Modelling the urban heat island in Birmingham, UK at the neighbourhood scale

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INTRODUCTION

Cities have higher peak temperatures compared to surrounding rural areas. The urban-rural surface air temperature difference is known as the urban heat island (UHI)[1]. As extreme heat exposure can lead to adverse health effects, information on UHI characteristics of cities is important for future urban climate planning strategies.

This study aims to simulate spatiotemporal variations of surface air temperature and UHI in Birmingham, UK, at the neighbourhood scale.

METHODOLOGY

This work used the ADMS-Urban climate model to calculate local temperature perturbations with respect to the upwind temperature profile by solving the governing equations for heat and moisture processes. This model has a range of input datasets for surface parameters, such as thermal admittance, surface resistance to evaporation, albedo (derived based on land use categories[2-3]), surface roughness length, normalised building volume and terrain elevation (Fig. 1).

This Linux version of the ADMS-Urban climate model was run on the University of Birmingham's BlueBEAR HPC using a single core. The overall elapsed time for a typical monthly contour simulation was about 22 hours.

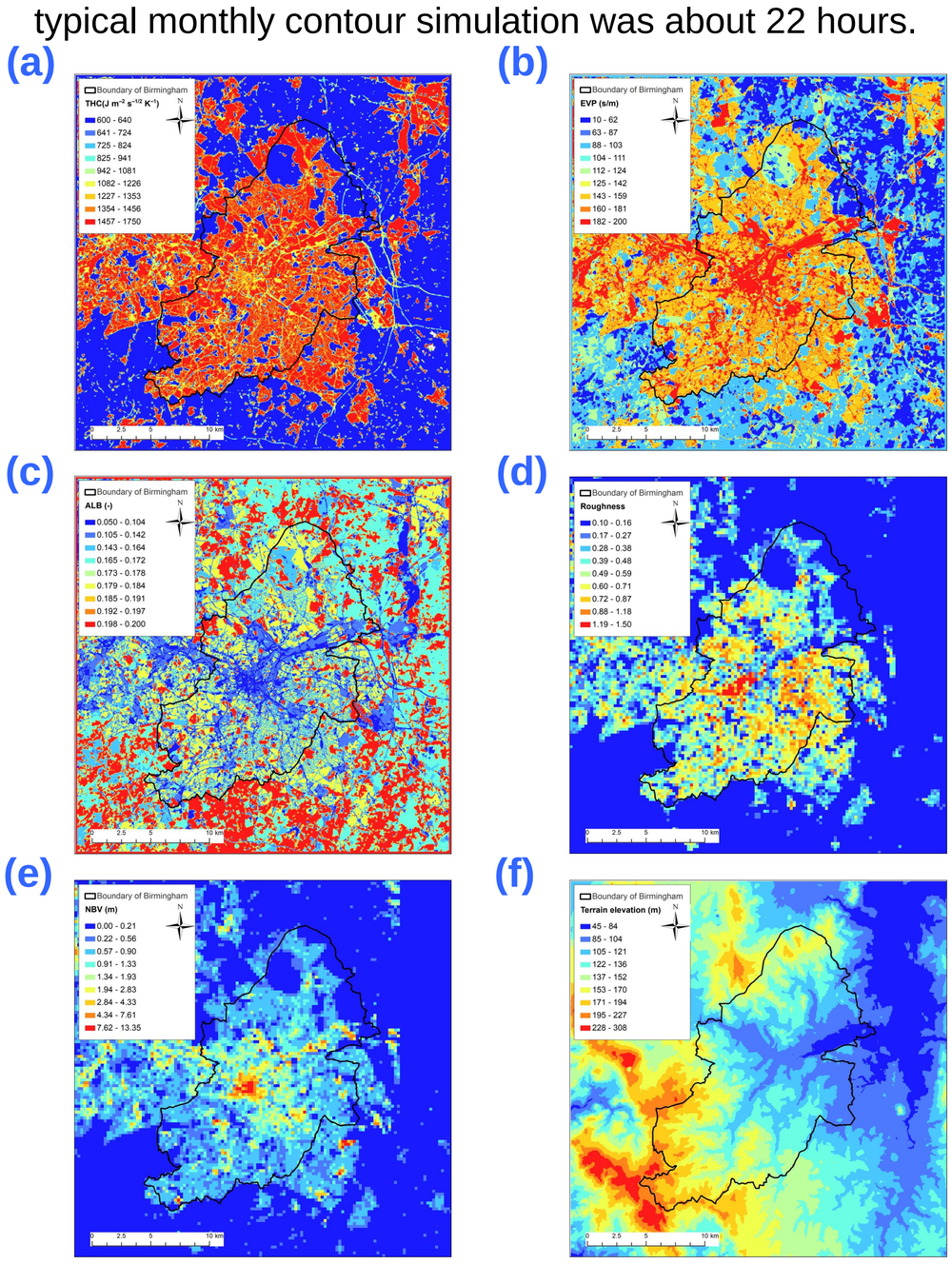

Fig. 1 Surface characteristics in the region of Birmingham at 50 m x 50 m resolution: (a) thermal admittance, (b) surface resistance to evaporation, (c) albedo, (d) surface roughness length, (e) normalised building volume and (f) terrain elevation.

RESULTS AND DISCUSSION

▪Model evaluation

Model evaluation was conducted by comparing the modelled and observed hourly temperature data from Met Office and Weather Underground sites (Fig. 2a-b). Anthropogenic emissions sources have not been modelled, which contributes to the model under-predictions in the winter. Modelled spatiotemporal temperature variation patterns were compared with the Landsat 8 satellite image[4] (Fig. 2c-d). Overall, the model tends to perform well.

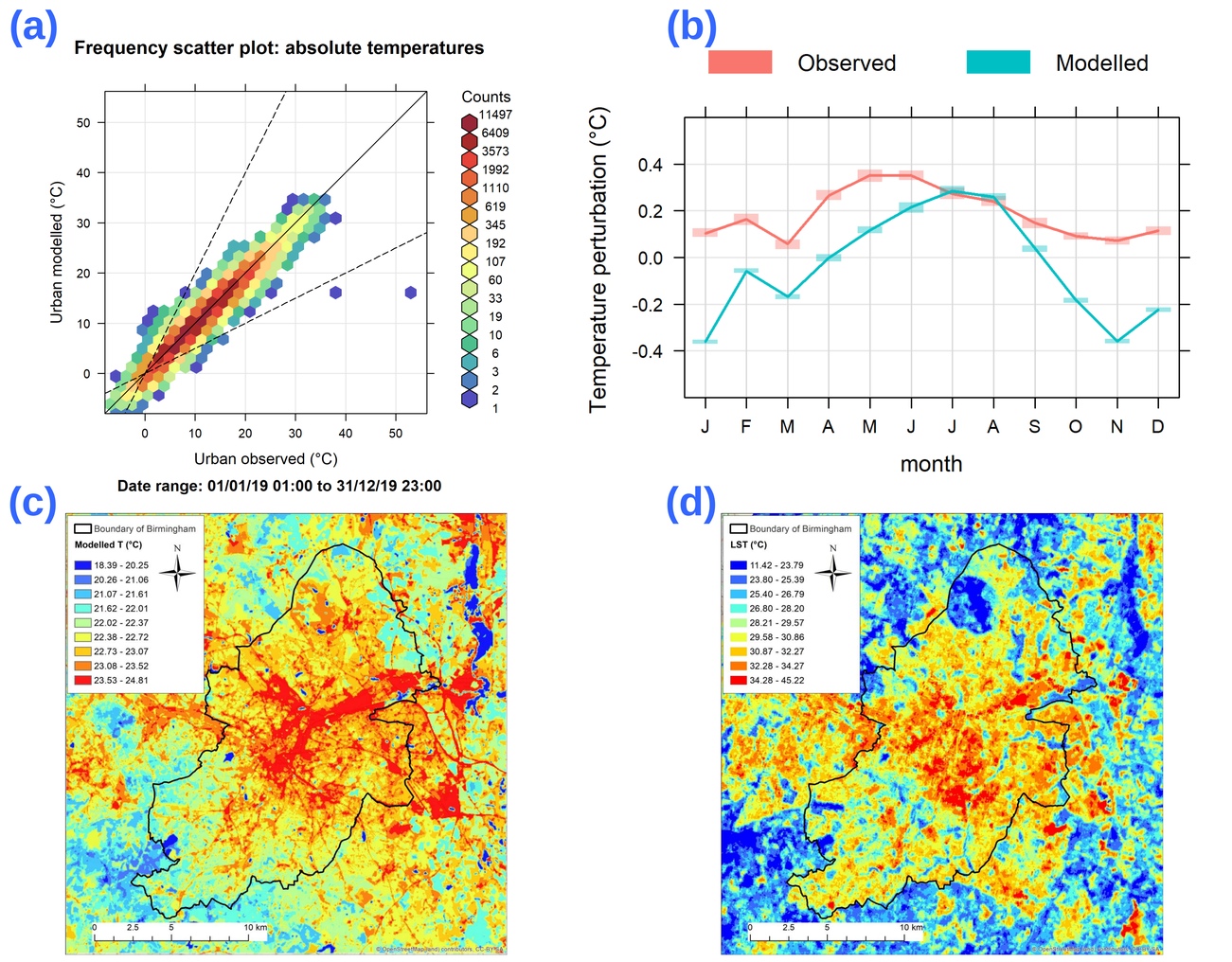

Fig. 2 (a) Frequency scatter plot for modelled and observed absolute temperatures, (b) Comparison between modelled and observed temperature perturbation (UHI), (c) Modelled near-surface air temperature mapping at 50 m x 50 m resolution in Birmingham, UK and (d) Landsat 8 derived land surface temperature at 11 GMT 26th August 2019.

▪Spatiotemporal UHI variations

Fig. 3 shows spatiotemporal UHI variations for different months in Birmingham, UK. Stronger UHI effect is found in summer. Monthly averaged temperature in urban areas can be up to 2 °C than that the upwind rural temperature.

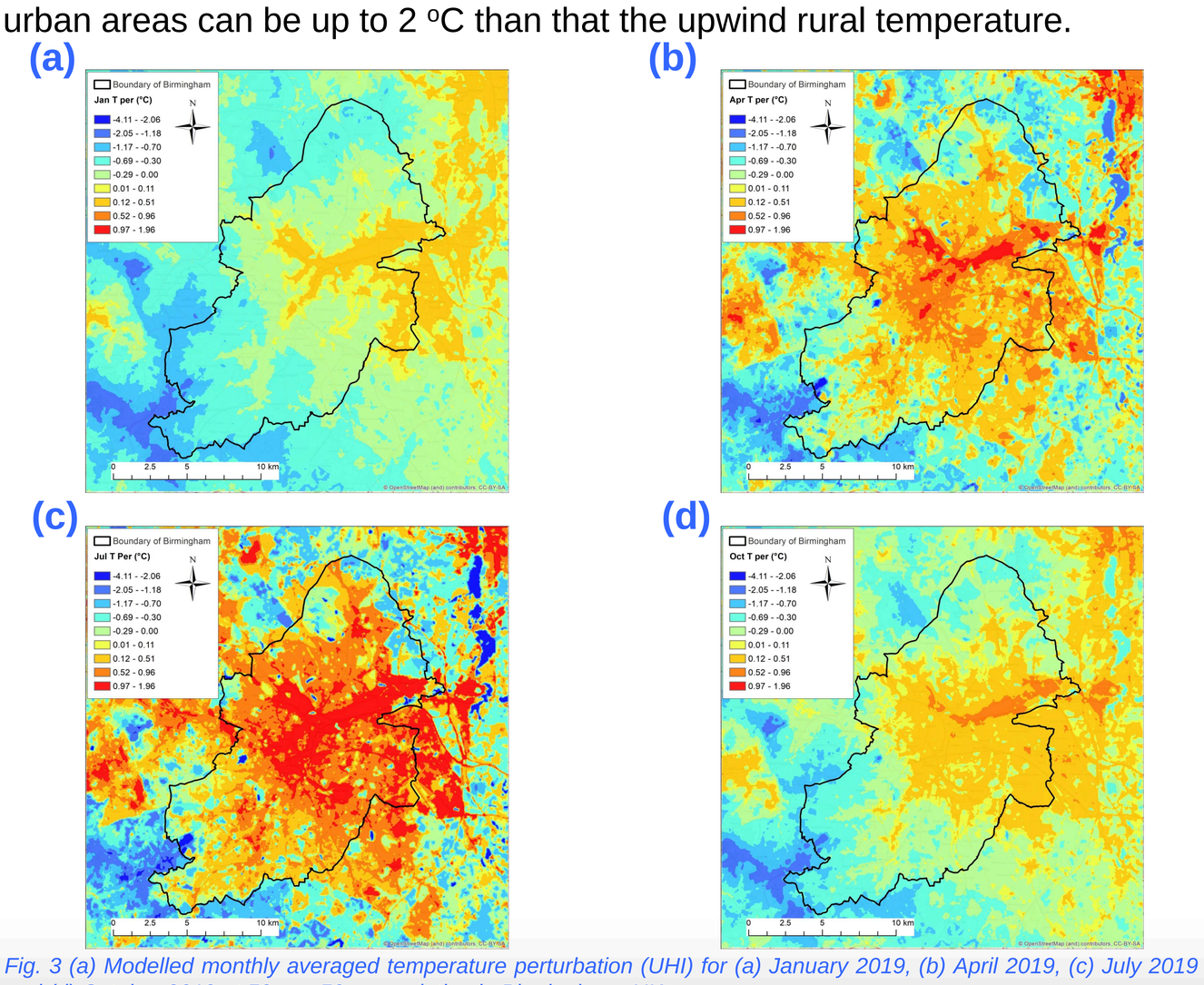

Fig. 3 (a) Modelled monthly averaged temperature perturbation (UHI) for (a) January 2019, (b) April 2019, (c) July 2019 and (d) October 2019 at 50 m x 50 m resolution in Birmingham, UK.

LITERATURE CITED

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CONCLUSION

▪Model evaluation shows that the ADMS-Urban climate model generally performed well to capture both absolute temperature and UHI.

▪Spatiotemporal UHI variations for different months can be generated.

▪UHI effect in summer is much stronger than other seasons and higher in the built up areas compared to rural areas.