Monitoring marine debris in protected coastal areas: an UAV approach

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ISMAR
Istituto di Scienze Marine

Consiglio Nazionale delle Ricerche
IFC - Istituto di Fisiologia Clinica

Previous experiences:

Standard monitoring protocols with manual collection and classification

S. Merlino, M. Locritani, G. Bernardi, C. Como, S. Legnaiuoli, V. Palleschi and M. Abbate. *2020 Submitted. Spatial and temporal distribution of polymerically characterized microplastic in Pelagos sanctuary coastal areas: focus on natural and urban beaches*. **Submitted to Water – MDPI .**

S. Merlino and L. Massetti. 2019. Marine Litter: *A Threat for Northern Gannet Breeding Success in Highly Anthropized Environment*. **Oceanography & Fishery Open Access J. 2019; 10(2): 555783. DOI:10.19080/OFOAJ.2019.10.555783**

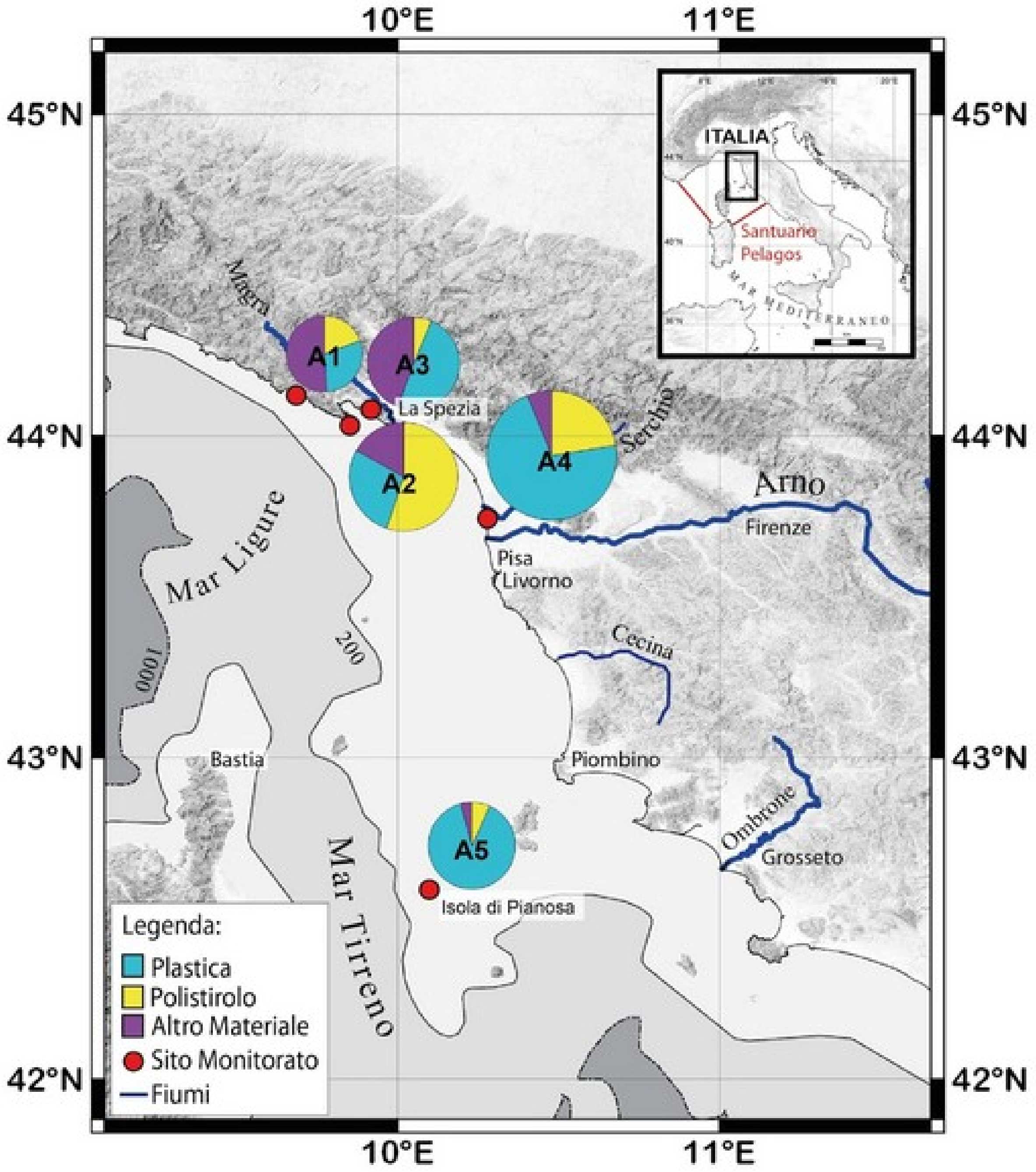
M. Locritani, S. Merlino, M. Abbate. 2019. *Assessing the citizen science approach as tool to increase awareness on the marine litter problem*. **Marine Pollution Bullettin. Special issue 6IMDC.**

A. Giovacchini, S. Merlino, M. Locritani, M. Stroobant. 2018. *Spatial distribution of marine litter along italian coastal areas in the Pelagos sanctuary (Ligurian Sea - NW Mediterranean Sea): A focus on natural and urban beaches*. **Marine Pollution Bulletin 130. pp 140–152.**

S. Merlino, M. Abbate, L. Pietrelli, P. Canepa and P. Varella. 2018. *Marine litter detection and correlation with the seabird nest content.* **Rend. Fis. Acc. Lincei (2018) 29:867-875.**

S. Merlino. 2016. *SeaCleaner Project: Monitoring Marine Litter on Beaches around the "Pelagos Sanctuary"*. **Human Ecology. Journal of the Commonwealth Human Ecology Council. WASTE. July 2016, V 26.**

Merlino S., Locritani M., Stroobant M., Mioni E., Tosi D. 2015. *SeaCleaner - Focusing citizen-science and environment education on unravelling the marine litter problem*. **In: Blue Future: education the next generation. Special issues of MTS Journal July/August 2015, V 49**

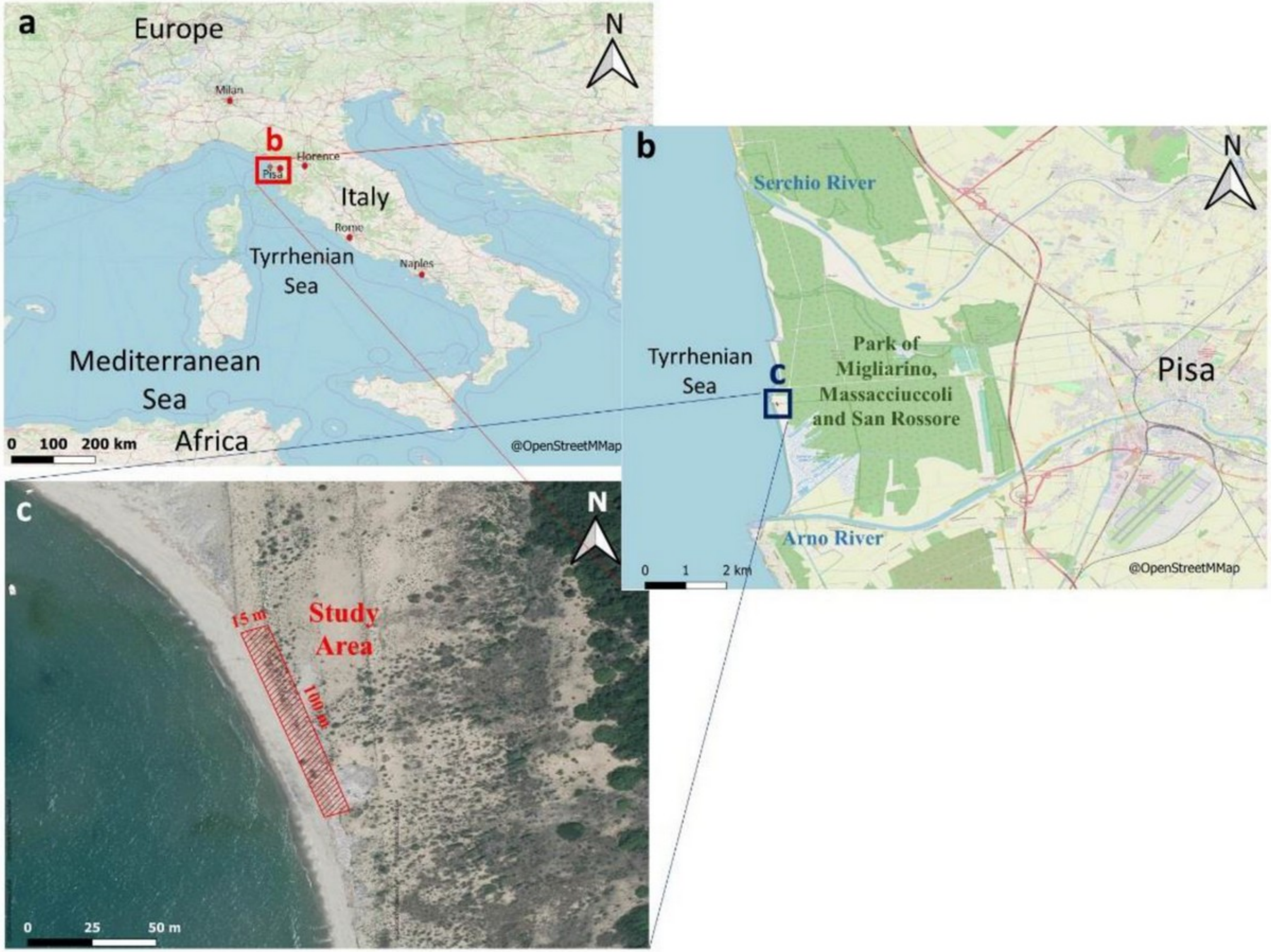


Previous experiences:
Standard monitoring protocols
with manual collection and classification

Disavantages:

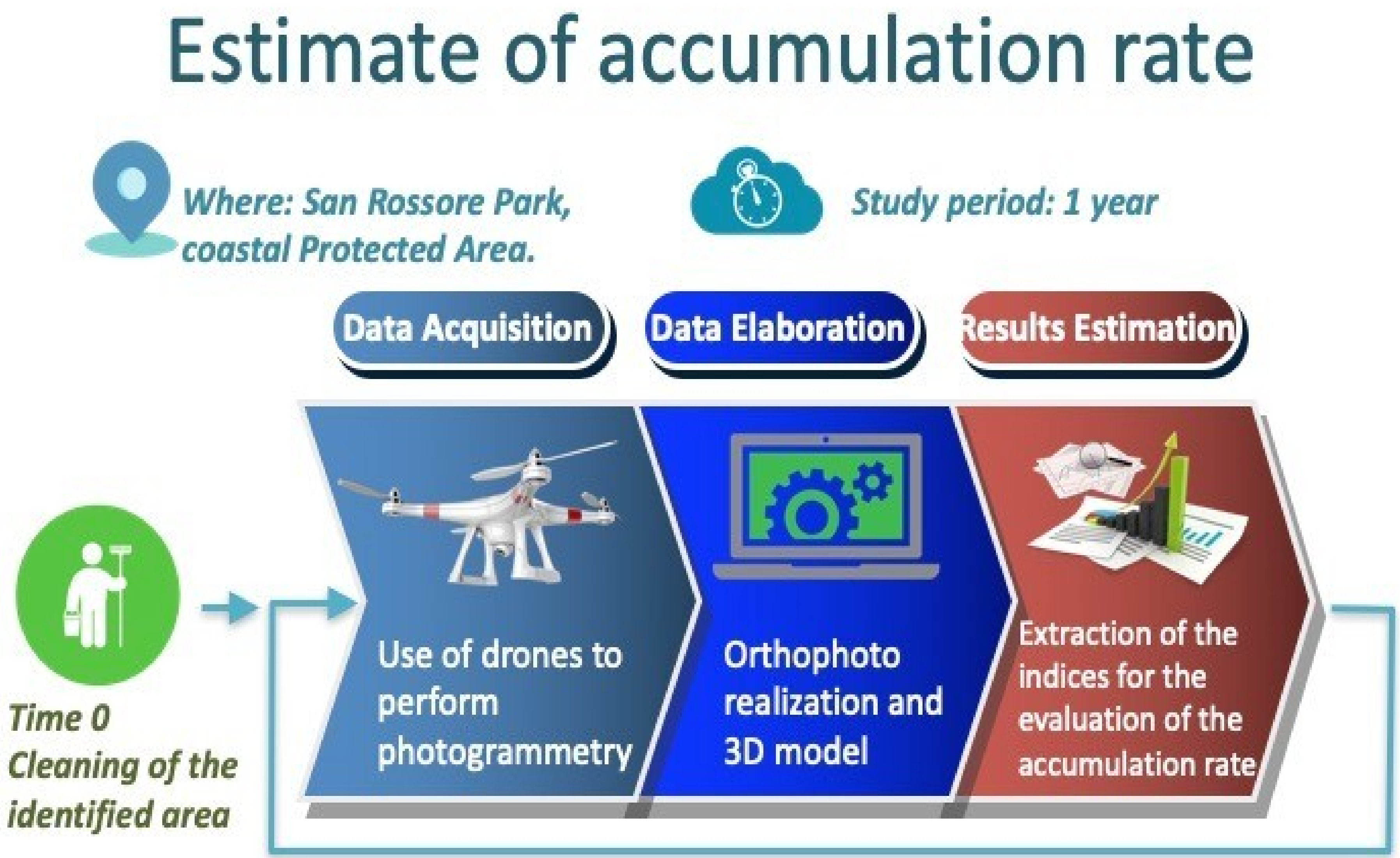
- They needs a lot of people and a lot of time (citizenscience, volunteers).
- No GPS coordinates: it is not possible to study the changes with time of the items spatial distribution

UAV use in protected Areas in Tuscany



- The area is a park area where human access is forbidden, but surrounded by densely populated areas.
- Everything we find on the coast has been deposited by the sea
- It is located between two important river outlets
- Here a high density of marine litter was found in the previous standard surveys, with a particular prevalence of plastic.

Purpose of the study



HOW? → UAV monitoring protocol

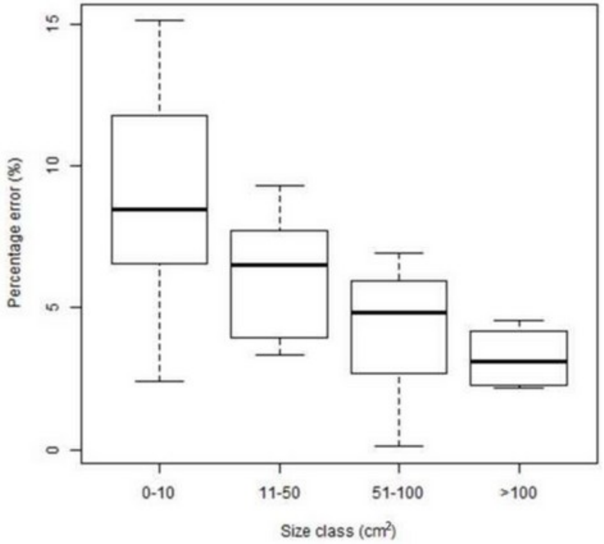
- Data Acquisition
  - ✓ *Phantom 4 Pro v. 2 was used to acquire the images*
  - ✓ *Drone Harmony software was used to manage the flight plan necessary for photogrammetry*
- Data Elaboration
  - ✓ *Agisoft metashape software was used to reconstruct the orthophoto and 3D model of the entire area*
- Results estimation
  - *Specifically developed software was used to derive some estimates: position and size of objects, number of objects, density of objects, etc.*
- Validation
  - ✓ *Error assessement*
  - ✓ *Comparison with standard surveys*

Advantages

- Few personal need
- GPS data adquired for each item
- Frequent surveys.

ERROR ASSESSMENT and validation

UAV procedure applied on knowed targets

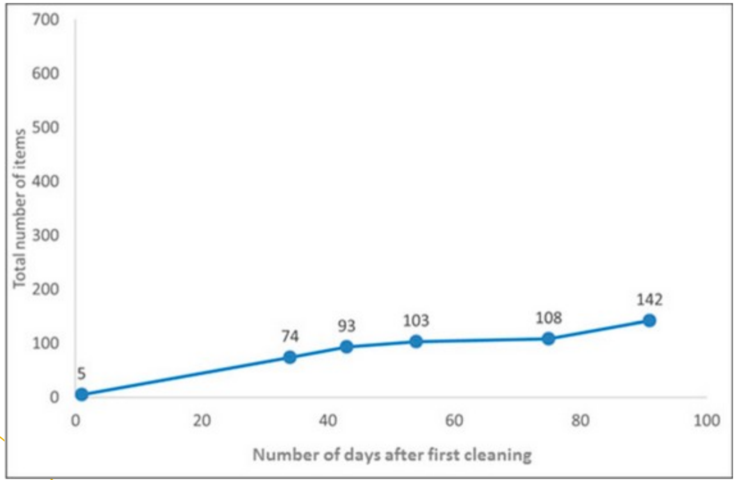


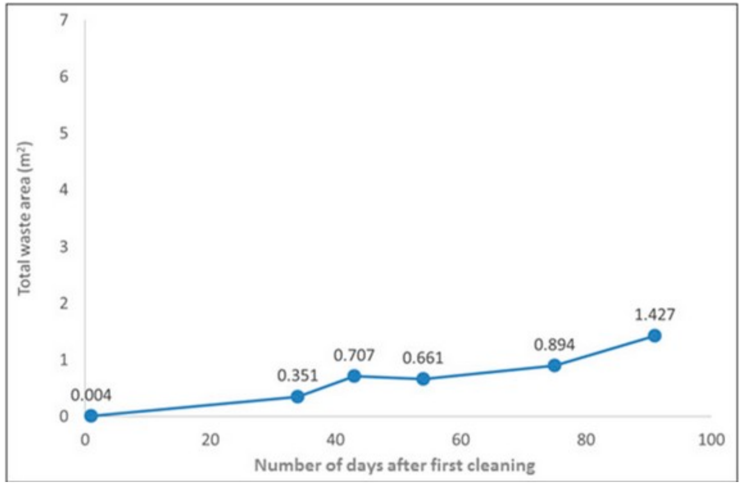
Standard Survey vs UAV Procedure

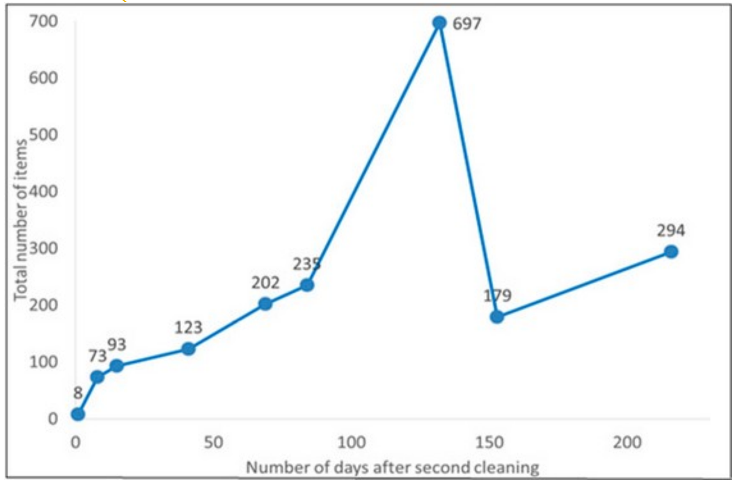
Date	12 April2019			13 July 2019		
	Standard Survey (Number of Items)	UAV Results (Number of Items)	UAV vs.* Standard(in Percentage)	Standard Survey	UAV Results (Number of Items)	UAV vs.* Standard(in Percentage)
Small (2.5–15 cm)	859	124	14.44%	716	103	14.39%
Medium (15–50 cm)	67	64	95.52%	49	46	93.88%
Large (> 50 cm)	17	15	88.24%	3	2	66.67%
Total	943	203	21.53%	768	151	19.66%

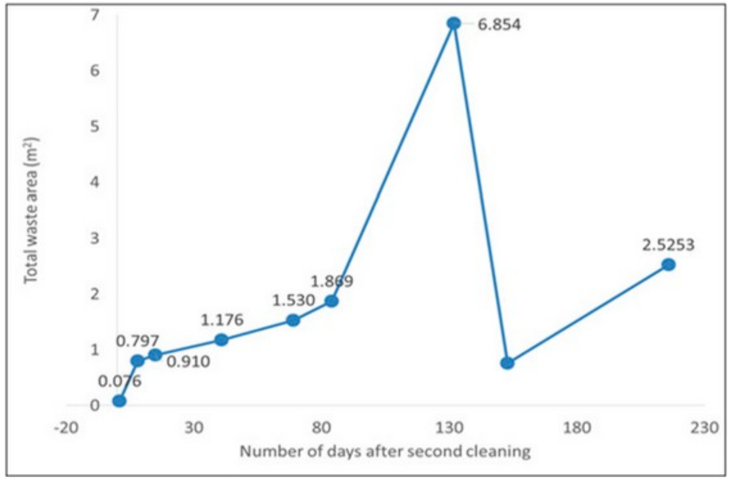
Notes: *Percentage of litter identification compared to that derived using the standard terrain assessment.

RESULTS: spatial coverage and number of items with time









remote sensing

MDPI

Article

Unmanned Aerial Vehicles for Debris Survey in Coastal Areas: Long-Term Monitoring Programme to Study Spatial and Temporal Accumulation of the Dynamics of Beached Marine Litter

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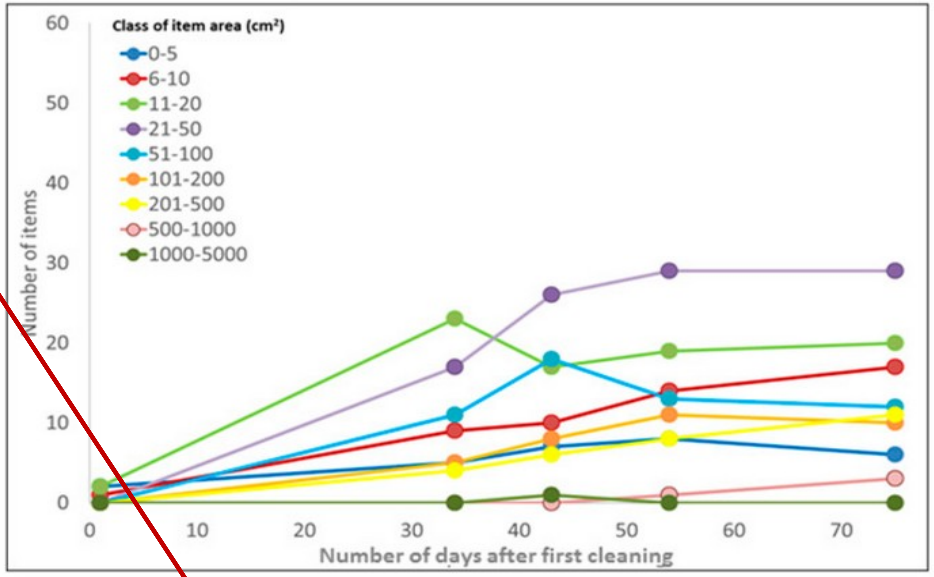
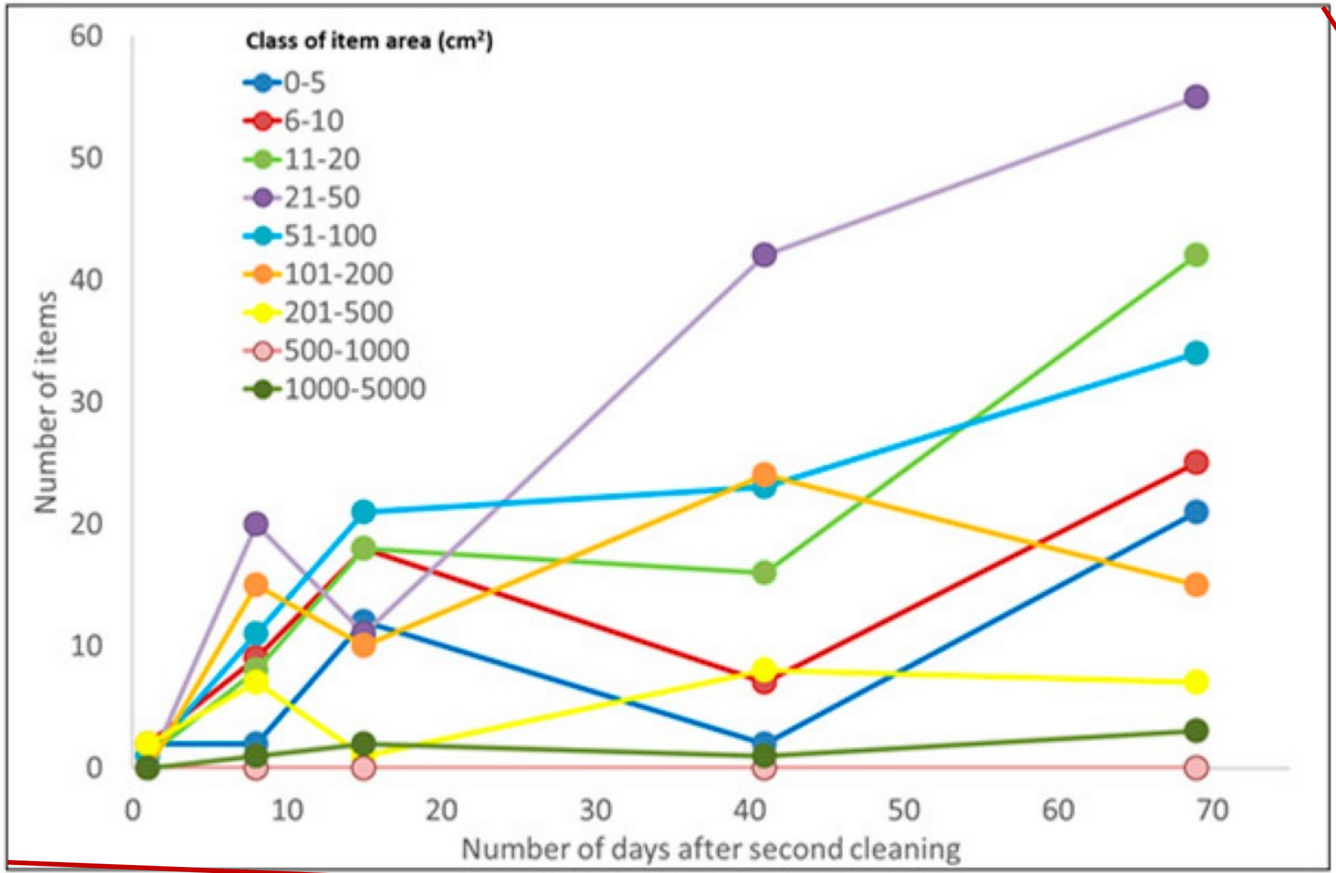
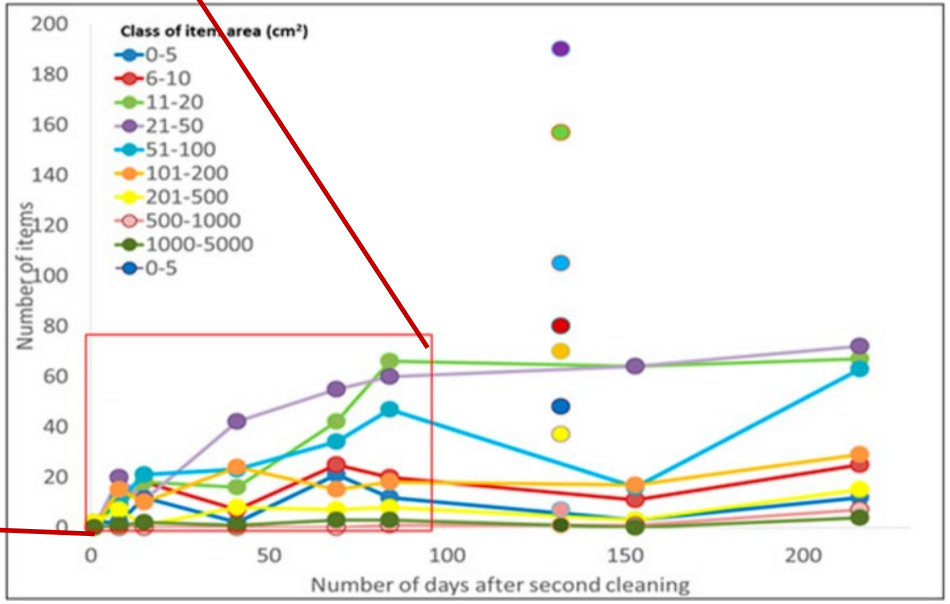
Abstract: Unmanned aerial vehicles (UAVs) are becoming increasingly accessible tools with widespread use as environmental monitoring systems. They can be used for anthropogenic marine debris survey, a recently growing research field. In fact, while the increasing efforts for offshore investigations lead to a considerable collection of data on this type of pollution in the open sea, there is still little knowledge of the materials deposited along the coasts and the mechanism that leads to their accumulation pattern. UAVs can be effective in bridging this gap by increasing the amount of data acquired to study coastal deposits, while also limiting the anthropogenic impact in protected areas. In this study, UAVs have been used to acquire geo-referenced RGB images in a selected zone of a protected marine area (the Migliarino, Massacciuccoli, and San Rossore park near Pisa, Italy), during a long-term (ten months) monitoring programme. A post processing system based on visual interpretation of the images allows the localization and identification of the anthropogenic

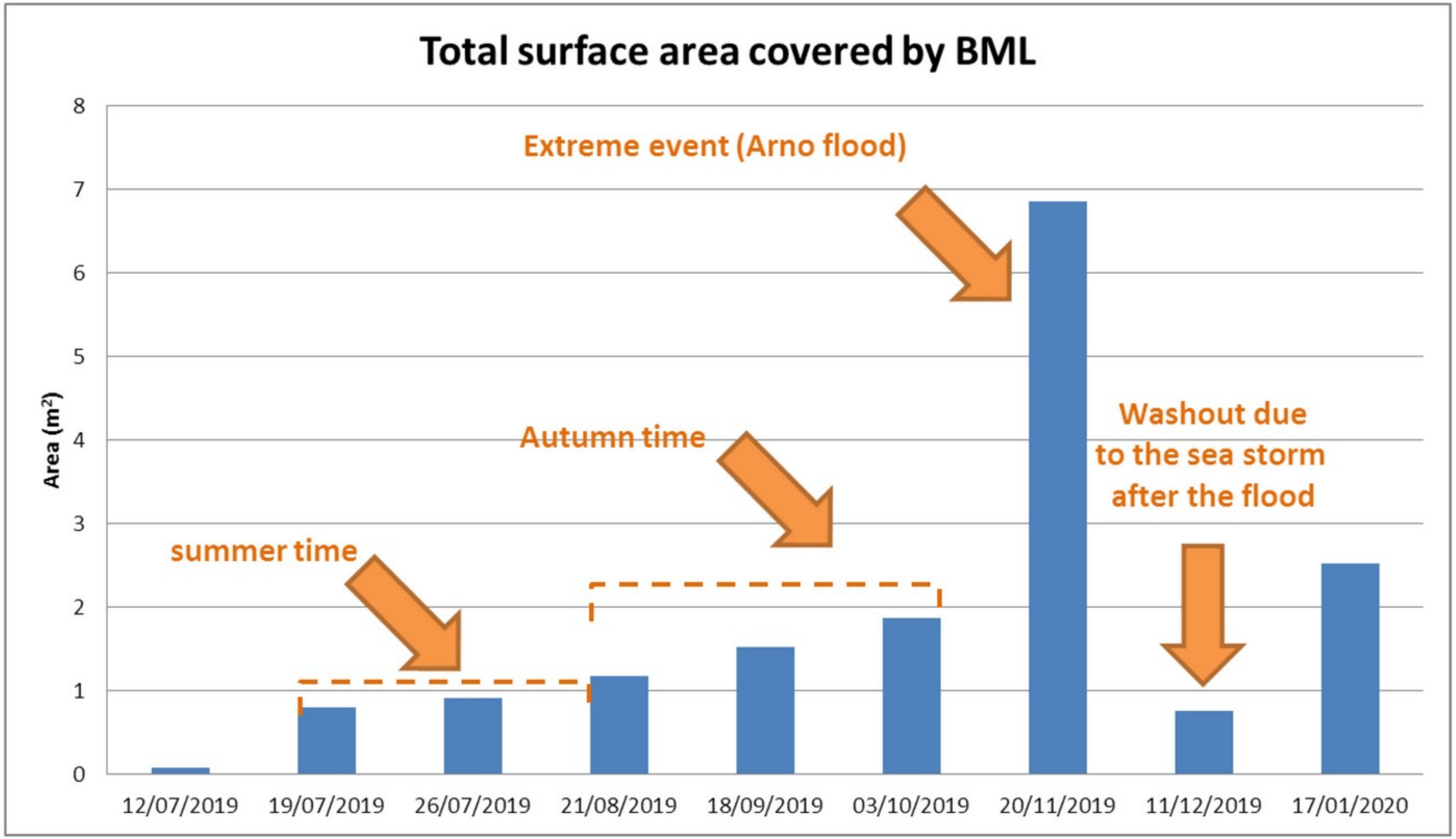
RESULTS: accumulation dynamic, equilibrium and objects spatial dimension





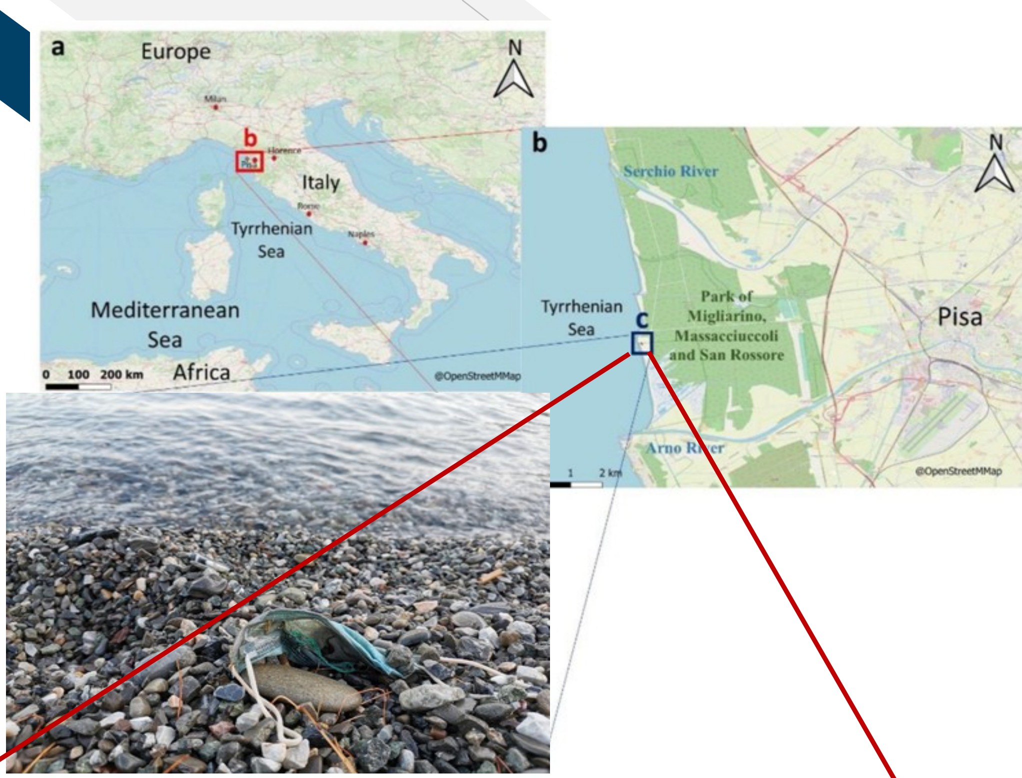


RESULTS: total period and flood emergence



Present and future marine litter monitoring:

Survey extended areas; COVID-19 personal protective equipment mapping



- Study the ML distribution on a larger area
- Using QGIS as georeferencing procedure
- Focus the attention on COVID-19
- personal protective equipment
- Comparison with selected submarine coastal transects (thank to CNeS, Centro Nautico e Sommozzatori di La Spezia)

Partners: CNR-ISMAR; CNR-IFC; INGV

Present and future marine litter monitoring :

- A multidisciplinary method to study the marine litter dispersion from the Arno river mouth: a study case with citizen science support
- “Progetto di ricerca libera INGV 2019”, financed by INGV.
- Proposer : INGV – Portovenere; Partners INGV- Bologna; Associates: CNR-ISMAR; CNR-IFC

Present and future marine litter monitoring:

Inter-observer reliability in marking marine litter items on UAV orthophoto"

- INESC-Coimbra - University of Coimbra Coimbra, Portugal
- CNR (ISMAR and IFC), Italia
- Dipartimento Scienze della Terra, UNIPI, Italia
- Geología, Geofísica y Procesos Marino-Costeros Research Group, Universidad del Atlántico, Barranquilla, Colombia.
- Marine Remote Sensing Group, Department of Marine Sciences, University of the Aegean, Mytilene, Greece

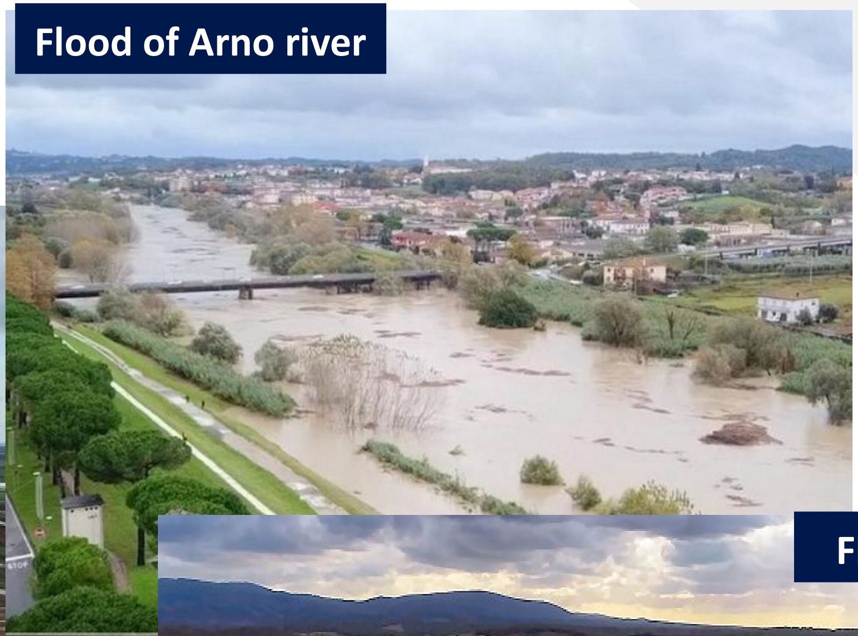
Present and future waste monitoring :

Waste searches in specific situations: the example of a lake

OTHER UAV reasearch projects

Aerial monitoring of exceptional events


Minor water network connected to the Arno river


Flood of Arno river


Flooded land

OTHER UAV reasearch projects

Shoreline measures and erosion assessment

Partners: CNR-ISMAR; CNR-IFC; DST-UNIPI

water

MDPI

Article

A new beach topography-based method for shoreline identification

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Received: date; Accepted: date; Published: date

Abstract: The definition of shoreline is not the same for all contexts and it is often a subjective matter. Various methods exist which are based on the use of different instruments that can determine and highlight a shoreline. In recent years, numerous studies have employed photogrammetric methods, based on different colours, to map the boundary between water and land. These works use images acquired by satellites, or drones, or cameras, and differ mainly in terms of resolution. Such methods can identify a shoreline by means of automatic, semi-automatic, or manual procedures.

Reconstruction of a high-resolution Digital Elevation Model by means of a UAV image acquisition and comparison with DGPS.

OTHER UAV reasearch projects

Search and mapping distribution of “alien” (NIS) plants

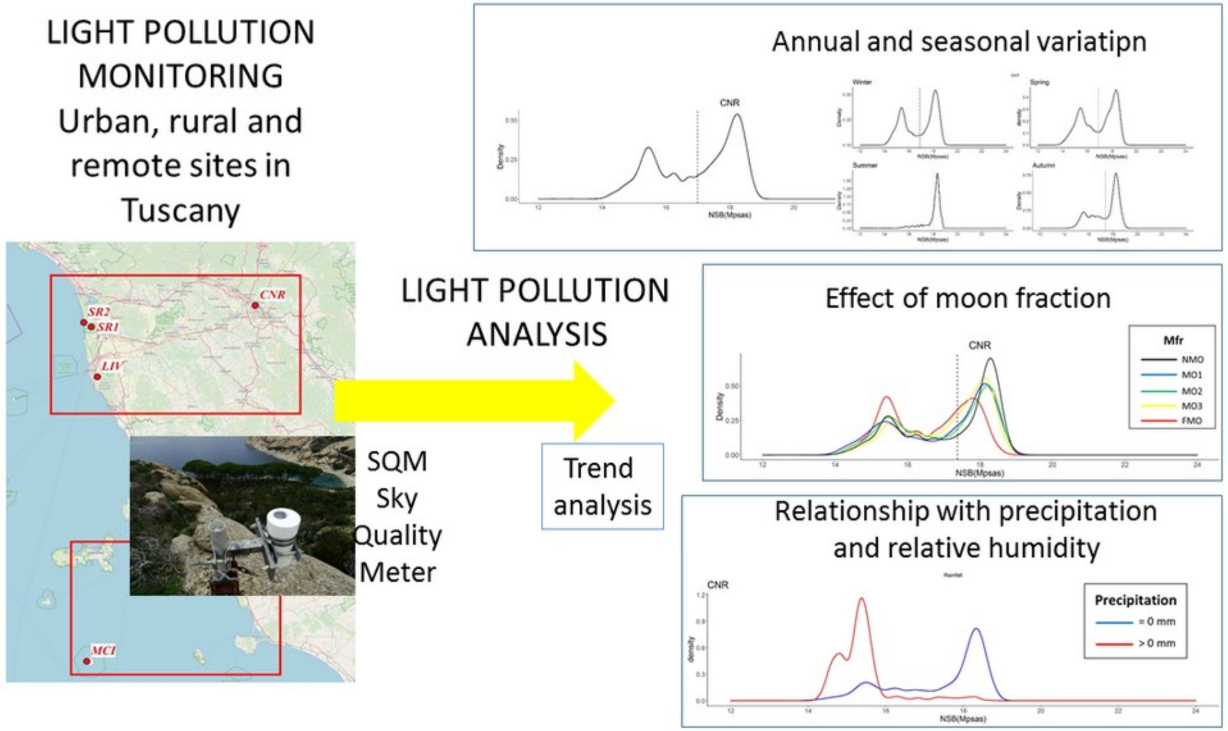
Yucca gloriosa

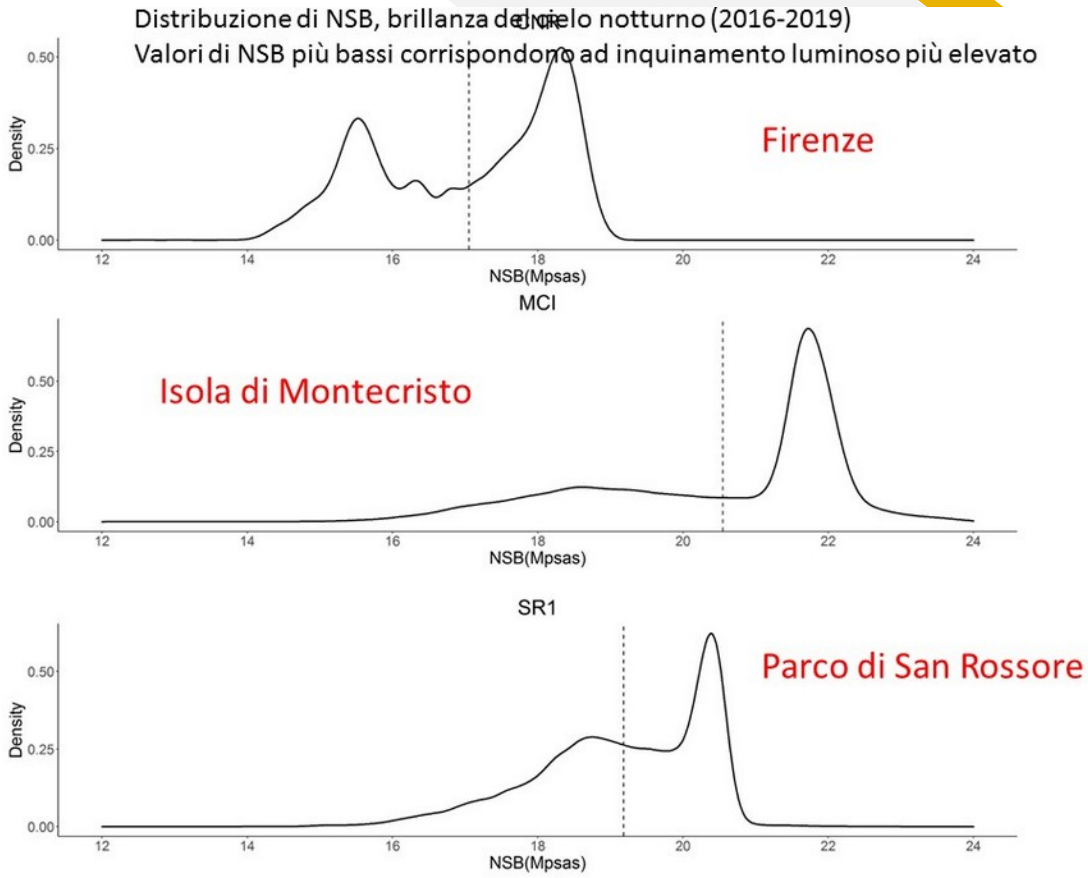
Partners: CNR-ISMAR; CNR-IFC; CNR-IBE; DBM-UNIPI

OTHER UAV reasearch projects

Mapping Night Sky Brightness (NSB) trough UAV

Partners: CNR-IBE, CNR-IFC, CNR-ISMAR





Massetti, L. 2020. *Drivers of artificial light at night variability in urban, rural and remote areas*. Journal of Quantitative Spectroscopy & Radiative Transfer.

L'uso dei droni

Stima accumulo rifiuti

Fotogrammetria

SAPR utilizzato

Phantom 4 PRO v.2

Caratteristiche generali:

Autonomia: **30 min**
Distanza max dal pilota: **7 Km**
Peso: **1375 g**
Stabilizzazione: **3 assi**
Costo **medio**

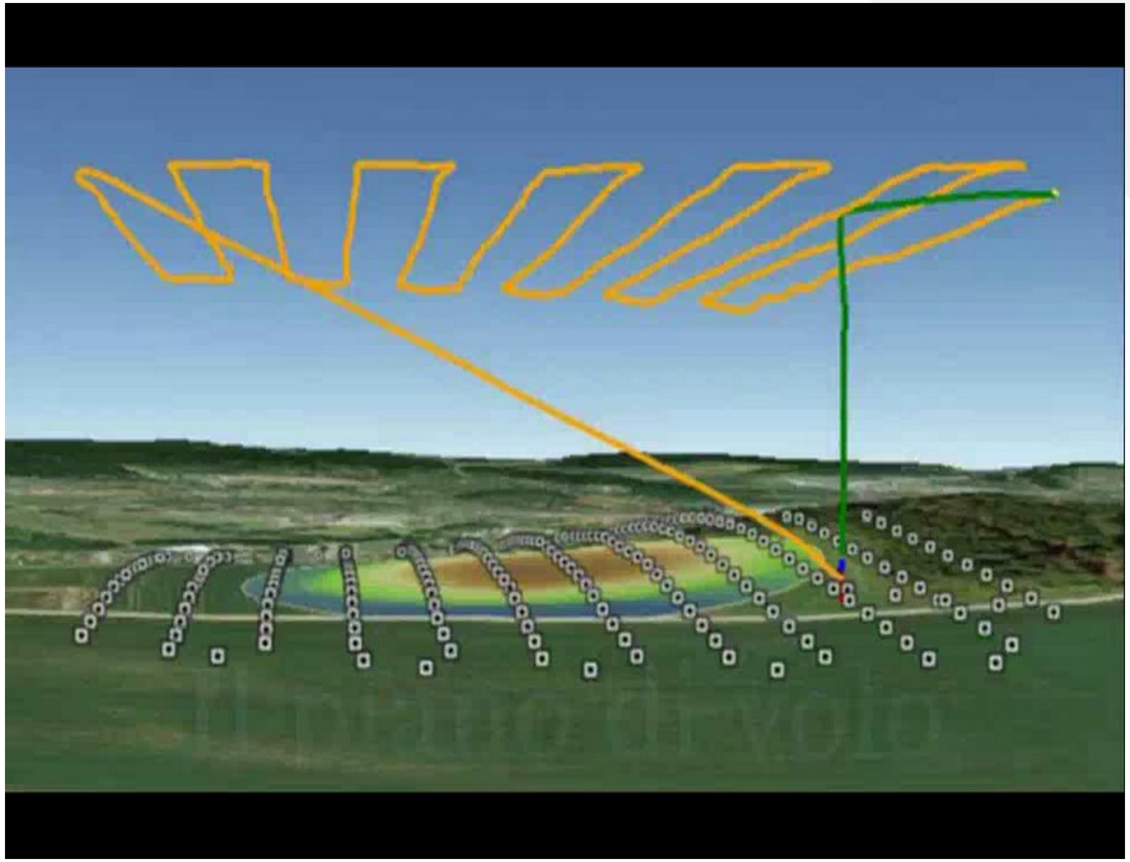
Caratteristiche sensore:

Larghezza immagine: **5472px**
Altezza immagine: **3078px**
Larghezza sensore: **13.2mm**
Altezza sensore: **8mm**
Lunghezza focale: **8.8mm**

Altezza (m)	GSD (cm/pixel)	Larghezza immagine (m)	Altezza immagine (m)	Superficie (m2)
6	0,18	9,8	5,5	54,6
10	0,3	16,4	9,2	151,6
20	0,59	32,3	18,2	586,3
50	1,48	81,0	45,6	3689,3
100	2,95	161,4	90,8	14657,5

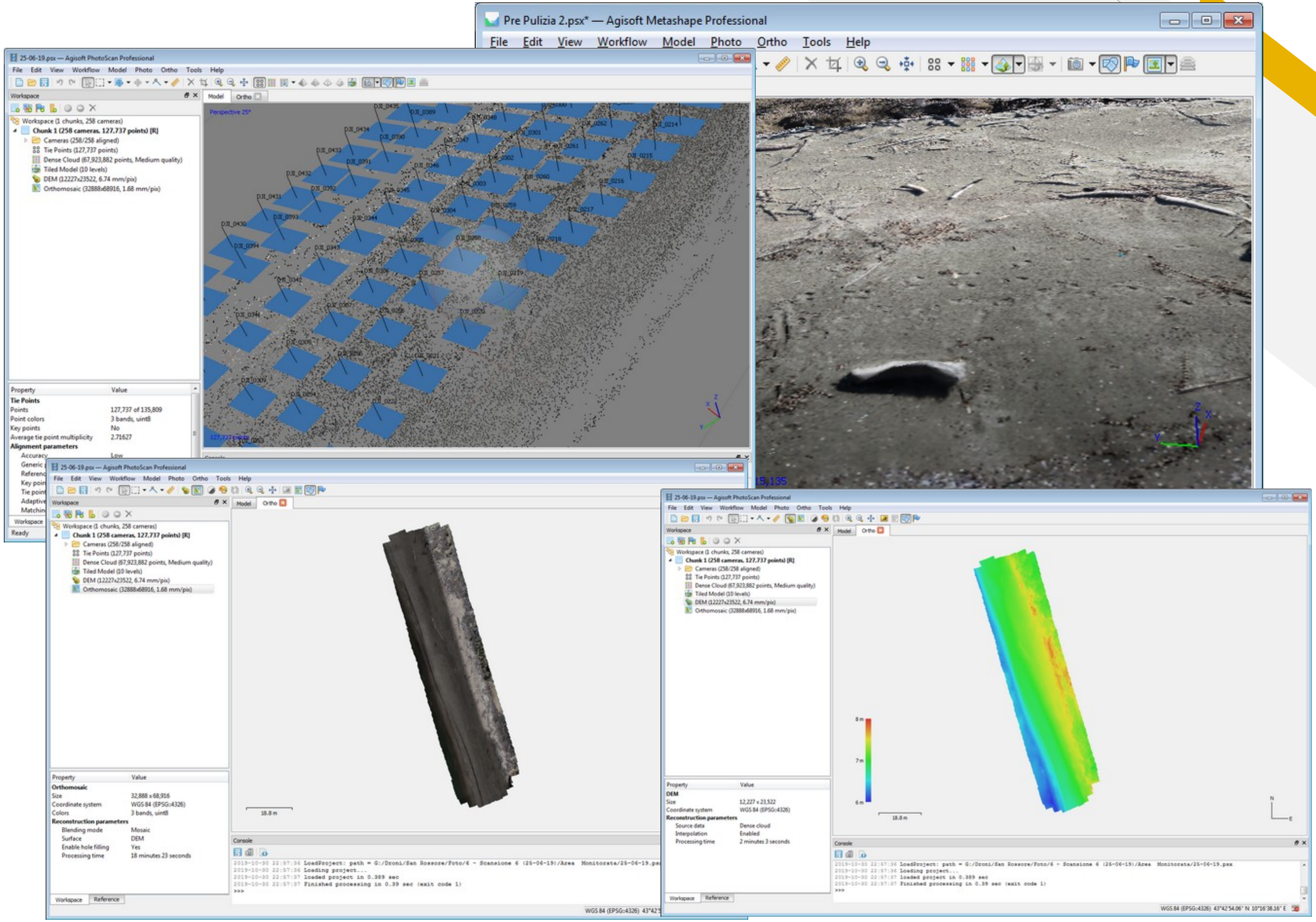
Pianificazione e gestione del volo

DRONE HARMONY



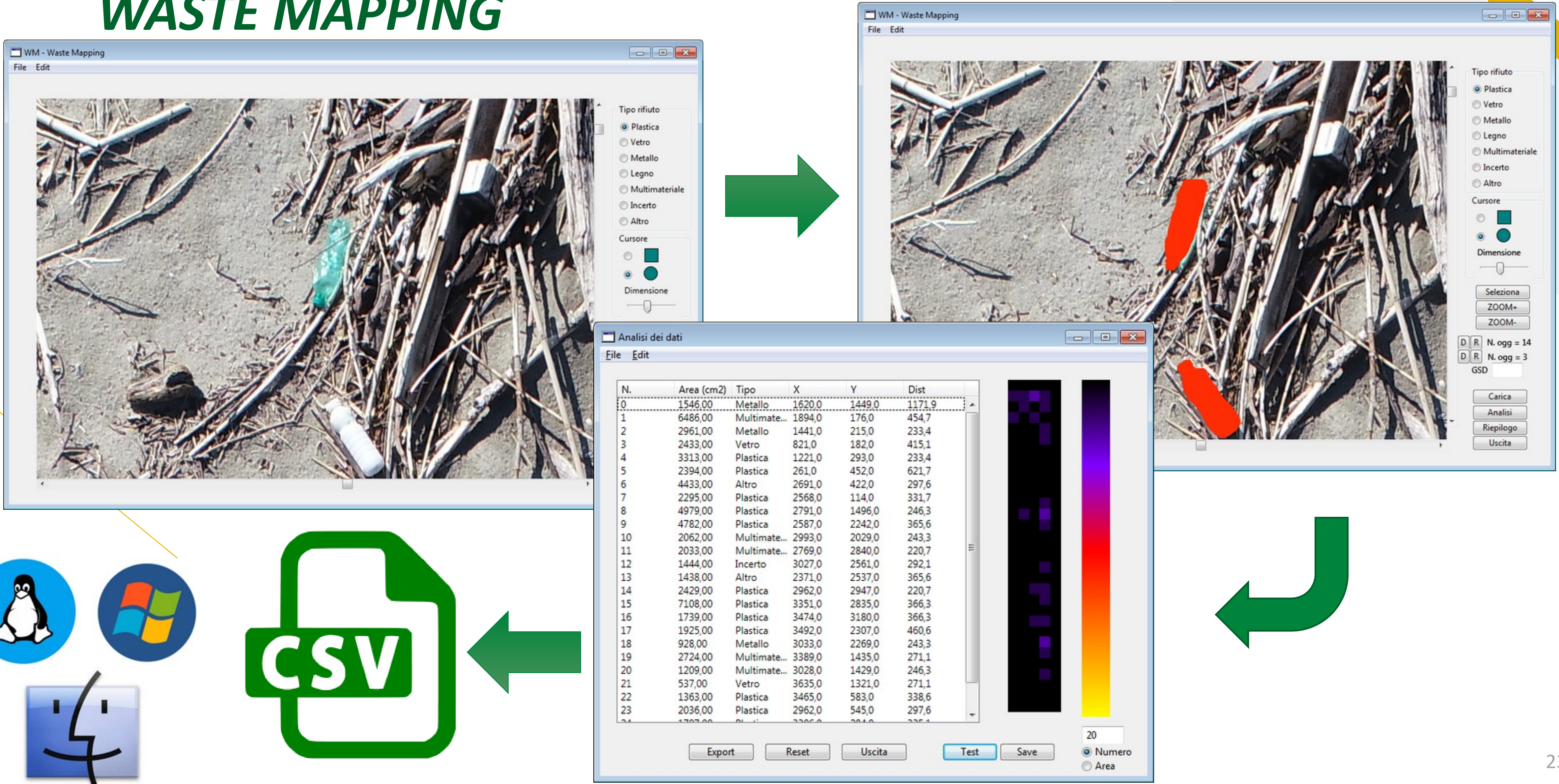
Fotogrammetria

Agisoft
Metashape



La quantificazione dei rifiuti

WASTE MAPPING



N.	Area (cm2)	Tipo	X	Y	Dist
0	1546,00	Metallo	1620,0	1449,0	1171,9
1	6486,00	Multimate...	1894,0	176,0	454,7
2	2961,00	Metallo	1441,0	215,0	233,4
3	2433,00	Vetro	821,0	182,0	415,1
4	3313,00	Plastica	1221,0	293,0	233,4
5	2394,00	Plastica	261,0	452,0	621,7
6	4433,00	Altro	2691,0	422,0	297,6
7	2295,00	Plastica	2568,0	114,0	331,7
8	4979,00	Plastica	2791,0	1496,0	246,3
9	4782,00	Plastica	2587,0	2242,0	365,6
10	2062,00	Multimate...	2993,0	2029,0	243,3
11	2033,00	Multimate...	2769,0	2840,0	220,7
12	1444,00	Incerto	3027,0	2561,0	292,1
13	1438,00	Altro	2371,0	2537,0	365,6
14	2429,00	Plastica	2962,0	2947,0	220,7
15	7108,00	Plastica	3351,0	2835,0	366,3
16	1739,00	Plastica	3474,0	3180,0	366,3
17	1925,00	Plastica	3492,0	2307,0	460,6
18	928,00	Metallo	3033,0	2269,0	243,3
19	2724,00	Multimate...	3389,0	1435,0	271,1
20	1209,00	Multimate...	3028,0	1429,0	246,3
21	537,00	Vetro	3635,0	1321,0	271,1
22	1363,00	Plastica	3465,0	583,0	338,6
23	2036,00	Plastica	2962,0	545,0	297,6

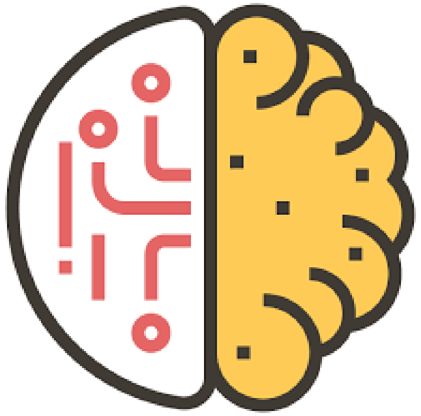
CSV

Work in progress

Artificial Intelligence to classify

Dataset from previous human classification

Acquisition



Deep learning

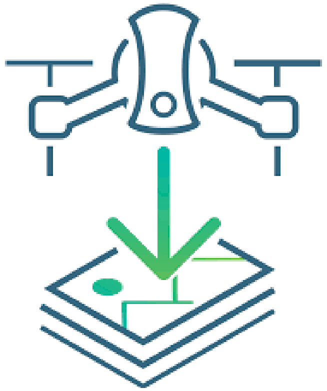
Classification

Best practices
(consigli dalla nostra esperienza)

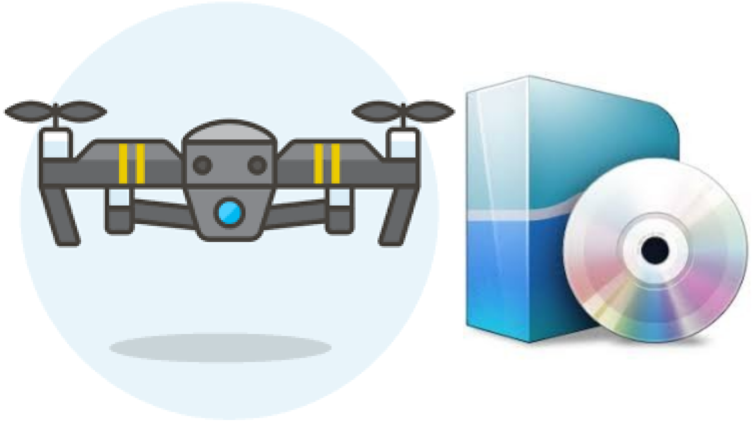
Sicurezza delle persone

Sicurezza del drone

Procedura di acquisizione

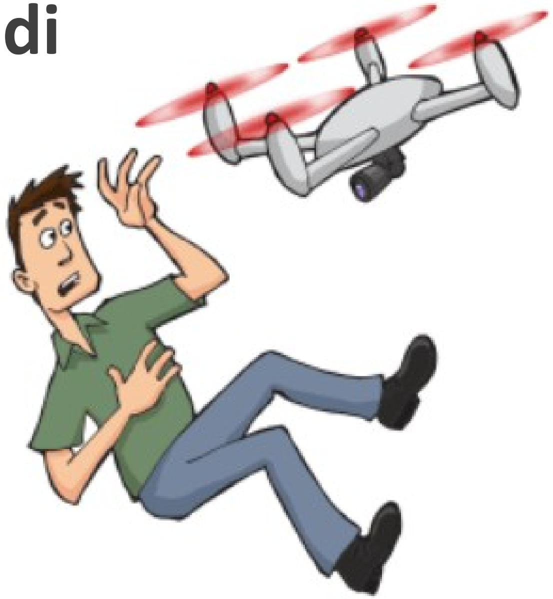


Scelta degli strumenti



Sicurezza delle persone

- Scelta della giusta distanza del pilota (e persone) dal drone a partire dal decollo fino all'atterragio
- Nessuna persona nell'area delle operazioni (atterraggio forzato se qualcuno entra nell'are; se necessario, uso di assistenti per controllare l'accesso all'area)
- Sistemi di protezione individuale
- Gestione del confort climatico
- Team minimo: due persone

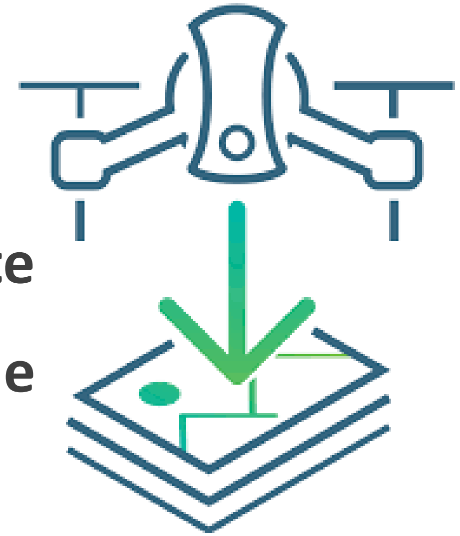


Sicurezza del drone e del volo

- Analisi dei vincoli presenti nell'area operativa
- Piano di prevenzione dei rischi prima delle operazioni
- Stima delle condizioni climatiche (vento, aerosol marino, temperatura, ecc)
- Pre-check prima del volo
- Durata del volo (controllo continuo delle batterie per evitare di scendere sotto il 30% della carica, se freddo a soglia sale al 50%)
- Larghe ed adeguate piattaforme di decollo e atteraggio soprattuto se presenti sabbia o detriti
- Pulizia dopo ogni operazione di volo
- Rispetto del piano di manutenzione

Procedura di acquisizione

- Altezza di volo scelta in base alla risoluzione richiesta
    - 6-10 m per piccoli oggetti, 10-25 m per taglia media, sopra 25 m per grandi oggetti
- Sotto I 10 metri la modalità *stop and shoot* é preferita
- Fuoco manuale ad infinito ed esposizione automatica disabilitata
- Luminosità scelta all'inizio del volo ed orientata verso la parte inferiore dell'istogramma
- Si scelgono, quando possibile, gli orari della mezza giornata
- Si preferisce un giorno privo di nuvole o almeno con luminosità costante
- Si sceglie un piano di volo che prevede almeno il 70% di sovrapposizione delle foto
- Target a terra per la calibrazione spaziale



Scelta degli strumenti

Se possibile si preferiscono:

- Droni commerciali
- Software commerciale

QUALI?

- Quelli che hanno I requisiti richiesti
- Sono utilizzati e molto testati

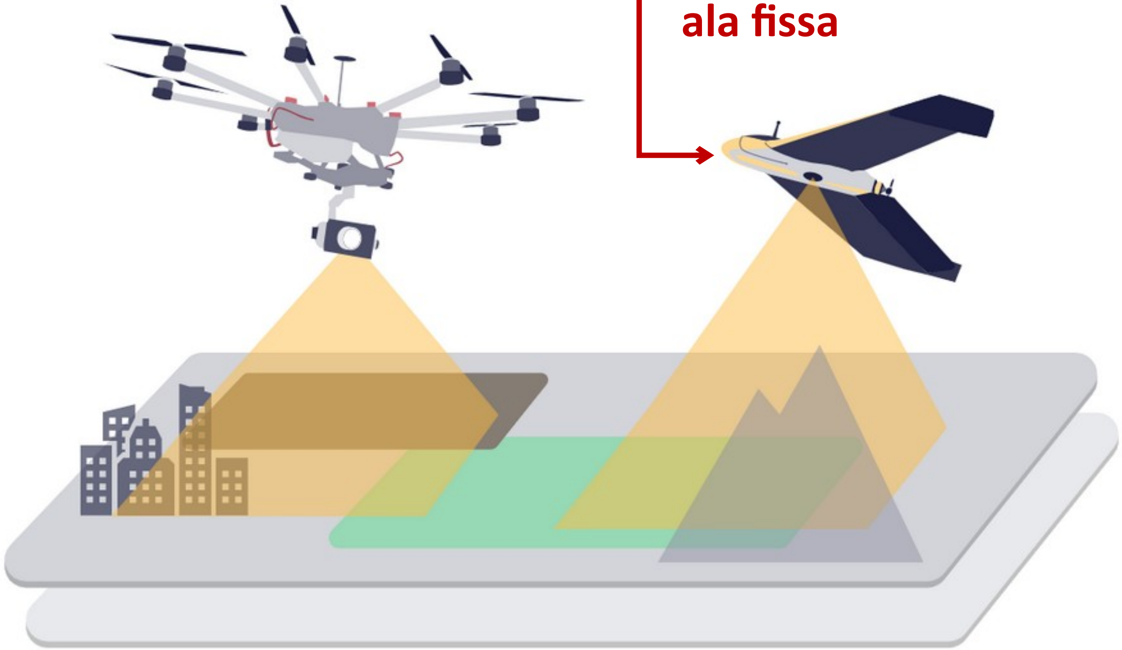
PERCHE?

- Riproducibilità delle procedure
- Condivisione di problemi e risultati
- Per avere strumentazione affidabile

Principali limiti della tecnologia SAPR

- Condizioni climatiche
- Condizioni operative dell’area
- Durata del volo
- Area analizzata

Limiti ridotti con SAPR ad ala fissa



Perché la tecnologia SAPR?

Esistono diverse metodiche di monitoraggio di un territorio, ognuna con le sue peculiari caratteristiche

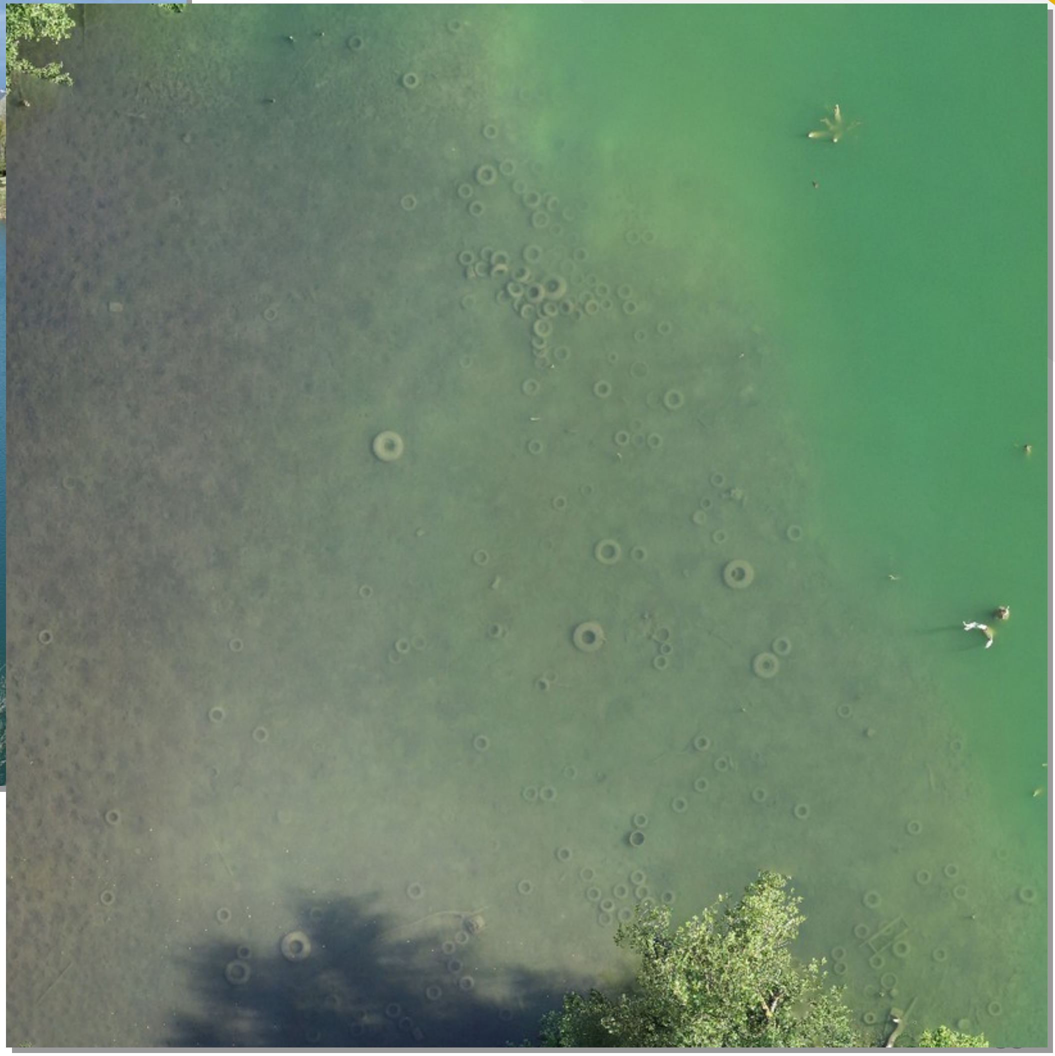
I SAPR sono competitivi per:

- ✓ Risoluzione spaziale e temporale
- ✓ Costi
- ✓ Appropriatezza

Quando l'osservazione dal cielo rileva sorprese

Alcuni casi di voli vissuti....

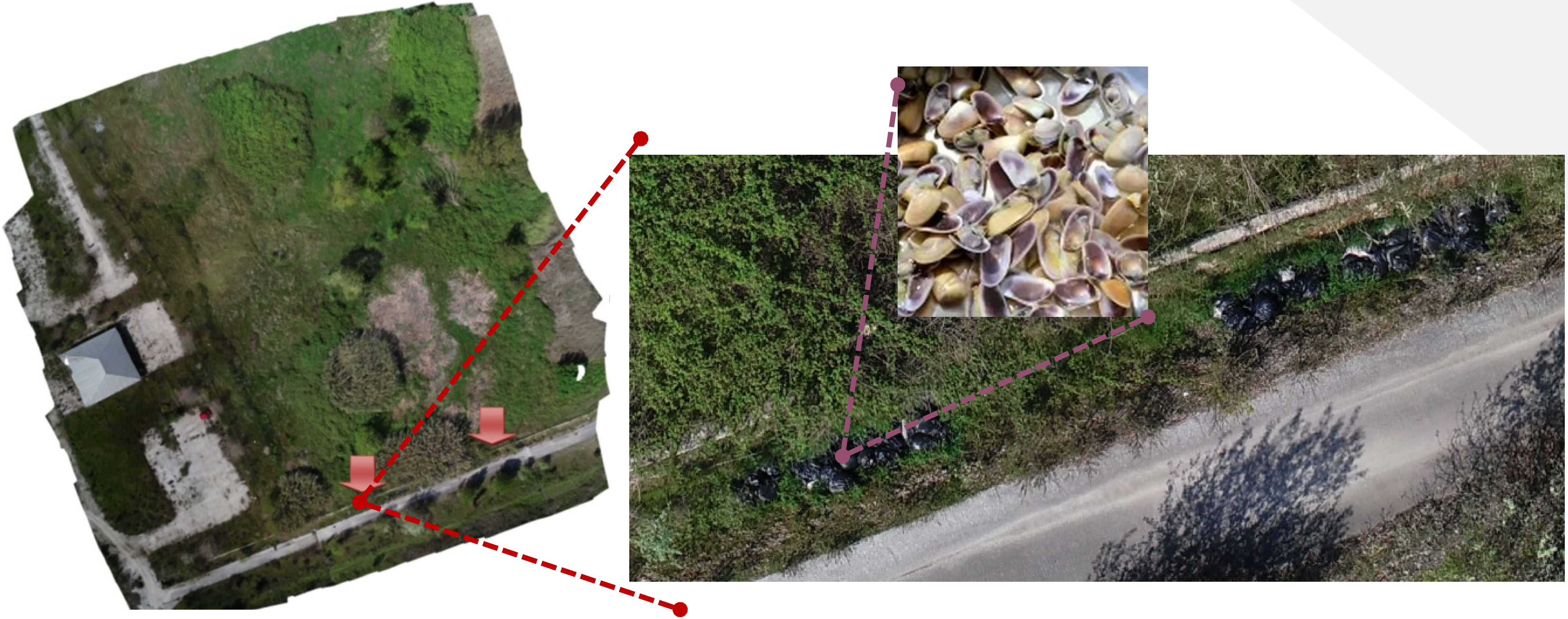
L'importanza del punto di vista



STIMA densità: 1 pneumatico ogni 7 m^2

La visione e l’accessibilità di un territorio

Indicazioni per approfondire



Un quadro regolatorio in aggiornamento

Team

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L’importanza della condivisione

- Interessi scientifici
- Procedure ed esperienze nei vari contesti
- I problemi legati a questa tecnologia
- Incidenti di volo o near missing durante le attività scientifiche

Condividere …. Per incrementare l’uso degli aeromobili a pilotaggio remoto nelle attività di ricerca scientifica

Conclusioni

Lo squardo dal cielo offerto dai sistemi aerei a pilotaggio remoto offre oggi un occasione interessante per ricerche scientifiche e monitoraggi ambientali

……. Questo è solo l'inizio!!!!

“Non c’è mai abbastanza tempo.
Grazie per il vostro “ *Dan Geer*

ISMAR

IN SUPREMÆ DIGNITATIS 1343

ENTE PARCO REGIONALE MIGLIARINO SAN ROSSORE MASSACIUCCOLI

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