ARPHA Conference Abstracts 9: e221214
doi: 10.3897/aca.9.e221214

OPEN ACCESS

Conference Abstract

Impacts of Pre-season climatic and functional drivers on the spring onset of phenocam-derived GCC

Sabica Naz‡, Tomas Rusnak‡, Lubos Halada‡

‡ Slovak Academy of Sciences, Nitra, Slovakia

Corresponding author: Sabica Naz ()

Received: 28 Oct 2026 | Published: 28 Oct 2026

Citation: Naz S, Rusnak T, Halada L (2026) Impacts of Pre-season climatic and functional drivers on the spring onset of phenocam-derived GCC. ARPHA Conference Abstracts 9: e221214.
https://doi.org/10.3897/aca.9.e221214

Abstract

Understanding how winter and early-spring environmental conditions shape the timing of canopy greening is critical for predicting forest responses to ongoing climate change in Central Europe. This study analysed the pre-season climatic and functional drivers of the onset of the growing season in two experimental plots with different canopy structures of the hornbeam Bab forest in western Slovakia. Plot A73 represented a closed-canopy stand, while plot P38 is characterised by a more open canopy. In A73, three phenocam regions of interest (ROIs) captured canopy segments dominated by *Carpinus betulus*, *Quercus cerris*, and *Acer campestre*, while in P38, 3 ROIs corresponded to *Quercus robur* , *Acer campestre*, and *Carpinus betulus*, respectively. The study compared species-level spring phenology in contrasting light environments within the same regional climate.

Near-surface phenology was monitored using digital phenology Watchman cameras, and GCC (green chromatic coordinate) was extracted for each ROI and image using a PhenoPix package in R. For each plot, daily GCC time series were extracted and smoothed using Savitzky–Golay filtering to reduce high-frequency noise of GCC time series of PhenoCam data. We focused on the 95th percentile GCC across all four tree species to capture the high values of greenness, which is less sensitive to shadows and occasional misclassified pixels than lower percentiles or raw means. The start of season

© Naz S et al. This is an open access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

(SOS) was then identified from the smoothed 95th percentile GCC values as the point at which GCC exhibited a sustained increase from the winter baseline towards the spring peak, with a threshold of 20% of the GCC amplitude across all species.

To analyse the environmental impacts on SOS, we set the six-month pre-season window for each species, typically spanning October to March. Daily global radiation (GL; W/m^2), Photosynthetically Active Radiation (PAR) energy measurements (W/m^2), Total precipitation (RG; mm/h), Relative air humidity (RH; %), Soil moisture at 20 cm depth (SM20; $m^3.m^{-3}$), Air temperature at 0.5 m height (TA0.5; °C), Ground temperature at 20 cm depth (TG20; °C) were obtained from the meteorological station situated less than 1 km from the Bab forest, which provided a high-quality local climate record. From this data, we derived summary metrics of winter chilling and spring forcing temperature, along with other climatic indicators used in phenological modelling. Photoperiod was calculated using the Meteor Package in R based on the site's geographic coordinates, and was aligned with the GCC and climate time series to capture daylength progression during the pre-season period. Functional trait information was incorporated, including leaf dry matter content (LDMC) and specific leaf area SLA) computed from field-collected leaves. Fresh and dry masses were measured for all species to reveal species-level differences in dry-matter and leaf tissue density. In addition, tree height and diameter at breast height (DBH) were measured with a SLAM-based device to describe stand structure, and these structural attributes were used to interpret how canopy architecture responded to climatic drivers.

The GCC trajectories showed a clear transition from winter to spring in both plots, but with distinct dynamics at both the plot and species level. In the closed-canopy plot A73, aggregated 95th percentile GCC values were around 0.34–0.35 in mid-winter and rose steadily to approximately 0.58 at the spring peak, showing a strong leaf-out under relatively shaded conditions. In this plot, no tree species greened simultaneously, as species-specific GCC curves showed different SOS timings and rates of increase, indicating that Carpinus betulus, Quercus cerris, and Acer campestre each responded slightly differently to the same pre-season environment, given their contrasting leaf traits and canopy positions. In the more open-canopy plot P38, the GCC increased from about 0.37 in winter to over 0.60 at peak greenness, which indicated a sharper, slightly higher-amplitude greening due to higher light penetration into the canopy. Here, the GCC values of *Quercus robur*, *Acer campestre*, and *Carpinus betulus* similarly showed a spread of SOS dates and different greening amplitudes, indicated that species-level spring phenology in the open stand is also shaped by functional traits and microclimatic light and temperature conditions rather than by plot structure alone.

During mid-winter, mean air temperature was below 0 °C, with daily averages near −3 °C, low global radiation and PAR, and short photoperiods of about 8.4 h, all of which maintained GCC in the winter season for all species. As the spring season started, forcing temperatures increased, with daily mean air temperatures rising into the positive range and exceeding 5–10 °C, while photoperiod extended to around 12–13.5 h and radiation inputs increased significantly, which influenced the onset and rapid rise of GCC in both plots. Preliminary analysis of grouped pre-season drivers suggested that winter

chilling and spring forcing temperatures indicated the strongest influence for SOS timing, with evidence that chilling effects generally outweigh photoperiod and interact with forcing temperatures to shape spring phenology in woody species, while differences in LDMC, SLA and canopy openness between species and plots appeared to highlight how strongly GCC responds to similar climatic conditions. Observations concluded that GCC-derived SOS can be robustly estimated across multiple species with contrasting canopy structures, and that timing of spring onset is best understood within an integrated framework that combines pre-season climate, photoperiod, and functional traits rather than relying on climate alone.

Keywords

GCC, Phenocam, Spring Phenology, Climate

Presenting author

Sabica Naz

Presented at

Oral Presentation

Grant title

Development and strengthening of long-term ecological research of selected types of ecosystems.

Hosting institution

Institute of Landscape Ecology, Slovak Academy of Sciences.

Conflicts of interest

The authors have declared that no competing interests exist.