Department of Mathematics and Statistics

2015 PhD Projects

The Open University

Project title	Analysing Clouds
Principal supervisor	Michael Wilkinson
Second supervisor	Marc Pradas
Discipline	Applied mathematics
Research area/keywords	meteorology, fractals, turbulence, phase separation
Suitable for	Full time or part time students

Project background and description

Clouds play a central role in determining weather and climate, but many aspects are poorly understood. In particular, there is no satisfactory theory for the rapid onset of rainfall from clouds that are do not contain ice crystals.

The project will address two aspects of this problem. The first concerns the mechanism for microscopic water droplets to achieve sufficient size to undergo runaway growth. Attempts to explain this by collisional mechanisms have not been successful. Non-collisional mechanisms, involving transfer of water from one droplet to another by evaporation and condensation of water vapour, are a promising alternative approach [1]. Analysing these mechanisms depends upon understanding the supersaturation field of water vapour, how droplets move through this field and sample it [2]. This will be approached by defining and analysing models involving the fractal structure and turbulent motion of a cloud [3].

The second aspect concerns the growth of microscopic water droplets to form raindrops. After droplets reach a critical size, they grow by sweeping up smaller droplets in their path. This is a 'runaway' process where the droplet size diverges in a finite time. This problem has been analysed using the Smoluchowski equation, a standard mathematical description for collision processes, and it has been found that the singularity occurs at zero time [4]. There is something wrong with applying the Smoluchowski equation to this problem. The project will identify the problem and formulate an alternative treatment of collisions.

Background reading/references

[1] A Test-Tube Model for Rainfall, M. Wilkinson, *Europhys. Lett.*, **106**, 40001, (2014).

[2] Convective Ripening and Initiation of Rainfall, M. Wilkinson, *Europhys. Lett.*, **108**, 49001, (2014).

[3] Triangular Constellations in Fractal Measures, M. Wilkinson and J. Grant, *Europhys. Lett.*, **107**, 50006, (2014).

[4] Exchange Driven Growth E. Ben-Naim and P.L. Krapivsky *Phys. Rev. E* **68**, 031104 (2003)