New composite strategy leaves coverage questions behind, researchers report

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Final clean Landsat composite image for the conterminous United States: (a) 2019 leaf-off, and (b) 2019 leaf-on. Credit: [Suming Jin, U.S. Geological Survey Earth Resources Observation and Science Center]

Answers could be cloudy for researchers using Landsat images to investigate the coverage of the continental United States. The National

Land Cover Database (NLCD) are useful products for scientists to understand how things like tree canopy and road coverage changes over time, but something as simple as cloud coverage can be misinterpreted in the satellite images as a significant surface coverage change. How can researchers be sure they're getting a truly representative understanding of any one area?

The answer lies in composite images—for which researchers with the U.S. Geological Survey (USGS) and the University of Connecticut have developed a new strategy to produce clean images.

They published their approach in the *Journal of Remote Sensing*

"Our goal was to produce clean Landsat—the satellite program that monitors Earth's surface for natural and human-caused changes—images without clouds and cloud shadows," said corresponding author Suming Jin, physical scientist with USGS Earth Resources Observation and Science (EROS) Center. "We need consistent and clean Landsat images without any gaps to help prepare for large operational applications, such as mapping land cover or detecting changes."

The National Land Cover Database (NLCD), established in 2001, is updated every 2-3 years with satellite images categorized by tree covers, urban areas, roads and more. NLCD has had eight epochs so far, with the most recent database available was released in 2019 . Before NLCD 2019, images from 435 pathways—or organized rows Landsat follows as it collects images—were used to map the continental United States.

"Despite the best efforts of the NLCD operation team to acquire a single leaf-on image with less than 20% cloud cover from the target year, a mean of 70% of individual Landsat images were from the seven target years, 25% of images were one year deviated from the target years, and 5% of images were more than one year off," Jin said.

When Landsat cannot capture a clear enough image in a specific year, the dataset is filled in with images from other years. This provides a better understanding than having no image of a particular area, but land coverage can change significantly in a year or more.

"Substantial time and effort were spent on producing the final clear Landsat images, which included cloud and shadow detection, a gap-filling method and hand editing," Jin said. "To shorten the latency of producing the new NLCD product and to reduce the amount of work needed to process individual-date Landsat imagery, we developed a more efficient image compositing strategy to generate clean images."

The researchers developed an algorithm that selects an image pixel from a single date over time—such as June 5 over a set time window—that is as close as possible to the virtual median-value point. This virtual point has a median value from each band of all valid observations. The team also developed a method to detect and replace clouds and cloud shadows pixels on composite images. For example, for an image pixel of a forested area, the algorithm may identify that a clouded area isn't a different type of coverage by comparing it to surrounding points. It can then splice images together to correct gaps or otherwise misunderstood information.

"We developed a new and straightforward image compositing method," Jin said. "Our algorithm was shown to produce the best results for seasonal composites in the spectral and application evaluations among 10 compositing algorithms."

This method was also applied to the National Land Cover Database 2019 data and produced the final clean images, which were released in July 2021.

"The new strategy not only solves the issue of residual cloud, shadow and

missing-value areas on composite images, but also reduces redundancy and improves efficiency by reducing overlap areas among mapping units compared to using individual Landsat path/row scenes," Jin said. "The new strategy for producing clean Landsat composite images improved both National Land Cover Database 2019 operational efficiency and quality."

More information: Suming Jin et al, National Land Cover Database 2019: A New Strategy for Creating Clean Leaf-On and Leaf-Off Landsat Composite Images, *Journal of Remote Sensing* (2023). DOI: 10.34133/remotesensing.0022

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