2022_94_Physics_Gryspeerdt: Measuring the timescales for precipitation - how quickly can you make a cloud rain?

**Supervisors:** Edward Gryspeerdt, Physics (mailto:e.gryspeerdt@imperial.ac.uk), Adrian Hill (Met Office)

**Department:** Department of Physics

Clouds are a central component of the Earth system, modulating the Earth's energy budget and playing a central role in the water cycle. However, their response to human activity and to rising temperatures remains a leading uncertainty, both in the forcing and response of the climate system. Due to their multi-scale behaviour, cloud processes must be parametrised, but formulating these parametrisations is difficult and relies on accurate observations. This project uses satellite data and high resolution model simulations to measure key cloud processes, particularly those around the formation of precipitation.

Precipitation is key for understanding the impact of aerosol on low, liquid clouds. As almost all cloud droplets form on an aerosol particle, a cloud in a high aerosol environment has more, smaller droplets. Smaller droplets are less likely to form precipitation, which can increase the amount of water held by clouds. The size of this effect is highly uncertain. Climate models represent it through a modification of the 'autoconversion' process, but this has up to now been difficult to measure.

This project explores a new way to measure process rates, using isolated aerosol perturbations (ships) to study cloud changes over time, providing a window into these process rates (Gryspeerdt et al., 2021). Using these observations, the project will focus on measuring the timescales for these processes for the first time and then using these observations to constrain climate models, together with modelling partners at the UK Met Office.

Specific questions addressed in this project will include:

- How do clouds develop downwind of aerosol sources? What are the timescales for these changes, particularly for precipitation?
- What modifications to precipitation processes are necessary to reproduce this development in a high-resolution model?
- What impact do these changes have on the simulated global climate and its response to human activity?

The project will involve the use of state-of-the-art satellite observations, cloud-resolving, regional and global climate models to answer these questions. These results will be compared with results from other modelling centres to develop strong observation-based constraints of the anthropogenic aerosol impact on climate.

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