Spatial and temporal characteristics of anthropogenic heat and its environmental impact

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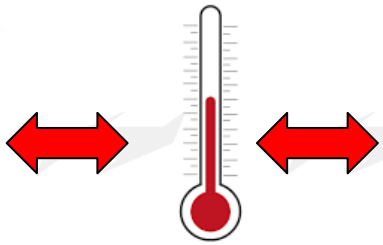
Background

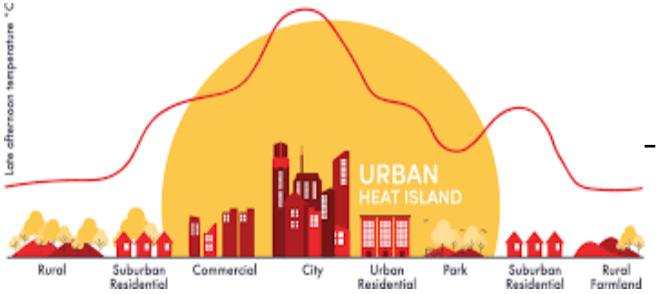
A large amount of anthropogenic waste heat is emitted into the atmosphere along with urban energy consumption.

Anthropogenic heat

Urban heat island

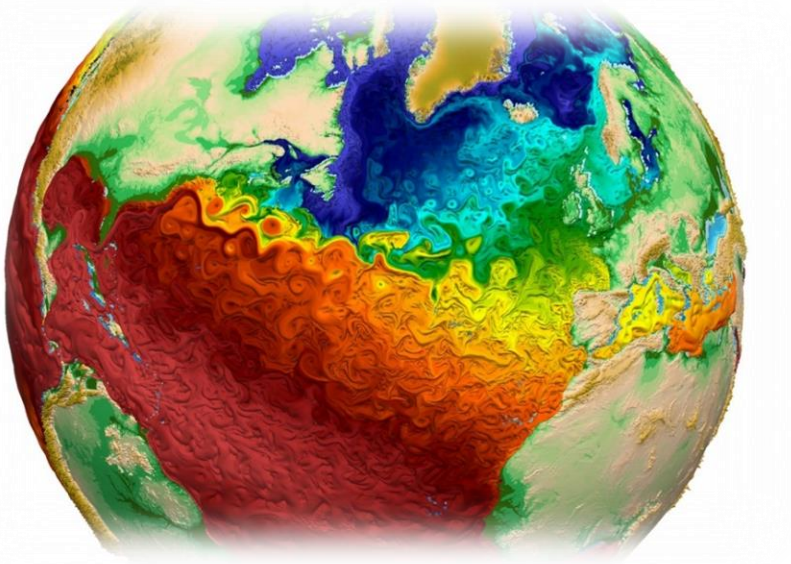
mutual reinforcement





Background

Accurate AH estimation can effectively reflect the spatial and temporal distribution patterns of human activity and energy consumption. Meanwhile, AH serves as an important input to regional or global-scale climate simulations, it is an essential basis for solving the problems of climate warming, urban heat island, and air pollution.



Anthropogenic heat flux (AHF, unit: W/m^2) is the anthropogenic heat emission per unit area and time, and it is the main objective of the AH estimation.

Research Framework

➢ AH quantification

- **Large-scale quantification of AH based on energy consumption and machine learning**
- **Small-scale AH estimation based on an adjusted remote sensing-surface energy balance model**
- **Further optimization and application of our large-scale AH model**

➢ AH impacts on the urban environment

- **Analysis of AH impact on urban thermal environment based on mathematical or statistical methods**
- **Numerical simulation-based study of the AH impacts on urban climate and air quality**

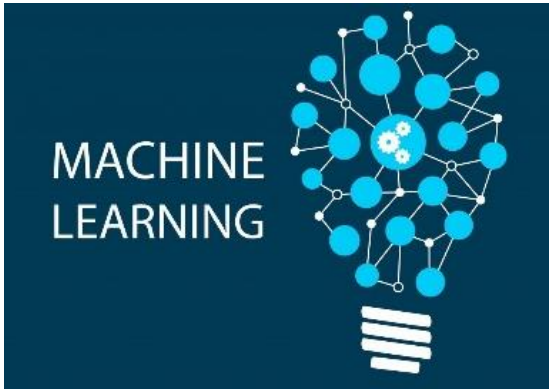
AH quantification

- **Large-scale quantification of AH based on energy consumption and machine learning**

AH training labels base on the energy consumption inventory method:

It estimates AH according to socioeconomic data and various types of energy consumption data.

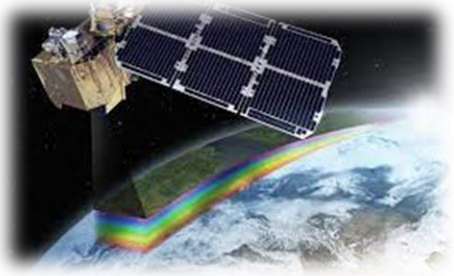
$$Q_F = Q_B + Q_V + Q_I + Q_M$$



OpenStreetMap

ECMWF

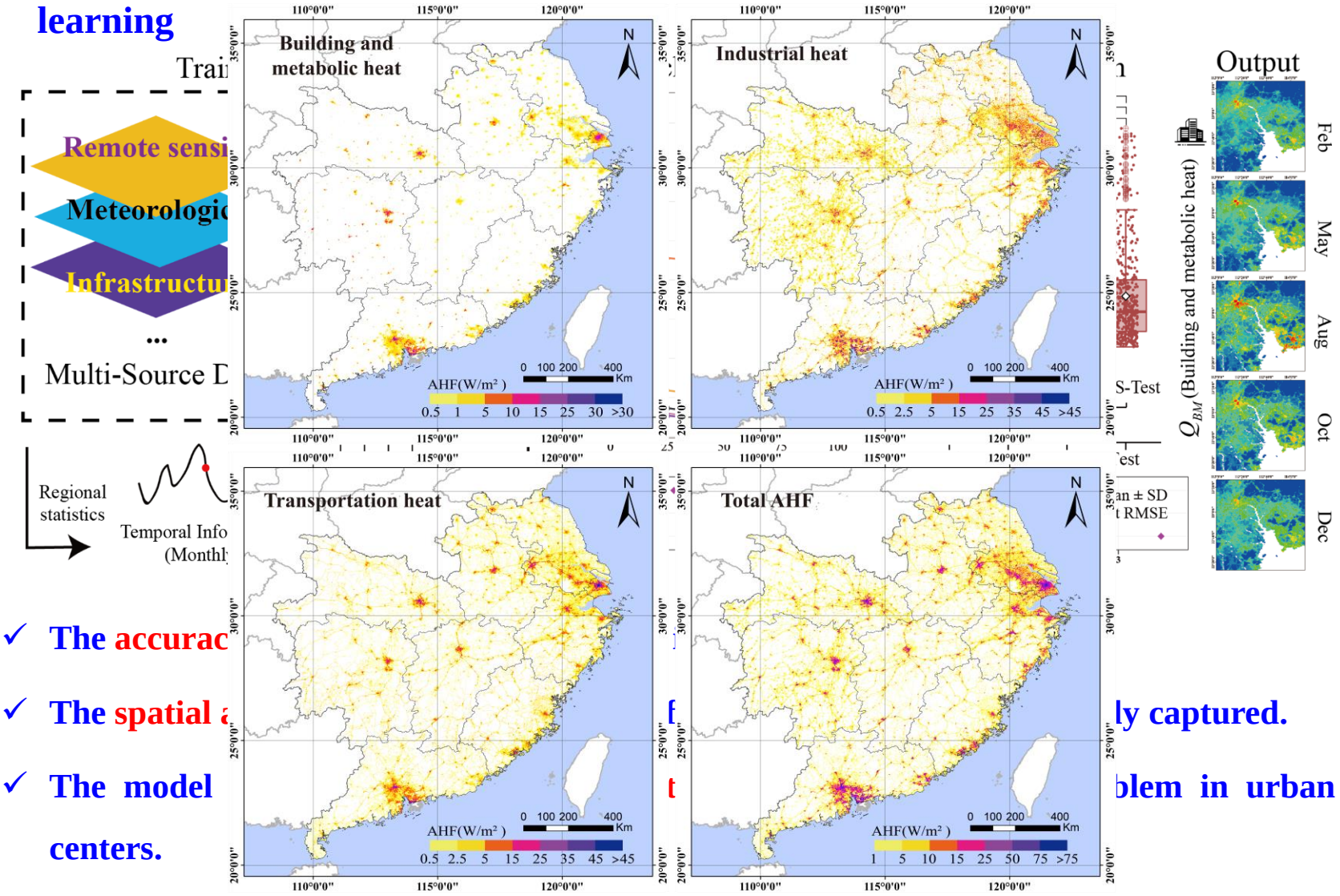
EUROPEAN CENTRE FOR MEDIUM RANGE WEATHER FORECASTS



Google Earth Engine

AH quantification

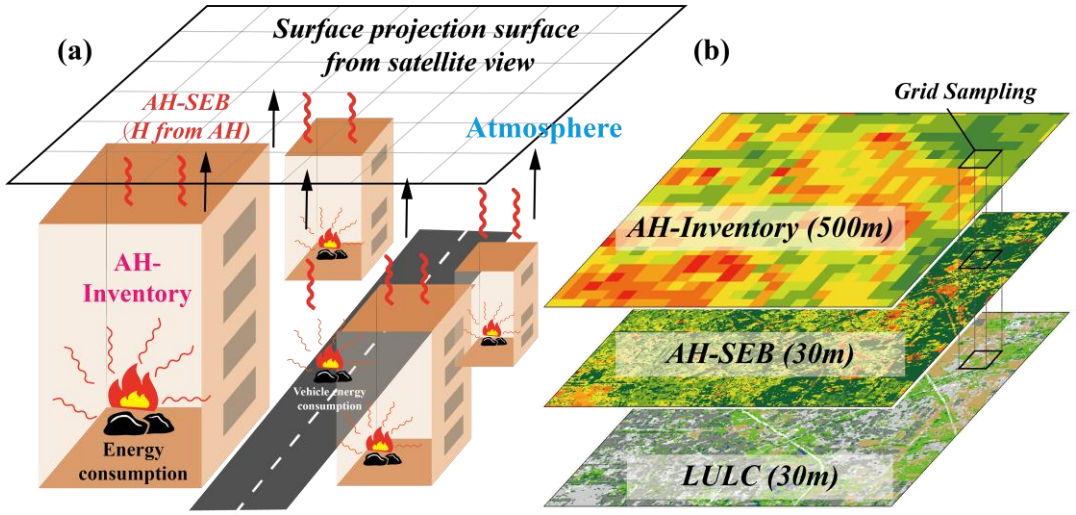
- **Large-scale quantification of AH based on energy consumption and machine learning**

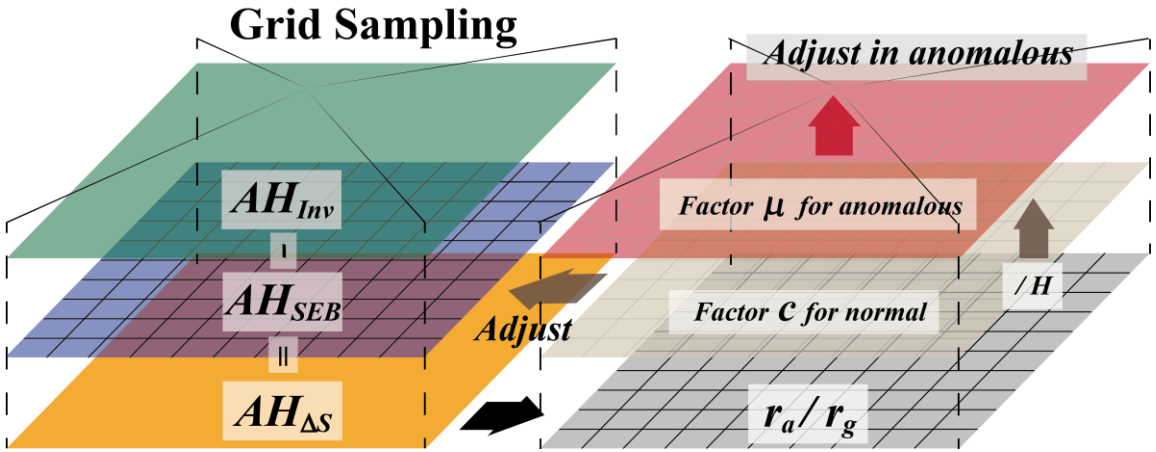


- ✓ **The accurac**
- ✓ **The spatial a** **ly captured.**
- ✓ **The model** **blem in urban centers.**

AH quantification

- **Small-scale AH estimation based on an adjusted remote sensing-surface energy balance model**





Remote sensing-surface energy balance model

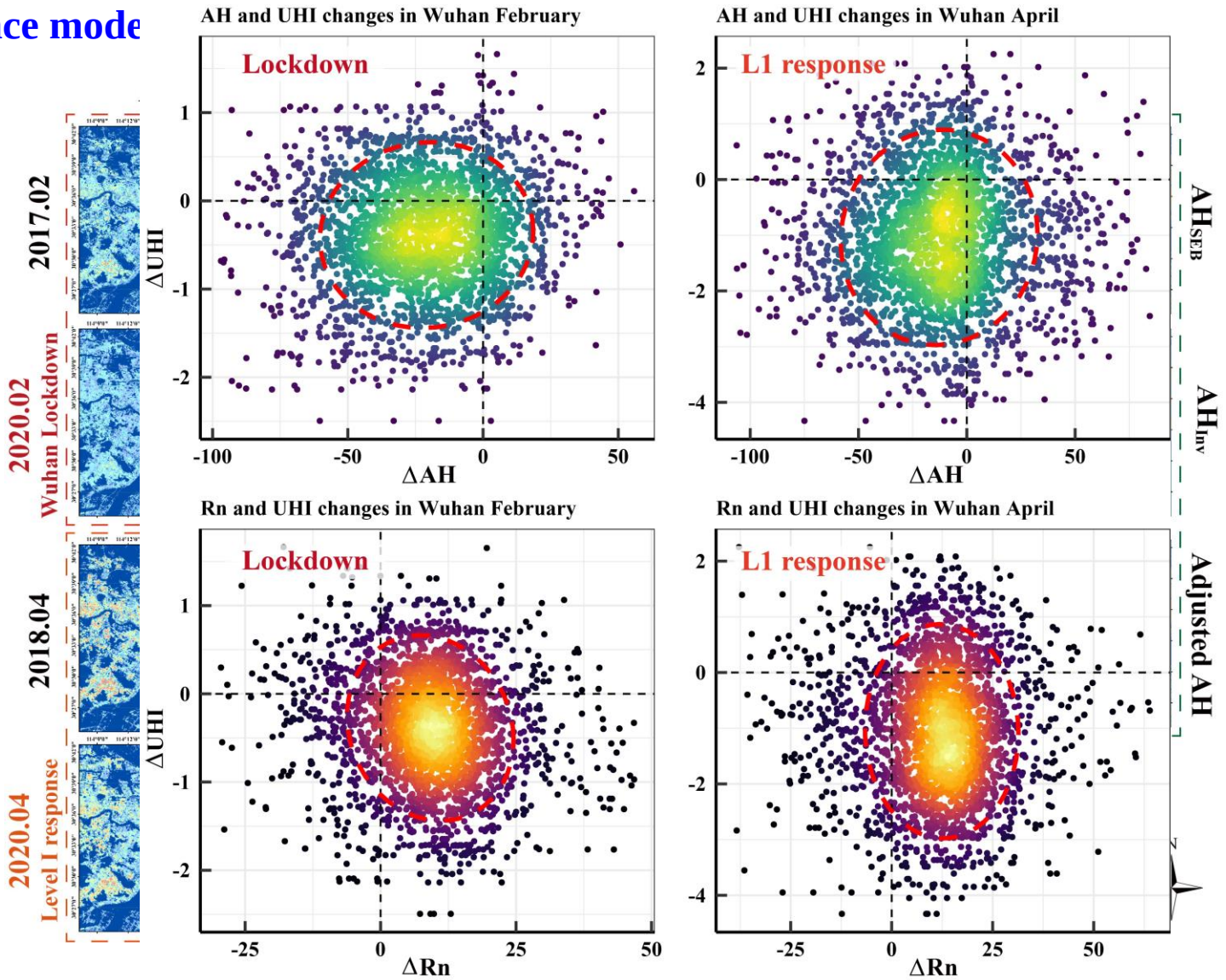
Shadow calibration

Thermal stability analysis framework

Coarse-resolution AH based on energy inventory model

AH quantification

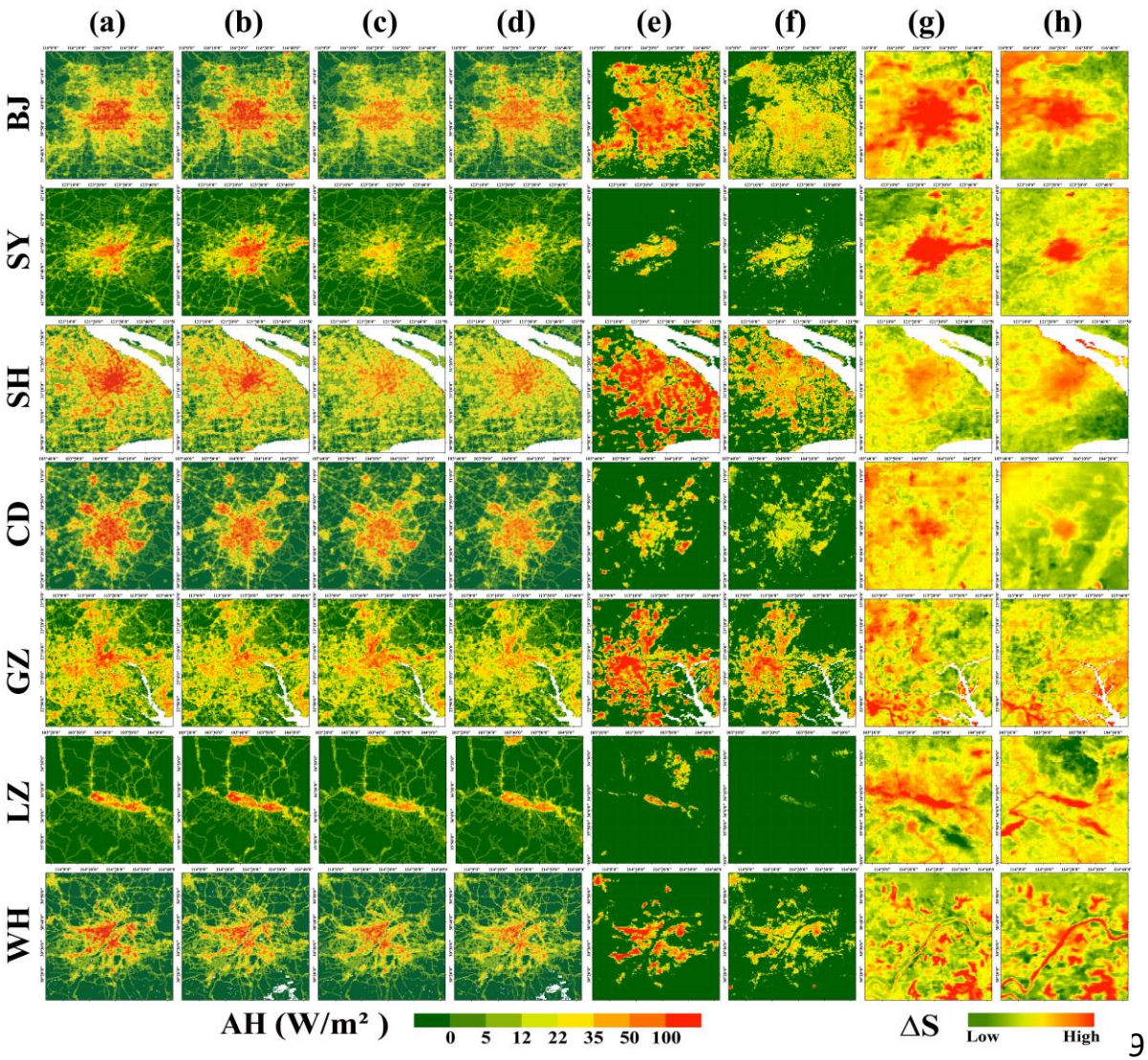
- **Small-scale AH estimation based on an adjusted remote sensing-surface energy balance mode**



AH impacts on the urban environment

- **Analysis of AH impact on urban thermal environment based on mathematical or statistical methods**

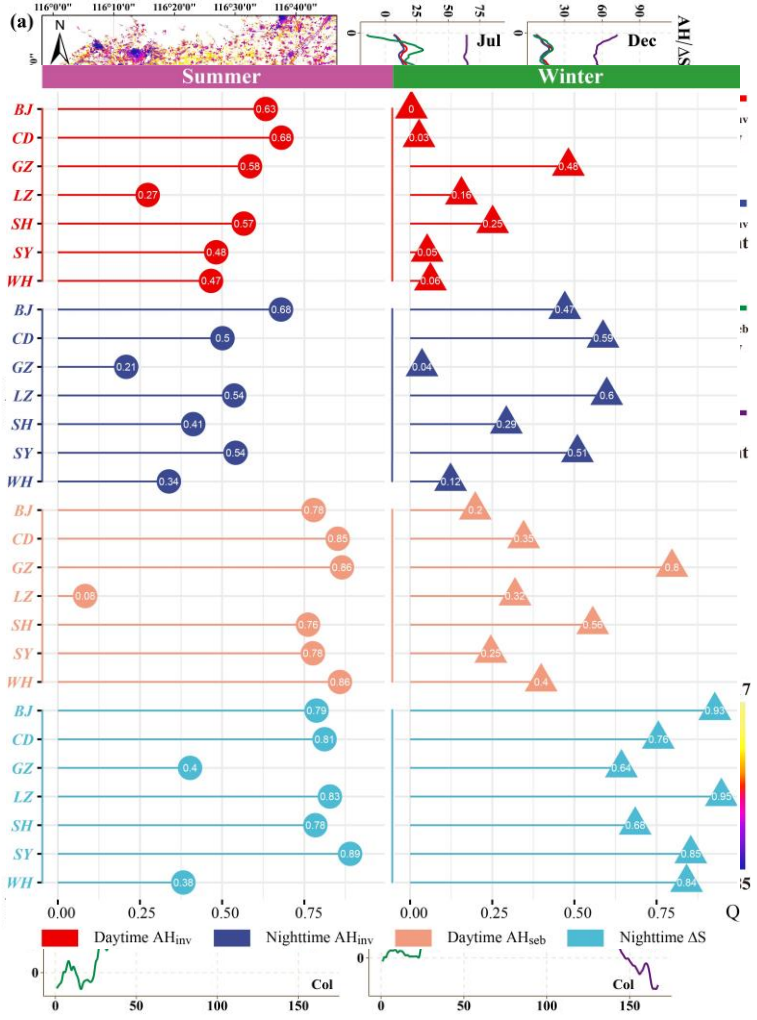
➢ **A more detailed comparison of the differences between AH obtained based on different methods.**

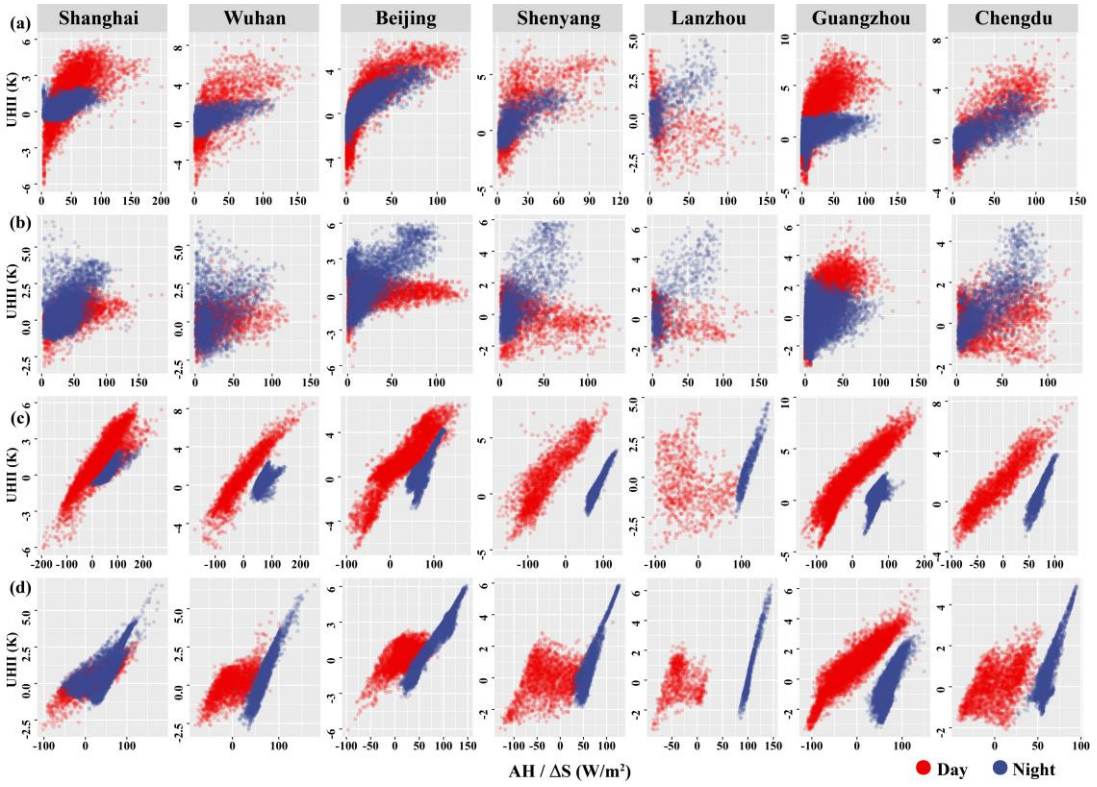


Spatial and temporal distribution of AH and nighttime heat storage: (a)–(d) AH_{inv} in summer daytime, winter daytime, summer nighttime and winter nighttime, respectively; (e)–(f) AH_{seb} in summer and winter daytime, respectively; (g)–(h) heat storage (ΔS) in summer and winter nighttime based on RS-SEB, respectively.

AH impacts on the urban environment

- **Analysis of AH impact on urban thermal environment based on mathematical or statistical methods**





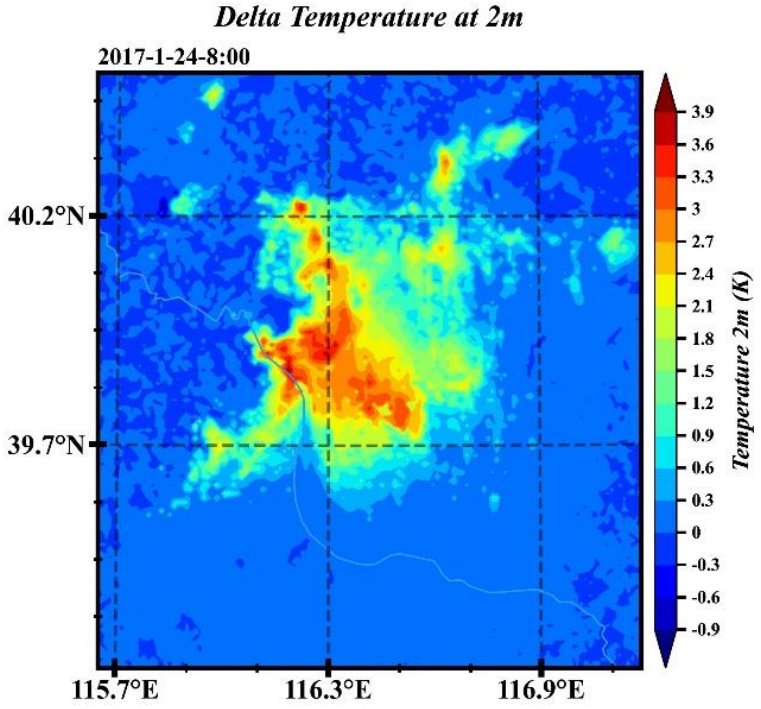
AH impacts on the urban environment

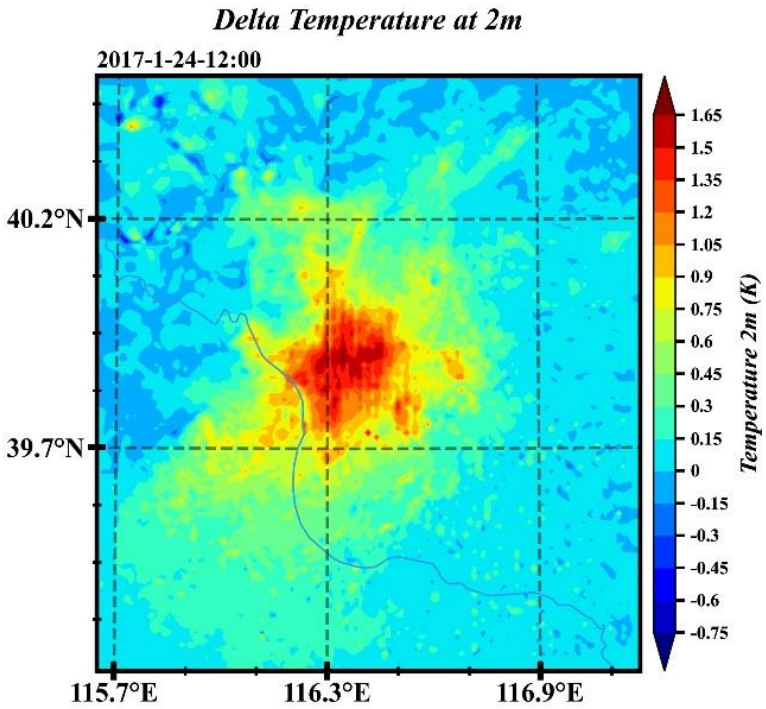
- **Numerical simulation-based study of the AH impacts on urban climate and air quality**

  - **Based on Weather Research and Forecasting Mode (WRF)**
  - **Replace the default AH parameters in the WRF with our own spatiotemporal heterogeneity AH data, and it can be used as a new way to validate AH estimation.**
  - **Sensitivity experiments combined with chemistry mode (WRF-Chem) to investigate the impacts of AH on meteorological parameters and air quality.**

AH impacts on the urban environment

- **Numerical simulation-based study of the AH impacts on urban climate and air quality**
  - ✓ **Higher resolution land use and topographic data**
  - ✓ **LCZ and single-layer urban canopy model in built-up areas**
  - ✓ **Replacing AH parameters with own AH estimation results**
  - ☐ **Multi-regional and sensitivity experiments**
  - ☐ **Validation of simulation results**






Thank you!