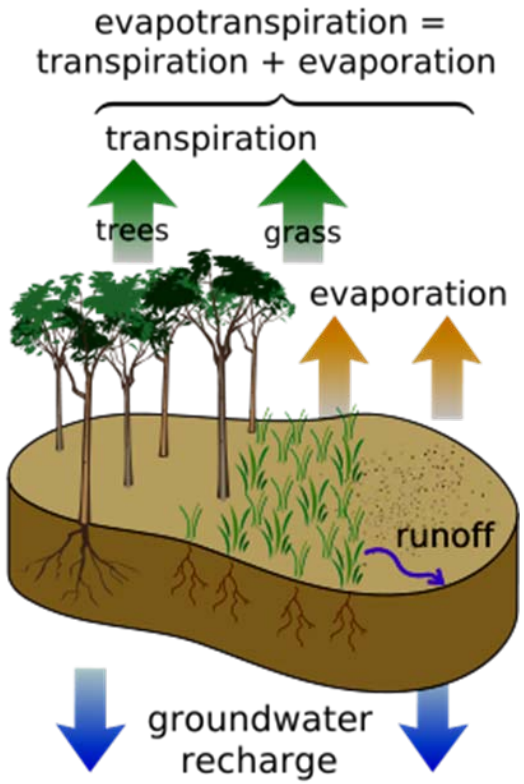








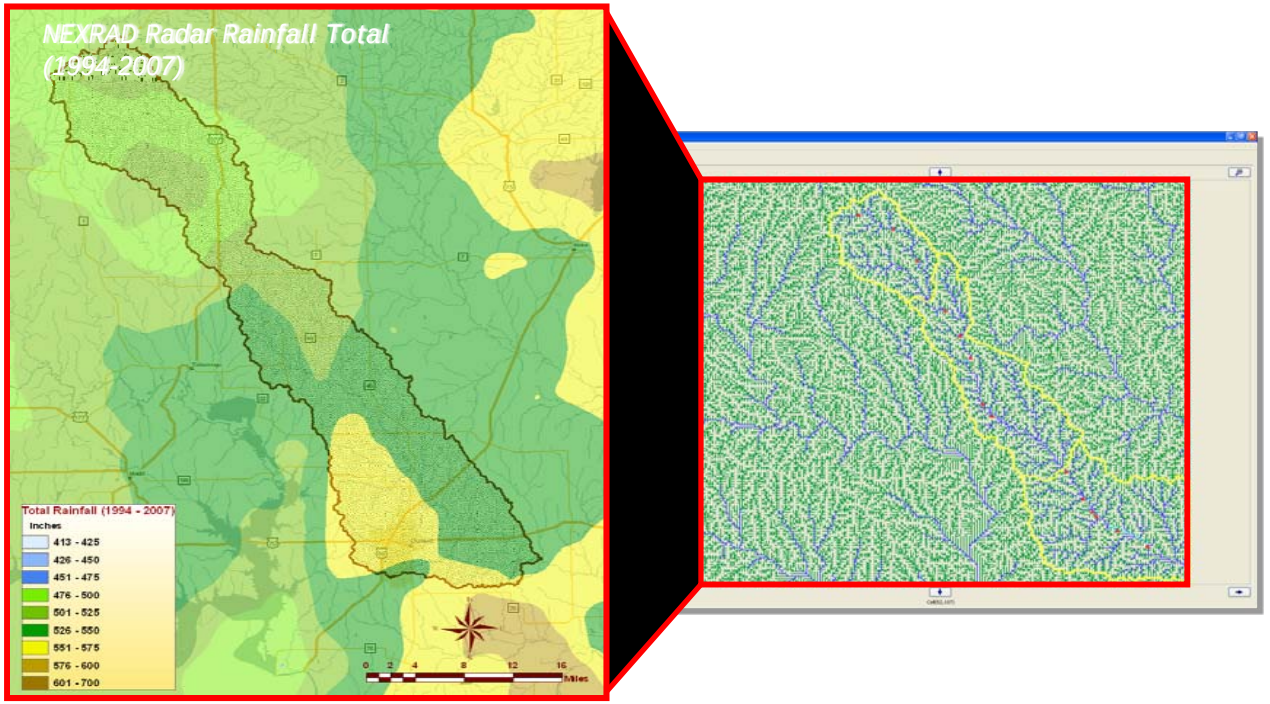
Water Balance Modeling



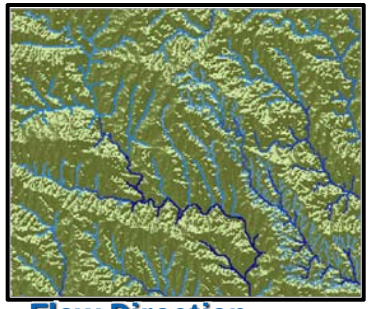
$$ET = P + Inflow - Runoff - \Delta GW \pm \Delta Soil\ Water\ Storage$$

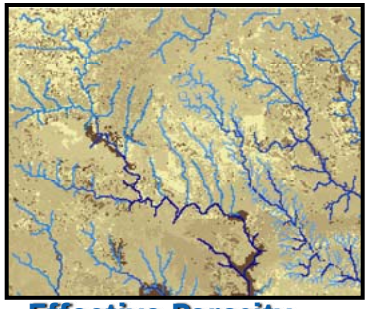
- Apply the SSEBAL to river basin modeling in the Blue River
- Validate through comparison to previous results obtained in the Arbuckle-Simpson Water Study

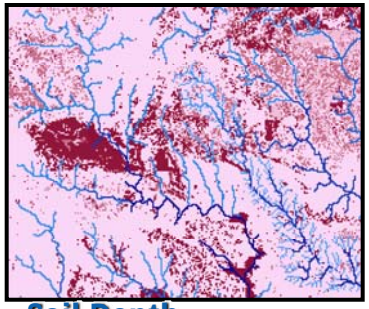
Distributed Hydrologic Modeling Parameters and Rainfall

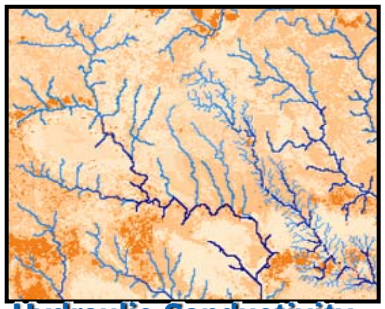


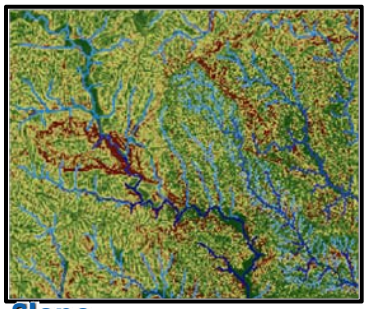
Vflo™


Flow Direction

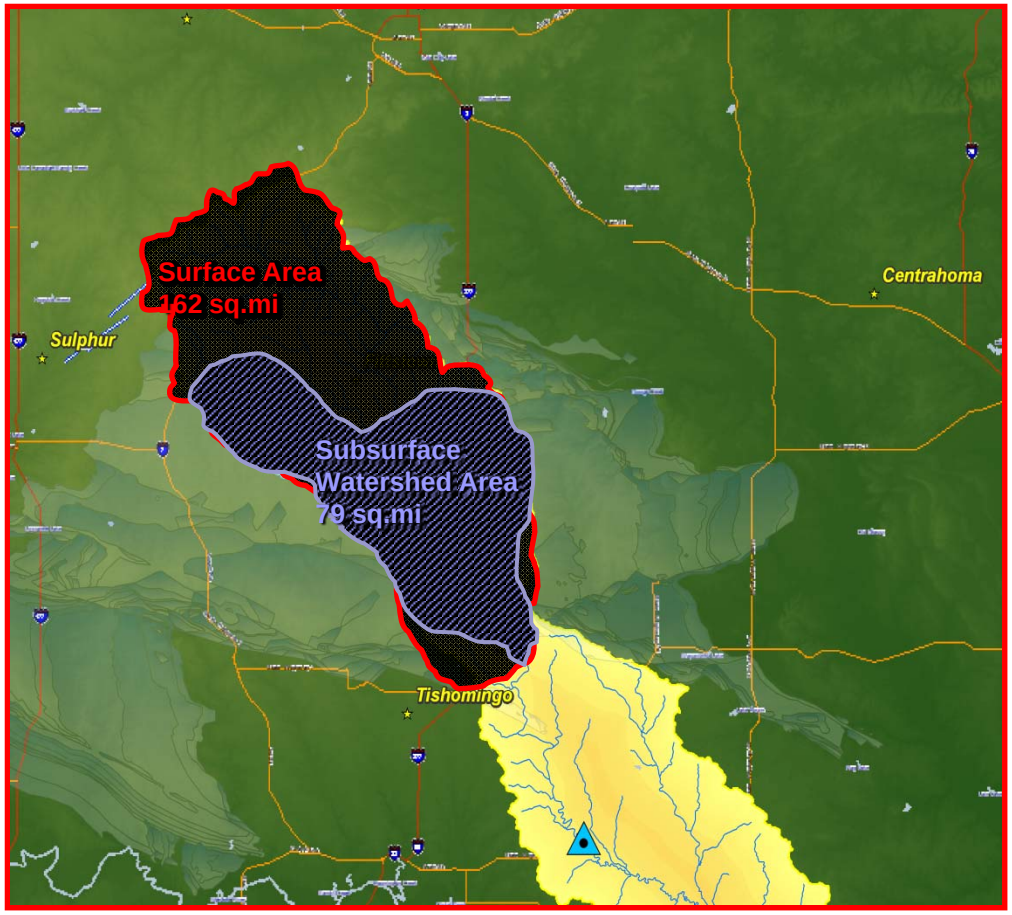

Effective Porosity


Soil Depth


Hydraulic Conductivity


Slope

Arbuckle Simpson Water Balance



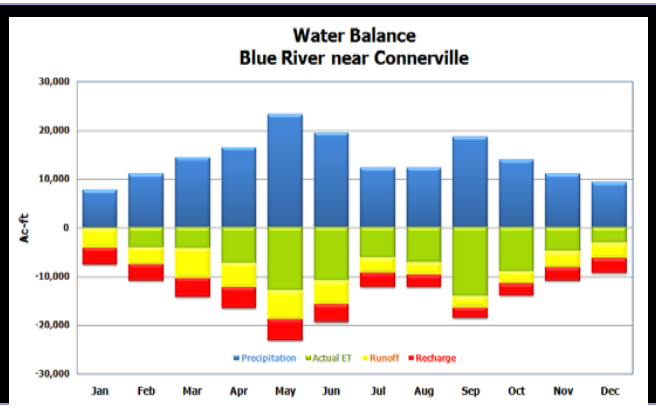
- The subsurface Blue River Watershed is included.

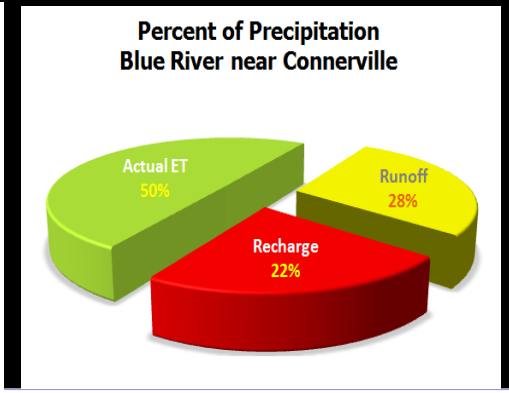
USGS Gauging Station	Surface drainage area	Total Area used in the Water Balance
Connerville USGS 07332390	162 mi^2	79 mi^2
Milburn USGS 07332400	203 mi^2	120 mi^2
Blue USGS 07332500	476 mi^2	393 mi^2

Source: **Neel, C. R., (2007). Subsurface Watershed Delineation, OWRB.*

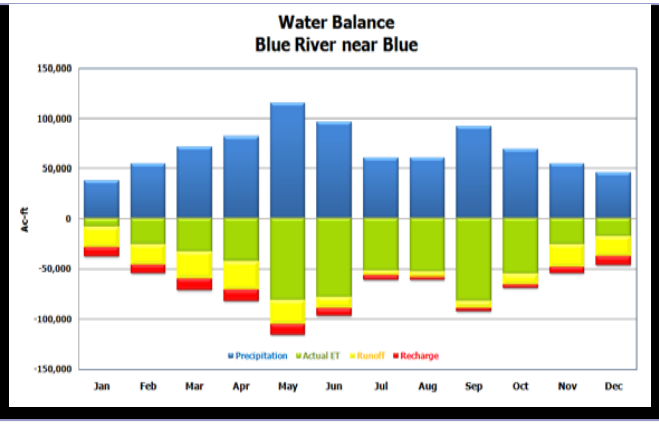
Streamflow Components

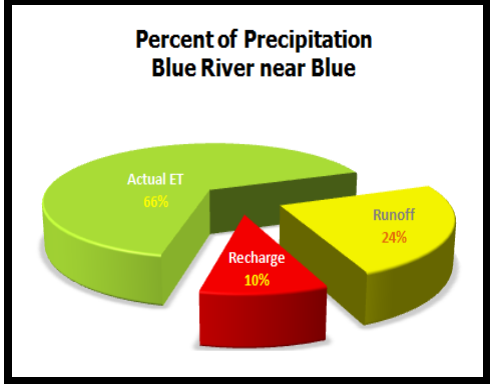
Seasonal Water Balance





Component	Mean Annual (Inches)	% P
Precipitation	40.10	
Runoff	11.14	28%
Recharge	9.00	22%
Actual ET	19.96	50%

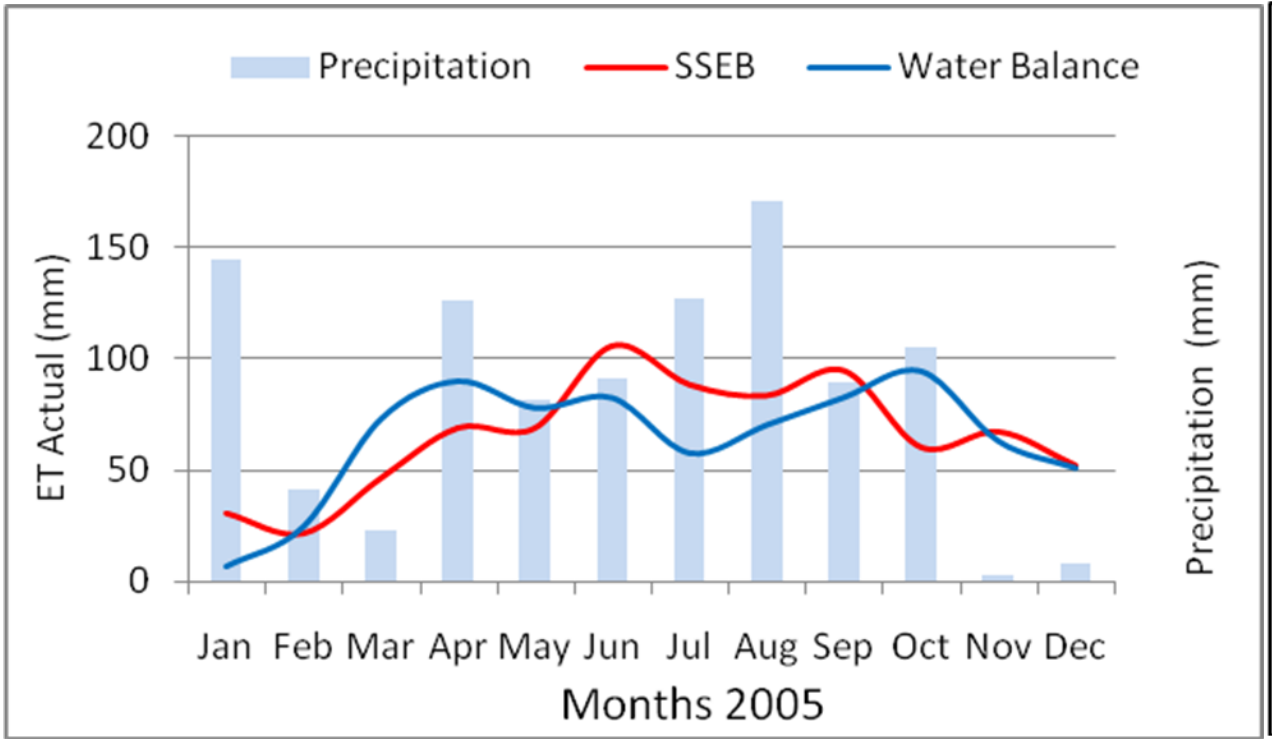


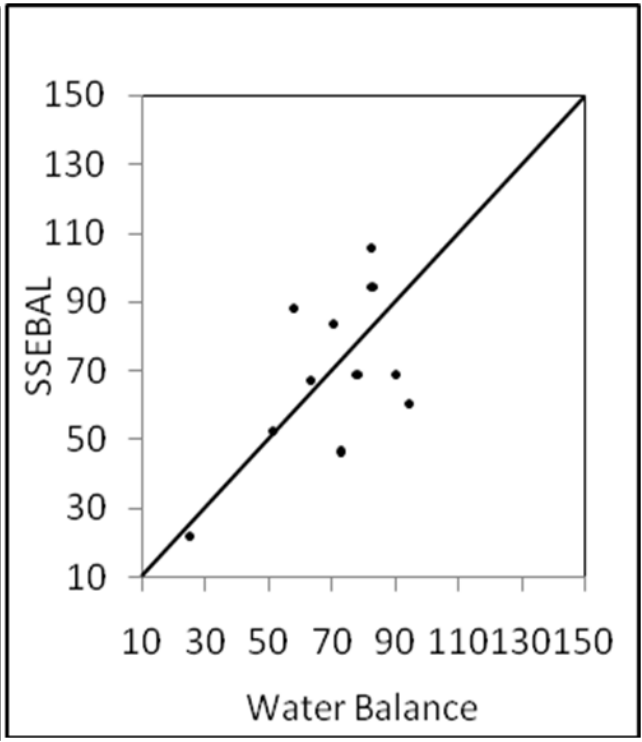


Component	Mean Annual (Inches)	% P
Precipitation	40.10	
Runoff	9.74	24%
Recharge	3.90	10%
Actual ET	26.47	66%

Aquifer recharge = discharge (baseflow)

Actual ET Comparison





Basin-average Monthly: Bias ratio 2.1%

Summary of Validation Results

Evaluated the robustness of the Surface Energy Balance approach using site-based flux tower observations and hydrologic modeling results

1. Ameriflux Towers (Lamont and El-Reno)
   Period: 2005 and 2006 (Daily or 8-day Mean)
   Bias Ratio 5~8% and CC 0.75~0.86

2. Crop ET (Mesonet sites)
   Period: 2005 and 2006 (Daily or 8-day Mean)
   Bias ratio -13~2% and CC 0.70~0.85

3. Water Balance ET Modeling over Blue River
   Period 2004~2006 (Basin-average Monthly)
   Bias ratio 1.5%~2.3%

Water Research Summary

- Improve aET Algorithm
  - Increase resolution
    - Currently MODIS at 250-m resolution
    - Landsat/ASTER for 30-m resolution
  - Validate and refine beyond point comparisons
    - Basin-level hydrologic water balance
    - Irrigation-district level water use
- Estimate water use (P – aET) and water balance for targeted areas
  - Lugert-Altus Irrigation District water use
  - Texas County water use by crop type or reports
  - Urban water use in Metro OKC
  - Blue River Water Balance

Summary

- From our current studies it is clear that the remote sensing of actual ET is feasible and has the potential for application to water use and availability studies over broad areas in Oklahoma
- Refines our understanding of actual evapo-transpiration estimation by remote sensing methods
- Extend to water use estimation in rural and urban areas where P–aET is dominant.

Acknowledgement

OSU-OWRRI/USGS and the OWRB

State Competitive Grants Program

TITLE OF PROPOSAL: **Quantification of water fluxes and irrigation use through remote sensing**

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