CROCUSMEPRAPC SOFTWARE: A TOOL FOR LOCAL SIMULATIONS OF SNOW COVER STRATIGRAPHY AND AVALANCHE RISKS

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Abstract : To help the regional avalanche forecaster and to describe the great variability of the snow pack and the avalanche risk, the CEN (Centre d'Etudes de la Neige) has developed the SafranCrocusMepra automatic chain, which simulates snow cover stratigraphy and avalanche risks on many typical slopes representative of the different French massifs.

With this tool under Unix operating system, local simulations using snow pit and meteorological data are not easy to make. Then, a PC software has been developed in an oriented object language (Visual C++) using only Crocus and Mepra models. This first version of CrocusMepraPC allows us to :

- make easily Crocus and Mepra simulations in a local mode using window interface to input the initial snow profile and meteorological data, run the models and visualize the results : detailed graphics of Crocus stratigraphic and ram profile, Mepra natural and accidental risks, unstable levels...and graphics of hourly snow surface temperature and water bottom runoff for the whole simulation.
- compare easily the results of different runs in analyse or forecast mode
- have a portable and an education tool

Keywords : snow model, avalanche forecasting , computer tool

1. Introduction

Since the 70's, different models have been developed and used by various snow and avalanche research centres for local or regional avalanche forecasting. Statistical methods using discriminant analysis and nearest neighbours seem to be the most popular approaches (Bois et al., 1975; Buser et al., 1987).

At the same times, numerical models have been developed to simulate snow cover processes (Anderson, 1976; Colbeck, 1973; Obled and Rossé, 1975; Navarre, 1975). These physically-based models simulate the evolution of the snow cover as a function of the weather conditions. They include a representation of the principal phenomena affecting the energy and mass balance of the snow pack and also metamorphism for a new generation (Brun et al., 1992; Lehning et al, 1998). The last avalanche forecasting method is based on expert system or symbolic models which are a very popular approach in the 80's decade. Their initial objectives are to reproduce the expert human reasoning in a particular field. Most of them use production rules organised in bases (Lafeuille et al., 1987, Giraud, 1992). Recently, hybrid expert systems were developed by coupling expert system and statistical (Bolognesi, 1994, Schweizer and Föhn, 1994a, Weir and Mc Clung, 1994) or neural network approaches (Schweizer et al., 1994b).

At the end of the 80's, the CEN (Centre d'Etudes de la Neige) decided to develop the Safran/Crocus/Mepra automatic suite with an analysis meteorological model named Safran (Durand et al, 1993), the Crocus snow model and an expert system to estimate the avalanche risks named Mepra (Giraud et al, 1992). This chain simulates the snow cover stratigraphy and the avalanche risks on many typical slopes representative of the different French massifs. These slopes are characterized by different orientations (North, East, Soith East, South, South West and West), different angles and different elevations with a vertical discretisation of 300 meters. This automatic suite is an interesting tool for regional avalanche forecasters.

Recently, the CEN has developed a new tool using only Crocus and Mepra models on a PC for

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different applications. This tool is described in the following.

2. Crocus and Mepra models

Crocus (figure 1) is the French numerical snow model which calculates the energy and mass evolution of snow cover. Using hourly meteorological data, Crocus simulates the evolution of temperature, density, liquid water content and layering of an initial snow pack. The originality of this snow model comes from its ability in simulating snow metamorphism. Snow albedo and extinction coefficient depend on the wavelength and the surface snow type and age.

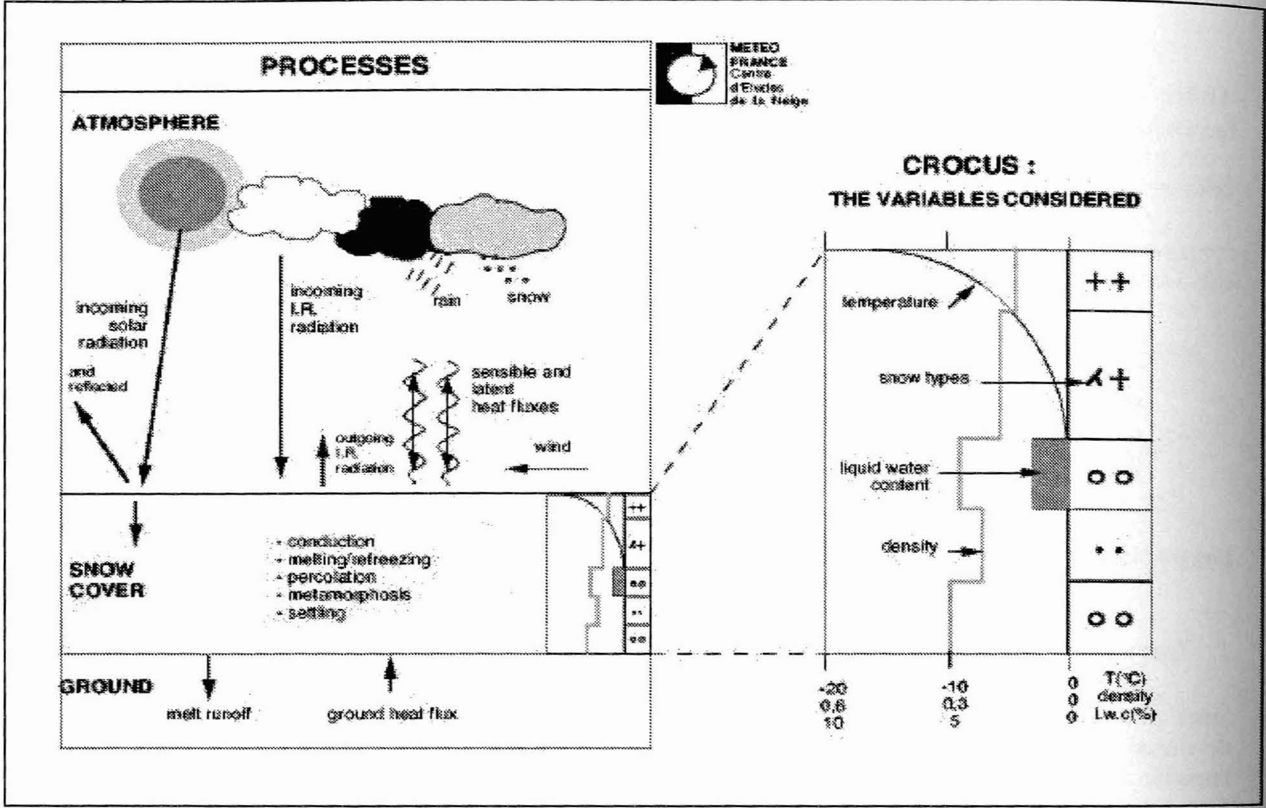


Figure 1 : Crocus processes and variables

Mepra (figure 2) is an expert system for avalanche risk forecasting. This expert system deduces from the Crocus snow pack simulations additional characteristics (shear strength, ram resistance and grain types...). After classifying the ram and stratigraphical snow profile, this model studies the natural and accidental mechanical stability of the simulated snow pack and then deduces a natural avalanche risks on a 6 levels scale (very low, low, moderate increasing, moderate decreasing, high and very high) and an accidental avalanche risks on a 4 levels scale (very low, low, moderate, high).

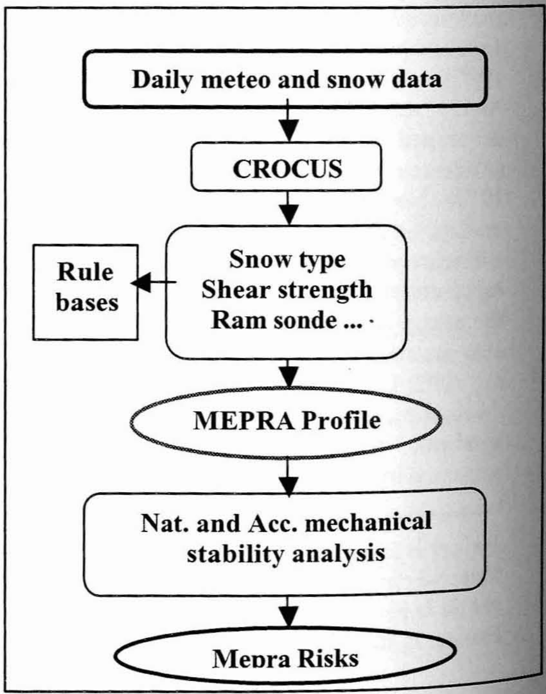


Figure 2 : Architecture of the Mepra expert system

3. CrocusMepraPC tool

CrocusMepraPC software is a tool running on a PC. This software has been developed in an oriented object language (Visual C++). At the start of the CrocusMepraPC software, a toolbar appears with file, display and window menus. To make a CrocusMepra run, the user must choose a geographical point of simulation, an initial snow profile and meteorological conditions during the simulation. Then a new "tool" menu and a "start" icon appear, the avalanche forecaster can run Crocus and Mepra models. Some window views allow him to visualise the results under different forms.

3.1 Geographical data of simulated point

For the user, the first selection is the choice of a local simulation point using a dialog box (figure 3). The user may choose a post in a list, create a new post or modify the geographical characteristics and save them. Classical geographical parameters are inputted as : orientation, altitude, slope ….and solar masks to calculate the solar radiation at the snow surface.

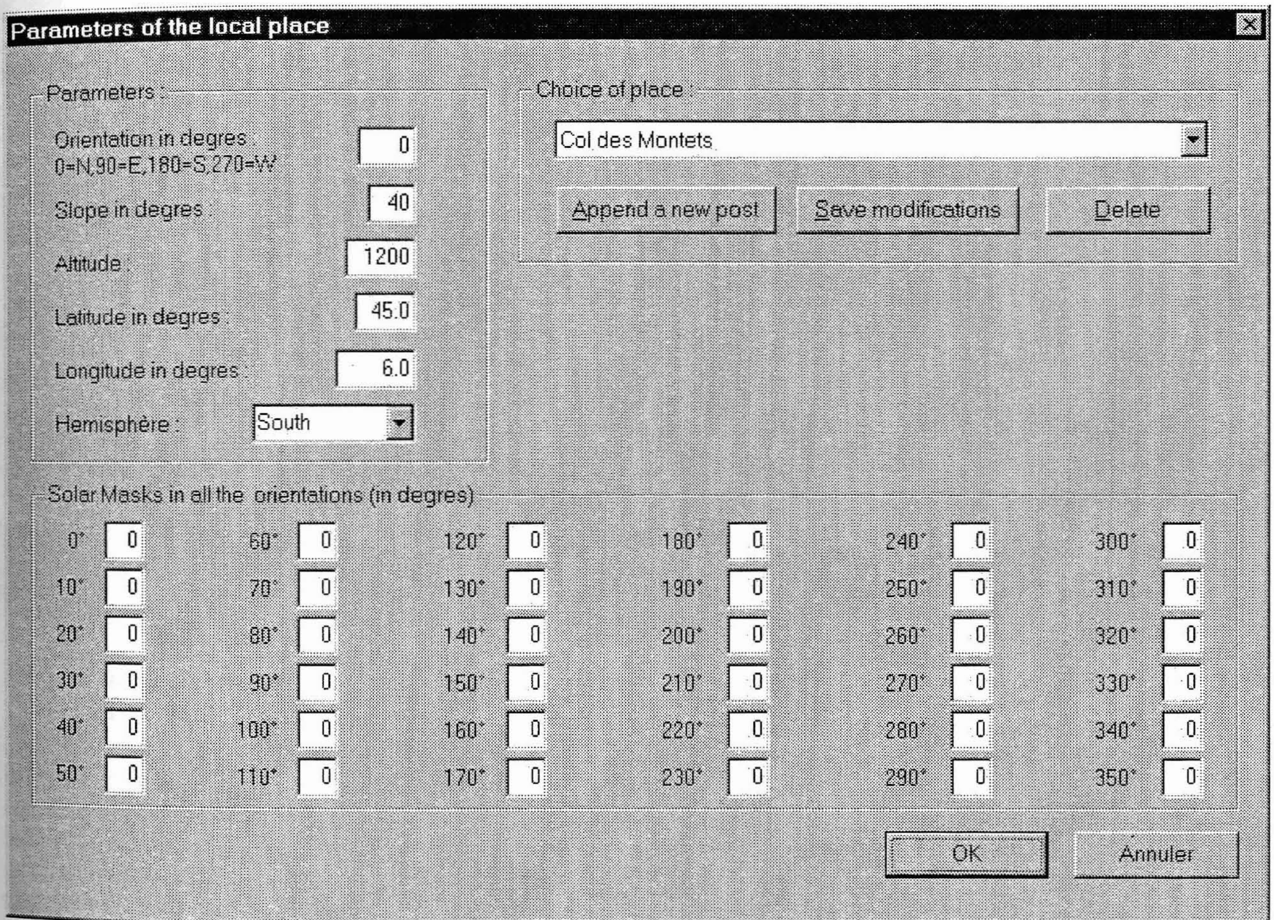


Fig 3 : Example of a dialog box to input the geographical data of a simulated local point .

3.2 Initial profile and simulation date

After choosing a local point of simulation, the forecaster must input an initial profile with its date using another dialog box (figure 4). Each layer of the snow profile is described by some current parameters like depth, density, LCW (liquid water content), temperature and size of grains but also by some Crocus typical grain parameters like : dendricity, sphericity and historical. It is possible to load a Crocus saved snow profile or an input old snow profile. About the number of simulation days, the limit is 10 days. The backup of Crocus simulated snow profiles allows us to run again the models for a long time if necessary.

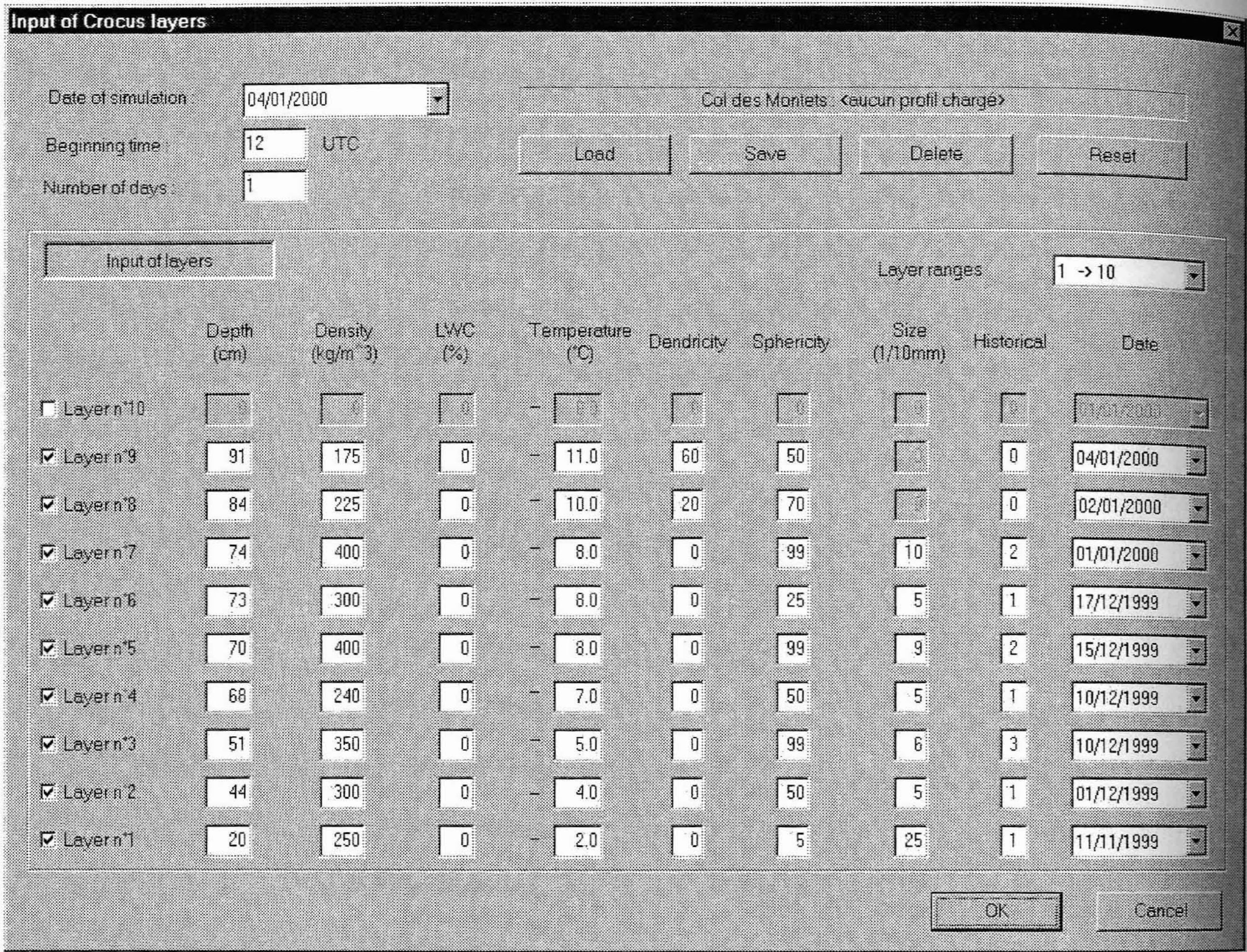


Figure 4 : Dialog box of initial snow profile

3.3 Meteorological data

To make a run of Crocus and Mepra models, meteorological data at hourly time during the simulation are necessary. These meteorological parameters are : air temperature, humidity, wind speed, nebulosity and rain or snow precipitations. A dialog box with window tabs (figure 5) allows the user to input these meteorological data twice per day of simulation at 8 and 13 local time. For all the parameters except temperature, the CrocusMepraPC software makes linear interpolation to give hourly meteorological parameters to Crocus. For the air temperature parameter, the avalanche forecaster must choose between a linear or algorithm interpolation using the "time setting" dialog box of the configuration menu (principal toolbar). The second choice indicates that a complex interpolation will be made using two sinusoidal functions to take into account the day and night evolution of the air temperature

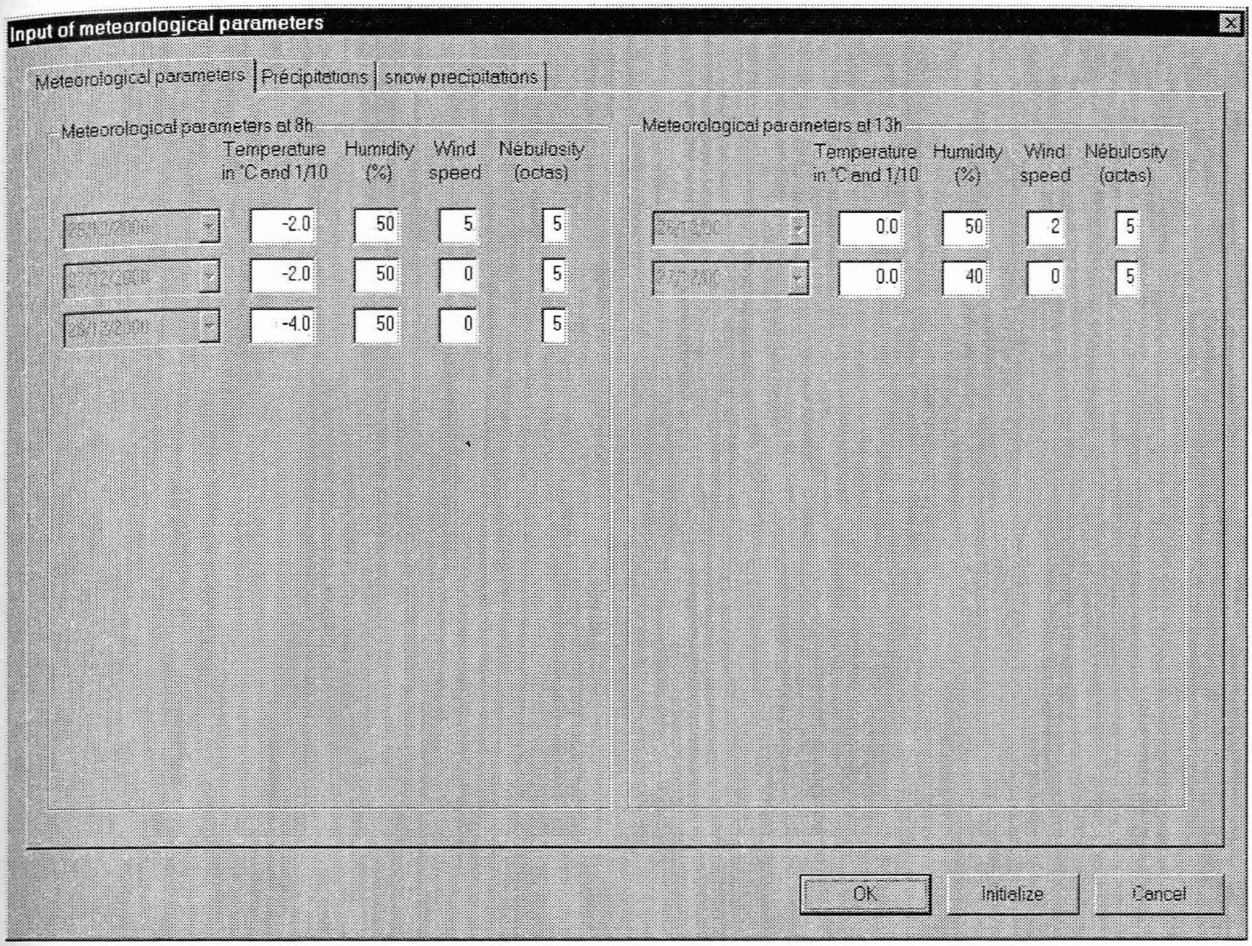


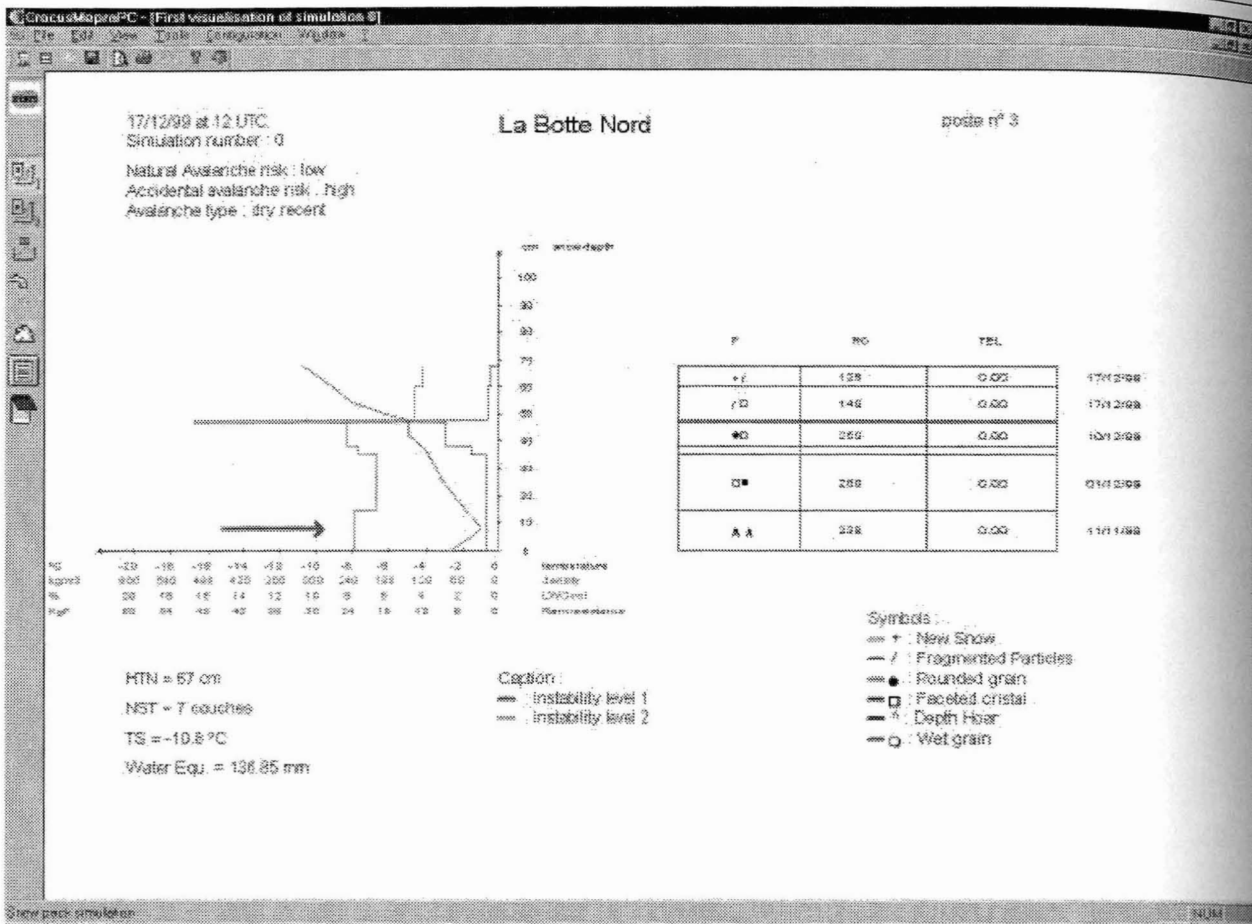
Figure 5 : Dialog box for input of meteorological parameters

3.4 Visualisation of CrocusMepraPC results

With the geographical characteristics of the simulated point, the initial snow profile and the hourly meteorological temperature, the user can make a Crocus and Mepra run using the start icon or the toolbar menu. After that, the results of the 1 to 10 days CrocusMepra simulations are visualized until 3 types of charts :

- complete and detailed simulated snow profiles with Mepra avalanche analysis risks for 2 selected hours of simulation (see figure 6)
- graphics of snow surface temperature during the whole simulation
- graphics of hourly and complete water runoff at the bottom of the snow pack

The user can also look at the hourly meteorological data, the hourly flux calculated by Crocus and the mark of the simultion.



4. Conclusion

Some tests and validations have been made using in situ snow and avalanche data. The ISSW paper named "In-Situ" measurements to test CrocusMepraPC tool gives more information about these tests and validations (Coleou and al, 2002).

The main limits of this tool are due to the use of only one dimensional models which don't allow us to take into account the spatial variability of the snow pack at the slope scale. The Mepra mechanical analysis uses only the Crocus simulated snow pack and doesn't take into account the snow drift and its local effects. In the future, using the results of the Sytron snow drift model (Durand and al, 2002), some improvements are expected

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