Introduction

During the last ten years, high-resolution models have become operational in most European National Meteorological Centres. These models have changed the nature of forecasting because they give realistic details of meteorological features. It is not necessary anymore for the forecasters to imagine small-scale phenomena from the outputs of global models, but part of the forecaster’s job is now to validate, or not, details given by high resolution models. To estimate the confidence which can be granted to high resolution models, it is however advisable to know which type of meteorological situation prevails. Three main cases may be distinguished:

- No synoptic forcing.
- Synoptic forcing and mainly large-scale vertical motion.
- Synoptic forcing and mainly deep convection and therefore mesoscale features.

These three types of situations are illustrated by examples. Note that the resolution of models in the examples provided is respectively 16 km for ECMWF (global model, hydrostatic), 7.5 km for ARPEGE (hydrostatic) and 1.3 km for AROME (local model, non-hydrostatic).

Case n°1: Meteorological situations without significant synoptic forcing

This case includes anticyclonic winter situations with problems of low cloud or fog, and flat lows in summer with problems of localised deep convection.

Example from June 9th, 2015. This was a typical flat low situation with development of thunderstorms over the mountains of south-eastern France during the afternoon, extending to the neighbouring plains in the evening.

The main thunderstorms are clearly more realistic with AROME compared to ARPEGE. In ARPEGE, deep convection is parametrized so the result is large area of rain (even when undermesh rain is detailed) which is not realistic.
Case n°2: Meteorological situations with synoptic forcing and mainly stratiform rain

This case includes the majority of frontal passages, as well as rain accumulation by orographic forcing.

Example of a narrow cold front band

A comparison between radar images and forecast reflectivity by AROME shows the model’s ability in forecasting realistic mesoscale features within large synoptic features. Note that this example is not an isolated case. During a whole winter, all forecasts of narrow bands along cold fronts were almost exact. My empirical explanation is that the synoptic forcing is preponderant and thus leaves few degrees of freedom to the coupling model. That is why details given by high resolution model are often relevant in such cases.

Example of orographic rain

A realistic representation of the relief is an essential factor to forecast amounts of precipitation correctly, especially in cases of stable precipitation and flow perpendicular to relief. Considering the example of the 24th of December 2013, stratiform rain lasted almost 18 hours with mean intensity about 3 to 4 mm/h. The hills are modest and reach 387 metres at the highest point, but strikingly influence the amounts of precipitation: 20/30 mm measured on the south-western coast and up to 80 mm on hills.

Comparison between the rainfall amounts forecast by ECMWF, ARP and AROME show an increase as resolution improves. The rainfall forecast by AROME is quite realistic.

Figure 3a: Topography of Brittany with plotted 24 hour rainfall accumulation (more than 70 mm shown in red)

Figures 3b-3c-3d: 24 hour rainfall accumulation forecast by ECMWF (top) ARPEGE (middle) AROME (below)
Case n°3: Synoptic forcing with mainly deep convection

In this kind of situation, deep convection frequently becomes organized in mesoscale structures that have a feedback and modify the synoptic scale. In consequence, big differences can appear between a global model’s solution and a coupled model’s solution, because the latter explicitly resolves deep convection. These differences occur mainly in rainfall patterns as well in the chronology of disturbances. According to my experience, the advantage is almost in favour of the mesoscale model.

Example of a squall line on the 31th of August 2015

Notice the differences between ARPEGE and AROME about the chronology of the squall line that crosses southwest of France between 18Z and 20Z (figure 4).

Figure 4: One hour forecast rainfall between 18Z and 20Z by ARPEGE (left) and AROME (right)
The front in ARPEGE is much slower than in AROME. The explanation for this difference comes from the fact that AROME more realistically forecasts the dynamics of the phenomena with strong subsiding motion behind the front, which accelerates the system eastward. Figure 5 shows that the solution from AROME is quite good in terms of chronology and localisation of the squall line (at the end of the period, the model is even too fast).

Appropriate precautions

Of course, a forecast from high resolution model is not always perfect. The main issues are variability from run to run and false alarms.

Something often unknown by forecasters is that the true resolution of the model (i.e., the details it can really describe) is often greater than its mesh size (due for example to the numerical scheme used). Does a 1.3 km resolution mean that all details are true at this scale? Of course not! However, the communication of an NMS to public and authorities tends, whether we intend it or not, to endorse the idea there are no more forecasting problems or uncertainty. The chaotic character of the atmosphere is not easy to explain and meteorological science improves relatively slowly. I hope that NMSs will not make the same communication mistake with future developments of numerical forecasts.

Conclusion

In virtually every kind of situation, it is advisable to favour the solution proposed by high resolution model (see figure 6).

However, this kind of model must be used carefully and requires expertise from a forecaster. And the same conclusion applies to the next generation of numerical forecasts with ensembles of high resolution models and nowcasting high resolution models.

Figure 5: Forecast radar reflectivity by AROME at 18Z (bottom) and radar reflectivity at 18Z (top)

Figure 6: decision tree about high resolution model use.