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Assessing the impact of bio-albedo upon Greenland Ice Sheet melting

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Areas of dark ice have appeared along the margins of the Greenland Ice Sheet during most melt seasons since at least 2000. Dark ice exhibits very low albedo and, as albedo is a major control upon the surface energy balance, it is essential to understand the evolution of dark ice under projected climate change. However, regional climate models have not simulated the albedo of dark ice because the processes responsible for dark ice have not been identified.

Recent field evidence indicates that the darkening along the western margins of the GrIS is driven strongly by the growth of pigmented ice algae, hence the term ‘bio-albedo’. Here, we use observations made along the south-west margin of the GrIS over two melt seasons together with modelling in order to assess the impact that ice algae has upon GrIS melting.

We demonstrate that the growth of ice algae and subsequent impact upon ice albedo can be physically parameterised in a regional climate model. We model the quantity of ice algae present on the surface as a function of meteorological conditions. We explore the importance of inorganic particulate material in providing spatial constraints upon algal growth. We then compute the surface albedo, including the impact of surface impurities, by solving the two-stream Snow, Ice and Aerosol Radiative (SNICAR) 2-stream model coupled to the regional climate model MAR. This approach enables us the explore the sensitivity of GrIS melting and runoff to bio-albedo both in the past and by the end of the 21st century.