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Combined analysis of tree rings and MODIS images to evaluate beech forest productivity along geographic gradients

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Remote sensing is widely used for monitoring vegetation status and ecosystem productivity. The increasing interest in connecting satellite vegetation indices to actual forest productivity has led to explore their relationship mainly at coarse spatial resolution and continental scale. The aim of this study is to find a connection and predict tree growth using medium resolution multispectral images and tree ring data for a sample of Italian and Austrian beech forests along latitudinal and altitudinal gradients. Beech tree ring data were collected and analyzed during the last 20 years, recording tree positions with a GPS device. MODIS pre-composite 250 m 16 days images (MOD13Q1) from 2000 to 2018 were first re-projected and quality checked using the MODIS quality assessment. Vegetation indices (NDVI and EVI) were extracted within a distance of 750 meters from every site centroid. Only deciduous forests (assessed by Corine Land Cover) with a dense canopy cover (assessed by Global Forest Change tree cover) were selected. Eight different phenology metrics were calculated using a threshold method and a modified one and then correlated with tree ring data (Basal Area Increment, BAI). The overall network and the relationship between metrics were characterized first with a Principal Component Analysis (PCA), and then evaluating the mean phenology, exploring its relationship with environmental variables (elevation, temperature). Last, the model for predicting BAI at every site was calculated for the period 2000-2009 using the metrics as predictors in a multiple linear regression. Two group of metrics were identified from PCA: the first is made of metrics based on dates (named DOY, e.g. start of growing season), the second on the vegetation index values (named VALUE, e.g. peak value,). BAI was modeled using as predictors the highest correlate from each of the two groups of metrics. BAI predictions for every site were generally significant: the 61% of the sites had at least one significant predictor, with a mean R-squared of 0.55 over the 41 sampled sites. DOY metrics were significantly related to altitude and temperature. Because of the wide latitudinal gradient of the study sites, mean annual temperatures showed higher correlations than the altitude with the DOY metrics. The mean growing season was longer for warm sites at low altitude. The relation between multispectral images and beech populations actual growth at medium spatial resolution is consistent even for those sites that are in complex environmental conditions, making possible to predict the annual diameter growth.