

# AVALANCHE RISK FORECASTING ORGANISATION DURING THE WINTER OLYMPIC GAMES OF ALBERTVILLE (FRANCE)

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## ABSTRACT

From 27 January to 24 February 1992, METEO-FRANCE covered the winter olympic games meteorological operations in ALBERTVILLE. The avalanche risk forecasting (A.R.F.) was one point of this assistance that has been operated through an exemplary collaboration between METEO-FRANCE and the security services of ski resorts, the "SAVOIE" road services and the mountain policemen. The "A.R.F." team's objective was to give some relevant avalanche risk estimations on the access roads and information on avalanche warning to people in the mountains .

## A.R.F. TEAM'S OBJECTIVES

The C.O.J.O. (organisation committee of the winter olympic games) had asked METEO-FRANCE to give specific avalanche forecasts on the olympic massifs Beaufortin, Vanoise, Haute tarentaise and on access roads of olympic resorts. This information, more accurate and local, was a complement of the usual "SAVOIE" avalanche forecast available for all the massifs of the department.

The A.R.F. team's objectives were to give:

- decisive information on the avalanche risks near the access road, dwelling if necessary, on the exceptional character of high avalanche risk forecasting
- information on real or forecast avalanche warnings to people in the mountains especially to off-piste skiers.

## A.R.F. TEAM'S ORGANISATION

The A.R.F. team in charge of the avalanche risk forecasting was installed at the meteorological center of Albertville (C.M.A.) in the C.O.J.O. building. Twelve forecasters were employed on 5 permanent (round the clock) work posts. To be as efficient as possible, the "SAVOIE" snow avalanche centre, normally localized at Bourg Saint Maurice, was moved to the C.M.A. and worked with the olympic team.

During the day, 3 A.R.F. posts were in charge of:

- collect, storing, display, transmission and analysis of all the snow and meteorological data coming from the French snow weather station network.

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- running and interpretation of snow model results
- working out avalanche forecast reports

A night post allowed us to survey the night weather conditions and if necessary to diffuse report amendments.

A "field" post allowed us to dispose of local information depending on snow and avalanche conditions and completing the snow weather network's information.

Of course, the "A.R.F." team used the weather forecast of the C.M.A. and the collaboration of computer and electronic teams.

## A.R.F. TEAM'S MEANS

### *Available data*

*The French snow weather network* : A network of 150 observation points covering the Alps and Pyrenees where ski patrols measure twice a day weather and snow surface parameters (8 A.M. and 1 P.M.) and perform once a week a snow pit observation. During the winter olympic games and for all the "Savoie" ski patrols (around 10 posts), a new observation was carried out at 5 P.M. every day.

### *Automatic weather stations*

Two networks were used :

- "Nivose" stations developed by the C.E.N. and in operation in remote areas with real time data collection by satellite throughout the year (figure 1).

- Meteorological stations, installed for the olympic games with C.O.J.O. funding .

All these stations perform hourly measurements of air temperature, wind velocity, humidity. Some of them, particularly Nivose stations, give hourly snow depth and reflected radiations. For the whole "Savoie" olympic games department, about 20 stations were used at an altitude of 1600/3000 m.

### *Mountain missions*

Every day, mountain missions were organised with ski patrolers when the snow measurements sites were near the pistes otherwise with mountain gendarmes or policemen. The choice of the sites and the type of measures, defined by the snow situation, allowed us to give snow data on zones without information (high mountains, steep slopes..) and to confirm the model results.

Many various measures were taken :

- classical snow pit and ramtest
- observation of snow conditions on avalanche zones near the access roads of the olympic villages
- many measurements on the superficial layers of the snow pack: stratigraphy, density, liquid water content, ram resistance .. with different orientations, slopes and altitudes.

METEO-FRANCE

NIVOSE BELLECOTE

CNRM / CEN

MASSIF:Vanoise DEPARTMENT:Savoie ALTITUDE:3000m EXPOSITION:West  
ARGOS: 8410 FIRM: METEO-FRANCE

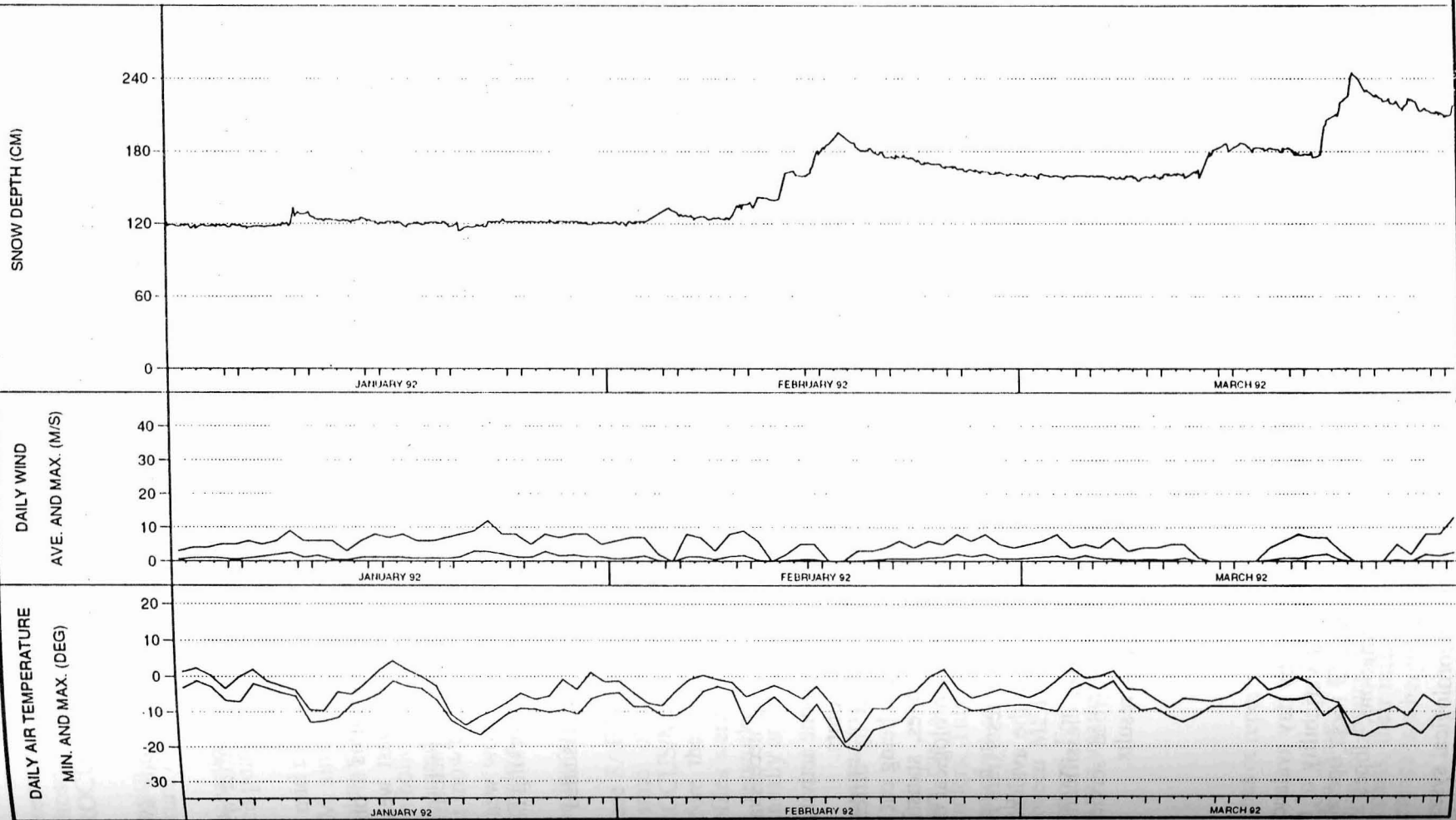


Figure 1 : Example of "Nivoise" station graphics

For these sometimes difficult mountain missions, we used a helicopter twice :

- to carry out a snow pit near an avalanche departure after an accident (one soldier died)

- to observe all the avalanche zones near the "Val d'Isere" access road after windy snowfalls (16/17 February)

### *Road services measurements*

A collaboration with the road services of Moutiers and Bourg Saint Maurice allowed us to obtain during night time meteorological information such as fresh snow, present and past weather conditions, wind velocity...

These services indicated also the position of observed avalanches with their characteristics: identification, type (natural or artificial), roads cut off...

This information, interesting for the road forecast, was essential to replace the snow weather network and to survey the weather conditions during the daily period outside the working hours of the network (5 P.M., 8 A.M.) .

The collect, storing, display and visualisation of this very different data necessitated the development of new specific software.

### *Statistical studies on olympic access road areas*

The working scale and the originality of the access road avalanche forecasting necessitated statistical studies on all the specific zones.

The statistical studies' objective was to work out a relation between the past avalanche activity of the road being cut off and the snow meteorological data of reference observation points.

With this aim in mind, every access road's avalanche zone was characterized by different topographical data and by its past avalanche activity : dates and number of roads being cut off were brought to the C.E.N. by the road services. A statistical analysis (averages, statistical correlations, principal component analyses..) were carried out on the snow meteorological data of the reference snow weather stations (10 to 20 past years).

This study enabled a classification in which every group of days, defined by snow tests (rain fall, snow fall, air temperature, sum of fresh snow for 4 days...), was described by the avalanche activity (number and type of avalanches, dates, localization).

In every access road report, the forecast day was characterized by its day by day classification. To help the interpretation of this daily information, every involved person (road services, C.O.J.O., state administrations, ski patrolers...) received an abstract of the studies' results.

### *Objective models*

For the first time, the avalanche forecasters used new objective tools for day by day avalanche forecasting. With these models, they were able to describe the great spatial variability of the snowpack and the avalanche risk in the olympic mountain massifs. In fact, 3 tools operated automatically in quasi real time at numerous locations under different orientations, slopes and altitudes with a vertical discretisation of 300 meters:

SAFRAN : (French word for "Saffron" / Durand, 1992) a meteorological system, using the results of the "Peridot" French meteorological mesoscale model and all the available

observed weather data (automatic or manmade networks, meteorological model, radiosoundings), that estimates hourly relevant parameters for the French snow numerical model, CROCUS .

CROCUS : A numerical model that simulates the evolution of temperature, density, liquid water content, stratigraphy of snow cover as a function of weather conditions (Brun, 1992).

MEPRA : An expert system for avalanche risk forecasting that analyses the mechanical stability of the SAFRAN/CROCUS snowpacks and deduces an avalanche risk for each point (Giraud, 1992).

At mid morning, the forecaster was able to analyse the SAFRAN/CROCUS/MEPRA results of 6 A.M. simulations. A sophisticated color display software allowed us to visualize the snowpacks' evolution in their great diversity (massif, slope, orientation, altitude) by :

-symbolic representations or projections on a ground numerical model (75 m mesh) of some elaborated parameters : surface snow temperature, snow depth, avalanche risk, avalanche type, wet snow depth, refreezing snow depth..(figure 2)

-complete and detailed graphics of stratigraphic and ram profiles (figure 3)

-continuous evolution of stratigraphy from the beginning of the winter season

These SAFRAN/CROCUS/MEPRA simulations were carried out in analysis and gave therefore a state of the snowpack and avalanche risks. To dispose forecast results, punctual CROCUS/MEPRA simulations were made daily on 5 sites near avalanche access road areas. Before the beginning of the winter olympic games, on the chosen sites, ramtest and snow profiles were carried out and allowed for the initialization of the CROCUS model. Then , with the networks data and the C.M.A. weather forecasts, we ran the CROCUS/MEPRA models manually and had a lot of help for the local avalanche access road forecast.

### *Snow and avalanche phone discussion*

Every day, at 11.30 A.M., the C.M.A. avalanche forecasters discussed with around 8 snow ski patrolers. This exchange of information allowed them to be given meteorological forecasts and allowed us to compare the C.M.A. snow pack stability analyses with the snow patrolers'local analysis.

Between METEO-FRANCE and the ski patrols, this type of collaboration gave way to new relations. For all the patrolers and forecasters, this phone discussion encountered great success and was unanimously appreciated.

## **REPORTS EMITTED**

3 types of reports :

- "Snow and Avalanche" report for the whole "Savoy" department and covering all the "Savoy" mountain massifs. This is the report daily emitted by the mountain meteorological station of Bourg Saint Maurice. It includes a description of the snow cover, short weather forecasts, their influence on the snow cover and an estimation of the avalanche forecast risk in reference to a height level hazard scale.

# Humidification

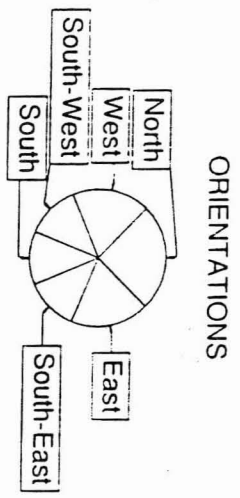
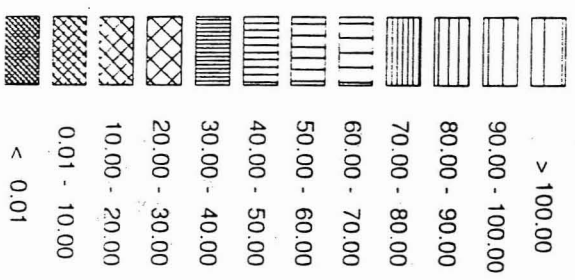
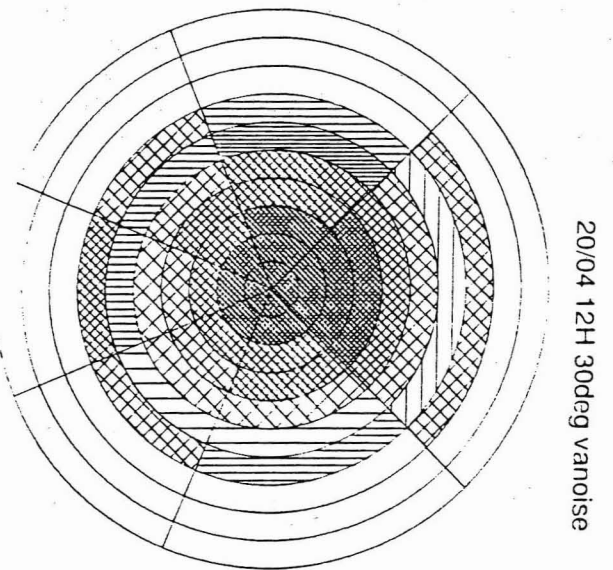
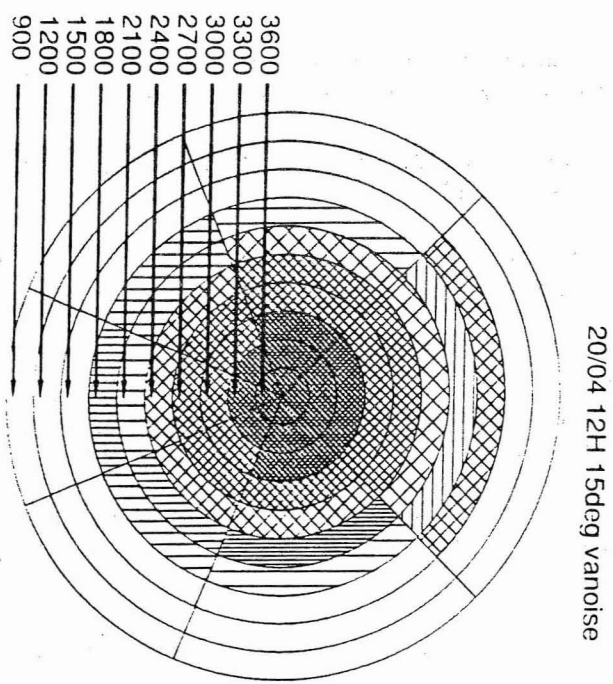


Figure 2: Example of SAFRAN/CROCUS/MEPRA symbolic colour print representation : humidification surface depth parameter

vanoise 12/02/1992 12H  
 expo.: S slope: 30 degrees

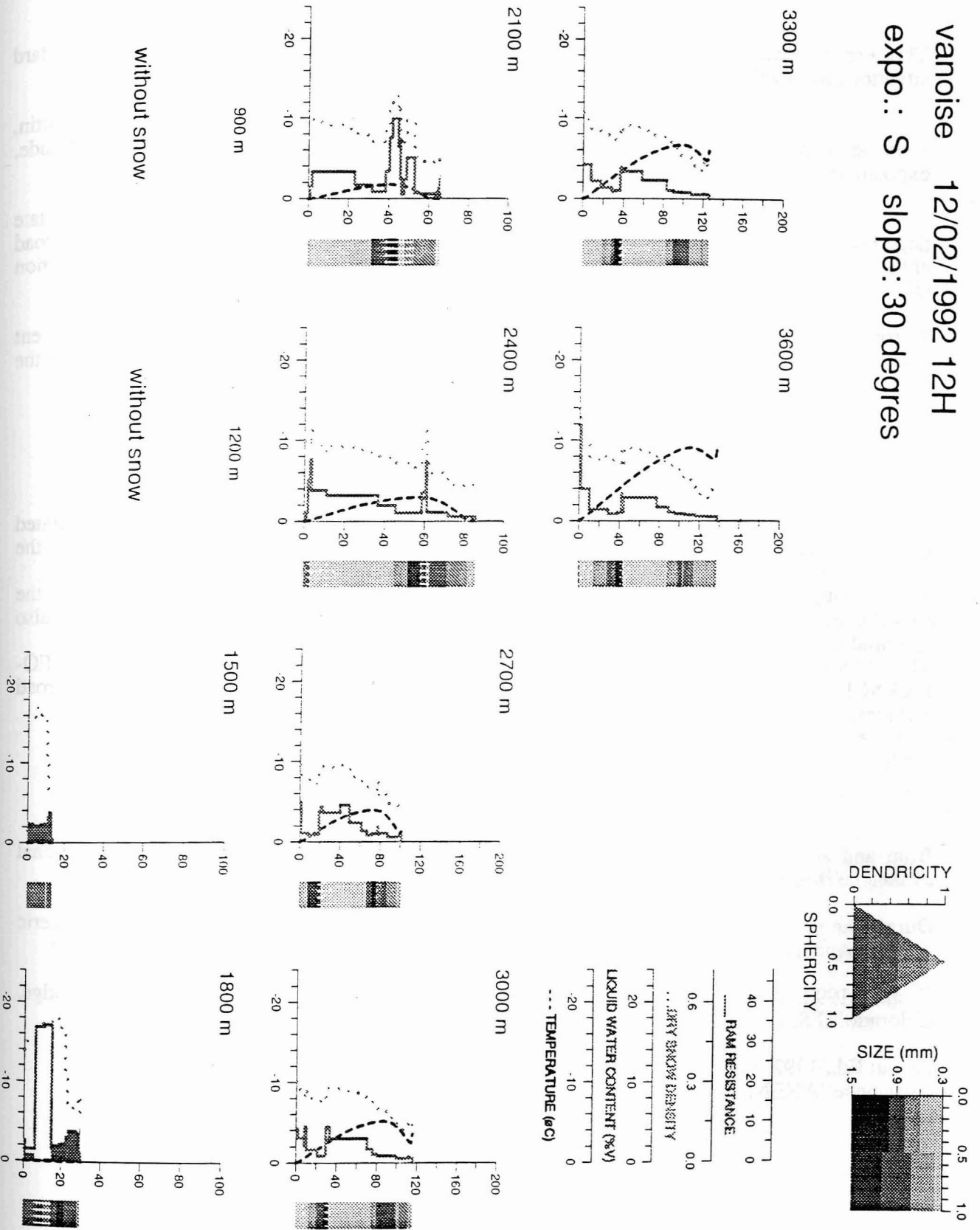


Figure 3 : Example of SAFRAN/CROCUS/MEPRA snowpack profiles (ram resistance, temperature, liquid water content, density and stratigraphy) for a south exposition, 30 deg. slope and every 300 m altitude levels.

This French scale allows for classifying the forecast snow conditions among height standard situations for level 1 ("minimum risk") to level 8 ("extreme avalanche conditions").

- three area reports of a similar type for each of the olympic massifs (Beaufortin, Vanoise, Tarentaise). Much more detailed information and avalanche risks given by altitude, exposition, time can appear (figure 4).

- eight synthetic access road reports were fitted to the needs of the safety state department responsible. They include a short description of the snowpacks in the avalanche road area, an evaluation risk of the road being cut off and a reference to the day by day classification (figure 5).

These reports were emitted to the C.O.J.O. and to some state safety administration department every day between 2 and 5 P.M. and it was possible to amend them at any hour, the day or the night.

## CONCLUSION

During the winter olympic games of Albertville, the METEO-FRANCE snow aid necessitated many software developments for the acquisition, storing, display and visualization of the information.

The olympic project allowed us to develop, test and operationally use the SAFRAN/CROCUS/MEPRA avalanche risk forecasting models. Statistical studies were also essential to carry out better avalanche forecasts on the access road areas.

This operation has been possible thanks to an exemplary collaboration between METEO-FRANCE and its usual partners: ski patrolers, mountain gendarmes or policemen and road services.

## REFERENCES

Brun and alii, 1992, A numerical model to simulate snow-cover stratigraphy for operational avalanche forecasting, *Journal of Glaciology*, Volume 38 n°128

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**METEO FRANCE  
METEOROLOGICAL CENTER OF ALBERTVILLE  
OLYMPIC GAMES 1992**

**AVALANCHE RISK FORECASTING /AREAS**

AREA ---> TARENDAISE

REPORT FROM 17 FEBRUARY 1992 AT 4 p.m.  
VALID UNTIL 18 FEBRUARY 1992 AT 4 p.m.

**1/ STATE OF THE SNOWCOVER AT MID DAY:**

The night stormy wind (blast upper 100 km/h near the crest) is not so strong this morning. The snowfalls during the last 24 hours seem to be small (10 to 20 cm) but not easily measurable with the strong wind. New accumulations and slabs, locally thick, have formed. Inside the snowpack, the layers humidified by rain during Saturday/Sunday night are slowly refreezing without significant consolidation. The upper layers, made of light cohesion snow remain unstable.

**2/ FORECAST EVOLUTION :**

The return of more mild weather conditions will not make perceptible changes on the snow conditions. In spite of cold temperatures, natural departures of small stuffs on steep slopes may induce slab avalanches.

Actually, the principal danger will be an accidental risk. Many wind slabs in a lot of expositions, altitudes and slopes leave the snowpack very weak, liable to overloading.

**3/ RISKS ESTIMATION : NATURAL MODERATE RISK WITH AN ACCIDENTAL GENERALIZED RISK**

Next report 18 February at 4 p.m.

END

Figure 4 - Example of area report

METEO FRANCE  
METEOROLOGICAL CENTER OF ALBERTVILLE  
OLYMPIC GAMES 1992

AVALANCHE RISK FORECASTING /ROAD ACCESS

SITE ---> CD 915 PRALOGNAN ACCESS

REPORT FROM 17 FEBRUARY 1992 AT 5 p.m.  
VALID UNTIL 18 FEBRUARY 1992 AT 5 p.m.

1/ STATE OF THE SNOWCOVER AT MID DAY:

In the "Corbassiere" zone, the snow depth is very low. In the other areas, 20 to 25 cm of new snow have settled on a snowpack superficially humidified by rain and presently slowly consolidating by refreeze under 2200/2400 m and made of recent snow above 2200/2400 m. North-West stormy wind permitted the development of slabs and accumulations especially near "Saugine" and "Creux de l'ours" areas.

2/ FORECAST EVOLUTION :

Cold or very cold temperatures during the night and a sunny day will not modify the snow conditions of the area.

Recent snow stuffs or even avalanches are possible, especially on the sunny slopes, and may induce slab avalanches. It is unlikely that the road will be cut off.

3/ 1981/1991 PERIOD REFERENCE :

In this class (3200), the roads were never cut off by an avalanche.

Next report 18 February at 5 p.m.

END

Figure 5 - Example of road access report