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THE MODERNISATION OF THE AVALANCHE DANGER FORECASTING SYSTEM IN THE POLISH TATRAS – PAST AND PRESENT STATUS

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ABSTRACT

The paper presents on overview of the problems and challenges related to the complex modernisation of the system for the avalanche hazard permanent monitoring and forecasting in the area of Polish Tatras. These works were undertaken by the hydro-meteorological service in the Institute of Meteorology and Water Management (IMWM) in Kraków,
This system includes the meteorological and snow data measurements collection, production of avalanche forecasts and bulletins as well as their distribution. It also includes the general public education campaign. The avalanche hazard will be prepared using the French numerical models such as Crocus, Safran, Mepra and Aladin. These models were obtained from METEO FRANCE (CEN - Grenoble and GMAP - Toulouse) as a result of the long-term close co-operation between METEO FRANCE and IMWM. The experience gained during installation and implementation of these models will be presented.
It is expected that the system will enable to increase the people's safety in the mountains as well as will help to mitigate the economical and ecological damages of the environment.

Key words: snow avalanche, Tatra Mountains, avalanche hazard forecasting

THE TATRAS ENVIRONMENT

The Tatras (Fig.1) are the highest mountain chain in the whole large arch of Carpathians in the line connecting the Alps with Caucasus. The total surface is 808 sq.km. Its full extent in the parallel line is 51 km, and along the main ridge is 82 km. From the geological and landscape point of view, the Tatras are divided to 3 parts: Western Tatras , High Tatras and Bielskie Tatras. The Polish Tatras cover the area of 175 sq. m which is almost ¼ of the total surface. The highest summit on the Polish-Slovakian border is Rysy 2499 m above the sea level, and on the Polish side – Kozi Wierch 2291 m above the sea.

Geologically the Tatras belong to the folded mountains of the Alpine character. They are built up from the sedimentary and crystalline rocks. The sedimentary layers origin from the Triassic, Jurassic and Cretaceous periods, and the Alpine movement creating the highlands folded them up. The present situation of the Polish Tatras is the result of many morphological changes in which the glaciers were the most important.. During the glacial period the Tatras were glaciated four times.

Climate of Tatras is typical for high mountains and severs with altitude. Temperature goes down 0,6 ^{o}C every 100 meter of altitude. Winter on the altitude of 1991 m above the sea level

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Fig.1 map of Tatras

(High Mountain Meteorological Observatory IMGW on Kasprowy Wierch Mt.) lasts from the mid October till the beginning of May, summer from the mid June till the end of August. The most important factors of the climate in the period between 1951 – 1997 (based on the data from Kasprowy Wierch) are shown below in Fig 2 and Fig 3.

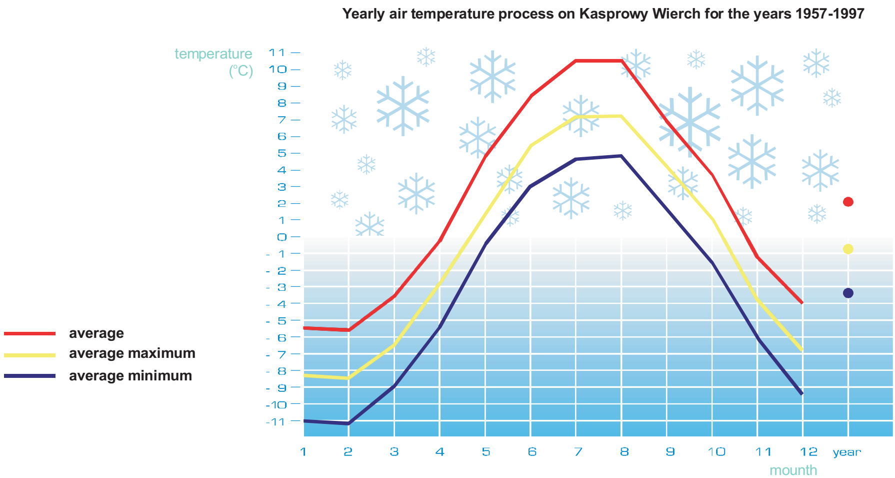

Fig 2: Air temperature on Kasprowy Wierch

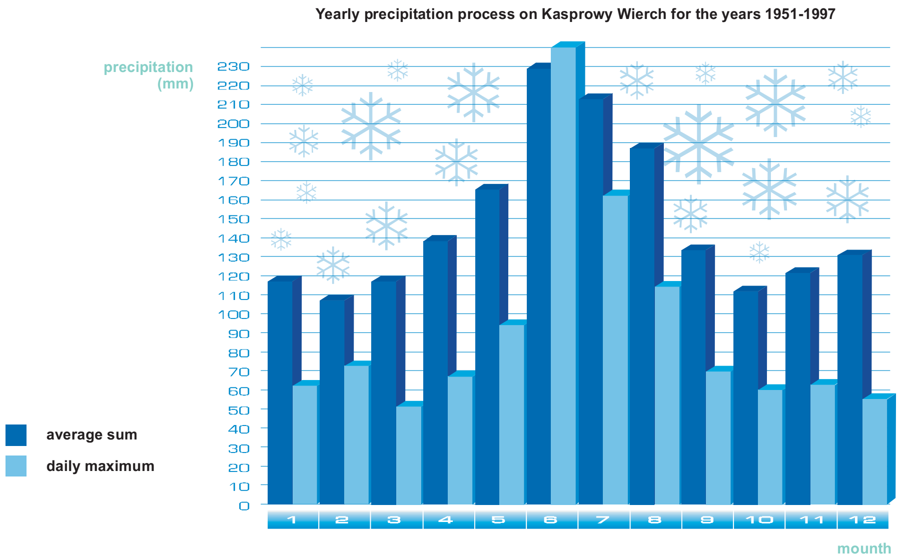

Fig 3: Precipitation on Kasprowy Wierch

In the summit parts the yearly sum is above 1800 mm, and over the altitude of 1520 m above the sea every month the snow falls are noticed as shown on Fig 4 and Fig 5.

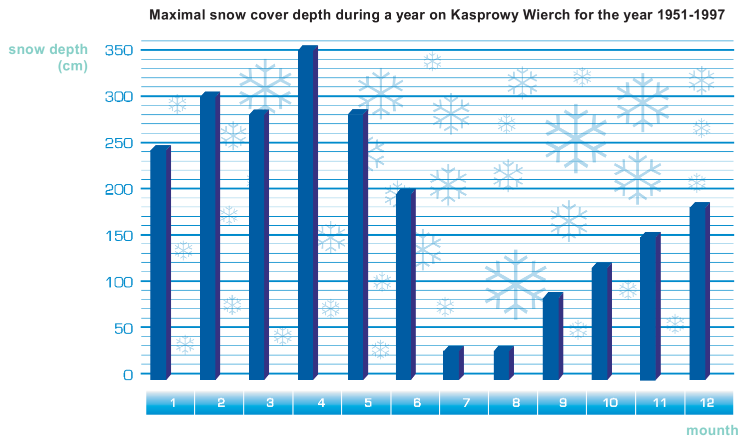

Fig 4: Maximal snow cover on Kasprowy Wierch

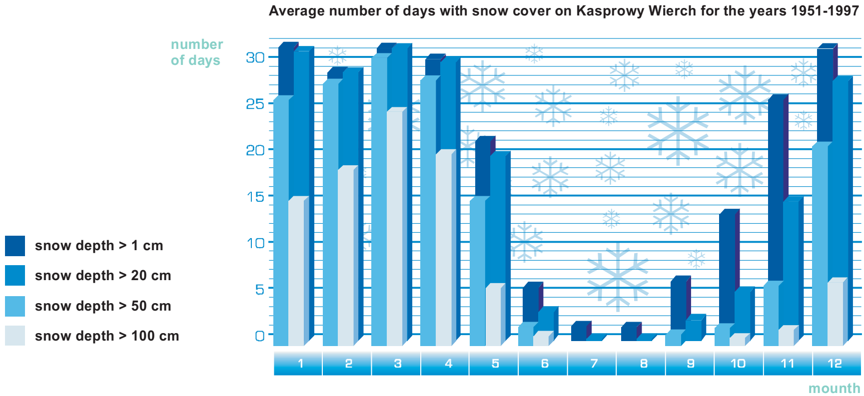

Fig 5: Average number of days with snow cover on Kasprowy Wierch

Tab. 1: Observations

MONTH	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	YEAR
average number of days with fog	24,3	22,2	24,4	23,7	24,1	24,7	24,3	23,0	24,2	22,6	25,1	24,6	287,3
average number of days with strong wind	21,6	18,5	18,4	15,9	13,6	11,5	11,8	11,9	14,9	17,5	20,0	20,8	196,4
average number of days with very strong wind	9,9	7,6	7,2	4,5	2,7	1,9	1,7	2,1	3,7	6,4	8,7	9,8	66,1

The vegetation in Tatras is very rich and changes accordingly to the altitude. There is six vegetation levels:
the level of cultivation – up to 1000 m above the sea level
the level of ldeciduous forest - up to 1200 m above the sea level – so called regiel dolny
the level of coniferous forest - up to 1550 m above the sea level – so called regiel górny
subalpine level of dwarf pine trees – up to 1800 m above the sea level
Alpine meadows level (hale) – up to 2300 m above sea level
Crag level (subnivo)– over 2300 m above the sea level
In Tatras there is over 1000 species of plants with 250 species typical for the mountains. There is also some species growing up only in the Tatras.

The fauna is also very rich. In the lower parts of the mountains there are the same species as in the whole Carpathians like deer, fox, lynx. In higher parts of Tatras there are species typical for high mountains such as: chamois, marmot, polnik and darniowka. There are also brown bears.

TOURISM IN THE TATRAS - AVALANCHES ACCIDENTS

The whole Tatras are on the area of the Tatra National Park. Sport and recreation is allowed, though limited by special rules. One can move only on the appointed paths, and taternism (Polish Alpinism) is allowed only for the members of Alpine organisations. There are appointed areas for downhill skiing , and ski random is possible along the summer paths.
The Tatras as every other mountains are very attractive for tourism and recreation. Every year the number of visitors grows up as the skiing , Alpinism , paragliding and hiking becomes more and more popular. People coming to the Tatras face up the mountain dangers. One of them are snow avalanches.
Every winter season there are the avalanche accidents. The number of these accidents in period 1985-2000 is shown in Fig 6.

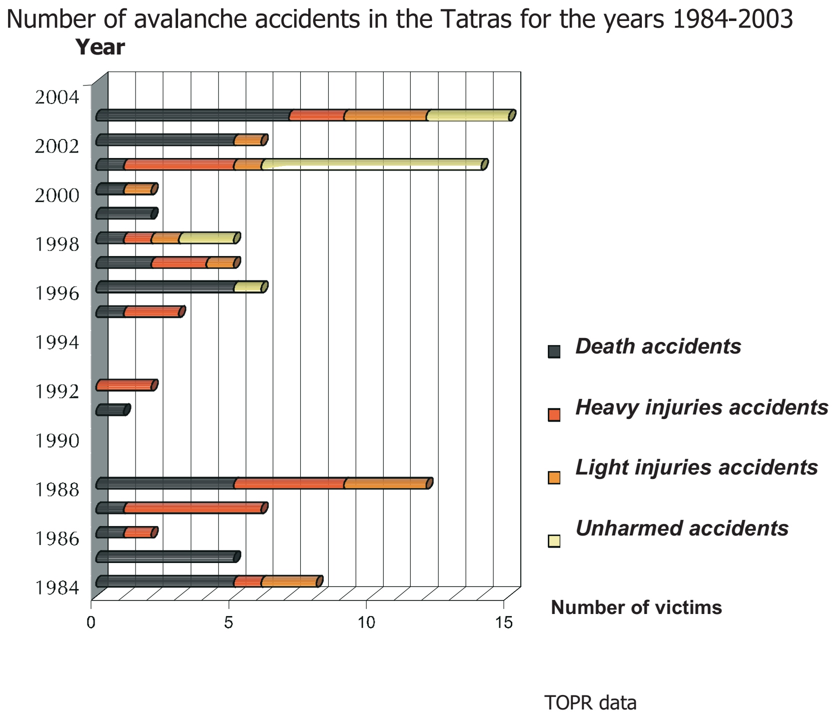

Fig 6: Avalanche accidents statistics in Tatras

- 21st of February 1996 the one of the most tragic accidents had place. The group of 7 persons walking off appointed path was sweep away by avalanche, which felt down from the Miedziany slope. Three persons were partially covered, but 4 others died on the place as the result of suffocation.

- 14 of December 1997 two climbers were taken by avalanche from the Koscielec eastern wall. Avalanche was so large, that felt down on the Czarny Staw Lake and crushed the thick layer of ice. The bodies of taternics were pushed under the ice.

- The group of 10 young adults got covered by the avalanche that started below Rysy Mt. in the last days of January 2003. Three persons were rescued. Unfortunately, seven others died. The bodies of four victims were only found in April in Czarny Staw Under Rysy Mt. They were pushed by the avalanche into the water breaking a thick ice cover.

Above there is a quotation of only few accidents. Potentially the danger grows up every year because of increasing number of tourists coming to Tatras. This increasing danger for human life forces the activity of prevention in order to make avalanches forecasting and warning possible. Efficiency of such a system depends on data collecting , sending and processing , implementing the new forecasting techniques and sending the warnings and announcements to the decision makers and to the society.

In Poland, the avalanches forecasting system in Tatras is done by Tatra Voluntary Rescue Service - TOPR together with the Institute of Meteorology and Water Management (IMGW) in Kraków. The partnership between this two organisations has been developed for 50 years. Not regularly snow survey were done in the beginning of 20^{th} century, methodically they have started to be done since 1959 and till now they have been surveyed in the Nival Meteorologic Research Station (NMRS) of IMGW on Hala Gasienicowa. The collected materials are the result of snow research done by K. Chomicz and scientific work of M. Kłapowa who was the Manager of the Tatra Hydrology and Meteorology Office IMGW in Zakopane.

In 1996 in the Kraków Branch of the Institute of Meteorology and Water Management, in the Department of Observation and Measurement Service the decision of modernisation of the existing and starting a new avalanche hazard forecasting system, accordingly to European standards, was taken. Avalanches Warning System is being modernised with the co-operation of Snow Research Centre in Grenoble.

The mutual contacts in this respect started in 1995. The IMGW employees were trained in avalanche service organisation, measurements' methods and their interpretation. They were also trained in avalanche forecasting and avalanche bulletin edition. They received a lot of training materials and instructions invaluable in service modernisation. Also, there were several specialist software packages donated by CEN. The most important, however, was the fact that the Polish team obtained numerical models such as Safran, Crocus and Mepra for the spatial and temporal modelling of the snow cover that are co-operating with the forecasting Alladin model. Tatra Voluntary Rescue Service (TOPR) also participates in modernisation activities in the Tatras area.

THE STRUCTURE OF THE SYSTEM

The general system components are:

- observations and measurements of meteorological situation and snow cover
- analysis and forecasts of meteorological situation and snow cover evolution
- information and statements about:
  - meteorological conditions (present and forecasted)
  - forecasted level of avalanche danger

1. Observations and measurements

The meteorological data concerning the present weather conditions and some snow cover characteristics will are obtained from the presently operating measurement network of the IMGW situated in the Tatras. After being coded, data is sent (in the form of dispatch) in the operational system twice a day to the Local Avalanche Service Centre (LOSL) on Hala Gasienicowa and next to Avalanche Service Centre in Kraków and TOPR Centre in Zakopane. The observations are collected by IMGW observers. In future a few automatic stations' installation is planned particularly in the higher parts of the mountains.

Fig 7: Meteo measurement site on Hala Gasienicowa

The meteorological network system consists of:

1. Nival Meteo Research Station (NMRS) on Hala Gasienicowa –LOSL
   - 1520 m above the sea level
   - SYNOP observations every 3 hours
2. High Mountain Meteorological Observatory on Kasprowy Wierch
   - 1991 m above sea level
   - SYNOP observations every hour
3. Meteo Post. Dolina Pieciu Stawow Polskich
   - 1670 m above sea level
   - meteo observations three times a day
4. Meteo Post Morskie Oko
   - 1408 m above sea level
   - meteo observations once a day
5. Meteo Post – Polana Chocholowska
   - 1147 m above sea level
   - meteo observations three times a day
6. Meteo Post Hala Ornak
   - 1109 m above sea level
   - meteo observations three times a day

All meteorological parameters are included in the measurement range.

To make snow cover measurement, statigraphic profile and sounding by stamping the following seven measurement points have been chosen :

1. Morskie Oko
   1408 above the sea level – next to meteo plot
2. Dolina Pieciu Stawow Polskich
   1670 above the sea level – next to the meteo plot
3. Hala Gasienicowa
   1520 m above the sea level – next to the meteo plot
4. Posredni Goryczkowy
   1872m m above the sea level – under the summit
5. Kalatowki in Suchy Zleb
   1250 m above the sea level – on the slope
6. Hala Kondratowa
   1333 m above the sea level – next to the tourist shelter
7. Polana Chocholowska
   1147 m above the sea level – next to meteo plot

These measurements are taken once a week or, if necessary, more frequently by TOPR rescuers on duty. The results are faxed in operational system to LOSL on Hala Gasienicowa, and from here, additionally, to Kraków, where the main system centre is created.
It is planned to introduce the measurements and records of observed avalanches. The information about fallen avalanches will be delivered to IMGW by TOPR rescuers as well as the guards of Tatra National Park patrolling the park every day. The talks are presently held regarding this matter.
The information regarding falling and past avalanches incude :

- date and hour of the avalanche fall
- the avalanche location and its morphological characteristics
- type of avalanche fall

- weather conditions at the time of the avalanche fall
- avalanche type
- abruptness characteristic
- avalanche trail characteristic
- avalanche cone characteristic
- damages and losses caused by falling avalanche

There is a plan to publish the archived meteo and snow data measurements as well as to prepare popular and scientific comparisons in bulletins under the working titles “Snow and weather” and “Snow and avalanches in season.....” after the winter season.

2. Analysis and forecasting

Preliminary hazard avalanche forecast level will be made in Kraków Avalanche Service Centre, where French numerical models SAFRAN, CROCUS and MEPRA are installed on the working station and adapted to the Polish conditions. The French model ALLADIN which has already been working in the Regional Forecast Office in Kraków will be used as a forecasting meteorological model. Presently, the adaptation works and tests are performed. The personnel is trained in its operating.
Completed data in OSL, collected in such a way, will serve a basis to further hazard avalanche forecast and Avalanche Bulletin edition. Both information will be sent to the TOPR Central Office in Zakopane. After consultations, the level of hazard as well as the bulletin will be published. Such a procedure must be kept, because accordingly to the rules presented above, the hazard level is decided by TOPR in co-ordination with IMGW.

3. Informations and bulletins

The Avalanche hazard forecasting system and Avalanche Bulletin will be the “final product” of the system.
It will be mailed to:
- IMGW and TOPR web pages (Fig 8. and Fig 9.)
- Tatra National Park
- Mass media
- Local authorities
- Mountain shelters
- Tourist centres
- Hotels
- Polish Cable Railways

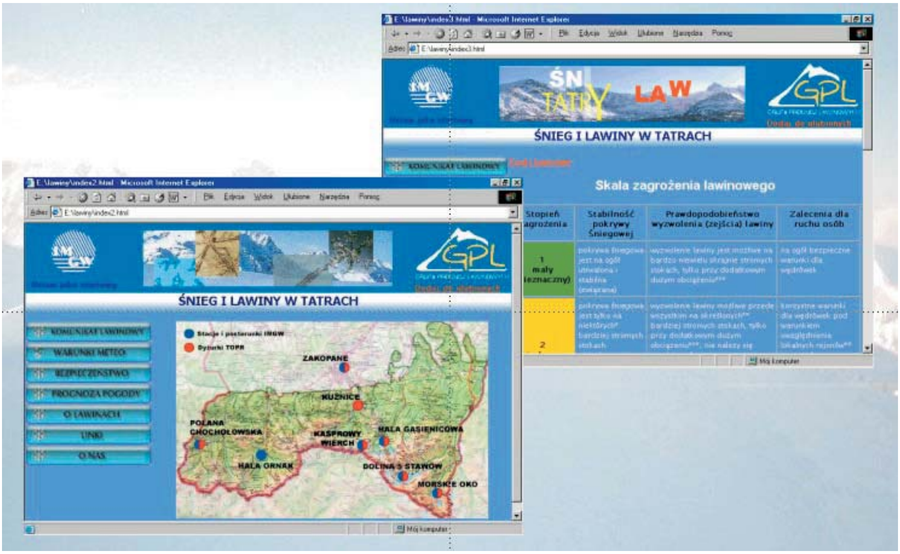

Fig 8: IMGW avalanche web site

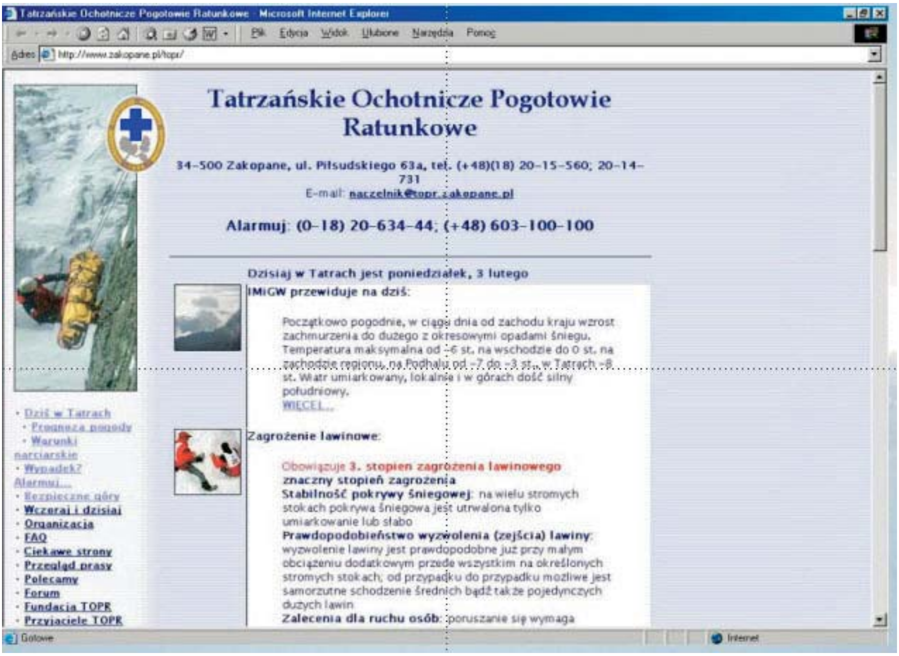

Fig 9: TOPR web site

THE PRESENT STATUS OF THE WORKS

At the present time standard meteo observations are being held, and data is sent to LOSL on Hala Gasienicowa in form of dispatch. The statigraphic profile of snow cover are being done in the presented points and sounding by stamping. The results are faxed to LOSL on Hala Gasienicowa and OSL in Kraków. Snow tubes produced after French documentation were delivered to TOPR rescuers by IMGW.

All data coming to LOSL and OSL are entered to program GELINIV, which archives data and shows in graphic form. As mentioned above, this program was delivered by CEN in Grenoble together with documentation .

IMGW supervises the whole work organising also training, lectures, delivering the instructions and measurement equipment. The LOSL staff on Hala Gasienicowa consult the level of avalanche hazard. In preventive action ten information panels have been done together with TOPR. Such panels are displayed in tourist shelters and at the cable-lift stations in order to warn tourists about the avalanche hazard, weather forecast and meteo conditions. The level of avalanche hazard is sent also to TV station and to newspapers as well as to the TOPR web site, and also to IMGW from 2003/2004 season. Publishing of a leaflet (Fig 10.) by IMGW and TOPR became a standing element of educational practice. The leaflet includes the avalanche signs, avalanche hazard scale, alarm phone numbers as well as the map showing the IMGW measurement points and TOPR posts. This leaflet has also a practical value, there is a calendar on one page and the ruler. These leaflets are available in all places frequently visited by the tourists, i.e. in hotels, shelters, cable railways stations, sport shops, etc.

Education is very important element in reaching the main goal – protection of human life. Such education should explain the meaning of expressions and vocabulary used in bulletin. It is very important to develop the habit among tourist and skiers to read the information from bulletin in order to take the right decision and to observe the safety rules accordingly to existing weather conditions. It seems that the last mentioned factor is the most difficult task to be fulfilled among many others mentioned above.

Fig 10: IMGW and TOPR published leaflet