FoxLab — Consiglio Nazionale delle Ricerche Istituto di Biometeorologia — crea

Bando 2014 per progetti di ricerca scientifica svolti da giovani ricercatori

FONDAZIONE CARITRO

Convegno

APR laser scanner per applicazioni forestali: esperienze a confronto e lezioni apprese

13 settembre 2018 2017, ore 9.30
c/o Sala Conferenze della Fondazione CARITRO
via Calepina, 1 – Trento

9.30-10.00	APERTURA E SALUTI Filippo Manfredi, Fondazione CARITRO Franco Miglietta, FoxLab e IBIMET – CNR Piermaria Corona, CREA Centro di ricerca Foreste e Legno
10:00 - 10:30	L'IMPIEGO DI SENSORI LIDAR IN APR: ASPETTI DA CONSIDERARE Marco Piras, Politecnico di Torino
10:30 – 11:00	RILIEVI LIDAR DA APR PER LA STIMA DI PARAMETRI DI GESTIONE FORESTALE SOSTENIBILE Marco Balsi, Università degli Studi di Roma "La Sapienza" Cesar Alvites, Università degli Studi del Molise
11:15-11:45	LIDAR DA APR PER LA FENOTIPIZZAZIONE DI SPECIE FORESTALI Mauro Maesano, Università degli Studi della Tuscia
11.45-12.45	LE ATTIVITÀ ED I RISULTATI DEL PROGETTO "UAV 4PRECIFOR": SVILUPPO DI UN SISTEMA LIDAR-APR TRASPORTATO PER APPLICAZIONI FORESTALI" Chiara Torresan, CREA Centro di ricerca Foreste e Legno (ex FoxLab – CNR-IBIMET)
12.45-13.00	Conclusioni

RILIEVI LIDAR DA APR PER LA STIMA DI PARAMETRI DI GESTIONE FORESTALE SOSTENIBILE

Marco Balsi, P. Fallavollita, S. Esposito

Sapienza Università di Roma — OBEN www.oben.it

Cesar Alvites, B. Lasserre, M. Marchetti, G. Santopuoli

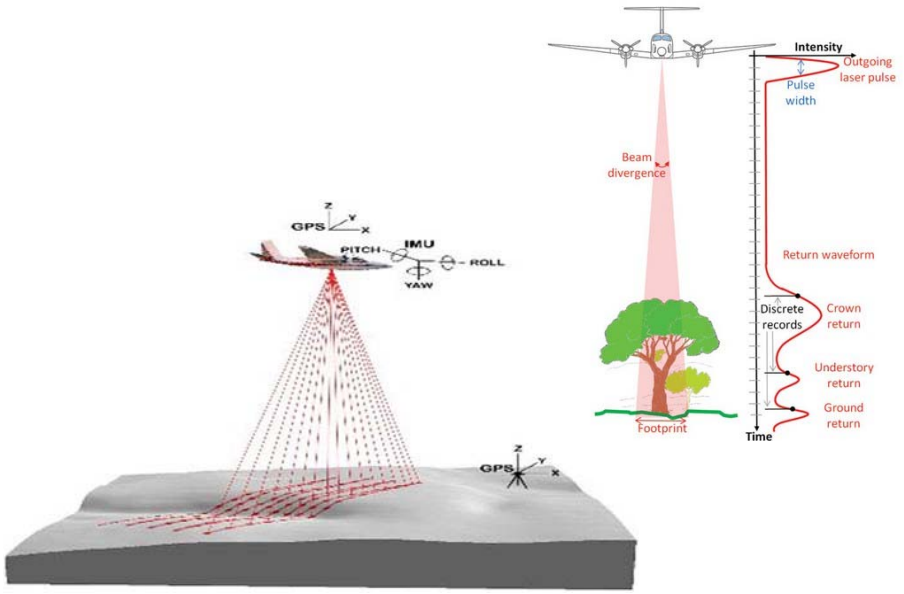
Università degli Studi del Molise — ArIA Area Interna e Appennini Centro di Ricerca

FRESH Life

SAPIENZA UNIVERSITÀ DI ROMA

OBEN

LiDAR principles



OBEN

FRESELIFE


Yellowscan Mapper
20.000 punti al secondo
3 echi
70-100m range effettivo

OBEN


ottocottero
diametro 1,80m
peso 16kg
autonomia max 20 minuti

OBEN


profilo di volo tipico
velocità 5 m/s
quota rispetto al suolo 70m
area rilevata tipica
20-50 ha/giorno

OBEN

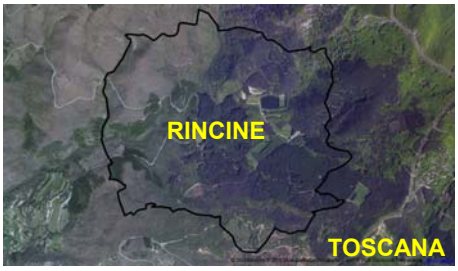

il volo a bassa velocità e bassa quota consente elevata densità di punti per unità di area
50-120 punti/m2 totale
1-10 punti/m2 a terra

OBEN

elicottero leggero Robinson R44

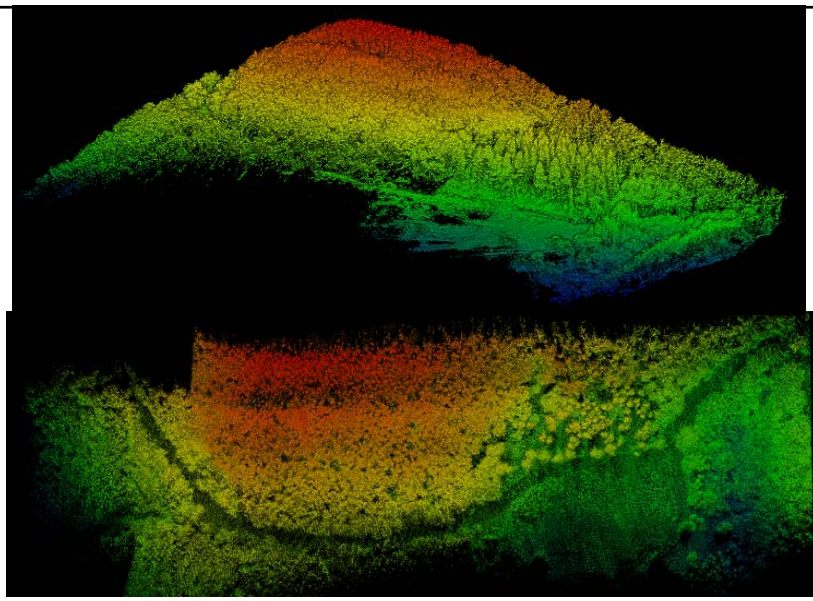
consente volo a bassa quota e bassa velocità
area coperta 100-200 ha/giorno
costo sostenibile
volo in area critica e spazio aereo condiviso/ristretto

SITI FREShLIFE

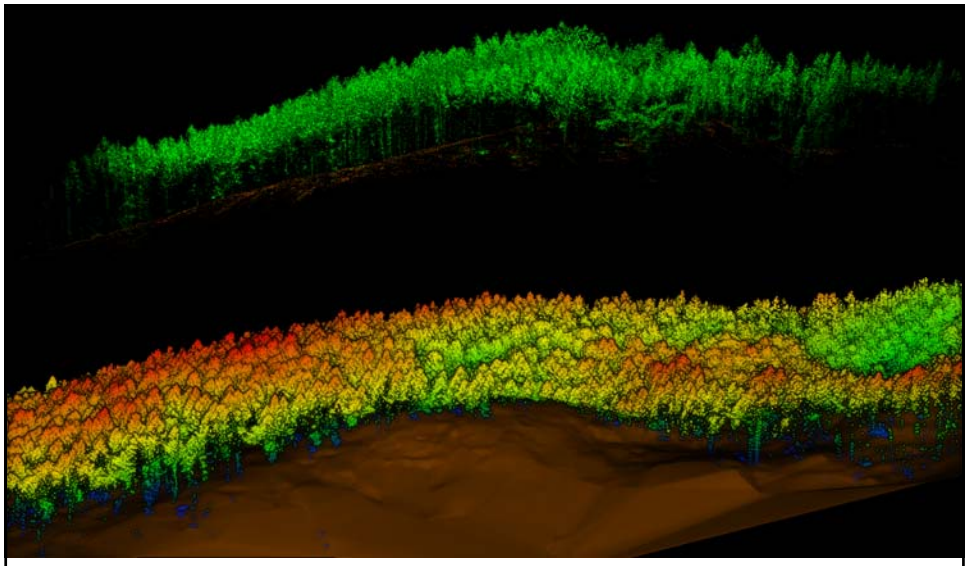


oltre 200 ha/sito
densità 71-113 punti/m²

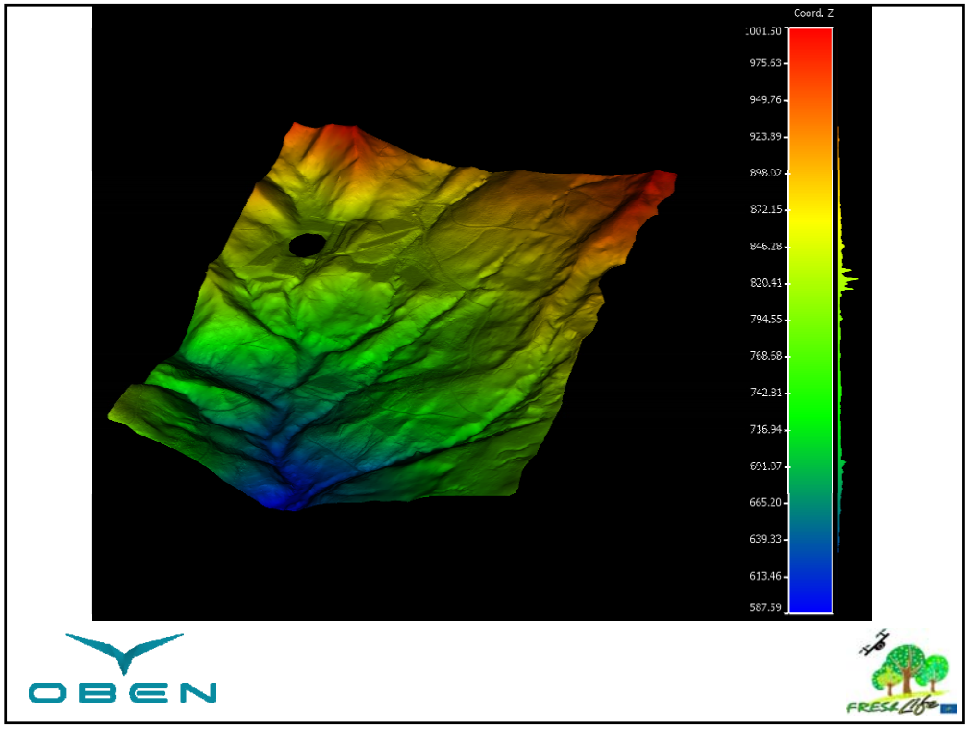
OBEN



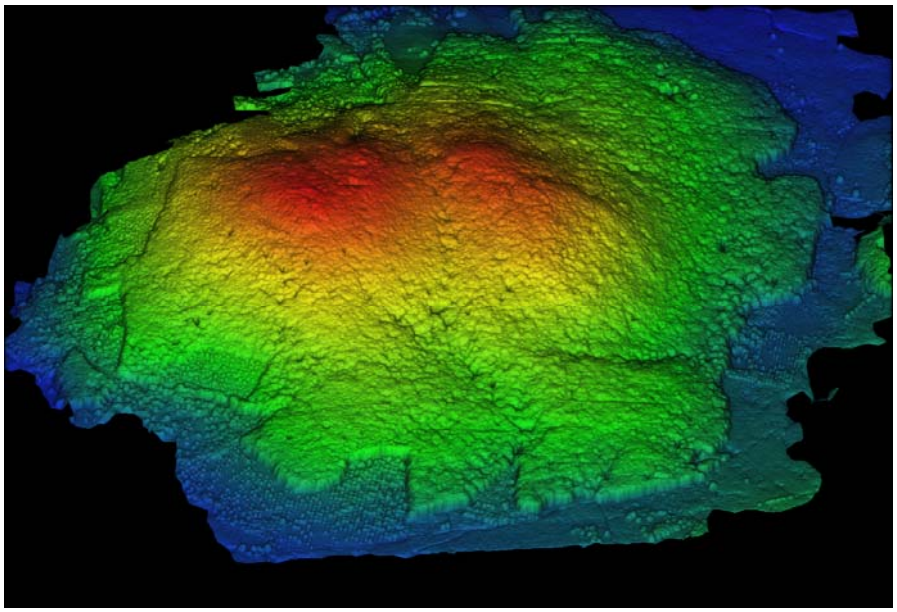
OBEN



OBEN


Coord. Z
975.53
949.76
923.99
872.15
820.41
794.55
768.58
716.94
691.07
665.20
639.33
613.46
587.59

OBEN



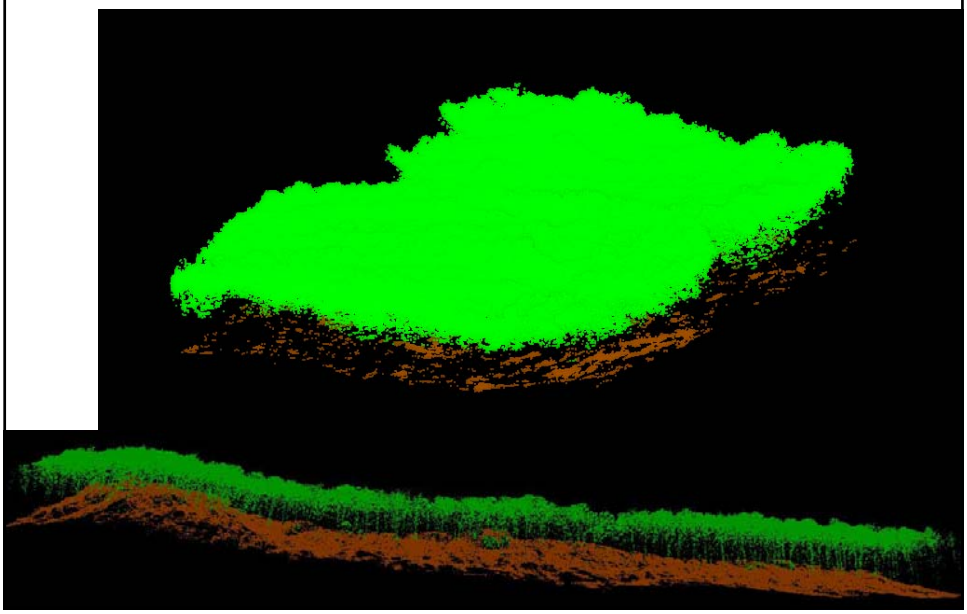
OBEN

FRESELife

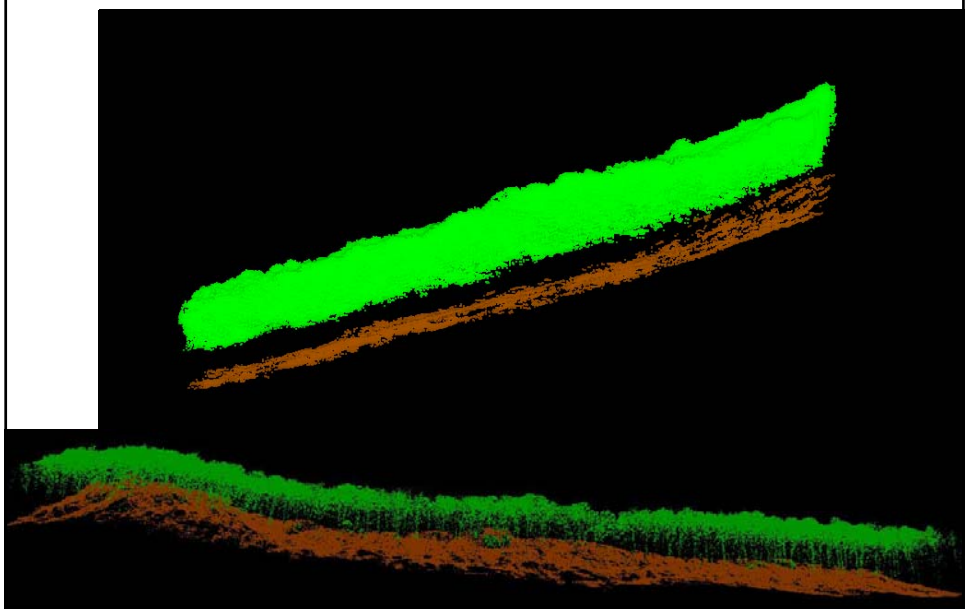
SAPIENZA
UNIVERSITÀ DI ROMA

OBEN

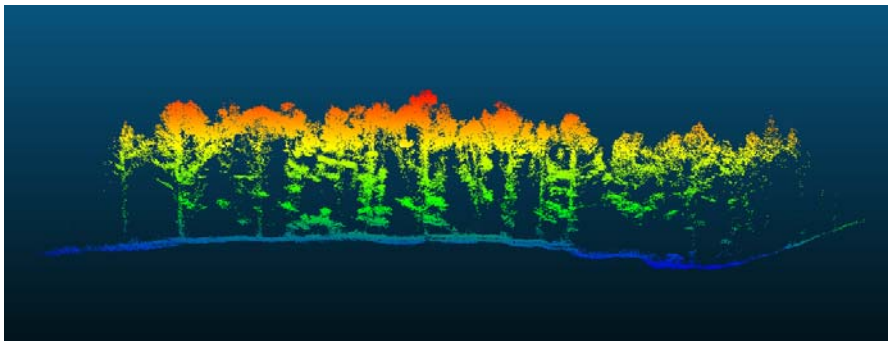
Classification



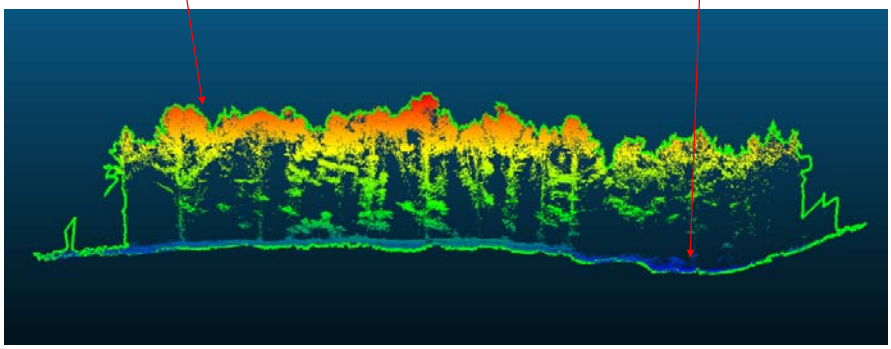
Classification



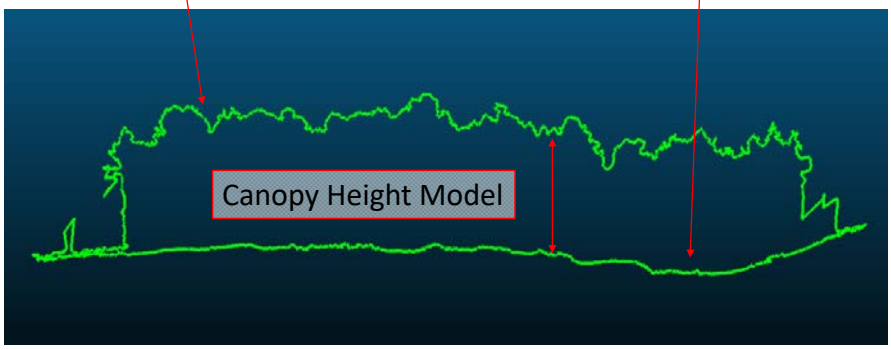
DSM, DTM, CHM



DSM, DTM, CHM

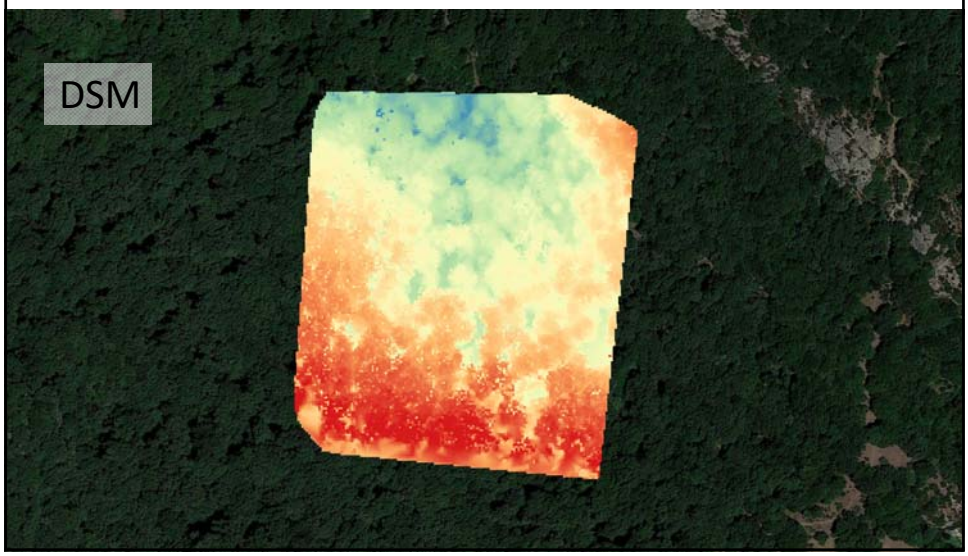


DSM, DTM, CHM

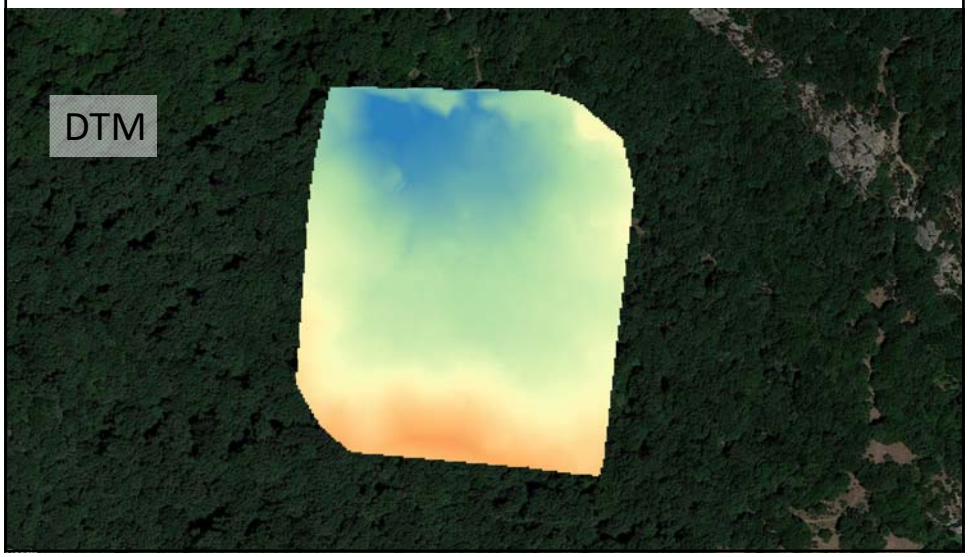


DSM, DTM, CHM

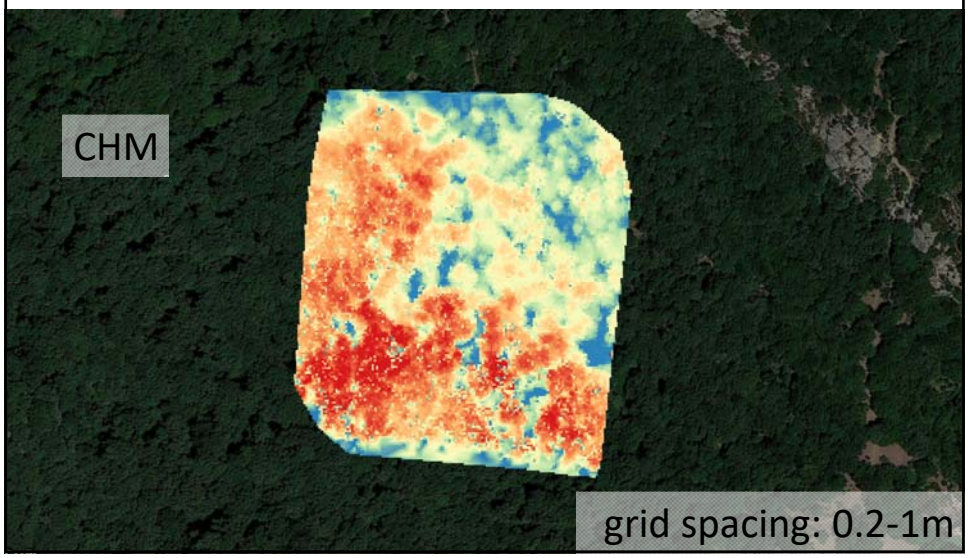
DSM, DTM, CHM



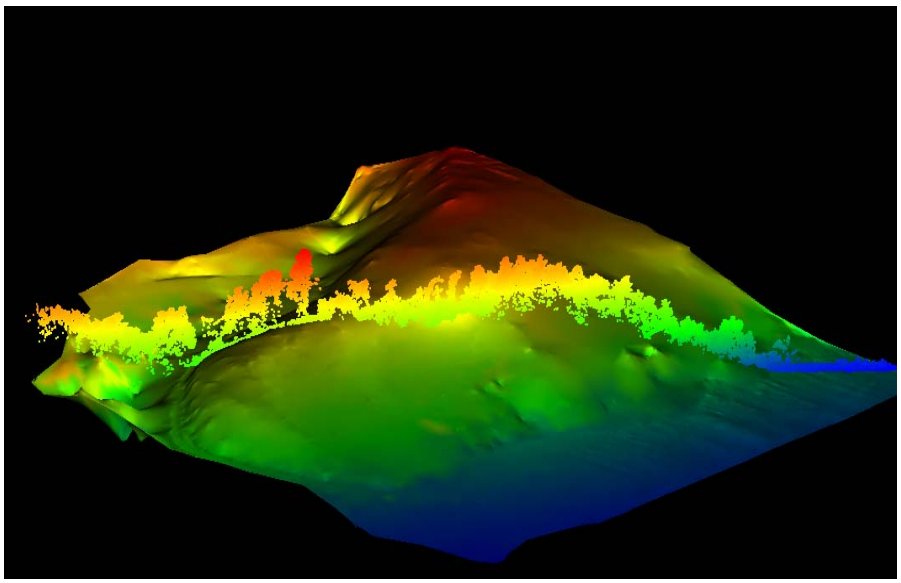
DSM, DTM, CHM

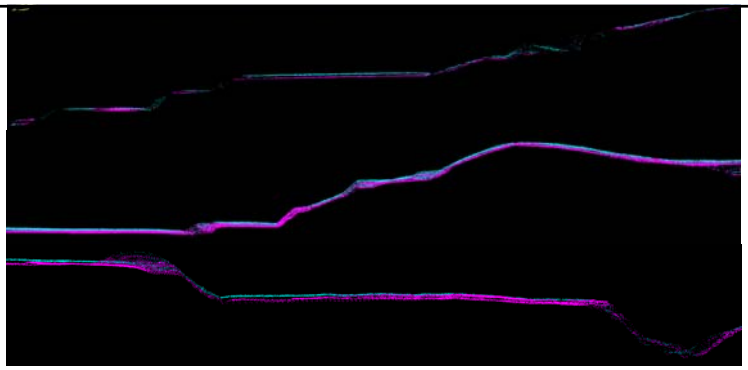


DSM, DTM, CHM



DSM, DTM, CHM





analisi degli errori:

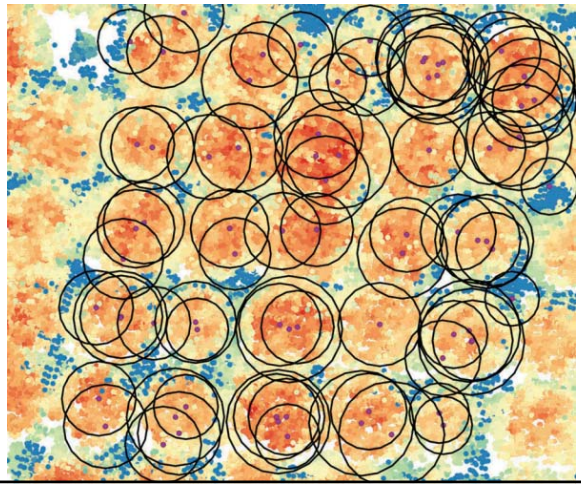
- deviazione standard locale: 0.3m
- errore di sovrapposizione: 0.3m su singolo volo, 0.6m tra voli differenti
- errore di posizione assoluta: 1.3m XY, 0.75m Z

EUROPEAN JOURNAL OF REMOTE SENSING, 2018
VOL. 51, NO. 1, 679–692
https://doi.org/10.1080/22797254.2018.1474722

Single-tree detection in high-density LiDAR data from UAV-based survey

M. Balsi [a], S. Esposito [b], P. Fallavollita [a,b] and C. Nardinocchi [c]

[a]DIET, Department of Information Engineering, Electronics and Communications, Sapienza University of Rome, Italy; [b]Oben s.r.l., Sassari, Italy; [c]DICEA, Department of Civil, Constructional and Environmental Engineering, Sapienza University of Rome, Italy



IX CONVEGNO NAZIONALE

ALS data for detecting Habitat Trees in a multi-layered Mediterranean forest

Santopuoli G., Di Febbraro M., Alvites Diaz C., Balsi M., Marchetti M., Lasserre B.

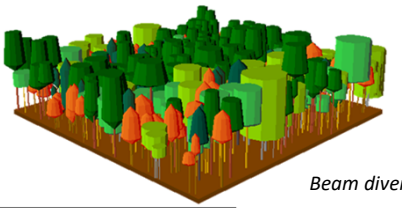
Forest inventory

OBEN

Field data collection

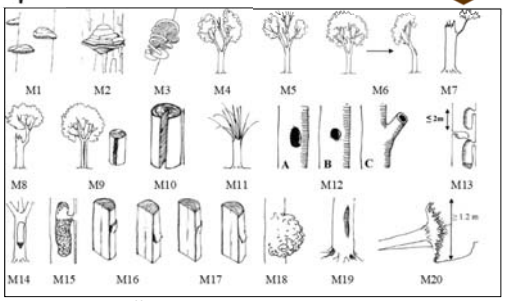
Tree position
Tree DBH
Tree height
Tree crowns

TreMs



ALS data acquisition

LiDAR Yellowscan
Wavelenght 905 nm
Sender: Pulser laser diode
Pulse repetition rate: 36 kHz
Pulse energy ≤ 375 nJ
Pulse widt: 4.5 ns
Returns per pulse 3
Beam divergence: 28.6 mrad x 1.43 mrad
Angular resolution: 0.125°
Scan angle (full range): 60°
Scan rate: 100 Hz
Scan pattern: parallel
Type of scanning mirror: rotating mirror

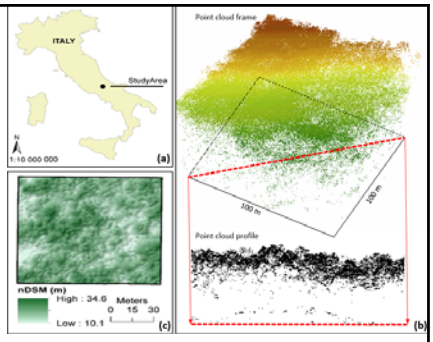


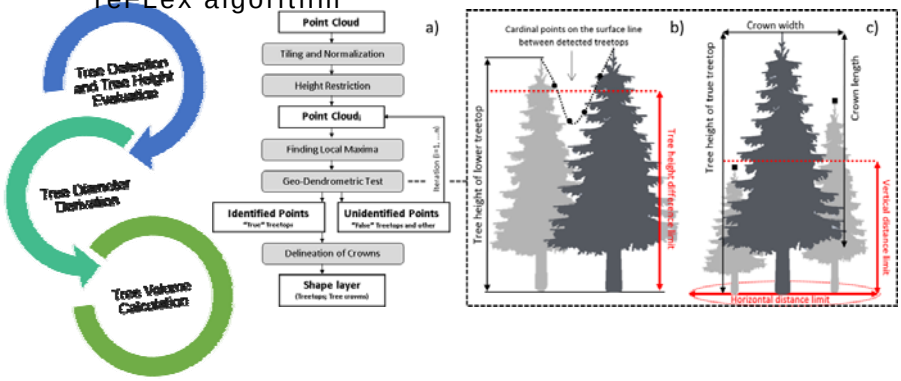
Winter & Möller, 2008

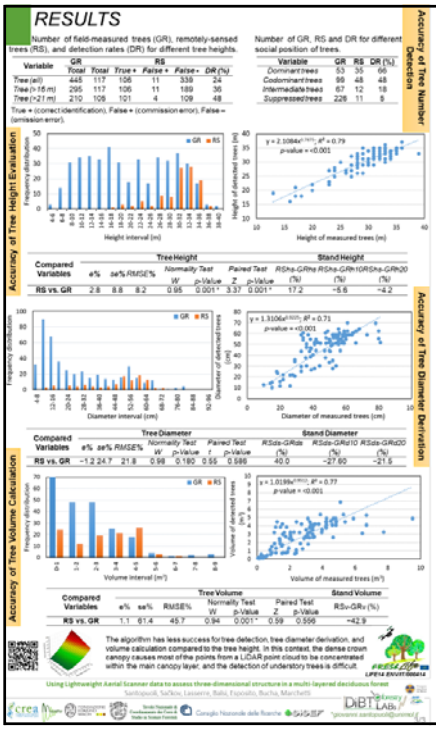
ALS data

YellowScan Mapper, absolute accurancy ±15cm and 3 echoes per laser pulse. Scan angle of ±50° and pulse frequency of 20kHz (30 pulses/m^2)

Treetops, tree crowns, and tree heights were detected, based on the reFLex algorithm







forests

MDPI

Article

Forest Inventory Attribute Prediction Using Lightweight Aerial Scanner Data in a Selected Type of Multilayered Deciduous Forest

Ivan Sačkov [1,*], Giovanni Santopuoli [2], Tomáš Bucha [1], Bruno Lasserre [2] and Marco Marchetti [2]

[1] National Forest Centre-Forest Research Institute Zvolen, T. G. Masaryka 22, Zvolen 96092, Slovakia; bucha@nlcsk.org

[2] Department of Biosciences and Territory, University of Molise, C.da Fonte Lappone, Pesche 86090, Italy; giovanni.santopuoli@unimol.it (G.S.); lasserre@unimol.it (B.L.); marchettimarco@unimol.it (M.M.)

* Correspondence: sackov@nlcsk.org; Tel.: +421-045-531-4360

Academic Editors: Chris Hopkinson, Laura Chasmer and Craig Mahoney
Received: 7 September 2016; Accepted: 1 December 2016; Published: 7 December 2016

Abstract: Airborne laser scanning is a promising technique for efficient and accurate, remote-based forest inventory, due to its capacity for direct measurement of the three-dimensional structure of vegetation. The main objective of this study was to test the usability and accuracy of an individual tree detection approach, using reFLex software, in the evaluation of forest variables. The accuracy assessment was conducted in a selected type of multilayered deciduous forest in southern Italy. Airborne laser scanning data were taken with a YellowScan Mapper scanner at an average height of 150 m. Point density reached 30 echoes per m^2, but most points belonged to the first echo. The ground reference data contained the measured positions and dimensions of 445 trees. Individual tree-detection rates were 66% for dominant, 48% for codominant, 18% for intermediate, and 5% for suppressed trees. Relative root mean square error for tree height, diameter, and volume reached 8.2%, 21.8%, and 45.7%, respectively. All remote-based tree variables were strongly correlated with the ground data (R^2 = 0.71–0.79). At the stand-level, the results show that differences ranged between 4% and 17% for stand height and 22% and 40% for stand diameter. The total growing stock differed by −43% from the ground reference data, and the ratios were 64% for dominant, 58% for codominant, 36% for intermediate, and 16% for suppressed trees.

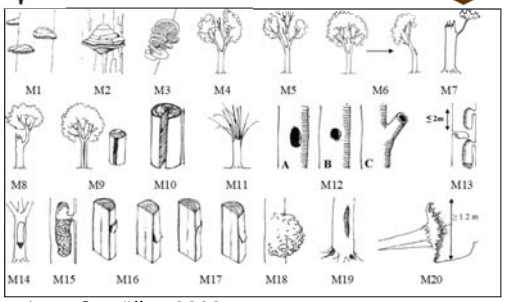
ALS data for detecting Habitat Trees in a multi-layered Mediterranean forest

Forest inventory

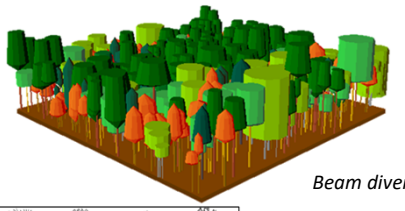
Field data collection

Tree position
Tree DBH
Tree height
Tree crowns

TreMs



Winter & Möller, 2008



ALS data acquisition

LiDAR Yellowscan
Wavelenght 905 nm
Sender: Pulser laser diode
Pulse repetition rate: 36 kHz
Pulse energy ≤ 375 nJ
Pulse widt: 4.5 ns
Returns per pulse 3
Beam divergence: 28.6 mrad x 1.43 mrad
Angular resolution: 0.125°
Scan angle (full range): 60°
Scan rate: 100 Hz
Scan pattern: parallel
Type of scanning mirror: rotating mirror

MATERIALS & METHODS

Habitat Trees
TreMs
TreMs Type
M4
M7
M12a
M12c

33 plot

Field data

38 ALS metrics

Generalized Linear Models (GLM)

Step AIC

with outliers

Poisson

Negative binomial

without outliers

Poisson

Negative binomial

Thematic map

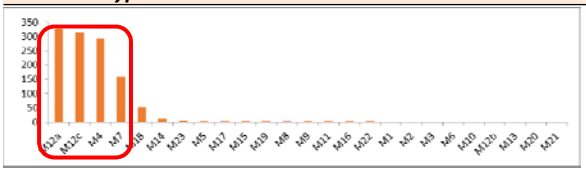
Rsq
RMSE

Cross validation (*leave one out*)

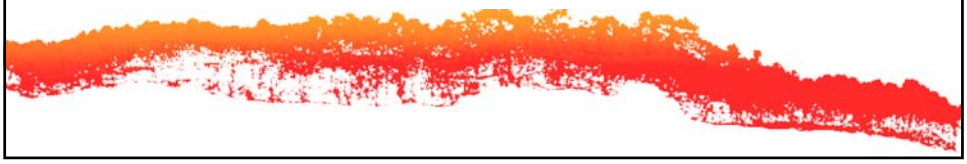
RMSE

RESULTS – FOREST STAND

	Min	1st Qu	Median	Mean	3rd Qu	Max
Tree (N/plot)	24.00	43.25	57.00	68.94	93.25	196.00
Tree (N/ha)	454.0	817.5	1077.5	1303.2	1762.8	3705.0
Tree specie (plot)	3.00	7.00	7.50	7.68	9.00	11.00
DBH	10.00	13.00	16.00	16.42	19.00	27.00
Hmax	17.60	24.80	28.40	28.10	31.07	39.60
G m²/ha	19.90	33.17	37.60	37.62	42.20	53.10
V m³/ha	142.0	311.2	372.5	387.2	447.8	647.0
Habitat Trees	4.00	11.00	15.00	16.56	20.75	32.00
TreeMs	6.00	17.25	23.50	25.14	30.00	61.00
TreeMsType	2.00	5.00	5.00	5.38	6.00	8.00



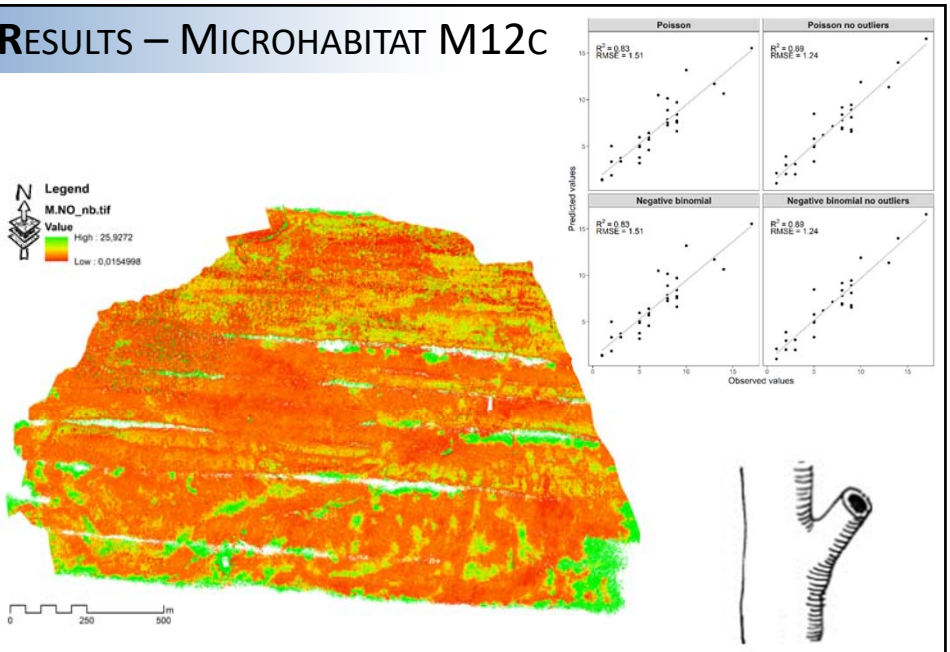
Few data for several TreMs



RESULTS

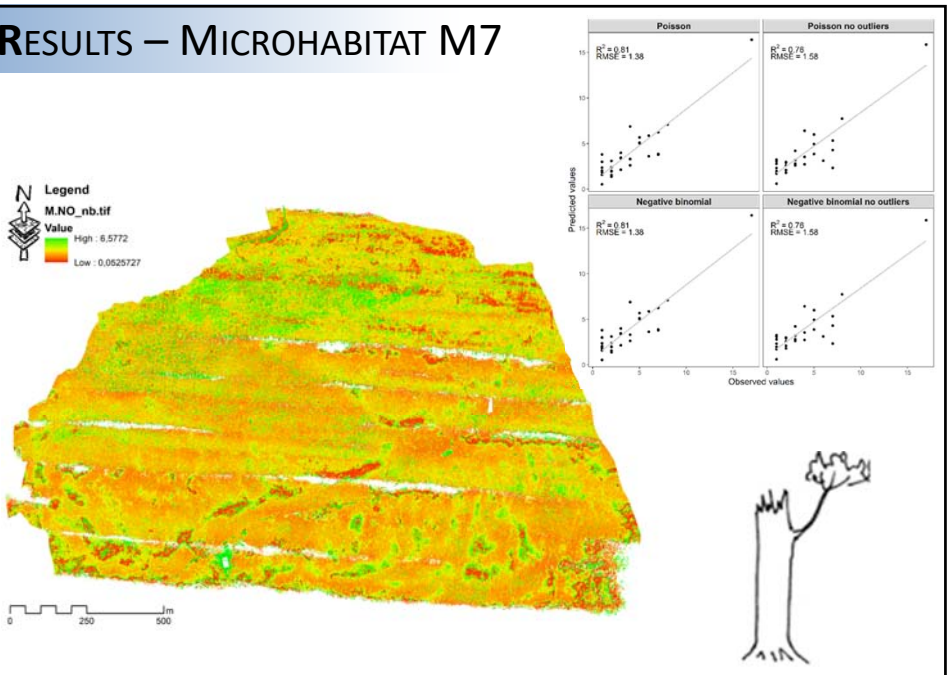
	Model	df	AIC	Rsq	RMSE	predRMSE
Habitat Trees	*M_pois*	13	222.5	0.7	4.5	179.2
	M.NO_pois	**15**	**201.8**	**0.8**	**3.4**	**333.8**
	M_nb	14	223.8	0.6	4.5	14.8
	M.NO_nb	**16**	**203.8**	**0.8**	**3.4**	**12.5**
TreMs	*M_pois*	17	252.4	0.7	6.4	164.1
	M.NO_pois	**15**	**226.2**	**0.8**	**5.9**	**25.1**
	M_nb	14	248.9	0.6	6.9	16.0
	M.NO_nb	**12**	**225.6**	**0.7**	**6.3**	**16.3**
TreMs Type	*M_pois*	1	136.4	0.0	1.3	
	M.NO_pois	1	123.7	0.0	1.2	
	M_nb	2	138.4	0.0	1.3	
	M.NO_nb	2	125.7	0.0	1.2	
M4	*M_pois*	13	165.4	0.6	1.6	19.1
	M.NO_pois	7	149.0	0.5	2.1	6.6
	M_nb	14	167.4	0.6	1.6	13.0
	M.NO_nb	**8**	**151.0**	**0.5**	**2.1**	**3.6**
M7	*M_pois*	13	135.7	0.8	1.4	3.7
	M.NO_pois	**9**	**125.9**	**0.8**	**1.6**	**2.5**
	M_nb	14	137.7	0.8	1.4	2.7
	M.NO_nb	**10**	**127.9**	**0.8**	**1.6**	**2.5**
M12a	***M_pois***	**15**	**211.7**	**0.5**	**3.8**	**6.0**
	M.NO_pois	19	197.7	0.6	3.4	400.2
	M_nb	16	204.7	0.4	3.9	6.0
	M.NO_nb	16	193.4	0.3	4.0	9.5
M12c	*M_pois*	13	151.5	0.8	1.5	3.5
	M.NO_pois	**13**	**137.9**	**0.9**	**1.2**	**2.3**
	M_nb	14	153.5	0.8	1.5	3.2
	M.NO_nb	**14**	**139.9**	**0.9**	**1.2**	**2.3**

RESULTS – MICROHABITAT M12C



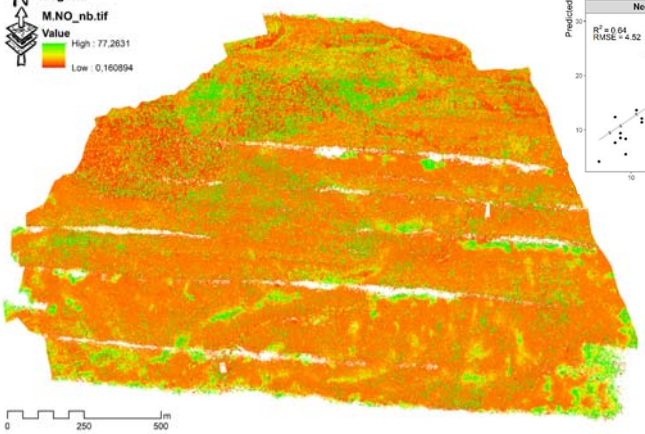
Cavities with >5 cm aperture, entrance at hollowed branch forms cavity in stem

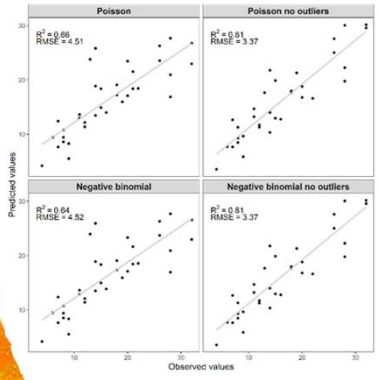
RESULTS – MICROHABITAT M7



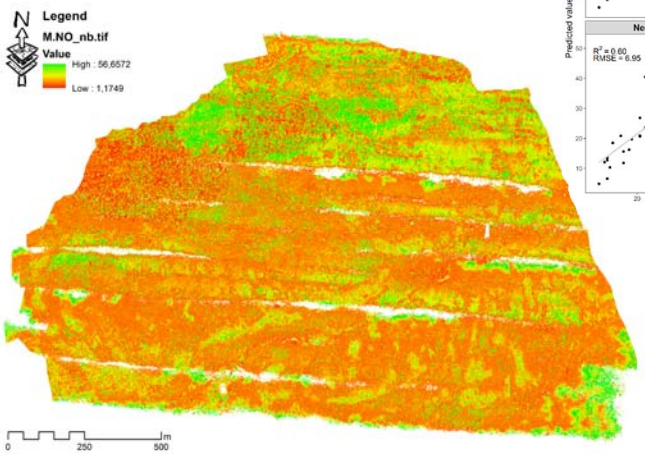
Broken stem

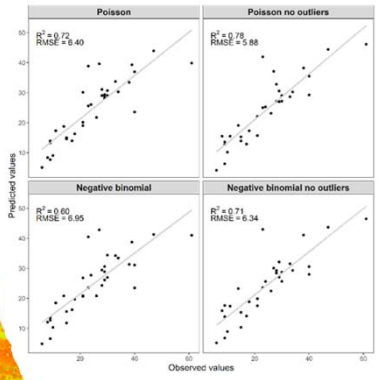
RESULTS – HABITAT TREES



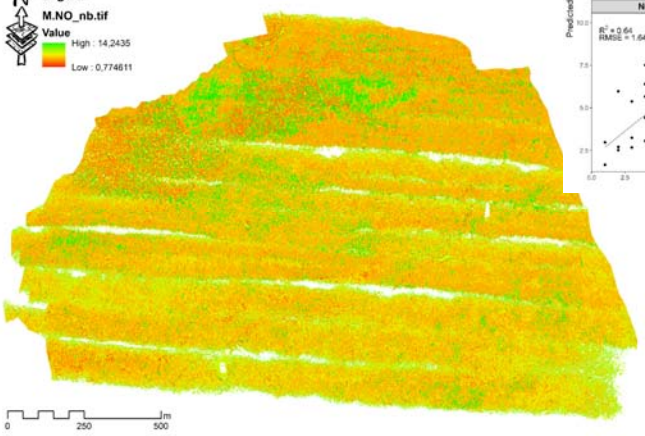


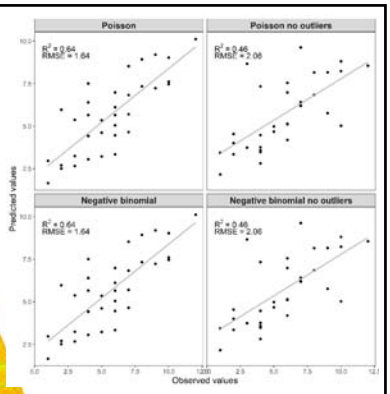
RESULTS - TREMS





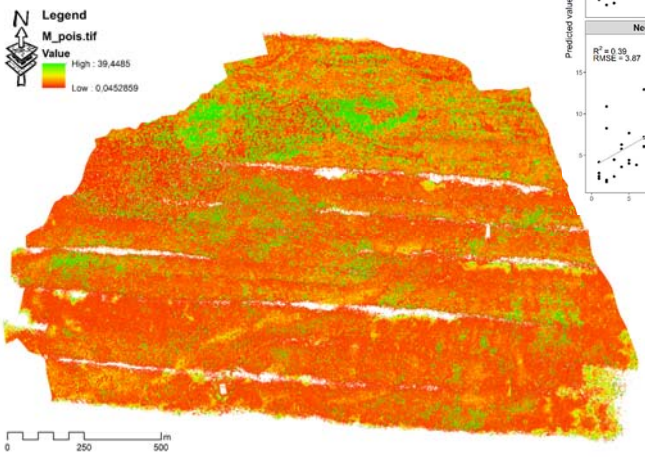
RESULTS – MICROHABITAT M4

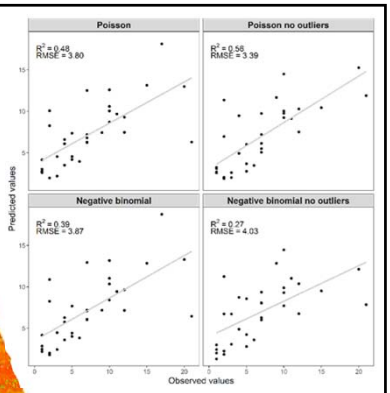




<50% of the crown broken

RESULTS – MICROHABITAT M12A

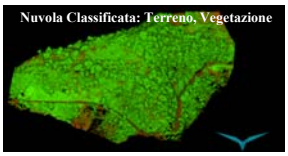


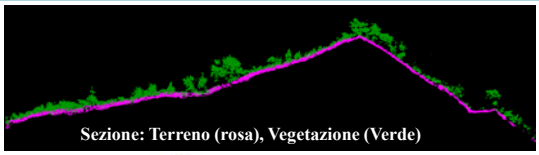


Cavities with >5 cm aperture: entrance of a Black Woodpecker Dryocopus martius cavity

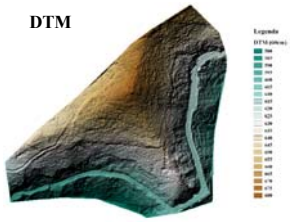
Rilievo Versante in Frana:

Supporto alla stabilizzazione del versante in frana





DTM



Punti terreno (all returns):

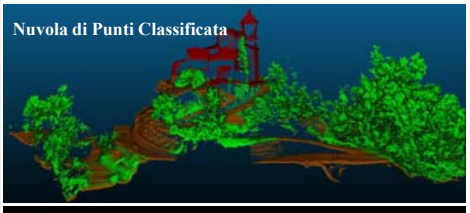
- Densità media : 56.82 p.ti/m^2
- Spaziatura media: 0.13m

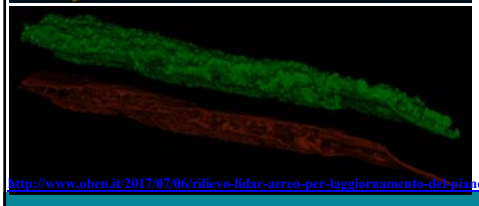
http://www.oben.it/2018/09/03/rilievo-lidar-stabilizzazione-del-versante-in-frana/

www.oben.it

Rilievo di Scarpate:

Valutazioni di Scarpate e Cigli





DTM

Punti terreno (all returns):

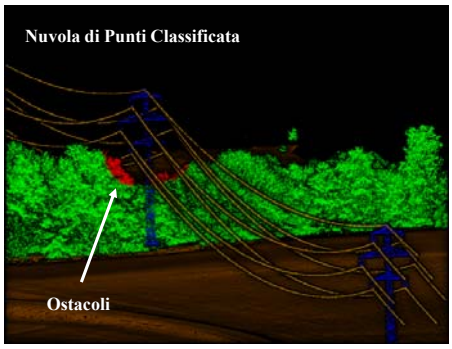
- Densità media : 37p.ti/m^2
- Spaziatura media: 0.16m

http://www.oben.it/2017/07/06/rilievo-lidar-aereo-per-laggiornamento-del-piano-regolatore-del-comuni-di-rapino-ch-linee-quotate-di-cigli-e-piedi-delle-scarpate

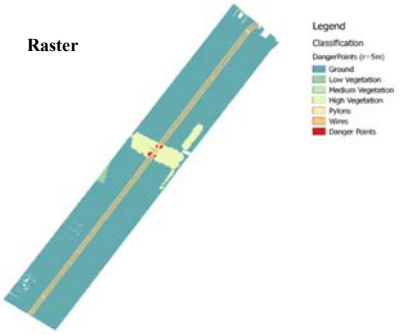
www.oben.it

Rilievo Linee Elettriche

Analisi degli ostacoli all'interno del corridoio definito dai cavi



Raster



http://www.oben.it/2017/11/13/rilievo-di-ostacoli-lungo-le-linee-elettriche/

www.oben.it

Lezioni apprese

- piattaforme (aeromobili)
- alta densità di punti → indicatori SFM
- regolamentazione
- IMU/AHRS
- RTK, PPK
- LiDAR vs. fotogrammetria

Lezioni apprese

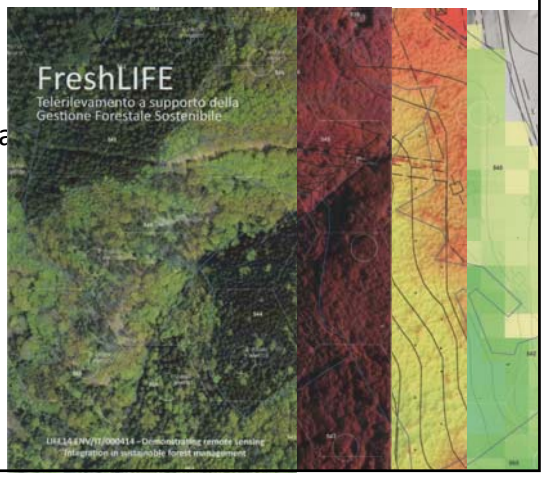
- **piattaforme (aeromobili)**
- alta densità di punti → indicatori SFM
- regolamentazione
- IMU/AHRS
- RTK, PPK
- LiDAR vs. fotogrammetria

costi ridotti
alta densità di punti




Lezioni apprese

- piattaforme (aeromobili)
- **alta densità di punti → indicatori SFM**
- regolamentazione
- IMU/AHRS
- RTK, PPK
- LiDAR vs. fotogrammetria



Lezioni apprese

- piattaforme (aeromobili)
- alta densità di punti → indicatori SFM
- **regolamentazione**
- IMU/AHRS
- RTK, PPK
- LiDAR vs. fotogrammetria

SKYOPENER - establishing new foundations for the use of Remotely-Piloted Aircraft Systems for civilian applications.

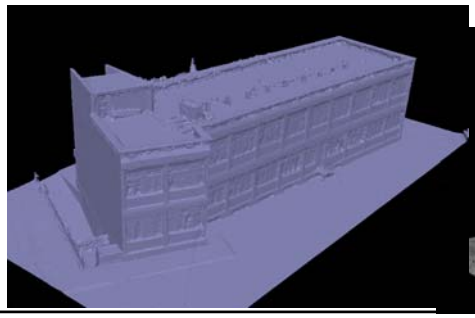
Lezioni apprese

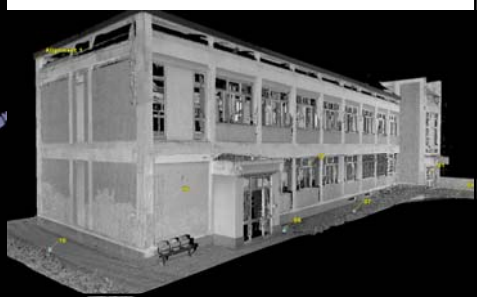
- piattaforme (aeromobili)
- alta densità di punti → indicatori SFM
- regolamentazione
- **IMU/AHRS**
- **RTK, PPK**
- LiDAR vs. fotogrammetria

Real Time Kinematic
Post Processed Kinematic

Lezioni apprese

- piattaforme (aeromobili)
- alta densità di punti → indicatori SFM
- regolamentazione
- IMU/AHRS
- RTK, PPK
- **LiDAR vs. fotogrammetria**





RILIEVI LIDAR DA APR PER LA STIMA DI PARAMETRI DI GESTIONE FORESTALE SOSTENIBILE

Marco Balsi, P. Fallavollita, S. Esposito

Cesar Alvites, B. Lasserre, M. Marchetti, G. Santopuoli