
mathsinside
www.mathspromotion.org.uk

velocity radar

Doppler effect wavelength

frequency pitch Doppler shift

ON THE SLIDE

Modelling avalanches with mathematics

Bunker at the Vallée de la Sionne avalanche test site courtesy of SLF, Switzerland.

Snow and mountains can be a great, fun combination. But they can also be a deadly one. Avalanches happen when large amounts of snow succumb to gravity and run down a mountain slope, flattening things in its path.

To help guard against avalanches, scientists are trying to get a better understanding of how avalanches flow. Avalanche risk in a particular location can then be analysed and engineers can either decide not to build in an area too susceptible to sliding snow, or help design protection for alpine villages that could be affected.

The *velocity* of the avalanche is a key part of the puzzle. To investigate this, scientists use a test site near Sion in Switzerland. In winter, avalanches are released down a 2.5 kilometre slope with a bunker at the bottom. The bunker contains a *radar* transmitter and eight radar receivers. Radar signals are transmitted towards the falling avalanche and the signals are then reflected back towards the receivers.

Scientists then make use of the *Doppler effect*. As an avalanche heads towards the receivers it encounters the radar waves, squashing them together. This decreases the apparent *wavelength* of the reflected radar – the distance over which the wave repeats itself. A shorter wavelength means the signal has a higher *frequency*. This is similar to the perceived drop in *pitch* in an ambulance siren as the ambulance approaches and passes you. When the ambulance is approaching, the sound is at a higher frequency because the speed of the ambulance is added to that of the sound of the siren. You hear a drop in pitch when the ambulance passes because of the longer wavelength. This is because the ambulance speed is now subtracted from the siren's sound wave speed.

Mathematics allows researchers to quantify this *Doppler shift* – the more the signal's frequency is shifted, the faster the avalanche is moving.

$$F_R = F_T \frac{(1+\frac{v}{c})}{(1-\frac{v}{c})}$$

In this equation F_R is the frequency received back at the bunker. Similarly, F_T is the frequency originally transmitted from the bunker. v is the speed of the avalanche and c is the speed of the radar waves.

The eight receivers mean that the reflected signal is received at slightly different times by each antenna. Consequently we can say something about the direction the avalanche is travelling in, rather than just the distance from the sensor. This all helps to more accurately model avalanches in an attempt to help to protect those who could find themselves in their destructive path.

LONDON MATHEMATICAL SOCIETY

Institute of mathematics & its applications

selected The Royal Society summer science exhibition 2012

mathsinside www.mathspromotion.org.uk

UCL

The University Of Sheffield.

UNIVERSITY OF CAMBRIDGE

NATURAL ENVIRONMENT RESEARCH COUNCIL

SLF

Design: www.blitzbranding.co.uk