

An aerial photograph of a city landscape. A multi-lane highway with a complex interchange runs diagonally across the frame. The highway is filled with cars. To the left of the highway, there are several tall, modern buildings with white facades. To the right, there is a dense forest of trees with green and yellow foliage. In the bottom right corner, there is a cluster of residential buildings with red roofs. The overall scene is a mix of urban infrastructure and natural greenery.

Urban tree cover and temperature

Final Project Presentation

12th July 2022

Studies of Socio-Ecological Production
Landscapes and Seascapes (SEPLS)

Professor Nishi, Professor Pastor-Ivars

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The role of urban trees in reducing
land surface temperatures in
European cities


Prepared by researchers of ETH Zurich

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Christine Bürgi
Eduard Davin


Research Rationale

Emerging Urban Heat Islands


Exemplary Urban Forest Ecosystem Services




Water provisioning




Oxygen provision and carbon sequestration



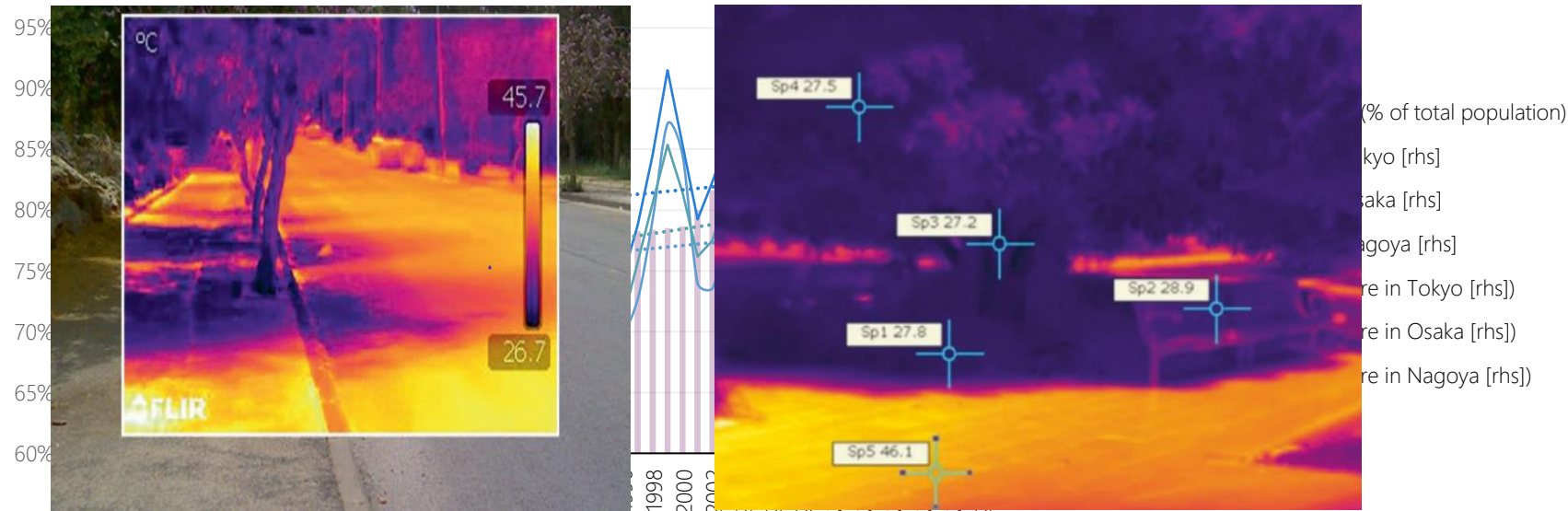
Land surface temperature regulation





Erosion and flooding protection



Non-wood and wood products



Methodology

Comparison			
Authors		Schwaab et al. (2021)	Our approach
Country			
City		Various	Tokyo
Köppen classification		Cfb, Csa	Cfa
Methods		Generalized Additive Model	Generalized Additive Model
Data source		Landsat 30m LULC Copernicus Urban Atlas EU-DEM v1.0	Landsat 8 LST 30m from RS Lab HRLULC from JAXA Japanese-DEM from JAXA MODIS Vegetation Model from NASA
Data requirement	Imagery	Minimum 80 per city	>36 for Tokyo*
	Timeframe	across 12 years	across 3 years*
Results		Urban trees contribute towards cooling, but extend depends on climate	...

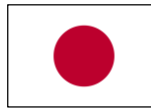


Data availability...



The role of urban trees in reducing land surface temperatures in European cities

Research Location Tokyo

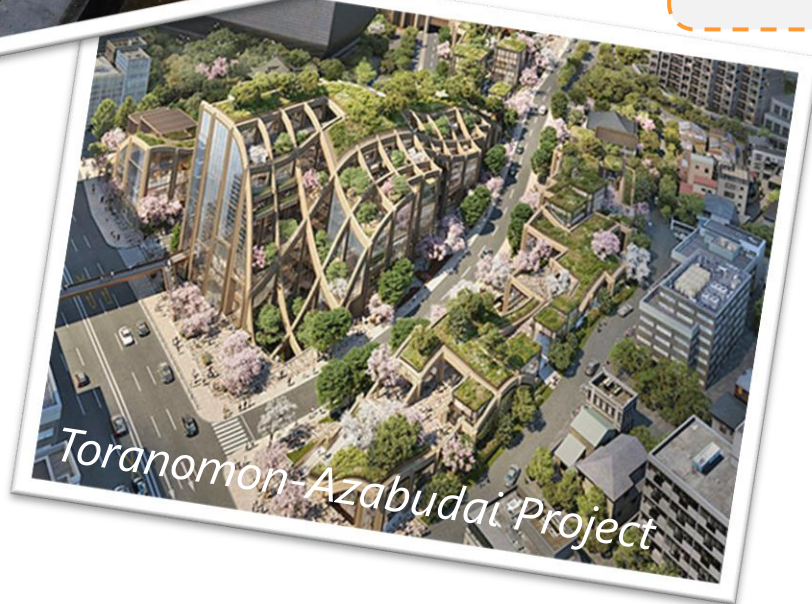


Shibuya Waterway

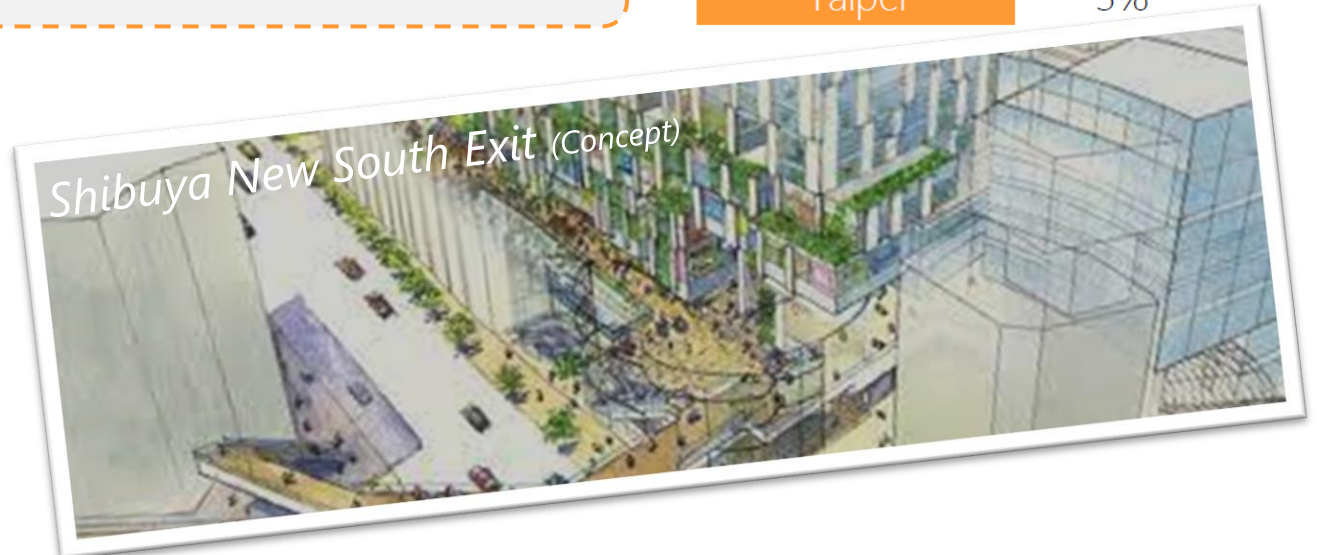
- Tailwind for existing change
- Personal interest
- Upside potential

Share of Urban green space (2015 data)
Source: World Cities Culture Forum (2022)

Singapore	47%
Chengdu	42%
Shenzhen	41%
Nanjing	41%
Hong Kong	40%
Seoul	28%
Guangzhou	20%
Shanghai	16%
Tokyo	7.5%
Taipei	3%

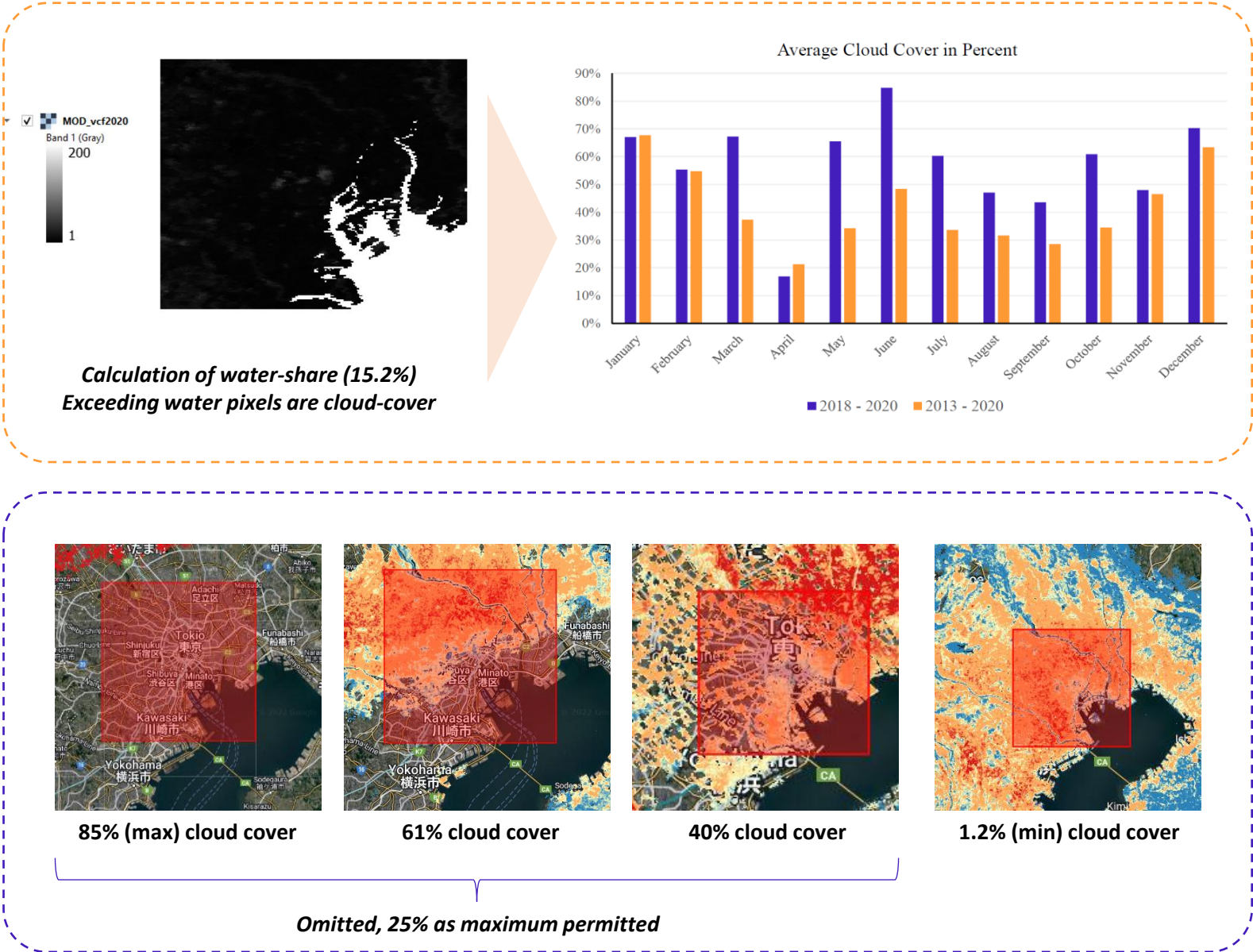
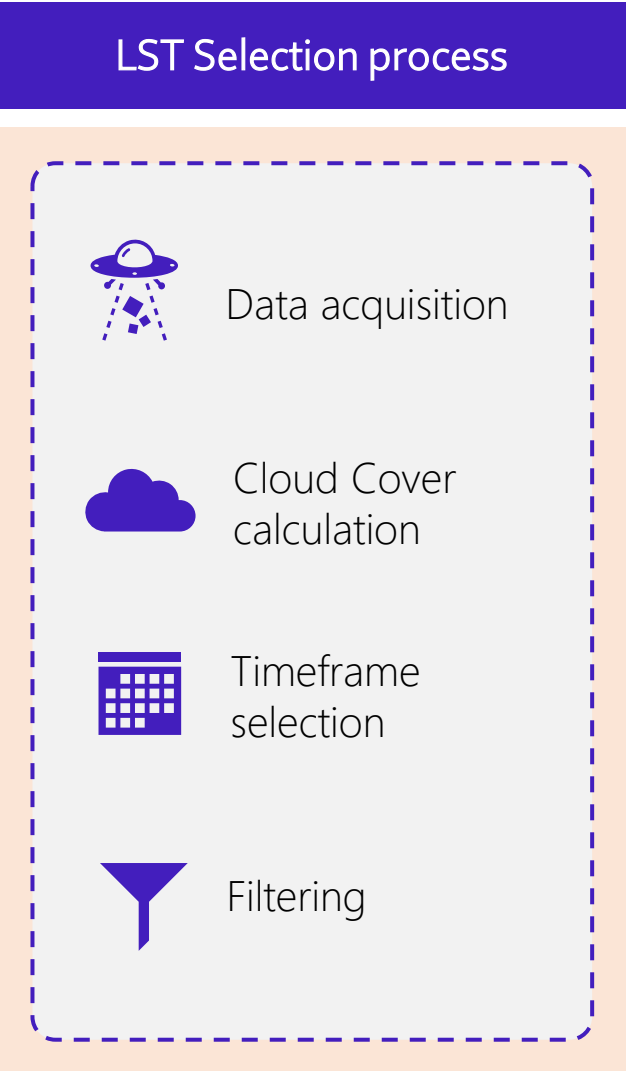


Toranomon-Azabudai Project



Shibuya New South Exit (Concept)

Pre-processing





85% (max) cloud cover



61% cloud cover



40% cloud cover



1.2% (min) cloud cover

Omitted, 25% as maximum permitted

Pre-processing

Predictor variable preparation



Data acquisition



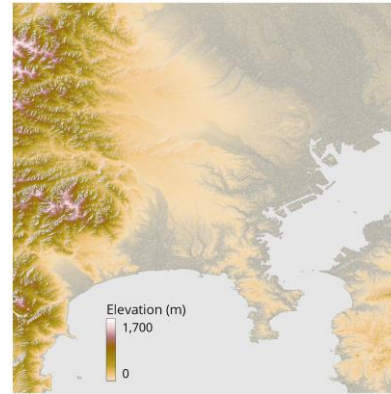
DEM
Aspect calculation



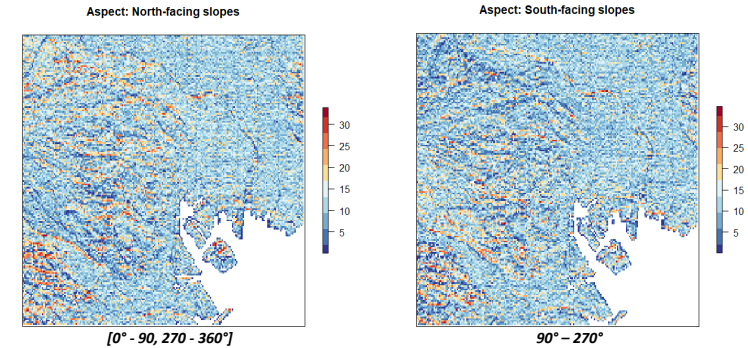
LULC
Subdivision



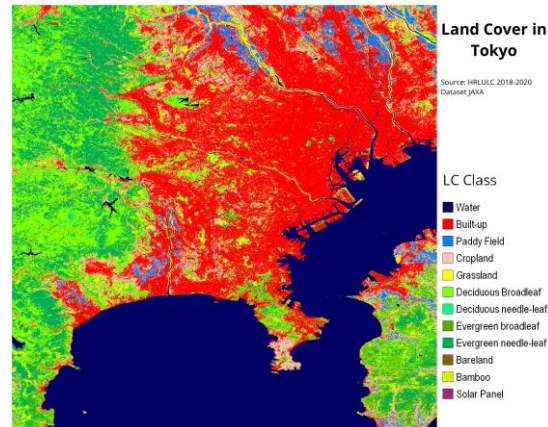
VCF
Vegetation Continuous Fields



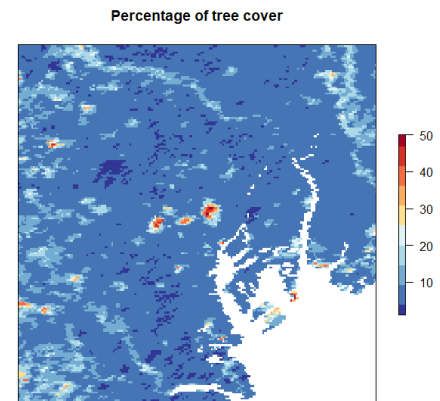
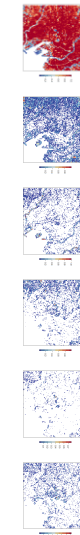
Digital Elevation Model
Tokyo, Kanagawa Prefecture



Calculate aspect and subdivide into distinct rasters
to allow for variability in solar radiation

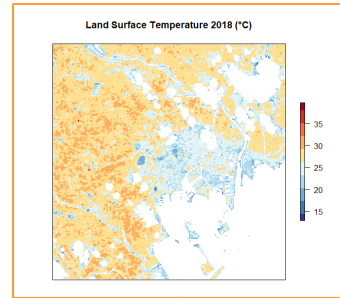


Subdivide into distinct LULC classes to
account for difference in VC type

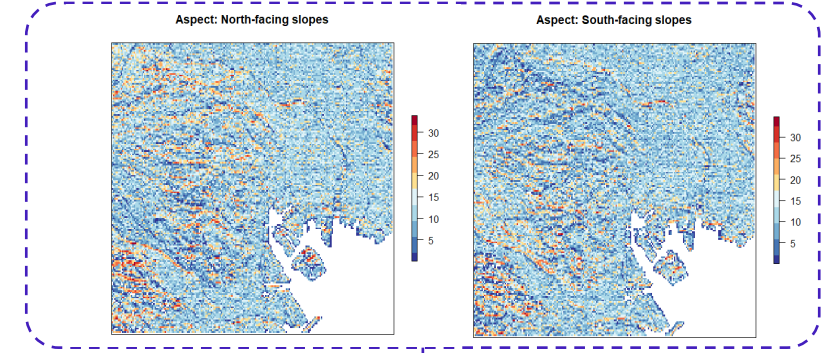
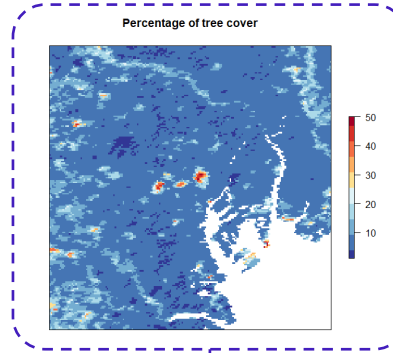


Reproject and adjust resolution

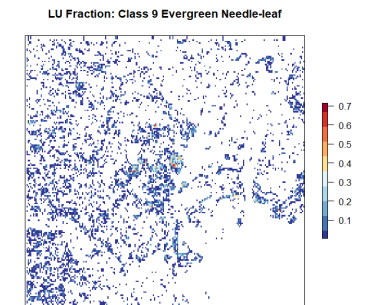
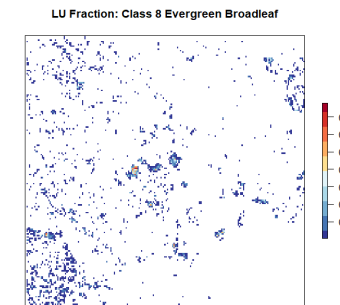
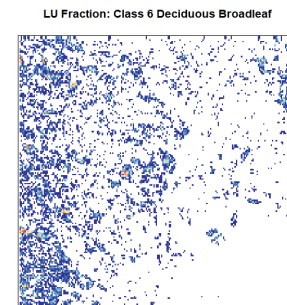
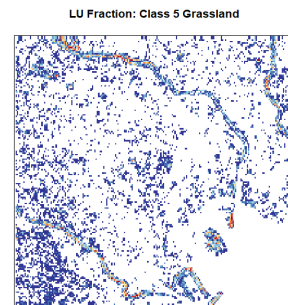
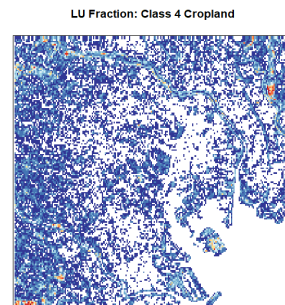
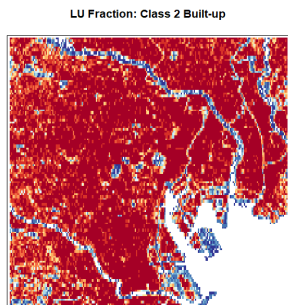
Model Fitting



X- and Y-coordinates as a two-dimensional smooth product in the model to minimize *spatial autoregression*.
Beale et al. (2010)



$$LST = \beta_0 + f_1(x, y) + f_2(VCF) + f_3(LULC_1, LULC_2, \dots, LULC_9) + f_4(DEM_1, DEM_2) + \epsilon$$



Our results (1)

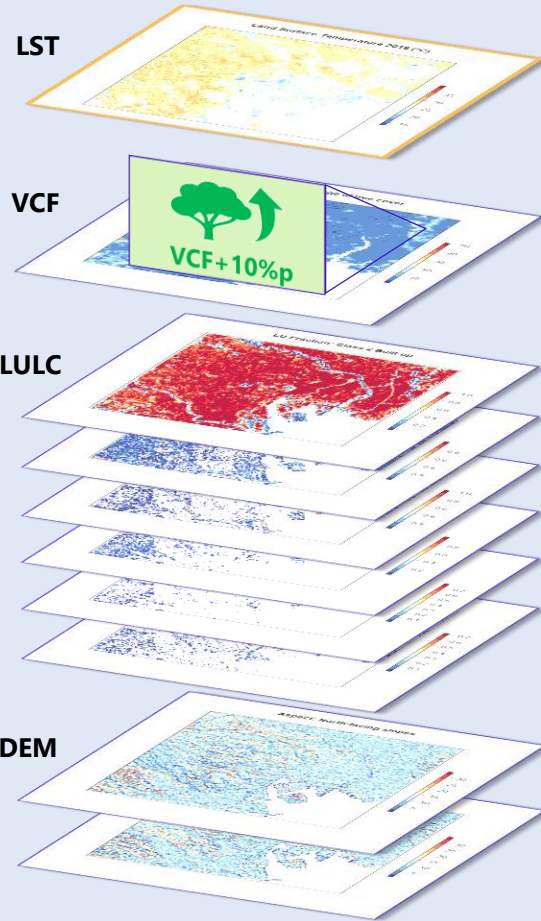
Generalized additive model

LST

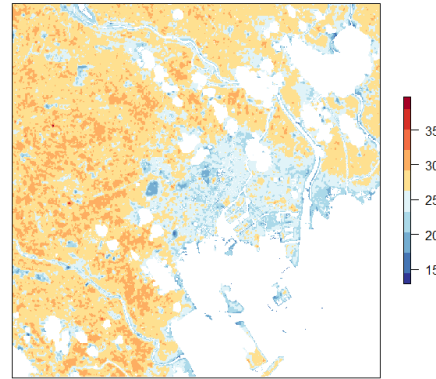
VCF

HRLULC

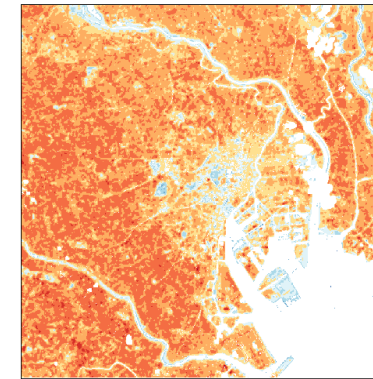
DEM



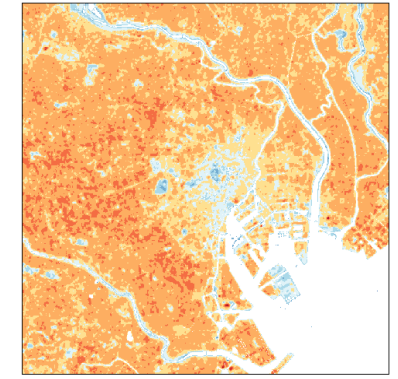
Land Surface Temperature 2018 (°C)



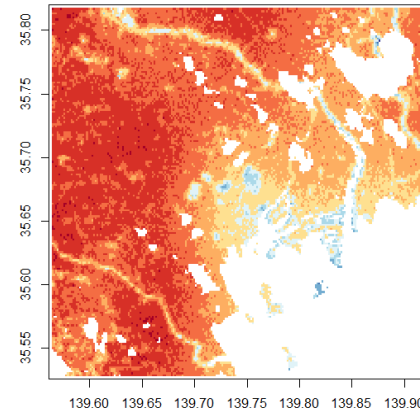
Land Surface Temperature 2019 (°C)



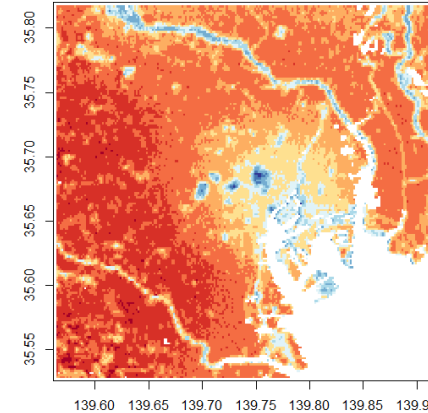
Land Surface Temperature 2020 (°C)



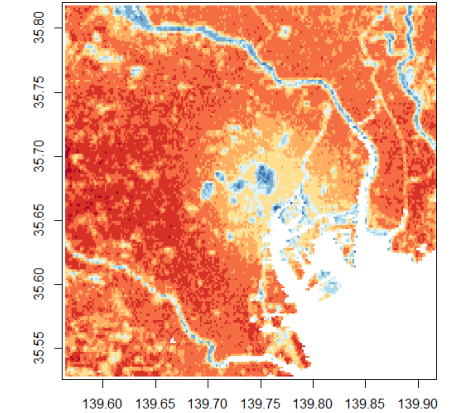
Land Surface Temperature (+10% cover) 2018



Land Surface Temperature (+10% cover) 2019



Land Surface Temperature (+10% cover) 2020



Our results (2)

Linear regression model

Year	2018	2019	2020
Date	08/04/2018	11/04/2019	29/04/2020
Cloud Cover	17.9%	3.9%	1.2%

LST - VCF corr	-0.321	-0.337	-0.447
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Intercept (β_0)	23.06274***	17.385577***	23.349387***
vcf_2018	-0.09823***	-0.024348***	-0.046549***
lu_percent_2	-3.94643***	-4.107929***	-5.687862***
lu_percent_4	3.07862***	2.896111***	3.767533***
lu_percent_5	-0.66237	-2.300663***	-2.240579***
lu_percent_6	-0.60247	0.817421**	-0.567646
lu_percent_8	-2.40762*	-0.336959	0.499397
lu_percent_9	-7.51984***	-6.891491***	-6.783993***
Northface_sum	0.04632**	0.047787***	0.034412**
Southface_sum	0.05804***	0.085887***	0.037603**

R-squared	0.4854	0.5573	0.6147
Adjusted R-squared	0.4825	0.5551	0.6128

Significance codes: '***' 0.001 '**' 0.01 '*' 0.05

VCF is significantly correlated with LST!

Generalized additive model

Year	2018	2019	2020
Date	08/04/2018	11/04/2019	29/04/2020
Cloud Cover	17.9%	3.9%	1.2%

R-squared	0.560	0.633	0.679
Deviance explained	56.30%	63.50%	68.10%

Pre-adjustment			
VCF	6.58%	6.80%	6.80%
LST mean	26.9°C	21.9°C	28.7°C
LST st.dev	2.4°C	1.7°C	2.7°C
LST min.	12.6°C	15.4°C	13.5°C
LST max.	41.1°C	27.7°C	38.4°C

Prediction (+10% vegetation cover)

Post-adjustment			
VCF	16.58%	16.80%	16.80%
LST mean	25.7°C	21.4°C	27.8°C
LST st.dev	1.7°C	1.3°C	1.7°C
LST min.	15.4°C	14.9°C	19.1°C
LST max.	29.2°C	23.9°C	31.3°C

Cooling range of [0.5; 1.2] °C while reducing St.dev

Interpretation

Limitation









Data availability



Albedo



Optimization vs.
Expansion

Authors	Country	City	Input	Impact
Wong et al. (2011)		Singapore	10%p	[-0.9°C , -1.2°C]
Stepanie et al. (2022)		Jakarta	10%p 40%p	[-1.5°C, -2.5°C]
Huang et al. (1987)		Multiple	10%p 25%p	11-18% 25-42% electricity reduction p.a
Wong et al. (2011)		Singapore	-1.2°C	4.5% electricity reduction p.a for adjacent buildings
Chen and Wong (2006)		Guangzhou	-1°C	5% electricity reduction p.a.
Yabe (2005)		Tokyo	+1°C	0.45% base-load increase, 180 MWh per peak-load

Quite in line with existing research and effects! (De Frenne et al. (2019))

Higher vegetation cover desirable – plant trees in the right spots to reap benefits!

Sources:

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Thank you for your attention!

Any comment, question or criticism would be highly appreciated!

