remote sensing

Editorial

Remote Sensing in Irrigated Crop Water Stress Assessment

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Optimizing water management in agriculture is of crucial importance, especially in arid and semi-arid regions where the existing water shortage is exacerbated by human activities and climate change. In these regions, water scarcity is one of the main factors limiting agricultural development, and thus, food security. The impact of such water scarcity is amplified by inefficient irrigation practices. This has led to important water loss, especially since irrigation consumes more than 85% of the available water in these regions. Increasing water use efficiency in agriculture is, thus, necessary to improve on-farm irrigation management by adjusting the irrigation amount to crop water requirements during the crop growing season.

Crop water stress can be detected by measuring the in situ root zone soil moisture to trigger irrigation. However, these point measurements are site specific, expensive, and time consuming. Therefore, remote sensing provides an alternative and cost-effective method for mapping and monitoring large areas, which can be used to assess crop water stress.

In this context, the current Special Issue focuses on the use of different remote sensing data for the assessment of crop water stress (CWS). Twelve papers are published in this issue. One paper is a review [1] that presents various remote sensing technologies used to detect crop water stress, including optical sensing systems, thermometric sensing systems, land surface temperature sensing systems, multispectral (space borne and airborne) sensing systems, hyper-spectral sensing systems, and the LiDAR sensing system.

Gu et al. [2] used the crop water stress index (CWSI) based on canopy temperature as a proxy of phenotyping maize performance under combined water and salt stress. The results show that this approach is valuable for predicting yield and improving water use efficiency.

Zhou et al. [3] tested a variety of spectral vegetation indexes (SVIs) for monitoring crop water stress. In this study, an experimental approach was carried out in order to examine the relationships between five SVIs (WI, NDWI, NDII, NDVI, and OSAVI) and plant water stress for analyzing the direct and indirect methods by which crop biomass and water content influence different SVIs.

Puig-Sirera et al. [4] used a combined approach of high-resolution thermal/spectral imagery acquired by UAVs to examine how different soil management practices affect the water status in complex rainfed vineyards. Specifically, the different soil management treatments were analyzed in terms of crop water status, vegetation vigor, and chlorophyll content through the thermal-based crop water stress index.

Two studies [5,6] evaluate the performance of the two-source energy balance (TSEB) model for estimating evapotranspiration in irrigated almond trees in Spain and over wheat crops in Morocco, respectively. Both studies evaluated the estimates of evapotranspiration (ET) against eddy covariance measurements. In the work of Jofre Cekalovicet al. [5], the TSEB model was driven by the sharpened Sentinel-2 and Sentinel-3 images, and the results show that the model is suitable for monitoring water use in almond trees under different irrigation regimes. For the work of Ait Hssaine et al. [6], the TSEB model was constrained by soil moisture derived from Sentinel-1 and SMAP, in addition to Landsat thermal data,

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and the results show that the integration of microwave data significantly improved the ET estimates, mainly for the irrigated sites.

An approach based on a soil water balance model driven by remote sensing data, implemented using SAMIR software, for assessing crop irrigation requirements and crop water stress, was assessed by Kharrou et al. [7]. The authors explored the spatio-temporal patterns of irrigation water use between fields in the Haouz plain (Morocco). Clear spatiotemporal variability was found in irrigation water demands and supplies, which is mainly due to the inadequate irrigation supply related to the lack of reliable spatial information on the current soil water status and the farmer management practices (cultivar, sowing date, irrigation, fertilizers, weed control, etc.).

For the efficient and optimized spatiotemporal allocation of irrigation water in a surface irrigation system, Belaqziz et al. [8] developed an innovative approach based on remote sensing data and on the covariance matrix adaptation–evolution strategy (CMA-ES), in order to optimize the spatiotemporal sowing date distribution of wheat crop in a large irrigation scheme located in Haouz plain. Six sowing date scenarios were simulated and compared to identify the most optimal spatiotemporal sowing calendar. The obtained results show that with reference to the existing sowing patterns, the early sowing of wheat (mid-November) leads to higher yields compared to late sowing. Compared with actual conditions in the study area, the spatial heterogeneity is highly reduced, which increases equity between farmers.

Surface albedo is a key land surface variable to constrain the surface radiation budget and, hence, the coupled water–surface energy balance. In order to capture the crop water stress over the growing season, optical remote sensing becomes impractical due to cloud cover in some periods. To overcome this problem, Amazirh et al. [9] developed an approach based on Random Forest (RF) algorithms to retrieve the cloudless surface albedo from Sentinel-1 data that offers a source of high spatio-temporal resolution images. The RF algorithms were based on the correlation between VV and VH polarization backscatter coefficients with the albedo derived from Landsat images. The approach was tested over an irrigated semi-arid zone in Morocco, which is known by its heterogeneity in terms of soil conditions and crop types. The results show that the RF approach achieves very good albedo modeling performances.

Shahzaman et al. [10,11] investigated the use of different remote sensing indices for the spatial monitoring of agricultural drought in south Asian countries. In their study [10], the authors analyzed the agricultural drought in Afghanistan, Pakistan, India, and Bangladesh, based on the following indices: the evaporative stress index (ESI), vegetation health index (VHI), enhanced vegetation index (EVI), and standardized anomaly index (SAI), which were derived from satellite remote sensing data from 2002–2019. The results indicate a severe agricultural drought during the year 2002, compared to the other years. The southeast region of Pakistan, and the north, northwest, and southwest regions of India and Afghanistan were also shown to be significantly affected by drought. However, Bangladesh faced substantial drought in the northeast and northwest regions during the drought year (2002).

The performances of other remote sensing data, such as soil moisture products (MERRA-2, CPC, FLDAS, GLDAS, and ERA5), precipitation products (CHIRPS and GPCC), and terrestrial water storage products (MERRA-2 TWS and GRACE TWS), were presented by Shahzaman et al. [11] to support agricultural drought characterization in South Asia based on standardized index/standardized anomaly and K-means algorithms. The relationships between crop yield and drought indices were also assessed in this study based on the yield anomaly index (YAI).

Finally, Rafik et al. [12] explored the potential of satellite imagery to detect the spatiotemporal variation of soil salinity in the Tafilalet plain (Morocco). In this study, 19 satellite images acquired from Thematic Mapper (TM), Enhanced Thematic Mapper Plus (ETM+), Operational Land Imager (OLI), and Multispectral Instrument (MSI) were used to produce spatial and temporal maps of soil salinity. As soil salinity is mainly controlled by the cyclicity of droughts in desert regions such as the Tafilalet plain, the precipitation data over a period of 36 years (1983–2019) are used to calculate SPAI (standardized precipitation anomaly index), which allows the impact of water stress on the soil salinization phenomenon to be assessed. The study showed that the spatio-temporal distribution of soil salinity in the Tafilalet plain is highly variable and negatively correlated with the SPAI (R^2 = 0.65). An accumulation of mineralization in soils occurred during the deficit periods due to the high values of evapotranspiration.

In summary, all the studies included in this SI constitute a set of the different methods and approaches used for modeling evapotranspiration, monitoring agricultural drought, and assessing crop water stress (CWS) based on remote sensing data, including optical, microwave, thermal, and UAV data.

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