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A new approach for improving representation of boreal forest phenology in land surface models

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In a boreal region, terrestrial vegetation carbon balance is controlled by vegetation phenology, which steers photosynthesis, respiration, and biomass turnover processes. In the absence of a full mechanistic understanding of environmental processes controlling vegetation phenology (i.e. senescence, dormancy, chilling), empirically-based models are often applied. These models are typically based on greenness proxies (obtained from satellite data) with fixed amplitude thresholds (e.g. of 15%, 50%, 90%) to determine timings of different phenological events. Yet, it is not known how well those percentiles correspond with the timings of events such as the green-up and the senescence. Especially in the boreal region, estimating timings of different phenological events across large spatial scales remains challenging due to the lack of sufficient ground validation data representative of both forest tree canopy and forest understory species compositions, which are both observed by a satellite sensor. From the land surface modeling perspective, there is a need to develop methods to improve the mapping of phenological events for prudent prediction of the land vegetation-atmosphere interactions under different future climates. In this study, we developed a new approach for calibrating boreal forest greenness amplitude thresholds which indicate timings of different phenological transitions in satellite data. The new approach to calibrate satellite-based greenness thresholds was demonstrated using boreal Finland as a case study area (60-70 N°). Using the approach, we computed satellite-based phenological events and compared them to ground reference data on temperature from a network of meteorological stations across Finland. We also investigated the effects of using different phenological events or ground reference temperature data on estimated growing season length. Results showed that while the standard greenness amplitude threshold values corresponded fairly well with the growing season start, the autumn phenology was not well captured by the standard greenness amplitude threshold values, which has direct impact on growing season length. Based on our data, boreal conifer forest senescence (default is 90%) corresponds with the timing of greenness amplitude of ~45%, while boreal conifer forest dormancy (default is 15%) corresponds with the timing of reaching greenness amplitude of ~0%. The approach allows flexible application across spatial scales (i.e. point or grid) and different satellite sensors, and may be combined with any land cover product, and it provides a meaningful linking between surface temperature data and seasonal reflectance measured by satellite sensors.