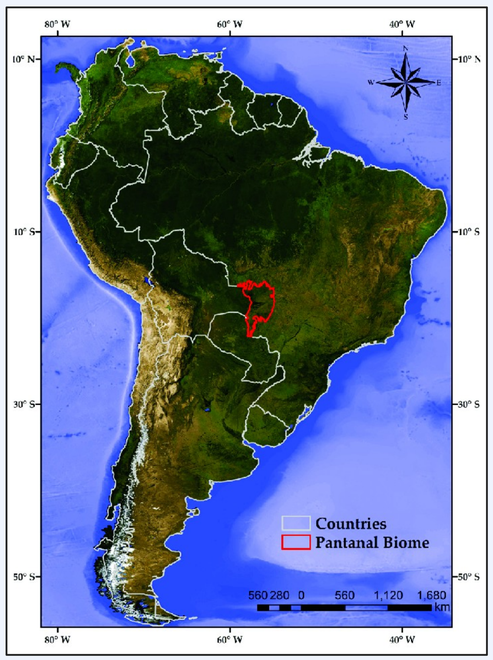
Detecting Landscape Degradation in the Pantanal Using ASCAT Imaging

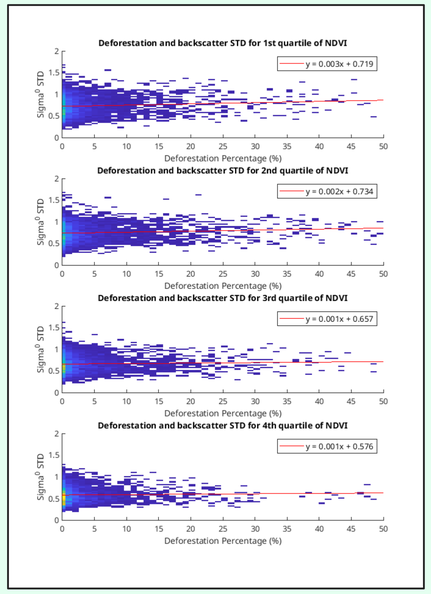
Alex McBride and David G. Long
Microwave Earth Remote Sensing Lab, Brigham Young University, Provo, UT

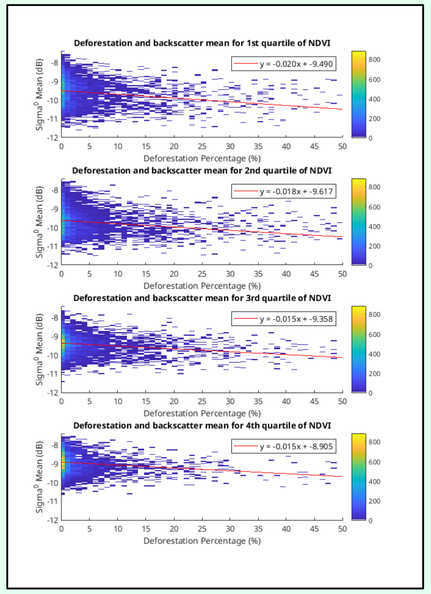
Abstract

The wetlands of South America are especially well documented in the scientific literature compared to other wetland regions around the world. Wetlands cover over 20% of the surface of the continent. Because of their apparent lack of economic productivity, they have suffered dramatic destruction from human sources over the past several decades. This landscape degradation has coincided with the expansion of remote sensing capabilities, which has resulted in a large volume of studies focused on classifying and monitoring these biomes.

One such biome is the Pantanal, a South American wetland located primarily in the central west region of Brazil as shown in the MODIS image below. Its landscape is highly varied, including forests, savannas, grasslands, and swamps, all of which undergo varying degrees of seasonal flooding during the wet season of the year. The wide range of ecosystems present have been rigorously classified and habitat destruction in the Pantanal is well-tracked, making it an ideal candidate for remote sensing studies. This study shows that microwave satellites have the potential to improve the detection of deforestation in conditions where optical sensors have limited capability.







The data show a strong correlation between increased deforestation, decreased σ^0 backscatter, and increased standard deviation. This holds across all types of vegetation considered.

Methodology

Ultra-high resolution ASCAT images were overlaid with landscape maps in order to compare deforestation area to backscatter on a per-pixel basis. Deforestation data was obtained from the PRODES dataset created by the Brazilian National Institute for Space Research, covering most years between 2008 and 2023. This dataset uses optical imaging from LANDSAT satellites to determine areas where deforestation has occurred and their most likely causes, including agriculture, mining, burns, and logging.

In order to account for the various subregions of the Pantanal, vegetation type must be considered alongside the density of deforestation. The Normalized Difference Vegetation Index (NDVI) was determined using 1km x 1km MODIS images.

Each pixel of ASCAT data within the Pantanal was processed to determine average backscatter and standard deviation over the course of a year, then the pixel's deforestation percentage was calculated using GIS tools. Finally, the pixels were binned by average NDVI for the span of that year. Areas with less than 1% deforestation area were not considered.

Results

Because the methodology is still being refined, a performance analysis of the linear fit has not yet been conducted. However, it serves to demonstrate the viability of ASCAT imaging as a tool for detecting areas of probable deforestation.

While there is substantial noise present in the plots, a simple linear regression suggests that deforestation can be linked to a decrease in backscatter compared to areas with little or no deforestation. A decreasing average backscatter—that is, the average of the annual mean σ^0 values of pixels with a given deforestation percentage— can be seen as deforestation increases. Notably, this is the case for the whole range of vegetation types in the Pantanal represented by the NDVI.

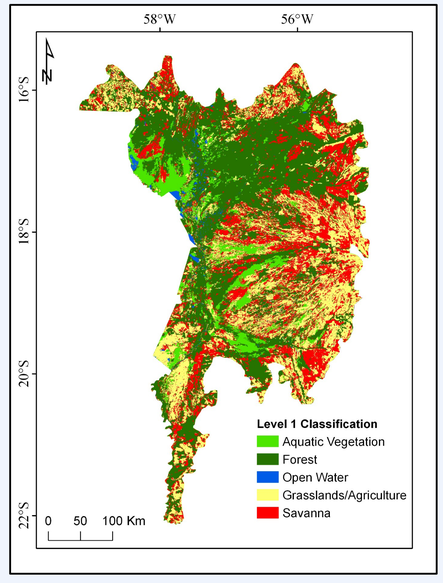
Deforestation is most often done in small, discontinuous sections rather than large swaths, and the majority of deforested pixels had less than 5% of their area affected. Even at low rates of deforestation, these pixels showed altered backscatter characteristics from unaffected pixels, meaning that a modeling function may be able to detect where deforestation is occurring.

Conclusion

In short, this preliminary study does show that there is a significant interaction between landscape degradation and microwave backscatter. More sophisticated approaches may be employed in future research to model the natural variations in backscatter that occur in healthy landscapes, such as determining the immediate effects of deforestation on ASCAT readings and characterizing different land cover classes' behavior under environmental stress.

It is also worth considering whether landscape degradation is simply more likely in some vegetation types than others, warranting a more targeted approach to deforested vs. non-deforested pixels that compares areas of similar vegetation density. Additionally, averaging backscatter and NDVI over an entire year can obscure the impact of seasonal variation on the landscape, such as regular flooding or wildfires. This can be addressed by processing in small timesteps, such as by month rather than by year.

A mature model would ideally highlight areas where deforestation is likely occurring, regularly monitoring the landscape under any atmospheric conditions. With further development, this approach may prove useful for conservation and environmental policy enforcement.



The Pantanal has a large variety of biomes. Much of the deforestation occurs in the eastern forests and savannah.