Developing a EO-based Service for Real-time Monitoring of Urban Temperatures

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Thermal Urban Environment

BEYOND

Centre of Excellence for

EO-based monitoring of Natural Disasters

Fires & Floods

Urban heat waves

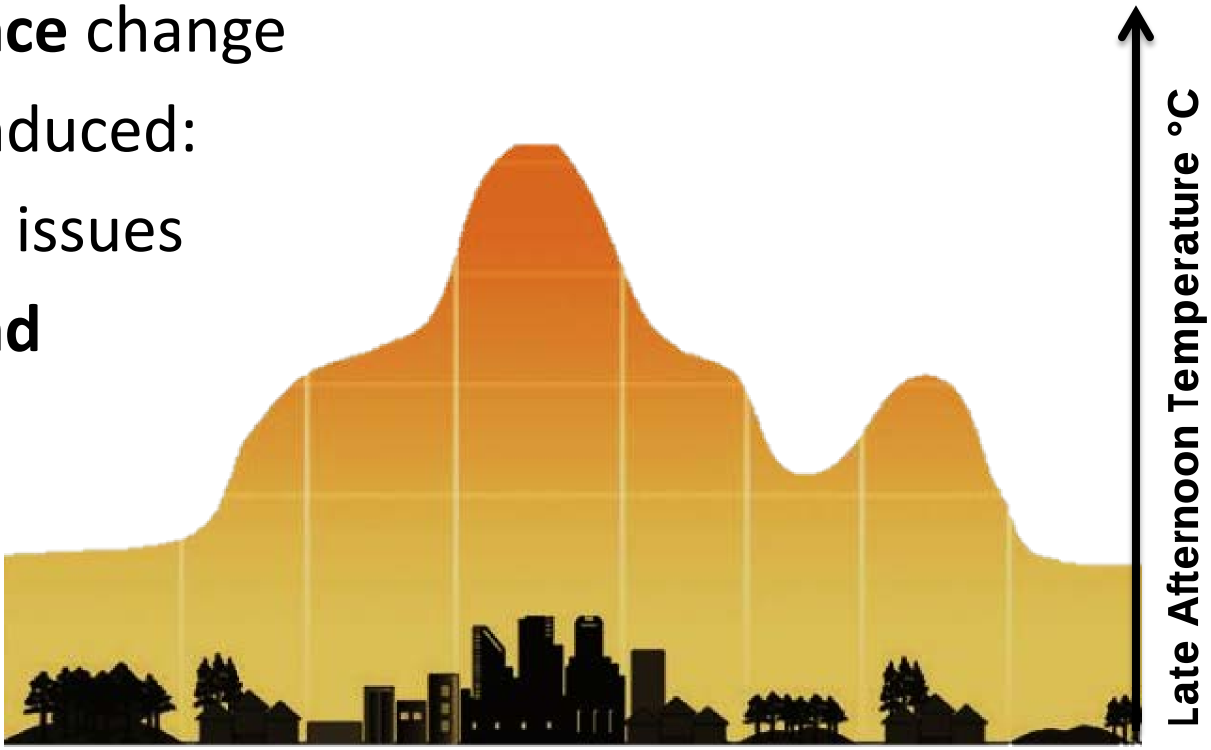
Geophysical hazards

Atmospheric & Weather related disasters

Thermal Urban Environment

The problem we are addressing:

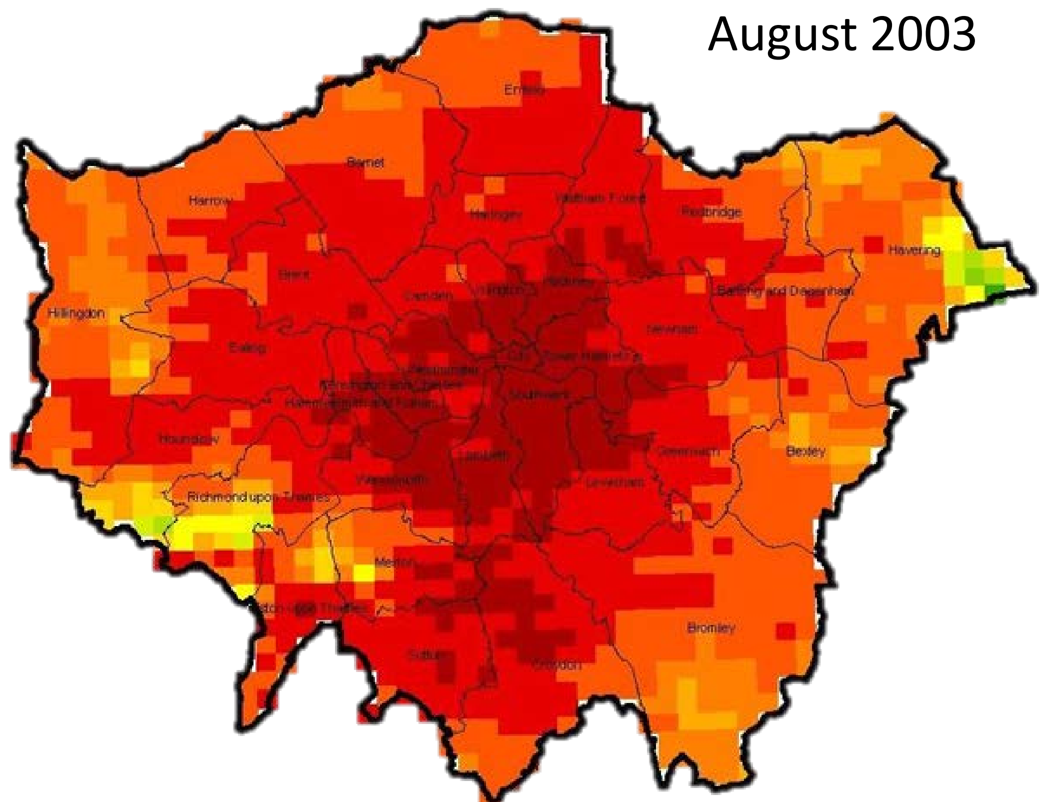
- **Surface Urban Heat Island (SUHI)** effect
- Urban **heat balance** change
- Adverse effects induced:
  - **Health** related issues
  - **Energy demand**



Basic Spatial Features of SUHIs:

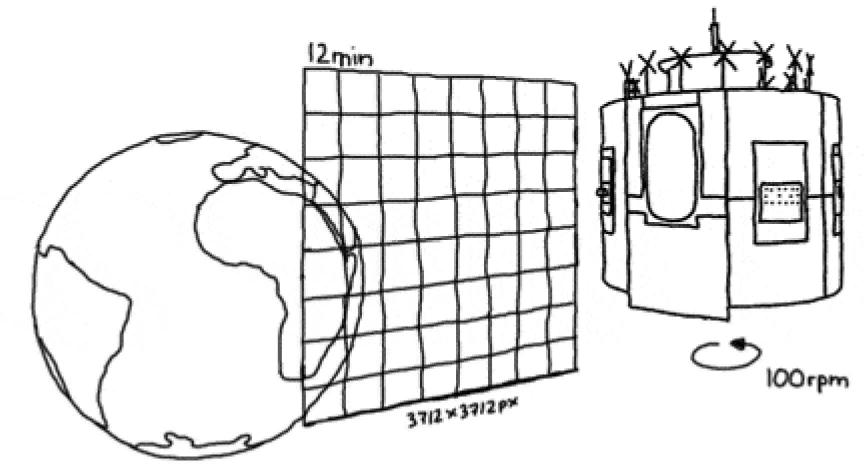
- Intensity
- Spatial Extent
- Orientation
- Centroid

London LST,
August 2003



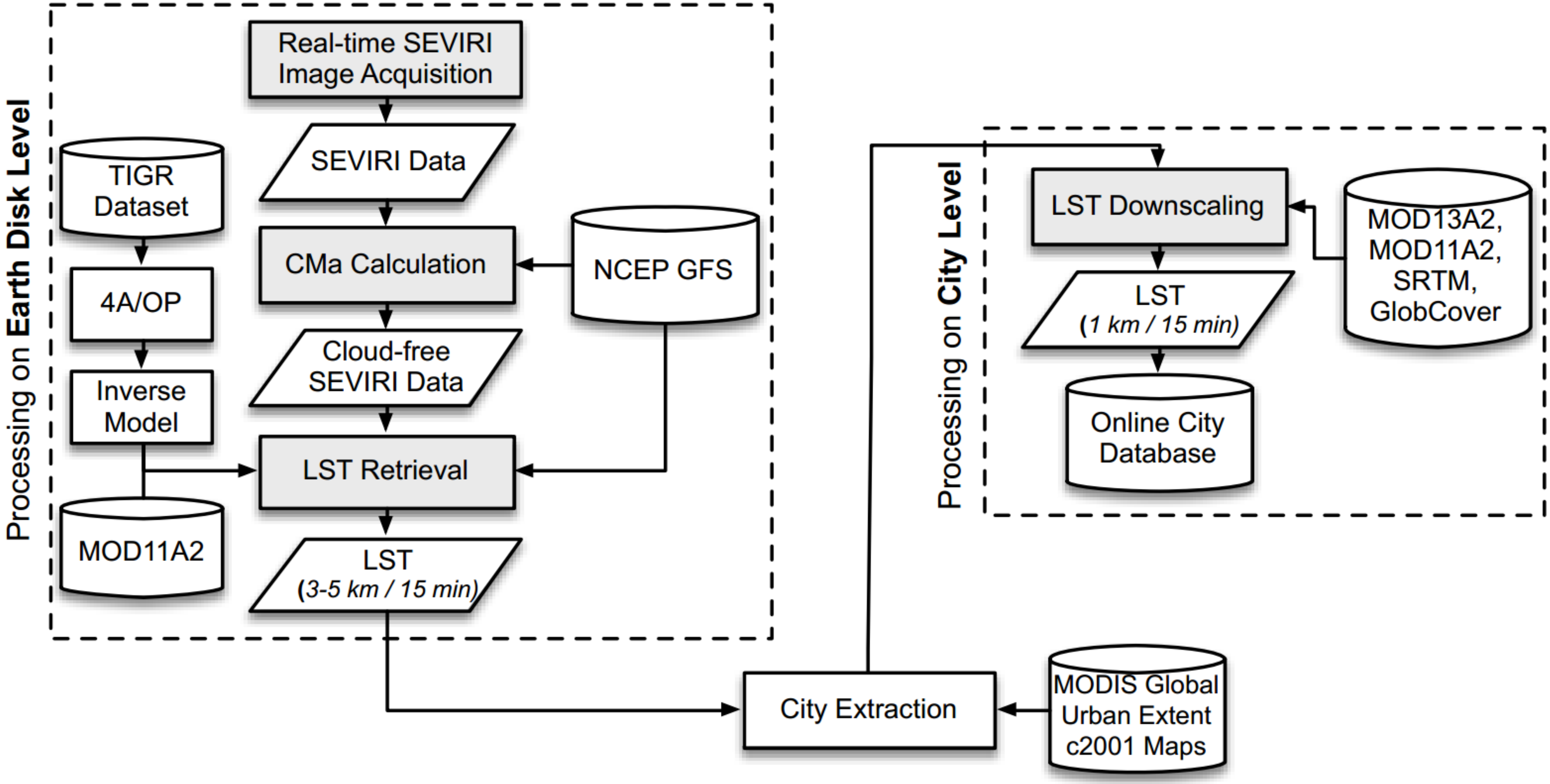
MSG2-SEVIRI

- **Geostationary** Satellite
- **4 VNIR** and **8 IR** Spectral Bands
- **3-5 km** Spatial Resolution
- **15 min** Temporal Resolution



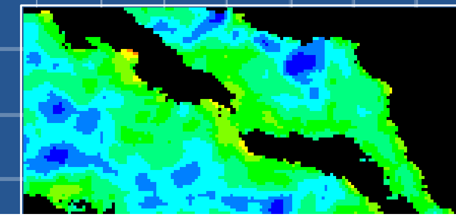
Urban heat waves in BEYOND

The System's Workflow



Land Cover

- Agriculture
- Urban
- Vegetation



Fine scale (1km)

Component **fine**

Coarse scale (3km)

Component **coarse**

Downscaling Geostationary Land Surface Temperature Imagery for Urban Analysis

Iphigenia Keramitsoglou, *Member, IEEE*, Chris T. Kiranoudis, and Qihao Weng, *Member, IEEE*

***Abstract*—Although Earth observation data have been used in urban thermal applications extensively, these studies are often limited by the choices made in data selection, i.e., either using data with high spatial and low temporal resolution, or data with high temporal and low spatial resolution. The challenge of advancing the low spatial (3–5 km) resolution of geostationary land surface temperature (LST) images to 1 km—while maintaining the excellent temporal resolution of 15 min—is approached in this letter. The downscaling was performed using different advanced regression algorithms, such as support vector regression machines, neural networks, and regression trees, and its performance was improved using gradient boosting. The methodologies were tested on Meteosat Second Generation (MSG) SEVIRI LST images over an area of 19 600 km^2 centered in Athens, Greece. The output 1-km downscaled LST images were assessed against coincident LST maps derived from the thermal infrared imagery of the Moderate Resolution Imaging Spectroradiometer, the Advanced Very High Resolution Radiometer, and the Advanced Along Track Scanning Radiometer. The results showed that support vector machines coupled with gradient boosting proved to be a robust high-performance methodology reaching correlation coefficients from 0.69 to 0.81 when compared with the other satellite-derived LST maps.**

***Index Terms*—Boosting, Earth observing system, support vector regression machines (SVR), temperature measurement, urban areas.**

I. Introduction

As HUMANS alter the characteristics of the natural landscape in the urbanization process, they affect and impact local energy exchanges that take place within the atmospheric boundary layer. The impact may be of a local, a regional, or a global scale, depending on the size of the area affected

These measurements provide essential data for analyzing urban thermal landscape patterns and their relationship with surface biophysical characteristics, assessing the surface urban heat island (SUHI) effect and relating LST with surface heat fluxes for characterizing landscape properties, patterns, and processes [2]. If the advantage of time-sequential observations of satellite sensors (and daytime and nighttime imaging) is considered, remote sensing data have great potential for studying the urban surface energy budget and the spatial pattern and temporal dynamics of urban thermal landscapes [2].

The LST distribution and the observed SUHIs have been studied [3] using mostly satellite sensors of coarse spatial resolution, such as Advanced Very High Resolution Radiometer (AVHRR) on board National Oceanic and Atmospheric Administration platforms or Moderate Resolution Imaging Spectroradiometer (MODIS) on board Terra and Aqua satellites. At medium spatial resolution (∼100 m), Thematic Mapper (TM) and Enhanced Thematic Mapper Plus (ETM+) on Landsat-5 and Landsat-7, respectively, and the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) on Terra provide sparse "snapshots" of the LST distribution due to the eight-day repeat cycle when both satellites were operational; however, these images provide a valuable insight into local-scale hot spots, which is particularly important to city planners. Nevertheless, their use in generating higher level products, such as time evolution of SUHIs and heat wave hazard zones delineation within a city, is limited. The geostationary-orbit thermal infrared sensors provide images of the Earth's disk from 36 000 km every 15 to 30 min, making them unique means for capturing the diurnal variability of SUHIs; however, their spatial resolution of 3–5 km has prohibited their extensive use

Urban Areas Coverage

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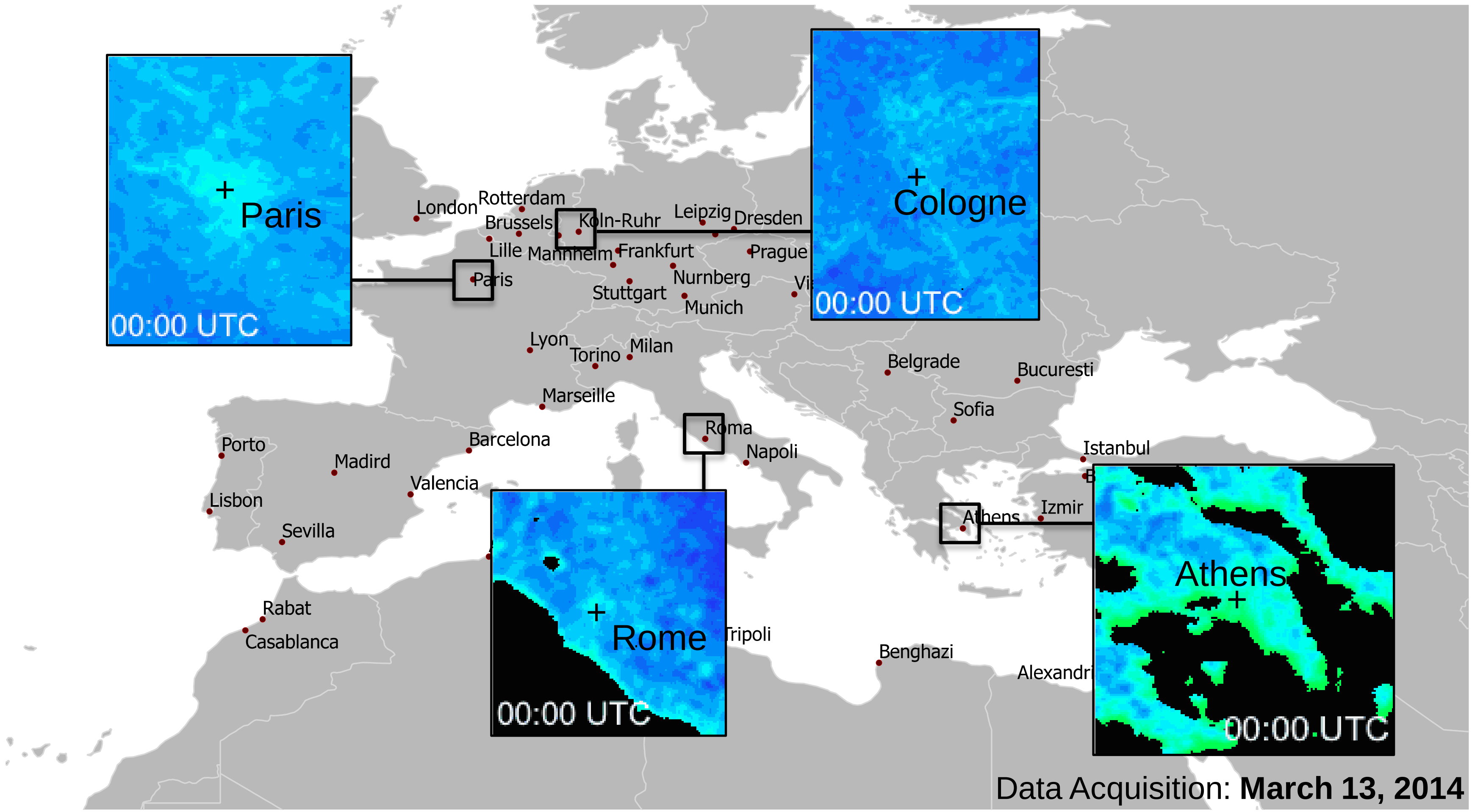
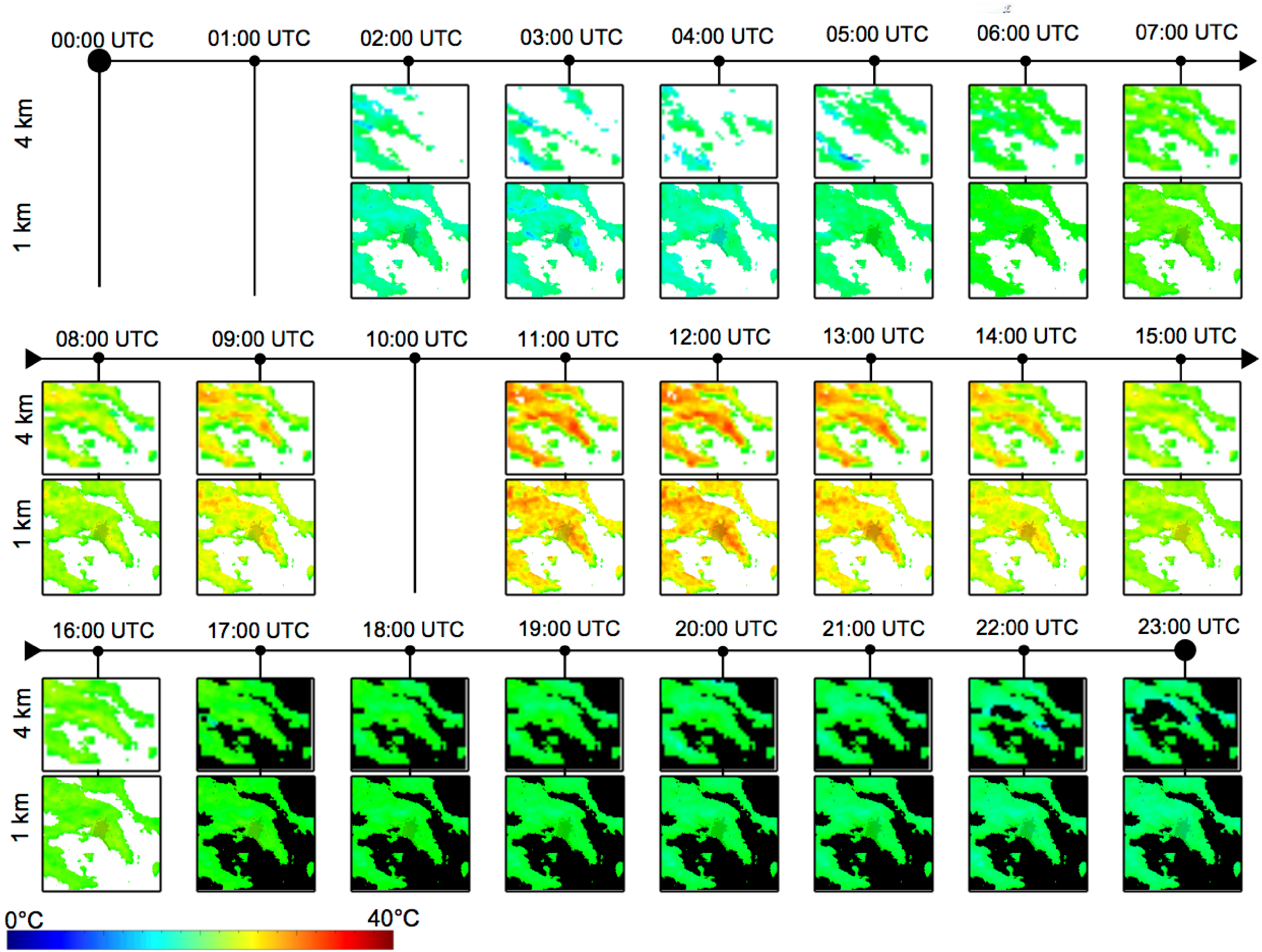
System's Output



Data Acquisition: **March 13, 2014**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21:00 UTC
22:00 UTC
23:00 UTC
4 km
1 km
0°C
40°C

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Performance **Assessment*** [Ongoing]

At 3-5 km – Comparison with LandSAF LST data						
	Athens	Paris	Rome	Istanbul	Madrid	**ALL**
Mean Difference	-0.66°C	-0.15°C	-0.14°C	-0.43°C	-0.89°C	**-0.45°C**
Correlation	99.8%	99.6%	99.7%	99.6	99.9%	**99.6%**

At 1 km – Comparison with MODIS LST data					
	Paris	Rome	Istanbul	Madrid	**ALL**
Mean Difference	+0.84°C	-0.14°C	+0.52°C	+0.56°C	**+0.45°C**
Correlation	67.0%	80.0%	52.2%	75.1%	**68.6%**

[***For June 2014.**]

What this system offers?

- This system can provide **LST data** that **combine high temporal** and **spatial resolution** for **monitoring** the **SUHI** effect.
- The **optimized exploitation** of the data t**ailored** for different purposes/applications/end-users.

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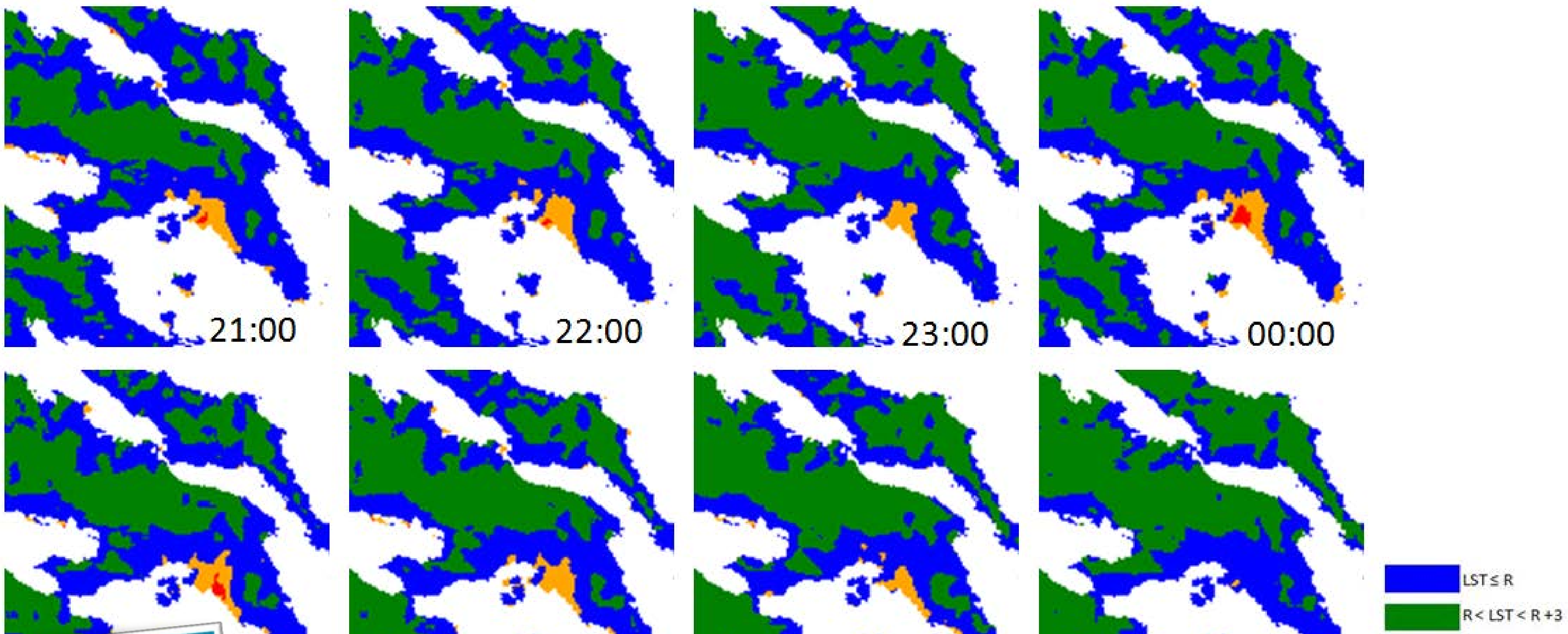
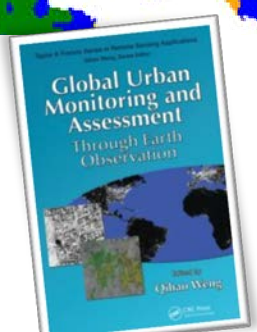
Surface UHI





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In Weng, Q. editor. **Global Urban Monitoring and Assessment through Earth Observation,** Chapter 13. Boca Raton, FL: CRC Press/Taylor and Francis. In press.

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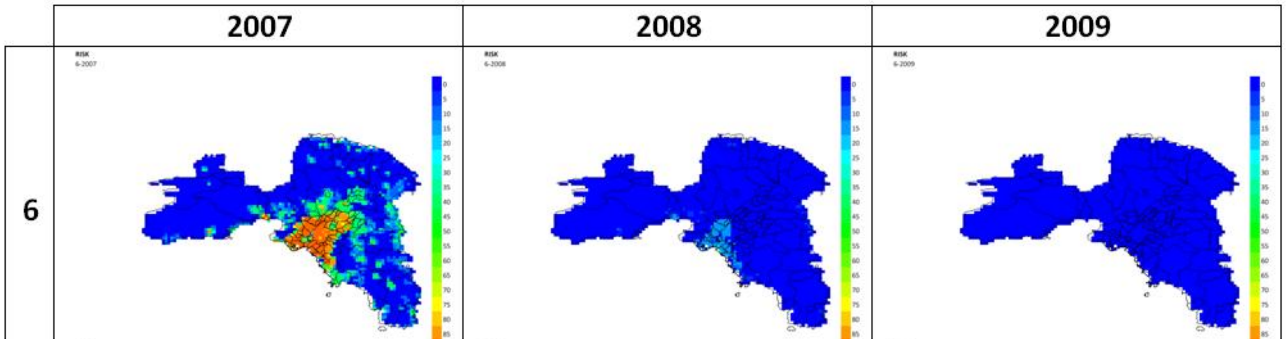
Monthly Heat Wave Risk



Environ Monit Assess
DOI 10.1007/s10661-013-3170-y

Heat wave hazard classification and risk assessment using artificial intelligence fuzzy logic

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Bino Maiheu · Koen De Ridder · Ioannis A. Daglis ·
Paolo Manunta · Marc Paganini

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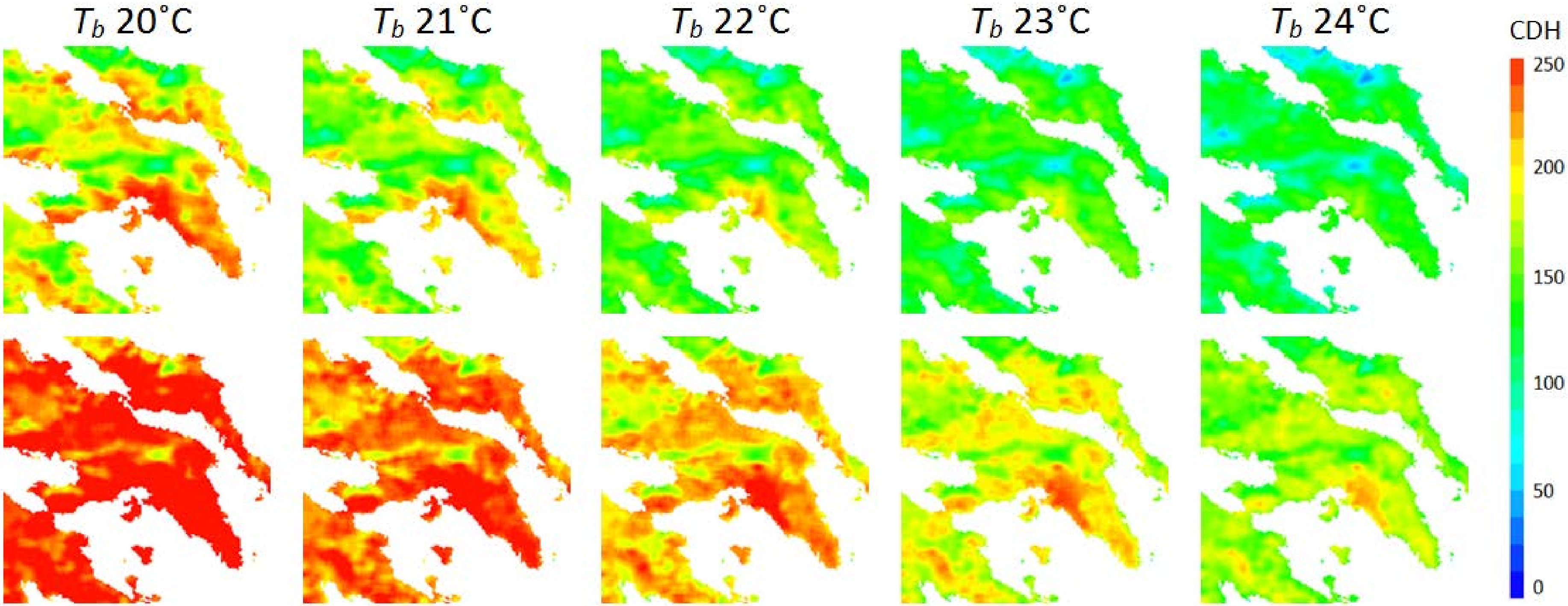
Cooling Degree Hours



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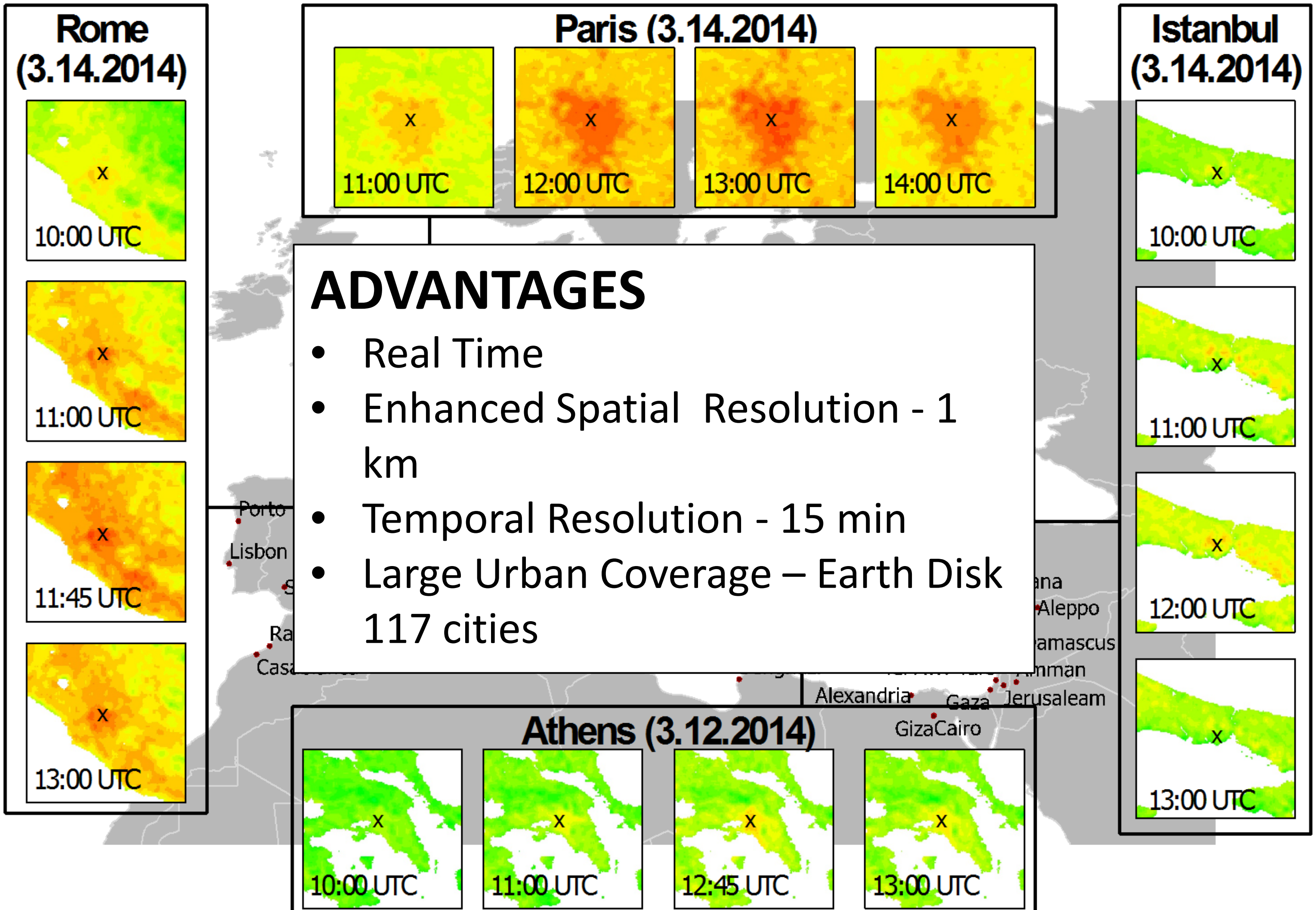

ADVANTAGES

- Real Time
- Enhanced Spatial Resolution - 1 km
- Temporal Resolution - 15 min
- Large Urban Coverage – Earth Disk 117 cities

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To find more details visit:

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