Accurate Terrain Extraction in Indonesia's Dense Tropical Forest using ICESat-2

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SUMMARY

Precise mapping and monitoring of the tropical forest region is essential for addressing the global climate crisis. Terrain information plays a critical role in forest mapping and monitoring by providing fundamental data for various applications, including biophysical mapping, carbon stock estimation, flood assessment, and ecosystem analysis. However, conducting in-situ terrestrial mapping within highly dense vegetated regions, such as in the tropical rainforest of Indonesia, poses significant challenges due to remote site locations and difficult accessibility. Therefore, remote sensing sensors have proven to be useful for mapping forest areas over the past decades. Among these sensors, LiDAR has been recognized as the most powerful tool due to its capability to directly acquire three-dimensional points (x,y,z) of the observed objects and its ability to penetrate the dense forest canopy. Moreover, the availability of the newly launched spaceborne LiDAR mission, such as ICESat-2, provides a new opportunity for foresters to access freely available LiDAR data with global coverage. In this study, we aim to understand how effectively spaceborne LiDAR can provide terrain information within dense tropical forests in Indonesia. This research mainly focused on using ICESat-2 for terrain extraction, with validation performed against high-resolution airborne laser scanning data. From our study, ICESat-2 achieved a high accuracy in the study area, with a root mean square error (RMSE) of 0.728 meters. Then, to produce a seamless and full coverage digital terrain model, a combination of geostatistical techniques and spatial interpolation methods was applied. The terrain model from ICESat-2 provides significantly better accuracy compared to Indonesia's National Digital Elevation Model (DEM) product, DEMNAS, with RMSE values of 1.403 m and 5.042 m, respectively. Therefore, it was proven that ICESat-2 data can be used as a robust and effective alternative for extracting terrain information in Indonesia's tropical forests.