4th CHRIS Proba workshop, 19 Semptember 2006

Tor Vergata University, Rome

Hyperspectral CHRIS Proba imagery over the area of Frascati and Tor Vergata: recent advances on radiometric correction and atmospheric calibration

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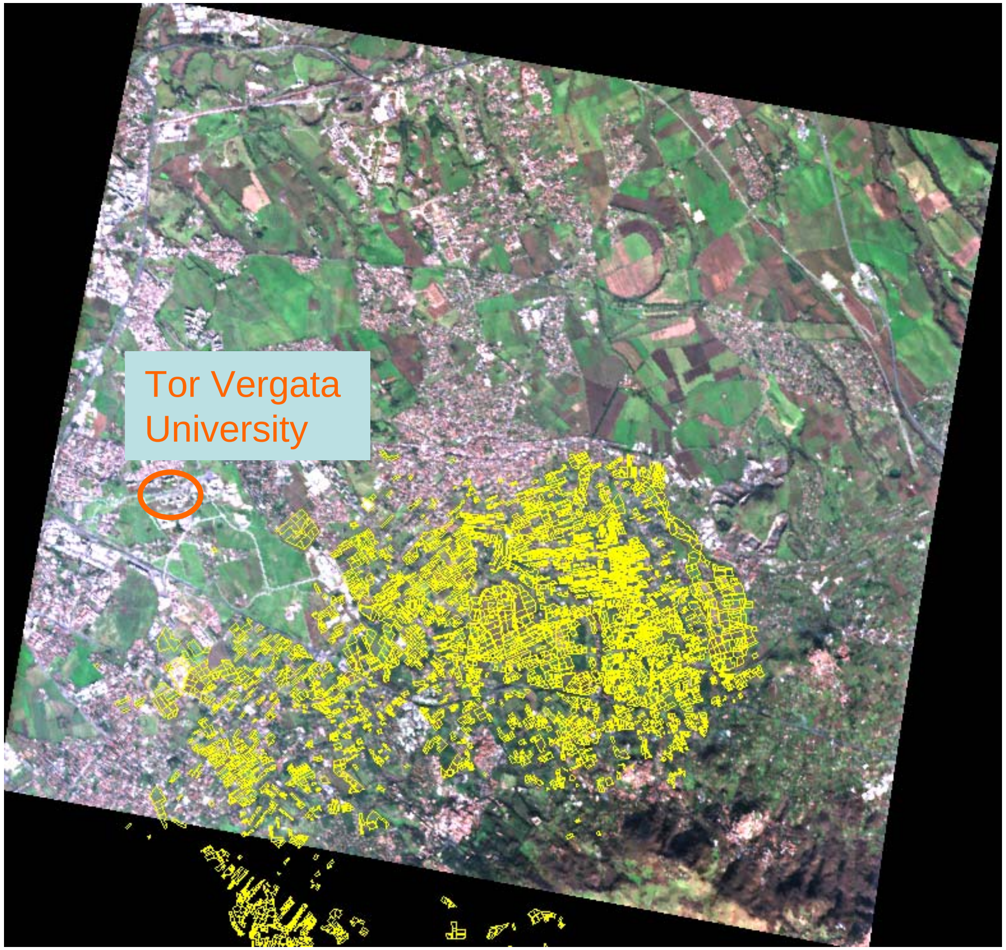
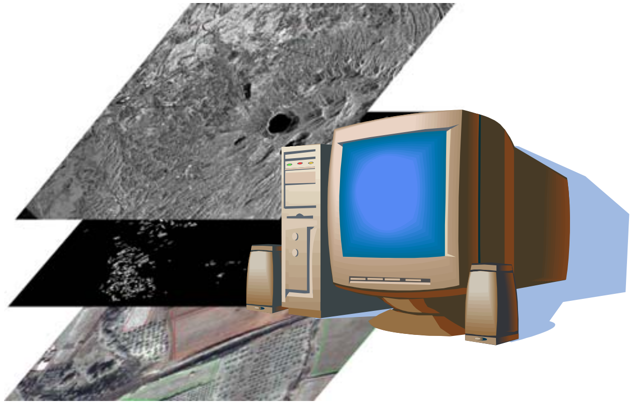
OVERVIEW

- The use of CHRIS hyperspectral images over the area of Frascati and Tor Vergata
- Radiometric correction and atmospheric calibration
- Reflectance extraction over some kinds of cultivated fields
- Multi-angle analysis: first results
- Conclusions and future developments

THE IMAGE DATASET OVER FRASCATI AND TOR VERGATA

Previous works and several projects about the Frascati/Tor Vergata area (e.g. Bacchus Doc, DiVino,…) provide a lot of information and data for this area like SAR products , GIS data, Landsat and high resolution images.





Proba images can integrate this kind of data allowing new analysis using the spectral bands and the new multi-angle capabilities.

In our ESA cat-1 (3075) one acquisition for month is planned over the target area of Frascati and Tor Vergata.
8 images has been acquired so far

WHAT WE ARE DOING

AIMS OF THE RESEARCH PROJECT

- Spectral analysis on specific crops and artificial surfaces
- Multi-angle reflectance analysis

FOR:

- Land use analysis and classification

… but before every analysis some corrections are necessary!

- **Radiometric correction** (black pixels correction, destriping)
- **Atmospheric calibration**
- **Rectification and GIS integration**

DESTRIPING USING THE FREQUENCY DOMAIN FILTERING: THE METHODOLOGY

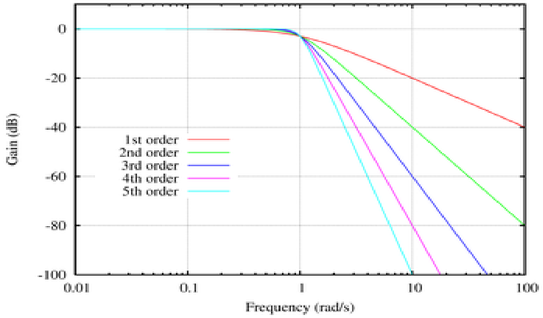
This algorithm has been proposed by M.J.Settle [Settle, 2004] [3] and includes some important steeps:

1. For each band, calculate an average radiance for each column of data
2. Calculate the logarithm for these averages
3. Apply a low pass filter to cut the high frequency components
4. Subtract the result of step 3 from the logarithm of averages to obtain the correction factors
5. Calculate the anti-logarithm
6. Apply the correction factors to each column of the image.

THE CRUCIAL STEP!

In particular we focused on the poin number 3 which now consists in making a low-pass filtering in the spatial frequency domain. The low-pass filter is a Butterworth filter.

$$\frac{1}{1 + C(R/R_0)^{2n}}$$

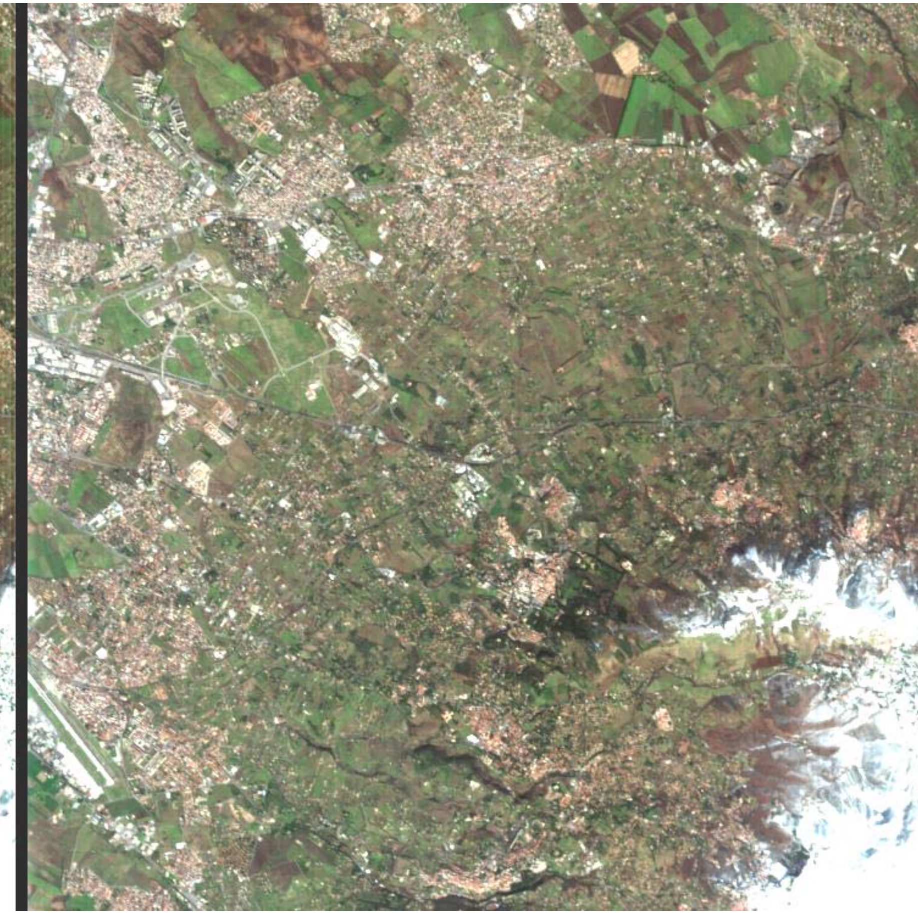


The destriping tool has been fully developed using IDL and it can operate having as input any CHRIS/proba images in any operation mode, in full resolution (18m) and medium resolution (30), in half swath and full swath.

SOME EXAMPLES ABOUT THE RADIOMETRIC CORRECTION (3/3)

Frascati/Tor Vergata

Before destriping



After destriping

THE METHODOLOGY FOR ATMOSPHERIC CORRECTION (1/2)

The atmospheric correction has been performed estimating the atmospheric parameters by using the radiative trasfer model LibRadTran

PRINCIPAL STEPS

1 Retrieval of the parameters for the correction by the use of the radiative transfer model (irradiance, difuse and direct transimmattance, radiance and atmospheric scattering) and of the CNR Tor Vergata aerosol measurements (http://aeronet.nasa.gov)

2 Computation of the recalibration coefficients by means of the comparison of the simulated radiances with the radiances measured on some soils (runway asphalt). For the simulated reflectance of these soils the JPL library has been used.

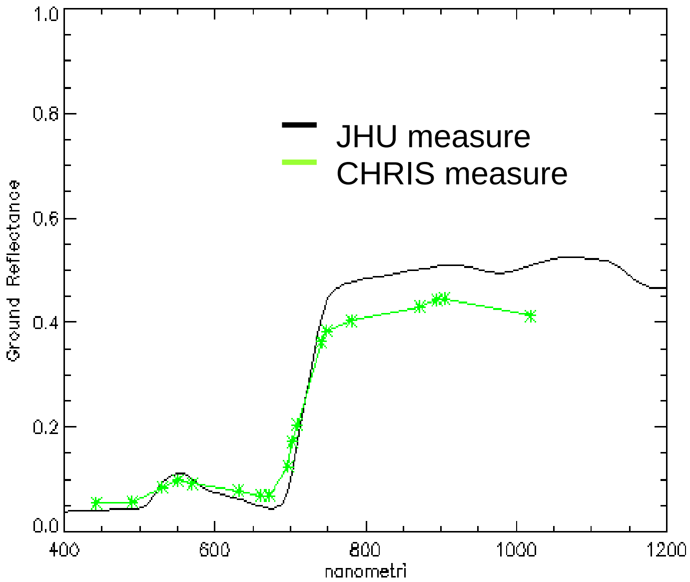
3 The adjacency effect is corrected by the use of weighted mean in a large window applied to all image pixels.

$$\rho^{(2)}(x,y) = \rho^{(1)}(x,y) + q\{\rho^{(1)} - \bar{\rho}(x,y)\}$$

$$\bar{\rho} = \frac{1}{N^2}\sum_{i,j=1}^{N} \rho_{i,j}^{(1)}$$

4 The CHRIS image has been finally corrected by applying:

$$\rho(\lambda,\theta) = \frac{\pi(L_{TOA}(\lambda,\theta) - L_{path}(\lambda,\theta))}{E_0(\lambda,\zeta)T(\lambda,\theta)}$$



A comparison with a measured reflectance for a grass surface has been done (http://speclib.jpl.nasa.gov).

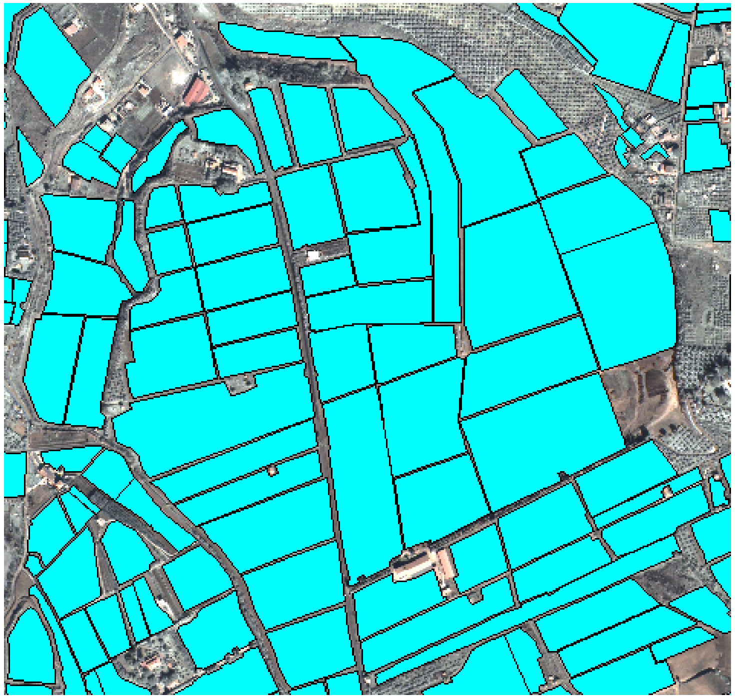
The measure is made by Johns Hopkins University and the grass was illuminated from directly above and the reflectance angle is 60 degree.

Multitemporal and multiangular analysis using the corrected images over the area of Pantano (Rome), Tor Vergata and Frascati

THE SELECTION OF SOME AGRICULTURAL FIELDS INTO THE CHRIS IMAGES

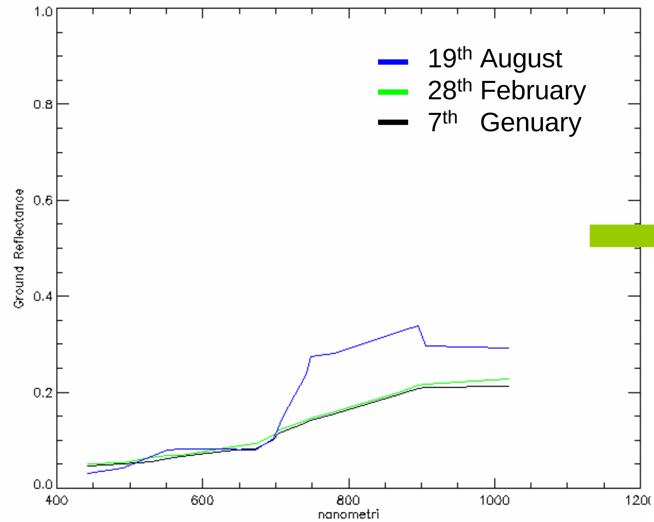
Some fields have been selected by the use of high resolution images, GIS instruments and ground truth:
Maize
Kiwi
Uncultivated fields

The vineyards have been selected using the vector layer provided by the GIS developed for the Bacchus Doc project

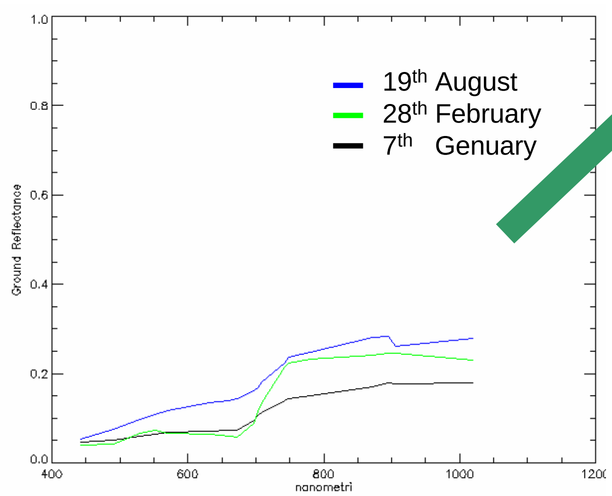


REFLECTANCE MEASURED OVER SOME CULTIVATED FIELDS

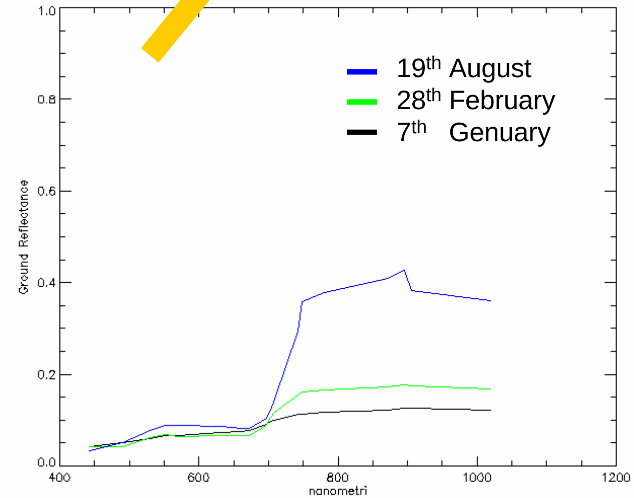
Kiwii



Uncultivated (mixed bare soil and grass)

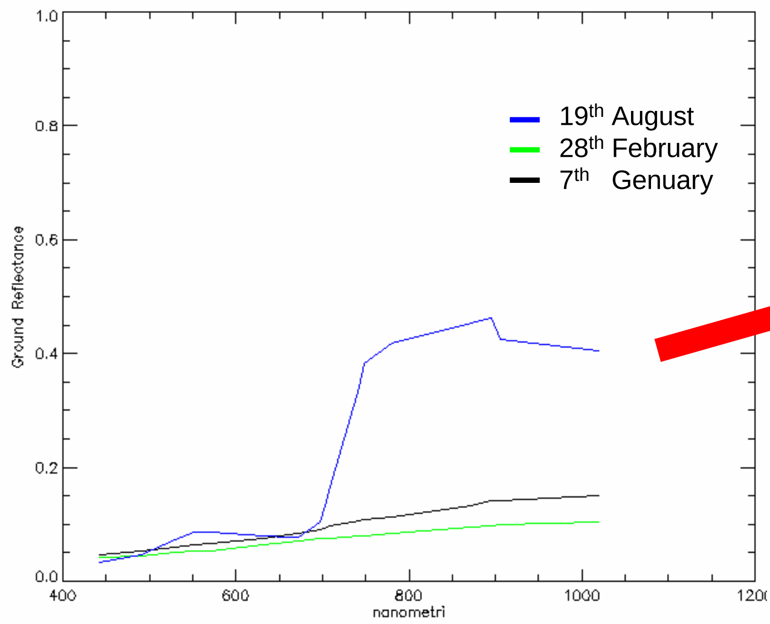


Maize

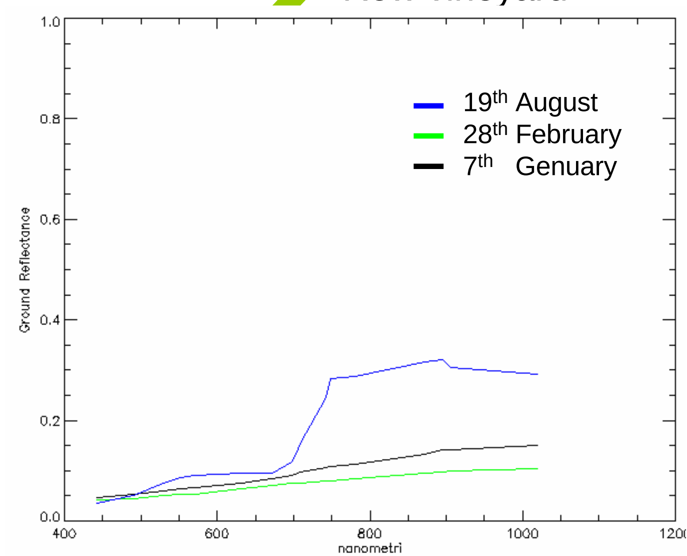


THE GROWTH OF THE WINEYARD

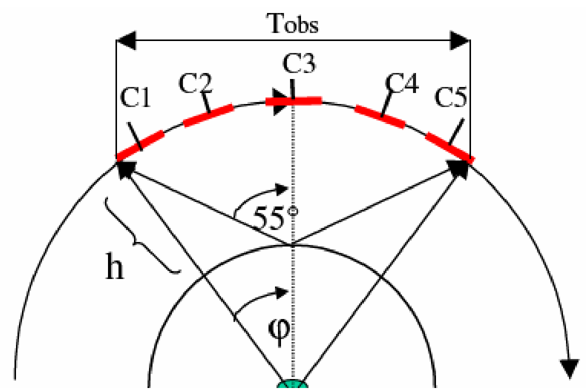
Tendone vineyard



Row vineyard



The reflectance is sensible to the vineyard growth. Infact it is possible to see how the reflectance increases during the summer season while the vineyard is having its strongest growth.
This is more evident for the Tendone respect to the row vineyard, because the Row vineyard is more influenced by the soil below the canopy.



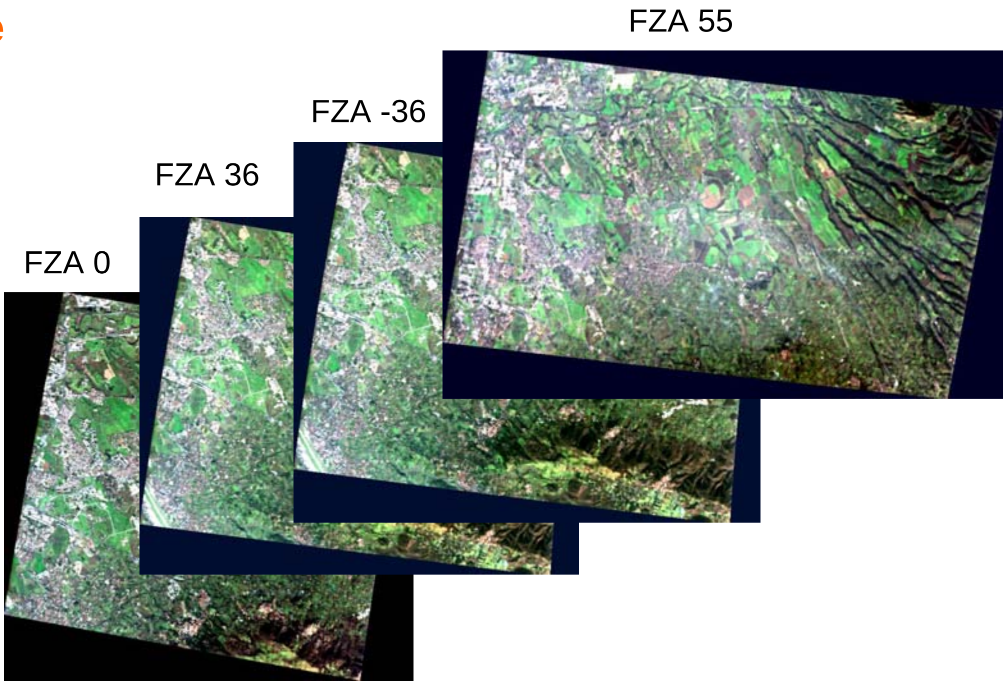
CHRIS acquires a set of up to five images of each area during each acquisition sequence (-55, -36, 0, +36, +55)

To correct the images for atmospheric effects we have used the acquisition parameters (zenith and azimuth of view) contained into the HDF header

But before the multiangle analysis the images must be rectified !

The rectification step has been done using the HR QuickBird of March 2002 which composes the image dataset for the Bacchus Doc project

The methodology:
- GCP rectification
- Polynomial transformation (second order)

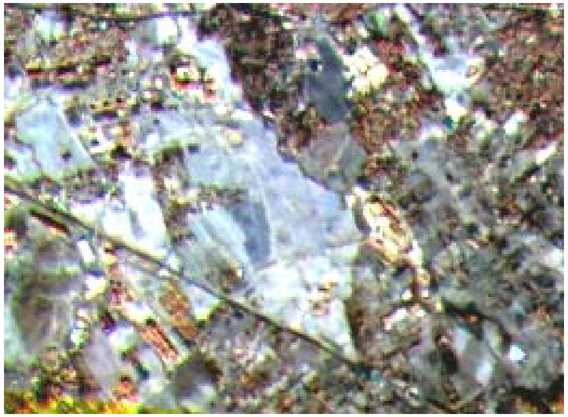


THE MULTI-ANGLE BAND COMPOSITION

Multi-angle band composition over the campus of Tor Vergata University (band 10, 703 nm)

RGB

FZA: -36, 0, 36



FZA: 0, 36, 55

MULTIBAND COMPOSITION OVER THE PANTANO CULTIVATED FIELDS

True Color

Band 8 multiangle composition

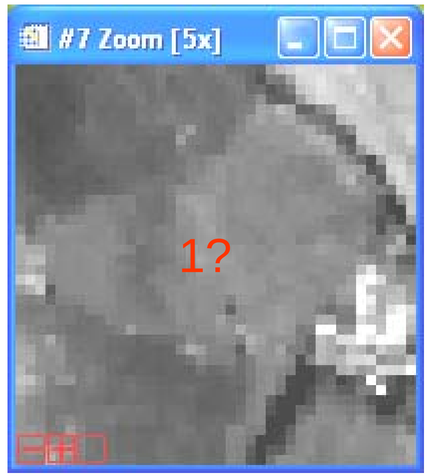
The band 8 composition evidences a radiance difference which could be due to a different structure or cultivation

The high resolution image confirms that the large triangular field is really composed by two different filelds

HOW MANY FIELDS ?

…another example of multiangle composition for radiance difference analysis applied to the land use

True Color



Single band (band 8)

Band 8 multiangle composition

The high resolution image confirms the presence of several fields for the same area

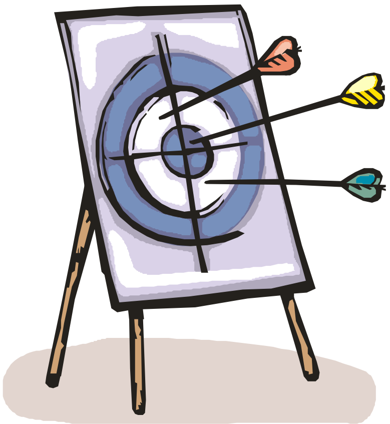
IDEA !

The multiangle capabilities could provide an improvement for classification, land use analysis and material mapping

CONCLUSIONS AND FUTURE IMPROVEMENTS

WHAT WE HAVE DONE

- An algorithm for CHRIS image destriping, based on the low-pass filtering in the spatial frequency domain has been realized
- A methodolgy for atmospheric calibration using the libradtran radiative trasfer model has been implemented
- Multitemporal reflectances have been retrieved over some cultivated fields
- Preliminary results for multi-angular analysis have been produced



BUT THE WAY IS STILL LONG…

- Measured atmospheric profiles and could improve the atmospheric calibration
- More multitemporal series of images could be analyzed over the cultivated fields
- New algorithms for classification (neural net) could be developed and improved using the spectral information and the multiangle capabilities.