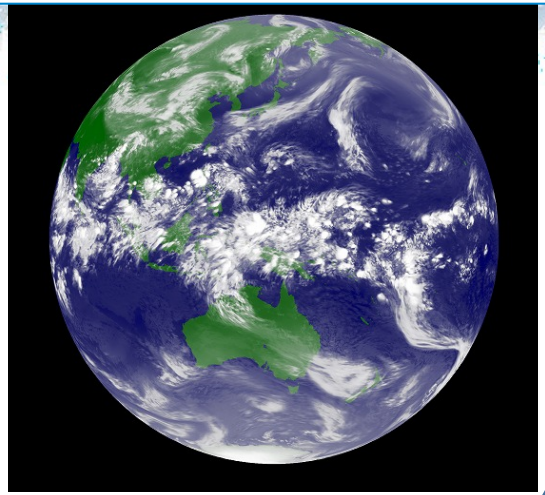
2014年4月10日　CCS-LBL Workshop
12時00～12時30分

Overview for Urban Climate Study

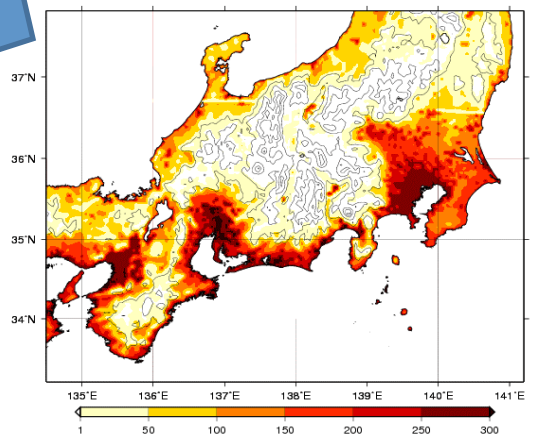
Associate Prof. of CCS
Hiroyuki Kusaka

GCM with 100km mesh

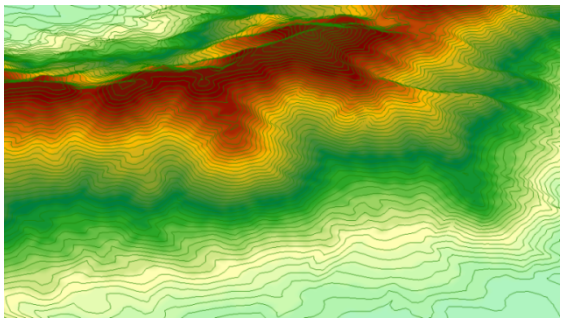


LES with 5m mesh
(Mitigation of UHI)

WRF/UCM
with 5km mesh
(Future climate)



Local Wind Model
With 50m mesh
(Wind power)



Dynamical downscaling
by the WRF and LES

Research Themes related with HPC

Developing Urban Canopy Model (UCM) and Dynamical Downscaling by the WRF/UCM model

Hiroyuki Kusaka, Asuka Suzuki-Parker, Doan Quang Van

Developing Local Wind Model

Ryosaku Ikeda, Takayuki Kato, Akifumi Nishi

Developing building-resolving LES Model

Ryosaku Ikeda, Yuko Akimoto

Research Themes related with HPC

Developing Urban Canopy Model (UCM) and Dynamical Downscaling by the WRF/UCM model

Hiroyuki Kusaka, Asuka Suzuki-Parker, Doan Quang Van

Developing Numerical Local Wind Model

Ryosaku Ikeda, Takayuki Kato, Akifumi Nishi

Developing LES Model

Ryosaku Ikeda, Yuko Akimoto

Improving the WRF model

(10^0) km spatial resolution

WRF is a regional model used in the world wide

2001

Kusaka-Model (one of the 1st UCM)

2004 WRFV2

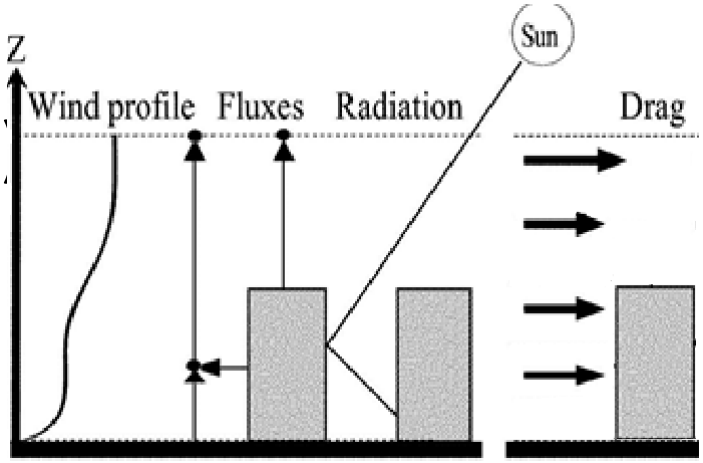
Coupling WRF with UCM

2006 WRFV2.2

Official Release WRF with UCM from NCAR (ucm option 1)

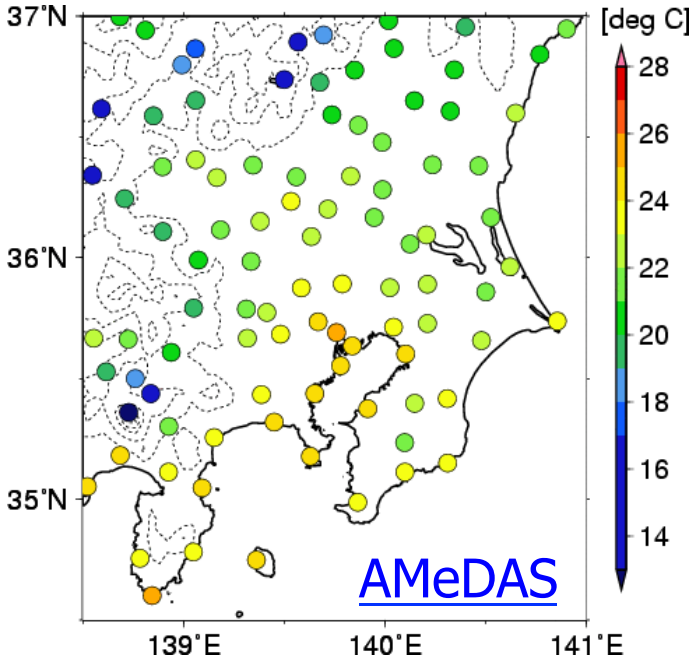
2008 WRFV3.0

Many researchers use WRF for Regional Climate Projection

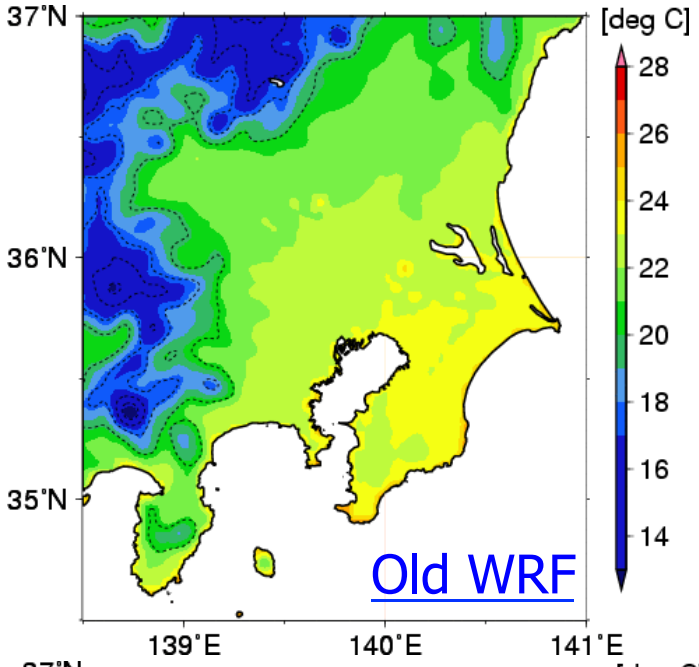


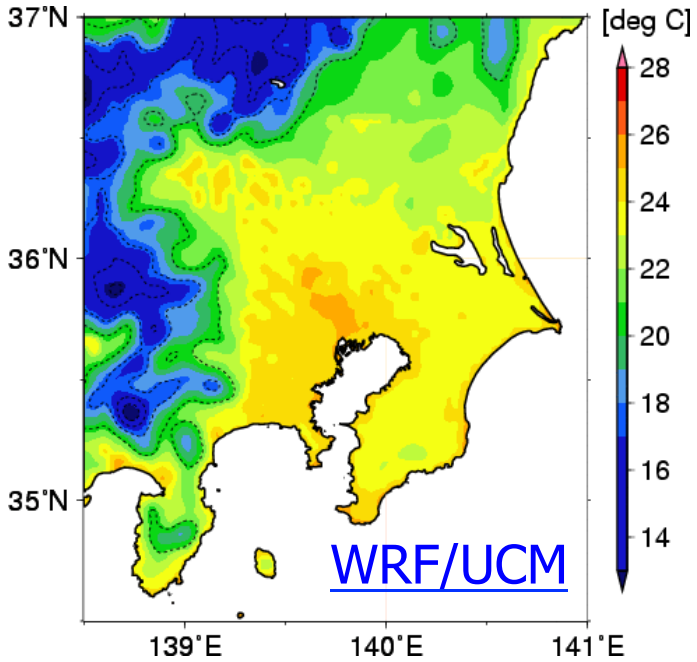
Kusaka Model is a standard UCM in the world and the number of citation of Kusaka (2001, BLM) is 361 times(google) and 161 (ISI web of science).

Impact of Coupling WRF and UCM



Temperature at 05 JST (August mean)

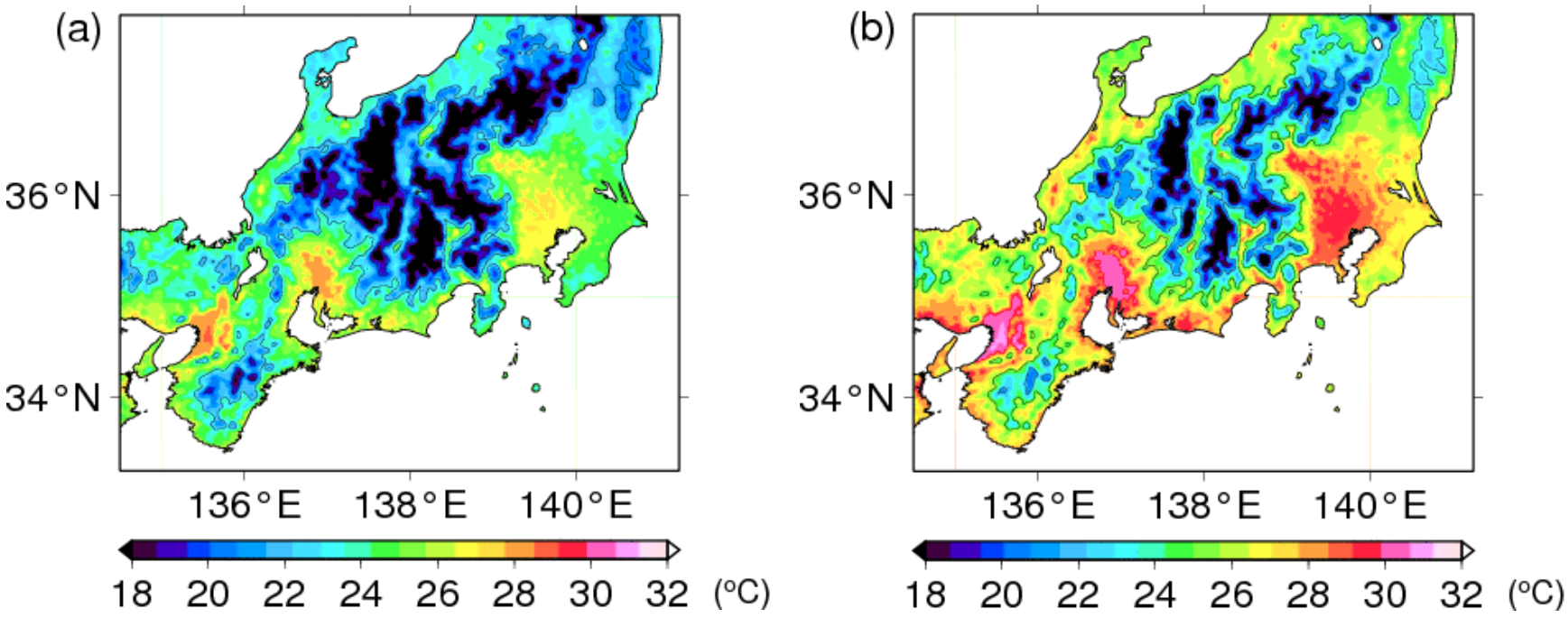




Kusaka et al. (2012a, JMSJ)

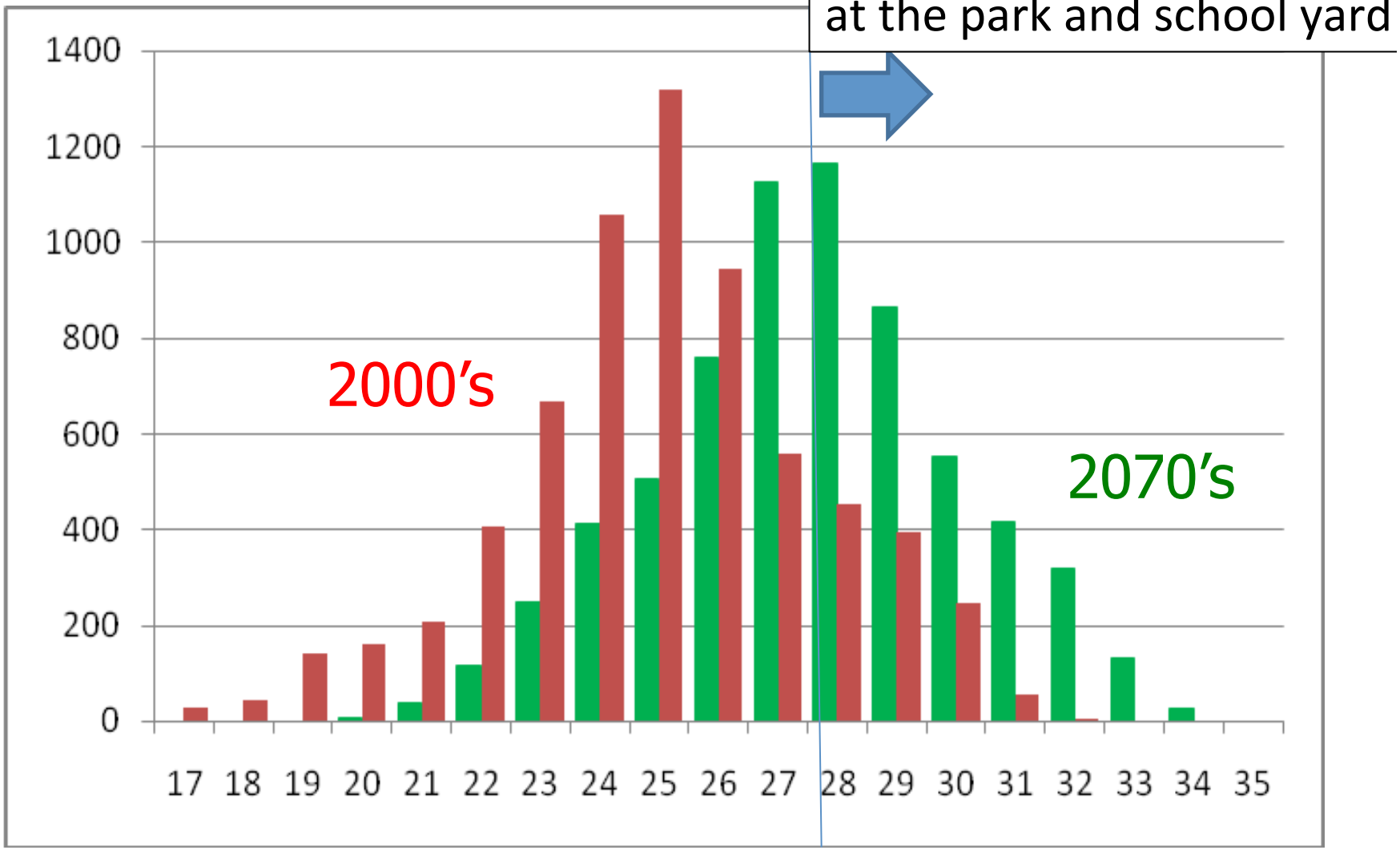
Regional Climate Projection by WRF/UCM

2000s **2070s**

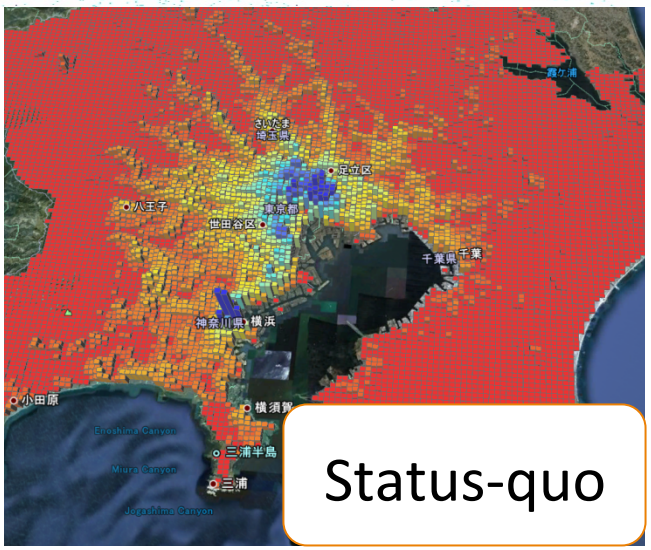


Kusaka et al. (2012b, JMSJ)

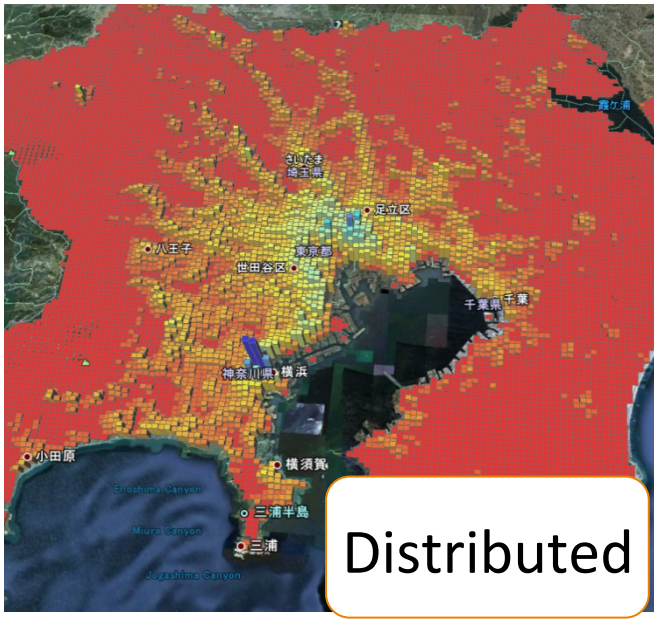
WBGT (heat index) at Tokyo
2000's vs 2070's summer



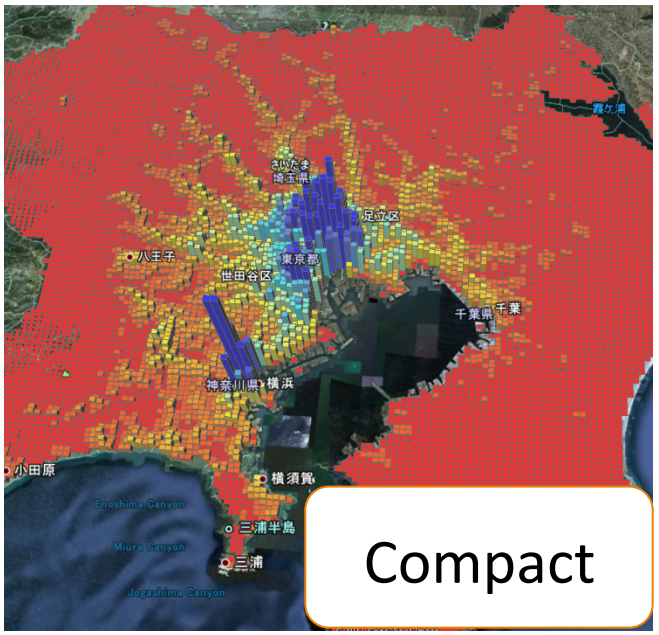
Our life style could mitigate future uncomfortable urban thermal environment.



Status-quo



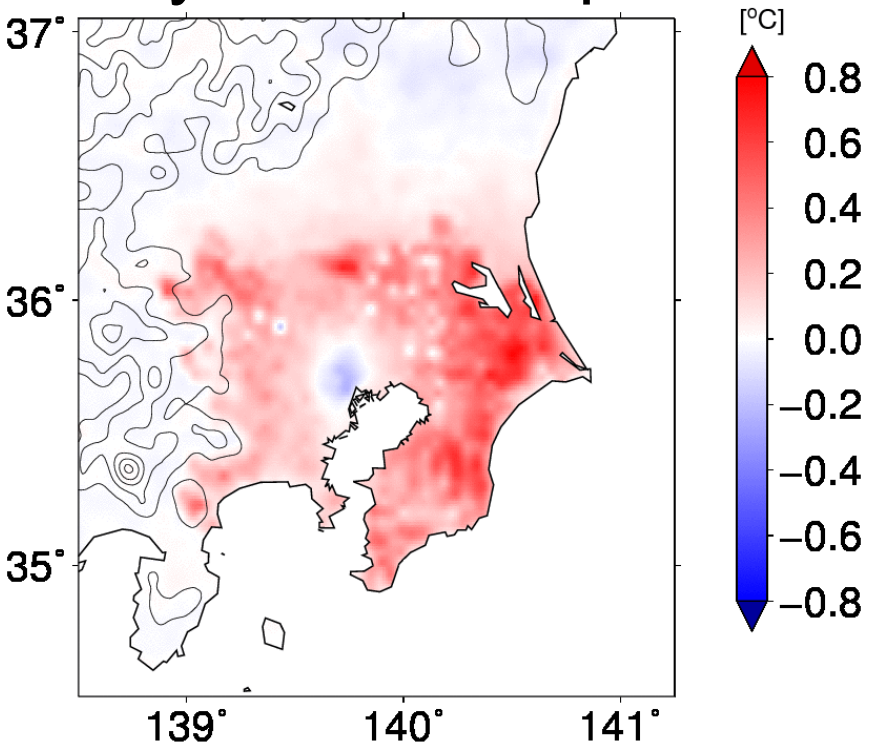
Distributed



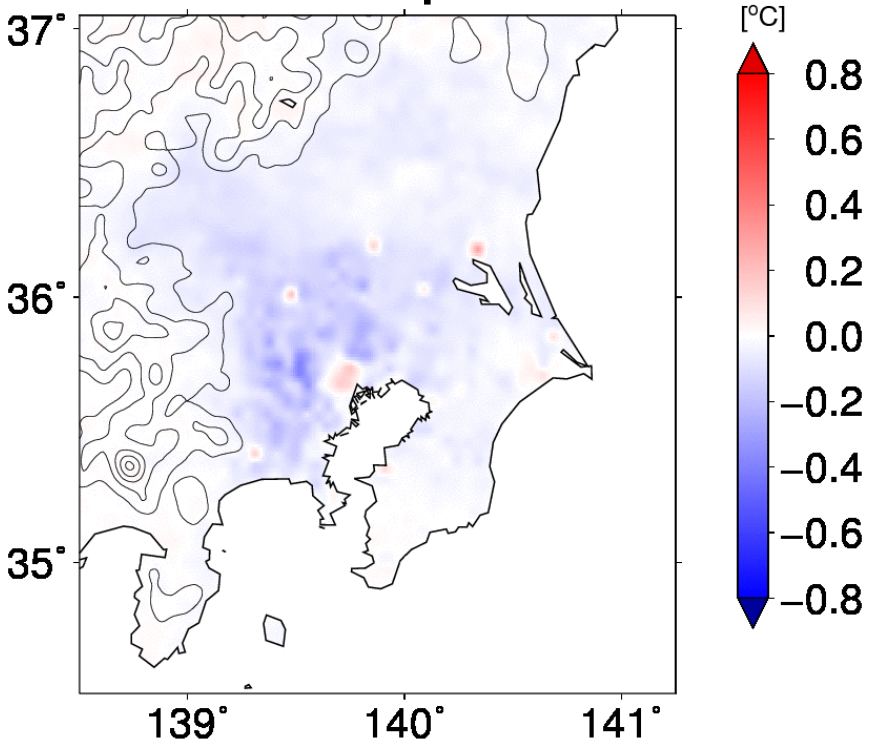
Compact

Which will you select, distributed or compact city?

- Impact of distributed city on the temperature



- Impact of compact city on the temperature



Energy Saving of 1.6 Billion kW ~ Nuclear-generated electric power

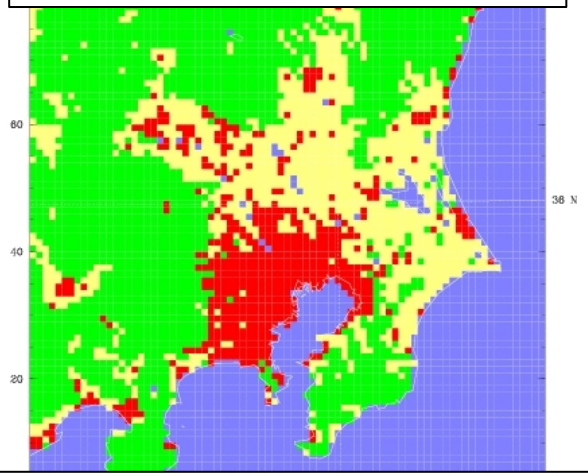
Impact of Urbanization on Precipitation Climatology in Tokyo

Many people concern urban impact on precipitation.

Observational study says
Yes (Fujibe et al. 2009, SOLA)
No (Kanae et al. 1999, JMSJ)

Note: Non-linearity (Chaos nature) in precipitation simulation brings large uncertainty in conclusion from a standard sensitivity experiment. Thus, there are still under discussion on this issue.

CTRL experiment



No Urban experiment

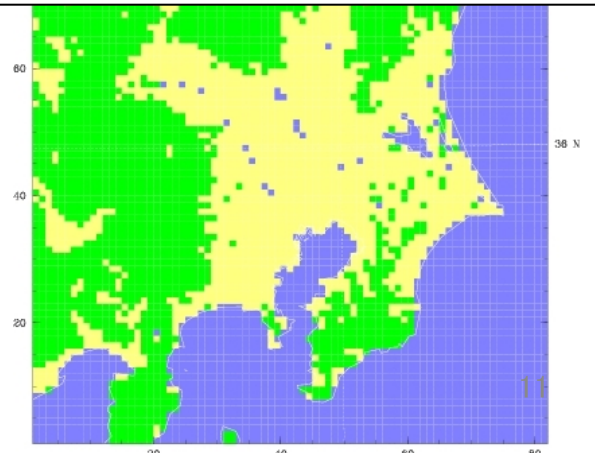
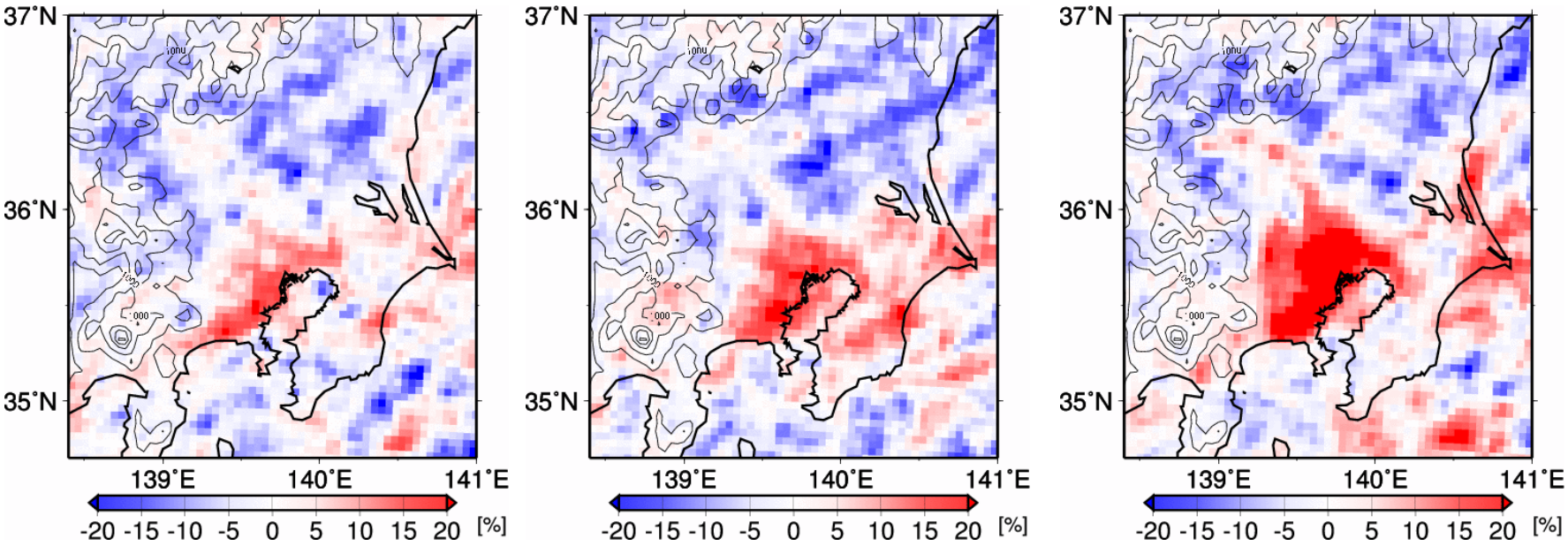
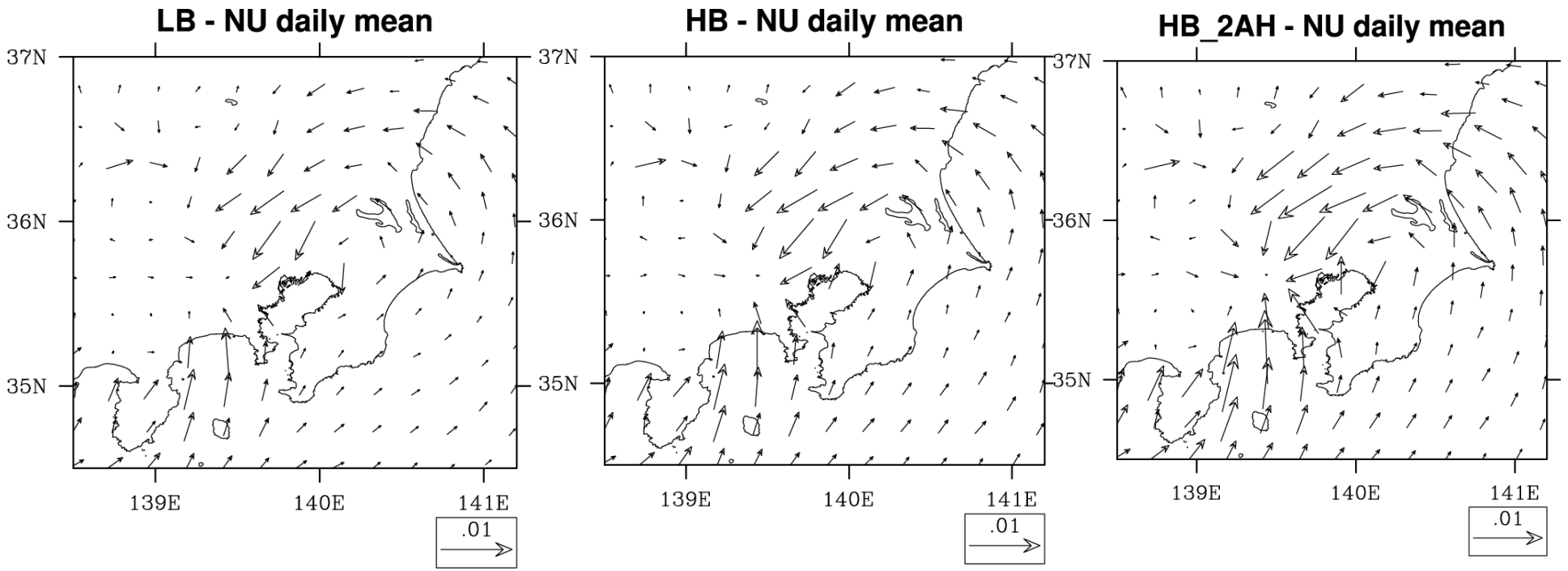


Fig.6: Urban impacts on the monthly precipitation amount in August during the 8-year period (2001-2008). (a) Residential city scenario case. (b) Commercial city scenario case. (c) Commercial city with double anthropogenic heat scenario case. Red and blue indicate the increase and decreased precipitation amount by existence of the urban areas, respectively. All results are an ensemble mean from the four WRF members.



Kusaka et al. (2014, JAMC)

Fig.14: Urban impacts on the horizontal moisture flux at 200 m level in August during the 8-year period (2001-2008). (a) Residential city scenario case. (b) Commercial city scenario case. (c) Commercial city with double anthropogenic heat scenario case.



Kusaka et al. (2014, JAMC)

Research Themes related with HPC

Developing Urban Canopy Model (UCM) and Dynamical Downscaling by the WRF/UCM model

Hiroyuki Kusaka, Asuka Suzuki-Parker, Doan Quang Van

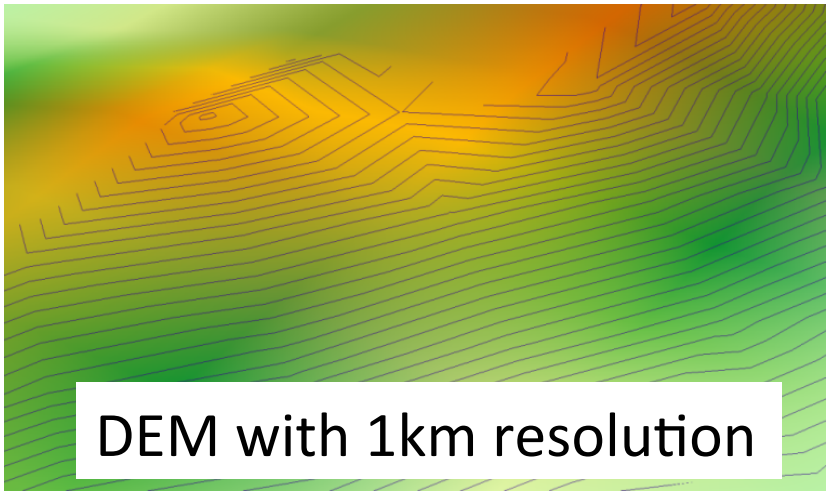
Developing Local Wind Model

Ryosaku Ikeda, Takayuki Kato, Akifumi Nishi

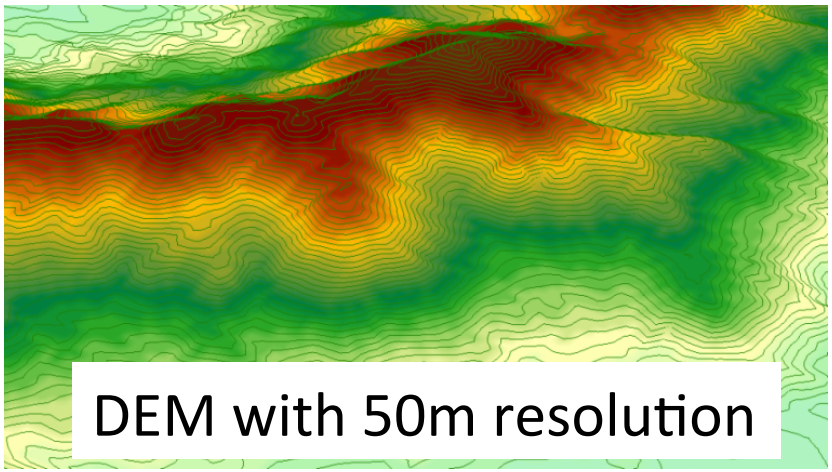
Developing LES Model

Ryosaku Ikeda, Yuko Akimoto

Developing Local Wind Model for the Complex Terrain



DEM with 1km resolution



DEM with 50m resolution

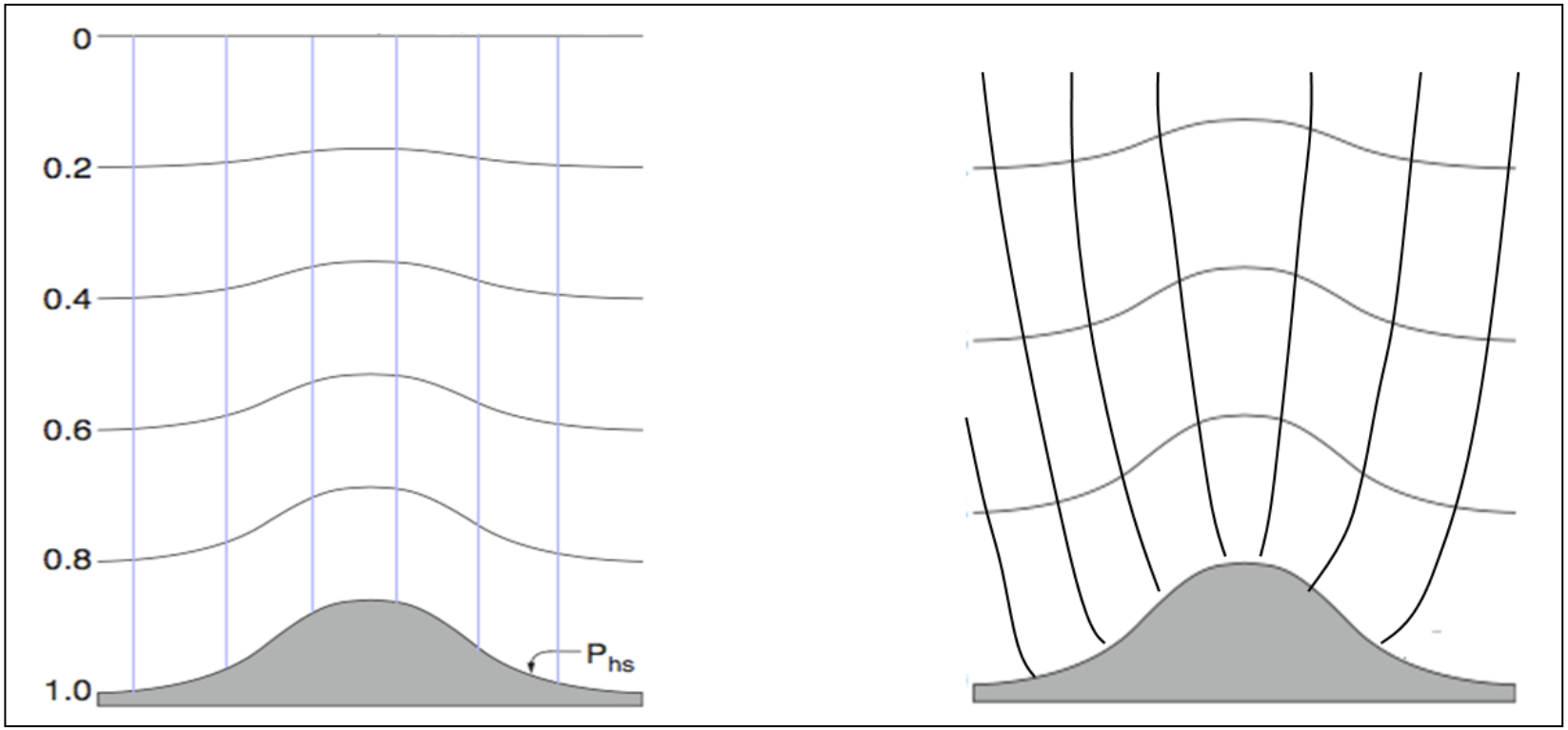
Higher and higher spatial resolution of Meteorological model.

(10^1) m spatial resolution

Grid-system and turbulence parameterization are recently significant issues.

RANS model can be used for lower than 500 m resolution

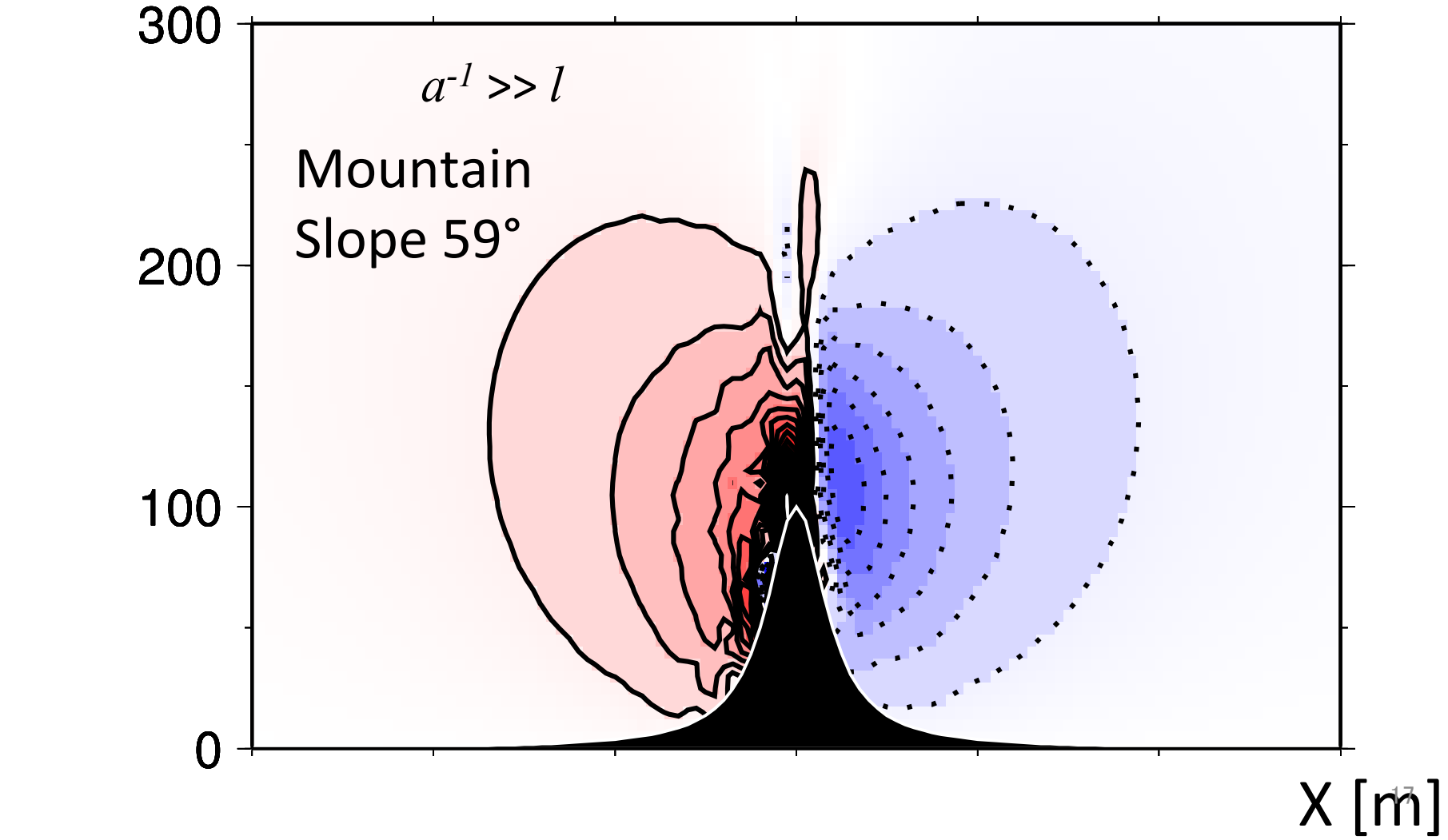
LES model can be used for higher than 100 m resolution



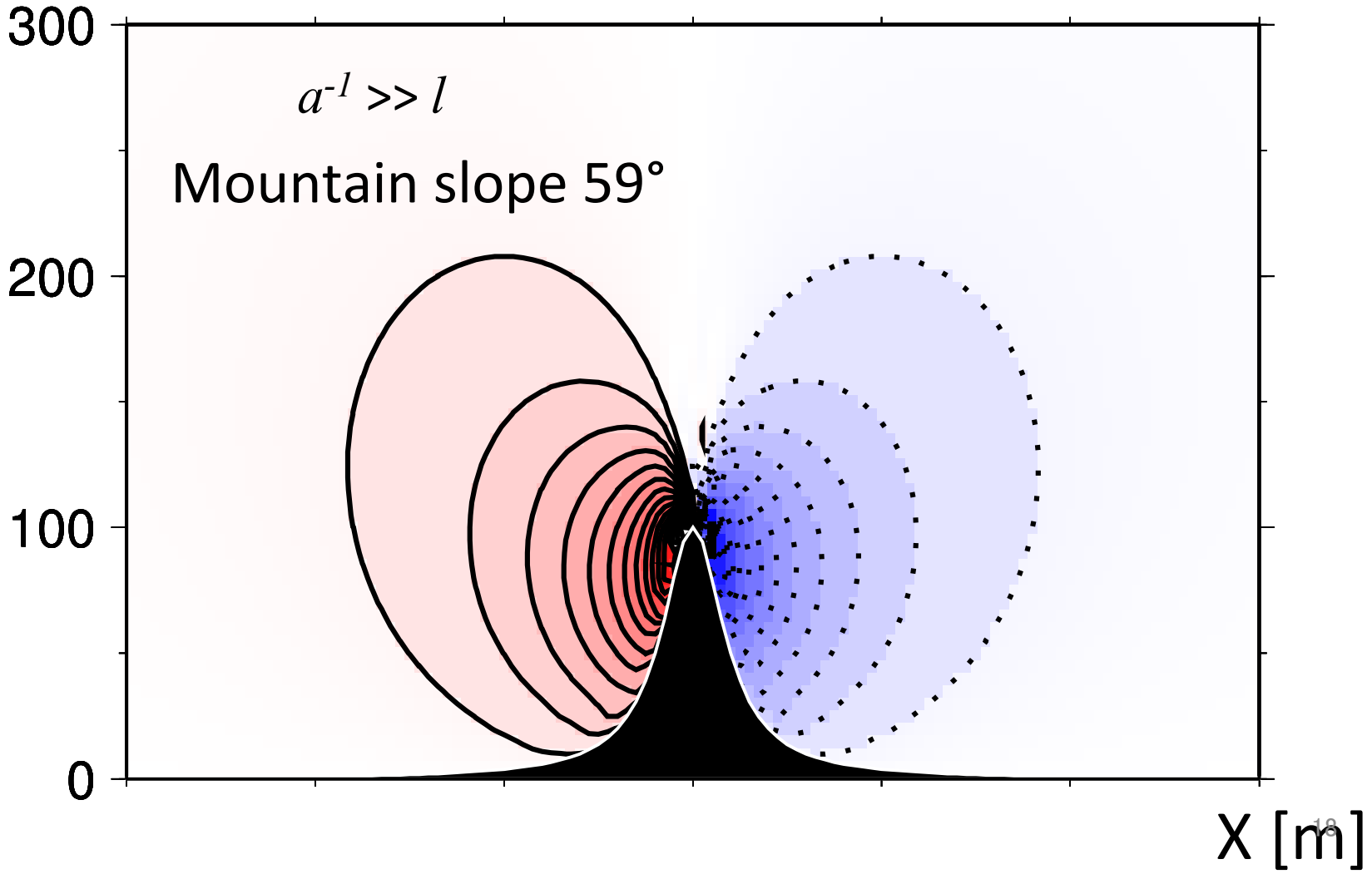
RANS with terrain-following coordinate
（NHM, WRF, RAMS, many RCMs and GCMs）

LES with generalized curvilinear coordinate (our Local Wind model)

Simulated w from our model
with terrain-following coordinate



Simulated w from our model with Generalized curvilinear coordinate



Research Themes related with HPC

Developing Urban Canopy Model (UCM) and Dynamical Downscaling by the WRF/UCM model

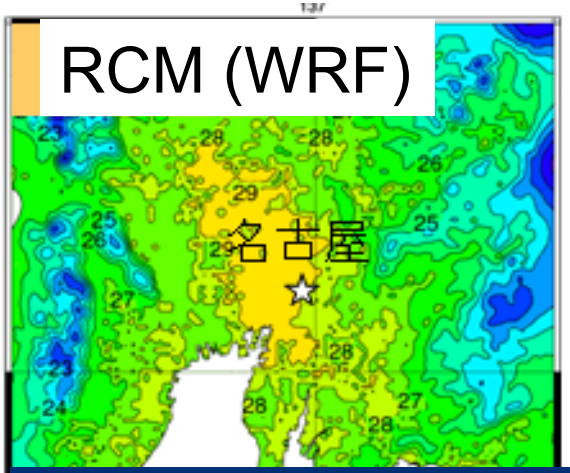
Hiroyuki Kusaka, Asuka Suzuki-Parker, Doan Quang Van

Developing Numerical Local Wind Model

Ryosaku Ikeda, Takayuki Kato, Akifumi Nishi

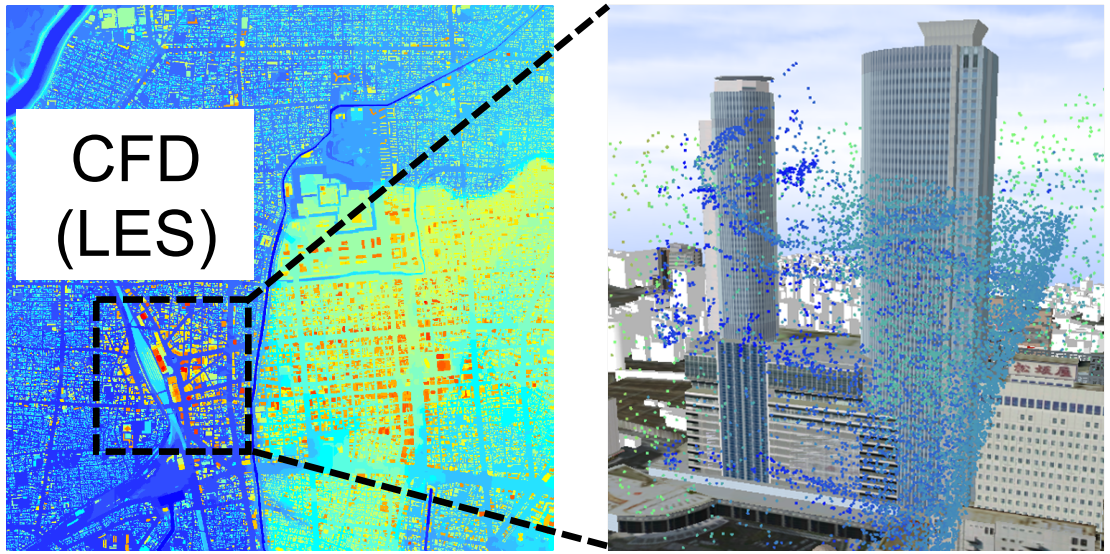
Developing building-resolving LES Model

Ryosaku Ikeda, Yuko Akimoto



The purpose is developing a new city-LES model and dynamical downscaling system by coupling WRF and LES.

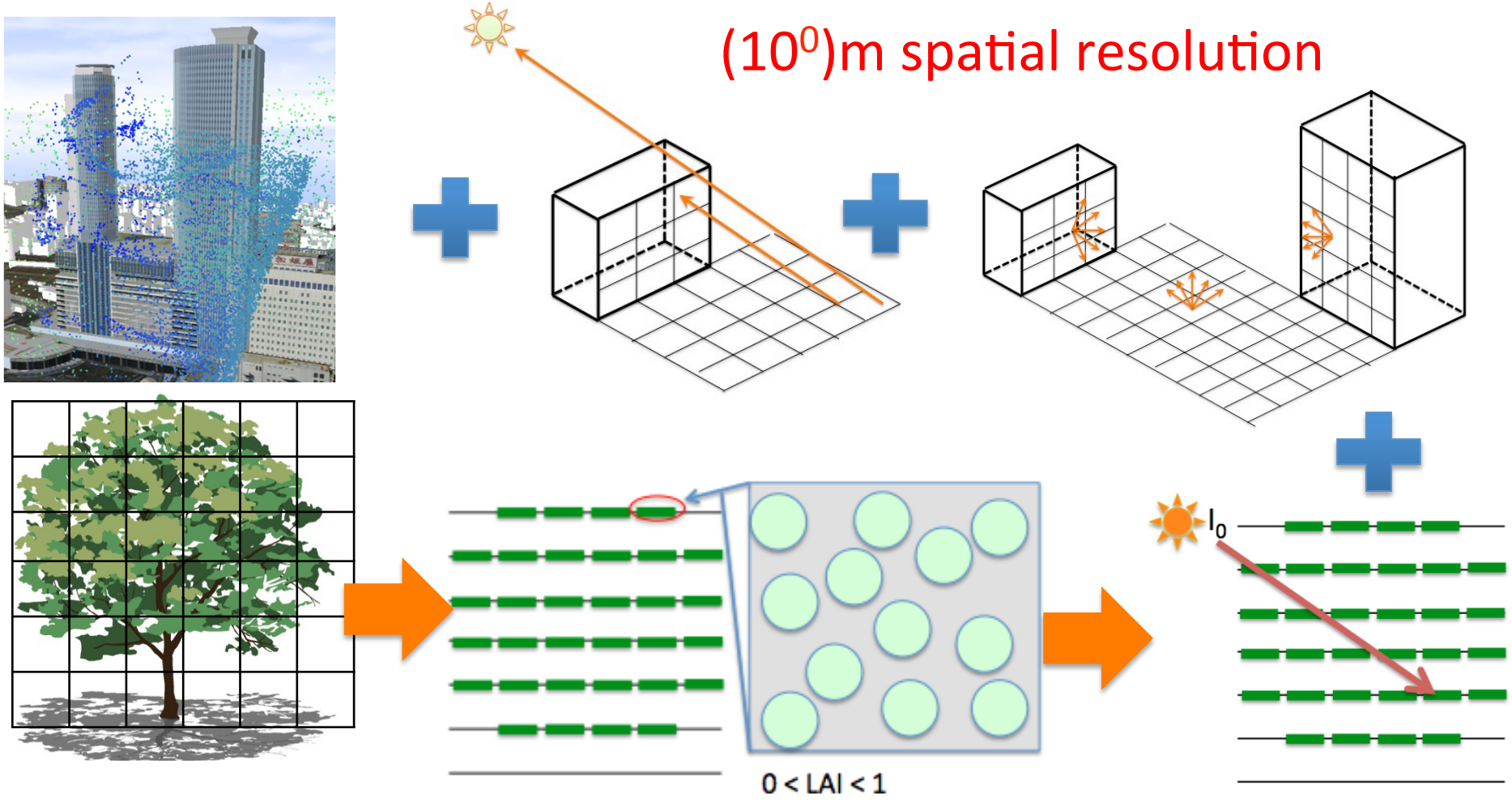
Collaboration between Meteorologists, engineering CFD researchers, HPC researchers must be the most important to solve the issue.



From Nagoya Univ. Prof. S. Iizuka

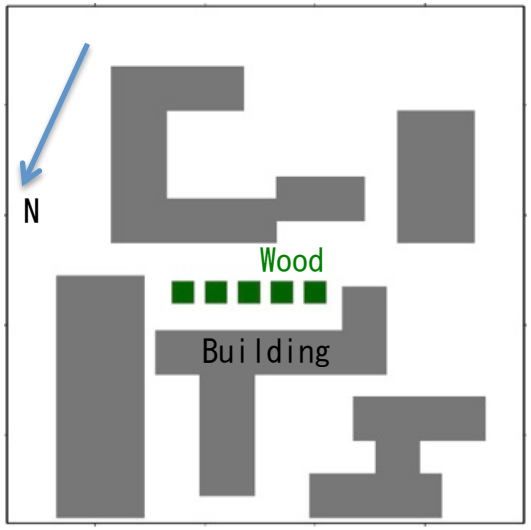
Building-resolving LES (our team's original):

(1) Basic equation and physics schemes comes from meteorological model, (2) LES with building-resolving technique comes from engineering CFD, (3) Radiations in the urban canopy layer come from the engineering CFD technique.



Test simulation about radiations and surface temperature in the canopy layer

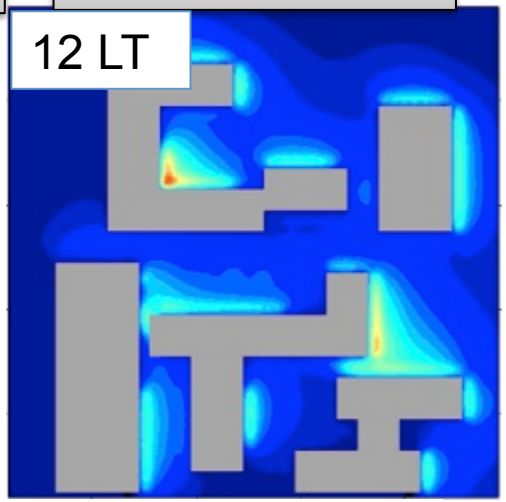
Buildings in our campus

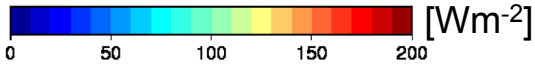


Date	Sep 1
Albedo	0.2
Emissivity	0.98
LAI	0.8

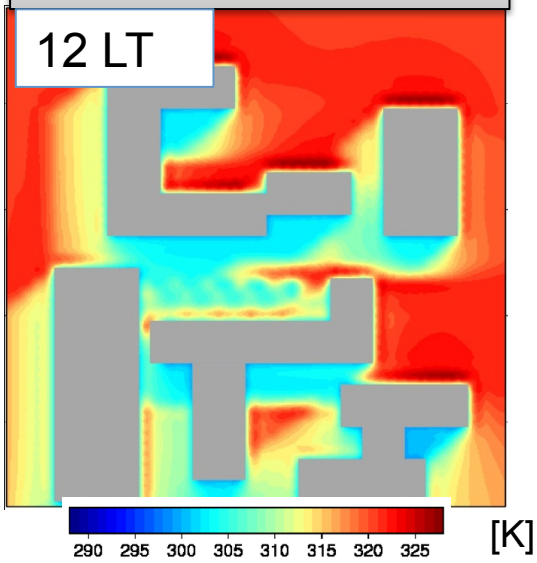
Solar direct radiation

Solar diffusive





Surface temperature

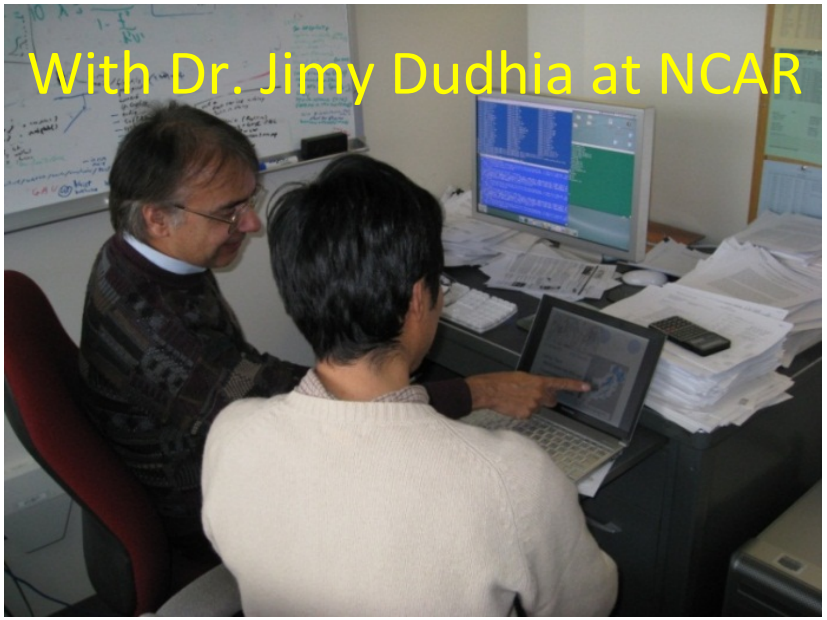


1 m spatial resolution

10^9 grids (1000*1000*1000)

Collaboration with International Institute

2013-	Badan Meteorologi, Klimatologi dan Geofisika (BMKG), Indonesia	Application of the GUI-based dynamical downscaling system
2012-	台湾中央研究院 (Academia Sinica), Taiwan	Dynamical downscaling for Taipei Urban Climate Study
2007-	NCAR, USA Jimy Dudhia, Fei Chen, Roy Rasmussen	Improving the WRF model Developing LES-Bin model



References

Kusaka, H., Nawata, K., Suzuki-Parker, A., Takane, Y. and Furuhashi, N., 2014: Mechanism of precipitation increase with urbanization in Tokyo as revealed by ensemble climate simulations, J. Appl. Meteor. Clim., 53, 824-839.

Urban Impact on precipitation climatology

Kusaka, H., Hara, M., Takane, Y., 2012: Urban climate projection by the WRF model at 3-km horizontal grid increment: Dynamical downscaling and predicting heat stress in the 2070's August for Tokyo, Osaka, and Nagoya metropolies. J. Meteor. Soc. Japan., 90B, 47-63.

Regional climate projection (urban-scale)

Ikeda, R. and Kusaka, H., 2010: Proposing the simplification of the multilayer urban canopy model: Intercomparison study of four models. J. Appl. Meteor. Clim., 49, 902-919.

Urban climate modeling

Thank you for your attention