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Machine learning-based estimate of carbon sequestration loss after earthquake in subalpine forests of the Jiuzhaigou National Nature Reserve, Eastern Tibet Plateau

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As a natural disaster, earthquake could cause remarkable impacts on terrestrial ecosystems, e.g. vegetation cover loss. Previous studies evaluating the impact of earthquake mainly focused on vegetation recover using normalized difference vegetation index or enhanced vegetation index, however, very limited studies assessed the impact of earthquake on carbon sequestration capability. Therefore, in current study, we quantitively assessed the carbon sequestration loss (indicated by aboveground net primary production (ANPP)) after the 7.0-magnitude earthquake in Jiuzhaigou National Nature Reserve (JNNR) in the Eastern Tibet Plateau combining Landsat 8, Sentinel 2 and field observations. Annual ANPP was estimated based on 50 fixed inventory plots set in 2018 and measured in 2019, 2020 and 2021. Mean ANPP of 2019-2020 and 2020-2021 was used in modelling to reduce its inter-annual variabilities. Three approaches - linear regression (LR) and two machine learning approaches - random forest (RF) and extreme gradient boosting (XGBoost) were used to predict ANPP across the whole JNNR. Results showed that observed forest ANPP of the JNNR varied from 0.8 to 11.5 Mg ha^{-1} $year^{-1}$ with an average of 4.07 Mg ha^{-1} $year^{-1}$. A total of 5.75% forest area was lost after the earthquake estimated from Sentinel-2 images. Both Landsat 8 and Sentinel-2 images successfully estimated ANPP using LR, RF and XGBoost respectively, however, the model performance varied greatly. Regardless of the modeling approaches, the integration of Landsat 8 and Sentinel-2 images significantly improved model efficiency. The results highlight a potential way to improve the prediction accuracy of forest ANPP in mountainous areas by integrating the Sentinel-2 and Landsat 8 images. Finally, XGBoost model performed the best with a model efficiency (R^2) of 0.67 and root mean square error ($RMSE$) of 1.23 Mg ha^{-1} $year^{-1}$ and then it was used for spatial modelling. Modelled forest ANPP showed a strong spatial variability across the study area, where the pre-earthquake forest ANPP was 2.1×10^5 Mg $year^{-1}$, and the post-seismic value was 1.65×10^5 Mg $year^{-1}$, indicating a total loss of 0.45×10^5 Mg $year^{-1}$, accounting for about 21.43% of total ANPP. This study proposed a potential approach to assess the loss of carbon sequestration caused by natural disaster in regional scales. Our findings also suggested a remarkable carbon loss after the earthquake and the natural disaster should be

considered in regional carbon sequestration estimate and biogeochemical models to accurately predict carbon cycling in terrestrial ecosystems.

Keywords: earthquake, carbon sequestration capacity, aboveground net primary production; Landsat 8; Sentinel-2

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