UTILISING WEATHER STATION, SATELLITE AND POPULATION DATASETS TO ESTIMATE URBAN HEAT ISLAND OVER LOCATIONS IN THE MIDDLE EAST AND NORTH AFRICA (MENA) REGION

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Introduction

- Local weather and climate conditions are affected by the presence of cities, through their perturbation of the surface energy balance

- Urban Heat Island (UHI) → land surface and near surface air temperatures are higher over a city compared to its rural surroundings

- In order to determine and project this local warming additionally to the large-scale global warming, reliable, observation-based UHI estimates are necessary for the evaluation of high-resolution, urban resolving climate model simulations

Aim of this work

- Combine air temperature station records with urbanization data derived from land and population data

- Examine and provide credible urban-rural temperature differences for the MENA region

Data & Methods - 1

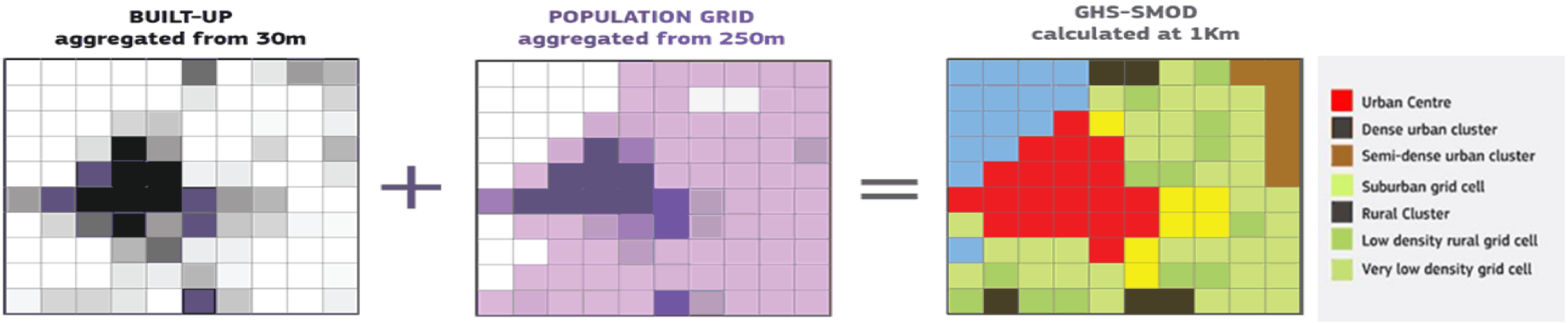
- **Integrated Surface Dataset (ISD) - Global Summary of the Day (GSOD)** is a global database which consists of raw daily weather elements: Td, Tmax, Tmin, Wind Speed etc.

- There are more than 10,000 stations globally in ISD-GSOD (including the MENA region)

- Quality control and analysis was performed in the provided data:
  - Multiple years of data were analyzed to ensure continuity: 2000 – 2010 year period was selected
  - Only valid stations were selected (number of NAs < 10% in 11-year period)
  - Mean values for each station were calculated based the 5/3 rule from WMO technical report

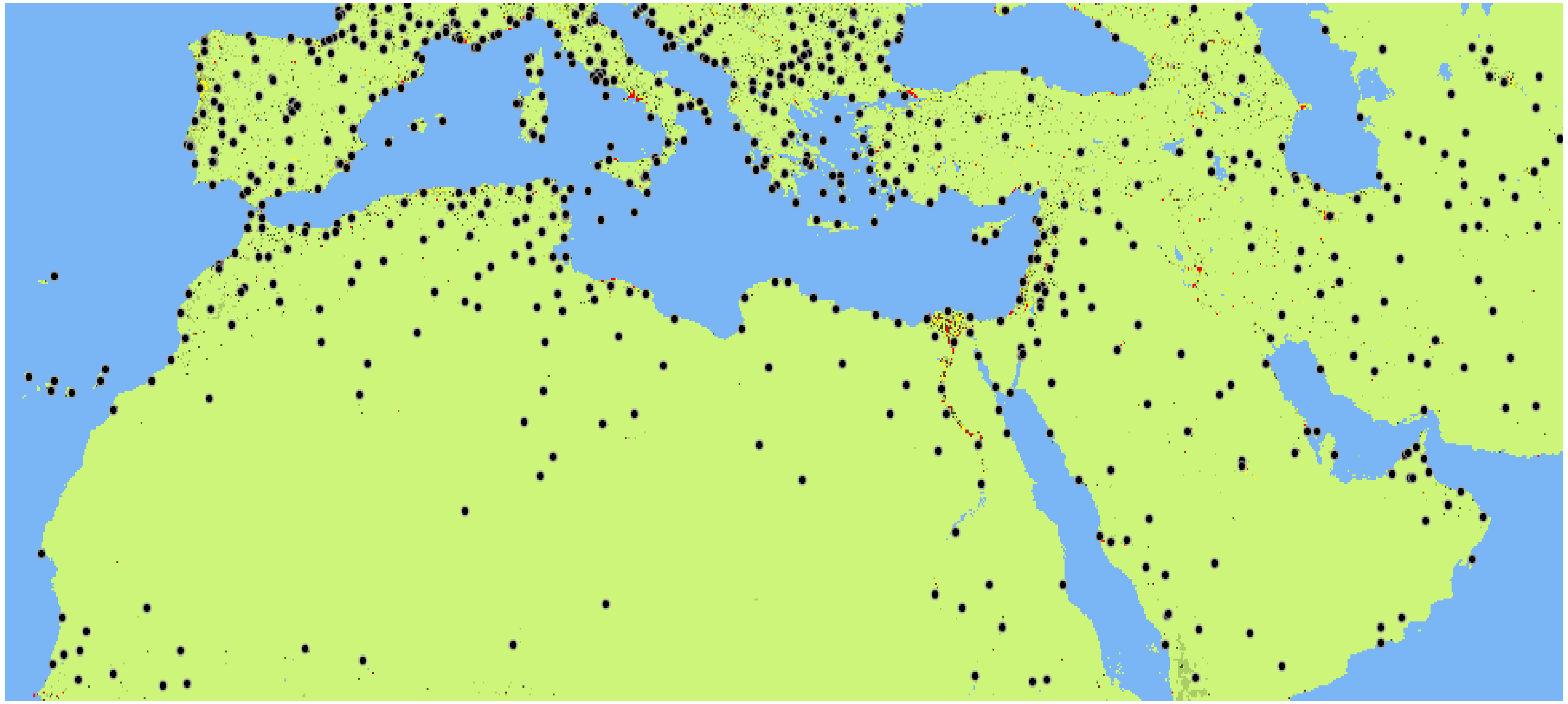
Data & Methods - 2

- **GHS Settlement Model layers (GHS-SMOD):** Derived from GHS-POP and GHSBUILT
- This method was designed to combine information from population censures with built-up data and to downscale population into a grid of 1 km resolution according to the presence or absence of built-up in the grid
- The new layer represents 7 classes characterization for each grid, based on the population of inhabitants per km^2 and the built-up surface share on permanent land

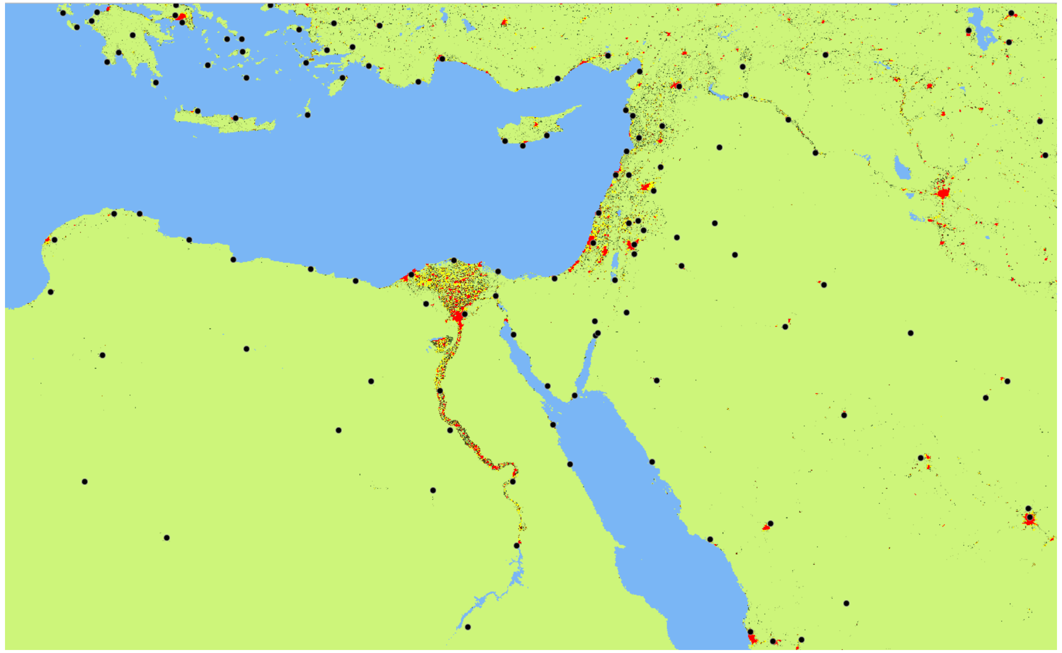


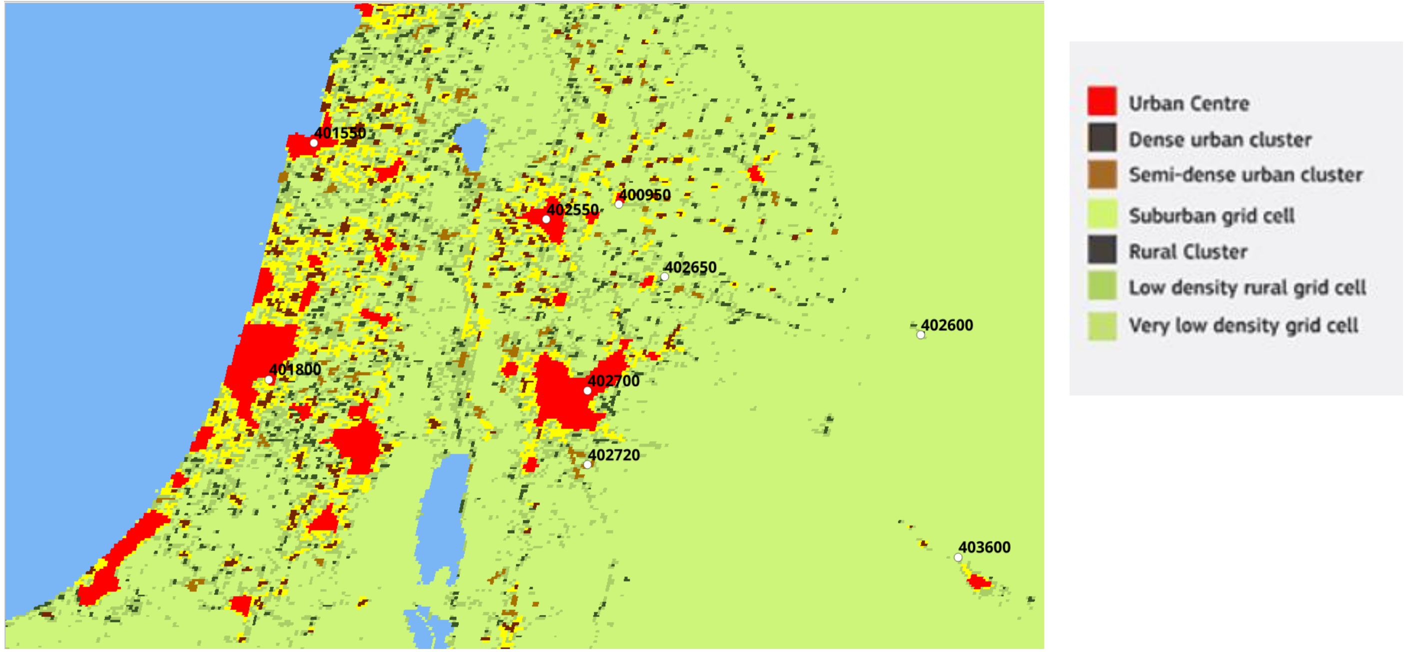
Representation of Data -1

- There are 640 valid daily stations for the MENA region
- **Valid station:** <10% missing values in 11-year period
- **Period selected:** 2000 – 2010



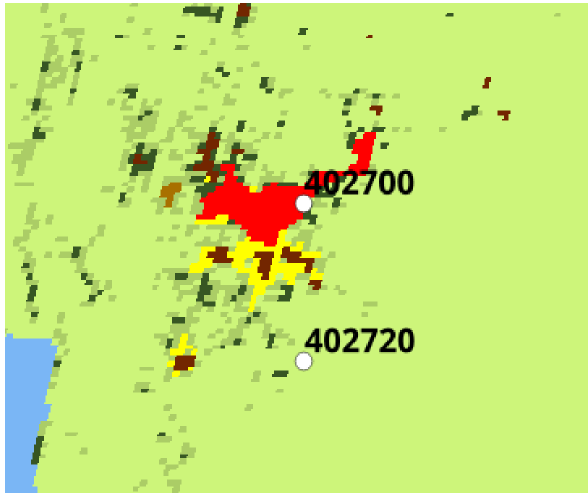
Representation of Data - 2



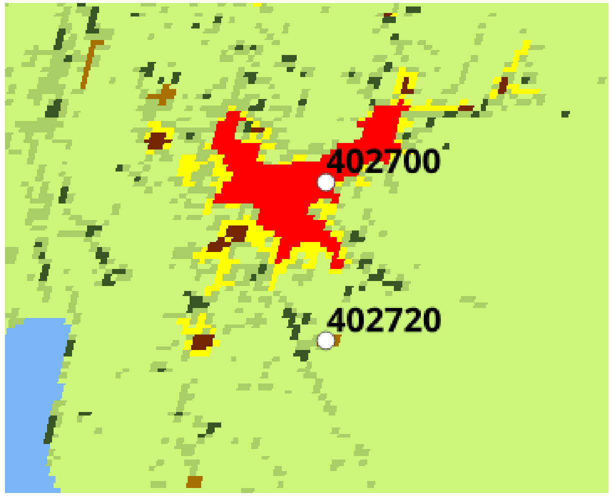


Representation of Data - 3

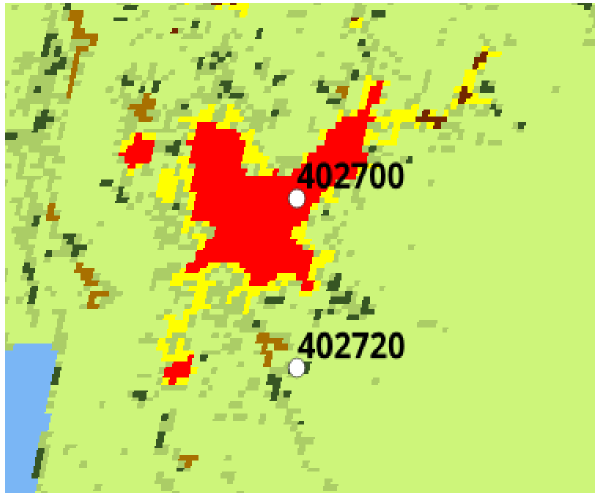
- A closer view of the GHSL layers
- Through the years cities are growing →changing the class of the grid
- Layer of year 2000 was selected for the following analysis based on the validity of the observation data
- This is an example of Urban-Rural pair of Stations in Amman, Jordan



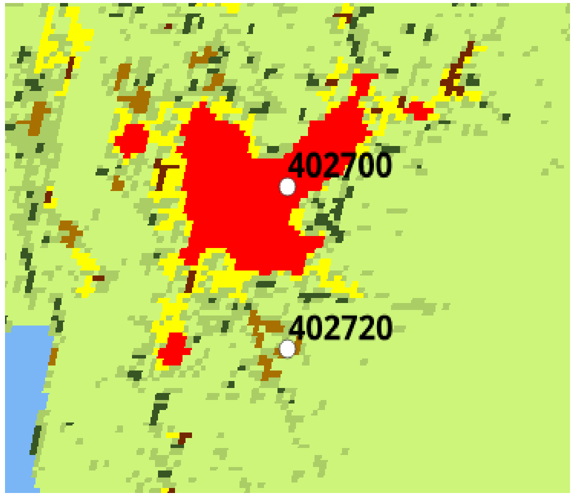
1975



1990



2000

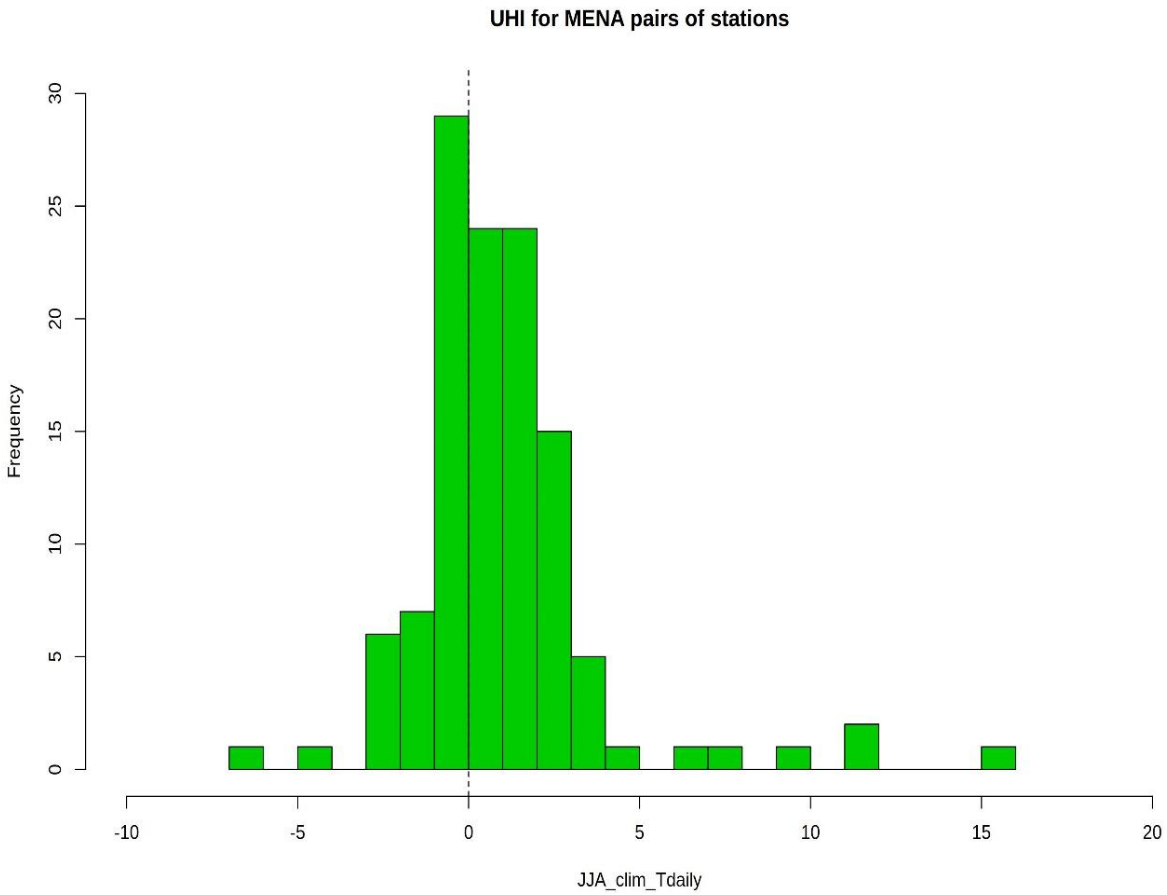


2015

Preliminary Results - 1

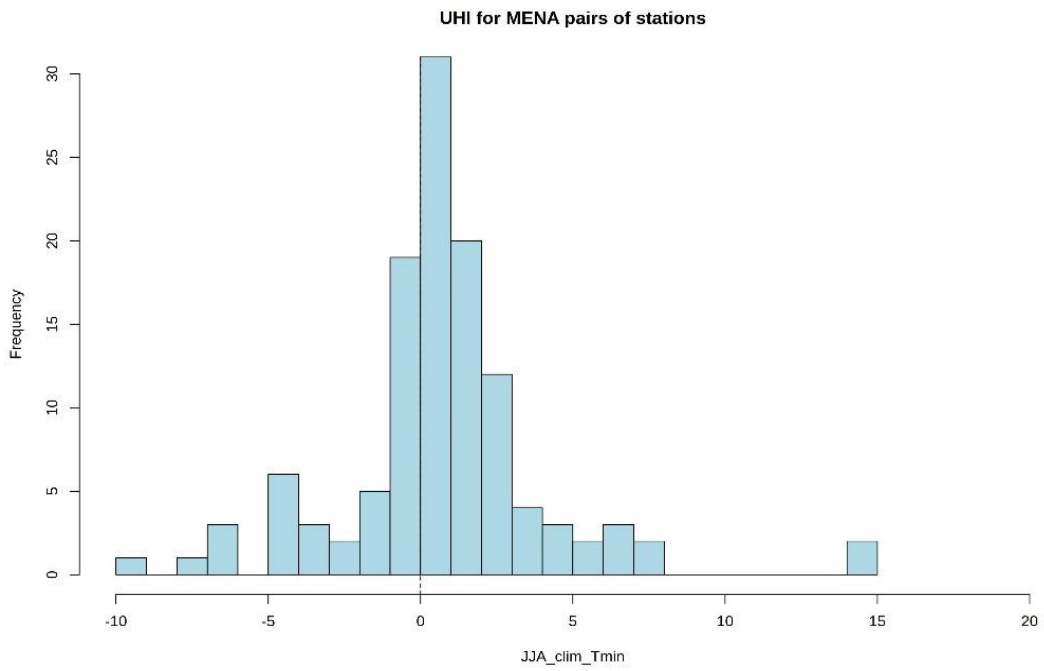
- For the MENA region 120 pairs of urban-rural meteorological stations were identified
- **Criteria used:**
  - Distance between the stations < 100 km (in country level)
  - Monthly mean followed by 5/3 rule:
    - Months with more than 5 NAs or 3 consecutive missing days → **monthly mean = NAs**
    - **JJA_clim** = average 11 years monthly data for each station

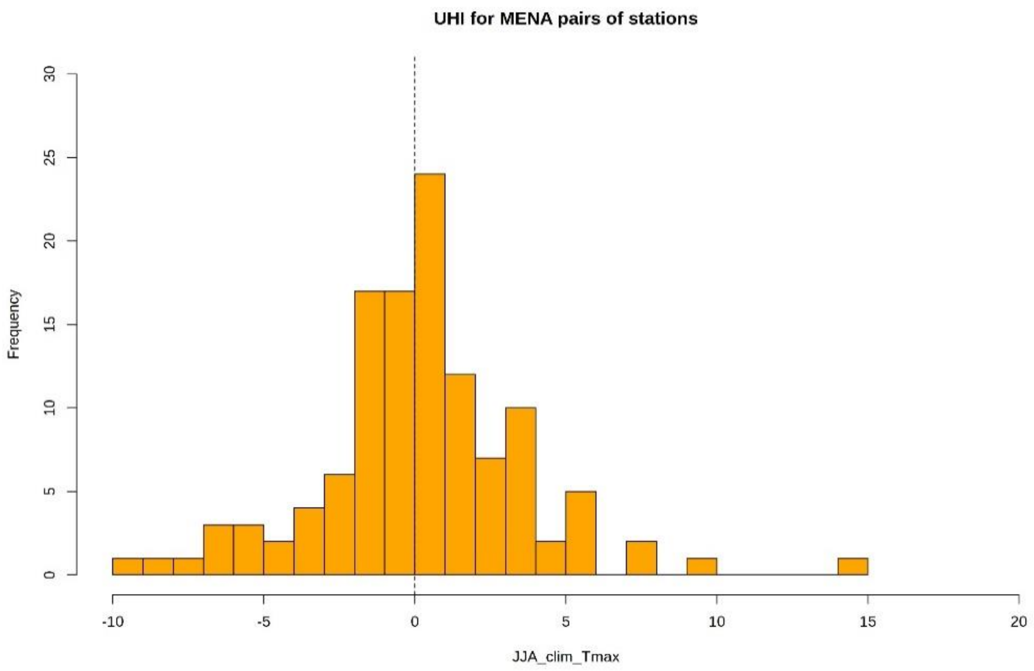
- Urban stations → “Urban Centre” from GHSL
- More than 70 pairs of stations have positive UHI(up to 5 degrees) in JJA climatology values



Preliminary Results - 2

- JJA_clim_Tmin → positive UHI for the night time values
- JJA_clim_Tmax → negative UHI for the day time values

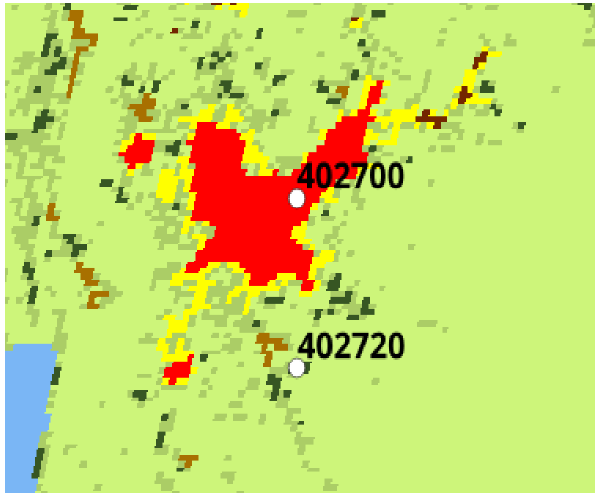


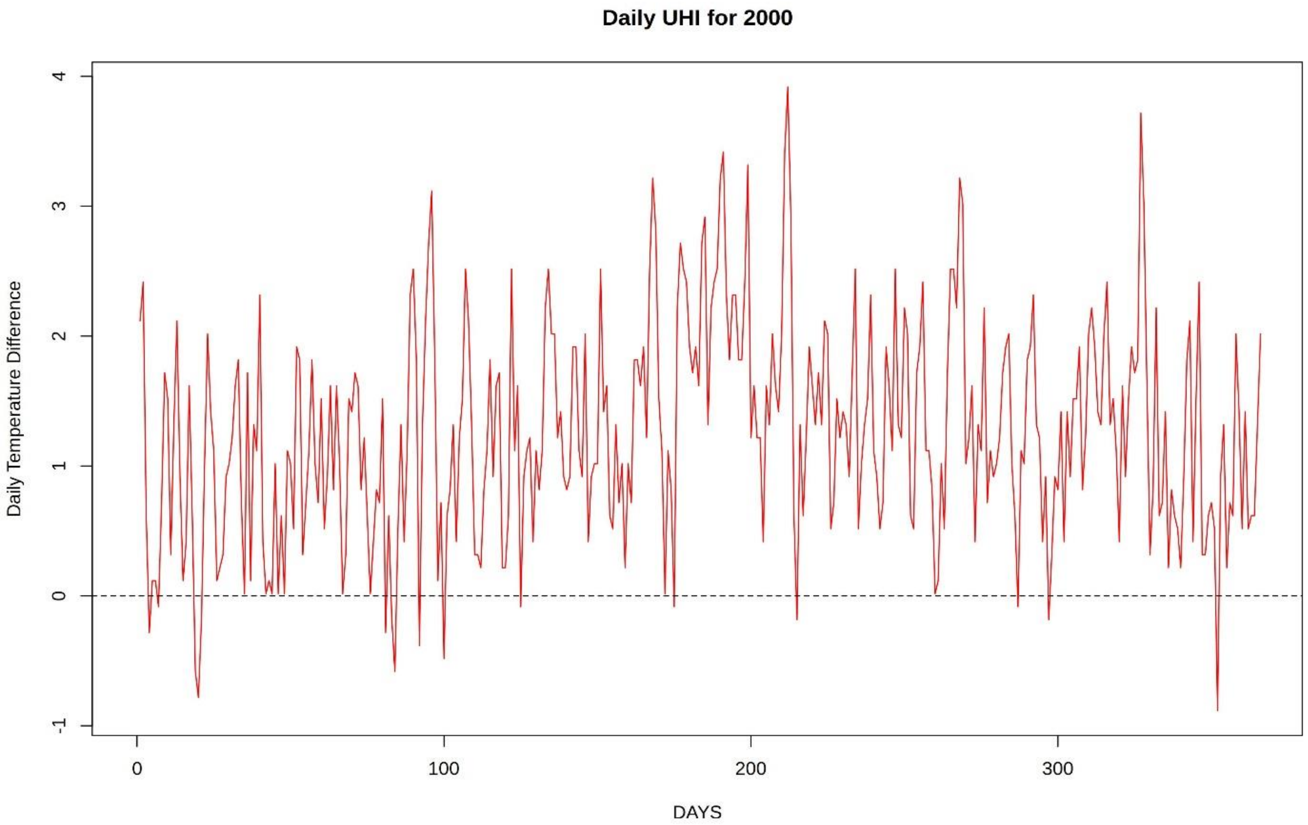


An example of a pair Urban – Rural Station

- **Location:** Jordan
- **Distance:** 27 km
- **Urban station:** Queen Alia Int. (402700)
- **Rural station:** Marka Int. (402720)

Lapse rate correction for elevation on Daily temperatures





UHI = Tdaily_urban – Tdaily_rural

Conclusions

- A combination of GHSL-SMOD data and temperature observations from ISD-GSOD stations was performed

- About 70 % of the pairs selected have positive UHI (from the summer monthly averages)

- Year 2000 → UHI_daily > 0 through out the year

Future work:

- In order to evaluate the model we have to consider other meteorological elements (i.e., Wind Speed) and geomorphological details of the region
- Same procedure with extended time period (i.e., 1980- 2020)
- Include hourly period calculations for diurnal cycle
- We want to finalize credible UHI pairs for RCM evaluation **(Constantinidou et al.)**

Thank you for your attention

Table 8 Settlement Model L2 synthetic explanation of logical definition and grid cell sets

Code	Logical Definition at 1 km² grid cell	Grid cell sets used in the logical definition (shares defined on land surface)			
		P_{dens}: Local Population Density lower bound ">" (people/km²)	P_{min}: Cluster Population lower bound ">" (people)	B_{dens}: Local share of Built-up Area lower bound ">" (km²)	T_{con}: Topological constrains
30	$(((P_{dens} \vee B_{dens}) \wedge T_{con}) \wedge P_{min}) \vee$ $\vee$ [iterative_median_filter(3-by-3)] $\vee$ [gap_fill(<15km2)][12]	1,500	50,000	0.50	4-connectivity clusters
23	$(((P_{dens} \vee B_{dens}) \wedge T_{con}) \wedge P_{min}) \wedge \neg 30$	1,500	5,000	0.50	4-connectivity clusters
22	$((((P_{dens} \wedge B_{dens}) \wedge T_{con\_1}) \wedge P_{min}) \wedge \neg (30 \vee 23)) \wedge T_{con\_2}$	300	5,000	0.03	1: 4-connectivity clusters; 2: farther than 3km (beyond 3 cells buffer) from 23 or 30
21	$(((((P_{dens} \wedge B_{dens}) \wedge (30 \vee 23)) \wedge T_{con\_1}) \wedge P_{min}) \wedge \neg (30 \vee 23)) \wedge T_{con\_2}$	300	5,000	0.03	1: 4-connectivity clusters; 2: within 3km (within 3 cells buffer) from 23 or 30
13	$((P_{dens} \wedge T_{con}) \wedge P_{min}) \wedge \neg (30 \vee 2X)$	300	500	none	4-connectivity clusters
12	$P_{dens} \wedge \neg (30 \vee 2X \vee 13)$	50	none	none	none
11	$T_{con} \wedge \neg (30 \vee 2X \vee 13 \vee 12)$	none	none	none	On Land (Land>=50% ∨ BU[13]>0% ∨ Pop>0)
10	T_{con}	none	none	none	Not on Land

Example of a pair Urban – Rural station