Application and verification of ECMWF products in Norway 2007

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1. Summary of major highlights

The ECMWF products are widely used by forecasters to make forecasts for the public, as boundary values in HIRLAM, as basis for LAM ensembles, as input to statistical methods, and more or less directly by customers. The forecasts are mainly verified directly against observations and less against computed areal observations. Results are presented in quarterly reports and on internal web pages.

2. Use and application of products

2.1. Post-processing of model output

2.1.1. Statistical adaptation

Probabilistic forecasts in terms of quantiles for maximum wind speed, 2 metre temperature and 24 hour accumulated precipitation have been generated operationally since autumn 2003. The forecasts are produced by local quantile regression (LQR) and based on daily ECMWF forecasts (12 UTC) and about 3 years of historical data. A Kalman filter procedure is operationally applied to 2 metre temperature forecasts. There is ongoing research in calibration of EPS.

2.1.2. Physical adaptation

The ECMWF model at 41 model levels in resolution 0.5 deg. is used to provide lateral boundary values for limited area modelling. HIRLAM with 20 km is run at 00, 06, 12 and 18 UTC. HIRLAM with 10 km resolution is run at 00 and 12 UTC, and provide lateral boundary values to HIRLAM with 4 km resolution and UM with 4 km resolution run at 00 and 12 UTC.

ECMWF is running a dedicated version of EPS for Norway. TEPS started running daily at ECMWF in mid February 2005. TEPS runs with the same set up and resolution as operational EPS at ECMWF, and hence it has been upgraded accordingly. TEPS differs from EPS in the following way; we have a local target area for the singular vectors. The target area is covering Northern Europe and adjacent sea areas. The forecast time is 72 hours, and we only run 20 + 1 ensemble members. Then TEPS is used for perturbing our LAMEPS system, both the initial conditions and the lateral boundaries are perturbed with TEPS. The LAMEPS system then has 20 + 1 members., and is run daily at 18 UTC for 60 hours. The current resolution for LAMEPS is about 20 km and 40 levels in the vertical. Our end product is a combination ensemble called NORLAMEPS. NORLAMEPS is a simple combination of TEPS and LAMEPS, thus giving us an ensemble with 41 + 1 members. In this way NORLAMEPS is designed to partly account for forecast error caused by model imperfections

2.1.3. Derived fields

Probability maps for selected weather parameters based on EPS are presented in the meteorological visualisation system, Diana.

2.2. Use of products

ECMWF products are indispensable in operational duties. Deterministic forecasts are presented as horizontal maps and vertical cross sections in Diana and as meteograms.

Seasonal temperature forecasts are presented on the external web for an area covering the Nordic countries, Iceland and Great Britain.

3. Verification of products

3.1. Objective verification

3.1.1. Direct ECMWF model output

Local weather parameters are continuously verified against a large number of observations. An example for 2 metre temperature is given in figure 1 with quarterly mean errors (ME) and standard deviations of errors (SDE) at all Norwegian synoptic stations for the autumn 2006. The results show large geographical variations, but in general the ME can mostly be explained by the differences in elevations.

Figure 2 demonstrates the quality of the precipitation forecasts at synoptic stations for the autumn 2006. In general, very large amounts are underestimated and small amounts seem to occur too often, at least when compared to rain gauge measurements. The precipitation is overestimated at coastal stations and just east of the mountains in the south of Norway where the climate is dry compared to the western part.

EPS verification is in progress.

3.1.2. ECMWF model output compared to other NWP models

An example of 10 metre wind speed forecasts from ECMWF compared to HIRLAM20, HIRLAM10 and UM4 is given in figures 3 and 4, with times series of monthly ME and SDE from March 2005 to May 2007. The results are averaged over different selections of stations. The new version of the ECMWF model has stronger 10 metre wind over Norway, reflected in higher ME for the autumn 2006 than 2005, when averaged over Norwegian stations. The overestimation leads to good results at wind exposed stations. Most noticeable are the results in mountainous regions where the underestimation is reduced considerably since August 2006. Along the coastline the wind speed forecasts are now unbiased. Figure 4 show that all models have similar quality of the 10 metre wind speed with respect to SDE.

Precipitation forecasts are verified by several measures in addition to ME, SDE and MAE. Figure 5 give Hite Rate, False Alarm Rate, False Alarm Ratio, Equitable Threat Score and Hanssen-Kuipers Skill Score as a function of exceedance treshold for the autumn 2006 for ECMWF, HIRLAM20, HIRLAM10 and UM4. For this season, dominated by frontal precipitation systems, ECMWF and UM4 had in general better scores than HIRLAM20/10.

3.1.3. Post-processed products

The quality of Kalman filter corrected 2 metre temperature forecasts (T2mK) has been compared to direct model output (T2m) and forecasts adjusted to station height (T2mH). The adjustment is simply to increase the temperature by 0.6deg pr. 100 meter difference between model and real orography. Figure 6 give MAE of T2m, T2mH and T2mK as a function of forecast lead time for HIRLAM10, HIRLAM20 and ECMWF. The results are averaged over 84 Norwegian synop stations and one year of data, March 2006 to February 2007. The Kalman filter procedure gives best results with respect to MAE, but also the simple 'height correction' procedure improve the quality of 2 metre temperature forecasts significantly.

3.1.4. End products delivered to users

3.2. Subjective verification

3.2.1. Subjective scores

The duty forecasters carry out subjective verification of some of the available numerical products. A few scores are daily calculated by looking at the position and strength of the most significant low or high in the forecast area and the position of the fronts associated with these systems. The studies conclude that the model of ECMWF still is the best.

3.2.2. Synoptic studies

4. References to relevant publications

Andersen, J.M.: Prognoseverifikasjon for året 2006. Internal web document (in Norwegian).

Bremnes, J.B., and **Homleid, M**.: Validation of operational numerical weather prediction models December 2005 to February 2006. met.no note, No. 5/2006

Bremnes, J.B., and **Homleid, M**.: Validation of operational numerical weather prediction models March to May 2006. met.no note, No. 7/2006

Bremnes, J.B., and **Homleid, M**.: Validation of operational numerical weather prediction models June to August 2006. met.no note, No.8/2006

Bremnes, J.B., and **Homleid, M**.: Verification of operational numerical weather prediction models September to November 2006. met.no note, No.13/2006.

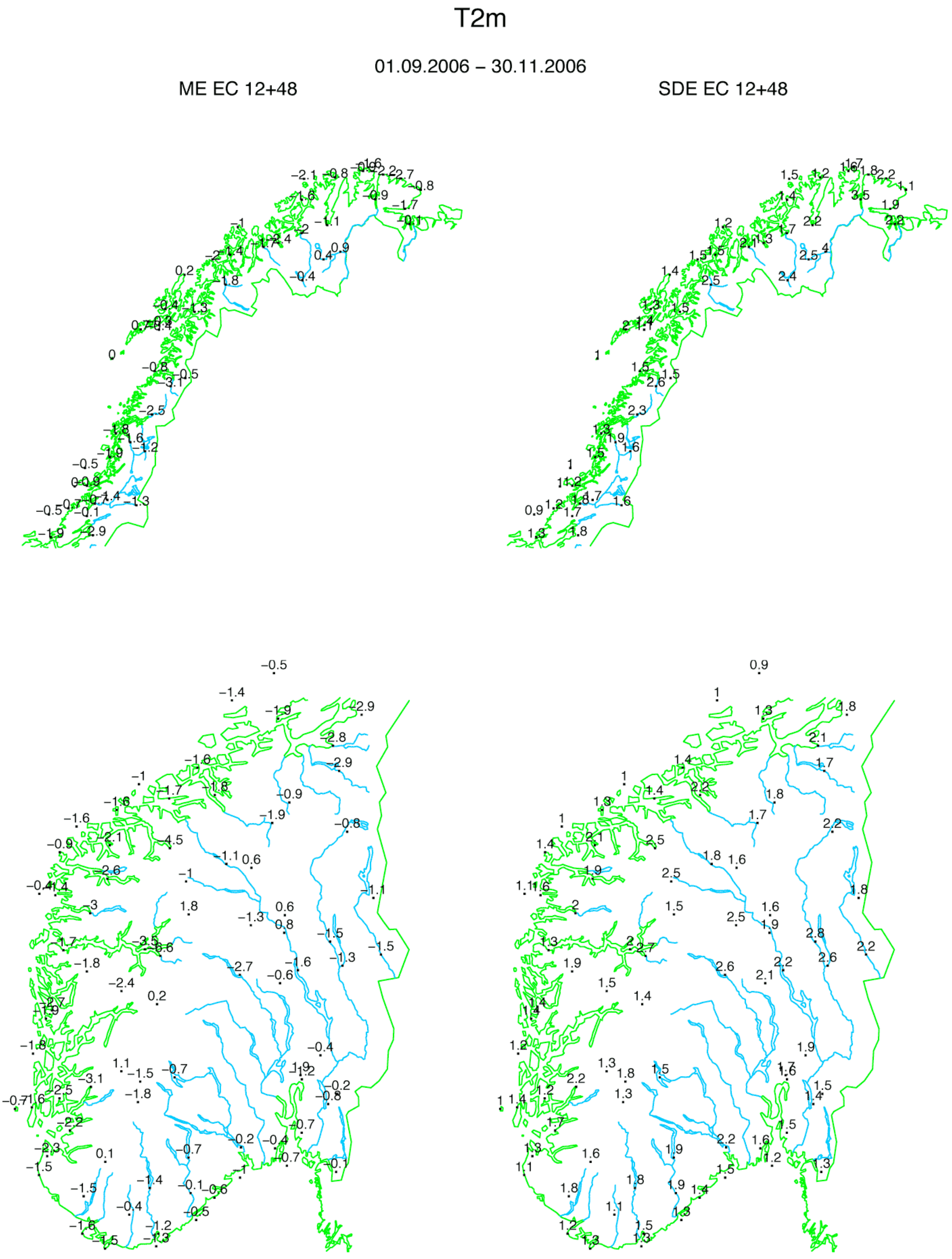


Fig. 1 Mean error (left) and standard deviation of error (right) of ECMWF 12+48 temperature (2m) forecasts.

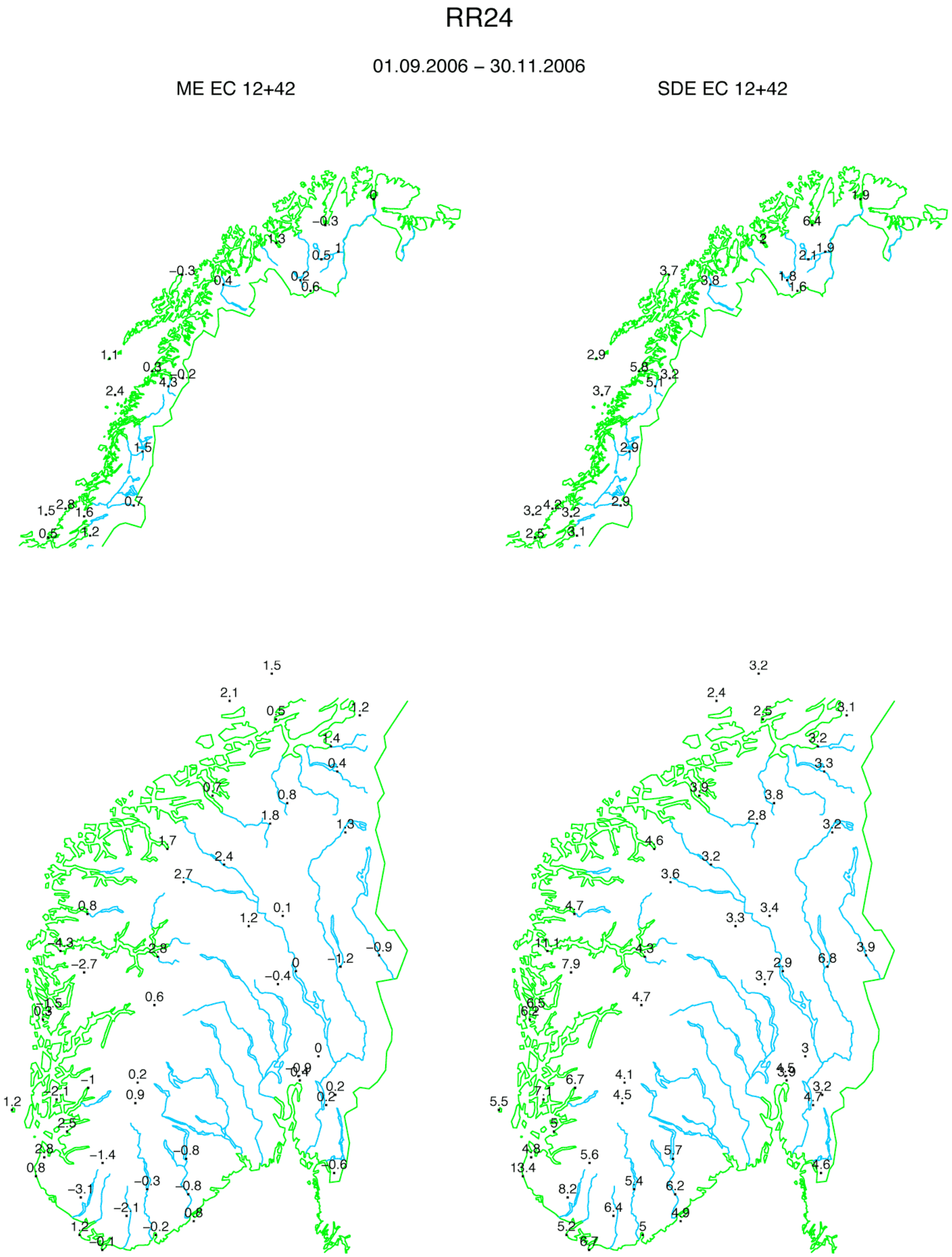


Fig. 2 Mean error (left) and standard deviation of error (right) of ECMWF 12+42 24h accumulated precipitation forecasts.

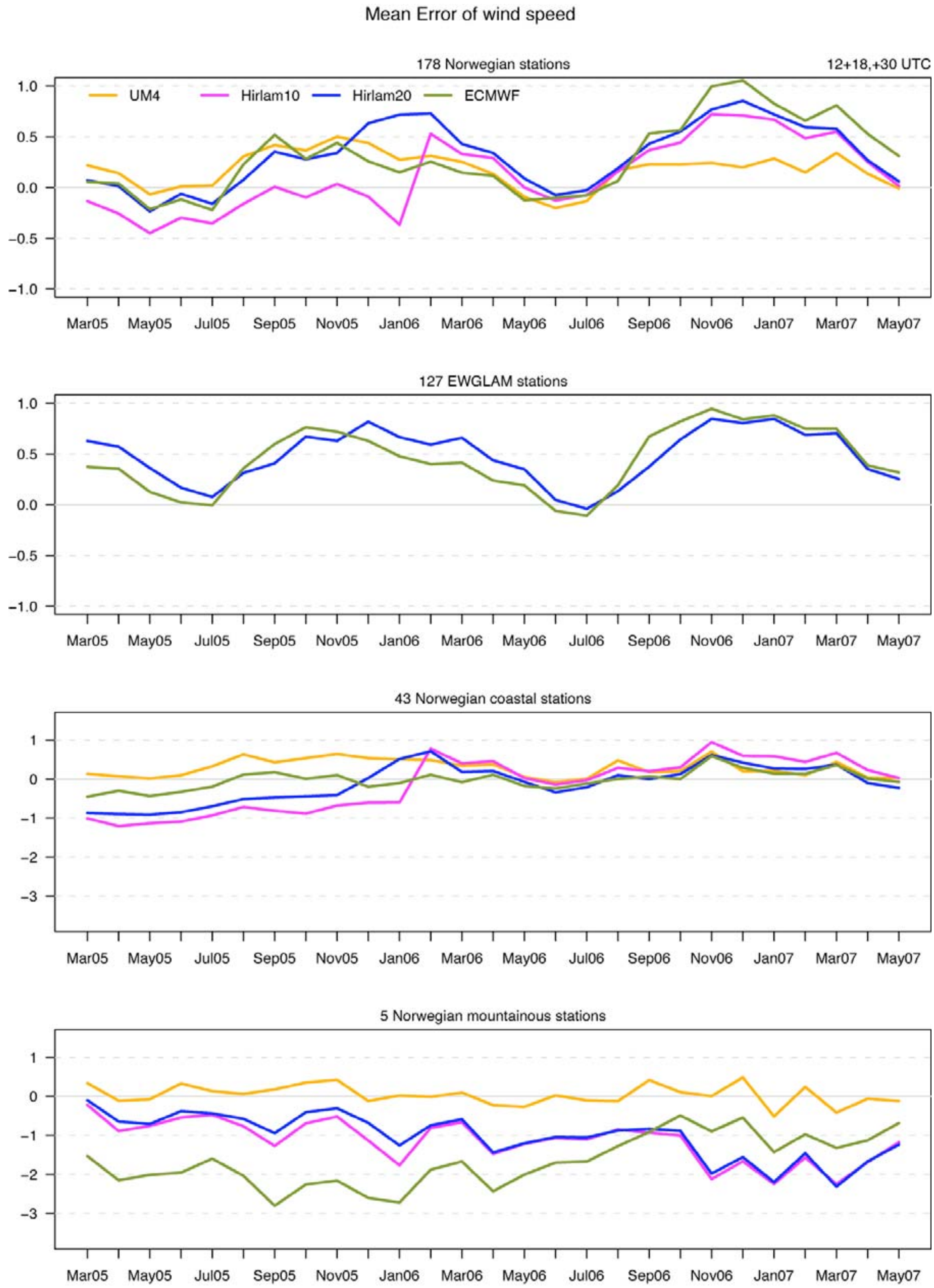


Fig. 3 Monthly mean errors from March 2005 to May 2007 of ECMWF, HIRLAM10 and HIRLAM20 12+18,+24,+36,+48 wind speed forecasts.

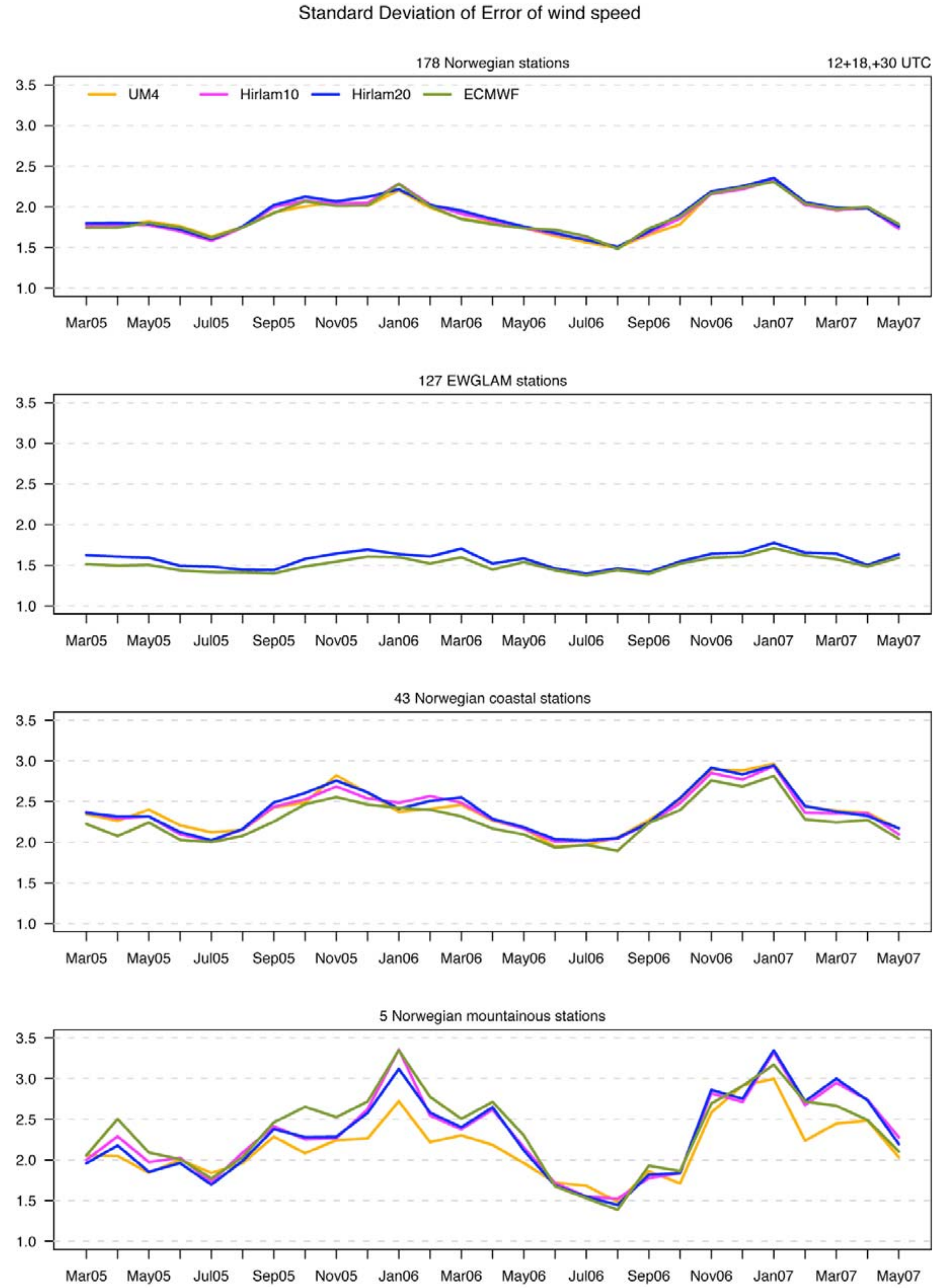
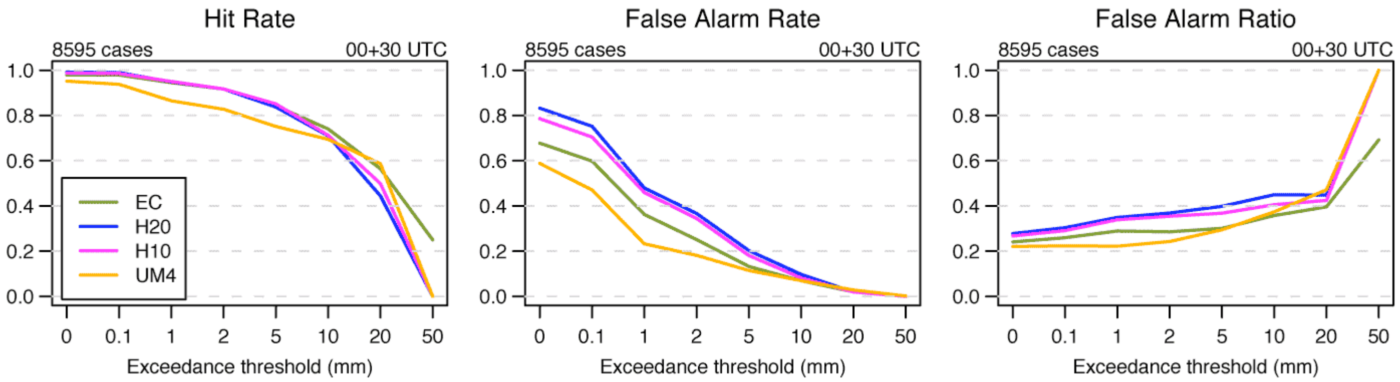
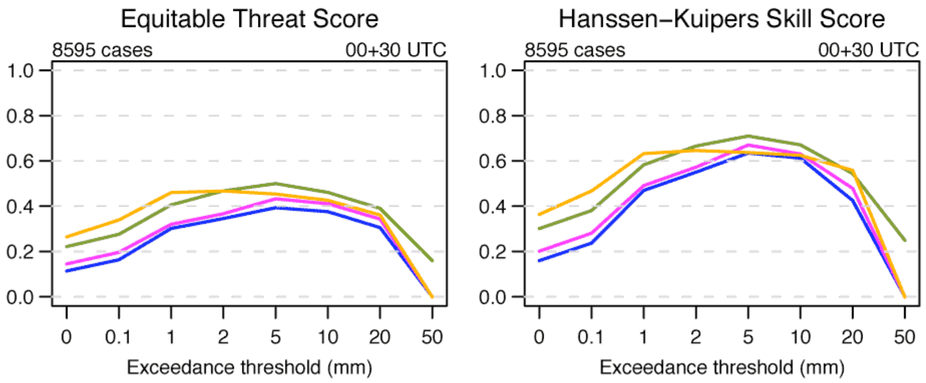


Fig. 4 Monthly standard deviation of errors from March 2005 to May 2007 of ECMWF, HIRLAM10 and HIRLAM20 12+18,+24,+36,+48 wind speed forecasts.





Daily precipitation <= 0.1 mm

8595 cases 00+30 UTC

	HR	F	FAR	ETS	KSS
EC	0.4	0.02	0.08	0.28	0.38
H20	0.25	0.01	0.07	0.16	0.24
H10	0.3	0.01	0.08	0.2	0.28
UM4	0.53	0.06	0.17	0.34	0.47

Fig. 5 Hit Rate, False Alarm Rate, False Alarm Ratio, Equitable Threat Score and Hanssen-Kuipers Skill Score for ECMWF, HIRLAM10 and HIRLAM20 00+30 24h accumulated precipitation forecasts for the autumn 2006.

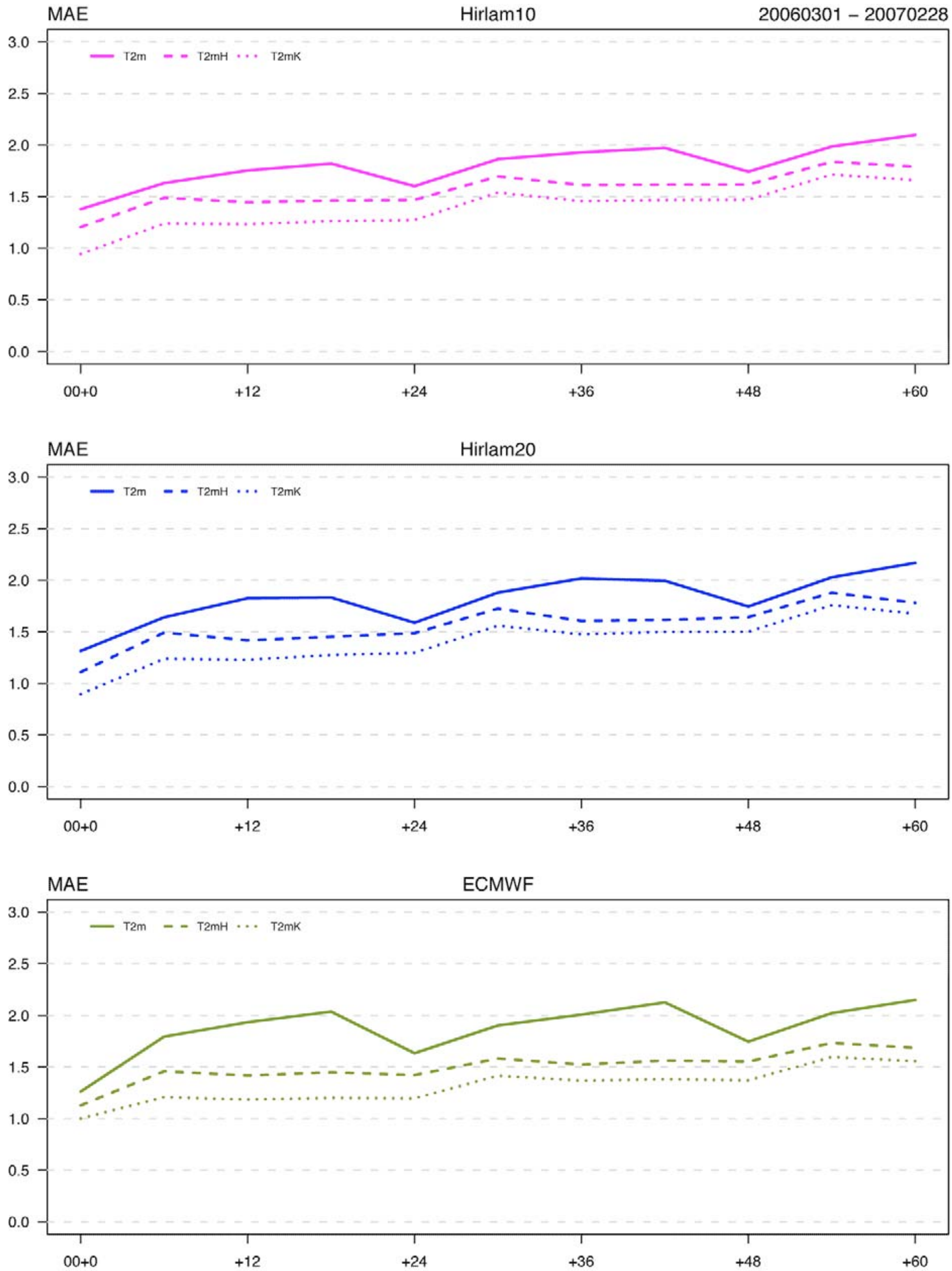


Fig. 6 MAE as a function of forecast lead time for 2 metre temperature HIRLAM10 (upper), HIRLAM20 (middle) and ECMWF (bottom) forecasts; direct model output (T2m), 'height corrected' (T2mH) and Kalman filter corrected (T2mK). The results are based on data from March 2006 to February 2007 and averaged over 84 Norwegian synop stations.