ONE Planet
Doctoral Training Partnership

Natural Environment Research Council

**Project title:** Improved models for particulate dispersal by naturally occurring plumes.

**Ref: OP2402**

**Keywords:** atmospheric dispersal, buoyant plumes, multiphase flow

**One Planet Research Theme:**
Climate & Climate Change X | Earth System Processes X | Anthropocene ☐ | Environmental Informatics ☐

**Lead Supervisor:**
Dr David Swailes (Applied Mathematics, Newcastle University)
https://www.ncl.ac.uk/maths-physics/people/profile/davidswailes.html

**Key Research Gaps and Questions:**
Why do existing models often fail to accurately predict large scale dispersal, and how can we improve them? Gaps to fill include better models for the effects of

- Turbulence structure on particle transport

- Particle inertia on fall-out and entrainment


Eyjafjallajokull eruption, Iceland (2010)

**Project Description:** Buoyant plumes characterise geophysical systems such as volcanic eruption columns and hydrothermal vents [1]. Particulates injected into these can, subsequently, be transported over great distances and remain present in the air/water for extended periods. A classic example was the 2010 eruption of the volcano Eyjafjallajökull. The ash cloud caused disruption to air-travel; estimated cost £3 billion. The need to accurately predict dispersal of such material is clear. However current plumes models can fail badly: the ash cloud from the Grimsvötn eruption (2011) was convected southwards, but models predicted clouds both north and south of the source! The plume models failed to properly account for mechanisms (inertia, sedimentation, aggregation) that induce separation between particle and gas phases in the plume.

These shortcomings will be addressed in this project: Building on a fundamental kinetic theory for turbulent dispersed particle transport [2,3] the PhD student will gain experience in a range of important modelling methodologies, and learn how develop and analyse two-phase integral plume models that incorporate separation processes in a physically rational way. An important part of the modelling will involve the formulation of particle fall-out from, and re-entrainment into, the plume.

Working closely with our project partners, the UK Meteorological Office (MO), the PhD student will assess model accuracy using CFD simulations, and investigate how results might be used to adapt current atmospheric dispersion forecast models used by the MO.

[1] Annu Rev Fluid Mech 2010, **42**, 391-412. *Turbulent Plumes in Nature*.
[2] ASME J Fluids Eng, 2021, **143**, 080803:1-52. A *kinetic theory for particulate flows.*
[3] Phys Rev E, 2021, **103**, 606101. *The mass flux of dispersed particles in turbulence.*

**Prerequisites:** Good 2.1 Hons or better in either applied mathematics; theoretical or computational physics; thermo-fluids engineering. Strong analytical skills. Familiarity with computational methods and experience of programming. Some knowledge of fluid dynamics. An ability to think and work independently. Strong communication skills.
For more information contact: Dr David Swailes, d.c.swailes@newcastle.ac.uk

Newcastle University

Northumbria University NEWCASTLE