SPECIAL PROJECT FINAL REPORT

All the following mandatory information needs to be provided.

Project Title:	Quantifying the uncertainty in volcanic ash cloud forecasts
Computer Project Account:	SPGBDACR
Start Year - End Year :	July 2015 – Dec 2015
Principal Investigator(s)	Helen Dacre
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Other Researchers (Name/Affiliation):	Natalie Harvey, University of Reading Helen Webster, UK Met Office Andrew Jones, UK Met Office

The following should cover the entire project duration.

Summary of project objectives

(10 lines max)

The main objective of this project was to run the ECMWF EPS for the period covering the eruption of the Eyjafjallajokull volcano in Iceland (April-May 2010) and to use output from the EPS as input for the UK Met Office's Volcanic Ash Transport and Dispersion (VATD) model, NAME, in order to produce an ensemble of volcanic ash forecasts.

Summary of problems encountered

(If you encountered any problems of a more technical nature, please describe them here.)

Extracting data from the MARS archive was slow as the large size of the files meant it was only possible to extract 2 or 3 forecast initialisation times at once. Also, transferring the EPS data from the ECMWF system onto JASMIN was very slow and took over a week to complete.

Experience with the Special Project framework

(Please let us know about your experience with administrative aspects like the application procedure, progress reporting etc.)

We found the application procedure straightforward. We were not required to produce a progress report as the project duration was only of 6 months duration.

Summary of results

(This section should comprise up to 10 pages and can be replaced by a short summary plus an existing scientific report on the project.)

Volcanic ash provides a significant hazard to aircraft by reducing visibility and causing both temporary engine failure and permanent engine damage. The presence of volcanic ash in the atmosphere can disrupt air traffic and result in large financial losses for the aviation industry. For example, the 2010 Eyjafjallajokull eruption closed European airspace for over 6 days, grounding over 95,000 flights and costing the airline industry over £1billion. The decision to close airspace is to a large extent based on advice from the Volcanic Ash Advisory Centers (VAAC's). There are 9 VAAC's worldwide, covering different regions of the globe. Each VAAC issues hazard maps of the predicted area covered by volcanic ash. These hazard maps are based on forecasts made using Volcanic Ash Transport and Dispersion (VATD) models. There can be large errors in these forecasts due to uncertainty in the input fields and approximations in the model itself. Current operational VATD models assume that both the input fields and the model are perfect. They therefore fail to represent the inherent uncertainty in the forecast which results in overconfidence in the model predictions and can lead to potentially incorrect decisions being made

There are several different methods of representing uncertainty in VATD modelling; (i) ensembles of different volcano eruption source parameters, (ii) ensembles of different VATD models, (iii) ensembles of different meteorological forecasts and (iv) a combination of one or more of the strategies above. Whilst progress has been made to represent both (i) and (ii), as yet no studies have been performed to represent the uncertainty in VATD model forecasts due to uncertainties in the meteorological forecast fields. This is because the data storage needed to archive the ensemble NWP model level data required as input to offline VATD models is prohibitive to perform on a routine basis.

In order to achieve our aim of quantifying the uncertainty in volcanic ash forecasts due to uncertainty in meteorological fields we used ECMWF EPS data as input to the UK Met Office's

VATD model and produced an ensemble of volcanic ash forecasts. To minimise the computational and data storage costs we designed a set of simulations in which we used a reduced number of ensemble members (21 members), reduced forecast length (7-days), reduced temporal resolution (6-hourly), reduced number of vertical levels (25 levels) and reduced spatial domain (North Atlantic and European). This made the project feasible both in terms of computing and data storage.

During the project, with help of Paul Dando at ECMWF, we successfully managed to perform the necessary ECMWF EPS simulations and extract the data using special scripts designed to reduce the number of archived model levels and to add surface pressure as an archived field. Following this, we extracted the data from the MARS archive and transferred it to JASMIN. With the help of Andrew Jones at the Met Office, we were able to convert the EPS data into NAME compatible format using special scripts designed to post-process the sensible heat flux, surface stresses, total precipitation, large-scale precipitation, convective precipitation and total snowfall fields. Finally, we used the NAME formatted EPS data to perform ensemble simulations of the 2010 Eyjafjallajokull eruption. We are currently in the process of analyzing these ensemble forecasts (see figure 1) with the aim of quantifying the uncertainty in volcanic ash forecasts.

If significant improvements in volcanic ash forecasting are found, it will provide a major incentive for a larger international initiative to create operational ensemble forecast products. This would then allow Civil Aviation Authorities (CAA's) to make better use of volcanic ash forecasts in their decision-making.

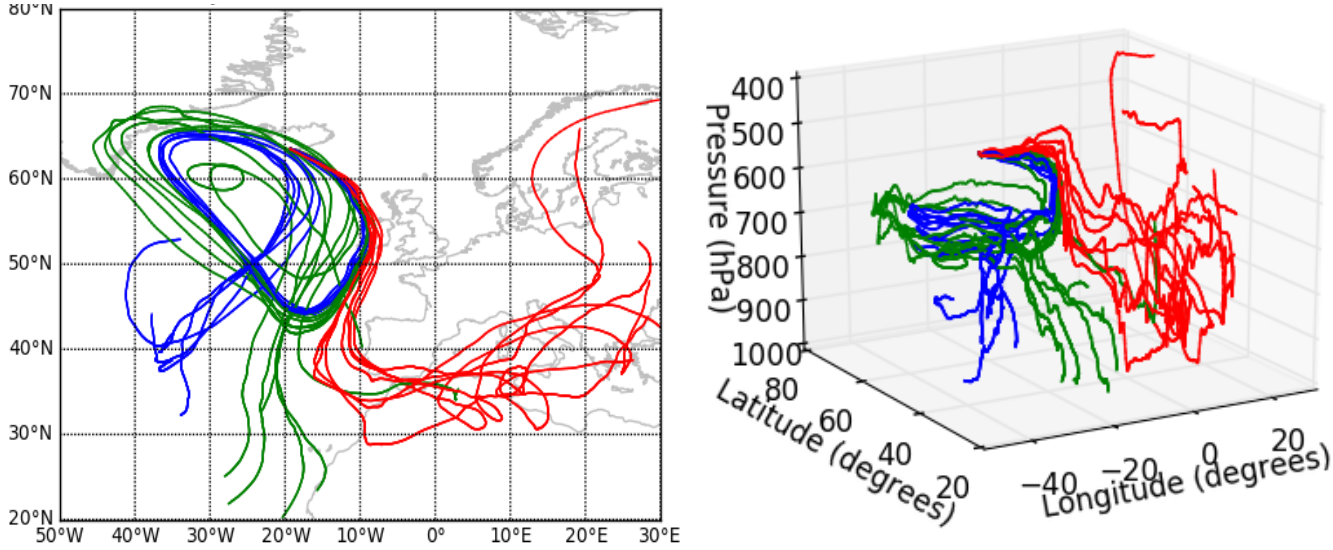

Figure 1. 11-day ash particle trajectories released at 02 UTC on 3 May 2010. Each trajectory is initialized with different ECMWF EPS flow field. Red, blue and green trajectories represent 3 different clusters of trajectories.

List of publications/reports from the project with complete references

As we are still analysing the NAME ensemble runs we do not have any peer-reviewed publications. We do however have a working document explaining the steps needed to create the ECMWF EPS data needed to run NAME. This is available from Helen Dacre (h.f.dacre@reading.ac.uk) on request.

Future plans

(Please let us know of any imminent plans regarding a continuation of this research activity, in particular if they are linked to another/new Special Project.)

We have already used the methodology developed in this special project (spgbdacr) to perform similar EPS simulations for the 2011 Fukushima Nuclear Explosion. These simulations were performed under UK Met Office project allocation gbmeto8. Following completion of the analysis of the Eyjafjallajokull simulations we are likely to continue this research activity in the near future.