EGU21-14548
https://doi.org/10.5194/egusphere-egu21-14548
EGU General Assembly 2021

Using high‐resolution aerial imagery and deep learning to detect tree spatio-temporal dynamics at the treeline

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Recent advances in deep learning techniques for object detection and the availability of high-resolution images facilitate the analysis of both temporal and spatial vegetation patterns in remote areas. High-resolution satellite imagery has been used successfully to detect trees in small areas with homogeneous rather than heterogeneous forests, in which single tree species have a strong contrast compared to their neighbors and landscape. However, no research to date has detected trees at the treeline in the remote and complex heterogeneous landscape of Greece using deep learning methods. We integrated high-resolution aerial images, climate data, and topographical characteristics to study the treeline dynamic over 70 years in the Samaria National Park on the Mediterranean island of Crete, Greece. We combined mapping techniques with deep learning approaches to detect and analyze spatio-temporal dynamics in treeline position and tree density. We use visual image interpretation to detect single trees on high-resolution aerial imagery from 1945, 2008, and 2015. Using the RGB aerial images from 2008 and 2015 we test a Convolution Neural Networks (CNN)-object detection approach (SSD) and a CNN-based segmentation technique (U-Net). Based on the mapping and deep learning approach, we have not detected a shift in treeline elevation over the last 70 years, despite warming, although tree density has increased. However, we show that CNN approach accurately detects and maps tree position and density at the treeline. We also reveal that the treeline elevation on Crete varies with topography. Treeline elevation decreases from the southern to the northern study sites. We explain these differences between study sites by the long-term interaction between topographical characteristics and meteorological factors. The study highlights the feasibility of using deep learning and high-resolution imagery as a promising technique for monitoring forests in remote areas.