The mystery of triangular atmospheric ice crystals

Supervisors: Dr Ben Murray and Dr Steven Dobbie

Introduction

We are all familiar with the hexagonal shape of snow and ice crystals and it is well established that their six-fold symmetry is derived from the arrangement of water molecules in a hexagonal crystal structure. However, many atmospheric ice crystals have three-fold symmetry (trigonal crystals), which is inconsistent with a hexagonal crystal structure. They are found in cloud types throughout the atmosphere from upper tropospheric cirrus to diamond dust to contrails and form at temperatures ranging from ~-84 to -5°C in the atmosphere.

Recent experimental studies of ice crystal structure have shown that ice under a wide range of atmospherically relevant conditions (at least up to -16°C) does not always conform to the standard hexagonal crystal structure (Malkin et al., PNAS, 2012). Instead, sequences corresponding to cubic structure can be interlaced with hexagonal sequences. This breaks the symmetry in the crystal structure which gives rise to the six-fold symmetry of hexagonal crystals, but this stacking disordered ice retains 3-fold rotational symmetry.

Ice crystal formation and shape has a large impact on our planet's climate, but remains very poorly understood. Crystal shape influences cloud radiative properties as well as the sedimentation speed of ice crystals. The crystal sedimentation speed and therefore the lifetime of cirrus clouds in global climate models remains a major source of uncertainty.

In this project you would use our laboratory equipment to quantify the conditions under which trigonal or triangular ice crystals grow and relate this to the crystal structure.

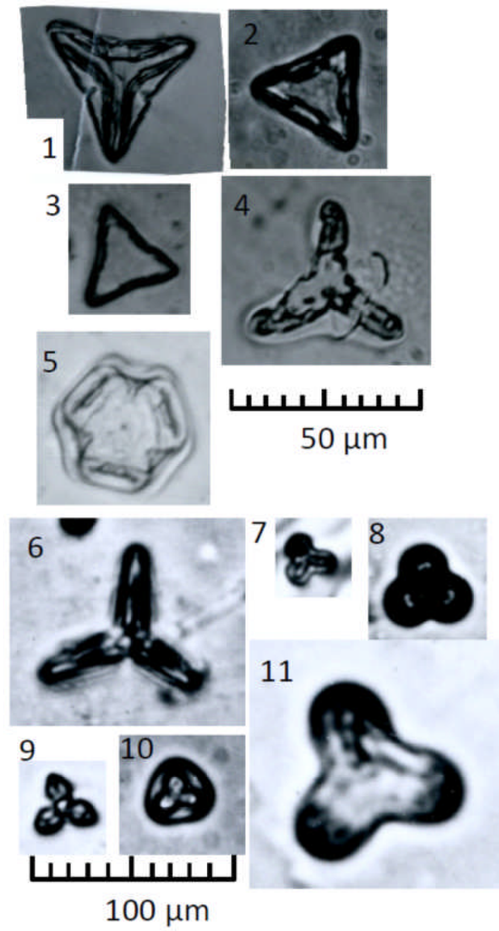

Figure 1. Shapes (or habits) of ice crystals crystals in the upper tropospheric cirrus clouds from Heymsfield et al. (J. Atmos. Sci., 1986).

PhD Objectives:

1) Nucleate ice on mineral dust particles, frozen droplets and other nuclei.
2) Grow the crystals under well-defined conditions and recording to establish for the first time under which conditions trigonal ice crystals form.
3) Relate this to measurements of crystal structure using X-ray diffraction.

Training

The successful PhD student will have access to a broad spectrum of training workshops put on by the Faculty that include an extensive range of training workshops in numerical modelling, through to managing your degree, to preparing for your viva. A full listing is available through here.

Requirements

A good first degree (1 or high 2i), or a good Masters degree in a discipline such as mathematics, physics, geophysics, engineering, meteorology or environmental science.

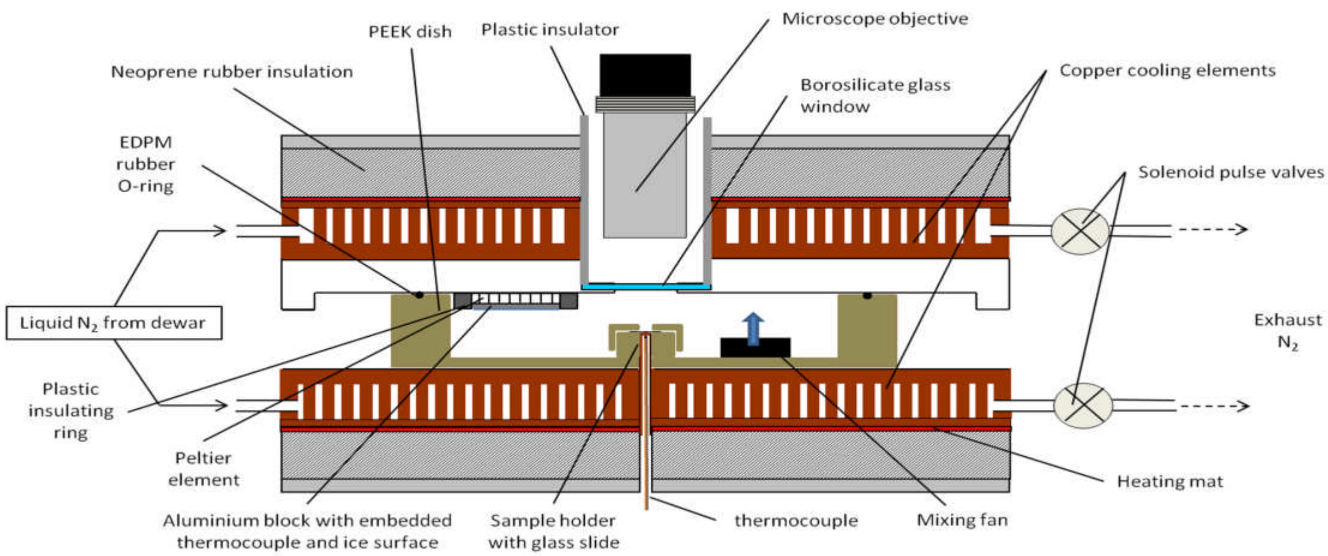

Figure 2. Ice nucleation and growth chamber. Ice crystals of ~ 20 microns will be grown on the sample holder.