WORKSHOP
CTMR 2015 - Color in Texture and Material Recognition

Analysis of albedo influence on surface urban heat island by spaceborne detection and airborne thermography

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Introduction

The detection of the surface urban heat island (SUHI) and the identification of the surface thermal and optical properties (albedo, in particular, which is a measure of a surface capacity to reflect solar radiation, and it is consequently connected with the surface temperatures) play a crucial role on the definition of cities microclimate, together with the monitoring of their evolution.

Satellite data fulfill the requirements of wide territory covering and availability of information relative to different periods; on the other hand, the resolution for the bands necessary for thermal analyses is around 100 m. This circumstance opens the theme of the detailed recognition and classification of materials constituting the urban texture.

The work proposes a comparison of satellite data with airborne infrared thermography images, characterized by a higher resolution (up to 1 m); the strengths and weaknesses of both methods are analyzed, and the correlation between the satellite retrieved surface albedo and the SUHI is investigated.

Description of data recovery

Landsat (TM) data

The Landsat Thematic Mapper (TM) sensor is composed by seven bands, six of them (TM1-5, TM7) in the visible, near infrared (NIR) and short-wavelength infrared (SWIR), and one band (TM6) in the thermal infrared (TIR) region.
TM has a native spatial resolution of 30 m for the six reflective bands and 120 m for the thermal band.

Landsat TM data were processed and calibrated in order to convert digital number values to at-sensor spectral radiance values and then to at-sensor reflectances for the reflective bands. Finally, an atmospheric correction was carried out to obtain at-surface reflectivities.

Airborne data

The airborne measurements were carried out by a research aircraft, with a thermal camera installed onboard, producing images of brightness temperature in the TIR region (7.5-13.0 μm).

Each thermal image has a resolution of 320 × 240 pixels with a nadir pixel size of about 1 m.

Description of data recovery

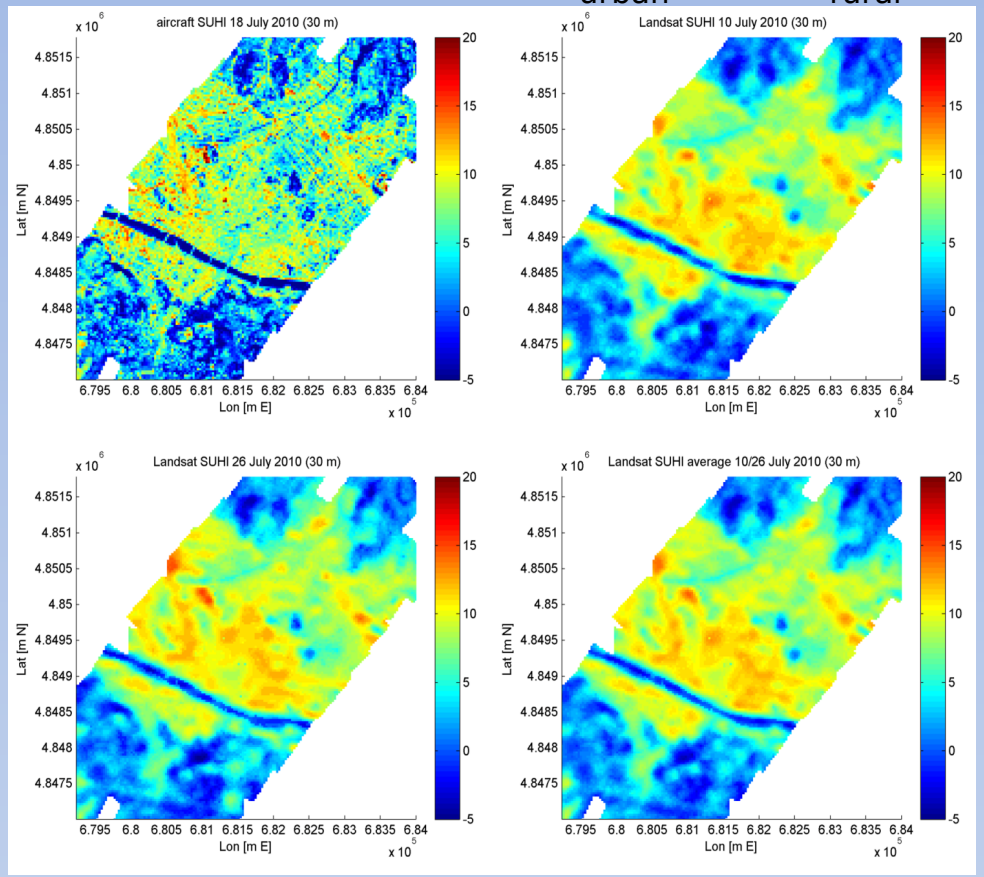
Florence - Area covered by the flight

Surface Urban Heat Island assessment

The SUHI intensity is a parameter used to quantify the urban heating effects: it is defined as the difference in surface temperature between the urban pixels and the surrounding rural areas, used as an average reference, within a given time period:

$$SUHI = LST_{urban} - LST_{rural}$$

The trends of the surface urban heat island pattern result similar.



Clear differences emerge in the detailed definition due to the different spatial resolution of the satellite and airborne sensor acquisitions

LST from the satellite thermal channel can be considered reliable to evaluate, for instance, the presence and the pattern of the SUHI over a wide urban area: however, it smoothes the heat discontinuities at a finer scale and it is not adequate to resolve details over a complex urban texture.

Albedo

Since the satellite sensor provides data on seven bands, it is possible to use five of them to retrieve the shortwave albedo, as described by Liang relation:

$$\alpha = 0.356\alpha_1 + 0.130\alpha_3 + 0.373\alpha_4 + 0.085\alpha_5 + 0.072\alpha_7 - 0.0018$$

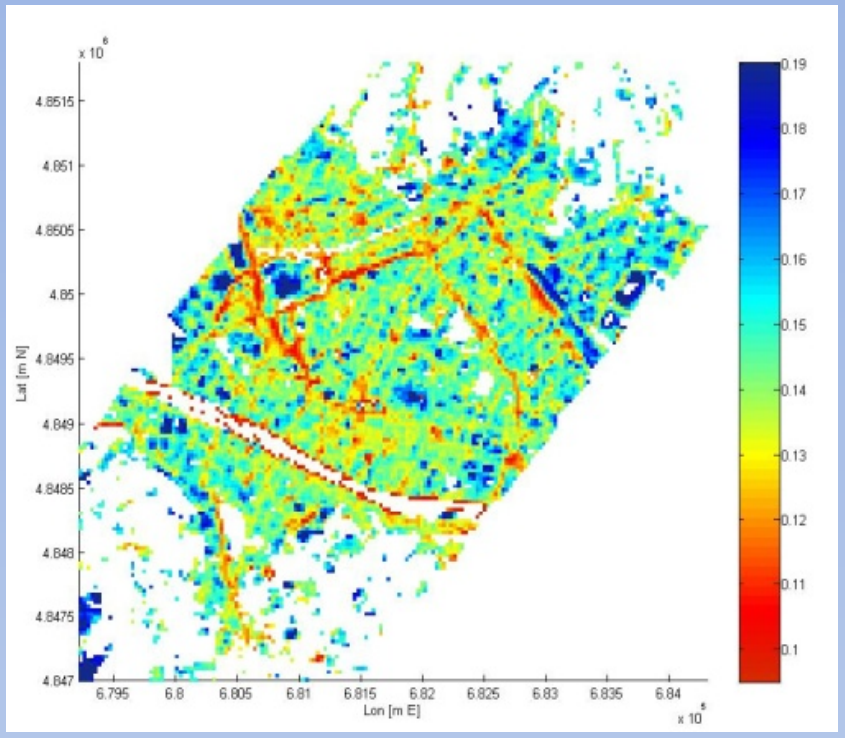
Surface albedo is defined as the ratio between the reflected flux density and the incident flux density at the surface level.

It represents one of the most influent input parameters in the regulation of the city environment thermal balance.

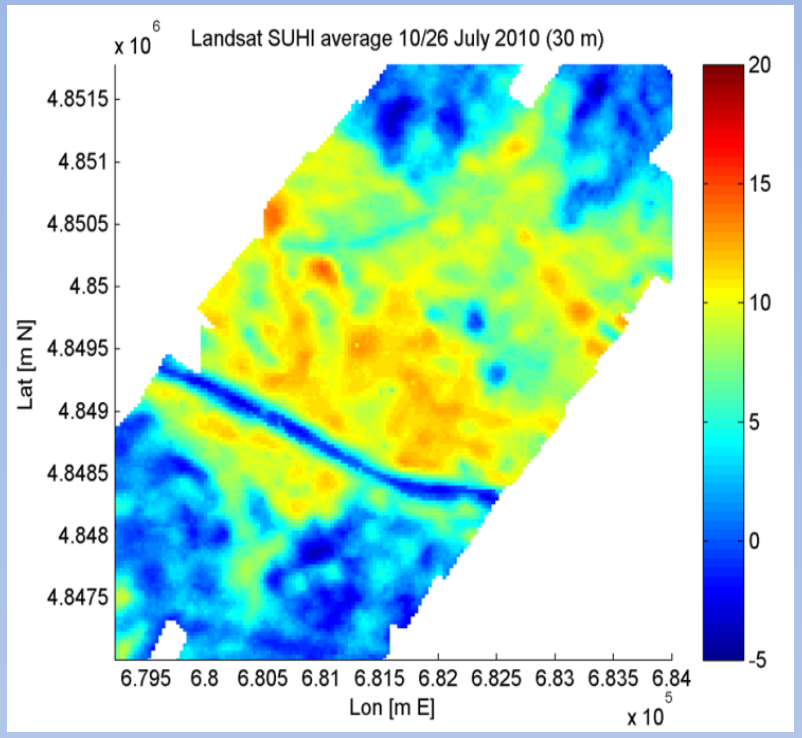
The presence of wide surfaces characterized by a high level of solar radiation absorption (low albedo) within city textures, seems linked to the SUHI effect increase.

it results interesting to compare the maps of SUHI (both the Landsat and the airborne ones) with albedo maps, looking for eventual correlations

Albedo



Albedo



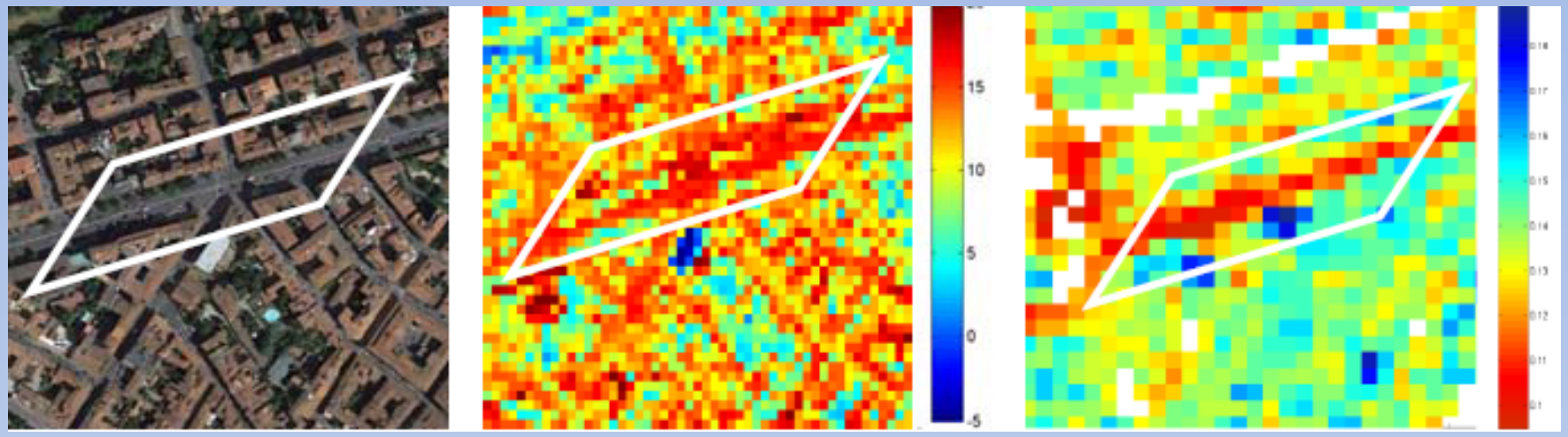
SUHI

The patterns result quite correlated (low albedo means higher temperature), confirming the albedo influence on SUHI, mainly because of the large presence of absorptive roofs and surfaces such as asphalt parking lots, roads, squares and pavements

Albedo

Comparison of spaceborne detected albedo with high definition airborne IR thermography

Asphalt road



Visible

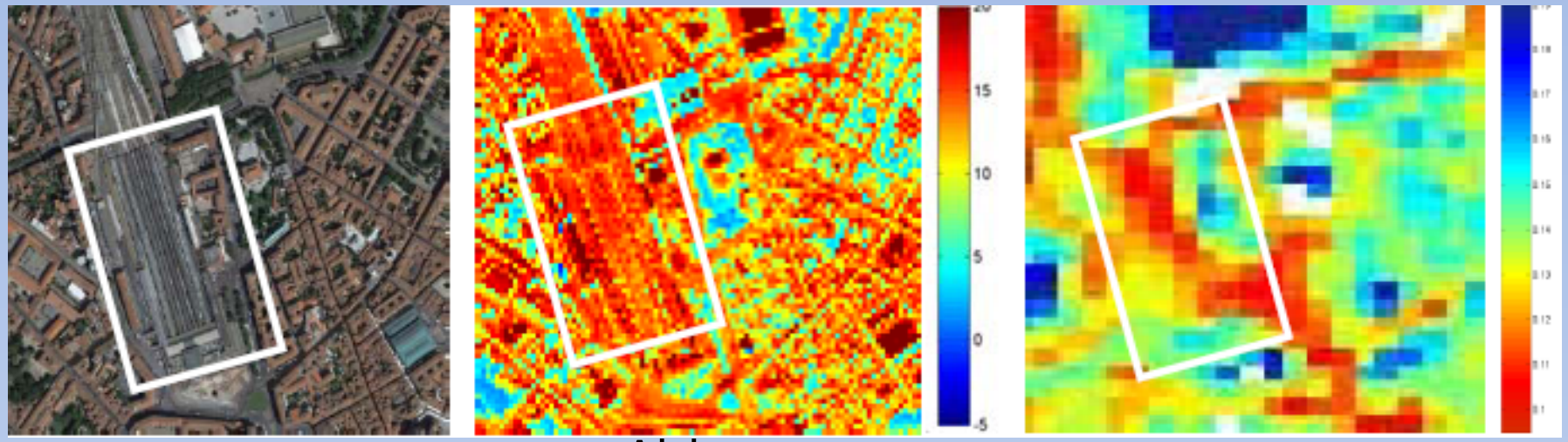
Airbone IR

Satellite

Albedo

Comparison of spaceborne detected albedo with high definition airborne IR thermography

Platform roof of Santa Maria Novella railway station



Visible

Airbone IR

Satellite

Albedo

The satellite albedo succeeds on detecting the noteworthy wide parts of the urban texture, as well as the high resolution IR thermography.

Overall, to recognize the thermal details within a urban environment the airborne image is obviously better than the satellite one, even though the spaceborne detection has already proven as un useful tool to detect large scale SUHI.

The future availability of spaceborne observations with higher spatial resolution at the visible, NIR and SWIR bands would allow to perform albedo analysis at a finer spatial scale.

It will be therefore possible to provide details that today are not distinguishable at the 30 m satellite resolution, detailing up to the single roof.

Conclusions

Peculiar surface properties such as the surface temperature and albedo, occupy a key position in the material classification and recognition in a urban texture.

The work points out the possibility to detect construction materials absorbing solar radiation (low albedo) and exposed to thermal effects (SUHI increase).

The availability of an airborne thermal image and of both thermal and reflective images from satellite over the city of Florence allowed to correlate the absorption and thermal characteristics of particular areas within a urban texture, and to analyze the role of the sensor spatial resolution.

Even if the current 30 m pixel size of the satellite data seems to be suitable for the construction material classification, the hoped-for availability of observations with higher spatial resolution would allow to perform albedo recognition at a finer scale. In fact, although aircraft surveys ensure a 1 m pixel size, they result sporadic, area-limited and expensive.