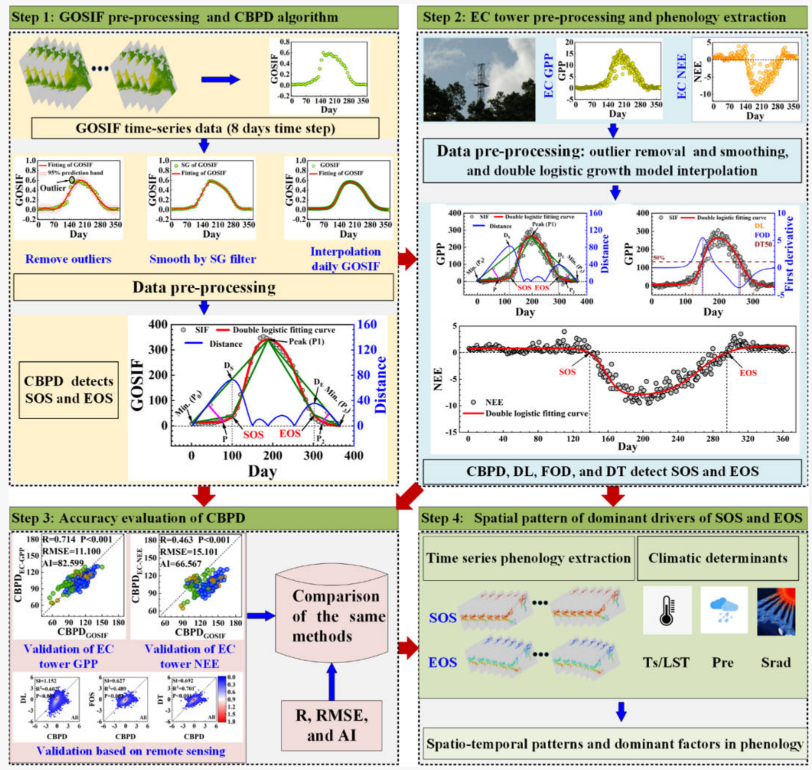
Innovative forest phenology monitoring technology: a new perspective for ecology

GA, UNITED STATES, March 6, 2025 /EINPresswire.com/ -- A new method for forest phenology detection, called the Change Point Estimation of Forest Photosynthetic Phenology based on the Maximum Perpendicular Distance (CBPD), has been developed to accurately extract the start and end of the growing season in forests. Using Solar-Induced Chlorophyll Fluorescence (SIF) data, this innovative approach provides a powerful tool for understanding how forests respond to climate change and offers crucial insights into forest ecosystem dynamics.



Technical flowchart of this study.

Forests are vital to the global carbon cycle and play a critical role in regulating climate stability. However, accurately detecting forest phenology—particularly the timing of photosynthetic activity—has long been a challenge. Traditional vegetation indices like normalized difference vegetation index (NDVI), while widely used, can only reflect the “greenness” of vegetation, and signal saturation is common in dense vegetation ecosystems such as forests, and cannot accurately capture forest photosynthesis phenology. The SIF remote sensing data contain abundance of plant physiological and biochemical information, which can directly reflect the dynamic process changes of the actual photosynthesis of vegetation. Yet, challenges remain in SIF data resolution and temporal continuity. To overcome these limitations, reconstructing high spatial and temporal continuity of SIF data to extract forest photosynthesis phenology is needed.

On February 20, 2025, a research team from Wuhan University and Emory University published a pioneering study (DOI: 10.34133/remotesensing.0425) in Journal of Remote Sensing, introducing the Change Point Estimation of Forest Photosynthetic Phenology based on the Maximum Perpendicular Distance (CBPD) method. This new approach, leveraging SIF data, offers a more accurate way to pinpoint the start and end of the growing season compared to traditional methods. It provides an essential tool for ecological research and climate change studies, with the potential to revolutionize forest phenology monitoring.

The standout feature of this study is the CBPD method, which outperforms traditional techniques such as Double Logistic (DL), First-Order Derivative (FOD), and Dynamic Threshold (DT) in accuracy. The CBPD method reduces Root Mean Square Error (RMSE) by 0.04 to 14.04 days, increases Pearson's correlation coefficient (R) by 0.03 to 0.30, and boosts the Agreement Index (AI) by 0.34 to 21.52. In addition, the study reveals that spring phenology is primarily driven by temperature, while autumn phenology is influenced more by radiation, highlighting how climate change is reshaping forest growth patterns.

The research team employed the Global OCO-2 SIF (GOSIF) dataset, which integrates machine learning with MODIS data and meteorological reanalysis to deliver high spatiotemporal resolution. Spanning two decades (2001–2020) and covering 38 eddy covariance flux tower sites across North America, the study validated CBPD by comparing it with daily Gross Primary Productivity (GPP) and Net Ecosystem Exchange (NEE) data from flux towers. The results demonstrated CBPD's superiority over traditional methods, particularly in complex climate conditions and diverse vegetation types.

"This study provides a fresh perspective on forest phenology monitoring," said the lead researcher. "The CBPD method not only enhances the precision of phenology parameter extraction but also offers valuable insights into how forests respond to climate change. Our next steps involve expanding its application to more ecosystems and vegetation types, further unlocking its potential."

To improve the accuracy of CBPD algorithm, the team applied several technical approaches. First, SIF data were smoothed using an 8th-order polynomial model and the Savitzky-Golay filter to remove outliers. Then, the DL growth model was employed to interpolate daily SIF values, identifying dormancy and peak growth phases. Finally, the change points for Start of Season (SOS) and End of Season (EOS) were determined by calculating the maximum perpendicular distances from points on the curve to the baseline.

The potential applications of this technology are vast. It can provide a solid scientific foundation for forest ecosystem management and conservation, while also offering valuable data for global climate change research. As higher-resolution SIF data becomes available, the CBPD method is poised to be applied to a broader range of ecosystems, paving the way for breakthroughs in global ecological research and environmental monitoring.

DOI
10.34133/remotesensing.0425

Original Source URL

https://doi.org/10.34133/remotesensing.0425

Funding information
This work was supported in part by the National natural science foundation of China under Grant 42090012; Sichuan science and technology program under Grant 2022YFN0031, 2023YFS0381, and 2023YFN0022; Intergovernmental International Science and Technology Innovation Cooperation Project under Grant 2023YFE0110400; Key Technology and Application Demonstration for Integrated Remote Sensing Monitoring of Safety in Key Projects under Grant 2023YFB3906100.

Lucy Wang
BioDesign Research
email us here
