Downscaling MODIS nighttime land surface temperatures in urban areas using ASTER thermal data through local linear forest

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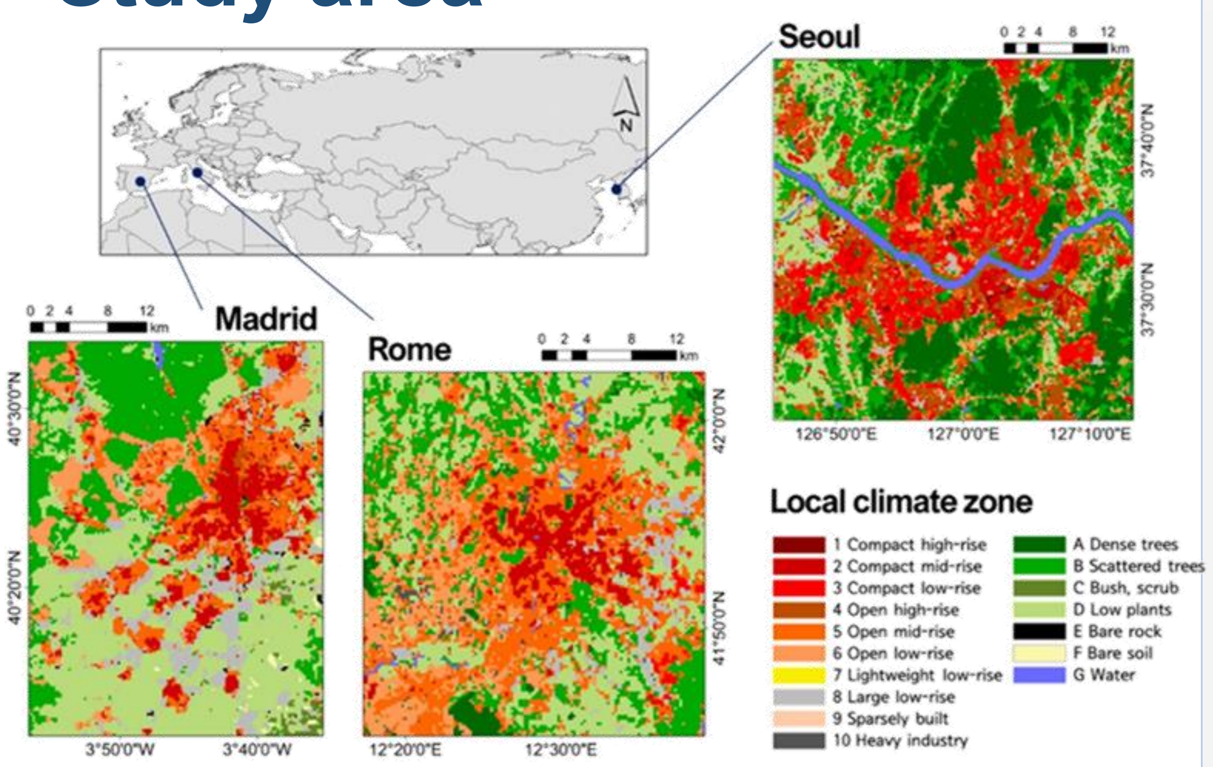
Motivation

Urban areas retain heat at night, but vegetation cools off faster. Nighttime shows clear evidence of positive UHI irrespective of climatic region and seasonal variation. However, few sensor provide high resolution nighttime thermal data (ASTER does, but irregular temporal resolution)

Spatial downscaling effectively produces **high spatiotemporal resolution land surface temperature (LST)** in urban areas. Although nighttime LST is an essential indicator in urban thermal research, few LST downscaling studies have focused on nighttime in fine resolution.

Study area



Rome, Madrid, and Seoul were chosen as the study areas. The three megacities are well-suited to evaluating the robustness of the proposed methodology since they reflect various geographic characteristics and unique urban architectures.

- Study periods: 2017-2020

Data

High resolution (250 m) input kernels

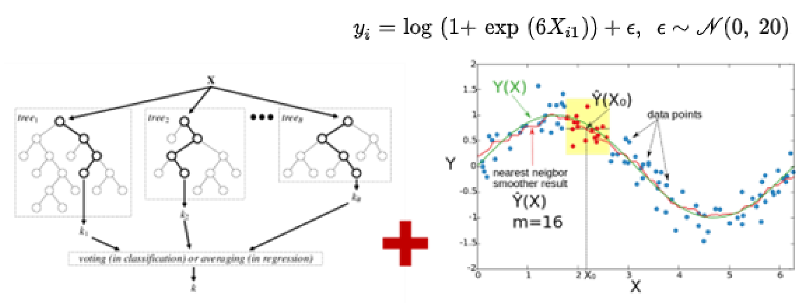
Acronym	Description	Source
ALST (°C)	ASTER Land surface temperature	ASTER Level2 LST
DEM (m)	Elevation	SRTM DEM
Slope (°)	Slope, steepness of a surface	SRTM DEM
Road (%)	Road density	OSM road data
Pop (%)	Population density	GHS-POP
Built (%)	Built-up area percentage	GHS-BUILT
DisBWC(m)	Distance from the built-up weighted Center	
Wind (m/s)	10-year averaged wind speed	Global Wind Atlas

*GHG: Global Human Settlement population and built-up grids

Target MODIS daily nighttime LST

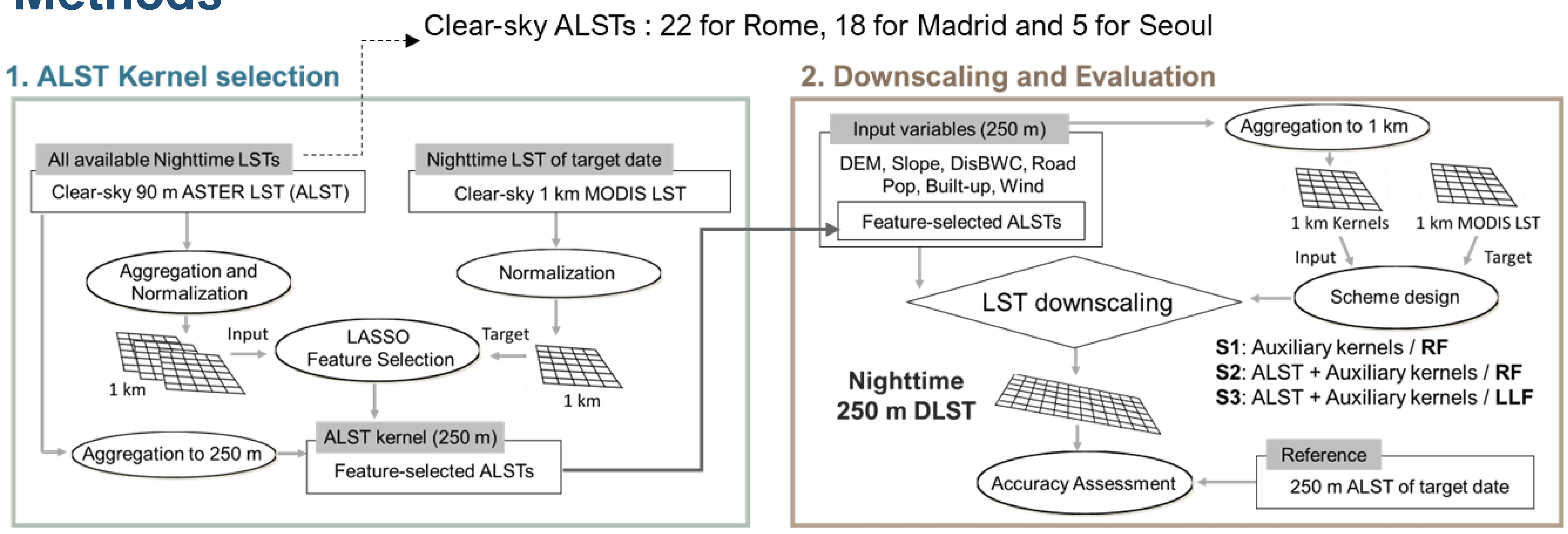
- MOD11A1 (Terra) LST products
- Daily, 1 km spatial resolution
- 10:30 p.m. local solar time

Local Linear Forest



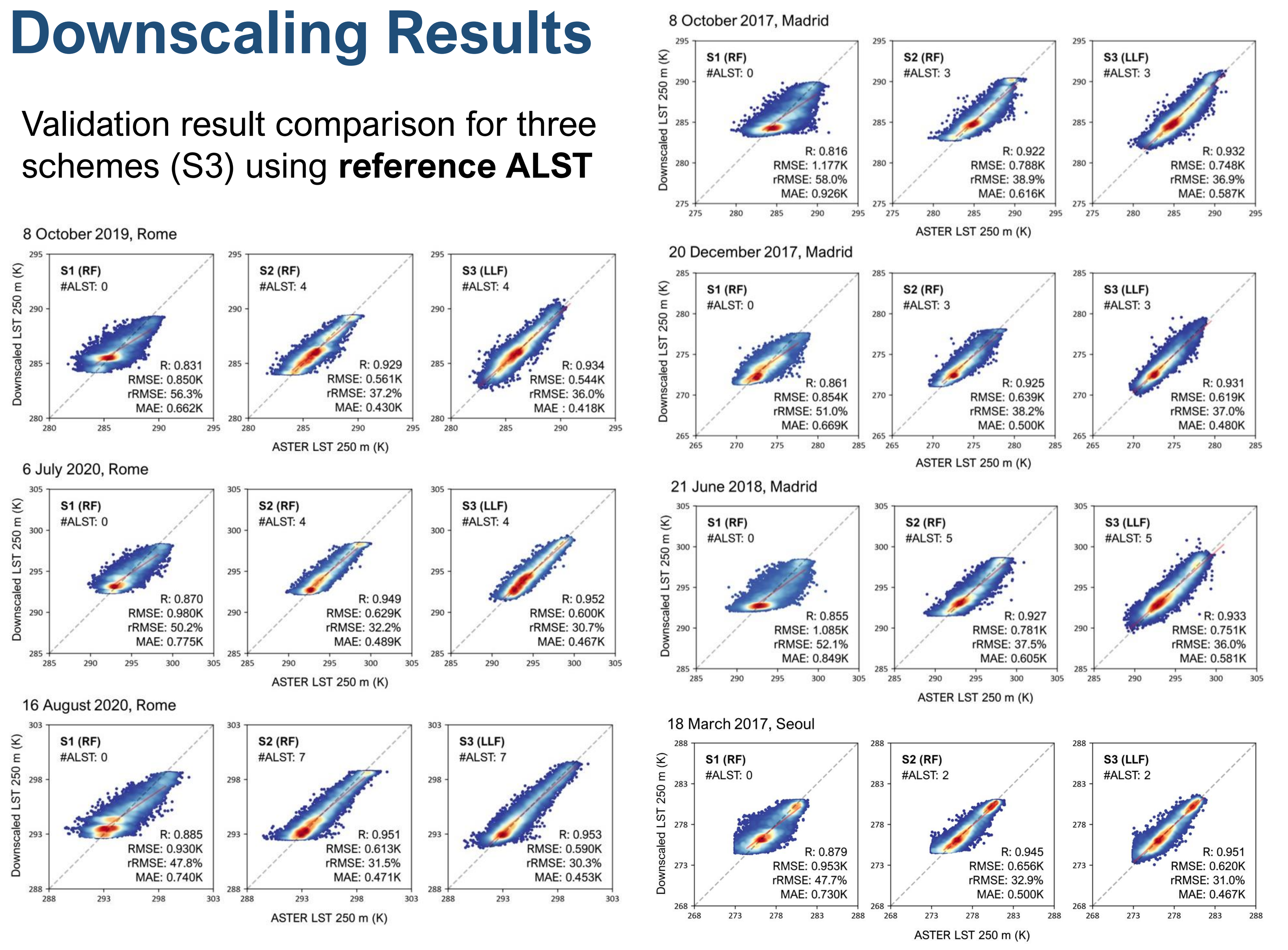
- RF is regarded as a useful model for many regression tasks thanks to its relatively high performance and low sensitivity to the parameters .
- However, RF cannot extrapolate target values outside the range of the training data.
- LLF leverages the strengths of RF and local linear regression to improve performance

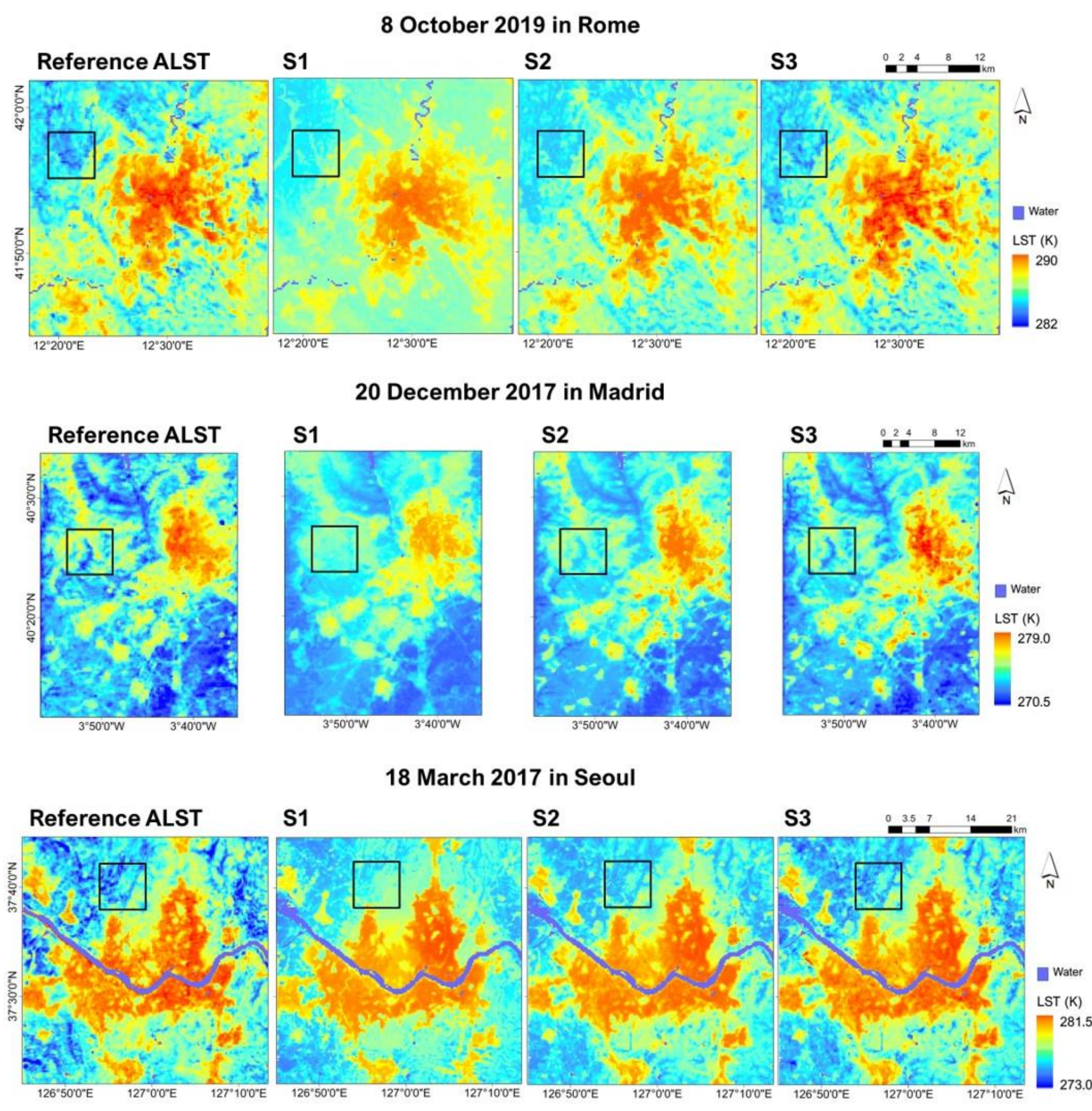
Methods



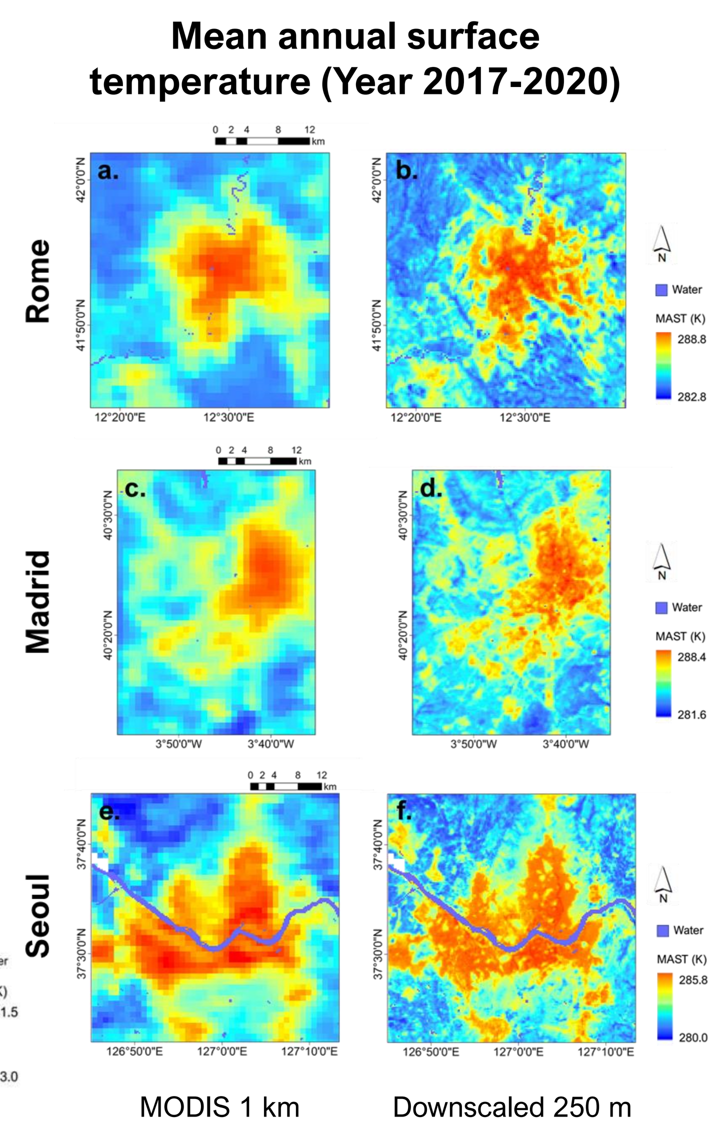
Downscaling Results

Validation result comparison for three schemes (S3) using **reference ALST**

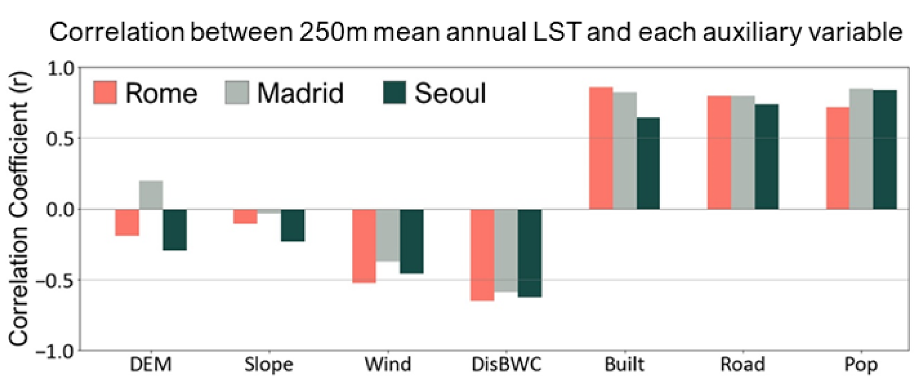




Spatial distribution of nighttime LST



Applicability for urban climate monitoring



Surface urban heat island (SUHI) intensity comparison using LCZ

	SUHI	Rome			Madrid			Seoul		
	LCZ	1km	250m	diff	1km	250m	diff	1km	250m	diff
Urban-type	Compact midrise	3.04	3.53	0.49	2.61	2.89	0.28	3.14	3.29	0.15
	Compact low rise							2.74	2.90	0.16
	Open high rise							2.24	2.47	0.23
	Open midrise	1.56	1.85	0.28	1.93	2.36	0.43	1.65	1.69	0.05
	Open low rise	0.65	0.70	0.04	0.86	1.10	0.24	1.18	1.14	-0.04
	Large low rise	1.10	1.37	0.26	1.04	1.16	0.11	1.12	1.21	0.09
Natural	Dense tree	0.82	0.78	-0.04				0.59	0.55	-0.04
	Scattered tree	0.17	0.10	-0.06	0.01	0.00	-0.01	0.39	0.34	-0.04
	Bush, Scrub				0.06	-0.02	-0.08			

$\mathrm{UHI_{LCZX}} = \mathrm{Temperature_{LCZX}} - \mathrm{Temperature_{LCZD}}$

Conclusion

This study presented a new nighttime LST downscaling method in which 250 m LSTs are generated from 1 km MODIS nighttime LST. Scheme 3 using LLF model predicted LST much better than other schemes especially for both extremes. Selected ALST kernels of the target date played a crucial role in producing accurate nighttime DLST. Downscaled LST showed larger UHI intensity on urban surfaces than 1 km MODIS LST.

Yoo, C., Im, J., Cho, D., Lee, Y., Bae, D., & Sismanidis, P. (2022). Downscaling MODIS nighttime land surface temperatures in urban areas using ASTER thermal data through local linear forest. *International Journal of Applied Earth Observation and Geoinformation*, *110*, 102827.