Urban Climate Adaptation Impacts: A multi-scale assessment to examine modeling robustness

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UHI Mitigation Strategies I
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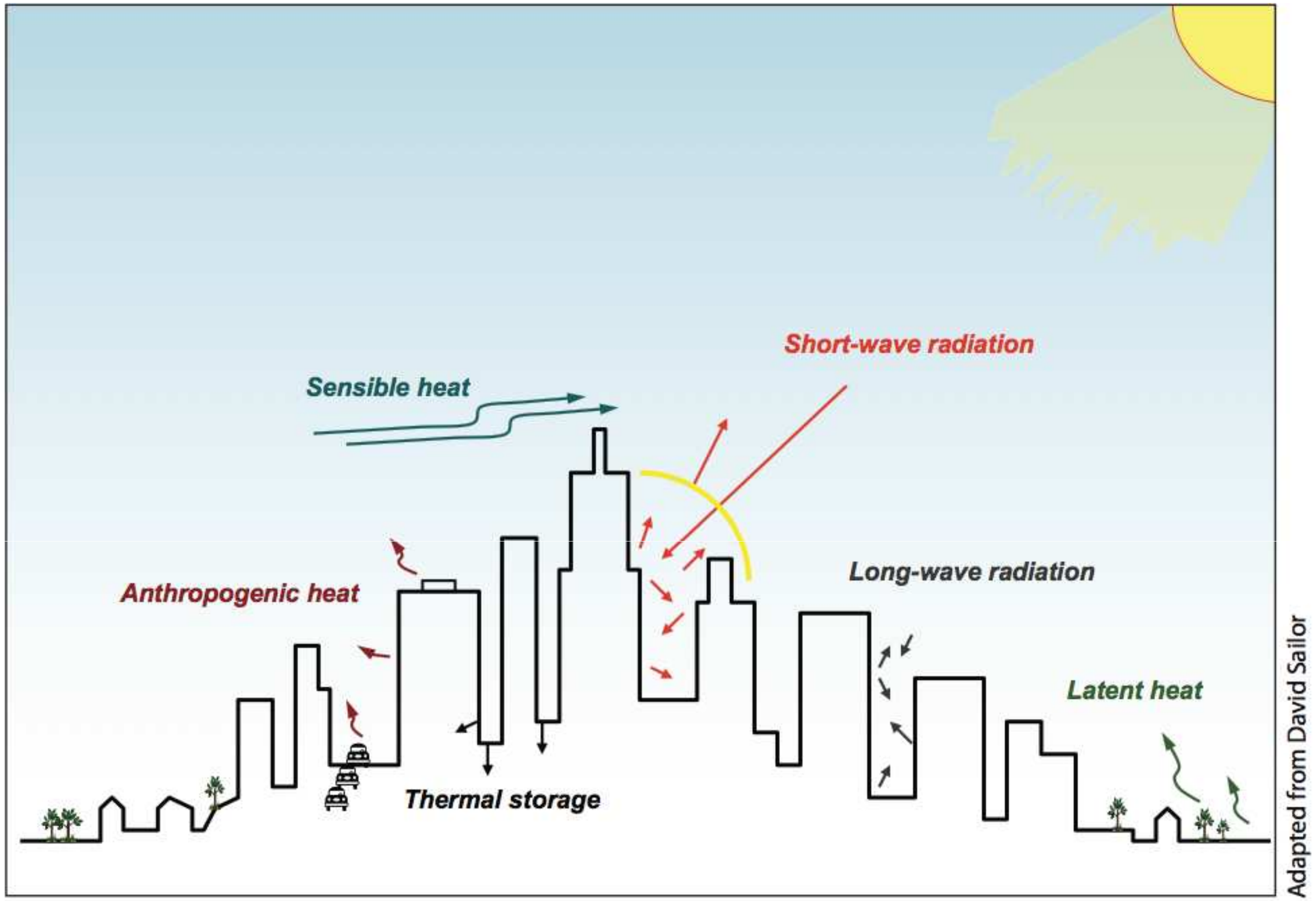
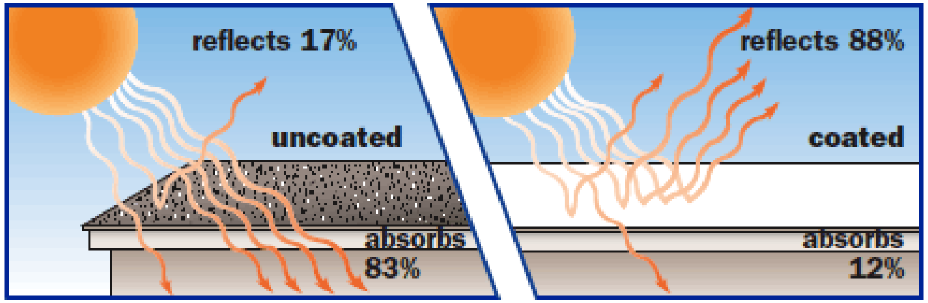
Our Urban [Climate] System



Balance of incoming and outgoing energy fluxes: Surface energy budgets of urban areas and their more rural surroundings differ because of variability in **(1)** land cover and surface characteristics, and **(2)** level of human activity (e.g., anthropogenic heat).

Common UHI Adaptation Strategies

Cool Roofs/Materials



Source: Henry Builders

Green Roofs

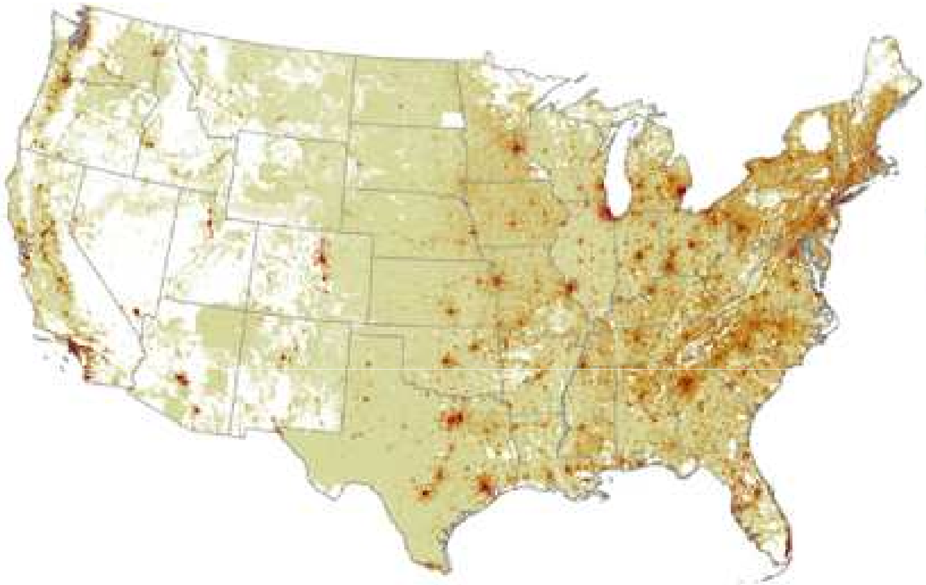
Chicago City Hall (Source: National Geographic)

Trees

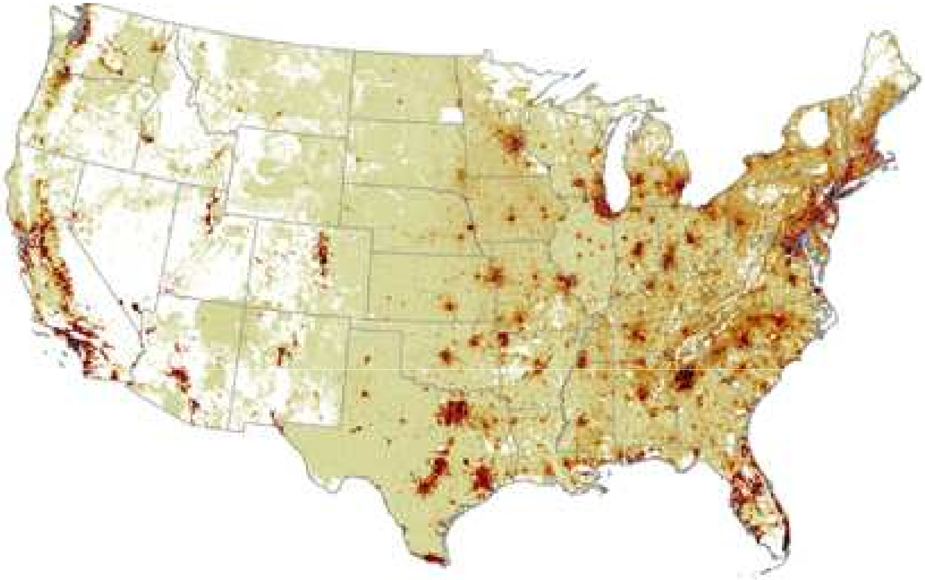
Phoenix Civic Space Park is located in downtown Phoenix. The city is attempting to increase vegetation cover to 25% across Phoenix. (Source: Phoenix Park and Recreation Department)

Projected Megapolitan Expansion (EPA)

Urban Cover: 2000



ICLUS_A2: 2100



Bierwagen et al., (2010), ***Proc. Natl. Acad. Sci., 107*****(49), 20887-20892**

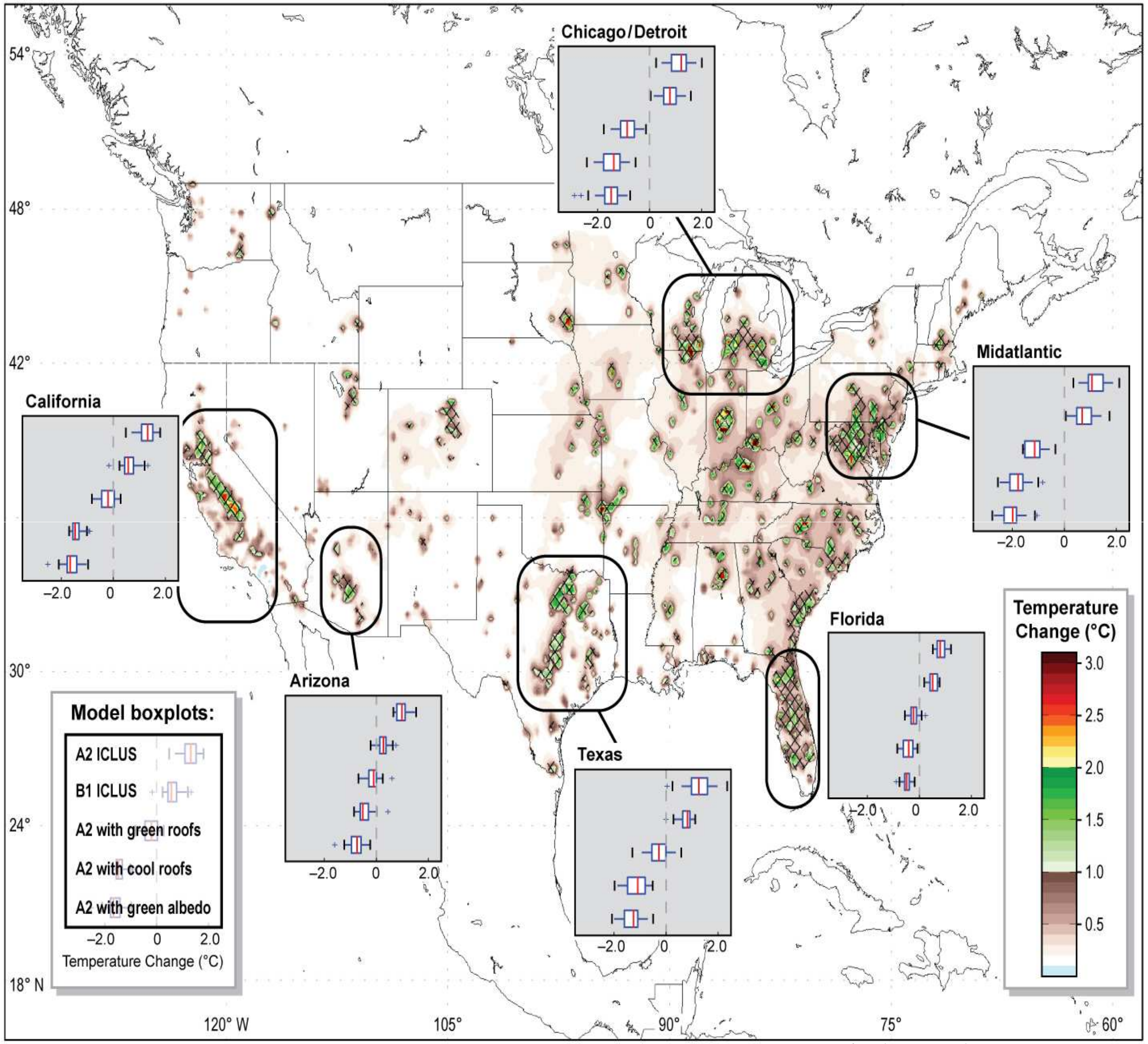
Expansion is consistent with SRES GHG emissions storylines rather than independent, locally generated projections, that may be in conflict with adjacent socioeconomic development (and may therefore be unrealistic).

WRF Specifications

Model Version:	Version 3.2.1
Horizontal Grid:	ΔX, ΔY, 20-km
Number of Points:	310 (X-dir.); 200 (Y-dir.)
Vertical Levels:	30 levels
Initialization Time:	*Variable*
Terminal Time:	December 31, 21Z 2008
Analysis Time:	January 1, 00Z 2001 - December 31, 21Z 2008
ΔT:	90 seconds
Radiation Scheme:	RRTM (longwave); RRTMG (shortwave)
Surface Model:	Noah
Cumulus Scheme:	Kain-Fritsch
Microphysics Scheme	WSM-3
PBL Scheme	Mellor-Yamada-Janjic
Surface Layer	Eta similarity
Urban Model	3-category Urban Canopy Model
Initial and Lateral Boundary Conditions:	FNL

- Each scenario represents 24 years of simulations (8 years X 3 ensemble members)
- Scenarios: **(1)** Control, **(2)** ICLUS_A2, **(3)** Cool Roofs, **(4)** Green Roofs, **(5)** Hybrid Roofs
- In total: 144 years of CONUS simulations (~2 mill. grid cells).

2m Temp difference (°C): JJA [ICLUS_A2–Control]



Georgescu, et al. (2014), *PNAS*, 111 (8), 2909-2914.

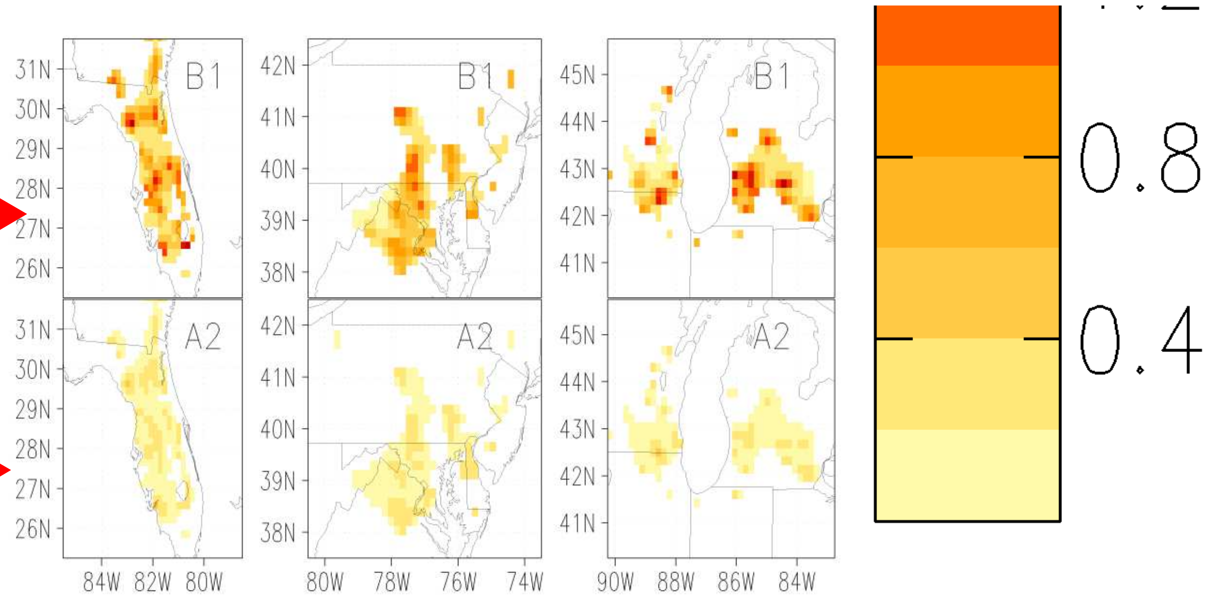
- For all regions, each urban adaptation strategy completely offsets urban-induced warming.
- Cool roofs are more effective at cooling than green roofs, but geography matters (e.g., Florida relative to California).
- Hybrid strategies reveal an urban adaptation saturation effect.

Max Ur
B

Min Urb
A

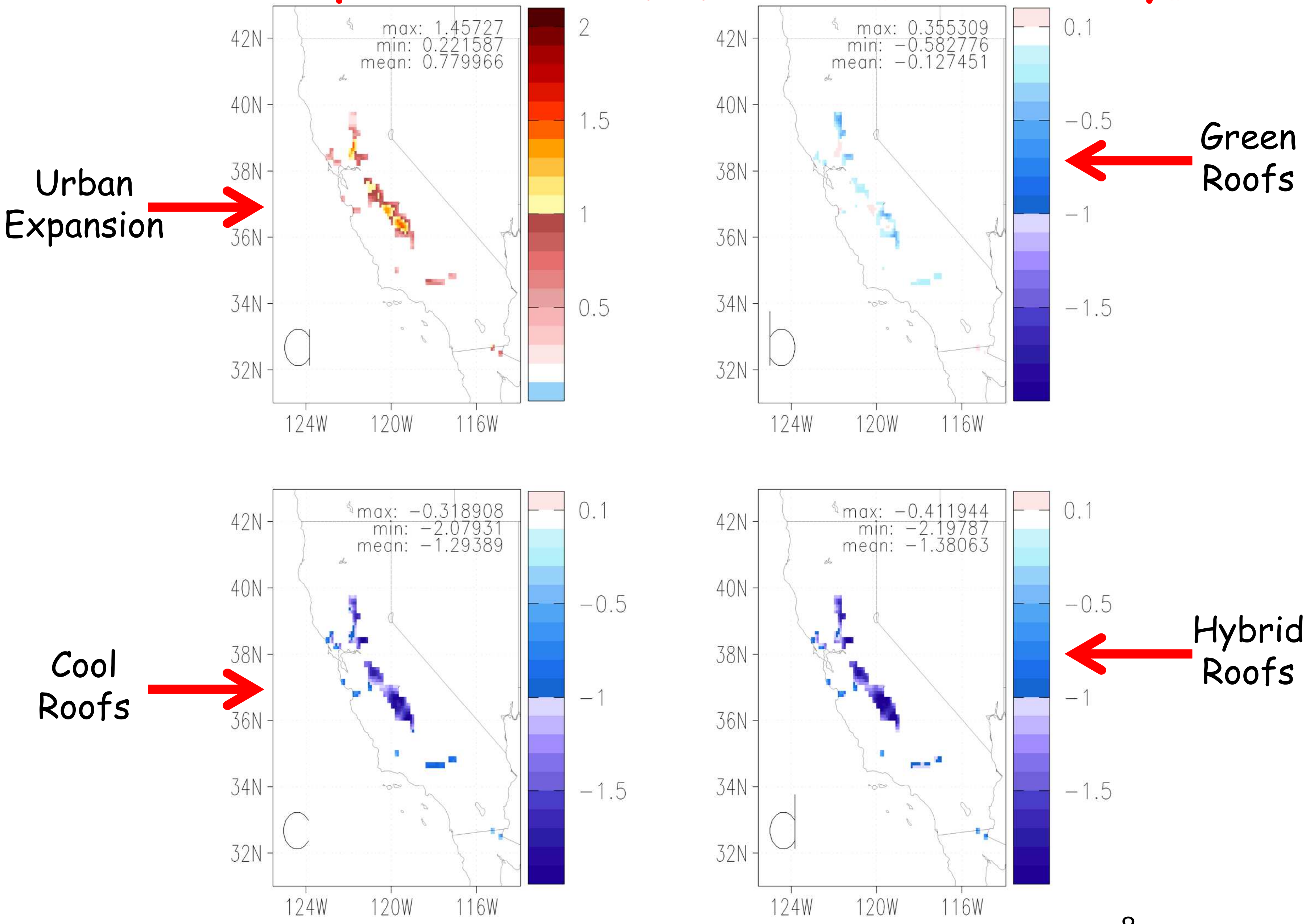
Max Urban Expansion
B1 GHGs

Min Urban Expansion
A2 GHGs

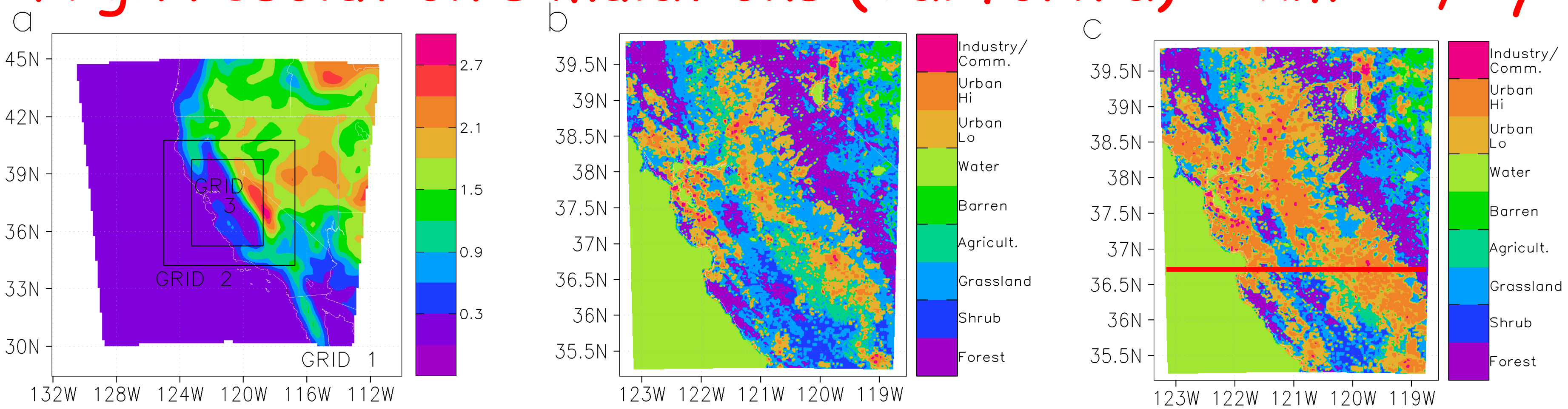


Georgescu, et al. (2014), *PNAS,* 111 (8), 2909-2914.

2m Temp difference (°C): JJA [20km Δx,Δy]



High resolution simulations (California): 2km $\Delta x, \Delta y$



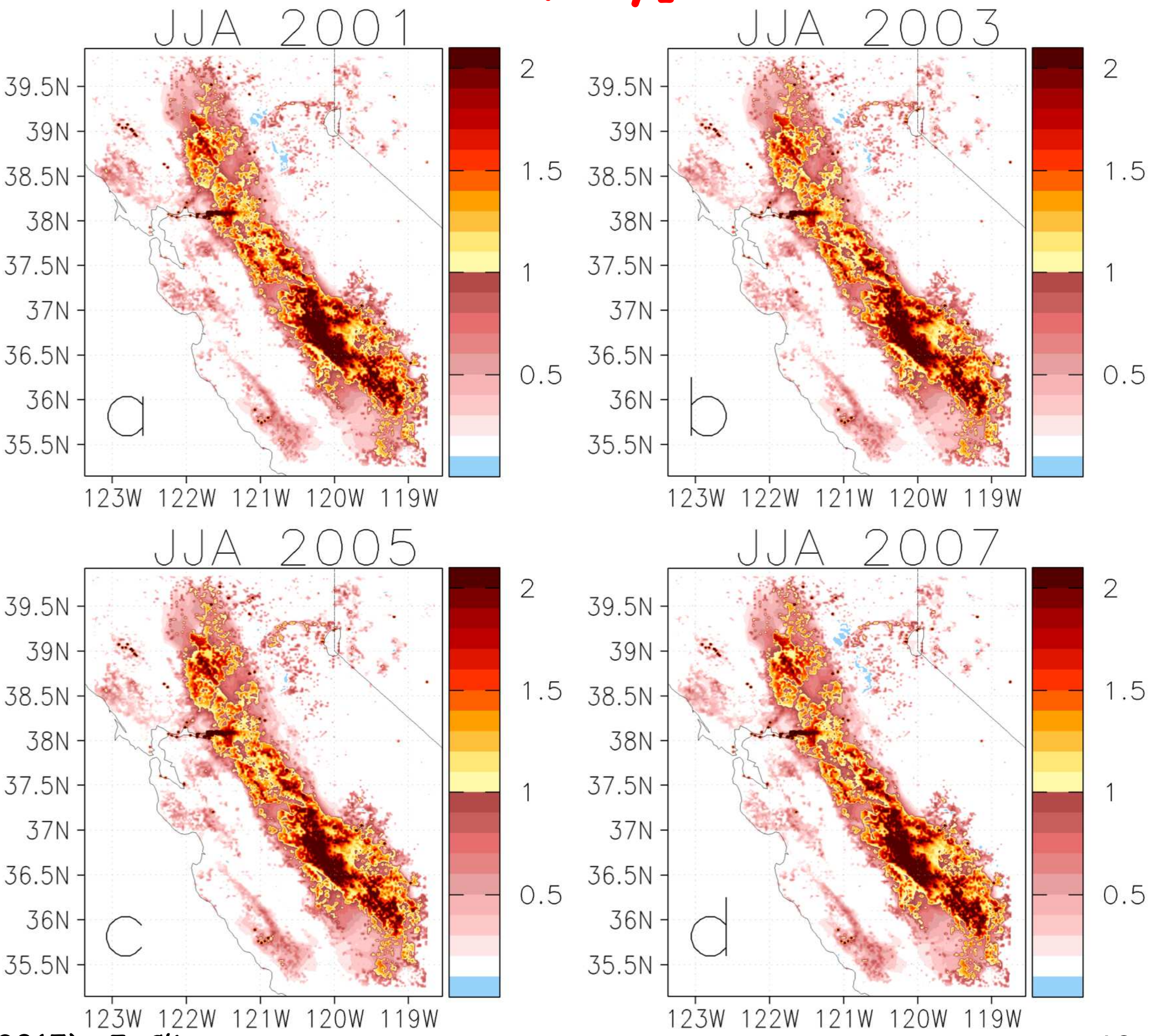
3 nested grids (32km, 8km, 2km)

Description of Simulations	Spin-up Period	Analysis Time
Control	May 24 – 31, 2001	June 1- Aug. 31, 2001
	May 24 – 31, 2003	June 1- Aug. 31, 2003
	May 24 – 31, 2005	June 1- Aug. 31, 2005
	May 24 – 31, 2007	June 1- Aug. 31, 2007
ICLUS_A2	May 24 – 31, 2001	June 1- Aug. 31, 2001
	May 24 – 31, 2003	June 1- Aug. 31, 2003
	May 24 – 31, 2005	June 1- Aug. 31, 2005
	May 24 – 31, 2007	June 1- Aug. 31, 2007
Cool Roofs	May 24 – 31, 2001	June 1- Aug. 31, 2001
	May 24 – 31, 2003	June 1- Aug. 31, 2003
	May 24 – 31, 2005	June 1- Aug. 31, 2005
	May 24 – 31, 2007	June 1- Aug. 31, 2007
Green Roofs	May 24 – 31, 2001	June 1- Aug. 31, 2001
	May 24 – 31, 2003	June 1- Aug. 31, 2003
	May 24 – 31, 2005	June 1- Aug. 31, 2005
	May 24 – 31, 2007	June 1- Aug. 31, 2007

ICLUS_A2

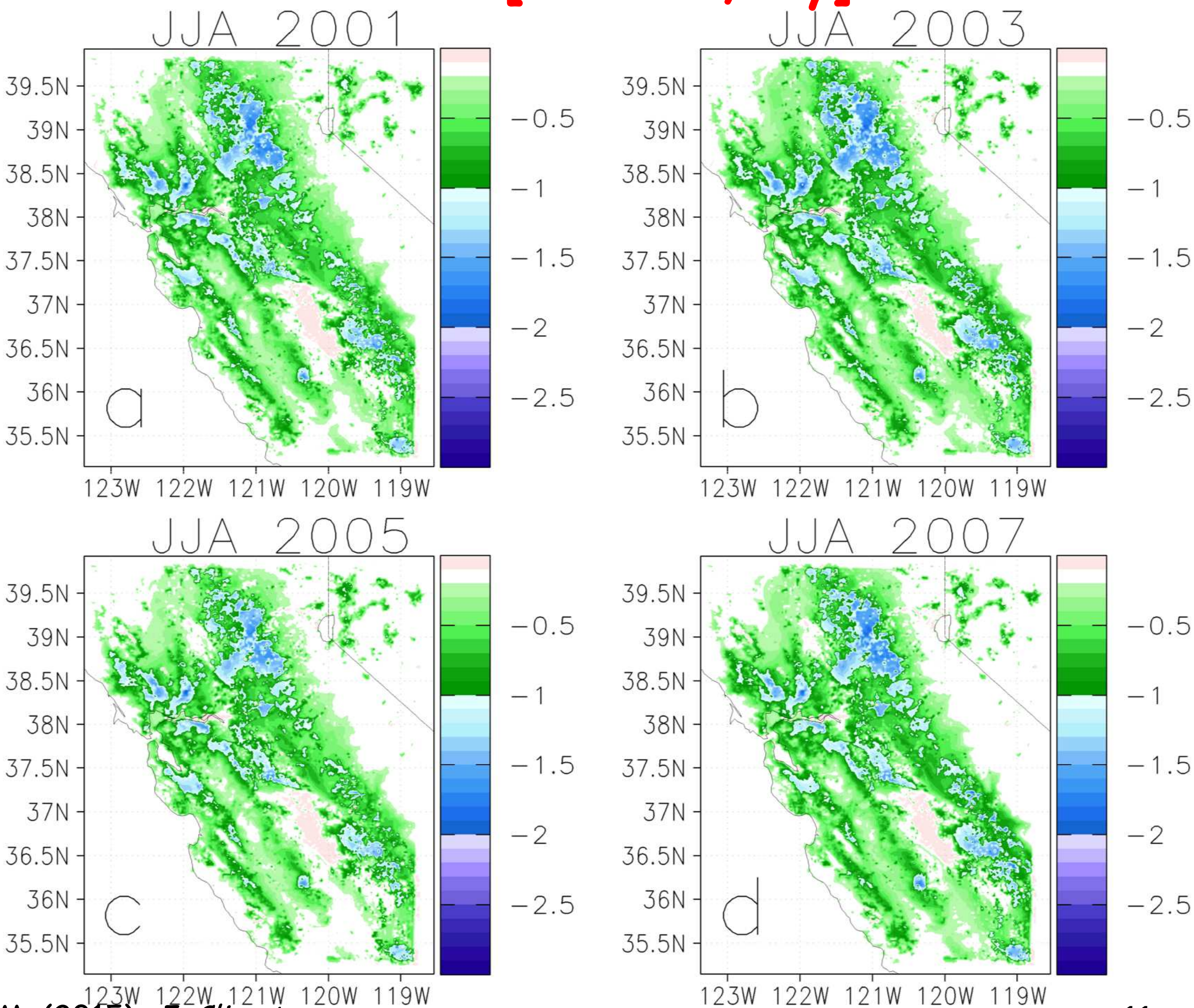
Georgescu, M. (2015), *J. Climate*, **28**, 2544-2563, doi: 10.1175/JCLI-D-14-00290.1

2m Temp difference (°C) [Urban Expansion]: JJA [2km Δx, Δy]



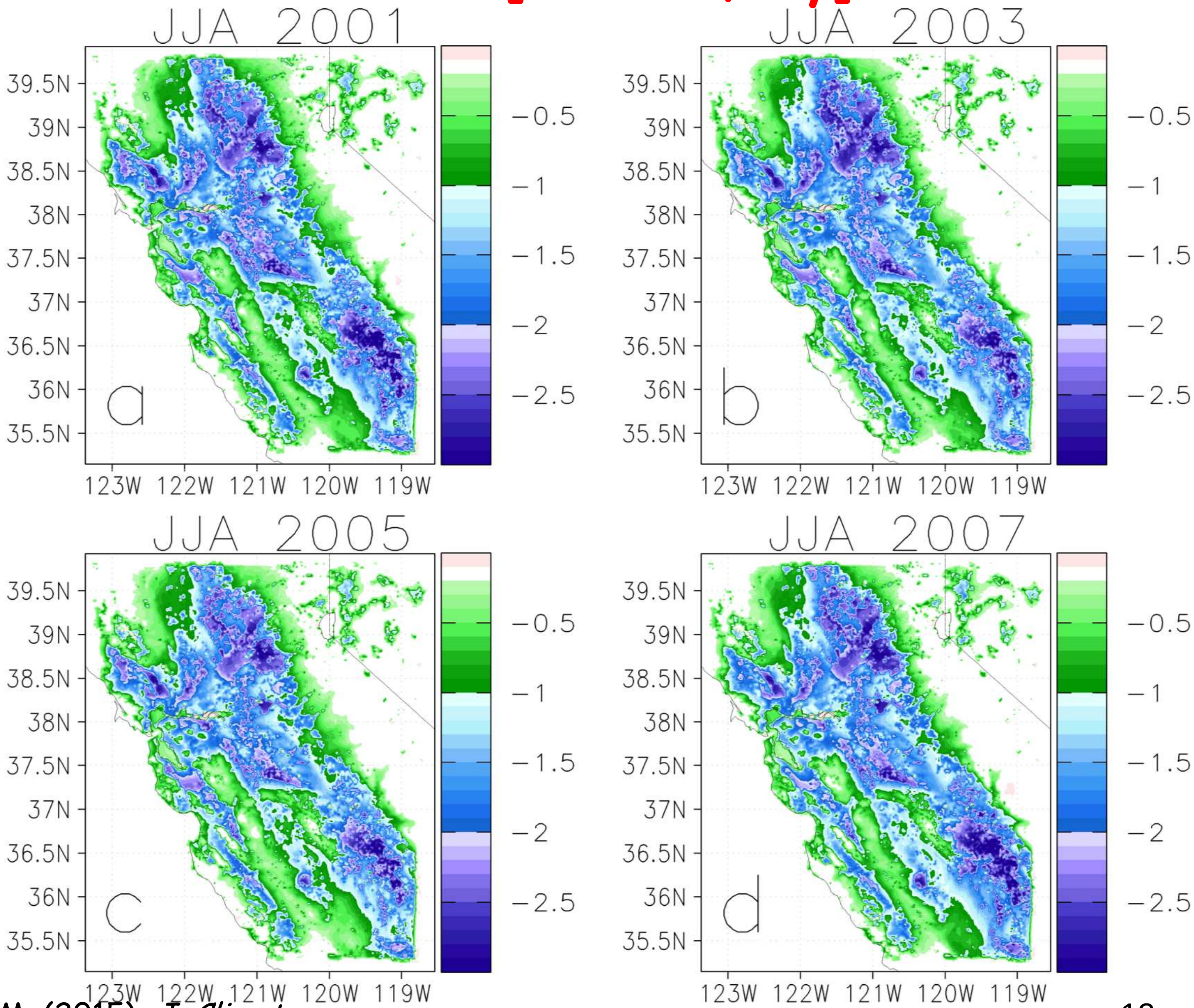
Georgescu, M. (2015), *J. Climate*

2m Temp difference (°C) [Green Roofs]: JJA [2km Δx, Δy]



Georgescu, M. (2015), *J. Climate*

2m Temp difference (°C) [Cool Roofs]: JJA [2km Δx, Δy]



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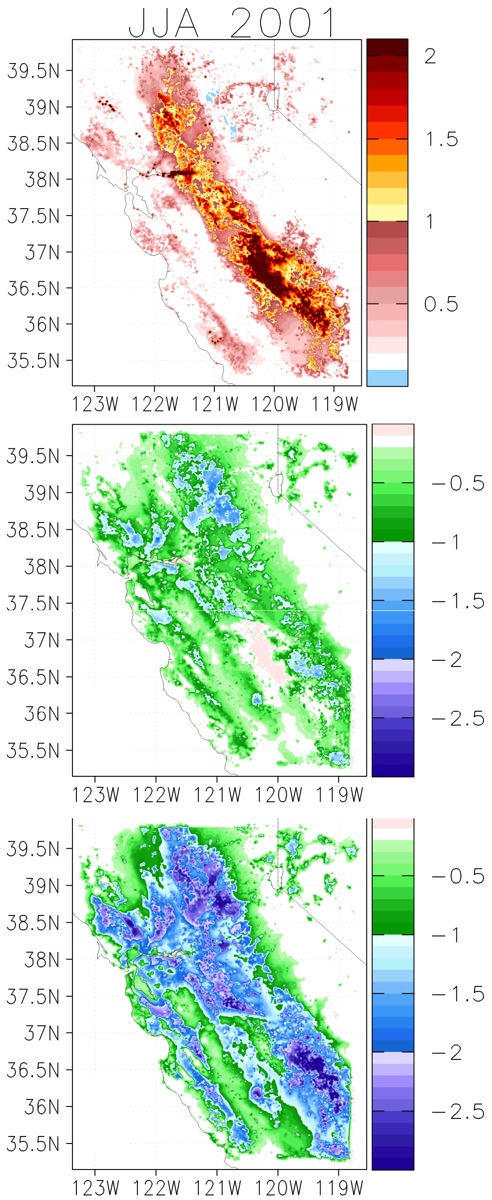
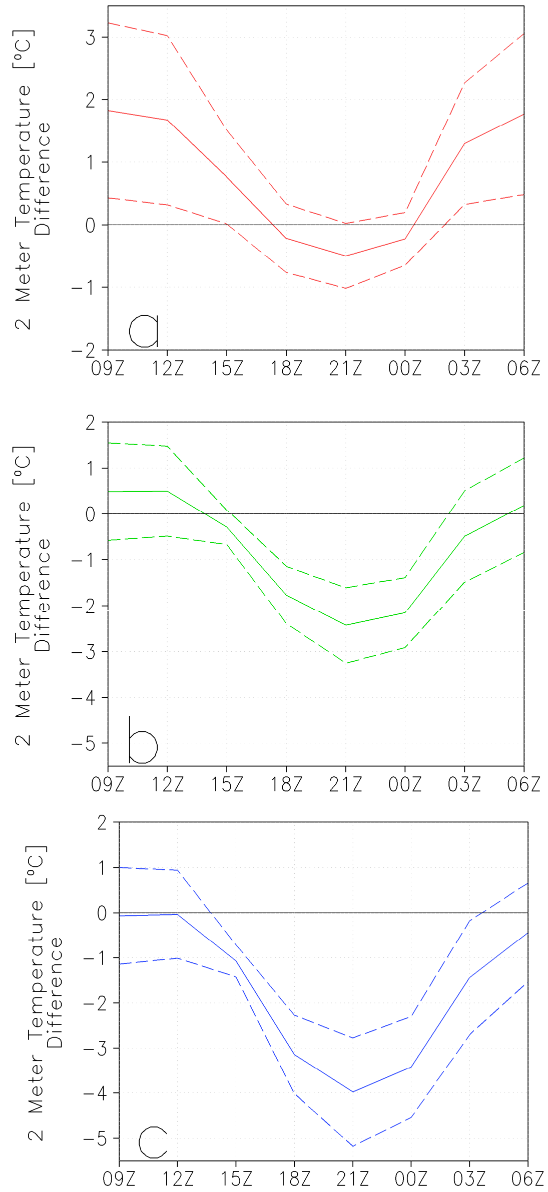
2m Temp JJA difference (°C): Diurnal Cycle



ICLUS_A2-Control

Green Roofs-Control

Cool Roofs-Control



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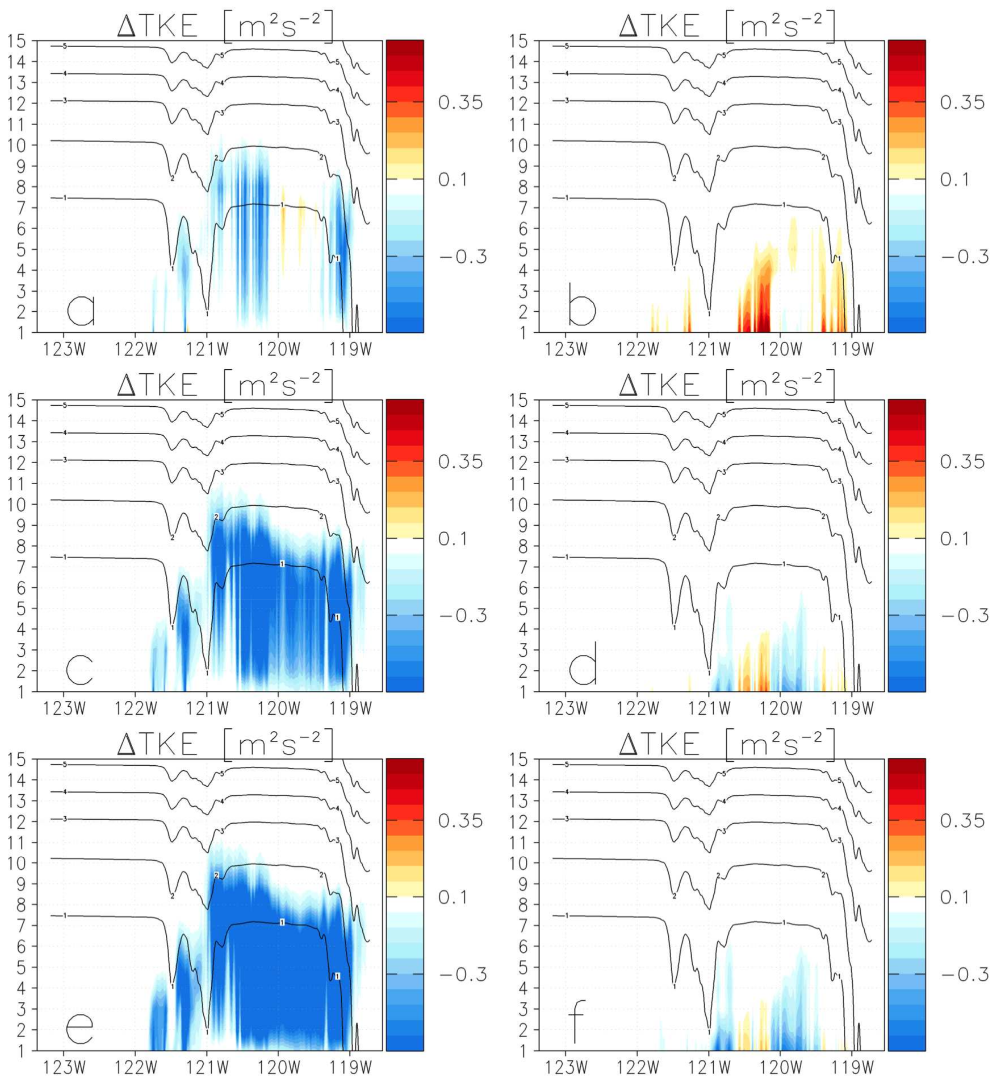
ΔTKE (JJA) difference (m^2s^{-2})



ICLUS_A2-Control (14 LST)

ICLUS_A2-Control (20 LST)

Green Roofs-Control (14 LST)

Green Roofs-Control (20 LST)

Cool Roofs-Control (14 LST)

Cool Roofs-Control (20 LST)

Georgescu, M. (2015), *J. Climate*

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PERSPECTIVE

Prioritizing urban sustainability solutions: coordinated approaches must incorporate scale-dependent built environment induced effects

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Abstract

Because of a projected surge of several billion urban inhabitants by mid-century, a rising urgency exists to advance local and strategically deployed measures intended to ameliorate negative

Conclusions and Acknowledgements

- Consistency between coarse (20km grid spacing) and fine-scale (2km grid spacing) simulations indicates robust climatic representation across scales.
- Urban adaptation strategies reduce DTR > 2°C.
- Urbanization induced hydroclimatic, energy, and air quality impacts require consideration ***in addition*** to similar effects due to GHGs.
- Prioritizing urban adaptation strategies is not straightforward – no silver bullets exist - and requires geographically contextualized evaluation.

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