Amplified climate change signal due to urban expansion at local scales from a RCM

Daniel Argüeso\textsuperscript{1,2}, J.P. Evans\textsuperscript{1,2}, L. Fita\textsuperscript{2,3}, A.J. Pitman\textsuperscript{1,2} and A. Di Luca\textsuperscript{2}

\textsuperscript{1}ARC Centre of Excellence for Climate System Science, University of New South Wales, Sydney, Australia
\textsuperscript{2}Climate Change Research Centre, University of New South Wales, Sydney, Australia
\textsuperscript{3}Laboratoire de Météorologie Dynamique, UPMC-Jussieu, CNRS, Paris, France

3\textsuperscript{rd} Lund Regional-scale Climate Modelling Workshop
Lund, Sweden, 16-19 June 2014
Motivation

FACTORS

- Anthropogenic climate change
- Climate in cities is distinct
- Urban population growth (urbanization)

QUESTIONS

- How will CC manifest in cities?
- What will be the combined effect of CC and urban expansion?
**Future climate at urban scales**

- **GCM (150-200km)**
  - **No cities at all**
  - **GCM** is the primary source of Climate Change information.
  - **But too coarse to represent cities**

- **RCM (10km)**
  - **Only urban land use**
  - **RCMs at 10k capture some features of the city, but urban areas are represented only as different landuse**
  - **Need for explicit representation of cities!**

---

*Climate Change Research Centre*
Future climate at urban scales

GCM (150-200km) - No cities at all
RCM (10km) - Only urban land use
RCM (2km) - Urban canopy model

Sydney
Experiment design

- Weather Research and Forecasting (WRF) system
- 2-km spatial resolution (nested in 10k and 50k)
  - CSIRO-MK3.5
- No cumulus parameterization in inner domain (explicit)
- Using Urban Canopy Model (SLUCM)\(^1\)

---

Source: Chen et al. (2011)

---

(1) Kusaka et al. (2001) Boundary-Layer Meteorology
Experiment design

- Three 20-y simulations:
  - 1990-2009: Present climate, present LU (CO)
  - 2040-2059: Future climate, present LU (CC)
  - 2040-2059: Future climate, future LU (CC_LU)
- Climate change (A2) + Urban expansion (red)
Present climatology daily Tmax and Tmin

Argüeso et al. (2014) Climate Dynamics
Changes in daily \( \text{Tmax} \) and \( \text{Tmin} \)

**CC only**
- \( \text{Tmax} \) changes: \( \sim 1.0 \) to \( 1.5^\circ \text{C} \)
- \( \text{Tmin} \) changes: \( \sim 1.5 \) to over \( 2.0^\circ \text{C} \)

**CC and LU change**
- \( \text{Tmax} \) changes: similar to CC only
- \( \text{Tmin} \) changes: \( \sim 3.0 \) to over \( 4.0^\circ \text{C} \) (LU change)
- Almost no footprint of urban expansion in \( \text{Tmax} \)
- Clear impact of urban expansion on \( \text{Tmin} \)
Changes in temperature diurnal cycle

**Summer**

**Winter**
Seasonal changes in daily Tmax and Tmin
Changes in daily Vapor Pressure

- Overall increase in VP due to global warming
- Substantially smaller in areas of urban expansion
Changes in daily heat stress

- Heat stress: simplified wet-bulb globe temperature
- \( W = 0.567T + 0.393e^{3.94} \)

### Change in daily heat stress

<table>
<thead>
<tr>
<th></th>
<th>Day</th>
<th>Night</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CC</strong></td>
<td>![Day CC map]</td>
<td>![Night CC map]</td>
</tr>
<tr>
<td><strong>CC + LU</strong></td>
<td>![Day CC+LU map]</td>
<td>![Night CC+LU map]</td>
</tr>
</tbody>
</table>

**Index:***

1. 1
2. 1.2
3. 1.4
4. 1.6
5. 1.8
6. 2
7. 2.2
8. 2.4
9. 2.6
10. 2.8
11. 3

**Difference**

---

*Climate Change Research Centre*
Exceedance of risk W thresholds
Conclusions

- Urban expansion + Climate change using RCMs:
  - City growth effect on local $T_{\text{min}}$ ~ climate change signal (A2)
  - No perceptible impact on $T_{\text{max}}$ changes
  - Reduced diurnal cycle
  - Larger effect during winter and spring
- Smaller increases in **humidity** (vapor pressure)
  - Particularly during the day
- Implications for **heat stress**: compensating factors
  - Day: cities reduce CC-induced heat-stress increase (humidity driven)
  - Night: cities enhance CC-induced heat-stress increase (temp. driven)