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Monitoring deciduous tree phenology estimates with Sentinel-2, phenocam and field measurements in Ireland

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Phenology is an important driver of ecosystem performance. However, studies of phenology in Ireland have been limited by the availability of data at high spatial and temporal resolutions. The new suite of Sentinel-2 sensors, with their enhanced spatial and temporal resolutions might help overcome some of these challenges. Additionally, the presence of red edge bands in the Sentinel-2 sensors provides a unique opportunity to evaluate the performance of different vegetation indices in tracking near surface (phenocam) and ground/laboratory measures of phenology. In this study, we present our initial analyses for the year 2020. Nine common lime trees (Tilia x europaea) on the University College Cork campus (Cork, Ireland) and three undisturbed broadleaf woodland sites from the National Park and Wildlife Services (NPWS) survey were selected. The phenology of these sites was analyzed from satellite derived vegetation indices of NDVI, EVI, GNDVI and NDRE. The available 24 cloud free Sentinel-2 images were pre-processed and interpolated to daily time steps. The start of season (SOS), position of peak (POP) and end of season (EOS) were then extracted from the daily time series using the half amplitude and maximum value method. Similarly, daily data from a phenocam overlooking three of the lime trees were processed to extract the phenological dates. Weekly measurements of leaf chlorophyll or chlorophyll content index (CCI) and maximum photosystem II efficiency (Fv/Fm) by sampling five leaves from each lime tree were made during June to November of 2020. Preliminary results indicate that different vegetation indices vary in their correlation to ground and phenocam observations. The dates of SOS, POP and EOS obtained from Sentinel-2 do not exactly match the ground and phenocam observations, nor are the different indices coincident with each other, with maximum deviations of up to a month and a week for EOS and SOS respectively. The phenological metrics estimated from the EVI time series were in general earlier (i.e. 116, 162 and 270 day of year for SOS, POP and EOS respectively) and those from the NDRE were the last (i.e. 131, 211 and 288 day of year for SOS, POP and EOS respectively). Although local differences were observed in the field, the Sentinel-2 time series data were shown to perform well in tracking the autumn phenology, and in most cases the observed mismatches in phenological data could be ascribed to differences in the scale of observations i.e. pixel vs point comparisons and on spectral basis i.e. sensor vs instrument for measuring CCI. A steeper drop in CCI and Fv/Fm values was also observed in the late autumn period. Such differences in the progression of each time series curve can possibly lead to mismatches in the phenology estimated from vegetation indices and from observations. Other mismatches could also emanate from the fact that field sampling of leaves was done from below the canopy whereas

the satellite view of canopy is from the top. Experience from the field revealed differences in the rates of greening and yellowing of the leaves in different regions of the tree canopy.