Application and verification of ECMWF products 2017

Royal Meteorological Institute of Belgium – Pascal Mailier

1. Summary of major highlights

Verification results of direct model outputs used operationally at the Royal Meteorological Institute of Belgium (RMIB) are presented for 2-m temperature, 2-m dewpoint and 10-m wind speed. The focus of this verification exercise is on the short range (up to 60 hours ahead) where a comparison between ECMWF HRES and the RMIB's own numerical model Alaro can be made. In most instances ECMWF HRES shows better accuracy than Alaro for 2-m temperature and dewpoint despite the latter model's higher resolution. HRES's benefits are less significant for 10-m wind speed. Forecast biases explain only part of the differences in accuracy. A feeble diurnal cycle can be seen in the accuracy at some stations once biases have been filtered out, possibly associated with natural changes in predictand volatility, and most visible with 2-m dewpoints.

3. Verification of products

3.1 Objective verification

3.1.1 Direct ECMWF model output (deterministic)

The Royal Meteorological Institute of Belgium (RMIB) uses a combination of various NWP model outputs to make fully automated forecast products out to 15 days (ModelBestGrid). The model that provides the basis for ModelBestGrid short-range scenarios up to 48 hours ahead is Alaro 7, the RMIB's own operational regional model run at a 7-km horizontal resolution. For the medium range, ECMWF HRES and ENS are used. Since 8th March 2016, HRES forecasts have been run at a horizontal resolution of ~ 9 km following the introduction of cycle 41r2. The RMIB, however, has continued to extract HRES surface products at the old horizontal resolution of ~16 km on the N640 Gaussian grid. The purpose of this investigation is twofold. Firstly, we want to demonstrate that the use of HRES output at a resolution of 16 km does not affect forecast accuracy significantly for key variables such as surface temperature, humidity and wind speed. Secondly, we want to know whether Alaro has delivered more accurate forecasts than HRES since cycle 41r2 became operational. The answer to this question is crucial given that Alaro continues to be the reference model for ModelBestGrid in the short range.

Four sets of forecasts based on daily 00-UTC analyses (365 days from 09/03/2016 to 08/03/2017) have been compared in this test:

- HRES forecasts run and retrieved at the full horizontal resolution of 9 km (HRES 9);
- HRES forecasts run at the full resolution of 9 km, but retrieved at the old resolution of 16 km (HRES16);
- Alaro forecasts run and retrieved at a horizontal resolution of 4 km (Alaro 4);
- Alaro forecasts run and retrieved at a horizontal resolution of 7 km (Alaro 7).

The variables considered are: surface temperature (t2m), surface dew point (d2m) and surface wind speed (wsp10m). Mean errors (ME) as well as root mean square errors (RMSE) of hourly forecasts have been computed for a selection of 10 synoptic stations across Belgium in order to asses bias and accuracy, respectively – for a thorough discussion of these scores, please see e.g. Jolliffe and Stephenson (2012). The selected stations are shown in Table 1.

WMO Code	Name	Latitude (N)	Longitude (E)	Elevation (m)
06407	Ostend/Middelkerke	51°12'	2°52'	5
06432	Chièvres	50°34'	3°50'	63
06447	Brussels/Uccle	50°48'	4°21'	104
06450	Antwerp/Deurne	51°12'	4°28'	14
06456	Florennes	50°14'	4°39'	299
06476	Saint-Hubert	50°02'	5°24'	557
06478	Liège/Bierset	50°39'	5°27'	178

06479	Kleine-Brogel	51°10’	5°28’	64
06484	Buzenol	49°37’	5°35’	324
06496	Elsenborn	50°28’	6°11’	570

Table 1: List of the 10 Belgian synoptic stations that were selected for this study.

The plotted scores are presented in Figs. 1 to 10 below (one figure per station). The blue curves show the scores achieved by HRES 9 (dark blue) and HRES 16 (light blue). The results show very little or no difference at all in performance at most stations. The full resolution appears to provide a marginal advantage in Middelkerke (coastal station, all variables) and Elsenborn (high ground, temperature only). However, the contrary can be observed elsewhere, e.g. in Saint-Hubert (high ground, all variables).

3.1.2 ECMWF model output compared to other NWP models

In contrast, the scores achieved by HRES and Alaro reveal significant differences in performance between models. HRES emerges as the more accurate model from the outset or soon after, except in Elsenborn for t2m, and in Saint-Hubert, Buzenol, Elsenborn, Uccle and Deurne for wsp10. Horizontal resolution does not seem to matter much. Not surprisingly, the scores tend to be worse in the southeastern part of the country where models have to deal with more complex terrains.

As good as all stations exhibit biases with conspicuous diurnal cycles. There are visible bias differences between models, but clearly these differences do not entirely account for Alaro’s lesser accuracy. RMSEs have also been calculated for the Kalman-filtered forecasts in order to assess the impact of biases on accuracy. As one might expect, the gaps between HRES and Alaro are reduced by the post-processing, but not eliminated. A feeble diurnal cycle in HRES forecast accuracy can also be seen at some stations, possibly associated with natural changes in predictand volatility (on average lowest at night and in the early morning, highest in the afternoon). This feature is more visible with d2m than with other predictands. Figure 11 shows the results obtained with Kalman-filtered forecasts for Uccle as a typical example (the other stations are not displayed owing to space restriction).

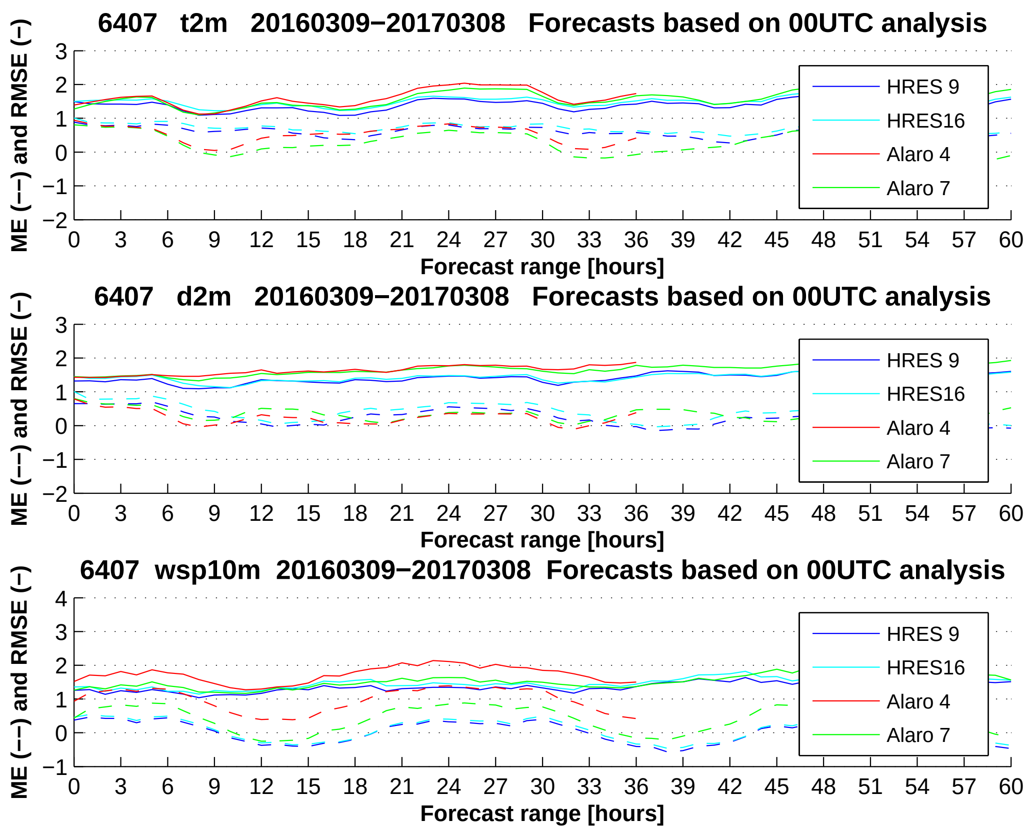

Figure 1: Forecast bias and accuracy in Middelkerke (06407). Mean (ME, dashed lines) and root mean square errors (RMSE, solid lines) of ECMWF HRES forecasts (dark and light blue) and of RMIB Alaro forecasts (red and green). Surface variables considered are: temperature (t2m, top), surface dew point (d2m, middle) and surface wind speed (wsp10m, bottom). Errors are in °C for t2m and d2m, and in m/s for wsp10m. Forecasts were produced daily from 00-UTC analyses from 09/03/2016 until 08/03/2017 (365 days).

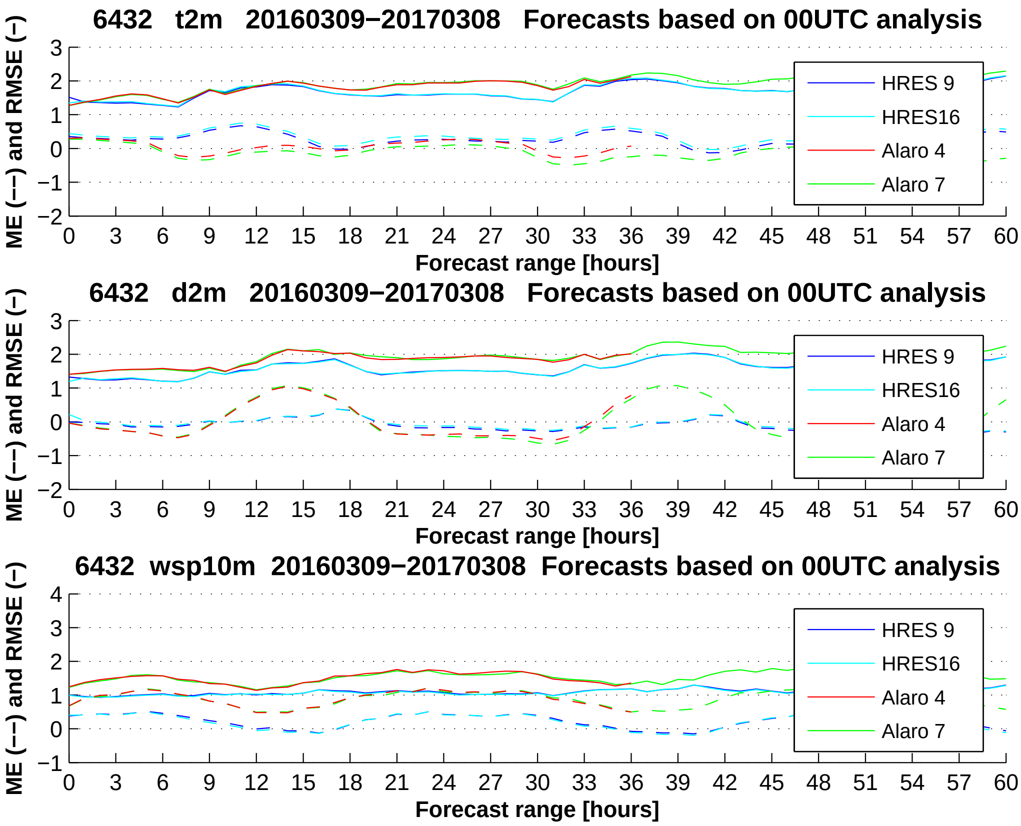

Figure 2: Forecast bias and accuracy in Chièvres (06432).

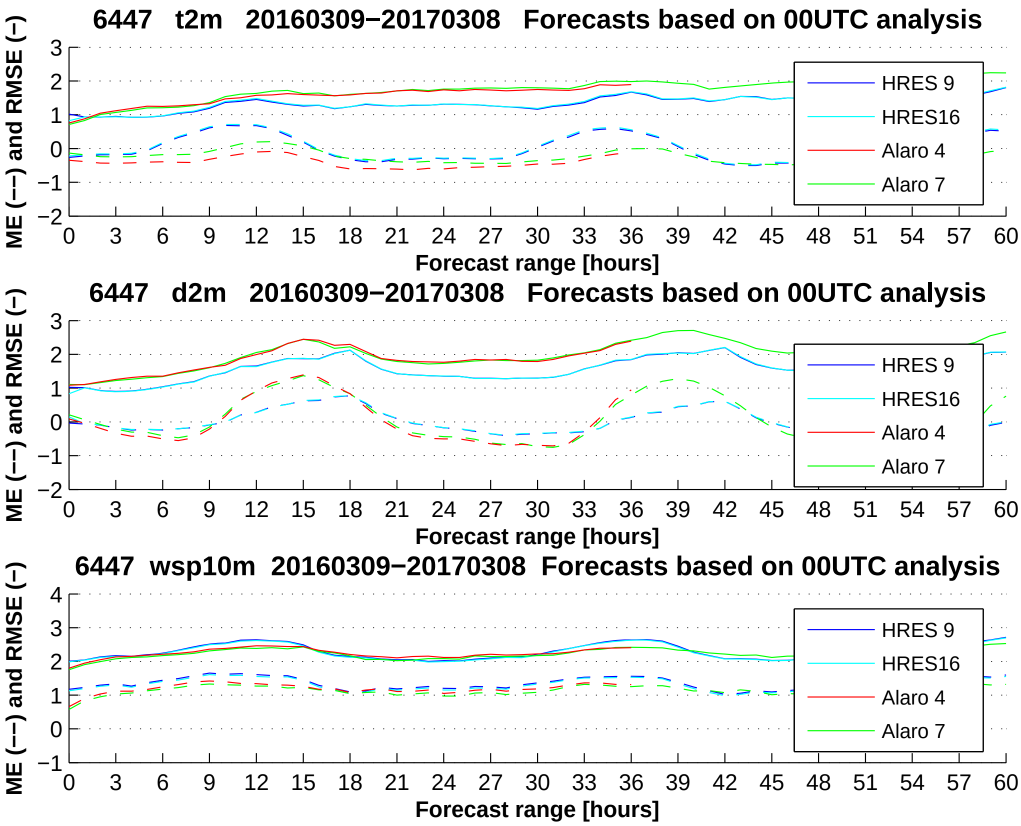

Figure 3: Forecast bias and accuracy in Uccle (06447).

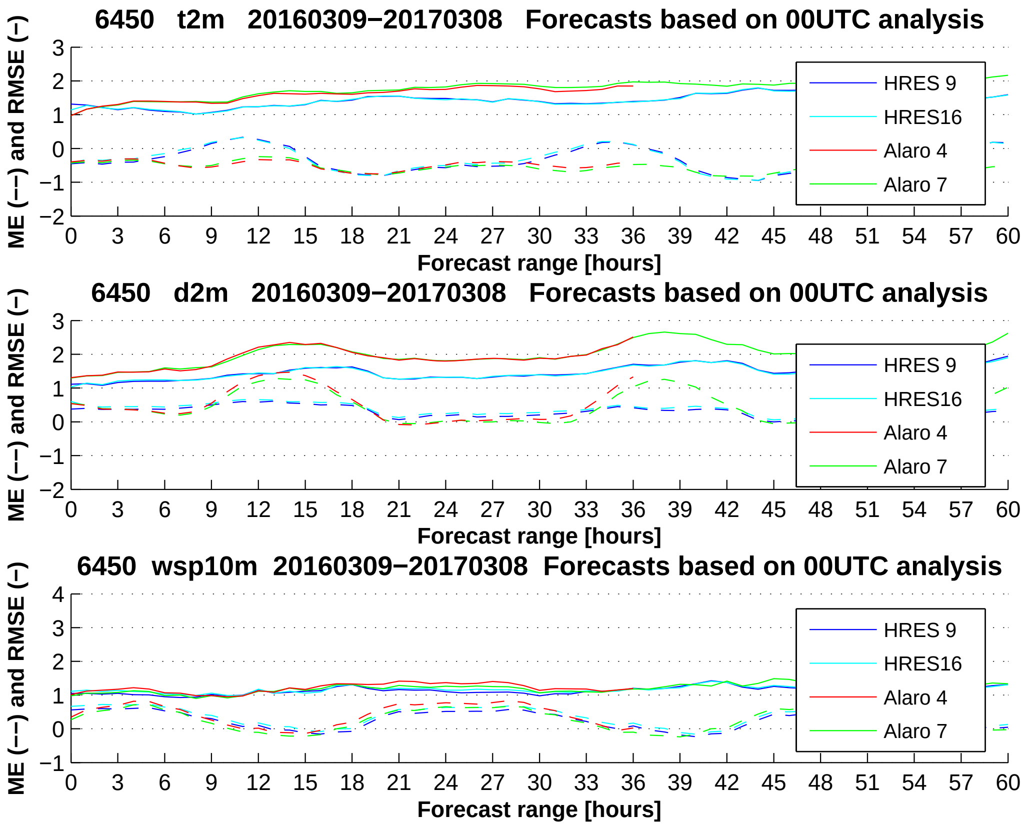

Figure 4: Forecast bias and accuracy in Deurne (06450).

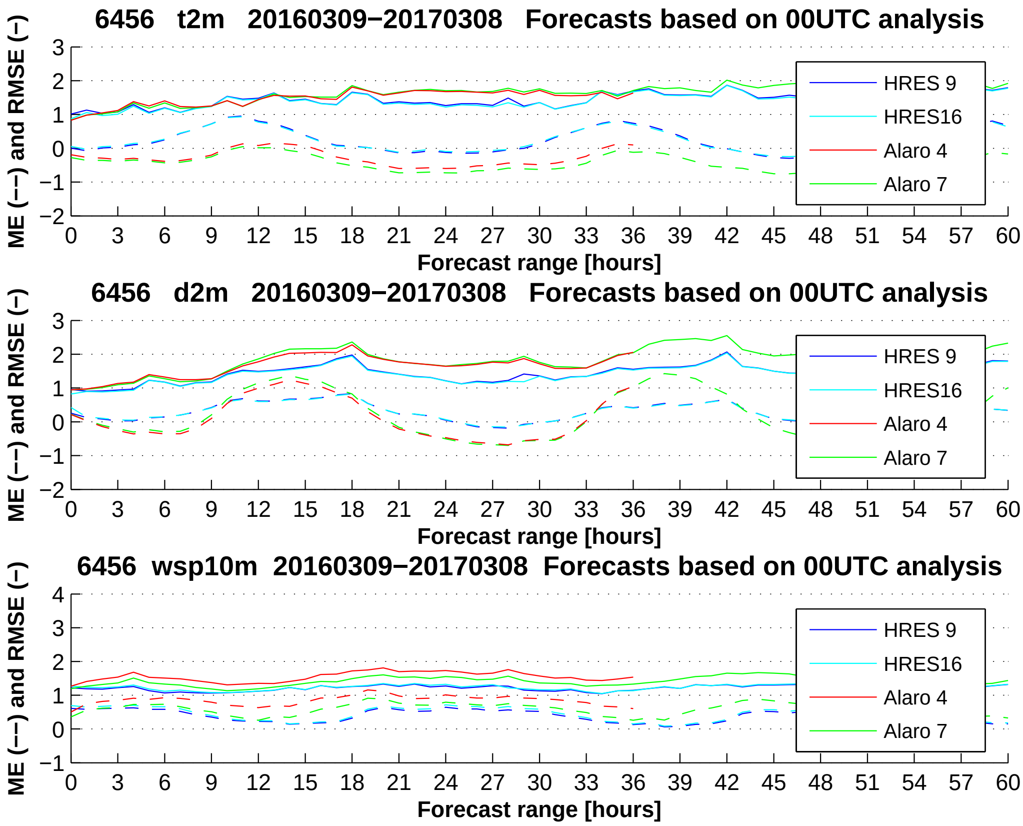

Figure 5: Forecast bias and accuracy in Florennes (06456).

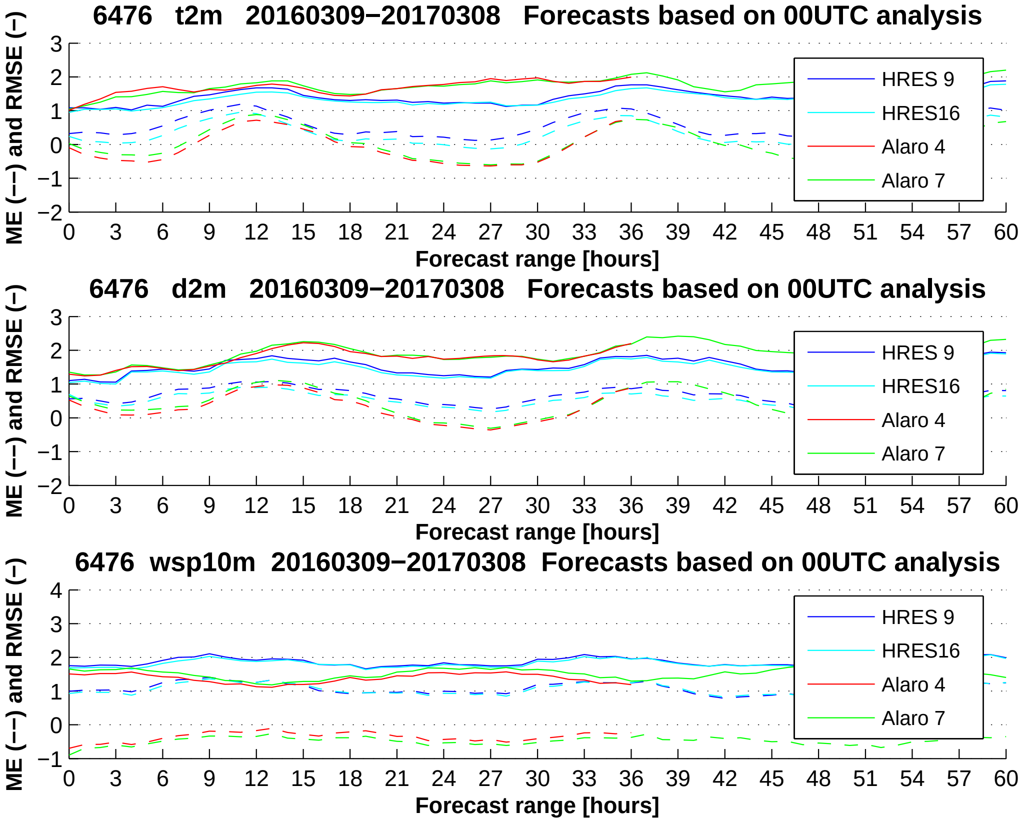

Figure 6: Forecast bias and accuracy in Saint-Hubert (06476).

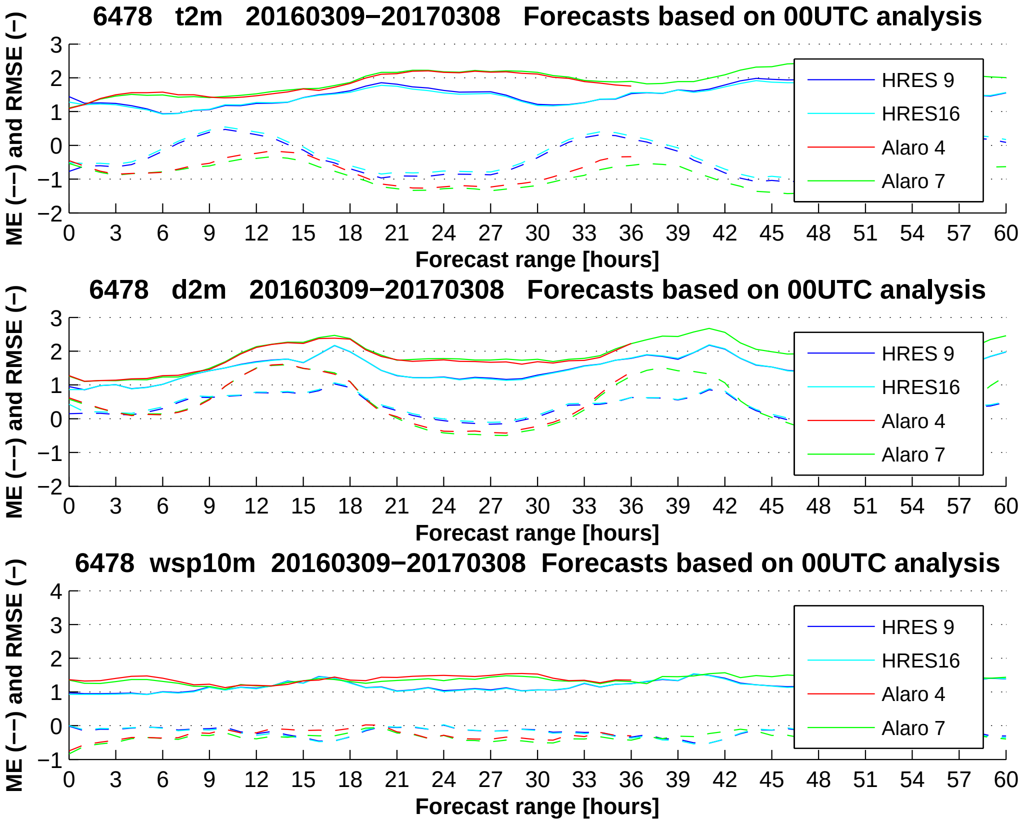

Figure 7: Forecast bias and accuracy in Bierset (06478).

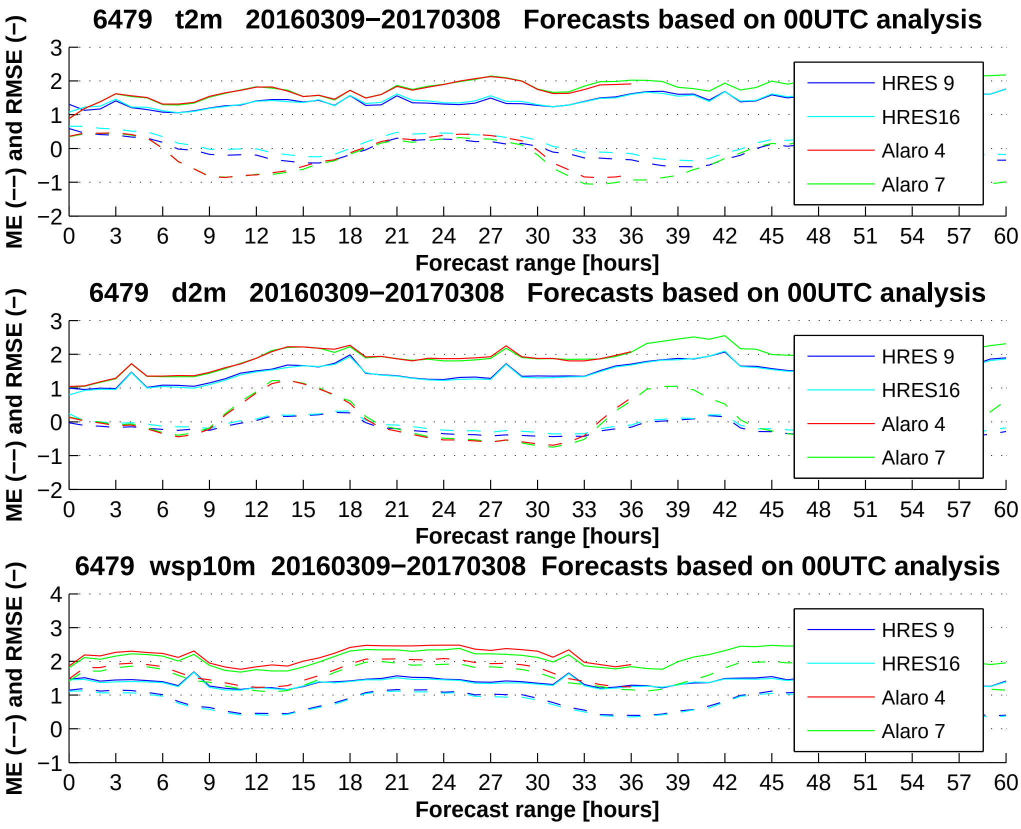

Figure 8: Forecast bias and accuracy in Kleine-Brogel (06479).

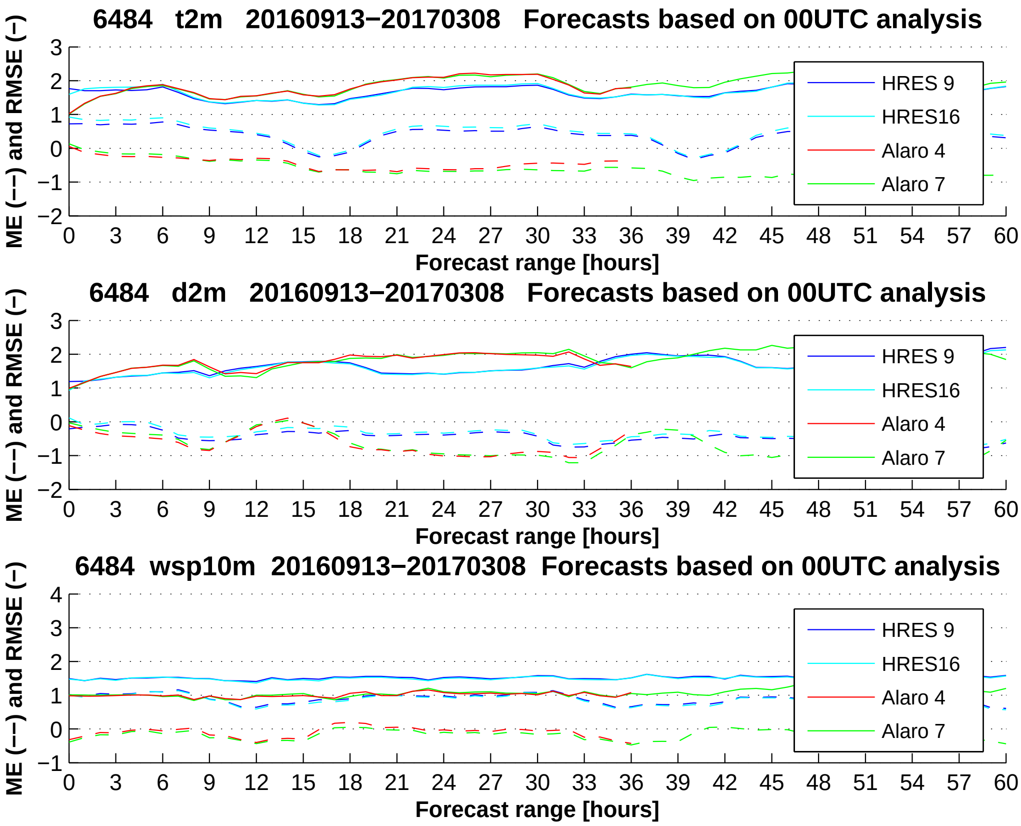

Figure 9: Forecast bias and accuracy in Buzenol (06484).

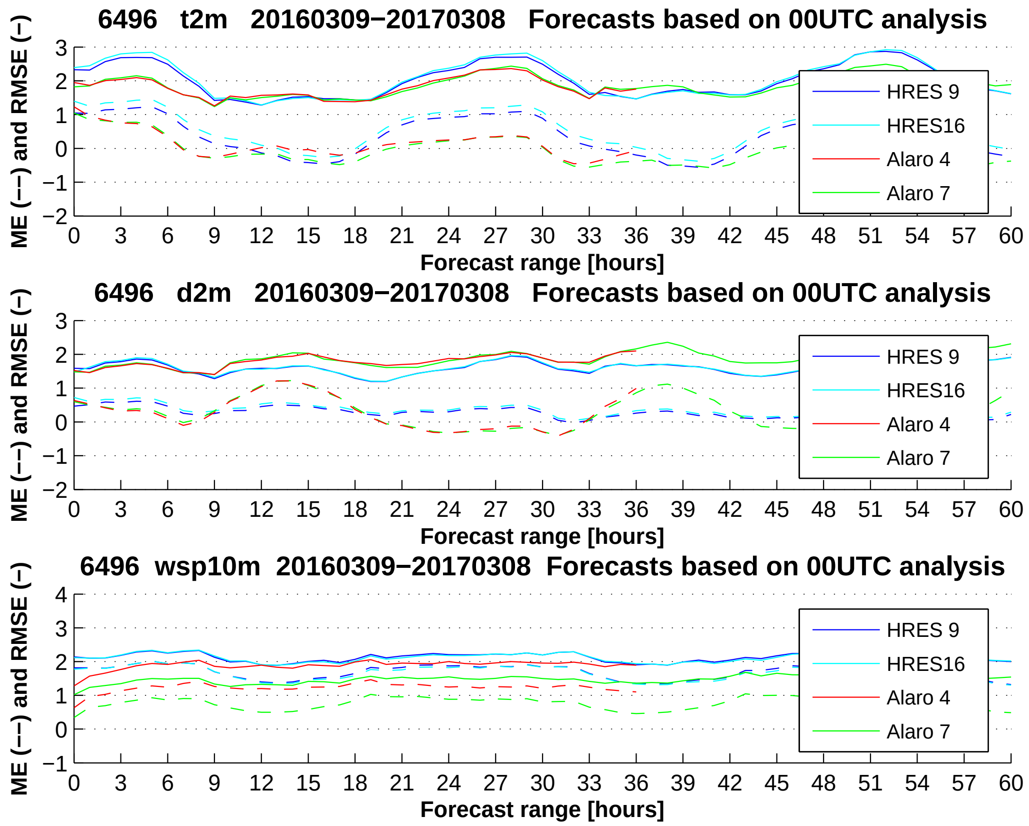

Figure 10: Forecast bias and accuracy in Elsenborn (06496).

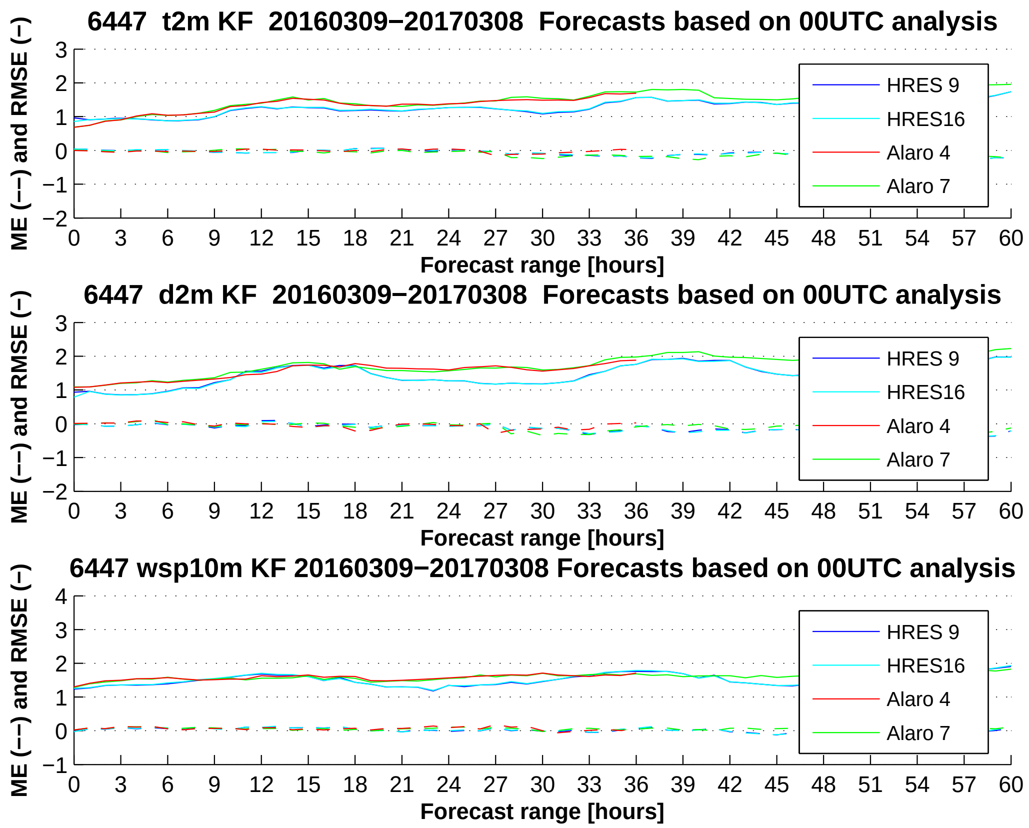

Figure 11: Forecast bias and accuracy in Uccle (06447), Kalman-filtered.

4. References to relevant publications

Jolliffe, I.T., and D.B. Stephenson, 2012: *Forecast Verification: A Practitioner's Guide in Atmospheric Science. 2nd Edition*. Wiley and Sons Ltd, 274 pp.