A statistical analysis of urban Big-Data toward real-time heatwave risk management

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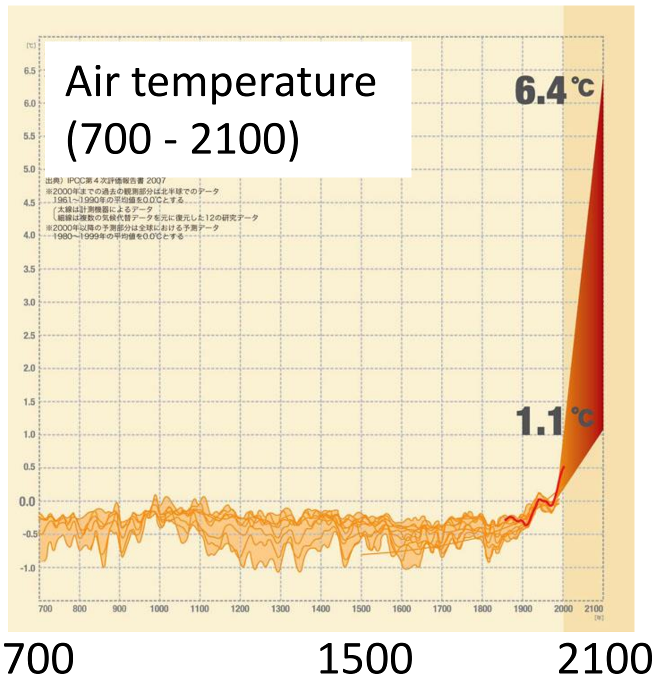
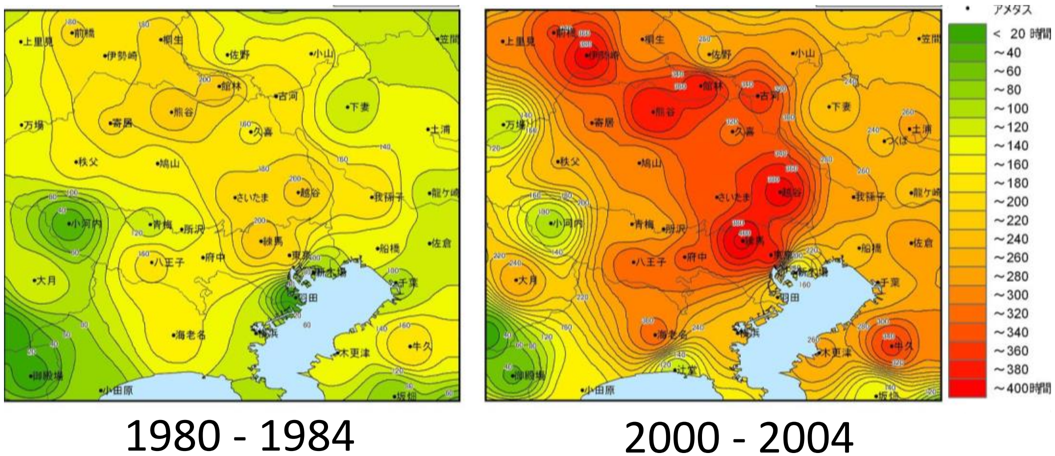
Introduction

Global warming

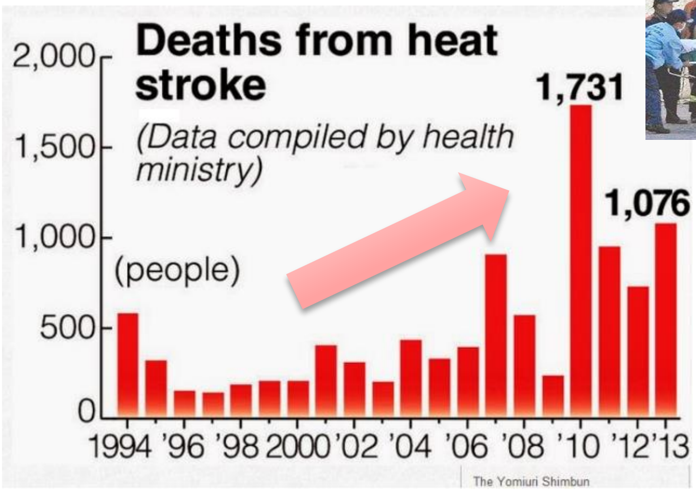


Urban heat island

Number of hot days
(temp. > 30) in Tokyo



Heatstroke risk

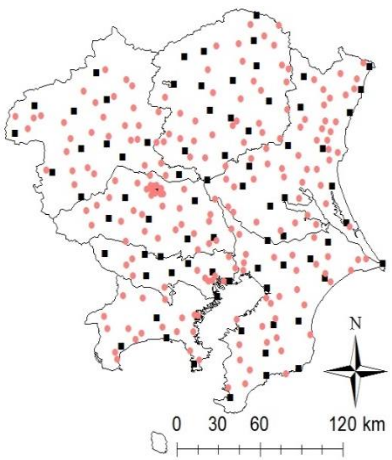


Monitoring heatstroke risk is increasingly important

Temperature data in the Tokyo metropolitan area

Air temp. data

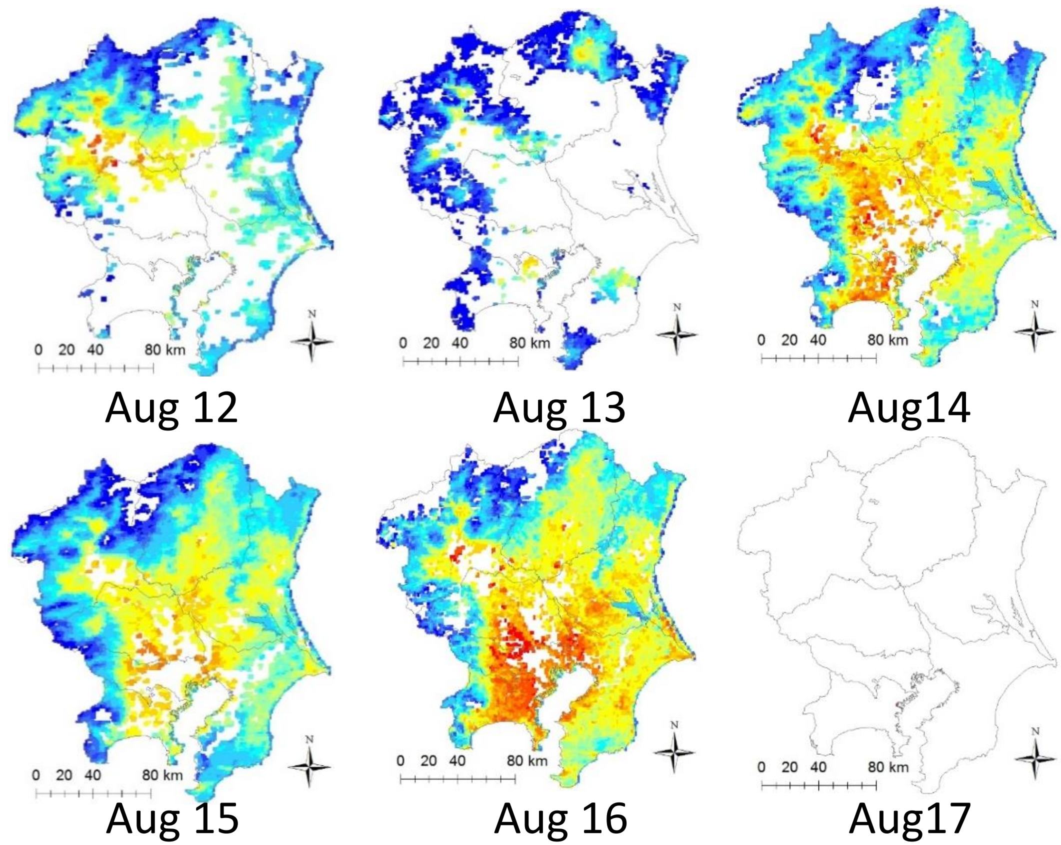
- Monitoring data
- 284 sites
- At every hour

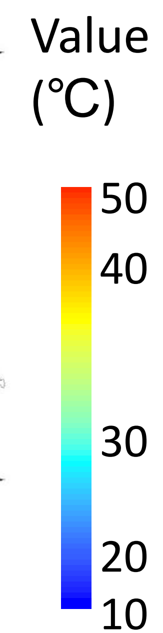


■ : AMEDAS data
● : NTT DoCoMo data

Ground temperature data

- MODIS data
- 30,572 sites (1 km grids; 80% are missing)
- At 10:30, 13:30, 22:30, 1:30





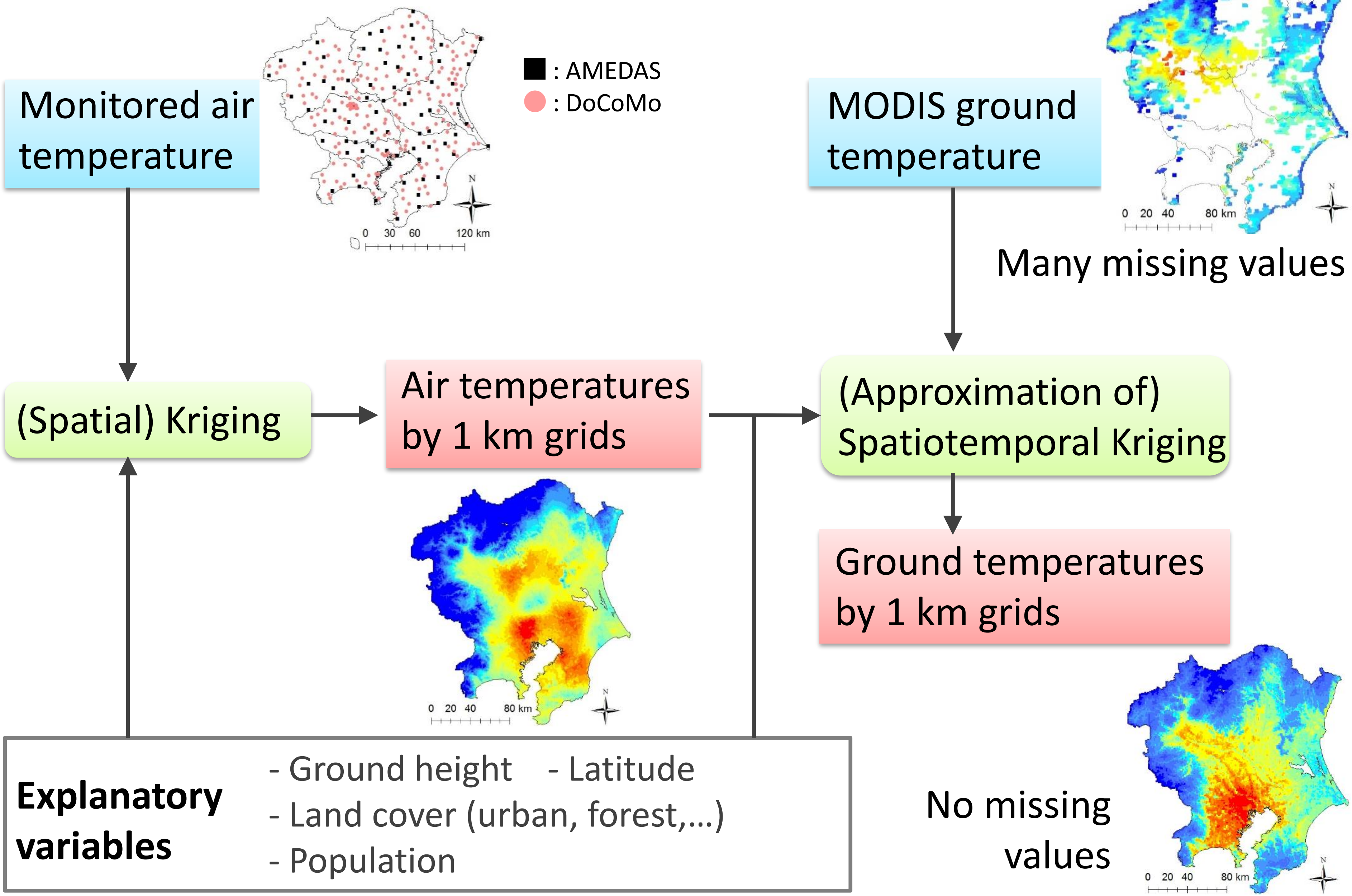
They capture **global-scale** urban climate.

Objective

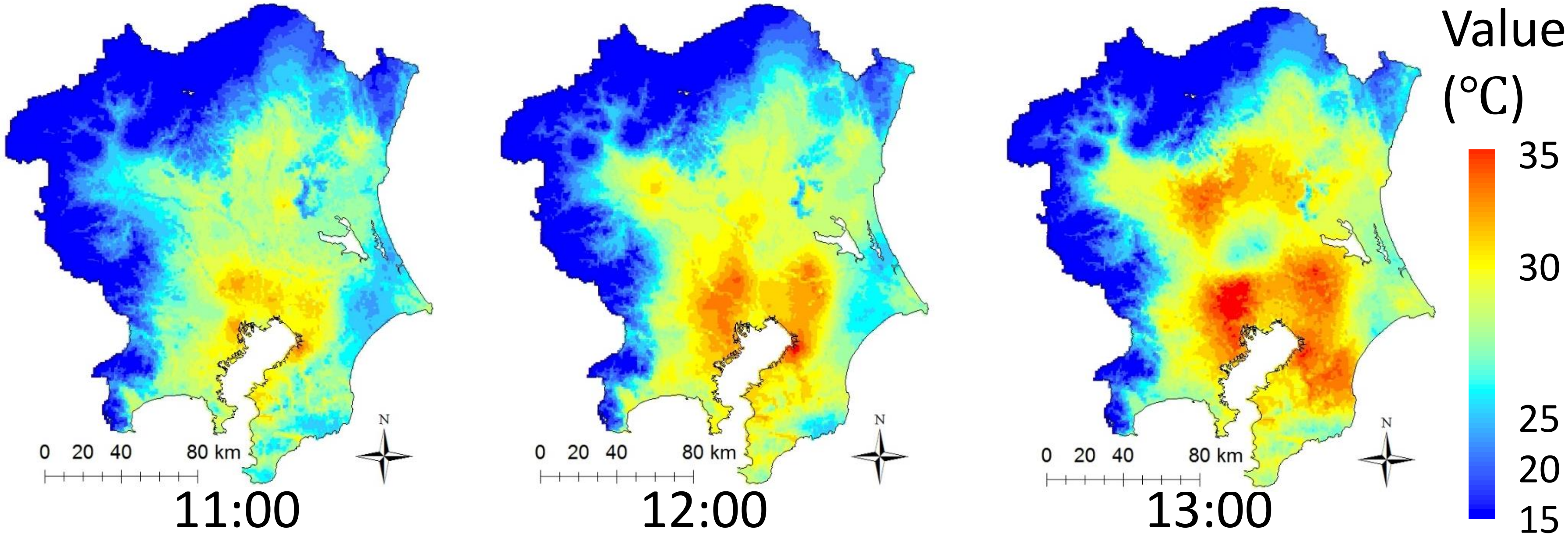
- Heatstroke risk changes significantly not only in a global-scale but also in a **local-scale**
  - e.g., heatstroke risk might be server on a road but not on a park, which is next to the road.

- Toward real-time urban climate monitoring, **we estimate ground temperatures in a local-scale**
  - We first estimate ground temperatures by **1 km grids** (without missing)
    - ✓ Data 1: Air temperature (AMEDAS+ DoCoMo)
    - ✓ Data 2: Ground temperature (MODIS; 80% are missing)
  - We then downscale the estimated temperatures into **0.5 m grids**
    - ✓ Data : Airborne observation data

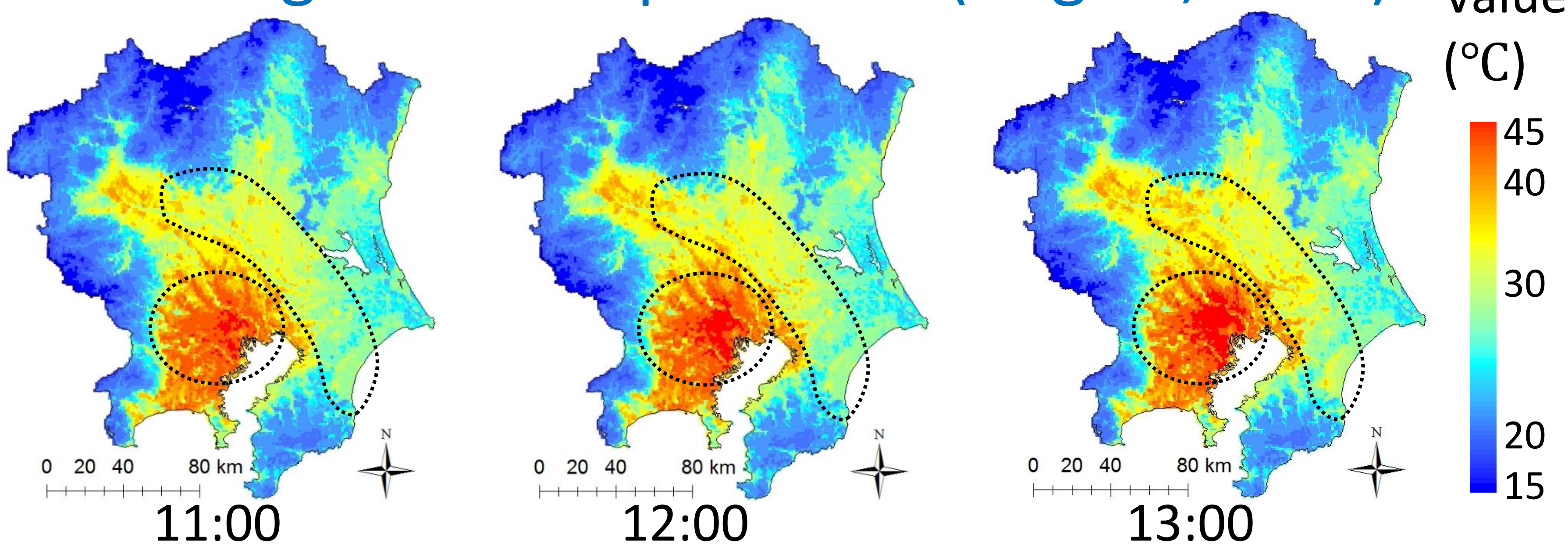
Procedure for the ground temperature estimation by 1 km grids



Estimated air temperatures (Aug.15, 2012)

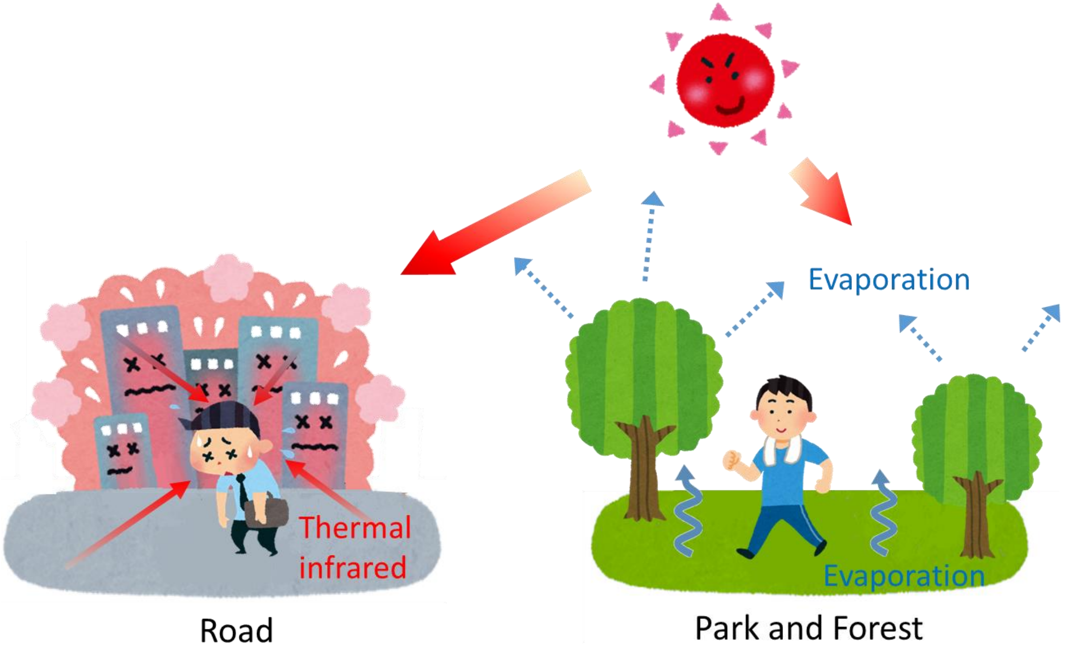


Estimated ground temperatures (Aug.15, 2012)



Discussion

- **<u>Air and ground temperatures have different spatial distributions</u>**
- **<u>Ground temperature tends to be severe in the central area</u>**
  - Because it considers hotness on asphalt and concrete
  - Ground temperature would be a better indicator of heatwave risk than air temperature.



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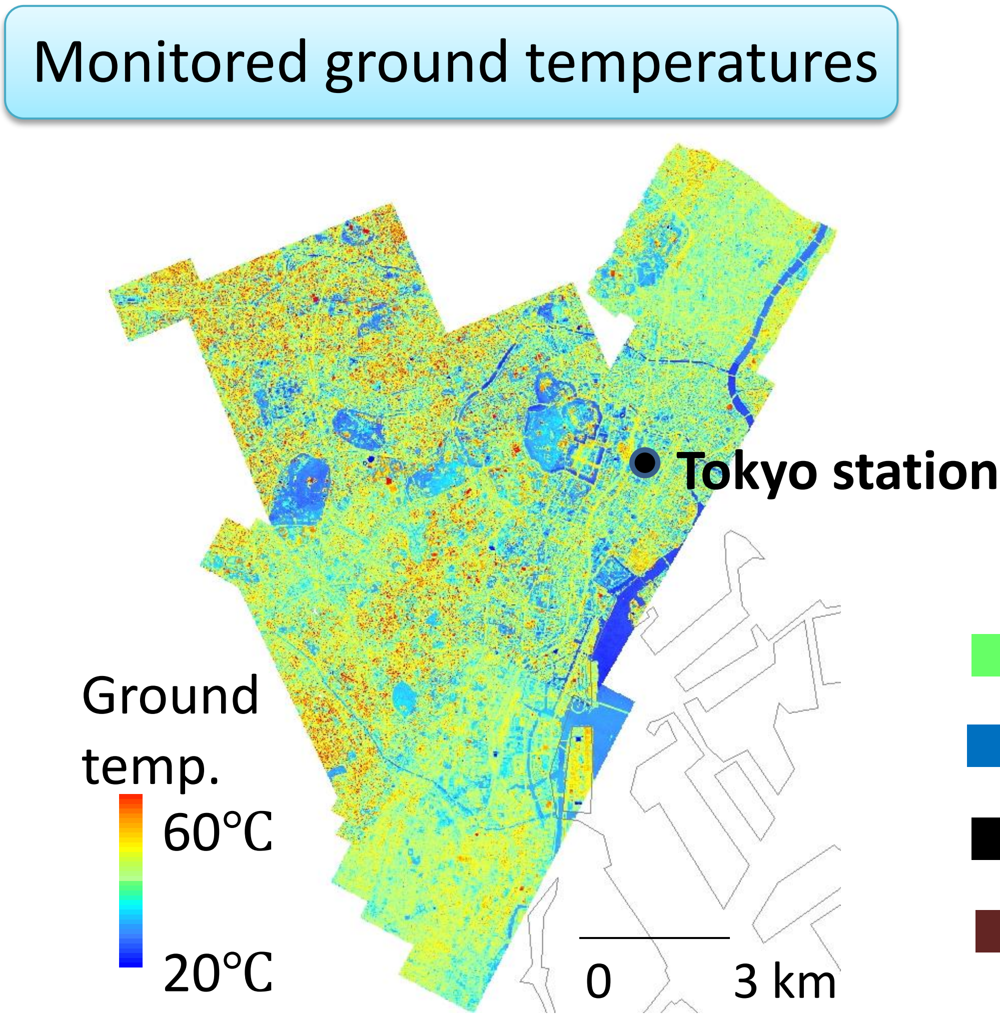
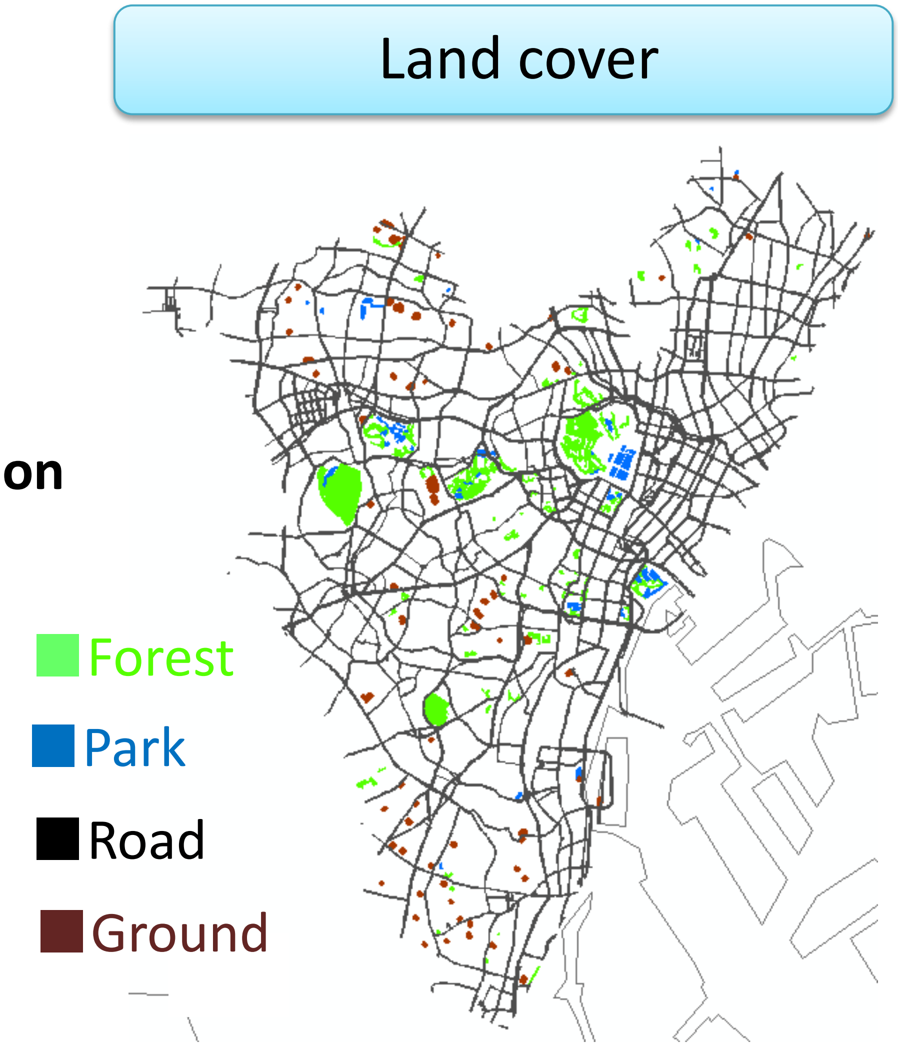
Airborne observation in the central area (13:30, Aug.19, 2015)

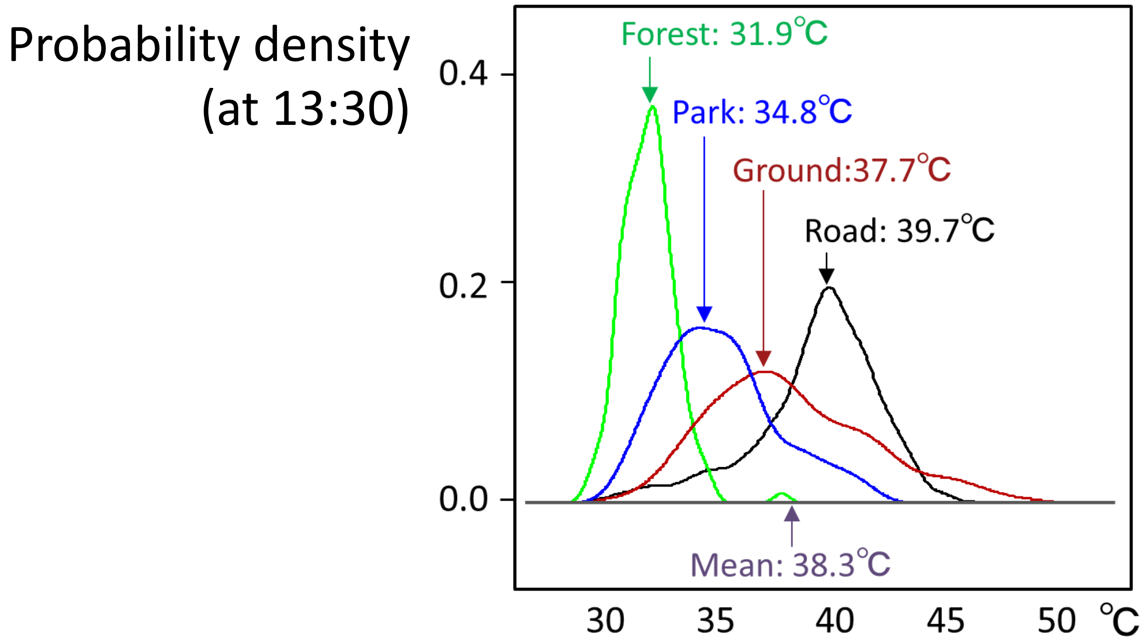




- **The airborne data is available only in the central area in that time.**
  - To estimate ground temperatures **in arbitrary area and time**, we use this data to estimate the relationship between ground temperatures and land covers.

Ground temperature in each land cover at 13:30

- Monitored ground temperatures are aggregated in {forest, park, ground, road}



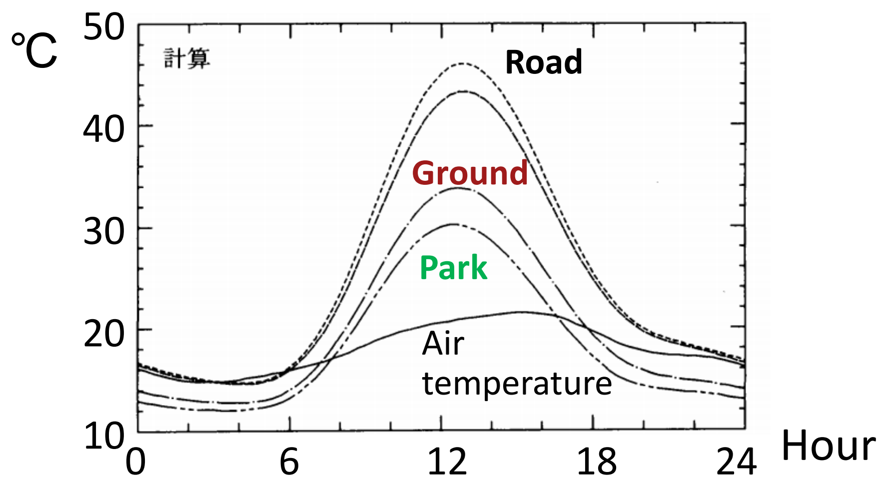
- **At 13:30**, ground temperatures in {forest, park, ground, road} are estimated by differentiating their mean from the global mean.

Ground temperature in a forest

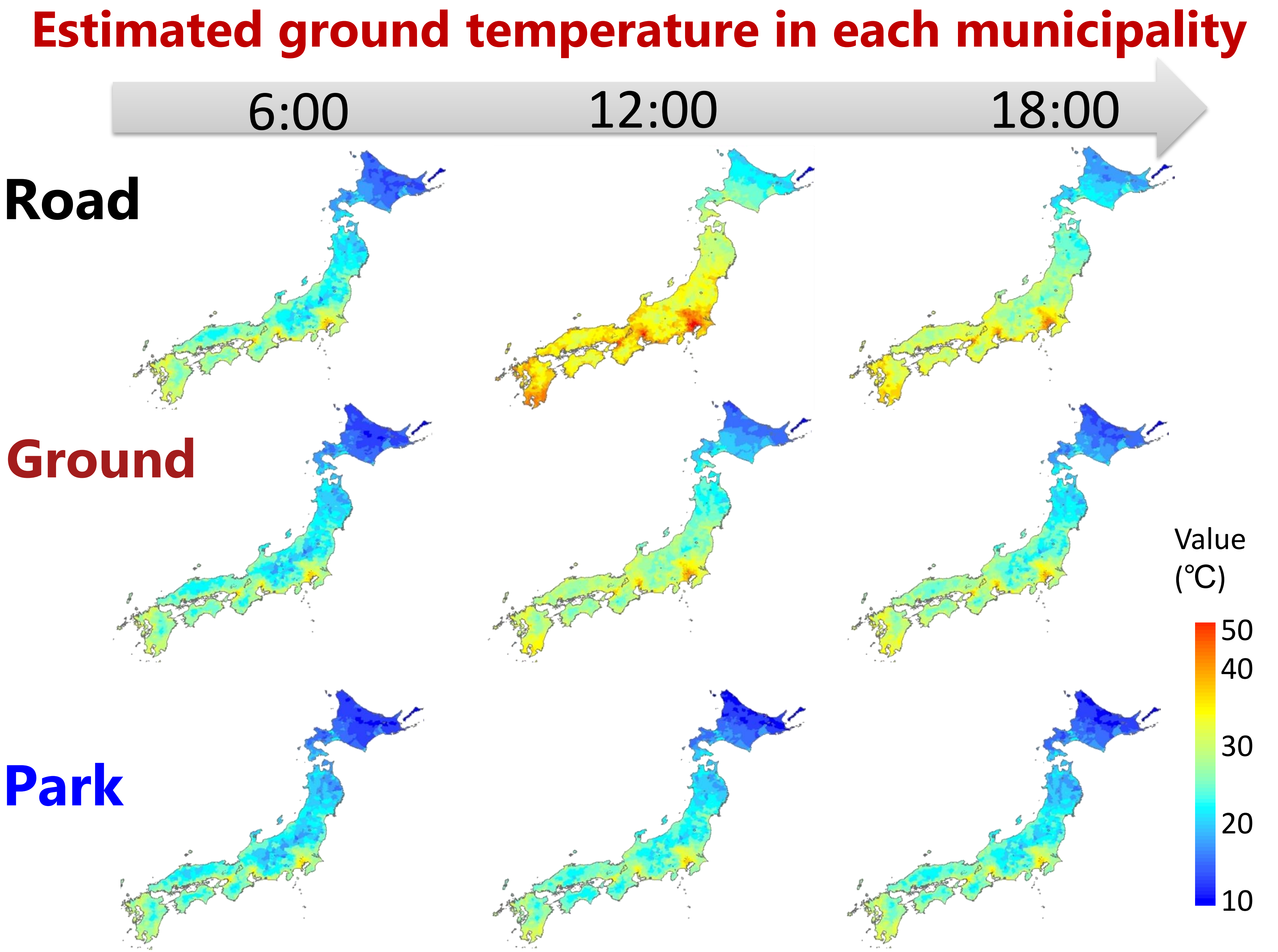
= Estimated ground temperatures - 6.4℃ (= 38.3-31.9)

Ground temperature in each land cover at other times

- Kondo and Sugawara (1995) simulated the difference of ground temperatures in a typical day.



- **Other than 13:30,** ground temperatures in {forest, park, ground, road} are estimated by scaling the temperature differences at 13:30 based on Kondo and Sugawara (1995)



Estimated ground temperature in each municipality
6:00
12:00
18:00
Road
Ground
Park
Value
(℃)
50
40
30
20
10

An app for heatstroke prevention

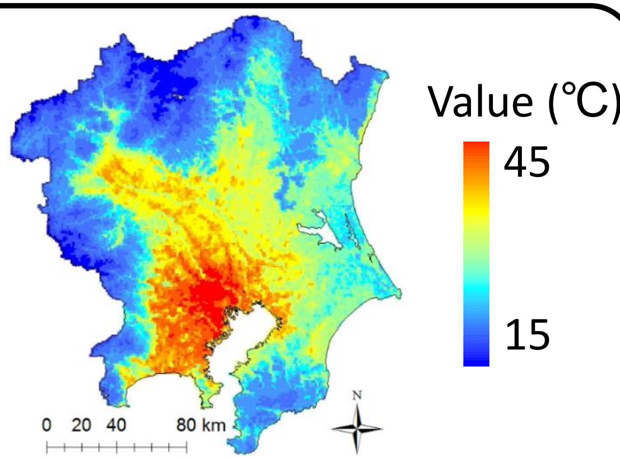
- We have developed an app in collaboration with NTT DoCoMo (release: May, 31)

- It informs real-time ground temperatures in road, park, and ground in the municipality where the app user is in.

Downscale of the ground temperature estimates

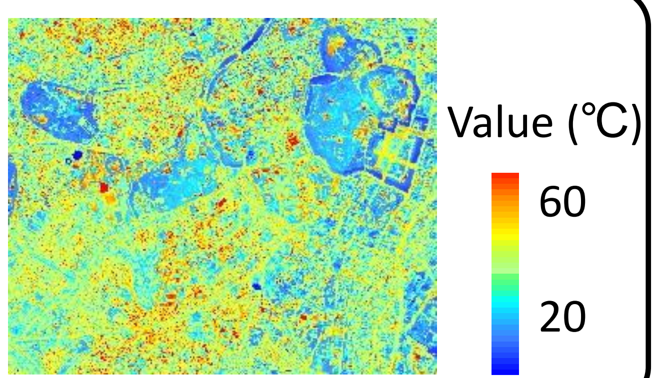
The following framework allows us estimating real-time district level ground temperatures without relying on airborne observation that is very expensive.

Ground temperatures **by 1 km grids**



Downscale

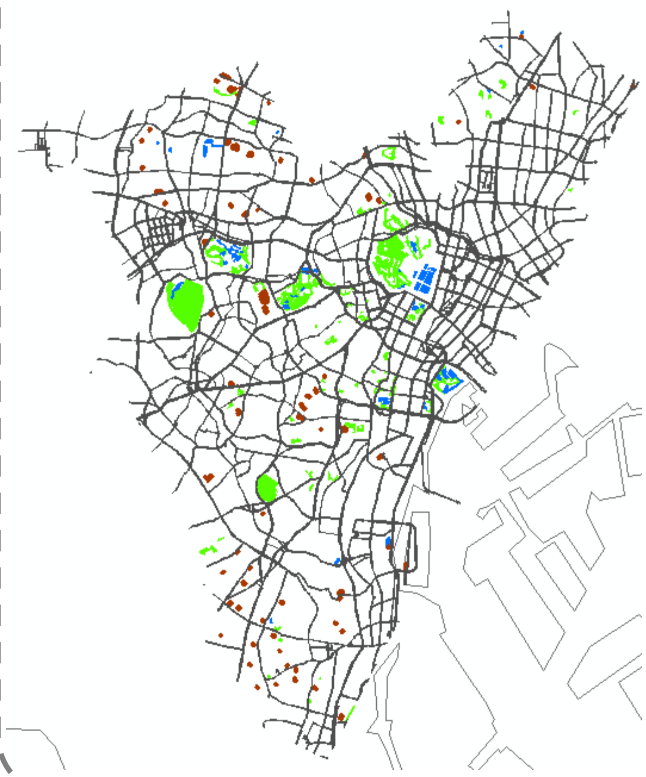
Ground temperatures **by 0.5 m grids**



Area-to-point Kriging

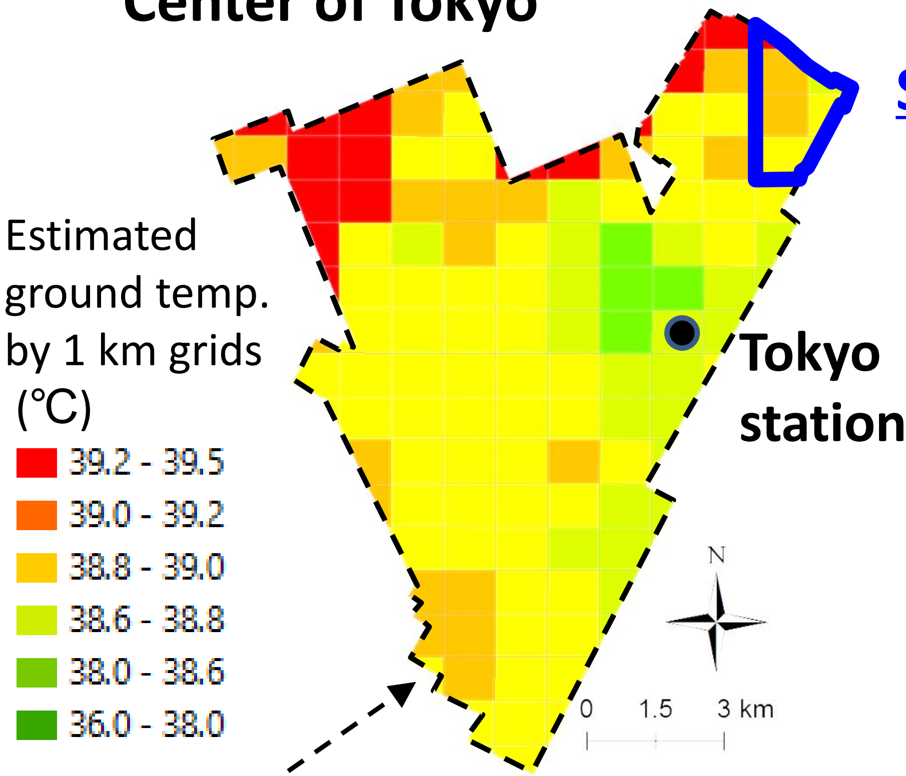
+

Land cover



DS accuracy assessment

Center of Tokyo



Site for validation: Asakusa

- A historical area
- Many foreigner hang around in this area.
- **Downscaling result is compared with temperatures observed by the airborne**

Site for DS model estimation

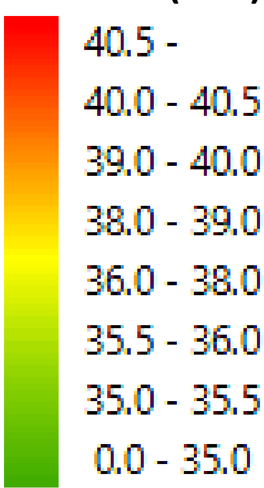
- Difference of ground temperatures on {road, forest, ground, park} are estimated in this area

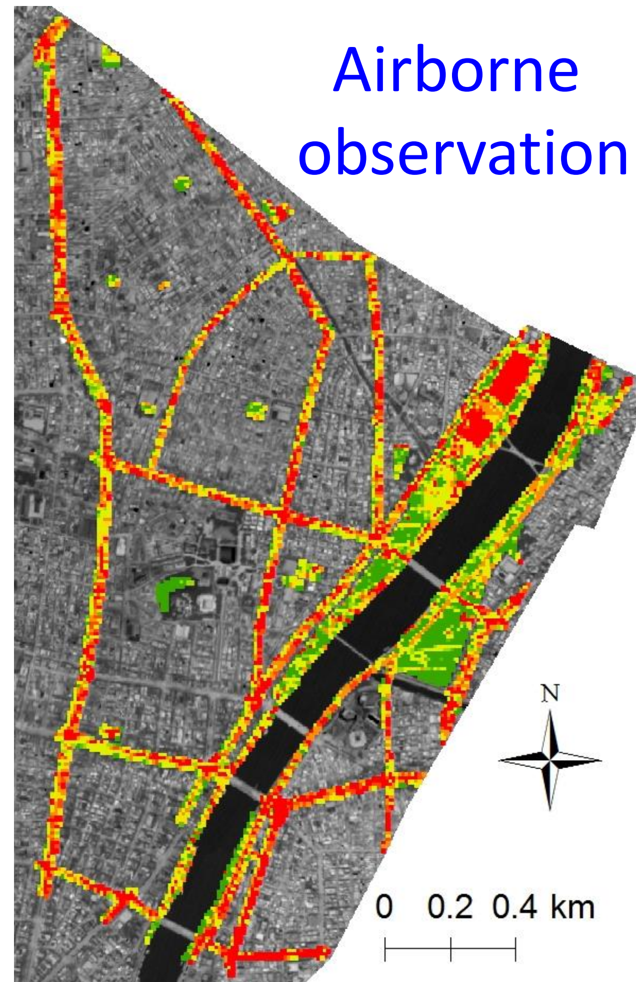
Result

- **DS result** has a similar distribution with **observed values**
- Consideration of micro attributes, such as location of trees, and buildings, is needed to improve the accuracy

Correlation coefficient : 0.51

Value (℃)





Future directions

- **We have demonstrated how to estimate district level ground temperatures.**
  - **This approach is available for real-time local ground temperature estimation.**
  - We want to utilize this approach for heatstroke risk prevention, e.g., through an app.

- Remaining issues
  - **Consideration of building locations, trees, and resulting shades**

    →3D urban model, which is based on a LiDAR observation, would be useful
  - **Improvement of the model accuracy**

    →State-space model + quantile regression+ kriging

    →Consideration of human sensor data