METHOD OF SELECTION AND INPUT DATA TO CREATE EVENT SCENARIOS

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ABSTRACT: The web-platform for the Avalanche Local Commissions (CLV) was developed as a operational tool to facilitate the avalanche hazard management. This tool allows accessing data present in the area (nivo data, weather, bulletin, snow-poles, etc ...), archiving and tracing all the CLV activities.
The Project Art_Up_Web as a part of P.O. Italy-France 2014-2020 (Alcotra) includes experimental implementation of the web-platform with a section dedicated of the pre-processed data, such as avalanche risk scenarios, referring to events that interact with the roads, infrastructures, … For the definition of the event scenarios we proceeded with the analysis of documented real events presents in the Regional Web Avalanche Cadastre (photographic documentation, the event area, snow and meteorological field data, ...), integrated with the data of the automatic weather stations (snow level, wind direction and intensity), and spatialized with specific numerical models (S3M - Snow Multidata Mapping and Modelling, COSMOi2). So a database has been structured for run a tool, in a GIS area, that define the automatic release area which can be integrated with avalanche dynamic models for the run-out area.
The goal is to make available, in real time, the images of the potential release scenario in relation to the expected weather conditions to facilitate an objective analysis of CLV.

KEYWORDS: Avalanche Local Commissions (CLV), Dataset, Avalanche scenarios, road management.

1. ROAD MANAGEMENT - INTRODUCTION

The Autonomous Region of the Aosta Valley (RAVA) is situated in the far north-western part of Italy. It is a completely mountainous region (3263 km²) 60% of its territory is at altitudes above 2000 m a.s.l. 12 lateral valleys flow into the main valley in herring bone formation, each one separated from the other by high mountains with steep slopes…During the winter the Aosta Valley is a tourist destination for winter sports and for that we need to keep the road open also along the lateral valleys. In the past ten years, 110 avalanches reached or obstructed the regional roads [Avalanche Warning Service of Aosta Valley, 2016]. Its high mountains are an ideal playground for Alpine skiing, free riding, free style snowboarding, cross-country skiing, skiing excursions, ski mountaineering, telemark, skiing, heliskiing, kite surfing. The most important ski areas are the international ones of Breuil–Cervinia (lying between Italy and Switzerland) and La Thuile (lying between Italy and France) and the three all –Italian Monterosa Ski Valleys. Nearly three quarters of the regional workforce is employed in the service sector with tourism and its connected activities as its heart.

In the past, to ensure and improve the risk avalanche management on the roads and infrastructures, it was decided to realize many defense structures (Fig. 1). In the last few years, the natural hazards risk management involves the consolidation of decisions based on approved methodologies and tools. Even more, in this time of economic hardship, the solution of the problems related to the management of natural hazards through the implementation of defense structures appear anachronistic and inappropriate. Often, in fact, the creation of these structures, costly in economic terms, solve specific problems linked to very specific cases. Moreover, these works require, in the following years, major interventions for maintenance and to ensure their effectiveness and efficiency. Vice versa, the implementation of consolidated methodologies and tools allows to extend the solution of the problem to wider geographical areas that are not related to a specific problem or territory, but which may extend to all natural hazards risk even beyond national borders. All of this involves a lower economic resources expenditure with the advantage of extending the benefit to a greater number of end users.

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Fig.1: Avalanche defense structure along the regional road to Cogne

Of course, the tools and methodologies, to be effective and to meet the real needs of land management, have to pass through an attentive validation phase, which can require years of testing and controls. This validation phase consists of surveys and tests on experimental sites, but also on the real sites where to apply the methods, to identify their strengths and weaknesses and try to extend the methodology to wider regional contexts. Even in this case, as in the design of engineering structures, still more effort is required in order to provide common natural risk management methodologies, through the development of reliable numerical models or modeling approaches which are applicable to situations in practice. In addition, the management implications arising from the methodologies application should be fully accepted by the stakeholders.

Example of the methodology applied to land management within the project Start it up (Alpine Space 2007-2013) is the development of web platform to support decision-making for the CLV. A tool that required a small cost, but that allows you to optimize the management of avalanche risk on an entire region [Segor V. et al., 2014].

The web platform was built in 2014 and has been tested during the 2014-2015 winter season. During the 2015-2016 winter season, it has been fully working and now can be considered the main tool, used by the CLV, to risk avalanche management on the Aosta Valley roads. More than 21.000 activities were carried out within the platform by the Commissions, including pages viewed, links clicked, reports, requested graphic, minutes, etc ...

2. THE ARCHITECTURE OF CLV PLATFORM

The Web platform is structured in several interactive sections (Fig. 2), described below:

Public home page. It is the institutional page and the only public one of the website. It presents a map of the Aosta Valley area divided into zones under the responsibility of each CLV;

CLV home page. Accessible only after the login at Public home page, the CLV home page is common and visible to all the CLVs;

Data – info box. It contains a list of dynamic and customizable links to monitor the current snow and weather conditions and prediction, the snowcover stability;

CLV Activities Register. It contains the history of the daily monitoring carried out during the winter;

Minutes. This is the page to support the CLV to prepare, thanks to predefined masks, reports of activities and technical support to the Mayor, especially in the case of critical situations;

Budget. Starting from the annual funding available for each CLV, in this page the CLV members can update the budget reporting the expenses incurred by each CLV;

Avalanche Activities Planning. It contains the PAV (as defined in the DGR n.2774/2010) directly connected to regional Web Avalanche Cadastre on regional platform "Partout" (Debernardi and Segor, 2013);

Registry. It is the CLV register containing the information of its components, together with a backup of the activities carried out in past winters - CLV Activities Register - archived in .rar format and that may be downloaded.

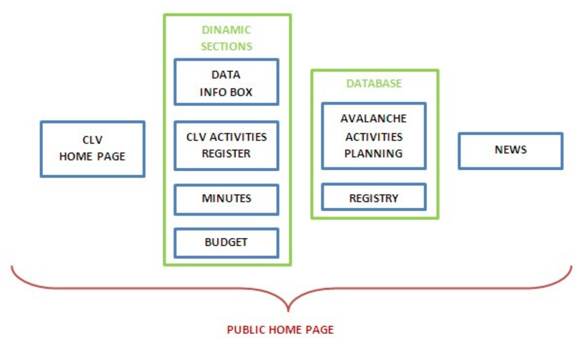

Fig. 2: Scheme of the CLV website with the contents of its interactive sections

For the design, construction and the production of the application, the choice fell on tools and frameworks exclusively Open Source, in order to optimize the initial costs of development that reduce future operating costs of the hardware and software supports, but also to facilitate the possible implementations and supplementary applications.

One of the additional applications, under development within the ART_UP_WEB project - Operational Programme "Italy - France (Alps - ALCOTRA) 2014-2020", involves a new section dedicated to the avalanche release area scenarios, using the avalanche tool PRA (@Potential Release Area). The tool PRA has been developed by SLF, also within the Operational Programme "Italy-Switzerland 2007-2013" - STRADA [Veitinger J. et al., 2014]. The GIS based tool estimates potential release areas, with introducing a scale dependent roughness parameter (Fig. 3).

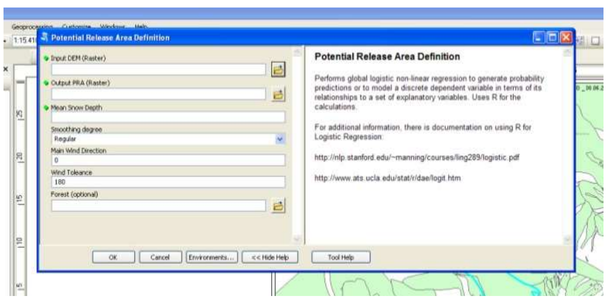

Fig. 3: Tool 'Avalanche' Potential Release Area Definition (PRA), in ArcGIS 10.2

Within the Operational Programme "Italy-Switzerland 2007-2013" - CAPVAL project, the Avalanche Warning Service of Aosta Valley (UNV) has tested the PRA tool in many real cases occurred in the Aosta valley. In order to develop a procedure to define the avalanche release area scenarios and to create a special "scenarios" section within the web platform. Therefore, the review of the data available was realized to carry out PRA simulations and to try to automate the scenarios creation processes.

3. DATASET STRUCTURE AND AUTOMATION PROCEDURES

The input data needed to PRA simulation are three:

DEM (2 meters), that simulates the roughness of the slope.

Hs, that defines the snow depth in the release area.

Wind, that defines the wind direction and the wind tolerance.

Corcerning the DEM data, the regional DTM data (mesh of 2 km) have been used with a resolution of 2 m, provided by regional Ufficio Cartografico. SLF in Davos is developing a tool for a resolution DEM of one meter.

Concerning Hs data, to try to objectify the input data selection, the Hs data modeled with S3M (Snow Multidata Mapping - provided by Centro funzionale) has been used and validated by comparing the simulated data from the model with the Snow and Avalanche bulletin data. The S3M model returns Hs data for 2 altitude range (between 1750 and 2250 meters a.s.l. and between 2250 and 2750 meters a.s.l.) and for 4 regional macro areas (A, B, C or D) (Fig. 4) . At the moment, from the information provided by SLF in Davos, the PRA tool only works with Hs value greater than 1 m, with an estimated DEM to 2 m of resolution.

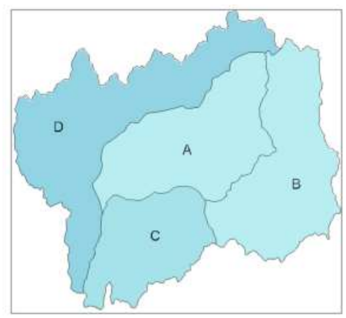

Fig. 4: Representation of regional macro areas, from which the Hs data were returned by S3M model

Concerning Wind Direction e Wind Tolerance data, to try to objectify the input data selection, a new methodology was developed. The new methodology uses the wind data modeled with COSMOi2 model, provided by Centro Funzionale.

Once collected the DTM, Hs and Wind data, the avalanche events to simulate with PRA tool have been chosen.

The choice of avalanches events to simulate was done following three criteria:

Availability of the photographic documentation of the release area.

Availability of the event perimeter realized by Avalanche Warning Service of Aosta Valley.

Slab detachment.

This choice was made to validate the results of the PRA tool modeling with the real data available in the regional Avalanche Cadastre (CRV) (Fig. 5).

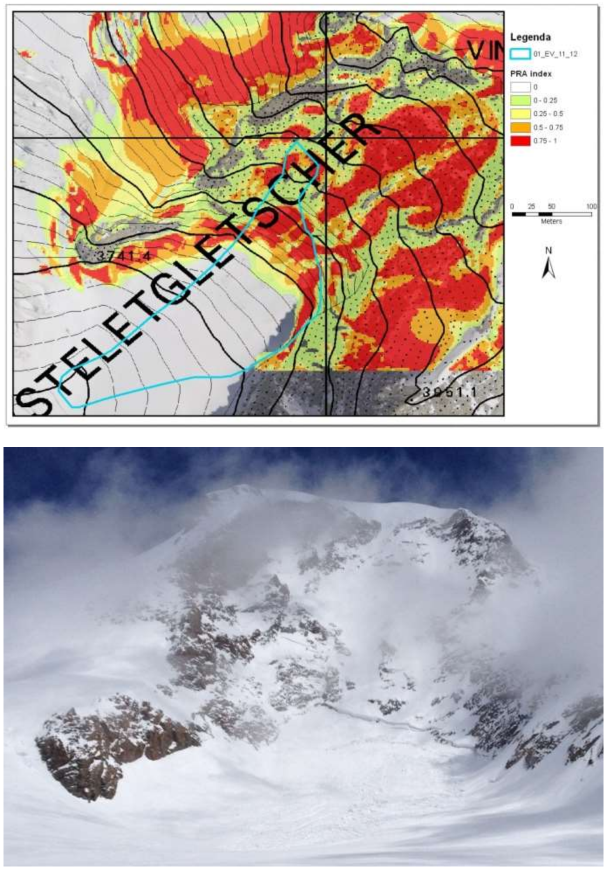

Fig. 5: PRA tool simulation (above) and event photo (below). In this case, there is a good correlation between the simulation and the real event. The blue line represents the release area limit.

In view of the volume of the historical data, the PRA simulations required a long time of manual data entry. Moreover, some problems were found relating to the different input data insertion. Two goals have been set: to solve the problems encountered in input data insertion and to speed up data entry, by automating processes.

First of all, in order to reduce the simulation number, the choice of avalanche sites to be analyzed was limited to only avalanche events contained within the P.A.V.(Plan Avalanche Activity). However, the number of events to simulate resulted very high.

At this point, a dataset has been structured in order to organize the data to allow a semi-automated input data insertion in the dataset and to automate the PRA simulation processes.

Through the "Python" language was possible as follows:

- concerning DEM data, a single DTM data was created by uniting the all DTM meshes of the Aosta valley. In fact, an avalanche area located on two or more DTM meshes required more PRA simulations, depending on the number of DTM meshes interested. Subsequently, a Script Python called “Estrai valanghe” has been created. The Script permit to cross the shapefile of the avalanches limit, referred to historical event, and the entire regional DTM, and to extrapolate, automatically, a .asc file for each avalanche areas of the P.A.V.. Then, the area of interest was enlarged with a buffer of 200 m, around the avalanche perimeter, in order to display a larger spatial context (Fig. 6);

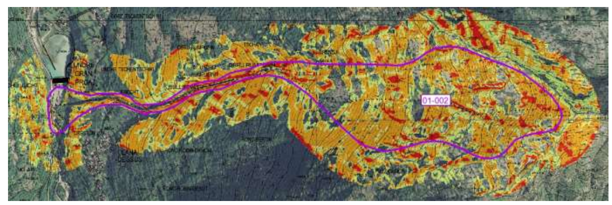

Fig. 6: Scenario PRA. In purple the extreme event perimeter. Note the 200 m buffer that allows a better visualization of the avalanche area.

-concerning Hs data, the data insertion required a double job: to define the altitude range, where you place the release area, and to define the Hs data for event date and for regional macro areas (Fig. 4). The procedure requires the insertion of data from multiple datasets, increasing the probability of error. A Script Python called “quote_auto” has been created. The Script permit to define, automatically, for each avalanche area, the altitude of the release area. Subsequently, a Script Python called “hs_auto” has been created. The Script permit to extrapolate, automatically, the Hs values (20th percentile, mean and 80th percentile), simulated by S3M model, according to the event date and the regional macro areas.

The available S3M data starts from 2008.10.01;

- concerning Wind direction data and the Wind tolerance data, the COSMOi2 data, provided for experimetal use, by the Centro funzionale, has been used. In particular, the wind direction and intensity data, at 10 m from the ground, have been used.

In the first step, a regular grid around the points provided by the model and included in the Aosta Valley has been built. Subsequently, a Script in R has been created to organize the wind intensity and direction data in a .xls table, according to COSMOi2 points and to event date, with an interval of 3 hours (Fig. 7).

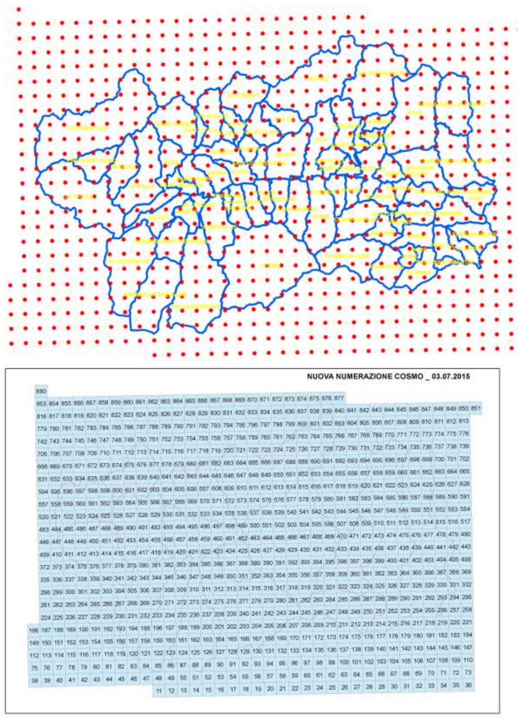

Fig. 7: Regular grid created around COSMOi2 points included in Aosta valley

Concerning Wind Direction and Tolerance data, it is a very important and sensitive parameter to vary considerably the propensity to detachment of an avalanche. The tests are still ongoing to correctly evaluate the wind direction and tolerance depending on the wind intensity, which affects the snow wind transport.

Moreover, the data of the COSMOi2 cell must be evaluated with the data of the neighboring cells (Fig. 8), in order to detect any anomalies.

5-250	8-250	6-260	9-180	12-250
8-240	10-200	10-220	10-250	10-180
10-230	12-230	8-250	12-200	8-180
6-180	8-220	9-180	10-250	5-150

Fig. 8: In red, the cell considered, in orange the cells that need to evaluate the Wind input data

4. AVALANCHE SCENARIOS FROM DATASET

The all input data (DTM, Hs and Wind direction and tolerance), necessary to the PRA tool simulation, are inserted, semi automatically, in a file .xls, through the use of the Script Python and R (Fig. 9). The data included in the dataset are as follows:

n. comprensorio (COMP), in which the Aosta valley has been divided;

n. avalanche (N_VAL), located within the comprensorio;

general data, such as: if the avalanche event considered to be inserted in the P.A.V. (PAV), if you have the release area shapefile (Shp distacco) and the Photo (Foto) and, in particular, the release area photos (Foto distacco);

event date (Data), date referred to the avalanche event;

altitude (Quota), according Hs data by S3M model;

link (Link CRV) to UNV dataset, showing photos and event informations contained in the avalanche CRV;

Hs (Hs 20, Hs med, Hs 80), by S3M model according altitude and event data;

Wind direction (direzione vento) and tolerance (tolleranza vento), resulting by Cosmoi2 model and in the process of further analysis;

the input data required for the PRA tool simulation, such as: Smooting e Forest;

DTM number (Num DTM) for the avalanche area, resulted automatically from the first two columns of the .xls table and the name (Nome DTM) that will be automatically assigned to the simulation to generate the .asc files.

Generale								
COMP	N_VAL	PAV	Shp distacco	Foto	Foto Distacco	Data	Quota	Link CRV
01	002	SI	SI	SI	Si/No	20081215	1750_2250	valanga01_002
01	002	SI	SI	SI	Si/No	20090429	1750_2250	valanga01_002
01	018	SI	SI	SI	Si/No	20081215	2250_2750	valanga01_018
01	029	SI	no	SI	Si/No	20081215	2250_2750	valanga01_029
01	029	SI	no	SI	Si/No	20081216	2250_2750	valanga01_029
01	029	SI	no	SI	Si/No	20090228	2250_2750	valanga01_029
01	029	SI	no	SI	Si/No	20090302	2250_2750	valanga01_029
01	029	SI	NO	SI	Si/No	20090305	2250_2750	valanga01_029
01	029	SI	NO	SI	Si/No	20090316	2250_2750	valanga01_029
01	029	SI	SI	SI	Si/No	20090429	2250_2750	valanga01_029

INPUT PRA									
Hs 20 [cm]	Hs med [cm]	Hs 80 [cm]	Hs 4 [cm]	direzione vento	tolleranza vento	Smoothing	Forest	Num DTM	Nome DTM
160	219	264		135	45	Regular		01_002	DTM_01_002.asc
180	268	328		270	45	Regular		01_002	DTM_01_002.asc
200	250	293		135	45	Regular		01_018	DTM_01_018.asc
200	250	293		135	45	Regular		01_029	DTM_01_029.asc
226	284	338		135	45	Regular		01_029	DTM_01_029.asc
146	171	201		315	45	Regular		01_029	DTM_01_029.asc
146	171	201		315	45	Regular		01_029	DTM_01_029.asc
194	225	263		180	45	Regular		01_029	DTM_01_029.asc
174	203	236		0	45	Regular		01_029	DTM_01_029.asc
267	357	420		270	45	Regular		01_029	DTM_01_029.asc

Fig. 9: The dataset organization with the input data for the simulation PRA

Obtained the input data with automated procedure, it worked to reduce the simulation timing. The PRA tool allows to perform a simulation at a time, occupying the operator's computer that, once a simulation performed, manually proceeded to the launch of other simulations. To solve this problem, the regional INVA company, which operates in the ICT (Information and Communication Technology), in collaboration with a student teacher of the UNV, have implemented the PRA tool to automate the processes of generation of the simulations, and they have created a new tool called PRA_BATCH, in Python code and GIS based.

The PRA_BATCH tool launches a routine, based GIS, that enters data manually for each individual simulation, taking the input data of every single line of the excel dataset. For each simulation, the tool generates a .asc file, a .pdf file and a .jpg file, to permit a rapid and immediate view of the avalanche release area scenarios. All files are automatically saved in folders explicitly indicated in the routine as "Output Folder" (Fig. 10).

NOME OUTPUT			
Sintesi Risultati	PRA: Hs1, W0	PRA: Hs1, W1	PRA: Hs1,W2
	01_002_20081215_160_135t45.asc	01_002_20081215_219_135t45.asc	01_002_20081215_264_135t45.asc
	01_002_20090429_180_270t45.asc	01_002_20090429_268_270t45.asc	01_002_20090429_328_270t45.asc
	01_018_20081215_200_135t45.asc	01_018_20081215_250_135t45.asc	01_018_20081215_293_135t45.asc
	01_029_20081215_200_135t45.asc	01_029_20081215_250_135t45.asc	01_029_20081215_293_135t45.asc
	01_029_20081216_226_135t45.asc	01_029_20081216_284_135t45.asc	01_029_20081216_338_135t45.asc
	01_029_20090228_146_315t45.asc	01_029_20090228_171_315t45.asc	01_029_20090228_201_315t45.asc
	01_029_20090302_146_315t45.asc	01_029_20090302_171_315t45.asc	01_029_20090302_201_315t45.asc
	01_029_20090305_194_180t45.asc	01_029_20090305_225_180t45.asc	01_029_20090305_263_180t45.asc

Fig. 10: View of the dataset with the name of the automatically generated output file for the simulation PRA

A layout that contains all the elements necessary for the correct interpretation of the file has been structured to coherently display the release area scenarios created by the PRA_BATCH tool. The layout contains: PRA legend, North, scale, indication of the comprensorio, indication of the avalanche event and the perimeter of the historical event (Fig. 11).

In additions, the name of the file created by PRA_BATCH tool (.asc, .pdf or .jpg) contains the main elements that characterize the scenario: indication of the comprensorio, indication of the avalanche event, event date, Hs data and Wind direction and tolerance data. These elements allow to collect orderly the files into pre identified folders. The file name is generated automatically thanks to the routine created in the .xls file (Fig. 10).

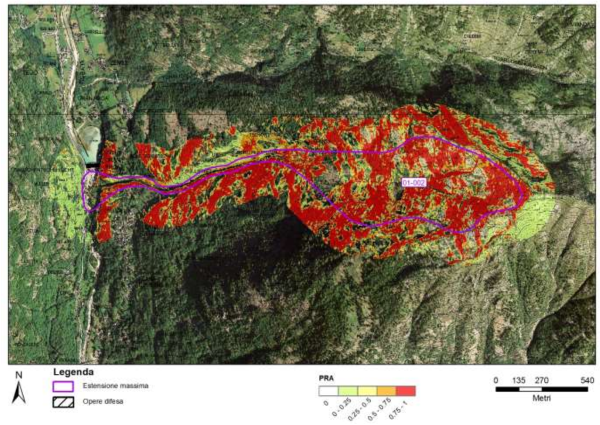

Fig. 11: Viewing the layout created for the PRA_BATCH tool

In consideration of the good results of the time reduction obtained for the creation of the one avalanche release area scenario, two different datasets have been created: one for the creation of the avalanche prediction scenarios and the other for the creation of avalanche scenarios obtained with the processing of historical data present in the Avalanche Cadastre of the Aosta Valley (CRV).

In the first dataset (prediction) the Hs data input and the Wind data input are generic, in order to represent, as far as possible, the greatest number of situations that might occur within each P.A.V. area. In this regard, four Hs values have been included (100, 200, 300 and 400 cm) and five wind conditions (wind absence, 0°, 90°, 180°, 270°, tolerance =+/- 30°) (Fig. 12 and 13).

Generale							INPUT PRA							
COMP	N_VAL	PAV	Shp distacco	Foto	Foto Distacco	Link CRV	Hs 1 [cm]	Hs 2 [cm]	Hs 3 [cm]	Hs 4 [cm]	Smoothing	Forest	Num DTM	Nome DTM
01	002	SI	SI	SI	Si/No	valanga01_002	100	200	300	400	Regular		01_002	DTM_01_002.asc
01	018	SI	SI	SI	Si/No	valanga01_018	100	200	300	400	Regular		01_018	DTM_01_018.asc
01	025	SI	SI	SI	Si/No	valanga01_025	100	200	300	400	Regular		01_025	DTM_01_025.asc
01	029	SI	SI	SI	Si/No	valanga01_029	100	200	300	400	Regular		01_029	DTM_01_029.asc
01	030	SI	SI	SI	Si/No	valanga01_030	100	200	300	400	Regular		01_030	DTM_01_030.asc
01	031	SI	SI	SI	Si/No	valanga01_031	100	200	300	400	Regular		01_031	DTM_01_031.asc
01	032	SI	SI	SI	Si/No	valanga01_032	100	200	300	400	Regular		01_032	DTM_01_032.asc
01	035	SI	SI	SI	Si/No	valanga01_035	100	200	300	400	Regular		01_035	DTM_01_035.asc
01	035_A	SI	SI	SI	Si/No	valanga01_035_A	100	200	300	400	Regular		01_035_A	DTM_01_035_A.asc

Fig.12: Viewing of the prediction dataset with the input data for the PRA_BATCH tool simulation. You can see the generic HS values (100, 200, 300, 400 cm). The wind direction and tolerance data are automatically included thanks to Python Script

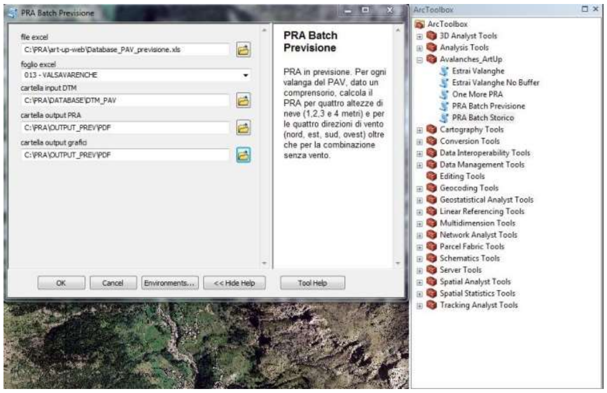

Fig.13: Viewing of the prediction PRA_BACTH tool, based GIS

Concerning the avalanche scenarios obtained with the processing of historical data, the input data represent the real Hs and Wind conditions recorded in the avalanche release area at the time of the event. These data are automatically retrieved from S3M model and Cosmoi2 model (Fig. 14).

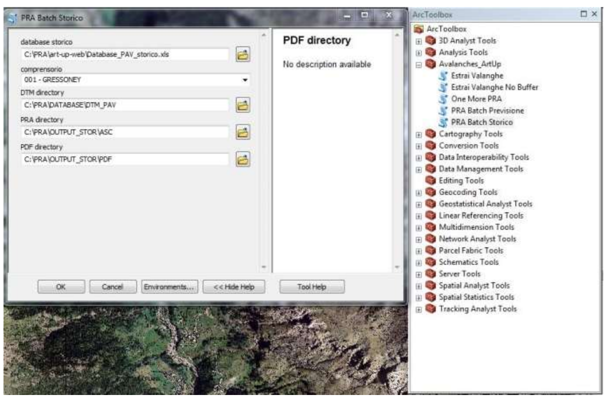

Figure 14: Viewing of the “historical” PRA_BACTH tool, based GIS

5. CONCLUSIONS

The application of the Python Script and R has allowed the reorganization of existing dataset, obtaining the Hs and Wind values, with automated procedures, for a large number of historical events. These events are confined to avalanche areas that have been characterized cartographically with a specific DTM.

Always with the Python script use, based GIS, it was possible to automate the PRA tool, developed by the SLF, and to create the new tool PRA_BATCH. This tool allows you to automate the creation of PRA simulation processes for avalanche release areas scenarios, both in prediction both processing the historical data contained in the CRV.

The automation has allowed to obtain, for different P.A.V. areas, a large number of scenarios with different probabilities of the avalanche release, created with the tool PRA.

However, this procedure is still experimental, because the input data are the result of subjective analysis (eg. Wind direction and tolerance) and of the data modelled by models (eg. COSMOi2 and S3M). The scenarios validation needs further analysis and investigations.

The next phase will see a critical analysis of the different scenarios through the comparison with the CLV Commissioners in order to characterize a single avalanche area. Subsequently, only the scenarios that have been validated will be included in the CLV web Platform to support the Commissioners in the avalanche risk management on the roads of the Aosta valley (Fig 15).

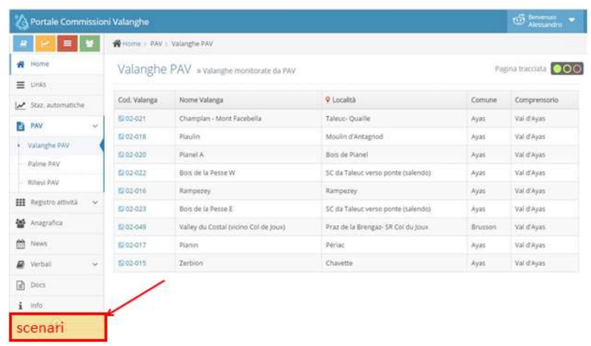

Fig.15: Viewing “scenarios” section, of the future creation, into the CLV web Platform

6. ACKNOWLEDGEMENTS

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- the project “STRADA” – “Strategies for adaptation to climate change for the management of natural hazards in the border region - Operational Programme under the

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