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# Researchers study how reflectivity of biofuel crops impacts climate

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Argonne environmental analyst Hao Cai, environmental scientist Jiali Wang and climate scientist Yan Feng sit in front of a US map that plots the albedo effects observed across various agro-ecological zones. Credit: Wes Agresta/Argonne National Laboratory

Researchers at the U.S. Department of Energy's (DOE's) Argonne

National Laboratory have conducted a detailed study of the reflectivity effects of converting land to grow biofuel crops.

Their study is part of an overall analysis of greenhouse gas emissions from land use change: instances where land that was previously forests, grasslands or pastureland is converted to producing biofuel crops. Historically, these types of analyses considered only changes in the amount of carbon stored in the soil and vegetation of these lands.

The new analysis, published in The Royal Chemistry Society's *Energy & Environmental Science*, incorporates the additional effect of changes in reflectivity, or "albedo." Albedo effects sum up the amount of incoming solar energy that gets reflected back into space; these changes, along with numerous other factors, in turn contribute to changes in greenhouse gas emissions.

While there is much data variability, the findings reveal that when a piece of land is changed to produce a biofuel crop, albedo effects also changed. When only albedo change effects are considered, researchers found that land converted to producing corn ethanol had a net cooling effect on climate. By comparison, land that was converted to producing miscanthus and switchgrass, two other plant sources for next-generation biofuels, had a net warming effect. But when carbon stock changes, another key effect of land use change, are also taken into account, corn and switchgrass ethanol exhibit net warming effects associated with land use change whereas miscanthus grass ethanol exhibits a net cooling effect.

Led by researchers in Argonne's Energy Systems and Environmental Sciences Divisions, the work outlines the importance of considering changes in reflectivity when assessing land use change-induced effects of biofuel production on climate.

"Our analysis is helping build a fuller picture of the climate effects of biofuel feedstock production," said Hao Cai, an Argonne environmental analyst and lead author of the study.

Cai and his team began their research by first collecting data on land cover and albedo gathered from the U.S. Department of Agriculture and NASA satellites, respectively. They mapped the albedo data associated with specific land types—say, corn cropland or prairie. Then they ran simulations where they converted different land types to produce corn, miscanthus and switchgrass, and looked to see what would happen to albedo and to the net cooling or warming of the atmosphere as a result.

In Cai, Feng and Wang's robust analysis, they investigated albedo effects and land usage in millions of sites across the U.S. Credit: Image by Wes Agresta/Argonne National Laboratory

Unlike past studies of albedo effects of land use change, which analyzed no more than 20 sites of specific land types, the team investigated millions of sites in more than a thousand counties in the U.S., covering 70 percent of the nation's corn production fields.

"Another factor that sets this study apart is the specific modeling approach used to simulate albedo effect on a finer scale and provide more robust data analysis," said Yan Feng, an atmospheric and climate scientist involved in the study.

The model allowed Feng and fellow researchers to examine the albedo dynamics of millions of parcels of land individually in squares just 500 meters at a side (5382 feet).

By analyzing a large number of sites in detail, the researchers were able to take into account site-specific variations to better represent albedo effects in their analysis. Albedo effects varied among corn, miscanthus and switchgrass crops in part due to differences in their size and shape, as well as growth and environmental factors—all of which can vary dramatically from one site to the next.

Albedo also varied considerably based on the type of land that was converted. For example, forest had the lowest albedo compared to other land covers, like shrubland and grassland, found within the same agro-ecological zone.

The magnitude of the area of land converted, as determined by economic modeling, also varied. For example, when the researchers compared miscanthus and switchgrass production necessary to produce a given biofuel volume, they found that converting land to miscanthus had a lower warming albedo effect compared to switchgrass. One cause for this is the fact that miscanthus requires less land than switchgrass to yield an equal volume of ethanol because miscanthus has higher yields.

The researchers used computing resources at the Argonne Leadership Computing Facility (ALCF), a DOE Office of Science User Facility, to process and visualize the albedo and land cover data.

"ALCF's high-performance computing resources were critical to our analysis based on the amount of data we were working with. The facility provides powerful and helpful tools for data-intensive analyses like this," said Jiali Wang, an Argonne atmospheric scientist involved in processing the data.

**More information:** H. Cai et al, Consideration of land use change-induced surface albedo effects in life-cycle analysis of biofuels, *Energy Environ. Sci.* (2016). DOI: 10.1039/C6EE01728B

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