This presentation originally contained animations.
Slides were duplicated in the PDF version

Urban tree cover and temperature

Final Project Presentation

12th July 2022

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

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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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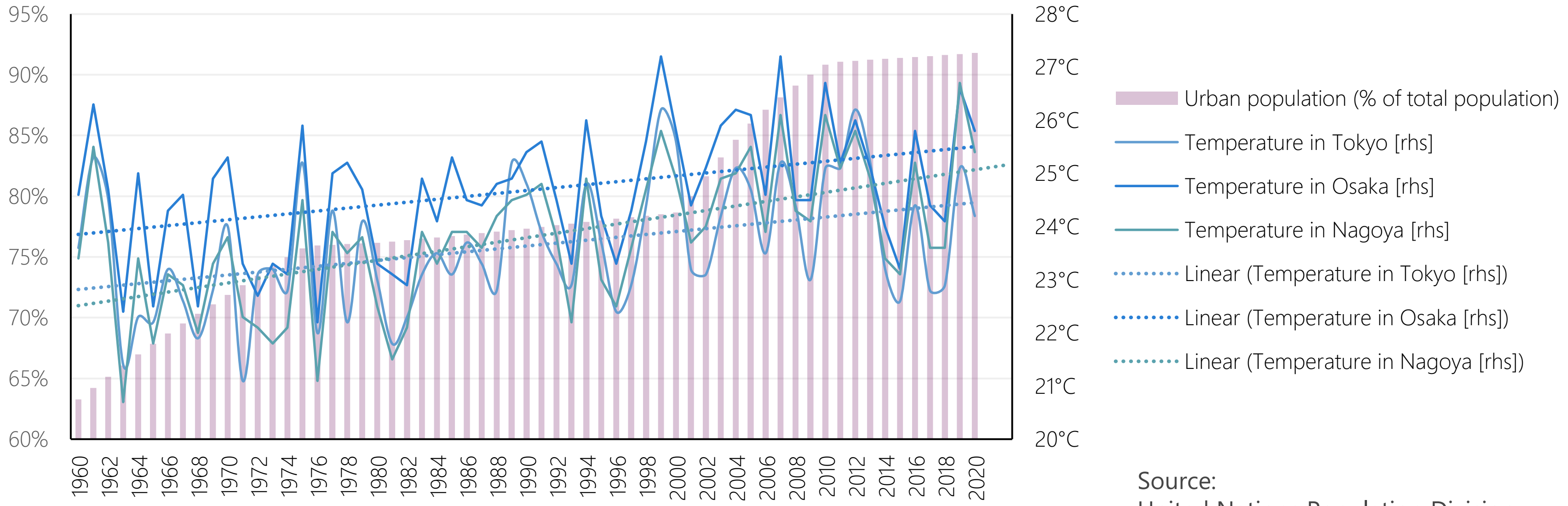
Research Rationale

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

Source: Hiemstra et al. (2017)



Source:
United Nations Population Division
Japan Meteorological Agency

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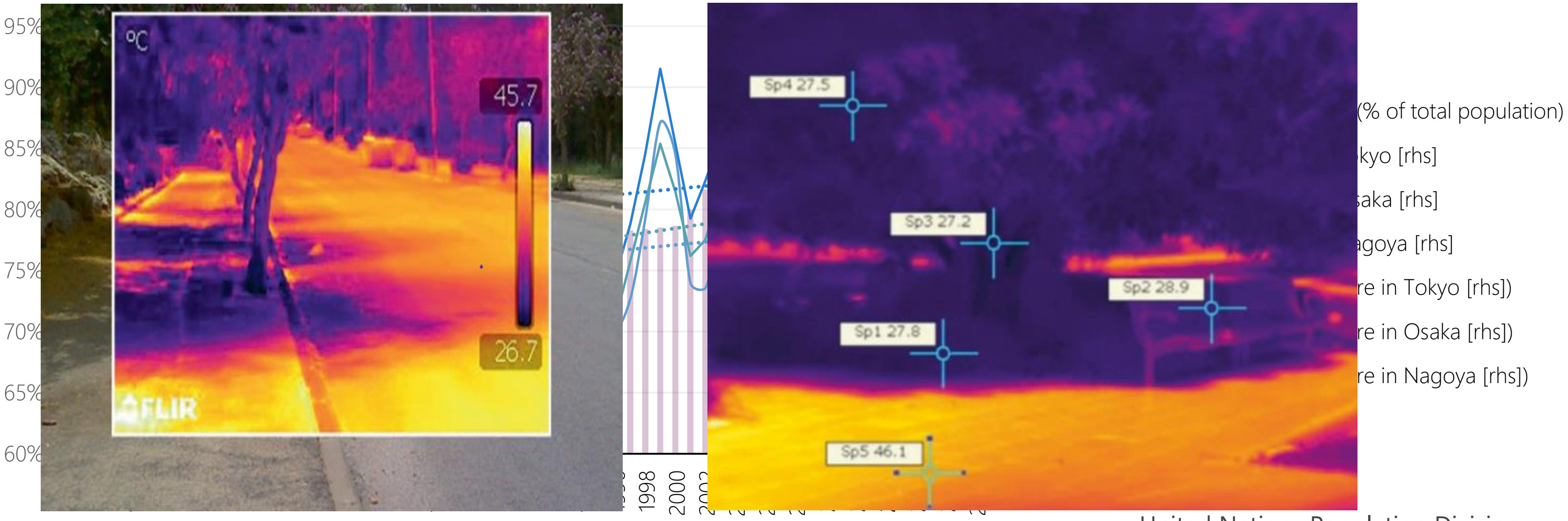


United Nations Population Division
Japan Meteorological Agency

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…

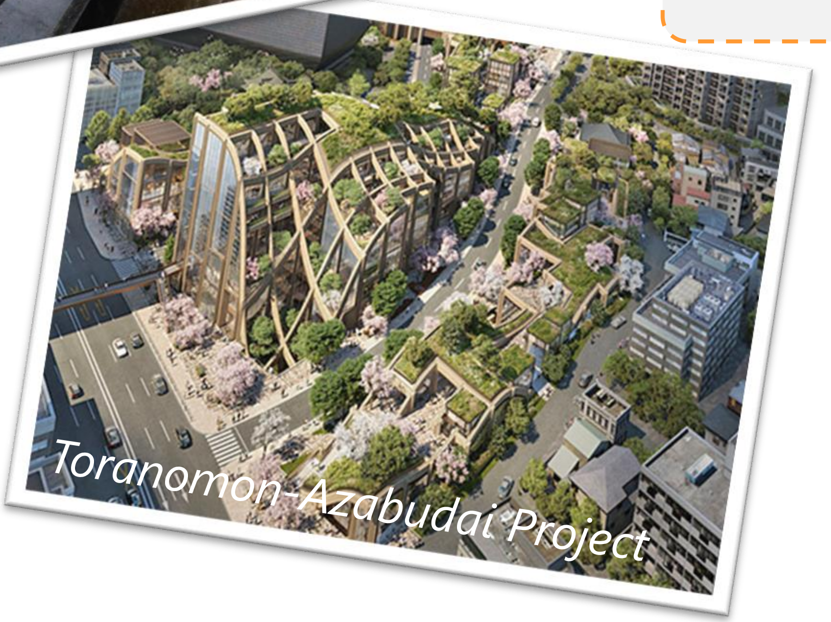
The role of urban trees in reducing land surface temperatures in European cities

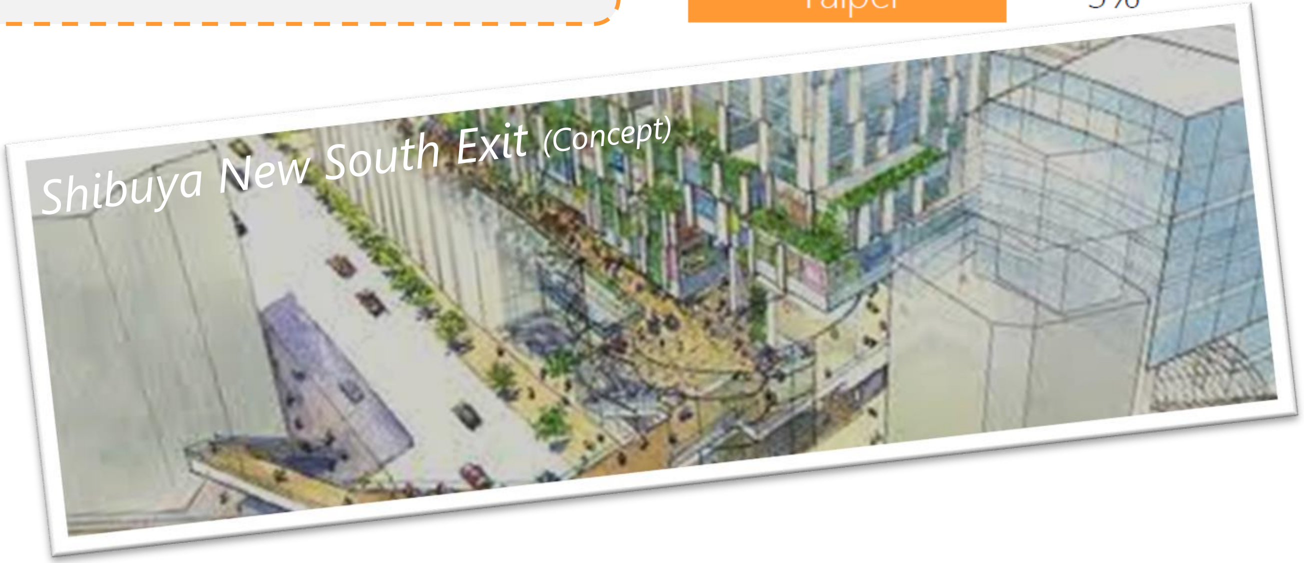
Research Location Tokyo

- 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%

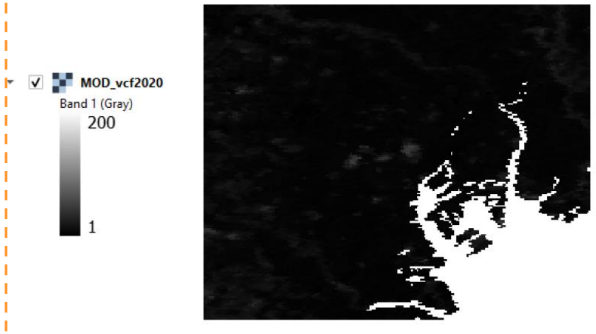




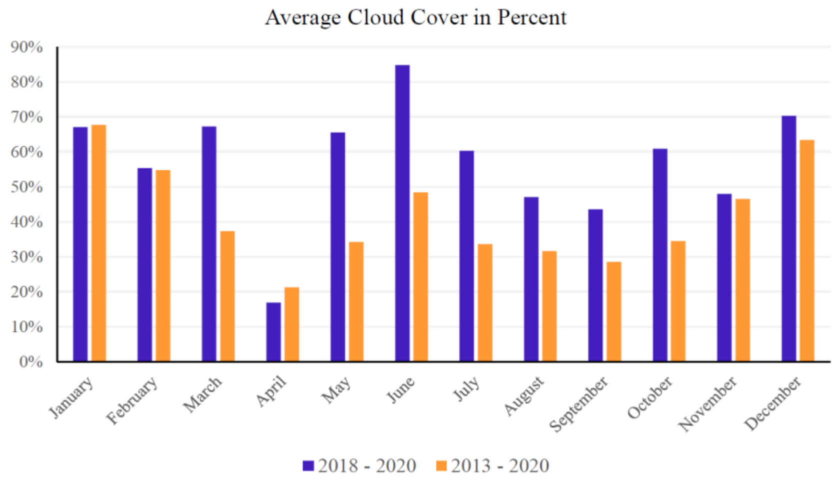
Pre-processing

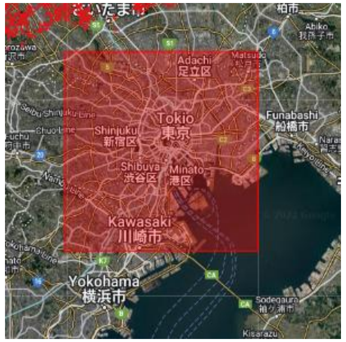
LST Selection process

- Data acquisition
- Cloud Cover calculation
- Timeframe selection
- Filtering

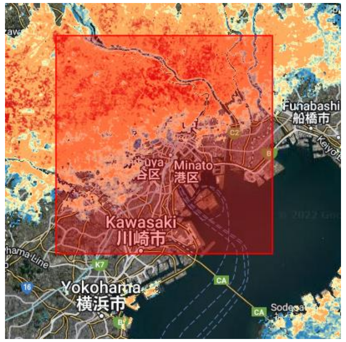


Calculation of water-share (15.2%)
Exceeding water pixels are cloud-cover



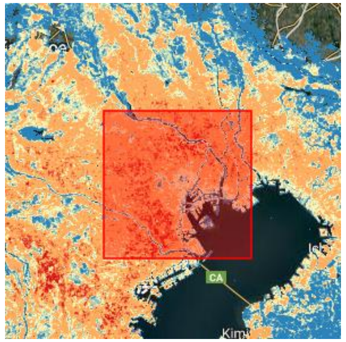


85% (max) cloud cover



61% cloud cover

40% cloud cover



1.2% (min) cloud cover

Omitted, 25% as maximum permitted

Pre-processing

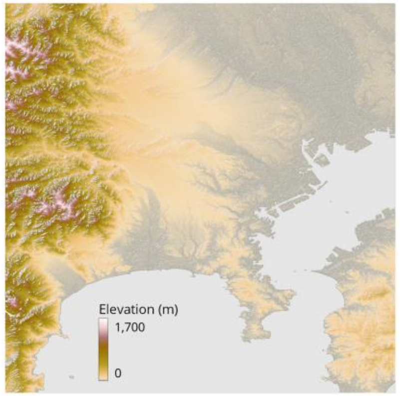
Predictor variable preparation

Data acquisition

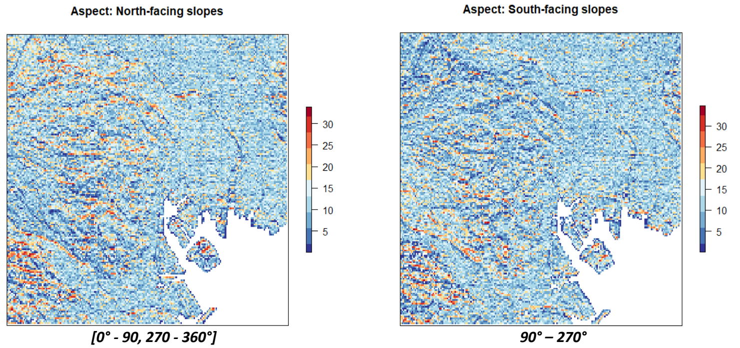
DEM
Aspect calculation

LULC
Subdivision

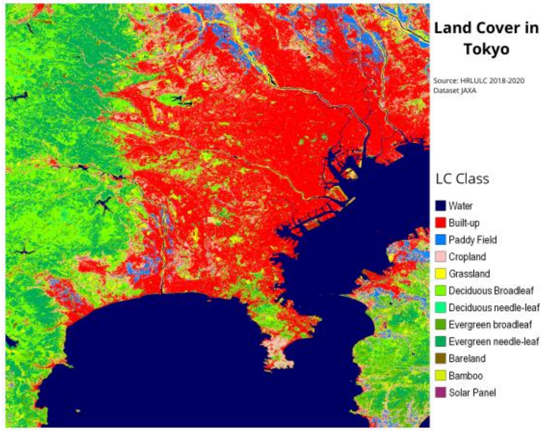
VCF
Vegetation Continuous Fields

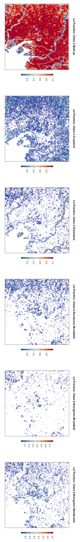


Digital Elevation Model
Tokyo, Kanagawa Prefecture

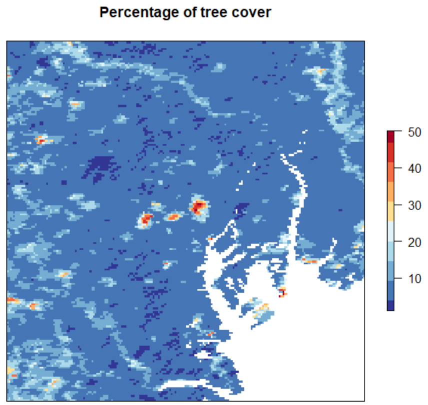


Calculate aspect and subdivide into distinct rasters to allow for variability in solar radiation



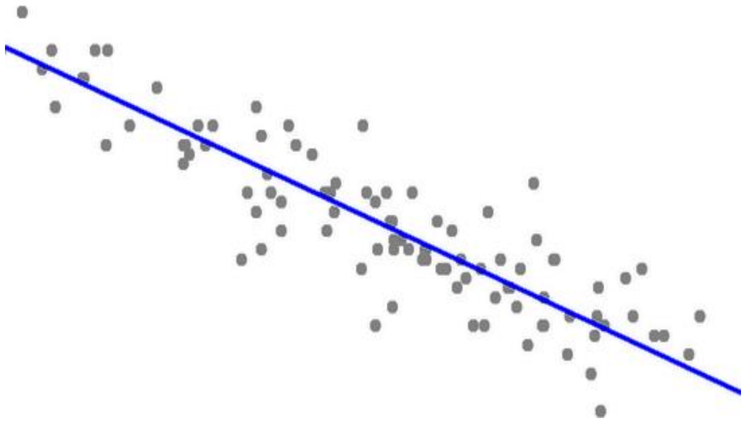


Subdivide into distinct LULC classes to account for difference in VC type



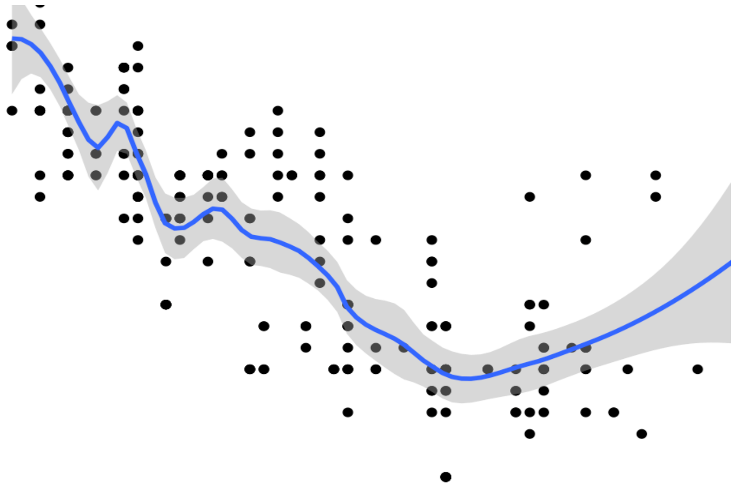
Reproject and adjust resolution

Model Fitting



Linear Regression model

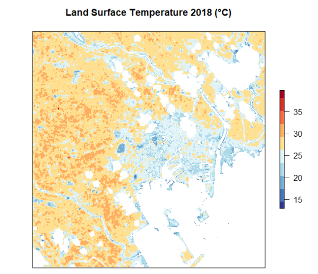
$$LST = \beta_0 + \boldsymbol{\beta_1}(VCF) + \boldsymbol{\beta_2}(LULC_1) + \cdots + \boldsymbol{\beta_{10}}(LULC_9) + \boldsymbol{\beta_{11}}(DEM_1) + \boldsymbol{\beta_{12}}(DEM_2) + \in$$



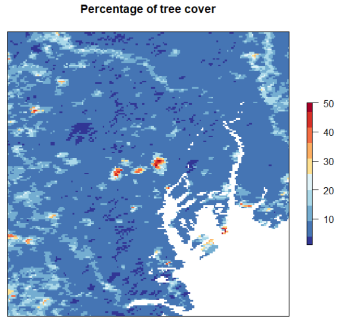
Generalized additive model

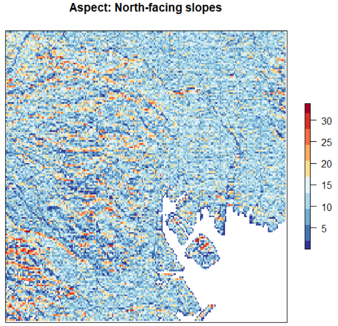
$$LST = \beta_0 + \boldsymbol{f_1}(x, y) + \boldsymbol{f_2}(VCF) + \boldsymbol{f_3}(LULC_1, LULC_2, \ldots, LULC_9) + \boldsymbol{f_4}(DEM_{1,}\ DEM_2) + \in$$

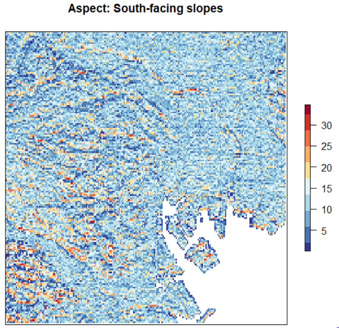
Model Fitting



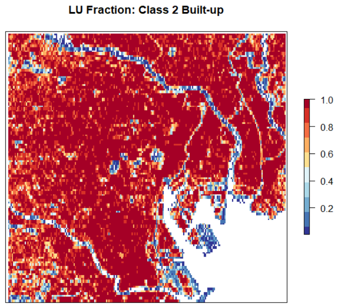
X- and Y-coordinates as a two-dimensional smooth product in the model to minimize ***spatial autoregression.*** *Beale et al. (2010)*

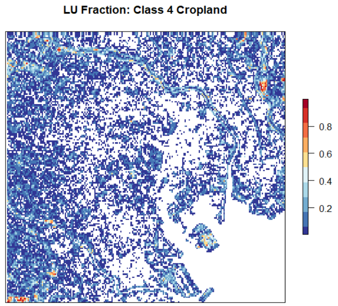


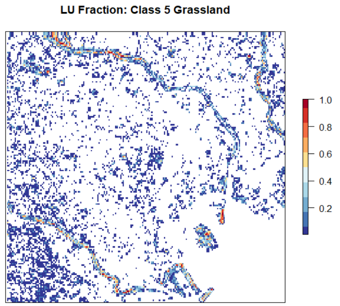


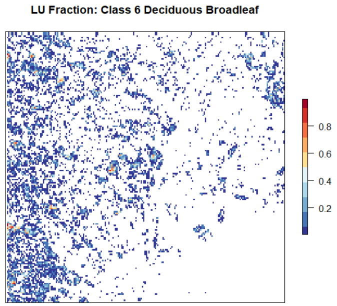


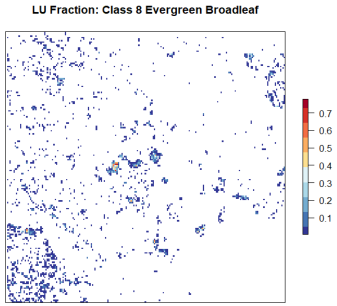
$$LST = \beta_0 + \boxed{f_1(x,y)} + \boxed{f_2(VCF)} + \boxed{f_3(LULC_1, LULC_2, \ldots, LULC_9)} + \boxed{f_4(DEM_1, DEM_2)} + \in$$

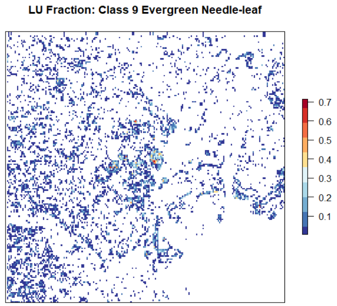




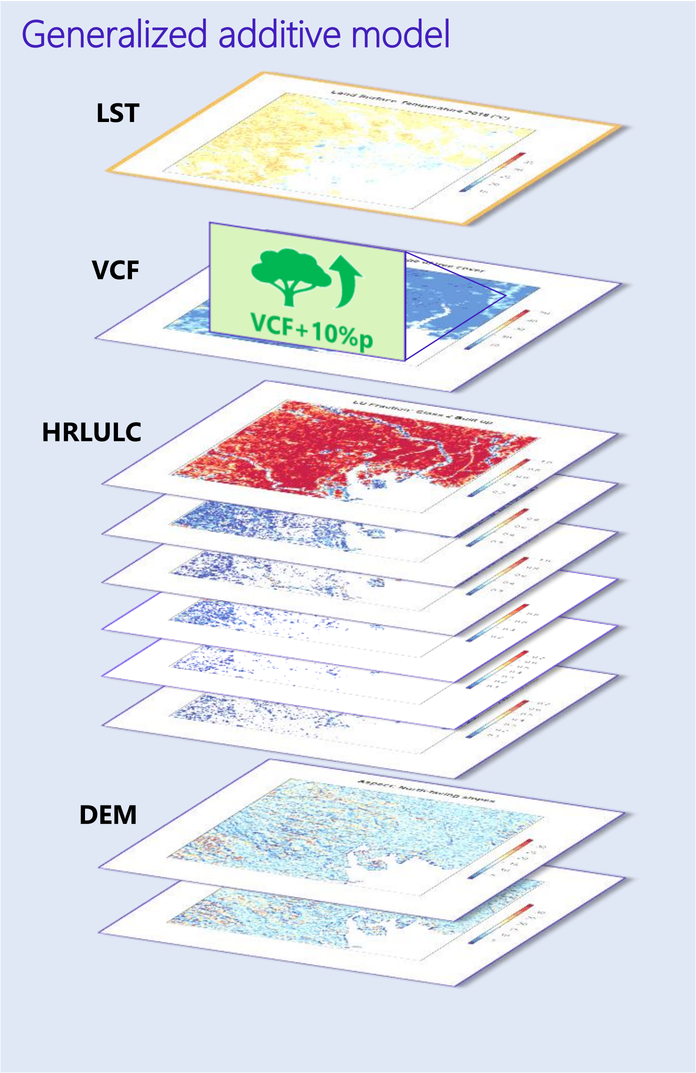


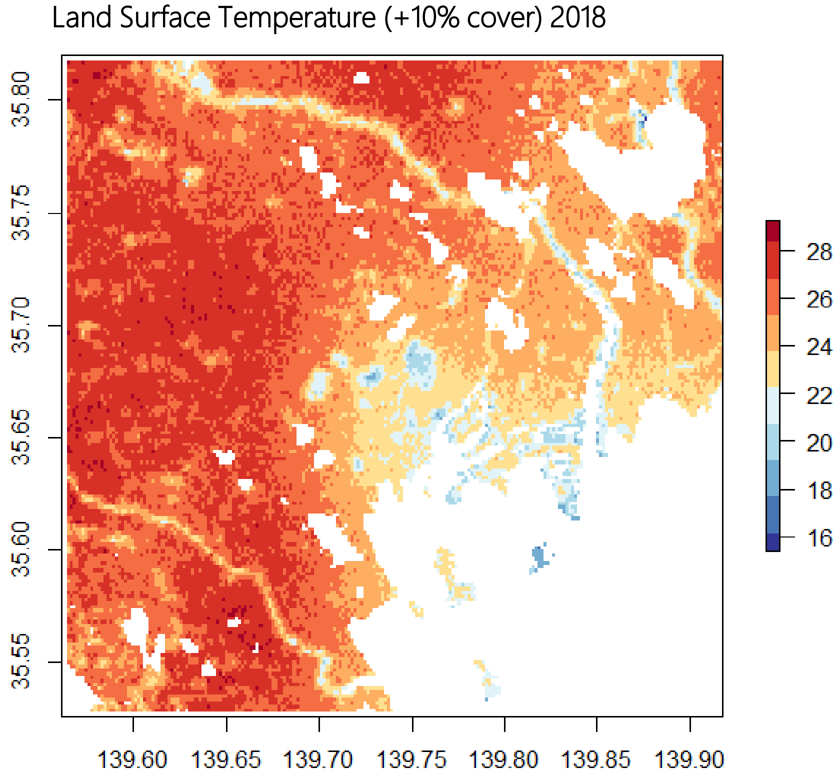






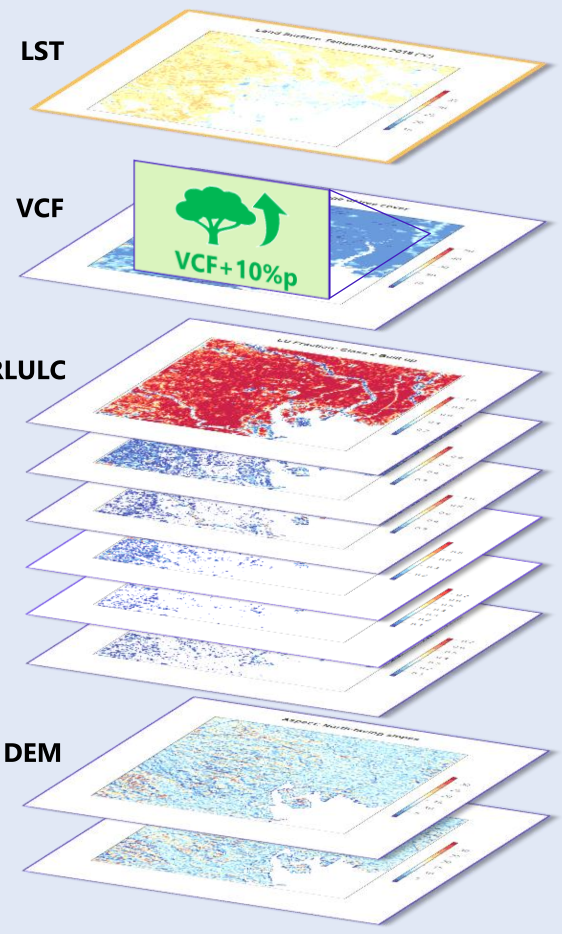
Our results (1)

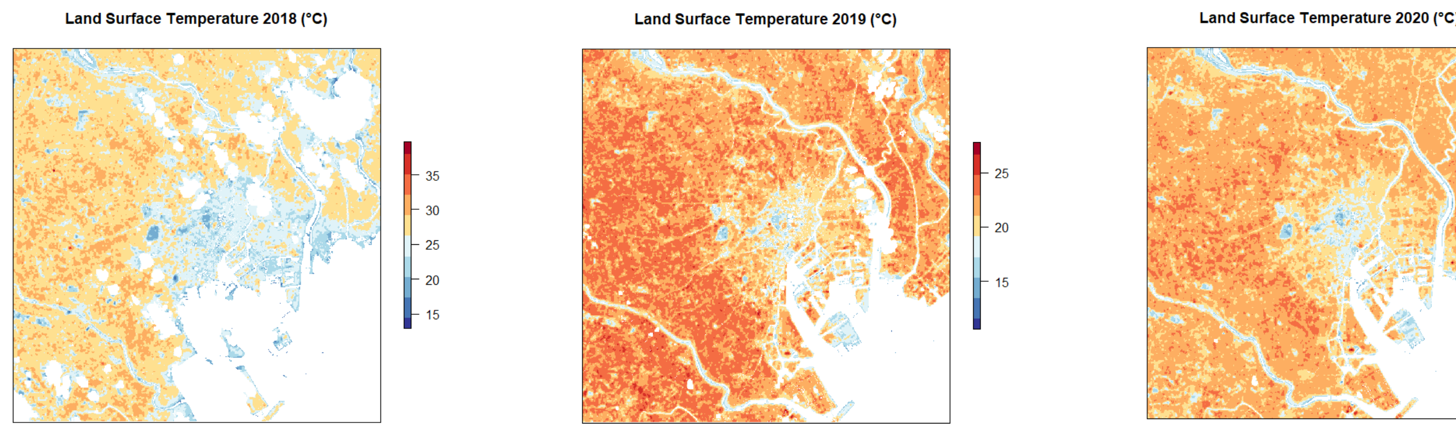


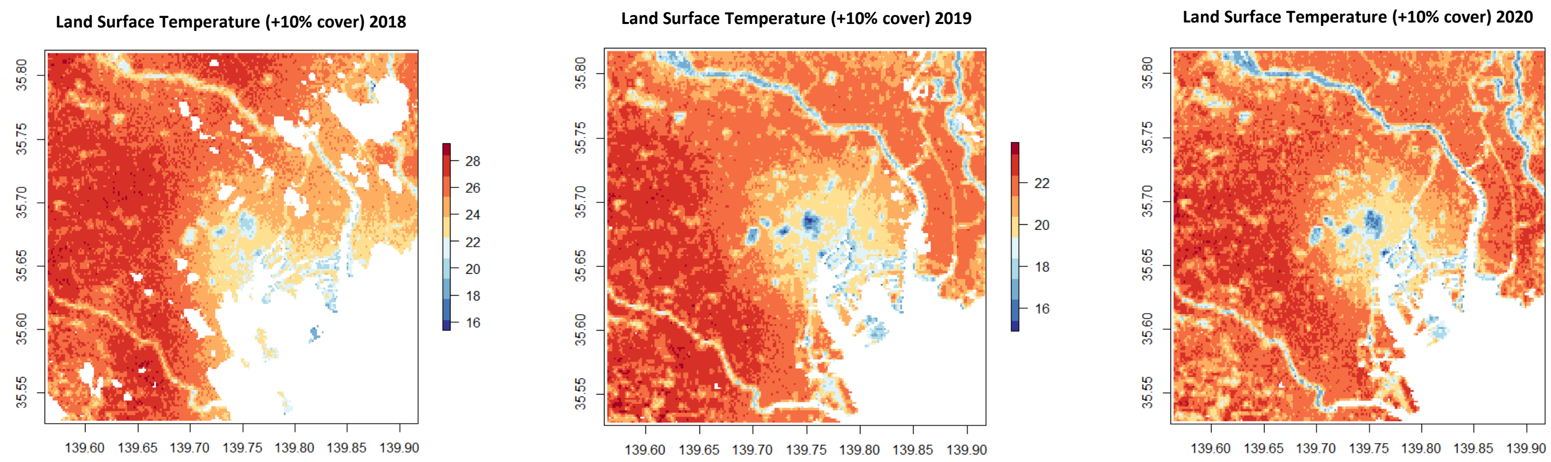


Our results (1)

Generalized additive model







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
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	Singapore	10%p	[-0.9°C , -1.2°C]
Stepanie et al. (2022)	Indonesia	Jakartha	10%p 40%p	[-1.5°C, -2.5°C]
Huang et al. (1987)	USA	Multiple	10%p 25%p	11-18% 25-42% electricity reduction p.a
Wong et al. (2011)	Singapore	Singapore	-1.2°C	4.5% electricity reduction p.a for adjacent buildings
Chen and Wong (2006)	China	Guangzhou	-1°C	5% electricity reduction p.a.
Yabe (2005)	Japan	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 <u>in the right spots to reap benefits!</u>

Sources:

Page 1
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Thank you for your attention!

Any comment, question or criticism would be highly appreciated!