Revealing spatiotemporal patterns of revegetation on volcanic slopes using optical satellite imagery and GIS

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Constraining the effects of vegetation on landform evolution is one of the biggest challenges in modern geomorphological studies. While there are many existing landform evolution models, not many studies have attempted to incorporate vegetation data explicitly due to difficulties in obtaining constructive quantitative data for integration into geomorphic transport functions. Quantification of the patterns and speeds of vegetation regrowth is integral to understanding the effects of vegetation on hillslope and other landform development. With time-robust remotely-sensed optical data and new platforms that allow for faster computation and processing, new opportunities to quantify vegetation changes at larger spatial and finer temporal scales are now available.

Quantifying vegetation recovery in volcanic areas, in particular, remains challenging due to the difficult topography found in volcanic areas, as well as the heterogeneous vegetation cover due to rapid land cover changes after events such as eruptions. Therefore, using the study areas of Unzen volcano and Miyakejima island in Japan, this study aims to quantify and characterize vegetation regrowth on volcanic hillslopes.

Satellite imagery from months June to August in the years of interest from the Landsat 5, 7, and 8 Surface Reflectance dataset was processed in Google Earth Engine, and Normalized Difference Vegetation Index (NDVI) time-series analyses were performed with help of GIS. The pixel-wise change of NDVI vegetation recovery index was then calculated from the derived yearly median NDVI values to show the change in NDVI from the baseline post-eruption vegetation state. Then, regression models were applied to determine the per-pixel change intensity, as well as to obtain significant factors contributing to the different vegetation recovery rates.

The methodology applied in this study successfully estimated vegetation recovery rates for the two volcanic areas. The results show that vegetation recovery rates are exponential, with the most rapid increases observed within the first five years post-eruption. However, spatial variation in the recovery rate is also observed. The trend of recovery differed based on the proximity to different kinds of vegetation and the initial type of disturbance affected by the vegetation.

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