Projection of Change in Urban Heat Island Intensity of Tokyo Metropolitan Area during Winter

M. Hara[1] (hara.masayuki@jamstec.go.jp), H. Kusaka[2], F. Kimura[1], Y. Wakazuki[1]
[1]RIGC, JAMSTEC, Japan, [2]CCS, Univ. of Tsukuba, Japan

Does the Global Warming modify Urban Heat Island Intensity?

$SAT_{future} = SAT_{present} + \Delta SAT_{global\ warming} + \Delta SAT_{heat\ island}$ **+α?**

Background

Daily Minimum of surface air temperature (SAT) is strongly affected by urbanization in winter

- Trend of annual mean SAT (ºC/100yr)(MEXT et al., 2009)

Areas	Trend (ºC/100yr)
Tokyo	3.0
Sapporo, Nagoya, Osaka, Fukuoka	2.0
all over Japan	1.1
coastal area in Japan	1.0

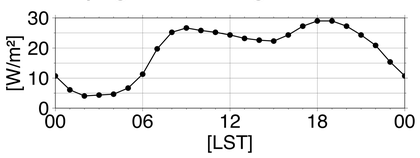
- Trend of max. and min.SAT in Jan.(1936-2007)(JMA, 2008)

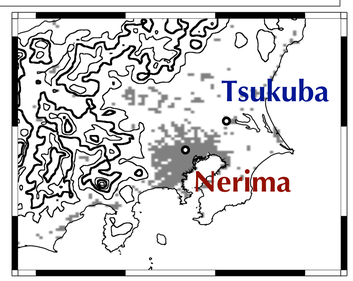
Areas	Trend in min. SAT(ºC/100yr)	Trend in max SAT(ºC/100yr)
Tokyo	7.54	1.58
Japan	2.60	1.44

Simulation Design

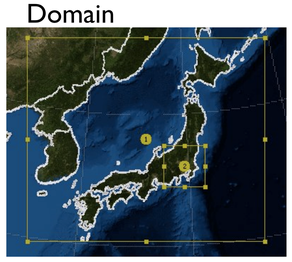
Numerical Model	ARW-WRF V3.1.1
Initial&Boundary	NCEP FNL analysis
Duration	Dec., 2006 (+10 days as spin-up)
Domain	Domain1: 140*120 (dx=15km) Domain2: 120*120 (dx=3km) 45 vertical layers
Land surface scheme and data	Noah LSM&Urban Canopy Model (Kusaka et al., 2001) Landuse: National Land Digital Data (MLIT, 1999)
GCM for PGW exp.	MIROC-medres simulations for CMIP3 (20C3M: 1990-1999, A1b: 2070-2079)

Anthropogenic Heating





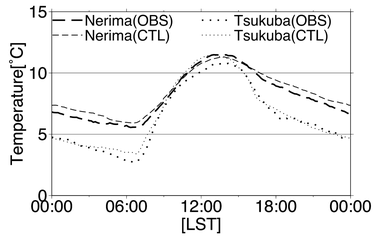
Domain



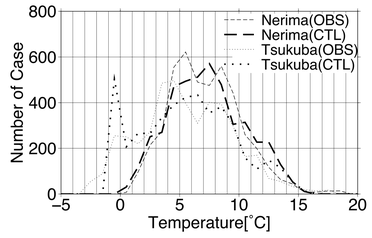
Run Name	Pseudo Global Warming	Urban or Grassland
CTL	× (present climate)	○ (1999's landuse)
CTLNU	× (present climate)	× (urban→grass)
PGW	○ (2070's climate)	○ (1999's landuse)
PGWNU	○ (2070's climate)	× (urban→grass)

Results

Validation of CTL run (AMeDAS vs. CTL)

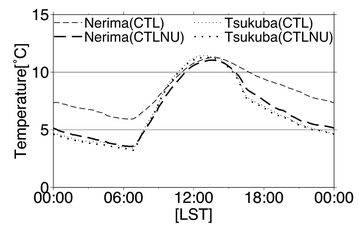


Monthly mean diurnal cycle of SAT

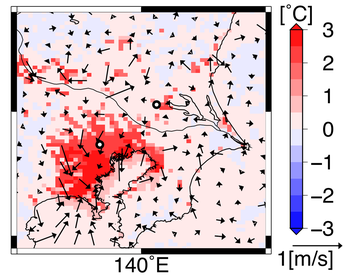


Frequency of appearance of SAT (10 min. snapshot)

Influence of Urban for SAT (CTL vs. CTLNU)



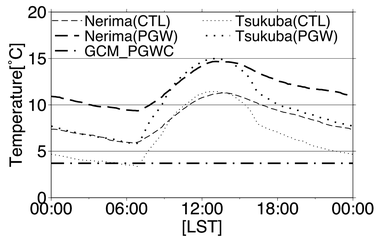
Monthly mean diurnal cycle of SAT



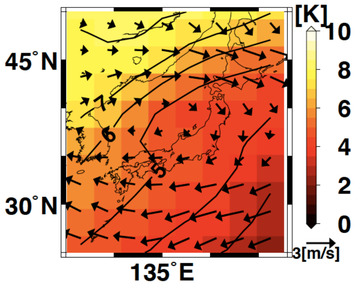
Monthly mean difference of SAT & surface wind at 05LT(CTL-CTLNU)

Large difference in night time over urban areas (similar as past study, c.f. Kimura & Takahashi, 1991)

Influence of Global Warming for SAT (CTL vs. PGW)



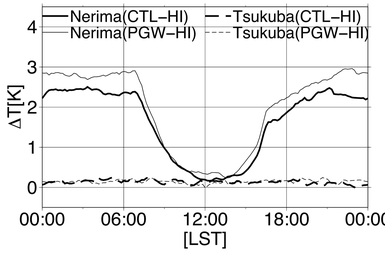
Monthly mean diurnal cycle of SAT



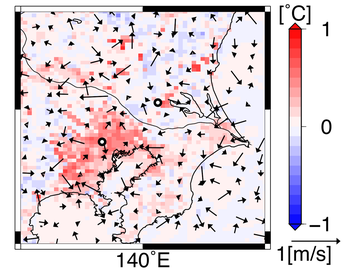
Difference of T & wind at 850hPa in 2070s' & 1990s' in GCM

The difference of PGW and CTL is small. To see the details of the difference, we check urban heat island chenge due to global warming.

Modification of urban heat island due to global warming (PGW-PGWNU vs. CTL-CTLNU)



Monthly mean diurnal cycle of SAT

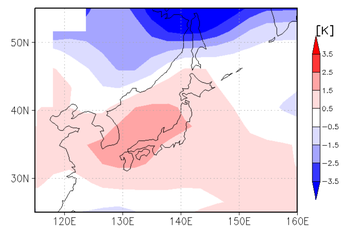


Monthly mean difference of SAT & surface wind at 05LT (PGW-PGWNU)-(CTL-CTLNU)

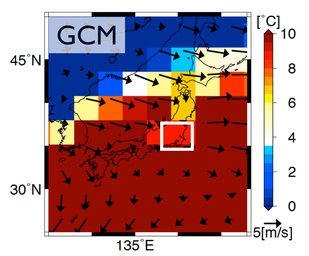
Modification is large in nighttime over urban areas (max. 0.5ºC; ~20% of the total increase of SAT)

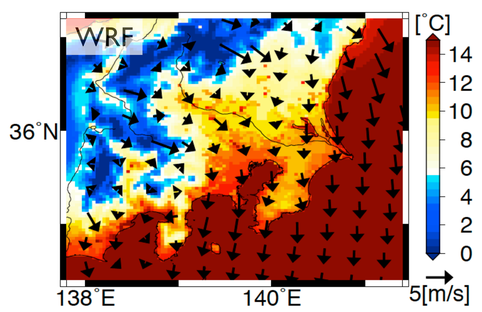
Summary

- $SAT_{future} = SAT_{present} + \Delta SAT_{global\ warming} + \Delta SAT_{heat\ island}$ **+α**
- large scale climate change over Japan
  - anti-cyclonic circulation in lower troposphere
  - more stable in lower troposphere
  - change in cloud appearance and PBL
  - urban heat island intensity change
- To estimate the uncertainty, more simulations using other GCMs, and/or longer simulations are essential.
- Downscaling is one of the most useful way to estimate urban-scale climate.



θ_{700hPa}-θ_{925hPa} in 2070s' &1990s'





Monthly mean SAT in Dec. 2070's