

“Il telerilevamento (da aereo o da satellite) per
la mappatura delle caratteristiche ambientali
della superficie terrestre e delle loro
variazioni nello spazio e nel tempo”
(parte2)

04 Aprile 2017
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Scopo dell'analisi di immagine:

interpretazione

finalizzata allo studio e la comprensione della superficie,
cioè alla natura e significato degli elementi che la
compongono

Immagine Google Earth Delta del Po



Immagini satellitari utilizzabili *free-of-charge*

Landsat7 ETM+ (1999)

Landsat 8 OLI (2013)

ASTER (1999)-Advanced Spaceborne Thermal Emission and Reflection radiometer

Sentinel 2a (2015)

Criteri di scelta delle immagini satellitari

- Immagini con caratteristiche opportune rispetto all'obiettivo perseguito
- Disponibilità dati *free-of-charge* o a basso costo

website → <http://earthexplorer.usgs.gov/> (accessibile con registrazione)

Search Criteria Data Sets Additional Criteria Results

4. Search Results

If you selected more than one data set to search, use the dropdown to see the search results for each specific data set.

Note: You must be logged in to download and order scenes

Show Result Controls

Data Set [Click here to export your results](#)

L7 ETM+ SLC-on (1999-2003)

65		Entity ID:LE719102919993228G900 Acquisition Date:18-NOV-99 Path:191 Row:29
66		Entity ID:LE71920291999313EDC00 Acquisition Date:09-NOV-99 Path:192 Row:29
67		Entity ID:LE71920291999281EDC00 Acquisition Date:09-OCT-99 Path:192 Row:29
68		Entity ID:LE71910291999274AG801 Acquisition Date:01-OCT-99 Path:191 Row:29
		Entity ID:LE71920291999249AG801 Acquisition Date:06-SEP-99

Search Criteria Summary (Show) Clear Criteria

Mapo Satellite

(46° 17' 25" N, 007° 42' 05" E) Options Overlays

Google

The up-to-date Google map is not for purchase or for download; it is to be used as a guide for reference and search purposes only.

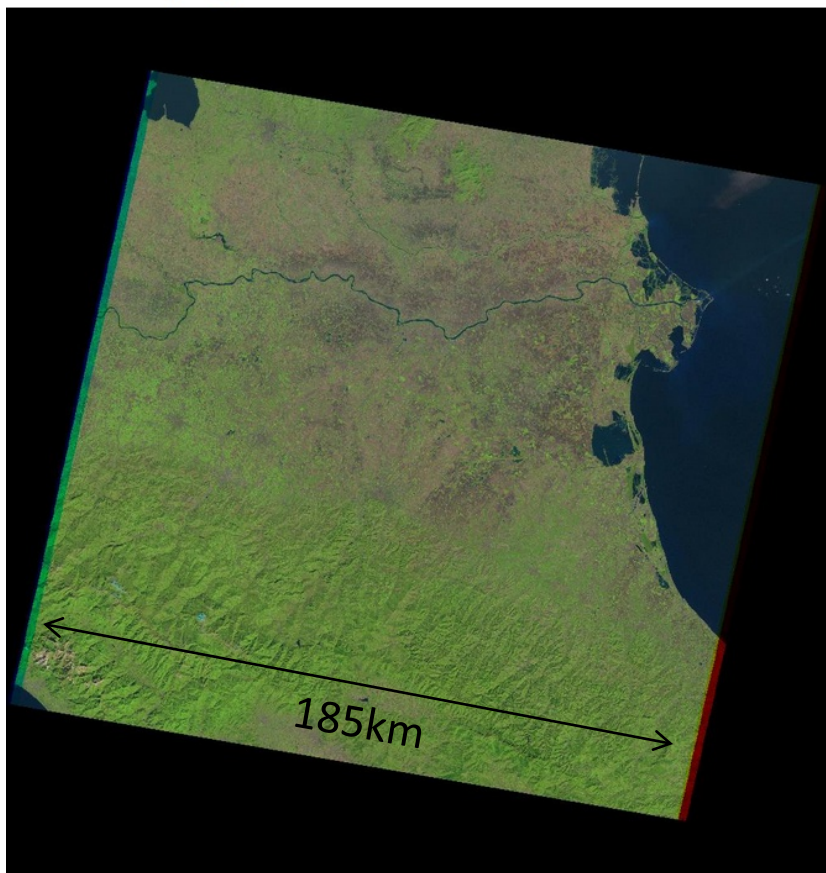
Data Set Attribute	Attribute Value
Landsat Scene Identifier	LE71920291999281EDC00
Sensor Mode	N/A
Station Identifier	EDC Sioux Falls, South Dakota, USA (aka LGS)
Day/Night	DAY
WRS Path	192
WRS Row	029
Date Acquired	1999/10/08
Start Time	1999-281:09:51:34.6840403
Stop Time	1999-281:09:52:01.5678750
Date L1 Generated	2014/12/11
Image Quality VICID 1	9
Image Quality VICID 2	9
Processing Software Version	LPGS_12.5.0
Calibration Parameter File	L7CPF19991001_19991123.18
Cloud Cover	0.02
Cloud Cover Quad Upper Left	0.01
Cloud Cover Quad Upper Right	0.01
Cloud Cover Quad Lower Left	0.05
Cloud Cover Quad Lower Right	0.01
Sun Elevation	37.2040291
Sun Azimuth	157.9336395

Landsat Archive

- L8 OLI/TIRS
- L8 OLI/TIRS Pre-WRS-2
- L7 ETM+ SLC-off (2003-present)
- L7 ETM+ SLC-on (1999-2003)
- L7 ETM+ Intl Ground Stations (Search Only)
- L4-5 TM
- L1-5 MSS

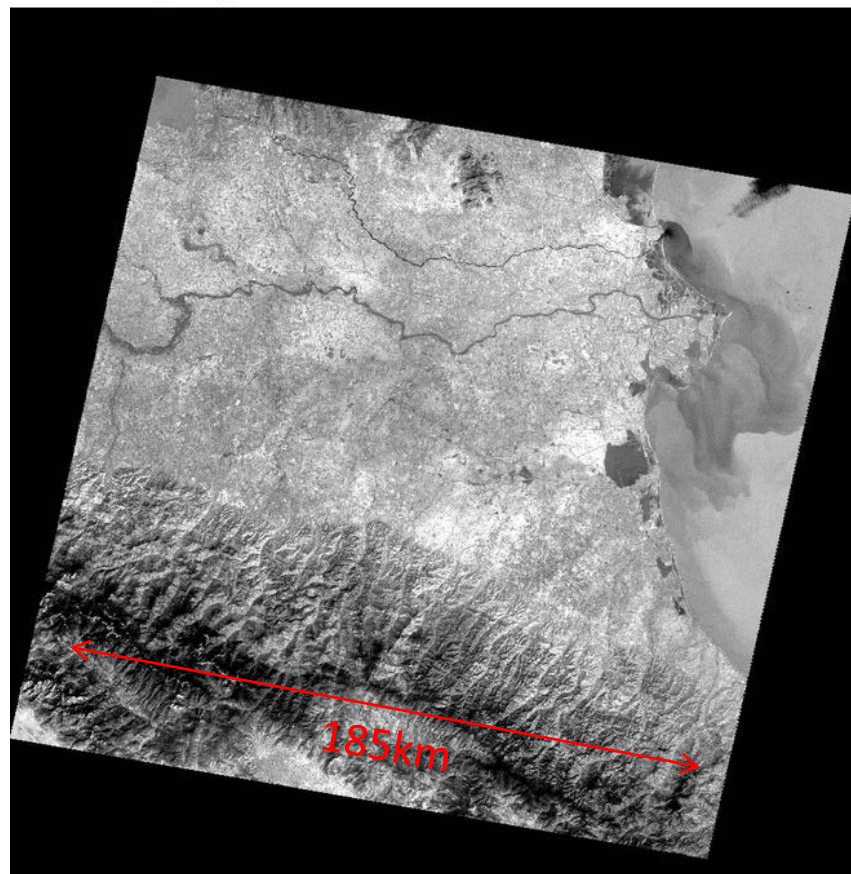
Immagine satellitare Landsat7 ETM+ Pianura Padana

Full Display of LE71920291999281EDC00



Colori «« naturali »»

Full Display of LE71920291999281EDC00

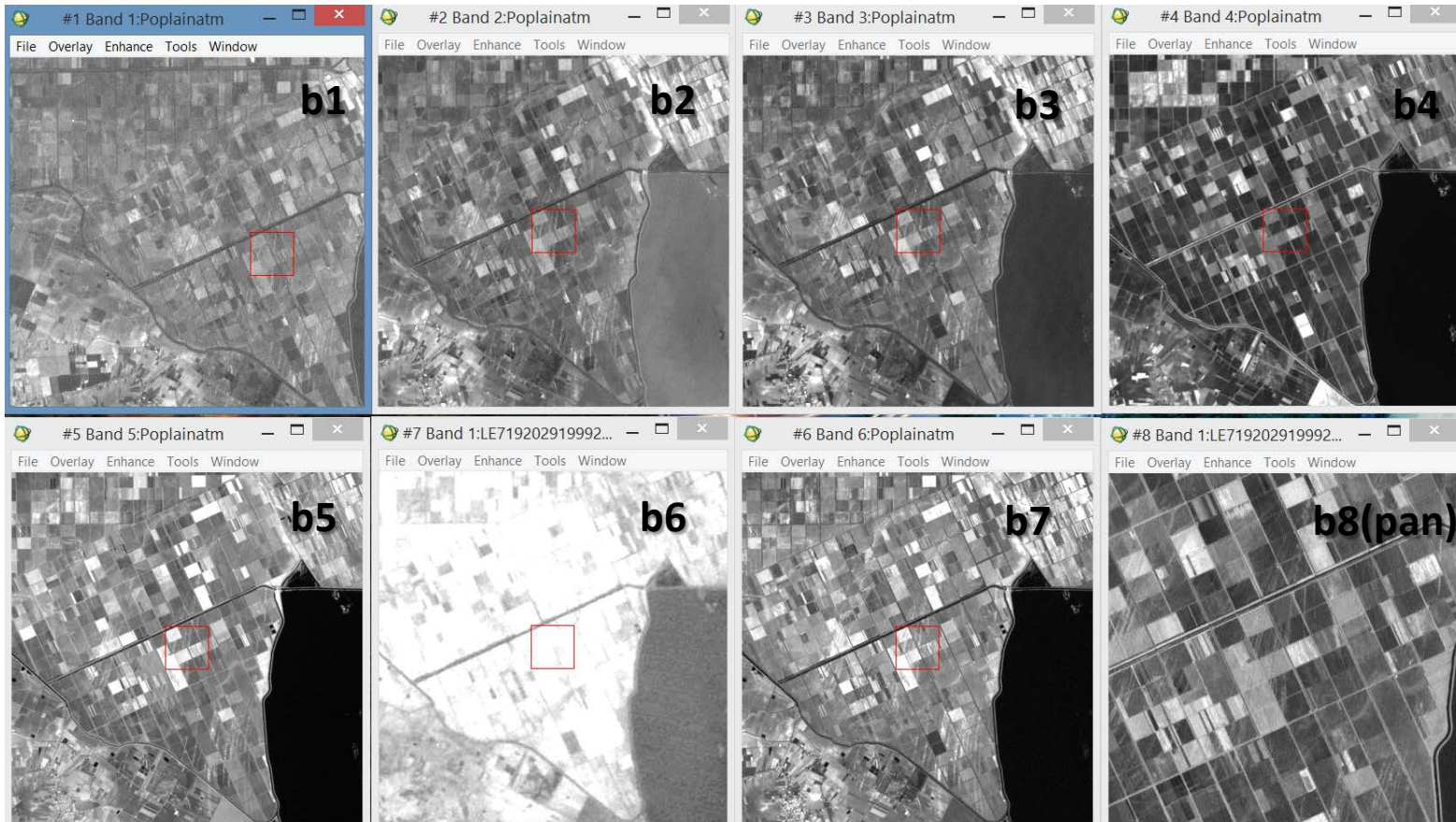


Infrarosso Termico

Bande Landsat 7 ETM+

Nome	Data	Tipo	Dimensione	T
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LE71920291999281EDC00_B2	11/12/2014 20:09	File TIF	54.500 KB	
LE71920291999281EDC00_B3	11/12/2014 20:09	File TIF	54.500 KB	
LE71920291999281EDC00_B4	11/12/2014 20:09	File TIF	54.500 KB	
LE71920291999281EDC00_B5	11/12/2014 20:09	File TIF	54.500 KB	
LE71920291999281EDC00_B6_VCID_1	11/12/2014 20:09	File TIF	54.500 KB	
LE71920291999281EDC00_B6_VCID_2	11/12/2014 20:09	File TIF	54.500 KB	
LE71920291999281EDC00_B7	11/12/2014 20:09	File TIF	54.500 KB	
LE71920291999281EDC00_B8	06/04/2016 00:30	File STA	2 KB	
LE71920291999281EDC00_B8	11/12/2014 20:09	File TIF	217.856 KB	
LE71920291999281EDC00_GCP	11/12/2014 20:09	Documento di testo	15 KB	
LE71920291999281EDC00_MTL	11/12/2014 20:09	Documento di testo	7 KB	

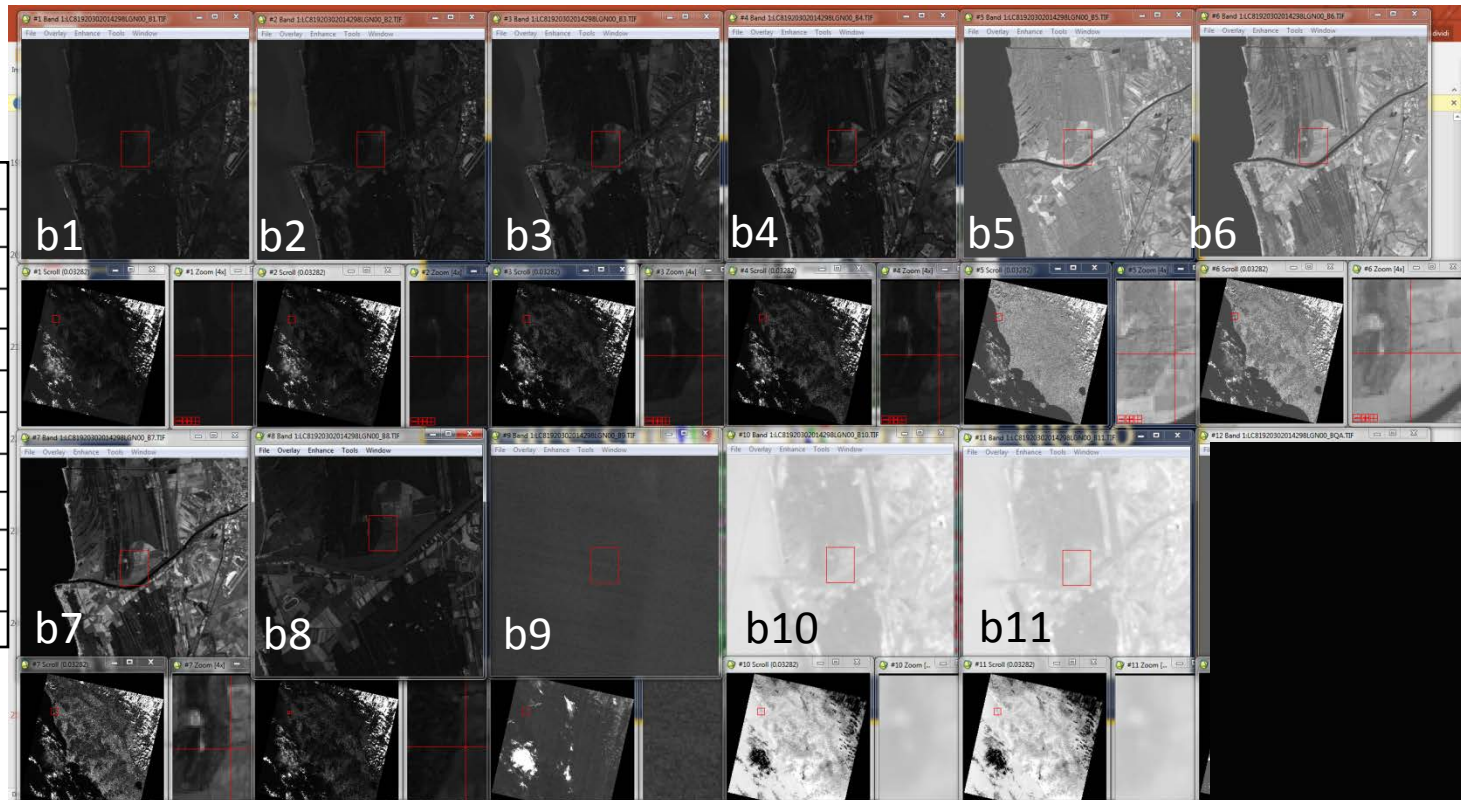
Landsat-7 ETM+ Bands (µm)		
Band 1	30 m Blue	0.441 - 0.514
Band 2	30 m Green	0.519 - 0.601
Band 3	30 m Red	0.631 - 0.692
Band 4	30 m NIR	0.772 - 0.898
Band 5	30 m SWIR-1	1.547 - 1.749
Band 6	60 m TIR	10.31 - 12.36
Band 7	30 m SWIR-2	2.064 - 2.345
Band 8	15 m Pan	0.515 - 0.896



Bande Landsat 8 OLI

Nome	Data	Tipo	Dimensione	Ta
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LC81920302014298LGN00_B2.TIF	25/10/2014 16:33	File TIF	116.940 KB	
LC81920302014298LGN00_B3.TIF	25/10/2014 16:33	File TIF	116.940 KB	
LC81920302014298LGN00_B4.TIF	25/10/2014 16:33	File TIF	116.940 KB	
LC81920302014298LGN00_B5.TIF	25/10/2014 16:33	File TIF	116.940 KB	
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LC81920302014298LGN00_B7.TIF	25/10/2014 16:33	File TIF	116.940 KB	
LC81920302014298LGN00_B8.TIF	25/10/2014 16:33	File TIF	467.574 KB	
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LC81920302014298LGN00_TIR.wld	18/02/2016 12:24	File WLD	1 KB	

Landsat-8 OLI and TIRS Bands (µm)		
30 m Coastal/Aerosol	0.435 - 0.451	Band 1
30 m Blue	0.452 - 0.512	Band 2
30 m Green	0.533 - 0.590	Band 3
30 m Red	0.636 - 0.673	Band 4
30 m NIR	0.851 - 0.879	Band 5
30 m SWIR-1	1.566 - 1.651	Band 6
100 m TIR-1	10.60 - 11.19	Band 10
100 m TIR-2	11.50 - 12.51	Band 11
30 m SWIR-2	2.107 - 2.294	Band 7
15 m Pan	0.503 - 0.676	Band 8
30 m Cirrus	1.363 - 1.384	Band 9



SOFTWARE PER VISUALIZZAZIONE E PROCESSING IMMAGINI

Commerciali

- **ENVI**
- ERDAS Imagine
- ER Mapper
- IDRISI
- WxtoIMG (professional version)
- ArcGIS (10)

Open source

- Multispec
- LEOWorks (ESA)
- WxtoIMG (standard version)
- Q-GIS

Band composition

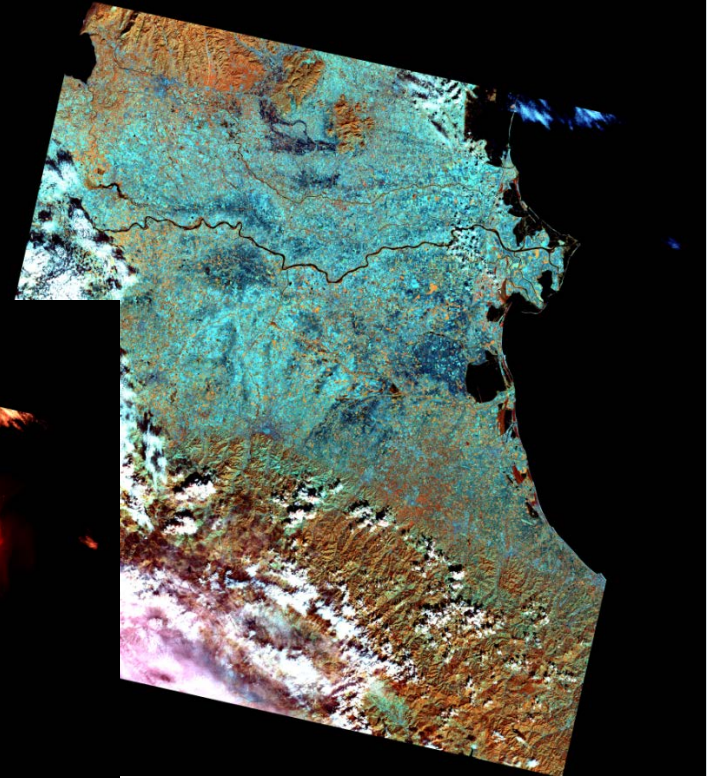
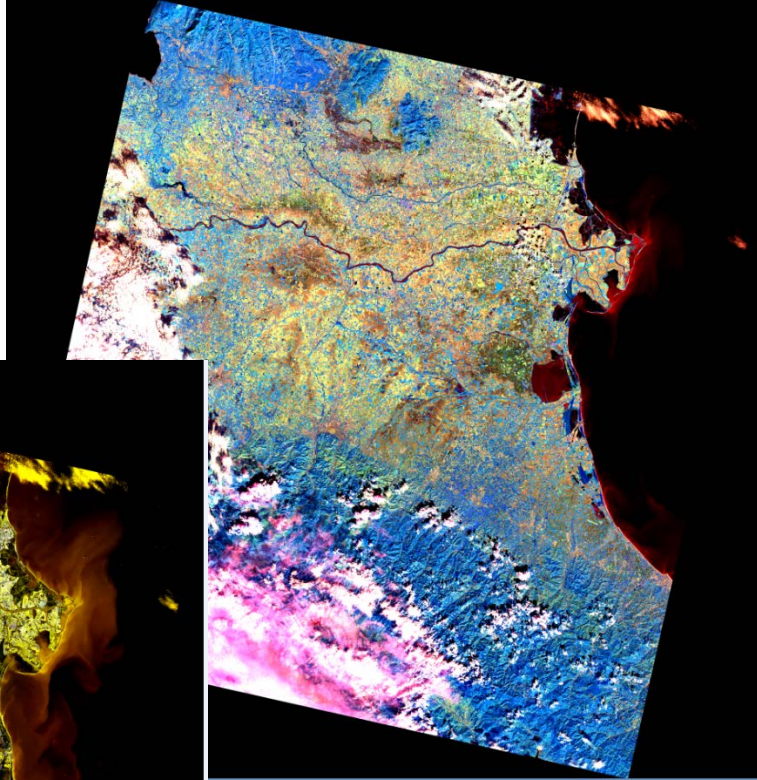
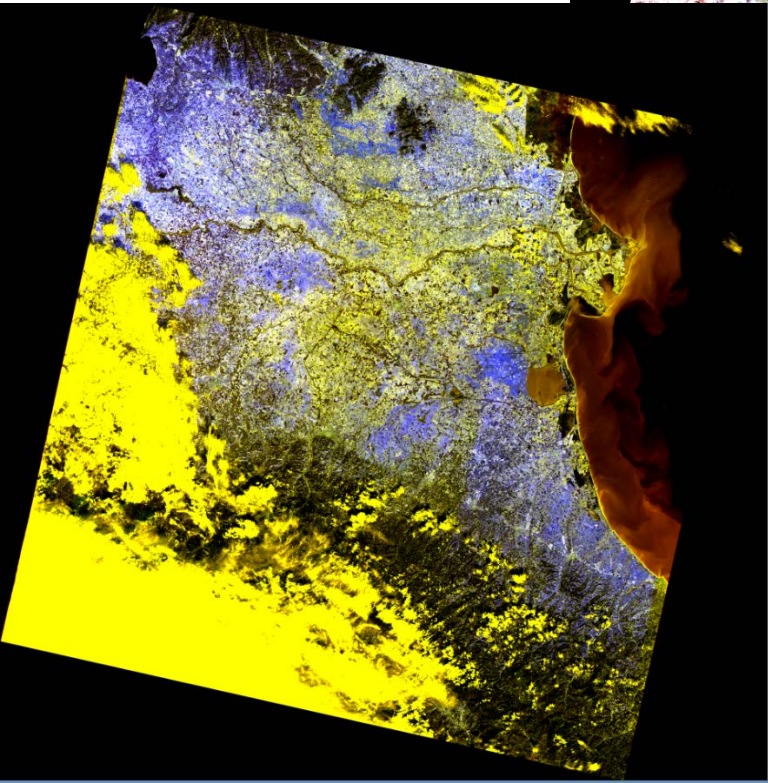
R, G, B	Potential Information Content
4,3,2	The standard "false color" composite. Vegetation appears in shades of red, urban areas are cyan blue, and soils vary from dark to light browns. Ice, snow and clouds are white or light cyan. Coniferous trees will appear darker red than hardwoods. This is a very popular band combination and is useful for vegetation studies, monitoring drainage and soil patterns and various stages of crop growth. Generally, deep red hues indicate broad leaf and/or healthier vegetation while lighter reds signify grasslands or sparsely vegetated areas. Densely populated urban areas are shown in light blue. This TM band combination gives results similar to traditional color infrared aerial photography.
3,2,1	The "natural color" band combination. Because the visible bands are used in this combination, ground features appear in colors similar to their appearance to the human visual system, healthy vegetation is green, recently cleared fields are very light, unhealthy vegetation is brown and yellow, roads are gray, and shorelines are white. This band combination provides the most water penetration and superior sediment and bathymetric information. It is also used for urban studies. Cleared and sparsely vegetated areas are not as easily detected here as in the 4 5 1 or 4 3 2 combination. Clouds and snow appear white and are difficult to distinguish. Also note that vegetation types are not as easily distinguished as the 4 5 1 combination. The 3 2 1 combination does not distinguish shallow water from soil as well as the 7 5 3 combination does.
7,4,2	This combination provides a "natural-like" rendition, while also penetrating atmospheric particles and smoke. Healthy vegetation will be a bright green and can saturate in seasons of heavy growth, grasslands will appear green, pink areas represent barren soil, oranges and browns represent sparsely vegetated areas. Dry vegetation will be orange and water will be blue. Sands, soils and minerals are highlighted in a multitude of colors. This band combination provides striking imagery for desert regions. It is useful for geological, agricultural and wetland studies. If there were any fires in this image they would appear red. This combination is used in the fire management applications for post-fire analysis of burned and non burned forested areas. Urban areas appear in varying shades of magenta. Grasslands appear as light green. The light-green spots inside the city indicate grassy land cover - parks, cemeteries, golf courses. Olive-green to bright-green hues normally indicate forested areas with coniferous forest being darker green than deciduous.

4,5,1	Healthy vegetation appears in shades of reds, browns, oranges and yellows. Soils may be in greens and browns, urban features are white, cyan and gray, bright blue areas represent recently clearcut areas and reddish areas show new vegetation growth, probably sparse grasslands. Clear, deep water will be very dark in this combination, if the water is shallow or contains sediments it would appear as shades of lighter blue. For vegetation studies, the addition of the Mid-IR band increases sensitivity of detecting various stages of plant growth or stress; however care must be taken in interpretation if acquisition closely follows precipitation. Use of TM 4 and TM 5 shows high reflectance in healthy vegetated areas. It is helpful to compare flooded areas and red vegetated areas with the corresponding colors in the 3 2 1 combination to assure correct interpretation. This is not a good band combination for studying cultural features such as roads and runways.
4,5,3	This combination of near-IR (Band 4), mid-IR (Band 5) and red (Band 3) offers added definition of land-water boundaries and highlights subtle details not readily apparent in the visible bands alone. Inland lakes and streams can be located with greater precision when more infrared bands are used. With this band combination, vegetation type and condition show as variations of hues (browns, greens and oranges), as well as in tone. The 4,5,3 combination demonstrates moisture differences and is useful for analysis of soil and vegetation conditions. Generally, the wetter the soil, the darker it appears, because of the infrared absorption capabilities of water.

7,5,3	This band combination also provides a "natural-like" rendition while also penetrating atmospheric particles, smoke and haze. Vegetation appears in shades of dark and light green during the growing season, urban features are white, gray, cyan or purple, sands, soils and minerals appear in a variety of colors. The almost complete absorption of Mid-IR bands in water, ice and snow provides well defined coast lines and highlighted sources of water within the image. Snow and ice appear as dark blue, water is black or dark blue. Hot surfaces such as forest fires and volcano calderas saturate the Mid-IR bands and appear in shades of red or yellow. One particular application for this combination is monitoring forest fires. During seasons of little vegetation growth the 7 4 2 combination should be substituted. Flooded areas should look very dark blue or black, compared with the 3 2 1 combination in which shallow flooded regions appear gray and are difficult to distinguish.
5,4,3	Like the 4 5 1 combination, this combination provides the user with a great amount of information and color contrast. Healthy vegetation is bright green and soils are mauve. While the 7 4 2 combination includes TM 7, which has the geological information, the 5 4 3 combination uses TM 5 which has the most agricultural information. This combination is useful for vegetation studies, and is widely used in the areas of timber management and pest infestation.
5,4,1	This will look similar to the 7 4 2 combination in that healthy vegetation will be bright green, except the 5 4 1 combination is better for agricultural studies.
7,5,4	This combination involves no visible bands. It provides the best atmospheric penetration. Coast lines and shores are well defined. It may be used to find textural and moisture characteristics of soils. Vegetation appears blue. If the user prefers green vegetation, a 7 4 5 combination should be substituted. This band combination can be useful for geological studies.

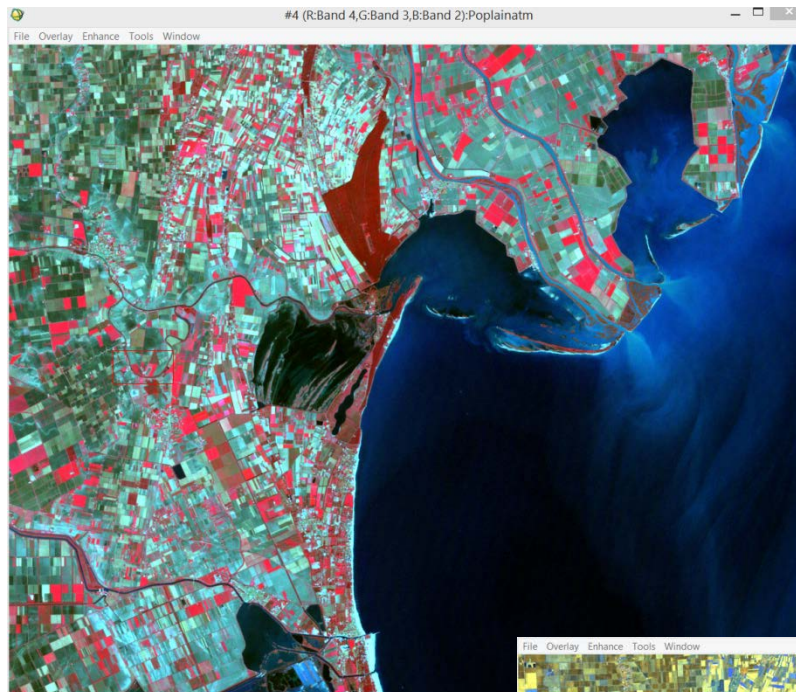
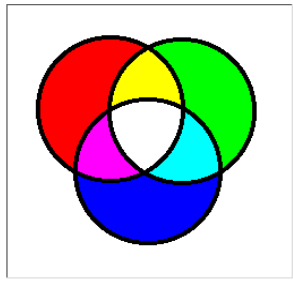
VISUALIZZAZIONE: spectral bands compositions (False Color Composition)

Po Delta



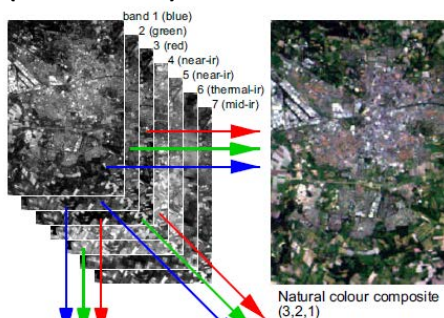
VISUALIZZAZIONE: band compositions (FCC)

Sintesi additiva
RGB



Esempio:
Enfatizzazione della vegetazione
(porzioni in rosso)

Spectral bands
(b1, b2, ..)



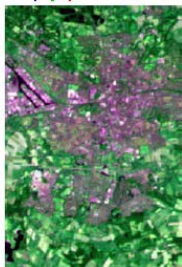
Natural colour composite
(3,2,1)

FCC 1

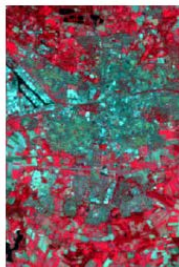


Esempio:
Enfatizzazione delle caratteristiche del
suolo (marrone e toni di beige)

FCC 3



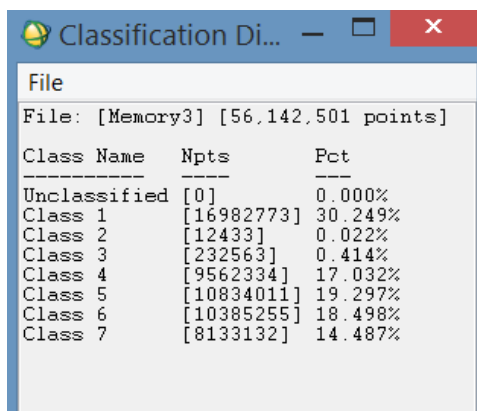
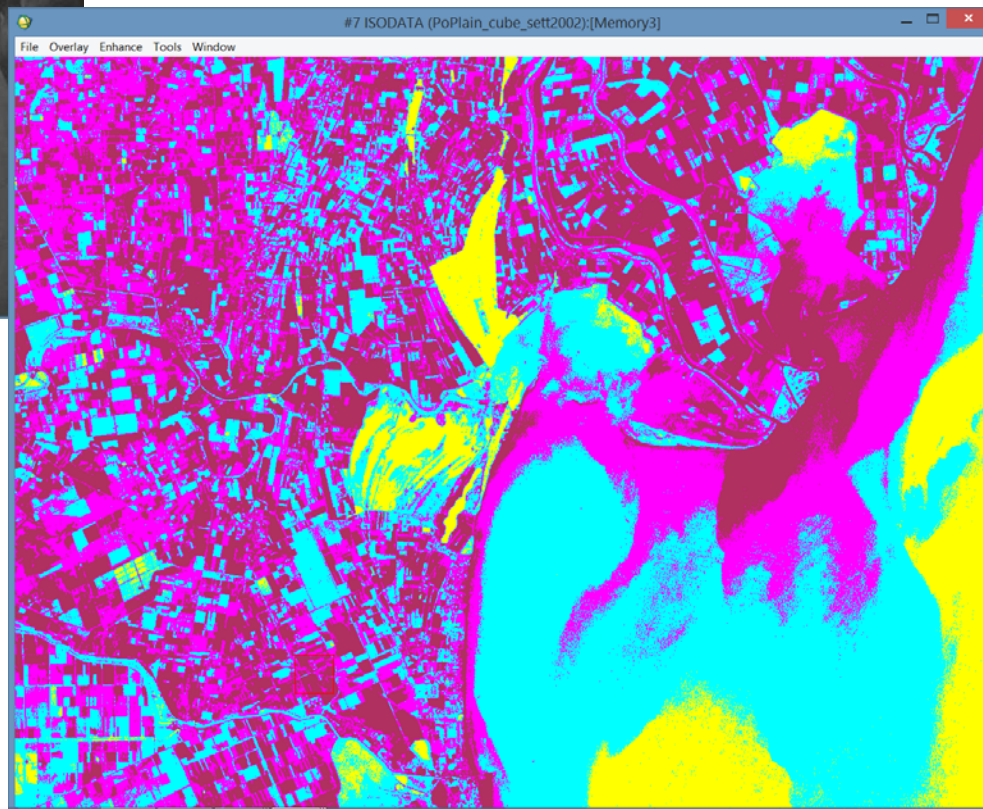
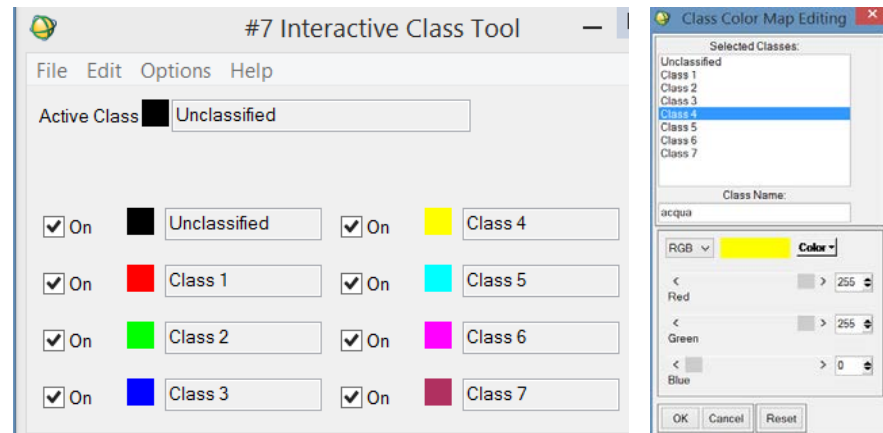
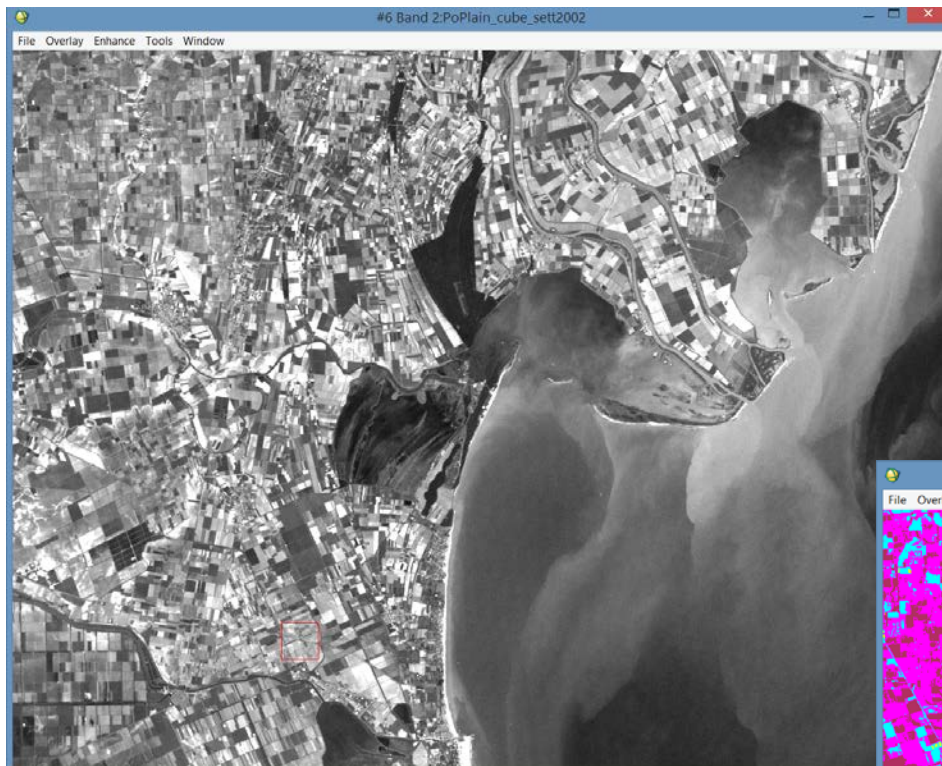
Pseudo-natural colour



False colour composite

FCC 2

Classificazione-Unsupervised



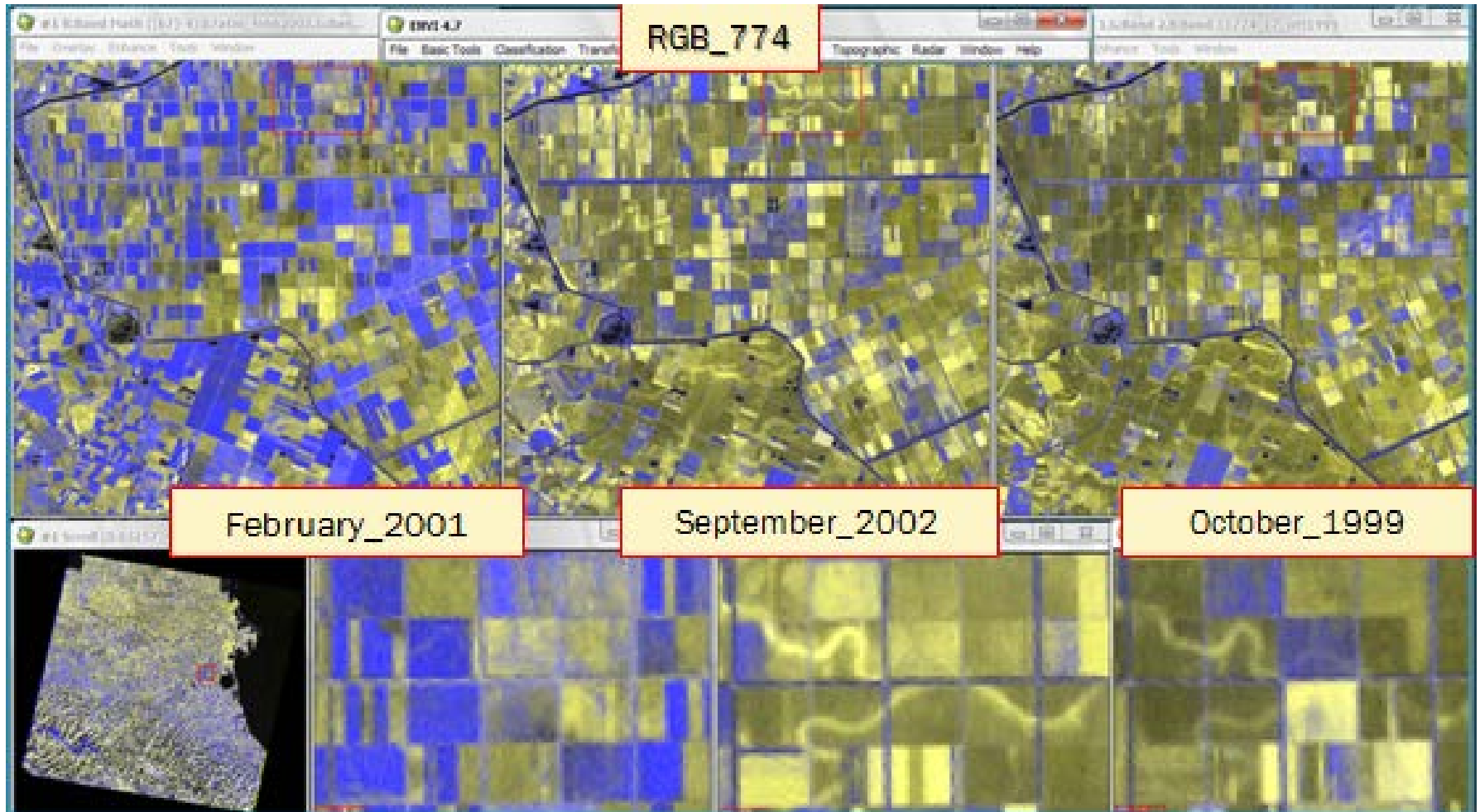
Classification Di...

File

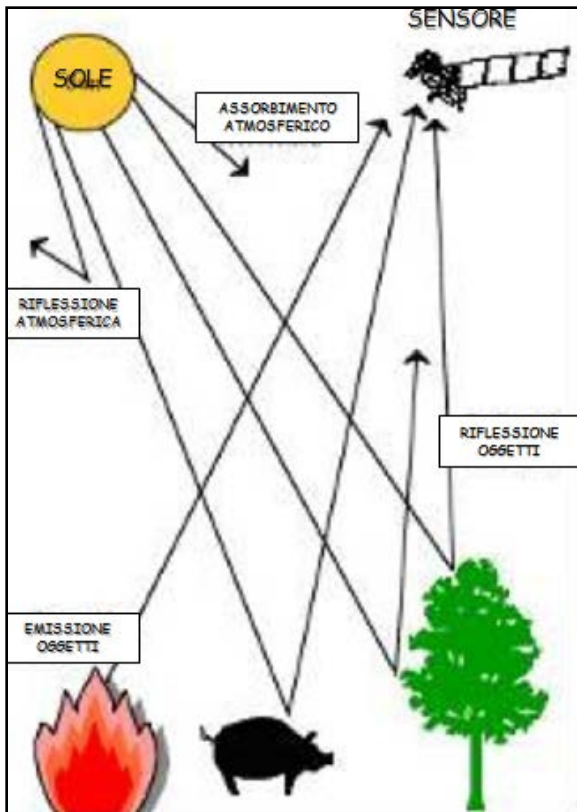
File: [Memory3] [56,142,501 points]

Class Name	Npts	Pct
Unclassified	[0]	0.000%
Class 1	[16982773]	30.249%
Class 2	[12433]	0.022%
Class 3	[232563]	0.414%
Class 4	[9562334]	17.032%
Class 5	[10834011]	19.297%
Class 6	[10385255]	18.498%
Class 7	[8133132]	14.487%

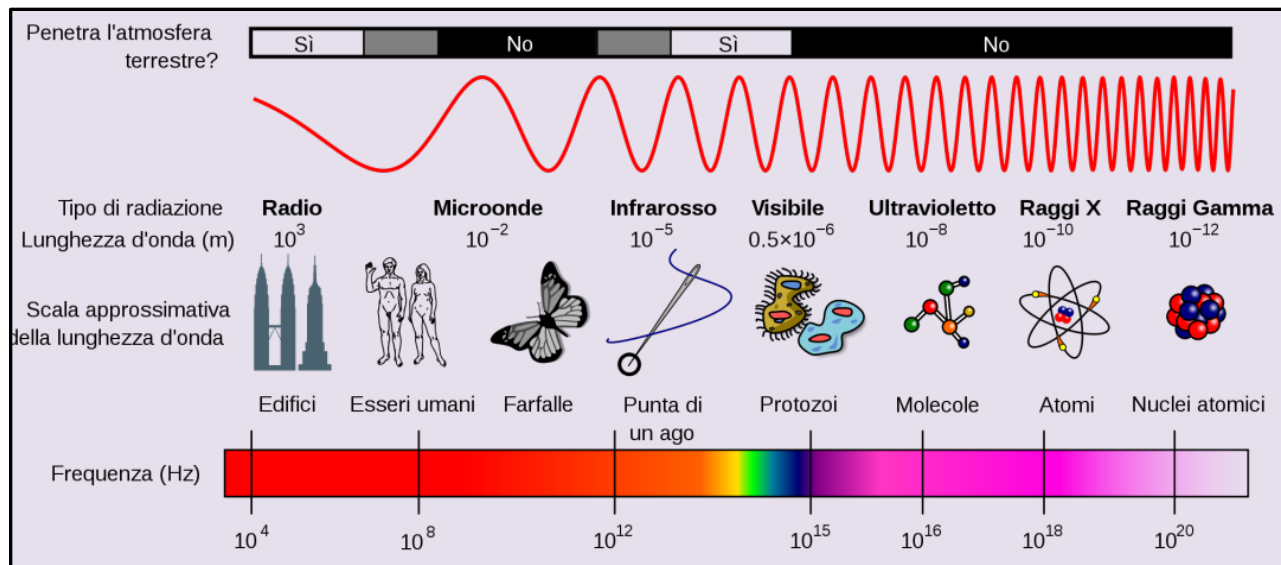
Analisi multitemporale delle immagini



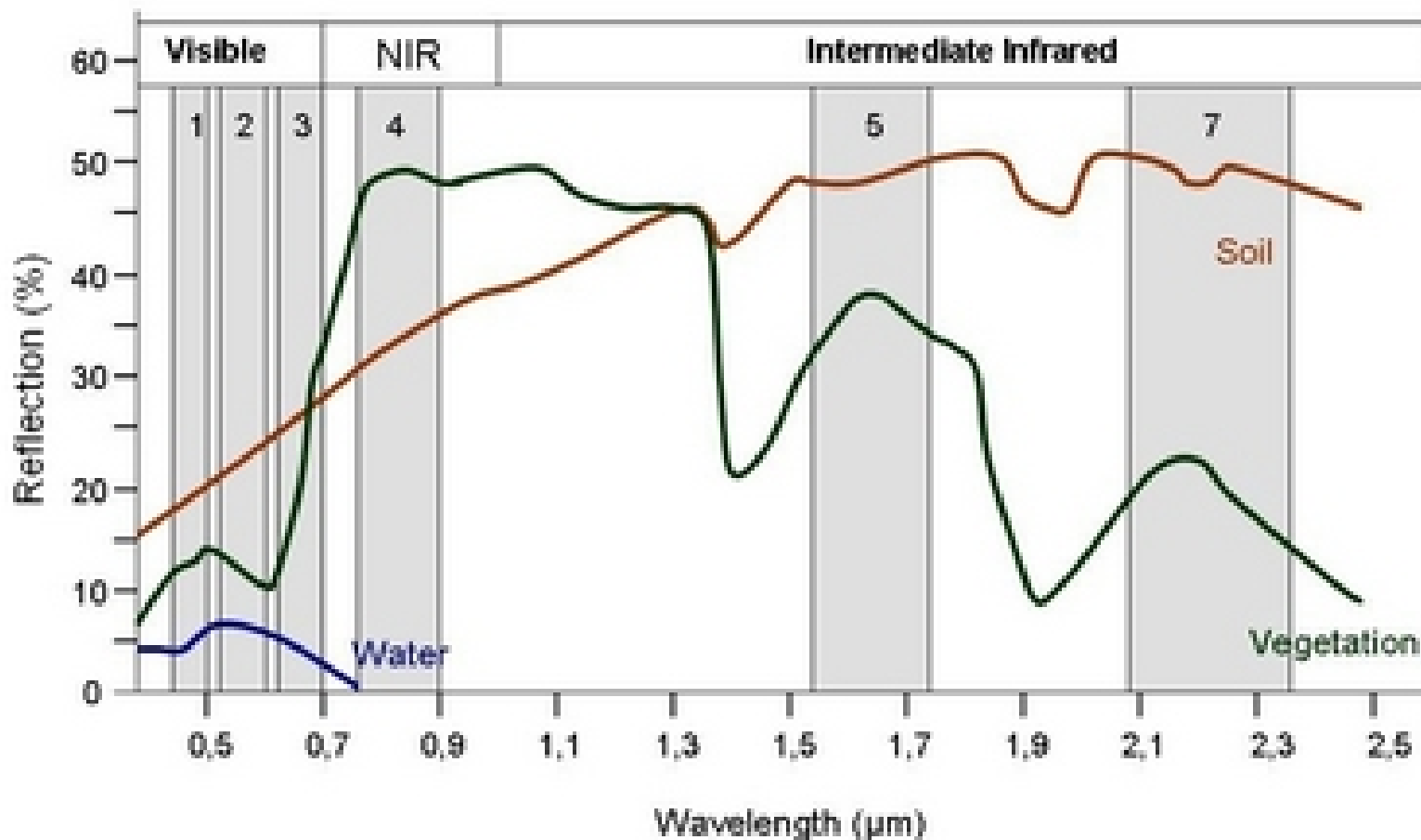
Sistema ottico passivo



Spettro Elettromagnetico



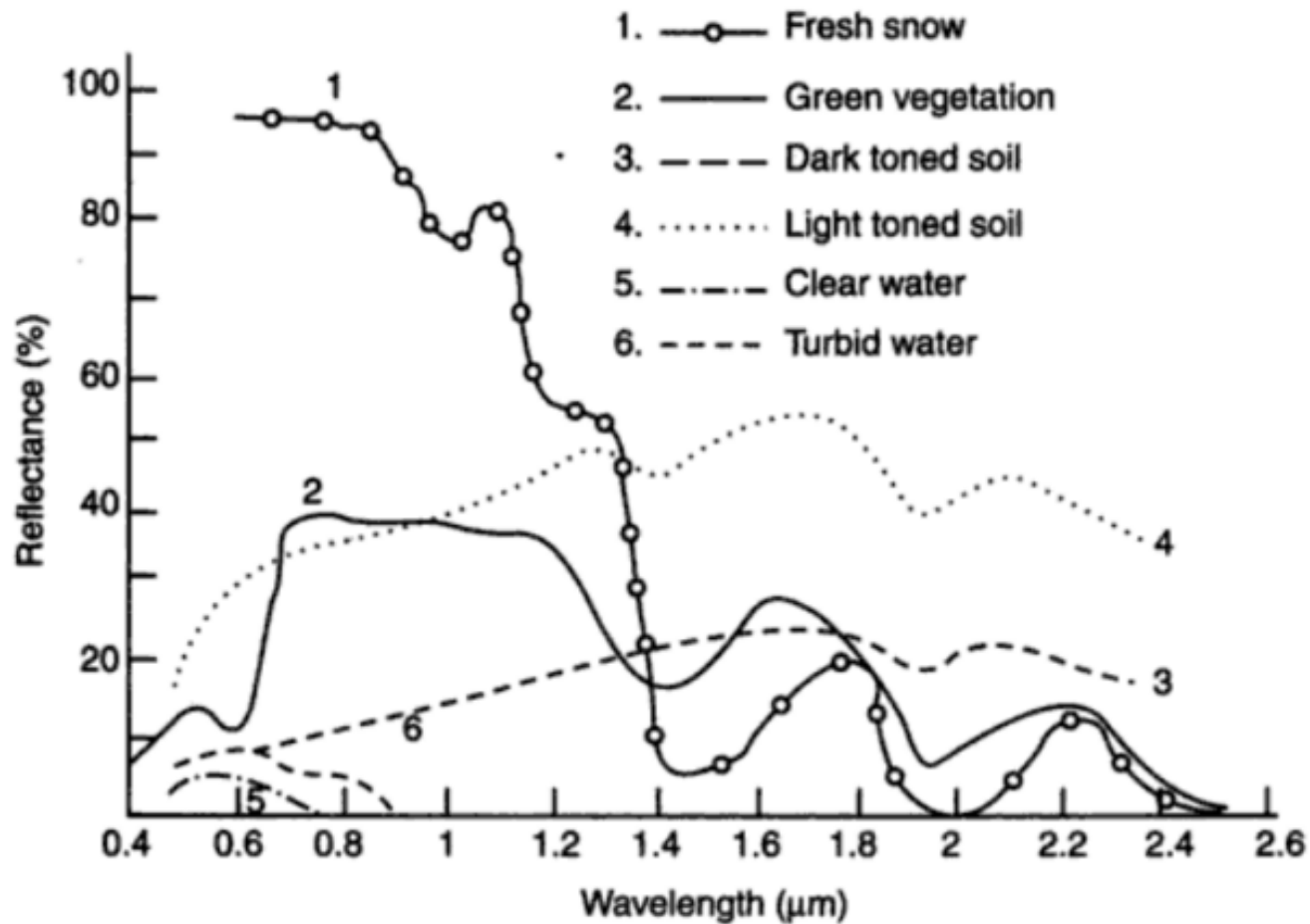
Bande Landsat 7 ETM+ e “firme spettrali” (suolo, vegetazione, acqua)



Firme spettrali

Risposta caratteristica di un oggetto alle varie lunghezze d'onda dello spettro elettromagnetico

Curve di riflettanza di alcune coperture del suolo



Effetto dell'umidità del suolo: spettri di suoli limosi

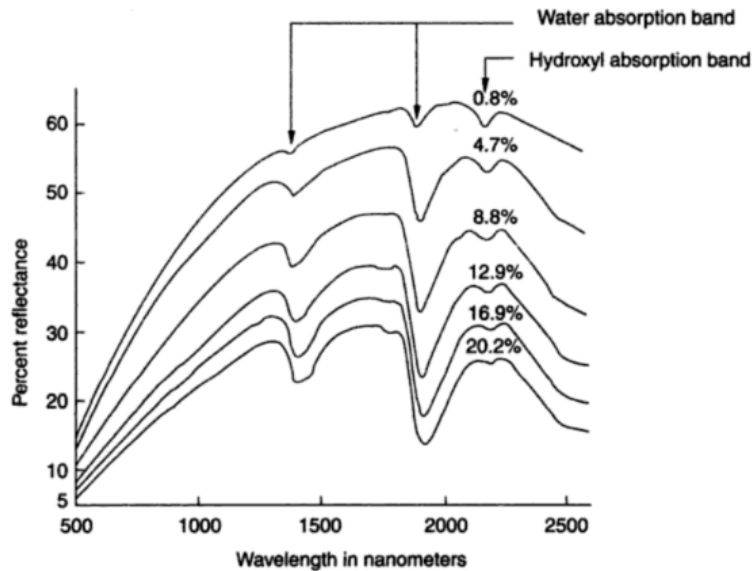


Fig. 4.15 Silt loam reflectance spectra for various moisture contents. (Moisture content indicated directly above each curve). (Adapted from Bowers and Hanks, 1965)

Effetto della materia organica: spettri di suoli organici

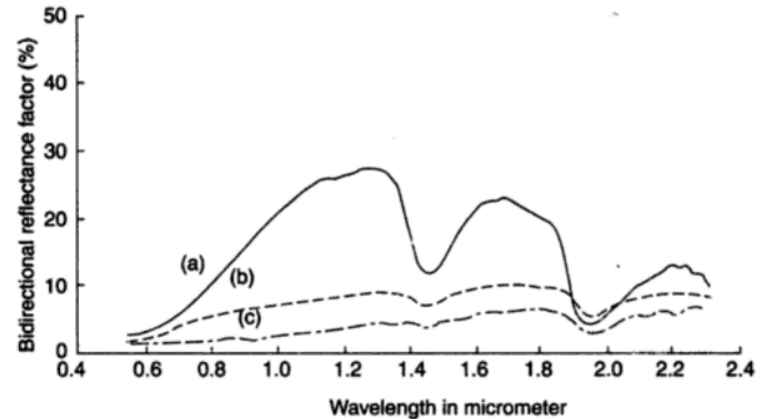


Fig. 4.18 Representative reflectance spectra for organic soils with: (a) minimally (fibric); (b) partially (hemic) and (c) fully (sapric) decomposed organic fibers. (Reprinted from characteristic variations in reflectance of surface soils, stoner, E.R., and M.F. Baumgardner, *Soil Science Society of America Journal*, 45, 1981 with permission)

Caratteristiche delle immagini telerilevate

- Risoluzione geometrica
 - Risoluzione radiometrica
- Risoluzione spettrale
 - Risoluzione temporale

Risoluzione geometrica

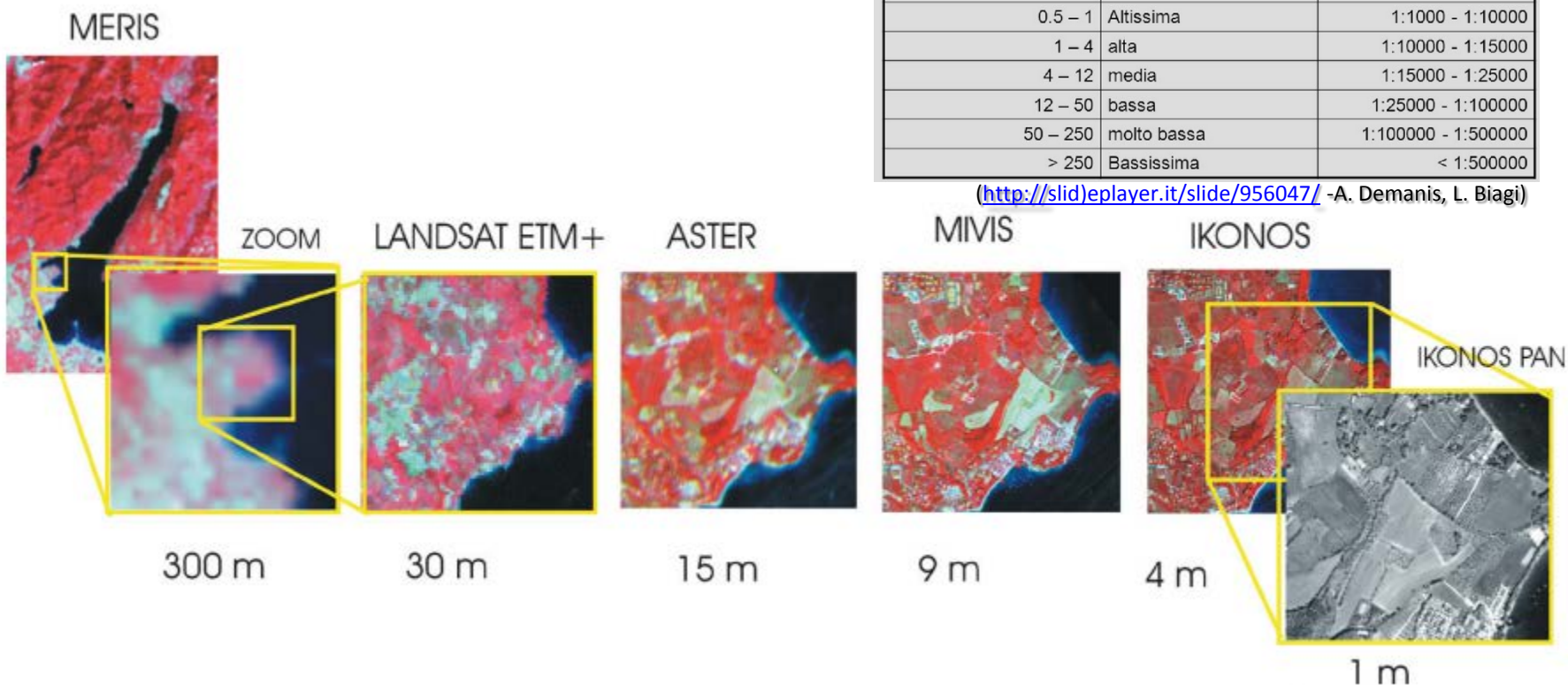
Si riferisce alle dimensioni della più piccola area rilevabile.

La risoluzione varia nei diversi satelliti come ordine di grandezza da metri (15m Landsat, 1m Ikonos, 0,75 m Quickbird) fino a chilometri (2,5 km per il Meteosat).

La dimensione del pixel é condizionata dalla quota alla quale si viene a trovare il sistema di ripresa e dalle sue caratteristiche di funzionamento, in particolare dall'angolo di vista del sensore che determina l'area vista sulla superficie terrestre (IFOV - Instantaneous Field Of View).

Risoluzione (m)	Definizione	Scala di applicazione
0.5 - 1	Altissima	1:1000 - 1:10000
1 - 4	alta	1:10000 - 1:15000
4 - 12	media	1:15000 - 1:25000
12 - 50	bassa	1:25000 - 1:100000
50 - 250	molto bassa	1:100000 - 1:500000
> 250	Bassissima	< 1:500000

(<http://slidplayer.it/slide/956047/> -A. Demanis, L. Biagi)



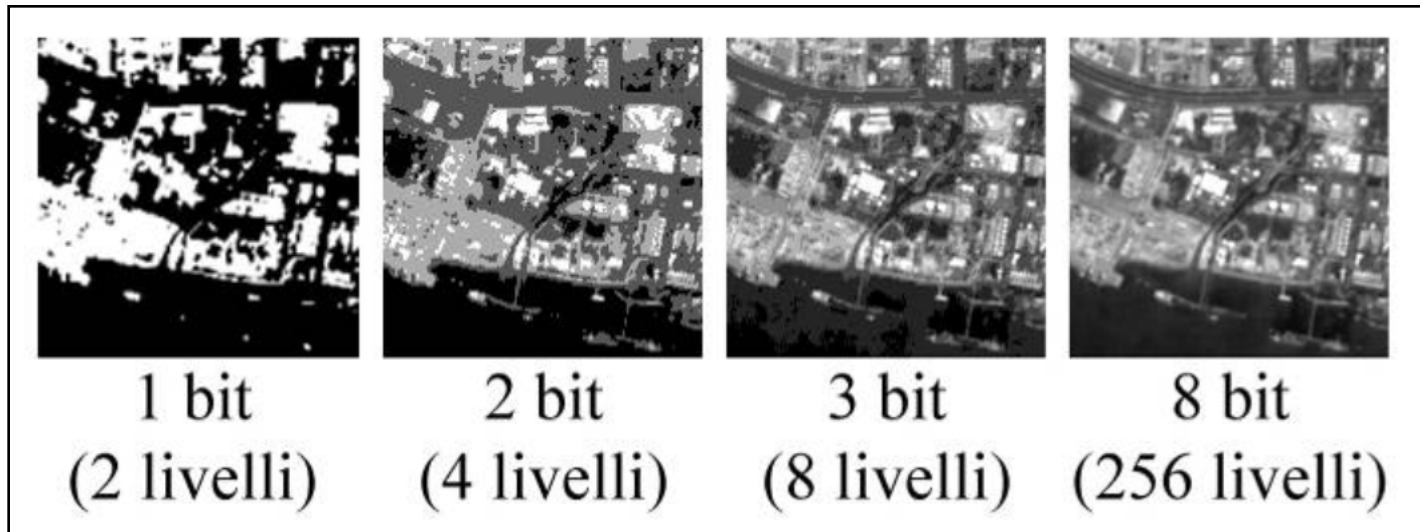
Risoluzione radiometrica

Rappresenta la minima differenza d'intensità che un sistema può rilevare tra due valori di energia radiante, ai quali corrispondono livelli di informazione registrata e livelli di grigio nell'immagine.

L'energia (radianza) viene "tradotta" dai sensori in numeri interi DN (Digital Numbers)
Il numero di DN varia a seconda del numero di bit usati nell'acquisizione.

Esempio:

- sensore a 8 bit per registrazione dati $\rightarrow 2^8$ (256, da 0 a 255) valori per rappresentare l'energia legata ad ogni pixel dell'immagine
- sensore a 3 bit $\rightarrow 2^3$ (8) valori e conseguentemente risoluzione radiometrica molto inferiore rispetto al precedente.



Risoluzione spettrale (Sensori multi e iperspettrali)

Il telerilevamento si basa sull'uso di più bande (piccoli intervalli dello spettro elettromagnetico) per il riconoscimento degli oggetti rilevati.

Teoricamente maggiore è il numero delle bande spettrali utilizzate maggiore è la capacità di indagine, e quindi la risoluzione spettrale del sensore.

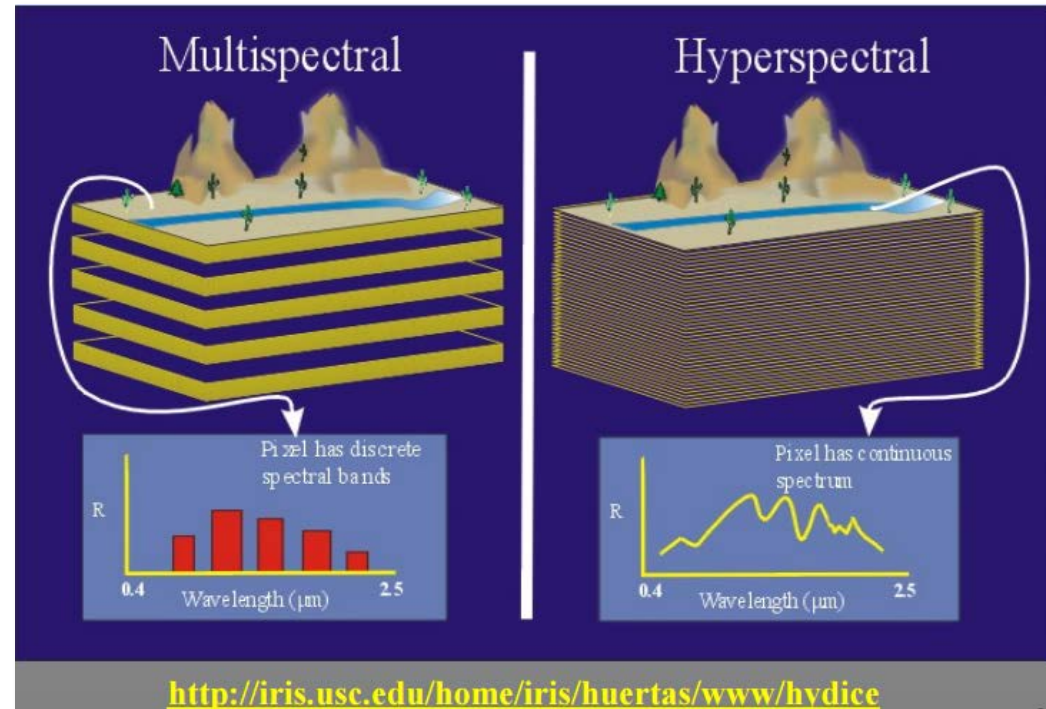
esempi

LANDSAT7 ETM+, ASTER, SENTINEL2→

Hanno sensori multispettrali,

rispettivamente 7, 13, 13 bande

HYPERION→ iperspettrale (220 bande)



Spettrale	
Pancromatiche	Scala di grigi sullo spettro visibile
Multispettrali	In genere B/G/R + una o più bande in infrarosso
Iperspettrali	≈ 100 bande
Pan-sharpened	Fusione di pancromatico e multispettrale

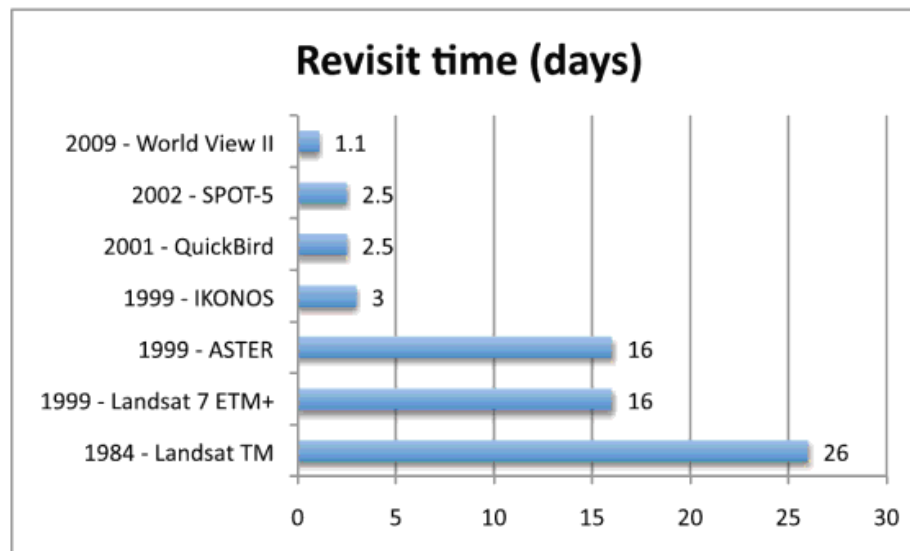
(<http://slideplayer.it/slide/956047/> -A. Demanis, L. Biagi)

Risoluzione temporale

Intervallo temporale dopo il quale un sistema ripassa sulla stessa area della superficie terrestre.

Può variare dai pochi minuti dei satelliti geostazionari, come il METEOSAT, alle ore del NOAA fino ai 26 giorni dello LANDSAT TM.

La possibilità di riprendere esattamente la stessa area della Terra ad intervalli regolari di tempo (confrontare immagini acquisite in momenti differenti) consente di effettuare **monitoraggi** per seguire i cambiamenti di un territorio o seguire l'evoluzione di un fenomeno, soprattutto su scala globale, caratteristica questa fra le più significative del Telerilevamento.



TERRA-ASTER (NASA)

(Advanced Spaceborn Thermal Emission Radiometer)

Caratteristiche	VNIR	SWIR	TIR
Range spettrale	Banda 1: 0.52 - 0.60 μm	Banda 4: 1.600 - 1.700 μm	Banda 10: 8.125 - 8.475 μm
	Banda 2: 0.63 - 0.69 μm	Banda 5: 2.145 - 2.185 μm	Banda 11: 8.475 - 8.825 μm
	Banda 3: 0.76 - 0.86 μm	Banda 6: 2.185 - 2.225 μm	Banda 12: 8.925 - 9.275 μm
	Banda 3B 0.76 - 0.86 μm Backward looking	Banda 7: 2.235 - 2.285 μm	Banda 13: 10.25 - 10.95 μm
		Banda 8: 2.295 - 2.365 μm Band 9 2.360 - 2.430 μm	Banda 14: 10.95 - 11.65 μm
Risoluzione spaziale	15 m	30m	90m
Angolo di puntamento (°)	± 24	± 8.55	± 8.55
Larghezza dello Swath	60 Km	60 Km	60 Km
Tipo di Detector	Si	PtSi-Si	HgCdTe
Quantizzazione	8-bit unsigned integer	8-bit unsigned integer	12-bit unsigned integer

<http://asterweb.jpl.nasa.gov/>

SENTINEL 2 MSI (ESA-Copernicus)

Sentinel-2A Satellite Sensor Specifications

	Spatial Resolution (m)	Band Number	Central Wavelength (nm)	Bandwidth (nm)
Sentinel-2A	10	2	490	65
		3	560	35
Sentinel-2A	10	4	665	30
		8a	842	115
Orbit	20	5	705	15
		6	740	15
		7	783	20
Georevisi	20	8b	865	20
		11	1 610	90
Desig	20	12	2 190	180
		60	1	443
	60	9	945	20
		10	1 380	30

http://www.esa.int/Our_Activities/Observing_the_Earth/Copernicus

EO-1_Hyperion (NASA)

Type	Sun-Synchronous, 10:01 am descending node
Altitude	705 km
Inclination	98.2 deg
Period	99 min
Repeat Cycle	16 days

Hyperion Sensor Characteristics

Spatial Resolution	30 m
Swath Width	7.75 km
Spectral Channels	220 unique channels. VNIR (70 channels, 356 nm - 1058 nm), SWIR (172 channels, 852 nm - 2577 nm)
Spectral Bandwidth	10 nm (nominal)
Digitization	12 bits
Signal-to-Noise Ratio (SNR)	161 (550 nm); 147 (700 nm); 110 (1125 nm); 40 (2125 nm)

<https://eo1.gsfc.nasa.gov/new/baseline/index.htm>

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Landsat7 ETM+

Comune utilizzo delle bande spettrali

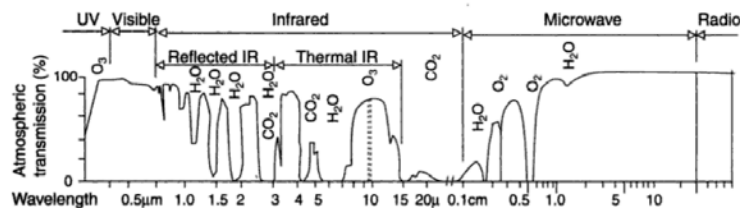


Fig. 2.10 Atmospheric windows. Gases responsible for absorption are indicated.

(From: *Remote Sensing Principles & Interpretation* by Floyd F. Sabins © 1978, 1987, 1997 by W.H. Freeman and Company/Floyd F. Sabins. Used with permission.)

Landsat 5 TM and Landsat 7 ETM+ Spectral Bands	Wavelength	Useful for mapping
Band 1 - blue	0.45-0.52	Bathymetric mapping, distinguishing soil from vegetation and deciduous from coniferous vegetation
Band 2 - green	0.52-0.60	Emphasizes peak vegetation, which is useful for assessing plant vigor
Band 3 - red	0.63-0.69	Discriminates vegetation slopes
Band 4 - Near Infrared	0.77-0.90	Emphasizes biomass content and shorelines
Band 5 - Short-wave Infrared	1.55-1.75	Discriminates moisture content of soil and vegetation; penetrates thin clouds
Band 6 - Thermal Infrared	10.40-12.50	Thermal mapping and estimated soil moisture
Band 7 - Short-wave Infrared	2.09-2.35	Hydrothermally altered rocks associated with mineral deposits
Band 8 - Panchromatic (Landsat 7 only)	.52-.90 15	meter resolution, sharper image definition

Landsat 8 OLI

Band	Wavelength	Useful for mapping
Band 1 - coastal aerosol	0.43-0.45	coastal and aerosol studies
Band 2 - blue	0.45-0.51	Bathymetric mapping, distinguishing soil from vegetation and deciduous from coniferous vegetation
Band 3 - green	0.53-0.59	Emphasizes peak vegetation, which is useful for assessing plant vigor
Band 4 - red	0.64-0.67	Discriminates vegetation slopes
Band 5 - Near Infrared (NIR)	0.85-.088	Emphasizes biomass content and shorelines
Band 6 - Short-wave Infrared (SWIR) 1	1.57-1.65	Discriminates moisture content of soil and vegetation; penetrates thin clouds
Band 7 - Short-wave Infrared (SWIR) 2	2.11-2.29	Improved moisture content of soil and vegetation and thin cloud penetration
Band 8 - Panchromatic	.50-.68	15 meter resolution, sharper image definition
Band 9 - Cirrus	1.36 -1.38	Improved detection of cirrus cloud contamination
Band 10 - TIRS 1	10.60 - 11.19	100 meter resolution, thermal mapping and estimated soil moisture
Band 11 - TIRS 2	11.5-12.51	100 meter resolution, Improved thermal mapping and estimated soil moisture

Analisi delle immagini (sintesi)

Visualizzazione (software dedicati ENVI, ERDAS,...)

Pre-processing

- correzione radiometrica: consente di passare da DN a grandezza fisica legata all'oggetto osservato eliminando gli errori dovuti al sensore e al suo eventuale cattivo funzionamento.
- correzione geometrica: per ridurre le distorsioni (sistematiche e non sistematiche) prodotte dal processo di acquisizione e per assegnare all'immagine un sistema cartografico.

Miglioramento (Enhancement)-Trasformazione:

stretching, band combination (FCC), pan-sharpening, principal component analysis (PCA),..

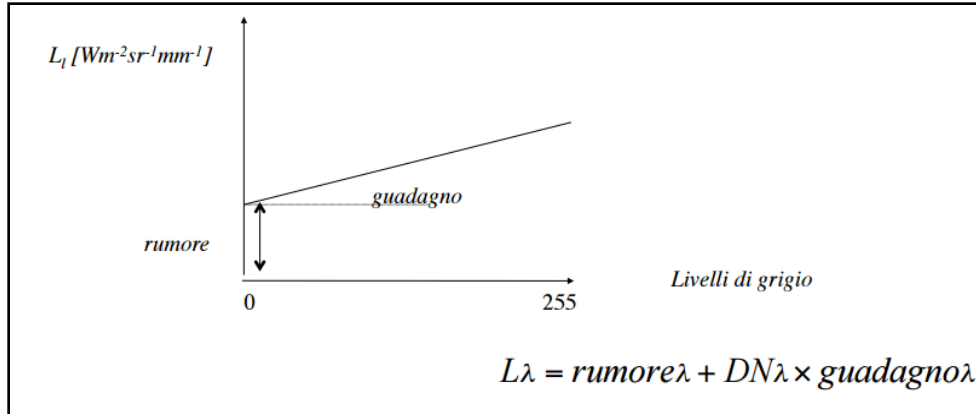
Estrazione delle informazioni:

- Fotointerpretazione (operatore)
- Classificazione → Classificazione unsupervised o supervised (operatore)

Pre-processing

(correzioni radiometriche)

Da DN a grandezza fisica (radianza)

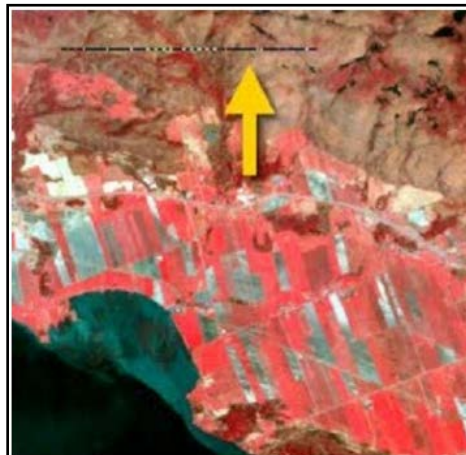
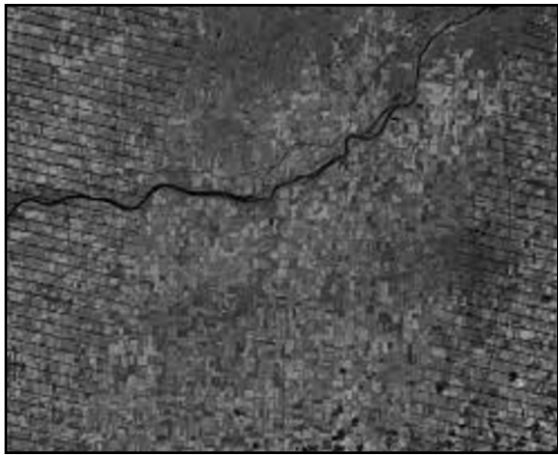


Calibrazione del sensore

$$L = (L_{max} - L_{min}) / 255 * DN + L_{min}$$

L_{max} e L_{min} sono forniti con i dati (header file)

De-stripping/Linee e pixel saltati



Correzione atmosferica

Basata sull'immagine

Sfrutta esclusivamente caratteristiche presenti nell'immagine:

esempio "Dark Pixel"

Correzioni meno accurate, ma più semplici

Basata su algoritmi di trasferimento radiativo

Necessitano della conoscenza delle proprietà dell'atmosfera al passaggio del satellite (modelli tipo 6S, Lowtran, Modtran, ...)

Correzioni più accurate, ma più complicate

Pre-processing

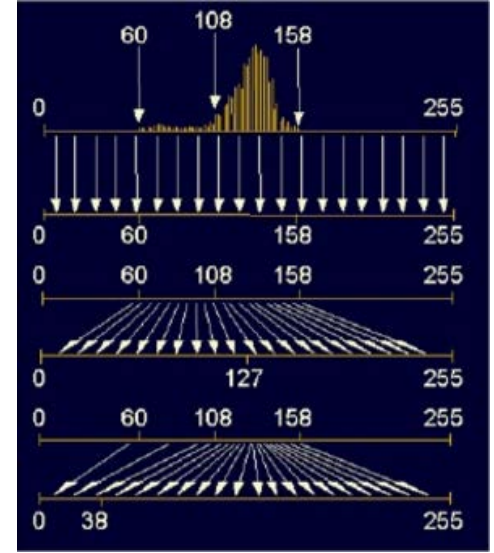
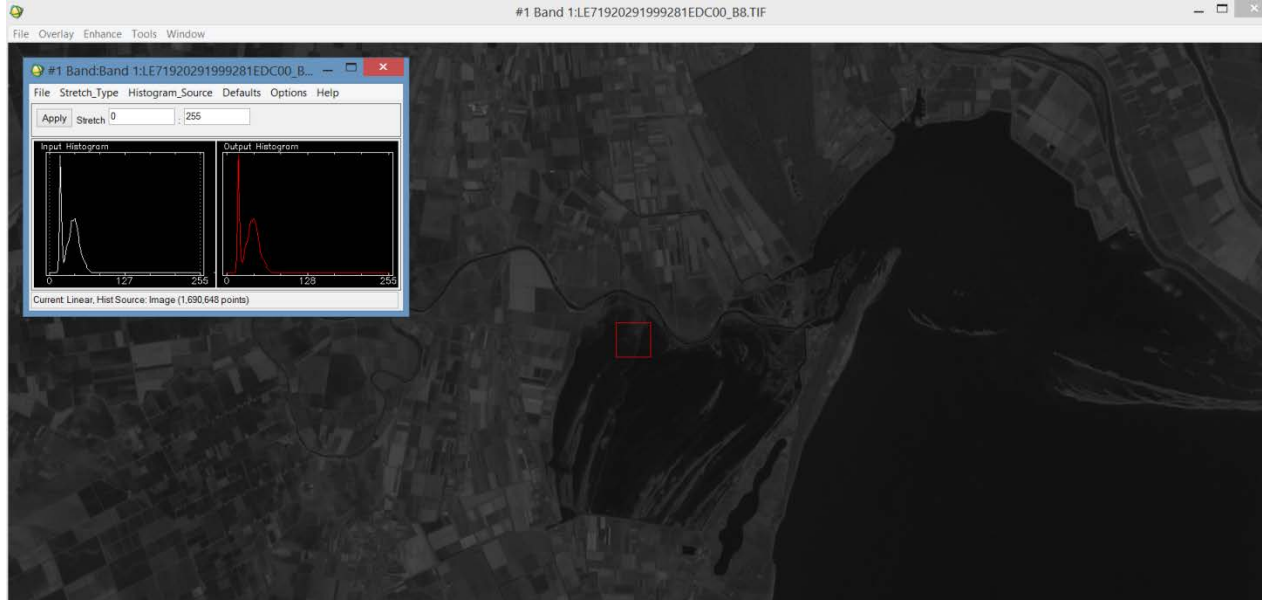
correzione geometrica

Finalizzata a ridurre gli effetti di distorsione sull'immagine

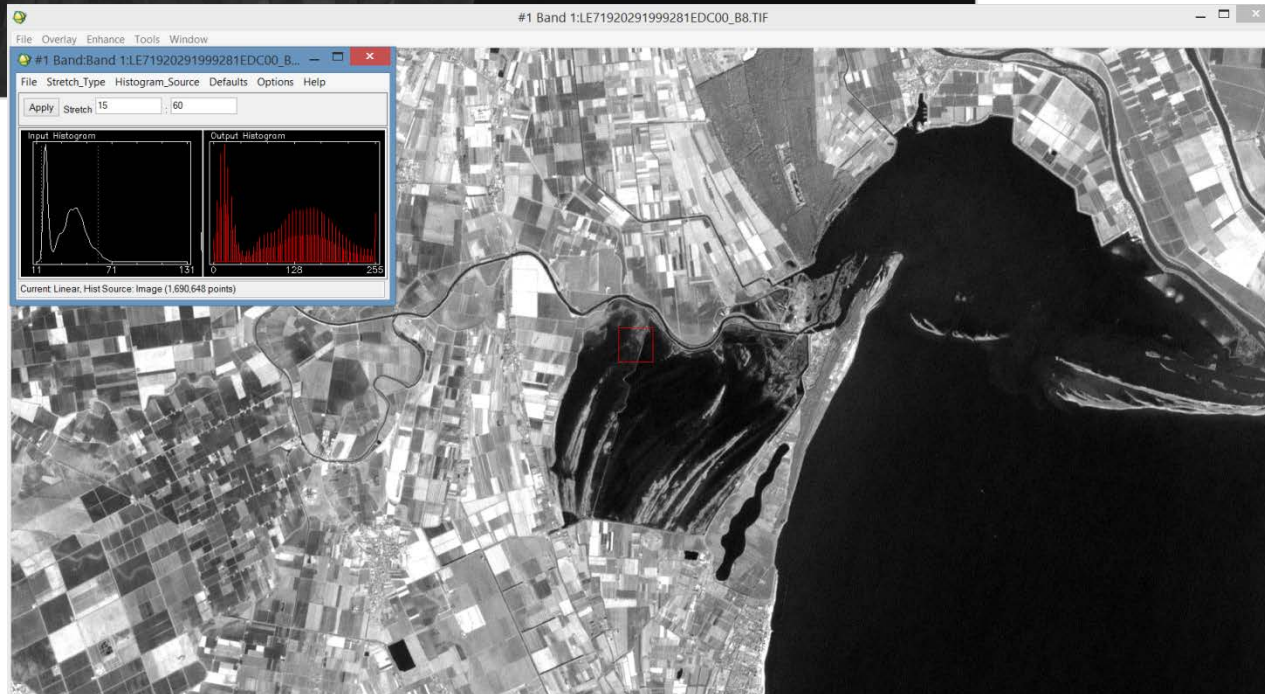
Sistematici: causati dalla rotazione terrestre, curvatura terrestre, variazione di velocità della piattaforma che trasporta il sensore,..

Non sistematici: variazioni di altitudine direzione della piattaforma, presenza di rilievi,...

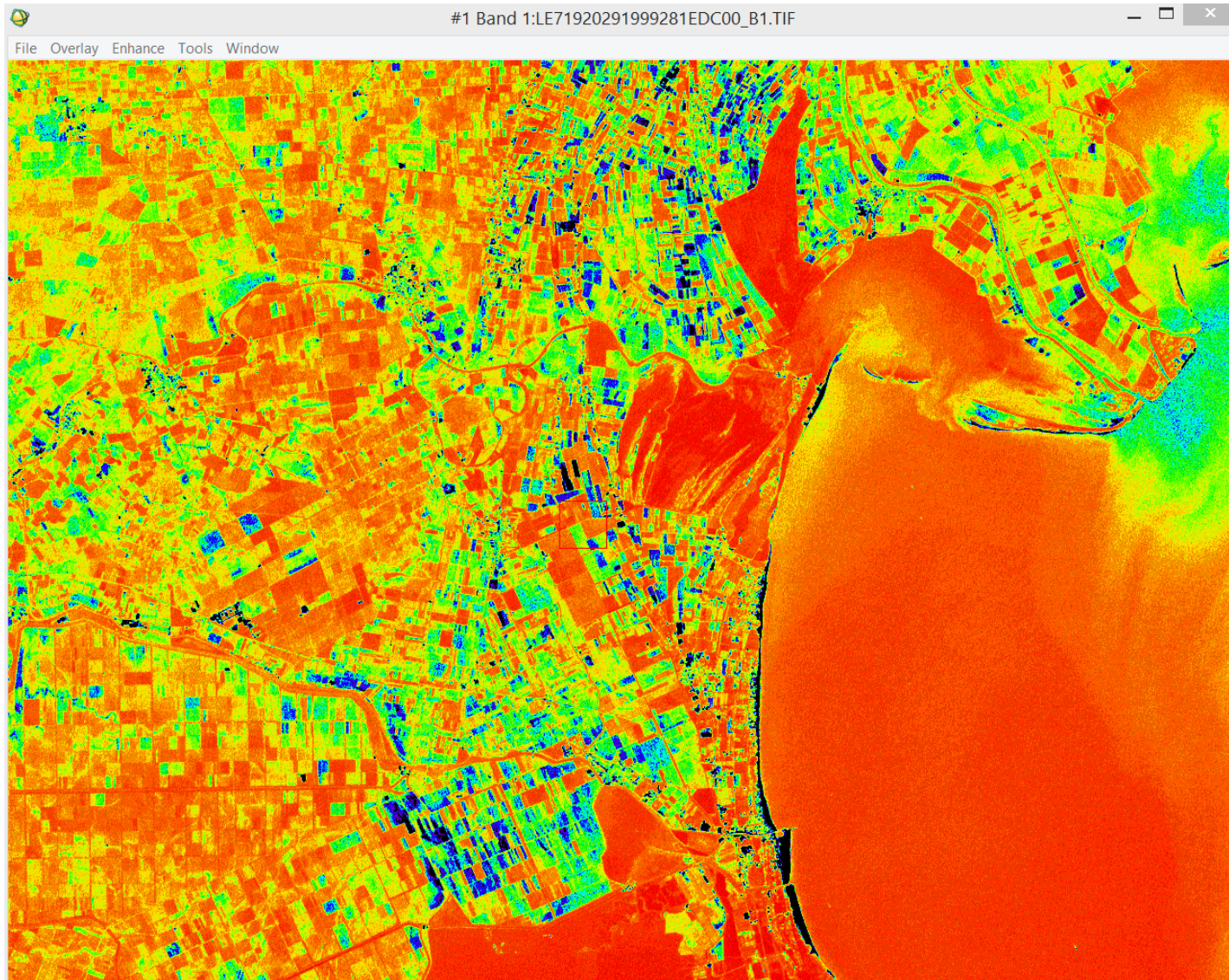
ENHANCEMENT: stretching (diversi algoritmi)



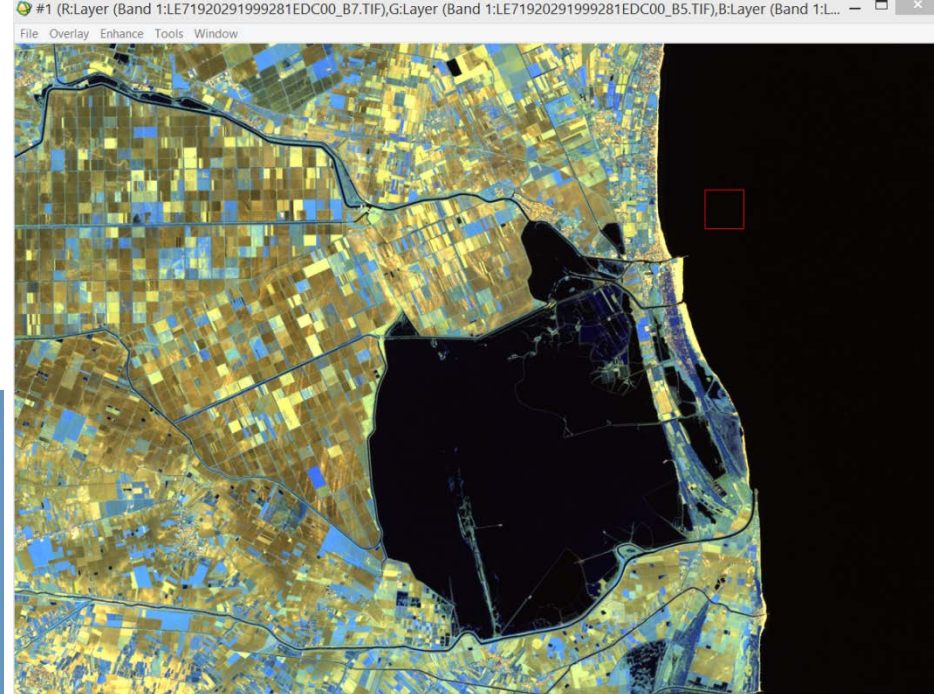
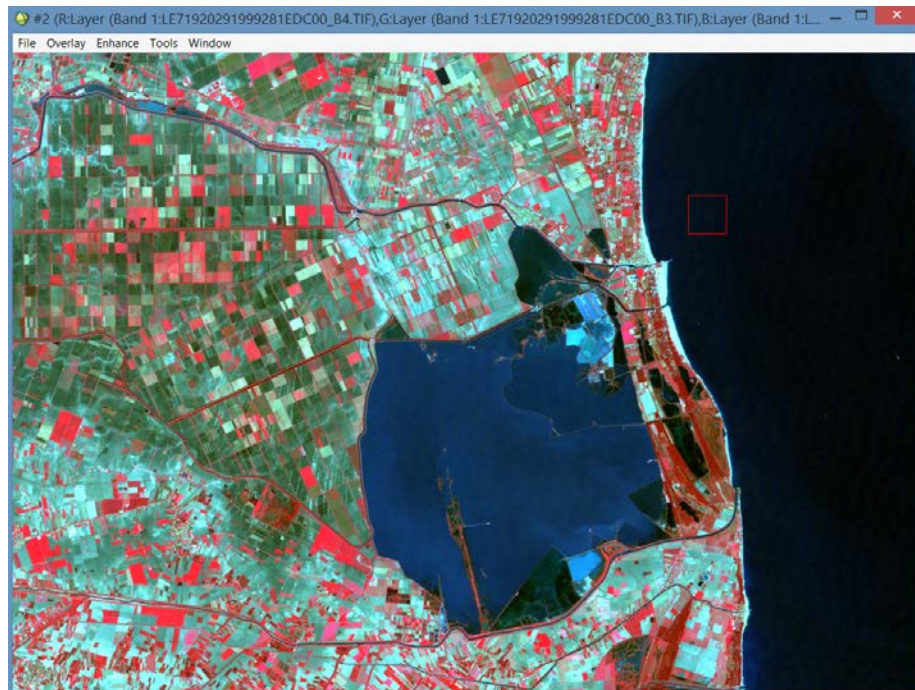
<http://www.slideshare.net/gmes/telerilevamento-fse-1028862>



VISUALIZZAZIONE: color mapping (esempio:eos-1)

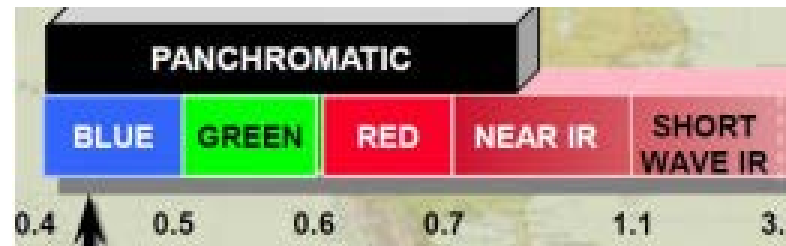


VISUALIZZAZIONE: band composition (false color composition-FCC)

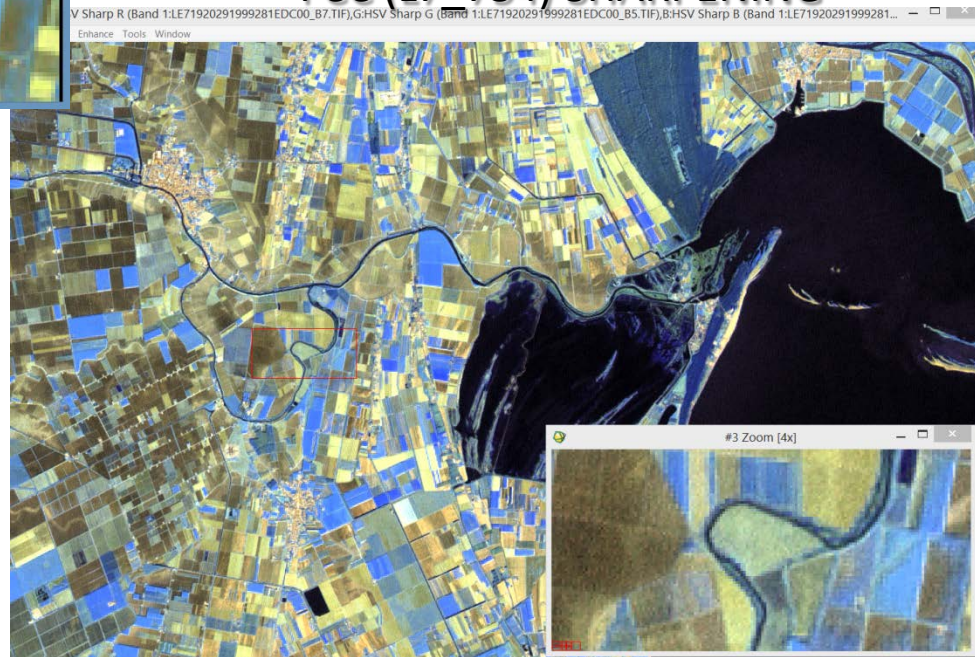


TRASFORMAZIONE: pan-sharpening

FCC (L7_754)



FCC (L7_754) SHARPENING



Esempio di miglioramento del dettaglio dell'immagine:

L7_754 → 30m

“+”

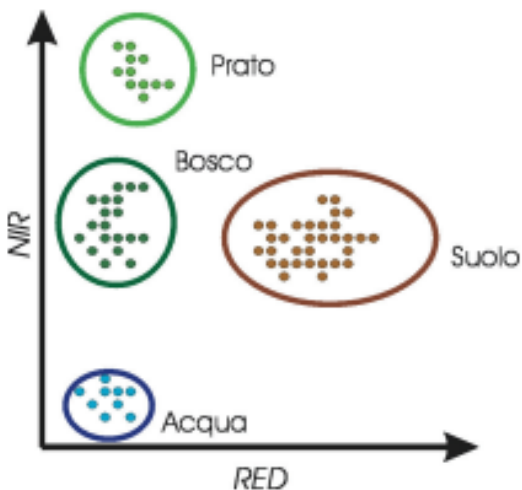
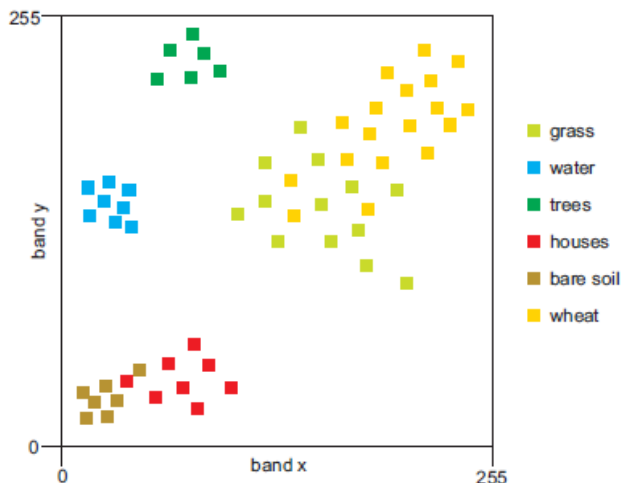
L7_Pancromatico → 15m (non presente in figura)

“=”

L7_754 → 15m

CLASSIFICAZIONE

Il procedimento di classificazione cerca di utilizzare le bande dove oggetti diversi presentano risposte diverse



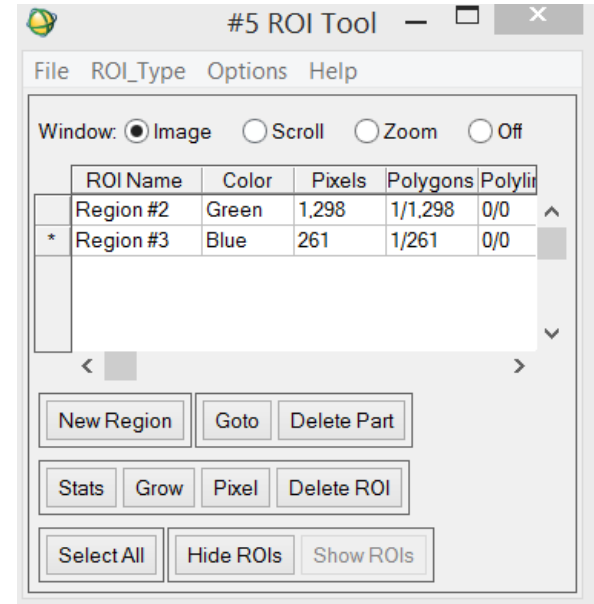
SUPERVISED:

richiede intervento a priori dell'operatore.
Riconoscimento di aree note (es: bosco, colture, suolo) sull'immagine che diventano riferimento delle varie classi.

UNSUPERVISED:

viene fatta automaticamente (senza *training sites*) sulla base di algoritmi che diversificano in classi i pixel dell'immagine sulla base della "somiglianza" (algoritmi vari).

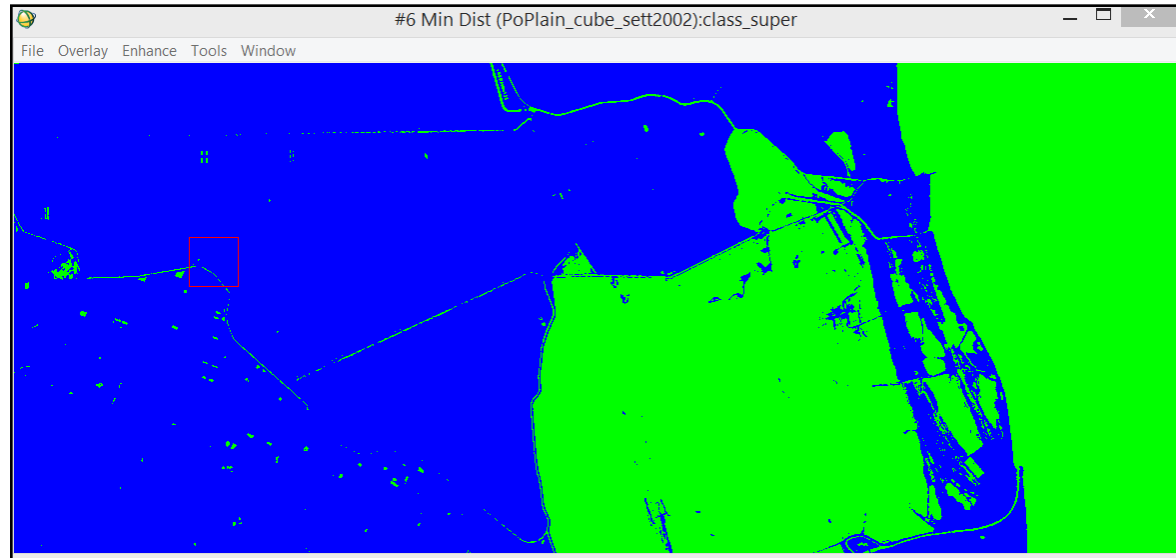
Classificazione-Supervised



Training sets:

Acqua → verde

Suolo → blu

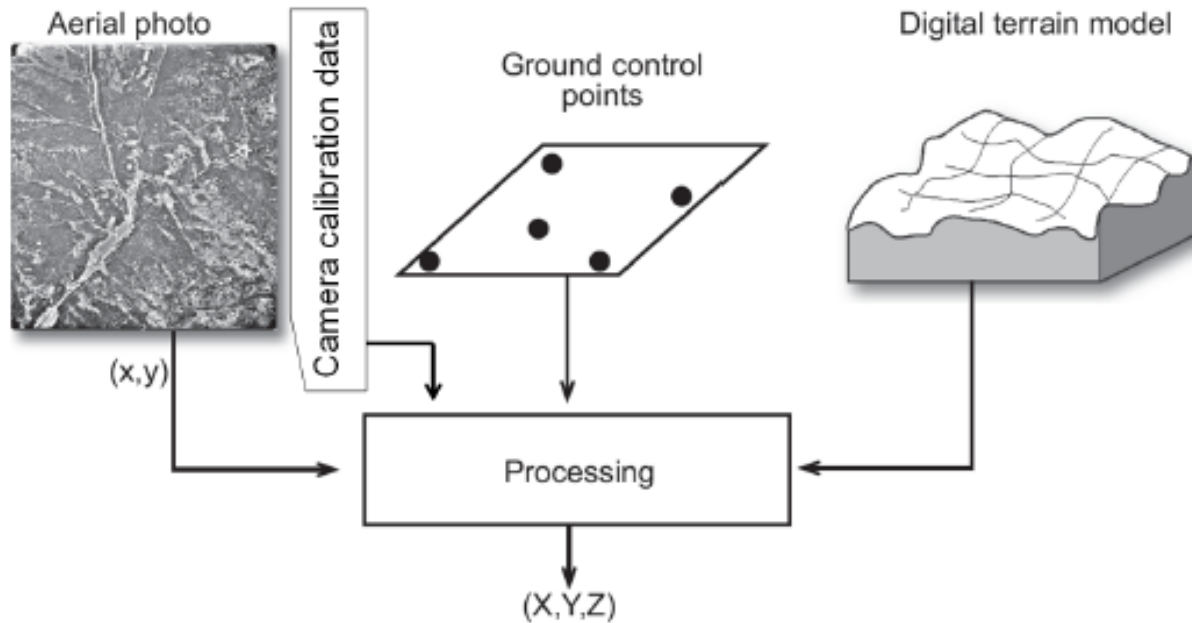


Modelli digitali del terreno

DEM: digital elevation model

DTM: digital terrain model

DEM-LiDAR (Light Detection and Ranging)



Risoluzione geometrica del DEM: 1m x 1m

Tolleranza altimetrica ordine di grandezza decine di centimetri

Sensore aviotrasportato che utilizza un raggio laser (IR) per rilevare la posizione del terreno o degli oggetti che si trovano su di esso.

Generazione di modelli digitali del terreno (DTM) per la creazione di mappe topografiche. Altri impieghi che stanno prendendo piede sono la creazione di modelli di edifici in 3D e la misurazione dell'altezza degli alberi nelle foreste.

quota di volo (metri)	velocità (nodi)	angolo di scansione (+/- gradi)	distanza media tra i punti (m)	ampiezza della strisciata (m)
1000	40	5°	0,32	174,27
		10°	0,47	351,93
1500	140	10°	1,07	524,34
		20°	1,54	1088,06
3000	140	10°	1,51	1055,80
		20°	2,17	2181,45

http://people.dicea.unifi.it/suracelu/empoli-pianificazione/materiale-didattico/7_elementi%20fotogrammetria/lidar_empoli.pdf

Grazie per l'attenzione

