Influence of snow cover properties on avalanche dynamics

Walter Steinkogler1,2, Betty Sovilla1, Michael Lehning1,2
1 WSL Institute for Snow and Avalanche Research SLF, Davos, Switzerland
2 École Polytechnique Fédérale de Lausanne (EPFL), Switzerland

Introduction

Snow avalanches with the potential of reaching traffic routes and settlements are a permanent winter threat for many mountain communities. Snow safety officers have to take the decision whether to close a road, a railway line or a ski slope. Those decisions are often very difficult and demand the ability to interpret weather forecasts, stability and structure of the snow cover and to evaluate the influence of the snow cover on avalanche run-out distances.

Discussion

- Very different dynamics can be observed for similar initial conditions and topography
- Similar flow regimes can develop for short vertical distances
- Avalanches with small initial mass can develop distinct flow dynamics (e.g. large impact pressures) if sufficient snow is entrained
- Snow density defines released and entrained mass but doesn’t seem to have a direct influence on flow dynamics
- Temperature effects seem to play an important role

- OUTLOOK: More detailed investigations on spatial and vertical temperature distributions (SNOWPACK and ALPINE3D)
- OUTLOOK: Influence of temperature on granular formulation

Results

In a first step all avalanches are investigated for the amount of snow they entrained along the track and their flow dynamical characteristics. Then the prevailing snow cover conditions are reconstructed by using data from local snow pits or modelled stratigraphy from SNOWPACK.

- Separation of avalanches in release, erosion and run-out zones
- All avalanches significantly increase their mass (see Table 1) along the path due to entrainment
- Entrained mass along the track was calculated by taking erosion depth from FMCW radar into account
- Run-out is limited by counterslope

- Erosion depths were identified for all avalanches (see Table 1)
- Different flow regimes can be identified: Highly turbulent flow in front of avalanche followed by more distinct flow regime, associated with the dense flow part
- Powder cloud is not seen in images

- Significant differences in intensity and peak values
- Flow regimes can be identified (compare to FMCW radar pictures in Fig. 11-14)

E.g. avalanche #816:
- Highly turbulent part from 0-20 s with values jumping from 0-1000 kPa
- Followed by more continuous flow (20-30 s) with max. values of 400 kPa

- Snow cover properties (e.g. density, temperature) of release and entrained snow identified by taking erosion depth from FMCW radar into account
- Average values are calculated (see Fig. 21 and Table 1)

Table 1: Summary of investigated avalanches.

<table>
<thead>
<tr>
<th>Nr.</th>
<th>#816</th>
<th>#5274</th>
<th>#628</th>
<th>#509</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data</td>
<td>Release mass (t)</td>
<td>7856</td>
<td>5635</td>
<td>4118</td>
</tr>
<tr>
<td></td>
<td>Entrained mass (t)</td>
<td>7942</td>
<td>9077</td>
<td>19428</td>
</tr>
<tr>
<td></td>
<td>Deposition Mass (t)</td>
<td>87848</td>
<td>64712</td>
<td>23546</td>
</tr>
<tr>
<td></td>
<td>Dep. Mass / Rel. Mass ($)</td>
<td>11.1</td>
<td>11.5</td>
<td>5.7</td>
</tr>
<tr>
<td></td>
<td>Snow density (kg m$^{-3}$)</td>
<td>216</td>
<td>151</td>
<td>191</td>
</tr>
<tr>
<td></td>
<td>Erosion depth (m) @ FMCW B</td>
<td>1</td>
<td>1.3</td>
<td>0.8</td>
</tr>
</tbody>
</table>

References