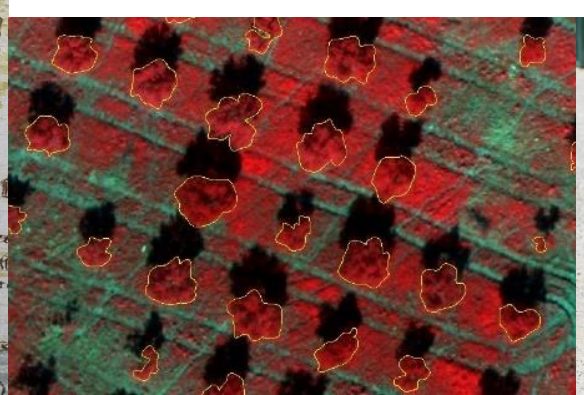
Opportunità e limiti dell'acquisizione dati ad altissima risoluzione in agricoltura tramite aeromobili a pilotaggio remoto

Ciclo di webinar su digitale, agricoltura e mondo rurale

Agricoltura digitale: dati rilevati da remoto per l'azienda agricola e le amministrazioni

Giuseppe **MODICA**
Dipartimento di Agraria
Università degli Studi *Mediterranea* di Reggio Calabria (Italy)



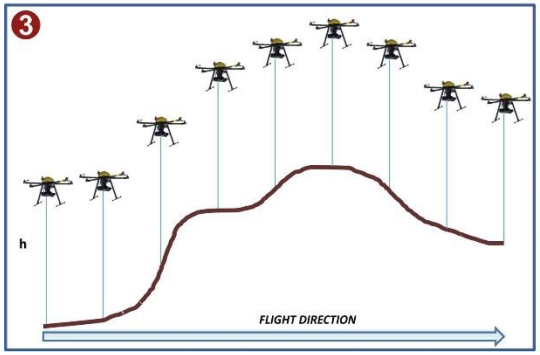


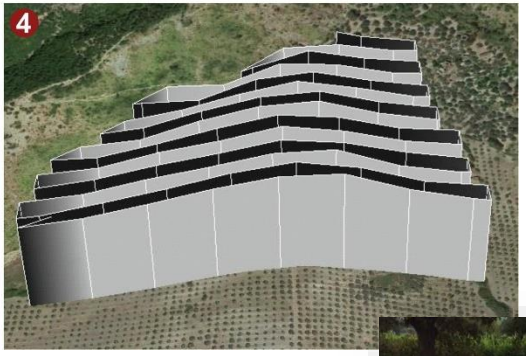


Rilievi UAV – sistema di rilevamento - 1









Tetracam µ-MCA 6

Multispectral imaging system

n° of bands: 6

GSD: ~ 4 cm of at 75 m a.s.l.

native file format: 10-Bit .RAW file

G4 Surveying Robot

Multi-copter

GPS L1 flight assistant

Max speed: 9 m/s

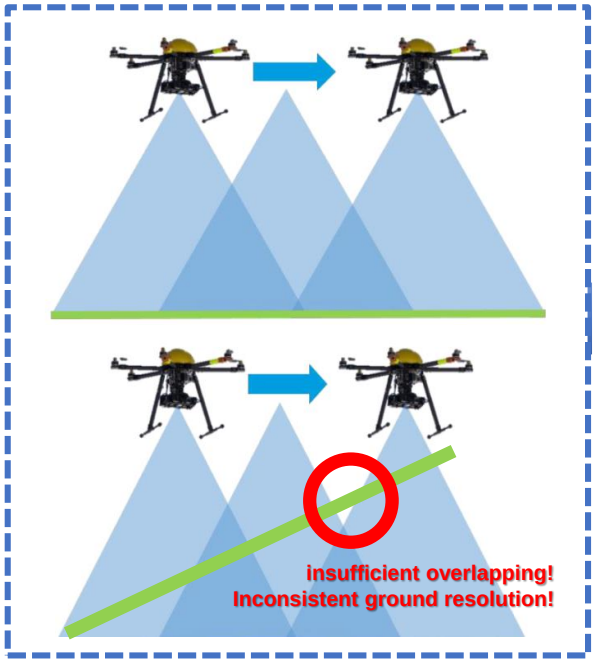
Max wind: 10 m/s

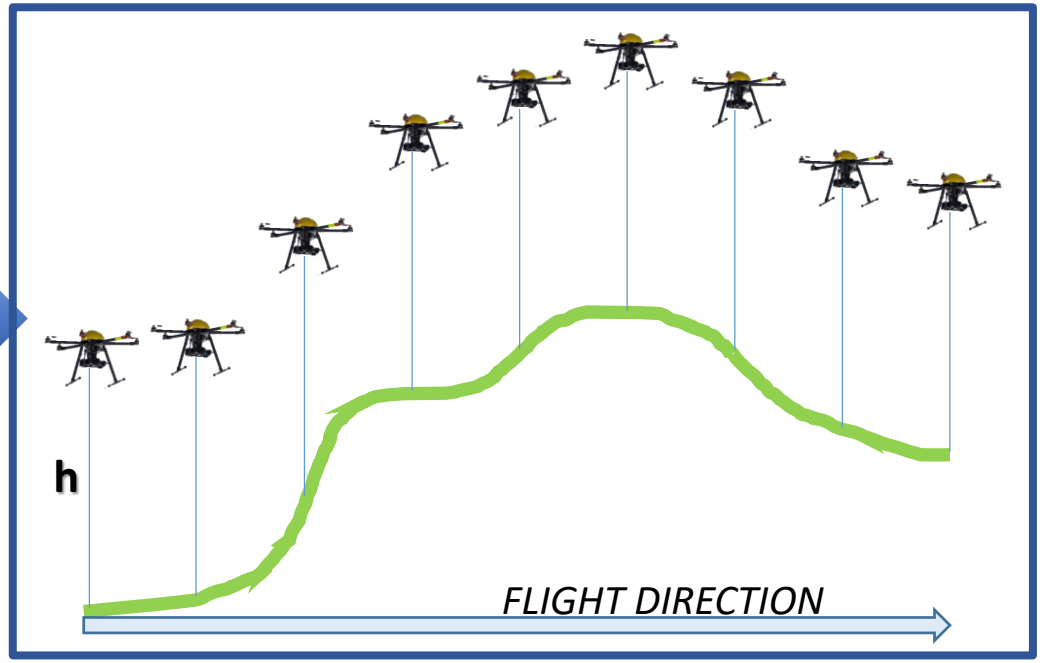
Time flight: 20'

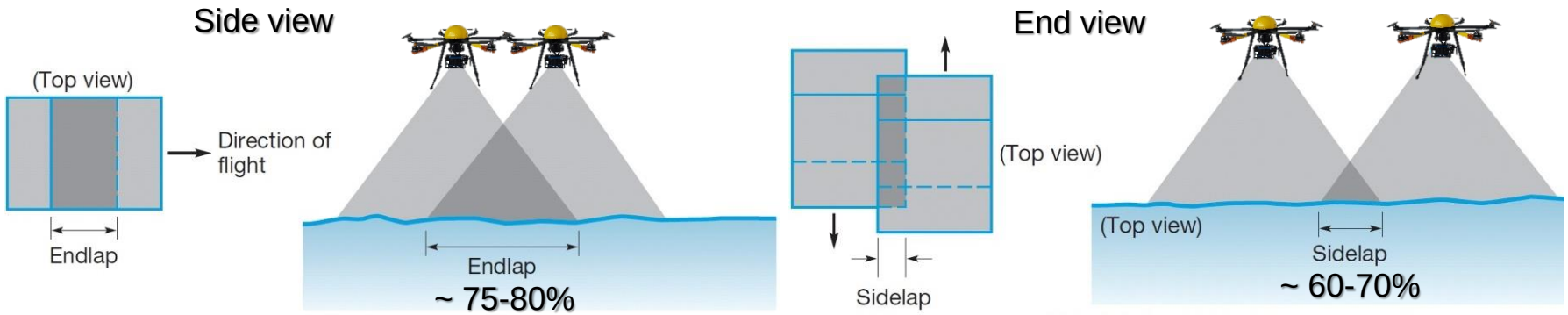
Payload: 2.3 kg (including batteries)



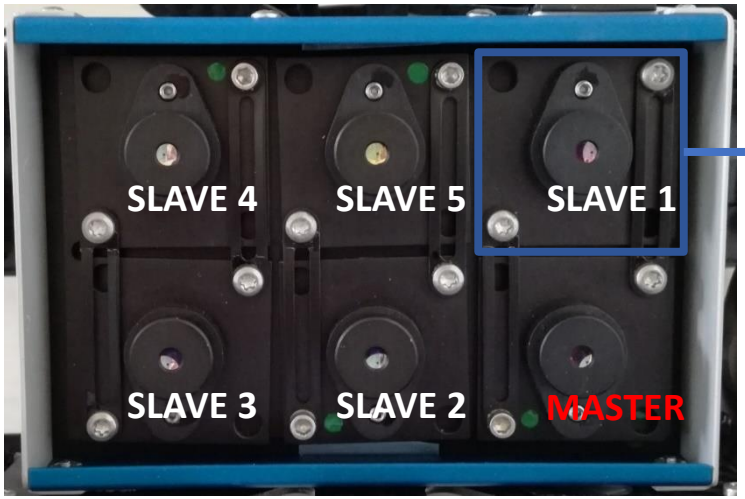
Rilievi UAV – Controllo piano di volo







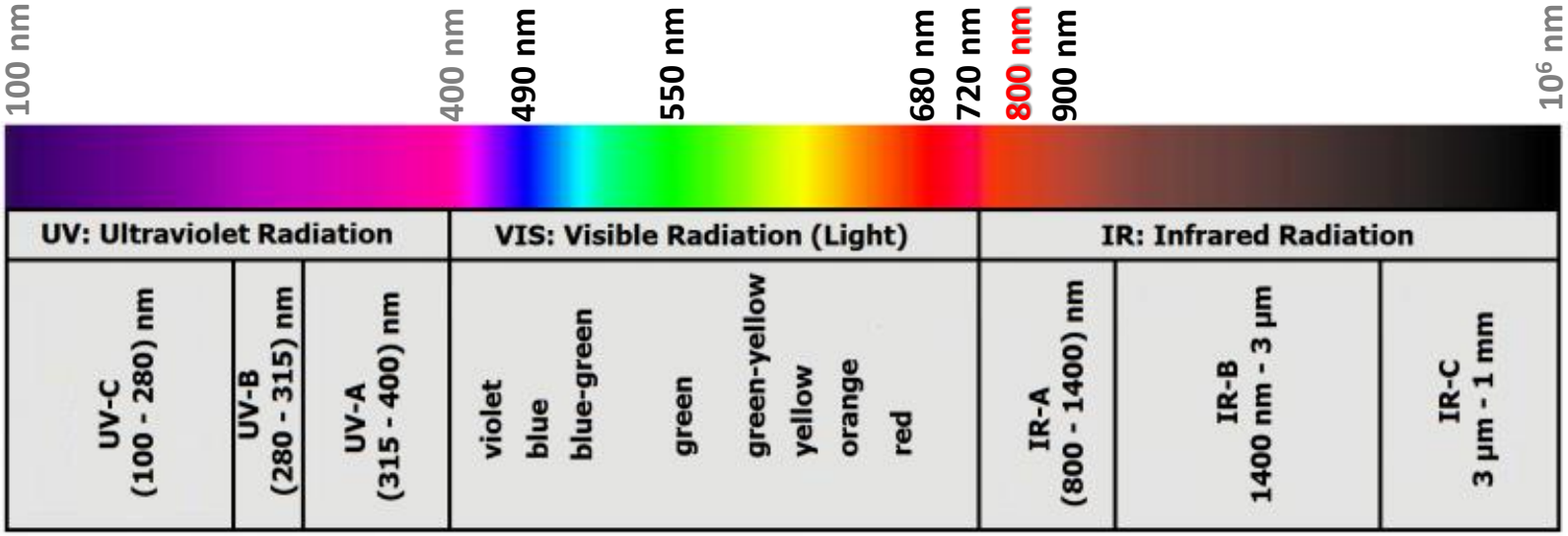
Rilievi UAV – Caratteristiche camera multispettrale 1





9.6 mm focal length
Band pass filter
1.3 Mpx CMOS optical sensor
6.66mm x 5.32mm
1280 x 1020 pixels

Master	**NIR1**	800 nm
Slave 1	**Blu**	490 nm
Slave 2	**Green**	550 nm
Slave 3	**Red**	680 nm
Slave 4	**RedEdge**	720 nm
Slave 5	**NIR2**	900 nm



Rilievi UAV – sistema di rilevamento - 2



Parrot Disco-Pro AG

Fino a 80 ha in un singolo volo

Size : 1150x580x120mm

Wingspan : 1150 mm

Parrot Sequoia

Multispectral imaging system

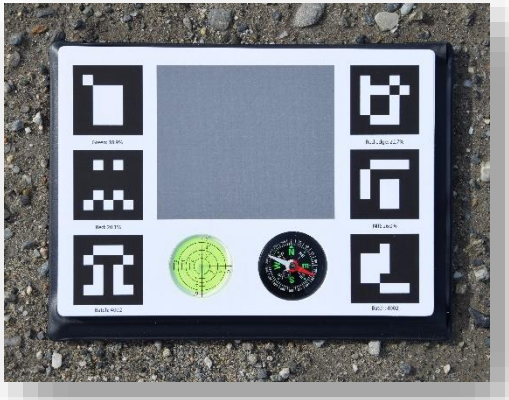
4 bande multispettrali (Red, Green, RedEdge, NearInfrared) a 1.2 Mpx.

+ RGB (16 Mpx)

GSD: ~ 5 cm a 50 m s.l.m.

native file format: 10-Bit





Giuseppe **Modica**

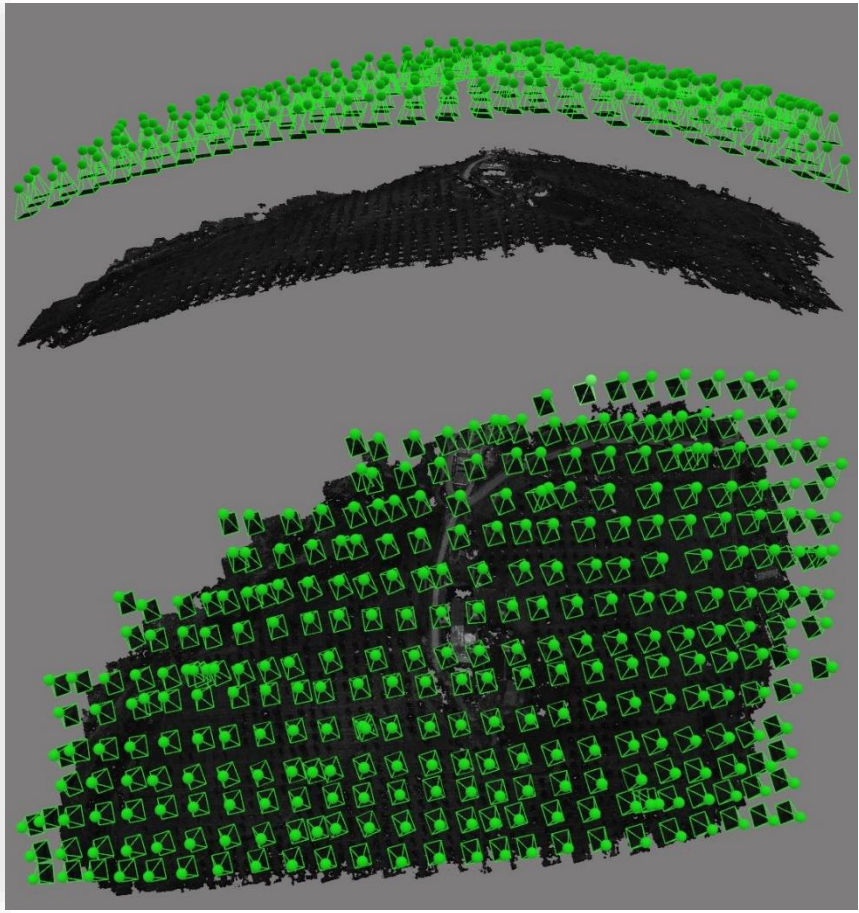
DIPARTIMENTO AGRARIA

UNIVERSITÀ DEGLI STUDI DI REGGIO CALABRIA Mediterranea

Rilievi UAV – Appoggio a terra con punti di controllo (GCP)











Caso studio in **ARBORETI DA FRUTTO** (**OLIVETI**).



In Calabria, gli oliveti coprono una suprficie pari a circa 18000 ha, con una produzione di 75000 t di olio di olive nel 2017.
Nel 2016 è stato ottenuto il marchio "IGP Olio di Calabria".

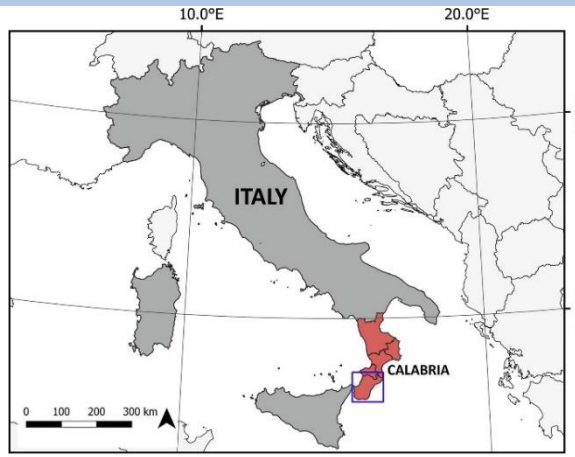
Caso studio in **ARBORETI DA FRUTTO** (**AGRUMETI**).

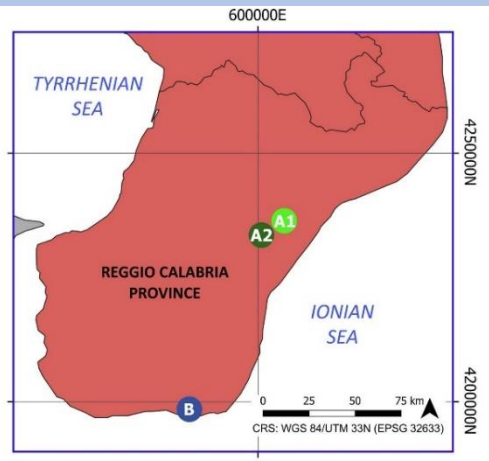


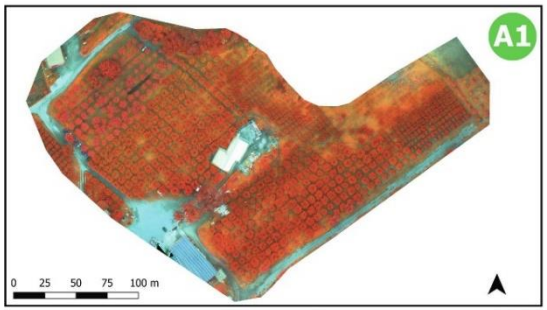


Nel 2001 è stata istituita la DOP "Bergamotto di Reggio Calabria – olio essenziale".

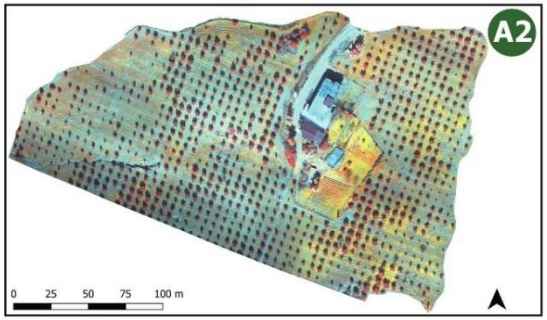
Il Consorzio di Tutela del bergamotto di Reggio Calabria è stato riconosciuto dal MIPAAF nel 2008.



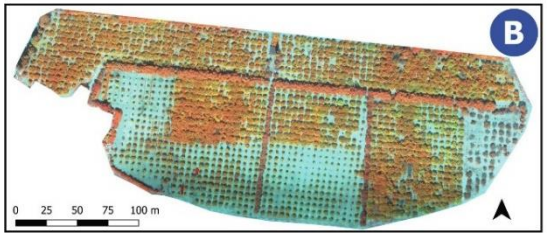














A1 - Clementine

A2 - Olivo

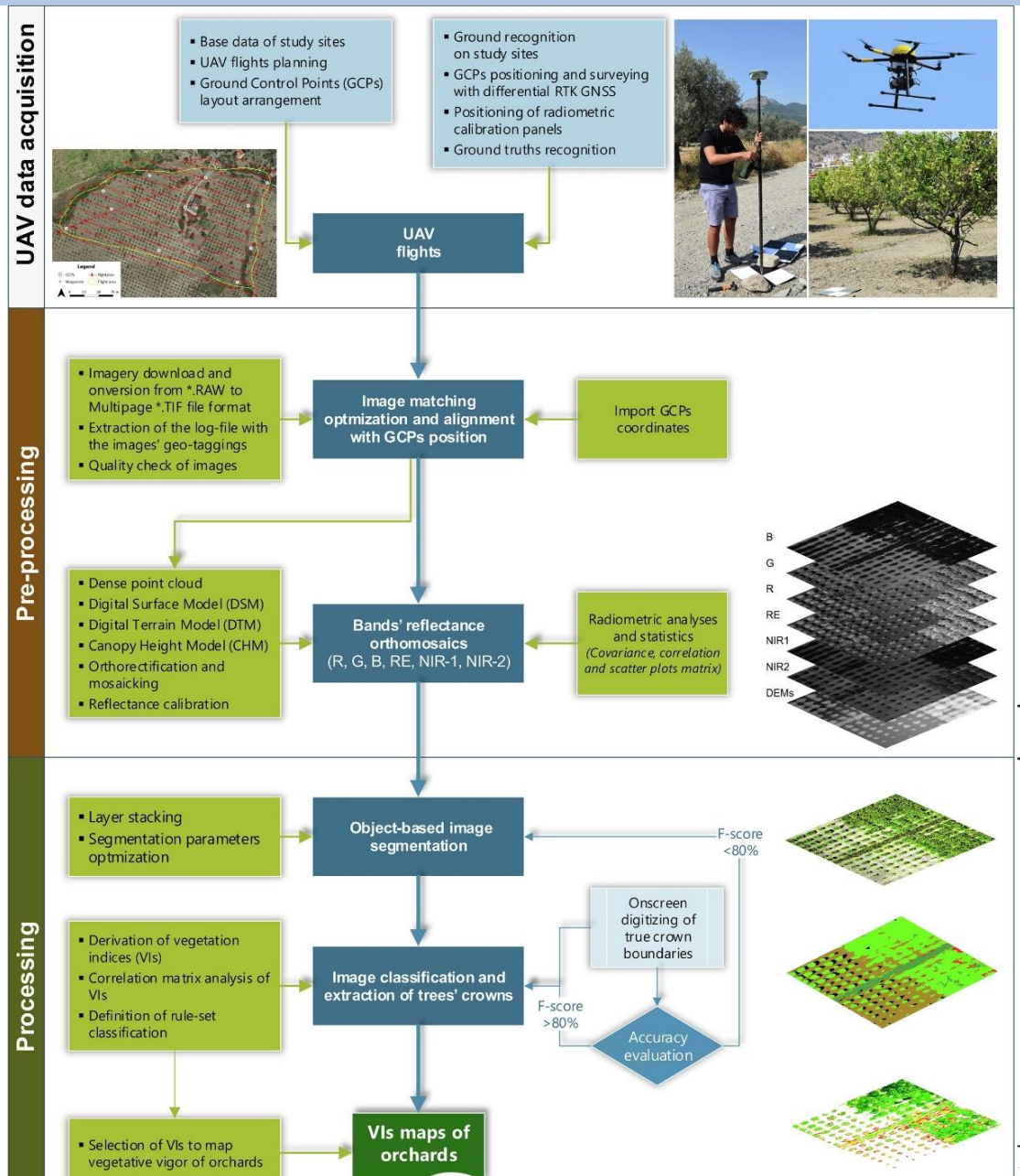
B - Bergamot e Olivo.

Giuseppe **Modica**

DIPARTIMENTO AGRARIA

UNIVERSITÀ DEGLI STUDI DI REGGIO CALABRIA Mediterranea

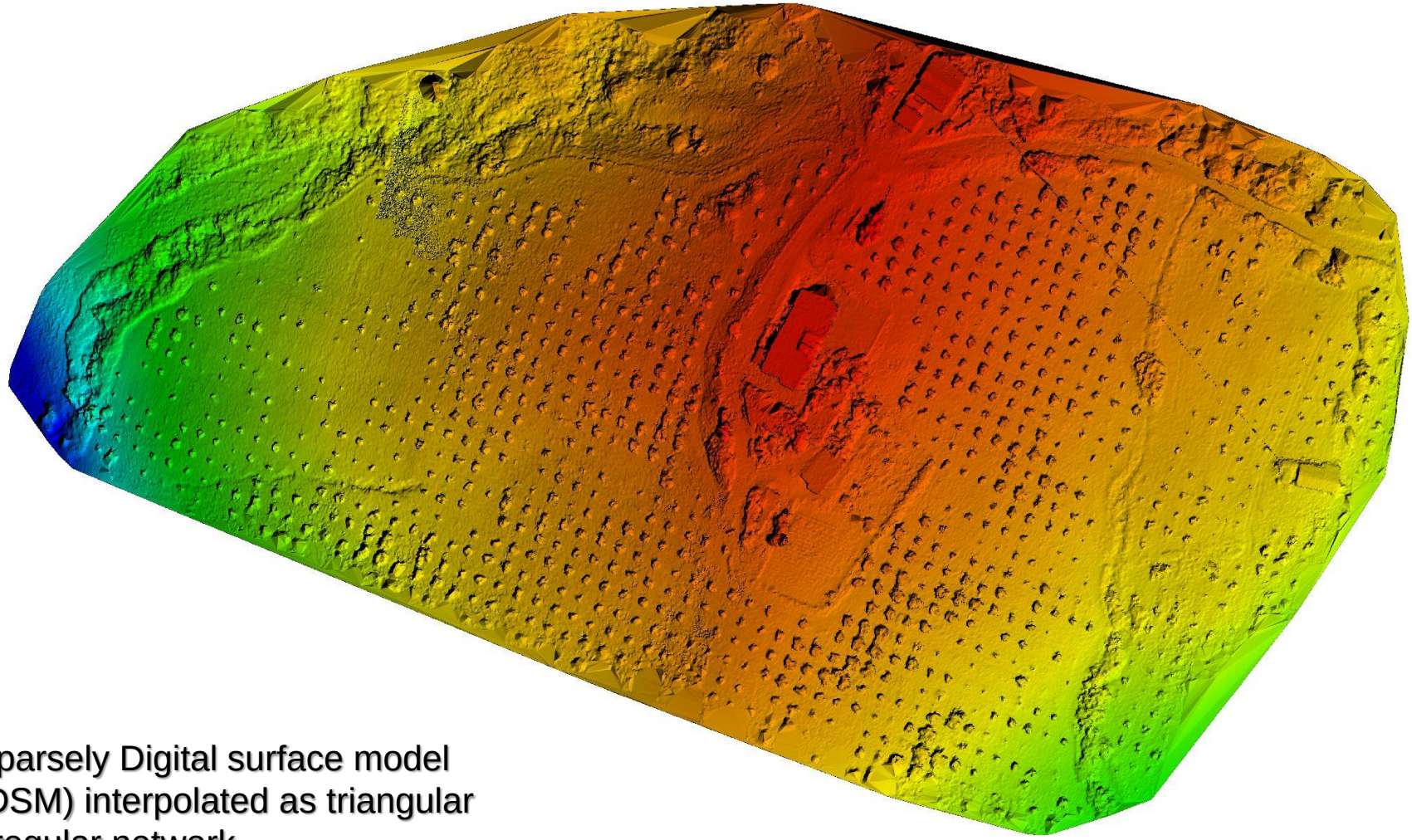
Workflow monitoraggio vigore vegetativo



Index denomination	Index formula
Normalized Difference Vegetation Index (NDVI)	$\frac{(\rho NIR1 - \rho Red)}{(\rho NIR1 + \rho Red)}$
Normalized Difference Red Edge Index (NDRE)	$\frac{(\rho NIR1 - \rho RedEdge)}{(\rho NIR1 + \rho RedEdge)}$
Soil-Adjusted Vegetation Index (SAVI)	$\frac{(\rho NIR1 - \rho Red)}{(\rho NIR1 + \rho Red + L)}(1 + L)$
Green Normalized Difference Vegetation Index (GNDVI)	$\frac{(\rho NIR1 - \rho Green)}{(\rho NIR1 + \rho Green)}$
Chlorophyll Vegetation Index (CVI)	$\rho NIR1 \frac{\rho Red}{(\rho Green * \rho Green)}$
Green and Red Normalized Difference Vegetation Index (GRNDVI)	$\frac{\rho NIR1 - (\rho NIR1 + \rho Red)}{\rho NIR1 + (\rho Green + \rho Red)}$

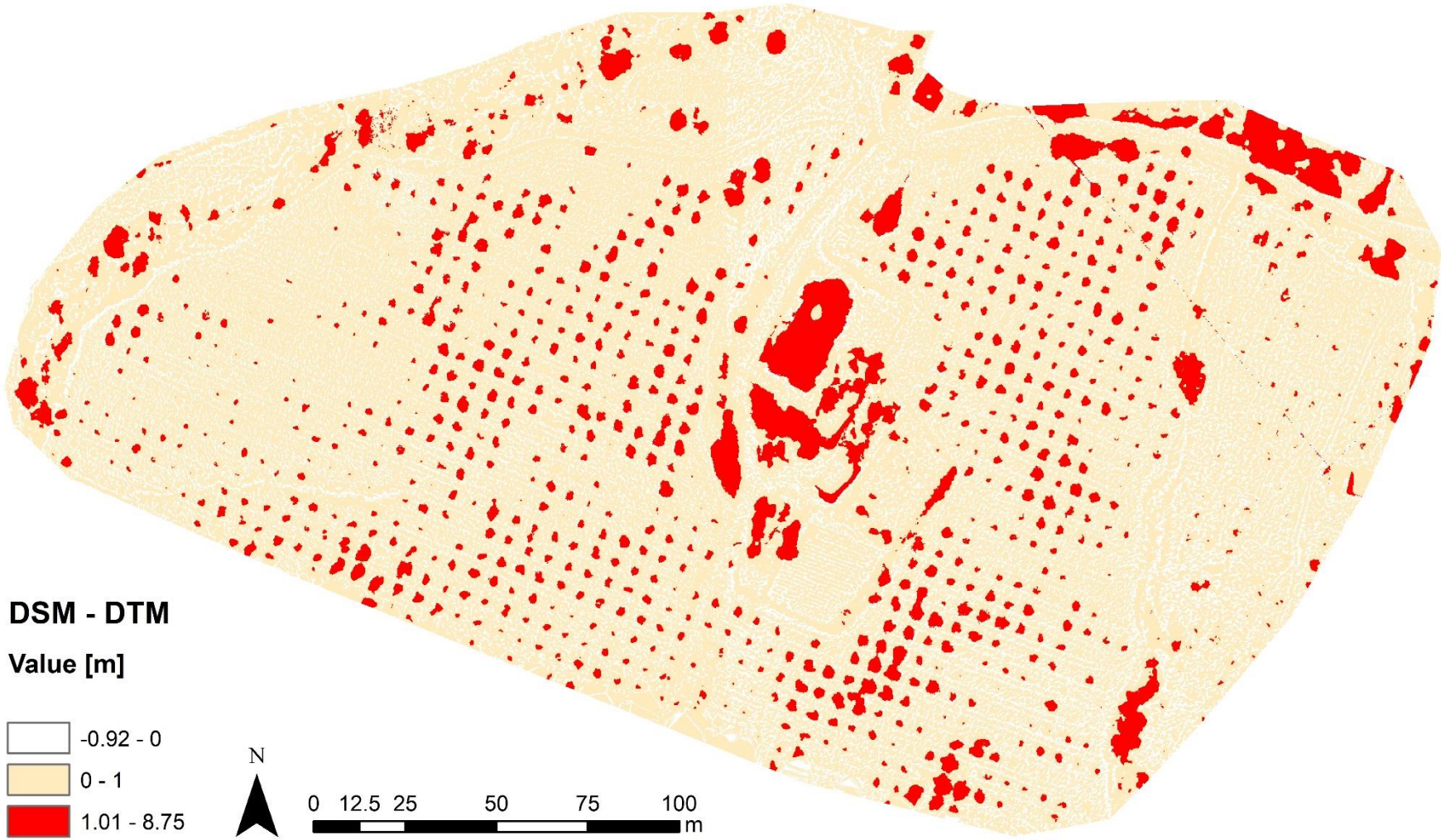
*ρ is the reflectance at the given wavelength.

UAV surveys – Morphological layers

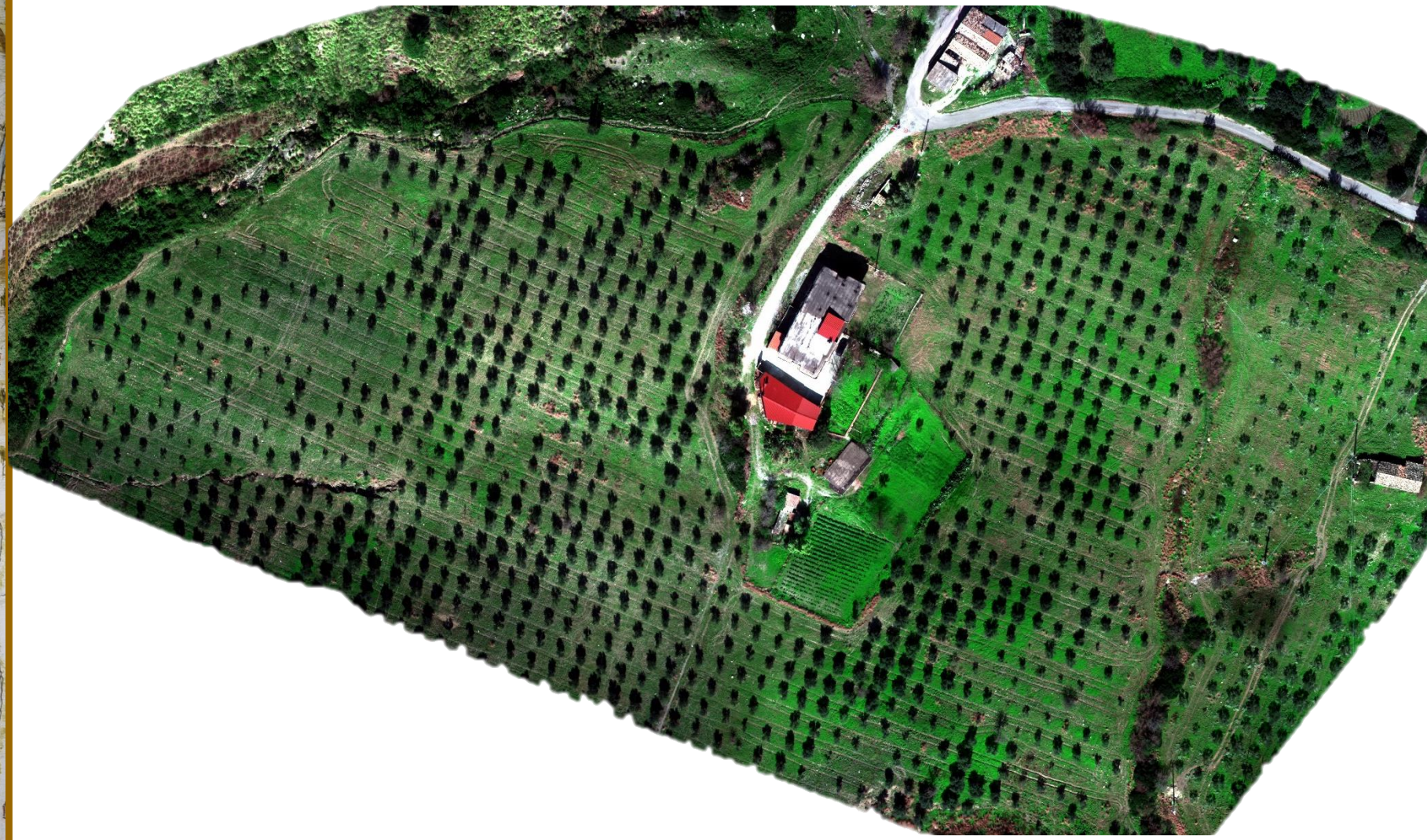


Sparsely Digital surface model (DSM) interpolated as triangular irregular network

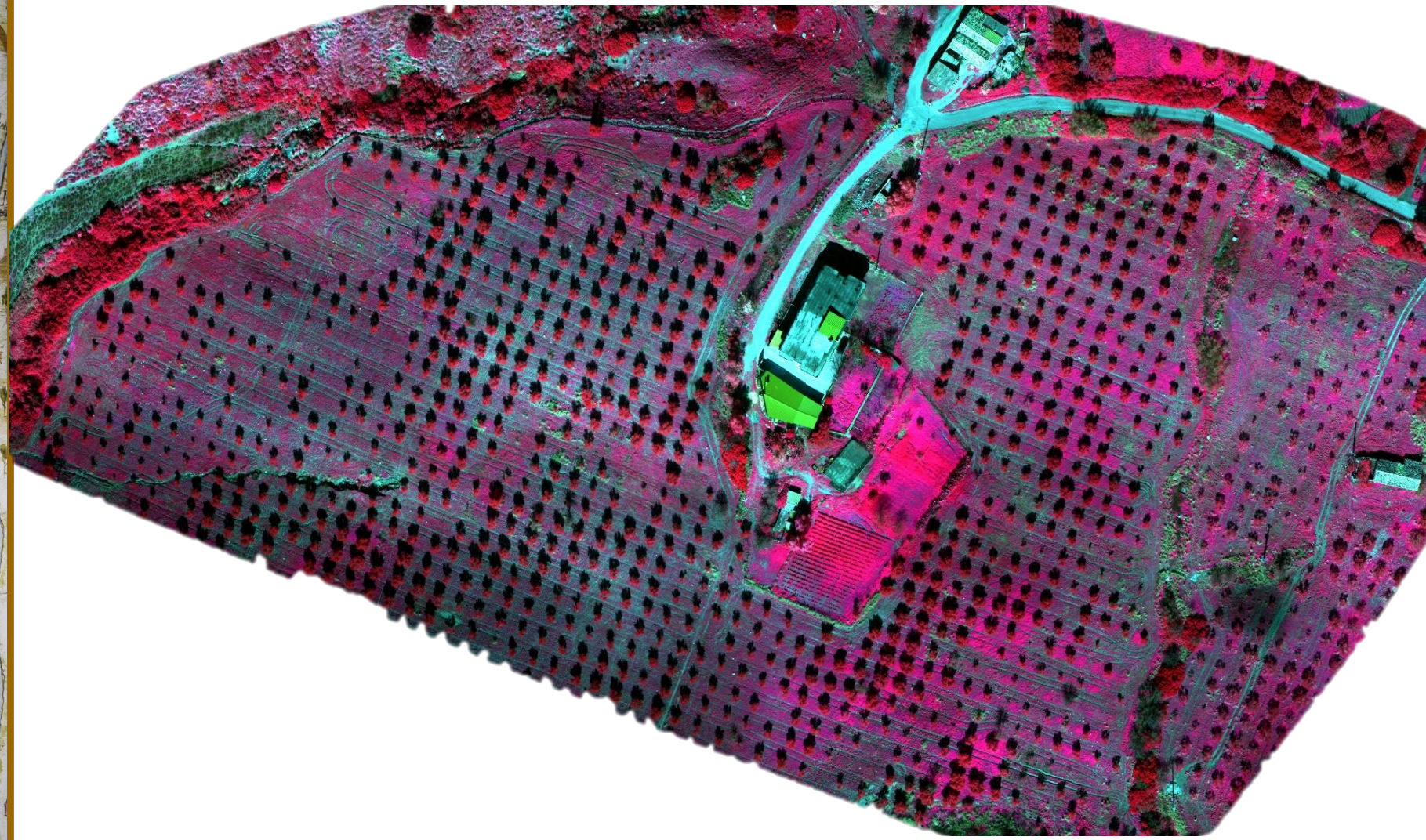
UAV surveys – Morphological layers



UAV surveys – Orthomosaic in real colour (Red, Green, Blue)



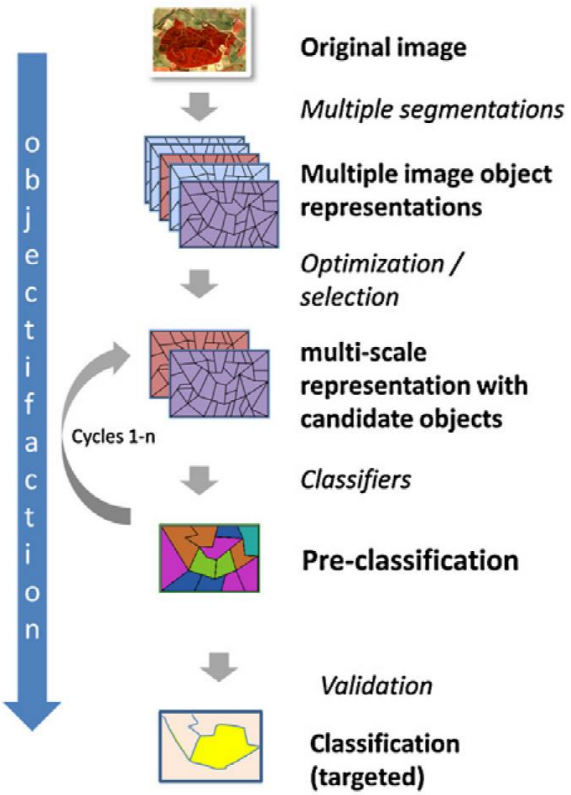
UAV surveys – Orthomosaic in false colour (NIR1, Red, Green)



Methods – from pixel to object classification

Beyond pixels……..

- Traditional image classification algorithms are based on classification of individual pixels.
- Per-pixel classifiers ignore contextual properties from surrounding pixels.
- Image analysis algorithms that go beyond pixels are classified as ***object-based image analysis*** (**OBIA**).
- OBIA techniques take into account spatial information producing a set of non overlapping image objects (polygons, lines,).
- Also called geospatial object based image analysis (**GEOBIA**) to specifically refer to the GISscience.







Methods – from pixel to object classification GeOBIA suites

Commercial software suites

- ERDAS Imagine Objective
- ENVI Feature Extraction Module
- Geomatica Object Analyst
- TerrSet IDRISI Image Processing
- Trimble eCognition

Free and open source software suites

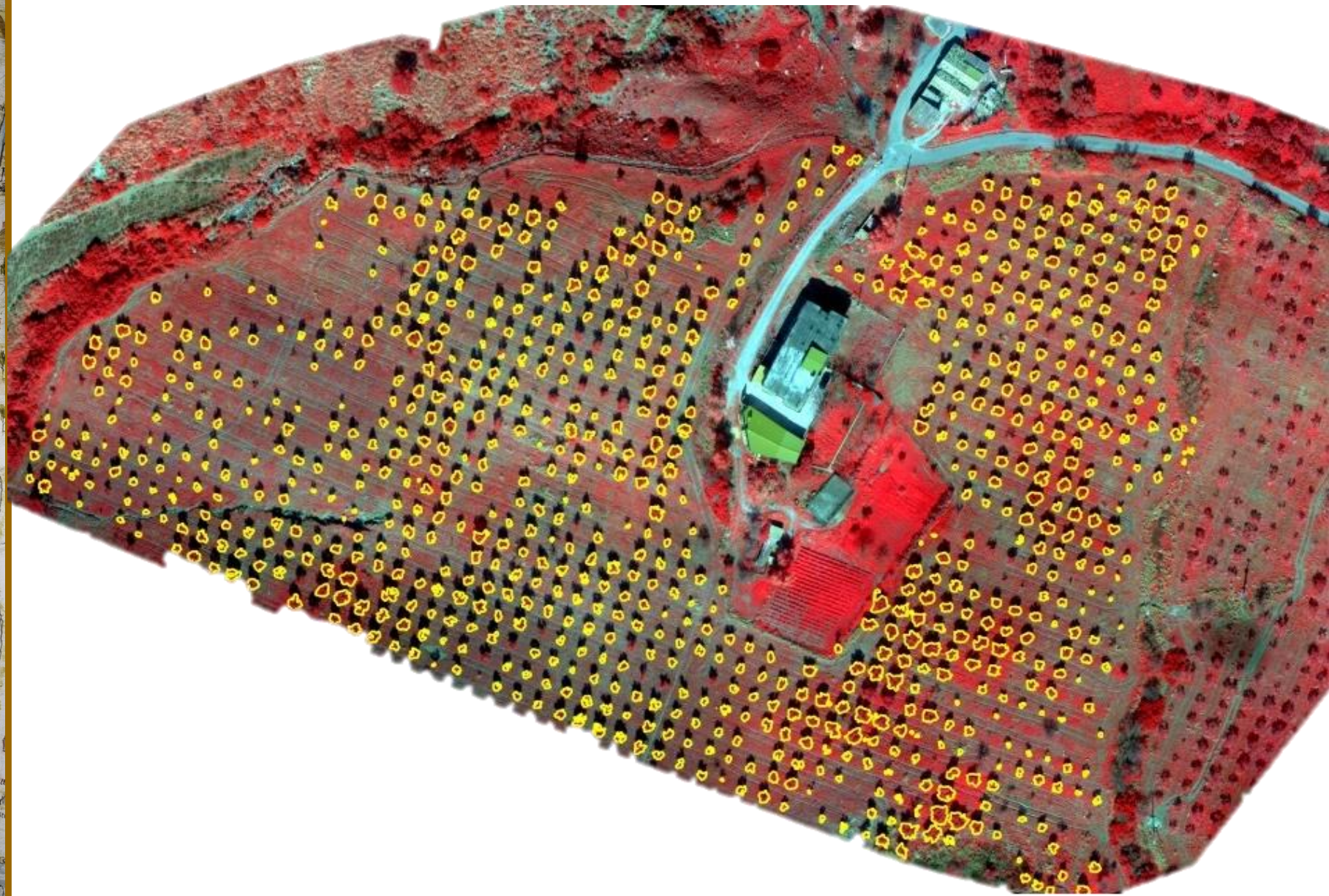
- **Hierarchical Image Segmentation** (HSEG) Software
- Orfeo toolbox
- **SAGA** (System for Automated Geoscientific Analyses)

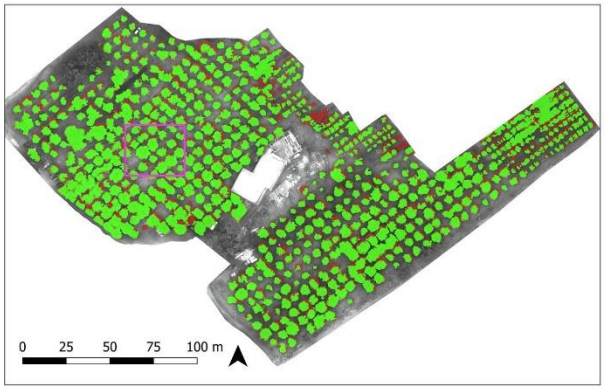
Giuseppe **Modica**

DIPARTIMENTO AGRARIA

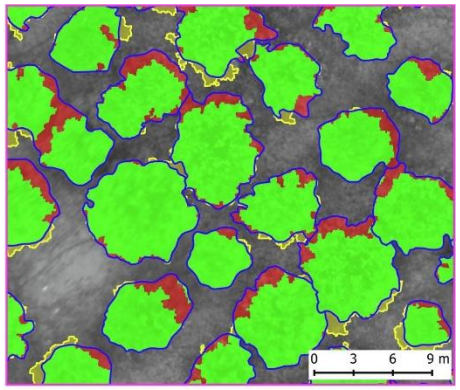
UNIVERSITÀ DEGLI STUDI DI REGGIO CALABRIA Mediterranea

UAV surveys – Orthomosaic in false colour (NIR1, Red, Green)

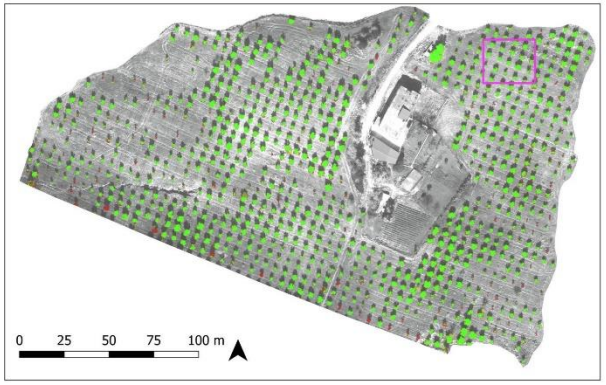




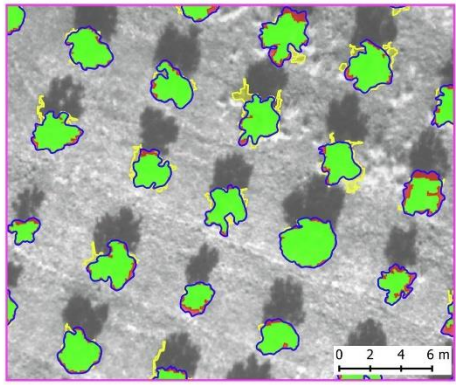
A1



Accuratezza classificazione



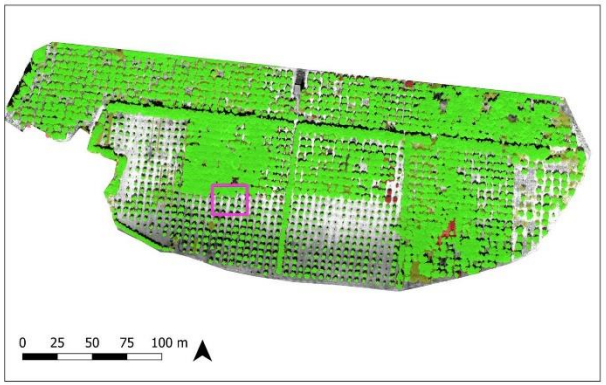
A2



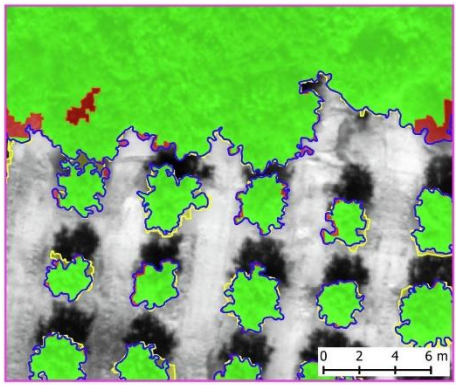
A1 - Clementine

A2 - Olivo

B - Bergamot e Olivo.



B



Legend

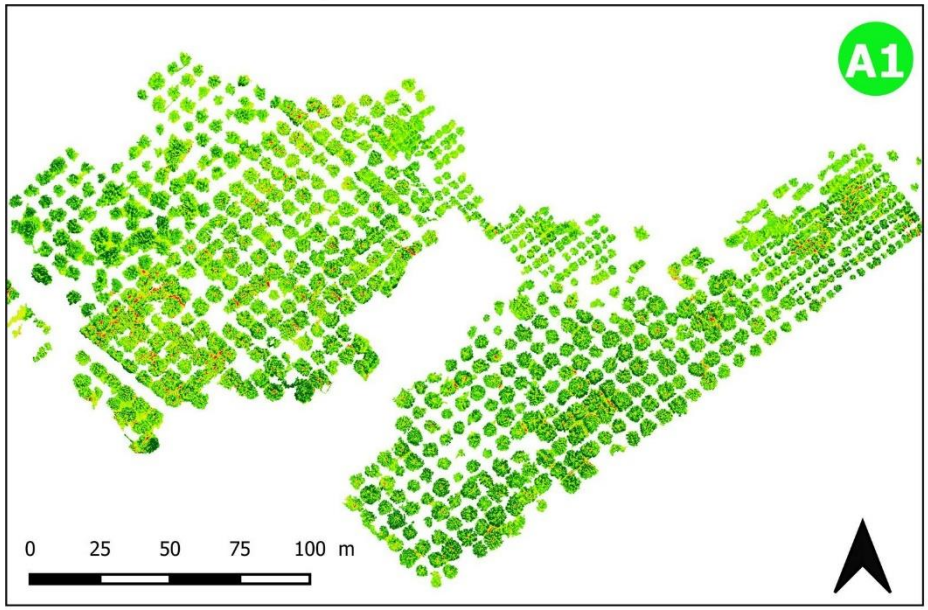
Reference canopy boundaries

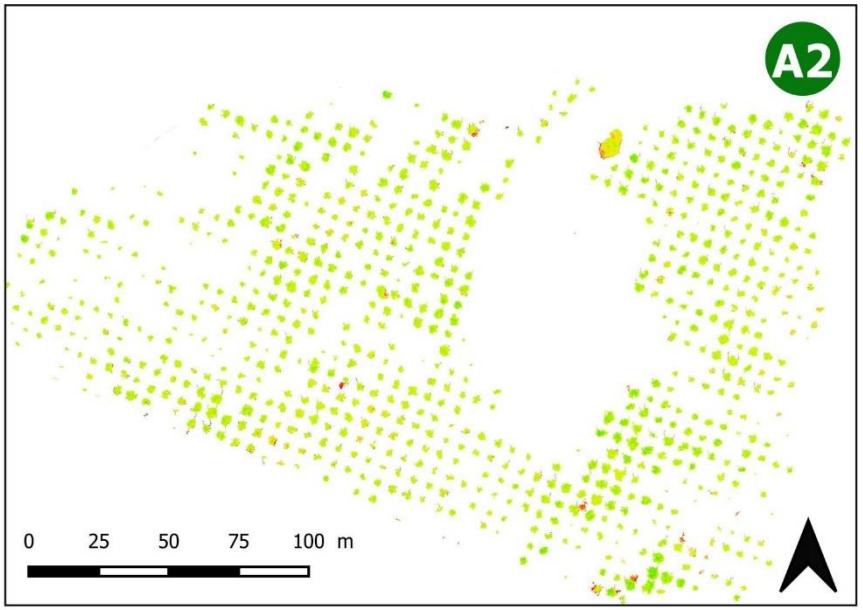
False Positives (**FP**)

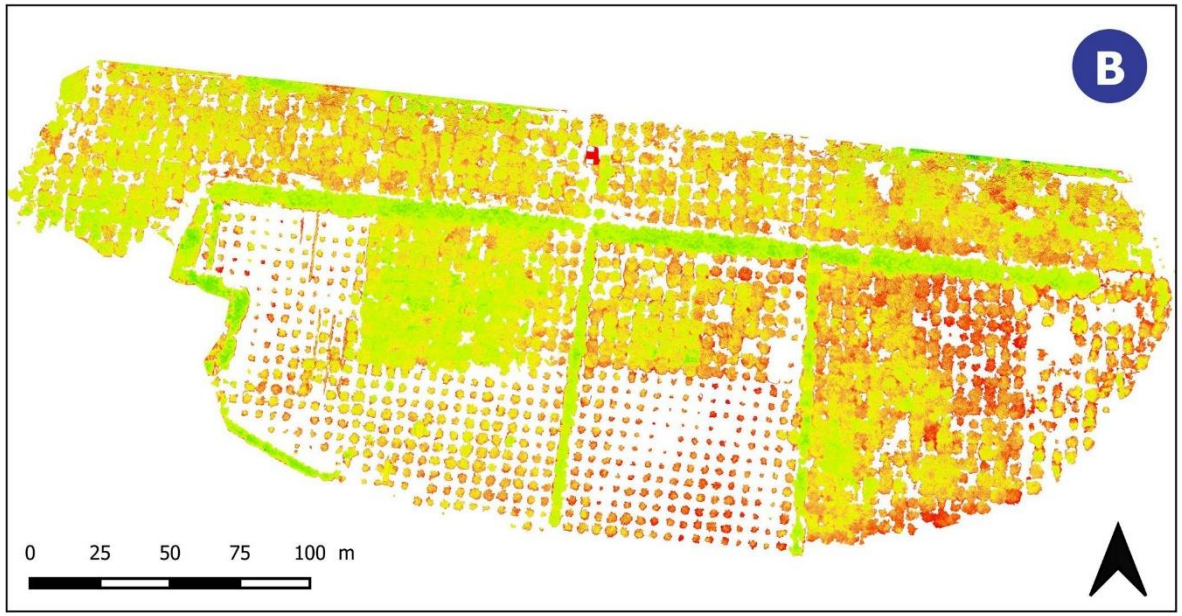
False Negatives (**FN**)

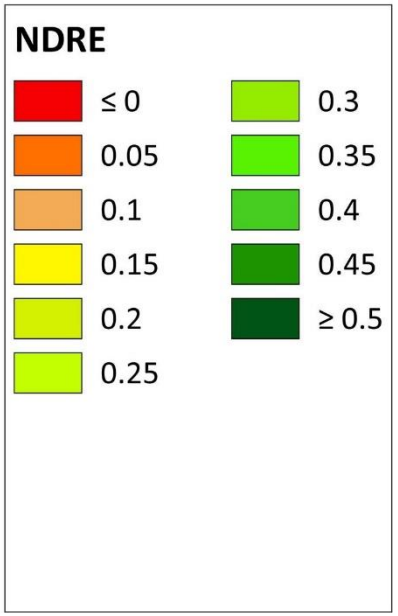
True Positives (**TP**)

Mappe di Vigoria









Caso studio **Cipolla Rossa di Tropea**.

Consorzio Cipolla Rossa di Tropea Calabria IGP



Circa 500 ettari di suolo a produzione certificabile Cipolla Rossa di Tropea IGP.

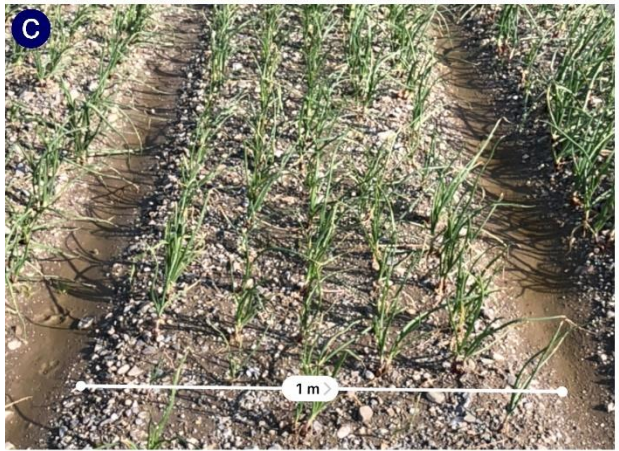
Giuseppe **Modica**

Caso studio **Cipolla Rossa di Tropea**.

Comparazione dati UAV, PlanetScope e Sentinel-2

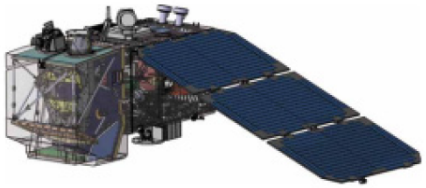


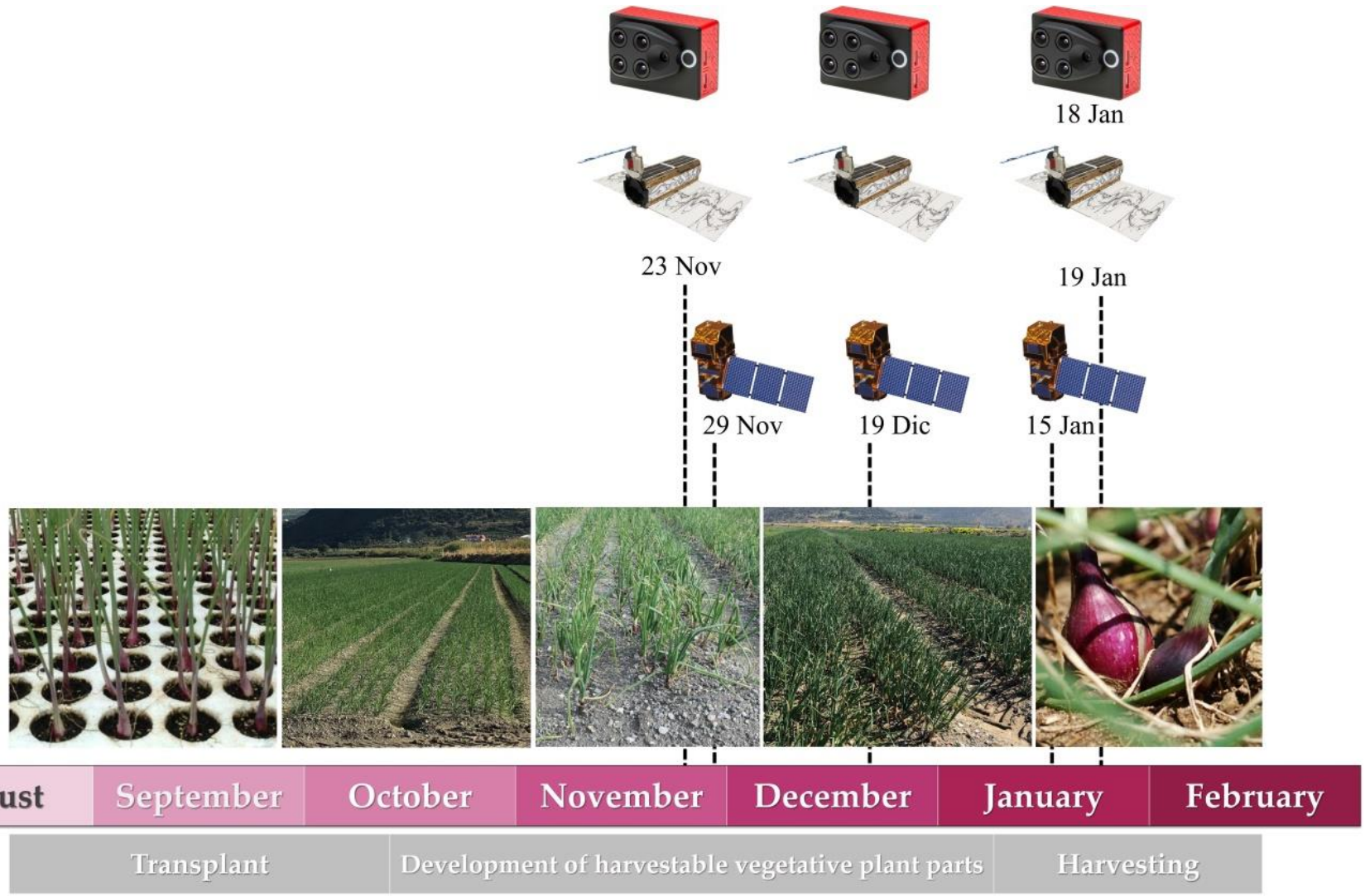




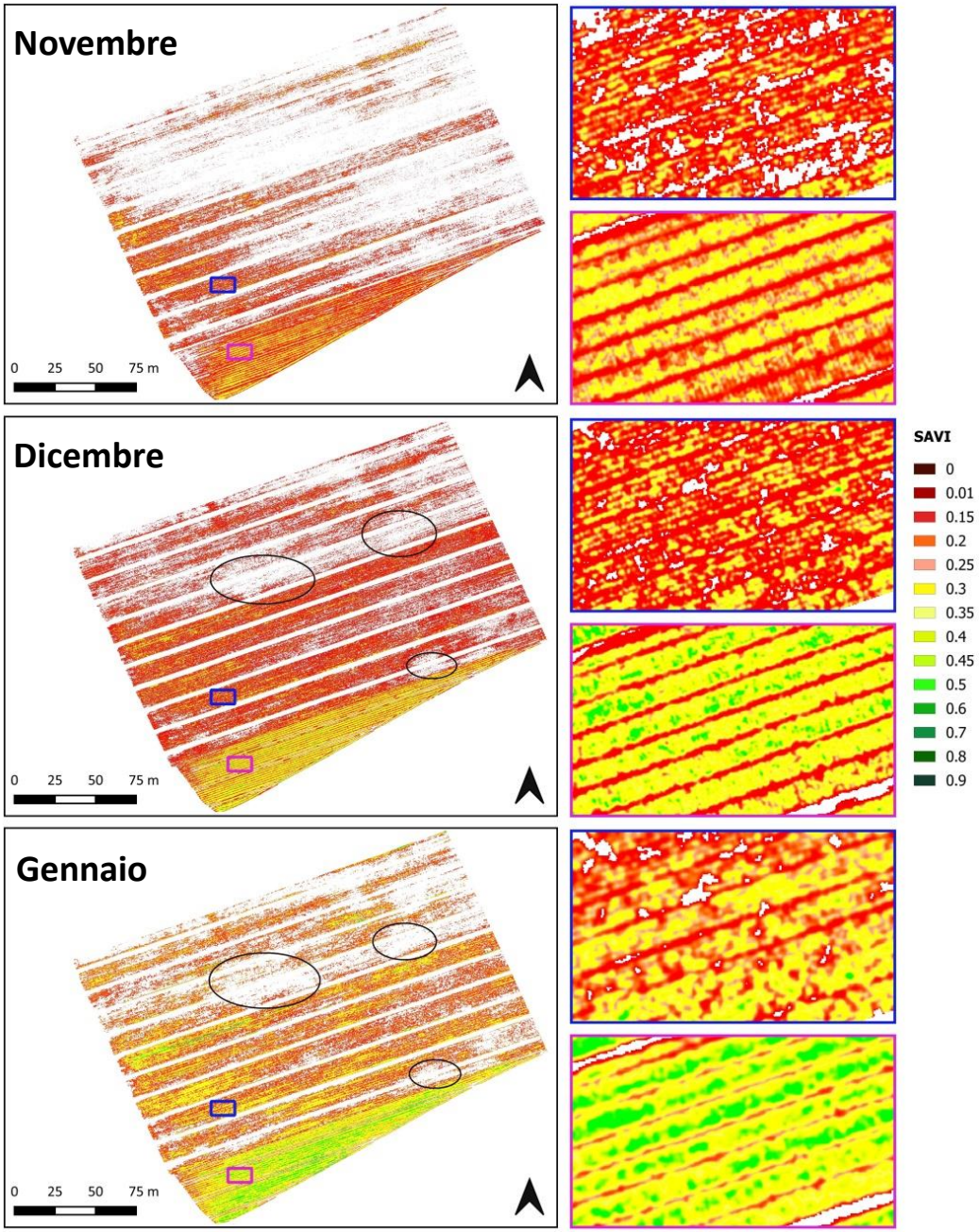


Caso studio **Cipolla Rossa di Tropea.**

	UAV	**SATELLITE**	
	Parrot Disco-Pro AG	Planet Scope	Sentinel-2
Platform	 Camera Parrot Sequoia	 3U Cubesat	
Number of channels	4	4	4
Spectral wavebands (nm)	Green 550 (width 40) Red 660 (width 40) Red Edge 690 (width 10) NIR 790 (width 40)	Blue 464-517 Green 547-585 Red 650-682 NIR 846-888	Blue 426-558 (width 66) Green 523-595 (width 36) Red 633-695 (width 31) NIR 726-938 (width 106)
Dimension	59 mm x41 mm x 28 mm	100 mm x100 mm x300 mm	3.4 x1.8 x2.35 m
Weight	72 g	4 kg	1000 kg
FOV	HFOV: 62° VFOV: 49°	HFOV: 24.6 km VFOV: 16.4 km	HFOV: 290 km
Flight quote AGL	50 m	475 km	786 km
Ground resolution distance (GSD)	5 cm	3.7 m	10 m
Number of images to cover the study site	>1000	1	1

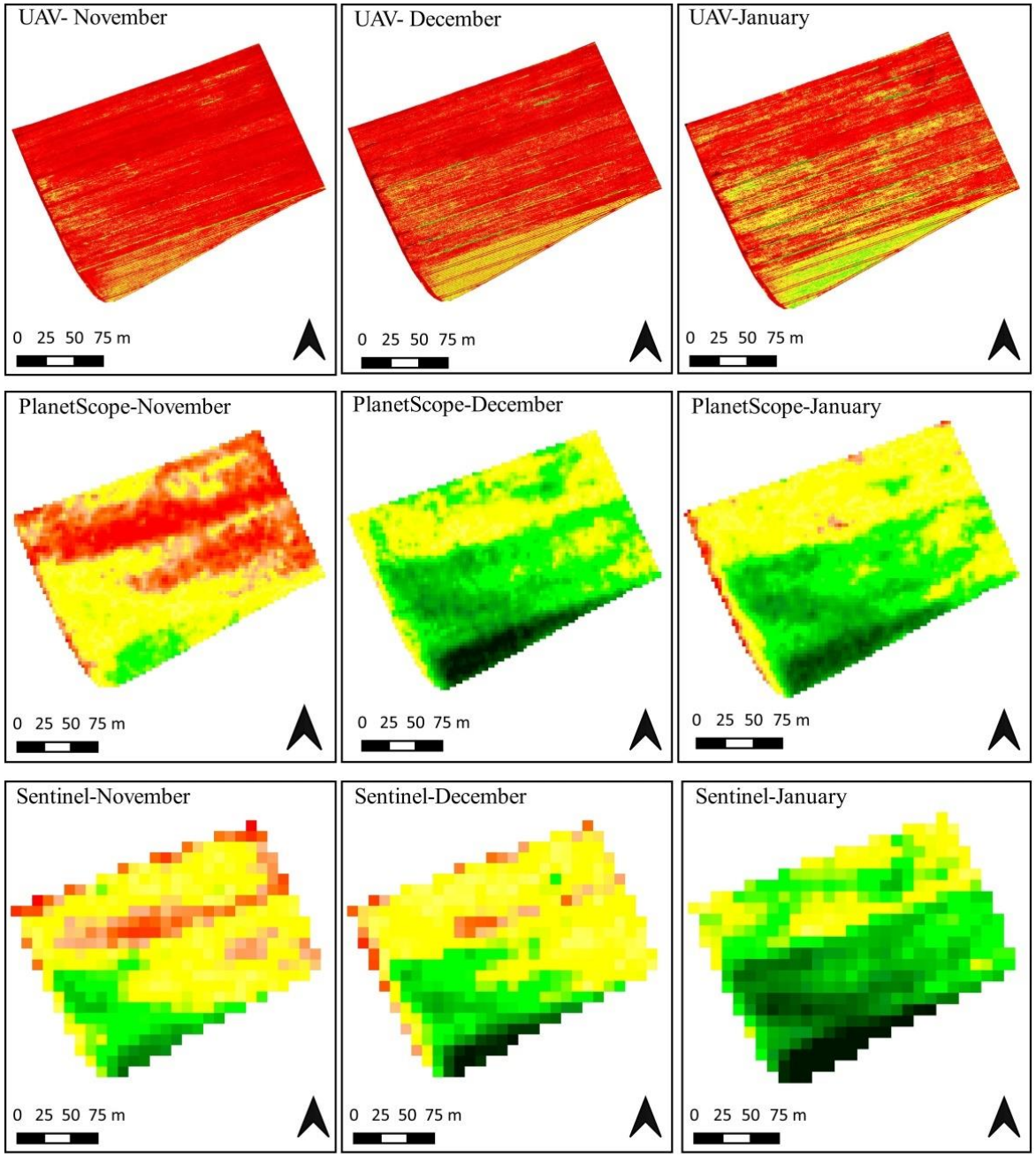


Quadro sinottico del ciclo fenologico della coltivazione della cipolla con ciclo autunno-invernale e delle dati di rilevamento UAV e di presa dei dati delle due piattaforme satellitari indagate (PlanteScope e Sentinel-2).

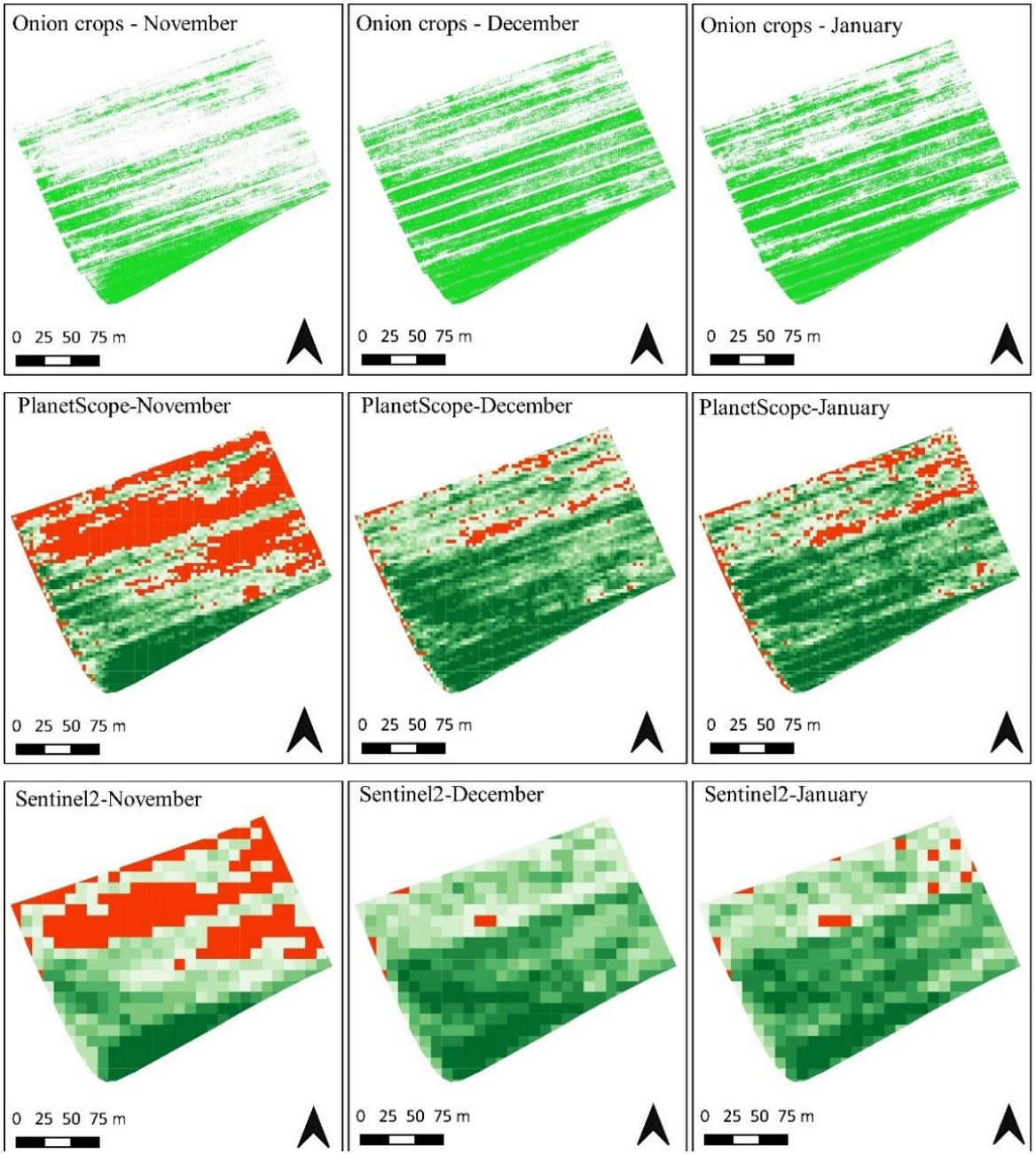


Mappe del vigore vegetativo della cipolla ottenute con l'indice di vegetazione **SAVI** (*Soil Adjusted Vegetation Index*) su dati da UAV a 5 cm.

Con procedura di classificazione GEOBIA è stato escluso il suolo.

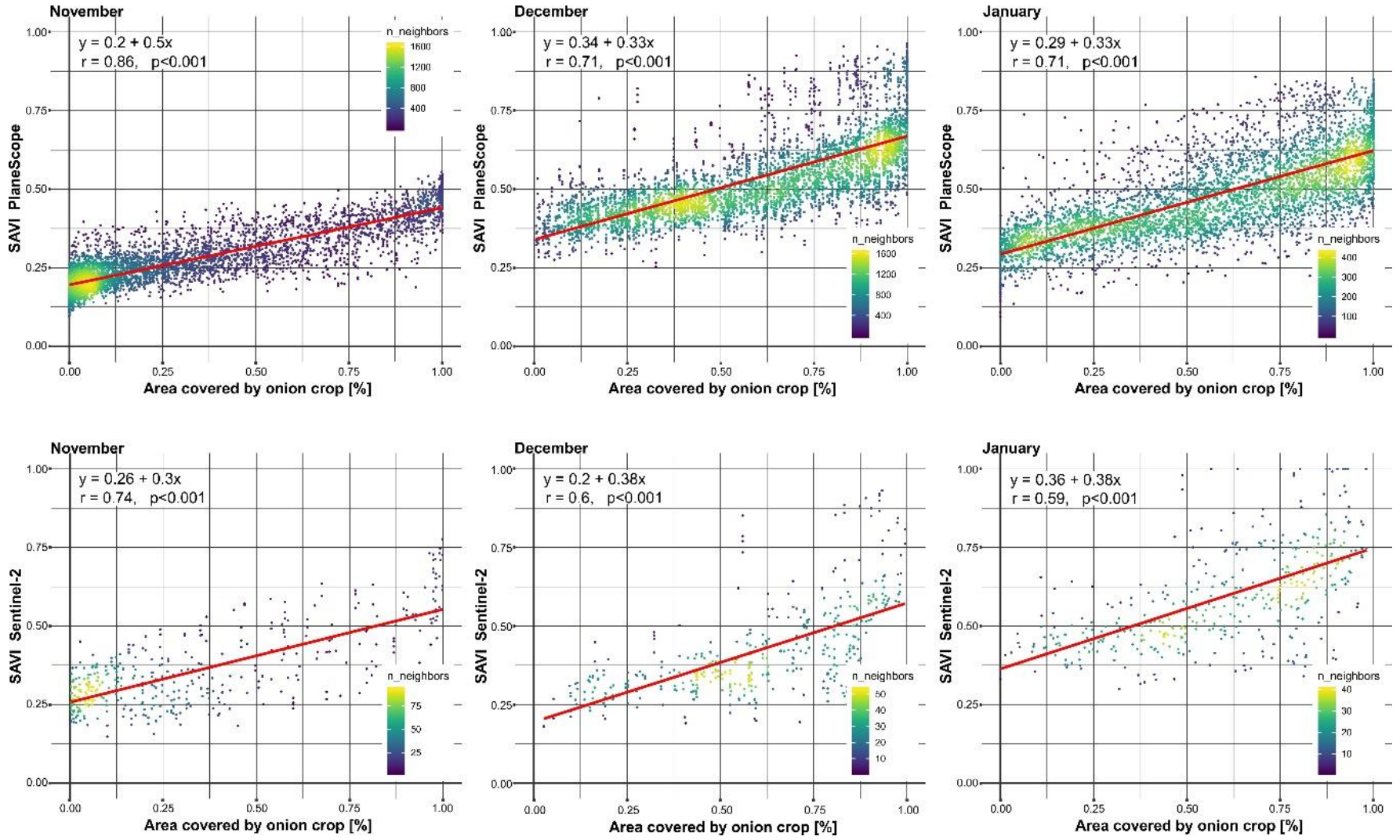


Mappe del vigore vegetativo della cipolla ottenute con l'indice di vegetazione **SAVI** su dati UAV e delle due piattaforme satellitari indagate (PlanteScope e Sentinel-2).



Copertura della cipolla classificata su dati UAV.

Area occupata dalla cipolla in ciascuno dei pixel su dati delle due piattaforme satellitari indagate (PlanteScope e Sentinel-2)



Gli Scatter plots mostrano la correlazione tra i valori di SAVI delle due piattaforme satellitari (PlanetScope e Sentine-2) (asse-Y) e la percentuale di area occupata da cipolla classificata su dati UAV (asse-X) nei tre messi indagati (Novembre, Dicembre, Gennaio).

Bibliografia recente

Computers and Electronics in Agriculture 175 (2020) 105500

Contents lists available at ScienceDirect

Computers and Electronics in Agriculture

journal homepage: www.elsevier.com/locate/compag



Original papers

Monitoring the vegetation vigor in heterogeneous citrus and olive orchards. A multiscale object-based approach to extract trees' crowns from UAV multispectral imagery

Giuseppe Modica*, Gaetano Messina, Giandomenico De Luca, Vincenzo Fiozzo, Salvatore Praticò

Dipartimento di Agraria, Università degli Studi Mediterranea di Reggio Calabria, Località Feo di Vito, I-89122 Reggio Calabria, Italy

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Keywords:
Multispectral unmanned aerial vehicles (UAVs) imagery
Multiresolution segmentation
Precision Agriculture (PA)
Spectral Vegetation Indices (VIs)
Geographic object-based image analysis (GEOBIA)
Vigor maps

ABSTRACT

Precision agriculture (PA) constitutes one of the most critical sectors of remote sensing applications that allow obtaining spatial segmentation and within-field variability information from field crops. In the last decade, an increasing source of information is provided by unmanned aerial vehicle (UAVs) platforms, mainly equipped with optical multispectral cameras, to map, monitor, and analyze, temporal and spatial variations of vegetation using ad hoc spectral vegetation indices (VIs). Considering the centimeter or sub-centimeter spatial resolution of UAV imagery, the geographic object-based image analysis (GEOBIA) approach, is becoming prevalent in UAV remote sensing applications. In the present paper, we propose a quick and reliable semi-automatic workflow implemented to process multispectral UAV imagery and aimed at the detection and extraction of olive and citrus trees' crowns to obtain vigor maps in the framework of PA. We focused our attention on the choice of GEOBIA data input and parameters, taking into consideration its replicability and reliability in the case of heterogeneous tree orchards. The heterogeneity concerns the different tree plantation distances and composition, different crop management (irrigation, pruning, weeding), and different tree age, height, and crown diameters. The proposed GEOBIA workflow was implemented in the eCognition Developer 9.5, coupling the use of multispectral and topographic information surveyed using the Tetracam μ-MCA06 snap multispectral camera at 4 cm of ground sample distance (GSD). Three different study sites in heterogeneous citrus (Bergamot and Clementine) and olive orchards located in the Calabria region (Italy) were provided. Multiresolution segmentation was implemented using spectral and topographic band layers and optimized by applying a trial-and-error approach. The classification step was implemented as process-tree and based on a rule set algorithm, therefore easily adaptable and replicable to other datasets. Decision variables for image classification were spectral vegetation indices (NDVI, SAVI, CVI) and topographic layers (DSM and CHM). Vigor maps were based on NDVI and NDRE and allowed to highlight those areas with low vegetative vigor. The accuracy assessment was based on a per-pixel approach and computed through the F-score (F). The obtained results are promising, considering that the resulting accuracy was high, with F-score ranging from 0.85 to 0.91 for olive and bergamot, respectively. Our proposed workflow, which has proved effective in datasets of different complexity, finds its strong point is the speed of execution and on its repeatability to other different crops with few adjustments. It appears worth of interest to highlights that it requests a working day of two good skilled operators in geomatics and computer image processing, from the on-field data collection to the obtaining of vigor maps.

Bibliografia recente

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A methodology based on GEOBIA and WorldView-3 imagery to derive vegetation indices at tree crown detail in olive orchards

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ABSTRACT

Precision agriculture (PA) is becoming an essential practice for tl
that encompasses the efficient use of resources and a systematic cr
spatial resolution of satellite imagery, coupled with their availab
bilities for generating accurate datasets on different crops variabl
data. The availability of very high-resolution (VHR) satellite image
the advanced potential of satellite Remote Sensing (RS), becoming
in precision agriculture (PA). In the broad overview of these proc
sification (GEOBIA) techniques, gained broad interest as method
ready format. In this paper, methodologies for a semiautomatic pi
tree crown detection in two different olive orchards in Calabria (
dures, in order to investigate olive tree spectral behavior and the r
(VIs). The semi-automated classification method, accomplished by
an operational processing chain for mapping and monitoring oliv
investigated: Normalized Difference Vegetation Index (NDVI),
(MSAVI 2), Normalized Difference Red Edge Vegetation Index (NI
Index Improved (MCARI2), and NDVI2. The obtained results we
sessed. Thematic accuracy ranges from 95.33% to 96% in both stu
96.8%. Statistical analysis showed that the major differences in s
investigated olive orchards, are mainly due to the component of th
spectrum (EM), where the red-edge becomes important in assessi
proposed methodology increases the possibility of detecting tree st
satellite-based approaches in terms of: larger area coverage, less
with more spectral information, thus reducing the need to collect

remote sensing

MDPI

Review

Applications of UAV Thermal Imagery in Precision Agriculture: State of the Art and Future Research Outlook

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Abstract: Low-altitude remote sensing (RS) using unmanned aerial vehicles (UAVs) is a powerful tool in precision agriculture (PA). In that context, thermal RS has many potential uses. The surface temperature of plants changes rapidly under stress conditions, which makes thermal RS a useful tool for real-time detection of plant stress conditions. Current applications of UAV thermal RS include monitoring plant water stress, detecting plant diseases, assessing crop yield estimation, and plant phenotyping. However, the correct use and interpretation of thermal data are based on basic knowledge of the nature of thermal radiation. Therefore, aspects that are related to calibration and ground data collection, in which the use of reference panels is highly recommended, as well as data processing, must be carefully considered. This paper aims to review the state of the art of UAV thermal RS in agriculture, outlining an overview of the latest applications and providing a future research outlook.

Keywords: unmanned aerial vehicles (UAVs); remote sensing (RS); thermal UAV RS; thermal infrared (TIR); precision agriculture (PA); crop water stress monitoring; plant disease detection; yield estimation; vegetation status monitoring

Bibliografia recente

Monitoring Onion Crops Using UAV Multispectral and Thermal Imagery: Preliminary Results

Gaetano Messina, Salvatore Praticò, Biagio Siciliani, Antonio Curcio, Salvatore Di Fazio and Giuseppe Modica

Abstract Agriculture constitutes one of the most important fields where Remote Sensing is employed, particularly in the aspects related to precision agriculture (PA). PA means a management strategy that aims at carrying out agronomic interventions in compliance with the actual crop needs and the biochemical and physical characteristics of the soil. PA analyses and manages the spatial variability of the field to optimize profitability, sustainability, and protection of agro-ecological services. The present paper shows the potentiality of coupling multispectral and thermal imagery acquired

Keywords Precision agriculture (PA) · Remote sensing (RS) · Unmanned aerial vehicle (UAV) · Thermal surveys · Multispectral surveys · Onion crop

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