Observed and modelled transpiration cooling from urban trees in Mainz, Germany

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Objective

• Examine transpiration-induced cooling effect of a few urban trees
  • Diurnal variation?
  • Influence of evaporative demand (VPD)?
  • Influence of drought stress?

• Can the effect be replicated with the ENVI-met model?
Study area: Mainz, Germany

- Air temperature and humidity (U23-001)
- Sap Flow (SF-L)
- Stem Radius (DR)

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• Increase in transpiration with VPD
• Drought stress?

Night/Day Sap Flow:

- $V_{PD\text{low}} (n=20) = 0.32$
- $V_{PD\text{moderate}} (n=20) = 0.33$
- $V_{PD\text{high, <7 days since precip}} (n=12) = 0.34$
- $V_{PD\text{high, >7 days since precip}} (n=8) = 0.26$

• Increased cooling and humidity at high VPD
• Nocturnal effect
• Cooling reduced due to drought stress?
Indications of transpiration-induced cooling?

Correlation between Sap Flow and $\Delta T_{\text{air}}$ / $\Delta H_{\text{spec,air}}$

Stronger transpiration $\rightarrow$ vegetated location cooler and more humid

Nocturnal transpiration cooling
Agreement between measured and modelled results

Vegetation transpiration is modelled in ENVI-met using the Jacobs’ A - gs model (Jacobs 1994)

Measured vs. modeled data
(n=3 in each category)
Summary:

- Nocturnal transpiration cooling
  - Increasing with VPD
  - Cooling reduced when dry?
- Model underestimates nocturnal cooling – assuming ceased nocturnal transpiration
Thanks for your attention!
Indications of transpiration-induced cooling?

Correlation between:

- **Courtyard - Street**
  \[ \Delta T_{\text{air}} \text{ and } \Delta H_{\text{(spec)air}} \]

- **Sap Flow and**
  \[ \frac{\Delta T_{\text{air}}}{\Delta H_{\text{(spec)air}}} \]

Stronger cooling = higher humidity → transpiration cooling

Stronger transpiration → vegetated location cooler and more humid

Nocturnal transpiration cooling
<table>
<thead>
<tr>
<th></th>
<th>$\text{VPD}_L$</th>
<th>$\text{VPD}_M$</th>
<th>$\text{VPD}_{\text{Hwet}}$</th>
<th>$\text{VPD}_{\text{Hdry}}$</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>TA, °C</strong></td>
<td>18.4</td>
<td>19.8</td>
<td>23.6</td>
<td>26.3</td>
</tr>
<tr>
<td><strong>Wind speed, ms$^{-1}$</strong></td>
<td>1.8</td>
<td>1.5</td>
<td>1.5</td>
<td>1.8</td>
</tr>
<tr>
<td><strong>VPD, kPa</strong></td>
<td>0.64</td>
<td>1.1</td>
<td>1.8</td>
<td>1.8</td>
</tr>
<tr>
<td><strong>HR, %</strong></td>
<td>67.4</td>
<td>55.3</td>
<td>48.7</td>
<td>42.7</td>
</tr>
<tr>
<td><strong>Solar radiation, % of daily max.</strong></td>
<td>20</td>
<td>47</td>
<td>59</td>
<td>65</td>
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</tbody>
</table>