LIFE ASTI: Thermal Perception of the Urban Heat Island effect and Future Projection

3rd ADAPTtoCLIMATE international Conference | LIFE UrbanProof Project

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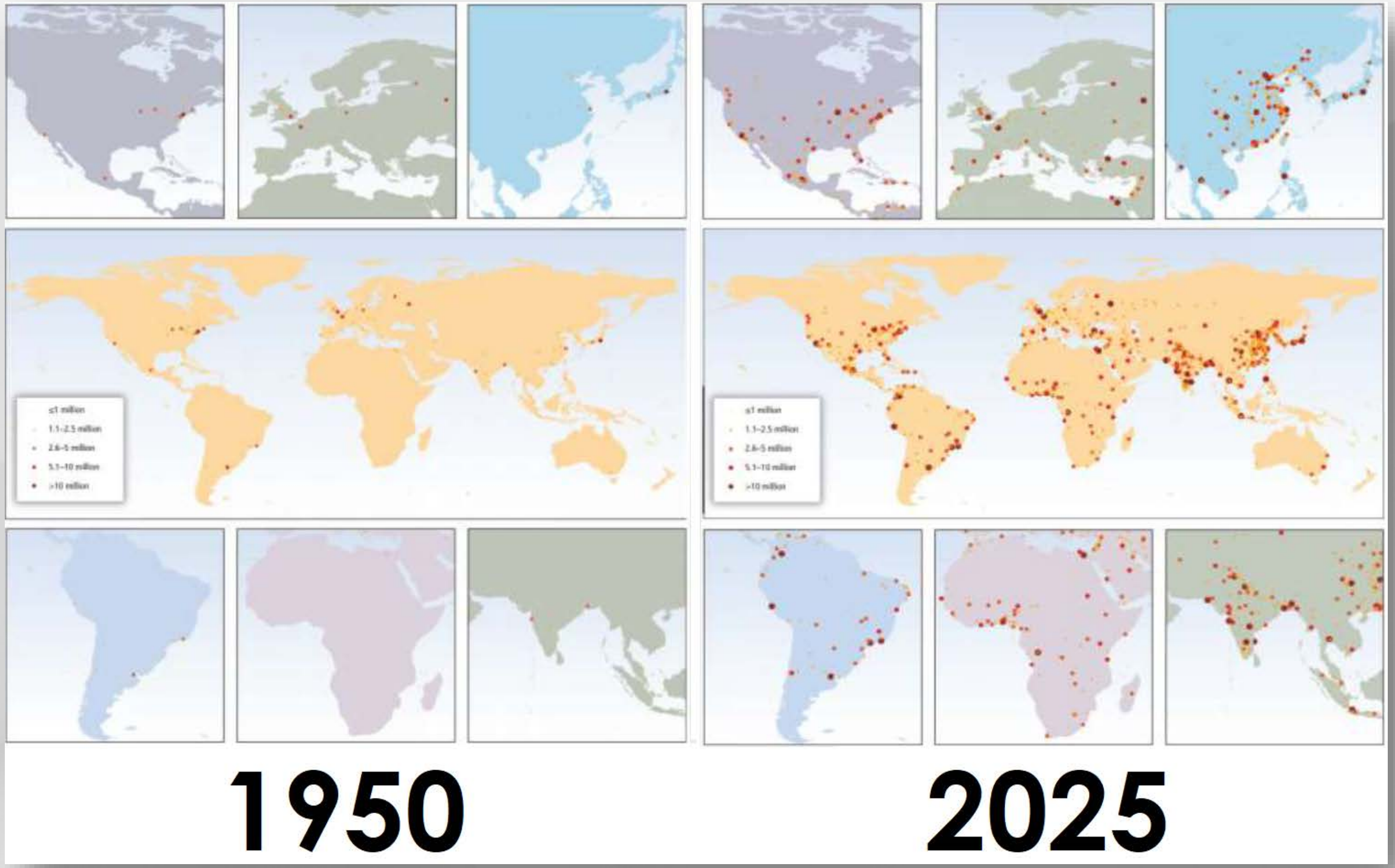
The project *Implementation of a forecAsting System for urban heaT Island effect for the development of urban adaptation strategies - LIFE ASTI* has received funding from the LIFE Programme of the European Union.

Outline

- Urbanization and Urban Heat Island (UHI)
- The LIFE-ASTI project
- LIFE-ASTI goals
- LIFE-ASTI results

Urbanization



Urban agglomerations with 750,000-plus inhabitants in 1950/2025 (derived from statistics in UN DESA Population Division, 2012)

Global Urban Population

1950: 30% of the population was urban

2018: 55%

2050: 68%

Urban Populations in the Present

Northern America: 82%

Latin America and the Caribbean: 81%

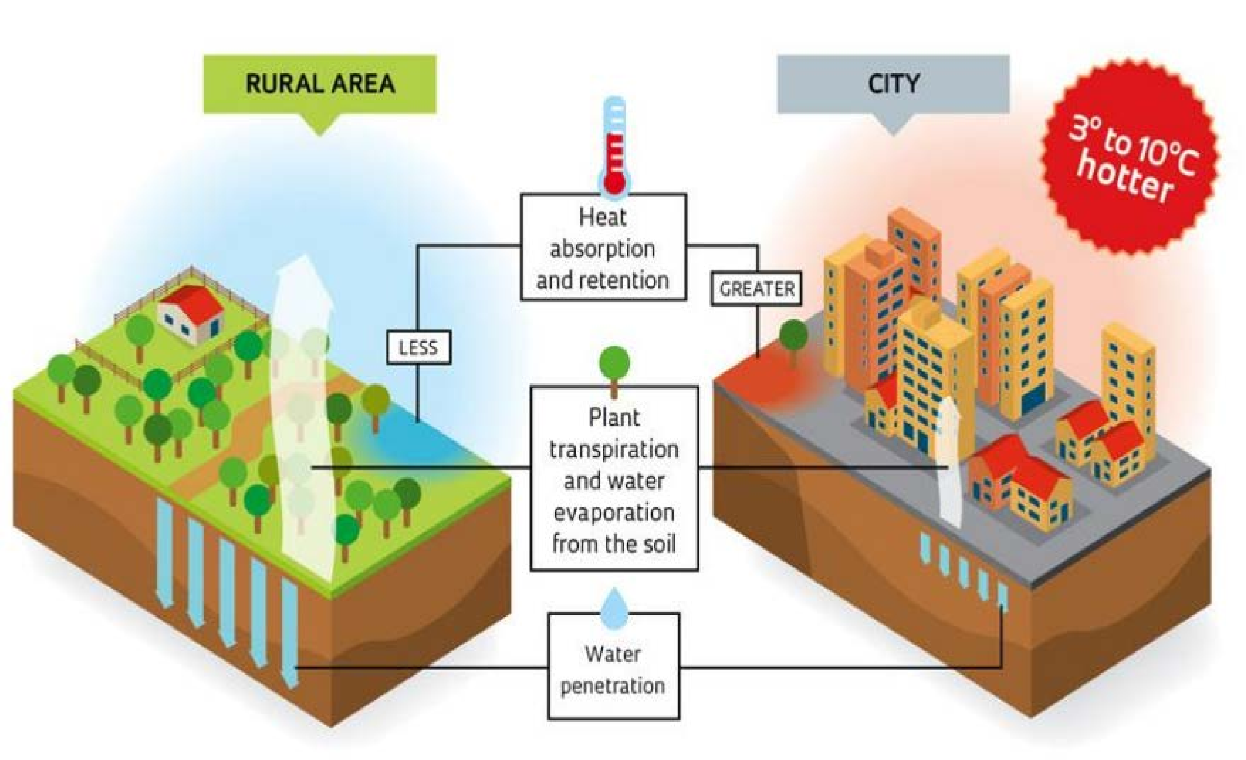
Europe: 74 %

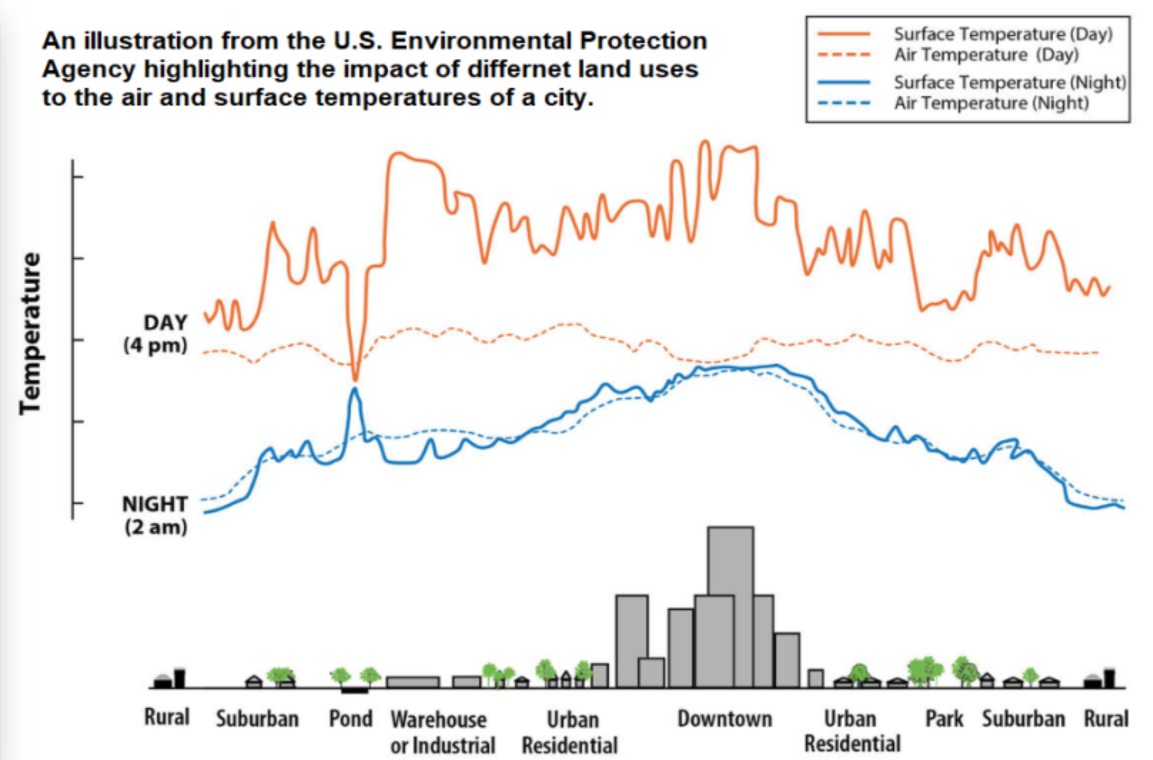
Urban Heat Island (UHI)

The **Urban Heat Island** (UHI) effect describes the temperature difference between an *urban*/metropolitan area and its surrounding *rural* areas due to human activities.

$$UHII = T_{urban} - T_{suburban}$$

Urban Heat Island (UHI)





UHI is more consistently **observed** during the **nighttime hours**

UHI is **stronger** in **early morning** hours, **weakening** and almost vanishing in **early evening**

UHI: Why do we care?

1998 - 2017: More than **166,000** people died due to extreme temperatures.

2003: 70,000 people in Europe died as a result of the June-August event.

2010: 56,000 excess deaths occurred during a 44-day heatwave in the Russian Federation.

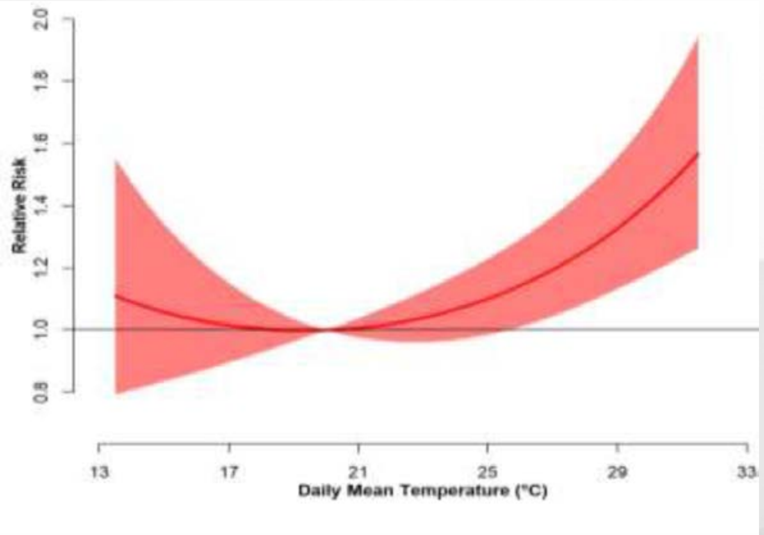
2000 - 2016: the number of people exposed to heat waves increased globally by around **125 million**.

Source: World Health Organization (*https://www.who.int/health-topics/heatwaves#tab=tab_1)*

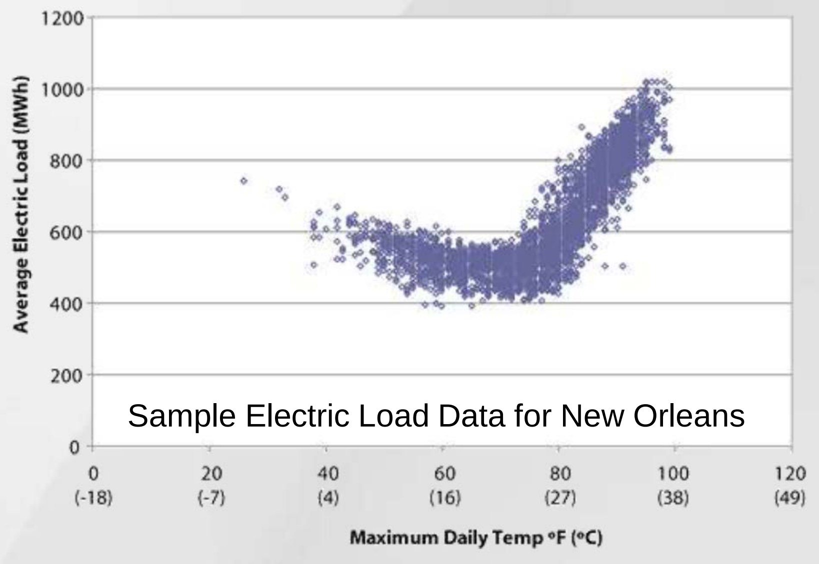
UHI: Why do we care?

Source: World Health Organization
https://www.who.int/news-room/fact-sheets/detail/climate-change-heat-and-health

UHI: Why do we care?



Francesca de'Donato, Matteo Scortichini, 2019



Sailor, D. J. 2002

Health

Urban is a living **environment** that is significantly **degraded**.

Increased thermal stress on residents and the public.

A significantly **increased** level and **risk** of morbidity and **mortality** due to **heat**

Power Consumption

As shown in the example from **New Orleans**, **electrical load** can increase (cooling energy usage and costs) steadily once temperatures begin to **exceed 25–27°C**.

Significant increases in peak energy demand.

LIFE ASTI: General information

Location: Thessaloniki, Greece + Rome, Italy

Replication: Heraklion, Greece

Duration: 01/09/2018 - 31/08/2021

Project implementors:

- **Aristotle University of Thessaloniki (coordinator)**
- Institute of Atmospheric Sciences and Climate, National Research Council of Italy
- Municipality of Thessaloniki
- Azienda Sanitaria Locale Roma 1
- Geospatial Enabling Technologies Ltd.
- Sympraxis Team P.C.

Making a weather-ready community

Communities that are prepared and appropriately responsive to extreme temperature events.

Key points:

- ✓ Reliable weather forecasting system with high resolution.
- ✓ Weather station network to provide observations.
- ✓ Online toolkit (website and mobile app) to make the scientific information immediately available to end users with clear-cut guidelines.
- ✓ Connection to local policy makers (local administration, hospitals, civil protection agencies etc.) to establish emergency plans.
- ✓ Promote the importance of public awareness through seminars, working tables, trainings.

Short-term adaptation tools for Rome and Thessaloniki

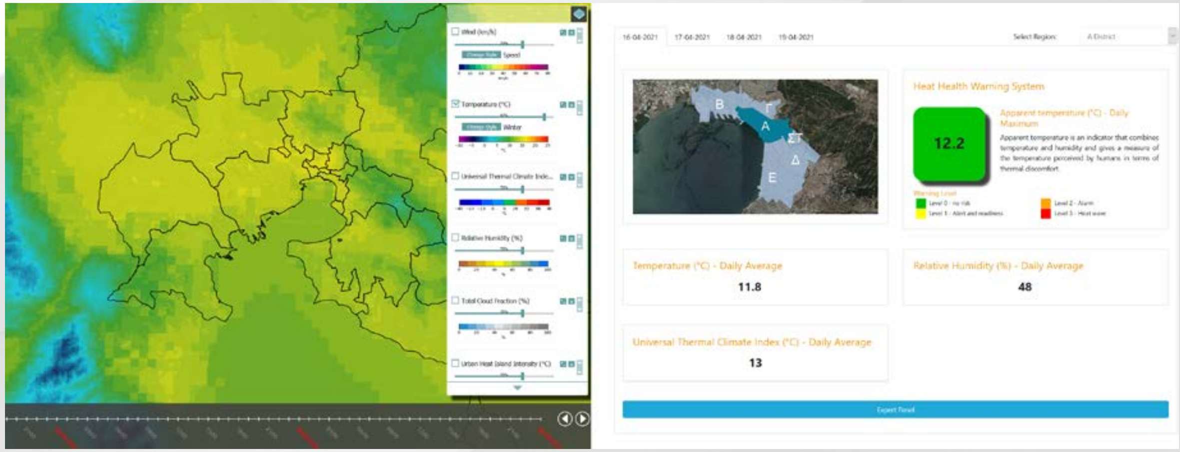
app.lifeasti.eu/

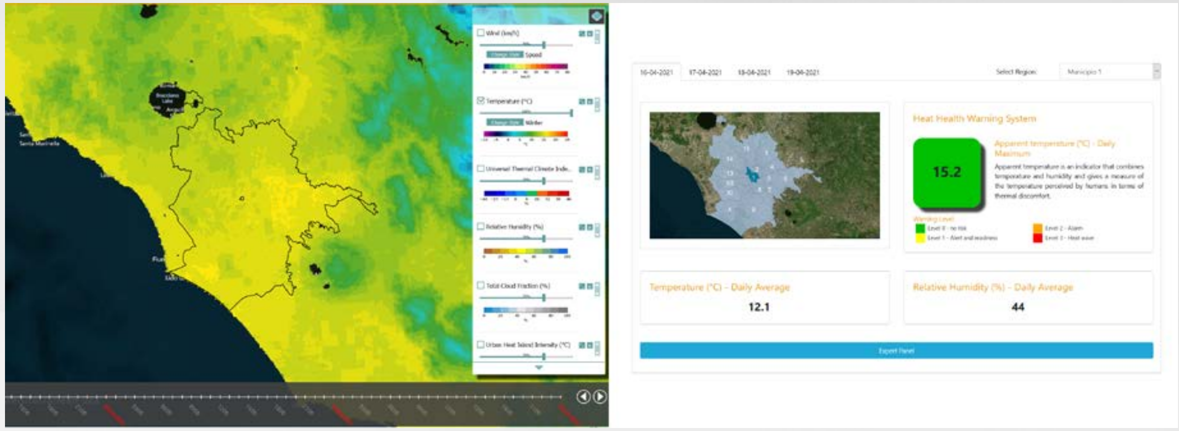
- ✓A web-based open access portal and a mobile application to **disseminate** forecasting products to authorities, stakeholders and the general public.

- ✓ Pilot UHI forecasting systems and monitoring stations in the two cities:

  - ✓ High-resolution (**250 m**) numerical model forecasts of UHI-related meteorological variables and related indices

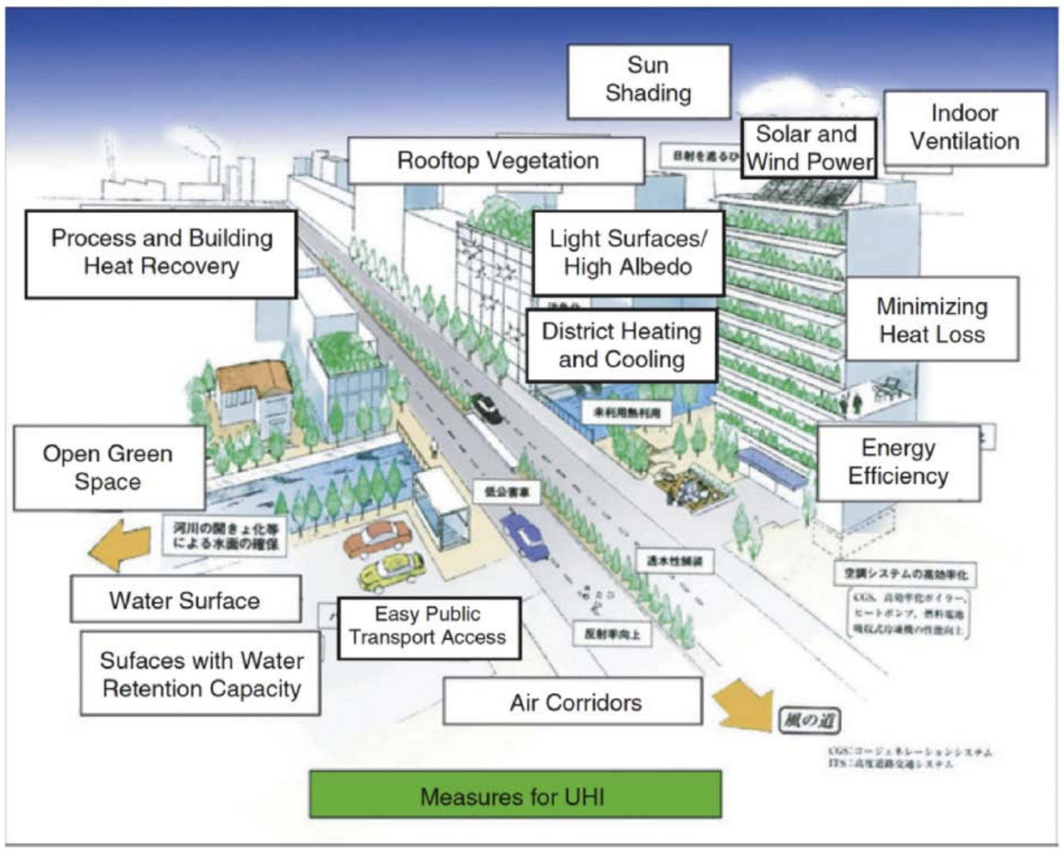
  - ✓ Heat Health Warning systems providing differential **alerts** within each involved city and the potential **effects on health** at high spatiotemporal resolution.





Long-term mitigation tools for Rome and Thessaloniki

- ✓ Assessment of the impact of future **climate change** on UHI.
- ✓ Sensitivity studies for assessing the impact of **adaptation and mitigation** strategies (e.g., green infrastructure).
  - UHI Adaptation Actions Plans Portfolios for each city.
- ✓ Good Practice Guidebook for **combating UHI** and increasing resilience to heat.

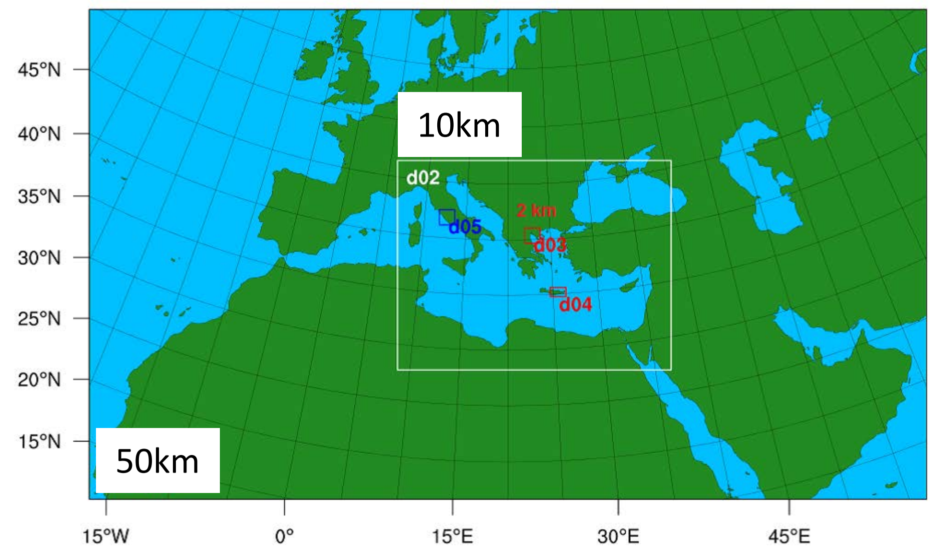


LIFE ASTI Replicability and Transferability plan

A plan that will support the potential of LIFE ASTI results to be utilized by authorities and stakeholders of other regions in Europe.

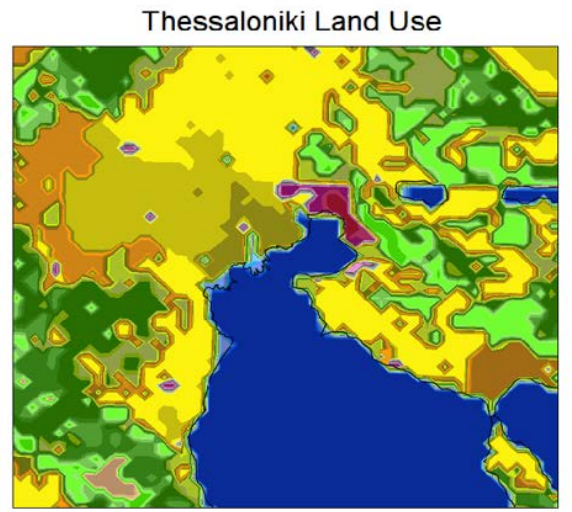
- ✓ The UHI forecasting and the Heat Health Warning Systems demonstrate a design that is modular and the implementation approach allows their straightforward replication and transfer to any urban area facing the adverse impacts of UHI effect.
- ✓ The provided forecasts at the Mediterranean forecasting domain provide the capability to identify potential cities that are vulnerable to heat wave events and UHI effect.
- ✓ Good Practice Guidebook will indicate the means, policies, examples of excellence, and financial tools for increasing resilience to heat at regional/local scale, beyond the targeted cities of Thessaloniki and Rome.

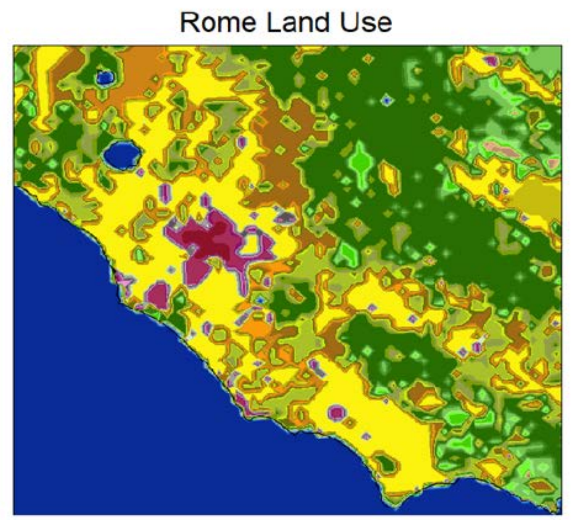
LIFE ASTI Numerical Model for Future Projections



Physics	Parameterization	References
Microphysics (clouds)	WRF single-moment 6-class (WSM6)	Hong and Lim (2006)
Cumulus (convection)*	Kain-Fritsch (KF)	Kain (2004)
Planetary boundary layer	YSU	Hong, Noh and Dudhia (2006, MWR)
Surface layer	Monin-Obukhov (Janjic Eta) scheme	Monin and Obukhov (1954); Janjic (1996)
Land surface	Noah model	Tewari et al. (2004)
Short-wave radiation	RRTMG	(Iacono et al. 2008, JGR)

* Cumulus parameterization will be used only for domains d01 and d02





WRF MODEL

- Similar parametrization schemes
- Similar domains
- Domain resolutions (50km – 10km – 2km)
- Scenario CMIP5 RCP8.5 (worst case or "business-as-usual" scenario)
- Simulated periods:

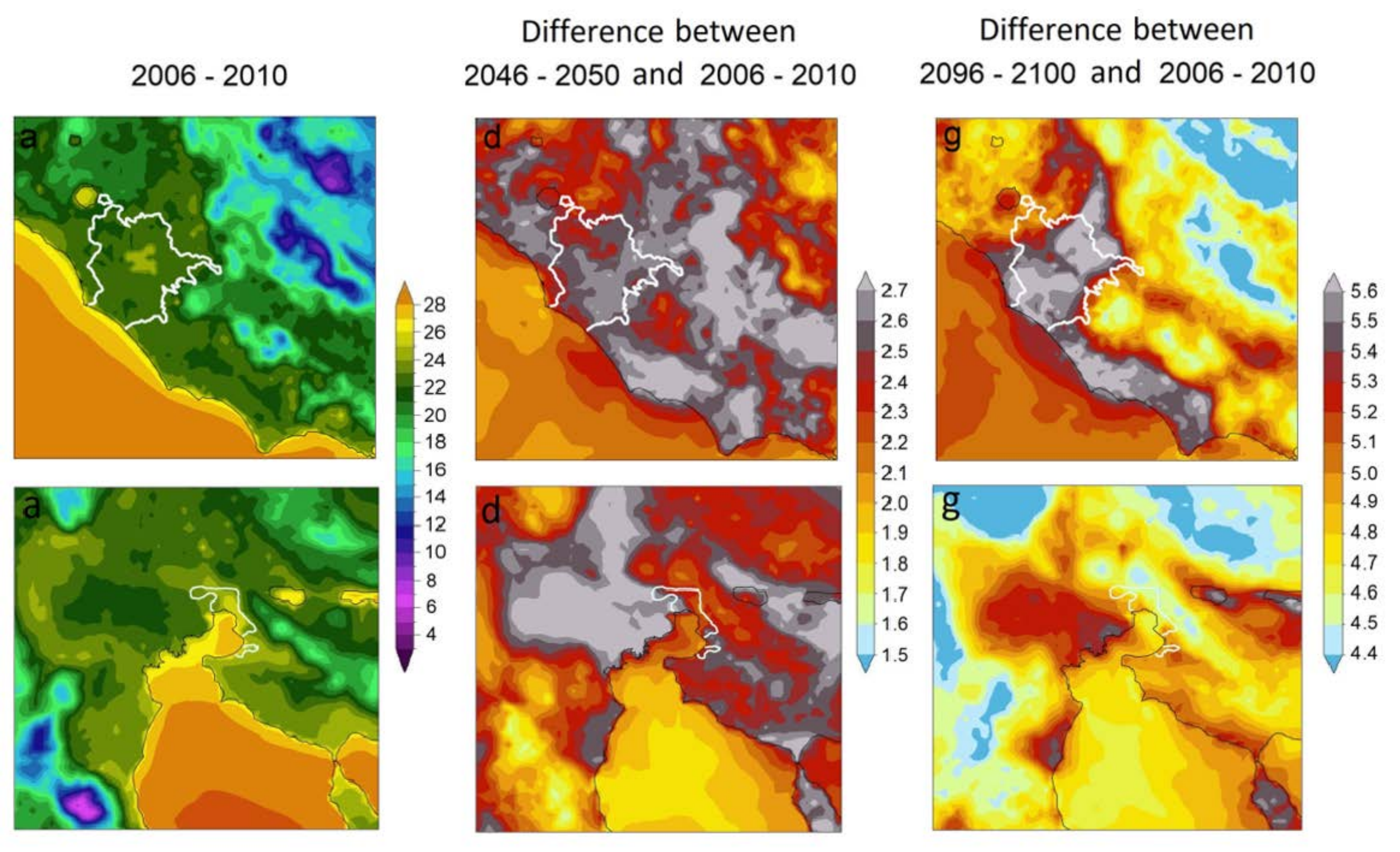
- 2006-2010 (Reference Period)

- 2046-2050

- 2096-2100

LIFE ASTI – Future Projection Results

Summer – $TAPP_{avg}$ at **03UTC** $TAPP = -2.653 + 0.994\ T + 0.0153 * T_{dew}^2$

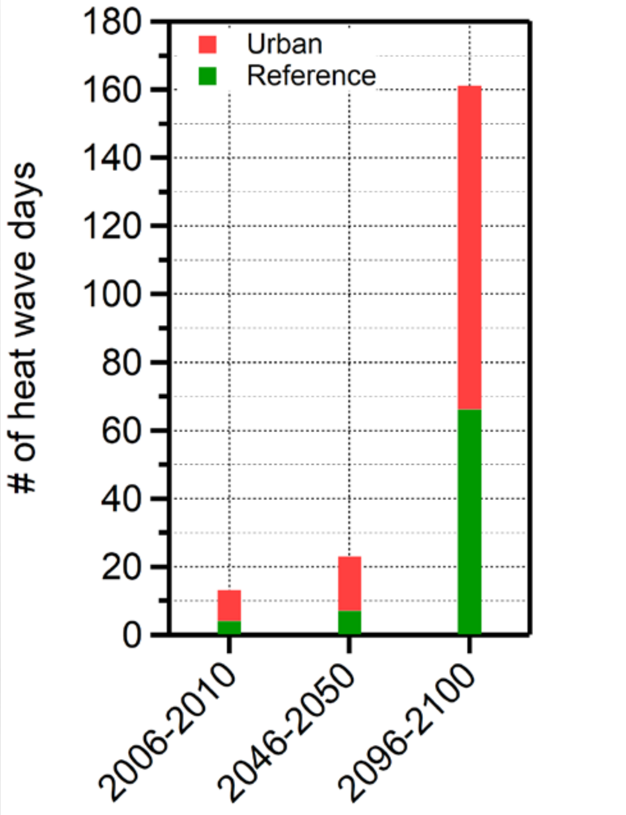


TAPP is **now** increased in **urban** areas early in the morning during summertime **by +3-4°C** comparing to the **surrounding** areas.

Considering **no changes** in the future over the **urban landscape/structure**:

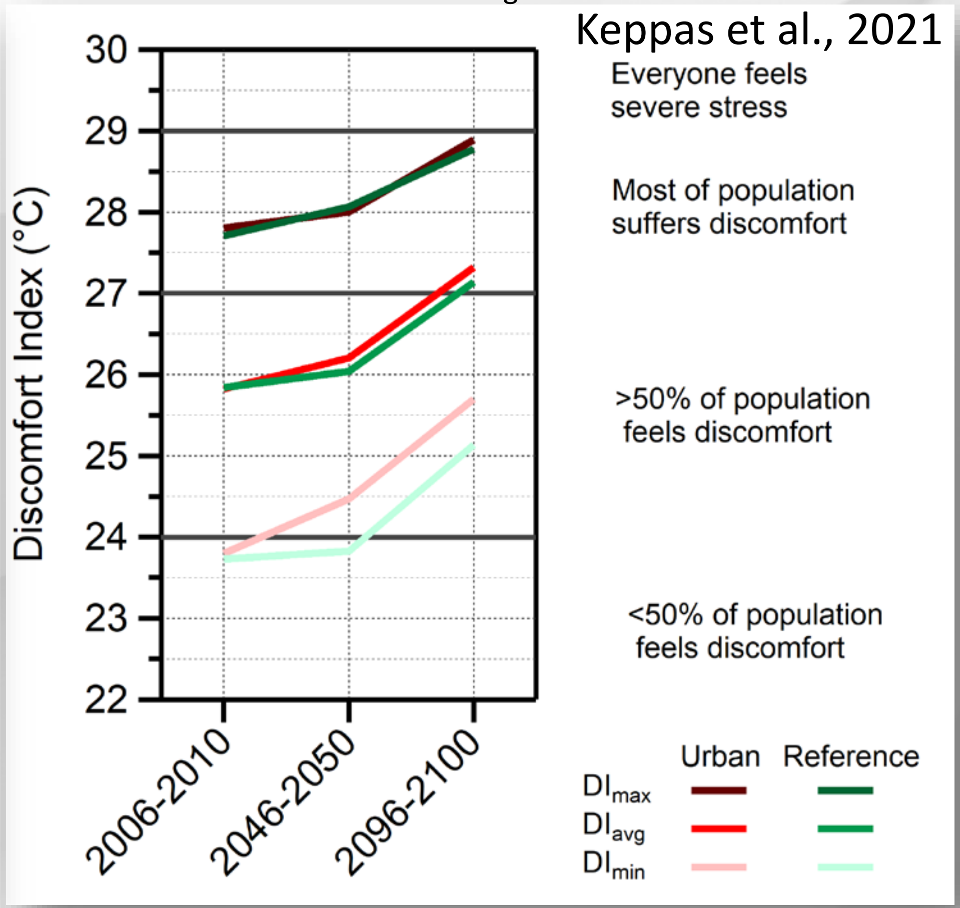
- There is a clear **extra stress** in the city of **Rome** as TAPP will increase by 2100 **by 0.5°C more** than the surrounding areas
- City of Thessaloniki will experience an increase in TAPP by **0.5-1°C less than surrounding areas** by 2100, but TAPP will **still be higher** in the urban area.

LIFE ASTI – Future Projection Results



Keppas et al., 2021

Mean DI_{min}, DI_{avg} and DI_{max}



$$DI = T – 0.55 (1 – 0.01 RH) (T – 14.5)$$

Thessaloniki (Urban)
Altitude: 33m
Land Use: Continuous Urban Fabric
Co-ordinates: 40.618, 22.956

Michaniona (Reference)
Altitude: 33m
Land Use: Agricultural Area
Co-ordinates: 40.618, 22.956

HEAT WAVE DAYS (HWD)

The criteria:

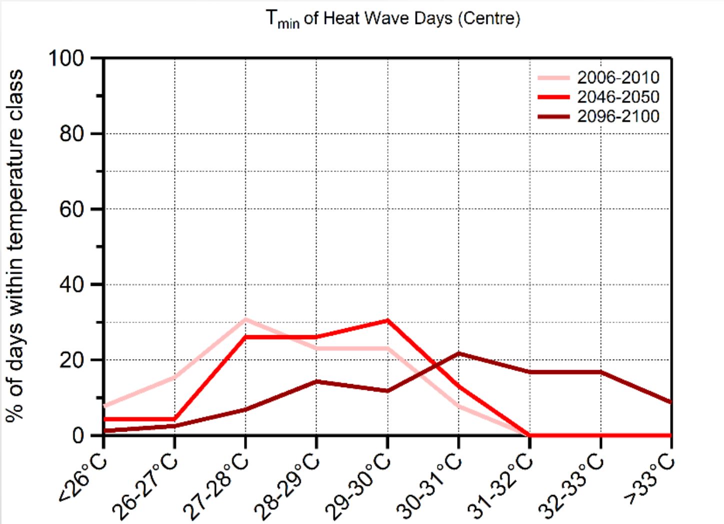
- $T_{max} \geq 37°C$
- $T_{avg} \geq 31°C$

(Metaxas, 1980)

LIFE ASTI – Future Projection Results

T_{min}

URBAN



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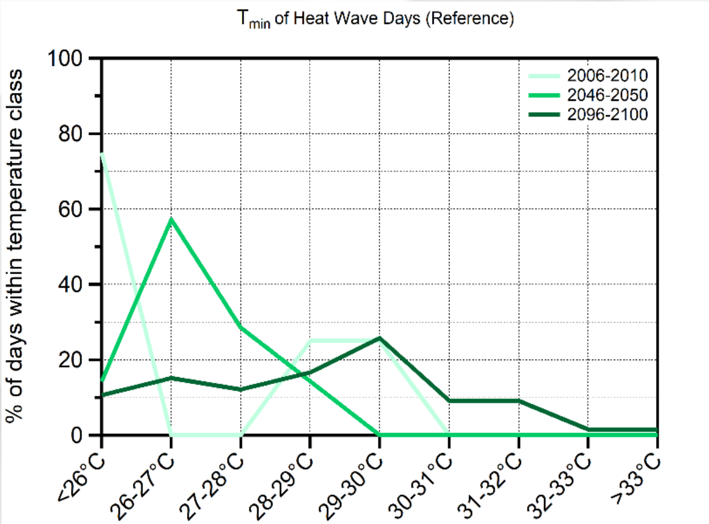

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- T_{min} in Urban will be exceeding 30°C in 63% of the HWDs in 2100 comparing to today (8%) and 2050 (13%).
- T_{min} in Reference will be exceeding only in 2100 in 20% of the HWDs.

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