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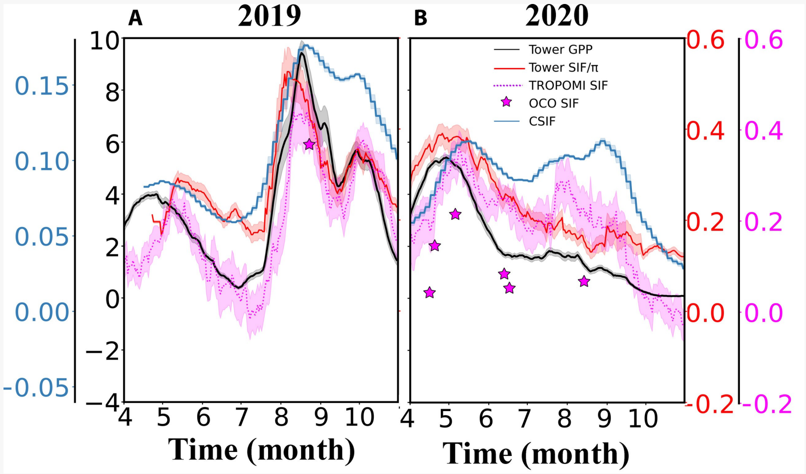
Better drought monitoring for dryland ecosystems



Time series of GPP and tower- and satellite-derived SIF in 2019 and 2020, with satellite observation footprints. (A and B) Approximately monthly (±14-d moving window) time series of GPP (μmol CO2 m−2 s−1), tower SIF/π (mW m−2 nm−1 sr−1) TROPOMI SIF (mW m−

GA, UNITED STATES, April 8, 2026 /EINPresswire.com/ -- A new field study shows that combining multiple optical signals can reveal not only how much carbon a semiarid grassland absorbs, but also how drought alters its internal functioning. By tracking solar-induced fluorescence, near-infrared vegetation reflectance, and a pigment-sensitive reflectance index together, the researchers found a more reliable way to follow seasonal productivity and drought stress than relying on a single indicator alone.

As droughts become more frequent and intense, scientists need better ways to monitor how ecosystems respond. One of the most important measures is gross primary productivity, or gross primary productivity (GPP), which reflects how much carbon plants fix through photosynthesis. Yet GPP cannot be directly observed across large areas. Traditional remote sensing methods often capture visible changes in vegetation structure, such as greener leaves, but miss physiological changes such as reduced light use efficiency under stress. In drylands, where grasses and shrubs shift dominance with water availability, this limitation becomes especially serious. Based on these challenges, deeper research is needed on how different optical signals capture ecosystem productivity and drought stress.

Published on 20 February 2026 in the Journal of Remote Sensing, the study was led by researchers from the University of Arizona, working with collaborators from Indiana University, the USDA Agricultural Research Service, the University of Iowa, the University of Virginia, the University of Montana, and Peking University. Focusing on a semiarid grassland in southeastern Arizona, the team tested whether ground-based optical measurements could better track productivity and drought responses in ecosystems where water stress rapidly changes which plants dominate and how efficiently they photosynthesize.

The researchers found that no single optical metric captured the whole story. Across both study years, solar-induced fluorescence (SIF) and NIRvP performed similarly in tracking biweekly GPP, with R^2 values of 0.77 and 0.79. But during the critical 2020 transition from a wet spring to an extreme summer drought, SIF and the photochemical reflectance index (PRI) outperformed NIRvP. SIF tracked GPP with an R^2 of 0.82 and zero bias, while PRI reached an R^2 of 0.80. These results show that metrics sensitive to plant physiology, not just greenness, become especially valuable when drought weakens photosynthesis without immediately changing canopy structure.

The study took place at the Walnut Gulch Kendall Grassland in Arizona during the 2019 and 2020 growing seasons. The site includes both grasses and woody shrubs, and 2020 provided a natural stress test because a wet spring was followed by an exceptionally hot, dry summer. In 2019, GPP followed a more typical bimodal seasonal pattern, peaking at about 4 μmol CO_2 m^{-2} s^{-1} in spring and 9 μmol CO_2 m^{-2} s^{-1} in summer. In 2020, spring GPP rose to about 6 μmol CO_2 m^{-2} s^{-1}, then steadily declined as drought intensified. During that shift, grasses remained dormant while shrubs became more important in ecosystem function. Biweekly analysis showed that PRI tracked light use efficiency best, with an R^2 of 0.81 and 14% bias, while normalized SIF also performed well, with an R^2 of 0.69 and only 4% bias. The team also compared tower data with satellite products and found that TROPOMI SIF aligned best with tower observations, reaching an R^2 of 0.51 and capturing major seasonal peaks better than CSIF.

Draft quote for press use: “Our results show that drought does not just reduce plant greenness—it changes the physiology of how ecosystems function. By combining fluorescence and reflectance signals, we can better detect when plants are under stress and improve the way dryland productivity is monitored and modeled.” This wording reflects the paper’s central conclusion that integrated optical indicators provide complementary insight into drought-driven ecophysiological change.

The team combined eddy covariance measurements of carbon exchange with ground-based optical sensing from April to October in 2019 and 2020. They measured SIF using a FluoSpec2 system and derived reflectance-based indices including NDVI, NIRv, NIRvP, and PRI from spectral sensors mounted above the canopy. They also estimated light use efficiency from photosynthetically active radiation and carbon uptake data, then compared ground observations with satellite SIF products from TROPOMI, OCO-2, OCO-3, and CSIF. Analyses were conducted at daily, weekly, and biweekly scales.

The findings suggest that integrating SIF, PRI, and NIRvP could improve drought monitoring and carbon-cycle modeling in drylands, where conventional greenness indicators often miss physiological stress. This matters because semiarid ecosystems cover vast regions and play a major role in global carbon dynamics. The study also points to future opportunities from emerging satellite missions and hyperspectral observations, which may allow these complementary signals to be tracked more consistently across larger landscapes. Better monitoring could ultimately support climate forecasting, ecosystem management, and drought-response planning worldwide.

References
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