Plate 3.2 Snow – Extreme Events

Introduction

Map 3.2 consists of three individual parts on the subject of snow. Their point in common is the depiction of extreme conditions: depths of snow with a 100-year return period, maximum observed water equivalents, as well as depths of snowfall resulting from extreme events. It is these extreme events that influence and shape life in the alpine regions.

Depths of snow at a 100-year return period

The map of the 100-year depths of snow was made on the basis of point measurement from 125 stations, compiled in the table according to their altitude above sea level. For each station, the following two variables were ascertained: the highest winter peak of the total depth of snow (HS_{max}) measured until 1982, and the depth of snow extrapolated according to the Fisher-Tippett or the Gumbel distribution at an average return period of 100 years (HS_{100}). It should be noticed that for some stations the number of measurement years considered (n) does not correspond to the length of the measurement period, due to intermissions in the measurement records.

The 100-year depths of snow are – regionally differentiated – dependent on the altitude above sea level. The zoning into the four areas depicted on the map can easily be discerned. A regression line was calculated for each zone based on the stations available for purposes of analysis. Above an altitude of 2600 m a.s.l. these lines are no longer supported by measurements.

The first step to estimate the 100-year depths of snow is the determination of the zone the location in question is assigned to. By means of the diagram or the appropriate equation of the regression line, an estimate of the depth of snow is obtained as a function of altitude above sea level. The depth of snow at a return period of 50 years equals about 90 % of the 100-year value.

Maximum water equivalents observed

The map on the water equivalents of the snow cover is based on point measurements taken at approximately eighty stations. For about thirty stations, the water equivalent had to be determined indirectly from the depth of snow. The measurement series available are inadequate for both frequency analyses and extrapolations for a standard return period. This map therefore focuses on the maximum values observed. Originally, these evaluations were carried out in view of a map on the effective snow loads [3].

Equal to the 100-year depths of snow, the maximum water equivalent observed depends on the altitude. Five zones can be distinguished. For each zone a so-called enveloping curve was determined, covering the maximum values observed in measurement series of varying length until 1989. By means of the graphs or the formulas it can be concluded, for example, that in zone 2 a snow-water equivalent of 500 mm is very rarely exceeded at a location of 1200 m a.s.l.

Depths of snowfall of extreme events

The snow cover build-up can be considered as the sum of individual snowfall events. Depending on the predominant weather conditions, wide variations in the development of the snow cover can be observed from one winter to another.

To allow statements on the spatial distribution of the snow, this depiction relates snowfalls to particular synoptic weather situations. These distribution patterns are useful, for example, for the spatial interpolation of snowfall depths. Because the build-up of the winter snow cover is frequently determined by single significant snowfall events and, in addition, the spatial distribution is more easily determined for such events, the extreme depths of snowfall are focused on in particular. For a comprehensive description the reader is referred to [2].

The depths of snowfall of approximately 300 stations were used for the investigation [1,4]. A total of fifty extreme snowfall events were analysed and related to the corresponding air flow and moisture conditions in the atmosphere.

For seven typical synoptic situations, the maps show the distribution pattern of the 24-hourly depths of snowfall. Arrows are used to describe the flow and moisture conditions in the atmosphere at altitudes of approximately 1500 m (850 hPa) and 3000 m (700 hPa). The orientation of the arrow indicates the direction of air flow, the length the flow velocity, and the width the moisture in the flowing air.

The first four maps show synoptic situations which led to large depths of snowfall in the south of the alpine ridge. In all four situations, moist air streamed towards the alpine crest from a southern or south-eastern direction. On 24th April 1976, the conditions are most interesting: on the southern side of the Alps, moist air streams from a ESE to SE direction. A counter-stream forms in the midland region: in the bottom layers of air a flowing from NE, and above them from WSW. Consequently, extreme depths of snowfall south of the alpine ridge, and the zone of maximum snowfall spreads to the northern side of the Alps.

Three further maps depict synoptic situations with maximum snowfall depths in the north of the alpine crest. On 31st January 1978 and on 3rd February 1978, moist air flows from W/NW. Unlike the January situation, the heavy snowfalls on 3rd February spread over the alpine ridge, because a zone of strong winds formed in the free atmosphere on the western side of the Alps.

On 18th January 1974, large amounts of snow fall in the central Grisons. From a NW to NNW direction, moist air streams against the alpine ridge.

References

[1] **Eidg. Institut für Schnee- und Lawinenforschung (1936/37–1987/88):** Winterberichte. Davos.

[2] **Lang, H., Rohrer, M. (1987):** Temporal and spatial variations of the snowcover in the Swiss Alps. In: IAHS Publication, No. 166:79–92, Wallingford.

[3] **SIA (1989):** SIA Norm 160 – Einwirkungen auf Tragwerke. Zürich.

[4] **Witmer, U. (1986):** Erfassung, Bearbeitung und Kartierung von Schneedaten in der Schweiz. Geographica Bernensia, G25, Bern.