AgroLife Scientific Journal - Volume 6, Number 2, 2017
ISSN 2285-5718; ISSN CD-ROM 2285-5726; ISSN ONLINE 2286-0126; ISSN-L 2285-5718

EARTH OBSERVATION SATELLITE DATA IN SUPPORT OFWATER MANAGEMENT FOR AGRICULTURE

Iulia Dana NEGULA[1,2], Alexandru BADEA[1], Cristian MOISE[1,2], Violeta POENARU[1,2]

[1]Romanian Space Agency, Mendeleev Street No. 21-25, District 1, Bucharest, Romania
[2]University of Agronomic Sciences and Veterinary Medicine of Bucharest, 59 Marasti Blvd., District 1, Bucharest, Romania

Corresponding author email: iulia.dana@rosa.ro

Abstract

The Earth Observation (EO) satellite data provided within the Copernicus Programme supports the monitoring and sustainable management of agriculture. For example, satellite data are useful for agriculture mapping, crop health monitoring, land planning, disease mitigation, crop yields estimation, precise agriculture, and sustainable irrigation water management. The identification of non-authorised water abstractions for irrigation is of high importance since the drought phenomenon is increasingly in the past decades due to climate change. This aspect is addressed by DIANA – "Detection and Integrated Assessment of Non-authorised water Abstractions using EO", a project funded by the European Commission in the frame of H2020 (European Union Framework Programme for Research and Innovation). The project will integrate data acquired by the Sentinel missions (Sentinel-1, Sentinel-2 and Sentinel-3) and as well Landsat and MODIS. Other types of data (meteorological, land use/land cover, digital elevation models, soil, etc.) will support the satellite data processing and the generation of value-added products. In addition, the project aims at significantly improve the monitoring and assessment of the water management policies and practices. As the project is in its initial phase, the results presented in this article are preliminary. The project will demonstrate the relevance of EO data for sustainable agriculture management and will bring societal and environmental benefits to the end users.

Key words: *Earth Observation satellite data, agriculture, water management, DIANA project, Copernicus Programme.*

INTRODUCTION

Today, Earth Observation (EO) satellite imagery represents an invaluable source of information that enables the assessment and monitoring of certain natural phenomena or anthropogenic processes on our planet. With more than forty-five years of continuous satellite acquisitions, evolution trends can be identified, thus the implementation of coherent and informed agricultural and environmental management programmes can be achieved based on a consistent background. Extensive scientific research has been conducted to extract meaningful information from long-term series of satellite data acquired by different remote sensing sensors in terms of imaging systems and resolution. But the transition from scientific research to operational services is of utmost importance. EO satellite data are increasingly exploited for operational agricultural services, covering a wide range of topics such as parcel and crop identification, crop growth and health monitoring and assessment, yield estimation and prediction, fertilization and pest management, land use and land cover change detection, soil mapping, water resources management, policy monitoring and control, etc. Hence, EO satellite imagery plays an important role in precision agriculture by providing accurate information with high frequency, over wide areas. Likewise, the identification of the irrigated area sand the estimation of the abstracted water volumes using EO satellite data represent a reliable basis for farmers, agronomists and responsible authorities in support of sustainable water management. Moreover, EO satellite imagery is beneficial in identifying the illegally irrigated areas and the non-authorised water abstractions for irrigation considering that it allows a significant reduction of the traditional field inspection costs for the detection and monitoring of the illegal activities. In this context, the Sentinel-1 and Sentinel-2 satellite missions of the Copernicus Programme provide timely and easily accessible information for regular land monitoring. The present study is developed within the H2020 DIANA Project that aims at leveraging the EO Copernicus data for the detection and integrated assessment of non-authorised water abstractions.

MATERIALS AND METHODS

The test area and one of the project's pilot cases is called "Urseni" and it is located southeast of Timisoara (latitude 45.69^0 N, longitude 21.31^0 E), in the historical Banat Region of Romania. The area is mainly covered by agricultural fields and villages and has an average altitude of 91 m. Urseni is situated within the Timis River Basin and has an exceptional aquifer potential.

The study was performed based on satellite images acquired by Sentinel-1, Sentinel-2 and Landsat 8 between July 30, 2015 and June 21, 2017. The Sentinel-1 mission is a constellation of two C-band Synthetic Aperture Radar (SAR) satellites orbiting the Earth 180^0 apart. The first satellite was launched in April 2014 and the second one in April 2016. The two satellites provide all-weather, day and night imagery for the Copernicus land and ocean services. Similarly, the Sentinel-2 mission is composed of two identical satellites placed in the same orbit. Each of the two satellites (launched in June 2015, respectively March 2017) carries an innovative wide swath (290 km) high-resolution multi-spectral imager with 13 spectral bands (visible, near-infrared and shortwave infrared) that acquires optical imagery (with the spatial resolution of 10 m/20 m/60 m) for the Copernicus land services(http://www.esa.int).

Landsat 8 was launched in February 2013 and it is equipped with two science instruments - the Operational Land Imager (OLI) and the Thermal Infrared Sensor (TIRS) - that collects data using 11 spectral bands (panchromatic, visible, near-infrared, shortwave infrared, thermal infrared) with a spatial resolution of 15 m/30 m/100 m (https://landsat.gsfc.nasa.gov/).

In the first phase of the study, 55 satellite images were downloaded, pre-processed and visually inspected. Part of them were discarded if the cropped image corresponding to the test area was covered by clouds or clouds shadow. Sentinel-1 data were acquired from a descending orbit (relative orbit: 80) using two polarisations (VV and VH). The downloaded Sentinel-1 data representLevel-1 Ground Range Detected (GRD) products that consist of focused SAR projected to ground range based an Earth ellipsoid model. A sample of terrain geocoded Sentinel-1 data (acquisition date: 16 April 2017)covering the Urseni test area is presented in Figure 1 (©Copernicus Sentinel data 2017). Sentinel-2 data consist of products with the 1C (top-of-atmosphere reflectances) or 2A (bottom-of-atmosphere reflectances in UTM WGS84 projection) processing level derived from data acquired from the relative orbit no 36. Figure 2 (© Copernicus Sentinel data 2017) illustrates a sample of Sentinel-2 data (acquisition date: 12 April 2017) corresponding to Urseni test area.

Landsat 8 data consists of images acquired from the 186/028 relative orbit. These images are radiometrically and geometrically (precision terrain) corrected (processing level L1T).A Landsat 8 satellite image (© Data available from the U.S. Geological Survey 2017) is presented in Figure 3 (acquisition date: 14 April 2017).

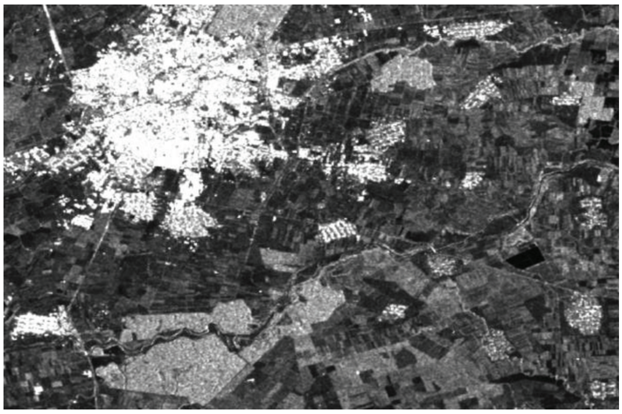

Figure 1a. Sentinel-1A image, VV polarisation, 10 m spatial resolution (© Copernicus Sentinel data 2017), available from Copernicus Open Access Hub

Figure 1b. Sentinel-1A image, VH polarisation, 10 m spatial resolution (© Copernicus Sentinel data 2017)

The normalised difference vegetation index (NDVI) is computed based on the near-infrared and the visible red spectral bands (Mandanici and Bitelli, 2016). NDVI is used to monitor crop phenology and condition and to estimate the potential yield for the current season in comparison with the historical average (Leslie et al., 2017).

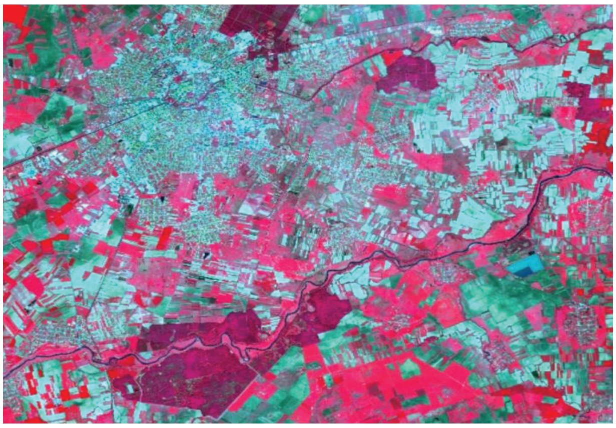

Figure 2. Sentinel-2A image, false-colour composition, 10 m spatial resolution (© Copernicus Sentinel data 2017), available from Copernicus Open Access Hub

Figure 3. Landsat image, natural colours composition, 30 m spatial resolution (© data available from the U.S. Geological Survey2017), USGS Glovis

The scientific literature contains a very large number of papers studies dedicated to NDVI as it is the most widely used remote sensing vegetation index.
Relevant examples include (but are not limited to) research related to the combined use of time series acquired by Sentinel-2 and Landsat 8 sensors given their spectral differences (Mandanici and Bitelli, 2016) and comparison of NDVI from Sentinel-2 and Landsat-8, for same-day acquisitions (Flood, 2017). The use of NDVI and other derived vegetation indices for the detection of non-authorised water abstractions is thoroughly described in (Lookwood et al., 2014).
The all-weather capability and sensitivity to surface characteristics endorse the use of SAR data for crop monitoring. For example, the accurate mapping of rice has been demonstrated using Sentinel-1 multitemporal data (Torbick et al., 2017). Also, the performance of Sentinel-1 has been proven for the monitoring of cereals (wheat and barley) and oilseed rapes crops, whereas the crop backscattering response has been correlated with the phenology cycle and the structural plant changes (Minchella, 2015).
The main objective of the present study is to find whether the radar backscatter is correlated with the NVDI values in case of the crops that are present within the test area, using time-series of Sentinel-1 and Sentinel-2/Landsat 8 data. This research subject has been approached for sugarcane monitoring (Davidse, 2015), irrigated maize assessment (Rolim et al., 2016), mountain crops evaluation (Notarnicola et al., 2017) etc.

RESULTS AND DISCUSSIONS

The preliminary results (Figures 4-6) indicate that the VH polarisation backscattering time series are more similar with NDVI in comparison with the ones resulting from the VV polarisation. Sentinel-1 images (VH and VV) are calibrated, speckle filtered and geocoded.
Future work includes an investigation related to the potential of SAR data in monitoring different types of crops considering that the backscatter signal contains information on both vegetation and soil condition. Moreover, the intensity of the SAR backscatter depends on the surface roughness and soil moisture. For this scope, ground-truth data and detailed phonologic informational are mandatory.
As demonstrated also by the previous studies, the NDVI derived from multitemporal optical satellite imagery (in this study, Sentinel-2 and Landsat 8) enables an accurate identification of the crop growth stages.

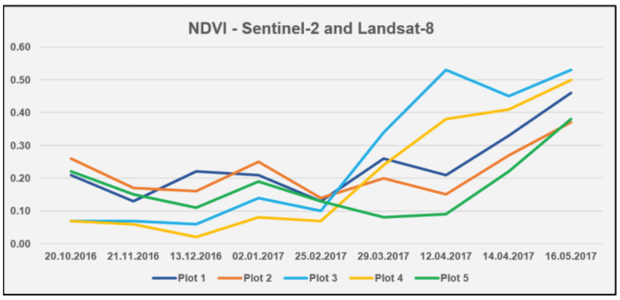

Figure 4. NVDI – S2/L8 (5 different crops)

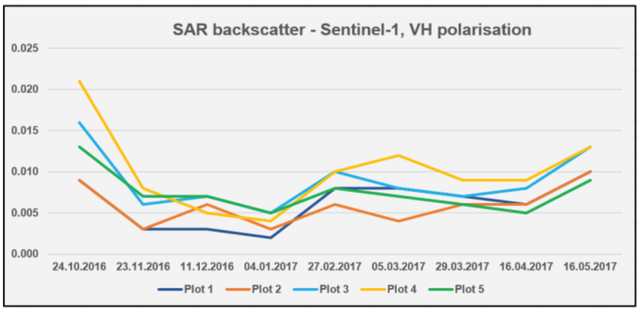

Figure 5. SAR backscatter – S1, VH (5 different crops)

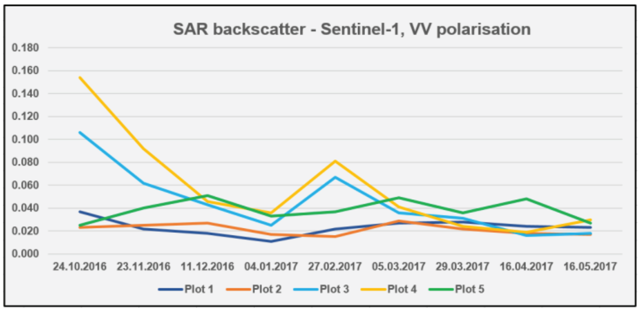

Figure 6. SAR backscatter – S1, VV (5 different crops)

CONCLUSIONS

The high temporal resolution provided by the Sentinel missions allows an accurate monitoring of the crops. The data acquired by Sentinel-1 are useful especially when the use of optical satellite imagery is limited due to atmospheric conditions or cloud cover.

Although further thorough research is necessary, an integrated approach that combines optical (Sentinel-2, Landsat) and SAR (Sentinel-1) satellite data might be the optimal solution for the identification of non-authorised water abstractions for irrigation. Nevertheless, the use of Earth Observation satellite data for an efficient water management in support of sustainable precision agriculture has definite benefits and it will bring societal and environmental benefits to the end users that will have access to monitoring data and forecasts.

ACKNOWLEDGEMENTS

This work has been conducted within DIANA project – "Detection and Integrated Assessment of Non-authorised water Abstractions using EO". This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 730109.

REFERENCES

Davidse J., 2015. The relation between the NDVI and backscatter of Sentinel-1 for sugarcane monitoring (Case study in South Africa). Master course Geo-Information Science, Wageningen University, Netherlands.

Flood N., 2017. Comparing Sentinel-2A and Landsat 7 and 8 Using Surface Reflectance over Australia. MDPI - Remote Sensing, 2017, 9(7), 659, EISSN 2072-4292, doi:10.3390/rs9070659.

Leslie C., Serbina L., Miller H., 2017. Landsat and agriculture - Case studies on the uses and benefits of Landsat imagery in agricultural monitoring and production. U.S. Geological Survey Open-File Report 2017–1034, 27 p., ISSN 2331-1258 (online), https://doi.org/10.3133/ofr20171034, Reston, Virginia.

Lookwood S., Sarteel M., Mudgal S., Osann A., Calera, A., 2014. Applying Earth observation to support the detection of non-authorised water abstractions, Report for the European Commission, DG Environment, Bio by Deloitte, Universidad de Castilla-La Mancha, pp. 52.

Mandanici E., Bitelli G., 2016. Preliminary Comparison of Sentinel-2 and Landsat 8 Imagery for a Combined Use, MDPI - Remote Sensing, 2016, 8, 1014, ISSN 2072-4292, doi:10.3390/rs8121014.

Minchella A., 2015. Open satellite data in agriculture, Workshop on Open Satellite Data for Agriculture, Satellite Applications Catapult, Harwell, Oxfordshire.

Notarnicola C., Asam S., Jacob A., Marin C., Rossi M., Stendardi L., Pascual I., 2017. Mountain crop monitoring with multitemporal Sentinel-1 and Sentinel-2 imagery. MultiTemp Conference, Bruges.

Rolim J., Navarro A., Saraiva C., Vilar P., Catalaob, J., 2016. Using optical and SAR data for crops characterisation and identification. 22nd IACS/CAP Conference, Lisbon, Portugal.

Torbick N., Chowdhury D., Salas W., Qi J., 2017. Monitoring Rice Agriculture across Myanmar Using Time Series Sentinel-1 Assisted by Landsat-8 and PALSAR-2. MDPI - Remote Sensing, 2017, 9, 119, doi:10.3390/rs9020119.

***ESA: Our Activities, Observing the Earth, Copernicus, Sentinel-1, Introducing Sentinel-1. http://www.esa.int/Our_Activities/Observing_the_Earth/Copernicus/Sentinel-1/Introducing_Sentinel-1, accessed August 2017.

***ESA: Our Activities, Observing the Earth, Copernicus, Sentinel-2. Introducing Sentinel-2, http://www.esa.int/Our_Activities/Observing_the_Earth/Copernicus/Sentinel-2/Introducing_Sentinel-2, accessed August 2017.

***NASA: Landsat Science, Landsat 8, Landsat 8 Overview. https://landsat.gsfc.nasa.gov/landsat-8/landsat-8-overview/, accessed May 2017.