A discussion on the paper"Contrasts between Urban and Rural Climate in CCSM4 CMIP5 Climate Change Scenarios"

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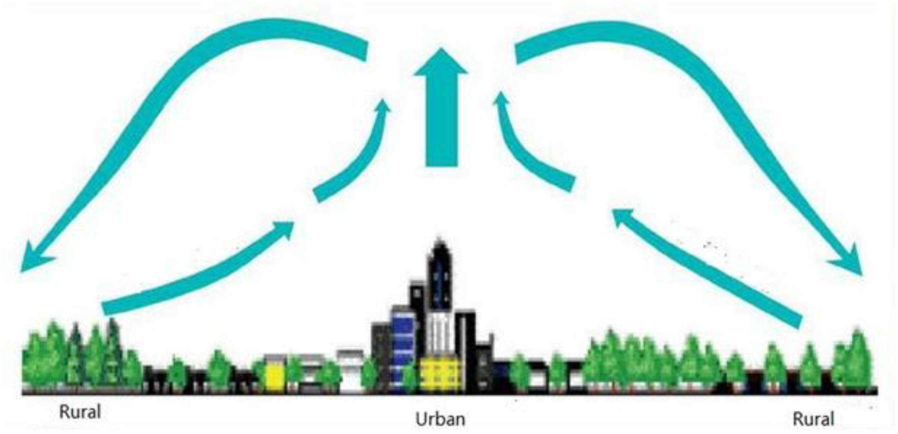
Outline

- Introduction
- Methods
- Result
- Conclusions

Why do we study the climate difference between urban and rural by CCSM4?



UHI

Introduction

- There are limitations to representing urban areas within global climate models(Best, 2006).
- The global problem caused by the increasingly urban population is crucial(Bettencourt and West 2010).
- An coupled model (CCSM4,2008)means that the response of urban areas can be studied under the full range of atmospheric conditions produced from future climate scenarios.

Methods

- Run range

Historical： 1850-2005 (five ensemble members)

RCP Scenarios: 2006-2100 (five ensemble members for each RCP)

Scenarios	Assumption
RCP 2.6	Low scenario with radiative forcing peaking at 3.2W/ m^2 by midcentury, returning to 2.6 W/ m^2 by 2100. CO_2 levels reach 421 ppm.
RCP 4.5	Medium scenario with radiative forcing stabilizing at 4.5 W/ m^2 after 2100. CO_2 levels reach 538ppm.
RCP 8.5	High emissions scenario with radiative forcing reaching 8.5 W/ m^2 near 2100. CO_2 levels reach 940ppm.

- Resolution : $1.9^\circ \times 2.5^\circ$

Methods

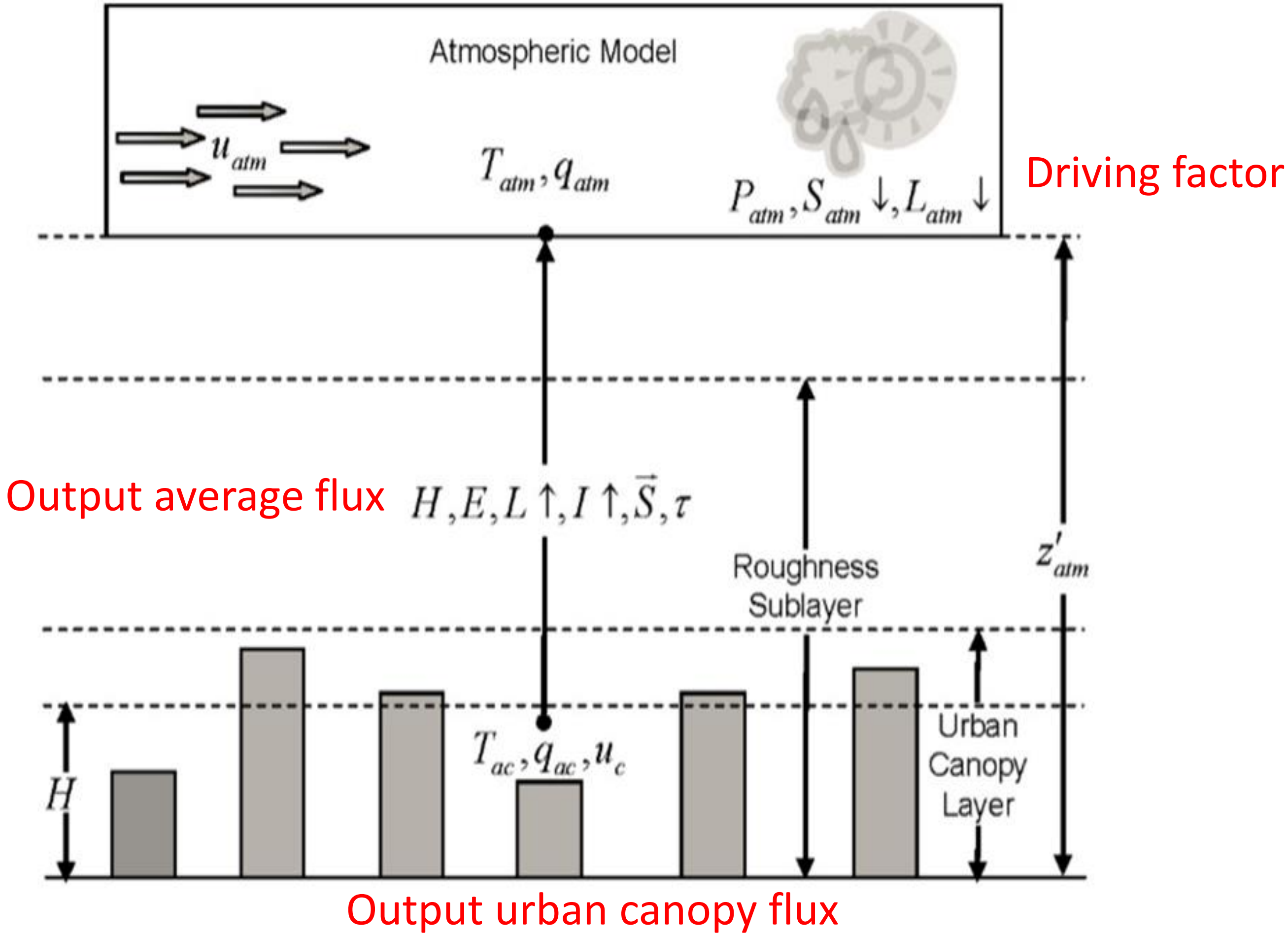


FIG. 1. Schematic of urban and atmospheric coupling

Result

Result

1.Global time series of land, urban, rural temperature

TABLE 1. Global, land, urban (U), and rural (R) average 2-m air temperatures (°C) for 1850–69 and 1986–05 simulations, and differences from present day base period 1986–2005 at three future time periods from the RCP8.5, RCP4.5, and RCP2.6 simulations.

Scenarios		Global	Land	*U* AVG	*R* AVG	*U* − *R* AVG	*U* − *R* TMAX <	*U* − *R* TMIN
Twentieth-century	1850–1869	13.34	7.39	17.51	16.06	1.45	0.56	2.02
	1986–2005	14.30	8.56	18.35	16.93	1.42	0.55	1.98
RCP8.5	2011–30	0.66	0.84	0.72	0.73	1.41	0.53	1.96
	2046–65	1.91	2.48	2.12	2.16	1.38	0.48	1.93
	2080–99	3.48	4.48	3.75	3.82	1.35	0.42	1.91
RCP4.5	2011–30	0.58	0.75	0.65	0.65	1.42	0.53	1.98
	2046–65	1.29	1.65	1.44	1.43	1.43	0.53	2.00
	2080–99	1.62	2.03	1.76	1.75	1.43	0.49	2.00
RCP2.6	2011–30	0.60	0.77	0.68	0.68	1.42	0.53	1.97
	2046–65	0.88	1.12	0.97	0.98	1.41	0.52	1.98
	2080–99	0.85	1.04	0.91	0.91	1.42	0.53	1.97

Average 2-m air temperatures increasing

The UHI decreased in RCP8.5 scenarios

Result

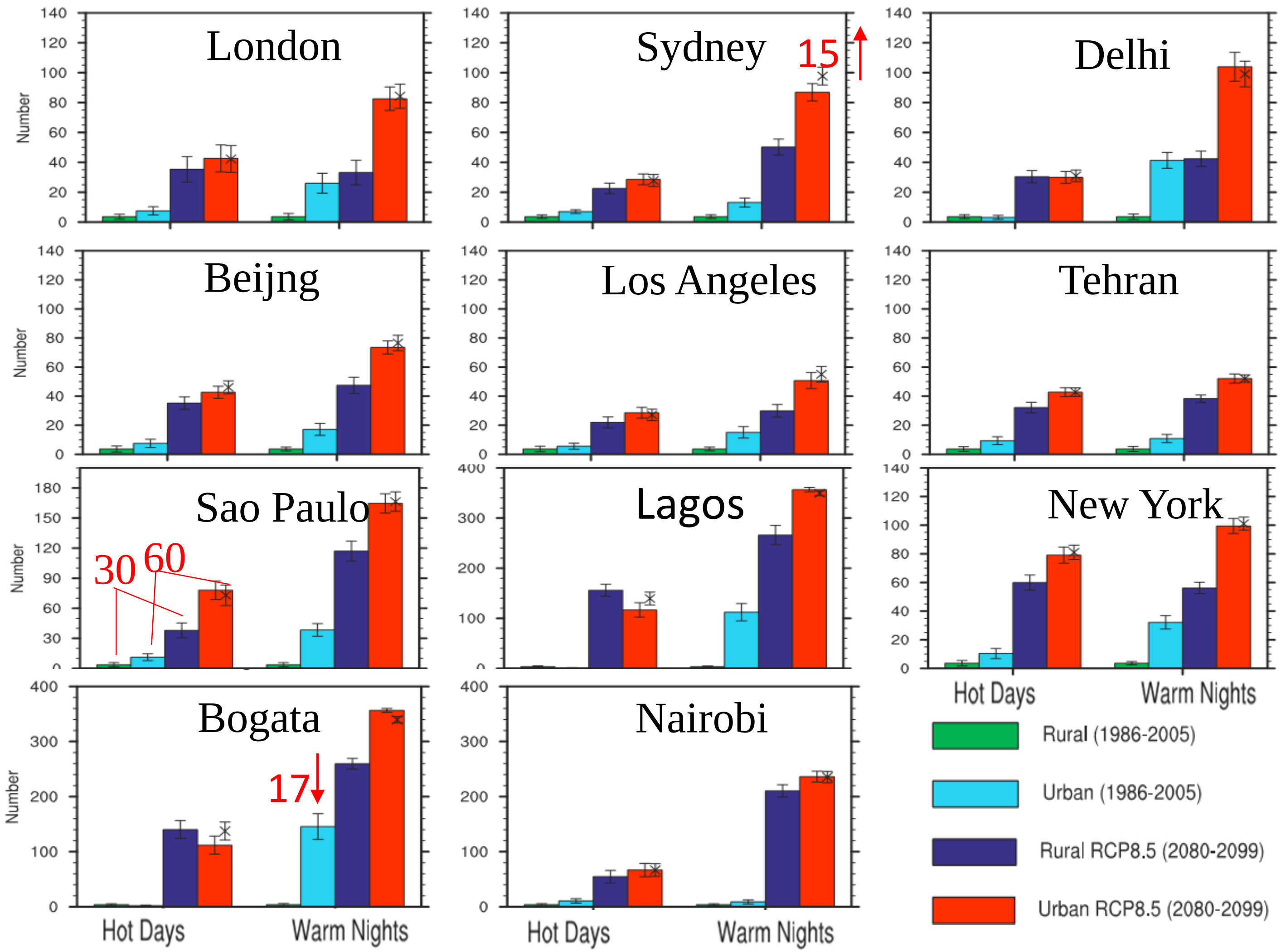
2. Spatial and seasonal variability in the heat island

TABLE 2. Regional averages for the present-day heat island (1986–2005 U-R air temperature), climate change in RCP8.5 (the end of 21C minus present land air temperature), and change in the heat island (ΔHI; RCP8.5 the end of 21C U-R minus present U-R air temperature)(°C). Region boundaries defined as in McCarthy et al. 2010a

	DJF			JJA		
Region	Present-day HI	Climate change	ΔHI	Present-day HI	Climate change	ΔHI
WNA	1.80	3.80	−0.16	1.58	4.49	0.00
ENA	2.04	4.43	−0.17	$\boxed{2.00}$ Max	4.66	0.11
CAm	1.01	3.35	−0.13	1.06	3.62	−0.11
SAm	1.13	3.65	−0.08	1.60	3.64	−0.01
EU	1.35	2.68	−0.16	1.60	5.06	0.16
WAf	1.86	3.75	−0.11	$\boxed{1.02}$ Min	3.52	−0.06
ME	1.04	3.80	−0.10	1.32	4.87	0.01
EAf	$\boxed{0.94}$ Min	3.35	0.01	1.18	3.39	0.00
CAs	$\boxed{2.26}$ Max	4.19	−0.02	1.14	3.71	−0.06
EAs	1.93	3.69	−0.14	1.29	3.69	−0.10
ANZ	1.07	3.52	−0.09	1.44	3.20	−0.13

Result

3. Changes in hot days and warm nights



UHI:

Day < Nocturnal

FIG. 2. Average annual frequency of hot days and warm nights for selected cities for the 20c simulation and the RCP8.5 simulation for urban and rural areas.

Result

4. Attribution of changes in the heat island

TABLE 3. Simple (S) and partial regression coefficients (P) between RCP8.5 in rural diurnal temperature range [dtr(r)] and nocturnal heat island (tmin hi), and humidity (q), wind speed (w), total cloud (tc), leaf plus stem area index (lsai), soil moisture [b(r), b(u)], wasteheat (wh) over Europe .

	JJA RCP8.5				DJF RCP8.5			
	dtr(*r*)		tmin hi		dtr(*r*)		tmin hi	
	S	*P*	*S*	*P*	*S*	*P*	*S*	*P*
q	**−0.28**	**0.15**	**−0.29**	**−0.07**	−0.04	**−0.11**	**−0.12**	**−0.10**
w	**−0.20**	**0.10**	**−0.33**	**−0.09**	**−0.50**	**−0.10**	**−0.28**	**0.12**
tc	$\boxed{\textbf{−0.67}}$	**−0.56**	**−0.45**	**−0.11**	**−0.89**	**−0.67**	**−0.57**	**−0.17**
lsai	$\boxed{\textbf{0.69}}$	**0.57**	$\boxed{\textbf{0.80}}$	**0.68**	−0.03	**0.26**	−0.01	**0.38**
b(*r*)	**−0.40**	**−0.15**	**−0.36**	**−0.13**	**−0.78**	**−0.37**	**−0.53**	**−0.91**
b(*u*)	—	—	**−0.31**	**−0.12**	—	—	**−0.52**	**0.16**
wh	—	—	0.07	**0.10**	—	—	**0.14**	**0.16**
R^2	—	**78**	—	**74**	—	**93**	—	**70**

Conclusions

(1) The average UHI is increased at the end of the 21 century, is similar to present day in RCP2.6 and RCP4.5,but decreases in RCP8.5. Both the daytime and nocturnal UHIs decrease in RCP8.5,caused by changes in evaporation.

(2) Climate change increases the number of warm nights in urban areas substantially more than in rural areas. Daytime weaker than nocturnal UHIs

(3) In Europe, the response to climate change of rural leaf–stem area in summer and clouds and rural soil moisture in winter explains the majority of this variability.

These results provide evidence that urban and rural areas respond differently to climate change. Thus, the unique aspects of the urban environment should be considered when making climate change projections, particularly since the global population is becoming increasingly urbanized.

Conclusions

Limitations of modeling urban and rural climate

(1) A single medium density urban landunit in each gridcell. CLM 4.5 has expanded to three density types.

(2) In this modeling framework the urban and rural areas within a given grid cell are forced by the same atmosphere and share the same boundary layer. Ignored the differences between urban and rural boundary layers , the model cannot capture mesoscale processes that affect the UHI.

Thank you