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Herbage Biomass Estimation From UAV And Sentinel-2: Preliminary Results From PINDARICO And PRECISION SHEEP Projects

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Introduction

Grassland-based mixed farming systems characterize Mediterranean marginal inland areas and guarantee the provision of several agroecosystem services. In this context, decision support systems (DSS) offer a great opportunity for farmers to increase knowledge on herbage availability.

Materials and Methods

The test site of this study is located in the southern Tuscany, Italy. Herbage biomass samples were collected considering the different growth cycle of each crop from July 2020 to November 2020. The harvest was carried out with a monthly frequency by destructive sampling of vegetation by referring to Sentinel-2 overpass and unmanned aerial vehicle (UAV) measurements.
The relationship between multispectral bands (Red, Green, NIR and Red-Edge) from S2 and UAV, and AGB was evaluated by (i) machine learning algorithms (MLRAs): gaussian process regression (GPR) and neural network (NN), (ii) multiple linear regression model (MLR) and (iii) a linear regression model (LR) with Normalized Difference Vegetation Index (NDVI) and AGB. For this analysis, the MLRA toolbox of the software Automated Radiative Transfer Models Operator (ARTMO) and R environment were used.

Results

Table 1. Cross-validation results of AGB estimation with Least squares linear regression-LSLR; Partial least squares regression-PLSR, Gaussian process regression-GPR; Neural Network-NN. Multiple Linear Regression (MLR) tested on multispectral bands. Linear regression model (LR) was carried out with NDVI. MAE, Mean Absolute Error. RMSE, Root Mean Squared Error.

Sensor	Methods	Algorithms	MAE [g DM 0.25m^{-2}]	RMSE [g DM 0.25m^{-2}]	R^2	Time Total [s]	Time Train [s]	Time Test [s]
S2	MLRA	GPR	7.3	9.4	0.71	0.31	0.31	0
		NN	7.87	10.34	0.65	4.78	4.76	0
		LSLR	9.33	11.87	0.54	0	0	0
		PLSR	9.31	11.87	0.54	0.01	0.01	0
	MLR		3.5	4.16	0.76			
	LR		4.33	5.99	0.62			
UAV	MLRA	GPR	7	9.42	0.71	0.35	0.35	0
		NN	8.29	10.64	0.64	4.59	4.57	0.01
		LSLR	8.24	10.64	0.63	0	0	0
		PLSR	8.23	10.65	0.63	0.01	0	0
	MLR		8.12	9.85	0.66			
	LR		9.24	11.99	0.51			

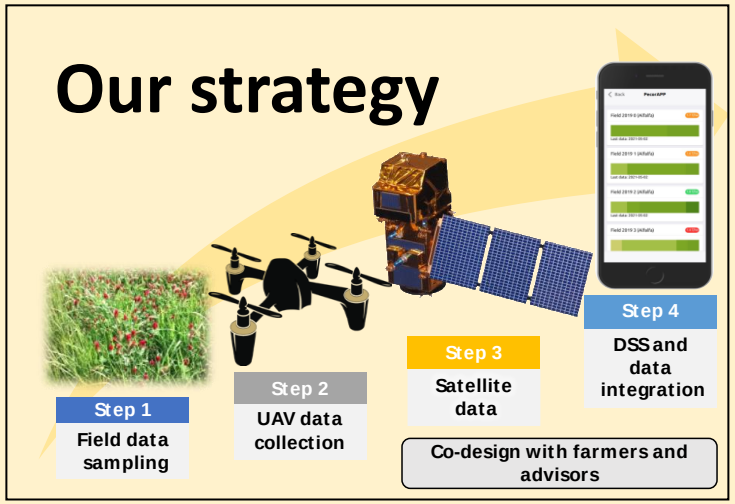

Table 1 shows the performance of the MLRAs, MLR and LR tested for AGB estimation using high-resolution and medium-resolution RS data. Results of MLRAs showed that UAV and S2 sensor had similar performance for AGB estimation with R^2 of 0.711 and 0.709. Moreover, among the tested MLRAs for both sensors, GPR and NN exhibited the highest R^2 (>0.63) and the lowest error (RMSE<10.64). Conversely, the worst result was obtained using the LR. LR showed an R2 of 0.62 and 0.51 for S2 and UAV respectively. The results showed that S2 can deal with biomass variability when AGB retrieval is carried out using the MLRAs and MLR approaches.

Conclusions

This study examined the performance of parametric and non-parametric regression models for AGB estimation using both medium (S2) and high (UAV) resolution images. As further steps, a prototype of a smartphone application will be developed to assess how to communicate to farmers the results of the model. The outcomes from this study can serve as opportunity to develop operational temporary grassland monitoring systems.

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