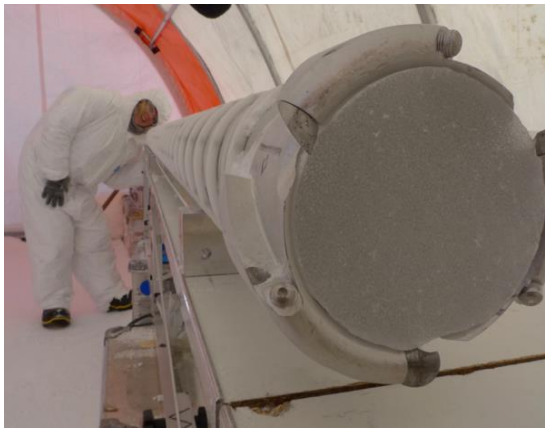
British Antarctic Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

NERC GW4+ Doctoral Training Partnership

PROJECT TITLE:	**Atmospheric ice nucleating particles - is there a fingerprint of past changes in polar snow and ice?**
Lead Institution:	**British Antarctic Survey**
Lead Supervisor:	**Dr. Markus M. Frey, British Antarctic Survey, Atmosphere, Ice & Climate Team**
Co-Supervisor:	**Prof. Walther Schwarzacher, University of Bristol, School of Physics**
Co-Supervisor:	**Dr. Amélie Kirchgässner, British Antarctic Survey, Atmosphere, Ice & Climate Team**

Project Enquiries & Applications: Dr. Markus M. Frey - maey@bas.ac.uk

Atmospheric ice nucleating particles (INP) can have a large impact on polar clouds and climate but are still poorly understood.



Ice cores may hold information on past changes of atmospheric ice nucleating particles (INP) in the polar regions, which is key to understand modern climate change.

Project Background

Cloud droplets freeze homogeneously at temperatures below -37ºC, but the presence of ice nucleating particles (INP) can induce freezing at much higher temperatures. Even small numbers of INP have a large impact on cloud optical properties and lifetime, precipitation and therefore climate. However, INP sources and their temporal and spatial variability are only poorly understood causing significant uncertainty in the representation of clouds in climate models in the Arctic and above the Southern Ocean, including coastal Antarctica. A quantitative understanding of the origin and temporal variability of INP is needed to reduce uncertainties in regional and global climate predictions, especially in the high latitudes, which currently experience the strongest warming. Recent observations suggest that some INP are preserved in polar snow and ice. Thus, polar ice cores may be a potential tool to extend the instrumental record and to infer changes of INP abundance in polar regions over past centuries and millennia.

Project Aims and Methods

The project objectives are (a) to establish the relationship of ice nucleating particle (INP) concentrations in polar air and snow and (b) to evaluate the century-scale atmospheric INP variability at a polar location, based on measurements of available ice core samples. In a first step the student will adapt and validate an existing droplet assay method to measure INP concentrations in polar snow and ice core samples. Then the student will quantify

the modern air-snow relationship of INP, measuring INP spectra from air filter and snow samples. Samples will be available from the year-round sea ice drift expedition (MOSAiC) in the Arctic during 2019-20 as well as from Halley station in coastal Antarctica. And finally, the student will estimate the historic variability and trends of INP abundance over the past few centuries, from the pre-industrial to present day, by measuring INP concentrations in polar ice core samples held in the BAS archive. The atmospheric relevance and climate impacts of the inferred regional atmospheric INP record will be assessed based on a sensitivity study in close collaboration with chemistry and climate modellers at BAS.

Candidate Requirements

Degree in physics, chemistry or related Earth/Environmental Science, with experience in experimental work in the laboratory and good numerical skills (e.g. basic knowledge of Matlab, Python or equivalent).

Training

You will be part of a dynamic research team (AIC) at BAS, which is working on a wide range of environmental topics in the polar regions, and one that is studying fundamental aspects of ice nucleation in the School of Physics (Univ. of Bristol). You will have outstanding opportunities to develop practical and data analysis competences and gain a deep understanding of both climate science and ice physics. Full training in the instrument, laboratory and modelling techniques will be provided, together with broader transferrable skills training. You will have a potential field work opportunity at a site in the Arctic or Alps. You will attend an atmospheric sciences summer school and receive support to publish results in peer-reviewed journals and at (inter)national conferences.

References / Background reading list

References: font size may be reduced to provide additional space elsewhere

Harrison, A. D., Whale, T. F., Rutledge, R., Lamb, S., Tarn, M. D., Porter, G. C. E., Adams, M., McQuaid, J. B., Morris, G. J., and Murray, B. J.: An instrument for quantifying heterogeneous ice nucleation in multiwell plates using infrared emissions to detect freezing, Atmos. Meas. Tech. Discuss., 2018, 1–22, doi:10.5194/amt-2018-177, URL https://www.atmos-meas-tech-discuss.net/amt-2018-177/, 2018.

Hiranuma, N., et al.: A comprehensive laboratory study on the immersion freezing behavior of illite NX particles: a comparison of 17 ice nucleation measurement techniques, Atmos. Chem. Phys., 15, 2489–2518, doi:10.5194/acp-15-2489-2015, URL https://www.atmos-chem-phys.net/15/2489/2015/, 2015.

Rangel-Alvarado, R. B., Nazarenko, Y., and Ariya, P. A.: Snow-borne nanosized particles: Abundance, distribution, composition, and significance in ice nucleation processes, J. Geophys. Res., doi:10.1002/2015JD023773, URL http://dx.doi.org/10.1002/2015JD023773, 2015JD023773, 2015.

Rhodes, R. H., Yang, X., Wolff, E. W., McConnell, J. R., and Frey, M. M.: Sea ice as a source of sea salt aerosol to Greenland ice cores: a model-based study, Atmos. Chem. Phys., 17, 9417–9433, doi:10.5194/acp-17-9417-2017, URL https://www.atmos-chem-phys.net/17/9417/2017/, 2017.

Useful links

https://www.bas.ac.uk/
https://www.bas.ac.uk/science/science-and-students/nerc-doctoral-training-opportunities/

Interested in a project? Contact the lead project supervisor for more information.

To apply, please send the following documents directly to the project supervisor:

- A full CV
- Copies of transcripts and degree certificates
- A statement of interest (no more than 2 sides A4)
- Name/email address of two professional referees

For general enquiries: Contact Ali Teague alag@bas.ac.uk in the BAS Student Office

The application deadline is 1600 hours GMT Monday 7 January 2019 and interviews will take place between 4 and 15 February 2019. For more information about the NERC GW4+ DTP, please visit https://nercgw4plus.ac.uk.