Remote Sensing of Environment

Assessment of the mapping of fractional woody cover in southern African savannas using multi-temporal and polarimetric ALOS PALSAR L-band images

Mikhail Urbazaev [a,] Christian Thiel [a,] Renaud Mathieu[b,c], Laven Naidoo [b,] Shaun R. Levick [d,] Izak P.J. Smit [e,f,] Gregory P. Asner [g,] Christiane Schmullius [a]

[a] Department of Earth Observation, Institute of Geography, Friedrich Schiller University Jena, Jena, Germany
[b] Ecosystem Earth Observation, Council for Scientific and Industrial Research, Pretoria, South Africa
[c] Department of Geography, Geoinformatics and Meteorology, University of Pretoria, Pretoria, South Africa
[d] Department of Biogeochemical Processes, Max Planck Institute for Biogeochemistry, Jena, Germany
[e] Scientific Services, South African National Parks, Skukuza, South Africa
f Centre of African Ecology, School of Animal, Plant and Environmental Sciences, University of Witwatersrand, Johannesburg, South Africa
[g] Department of Global Ecology, Carnegie Institution for Science, Stanford, CA, USA

Abstract

Woody vegetation cover affects several ecosystem processes including carbon and water cycling, energy fluxes, and fire regimes. In order to understand the dynamics of savanna ecosystems, information on the spatial distribution of woody vegetation over large areas is needed. In this study we sought to assess multi-temporal ALOS PALSAR L-band backscatter to map woody cover in southern African savannas. The SAR data were acquired from the JAXA archive, covering various modes and seasons between 2007 and 2010. We used high resolution airborne LiDAR data as reference data to interpret SAR parameters (including backscatter intensities and polarimetric decomposition components), to develop SAR-based models as well as to validate SAR-based woody cover maps. The LiDAR survey was carried out in April 2008 with the Carnegie Airborne Observatory (CAO, http://cao.ciw.edu). The highest correlations to the reference data were obtained from SAR backscatters of the dry season, followed by the wet season, and the end of the wet season. The volume components from polarimetric decompositions (Freeman-Durden, Van Zyl) were calculated for the end of wet season, and showed similar correlations to the LiDAR data, when compared to cross-polarized backscatters (HV). We observed increased correlation between the SAR and LiDAR datasets with an increase in the spatial scale at which datasets were integrated, with an optimum value at 50 m. We modeled woody cover using three scenarios: (1) a single date scenario (i.e., woody cover map based on a single SAR image), (2) a multi-seasonal scenario (i.e., woody cover map based on SAR images from the same year and different seasons, based on key phonological difference), and (3) a multi-annual scenario (i.e., woody cover map based on SAR data from different years). Predicted SAR-based woody cover map based on Fine Beam Dual Polarization dry season SAR backscatters of all years yielded the best performance with an R2 of 0.71 and RMSE of 7.88%. However, single dry season SAR backscatter achieved only a slightly lower accuracy (R2 = 0.66, RMSE = 8.45%) as multi-annual SAR data, suggesting that a single SAR scene from the dry season can also be used for woody cover mapping. Moreover, we investigated the impact of the number of samples on the model prediction performance and showed the benefits of a larger spatially explicit LiDAR dataset compared to much smaller number of samples as they can be collected in the field. Collectively, our results demonstrate that L-band backscatter shows promising sensitivity for the purposes of mapping woody cover in southern African savannas, particularly during the dry season leaf-off conditions.