A huge thunderstorm with mammatus clouds approaches the Montana State University campus in Bozeman, Mont., U.S.A.

Joseph Shaw

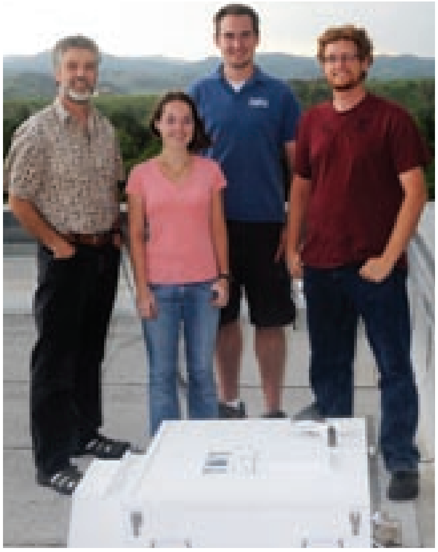
Cloud Imaging Benefits Earth-Space Communications

Researchers at Montana State University (Bozeman, Mont., U.S.A.) have discovered that a cloud-imaging system developed for climate research also shows promise for enhancing Earth-to-space optical communications (Opt. Express **17**, 7862). "We originally developed the Infrared Cloud Imager (ICI) to address the enormous need for better cloud characterizations in climate science," said Joseph Shaw, professor of electrical and computer engineering and director of the Optical Technology Center at MSU. "But when we heard from NASA scientists about their need to measure the complex distribution of clouds in space and time at potential optical communications stations, we saw another ideal use of the ICI."

In Earth-to-space optical communications systems, clouds obstruct the laser beams used for high-bandwidth communication links, such as those used from ground-based control centers to near-Earth and deep-space platforms. As an alternative to radio-based links, high-data-rate communication between, for example, a ground station and a satellite typically requires a cloud-free sky. The ability to classify the optical depth of clouds and the resulting attenuation of communications channels can help researchers choose the best site for a potential ground station and optimize communication at existing sites even through thin clouds.

The ICI2 system uses an uncooled, 324 × 256 microbolometer detector array to observe thermal emission caused primarily by water vapor, carbon dioxide and ozone in the long-wave infrared (IR) range between 8 and 13 μm. With a spatial resolution of 50 m or less for clouds 10 km above the Earth, the ground-based system exceeds the analysis ability of satellites, which can only image clouds at a resolution of down to a kilometer or so. The system measures the band-integrated down-welling radiance ($W \cdot m^{-2} \cdot sr^{-1}$) of the sky, calculated by subtracting clear-blue-sky emission and correcting for ambient temperature drifts of the camera. The calculated IR radiance is then used to derive the cloud optical depth (OD) at 550 nm. The resulting map enables discrimination of thick clouds of OD > 3 from thin clouds of OD ≤ 1. The team estimates that optical communication links with a link margin greater than 4.3 dB would be transmittable through clouds with an OD ≤ 1.

Joseph Shaw



The ICI-3 infrared cloud imager with its creators, Joseph Shaw (left), Jennifer Johnson, Ben Staal and Paul Nugent.

The ICI2 cloud-imaging system could be used to classify the cloud base day and night to identify the optimal time of day for operating optical communications links. Even sites that suffer from near-constant cloud cover can effectively relay optical transmissions through thin cirrus clouds. A long-term deployment of the system is planned at the NASA-JPL Table Mountain Facility in Wrightwood, Calif., U.S.A.

DID YOU KNOW?

Australian researchers at Swinburne University of Technology (Hawthorn, Victoria, Australia) have unveiled a new type of optical disc that can store 1.6 terabytes of data—up to 10,000 times more than that of current DVD and Blu-ray discs. Such a disc could store whole libraries of films, as well as medical, military and financial records.

Developed by optoelectronics professor Min Gu and colleagues, the technology uses the unique properties of surface plasmons in gold nanorods to take advantage of information in five dimensions: the three spatial domains, wavelength and polarization (Nature Lett. **459**, 410). The nanorods, which are coated in polyvinyl alcohol and mounted on a glass substrate, can be selectively recorded in layers by laser light, due to their unique optical and photothermal properties. Gu and his team have recorded ten layers and believe up to 100 may be feasible, for a potential disk capacity of 7.2 TB. The researchers have already signed an agreement with Samsung; they predict the discs will be commercially available within 5 to 10 years.

USDA Food Components and Health Laboratory, S. Britz

Exposing red-leaf lettuce to UV-LED lights results in an enhanced red “tan” from anthocyanin accumulation. Plants were exposed continuously for 48 hours at 23° C at 10 mW m^{-2} with background low-pressure sodium illumination: (a) unexposed control plant, (b) 282 nm light, (c) 296 nm light and (d) 308 nm light.

Ultraviolet LEDs Enhance Lettuce Nutrients

Can exposing our food to low-energy light-emitting diodes (LEDs) improve its nutritional quality? A new report from the U.S. Department of Agriculture (USDA) says yes. Greenhouse cultivation allows high-quality, local produce all year long, but most greenhouse coverings filter out the short ultraviolet wavelengths from the solar spectrum, decreasing the synthesis and accumulation of some nutrients.

Now, scientists at the USDA’s Food Components and Health Lab (Beltsville, Md., U.S.A.) have found that applying supplemental ultraviolet-B (UVB) radiation (280 to 320 nm) to red-leaf lettuce increases the production of polyphenolic compounds and possibly the storage lifetime of the chemicals. Research plant physiologist Steven Britz presented the research in June at the 2009 Conference on Lasers and Electro-Optics/International Quantum Electronics Conference (CLEO/IQEC) in Baltimore.

Polyphenolic compounds develop upon exposure to UV light, blocking damaging rays and enriching plants with flavonoids such as quercetin and cyanidin, a red pigment found in red onions and apples. In most studies of UV stimulation of plant polyphenols, researchers have investigated how stratospheric ozone destruction causes the plants to be more exposed to solar UV radiation. However, relatively little is known about low-level irradiance or the wavelength-dependence of UVB exposure for nutritional enhancement.

Britz and colleagues exposed several “Galactic” variety red-leaf lettuce plants to low-level emission from three different UVB LEDs emitting at peak wavelengths of 282, 296 and 308 nm. High-intensity sodium light was used as a background to provide for photosynthesis and to control an additional photoreceptor called phytochrome, which is sometimes involved in pigment accumulation. After 48 hours of exposure, the UVB-treated lettuces showed twice the accumulation of polyphenols compared to the non-UVB-treated plants, with the largest effects at the shortest wavelengths.

LEDs are safer than the fluorescent sun lamps that are currently used; those are more fragile and contain mercury. “More importantly, LEDs can be tuned to the most efficient part of the spectrum for the optimal biological response,” said Britz. “Also, LEDs are directional, eliminating the need for inefficient reflectors.”

The technology could someday have widespread application by greenhouse growers to optimize antioxidant levels in their produce. “A usable device could be available within a year,” says Britz. “Greenhouse testing will take longer. The magnitude of the response to the UVB exposure seems to vary greatly depending on the genetic variety of plant. Selecting varieties with a good response and high levels of antioxidants will become part of the process.”

Will the enhanced red-leaf lettuce taste different to consumers? Britz believes it won’t, and that any nutritional enhancement can only be a good thing. “Although the UVB-exposed red-leaf lettuce has higher levels of flavonoids and phenolic compounds (chlorogenic, caftaric and chicoric acids), it’s hard to taste much difference between UVB-treated and non-treated lettuce.”

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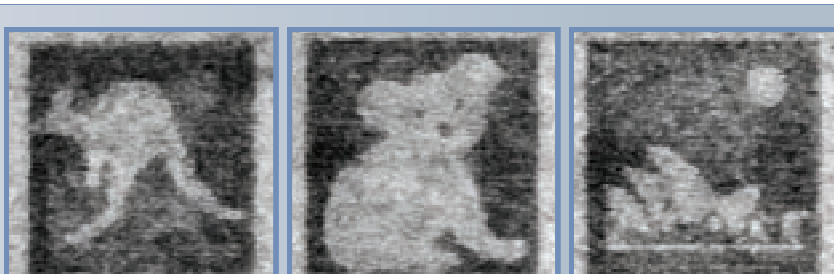

Swinburne University of Technology

Three polarization states are encoded at 0°, 60° and 120° with femtosecond laser pulses at 840 nm and a pulse energy of 160 pJ. Each image is 75 x 75 pixels and measures 100 x 100 μm.