

Landcover classification of agricultural sites using multi-temporal COSMO-SkyMed data¹

G. Satalino, A. Balenzano, A. Belmonte, F. Mattia
CNR-ISSIA, Bari, Italy, satalino@ba.issia.cnr.it

D. Impedovo

Dipartimento di Informatica, Università degli Studi di Bari

Abstract: The objective of this paper is to report on the crop classification activities carried out during the first year of the Italian project “Use of COSMO-SkyMed data for LANDcover classification and surface parameters retrieval over agricultural sites” (COSMOLAND), funded by the Italian Space Agency. The project intends to contribute to the COSMO-SkyMed mission objectives in the agriculture and hydrology application domains. In particular, the objective of the classification activities is to assess the potential of multi-temporal series of X-band COSMO-SkyMed SAR data for crop classification. The selected agricultural site is located in the Capitanata plain close to the Foggia town (Puglia region, Southern Italy). Over this area, 8 Stripmap PingPong COSMO Sky-Med images at HH/HV polarization and at low incidence angle were acquired from April to August 2010. In the paper, a classification scheme based on the Maximum Likelihood algorithm is applied to the multi-temporal data set and its accuracy is assessed with respect to a reference map obtained by means of SPOT data.

Keywords: Land cover classification, SAR, COSMO-SkyMed, multi-temporal data

1. Introduction

The mapping of land cover/use and the monitoring of spatial and temporal variability of land surface parameters are important issues in the management of land and water resources. The improved spatial resolution and the reduced revisiting time of the new generation of spaceborne SAR systems, such as Cosmo-SkyMed, aroused an increasing interest in SAR data for land use classification. Several past studies have assessed the sensitivity of SAR data at C and L band to various crop or land classes and their use for crop mapping or land classification (McNairn et al., 2004, Skriver et al., 2010). On the contrary, relatively little work has been conducted up to date by using X-band SAR data due to the lack of long series of data. Nowadays, the availability of spaceborne SAR systems operating at X-band and characterized by a short revisiting time represents a good opportunity to deeper explore the use of this frequency for land cover classification.

In this context, the objective of this paper is to report on the crop classification activities carried out during the first year of the Italian project “Use of COSMO-SkyMed data for LANDcover classification and surface parameters retrieval over agricultural sites”

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(COSMOLAND), funded by the Italian Space Agency. The activities are still in progress and their final aim is to assess the potential of multi-temporal series of X-band COSMO-SkyMed SAR data (ASI ref., 2010) for crop classification.

In this paper, a multi-temporal series of X-band COSMO-SkyMed SAR data acquired in 2010 over an agricultural area in the Capitanata plain, Southern Italy, is investigated. The experimental data set is described in the next section, then the adopted classification algorithm and the first obtained results are illustrated and discussed. Finally, a summary and future work are drawn.

2. Materials and Methods

The investigated site (Figure 1) is located in the Capitanata plain close to Foggia town (Puglia region, Southern Italy), which is the second largest plain in Italy. The study area of approximately 700km² is mainly devoted to durum wheat cultivation (more than 50% of the total cultivated area). Other important seasonal crops are tomato and sugar beet. The classification image reported in Figure 1 shows an updated land cover map derived from 2 SPOT images acquired in 2010 (SPOT4 on 04/07/2010, and SPOT5 on 26/07/2010) classified by using the Maximum Likelihood algorithm. It is worth noting that wheat fields are already harvested in June, and therefore the class “wheat” on these dates was obtained classifying “harvested wheat”. The overall accuracy obtained is approximately 89%.

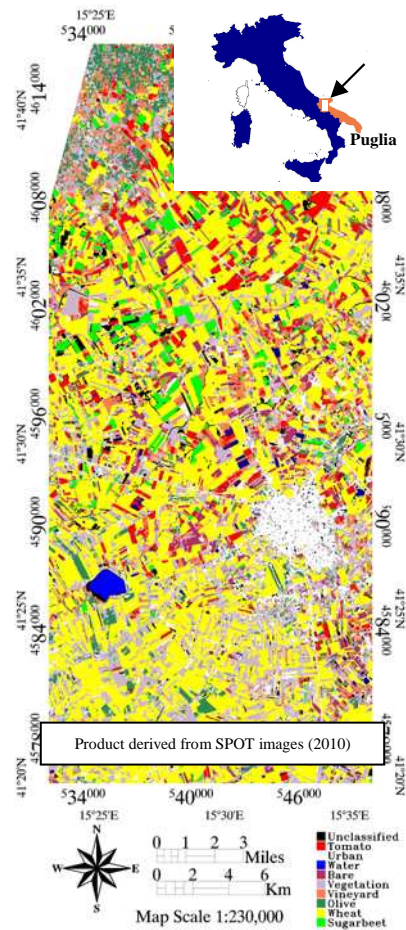


Figure 1: Land cover map of the Foggia site derived from SPOT data acquired in 2010.

Over this area, 8 Strip-map (Ping-Pong) level 1C-Geocoded Ellipsoid Corrected (GEC) products, at HH and HV polarization and at 26° mean incidence angle were also acquired from April to August 2010 (Table 1). It may be worth noting that there were no SAR acquisitions in June, which is an important period of the growing season. The SAR images were coregistered, geocoded, and spatially filtered with a Boxcar filter of 5x5 pixels.

ID	Date	Mode swath	Mean incidence angle [°]	Polarization
D1	03/04/10	StripMap PP02	26	HH/HV
D2	27/04/10	StripMap PP02	26	HH/HV
D3	21/05/10	StripMap PP02	26	HH/HV
D4	29/05/10	StripMap PP02	26	HH/HV
D5	08/07/10	StripMap PP02	26	HH/HV
D6	24/07/10	StripMap PP02	26	HH/HV
D7	01/08/10	StripMap PP02	26	HH/HV
D8	09/08/10	StripMap PP02	26	HH/HV

Table 1: COSMO-SkyMed images (level 1C-Geocoded Ellipsoid Corrected (GEC) products) acquired over the Foggia test site in 2010 .

3. Results

Previous results have shown that single-date SAR data usually are not sufficient to accurately discriminate crop classes, on the contrary multi-temporal information can significantly improve the classification accuracy (Skriver et al., 2011). To investigate the extension to which such a result holds for the Foggia site, two different scenarios were compared:

- 1) classification of 1-date SAR image at HH & HV;
- 2) classification of 3-dates SAR images at HH & HV.

The selected classes are: wheat, sugar beet, tomato, vineyard and olives. Whereas, the selected dates are from ID D1 to D6, as reported in Table 1 (i.e. 6 out of 8 COSMO-SkyMed data-taken available), because they cover the main phenological cycles from April to July of the non-permanent crops. In August and September all the crops are either already harvested or about to be harvested. The adopted classification algorithm is the Maximum Likelihood (ML) for multivariate Gaussian distributed data, as SAR data with a number of looks larger than 10 can be assumed. Training data extracted from the SAR images in correspondence of fields cultivated with the selected crops, were identified and used in the ML algorithm.

The overall accuracy (OA%) of correct classification is reported in Figure 2 for the two investigated scenarios. By using single-date SAR data (i.e. D1,...,D6), the OA ranges between 70% and 80% whereas, by using multi-date SAR data (e.g. 3D4 means 3 dates: D4, D5 and D6), the OA ranges between 80% and 90%. Therefore, multi-temporal information can bring an improvement ranging between 10% and 20%. It is also worth emphasising that a significant dependence of the OA on the specific dates is observed. For instance, on D3 and D4 the OA is significantly lower than on D1, D2, D5 and D6.

This is likely due to the fact that on D3 and D4 there is a reduced separation in the radar response of the five crop classes related to their phenological stages.

Figure 3 shows an example of land cover image obtained from multi-temporal, dual polarization COSMO SkyMed images (i.e. case 3D4, HH+HV).

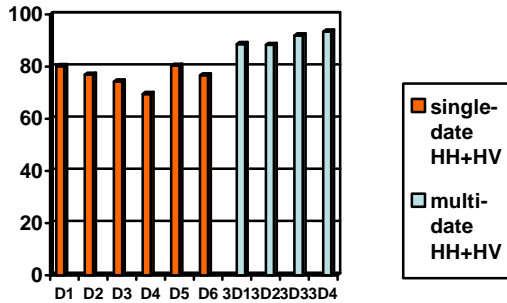


Figure 2: Overall accuracy % of single / multi-temporal, single / multi-polarization images obtained for training data. D1 to D6 are the dates of the COSMO-SkyMed images. 3D1 to 3D4 are the groups of 3 images starting from date D1 up to D4.

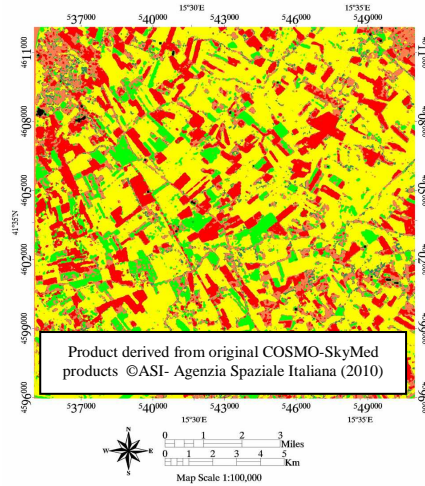


Figure 3: Land cover image obtained from HH+HV, multi-temporal COSMO-SkyMed images (acquisition dates 2010-05-29, 2010-07-08, 2010-07-24). Wheat, sugar beet, and tomato fields are in yellow, green and red, respectively.

4. Concluding remarks

This paper reported on the classification activities carried out during the first year of the COSMOLAND project. A multi-temporal series of X-band COSMO-SkyMed SAR data acquired over the Foggia agricultural site was used to investigate the potential of SAR data for crop classification. Results showed that classification accuracies improve of 10%-20% by using multi- with respect to single-date X-band SAR data. Future work will be dedicated to extend the analysis to a larger set of test fields over the Foggia site, to longer time series of COSMO data and to the other agricultural sites included in the COSMOLAND project.

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