PROJECT ALBINA: THE TECHNICAL FRAMEWORK FOR A CONSISTENT, CROSS-BORDER AND MULTILINGUAL REGIONAL AVALANCHE FORECASTING SYSTEM

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ABSTRACT: Effective avalanche forecasting relies on two major factors: (1) a consistent danger assessment based on various sources of information and physics-based knowledge in natural processes by the forecasters and (2) a consistent and coherent way of communicating the forecasted avalanche situation. However, recent analyses showed that comparison between neighboring avalanche danger forecast systems revealed potential sources of inconsistency in both assessing and communicating avalanche situations. Therefore, starting with the winter season 2018-2019 Tirol, South Tyrol and Trentino will operationally use a common conceptual framework and communicate avalanche danger assessments under a common website: avalanche.report. We will present technical aspects underlying this common conceptual framework. The technical aspects are all based on state-of-the-art analysis and IT technologies and were chosen and applied with the ulterior motive to be generally valid when virtually merging different avalanche forecasting centers. In order to connect different avalanche warning services efficiently, a multilingual web application was developed to interactively compile and produce avalanche forecasts and exchange assessments. When using the application, forecasters of neighboring warning services can directly discuss and suggest avalanche danger situations at their boarders and adjust inconsistencies. We used the Swiss-based catalogue of phrases for describing details on the prevailing avalanche situation. Additionally to the Swiss version, we added the possibility to switch the input language from German to Italian and amplified the possibilities to better describe the stability of the snowpack. Technical aspects of user-friendly and effective maps and an appealing, vivid design complete an operative and consistent communication of information on avalanche danger to the public.

KEYWORDS: software application, avalanche forecasting, avalanche warning.

1. INTRODUCTION

Publishing regional avalanche forecasts has a long tradition in the European Alps. Since the late 1960ties countries within the European Alps are assessing and communicating regional avalanche danger to the public. At the beginning forecasters published the avalanche danger assessment in a short non-standardized text twice to three times a week or whenever weather or snowpack conditions changed dramatically. Only radio stations broadcasted the information from the avalanche forecast by that time (Mitterer, 2015a). From the mid 1980ties on, avalanche forecasts were still based on text only, but were spread via Telex or later Fax. The revolution in communicating, publishing and distributing avalanche danger forecasts started when more and more people had access to the World Wide Web. In Switzerland for example, requests for information via Internet increased by a factor of five between the winters 1996-1997 to 1997-1998 (Russi et al., 1998) and so solutions tailored for use in the Internet became more and more popular among forecasting centers. However, it took until 2011-2012 until the forecasting services of Norway, Canada and Switzerland revised or newly introduced a format on avalanche forecasts that was optimized for Internet and smartphone users (Ruesch et al., 2013; Stoffel and Niederer, 2013; Winkler et al., 2013). Since then, interactive, responsive websites and applications have become more and more popular when assessing, describing and communicating regional avalanche danger to the public. The step towards interactively displaying avalanche forecasts up to two times a day in several languages (e.g. Switzerland) implies the need for specifically designed software tools to support the avalanche forecasters in their daily work of producing the avalanche forecasts and make them publicly accessible (Ruesch et al., 2013). Aside from state-of-the-art software applications,

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effective avalanche forecasting relies on consistency in assessing and communicating the forecasted avalanche situation (Mitterer, 2015b). Particularly those consulting avalanche forecasts published by different forecast centers rely on coherent warnings. However, recent studies showed that comparison between neighboring avalanche danger forecast systems revealed potential sources of inconsistency in both assessing and communicating avalanche situations (Techel et al., 2018).

In order to tackle possible sources of inconsistency, we started the Interreg project ALBINA, where we had the opportunity to develop and apply a concept for a consistent, cross-border and multilingual regional avalanche forecasting system, which strictly follows best practices and standards of the European Avalanche Warning Services (EAWS). The system and concept was developed for the avalanche warning services of Tirol, South Tyrol and Trentino which represent the so-called Euregio (Mitterer et al., 2018).

While Mitterer et al. (2018) focus on the conceptual aspects of the ALBINA framework, we want to present our developments on the technical aspects assisting the forecaster in producing and communicating avalanche danger assessments across forecasting boarders and in several languages.

2. AGILE SOFTWARE DEVELOPMENT

We based the implementation of the technical framework on the agile software development approach (Figure 1). Agile software development is everything but new, since iterative and incremental development methods in software development can be traced back as early as to 1957, with adaptive software development emerging in the early 1970s. It is though worth mentioning, since this approach is very utile for technical implementations in the context of avalanche forecasting and within the forecasting community. Creating software application faces often the fact that at the beginning of the developing process customers do not explicitly know their exact needs – which in turn complicates the implementation. The knowledge on exact requirements and workflows mostly evolves during the programming process. Basically, agile adoption intends to prevent a clash between software developing team and the changing perception and/or wish list of forecasting teams and end users. The approach describes a method of software development under which requirements and solutions evolve through the collaborative effort of self-organizing and cross-functional teams and their customer(s) and/or end user(s). In our case avalanche forecaster represent partly the cross-functional developing team and the customers of the developed software.

As an example for agile software development (Figure 1), we want to re-sketch the implementation of the so-called Typical Avalanche Problems (EAWS, 2017b) and its consequences for the development of the web application (Figure 2). Since EAWS definitions on the use of Typical Avalanche Problems are rather vague and specify only to report at maximum two different Typical Avalanche Problems per warning region, the development team started suggesting an approach where the two Typical Avalanche Problems (TAP) were fixed to the given elevation bands of the danger rating, i.e. that one elevation band could include only one TAP. When discussing with experienced forecasters on that proposal, it became very clear that the suggested approach was inadequate for communicating two TAPs within one elevation band – a danger situation that may frequently occur. Consequently, the development team revised its approach which had implication for both the development of the data entry module and the designed templates for the future website.

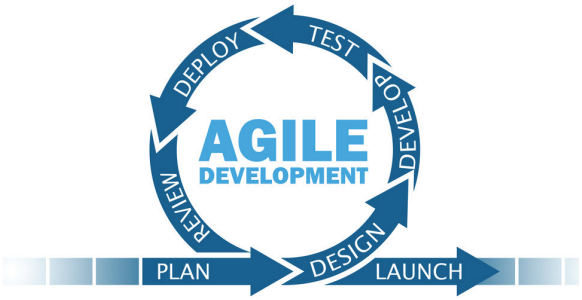

Figure 1: Schematic representation of agile software development, where software solutions evolve through the collaborative effort of self-organizing and cross-functional teams, in our case software developer and avalanche forecaster.

3. SOFTWARE DEVELOPMENT FOR AVALANCHE FORECASTING

Since our project covers three different avalanche warning services, avalanche forecasters work in different locations (in our case Innsbruck, Bozen – Bolzano and Trento). We therefore identified several constraints and requirements our software had to fulfill in order to produce a Euregio-wide avalanche forecast. The software has to

- predetermine a workflow in assessing and writing avalanche danger across the borders of forecasting centers by different

forecaster without causing conflicts of data entry,
- offer data entry and publication in different languages,
- give the possibility of effective communication between the various forecasting centers and
- handle various possible status of the avalanche forecast (e.g. draft vs. publication) during the process of avalanche danger assessment.
- In addition, relevant data for producing avalanche forecasts are mostly stored and managed in abstracted data formats and structures. Therefore, avalanche forecasters need a graphical user interface (GUI) to enter the assessed danger description for the avalanche forecast.

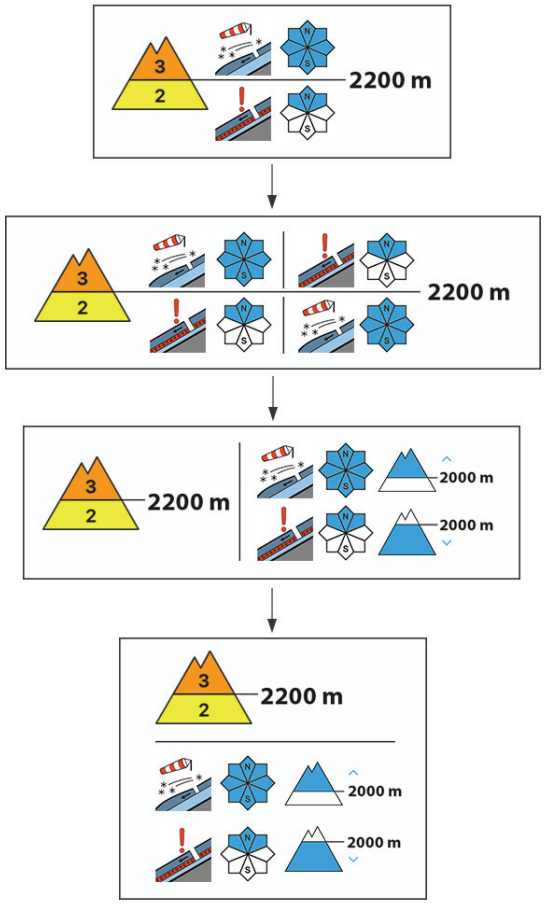

Figure 2: Evolution of arrangement of danger level and Typical Avalanche Problems during the development of the Admin GUI and template process of the website.

Based on these requirements, we developed a technical framework that is built on four main components (Figure 3): (1) a web-based data entry and communication software (Admin GUI), (2) a map service that produces various representations of snow, weather and avalanche forecasting parameters, (3) a server application that handles the logic of the Admin GUI and directs generated outputs to (4) the homepage for the public. The Admin GUI is a Javascript based web application (Angular), whereas the server application is implemented in Java with a persistence layer abstracted via Hibernate. The web application connects to the server application via secured REST interfaces (JWT) and real-time event-based communication (SocketIO).

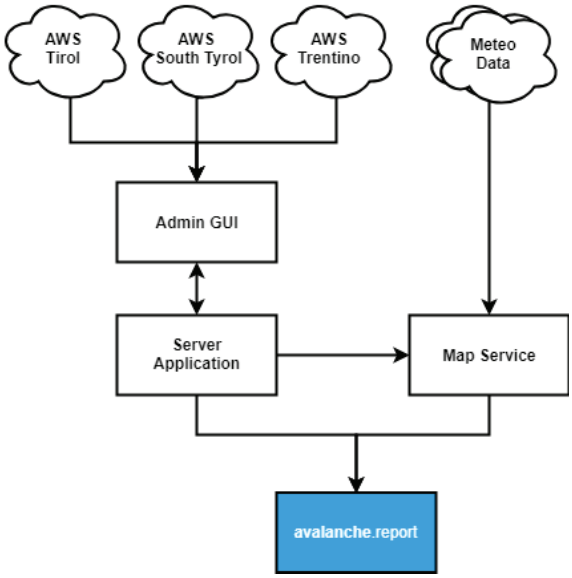

Figure 3: Technical framework within the project ALBINA.

3.1 *Supporting workflow between forecasting centers*

The Admin GUI was designed to support avalanche forecasters to assess avalanche danger in a well-structured, consistent workflow which follows EAWS standards (EAWS, 2017c), in particular the concept of the informational pyramid (EAWS, 2017a). An interactive map represents the three States/Provinces within the Euregio, subdivided in 70 subareas, in which avalanche forecasters have to aggregate regions according to prevailing snow, weather and avalanche conditions (Figure 4). For one aggregated region, the avalanche forecaster must assess and report on all information along the informational pyramid. The number of aggregated regions is technically not limited.

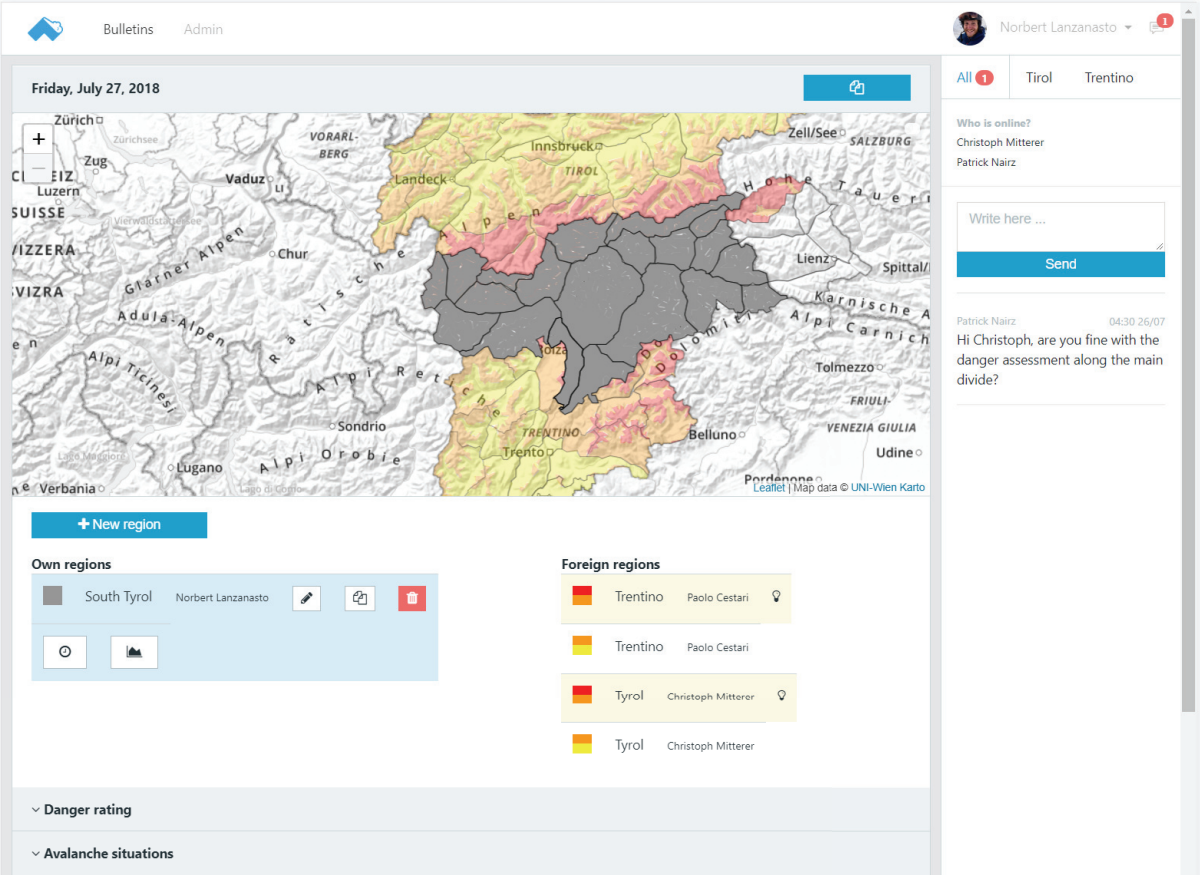

Figure 4: Screenshot of the interactive web application Admin GUI. The software merges the avalanche forecasters daily workflow in avalanche danger assessment, data entry, and effective communication between various forecasting centers through danger assessment proposals (map and middle column) and chat rooms (right sidebar).

However, by using danger level rating only, Mitterer et al. (2018) could show that during the winter seasons 2011-2012 until 2015-2016, 75% of the days with an avalanche forecast (= 568 days) were represented by five or less aggregated regions to describe the avalanche danger level within the entire Euregio. These numbers are in line with experiences from Switzerland and Trentino.

Having determined an aggregated region, the avalanche forecaster assess the danger level for one or two elevation bands and if necessary for a morning and afternoon situation. In addition, dangerous terrain (aspect, elevation), typical avalanche problems, description of avalanche situation and snowpack as well as the tendency are assessed and described. In order to facilitate assessments across boarders of the three forecasting services, a forecaster from e.g. Trentino may extend his/her entire danger assessment and description to regions of South Tyrol, because she/he has evidence that the assessment is also valid for these regions. However, due to administrative and legal constraints, forecasters from other States/Provinces do not have authorization for publishing general warnings on natural disasters. Therefore, the web application offers the opportunity to suggest an assessment across borders to the authorized forecaster (cp. small bulb and yellowish background at lower right in Figure 4) who in terms must decide to accept or reject the suggestion. In case she/he accepts the suggestion made by her/his neighboring colleagues, the assessment will be applied, otherwise the authorized forecaster must revise and completely reassess the situation for the respective regions. For an effective workflow, forecasters have the possibility to copy entire forecasts or parts of it and re-edit them for the new assessment. If neighboring forecaster want to discuss parts of the danger assessment, they may go directly through the chat-function incorporated within the web application (right sidebar in Figure 4).

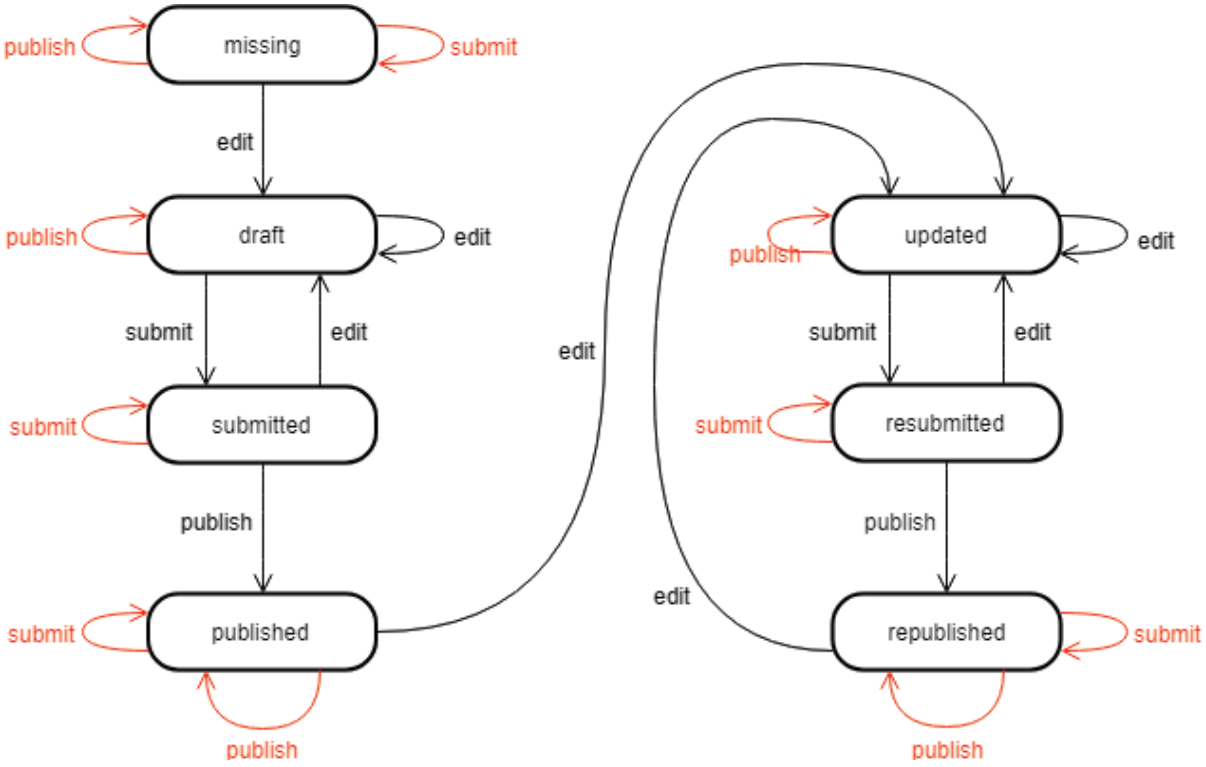

Figure 5: Sequential status of avalanche forecasts during the production process. In black we denoted allowed status changes, in red status changes, which are not possible.

3.2 *Supporting communication between forecasting centers*

The option of proposing entire danger assessments to neighboring forecasting centers has strong implications on the architecture and processing of avalanche forecasts. In order to publish and/or update the avalanche forecast from three forecasting centers simultaneously and prevent misunderstandings or duplicated data entries for a specific region at the same day, every avalanche forecast must undergo a consistent sequence with varying status (Figure 5). Basically, an avalanche forecast undergoes the following sequence: Before any assessment is done, the avalanche forecast is missing, as long as an avalanche forecaster works on the assessment, the avalanche forecast has draft status. When finished, the forecaster submits her/his draft, which might be edited until the planned moment of concurrent publication (in our case 17:00 and 08:00). As soon as the avalanche forecast is published, it cannot be edited or changed. In cases where the forecaster wants to edit a published avalanche forecast, she/he must prepare a full update, i.e. undergo the loop of draft-submission-publication again (right branch of flow chart in Figure 5). For minor adjustments only (e.g. correcting elevation), there is the possibility of editing without triggering the whole publication process.

Since the avalanche forecasting centers participating at the project are partly in Austria and Italy, the system has to work at least in Italian and German language. In addition, the Euregio Tirol – South Tyrol – Trentino is a well-known tourist destination – especially during the winter season. Consequently, avalanche forecast should be available in German, Italian and English. In order to tackle these requirements, we implemented the fully automated translation system successfully developed and applied by the Swiss avalanche warning service since 2011-2012 (Winkler et al., 2013). The translation system no longer relies on freely written text but chosen text from a catalogue of standard phrases. The individual sentences are not static but consist of a succession of up to ten segments. In each segment of the phrase, the forecasters can select from a pull-down menu of predetermined options for a segment. These options can likewise consist of a series of subsegments with selectable options. While the avalanche warning service of Switzerland uses German only as source languages and French, Italian and English as the target languages, we introduced Italian as additional source language. Further, we implemented the possibility to produce the translation on-the-fly and changed the general structure into a services-oriented architecture (Figure 6).

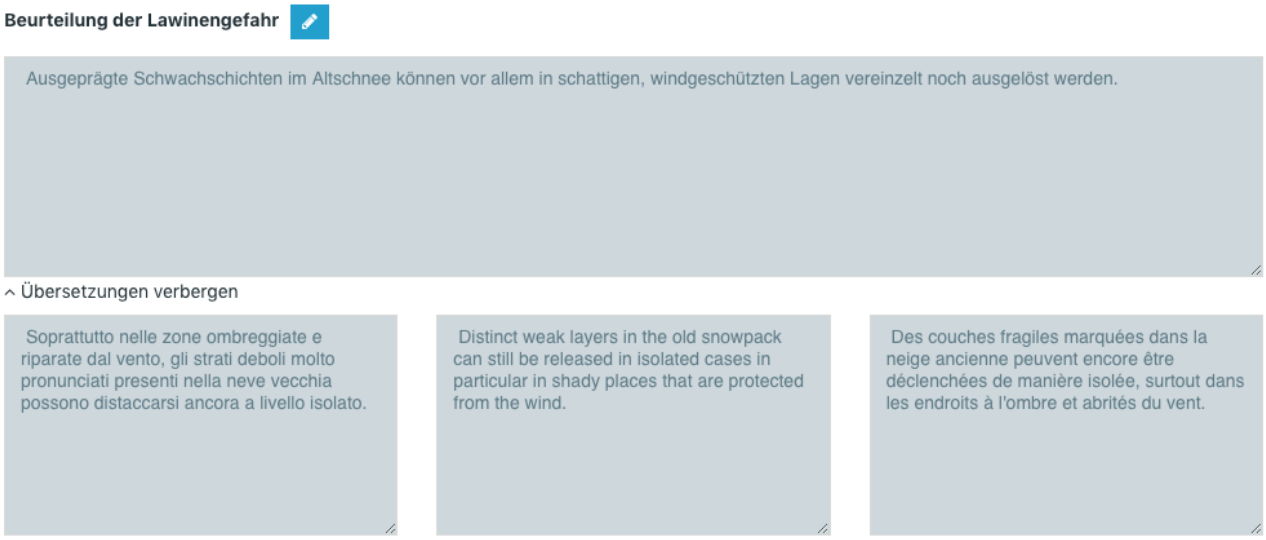

Figure 6: Avalanche danger description composed with an automated translation system based on a catalogue of phrases. Large box is source language (in this case German), small boxes show on-the-fly translations into target languages. Source language might be changed to Italian

4. TEMPLATE PROGRAMMING FOR RESPONSIVE WEB PRESENCE

Communicating avalanche forecasts via the Internet in a more and more interactive way demands nowadays an appealing, user-friendly and vivid design, effective maps and coherent communication via short concise text description. All of that must comply with EAWS standards, but more important, must have a nice look and feel, regardless of the resolution of the used device. Again, a proper, consistent communication and transportation of content, in our case avalanche danger, is as important as a danger assessment with high quality. Therefore, we applied again the concept of agile adoption for the designing and programming of the future website, where the common avalanche forecast is finally communicated to the public. Close collaboration between web design and geo-communication experts during several feedback loops led to a website peaking in a very useful interaction between functionalities of several maps representing the danger rating and the related content describing the avalanche danger conditions. The final look and feel of the website evokes a joy of use regardless of being consumed with a wide-screen desktop computer or on a smartphone (for your own experience check avalanches.report).

5. CONCLUSION

Effective avalanche forecasting is the product of a consistent danger assessment and a coherent way of communicating the forecasted avalanche situation. It is obvious that nowadays avalanche forecasts cannot be produced manually and that their production includes several complex interactions of state-of-the-art software technologies and architectures. Within the Interreg project ALBINA we had the opportunity to establish a conceptual and technical framework for producing and communicating regional avalanche danger to the public. The results and experiences of this framework help to link three different avalanche warning services, namely Tirol, South Tyrol and Trentino. We presented our technical framework and the most important component: a web-based, interactive application to assess and propose regional avalanche danger, effectively communicate and analyze avalanche-relevant data via chat and publish avalanche forecasts across the boarders of several forecasting centers. Our approach showed that the technical reliability as well as the usability of the software system is convincing and could only be reached by a close cooperation between system engineers and avalanche forecasters. The system is generally valid, complies with EAWS standards and is virtually open to add or merge several other forecasting centers. In combination with the conceptual framework, the presented technical features deliver the necessary basis to assure consistency in producing and communicating avalanche danger.

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REFERENCES

EAWS, 2017a. Content and structure of public avalanche bulletins, European Avalanche Warning Services.

EAWS, 2017b. Definition of Typical Avalanche Problems, EAWS General Assembly, Tutzing - Munich.

EAWS, 2017c. Memorandum of understanding for the European Avalanche Warning Services (EAWS), European Avalanche Warn- ing Services (EAWS).

Mitterer, C., 2015a. Der Lawinenlagebericht - das ungelesene Wesen. In: A. Riegler and G. Zenkl (Editors), Saisonbericht der Österreichischen Lawinenwarndienste 2014/15. Arbeitsgemeinschaft österreichischer Lawinenwarndienste, pp. 260-262.

Mitterer, C., 2015b. Der Lawinenlagebericht - eine unverstandene Liebe?. Bergundsteigen - Zeitschrift für Risikomanagement im Bergsport. Oesterreichischer Alpenverein, Innsbruck, Austria(4): 62-67.

Mitterer, C., Lanzanasto, N., Nairz, P., Boninsegna, A., Munari, M., Geier, G., Rastner, L., Gheser, F., A., T., Begnini, S., Tognoni, G.-L., Pucher, A., Nell, D., Kriz, K. and Mair, R., 2018. Project ALBINA: A conceptual framework for a consistent, cross-border and multilingual regional avalanche forecasting system, ISSW - International Snow Science Workshop, Innsbruck, pp. this issue.

Ruesch, M., Egloff, A., Gerber, M., Weiss, G. and Winkler, K., 2013. The software behind the interactive display of the Swiss avalanche bulletin. In: F. Naaim-Bouvet, Y. Durand and R. Lambert (Editors), Proceedings ISSW 2013. International Snow Science Workshop, Grenoble, France, 7-11 October 2013. ANENA, IRSTEA, Météo-France, Grenoble, France, pp. 406-412.

Russi, T., Ammann, W., Brabec, B., Lehning, M. and Meister, R., 1998. Avalanche Warning Switzerland 2000, ISSW - International Snow Science Workshop, Sunriver, Oregon, U.S.A., pp. 146-153.

Stoffel, A. and Niederer, U., 2013. Software tools developed for the Swiss avalanche warning service - a system overview. In: F. Naaim-Bouvet, Y. Durand and R. Lambert (Editors), Proceedings ISSW 2013. International Snow Science Workshop, Grenoble, France, 7-11 October 2013. ANENA, IRSTEA, Météo-France, Grenoble, France, pp. 451-452.

Techel, F., Ceaglio, E., Colêou, C., Mitterer, C., Morin, S., Purves, R. and Rastelli, F., 2018. Spatial consistency and bias in avalanche forecasts - a case study in the European Alps. Natural Hazards and Earth System Sciences Discussion.

Winkler, K., Bächtold, M., Gallorini, S., Niederer, U., Stucki, T., Pielmeier, C., Darms, G., Dürr, L., Techel, F. and Zweifel, B., 2013. Swiss avalanche bulletin: automated translation with a catalogue of phrases. In: F. Naaim-Bouvet, Y. Durand and R. Lambert (Editors), Proceedings ISSW 2013. International Snow Science Workshop, Grenoble, France, 7-11 October 2013. ANENA, IRSTEA, Météo-France, Grenoble, France, pp.437-441.