

- **Context and Outcome** - How does your proposal fit within your research discipline and in what ways will it contribute to the global advancement of science. Applications for Class A projects should take care to explain the "High Impact" nature of their project.

The April 2010 eruption of the Eyjafjallajökull volcano caused havoc for European airlines, in terms of financial losses, and for passengers, in terms of disrupted travel. Along with the disruption to air travel, the situation revealed several deficits in Europe's capabilities in terms of accurately detecting and predicting the ash plume mass density, thickness and vertical distribution (particularly in terms of layering effects) in real-time. Further, many airlines raised serious doubts over the accuracy of the Volcanic Ash Advisory Centres (VAACs) predictions. As the crisis developed, and air fleets were grounded, the airlines pushed engine manufacturers to specify a safe ash mass loading threshold, below which it could be regarded as safe to fly in the plume. Once a threshold was specified by the engine manufacturers, the VAACs were required to move from a total avoidance forecast to a threshold forecast. Questions have also been raised about the level of sophistication of the VAAC models used since much ash micro-physical and chemical evolution processes are typically not present in VAAC models. The development of an accurate and timely forecasting model represents an important tool for Irish government and policy makers in order to respond quickly and efficiently to the impacts associated with volcanic ash emissions. A more accurate forecasting may also lessen the economic impact of such emissions.

- **Methodology** - Explain the approach you intend to follow to meet your objectives. For example, which algorithm(s) and simulation technique(s) do you intend to use, which code(s), etc.

This question will be addressed by the further development, validation and utilisation of a three-dimensional on-line climatechemistry/aerosol model called REMOTE (Regional Model with Tracer Extension (Langmann, 2000; Marmer and Langmann, 2007) in ash plume forecast mode. This is a regional climate model that determines the physical, photochemical and aerosol state of the model atmosphere at every model time step, thus offering the possibility to consider trace species effects on climate (e.g. Langmann, 2007). The dynamical part of the model is based on the former regional weather forecast system of the German Weather Service. Beside the German Weather Service physical parameterisations, those of the global climate model ECHAM-4 (Roeckner et al., 1996) have been implemented in REMOTE. After being released in the atmosphere, gas phase and aerosol phase species undergo transport processes (horizontal and vertical advection (Smolarkiewicz, 1983), transport in convective clouds (Tiedtke, 1989), vertical turbulent diffusion and are removed from the atmosphere by sedimentation, dry and wet deposition. Photochemical production and loss in REMOTE is determined by the RADM II chemical scheme (Stockwell et al., 1990) by 163 chemical reactions in the gas phase including a wide range of hydrocarbon degradation reactions. During the recent Eyjafjallajökull eruption a provisional operational volcanic plume forecasting model was developed in order to provide Ireland's with its own capability of assessment and prediction (see Fig.1

for typical output). The work outlined here will seek to develop this forecasting system so as to be one of the most sophisticated in Europe.

The following additional information is required for **Class A** and **Class B** applications:

- **Justification** - Describe the performance and properties of the code you intend to use (assuming it already exists - if not, please specify), etc. Explain how many runs you intend to carry out, their memory requirements, expected run-times, on how many CPUs, etc. It is important that all Class A and Class B applications justify adequately the levels of resources they are applying for. In the case of Class B GPU projects the added technical complexity of using the GPUs effectively means that a greater level of technical detail is expected.

The code is non-parallelised and as such requires the use of only 1 cpu. We intend to do somewhere in the region of 10 runs over the complete duration of the project.

- **Workplan** - Applicants are required to provide a short workplan and utilisation profile. This will assist us in determining the likely demand over time and tune our scheduling policies to optimise usage of our resources. Applicants must also specify the number and type of staff who will be undertaking the research described in the proposal (PhD students, post-docs, PI in person). Failure to provide either will result in the application being held back until such information has been provided.

Short workplan and utilisation profile

Short workplan Volcanic risk assessment

20 year volcanic risk assessment: Long term volcanic risk assessment simulations (20 year runs) will be performed based on ECMWF reanalysis data. Domain data for years 1989-2009 will be used and a risk assessment based on this climatology and probability of eruption of Icelandic volcanos, and continuous eruption scenarios, will be performed. Analysis of ash cloud mass density threshold exceedences will be conducted as a function of different VAAC air space (e.g. London VAAC and Toulouse VAAC). Aircraft downtime will be statistically quantified based on the dispersion frequency of the above-threshold ash cloud (i.e. 2 mg m^{-3}).

Utilisation profile

There will be a number of people undertaking this research including 2 post doctoral worker and a number of PhD students.

List of Relevant Publications

Langmann B., Numerical modelling of regional scale transport and photochemistry directly together with meteorological processes. Atmos. Environ., 34, 3585–3598, 2000.

Marriner E. and B. Langmann. Aerosol modelling over Europe Part I: Inter-annual variability of aerosol distribution. *J. Geophys. Res.*, 112, D23S15, doi:10.1029/2006JD008113, 2007.

Langmann B., A model study of the smoke-haze influence on clouds and warm precipitation formation in Indonesia 1997/1998, *Atmos. Environ.*, 41, 6838–6852, doi:10.1016/j.atmosenv.2007.04.050, 2007.

Roeckner E., K. Arpe, L. Bengtsson, M. Christoph, M. Claussen, L. Dümenil, M. Esch, M. Giorgetta, U. Schlese and U. Schulzweida. The atmospheric general circulation model

ECHAM-4: Model description and simulation of present-day climate, MPI-Report No. 218, Max Planck Institute for Meteorology, Hamburg, Germany, 1996.

Smolarkiewicz P. K., A simple positive definite advection scheme with small implicit diffusion, *Mon. Weather Rev.*, 111, 479–486, 1983.

Tiedtke M., A comprehensive mass flux scheme for cumulus parameterisation in large-scale models. *Mon. Weather Rev.*, 117, 1778–1800, 1989.