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# Use of a digital camera onboard an unmanned aerial vehicle to monitor spring phenology at individual tree level

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The monitoring of forest phenology, in a cost-effective manner, at a fine spatial scale and over relatively large areas remains a significant challenge. To address this issue, unmanned aerial vehicles (UAVs) appear as a potential new option for forest phenology monitoring. The aim of this study is to assess the potential of imagery acquired from a UAV to track seasonal changes in leaf canopy at individual tree level.
UAV flights, deploying consumer-grade standard and near-infrared modified cameras, were carried out over a deciduous woodland during the spring season of 2015, from which a temporal series of calibrated and georeferenced 5 cm spatial resolution orthophotos was generated. Initial results from a subset of trees are presented in this paper. Four trees with different observed Start of Season (SOS) dates were selected to monitor UAV-derived Green Chromatic Coordinate (GCC), as a measure of canopy greenness. Mean GCC values were extracted from within the four individual tree crowns and were plotted against the day of year (DOY) when the data were acquired. The temporal GCC trajectory of each tree was associated with the visual observations of leaf canopy phenology (SOS) and also with the development of understory vegetation.
The chronological order when sudden increases of GCC values occurred matched with the chronological order of observed SOS: the first sudden increase in GCC was detected in the tree which first reached SOS; 18.5 days later (on average) the last sudden increase of GCC was detected in the tree which last reached SOS (18 days later than the first one). Trees with later observed SOS presented GCC values increasing slowly over time, which were associated with development of understory vegetation.
Ongoing work is dealing with: 1) testing different indices; 2) radiometric calibration (retrieving of spectral reflectance); 3) expanding the analysis to more tree individuals, more tree species and over larger forest areas, and; 4) deriving phenological metrics from the fitted time series of UAV data.
It is concluded that UAV imagery has the potential to track leaf phenology at the individual tree level, but further studies are necessary to better understand this new scale of information detected from UAVs.