IOP Conference Series: Earth and Environmental Science

PAPER • OPEN ACCESS

Big Data from Space for Precision Agriculture Applications

To cite this article: F Bovolo *et al* 2020 *IOP Conf. Ser.: Earth Environ. Sci.* **509** 012004

IOP Conf. Series: Earth and Environmental Science **509** (2020) 012004 doi:10.1088/1755-1315/509/1/012004

Big Data from Space for Precision Agriculture Applications

F Bovolo[1], L Bruzzone[2], D Fernández-Prieto[3], C Paris[2], Y T Solano-Correa[1], E Volden[3], M Zanetti[2]

[1] Fondazione Bruno Kessler, Center for Information and Communication Technology, Trento, Italy
[2] Dep. of Information Engineering and Computer Science, University of Trento, Trento, Italy
[3] European Space Agency (ESA), ESRIN, Frascati, Italy

Corresponding author: bovolo@fbk.eu

Abstract. This paper presents an approach for precision agriculture large scale applications based on the analysis of big data consisting in Satellite Image Time Series (SITS) acquired by ESA Sentinel-2 (S2) satellite constellation. The approach has been developed in the framework of the ESA SEOM - Scientific Exploitation of Operational Missions - S2-4Sci Land and Water project [1]. To focus only on agricultural areas, images are first filtered based on a land cover (LC) map that is generated by updating available old maps by means of recent images. Then S2 SITS are used to analyse agricultural areas. Two macro challenges are therefore considered: (i) automatic update of LC maps and generation of agricultural areas mask; and (ii) unsupervised multi-temporal (MT) fine characterization of land plots.

1. Introduction

Applications of Remote Sensing (RS) in agriculture benefit from the prior knowledge about the areas dedicated to agricultural activities. Few LC maps exist, and they are seldom updated. Further, timely ground reference data are seldom available at large scale. A possibility to recover agricultural area information is to update existing thematic products. To this end they can be employed as an information source for extracting weak labeled training samples. Thematic information is then updated both in time and space, and effectively up-scaled to the desired spatial resolution (in this case the one of S2) by means of the weak labeled training samples and MT remote sensing images. Agriculture-related classes from the thematic maps are then ingested by a module for MT fine characterization of agricultural fields. The module is flexible and adaptive. It effectively handles massive data quantities from long SITS of RS images to identify single crop fields and perform phenological parameter extraction at parcel level with a fine characterization in space and time. These parameters are used to build crop parameter maps and informative layers to be employed by the farmers for precision agriculture management initiatives.

2. Methodology

Figure 1 depicts the general block scheme of the proposed approach for precision agriculture by using big data from space. A flexible and automatic processing chain has been designed that is able to: (i) automatically update LC maps [2], and (ii) generate unsupervised multi-temporal fine characterization of land plots [3], [4]. The method is applied at country level (Italy) and by using S2 data over an entire year (compatible with an agrarian year). Since the focus of this study is on agricultural areas, we first need to obtain an updated agricultural areas mask (based on a LC map). Only then we focus on the analysis over single crop fields (land plots). The required S2 data are first pre-processed for atmospheric and geometric corrections, as well as to extract clouds and shadows masks per granule. At this same stage, map rescaling and legend conversion to generate and updated LC map is carried out. Once the LC map is produced, agricultural areas mask is produced by selecting the areas classified as agricultural ones. This mask is used as a filter for the unsupervised land plots characterization. The proposed processing chain can be applied in the same way to any other area or any studied year.

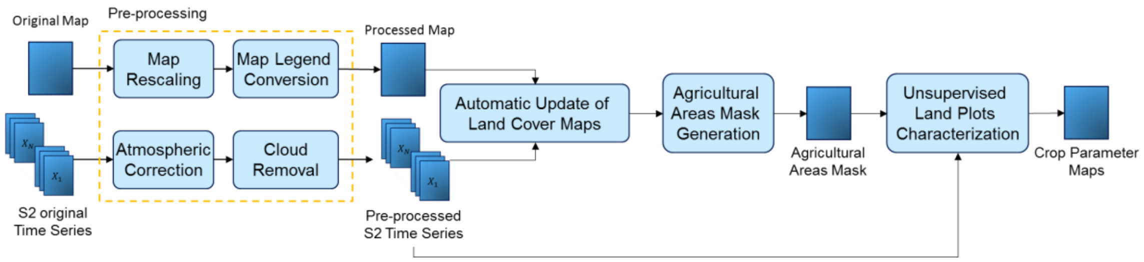

Figure 1 Block scheme of the proposed method for precision agriculture analysis from big data.

2.1. *Automatic update of land cover maps*

The system architecture of the proposed land-cover map updating method is based on three main phases: (i) pre-processing, (ii) automatic "pseudo" training set identification, and (iii) S2 time series classification. The method is based on the following constrained assumptions: i) the semantic of the classes of the thematic product can be converted in an exhaustive set of classes discriminable with the spectral content of the available time series of S2 images; and ii) the available LC map is provided at polygon level labelled according to a majority rule criterion (i.e., the associated label represent the dominant class of the polygon). Once an updated LC map is produced, agricultural areas are filtered out to produce an agricultural areas mask.

2.2. *Unsupervised multi-temporal fine characterization of land plots*

This step uses as input the pre-processed S2 SITS and the agricultural areas mask. Images with a cloud percentage higher than 75% are not considered for further analysis because considered too noisy. The method is based on three main steps: (i) spatio-temporal fusion, (ii) time series reconstruction, and (iii) crop parameter estimation. First, a crop field map is built by exploiting the spectral, spatial and temporal evolution of Normalized Difference Vegetation Index (NDVI) SITS and agricultural areas mask. Second, crop field map is used as a mask to reconstruct continuous NDVI SITS, at the single crop field level. Finally, phenological parameters are extracted at single crop field level, and thematic/informative maps are generated that allow an expert user to manage agricultural areas by precision agriculture.

3. Acknowledgement

This research has been developed under the project "SEOM - Scientific Exploitation of Operational Missions - S2-4SCI - Land and Water – Multi-temporal Analysis" funded by ESA: https://rslab.disi.unitn.it/projects/mta/.

References

[1] "ESA SEOM-S2-4Sci Land and Water Multitemporal Analysis (MTA) | RSLab," 29-Oct-2018. .
[2] C. Paris, L. Bruzzone, and D. Fernández-Prieto, "A Novel Approach to the Unsupervised Update of Land-Cover Maps by Classification of Time Series of Multispectral Images," *IEEE Transactions on Geoscience and Remote Sensing*, vol. 57, no. 7, pp. 4259–4277, Jul. 2019.
[3] Y. T. Solano-Correa, F. Bovolo, L. Bruzzone, and D. Fernández-Prieto, "Spatio-temporal evolution of crop fields in Sentinel-2 Satellite Image Time Series," in *MultiTemp 2017*, pp. 1–4.
[4] Y. T. Solano-Correa, F. Bovolo, L. Bruzzone, and D. Fernández-Prieto, "Automatic Derivation of Cropland Phenological Parameters by Adaptive Non-Parametric Regression of Sentinel-2 NDVI Time Series," in *IGARSS 2018*, 2018, pp. 1946–1949.