Forecasting severe weather events, more than 24 hours ahead at Météo-France: A plea for a human expertise

Introduction

For the short range, typically **24 hours ahead,** severe weather forecast procedures have been in effect for a long time. The French "vigilance" watch map, operational since 2001, puts in concrete form the primary role of METEO FRANCE in the domain of protection of persons and goods, and has proved generally successful. Improvements in numerical weather prediction during recent years, now enable a focus on forecasting dangerous weather phenomena at longer ranges (e.g. within the Medium Range between D+2 and D+4 – see Figures 1, 2) and beyond the requirements for triggering a "Vigilance" warning. However, this can't be just a simple extension of the validity of the vigilance watch map, because uncertainty generally quickly increases with the forecast range and makes a **deterministic** approach difficult. At present, no specific products are available for governmental services, media, or general public for this type of forecast. This article deals with an experiment that has been conducted at the national forecast service of METEO FRANCE for 3 years.

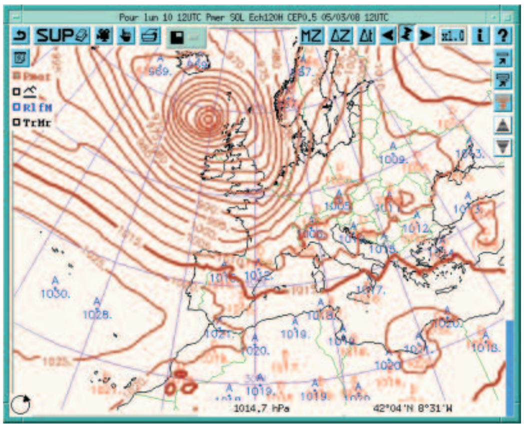


Figure 1: An example of a D+4 forecast by the ECMWF model, the storm Johanna on 2008-03-10.

There has been much research on forecasting severe or hazardous weather events, mostly based on the ensemble prediction system (EPS) - see **"References".** In general, the idea is to provide indices or probabilities according to different severe or abnormal weather thresholds using sophisticated methods of calibration in time and space. The outputs can be displayed in two forms: On the one hand, for **a given location** with the time evolution of the distribution of parameters above severe weather thresholds, and on the other hand, for **a given time or a time-window,** with the probabilities associated with these thresholds on a geographical area. Accuracy and skill of these forecasts have been shown but interpretation of these outputs is not often simple for users who lack any meteorological background. It's not easy to provide these users directly with these kinds of products in a way that can be easily understood by non-professional meteorologists.

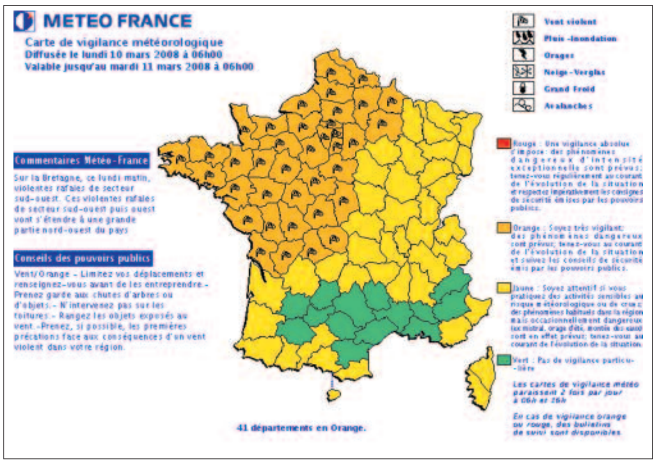


Figure 2: The vigilance watch map, issued by METEO FRANCE for this day at 6 o'clock in the morning. Some formalised information could have been indicated four days ahead…

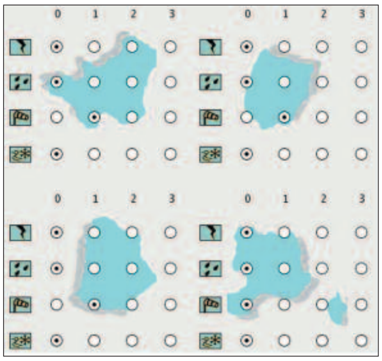


Figure 3: The "web" form filled in by the forecasters each morning.
The example of the D+4 forecast for the cyclone Johanna on 2008-03-10.

Method

In our experiment, the approach used in the vigilance procedure is retained. For a given geographical area, an estimation of the risk of dangerous phenomenon occurrence has to be provided for ranges beyond the period covered by the vigilance watch map, for each given day, from D+2 to D+4. As it is impractical to work at the scale of the administrative units (Departments), France is divided into four parts, which are on a spatial scale more relevant for these forecast ranges. This zoning is as close as possible to the METEO FRANCE regional service zoning. Within each zone, a risk index is selected from: no risk (0), unlikely (1), likely (2), certain (3). The phenomena considered are violent winds, heavy rain, violent thunderstorms and snow/ice. Each morning since 2005, forecasters have assessed the risk index based on their study of the deterministic models, EPS products, EFI and so on, and filled in the "web" form (figure 3). It is important to mention that forecasters are familiar with this system, which has been in use for rare and uncertain events for a long time.

Use and limits

Two aspects must be investigated:

1 - From the forecaster's point of view, the most important question is this: for each risk index level, what was the outcome? What percentage of forecasts for each index actually correspond to severe weather events?

2 - From the user's point of view, the key issue is this: for the observed conditions, what was the forecast? Is the forecast able to discriminate between events and non-events?

The answers to these questions will lead to the **forecast formulation,** to put the forecast in a significant concrete form **(the final product)** for the decision maker, and to estimate the potential usefulness for him.

The first step was to choose **reference** or **"truth" data** about severe weather events. In this study, it is the colour of the vigilance watch map at the scale of the defined quarters of France. A dangerous phenomenon depending on the parameter is considered to happen when at least, one department received an orange or red level within the quarter and day examined.

The best way to investigate **the first point** is to plot the frequency of occurrence of an event against the forecast risk index, leading to reliability and sharpness diagrams. These are very informative. Some results are presented in figures 4 and 5. Of course the season is taken into account depending on the parameters (eg. snow will never be forecast in the summer!).

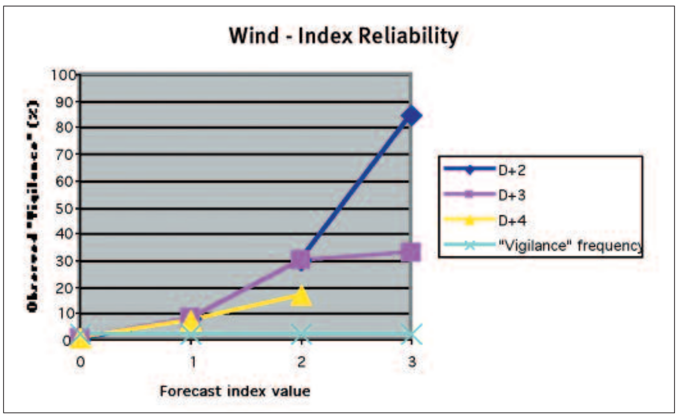


Figure 4:"Reliability" diagram and "Sharpness" table for the Wind over all four quarters of France.
For each index level, the rate of observed "Vigilance" is calculated.
The table gives the number of cases.

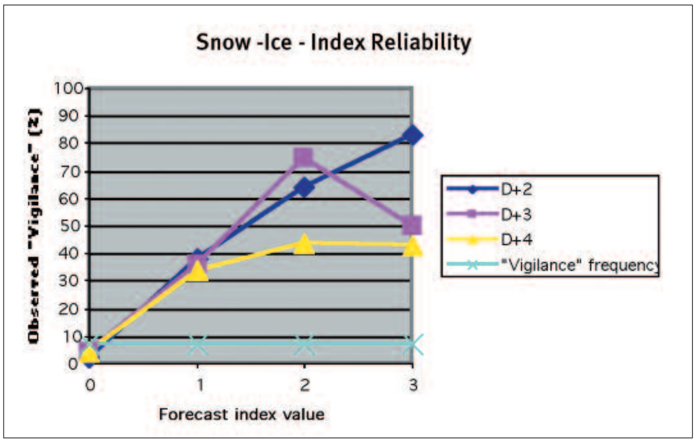


Figure 5: "Reliability" diagram and "Sharpness" table for Snow-Ice - total of all four quarters of France.

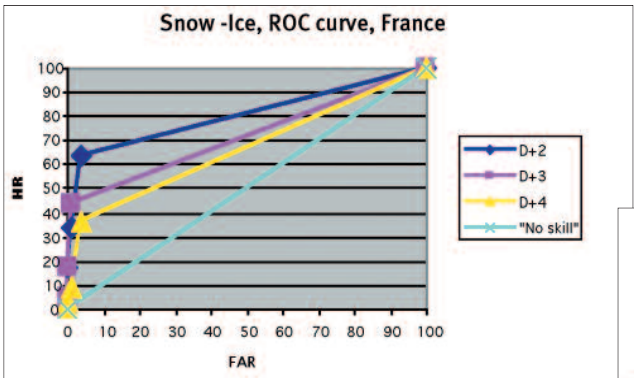
The first conclusions which could be drawn are as follows:

Sharpness is generally important. Forecasters take risks by choosing high-level index, especially at D+2. At this range, reliability can be considered as excellent with discrimination between the four levels of the index, and a significant difference from the "climatological" frequency of vigilance. In particular for index 0, the misses (severe weather events observed but not forecast) are very low, and for index 1, significantly above the average frequency of severe weather events. Beyond D+2, the discrimination between index 2 and 3 becomes quickly weak, whereas the discrimination remains much the same for index 0 and 1. We notice as well that the behaviour of the forecast (slope of curves) varies with the parameter being considered which surprises forecasters. This is also an opportunity to give them feedback about their own forecast process.

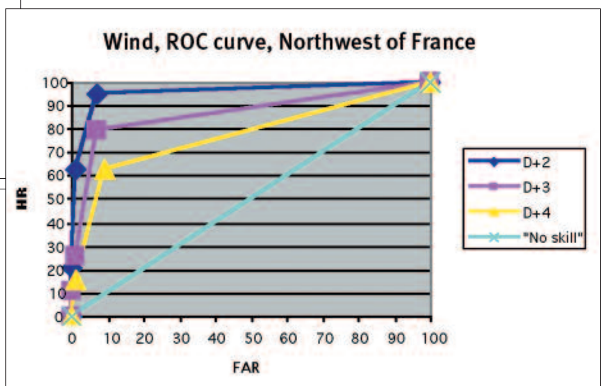
The second point can be synthesized by drawing ROC curves (figure 6, 7, 8), less well known among the forecasters community than Reliability diagrams but equally useful. Consider the following contingency table:

Observed		Forecast		
		Yes	No	Total
	Yes	Hits	Misses	Observed yes
	No	False alarms	Correct negatives	Observed no
	Total	Forecast yes	Forecast no	TOTAL

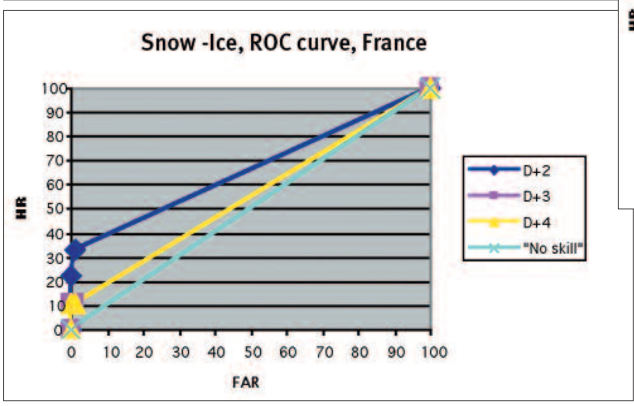
ROC curves plot Hit Rate (**HR**=Hits/(Hits+Misses), representing the fraction of observed "yes" events correctly forecast) against False Alarm Rate (**FAR**= (False alarms+Correct negatives), representing the fraction of observed "No" events incorrectly forecast as "Yes") for a range of index thresholds (values 1,2,3 together, then 2 and 3 together, and lastly 3 alone).



◀ *Figure 6: ROC curves for Snow-Ice - total of the four quarters of France.*



▲ *Figure 7: ROC curves for the Wind for the northwest quarter of France.*



◀ *Figure 8: ROC curves for the Wind for the northeast quarter of France.*

The graphs show clear evidence of skill, in particular for violent wind within the northwest region of France (points are near the upper-left part of the graph where HR=1, FAR=0). The results are less good within the northeast region with no discriminating power at D+3 and D+4 (curves near the straight line HR=FAR), showing large differences at regional scale! In that case, explanation can be found in the continental character or the smaller scale of phenomena leading to violent winds on the northeast of France, making the forecast trickier in this area than on the northwest part. This is another chance to make forecasters aware of these difficulties!

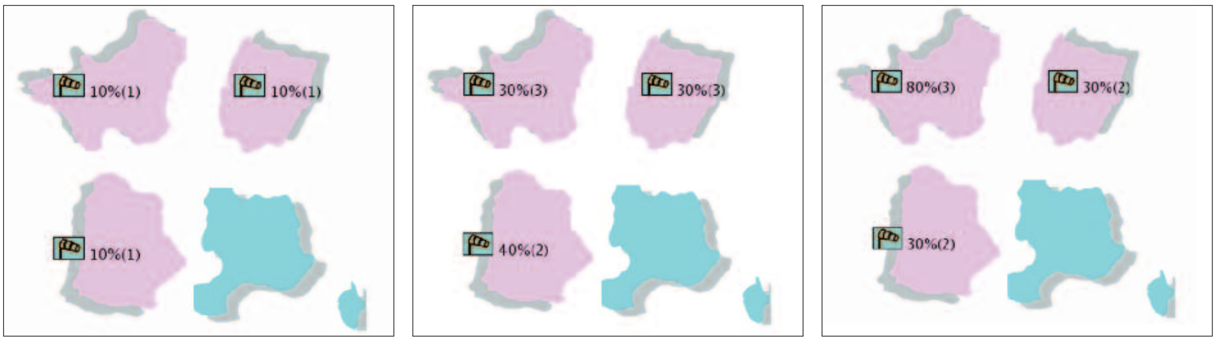
Final product

The idea is simply to provide, in real time, the probabilities corresponding to the reliability of the chosen index for each parameter (figures 9, 10, 11), taking into account:

- The sample representativeness. Reliability is calculated at the regional scale if the sample size is sufficient, or at scale of France as a whole if the sample size is small.

- The discrimination between indexes. Reliability is calculated for each index if the discrimination is sufficient, or for a combination of indexes if the discrimination is not sufficient. For example at D+3, three relevant indexes have to be considered: 0, 1 and, 2 and 3 taken together (Wind and Snow-Ice).

Of Course, these probabilities will be refined as the sample sizes increase. The evolution of the risk level day after day could be also examined.



Figures 9, 10, 11: The final product: the production issued for the situation on 2008-03-10, from D+4 (left) to D+2 (right) forecast. These charts daily are available on an internal webpage.

Conclusion

The first results make the forecasters very confident in their capacity to produce relevant information about severe weather events more than 24 hours ahead, and to draw a decision maker's attention to the threat. Despite small sample sizes, the forecast reliability is established and will obviously improve day by day. Forecasters are now used to systematically discussing the risk index after looking at the numerous EPS products and deterministic models. This experiment gives the opportunity to communicate in terms of probabilities, the most appropriate way in this case but not the most common at METEO FRANCE. A trial is due to be held this autumn with a few governmental services in order to evaluate the potential usefulness of this type of forecast. But some questions from users already show that the properties of probabilities must be explained. In fact, one still thinks that a probability of 50% corresponds to the toss of a coin, whereas it's significantly high when the climatological frequency of the phenomenon is low. Finally, the most important criticism, which already emerges, concerns the zoning of France into four parts. We believe that the method remains valid because a decision maker will always be responsible for a given geographical area and would like quickly to know what might occur within this area. The zoning has to be then well defined. An example of this principle could be applied with METEOALARM chart at the scale of European countries.

References

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