PROSNOW

PROVISION OF A PREDICTION SYSTEM ALLOWING FOR MANAGEMENT AND OPTIMIZATION OF SNOW IN ALPINE SKI RESORTS

PROSNOW demonstrator initial specifications

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Author(s)	Sébastien Bruyère (TEC), Catherine Simonet (TEC)

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Objective of the document

The objective of this document is to give assessments of data visualisation for the PROSNOW demonstrator, considering the demand side and the modeler's suggestions. This is therefore a description of the service, which should be used as an input for the development of the first version of the demonstrator.

The document is also intended to be used for the future service developers which will be interested in replying to the call for interest for the upcoming development and estimate the needed work effort. A call for interest is attached to the current document.

1. Introduction

The PROSNOW project

Snow on the ground is a critical resource for mountain regions to sustain river flow, to provide freshwater input to ecosystems and to support winter tourism, in particular in ski resorts. The level of activity, employment, turnover and profit of hundreds of ski resorts in the European Alps primarily depends on meteorological conditions, in particular natural snowfall but also increasingly conditions favourable for technical snowmaking (production of artificial snow). Since the seventies, ski resort managers have massively improved their snow management practices, initially to mitigate the impact of the large inter-annual variability of snow conditions, and more recently as adaptation measure to the effects of climate change.

Therefore, ski resorts highly depend on appropriate conditions for technical snowmaking (mainly the availability of cold water, as well as sub-freezing temperature with sufficiently low humidity conditions). By means of modern slope preparation and maintenance, snow stock management and technical snow making, a typical resort can approximately maintain the same season duration with 30% less snow. The ski industry increasingly uses advanced technological means for monitoring snow conditions and operating the management methods and could strongly benefit from anticipation tools to assist the decision-making process.

Beyond the time scale of weather forecasts, managers of ski resorts have to rely on various and scattered sources of information, hampering their ability to cope with highly variable meteorological conditions. Improved anticipation capabilities at all time scales, spanning from “weather forecast” (up to 5 days usually) to “climate prediction” at the seasonal scale (up to several months) holds significant potential to increase the resilience of socio- economic stakeholders and supports their real-time adaptation potential.
The PROSNOW project will build a demonstrator of a meteorological and climate prediction and snow management system from one week to several months ahead, specifically tailored to the needs of the ski industry. PROSNOW will apply state-of-the-art knowledge relevant to the predictability of atmospheric and snow conditions. The associated products will address ski resorts needs beyond state-of-the-art tools.

The added value of such services for ski resorts will be investigated and documented. The project proposes an Alpine-wide system (including ski resorts located in France, Switzerland, Germany, Austria and Italy). It will join and link providers of weather forecasts and climate predictions at the seasonal scale, research institutions specializing in snowpack modelling, a relevant ensemble of at least 8 representative resorts in the Alps, technical bodies representing ski resorts managers, and a group of private providers proposing high tech services for snow management (on-tracks snow depth monitoring, snowmaking systems, prediction systems, apps, up to the slope scale …). The added value of the demonstrator will be assessed for the ski industry, but also for additional stakeholders including local and regional tourism authorities, hydropower managers, and natural hazard forecasters and planners. Beyond the design, development and

implementation of the demonstrator itself, PROSNOW will assess the economic added value of the developed product, consolidate the legal frameworks capable of allowing the operational implementation of the demonstrator, and initiate a market dissemination.

2. Overview of the demonstrator characteristics

Main objective

The PROSNOW project will build a demonstrator of a meteorological and climate prediction and snow management system from one week to several months ahead, specifically tailored to the needs of the ski industry. PROSNOW will apply state-of-the-art knowledge relevant to the predictability of atmospheric and snow conditions. The associated products will address ski resorts needs beyond state-of-the-art tools.

Service description

The PROSNOW product will blend data from various sources, including:

- Observations from ski resorts themselves (meteorological data from standard observing stations as well as sensors associated to snowmaking units (e.g. TECHNOALPIN systems), snow depth outside and on ski slopes using sensors embedded in grooming machines provided by existing technology (e.g. SNOWSAT, CGX AERO) and from remote sensing data (snow cover map at various geographical scales (e.g. EURAC contribution).
- Seasonal forecast data (Copernicus Climate Change Services) will be downscaled and adjusted to ski resorts conditions using the meteorological records available (statistical techniques) by MF. Seasonal forecasts will be complemented by submonthly forecasts provided by ECMWF through MF or other scientific partners (WSL, UIBK, BOKU).

Then, these downscaled predictions will be used as such in terms of future meteorological conditions (e.g. forecast of conditions appropriate for snowmaking) or to drive snowpack models equipped with the simulation of processes occurring on ski slopes (grooming, snowmaking) so as to provide an integrated vision of the future state of snow on ski slopes at the submonthly to seasonal time scale, depending on the management decision (e.g. with and without snowmaking). Such results, both concerning meteorological and snowpack state, will be produced in an ensemble framework.

This is rendered necessary to handle the uncertainty of the prediction given the dispersion of meteorological scenarios at the sub-monthly to seasonal scale, and this will require appropriate visualization and statistical post-processing in order to make it usable by technical resort managers. This essential step will be carried out in collaboration with the ski resorts. Prediction data will be systematically provided alongside the climatological state, in order to assess deviations to the “normally expected” situation at the ski resort level and infer the added- value of the PROSNOW product.

What is the demonstrator

The PROSNOW demonstrator is defined by the visualization of the PROSNOW data on all supports, i.e. information managed by existing cooperating providers and displayed as complementary information on their interfaces (referred as *integrated demonstrator*), and

information displayed on internally developed interface (referred as *stand-alone demonstrator*). The specifications here-mentioned do only refer to the *stand-alone*.
The PROSNOW demonstrator is a web-based user oriented platform.

End-users

The end-users of the PROSNOW demonstrator are the ski resort technicians, which means :

- Ski resort managers
- Snow production managers
- Grooming managers
- Ski lift managers
- Tourism office managers

The aimed ski resorts are the ones from the Alpine-wide system in a first approach but will lately be extended to other areas.
According to their different needs, the choice of visualised variables may differ from one end-user to another.

Technology

To enhance the access and the use of the service, the demonstrator shall be a web-based interface with geolocated information and interactive chart display. Eventually, smart applications will be developed if complementary surveys conducted by the project team show interest from end-users.
Technology choices for the development will be at the developer's choice as long as they do meet the mandatory functionalities.

Main functionalities

The demonstrator shall allow end-users to :

- Browse spatially geolocated information on an interactive map (scrollable)
- Browse data for different time scales using buttons or other functions (interactive timeline)
- Display several colors on each polygonal grid point on the map (which will correspond to a pre set-up zone fitting to ski slope parts and named SRU for Ski Resort Unit)
- Manage different data configurations (related to snow or meteorological variables) corresponding to snow scenarios, which can correspond to different data layers
- Display interactive charts with specific information attached to each SRU

3. Demonstrator main architecture

Overall architecture

The demonstrator architecture shows the link between interface screens of the demonstrator.

This architecture is based on the current tool mock-up and is likely to evolve.

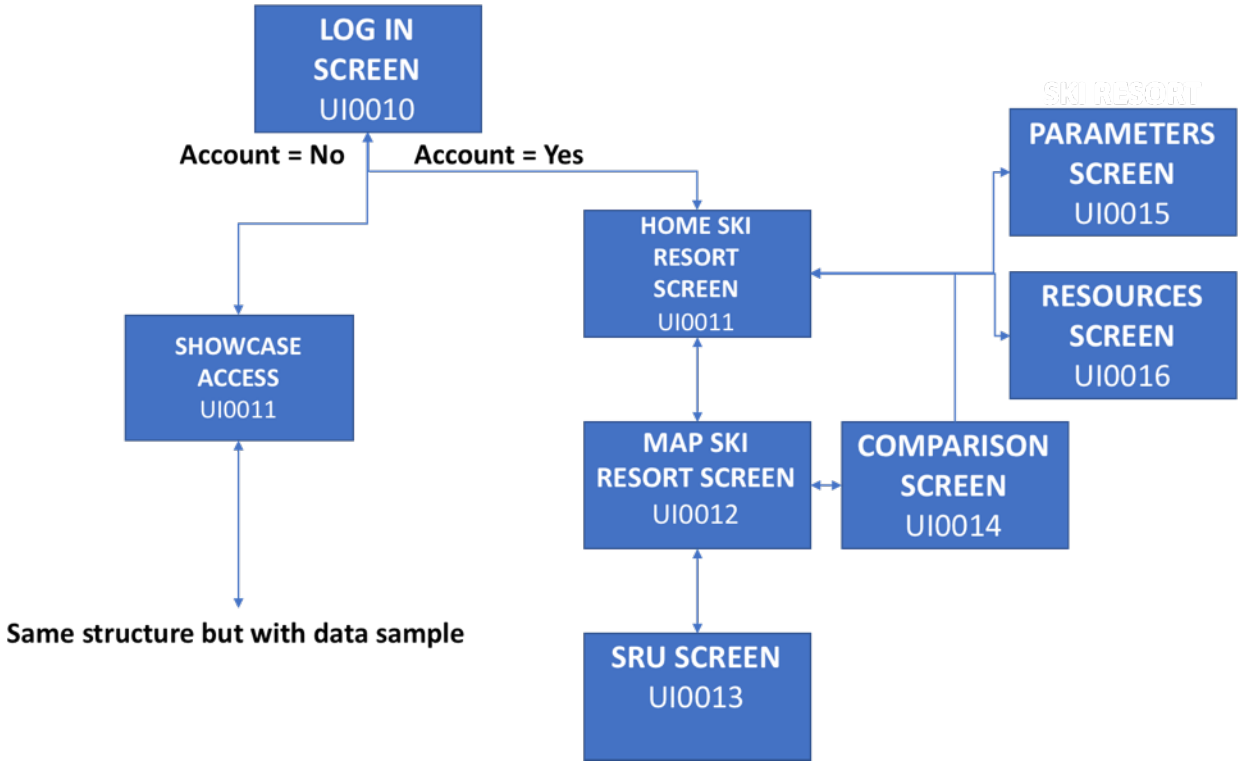

Figure 1 : demonstrator architecture

Detailed content of each screen

Screen log	Screen log	Specificities
UI0010	If the user is not logged in to the website, the Demonstrator SHALL present an interactive access of an example of ski resort (showcase) based on a voluntary ski resort or fictitious one (not real time access).	- Password (log in)
UI0011	The *home ski resort* screen is the entrance screen, SHALL display an overview of the ski domain with favorite colored geolocated variables. It shall also provide browsing functionalities to circulate quickly between critical ski resort zones (depending on values or sectors).	- Geolocated data - Adjustable zoom - Report functionalities - Warning systems
UI0012	The *map ski resort* screen corresponds to the interactive display of the geolocated information. It is a full screen with geolocated information. It shall be possible to geographically browse the data and to click on each SRU.	- Adjustable zoom - Adjustable pan - Selectable zones (SRU) - Selectable variables or time/data configurations
UI0013	The Ski Resort Unit screen (*SRU* screen) is the display of specific information related to each SRU (charts, values, other information).	- Specific charts - Data log - Adjustable timeline - Selectable charts - Interactive detailed information reading
UI0014	The *comparison* screen corresponds to the opportunity to split the screen and compare two different configurations of geolocated information	- Display of two types of information - Split screen - Independent adjustable zooms
UI0015	The *parameters* screen will gather functionalities to set up or customize the use of the demonstrator (choice of colors for the scales, favorite variables, critical slopes)	
UI0016	The *resources* screen will display report information about the use of the service (savings, efficiency).	

Graphic charter

The graphic charter will be based on the one from the mock up and graphic elements used on PROSNOW communication tools.

4. Data visualization principles

General visualization

The interface of the demonstrator shall display 2 main data categories, geolocated data (colored SRUs according with colors related to different scalable variables) and charts for each SRU (different kind of charts according to the type of variable).
The input data will be provided with data containers containing all needed values for each SRU and for each needed time window (pre-selected time windows, from hour 0 up to day 90).

Type of variables

The variables managed by the interface are from different kinds :

- Meteorological (air temperature, wind speed, precipitation, etc.)
- Climatology (use of past tendencies and thresholds)
- Snow related (snow depth, snow water equivalent, production period, etc.)
- Water related (water consumption, production time)

Each variable has specific units (mm, °C, m3, etc.) but some shall appear on geolocated map (with colors) and when the data is not available for geolocation, it shall only appear while clicking on each SRU screen (wind for instance).

Geolocated information

Scalable variables shall be displayed on geolocated maps, with adjustable zoom and scrolling functions. Regarding the specific scale of each variable, a colored legend will be applied for each variable.
Example : the snow depth shall appear in different colors (red for snow depth lower than 4 cms up to blue for more than 150 cms) according to the average snow depth value of each SRU.
The lower zoom shall correspond to the SRU size (100 m) . The higher zoom shall correspond to the ski resort domain (up to 20 km X/Y).
The definition of the color and its transparency shall be customizable for each user. Therefore the demonstrator should manage and apply different colors for different variable scales, according to the user's choice.

Data aggregation

Depending on the zoom level, the geolocated data eventually might be aggregated and show aggregated values corresponding to multiple SRUs.

Warning

Warning systems eventually might be used to highlight critical values. These warning systems shall depend on the type of variable and the defined thresholds.

Charts

Each SRU will be attached a series of values for each needed variable and each simulation time window. While clicking on the SRU, the charts shall be automatically displayed. Different types of charts shall be displayed, quantile charts, bar charts, histograms, etc. These charts shall be displayed on mid to long term periods (from hours to months) and the display of time periods shall be interactively manageable (interactive timeline).
The timeline parameters shall be customizable, according to the user's choice.

Comparison

The comparison of the data shall be managed with split screens. Therefore it shall be possible to display two configurations or two variables on the screen.

Customized interface

As the different end-user may have different expectations, the interface shall offer enough parameter options to customize the data display of variables and charts, especially on the SRU screen.
Therefore, the choice of chart types, the favorite variables and the definition of colors shall be customizable according to each user's choice.

Complementary visualization functionalities

Complementary icons and buttons shall be active on each screen when needed to allow :

- Circulation between screens
- Come back to the home screen
- Get a printable output of the screen
- Display legends (scales and units)
- Switch between variables, time windows or data configurations

5. Data flow

Data flow overview

Once the data is produced and post-processed (by the PROSNOW team), it will be channelized through an information system allowing direct integration (through webservices) in the graphical user interface of the end-users, i.e the demonstrator.

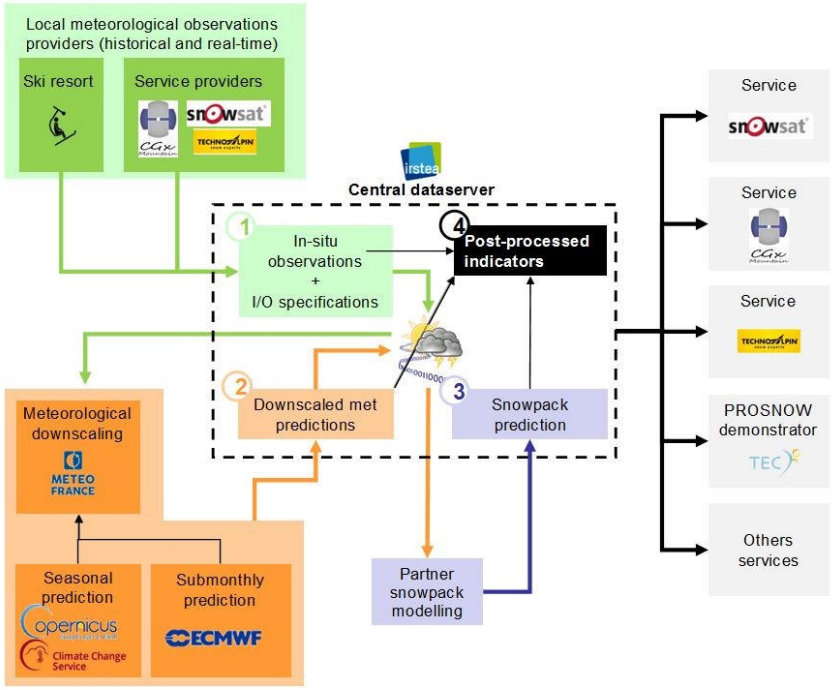

Figure 2 : data flow overview

Input data

The input data will be provided by the PROSNOW team and sent from a unique source, a central data server.

Details of file formats will be provided by the team. And a data sample will be prepared for development needs.
The demonstrator is not expected to compute the input data.

Data management

The demonstrator will focus on the display of the input data. Eventually, it should manage the data for reporting needs.
The data flow

Output data

The data displayed by the demonstrator shall be exportable, either with printable image or with a report file.
No data needs to be sent back to the central data server.

Update frequency

The update frequency of the data is expected to be between 6 and 12 hours, depending on the update frequency of the input data.

6. Data management

Confidentiality

As the demonstrator shall provide confidential data for its users, the confidentiality of the data managed for each account needs to be ensured. The web-based interface should provide restriction access (account).

Data log

The data log shall be used for reporting needs. It can be either done on a central server or stored on computers.

7. More information

More information is available on the PROSNOW website : www.prosnow.org .

Or @ : sebastien.bruyere@tec-conseil.com

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