ENHANCING SALT MARSHES MONITORING: ESTIMATING BIOMASS WITH DRONE-DERIVED HABITAT-SPECIFIC MODELS

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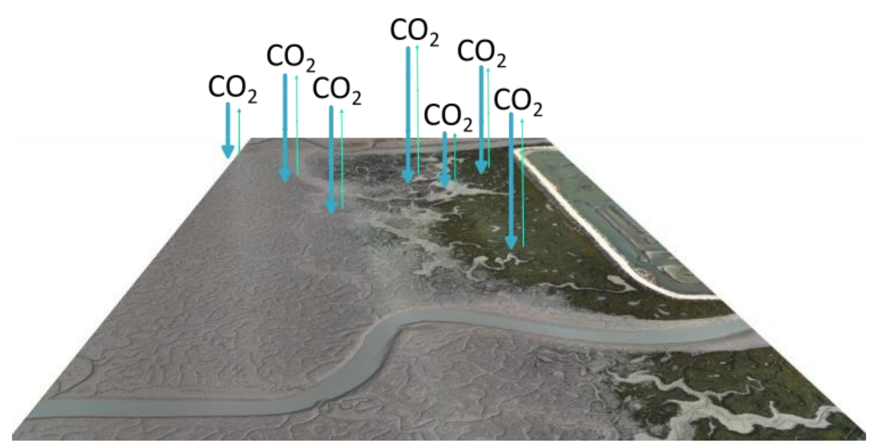
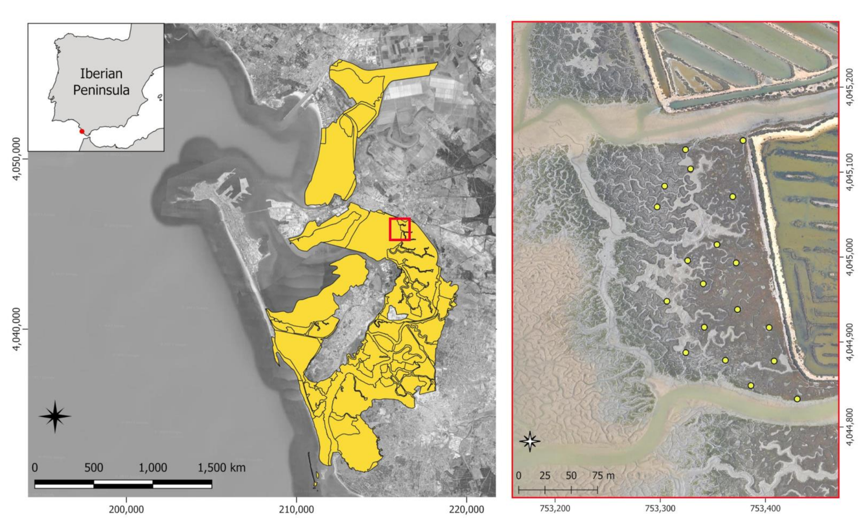
1. Introduction

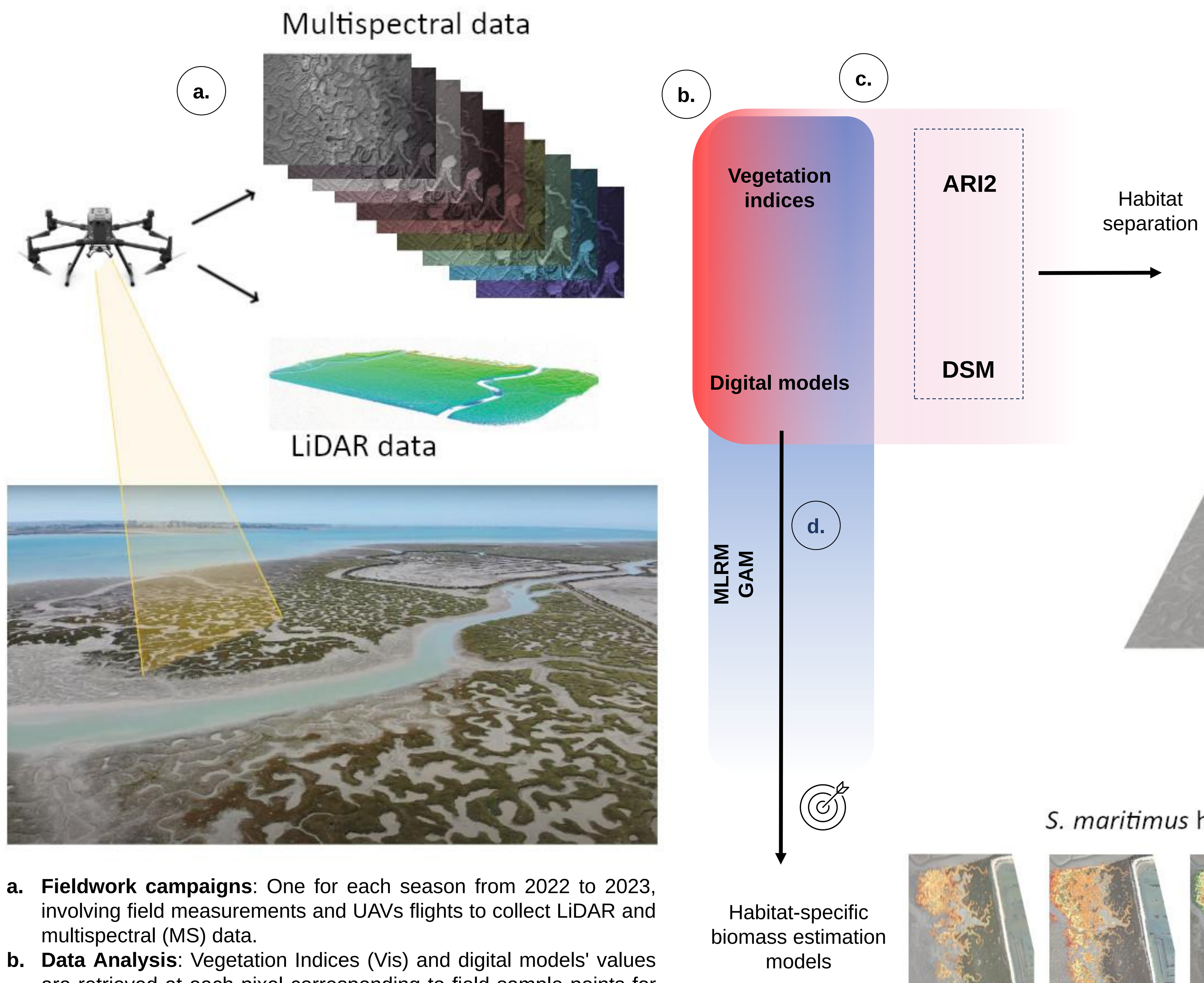


Estimating aboveground biomass (AGB) is crucial for quantifying the carbon sequestration capacity of the salt marsh system. However, traditional fieldwork methods for salt marshes studies are time-consuming, demanding, and detrimental to marsh ecosystems. We propose utilizing low-altitude remote sensing for biomass assessment.

2. Methodology

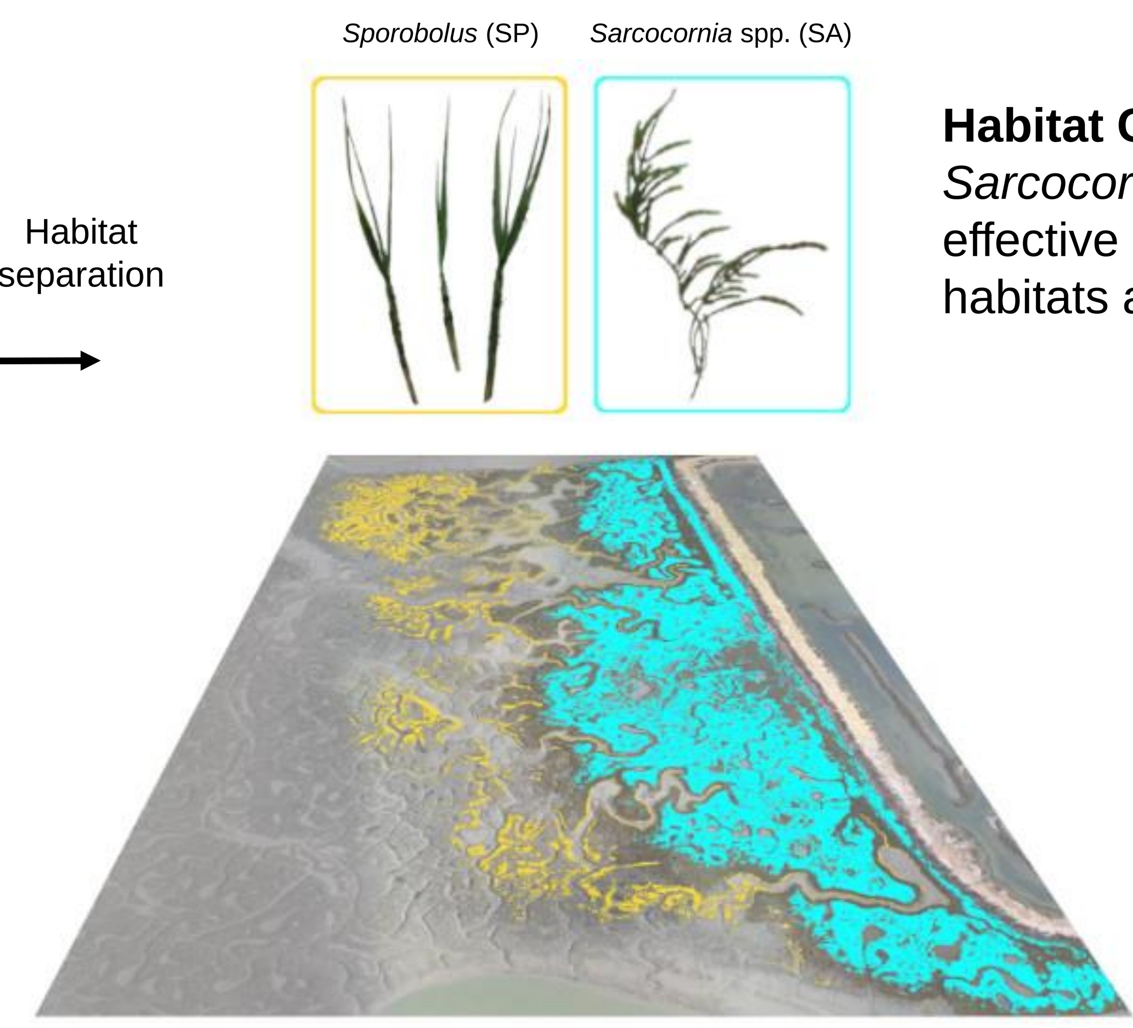
The study area is an excellent example of salt marsh plant zonation. The proposed method is expected to apply to other mid-latitude tidal salt marshes worldwide, as low and medium horizons of tidal marshes often display similar structural characteristics.





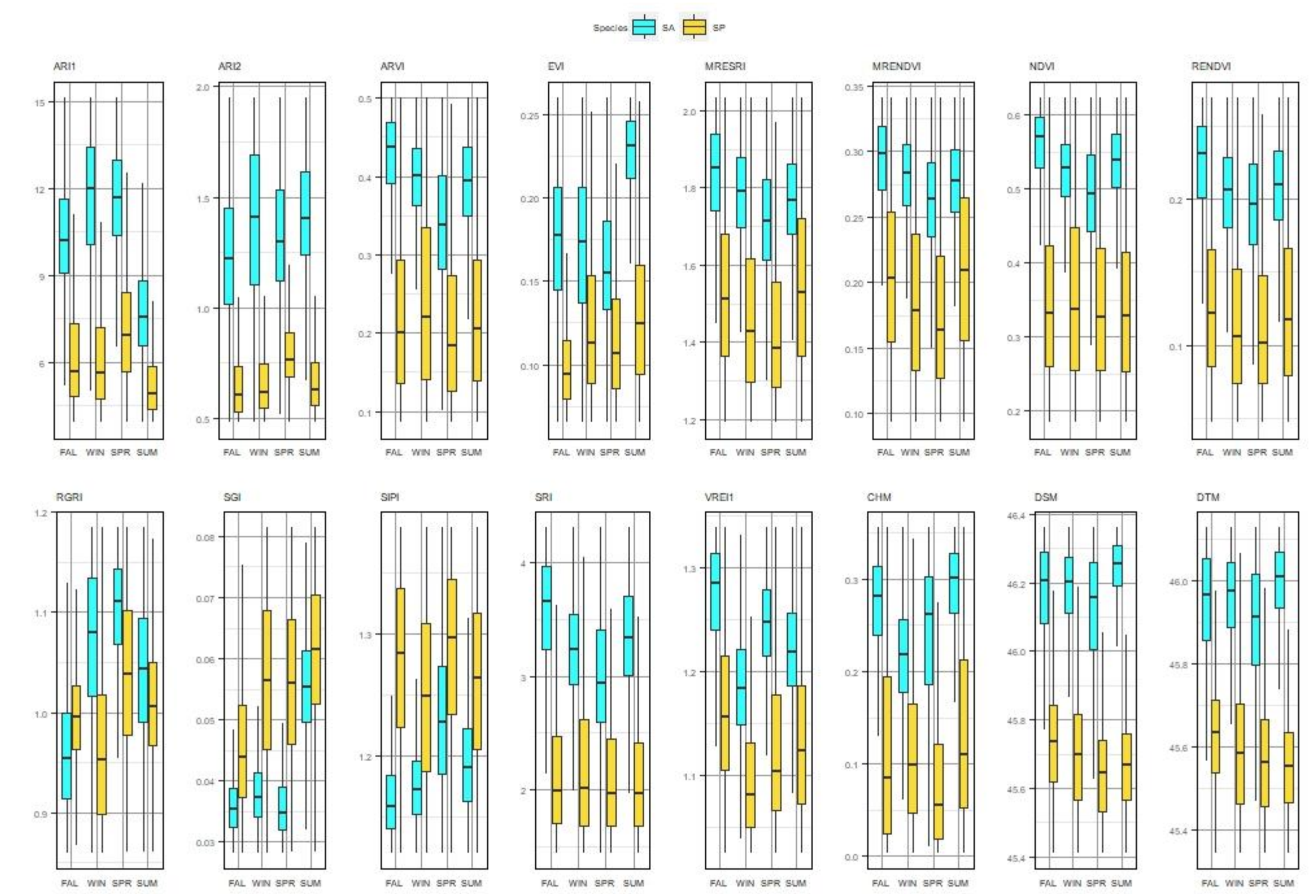
a. **Fieldwork campaigns**: One for each season from 2022 to 2023, involving field measurements and UAVs flights to collect LiDAR and multispectral (MS) data.
b. **Data Analysis**: Vegetation Indices (Vis) and digital models' values are retrieved at each pixel corresponding to field sample points for biomass estimation.
c. **Habitat Separation and Seasonal analysis**: Salt marsh habitats are classified into those dominated by a single species using preliminary classification and exploratory data analysis (EDA) techniques. Seasonal variations in VIs and digital models are analysed to understand biomass fluctuations and assess intra-annual trends.
d. **Biomass Estimation Models and Validation**: Development of generalized additive models (GAM) and multiple linear regression models (MLRM) for seasonal biomass mapping, verifying them by comparing results with field measurements.
e. **Landscape-scale Biomass Estimation**: Total aboveground biomass (AGB) is estimated for the whole marsh (WM) and individual habitats, including a transition zone (TR) assumption and comparison of biomass estimates for individual habitats with marsh-wide AGB estimates.

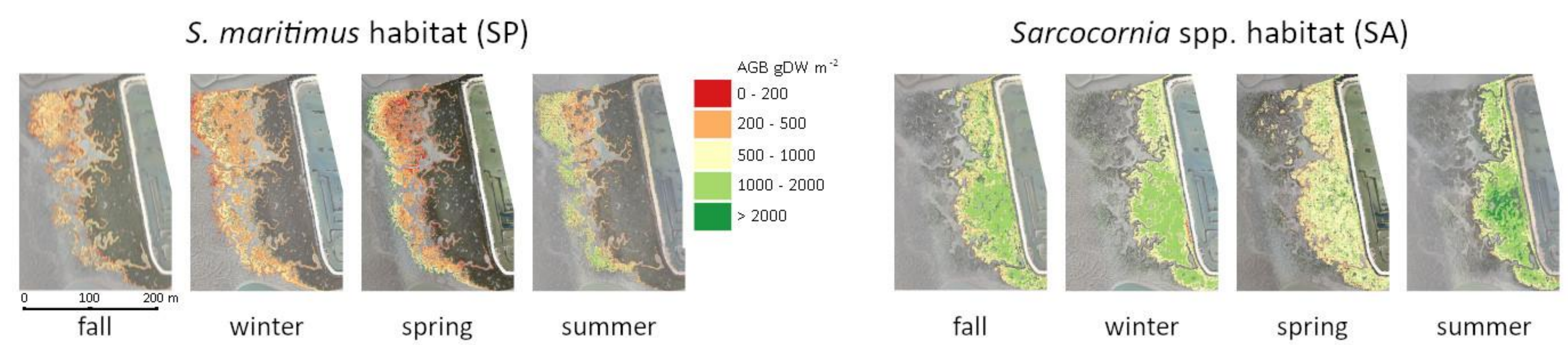
3. Results and discussion



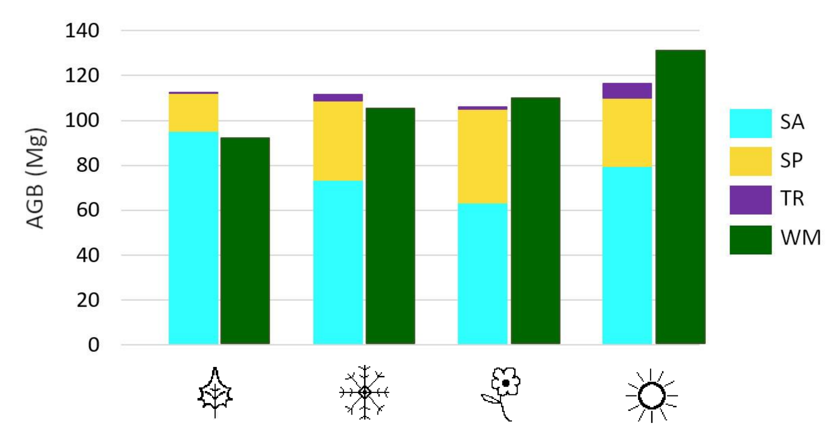
Habitat Characterization and Separability: Differences in VIs and digital models between *Sarcocornia* spp. (SA) and *S. maritimus* (SP) emphasize the importance of specific variables for effective habitat distinction. ARI2 and DSM have been identified as key variables for distinguishing habitats and separating tidal salt marsh horizons.

Seasonal Trend: Seasonality affects the two species differently, requiring separate analysis for accurate intra-annual tracking. Distinct seasonal patterns emerge in digital models and Vis for each species.





Biomass Models: Species presence influences correlations between biomass measurements and UAV-derived variables, with stronger associations in single-species areas. The more accurate developed statistical models stress the importance for species-specific analyses and the selection of suitable predictor variables.



Landscape-scale Biomass Estimation: Total AGB estimates vary between whole marsh and species-specific models across seasons. Despite mixed characteristics in the transition zone, species-specific models show higher accuracy than general ones. This underscores the importance of species-specific models for accurate biomass estimation, as dominant species contribute differently to biomass production.

4. Conclusion

1. **Integrated Approach:** Combining UAV-based MS and LiDAR data allows for accurate biomass estimation, species identification, and seasonal change detection, leveraging advantages in spatial resolution and reduced uncertainty compared to satellite data. This approach provides detailed salt marsh vegetation characterization and prediction without destructive fieldwork.
2. **Species-Specific Insights**: The analysis reveals stronger correlations between UAV-derived variables and biomass measurements across seasons and species, particularly emphasizing the significance of ARI2 and DSM in species-specific habitat identification.
3. **Improved Predictive Models:** Utilizing UAV-derived data to develop statistical models with enhanced predictive capability, demonstrating lower errors compared to prior studies**.** This highlights the potential of UAV data to enhance biomass estimation, aiding better management and conservation.
4. **Incorporating Various Data Sources**: it is highlighted the necessity of integrating spectral and geomorphological data for precise biomass estimation. This comprehensive approach ensures that key factors influencing biomass dynamics are adequately accounted for, leading to more robust and insightful conclusions.

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