Heat Island and Urban Climate

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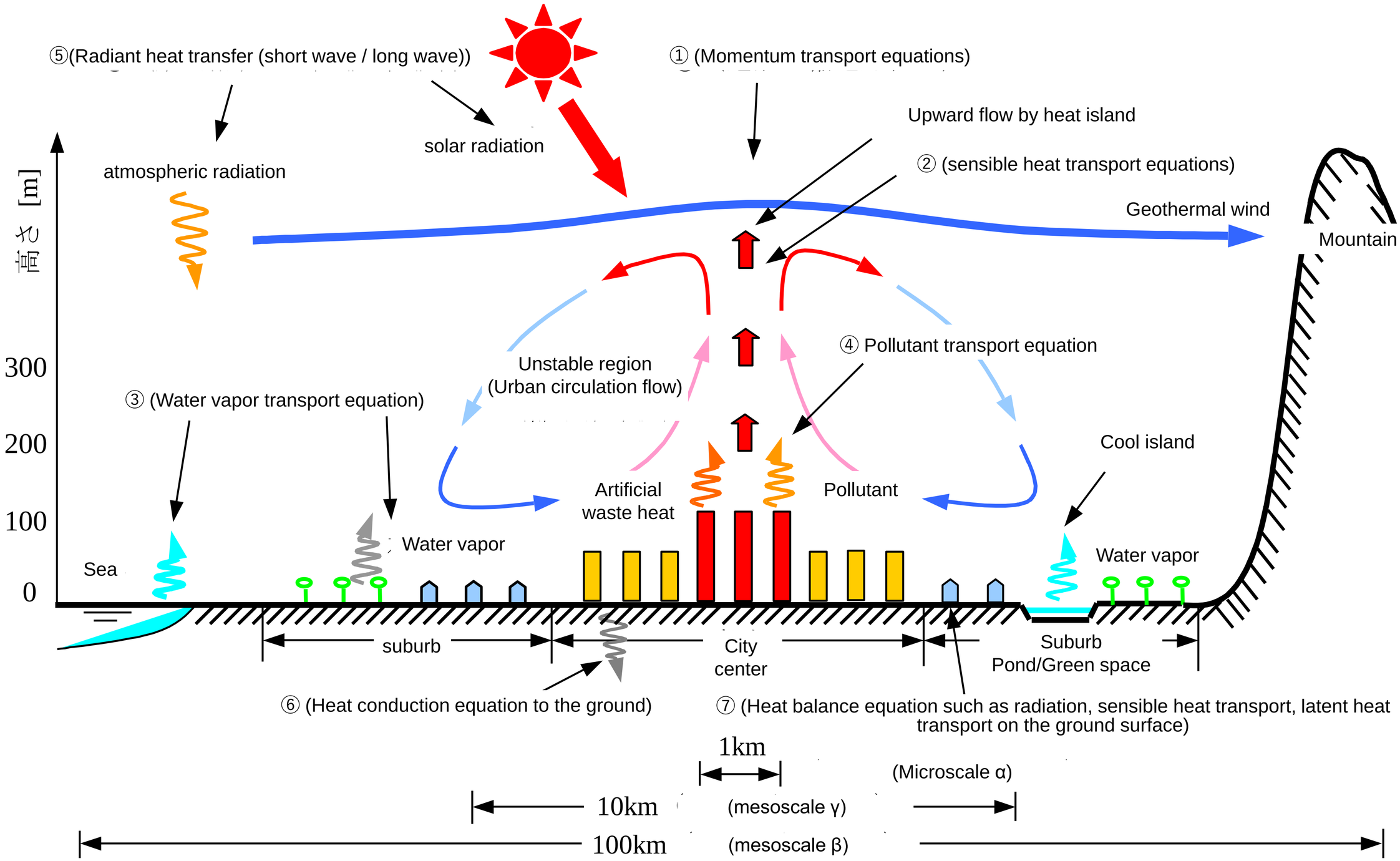
Kato Lab., Ooka Lab., and Kikumoto Lab.

The Concept of Urban Climate



Urban climate analysis using MM5

MM 5 (The Fifth-Generation NCAR / Penn State Mesoscale Model)

Community model provided by NCAR (National Center for Atmospheric Research). In the early 1970s, various improvements were added based on the mesoscale model developed by Anthes. Features of MM5 are as follows.

(I) Introduction of non-hydrostatic pressure model

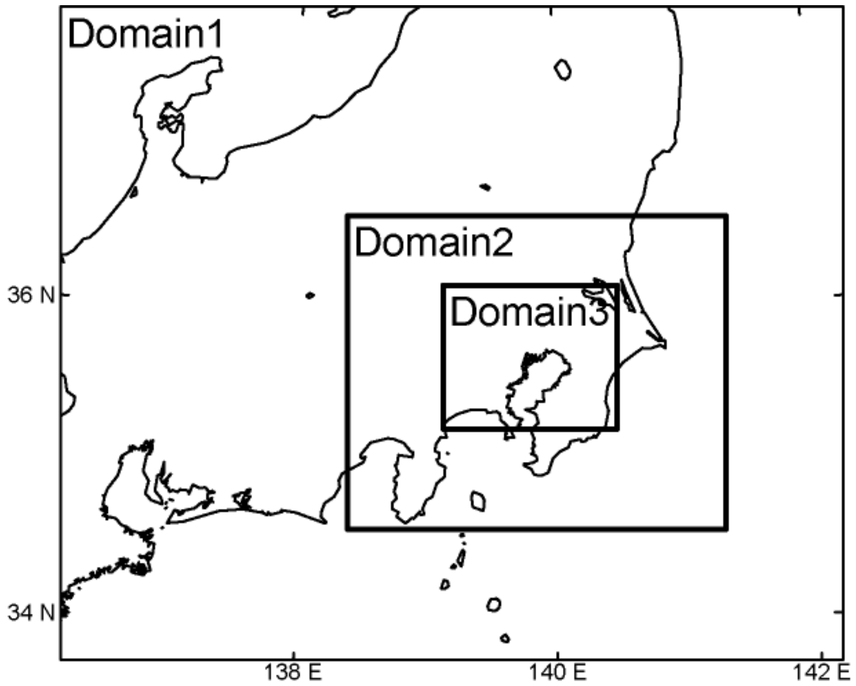
(Ii) Various physical options (cloud physics, rainfall, turbulence model, etc.)

(Iii) Multi-stage nesting · 2-way nesting possible

(Iv) Create initial field from observation data etc.

(V) 4 dimensional assimilation possible

(Vi) Available on various platforms



Analysis region

Mesh split

	Mesh split X × Y	Horizontal mesh width [km]
Domain1	50 × 60	9
Domain2	78 × 87	3
Domain3	99 × 120	1

Comparison between static model and non-hydrostatic model

Analysis date: August 4, 2005 9: 00 ~ 6 0:00

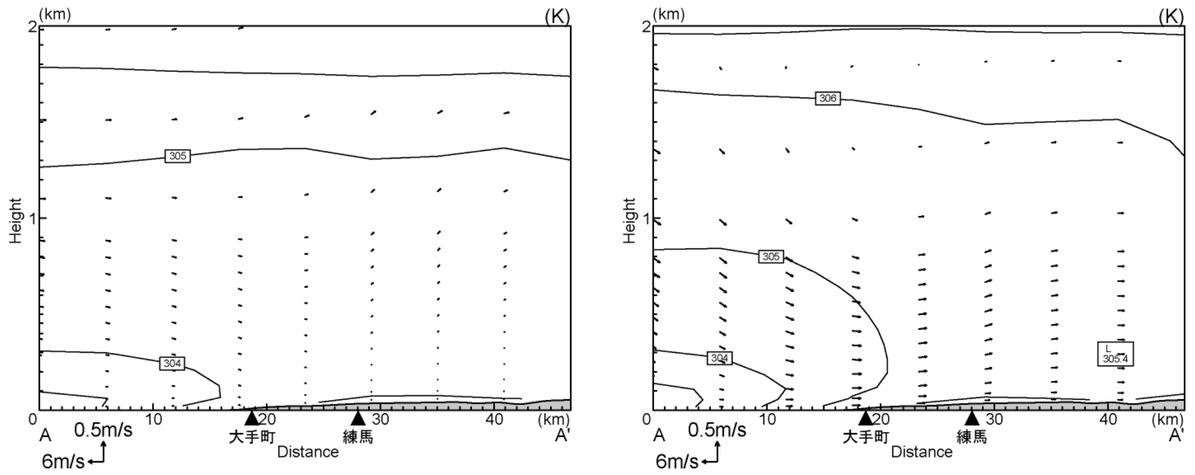
Analysis model: MM5 ver.2.12

Turbulence model: MRF PBL scheme

Radiation model: Radiation scheme by Dudhia

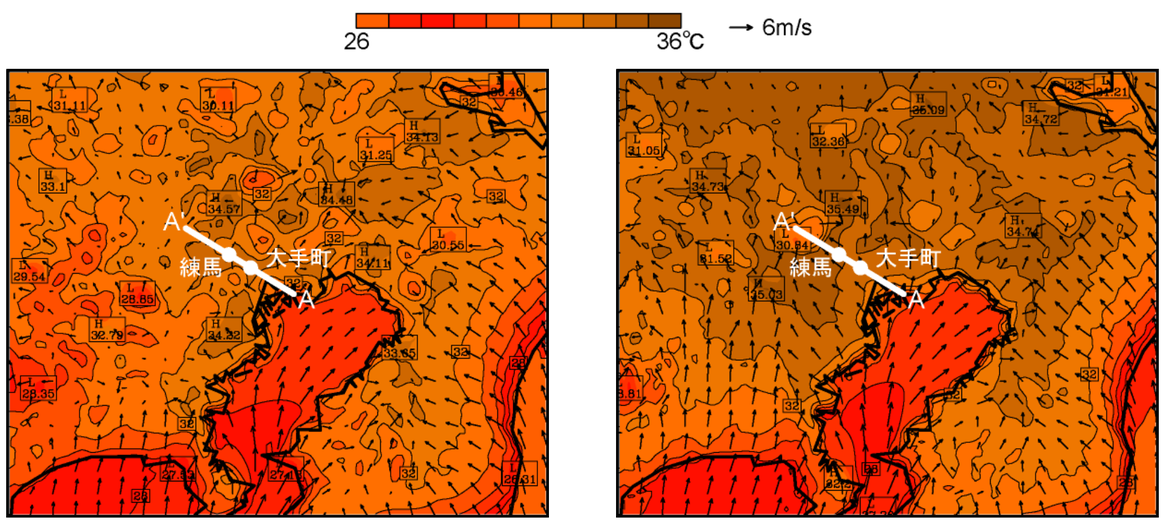
Initial condition: initial field created from NCEP final analysis data

Dynamical model: Static dynamics model (Hydrostatic; HY) and Non-hydrostatic model (NH)



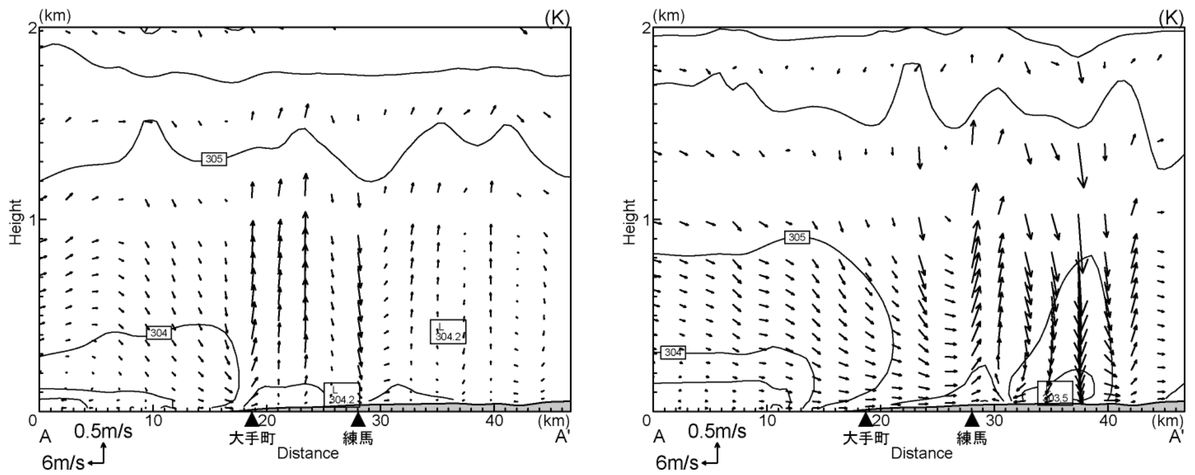
HY model　　NH model

Velocity / Wind Velocity Vector Vertical Distribution
(Domain 1, August 5, 2005, 12:00)



HY model　　NH model

Air temperature (2 m above the ground) · Wind velocity vector (10 m above the ground) Horizontal distribution
(Domain 3, August 5, 2005 12:00)



HY model　　NH model

Velocity / Wind Velocity Vector Vertical Distribution
(Domain 3, August 5, 2005 12:00)

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Improvement of MM5

Method of setting ground surface parameters and artificial exhaust heat

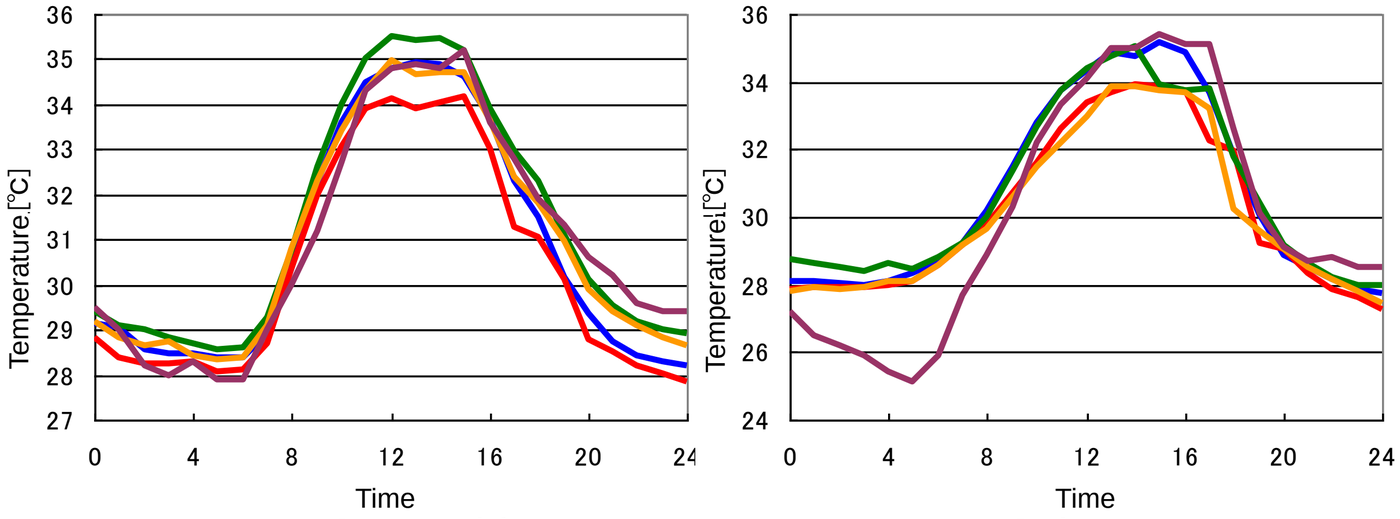
Analysis Case:

Case 1: ground surface parameter setting of the MM 5 standard, No artifical waste heat (base)

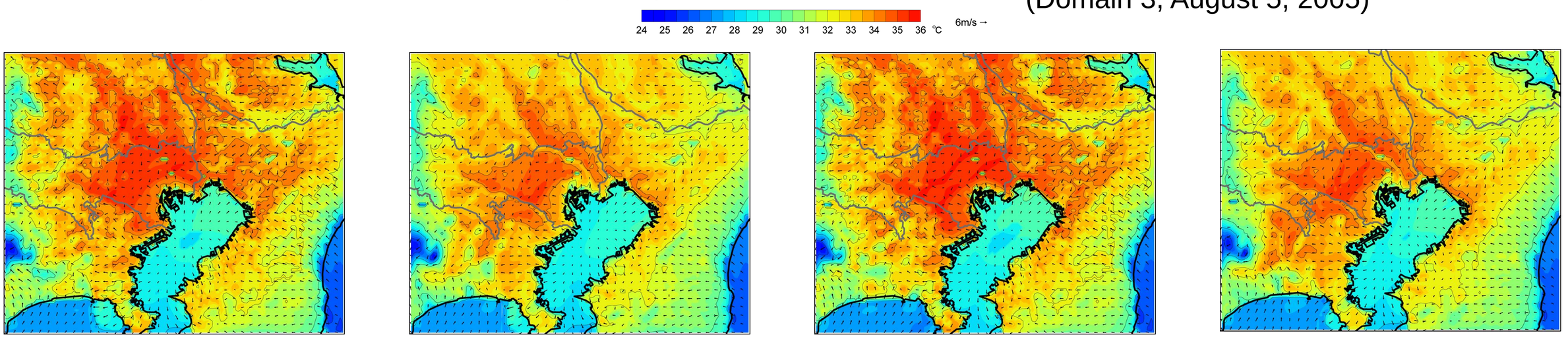
Case 2: Use land use data of national land numerical information, No artificial exhaust heat (lu)

Case 3: ground surface parameter setting of the MM 5 standard, Integrated artificial waste heat (ah)

Case 4: Use land use data of national land numerical information, Incorporate artificial exhaust heat (lu + ah)



Comparison with AMeDAS observations
(Domain 3, August 5, 2005)



Case1 (base) Case2 (lu) Case3 (ah) Case1 (lu + ah)

Air temperature (2 m above the ground) · Wind velocity vector (10 m above the ground) Horizontal distribution
(Domain 3, 12: 00 August 6, 2005)

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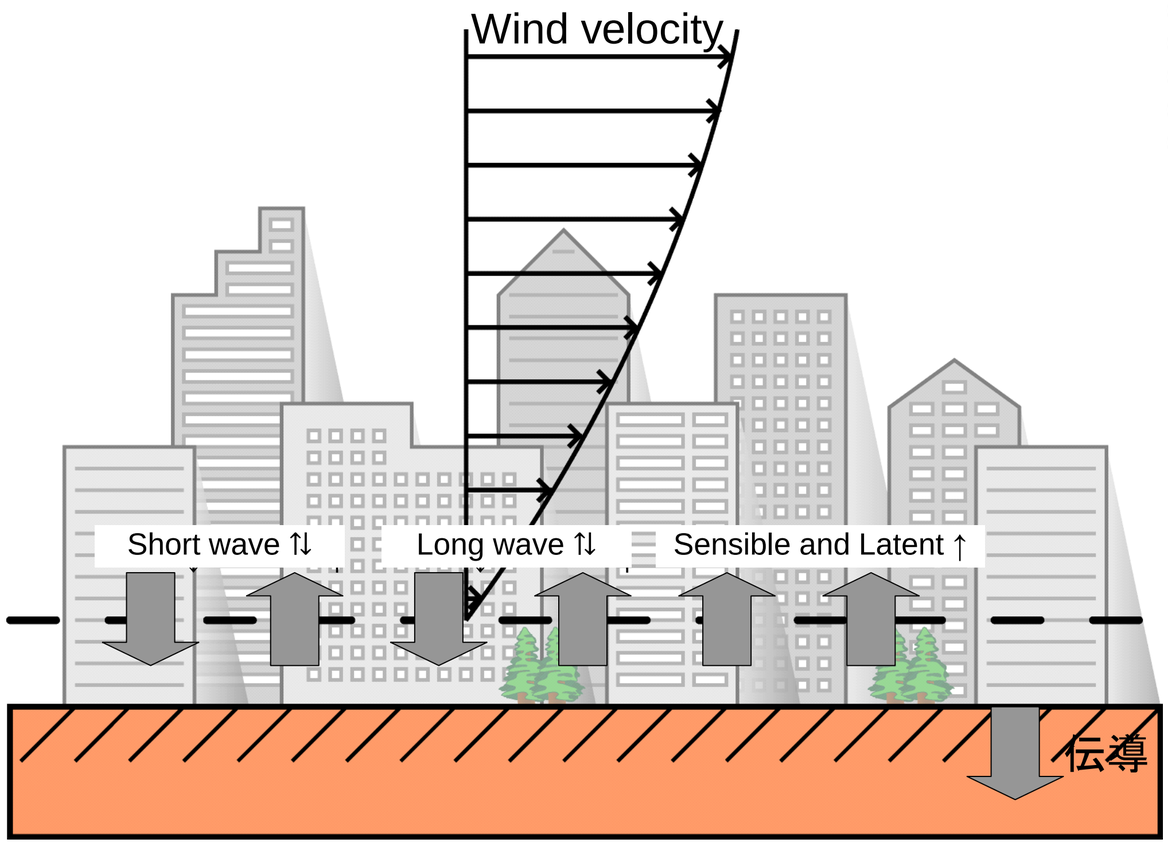
Urban climate analysis model incorporating city canopy model



A mesoscale model using roughness length (case z 0)

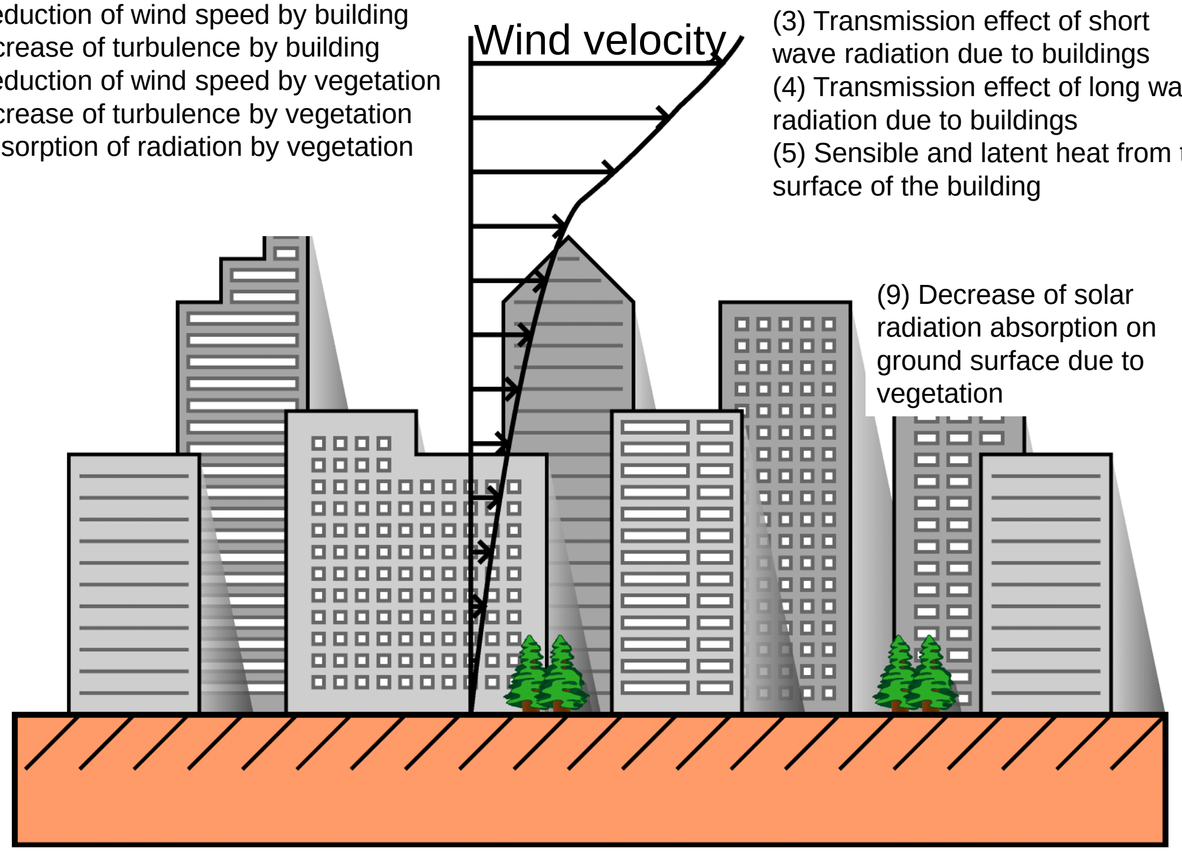
Modeling nearby buildings, trees, etc. by roughness length value

Since it is a model focusing on the flow of the upper layer of the city canopy height, it is impossible to reduce the lattice division in the vertical direction

(1) Reduction of wind speed by building
(2) Increase of turbulence by building
(6) Reduction of wind speed by vegetation
(7) Increase of turbulence by vegetation
(8) Absorption of radiation by vegetation

(3) Transmission effect of short wave radiation due to buildings
(4) Transmission effect of long wave radiation due to buildings
(5) Sensible and latent heat from the surface of the building

(9) Decrease of solar radiation absorption on ground surface due to vegetation



Urban canopy model as surface boundary condition Incorporated mesoscale model (case UC)

Evaluate the thermal environment of the height at which humans are active

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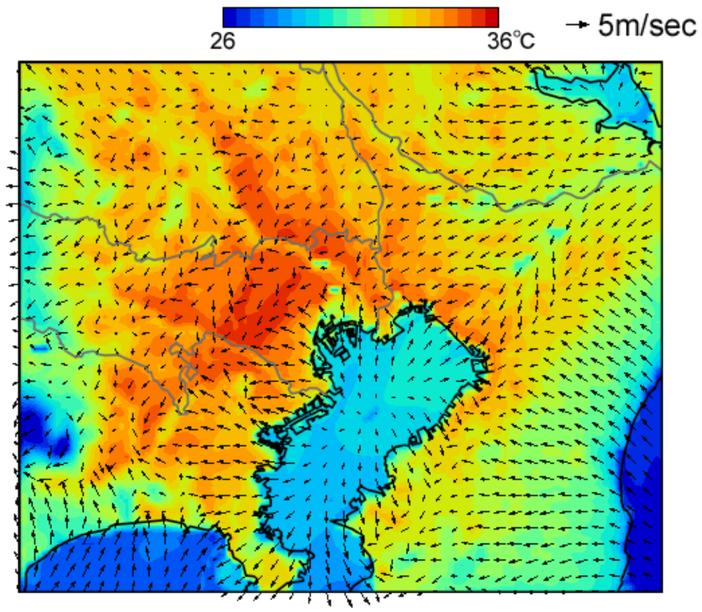
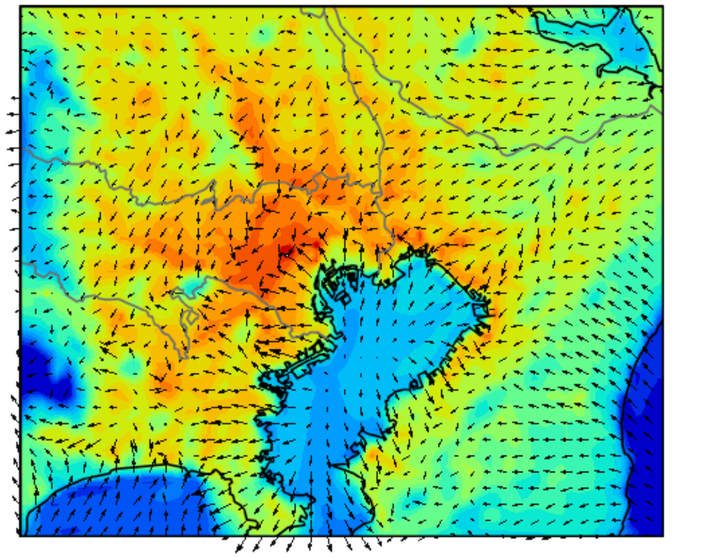
MM 5 analysis result incorporating urban canopy model

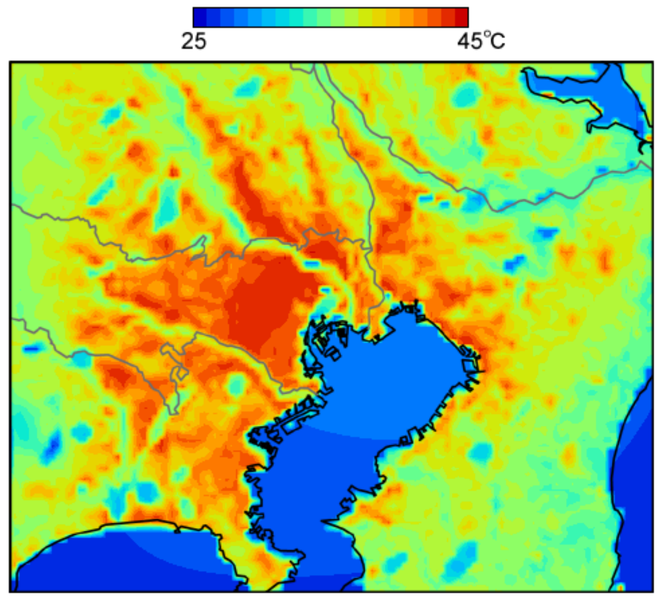


a) case z_0

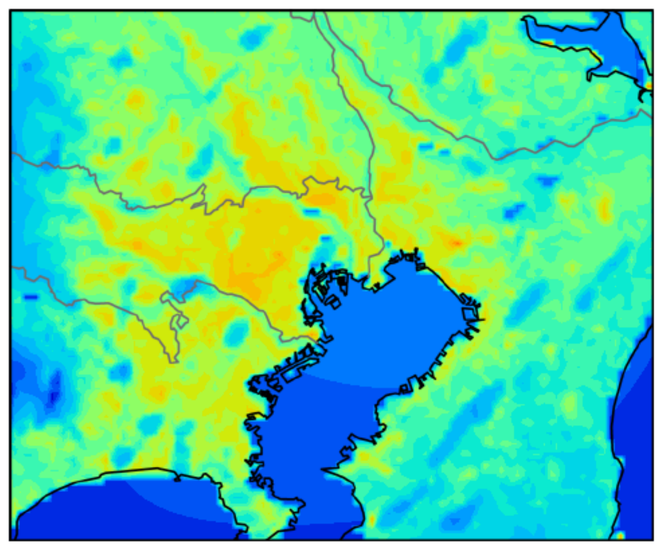


b) case UC

Air temp. / wind speed vector horizontal distribution (12: 00 August 5, 2005)

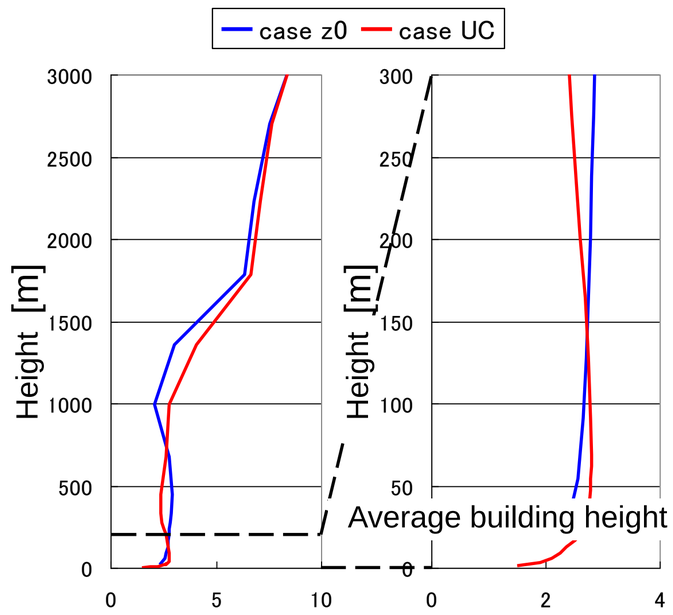


a) case z_0

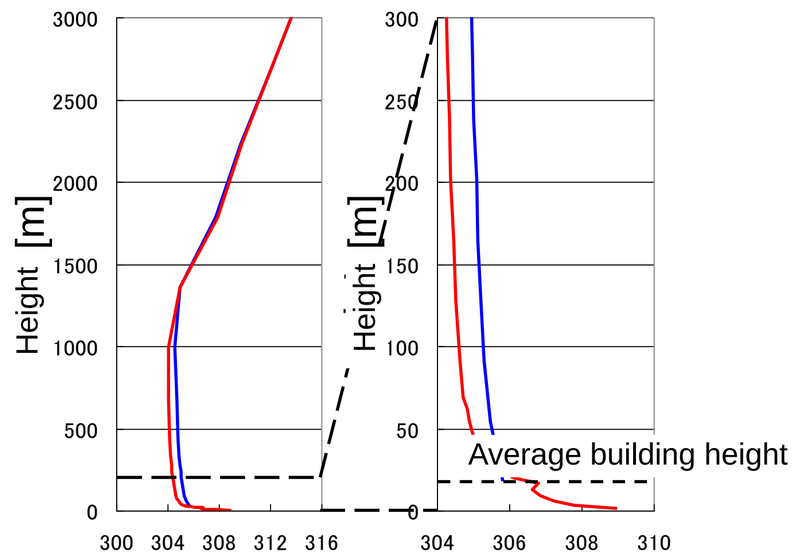


b) case UC

Surface temperature distribution (12: 00 August 5, 2005)



Wind speed profile [m / sec]
(12: 00 August 5, 2005, Otemachi)



Temperature profile [K]
(12: 00 August 5, 2005, Otemachi)

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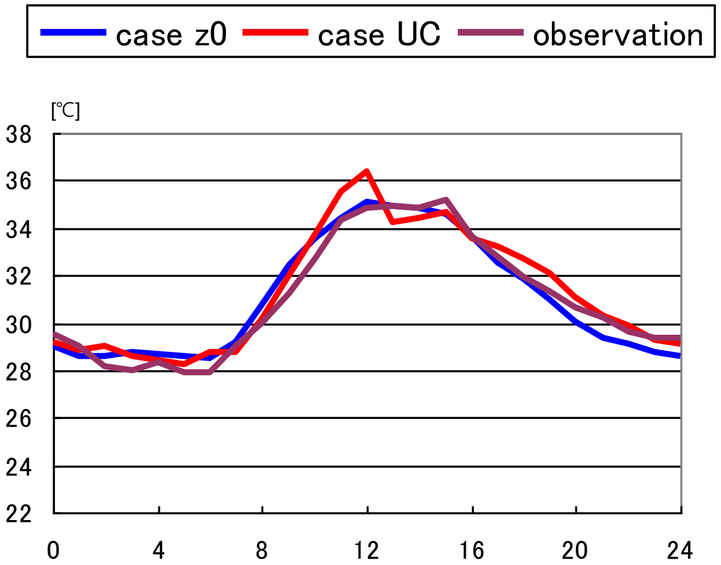
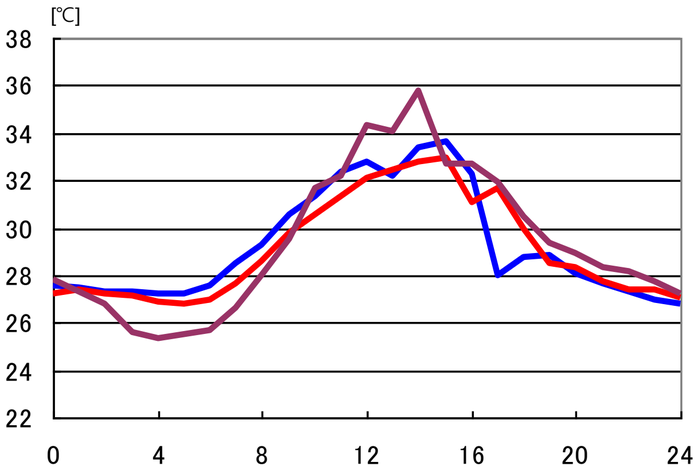
MM 5 incorporating urban canopy model

Comparison with AMeDAS observations

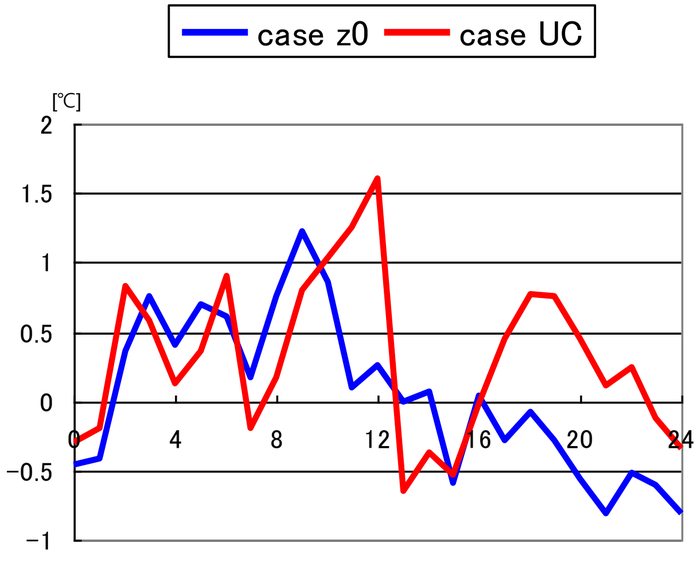


a) Otemachi

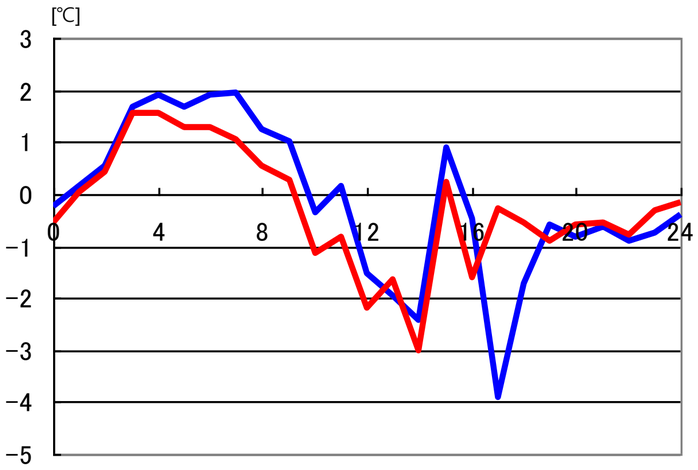


b)Tokorozawa

Temperature diurnal change
(August 5, 2005)



a) Otemachi



b)Tokorozawa

Temperature analysis error
(August 5, 2005)

Comparison of ME and RMSE

	ME		RMSE	
	case z0	case UC	case z0	case UC
Otemachi	0.034	0.309	0.557	0.653
Oume	0.165	-0.003	1.025	1.273
Nerima	-0.167	-0.536	0.957	1.030
Hachioji	0.227	0.098	1.027	1.092
Fuchyu	0.220	-0.047	0.946	1.051
Shinkiba	-0.223	-0.219	1.898	1.709
Haneda	0.136	0.160	1.192	1.024
Kuki	0.143	-0.309	1.632	1.675
Hatoyama	0.732	0.234	1.747	1.700
Saitama	0.111	-0.681	1.412	1.631
Koshigaya	0.194	-0.048	1.708	1.774
Tokorozawa	-0.144	-0.270	1.472	1.159
Abiko	0.449	0.140	1.622	1.689
Funabashi	1.057	0.857	1.653	1.605
Sakura	0.919	0.687	2.039	1.993
Chiba	-0.915	-0.441	2.467	1.931
Mohara	0.451	0.394	1.603	1.705
Kisarazu	0.360	0.542	1.541	1.643
Ushiku	0.727	0.314	2.357	2.364
Narita	2.102	1.487	2.442	2.123
Ebina	0.270	0.154	1.328	1.556
Yokohama	-0.112	0.043	1.243	1.300
Tujido	0.922	0.830	1.275	1.177
Odawara	1.224	1.398	1.661	1.966
Tateno	1.781	1.216	2.269	2.074
Ryugasaki	0.942	0.545	2.063	1.923
Average	0.446	0.264	1.655	1.622