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Assessing annual forest phenology: A comparison of Unmanned Aerial Vehicle (UAV) and Phenocamera Datasets

Near-surface remote sensing platforms such as Unmanned Aerial Vehicles (UAVs) and phenocameras appear to be potential platforms for keeping track of seasonal dynamics at a local scale. This research focusses on extracting time series of different vegetation indices (VIs) from both platforms, computing seasonality events from them and comparing the results against spectral sensor data.

Time series of UAV derived Normalized Difference Vegetation Index (NDVI) and phenocamera based Green Chromatic Coordinate (GCC), Excess Green Index (ExG) and Normalized Difference of Green & Red (VIgreen) indices were extracted for growing season of years 2018 and 2019. There was a good agreement between the UAV and spectral sensor-derived NDVI as reflected in high Pearson's correlation coefficients (r_{2018} = 0.780 and r_{2019} = 0.903). Phenocamera-based GCC best approximates NDVI measurements from the spectral sensor, with correlation coefficients of r_{2018} = 0.848 and r_{2019} = 0.80, closely followed by ExG (r_{2018} = 0.777 and r_{2019} = 0.798), while they were lowest in the case of VIgreen (r_{2018} = 0.719 and r_{2019} = 0.773). Due to small number of records, UAV-derived NDVI, led to slightly lower correlation coefficients when compared with phenocamera VIs, with GCC and ExG being the best (r_{2018} = 0.670, r_{2018} = 0.695), while no correlation exists for the year 2019 ($\rho > 0.05$). Time series data were fitted with double logistic function for spectral sensor NDVI and phenocamera-based VIs, whereas a spline interpolation method was employed to fit UAV-NDVI time series. Despite, the offset between spectral sensor NDVI and UAV-NDVI in 2018, the UAV curve follows nicely the spectral sensor curve except for the year 2019. GCC, ExG, and UAV-NDVI based phenological transition dates estimation were consistently more closely associated with the visual assessments of phenology, at an accuracy of less than 8 days with year 2019 as an exception where Start Of Spring (SOS) was 14 days earlier. SOS from VIgreen and spectral sensor NDVI occurred earlier (24 and 27 days respectively), compared to visually observed phenophase dates. The transition dates from all platforms over the study period revealed a shift ranging between 6 – 12 days in all seasonality events. Due to hourly temporal resolution of phenocamera, it provided more flexiblity in estimating important phenophase dates. Tree-canopies level quality information including NDVI

can be obtained with high temporal resolution and large spatial coverage of UAV, unmatched by any other methods discussed. The agreement between UAV-NDVI and spectral sensor NDVI for evergreen spruce forest reveals the adequacy of these platforms for the monitoring of tree dynamics. In addition, phenocameras demonstrated to offer a detailed insight into plant phenology at fine spatio-temporal scales.

Keywords: Geography, Ecosystem Analysis, Near-surface Remote Sensing, UAV, Phenocamera, Forest Phenology, Phenophase, Seasonality, NDVI, GCC

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