A multi-layer perceptron approach on downscaling land surface temperature for the study of surface urban heat islands

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Overview

Limitations of remote sensing

- In highly heterogeneous areas with different surface materials
- In areas with varying horizontal and vertical structure
- Trade-of between spatial and temporal resolution

Spatio-temporal trade-of

- Usual approach: downscaling coarse spatial resolution to a finer one, taking advantage of the higher rate of observations of coarser resolution products

LST downscaling

- Multi-layer perceptron (MLP): finding a non-linear function linking a set of input variables to a target variable (downscaled LST)

Case study city: Madrid

Downscale from ~4.5 km to 750 m

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Data

Sensor	Platform	Product	Temporal resolution	Spatial resolution	Time Period
SEVIRI	MSG3-4	SEVIRI Level 1.5	15 minutes	4.5 km	2019-2024
VIIRS	SNPP	VNP02MOD/ VNP03MOD	Twice daily	750 m	2019-2024
VIIRS	JPSS-1	VJ102MOD/ VJ103MOD	Twice daily	750 m	2023-2024
VIIRS	JPSS-2	VJ202MOD/ VJ203MOD	Twice daily	750 m	2023-2024
SLSTR	Sentinel-3A	S3A_SL_1_RBT	Twice daily	1000 m	2023-2024

Training and testing

SEVIRI & VIIRS/SNPP
2019 - 2022

80% training
20% testing

Further evaluation

SEVIRI, VIIRS/SNPP, VIIRS/JPSS-1, VIIRS/JPSS-2 & Sentinel-3A
2022 - 2024

Model structure

MLP is a is a classic feedforward NN.

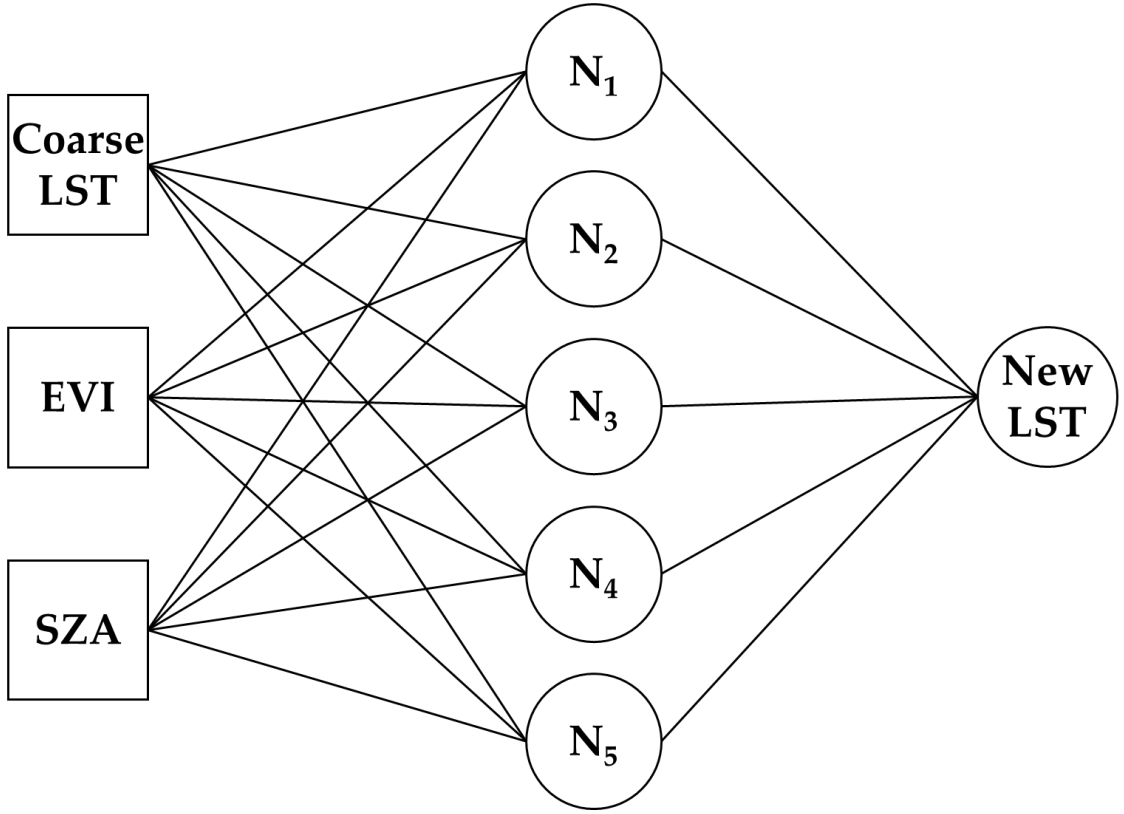
3, 5 and 1 neurons in the input, hidden and output layers, respectively.

It has been proven that one hidden layer can approximate any continuous function, given sufficient samples.

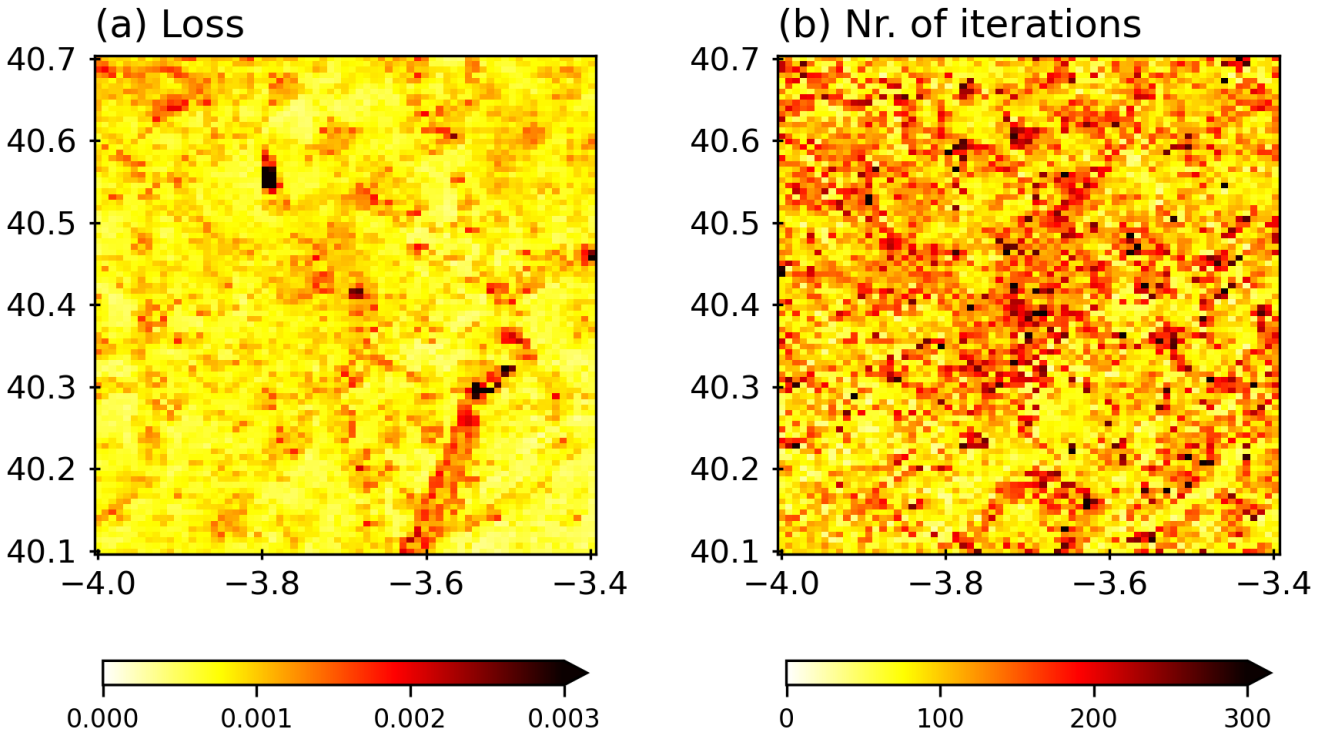
The objective of the MLP is to minimize the measure of error between the target and the predicted output.

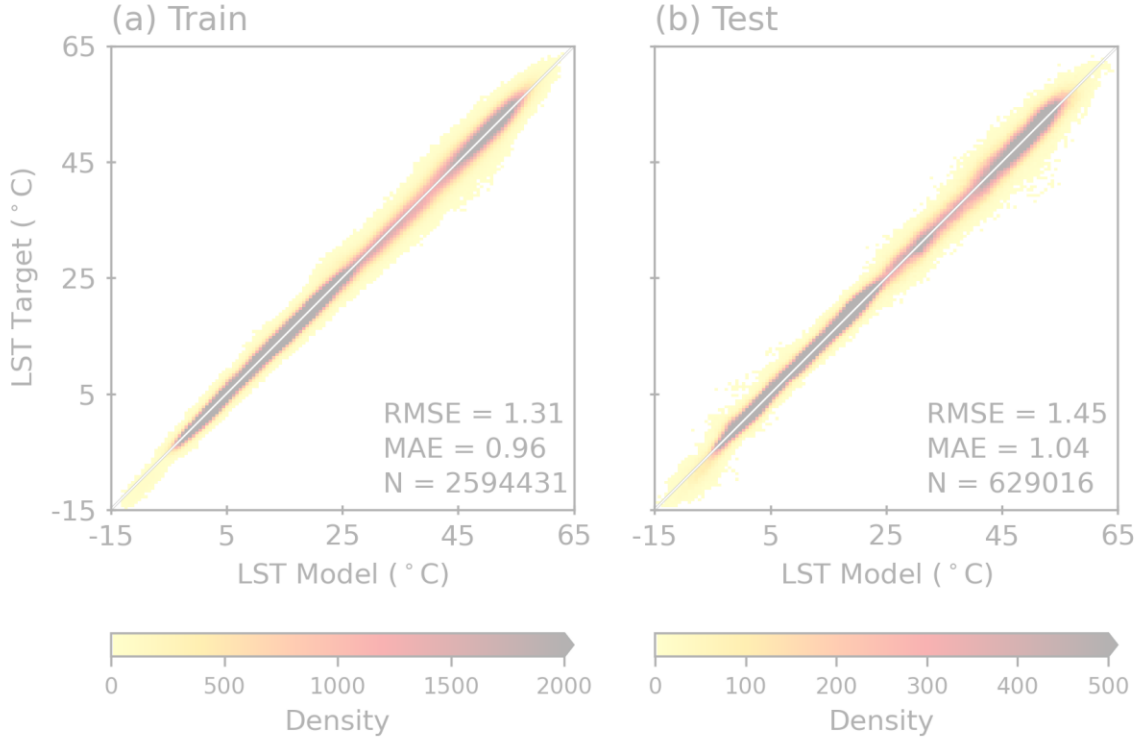
Training was performed pixel by pixel:

- decrease the compromise between minimizing the error over heterogeneous areas.
- accommodate the complexity of the surface and the need for additional inputs.



Model performance 2019 - 2022





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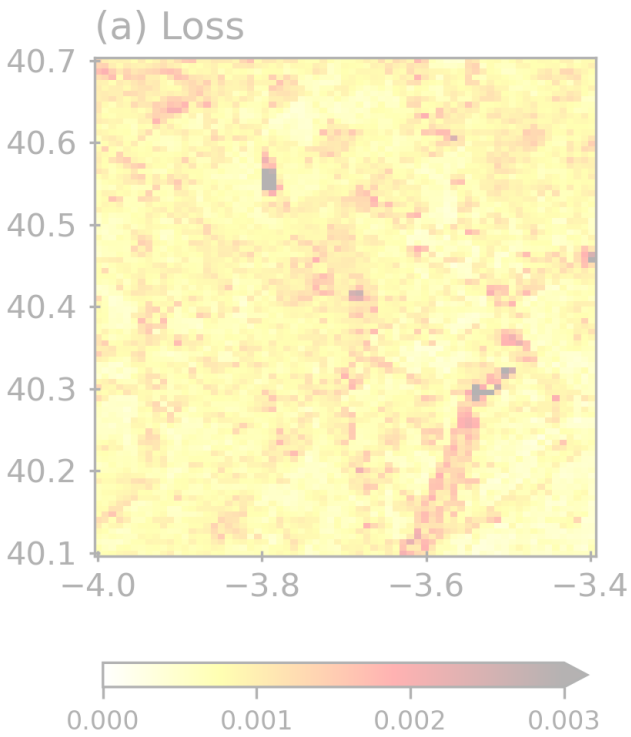
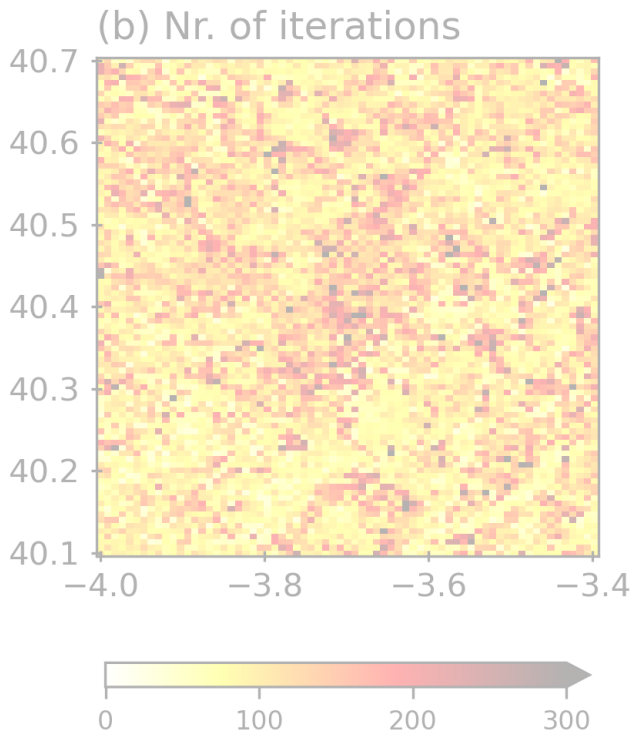
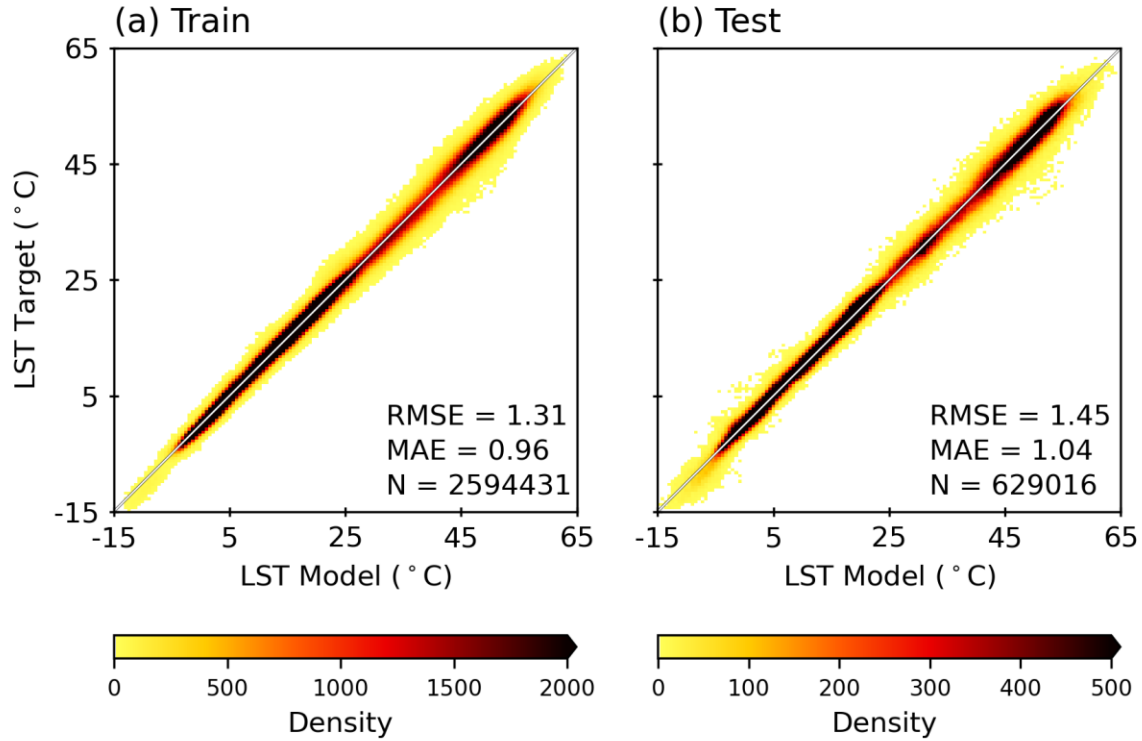
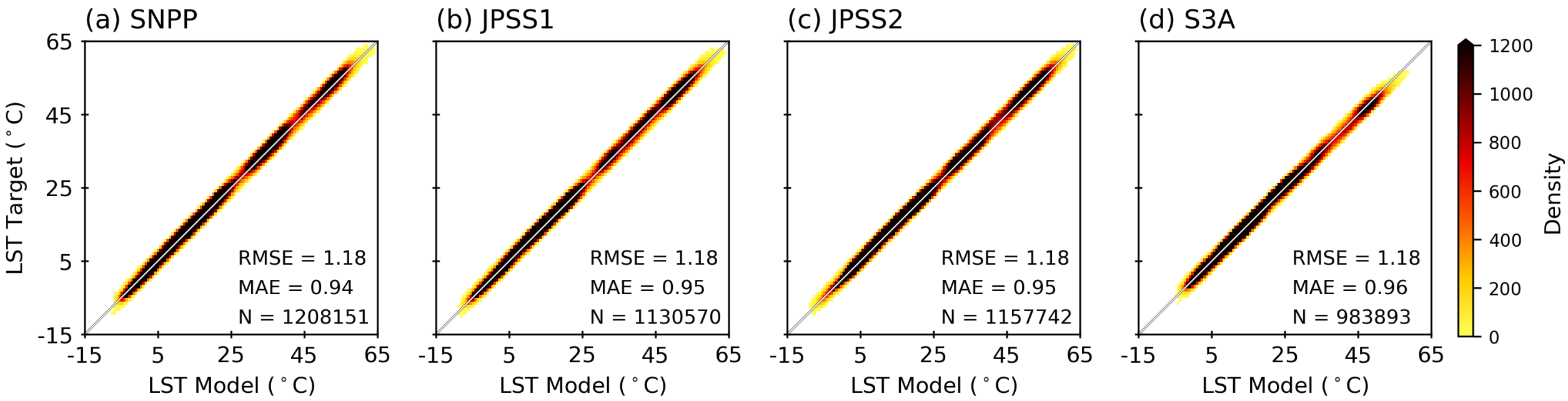


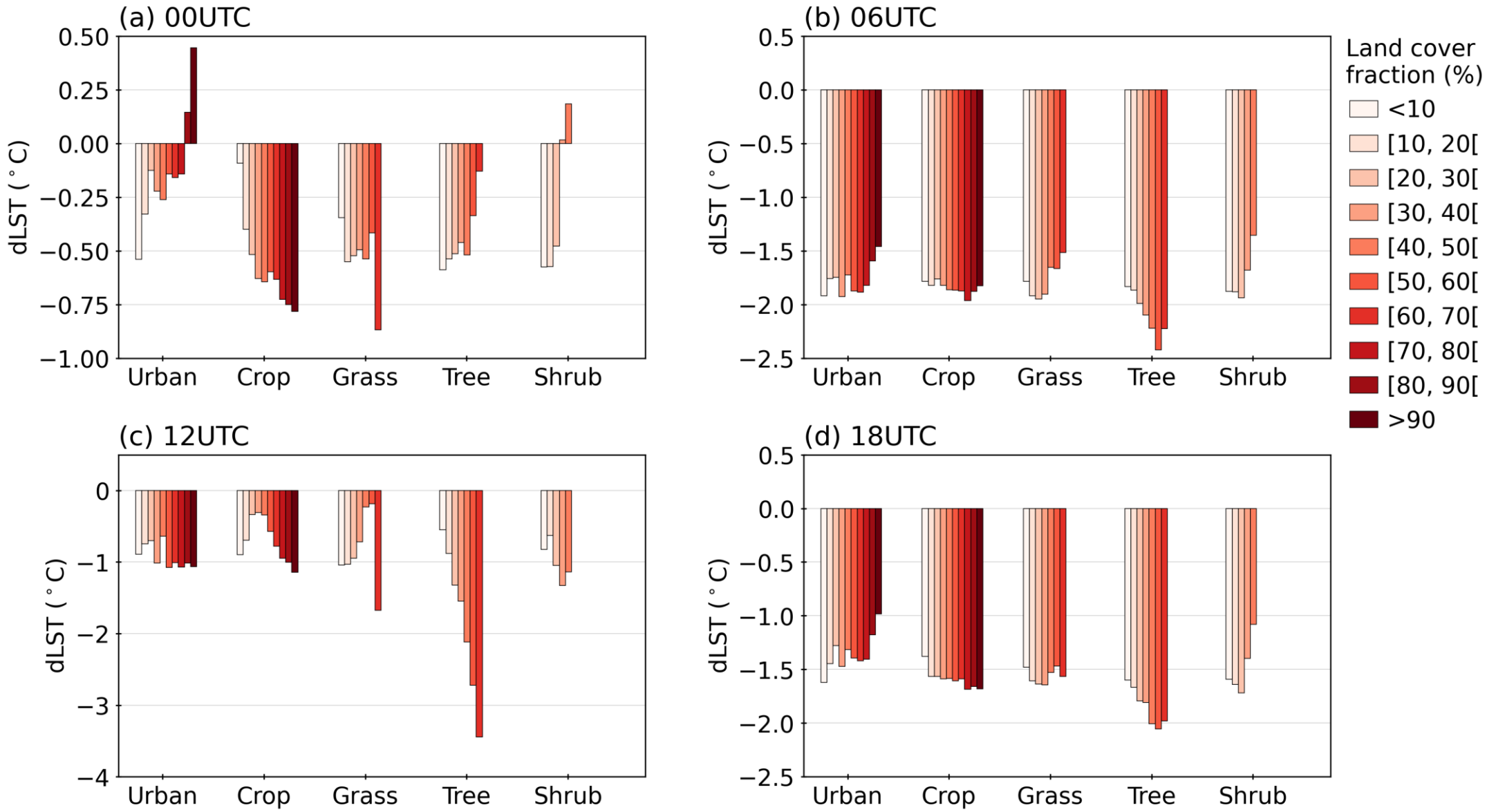




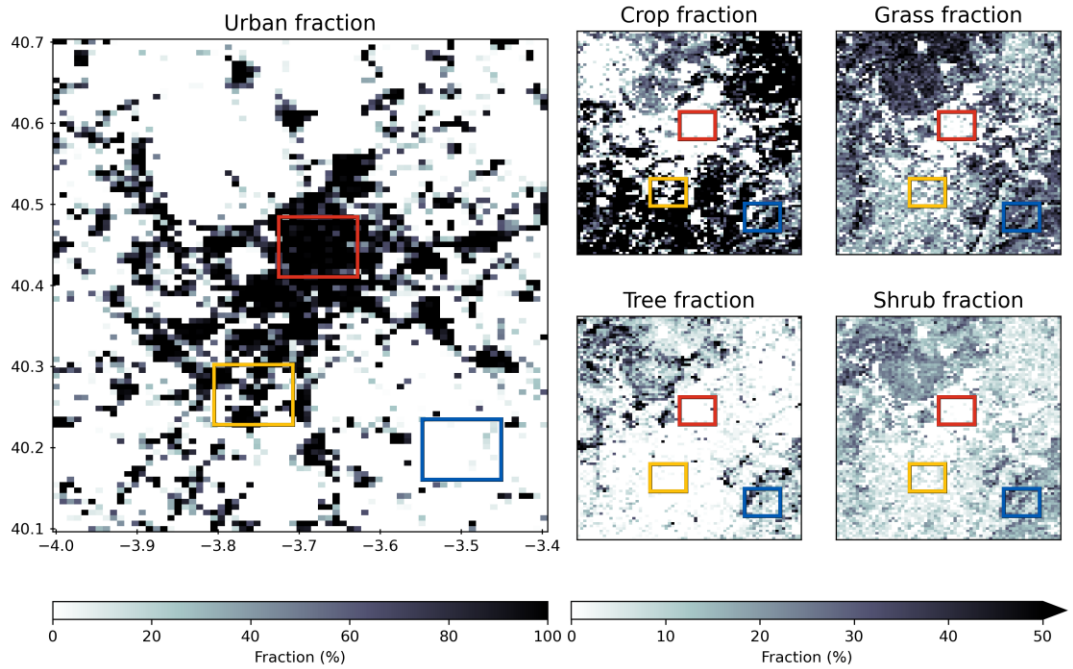
Further evaluation 2023 – July 2024

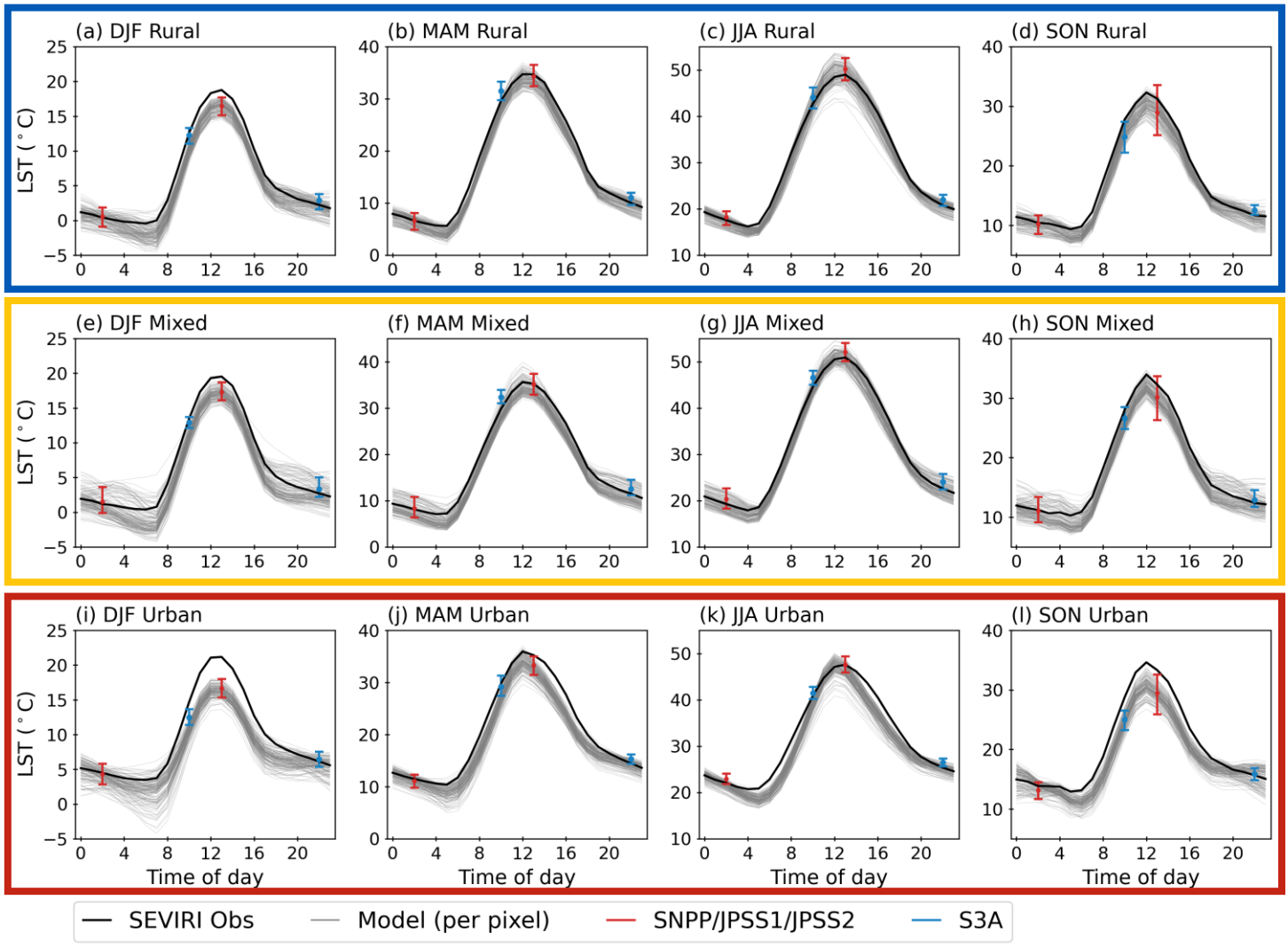


Added value on spatial resolution 2023 – July 2024

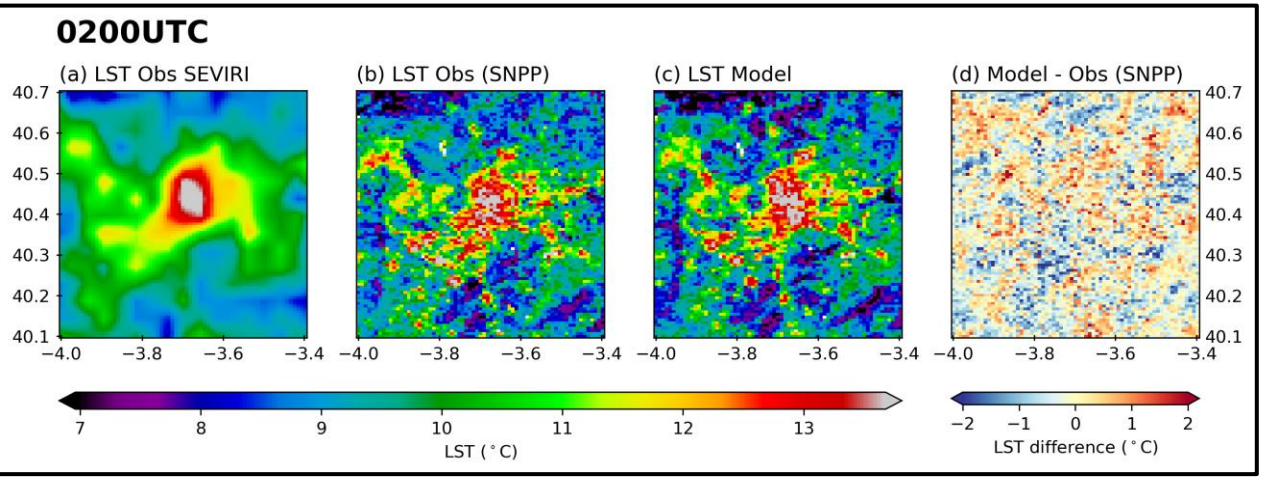


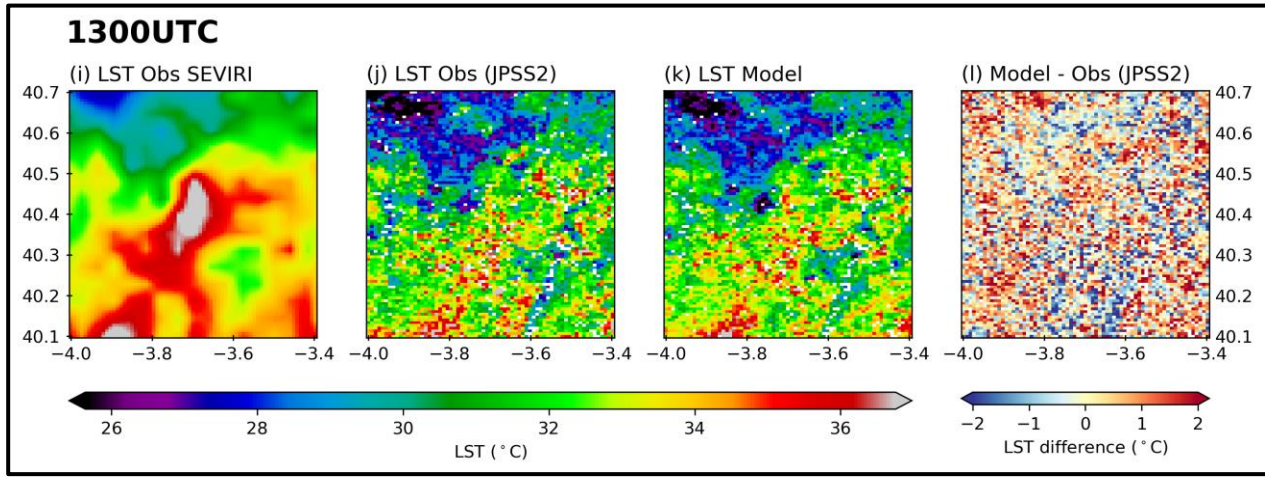
Added value on temporal resolution 2023 – July 2024

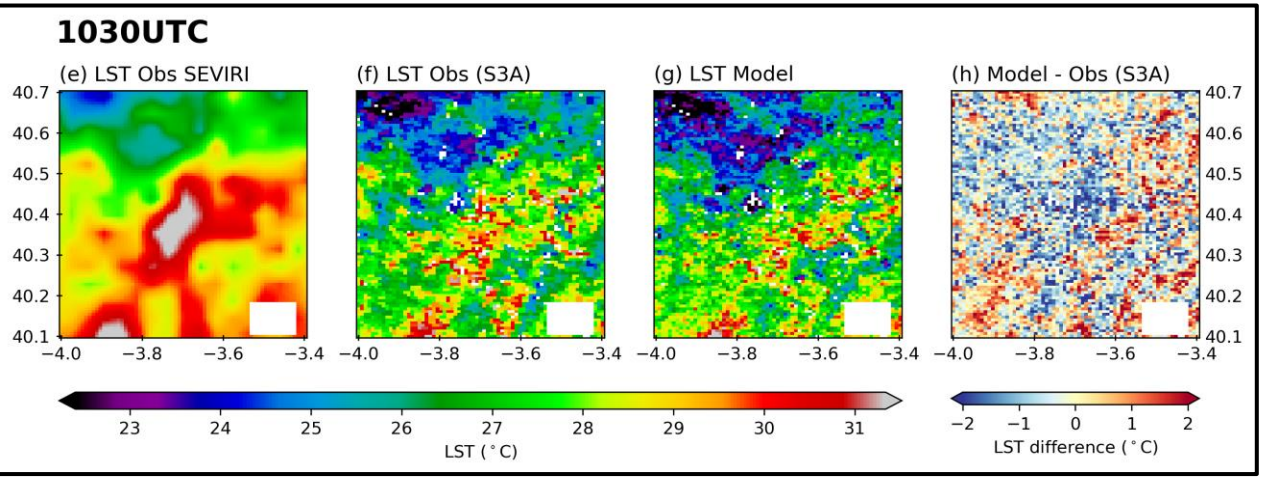


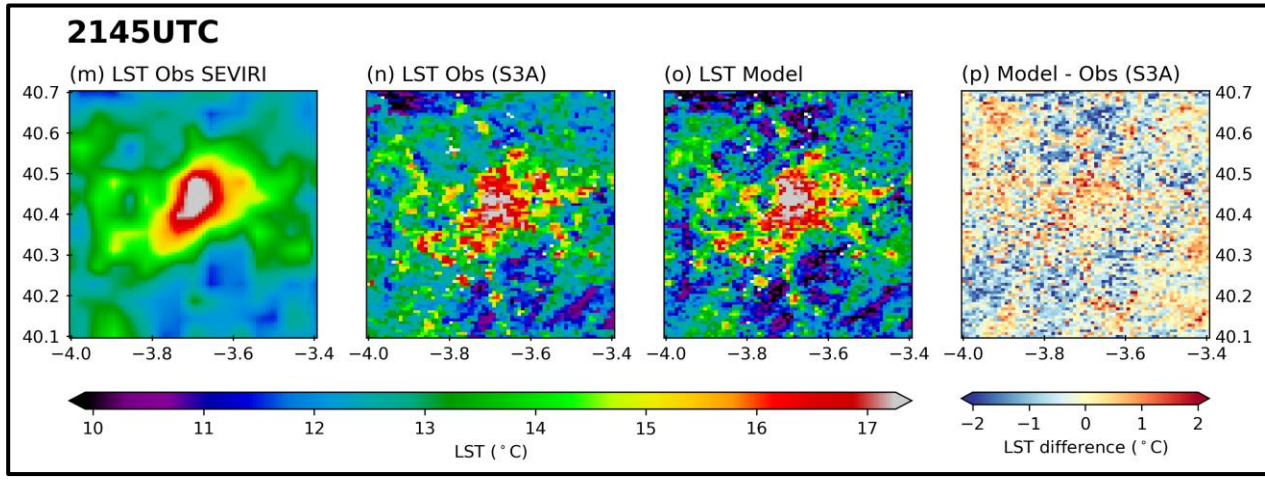


Maps of downscaled LST September 23rd, 2023









Conclusions

Spatio-temporal resolution

Methodology takes advantage of the spatial resolution provided by sensors onboard polar orbiting satellites and the high observation frequency of one onboard a geostationary satellite.

Multy-layer perceptron

A multi-layer perceptron based methodology was shown to be capable of reproducing the heterogeneities of surface temperature based on SEVIRI LST, EVI and time of day.

Pixel-wise training

By training the model pixel-by-pixel, it is possible to obtain a model with high accuracy while requiring few input information on the very complex surface of urban areas.

Adequate performance

The downscaled LST was also compared to additional polar orbiting sensors, showing a good quality of the model for different surface conditions, and times-of-year and day, with a RMSE of 1.18°C and MAE ranging from 0.94 °C to 0.96 °C.

Generalization potential

This methodology can easily be extended to other regions, given the simplicity of the method and the few input data necessary.

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Thank you

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