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Combination of Sentinel-2 change detection and forest site factors to reveal patterns of forest degradation in Thuringia

Abstract

Forests are increasingly affected by degradation phenomena in Germany. The consequences of the prolonged drought of recent years and the additional weakening caused by pests and storm events have already led to larger areas of calamity, especially in spruce stands but also in deciduous forests. Remote sensing data is increasingly being used for operational monitoring the status and dynamics of forest stands. Although changes in tree vitality and extent of damaged areas are well detectable from space, there is currently a lack of understanding of the role of well-established forest site factors to interpret and explain detected forest degradation. However, an understanding of the remotely sensed change signal and its relationship to ecological and hydrological geoinformation is of interest for risk assessment and future forest management.

In this study, we address the question to what extent the changes detectable by remote sensing methods can be explained by information on forest site factors and water availability in Thuringian forest areas. For this purpose, data of a forest site survey system was used, which is founded on uniform soil and site mapping since the 1950s. Recently, this database has been enriched with high-resolution geoinformation of soil water supply by the means of digital soil mapping. Cloud-free Sentinel-2 data was collected (2016-2021) and atmospherically corrected for different study areas in the Thuringian Forest and Southern Harz.

Time series of several vegetation indices describing vitality status (sensitive to cell-bound water and chlorophyll content) were calculated for each image and site. A modified change detection procedure based on index differencing and time series analysis was developed to prevent false positive vitality signal due to rapid scrub encroachment on recently degraded or deforested areas. Therefore, after applying an outlier correction and smoothing routine to the time series (e.g., to correct for low index values due to undetected cirrus clouds), the maximum period of the negative trend was identified to calculate the index difference for each pixel. The resulting composite difference image was used to examine the effects of various forest site factors (e.g., slope, aspect, soil substrate) by applying analysis of variance.

Preliminary results show a high explanatory potential of the soil substrate for observed vitality losses. However, not all vegetation indices studied are equally sensitive to changes so that site-specific adjustments of the method are required to account for the dominant tree species. The initial conclusions can be drawn that the combination of Sentinel-2 change detection and forest site factors contributes to a better understanding of recent forest degradation. The integration of remote sensing with forest site data can be used to assess vulnerability to prolonged droughts, identify areas of risk and ultimately support decision making for successful forest restoration.