An Evaluation of Mean Radiant Temperature Estimations in an Arid Urban Climate

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Introduction

- Urban thermal conditions are a growing health concern.
- Mean radiant temperature (T_{\text{mrt}}) improves thermal environment estimation (Fig. 1).
- Radiation loads are dependent on urban form.
- We seek to understand the efficacy of and limitations to Rayman® and ENVI-met® models for T_{\text{mrt}}, and compare them to physical measurements in downtown Tempe, AZ, USA.

Methods

- Measured data from Rayman® and ENVI-met® models were compared to physical measurements.
- Mean radiant temperature (MRT) was estimated using Rayman® and ENVI-met® models.

Results

- Figure 6 shows ENVI-met® simulated T_{\text{mrt}} for 3 pm in February 2015 and June 2017.
- Figure 8 shows linear regression of February 2015 mean radiant temperature (from Kestrel) for Rayman®.
- Figure 9 shows linear regression of June 2017 mean radiant temperature (from MaRTy) for Rayman®.

Discussion

Table 1: Dimension of errors for Rayman® and ENVI-met® simulations relative to observed mean radiant temperature.

<table>
<thead>
<tr>
<th>Simulation</th>
<th>RMSE MRT Urbano</th>
<th>RMSE Systematic</th>
<th>MeanBias Error</th>
<th>Mean Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rayman_Kestrel</td>
<td>16.716</td>
<td>12.080</td>
<td>-5.837</td>
<td>11.163</td>
</tr>
<tr>
<td>Rayman_MaRTy</td>
<td>9.141</td>
<td>5.935</td>
<td>-0.827</td>
<td>4.800</td>
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<tr>
<td>ENVI-met_Kestrel</td>
<td>15.386</td>
<td>12.267</td>
<td>-5.837</td>
<td>11.249</td>
</tr>
<tr>
<td>ENVI-met_MaRTy</td>
<td>16.827</td>
<td>12.553</td>
<td>-5.837</td>
<td>13.549</td>
</tr>
</tbody>
</table>

Conclusions

- Rayman® results indicate better congruence with modeled T_{\text{mrt}} than Kestrel observational data.
- Wilmott Index of Agreement gives a standardized evaluation metric.
- Error dimensions decrease with higher sun angles.
- Sun angle is important for estimating T_{\text{mrt}} in deep urban canyons.
- Rayman® & ENVI-met® perform well in T_{\text{mrt}} estimation.
- Variation in agreement attributed to SVF input (Rayman® and grid resolution (ENVI-met®).
- MaRTy incorporates more radiation data to calculate T_{\text{mrt}} and thus is a better fit to numerical models.
- Highly relevant to arid climates with complex, deep urban canyons.

Acknowledgements

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References

- Kestrel Instruments, 2011: Kestrel 4500 data sheet.