AROME Airport: Nowcasting with a High-Resolution Configuration of the Operational French Meso-Scale AROME Model

Susanna Hagelin, Ludovic Auger, Pascal Brovelli and Olivier Dupont

CNRM-GMAP and DPrévi-PI, Météo-France, Toulouse, France

Abstract

AROME Airport is a further development of the AROME-NWC [1] and is designed to provide hourly forecasts, with a 500 m resolution, for the area around an airport which can help in the planning of the use of the runways, particularly as part of a system to support the dynamic separation of aircrafts.

AROME Airport is intialised by the forecasts from the operational AROME model [2], which provide the initial and lateral boundary conditions for a version of AROME-NWC with the same resolution as the operational model (2.5 km) but run on a smaller domain, where the data assimilation is performed. This data is then used for the intial and boundary conditions of the high-resolution AROME Airport.

In this study we present the first results from AROME Airport at Paris - Charles de Gaulle airport during two test periods, early summer 2011 and autumn 2012. The forecasts from AROME Airport are validated against screen level observations of temperature and wind speed as well as dedicated wind speed profiler data, available from the observation campaigns during these two periods. The impact of using these profiler data in the data assimilation is discussed as well as the sensitivity of the data assimilation system of AROME Airport. The performance of AROME Airport is compared to the performance of its coupling model and the operational AROME model.

Introduction

The SESAR projetc aims to increase the efficiency and safety of the European air traffic and AROME Airport is a small part of this project. The aim of AROME Airport is to provide hourly short-range high-resolution forecasts for the airport area which can be used to aid the efficiency of the airport. These forecasts can then be used as the initialisation data for a wake vortex prediction model which could allow a dynamic separation of the aircrafts, depending on the weather conditions.

The Paris - Charles de Gaulle airport was choosen as the test area for the AROME Airport model and this presentation aims to give an overview of the evaluation of the performace of AROME Airport during two four-week test periods in early summer 2011 and autumn 2012. During these two periods extra data from several wind speed profilers were available.

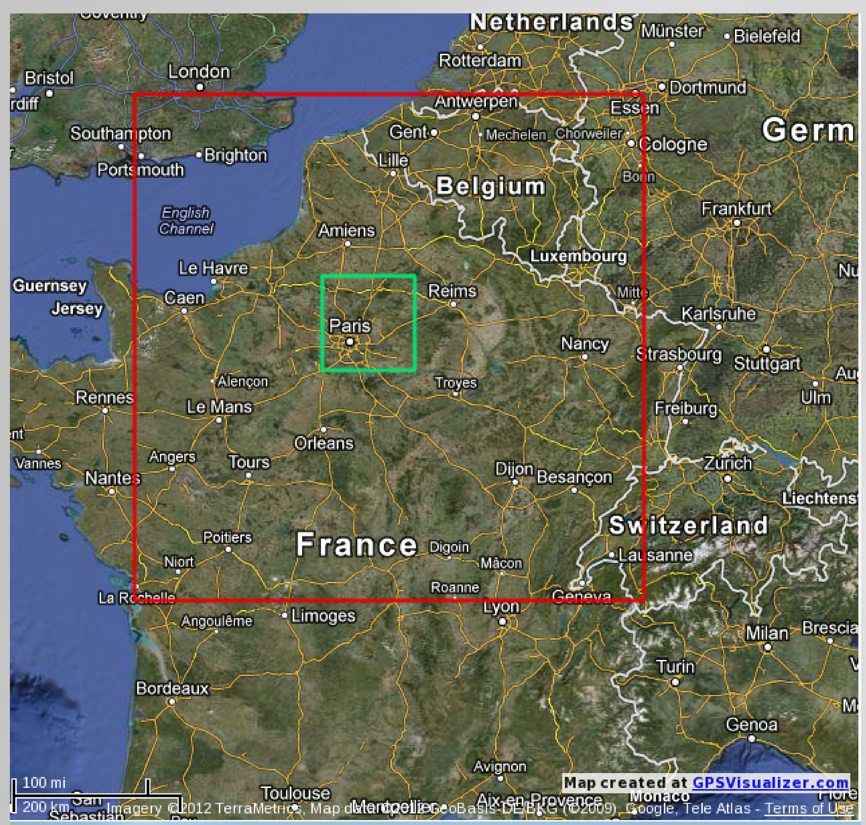

Fig. 1: Area covered by the models, the outer Paris domain (red) and the inner high-resolution CDG domain (green).

The Model Configuration

AROME Airport is a one-way nested model with three components. The initial and lateral boundary conditions are provided by the 2.5 km operational AROME model. Inside this model a smaller domain is defined, using the same resolution and covering most of northern France, and this domain is also used to assimilate additional data, which might not have been available to the operational model. The innermost domain is centred on the airport and has a resolution of 500 m and 113 vertical levels. The areas covered by both domains of AROME Airport are shown in Fig. 1

AROME Airport provides a five hour forecast every hour. The model is not cycled in order to allow a simpler configuration, so each hourly run is independent.

Wind Speed Profiler Data

During both measurement campaigns, XP0 and XP1, extra data from vertical wind speed profilers were available: a lidar, a sodar and two UHF profilers. These data were assimilated by AROME Airport and their impact on the performance of the model is shown in Fig. 2. There is a small improvement in the performance of the high resolution CDG domain but the difference between the Paris domain, were the data assimilation of these profilers is performed, and the operational AROME is negligible.

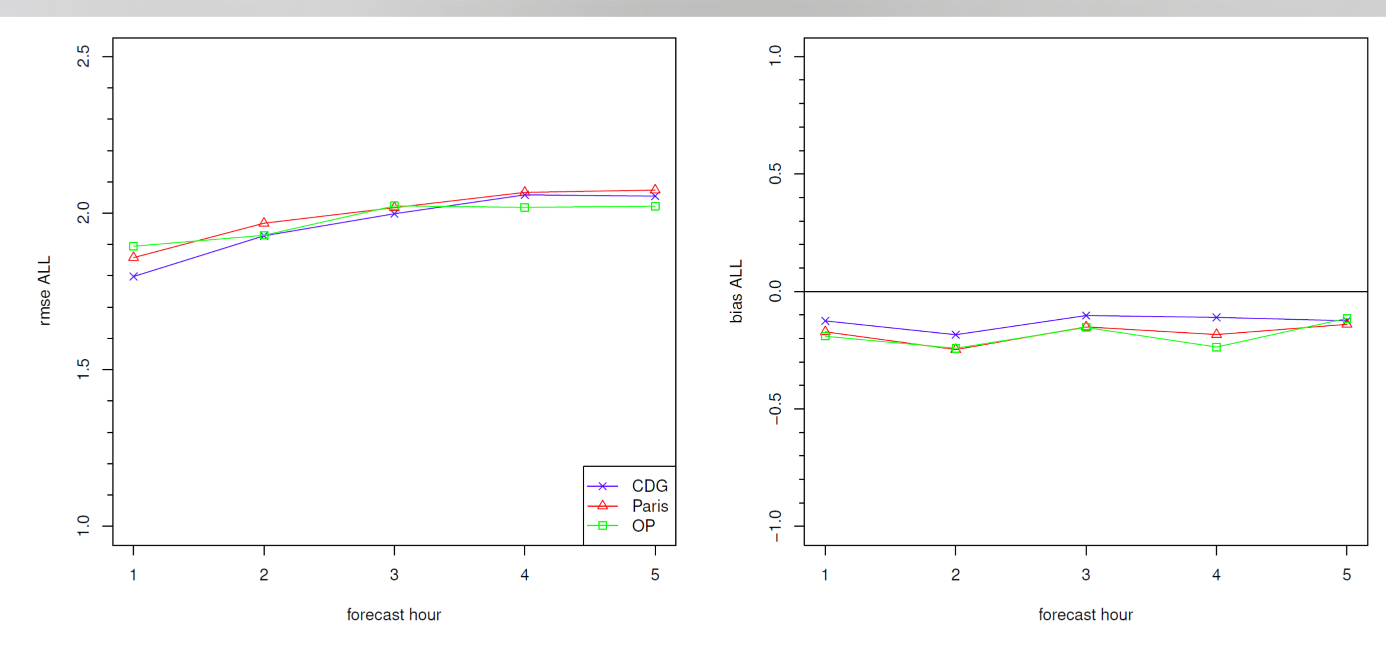

Fig. 2: The RMSE (left) and the bias (right) of the AROME model compared to the wind speed profilers during the two measurement campaigns

Sensitivity of the Data Assimilation

The sensitivity of the data assimilation of the 2 m temperature was investigated for the larger Paris domain, mainly because this is the domain where the data assimilation is performed and because there are more data available for this domain. The different configurations are compared to the standard configuration for AROME Paris and to the operational AROME model. The differences are the following:

config i - Increasing the background error covariances (B-matrix) used in the data assimilation by a multiplicative coefficient
config ii - Introducing a stricter cut-off limit so that observations which arrive too late are not included in the data assimilation
config iii - Removing all observations of the temperature and the humidity at two meters from the data assimilation

Fig. 5 shows the RMSE (left) and the bias (right) for all versions of the AROME model at the synoptic hours for the 2 m temperature during a test week during XP1 in Oct 2012. It clearly shows that the spread is largest for the analyses and that the operational AROME model has the best scores. However these are the results from using the analyses and forecasts which are starting at the synoptic hours. Realistically these would not yet be available and using the forecasts which actually are available from the operational AROME model (dashed lines) shows the worst scores. Keeping this in mind, the results from AROME Paris are encouraging in that they show better scores than the forecasts from the operational model which are available. Increasing the value of the B-matrix coefficient reduces the RMSE values with respect to the standard configuration, the introduction of a stricter cut-off limit marginally increase the RMSE values and the largest increase is obtained for the third configuration which removed all 2 m temperature and humidity data from the data assimilation.

These results indicate that using screen-level observations in the data assimilation has a large positive influence on the forecasts, something also shown by Brousseau et al. [3], while the impact of better tuned B-matrix and a longer cut-off, though positive, seem less important for nowcasting ranges of a few hours than for longer forecasts.

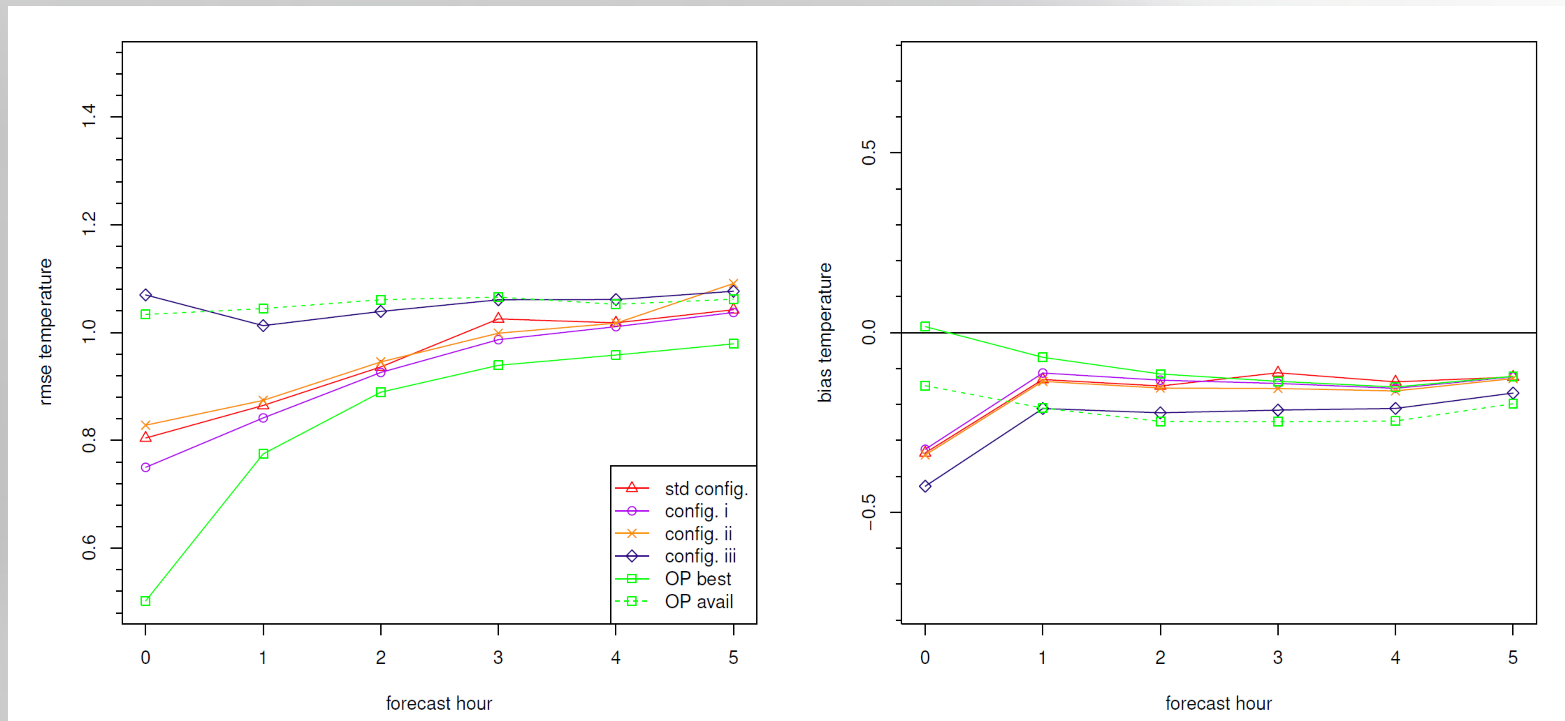

Fig. 5: The RMSE (left) and the bias (right) of the 2 m temperature for the Paris domain with different data assimilation strategies.

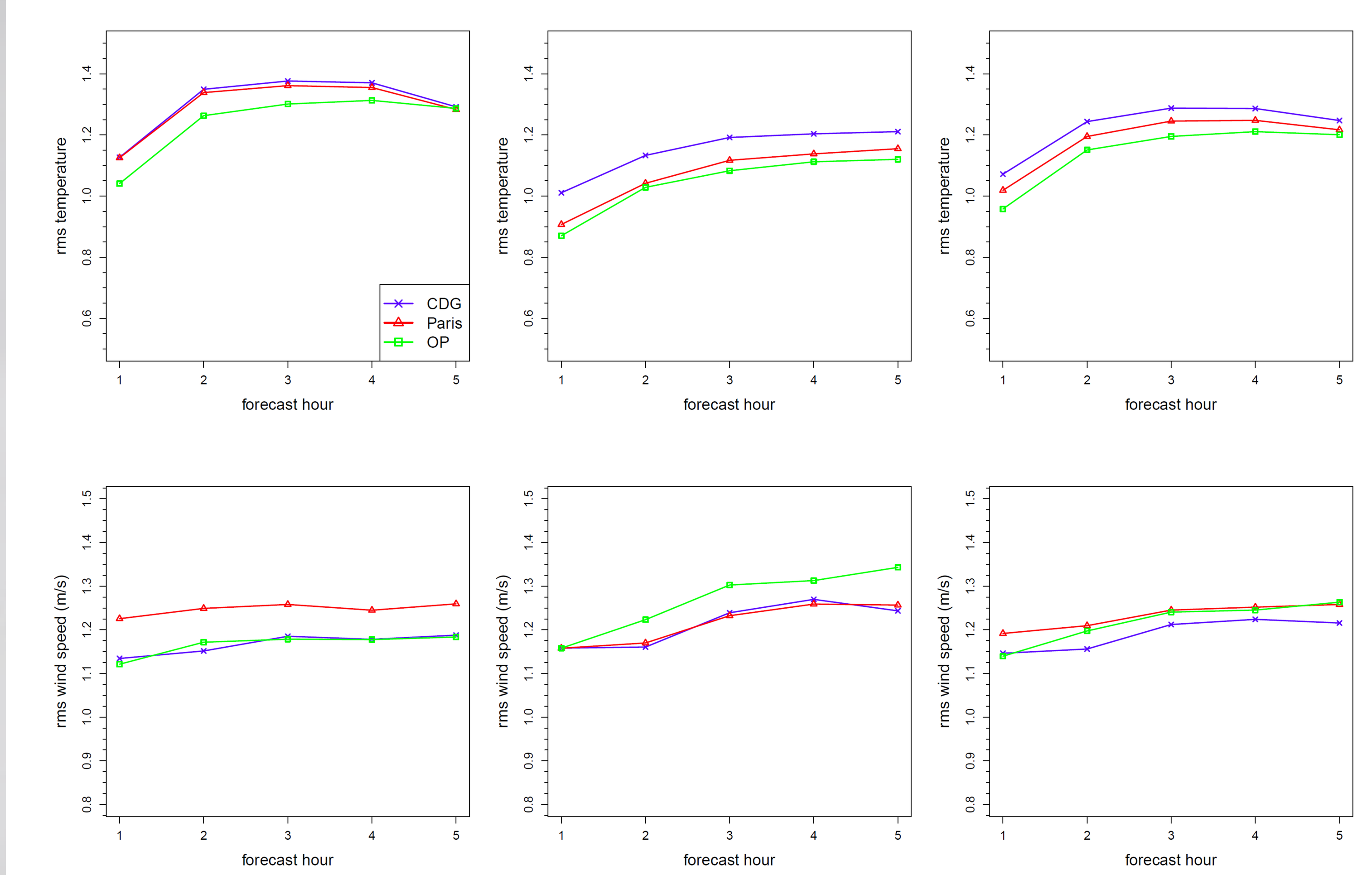

Fig. 3: Root mean square error for the 2 m temperature (top) and the 10 m wind speed (bottom) for the synoptic hours for XP0 (left), XP1 (middle) and both periods combined (right).

Root Mean Square Error of the 2 m Temperature and the 10 m Wind Speed

The forecasts from AROME Airport on both domains, as well as from the operational model have been compared to the screen-level observations of the temperature and the wind speed on the CDG domain (marked in green in Fig. 1). Firstly this comparison is made for the synoptic hours only in order to have an idea of the performance of the AROME Airport configuration with respect to the operational model for the same forecast hours and evaluate the impact of the extra data used in the data assimilation. The results are shown in Fig. 3 which shows the root mean square error (RMSE) of the 2 m temperature (top) and the 10 m wind speed (bottom) for the synoptic hours during the two test periods: XP0 (left), XP1 (middle) and both periods combined (right). For the 2 m temperature the best results are obtained from the operational model and the worst results come from the high-resolution CDG domain, regardless of the period investigated. For the wind speed the situation is somewhat reversed with the best forecasts coming from the CDG domain and the worst results coming from either the Paris domain or the operational model.

However, AROME Airport is supposed to be used in a nowcasting environment so it is more important to look at the performance of AROME Airport for all 24 hours. The same comparison as above is made using all available forecasts from AROME Airport and comparing them to both the most recent forecast from the operational AROME (solid green lines) which are not available for a real time system and the forecasts from the operational AROME which realistically are available (green dashed lines). These are also the forecasts used for the initialisation and the boundary conditions for AROME Airport and they can be from up to 9 hours earlier. All of the models are also compared to the forecast by persistence method (black lines) which turns out to be the worst method of forecasting in this case since, with some exceptions during the first forecast hour, all model configurations outperform the forecast by persistence method for both parameters. Comparing the results of the 2 m temperature for 24 hour with the result from the synoptic hours there is a clear improvement for the RMSE-values from the AROME Airport system which outperforms both versions of the operational model. However it is curious that the results are better on the Paris domain than for the CDG domain. The RMSE for the 10 m wind speed show a similar trend for both the synoptic hours and the full 24 hours, where the lowest RMSE values are obtained from the high-resolution CDG domain and the worst model is the operational AROME.

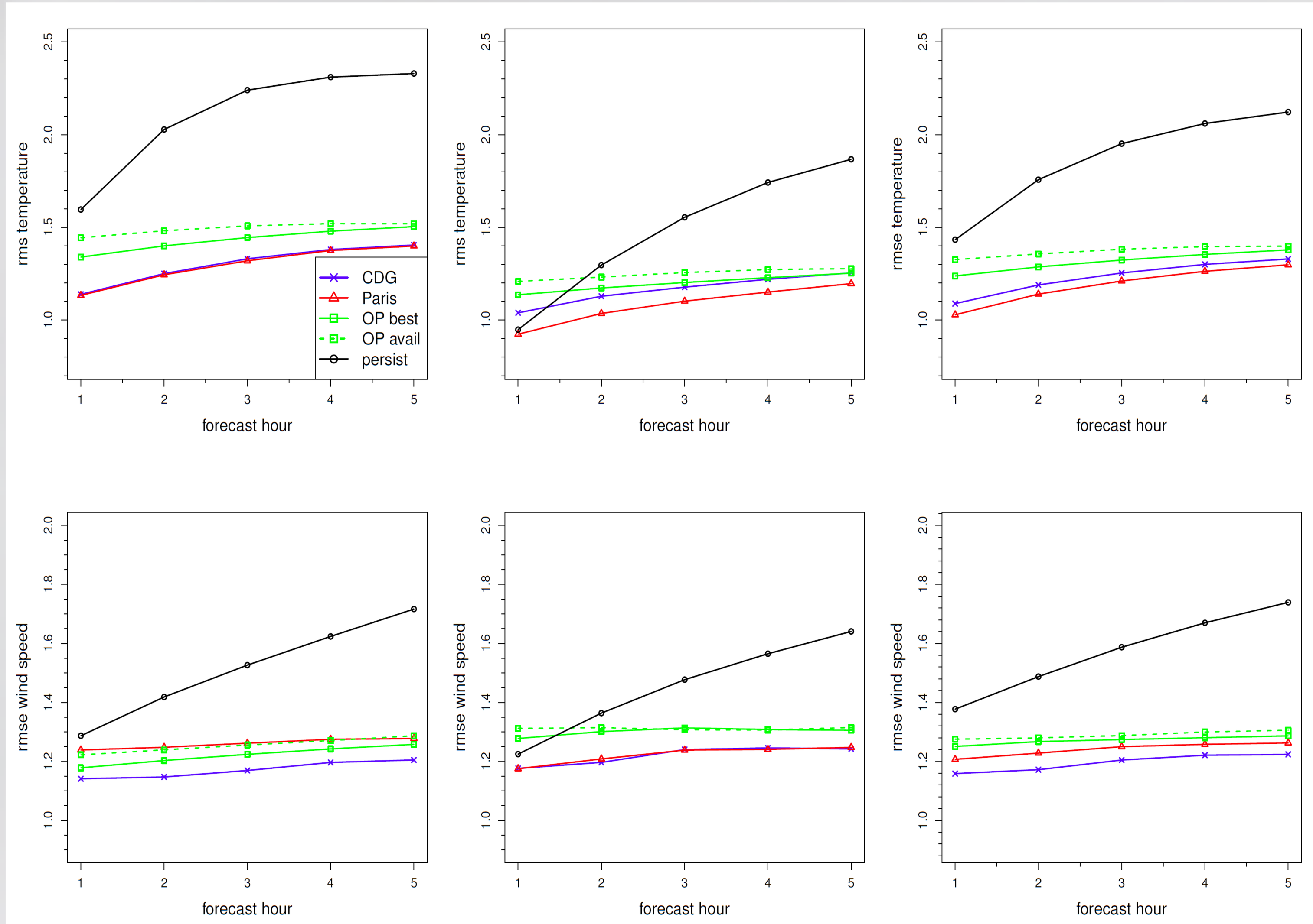

Fig. 4: Root mean square error for the 2 m temperature (top) and the 10 m wind speed (bottom) for the all 24 hours for XP0 (left), XP1 (middle) and both periods combined (right). The two green lines representing the operational model using the most recent forecasts (solid line) and the forecasts which realistically are available (dashed lines).

Conclusions and Perspective

AROME Airport is the short range high-resolution version of the French operational mesoscale AROME model and is designed as a nowcasting system and can be used as a help in the operations of airports by providing input data to a wake vortices prediction model to allow for a dynamic separation of the aircrafts.

The forecasts from AROME Airport have been evaluated for the region around Paris - Charles de Gaulle airport during two four week-periods when there are extra data from several wind speed profilers available from two measurement campaigns in early summer 2011 and autumn 2012.

The scores for the screen-level observations of temperature for the synoptic hours as well as for all 24 hours shows that in the first case the operational model gives the best scores, whereas in the latter the Paris domain (the coupling model for the high-resolution domain) has the best scores. Looking at the wind speed, the best forecasts comes from the high-resolution CDG domain for both the synoptic hours and the full 24 hours. The vertical wind speed profile is also somewhat better described by the CDG domain.

The data assimilation of the 2 m temperature and humidity has a positive influence on the performance of AROME Airport on its bigger Paris-domain. A B-matrix specifically calculated for AROME Airport as well as a longer cut-off time would improve the results from AROME Airport.

AROME Airport has already been run in a semi-operational test during XP1 and a new test run using operational conditions is planned at Paris - Charles de Gaulle airport during 2014 (XP2) using AROME Airport in real-time.

METEO FRANCE
Toujours un temps d'avance

References
[1] Auger, L., Dupont O., Brousseau, P., Hagelin, S. and Brovelli, P., 2013, AROME-NWC : an Adaptation of the Meso-Scale NWP Model AROME to Nowcasting, this conference
[2] Seity, Y., Brousseau, P., Malardel, S., Hello, G., Bénard, P., Bouttier, F., Lac, C. and Masson, V., 2011, The AROME-France convective-scale operational model, MWR, vol 139, 976-991
[3] Brousseau, P., Desroziers, G., Bouttier, F. and Chapnik, B., 2013, A posteriori diagnostics of the impact of the observations on the AROME-France convective-scale data assimilation system, Quart. Jour. Roy. Meteor. Soc., DOI: 10.1002/qj.2179