EGU General Assembly 2022

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Hourly air temperature mapping in Guangdong province utilizing machine learning

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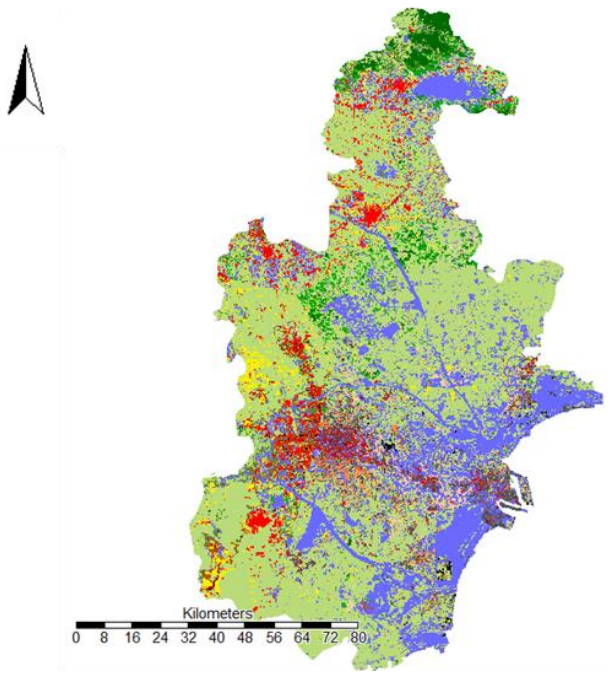
Introduction

- The rise of mega- and high-density compact urban regions are now non-reversible trends of urbanization. High-density mega-urban living has brought a series of environmental challenges and problems, such as intensified urban heat island and air pollution.
- Characterizing the spatiotemporal variability of the near-surface air temperature at fine resolutions is of importance to investigate the urban heat, energy consumption, thermal comfort and heat-related risks. It is becoming even more important in the context of climate change.
- An accurate and in-depth understanding of air temperature will help to provide scientific evidence-based findings for policymakers to achieve sustainable development.

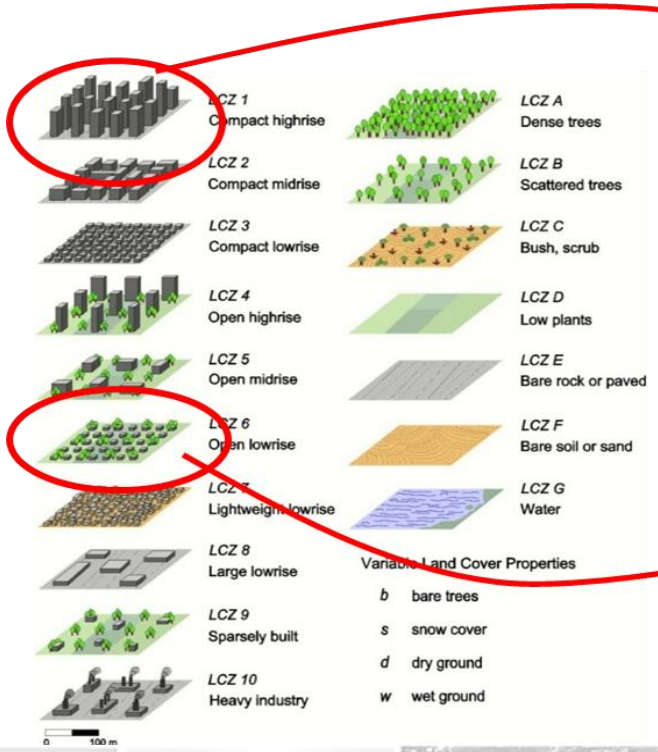
General routes for mapping air temperatures

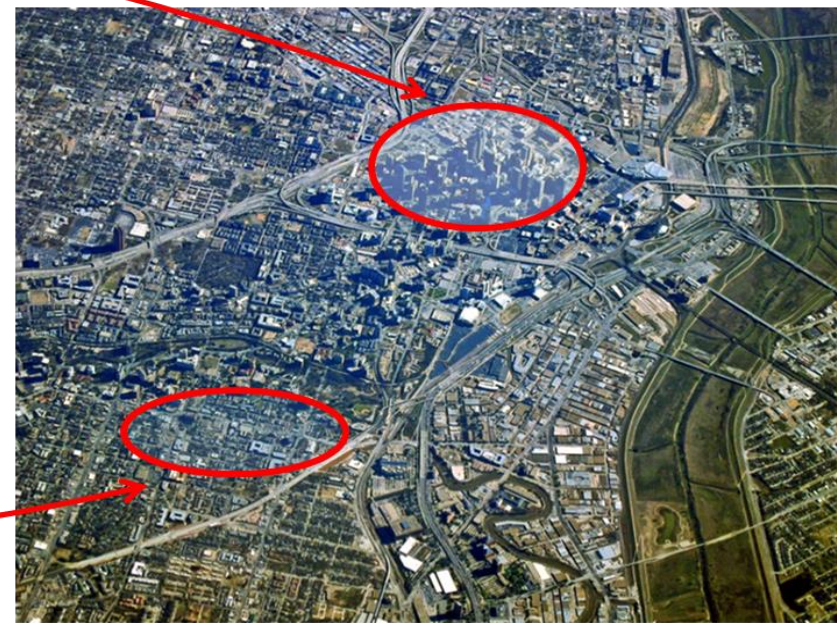
- Interpolation or regression using weather station data
  - **Advantage**: high temporal resolution, long-term archive, stable availability
  - **Disadvantage**: limited number of stations, difficulty in capturing spatial variation of air temperature in heterogeneous regions
- Climate model simulation
  - **Advantage**: high temporal resolution, applicable to different scales
  - **Disadvantage**: usually coarse spatial resolution, high requirement for computing resources
- Inversion based on remote sensing data
  - **Advantage**: broad spatial coverage, various spatial and temporal resolutions
  - **Disadvantage**: high demands on weather conditions

Local climate zone (LCZ)



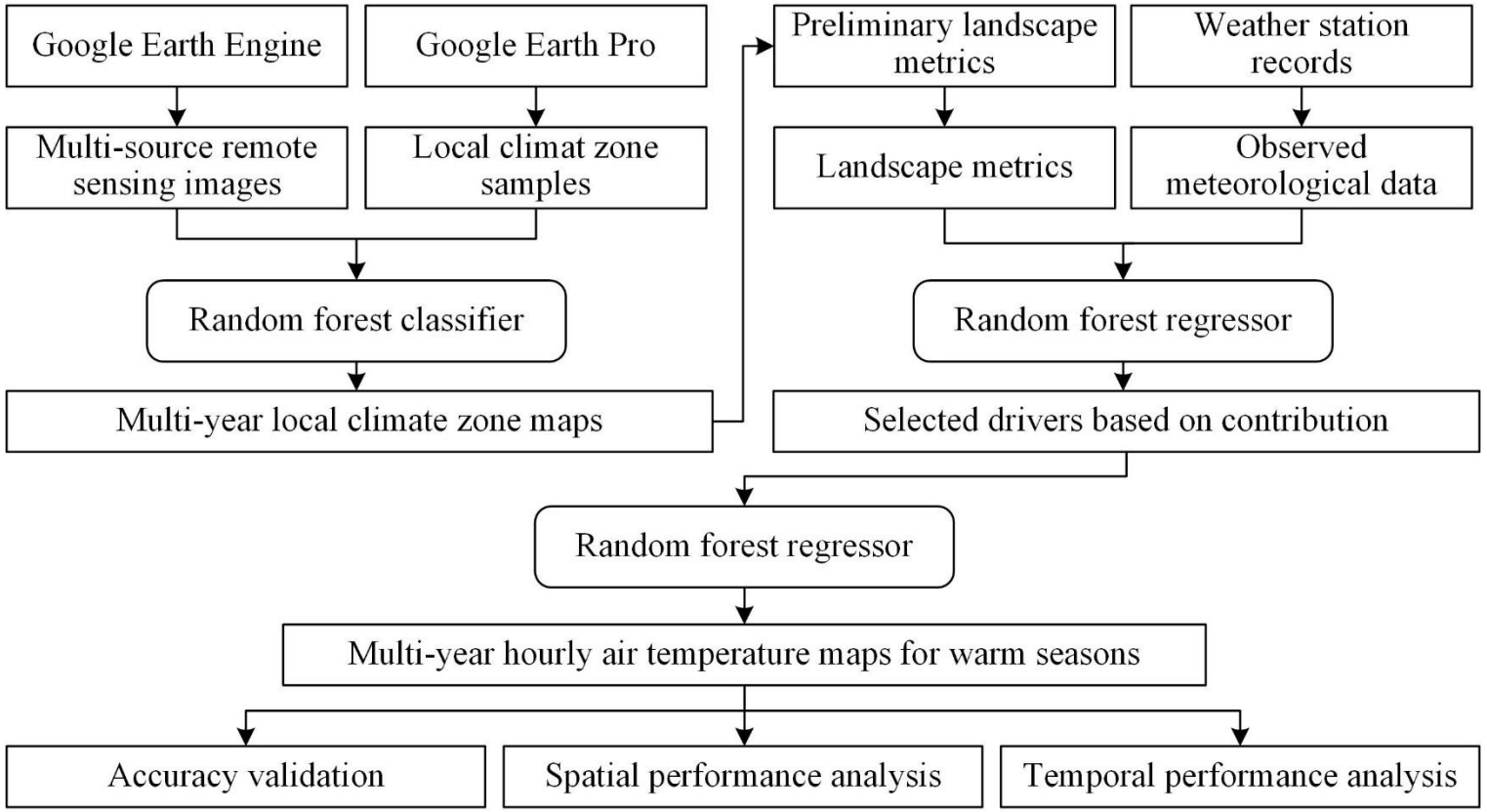
- LCZ 1 Compact high-rise
- LCZ 2 Compact mid-rise
- LCZ 3 Compact low-rise
- LCZ 4 Open high-rise
- LCZ 5 Open mid-rise
- LCZ 6 Open low-rise
- LCZ 7 Lightweight low-rise
- LCZ 8 Large low-rise
- LCZ 9 Sparsely built
- LCZ 10 Heavy industry
- LCZ A Dense trees
- LCZ B Scattered trees
- LCZ C Bush, scrub
- LCZ D Low plants
- LCZ E Bare rock or paved
- LCZ F Bare soil or sand
- LCZ G Water





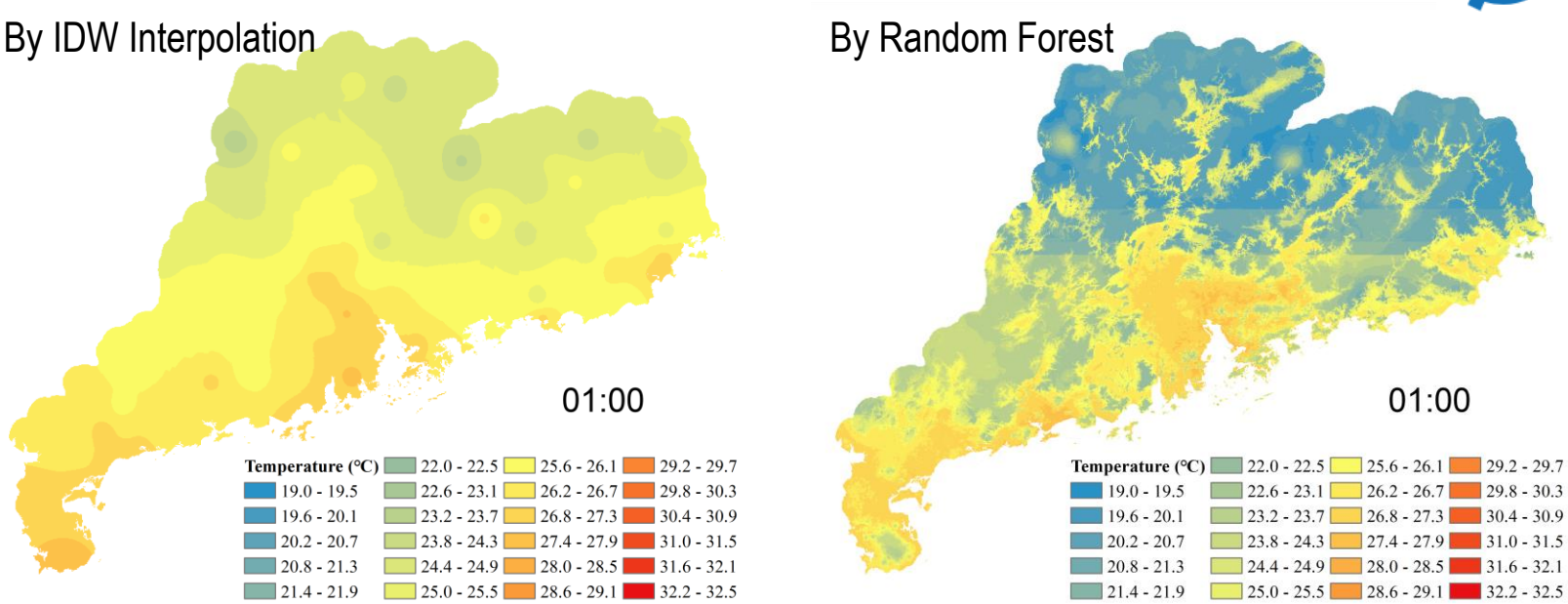
Solution

We aim to combine weather station data, LCZ-based landscape patterns and machine learning methods (random forest, RF) to estimate the hourly air temperature distribution in warm seasons from 2008 to 2019 in Guangdong Province, a highly urbanised region with complex urban morphology, at a 1 km resolution.

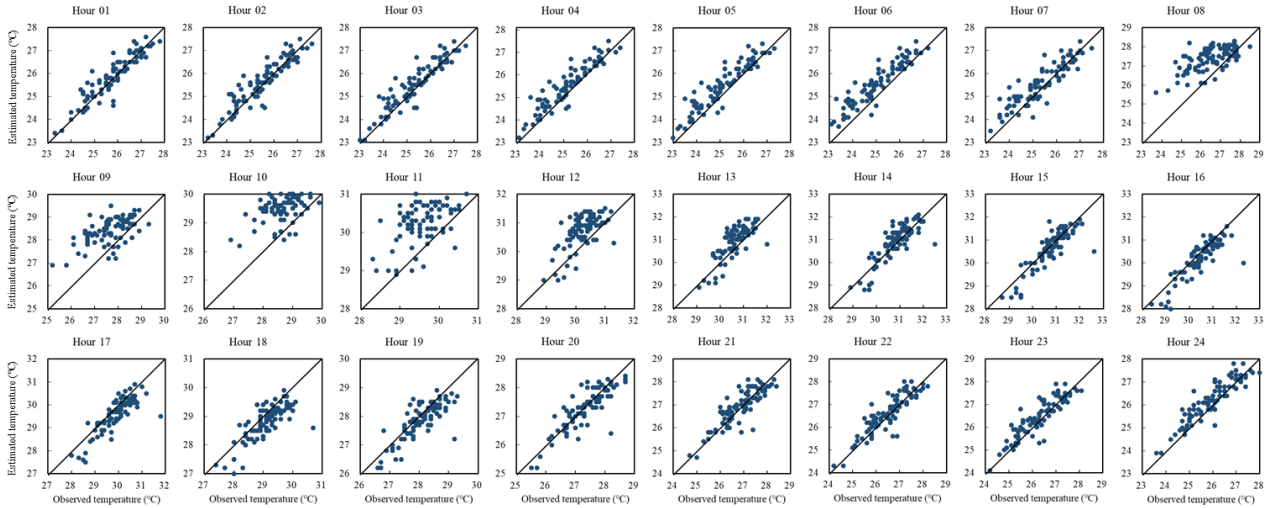


Hourly temperature mapping in Guangdong

- Hourly air temperature maps achieved good accuracy from 2008 to 2019, with mean values of R^2, RMSE and MAE were 0.8001, 1.4821℃ and 1.0872℃, respectively.
- The air temperature distribution estimated by the RF model was generally consistent with that estimated by the inverse distance weighted (IDW) interpolation.
- Scatter plots of estimated values versus observed values for different hours show a good linear relationship.

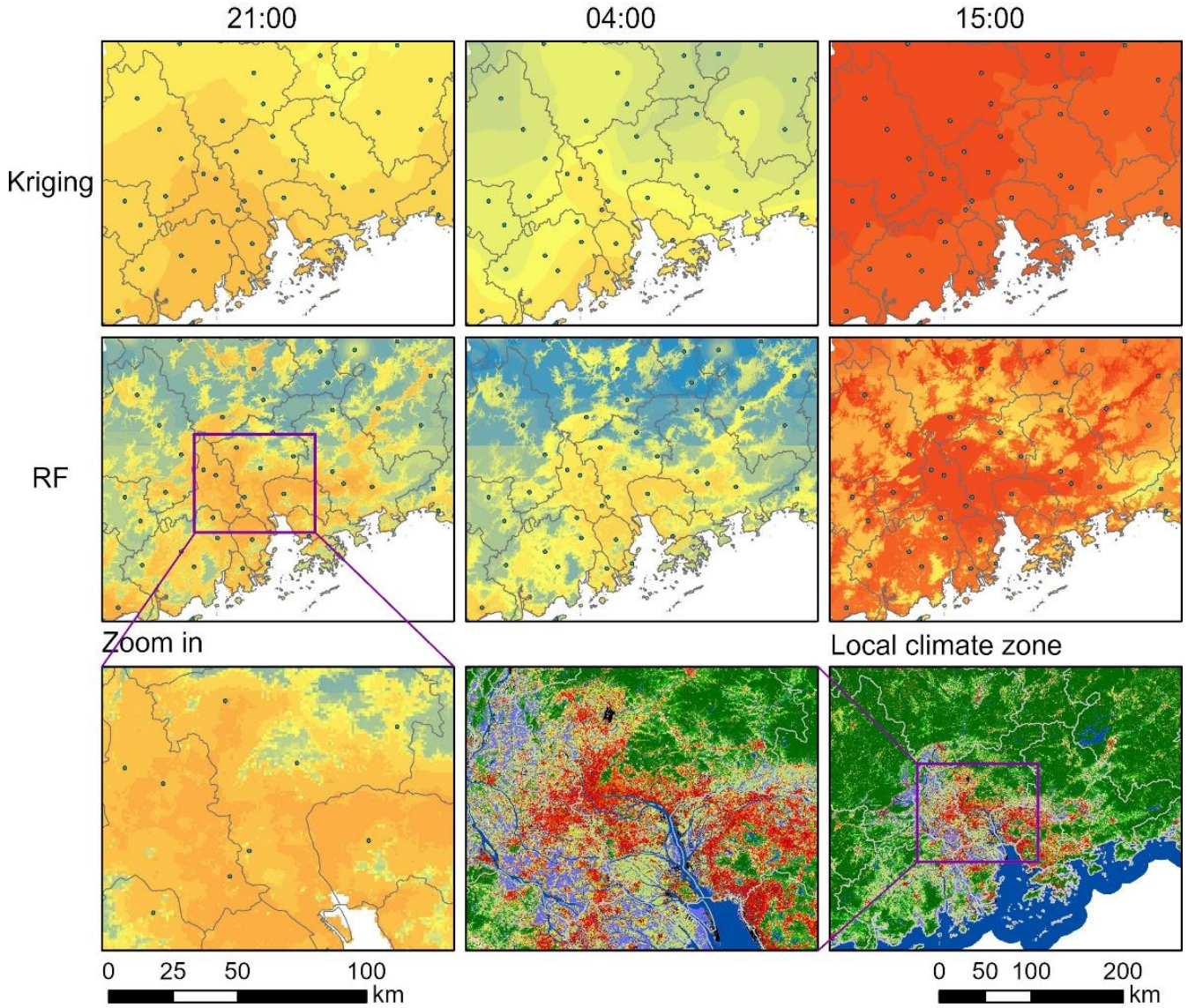


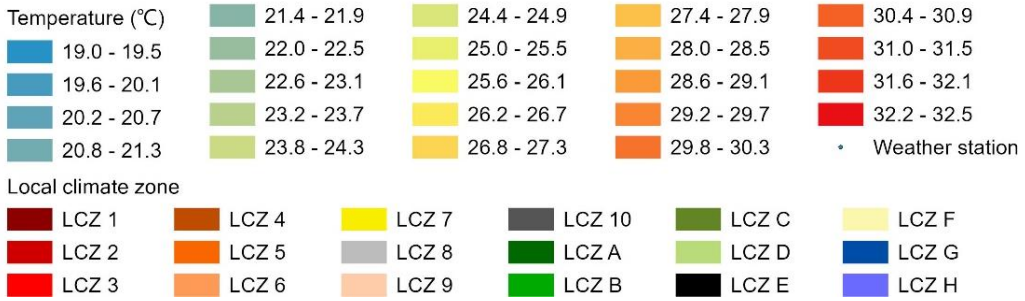
Mean hourly temperatures for 2019 warm seasons in Guangdong



Scatter plots of estimated versus observed air temperature for different hours in 2019

Hourly temperature mapping in Guangdong





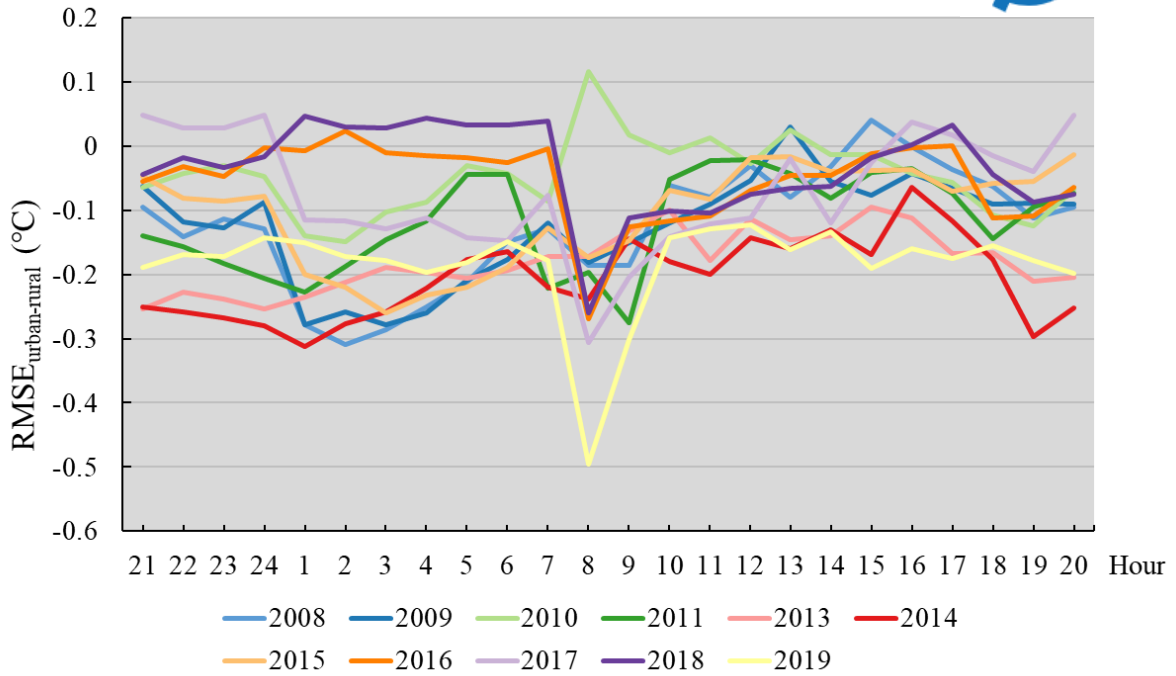
- There is a clear pattern of urban-rural divergence. For example, temperatures in the Greater Bay Area and some coastal agglomerations are significantly higher than in other rural areas, especially at nighttime.
- During the nighttime, the urban core area cools more slowly than the urban fringe area.

Comparing Kriging interpolation with the RF model for the spatial performance of the air temperature estimation in the case of the mean air temperature in warm season in 2019

Hourly temperature mapping accuracy

◆ Accuracy difference between urban and rural

- $RMSE_{urban\text{-}rural}$ indicates the RMSE of urban minus the RMSE of rural, i.e. it indicates better accuracy in urban areas than in rural areas when it is less than 0.
- The $RMSE_{urban\text{-}rural}$ were consistently smaller than 0 throughout the day, indicating better performances in urban areas.



Differences in RMSE between urban and rural areas in different years for hourly air temperature estimations

◆ Comparison to other studies

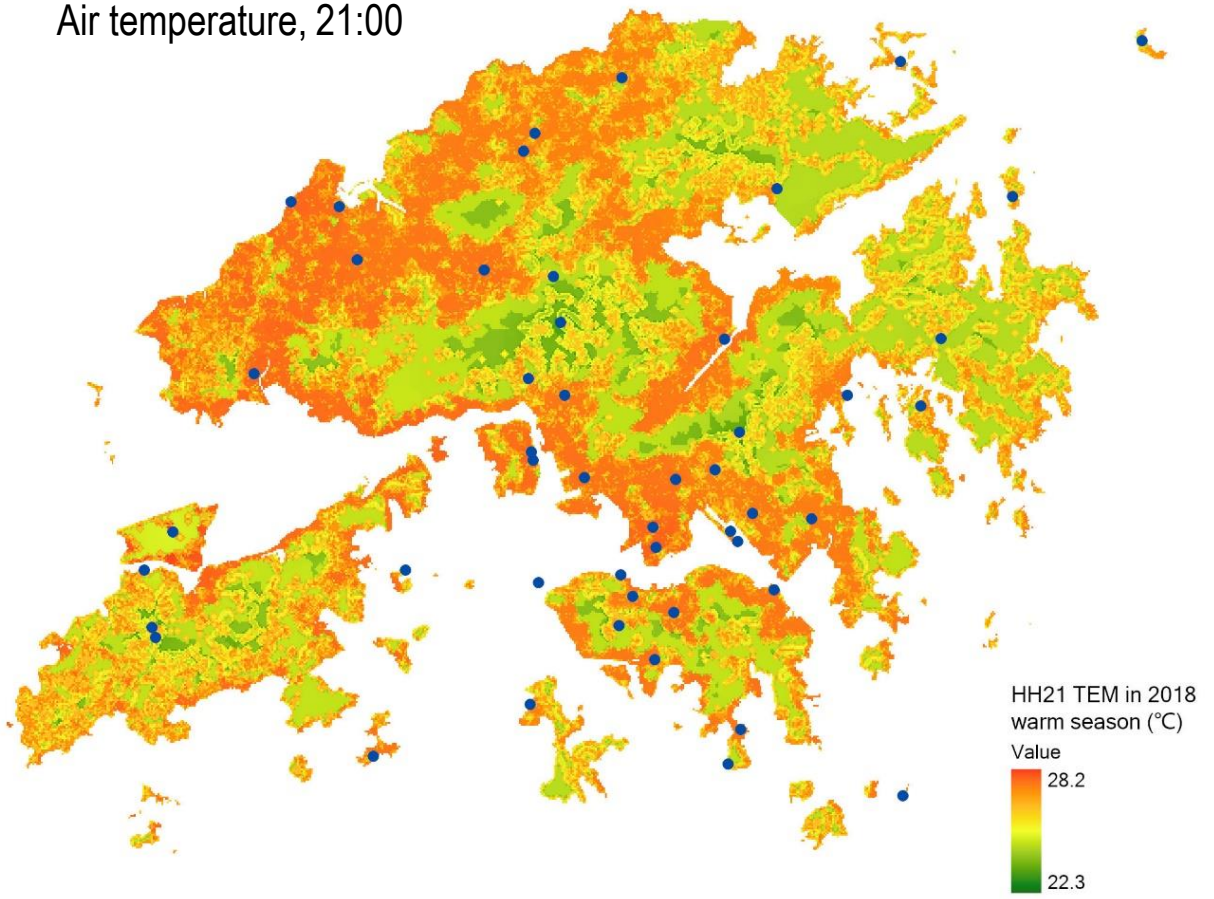
- Our hourly air temperature mapping achieves comparable or even better accuracy.

Comparison to other studies

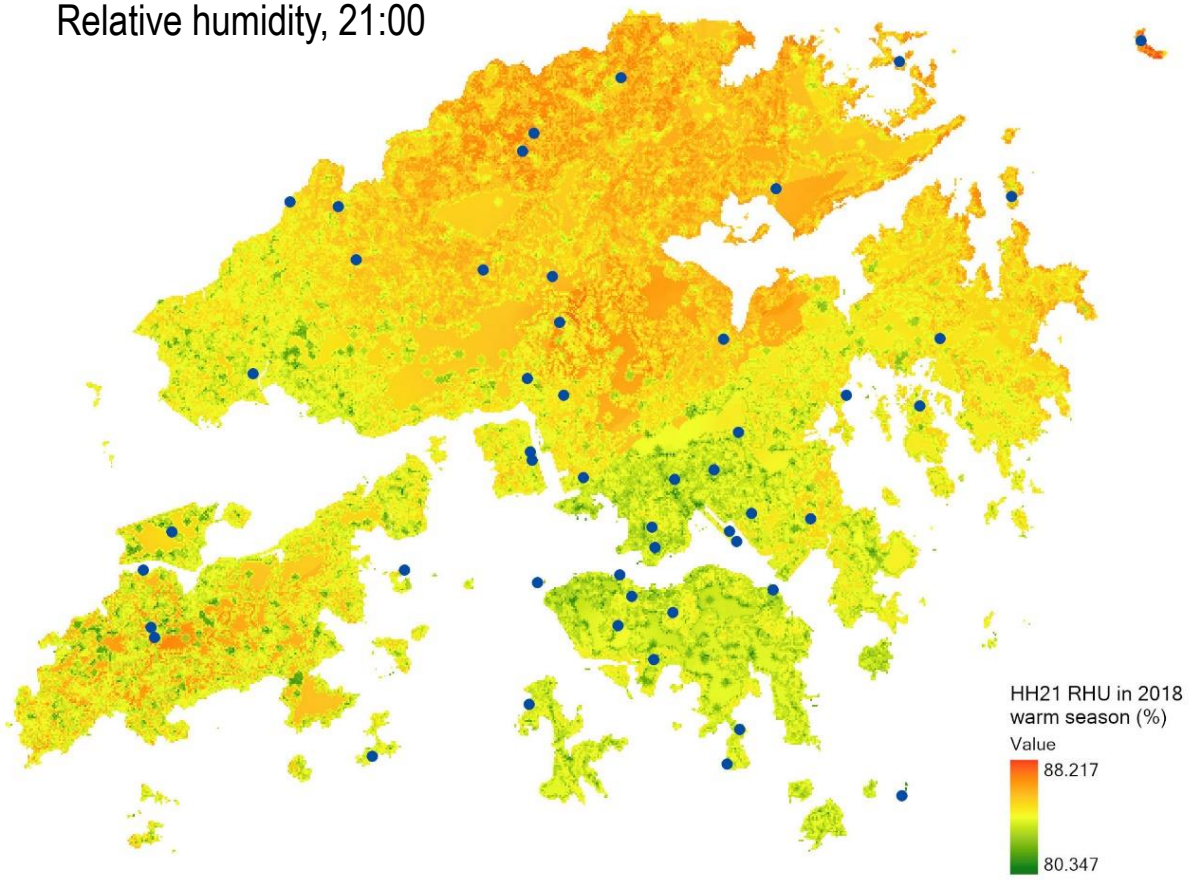
Case study	Temporal resolution	RMSE (℃)	MAE (℃)
Ours	Hourly	1.48	1.09
Zhou et al. 2020; Zhang et al. 2022	Hourly	0.8~1.9	0.6~1.5
Shen et al. 2020	Daily	2.0	1.5

Hourly thermal comfort dataset in Hong Kong

Air temperature, 21:00



Relative humidity, 21:00



Mean hourly air temperature and relative humidity by random forest model for 2018 warm seasons in Hong Kong

- Hourly air temperature maps achieved good accuracy in 2018, with mean values of R^2, RMSE and MAE were 0.9156, 0.97℃ and 0.71℃, respectively.
- Hourly relative humidity maps achieved good accuracy in 2018, with mean values of R^2, RMSE and MAE were 0.8258, 5.39 % and 3.81%, respectively.

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Thanks

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Chen et al. (2022) Integrating weather observations and local climate zone-based landscape patterns for regional hourly air temperature mapping using machine learning. *Science of Total Environment*. (Under review)