

Evidence essay · Land and freshwater

Greenland's dark ice has more than one cause

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ABSTRACT

Dark Greenland ice can reflect snow retreat, light-absorbing material, glacier algae, water, and changing surface texture. This essay separates observed colour, attribution of reflectivity changes, and consequences for melt. NOAA's Greenland assessment provides seasonal context, while a western Greenland study illustrates how biological sampling, radiation measurements, and aerial observations constrain the contribution of algae alongside the physical weathering crust. Neither source makes every dark patch biologically equivalent. The discussion explains why a satellite pixel can miss small algal patches and why a selected ground measurement may not represent the wider footprint. Its central implication is methodological: compatible scales, timing, and illumination are needed before linking surface appearance to mechanisms or melt, and local findings cannot be expanded into an ice-sheet-wide total without further evidence.

Keywords: Greenland · albedo · glacier algae · surface energy balance · spatial sampling

Adapted from the Still North field journal. Original article. A source-based editorial text, not a report of original Still North research. Examples and imagery are illustrative.

A dark patch on Greenland's ice is a useful observation, but not yet an explanation. It could reflect exposed bare ice after snow loss, light-absorbing particles, pigmented organisms, liquid water, or the physical texture of the surface. Lighting and camera settings add another complication to photographs. Asking what made the patch dark is the start of the science, not an optional detail after the headline.

The question matters because reflectivity influences the energy absorbed by snow and ice. Yet a darker image is not a direct measurement of melt, and finding algae does not establish that biology accounts for every dark surface. A useful account links the mechanism to measurements at the place and scale where it was studied.

Reflectivity is a share of incoming energy

Albedo describes the fraction of incoming shortwave radiation reflected by a surface. Other conditions being equal, a lower albedo leaves more of that incoming energy available for absorption. But the amount of incoming sunlight also varies, and melting depends on the wider surface energy balance. Air temperature alone, or albedo alone, cannot fully account for every day's melt.

Fresh snow and bare glacier ice differ substantially in reflectivity. The date when seasonal snow retreats therefore changes how long darker ice is exposed. A late snowfall can brighten the surface again. In its 2025 Greenland assessment, NOAA describes summer snowfall raising albedo and likely helping limit melt extent. That is a seasonal system response, not evidence that the ice sheet stopped losing mass.

The same chapter notes that late-August albedo reduction coincided with wildfire smoke along western Greenland, while explaining that particles can enhance melt if

deposited on the ice. The qualification matters. Smoke overhead and particles measured on a surface are not the same observation, and a coincidence should not be retold as complete attribution.

There is life on bare ice

Glacier algae are not simply an analogy for dirty ice. They are organisms whose pigments absorb light. In a 2020 study of western Greenland, Andrew Tedstone and colleagues combined surface samples, ground measurements, and aerial observations to investigate their contribution to albedo. Pigmented algae contributed to darkening both inside and outside the south-western dark zone examined by the research.

That finding is spatially bounded. It does not establish the same biological contribution everywhere across Greenland, in every season, or on every glacier. Snow cover, meltwater, light, and the length of the exposed-ice season affect algal growth. A photograph with a brownish tint cannot replace biological sampling or identify the relative role of organisms and mineral material.

Biology and physics also interact. The study describes a porous near-surface weathering crust whose changing condition affects reflection and water storage. The authors found this surface state important alongside light-absorbing impurities. A useful mechanism therefore need not have a single winner: algae can matter while the ice structure also materially changes what an instrument sees.

The patch is smaller than the pixel

A ground instrument can sample a small surface area that differs from its surroundings. A satellite pixel combines many such surfaces. Tedstone and colleagues found that patchiness smaller than Sentinel-2's resolution made

satellite detection of algal blooms conservative in their study. The absence of a classified bloom pixel was not equivalent to a surface sample showing no algae.

This creates a practical comparison problem. Choosing the darkest ground patch and comparing it with the average of a much larger pixel is not a fair validation exercise. Measurements need a sampling design that represents the wider footprint, together with compatible timing and illumination. Clouds or a fresh snowfall between observations can change the surface before the comparison is made.

Keep colour, mechanism, and consequence separate

Three linked claims need three kinds of support: the surface became less reflective; particular materials or organisms contributed; that change altered melt under the conditions present. Calibrated radiation measurements address the first, sampling and classification inform the second, and energy-balance observations or modelling help investigate the third. Moving directly from a dramatic photograph to an ice-sheet-wide melt total skips those links.

Our [Arctic change in 2025](#) brief puts the Greenland mass budget in context. [Wildlife and food webs](#) introduces the broader habit of reading organisms within their environment. Dark ice is a reminder that a surface can be physically changing and biologically active at once, and that understanding the interaction is more useful than naming one universal cause.

References

1. [2025 Greenland assessment](#) (arctic.noaa.gov)
2. [2020 study of western Greenland](#) (tc.copernicus.org)