Benefits of regional climate models for heat wave studies

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Introduction

• NARClIm Project: Regional Climate Projections over NSW and ACT \(^1\)
  – Future climate projections at regional scales
  – Provide climate change information to state agencies and impact community

• Urban-induced changes in climate
  – Urban expansion and climate change

(1) Evans JP et al. (2014) Geoscientific Model Development
Heatwaves: key feature of future climate

- Extreme heat has caused more fatalities in the last Century (1900-2011) than all other natural hazards combined: at least 55.2% of 8256

  But also:
  - Increase vulnerability of natural systems
  - Increase probability of other extreme events occurrence (fire weather)
  - Enhance heat stress/sleep disruption
  - Overload health and emergency services
  - Affect food security
  - Increase energy consumption
  - Affect infrastructure (e.g., transport)

(2) Coates et al. (2014) Environmental Science and Policy
Heatwaves: key feature in cities

Cities

• Hold 90% of Australian population
• Will substantially grow in the future
• Are warmer than surroundings

But also:

• Have great potential for adaptation and effect change
Introduction

Heatwaves are a key feature in:

- future climate projections
  - Changes in heatwaves characteristics
- study of urban climate
  - Impact of urban design on heatwaves
Measuring heatwaves

- Data: Observations (AWAP), Regional Climate Model and Global Climate Models.

- Index suitable for us:
  - Applicable to different locations
  - Bias-resistant (Models do have substantial biases)
  - Provide information on heatwave features
  - Suitable for present and future climates
  - Based on percentiles

- Excess Heat Factor (EHF) ³
  - Particularly hot conditions persistent in time
  - Acclimatisation factor

Measuring heatwaves

• What would we need from an index?
  That is currently problematic in EHF
  – Applicable to different periods (how percentiles are calculated)
  – Human adaptation to long term changes (acclimatisation)
  – Appropriate metric for mean magnitude of heatwaves
  – Index that is easier interpretable by non-experts (°C²???)

• Other interesting aspects:
  – Incorporating heat stress (i.e., humidity, wind and radiation)
Future heatwaves by Global Climate Models

- GCMs are very useful tools to investigate the climate system at large scales.
- Future climate projections
- Spatial resolutions of 150-200km

Peak (HWA in °C²)
Future heatwaves by Global Climate Models

- GCMs are very useful tools to investigate the climate system at large scales.
- What about impact studies?

MIROC 3.2 med-res
Mean annual temp. (1990-2009)
Regional Climate Models to gain detail

Take info from GCM and solve equations of the climate system at higher resolution

– Physically consistent
– Full spatiotemporal coverage
– Multiple variables
– ‘Dynamic’ understanding of the climate
– Valid for future climate conditions**
– Allow us to explore mechanisms and processes
Figure 2.5: Seasonal and annual means of AW AP near-surface air temperature for years 1990-2009 [°C]. White circles (top to bottom): Brisbane, Sydney, Melbourne.

Figure 4.1: Seasonal and annual means of MIROC3.2 near-surface air temperature for years 1990-2009 [°C]. White circles (top to bottom): Brisbane, Sydney, Melbourne.

Mean Annual Temp. (1990-2009)

(4) Olson et al. (2014) NARClIM Tech Note 4
Information from Regional Climate Models

MIROC 3.2

Mean Annual Temp. (1990-2009)

AWAP obs.

NARClIM: NSW/ACT Regional Climate Modelling Project

(4) Olson et al. (2014) NARClIM Tech Note 4
Heatwaves projections in NARClíM

AWAP (1990-2009)

Peak (HWA)

Frequency (HWF)

Longest HW (HWD)

NARClíM Changes (2060-2079 minus 1990-2009)

(5) Argüeso et al. (2015) NARClíM Tech Note 5
Very high resolution models

- Heatwaves in cities

GCM (150-200km)

No cities at all
Very high resolution models

- Heatwaves in cities

GCM (150-200km) - No cities at all

RCM (10km) - Only urban land use

RCM (2km) - Urban canopy model
Future temperature changes in new urban areas

CC only
- Tmax changes: ~ 1.0 to 1.5°C
- Tmin changes: ~ 1.5 to over 2.0°C

CC + URB:
- Tmax changes: similar to CC only
- Tmin changes: ~ 3.0 to over 4.0°C (LU change)
- Almost no footprint of urban expansion in Tmax
- Clear impact of urban expansion on Tmin

(6) Argüeso et al. (2014) Clim Dyn
Summary

• RCMs add crucial spatial detail for heat wave studies
• RCMs provide variables beyond temperature
• Allow us to study fine-scale processes missing in GCMs (i.e. urban effects)
• All this in a physically-consistent framework.