THE DOWNSCALED METHOD USED BY SAFRAN FOR METEOROLOGICAL PARAMETER ESTIMATION AT MASSIF SCALE

Laurent Mérindol [1], Yves Durand [1], Gilbert Guyomarc'h [1]

[1] GAME/CNRM-CEN (Météo-France, CNRS), Grenoble, France

E-mail : laurent.merindol@meteo.f r

Abstract:

Since 1990, in order to provide a snow cover evolution model with hourly relevant meteorological parameters, the software SAFRAN has been developed by Météo-France (CEN).
In this presentation, we shall describe the goals to reach, the methods used, and the evaluation of the results in different zones.
We focus our attention on several points like :
- nearest neighbour research
- precipitation module
- operational constraints

Keywords: *downscaling, analysis, forecast, alpine meteorology, massif*

1. INTRODUCTION

In France, an atmospheric analysis system especially built for the mountain region was developed in the nineties in order to provide the atmospheric conditions to a snow model for the avalanche hazard forecast (Durand and al. 1993, 1999).

The system is called SAFRAN, a French acronym for "Système d'Analyse Fournissant des Renseignements à la Neige" which means : analysis system that provides data to snow model at the snow-air interface.

2. METHOD

The main specifications of SAFRAN were to provide hourly to the snow model CROCUS (Brun and al. 1989, 1992) relevant parameters, for predefined vertical levels, on several mountainous areas and for different slopes and aspects. The mountainous area is described not as a regular grid but by a discretisation in terms of massifs, vertical levels, aspects and slopes. The combination of SAFRAN, CROCUS, and MEPRA, an expert system for avalanche risk estimation, led to an operational application used to forecast avalanche risk in France (Durand and al 1999)

SAFRAN uses different methods to analyse the parameters, mixing Optimal Interpolation (Gandin 1963) and now variational methods (Courtier and al. 1993 ; Rutherford 1976 ; Durand and al 2000). One of the main originalities of SAFRAN is that the analysis is done over climatically homogeneous zones named massifs, which are areas of irregular shape covering a surface usually smaller than 1000km2 and where the horizontal climatic gradient (especially for precipitation) are weak.

SAFRAN estimates one value of each parameter for each zone or massif at several altitude levels. Within the zone, analysed parameters depend only on elevation and aspect. The massifs are not isolated : observations from the neighbouring zones are used if necessary.

As a preliminary to the analysis, SAFRAN does a quality control of the observations. It is based on the comparison between observed and analysed quantities at the observation location. The process is iterative.

The analysis of temperature, humidity, wind speed and direction, and cloudiness is performed every six hours using all available observations. For this part, the first grid guess comes from the large scale operational weather prediction model ARPEGE (Courtier and al. 1991)

.

The analysis is performed in two steps. Firstly the vertical profiles of temperature, wind, humidity and cloudiness are analysed. These profiles are calculated with a vertical step of 300m. Secondly SAFRAN determines the surface parameters following the Cressman Method .This method use the notion of the radius of influence, according several iterations in order to analyse different spatial scales. In this case, the first guess is deduced and updated from the result of the previous analysis. See Figure 1.

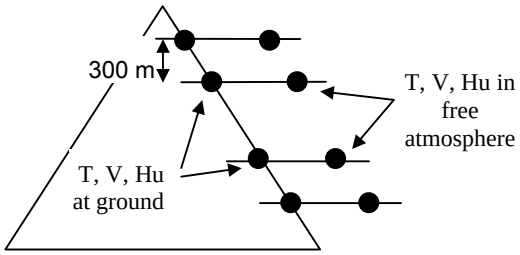

Figure 1 : Scheme of ground and altitude levels in one massif zone

2.1 Precipitation module.

The precipitation analysis is done daily between 6h UTC the current day and 6h UTC the previous day, in order to include in the analysis the numerous precipitations observed only on a daily basis in particular in snow observation network and also in climatological network. An Optimal Interpolation (OI) analysis package is used with this tunings : a) we can select observations farther away if local observations is not available, b) there is no vertical correlation for this surface parameter. In this case, the first guess is deduced from climatological field elaborated with weather types or more simply without weather types.

2.2 Hourly interpolation and Operational constraints.

For the needs of CROCUS, we must interpolate all our previous analysis hourly on every analysis location. Except for the precipitation quantities , all the other parameters are analysed every six hours. For precipitation, the daily analysis is split into 24 hourly parts with the help of relative humidity and also with an estimation of clouds heights bases on observed averages. In future, we plan to use radar information to refine this hourly estimation.

For temperature, we adjust the hourly interpolation by using the previously computed solar radiation and a relaxation to an equilibrium temperature (Martin and Mainguy, 1988).

After this interpolation step, a variational method is used taking into account the non-synoptic observations. With the new network RADOME, we have hourly observations on temperature, precipitations and this information is used to refined our interpolation scheme.

The first operational use of SAFRAN results was made during the Winter Olympic Games held in Albertville region in 1992. To better insert our software in informatics' management at Météo-France a new project are been developed named DOLMEN (Dumas and al. 2006), so now, SAFRAN runs daily in national informatics' centre held in Toulouse and after SAFRAN outputs are send to all mountains forecast service to run locally CROCUS and MEPRA. This suite is now completely embedded in forecast tools usable in weather and snow services in French Alps and Pyrenean chain.

3. FORECAST

A forecast version is also available and runs at a range of two days. It is based on downscaling operators treating the information from larger numerical weather prediction (NWP) models like ARPEGE or ALADIN (Geleyn and al. 1995) and on the use of observations of analogous weather situations of the past.

3.1 nearest neighbour research.

This search is used to mix, the precipitation coming from NWP and precipitations deduced from analogous days in the past. This past file have now more than 40 years included by using ERA40 reanalysis field. The criterion applied to calculate the distance among the past day file is based principally on

meteorological fields including the humidity at 700hPa level following the work made in 2004 (Dufour 2004). The other fields used are Z500 hPa, Z700 hPa, T700 hPa and thermal advection at 700hPa. The distance is based on a quadratic formula with weights taken into account the spatial variance of each field. A second algorithm is then applied with a comparison of the precipitation field of each analogous day and the averaged precipitation field of the four first analogous day. The result is used to re-order the analogous days and in final to choose the first one, see figure 2 as illustration. This method have the great advantage to give a realistic precipitation field, the precipitation field based on NWP products being always too smoothed in mountainous region. This fact is partially due to the difficulty to represent all the complexity of orography over Alps or Pyrenean chain in the numerical weather models.

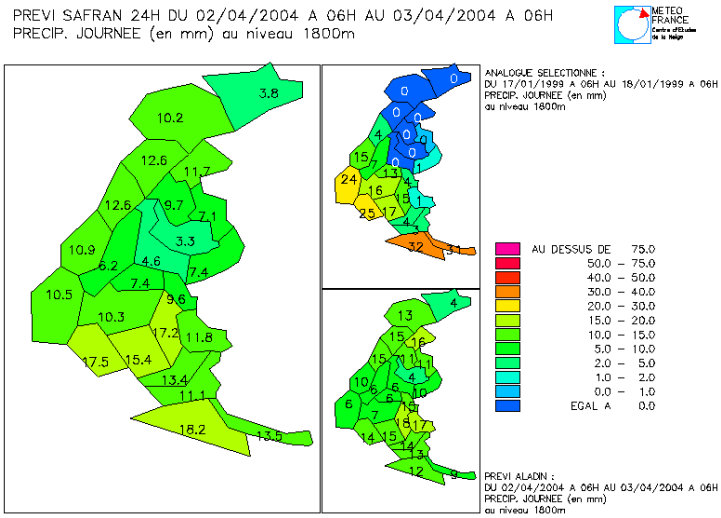

Figure 2 : daily precipitation forecast
left panel SAFRAN 24h forecast, upper right selected analogous day input, lower right ALADIN 24h forecast

4. APPLICATIONS AND RESULTS

4.1 SCM in French mountains.

The validation of SAFRAN is made by comparison of forecast and analysis results for the precipitations or for the others relevant parameters. Like an illustration, we show above figure 3 obtained on Pyrenean mountains. When, new input is available like now ALADIN or very soon AROME, we made new studies to evaluate this new model in our alpine context.

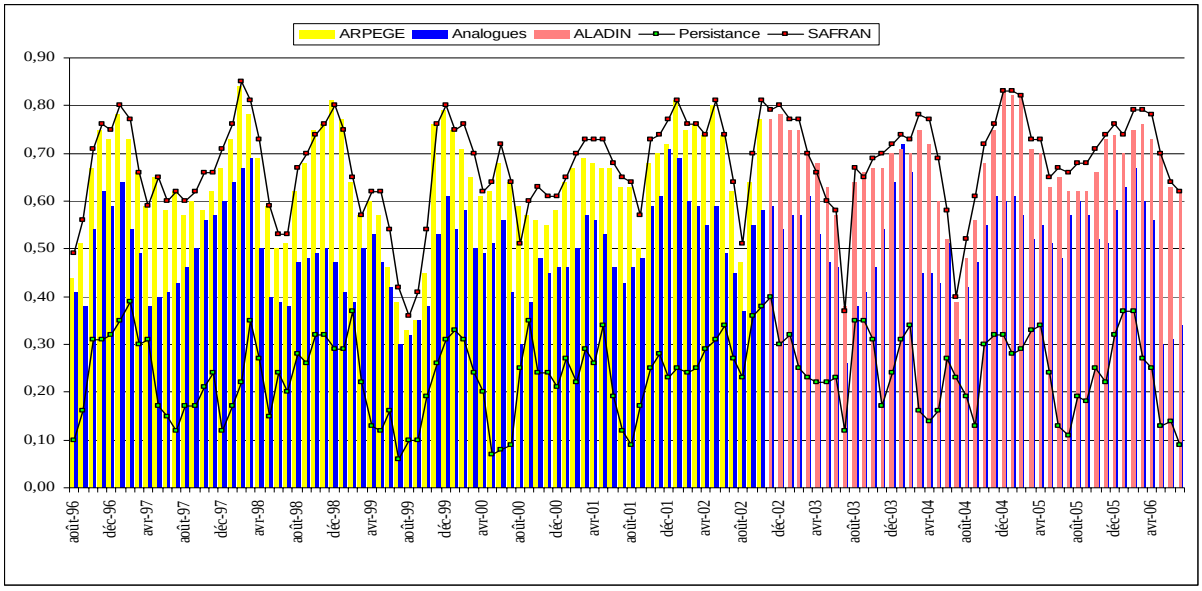

Figure 3 : Correlation between different 24h forecast on French Pyrenean massifs and the analysis value. All the massifs are averaged on a three months window at 1800m level.

4.2 SIM

In an hydrologic context, SAFRAN is used with two others models, ISBA a ground model and MODCOU an hydrological model. Now, this suite is available on all French rivers in analysis mode. See (Quintana Segui 2006 and Rousset and al. 2004) for more details.

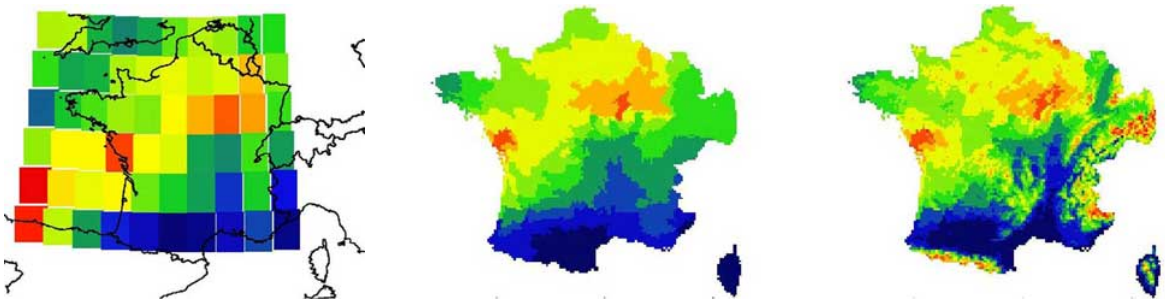

Figure 4 : Spatial desagregation of precipitations (ten days sum, based on forecast 2004/10/17th, in mm)
Left panel raw fields on ECMWF grid, centre panel on Symposium zones,
right panel altitude gradient take into account.

4.3 SIR

We give an other context of SAFRAN utilisation, coupled with ISBA again and applied in road environment to give some advices in case of icing on roads. Many works are conduct in this way, but actually is not completely operational.

REFERENCES

Geleyn J.-F ,Bubnova, R., Hello, G., and Benard, P.: Integration of the fully elastic equations cast in the hydrostatic pressure terrain- following coordinate in the framework of the ALADIN NWP system, Monthly Weather Review, 123, 515–535, 1995

Brun E., P. David, M. Sudul and G. Brugnot 1992. A numerical model to simulate snow cover stratigraphy for operational avalanche forecasting. *Journal of Glaciology*., 38(128), 13-22.

Courtier Philippe and others. 1993: The ECMWF implementation of three dimensional variational assimilation (3D-Var). Part 1: Formulation. *Q. J. R. Meteorol*. **123**.

Dufour, Bénédicte 2004. Prévision des précipitations en zone montagneuse par une méthode de recherche de situations analogues Rapport EITM n°930 ENM (in french)

Dumas J.L, Y. Danielou, C. Gendre, G. Giraud and E. Pougatch 2006 The French nivological workstation an integrated software for regional snow data analysis. p624-627 International Snow Science Workshop Proceedings Telluride

Durand Y., Brun E., Mérindol L., Guyomarc'h G., Lesaffre B. and Martin E. 1993: A meteorological estimation of relevant parameters for snow models, *Annals of Glaciology*., ***18***, *65-71*.

Durand, Y., G. Giraud, E. Brun, L. Mérindol and E. Martin, 1999. A computer-based system simulating snow-pack structures as a tool for regional avalanche forecast. *Journal of Glacio*logy, 45(151), 466-484.

Durand, Y., Guyomarc'h G., Mérindol L. 2000. Prise en compte des observations horaires dans l'analyse Safran, Atelier Modélisation Atmosphérique, Toulouse. (in french)

Gandin, L.S. 1963. Objective analysis of meteorological fields Jerusalem, Israel Program for Scientific Translations.

Martin S. and J. Mainguy. 1988. Potentialités climatiques de l'enneigement artificiel en moyenne montagne. *CIMA 1988 XX Congresso Internazionale di Meteorologia Alpina, Sestola*

Quintana Segui P. and others, 2006. Analysis of near surface atmospheric variables : Validation of the SAFRAN analysis over France**. submitted** to *Journal of Applied meteorology and Climatology*

Rousset, F., F. Habets, E. Gomez, P. Le Moigne, S. Morel, J. Noilhan, and E. Ledoux **:** Hydro-meteorological modelling of the Seine basin using the SAFRAN-ISBA-MODCOU model, Journal of Geophysical Research., 2004

Rutherford. 1976 : An operational three-dimensional multivariate statistical objective analysis scheme. *The GARP Program on numerical experimentation; rapport n° **11***, January 1976.