The utility of SAFRAN as analysis of near-surface atmospheric variables: the case of the snowstorm in Catalonia on 8th March 2010

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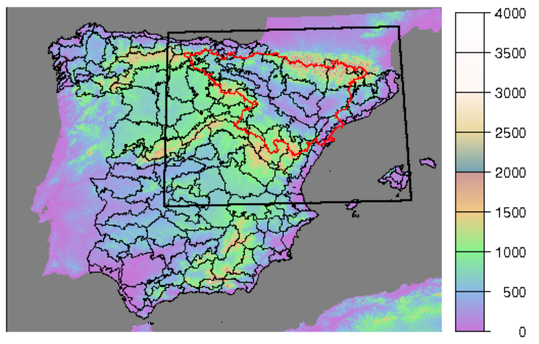
Introduction

SAFRAN (Durand et al., 1993; Quintana-Seguí et al. 2008) is a mesoscale atmospheric analysis system for screen-level variables. It produces a meteorological analysis at the hourly time step using all available ground data observations and the outputs of a meteorological model, by means of optimal interpolation. One of its main features is that it is based on climatically homogeneous zones (areas where spatial gradients of meteorological variables are not very relevant) and is able to reliably take vertical variations into account. Originally intended for mountainous areas, it was later extended to cover the whole of France (SAFRAN/F).

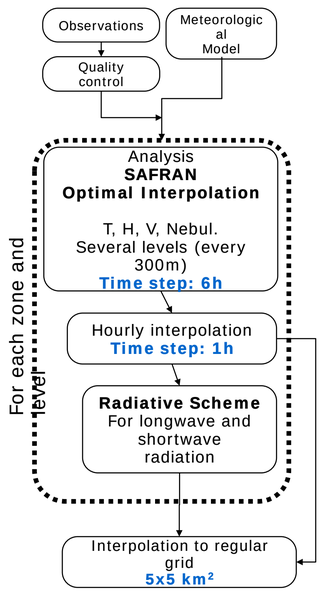
We have implemented SAFRAN on the NE of the Iberian Peninsula (SAFRAN/NEIP). Currently, this project is being done in collaboration with AEMET, which provides us with all the available data from their synoptic and climatological networks and with the outputs of the HIRLAM meteorological model, to use as first guess. We have adopted the same grid as HIRLAM (~5 km of resolution). The first prototype of the system was implemented for the hydrological year September 2009 - August 2010.



Study area
- The currently SAFRAN it has been tested on the NE of the Iberian Peninsula (black square)
- Focus on
  - the Ebro river basin (red line)
  - Internal basins of Catalonia (NE tip of the Peninsula)
- The black borders show the meteorological alert-zones of AEMET, the Spanish meteorological service.

Time period:
Our first prototype of the system is applied to the hydrological year **2009/2010**.
Here a case study: the snowstorm in Catalonia on 8th March 2010

SAFRAN Meteorological Analysis



SAFRAN (Durand et al., 1993; Quintana-Seguí et al., 2008) provides the meteorological forcing to the system.

Inputs:
- Temperature, wind, relative humidity, cloudiness, precipitation (solid and liquid), incoming solar radiation and downward infrared radiation.
- First guess (meteorological model HIRLAM HNR)

Outputs:
- A gridded dataset of screen-level atmospheric observations:
  - all variables necessary to force a land-surface model.
  - high resolution: temporal (hourly) and spatial (5 km).

The analysis is done over irregular zones which are "climatically homogeneous".

Ideally, within each zone, the spatial gradients are only due to differences in topography (altitude). There must be observations within each zone.
There is one analysis for each zone and level (there is a level each 300 m.).

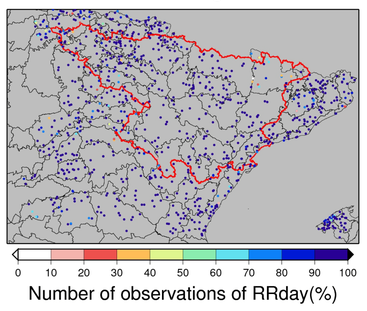
The method is well adapted to mountainous areas (common in the NE of Iberian Peninsula), as it deals very well with vertical gradients.

Long and short wave radiation is calculated with a radiation scheme due to the lack of observations.

SAFRAN Zones and STATIONS

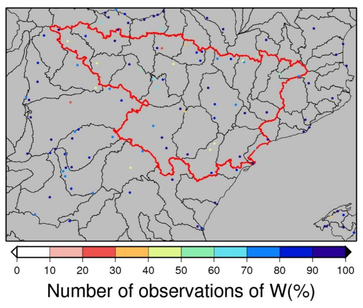
Two possible sets of "climatically homogeneous" zones are being tested:

AEMET's Meteorological Alert Zones and raingauges



- Defined using the experience of AEMET
- They respect the adminstrative borders
- The French zones are smaller than the Spanish ones.
- Relatively high raingauges coverage

Eurocatchment basins and wind stations



- Hydrological basins
- Water management borders
- Size is very variable
- Few wind stations

Preliminary test: we have compared the general statistics using both sets of zones and we compare them to the scores in France (from Quintana-Seguí et al 2008).

	Temperature (C)		Wind Speed (m/s)		Precipitation (mm/d)	
	<Bias>	<RMSE>	<Bias>	<RMSE>	<Bias>	<RMSE>
meteoalerta	0,0	0,9	−0,2	1,1	0,0	3,2
eurocatchment	0,0	0,8	−0,3	1,1	0,0	2,5
SAFRAN/F 0102	0,0	1,5	−0,3	1,4	0,0	2,4
SAFRAN/F 0405	0,0	1,4	−0,2	1,4	0,0	2,4

The scores of SAFRAN in Spain are comparable to the scores in France.

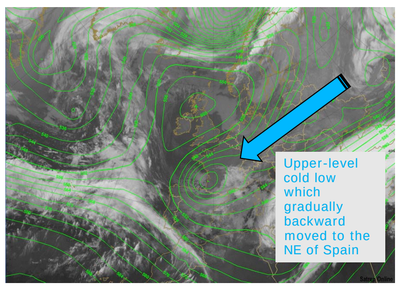
- Biases are generally small,
  - but sometimes there are some dipolar structures when the zones are not climatically homogeneous.
- The results are similar with both divisions.
- The number of stations for some variables is too small, there are zones without observations. In this areas, SAFRAN cannot do the analysis reliably.

Analysis of the snowstorm

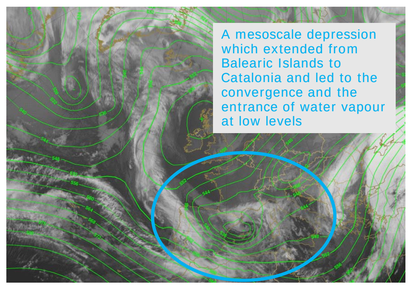
Heavy precipitation occurred on 8th March 2010 in Catalonia (in the northeast of Spain), with total amount that locally exceed 100 mm and snowfall amount of more than 40 cm measured in many places. In the Barcelona city as well as in the Girona province, this precipitation were joint to thunderstorm and strong gusts.

Synoptic conditions: analysis of the geopotential at 500 hPa (ECMWF model) and images from Meteosat. Source: www.satreponline.org

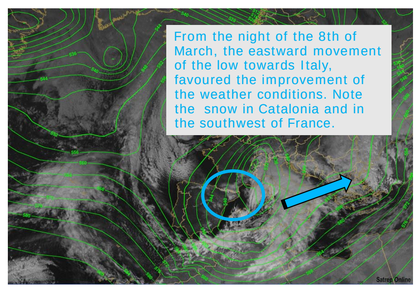
08-03 00UTC -infrared ch.



08-03 18UTC -infrared ch.



09-03 12UTC visible channel

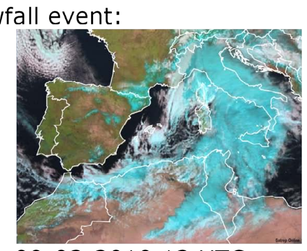


Analysis of the impacts

This event had an high impact in Catalonia since it created hazardous road conditions and important problems in the electrical supply in the Girona province. The regional government approved funds of 21.4 millions of Euros to mitigate the damage caused by this snowfall. The precipitation was unusual due to combination of low snow level for this month and the presence of thunderstorms. In particular this event was characterized by "wet snow", a kind of snow that favours the accretion on the electric lines and may cause the breaking of the line and often an electrical failure.

Before and after the snowfall event:

06-03-2010 12 UTC



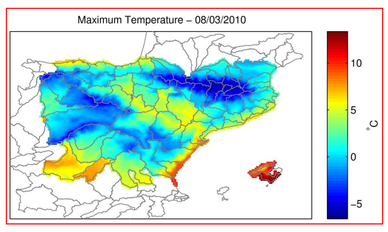
09-03-2010 12 UTC

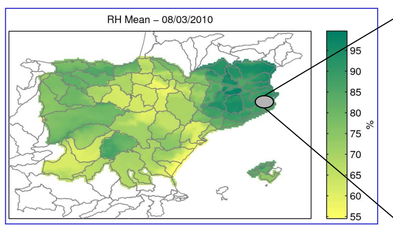
Image from Meteosat (RGB channel). Source: www.satreponline.org

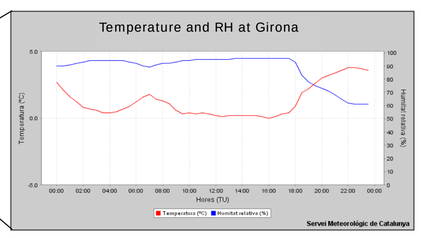
Portbou (Girona). The snow caused many damages to the electricity network. Especially in Girona and Barcelona. Source: www.elperiodico.com

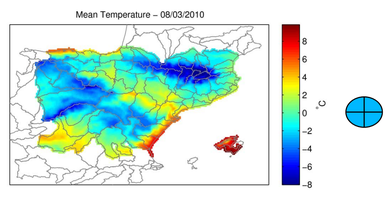
Las Gavarres (Girona). Trees that have fallen due to the effect of snowfall and wind. Source: www.elperiodico.com

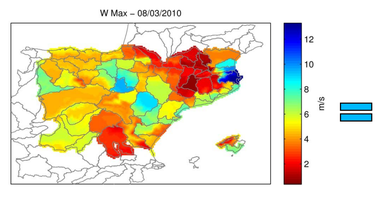
Analysis of SAFRAN for the snowstorm

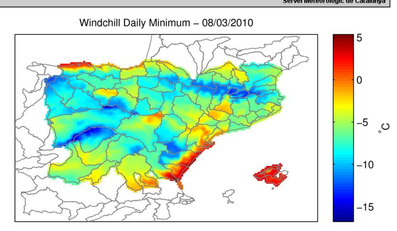




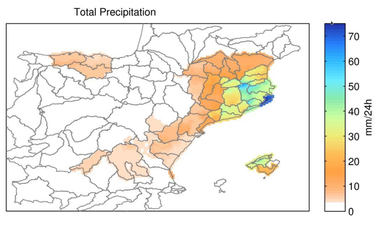


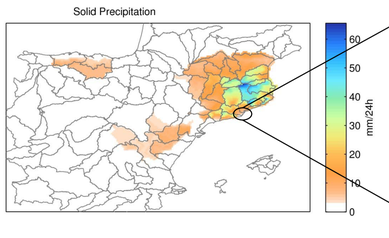






In many areas of Catalonia the temperatures ranges from -1ºC and 2ºC with high humidity and snow intensity values, determining the type of snow called "wet snow" (Farzaneh, 2008). The combination of wet snow and wind can be a risk because of the ice-weight accumulated on objects (as the electricity pylons).





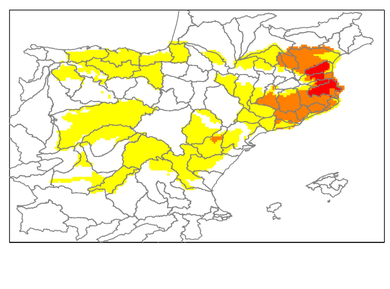
Sagrada Família Barcelona

WET-SNOW WIND RISK MAP

We test a new risk index following a simple approach, taking into account the uncertainties of the input data. This map correlates well with the areas on the highest impacts.

WET-SNOW WIND RISK = SNOW * TEMP * WIND

Where:
SNOW = 1 (if snow intensity > 0.25 cm/h), 2 (if snow > 0.5), 3 (if snow > 1), 4 (if snow > 2)
TEMP = 0 (if T<-4 or >4 ºC), 1 (-4<=T<-1 or 2<T<=4), 2 (if -1<=T<=2)
WIND = 1 (if W<15 km/h), 2 (if 15<=W<30), 3 (if W>=30 km/h)



Summary and conclusions

- SAFRAN has been successfully implemented on the NE of the Iberian Peninsula.
  - Our results are still preliminary: more data of some variable (e.g. wind) is needed.
  - The choice of SAFRAN for this area of study is pertinent, as it performs similarly as it does in France, where it is operationally used in many contexts.
  - The meteorological alert zones are generally homogeneous, nevertheless, our preliminary results show that the division in basins (eurocatchment) is better, mainly for precipitation
- SAFRAN analysis system provides a mesoscale atmospheric knowledge of near-surface atmospheric variables in which the observations are checked for their quality and finally the output variables are consistent among them.
  - Consequently SAFRAN permits to calculate risk indices as for example the wind-chill or risk map as in this case study.
  - This is the first step to complete hydro-meteorological model including a land-surface model forced by SAFRAN (Habets et al. 2008, Quintana Seguí et al., 2009). The availability of a good data set is usually the major difficulty to overcome before using a land-surface model.
  - The SAFRAN gridded database and the simulations of the water balance will be very useful for research on meteorology (mesoscale analysis), hydrology (water resources, drought, etc. as in Quintana Seguí et al., 2010), risk of forest fires, etc.

References

Durand, Y et al. 1993. "A meteorological estimation of relevant parameters for snow models." Annals of Glaciology 18:65-71.
Habets, F. et al. 2008. "The SAFRAN-ISBA-MODCOU hydrometeorological model applied over France." Journal of Geophysical Research 113.
Quintana-Seguí, P. et al. 2008. "Analysis of Near-Surface Atmospheric Variables: Validation of the SAFRAN Analysis over France." Journal of Applied Meteorology and Climatology 47:92.
Quintana Seguí, P, E Martin, F Habets, and J Noilhan. 2009. "Improvement, calibration and validation of a distributed hydrological model over France." Hydrol. Earth Syst. Sci. 13:163-181.
Quintana Seguí, P., A. Ribes, E. Martin, F. Habets, and J. Boé. 2010. "Comparison of three downscaling methods in simulating the impact of climate change on the hydrology of Mediterranean basins." Journal of Hydrology 383:111-124. http://linkinghub.elsevier.com/retrieve/pii/S0022169409006246.
Farzaneh M. Atmospheric Icing of Power Networks. Springer; 2008.

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