ACTIVE REMOTE SENSING OF BIOMASS IN SAVANNA REGIONS

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1. INTRODUCTION

In this paper, we review the state of the art in estimating biomass in savanna regions using active remote sensing: SAR, SAR interferometry and LiDAR. Savannas occur across approximately 20 % of the land surface occurring largely in the tropics and sub-tropics. These ecosystems are also structurally diverse, containing varying proportions of tree, shrub and grass cover depending upon mean annual rainfall and temperature variations as well as different responses to fire (frequency and intensity) and herbivore grazing. Savanna regions are increasingly under pressure from human activities that range from deforestation through to fuelwood extraction, selective thinning and grazing. Regeneration following clearance, woody thickening and rainforest encroachment are also occurring across large areas of savannas. For these reasons, significant changes in carbon stocks and fluxes are occurring but are not well quantified.

2. LIDAR

Active sensors play a key role in the estimation of biomass in savannas at scales ranging from individual trees to the landscape. At the tree level and for delineated tree crowns, biomass can be estimated using LiDAR-derived estimates of height or other structural attributes as input to allometric equations that estimate biomass. As equations are typically species or genus-specific, the association of each delineated tree crown with a species type (e.g., as classified using hyperspectral data) leads to better estimation [1]. Even so, such approaches are increasingly limited with closure and multi-layering of the canopy. For estimating biomass at the stand level, studies have largely utilised allometric equations between biomass and LiDAR-derived metrics relating to height, canopy cover or depth volume [2]. Time-series of these data can be used to detect changes in savannas at both the tree and stand level.

2. SAR (INTENSITY)

Empirical relationships have commonly been established between SAR intensity data and biomass. However, in savannas, these relationships are compromised by saturation of the intensity at relatively low levels of biomass (typically < 100 t/ha), the variability in the structure and also the subsurface and surface moisture content. Lower frequency SAR (particularly P-band but to a certain extent L-band) do not observe the smaller woody structures and variability in the relationships are also compromised by size class distributions and density. For this reason, other approaches (e.g., non-linear estimation) that take account of the variability in structure in savannas have been evaluated as an alternative to the use of empirical relationships.

3. INSAR

InSAR also allows retrieval of tree and stand height [3]. The vertical location of the InSAR-retrieved height is determined indirectly through analysis of the relative scattering contributions from the stems, branches and leaves and the ground surface in combination with radar characteristics such as frequency (and wavelength), polarisation and incidence angle. The use of InSAR in savannas is, however, complicated by sensor parameters (e.g., spatial resolution) and also the relative openness of the canopy as the high values of backscatter from the ground surface effectively lower the scattering phase centre.

4. POLINSAR

Polarimetric interferometry (PolInSAR) uses the polarimetric information from single frequency InSAR to distinguish canopy and ground returns. As this technique relies on SAR penetration to the ground surface to obtain contributions from the canopy and the ground, fully polarimetric L-band is considered to be most suitable amongst today's available data sets. In contrast, ground surface and trunk-ground interactions have a distinctive polarimetric response. This differentiation between crown and ground scattering enables forest height (DSM) and ground height (DEM) retrieval, which is typically undertaken through inversion of a forest backscattering model (e.g., the Random Volume over Ground (RVoG) model).

4. CONCLUSIONS

The paper will provide an overview of the relative benefits of LiDAR, SAR, InSAR and PolInSAR for retrieving the biomass and structure of savannas, using case studies taken from Australia, Central America and Africa. Recommendations as to the optimal sensors and combinations of these (including with optical data) will be presented.

11. REFERENCES

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