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?
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)
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

<table>
<thead>
<tr>
<th>ARM SGP Site</th>
<th>Lat/ Long</th>
<th>Elevation (m)</th>
<th>County</th>
<th>Crop Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>El Reno</td>
<td>35.557 N, 98.017 W</td>
<td>421</td>
<td>Canadian</td>
<td>Pasture</td>
</tr>
<tr>
<td>Lamont</td>
<td>36.607 N, 97.488 W</td>
<td>315</td>
<td>Grant</td>
<td>Wheat &amp; Pasture</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Mesonet Sites</th>
<th>Lat/ Long</th>
<th>Elevation (m)</th>
<th>County</th>
<th>Crop Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medford</td>
<td>36.473 N, 97.444 W</td>
<td>332</td>
<td>Grant</td>
<td>Wheat &amp; Pasture</td>
</tr>
<tr>
<td>El Reno</td>
<td>35.325 N, 98.211 W</td>
<td>419</td>
<td>Canadian</td>
<td>Pasture</td>
</tr>
</tbody>
</table>
Validation by AmeriFlux Latent heat Flux: SGP Lamont Site

<table>
<thead>
<tr>
<th>Lamont site</th>
<th>AmeriFlux mean (mm)</th>
<th>SSEB mean (mm)</th>
<th>Bias (mm)</th>
<th>Bias ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Summer</td>
<td>2.46</td>
<td>2.62</td>
<td>0.16</td>
<td>6.5</td>
</tr>
<tr>
<td>Fall</td>
<td>1.70</td>
<td>1.83</td>
<td>0.13</td>
<td>8.0</td>
</tr>
</tbody>
</table>
Comparisons of AET with AmeriFlux at ARM SGP El-Reno site (when available)

2005 growing season

R = 0.86
Bias = 7.6%

2006 growing season

R = 0.75
Bias = 5.9%
Water Balance Modeling

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

\[ ET = P + \text{Inflow} - \text{Runoff} - \Delta GW \pm \Delta \text{Soil Water Storage} \]
Distributed Hydrologic Modeling Parameters and Rainfall

Vflo™

The subsurface Blue River Watershed is included.

<table>
<thead>
<tr>
<th>USGS Gauging Station</th>
<th>Surface drainage area</th>
<th>Total Area used in the Water Balance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Connerville</td>
<td>162 mi²</td>
<td>79 mi²</td>
</tr>
<tr>
<td>Milburn</td>
<td>203 mi²</td>
<td>120 mi²</td>
</tr>
<tr>
<td>Blue</td>
<td>476 mi²</td>
<td>393 mi²</td>
</tr>
</tbody>
</table>

Streamflow Components
Seasonal Water Balance

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

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

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