Early Warnings for extreme snowfall in the Swiss Alps

Patrick Hächler and Daniel Gerstgrasser
MeteoSwiss, Zurich, Switzerland

ABSTRACT: For more than 10 years MeteoSwiss provides warnings in case of heavy snowfall in the Alps. It helps the Swiss Institute for snow and avalanche research and the responsible people for road and railway circulation to assess the risk of big avalanches and to make their decisions. But a forecast of any extreme event is very difficult. This poster shows how forecasters of MeteoSwiss manage this problem, from climatological aspects to typical weather situations and model results. It will also be shown how quality varies in different parts of the country as well as quality has developed in the last 10 years.

KEYWORDS: weather forecast, extreme snowfall, avalanche forecast, safety

1 WARNINGS IN SWITZERLAND

For more than 70 years MeteoSwiss, the National Weather Service in Switzerland, is active in warning authorities and population in case of dangerous weather. In the 1930ies it warned only in case of wind gusts of more than 25 knots at the lakes. Later, warnings in case of frost in spring for the agriculture were added. In the eighties of the last century in the southern parts of Switzerland, warnings in case of strong rainfall were started.
In 1998, in cooperation with the SLF, special warnings for 1 m new snow within 3 days were developed. These are not warnings for tourists, but for situations when also main roads or populated areas can be touched by avalanches. This type of warnings is given in form of probabilities in four steps: 0 to 10%, 10 to 40%, 40 to 70% and more than 70%.
Since 2001 a severe weather warning system for the whole country is active. The weather phenomena concerned are storm (>90km/h), rain (>50mm/day) and snow (>50cm/day). Smaller risks like wind gusts at the lakes or frost in spring or icy roads in winter are still warned.

2 FORMER STUDIES: THE VERY DANGEROUS CONSTELLATIONS!

Situations with very high avalanche impact were analysed in former times (e.g. Hächler, 1989). It was shown that for the northern Alps strong airstreams from west to northwest as well in low as in high altitudes are the most dangerous. Basing on the surface weather charts the mean of the wind direction seems to be about 305 degrees, the mean velocity being 31 knots. In such cases frontal and orographic uplift are combined and produce 20-50 mm of

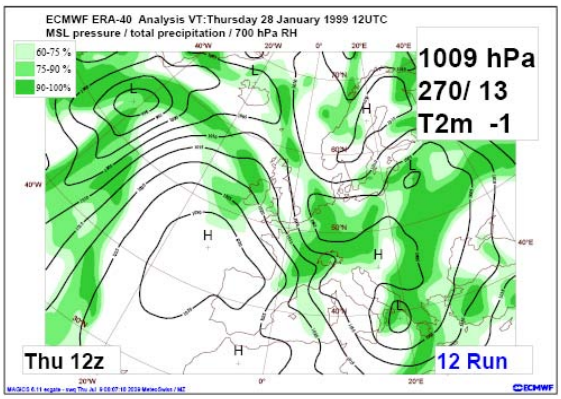

Figure 1: Mean sea level pressure field and humidity at 3000 m (source: ECMWF ERA-40 reanalysis).

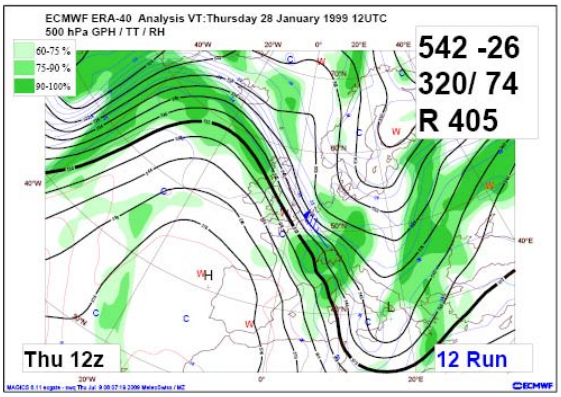

Figure 2: Geopotential hight and humidity at 500 hPa (5400 m), on 28 Jan 1999. Strong NW advection against the Alps (source: ECMWF ERA-40 reanalysis).

precipitation per day at the northern slope of the Alps. Thus in three days more than 1 m of new snow is possible.
In 1999 such situations occurred several times in the Swiss Alps and caused the worst problems since 1951 (e.g. Eidg. Institut für Schnee- und Lawinenforschung, 2000). This constellation gave a good opportunity to test the newly defined 1 m warning procedure.

3 CLIMATOLOGICAL ASPECTS

How often situations with 1 m of new snow in 3 days do occur?

This is a relatively rare event, which is therefore quite difficult to predict. Table 1 shows an analysis for the two stations Davos (1590 m, eastern Alps, 72 years of observation) and Grimsel Hospiz (1950 m, central Alps, 39 years of observation). At Davos a 3-day new snow accumulation of 1 m is expected every 3 to 5 years, at Grimsel Hospiz approximately every 1-2 years. This sample is quite representative for the northern slope of the Swiss Alps.

	1m / 3d every…	Max. acc.	Date
Davos, 1590 m	3-5 yrs	190 cm	18th Jan. 1951
Grimsel Hospiz, 1950 m	1-2 yrs	207 cm	23th Dec. 1968

Table 1: New snow climatology for the Stations Davos (1931-2004) and Grimsel Hospiz (1964-2004), source: EVA/Meteorisk

4 WARNINGS BY METEOSWISS

As above mentioned MeteoSwiss makes warnings if the probability for 1 m new snow in one ore more oft the 6 regions reaches at least 40%. Decision time is before noon, updates follow daily. The first warning starts if possible 1 day before it starts snowing. In case of a relevant risk of a dangerous avalanche situation, the SLF makes itself a corresponding avalanche warning.

In order to assess the precipitation quantities the forecasters of MeteoSwiss use model results, MOS (model output statistics) and EPS products (ensemble prediction system). But also the experience of the forecasters is important. Warnings of this type are very difficult by two reasons: such situations happen seldom and the forecasts of strong precipitation are not at all perfect. Precipitation forecasts often have errors in the order of a factor 2. On the other hand the risk is growing slowly during many hours, which enables usually enough time to take measures.

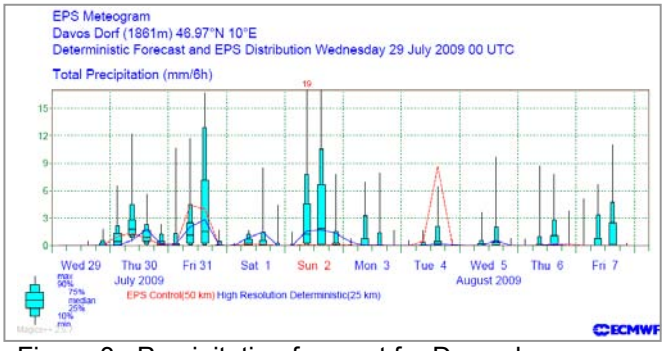

Figure 3: Precipitation forecast for Davos by the ECMWF Ensemble Prediction System (EPS). With the help of such diagrams, the reliability of the forecast can be estimated.

5 QUALITY OF THE SNOW WARNINGS

In the last 11 winters, 161 warnings were produced. The main statistical parameters show the following quality for all Swiss Regions and for those two areas with the highest climatic difference:

	CH	S	E
Probability of detection POD	68%	75%	55%
False alarm ratio FAR	45%	30%	33%

Table 2: Quality of warnings

The warnings in the region S (south) are clearly better than the national average (CH), E (east) is worse than S.
The POD for all regions shows increasing trend in the last years, but also the FAR is slightly increasing. The strategy of issuing

warnings seems to change in time, but also quality is slowly rising due to better computer models and human experience.

6 FURTHER DEVELOPMENTS

The weather forecasts now have achieved a fairly high standard. But: the most difficult forecast-parameter is the amount of precipitation (rain and snow), mainly because of the complex orographic situation in the alpine regions. In the field of numeric simulation, great efforts are taken in order to refine the horizontal and vertical model resolution. Thus, MeteoSwiss since February 2008 works with the COSMO2 model with a horizontal resolution of 2.2 km. But also the COSMO7 model with a horizontal resolution of 6.6 km and several other models are used by the forecasters. The reason is that an improvement in model resolution by a factor of 3 doesn't automatically cause a three times more accurate precipitation forecast (see Figure 4 and 5). Which forecast is more accurate? The meteorologist has to answer this question.

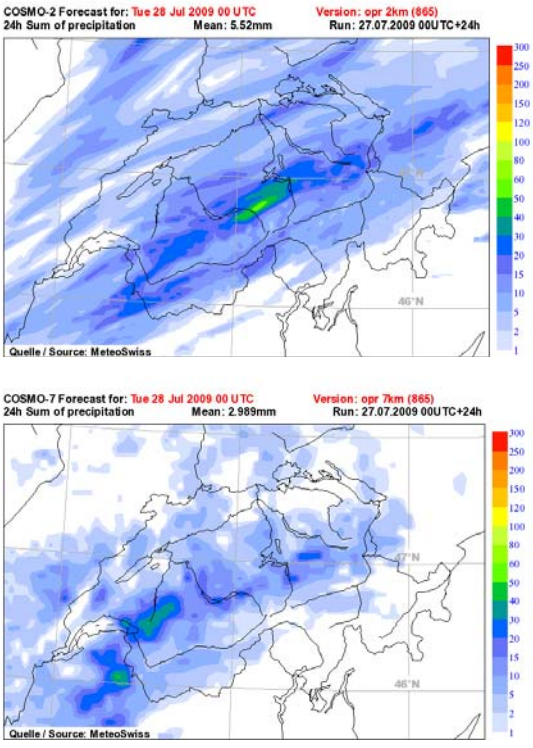

Figure 4 and 5: Example of a precipitation forecast (24h accumulation) of two different models (top: COSMO2, bottom: COSMO7) for the same time step and the same region.

One of the main points while preparing a high quality snow forecast (or snow warning) is the experience of the meteorologist ("human factor"). Only he can correctly interpret the myriad of model data together with his synoptic experience and his knowledge of the different alpine regions.

7 CONCLUSIONS

Warnings in case of heavy snowfall are very important. In Switzerland they help to avoid human tragedies and (partially) damages. The warning procedure defined by MeteoSwiss and the SLF is well established and gives useful informations mainly to the responsible authorities. The quality of these warnings shows an increasing trend. Better computer forecasts will help to improve the warnings in the future.

8 REFERENCES

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