Evaluation of the connection between urban surface and air temperature – case study in Szeged

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Study area: Szeged, in the southern region of the Great Hungarian Plain (Fig. 1).

T_{air}: Obtained from the meteorological monitoring network in Szeged. All stations are representative of the Local Climate Zones (LCZs) within the city and the spatial pattern of the network is capable of revealing the spatial structure of the UHI (Fig. 1).

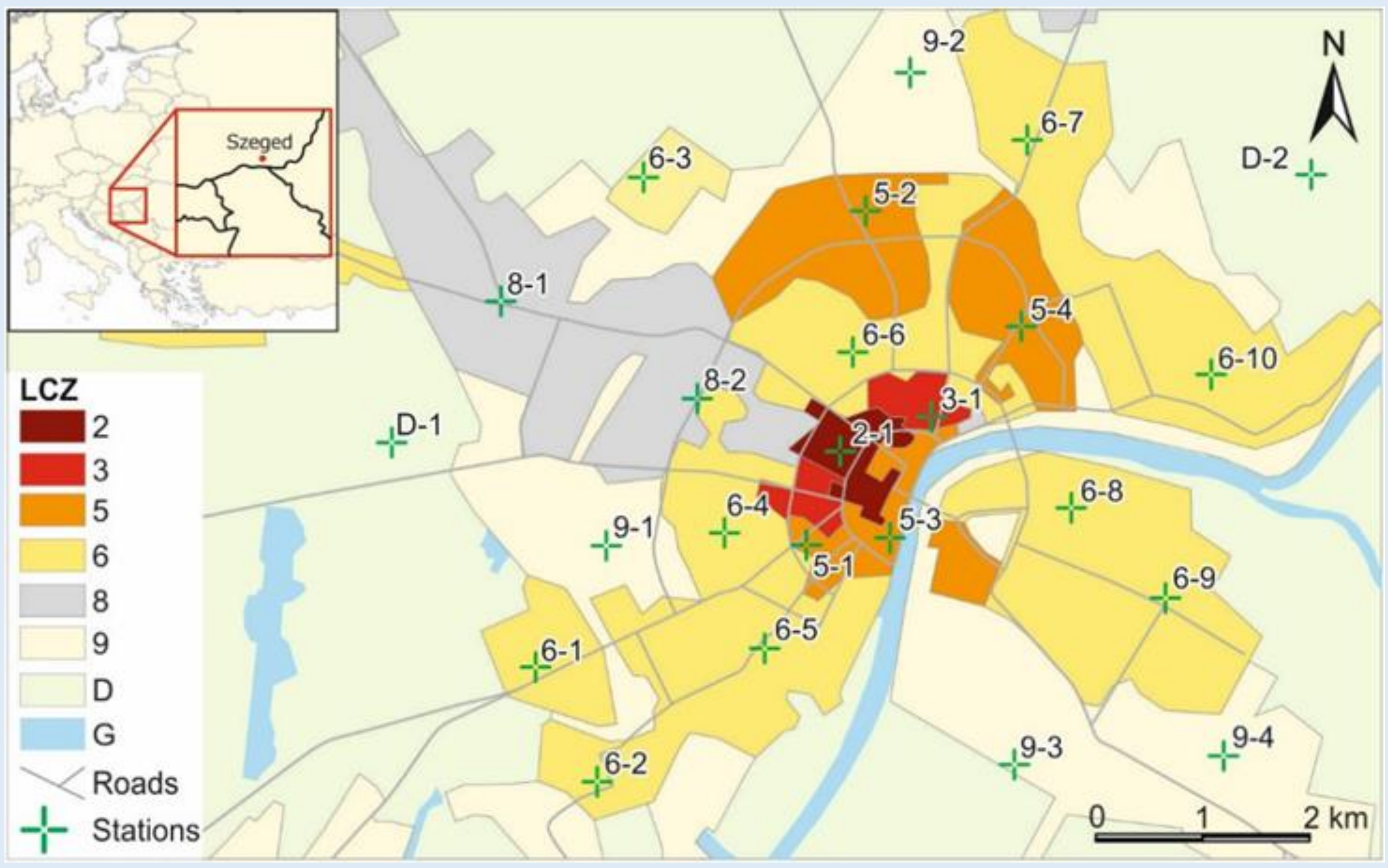


Fig. 1 Geographical location of Szeged and LCZ map of the study area with station sites of the urban meteorological network

Statistical Methods: Pearson correlation coefficient (r), root-mean-square error(RMSE), mean-absolute error (MAE) and linear regression models.

LST, NDVI: LST were retrieved from Landsat-8 (Fig. 2a) and MODIS (Fig. 2e-2h), NDVI were calculated from Landsat-8 (Fig. 2c). 13 cloud free days were selected to collect satellite data. After pairing LST with T_{air}, we got the final temperature data pairs (Table 1). The distance-weighted spatial averages of NDVI and $LST_{Landsat-8}$ were calculated (Fig. 2b & 2d).

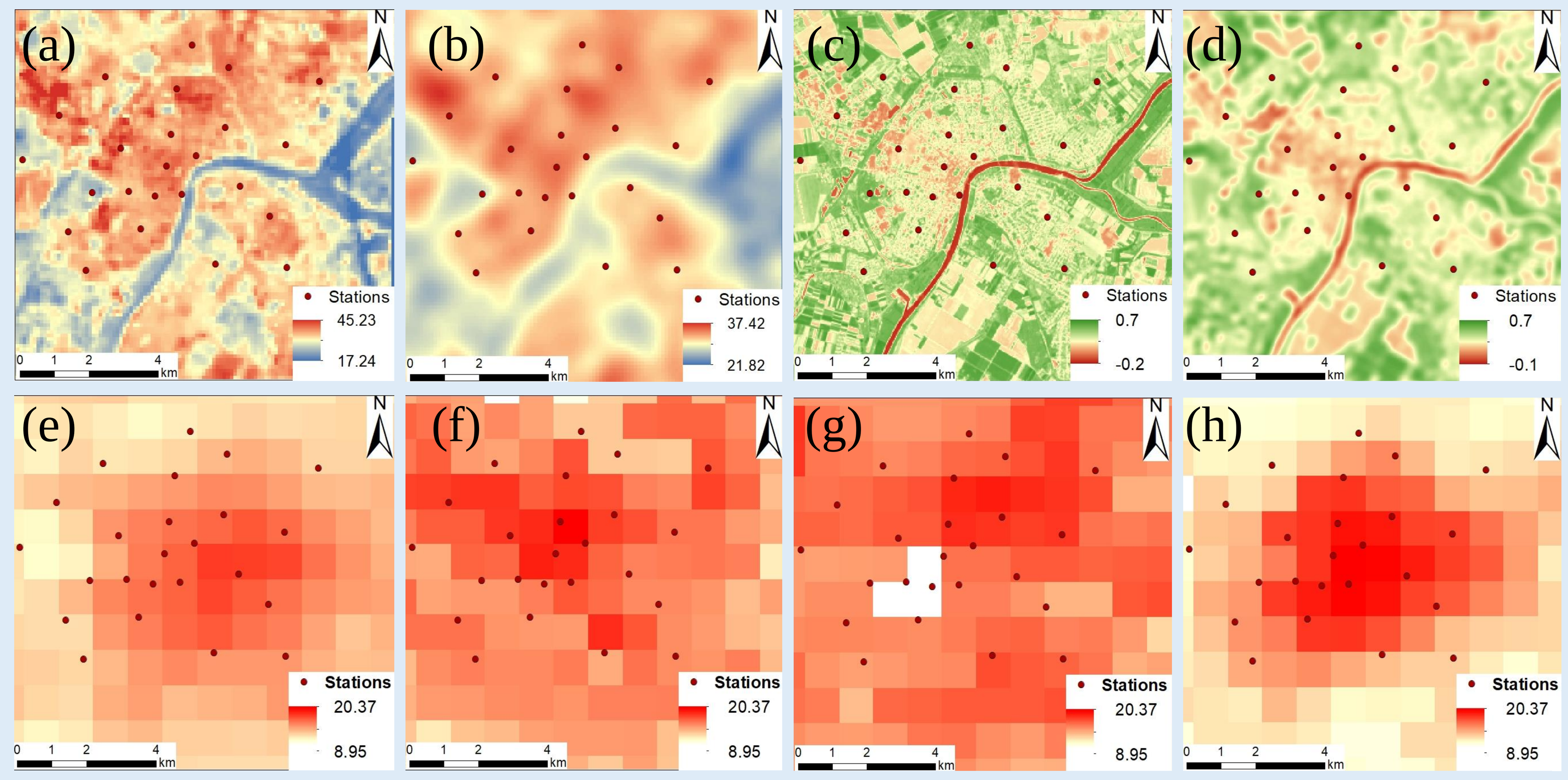
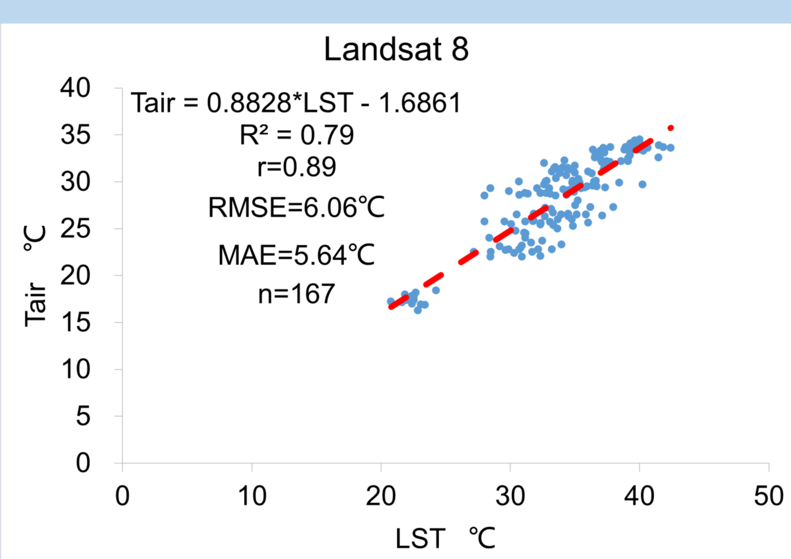


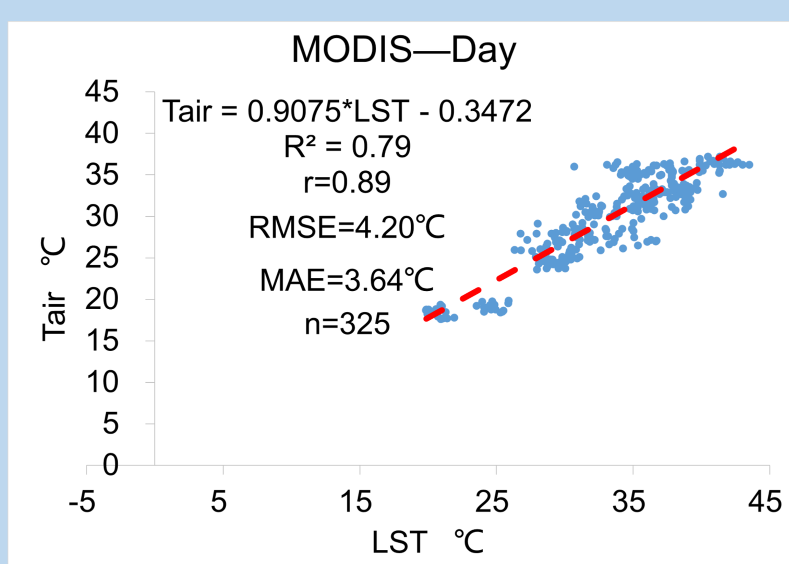
Fig. 2 Examples of spatial patterns of LST and NDVI

Table 1 Information on satellite data

Data source	Resolution	Observation time (UTC)	Amount of pairs of T_{air} and LST	
			2016	2017−2019
$LST_{Landsat-8}$	100 m	9:27	91	167
$LST_{MODIS-day}$	1000 m	10:54, 12:36	181	326
$LST_{MODIS-night}$	1000 m	1:30, 20:24	160	179
$NDVI_{Landsat-8}$	30 m	9:27	91	167

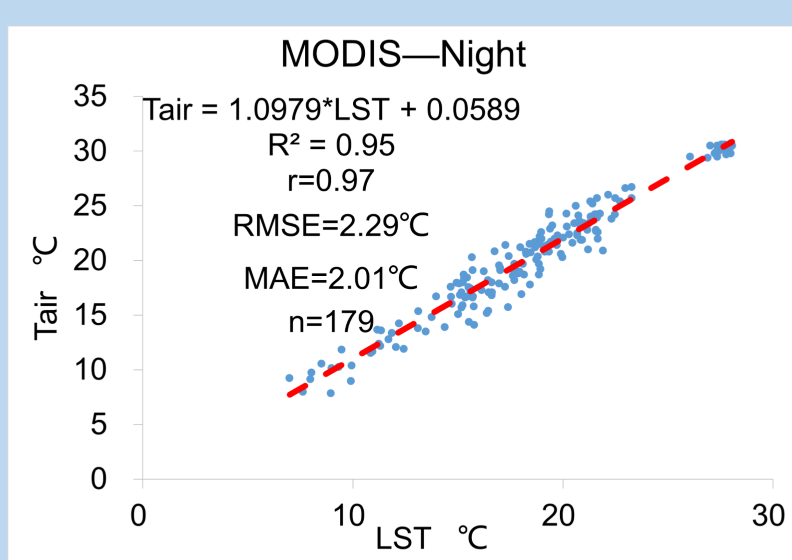
Connection between T_{air} and LST (2017-2019)

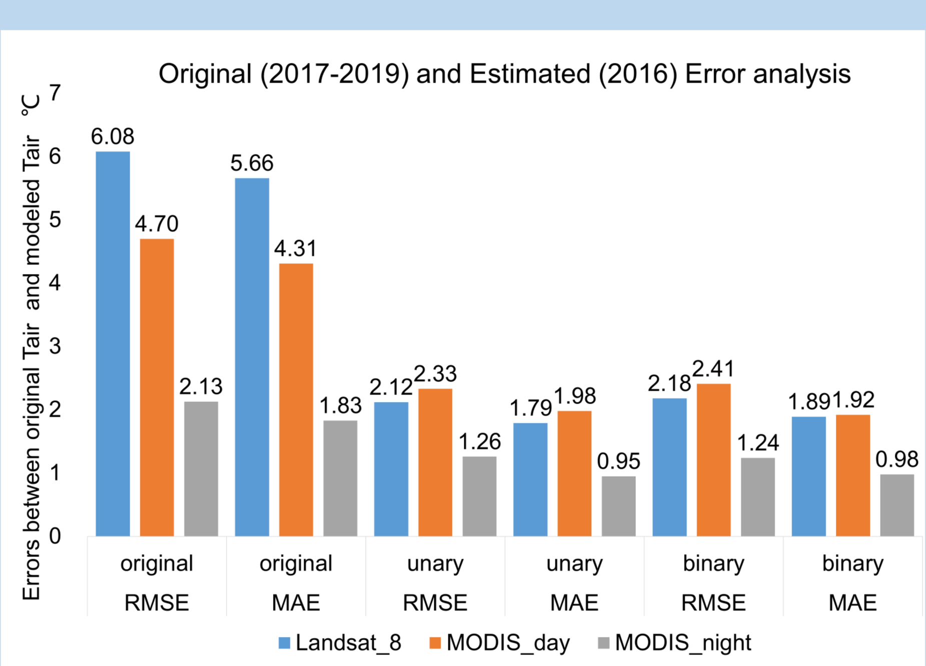




T_{air} had a strong correlation with both $LST_{Landsat-8}$ and LST_{MODIS} during daytime (r=0.89). However, the errors between T_{air} and $LST_{Landsat-8}$ were relatively larger, compared with LST_{MODIS}.

The correlation between T_{air} and LST_{MODIS} was stronger at night (r=0.97) compared with daytime.

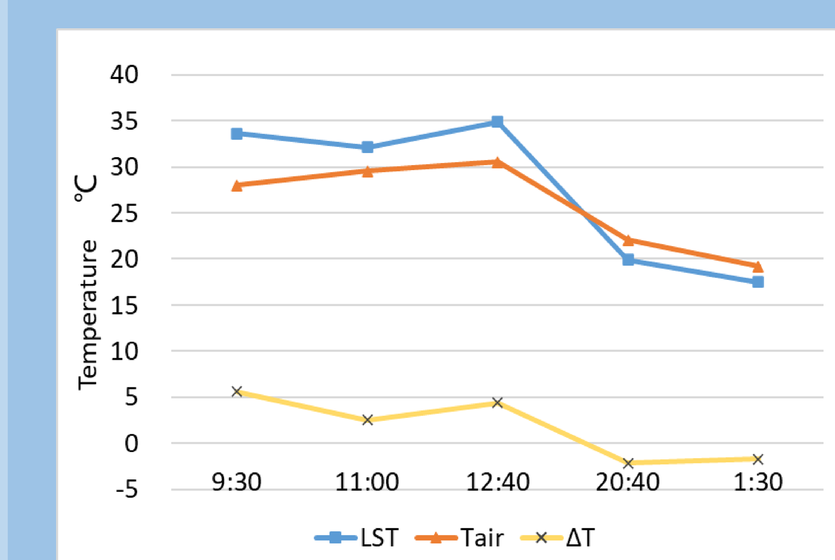


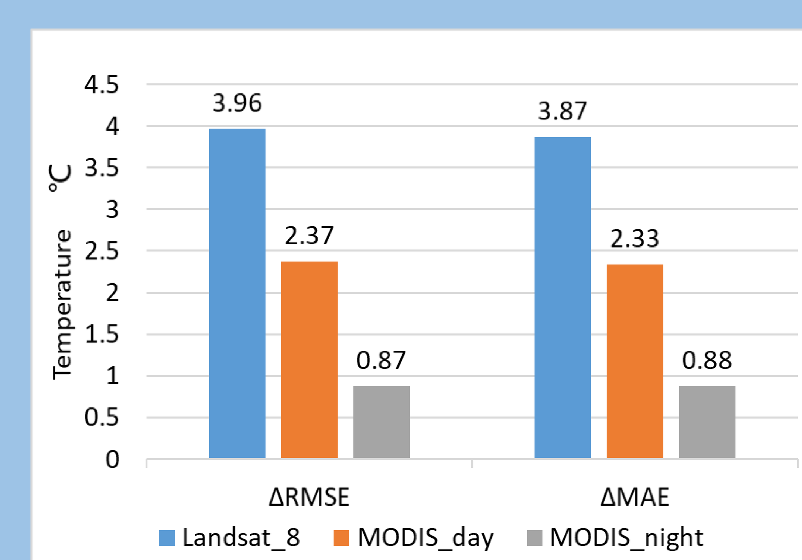


Both unary (LST) and binary (LST and NDVI) linear regression models could effectively reduce errors between T_{air} and LST. But NDVI could not enhance the accurate of prediction models.

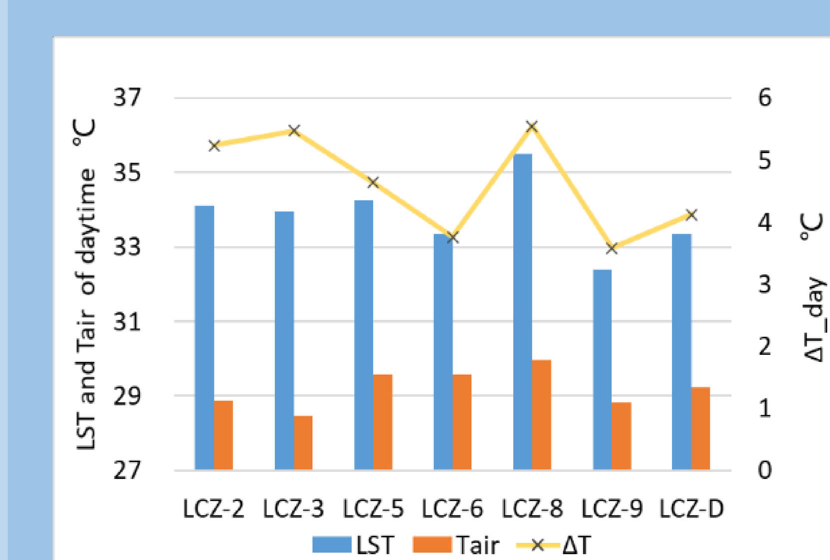
- All models can perform well, especially during nighttime with an error less 1.5℃.
- The addition of NDVI into the linear regression models did not significantly improve the accuracy of the models, and even had a negative effect.

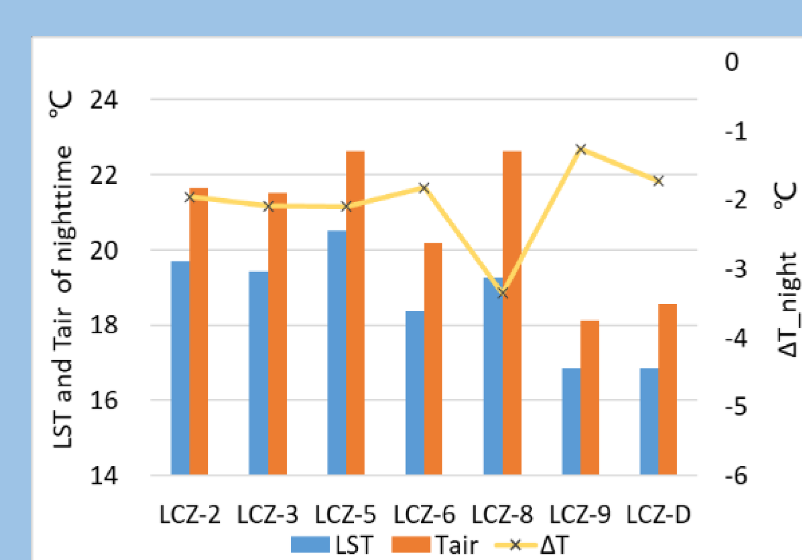
Discussion





$LST_{Landsat-8}$ (9:30) has a larger errors with T_{air}, compared with $LST_{MODIS-day}$ (11:00-12:40). On the other hand, the models based on $LST_{Landsat-8}$ can reduce errors more effectively (ΔRMSE and ΔMAE).





The relationship between LST and T_{air} has obvious spatial and temporal variability. LST is higher than T_{air} during daytime, and the opposite is true at night. The difference between T_{air} and LST is relatively higher in LCZ-2, LCZ-3 and LCZ-8 with more artificial surfaces, compared with other LCZs with more vegetation.

Conclusions

- There is a strong correlation between T_{air} and LST throughout the day, with the stronger correlation and smaller errors during the nighttime compared with daytime.
- The satellite data source and its observation time, as well as the heterogeneity of the urban surface can affect the analysis results of the relationship between T_{air} and LST.

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