The benefit of textural features for SAR-based tropical forest disturbance mapping

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Cloud penetrating Synthetic Aperture Radar (SAR) imagery has proven effective for tropical forest monitoring at national and pan-tropical scales. Current SAR-based disturbance detection methods rely on identifying decreased post-disturbance backscatter values as an indicator of forest disturbances. However, these methods suffer from a major shortcoming, as they show omission errors and delayed detections for some disturbance types (e.g., logging or fires). Here, post-disturbance debris or tree remnants result in stable SAR backscatter values similar to those of stable forest. Despite fairly stable backscatter values we hypothesize that different orientation and arrangement of tree remnants lead to an increased heterogeneity of adjacent disturbed pixels. Increased heterogeneity can be quantified by textural features. We assessed six Gray-Level Co-Occurrence Matrix (GLCM) textural features utilizing Sentinel-1 C-band SAR time series. We used a pixel-based probabilistic change detection algorithm to detect forest disturbances based on each GLCM feature and compared them against forest disturbances detected using only backscatter data. We further developed a method to combine both backscatter and GLCM features to detect forest disturbances. GLCM Sum Average (SAVG) performed best out of the tested GLCM features. Omission errors were reduced of up to 36% and the timeliness of detections was improved of up to 30 days by applying the combination method of backscatter and GLCM SAVG. Test sites characterized by large unfragmented disturbance patches (e.g., large-scale clearings, fires and mining) showed the greatest spatial and temporal improvement. A GLCM kernel size of 5 leads to the best trade-off of improving timeliness of detections and reducing omission errors while not introducing commission errors. The robustness of the developed method was verified for a variety of natural and human-induced forest disturbance types in the Amazon Biome. Our results show that combined SAR-based textural features and backscatter can overcome omission errors caused by post-disturbance tree remnants. Combining textural features and backscatter can support law enforcement activities by improving spatial and temporal accuracy of operational SAR-based disturbance monitoring and alerting systems.