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Machine learning modelling of crop structure within the Maize Triangle of South Africa

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Abstract

Maize has been identified as a strategic commodity for the reduction of poverty and enhancement of food security in the African continent. Climate variability and difficult economic conditions are pressuring farmers to produce higher (maize) yields with fewer inputs, per hectare. The remote sensing of crop specific structural parameters are essential in identifying the particular growth stages of the maize crop which require specific tasks from the farmer (e.g. weed control, top dressing, pesticide application for disease and borer control and critical moisture phase). This study sought to assess the performance of multiple linear regression (LR), Random Forest (RF) and Gaussian Process Regression (GPR) in the estimation of four maize crop structural parameters in a study area in the Vereeniging region of the Maize Triangle of South Africa. These parameters were leaf area index (LAI), stem height (HT), stem diameter (DIA) and stem density (SD). An additional aim was to investigate whether the combination of selected spectral vegetation indices (red-edge, chlorophyll, senescence and greenness) with Sentinel-2 reflectance bands as modelling predictors yielded improved results over the individual spectral bands alone. Combining reflectance bands and vegetation indices as modelling predictors yielded the highest validation accuracy, over other scenarios, for only one out of the four crop structural parameters (DAI). The reflectance bands only scenario yielded the highest validation accuracies for two crop structural parameters (HT and SD). The use of spectral vegetation indices alone as modelling predictors yielded the highest modelling accuracies for the LAI crop parameter than the other scenarios. These trends indicate that the combination of Sentinel-2 reflectance bands and derived vegetation indices do not always yield improved modelling results for the four crop structural parameters under investigation. As a result, reflectance bands (mostly) or indices alone could suffice for nearly all of the parameters. With respect to the modelling algorithms, LR yielded the highest accuracies for DIA and SD (Standard Error of Prediction or SEP values of 22.40%±4.65 and 34.15%±2.72 respectively). GPR yielded the highest accuracies for LAI and HT (SEP values of 28.69%±3.84 and 23.19%±2.27 respectively) while RF did not yield the highest validation accuracy for any of the crop structural parameters.