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correspondence

Biological impact on Greenland's albedo

To the Editor — Dumont *et al.*[1] recently suggested that the springtime darkening of the Greenland Ice Sheet since 2009 is a consequence of an increased load of light-absorbing impurities in snow. They proposed that the impurities consist of soot or dust derived from new snow-free areas. Dumont *et al.* mention microorganisms as potential light-absorbing impurities, but do not incorporate biological activity into their numerical snow model. We argue that microorganisms, such as the pigmented algae that reside in snow and ice, can cause a substantial reduction in albedo and that this effect needs to be included in numerical albedo models of the Greenland Ice Sheet.

The eukaryotic algae that reside in and on snow can change the snow's colour from white to green to red over a period of weeks as the algae bloom[2]. Furthermore, complete melting of the snow exposes large areas of underlying grey ice that host brown–black pigmented ice-algae[2–5], in addition to the soot and mineral dust impurities discussed by Dumont and colleagues[1]. The rapid colour change — and the associated reduction in albedo — of a Greenland glacier during the extreme 2012 summer melt season has been shown to be primarily driven by algal growth[2]. Green and red snow algae and brown-black ice-algae reduced snow and ice albedo, respectively, by between 30 and 40%, relative to clean snow and ice[2,3].

Bacteria also contribute to the darkening of ice sheets. For example, cryoconites — windblown dust particles made up of rock particles, soot and bacteria — similarly dirty Greenland's ice surface and reduce its albedo[4,5].

The relative importance of biological activity versus inorganic dust and soot in the recent darkening of Greenland's snow and ice remains an open question. Dust and soot are dependent on aeolian delivery from snow- and ice-free areas, which are expanding in some regions of the Arctic as glaciers retreat. The biological contribution to albedo is, in contrast, a local, annually varying and highly dynamic feature of spring and summer melting, which could be rapidly altered by changes in the timing and duration of these seasons. We hypothesize that, as the climate warms and melt seasons become longer, biological habitats will expand and will increasingly contribute to the darkening of the Greenland Ice Sheet. Thus, we urge the inclusion of biological effects in model projections of Greenland's future albedo. ❐

References
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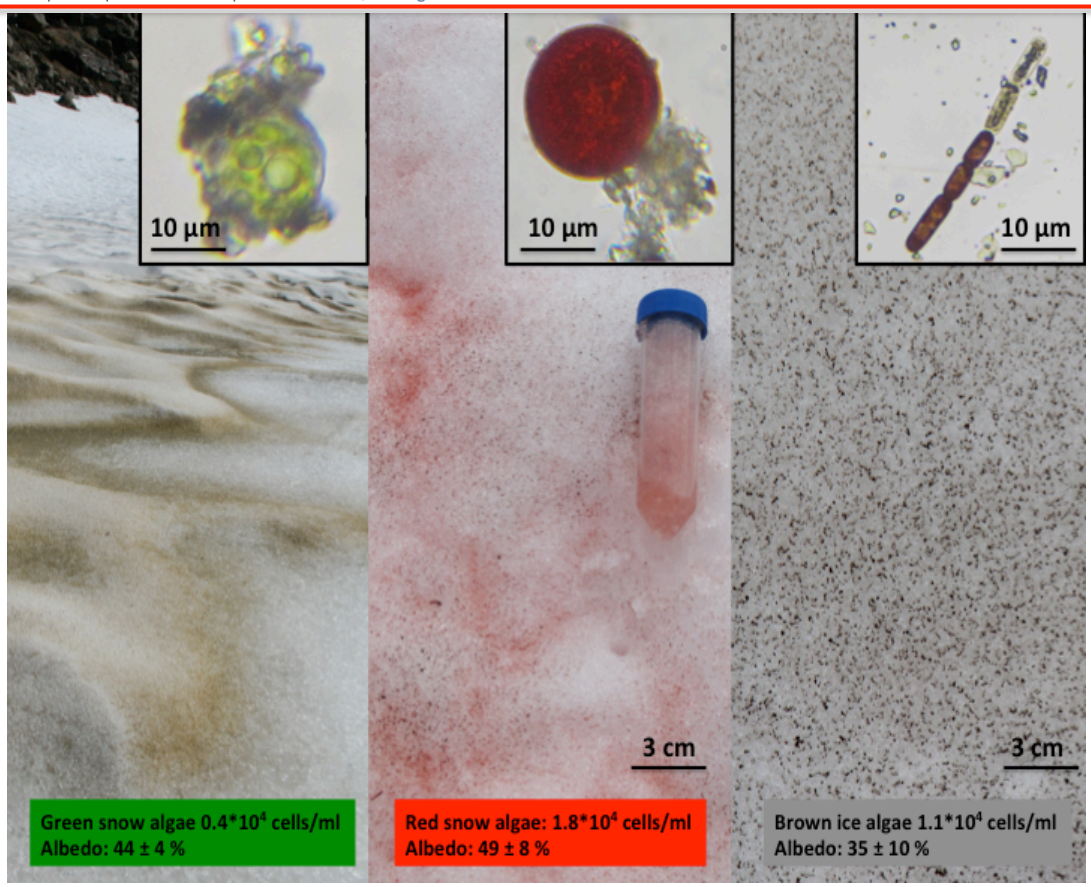

Figure to explain: Importance of biology for albedo reduction? Green (left) and red (middle) snow and grey ice (right) images with insets showing main inhabitants and associated inorganic debris particles; cell abundance and albedo values for each habitat are from Lutz et al.[2].