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Satellite Data Reveal Rapid Darkening of the Arctic

Forty-five years after scientists hypothesized that global warming would make Arctic Ocean surfaces darker, Scripps team determines how much the planet's albedo has diminished

The retreat of sea ice in the Arctic Ocean is diminishing Earth's albedo, or reflectivity, by an amount considerably larger than previously estimated, according to researchers at UC San Diego's Scripps Institution of Oceanography.

As the sea ice melts, its white reflective surface is replaced by a relatively dark ocean surface. This diminishes the amount of sunlight being reflected back to space, causing the Earth to absorb an increasing amount of solar energy.

The Arctic has warmed by 2° C (3.6° F) since the 1970s. The summer minimum Arctic sea ice extent has decreased by 40 percent during the same time period. These factors have decreased the region's albedo.

Scripps graduate student Kristina Pistone and climate scientists Ian Eisenman and Veerabhadran Ramanathan used satellite measurements to calculate changes in the albedo of the Arctic region associated with the changing sea ice cover. Albedo is measured as a percentage. A perfectly black surface has an albedo of zero percent and a perfectly white surface has an albedo of 100 percent. The albedo of fresh snow is typically between 80 and 90 percent whereas the albedo of the ocean surface is less than 20 percent. Clouds and other factors also influence the albedo of the Earth.

The researchers calculated that the albedo of the Arctic region fell from 52 percent to 48 percent between 1979 and 2011.

“It’s fairly intuitive to expect that replacing white, reflective sea ice with a dark ocean surface would increase the amount of solar heating,” said Kristina Pistone. “We used actual satellite measurements of both albedo and sea ice in the region to verify this and to quantify how much extra heat the region has absorbed due to the ice loss. It was quite encouraging to see how well the two datasets – which come from two independent satellite instruments – agreed with each other.”

The National Science Foundation-funded study appears in the journal *Proceedings of the National Academy of Sciences* 45 years after atmospheric scientists Mikhail Budyko and William Sellers hypothesized that the Arctic would amplify global warming as sea ice melted.

The Scripps study is the first to use direct satellite measurements to assess the changes in albedo associated with retreating sea ice. Previous studies have relied on computer models. The Scripps team used NASA’s CERES satellite instruments as well as observations of sea ice cover made with other satellites.

The researchers found that the magnitude of surface darkening has been two to three times as large as that found in previous studies. They also compared their results to model simulations to assess the capability of computer models to portray and forecast albedo changes.

“Scientists have talked about Arctic melting and albedo decrease for nearly 50 years,” said Ramanathan, a distinguished professor of climate and atmospheric sciences who has previously conducted similar research on the global dimming effects of aerosols. “This is the first time this darkening effect has been documented on the scale of the entire Arctic.”

“Based on our results, the albedo forcing from Arctic sea ice retreat is quite large,” said Eisenman, an assistant professor of climate dynamics. “Averaged over the entire globe, it’s one-fourth as large as the direct radiative forcing from CO2 during the same period. This suggests that Arctic sea ice retreat has been an important player in the global warming that we’ve observed during recent decades. Although more work is needed, a possible implication of these results is that the amplifying feedback of Arctic sea ice changes on global warming is larger than previously expected.”