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Estimating above ground biomass as an indicator of carbon storage in vegetated wetlands of the grassland biome of South Africa

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Abstract

Wetlands store higher carbon content relative to other terrestrial ecosystems, despite the small extent they occupy. The increase in temperature and changes in rainfall pattern may negatively affect their extent and condition, and thus the process of carbon accumulation in wetlands. The introduction of the Sentinel series (S1 and S2) and WorldView space-borne sensors (WV3) have enabled monitoring of herbaceous above ground biomass (AGB) in small and narrow wetlands in semi-arid areas. The objective of this study was to assess (i) the capabilities of the high to moderate resolution sensors such as WV3, S1A and S2A in estimating herbaceous AGB of vegetated wetlands using SAR backscatter, optical reflectance bands, vegetation spectral indices (including Leaf Area Index or LAI measurements) and band ratio datasets and (ii) whether significant differences exists between the AGB ranges of wetland and surrounding dryland vegetation. A bootstrapped Random Forest modelling approach, with variable importance selection, was utilised which incorporated ground collected grass AGB for model calibration and validation. WorldView-3 (WV3) yielded the highest AGB prediction accuracies (R2=0.63 and RMSE=169.28g/m2) regardless of the incorporation of bands only, indices only or the combination of bands and indices. In general, the optical sensors yielded higher modelling accuracies (improvement in R2 of 0.04-0.07 and RMSE of 11.48–17.28g/m2) than the single Synthetic Aperture Radar (SAR) sensor but this was marginal depending on the scenario. Incorporating Sentinel 1A (S1) dual polarisation channels and Sentinel 2A (S2) reflectance bands, in particular, yielded higher accuracies (improvement in R2 of 0.03–0.04 and RMSE of 5.4–16.88g/m2) than the use of individual sensors alone and was also equivalent to the performance of the high resolution WV3 sensor results. Wetlands had significantly higher AGB compared to the surrounding terrestrial grassland (with a mean of about 80g/m2 more). Monitoring herbaceous AGB at the scale of the wetland extent in semi-arid to arid grasslands enables improved understanding of their carbon sequestration potential, the contributions to global carbon accounting policies and also serving as a proxy for functional intactness.