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Editorial: Recent advances in agrometeorological analysis techniques for crop monitoring in support of food security early warning

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Editorial on the Research Topic
Recent advances in agrometeorological analysis techniques for crop monitoring in support of food security early warning

Agrometeorological analysis is an essential component of effective crop monitoring systems, providing cost-effective complementarity to field surveys typically used to assess crop conditions and potential food security outcomes during each agricultural season. Using satellite-based agrometeorological techniques to strengthen crop monitoring can present significant cost saving to traditional field-based methods typically used for crop assessment. However, remote-sensing-based agrometeorological methods are not a replacement for field-based methods but complement, as the accuracy of the satellite-based methods often cannot be fully assessed or calibrated without compatible field-based measurements or equivalents.

In this collection, over thirty authors wrote articles that highlight critical aspects of agrometeorological analyses applied to crop monitoring for food security early warning. The themes covered a wide range of topics, including; (1) agrometeorological forecasting, (2) crop monitoring (including crop water balance and the assessment of pest damage), (3) estimation of crop production, (4) assessing water stress for croplands at a watershed scale, and (5) how to effectively deliver agrometeorological advisories to farmers. This set of themes can provide helpful guidance to assist practitioners develop and strengthen practical agrometeorological analysis and advisory systems.

The low-cost advantage of agrometeorology-based techniques is significant for poorly resourced institutions mandated with providing agrometeorological support for food security monitoring. Mashonganyika et al. used 10 m resolution satellite data from Sentinel-2 data to estimate wheat area in Zimbabwe, with an R-squared of 0.98 compared to farmer-reported planted area. Focusing on Malawi, Peterson and Husak used Sentinel-2 satellite data to map crop area with Google Earth Engine to an accuracy of 74% compared with official statistics. These examples illustrate the opportunity to use vast amounts of data at low cost, harnessing the power of cloud computing from a relatively low-end computer and on a small budget, which would be the typical scenario in a low-resourced institution. Mashonganyika et al. further highlighted the economic importance of such enhanced crop monitoring for developing country government initiatives. Many developing countries have agricultural input subsidy programmes to help farmers maximize agricultural productivity due to high input costs that would otherwise curtail farming activities. However, these subsidy programs, need to be monitored to ensure compliance and maximize outcomes. Large-scale, field-based crop monitoring is an expensive exercise that could quickly be sidelined due to the financial constraints typically facing developing country governments. The satellite-based crop monitoring methods demonstrated in this collection can thus play a critical role in effective crop monitoring.

Although the satellite analysis methods and services described in these articles are currently low-cost within a research framework, one risk in their application for operational use is the possibility of commercialization of these services in the future, which could put the benefits out of the reach of many under-funded institutions. Some tools and datasets are open access for research purposes, and operational or commercial uses require paid licenses.

While remote sensing agrometeorological applications have come a long way since the launch of the first earth observation satellites, not all remote sensing methodologies for agrometeorological monitoring have reached full maturity for operational use, highlighting the need for continual research and development. Adams et al. attempted to assess the impacts of the 2020 desert locust outbreak in East Africa using satellite data from various sensors. This proved largely unsuccessful—the localized nature of locust outbreaks could not be easily distinguished from senescence using satellite image analysis, underscoring the necessity of ground truth data.

Crop production is calculated as a function of yield and cropped area. Peterson and Husak and Mashonganyika et al. demonstrated how crop area could be estimated from remote sensing methods. However, to get a complete picture of crop performance, evaluating potential yield outcomes is equally important. Pervez et al. demonstrated an improved approach for seasonal vegetation monitoring that combines the use of two satellite-based analysis methods—normalized difference evapotranspiration (NDVI) and evapotranspiration (ET)—by identifying where each performs better, thus allowing optimal use of these methods for seasonal vegetation monitoring, an important step toward yield estimation.

Food and water security are inextricably linked, given agriculture's dependence on water. Khand et al. demonstrated how water stresses for rainfed and irrigated croplands could be estimated at a basin-scale and compared water stress levels for different basins and different years. This type of basin-scale analysis provides an opportunity for linking food security analysis into a more holistic basin-management approach.

Crop monitoring techniques compatible with short to medium-term forecasts facilitate planning food security, agricultural production, and disaster risk reduction. Funk, Turner et al. discussed a novel approach that simplifies the dekadal water requirements satisfaction index into a seasonal-scale parameter that can be used with medium-range to seasonal-scale forecasts. This will allow farmers and disaster risk reduction managers to make informed decisions regarding options for managing upcoming seasons and refine and update their plans as more observational data becomes available.

Ultimately, the agrometeorological techniques described above must be delivered to end-users through accessible systems. This is typically not a one-off process, as illustrated by Walker using three case studies of agrometeorological advisories for farmers, but rather involves extended interactions and feedback loops with users to refine the products and achieve high levels of acceptance and adoption by the user. Thus, agrometeorological analysis methodologies need to be developed in consultation with the intended users to ensure products with a high level of societal benefit and application for food security.

Concluding remarks

Despite the opportunities availing with the steady progress in technology, a fundamental limitation to the use and applications of agrometeorological innovations within critical institutions in developing countries remains the availability of skilled personnel to undertake the types of analyses described in this collection. Under-resourced agrometeorological institutions in developing countries need to highlight to beneficiaries the economic benefits of investing in their operations, both in terms of the technological and the human resource requirements, given the potential benefits that governments can realize from effectively utilizing agrometeorological analysis for crop monitoring in support of food security early warning.

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