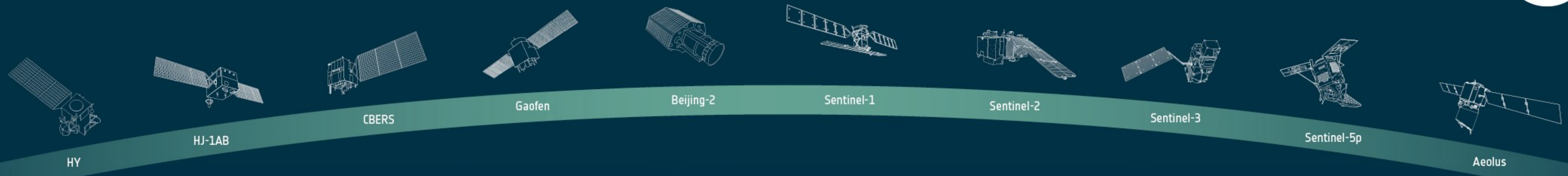

2022 DRAGON 5 SYMPOSIUM

MID-TERM RESULTS REPORTING

17-21 OCTOBER 2022

PROJECT ID. 58897

EARTH OBSERVATION SERVICES FOR CLIMATE FRIENDLY AND SMART CITIES

TUESDAY, 18/OCTOBER/2022

ID. 58897

PROJECT TITLE: EARTH OBSERVATION SERVICES FOR CLIMATE FRIENDLY AND SMART CITIES

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PRESENTED BY: ILIAS AGATHANGELIDIS

Project themes

The project addresses, using mainly Earth Observation data and techniques, two distinct themes with strong interlink:

Climate change as this relates to the thermal resilience of cities:

- support climate friendly cities through the drafting of climate change adaptation plans to combat urban heat

Urbanization and environment:

- to detect and assess urban geological hazards

The areas of application are the greater Athens and Beijing urban areas, although results have strong replication potential for other cities as well.

Project objectives

In terms of climate change, the scientific objectives are:

(a) to assess the impact of climate change to the urban thermal environment

(b) to study the relationship between urban form and urban thermal environment

(c) to define a methodology for the detection of intracity thermal heat spots

(d) to define and map urban heat risk and assess climate resilience

(e) to work out a methodology for delineating cities into urban climate zones

Project objectives

In terms of urbanization and environment (smart cities), the objectives are:

(a) to monitor and model urban geological hazards

(b) to combine remote sensing, geophysical prospecting, and hydrogeological theories methods (by using InSAR, ground penetrating radar, and multi-field numerical analysis) to establish three-dimensional monitoring network of land subsidence in urban area for hydrogeological process

(c) to identify land subsidence mode, establish dynamic models, quantify multi-field contributions, and reveal the mechanisms of land subsidence.

In this presentation, results for the part of project related to “Cities and Climate Change” are provided (items a, b, c and d of slide 4).

EO Data Delivery

Copernicus Sentinels	No. Scenes
1. Sentinel-2 MSI	
2. Sentinel-3 SLSTR	
3.	
4.	
5.	
6.	
Total:	
Issues:	

ESA Third Party Missions	No. Scenes
1. Landsat 5 TM	
2. Landsat 7 ETM+	
3. Landsat 8 OLI/TIRS	
4. MODIS Aqua	
5. MODIS Terra	
6.	
Total:	
Issues:	

Chinese EO data	No. Scenes
1.	
2.	
3.	
4.	
5.	
6.	
Total:	
Issues:	

Climate extremes analysis

- Indices focusing on the thermal environment and health
- Standardized indices for comparing results across time periods & regions based on daily maximum and minimum temperatures

- Assessing changes in extremes
- Examine the variability and trends in climate
- Detection of monotonic upward or downward trends in climate series using the Mann–Kendall non-parametric test and Sen's linear slope estimator

Climate data

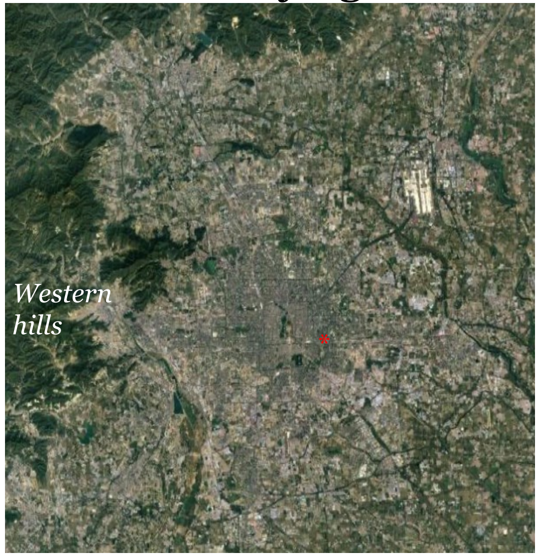
Air Temperature

Data: ERA-5 Temporal resolution & coverage : Hourly data from 1981-2020 (40 years)

Horizontal coverage and resolution: Global at 0.1° x 0.1° (approximately 9 km)

Athens

Beijing



Descriptive indices of extremes

- Summer days (SU): Annual count of days when daily maximum temperature > 25°C
- Tropical nights (TR): Annual count of days when daily minimum temperature > 20 °C
- Warm spell duration index (WSDI) : annual count of days with at least 6 consecutive days when daily maximum temperature > 90th percentile
- Fraction of days with above average temperature (TXgt50p): Percentage of days when daily maximum temperature > 50th percentile
- Hot days (HD): Annual count of days when daily maximum temperature > 35 °C
- Heating degree days (HDD): Measure of the energy demand needed to heat a building.
- Cooling degree days (CDD): Measure of the energy demand needed to cool a building.
- Heatwave number (HWN): The number of individual heatwaves (3 or more days where the Excess Heat Factor is positive)

Changes in extremes

	Athens		Beijing	
	Slope	St. Sig	Slope	St. Sig
TXgt50p	0.50	**	0.40	**
SU	0.13	-	0.36	**
HD	0.20	**	0.27	*
TR	0.87	**	0.44	**
CDD	5.63	**	5.60	**
HDD	-7.48	**	-6.56	**
HWN	-	-	-	-
WSDI	-	-	-	-

Theil-Sen slope
Simple linear regression method
Robust estimator insensetive to outliers

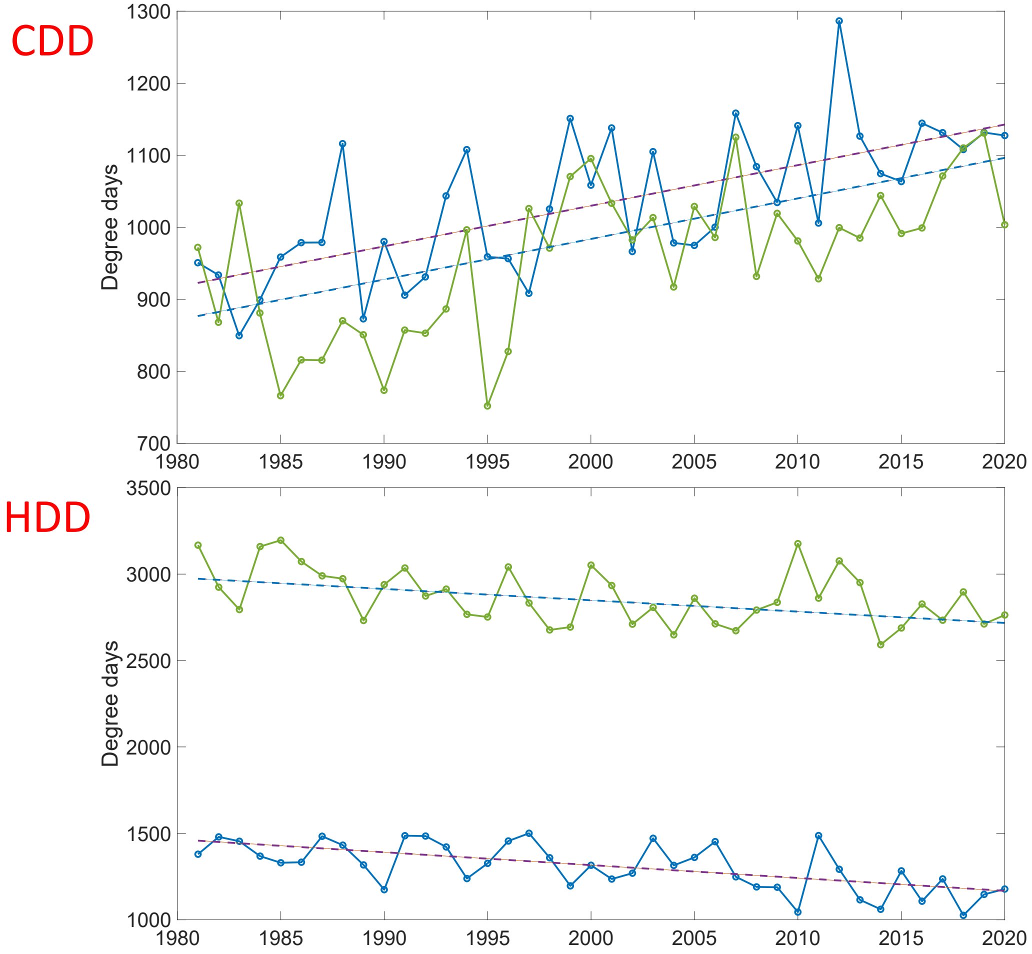
Mann-Kendall test
H_0: Data come from a population with independant realizations and are identically distributed
H_1: Data follow a monotonic trend

In both cities for all indices (except SU for Athens)
The null hypothesis is rejected
Statistical significant trends at 99% or 95% confidence levels

Results

Changes in extremes

Changes in extremes



Similar increases/decreases for cooling/ heating energy demands.

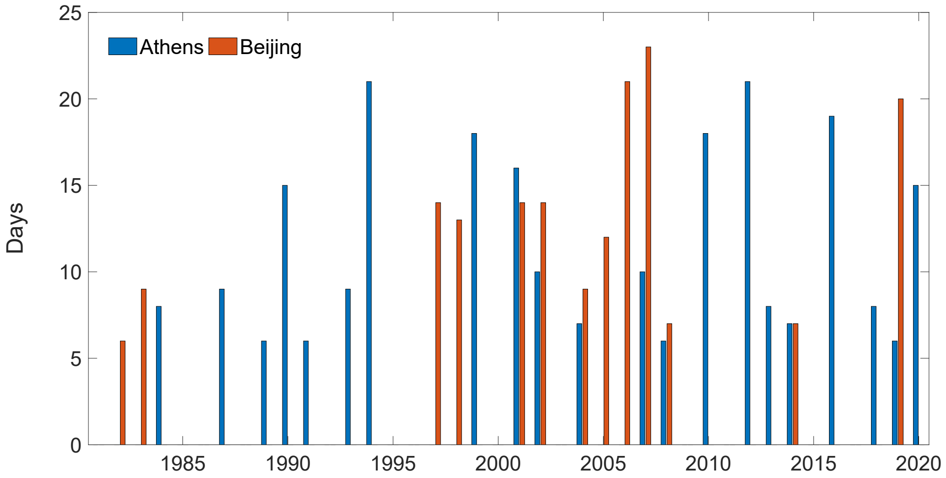
CDD for 2011-2020 vs. 1981-1990
Athens: 11.67 % increase
Beijing: 16.85% increase

Dissimilar heating demand patterns due to diffeernces in climatic conditions
Athens: Mediterranean climate
Beijing: Hot summer continental climate

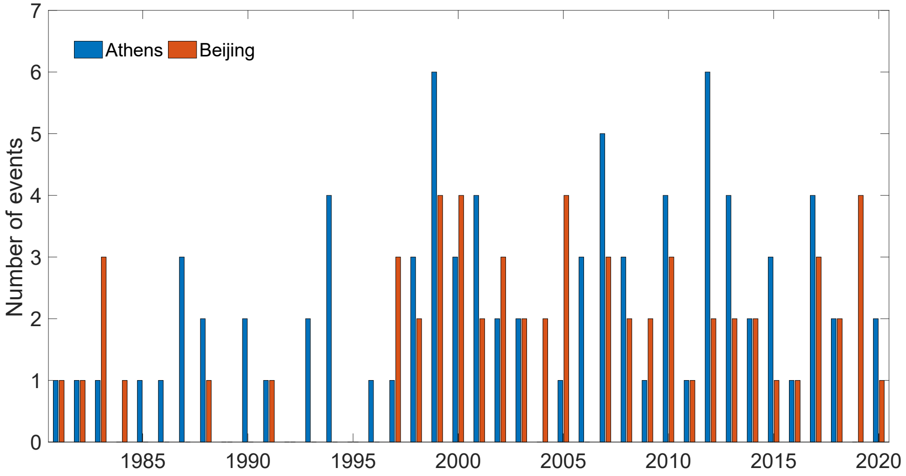
Results

Changes in extremes

WSDI



HWN



Days per decade

	81-90	91-00	01-10	11-20
Athens	38	54	67	84
Beijing	15	27	100	27

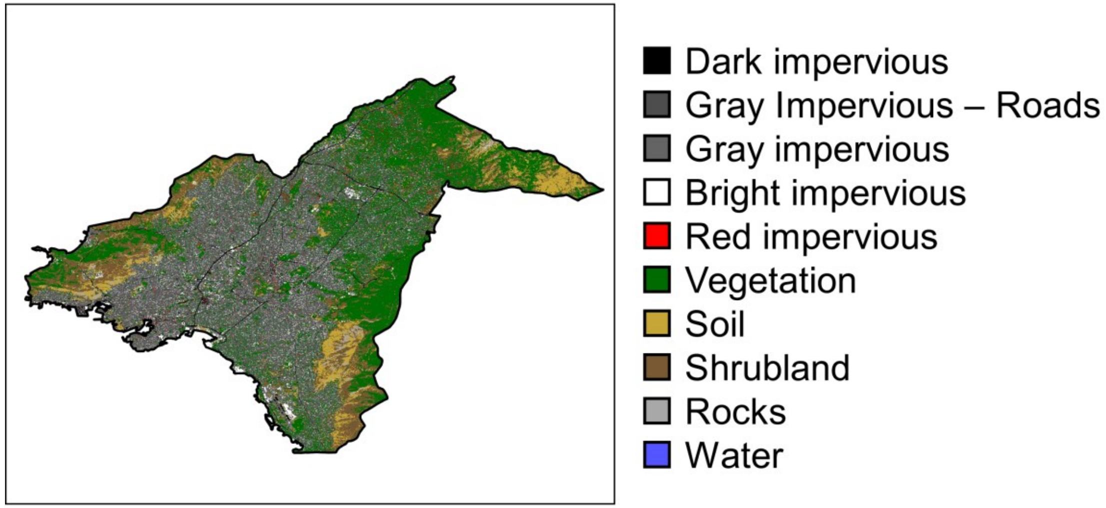
Events per decade

	81-90	91-00	01-10	11-20
Athens	12	21	25	25
Beijing	7	14	23	19

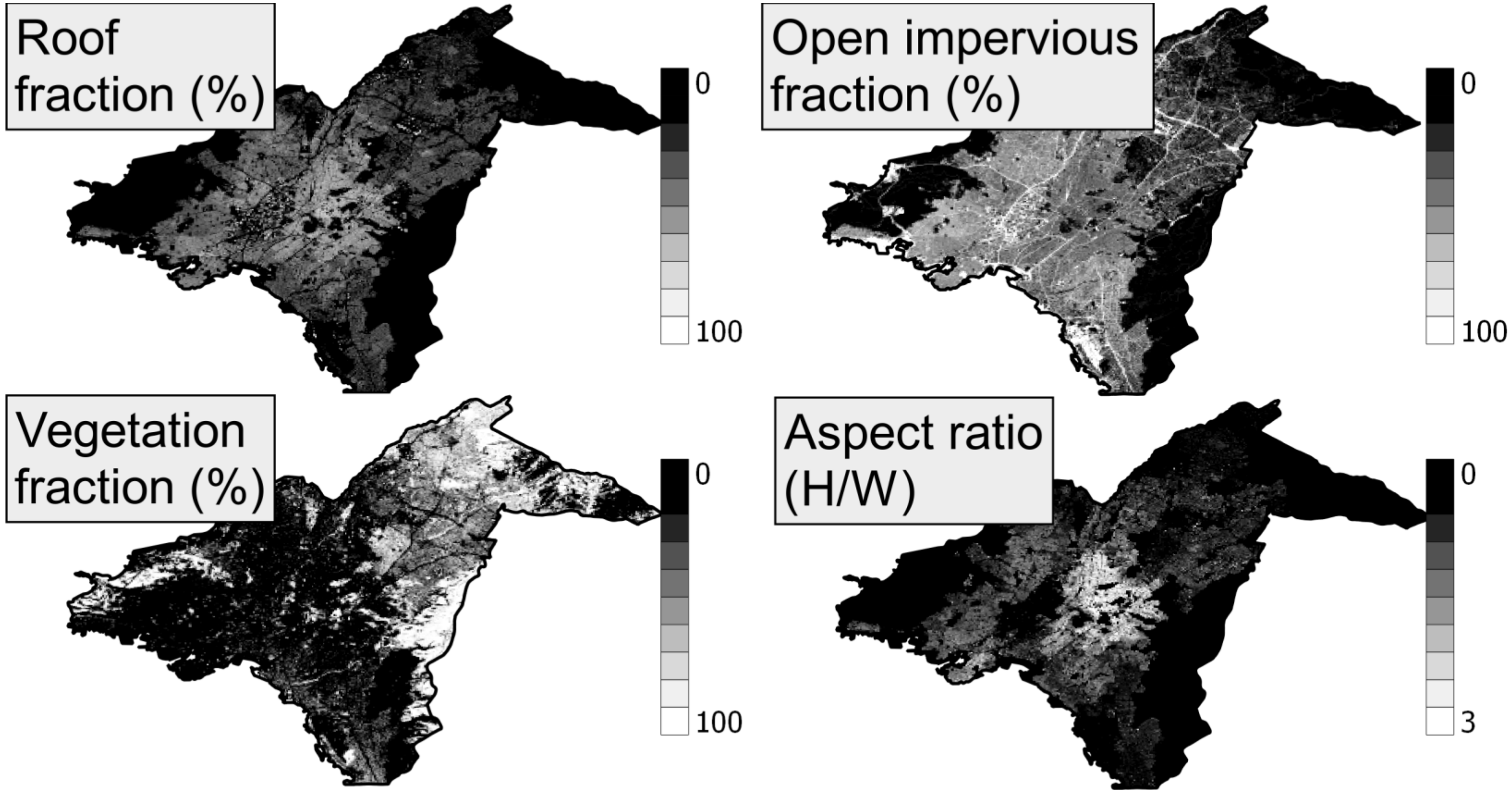
Assessing the urban environment through Earth Observation

High-resolution urban land cover detection using Sentinel-2

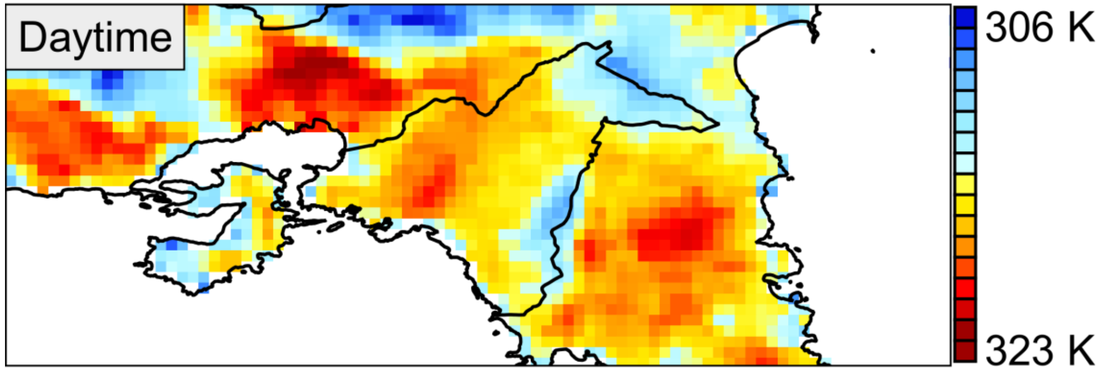
- Need to monitor urban dynamics with high-resolution observations
- A new classification approach was developed integrating machine learning techniques with the 10-meter bands of Sentinel-2, land use information from the Copernicus Land Monitoring Service, and digital elevation models
- High classification performance was achieved (approximately 90%)



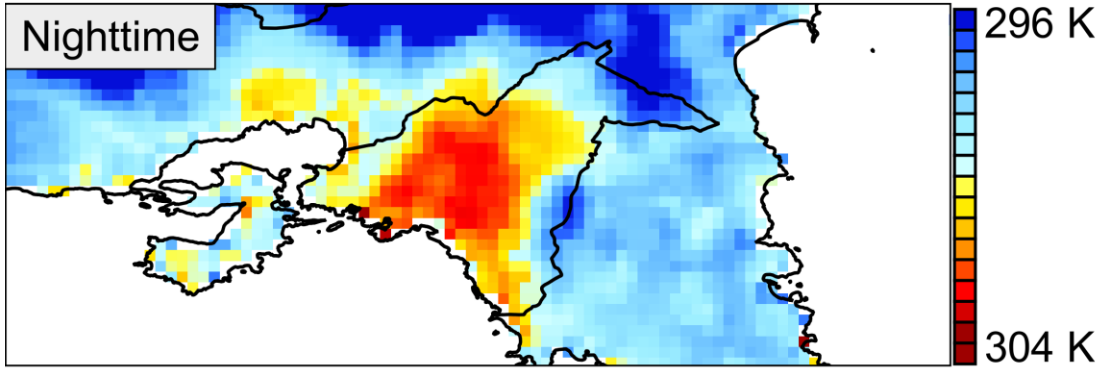
Spatial mapping of the Urban Form



Surface Urban Heat Island (Sentinel-3)



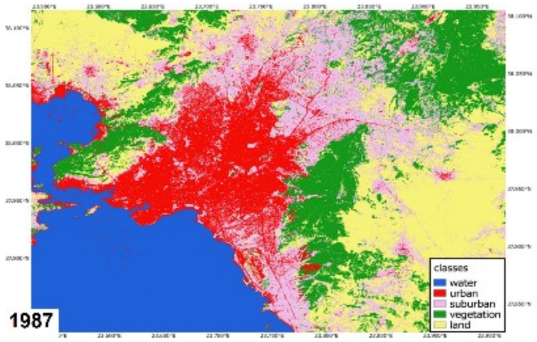
Morning/Noon:
Weak or Cool Island

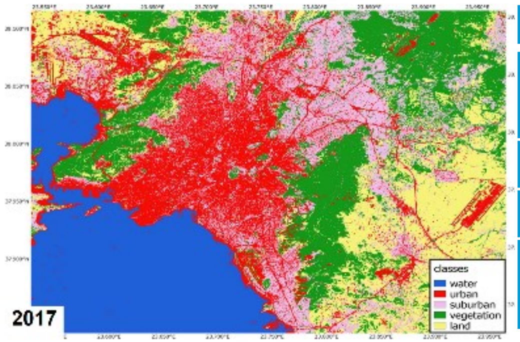


Night:
Strong SUHI

Multitemporal assessment of urban thermal characteristics in Athens, Greece over a 31-year period

- Multiple cloud free images for years 1987 to 2017 from Landsat missions
- Land cover maps were developed using the maximum likelihood algorithm
- The Land Surface Temperature (LST) increase was associated with i) land cover changes and ii) a further increase of impervious materials within existing built-up areas, and a rise in the anthropogenic heat emissions





	LST (K)			
	Urban	Suburban	Vegetation	Bare land
1987-2001	309.5	310.5	309.0	313.2
2002-2017	314.0	314.0	312.5	316.4
Change:	4.5 (+1.5%)	3.5 (+1.1%)	3.5 (+1.1%)	3.2 (+1.0%)

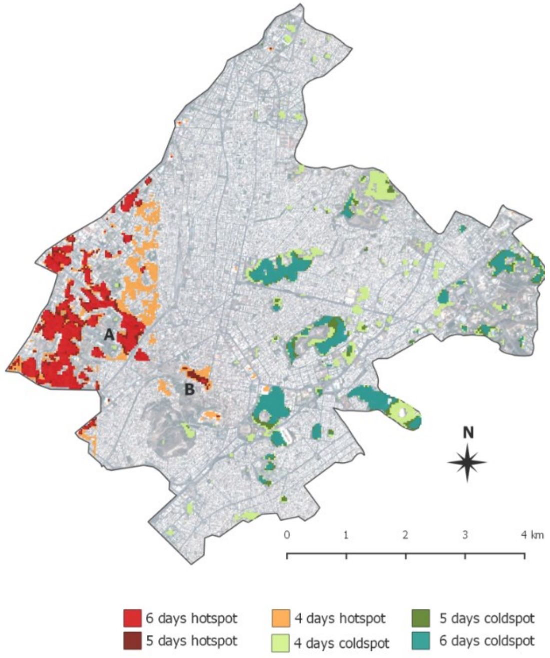
Results

Identification of urban thermal hot and cold spots using downscaled MODIS LST observations

A pixel is an urban <u>hot spot</u> when:

1. It is a local LST maximum for consecutive days using daily downscaled MODIS LST
2. It is part of a cluster of pixels with statistical significant higher LST, when compared to the average surface temperature of the study area.

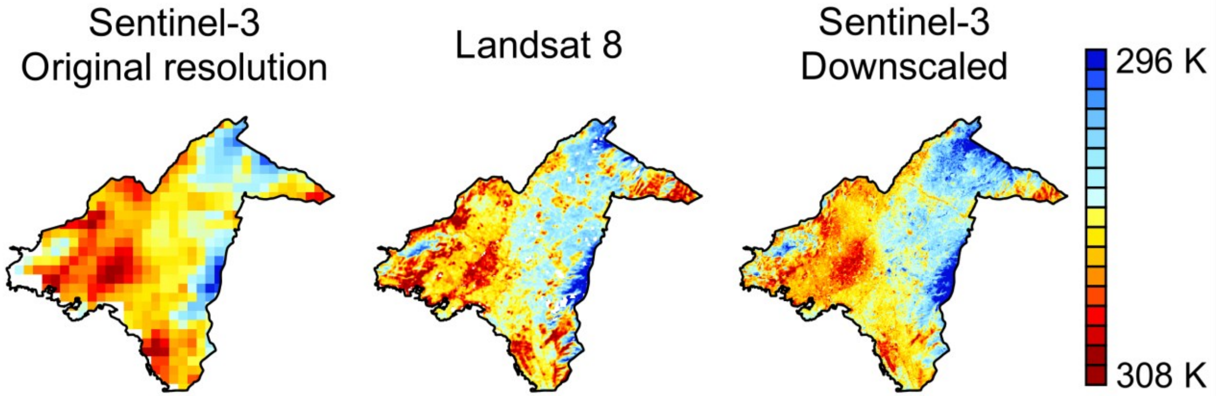
✓ Hot spots had on average a significantly higher LST (from 2.2 to 4.4 K) and were mostly found at the industrial, high-density urban and highway land cover types

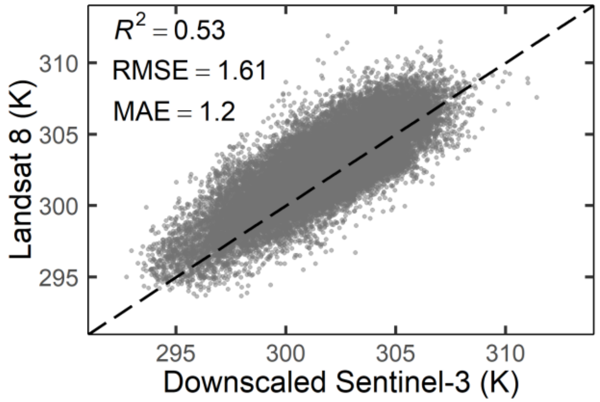


Statistical downscaling of thermal observations through a synergy of Sentinel-2 and Sentinel-3

Statistical downscaling steps:

- Develop a parametric relationship between radiances and predictors (urban an vegetation indices) at the coarse scale (Sentilel-3, 1 km).
- Apply relationship at fine scale using predictors from Sentinel-2 (100 m)
- Calculate LST using a split window algorithm and a land cover based emissivity.
- Validation of downscaled LST using Landsat 8



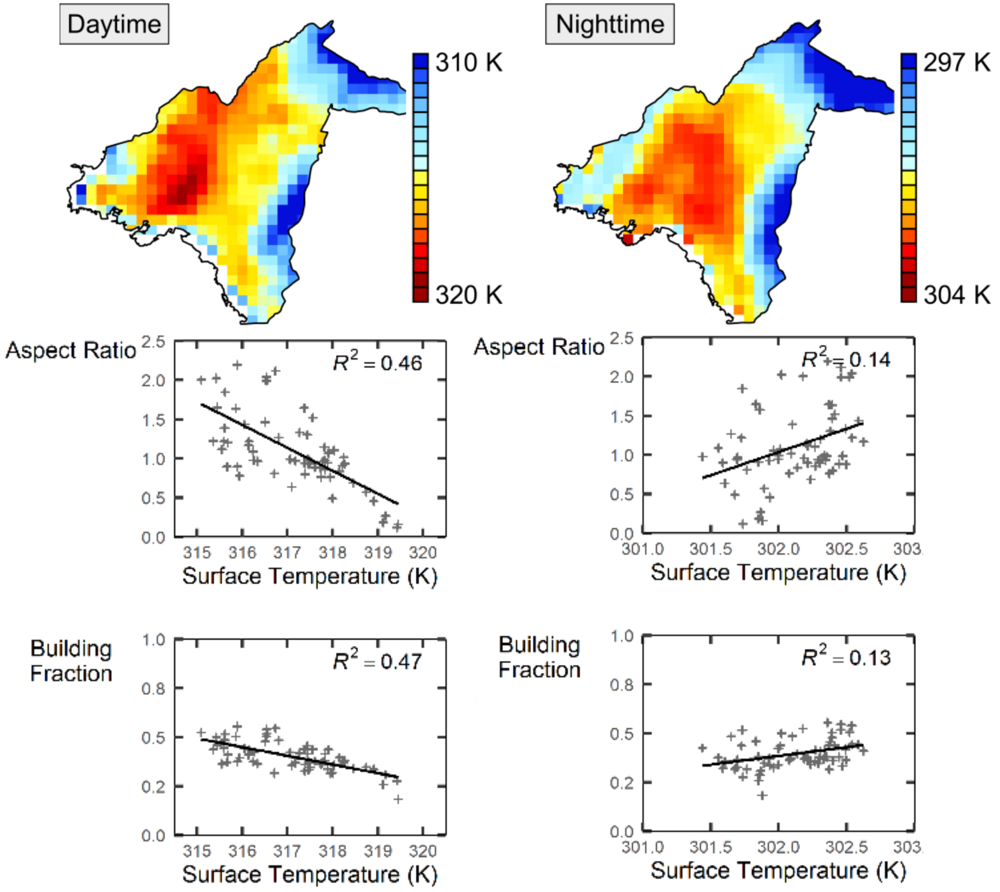


Evaluating the neighbourhood-scale effect of urban form on the surface thermal environment using Sentinel-3

Examining a 20-day summer period for Athens, Greece using Sentinel-3 LST

(20 June – 09 July, 2017), Overpasses at 11:30 and 21:30 local time

- ✓ In daytime closely spaced and high-rise buildings found to have a distinct, negative relation to LST in daytime
- ✓ At night, the thermal patterns are reversed and temperature is increasing with increasing height-to-width aspect ratio and building fraction.



Discussion

Summary:

- Changes in extremes support the detection and attribution of anthropogenic influences on climate.
- Changes in extreme climate events have significant impacts in cities (e.g. health, energy).
- Climate change signal for both Athens and Beijing – different characteristics due to climatic differences.
- Earth observation techniques assist in the direction of smart and sustainable urbanization.
- A multi-faceted investigation of the urban effects at various spatial and temporal scales is needed.
- Through remote sensing the most thermally vulnerable areas within cities can be identified.
- Support the drafting of mitigating plans for counteracting the overheating of urban areas.
- The applied methods are standardized and have strong replication potential.