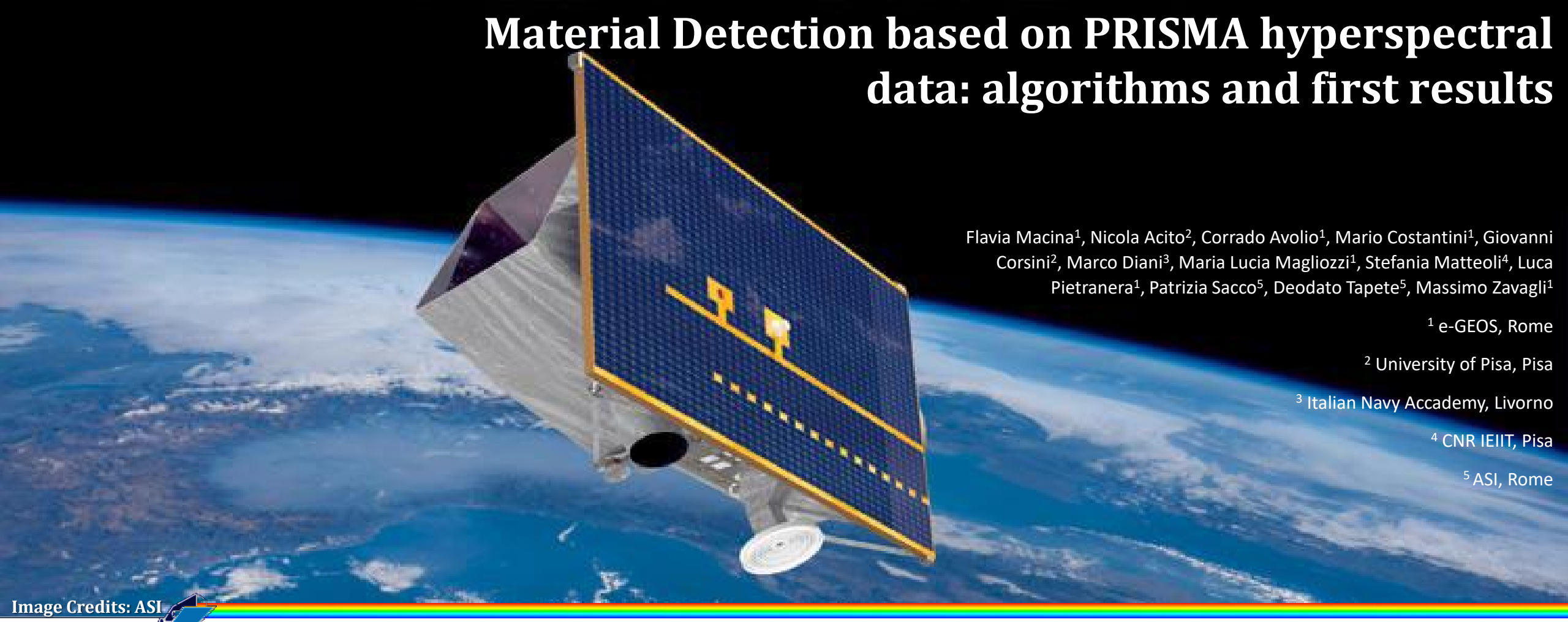
Material Detection based on PRISMA hyperspectral data: algorithms and first results



Flavia Macina[1], Nicola Acito[2], Corrado Avolio[1], Mario Costantini[1], Giovanni Corsini[2], Marco Diani[3], Maria Lucia Magliozzi[1], Stefania Matteoli[4], Luca Pietranera[1], Patrizia Sacco[5], Deodato Tapete[5], Massimo Zavagli[1]

[1] e-GEOS, Rome

[2] University of Pisa, Pisa

[3] Italian Navy Accademy, Livorno

[4] CNR IEIIT, Pisa

[5] ASI, Rome

Image Credits: ASI

Agenzia Spaziale Italiana

AN ASI / TELESPAZIO COMPANY

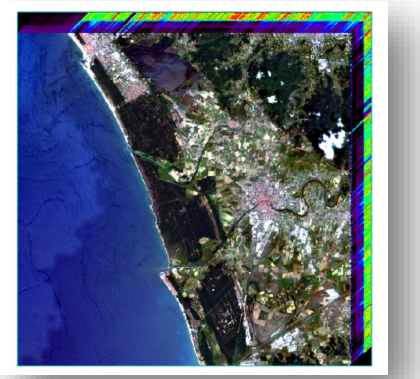
Project Framework

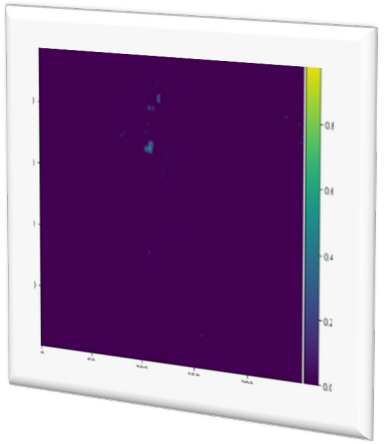
- The Material Detection prototype was developed in the framework of the ASI Contract no. 2021-7-I.0, whose main objective is the prototyping of Level 3 / Level 4 value-added products based on hyperspectral satellite data
- Development of 8 prototypes based on PRISMA data
- Partnership between companies and science and research groups

Material Detection: overview

The Material Detection prototype provides maps, in the monitored area, with the possible locations of the target material.

Material detection in hyperspectral images is based on algorithms that exploit spectral information. They identify image pixels whose spectrum exhibits a high degree of similarity with the reference signature. The reference spectrum of the material of interest can be obtained from a spectral library or from an identified in-scene target pixel.



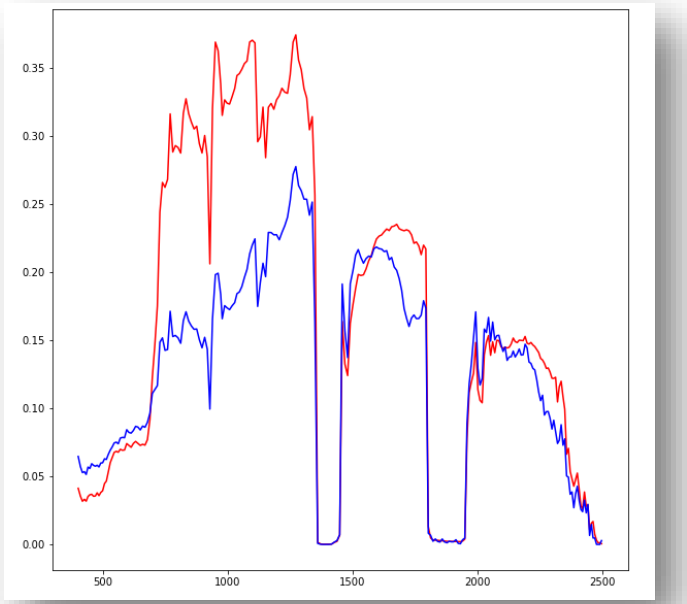


Data generated by e-GEOS and UNIPI, under an ASI License to Use; Original PRISMA Product - © ASI – (2021

Material Detection: PRISMA contribution

Continuos spectrum
High spectral resolution
230 bands

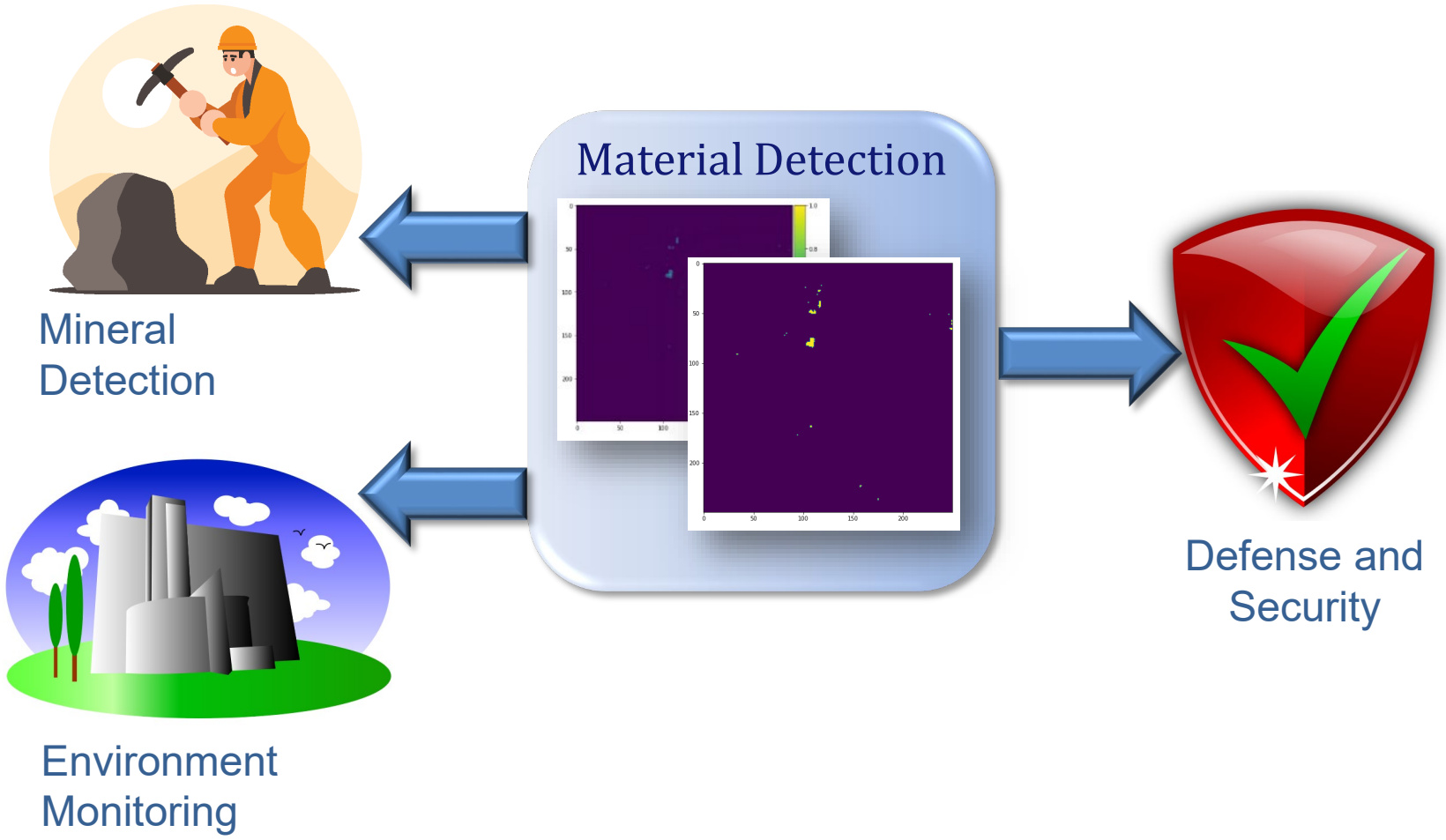
Distinction between target spectrum and background spectrum



Satellite platform

High spatial coverage
Periodic monitoring

Material Detection: applications

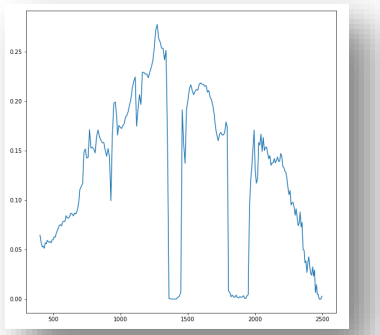


Data generated by e-GEOS and UNIPI, under an ASI License to Use; Original PRISMA Product - © ASI – (2021

Material Detection: algorithm

- The Material Detection algorithm is based on the Generalized Likelihood Ratio Test (GLRT)
- The detector is based on the ACE (Adaptive Cosine Estimator) detector
- The GLRT measures the similarity between each pixel of the image and the reference material spectrum
- The background characteristics needs to be estimated in terms of mean value and covariance matrix

Hyperspectral cube
PRISMA L2C



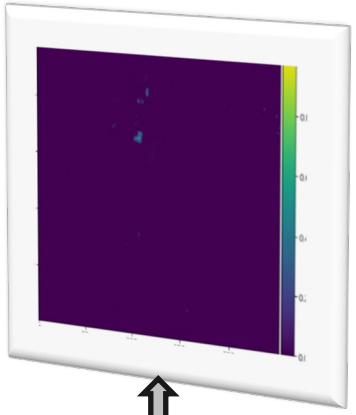
Reference Spectral Signature

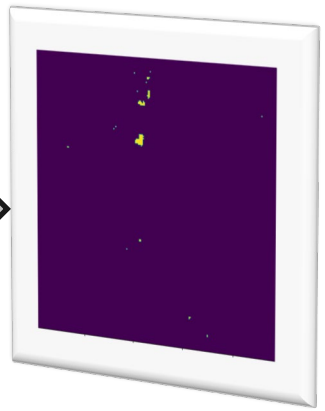
$$GLRT(\boldsymbol{x}) = \frac{[(\boldsymbol{t}-\boldsymbol{\mu})^T \boldsymbol{C}^{-1}(\boldsymbol{x}-\boldsymbol{\mu})]^2}{[(\boldsymbol{t}-\boldsymbol{\mu})^T \boldsymbol{C}^{-1}(\boldsymbol{t}-\boldsymbol{\mu})][a + b(\boldsymbol{x}-\boldsymbol{\mu})^T \boldsymbol{C}^{-1}(\boldsymbol{x}-\boldsymbol{\mu})]}$$

GLRT

$$\frac{f(\boldsymbol{x}|H1)}{f(\boldsymbol{x}|H0)} \gtrless \eta$$

Thresholding





Data generated by e-GEOS and UNIPI, under an ASI License to Use; Original PRISMA Product - © ASI – (2021

Material Detection: background characterization

- The Material Detection algorithm needs the characteristics of the background.
- The pixel belonging to the target should not significantly affects the background characterization
- Different choices can be made to select pixels to estimate the background
- Exclusion strategies can be used to delete target-like pixels from background

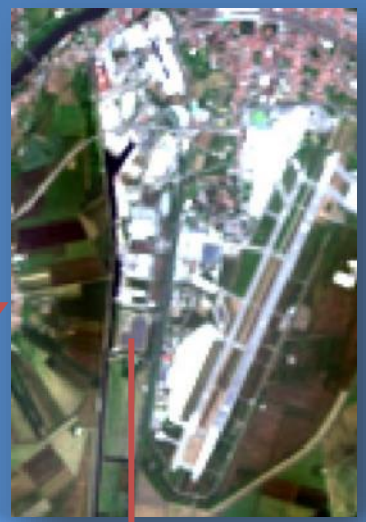
Global Background

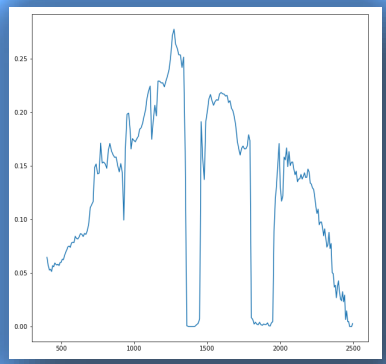
Local Background

Cluster-Based Background

Material Detection: First Results – Photovoltaic Panels

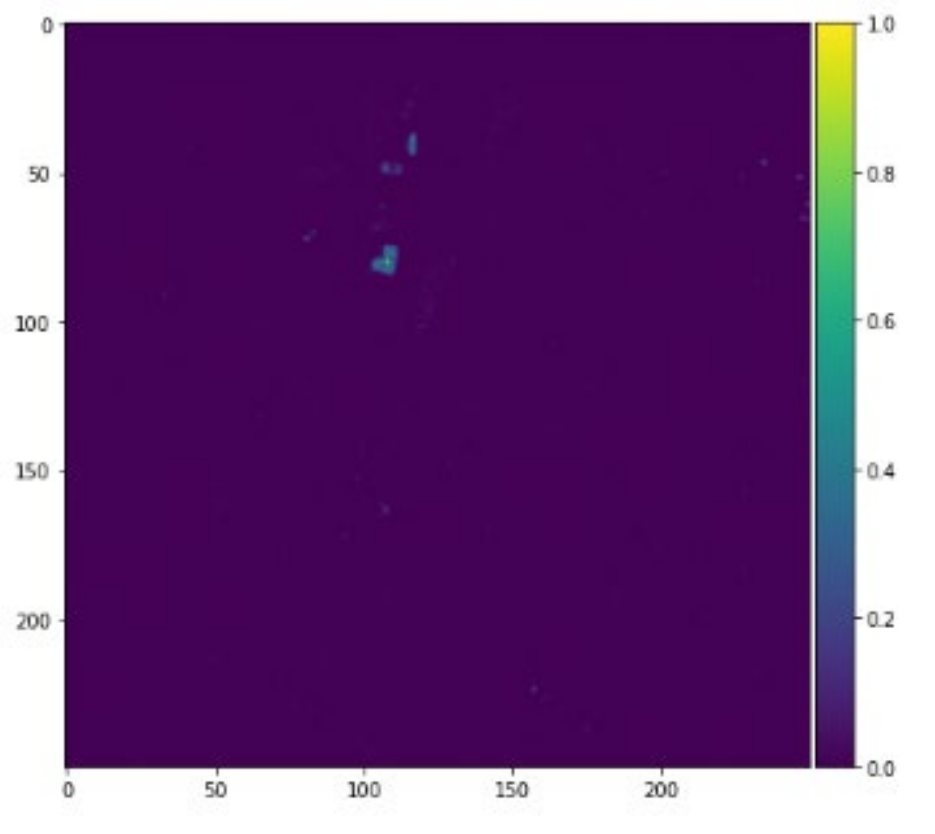
PISA – 2021/06/10

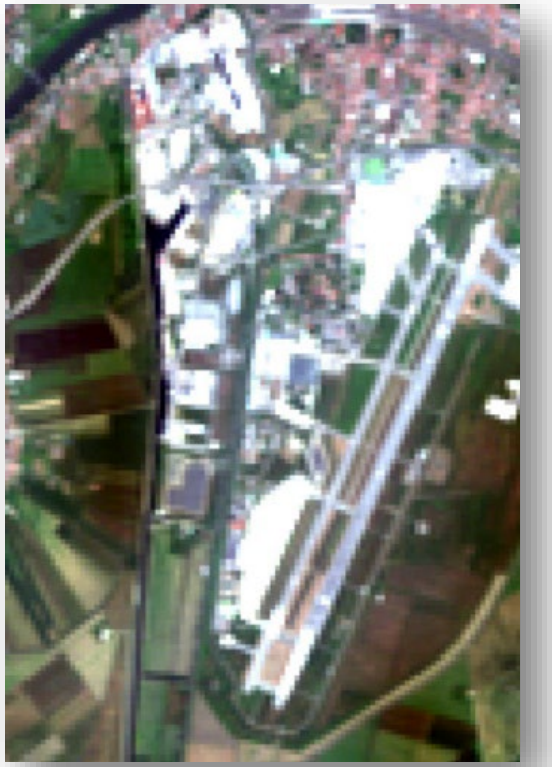




Data generated by e-GEOS and UNIPI, under an ASI License to Use; Original PRISMA Product - © ASI – (2021); Google satellite image © Google.

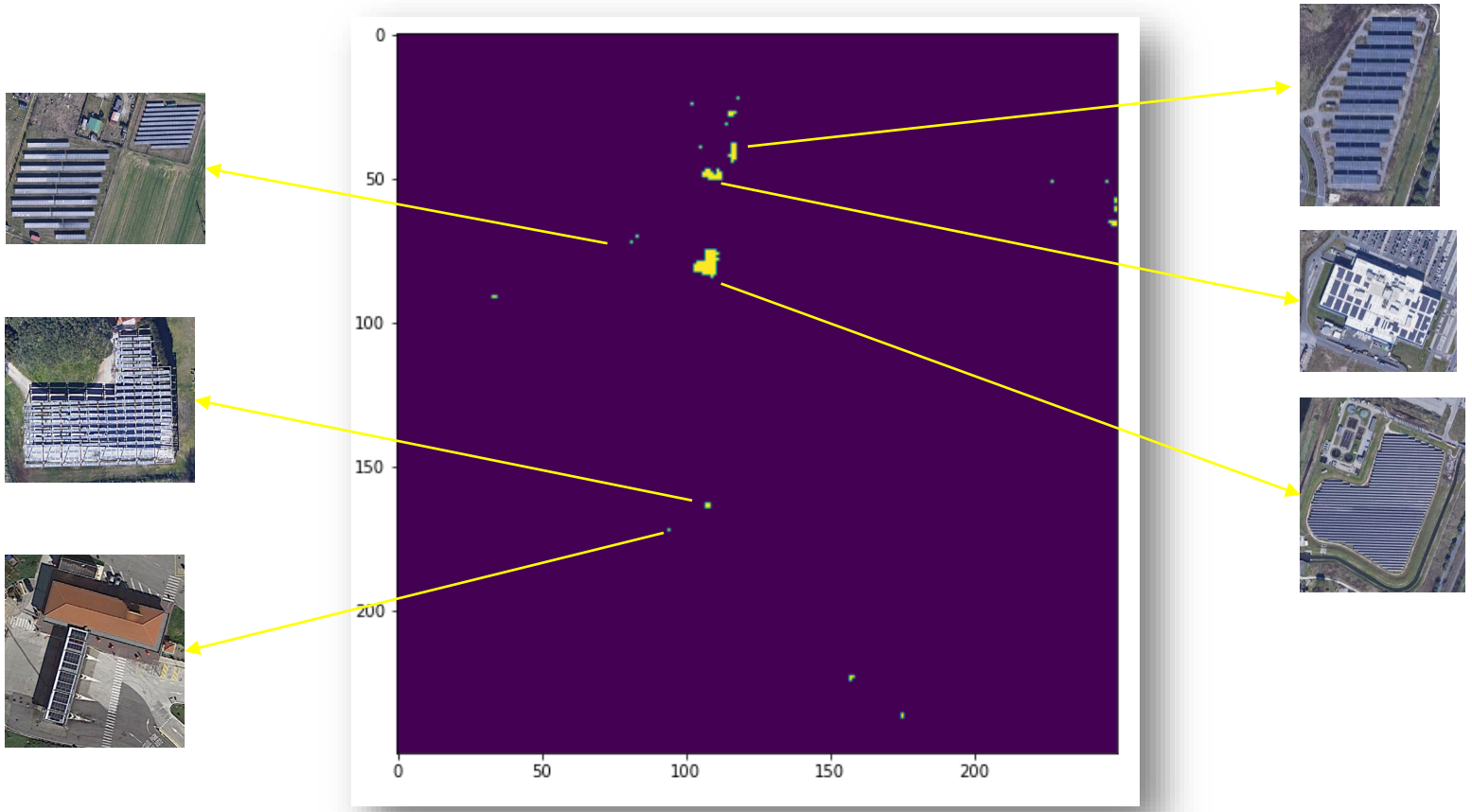
Material Detection: First Results – Photovoltaic Panels





Data generated by e-GEOS and UNIPI, under an ASI License to Use; Original PRISMA Product - © ASI – (2021)

Material Detection: First Results – Photovoltaic Panels



Data generated by e-GEOS and UNIPI, under an ASI License to Use; Original PRISMA Product - © ASI – (2021); Google satellite image © Google.

Material Detection: First Results – Photovoltaic Panels

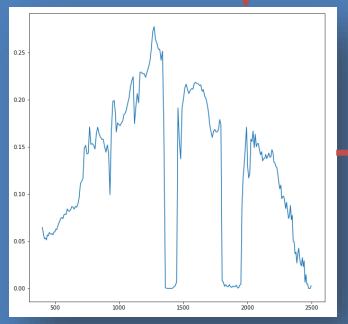
Pisa, 2021/06/10

Pisa, 2021/08/01

Data generated by e-GEOS and UNIPI, under an ASI License to Use; Original PRISMA Product - © ASI – (2021)

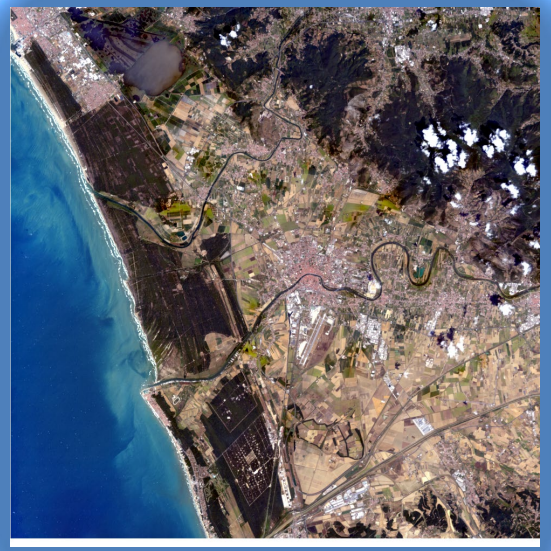
Material Detection: First Results – Photovoltaic Panels

PISA – 2021/06/10



Reference Spectral Signature

PISA – 2021/08/01



Material Detection Prototype

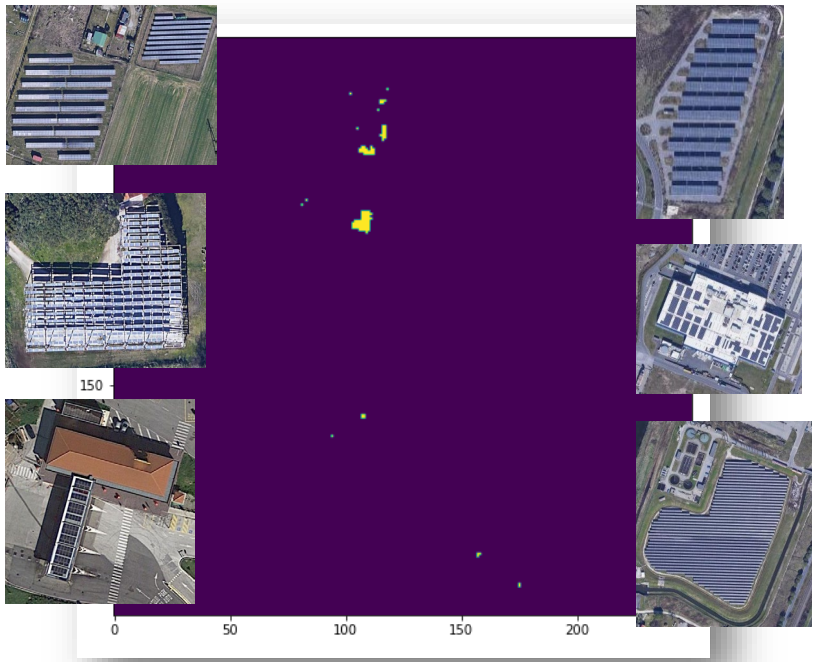
Data generated by e-GEOS and UNIPI, under an ASI License to Use; Original PRISMA Product - © ASI – (2021)

Material Detection: First Results – Photovoltaic Panels

Data generated by e-GEOS and UNIPI, under an ASI License to Use; Original PRISMA Product - © ASI – (2021); Google satellite image © Google.

Material Detection: Conclusions

- Material Detection methodologies for exploiting PRISMA DATA.
- Robust method w.r.t. the spectral variability of the background (e.g. vegetation)
- Good sub-pixel detection capability.



Data generated by e-GEOS and UNIPI, under an ASI License to Use; Original PRISMA Product - © ASI – (2021); Google satellite image © Google.

Material Detection: Future Developments

- Enhancement of spectral database of materials with new reflectance measurements (most frequently used materials in the areas of interest)
- Possibility to exploit spatial information, useful in the case of extended target
- Investigation of data fusion methods to improve performances by using different instruments (spaceborne, airborne)
- User-friendly interfaces to ease the operational use by non-expert users of material detection algorithm
- Improvement of spatial resolution of new spaceborne hyperspectral sensors

Thank you for your attention!