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Nutrient content and provenance of dust deposition along a 460km W-E transect on the Greenland Ice Sheet

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The melting of Greenland's Ice Sheet (GrIS) is accelerating due to climate change, with rising temperatures over extended periods and the proliferation of pigmented algae contributing to the emergence of a 'Dark Zone'(DZ). This algal growth peaks in the summer lowers the ice's albedo and accelerates melting[1]. Nutrients, which play a key role in stimulating algal growth, are therefore crucial in the expansion of DZ[2].Here, we focus on the nutrients supply that algal blooms receive from atmospheric deposition. We conducted a quantitative analysis of nutrients, particularly phosphorus and nitrogen, contained in dust collected from snow samples at fifteen sites along a 460 km west-to-east transect through the DZ and GrIS.

The snow samples were melted and filtered to 0.2µm in the laboratory and were analyzed for (i) their mineralogy and morphology (SEM-EDS) (ii) their chemical composition (Rare Earth Elements and speciation of phosphorus and nitrogen) and (iii) grain size distribution. Our results reveal that the amount of phosphorus is higher near the front of GrIS and decreases with altitude. This west-to-east phosphorus gradient is mainly driven by the content of organic phosphorus, which varies from ~90% of total phosphorus in the DZ to below detection levels at the summit, while inorganic phosphorus concentrations remain roughly constant. In contrast, nitrogen content along the transect is low and patchy, with only a few sites showing higher concentrations. Those results highlight the significant presence of organic phosphorus across most the GrIS and underscore the need to trace the origin of atmospheric deposition. Dust content and grain size measurements reveal that the proportion of coarse particles (>5µm), generally associated to local dust, is larger near GrIS front but decreases eastward, while the fine particle (2-5µm), attributed to distant sources, remain relatively constant throughout the transect. To further refine the provenance of dust, we are currently developing a mixing model using Rare Earth Elements patterns[3]. Overall, our results show that most of the phosphorus delivered by dust over the DZ is bound to organic matter, which may potentially represent a significant source of nutrient for algal blooms.

[1] www.the-cryosphere.net/5/589/2011/
[2] https://doi.org/10.1038/s41467-020-20627-w
[3] https://doi.org/10.1016/j.scitotenv.2023.163450