

ICT4snow

Exploring ICT solutions for snow and avalanche assessments

1. A project financed in the frame of the 4th ICT for the Future CallIntroduction

In the exploratory study, ICT4snow, we tested the technical feasibility of a real-time-snow-and-avalanche platform and assessed its potential benefit for end-users. This required the integration of various data sources, the processing of data in different formats, the analysis and forecast of snow and avalanche information and the real-time transfer of the results to the end-user. This implicates high demands on the technological infrastructure of ICT4snow.

The documentation tool 'Wikisnow' operated by the Alpincenter, served as basis for the analysis on the ICT4snow platform. As Wikisnow has been running in an operational mode for several years, it was possible to not only assess the technical feasibility, but also evaluate the value of the system's information for the end-user based on longer-term experience. The choice of an agile software development framework enabled us to respond directly to the suggestions and wishes of the end-user. The accompanying research on the acceptance and user experience heightened the performance and relevance of the complete system. The web-based platform, ICT4snow, shall be maintained in the future to support dynamic integration of heterogeneous data and serve as a risk management tool for various decision makers. An extended data basis will help us tailor specific information packages to the end-users needs and requirements. The platform is designed to flexibly integrate applications that are not restricted to stability evaluations and avalanche documentation.

The motivation for this exploratory study came from the observed increasing demand for up-to-date information on snow conditions and avalanches in decision-making processes. Today ICT-solutions allow the use of information in a high spatial and temporal resolution as consequence of the availability of internet access, high computing capacities and affordable mobile end-devices.

Besides the request for a real-time information exchange with respect to the daily work procedures, legal requirements are of primary concern for the growing interest of efficient documentation tools. In case of an avalanche accident for example, a good documentation helps to comprehend the decisions taken. Up to now, companies (e.g. ski areas, railway operators) record weather, snowpack and avalanche data in their own databases (analogous

or digital). In order to make decisions transparent, a benefit is seen in a regional network to share available data and connect stakeholders (Figure 1).

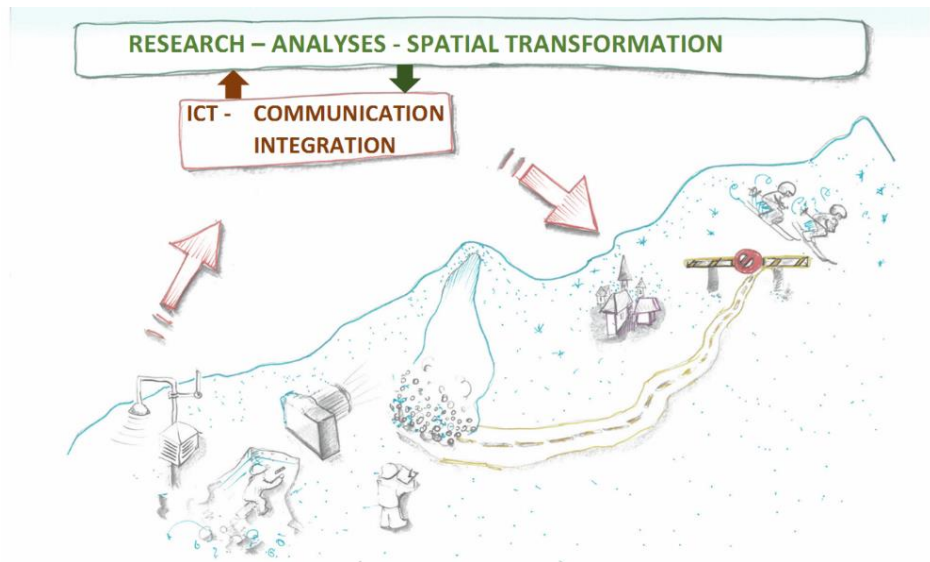


Figure 1 Regional view on snow and avalanches

2. Implementations in ICT4snow

The following list summarizes the highlights of this exploratory study; a detailed description follows in the next sections:

- **Agile software development:** The direct communication between user groups worked very well and therefore it was possible to implement requested modifications immediately. Due to the application area and timing (ski area during high-season) the test period was short (February/March), but intensive. This required the willingness for flexibility, especially of the IT-experts.
- **Implementation ICT4snow-Plattform:** The IT-experts provided a stable server infrastructure and implemented interfaces in order to integrate data from different sources and to enable a real-time-information exchange. This provided the basis for successfully testing the system and the achievement of the project goals.
- **Wikisnow – up-grades:** In ICT4snow we achieved an improvement of the compilation of daily bulletins and the visualisation of selected parameters. In addition, we implemented a Chat-add-on App and an App for emergency notifications.
- **Satellite data App:** The development of a web-application by the company Programmierfabrik and its integration on the ICT4snow platform allows the end-users of the project to access freely available in-time optical satellite data. In ICT4snow this

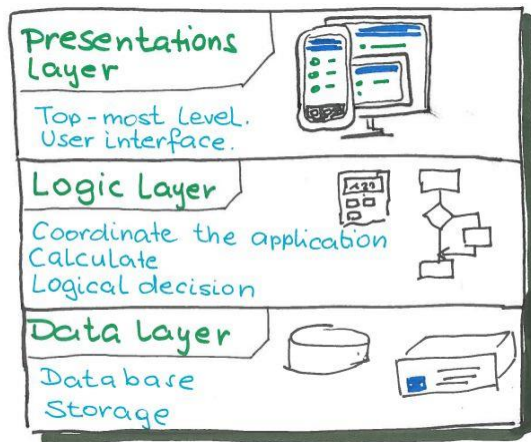
data added great value to the determination of snow distribution, e.g. for tour planning in spring.

- **Integration and visualisation of forecast data:** For the assessment of the snow conditions and avalanche situation, locally forecasted weather data is essential. During the test winter more than 4 million data sets were generated, transferred, stored, analysed and visualized. The forecast, by means of a time lapse GIS-application, was provided as kmz file that can be loaded into GoogleEarth.
- **Conceptualization and implementation of Apps:** We implemented and tested an App for data entry and real-time transmission that showed the potential for facilitating the documentation for a wide range of applications. The further development will be part of a workpackages in the follow-up proposal. In addition, during the project two students at the University of Vienna conceptualized prototypes for data entry by voice and automated local avalanche assessments that are on the ICT4snow platform for testing and possibly implementation.
- **Collaboration IT – end-user - research:** The project team benefited from the close collaboration in multiple ways. During the project, it was possible to develop a mutual understanding for the work requirements of the respective other groups and to agree on a common working plan. Due to the versatility of ICT4snow, it was possible to develop forward-looking ideas and select relevant stakeholders beyond the „typical“ project partners. New perceptions opened to each project participant that will, we believe, allow an easier implementation as well as higher acceptance of new ICT-solutions in the future.

3. Technical implementation of the ICT4snow-platform

3.1. Software Architecture

The set-up of the ICT4snow-platform (Figure 2) follows the typical structure of a three-tier-architecture (e.g. Wikipedia):



- Presentation layer: Is responsible for the representation of data, user input and the user interface.
- Logic layer: Comprises the entire processing; unifies the logical aspect of the application.
- Data layer: Includes the database and is responsible for saving and loading data.

Figure 2 ICT4snow software architecture: Three-tier-model

3.2. Interface descriptions

Figure 3 shows the interfaces realized in the exploratory project ICT4snow.

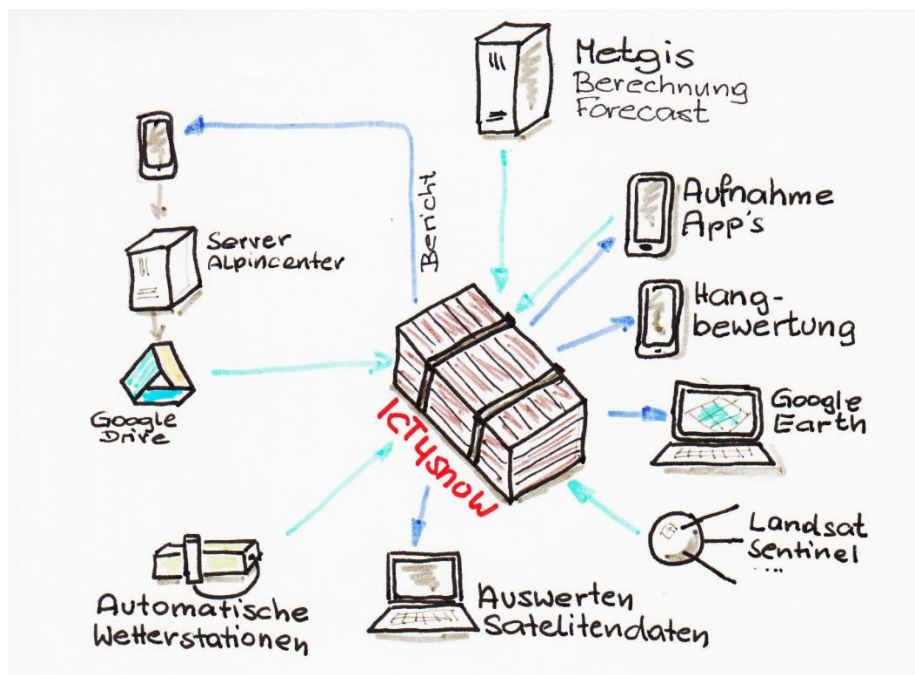


Figure 3 Implementations in the exploratory study ICT4snow

3.2.1. Interface - Wikisnow

This interface connects the documentation tool Wikisnow and the ICT4snow-server. Currently this is the most important interface and Wikisnow is both a data provider as well as a user of this data.

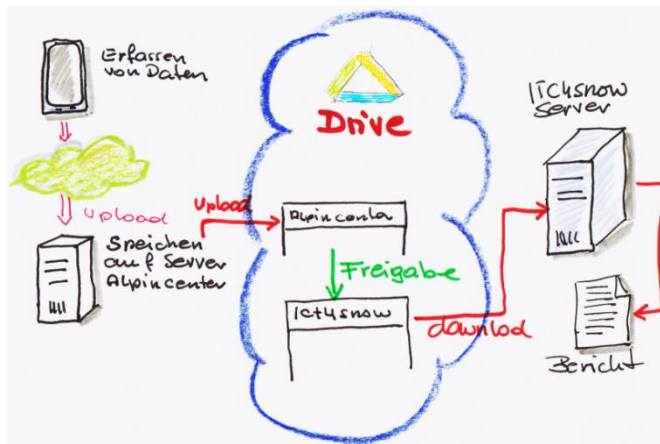


Figure 4: Interface Wikisnow

The data is not directly downloaded from the server of the Alpincenter, but is provided as an excel-file on Google Drive (Figure 4). The download is carried out every 10 minutes during the day-list-hours. The excel-file contains 76 fields.

This procedure does not require the exchange of passwords between the sender and the receiver. The data provider approves the download of data from Google Drive. He has complete control of the data extent and data quality. The automatically analysed data on the ICT4snow platform is in turn transferred in real-time to an external Wikisnow-application and thus to the end-users (Figure 5). The data export is realised via a web service and is initiated by an http-request.

QUERY:

path Flag of the web services
p Password, to prevent abusive use
curdate Optional, due day for data processing
out Optional, output format (empty, list, bubble, json)

Response in case of an error:

The program returns a JSON String with two fields

Status 200 OK, 500 error, 403 unknown password

Response – normal case.

Depending on the content or existence of the transfer parameters *out*:

- **empty** (default)
 Output of HTML-data as a formatted list;
 the hazard graphic is attached to the list

- **list**
HTML-export of unformatted data
- **bubble**
Delivery of the hazard graphic in SVG-format
- **json**
Delivery of the data in JSON-format

Figure 5 Data export for WikiSnow

The data that is processed on the ICT4snow-platform comprises information on the skied areas, the individual hazard assessments, snow conditions, observed impacts on the snowpack, observations on drifting snow, release probabilities, avalanche danger, avalanche hazard forecast, avalanche hazards by elevation levels and the respective expositions. With this, a visually better and faster display (real-time) of relevant data from the Wikisnow daily reports is possible. The users give good feedback on this new feature of Wikisnow. Feedback such as good summary, clearly represented, comprehensible, good to read etc. were among the comments.

3.2.2. MetGIS

The most extensive data import is through the MetGIS-interface. Every 24 hours 90.000 requests from the ICT4snow server were sent to the MetGIS server. Each request delivered data for one measurement point, including a forecast for 10 parameters. Each parameter included a forecast of 79 forecast steps. During the delivery period, more than 4 million datasets were processed.

The data, a JSON-object, was saved in a MongoDB (noSQL database). As a semi-structured database, MongoDB can account for less structured data. A dataset can comprise columns without predefined names and types and the number of columns can vary from dataset to dataset. We choose MongoDB, because of its data interface and the high performance in the area of *Insert* and the amount of datasets.

3.2.3. Automatic weather stations

Additional interfaces were established to receive current weather data from two automatic weather stations within the study area. This data served as a verification for the MetGIS forecast. The measured data is delivered to an FTP-server at an intervall of 10 minutes. We saved this data every hour to the database in a CSV-file. The target database is also a MongoDB.

3.2.4. Hummel

We developed an App (Hummel) for recording the header-information routinely documented for snow profiles and avalanche events. Some of the recording fields are automatically filled in, e.g. GPS-location. As a special application for ICT4snow, it is possible to record the density of the snow layers based on the measured weight of a snow sample. The App delivers the data as JSON-data stream. Besides the possibility to record the measurement data locally with the App, the App also serves as tool to enable a real time data exchange. The challenges included the local storage for enabling alternative transfer options in case of poor reception.

4. Wikisnow and its up-grades in ICT4snow

4.1. Description of Wikisnow

The idea behind Wikisnow is to obtain the most accurate image of the current snow conditions, based on many subjective assessments and the expert-knowledge of snow-professionals. On a daily basis, these professionals are skiing, snowboarding etc. in close vicinity to the ski-area. This is referred to as “out-of-bound skiing” and ski touring. The goal of Wikisnow is to enable an open exchange of daily experiences within an expert or user group in form of a daily protocol that is accessible to each user. Each mountain and ski tour guide writes an online-daily-report, including parameters for snow quality, weather, skied runs, and the individual assessment of the avalanche situation as well as observed avalanche events. The belief is that the more subjective user-opinions and observations are provided, the more accurate the image of the actual (objective) situation will be. In addition, it is possible to document and send information on avalanche observations directly from the field to the database and share the information with registered users via the Wikisnow App. In detail, the following parameters are recorded in the daily reports (Figure 6).

Programm:

- ☐ off Piste
- ☐ Skitour
- ☐ Heliskiing
- ☐ Schneeschuhwandern

Verhältnisse Allgemein:

- ☐ sehr gut
- ☐ gut
- ☐ mittel
- ☐ schlecht

Lawinengefahr:

EINSCHÄTZBAR

- ☐ leicht
- ☐ mittel
- ☐ schwer

Einflüsse auf die Schneedecke:

- ☐ Temp (+)
- ☐ Temp (-)
- ☐ Sonne
- ☐ Regen
- ☐ Wind
- ☐ wumm

Neuschnee der letzten 24Std

0 cm

Gefahrenstufe:

EIGENES ERMESSEN:

Entwicklung der Lawinengefahr

gleichbleibend

frischer Triebsschnee:

- ☐ Nord
- ☐ Ost
- ☐ Süd
- ☐ West
- ☐ hart
- ☐ weich
- ☐ kleiner 30cm
- ☐ groesser 30cm
- ☐ gut erkennbar Polster Dünen
- ☐ schwierig zu erkennen - versteckt
- ☐ Auslösewahrscheinlichkeit - sofort, 1 Person
- ☐ eher stabil, selten nur von einer Gruppe

Gefahrenstufen nach eigenem Ermessen in den Expositionen und Höhenlagen

- ☐ Variantenbereich
- ☐ Tourenbereich

Gefahrenstufen

| | | | | |
|------------|-----------|----------|----------|-----------|
| 1000-2000m | 0 Nord | 0 Süd | 0 Ost | 0 West |
| 2000-2500m | 0 Nord | 0 Süd | 0 Ost | 0 West |
| 2500-3000m | 0 Nord | 0 Süd | 0 Ost | 0 West |

Figure 6 Screenshot – daily report (Wikisnow)

Additional interfaces

Wikisnow also has an interface to an application called AVADO. This application delivers information on avalanches triggered by explosives in the secured ski area, along roads, winter hiking trails and cross-country tracks to the members of the local avalanche commission. The data is represented in different formats (diagrams, flags on Googlemaps, tables, pictures). In addition, there are interfaces to weather stations that deliver e.g. wind speed and direction, temperature, snow height, solar radiation, humidity and pictures via Webcam).

4.2. Wikisnow App Chat-add-on

A chat, similar to an instant messenger, was appended to the existing Wikisnow-App to improve the visual representation of observations. An avalanche alert sent by a smartphone from the field, pops up in real time in each participant's chat-window, including a text field with relevant avalanche information and a photo.

4.3. App for emergency alerts

We tested an emergency alert App in alpine terrain, where limited reception often only allows sending an SMS. This App sends SMS messages to predefined recipients, including the location as link to Googlemaps and the coordinates in number format, plus an optional text.

5. Weather data - forecast

5.1. MetGIS-data

On the website of MetGIS® the company promises ultra-precise weather data for better decisions (www.metgis.com) and say about themselves: „MetGIS combines exact weather models and terrain data and thus creates ultra-precise forecasts. With a resolution of up to 30 m MetGIS forecasts are among the best in the world. For you this means: Better decisions, targeted actions and new opportunities”.

Such local forecasts of weather data are interesting for various applications. For example, it is possible to improve tour planning or to optimize the snow management of ski areas. During the test winter, MetGIS provided these high-resolution forecast data for our study site, the Arlberg region. The forecast included the following parameters: temperature, precipitation (amount and type), cloud cover, wind, radiation, new snow density and sunshine duration.

For this exploratory study we downloaded the forecast data once a day, implemented it in a GIS-application and exported it as kmz-file for visualization in GoogleEarth (Figure 7). By means of a slider, we animated the forecast for the next 72 h. Applications that are more

complex will be the focus of future work. There will be additional challenges with regard to the real-time use of the forecast data on mobile end-devices, e.g. the availability of the newest forecast during the day, time-constraints regarding download – visualization – provision, long-term storage or visualization on Smartphones.

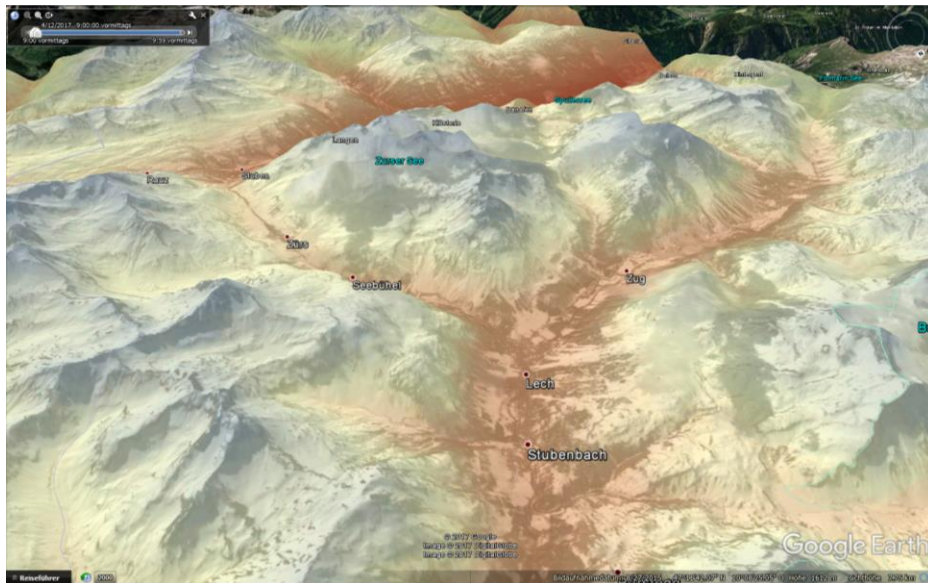


Figure 7 Example of the visualized forecast data (here temperature). The slider enables an animation for the next 72 hours.

6. Mobile measurements

Application and verification of mini-sensors: We tested several low-cost mini-sensors with regard to their robustness, accuracy and applicability for measurements of meteorological and nivological parameters (e.g. air & snow temperature; wind direction & speed, humidity, snow density). The collected data were evaluated using highly precise (scientific) instruments (e.g. Snow Micro Pen for measuring the snow hardness). In spite of the short duration of the project (one test winter) it was possible to build-up a considerable datapool that allowed us to assess whether the single sensors have the potential for future use in terms of the quality of the measured values and the ease of data exchange possibilities.

6.1. Mobile weather station – Skywatch BL 500

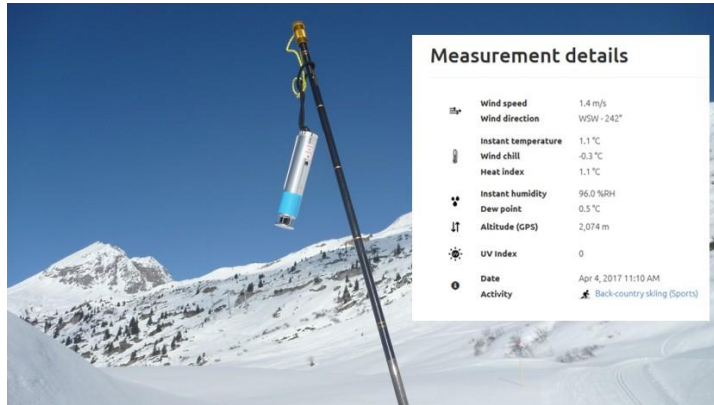


Figure 8 Skywatch BL 500 in the field

We tested a small mobile weather station that measures temperature, wind speed, radiation, air pressure, etc.).

Device: Skywatch BL 500

The strength of Skywatch is that the device is small, light, and easy to handle. Bluetooth facilitates data transfer to the smartphone. So far, a systematic verification of the measured parameters with data from a permanent weather station was not possible. Although the data seems plausible, the Skywatch's limitation is that the measurements can only be shared on the Skywatch-Website, while the raw data is not accessible. Therefore, it is not possible to easily process, analyse and exchange measured data on the ICT4snow platform.

6.2. Snow hardness – Avatech SP2, Scope

One possibility to assess the stability of the snowpack is the observation of hardness profiles. While recording a snow profile it is common to measure the hand hardness for each layer of the snowpack. This procedure is too imprecise for scientific purposes and is time consuming. In the past years several probes (Figure 9) were developed, which measure the penetration resistance with a high-resolution (per mm). In ICT4snow we were able to test two transportable probes, Avatech SP2 and Scope, and compared the measured data to hand hardness profiles and the data from a reference probe, the SMP. The SMP – SnowMicroPen is a digital penetrometer that measures the penetration resistance and depth accurately. However, the SMP is only suited to a limited extent for field work, as it is not easy to transport.

Avatech SP2 – A force sensor on the tip of the probe measures the penetration resistance and records the forces in mm steps up to a depth of 1.47 m. The depth is determined by an infrared sensors and an acceleration meter. The probe is operated manually. **Conclusion:** As a mobile measurement device, the probe is an additional weight for the user in the backpack. In addition, the results were not satisfactory and the handling not acceptable. The number of mismeasurements was very high and therefore there was no time saving, compared to a hand

hardness profile. Moreover, the depth and the absolute resistances deviated significantly from the SMP measurements and hand hardness.

Scope – Follow-up model of the Avatech SP2. The results are promising. The improvements in snow depth accuracy are obvious. Even though the absolute resistances still deviates from the hand hardness and SMP, the general form of the hardness profiles are similar, indicating that the same layers are identified. **Conclusion:** Due to the improvements of the sensoric setup and the reduction of mismeasurements, the probes is now suitable for the use in the field. The probe is integrated in a ski pole that may be a plus. A quantification of the measured data was not possible due to the limited data acquired. Anyhow, the question on how to visualize the data so that the end-user does not interpret the measurements incorrectly, remains open.



Figure 9 Overview of the used probes; comparison of hand hardness (orange) and scope data (blue)

6.3. Time lapse camera

We experimented with recording the ski tracks on a selected test slope. The goal was to assess the hazard behavior, timing of first tracks, maintaining safety distances and the selection of meeting points. A time-lapse camera was installed on the counter slope and photographs were taken at an interval of 5 seconds to subsequently compile a time-lapse video.

Camera: brinno TLC 200 Pro, lens F2, angular field 112°

Video: 720P, HDR, AVI format

The challenge was to select a suitable slope and a suitable location for the camera. Finding a day and time of day for intense skiing was less difficult, as the entire region is highly frequented by out-of-bound skiers. We selected a south-east exposed slope. The skiers access the slope

at an elevation of 2.400 m; the total width of the skied area is about 700 m and the elevation difference 400 m. The camera was located 750 m away at an elevation of 2.100 m and a deviating angle of 15° to the middle. Unfortunately, the resolution of the camera did not deliver accurate photographs, especially under head-on solar radiation and increasing cloud cover. The best visibility of the tracks on the pictures was at low sun light.

CAT S60 – Thermal image camera

A CAT S60 Smartphone is able to record thermal images. According to the producer, it is possible to detect people buried in an avalanche. During the winter we performed several experiments; unfortunately, under suboptimal conditions. The air temperatures were quite warm and the snowpack isothermal.

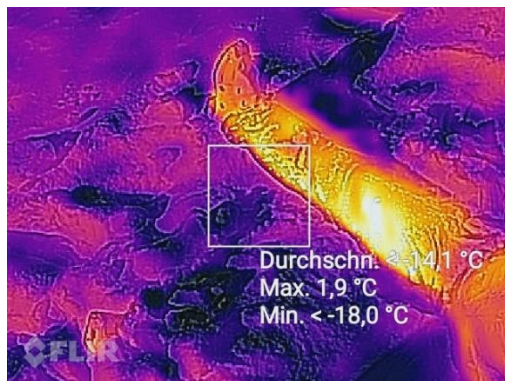


Figure 10 Thermal image from the CAT S60

Outlook: We expect better results in cold temperatures. In case it would be possible to detect a person underneath the snow, this would be of great help to determine the position of the buried person's head to faster dig out a breath cavity.

7. Additional Apps – prototypes

7.1. App-conceptualisation: Determination of local slope hazards based on the regional avalanche bulletin

In coopertion with the University in Vienna, Philipp Dangl developed a concept in the frame of his Bachelor thesis.

Background: Several platforms provide local information on avalanche accidents, snow profiles and snow conditions. From other websites, it is possible to download terrain information (e.g. slope angle, exposition). Usually this information is visualized on topographical maps or arial photographs showing summer conditions. Often the information is regional, but is not further processed to delineate information for a specific slope. However, in the field it is desireable to get access to filtered local data that only represents a slope or a smaller area.



Figure 11 App-Lumi screeshot

Idea: GPS-positioning of the location. Selection of the slope or catchment that is relevant to the interest groups. All information are dynamically accessed and locally visualised. Included are for example last reported avalanches, avalanche size, release height.

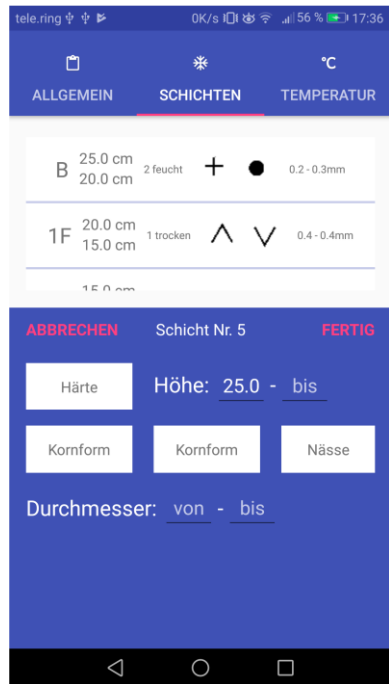
Why: Information is available for locally relevant areas in the field, sometimes even for specific slopes. Responsible blasting experts can use this information, e.g. to select slopes, where until now no avalanche occurred during the winter.

Stakeholders: Skiers, safety experts, blasting staff.

Outlook: Further development and implementation.

7.2. App-conceptualization: Voice entry of snow profiles

In coopertion with the University in Vienna, Fabian Türk developed a concept in the frame of his Bachelor thesis.



Summary: With the high-fidelity prototype *Polarfuchs*, an Android-App was developed that enables the entry of snow profile observations in the field by voice. This shall ease the problem of entering data with cold fingers or gloves and reflecting displays due to solar radiation. The volume control of a smartphone is activated for the voice entry. Nevertheless, the App *Polarfuchs* cannot only be handled via headset, as the Google voice entry sometimes requires touch entries. The use of voice entry shall meet the problem of the low battery power in cold temperatures as the users can leave the smartphone in their jackets or pants.

Figure 12 Screenshot of the App *Polarfuchs*

During first trials, the entry by voice was considered as complicated, because of control loops. The entry of the snow profile was divided in smaller packages, the visualization of the snow layers and the temperature, with few loss of information, but usable with a smartphone.

Outlook: Further development and implementation.

8. User-experience

Meeting-Workshop Wikisnow User 11.04.2017 in Lech

Focus: Communication & documentation

Participants: 32 mountain and ski guides form the Arlberg

Programm:

- 1) Introduction Schuster/Berner/Giorgio
- 2) Overview of interviews – new media -Wikisnow -application, Anna Zechling
- 3) Workshop, 15 min. and subsequently presenting 3 important points-FLIPCHART in 5 groups of 6 participants each.

Guiding questions

- Communication/documentation reasons in favour
- Communication/documentation reasons against
- Future: What would we like? What can we imagine?

The following table is an overview of the results of the workshop:

| Zu a, b) Reasons / reservations for documentation (activities, avalanches, ...) | | | |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------|------------------------------------------------------|---------------|
| in favour | | against | |
| reason | number | reason | number |
| Legal protection | 20 | Additional amount of work | 23 |
| Information exchange between guides | 18 | Possible negative utilization | 16 |
| Increased safety / reduction of residual risk | 12 | Excessive transparency of field activities | 13 |
| Increase of self-reflection | 10 | Ease of copy effect?? | 13 |
| Overview: snow conditions | 10 | Push-effect because of the comparisons of runs skied | 3 |
| Quality intensification guiding | 9 | Influence on the own judgement due to the reports | 3 |
| Stimulating ideas for trip destinations | 9 | Loosing "secret" runs | 0 |
| Influence on the official avalanche bulletin | 6 | | |
| Zu c) future | | | |
| <ul style="list-style-type: none"> ➔ Regulars's table ➔ The use of differentiated hazard classifications ➔ Better exchange between areas (St.Anton, Warth) ➔ Improvements in the communication between guides ➔ Spread of critical information in real time ➔ Increased participation ➔ Display the best routes of everyone ➔ Agreement on route names, improved descriptions ➔ User contact list | | | |

- 4) Presentation of the new features of Wikisnow, desktop application and App, one touch location, daily reports MB

Conclusion: The number of participants, 32, was well above the expectation. Within a short timeframe, it was possible to set goals in a factual and constructive way. The participants agreed on willingness for data documentation; the remains will be seen in the next winter season. The next goal is the organisation of a meeting at the beginning of the season 2017/18.



9. Satellite data App

The Europa Space Agency (ESA) provides Sentinel 2 data free of charge, offering high-resolution (10 m), near-realtime (available few minutes after the assimilation) images, with a high revisit rate of 6-8 days. In the context of ICT4snow these are valuable information for example tour planning in spring. However, the accessibility and the processing of the data was an expert-task. A web application, developed in ICT4snow, is now available allowing the project participants to easily select areas of interest, retrieve relevant data and freely use the information in their work. Further processing and analysis of the data was not feasible in this exploratory project, but as the basis for further use is now laid, satellite data will be of great importance in future.

Outlook: This web application is the prerequisite for further applications such as the study on snow depth distribution and avalanche detection. In the follow-up project we intend to apply methods such as deep learning and machine learning to get the most suitable information from the satellite data for snow and avalanche topics.

10. Photonics (summary of literature research)

Over the past years, aspects of photonics (measurements, analysis) were used in the snow and avalanche research. Maybe the most common application is the use of laser technology, also called LiDAR (Light Detection and Ranging) that is an active remote sensing system

working independently from natural radiation (Wehr und Lohr, 1999). It allows a dense sampling of the surface or object within a short time frame and has revolutionized 3D data imaging in the sense that it offers a high-performance alternative to the traditional data sampling methods (Pfeifer und Briese, 2007b). The principles of laser scanning are similar to the microwave and radar and are considered as an expansion of these techniques. The fundamental difference is that laser scanning uses shorter wavelength and consequently is able to acquire data in a higher resolution and higher accuracy (Jelalian, 1992). The use of laser light combine several advantages: high collimation (minor beam divergence), high optical performance and the possibility to trigger very short light pulses (Donges, 1988). Due to the use of relative short wavelength (near infrared), there is a diffusion and scattering of the laser pulses on the particle of the atmosphere (rain, snow or fog) (Jelalian, 1992). The two most important measuring systems in LiDAR are: i) the measurement of the time of flight of the short laser impulses, ii) the determination of the phase displacement between the sent and the received signal (principle of sustained oscillation) (Wehr und Lohr, 1999, Pfeifer und Briese, 2007b). Terrestrial laser scanning (TLS) is a ground based application of LiDAR. It allows the spatial measurement of snow height from several kilometers away, even in difficult terrain, with a high spatial resolution and accuracies of ± 0.05 m (1σ) (additionally a distance dependant error of ≤ 20 ppm) (Adams, 2009; Prokop, 2008). Since 1999 the BFW uses TLS-Systems and further activities are planned in the follow-up project.

Another topic of interest for the use of photonics in snow and avalanche applications is the use of Optical Wireless in combination with existing communications networks such as radio. In mountainous terrain it is often difficult to guarantee a reliable transmission. First talks with experts sparked the hope that a good set-up can be found.

11. The future of the ICT4snow-platform

The experiences that we gathered during the exploratory project are the basis for the concept of a follow-up project proposal. The lessons learnt from ICT4snow are the following:

- 1) **Local contributions - regional profit:** A regional network for the exchange of current snow and avalanche information is seen as an asset, as information become (more easily and faster) accessible, that can otherwise only be retrieved with a high time and effort. This requires that the local end-users will provide their data, but at the same time get access to other data in the time they are relevant and not with a time lag. The following aspects have

to be considered in the future: quality of data, relevance of data, privacy, terms of use etc.

- 2) **Adaptations:** The potential users of the platform have different responsibilities in their area of interest. Therefore, the information representation should be tailored to their specific needs so that each user group gets the maximum asset. Therefore, the implementation should continue to follow the principles of an agile software engineering and the IT-infrastructure should be flexible. This shall meet the wish of a common database, but with user specific analysis options.
- 3) **Interfaces:** The „fear“ of potential users is that they will be confronted with a new system. In many operations, it took a long time until a digital documentation system was accepted and trusted. It cannot be expected that the employees work with a completely new system. Therefore, it is important to establish interfaces to existing systems and not to develop yet another isolated application.
- 4) **Flexible application areas:** User groups that require snow and avalanche information are often not only interested in one specific task. The request for an all-encompassing solution is high. For example a ski area needs to guarantee avalanche safety, but at the same time need to optimise their artificial snow production. Often the decisions in different areas of interest are assessed using the same database. Thus, the data should be analysed and represented for different purposes at the same time.

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