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Editorial

Water Management Using Drones and Satellites in Agriculture

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Abstract: This document intends to be a presentation of the Special Issue "Water Management Using Drones and Satellites in Agriculture". The objective of this Special Issue is to provide an overview of recent advances in the methodology of using remote sensing techniques for managing water in agricultural systems. Its eight peer-reviewed articles focus on three topics: new equipment for characterizing water bodies, development of satellite-based technologies for determining crop water requirements in order to enhance irrigation efficiency, and monitoring crop water status through proximal and remote sensing. Overall, these contributions explore new solutions for improving irrigation management and an efficient assessment of crop water needs, being of great value for both researchers and advisors.

Keywords: precision agriculture; irrigation management; crop water requirements; remote and proximal sensing

1. Introduction

New technologies related to several aspects of crop management have entered with force in agriculture over the past twenty years. Mainly, these technologies are focused in facilitating the increase of net income to farmers by following the recommendations of researchers and advisors for making a sustainable use of raw materials and scarce resources, such as water. However, drones and satellites have been used to manage specific crops, with a high added value, as reviewed by Pádua et al. [1], and not always to study aspects linked to crop water management, although some attempts for compiling the advantages of using drones for this characterization have been published [2]. For this reason, the current Special Issue intends to include recent studies that address the characterization of water bodies, crop water requirements and monitoring crop water status by using new methodologies/approaches, including the most innovative satellites, such as Sentinel, and the most advanced multispectral and/or thermal cameras included in drones with great flight capacity/autonomy. Both tools, satellites and drone technologies [3,4], have been described in depth, including their advantages and disadvantages for being applied to agriculture; however, specific methodologies should be defined to achieve a real application of these techniques in precision agriculture, specifically for crop water management.

This Special Issue has been developed within the framework of the Spanish "III Symposium Nacional de Ingeniería Hortícola, Lugo – Spain" (SNIH18), where more than 70 scientific studies were presented, some of them related to the use of satellite and drone tools for managing water resources and crop water requirements. The objective of this Special Issue is to provide an overview of recent advances in the methodology of using remote sensing for agricultural water management.

2. Overview of this Special Issue

This issue contains eight papers that focus on several aspects of the management of water in agricultural systems with drones and satellites. The key points are: (i) the design of new equipment for sampling and monitoring water bodies [5–7]; (ii) tools for assessing crop water requirements from satellite images [8,9]; and (iii) development of novel algorithms and indicators for determining crop water status from proximal and remote sensing technologies [10–12].

2.1. Design of New Equipment for Characterizing Water Bodies

Three papers of this issue examine the first key point, which is the design of new equipment for characterizing water bodies. Firstly, Koparan et al. describe a system for performing water quality measurements on site [5]. This system consists of a custom-built hexacopter equipped with a multi-probe based on open-source electronic sensors that allow for measuring water temperature, electrical conductivity, dissolved oxygen, and pH. This device was tested on a 1.1 ha agricultural pond and the measurements proved to be reasonably accurate, allowing one to obtain maps displaying the spatial distribution over the pond of the measured parameters. The authors pointed out the main advantages, such as the ability for conducting measurements in remote and inaccessible waterbodies, and limitations, such as limited flight duration, of this new system [5].

A couple of works in this volume deal with new techniques for measuring the water level in reservoirs [6,7]. In this sense, Gao et al. [6] explore the advantages of integrating unmanned aerial vehicle (UAV) photogrammetry and image recognition for measuring water level. The developed system captures water fluctuation using an UAV airborne camera, and the obtained imagery is processed for measuring the water level by calibrating a set of parameters. The authors introduced a correction method for overcoming UAV drift. Finally, the authors tested their methodology in a Chinese hydropower station, obtaining reliable results [6].

Erena et al. [7] describe new equipment (aerial, floating and underwater drones) based on open-source technology that allow for data acquisition in water reservoirs and performing bathymetric surveys. The authors tested their devices on 21 reservoirs from the Segura River Basin in South-East Spain. For each reservoir, the authors carried out two flights, acquiring aerial images that allowed them to obtain a photogrammetry survey of the reservoirs. Surface water vehicles and underwater remote-operated vehicles were used for bathymetric surveys. Moreover, underwater vehicles performed water-quality measurements. Their results showed that the annual loss rate of water storage capacity was 0.33% on average for the surveyed reservoirs.

2.2. Assessing Crop Water Requirements from Satellite Images

Two articles refer to the second key point consisting of the determination of crop water needs from free satellite imagery. If spread, this kind of tool would facilitate the work of irrigation advisors and technicians, as well as promote a more efficient use of water resources. First, Aguilar et al. [8] present an evaluation and validation of the MOD16 algorithm, based on satellite information. The evapotranspiration values obtained by this approach were compared with ground-based eddy covariance measurements in five Northwestern Mexico locations. These sites are arid or semiarid and devoted to wheat cultivation or natural vegetation (shrubs). The indicators used showed a high variability among the studied sites in the performance of MOD16, usually underestimating evapotranspiration. The authors concluded that MOD16 allows for a fair estimation of crop water needs in the studied sites; however, due to the lack of ground-based measurements, a generalized use of this satellite-based approach cannot be supported by the current data.

Ramírez-Cuesta et al. [9] present a tool integrated into ArcGIS for estimating crop water needs from satellite images. The authors combined the dual crop coefficient approach [13] with imagery from

Landsat 7 and 8, and Sentinel 2A. This work shows a user-friendly tool that requires a low number of inputs (commonly available), and describes the spatial variability of crop water demands within an entire field. The authors compared the basal crop coefficients estimated by their approach with those employed as a reference for two different species: lettuce and peach, over an entire growing season. The statistical indicators showed good adjustments, with root mean squared errors ranging from 0.01 to 0.02 in both crops; however, certain underestimations were observed. In conclusion, this tool could be incorporated into decision support systems for irrigation scheduling.

2.3. Algorithms and Indicators for Characterizing Crop Water Status

Finally, three articles refer to the third key point, which is the development and use of novel algorithms and indicators for characterizing the status of crops, using drones or satellites. In this sense, the changes in lighting intensity throughout the day can alter the performance of machine vision systems used in precision agriculture for managing irrigation. In order to solve this issue, Sabzi et al. [10] developed a five-step algorithm for apples grown in outdoor conditions. Authors trained and tested this algorithm in an apple orchard under 16 different light intensities. The accuracy of the proposed algorithm was higher than 99%, outperforming existing methods. The authors related their results to decision making for irrigation scheduling, although they did not perform any experiments on this matter.

Serrano et al. [11,12] focused on characterizing the quality of the Montado ecosystem, which occupies a large surface in Mediterranean countries. The natural dryland pasture is the main source for animal feed in extensive grazing within this system. The inter-annual variability of rainfall affects the development of pastures in this system, and, consequently, their nutritive values. First, Serrano et al. [11] aimed to evaluate two approaches for monitoring the evolution of pasture quality during the period of highest vegetative development. These approaches consisted of proximal sensing (using an optical sensor) and remote sensing (using images from Sentinel 2 satellite). From the information obtained, the authors calculated the Normalized Difference Vegetation Index (NDVI) and the Pasture Quality Degradation Index (PDQI), showing significant correlations between both indices obtained by proximal or remote sensing. The NDVI below 0.6 (and PDQI above 0.7) indicated the need for food supplementation. The authors reported operational advantages of remote over proximal sensing but noted that frequent cloudiness in spring may be an impediment for determining NDVI and PDQI from satellite images. In conclusion, the authors suggested the combined use of both techniques for soil, pasture and grazing management.

Finally, Serrano et al. [12] assessed the usefulness of the Normalized Difference Water Index (NDWI) based on Sentinel 2 imagery as a tool for monitoring pasture seasonal dynamics and inter-annual variability in the Montado system. The authors used 41 valid NDWI records from 2016 to 2018 and correlated them to measurements of soil water content, pasture moisture content, surface temperature, biomass productivity, and PDQI. Significant correlations were observed between NDVI and the variables measured in the field; the regression coefficients ranged from 0.54 to 0.89. Therefore, satellite-derived NDWI could be used for supporting decision-making in site-specific management of the Montado ecosystem.

3. Conclusions

At present, remote sensing technologies (including images and vegetation indices obtained by drones and satellites) have begun to be widely used for managing irrigation and other agricultural practices in agro-systems. Nevertheless, a generalized use of these tools requires a deep knowledge of crop water demands and the relations between them and the indices obtained by remote sensing. This Special Issue on “Water Management Using Drones and Satellites in Agriculture” presents several techniques able to cope with monitoring water level in reservoirs, accurately determining crop water needs, and novel indices for monitoring crop water status and quality.

Contributions to this Special Issue, exploring novel equipment and mathematical tools for monitoring water reservoirs and assessing crop water demands, are expected to be valuable for both researchers and agronomists, as well as for farmers and advisors. The technologies described in this Special Issue could be of great help for improving water use efficiency in agricultural systems.

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