Examples of ARPEGE ensemble forecast use

Introduction

The ensemble model based on ARPEGE is named PEARP (PEARP=Prévision d'Ensemble ARPege). It is a small ensemble of eleven members including ARPEGE as the control run and ten perturbed members with the same resolution as ARPEGE. The perturbed runs are built with the singular vectors method (16 first singular vectors, optimization time window 0-12 hours, total energy norm, no physics, singular vector computation with a T63 regular truncation). The ensemble PEARP is run once a day at 18 UTC with a 60-hour range.

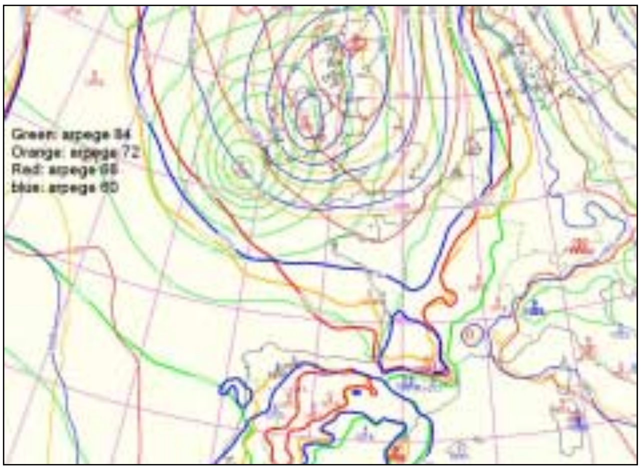


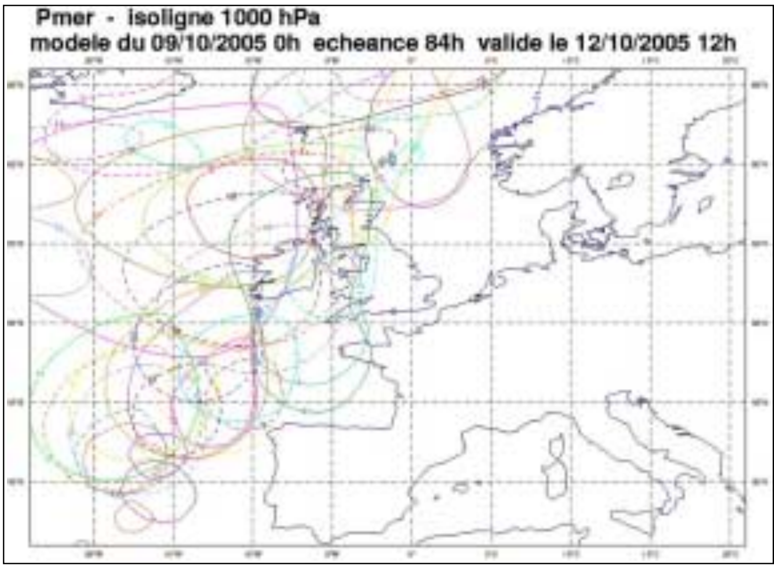
Figure 1: Positions of the storm on 12th Oct 2005 12 UTC based on successive ARPEGE runs

The spatial domain of PEARP covers the Northern Atlantic Ocean and Western Europe. The prime objective is to capture storm tracks but it is also used by forecasters on a day-to-day basis in conjunction with other available models.

In this article, two examples demonstrate how output from PEARP can be applied to typical forecast problems.

Example 1: risk of deep low over Western Europe at D+2, 10th Oct 2005

In a rapid southwesterly flow, all the deterministic models forecast an intense cyclogenesis event at D+2 near the British Isles but there was a large spread of solutions between successive model runs and different models.



The ECMWF ensemble forecast also gave an indication of great uncertainty. Figure 2 shows the 1000 hPa isobar plotted for each ensemble member with the cone of uncertainty ranging from north of the United Kingdom to west of Iberia.

Figure 2: Positions of the low in the 84 hour forecast for each of the 50 members of the ECMWF ensemble forecast (data time: 9th Oct 2005 00Z)

Verification of the initial conditions

In the initial conditions, the low did not exist. It developed as a secondary wave along a cold front to the southwest of Ireland. At upper levels, a rapid westerly jet stream extended from Newfoundland to the central Atlantic and then turned to the southwest towards Ireland. PV anomalies circulated along the polar side of the jet and initiated the early stages of deepening. A secondary northwesterly jet stream brought colder air from Labrador and probably played an important role in the subsequent deepening process. However the main source of uncertainty was the presence of a tropical storm named "Vince" in an unusual place near Madeira. The warm low-level air of the tropical storm was caught ahead of the cold front and helped to trigger the cyclogenesis process. There was no clear misfit between the model analysis and observations, water vapour and IR satellite imagery (see Figure 3).

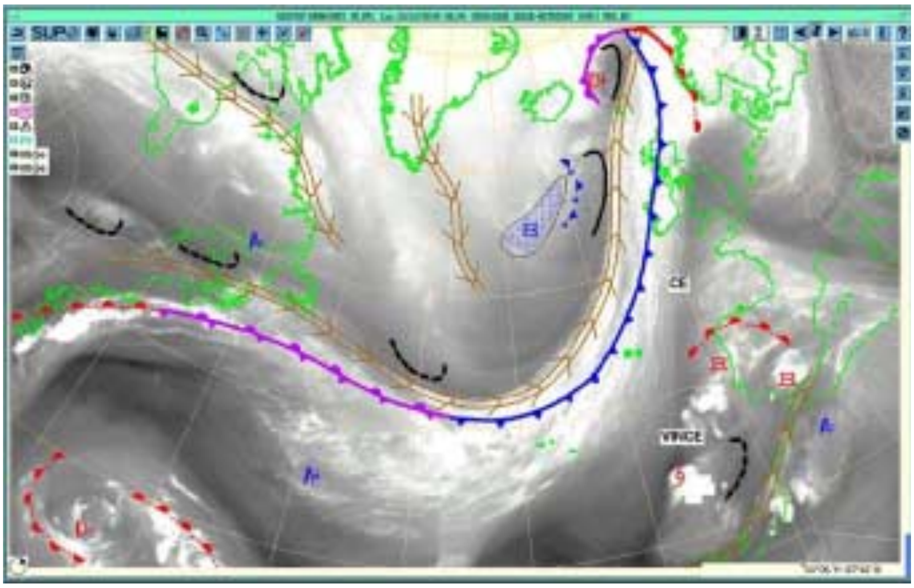


Figure 3: Water vapour imagery and synoptic features on 10th Oct 2005 06 UTC.

The individual runs of PEARP show three different types of forecast but with an almost equal number of members. So it didn't really help the forecaster to make a choice.

Type 1: a deep low

Type 2: a moderate low

Type 3: a trough

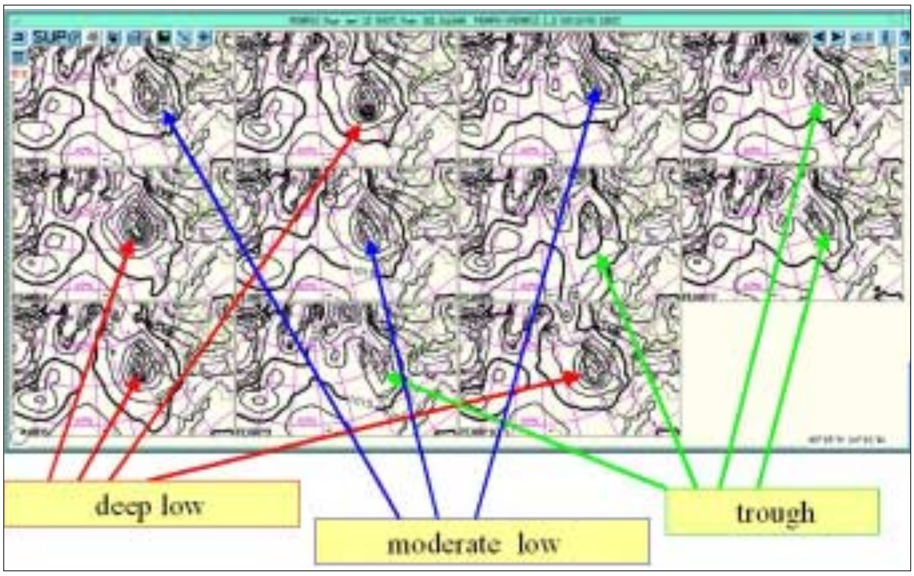


Figure 4: 54 hour forecast of MSLP from the 10 members of the Arpège ensemble.

Conclusion

In this case, the forecaster had no objective way to choose a scenario. The latest runs of models were chosen (a deep low) but it was a wrong choice: the resulting analysis showed a large and smooth trough.

Forecasters are still faced (very rarely hopefully) with such cases where everything is possible without solid arguments that allow a choice between different scenarios, either in the initial state, or in the model evolution.

Example 2: verification of the D+2 forecast for Saturday 15th April 2006

On 15th April 2006, a dynamic short wave trough crossed France with a band of heavy rain (see Figure 5).

The D+2 forecast for this day was based on ARPEGE rather than ECMWF because it gave more rain associated with the trough and indicated a faster movement. Furthermore, this scenario was supported by others models.

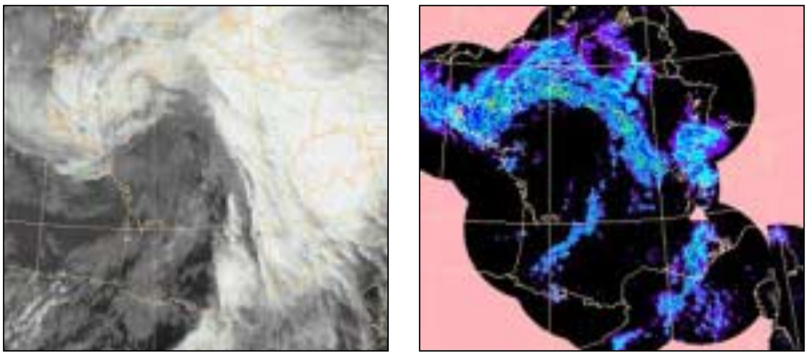


Figure 5: IR and radar images on Saturday15th April 2006 12 UTC

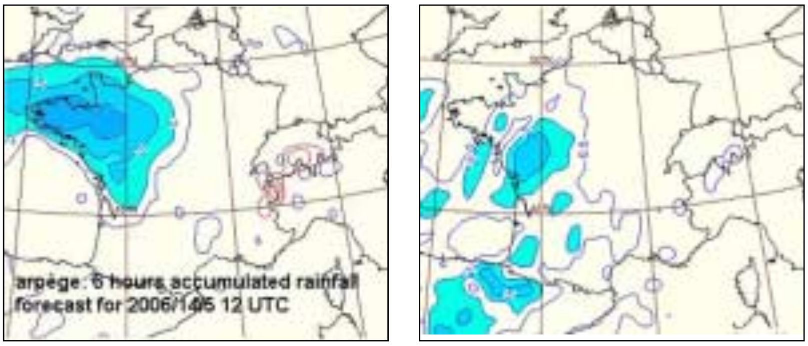


Figure 6: Comparison between Arpège and ECMWF 6 hours accumulated rainfall forecast for 15th April 2006 12 UTC.

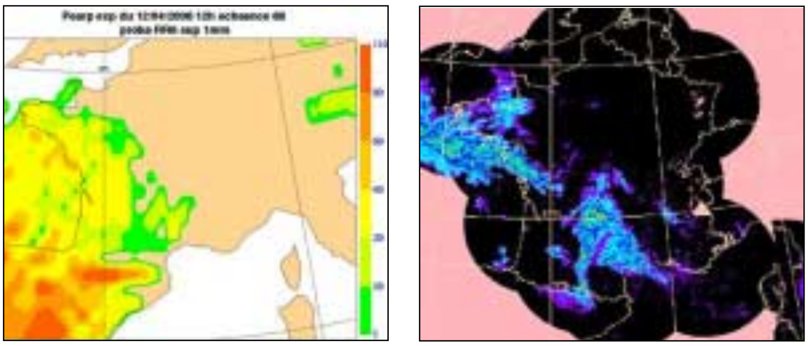


Figure 7: Comparison between the forecast probabilities of rain based on PEARP and the radar precipitation image.

The comparison between the forecast and the analysis showed that it was a good choice. However the forecast was not perfect. The rain area in the southeastern part of France was not forecast correctly.

Would it be possible to improve the forecast with the use of PEARP, the ensemble model based on ARPEGE? In this case, the answer was 'yes' because the rainfall probabilities indicated clearly the possibility of rain in the south-eastern part of the rainfall band, and was therefore a better fit to the radar images relative to the rainfall forecast by ARPEGE.

General conclusion

In some cases, the ensemble forecast PEARP based on Arpège could provide a help to the forecaster by indicating other scenarios or alternative timings of synoptic features. That could happen not only in very active situations (for example in rapid cyclogenesis events) but also in the day-to-day forecasting of less active features.

However, the ensemble forecast PEARP should be improved to give a better spread of solutions. The area over which perturbations to the initial state are generated should be extended and, above all, the number of members in the ensemble should be increased.

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