|  |
| --- |
| **Predicting countrywide growing stock volume using airborne laser scanning, Landsat time series, and national forest inventory data in Japan** |
| **Introduction/Aim:**  Predicting large-scale forest structural attributes is important for sustainable forest management. Airborne laser scanning (ALS) data has been acquired in many regions over the past few decades; however, it is usually collected regionally across different projects and does not cover the entire country. Although ALS-derived three-dimensional information can aid an accurate prediction of forest structure, such as growing stock volume, the prediction methods using spatially and temporally biased ALS data have not been fully investigated for wall-to-wall national-scale mapping. In this study, we investigated and assessed the methods for predicting growing stock volume in Japan for 1990­–2020 using ALS data collected in different regions, national forest inventory (NFI) data, and Landsat time series data.  **Methods:**  We collected ALS data acquired in different regions and years across Japan, which covers 4.6 million ha (i.e., 12% of the total land area of the country) in total. We processed the original point cloud data to generate area-based metrics at 30 m spatial resolution in each ALS extent through the ground/non-ground classification, digital terrain model generation, and point normalization. Then, the latest NFI data was used to build a prediction model for growing stock volume in the ALS extent. In this stage, we used area-based metrics from ALS and growing stock volume from NFI data in a generalized linear model for prediction. After building the NFI-ALS model, we predicted growing stock volume for ALS extent and then used them to build second stage models for wall-to-wall national-scale mapping. We derived predictor variables from Landsat time series data for 1985–2021, the forest disturbance map, and topographic data. We implemented Continuous Change Detection and Classification and LandTrendr algorithms using Landsat time series data to derive times series variables covering the entire country. This study employed a deep learning algorithm, U-net network, to predict ALS-derived growing stock volume. The prediction accuracy was evaluated using the validation data from ALS-derived growing stock volume and independent field surveys.  **Results:**  The root mean squared error (RMSE) of the U-net prediction model was 147.4m3/ha (relative RMSE of 37.4%) based on validation data from ALS-derived growing stock volume. The independent field survey data showed possible regional differences in prediction accuracies. The mapping results over the country indicated that there were growing stock volume of 8.65 billion m3 in 2020, which is almost the same amount estimated by the latest NFI data (i.e., 8.62 billion m3). The overestimation was observed for the estimates in 1990, which might be caused by a lack of forest disturbance information prior to 1985.  **Conclusion:**  This study shows a potential strength of ALS data that were acquired in different regions across the country to predict wall-to-wall forest growing stock when combined with NFI and Landsat time series data. Although the prediction accuracy might be lower in 1990, spatially explicit estimates from this study can improve the understanding of countrywide forest dynamics. |

*Please note the headings provided are optional, please remove or change to best suit your content.*