PhD proposal: Analysis of Avalanche Dynamics Field Data using Advanced Data Processing Techniques

The department of Civil and Structural Engineering , University of Sheffield, U.K. in collaboration with IRSTEA (formerly CEMAGREF), Torrent Erosion Snow and Avalanche Research Unit, Grenoble, France.

http://www.sheffield.ac.uk/civil

http://www-php.cemagref.fr/en/research/research-units/etgr

The Nature of the Research

Snow avalanches are an important class of natural hazard that have a significant impact on the livelihoods and economies of alpine communities. Understanding the physics of these flows and the extent to which ideas from granular flow mechanics underpin the relevant dynamics is currently an important research area.

The aim of this project is to obtain new data and to process existing datasets on the dynamics of flowing snow/avalanches in order to obtain a greater insight into the relevant physics. The primary data source will be the experiments on flowing snow from the Col du Lac Blanc test chute (Fig. 1) at Alpe d'Huez and administered by IRSTEA. These data permit velocity profiles to be derived under controlled conditions, which may in turn be studied to infer rheological parameters. In addition, although depending on release conditions, data from the radar at the full-scale Vallée de la Sionne avalanche test site in Switzerland may be available (Fig. 2). This radar was developed by a U.K. team (Cambridge, Sheffield, UCL) and gives high resolution velocity data on avalanches released in the path.

Fig. 1. The Col du Lac Blanc chute.Fig. 2. The protective bunker

The range of methods we will apply to these data (beyond basic filtering and processing) reflect the expertise of the supervisory team. These include Hierarchical Bayesian model calibration and time series techniques (including wavelet analysis), and the comparison of real data to synthetic datasets that provide suitable null models, enabling hypotheses concerning the nonlinear nature of the real data to be evaluated.

in the Vallée de la Sionne test path. Our radar receivers are the white rectangles in the windows

Through the application of such techniques to the data, we aim to extract much greater detail than

previous studies have managed, which will provide new insights into rheology and fluid mechanics, for instance mean velocity profiles and fluctuations as functions of environmental covariates (slope, temperature, grain size, etc.). Thus, within the scope of this project there is the potential for the student to both develop signal processing techniques and to elucidate new physics.

Practical organisation of the PhD

The student will be mainly based in Sheffield, but several extended working periods in France will be organised during the PhD. The length of these stays will be flexible, depending on the student's requirements (e.g. family constraints) and on the work timetable.

As well as a general introduction to avalanche dynamics provided by the supervisors, the applicant will complete the University of Sheffield doctoral development programme, which will provide them with the opportunity to take relevant courses in computer programing, fluid mechanics, signal processing and statistical analysis. The student will also be integrated into the Sheffield Fluid Mechanics Group (http://www.sheffieldfluidmechanics.co.uk), which brings together colleagues working in fluid mechanics from Civil, Control and Mechanical Engineering with their compatriots in Mathematics. While working in France, the student will be a full member of the ETNA team, which includes access to team seminars and facilities (desk, computer, etc.) during their times in France. The work will be carried out in the framework of the European interreg MAP3 project, which will involve discussion and collaboration with Italian partners.

The applicant

You should be a citizen of the U.K., France or another EU nation. You should have a very good Batchelors degree in a relevant quantitative discipline (Mathematics, Statistics, Physics, Geophysics, Engineering) and a higher degree would be advantageous. You need to be able to work independently and engage both with an understanding of the flow physics and the relevant analysis techniques. You should have previous experience in statistical modelling and/or data analysis (e.g. as part of an undergraduate or Masters' level thesis). You should have a previous familiarity with computer programming or be willing to develop such skills. Your proficiency in English must meet the requirements of the University of Sheffield (IELTS score of 7.0 or higher). Competence at speaking and reading in French would be an advantage.

Supervisors:

Dr Chris Keylock, Sheffield and Dr Nicolas Eckert, Grenoble

Chris Keylock's work on avalanches started with his M.Sc. research on avalanche risk in Iceland. More recently he has developed wavelet-based surrogate data analysis methods, methods for analysing turbulence datasets and has worked on the development of a radar instrument for the high resolution imaging of snow avalanches. Nicolas Eckert has pioneered the use of Bayesian statistical techniques in avalanche risk analysis. His work includes both statistical analysis of existing

datasets but also combining Bayesian methods with models for avalanche dynamics to derive optimal model parameterisations. The two supervisors have previously collaborated on assessing non-stationarities in snow avalanche risk. More generally, collaboration between Keylock and IRSTEA/CEMAGREF extends back over 15 years and includes two successful European research projects. Find out more at http://www.chriskeylock.net and http://www.irstea.fr/eckert or e-mail us at c.keylock@sheffield.ac.uk or nicolas.eckert@irstea.fr

Salary conditions and financial support:

The successful applicant will receive a PhD stipend in line with that awarded by UK research councils, which currently amounts to £13 590 per annum. In addition, financial support will be provided to fund the Sheffield-Grenoble travels as well as the stay in France and/or Sheffield .

How to apply:

Please e-mail us to discuss the project before applying. The on-line application procedure is explained at: http://www.sheffield.ac.uk/postgraduate/research/apply

Relevant references:

Ash, M., Chetty, K., Brennan, P., McElwaine, J., Keylock, C. 2010. FMCW radar imaging of avalanche-like snow movements, *IEEE Radar Conference 2010*, p.102-107, doi: 10.1109/RADAR.2010.5494643

Eckert, N., Naaim, M., Parent, E. (2010). Long-term avalanche hazard assessment with a Bayesian depth-averaged propagation model. Journal of Glaciology. Vol. 56, N° 198. pp 563-586.

Keylock, C.J. 2010. Characterizing the structure of nonlinear systems using gradual wavelet reconstruction, *Nonlinear Processes in Geophysics* 17, 615-632.

Rognon, P., Chevoir, F., Bellot, H., Ousset, F., Naaim, M., Coussot, P. (2008). Rheology of dense snow flows: Inferences from steady state chute-flow experiments. Journal of Rheology. Vol. 52, Issue 3. pp. 729-748.

Rougier, J.C. and M. Kern (2010), Predicting Snow Velocity in Large Chute Flows Under Different Environmental Conditions. *Applied Statistics*, 59(5), 737-760.