Assimilation of hourly KLM AMDARs in HIRLAM

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Abstract

In this study the regional impact of KLM AMDAR observations on the short range numerical weather forecast of temperature, wind and humidity in the vicinity of Schiphol Airport is investigated. To achieve this goal, two runs are performed, one with the normal AMDAR coverage and one with additional KLM AMDARs.

The results of the numerical weather prediction model for a winter period show a neutral (slightly positive and slightly negative) impact on wind forecast when the forecasts are compared to AMDAR and radiosonde observations. No impact on temperature or humidity is found. Also outside the Schiphol area, no impact of adding KLM AMDARs was observed.

It was envisaged to perform a winter and a summer run to gain insight in the impact on the model of these additional observations in both seasons. However, due to an unforeseen problem, only the winter run was successful.

Chapter 1

Introduction

Improvements of the quality of meso-scale numerical weather prediction are very relevant for now-casting and short-range weather forecasting. In general, the initialisation of these models is established through assimilation of observations of wind, temperature an humidity from aircraft (AMDAR) and radiosondes. High resolution models may benefit from high resolution observations (both in space and time). In this study, HIRLAM runs with a horizontal resolution of 11km has been set up, with an update frequency of one hour to exploit the high temporal resolution of AMDAR.

The additional KLM AMDARs are selected such that every hour a profile of wind and temperature is measured by aircraft landing at, or departing from Schiphol Airport. It is particularly interesting to investigate the impact of high AMDAR observation density in the lower troposphere, near Schiphol Airport, on the forecast skill of temperature and wind in the vicinity of Schiphol.

In the next sections a short overview is given of the necessary model preparations for this study, a description of the results from the impact study, a discussion on the main findings followed by our conclusions and recommendations.

Chapter 2

HIRLAM experiments

To estimate the impact of the KLM AMDARs on the accuracy of the short range model forecast, an observation denial experiment was conducted. In the reference experiment all observations operationally available in HIRLAM version 7.3 were used including AIREPs, AMDARs and thus also the KLM AMDARs. In the denial experiment, KLM AMDARS were removed from the set of observations used for assimilation. In the experiments the HIRLAM Forecasting System is operated in an hourly cycle for the assimilation of observations.

2.1 Nesting

The HIRLAM Numerical Weather Prediction (NWP) model has a limited area domain, it does not span the whole globe. Therefore it needs lateral boundaries from a nestor model. In operational forecasting, lateral analysis and forecast boundaries for the HIRLAM model are supplied by the ECMWF global spectral model at 3-hour intervals. To run an hourly HIRLAM model requires lateral boundaries at hourly intervals [1]. These boundaries are obtained in a double nesting configuration (cf. Figure 2.1) using a nestor experiment on the large domain (red area in Figure 2.1) with 0.15 degree resolution. This nestor experiment has a 3-hour assimilation cycle and an 15-hour forecast for every cycle and was run with large scale mixing.

The AMDAR experiments were run with .1 degree resolution on the H11-domain (blue area in Figure 2.1) with a hourly update cycle and 0.1 degree resolution. The experiment without the KLM AMDARs is abbreviated by REF, while the experiment with KLM AMDARs is abbreviated by BCA (short for Business Case AMDAR).

During the nestor forecast, ECMWF lateral boundaries are used every 3 hours starting at analysis time and intermediate results of the model forecast are stored every hour. These hourly forecasts are used as boundaries for the hourly HIRLAM model run on the smaller domain H11.

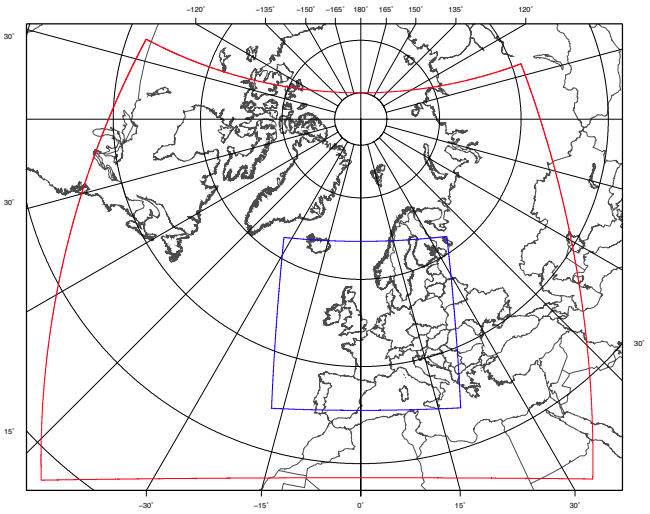

Figure 2.1: Nesting configuration. The domain used to calculate the boundaries is depicted in the red outline, the H11 domain in blue.

2.2 Use of Observations

Surface pressure observations are used in each assimilation step. Apart from conventional observations and the AMDARs of KLM and other airlines, AIREP aircraft observations and satellite derived ATOVS (Advanced TIROS Operational Vertical Sounder, on board polar orbiting satellites) temperature and specific humidity profiles are assimilated as well. Note that in an operational setting with an hourly update cycle some of these observations types have a latency of more than 45 minutes (radiosondes and ATOVS data).

2.2.1 AMDAR Observation coverage

Figure 2.2 shows the total number AMDAR observations and the KLM AMDAR observations in the domain (left panel) and in the vicinity near Schiphol Airport. Clearly, the number of KLM AMDAR in the region is a fraction of the the total number of AMDAR observations. In the vicinity of Schiphol however, the number of KLM AMDARs is around between one third and half of the total AMDAR observations. The area close to Schiphol is bounded by latitude 50.9 and 53.5 and longitude 3.5 and 7.

2.2.2 Radiosonde and Surface Observations

Figure 2.3 (left panel) shows the radiosonde launch sites (blue dots) and locations of the automatic radiosonde launches ASAP (Automated Shipboard Aerological Programme, denoted by crosses). In general, the launch frequency is twice per day, at 00 and 12 UTC, but some sites launch at different frequencies (four times) and/or hours. Note the erroneous location of an ASAP in northern Germany. The right panel of Figure 2.3

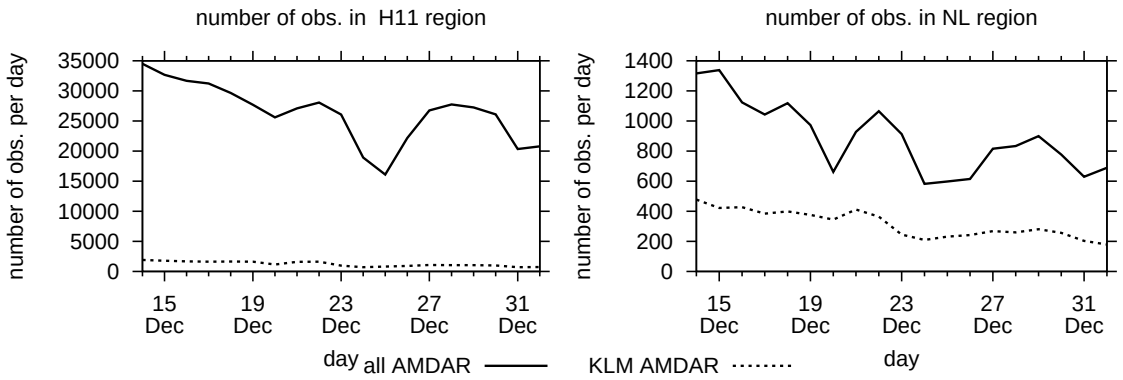

Figure 2.2: Available AMDAR observations for the winter period for the whole H11 domain. The KLM AMDARs constitute only a small fraction of the total in the total domain. The left panel shows the number of observations in the vicinity of Schiphol

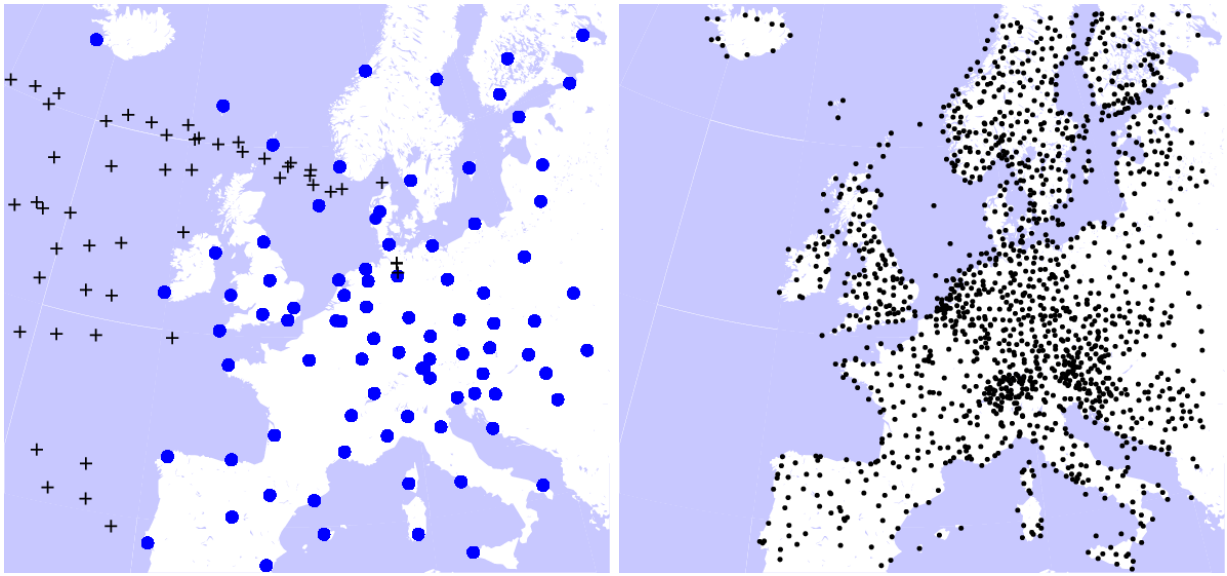

Figure 2.3: Left panel: Radiosonde and ASAP launch locations in the period under consideration. Right panel: Location of surface observations.

shows the locations of synop observations; these are also mainly concentrated to land, apart from a few platforms in the North Sea.

Chapter 3

Forecast verification

The forecasts of the two runs are evaluated for observations valid at forecast time. The observation used in the verification are the same as used later in the assimilation. Unfortunately, no independent observations were available and thus, at assimilation time, verification scores are influenced by assimilation.

Because of the relative low number of additional observations outside the Schiphol area, the main focus of the verification is on the Schiphol area. Outside this area, no impact is observed in wind temperature and humidity was observed.

In Figures 3.1 and 3.2 the statistics of the comparison of observation and model are shown. The bottom line denotes the bias of observation and model, while the top line shows the standard deviation between observation and model. From the comparison with radiosonde and AMDAR wind observations a mixed impact is observed. For level 600hPa a small negative impact on bias and standard deviation is present in both AMDAR and radiosonde, see Figures 3.1 and 3.2. The wind bias at 875hPa is improves slightly. More small differences are observed but no firm conclusion can be made.

Neutral impact is observed for wind at other levels when compared to AMDARs near Schiphol and radiosonde De Bilt. Temperature and humidity forecasts show also no impact when compared to radiosonde and AMDARs.

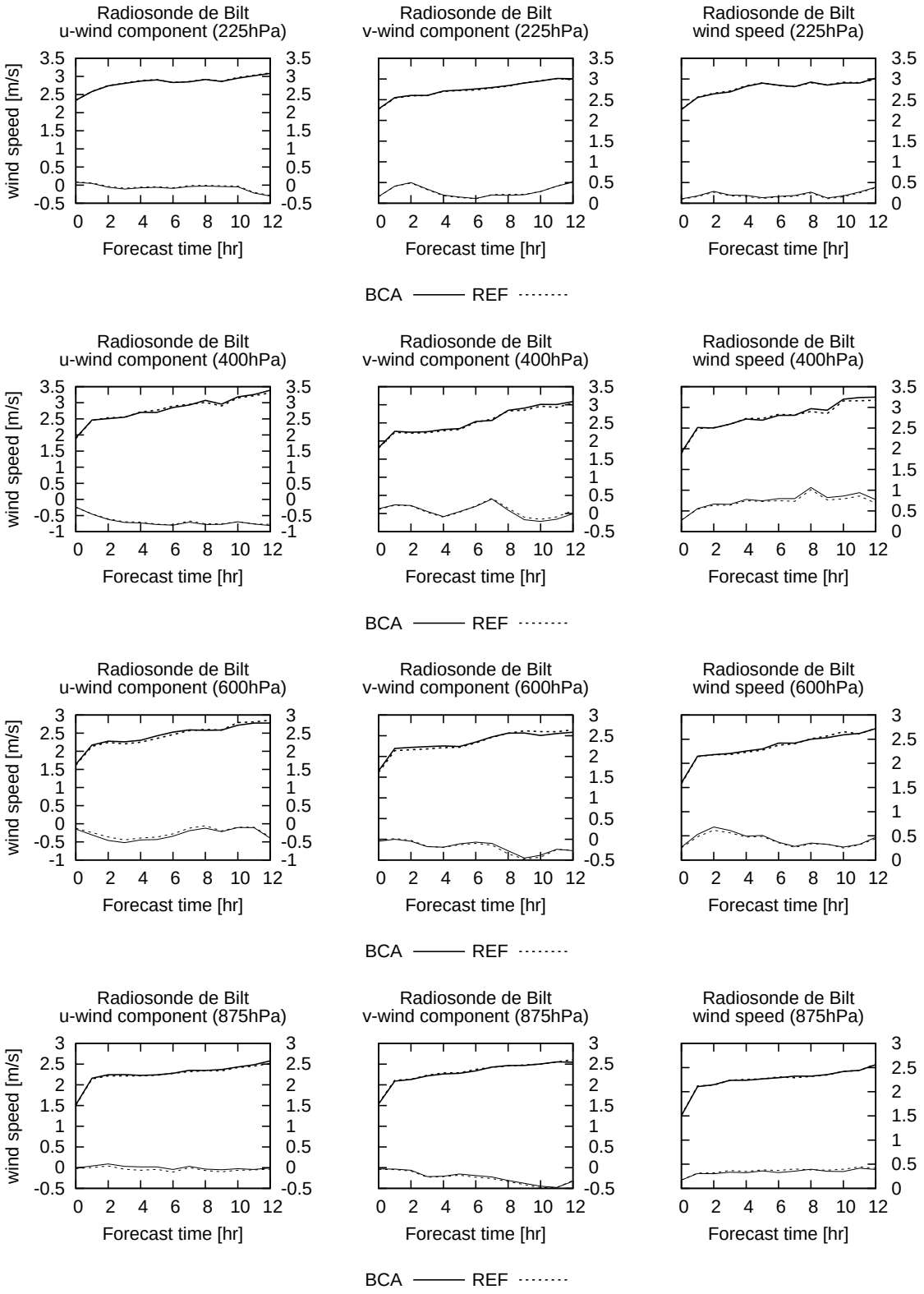

Figure 3.1: Wind forecast versus radiosonde observations at 225hPa, 400hPa, 600hPa and 875hPa. Bottom line in each panel represents bias of observation minus model; top line represents the standard deviation.

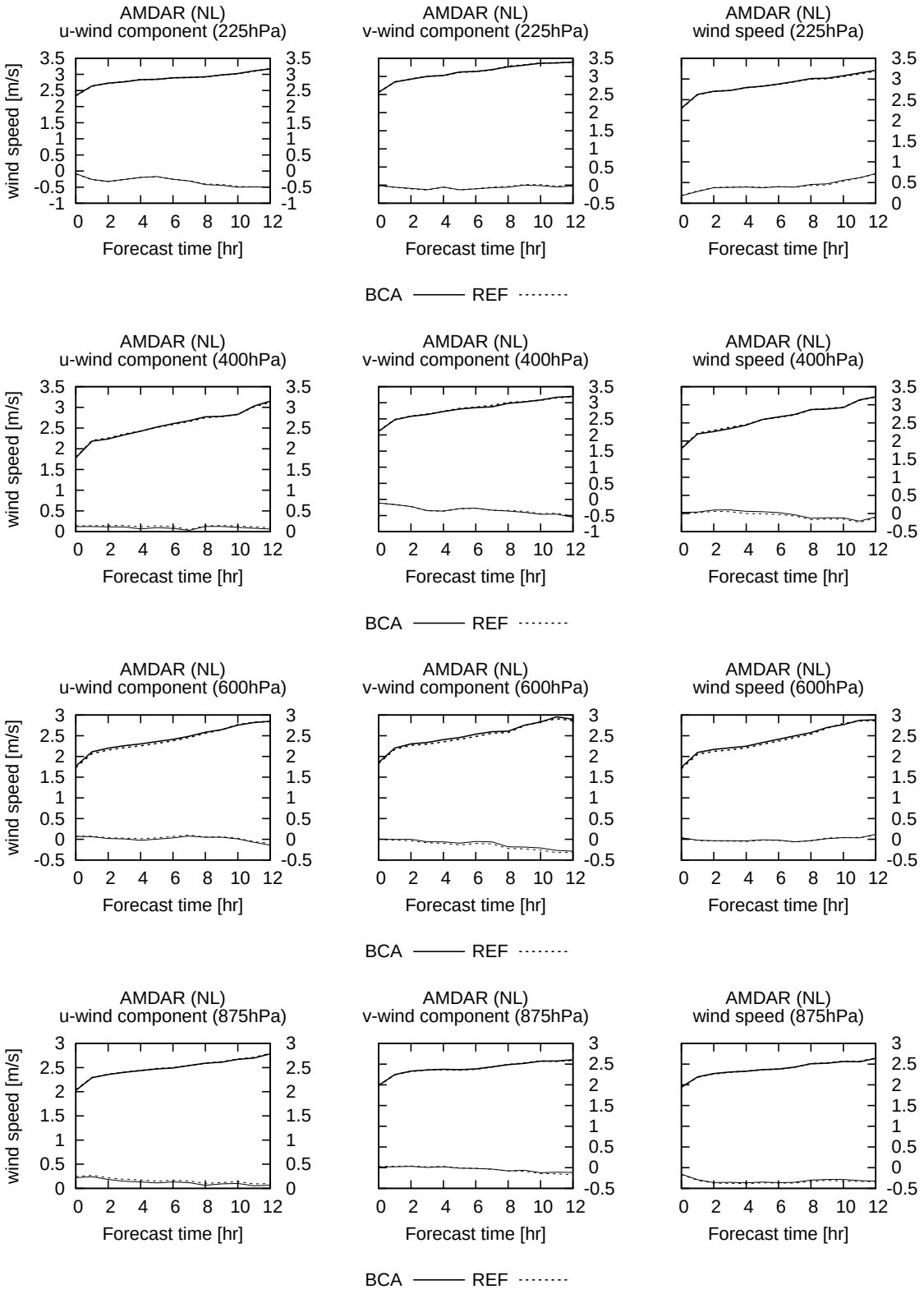

Figure 3.2: Wind forecast versus AMDAR observations at 225hPa, 400hPa, 600hPa and 875hPa. Bottom line in each panel represents bias of observation minus model; top line represents the standard deviation.

Chapter 4

Conclusions

In this study the impact of hourly AMDAR observations in HIRLAM is investigated. Two NWP runs were performed, one without and one with these KLM AMDARs for a 20 day winter period.

From the comparison with upper air wind, temperature and humidity observations from AMDAR and radiosonde it is concluded that the impact on the forecast is neutral. In a region around Schiphol and at a level around 600hPa a very small negative impact of assimilation of additional KLM AMDARs is observed in wind when compared to AMDAR and radiosonde De Bilt, while at 875hPa a small positive impact on the wind bias is observed. The signal of the impact is very small and is not significant.

Outside the Schiphol region no impact is observed. Since the additional value of KLM AMDARs is so small it is concluded that the current model setting cannot benefit from these observations.

As said, only a winter trial has been performed. A summer trial might show more impact of KLM AMDARs, especially in convective and unstable situations.

References

[1] S. de Haan and A. Stoffelen. Assimilation of High Resolution Mode-S Wind and Temperature Observations in a Limited Area NWP-model. KNMI-WR-2010-03, Royal Netherlands Meteorological Institute, 2010.