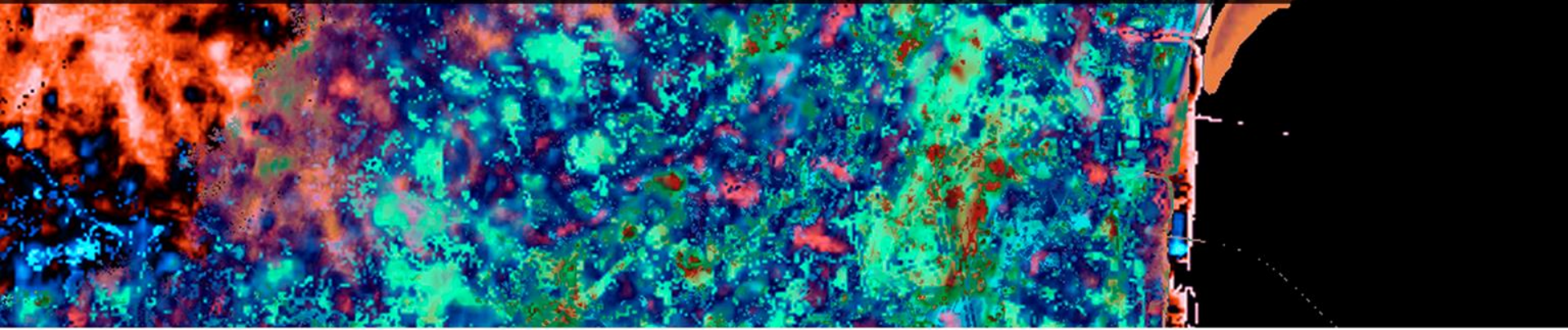

Land Surface Temperature derivation using Landsat 8 Data: a case-study of Surface Urban Heat Island [UHI] in 5 Mediterranean Cities

Ana Oliveira[1], Samuel Niza[2], António Lopes[3]
1 SES PhD Student, MIT Portugal Program, IST - Universidade de Lisboa
2 Professor and Researcher, IST - Universidade de Lisboa
3 Professor and Researcher, IGOT - Universidade de Lisboa

FCT Fundação para a Ciência e a Tecnologia
FUNDAÇÃO LUSO-AMERICANA
MIT Portugal

1. Introduction
   a) Definition, Causes and Consequences
   b) Why Mediterranean Cities?
   c) Research Question
2. Methodology
3. Results
   a) Overview
   b) Marseilles, France
   c) Barcelona, Spain
   d) Statistical Analysis
4. Conclusions

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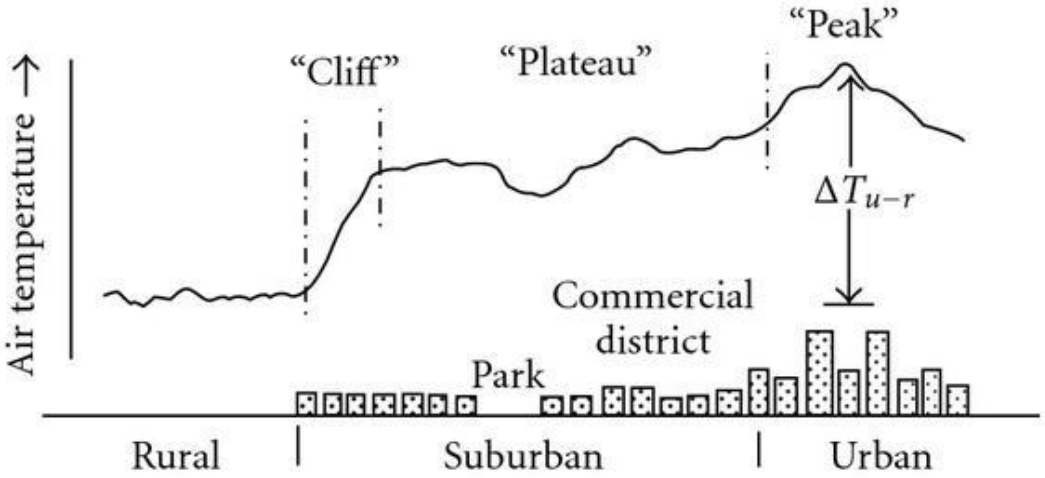
Urban Heat Island [UHI]

The air temperature difference between urban centers and their non-urban surroundings.

(Oke, 1978)



A stylized cross-section of a typical urban heat island.
Source: Oke, 1978: *Boundary Layer Climates*, Timothy R. Publisher, London.

I. Changes in Land Surface

II. Anthropogenic Activities

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I. Artificial materials
II. High level of soil sealing
III. High built mass/high roughness
IV. Reduced vegetation / water surfaces

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ii. Air pollution

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i. Heat discharges from human activities
ii. Air pollution

Increasing heat absorption and discharges

Reducing natural cooling

Consequences:
I. Health
(e.g. morbidity, mortality)
II. Economical
(e.g. energy demand and peak power)
III. Environmental
(e.g. $C0_2$ concentration, air quality loss)

Feature	Atmospheric UHI	Surface UHI [sUHI]
Temporal Development	Small or non-existent during the day Intense at night and winter	Present at all times day and night Intense during the day and summer
Peak Intensity	Day: -1 to 3°C Night: 7 to 12°C	Day: 10 to 15°C Night: 5 to 10°C
Typical identification method	Direct measurement Fixed weather stations Mobile traverses	Indirect measurement Remote sensing
Typical depiction	Isotherm map Temperature graph	Thermal image

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III. **Micro-scale modelling prevails**

IV. **Further investigation is needed**

   i. **Building scenarios for the future:**

      a. **Urban development prospects**

      b. **Climate change forecasts**

      c. **Countermeasures efficiency**

Global

I. **Urban Population Growth Prospects**

II. **Climate Change Forecasts**

Why the Mediterranean bioregion?

Global

I. **Urban Population Growth Prospects**
II. **Climate Change Forecasts**

Local

i. **Local Impacts and Adaptation needs**
ii. **Urban Sprawl and ''Coastalisation''**
iii. **Social/economical vulnerability**

Research Question?

I. Using Land Surface Temperature [LST] as dependent variable, what urban surface indicators can predict it the most?

II. Considering cities within the same regional climate, do this indicators show similar behaviour among them?

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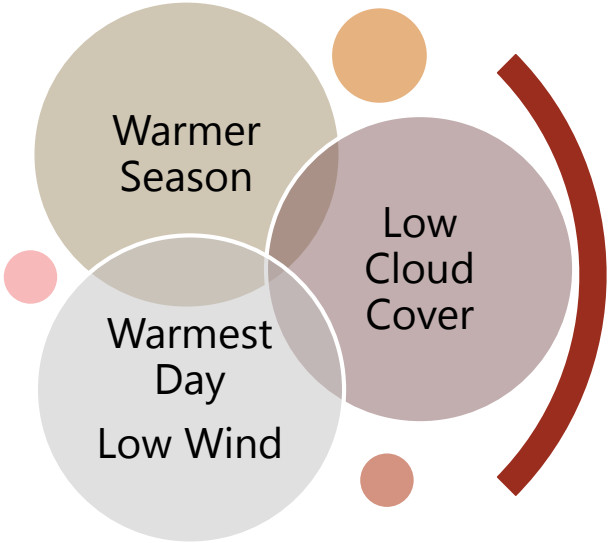
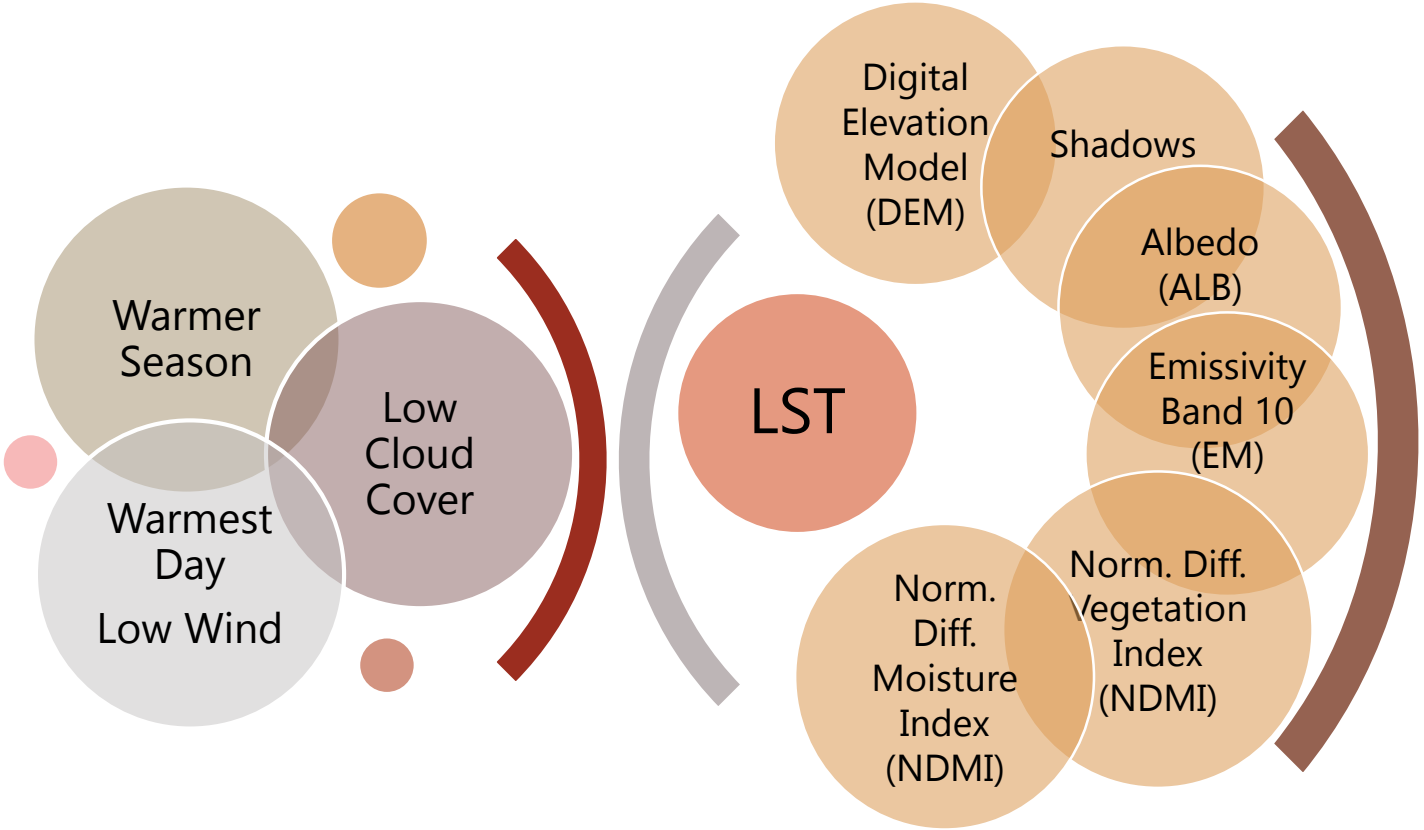


Data Selection

Land Surface Temperature derivation using Landsat 8 Data:
a case-study of **Surface Urban Heat Island [UHI]** in
5 Mediterranean Cities



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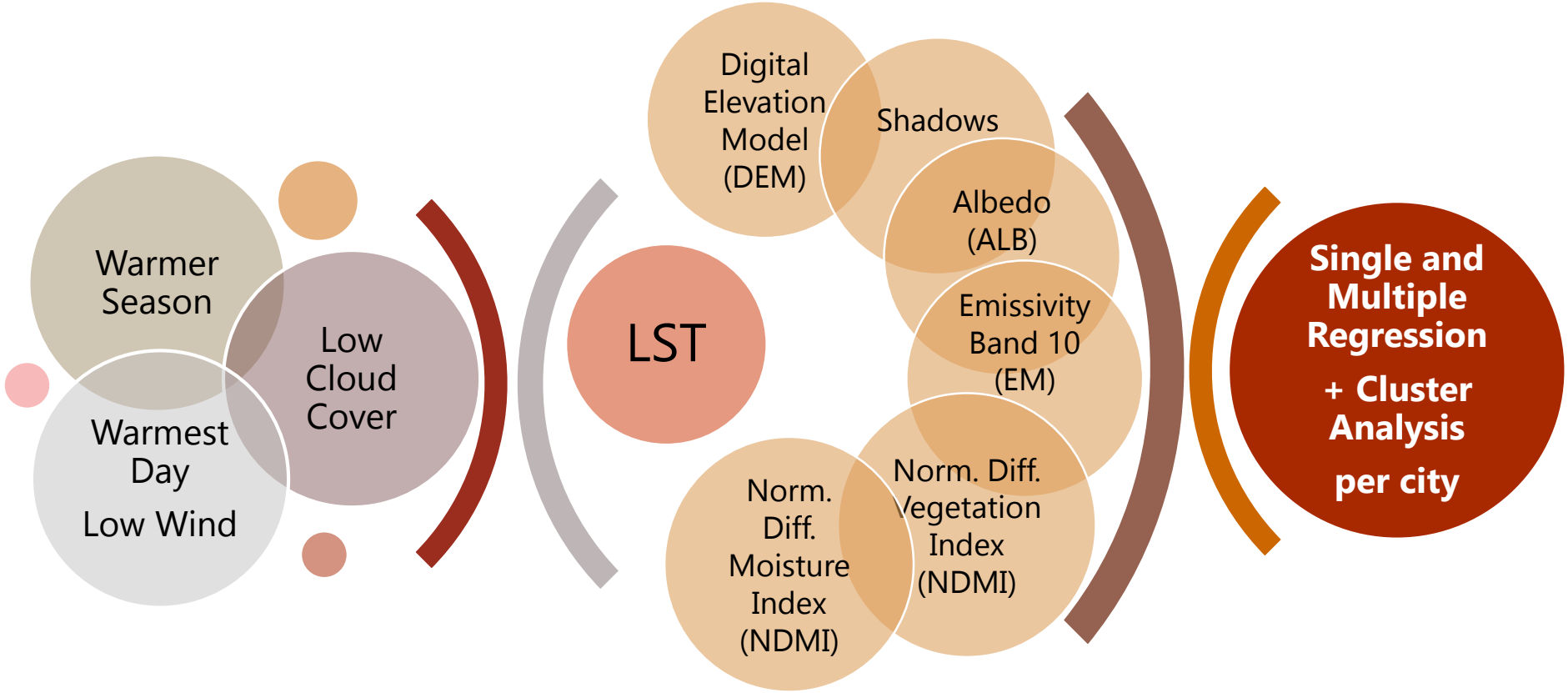

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Pre-Processing
(DOS-1; DN Conversion; Water/Cloud Masks)

Landsat 8[1] - Operational Land Imager (OLI) + Thermal Infrared Sensor (TIRS)

ASTER - GDEM[2]

OLI Bands 2, 3, 4 , 5

NDVI (NASA, 2015)
FVC (Xiaolei *et al.*, 2014)
Land Surface Emissivity (LSE) – NDVI Threshold Method (Xiaolei *et. Al.*, 2014)

TIRS Bands 10, 11

Bands 10 and 11 TOA Brightness Temperature (BT_{10}, BT_{11}) (NASA, 2015)

OLI Bands 1, 3, 4 , 5, 6, 7

ALB (Smith, 2010)
EM (Xiaolei *et al.*, 2014)
NDVI (NASA, 2015)
NDMI (NASA, 2015)

GDEM[2]

DEM SHADOWS

Water Vapour content (AERONET)

Atmospheric Transmittance Coefficients (Rozenstein, *et al.* 2014)

$$LST^{*} = A_0 + A_1.BT_{10} - A_2.BT_{11}$$

*Split-Window Algorithm (Rozenstein *et al.*, 2014)

Statistical Analysis

1"Landsat imagery courtesy of NASA Goddard Space Flight Center and U.S. Geological Survey"
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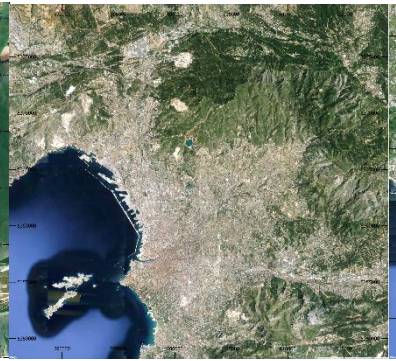
ATHENS

BARCELONA

LISBON



MARSEILLES

NAPLES

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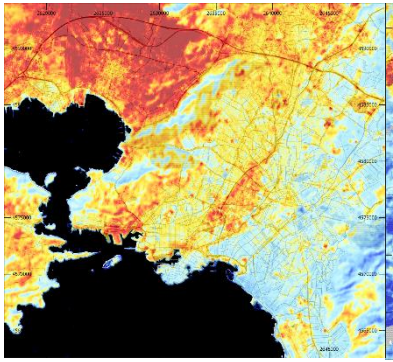
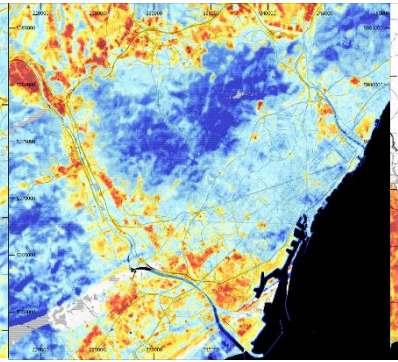


ATHENS
(Air temp.: 27ºC)



BARCELONA
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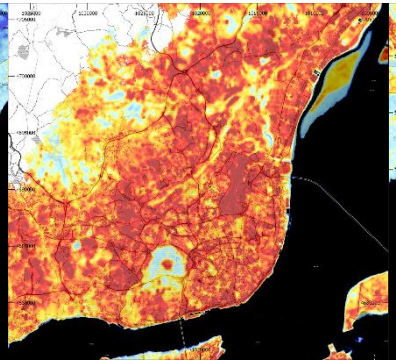
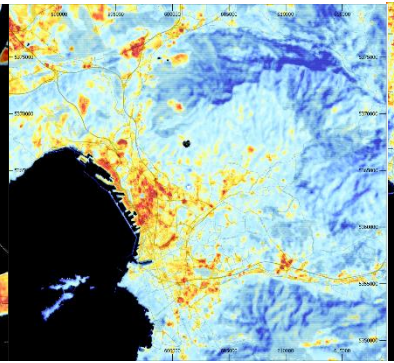
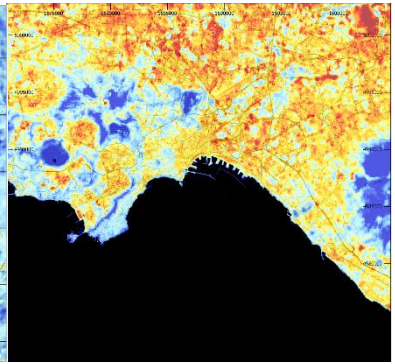


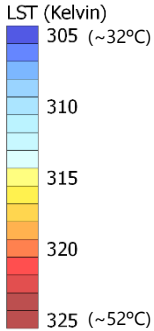
LISBON
(Air temp.: 30ºC)



MARSEILLES
(Air temp.: 30ºC)



NAPLES
(Air temp.: 29ºC)



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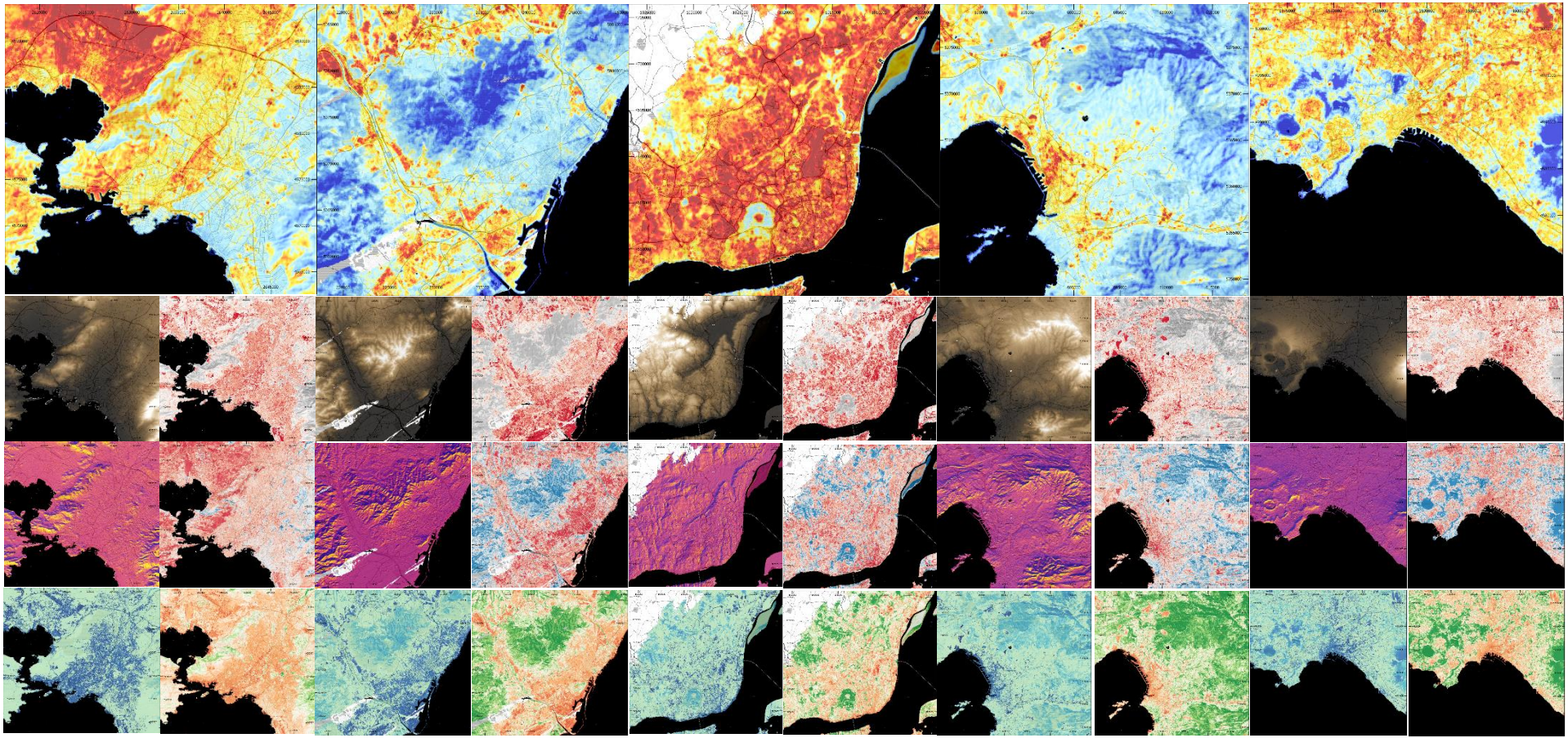

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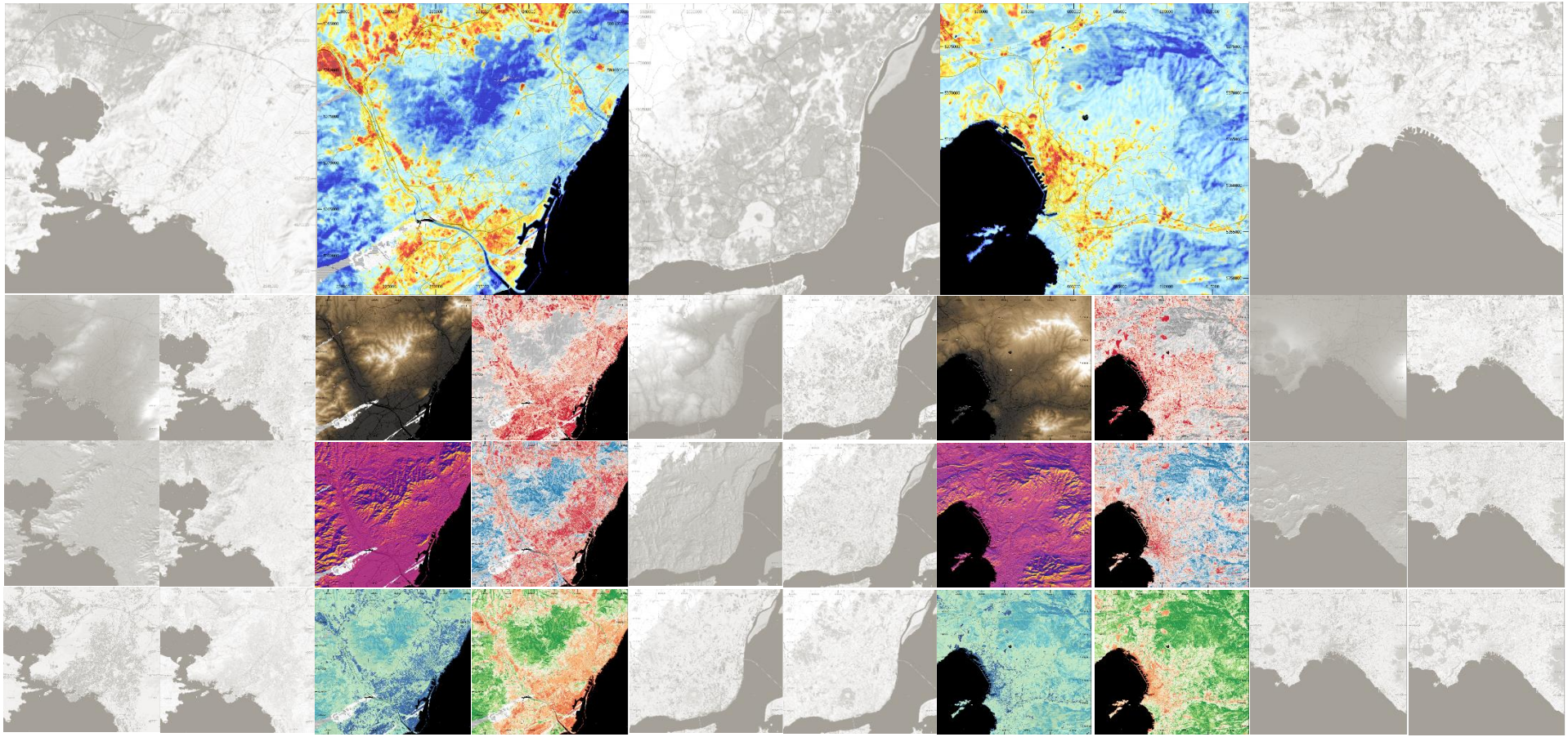

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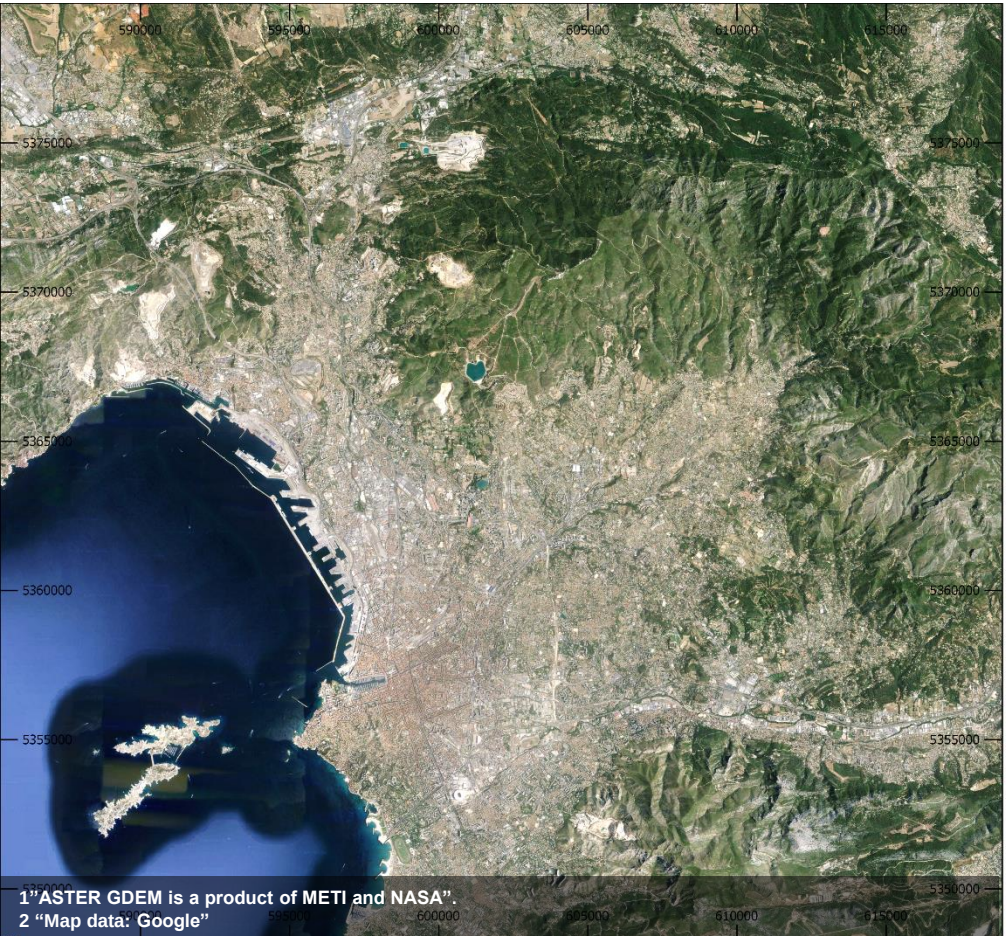
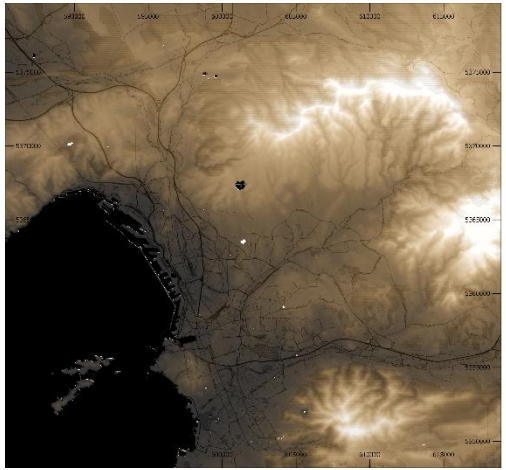
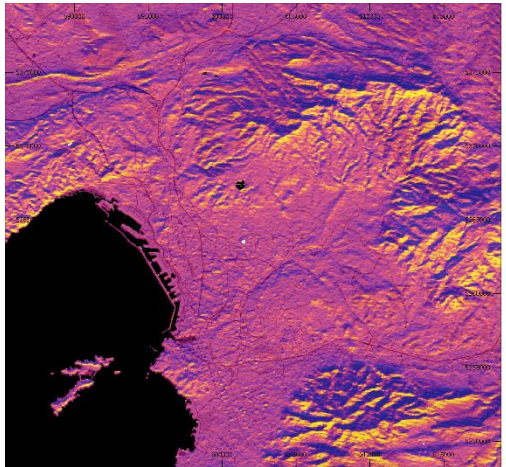


GOOGLE SATELLITE (1)

0 2.5 5 km





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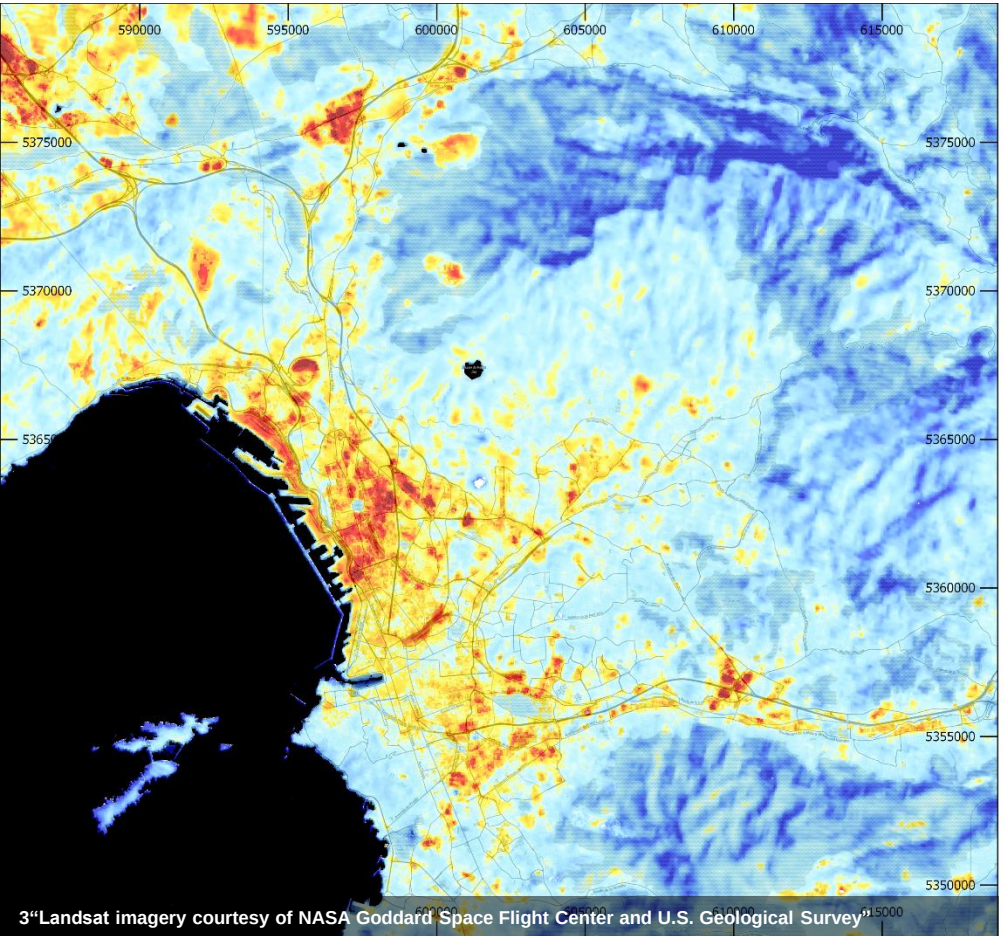

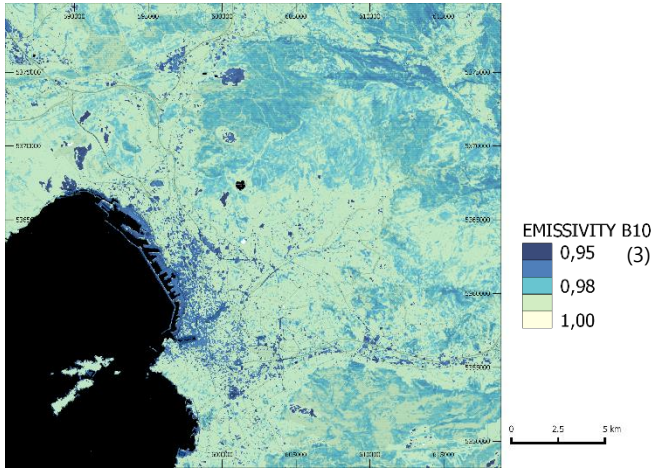

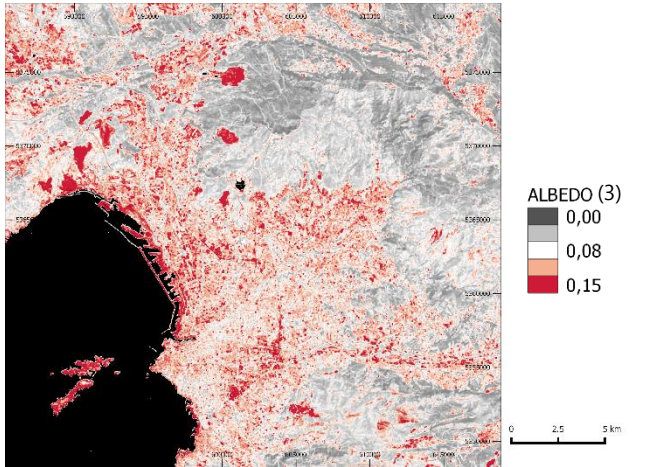

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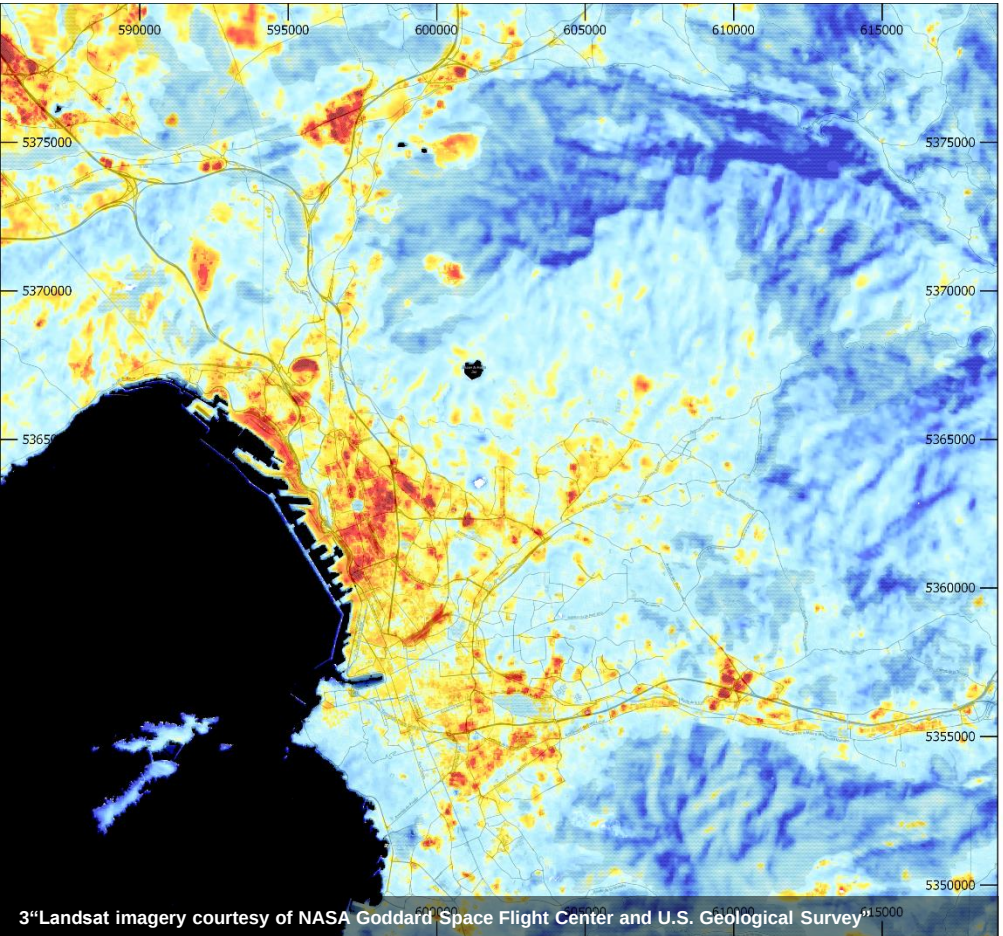

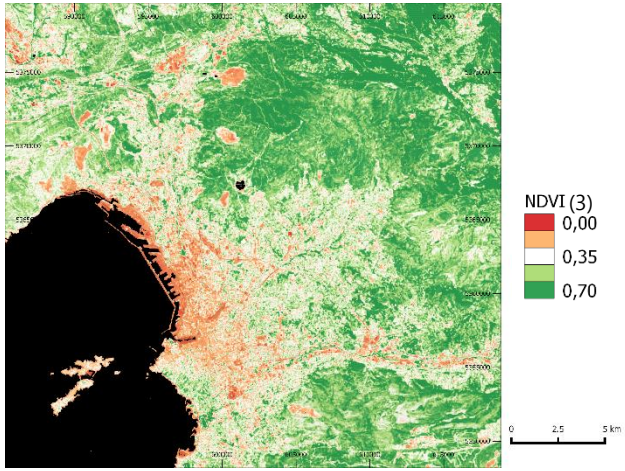

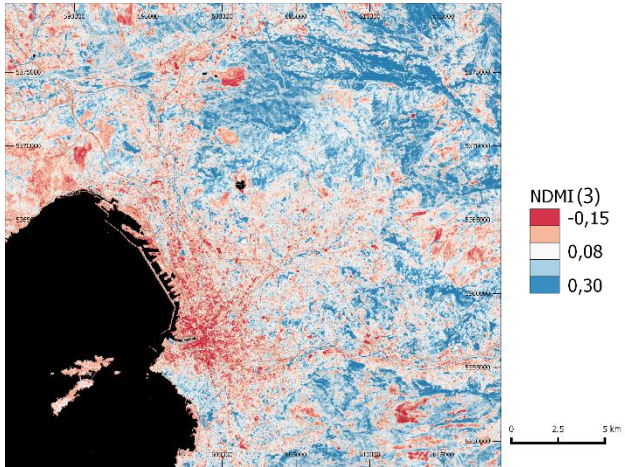

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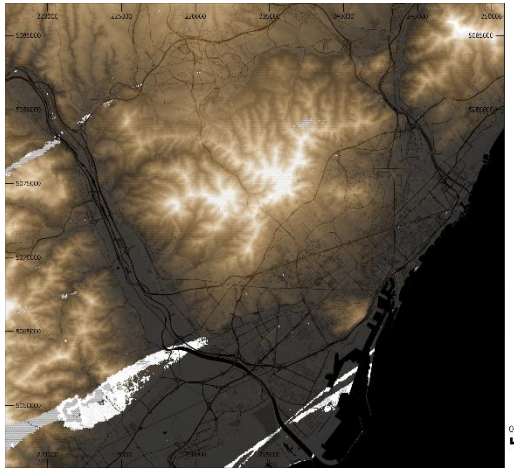

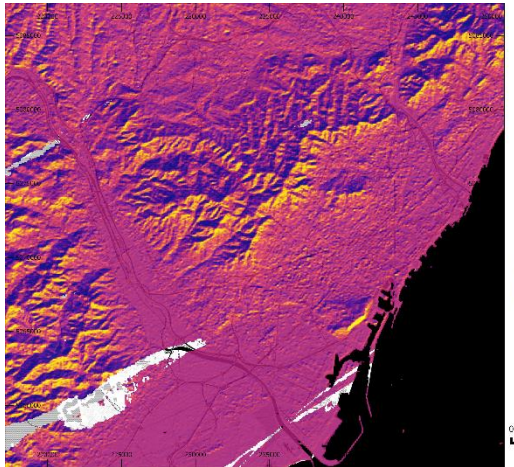

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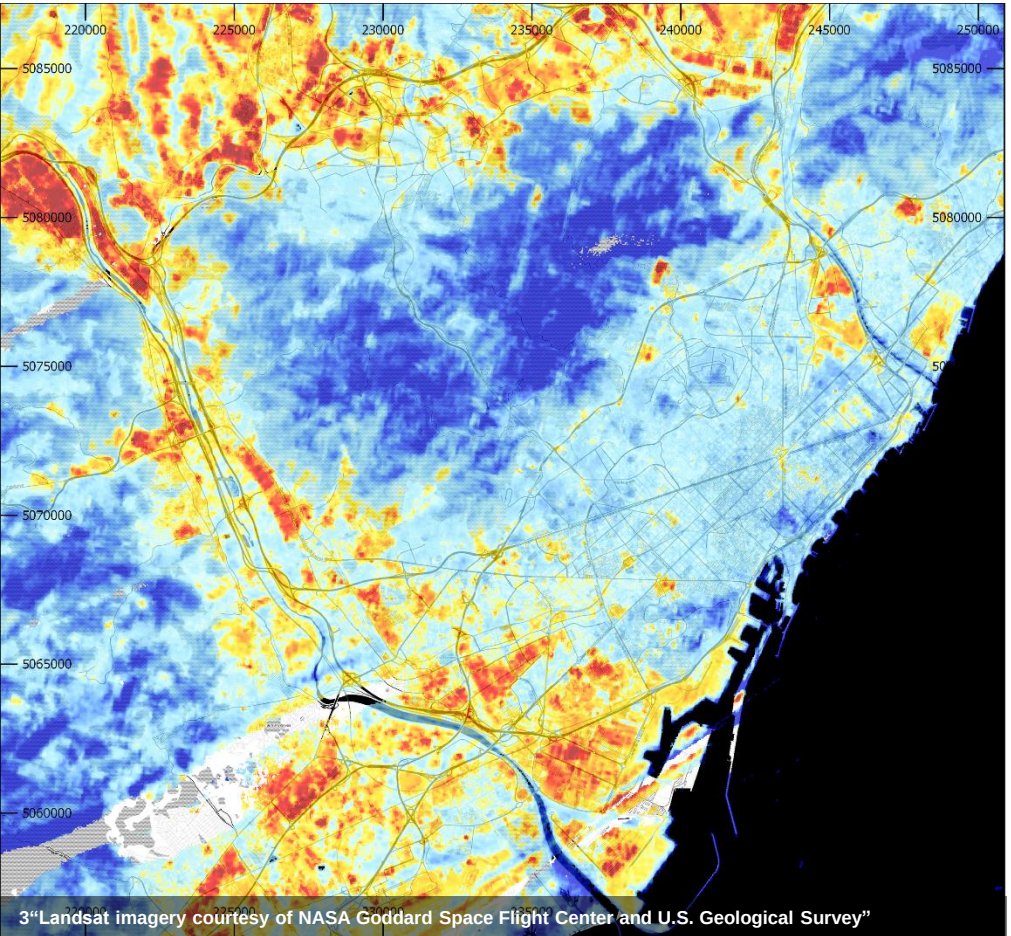

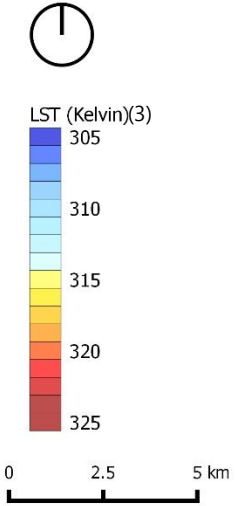

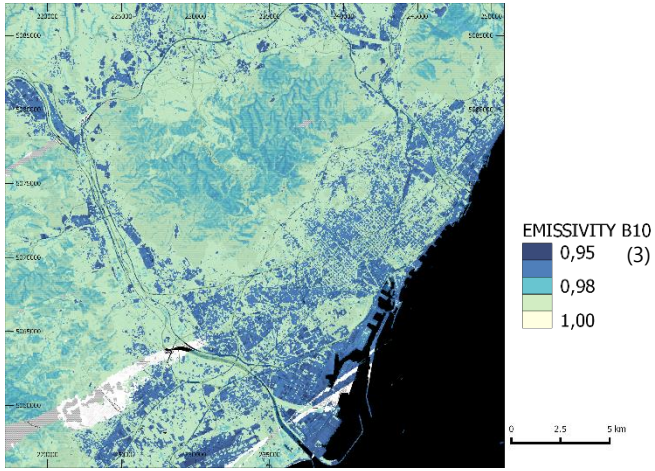

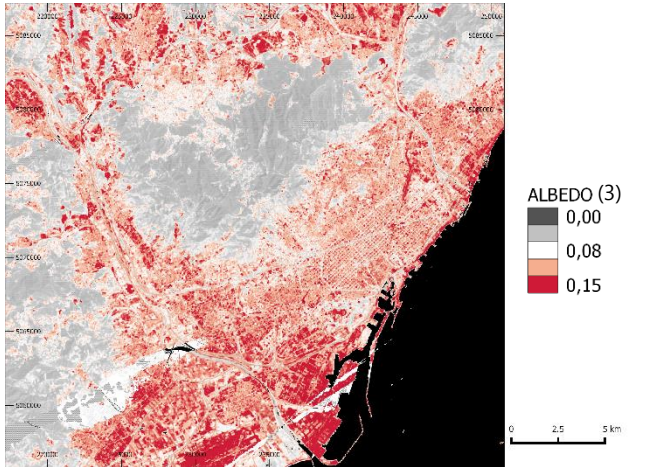

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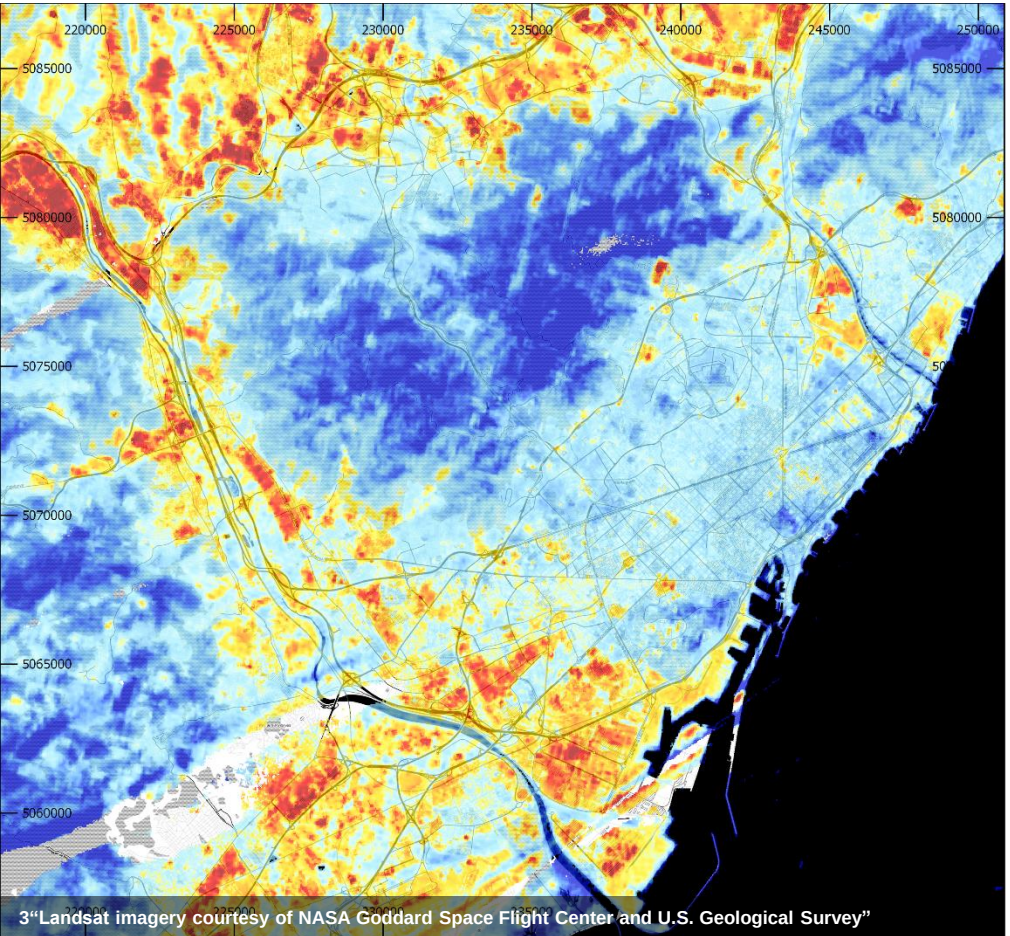

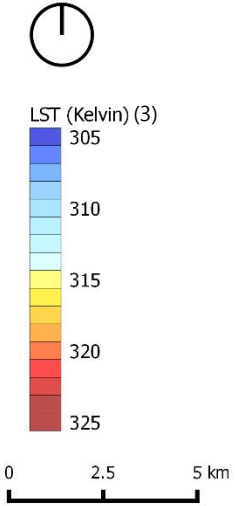

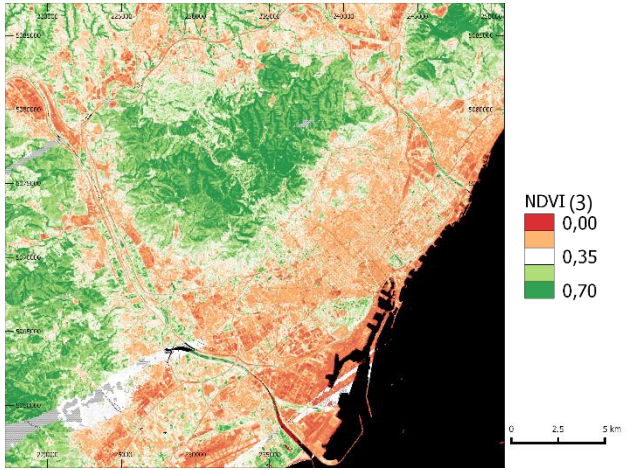

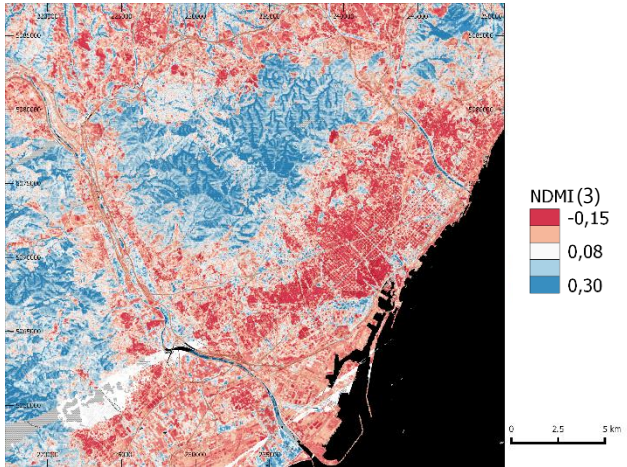

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City	ALB		EMISSIVITY 10		NDVI		NDMI		DEM		SHADOWS	
	r2	P-value	r2	P-value	r2	P-value	r2	P-value	r2	P-value	r2	P-value
Athens	0,09	> 0,00	0,05	> 0,00	0,15	> 0,00	0,41	> 0,00	0,09	> 0,00	0,03	> 0,00
Barcelona	0,47	> 0,00	0,08	> 0,00	0,47	> 0,00	0,43	> 0,00	0,23	> 0,00	0,02	> 0,00
Lisbon	0,29	> 0,00	0,09	> 0,00	0,35	> 0,00	0,35	> 0,00	0,02	> 0,00	0,02	> 0,00
Marseilles	0,30	> 0,00	0,00	> 0,00	0,35	> 0,00	0,26	> 0,00	0,26	> 0,00	0,04	> 0,00
Naples	0,31	> 0,00	0,02	> 0,00	0,46	> 0,00	0,50	> 0,00	0,28	> 0,00	0,01	> 0,00
AVERAGE	0,29		0,05		0,36		0,39		0,18		0,02	

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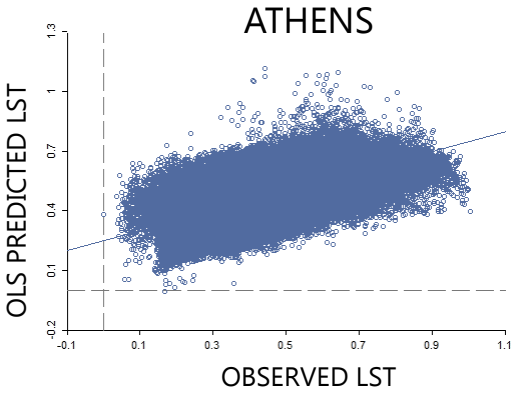
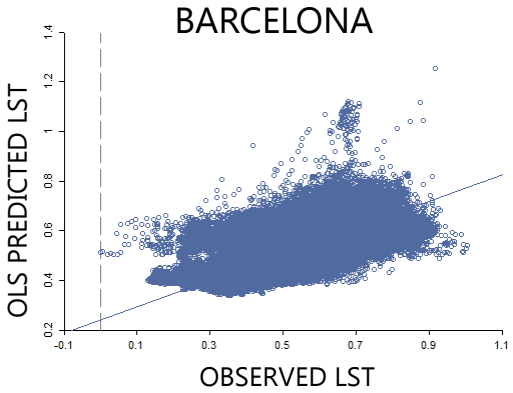
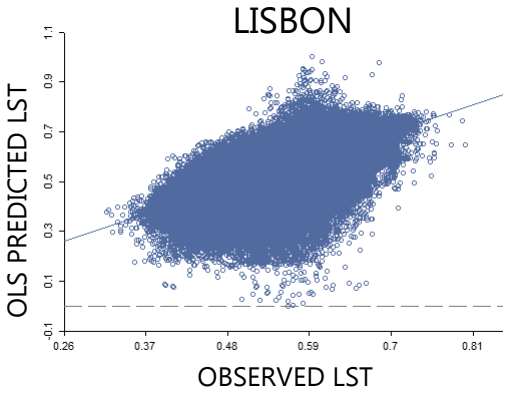
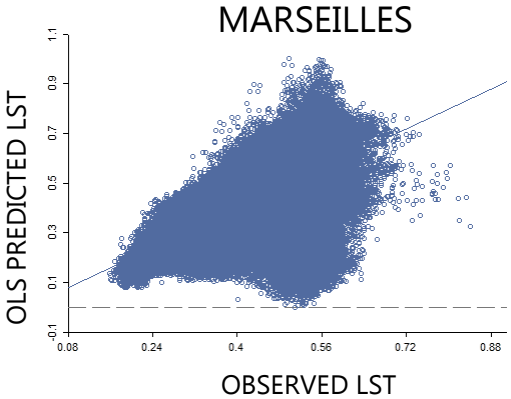
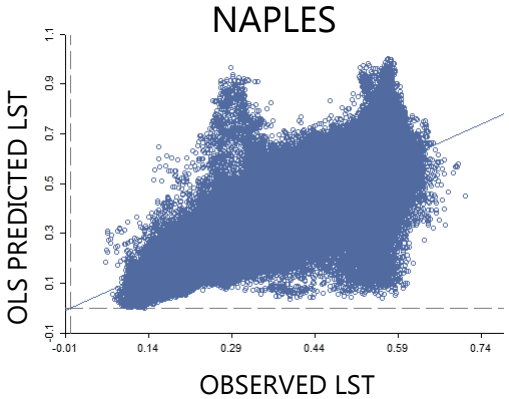




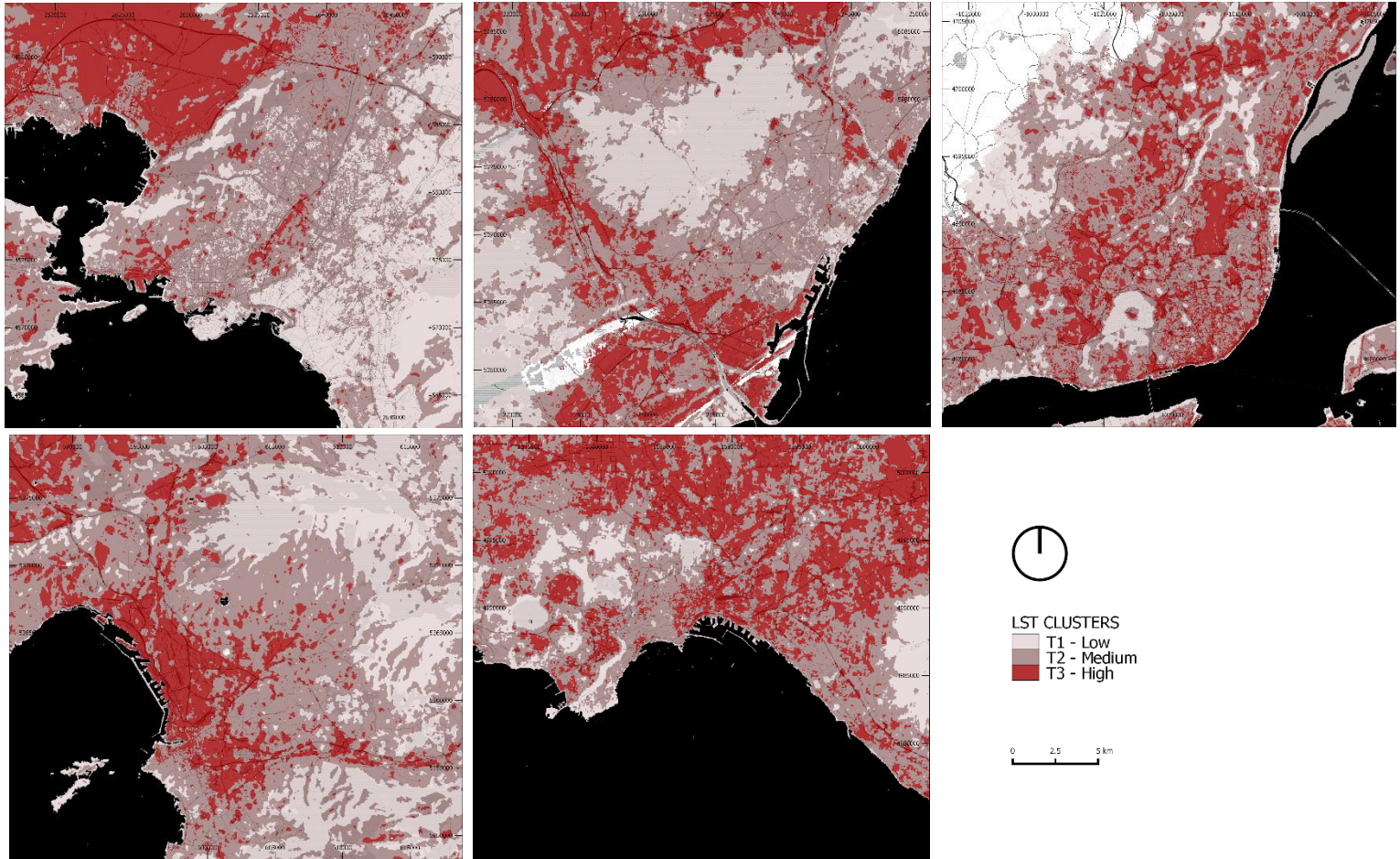






City	MULTIPLE REGRESSION	
	r2	p-VALUE
Athens	0,50	> 0,00
Barcelona	0,53	> 0,00
Lisbon	0,46	> 0,00
Marseilles	0,45	> 0,00
Naples	0,58	> 0,00

Land Surface Temperature derivation using Landsat 8 Data: a case-study of **Surface Urban Heat Island [UHI]** in **5** Mediterranean Cities



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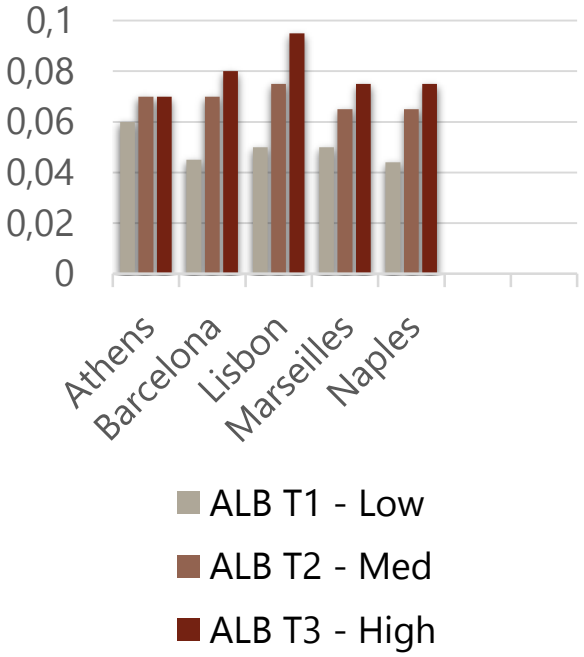
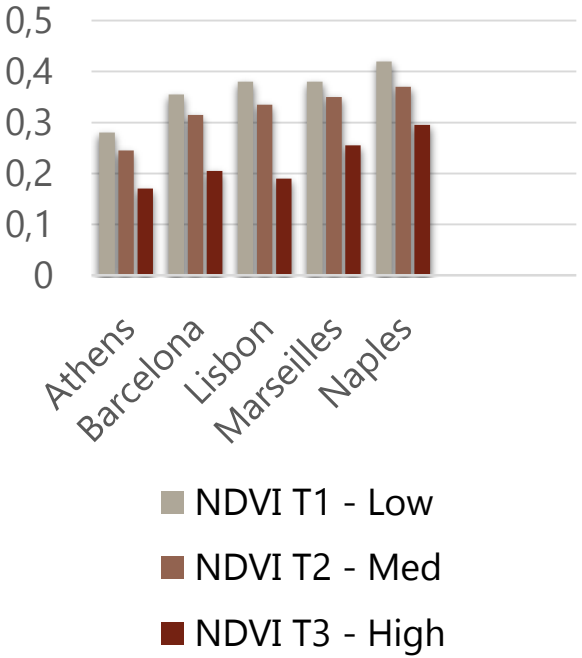
5 Mediterranean Cities

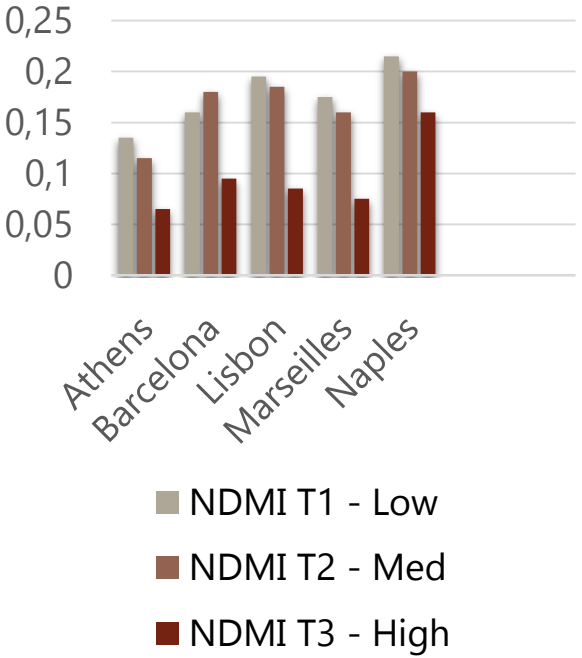
ALBEDO (Average per LST category)



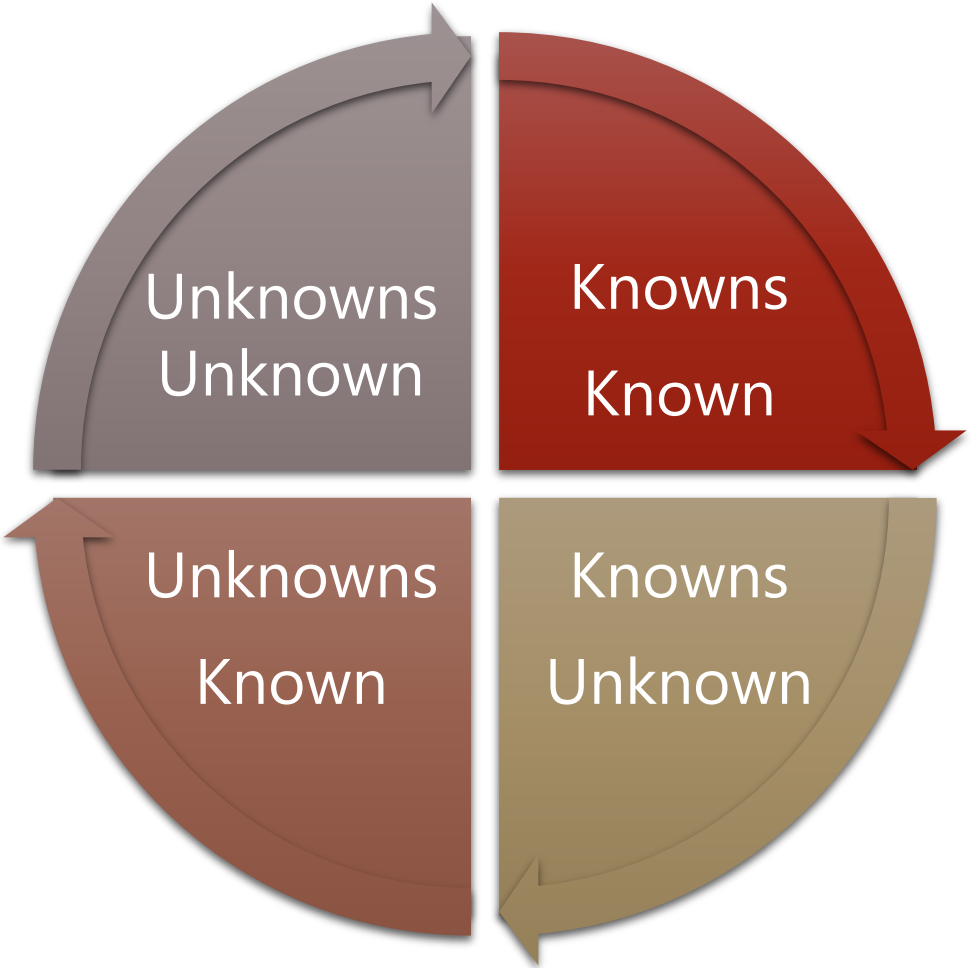
NDVI (Average per LST category)



NDMI (Average per LST category)



1. Introduction: the UHI effect
   a) Definition, Causes and Consequences
   b) Why Mediterranean Cities?
   c) Research Question
2. Methodology
3. Results
   a) Overview
   b) Marseilles, France
   c) Barcelona, Spain
   d) Statistical Analysis
4. Conclusions


Unknowns
Unknown
Knowns
Known
Unknowns
Known
Knowns
Unknown

Knowns

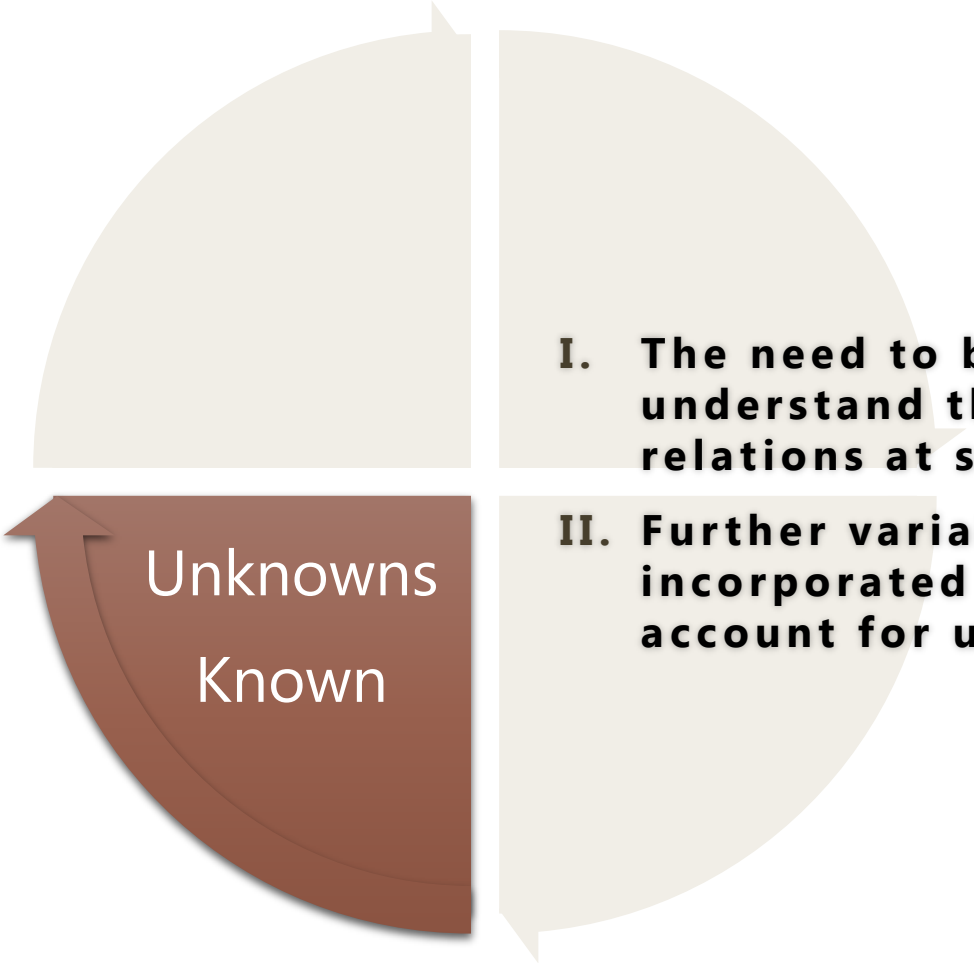
Known

I. **Causal factors did not predict the LST adequately**

II. **However, Albedo, NDVI and NDMI seem more significant**

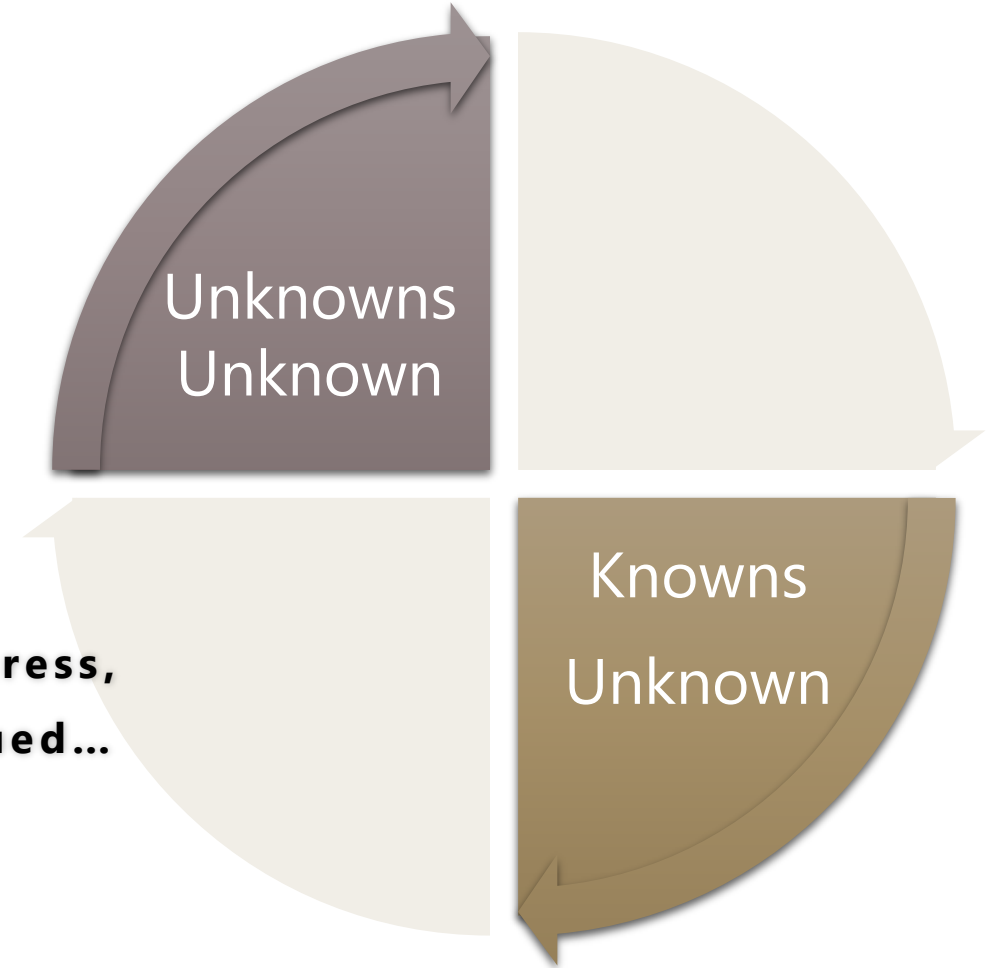
III. **Regression results are similar among cities**

IV. **Cluster Analysis showed a clearer relations between variables**



I. **The need to better understand the complexity of relations at stake;**

II. **Further variables have to be incorporated in the model to account for urban parameters**



Work in progress,

to be continued…

Thank you!

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a case-study of **Surface Urban Heat Island [UHI]** in

5 Mediterranean Cities

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