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Sensitivity of Sentinel-1 Backscatter Signal to Vegetation Dynamics over Mozambique: A comparison with MODIS data

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Sentinel-1, a pair of Synthetic Aperture Radar (SAR) sensors, provides valuable all-weather and day-night imaging capabilities, enabling continuous monitoring of vegetation dynamics even in the presence of cloud cover. SAR sensors excel at penetrating vegetation canopies and providing information on crucial factors like vegetation structure, biomass, and moisture content. However, most remote sensing vegetation studies have primarily relied on optical data, benefiting from longer historical datasets but facing challenges due to atmospheric interference, limited temporal resolution. Moreover, there is no research assessing the sensitivity of optical and radar data to the dynamics of vegetation in Mozambique. This study investigates the sensitivity of the Sentinel-1 (S-1) backscatter signal to vegetation dynamics over Mozambique. We compare it with the Normalized Difference Vegetation Index (NDVI) from MODIS data and explore its relationship with precipitation variability and droughts across different land covers, including forest, cropland, herbaceous vegetation, and herbaceous wetland in Mozambique.
The Sentinel-1 VV and VH polarized images were used to calculate the Cross Ratio (CR=VH/VV). Temporal behaviors of CR S-1 and MODIS NDVI were analyzed from 2017 to 2022, examining seasonal patterns, inter-annual variability, trends, and outliers. NDVI anomalies were calculated to identify the spatial and temporal occurrence of agricultural droughts, while CHIRPS precipitation data was utilized to detect fluctuations in the CR S-1 and NDVI time series relative to precipitation. The analysis revealed distinct seasonality in the CR time series data across all land cover types. Notably, croplands, herbaceous vegetation, and herbaceous wetlands exhibited a consistent increase in CR during winter months, followed by a decline during summer months. In contrast, forests displayed an inverse trend, with CR decreasing in winter and increasing in summer. Furthermore, no pronounced CR patterns were observed in herbaceous wetlands during 2019, coinciding with the agricultural drought between 2018 and 2019. Additionally, the seasonality of MODIS NDVI time series remained consistent across all land cover types, with no noticeable differences. It was observed that fluctuations in NDVI time series preceded those in CR for these specific land cover types, suggesting a potential correlation with photosynthetic activity and subsequent biomass production. Significantly, this trend was found to be opposite in forested areas. Overall, the CR trend exhibited a clear correlation with rainfall seasonality across the various land cover types, except for forests where an inverse relationship was observed. On the other hand, NDVI demonstrated a higher sensitivity to changes in precipitation across the different land cover categories.

These findings highlight the unique sensitivity of Sentinel-1 SAR data in capturing the intricate dynamics of vegetation across diverse land cover types in Mozambique, providing valuable complementary information to traditional optical data sources.