Climate Change Research Centre

ARC CENTRE OF EXCELLENCE FOR CLIMATE SYSTEM SCIENCE

UNSW AUSTRALIA

Changes of temperature and humidity in areas of city sprawl under climate change conditions

Never Stand Still | Science | Climate Change Research Centre

D. Argüeso, J.P. Evans and A. Di Luca

ARC Centre of Excellence for Climate System Science & Climate Change Research Centre
University of New South Wales, UNSW, Sydney Australia

Email: d.argueso@unsw.edu.au

9th International Conference on Urban Climate (ICUC9) – Toulouse 20 July 2015

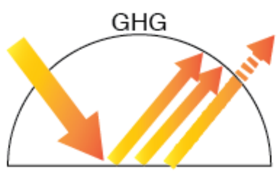
Motivation

FACTORS

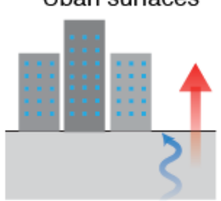
Climate in cities is distinct

Anthropogenic climate change

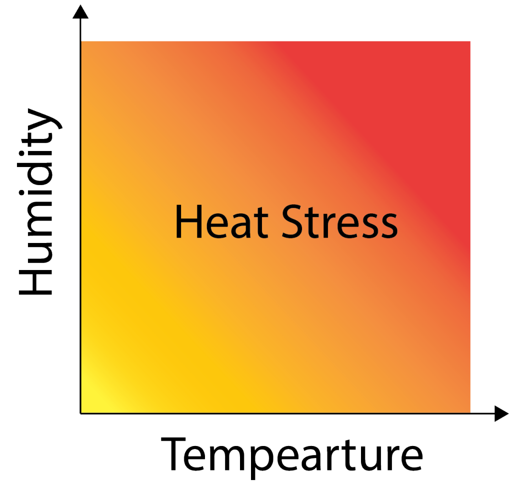
Urban population growth (urbanization)



+



= ?

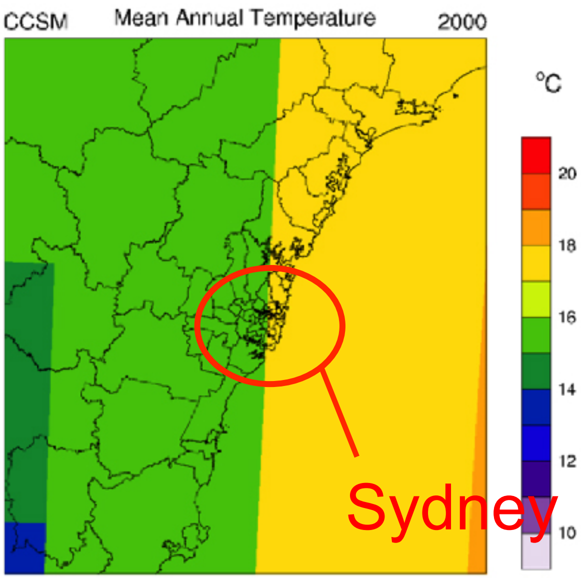


QUESTION

What will be the combined effect of CC and urban expansion?

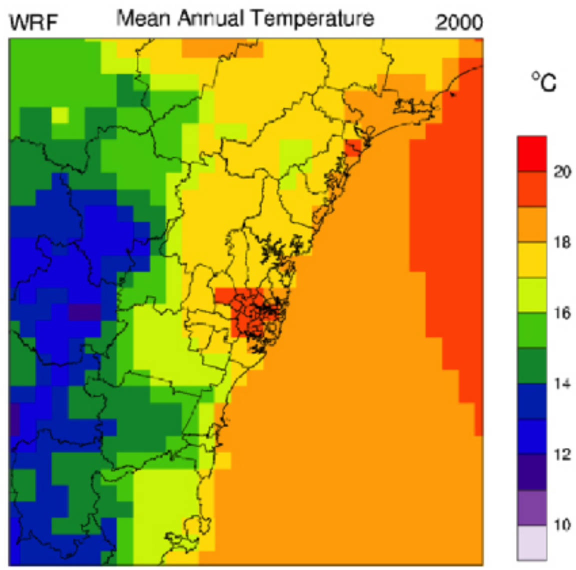
Future climate at urban scales

GCM (150-200km)



No cities at all

RCM (10km)

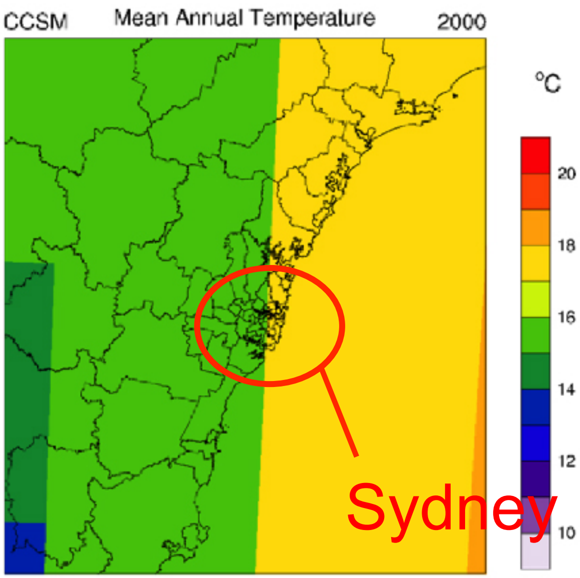


Only urban land use

- GCM primary source of Climate Change information
- But too coarse to represent cities
- RCMs at 10k capture some features of the city, but urban areas are represented only as different land use
- Need for explicit representation of cities!

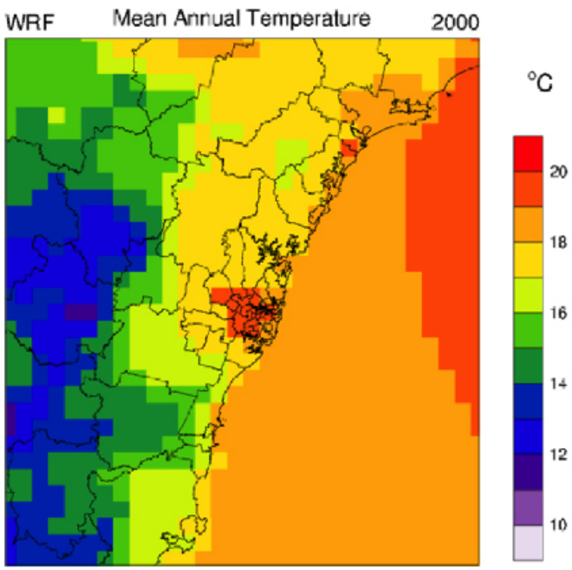
Future climate at urban scales

GCM (150-200km)



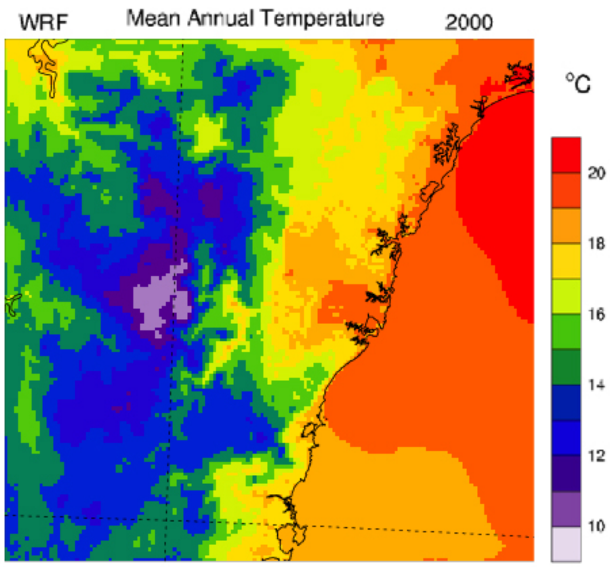
No cities at all

RCM (10km)



Only urban land use

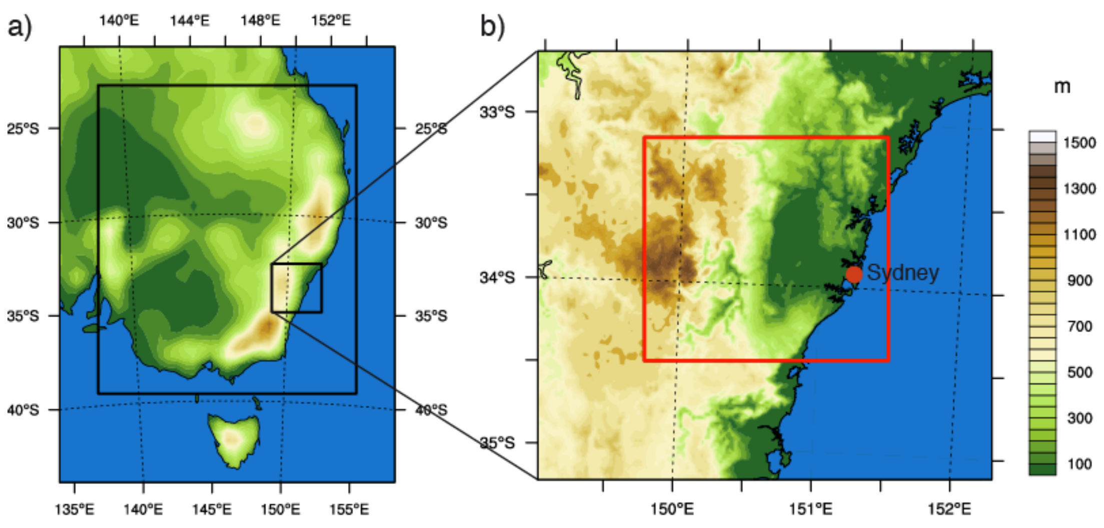
RCM (2km)

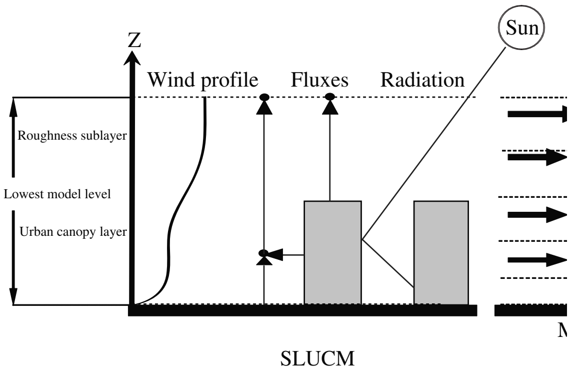


Urban canopy model

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]



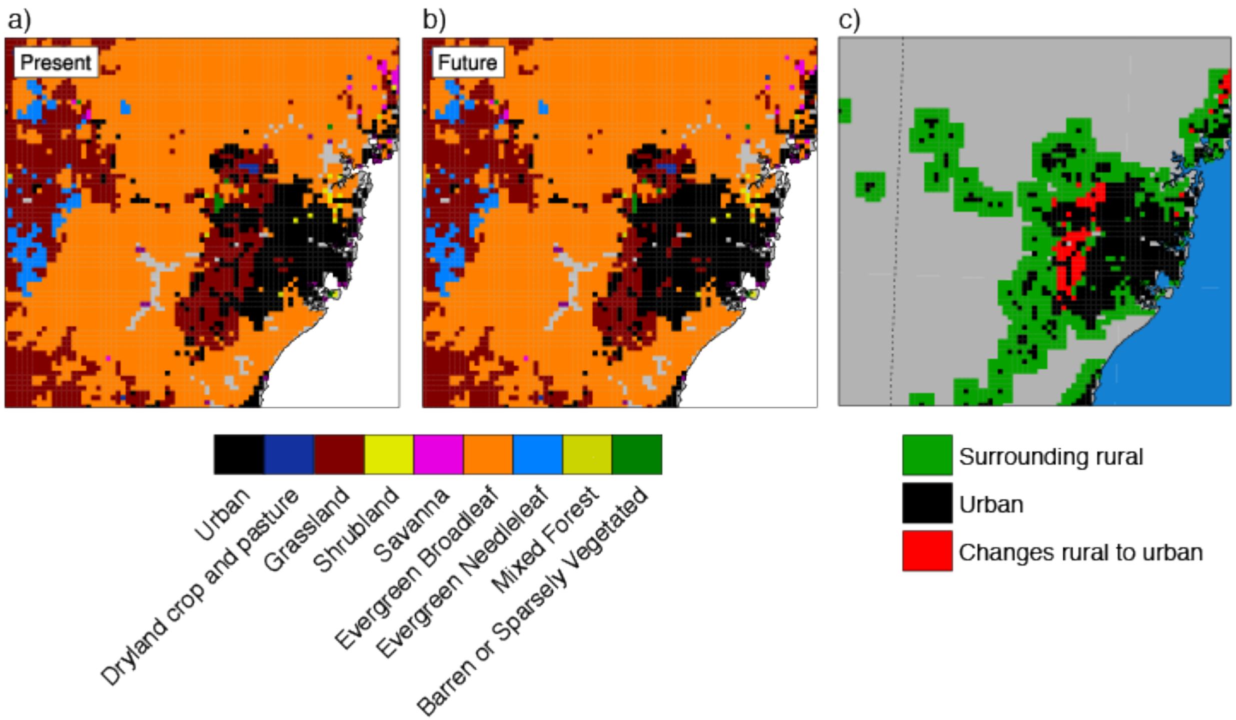


Source: (2) Chen et al. (2011)

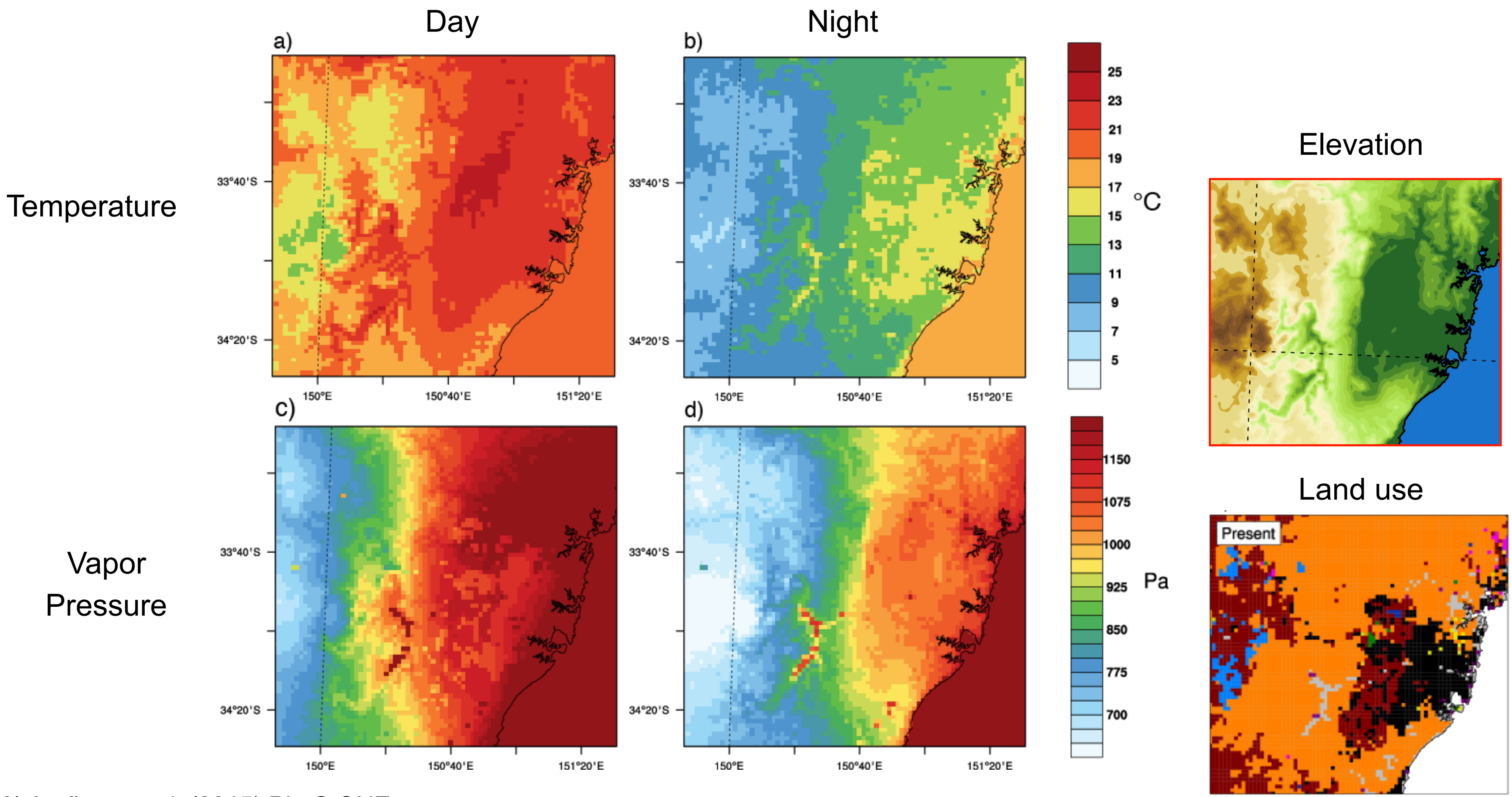
(1) Kusaka et al. (2001) Boundary-Layer Meteorology

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 + URB)
- Climate change (A2) + Urban expansion (red)

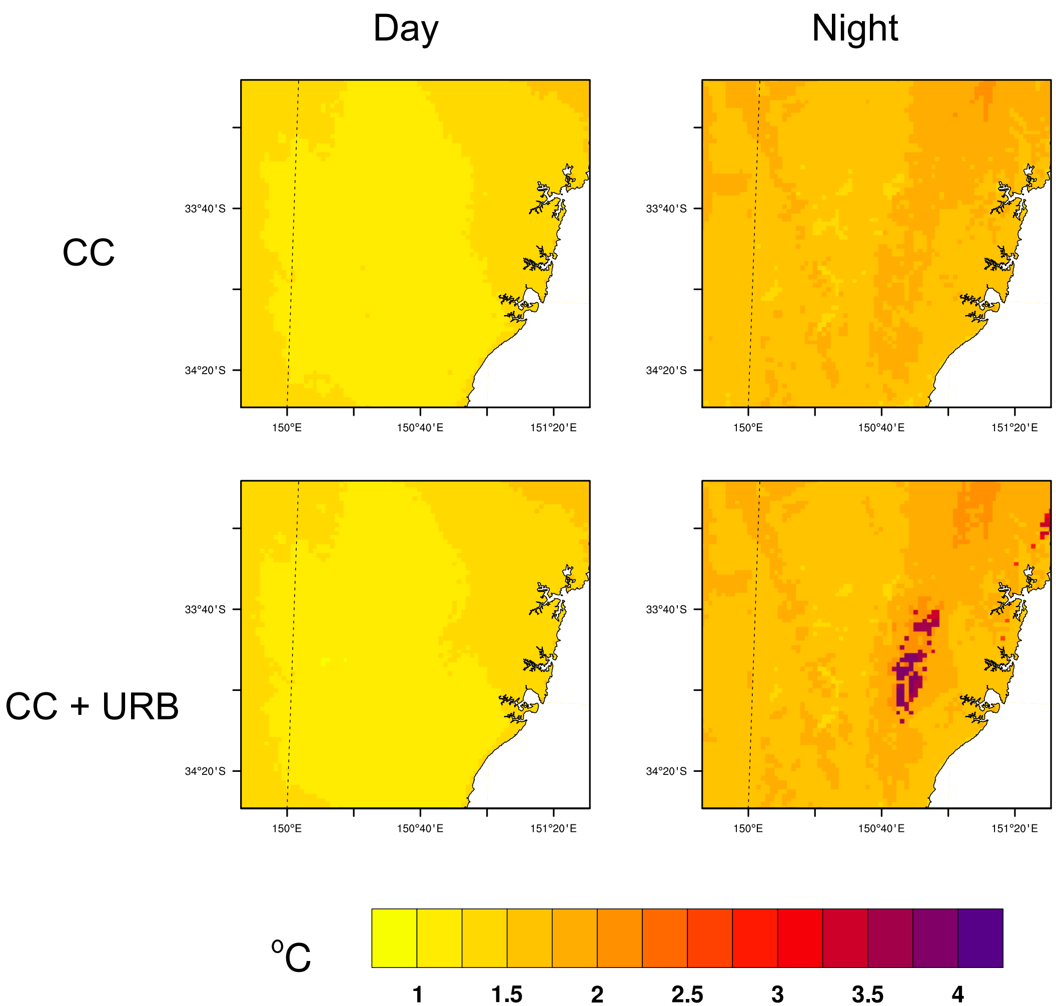


Temperature and humidity climatology



(3) Argüeso et al. (2015) PLoS ONE

Changes in temperature



(2) Argüeso et al. (2014) Clim Dyn

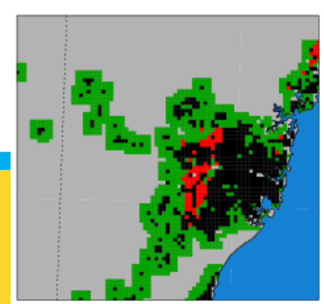
CC only

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

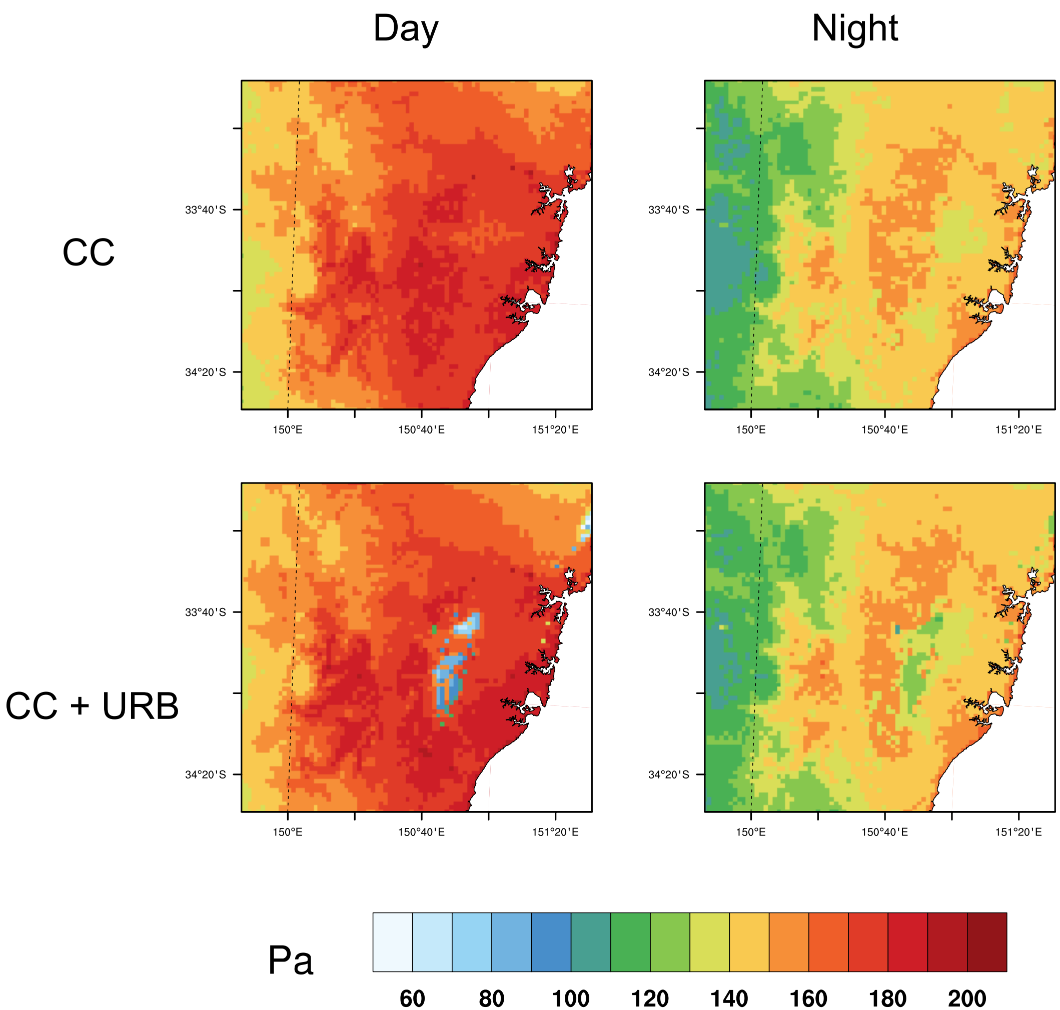
CC + URB:

- 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



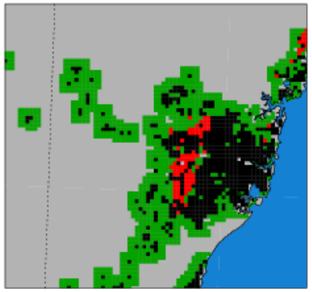
Changes in humidity (vapor pressure)



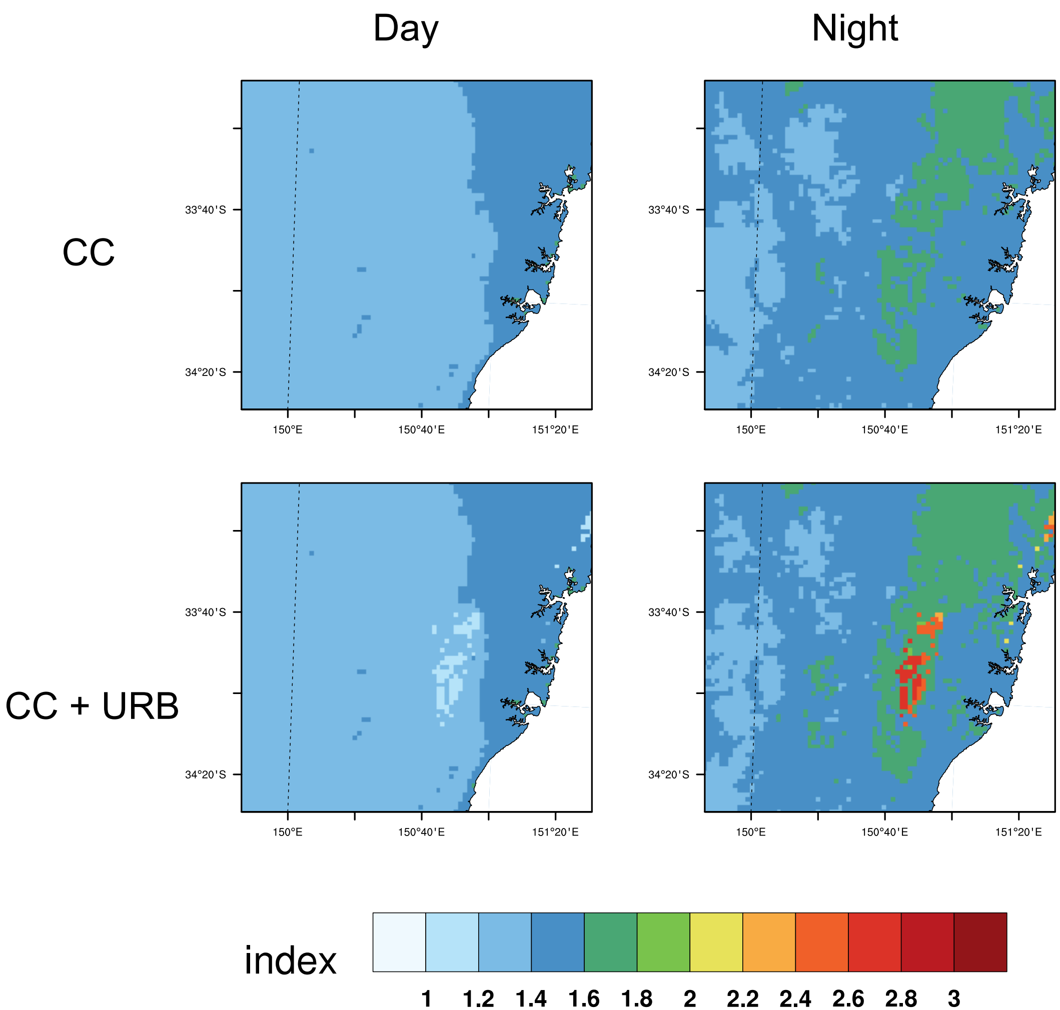
Overall increase in VP due to global warming

But substantially smaller increases in new urban areas, particularly during the day

(3) Argüeso et al. (2015) PLoS ONE

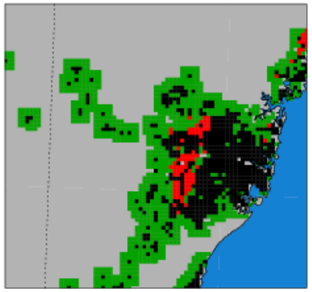


Changes in heat stress



- Heat stress: simplified wet-bulb globe temperature
- W = 0.567*T+0.393e+3.94

(3) Argüeso et al. (2015) PLoS ONE



Conclusions

- Urban expansion + Climate change using RCMs:
  - City growth effect on local Tmin ~ climate change signal (A2)
  - No perceptible impact on Tmax changes
  - Reduced diurnal cycle
- Smaller increases in **humidity** (vapor pressure)
  - Less than half of the CC-only increase 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)
- Highlights the need to include other variables to assess human vulnerability in future cities

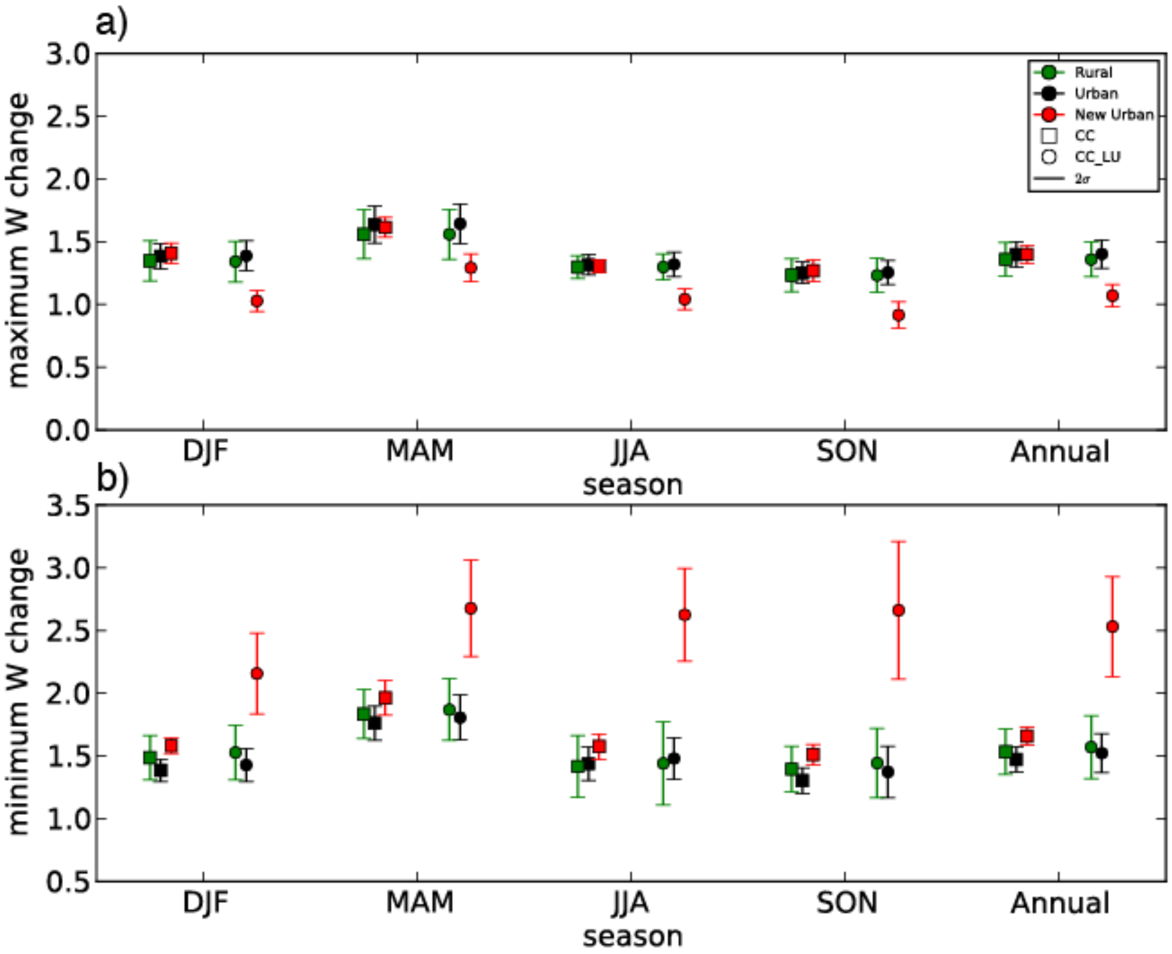
References

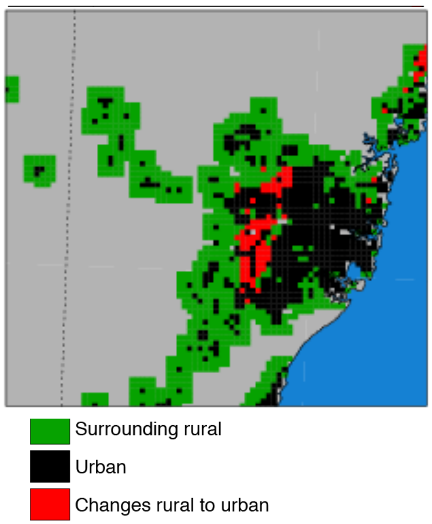
- (1) Kusaka H, Kondo H, Kikegawa Y, Kimura F (2001) A simple single-layer urban canopy model for atmospheric models: Comparison with multi-layer and slab models. Boundary-Layer Meteorology 101:329–358.
- (2) 1. Chen F, Kusaka H, Bornstein RD, et al. The integrated WRF/urban modelling system: development, evaluation, and applications to urban environmental problems. Roth M, Emmanuel R, Ichinose T, Salmond J, eds. Int J Climatol. 2011;31(2):273–288. doi:10.1002/joc.2158.
- (3) Argüeso D, Evans JP, Pitman AJ, Di Luca A (2015) Effects of City Expansion on Heat Stress under Climate Change Conditions. PLoS ONE 10:e0117066–19. doi: 10.1371/journal.pone. 0117066
- (4) Argüeso D, Evans JP, Fita L, Bormann KJ (2014) Temperature response to future urbanization and climate change. Clim Dyn 42:2183–2199. doi: 10.1007/s00382-013-1789-6

Thanks!

Questions and comments?

Seasonal changes in daily heat stress





Contribution to heat stress changes in urban expansion areas