Application and verification of ECMWF products 2018

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1. Summary of major highlights

Verification results of ECMWF high-resolution direct model outputs used operationally at the Royal Meteorological Institute of Belgium (RMIB) are presented for 2-metre temperature, 2-metre dew point, 10-metre wind speed and direction, total cloud cover and 6-hour accumulated precipitation. Frequent diurnal temperature-wind oscillations in the scores could be imputed to surface and planetary boundary layer parameterisations, but of course further investigation is needed to test this conjecture. In contrast, predictions of cloudiness and precipitation appear to be reasonably well calibrated in many locations.

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 different NWP model outputs to produce fully automated forecast products out to 15 days (ModelBestGrid). ECMWF HIgh-RESolution model (HIRES) forecasts provide one of several NWP elements to build ModelBestGrid deterministic scenarios. HIRES forecasts are also used extensively by RMIB forecasters in the short and early medium range.

The verification results presented in this report focus on bias and accuracy of HIRES operational forecasts based on both 00-UTC and 12-UTC analyses out to 72 hours. Forecasts have been compared against hourly synoptic observations at 13 Belgian reference stations over one complete year (365 days from 01/06/2017 to 31/05/2018). The reference synoptic stations are listed in Table 1 together with their respective geographical coordinates.

WMO Code	Name	Latitude (N)	Longitude (E)	Elevation (m)	Cloud cover observations available ?
06400	Koksijde	51°05’	2°39’	9	Y
06407	Ostend/Middelkerke	51°12’	2°52’	5	Y
06431	Ghent/Industry Zone	51°11’	3°49’	13	N
06432	Chièvres	50°34’	3°50’	63	N
06447	Brussels/Uccle	50°48’	4°21’	104	N
06449	Charleroi/Gosselies	50°28’	4°27’	192	Y
06450	Antwerp/Deurne	51°12’	4°28’	14	Y
06451	Brussels National	50°54’	4°32’	58	Y
06456	Florennes	50°14’	4°39’	299	Y
06478	Liège/Bierset	50°39’	5°27’	178	Y
06479	Kleine-Brogel	51°10’	5°28’	64	N
06484	Buzenol	49°37’	5°35’	324	N
06490	Spa/La Sauvenière	50°29’	5°55’	482	N

Table 1: List of the 13 Belgian synoptic stations that were selected for this study. The last column indicates whether total could cover observations are available (Y = “Yes”, or N = “No”)

The following meteorological variables have been considered: 2-metre temperature, 2-metre dew point, 10-metre wind speed and direction, total cloud cover and 6-hour accumulated precipitation. As reliable cloud observations are only available at some airports, predicted total cloud cover verification has only been performed for seven stations. Mean errors (ME) as well as mean absolute errors (MAE) have been computed to measure bias and accuracy, respectively – please see e.g. Jolliffe and Stephenson (2012) for a thorough discussion of these scores. ME scores were not computed for predicted 10-m wind direction (circular data).

The plotted scores are presented in Figs. 1 to 13 below (one figure per station). ME and MAE plots often exhibit distinct diurnal cycles – more in particular in the cases of temperature, dewpoint and wind. Although these coupled oscillations may point to surface and planetary boundary layer parameterisations, in practice biases can be removed through simple post-processing (e.g. Kalman Filter) with often a significant improvement in accuracy as a result.

Overall, forecasts tend to be more skilful at stations located north of the Sambre and Meuse valleys, where the topography is less complex. This is not always true though. A comparison between the two coastal stations 06400 (Koksijde, Fig. 1) and 06407 (Ostend/Middelkerke, Fig. 2) rather suggests a sea/land grid-point issue with the latter. 06407 scores for predicted night-time temperature and dew point improve significantly when using exactly the same forecasts as for 06400. Station 06431 (Ghent/Industrial Zone, Fig. 3) is located in a heavily industrialised area exposed to heat and moisture, which explains the cold temperature and dew-point biases in the forecasts.

Wind-speed overforecasting tends to be more pronounced overnight while directional errors take drastic increases (up to 40° or even more). This association is not surprising as wind direction gets more variable at slow speeds. After censoring cases with light wind from de dataset (i.e. selecting only cases where 10-metre wind speed is greater than 4 ms^{-1}), directional errors drop by 10° or more. The most dramatic case is observed at station 06479 (Kleine-Brogel, Fig. 11) where censoring brings directional errors from 20°-50° down to 10°.

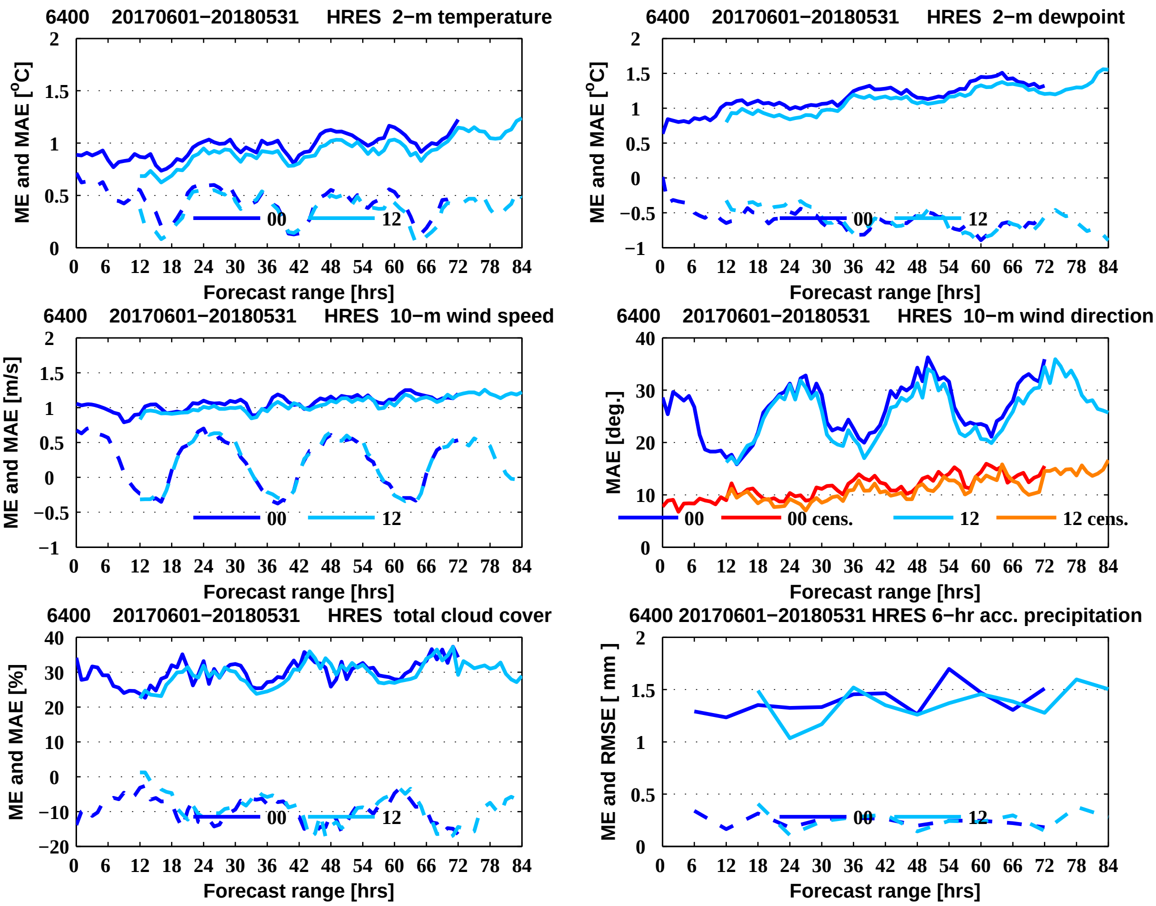

Figure 1: Forecast bias and accuracy in Koksijde (06400). Mean errors (ME, dashed lines) and mean absolute errors (MAE, solid lines) of ECMWF HRES forecasts based on 00-UTC ("00", dark blue/red) and 12-UTC analyses ("12", light blue/orange). Variables considered are: 2-metre temperature (top left), 2-metre dew point (top right), 10-metre wind speed and direction (middle), total cloud cover (bottom left when available) and 6-hour accumulated precipitation (bottom right). For assessing predicted 10-metre wind direction, MAE scores only are shown before (dark/light blue) and after censoring light winds ("cens.", red/orange) from the dataset. Forecasts from 01/06/2017 to 31/05/2018.

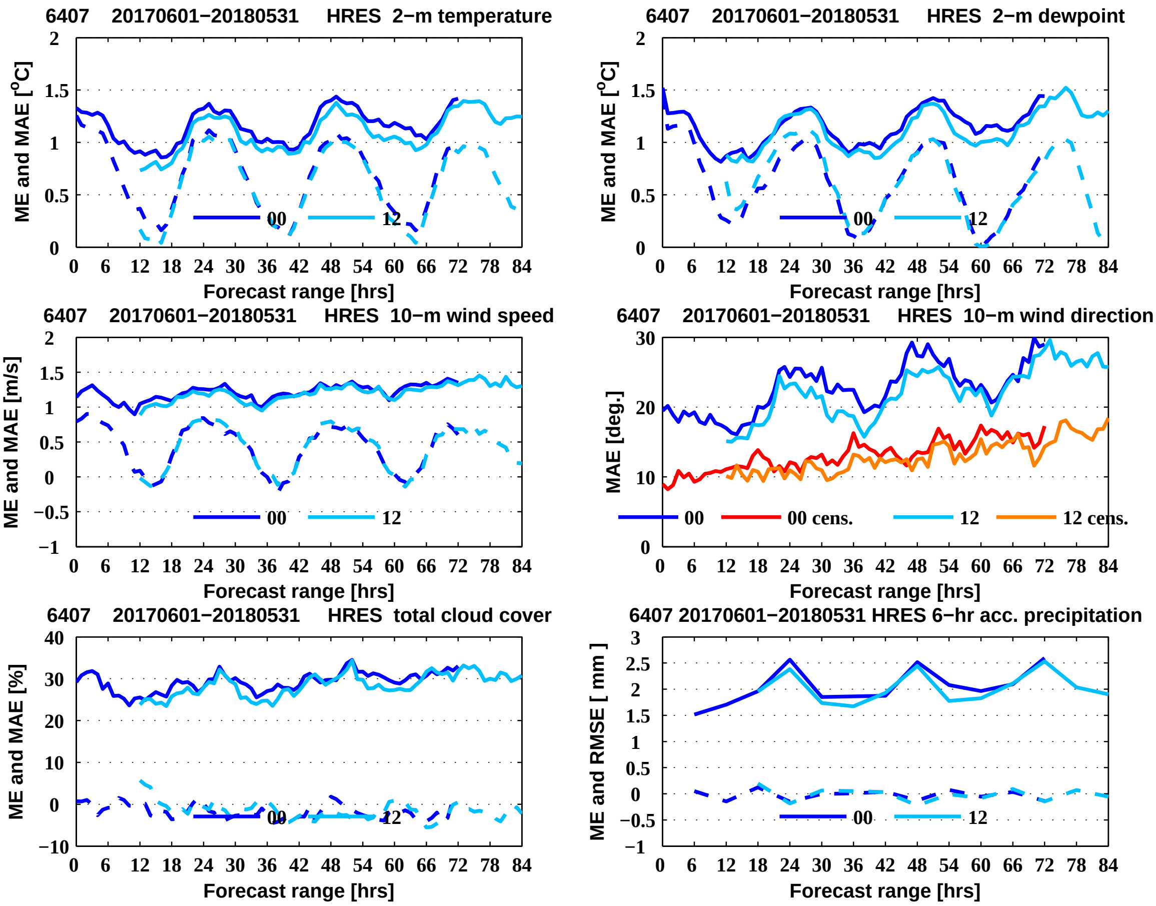

Figure 2: Forecast bias and accuracy in Ostend/Middelkerke (06407).

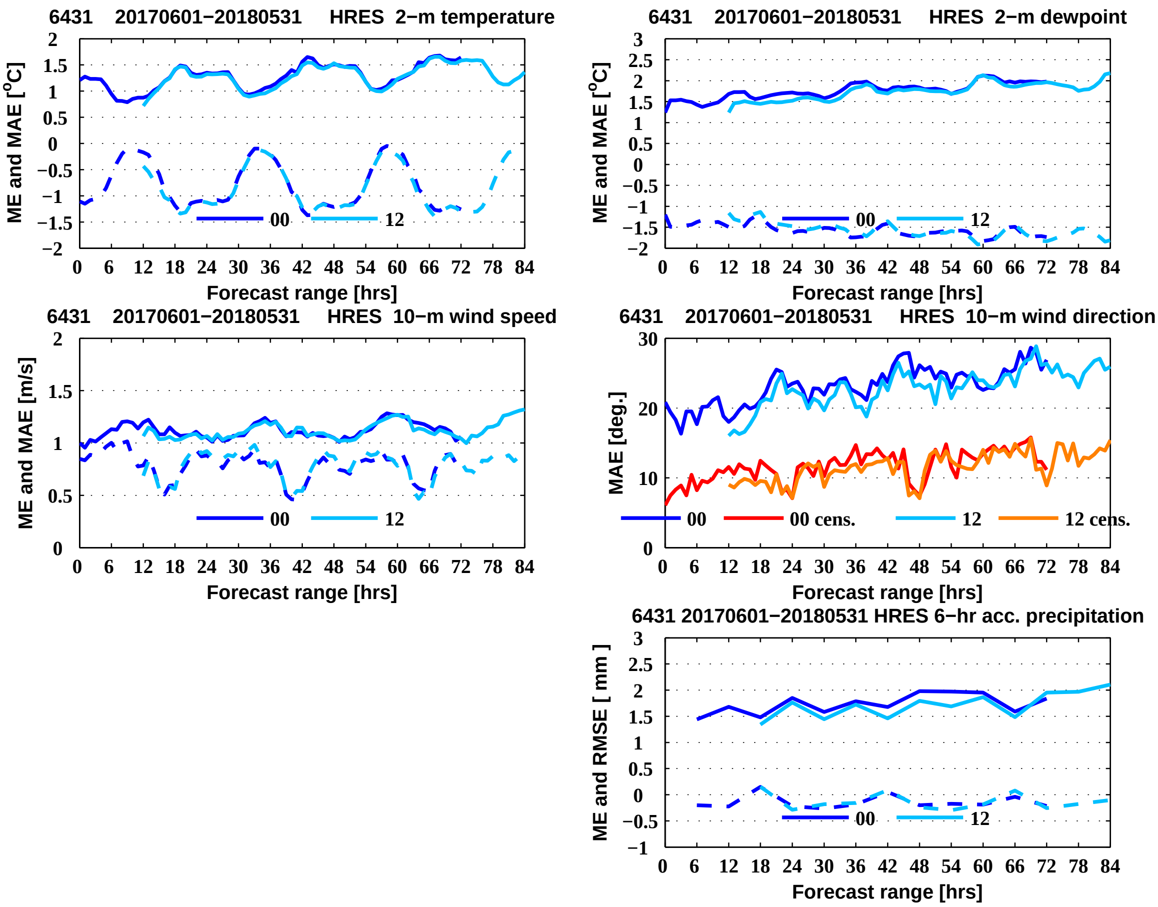

Figure 3: Forecast bias and accuracy in Ghent/Industry Zone (0631).

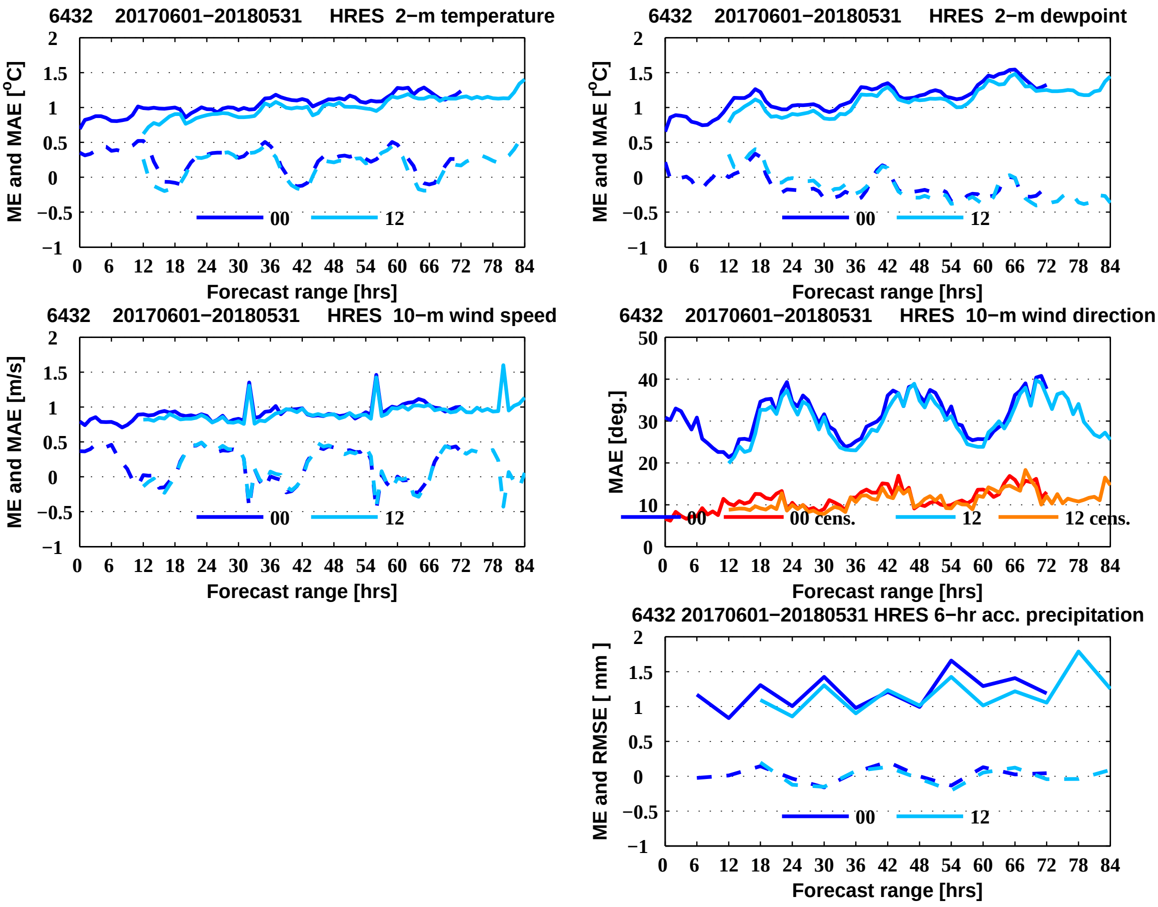

Figure 4: Forecast bias and accuracy in Chièvres (06432).

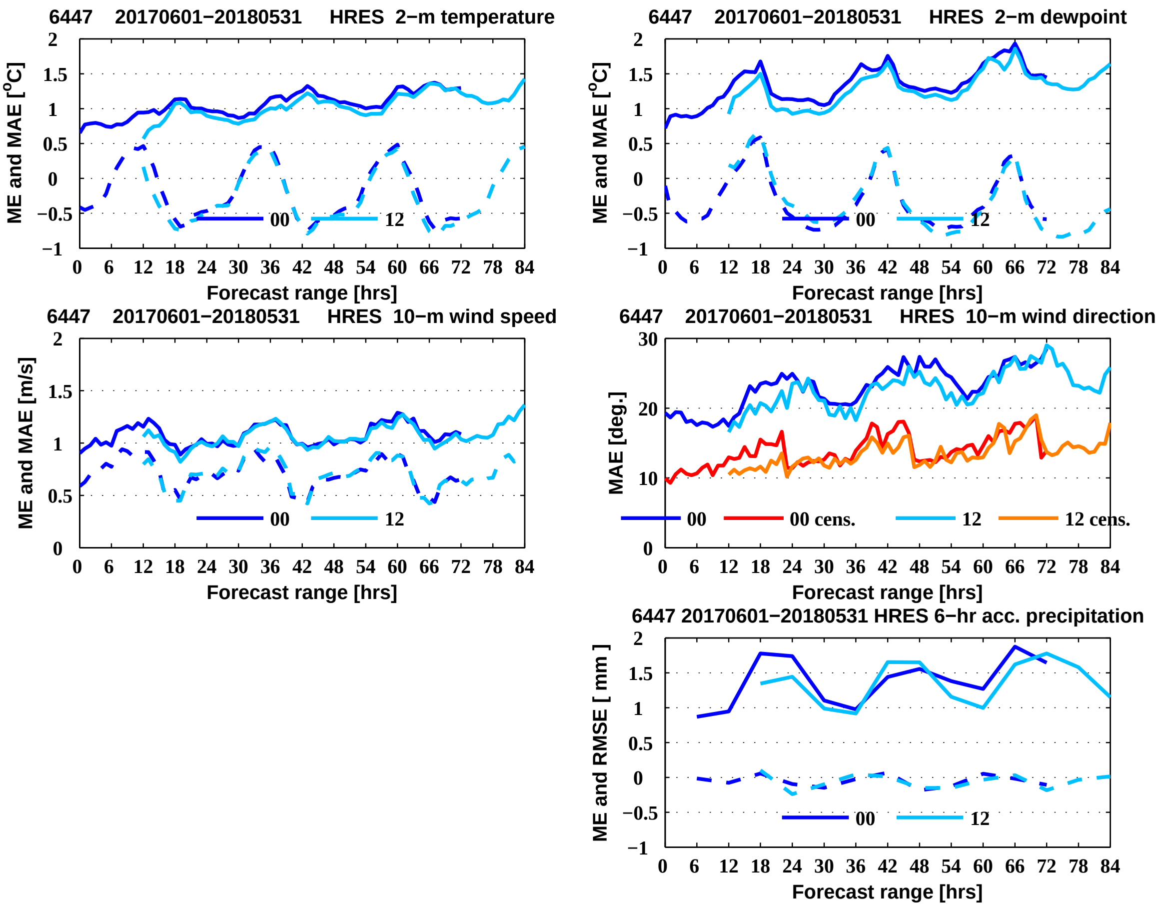

Figure 5: Forecast bias and accuracy in Brussels/Uccle (06447).

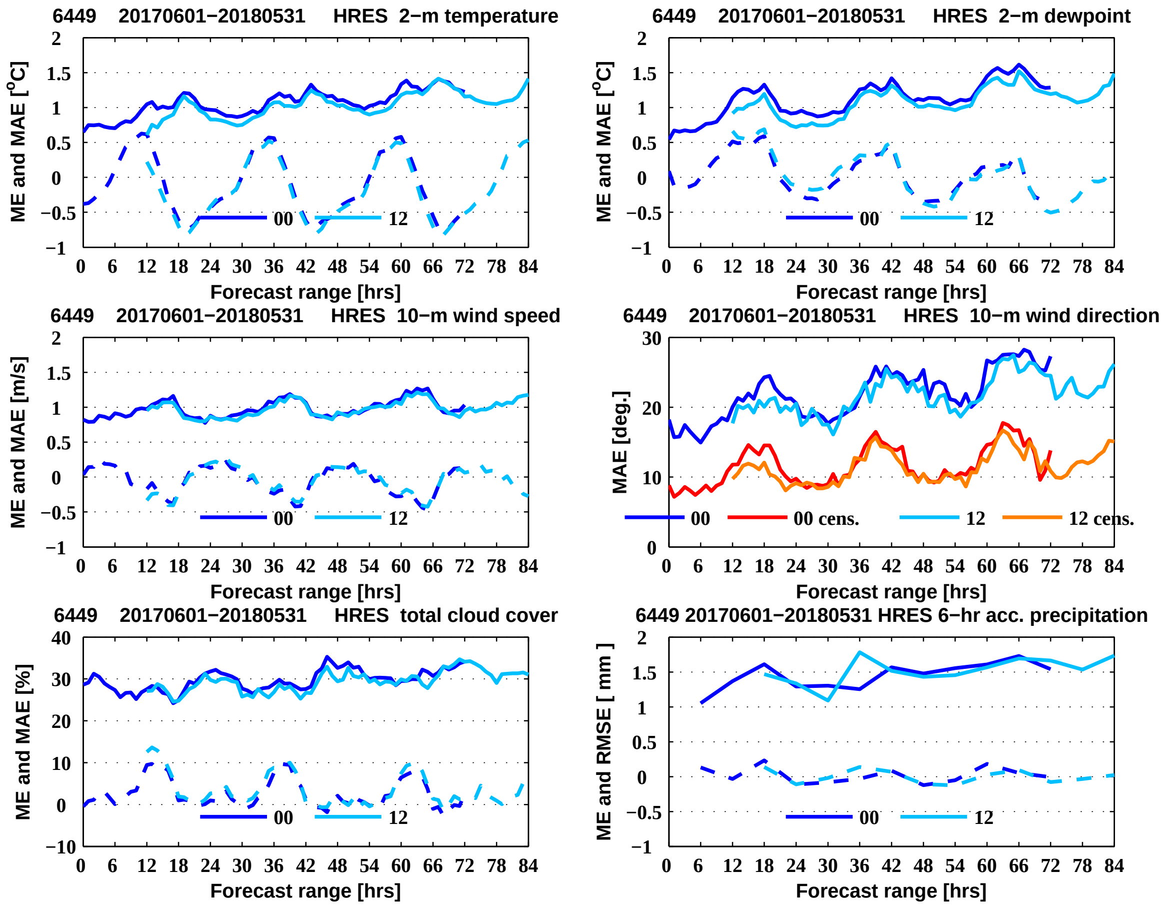

Figure 6: Forecast bias and accuracy in Charleroi/Gosselies (06449).

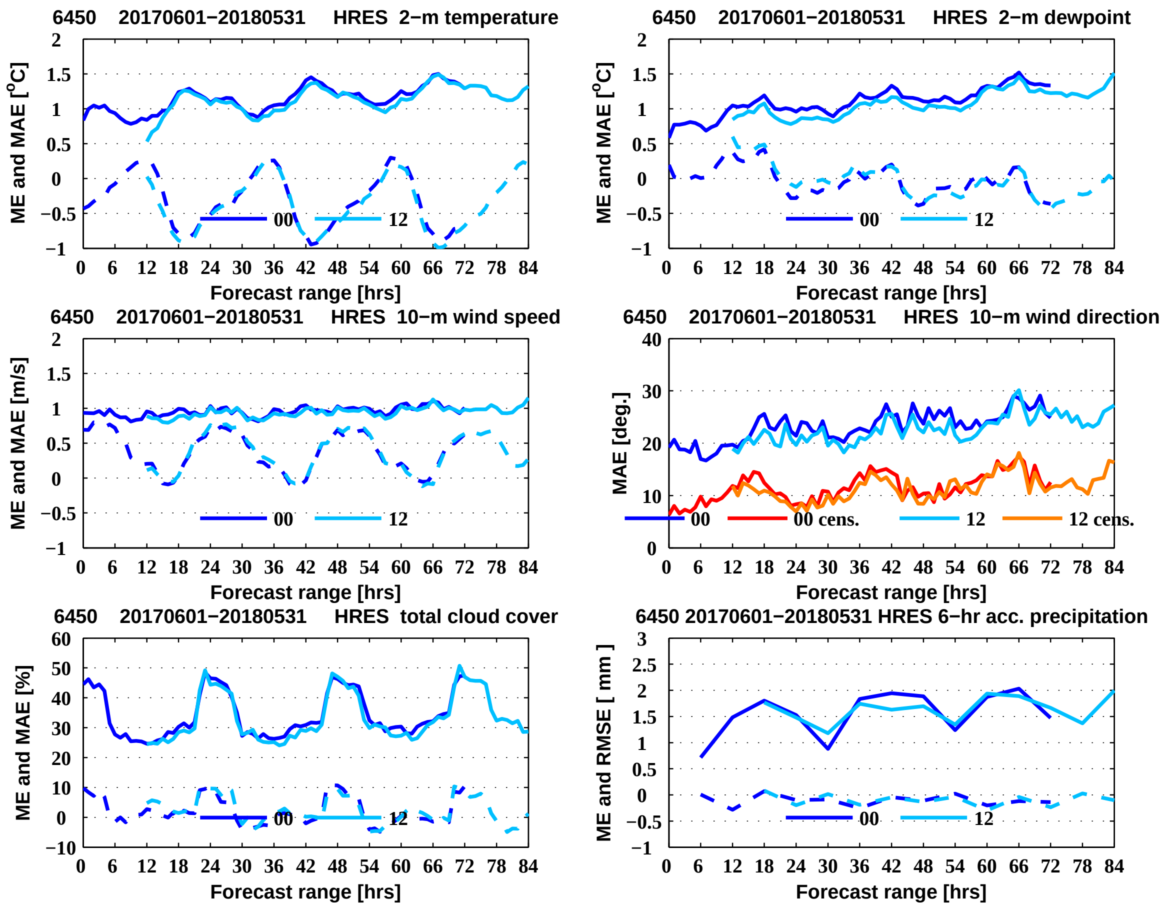

Figure 7: Forecast bias and accuracy in Antwerp/Deurne (06450).

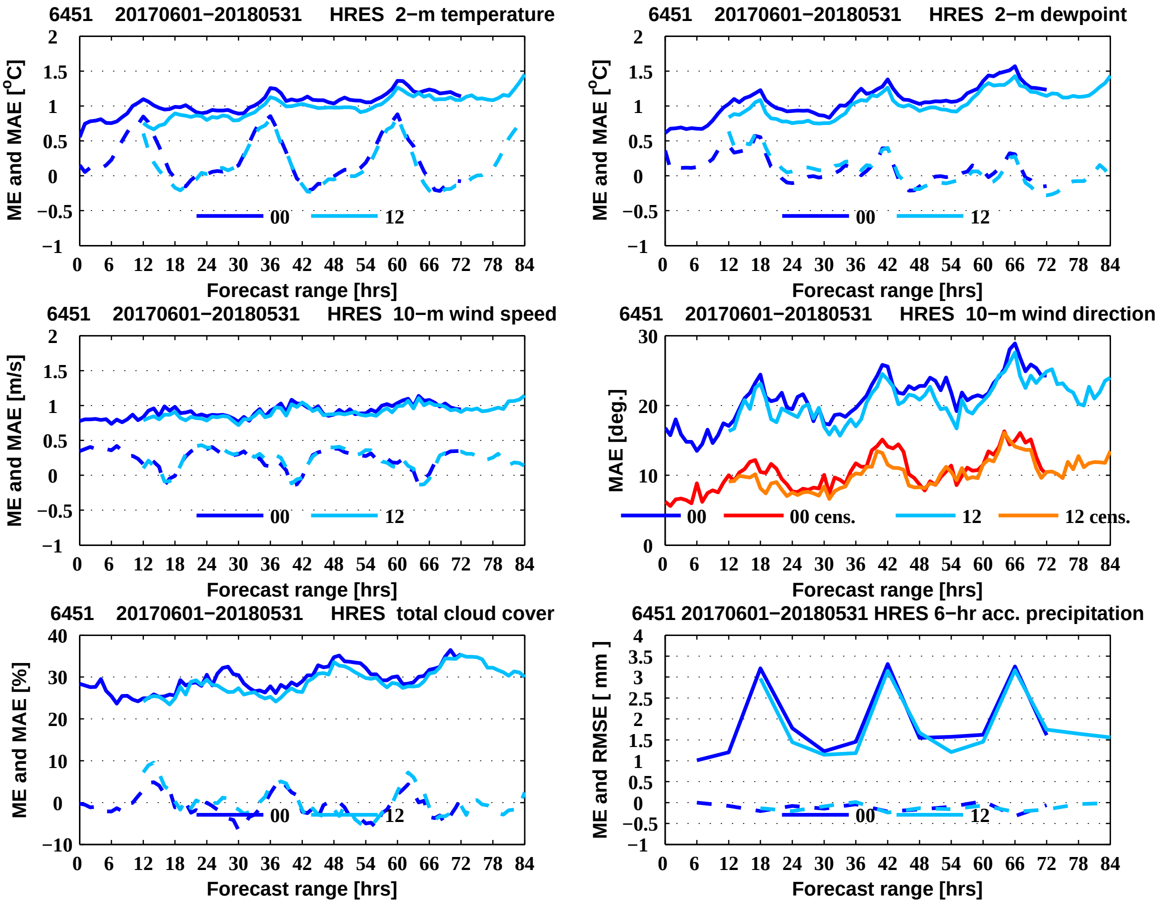

Figure 8: Forecast bias and accuracy in Brussels National (06451).

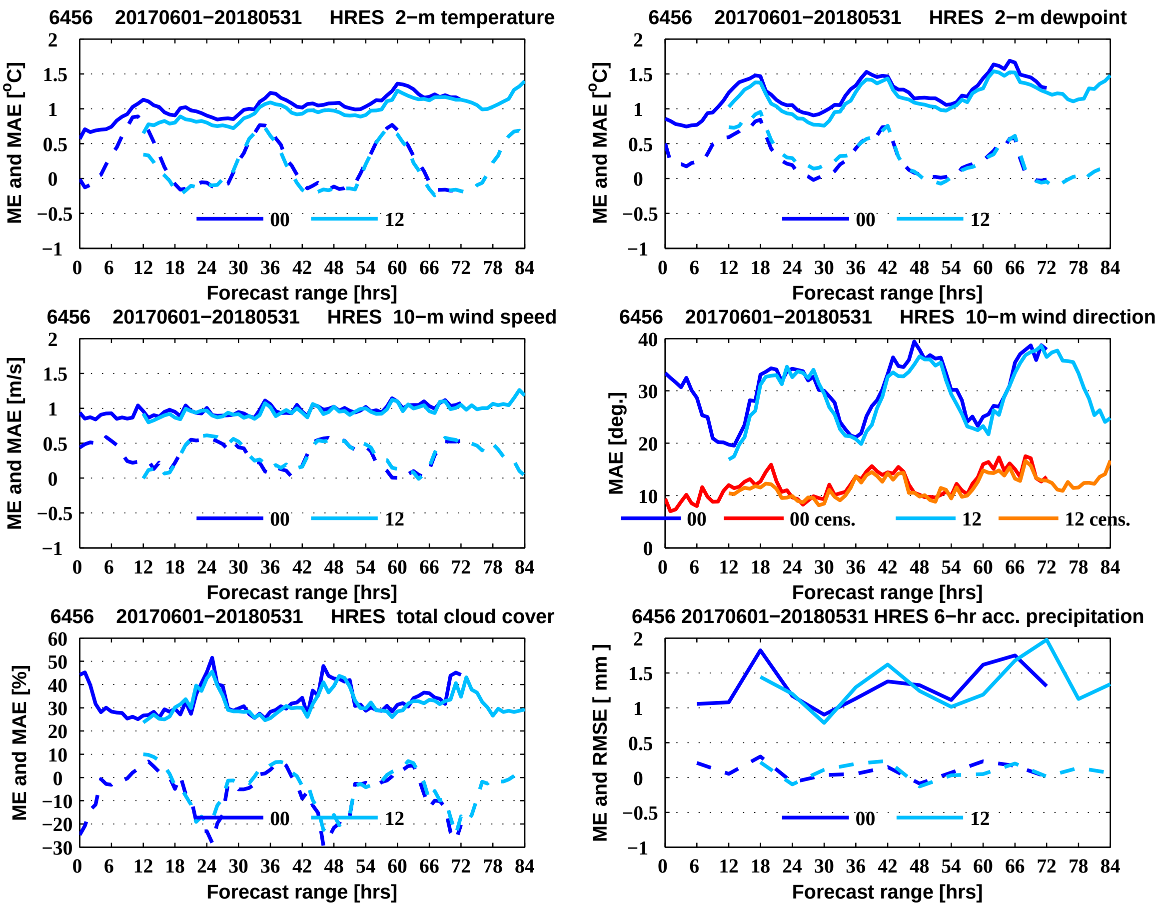

Figure 9: Forecast bias and accuracy in Florennes (06456).

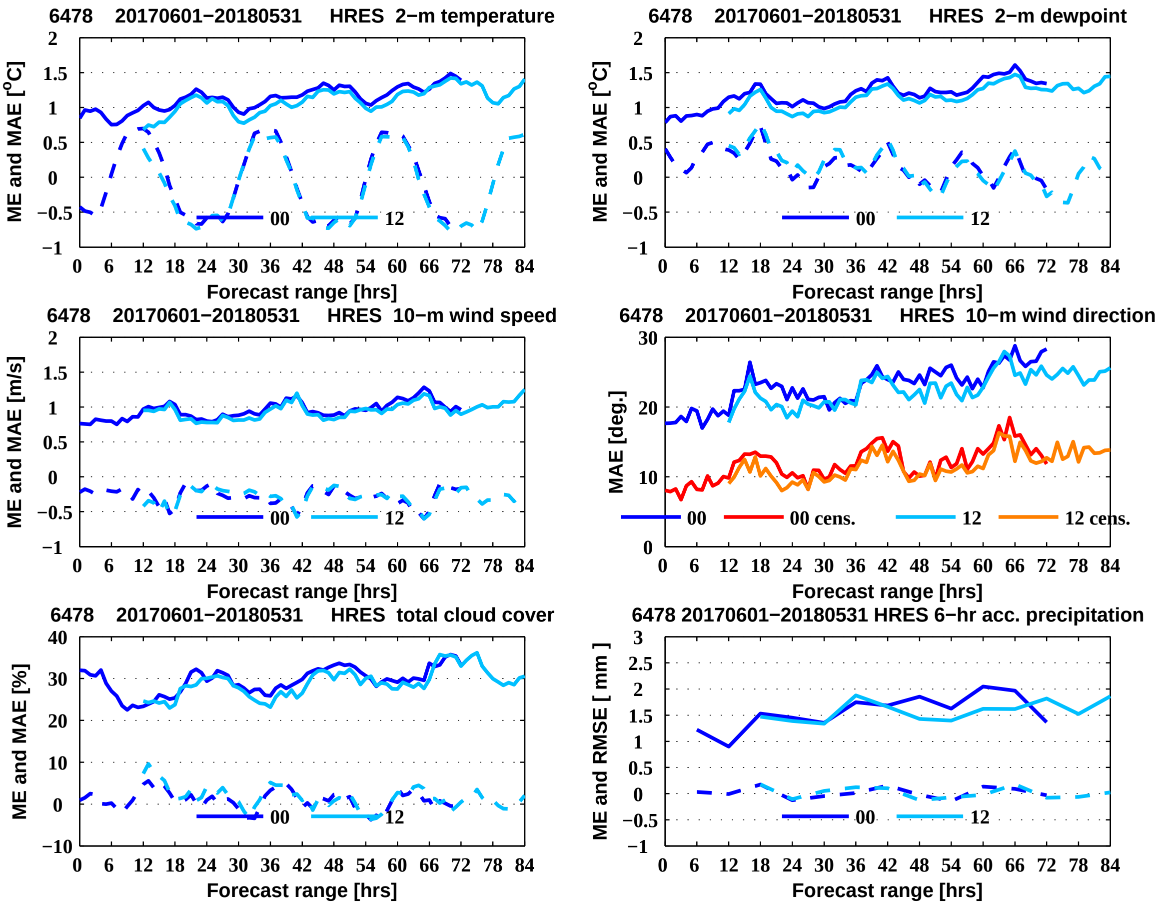

Figure 10: Forecast bias and accuracy in Liège/Bierset (06478).

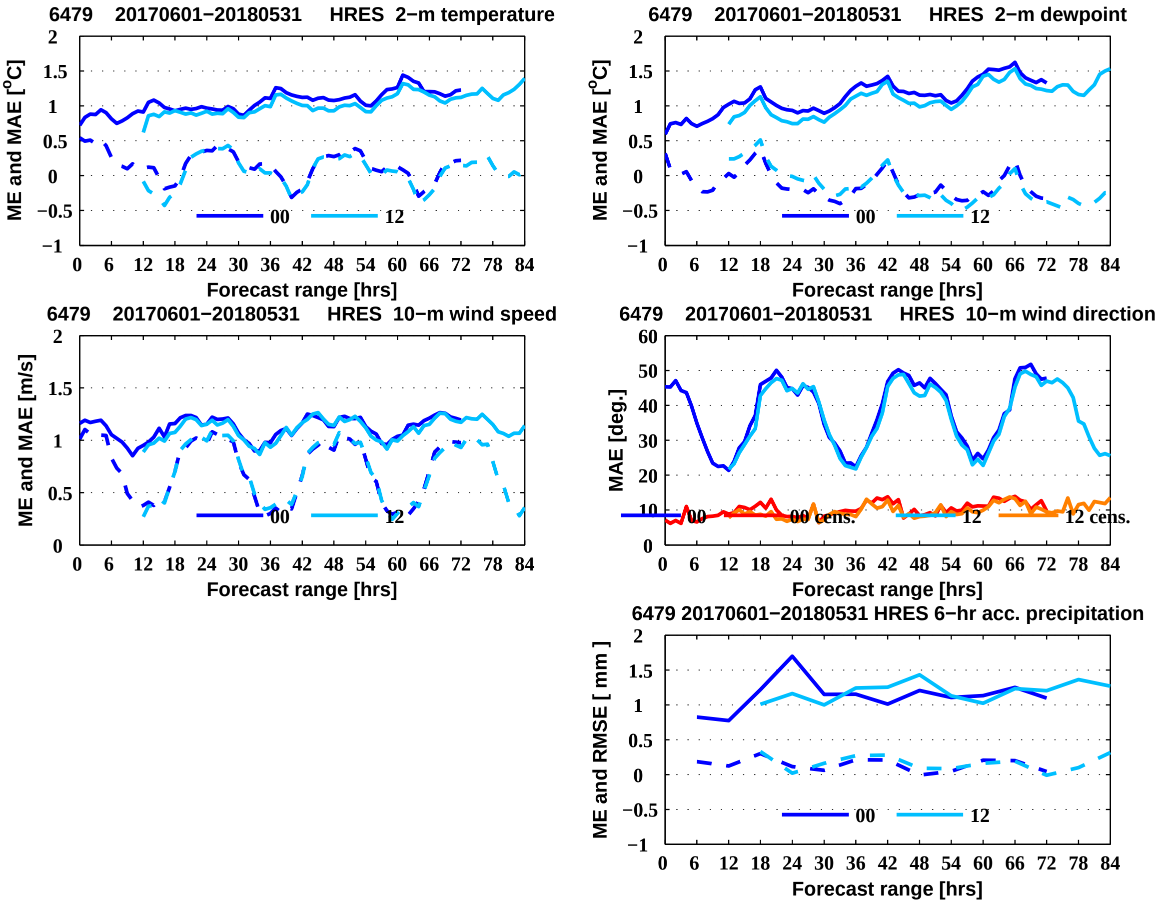

Figure 11: Forecast bias and accuracy in Kleine Brogel (06479).

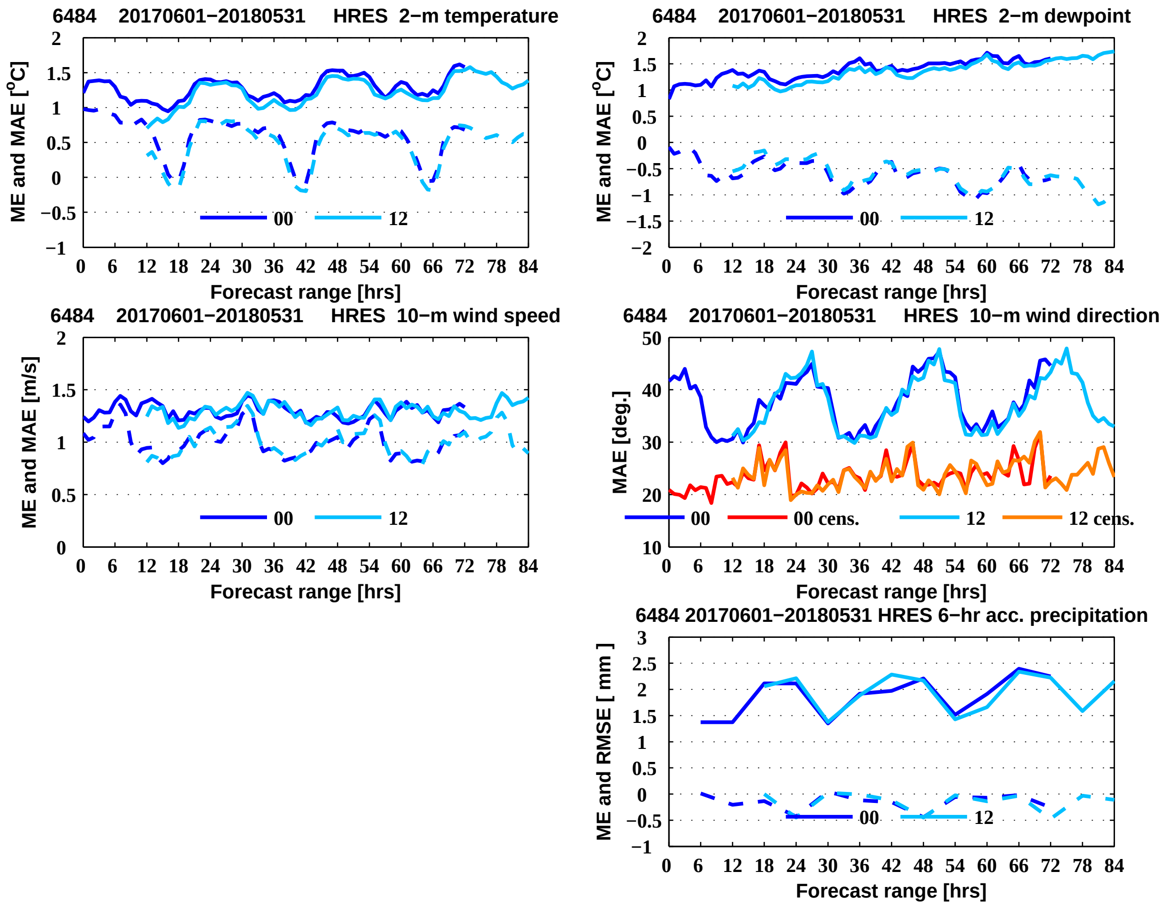

Figure 12: Forecast bias and accuracy in Buzenol (06484).

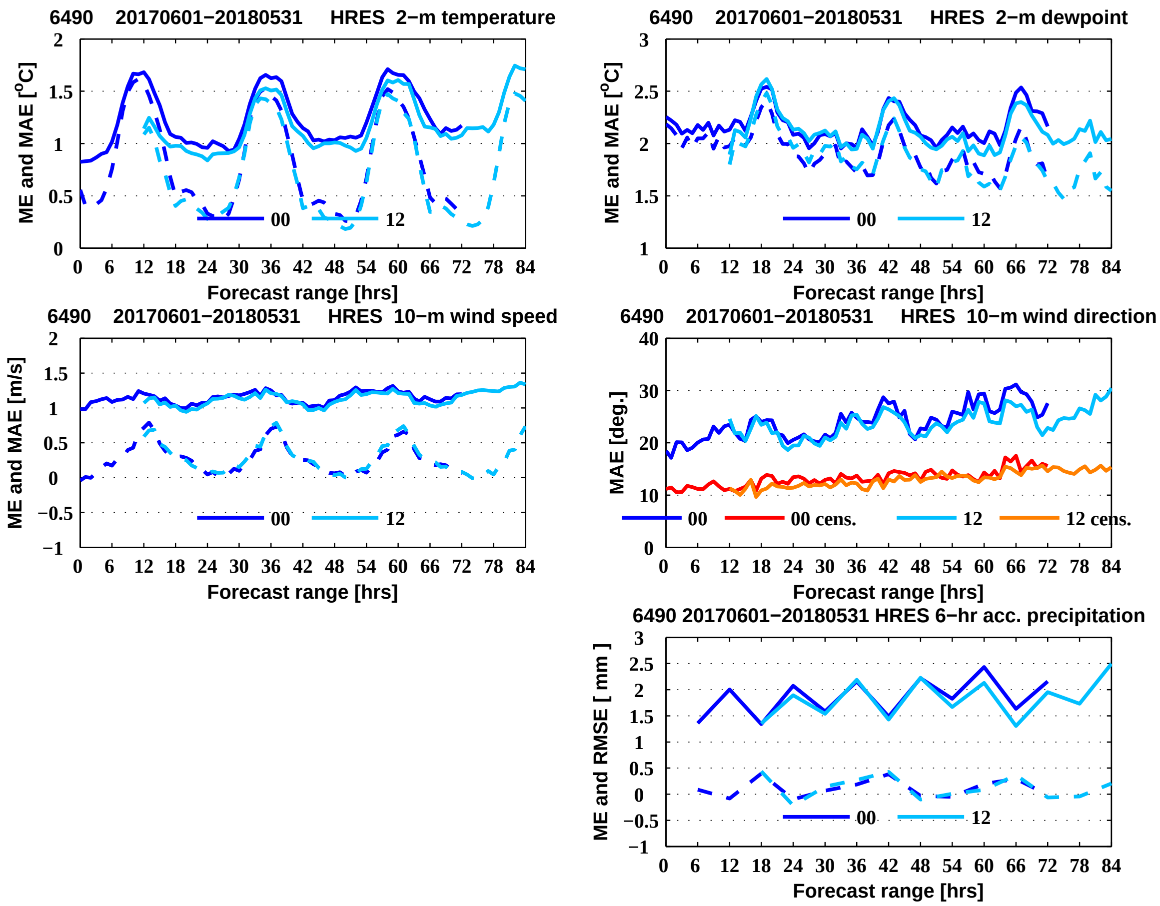

Figure 13: Forecast bias and accuracy in Spa/La Sauvenière (06490).

Due to their spatial properties, local verification of cloud and precipitation patterns must be interpreted with special care. Large errors can occur especially in cases where small to mesoscale (convective) systems are involved. Despite such errors, however, forecasts should be well calibrated. Precipitation forecasts feature mainly small biases regardless of occasional sizeable errors. Likewise, scores for predicted total cloud cover, where available, mainly show errors near 30% on average with little bias. Cloud forecast accuracy often appears better at daytime than at night-time, possibly owing to the well-known difficulty in predicting low-cloud sheets that occasionally build up overnight. Besides, night-time biases have larger negative impacts on accuracy than daytime biases. Stations 06456 (Florennes, Fig. 9) and, to a lesser extent, 06400 (Kosijde, Fig. 1) show some negative biases developing overnight, but these biases are statistically less significant because the numbers of night-time observations turn out comparatively rather small for these locations.

The slight improvement in accuracy of 12-UTC forecast runs compared with the preceding 00-UTC forecast runs is also visible.

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.