

Analysis of temperature maps of water bodies obtained from ASTER TIR images

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1. Introduction

The importance of remote sensing imagery in the thermal infrared (TIR) spectral region is well known since many years in the international scientific community.

The ASTER sensor is, currently, the main radiometer that acquires in the TIR region (8.125 - 11.65 μm) with a spatial resolution of 90 meters.

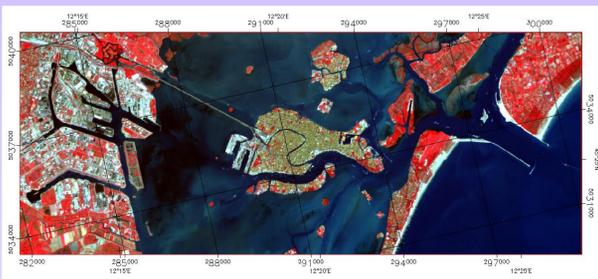


The purpose of this work is to develop a working methodology for the analysis of water temperature obtained from ASTER images. These analysis are aimed in particular at the monitoring of industrial effluents in reference to the limits of the law in force in Italy (Legislative Decree 152 of 2006).

Images were initially processed with an algorithm that improves the spatial resolution. Thus another purpose is to assess the effectiveness of this algorithm

2. Data set

Venice Lagoon, 05/09/2007, acquired from ASTER sensor. This image include also the industrial area of Porto Marghera (on the left).

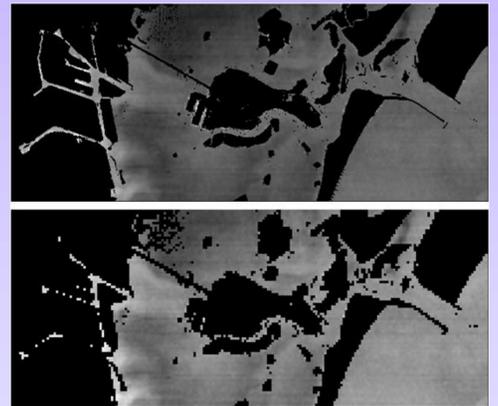


3. Pre-processing

- Application of the algorithm that improve the spatial resolution [Teggi, *in press*] from 90 to 30 meters, using information from the Visible-Near Infrared (VNIR) ASTER bands;

- Division of the three main classes of land cover : water, soil and vegetation (or not-water).

Venice image divided into water and not-water at 30 m (above) and 90 m (below)



4. Elaboration

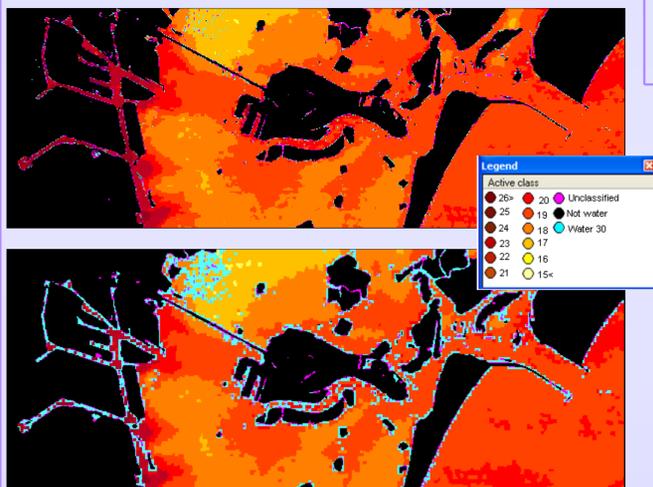
Three different procedures were developed:

- Study of water temperature in the lagoon;
- Study of the canals in Porto Marghera;
- Temperature profile near the coastline.

For each point, different procedures were developed. We are currently running tests with data obtained from fixed stations in the lagoon and provided by MAV (Magistrato delle Acque di Venezia)

4.1 Water temperature

Object oriented classification of the image at 30 and 90 m. Extraction of the size (square kilometers) of the different classes.



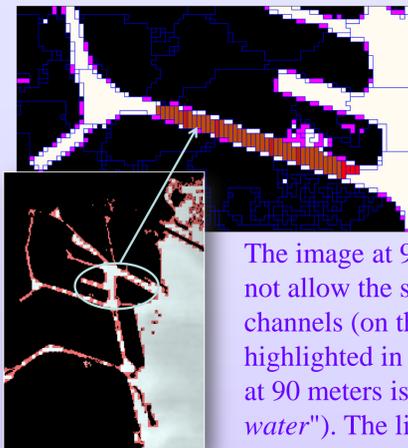
Class	Area (km ²)	
	30 m	90m
Water	78.5835	69.6339
Not water	52.1694	61.119
Unclassified	5.3721	5.3721
Total area	136.125	136.125

Above the image at 30 m and below at 90 m. The color cyan highlights what at 90 m is identified as "not-water" while at 30 m is "water". Tables show areas of different classes.

Class	Area (km ²)	
	30 m	90 m
Water at 30 but not at 90 m)	0	8.9496
<15	0.0018	0.1647
16	6.0606	4.9482
17	20.2716	19.224
18	41.0265	37.0836
19	7.1829	6.4395
20	2.034	1.3644
21-23	1.3374	0.4095
23-27	0.1116	0
27-30	0.0216	0

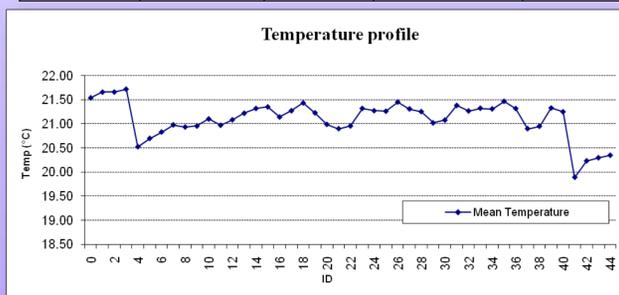
4.2 Canals

The channel is divided into sections normal to the axis, thus it is possible to calculate the average temperature of these sections.



The image at 90 m does not allow the study of channels (on the left is highlighted in red what at 90 meters is "not-water"). The limit value of 30 C for the max temperature is respected.

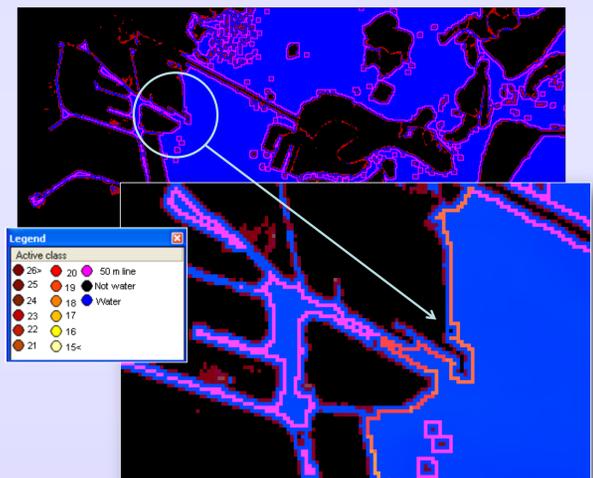
Sum Temp (C)	Mean Temp (C)	Std. Dev. Temp	Min Temp (C)	Max Temp (C)
1899.35	21.10	0.38	19.89	21.72



Statistical parameters calculated on the axis of the channel and the temperature profile along the axis

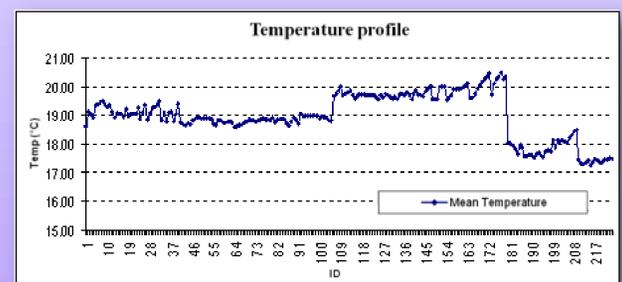
4.3 Coastline

A 50 meters away from the coast is identified (as required by Italian law). Then the line is segmented and classified with an object-oriented approach.



Above the image and the details of the line studied. Below the temperature profile and the statistical parameters. The limit value of 3 C for the last parameter is not respected.

Sum Temp (C)	Mean Temp (C)	Std. Dev. Temp	Min Temp (C)	Max Temp (C)	Max-Min Temp (C)
4252.02	18.98	0.78	17.23	20.49	3.26



5. Conclusions and future developments

- It has been tested the effectiveness and validity of the algorithm. It greatly improves the image particularly in rivers and along the coast;
- Automated procedures (easy to apply) have been developed to study the temperature of water bodies;
- Using the procedures developed, statistical parameters and graphs are extracted easily to verify compliance with the legal limits;
- With maps of temperature, industrial discharges can be identified (especially in channels) ;
- A critical aspect is the lack of ground truth data: it has however been requested, thus as soon as possible we will proceed to the comparison;
- The procedures will be soon applied to a wider range of images: the first application will be on the Po Delta to study the effectiveness of the algorithm in the analysis of rivers of various widths [Cherkauer *et al*, 2005]

6. References

- S. Teggi, *Temperature of coastal waters and of watercourses from ASTER images*, In press
- K. A. Cherkauer, S. J. Burges, R. N. Handcock, J. E. Kay, S. K. Kampf, and A. R. Gillespie, *Assessing satellite-based and aircraft-based thermal infrared remote sensing for monitoring pacific northwest river temperature*, Journal of the American Water Resources Association, 41(5):1149-1159, 2005.
- EC, *Water framework directive (2000/60/ec)*, Official Journal (OJ) of the European Union, 327:1-73, 2000.