Arome, the new high resolution model of Météo-France

Introduction

In 2007, the numerical forecast system of Meteo-France was based on a global model, Arpège and a limited area model, Aladin. This operational system will be complemented in 2008 by a new high-resolution model named Arome.

The characteristics of Arome will be presented, as well as some preliminary results of its potential capability and skill through a selection of model fields.

Characteristics

The aim of the Arome project is to improve local forecasts, especially for dangerous convective phenomena (thunderstorms, flood risk, heavy precipitation) and low-level conditions (wind, temperature, ground state, fog, heat islands, etc). The tool used is the Arome software, based on a new model with its own data assimilation.

Model features

- Fine horizontal grid of 2.5 km for a better surface description (see Fig 1)
- Non-hydrostatic model with prognostic cloud representation (clouds with ice and hail/graupel phase, 3D advected hydrometeors)
- Prognostic turbulent mixing
- Sub-gridscale shallow convection
- The physical model for surface/atmosphere interaction is named Surfex. It uses a high resolution land database over Europe to represent detailed geographical features such as vegetation, soil types, seas, lakes, cities, snow, ice, etc.

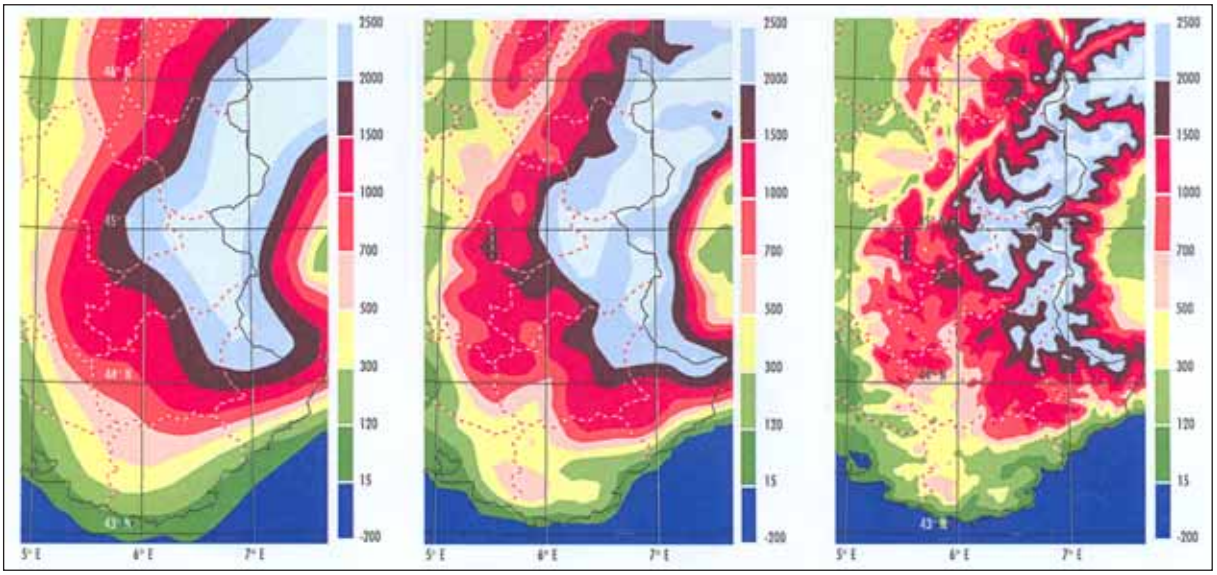


Figure 1: Orography in the Alpine region - Arpège (left), Aladin (middle), Arome (right).

Assimilation

The analysis is based on a 3DVAR assimilation process similar to Aladin but with a higher density selection of observations over France. One of the most interesting features is that Arome will assimilate radar data (Doppler winds and 3D reflectivities) and satellite radiances.

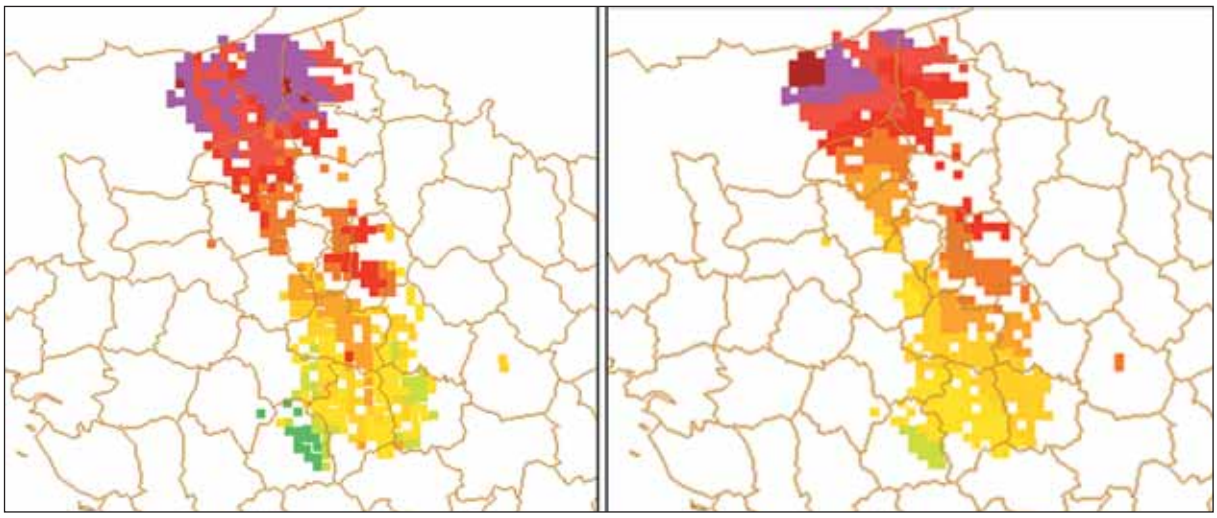


Figure 2: Radial Doppler winds observed by the meteorological radar in Trappes (top) compared to winds simulated by a model (bottom). These data are interpolated at the same spatial resolution, 10 km. (Doppler radar information can be ambiguous and is difficult to interpret directly. However, it can be easily incorporated into the 3DVAR assimilation to improve the wind field analysis).

First results

Heavy precipitation events

The most anticipated contribution of Arome is its ability to forecast heavy rain especially during Mediterranean events named "Cevenol events", in

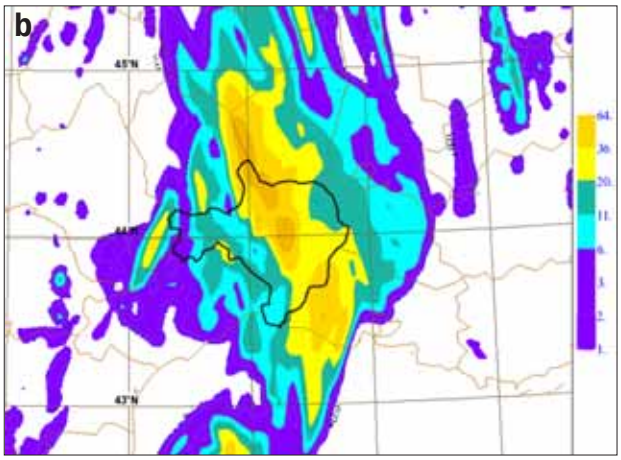
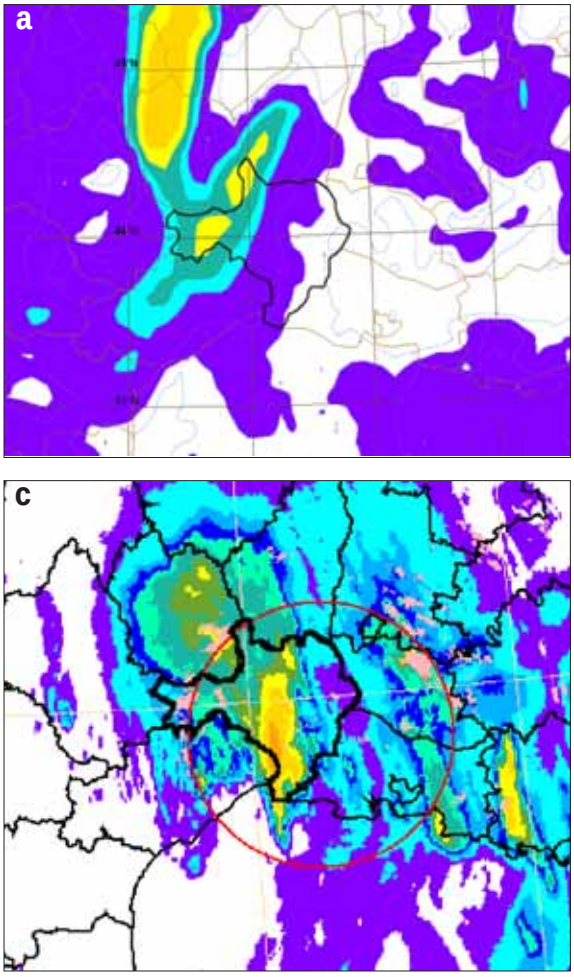


Figure 3: 3-hour rainfall accumulation during the flooding episode of September 6th, 2005.

Top: Forecast by Aladin;
Middle: Forecast by Arome without own assimilation;
Bottom: Analysis based on observations (radar adjusted by observed data).
Arome is better than Aladin although its initial conditions and boundaries are provided by Aladin



reference to the Cevennes mountains on the southern side of the Massif central where heavy rains occur during southerly flow, especially in autumn. Although the assimilation system is not yet complete, initial tests have shown that Arome forecasts are much more realistic than those given by Aladin and Arpege in terms of timing and rainfall distribution, especially during intense events, although the precise location of the rainfall features is not always accurate. Furthermore, the initial tests were carried out using a direct coupling of Arome to Aladin without high-resolution assimilation. Some additional improvement has already been shown when high-resolution assimilation has been used in other experiments.

Heavy convective features

Arome is able to forecast isolated heavy thunderstorm cells and their associated gust fronts. Intense line convection and banded structures within frontal systems are also well predicted by the model. One key point of Arome is the good forecast of squall lines forced by orography and convergence.

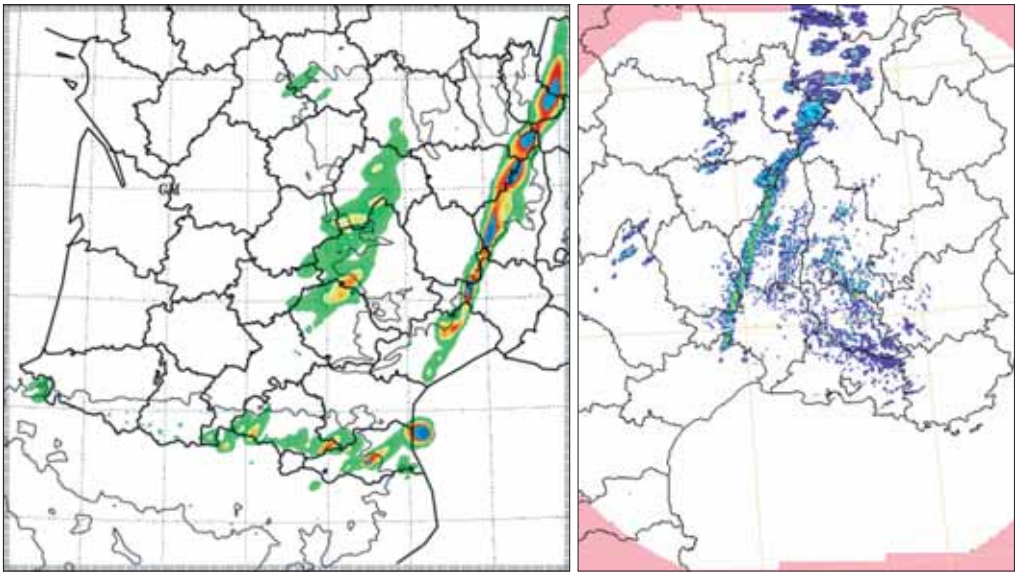


Figure 4: Example of a squall line associated with low-level convergence forced the combined orographic effects of the Pyrenees and Massif central. Left: Rainfall forecast by Arome; Right: rainfall observed by radar.

Fog

Features in Arome such as explicit boundary layer forcing and fine scale humidity analysis seem to have the potential to improve the forecasting of fog development and dispersal.

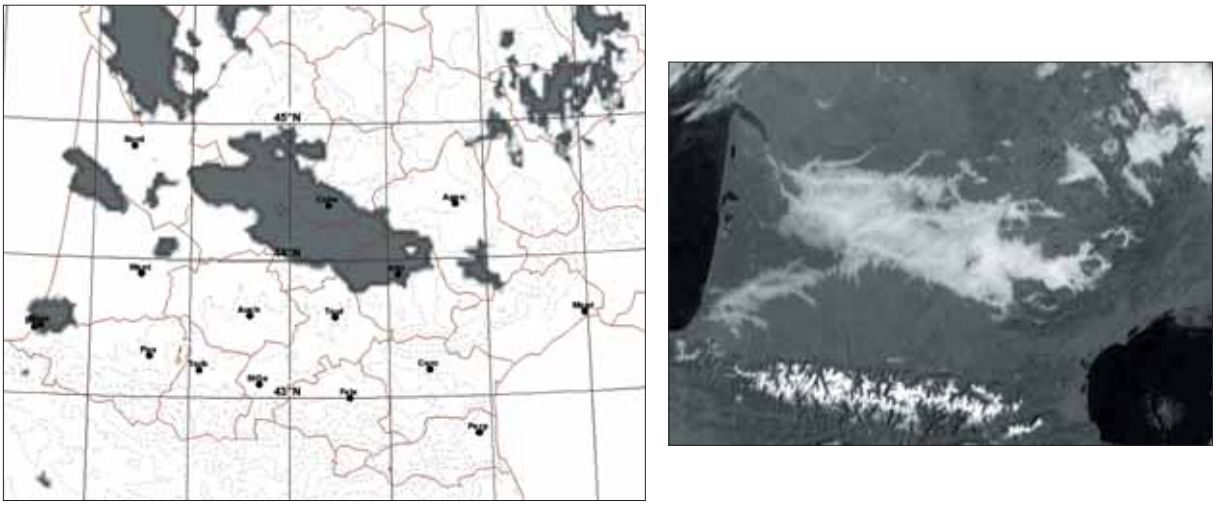
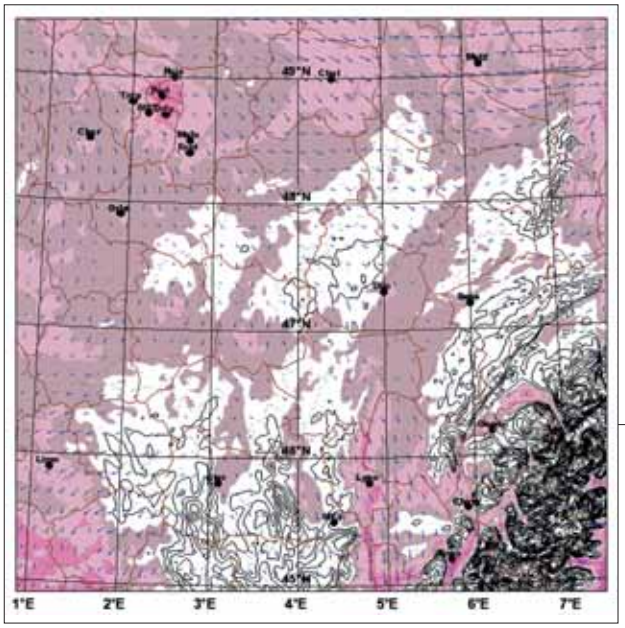


Figure 5: Example of a fog forecast by Arome (fog forecast is in grey on the left map) with observed fog distribution on the right (based on the Meteosat visible image, the area of fog over southwest France appears in light grey).



Impact of finer grid resolution

The higher resolution of the model improves the meteorological impact of geography in a spectacular way. For instance, the meteorological effects of cities, coasts and large valleys are well represented: urban heat islands, diurnal cycle of sea breezes and valley breezes, frost zones, local winds forced by orography etc.

Figure 6: Arome simulation of 2m temperature on February 10th 2006 over north-eastern France. Note in pink the 'hot' spots in the big cities (Paris, Lyon) and the relative mildness of Lake Leman. The white areas indicate frost on higher ground and in mountainous areas.

Conclusion

Arome is being tested in close co-operation with forecasters during autumn and winter 2007-2008. Continuous improvements are being made by researchers with particular attention towards stratiform clouds and light precipitatio.

A fully operational system should be implemented in autumn 2008. It will be a great challenge to forecasters to use this model in the appropriate way. To do that, forecasters must have the best possible knowledge of mesoscale meteorological features in order to interpret the model fields.

Like any other numerical forecasting system, Arome is intended to improve and diversify towards new applications. Amongst these, the following are likely:

• Very short range forecasts with frequent updates of the model run

• Introduction of a high resolution ensemble forecast system

• Evolution of a very high resolution system for local applications (factories, airports, big cities, etc.) thanks to an integrated approach to the modelling of the environment.

François **Bouttier** et Bernard **Roulet**,
Météo-France