

Site – specific avalanche warning, Definitions and Recommendations

0 Introduction

Avalanche hazards can be addressed at different scales from large regions down to the layering of the snowpack. All these scales serve different purposes and user groups. While regional avalanche warning gives a general overview over a large area with different elevation bands, aspects and weather conditions, many applications ask for a more specific assessment for well-defined avalanche paths. These local assessments are required as a decisive input to avalanche risk management for settlements, roads and railroads, other infrastructure alongside activities (professional and recreational) in avalanche prone terrain.

The European Avalanche Warning Services (EAWS) traditionally coordinates the regional avalanche warning services in Europe. However, some of the members also supply more detailed avalanche assessments and warning. Many more of such services are currently not organised through any common group. Therefore, the EAWS general assembly decided in 2017 to establish a working group on local avalanche warning. The objectives of the group were to establish an overview over the current methods and routines used in the local avalanche services in Europe, study if and how the EAWS standards are applied in local avalanche warning, find a conclusive definition of regional versus local avalanche warning and suggest common standards for such services. After two years, the mandate of the working group was extended to another period with a higher focus on definitions and recommendations. This document presents the conclusions of the working group as to be approved by the general assembly in 2022.

This document is divided into two sections. In section 1, we give a basic definition of site-specific avalanche warning followed by a list of definitions for all terms and processes commonly used in both site-specific and regional avalanche warning. In section 2, we give recommendations on how to organize and provide site-specific avalanche warning services.

1 Definitions

The working group has used substantial time to discuss and evaluate a clear definition of local avalanche warning. These discussions alongside results from the 2018 survey (Jaedicke et al., 2018) and the experience from the working group and other EAWS members, formed the background for the following definitions. Both regional and local avalanche warnings use many of the same methods and procedures, but often in a slightly different way. Therefore, we suggest a process-based definition rather than a spatial definition (as used earlier). In the EAWS discussions many languages and linguistic nuances need to be taken care of. The term "local" did not match the purpose of our work and the working group therefore suggests the alternative term "site-specific".

Site-specific avalanche warning assesses the probability of an avalanche to release in one or several specific avalanche paths and whether its runout might endanger people or infrastructure (modified after Stoffel, Schweizer, 2008). Estimates about the release probability and avalanche runout probability for an individual path generally have a high uncertainty. This uncertainty needs to be considered when decisions on temporary measures are taken.

This definition alone does not provide indications on how site-specific avalanche warning relates to regional avalanche warning and the common methods and standards used by the EAWS members. The working group therefore supplies a list of relations and definitions to clearly define the difference in these to two scales of avalanche warning.

The general definition of avalanche danger applies for both site-specific and regional avalanche warning: Avalanche danger depends on snowpack stability, the frequency distribution of snowpack stability and avalanche size for a given area and time period.

Site-specific avalanche warning	Regional avalanche warning
Spatial extent	
Site-specific avalanche warning assesses the avalanche danger in selected and predefined avalanche paths.	The regional avalanche warning covers an area large enough to encompass a variety of terrain, elevations, snow and weather conditions.
Temporal extent	
Duration and regularity of the service depends on the objectives of the site-specific warning. However, the development of the snow and weather conditions should be monitored since the beginning of the winter season.	The regional bulletin is distributed regularly through the winter season.
Validity of avalanche warning	
Site-specific avalanche warning is based on an assessment of the current situation (nowcasting) and, for most of the applications, includes a forecast for a defined number of hours depending on the needs of the users and the available data.	The regional avalanche bulletins describe the avalanche situation within a given time period (nowcasting and/or forecasting).
User group	
The site-specific avalanche warning is oriented to the needs of specific users and their activities.	Regional avalanche danger assessments target a wide group of users ranging from public safety administration and professional users of the back country to private people.
European avalanche danger scale	
The European avalanche danger scale is not to be used to describe the avalanche danger in specific slopes or faces of a mountain or a massive.	The European avalanche danger scale is used to summarize the avalanche danger in an area that includes all aspects and several elevation bands. It includes an indication about the snowpack stability, the frequency distribution of snowpack stability and avalanche size for a given area and time period.

Regional avalanche danger levels, if available, can be used as an input to the site-specific assessment.	Site-specific avalanche warning, if available, can be used as an input to the regional avalanche warning.
The sub region	
In approaching a site-specific assessment, often an onsite verification of the regional bulletin is the first step. This process may result in an avalanche danger level expressed according to the European danger scale representing the situation in that specific sub-region where the site-specific warning is operating.	Local observers are usually asked to provide an avalanche danger level for their area which generally only covers a fraction of the entire warning region.
Product	
The avalanche warning service provides a danger assessment for a specific site and evaluates the probability of an avalanche to release and to reach a certain point/object in the avalanche path (impact probability). The danger classification, selection and form of the communicated information, methods of communication and mitigation actions vary accordingly.	The avalanche danger is described in the form of a bulletin that describes the avalanche situation following the information pyramid.
Data	
All available data from <i>single</i> or <i>multiple</i> observations, tests and weather stations are used to assess avalanche danger in the specific site covered by the warning service. In addition, information from representative neighbouring areas (e.g. spontaneous avalanche activity) can be evaluated and included in the assessment of a specific avalanche path.	Data from <i>multiple</i> observations and weather stations are aggregated to assess the general avalanche danger of the whole region.

Data processing steps	
Avalanche problems	
Avalanche problems (EAWS) can be used to describe the most prominent avalanche problem in single slopes on a mountain.	Avalanche problems (EAWS) are used to give an indication on the most prominent avalanche problems in a larger region.
Avalanche impact probability	
The site-specific avalanche hazard is a function of the (in)stability of the snow cover in a given avalanche path (not an area) and the probability of an avalanche to reach a certain object or point in the given path (impact probability). Figure 1	The regional avalanche danger does not describe an impact probability, but it describes the likelihood (expected probability) of occurrence and the possible size (and their damage potential) of avalanches in a specific region.

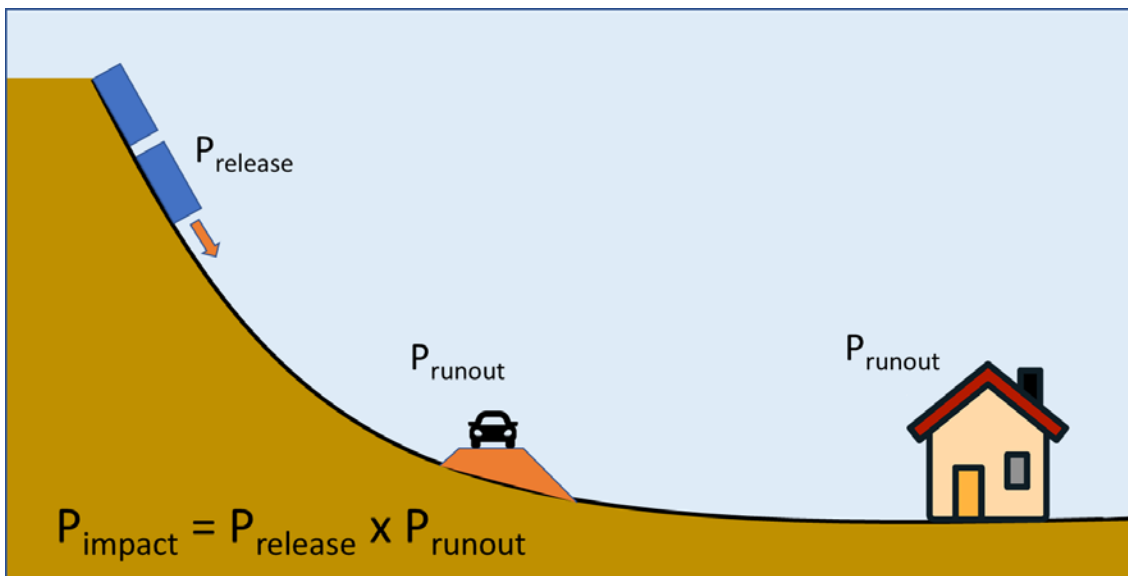
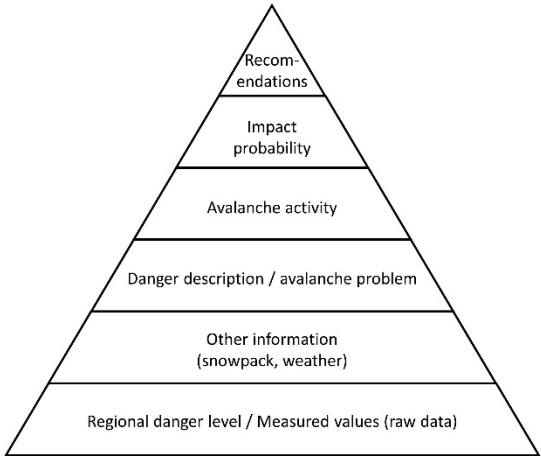
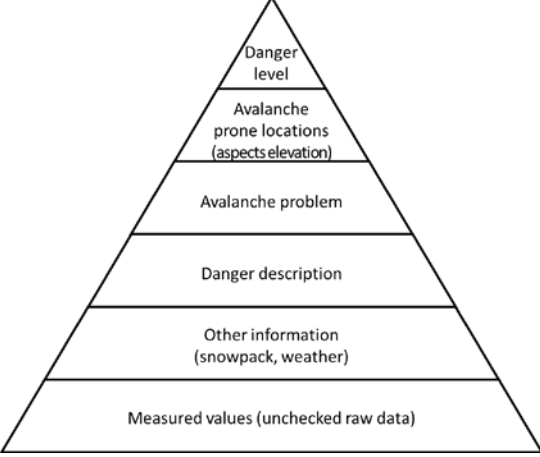


Figure 1: Illustration of impact probability as a product of avalanche release probability and avalanche runout probability. The impact probability depends on the location of the object in the avalanche path and can be different for two objects while the release probability is the same.

<p>Avalanche size</p>	
<p>Site-specific avalanche warning evaluates the possible sizes of an avalanche in relation to the exposed object / point in the avalanche path.</p>	<p>The largest expected avalanches are considered in the assessment of the regional avalanche danger. However, location and size of the avalanches cannot be accurately predicted and described.</p>
<p>Presentation of avalanche warning to user</p>	
 <p>A pyramid diagram with six horizontal layers. From top to bottom, the layers are: Recommendations; Impact probability; Avalanche activity; Danger description / avalanche problem; Other information (snowpack, weather); and Regional danger level / Measured values (raw data).</p>	 <p>A pyramid diagram with six horizontal layers. From top to bottom, the layers are: Danger level; Avalanche prone locations (aspects/elevation); Avalanche problem; Danger description; Other information (snowpack, weather); and Measured values (unchecked raw data).</p>
<p>Other specifications</p>	
<p>Site-specific avalanche hazard assessments carried out by professionals and snow observatories are a very valuable source of information for regional danger analysis, assessment and verification. Therefore, the assessment of the site-specific danger arises as a unit within the regional danger but may differ substantially if the site-specific situation deviates significantly from the regional situation.</p>	<p>Regional avalanche danger assessments are useful information at the site-specific level to frame the operational context but are not sufficient to adequately characterise the danger situation of the individual avalanche path.</p>

2 Recommendations for site-specific avalanche warning services

Site-specific avalanche warning services can be organised in many ways. A common standard, method or product does not currently exist in Europe. Therefore, the EAWS collected a set of requirements that are essential for a modern and well organised site-specific avalanche warning service.

The recommendations give guidelines on how to organise and document an avalanche warning service that works at a site-specific scale (Figure 3). These recommendations are based on the surveys and experience of the working group members and represent a minimum standard for site-specific avalanche services. We encourage all services that work at this scale to adopt and adhere to these recommendations to guarantee for the professionalism of the supplied assessments.

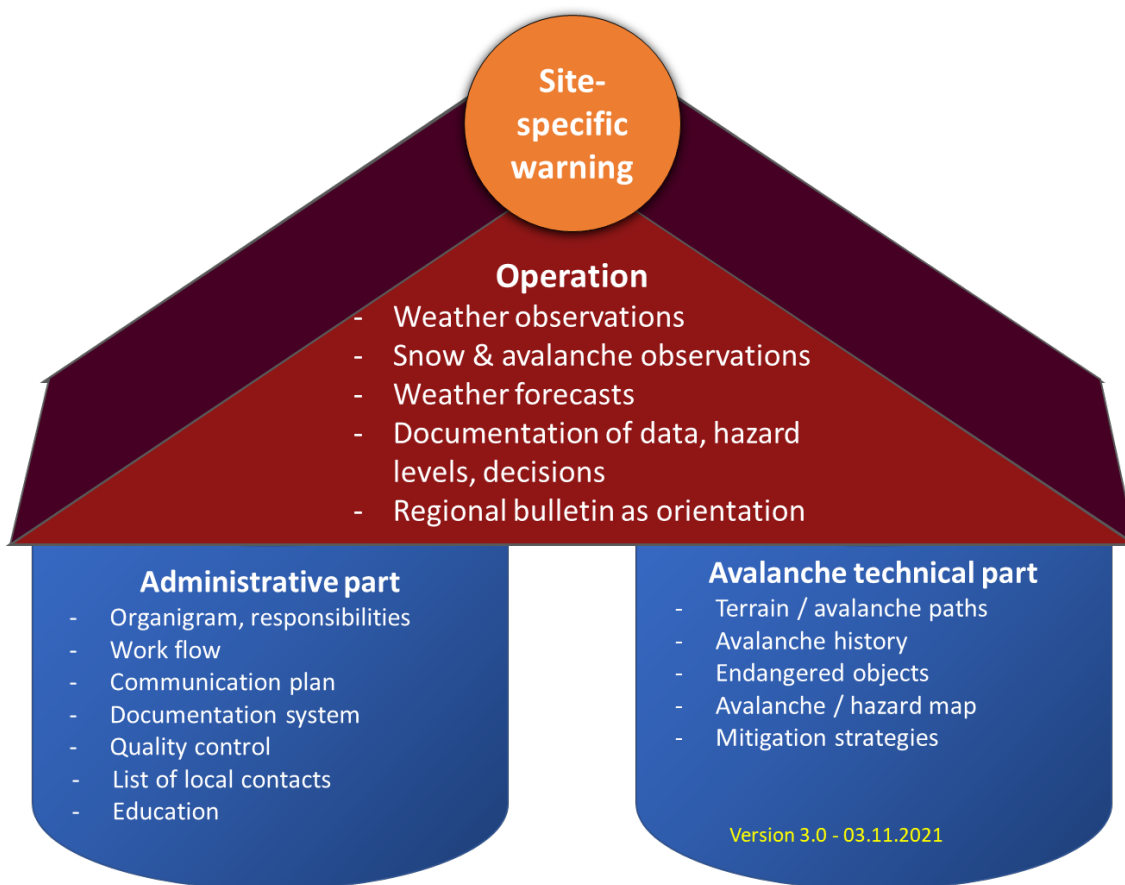


Figure 2 Schematic illustration of the proposed setup for a site-specific avalanche warning service

2.1 Organisation of the service: administrative part

2.1.1 Organigram, responsibilities

An organigram that presents the roles and responsibilities in the service should exist. All persons involved in the warning service and their role and responsibilities should be listed to ensure that everyone knows what to do and when. This may include the leader, forecasters, observers,

communicators and other roles that are involved in the service. The leader ensures that all roles and responsibilities are known for all members of the team.

2.1.2 Workflow

A workflow for the avalanche warning service should be established and documented. Starting with the input data, data processing and documentation, danger assessment and communication of the final avalanche warning. The workflow for the warning service stops when avalanche warning and the impact probabilities are conveyed to the risk owner. In this meaning, the risk owner is the administrative entity that manages the risk in a given situation by enforcing actions to reduce the risk for persons and /or infrastructure.

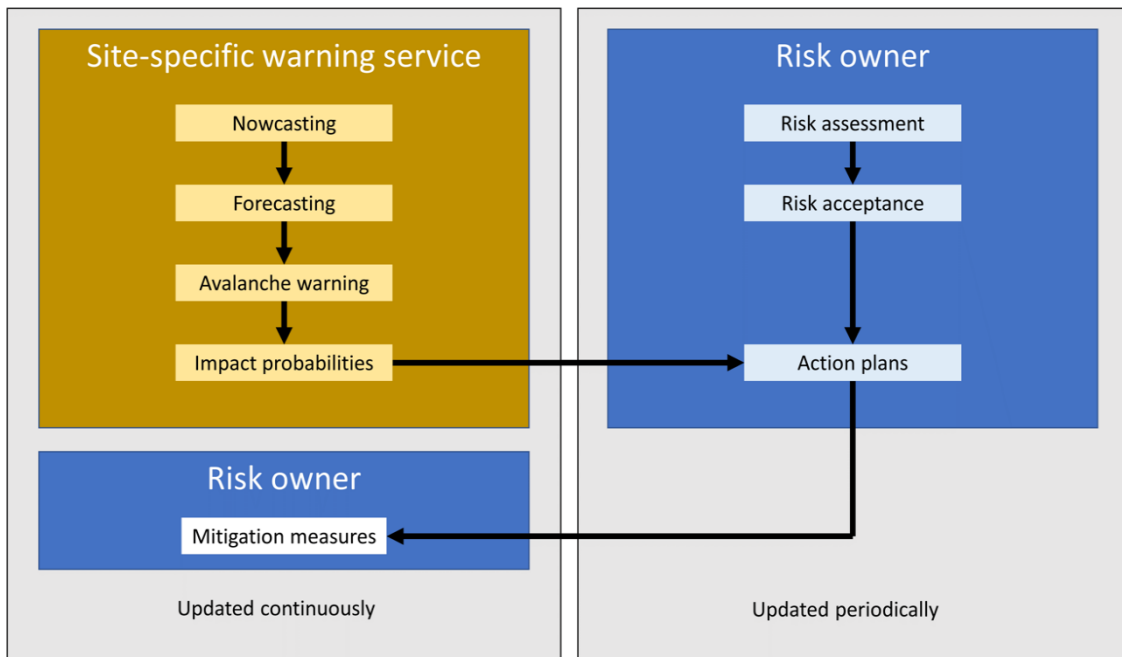


Figure 3 Workflow and responsibilities as recommended by the working group. The deployment of mitigation measures might be organised differently in some member countries where the warning service is a part of the risk owner. Here, the risk owner is the administrative entity that manages the risk in a given situation by enforcing actions to reduce the risk for persons and /or infrastructure.

2.1.3 Communication plan

A communication plan should include the target group of the avalanche warning and which communication channels are used to ensure that the appropriate users receive and understand the avalanche warning.

2.1.4 Documentation system

The service should have a documentation system to store and archive all relevant documentation for the service, such as basic information on the monitored area, avalanche history etc. In addition, a logging system is recommended to store the meteorological, nivological and avalanche activity data alongside the assessments and final products.

2.1.5 Quality control

An internal quality control and evaluation scheme should be established and documented for the service. The minimum requirement is a discussion of the final avalanche warning by two experts before issuing it to the target group (four-eye principle). In small operations, there must be at least a formalized self-evaluation.

2.1.6 Education

The service needs to assure that the involved experts have the appropriate training and education. A list of involved experts and their qualification or training should be established.

2.1.7 List of local contacts

Often, site specific services have local contacts, contractors or subcontractors. Their names, contact details and role should be listed in the documentation of the service.

2.2 Basics of the service: avalanche technical part

2.2.1 Terrain / avalanche paths

Documentation of the monitored terrain and the potential or known avalanche paths on GIS or (paper) maps.

2.2.2 Avalanche history

Documentation of the known avalanche history in each monitored path including whenever available the frequency and size of observed avalanches.

2.2.3 Avalanche or hazard map

If possible, an avalanche hazard map (or an avalanche hazard indication map) for the monitored areas should be used for supporting the warning service operations.

2.2.4 Avalanche endangered objects

The endangered objects that are covered by the avalanche warning service must be known (e.g. indicated on a map). Type of the exposed objects, their location and, possibly, their structural characteristics need to be known to assess the avalanche impact probability¹ for the object.

2.2.5 Mitigation strategies

List of the applicable temporary mitigation measures to reduce the avalanche risk in the monitored area. For example, evacuations, road closures etc.

Existing physical/permanent mitigation in the monitored area and avalanche paths should be listed. Their maintenance status and effectiveness against avalanches should be evaluated regularly and documented.

¹ Impact probability is defined as the probability of an avalanche to reach a certain point in a given avalanche path

2.3 Operation of the service

2.3.1 Weather observations

Specify the source and type of data used for meteorological observations.

2.3.2 Snow and avalanche observations

Specify the source and type of data used for snow observations.

2.3.3 Weather forecasts

Specify the source and type of data used for weather forecast.

2.3.4 Regional bulletin as orientation

Site specific services are recommended to use the regional bulletin for their area as an orientation for the site-specific assessment. If available, the regional danger level can be logged alongside other information in the logging system.

2.3.5 Documentation / logging of data, hazard levels, decisions

Meteorological, nivological data, the assessments and final avalanche warning products as well as eventual decisions made on this basis should be continuously logged in a suitable manual or digital system.

2.4 Product of the service

2.4.1 Site specific warning

The service should aim at providing an avalanche impact probability² for the monitored objects for the warning period considering the meteorological and nivological conditions and the location of the exposed object. The avalanche warning service should provide a description of the meteorological and nivological conditions and their development for the monitored area. This should include an estimate of uncertainty of the applied data and the avalanche assessment.

2.4.2 EAWS standards

The site-specific avalanche warning should follow the standards of the EAWS such as the modified [information pyramid](#), the [avalanche problems](#) and [avalanche size](#). The [avalanche danger scale](#) can be applied for sub-regions, large enough to encompass a variety of terrain, elevations, snow and weather conditions, but not for selected slopes or single avalanche paths.

3 References considered for this work

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² Impact probability is defined as the probability of an avalanche to reach a certain point in a given avalanche path

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