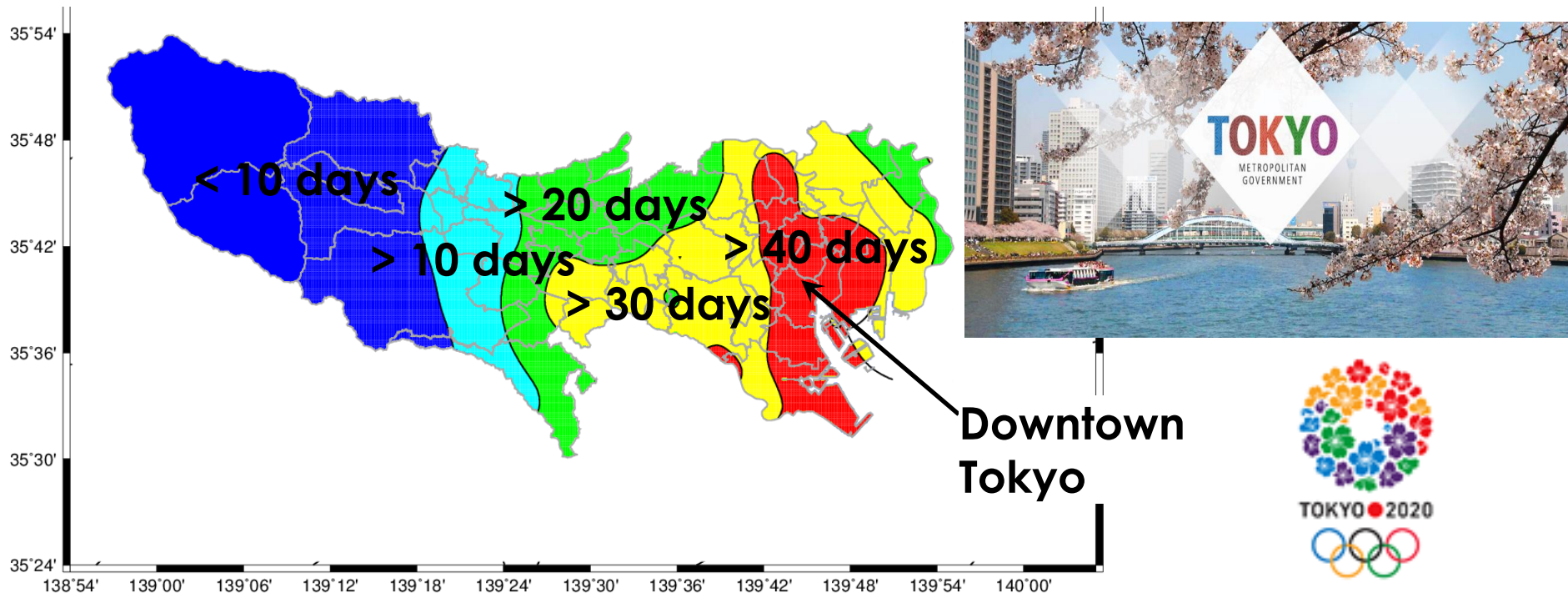


Impacts of urban heat island mitigation strategies on surface temperatures in downtown Tokyo

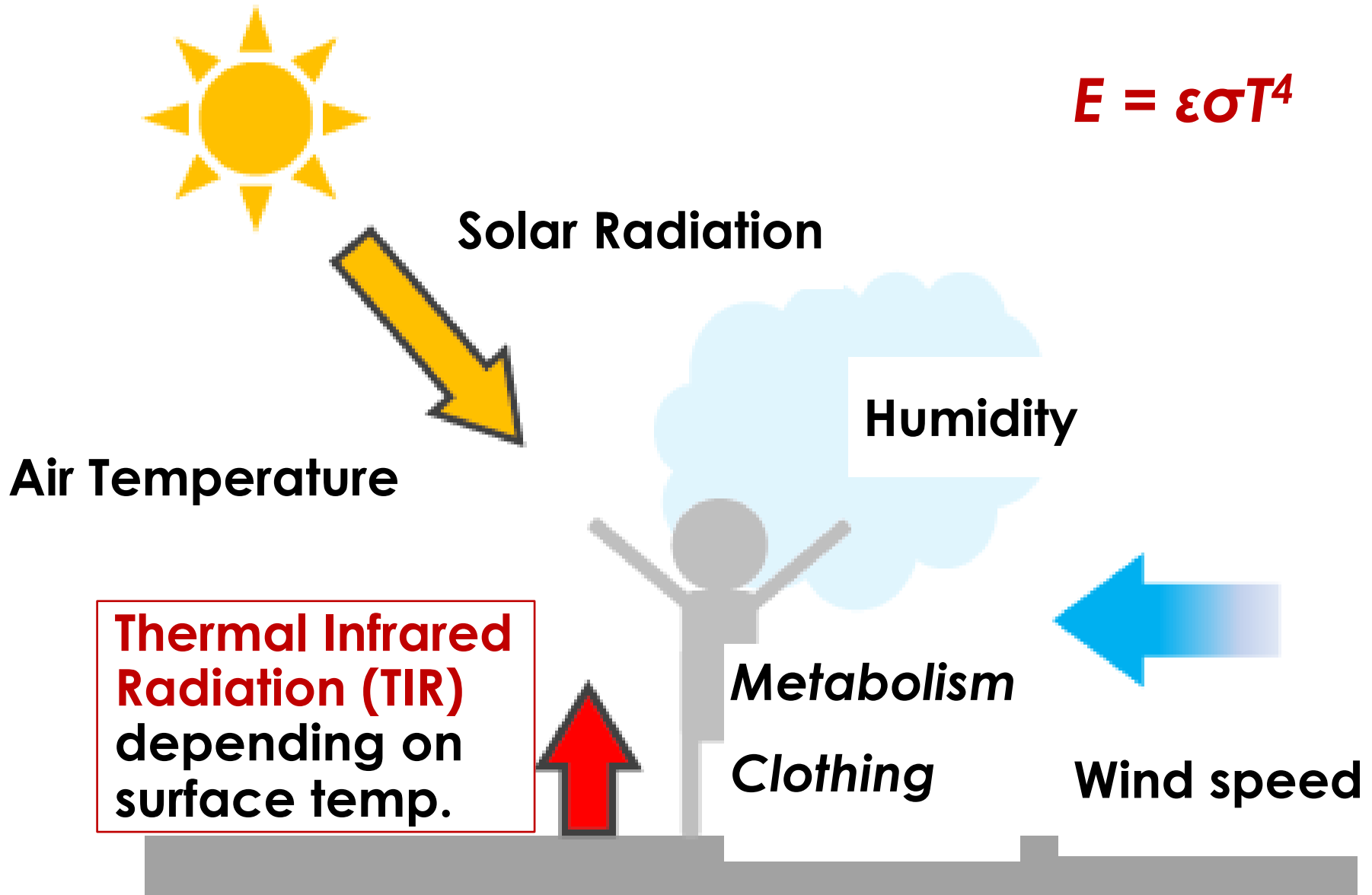
The total number of **tropical nights** in July-September 2013 in **Tokyo metropolis** obtained from high-density surface meteorological observations.



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Haruo ANDO¹, Futoshi MATSUMOTO³, Yoshihito SETO⁴, Nobuhiko SHIGYO²**
¹Tokyo Metropolitan Research Institute for Environmental Protection, ²Chiba University,
³Keiai University, ⁴Tokyo Metropolitan University

Environmental factors affecting **feels like temperatures**

$$E = \varepsilon \sigma T^4$$



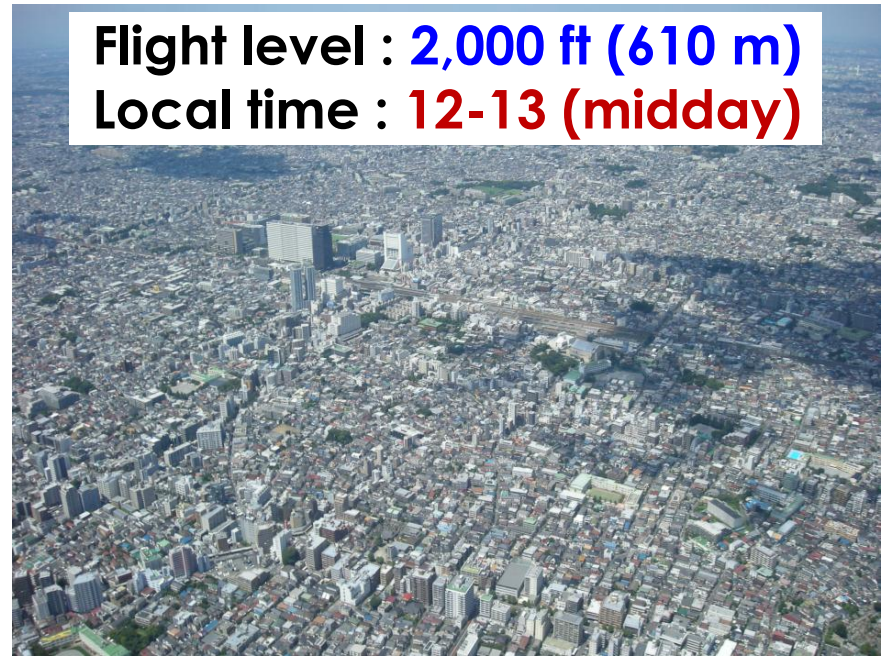
(Source: Ministry of the Environment, Japan)

Characteristics of natural environmental factors affecting feels like temperatures **in terms of implementation of UHI adaptation and mitigation strategies:**

Environmental factors	Control in outdoor	Trade-off relation
Air temperature	Difficult	Weak
Humidity	Difficult	Weak
Wind speed	Possible	Strong
Radiant heat	Possible	Weak

- Radiant heat (**TIR**) **can be easily controlled** by implementation of measures lowering surface temperatures with **weak trade-off**.
→ **Reducing radiant heat is therefore considered to be suited for UHI adaptation and mitigation strategies.**

Airborne measurements of thermal infrared (TIR)



Flight level : 2,000 ft (610 m)
Local time : 12-13 (midday)



← A **TIR imaging camera** (Nippon Avionics Co., Ltd.; TS7302) installed on a Robinson R22 helicopter can detect infrared radiation at wavelengths of 8-14 μm .

▪ **Visible images** were acquired simultaneously, using a high definition camera. →



- Horizontal **spatial resolutions** of data are approximately **2 m**.
- The imaging data were geometrically corrected by orthorectification.

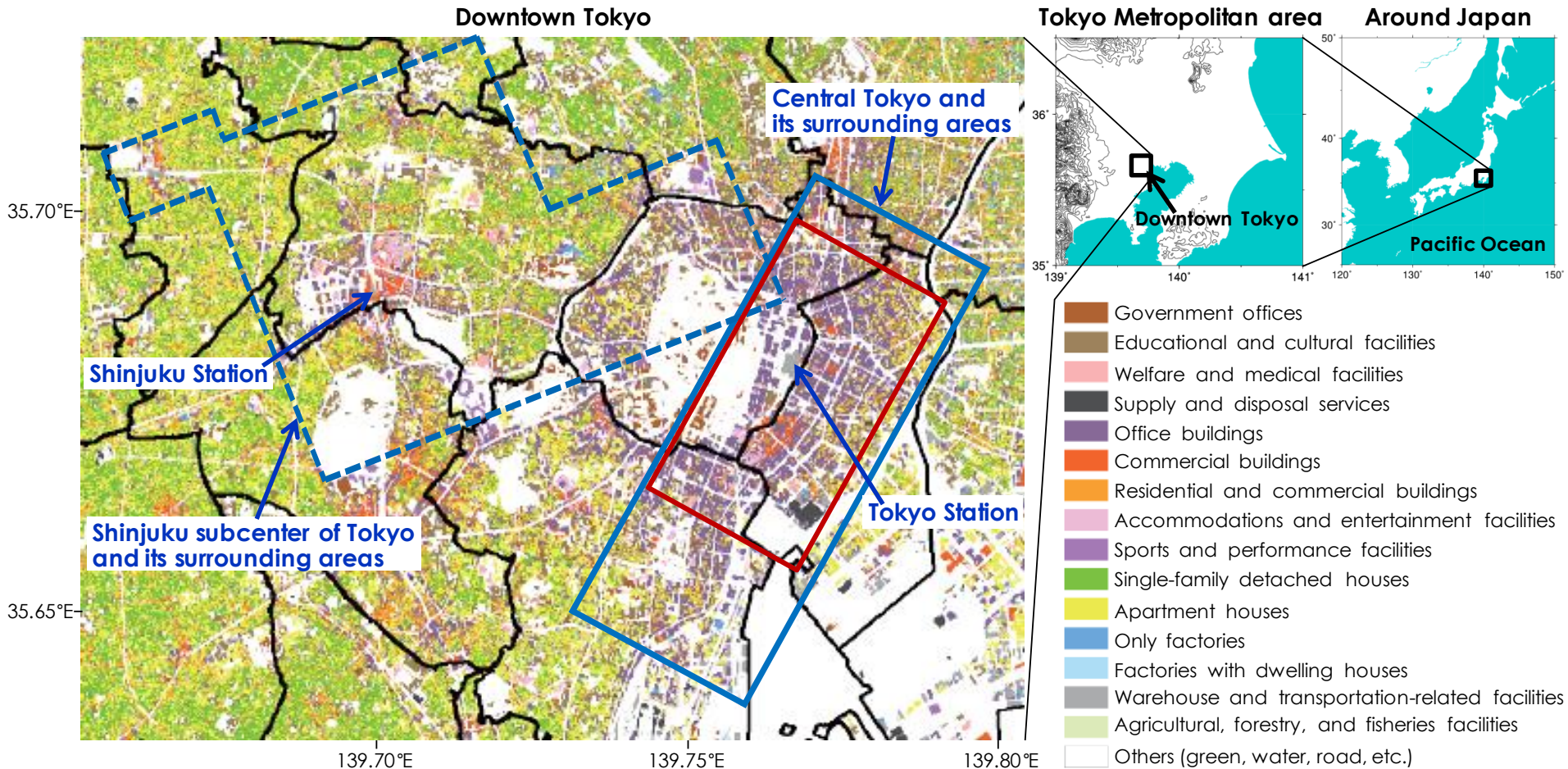
Surface weather conditions at Central Tokyo at 1200 LT (data provided by Japan Meteorological Agency):

Date (TIR measurements)	Air Temperature °C	Hourly Global Solar Radiation MJ/m ²	Relative Humidity %
<u>Aug. 7, 2007</u> (M2007)	32.0	3.10	50
<u>Aug. 19, 2013</u> (M2013)	33.1	3.11	58
<u>Aug. 19, 2014</u> (M2014)	33.3	3.17	55



- North Pacific High covered Tokyo. Air temperatures at Central Tokyo exceeded 32 C under large amounts of solar radiation.
→ **Much similar weather conditions!**

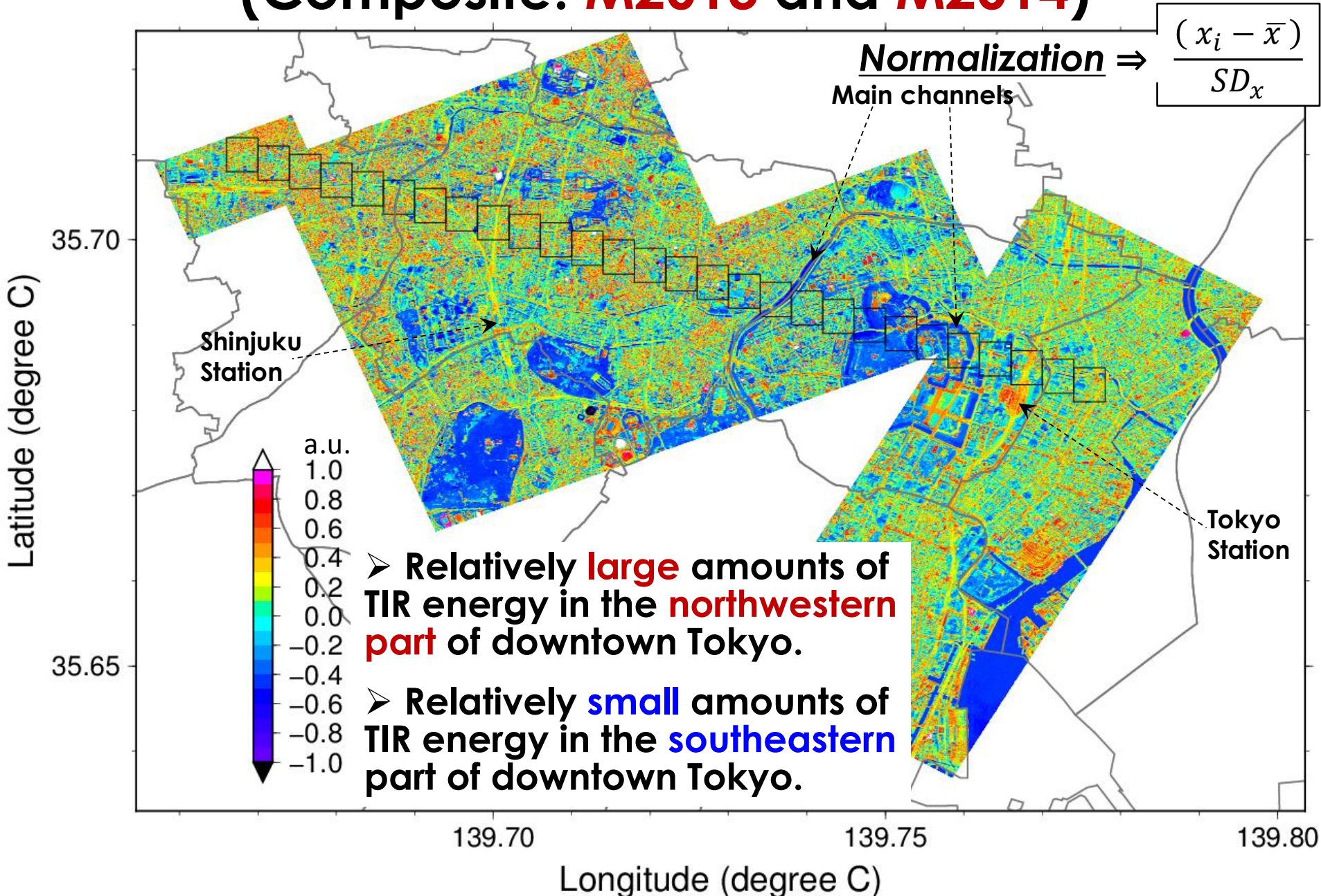
Airborne TIR measurements in downtown Tokyo



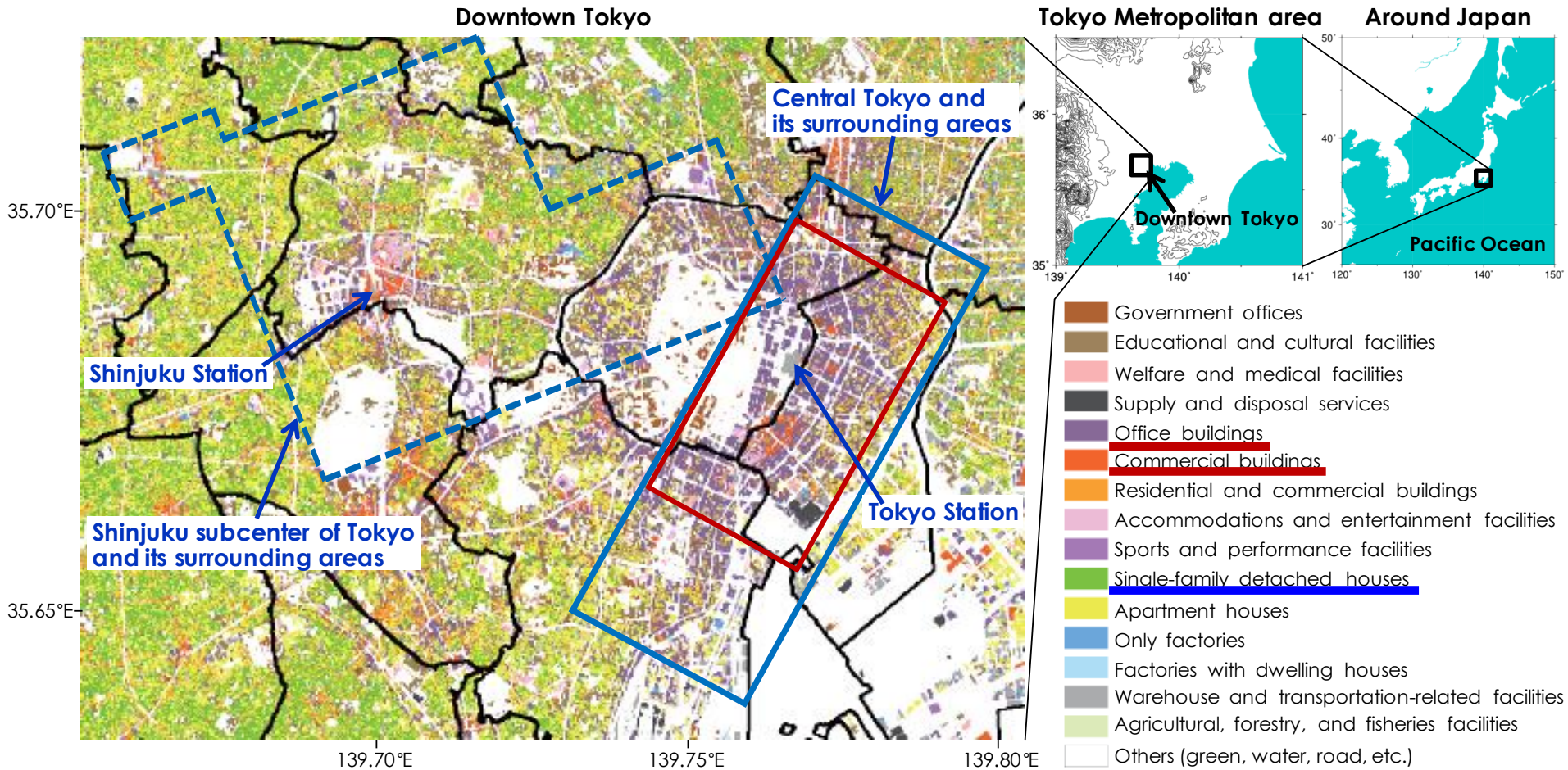
➤ Maps and **land uses/covers** in **downtown Tokyo**.

- The red box (Central Tokyo): M2007
 - The blue box (Central Tokyo): M2013
 - The thick broken blue lines (Shinjuku subcenter of Tokyo): M2014
- (The thick solid black lines indicate municipal boundaries.)

Normalized amounts of attenuated TIR energy (Composite: **M2013** and **M2014**)

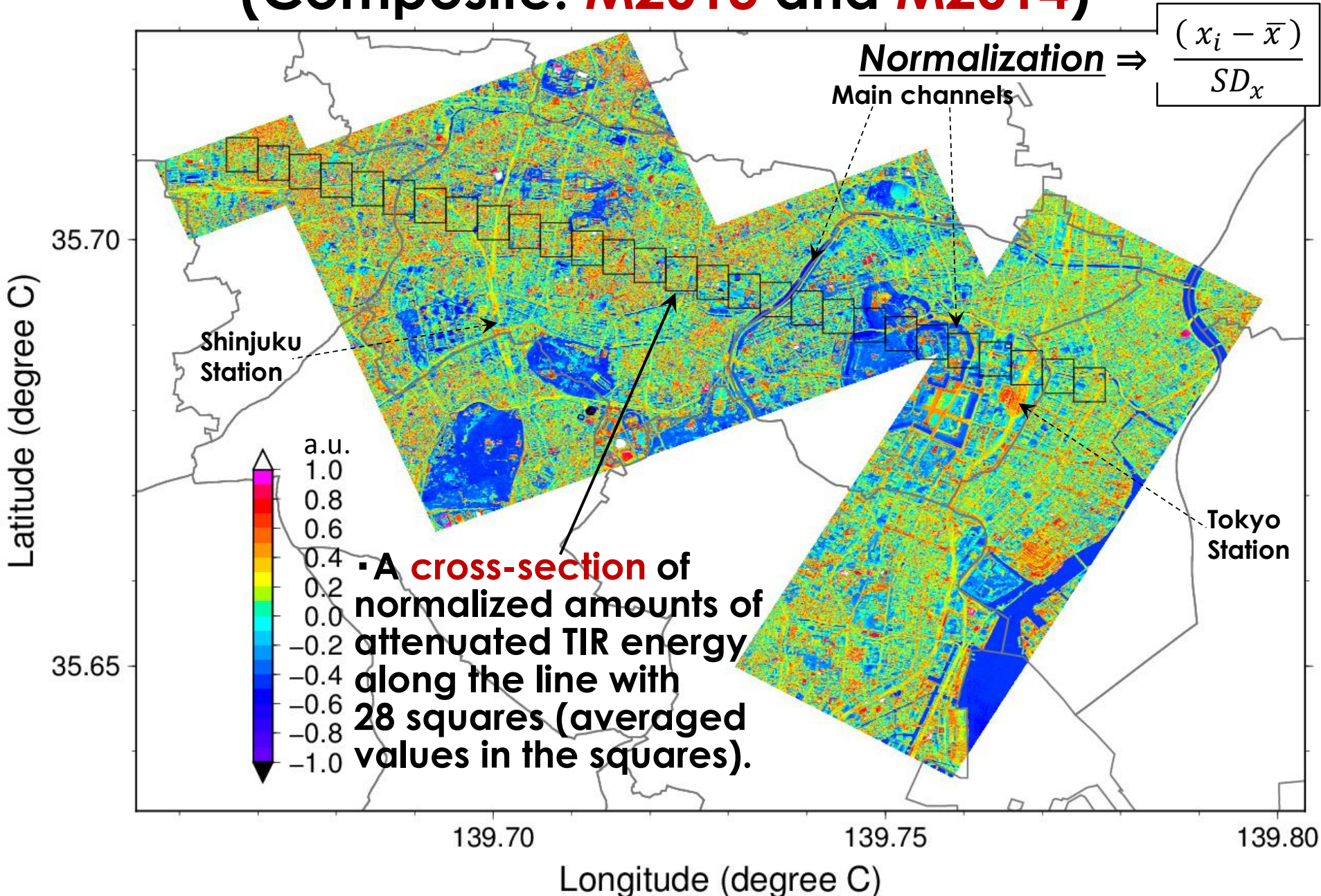


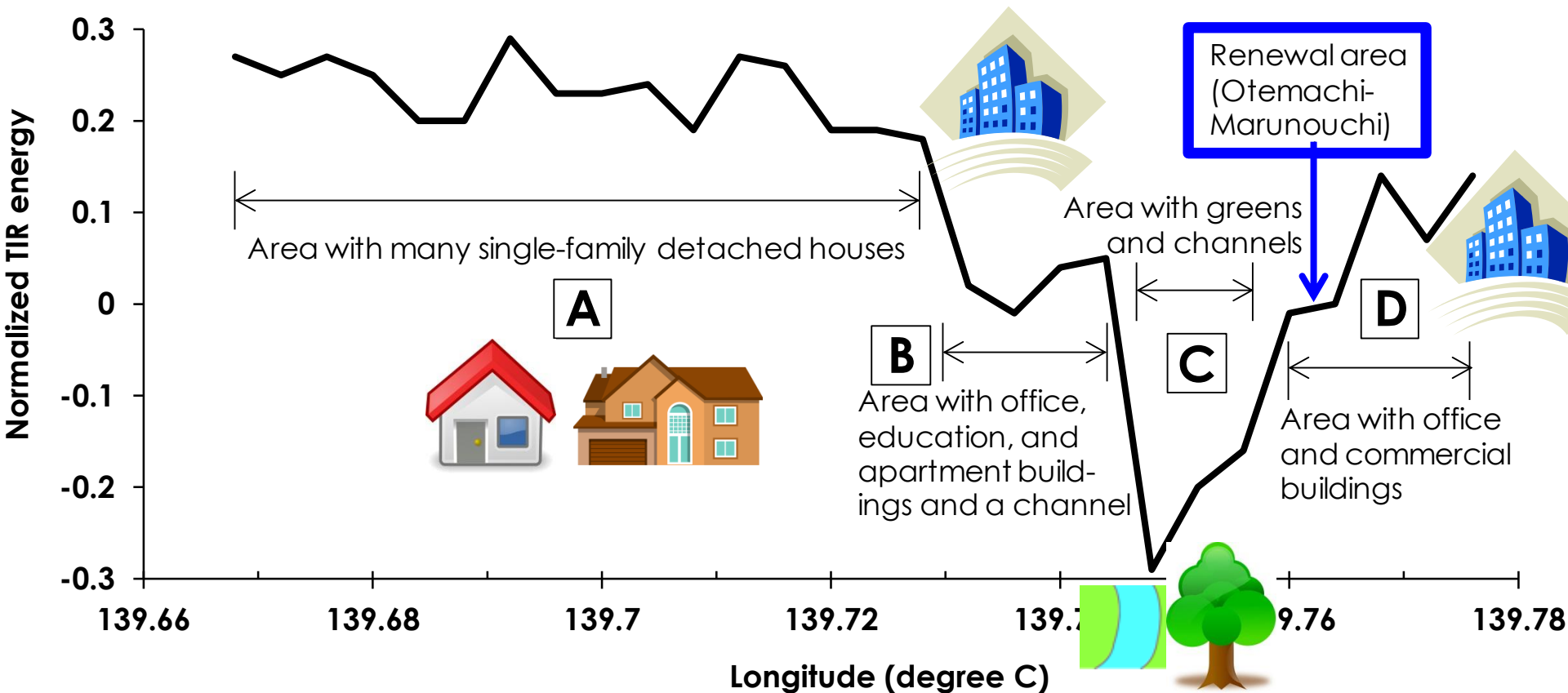
Airborne TIR measurements in downtown Tokyo



- Many **single-family detached houses (high density wooden houses)** are located in the **northwestern part of downtown Tokyo**.
- Many **office and commercial buildings** are located in the **southeastern part of downtown Tokyo**.

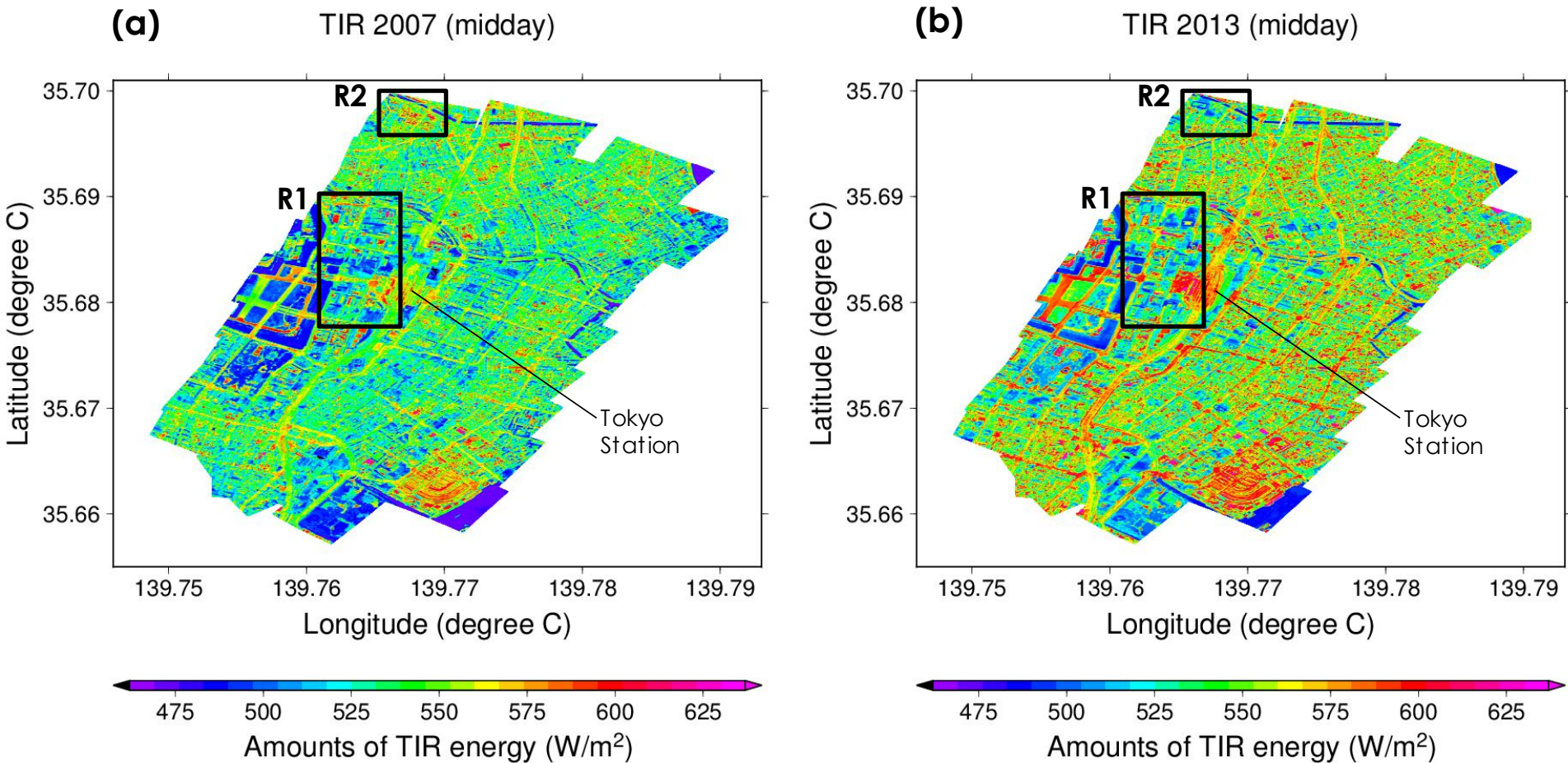
Normalized amounts of attenuated TIR energy (Composite: **M2013** and **M2014**)





- Amounts of TIR energy are **especially large** in the area with many single family detached houses (**high density housing area**; “A”), but suddenly change to **smaller amounts** in the area with office buildings et al. (“B”).
- Amounts of TIR energy in **the western part of the area “D”** are slightly smaller than those in the eastern part of the area “D” and the area “B” in spite of the similar land uses/covers. This part corresponds to an **urban renewal area**, redeveloped in the past several years. → **Why??**

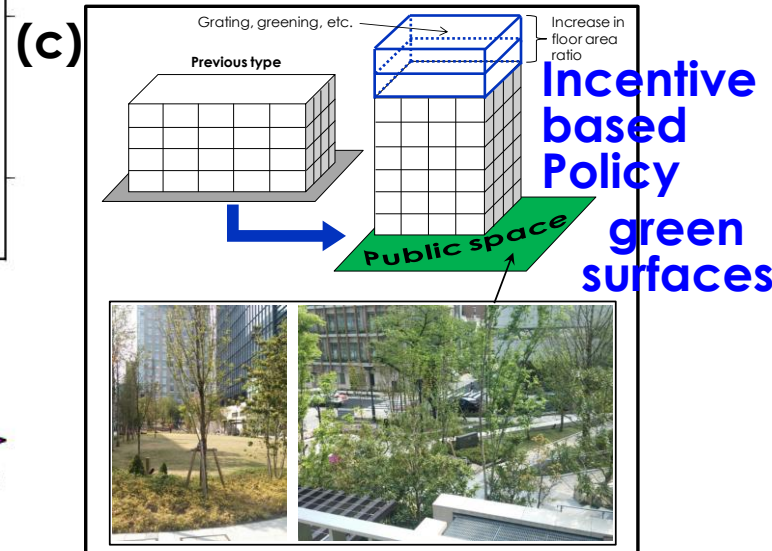
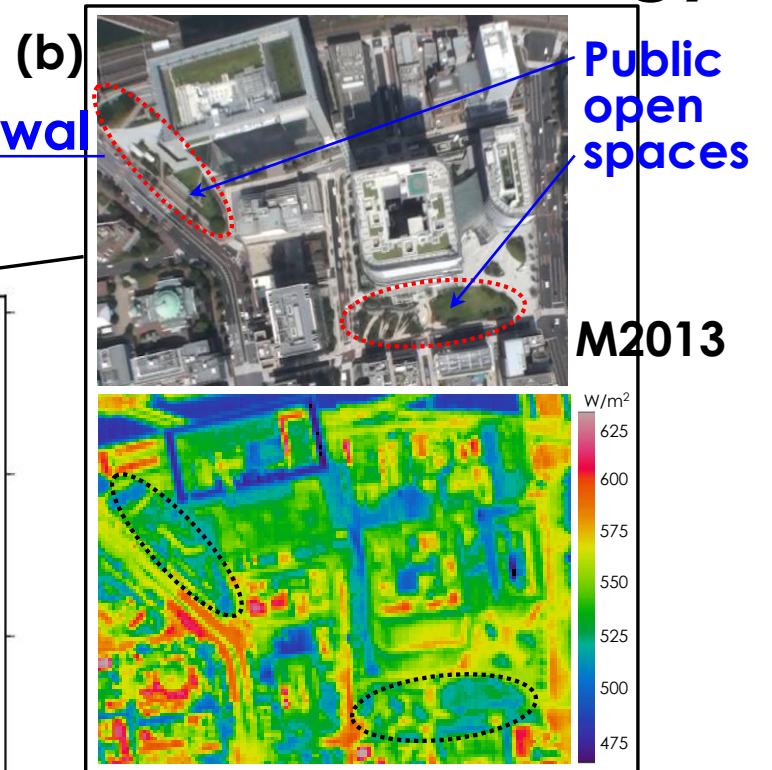
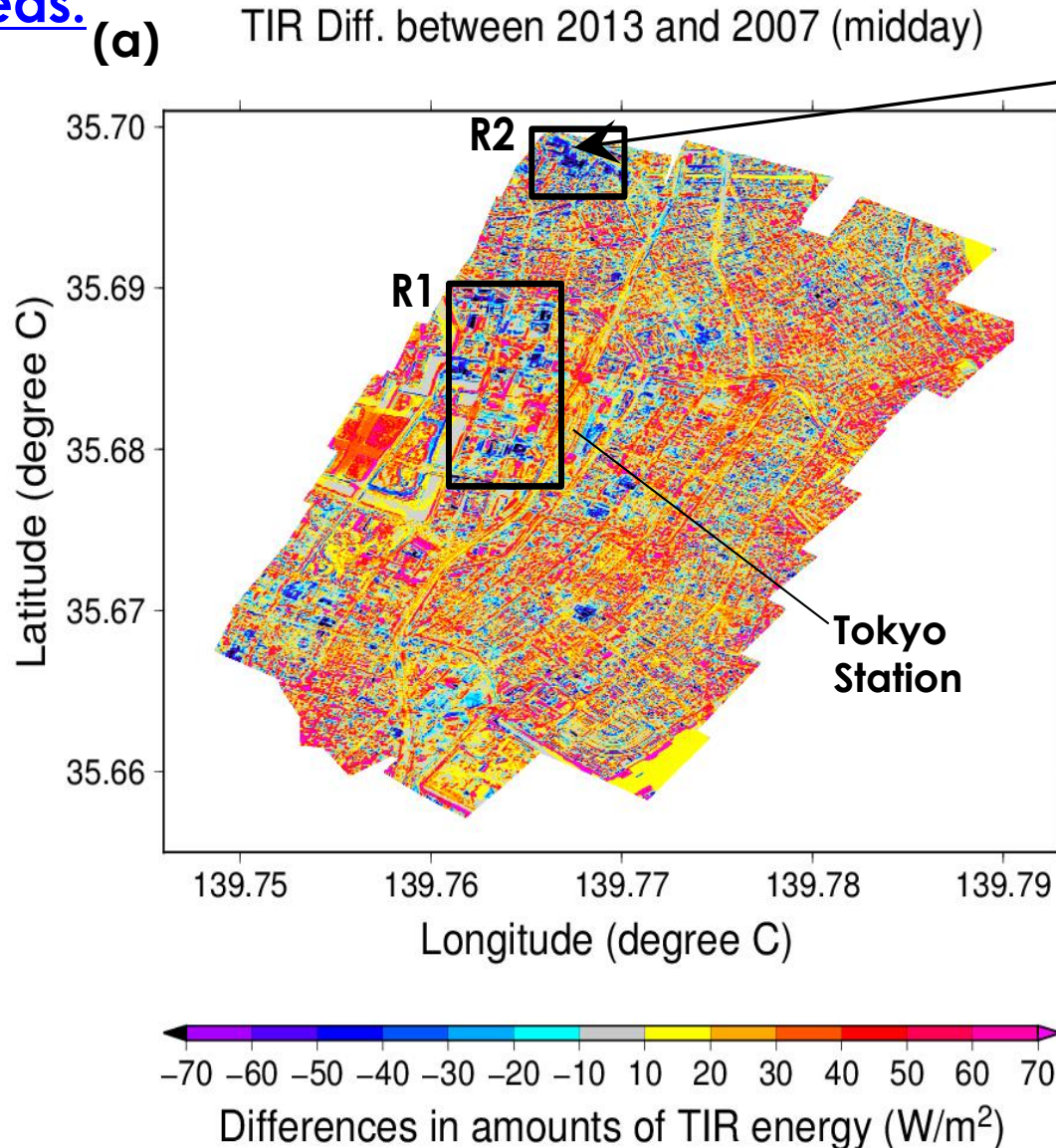
Absolute values of amounts of attenuated TIR energy in Central Tokyo: M2007 (L) and M2013 (R)



- The boxes marked “R1” and “R2” represent two urban renewal areas: “Otemachi-Marunouchi” and “Ochanomizu”, respectively.
- Prior to M2013, abnormally hot weather conditions persisted.
 - Relatively large amounts of TIR energy in many parts of the domain.

Differences in amounts of attenuated TIR energy between M2013 and M2007

! Remarkable decreases in TIR in urban renewal areas.

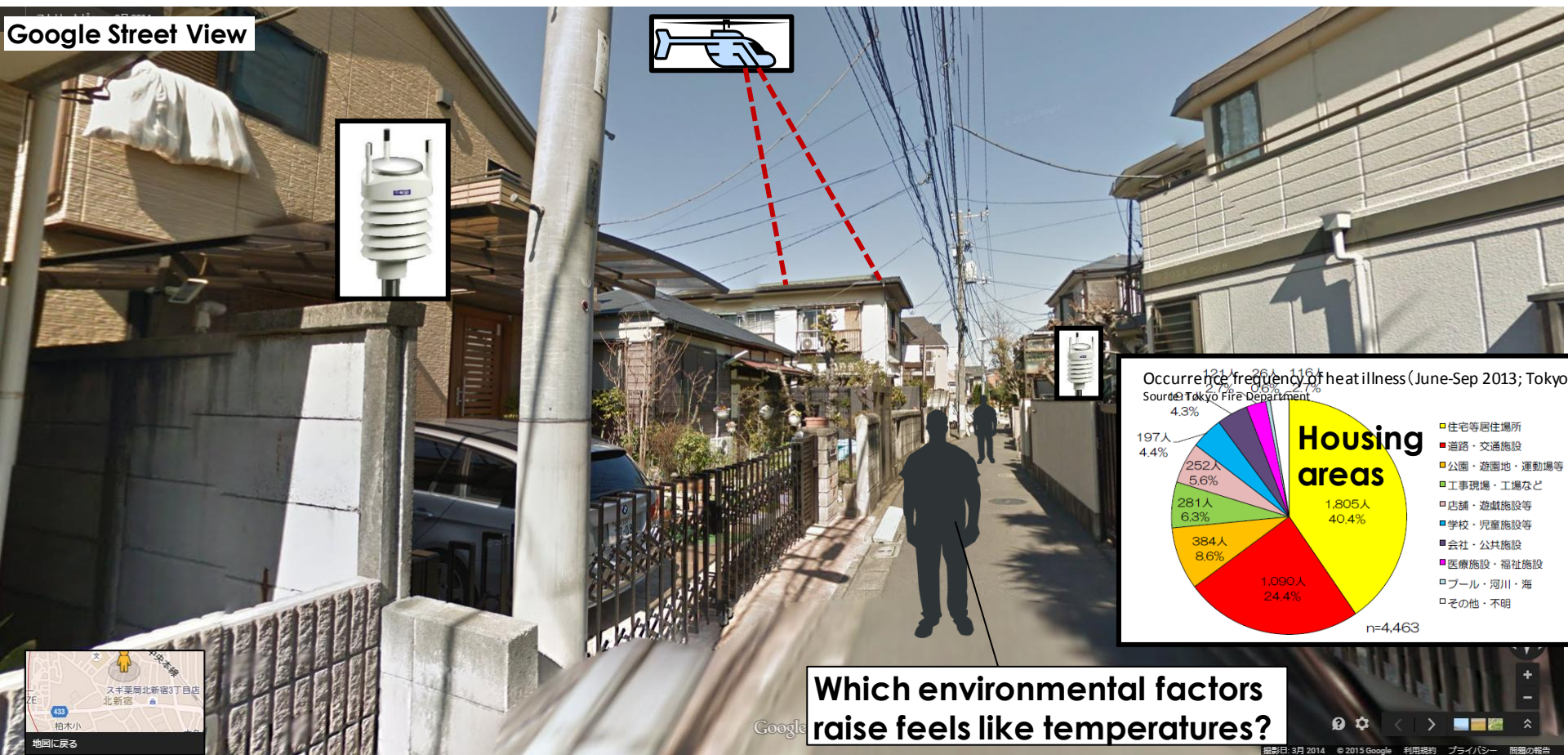


Summary and Conclusion

- Spatiotemporal changes in **amounts of outgoing TIR energy** in downtown Tokyo in midday and **their relations to land uses/covers** were investigated. (TIR: **2 m spatial resolution data** obtained from airborne measurements).
- The results showed that amounts of TIR energy are **especially large in the areas with high density housing**, compared with those in the areas with office and commercial buildings.
- We found **remarkable decreases in amounts of TIR energy in urban renewal areas** where many green surfaces have been provided in **public open spaces** following incentive-based policies enacted by the Tokyo metropolitan government for environmental protection, disaster prevention, and **UHI adaptation and mitigation strategies that reduce surface temp.**

Summary and Conclusion

- Detailed investigations in thermal environment in the areas with **high density housing** are needed as a future work. The maximum occurrence frequency of heat illness tends to be recorded in residential areas and in midday.





Full paper:

Tsunematsu, N., H. Yokoyama, T. Honjo, A. Ichihashi, H. Ando, and N. Shigyo, 2015: Relationship between land use/cover variations and amounts of thermal infrared energy emitted from urban surfaces in downtown Tokyo on hot summer days, **Remote Sensing Applications: Society and Environment (Elsevier)**, *in revision*.

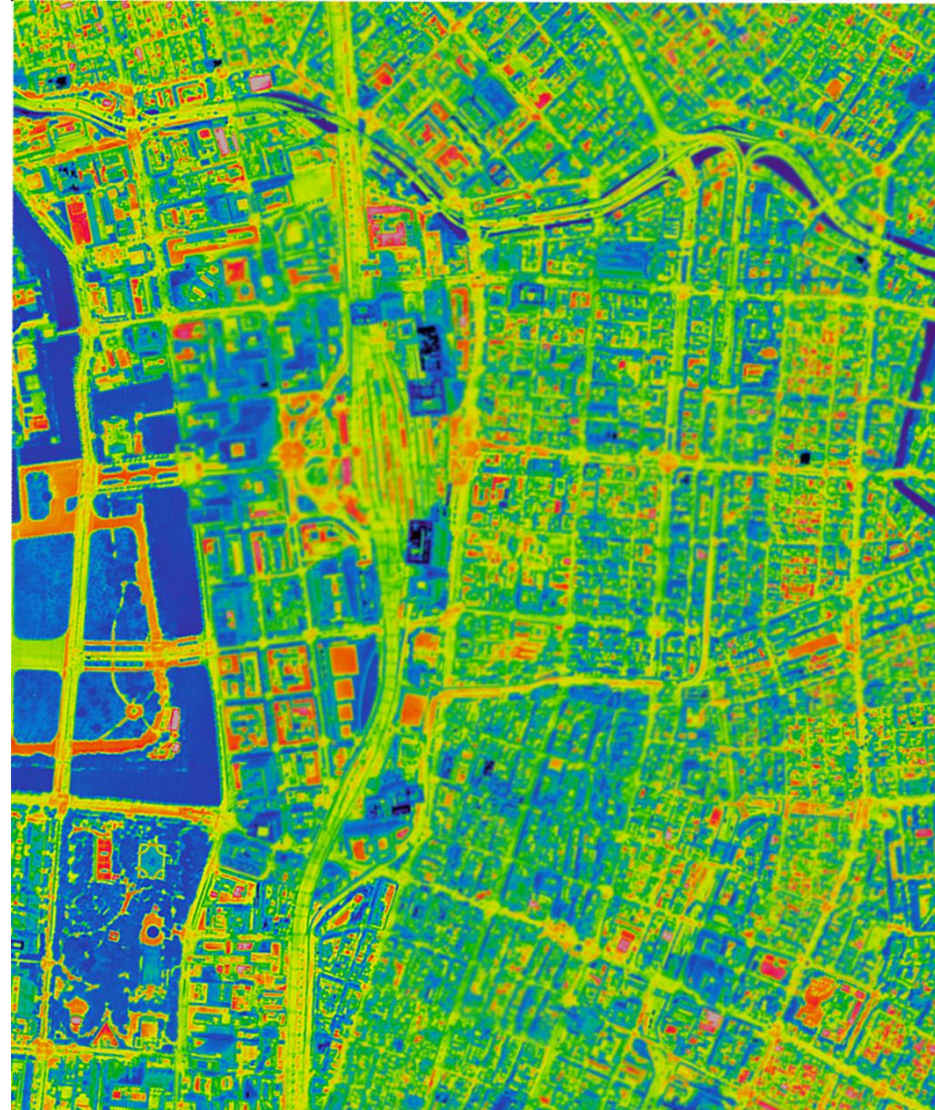
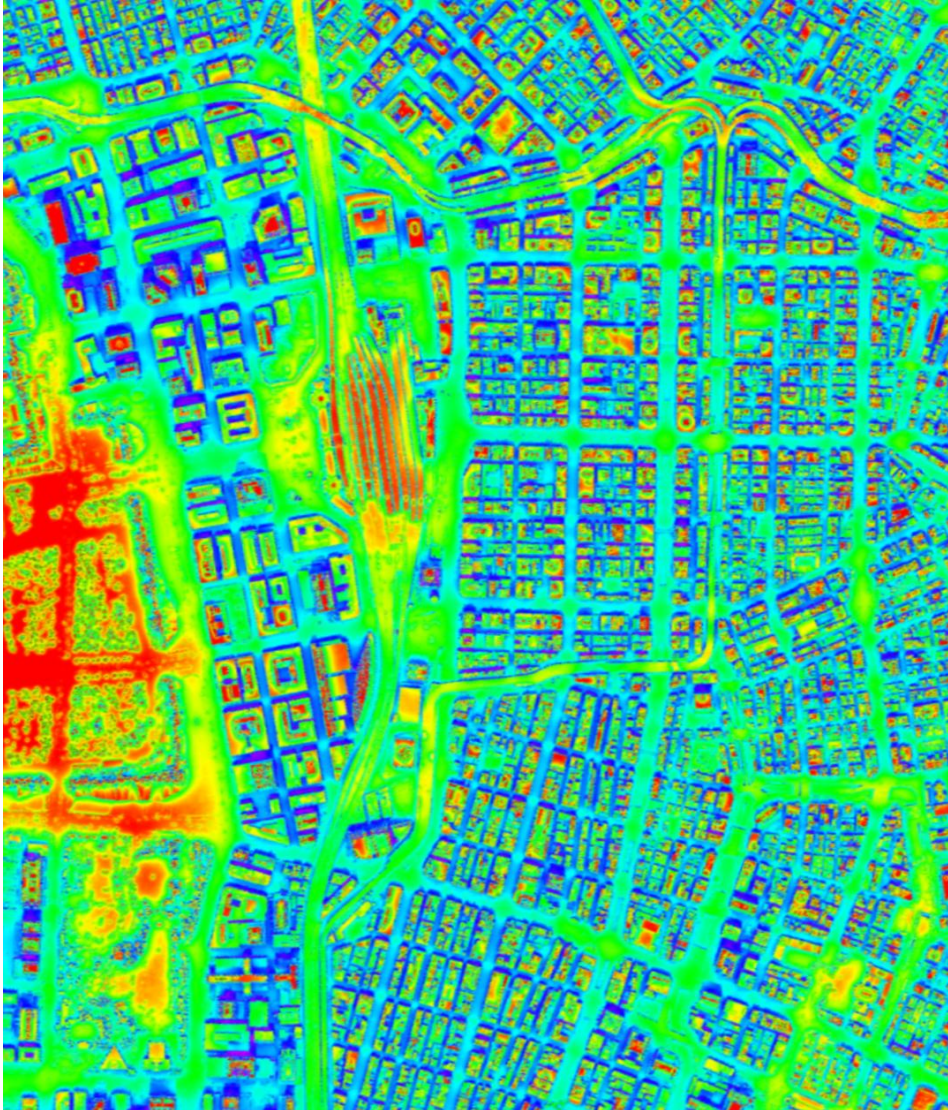
ResearchGate:

http://www.researchgate.net/profile/Nobumitsu_Tsunematsu

Sky view factors and amounts TIR energy

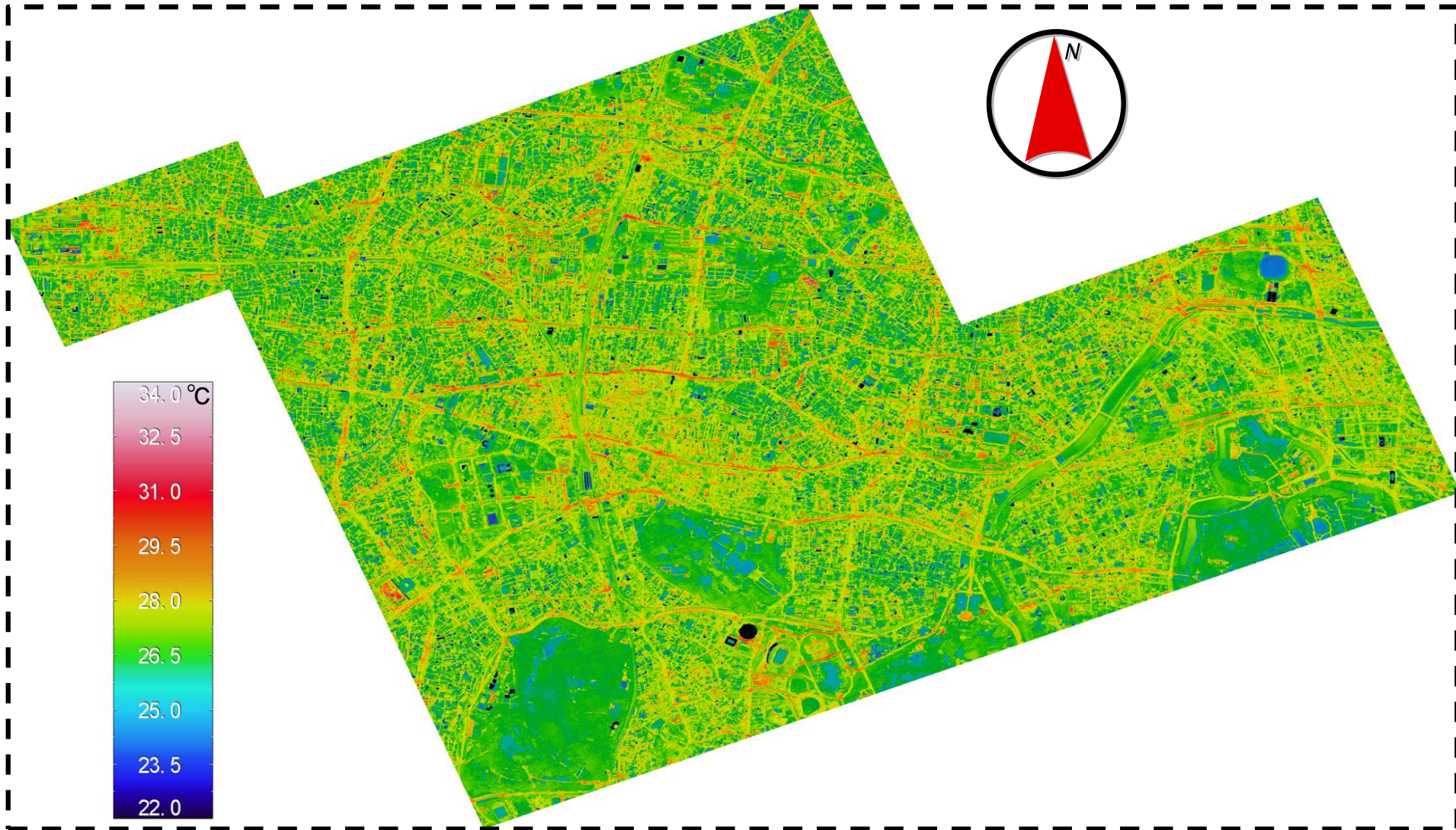
SVF (SOLWEIG)

TIR (observations)

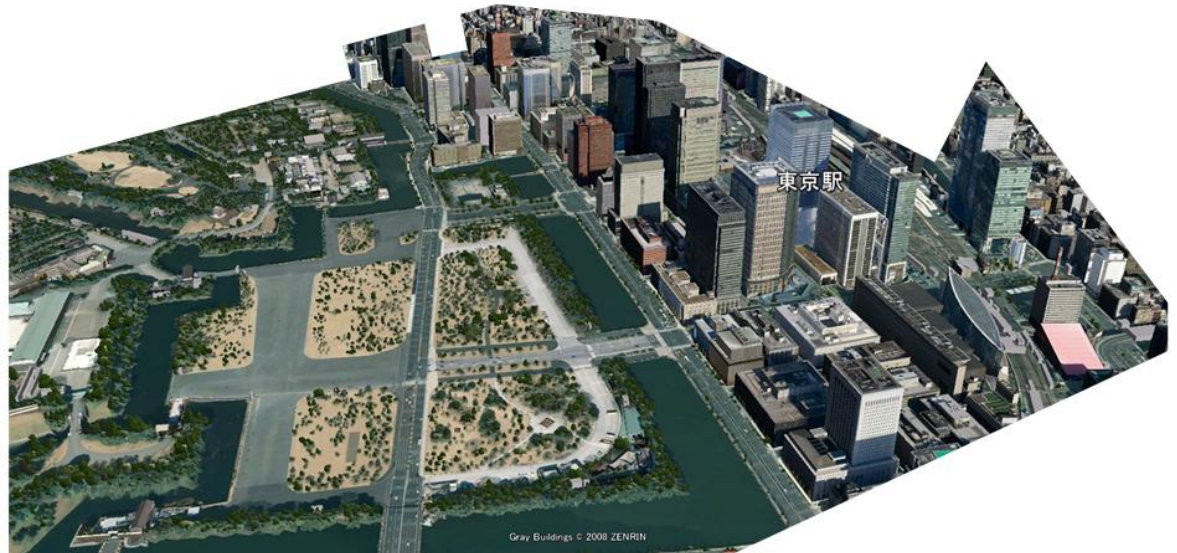
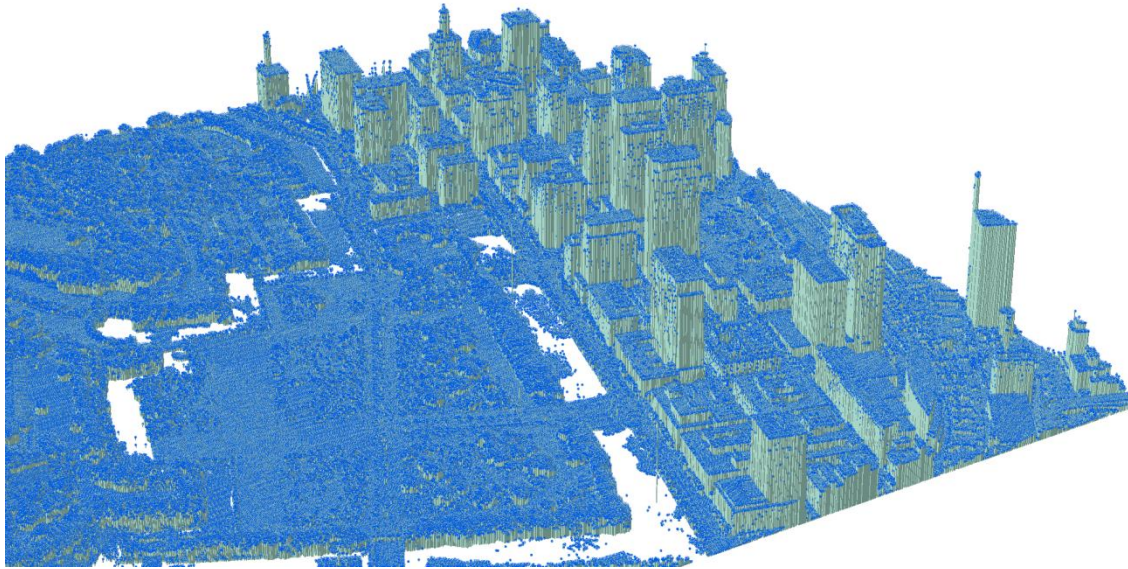


(Aug. 7, 2007; midday)

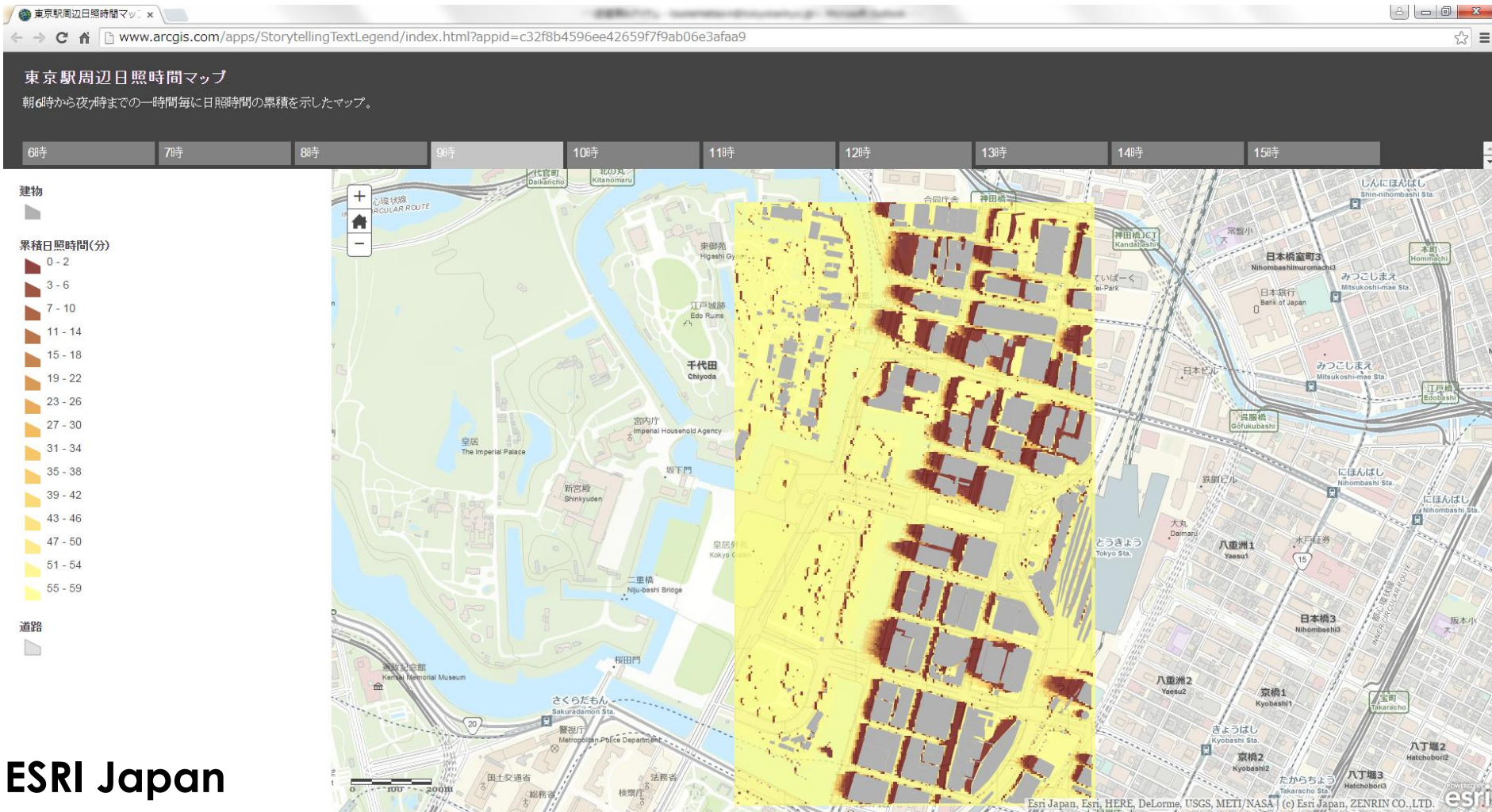
Nighttime TIR (M2014)

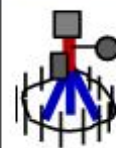


LiDAR



Analyses of shadow areas





AMS measurements



Globe temperature



Camera

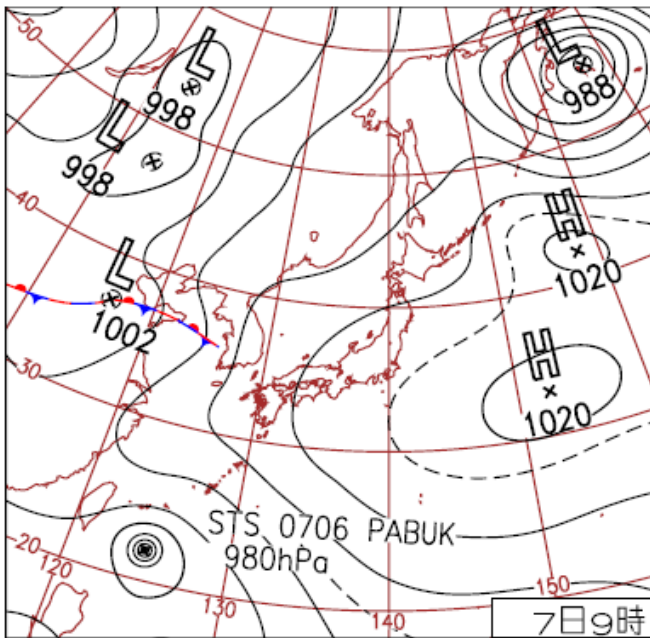


Awning

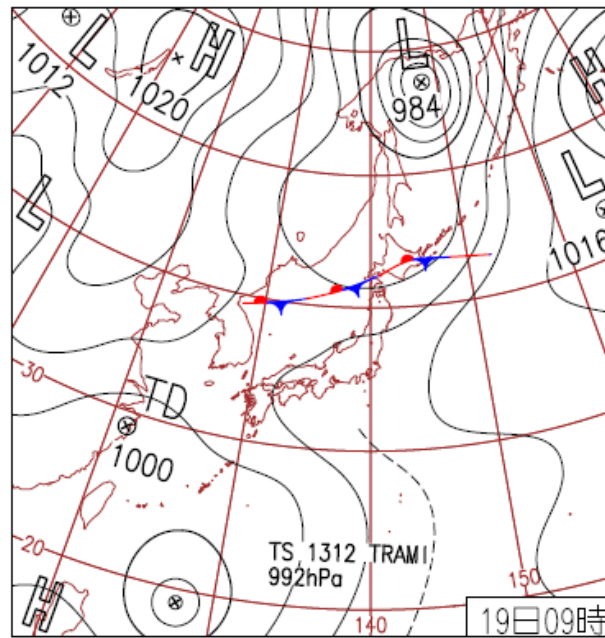
Surface weather charts at 0900 LT

(Source: Japan Meteorological Agency website)

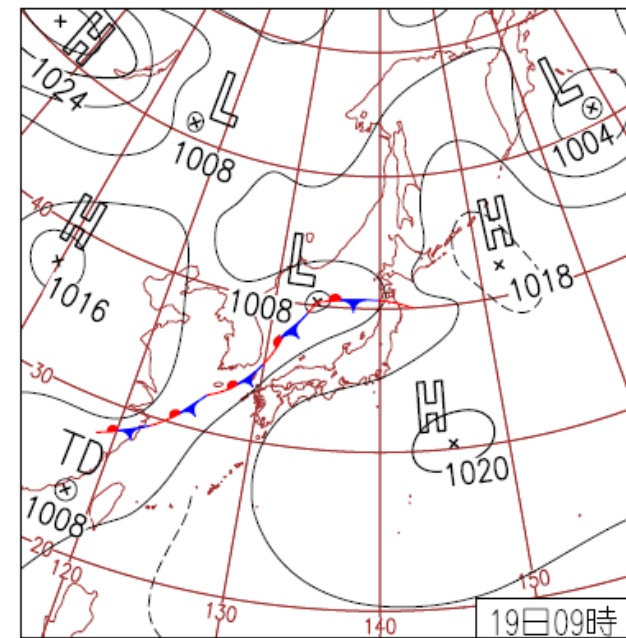
Aug. 7, 2007 (M2007)



Aug. 19, 2013 (M2013)



Aug. 19, 2014 (M2014)



➤ North Pacific High covered the Tokyo metropolitan area on the days when M2007, M2013, and M2014 were carried out.



Full paper:

Tsunematsu, N., H. Yokoyama, T. Honjo, A. Ichihashi, H. Ando, and N. Shigyo, 2015: Relationship between land use/cover variations and amounts of thermal infrared energy emitted from urban surfaces in downtown Tokyo on hot summer days, **Remote Sensing Applications: Society and Environment (Elsevier)**, *in revision*.

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