Regional carbon fluxes by simultaneous assimilation of multiple flux towers in a simple ecosystem model

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The Dilemma: Reconciling stand-scale and regional flux

- Extensive sampling of net ecosystem exchange (NEE) of CO₂ by a dense mesonet of eddy covariance flux towers in northern Wisconsin and Michigan shows that no single stand-scale tower (Fig. 1) can represent a regional flux as estimated by a very tall tower, ABL budgets or high resolution observationally-constrained models (Fig. 2) (Desai et al., in press)

- This is true despite climate forcing being roughly the same across the mesonet

- Large scale landcover and models typically classify entire area as “mixed forest” and compute the same flux for all portions of the region. This flux is unlikely to be the true regional mean flux

The Tool: Sipnet and Markov Chain Monte Carlo

<table>
<thead>
<tr>
<th>Growth parameters</th>
<th>Prior</th>
<th>Posterior</th>
</tr>
</thead>
<tbody>
<tr>
<td>photosynthetic capacity (amax)</td>
<td>112</td>
<td>58.6 +/- 2.2</td>
</tr>
<tr>
<td>VPD modifier (dVPD_slope)</td>
<td>0.05</td>
<td>0.066 +/- 0.009</td>
</tr>
<tr>
<td>Leaf saturation PAR</td>
<td>17</td>
<td>9.0 +/- 0.76</td>
</tr>
<tr>
<td>Light attenuation</td>
<td>0.5</td>
<td>0.67 +/- 0.02</td>
</tr>
<tr>
<td>WUE factor</td>
<td>10.9</td>
<td>13.4 +/- 0.48</td>
</tr>
</tbody>
</table>

Decomposition parameters

- Lloyd-Taylor E1: 309 | 448 +/- 121 |
- Lloyd-Taylor T0: -46 | -95.5 +/- 10.6 |
- Growth respiration fraction | 0.33 | 0.34 +/- 0.06 |
- Plant woody turnover rate | 0.03 | 0.19 +/- 0.02 |

Cumulative NEE from 1997-2005 from observed (black) and modeled prior (red) and posterior (blue) parameter sets. 2002 missing in data due to instrument failure and removed from modeled.

Table 1: Prior parameter values and MCMC estimated posterior mean and standard deviation of >14,000 accepted parameter sets. * implies parameter approached constraint range. Some parameters (B0, TO) were strongly correlated

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The Plan: Multiple Flux Tower Assimilation

- MCMC approach was modified to allow simultaneous assimilation from multiple sites across space
- Goal is to find a regional parameter set that when applied to large scale models with regional climate forcing and landcover maps is able to reproduce estimated regional flux

- Some parameters are allowed to vary spatially while others are fixed for all sites
- Cost function (minimization/objective function) is modified to sum RMS model-data error at all sites and new parameter matrix is all accepted or rejected as a group for all sites

- For spatially varying parameters, quasi-random walk is independent at each site. For spatially invariant parameters, parameters are changed in same direction at each location

The Future: Next steps

- Develop regional prior parameter set from ecological and biometric data observed in region

- Assimilate mesonet of flux towers (Fig. 4) in an upland-wetland-set and other combinations to create robust MCMC constrained regional ecosystem parameters

- Test scaling approaches with different land cover sets (e.g., Fig. 5)

- Evaluate multiple site assimilated model against regional flux estimates

- Use regional parameter set to make predictions, test climate change scenarios and evaluate against future observations

References


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