What is SIF?
SIF (Solar Induced Fluorescence) is the measurement of infrared and red light that plants emit as a byproduct - much like oxygen - when they undergo photosynthesis. Since SIF emanates directly from photosynthetic processes, studying it can give us insight on plant health and productivity. However, the amount of infrared light they emit is so small, that previously it could only be measured on a leaf-by-leaf basis. Plants are highly reflective in the same region of the electromagnetic spectrum that fluorescence occurs in, reflecting up to 70% of the light in this region, compared to the small fraction (1-2%) of light emitted as fluorescence. So how can such a tiny signal be measured from space?

Seeing SIF from Space
The ability to study SIF globally comes from NASA’s Orbiting Carbon Observatory-2 (OCO-2) satellite and was only discovered because of a similar satellite’s specific design. OCO-2 was built to measure carbon dioxide in the atmosphere, and to do so it needed a spectrometer (an instrument that splits light into separate colors) that was very detailed in the amount of spectral lines it covered. In these narrow spectral lines, there are some wavelengths of light that never leave the Sun’s photosphere (Fraunhofer lines). As such, Fraunhofer lines are narrow gaps (dark lines) in the electromagnetic spectrum of Earth’s atmosphere. OCO-2 was designed to use those dark lines as a reference point for carbon dioxide in the atmosphere, as they should have no light in them. However, when OCO-2 scientists looked in the Fraunhofer lines, the team found that there was light. But if the Sun doesn’t emit that wavelength of light, making it not present on Earth, where was the light coming from? It turns out that light was SIF! The glow of light in the Fraunhofer lines was in fact coming from plants, as fluorescence.

Fraunhofer lines (A-K) in the electromagnetic spectrum

SIF over the Chicago area, showing low vegetation over the urban area (purple) and higher levels over agricultural areas (green).
SIF Data Improvements

Previous plant photosynthesis estimates were created by scaling up individual leaf data or measurements from canopy towers. With SIF data gathered from space using OCO-2, a global map of fluorescence is now possible, instead of inferences that came about from scaling up single measurements. A more accurate picture has emerged thanks to the improved spectral and spatial OCO-2 resolution, allowing scientists to see plant and ecosystem health globally, including in places where it might be hard to send in scientists to do the manual, leaf-by-leaf analyses.

Global SIF data map from August through October 2014. Photosynthesis is highest over the tropical forests of the Southern Hemisphere (where it is spring) but still occurs over much of the U.S. The northern forests have shut down for winter.

Scientists at JPL and Caltech are matching ground based measurements of photosynthesis with spectral measurements similar to those made on OCO-2.

SIF’s Bright Future: Applications

Studying SIF data can provide unprecedented data to help many different fields. Because SIF is a measurement of how much plants are photosynthesizing, it can indicate areas of drought long before plants show any outward signs of stress, such as discoloration. This information can help agricultural areas to prepare and try to offset the effects of a drought far earlier. SIF data can also help improve climate models; land uptake of carbon dioxide is the greatest uncertainty in current models, and now this data can be used to more accurately quantify exchanges of carbon dioxide between the atmosphere and land.

The research was carried out at the Jet Propulsion Laboratory, California Institute of Technology, under a contract with the National Aeronautics and Space Administration.


CL#18-4762