Development of Snow avalanche forecasting system in Japan -present and future-

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http://env.sc.niigata-u.ac.jp/˜knishi/index_e.html

To reduce the number of avalanche-related accidents, the Japanese Meteorological Agency issues an avalanche warning during winters. However, their method depends only on the air temperature and the estimated storm snow depth. Moreover, the warning covers an area as large as a prefecture. Local communities as well as ski area managers strongly desire a more precise avalanche danger prediction system. In this presentation, we describe the development of an avalanche warning system. Nishimura et al.(2006) set the study area in southern part of Niigata prefecture, where we had huge amount of snow in winter 2005-2006 and the snow depth exceeded 4m in February.

They used the snow cover model SNOWPACK, which was developed at the Swiss Federal Institute for Snow and Avalanche Research. It is a one-dimensional model of the snow cover and has been used in the Swiss Alps to predict snowpack settlement, layering, surface energy exchange, and mass balance. The model has been improved and is now useful for the conditions in Japan.

The meteorological data and a snow profile output with SNOWPACK at a single position give little information on the avalanche probability on slopes and even less for a region. Precise, fine-scale meteorological conditions over the whole study area are required. Wind speed variations over complicated terrain, and in particular, the subsequent erosion of snow from a ridge and deposition in a valley are key factors for determining the avalanche danger in a given area.

Following four steps were applied to estimate the snowdrift over complex terrain: 1) snowfall input is assumed to be uniform over the entire study area, 2) calculation of the wind field, 3) calculation of snow transport by saltation and suspension, and 4) calculation of the accumulation and erosion of snow on the surface. The wind speed field was obtained using a digital elevation map with a grid size of 10 m. Variations of wind speed depended on terrain inclination and curvature. Once the wind speed was obtained, we determined the friction velocity u_*at each position and estimated the snow transport by saltation and suspension.

In addition to the wind speed, we calculated the distributions of other meteorological variables including air temperature and incoming shortwave radiation (solar radiation). The temperatures were obtained assuming a temperature lapse rate of 0.6 deg/100 m and the local shortwave radiation was calculated using a digital elevation map of the area.

By substituting the derived distributions of meteorological data into the SNOWPACK model, the stability index SI was calculated. This index is defined as the ratio of snow shear strength to the shear stress exerted by the snow load. Thus, a low index indicates low stability and vice versa. Calculated snow depth and the stability index distributions were compared with the direct measurements provided by the aircraft-borne laser profilers and with the avalanche release map obtained by the aerial photograph.

The stability predictions agreed reasonably well with the field observations and the avalanche release map obtained by the aerial photograph.

However, a number of improvements are still necessary in each of the processes. In particular we need to develop a method that can estimate the snow depth distribution precisely. Measurements with the aircraft-borne laser profiler cost extremely high and are not suitable for the practical implementation in general. The goal is to increase the accuracy so that the model can become part of the avalanche danger forecasting operations.