How bright is the moon, really?

October 16 2017

Moonset on the NIST campus. These white domes will house the equipment used in the Moon brightness experiment. Eventually the domes and equipment will be moved to the Mauna Loa Observatory in Hawaii. Credit: Jennifer Lauren Lee/NIST

The "inconstant moon," as Shakespeare called it in Romeo and Juliet, is more reliable than his pair of star-crossed lovers might have thought. Now researchers at the National Institute of Standards and Technology (NIST) plan to make the moon even more reliable with a new project to measure its brightness.

Scientists put the moon to work daily as a calibration source for space-based cameras that use the brightness and colors of sunlight reflecting off our planet to track weather patterns, trends in crop health, the locations of harmful algal blooms in oceans and much more. The information sent from Earth-facing imagers allows researchers to predict famines and floods and can help communities plan emergency response and disaster relief.

To make sure that one satellite camera's "green" isn't another's "yellow," each camera is calibrated—in space—against a common source. The moon makes a convenient target because, unlike Earth, it has no atmosphere and its surface changes very little.

The trouble is that, for all the songs written about the light of the silvery moon, it's still not understood exactly how bright the moon's reflected light is, at all times and from all angles. Today's best measurements allow researchers to calculate the moon's brightness with uncertainties of a few percent—not quite good enough for the most sensitive measurement needs, says NIST's Stephen Maxwell. To make up for these shortcomings, scientists have developed complicated workarounds. For example, they must periodically check the accuracy of their satellite images by making the same measurements multiple ways—from space, from the air and from the ground—simultaneously.

Or, if they want to compare images taken at different times by different satellites, they have to ensure that there is some overlap during their time in space so that the imagers have the chance to measure the same part of the planet at roughly the same time. But what happens if a research team can't get a new camera into space before an old one is retired? "You get what's called a data gap, and you lose the ability to stitch together measurements from different satellites to determine long-term trends," Maxwell says.

Really knowing how bright the moon is—with uncertainties of much less than 1 percent—would reduce the need for these logistically challenging solutions and ultimately save money.

So NIST is setting out to take new measurements of the moon's brightness. Researchers hope they will be the best measurements to date.

"Brightness" here means, specifically, the amount of sunlight reflecting off the surface of the moon. Its apparent magnitude is about 400,000 times smaller than the Sun's, but the moon's exact brightness depends on its angle with respect to the Sun and Earth. And those angles follow a complex pattern that repeats roughly every 20 years.

To capture moonlight in their new experiment, researchers will use a small telescope as what Maxwell calls a "light bucket," designed to collect everything from ultraviolet radiation (about 350 nanometers, billionths of a meter) through the visible spectrum and into the short-wave infrared (2.5 micrometers, millionths of a meter). The 150-mm (6-inch) telescope's single lens is made of a compound called calcium fluoride, which—unlike more common glass—can focus the moonlight from this wide range of wavelengths into a detector.

But that telescope will need to be calibrated before each measurement. So about 15 to 30 meters (50-100 feet) away, the research team will set up a broadband light source—that is, one with a wide distribution of wavelengths—with a reliable output. To validate the broadband source, the scientists will also use a second lamp that emits only a narrow band of wavelengths at a time and can be tuned to different bands as needed. Nightly tests with these calibrated sources will tie the team's moon findings to the International System of Units (SI).

Fortunately, the NIST study won't need to collect data for 20 years, Maxwell says; three to five years will be enough time to gather more than 95 percent of the angles they will need. To get as much unadulterated moonlight as possible, the experiment is scheduled to start taking measurements in 2018 at the Mauna Loa Observatory in Hawaii. Sitting at about 3,300 meters (11,000 feet), on one of the world's largest volcanoes, the planned site is above much of the distorting influence of Earth's atmosphere.

Though the experiment will take years to complete, Maxwell thinks even preliminary data will be useful to the community "almost immediately," as a check against the current system. Earth-facing imagers that could benefit from NIST's new dataset include the Landsat series, GOES-16 and dozens of commercial satellites.

Provided by National Institute of Standards and Technology