Estimating Forest Water Use in Gyeonggi Province, Korea for User-Customized Forest Management Using Localized JULES Model

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• Evapotranspiration occupies about 60% of total precipitation (Choudhury et al. 1998, Alton et al. 2009)

• Amount of the evapotranspiration in forest ecosystem affects downstream flow rate, so also influences the downstream user including human population
ATMOSPHERE

- CO₂ Fluxes
- NPP, Heat Fluxes
- Surface Parameters
- Soil Water Stress
- Snow Cover
- Surface Hydrology
- Infiltration
- Soil Moisture, Temperature
- Evaporative Fluxes
- Surface Exchange
- Urban
- Vertical Fluxes
- Litterfall
- Soil Carbon
- Surface Conductance
- Plant Physiology
- Vegetation Dynamics

Model
- aDGVM (adaptive dynamic global vegetation model) (Scheiter and Higgins 2009)*
- BATS (Biosphere-atmosphere Transfer Scheme) (Dickinson et al. 1984)
- BETHY (Biosphere Energy Transfer Hydrology Scheme) (Knorr 2000; Ziehn et al. 2011)*
- BIOME3 (Haxeltine and Prentice 1996a)
- BIOME4 (Kaplan et al. 2003)*
- BIOME-BGC 4.2 (Running et al. 2010)*
- CLM 4.5 (Community Land Model) (Oleson et al. 2013)*
- CTEM (Canadian Terrestrial Ecosystem Model) (Arora 2003; Arora and Boer 2010)*

Photosynthesis
- FvCB (Best et al., 2011)
- FvCB and Bayesian approach
- FvCB, Haxeltine and Prentice (1996a)
- FvCB
- FvCB

Stomatal Conductance
- Collatz et al. (1991)
- Collatz et al. (1992)
- No
- Jarvis (1976)
- Ball et al. (1987)
- Jarvis and McNaughton (1986)
- Haxeltine and Prentice (1996a)
- Kömer (1995)
- Collatz et al. (1991)
- Collatz et al. (1992)
- Sellers et al. (1996)
- Collatz et al. (1991)
- Collatz et al. (1992)

Joint UK Land Environment Simulator

(Best et al., 2011)

(Rezende et al., 2016)
Objectives

- Test the localized JULES model performance in estimating evapotranspiration
  - Comparison with eddy covariance measurement

- Estimating amount of forest water use in Gyeonggi Province using high-resolution meteorological input data
  - Using a configuration optimized to study site
Sensitivity Analysis

• Basic information for localization

• Sensitivity \( (\Delta) = \frac{Modified - Default}{Default} \times 100 \) (%)

• Change one parameter at a time from -30 % to +30 % (by 10 %)

• Default setting of JULES loobos dataset added with
  • Soil ancillary information
  • Trait-based physiology (Another way for calculating \( V_{cmax} \))
  • Spin-up so that the model environment stabilized (Tolerance of Soil moisture and soil temperature is 1 %)

⇒ Default Configuration
• Default Configuration + local parameter value
  • Leaf Mass per Area (LMA), Leaf nitrogen content, canopy height, soil carbon, specific soil respiration rate

➔ Optimized Configuration

• Two forest types (Conifer: TCK, Deciduous: TDK) in Mt. Taehwa

• Comparison with eddy covariance measurement

• Running Period
  • TCK: Jan. 1, 2015 ~ Jul. 20, 2017
  • TDK: Mar. 1, 2015 ~ Jul. 20, 2017
Extend to Gyeonggi Province

Tree Species Re-classification
- 2 types as default (needleleaf trees, broadleaf trees)
- 5 types as re-classification
  (Pinus spp., Larix spp., other needleleaf trees, Quercus spp., other broadleaf trees)

- 12-days weather forecasting data
- 810 m x 810 m, hourly
Sensitivity of Evapotranspiration

Change in Evapotranspiration

-40.0%
-30.0%
-20.0%
-10.0%
0.0%
10.0%
20.0%
30.0%
40.0%

Soil Carbon
leaf mass/leaf area
Nitrogen content of upper canopy leaf
Quantum efficiency
$V_{c_{max}} - N$ linear regression coeff.
$[CO_2]$
Canopy height
Vertical nitrogen distribution pattern within canopy

Soil Respiration at 25 °C of soil
Temp.

-30%  -20%  -10%  10%  20%  30%
## TCK Evapotranspiration

<table>
<thead>
<tr>
<th></th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Annual Sum</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Observed</td>
<td>465.8</td>
<td>427.5</td>
<td>244.3</td>
</tr>
<tr>
<td>w/o condensation</td>
<td>490.5</td>
<td>459.9</td>
<td>249.1</td>
</tr>
<tr>
<td>Default</td>
<td>708.9 (+45%)</td>
<td>723.5 (+57%)</td>
<td>306.0 (+23%)</td>
</tr>
<tr>
<td>Optimized</td>
<td>725.0 (+48%)</td>
<td>749.5 (+63%)</td>
<td>310.9 (+25%)</td>
</tr>
</tbody>
</table>

**ET**

<table>
<thead>
<tr>
<th></th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
</tr>
</thead>
<tbody>
<tr>
<td>Obs</td>
<td>465.8</td>
<td>427.5</td>
<td>244.3</td>
</tr>
<tr>
<td>EST_Default</td>
<td>490.5</td>
<td>459.9</td>
<td>249.1</td>
</tr>
<tr>
<td>EST_Opt</td>
<td>725.0 (+48%)</td>
<td>749.5 (+63%)</td>
<td>310.9 (+25%)</td>
</tr>
<tr>
<td></td>
<td>2015</td>
<td>2016</td>
<td>2017</td>
</tr>
<tr>
<td>----------</td>
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</tr>
<tr>
<td><strong>ET</strong></td>
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<td></td>
<td></td>
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<tr>
<td><strong>Obs</strong></td>
<td>480.1</td>
<td>484.1</td>
<td>228.1</td>
</tr>
<tr>
<td><strong>w/o</strong></td>
<td>494.2</td>
<td>505.9</td>
<td>232.5</td>
</tr>
<tr>
<td><strong>condensation</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Default</strong></td>
<td>553.9 (+12%)</td>
<td>766.0 (+51%)</td>
<td>268.2 (+15%)</td>
</tr>
<tr>
<td><strong>Optimized</strong></td>
<td>557.8 (+13%)</td>
<td>782.6 (+55%)</td>
<td>271.3 (+17%)</td>
</tr>
</tbody>
</table>

**TDK Evapotranspiration**

- **Obs**: Observed ET values.
- **Est_Default** and **Opt** represent ET estimates with and without condensation, respectively.
- **Annual Sum** shows the total ET over the years with percentage increases compared to the previous year.

*Graph showing the daily ET from 2015 to 2017 with observed and estimated ET values.*
TCK GPP

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<th>2017</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Observed</strong></td>
<td>1729.0</td>
<td>1664.2</td>
<td>1062.8</td>
</tr>
<tr>
<td><strong>Default</strong></td>
<td>1690.1 (-2%)</td>
<td>1824.6 (+10%)</td>
<td>893.0 (-16%)</td>
</tr>
<tr>
<td><strong>Optimized</strong></td>
<td>1654.2 (-4%)</td>
<td>1926.3 (+16%)</td>
<td>1032.5 (-3%)</td>
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</table>
TDK GPP

<table>
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<tr>
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<th>2016</th>
<th>2017</th>
</tr>
</thead>
<tbody>
<tr>
<td>Observed</td>
<td>1465.4</td>
<td>1788.6</td>
<td>1027.2</td>
</tr>
<tr>
<td>Default</td>
<td>2163.9 (+48%)</td>
<td>2169.5 (+21%)</td>
<td>913.9 (-11%)</td>
</tr>
<tr>
<td>Optimized</td>
<td>1814.8 (+24%)</td>
<td>1749.9 (-2%)</td>
<td>794.9 (-23%)</td>
</tr>
</tbody>
</table>
Forest Water Use in NCAM-LAMP Domain

Period

Jul. 2, 2017 12:00 - Jul. 14, 2017 12:00

Evapotranspiration

284,366.7 mm / 16641 cells
Daily avg. 1.42 mm
Obs. daily avg. 1.17 mm
• Evapotranspiration in JULES is most sensitive to $C_i/C_a$ ratio and vertical nitrogen distribution pattern within canopy.

• Evapotranspiration in JULES seems to overestimate in both needleleaf and broadleaf stands partly due to the no consideration on water condensation. This tendency is more notable in the needleleaf stand.

• There seems minor improvement between default configuration and optimized one.

• The improvement can’t be made until the parameter which is sensitive to estimating evapotranspiration is measured and used.

• For the estimation in large extent, it’s needed to prepare more observation sites or another estimating method to compare and validate the estimation performance.

Summary
Thank you