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Features

Career interview: Avalanche researcher

by Danielle Stretch

Plus caught up with jet−lagged avalanche researcher, Jim McElwaine, who had just flown back from Japan to begin a new job in Cambridge. Jim completed a mathematics degree at Cambridge University and then went on to do research for a PhD in quantum mechanics. (Quantum mechanics involves the study of matter and radiation at an atomic level.) It was not until the end of his PhD that he made the decision to change direction and go into avalanche research.

"I've been climbing since I was a boy and when I went to University I did a lot of alpine climbing and skiing. On one climbing trip to the Himalayas I was actually buried in an avalanche. I was up to my neck in snow and it felt completely solid... as if someone had poured a wall of concrete around me and I was unable to move. Fortunately, there was someone around to dig me out..."

"I have always been interested in mathematics and physics and wanted to do research. I chose my PhD area partly because I wanted to research some of the most basic and difficult parts of physics. My PhD work was not directly relevant to working on avalanche research but it did show me how to carry out mathematical research and computer simulations."

Jim's decision to go into avalanche research was triggered by watching a television programme on the subject. "I was watching a Channel 4 series called Equinox on avalanche research with some friends. One of them said that I should be doing that and I just told them not to be so stupid. Afterwards I realised that it was a fantastic opportunity to combine the two things that I love most − mathematics and mountaineering."

Jim's work has taken him to Hokkaido University in Japan followed by a two−year stint at the University of Grenoble in the French Alps before returning for further work in Japan. His activities outside work include mountain skiing (six hours to go up Mt. Fuji and half an hour to come down) and river climbing. "River climbing is just as dangerous as it sounds. Most of us ended up in hospital after our first attempt in 1998." Jim

was also part of a team that carried out an expedition to attempt to climb Manda III in the Himalayas in 1992.

The field work that Jim carries out often requires both mathematical and mountaineering skills. In 1999, he was one of a team that was sent out to investigate the avalanche which killed 12 people near Chamonix in the Swiss alps.

"Being able to travel safely through the mountains in Winter is essential and this requires Winter mountaineering and ski mountaineering experience. I teach the other members of the investigation team simple rope work and I also instruct on avalanche safety courses."

Avalanche

Jim went on to explain the type of conditions in snow that can trigger avalanches.

"Avalanches occur when the weight of the snow exceeds the strength of a layer in the snow or the strength of the bonding to the ground. Certain factors which increase the load, such as a skier going down the mountain or falling ice, can also help to trigger an avalanche."

Avalanches are categorised as either loose snow or slab avalanches and within these categories they are also subdivided into wet or dry.

Dry loose snow avalanches often occur during storms or within 48 hours of a storm when lots of snow has fallen. If the weight increases faster than the snow is consolidating and strengthening it fails and an avalanche occurs. The angle is usually between 30 and 50 degrees. Not much snow will stick on steeper slopes.

Wet loose snow avalanches occur in spring or when rain falls. If there is enough water in the snow and it reaches the ground it can form a lubricating layer and a full−depth (all the snow right down to the ground) avalanche occurs. The slope need only be 15 degrees steep. These are particularly frequent at high latitudes when they can have a very high water content and become slush flows.

Slab avalanches occur when there is a weak layer in the snowpack. The most frequent cause in the European alps is caused by the wind transporting snow and redepositing as stiff slabs. Often a skier moves into the middle of a slab and then it fractures so that the entire slope starts to move simultaneously.

Snow metamorphism caused by temperature gradients can also lead to weak layers which can survive for weeks in the snow until an avalanche occurs. They need only be 1mm thick and can be very difficult to spot.

There are various methods of simulating avalanches in experimental conditions.

"In winter we use real snow and drop it down chutes and in summer we use ping−pong balls. Other people do small scale experiments in the laboratory in water tanks with suspensions of fine grains, or in experiments on slopes with sand or ice particles."

Jim was recently involved in an avalanche simulation experiment where up to 550,000 ping pong balls (more than 1 ton in weight) were released at the top of the Miyanomori ski jump in Japan and their subsequent motion was analysed using video cameras. The flows caused by such simulations are much simpler than real avalanches but they do have similarities and any model that cannot explain these flows will almost certainly fail on real avalanches.

We asked Jim how mathematics is used to forecast avalanches.

Avalanche forecasting involves synthesising models over many scales. The primary input is the current weather and the weather history obtained from a large−scale meteorological model. This is fed into a local meteorological model that can calculate wind speed, precipitation and temperature on a local level of about 1km. If topographic effects are important a much finer model must be used that can provide data down to 1m or so. The meteorological data provides the input for a snowpack models that simulates the evolution of the individual snow crystals. The output of this is then examined by an expert system that decides whether or not the snowpack is stable and what the avalanche hazard is. Experts with local knowledge are still very important and complete forecasting systems are only in their infancy.

There are three possible routes to becoming an avalanche researcher. One is to work as an academic in a university department. This is not particularly well paid but you have a lot of freedom to pursue your own interests. Another possibility is to work in an avalanche research laboratory. This is better paid but more like consulting engineering with less choice about what one does. Norway, France and Switzerland all have research laboratories of this type. The third route is to work directly with avalanches on a day−to−day basis either in a ski resort or in a region where daily forecasts are necessary to protect transport links or habitation.

Finally, we asked Jim how he proposed to continue with his research in Cambridge which is an area where mountains, or even hills, are somewhat hard to find and must surely be one of the least avalanche−prone regions of Europe.

Dr. Jim McElwaine

" There are plenty of researchers in the UK studying glaciers and volcanoes even though there haven't been any glaciers since the last ice age and volcanoes are none too common either. For practical applications of my research and field data I'll continue to work closely with colleagues around the world. But one of the beauties of mathematical research is that it can often be applied in different fields. Snow avalanches can be regarded as a special case of a granular flow and the research can be applied to anything from pouring salt out of a salt cellar to undersea landslides and industrial processes."

About the author

Danielle Stretch has spent the past eight years working for the Department of Applied Mathematics and Theoretical Physics at Cambridge University. Prior to that, she worked in various administrative positions for visual artists, politicians, writers and engineers. She says that working for a mathematics department has changed the way that she thinks about the subject. "Before working here I did not have any conception of how mathematical research operated or how, in a different way, it is every bit as creative and exciting as working in the arts and with its own sort of beauty".

Plus is part of the family of activities in the Millennium Mathematics Project, which also includes the NRICH and MOTIVATE sites.

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