

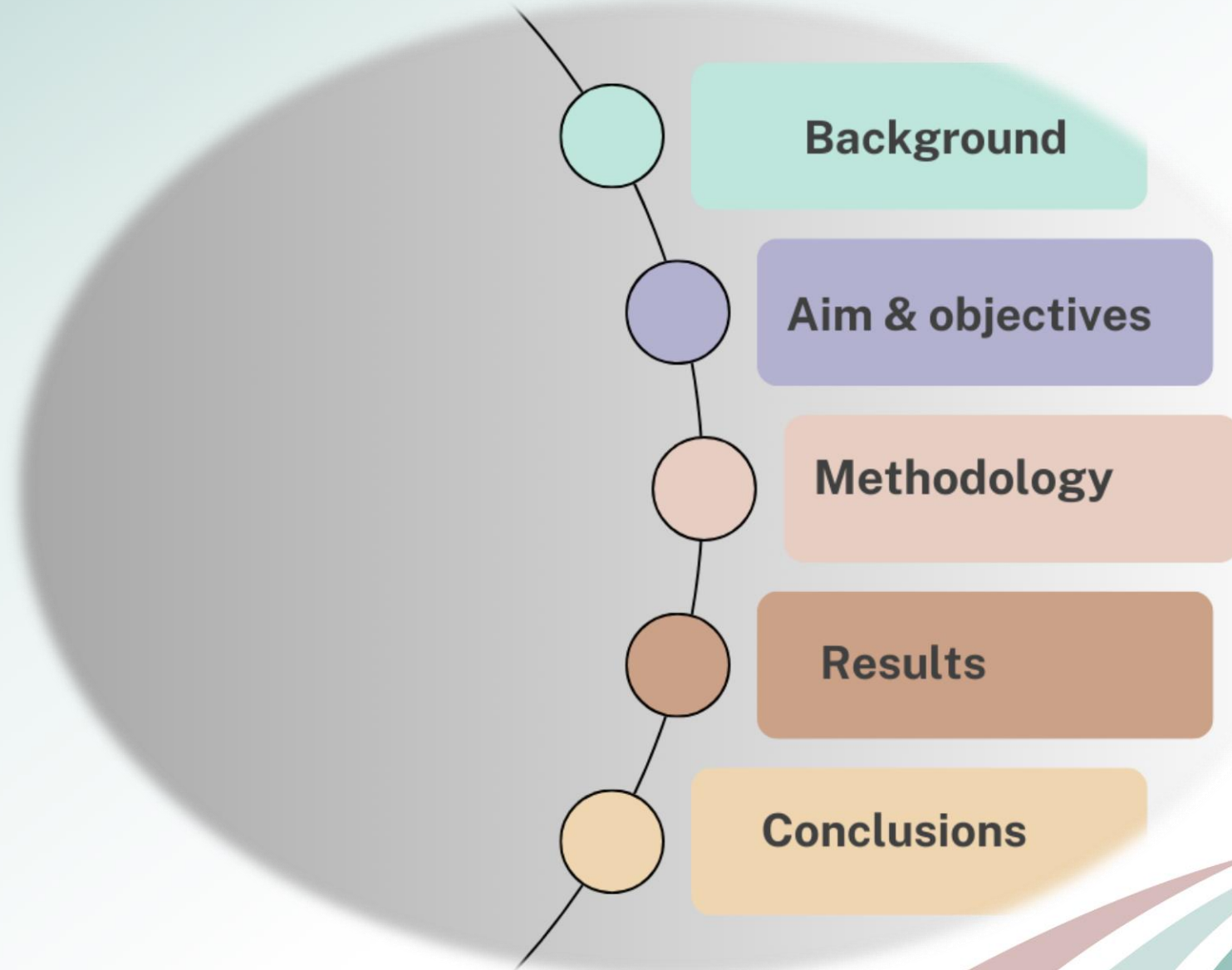
Boosting above-ground grass carbon stocks predictions: A multi-parameter coalescing approach

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Outline



Background

WHY SAVANNAH

- Extensive in area
- Characterised by rich biodiversity
- dominated by grasslands co-existing with woody layer

THE WOODY LAYER AS MAIN SINK

- Threatened by extreme weather conditions such as drought, heatwaves and increased fire activity

THE GRASS LAYER AS SUSTAINABLE SINK

- Resilient to various disturbances compared to the woody layer
- Sustainably maintain a relatively stable carbon stock over time

ABOVE-GROUND GRASS CARBON STOCK ESTIMATION

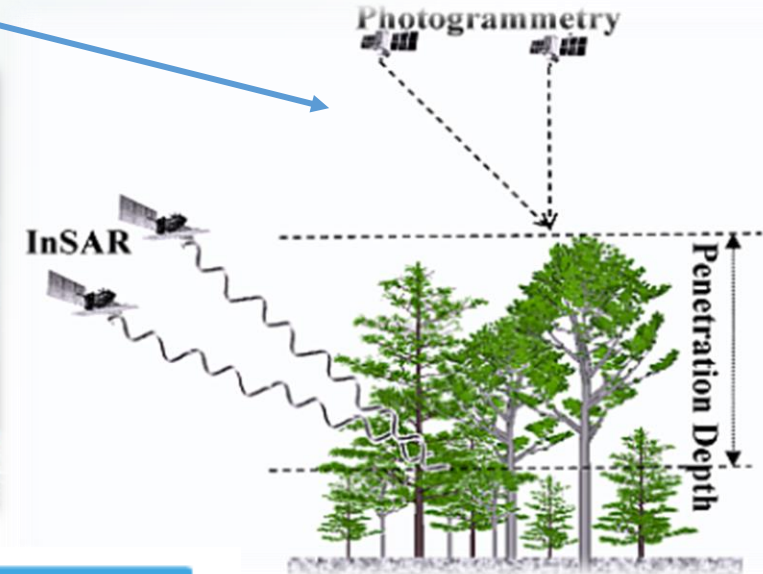
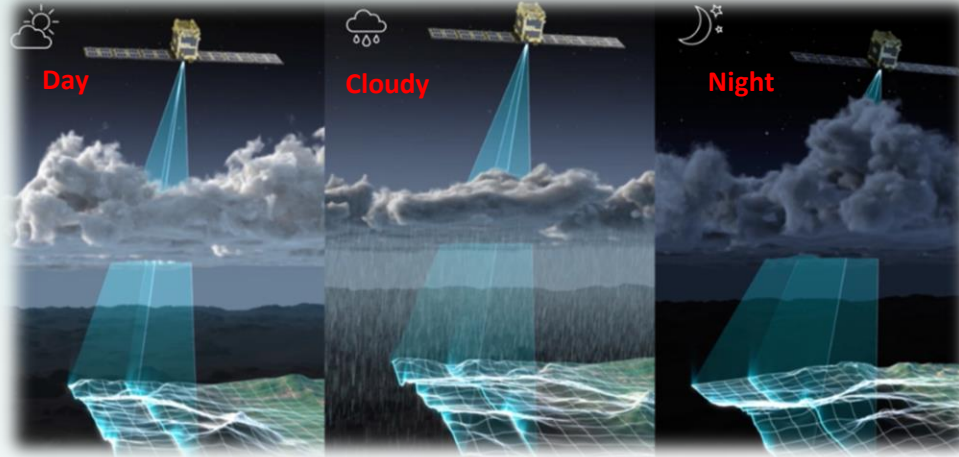
- Inform emission reduction policies
- Aids in minimising the risks associated with future climate change

Background....cont'd

Optical data



SAR data



REASERCH ON OPTIMAL MODELS

- relies on optical data
- limited to cloud-free conditions.
- mainly interact with the canopy structure of vegetation

ACCESS TO SAR DATA

- hindered by its price tag
- S1 offers free data to quantify and monitor AGGCS:
 - under all weather conditions
 - beyond the canopy structure of the vegetation

CAPABILITY OF SAR

- contains several metrics
 - to quantify AGGCS
 - optimal SAR metrics documented for forests and agricultural landscapes

HOW MUCH IS KNOWN ON GRASSES

Little is known for grasslands, particularly in savannah ecosystems

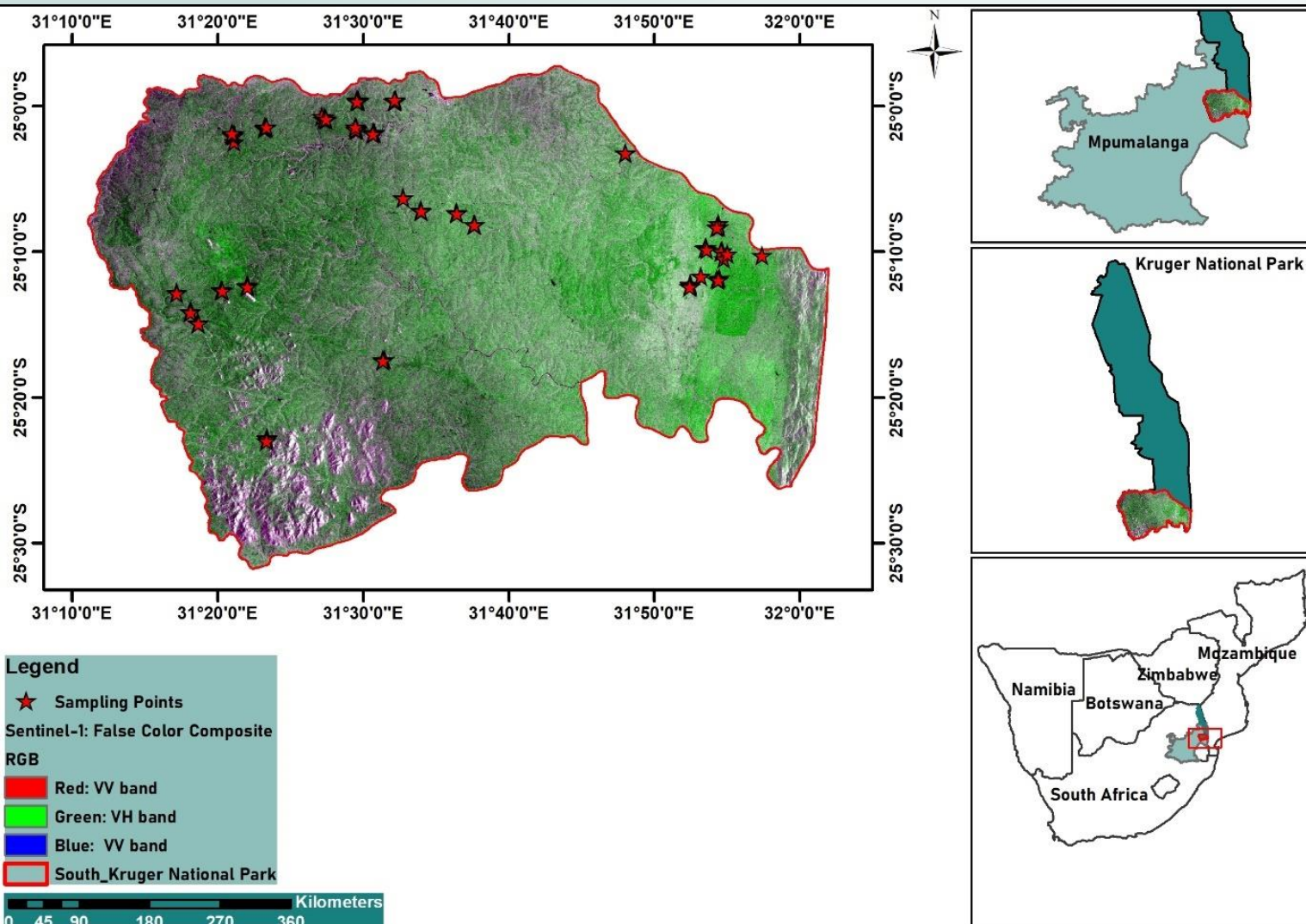
Research aim and objectives

Objective



To determine whether coalescing texture matrices with Synthetic Aperture improves the accuracy of predicting above-ground grass carbon stocks in savannah ecosystems

Study site



- **Kruger National Park**

- one of Africa's well-known wildlife reserves
- Located
 - Lowveld region of north-eastern South Africa,
 - within the savannah ecosystem
- Experiences
 - Summer rainfall, annual ranging between 500 to 700mm
 - Brief and dry The winters are
- Consist of
 - dense woodlands and
 - grassy plains

Methodology

FIELD DATA COLLECTION WORKFLOW



94 samples were collected

Methodology.....cont'd

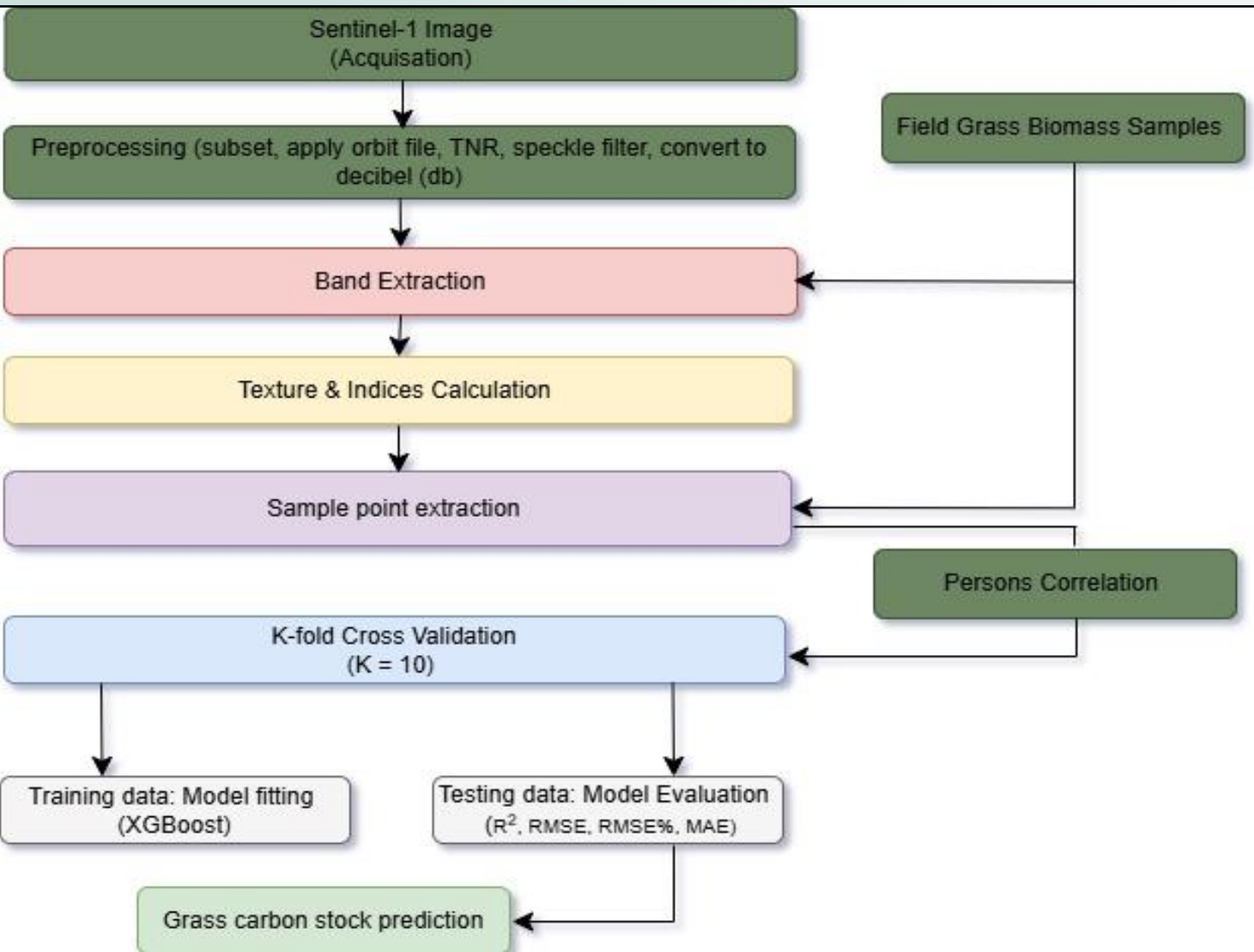
Field data collection team



- Pictorial illustration of field data collection

Methodologycont'd

The data acquisition & pre-processing chain:



• Product

- Level-1 Sentinel-1 (S1) C-band in the Interferometric Wide (IW) Mode

• Acquisition date

- 10 of February 2020

• Source

- ESA (Copernicus Open Access Hub, accessible at <https://scihub.copernicus.eu/dhus/>)

• Processing Software

- Sentinel Application Platform (SNAP) software

Methodology.....cont'd

Predictor variable	Expression/Description
Polarisation backscatter coefficients	VH (Vertical Transmit/horizontal receive) VV (Vertical Transmit/vertical receive)
Polarisation Intensity ratios	VH/VV VV-VH/VV+VH
Radar Indices (RI)	RVI (Radar Vegetation Index)
Arithmetic Intensity Computations	VH-VV VV+VH
Texture Matrix	VH/VV _{Con} (Contrast) VH/VV _{Dis} (Dissimilarity) VH/VV _{Hom} (Homogeneity) VH/VV _{ASM} (Angular Second Moment) VH/VV _{Ene} (Energy) VH/VV _{Max} (Maximum Probability) VH/VV _{Ent} (Entropy) VH/VV _{Mea} (GLCM Mean) VH/VV _{Var} (GLCM Variance) VH/VV _{Cor} (GLCM Correlation)

Methodologycont'd

- **Statistical analysis**



Extreme Gradient Boosting (XGBoost)

- Regress field-measured grass carbon stock against Sentinel-1 derived variables
- The optimal parameter identification process is based on a grid search method where hyperparameters are selected based on the lowest Root Mean Squared Error (RMSE) from a 10-fold Cross Validation (CV) resampling strategy

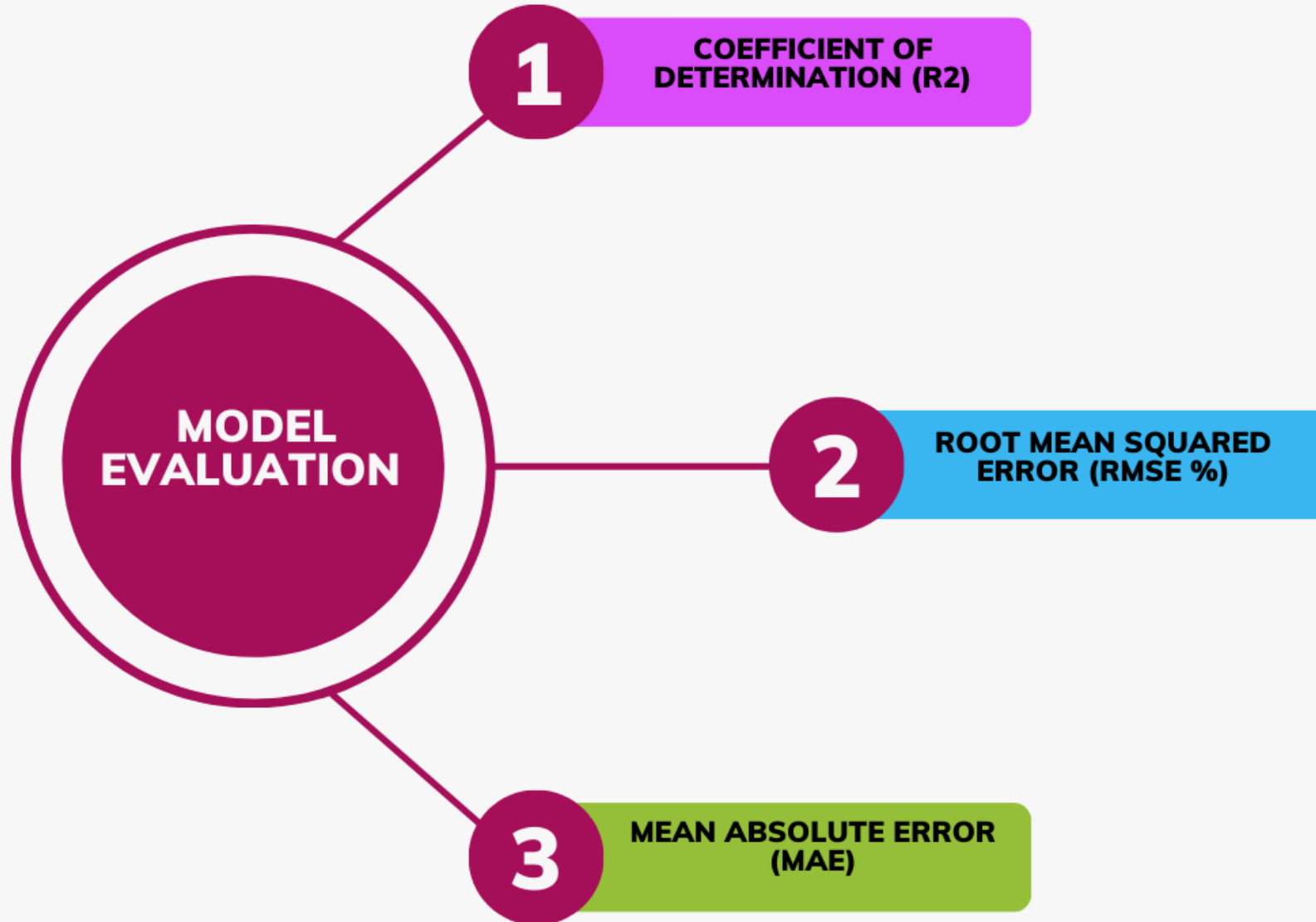
Methodology (cont'd)

- **Levels of analysis**

- Variable configurations:

Analysis level	Configurations	Description
1	VV, VH	Intensity Linear Polarisation
2	VH/VV VV-VH/VV+VH	Polarisation Intensity ratios
3	VH-VV, VV+VH	Arithmetic Intensity Calculations
4	RVI	Radar Vegetation Indices
5	Optimal SAR polarisations	
6	VH/VV _{texture}	Texture matrices
7	Optimal variables	

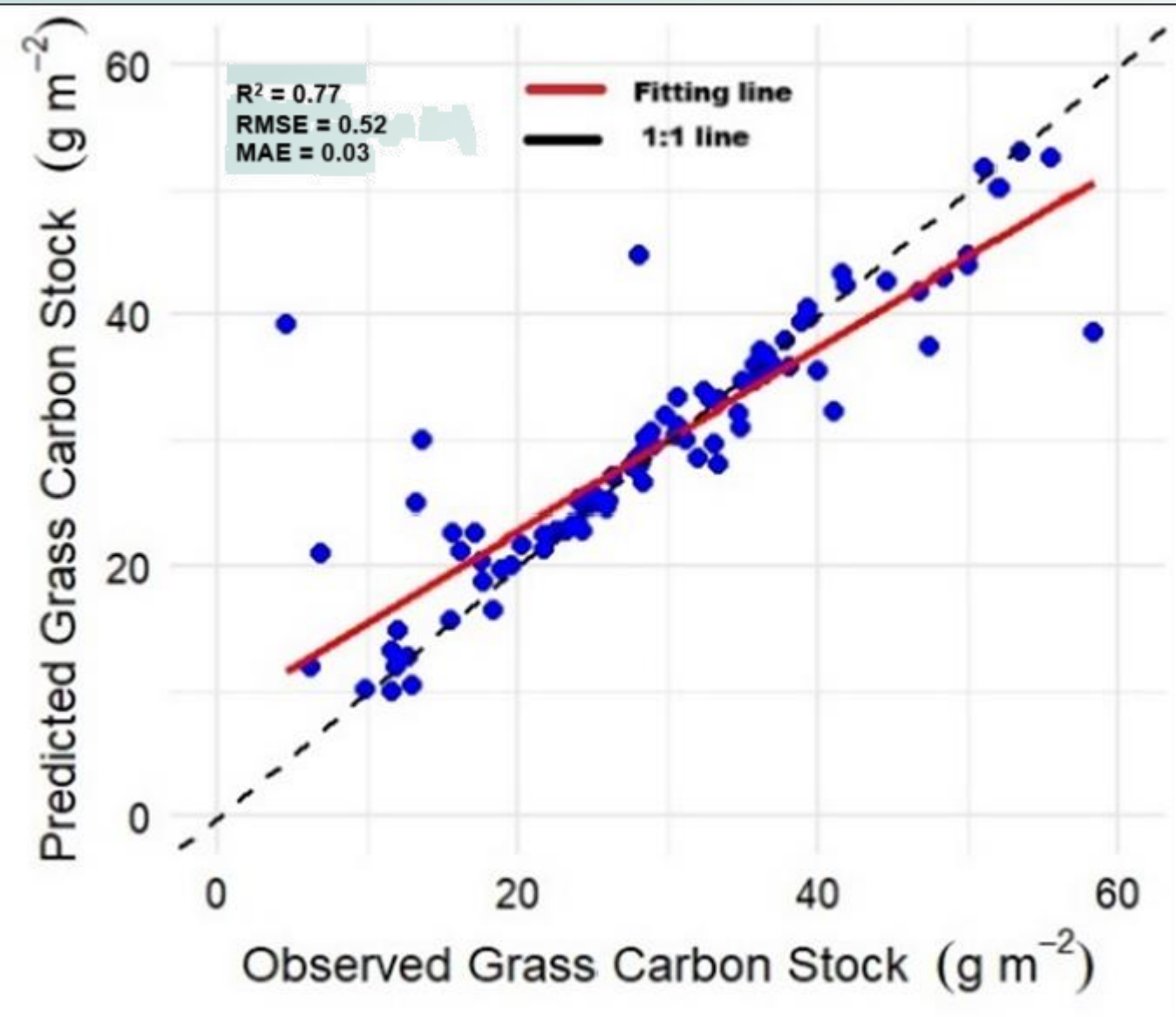
Methodology....cont'd



Results (cont'd)

Experiment	Matrices	R ²	RMSE (g m ⁻²)	MAE
1	Linear polarisation (LI)			
	Intensity (VH)	0.38	33.22	6.86
	Intensity (VV)	0.38	31	6.87
2	Radar Vegetation Index (RVI)			
	RVI	0.39	30	6.77
3	Intensity ratios (IR)			
	VH/VV	0.37	31.03	6.9
	VV-VH/VV+VH	0.37	31.11	6.9
4	Arithmetic Computations (AC)			
	VH-VV	0.36	30.84	6.73
	VV+VH	0.37	31.31	6.84
5	All variables			
	All optimal S1 variables	0.36	30.84	7.02
6	Texture Matrices			
	VH	0.40	30	5.32
	VV	0.39	30	5.21
7	Optimal S1 variable + Texture			
		0.77	20	0.03

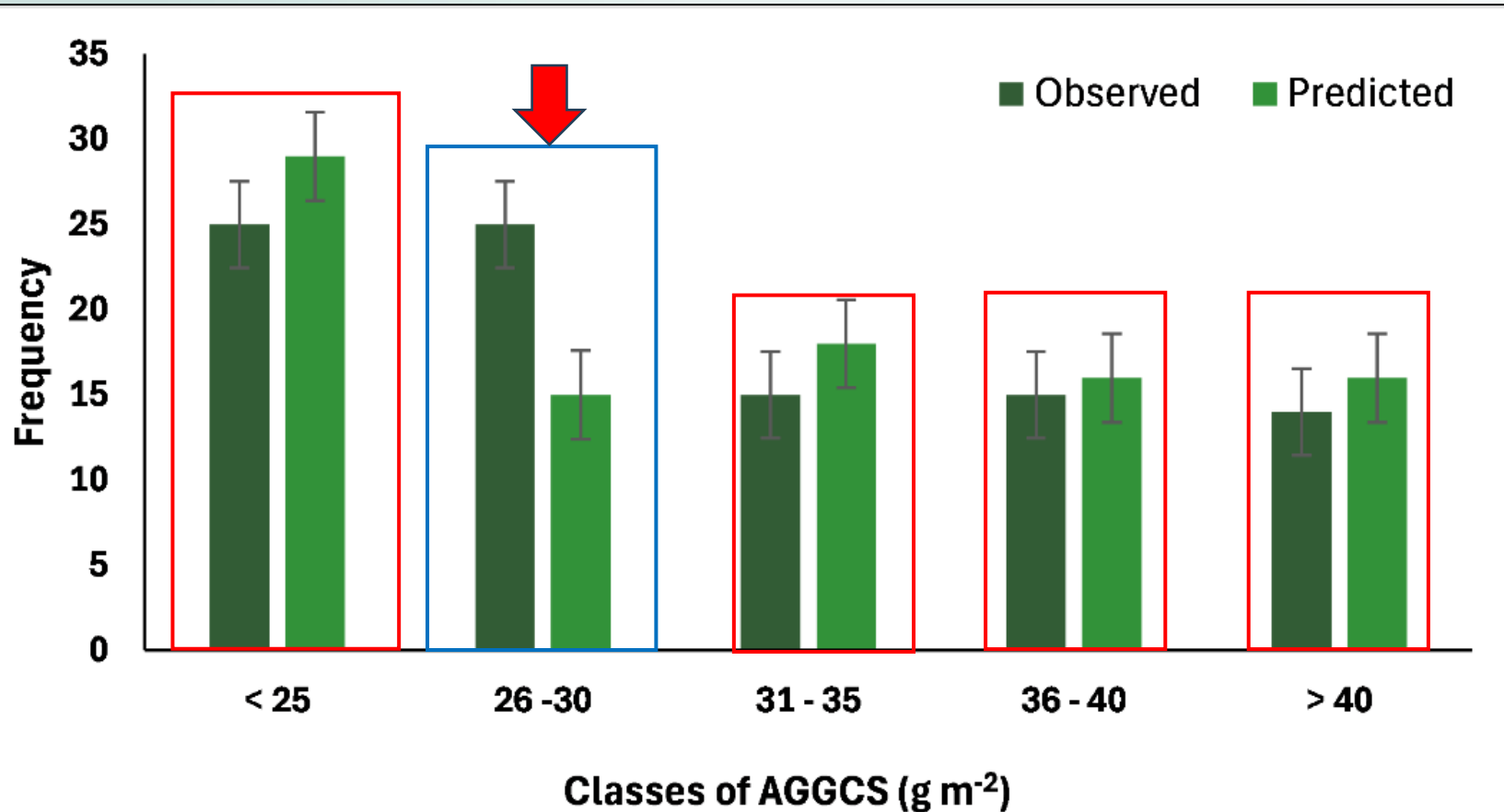
Results (cont'd)



A scatterplot showing the relationship between observed and predicted above-ground grass carbon stock of optimal model

Results....cont'd

- Measured vs predicted AGGCS



The predicted AGGCS for most classes (i.e. $<25 \text{ g m}^{-2}$, $31-35 \text{ g m}^{-2}$, $36-40 \text{ g m}^{-2}$ and $>40 \text{ g m}^{-2}$) are close to the observed values. An exception is the $26-30 \text{ g m}^{-2}$ range which shows a huge underestimate compared to the observed values

Conclusion

- In conclusion,
 - when utilised separately, SAR parameters and texture matrices tend to underperform ($R^2 = 0.36-0.40$, RMSE = 5.21 – 6.9), suggesting that SAR data alone seems to not fully capture the variability in above-ground grass carbon stock, particularly in the complexly configured savannah ecosystems.
 - When combined SAR polarizations and texture matrices improve the accuracy (R^2 of 0.39 and an RMSE of 8.75), suggesting that texture matrices may improve the predictive ability of SAR data for AGGCS estimation
 - Future studies factor in these topo-climatic parameters with SAR backscatters, ratios and indices to acquire a better understanding of the AGGCS across such landscapes

References

- Ni, W., Zhang, Z., Sun, G., Guo, Z., & He, Y. (2014). The penetration depth derived from the synthesis of ALOS/PALSAR InSAR data and ASTER GDEM for the mapping of forest biomass. *Remote Sensing*, 6(8), 7303-7319.
- <https://synspective.com/press-release/2022/tpa-syns/>

Thank you



CERTIFIED EXCELLENCE IN EMPLOYER CONDITIONS