Generating and evaluating the next generation of ensemble atmospheric dispersion volcanic ash forecasts

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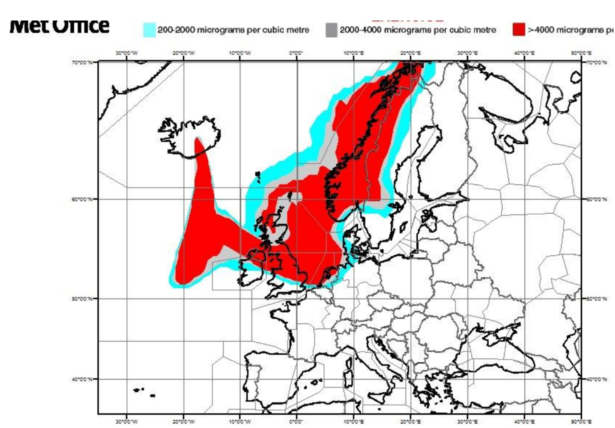
Explosive volcanic eruptions can send ash and gas high up into the atmosphere, which in turn can pose a significant hazard to aircraft. When ash is ingested into engines it can cause engine failure, putting the lives of aircrew and passengers at risk. Encounters between aircraft and volcanic ash clouds can also lead to permanent engine damage, resulting in expensive replacement of engine components and time-consuming maintenance procedures. Flights are therefore significantly restricted if there is volcanic ash present in airspace, which disrupts air traffic and causes large financial loses to the aviation industry and beyond. For example, the 2010 Eyjafjallajokull eruption grounded over 95,000 flights, costing the airline industry over £1 billion pounds.

To ensure safe and optimised flight operations during volcanic eruptions, accurate forecasts of ash location and concentration are needed. This requires accurate knowledge of the volcano's eruption characteristics and perfect representation of the atmospheric processes controlling the transport of volcanic ash in the atmosphere. Current forecasts (see figure) do not explicitly take into account the inherent uncertainty in our knowledge of these factors. Thus, airline flight operators currently have incomplete information regarding the risk of flying when there is volcanic ash present in airspace. To address this problem, it is necessary to develop the next generation of volcanic ash forecasts. In this project we will address the issue of missing uncertainty representation by producing probabilistic volcanic ash forecasts using ensemble forecasting techniques. The aim of this project is to explore methods for generating and evaluating the reliability and skill of volcanic ash ensemble forecasts with a view to developing an operational dispersion ensemble prediction system. We will achieve this by bringing together the latest research into volcanic ash forecasting, probabilistic prediction and uncertainty communication.

In the project we will perform ensemble volcanic ash simulations for a number of historic eruptions. Using the ensemble simulations and satellite data we will calculate the skill of each ensemble member forecast. The PhD student will work with members of the Atmospheric Dispersion and Air Quality group at the Met Office to investigate the most reliable and skillful dispersion ensemble prediction system and also to develop the capability to communicate the reliability and skill to end users.



Current VAAC volcanic ash hazard chart showing the location of volcanic ash in a single vertically integrated layer of the atmosphere during the 2010 Eyjafjallajokull volcanic eruption

Training opportunities:
The student will visit the Met Office at least twice during the project to discuss the design and implementation of experiments using the Met Office Dispersion Model.

Student profile:
This project will be suitable for students with a degree or extensive experience in mathematics or physics or a closely related physical or environmental science. Students should have a strong interest in high impact atmospheric dispersion events and their predictability.

Funding particulars:
This project is CASE funded by the Met Office

References:
Prata, A.T., Dacre, H.F., Irvine, E.A., Mathieu, E., Shine, K.P. and Clarkson, R.J., 2019. Calculating and communicating ensemble-based volcanic ash dosage and concentration risk for aviation. *Meteorological Applications*, *26*(2), pp.253-266.

Harvey, N.J., Huntley, N., Dacre, H.F., Goldstein, M., Thomson, D. and Webster, H., 2018. Multi-level emulation of a volcanic ash transport and dispersion model to quantify sensitivity to uncertain parameters. *Natural hazards and earth system sciences.*, *18*(1), pp.41-63.

https://research.reading.ac.uk/scenario/