Diagnostics of first guess errors and sensitivity to provide help to forecasters

First Guess error diagnostic

The aim of the analysis is to minimise the difference between the first guess and the observations. To do that, the model uses a matrix of variance and covariance of forecast errors and observational errors. These quantities are related to the statistical confidence in both the numerical model and observations, and the finalised analysis is weighted towards one or the other. However, the forecaster has no clear idea of what the model really does with the analysis. To resolve this problem, the forecast laboratory at Météo-France have developed two charts of first guess error diagnostics, one for low levels (surface-700 hPa) and the other one for upper levels (400-200 hPa).

What is the principle of these charts?

The variance of the difference between the first guess and the observations is calculated and then the ratio between this calculated error and the climatological error is plotted.

If this ratio is near 1.0, the forecast error of the model is acceptable; the analysis is an optimal minimisation between the first guess and the observations.

If this ratio is clearly lower than 1.0, the real variance is weaker than the climatological one and the analysis will tend to move away from the first guess and draw towards the observations.

If the ratio is clearly higher than 1.0, the real variance is more important than climatological one and the analysis will tend to draw too much towards the first guess to the detriment of the observations.

A colour coded identification scheme is used to separate two kinds of observations: crosses and lines when the assimilation draws towards the observations and red, grey and yellow when the assimilation draws towards the first guess.

Examples of these charts are shown in Figures 1 and 2 below.

The weakness in surface pressure to the southwest of Ireland as analysed by Arpège at 1800 UTC and 0000 UTC generates strong winds in the respective forecasts. However, confidence in the analysis is low because the assimilation has drawn towards the first guess (red and yellow points).

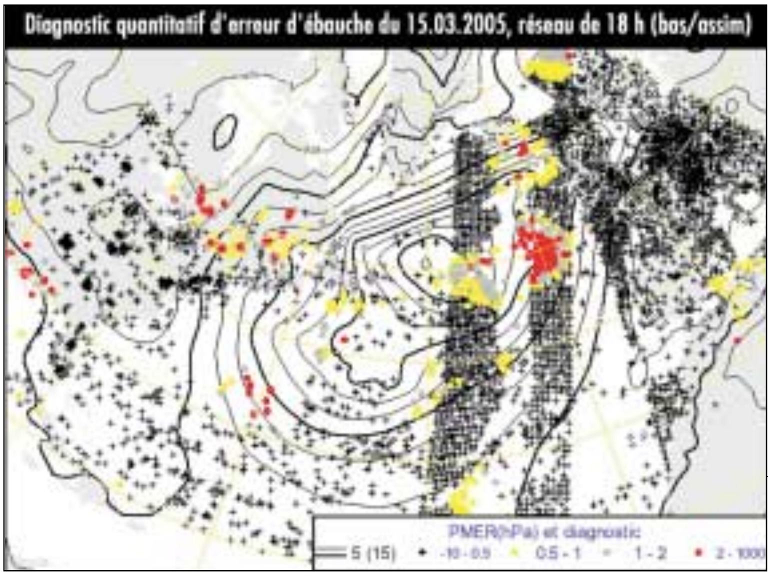


Figure 1. Mean sea level pressure on 2005/03/15 18 UTC with guess error diagnostic

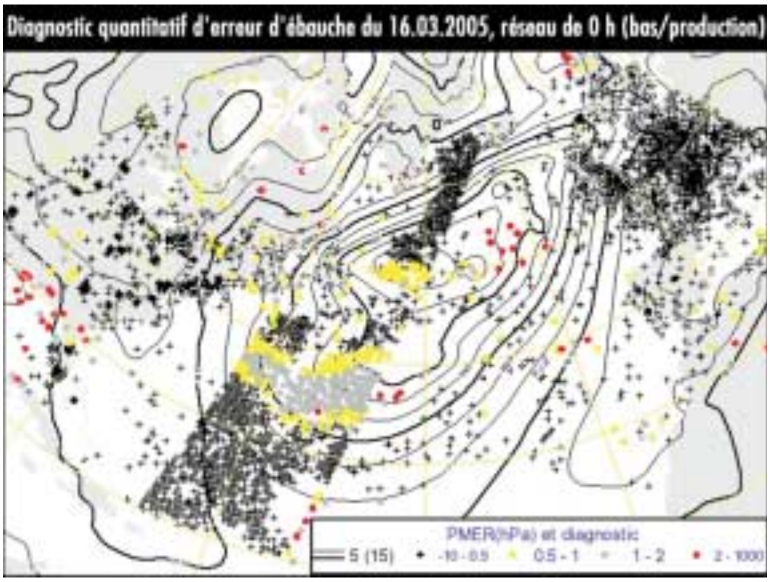


Figure 2. Idem figure 1 for 2005/03/16 00 UTC

In conclusion, this diagnostic brings more transparency to the assimilation. The forecaster can visualise areas where there is a potential conflict between the first guess and observations and make subjective assessments on the model analysis. However, although it is useful to identify problems in the analysis, the forecaster also needs to assess the potential consequences on the forecast. There is a need for a diagnostic tool of foreseeability.

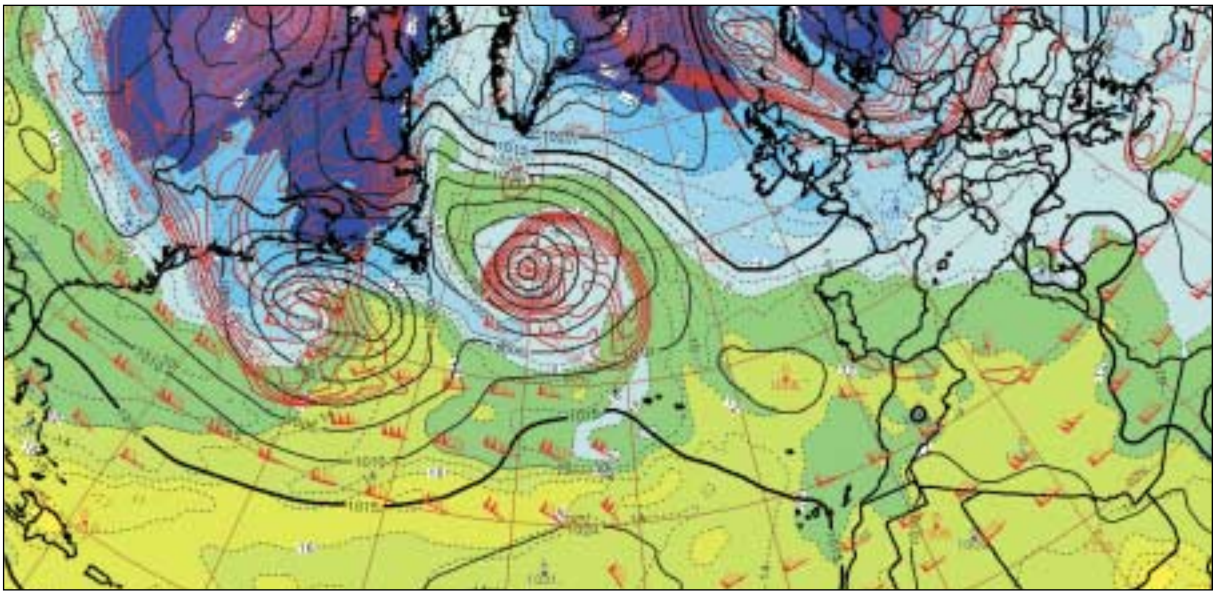
Progress in foreseeability

A parallel process within Arpège allows the forecaster to identify the sensitive areas for the forecast. This tool is based on an explicit diagnostic calculated on the first four singular vectors. After each run of Arpège, four charts of sensitive areas are provided, two for H+30 (lower levels and upper levels) and two for H+48. The use of these charts will be illustrated with an example: The situation of 13th March 2005.

Fields on these composite charts are surface pressure, 850 hPa wet-bulb potential temperature (shaded colours), height of the 1.5 PVU surface and winds at 1.5 PVU level.

We focus on the warm front, depicted by the 850 hPa wbpt gradient, which lies across Spain on the analysis and reaches the southwest of France on the 30 hour forecast. We could imagine that the main feature controlling the evolution is the frontal system in the middle of the Atlantic Ocean associated with a deep low. However, the area of sensitivity at upper levels is situated between Greenland and Iceland on the analysis (see figure 5 below).

Figure 3. 2005-03-13 00 UTC analysis



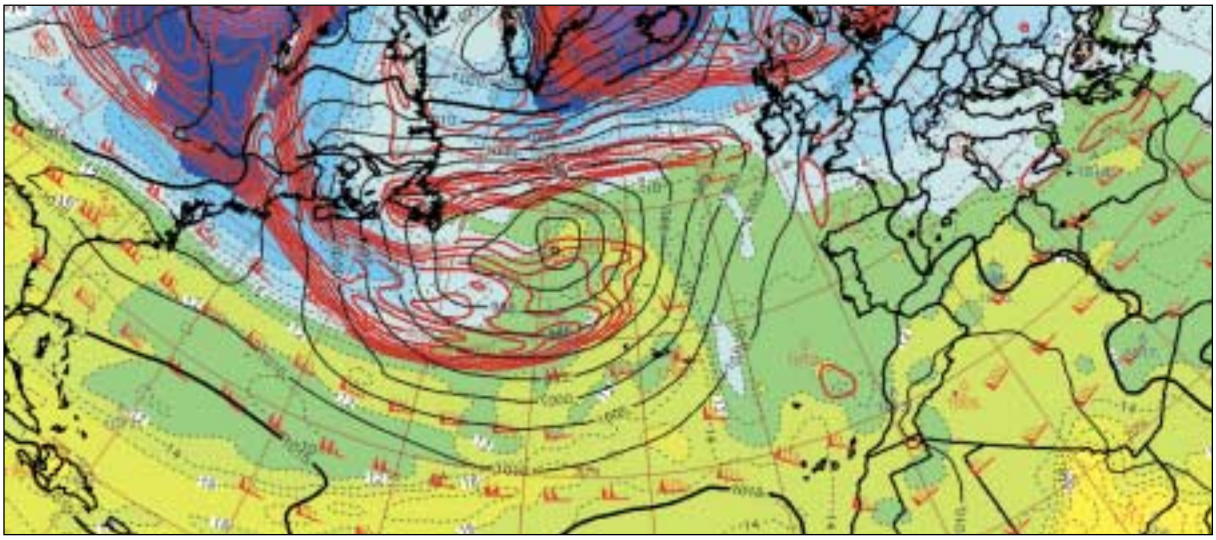


Figure 4. 30 hours forecast for 2005-03-14 06 UTC

In this area, the comparison between the water vapour imagery and the height of the 1.5 PVU surface suggests some problems in the model analysis. In order to obtain a better fit with the water vapour pattern, the forecaster makes some adjustments to the PV fields associated with the trough approaching Iceland in the strong north westerly flow aloft.

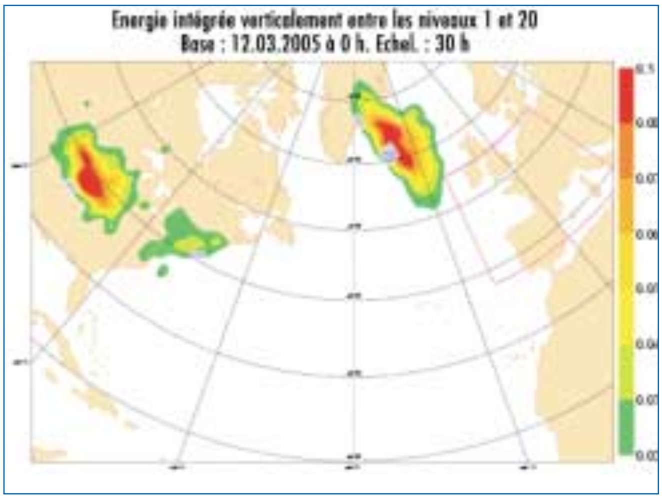


Figure 5. Area of sensibility in altitude for the 30 hours forecast over France

Figure 6 shows the differences between Arpège and the modified 0000 UTC analysis for the height of the 1.5 PVU surface. In blue, the positive difference near Iceland means that the forecaster has enhanced the trough. Note that there is no difference to the large-scale low system in mid-Atlantic and only minor differences on the trough over central Europe.

The next step is then to rerun the model and monitor the evolution of the difference between the previous model and the new run with the modified analysis.

At H+12 (see figure 7), the initial differences weaken between Iceland and Scotland but others appear on the trough over the Atlantic Ocean, as if there were interactions between these two main features of the circulation.

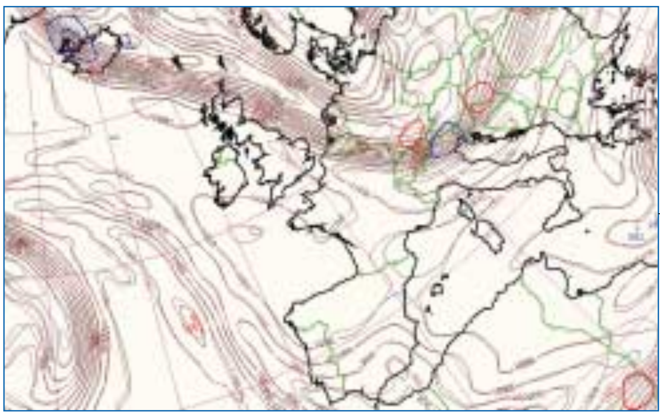


Figure 6. 2003/03/13 00 UTC analysis of Z = 1.5 PVU. In blue, positive differences of the altitude of the 1.5 PVU surface at 00 UTC between Arpège and the modified model by the forecaster. In red, negative differences.

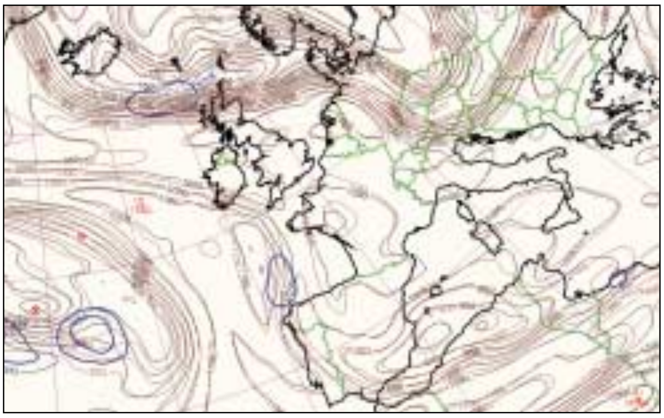


Figure 7. Same as figure 6 but for T+12 forecast

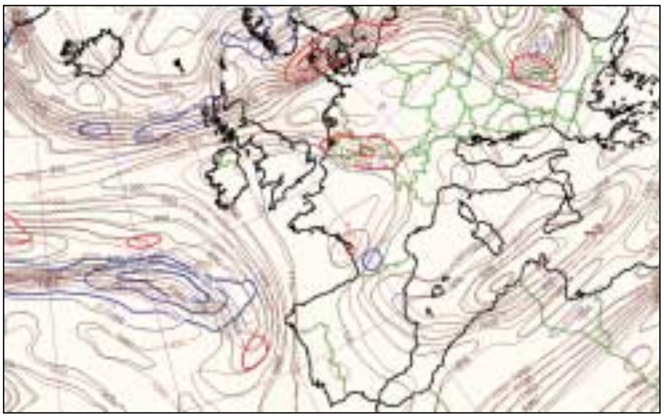


Figure 8. Same as figure 6 but for T+24

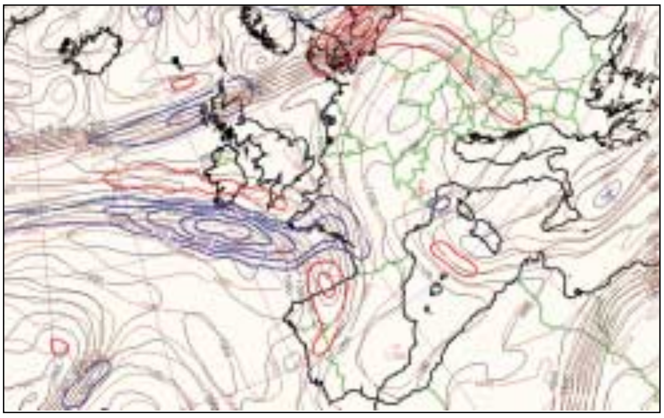


Figure 9. Same as figure 6 but for T+36 forecast

At H+24 (see figure 8), the differences over the Atlantic, to the northwest of Spain, are growing. The positives differences mean that the trough moves more slowly to the east in the modified Arpège run.

At H+36 (see figure 9), the differences on the trough reaching the Bay of Biscay continue to grow. As a consequence, the forecast over France is different between the initial and modified Arpège runs, especially with respect to the position of the warm front.

The sensitivity diagnostic has therefore allowed the identification of the areas where modifications will have a significant effect on the forecast.

Conclusion

Two new tools for the forecaster have been presented. The first guess error diagnostic provides more transparency on the assimilation and highlights areas where the bias towards the observations is weak. The sensitivity diagnostic provides a better understanding of the main synoptic features. It also allows the forecaster to monitor the critical areas where observations could be important and where field modifications (using PV inversion techniques) will have a marked effect when the model is rerun.

Hubert **Dreveton,**
Bernard **Roulet**
Météo-France