Session Remote sensing application in agriculture
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Bracco Classroom - Chairman: Mario Gomarasca

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Mapping irrigated croplands using Sentinel-2 data in Sardinia- Italy

Introduction
This work intends to discuss the results of the research carried out for the monitoring of irrigated areas in an intensively cultivated sector of western Sardinia. Due to the limited availability of water resources in this area, the large amount required by crops need to be necessarily monitored and managed rationally. This issue involves the local administration that has to control water supplies to farmers and verify the effective usage as declared by themselves, where automatic monitoring systems are not completely used. The current availability of mid-resolution multispectral satellite data allows to continuously monitor the observed surfaces, allowing the recognition of irrigated surfaces based on the spectral characteristics.
Therefore, a remote sensed control system seems to be the best operative tool for the management of water resources in agriculture. The ESA (European Space Agency) Sentinel-2 data were used in this work to generate maps of spectral indexes for the detection of irrigated surfaces, in the perspective of a low-cost monitoring system. The study is part of a scientific partnership between the University of Cagliari and the "Consorzio di Bonifica dell'Oristanese" (CBO), and the scientific support of the University of Turin.

Study area, data and methodology
The study area covers the Arborea plain, in central-western Sardinia. This area is characterized by an intensive agriculture and croplands are irrigated during the growing season. These consist in particular of spring-summer crops with a phenological cycle from April to September. In particular the moment when water is required starts in April / May and throughout the summer, depending on the crop.
On the basis of the information provided by CBO, the Sentinel-2 MSI (Multi Spectral Instrument) data were selected as the most suitable for this purpose due to the following features: a) geometric resolution (10 - 20 m) and size of the plots, b) spectral resolution (12 band in the VNIR-SWIR region between 0.429-2.323 μm), with reference to the crop characteristics, c) temporal resolution (5 days), with reference to agronomic calendars of crops, d) the limited cloud cover during the growing season observed. Successively a dataset of 29 Sentinel-2 images from March to November 2017 have then been acquired by the ESA Sentinel-2 Data Hub.
A methodology based on the application of spectral indices has been proposed. In particular, after pre-processing steps, the Normalized Differencing Vegetation Index and the Normalized Differencing Water Index, selected as proxy of vegetation vigour and soil moisture respectively, were generated according to equations [1] and [2]:

$$NDVI = \frac{\rho NIR - \rho RED}{\rho NIR + \rho RED} \qquad [1]$$

$$NDWI = \frac{\rho GREEN - \rho MIR1}{\rho GREEN + \rho MIR1} \qquad [2]$$

where ρGREEN, ρRED, ρNIR and ρMIR1 are respectively the at-the-ground reflectance in band 3 (0.537–0.583 μm), band 4 (0.645–0.683 μm), band 8 (0.762–0.907 μm) and band 11 (1.541 – 1.685 μm) of Sentinel-2 imagery. The NDVI was initially used to separate vegetated and not-vegetated surfaces by a threshold (0.4). Successively, the NDWI was used to map the different levels of water content. In general, the NDWI assume: a) values below to 0 for the vegetated and bare soil surfaces, increasing with the increase of surface water content, b) values above 0 for surfaces with exposed water. Some maps representing vegetated areas with different values of water content, and b) images representing bare soils with different values of soil moisture were then generated for the study area.

Results and conclusions
The results allowed to obtain two classifications of water content values (irrigated areas) both on vegetation-

covered particles and on particles with bare soil.
The validation of the obtained results was discussed with the CBO technicians and was carried out on two levels:
- Verification of existing irrigation questions by the owners.
- Verification on the field of the particles irrigated at the time of acquisition of the satellite data.
The results obtained were extremely interesting:
- the values of presence /absence of water are compatible with field checks;
- anomalies have emerged with respect to what could be expected, and these have been attributed to possible water losses of the pipelines;
- some irrigated particles were not associated with irrigation demand.
Although the test area is strongly fragmented, the geometric resolution of the Sentinel-2 data allows to discriminate the behaviour of the individual plots and to associate them with the surface registry data of the properties.
The availability of a continuous time series allows to provide an effective monitoring tool for the soil moisture status, which can be associated with irrigation management.

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