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SYNTHESIS: THE ONLINE TOOL PROVIDING EASY ACCESS AND SYSTEMATIC CROSS-CHECKING OF ALL USEFUL INFORMATION FOR AVALANCHE DANGER ASSESSMENT

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ABSTRACT: Having a clear vision of current and future snow and avalanche situation depends on a limited number of criteria widely accepted in our community. According whether it is carried out by a forecaster or a practitioner, this task nevertheless requires a significant amount of information to be cross-checked. Due to either lack of time or negligence, such a cross-checking is not systematically carried out. Here again, human factors sometimes prevail over common sense. The originality of our approach lies in the stated wish to make rational use of digital tools to automatize this task, or at least simplify it. For this reason, we have developed the *SYNTHESIS* tool, accessible via the www.data-avalanche.org platform. On the one hand, it provides an innovative graphical representation that overlays recent avalanche observations, snow tests results, the positions of automatic measuring stations, the danger level, and the critical slope aspects from official bulletins. On the other hand, *SYNTHESIS*, as suggested by the name, brings together in a single place all useful information available online: avalanche danger bulletins, slope gradients map, descriptions of recent avalanche observations as well as the map of avalanche areas' history, data from automatic measuring stations, and finally snow tests graphical representations. Such information corresponds to the six criteria of the *CRISTAL* approach. The objective of *SYNTHESIS* is not to produce an automatic avalanche danger assessment, but to simplify as much as possible data retrieving and exploitation tasks.

KEYWORDS: Risk-communication, avalanche forecasting, cross-checking information, data retrieving.

1. INTRODUCTION

Forecasting avalanche risk without being on the field faces challenges encountered by forecasters and especially by practitioners in identifying and accessing the most useful information. Often overlooked or simply not carried out due to its tedious nature, this task is nonetheless necessary to have a clear understanding of avalanche activity and current snow conditions in a specific area.

The importance of systematically evaluating a limited number of tangible and observable criteria was established as early as the 2000s, especially to counter the influence of human factors on decision-making [McCammon, 2000]. Following the Obvious Clues Method [McCammon, 2006], complemented by the Bounded Vigilance Model [McCammon, 2009], it has now been more

than ten years since [Duclos, 2012] adopted six criteria that form the structure of what we consider as "useful information". This approach is known as *CRISTAL* and is the specific subject of another article in this ISSW issue. As the corresponding digital data is scattered across the internet, *SYNTHESIS* was designed to gather, process, and present the data in the most readable manner (see Figure 1-1). Accessible both on PCs and smartphones, the objective is to not only cross-check specific information but also consolidate it in a single location.

In addition to data from automatic measuring stations, official bulletins, and other conventional sources, *SYNTHESIS* leverages data recorded by the French association data-avalanche (www.data-avalanche.org). This data consists of observations shared by the mountain community, covering both avalanche activity and stratigraphy. As of now, between 300 and 800 avalanches are recorded each winter (totaling 4635), often in near-real-time, described, geolocated, and illustrated by text and photos. Stratigraphy is primarily depicted through snow testing, often supplemented by complete stratigraphic profiles, conducted following the protocol described in another article in this ISSW issue (nearly 200 per winter in the French Alps currently, with a total

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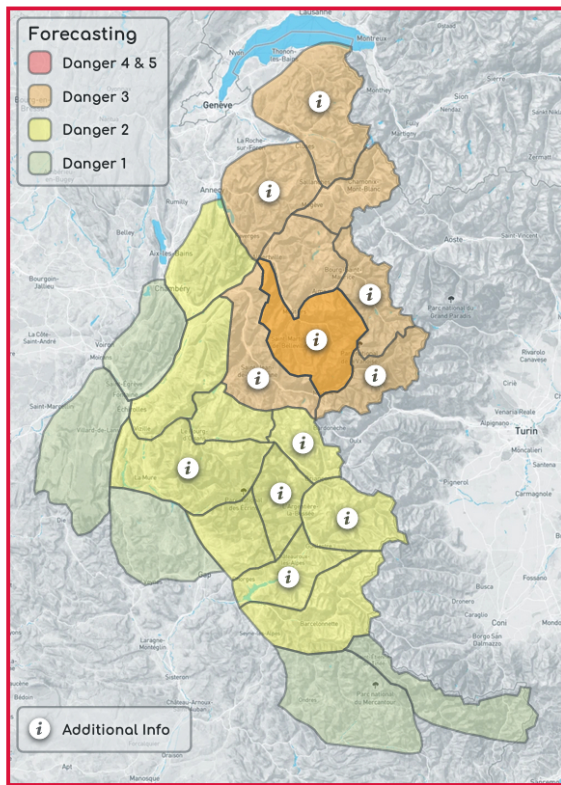
5 chemin de bellevue

74944 Annecy-le-Vieux

FRANCE

tel: +33 450 666 002,

email: frederic.pourraz@univ-smb.fr



Contribute to information sharing!
Report your avalanche observations

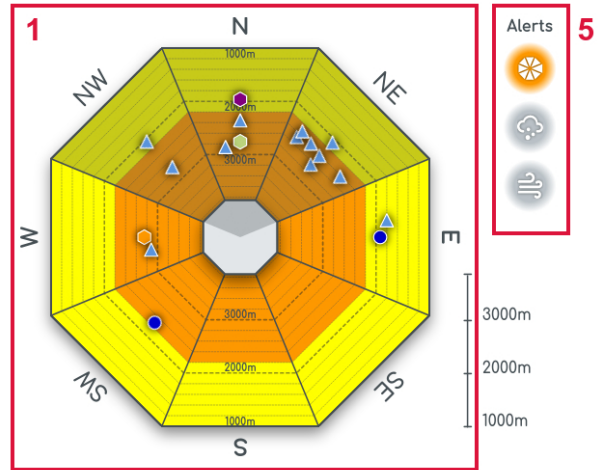
Watch the video that explains it all



2 Vanoise

sun. 19 march 2023, 20:00:16

Viewing cone Detailed map **6**



5

Alerts

History: 5 day(s) **4**

7

Move towards a good decision with **CRISTAL**

▼ Viewing cone pictograms

3

- Recent avalanche observation
- ROMANsns snow test
- FlowCapt measurement station

► [Danger level scale](#)

► [ROMANsns snow test](#)

► [data-avalanche alerts](#)

Figure 1: *SYNTHESIS* online tool

of 543 conducted since the winter of testing in 2020-2021). All of this data is now automatically processed and cross-checked, aiming to save mountaineers as much energy as possible for the crucial phases of analysis and decision-making that require deep thought. Currently, *SYNTHESIS* is primarily intended for use during the planning stages of a winter outings (Phase 1 of the 3x3 method [Munter, 1997]).

In Section 2, we will provide a more detailed presentation of the various cross-checked information. In Section 3, we will explain how to associate the relevant data with the evaluation of the six criteria of the *CRISTAL* approach. Section 4 will offer a critical perspective on the tool and its limitations, before concluding in Section 5.

2. CROSS-CHECKING INFORMATION

The task, previously entirely reliant on human effort, of cross-checking recent avalanche observations, snow tests, and certain information from the danger assessment bulletin, is now greatly facilitated by the graphical representation shown in Figure 1-1. This representation depicts a truncated cone, viewed from the top, with each face corresponding to a cardinal direction. The outer edges of the cone represent an altitude of 1000 meters. Its apex is truncated at the maximum altitude of the considered mountain massif, limited to 4000 meters in altitude. Level curves are also depicted every 200 meters of elevation change. This cone is currently available for each of the French Alpine massifs. The first step is to

select a massif on the left-hand map (see Figure 1-2). The divisions used correspond to those employed by Météo-France, sometimes modified to correct certain inconsistencies. We will address the limitations of this division in Section 4. The color of each massif corresponds to the highest danger level for the day, extracted from the currently valid official bulletin (see legend in the upper left corner). It's important to note that all the data is automatically updated hourly. The white "i" icon, sometimes overlaying a massif, signifies that in addition to the danger level, one or more observations (avalanche(s) and/or snow test(s)) and/or one or more alerts (which will be discussed later) are also available. When viewed on a computer, the name of the massif is displayed when hovering the mouse over it. Below this map, there is a link for reporting a new avalanche observation (a historical practice of the data-avalanche association) as well as a link to a video presenting all the tool's functionalities (currently available only in French).

When selecting a massif, all the information displayed on the right panel is updated accordingly, starting with the name of the massif, date, and time of the last update. Regarding the cone, the danger level is more detailed than on the massif map, as differences can occur based on altitude

thresholds occasionally mentioned in the bulletin. This later sometimes highlights more critical aspects than others. This is depicted by graying out the corresponding orientation sectors and the truncated cone summit to provide a clearer visualization of this information. Several icons (refer to legend in Figure 1-3) may overlay the cone, depending on the massifs and available observations. Light blue triangles correspond to recent avalanche observations, hexagons denote snow tests, and blue circles indicate the presence of an autonomous snow-meteorological station, such as the FlowCapt system [Bourgeois et al., 2013], installed on the field. The color of the hexagons depends on the result of the respective test. Four different colors are used to represent the criticality of the test, indicating the propensity of local crack to propagate in an identified weak layer (as described in another article within this ISSW issue, as mentioned earlier). All these icons are positioned at a specific altitude and aspect, determined by the geolocation of the information they represent. They are also clickable, providing access to information details, including avalanche descriptions, propagation test outcomes, stratigraphic and temperature profiles, autonomous station measurements (windward and leeward snow depths, snow transport, air and surface snow temperatures, wind speed, etc.).

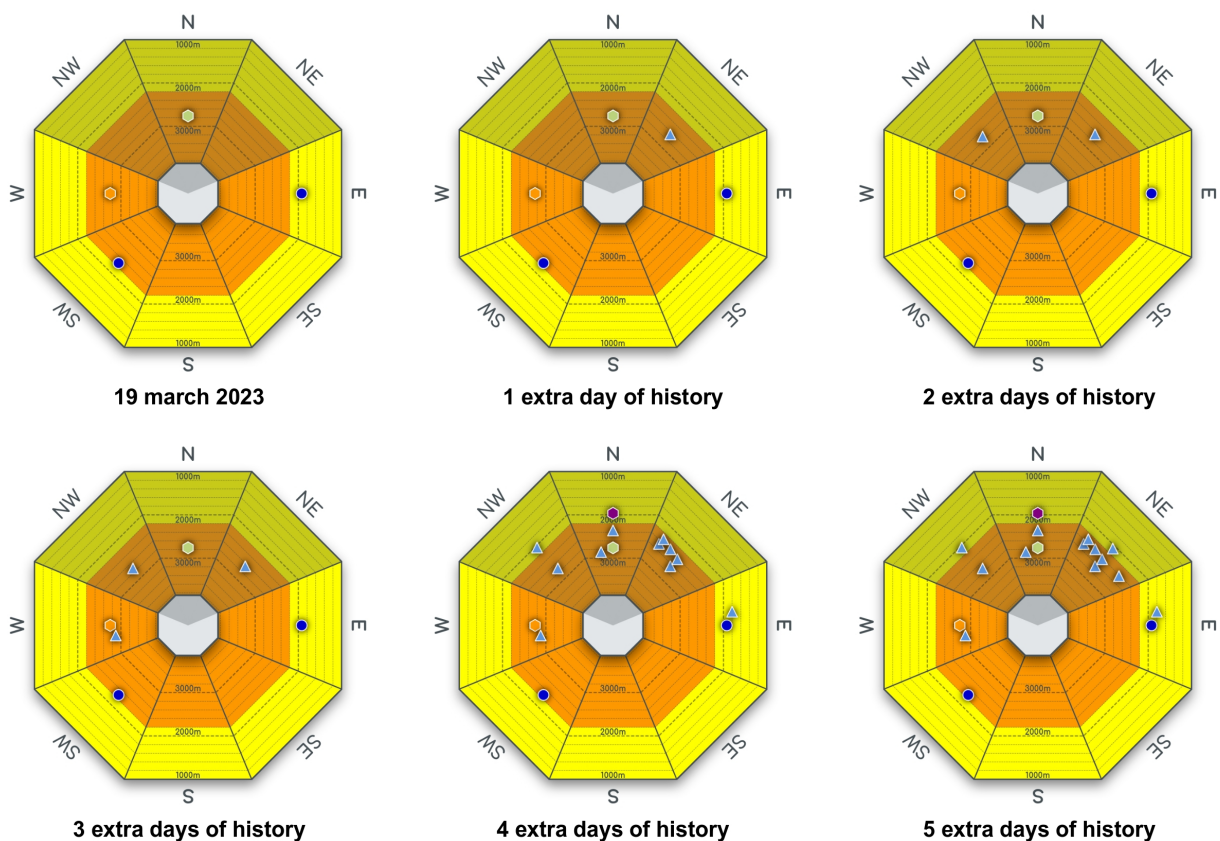


Figure 2: Information's history

This cone allows for the automatic cross-checking of various pieces of information, providing a better perception of the current snow situation. To complement this, users have the option to view all this information over a 10-day history by simply adjusting a slider (see figure 1-4). Indeed, depending on the weather conditions of the preceding days, it is valuable to accumulate information over a shorter or longer time span. Figure 2 illustrates an example of this accumulation, starting from March 19, 2022, and going back up to 5 days prior. We can observe that even though the situation seems to be improving (the two snow tests conducted on the 19th are not in purple, unlike the test conducted 4 days earlier), avalanche observations have been reported in the preceding days, sometimes even outside the critical aspects indicated in the official bulletin. These avalanche observations are the subject of a current alert (see figure 1-5). Indeed, any practitioner can sign up to receive email alerts from the data-avalanche association, and these alerts are also visually accessible through [SYNTHESIS](#). These alerts cover three types of information: the ongoing avalanche situation, precipitation (snow/rain), and snow transport by the wind. Each type is categorized into three levels: situation to monitor (yellow alerts), concerning situation (orange alerts), and unusual situation (red alerts).

Lastly, all this information (observations, measurement stations, and alerts) can also be viewed on a map (see tab in figure 1-6). This second, more conventional visualization offers a more precise geolocation of data but loses the advantage of cross-checking. Therefore, these two types of visualization are complementary.

3. RETRIEVING USEFUL DATA

To facilitate the implementation of the [CRISTAL](#) approach introduced in section 1, [SYNTHESIS](#) also gathers all the relevant information for evaluating the six criteria, in order to systematize their consideration during each outing. Each criterion is represented by a clickable icon (see figure 1-7).



The first icon (danger level) provides access to the complete current snow bulletin, which is posted daily by the services of Météo-France. This bulletin naturally corresponds to the massif previously selected on the left-hand map (see figure 1-2).



The second icon (slopes steeper than 30°) provides access to the geographical portal of the French government. This website offers a 1:25,000 scale map, along with an additional layer that colors and identifies slopes steeper than 30° (a key factor in avalanche triggering), categorized in 5° increments (see figure 3).

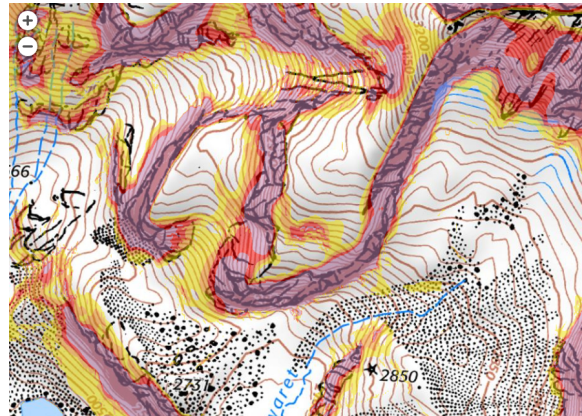


Figure 3: 2D map with slope steepness layer see: <https://www.geoportail.gouv.fr>



The third icon (recent avalanches observed) opens a dialog box that provides access to (i) the database of all avalanches recorded by the data-avalanche association: www.data-avalanche.org/now; (ii) the same geographical portal as mentioned earlier but with an other additional layer depicting the historical record of avalanches in the French mountains: CLPA (Map of Avalanche Phenomena Localization - see figure 4). Although not exhaustive and sometimes subject to uncertainties, this map can still provide valuable information about the potential extent of an avalanche.

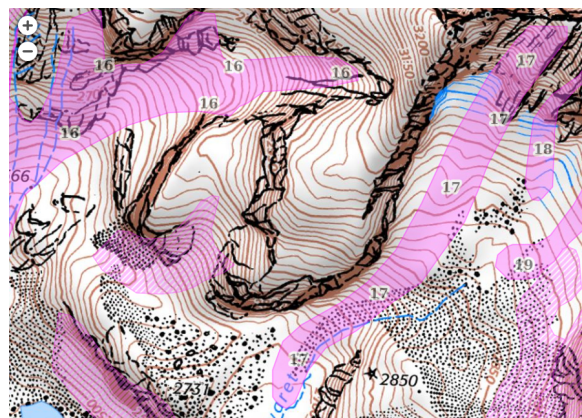


Figure 4: 2D map with historical avalanches layer see: <https://www.geoportail.gouv.fr>



The fourth icon (temperature increase, snow thawing) and the fifth icon (new overloading: wind-driven accumulation, fresh snow, rain) both open a dialog box that provides access to the list of all autonomous snow and weather stations in the selected massif (FlowCapt stations and NIVOSE stations by Météo-France). Selecting a station provides access to all the measured data. This is particularly the case for FlowCapt stations, which offer a large number of metrics and unlimited access to the entire historical data (see figure 5). The data from NIVOSE stations, on the other hand, is much more limited.

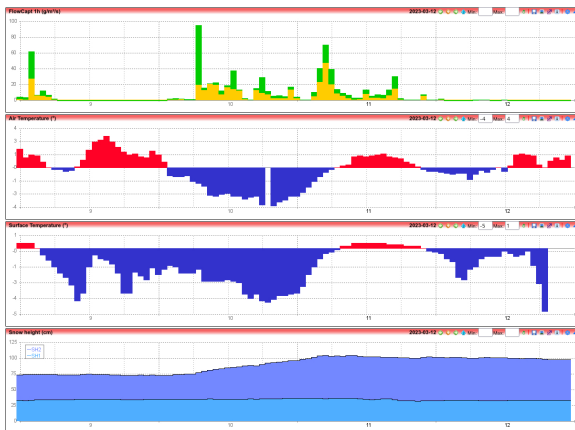


Figure 5: FlowCapt example of measured data: wind transport of snow, air temperature, snow surface temperature, snowpack height windward and leeward



The sixth icon (a possible buried weak layer) opens a dialog box that provides access to (i) the database of all snow tests recorded by the data-avalanche association, which can be visualized graphically (see figure 6); (ii) the website <https://www.regobs.no>, which lists a few tests in France (mainly column tests).

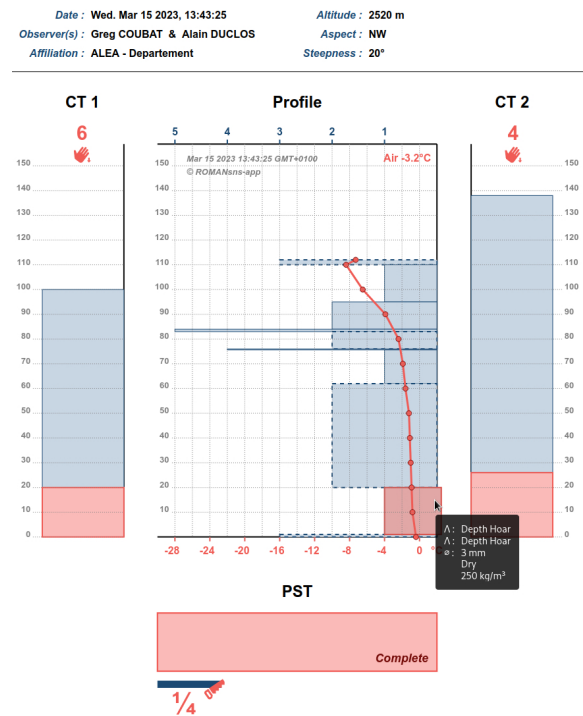


Figure 6: Graphical test's results see: <https://www.data-avalanche.org/romansns>

Finally, the **CRISTAL** logo (see figure 1-7) provides access to our tool that supports the approach (see figure 7).

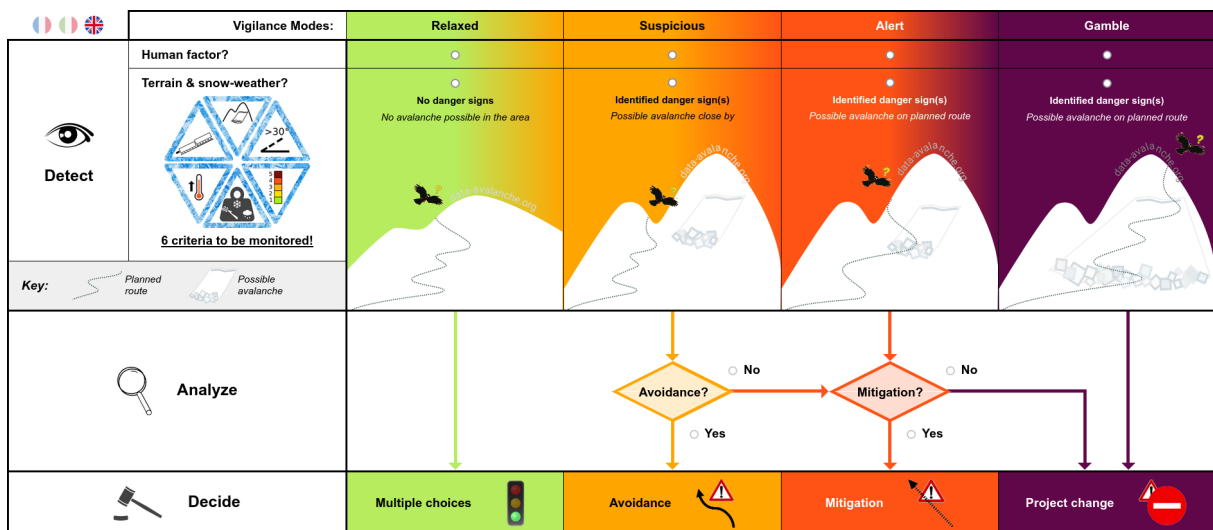
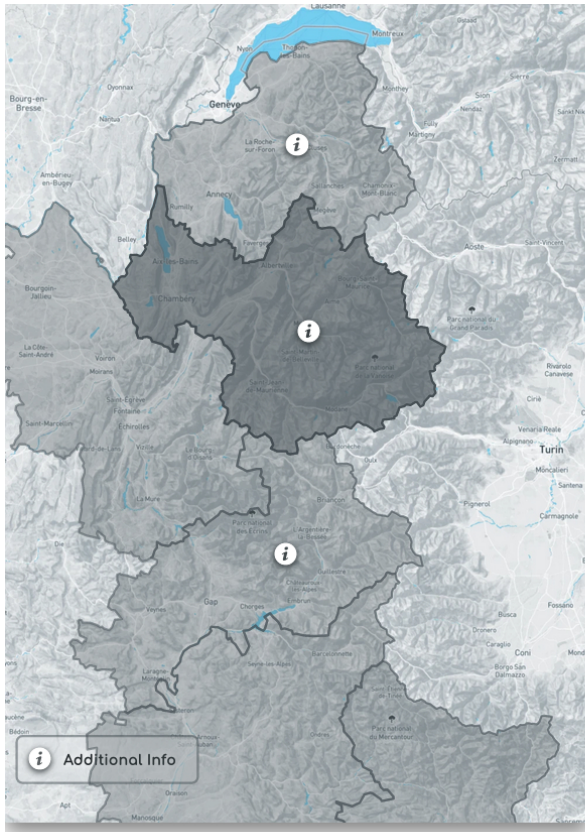


Figure 7: **CRISTAL**'s tool supporting the framework



Savoie

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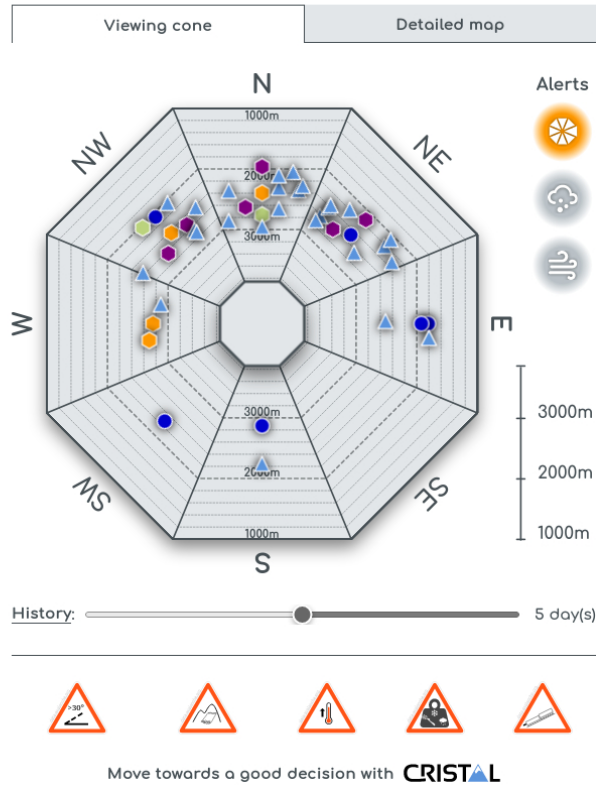


Figure 8: *SYNTHESIS* "departments" view

4. DISCUSSION

As we have just seen, *SYNTHESIS* facilitates the collection and cross-checking of useful information, both for practitioners and for forecasting purposes. After more than one season of successful operation, one particular point emerges as a certain limitation. The division by massif implied by the consideration of the danger assessment bulletin sometimes masks certain situations. Indeed, this delimitation is not always consistent with the snow and weather conditions, and a set of observations (recent avalanches and/or snow tests) indicative of a concerning avalanche situation can be at the boundary of 2 or more massifs. If the user restricts themselves to the information from a single massif, they may underestimate this situation. It is therefore important to have a broader view of the concept of massif by also exploring peripheral data. For this reason, all the information is also accessible on a map (see tab figure 1-6), which provides a wider view of the data location but loses the advantage of data cross-checking through the cone representation.

All of this data is also used daily by three French "departments" (Savoie, Isère, Hautes-Alpes) for ensuring road safety and reopening major Alpine

mountain passes at the end of the season. In order to facilitate this forecasting task and address the aforementioned limitation, we have also implemented a version organized by "departments" (see figure 8). This division provides an overview of multiple massifs, which is why information related to snow bulletins by individual massifs is absent from this representation. Nevertheless, all observations within the "departments" are cross-checked through the cone representation to offer a comprehensive view of the past and ongoing situation. However, situations that straddle the borders of two or more "departments" can still be obscured. For the upcoming winter, we are working on a new evolution of the tool that allows users to select sectors to be grouped into a single cone, aiming to address this issue.

5. CONCLUSION

The objective analysis of the current snow and avalanche situation is often complicated by the need to cross-check numerous pieces of information from various sources, accessible but scattered across the Internet. This situation leaves too much room for hasty interpretations often driven by human factors. *SYNTHESIS* has emerged from this premise and our belief that a rational use of digital tools would provide valu-

able assistance. Developed within an academic and association framework, this application is now fully operational. It is available for free and unrestricted access.

Following an initial effort of data collection and cross-checking, *SYNTHESIS* offers an innovative graphical representation (see Figure 1-1) along with essential information corresponding to the six criteria of the *CRISTAL* approach (see Figure 1-7).

All within a single virtual cone (altitude and aspect bands), one can find recent avalanche observations, results of snow tests, the locations of automatic measuring stations, the danger level, and the critical aspects from official bulletins. All of these pieces of information are updated on an hourly basis and are presented in the context of the French Alpine massifs (see Figure 1-3). Moreover, users have the option to select a historical range of up to 10 days (see Figure 1-4). Alerts are also included, providing additional interpreted information based on predetermined thresholds or expert insights: precipitation, snow transport by wind, or specific avalanche conditions (see Figure 1-5).

Each of the 6 icons in the *CRISTAL* approach includes links to relevant information for the specific massif under consideration: current danger bulletin, automatic measuring stations, slope map, observed recent avalanches, envelope of recorded notable avalanches (CLPA), and snow tests.

The objective of *SYNTHESIS* is not to automatically produce an estimation of avalanche danger, but rather to simplify the tasks of data collection and analysis as much as possible. Since its public release in March 2022, it has already received a number of visits that exceeded our expectations: more than 35,000 in just over a year, with an average consultation time of around 4 minutes.

By consolidating all the relevant and available information online in one place, *SYNTHESIS* likely contributes to avalanche risk prevention and certainly to the education of practitioners.

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