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PRESS RELEASE (2025/03/19)

The changing sky that plants see

Researchers introduce a numerical tool to predict sunlight patterns to help improve agriculture

Fukuoka, Japan—Researchers from Kyushu University have developed a new numerical model to explain the behavior of sunlight under various weather conditions. Unlike previous methods that focused on how plants perceive sunlight as a pure source of energy, this study introduces a metric to quantify sunlight intensity and its influence on plant growth and blooming patterns. Published in *Ecological Informatics*, the team hopes their research can benefit the agricultural industry and help farmers make better decisions about crop growth. This advancement is crucial for understanding the variations in plant photosynthesis in response to different sunlight and weather patterns, moreover it may also provide new insight into how changes in cloud cover due to climate change affect vegetation carbon dioxide uptake.

We know plants need the sun to live because it provides the energy for photosynthesis. And while conventional wisdom suggests that the more sun a plant gets the better, it is always not the case. In fact, because of how light is scattered, cloudy weather can greatly benefit a plant's growth. On cloudy days, sunlight is scattered out more evenly, allowing it to reach lower parts of the plant. In contrast, on sunny days, sunlight energy is stronger but comes from a single direction, causing the leaves on the lower parts of the plant remain shaded, and therefore do not absorb as much sunlight.

"Plants also respond to different wavelengths of sunlight. If you have ever seen a rainbow, you know that sunlight is made up of many wavelengths. Plants sense these different wavelengths of light and alter their growth responses," explains Amila Siriwardana, first author and PhD student at Kyushu University's Faculty of Agriculture.

Plants can detect the ratio of wavelengths to understand their surroundings. These ratios are affected by many factors, including atmospheric density, cloud cover, or the altitude of the sun. However, such information had not been categorized in the context of plant physiology and ecology. So, to see how daily sunlight changes during different weather conditions, the research team began a project collecting yearlong sunlight data.

"While many projects look at only the 'energy' produced by the sun, our methods set out to categorize both the 'energy' and 'quality' of light. By sorting sunlight into five categories, from clear skies to overcast, we can better understand how plants can adjust and respond to different light conditions," adds Professor Atsushi Kume, who led the team.

To record sunlight across different times of day and weather conditions the researchers used a device called a spectroradiometer that measures the full spectrum of sunlight. The spectroradiometer was placed on top of Kyushu University's Faculty of Agriculture building on Ito campus, where it collected data from sunrise to sunset every day in 2021.

Using the collected data, the researchers then developed a machine learning model to sort and predict how sunlight changes. The model works by spotting patterns in weather data such as how much sunlight reaches the ground, how much the light is scattered, how polluted or clear the weather is, and humidity. From these patterns, the model categorized sunlight into five groups on a sliding scale. For example, group one was categorized as a clear sunny day, while group five described overcast cloudy days.

The team noticed that on clear days, like those categorized as group one, more sunlight energy reaches the ground. Conversely, as the sky becomes more overcast, the sunlight energy decreased, but at the same time the scattering of light and the proportion of ultraviolet light increased. Additionally, the color of sunlight shifts slightly, moving from red tones on sunny days to blue tones under cloudy conditions.

Once the numerical model was trained, it could make highly accurate predictions of sunlight patterns using simpler weather data.

“Our method achieved 94% accuracy in predicting sunlight category without the need for expensive advanced equipment,” says Siriwardana. “Our model is especially relevant for regions experiencing four distinct seasons similar to Japan's.”

“We hope our model can be used to address the challenges in modern agriculture. Farmers can use this information to improve greenhouse conditions and planting schedules throughout the year,” Kume explains. "For instance, during Japan's cloudy rainy season in June, farmers might adjust their greenhouse operations or crop spacing to maximize available light. Even in the fall and winter, when sunlight patterns change, farmers can adapt their strategies based on our model.”

In the future, the team hopes to expand the model to cover more climate types, such as high-altitude or tropical regions, and further understand how sunlight affects the environment.

(Written by Science Communicator Intern, Negar Khalili)

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For more information about this research, see "Introducing the spectral characteristics index: A novel method for clustering solar radiation fluctuations from a plant-ecophysiological perspective," Amila Nuwan Siriwardana, Atsushi Kume, *Ecological Informatics*, https://doi.org/10.1016/j.ecoinf.2024.102940

About Kyushu University
Founded in 1911, Kyushu University is one of Japan's leading research-oriented institutes of higher education, consistently ranking as one of the top ten Japanese universities in the Times Higher Education World University Rankings and the QS World Rankings. The university is one of the seven national universities in Japan, located in Fukuoka, on the island of Kyushu—the most southwestern of Japan’s four main islands with a population and land size slightly larger than Belgium. Kyushu U’s multiple campuses—home to around 19,000 students and 8000 faculty and staff—are located around Fukuoka City, a coastal metropolis that is frequently ranked among the world's most livable cities and historically known as Japan's gateway to Asia. Through its VISION 2030, Kyushu U will “drive social change with integrative knowledge.” By fusing the spectrum of knowledge, from the humanities and arts to engineering and medical sciences, Kyushu U will strengthen its research in the key areas of decarbonization, medicine and health, and environment and food, to tackle society’s most pressing issues.

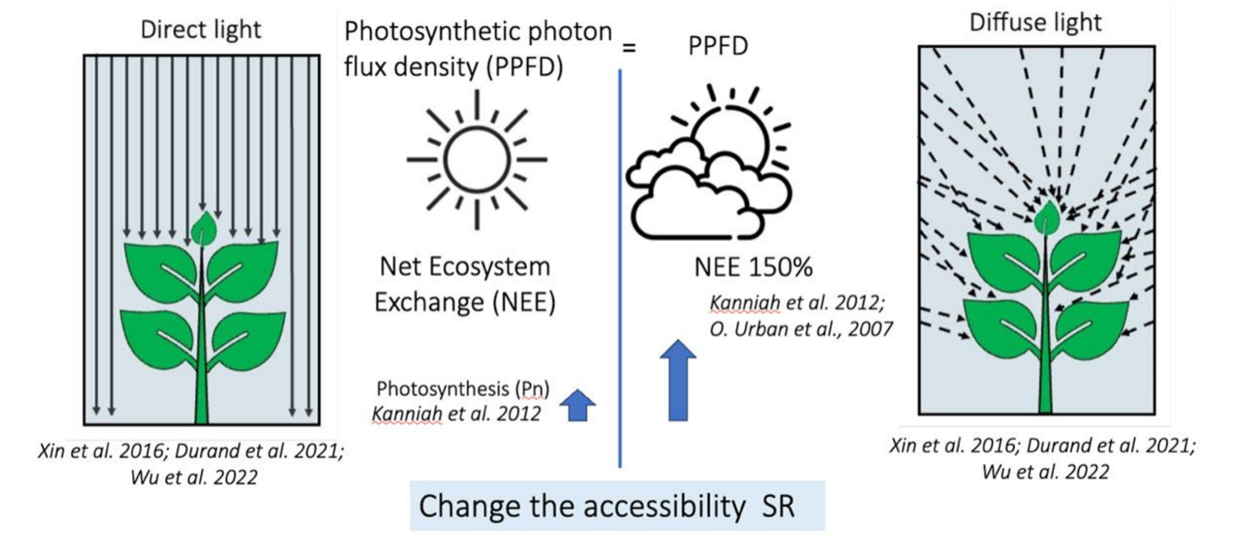

Fig. 1. Differences between sunny days and cloudy days. Left: on sunny days, the sun shines directly and mainly reach the top leaves. Right: on cloudy days, sunlight is scattered in all directions, which allows lower leaves to receive more light. Recognizing this difference helps farmers enhance their planting schedules. (Kyushu University/Kume lab)

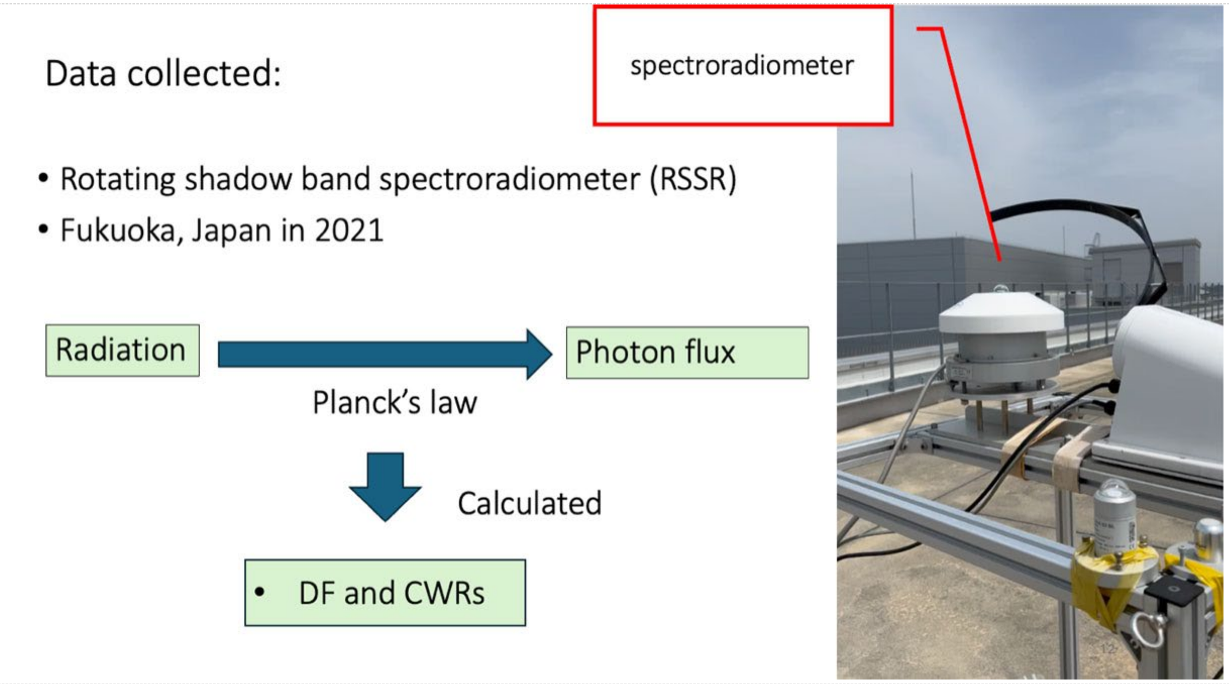

Fig. 2. Image of the Spectroradiometer. The Rotating Shadow band Spectroradiometer (RSS) that measures sunlight. It has a rotating band that intermittently blocks the sunlight, helping scientists measure two types of light: direct sunlight when the band is out of the way, and diffused light when the band shades the sensor. By doing this, researchers can better understand how plants receive and use sunlight throughout the day in various weather conditions. (Kyushu University/Kume lab)

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