

# L'IPERSPETTRALE COME STRUMENTO DI MONITORAGGIO AMBIENTALE

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**Applicazioni a supporto della sicurezza della popolazione:**  
*carattere tattico* della tecnologia quando impiegata su piattaforma aerea  
e il *carattere strategico* della soluzione satellitare

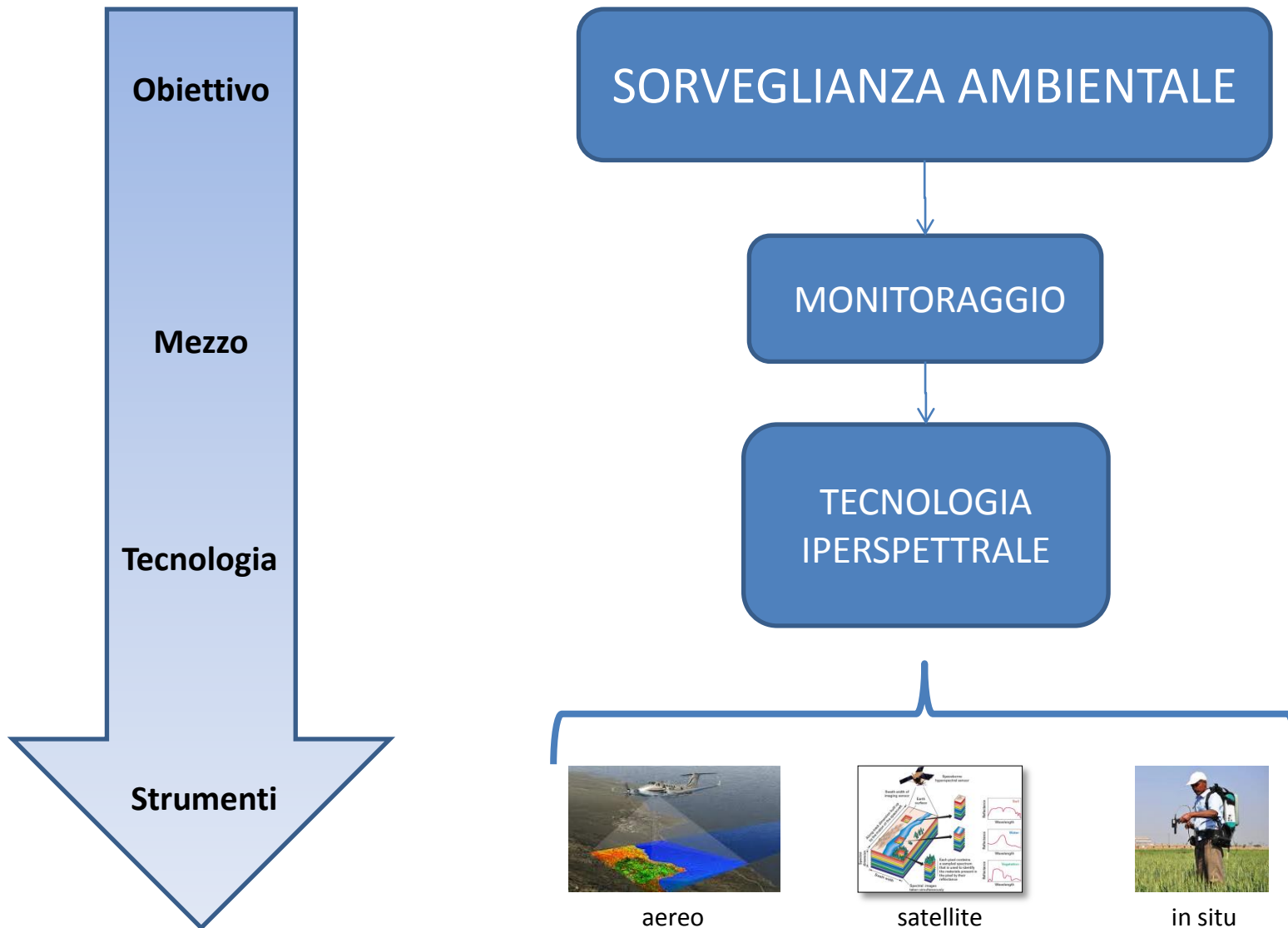
*Il telerilevamento iperspettrale per applicazioni civili e scientifiche*  
21 Settembre 2018  
C.I.S.A.M. - Via della Bigattiera, 10 San Piero a Grado (PI)

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## OBBLIGHI DI LEGGE IN MATERIA DI AMBIENTE (Direttive europee)

	Theme	Sub-theme
Nitrati (91/676/EEC) Habitat (92/43/EEC)	<b>Agriculture &amp; Food Security</b>	<i>Assessment of Biophysical and Biochemical Variables Related to The Crops and of Agronomic Interest Top Soil Properties</i>
Uccelli (2009/147/EC)	<b>Ecosystem structure &amp; composition (biodiversity)</b>	<i>Land Cover and Use Land Degradation Vegetation Degradation</i>
Strategia Marina (2008/56/EC)	<b>Inland &amp; Coastal water</b>	<i>Water quality monitoring and assessment of biophysical parameters Bottom Substrate Characterization, Benthic Communities Mapping And Monitoring Shallow Water Bathymetry Characterization And Detection Of Floating Materials Emerging Habitats And Wetlands</i>
Materie prime (COM 2008/699) Natural Capital COM/2013/0249	<b>Geology &amp; minerals / soils</b>	<i>Geophysical parameter of Volcanic activities</i>
	<b>Urban environment</b>	-
Alluvioni (2007/60/EC)	<b>Natural and man-made hazards</b>	<i>Forest Fire Front Identification And Damage Assessment Measurement Of Air Pollution And The Detection Of Surface Phenomena From The Identification Of Man Made And Natural Gas Emission Soil Pollution Related To Human Activities Marine Hazard</i>
UNESCO (Parigi 1972)	<b>Cultural Heritage</b>	<i>Archaeology site identification</i>
Nuova Strategia forestale	<b>Forestry, Vegetation Parameters and Processes</b>	-
No riferimenti specifici	<b>Ice and Snow</b>	-

Table 3. Ad hoc taxonomy for the hyperspectral applications survey





# CARATTERE TATTICO E STRATEGICO DELLA TECNOLOGIA IPERSPETTRALE PER L'AMBIENTE

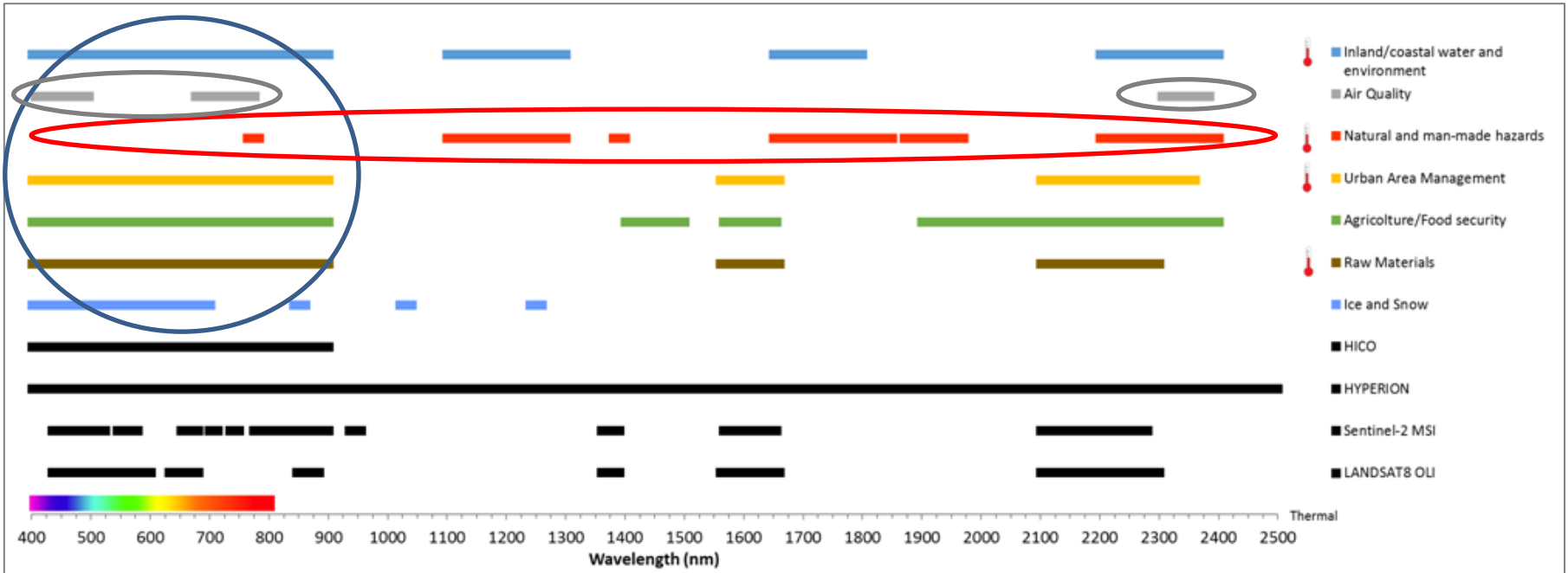
## CARATTERE TATTICO

- +** **Quantità e qualità dell'informazione** → Riduzione del dato da archiviare sulla base dei requisiti utente
- +** **Sinergie con altri strumenti**  
(Bassa Velocità dell'informazione) → Aumento delle sinergie con altri satelliti, con dati da aereo, drone ed in situ per calibrazione elaborazione e validazione.

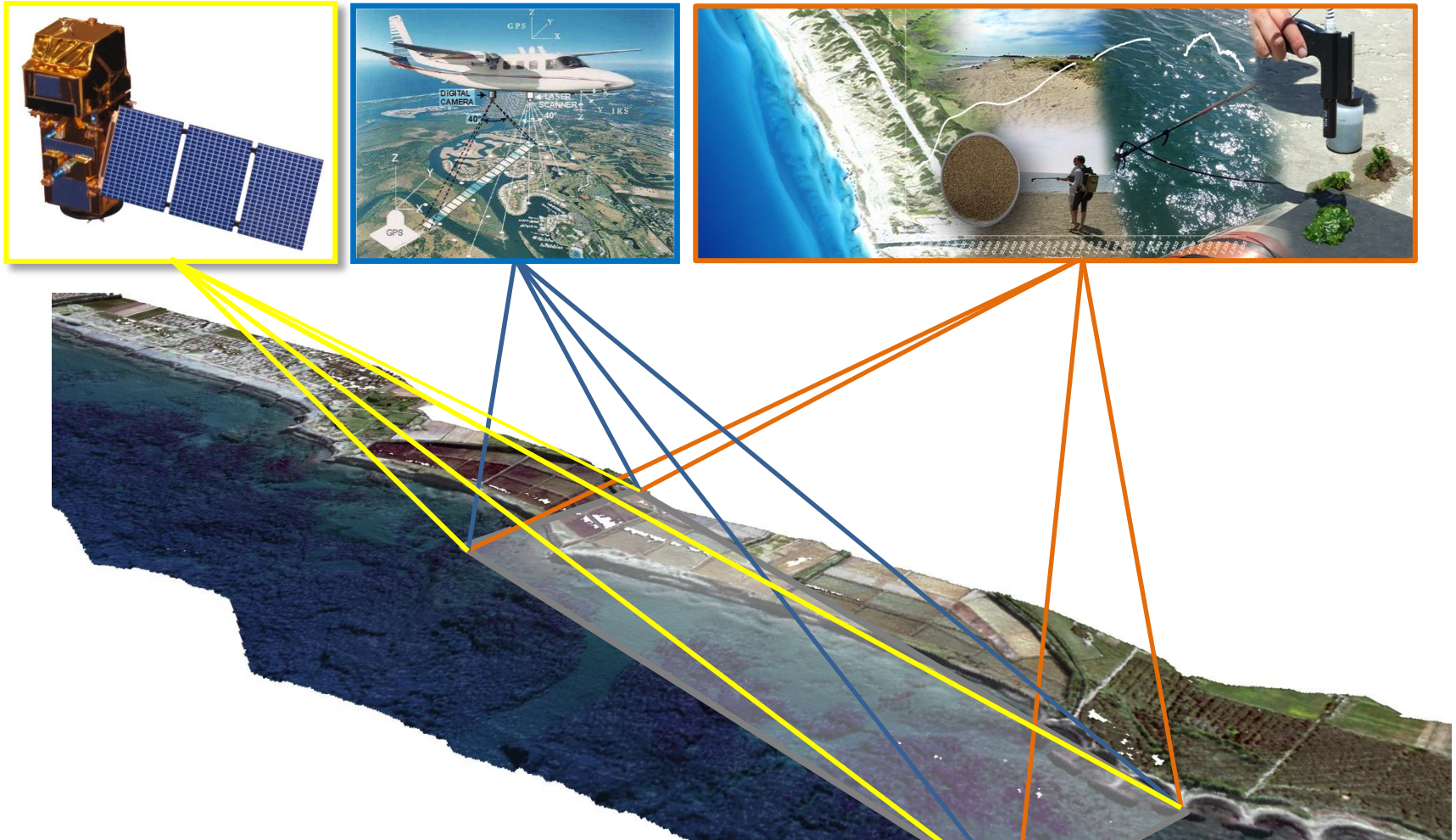
## CARATTERE STRATEGICO

- +** **Copertura dell'informazione** → Aumento della precisione e dell'accuratezza del dato spazializzato e multitemporale
- +** **Campi di applicazione** → Aumento delle applicazioni di previsione, di ricerca e recupero, dei servizi di mappatura e modellistica

Analisi dei domini applicativi **IN FUNZIONE DEI** relativi range spettrali di interesse



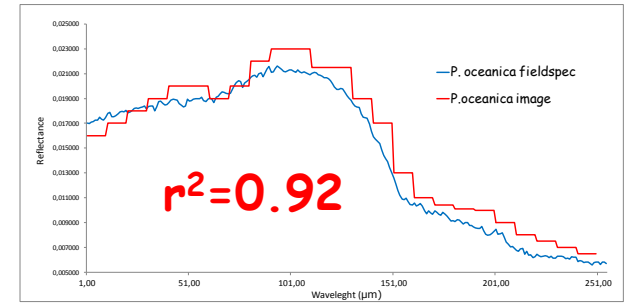
1. CI SONO RANGE SPETTRALI RILEVANTI IN TERMINI DI NUMERO DI DOMINI APPLICATIVI (VIS)
2. ALCUNI DOMINI APPLICATIVI BENEFICIANO DELL'IPERSPETTRALE ANCHE GRAZIE ALLA SINERGIA CON ALTRI SENSORI (TERMICO)



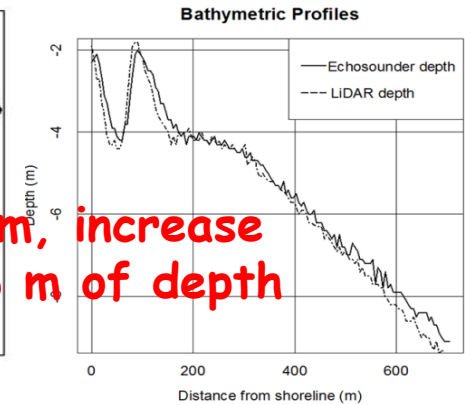
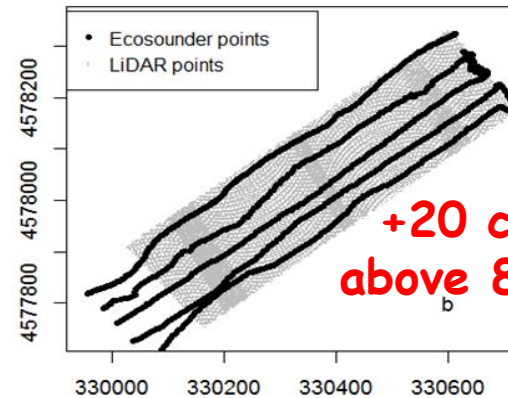
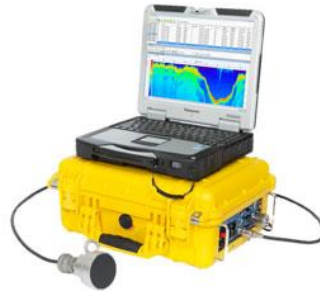
Il rilievo da piattaforme aeree e di campo non è ostacolato dalla (in) accessibilità di un sito che è spesso un problema ad esempio nelle zone costiere, esso permette di coprire grandi superfici in breve tempo per studiare i modelli ecologici e geofisici a scala d dettaglio.



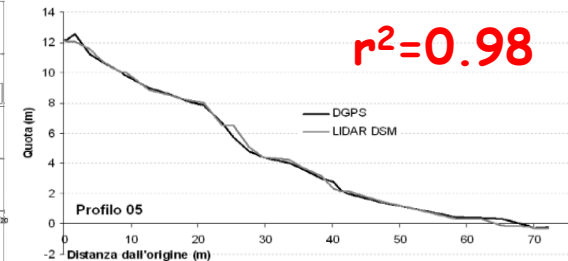
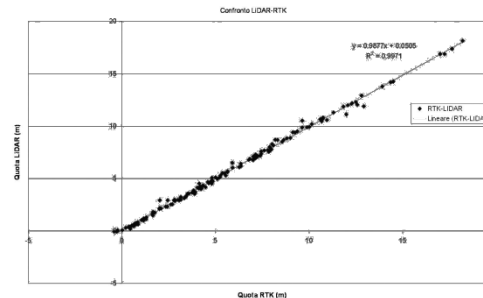
Misurazioni in situ  
(campionamenti di  
vegetazione, acque, e  
sedimenti) per validare il  
dato e i risultati derivati dal  
dato iperspettrale



Validazione della  
batimetria da LIDAR  
tramite Echo sounder  
per ottenere  
informazioni accurate  
su posizionamento e  
quota



Acquisizione di misure  
in situ tramite DGPS e  
laser scanner per  
validare l'altopografia  
da LIDAR



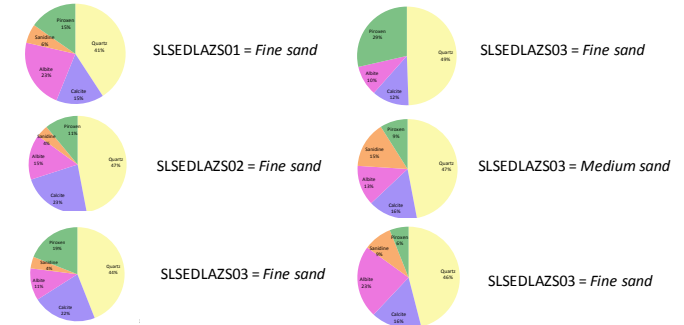
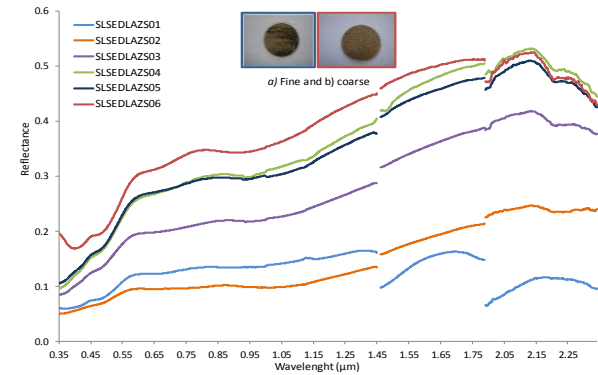
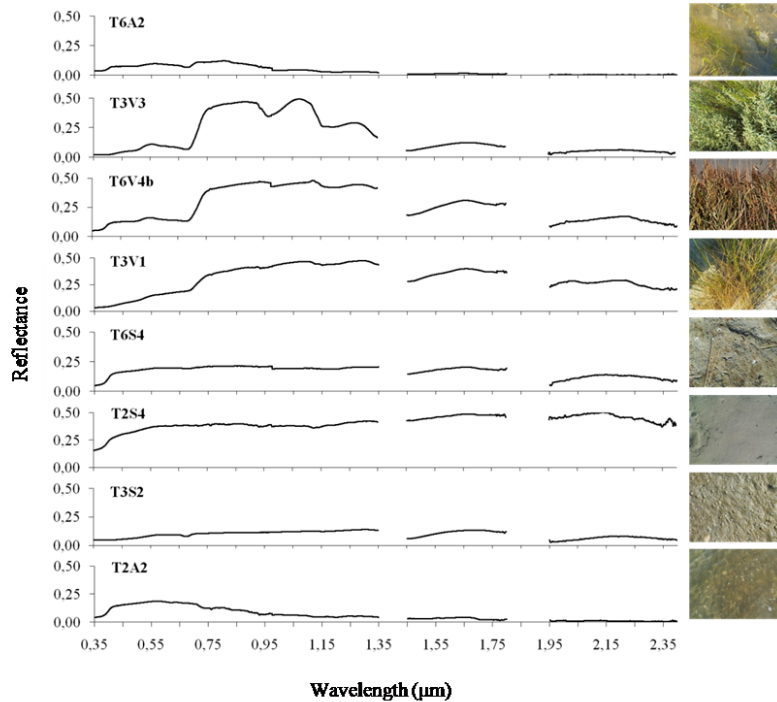


Fieldspec FR Pro SPECIFICATION	SPECTRAL INTERVAL ( $\mu\text{m}$ )	SPECTRAL RESOLUTION ( $\mu\text{m}$ )	SAMPLING INTERVAL ( $\mu\text{m}$ )
SPECTRAL RANGE	0.35 – 1.00 1.00 – 2.50	0.3 0.1	0.14 0.20
DIGITAL RESOLUTION	14 bit		
FIELD OF VIEW	5° – 25°		
SPECTRAL ACCURACY	$\pm 0.01\mu\text{m}$		



Radioimetria spettrale di campo per costruire librerie spettrali e misurare le proprietà di target invariati in situ, ex situ e per contatto.

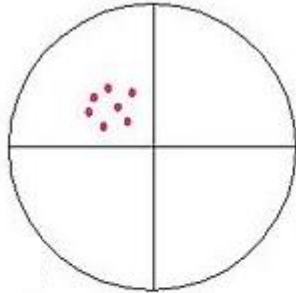
### VEGETAZIONE EMERSA E SEDIMENTI



### Libreria spettrale marina costiera

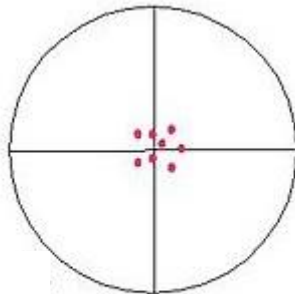
Code	Target Name	Depth	Date	GMT Time	Secchi depth	Wavelength (μm)																												
						0,45	0,46	0,47	0,48	0,50	0,51	0,52	0,54	0,55	0,57	0,58	0,59	0,60	0,61	0,62	0,63	0,64	0,65	0,66	0,67	0,68	0,70	0,71	0,72	0,73	0,74	0,75	0,76	0,77
SLSUBLAZS01	<i>P. oceanica</i> (in contact)	4.00	20110401	10.00	4.00						○																						●	_____
SLSUBLAZS02	<i>P. oceanica</i> with epiphytes (in contact)	4.00	20110401	11.00	4.00																												○	_____
SLSUBLAZS03	Decomposing <i>P. oceanica</i> (in contact)	4.00	20110401	9.10	4.00																													
SLSUBLAZS04	Dry <i>Posidonia oceanica</i> (in-situ)	0.00	20100513	10.30	0.00																													●
SLSUBLAZS05	<i>P. oceanica</i> (in-situ)	4.00	20110331	13:20	4.00				○				○																					●
SLSUBLAZS06	<i>P. oceanica</i> with epiphytes (in-situ)	3.50	20110401	10:30	3.50				○				○																					●
SLSUBLAZS07	<i>P. oceanica</i> on roky seabed (in-situ)	2.50	20110401	10:45	2.50								○																					●
SLSUBLAZS08	<i>P. oceanica</i> on mixed seabed (in-situ)	1.00	20110401	12:15	1.00								○																					●
SLSUBLAZS09	Red seaw eed (ex-situ)	0.50	20100513	10:30	0.50								○																					○
SLSUBLAZS10	Red seaw eed (ex-situ)	0.50	20100513	11:40	0.50								○																					○
SLSUBLAZS11	Green seaw eed (ex-situ)	0.50	20100513	12:50	0.50																													○
SLSUBLAZS12	Dead seaw eed (ex-situ)	0.50	20100513	11:00	0.50																													○
SLSUBLAZS13	Red seaw eed (in-situ)	0.50	20100513	11:20	0.50								○																					○
SLSUBLAZS14	Red seaw eed (in-situ)	0.50	20100513	15:30	0.50								○																					○
SLSUBLAZS15	Green seaw eed (in-situ)	0.50	20100513	16:30	0.50																													○
SLSUBLAZS16	Seaw eeds on roky seabed (in-situ)	2.50	20110401	11:30	2.00																													○
SLSUBLAZS17	Seaw eds on sandy seabed (in-situ)	7.00	20110401	11:45	5.50																													○
SLSUBLAZS18	Roky seabed (in-situ)	13.00	20110401	13:20	8.00								○																					○
SLSUBLAZS19	Gravelly seabed (in-situ)	5.00	20110331	12:55	5.00								○																					○
SLSUBLAZS20	Sandy seabed (in-situ)	3.00	20100526	10:00	3.00																													○

- Assorbimento
- Riflessione

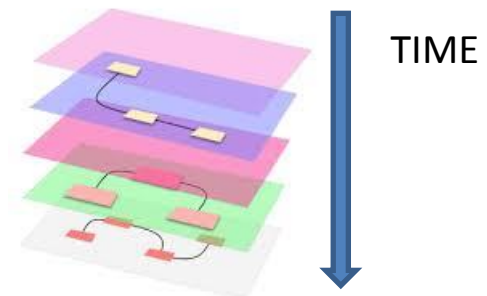


Preciso, non accurato

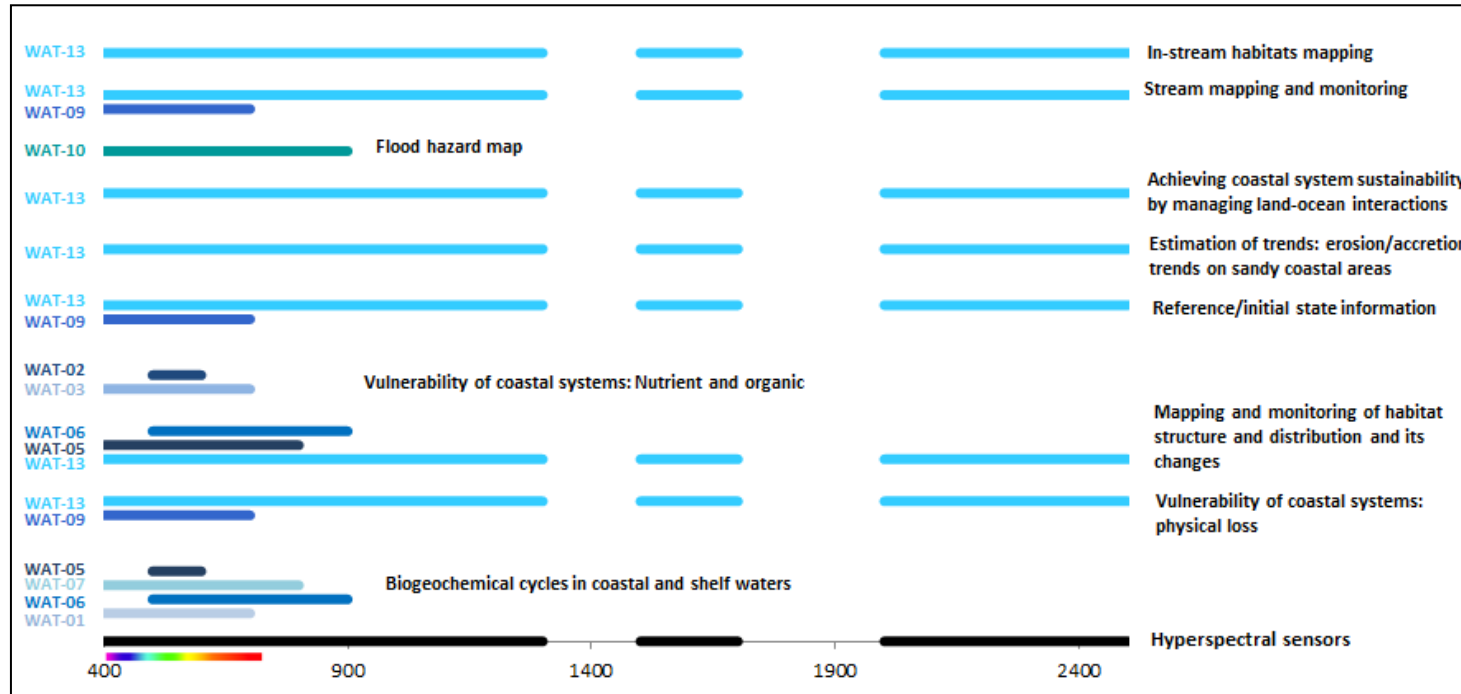
**CALIBRAZIONE** con  
dati ancillari



Accurato, preciso

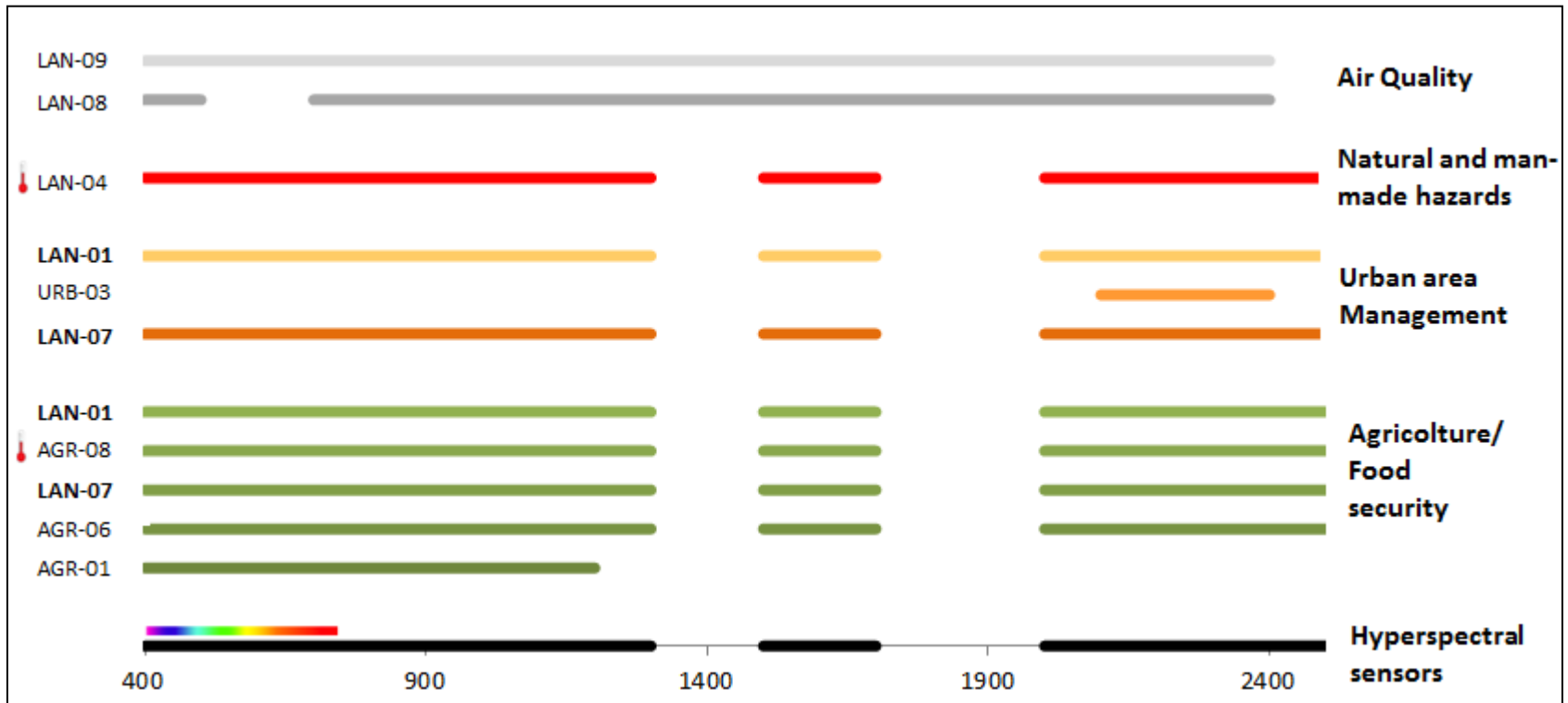


### INLAND/COASTAL WATER AND ENVIRONMENTAL



LAYER	DESCRIPTION	LAYER	DESCRIPTION
WAT-01	Chlorophyll (CHL)	WAT-06	Turbidity
WAT-02	Cyano-Phycocyanin (CPC) and Cyano-PhycoErythrin (CPE)	WAT-09	Substrates Type and Coverage
WAT-03	Phytoplankton Functional Types (PFT)	WAT-10	Bottom Depth
WAT-05	Suspended Particulate Matter (SPM) or Total Suspended Matter (TSM)	WAT-13	Emerged Habitats: Macrophytes Mapping

### LAND COVER/LAND USE PARAMETER



LAYER	DESCRIPTION	LAYER	DESCRIPTION
AGR-01	Leaf Area Index	LAN-01	Improved Land Cover Classification Map
AGR-06	Crop Biotic Stress (pathogens)	LAN-04	Object/Material Detection Map
AGR-08	Soil Texture	LAN-07	Ecosystems Fragmentation Level
		LAN-08	Damage Severity Index
URB-03	High Definition Asbestos Distribution Maps	LAN-09	Vegetation Fraction Cover

# MONITORAGGIO AMBIENTALE CON IPERSPETTRALE: Metodologia per prioritizzare parametri e requisiti utente

Code	Application Domains	European Directives	National and local regulations and laws	Objectives	Requirement submitted	Environmental Compartment	Requirement details	Parameters	Type	Importance value from 1 (low) to 5 (high)	Expected Spatial Resolution	Expected Revisit Time
AF-1.1	Agriculture/Food security	Nitrates European Directive (91/676/EEC)	D.lgs 152/2006 e ss.mm.ii.	water quality monitoring and assessment	mapping of the soil physical degradation, including the soil conditions and erosion	Soil/Sediments	Physical features	land cover/land use	qualitative			
AF-2.1	Agriculture/Food security	Nitrates European Directive (91/676/EEC)	D.lgs 152/2006 e ss.mm.ii.	water quality monitoring and assessment	estimation of soil texture in agricultural fields (when without cultivation), i.e. the particle size distribution of mineral soil fraction expressed as the relative proportions of clay, sand and silt	Soil/Sediments	Physical features	soil texture	quantitative			
AF-3.1	Agriculture/Food security	Nitrates European Directive (91/676/EEC)	D.lgs 152/2006 e ss.mm.ii.	water quality monitoring and assessment	estimation and mapping of soil organic carbon (SOC) in agricultural fields as input for simulation models of crops, hydrological and hydrogeological models	Soil/Sediments	chemical features	SOC	quantitative			

## EXPECTED TEMPORAL RESOLUTION

Parameters	Type	Importance value from 1 (low) to 5 (high)	Expected Spatial Resolution	Expected Revisit Time
land cover/land use	qualitative			
soil texture	quantitative			<ul style="list-style-type: none"> <li>giornaliero</li> <li>mensile</li> <li>semestrale</li> <li>annuale</li> </ul>
SOC	quantitative			

## EXPECTED SPATIAL RESOLUTION

Parameters	Type	Importance value from 1 (low) to 5 (high)	Expected Spatial Resolution	Expected Revisit Time
land cover/land use	qualitative			
soil texture	quantitative		<ul style="list-style-type: none"> <li>&lt;1m</li> <li>1-4m</li> <li>4-10m</li> <li>10-30m</li> <li>100m</li> <li>&gt;300m</li> <li>&gt;1km</li> </ul>	
SOC	quantitative			

## EVALUATION OF PRIORITY VALUE FOR EACH REQUIREMENT

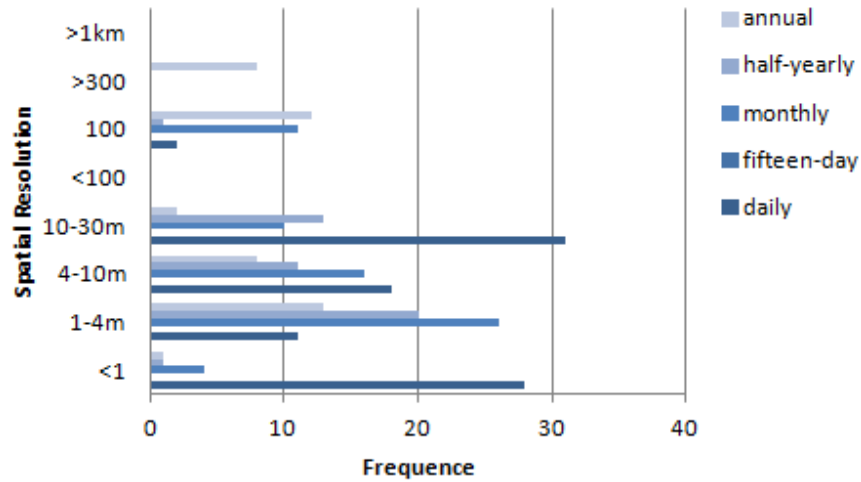
Parameters	Type	Importance value from 1 (low) to 5 (high)	Expected Spatial Resolution	Expected Revisit Time
land cover/land use	qualitative			
soil texture	quantitative	<ul style="list-style-type: none"> <li>1</li> <li>2</li> <li>3</li> <li>4</li> <li>5</li> </ul>		
SOC	quantitative			

$$Priority\ value = \frac{100}{max\ Importance\ value} \frac{1}{N_{users}} \sum_{i=1}^{N_{users}} Importance\ value_i \quad (1) \quad (2)$$

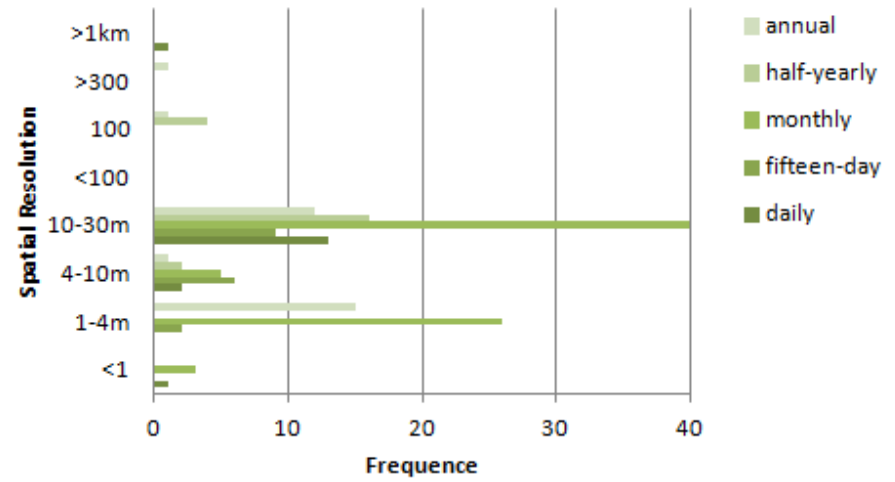
(1) The Effectiveness of Requirements Prioritization Techniques for a Medium to Large Number of Requirements: A Systematic Literature Review - Qiao Ma Auckland University of Technology - November 2009  
 (2) JOURNAL OF OBJECT TECHNOLOGY- ETH Zurich, Chair of Software Engineering ©JOT, 2004 Vol. 3, No.8, September-October 2004 Donald Firesmith: "Prioritizing Requirements"



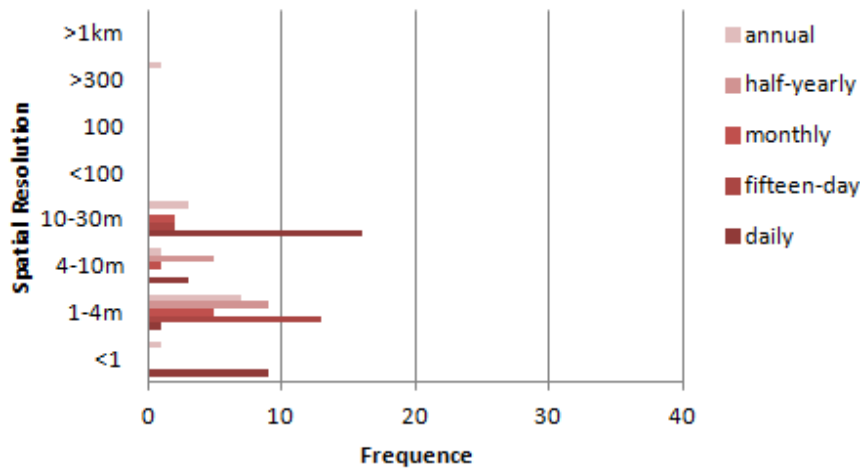
### Inland/coastal water and environment



### Agriculture/Food Security

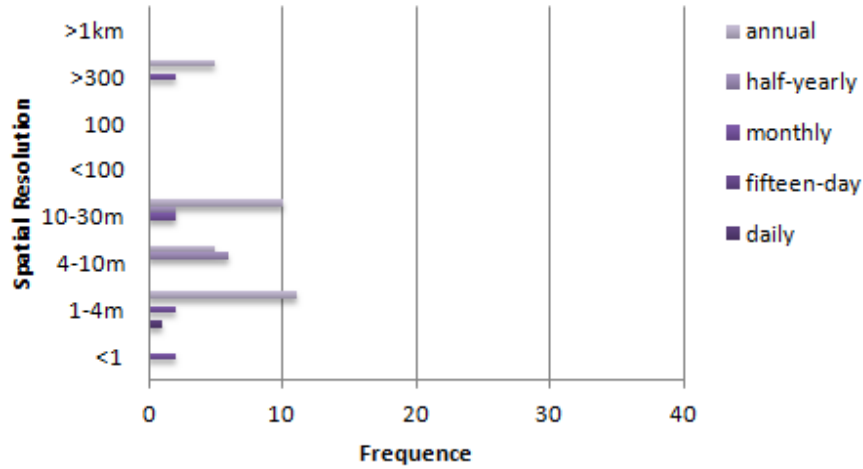


### Natural and man-made hazards

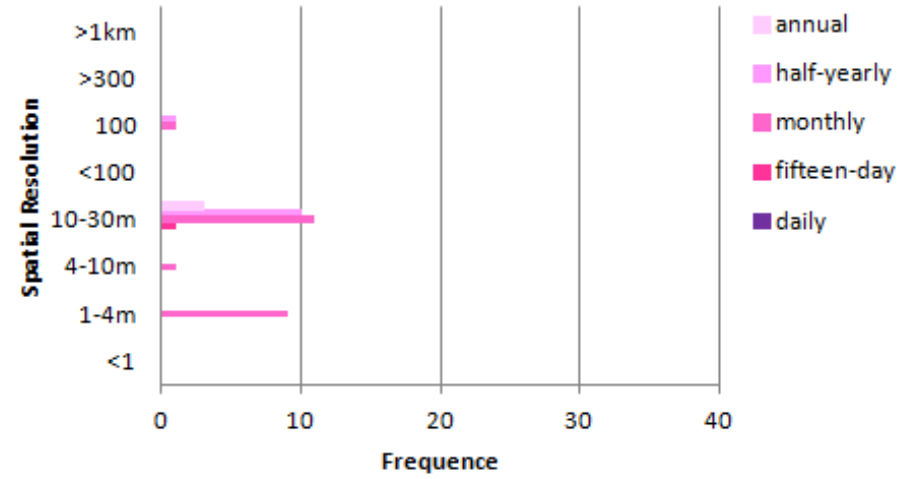


*SPATIAL RESOLUTION  
AND  
REVISIT TIME*

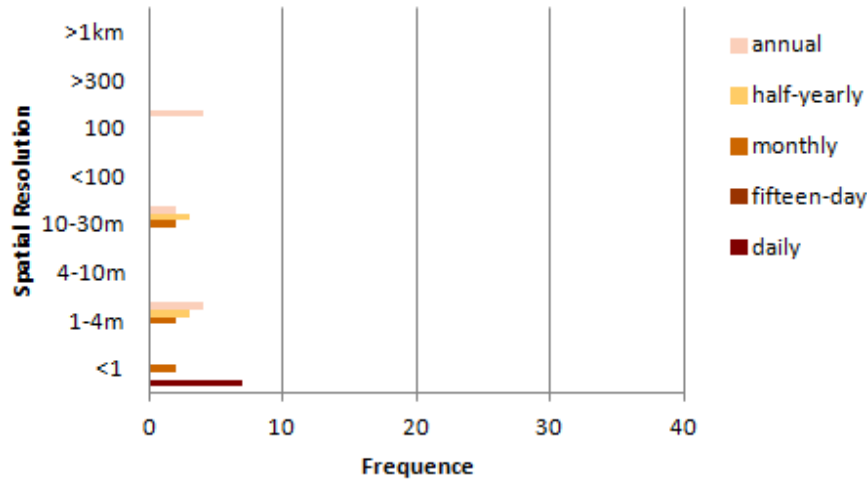
### Urban area management



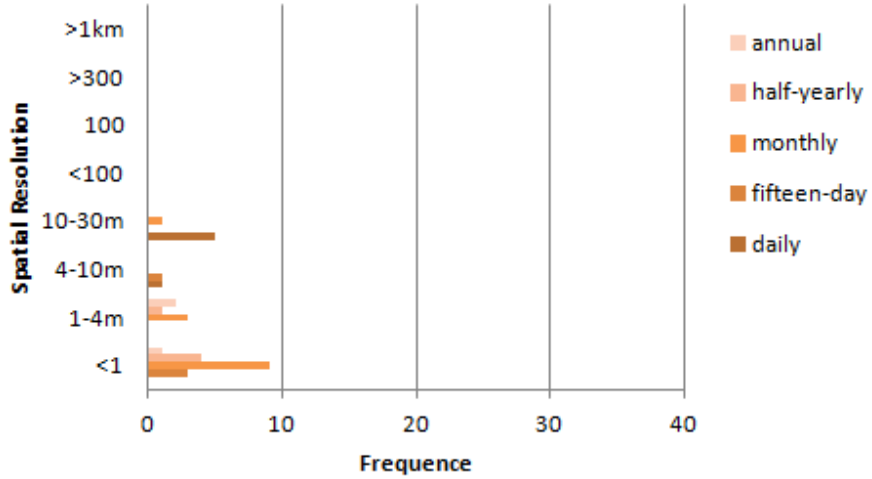
### Ecosystem structure / composition



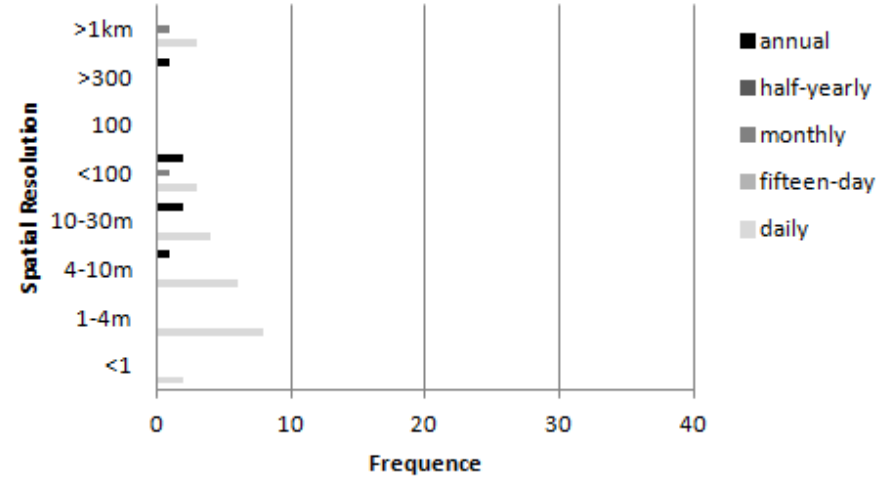
### Raw material



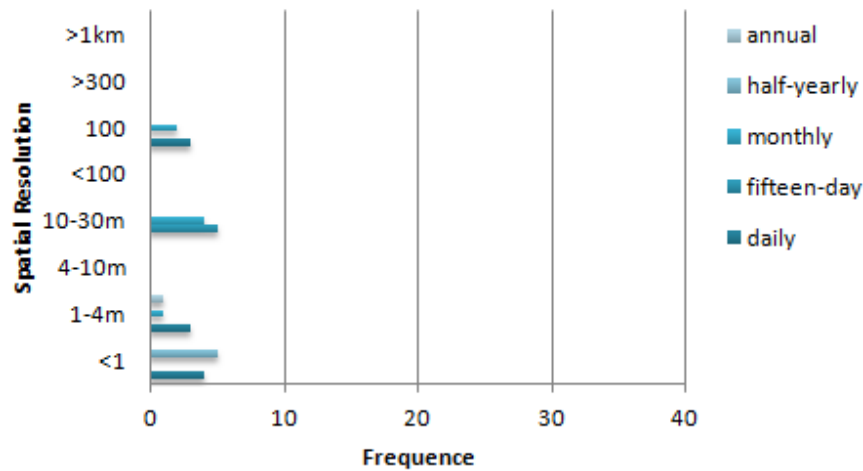
### Cultural Heritage



### Air quality



### Ice and snow



*SPATIAL RESOLUTION  
AND  
REVISIT TIME*

## PASSI SUCCESSIVI

1. ANALISI DI SENSITIVITÀ - Hyperspectral Mission Requirements  
Consolidation
  2. PRODOTTI E SERVIZI – Copernicus Downstreaming services
  3. SCENARI OPERATIVI – Sistema Nazionale Protezione Ambientale
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## Hyperspectral Mission Requirements Consolidation



The **objective** is to assess if the development of a hyperspectral satellite mission provides potential value added to current Sentinel missions in the "Agriculture food security & raw materials" application domains. The project follows up previously studies with the aim to extend the bibliographic review and the identification of algorithms and approaches already available, in order to obtain quantitative results regarding the possible improvement of products compared to Sentinel 2 mission.

A truly **Copernicus** oriented study, guided by user requirements to provide a link between study activities and domains i) Agriculture/Food Security (crop and soil parameters) and ii) Raw Materials Exploration within the Copernicus fora and procedures (e.g. Copernicus User Forum). A study exploiting already existing user uptake activities to validate the intermediate and final results with operational activities

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*Grazie per l'attenzione*

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Alessandra Nguyen Xuan, Serena Geraldini, Antonella Tornato, Andrea Taramelli



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