Characterising Vegetation Structure and Disturbance using TanDEM-X: A Case Study in East Kalimantan

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Forest disturbance due to fire and subsequent regeneration are important processes particularly in South East Asia. Forests damaged by fire are still valuable in terms of conservation due to their ability to recover, sequester carbon and restore ecosystem services and should therefore be monitored. Sungai Wain Protected Forest (SWPF) located near the city of Balikpapan, East Kalimantan was affected by fires driven by El Nino Southern Oscillation (ENSO) in 1998 which led to the degradation of a previously undisturbed Dipterocarpacea forest. With the frequency and magnitude of ENSO events likely to increase in the future it is important to monitor forest regeneration after fire in the long term with Remote Sensing being a particularly valuable option. Spaceborne Interferometric Synthetic Aperture Radar (InSAR) offers an alternative to optical sensors in tropical areas where cloud cover and haze is frequent and hampers the retrieval of meaningful information. In particular, the TanDEM-X missions offers the opportunity to acquire data in interferometric mode thanks to two satellites closely orbiting in a double helix formation with minimization of temporal baseline and at high spatial resolution (approximately 2 m ground resolution at 41° incidence angle in StripMap single polarisation) compared to previous satellite missions. Typically temporal decorrelation has severely limited the ability to use coherence to monitor forests. The unprecedented provision of TanDEM-X coherence through simultaneous capture, thus without the limitation of temporal decorrelation, solves this problem. The aim is to assess the sensitivity of TanDEM-X coherence to horizontal vegetation structure (canopy cover) and vertical structure (vegetation height) these being derived from a high resolution airborne LiDAR (1 m resolution). Tests were done on 150 plots (35 x 35 m) located in secondary forest and agriculture, with mean canopy cover of 73% and height between 0.4 to 36.4 m (mean 14.7 m). Results indicate a negative linear relationship between TanDEM-X coherence and canopy cover ($R^2=0.64$) ($n=150$). This suggests that coherence is sensitive to the spatial distribution of scattering volume which causes decorrelation proportional to canopy cover. However, it was found that for fully regenerated secondary Dipterocarp forest with high canopy cover coherence ranges between 0.4 and 0.8 resulting in high scatter for high canopy cover. This was further investigated by assessing whether topography played a role in lowering coherence. No correlation between slope and coherence was found. Another possible cause for low coherence could be due to layover. Hoekman and Varekamp (2001) suggest that a high height difference between the forest components (presence of tall emergent trees) results in lowered coherence due to geometric decorrelation. Moreover, relationship between the vertical structure component (vegetation height derived from a LiDAR Canopy Height Model- CHM) was also tested resulting in a good correlation with coherence ($R^2=0.68$) while, a weaker relationship was found with LiDAR CHM mode ($R^2=0.63$) and, lower still with the distribution of standard deviation ($R^2=0.5$): but some of these independent correlations offer possibilities for better mapping of canopy cover. These results offer a promising potential for the use of coherence for detecting forest structural parameters such canopy cover and forest height.