Dispersion of Biogenic Aerosols in the Antarctic

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Is this a CASE studentship? YES

If so, please state intended CASE partner: British Antarctic Survey (BAS)

Introduction

The Antarctic ocean-ice-atmosphere system remains one of the last fully explored regions on the planet. Recent understanding has shown that there can be potentially strong feedbacks between these systems as surface ice melts. These feedback processes between ocean, ice surfaces clouds and aerosols can be very nonlinear and highly spatially heterogeneous processes. These feedback processes are very poorly understood in the Antarctic atmospheric due to a lack of observations of the sources of the regions aerosols, which can have both biogenic and non-biogenic sources there and how they influence cloud and precipitation formation. Knowing the emission and evolution of the regions aerosol populations and how these change over the Austral Summer-Winter season in response to biogenic activity and solar input is critical to understanding and modeling the continent's response to climate warming.

Project Description

Until recently work in Antarctica to investigate aerosols and their sources relied on low temporal resolution methods such as collection of airborne particles onto filters for subsequent analysis in a laboratory. Such studies have therefore been spatially and temporally limited and so unable to answer many important questions, particularly with regard providing statistically quantifiable data for modeling of impacts ranging from predicting ecosystem diversity changes to aerosol-cloud interaction and precipitation and how these affect changes in snow-ice mass balance for the region. With new field deployable real-time aerosol composition measurements techniques this is now changing, Giordano et al. (2017). As part of a new Antarctic research initiative this project will contribute to improving our knowledge of many Antarctic ocean-ice-atmosphere feedback processes by investigating a poorly studied area of these feedback processes, bioaerosol-climate feedback.

In this project the student will make use of new real-time detection techniques for airborne primary biological (PBA) as well as other aerosols and their composition, to identify their sources, emission rates, and dispersion patterns over the Weddell Sea region. This project will combine survey sampling of these aerosols along the Brunt ice shelf, with measurements through the

Weddell Sea region collected on board the new research ship RSS Sir David Attenborough, as well as continuous long-term measurements at the new Halley research base. The objective of this work, which will be conducted with scientists at BAS and Manchester, will be to combine a deeper knowledge of emission processes of these particles and place them in a climate change context using the long term seasonal observations. Aerosol-cloud interactions are recognized as the largest uncertainty in current climate models particularly for remote regions such as Antarctica.

A further area of study is the impact on ecosystem development due to long-range transport and subsequent intra-continent dispersion of primary biological particles (bacteria, fungal spores and pollen). New real-time measurement techniques now allow the concentrations of general classes of these particles to be detected rapidly, with relative ease allowing these processes to be investigated in detail. As the Antarctic surface warms these particles can better establish micro-ecosystems upon which other biological systems rely in order to become established. Some of the processes by which this occurs include synergistic transport and surface establishment with non-biological particles such as dust and black carbon (e.g. via so-called cryoconite holes). In particular, their subsequent intermittent deposition, modification or regeneration, re-suspension and re-dispersion (region-hopping) has been suggested as an important pathway for potential re-colonisation and “greening” of this remote biome (e.g. Pearce et al., 2016).

The SS Sir David Attenborough would also be used to provide N-S latitudinal measurements of aerosol composition (including black carbon measurement instruments) in the Southern Ocean-Weddell Sea region for comparison Eulerian/Lagrangian transport models. Filter samples of bioaerosols (bacteria and fungal spores) would be collected for analysis as part of a larger programme of bioaerosol surveys which the student can become involved with.

The project therefore encompasses a wide range of processes from the small–scale up to continental scale dispersion processes and these new results will be used to improve and validate model dispersion rates and the potential impacts of these aerosols on cloud and precipitation processes to understand the sensitivities of Antarctic climate to future changes in aerosol populations. A range of models will be made available for the student to take advantage of their field-work results, depending on their skill set and research objectives, from high resolution large eddy simulation models (LEM) to regional scale emission and aerosol-cloud interaction (WRF-CHEM) models.

This project is therefore multi-faceted and multi-disciplinary and will easily accommodate students with a range of different backgrounds (the team already includes students with degrees in physics, chemistry, biology, geography and mathematics) but appeal to those with a sense of adventure and an interest in “learning the world”. The student will form part of a large scientific team made up of scientists at BAS and Manchester who will support their work and provide training. The majority of the student’s time will be spent at the Centre for Atmospheric Science (CAS) in Manchester with regular detachments to BAS-Cambridge for field training and science meetings. Field expeditions will take place at the BAS research stations in Antarctic and on the RSS Sir David Attenborough. Contribution to other polar research expeditions may also be possible. Full training will be provided in all aspects of the work from instrument operation and calibration (using facilities at the Manchester CAS, who will also provide new state of the art instrumentation for this project) to data analysis-programming and computer modeling using newly developed software tools including neural network/machine learning tools. The project will allow the student’s strengths and interests to be explored and developed.

References

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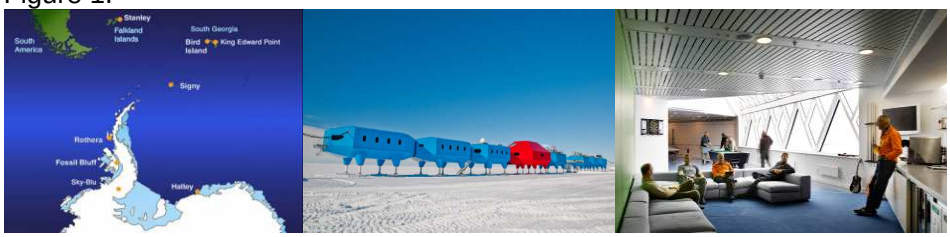
Figure 1.



Legend to Figure 1:
Halley VI Research Base where the work will be based

Figure 2.

Legend to Figure 2:
RSS Sir David Attenborough on which survey measurements of aerosols in Antarctica will be made.