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Impact of Extreme Weather and Climate on Urban Environment

Numerical Investigation of Summer Sea Breeze Using Updated Urban Aerodynamic Parameters in Kanto Region

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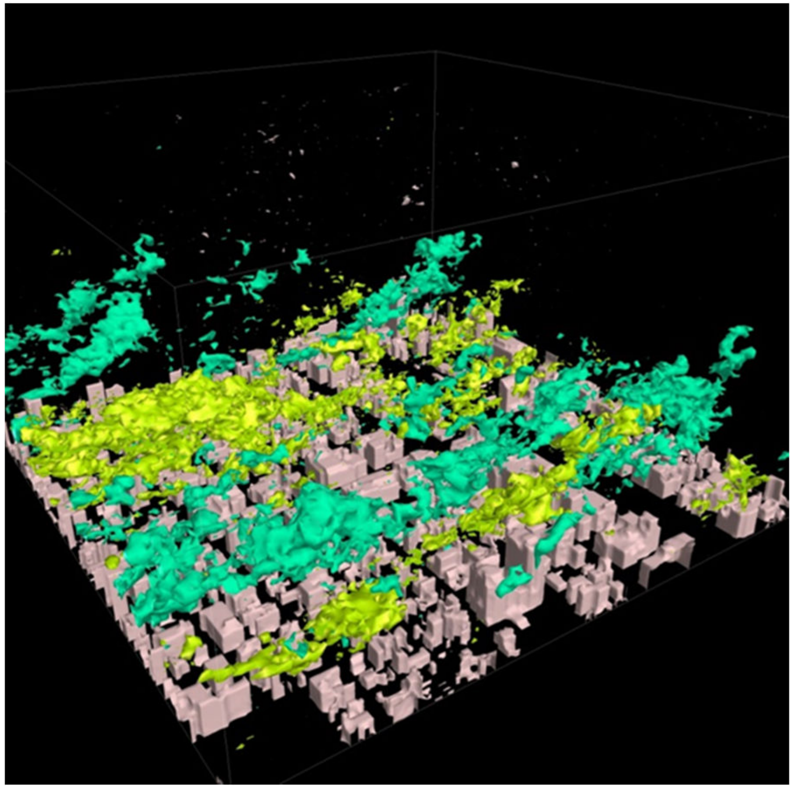
TOKYO TECH

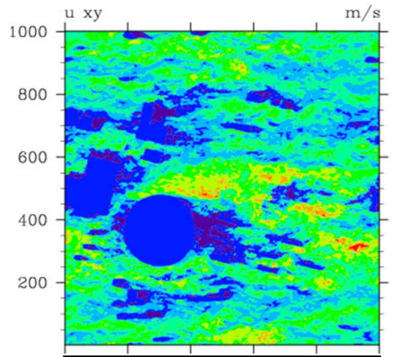
Update on Roughness Parameters

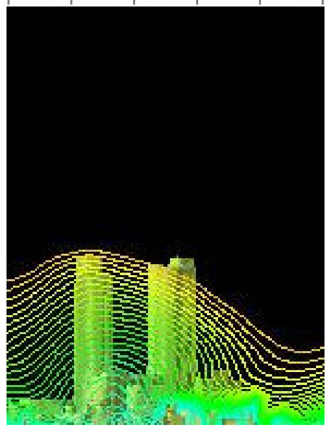
- Thanks to Large Eddy Simulations, a precise estimate of drag and aerodynamic parameters have been made possible.

Updates to roughness parameters *z0* and *d* by Kanda et al. (2013)

1 km resolution of *z0* and *d* were prepared.

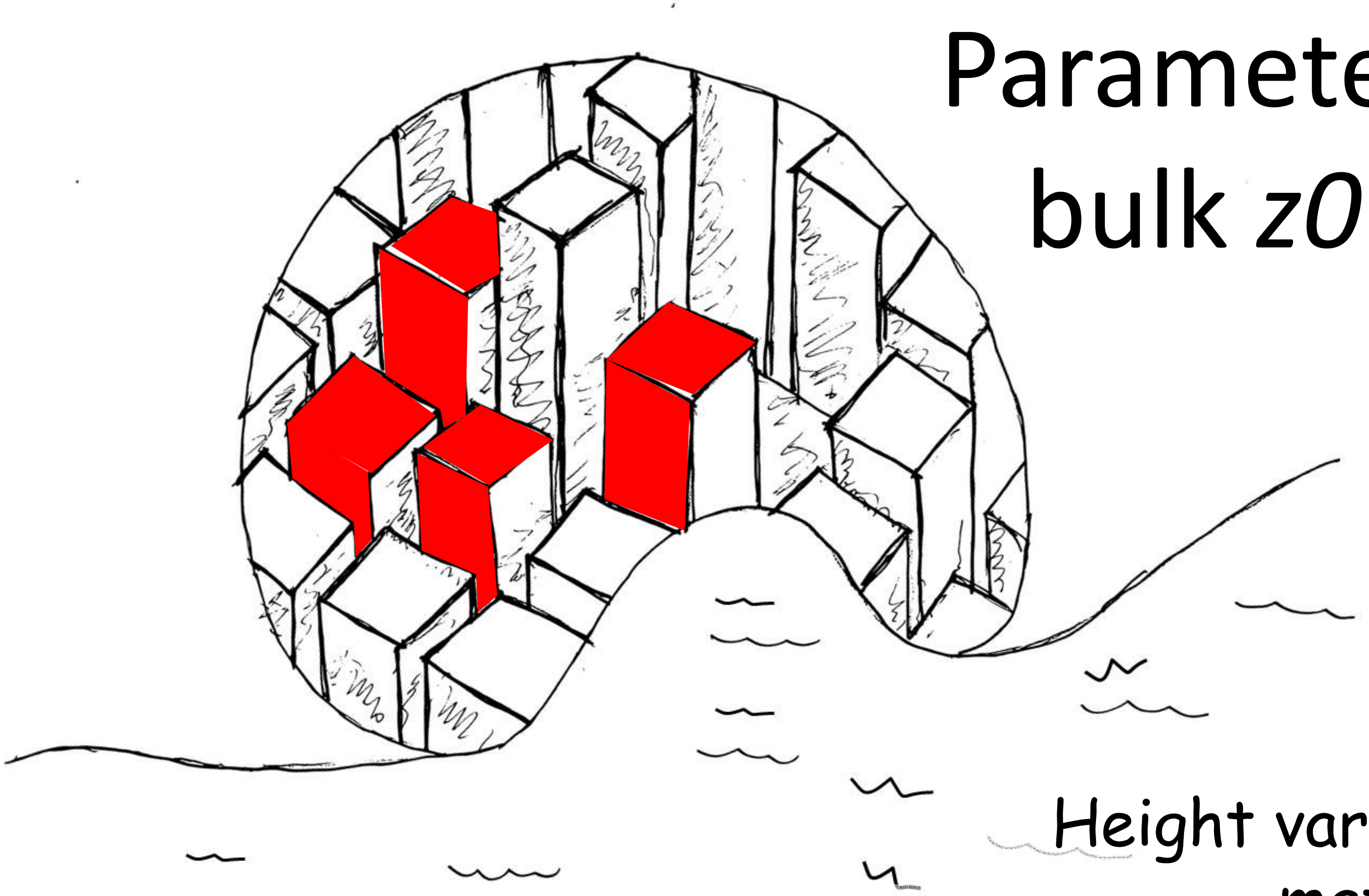




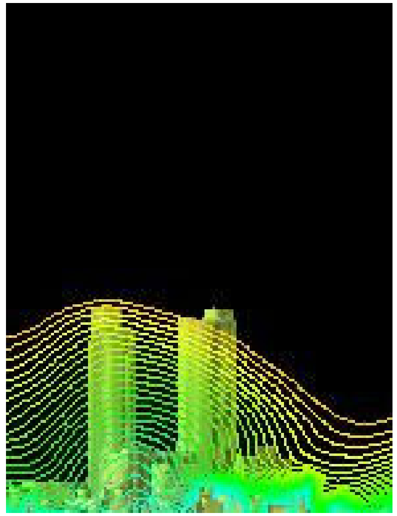


Building Database source: CAD CENTErR

Parameterizing bulk *z0* and *d*



Previously, frontal area and plane area with average building height (Macdonald et al., 1998)



Height variation in grid matters (Kanda et al., 2013)
Consideration of

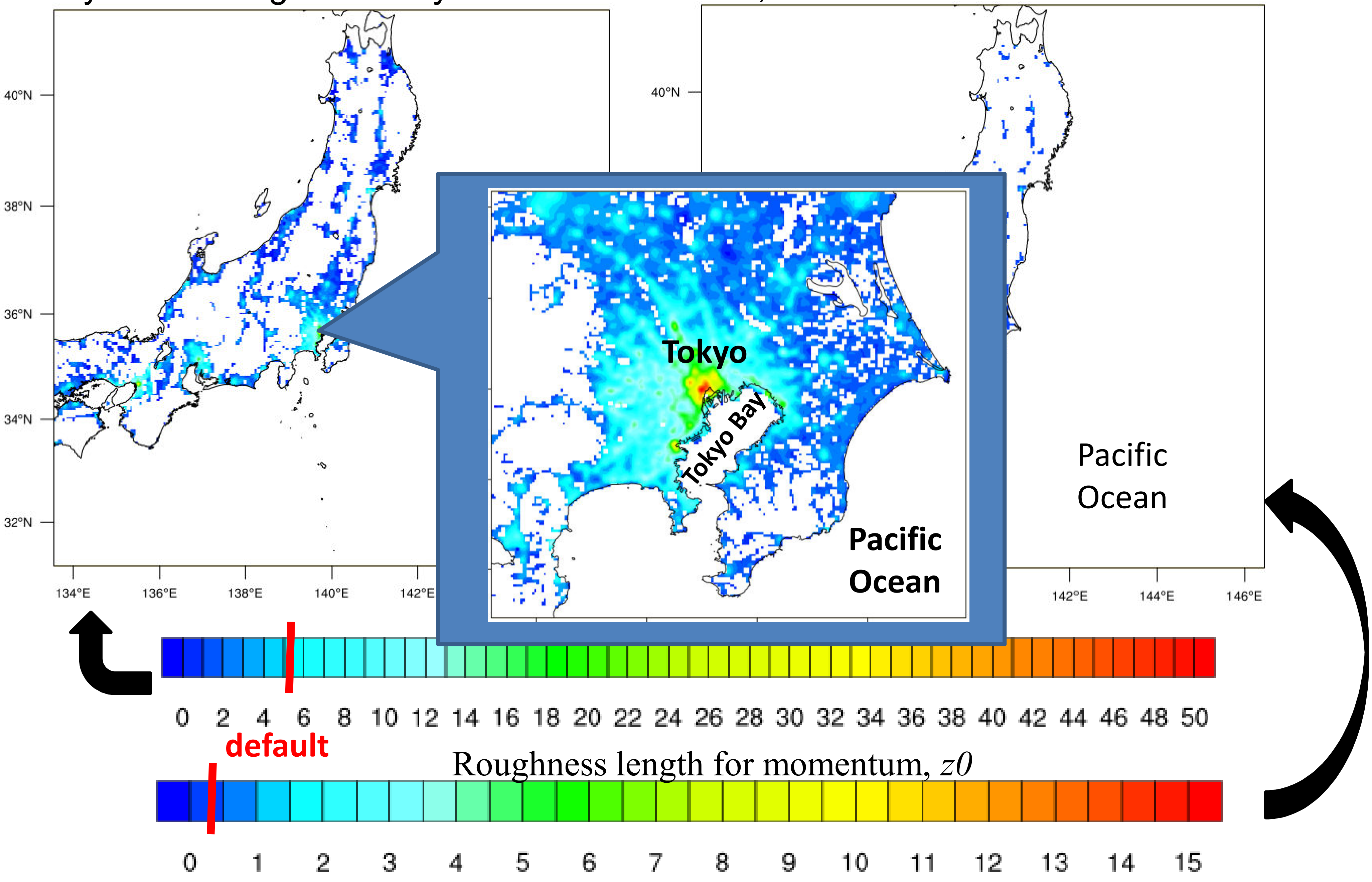
H_{max} **and** $\boldsymbol{\sigma}_H$

Today's Objective

- How distributed parameters parameters is incorporated in WRF-UCM?
- How significant is this update in numerical simulations?
- Will this improve our understanding and the simulation of wind circulation (in today's case, sea breeze)?

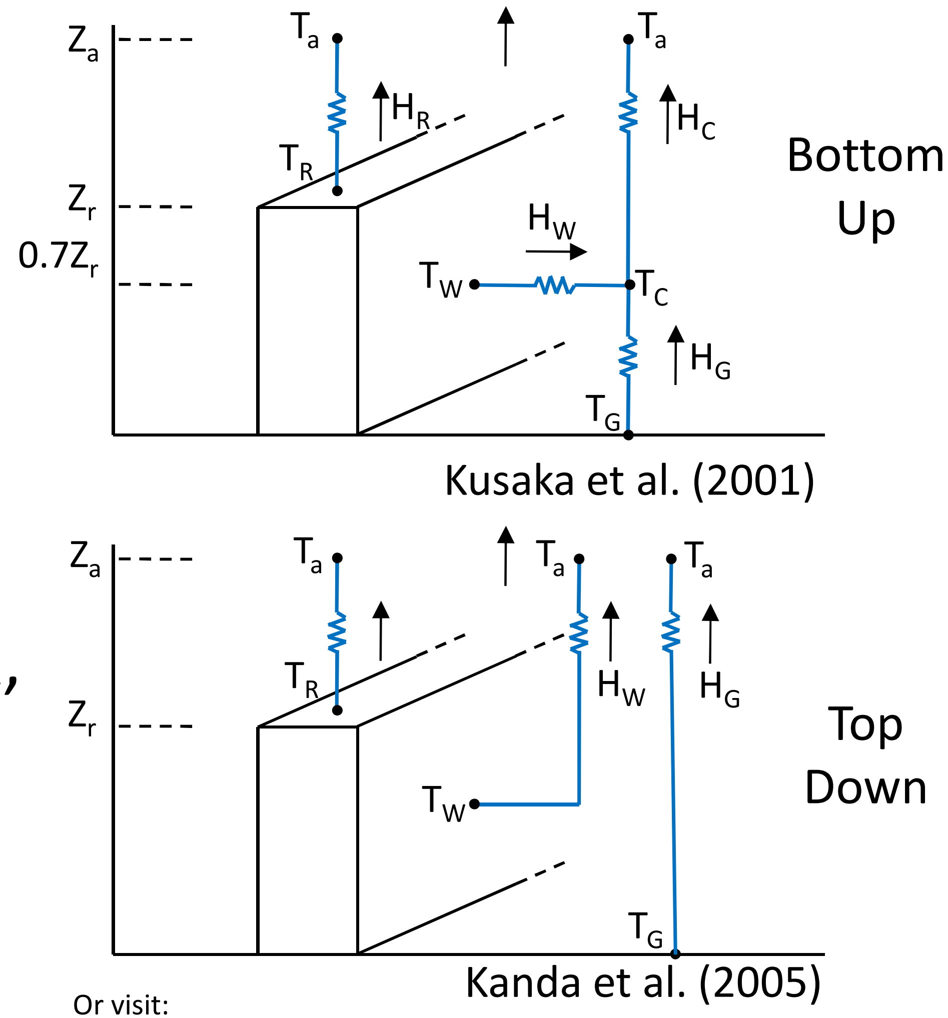
Default and Updated *z0* and *d*

By **default** High-intensity Residential in WRF, **5.71 m** and **0.33 m** for *d* and *z0m*



Incorporating new aerodynamic parameters into the UCM

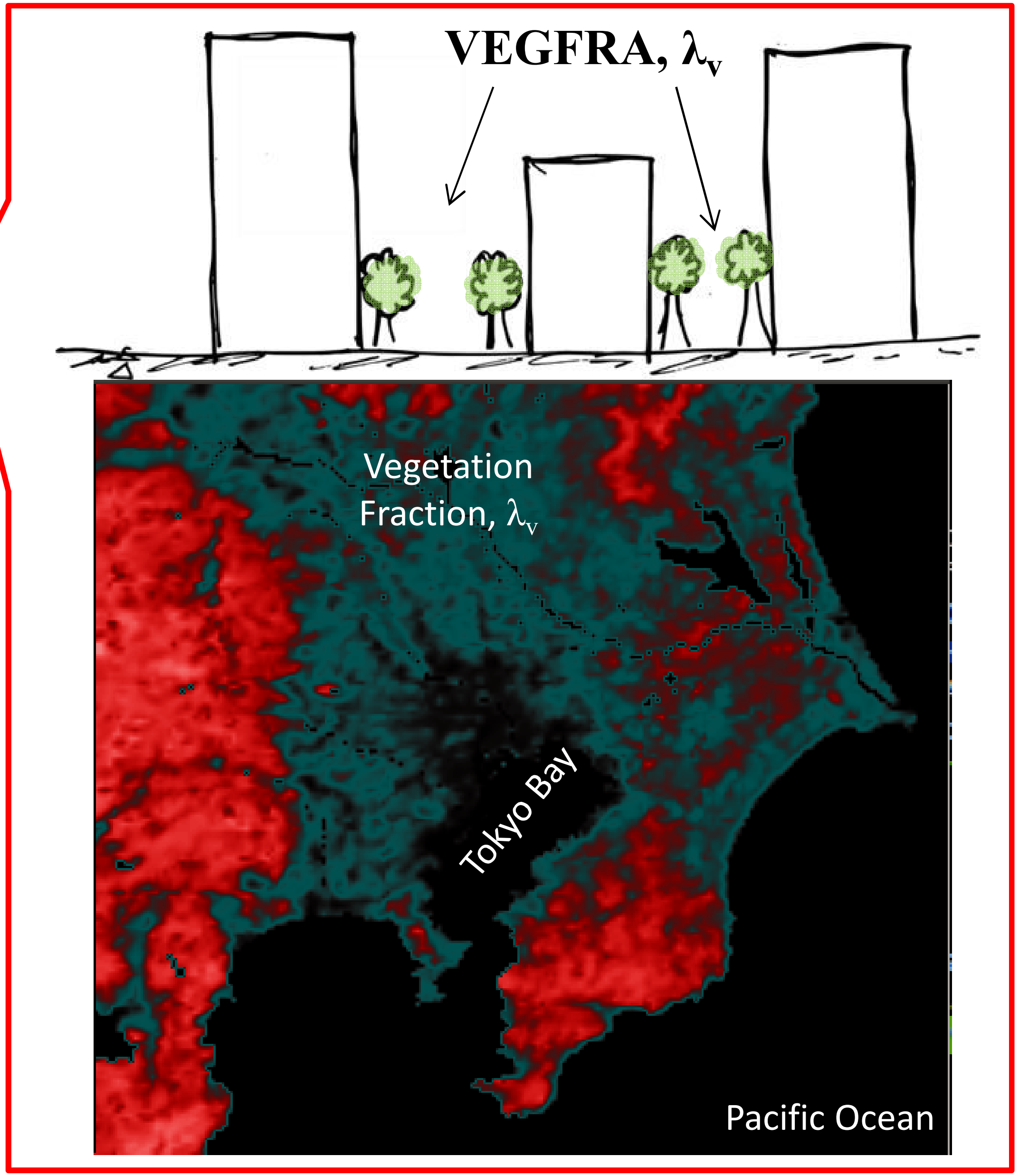
- Issue: default UCM relies on two *z0m*, for roof and canopy.
- Bottom-up → Top-down scheme
- Bulk transfer coefficient acquired from high-resolution *z0m*
- Local transfer coefficients (CHR, CHB, and CHG) were determined directly from bulk transfer coefficient (CHC)



Or visit:
http://www.ide.titech.ac.jp/~kandalab/en/research/research.html

Additional improvements

- Oasis Effect (new formulation of *z0h**) from Kawai et al., 2009
- Modification of urban fraction using available high-resolution 100-m land use data
- Distributed sky-view factor from Kanda et al., 2005



* Roughness Length for Heat

Additional improvements

- Oasis Effect (new formulation of *z0h**) from Kawai et al., 2009
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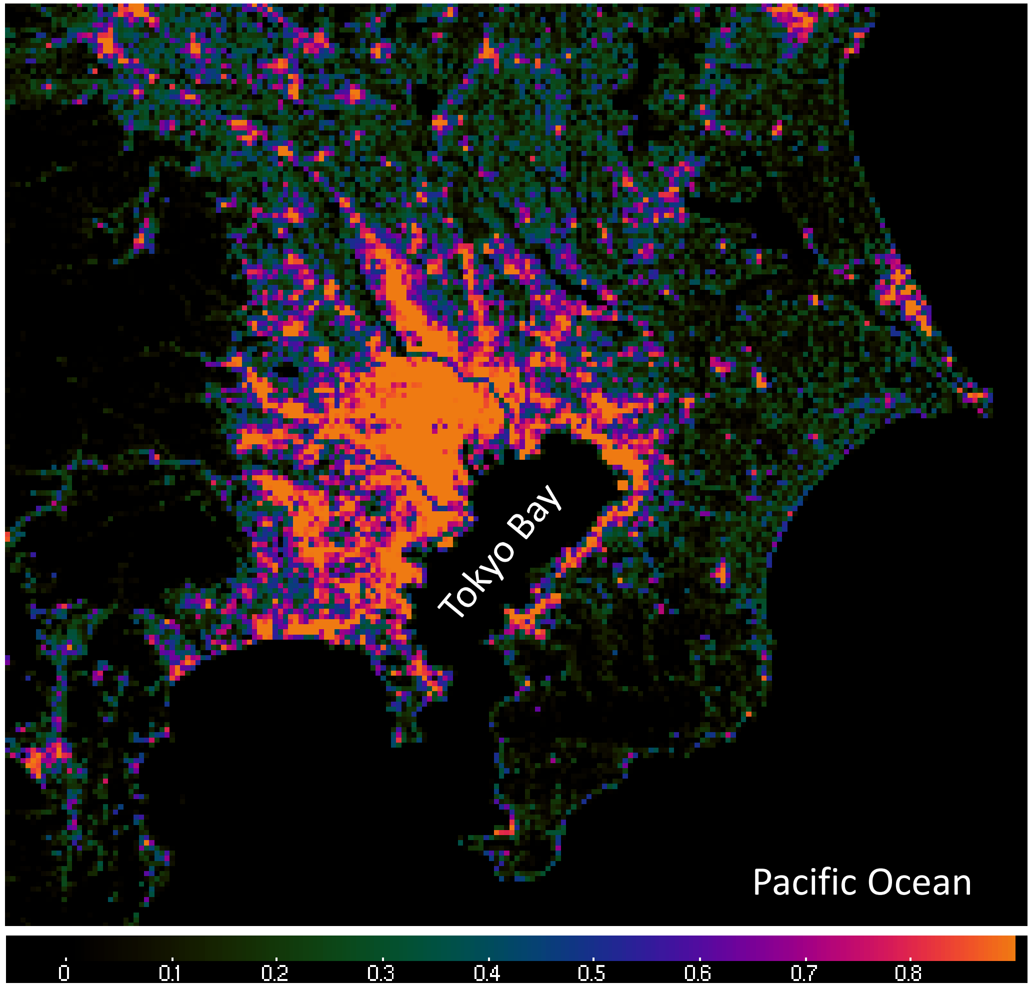
Default for High-Intensity Residential Urban: **0.9**

Distribution below derived from Japan GSI DEM



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Additional improvements

- Oasis Effect (new formulation of *z0h**) from Kawai et al., 2009
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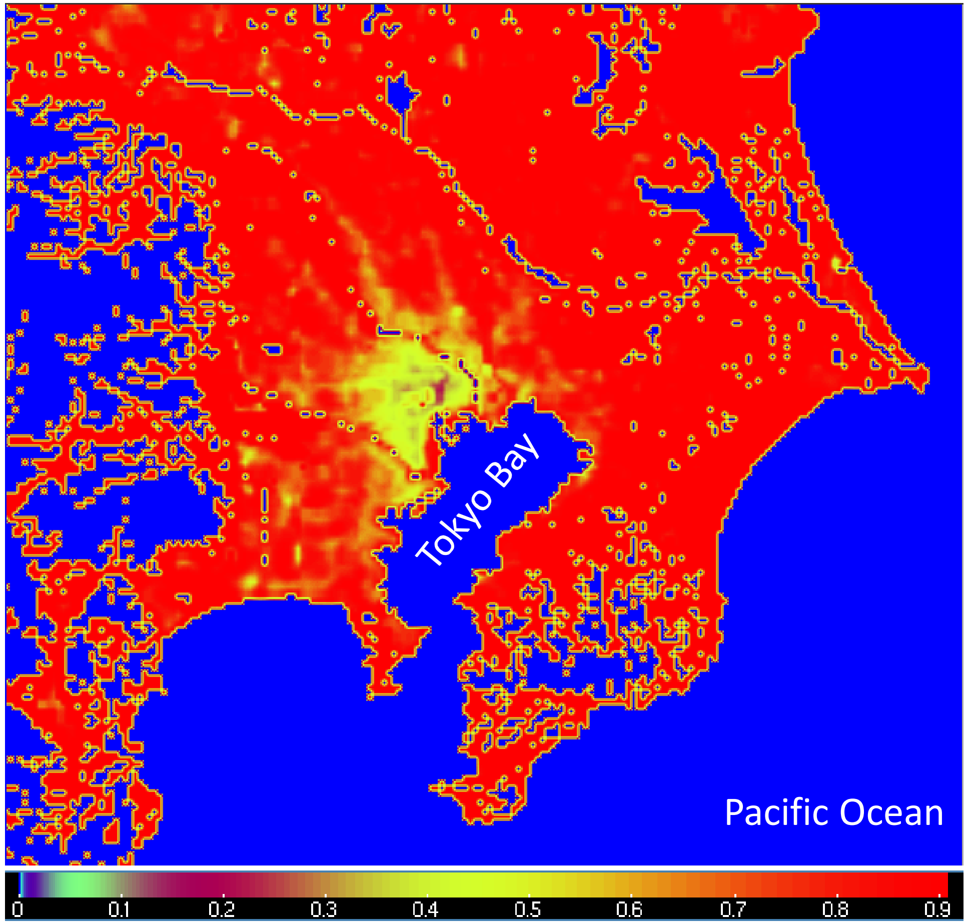
Default for High-Intensity Residential Urban: **0.48**

$$V_{loc} = \cos\left\{\tan^{-1}(2H/L)\right\}\left\langle 2 - 4/\pi \tan^{-1}\left[\cos\left\{\tan^{-1}(2H/L)\right\}\right]\right\rangle,$$

$$V_{\mathrm{mod}} = 0.1120\lambda_P V_{loc} - 0.4817\lambda_P + 0.0246V_{loc} + 0.9570,$$

$$SVF = V_{loc}V_{\mathrm{mod}}$$



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3 Cases

Parameters	CNTL	SDLC
Z0 and *d*	Fixed 0.33,5.71	Distributed
Urban Fraction	Fixed 0.90	Distributed
SVF	Fixed 0.48	Distributed
AHE*	Distributed	Distributed
CH Scheme	Bottom-up	Top-down

Additional:
CNTL case w/ Urban Areas set to Grassland
VEGE case

* Patterned after Moriwaki et al., 2008

Numerical Settings

- Meteorological Boundary Condition

  Atmosphere

  Japan Meteorological Agency Nonhydrostatic Mesoscale Model (MSM) – 3-hr., 0.1° x 0.125°

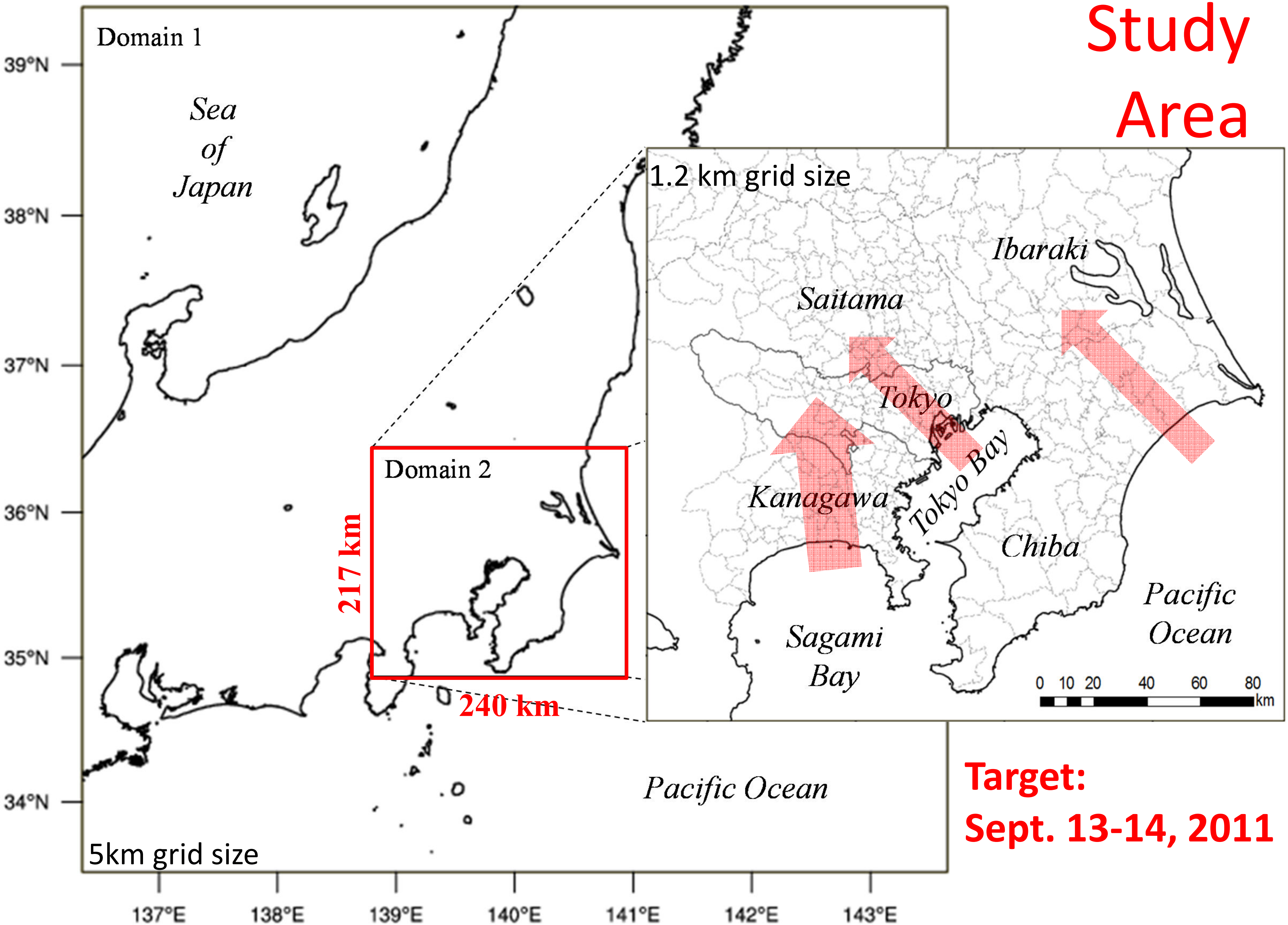
  Surface

  NCEP FNL – 6-hr., 1.0 ° x 1.0 °

Parent to Nest Time-Step Ratio from 15s	
1	7

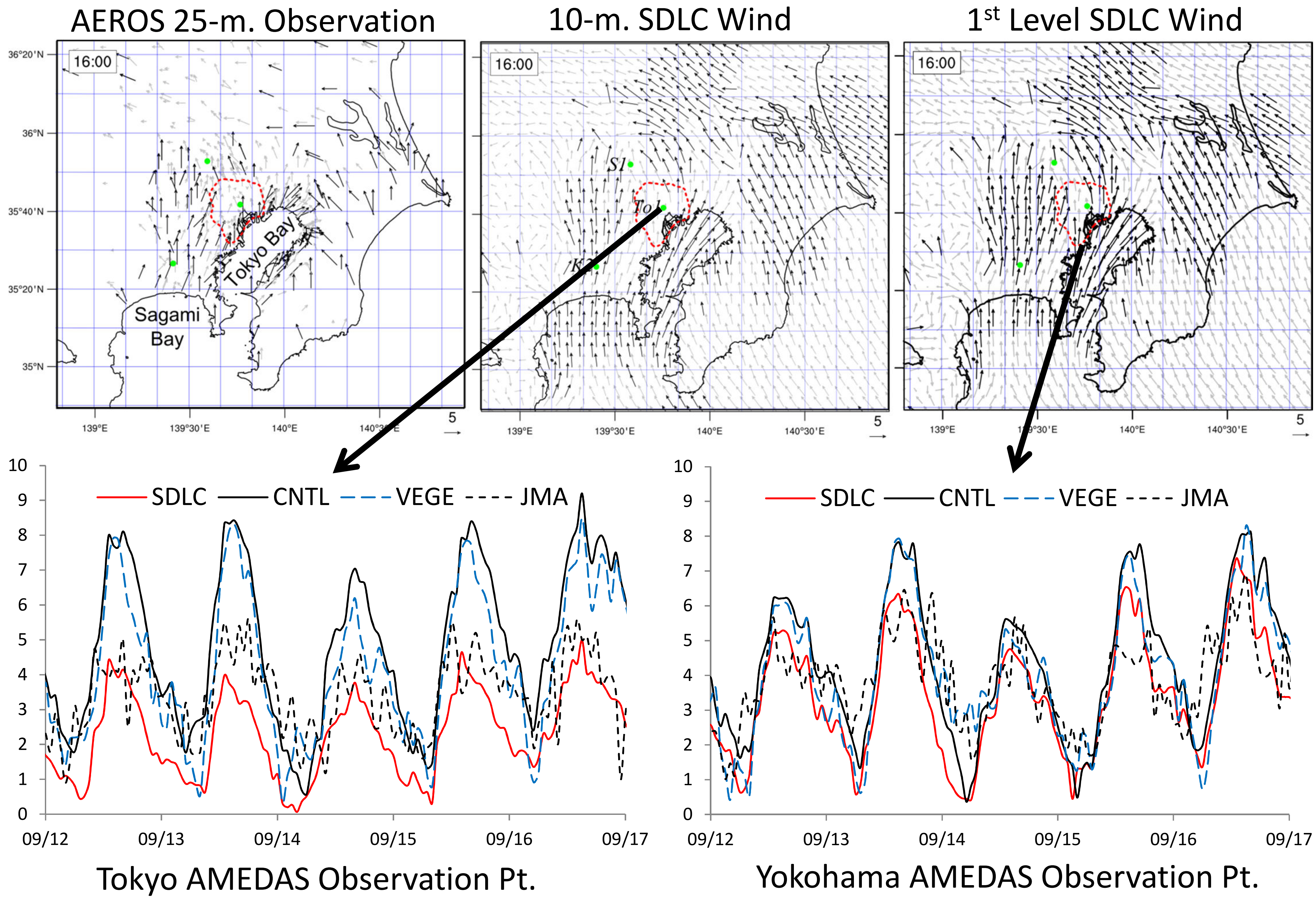
Microphysics	**New Thompson et al. Scheme**
Longwave Radiation	**Rapid Radiative Transfer Model**
Shortwave Radiation	**Goddard Shortwave**
Surface Layer	**MM5 Similarity**
Land Surface	**Noah LSM**
P.B.L.	**MYNN Level 2.5 PBL**
Cumulus Parameterization	**Kain-Fritsch Scheme**

Study Area

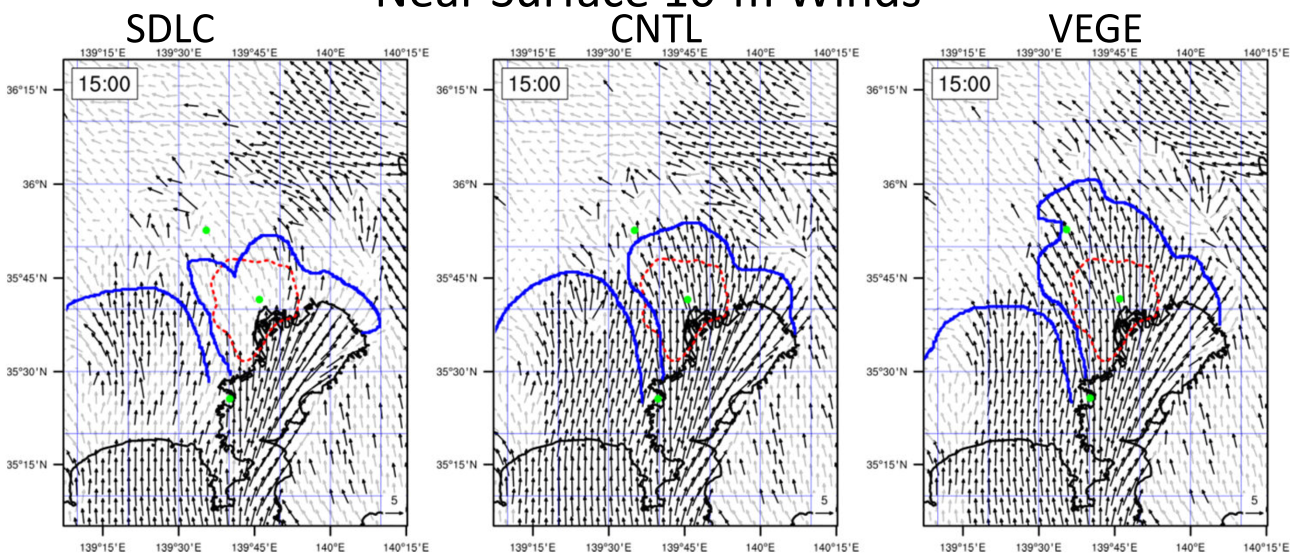


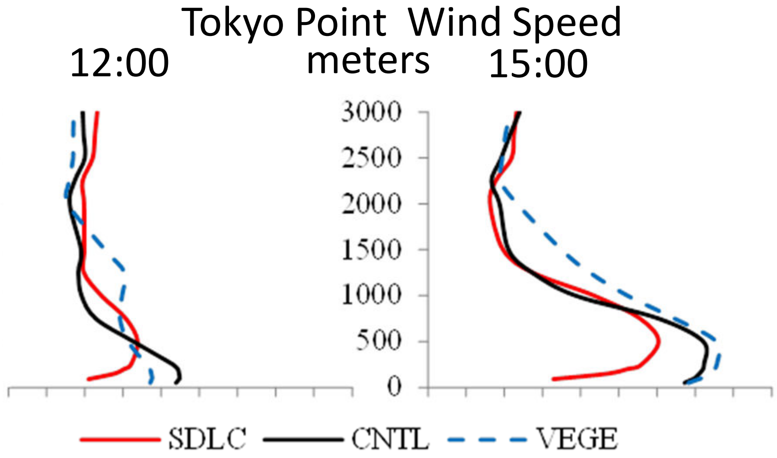
Target:
Sept. 13-14, 2011

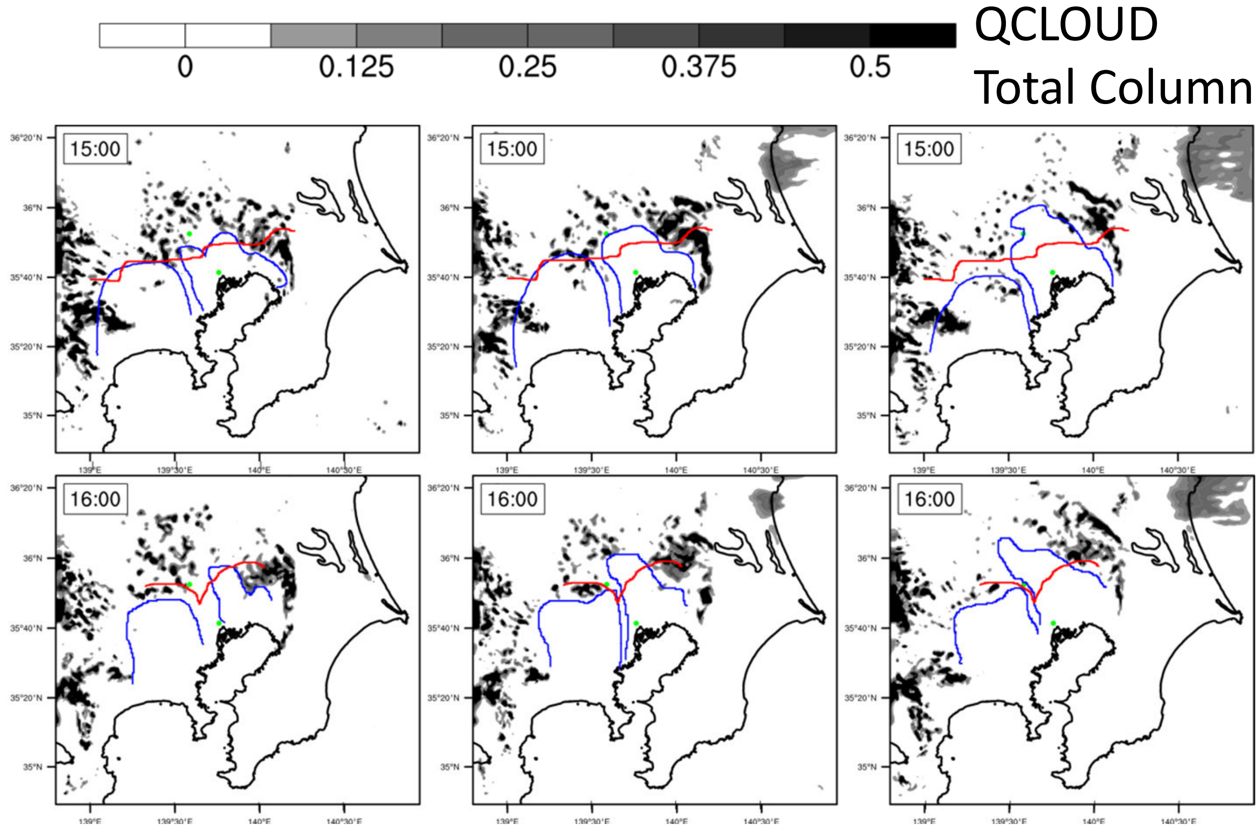
Results 1: Validation



Results 2: Understanding Sea Breeze







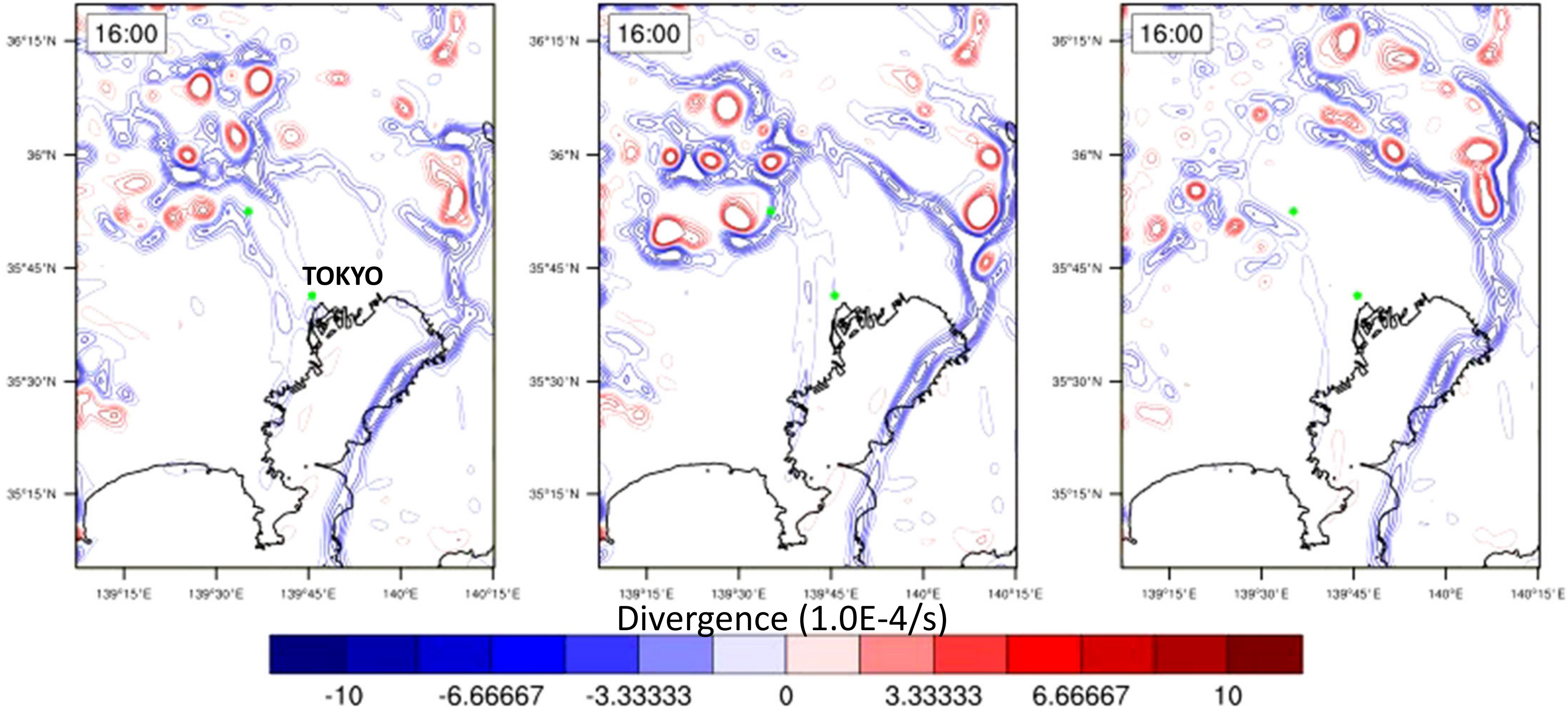
- Weaker low-level trailing winds manifested at highly urbanized areas
- Simulation of clouds appear to be improved
- Reduction of wind speeds reach 500-m above ground

Sea breeze Front Delineations

Simulated 10 m Convergence

Geostationary Satellite (Rapidscan)

Results 2: Understanding Sea Breeze



- Strong <u>convergence/divergence</u> leeward from Tokyo could be seen when urban areas are considered.
- Believed to be reason for localized heavy rain during summer.
- Extended convergence line wider in SDLC case due to large roughness at Tokyo.

Conclusion and Recommendations

- Drag at highly rough surfaces are represented more when new roughness parameters are employed.

- Accuracy of wind field improves. However, thermal outputs need further validation (difficulty in T2 observation gauge representativity).

- Influence of urban areas to the atmosphere is underestimated when default WRF-UCM is directly applied.

- Future sensitivity tests are necessary to understand individual contribution of detailed parameters.

Acknowledgments

MEXT
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CULTURE, SPORTS,
SCIENCE AND TECHNOLOGY-JAPAN

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