## Investigating the impacts of biological activity in Arctic snow and firn on the emission of climate-reactive gases

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**Project description:** Permanent snow cover and glacial firn is present over >10% of the present Earth's surface and is predicted to undergo substantial changes in a warming climate. This material acts as a repository and a reactor for a range of atmospheric species and in turn, influences the chemistry of the lower atmosphere. Beneath the firn, chemical species trapped in glacial ice are used to reconstruct past climate via ice cores. There has been intensified interest over the last decade into snow-atmosphere chemical interactions, particularly in relation to photochemical processes and the depletion of ozone which affects climate. The potential for biological activity within snow and firn, however, to influence emissions of climate-reactive species remains largely unexplored.

Snow and firn contain significant populations of micro-organisms which remain active despite sub-zero temperatures. Continued metabolism of these microbes within snow/firn may influence the production of ozone-depleting species and their precursors in three ways. First, biological nitrogen cycling in snow influences the availability of nitrogen for photo-denitrification; a process which drives emission of potentially ozone-depleting nitrous oxide ($NO_x$) species and reduces the snowpack nitrogen content. Second, methyl halides, which are pre-cursors to ozone-depleting halogens, may be produced in snow/firn by marine algae and bacteria deposited within snowfall. The presence of anomalously high concentrations of methyl halides ($CH_3Br$ and $CH_3Cl$) in some Arctic ice cores [1] is consistent with this. Third, volatile organic species generated biologically in snow may interact with reactive halogen chemistries [2], influencing their emission characteristics. These hypothesized biological influences upon snowpack nitrogen and active halogen chemistry merit study because of their potential to impact lower atmosphere chemistry and to create artefacts in ice cores.

This PhD will characterise and quantify the influence of biological activity in polar snow and firn upon climate-reactive gas emissions, with a focus upon: a) nitrogen cycling and NOx emissions and b) alkyl halide production. It will employ novel, custom-designed field and laboratory experiments to determine a) the abundance of nitrogen-cycling and alkyl-halide-producing microbes in Arctic snow/firn and b) rates and pathways of these biogenic cycling pathways (including secondary effects via autochthonous organic carbon production). The project will also conduct a suite of similar analyses upon ice core samples (e.g. NEEM core, Greenland) where high levels of methyl halide gases have been reported. The student will draw upon these experiments and analyses to propose new models for the biogenic production of climate-reactive species within snow-covered environments.

1. Aydin, M., M.B. Williams, and E.S. Saltzman, *Feasibility of reconstructing paleoatmospheric records of selected alkanes, methyl halides, and sulfur gases from Greenland ice cores.* Journal of Geophysical Research-Atmospheres, 2007. **112**(D7).

2. Swanson, A.L., et al., *Are methyl halides produced on all ice surfaces? Observations from snow-laden field sites.* Atmospheric Environment, 2007. **41**(24): p. 5162-5177.