Application and verification of ECMWF products 2010

The Norwegian Meteorological Institute

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 end users. 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

Output from the ECMWF model is used to provide lateral boundary values for limited area modelling. Two HIRLAM models are run with 12 km and 8 km resolution (HIRLAM12/8), respectively, at 00, 06, 12 and 18 UTC. The latter provide lateral boundary values to a HIRLAM model with 4 km resolution (HIRLAM4) and a Unified Model with 4 km resolution (UM4) both run at 00, 06, 12 and 18 UTC.

The ECMWF is running a dedicated version of EPS for Norway called TEPS which started daily runs at the ECMWF 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; it has a local target area for the singular vectors covering Northern Europe and adjacent sea areas. The forecast time is 72 hours, and only 20 + 1 ensemble members are run. 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 combined ensemble called NORLAMEPS. NORLAMEPS is simply a combination of TEPS and LAMEPS, thus giving us an ensemble with 40 + 2 members. In this way NORLAMEPS is designed to partly account for forecast errors 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 at yr.no to the public. 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 winter 2009/2010. The results show large geographical variations. The MEs can partly be explained by the differences in elevations, but relatively large negative MEs at many coastal stations in autumn and winter indicate that the forecasts could have been more influenced by the sea temperature. The EPS has very large negative biases during winter time for certain weather types in areas around e.g. Tromsø, Narvik and Molde (not shown).

Figure 2 demonstrates the quality of the precipitation forecasts at selected synoptic stations for the autumn 2009. 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

Examples of 10 metre wind speed forecast verification of the ECMWF model compared to HIRLAM12, HIRLAM8, HIRLAM4 and UM4 are given in figures 3 and 4 showing times series of monthly mean and standard deviation of errors from March 2008 to May 2010. The results are averaged over various selections of stations. Large negative mean errors for the 5 mountainous stations demonstrate that the wind speed is too weak 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 standard deviation of errors.

Precipitation forecasts are verified using several measures in addition to ME, SDE and MAE. Figure 5 shows the hit rate, false alarm rate, false alarm ratio, equitable threat score and Hanssen-Kuipers skill score as a function of exceedance threshold for the autumn 2009 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 adjusted 2 metre temperature forecasts (T2mK) has been compared to direct model output (T2m) and forecasts adjusted to station height (T2mH). The latter adjustment is simply to increase the temperature by 0.6° per 100 meter difference between model and real orography. Figure 6 give mean absolute errors 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 2009. The Kalman filter procedure gives best results with respect to mean absolute errors, but also the simple 'height correction' procedure improves 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

Bremnes, J.B., and **Homleid, M**.: Validation of experimental and operational numerical weather prediction models December 2008 to February 2009. met.no note, No. 5/2009.

Bremnes, J.B., and **Homleid, M**.: Validation of operational numerical weather prediction models March to May 2008. met.no note, No. 17/2009.

Bremnes, J.B., and **Homleid, M**.: Validation of operational numerical weather prediction models June to August 2008. met.no note, No.23/2009.

Bremnes, J.B., and **Homleid, M**.: Verification of operational numerical weather prediction models September to November 2008. met.no note, No.28/2009.

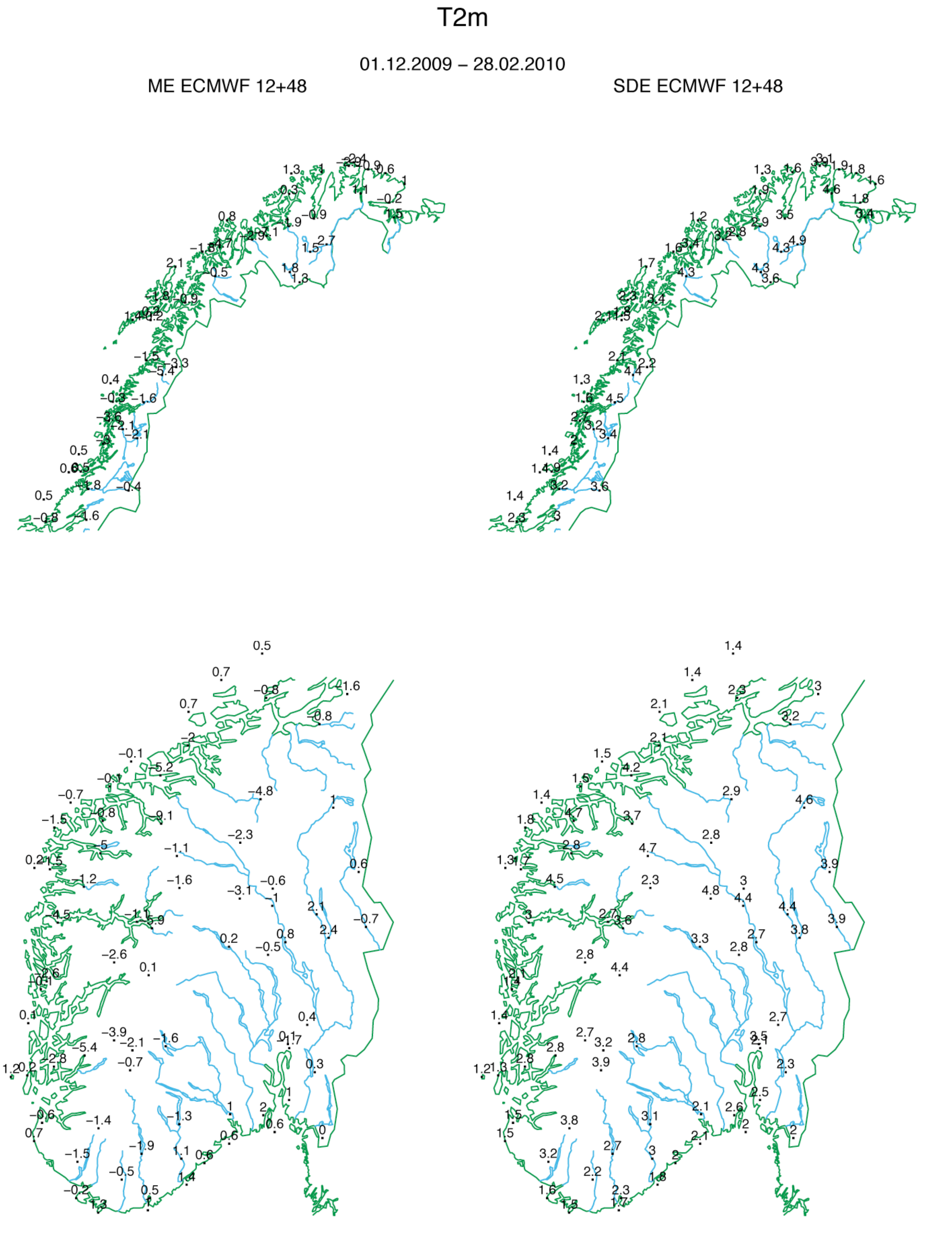


Fig. 1 Mean error (left) and standard deviation of error (right) of ECMWF 12+48 **2 metre temperature** forecasts for the winter 2009/10.

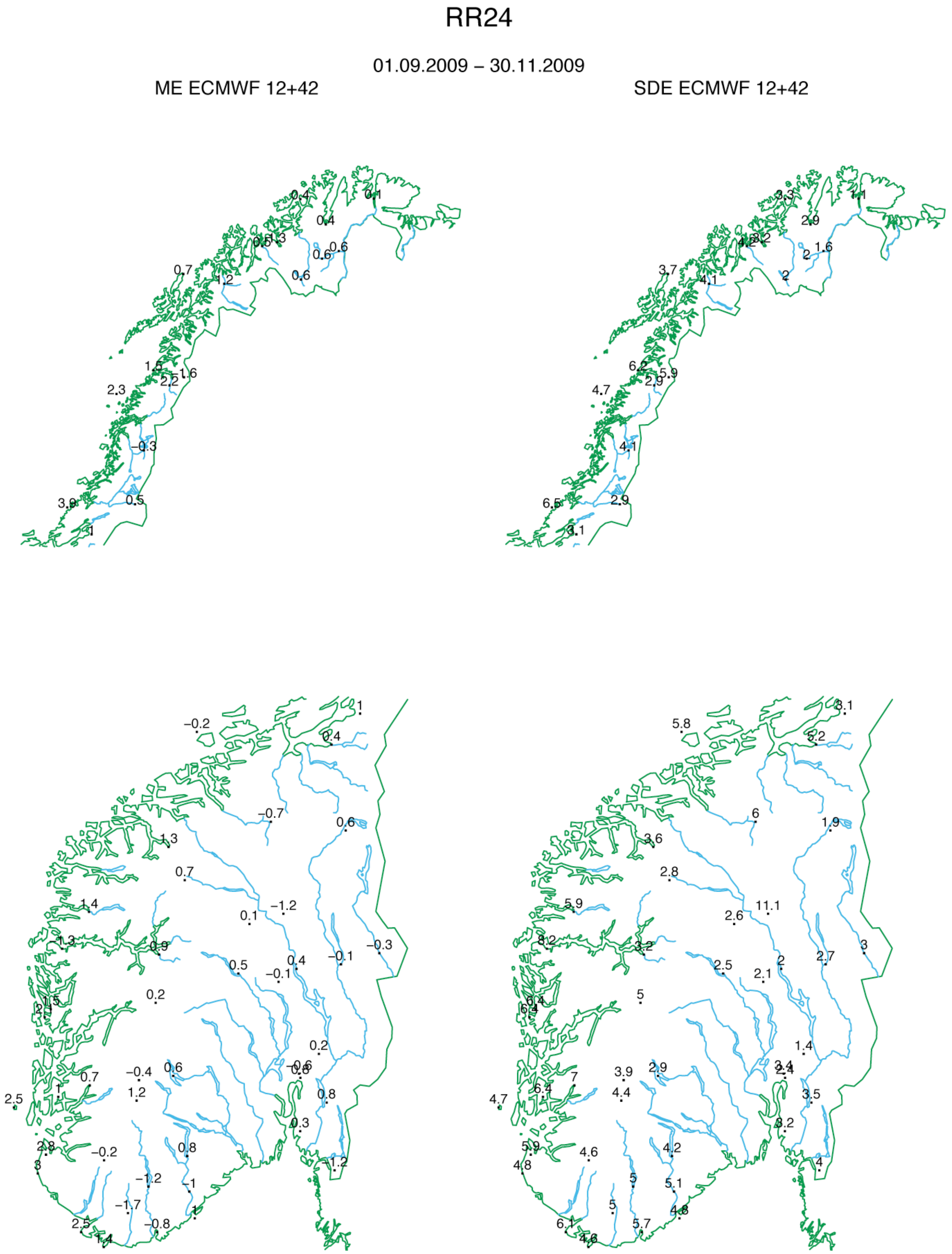


Fig. 2 Mean error (left) and standard deviation of error (right) of ECMWF 12+42 **24h accumulated precipitation** forecasts for the autumn 2009.

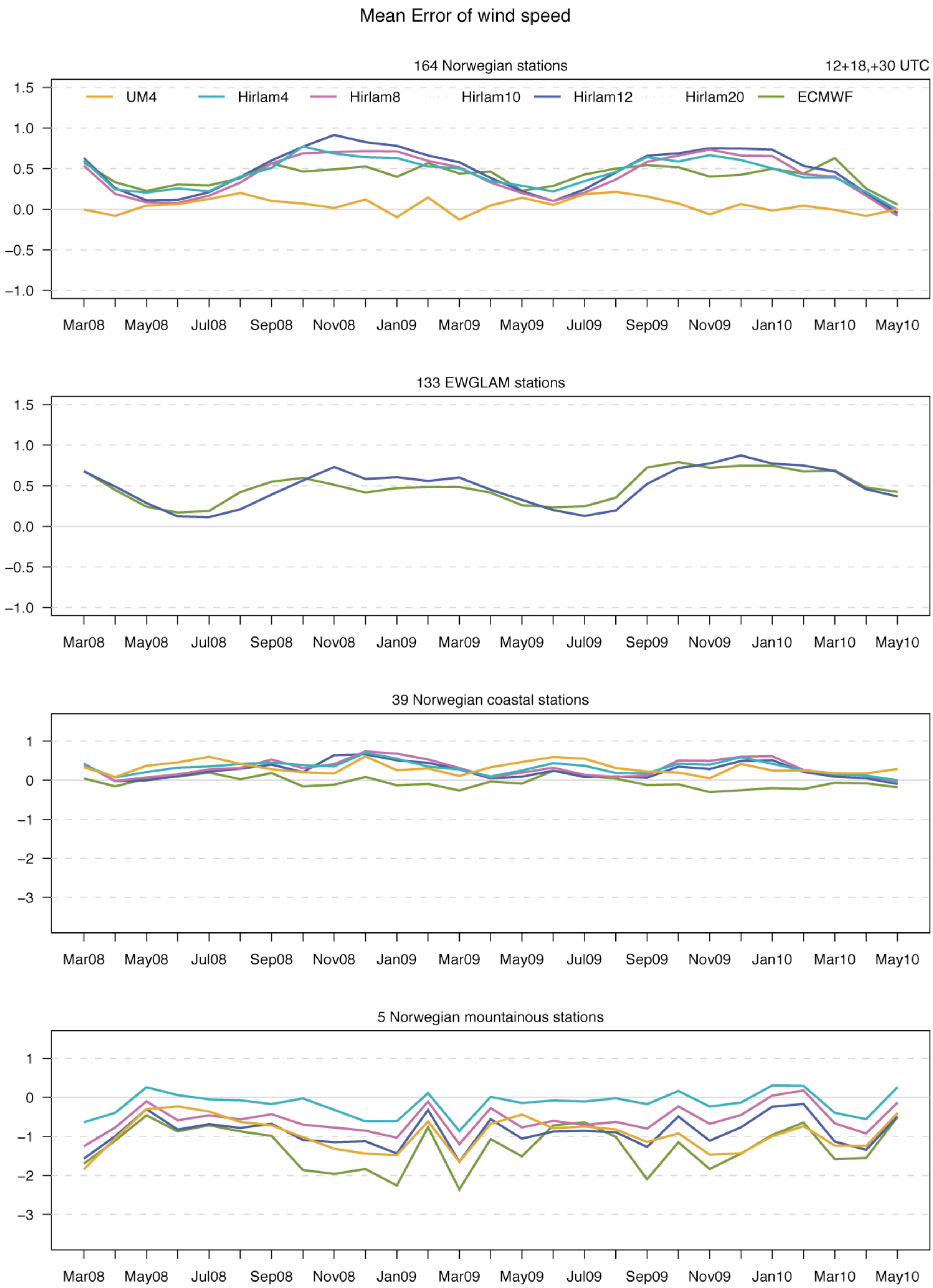


Fig. 3 Monthly mean errors from March 2008 to May 2010 of ECMWF (olive), HIRLAM12 (blue), HIRLAM8 (magenta), HIRLAM4 (cyan) and UM4 (orange) 12+18,+30 **wind speed** forecasts.

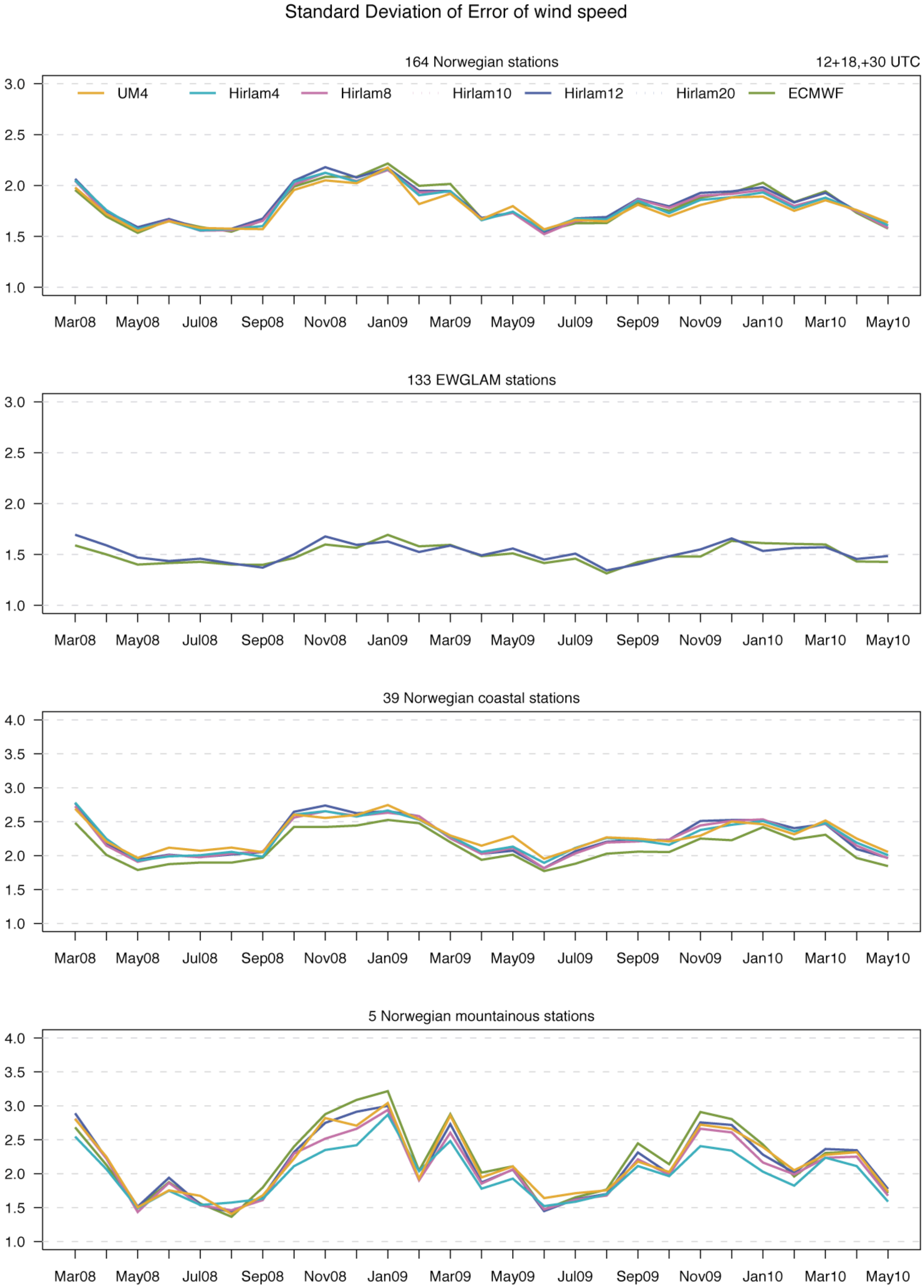
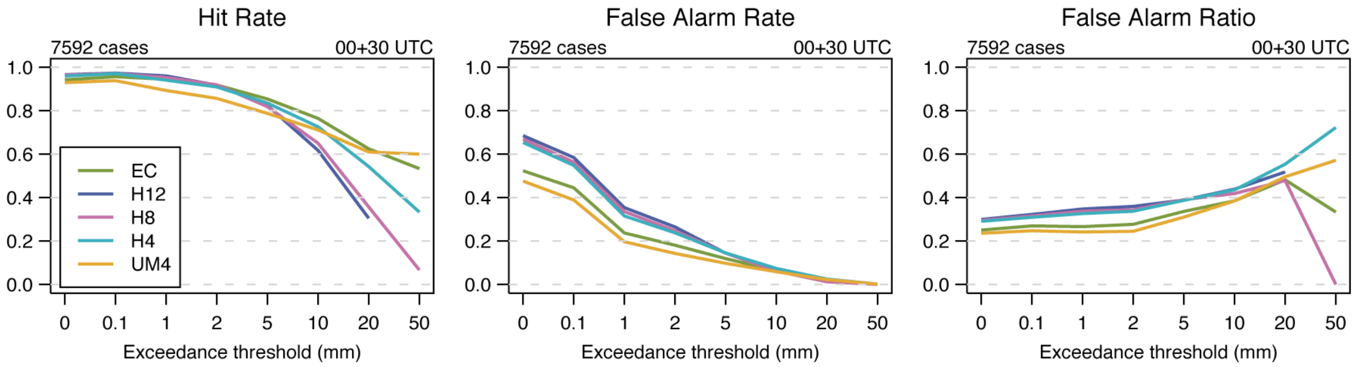
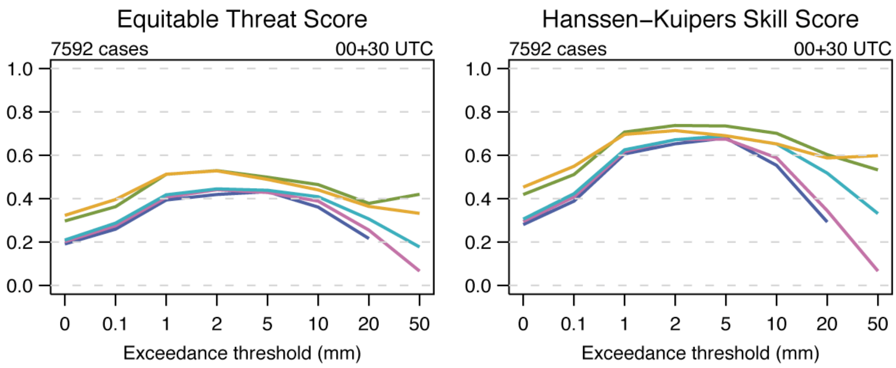


Fig. 4 Monthly standard deviation of errors from March 2008 to May 2010 of ECMWF (olive), HIRLAM12 (blue), HIRLAM8 (magenta), HIRLAM4 (cyan) and UM4 (orange) 12+18,+30 **wind speed** forecasts.





Daily precipitation <= 0.1 mm

7592 cases 00+30 UTC

	HR	F	FAR	ETS	KSS
EC	0.55	0.04	0.09	0.36	0.51
H12	0.42	0.03	0.08	0.26	0.39
H8	0.44	0.03	0.08	0.28	0.41
H4	0.45	0.03	0.08	0.29	0.42
UM4	0.61	0.06	0.11	0.4	0.55

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 2009.

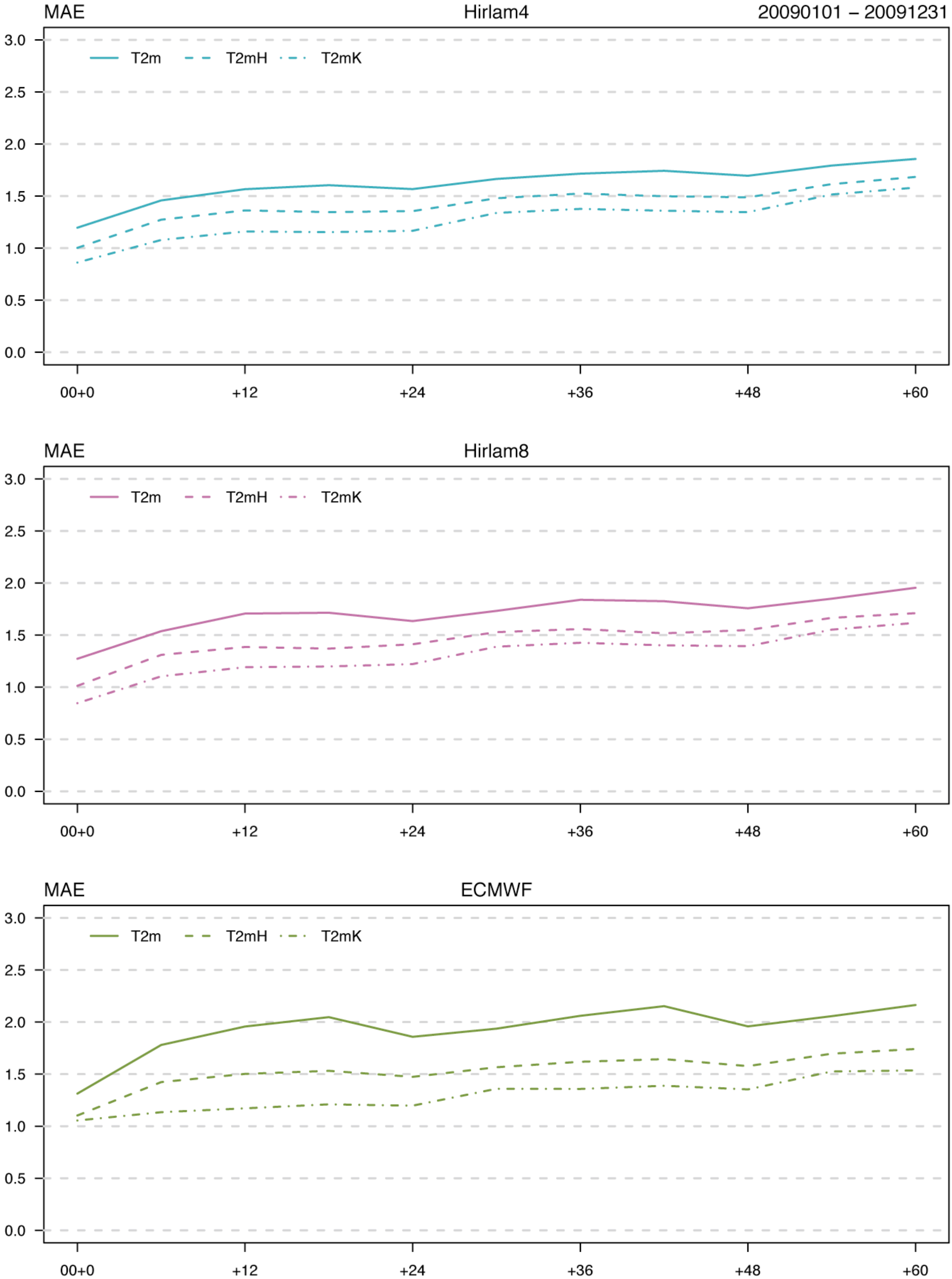


Fig. 6 Mean absolute errors as a function of forecast lead time for **2 metre temperature** HIRLAM4 (upper), HIRLAM8 (middle) and ECMWF (bottom) forecasts; direct model output (solid lines), 'height corrected' (dashed lines) and Kalman filter corrected (dashed-dotted lines). The results are based on data from January to December 2009 averaged over 73 Norwegian synop stations.