The albedo effect and global warming

What The Science Says:
The long term trend from albedo is of cooling. Recent satellite measurements of albedo show little to no trend.

Climate Myth: It's albedo
"Earth's Albedo has risen in the past few years, and by doing reconstructions of the past albedo, it appears that there was a significant reduction in Earth's albedo leading up to a lull in 1997. The most interesting thing here is that the albedo forcings, in watts/sq meter seem to be fairly large. Larger than that of all manmade greenhouse gases combined." (Anthony Watts)

The Unsettled Science of Albedo

> "Clouds are very pesky for climate scientists…"
>
> *Karen M. Shell, Associate Professor, College of Earth, Ocean, and Atmospheric Sciences, Oregon State University, writing about cloud feedback for RealClimate*

Albedo is a measure of the reflectivity of a surface. The albedo effect when applied to the Earth is a measure of how much of the Sun's energy is reflected back into space. Overall, the Earth's albedo has a cooling effect. (The term 'albedo' is derived from the Latin for 'whiteness').

The basic principle is analogous to strategies employed by people who live in hot places. Building are finished with white exteriors to keep them cool, because white surfaces reflect the sun's energy. Black surfaces reflect much less. People wear light colours in summer rather than dark ones for the same reason.

The Earth's surface is a vast patchwork of colours, ranging from the dazzling white of ice and snow, to the dark surfaces of oceans and forests. Each surface has a specific effect on the Earth's temperature. Snow and ice reflect a lot of the sun's energy back into space. The darker oceans absorb energy, which warms the water. Oceans help keep the Earth warm because they absorb a lot of heat (approximately 90%). This warming increases water vapour, which acts as a greenhouse gas and helps to keep temperatures within ranges humans have largely taken for granted for millennia.

A Cloudy Outlook

It isn't just the Earth's surface that has a reflective quality. Clouds also reflect sunlight, contributing to the cooling effect of albedo. They also contribute to warming *at the same time*, because they consist of condensed water vapour, which retains heat.

And if clouds complicate matters, so too do the seasons. Every year, albedo peaks twice. The first peak occurs when the Antarctic sea-ice is at its winter maximum. The second peak, which is larger, occurs when there is snow cover over much of the Northern Hemisphere.

Albedo also changes due to human interaction. Forests have lower albedo than topsoil; deforestation *increases* albedo. Burning wood and fossil fuels adds black carbon to the atmosphere. Some black carbon settles on the surface of the ice, which *reduces* albedo.

Albedo and Global Warming

The most significant projected impact on albedo is through future global warming. With the exception of

Antarctic sea-ice, recently increasing by 1% a year, nearly all the ice on the planet is melting. As the white surfaces decrease in area, less energy is reflected into space, and the Earth will warm up even more.

The loss of Arctic ice is of particular concern. The ice is disappearing quite fast; not only is albedo decreasing, but the loss triggers a positive feedback. By exposing the ocean surface to sunlight, the water warms up. This melts the ice from underneath, while man-made CO2 in the atmosphere warms the surface. Humidity also increases; water vapour is a powerful greenhouse gas. More ice therefore melts, which exposes more water, which melts more ice from underneath…

This loop fuels itself, the effect getting more and more pronounced. This is a good example of a positive feedback. Increased water vapour also has another effect, which is to increase the amount of cloud. As mentioned already, clouds can increase albedo (a negative feedback), but also warming (a positive feedback).

Measuring Albedo

The albedo of a surface is measured on a scale from 0 to 1, where 0 is a idealised black surface with no reflection, and 1 represents a white surface that has perfect reflection.

Taking measurements of something with so many variables and influences is clearly going to be a challenge. Satellite data is constrained by the orbit of the satellite. Clouds can be hard to distinguish from white surfaces.

Indirect measurement may also be problematic. The Earthshine project investigated a phenomenon where light reflected by Earth illuminates the dark side of the moon. By measuring the brightness, the amount of albedo - reflectivity - could be estimated.

The project reported a counter-intuitive finding. The Earth's albedo was rising, even as the planet was warming. This seems contradictory, as Anthony Watts was quick to note when he voiced his sceptical argument in 2007. If higher albedo was having a cooling effect, how could global warming be taking place?

Tricky Business

Science constantly seeks to improve itself. The first Earthshine paper,Palle (2004), claimed to have discovered a very significant cooling effect through a big increase in global albedo.

The results were problematic. They flatly contradicted the NASA CERES satellite observations, and the discrepancy became the subject of investigation. In 2004, a new telescope was installed at the Big Bear observatory, where the project was located. It became evident that the original analysis was in inaccurate. Once corrected, the Earthshine project and the satellite measurements were more consistent.

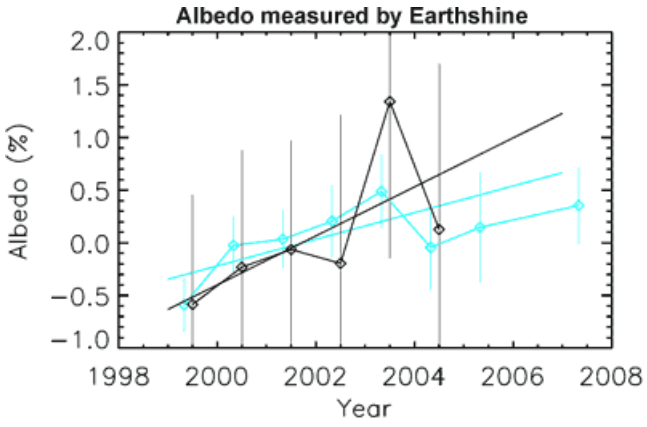

Figure 1: Earth albedo anomalies as measured by earthshine. In black are the albedo anomalies published in 2004 (Palle 2004). In blue are the updated albedo anomalies after improved data analysis, which also include more years of data (Palle 2008).

Over a five-year period, scientists found that albedo did increase slightly. Since 2003 the CERES satellite records shows a very slight reduction.

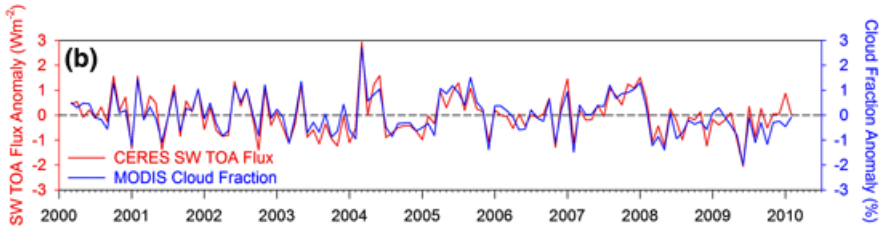

Figure 2: CERES Terra SW TOA flux and MODIS cloud fraction for 30S–30N between March 2000 and February 2010 (Loeb et al. (2012) - PDF)

Global versus Local

There are contradictory assessments of current trends in global albedo, possibly because the changes and effects are small. Research is being conducted into the role of clouds, both as forcings and feedbacks, and the role of albedo in cloud formation.

Recent research indicates that global albedo is fairly constant, and having no material effect on global temperatures. Local effects may be more pronounced. Loss of albedo in the Arctic could heat the water sufficiently to release methane stored in ice crystals called clathrates. (Methane is a greenhouse gas far more potent than CO2).

Loss of albedo in the Arctic will accelerate warming across adjacent permafrost, releasing methane. Melting permafrost may reduce its albedo, another positive feedback that will accelerate warming. Ocean warming from reduced Arctic albedo will also accelerate melting at the edges of the Greenland ice cap, speeding up sea level rise.

Conclusions

Albedo is a subject needing a lot more research. It's an important feature of our climate, and a complex one. It is not yet possible to make definitive statements about what the future may hold. In fact, it is a good example of the 'unsettled' nature of climate change science.

We know the planet is warming, and that human agency is causing it. What we cannot say yet is how climate change is affecting albedo, how it might be affected in the future, and what contribution to climate change - positive or negative - it may make.

Basic rebuttal written by GPWayne

This rebuttal was updated by Kyle Pressler in September 2021 to replace broken links. The updates are a result of our call for help published in May 2021.

Skeptical Science explains the science of global warming and examines climate misinformation through the lens of peer-reviewed research. The website won the Australian Museum 2011 Eureka Prize for the Advancement of Climate Change Knowledge. Members of the Skeptical Science team have authored peer-reviewed papers, a college textbook on climate change and the book Climate Change Denial: Heads in the Sand. Skeptical Science content has been used in university courses, textbooks, government reports on climate change, television documentaries and numerous books.