学 位 論 文 内 容 の 要 旨/Dissertation Abstract

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学 位 論 文 題 名/Title of Dissertation

Synergy of multi-source remote sensing and multi-model approaches for understanding post-disaster vegetation dynamics and terrain characteristics in Hokkaido, Japan
（北海道における災害後の植生動態と地形特性の理解に向けたマルチソースリモートセンシングとマルチモデルアプローチのシナジー）

In recent years, the frequency and severity of natural disasters, such as typhoons and earthquakes, have significantly impacted ecosystems and the environment. This dissertation addresses the pressing need for efficient monitoring and assessment of post-disaster environmental impacts by presenting five case examples, particularly in the context of the rising frequency and intensity of natural disasters in Japanese mountain ecosystems. By advancing remote sensing applications, this work highlights innovative methods for post-disaster damage extraction, focusing on Hokkaido, Japan.

The first case study investigates forest damage from three typhoons in Hokkaido in 2016. Using Landsat 8 imagery, vegetation indices, machine learning classifiers, and the CLASlite software, various approaches to damage estimation were compared. Machine learning classifiers, especially Random Forest (RF) and Support Vector Machines (SVM), demonstrated high accuracy (80.36% overall accuracy) when using Fractional Cover as a predictor. Among vegetation indices, DNDVI showed superior performance, effectively identifying damage areas. This analysis revealed that forest damage was more severe on windward slopes and at higher elevations, emphasizing the role of landscape features in damage distribution.

The second case study examines topographic changes and vegetation dynamics in areas affected by the 2018 Mw 6.6 Hokkaido Eastern Iburi earthquake. Using high-resolution digital elevation models (DEMs) and multi-temporal satellite imagery from Sentinel-2 and Planet, landslide activity was mapped and vegetation regrowth tracked as a stability indicator. Results showed significant topographic steepening due to the earthquake, with vegetation recovery proceeding slowly, suggesting ongoing vulnerability to debris flows and gully erosion. These findings underscore the need for long-term monitoring to assess landscape stability after seismic events.

In the third and fourth case studies, high-resolution topographic changes in landslide-affected areas following the 2018 earthquake were analyzed using LiDAR-derived DEMs. Changes in slope, relief, and texture were examined, and comprehensive volume estimates of shallow landslides were compared with global area-volume relationships, highlighting uncertainties in scaling for earthquake-induced landslides. Findings suggest that the earthquake not only steepened the topography but also generated debris volumes exceeding typical uplift rates, contributing valuable insights to co-seismic uplift and erosion assessments.

The final study uses UAV-LiDAR data to capture microtopographic changes in the Iburi region, focusing on rill erosion dynamics in areas with minimal vegetation regrowth. A high-resolution DEM from a Zenmuse L1 LiDAR system enabled the application of an automatic rill extraction algorithm, providing detailed data on rill density, width, depth, and sediment loss over time. This study demonstrates UAV-LiDAR's potential for microtopographic analysis and monitoring of rill erosion in post-landslide landscapes.

Collectively, the methodologies and findings presented in this dissertation demonstrate the effectiveness of integrating multi-source remote sensing data and advanced processing techniques to enhance post-disaster damage extraction. These insights can guide future monitoring and risk assessment efforts in disaster-prone regions, supporting more resilient environmental management strategies.