

Abstract

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Thesis title Investigation of vegetation indices for canopy-scale photosynthesis and phenology assessment in Japanese cypress (*Chamaecyparis obtusa*) forests (ヒノキ林における樹冠スケールでの光合成及びフェノロジー評価のための植生指標の検討)

Accurate assessment of canopy-scale photosynthesis and phenology is essential for understanding forest carbon dynamics and ecosystem responses to environmental changes. This study investigates the utility of vegetation indices (VIs) in monitoring seasonal variations in photosynthetic activity and phenological transitions in a Japanese cypress (*Chamaecyparis obtusa*) forest. By integrating tower-based remote sensing techniques with eddy covariance measurements, this study evaluates the effectiveness of traditional and novel spectral indices in tracking canopy light-use efficiency (LUE) and net ecosystem exchange (NEE) during specific and annual phenological events. The winter-specific phenomenon of leaf reddening, which functions as a photoprotective strategy in evergreen conifers, has garnered particular attention. A novel spectral vegetation index, designated as the rhodoxanthin index (RI), has been developed and integrated with established indices, including the photochemical reflectance index (PRI), the chlorophyll/carotenoid index (CCI), the triangular photochemical reflectance index (tri-PRI), and the red-green vegetation index (RGVI). This comprehensive methodology is employed to monitor winter-specific phenological events and to elucidate the underlying photoprotective mechanisms. This study further investigates the effectiveness of various vegetation indices (VIs), specifically the normalized difference vegetation index (NDVI), PRI, CCI, RI, and RGVI, in monitoring annual phenological events and the changes associated with LUE and net ecosystem exchange NEE. The findings indicate that both PRI and CCI serve as reliable indicators of seasonal photosynthetic activity, while RI demonstrates a capacity for effectively capturing physiological stress associated with winter conditions. This study advances the integrated application of remote sensing and eddy covariance method for monitoring forest phenology and photosynthesis. Our findings highlight the potential of combining spectral indices to enhance the understanding of phenological patterns in evergreen forests and the associated photoprotective mechanisms. Furthermore, this approach may refine predictions related to ecosystem carbon dynamics.