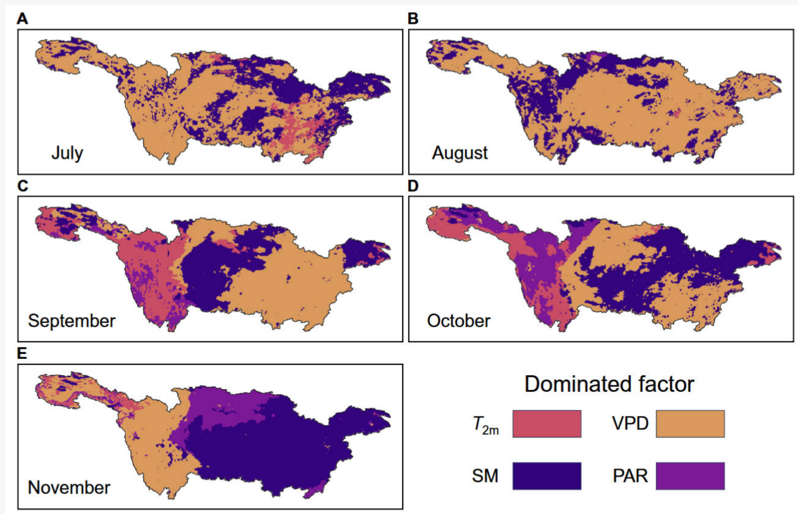
New SIF model tracks drought effects in real-time

GA, UNITED STATES, March 5, 2025 /EINPresswire.com/ -- A new study has unveiled a high-resolution, hourly solar-induced chlorophyll fluorescence (SIF) dataset designed to monitor vegetation photosynthesis during droughts. This innovative approach offers unprecedented insights into how plants respond to drought stress, providing a powerful tool for real-time drought monitoring and ecosystem management.



Spatial distribution of dominant factors contributing to the SIF decline in YRB.

The frequency and intensity of droughts have increased as global warming accelerates, disrupting vegetation photosynthesis and affecting the global carbon cycle. Traditional methods for assessing drought impacts on vegetation typically rely on daily or monthly datasets, which overlook critical diurnal physiological changes, such as midday depression. This phenomenon occurs when plants close their stomata to conserve water during the hottest parts of the day. Given these limitations, there is an urgent need for high-resolution solar-induced chlorophyll fluorescence (SIF) datasets that can capture these rapid, daily changes to improve our understanding and mitigation of drought impacts.

In a study (DOI: 10.34133/remotesensing.0445) published on February 24, 2025, in Journal of Remote Sensing, a team of researchers from the China University of Geosciences (Wuhan), the Institute of Geographic Sciences and Natural Resources Research (CAS), and East China Normal University introduced a pioneering method for generating hourly SIF data from the OCO-2 and OCO-3 satellites. This breakthrough overcomes the temporal resolution limitations of existing SIF products, offering real-time insights into how vegetation reacts to drought stress. The new dataset provides continuous, high-resolution data, enhancing our ability to monitor photosynthesis and vegetation health in real time.

The key innovation of the study is the development of a continuous hourly SIF dataset, HC-

SIFoco, which tracks vegetation photosynthesis dynamics during droughts. With a high level of accuracy, the dataset demonstrated R^2 values of 0.89 for SIF and 0.94 for gross primary productivity (GPP) when compared to ground-based observations. Findings revealed that drought stress causes a rapid decrease in vegetation fluorescence efficiency (Φf), leading to anomalies in SIF and canopy structure. The study also showed that midday depression in photosynthesis increased by around 3% during the 2022 drought in the Yangtze River Basin, and that the seasonal peak of photosynthesis occurred earlier than in previous years.

To create the HC-SIFoco dataset, the team employed machine learning techniques, specifically the LightGBM model, to fuse SIF data from OCO-2 and OCO-3 satellites. The model integrated critical variables such as photosynthetically active radiation (PAR), temperature, vapor pressure deficit (VPD), soil moisture (SM), and land cover types. Spanning from September 2014 to September 2023, the dataset covers the Yangtze River Basin with a spatial resolution of 0.05°. Validation against ground-based and satellite data confirmed the accuracy of the dataset in capturing both diurnal and seasonal photosynthesis dynamics. Notably, the research highlighted that VPD accounted for over 70% of the decline in SIF during drought conditions, with soil moisture playing a key role in the later stages.

“Our study provides a new lens through which to observe how vegetation responds to drought in real time,” said Dr. Zhuoying Deng, lead author of the study. “The hourly SIF dataset not only deepens our understanding of drought impacts but also presents exciting new opportunities for early drought warning systems and ecosystem management.”

The researchers used advanced machine learning algorithms to extend the spatiotemporal coverage of OCO-2 and OCO-3 SIF data. The LightGBM model was specifically designed to process large datasets efficiently and capture complex, nonlinear interactions among environmental variables. The model was trained using critical factors such as PAR, temperature, VPD, SM, and land cover, and rigorously validated against both ground-based SIF and GPP observations.

This high-resolution SIF dataset holds great potential for real-time drought monitoring and ecosystem management. In the future, it could be integrated with climate models to forecast vegetation responses to extreme weather events. Furthermore, the dataset could play a key role in developing strategies to mitigate drought impacts on agriculture and biodiversity, contributing to global efforts to combat climate change.

DOI
10.34133/remotesensing.0445

Original Source URL
https://doi.org/10.34133/remotesensing.0445

Funding information

This work was financially supported by the National Natural Science Foundation of China [grant numbers 42101479, 42250205].

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