



Synergetic Use of Sentinel-1 and Sentinel-2 data for Wheat Crop Height Monitoring Using Machine Learning

Dr Cilence Munghemezulu

e-Mail: MunghemezuluC@arc.agric.za



AGRICULTURAL RESEARCH COUNCIL

Outline

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- Project Information

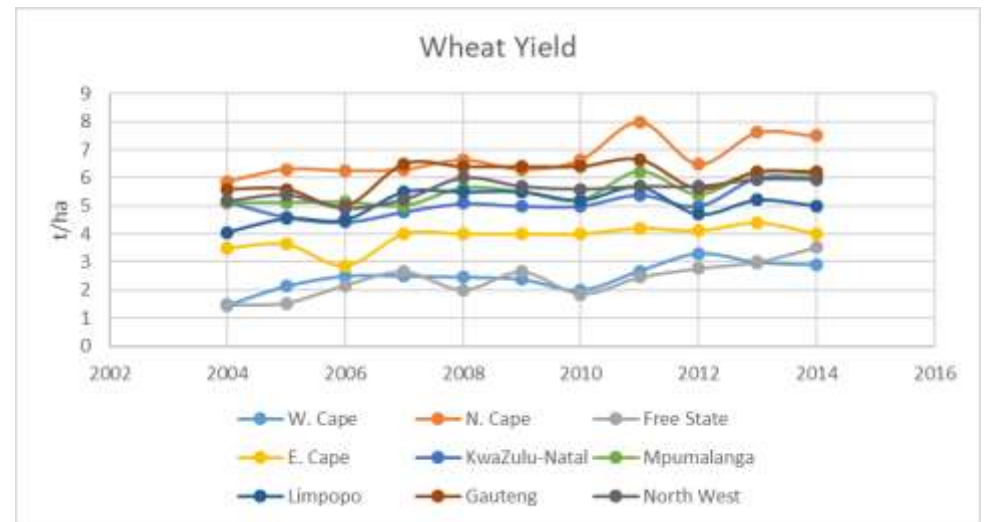
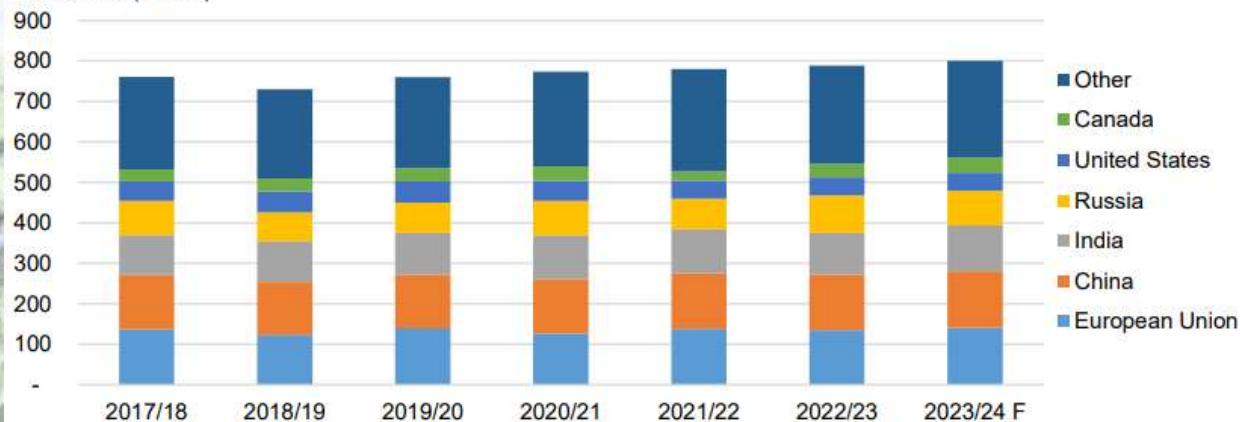


Wheat Crop

- Millions of people depend on wheat crop
- Supply is affected by climate, global geopolitics, etc.
- Increase in basic food prices affects food security
- Sentinel-1&2 can contribute towards wheat crop management, thus towards food security

Top wheat producing countries, 2017/18–2023/24

Metric tons (million)

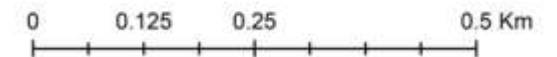
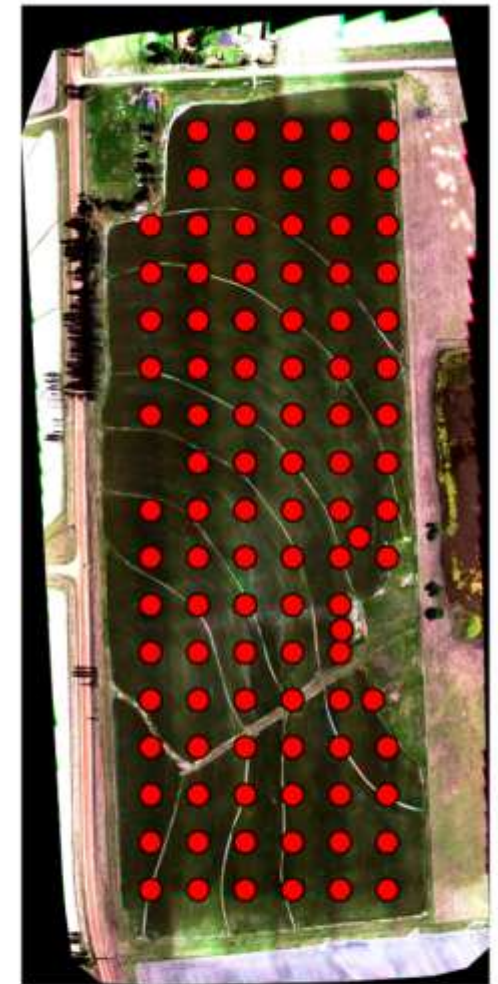
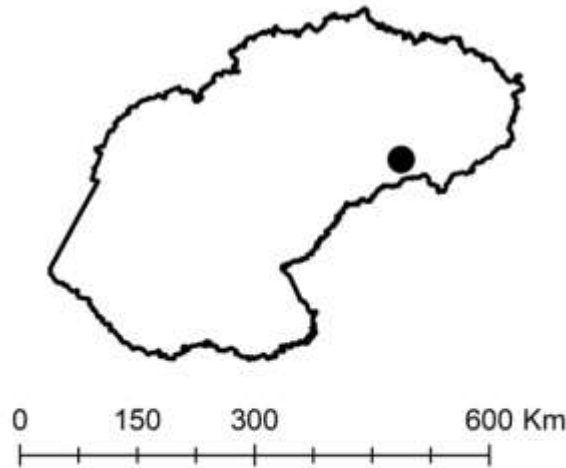
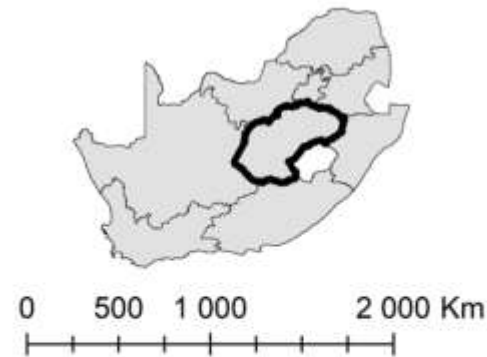


Study Area

- Site is in Clarens, within Thabo Mofutsanyane district in Free State Province
- The site receives an annual average rainfall of 688 mm
- Minimum and maximum of 7.8- and 20.7-degree Celsius average temperatures during the winter and summer seasons respectively

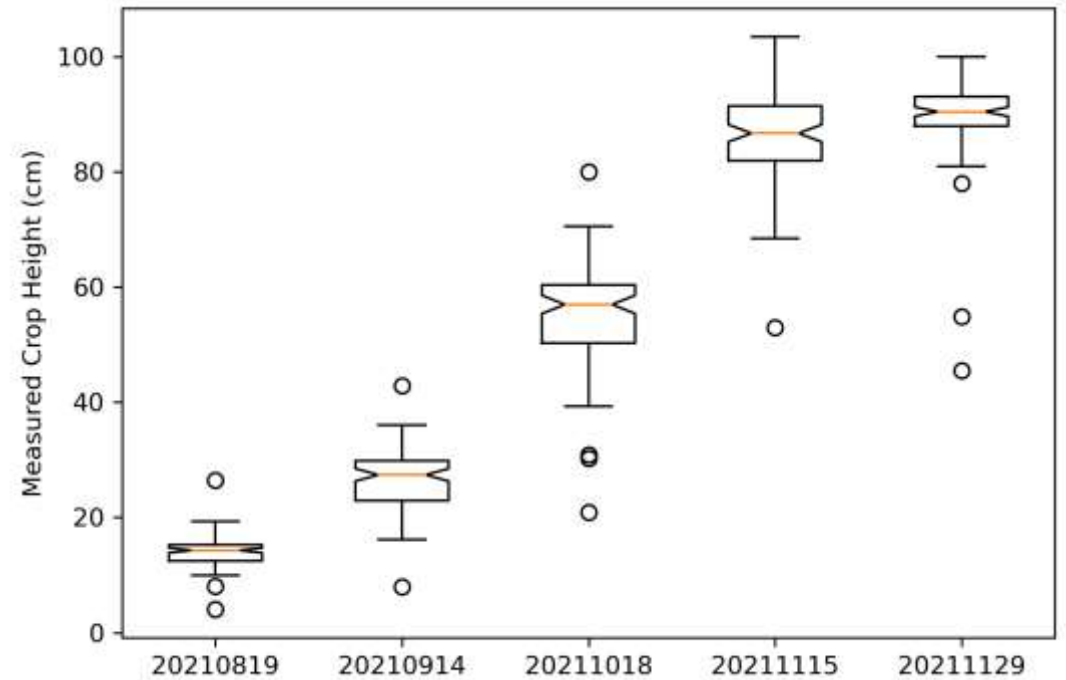
Table 1: Phenological stages of the wheat crop

Phenological Stages	Dates	Activity
Seeding	2021/07/02	Planting
Early germination	2021/08/19	Sentinel-1-&-2
Early Development	2021/09/14	Sentinel-1-&-2
Late Development	2021/10/18	Sentinel-1-&-2
Maturity Stage	2021/11/15	Sentinel-1-&-2
Senescence	2021/11/29	Sentinel-1-&-2



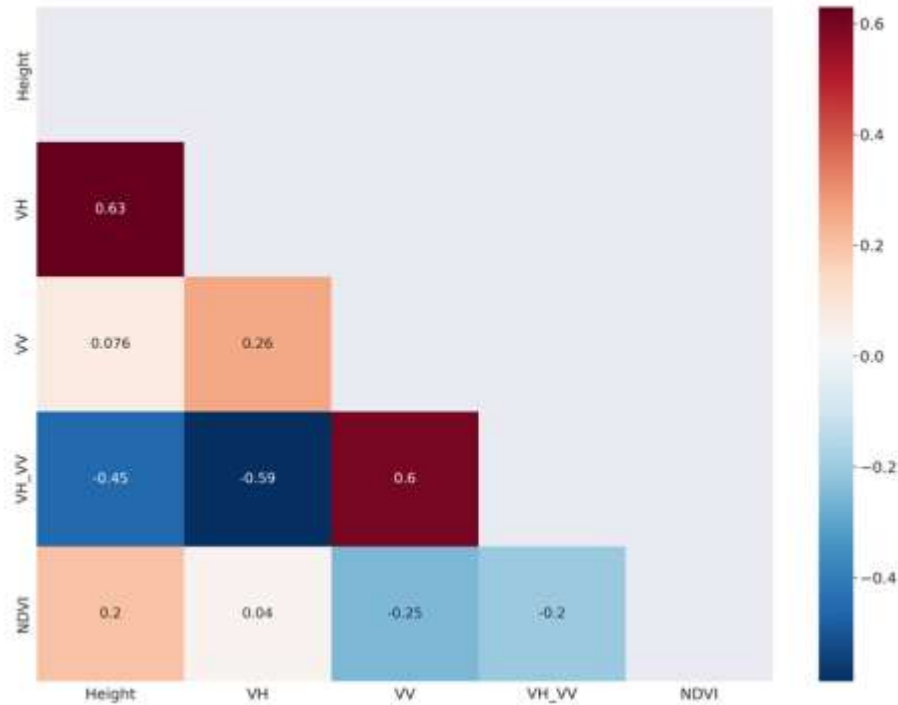
Method

- **Goal:**
 - Generate simple and usable model but accurate
- **Variables:**
 - Sentinel-2
 - NDVI
 - Sentinel-1
 - VH & VV
 - VH/VV
 - Measured height (cm)
 - N=100
- **Models:**
 - Random Forest (RF)
 - Support Vector Machine (SVM)
- **Validation:**
 - 70%-training and 30%-validation data split
 - 5-fold cross validation
 - RMSE
 - R-squared



Results and Discussion

Correlation matrix



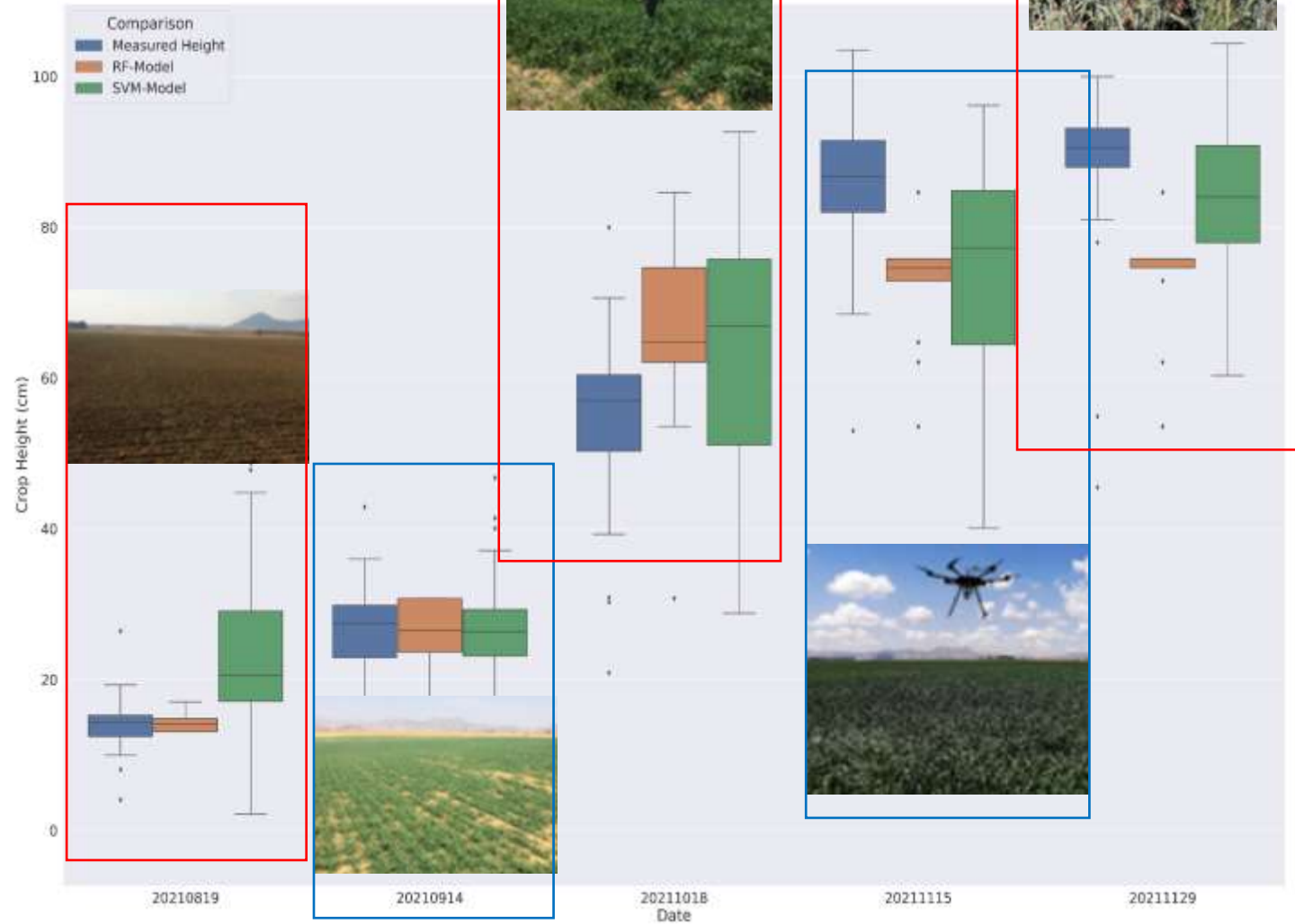
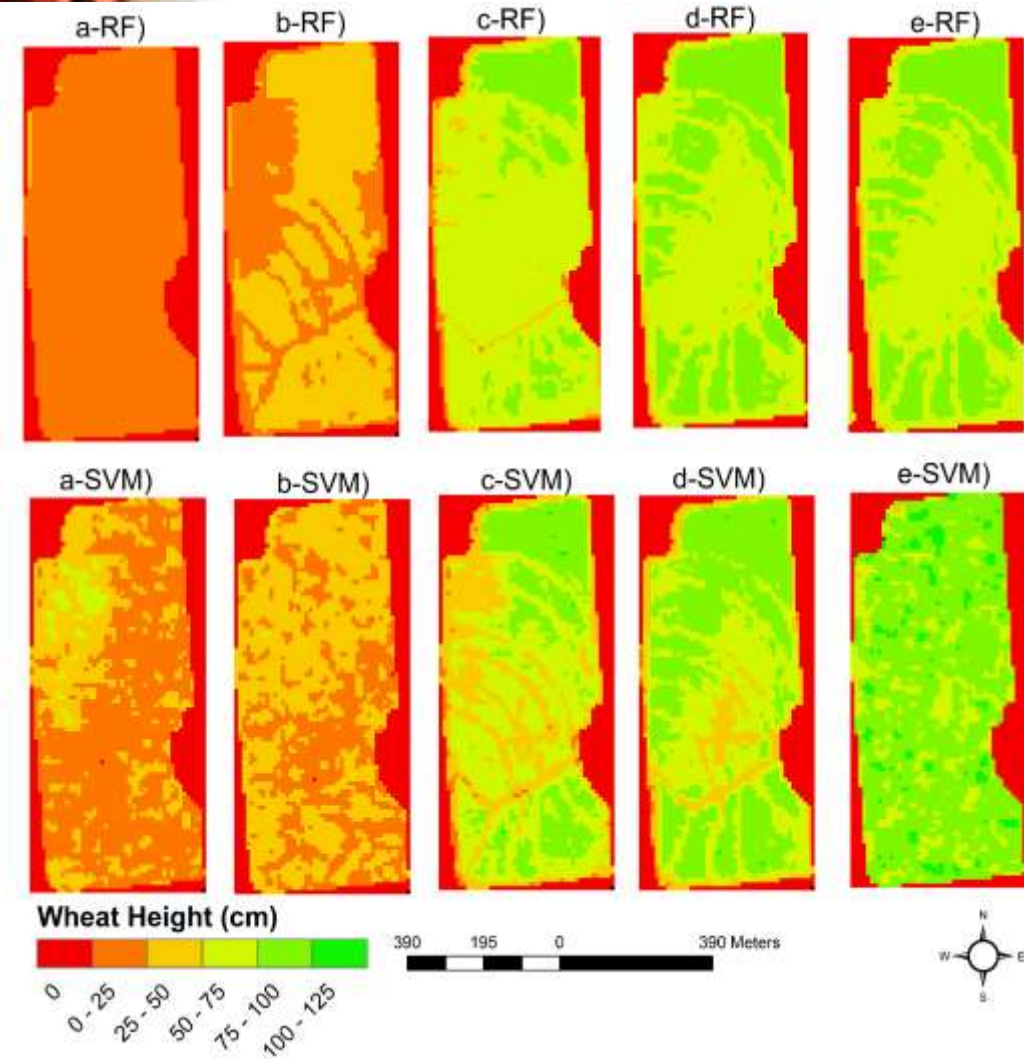
Mean values during crop stages



Model performance

Methods	Sentinel-1		Sentinel-1+Sentinel-2 NDVI	
	R2	RMSE (cm)	R2	RMSE (cm)
SVM	0.40	24.246	0.74	16.075
RF	0.35	25.334	0.84	12.58

Results and Discussion



Conclusion and Future Research

- Sentinel-1&2 datasets have proven to be very useful in modelling wheat height during different crop stages
- Farmers can benefit from such product in monitoring and managing their investments
- Models of different crops should be developed to assist more farmers



Project Information

- Collect multi-temporal UAV datasets of different crops and develop models to generate level 3 products and upscale to satellite-level
- Funded by CSIR and DSI in 2021/22/23 FY
- Different crops: maize, wheat were collected.
- More crops to be added in the future
- Two PhD students: Mrs Colette de Villiers and Mr Lwandile Nduku

Global Research Trends for Unmanned Aerial Vehicle Remote Sensing Application in Wheat Crop Monitoring

Keywords: Wheat, UAV, remote sensing, crop monitoring, precision agriculture, yield prediction, crop stress, crop health, crop growth, crop yield, crop quality, crop management, crop production, crop loss, crop damage, crop insurance, crop risk, crop resilience, crop sustainability, crop security, crop safety, crop health, crop quality, crop yield, crop production, crop loss, crop damage, crop insurance, crop risk, crop resilience, crop sustainability, crop security, crop safety.

Abstract: Wheat is an important staple crop in the global food chain. The production of wheat in many regions is constrained by the lack of use of advanced technologies for wheat monitoring. Unmanned Aerial Vehicle (UAV) remote sensing is an important platform to monitor wheat for pest infestation and crop yield estimation. This review article is a critical analysis of the current research on UAV remote sensing for wheat crop monitoring. The review covers the following areas: 1) UAV remote sensing for wheat crop monitoring; 2) UAV remote sensing for wheat crop yield estimation; 3) UAV remote sensing for wheat crop stress detection; 4) UAV remote sensing for wheat crop quality assessment; 5) UAV remote sensing for wheat crop loss estimation; 6) UAV remote sensing for wheat crop damage assessment; 7) UAV remote sensing for wheat crop insurance; 8) UAV remote sensing for wheat crop risk assessment; 9) UAV remote sensing for wheat crop resilience assessment; 10) UAV remote sensing for wheat crop sustainability assessment; 11) UAV remote sensing for wheat crop security assessment; 12) UAV remote sensing for wheat crop safety assessment.

Current research output

Unmanned Aerial Vehicle (UAV) and Spectral Datasets in South Africa for Precision Agriculture

Abstract: Remote sensing data play a crucial role in precision agriculture and natural resource monitoring. The use of unmanned aerial vehicle (UAV) can provide solutions to challenges faced by farmers and natural resource managers due to its high spatial resolution and flexibility compared to satellite remote sensing. This paper presents UAV and spectral datasets collected from different points in South Africa, covering different crops at the farm level as well as natural resources. UAV datasets consist of five hyperspectral bands corrected for atmospheric effects using the P4x40 software to produce false-color images. The spectral datasets are derived using the study of Guly 2016, corrected for Multiple Scatter Correction (MSC). The first and second derivatives and the Continuous Wavelet Transform (CWT) spectra are also calculated. These datasets can provide baseline information for developing solutions for precision agriculture and natural resource challenges. For example, UAV and spectral data of different crop fields captured at spatial and temporal resolutions can contribute towards identifying suitable images, thus improving the accuracy of the derived satellite products.

Weed detection in rainfed maize crops using UAV and PlanetScope imagery

Abstract: Weed invasion of crop fields such as maize is a major threat leading to yield reduction or crop right-of-farm for smallholder farmers, especially in developing countries. A remote view and accurate detection of weed invasions can save the crop. The Sustainable Development Goals (SDGs) identified food security as a major issue point. The objectives of this study were to: 1) Assess the possibility of mapping maize-weed infestations using multi-temporal data, Unmanned Aerial Vehicle (UAV) and PlanetScope data by utilizing machine learning algorithms; 2) Determine the optimal timing during the maize growing season for effective weed detection. The UAV and PlanetScope satellite imagery were used to map weeds using machine learning algorithms: Random Forest (RF) and Support Vector Machine (SVM). The input features included spectral bands, adding space channels, and various vegetation indices derived from the datasets. Feature principal component analysis (PCA) was used to produce PCs that served as input to the classification. In this study, 1) correlated eight experiments, four each for UAV and PlanetScope datasets spanning four months. Experiment 1 utilized all bands with the RF classifier. Experiment 2 used all bands with SVM. Experiment 3 employed principal components (PCs) with RF, and Experiment 4 utilized PCs with SVM. The results revealed that PlanetScope achieved accuracies below 40% in all four experiments. The best overall performance was observed for Experiment 1 using the UAV based on the highest mean accuracy score (mAP), which included the overall accuracy, precision, recall, F1 score and cross-validation scores. The most optimal stage for weed detection was found to be during the reproductive stage of the crop cycle based on the best F1 score being indicated for the maize and weeds class. This study provided pivotal information about the spatial distribution of weeds in maize fields and we believe that such information is essential for sustainable weed management in agricultural activities.

