ASSOCIAZIONE ITALIANA DI INGEGNERIA AGRARIA

TESAF Dipartimento Territorio e Sistemi Agro-Forestali Università di Padova

workshop organized by the **Italian Society of Agricultural Engineering (AIIA)**

Book of abstracts

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Paolo Tarolli, University of Padova, Italy
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Giuseppe Modica, Università degli Studi Mediterranea Reggio Calabria, Italy
Claudio Gandolfi, University of Milan, Italy

Invited Speakers

Matthias Forkel, TU Dresden, Germany
Jean-Stephane Bailly, AgroParisTech, France
Xiangzhou Xu, Dalian University of Technology, PR China
Anette Eltner, TU Dresden, Germany
Niculita Mihai, Alexandru Ioan Cuza University of Iasi, Romania

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Programme

09:00 *Welcome Chairman* **Paolo Tarolli**, University of Padova, Italy

09:05 *Welcome President AIIA* **Giacomo Scarascia Mugnozza**, University of Bari, Italy

Panel 1 – Ecosystem (moderator **Paolo Tarolli**)

09:10 *Earth observation, machine learning and ecosystem modelling for agricultural drought monitoring and impact prediction*
Matthias Forkel[1], **Laura Crocetti**[2], **Wouter Dorigo**[1], [1]TU Dresden, [2]Vienna University of Technology *invited talk*

09:25 *Landsat-based surface energy balance modelling of daily actual evapotranspiration in a Mediterranean ecosystem*
Hassan Awada, Simone Di Prima, Sirca Costantino, Mario Pirastru, University of Sassari, Italy

09:35 *A multi-platform approach to dissect the evapotranspiration response to drought of black poplar*
Flavia Tauro[1], **Antonino Maltese**[2], **Antoine Harfouche**[1], **Salvatore Grimaldi**[1], [1]University of Tuscia, [2]University of Palermo, Italy

09:45 *Comparison of remote and ground sensing technologies to compute NDVI values of diseased and healthy grapevine*
Gabriele Daglio, Damiano Zampieri, Raimondo Gallo, Fabrizio Mazzetto
Free University of Bozen, Italy

09:55 *> discussion*

Panel 2 – Vegetation & Landuse (moderator **Fabrizio Mazzetto**)

10:15 *Monitoring from close-range remote sensing the hydraulic resistance (Manning) of agricultural channel network*
Jean-Stephane Bailly[1,2], **Fabrice Vinatie**[1], **Gabrielle Rudi**[3], [1]LISAH Univ Montpellier, [2]AgroParisTech, [3]G-Eau Univ Montpellier, France *invited talk*

10:30 *Assessment of the riparian leaf density using different satellite imagery in a mountain stream*
Giovanni Romano, Giovanni Francesco Ricci, Francesco Gentile, University of Bari Aldo Moro, Italy

10:40 *Use of remotely sensed data for the evaluation of inter-row cover intensity in vineyards*
Francesco Palazzi[1], **Marcella Biddoccu**[1], **Enrico Borgogno Mondino**[2], **Eugenio Cavallo**[1], [1]National Research Council (CNR), [2]University of Turin, Italy

10:50 *Comparison between two methodologies for the Individual Tree Height Estimation through a LiDAR mounted on a drone*
Monica F. Rinaldi, Gabriele Daglio, Raimondo Gallo, Fabrizio Mazzetto, Free University of Bozen–Bolzano, Italy

11:00 *Sentinel-1 SAR satellite data and open-source Python algorithms for unsupervised burned area detection in Mediterranean ecosystems*
Giandomenico De Luca[1], **João M.N. Silva**[2], **Giuseppe Modica**[1], [1]Università degli Studi Mediterranea di Reggio Calabria, Italy; [2]University of Lisbon, Portugal

11:10 *LULC object-oriented classification in Google Earth Engine: an application in the Trasimeno Lake area*
Andrea Tassi, Marco Vizzari, University of Perugia, Italy

11:20 *Designing and implementing a multifunctional network of urban green infrastructures*
Stefano chiappini[1], **Francesco Paci**[1], **Nicole Hofmann**[1], **Andrea Galli**[1], **Adriano Mancini**[1], **Ernesto Marcheggiani**[1,2], [1]Università Politecnica delle Marche, Italy; [2]University of Leuven, Belgium

11:30 *> discussion*

Panel 3 – Digital Terrain Analysis & Soil erosion (moderator **Giuseppe Modica**)

11:50 *Topography meter: remote sensing with a novel 3D surface measuring technique*
Xiangzhou Xu, Dalian University of Technology, PR China *invited talk*

12:05 *Monitoring of vegetated agricultural terraces systems through SfM-TLS data fusion technique*
Sara Cucchiaro[1,2], **Daniel J. Fallu**[3], **Antony G. Brown**[3], **Paolo Tarolli**[2], [1]University of Udine, [2]University of Padova, Italy; [3]Tromso University Museum, Norway

12:15 *Soil erosion and SfM covering various spatio-temporal scales*
Anette Eltner, Technische Universität Dresden, Germany *invited talk*

12:30 *Assessing sediment dynamics and torrent control works efficiency in a debris-flow catchment using multi-temporal topographic surveys*
Federico Cazorzi[1], **Sara Cucchiaro**[1], **Lorenzo Marchi**[2], **Marco Cavalli**[2], [1]University of Udine, [2]National Research Council CNR-IRPI, Italy

12:40 *Primary impacts and cascading processes of the Vaia storm in the Rio Cordon mountain catchment (Belluno Province)*
Lorenzo Martini[1], **Giacomo Pellegrini**[1], **Riccardo Rainato**[1], **Lorenzo Picco**[1,2], [1]University of Padova, Italy; [2]Universidad Austral de Chile, Chile

12:50 *UAV-SfM 4D mapping of landslides activated in steep terraced agricultural context*
Luca Mauri[1], **Eugenio Straffelini**[1], **Sara Cucchiaro**[2], **Paolo Tarolli**[1], [1]University of Padova, [2]University of Udine, Italy

13:00 *> discussion & lunch break*

Panel 4 – Water Resources Management (moderator **Claudio Gandolfi**)

14:10 *Abandoned reservoirs and gully erosion analysis using LiDAR*
Niculita Mihai, Alexandru Ioan Cuza University of Iasi, Romania *invited talk*

14:25 *Remote Sensing advances in agricultural hydraulics and watershed protection*
Giulio Castelli, Elena Bresci, Daniele Penna, Federico Preti, University of Florence, Italy

14:35 *Analysis of time-series satellite images as a tool for planning river management strategies*
Paolo Fogliata, Daniele Masseroni, Alessio Cislaghi, Gian Battista Bischetti, University of Milan, Italy

14:45 *Early recognition of irrigated areas using Sentinel-2 data in Central Italy*
Lorenzo Vergni, Marco Vizzari, Alessandra Vinci, Francesco Santaga, Francesca Todisco, University of Perugia, Italy

14:55 *Soil Moisture Retrievals from Unmanned Aerial Systems (UAS)*
Nunzio Romano[1], **Ruodan Zhuang**[2], **Salvatore Manfreda**[1], **Silvano Fortunato Dal Sasso**[2], **Carolina Allocca**[1], **Paolo Nasta**[1], [1]University of Naples Federico II, [2]University of Basilicata, Italy

15:05 *> discussion*

15:25 *Conclusion* **Paolo Tarolli**, University of Padova, Italy

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Summary

Panel 1 – Ecosystem

Reference topic: remote sensing, drought monitoring, agricultural drought
Presentation type: oral (invited talk)

Earth observation, machine learning and ecosystem modelling for agricultural drought monitoring and impact prediction

Matthias Forkel[1*], Laura Crocetti[2], Wouter Dorigo[2]

[1]*Institute for Photogrammetry and Remote Sensing, Department of Geosciences, TU Dresden, Helmholtzstr. 10, 01069 Dresden, Germany (corresponding: matthias.forkel@tu-dresden.de)*
[2]*Department of Geodesy and Geoinformation, Vienna University of Technology, Wiedner Hauptstraße 8, 1040 Vienna, Austria*

Drought can cause severe impacts on agriculture in terms of reduced plant productivity and consequently yield losses. Climate warming, changes in evapotranspiration and precipitation can likely cause more frequent and more intense drought events. Remote sensing allows to monitor the development of drought events and to potentially estimate drought impacts on agriculture [1]. Here, we will first give an overview about recent developments in the satellite-based monitoring of agricultural droughts including soil moisture and vegetation state and about existing operational products and services. Secondly, we will outline the advantages and disadvantages of different approaches and describe the need to develop reliable systems to forecast potential impacts of drought on plant productivity and agricultural yield at monthly to seasonal scales. Thereby, machine learning approaches show a great potential to understand environmental controls and to predict plant productivity but they are highly depending on the quantity and quality of the underlying data. On the other hand, process-based environmental models are comprehensive and consistent tools that can be applied for environmental prediction but they rely on the built-in ecophysilogical knowledge. We propose to integrate Earth observation with machine learning and environmental models in order to better understand environmental controls on plant productivity and to more reliably predict drought impacts on agriculture.

References

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Reference topic: Remote sensing, Surfase energy balance, actual evapotranspiration
Presentation type: oral

Landsat-based surface energy balance modelling of daily actual evapotranspiration in a Mediterranean ecosystem

Hassan Awada*, Simone Di Prima, Sirca Costantino, Mario Pirastru

Dept. of Agraria, University of Sassari, Viale Italia 39, 07100 Sassari, Italy. (corresponding: hawada@uniss.it)

Quantifying Evapotranspiration (ET) over natural vegetation is crucial in evaluating water status of ecosystems. Remote sensing-based surface energy balance models have been used extensively for estimating ET_a in agro-environments, however the application of these models to natural ecosystems is still limited. The surface energy balance algorithm for land (SEBAL) physical-based surface energy balance model was applied to estimate the actual evapotranspiration (ET_a) over Mediterranean maquis in a natural reserve in Sardinia island, Italy. The model was applied on thirty Landsat 5 and 8 images from 2009 to 2014 and results were compared to the data of a micrometeorological station with eddy covariance flux measurements. Comparing the SEBAL-based evaporative fraction (Λ_S) to the corresponding tower-derived evaporative fraction (Λ_T) indicates good fluxes estimations at Landsat overpass time (R^2=0.83, RMSE=0.07 and MAE=0.05). The upscaling factor Λ_S was used to upscale instantaneous latent heat flux (λE) to daily actual evapotranspiration ($ET_{a,24}$) under the hypothesis of diurnal self-preservation. Compared to ground based measured daily actual ET, the up-scaled $ET_{a,24}$ on average overestimated the measured daily evapotranspiration by nearly 21%. The model estimations of daily actual ET were satisfactory taking into consideration the high variable ground cover and the inherent variability of the biome composition, which can't be properly represented in the Landsat moderate spatial resolution. In this study we tested the potential of SEBAL model application in a natural ecosystem. This modelling approach will be used to represent the spatial dynamics of ET, that will be integrated into further environmental and hydrological applications.

References

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3. Awada, H., Ciraolo, G., Maltese, A., Hidalgo, M. M., Provenzano, G., & Còrcoles, J. I. (2017, November). Assessing actual evapotranspiration via surface energy balance aiming to optimize water and energy consumption in large scale pressurized irrigation systems. In Remote Sensing for Agriculture, Ecosystems, and Hydrology XIX (Vol. 10421, p. 104210G). International Society for Optics and Photonics.

Reference topic: remote sensing, evapotranspiration, multi-platform sensing, poplar, UAV
Presentation type: oral

A multi-platform approach to dissect the evapotranspiration response to drought of black poplar

Flavia Tauro[1*], Antonino Maltese[2], Antoine Harfouche[1], Salvatore Grimaldi[1]

[1] *Department for Innovation in Biological, Agro-food and Forest systems, University of Tuscia, Via San Camillo de Lellis, 01100 Viterbo (VT), Italy (corresponding: flavia.tauro@unitus.it)*
[2] *Department of Engineering, University of Palermo, Palermo 90128, Italy*

High-throughput mapping of evapotranspiration (ET) is paramount to optimize water resources management and to accelerate forest tree genetic improvement against drought environmental stress. Ideally, investigation of the energy response at the tree level may promote tailored irrigation strategies and, thus, increase biomass productivity. However, data availability is limited and planning experimental campaigns can be complex. To this end, a multi-platform observational approach was adopted herein to dissect ET signature of a full-sib F_2 partially inbred poplar population ("POP6") at the canopy level. POP6 comprised more than 4600 trees representing 503 genotypes, whose F_1 was obtained from an intraspecific controlled cross between two *P. nigra* parents originated from natural populations in divergent environmental conditions [1]. Trees were located in two adjacent plots where different irrigation treatments (moderate drought and well-watered) were maintained.
Data collected from satellite and unmanned aerial vehicles remote sensing as well as ground-based sensors were integrated at consistent spatial aggregation and combined to compute the surface energy balance of the trees through a modified Priestley-Taylor approach.
ET response was significantly different between well irrigated and water limited trees, whereby genotypes in moderate drought conditions exhibited larger standard deviations. Genotypes classified as drought tolerant based on the stress susceptibility index (SSI) presented ET values significantly higher than the rest of the population. This study confirmed that water limitation in moderate drought field settings led to reduced soil moisture in the tree root zone and, therefore, to lower ET rates.

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Reference topic: remote sensing, NDVI, vineyard
Presentation type: oral

Comparison of remote and ground sensing technologies to compute NDVI values of diseased and healthy grapevine

Gabriele Daglio[1*], Damiano Zampieri[2], Raimondo Gallo[2], Fabrizio Mazzetto[1]

[1] Faculty of Science and Technology, Free University of Bozen (FUB) Piazza Università 5, 39100 Bolzano (BZ), Italy (corresponding: gabriele.daglio@unibz.it)

In precision agriculture several tools can be used to obtain rigorous information about the health status of the plants, as showed by several authors as Kerckech et al. (2020) and Al-Saddik el al. (2017).
This work proposes the comparison of two different approaches able to compute the NDVI value of diseased and healthy plants in a vineyard. The tests were carried out on *Vitis vinifera* plants cv. Dolcetto and Barbera. The following instrumentation was used during the test: i) Unmanned aerial vehicle (UAV) multirotor equipped with a multispectral camera, ii) a tracked bin carrier vehicle (ByeLab) equipped with mutiple devices.
The grapevines were categorized in healthy, low and high diseased and their position were georeferenced during a ground manual survey. Two UAV flew at different altitudes (30-70 meters) were made and the images collected by the multispectral camera were elaborated to compute the NDVI maps associating the NDVI value at each plant with QGIS. At the same time, the canopies of four vine rows were scanned two times with the ByeLab assessing the reflectance of every single plants. These data were analyzed using Matlab.
All NDVI values has been classified in the same categories as the ground survey.
For healthy plants we obtained values between 0.70 and 0.75 (Dolcetto cv), while for Barbera cv the values were between 0.70 to 0.73. Diseased plants showed lower NDVI values than the heathy plants for each cultivar at 0.64-0.70 (Dolcetto cv) and 0.68-0.7 (Barbera cv). This trend was detected for both the surveys, suggesting that both the technologies discern healthy from diseased plants.

References

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2. H. Al-Saddik, A. Laybros, B. Billiot, and F. Cointault, 2018,"Using image texture and spectral reflectance analysis to detect Yellowness and Esca in grapevines at leaf-level," *Remote Sens.*, vol. 10, no. 4.
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Panel 2 - Vegetation & Land Use

Reference topic: remote sensing, river management, satellite imagery
Presentation type: oral (invited talk)

Monitoring from close-range remote sensing the hydraulic resistance (Manning) of agricultural channel network

Jean-Stéphane Bailly[1,2*], Fabrice Vinatier[1], Gabrielle Rudi[3]

[1]*LISAH, Univ Montpellier, INRAE, IRD, Institut Agro, Montpellier, France (corresponding: bailly@agroparistech.fr)*
[2]*AgroParisTech, Paris, 75005, France*
[3]*G-Eau, Univ Montpellier, AgroParisTech, CIRAD, INRAE, IRD, Institut Agro, Montpellier, France*

Ditch vegetation has numerous positive effects on the main regulating services of agricultural channels, such as seed retention, pollutant mitigation, bank stabilization, and sedimentation. The channel vegetation also limits the water conveyance, and consequently is frequently removed by farmers (management practices) to increase its porosity and consequently decrease the hydraulic resistance. A large body of literature attempts to characterize vegetation characteristics affecting hydraulic resistance, through the introduction of the blockage factor of flow by vegetation. However, this factor has multiple definitions and is still difficult to assess in the fields with actual and diverse vegetation covers, especially for grassy plants of channels. In addition, the temporal variability resulting from growing vegetation and management practices make the objective monitoring of hydraulic resistance in channels highly challenging. Close-range remote sensing (photogrammetry, Flash Lidars) offers possibilities now to get time series of complex channel vegetation characteristics but up to know, it has never been studied up to the hydraulic resistance monitoring. This talk is presenting two experiments trying to overpass this challenge.

In the first experiment, we present an approach using a photogrammetric technique (SfM-MVS) to construct time series of herbaceous vegetation porosity (3D point clouds) in a real agricultural channel (ditch) variously managed by farmers. After point clouds time-series analysis, an indicator of vegetation porosity for the whole section and of the surface of the channel is computed. Results show that mowing and chemical weeding are the practices presenting the most favorable temporal evolutions of the porosity indicators regarding flow events. Burning did not succeed in restoring the porosity of the channel due to quick recovery of the vegetation and dephasing of the maintenance calendar with the flow events.

In the second experiment, we aim at predicting flow resistance from 3D vegetation characteristics using a close-range laser scanner also providing 3D point clouds. Flow resistance and vegetation 3D characteristics were defined using Manning coefficient and blockage factors, respectively. We tested combined effects of flow discharge against plant species and densities characterizing intermittent channels in a controlled channel flume. Our results showed a variability of Manning coefficient describing flow rugosity against species and densities, with a highest rugosity for sclerophyllous species than herbaceous ones. Different blockage factors were calculated on the basis of scan clouds

linked to Manning coefficients using non linear equation. The best relationship (R 2 = 0.9) were found for non linear equation relating Manning coefficients to a simplified blockage factor figuring the mean vegetation height deduced from the projection of the scan point cloud to the channel frontal area.

Linking these two experiments offers new possibilities to objectively monitor the hydraulic resistance of agricultural channel networks from 3D remote sensing sensors.

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Reference topic: remote sensing, digital terrain analysis, soil hydrological properties
Presentation type: oral

Assessment of the riparian leaf density using different satellite imagery in a mountain stream

Giovanni Romano[1], Giovanni Francesco Ricci[1*], Francesco Gentile[1]

[1] *Department of Agricultural and Environmental Sciences, University of Bari Aldo Moro, Bari 70032, Italy (corresponding: giovanni.ricci@uniba.it)*

In the last years, remote sensing techniques may provide a useful tool in retrieving Vegetation indices (VIs) and evaluating vegetation features. Image pixel resolution can affect data analysis and results accuracy. The potential of three satellite images in retrieving the Leaf Area Index (LAI), with high and medium resolution (Pleiades 1A, Sentinel-2 and Landsat 8) was tested in two Mediterranean streams, in a nearby deciduous forest and in a winter wheat field.
The Caraux-Garson, the Lambert-Beer, and the Campbell-Norman equations were used to calculate LAI from the Normalized Difference Vegetation Index (NDVI). To validate the sensor data observed LAI values were detected in-situ with the Licor LAI 2200 Plant Canopy Analyzer and compared with LAI retrieved from the satellite imagery. Generally, Pleiades 1A and Landsat 8 images performed better statistical results than Sentinel-2. The former in deciduous forest or in sites characterized by stable riparian vegetation with high canopy closure, the latter in winter wheat sites or in stream reaches where the vegetation cover was homogenous or, conversely, almost absent. Sentinel-2 images provided more accurate results in terms of the range of LAI values. Regarding the different equation used, the Lambert-Beer generally performed best in estimating LAI, especially in areas, such as deciduous forests, that are geomorphologically stable or with a denser vegetation cover.

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Reference topic: remote sensing, vineyards, grass
Presentation type: oral

Use of remotely sensed data for the evaluation of inter-row cover intensity in vineyards

Francesco Palazzi[1], Marcella Biddoccu[1*], Enrico Borgogno Mondino[2], Eugenio Cavallo[1]

[1]Istituto di Scienze e Tecnologie per l'Energia e Mobilità Sostenibili (STEMS) – Consiglio Nazionale delle Ricerche (CNR), Sede Secondaria di Torino (corresponding: marcella.biddoccu@cnr.it)
[2] Dipartimento di Scienze Agrarie, Forestali e Alimentari (DISAFA) – Università degli Studi di Torino, Grugliasco (TO).

Vineyards are a high-income crop and can also have an important landscape value, especially in certain areas of Italy. Vineyards show large soil erosion rates depending on climate variability, local topography and vine management. Farming machineries can also determine compaction and affect soil hydraulic properties, runoff and erosion at different levels depending on inter-rows soil management.

This work, with focus on a pilot area located in the municipality of Carpeneto, Alessandria province (Piedmont, NW Italy), concerns the adoption of satellite optical data from the Copernicus Sentinel 2 (S2) mission to describe vineyard properties. A first analysis was addressed at testing if and how S2 data can map differences in vineyards management and behaviour. It was achieved at field level with reference to some experimental plots presenting different inter-row soil management (tillage -CT-, tillage with downstream 10-m-strip grass cover -ST- and total permanent grass cover -GC-). Reference vineyards were placed on sloping areas and set with up-and-down tillage ('rittochino' in Italian language). A NDVI image time series (TS) was obtained from the level 2 S2 data for the growing season 2017-2018. TS was processed at plot level and proved to be effective in showing vegetation response to mechanical interventions during the growing season; in particular ripping in CT and shredding in GC in late spring and, during summer, mowing and topping were highlighted; minor variations in NDVI were observed after harvest in all plots.

Secondly, a wider analysis was achieved including all the vineyards located in the municipality of Carpeneto. These were mapped by photo-interpretation and grouped in clusters with reference to the local NDVI TS (averaged at plot level). Clustering was obtained by K-means unsupervised classification. Results suggest that vineyards can be classified according to the intensity of inter-row's soil management.

A further analysis was aimed at exploring the role of the native S2 bands in describing vineyard differences and inter-row coverage. Preliminary results suggest that single-bands data could be jointly used with vegetation indices to better describe vine growth dynamics in row-crops. Further studies on remotely sensed data could provide spatially variable inputs for applications in erosion risk management and land analysis.

Reference topic: remote sensing, Unmanned Aerial Vehicle (UAV), Light Detection And Ranging (LiDAR), tree metrics, forestry
Presentation type: oral

Comparison between two methodologies for the Individual Tree Height Estimation through a LiDAR mounted on a drone

Monica F. Rinaldi[1*], Gabriele Daglio[1], Raimondo Gallo[1], and Fabrizio Mazzetto[1]

[1] Faculty of Science and Technology, Free University of Bozen–Bolzano, Piazza Università 5, I-39100 Bolzano, Italy (corresponding: MonicaFernanda.Rinaldi@unibz.it – ID-ORCID: 0000-0002-8939-7766)

Nowadays, forest areas can be assess using Unmanned Aerial Vehicle (UAV) carrying a Light Detection And Ranging (LiDAR) sensor in order to estimate the tree metrics. A forest area in Alto-Adige Region – Italy was selected for this study where an aerial survey was conducted with the Yellowscan Surveyor device mounted on a DJI S900. The aim of this research was to identify the individual tree crown (ITC) in order to estimate the tree height (TH) through a Point Cloud Segmentation and Canopy Height Model (CHM) Segmentation. The results were also compared with ground based measurements monitoring where the location of each tree was georeferenced, and the TH was measured through a Haglöf vertex. The expected result is to obtain the most accurate TH estimator for the study area to propose a reliable solution for a fast and precise above ground biomass volume estimation in forestry inventories.

The data for this research was collected during the WEQUAL Project “Web service centre for a QUAlity multidimensional design and tele-operated monitoring of Green Infrastructures” developed withing the European EFRE-FESR Südtirol-Alto Adige framework.

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TESAF Dipartimento Territorio e Sistemi Agro-Forestali Università di Padova

Reference topic: remote sensing, burned area detection,
Presentation type: oral

Sentinel-1 SAR satellite data and open-source Python algorithms for unsupervised burned area detection in Mediterranean ecosystems

Giandomenico De Luca[1], João M.N. Silva[2], Giuseppe Modica[1*]

[1] Dipartimento di Agraria, Università degli Studi Mediterranea di Reggio Calabria, Località Feo di Vito, I-89122 Reggio Calabria, Italy (corresponding: giuseppe.modica@unirc.it)
[2] Forest Research Centre, Instituto Superior de Agronomia, University of Lisbon, Tapada da Ajuda, 1349-017 Lisbon, Portugal.

In this research, we explore the capability of the free synthetic aperture radar (SAR) Sentinel-1 (S-1) C-band data to map burned areas in the Mediterranean forest ecosystems. The workflow is based on unsupervised machine learning open-source processing developed in python-based scripts, the ESA SNAP-Python interface (ESA snappy) for S-1 image pre-processing, and the Scikit-learn libraries for the image processing and classification.
We used a multitemporal filter to reduce the speckle noise effects and the backscatter time-averages of pre- and post-fire datasets. The contrast between changed and unchanged areas was enforced by calculating two mono-polarimetric radar indices, the radar burn difference (RBD) and logarithmic radar burn ratio (LogRBR), and two temporal difference of dual-polarimetric radar indices (delta modified radar vegetation index (ΔRVI), delta dual-polarization SAR vegetation index ΔDPSVI), exhibiting greater sensitivity to the backscatter changes. We enhanced the spatial details and the scene's contrast by extracting the Gray Level Co-occurrence Matrix (GLCM) textures (dissimilarity, entropy, correlation, mean, and variance) from the four indices and using them as input image layers. The burned area was delineated through unsupervised classification using the k-means machine learning algorithm, and the number of clusters was set using a silhouette score analysis. To assess the accuracy of the resulting detected burned areas, the recall (r), precision (p), and the F-score accuracy metrics were calculated. The obtained results confirm the satisfactory performances of the proposed approach. Moreover, the proposed workflow, wholly based on free and open-source software and data, offers high adaptation flexibility, repeatability, and custom improvement.

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Reference topics: remote sensing, LULC, Sentinel-2, Google Earth Engine, Machine learning, GEOBIA
Presentation type: oral

LULC object-oriented classification in Google Earth Engine: an application in the Trasimeno Lake area

Andrea Tassi[1], Marco Vizzari[1*]

[1] *Department of Agricultural, Food and Environmental Sciences, University of Perugia, Borgo XX Giugno 74, 06124, Perugia, Italy (corresponding: marco.vizzari@unipg.it)*

LULC (Land-Use/Land-Cover) maps play a key role in landscape monitoring and assessment, supporting the definition of policies and strategies for sustainable landscape planning and management. Google Earth Engine (GEE) is a free, cloud-based geospatial analysis platform that allows users to solve in a very efficient way the primary problems related to the storage of huge amounts of remote sensing data, their management, processing, and analysis. Machine Learning algorithms (e.g. Random Forest – RF) combined with object-oriented techniques (GEOBIA – Geographic Object-Based Image Analysis) for LULC classification is still no common in this environment. In this direction, this work is aimed at implementing a GEOBIA approach, combined with an RF algorithm, in a user-friendly GEE code which allows the user to produce a LULC classification and assess its accuracy through a confusion matrix and a kappa statistic. The proposed procedure was tested in a study area, 154.4 Km2 wide, located in the Lake Trasimeno area (central Italy), using Sentinel 2 data. The area was selected considering its complex LULC mosaic mainly composed of artificial surfaces, annual and permanent crops, small lakes, and wooded areas. In this study area, the approach produced a very good overall accuracy and the kappa statistics (86% and 0.82). The code application has shown high reliability of the whole process, even though the object-oriented classification results quite computational demanding and tends to slow down the code execution.

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Reference topic: remote sensing, green infrastructure, sustainable management of urban green network
Presentation type: oral

Designing and implementing a multifunctional network of urban green imfrastructures

Stefano Chiappini[1*], Francesco Paci[1], Nicole Hofmann[1], Andrea Galli[1], Adriano Mancini[3] and Ernesto Marcheggiani[1,2]

[1] Department of Agriculture, Food and Environmetal Sciences, Università Politecnica delle Marche, Ancona, Via Brecce Bianche 10, 60131, Ancona (AN), Italy
[2] Division of Forest, Nature and Landscape (FNL), University of Leuven, Celestijnenlaan 200e, 3001 Leuven (Belgium) (corresponding: stefano.chiappini@staff.univpm.it)
[3]Department of Information Engineering, Università Politecnica delle Marche, Ancona, Via Brecce Bianche 10, 60131, Ancona (AN), Italy

With the occasion of the meeting in Padova, we would like to present a work about the possibilities offered by nowadays jointed advanced and traditional geomatics approaches. The experiment sets a multi-disciplinary environment, where botanists, planners, agronomists, software and geospatial engineers teaming up to offer the city of Ancona a bold solution to manage urban green infrastructures and the rich cultural heritage attached to them.

Along with a previous initiative, the Cost Action Cybrparks aiming at shedding light on the potentials of communication technologies and ICTs to foster the multifunctional role of green urban areas, the ongoing project "The network of botanical gardens" follows the same path. Aiming at far-reaching meaningful results and thanks to the promising outcomes gotten previously for the city park Cardeto as published in (1 and 2), we expanded the study area to three new parks and botanical gardens: Selva di Gallignano, the garden of Montedago and the marine Falesia, which altogether make up the backbone of the whole city green fabric.

Several devices, such as 3D and thermal Cameras or Beacons, and a set of surveys (Global Navigation Satellite Systems and UAVs) have been performed to dress the area with sets of cyber sensors creating a flux of information about positional and phenological characteristics of the city green infrastructures along the course of time. This flux of information, if soundly streamed to the city public shall make the object of a future experiment to prove that gamification and socialisation of urban green values could represent a cornerstone to urban green monitoring, planning and design.

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Panel 3 – Digital Terrain Analysis & Soil Erosion

Reference topic: remote sensing
Presentation type: oral (invited talk)

Topography meter: remote sensing with a novel 3D surface measuring technique

Xiangzhou Xu

School of Hydraulic Engineering, Dalian University of Technology, Dalian 116024, China (corresponding: xzxu@dlut.edu.cn)

Gravity erosion is one of the most remarkable natural hazards in mountainous regions, especially on the Loess Plateau of China. Nevertheless, the measurement of failure mass is very difficult because gravity erosion usually occurs randomly and it combines with hydraulic erosion. Here we present a novel testing technique that could quantitatively measure time-variable gravity erosion on the steep loess slopes. A structured light 3D surface measuring apparatus, the Topography Meter, was designed and manufactured in our laboratory. Dynamic variation of the steep slope relief was monitored under rainfall simulation and the slope deforming process was recorded by a computer video technology. With the help of laser marking, plane figures were transformed into 3D graphs, thus the shape of target surface was accurately computed. By comparing the slope geometries in the moments before and after the erosion incident on the snapshot images at a particular time, we could obtain the volume of gravity erosion and many other erosion data, including the volume of slide mass, the amount of soil loss eroded by overland flow, etc. A series of calibration tests were conducted and the results showed that the accuracy of this technique was high and sufficient for exploring the mechanism of slope erosion. More than 200 rainfall simulation events were subsequently tested with the apparatus, further confirming its feasibility and reliability.

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Reference topic: remote sensing, data fusion; TLS; SfM; agricultural terrace; coregistration; direct georeferencing
AIIA section: 7 section
Presentation type: oral

Monitoring of vegetated agricultural terraces systems through SfM-TLS data fusion technique

Sara Cucchiaro[1,2*], Daniel J. Fallu[3], Antony G. Brown[3], Paolo Trolli[2]

[1] *Department of Agricultural, Food, Environmental and Animal Sciences, University of Udine, Via delle Scienze, 206, 33100 Udine, Italy (corresponding: sara.cucchiaro@uniud.it)*
[2]*Department of Land, Environment, Agriculture and Forestry, University of Padova, Agripolis, Viale dell'Università 16, 35020 Legnaro (PD), Italy*
[3] *Tromso University Museum, UiT The Artic University of Norway, Kvaløyen 30, 9013 Tromsø, Norway*

Terraced landscapes can be considered a historical heritage and a cultural ecosystem service to be adequately preserved by increased soil degradation due to climate change and land abandonment. In the last two decades, important developments in High-Resolution Topographic (HRT) techniques, methods, sensors, and platforms has greatly improved our ability and opportunities in the assessment and monitoring of such cultural ecosystem services. However, due to the limitations imposed by rugged topography and the occurrence of vegetation, the application of a single HRT technique is challenging in these particular agricultural environments. Therefore, data fusion from different acquisition platforms can be a useful solution to overcome specific detection problems. Terrestrial laser scanning (TLS) and structure from motion (SfM) was tested for the first time in agricultural terraces context, to realize detailed digital terrain models (DTMs) of two sites, Soave (North-east of Italy) and Martelberg in Saint-Martens-Voeren (East Belgium), both characterized by the presence of vegetation that covers parts of the subvertical surfaces, complex morphology, and inaccessible areas. In the unreachable zones, where was impossible to locate the GCPs, we tested the direct georeferencing (DG) method, exploiting onboard multi-frequency GNSS receivers for unmanned aerial vehicles (UAVs) and post-processing kinematic (PPK) data. The research demonstrated how survey planning and co-registration were fundamental phases for data fusion that is required to obtain accurate DTMs that reflect the real surface roughness of terrace systems without gaps in data.

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Reference topic: remote sensing, high resolution topography, soil erosion
Presentation type: oral (invited talk)

Soil erosion measurement across spatio-temporal scales

Anette Eltner[1]

[1]*Department of Environmental Sciences, Institute of Photogrammetry and Remote Sensing, Technische Universität Dresden, Helmholtzstr. 10, 01069 Dresden, Germany (corresponding: anette.eltner@tu-dresden.de)*

Soil erosion due to water is a worldwide phenomenon caused or increased by human cultivation. The quantification of the eroded soil material is a methodological challenge. Accurate estimation of soil erosion forms the basis for monitoring programs as well as modelling approaches. Modern methods for the generation of high-resolution 3D point clouds enable microscale recording of the soil surface and thus highly precise capturing of different erosion forms. In this talk, methods applicable on different scales for the recording of the consequences of different erosion processes and the subsequent quantification of soil loss are presented. The challenges and benefits of high-resolution and mm-accurate measurement of the soil surface will be demonstrated. Different (semi-)automated methods for determining erosion volumes based on 3D point data will be discussed. The introduced approaches enable event-based soil erosion assessment from plot to field scale.

Reference topic: remote sensing, Debris flow, Check dam, High-resolution topography, DTM, Multi-temporal analysis, Sediment connectivity
Presentation type: oral

Assessing sediment dynamics and torrent control works efficiency in a debris-flow catchment using multi-temporal topographic surveys

Federico Cazorzi[1], Sara Cucchiaro[1*], Lorenzo Marchi[2], Marco Cavalli[2]

[1] *Department of Agricultural, Food, Environmental and Animal Sciences, University of Udine, Via delle Scienze, 206, 33100 Udine, Italy (corresponding: sara.cucchiaro@uniud.it)*
[2] *CNR-IRPI, Italy*

Torrent control works have always been a fundamental tool for preventing torrential hazard in mountain catchments, where the sediment transport phenomena as debris flows are one of the most dangerous geomorphic processes affecting small steep basins. Among the hydraulic engineering structures, check dams represent one of the most common hydraulic engineering solutions to manage debris-flow risk. These structures could have important effects on sediment dynamics. In spite of the widespread presence of such hydraulic structures in steep mountain streams worldwide, very little researches considered the role of check dams on sediment dynamics in debris-flow environments over time to enhance the planning of the torrent control works. In the last two decades, High-Resolution Topography (HRT) has provided new opportunities to characterize debris-flow activity at different scales. In this research, the effects of check dams on debris-flow dynamics were investigated by means of multi-temporal SfM and LiDAR surveys in the Moscardo torrent (eastern Italian Alps) where several check dams have been built over time. Methodological workflows enabled the realization of multi-temporal Digital Terrain Models (DTMs) which were compared (i.e., DoD) to quantify the debris mobilized and the time evolution of erosion and deposition patterns in debris-flow channels equipped with check dams. The DoDs data were integrated with a sediment connectivity analysis to have a whole assessment of debris-flow dynamic. The results show that the check dams considerably modified debris-flow dynamics in the studied channel but their performance cannot be considered satisfactory. The analysis proposed could help to improve design approaches and, in this way, select better solutions.

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Reference topic: remote sensing, digital terrain analysis, sediment transport
Presentation type: oral

Primary impacts and cascading processes of the Vaia storm in the Rio Cordon mountain catchment (Belluno Province)

Lorenzo Martini[1*], Giacomo Pellegrini[1], Riccardo Rainato[1], Lorenzo Picco[1,2,3]

[1] *Department of Land, Environment, Agriculture and Forestry, University of Padova, Agripolis, Viale dell'Università 16, 35020 Legnaro (PD), Italy (corresponding: lorenzo.martini.2@phd.unipd.it)*
[2]*Universidad Austral de Chile, Faculty of Engineering, Valdivia, Chile*
[3]*Universidad Austral de Chile, RINA – Natural and Anthropogenic Risks Research Center, Valdivia, Chile*

Mountain basins can be rapidly affected by large infrequent disturbances (LIDs), supplying high amounts of water, sediments, and large wood. Subsequent cascading processes are often underestimated although their understanding would improve the catchment management strategies. The recent improvements in the field of remote sensing have become essential for the analysis and monitoring of such chain of secondary events triggered by the LIDs. Therefore, this contribution aims at presenting the recent dynamics caused by the Vaia storm on the Rio Cordon basin (5 km^2, Veneto Region). The primary impact was investigated using LiDAR data (DoD technique), while the subsequent cascading processes were monitored with multiple UAV surveys at catchment and reach scale, respectively. Fourteen sediment source areas were activated along the hillslopes, contributing with a total amount of 450 m^3. The main channel network was eroded, delivering 6,900 m^3 to the outlet (Martini et al., 2020). Moreover, the Vaia storm was able to blow down 139 trees for a total amount of 106 m^3 (Picco et al., 2020) that were removed afterwards. All these primary impacts are affecting the stability of the active channel and the surrounding areas. To better understand the ongoing and future dynamics, a detailed monitoring of the sediment suspended load has started. Continuous UAV surveys and water quality sonde are being used to assess the sediment transport. The combination of the remote sensing and field measurements represents a suitable and promising approach for an holistic view of the future developments in a mountain basin after a LID.

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Reference topic: landslides; roads; agricultural systems; UAV; GIS
Presentation type: oral

UAV-SfM 4D mapping of landslides activated in steep terraced agricultural context

Luca Mauri[1*], Eugenio Straffelini[1], Sara Cucchiaro [2,1], Paolo Tarolli[1]

[1] Department of Land, Environment, Agriculture and Forestry, University of Padova, Agripolis, Viale dell'Università 16, 35020 Legnaro (PD), Italy (corresponding: luca.mauri.2@phd.unipd.it)
[2] Department of Agricultural, Food, Environmental and Animal Sciences, University of Udine, Via delle Scienze, 206, 33100 Udine (UD), Italy

The presence of roads is closely linked with the activation of land degradative phenomena such as landslides (Sidle and Ziegler, 2012). In agricultural contexts, road networks bring numerous advantages in economic and logistic terms, representing a crucial infrastructure for farm management and production. However, factors such as ineffective road management and design, as well as specific geomorphological elements like terrain slope, soil characteristics and local rainfall regimes actively influence landslides occurrence. In this context, high-resolution topography data can provide useful information to more in-depth investigate the presented issue. Indeed, recent developments in digital photogrammetry (e.g. Structure from Motion; SfM) paired with UAV systems increase our possibilities to realize low-cost and recurrent topographic surveys (Siebert and Teizer, 2014). This allows the realization of multi-temporal (hereafter 4D) and high-resolution Digital Elevation Models (DEMs), fundamental to analyse geomorphological features and quantify processes at the fine spatial and temporal resolutions at which they occur. This research aims to propose a multi-temporal comparison of the main geomorphometric indicators describing a landslide-prone terraced vineyard, in order to assess the observed high-steep slope failures. The possibility to investigate the evolution of landslides affecting steep agricultural systems through high-resolution and 4D comparison of such indicators is still a challenge to be investigated. In this article we considered a case study located in the central Italian Alps, where two landslides were activated below a rural road within a terraced agricultural system. Multi-temporal computation of Relative Path Impact Index, terrain curvature, roughness and features extraction were derived from SfM-based DEMs reconstruction. The dynamics of the landslides were monitored through the comparison of repeated DEMs (DEM of Difference, i.e. DoD), that offers essential information on the evolution of erosion and deposition patterns, and allows the volumes quantification of topographic changes. The results highlight the usefulness of high-resolution and 4D UAV-based SfM surveys for the investigation of landslides triggering due to the presence of roads at hillslope scale in agricultural systems. This work could be a useful starting point for further investigations of landslide-susceptible zones at wider scale, in order to preserve the quality and the productivity of affected agricultural areas. In addition, the alteration of superficial water and sediment flows, due to the presence of the road close to landslide zones, could be implemented through the adoption of specific hydrological models, such as SIMWE (Mitasova et al., 2103).

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Panel 4 – Water Resources Management

Reference topic: remote sensing, digital terrain analysis, gully erosion, landslides
Presentation type: oral (invited talk)

Abandoned reservoirs and gully erosion analysis using LiDAR

Mihai Niculita[1]

[1] *Department of Geography, Faculty of Geography and Geology, Alexandru Ioan Cuza University of Iasi, Carol I 20A, 700505 Iasi (IS), Romania (corresponding: mihai.niculita@uaic.ro)*

Gullies and landslides are processes that have an important role in erosion, and for soil erosion especially from an anthropic point of view. Although spatially these processes do not have an important extension for agricultural lands, from a rate of change perspective, are important, because the dynamics of these processes impose tough restrictions for agriculture. The availability for wide areas of high-resolution LiDAR DEMs and the availability of affordable SfM technology (camera, drone/UAV, software) with which high-resolution DEMs can be obtained, opens the possibility of rate of change monitoring. By applying rate of change techniques (DoD/Geomorphic Change Detection), precise monitoring of gullies and landslides can be achieved, which coupled with geomorphological mapping on the high-resolution imagery and DEM can greatly improve the understanding of the evolution of these processes, in order to be able to apply remedial measures. A study case of gullies developed on abandoned reservoir bottoms is presented with two methodological persepctives: geomorphometric detection and geomorphic change detection.

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Reference topic: remote sensing, hydrology, soil moisture, watershed protection, terracing, water harvesting
Presentation type: oral

Remote Sensing advances in agricultural hydraulics and watershed protection

Giulio Castelli[1,2,3*], Elena Bresci[1,2,3], Daniele Penna[1,4], Federico Preti[1,4]

[1] *Dipartimento di Scienze e Tecnologie Agrarie, Alimentari, Ambientali e Forestali (DAGRI), Università degli Studi di Firenze, Firenze, Italy (corresponding: giulio.castelli@unifi.it)*
[2] *Water Harvesting Lab, DAGRI*
[3] *COPERNICUS Research Unit, Università degli Studi di Firenze*
[4] *Laboratory of Environmental-Hydrological Modelling and Soil and Water Bioengineering (MAIN), DAGRI*

Among the different sectors of agricultural engineering, remote sensing has represented a ground-breaking innovation in the field of agricultural hydraulics and watershed protection due to the availability of new sensors and supports (Unmanned Aerial Vehicles – UAVs)[1] and advanced platforms for data analysis (Google Earth Engine)[2]. The combination of such technologies opened new possibilities for monitoring hydrological processes, from snow cover[3] to soil moisture[4], and the effect of soil and water conservation structures[4], with multi-scale options (from the single structure to the agricultural/hilly catchment area), across different geographic areas and climates. The present contribution will examine a portfolio of possible innovative applications of remote sensing in the field of agricultural hydraulics and watershed protection, built on the experiences of the group at the Università degli Studi di Firenze, analyzing possible development pathways, synergies with other sectors, and future technological advancements (e.g. High-altitude platform station (HAPS) or FAO EarthMap - https://earthmap.org/).

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Reference topic: remote sensing, river management, satellite imagery
Presentation type: oral

Analysis of time-series satellite images as a tool for planning river management strategies

Paolo Fogliata[1*], Daniele Masseroni[1], Alessio Cislaghi[1,2], Gian Battista Bischetti[1,2]

[1]*Department of Agricultural and Environmental Sciences-Production, Landscape and Agroenergy, University of Milan, Via Celoria 2, Milan 20133, Italy (corresponding: paolo.fogliata@unimi.it)*
[2]*Centre of Applied Studies for the Sustainable Management and Protection of Mountain Areas-Ge.S.Di.Mont., University of Milan, Via Morino 8, Edolo 25048, Brescia, Italy*

River management requires actions based on best practices aim to combine hydraulic safety, river functionality, and ecological/environmental quality. Planning such actions require a detailed awareness of past river processes and a reliable prediction of their consequences on the fluvial inheritance (Scorpio, 2020). In this context, remote sensing technologies, applied for identifying the river changes, offer a viable decision-making instrument (Piégay, 2020). In particular, time-series satellite images are valid data to detect fluvial forms, vegetation and sediment transport dynamics at different spatio-temporal scales. These data allow to detect present river trajectories and to explore alternative paths more appropriate for a specific river morphology.

Exploiting the greater availability of remote sensing data, this study investigated the spatio-temporal dynamics of vegetation and sediment within the bankfull stream over the last 15 years. The study sites are several reaches of Oglio River, characterized by different morphological elements. Using an automatic procedure that combines image segmentation and classification algorithms, we identified the evolution of sediment bars/islands, the vegetation dynamics (distinguishing pioneer and mature stands) and the consequences of human and natural disturbances (morphological change after flood event, vegetation harvest, impacts of soil bioengineering work or construction of bank protection). The results clearly show, over the sediment islands, how the pioneer species occupy the empty spaces within the first 5 years and reach a vegetation stability only after 9-12 years. Based on such spatio-temporal dynamics, we can plan the management practice on the riparian vegetation indicating both timing- intensity and economic costs over time.

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ASSOCIAZIONE ITALIANA DI INGEGNERIA AGRARIA

TESAF Dipartimento Territorio e Sistemi Agro-Forestali Università di Padova

Reference topic: remote sensing, irrigation, Sentinel-2
Presentation type: oral

Early recognition of irrigated areas using Sentinel-2 data in Central Italy

Lorenzo Vergni[1*], Marco Vizzari[1], Alessandra Vinci[1], Francesco Santaga[1], Francesca Todisco[1]

[1]*Department of Agricultural, Food and Environmental Science, University of Perugia, Borgo XX Giugno 74, 06124, Perugia, Italy (corresponding: lorenzo.vergni@unipg.it)*

The large-scale recognition of irrigated areas, based on remote-sensing data, is extremely useful information for water resources planning and management. In this work, the time series of three optical indices derived from Sentinel-2 (S2) data were analyzed to classify 92 areas (34 non-irrigated and 58 irrigated) in the period 2017-2019 in Central Italy. The indices considered are the Normalized Difference Vegetation Index (NDVI), the Modified Soil-Adjusted Vegetation Index (MSAVI2), and the Normalized Difference Moisture Index (NDMI). Two different techniques were tested in the classification, based respectively on Random Forest (RF) and Dynamic Time Warping (DTW). The overall accuracy (OA) of the classification was assessed gradually increasing the number of S2 observations from the beginning of the irrigation season (May 15), thus allowing to evaluate how early a sufficiently reliable recognition is obtained. The results show that NDVI and MSAVI (both based on the near-infrared wavelengths) are usually more accurate than NDMI (based on the shortwave infrared). The two classification algorithms have very similar OA values (about 90%) when applied to the entire series of observations available at the end of the season. Instead, early recognition occurs more effectively with the RF technique than with DTW. For RF we get OA values close to 90% as early as mid-July (2 months of data), whilst DTW reaches the maximum accuracy starting from mid-August (3 months of data).

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Reference topic: remote sensing, soil moisture, Unmanned Aerial Systems
Presentation type: oral

Soil Moisture Retrievals from Unmanned Aerial Systems (UAS)

Nunzio Romano[1], Ruodan Zhuang[2*], Salvatore Manfreda[3], Silvano Fortunato Dal Sasso[2], Carolina Allocca[1], Paolo Nasta[1]

[1] Department of Agricultural Sciences, AFBE Division, University of Naples Federico II, Portici, Via Università 100, 80055, Portici (NA), Italy (paolo.nasta@unina.it, carolina.allocca@unina.it, nunzio.romano@unina.it)
[2] Department of European and Mediterranean Cultures, Architecture, Environment, Cultural Heritage, University of Basilicata, Via Lanera 20, 75100 Matera (MT), Italy (ruodan.zhuang@unibas.it, silvano.dalsasso@unibas.it)
[3] Department of Civil, Architectural and Environmental Engineering, Università degli Studi di Napoli Federico II, Via Claudio 21, 80125 Napoli (NA), Italy (salvatore.manfreda@unina.it)

Spatial and temporal dynamics of soil moisture is vital for water resources management. Unmanned Aerial Systems (UAS) offer a great potential in monitoring this variable at sub-meter level and at relatively lowcost. In this research, UAS-based soil moisture products have been tested using different algorithms: 1) thermal inertia; 2) random forest regression; and 3) temperature–vegetation trapezoidal model. The thermal inertia model, which builds upon the dependence of the thermal diffusion on soil moisture, requires the soil thermal inertia estimation that is quantified by processing visible and near infrared and thermal infrared images acquired at two different times of a day. The random forest regression model is used to downscale gridded soil moisture from 1km to 15cm grid size by applying UAS data and Digital Elevation Model (DEM) information. Finally, the temperature–vegetation trapezoidal model is used to map soil moisture over vegetated pixels. The comparison of the three algorithms helps to identify the advantages and disadvantages of each procedure for retrieving soil moisture with UAS. As a case study, a typical cropland area called MFC2 (about 8 ha) covered by olive, cherry and walnut trees in southern Italy, is used, where optical and thermal images and in-situ data were simultaneously acquired. MFC2 belongs to the Alento hydrological observatory, where long-term studies on vadose zone hydrology have been conducted across a range of spatial scales. Our findings provide a contribution towards improving our knowledge on evaluating the ability of UAS to map soil moisture.

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