

Do macro-nutrients limit ice algal blooms in Northwestern Greenland?

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The surface of the Greenland Ice Sheet (GrIS) has experienced consistent summer darkening over the last 20 years. This darkening is associated with the proliferation of Streptophyte glacier ice algae, a microalgae characterized by its dark purple pigment. While these algae are prevalent throughout the cryosphere, the factors promoting or regulating their spread remain poorly understood. Surface ice is often considered nutrient limited, suggesting that low concentrations of nitrogen (N) and phosphorus (P) may prevent algal growth. Intra-cellular carbon (C):N:P ratios in ice algae have been determined to be ~510:26:1, suggesting that only low concentrations of N and P are required for these organisms. The extremely low nutrient concentrations at the ice surface make it challenging to determine whether N and P concentrations are sufficient to meet algal metabolic requirements and conclude if either nutrient is limiting their growth.

We developed a continuous flow analyser capable of measuring low nanomolar concentrations of N and P found in these environments. We then investigated the concentrations of inorganic and organic N and P found in Greenland surface ice and assessed how they relate to the N:P ratios within ice algae. Shallow ice cores (~90 cm) were collected at two locations in northwest Greenland, the Qaanaaq Ice Cap and on the nearby GrIS. Three depths were sampled: the top 5 cm (the active weathering crust), 5 – 10 cm (transition from weathered to unweathered ice), and the bottom 5 cm (unweathered ice).

All samples had N and P concentrations above validated detection limits. Nutrient concentrations were higher at the ice surface than in the unweathered ice. An exception was inorganic N, which was slightly lower at the ice surface than at depth. Species of N were primarily in the forms of ammonium (NH_4^+) at the surface and nitrate (NO_3^-) at depth. The concentrations of these nutrients were highly variable, ranging from 12 – 90 nM P and 0.4 – 4.5 μM N, highlighting the heterogeneous nature of these environments. Despite low nutrient concentrations, we determined the availability of N and P is sufficient to sustain the algal community on the ice surface.