

Spruce Forest Damage Assessment Using Machine Learning on Sentinel-2 Time Series in the Tatra Mountains

Summary for the general public

I. Motivation and rationale

Forests play a crucial role in the Earth's ecosystem, providing vital benefits like carbon sequestration, wildlife habitat, and water regulation. However, forests are increasingly threatened by human activities, climate change, and disturbances such as bark beetle infestations. These disturbances have significant ecological impacts, especially in vulnerable mountain forests. To effectively manage and conserve mountain forests, continuous monitoring is essential, particularly in areas prone to bark beetle outbreaks. The Tatra Mountains, a UNESCO transboundary biosphere reserve and the highest mountain range in the Carpathians, offer a unique opportunity to study the impact of disturbances. With a protected status and limited human intervention, this region allows for the examination of ecological consequences without external influences. Monitoring forest stands using satellite remote sensing is an innovative approach that provides timely and accurate information on forest health. European Sentinel-2 satellites, with their short revisit time and open data access, are valuable resources for environmental studies. This scientific project aims to assess the health condition of Tatra mountain stands affected by bark beetles using satellite data. Sentinel-2 images will be analysed to evaluate the extent and severity of infestations and their impact on forest health. Ground-truth measurements obtained from field surveys will validate the satellite-based assessments and improve accuracy.

II. Research objectives and methods

This project aims to assess the impact of bark beetle infestation on the health condition of Tatra mountain stands using innovative and comprehensive approaches. The research objectives include: 1) Utilising a 10-year time series of Sentinel-2 satellite images (2015-2024) to analyse changes in stand health over time. 2) Employing chlorophyll fluorescence measurements as an indicator of early plant stress, enabling early detection of bark beetle infestation. 3) Analysing large mountainous regions to gain a comprehensive understanding of the impact of cambioptrophs on the ecosystems. The project will develop a repeatable method to efficiently analyse data and identify changes in stand health. 4) Identifying spectral indices and specific Sentinel-2 channels that effectively differentiate between infected and healthy spruces. 5) Developing an advanced tree species mapping method to ensure high classification accuracy for identifying dead wood and healthy spruce trees.

III. Significance of the project and expected results

Project represents a cutting-edge endeavour in remote sensing research, as it undertakes a comprehensive analysis of expansive mountainous forests through the utilisation of a long time series of satellite imagery. Use of the 10-years temporal coverage enables the precise estimation of bark beetle infestation in Tatra mountain stands, yielding insights into the intricate dynamics of their health condition. Through its innovative approach, the project aims to unravel the complexities of bark beetle impacts facilitating the preservation of these important ecosystems, paving the way for the implementation of targeted natural areas management. Through this analysis, the study will provide insights into the dynamics and magnitude of changes occurring in the bark beetle-infested areas in Tatras. This comprehensive assessment will contribute to a deeper understanding of the spread of bark beetle infestation within the mountain stands. The results and analyses will contribute to the monitoring network of the Tatra Mountains and especially to the geoportals of the Tatra National Park.