Application and verification of ECMWF products 2009

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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

There is ongoing research in calibration of EPS. A Kalman filter procedure is operationally applied to 2 metre temperature forecasts.

2.1.2 Physical adaptation

The ECMWF model at 91 model levels in resolution 0.5 deg. is used to provide lateral boundary values for limited area modelling. HIRLAM with 12 km is run at 00, 06, 12 and 18 UTC. HIRLAM with 8 km resolution is run also run at 00, 06, 12 and 18 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 at 06 UTC for 48 hours and at 18 UTC for 60 hours. The current resolution for LAMEPS is about 12 km and 60 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

The ECMWF EPS has since March 2009 been used to produce uncertainty and probability forecasts for the medium range to the public at yr.no. Uncertainty is indicated for weather, temperature and wind in terms of green, yellow and red boxes. Probability forecasts comprise the 10, 25, 75 and 90 percentiles for temperature and 6-hours precipitation, see for example http://www.yr.no/place/Norway/Oslo/Oslo/Oslo/long.html

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 (both deterministic and EPS)

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 2008. The results show large geographical variations. The ME can partly be explained by the differences in elevations, but relatively large negative ME at many coastal stations in autumn and winter indicate that the forecasts could have been more influenced by the sea temperature.

Figure 2 demonstrates the quality of the precipitation forecasts at synoptic stations for the autumn 2008. 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 but underestimated at stations recording the largest precipitation amounts.

EPS verification is carried out for the shortest lead times.

3.1.2 ECMWF model output compared to other NWP models

An example of 10 metre wind speed forecasts from ECMWF compared to HIRLAM20/12, HIRLAM10/8, HIRLAM4 and UM4 is given in figures 3 and 4, with times series of monthly ME and SDE from March 2007 to May 2009. The results are averaged over different selections of stations. The update of ECMWF 30 September 2008 seems to have effected the 10 meter wind speed forecasts. When summarized over Norwegian stations, ECMWF shows reduced overestimation the autumn and winter 2008/2009 as compared to the autumn and winter 2007/2008. The overall reduced wind speed implies reduced performance for the strongest winds, reflected in lower Hit Rate and ETS than previous winter, and relative to HIRLAM and UM4 (not shown). Large negative ME when averaged over 5 mountainous stations demonstrate that the speed is reduced also in mountainous regions. Along the coastline the wind speed forecasts were unbiased or slightly underestimated. Figure 4 shows that all models have similar quality of the 10 metre wind speed with respect to SDE, and that HIRLAM and UM were closer to ECMWF than previous winter.

Precipitation forecasts are verified by several measures in addition to ME, SDE and MAE. Figure 5 gives Hite Rate, False Alarm Rate, False Alarm Ratio, Equitable Threat Score and Hanssen-Kuipers Skill Score as a function of exceedance threshold for the autumn 2008 for ECMWF, HIRLAM12, HIRLAM8, HIRLAM4 and UM4. For this season, dominated by frontal precipitation systems, ECMWF and UM4 had in general better scores than HIRLAM12/8/4.

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 HIRLAM4, HIRLAM8 and ECMWF. The results are averaged over 73 Norwegian synop stations and one year of data, January to December 2008. 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 (including evaluation of confidence indices when available)

3.2.2 Synoptic studies

4. References to relevant publications

Bremnes, J.B., and **Homleid, M.**: Validation of experimental and operational numerical weather prediction models December 2007 to February 2008. *met.no note*, **No. 7**/2008.

Bremnes, J.B., and **Homleid, M**.: Validation of operational numerical weather prediction models March to May 2008. *met.no note*, **No. 9**/2008.

Bremnes, J.B., and **Homleid, M**.: Validation of operational numerical weather prediction models June to August 2008. *met.no note*, **No.21**/2008.

Bremnes, J.B., and **Homleid, M**.: Verification of operational numerical weather prediction models September to November 2008. *met.no note*, **No.17**/2008.

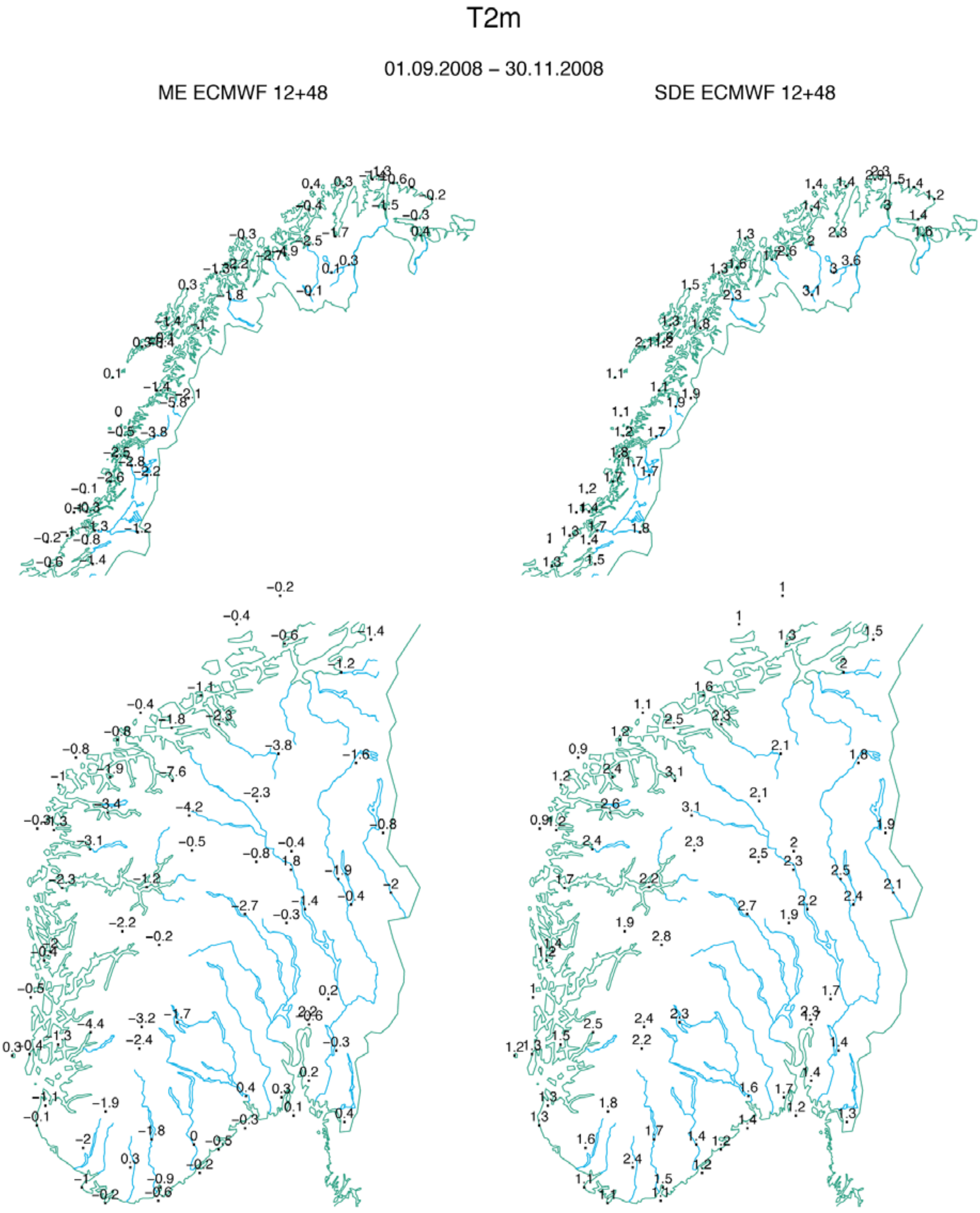


Fig. 1 Mean error (left) and standard deviation of error (right) of ECMWF 12+48 **2 metre temperature forecasts** for the autumn 2008.

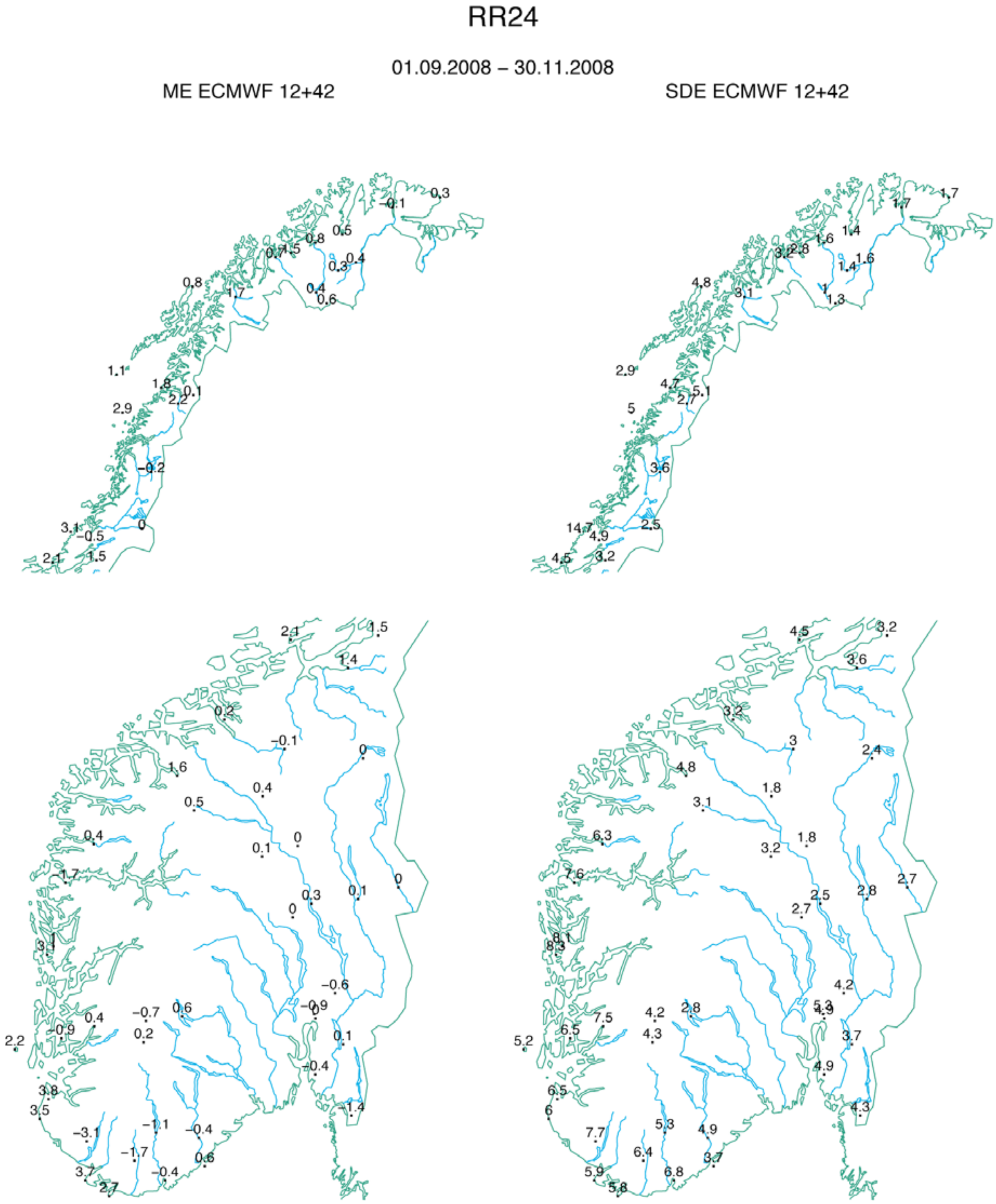


Fig. 2 Mean error (left) and standard deviation of error (right) of ECMWF 12+42 **24h accumulated precipitation** forecasts for the autumn 2008.

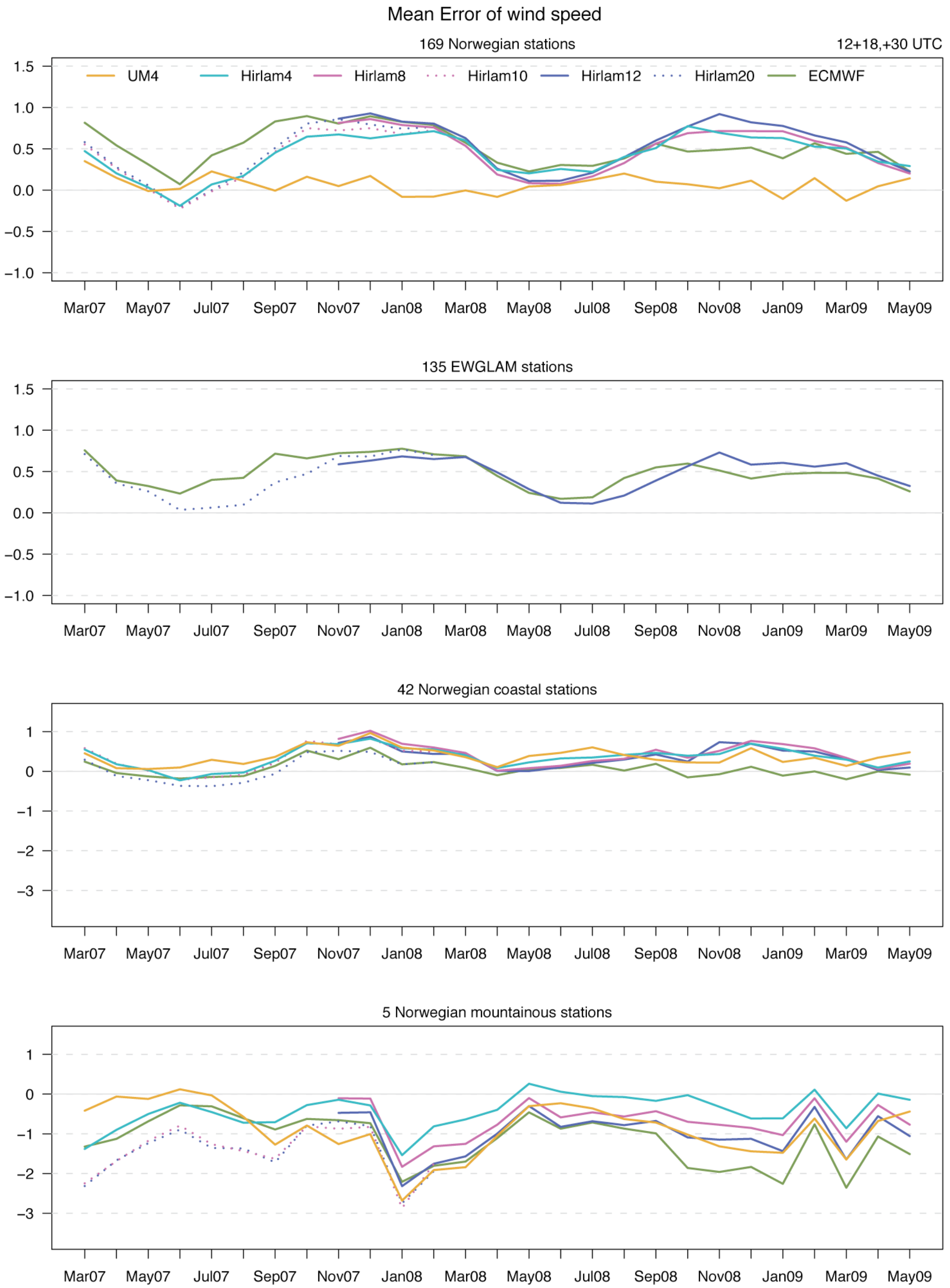


Fig. 3 Monthly mean errors from March 2007 to May 2009 of ECMWF (olive), HIRLAM20/12 (blue), HIRLAM10/8 (magenta), HIRLAM4 (cyan) and UM4 (orange) 12+18,+30 **wind speed** forecasts.

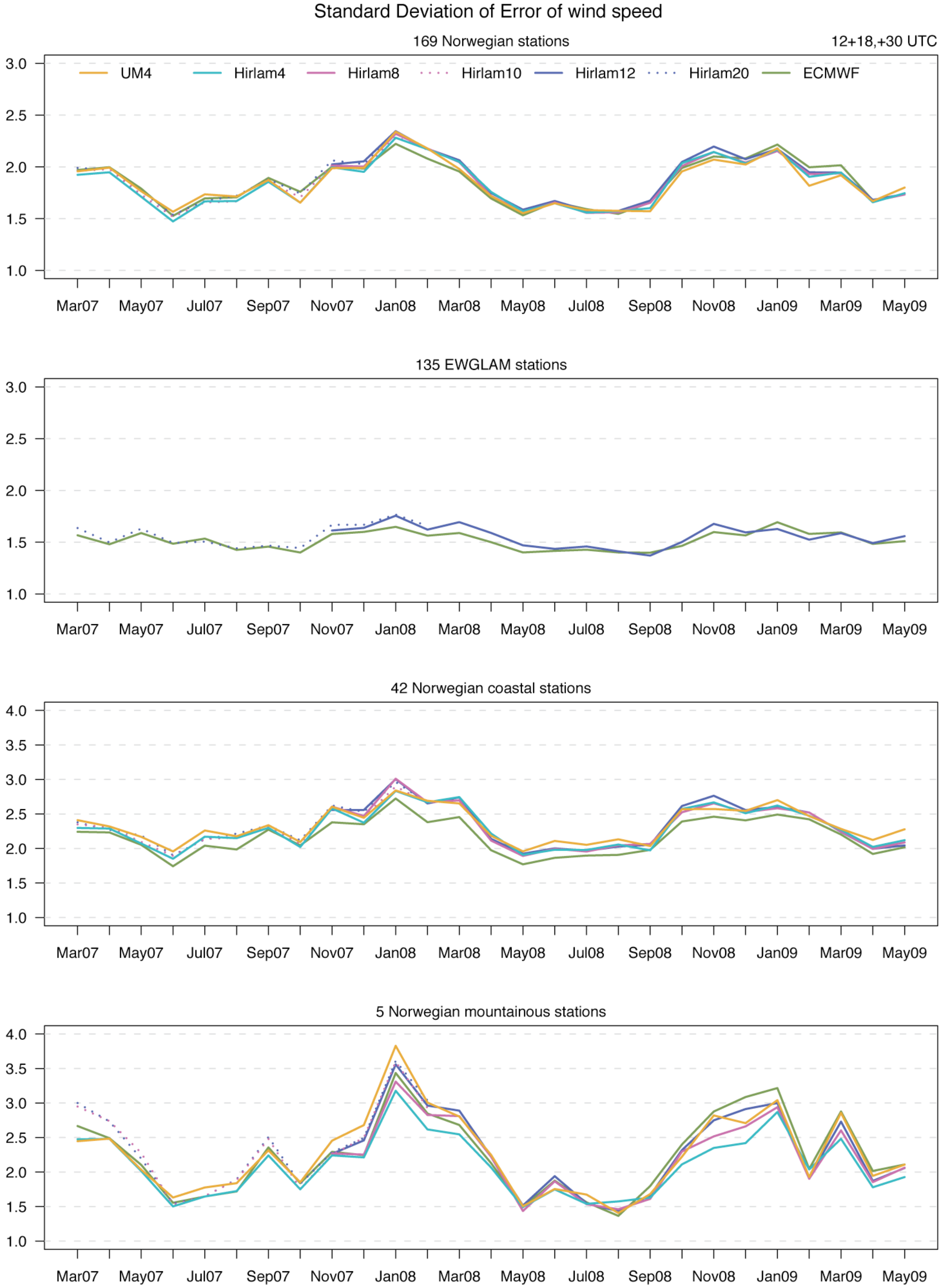
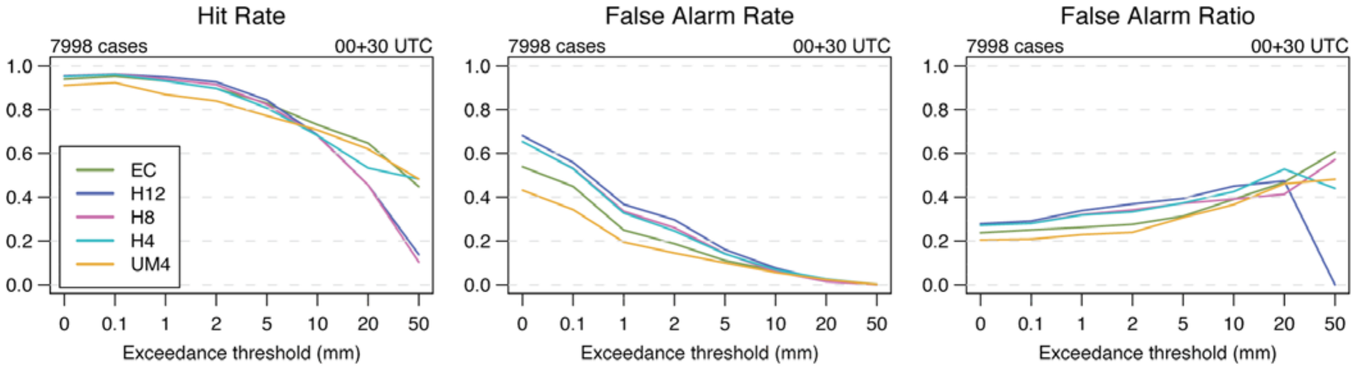
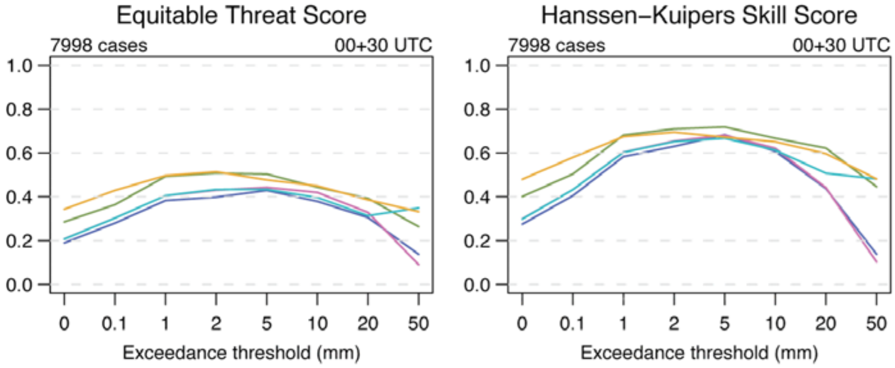


Fig. 4 Monthly standard deviation of errors from March 2007 to May 2009 of ECMWF (olive), HIRLAM20/12 (blue), HIRLAM10/8 (magenta), HIRLAM4 (cyan) and UM4 (orange) 12+18,+30 **wind speed** forecasts.





Daily precipitation <= 0.1 mm

7998 cases 00+30 UTC

	HR	F	FAR	ETS	KSS
EC	0.55	0.05	0.11	0.36	0.5
H12	0.44	0.04	0.11	0.28	0.4
H8	0.47	0.04	0.1	0.3	0.43
H4	0.47	0.04	0.1	0.3	0.43
UM4	0.66	0.08	0.14	0.43	0.58

Fig. 5 Hit Rate, False Alarm Rate, False Alarm Ratio, Equitable Threat Score and Hanssen-Kuipers Skill Score for ECMWF (olive), HIRLAM12 (blue) , HIRLAM8 (magenta), HIRLAM4 (cyan) and UM4 (orange) 00+30 **24h accumulated precipitation** forecasts for the autumn 2008.

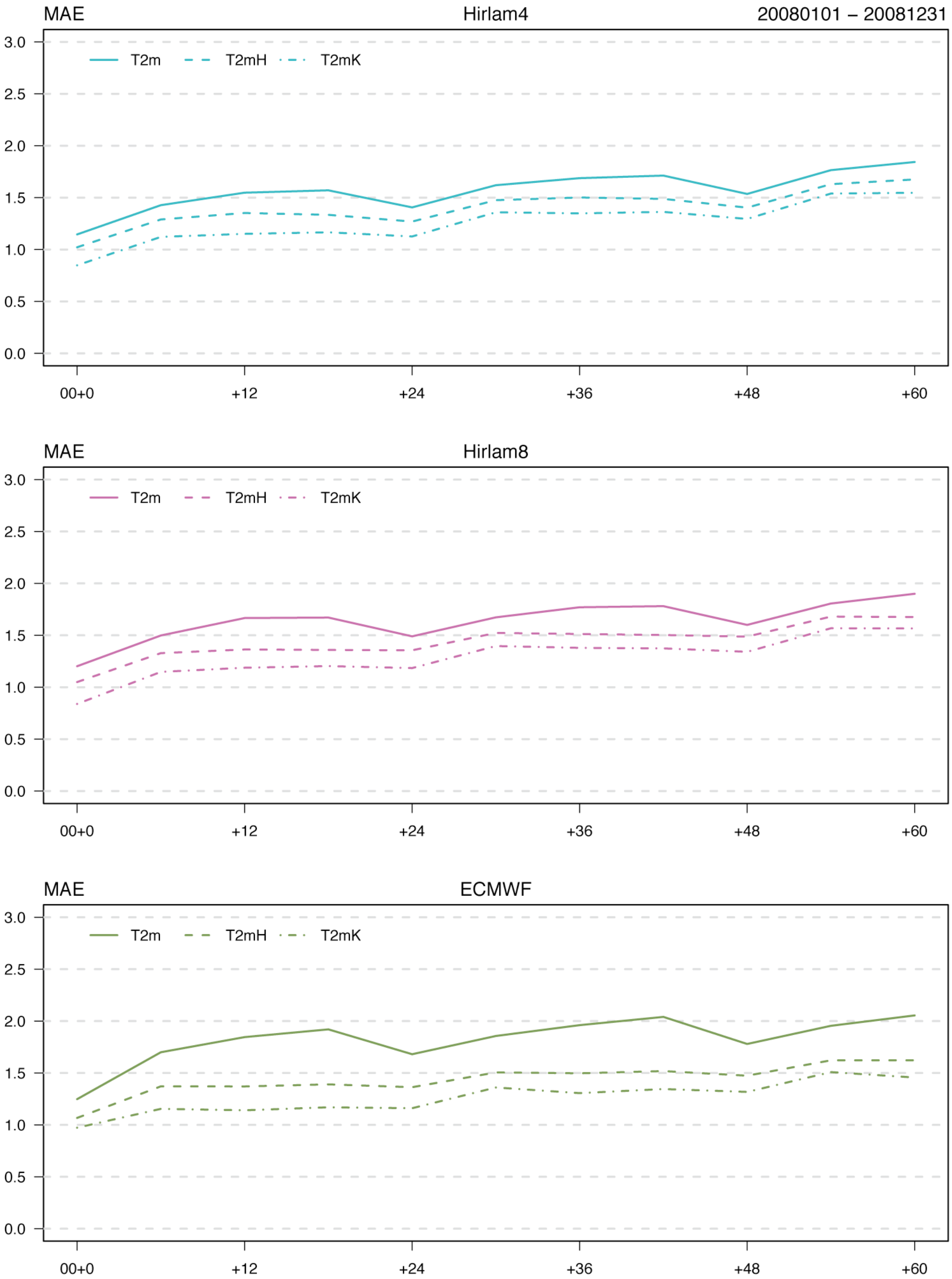


Fig. 6 MAE as a function of forecast lead time for **2 metre temperature** HIRLAM4 (upper), HIRLAM8 (middle) and ECMWF (bottom) forecasts; direct model output (solid lines), 'height corrected' (dashed lines) and Kalman filter corrected (dashed-dotted lines). The results are based on data from January to December 2008 and averaged over 73 Norwegian synop stations.