Norwegian Meteorological Institute

MET info 19/2014 Meteorology

Verification of Experimental and Operational Weather Prediction Models September to November 2014

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Contents

1 Models

The following models are verified in this report. All except EC are or have been running at MET.

EC	Global model (IFS) at the ECMWF. From 26 January 2010 resolution $T1279$ or approximately $16 \times 16\ km^2$ horizontally. Available resolution for verification at MET is $0.125°$ latitude and longitude. Number of vertical levels increased from $L91$ to $L137$ 25 June 2013.
Hirlam12 (H12)	Version 7.1, horizontal resolution defined by a $12 \times 12\ km^2$ grid since 13 February 2008.
Hirlam8 (H8)	Version 7.1, horizontal resolution defined by a $8 \times 8\ km^2$ grid since 13 February 2008.
Harmonie5.5	HARMONIE cycle 36h1.3 with ALARO physics run on a $5.5 \times 5.5\ km^2$ grid from 4 May 2011 to 15 January 2013.
Harmonie2.5	HARMONIE cycle 36h1.3 with AROME physics run on a $2.5 \times 2.5\ km^2$ grid from 4 May 2011 to 26 February 2013.
AROME-MetCoOp (AM25)	HARMONIE cycle 38h1.1 with AROME physics run on a $2.5 \times 2.5\ km^2$ grid on same domain as AROME-Norway; experimental since 9 December 2013.

Analysis and lead times of forecasts are denoted by e.g. 00+30 UTC which indicates forecast generated at 00 UTC and valid 30 hours later.

2 HARMONIE, AROME-Norway and AROME-MetCoOp

Experimental HARMONIE models have been run at MET Norway since August 2008, leading to AROME-Norway which on 1 October 2013 was introduced on yr.no, and AROME-MetCoOp which is run in cooperation between Swedish Meteorological and Hydrological Institue and MET Norway and replaced AROME-Norway on yr.no 27 May 2014. HARMONIE is the acronym for HIRLAM's meso-scale forecast system (Hirlam Aladin Regional/Meso-scale Operational NWP In Europe). The HARMONIE system includes several configuration options. This section presents some of the main components and setups that are or has been used at MET. More documentation is available on http://www.cnrm.meteo.fr/gmapdoc/.

2.1 ALARO-0 physics

ALARO-0 has physical parameterizations targeted for grey scale resolutions (4-10 km). It is a spin-off of the Météo-France physical parameterizations used in the globale ARPEGE, but with a separate radiation scheme, 3MT micro-physical frame work, and the Toucans turbulence scheme. Much of the development has been done by the RC LACE (Regional Cooperation for Limited Area modeling in Central Europe) community.

2.2 AROME physics

AROME (Applications of Research to Operations at MEsoscale) is targeted for horizontal resolution 2.5 km or finer. It uses physical parameterizations based on the French academia model Meso-NH and the external surface model SURFEX. AROME has been operational at Météo-France since 18 December 2008, with a horizontal resolution of 2.5 km.

2.3 SURFEX as surface model

SURFEX (Surface externalisée) is developed at Météo-France and academia for offline experiments and introduced in NWP models to ensure consistent treatment of processes related to surface. Météo-France is already using SURFEX for some of their configurations and is planning to use it for all their configurations. Surface modelling and assimilation benefits from the possibility to run offline experiments. SURFEX is also used for offline applications in e.g. hydrology, vegetation monitoring and snow avalanche forecasts.

SURFEX includes routines to simulate the exchange of energy and water between the atmosphere and 4 surface types (tiles); land, sea (ocean), lake (inland water) and town. The land or nature tile can be divided further into 12 vegetation types (patches). ISBA (Interaction between Soil Biosphere and Atmosphere) is used for modelling the land surface processes. There are 3 ISBA options; 2- and 3-layer force restore and a diffusive approach, where the first one is used in HIRLAM. Towns may be treated by a separate TEB (Town Energy Balance) module. Seas and lakes are also treated separately. The lake model, FLAKE (Freshwater LAKE), has recently been introduced in SURFEX. A global ECOCLIMAP database which combines land cover maps and satellite information gives information about surface properties on 1 km resolution. The orography is taken from gtopo30.

“SURFEX Scientific Documentation” and “User’s Guide” are available on http://www.cnrm.meteo.fr/surfex/

2.4 Data assimilation

NWP models are updated regularly using observations received in real-time from the global observing system. With one exception the models run at MET are updated at 00, 06, 12 and 18 UTC. AROME-MetCoOp is updated each third hour; at 00, 03, 06, 09, 12, 15, 18 and 21 UTC.

2.4.1 Surface analysis

Surface analysis is performed by CANARI (Code d'Analyse Nécessaire à ARPEGE pour ses Rejets et son Initialisation) (Taillefer, 2002). The analysis method is Optimal Interpolation and only conventional synoptic observations are used. 2 meter temperature and relative humidity observations are used to update the surface and soil temperature and moisture.

The snow analysis is also performed with CANARI in analogy with the HIRLAM snow analysis. Snow depth observations are used to update Snow Water Equivalent. The snow fields are analysed only at 06 UTC as there are very few snow depth observations at 00, 12 and 18.

The Sea Surface Temperature is not analysed, but taken from the boundaries. ECMWF uses the OSTIA (Operational Sea Surface Temperature and Sea Ice Analysis) product, including SST from UK Met Office and SIC from MET. The surface temperature over sea ice is taken from the boundary model and remains unchanged through the forecast.

2.4.2 Upper air analysis

AROME-MetCoOp runs three dimensional variational (3D VAR) data assimilation using conventional observations from synop stations, ships, radiosondes and aircrafts. AMSU-A and AMSU-B/MHS data from the polar orbiting NOAA and METOP satellites is also used.

2.5 Boundaries and initialization of upper air fields

Harmonie5.5 and Harmonie2.5 got their boundary values (3-hourly) from the ECMWF model at approximately 16 km resolution. The upper air fields were initialized from ECMWF forecasts each cycle. Harmonie5.5 had 60 vertical levels (ECMWF60 using the ECMWF definition). Harmonie2.5 had also 60 vertical levels (HIRLAM60 using the HIRLAM definition).

AROME-Norway and AROME-MetCoOp get their boundary values (1-hourly) from the ECMWF model at approximately 16 km resolution. They have currently 65 vertical levels. AROME-Norway do no upper air assimilation, the upper air fields are initialized from ECMWF forecasts

each cycle. None of the HARMONIE configurations at MET have applied digital filter initialization (DFI).

3 Verification measures

All model forecasts in this report are verified against observations by interpolating (bilinear) the grid based forecasts to the observational sites. As a consequence, it should be noted that it is the models' abilities to forecast the observations that is being quantifed and assessed. Thus, there is no attempt in this report to verify area averaged precipitation for example.

Verification is carried out both for raw and categorized forecasts. In the following, let $f_1, ..., f_n$ denote the forecasts and $o_1, ..., o_n$ the corresponding observations.

3.1 Forecasts of continuous variables

The verification statistics applied to continuous variables are defined in the table below

Statistic	Acronym	Formula	Range	Optimal score
Mean Error	ME	$\frac{1}{n} \sum_{i=1}^{n}(f_i - o_i)$	$-\infty$ to ∞	0
Mean Absolute Error	MAE	$\frac{1}{n} \sum_{i=1}^{n} \mid f_i - o_i \mid$	0 to ∞	0
Standard Deviation of Error	SDE	$\left(\frac{1}{n} \sum_{i=1}^{n}(f_i - o_i - ME)^2 \right)^{1/2}$	0 to ∞	0
Root Mean Square Error	RMSE	$\left(\frac{1}{n} \sum_{i=1}^{n}(f_i - o_i)^2 \right)^{1/2}$	0 to ∞	0
Correlation	COR	$\frac{\frac{1}{n}\sum_{i=1}^{n}(f_i - \bar{f})(o_i - \bar{o})}{SD(f)SD(o)}$	-1 to 1	1

In the formula for COR the following definitions are used

$$\bar{f} = \frac{1}{n}\sum_{i=1}^{n} f_i, \qquad \bar{o} = \frac{1}{n}\sum_{i=1}^{n} o_i$$

$$SD(f) = \Big(\frac{1}{n}\sum_{i=1}^{n}(f_i - \bar{f})^2\Big)^{1/2}, \qquad SD(o) = \Big(\frac{1}{n}\sum_{i=1}^{n}(o_i - \bar{o})^2\Big)^{1/2}$$

for the means and standard deviations of the forecasts and observations.

3.2 Forecasts of categorical variables

All variables in this report are continuous in raw form, but it is possible to categorize them and verify these. For example, wind speed above a given threshold could be of interest which would result in two possible outcomes (yes and no). The verification is then completely summarized by a contingency table as the one shown below

		event observed	
		yes	no
event forecasted	yes	*a*	*b*
	no	*c*	*d*

Verification statistics for such forecasts are listed in the following table

Statistic	Acronym	Formula	Range	Optimal score
Hit rate	HR	$\frac{a}{a+c}$	0 to 1	1
False alarm rate	F	$\frac{b}{b+d}$	0 to 1	0
False alarm ratio	FAR	$\frac{b}{a+b}$	0 to 1	0
Equitable threat score	ETS	$\frac{a-ar}{a+b+c-ar}$	$-1/3$ to 1	1 (0 = no skill)
Hanssen-Kuipers skill score	KSS	HR - F	-1 to 1	1 (0 = no skill)

In the formula for ETS $ar = (a+b)(a+c)/n$.

3.3 Observations

All observations come from Klimadatavarehuset at MET. Only synop stations are used, except for precipitation where all availiable stations are used for better spatial coverage. The model wind speed is verified against the mean wind FF observations. For post processed wind speed, the maxium 10 min mean wind speed last hour, FX, is used.

3.4 Changes since last report

- AROME-Norway now switched off

4 Norway

4.1 Comments to verification results

Mean Sea Level Pressure:
All models are less than 0.5hPa away from observed values for most lead times. ECMWF is still the best model for MSLP. AM25 is slightly more biased than the rest of the models during daytime, but the unsystematic error is lower, so it scores second best in MAE. All models have higher error during October than the rest of the months.

Wind speed:

Mean wind speed:
AM25 has almost no bias at all during the autumn season. The Hirlam models have a small positive bias, while the ECMWF model the opposite. AM25 has the highest hit rate (HR) for thresholds above $5ms^{-1}$, but also a quite low false alarm ratio (FAR). Combined, the equitable threat score (ETS) shows that AM25 is the best model for all thresholds.

However, the multible contingency table shows a clear under representation for all models for values above $11ms^{-1}$. Values above $21ms^{-1}$ were observed 354 times, while the best model AM25, only had 47 cases.

The long term verification show small changes the past few months, the errors were a bit higher in October than the rest of the months.

Max mean wind speed:
Compared to the max mean wind speed, the post processed AM25_PP forecasts have had around $0.5ms^{-1}$ too little wind. The post processed H8_PP forecast has a higher HR than AM25_PP, but also a higher FAR. AM25_PP scores better than H8_PP on the ETS.
After the post processing, there are significantly more cases of the higher wind speed. It was observed wind speeds exceeding $21ms^{-1}$ 581 times, while the post processed fields AM25_PP and H8_PP, forecasted it 243 and 481 times, respectively. However, even though H8_PP had twice as many cases as AM25_PP in the highest category, only two more cases were forecasted correctly.

Wind gust:
For gust, the model wind gust, FG is compared with the wind speed in the 925hPa-level, as this is commonly used by the meteorologist as a proxy for the wind gust. The gust in AM25 have been around $1ms^{-1}$ too low. The rest of the fields have a positive bias. AM25_FG scores lower

compared with the other models and parameters on HR. But the FAR is considerable lower, so for the lowest thresholds ($< 17.2ms^{-1}$) AM25_FG has the highest score.

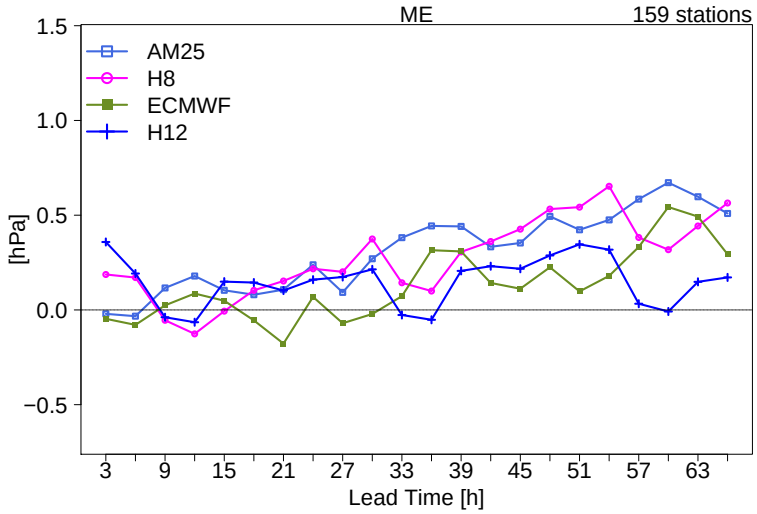
Temperature 2m:
Both ECMWF and AM25 have been a little too cold during the autumn, around -0.5°C, while the Hirlam models have almost no bias at all. SDE is lowest for AM25 for lead times shorter than 42 hours. The MAE is in total lowest for H8, but there are no large differences between the models.

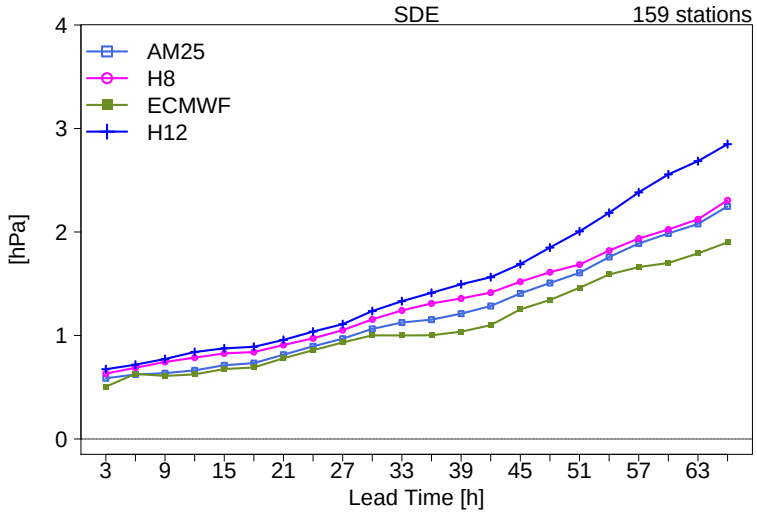
The negative bias in the AM25 and ECMWF temperature has increased significantly during the last three months. There is a slight increase in the SDE.

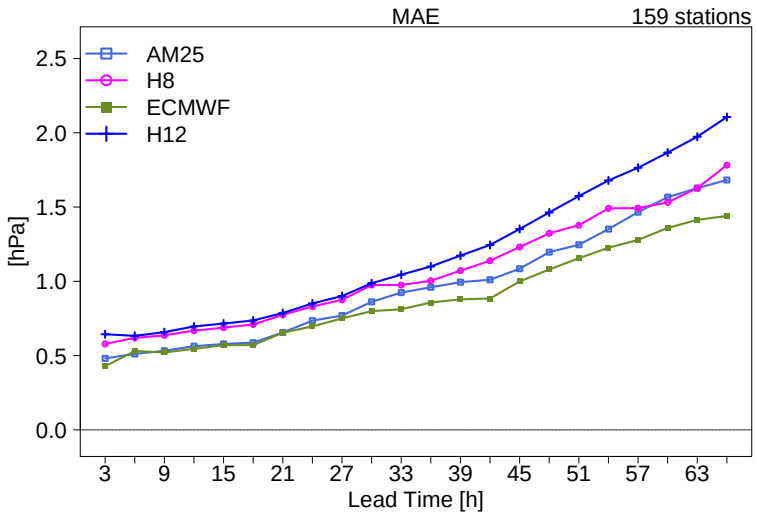
Post processed temperature:
Post processing the AM25 temperature reduces the negative bias from about -0.5 to -0.25°C. The effect of the post processing seen in SDE is largest for the first 15 hours, after this there is almost no difference between the raw data and post processed field. There are clear improvements in the MAE after post processing.

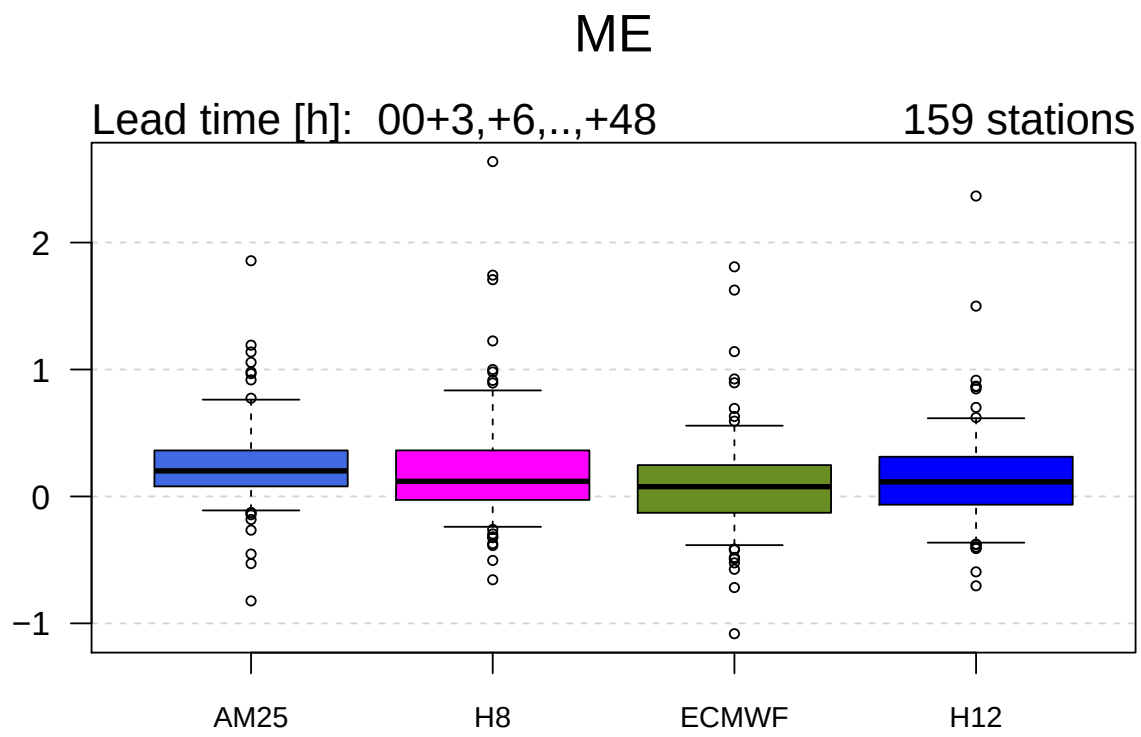
Daily precipitation:
Most of the models, except ECMWF, have been too dry compared with the observations during the autumn season. The post processed median field, AM25.med, is about 1 mm too dry. AM25 has the highest HR for thresholds above 12mm, and has also a quite low FAR compared with the other models, except AM25.med. For ETS, AM25 and AM25.med are tied for best for thresholds lower than 12mm. Above this, AM25.med scores drop, and AM25 is the single best model above 20mm. ECMWF also scores high for thresholds between 4-30mm. AM25 has the best bias frequency of the models. No large changes in the past few months

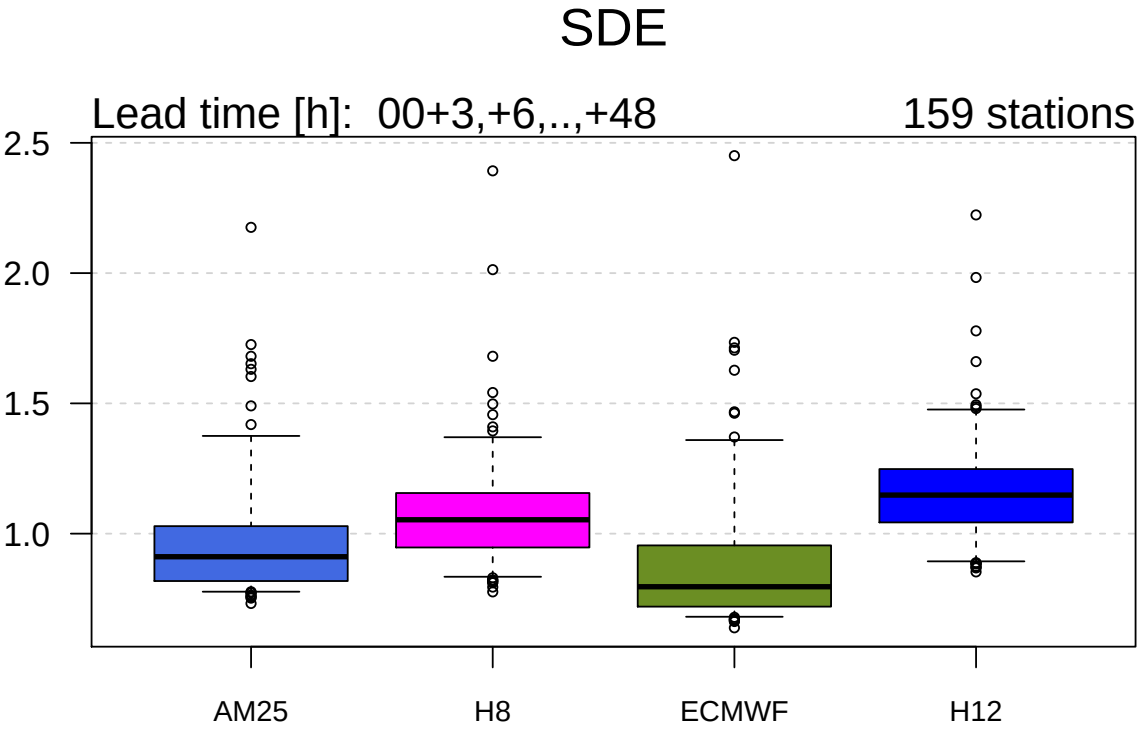
4.2 Pressure and variables at pressure levels



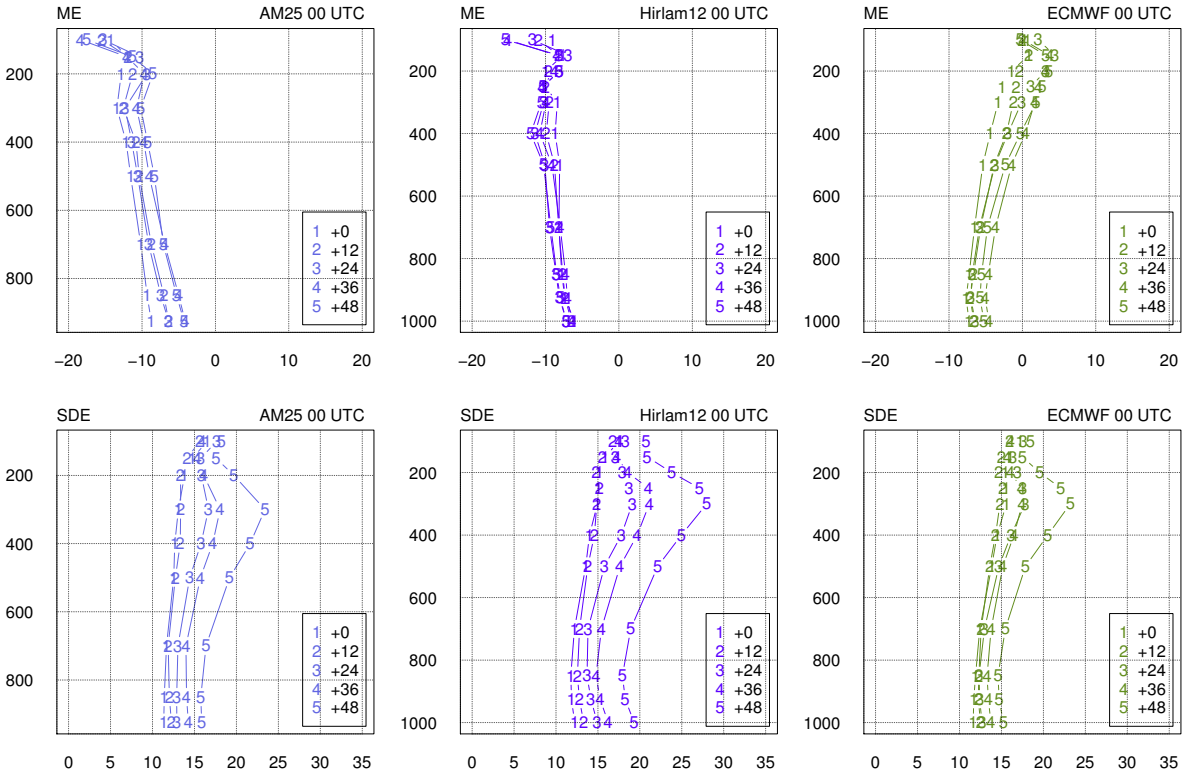




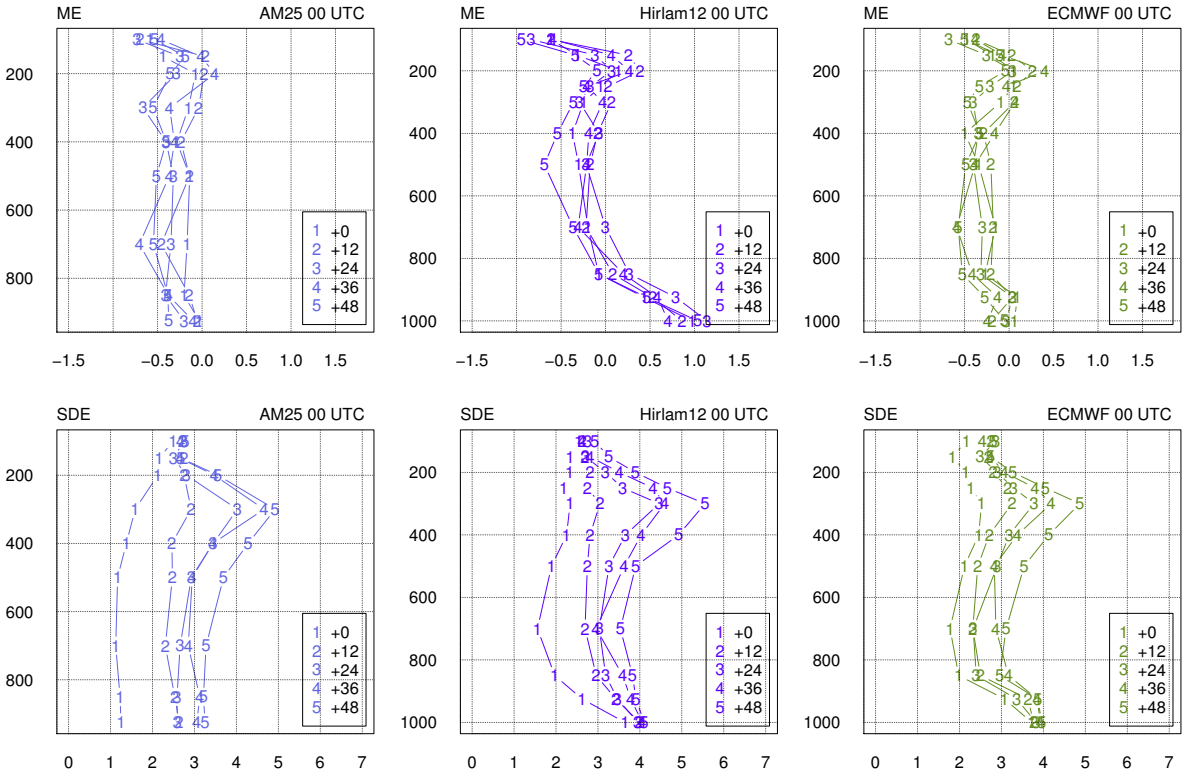

ME
Lead time [h]: 00+3,+6,..,+48
159 stations
2
1
0
−1
AM25
H8
ECMWF
H12

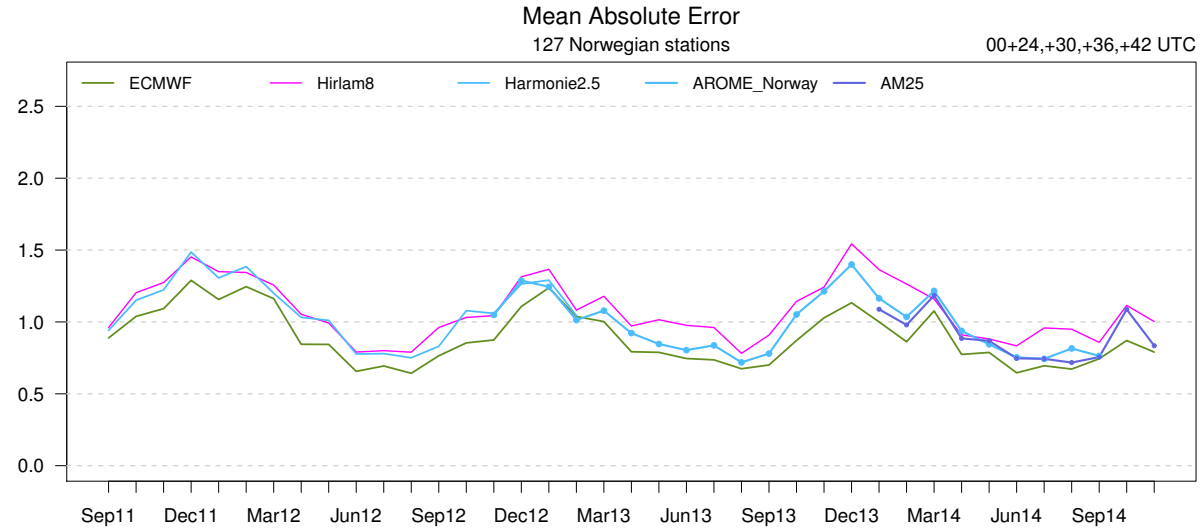

SDE
Lead time [h]: 00+3,+6,..,+48
159 stations
2.5
2.0
1.5
1.0
AM25
H8
ECMWF
H12

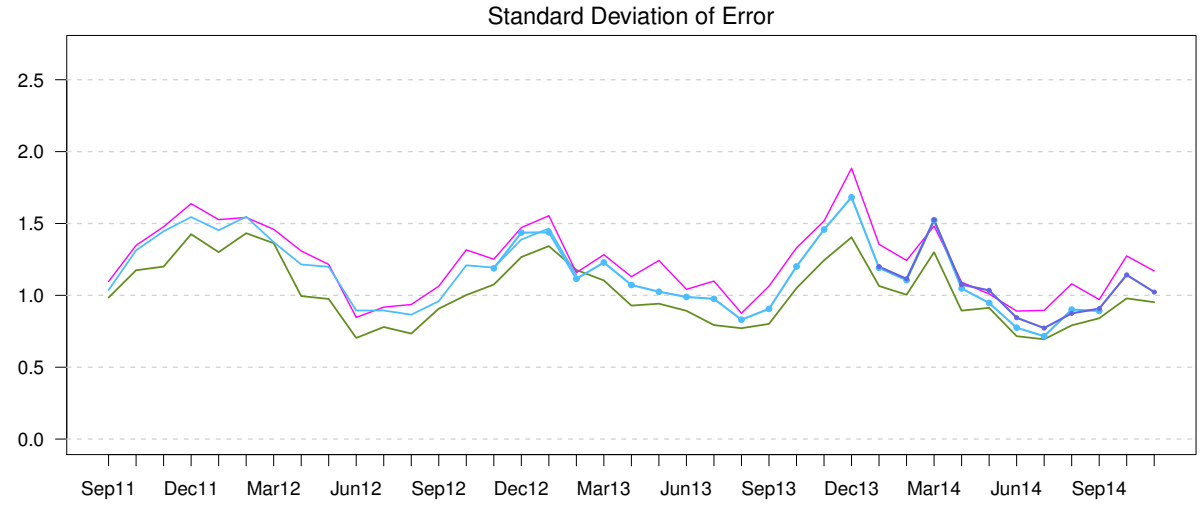
Geopotential height at 4 Norwegian stations

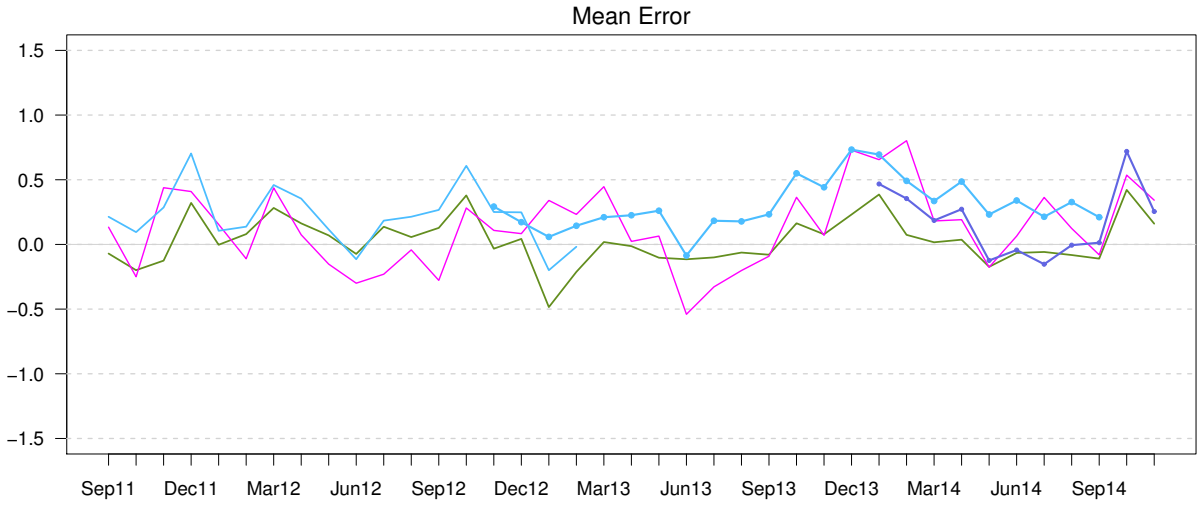


Wind speed at 4 Norwegian stations

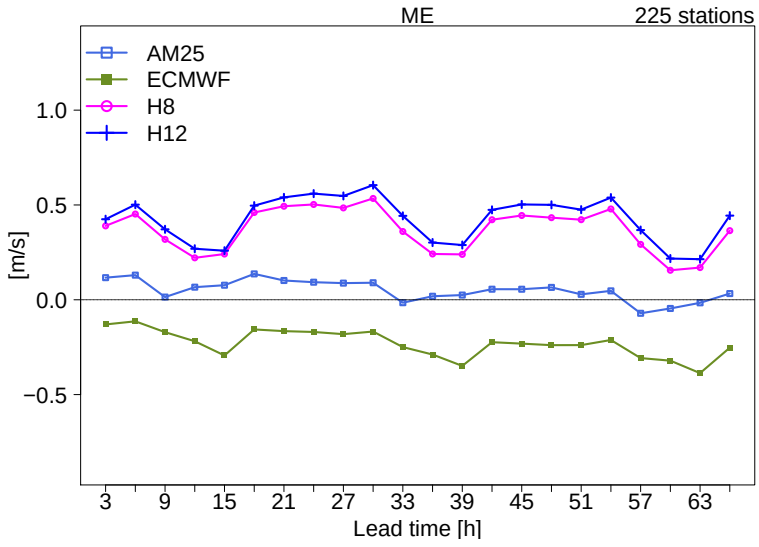


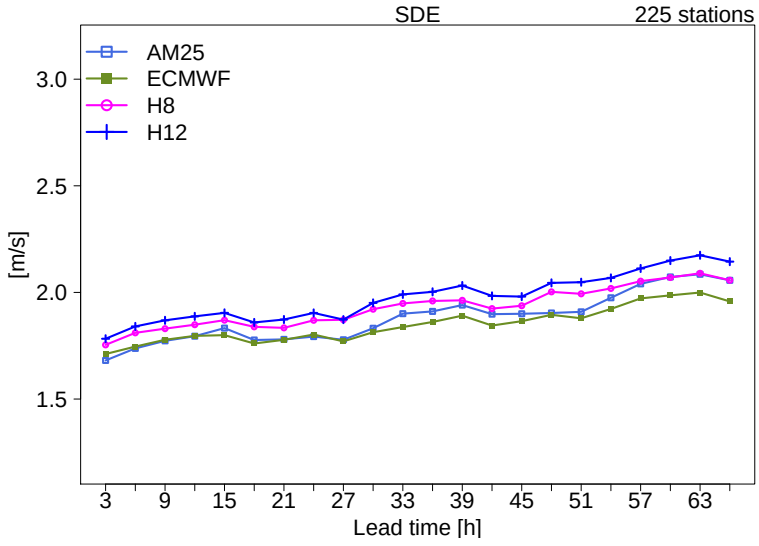

Mean Absolute Error
127 Norwegian stations
00+24,+30,+36,+42 UTC
ECMWF
Hirlam8
Harmonie2.5
AROME_Norway
AM25
2.5
2.0
1.5
1.0
0.5
0.0
Sep11
Dec11
Mar12
Jun12
Sep12
Dec12
Mar13
Jun13
Sep13
Dec13
Mar14
Jun14
Sep14

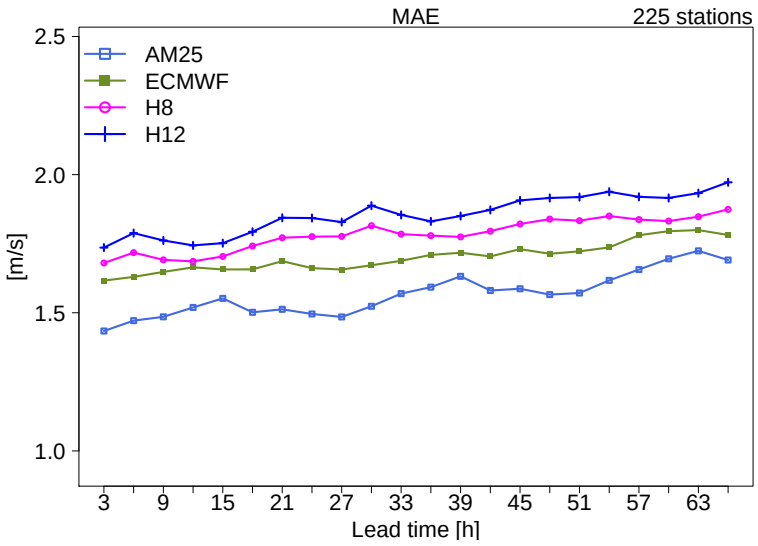

Standard Deviation of Error
2.5
2.0
1.5
1.0
0.5
0.0
Sep11
Dec11
Mar12
Jun12
Sep12
Dec12
Mar13
Jun13
Sep13
Dec13
Mar14
Jun14
Sep14

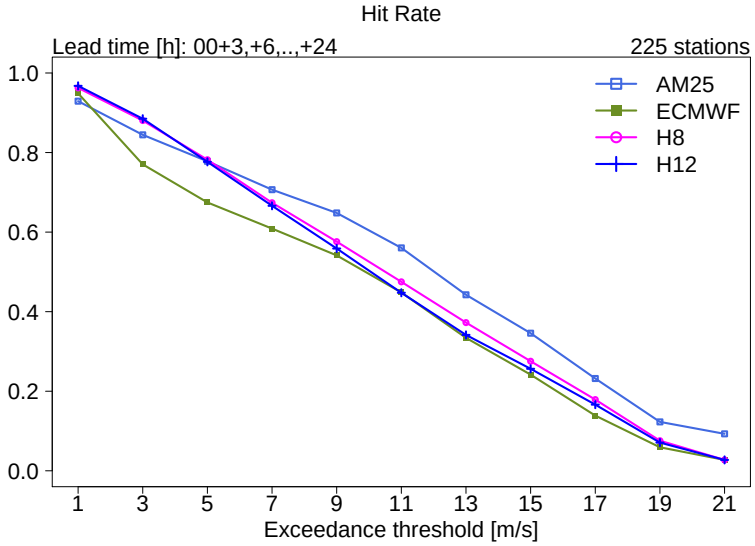

Mean Error
1.5
1.0
0.5
0.0
−0.5
−1.0
−1.5
Sep11
Dec11
Mar12
Jun12
Sep12
Dec12
Mar13
Jun13
Sep13
Dec13
Mar14
Jun14
Sep14

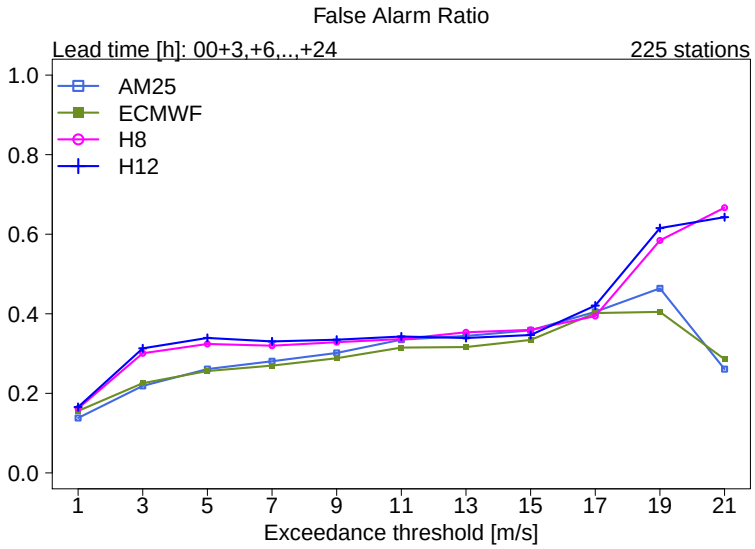
4.3 Wind Speed 10m

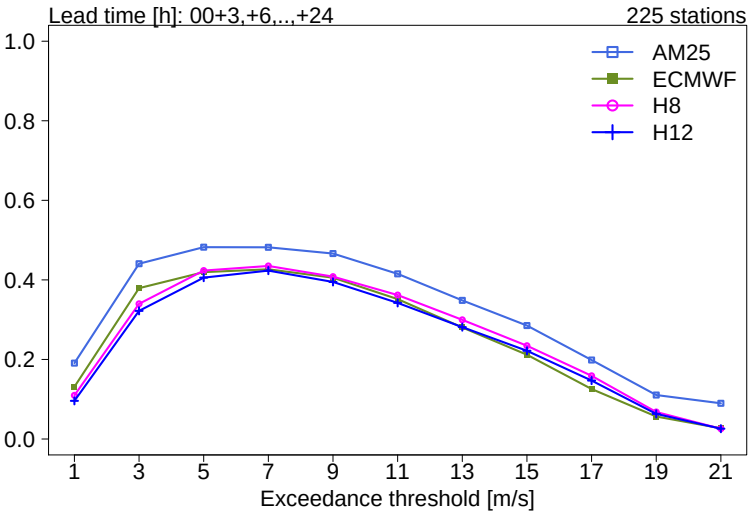


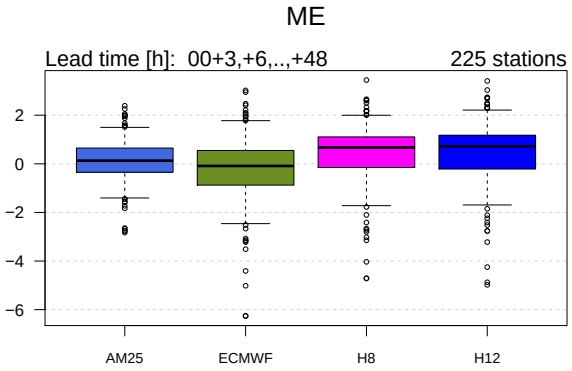


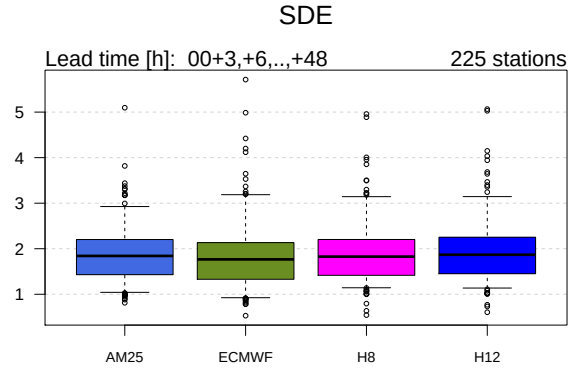



Hit Rate
Lead time [h]: 00+3,+6,..,+24
225 stations
AM25
ECMWF
H8
H12
1.0
0.8
0.6
0.4
0.2
0.0
1 3 5 7 9 11 13 15 17 19 21
Exceedance threshold [m/s]


False Alarm Ratio
Lead time [h]: 00+3,+6,..,+24
225 stations
AM25
ECMWF
H8
H12
1.0
0.8
0.6
0.4
0.2
0.0
1 3 5 7 9 11 13 15 17 19 21
Exceedance threshold [m/s]


Equitable Threat Score
Lead time [h]: 00+3,+6,..,+24
225 stations
AM25
ECMWF
H8
H12
1.0
0.8
0.6
0.4
0.2
0.0
1 3 5 7 9 11 13 15 17 19 21
Exceedance threshold [m/s]





Lead time [h]: 00+3,+6,..,+48 UTC 225 stations

AM25 — **OBS**

	[0,3]	(3,11]	(11,17]	(17,21]	(21,Inf]	Sum
[0,3]	109993	23046	73	3	0	133115
(3,11]	33137	96918	7027	209	30	137321
(11,17]	182	4423	6783	1017	188	12593
(17,21]	28	44	220	273	108	673
(21,Inf]	3	1	7	8	28	47
Sum	143343	124432	14110	1510	354	283749

H8 — **OBS**

	[0,3]	(3,11]	(11,17]	(17,21]	(21,Inf]	Sum
[0,3]	89127	17387	88	0	0	106602
(3,11]	54072	103120	7894	491	131	165708
(11,17]	124	3911	5942	816	127	10920
(17,21]	19	14	181	192	91	497
(21,Inf]	1	0	5	11	5	22
Sum	143343	124432	14110	1510	354	283749

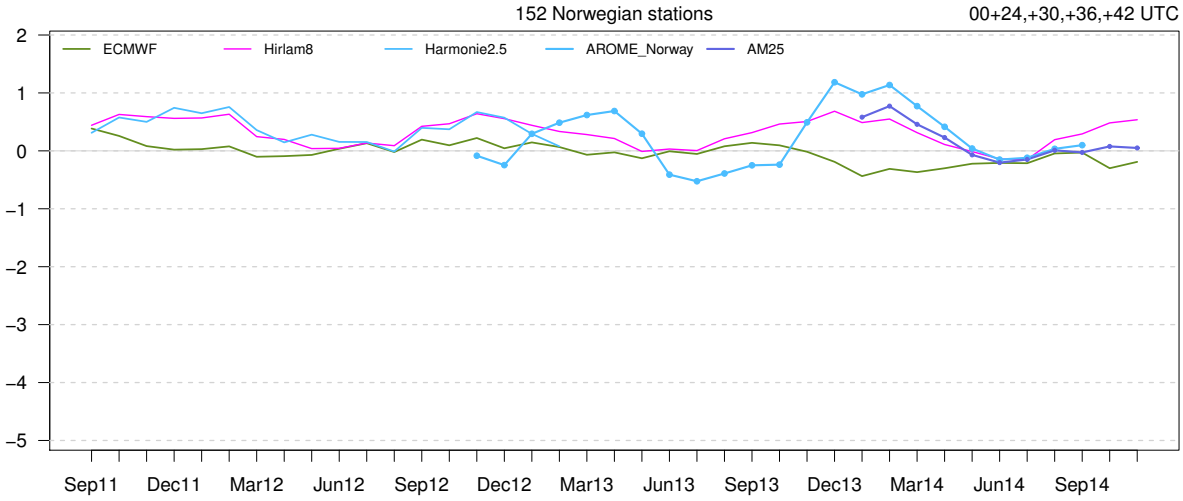
ECMWF — **OBS**

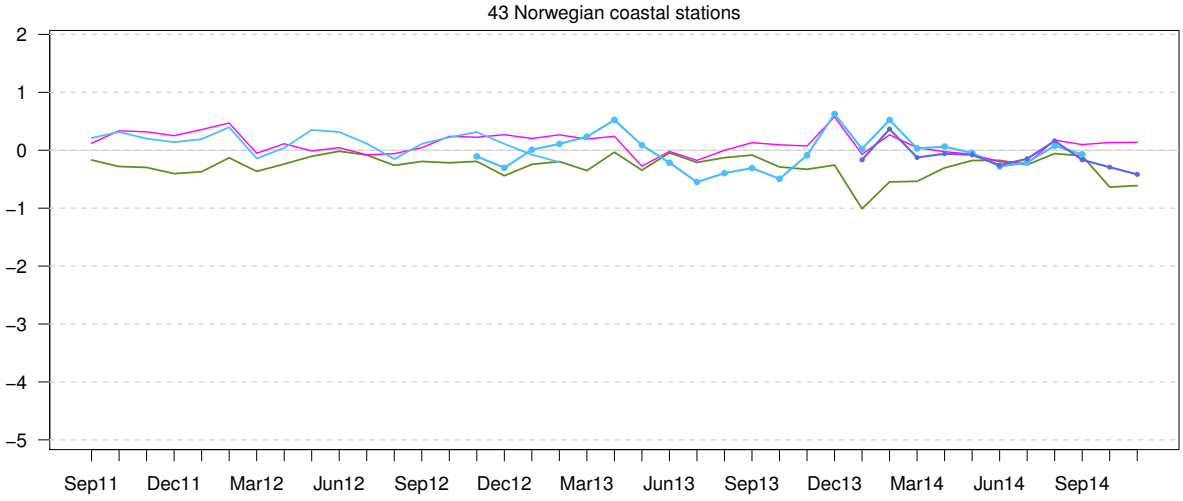
	[0,3]	(3,11]	(11,17]	(17,21]	(21,Inf]	Sum
[0,3]	111965	32844	610	88	21	145528
(3,11]	31277	88368	7813	393	81	127932
(11,17]	81	3204	5549	869	163	9866
(17,21]	20	15	138	157	82	412
(21,Inf]	0	1	0	3	7	11
Sum	143343	124432	14110	1510	354	283749

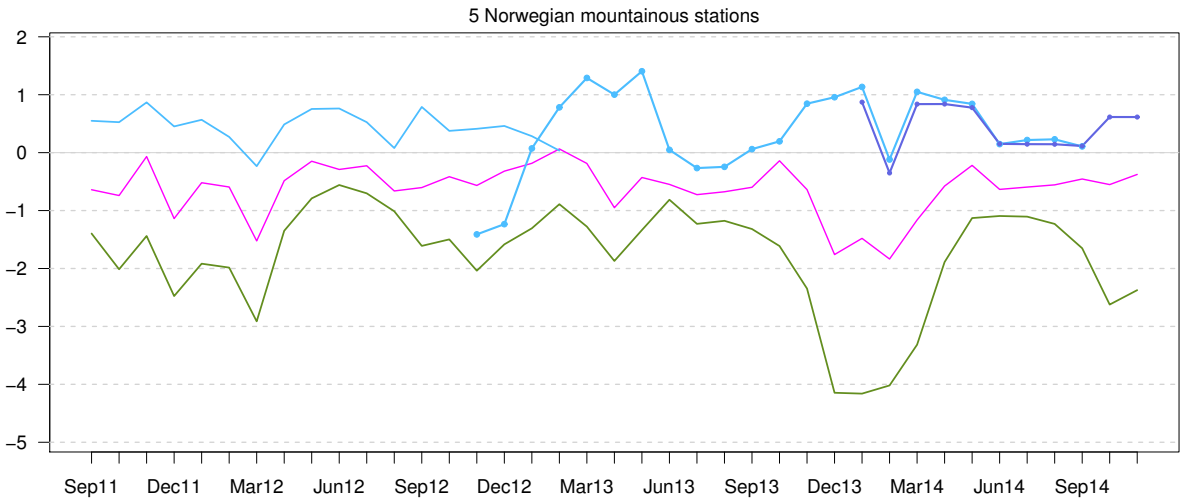
H12 — **OBS**

	[0,3]	(3,11]	(11,17]	(17,21]	(21,Inf]	Sum
[0,3]	85432	16657	128	3	1	102221
(3,11]	57770	103935	8198	512	116	170531
(11,17]	120	3819	5603	808	149	10499
(17,21]	20	20	177	176	81	474
(21,Inf]	1	1	4	11	7	24
Sum	143343	124432	14110	1510	354	283749

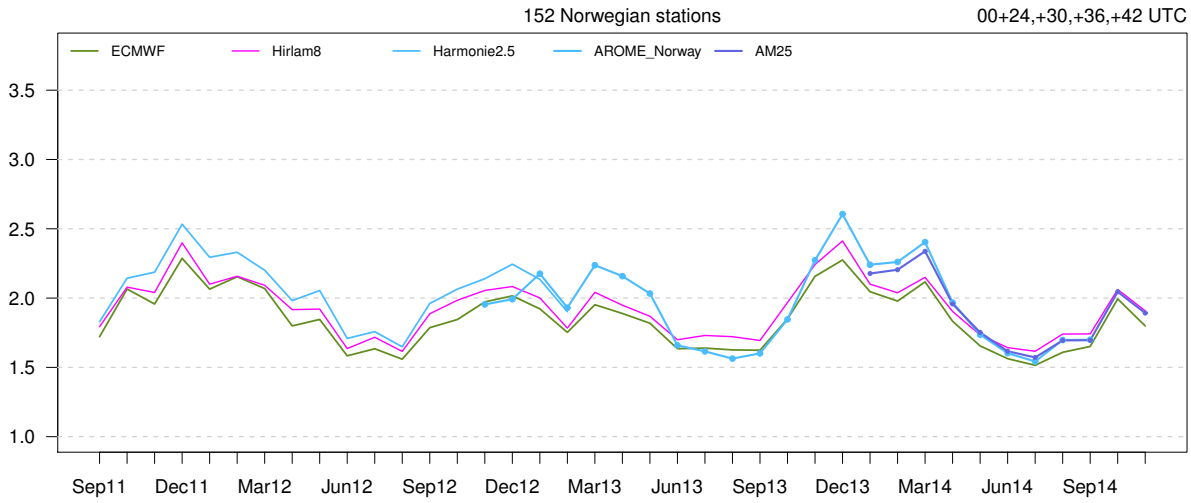
Mean Error

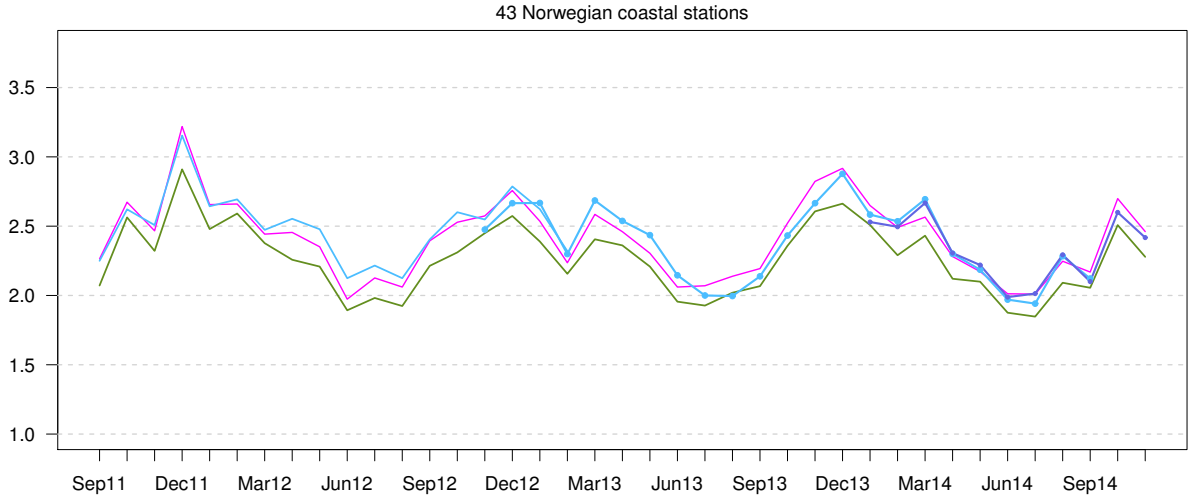

152 Norwegian stations
00+24,+30,+36,+42 UTC
ECMWF
Hirlam8
Harmonie2.5
AROME_Norway
AM25
2
1
0
−1
−2
−3
−4
−5
Sep11
Dec11
Mar12
Jun12
Sep12
Dec12
Mar13
Jun13
Sep13
Dec13
Mar14
Jun14
Sep14

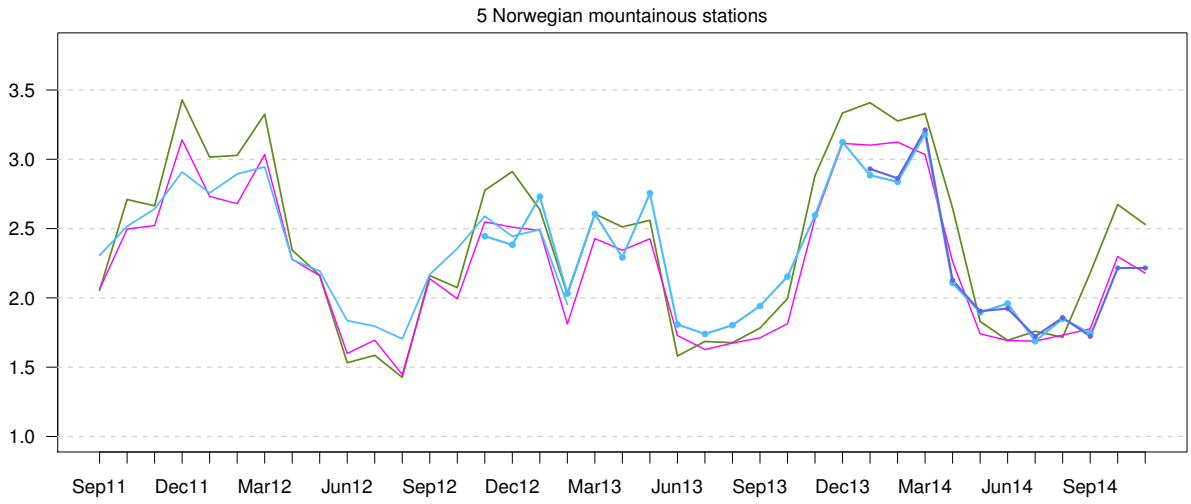

43 Norwegian coastal stations
2
1
0
−1
−2
−3
−4
−5
Sep11
Dec11
Mar12
Jun12
Sep12
Dec12
Mar13
Jun13
Sep13
Dec13
Mar14
Jun14
Sep14


5 Norwegian mountainous stations
2
1
0
−1
−2
−3
−4
−5
Sep11
Dec11
Mar12
Jun12
Sep12
Dec12
Mar13
Jun13
Sep13
Dec13
Mar14
Jun14
Sep14

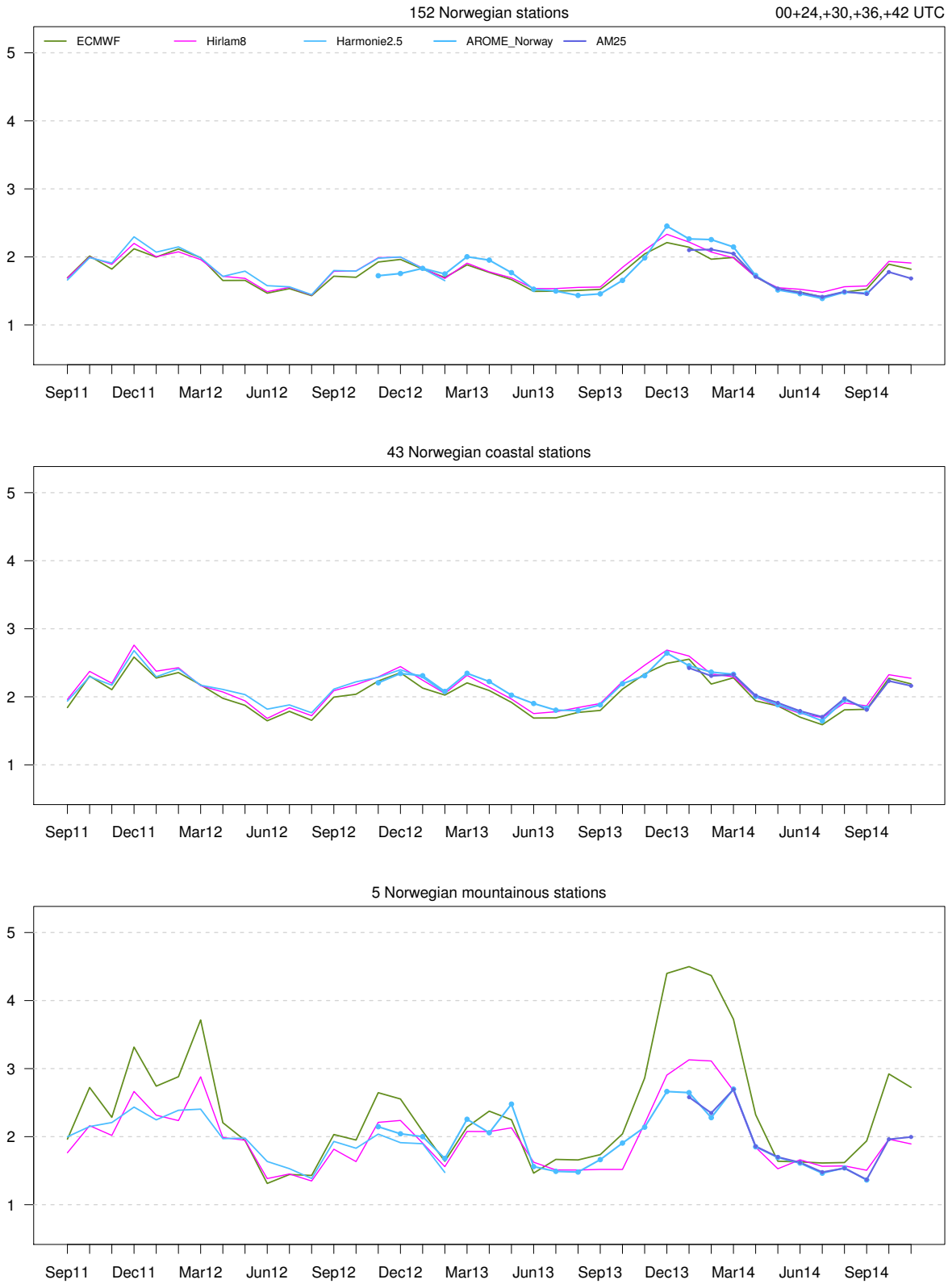
Standard Deviation of Error



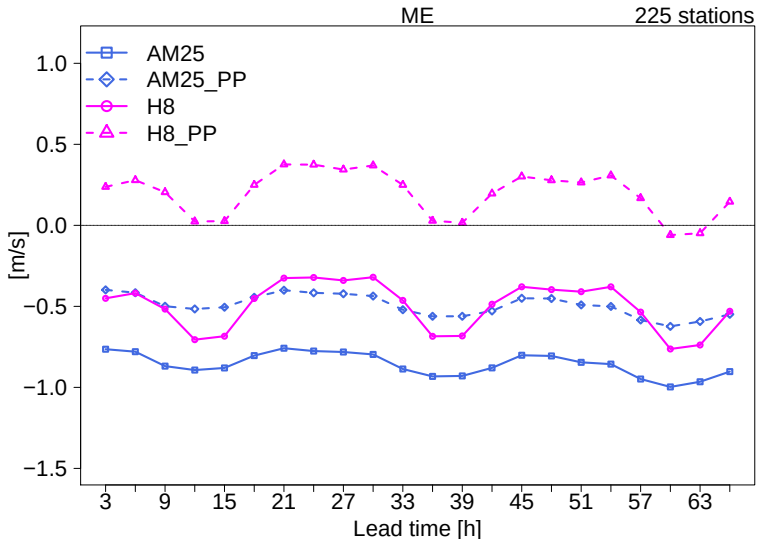


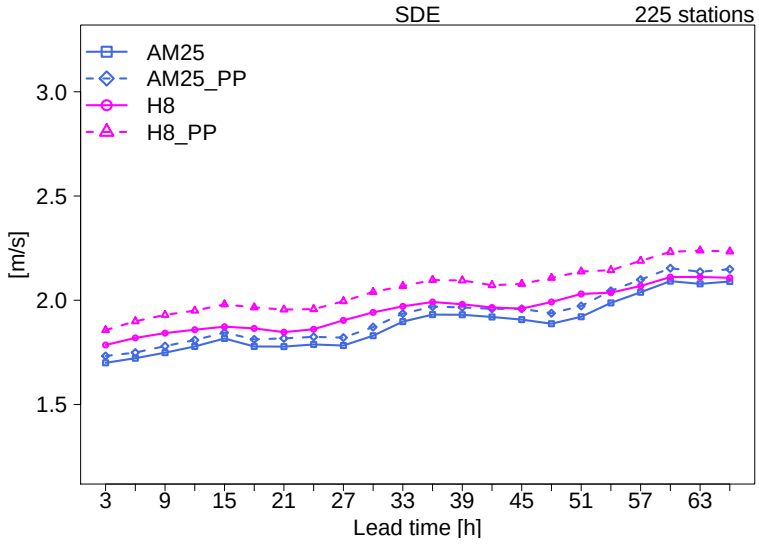


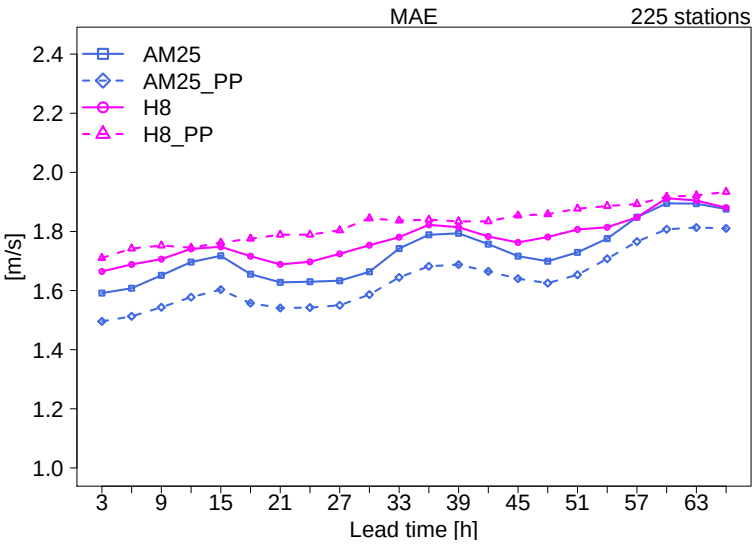
Mean Absolute Error

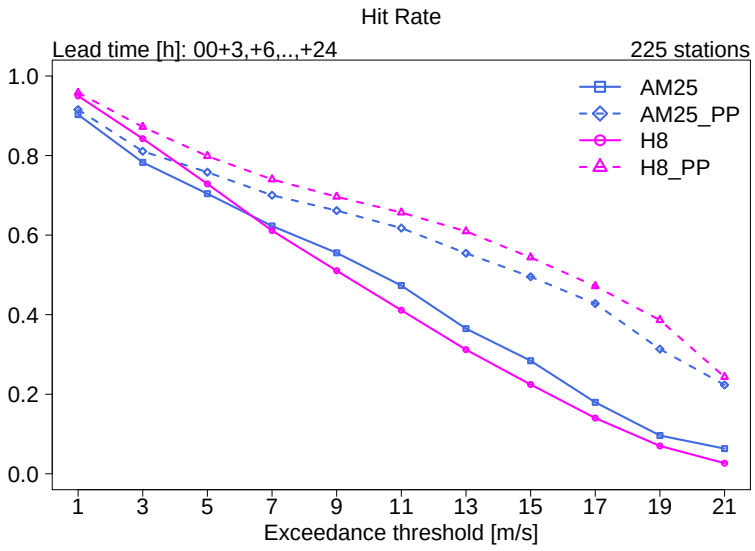


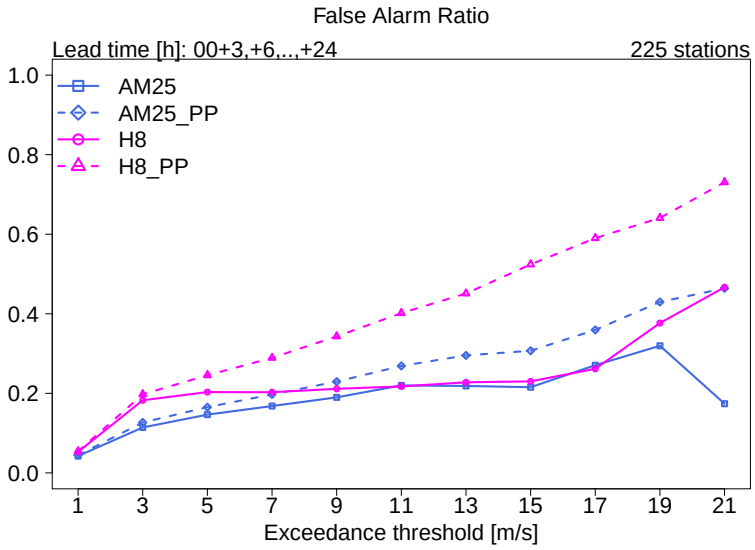
4.4 Max Mean Wind Speed 10m

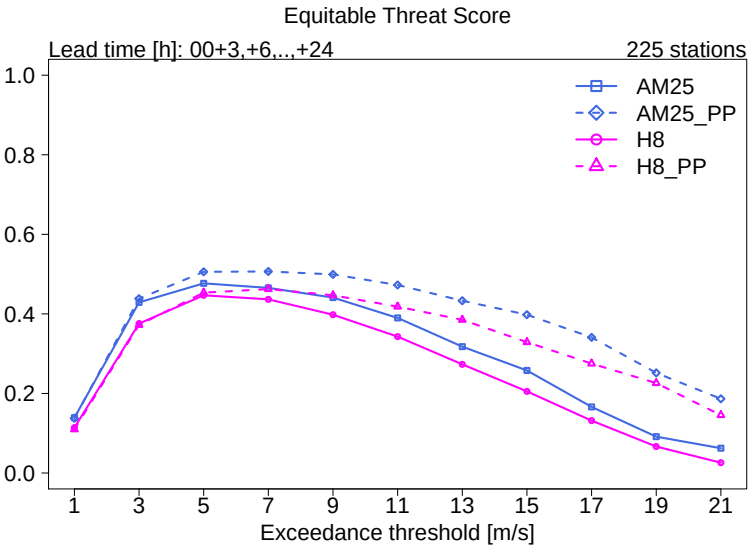




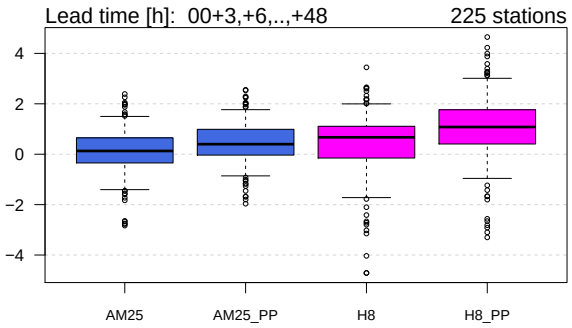



Hit Rate
Lead time [h]: 00+3,+6,..,+24
225 stations
AM25
AM25_PP
H8
H8_PP
1.0
0.8
0.6
0.4
0.2
0.0
1 3 5 7 9 11 13 15 17 19 21
Exceedance threshold [m/s]

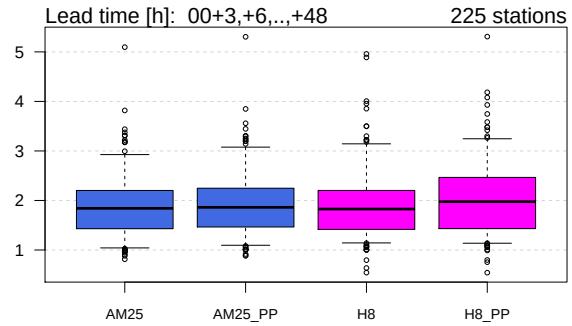

False Alarm Ratio
Lead time [h]: 00+3,+6,..,+24
225 stations
AM25
AM25_PP
H8
H8_PP
1.0
0.8
0.6
0.4
0.2
0.0
1 3 5 7 9 11 13 15 17 19 21
Exceedance threshold [m/s]


Equitable Threat Score
Lead time [h]: 00+3,+6,..,+24
225 stations
AM25
AM25_PP
H8
H8_PP
1.0
0.8
0.6
0.4
0.2
0.0
1 3 5 7 9 11 13 15 17 19 21
Exceedance threshold [m/s]

ME



SDE



Lead time [h]: 00+3,+6,..,+48 UTC 225 stations

AM25

OBS

	[0,3]	(3,11]	(11,17]	(17,21]	(21,Inf]	Sum
[0,3]	82775	35363	144	3	0	118285
(3,11]	16015	97345	10991	387	46	124784
(11,17]	79	2873	7205	1607	314	12078
(17,21]	23	25	149	280	188	665
(21,Inf]	2	2	1	10	33	48
Sum	98894	135608	18490	2287	581	255860

AM25_PP

OBS

	[0,3]	(3,11]	(11,17]	(17,21]	(21,Inf]	Sum
[0,3]	80195	30906	103	2	0	111206
(3,11]	18564	99720	8224	207	20	126735
(11,17]	96	4908	9558	1283	169	16014
(17,21]	21	66	591	716	268	1662
(21,Inf]	18	8	14	79	124	243
Sum	98894	135608	18490	2287	581	255860

H8

OBS

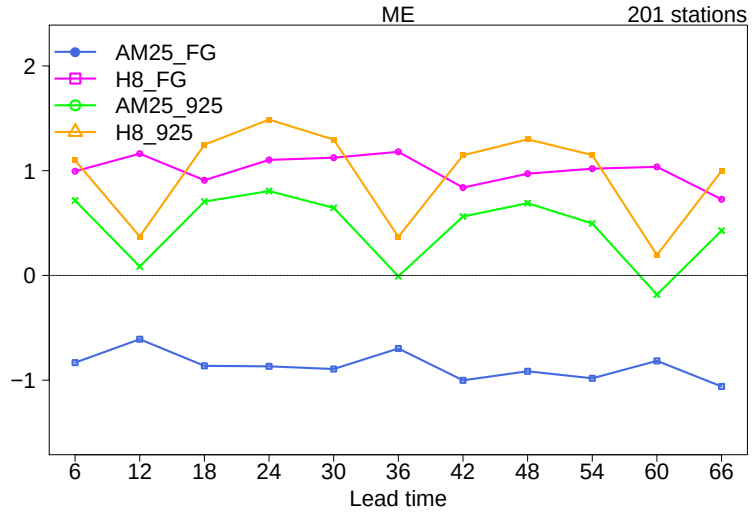
	[0,3]	(3,11]	(11,17]	(17,21]	(21,Inf]	Sum
[0,3]	68439	25332	167	4	0	93942
(3,11]	30367	107731	11738	678	183	150697
(11,17]	68	2541	6465	1374	254	10702
(17,21]	19	4	117	223	134	497
(21,Inf]	1	0	3	8	10	22
Sum	98894	135608	18490	2287	581	255860

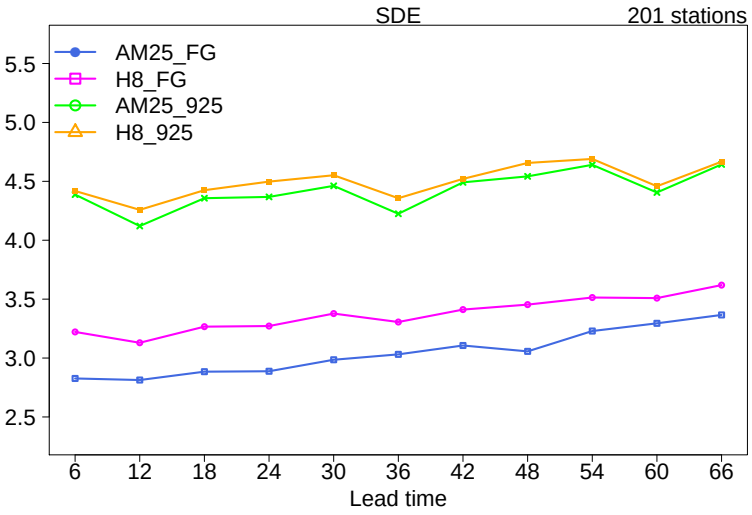
H8_PP

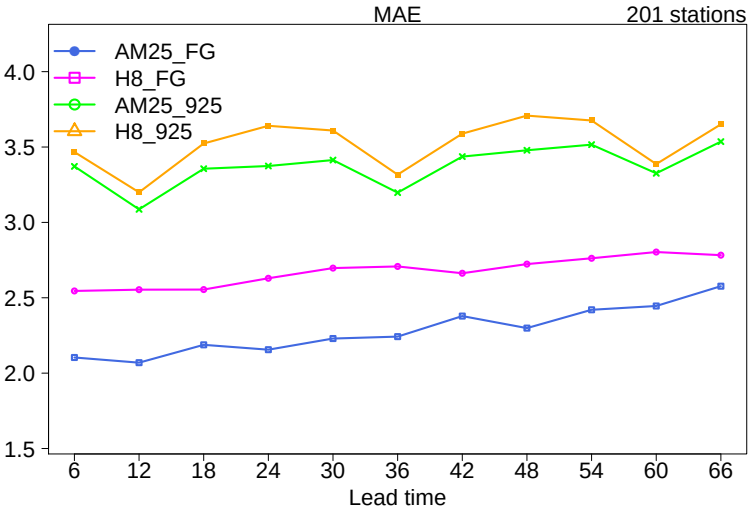
OBS

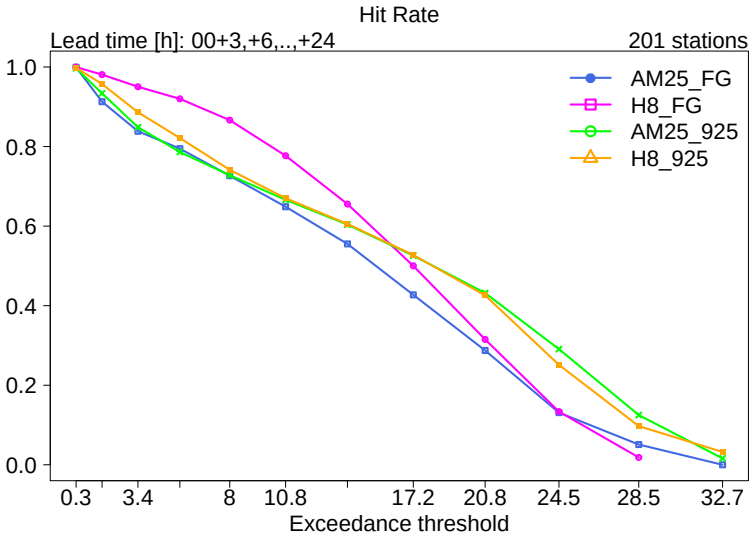
	[0,3]	(3,11]	(11,17]	(17,21]	(21,Inf]	Sum
[0,3]	64282	20594	85	0	0	84961
(3,11]	34403	105560	7134	360	89	147546
(11,17]	155	9192	9676	928	168	20119
(17,21]	38	251	1478	788	198	2753
(21,Inf]	16	11	117	211	126	481
Sum	98894	135608	18490	2287	581	255860

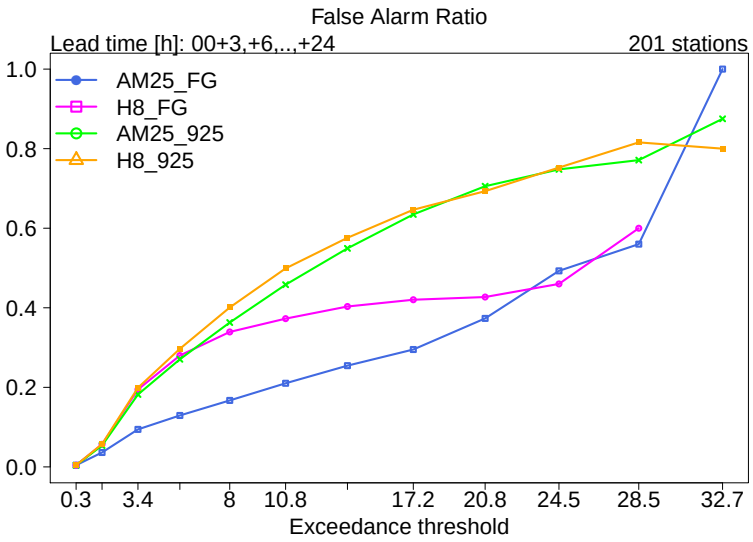
4.5 Wind gust

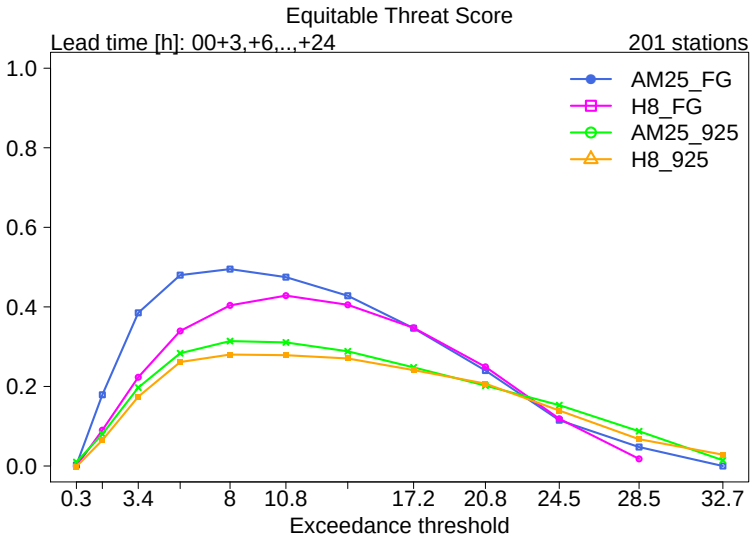

ME
201 stations
AM25_FG
H8_FG
AM25_925
H8_925
2
1
0
−1
6
12
18
24
30
36
42
48
54
60
66
Lead time


SDE
201 stations
AM25_FG
H8_FG
AM25_925
H8_925
5.5
5.0
4.5
4.0
3.5
3.0
2.5
6
12
18
24
30
36
42
48
54
60
66
Lead time

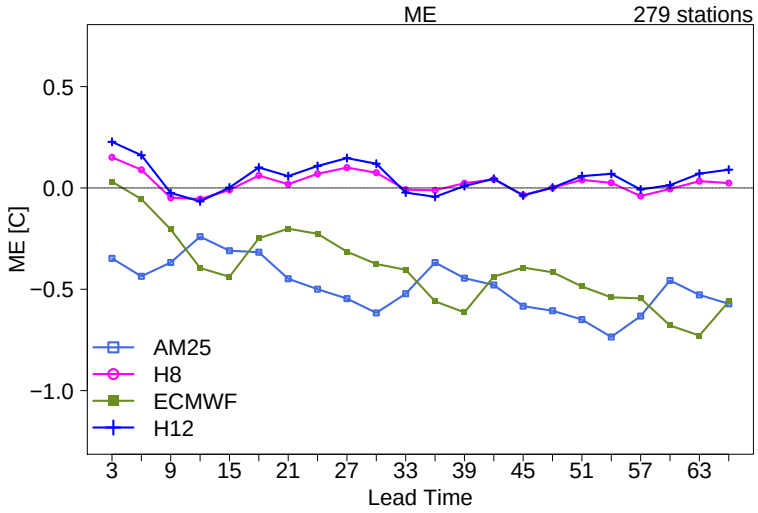

MAE
201 stations
AM25_FG
H8_FG
AM25_925
H8_925
4.0
3.5
3.0
2.5
2.0
1.5
6
12
18
24
30
36
42
48
54
60
66
Lead time

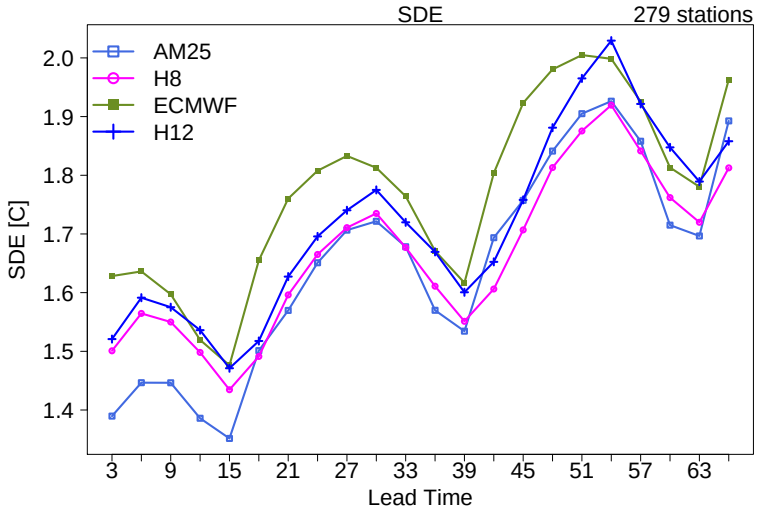

Hit Rate
Lead time [h]: 00+3,+6,..,+24
201 stations
AM25_FG
H8_FG
AM25_925
H8_925
1.0
0.8
0.6
0.4
0.2
0.0
0.3
3.4
8
10.8
17.2
20.8
24.5
28.5
32.7
Exceedance threshold

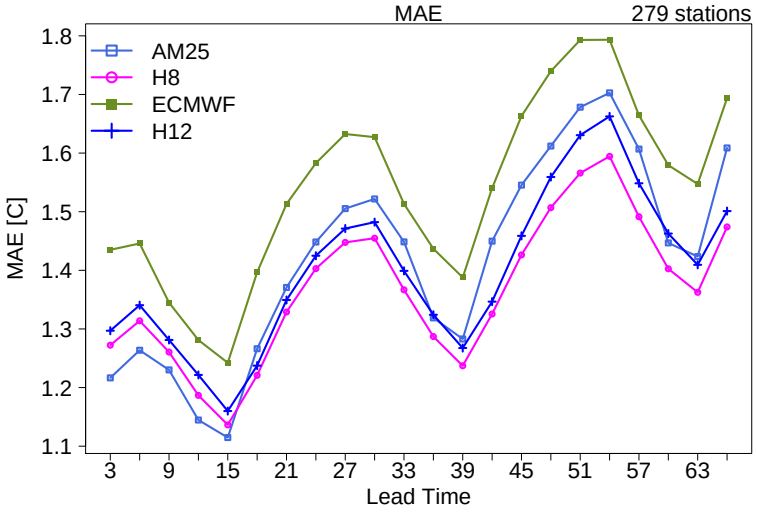

False Alarm Ratio
Lead time [h]: 00+3,+6,..,+24
201 stations
AM25_FG
H8_FG
AM25_925
H8_925
1.0
0.8
0.6
0.4
0.2
0.0
0.3
3.4
8
10.8
17.2
20.8
24.5
28.5
32.7
Exceedance threshold

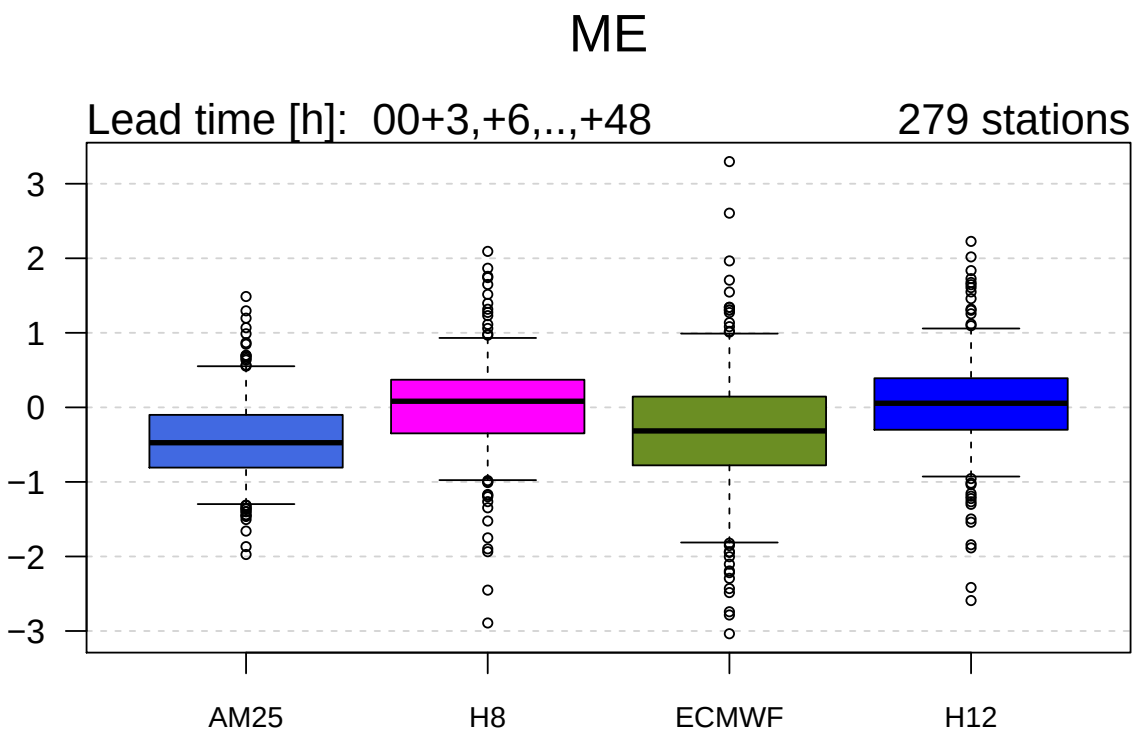

Equitable Threat Score
Lead time [h]: 00+3,+6,..,+24
201 stations
AM25_FG
H8_FG
AM25_925
H8_925
1.0
0.8
0.6
0.4
0.2
0.0
0.3
3.4
8
10.8
17.2
20.8
24.5
28.5
32.7
Exceedance threshold

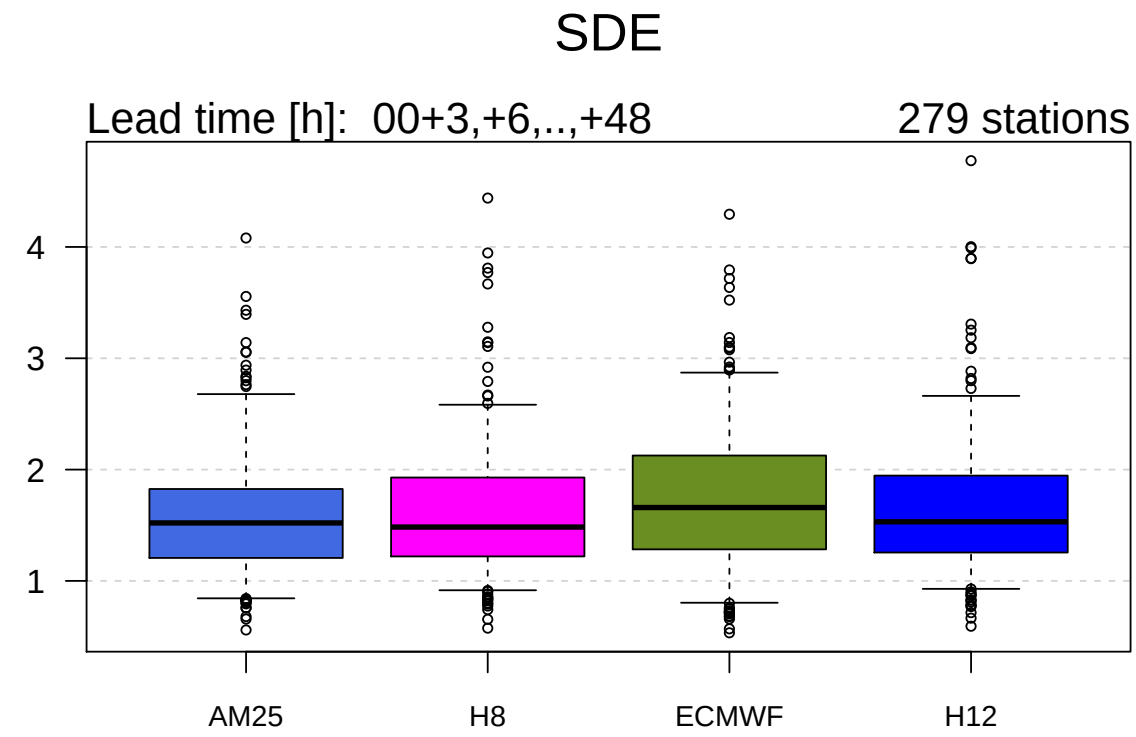
4.6 Temperature 2m







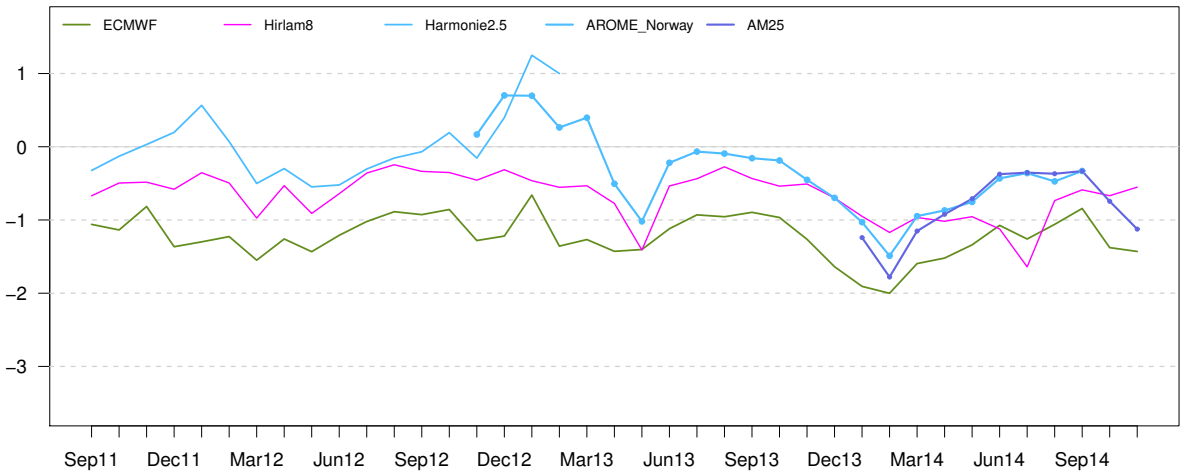

ME
Lead time [h]: 00+3,+6,..,+48
279 stations
3
2
1
0
−1
−2
−3
AM25
H8
ECMWF
H12


SDE
Lead time [h]: 00+3,+6,..,+48
279 stations
4
3
2
1
AM25
H8
ECMWF
H12

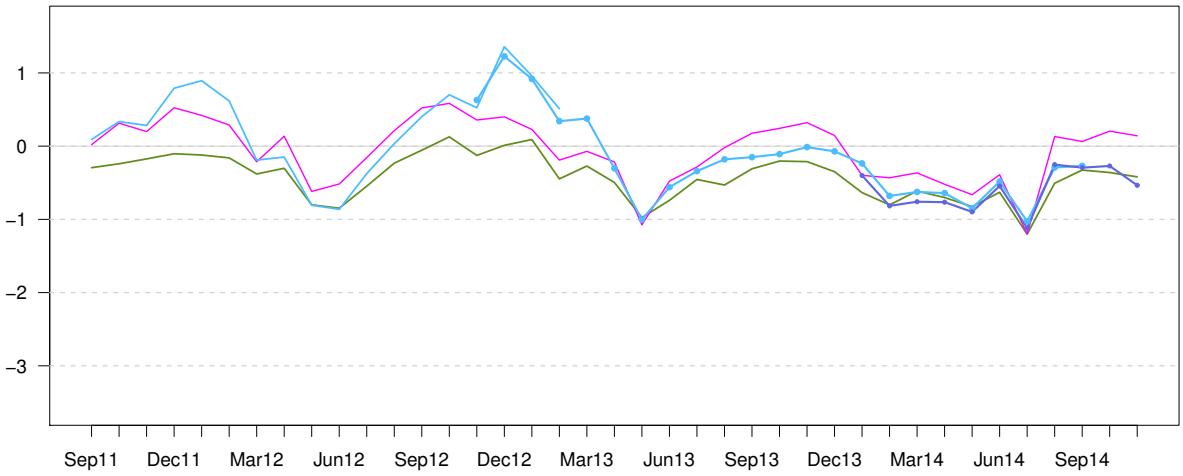
Mean Error

157 Norwegian stations

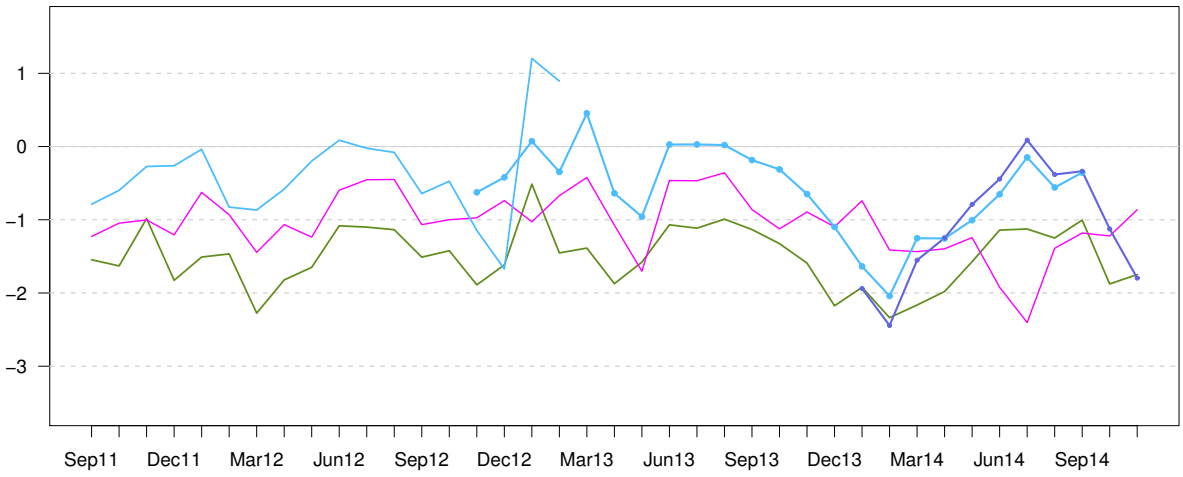
00+24,+30,+36,+42 UTC



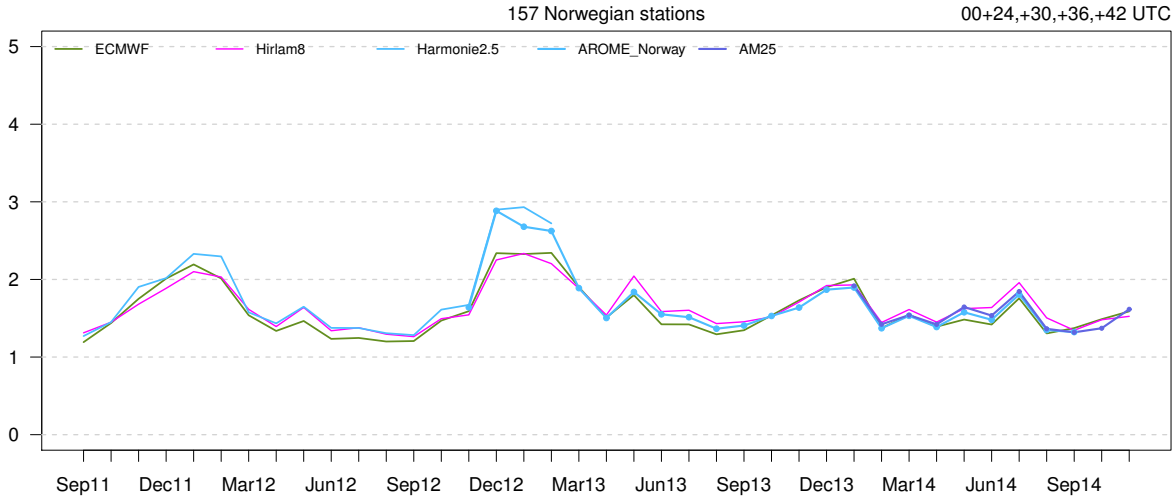
43 Norwegian coastal stations

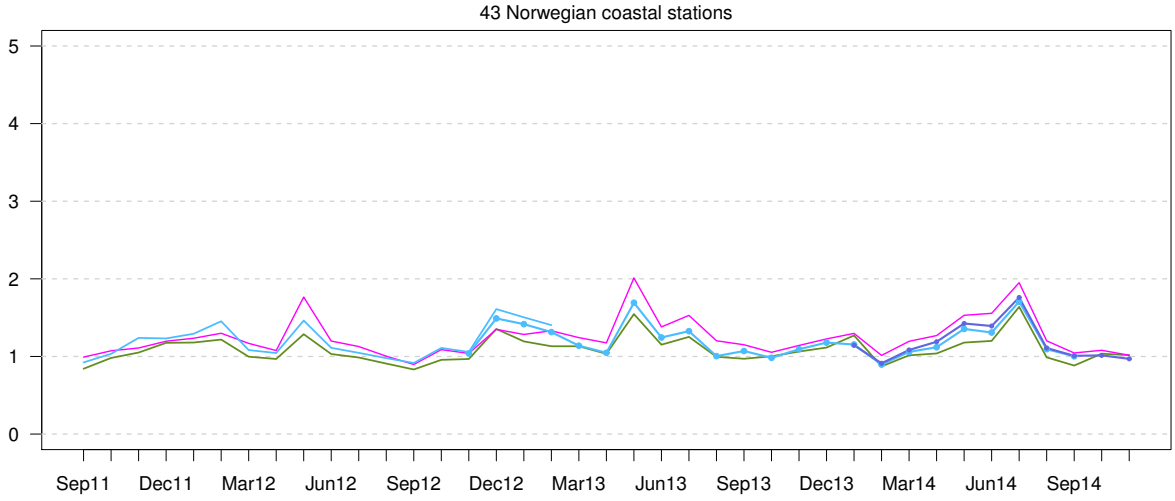


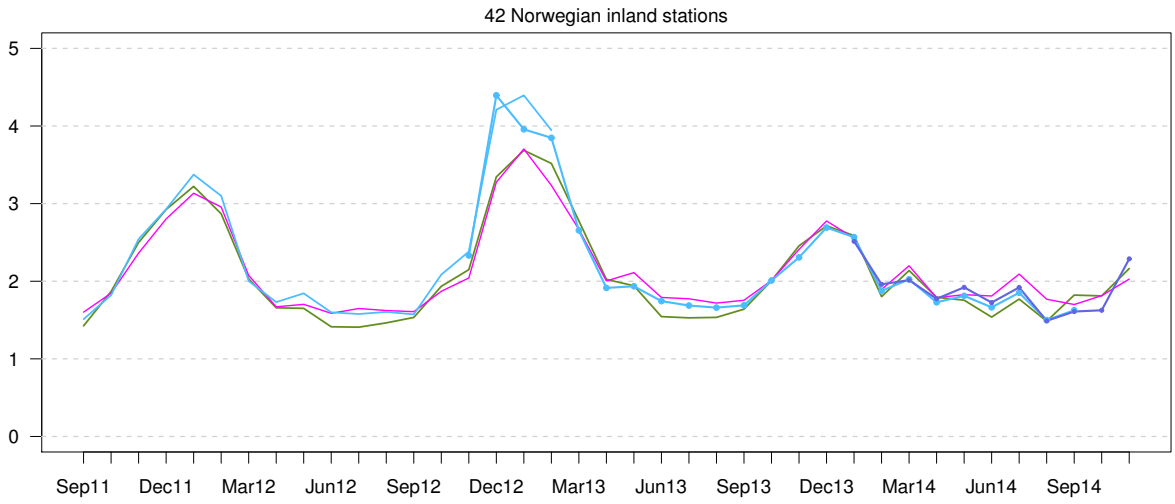
42 Norwegian inland stations



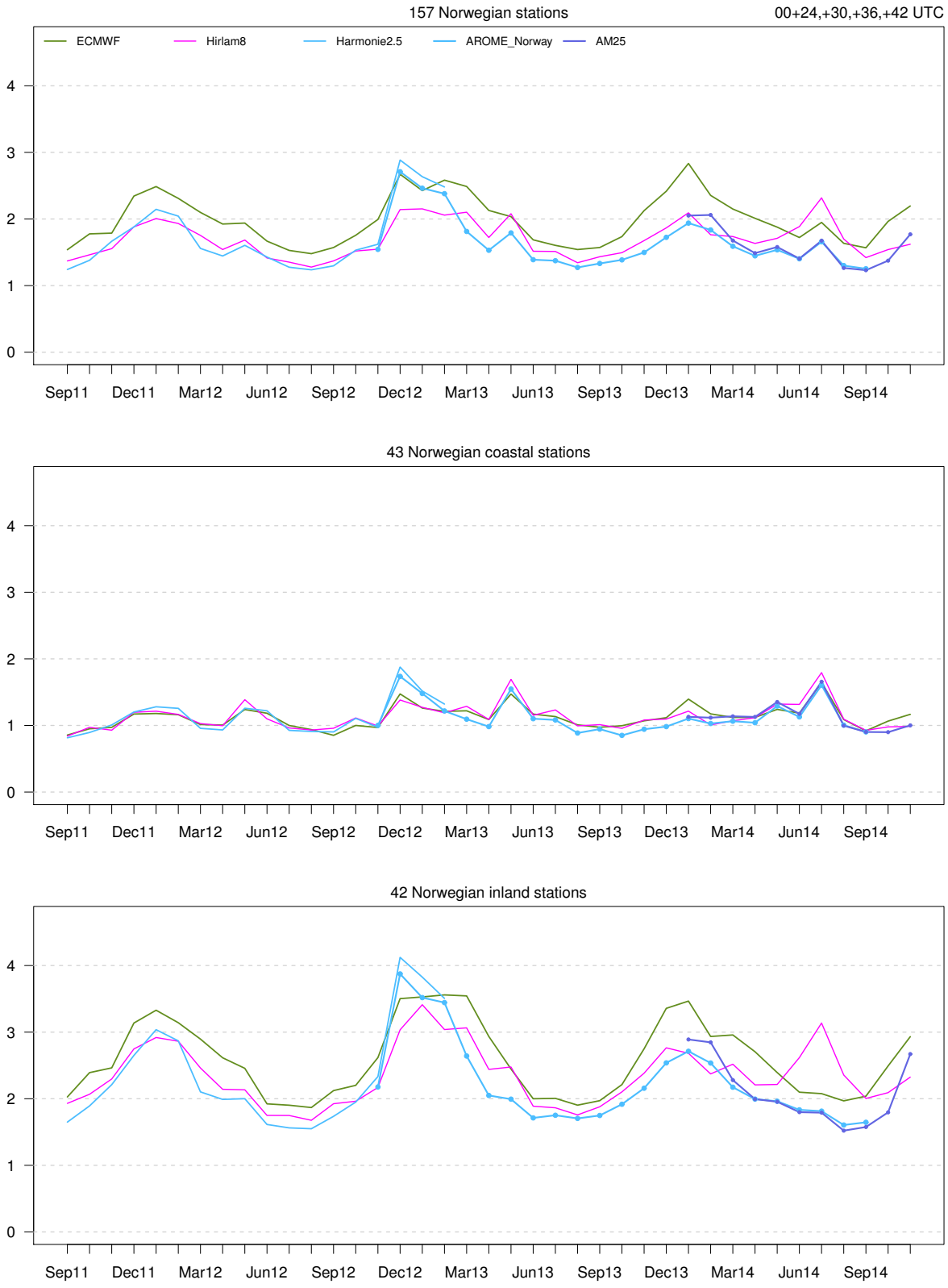
Standard Deviation of Error



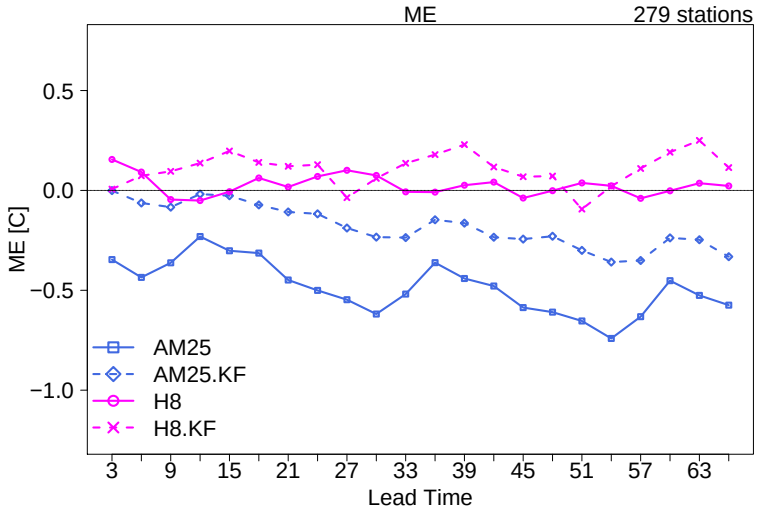


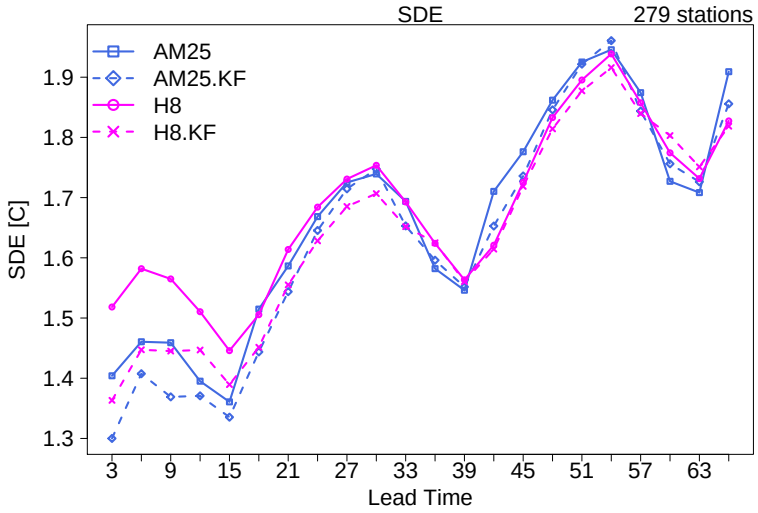


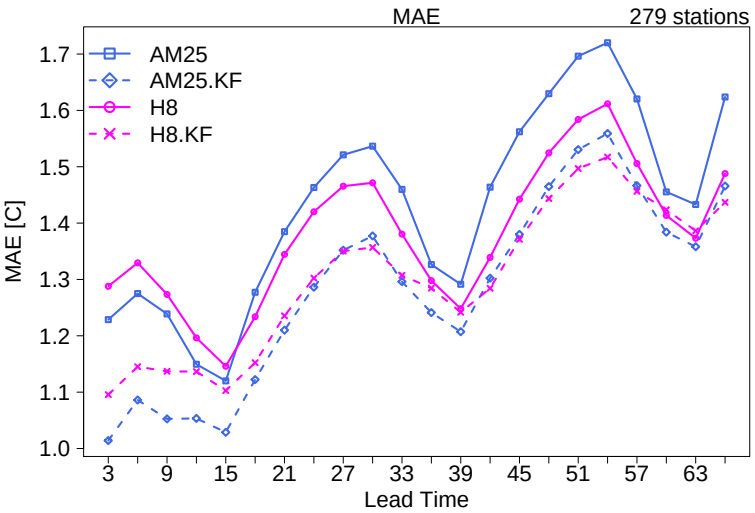
Mean Absolute Error

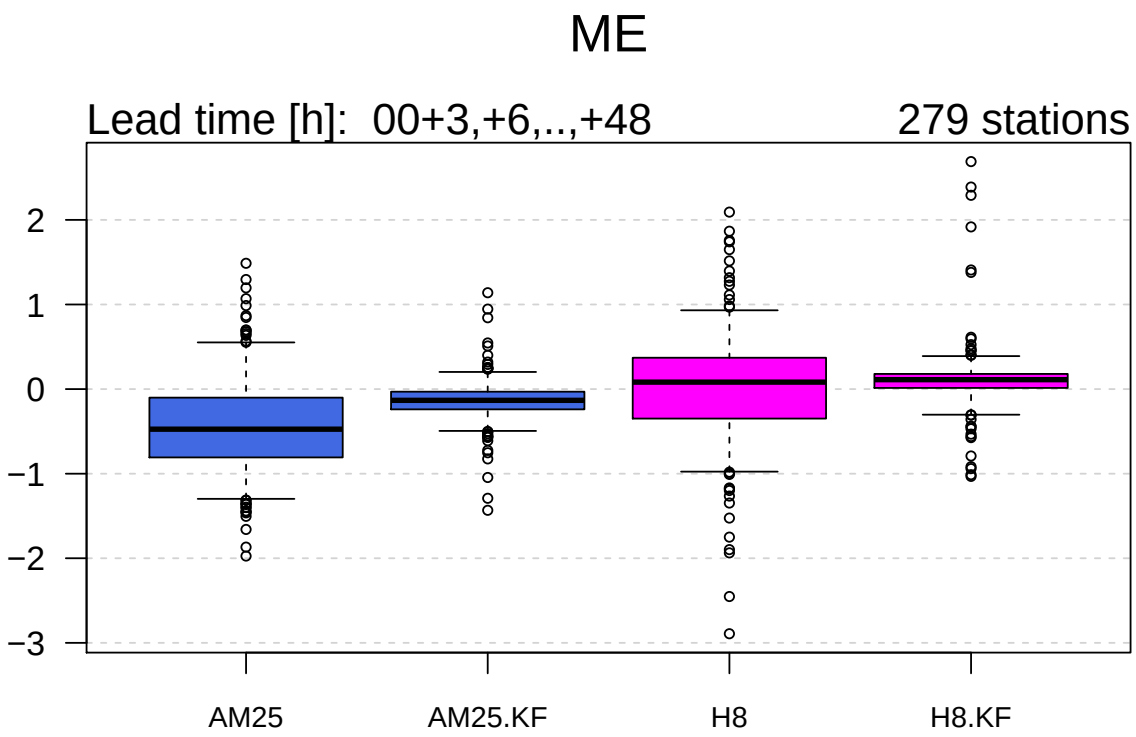


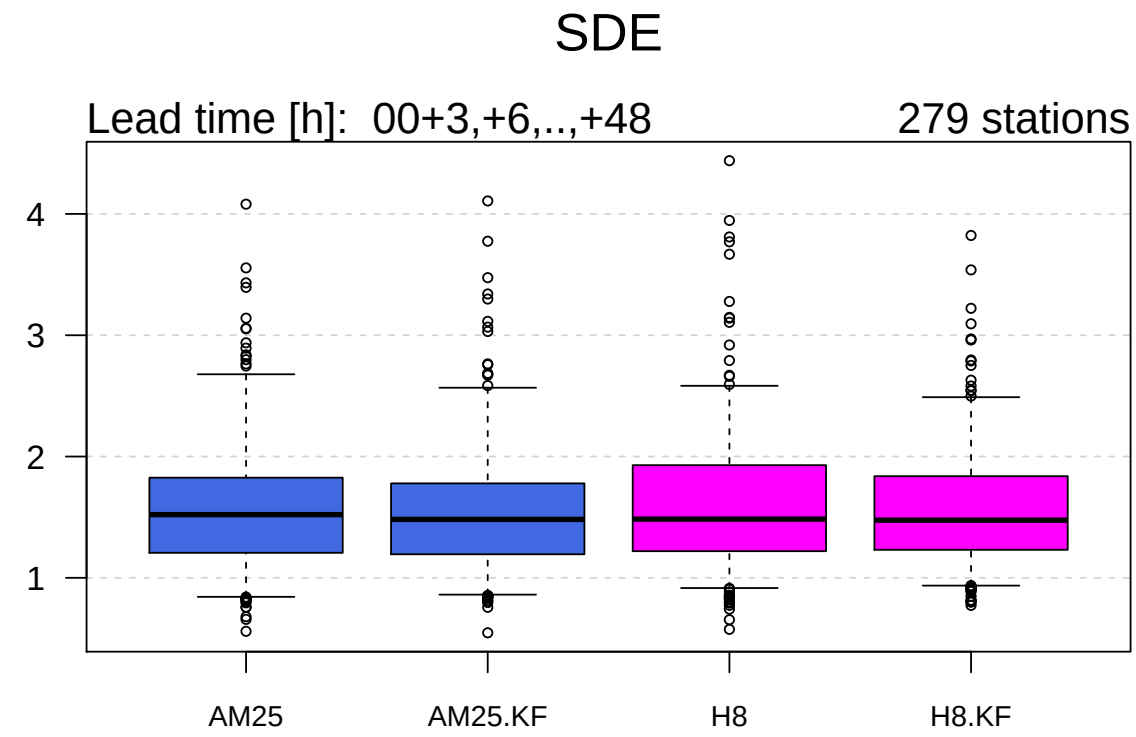
4.7 Post processed temperature 2m



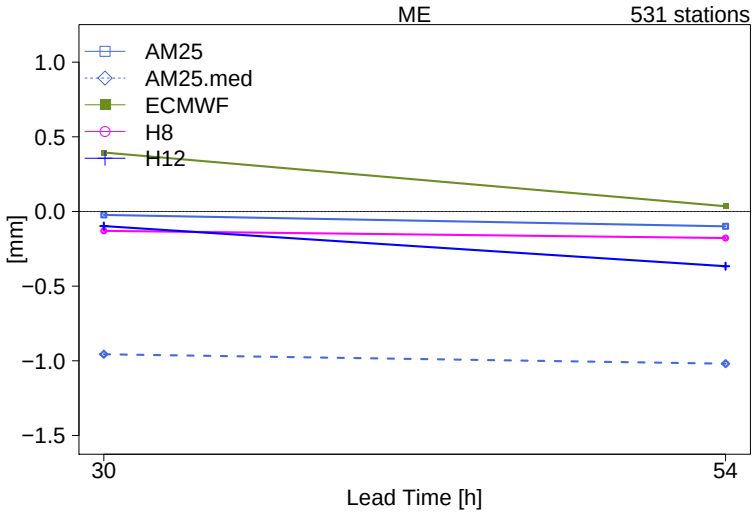


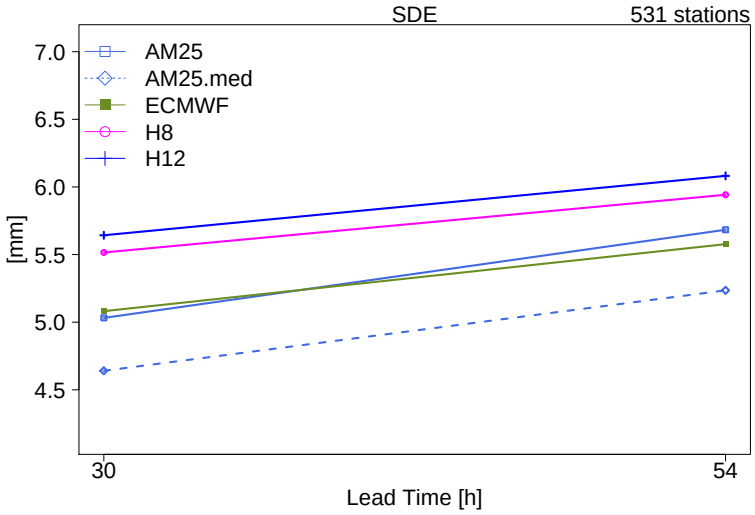


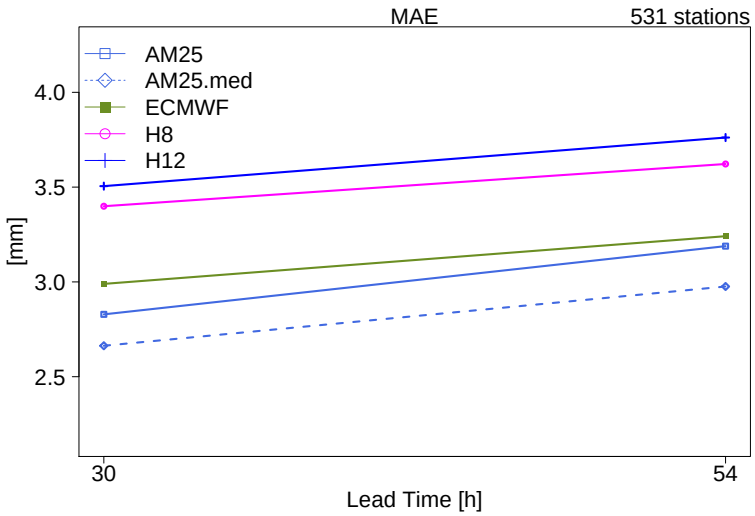

ME
Lead time [h]: 00+3,+6,..,+48
279 stations
2
1
0
−1
−2
−3
AM25
AM25.KF
H8
H8.KF

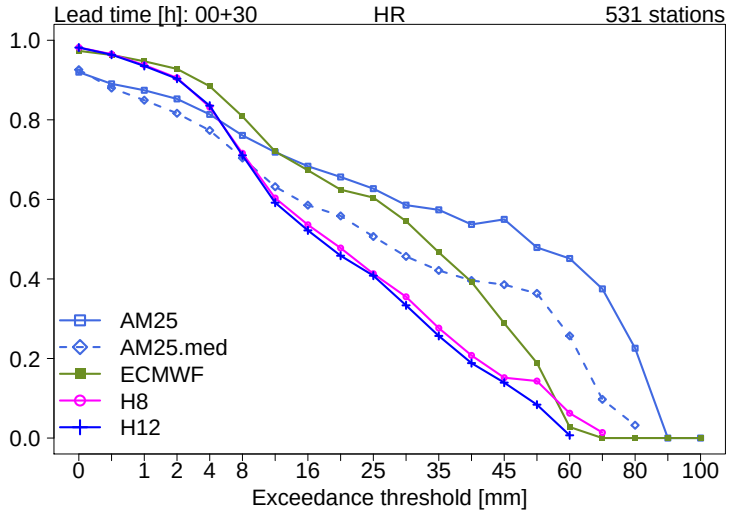

SDE
Lead time [h]: 00+3,+6,..,+48
279 stations
4
3
2
1
AM25
AM25.KF
H8
H8.KF

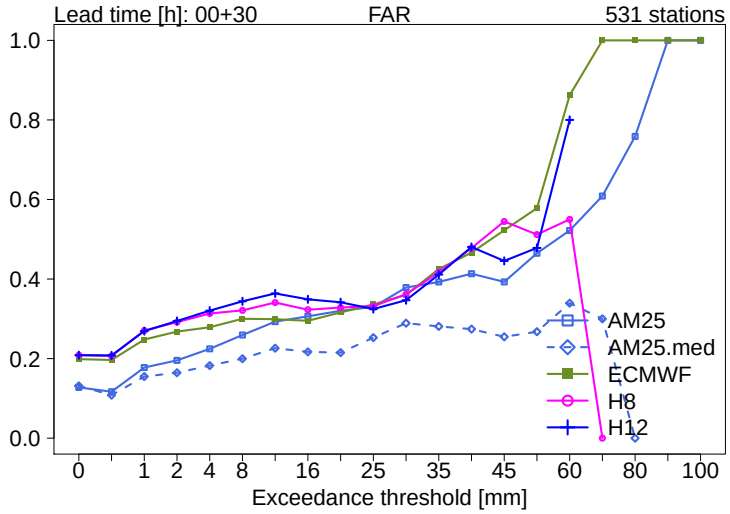
4.8 Daily precipitation

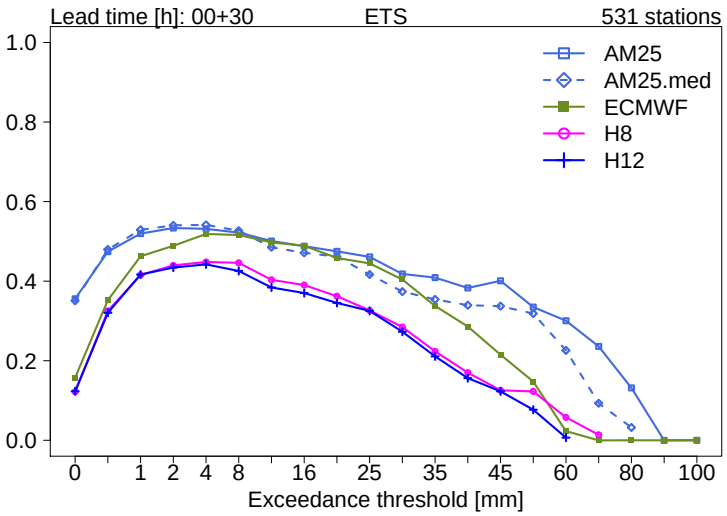


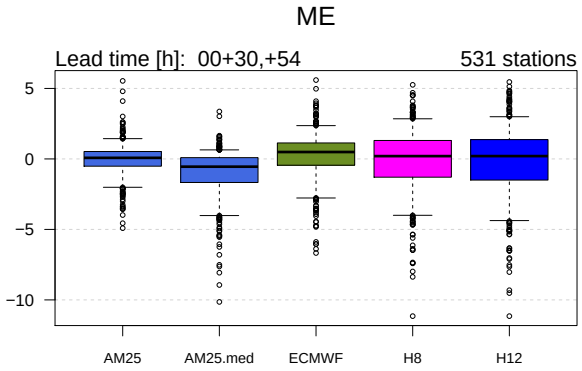


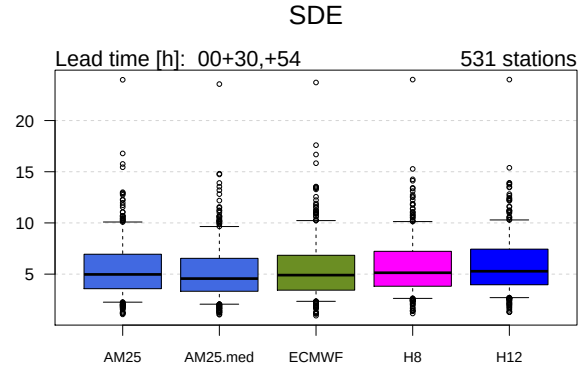



Lead time [h]: 00+30
HR
531 stations
1.0
0.8
0.6
0.4
0.2
0.0
AM25
AM25.med
ECMWF
H8
H12
0 1 2 4 8 16 25 35 45 60 80 100
Exceedance threshold [mm]


Lead time [h]: 00+30
FAR
531 stations
1.0
0.8
0.6
0.4
0.2
0.0
AM25
AM25.med
ECMWF
H8
H12
0 1 2 4 8 16 25 35 45 60 80 100
Exceedance threshold [mm]


Lead time [h]: 00+30
ETS
531 stations
1.0
0.8
0.6
0.4
0.2
0.0
AM25
AM25.med
ECMWF
H8
H12
0 1 2 4 8 16 25 35 45 60 80 100
Exceedance threshold [mm]





Lead time [h]: 00+30,+54 531 stations

AM25 — OBS

	[0,0.1]	(0.1,5]	(5,20]	(20,50]	(50,Inf]	Sum
[0,0.1]	16626	5528	194	9	4	22361
(0.1,5]	5341	17568	3780	167	13	26869
(5,20]	348	4537	9289	1535	41	15750
(20,50]	31	172	1321	2183	229	3936
(50,Inf]	3	4	19	216	233	475
Sum	22349	27809	14603	4110	520	69391

AM25.med — OBS

	[0,0.1]	(0.1,5]	(5,20]	(20,50]	(50,Inf]	Sum
[0,0.1]	17184	6029	234	6	5	23458
(0.1,5]	4958	18293	4530	227	16	28024
(5,20]	188	3427	9110	1875	65	14665
(20,50]	19	60	726	1926	271	3002
(50,Inf]	0	0	3	76	163	242
Sum	22349	27809	14603	4110	520	69391

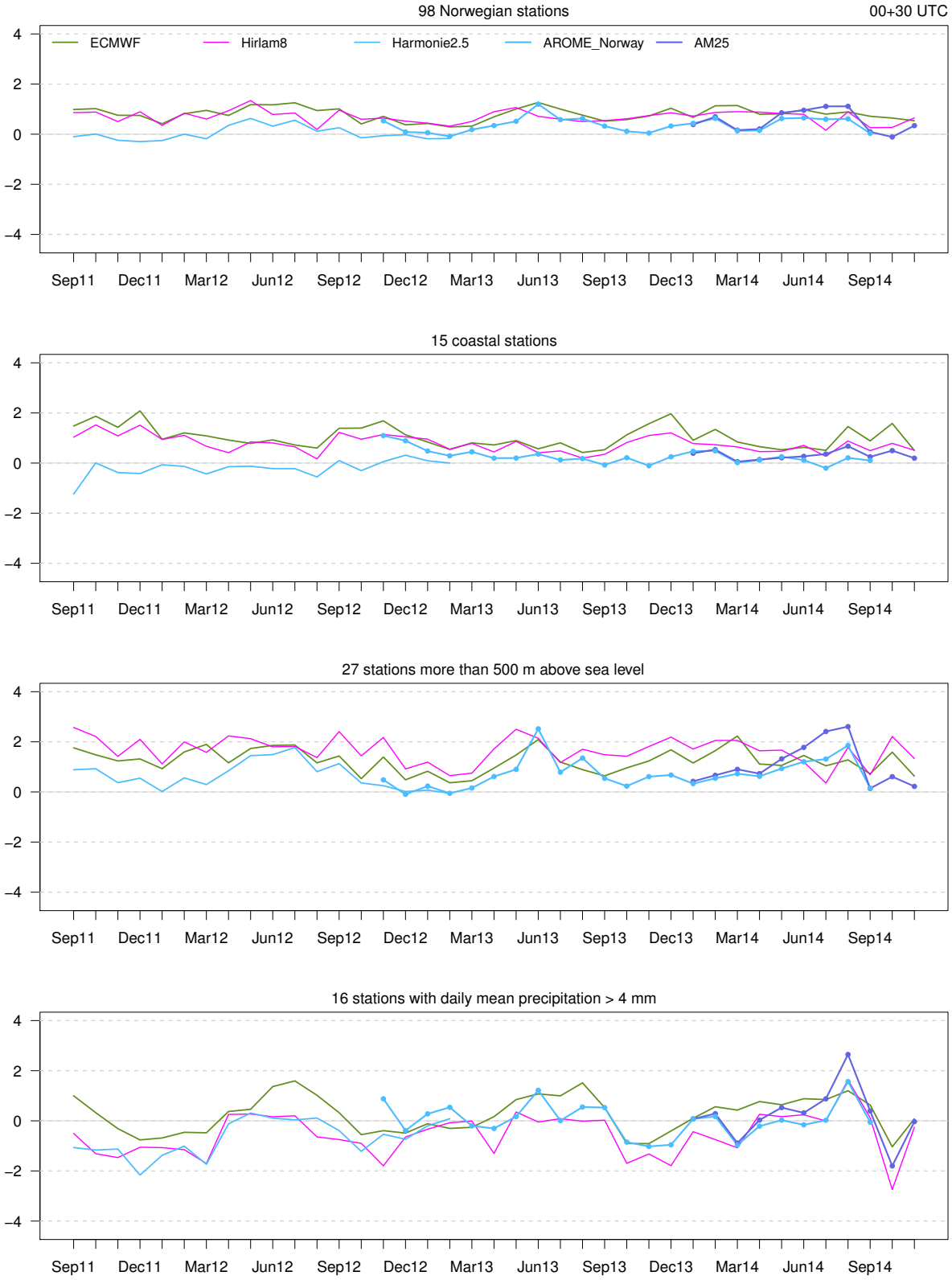
ECMWF — OBS

	[0,0.1]	(0.1,5]	(5,20]	(20,50]	(50,Inf]	Sum
[0,0.1]	11368	2023	58	0	2	13451
(0.1,5]	10485	19628	2849	108	4	33074
(5,20]	475	6032	10422	1770	67	18766
(20,50]	19	125	1250	2110	351	3855
(50,Inf]	2	1	24	122	96	245
Sum	22349	27809	14603	4110	520	69391

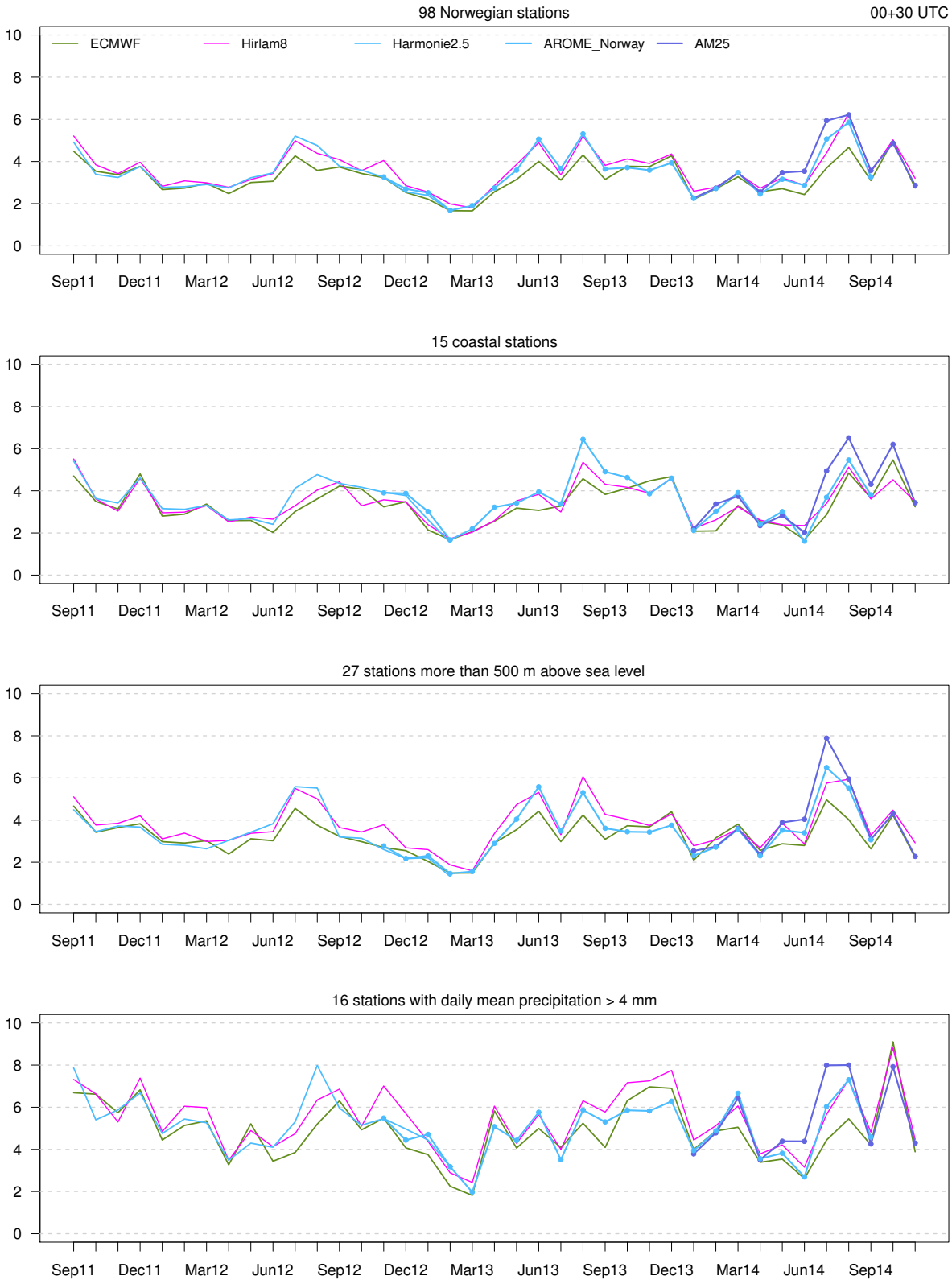
H8 — OBS

	[0,0.1]	(0.1,5]	(5,20]	(20,50]	(50,Inf]	Sum
[0,0.1]	10488	1990	61	3	2	12544
(0.1,5]	11166	19121	3861	214	16	34378
(5,20]	666	6563	9661	2235	116	19241
(20,50]	28	135	1015	1593	309	3080
(50,Inf]	1	0	5	65	77	148
Sum	22349	27809	14603	4110	520	69391

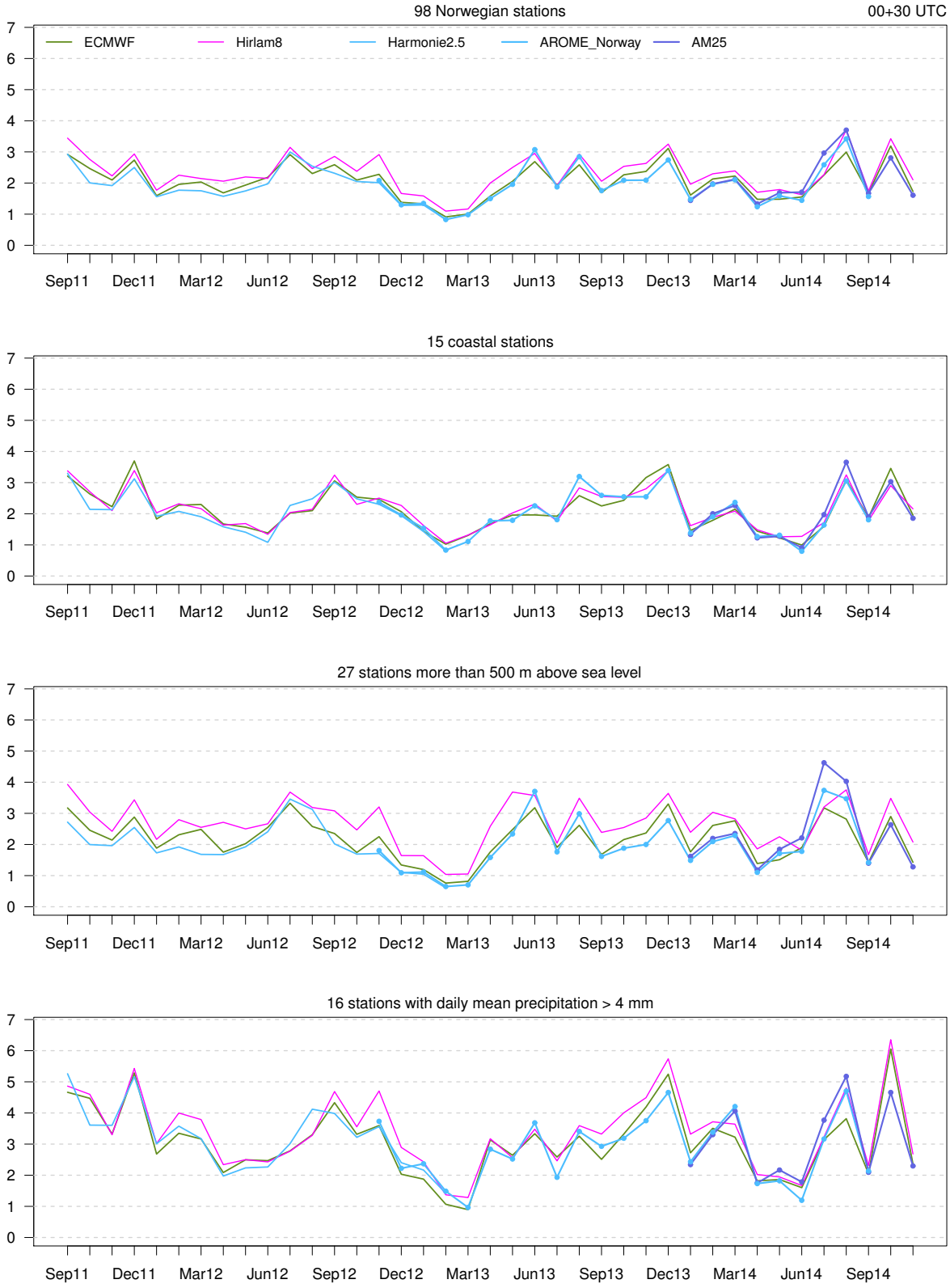
Mean Error


98 Norwegian stations
00+30 UTC
ECMWF
Hirlam8
Harmonie2.5
AROME_Norway
AM25
15 coastal stations
27 stations more than 500 m above sea level
16 stations with daily mean precipitation > 4 mm
4
2
0
−2
−4
Sep11
Dec11
Mar12
Jun12
Sep12
Dec12
Mar13
Jun13
Sep13
Dec13
Mar14
Jun14
Sep14

Standard Deviation of Error



Mean Absolute Error



5 Eastern Norway

5.1 Comments to the verification results

Problems with temperature and humidity near the surface in AM25

The case from 18 November show a convergence zone in AM25 with precipitation outside the coast of Skagerrakk. This is probably due to too low surface temperatures in AM25, so that a weak coldfront or convergence zone is generated outside the coast. The radar echo shows no precipitation in the area. There is a high pressure system over the southern parts of Norway that drives the cold air from the mainland out to Skagerrakk.

The case from 2 December is a comparison of vertical profile from the different models and data from a radio sonde. AM25 misses on the inversion and is therefore too dry near the ground. The other models have a more correct profile, and therefore more clouds. The forecast based on AM25 showed light clouds, while it was observed overcast with snow.

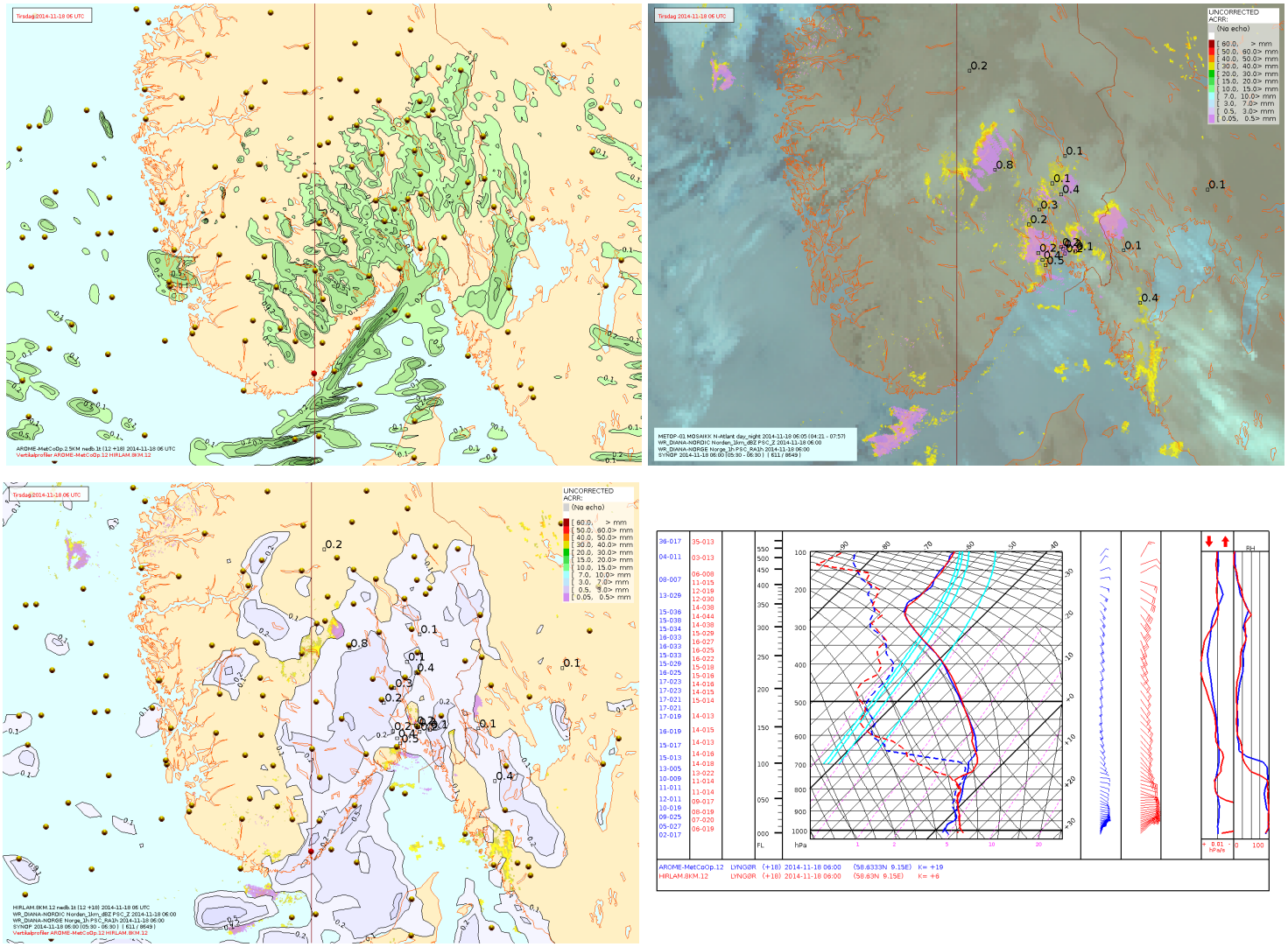


Figure 1: Figures from the 18 November case. Topleft: AM25 1h precipitation at 06 UTC showing a convergence zone outside the coast of Skagerrakk. Topright: Radar echo at 06 UTC. Bottomleft: H8 1h precipitation at 06 UTC compared with radar echo. Bottomright: Vertical profile at LyngÃ¸r, AM25 in blue and H8 in red.

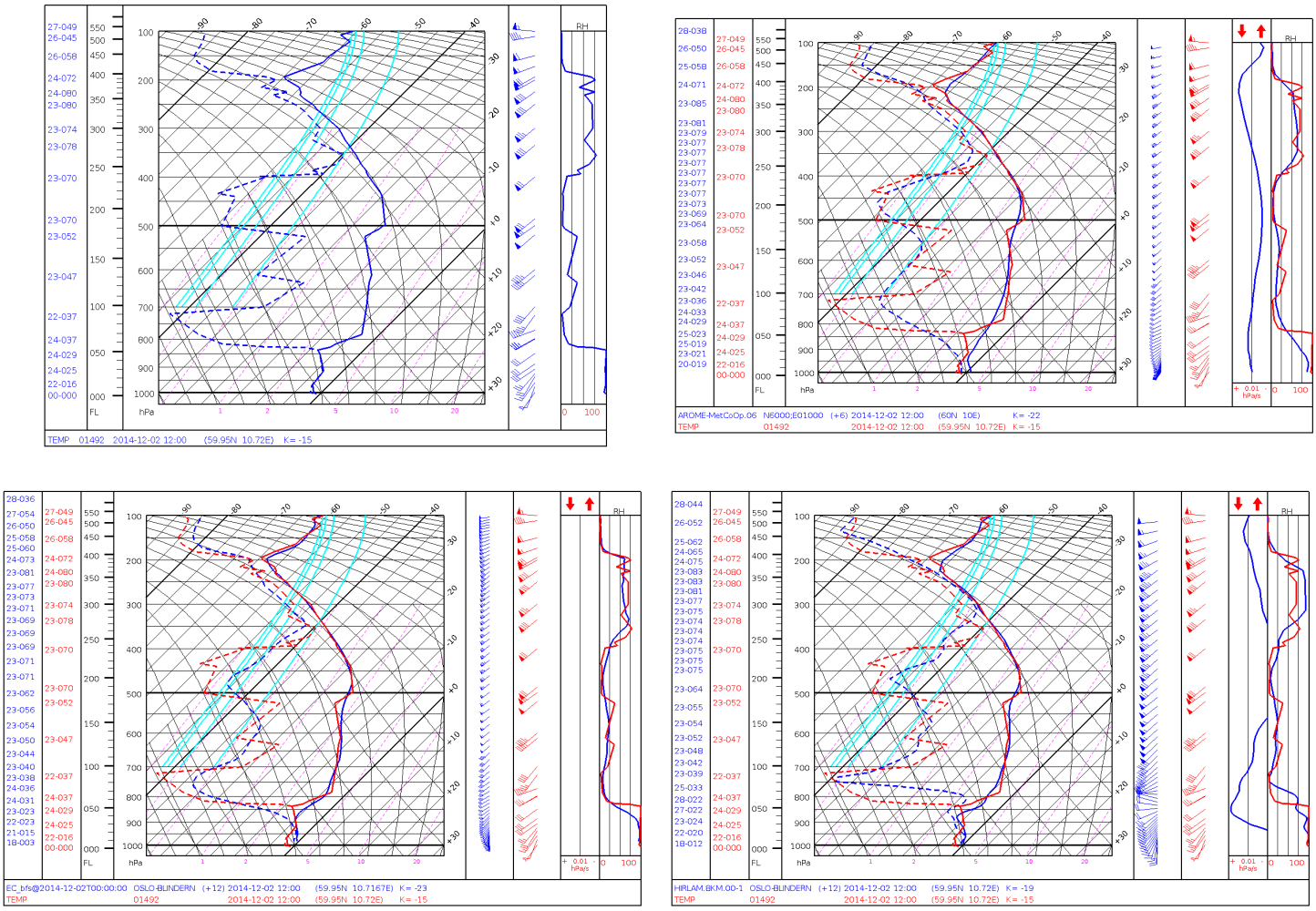
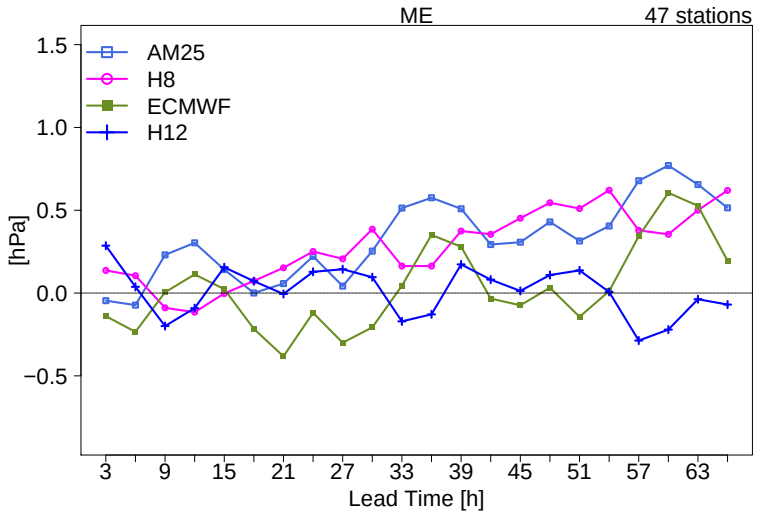
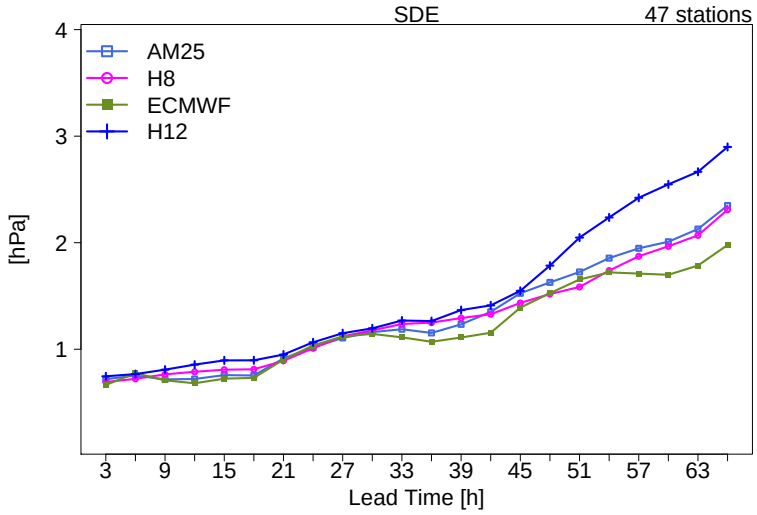
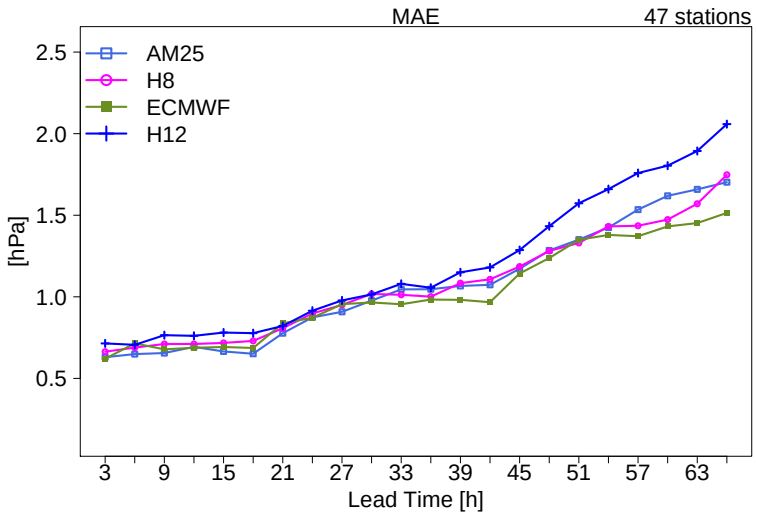


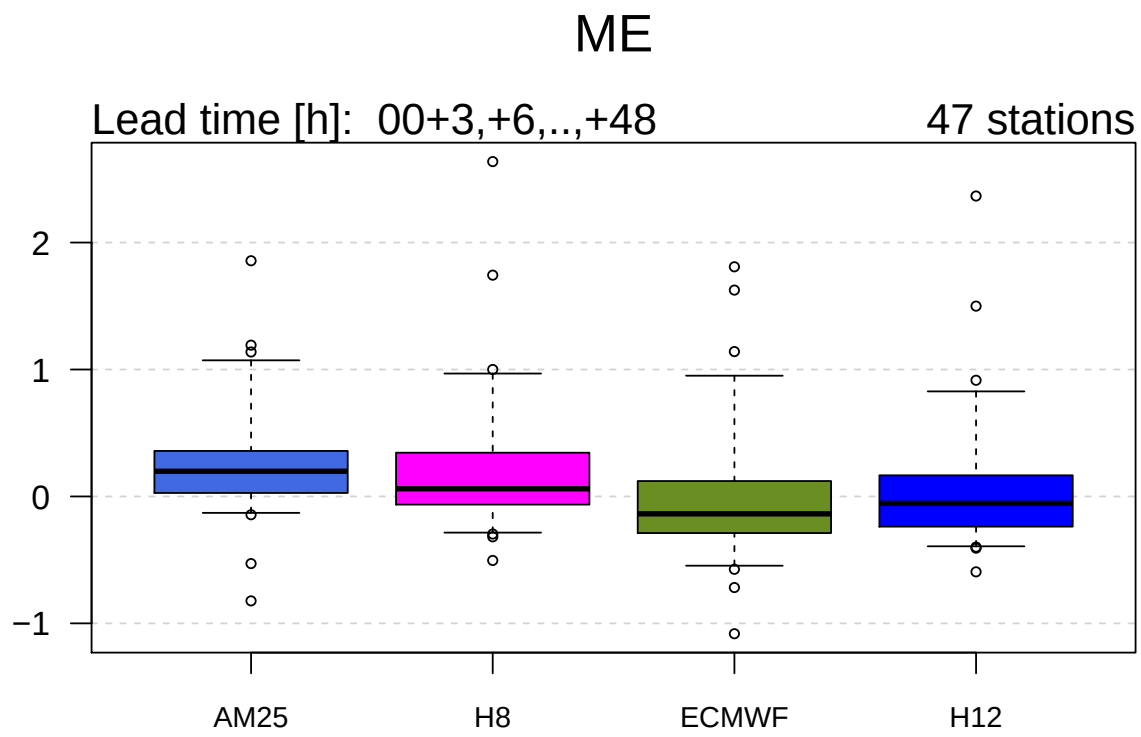
Figure 2: Vertical profiles at Blindern from the 2 December case. Topleft: Observed. Topright: AM25 (blue) vs observed (red). Bottomleft: ECMWF (blue) vs observed (red) Bottomright: H8 (blue) vs observed (red).

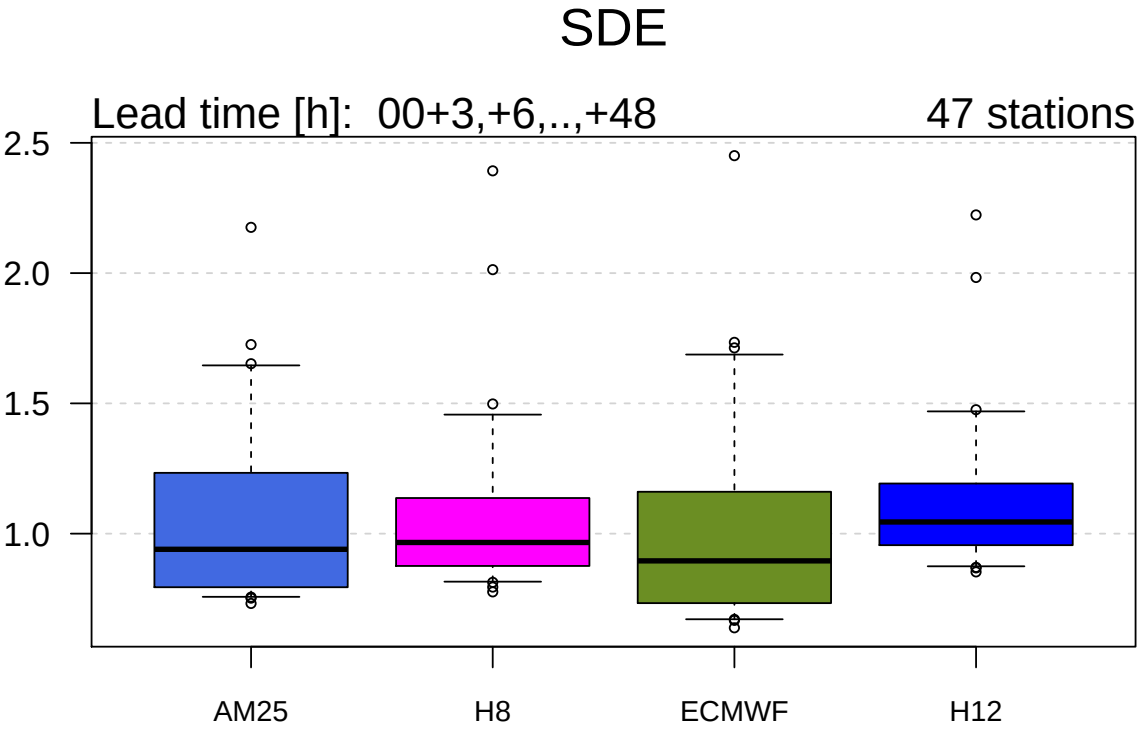
5.2 Pressure


ME
47 stations
AM25
H8
ECMWF
H12
[hPa]
1.5
1.0
0.5
0.0
−0.5
3
9
15
21
27
33
39
45
51
57
63
Lead Time [h]

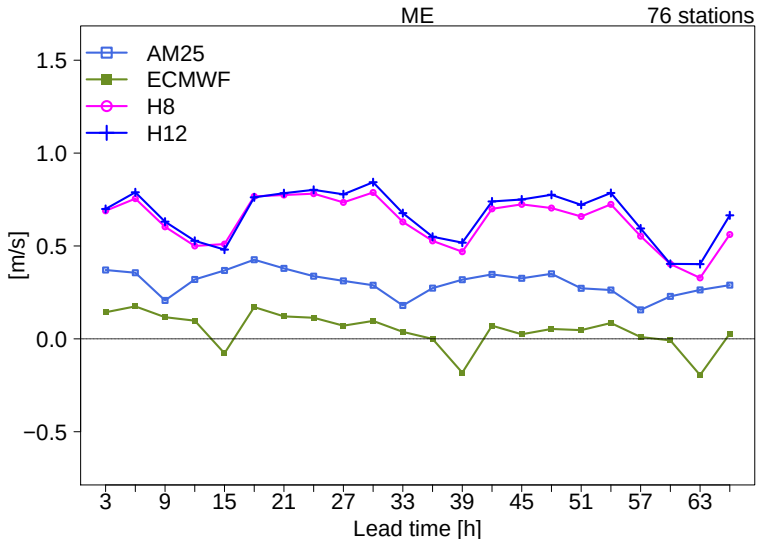

SDE
47 stations
AM25
H8
ECMWF
H12
[hPa]
4
3
2
1
3
9
15
21
27
33
39
45
51
57
63
Lead Time [h]

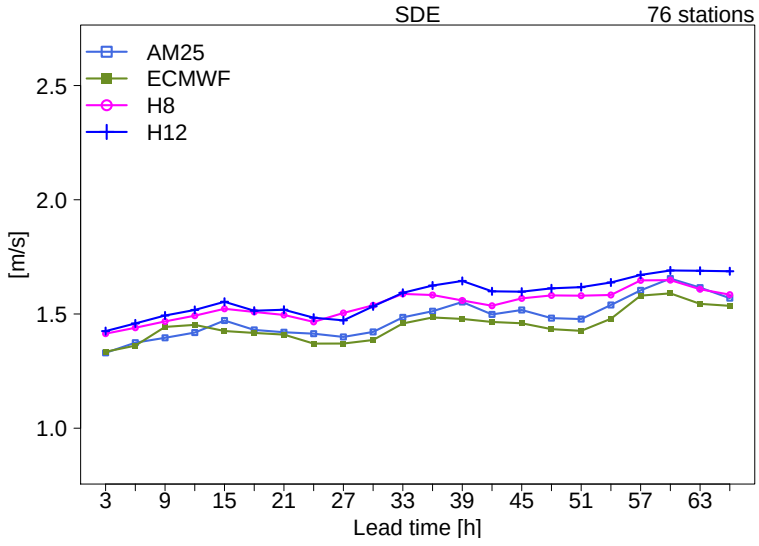

MAE
47 stations
AM25
H8
ECMWF
H12
[hPa]
2.5
2.0
1.5
1.0
0.5
3
9
15
21
27
33
39
45
51
57
63
Lead Time [h]

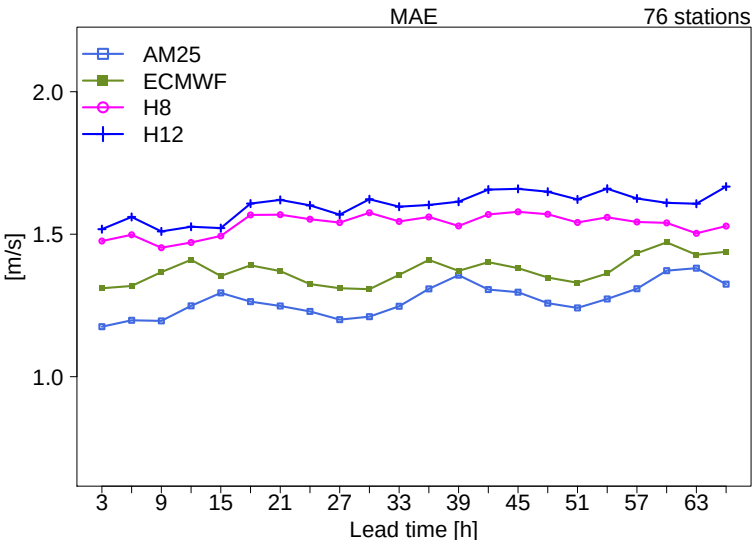

ME
Lead time [h]: 00+3,+6,..,+48
47 stations
2
1
0
−1
AM25
H8
ECMWF
H12

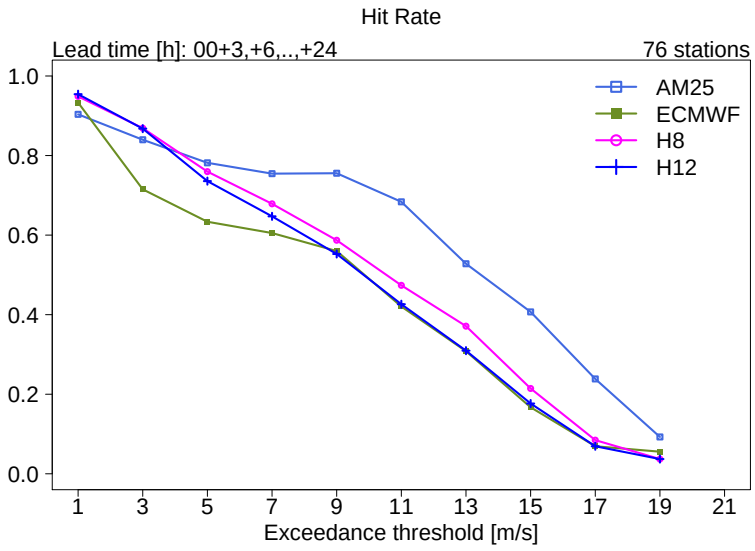

SDE
Lead time [h]: 00+3,+6,..,+48
47 stations
2.5
2.0
1.5
1.0
AM25
H8
ECMWF
H12

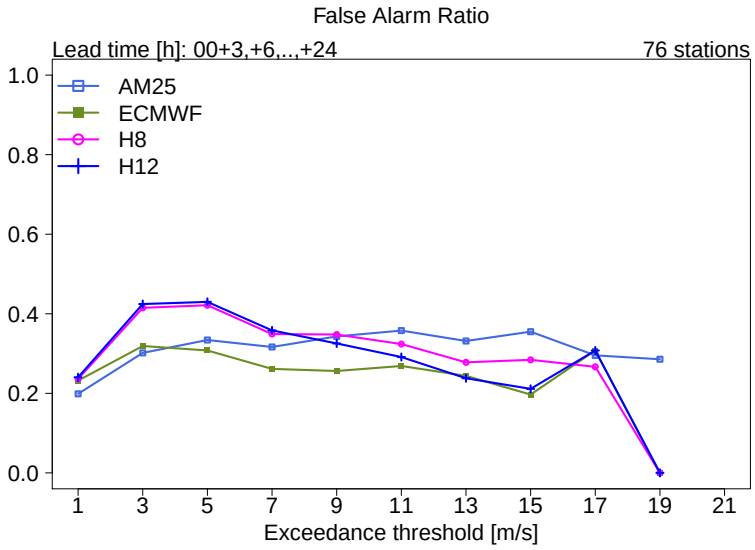
5.3 Wind Speed 10m

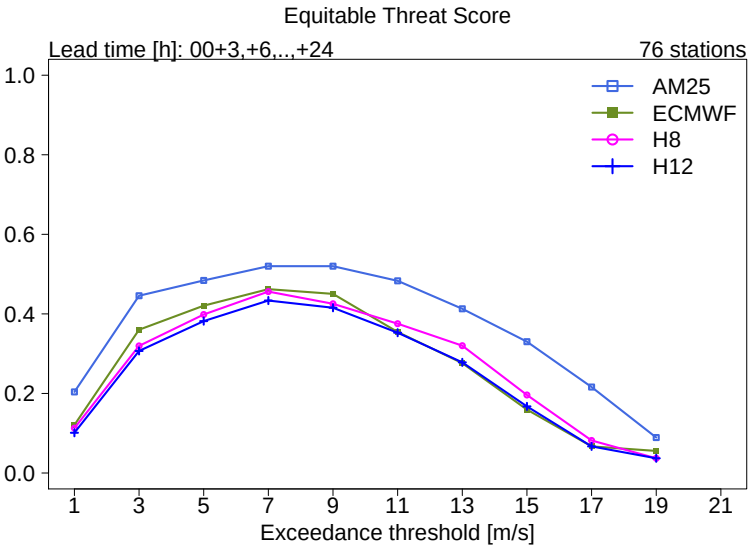


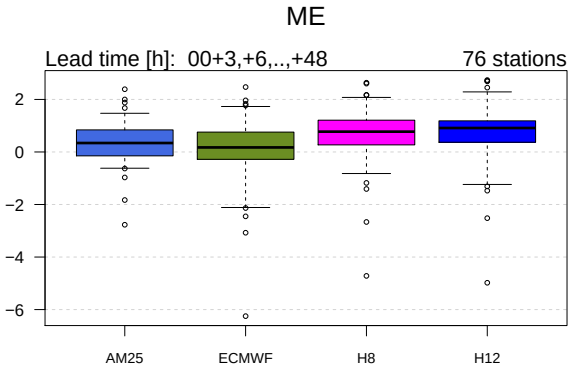


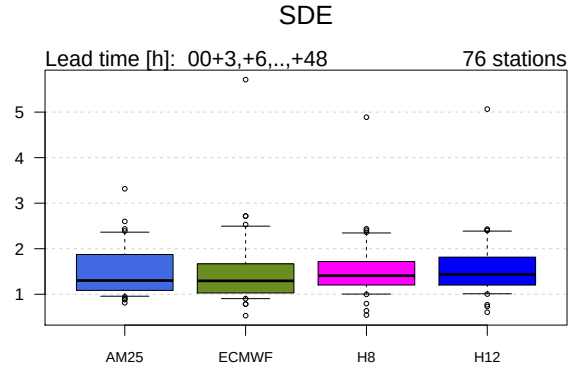



Hit Rate
Lead time [h]: 00+3,+6,..,+24
76 stations
AM25
ECMWF
H8
H12
1.0
0.8
0.6
0.4
0.2
0.0
1 3 5 7 9 11 13 15 17 19 21
Exceedance threshold [m/s]


False Alarm Ratio
Lead time [h]: 00+3,+6,..,+24
76 stations
AM25
ECMWF
H8
H12
1.0
0.8
0.6
0.4
0.2
0.0
1 3 5 7 9 11 13 15 17 19 21
Exceedance threshold [m/s]


Equitable Threat Score
Lead time [h]: 00+3,+6,..,+24
76 stations
AM25
ECMWF
H8
H12
1.0
0.8
0.6
0.4
0.2
0.0
1 3 5 7 9 11 13 15 17 19 21
Exceedance threshold [m/s]





Lead time [h]: 00+3,+6,..,+48 UTC 76 stations

AM25 — **OBS**

	[0,3]	(3,11]	(11,17]	(17,21]	(21,Inf]	Sum
[0,3]	49083	5574	8	1	0	54666
(3,11]	11614	22866	947	27	1	35455
(11,17]	37	1043	1533	153	18	2784
(17,21]	0	5	18	41	12	76
(21,Inf]	0	0	0	0	0	0
Sum	60734	29488	2506	222	31	92981

H8 — **OBS**

	[0,3]	(3,11]	(11,17]	(17,21]	(21,Inf]	Sum
[0,3]	40616	4496	33	0	0	45145
(3,11]	20108	24359	1372	100	27	45966
(11,17]	10	633	1094	105	0	1842
(17,21]	0	0	7	17	4	28
(21,Inf]	0	0	0	0	0	0
Sum	60734	29488	2506	222	31	92981

ECMWF — **OBS**

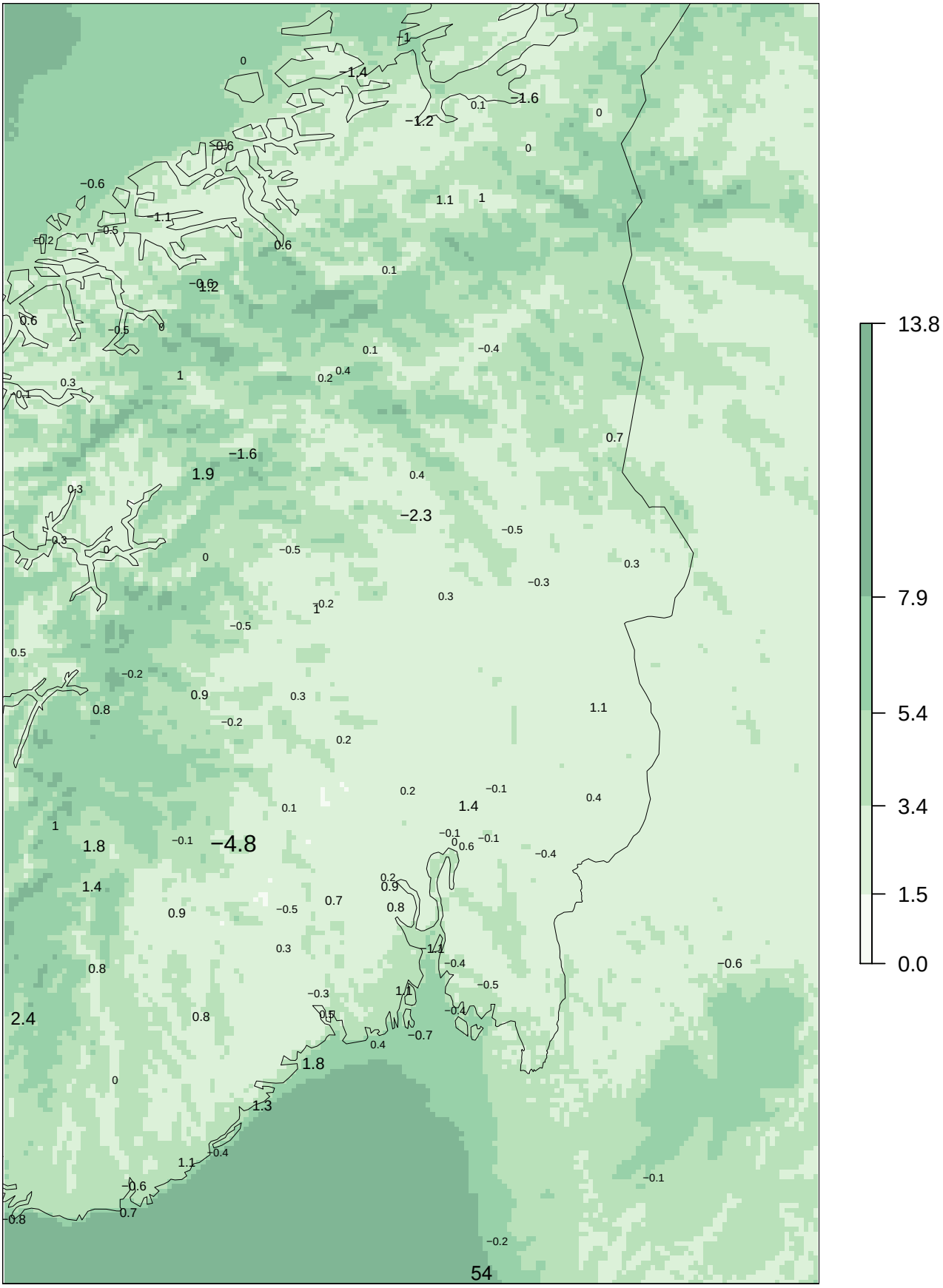
	[0,3]	(3,11]	(11,17]	(17,21]	(21,Inf]	Sum
[0,3]	50316	9326	311	81	19	60053
(3,11]	10413	19729	1193	26	8	31369
(11,17]	5	433	995	101	0	1534
(17,21]	0	0	7	14	4	25
(21,Inf]	0	0	0	0	0	0
Sum	60734	29488	2506	222	31	92981

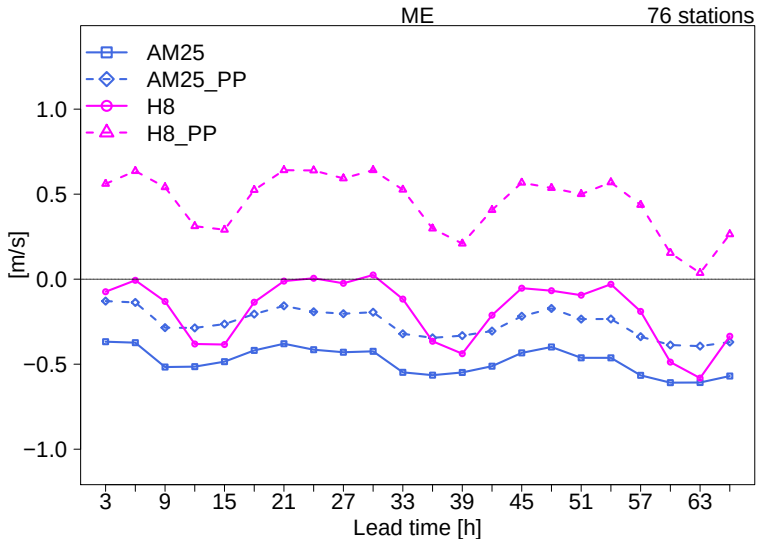
H12 — **OBS**

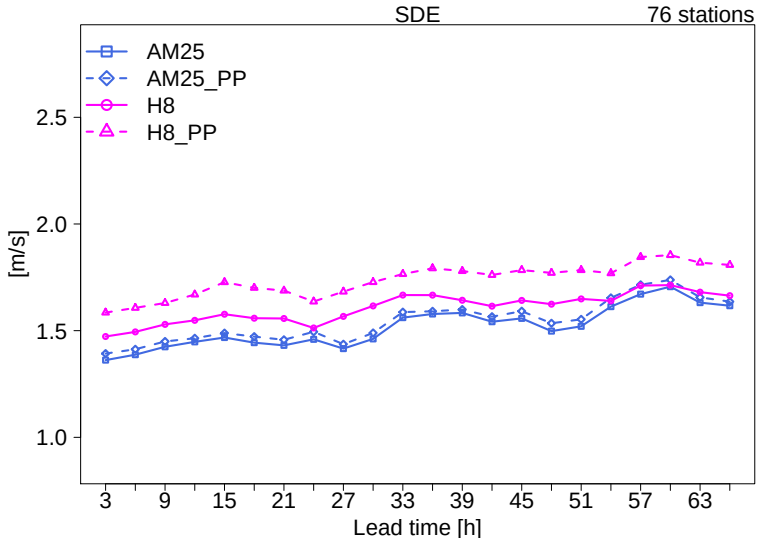
	[0,3]	(3,11]	(11,17]	(17,21]	(21,Inf]	Sum
[0,3]	39591	4483	38	1	1	44114
(3,11]	21132	24483	1431	97	26	47169
(11,17]	11	522	1027	107	0	1667
(17,21]	0	0	10	17	4	31
(21,Inf]	0	0	0	0	0	0
Sum	60734	29488	2506	222	31	92981

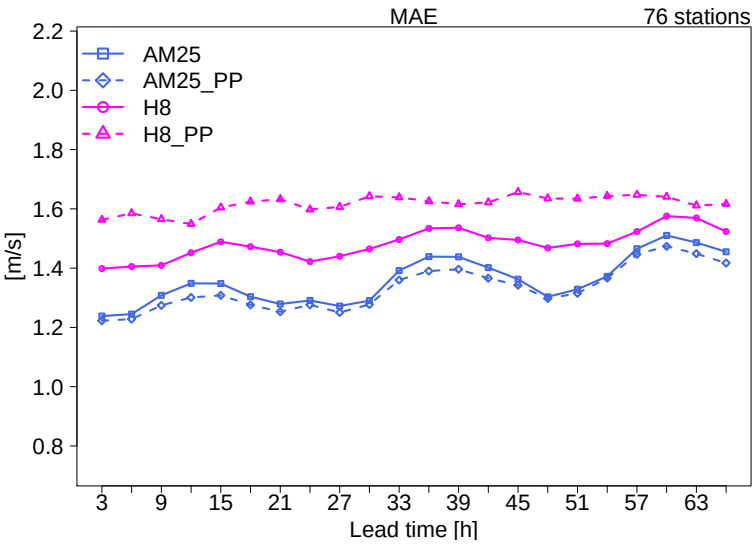
AM25 00+12

ME at observing sites forecast means 01.09.2014 − 30.11.2014



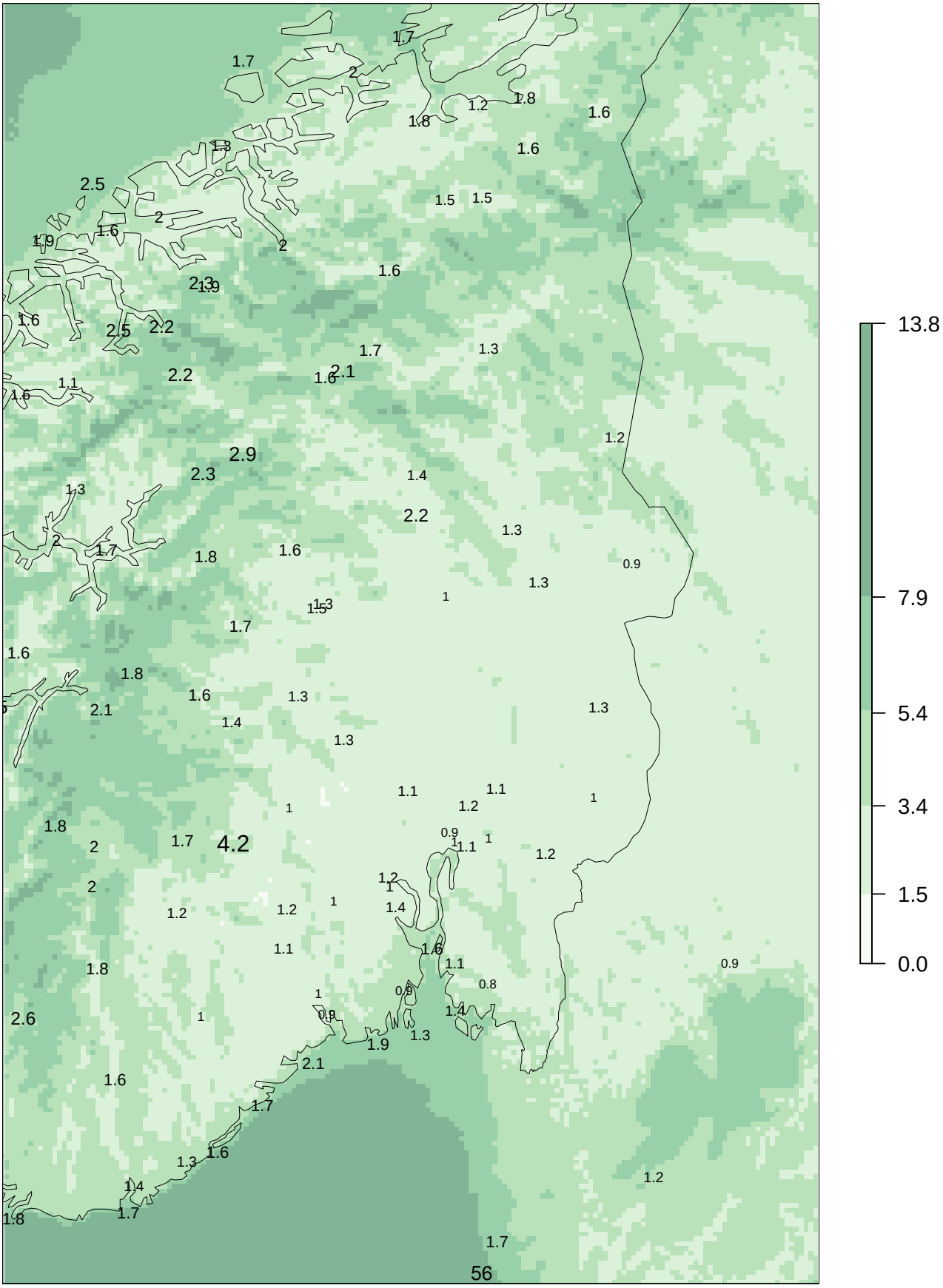

ME
76 stations
AM25
AM25_PP
H8
H8_PP
1.0
0.5
0.0
−0.5
−1.0
[m/s]
3
9
15
21
27
33
39
45
51
57
63
Lead time [h]

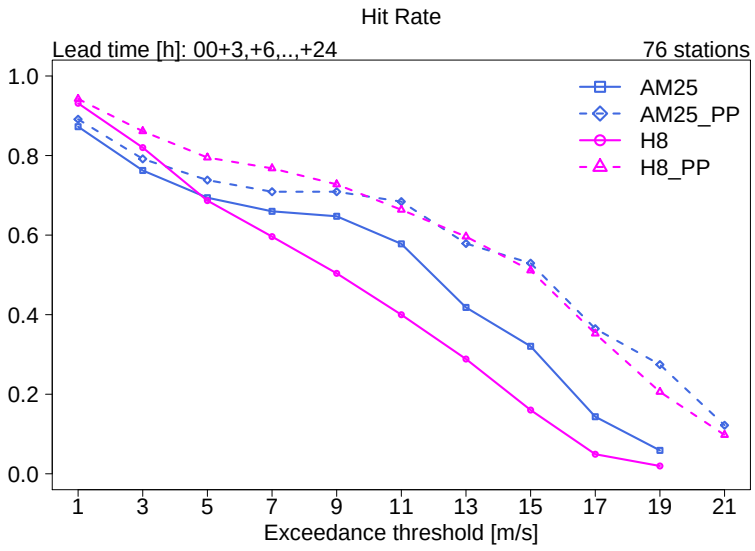

SDE
76 stations
AM25
AM25_PP
H8
H8_PP
2.5
2.0
1.5
1.0
[m/s]
3
9
15
21
27
33
39
45
51
57
63
Lead time [h]

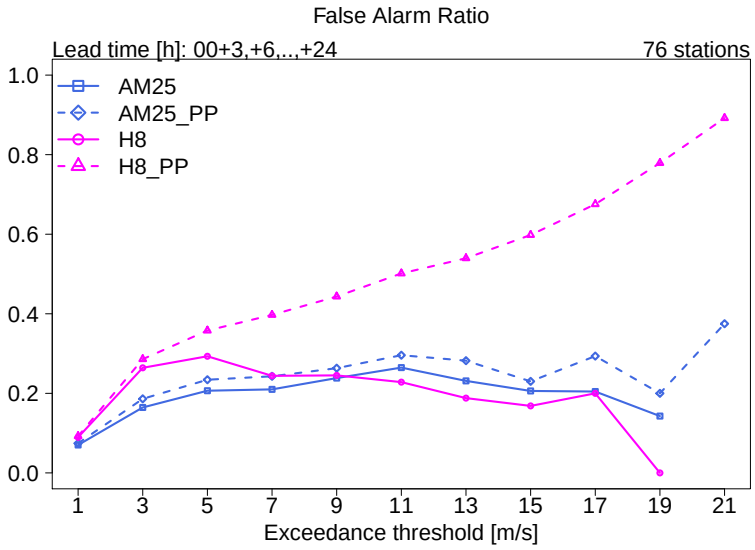

MAE
76 stations
AM25
AM25_PP
H8
H8_PP
2.2
2.0
1.8
1.6
1.4
1.2
1.0
0.8
[m/s]
3
9
15
21
27
33
39
45
51
57
63
Lead time [h]

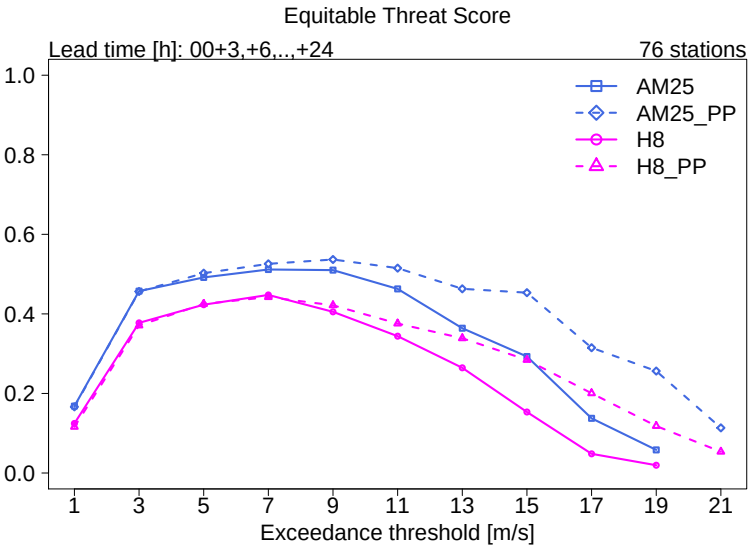
AM25 00+12

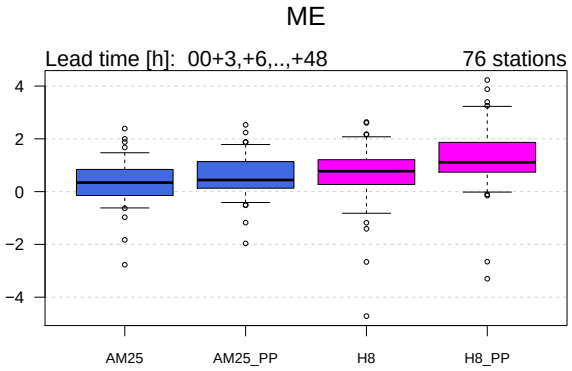
SDE at observing sites forecast means 01.09.2014 − 30.11.2014

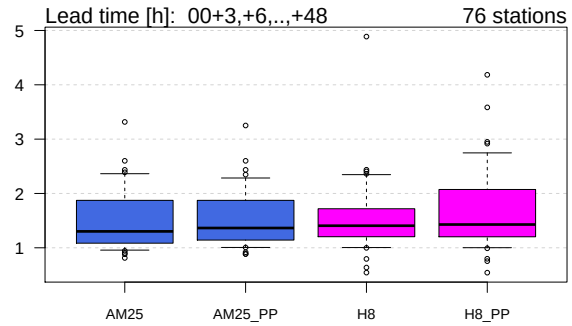



Hit Rate
Lead time [h]: 00+3,+6,..,+24
76 stations
AM25
AM25_PP
H8
H8_PP
1.0
0.8
0.6
0.4
0.2
0.0
1 3 5 7 9 11 13 15 17 19 21
Exceedance threshold [m/s]


False Alarm Ratio
Lead time [h]: 00+3,+6,..,+24
76 stations
AM25
AM25_PP
H8
H8_PP
1.0
0.8
0.6
0.4
0.2
0.0
1 3 5 7 9 11 13 15 17 19 21
Exceedance threshold [m/s]


Equitable Threat Score
Lead time [h]: 00+3,+6,..,+24
76 stations
AM25
AM25_PP
H8
H8_PP
1.0
0.8
0.6
0.4
0.2
0.0
1 3 5 7 9 11 13 15 17 19 21
Exceedance threshold [m/s]





Lead time [h]: 00+3,+6,..,+48 UTC 76 stations

AM25

OBS

	[0,3]	(3,11]	(11,17]	(17,21]	(21,Inf]	Sum
[0,3]	38377	9992	25	1	0	48395
(3,11]	6041	25511	1600	59	8	33219
(11,17]	12	787	1590	294	47	2730
(17,21]	0	4	12	41	19	76
(21,Inf]	0	0	0	0	0	0
Sum	44430	36294	3227	395	74	84420

AM25_PP

OBS

	[0,3]	(3,11]	(11,17]	(17,21]	(21,Inf]	Sum
[0,3]	37164	8815	14	1	0	45994
(3,11]	7251	26384	1244	34	2	34915
(11,17]	15	1091	1910	229	43	3288
(17,21]	0	4	59	124	20	207
(21,Inf]	0	0	0	7	9	16
Sum	44430	36294	3227	395	74	84420

H8

OBS

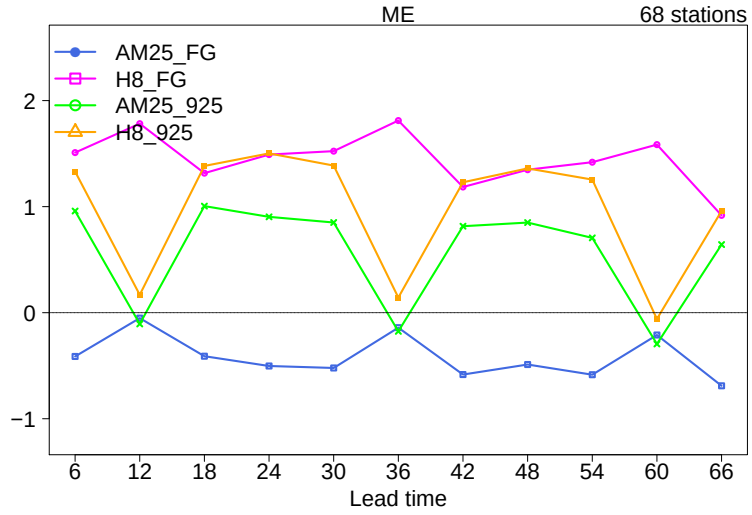
	[0,3]	(3,11]	(11,17]	(17,21]	(21,Inf]	Sum
[0,3]	32385	7532	56	2	0	39975
(3,11]	12038	28314	2034	154	66	42606
(11,17]	7	448	1133	223	0	1811
(17,21]	0	0	4	16	8	28
(21,Inf]	0	0	0	0	0	0
Sum	44430	36294	3227	395	74	84420

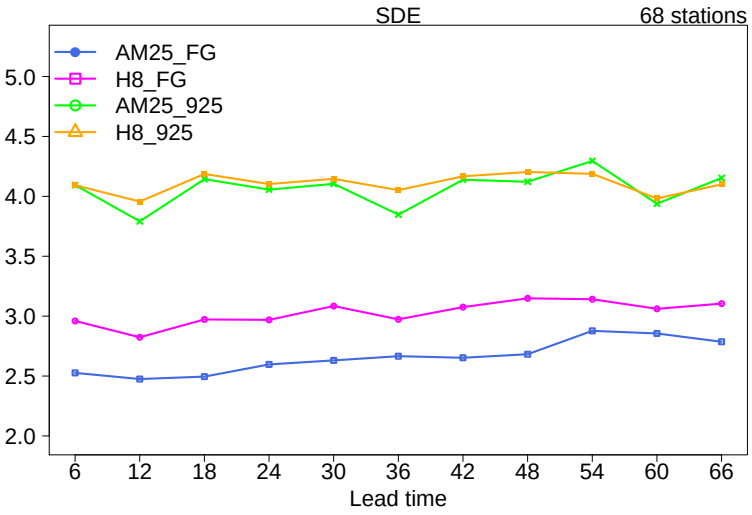
H8_PP

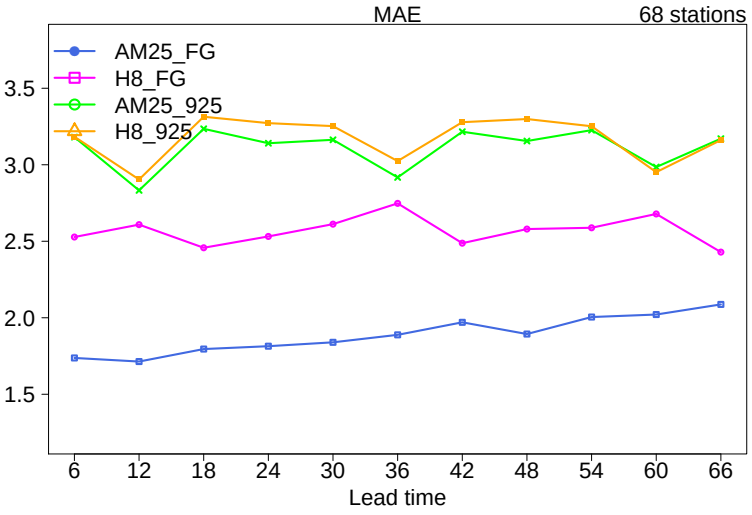
OBS

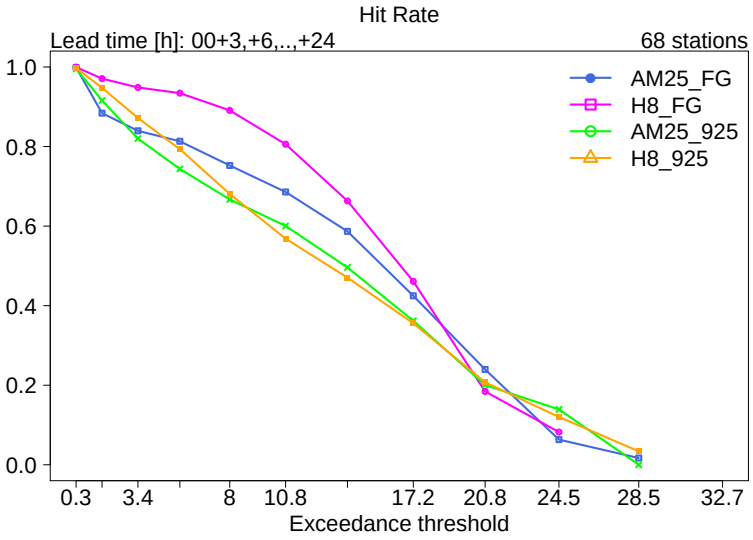
	[0,3]	(3,11]	(11,17]	(17,21]	(21,Inf]	Sum
[0,3]	30343	5854	27	0	0	36224
(3,11]	14021	28084	1120	140	62	43427
(11,17]	53	2305	1837	105	4	4304
(17,21]	13	44	215	126	0	398
(21,Inf]	0	7	28	24	8	67
Sum	44430	36294	3227	395	74	84420

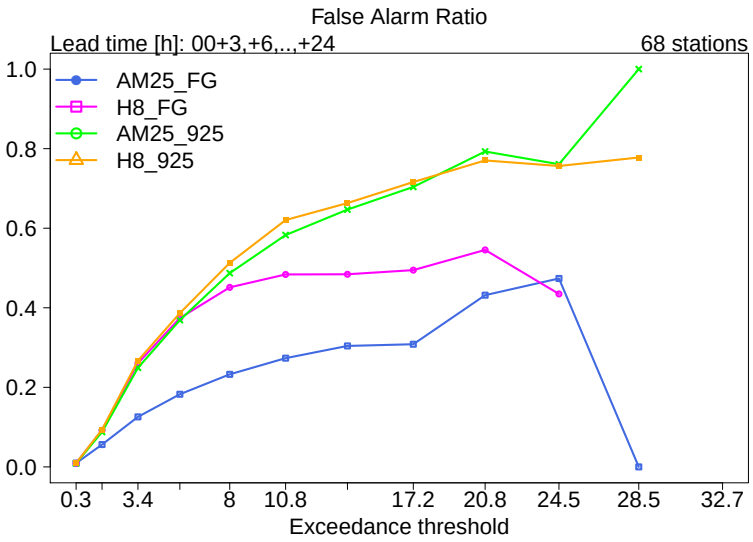
5.4 Wind gust

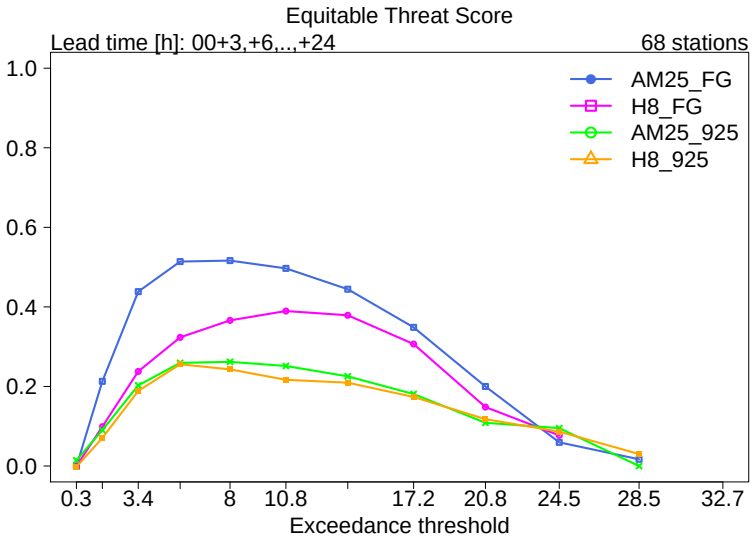

ME
68 stations
AM25_FG
H8_FG
AM25_925
H8_925
2
1
0
−1
6
12
18
24
30
36
42
48
54
60
66
Lead time


SDE
68 stations
AM25_FG
H8_FG
AM25_925
H8_925
5.0
4.5
4.0
3.5
3.0
2.5
2.0
6
12
18
24
30
36
42
48
54
60
66
Lead time

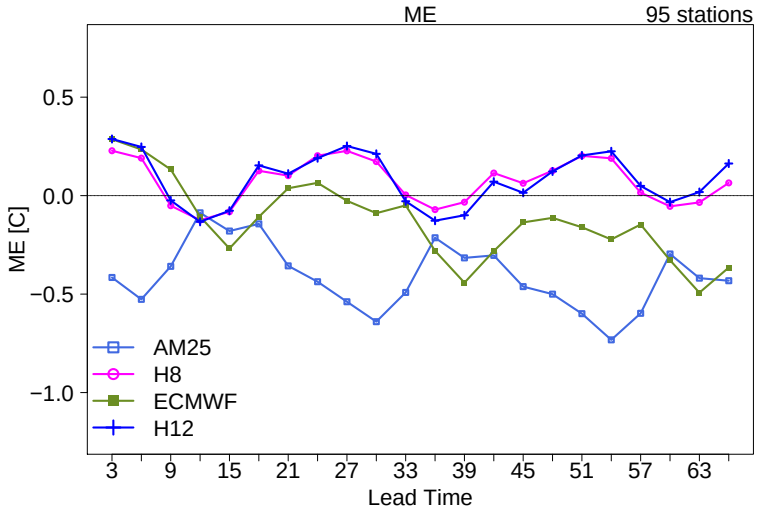

MAE
68 stations
AM25_FG
H8_FG
AM25_925
H8_925
3.5
3.0
2.5
2.0
1.5
6
12
18
24
30
36
42
48
54
60
66
Lead time

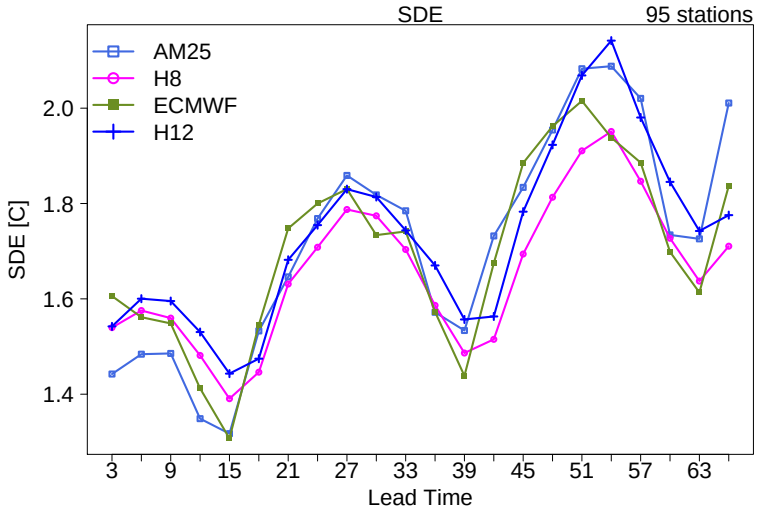

Hit Rate
Lead time [h]: 00+3,+6,..,+24
68 stations
AM25_FG
H8_FG
AM25_925
H8_925
1.0
0.8
0.6
0.4
0.2
0.0
0.3
3.4
8
10.8
17.2
20.8
24.5
28.5
32.7
Exceedance threshold

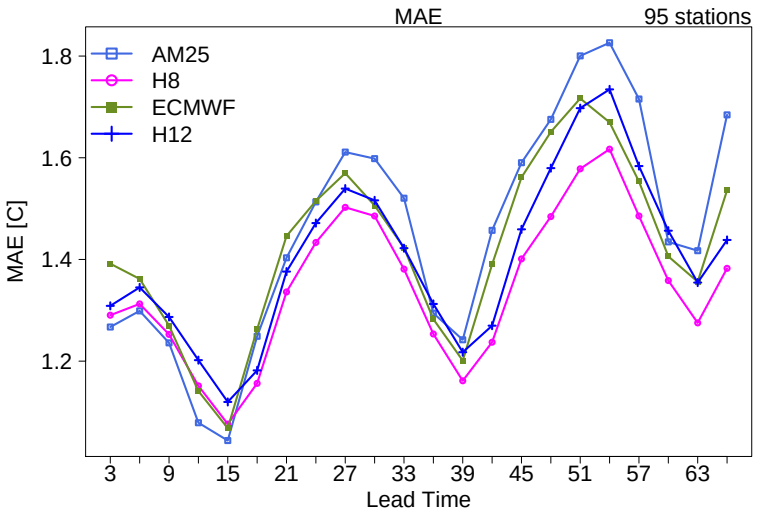

False Alarm Ratio
Lead time [h]: 00+3,+6,..,+24
68 stations
AM25_FG
H8_FG
AM25_925
H8_925
1.0
0.8
0.6
0.4
0.2
0.0
0.3
3.4
8
10.8
17.2
20.8
24.5
28.5
32.7
Exceedance threshold

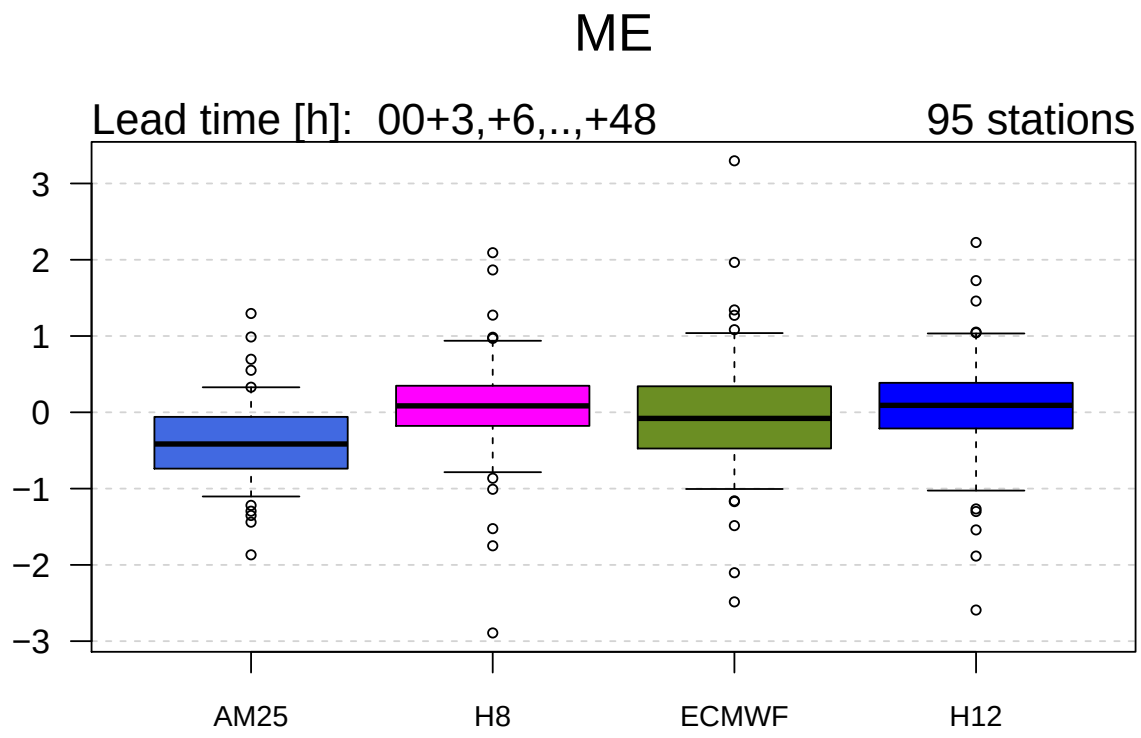

Equitable Threat Score
Lead time [h]: 00+3,+6,..,+24
68 stations
AM25_FG
H8_FG
AM25_925
H8_925
1.0
0.8
0.6
0.4
0.2
0.0
0.3
3.4
8
10.8
17.2
20.8
24.5
28.5
32.7
Exceedance threshold

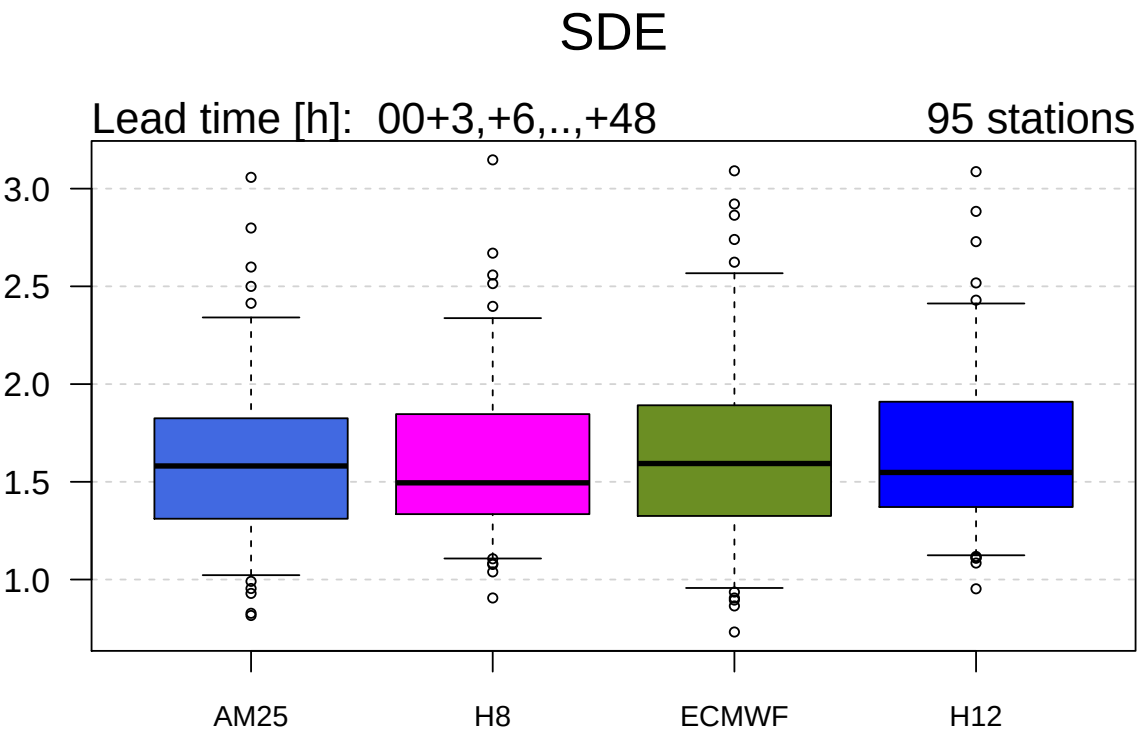
5.5 Temperature 2m





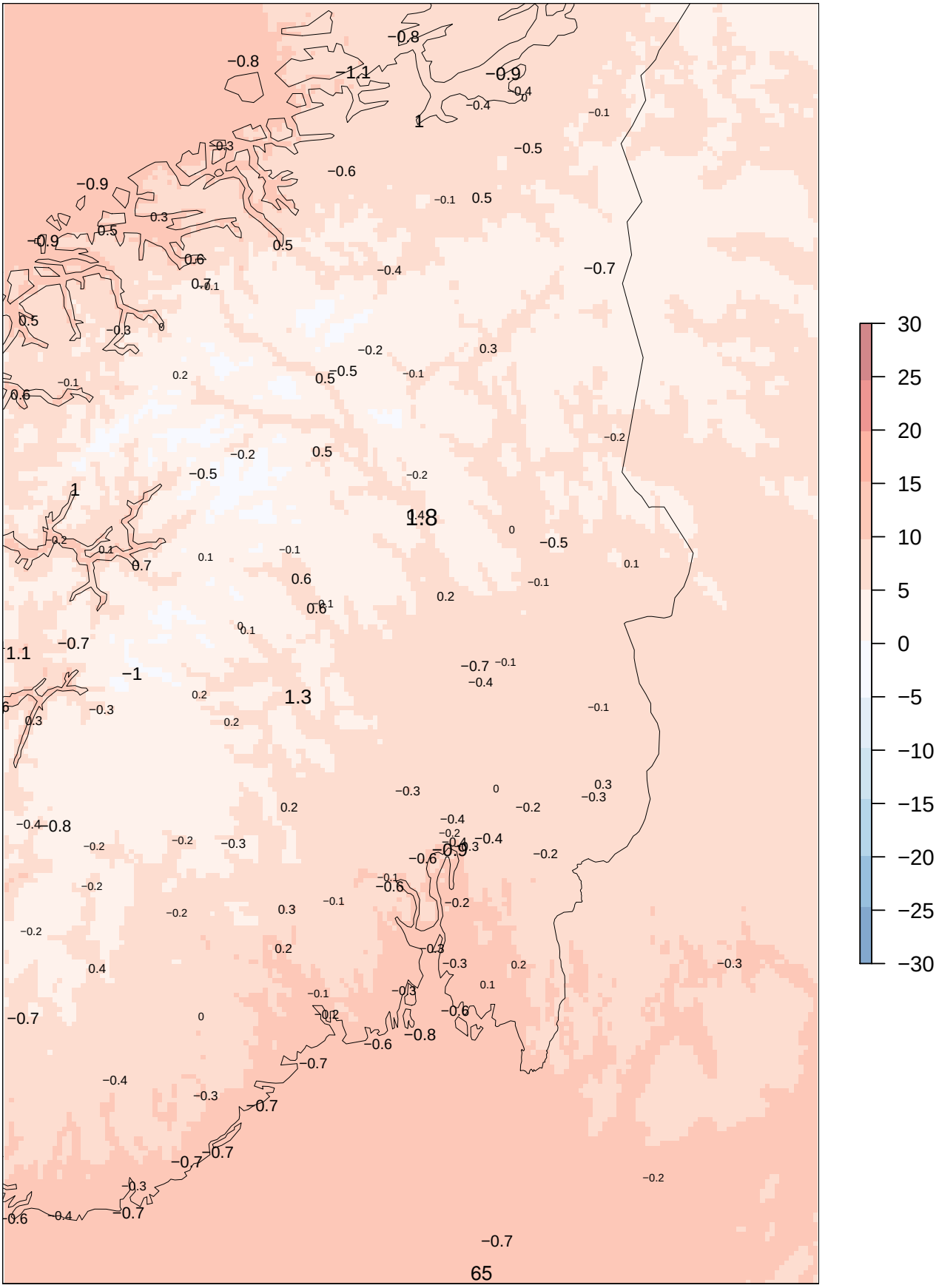



ME
Lead time [h]: 00+3,+6,..,+48
95 stations
3
2
1
0
−1
−2
−3
AM25
H8
ECMWF
H12


SDE
Lead time [h]: 00+3,+6,..,+48
95 stations
3.0
2.5
2.0
1.5
1.0
AM25
H8
ECMWF
H12

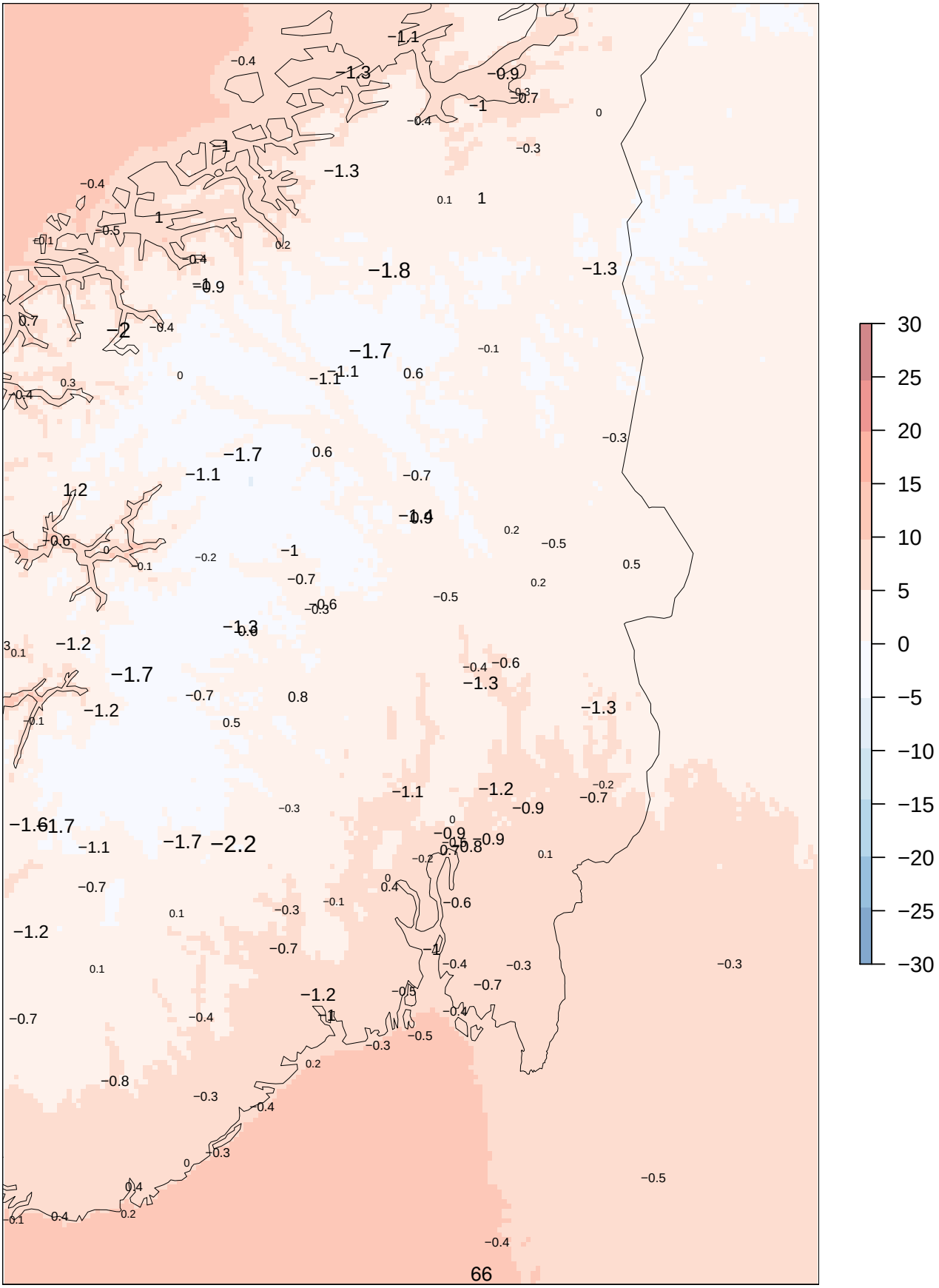
AM25 00+12

ME at observing sites forecast means 01.09.2014 − 30.11.2014



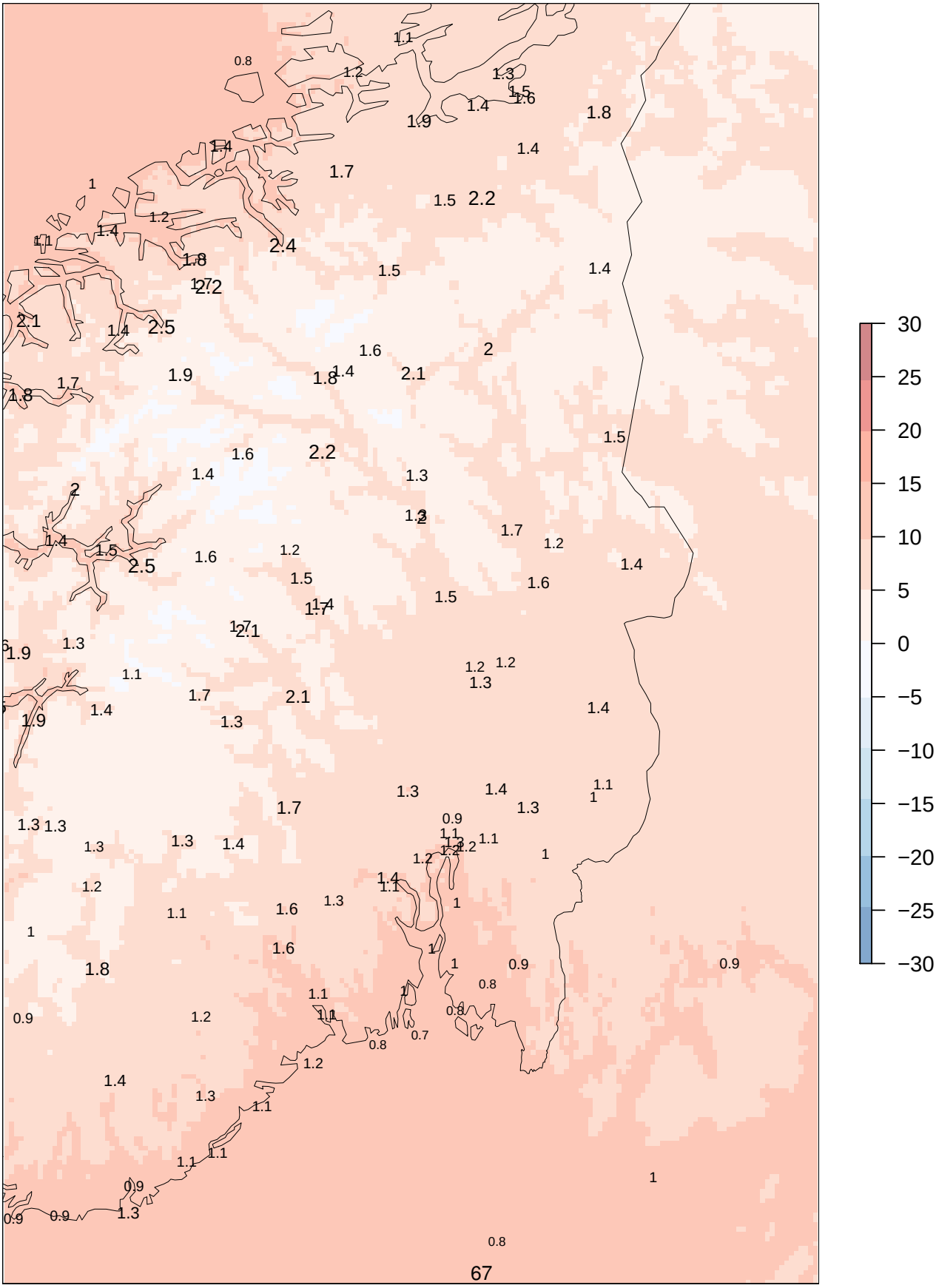
AM25 00+24

ME at observing sites forecast means 01.09.2014 − 30.11.2014



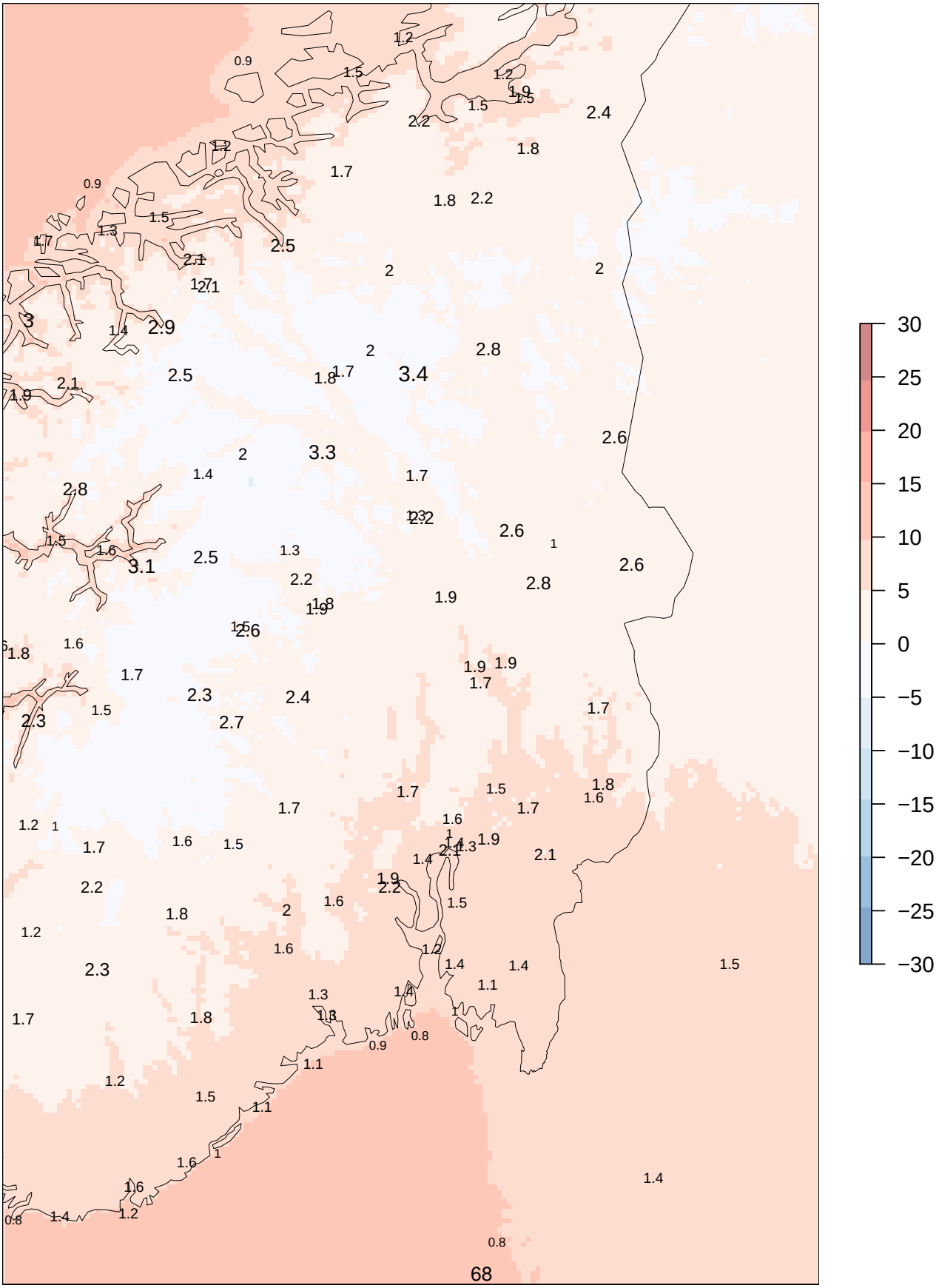
AM25 00+12

SDE at observing sites forecast means 01.09.2014 − 30.11.2014

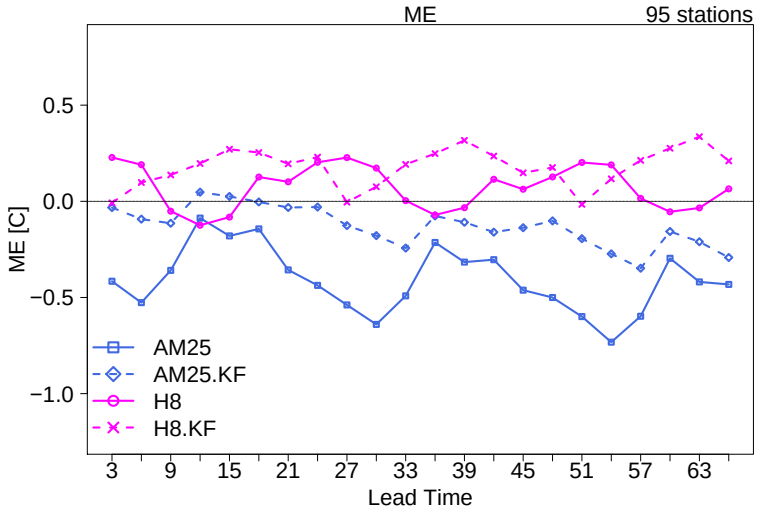


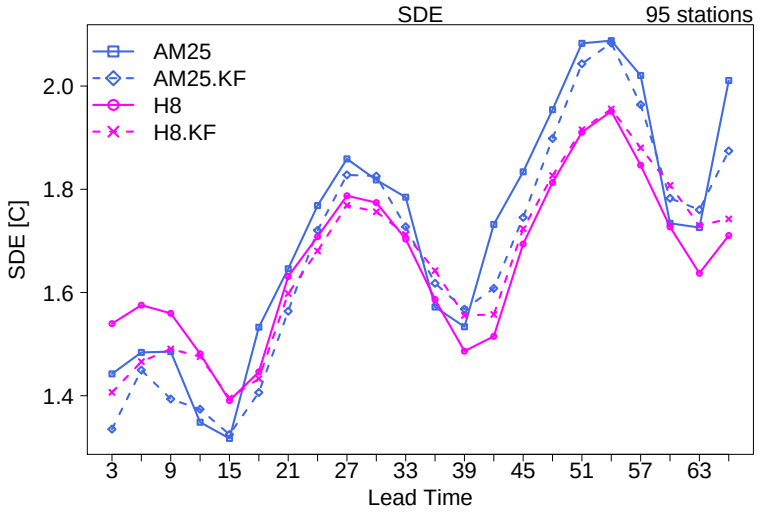
AM25 00+24

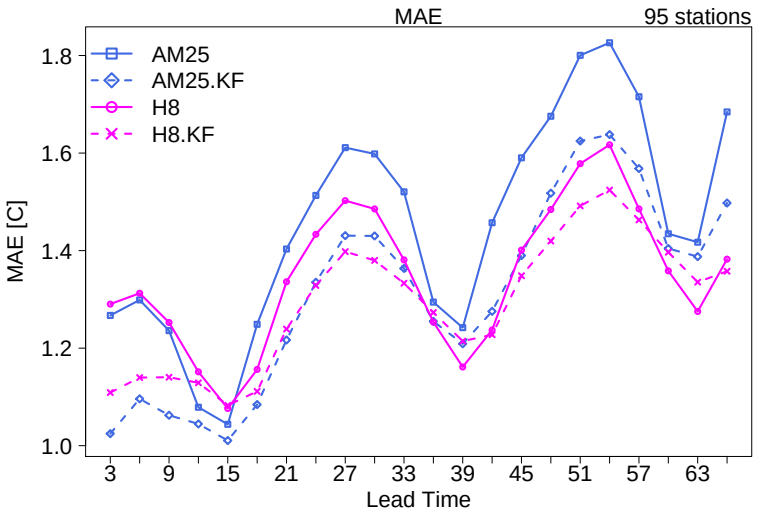
SDE at observing sites forecast means 01.09.2014 − 30.11.2014

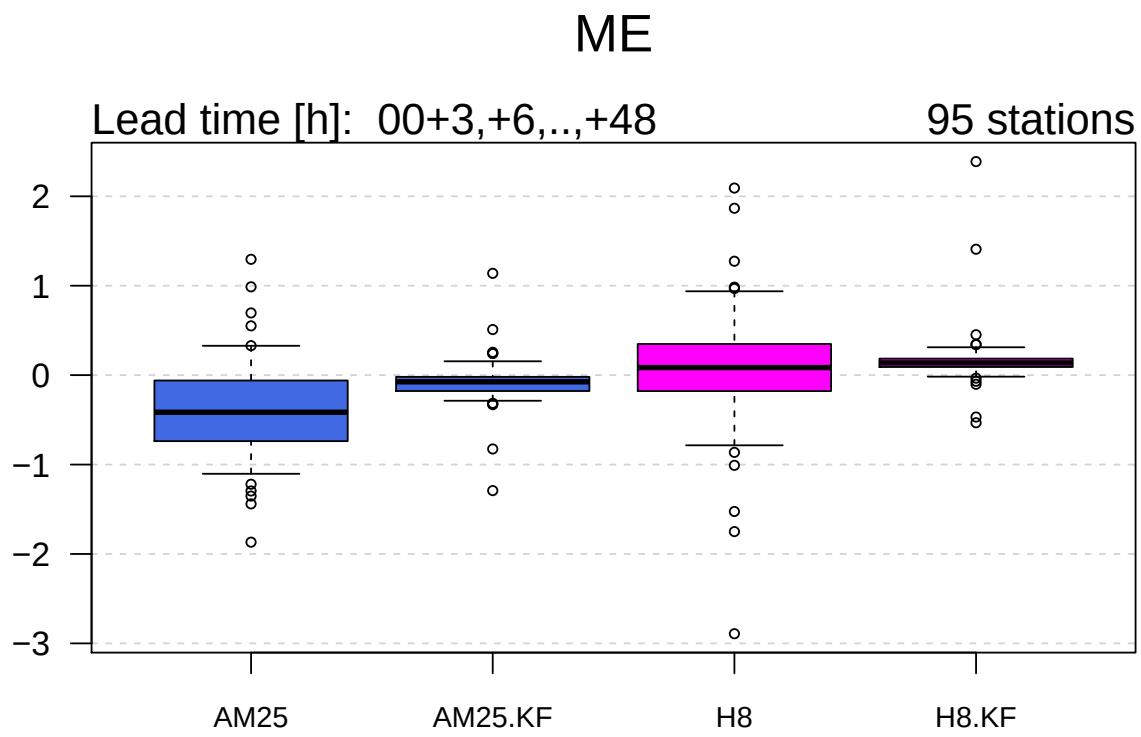


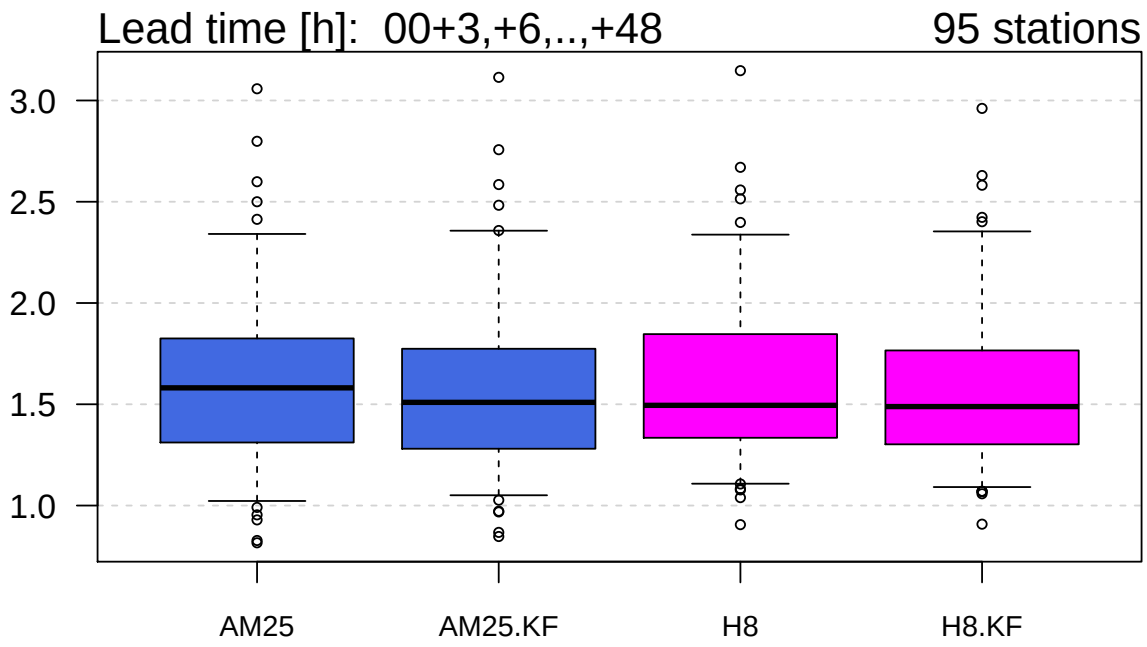
5.6 Post processed temperature 2m



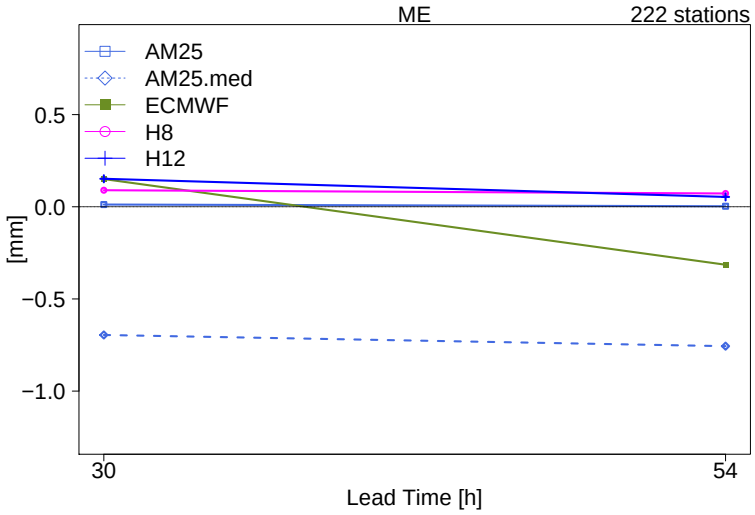


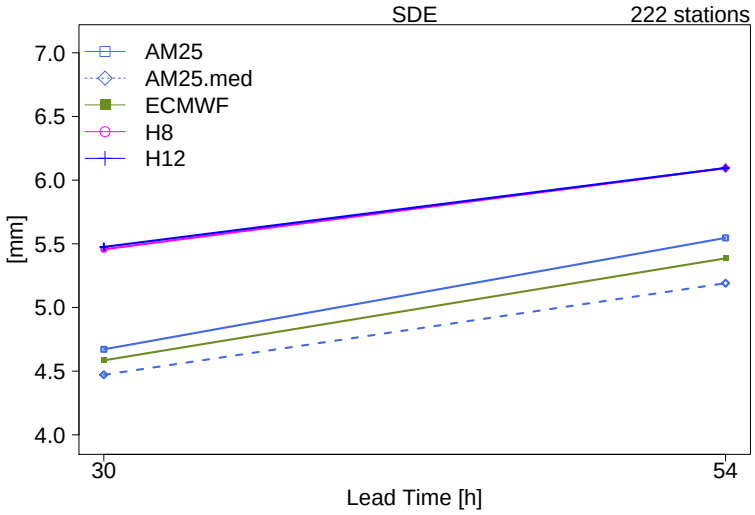


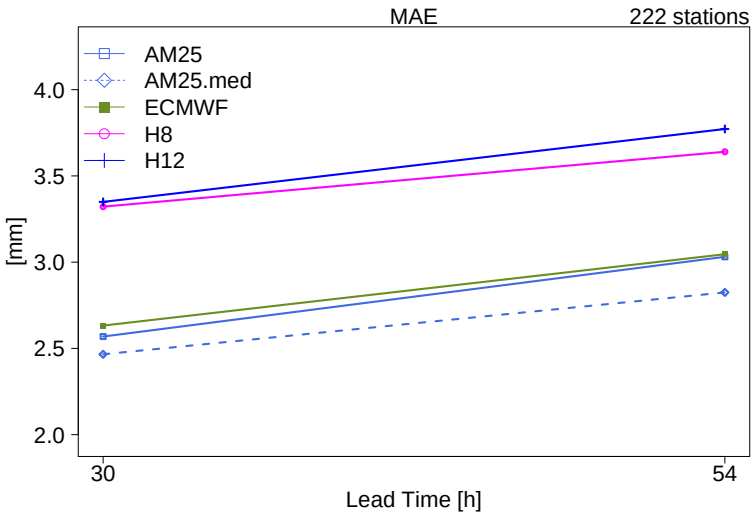

ME
Lead time [h]: 00+3,+6,..,+48
95 stations
2
1
0
−1
−2
−3
AM25
AM25.KF
H8
H8.KF

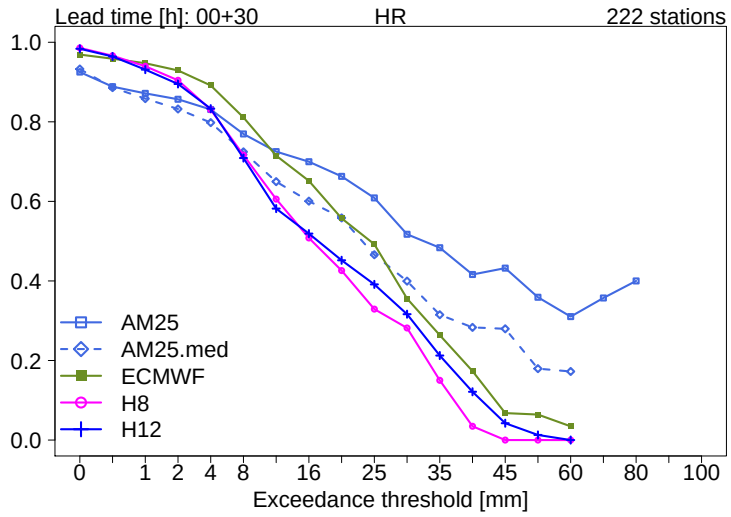

SDE
Lead time [h]: 00+3,+6,..,+48
95 stations
3.0
2.5
2.0
1.5
1.0
AM25
AM25.KF
H8
H8.KF

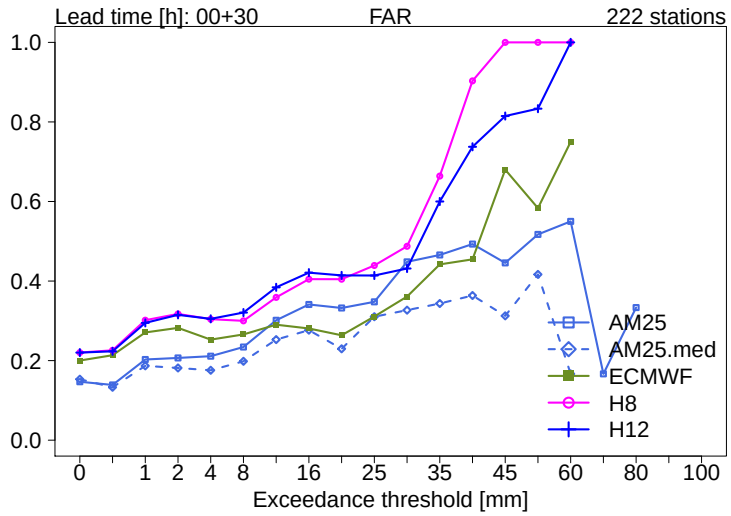
5.7 Daily precipitation

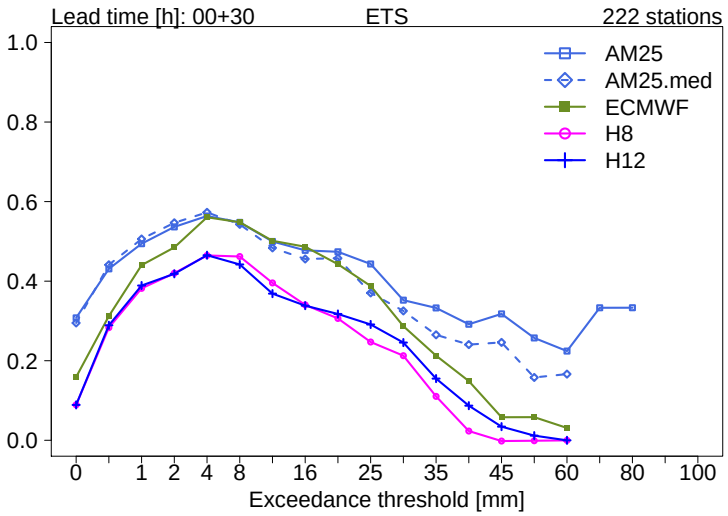


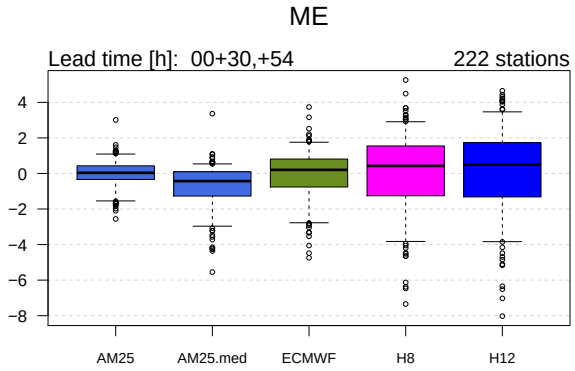


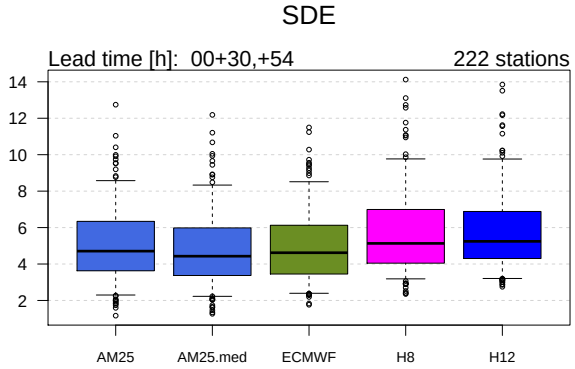



Lead time [h]: 00+30
HR
222 stations
1.0
0.8
0.6
0.4
0.2
0.0
AM25
AM25.med
ECMWF
H8
H12
0 1 2 4 8 16 25 35 45 60 80 100
Exceedance threshold [mm]


Lead time [h]: 00+30
FAR
222 stations
1.0
0.8
0.6
0.4
0.2
0.0
AM25
AM25.med
ECMWF
H8
H12
0 1 2 4 8 16 25 35 45 60 80 100
Exceedance threshold [mm]


Lead time [h]: 00+30
ETS
222 stations
1.0
0.8
0.6
0.4
0.2
0.0
AM25
AM25.med
ECMWF
H8
H12
0 1 2 4 8 16 25 35 45 60 80 100
Exceedance threshold [mm]





Lead time [h]: 00+30,+54 222 stations

AM25 — OBS

	[0,0.1]	(0.1,5]	(5,20]	(20,50]	(50,Inf]	Sum
[0,0.1]	6902	2438	54	1	2	9397
(0.1,5]	2904	7993	1494	59	2	12452
(5,20]	169	1816	4264	646	23	6918
(20,50]	18	94	567	1015	77	1771
(50,Inf]	0	1	10	48	52	111
Sum	9993	12342	6389	1769	156	30649

AM25.med — OBS

	[0,0.1]	(0.1,5]	(5,20]	(20,50]	(50,Inf]	Sum
[0,0.1]	7066	2457	73	4	2	9602
(0.1,5]	2810	8388	1709	73	1	12981
(5,20]	103	1464	4264	799	33	6663
(20,50]	14	33	342	876	97	1362
(50,Inf]	0	0	1	17	23	41
Sum	9993	12342	6389	1769	156	30649

ECMWF — OBS

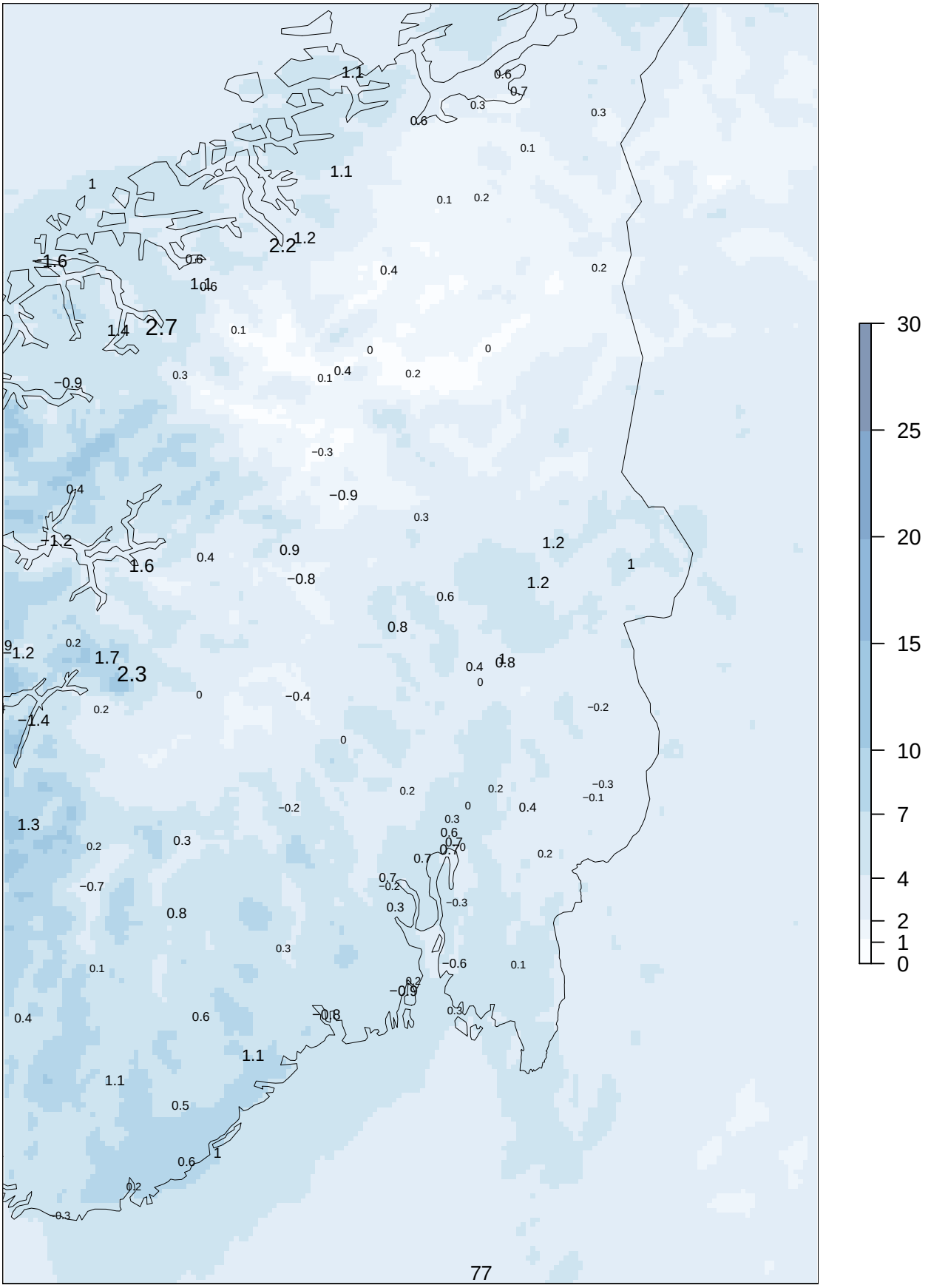
	[0,0.1]	(0.1,5]	(5,20]	(20,50]	(50,Inf]	Sum
[0,0.1]	4720	980	14	0	0	5714
(0.1,5]	5047	9195	1301	26	0	15569
(5,20]	214	2108	4680	867	31	7900
(20,50]	12	59	392	865	117	1445
(50,Inf]	0	0	2	11	8	21
Sum	9993	12342	6389	1769	156	30649

H8 — OBS

	[0,0.1]	(0.1,5]	(5,20]	(20,50]	(50,Inf]	Sum
[0,0.1]	4126	806	20	0	0	4952
(0.1,5]	5564	8749	1633	100	13	16059
(5,20]	286	2731	4199	960	53	8229
(20,50]	16	56	534	681	90	1377
(50,Inf]	1	0	3	28	0	32
Sum	9993	12342	6389	1769	156	30649

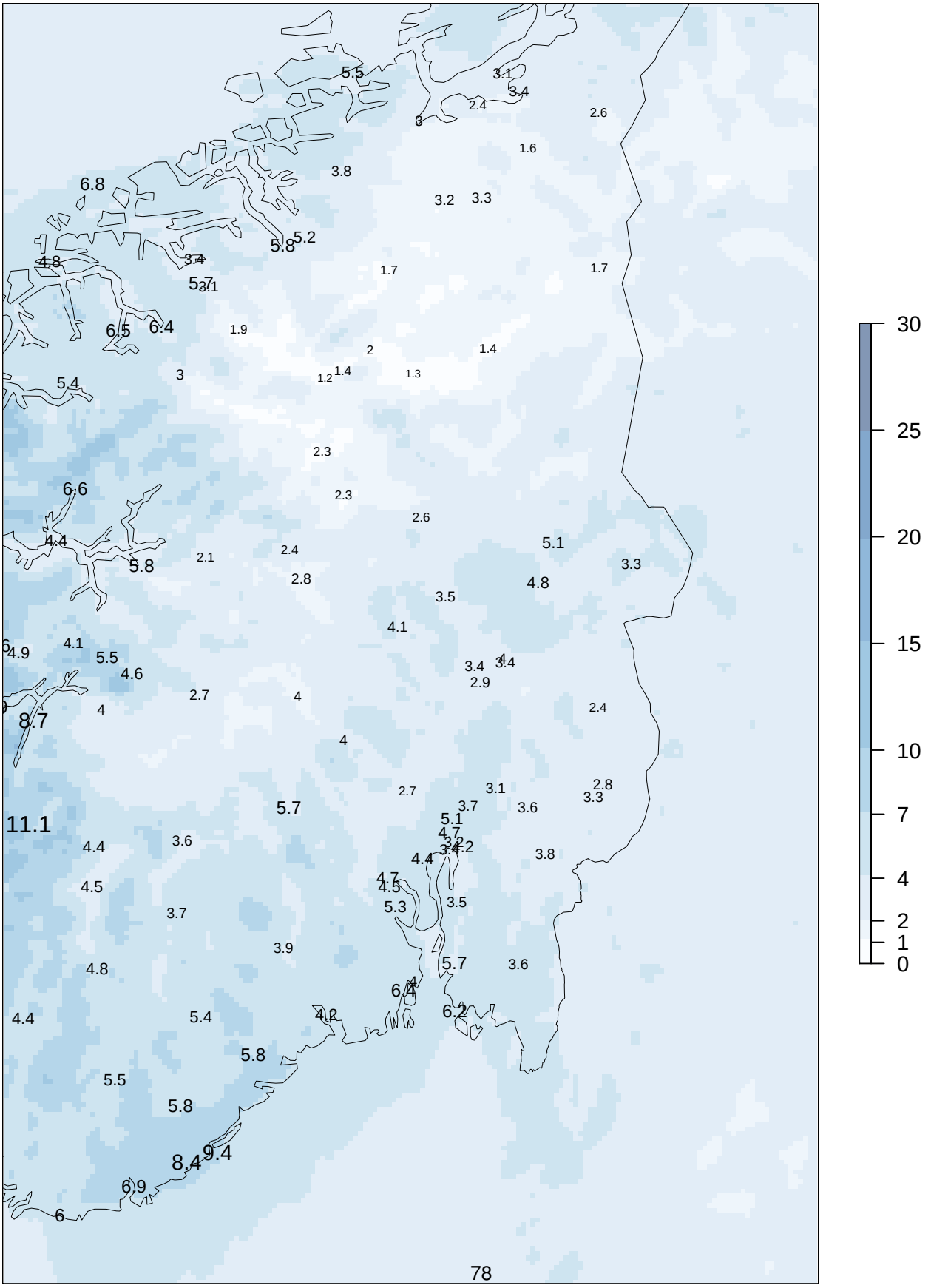
AM25 00+30

ME at observing sites forecast means 01.09.2014 − 30.11.2014



AM25 00+30

SDE at observing sites forecast means 01.09.2014 − 30.11.2014



6 Western Norway

6.1 Comments to the verification results

Wind speed 10 m:
For the period 1st of September to 30st of November 2014, AM25 has a small negative bias in wind speed during the afternoon and almost no bias during nighttime. Hirlam12, Hirlam8 and ECMWF has also a diurnal variation in bias. Hirlam12 and Hirlam8 has a positive bias during nighttime and almost no bias in the afternoon, while ECMWF has a negative bias during both daytime and nighttime. AM25 scores best for almost all wind speeds, except for wind speed between $15 - 17ms^{-1}$, where Hirlam8 is slightly better.

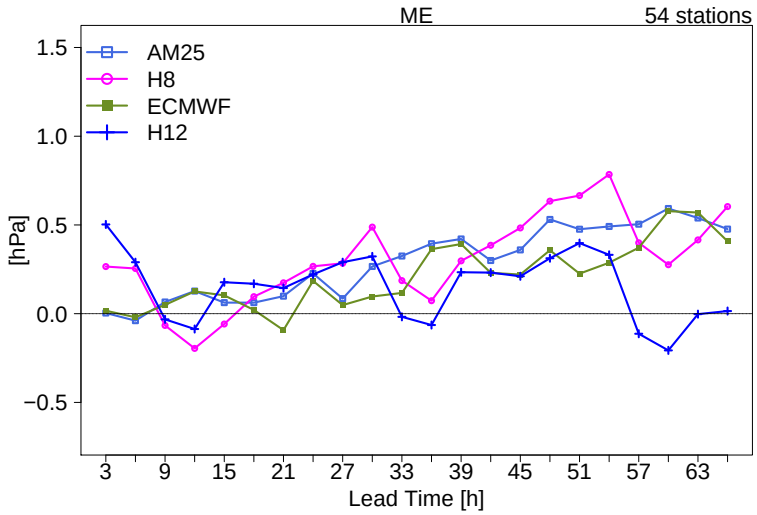
Max mean wind speed 10 m:
For Max Mean Wind Speed, both AM25 and Hirlam8 have a negative bias. After post processing the bias are about $-0.6ms^{-1}$ for AM25 and $+0.1ms^{-1}$ for Hirlam8. For Max mean wind speed AM25 scores better for weak winds and wind speeds above $17ms^{-1}$, while Hirlam8 scores slightly better for wind speeds between $11 - 16ms^{-1}$.

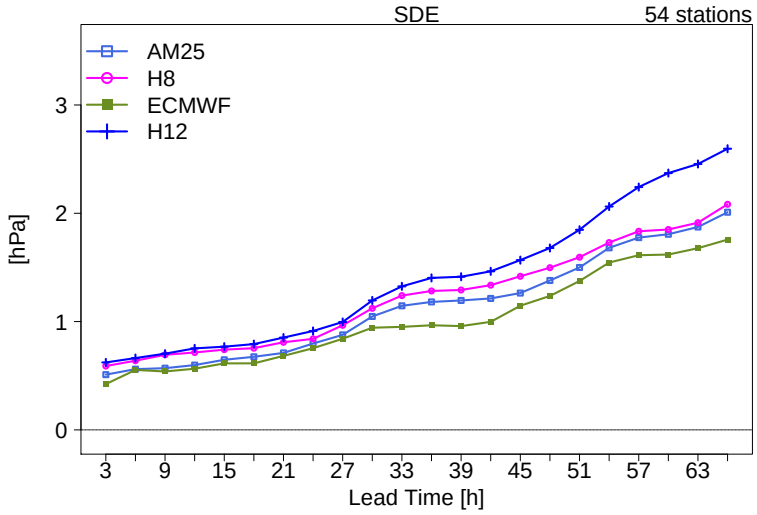
Wind gust:
For wind gust AM25 has a negative bias arond $-1ms^{-1}$, while Hirlam8 has a positive bias arond $+1.1ms^{-1}$. If we look at wind speed at 925 hPa (which often is used as an estimate of wind gust), the are only minor differences in bias between the AM25 and Hirlam8. The wind at 925 hPa scores better for the strongest winds than wind gust.

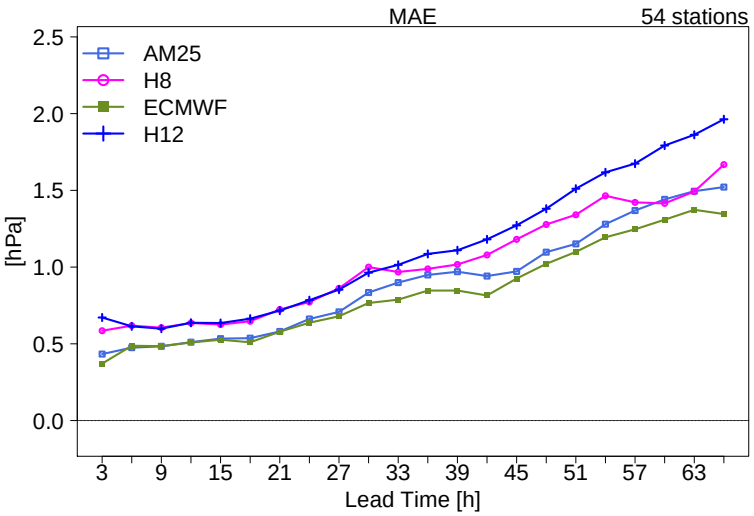
Temperature 2m:
For temperature Hirlam12 and Hirlam8 has almost no bias, while ECMWF and AM25 has a negative bias. After post-processing the bias is small and positive for Hirlam8 and small and negative for AM25.

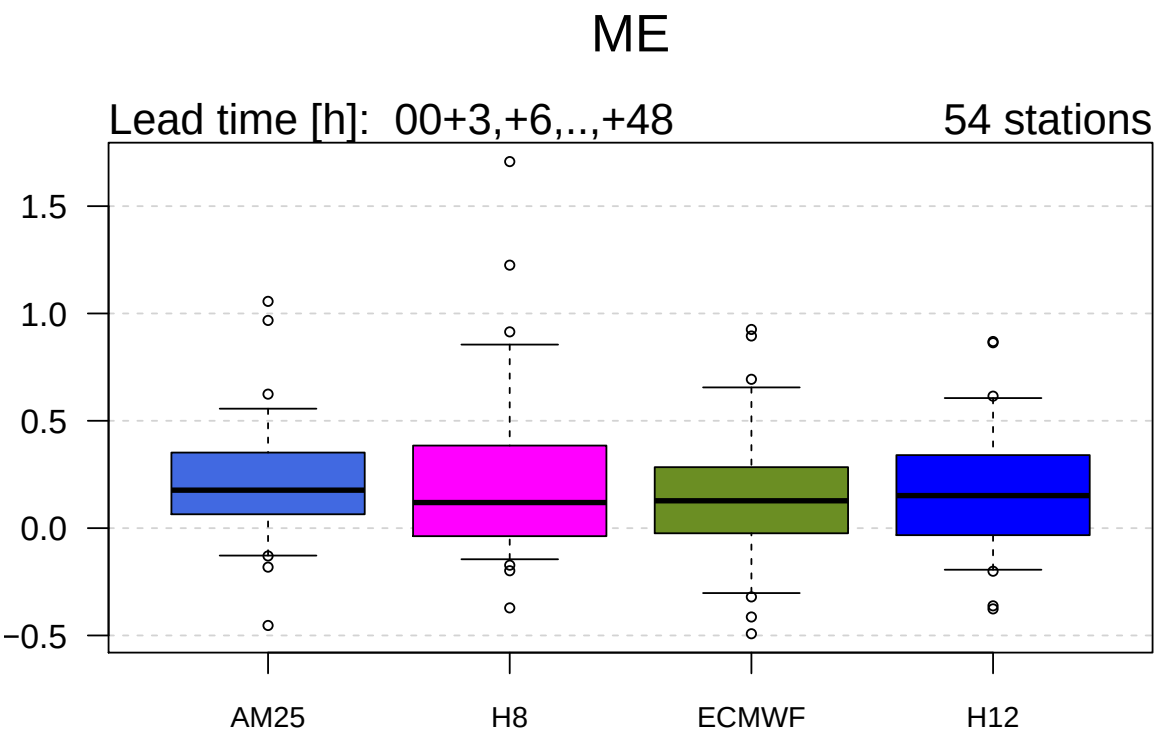
Precipitation:
For precipitation ECWMF has positive bias, while Hirlam12 and Hirlam8 and AM25 has a negative bias. For light and heavy precipitation AM25 are the best models, while ECMWF is slightly better for 24-hours precipitation between 5 and 30 mm.

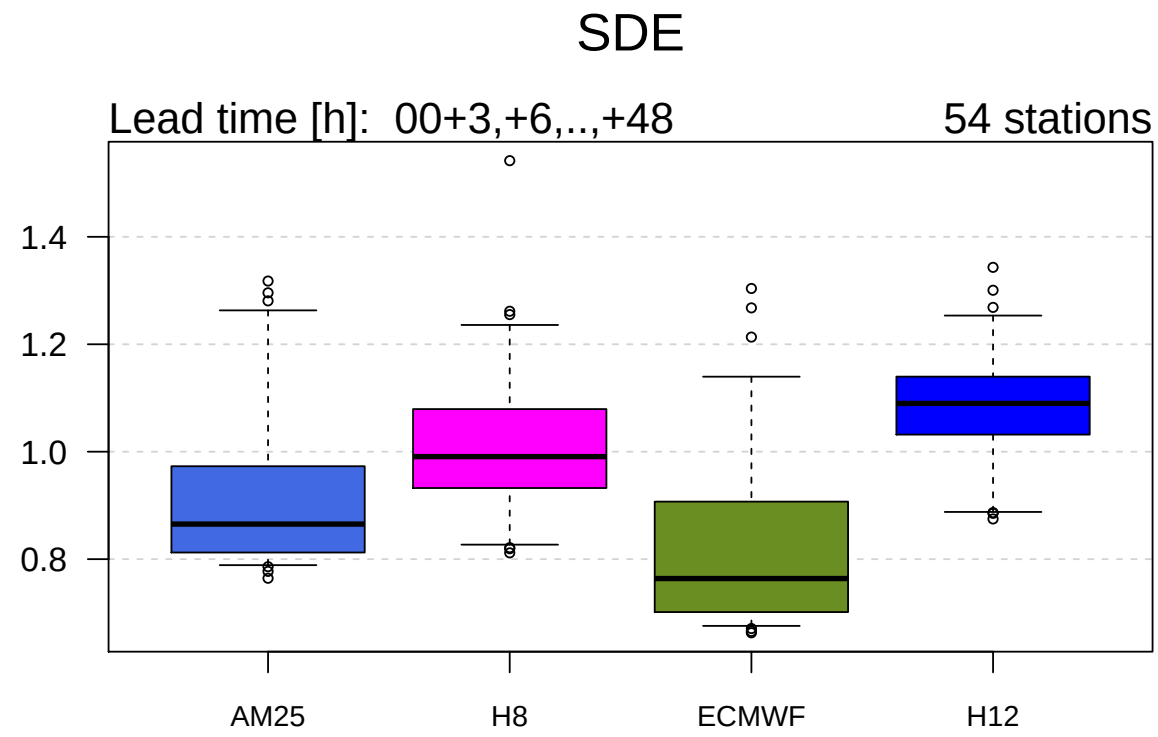
6.2 Pressure


ME
54 stations
AM25
H8
ECMWF
H12
[hPa]
1.5
1.0
0.5
0.0
−0.5
3
9
15
21
27
33
39
45
51
57
63
Lead Time [h]

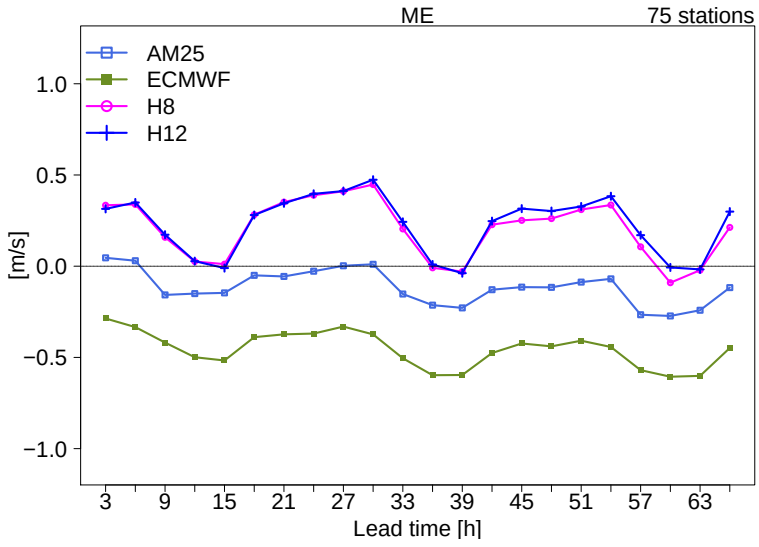

SDE
54 stations
AM25
H8
ECMWF
H12
[hPa]
3
2
1
0
3
9
15
21
27
33
39
45
51
57
63
Lead Time [h]

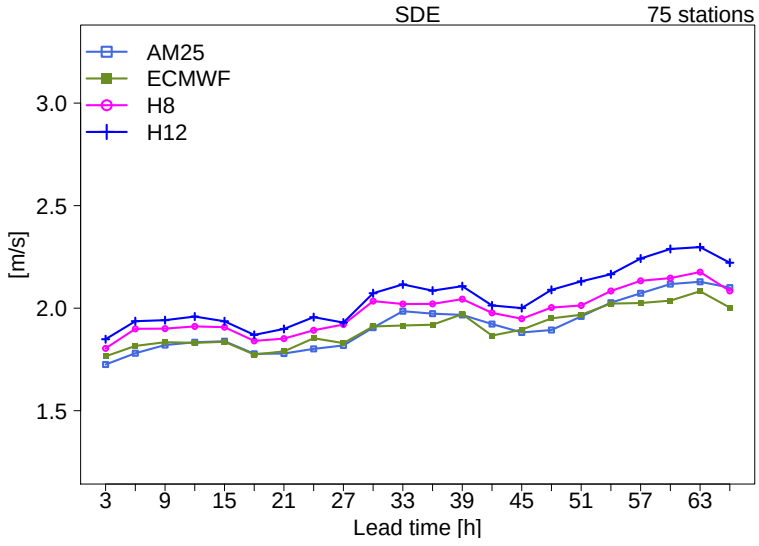

MAE
54 stations
AM25
H8
ECMWF
H12
[hPa]
2.5
2.0
1.5
1.0
0.5
0.0
3
9
15
21
27
33
39
45
51
57
63
Lead Time [h]

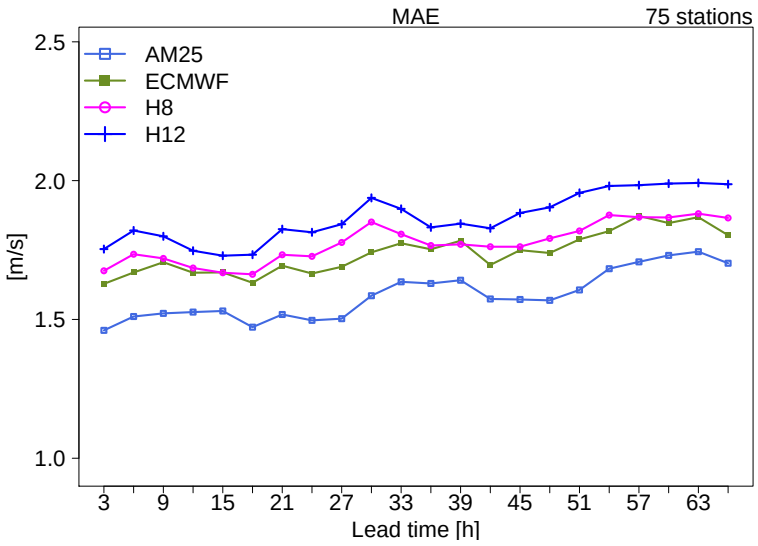

ME
Lead time [h]: 00+3,+6,..,+48
54 stations
1.5
1.0
0.5
0.0
−0.5
AM25
H8
ECMWF
H12

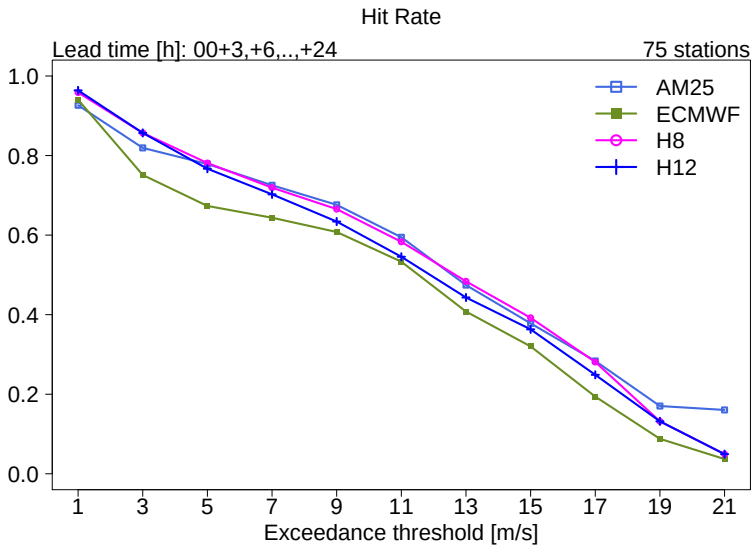

SDE
Lead time [h]: 00+3,+6,..,+48
54 stations
1.4
1.2
1.0
0.8
AM25
H8
ECMWF
H12

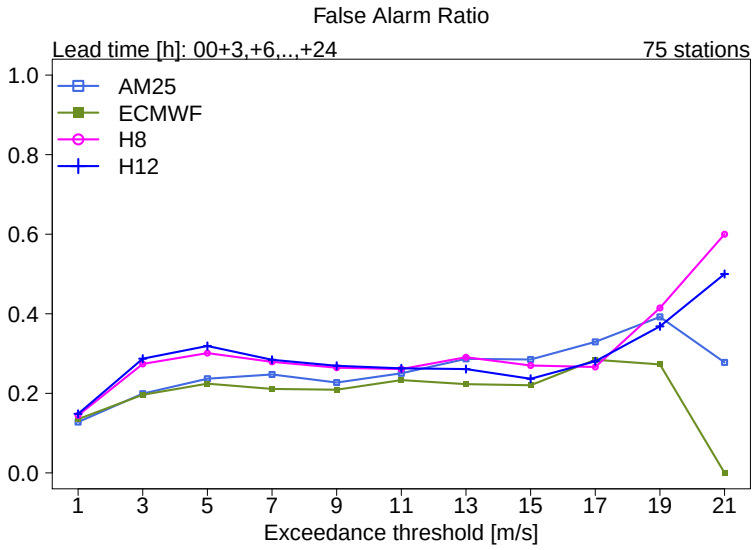
6.3 Wind Speed 10m

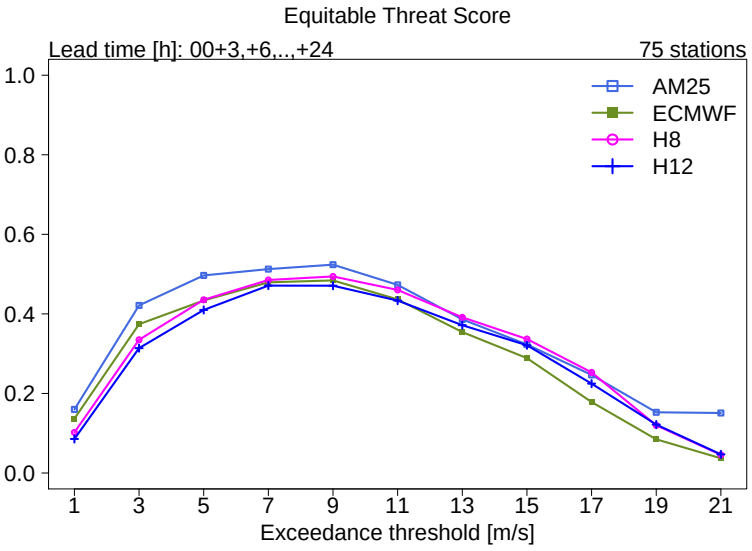


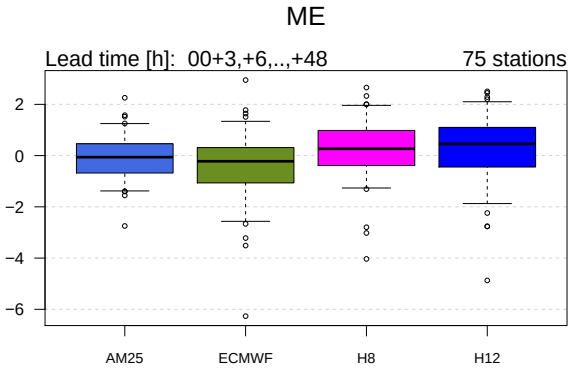


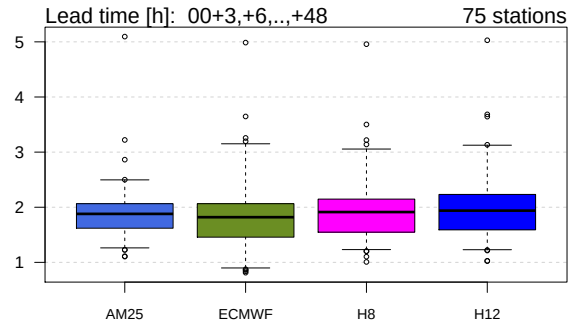



Hit Rate
Lead time [h]: 00+3,+6,..,+24
75 stations
AM25
ECMWF
H8
H12
1.0
0.8
0.6
0.4
0.2
0.0
1 3 5 7 9 11 13 15 17 19 21
Exceedance threshold [m/s]


False Alarm Ratio
Lead time [h]: 00+3,+6,..,+24
75 stations
AM25
ECMWF
H8
H12
1.0
0.8
0.6
0.4
0.2
0.0
1 3 5 7 9 11 13 15 17 19 21
Exceedance threshold [m/s]


Equitable Threat Score
Lead time [h]: 00+3,+6,..,+24
75 stations
AM25
ECMWF
H8
H12
1.0
0.8
0.6
0.4
0.2
0.0
1 3 5 7 9 11 13 15 17 19 21
Exceedance threshold [m/s]





Lead time [h]: 00+3,+6,..,+48 UTC 75 stations

AM25

OBS

	[0,3]	(3,11]	(11,17]	(17,21]	(21,Inf]	Sum
[0,3]	34638	9447	25	2	0	44112
(3,11]	10160	33008	2559	44	1	45772
(11,17]	73	1203	2789	446	76	4587
(17,21]	23	9	77	140	59	308
(21,Inf]	2	1	5	6	21	35
Sum	44896	43668	5455	638	157	94814

H8

OBS

	[0,3]	(3,11]	(11,17]	(17,21]	(21,Inf]	Sum
[0,3]	28540	7425	26	0	0	35991
(3,11]	16286	34927	2580	67	3	53863
(11,17]	50	1312	2782	445	77	4666
(17,21]	19	4	65	118	73	279
(21,Inf]	1	0	2	8	4	15
Sum	44896	43668	5455	638	157	94814

ECMWF

OBS

	[0,3]	(3,11]	(11,17]	(17,21]	(21,Inf]	Sum
[0,3]	35664	12783	185	6	0	48638
(3,11]	9172	29936	2739	56	4	41907
(11,17]	40	946	2488	495	91	4060
(17,21]	20	3	43	81	59	206
(21,Inf]	0	0	0	0	3	3
Sum	44896	43668	5455	638	157	94814

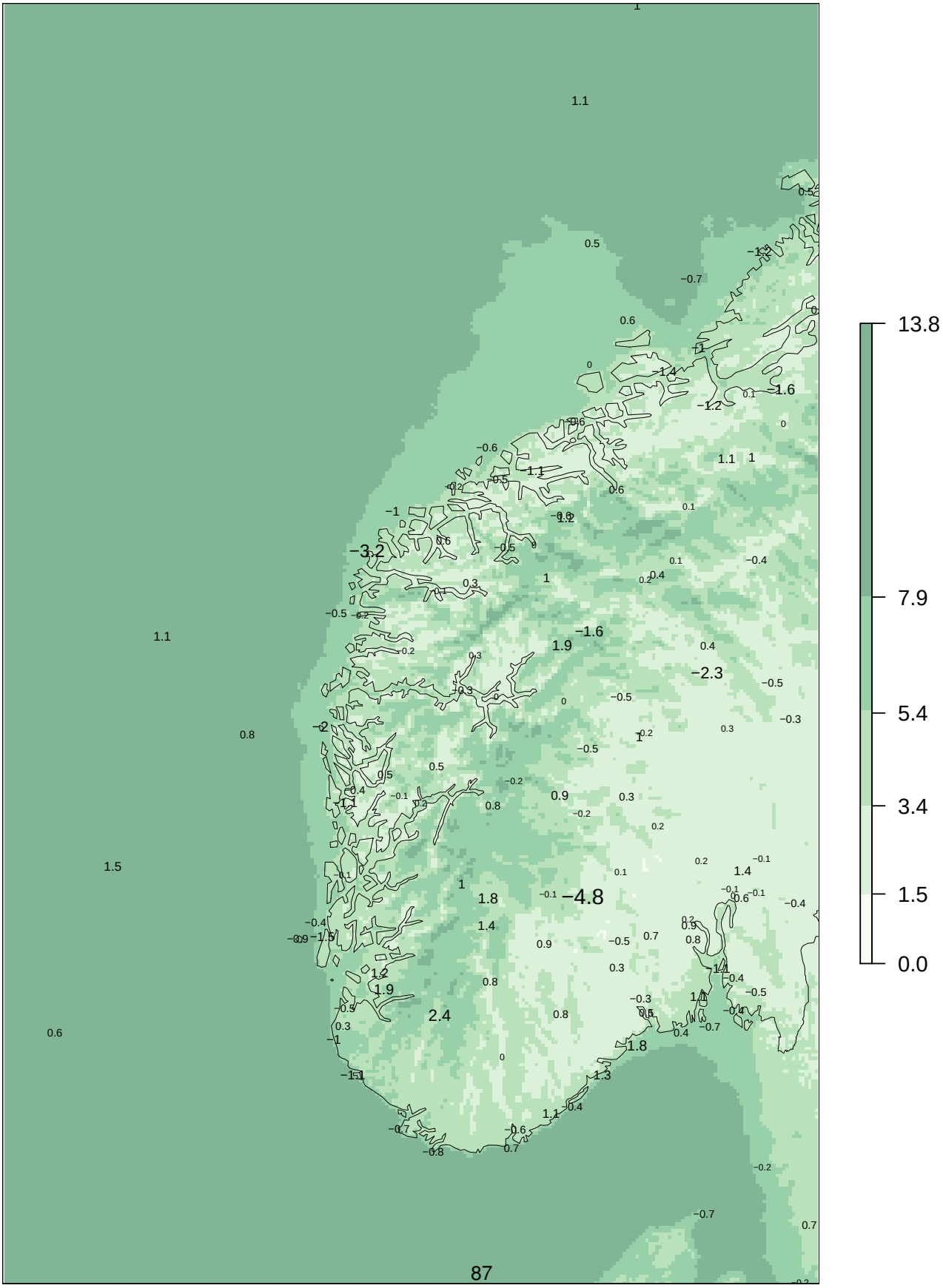
H12

OBS

	[0,3]	(3,11]	(11,17]	(17,21]	(21,Inf]	Sum
[0,3]	27398	7309	67	2	0	34776
(3,11]	17426	35096	2729	84	5	55340
(11,17]	51	1253	2612	441	87	4444
(17,21]	20	9	46	105	59	239
(21,Inf]	1	1	1	6	6	15
Sum	44896	43668	5455	638	157	94814

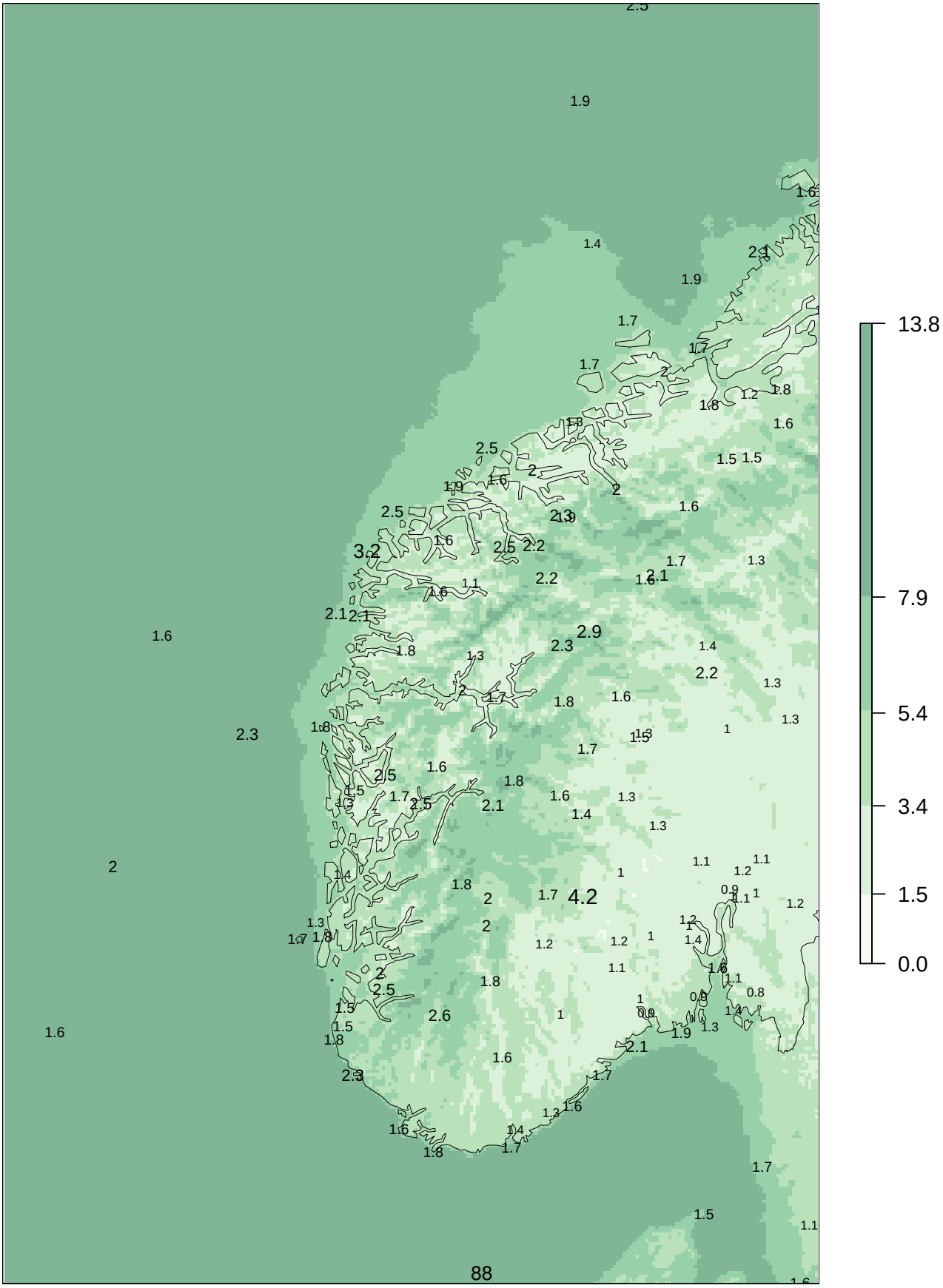
AM25 00+12

ME at observing sites forecast means 01.09.2014 − 30.11.2014

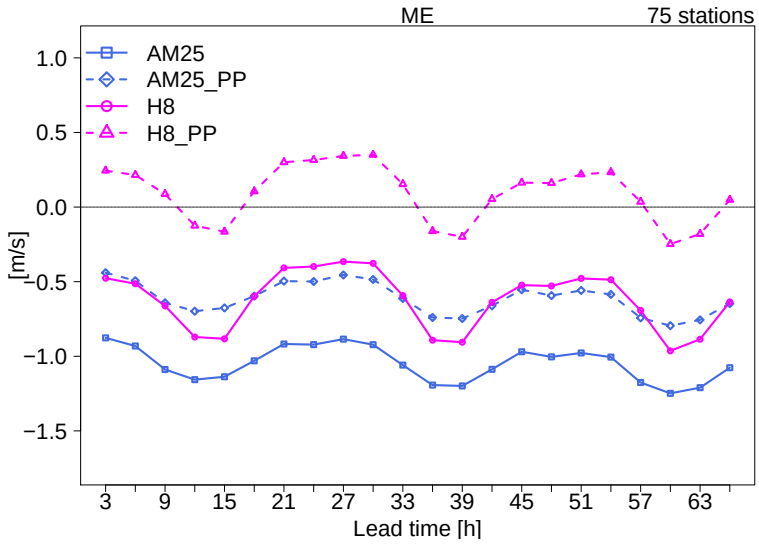


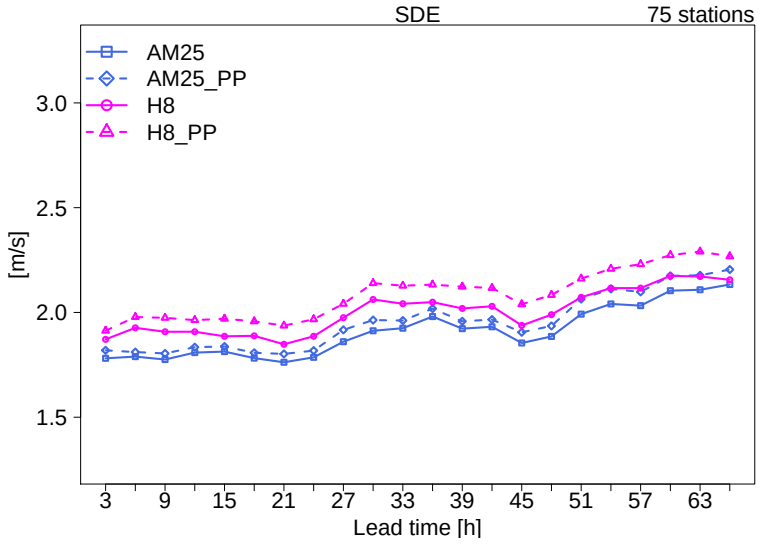
AM25 00+12

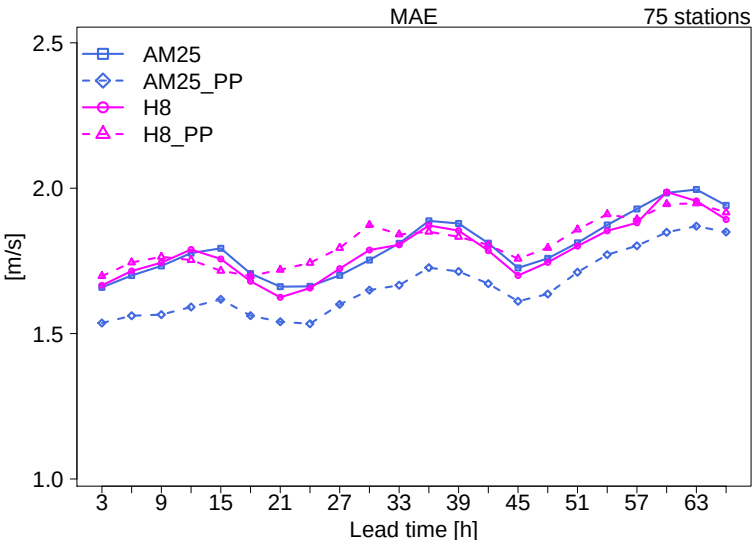
SDE at observing sites forecast means 01.09.2014 − 30.11.2014

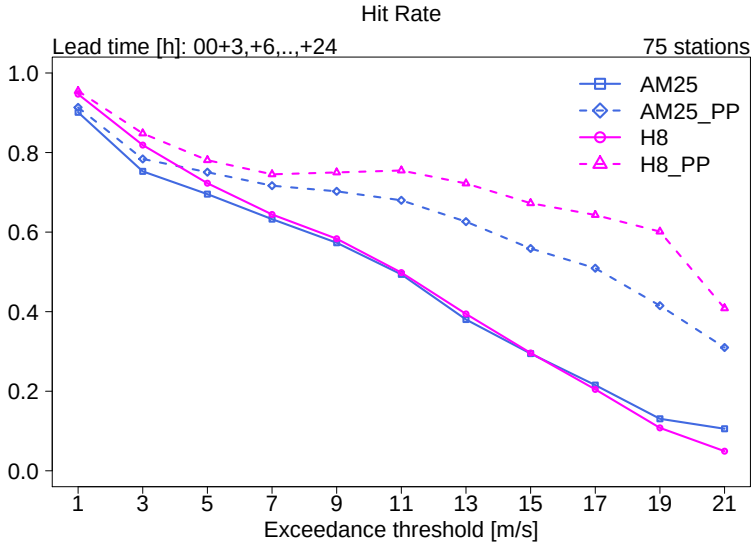


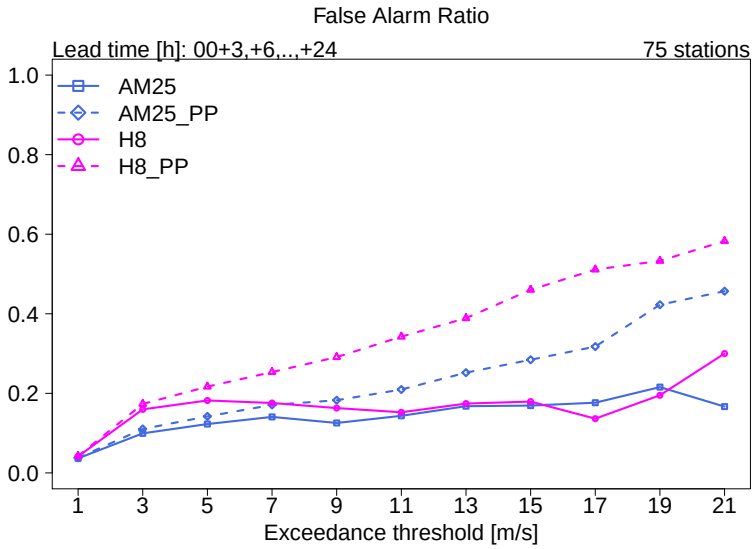
6.4 Max Mean Wind Speed 10m

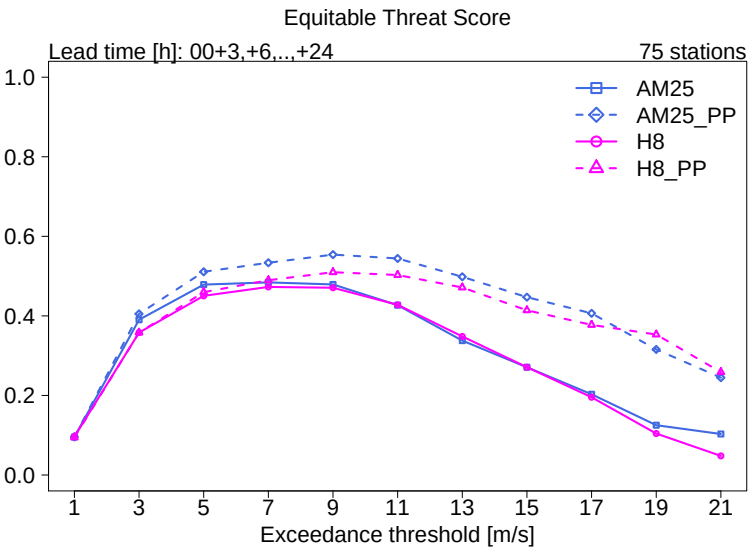


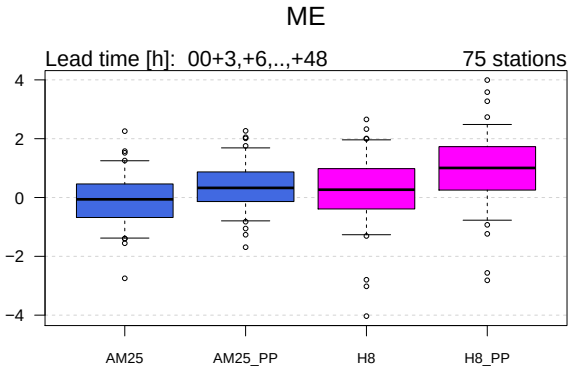


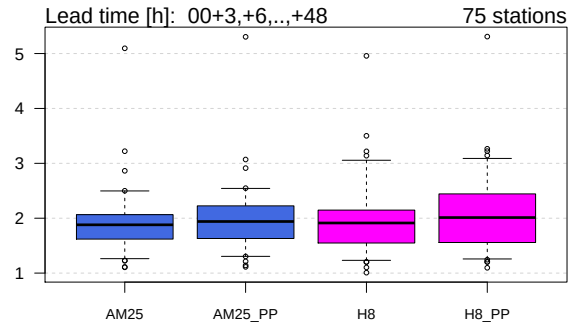



Hit Rate
Lead time [h]: 00+3,+6,..,+24
75 stations
AM25
AM25_PP
H8
H8_PP
1.0
0.8
0.6
0.4
0.2
0.0
1 3 5 7 9 11 13 15 17 19 21
Exceedance threshold [m/s]


False Alarm Ratio
Lead time [h]: 00+3,+6,..,+24
75 stations
AM25
AM25_PP
H8
H8_PP
1.0
0.8
0.6
0.4
0.2
0.0
1 3 5 7 9 11 13 15 17 19 21
Exceedance threshold [m/s]


Equitable Threat Score
Lead time [h]: 00+3,+6,..,+24
75 stations
AM25
AM25_PP
H8
H8_PP
1.0
0.8
0.6
0.4
0.2
0.0
1 3 5 7 9 11 13 15 17 19 21
Exceedance threshold [m/s]





Lead time [h]: 00+3,+6,..,+48 UTC 75 stations

AM25

	OBS					
	[0,3]	(3,11]	(11,17]	(17,21]	(21,Inf]	Sum
[0,3]	26425	14576	41	2	0	41044
(3,11]	4827	33467	4113	120	6	42533
(11,17]	44	665	2856	736	134	4435
(17,21]	23	1	33	142	109	308
(21,Inf]	2	1	0	7	25	35
Sum	31321	48710	7043	1007	274	88355

AM25_PP

	OBS					
	[0,3]	(3,11]	(11,17]	(17,21]	(21,Inf]	Sum
[0,3]	25627	12761	36	1	0	38425
(3,11]	5613	34440	2661	54	3	42771
(11,17]	44	1495	4078	526	58	6201
(17,21]	19	13	261	374	136	803
(21,Inf]	18	1	7	52	77	155
Sum	31321	48710	7043	1007	274	88355

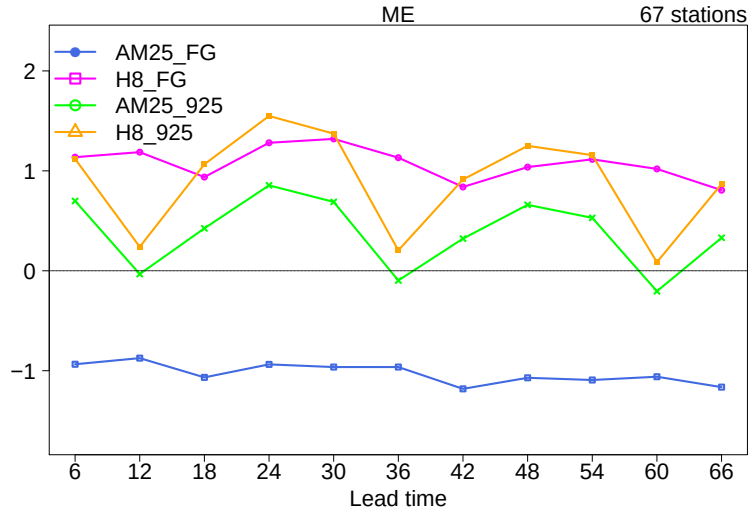
H8

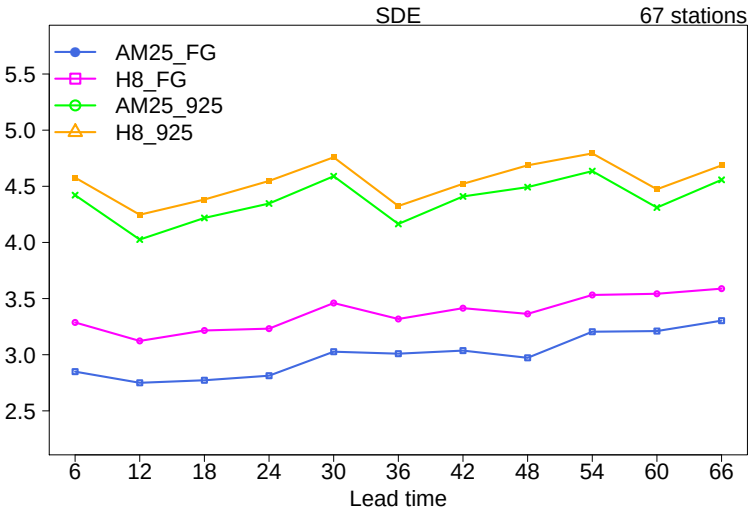
	OBS					
	[0,3]	(3,11]	(11,17]	(17,21]	(21,Inf]	Sum
[0,3]	22216	10634	51	2	0	32903
(3,11]	9048	37310	4010	140	7	50515
(11,17]	37	765	2953	736	152	4643
(17,21]	19	1	29	124	106	279
(21,Inf]	1	0	0	5	9	15
Sum	31321	48710	7043	1007	274	88355

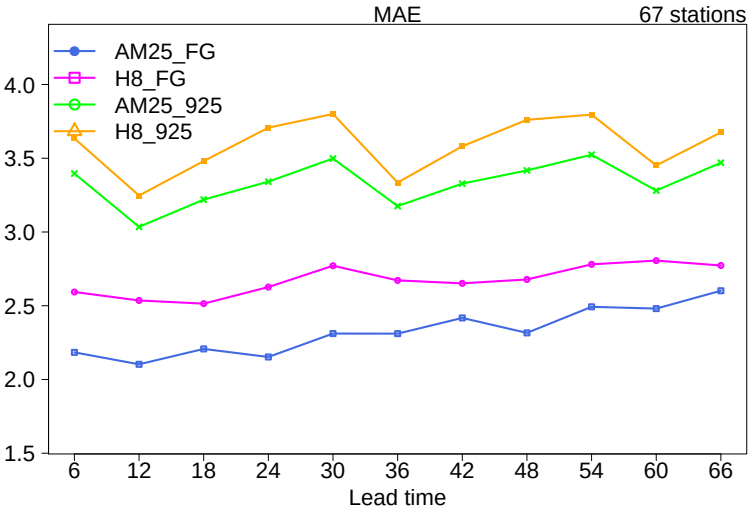
H8_PP

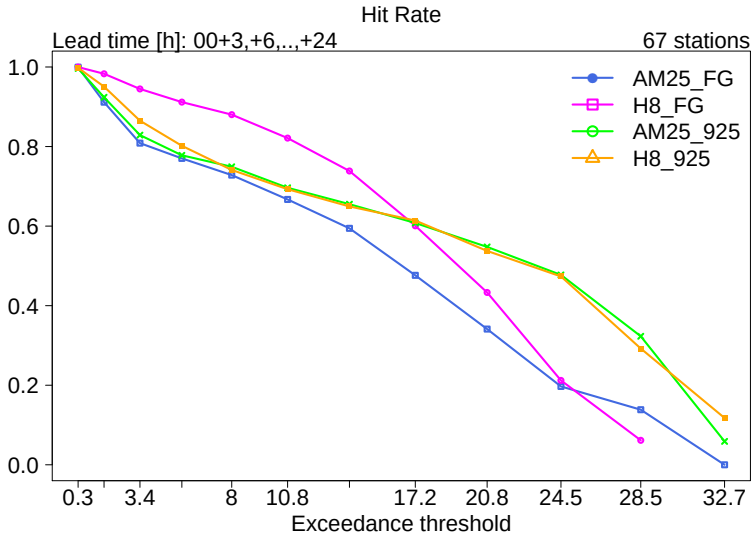
	OBS					
	[0,3]	(3,11]	(11,17]	(17,21]	(21,Inf]	Sum
[0,3]	20964	8857	21	0	0	29842
(3,11]	10275	36565	2103	52	2	48997
(11,17]	43	3214	4181	389	29	7856
(17,21]	23	73	716	454	141	1407
(21,Inf]	16	1	22	112	102	253
Sum	31321	48710	7043	1007	274	88355

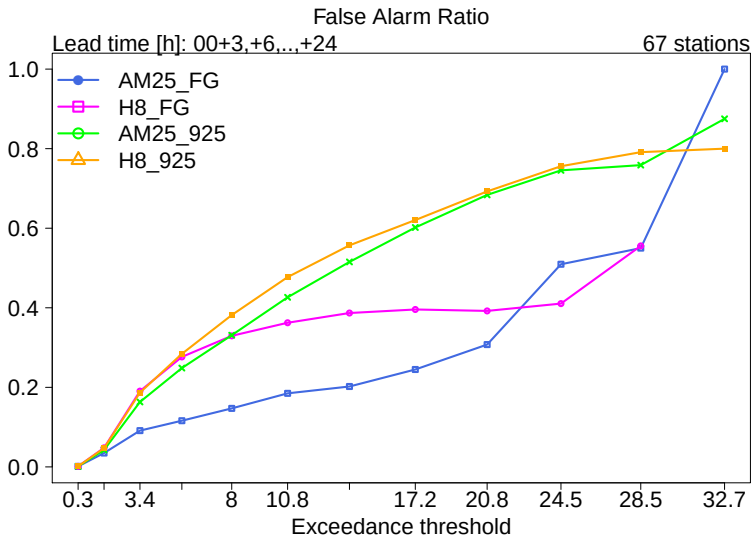
6.5 Wind gust

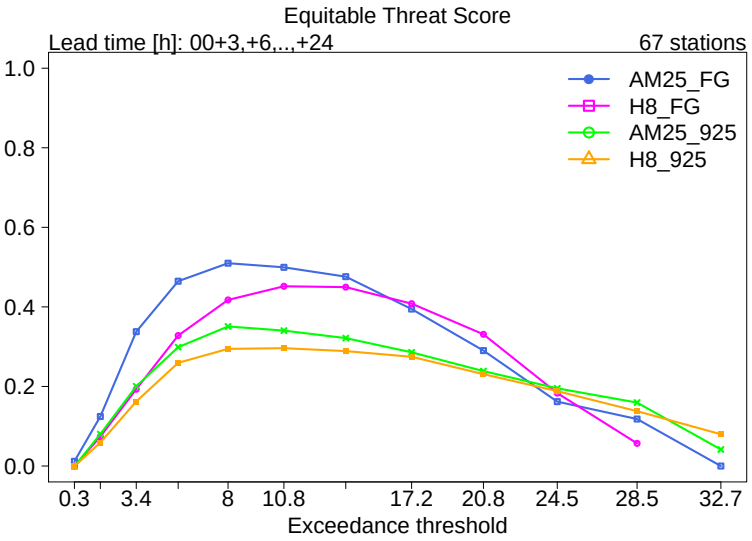

ME
67 stations
AM25_FG
H8_FG
AM25_925
H8_925
2
1
0
−1
6
12
18
24
30
36
42
48
54
60
66
Lead time


SDE
67 stations
AM25_FG
H8_FG
AM25_925
H8_925
5.5
5.0
4.5
4.0
3.5
3.0
2.5
6
12
18
24
30
36
42
48
54
60
66
Lead time

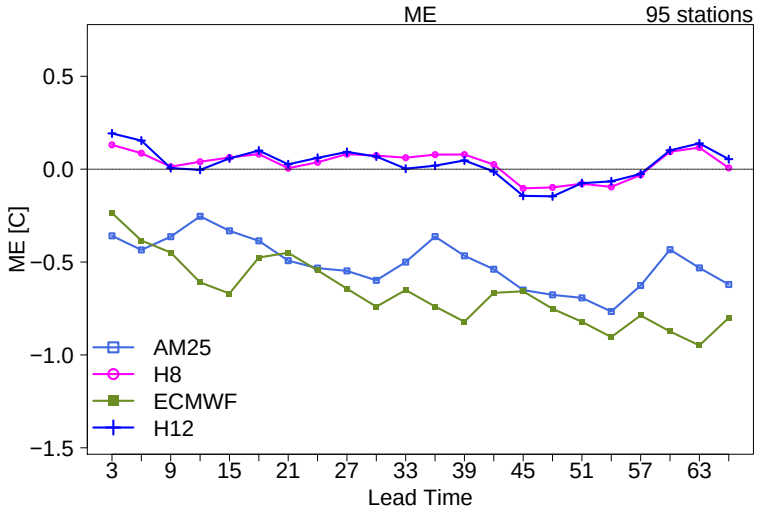

MAE
67 stations
AM25_FG
H8_FG
AM25_925
H8_925
4.0
3.5
3.0
2.5
2.0
1.5
6
12
18
24
30
36
42
48
54
60
66
Lead time

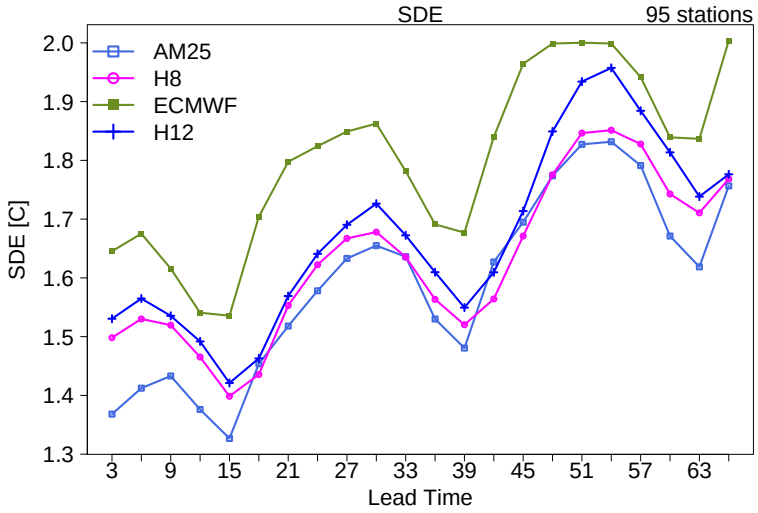

Hit Rate
Lead time [h]: 00+3,+6,..,+24
67 stations
AM25_FG
H8_FG
AM25_925
H8_925
1.0
0.8
0.6
0.4
0.2
0.0
0.3
3.4
8
10.8
17.2
20.8
24.5
28.5
32.7
Exceedance threshold

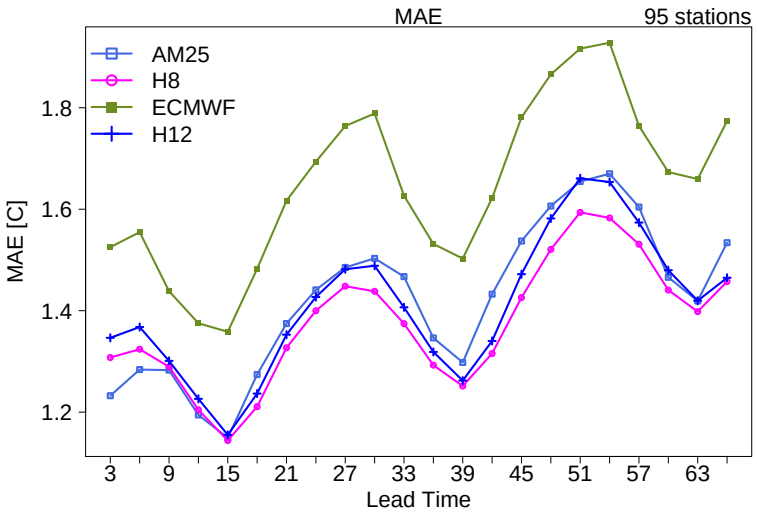

False Alarm Ratio
Lead time [h]: 00+3,+6,..,+24
67 stations
AM25_FG
H8_FG
AM25_925
H8_925
1.0
0.8
0.6
0.4
0.2
0.0
0.3
3.4
8
10.8
17.2
20.8
24.5
28.5
32.7
Exceedance threshold

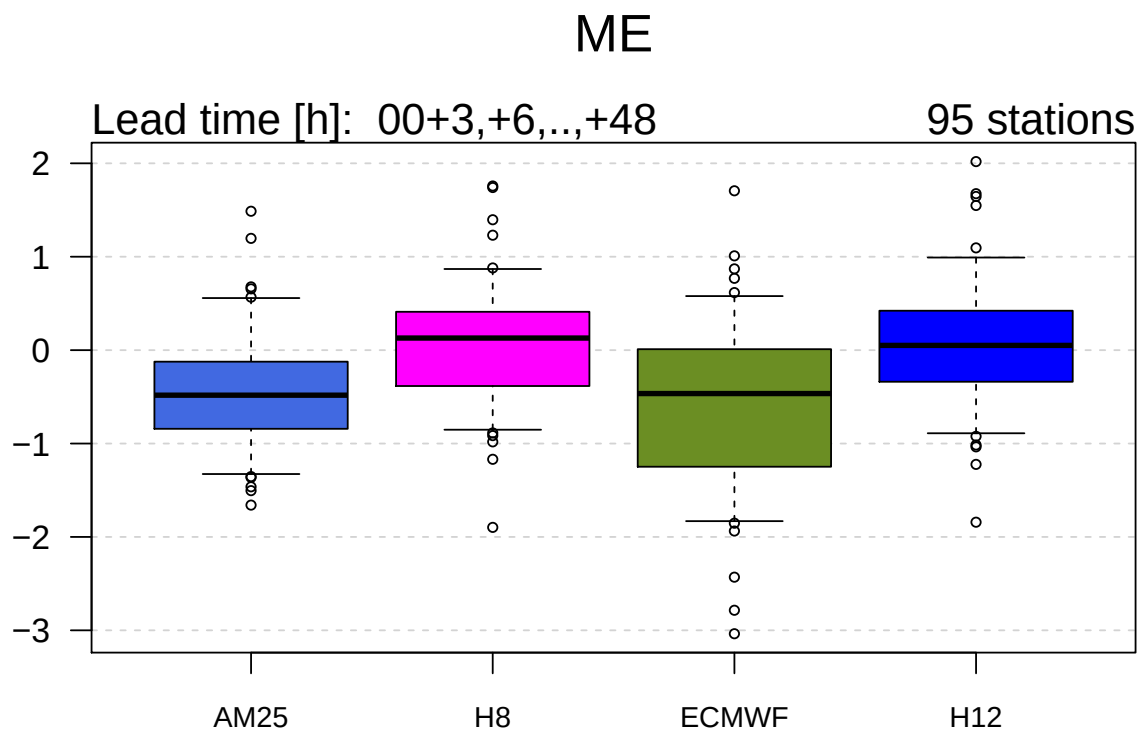

Equitable Threat Score
Lead time [h]: 00+3,+6,..,+24
67 stations
AM25_FG
H8_FG
AM25_925
H8_925
1.0
0.8
0.6
0.4
0.2
0.0
0.3
3.4
8
10.8
17.2
20.8
24.5
28.5
32.7
Exceedance threshold

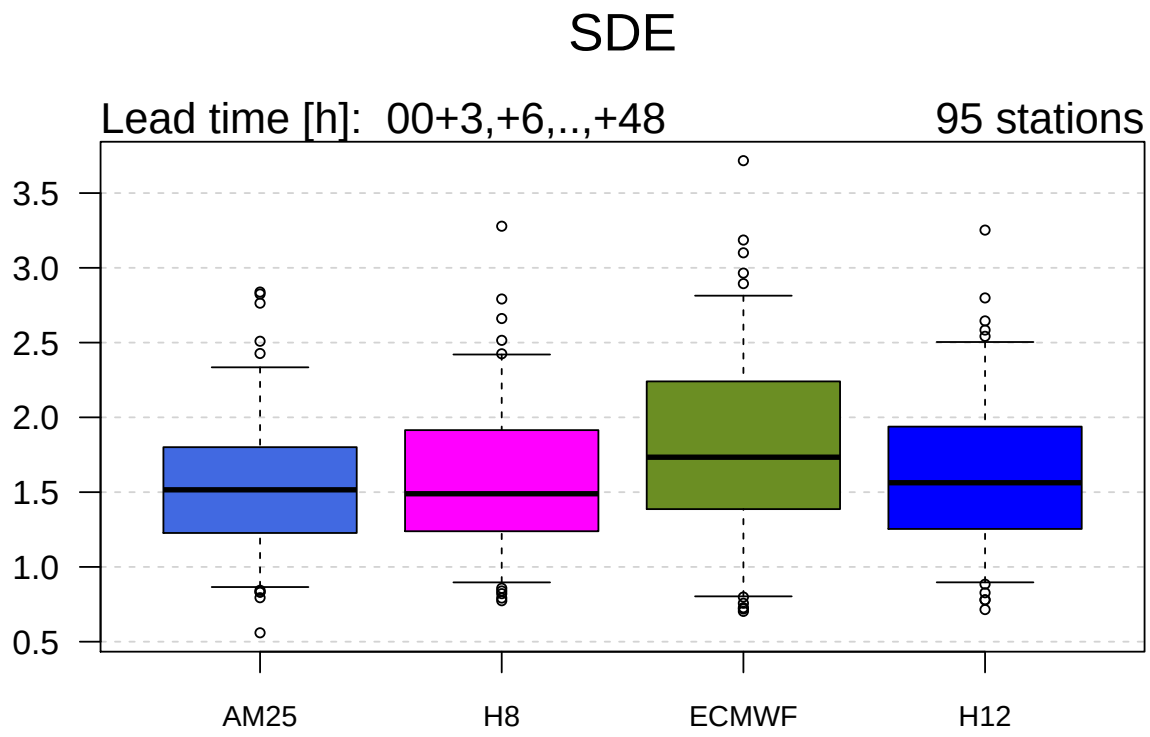
6.6 Temperature 2m





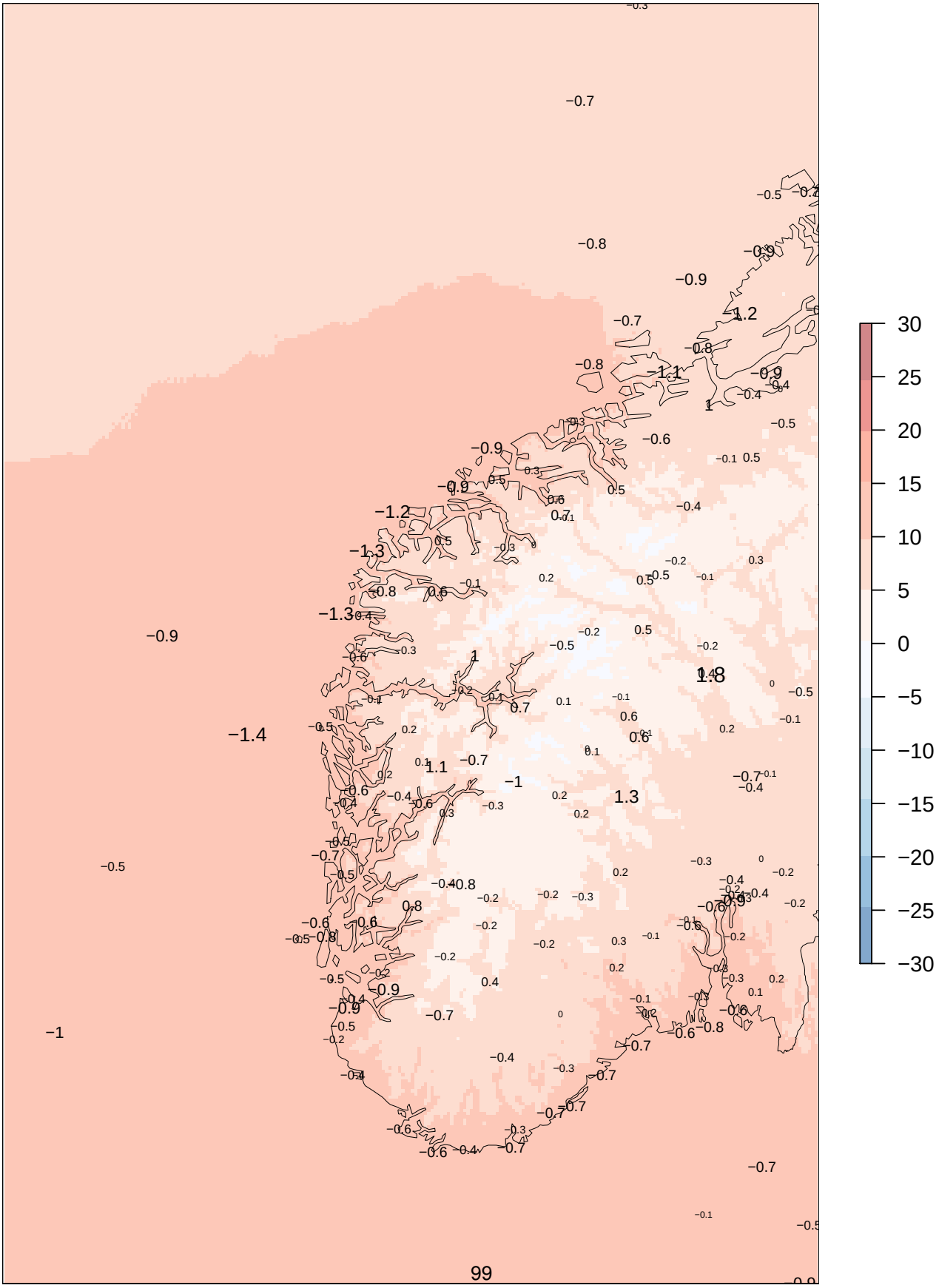



ME
Lead time [h]: 00+3,+6,..,+48
95 stations
2
1
0
−1
−2
−3
AM25
H8
ECMWF
H12


SDE
Lead time [h]: 00+3,+6,..,+48
95 stations
3.5
3.0
2.5
2.0
1.5
1.0
0.5
AM25
H8
ECMWF
H12

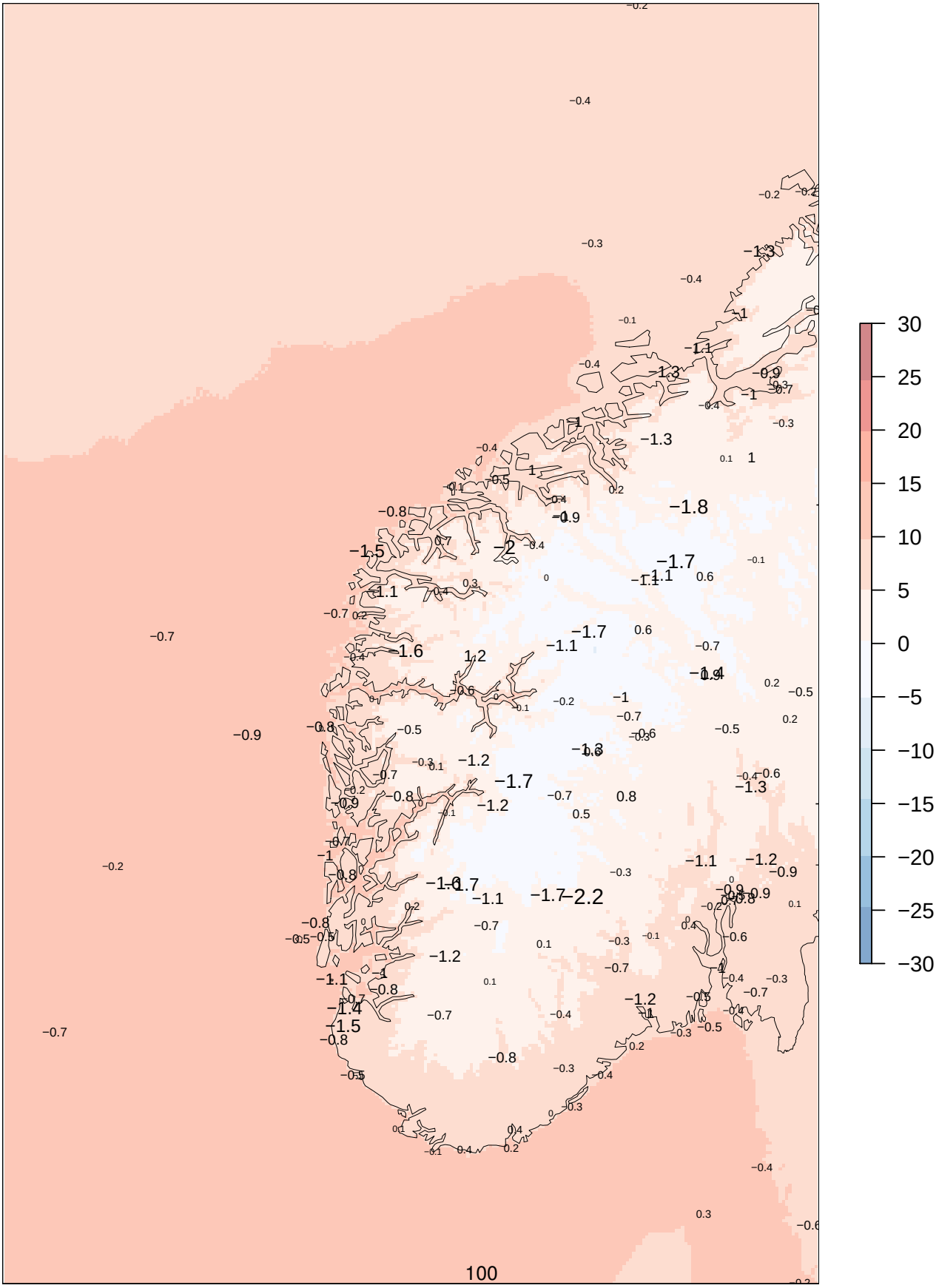
AM25 00+12

ME at observing sites forecast means 01.09.2014 − 30.11.2014



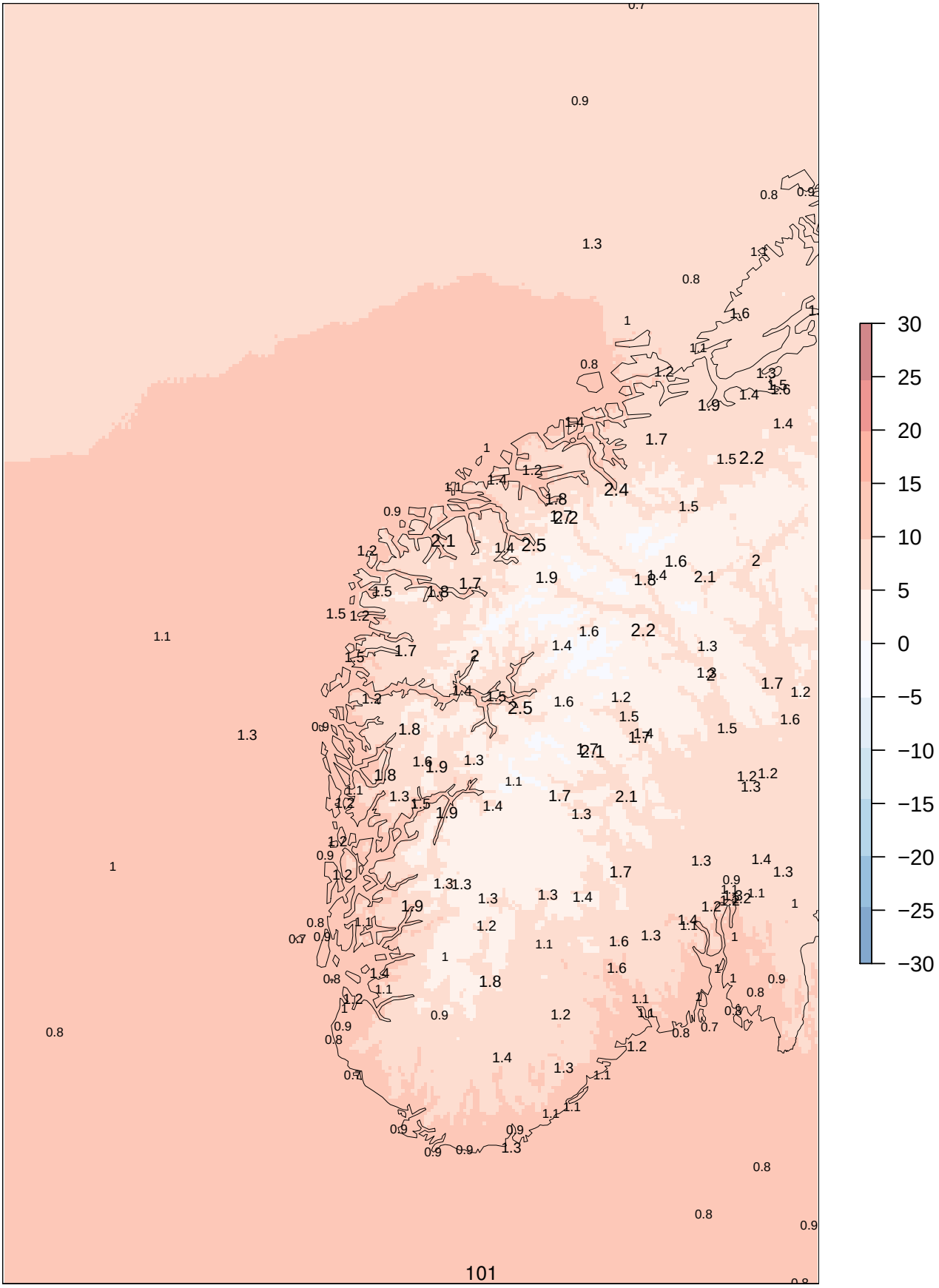
AM25 00+24

ME at observing sites forecast means 01.09.2014 − 30.11.2014



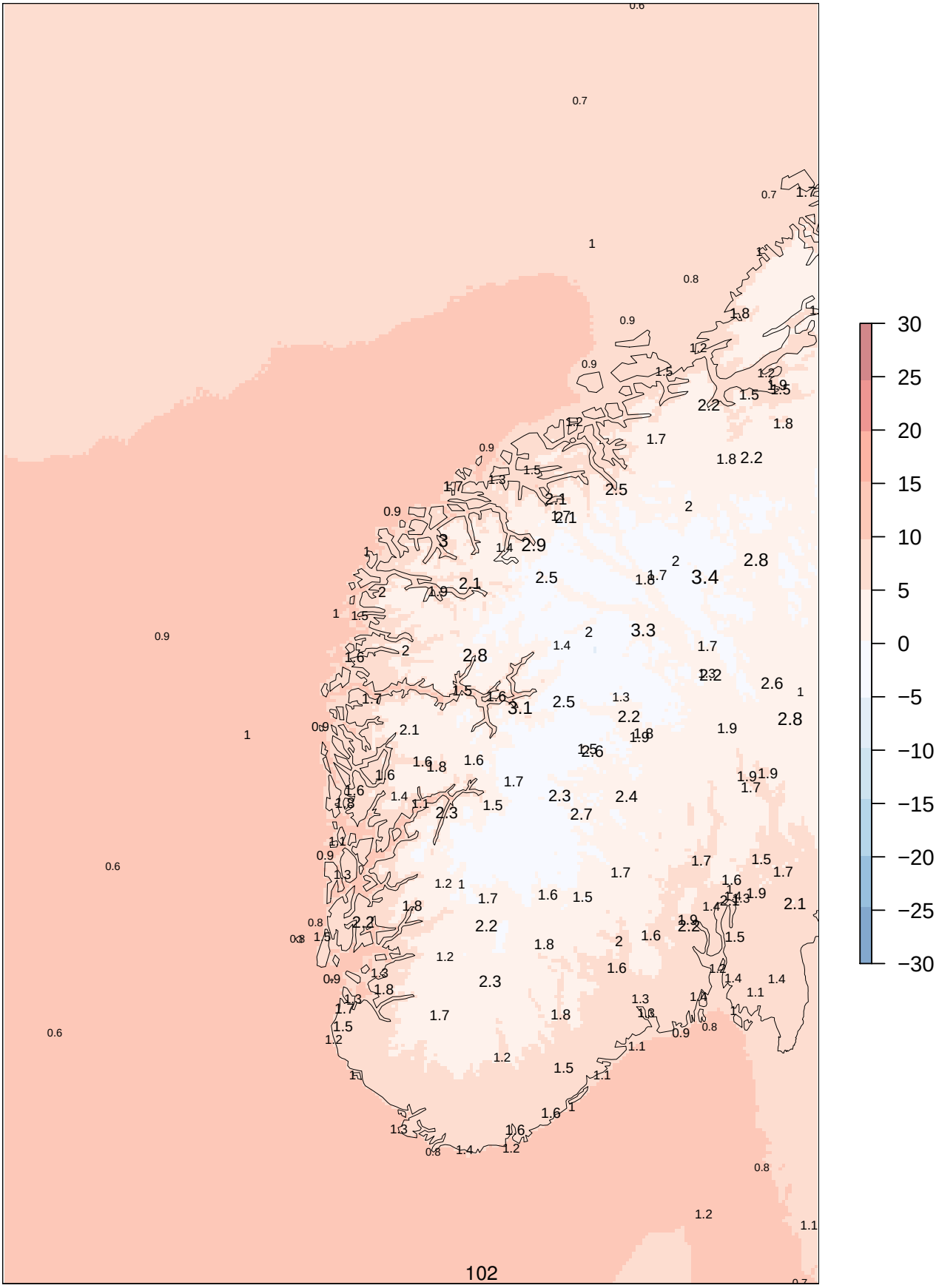
AM25 00+12

SDE at observing sites forecast means 01.09.2014 − 30.11.2014

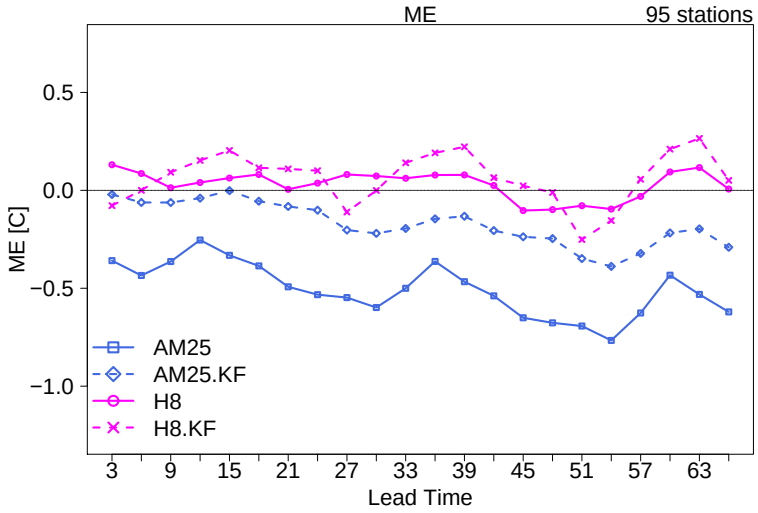


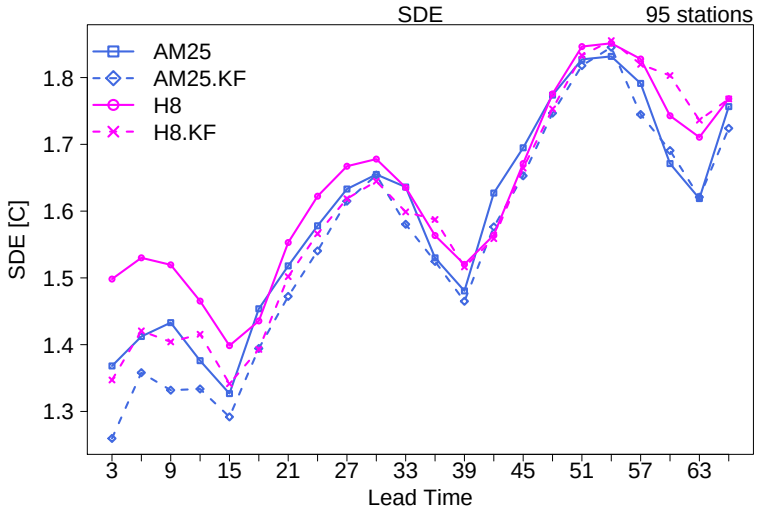
AM25 00+24

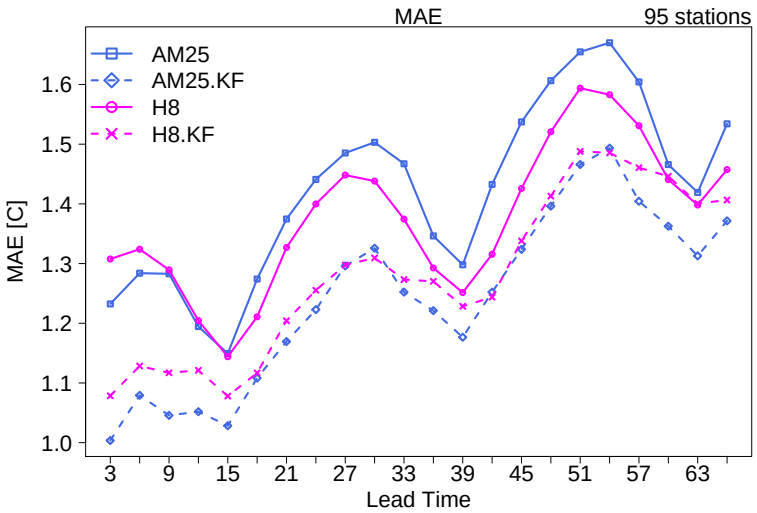
SDE at observing sites forecast means 01.09.2014 − 30.11.2014

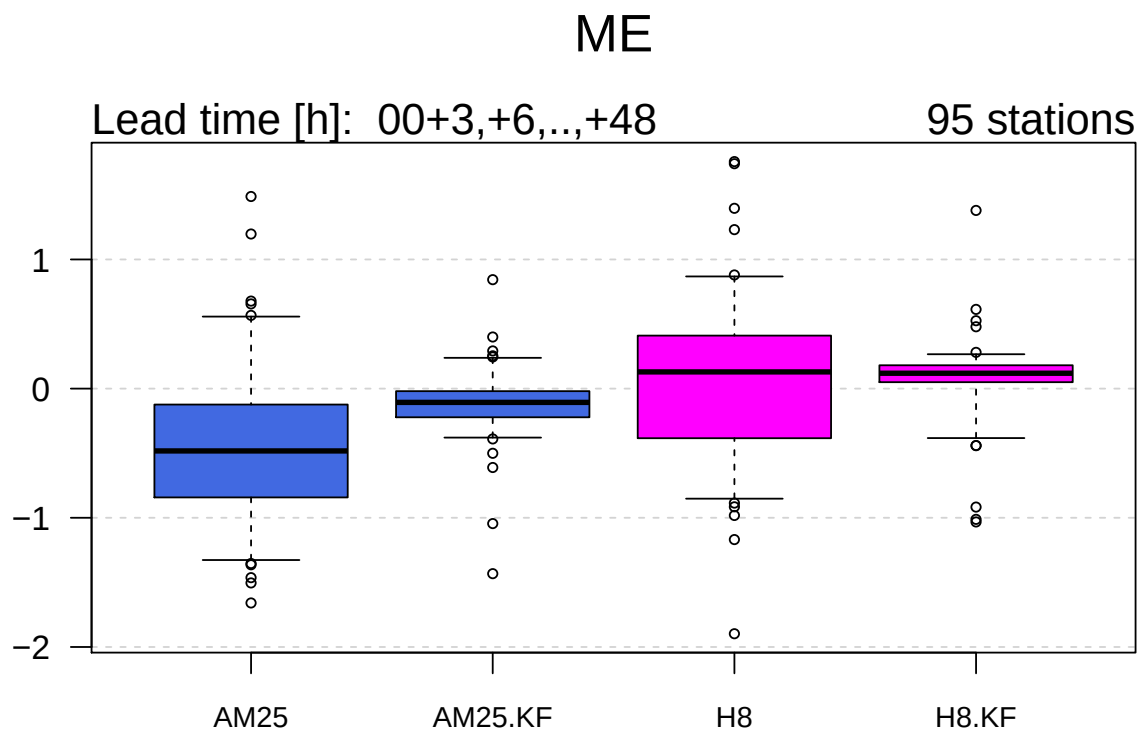


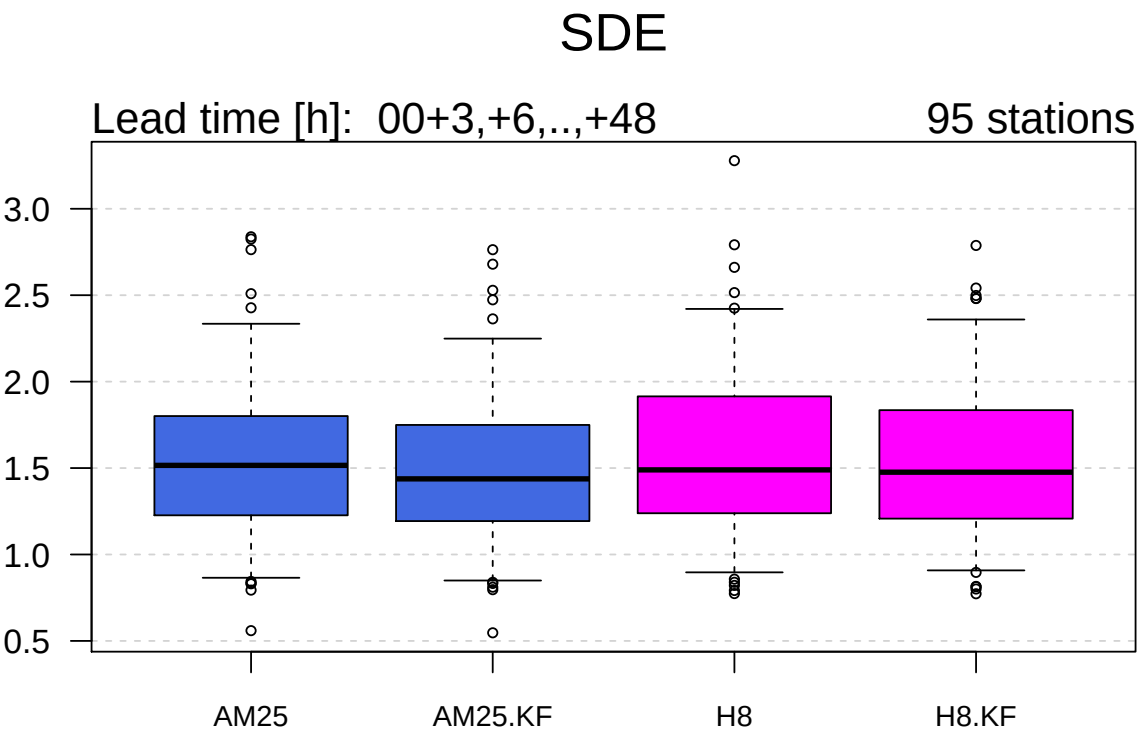
6.7 Post processed temperature 2m



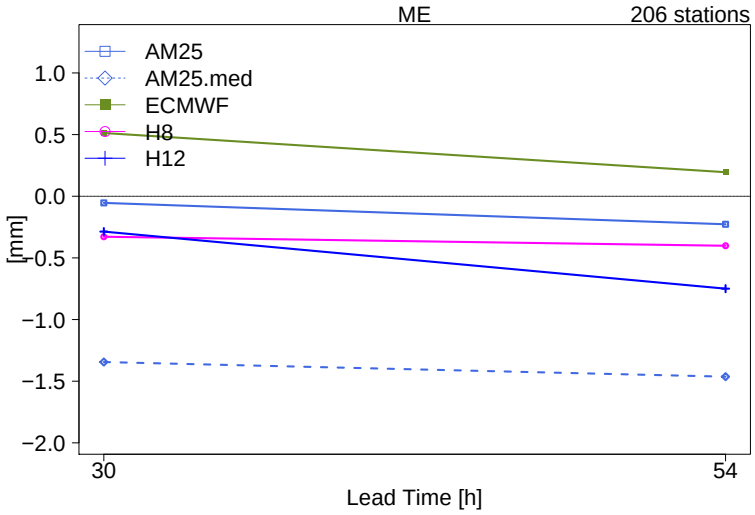


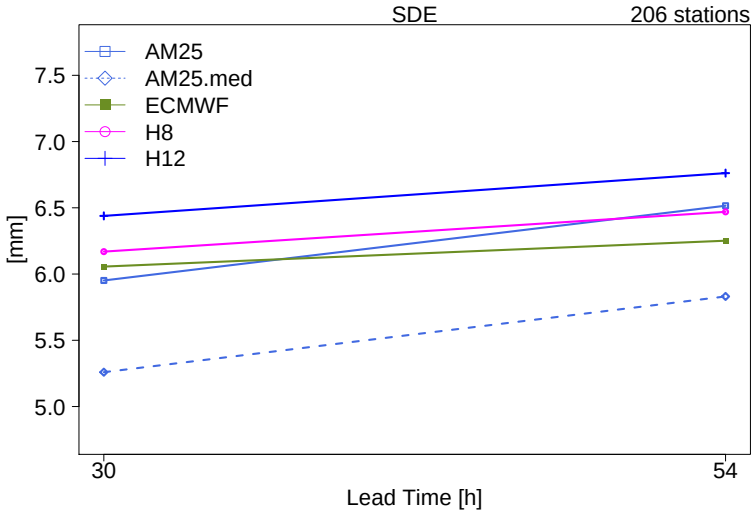


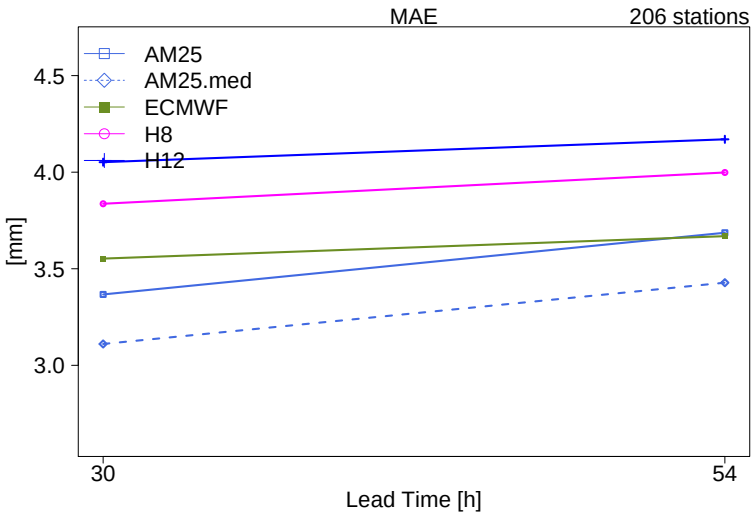

ME
Lead time [h]: 00+3,+6,..,+48
95 stations
1
0
−1
−2
AM25
AM25.KF
H8
H8.KF

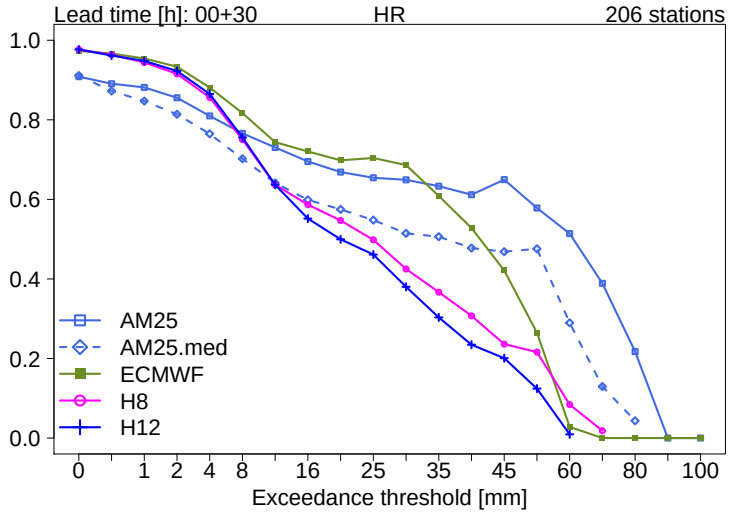

SDE
Lead time [h]: 00+3,+6,..,+48
95 stations
3.0
2.5
2.0
1.5
1.0
0.5
AM25
AM25.KF
H8
H8.KF

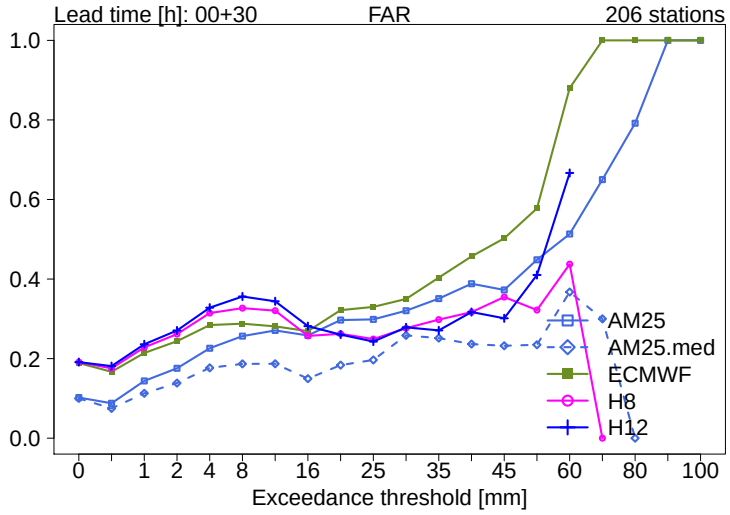
6.8 Daily precipitation

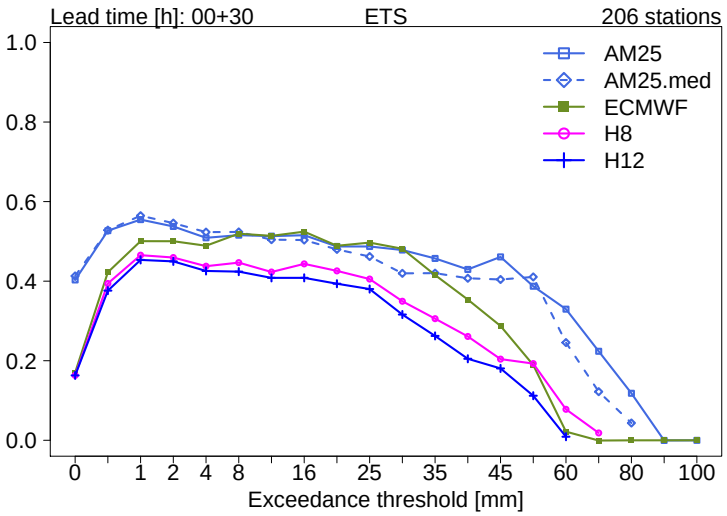


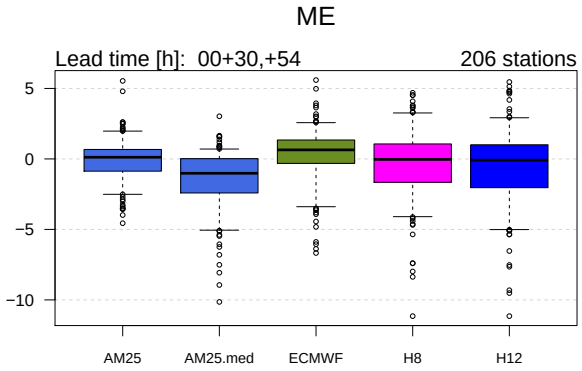


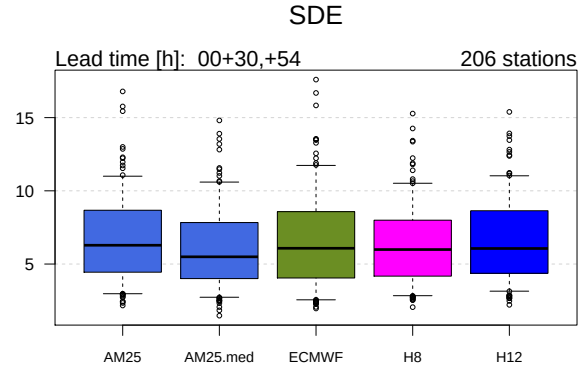



Lead time [h]: 00+30
HR
206 stations
1.0
0.8
0.6
0.4
0.2
0.0
AM25
AM25.med
ECMWF
H8
H12
0 1 2 4 8 16 25 35 45 60 80 100
Exceedance threshold [mm]


Lead time [h]: 00+30
FAR
206 stations
1.0
0.8
0.6
0.4
0.2
0.0
AM25
AM25.med
ECMWF
H8
H12
0 1 2 4 8 16 25 35 45 60 80 100
Exceedance threshold [mm]


Lead time [h]: 00+30
ETS
206 stations
1.0
0.8
0.6
0.4
0.2
0.0
AM25
AM25.med
ECMWF
H8
H12
0 1 2 4 8 16 25 35 45 60 80 100
Exceedance threshold [mm]





Lead time [h]: 00+30,+54 206 stations

AM25

	OBS					
	[0,0.1]	(0.1,5]	(5,20]	(20,50]	(50,Inf]	Sum
[0,0.1]	6618	2089	114	7	0	8828
(0.1,5]	1436	5905	1554	92	9	8996
(5,20]	123	1846	3454	701	14	6138
(20,50]	13	65	587	968	118	1751
(50,Inf]	3	3	7	166	177	356
Sum	8193	9908	5716	1934	318	26069

AM25.med

	OBS					
	[0,0.1]	(0.1,5]	(5,20]	(20,50]	(50,Inf]	Sum
[0,0.1]	6898	2452	133	2	0	9485
(0.1,5]	1231	6150	1942	129	14	9466
(5,20]	59	1284	3360	874	23	5600
(20,50]	5	22	279	872	143	1321
(50,Inf]	0	0	2	57	138	197
Sum	8193	9908	5716	1934	318	26069

ECMWF

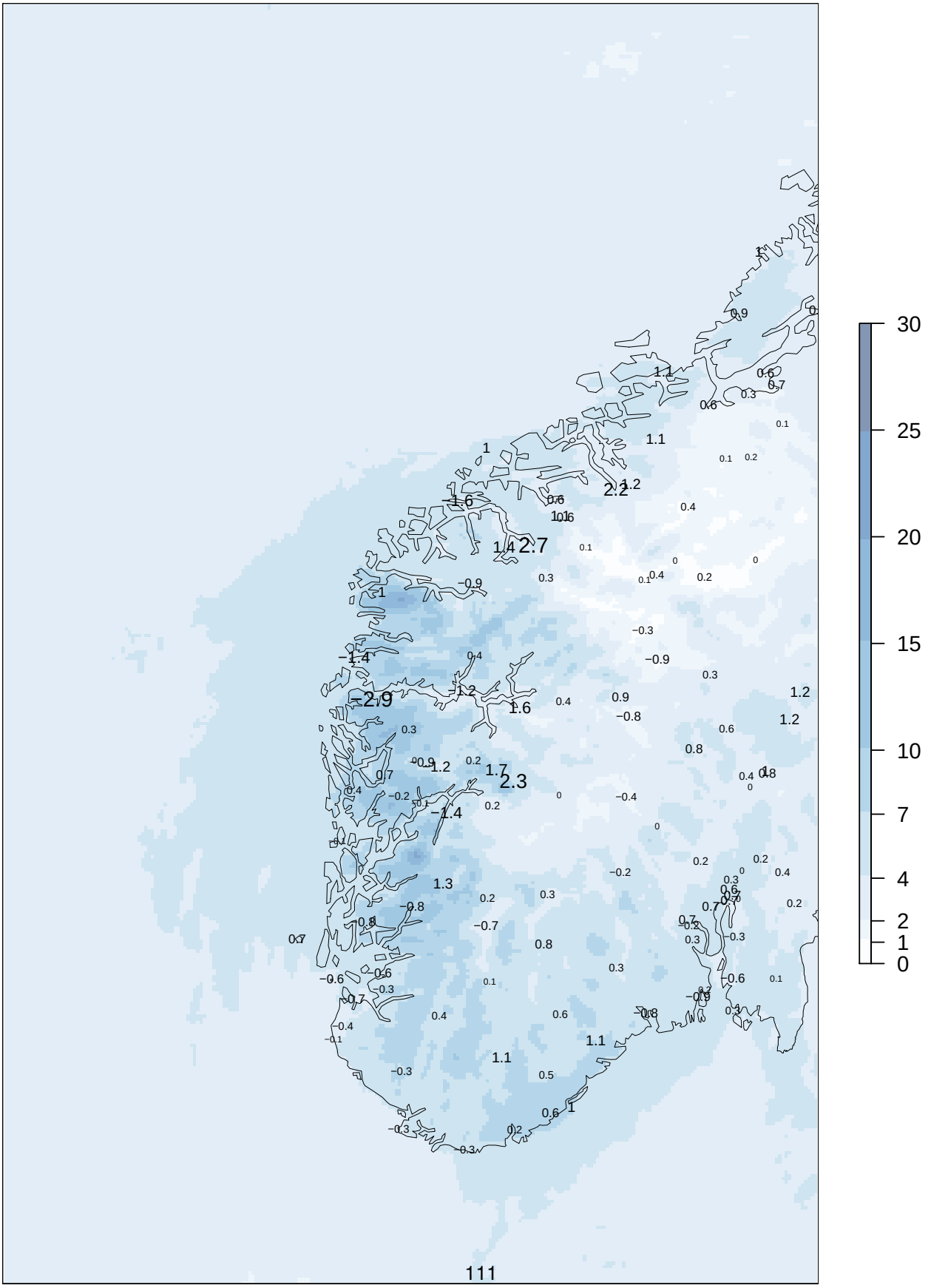
	OBS					
	[0,0.1]	(0.1,5]	(5,20]	(20,50]	(50,Inf]	Sum
[0,0.1]	4688	710	36	0	0	5434
(0.1,5]	3300	6565	1087	75	2	11029
(5,20]	196	2585	3914	702	21	7418
(20,50]	7	47	657	1046	207	1964
(50,Inf]	2	1	22	111	88	224
Sum	8193	9908	5716	1934	318	26069

H8

	OBS					
	[0,0.1]	(0.1,5]	(5,20]	(20,50]	(50,Inf]	Sum
[0,0.1]	4513	818	33	2	0	5366
(0.1,5]	3380	6311	1377	75	1	11144
(5,20]	288	2707	3910	1024	47	7976
(20,50]	12	72	395	796	194	1469
(50,Inf]	0	0	1	37	76	114
Sum	8193	9908	5716	1934	318	26069

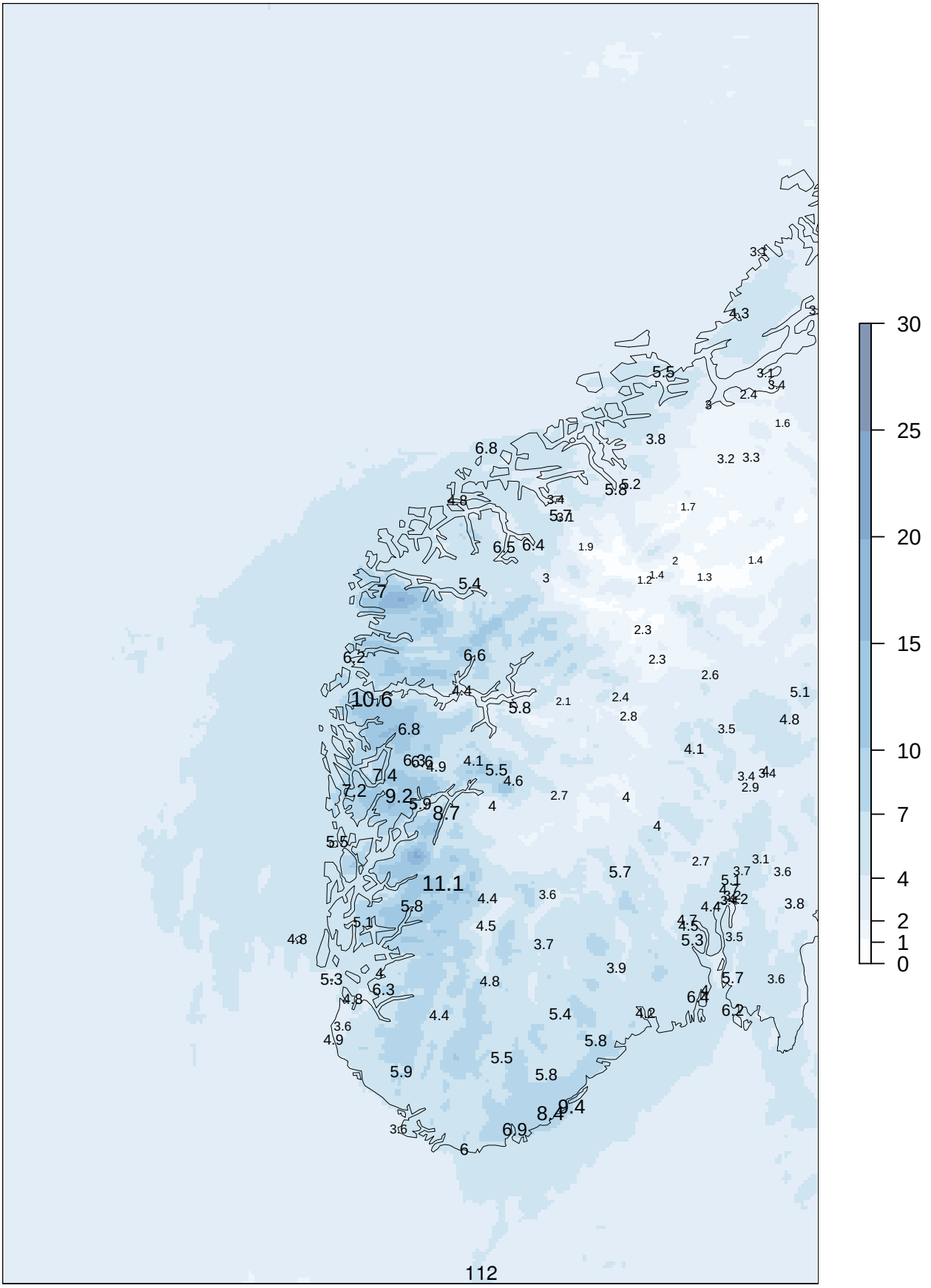
AM25 00+30

ME at observing sites forecast means 01.09.2014 − 30.11.2014



AM25 00+30

SDE at observing sites forecast means 01.09.2014 − 30.11.2014



7 Northern Norway

7.1 Comments to the verification results

Case study: Shallow convection over sea.
AM25 has difficulties with shallow convection over sea in cold air outbreaks, as illustrated. In the model, all areas upstream of the marked convection are covered with a homogen low cloud cover.
AM25 seems to have an on/off switch regarding this type of convection. When the model starts to form precipitation it seems to go directly to a deep convective regime with very high precipitation intensities.
The marked areas have unrealistic high intensities, 2-6 mm/1h, with a maximum of 8mm/1h. This is more than 10 times of expected intensities.
ECMWF has a large area with very low intensities (0.2-0.5mm/3h). However, it is almost impossible to tell if the precipitation actually starts as far upstream as in ECMWF, due to lack of observations.
The problems in AM25 is probably complex and might be divided into three parts:
1) Domain too small upstream in cold air outbreaks.
2) Direct transition to a deep convective regime.
3) Upspin. AM25 takes some time (up to 9-12h) to form smaller convective cells over sea.
Deep convection over sea (troughs, polar lows or deep convective cells in persistent cold air pools) seems to be handled much better than homogenous shallow convection.

Other comments:
Wind:
The post processed wind does not seem to give enough high values. Northen Norway had 233 observations of wind over $21ms^{-1}$, but the post processed wind only had 72 cases (33%).
Compared to Western Norway this is rather low. There it was 271 observations > $21ms^{-1}$ and 155 cases of post processed winds (57%). The lower bias frequency might be due to differences in post processing or related to weather situations. The post processing is differently handled in western and northern Norway, so this could be looked into.

Precipitation:
High amounts of precipitation was handled good at the observation sites with few false alarms (but still occasional high amounts close to mountains). The frequency bias is actually negative for >20mm, 453 observations and 422 Arome cases (93%). This is very close to the values for western Norway, 2252 observations and 2107 Arome cases (94%). For values above >50mm there is a regional difference of overforecasting in Western Norway (frequency bias 111%), a significant underforecasting in Northern Norway (17%), with Eastern Norway inbetween (frequency bias 71%).

Temperature:
An interstesting feature is that inner parts of Troms and Finnmark, have relatively small ME, but have the highest SDE values in Norway (and northern Sweden and Finland). It should be investigated if this is due to difficulties in cloud cover or have other causes.

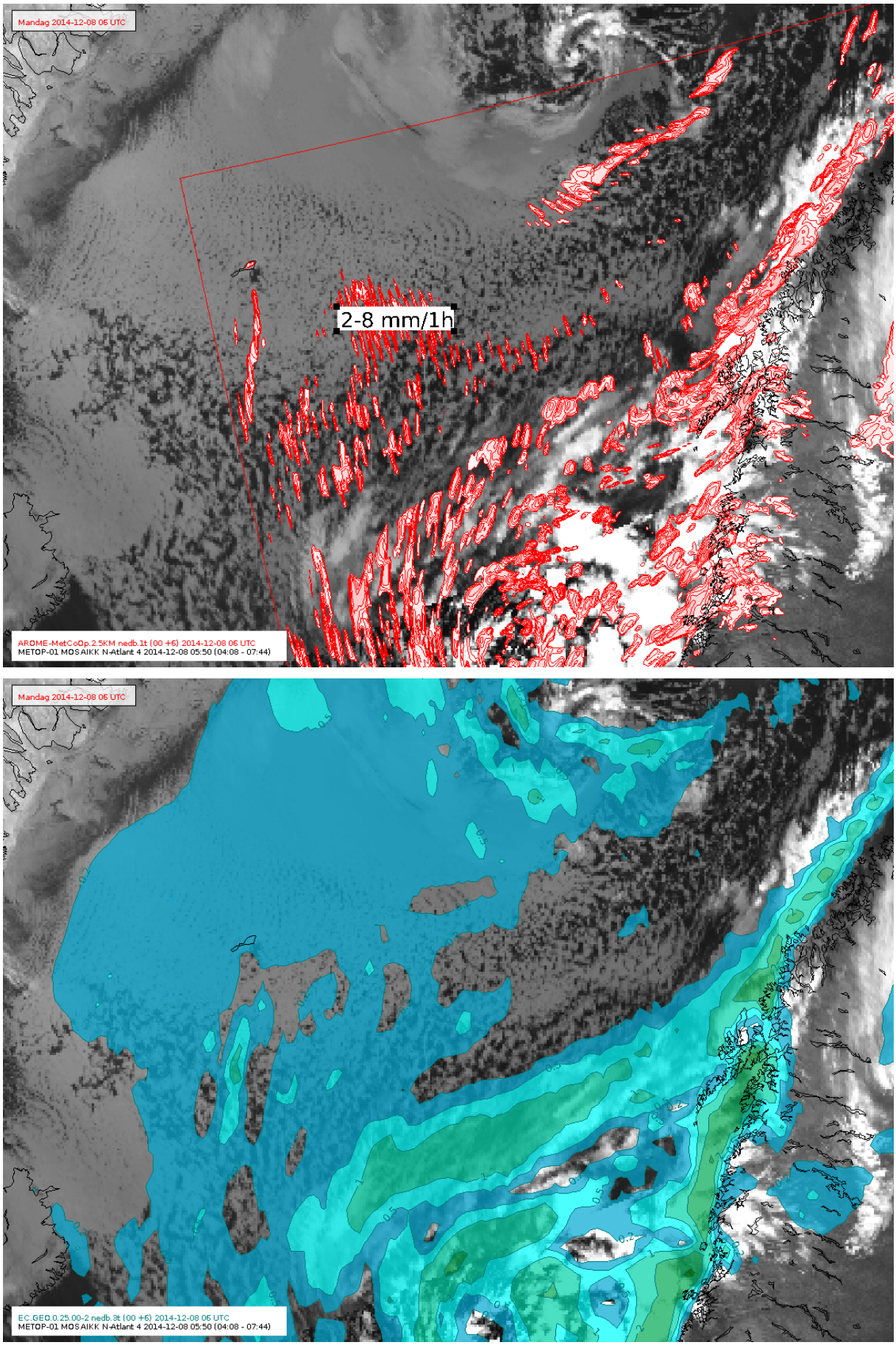
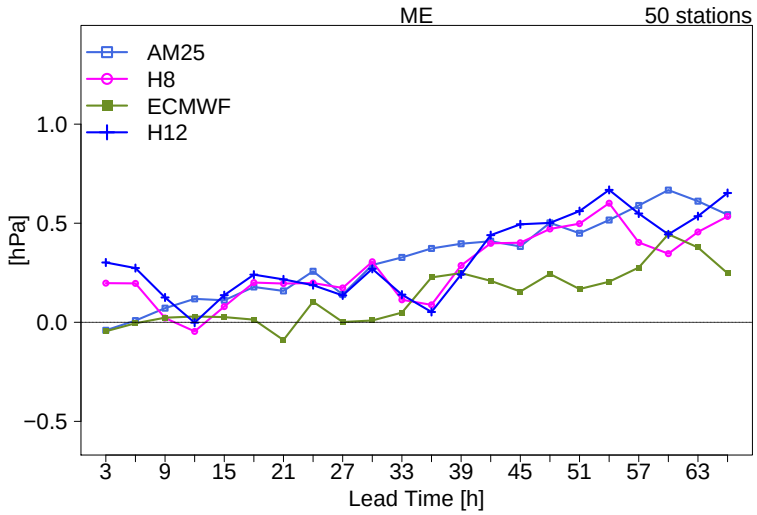
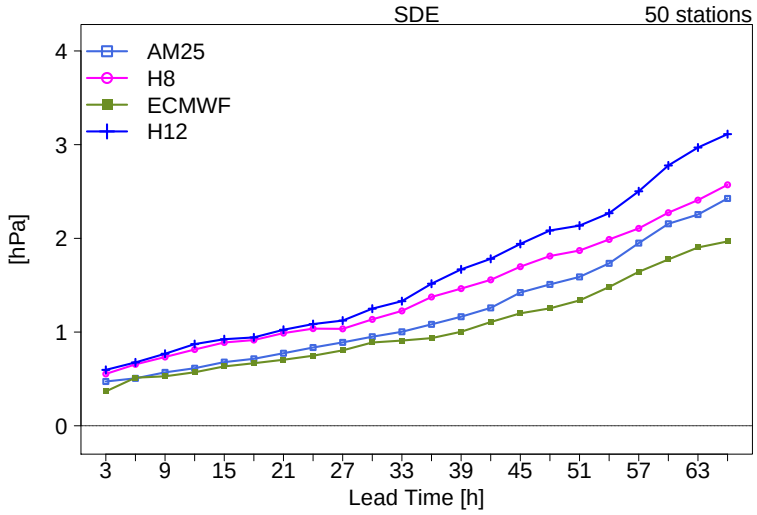
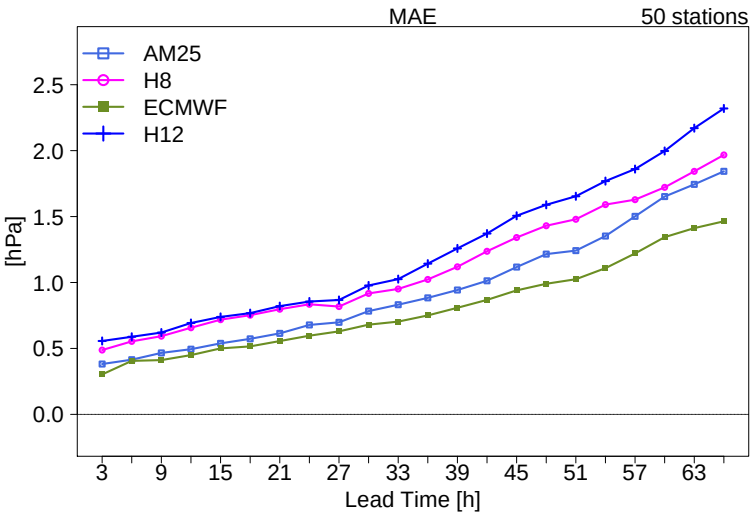


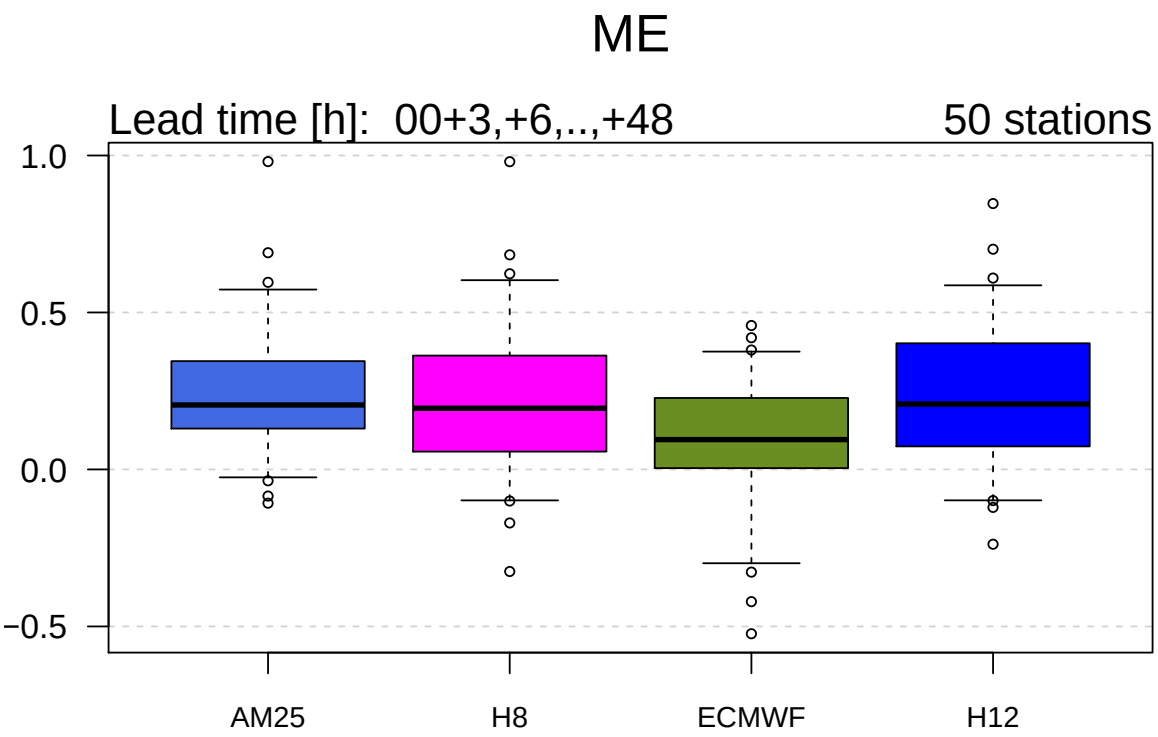
Figure 3: Figures from the Shallow convection case at 8 Dec 06 UTC. Top: Satellite image and AM25 1h precipitation. Bottom: Satellite image and ECMWF 3h precipitation.

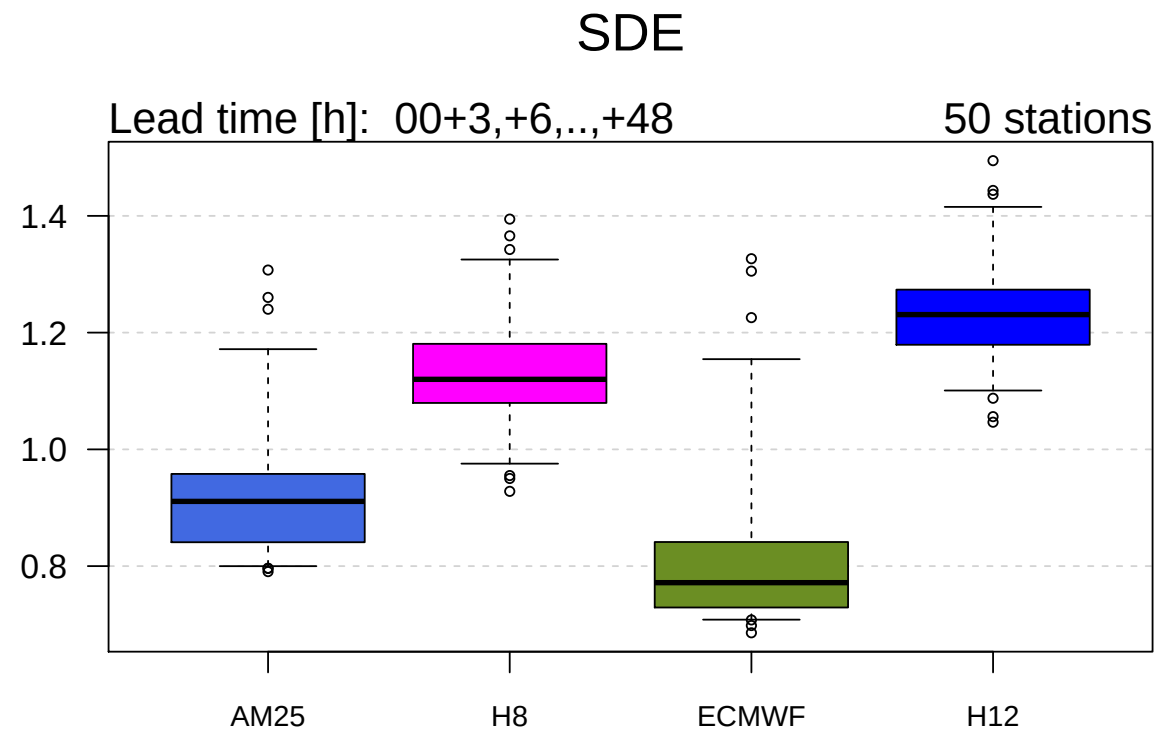
7.2 Pressure


ME
50 stations
AM25
H8
ECMWF
H12
1.0
0.5
0.0
−0.5
[hPa]
3
9
15
21
27
33
39
45
51
57
63
Lead Time [h]

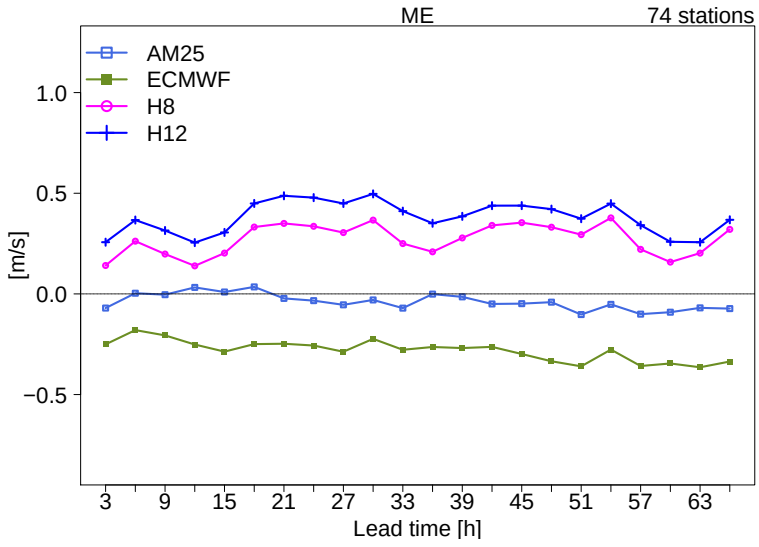

SDE
50 stations
AM25
H8
ECMWF
H12
4
3
2
1
0
[hPa]
3
9
15
21
27
33
39
45
51
57
63
Lead Time [h]

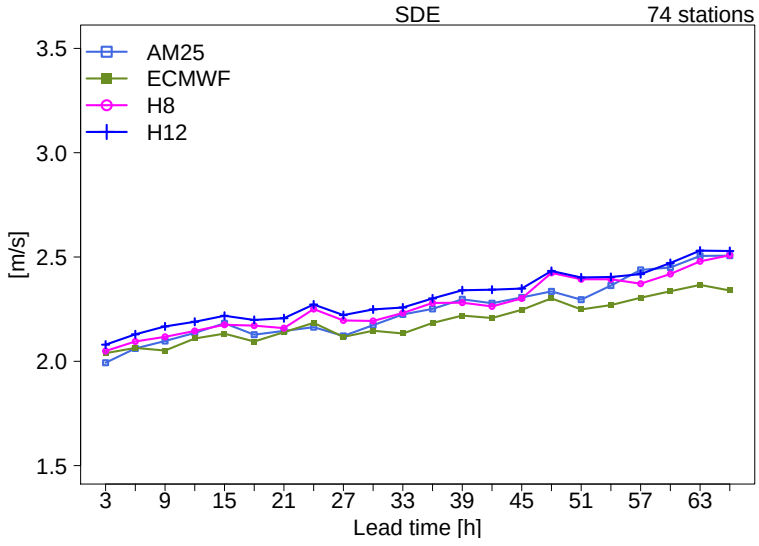

MAE
50 stations
AM25
H8
ECMWF
H12
2.5
2.0
1.5
1.0
0.5
0.0
[hPa]
3
9
15
21
27
33
39
45
51
57
63
Lead Time [h]

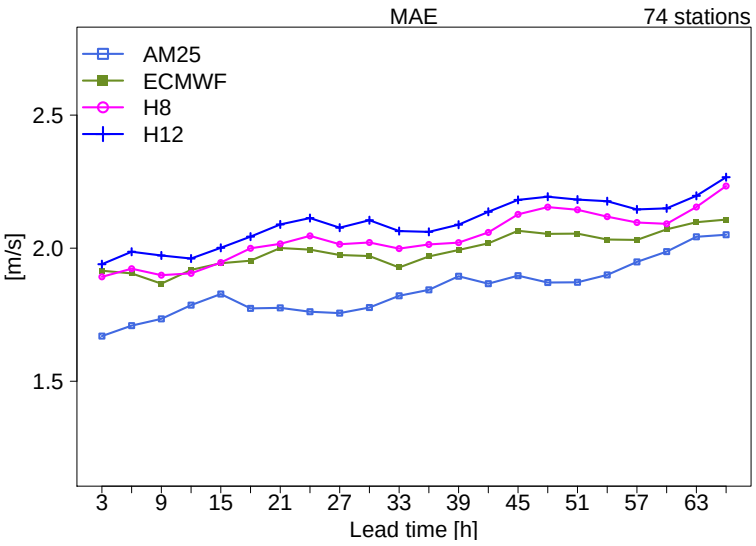

ME
Lead time [h]: 00+3,+6,..,+48
50 stations
1.0
0.5
0.0
−0.5
AM25
H8
ECMWF
H12

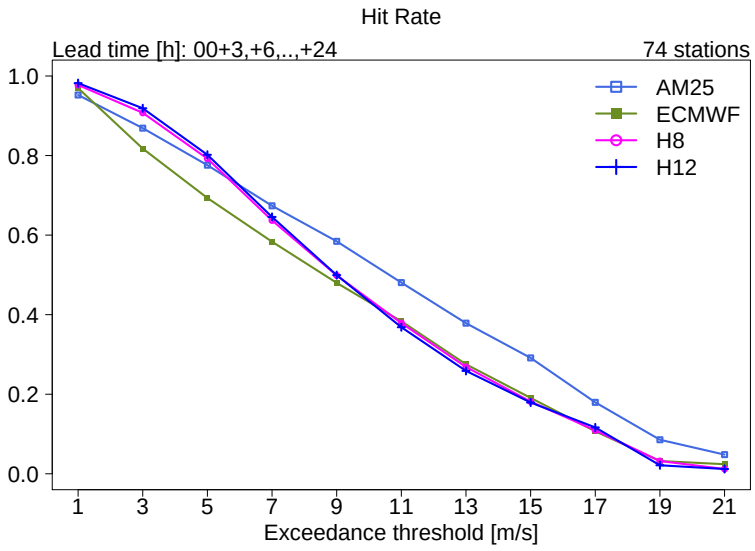

SDE
Lead time [h]: 00+3,+6,..,+48
50 stations
1.4
1.2
1.0
0.8
AM25
H8
ECMWF
H12

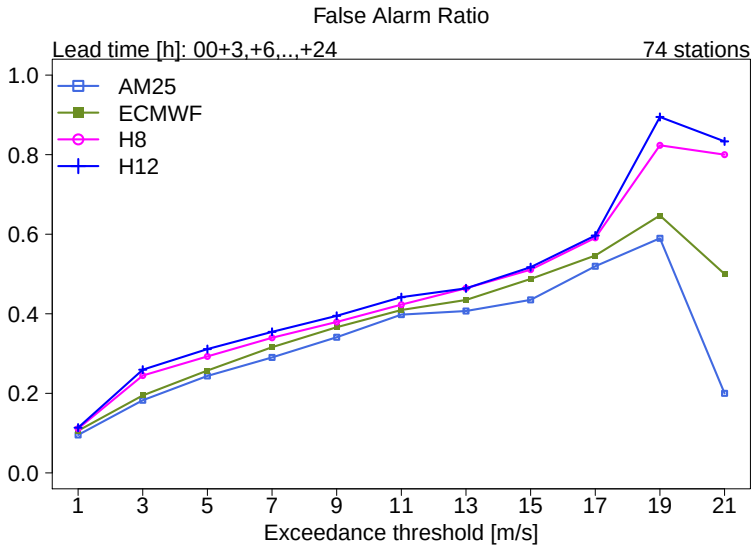
7.3 Wind Speed 10m

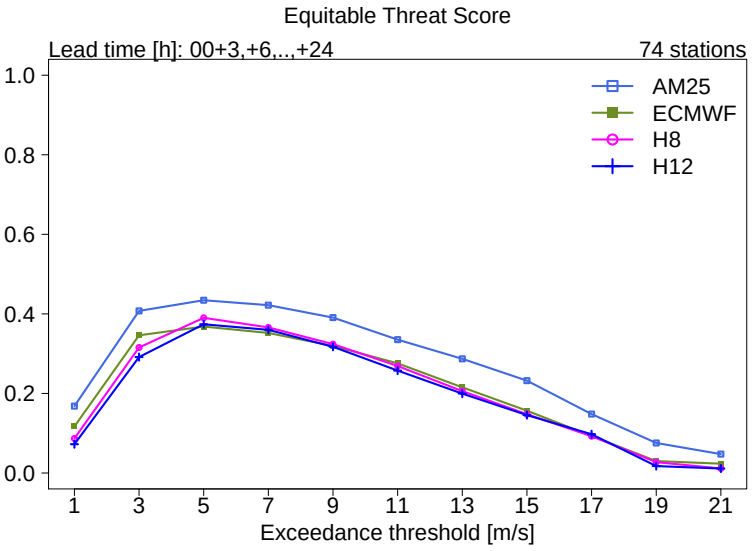


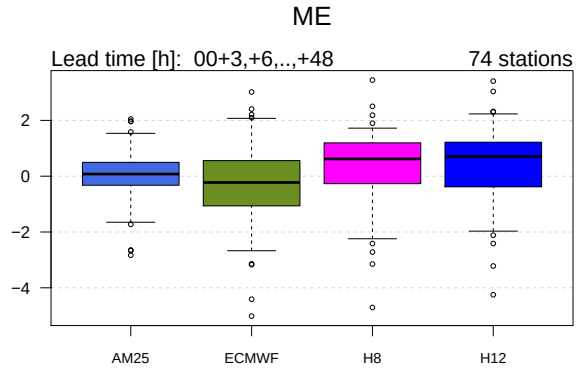


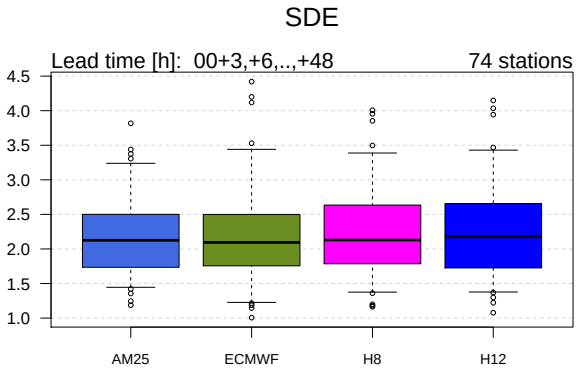



Hit Rate
Lead time [h]: 00+3,+6,..,+24
74 stations
AM25
ECMWF
H8
H12
1.0
0.8
0.6
0.4
0.2
0.0
1 3 5 7 9 11 13 15 17 19 21
Exceedance threshold [m/s]


False Alarm Ratio
Lead time [h]: 00+3,+6,..,+24
74 stations
AM25
ECMWF
H8
H12
1.0
0.8
0.6
0.4
0.2
0.0
1 3 5 7 9 11 13 15 17 19 21
Exceedance threshold [m/s]


Equitable Threat Score
Lead time [h]: 00+3,+6,..,+24
74 stations
AM25
ECMWF
H8
H12
1.0
0.8
0.6
0.4
0.2
0.0
1 3 5 7 9 11 13 15 17 19 21
Exceedance threshold [m/s]





Lead time [h]: 00+3,+6,..,+48 UTC

74 stations

AM25 vs **OBS**

	[0,3]	(3,11]	(11,17]	(17,21]	(21,Inf]	Sum
[0,3]	26272	8025	40	0	0	34337
(3,11]	11363	41044	3521	138	28	56094
(11,17]	72	2177	2461	418	94	5222
(17,21]	5	30	125	92	37	289
(21,Inf]	1	0	2	2	7	12
Sum	37713	51276	6149	650	166	95954

H8 vs **OBS**

	[0,3]	(3,11]	(11,17]	(17,21]	(21,Inf]	Sum
[0,3]	19971	5466	29	0	0	25466
(3,11]	17678	43834	3942	324	101	65879
(11,17]	64	1966	2066	266	50	4412
(17,21]	0	10	109	57	14	190
(21,Inf]	0	0	3	3	1	7
Sum	37713	51276	6149	650	166	95954

ECMWF vs **OBS**

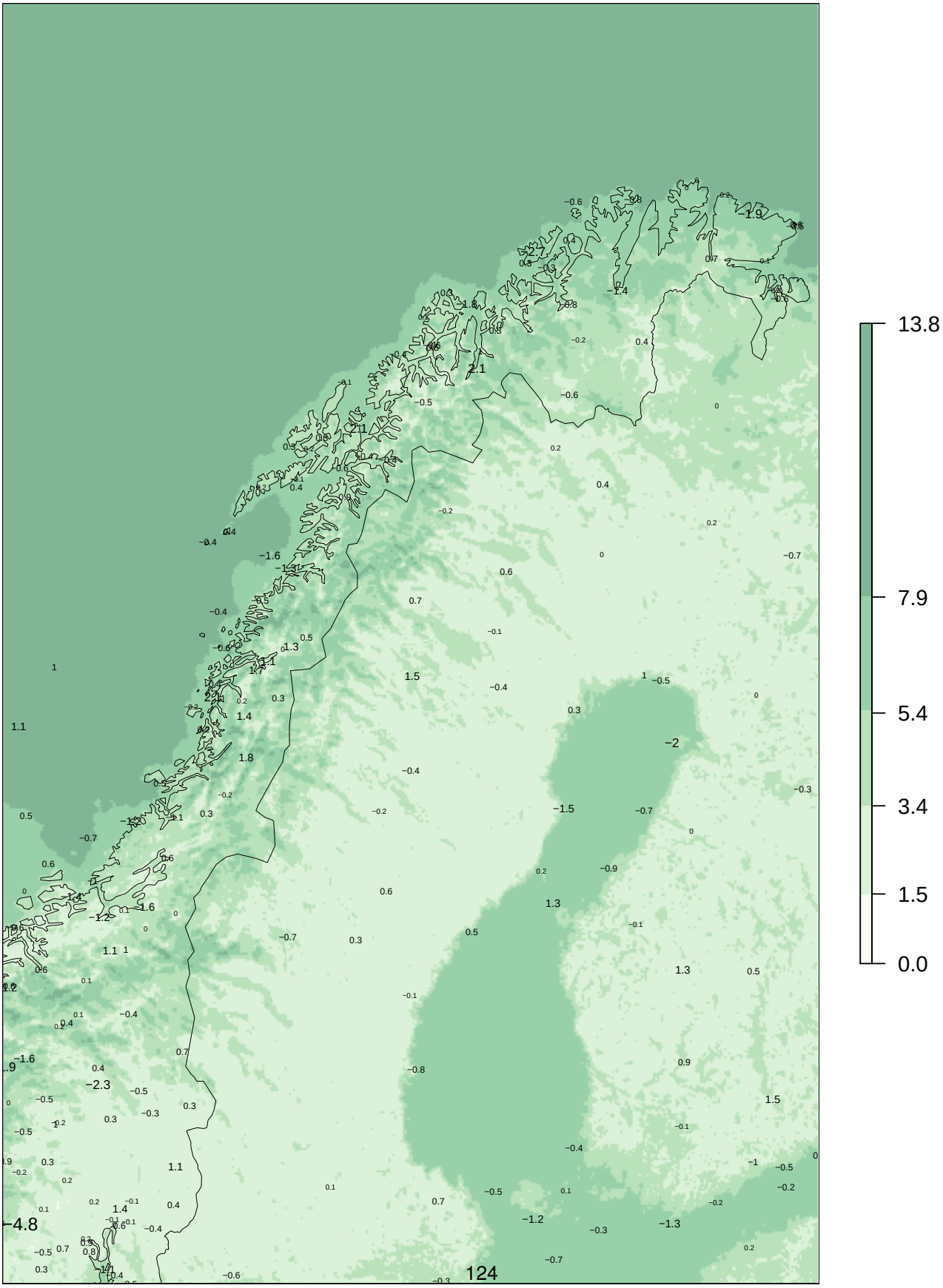
	[0,3]	(3,11]	(11,17]	(17,21]	(21,Inf]	Sum
[0,3]	25985	10735	114	1	2	36837
(3,11]	11692	38703	3881	311	69	54656
(11,17]	36	1825	2066	273	72	4272
(17,21]	0	12	88	62	19	181
(21,Inf]	0	1	0	3	4	8
Sum	37713	51276	6149	650	166	95954

H12 vs **OBS**

	[0,3]	(3,11]	(11,17]	(17,21]	(21,Inf]	Sum
[0,3]	18443	4865	23	0	0	23331
(3,11]	19212	44356	4038	331	85	68022
(11,17]	58	2044	1964	260	62	4388
(17,21]	0	11	121	54	18	204
(21,Inf]	0	0	3	5	1	9
Sum	37713	51276	6149	650	166	95954

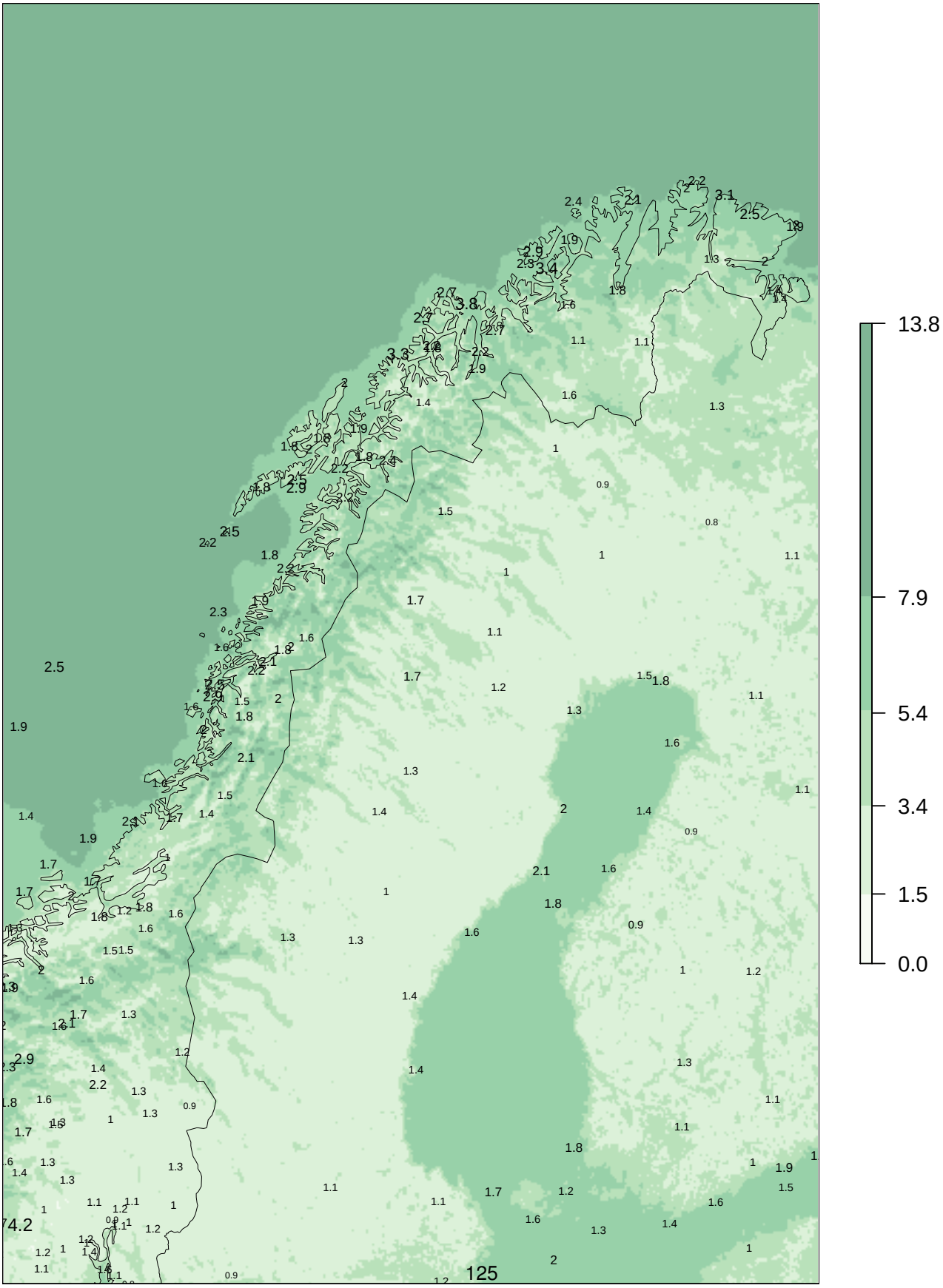
AM25 00+12

ME at observing sites forecast means 01.09.2014 − 30.11.2014

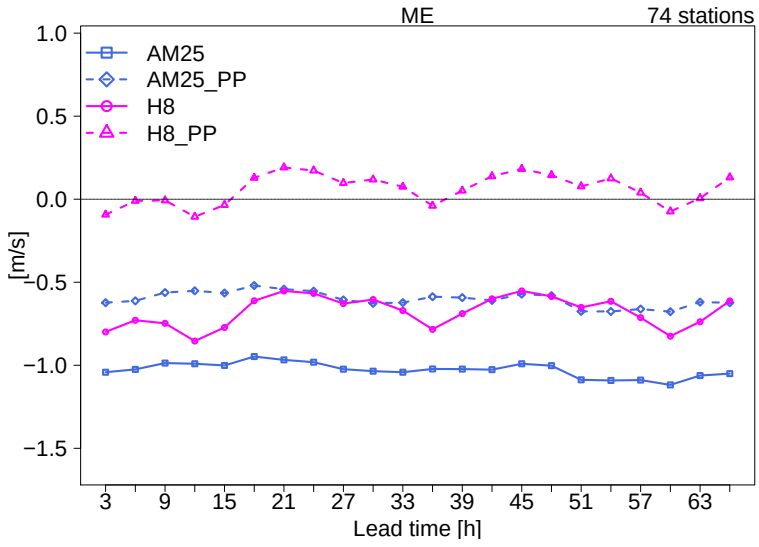


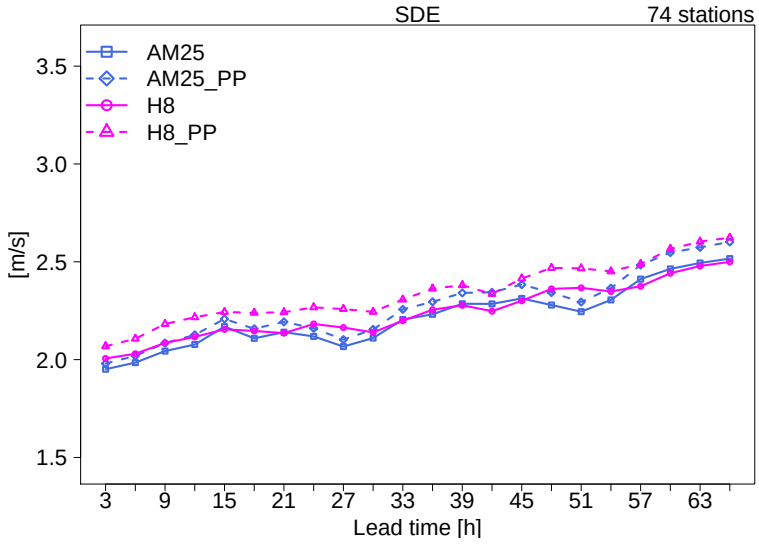
AM25 00+12

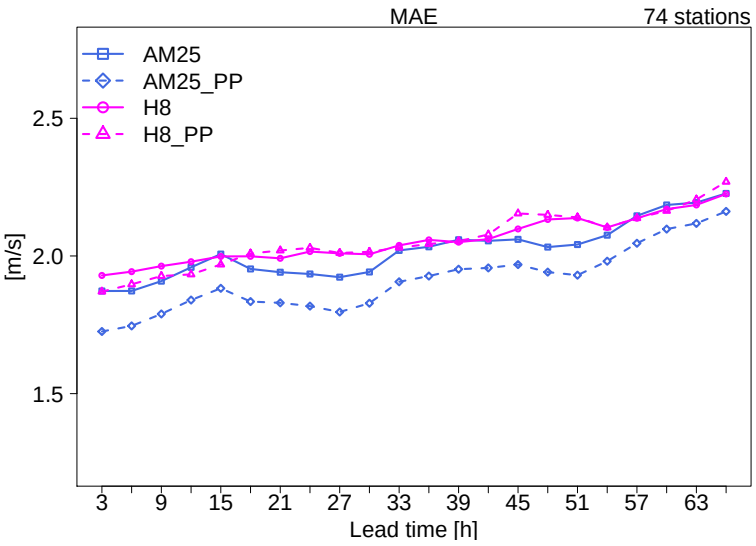
SDE at observing sites forecast means 01.09.2014 − 30.11.2014

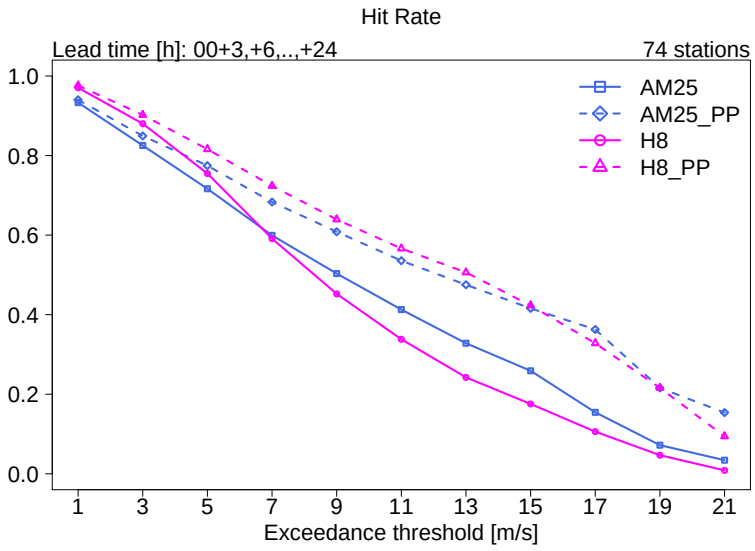


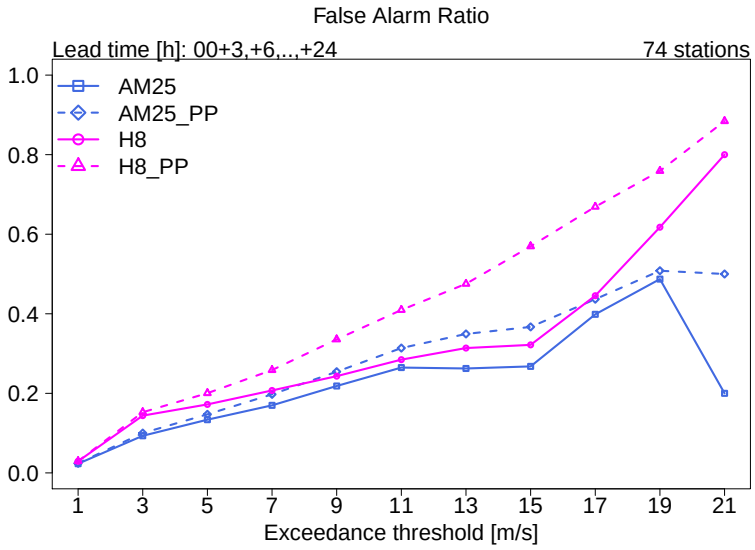
7.4 Max Mean Wind Speed 10m

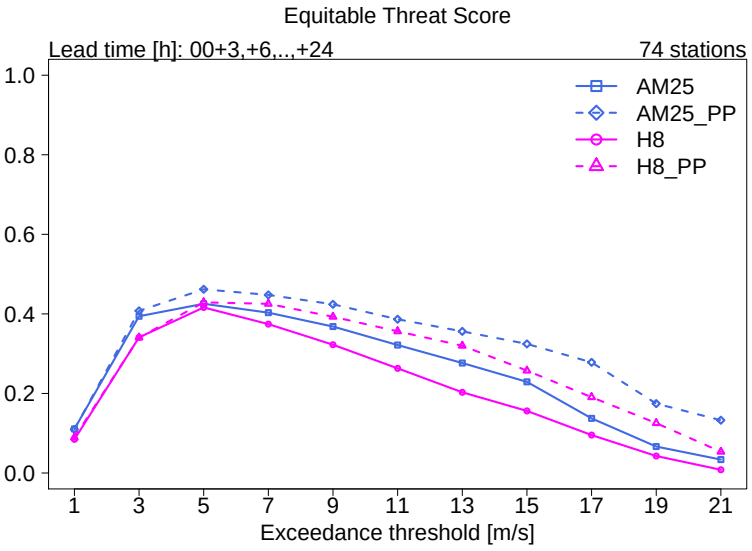


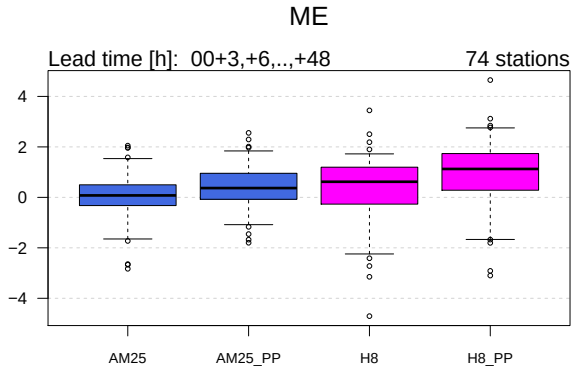


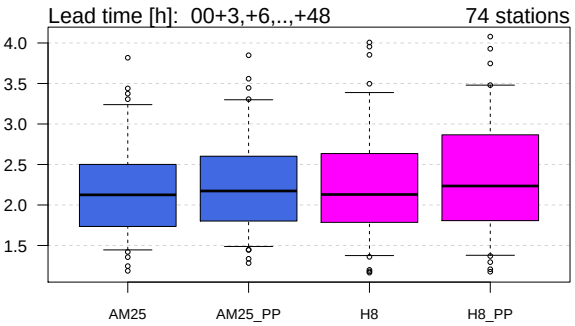



Hit Rate
Lead time [h]: 00+3,+6,..,+24
74 stations
AM25
AM25_PP
H8
H8_PP
1.0
0.8
0.6
0.4
0.2
0.0
1 3 5 7 9 11 13 15 17 19 21
Exceedance threshold [m/s]


False Alarm Ratio
Lead time [h]: 00+3,+6,..,+24
74 stations
AM25
AM25_PP
H8
H8_PP
1.0
0.8
0.6
0.4
0.2
0.0
1 3 5 7 9 11 13 15 17 19 21
Exceedance threshold [m/s]


Equitable Threat Score
Lead time [h]: 00+3,+6,..,+24
74 stations
AM25
AM25_PP
H8
H8_PP
1.0
0.8
0.6
0.4
0.2
0.0
1 3 5 7 9 11 13 15 17 19 21
Exceedance threshold [m/s]





Lead time [h]: 00+3,+6,..,+48 UTC

74 stations

AM25

OBS

	[0,3]	(3,11]	(11,17]	(17,21]	(21,Inf]	Sum
[0,3]	17973	10795	78	0	0	28846
(3,11]	5147	38367	5278	208	32	49032
(11,17]	23	1421	2759	577	133	4913
(17,21]	0	20	104	97	60	281
(21,Inf]	0	1	1	3	8	13
Sum	23143	50604	8220	885	233	83085

AM25_PP

OBS

	[0,3]	(3,11]	(11,17]	(17,21]	(21,Inf]	Sum
[0,3]	17404	9330	53	0	0	26787
(3,11]	5700	38896	4319	119	15	49049
(11,17]	37	2322	3570	528	68	6525
(17,21]	2	49	271	218	112	652
(21,Inf]	0	7	7	20	38	72
Sum	23143	50604	8220	885	233	83085

H8

OBS

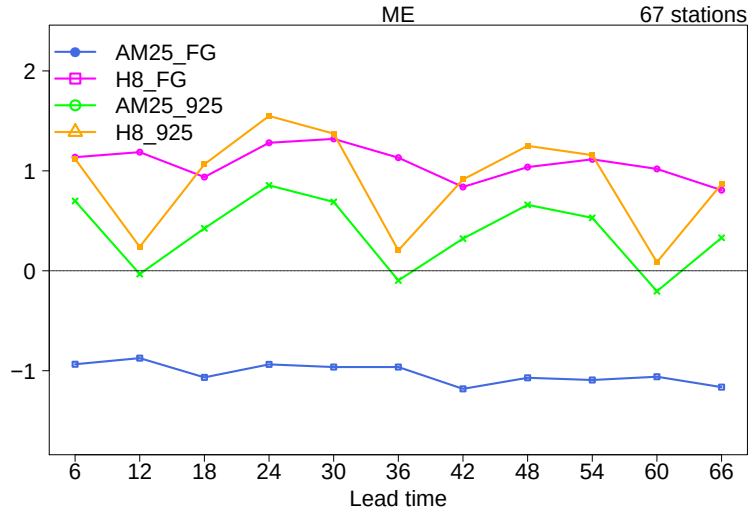
	[0,3]	(3,11]	(11,17]	(17,21]	(21,Inf]	Sum
[0,3]	13838	7166	60	0	0	21064
(3,11]	9281	42107	5694	384	110	57576
(11,17]	24	1328	2379	415	102	4248
(17,21]	0	3	84	83	20	190
(21,Inf]	0	0	3	3	1	7
Sum	23143	50604	8220	885	233	83085

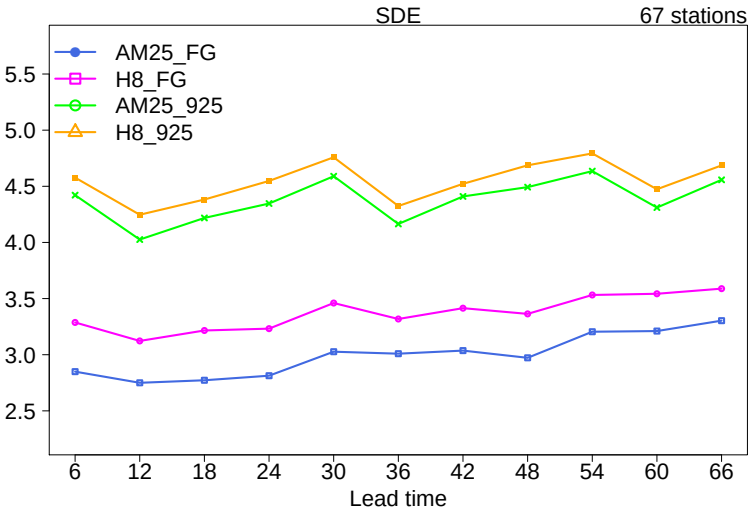
H8_PP

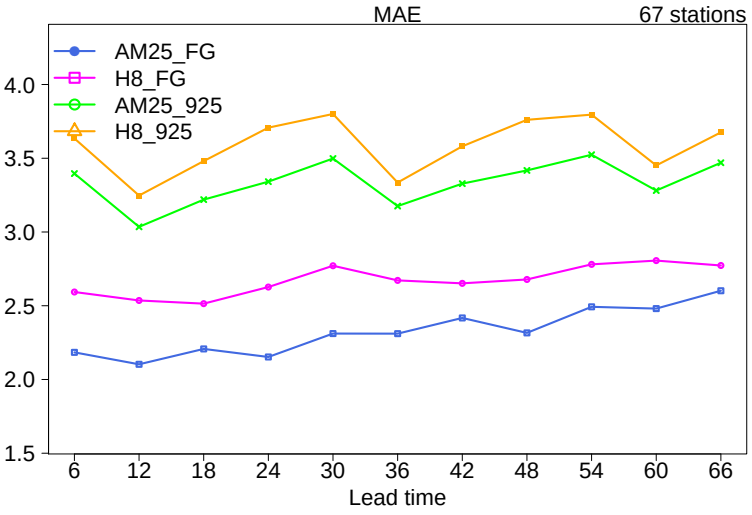
OBS

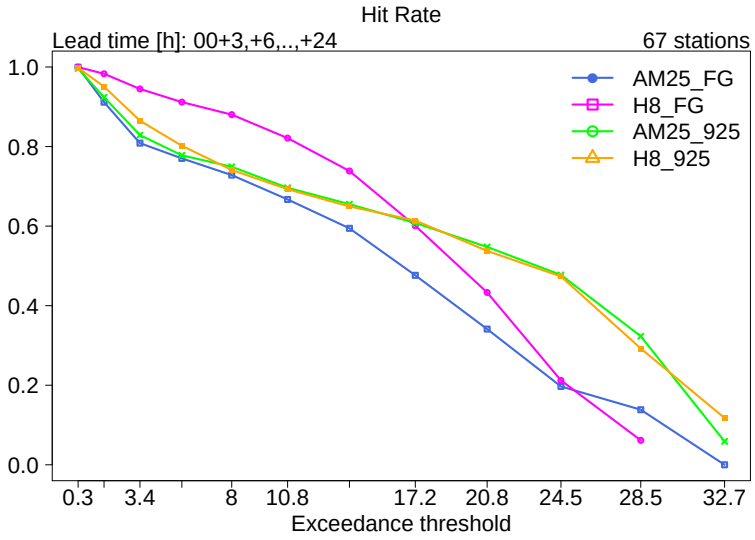
	[0,3]	(3,11]	(11,17]	(17,21]	(21,Inf]	Sum
[0,3]	12975	5883	37	0	0	18895
(3,11]	10107	40911	3911	168	25	55122
(11,17]	59	3673	3658	434	135	7959
(17,21]	2	134	547	208	57	948
(21,Inf]	0	3	67	75	16	161
Sum	23143	50604	8220	885	233	83085

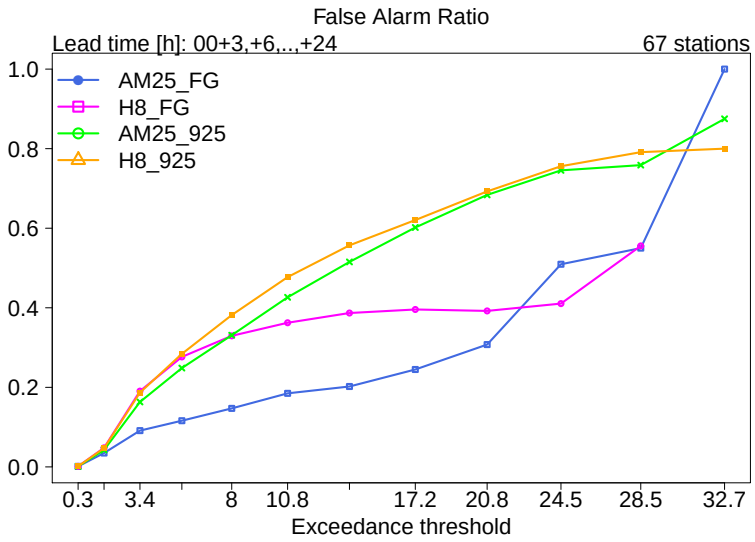
7.5 Wind gust

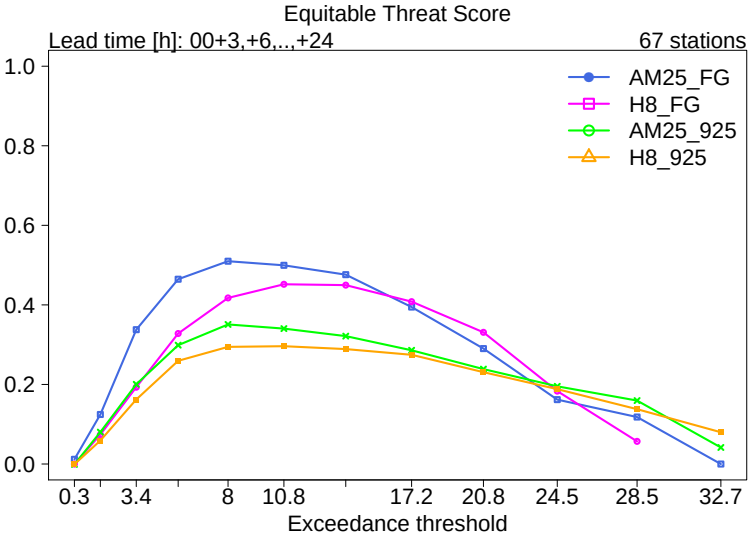

ME
67 stations
AM25_FG
H8_FG
AM25_925
H8_925
2
1
0
−1
6
12
18
24
30
36
42
48
54
60
66
Lead time


SDE
67 stations
AM25_FG
H8_FG
AM25_925
H8_925
5.5
5.0
4.5
4.0
3.5
3.0
2.5
6
12
18
24
30
36
42
48
54
60
66
Lead time

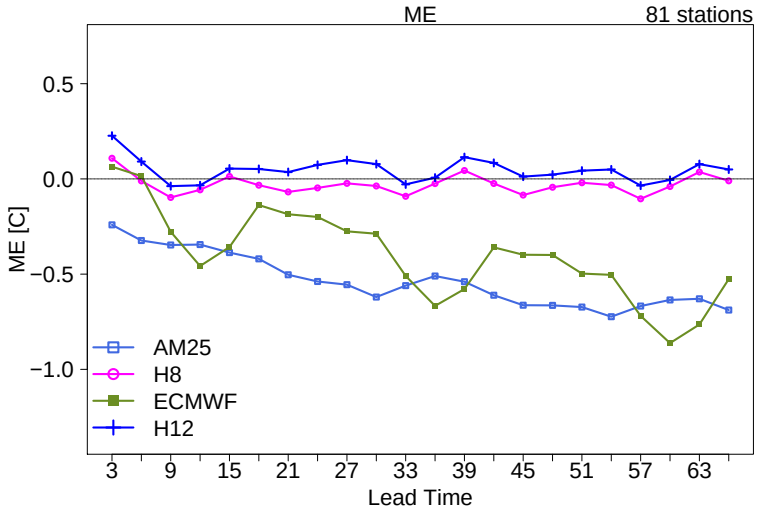

MAE
67 stations
AM25_FG
H8_FG
AM25_925
H8_925
4.0
3.5
3.0
2.5
2.0
1.5
6
12
18
24
30
36
42
48
54
60
66
Lead time

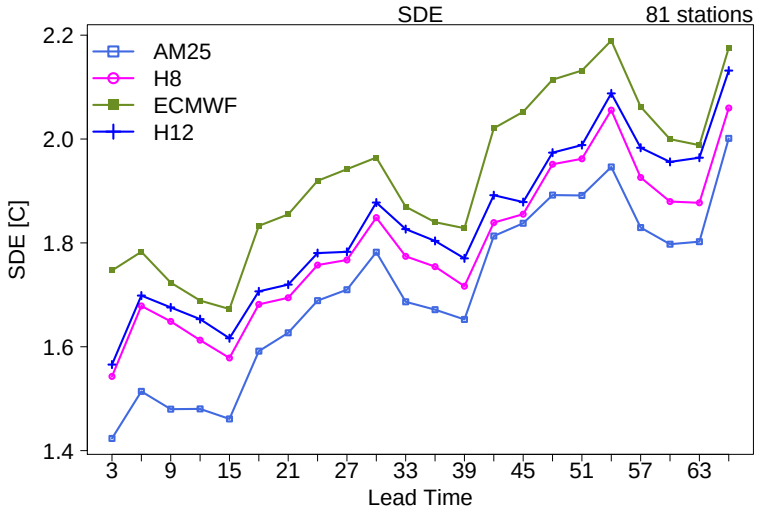

Hit Rate
Lead time [h]: 00+3,+6,..,+24
67 stations
AM25_FG
H8_FG
AM25_925
H8_925
1.0
0.8
0.6
0.4
0.2
0.0
0.3
3.4
8
10.8
17.2
20.8
24.5
28.5
32.7
Exceedance threshold

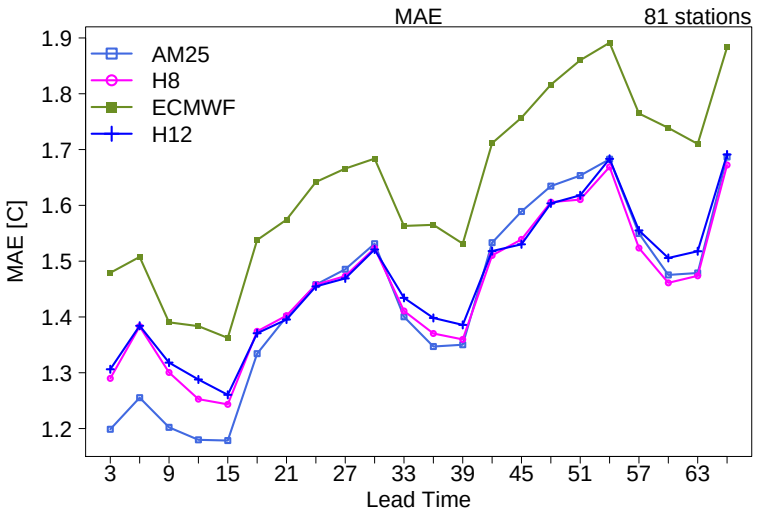

False Alarm Ratio
Lead time [h]: 00+3,+6,..,+24
67 stations
AM25_FG
H8_FG
AM25_925
H8_925
1.0
0.8
0.6
0.4
0.2
0.0
0.3
3.4
8
10.8
17.2
20.8
24.5
28.5
32.7
Exceedance threshold

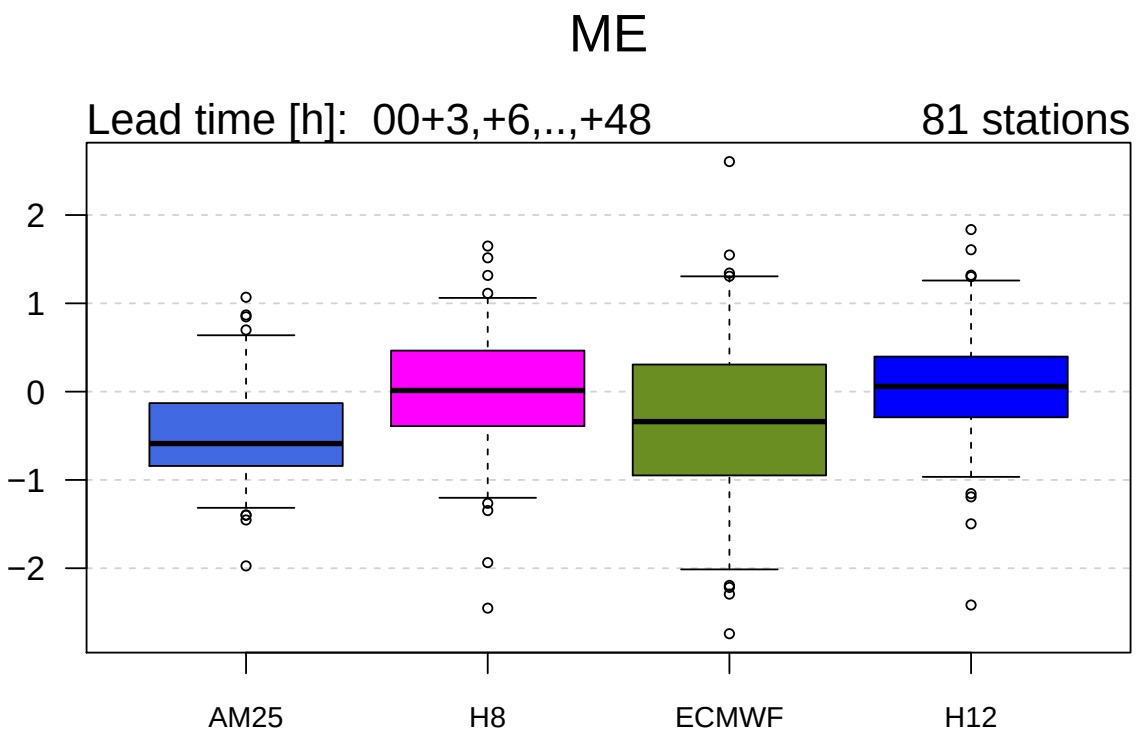

Equitable Threat Score
Lead time [h]: 00+3,+6,..,+24
67 stations
AM25_FG
H8_FG
AM25_925
H8_925
1.0
0.8
0.6
0.4
0.2
0.0
0.3
3.4
8
10.8
17.2
20.8
24.5
28.5
32.7
Exceedance threshold

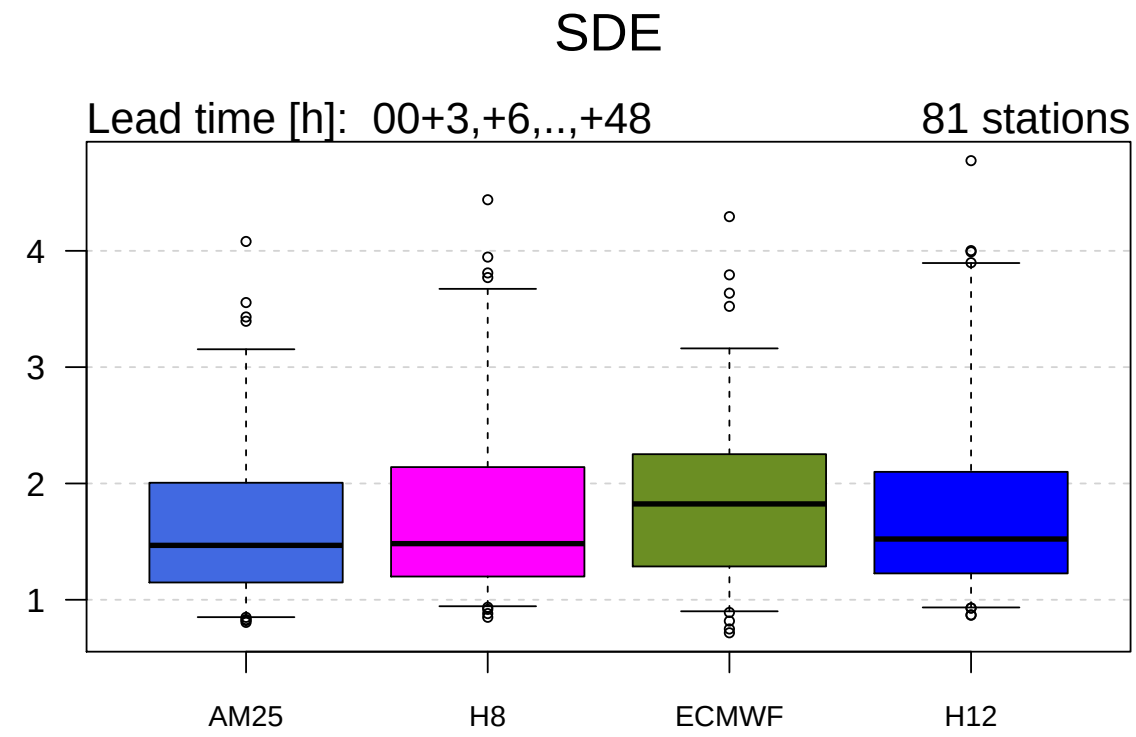
7.6 Temperature 2m





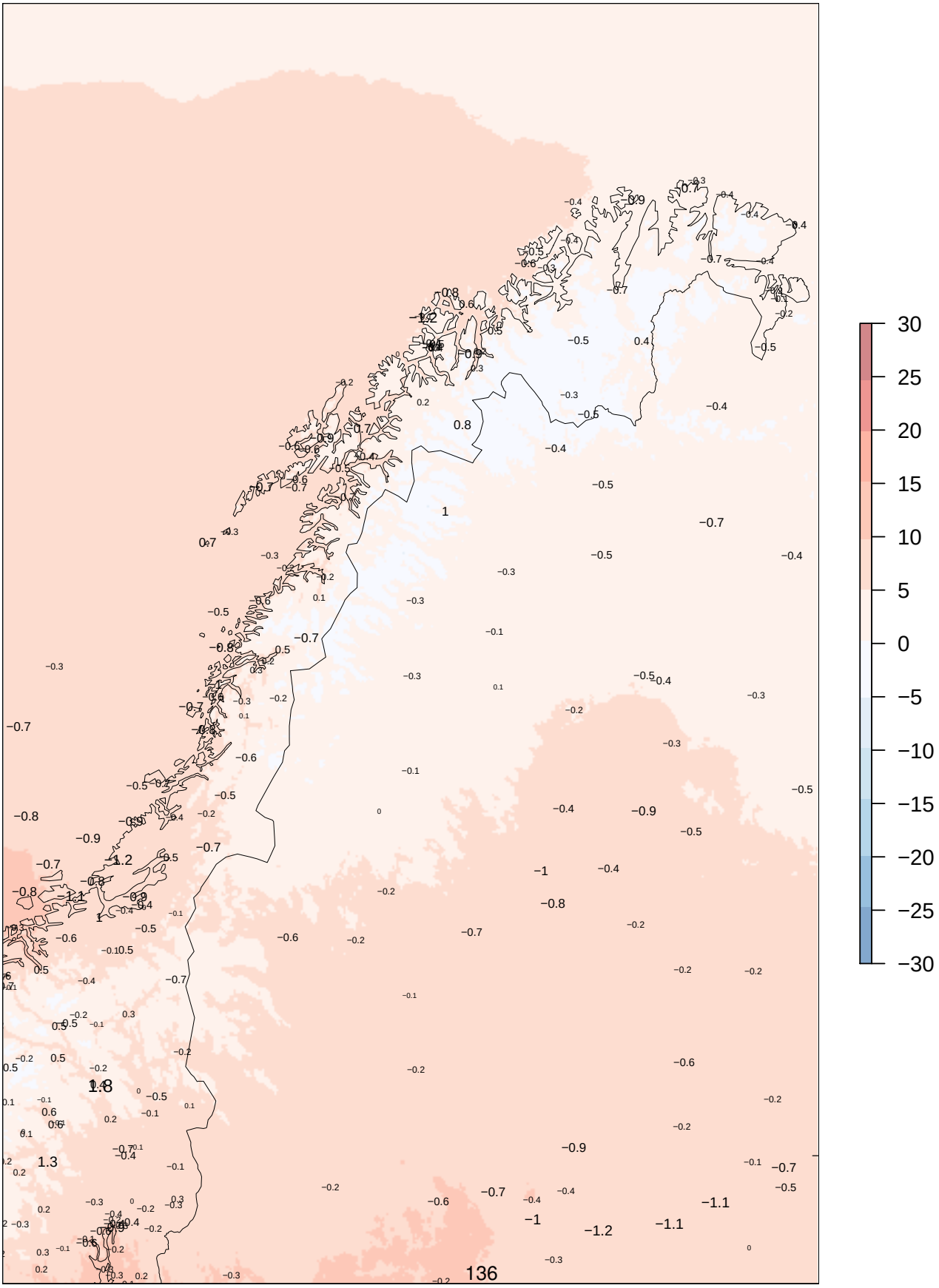



ME
Lead time [h]: 00+3,+6,..,+48
81 stations
2
1
0
−1
−2
AM25
H8
ECMWF
H12


SDE
Lead time [h]: 00+3,+6,..,+48
81 stations
4
3
2
1
AM25
H8
ECMWF
H12

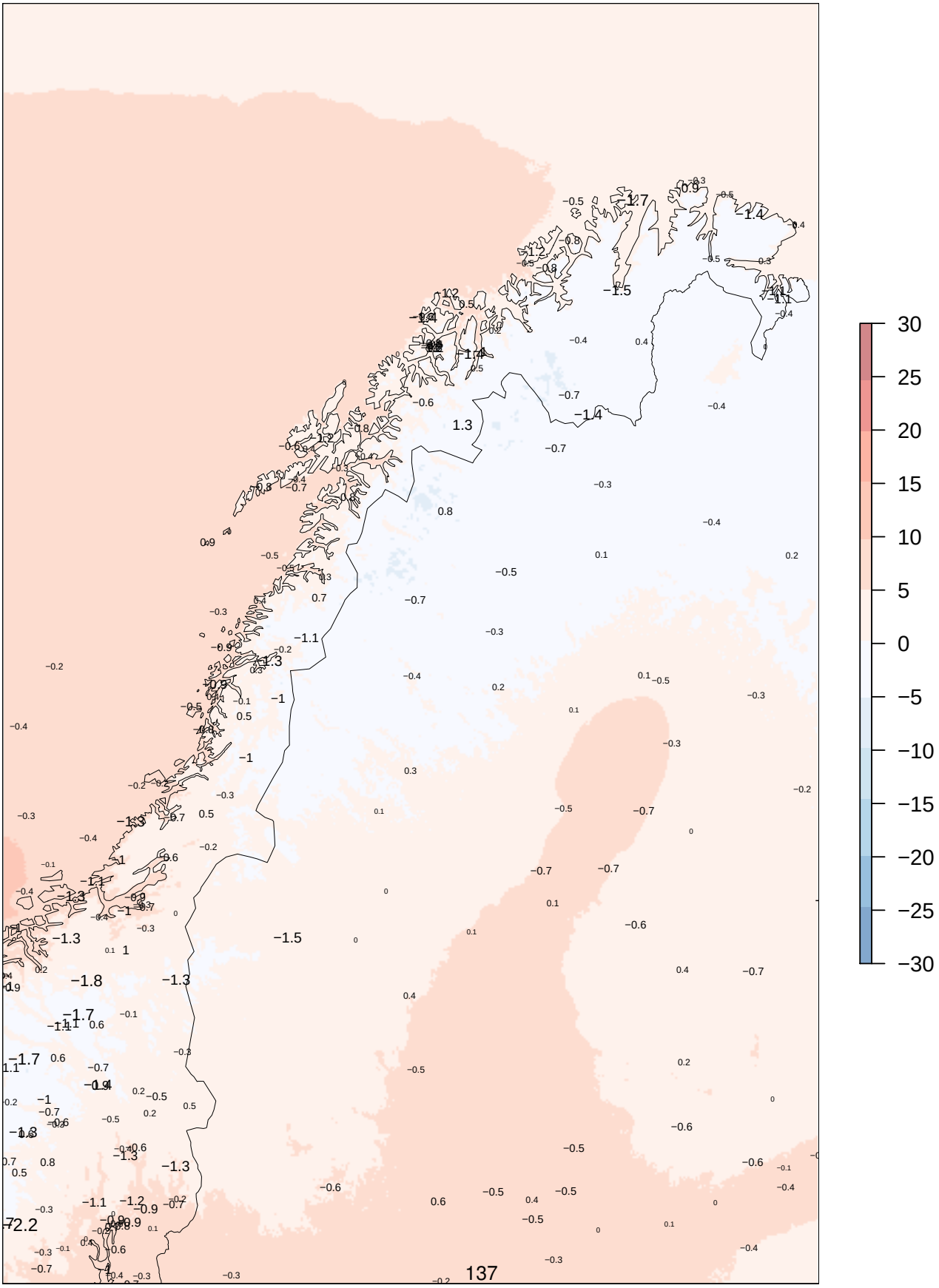
AM25 00+12

ME at observing sites forecast means 01.09.2014 − 30.11.2014



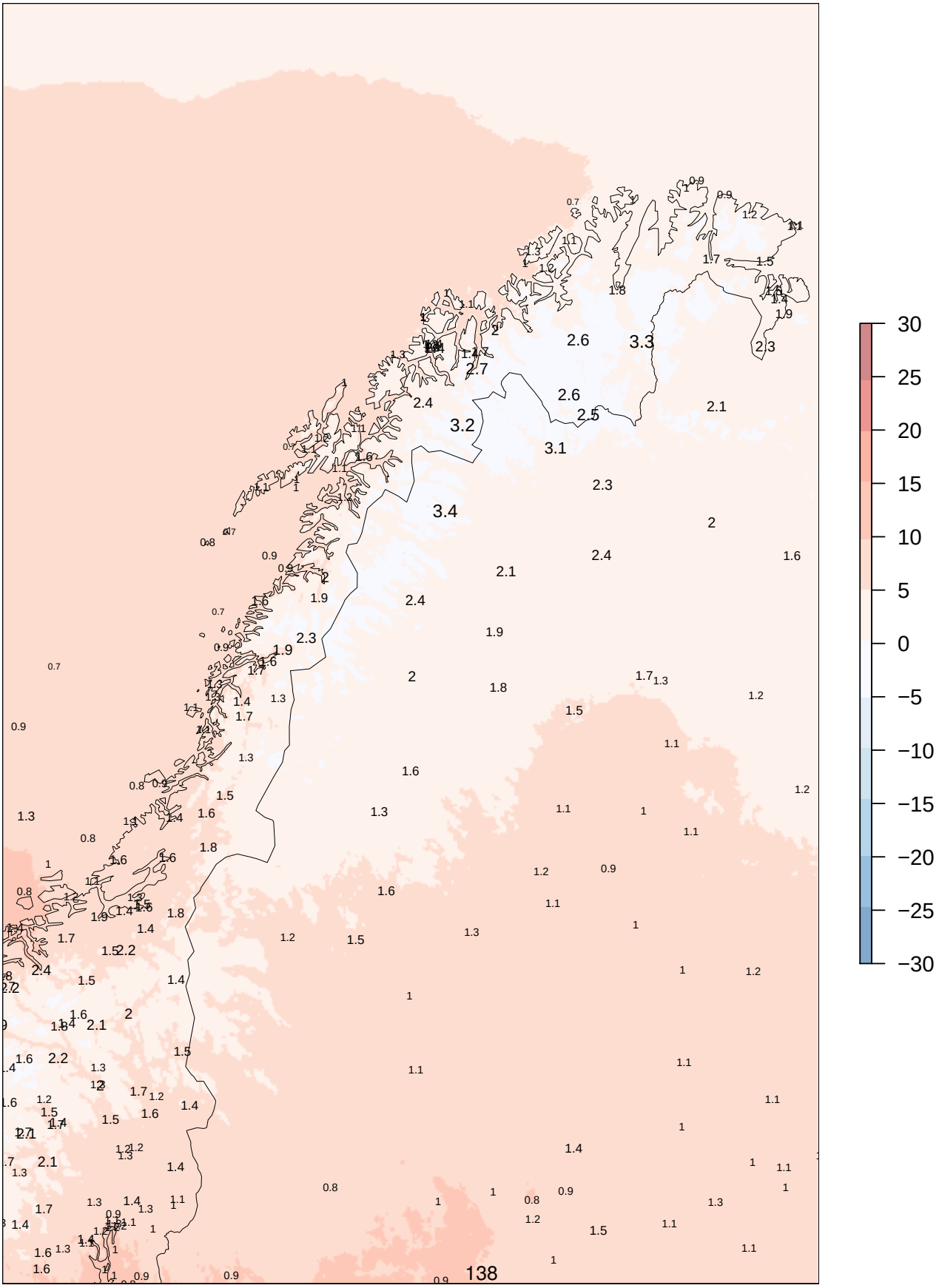
AM25 00+24

ME at observing sites forecast means 01.09.2014 − 30.11.2014



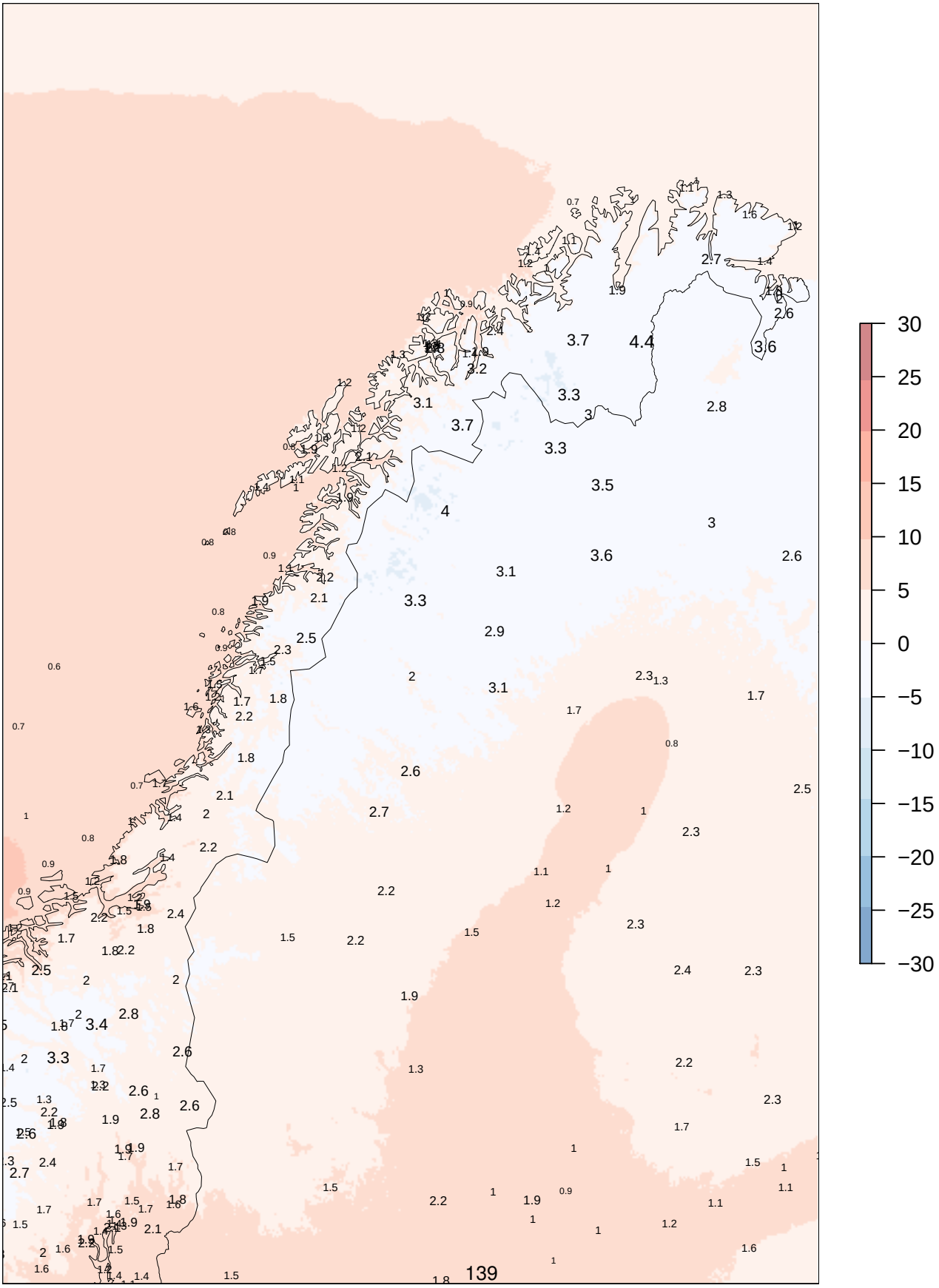
AM25 00+12

SDE at observing sites forecast means 01.09.2014 − 30.11.2014

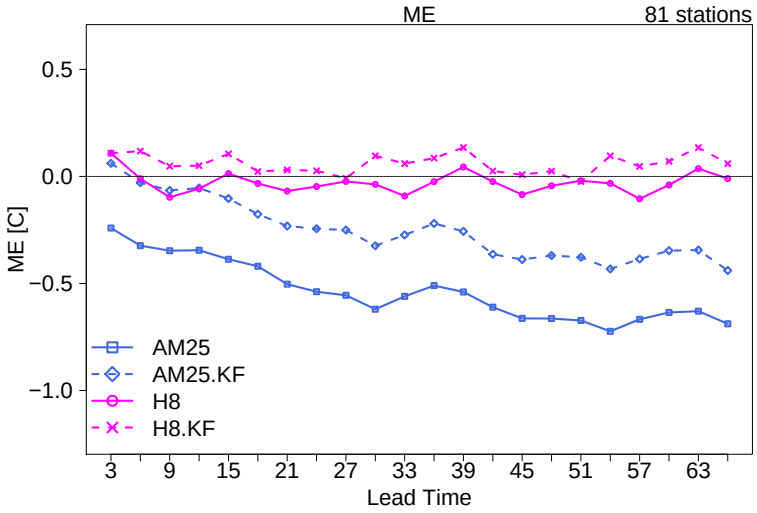


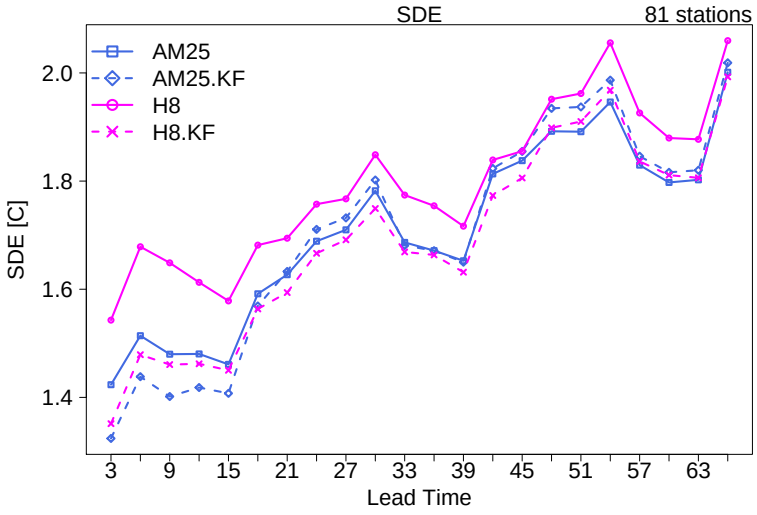
AM25 00+24

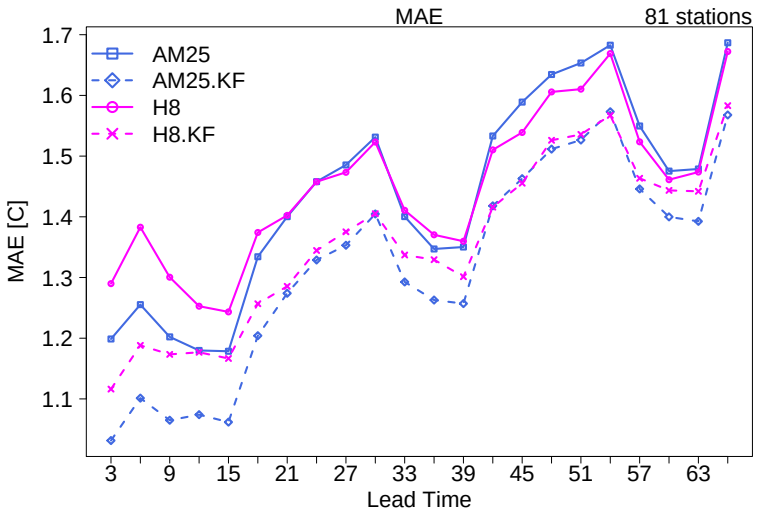
SDE at observing sites forecast means 01.09.2014 − 30.11.2014

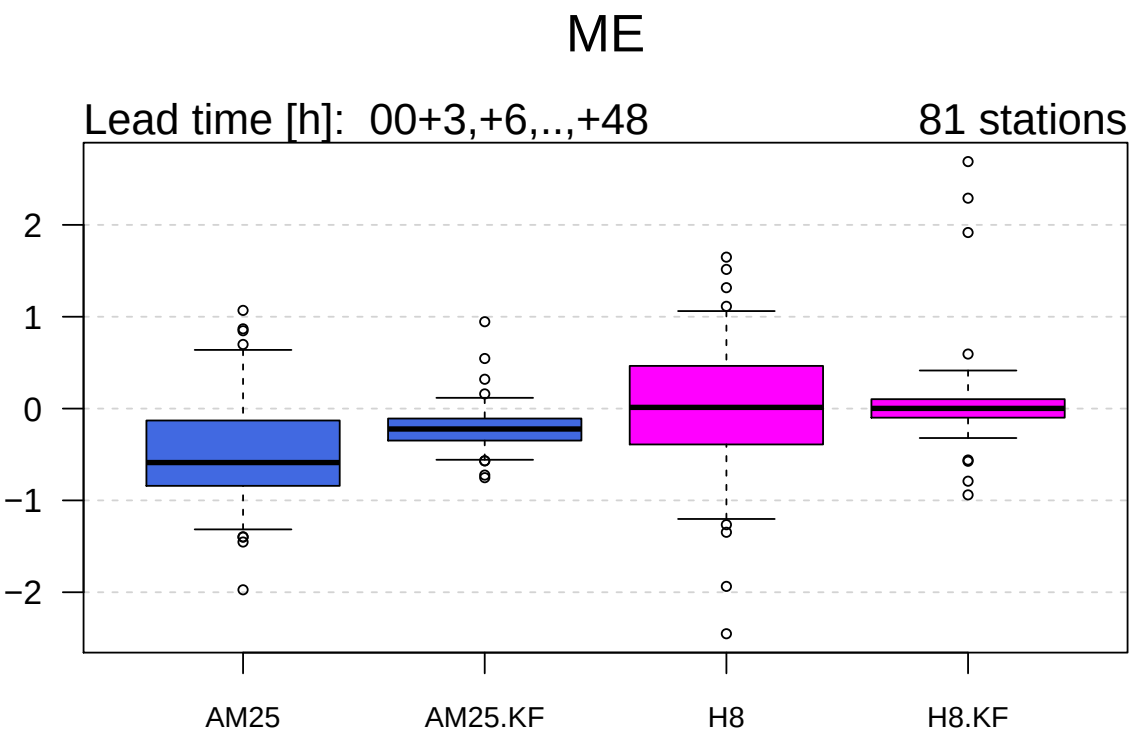


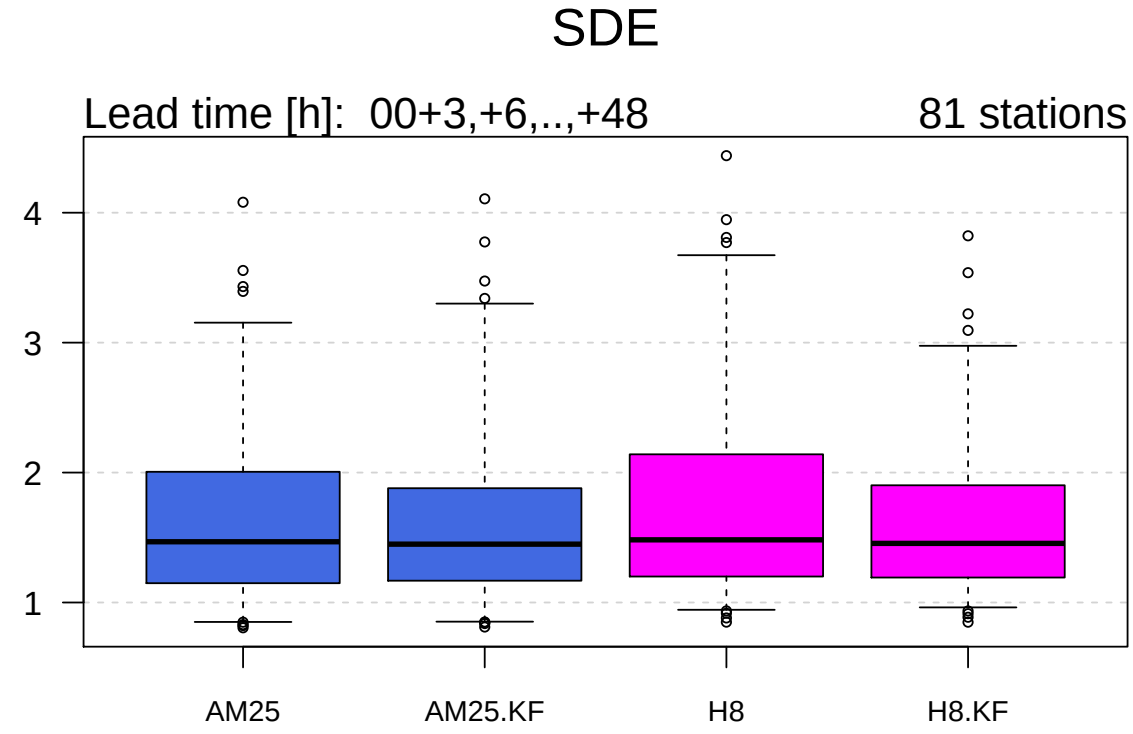
7.7 Post processed temperature 2m



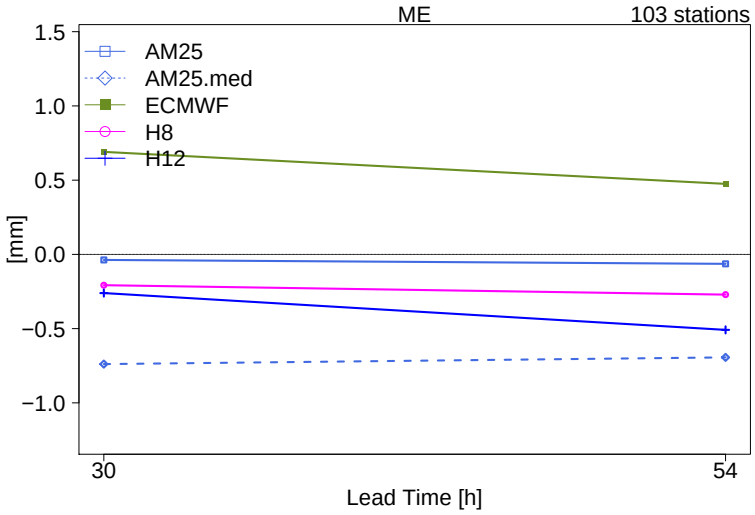


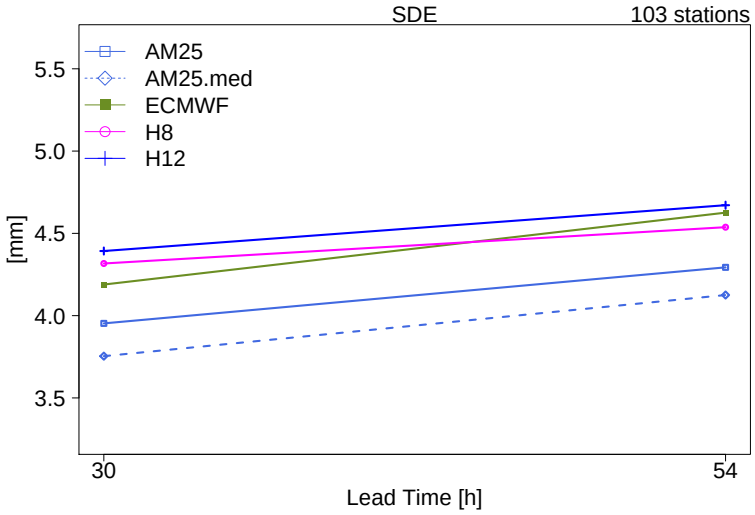


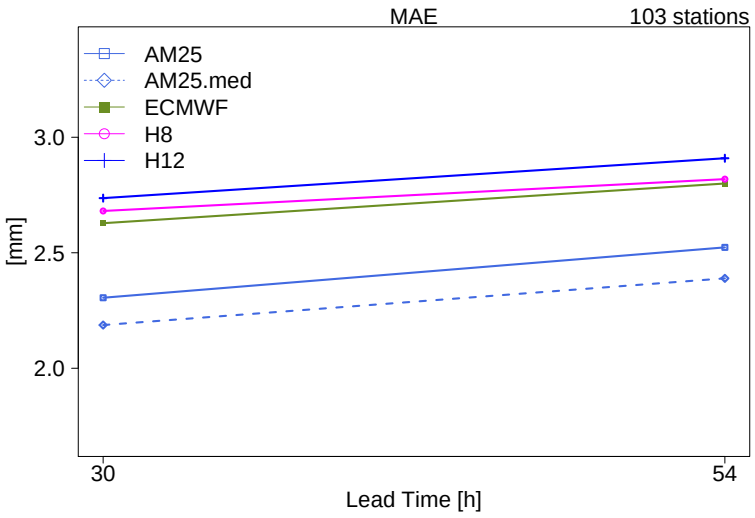

ME
Lead time [h]: 00+3,+6,..,+48
81 stations
2
1
0
−1
−2
AM25
AM25.KF
H8
H8.KF

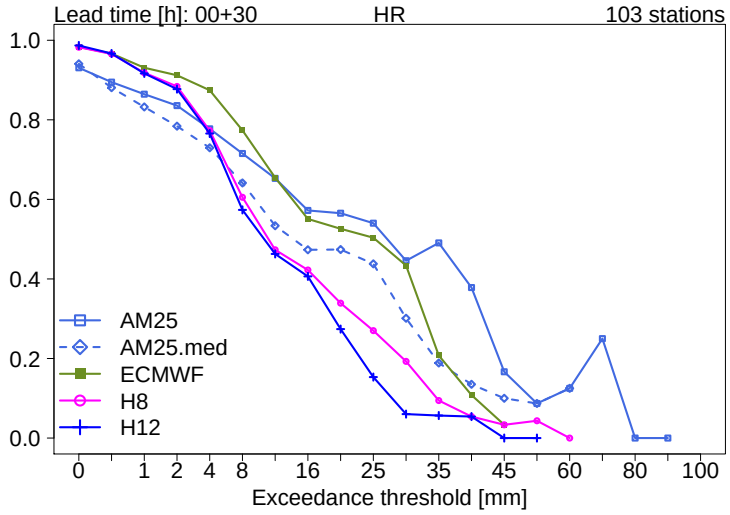

SDE
Lead time [h]: 00+3,+6,..,+48
81 stations
4
3
2
1
AM25
AM25.KF
H8
H8.KF

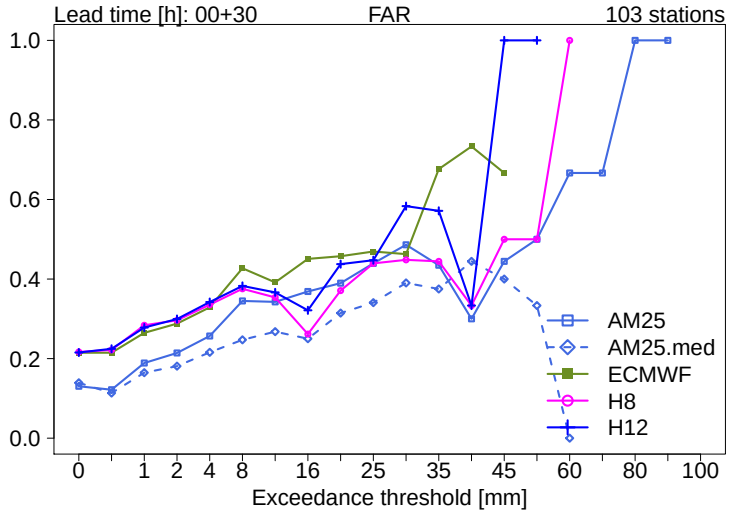
7.8 Daily precipitation

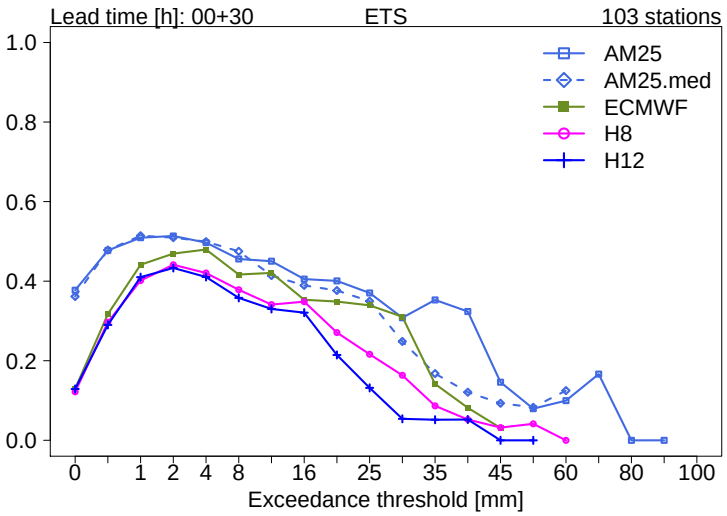


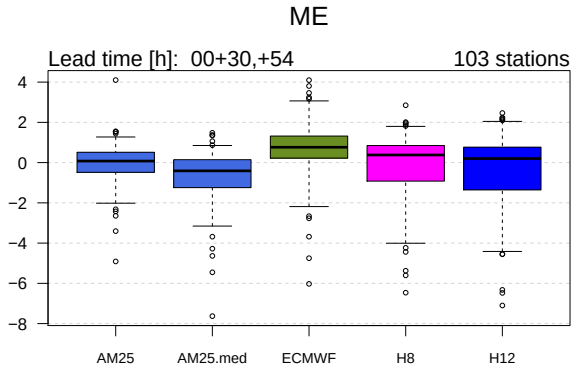


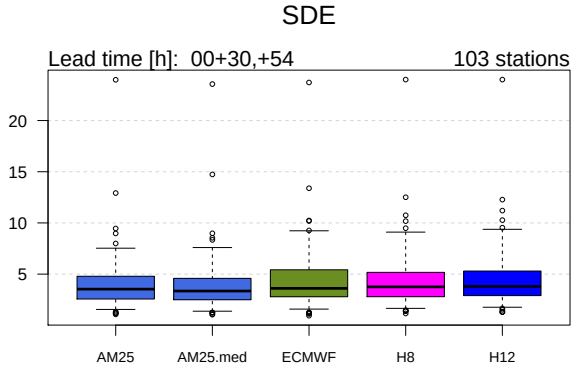



Lead time [h]: 00+30
HR
103 stations
1.0
0.8
0.6
0.4
0.2
0.0
AM25
AM25.med
ECMWF
H8
H12
0 1 2 4 8 16 25 35 45 60 80 100
Exceedance threshold [mm]


Lead time [h]: 00+30
FAR
103 stations
1.0
0.8
0.6
0.4
0.2
0.0
AM25
AM25.med
ECMWF
H8
H12
0 1 2 4 8 16 25 35 45 60 80 100
Exceedance threshold [mm]


Lead time [h]: 00+30
ETS
103 stations
1.0
0.8
0.6
0.4
0.2
0.0
AM25
AM25.med
ECMWF
H8
H12
0 1 2 4 8 16 25 35 45 60 80 100
Exceedance threshold [mm]





Lead time [h]: 00+30,+54 103 stations

AM25

OBS	[0,0.1]	(0.1,5]	(5,20]	(20,50]	(50,Inf]	Sum
[0,0.1]	3106	1001	26	1	2	4136
(0.1,5]	1001	3670	732	16	2	5421
(5,20]	56	875	1571	188	4	2694
(20,50]	0	13	167	200	34	414
(50,Inf]	0	0	2	2	4	8
Sum	4163	5559	2498	407	46	12673

AM25.med

OBS	[0,0.1]	(0.1,5]	(5,20]	(20,50]	(50,Inf]	Sum
[0,0.1]	3220	1120	28	0	3	4371
(0.1,5]	917	3755	879	25	1	5577
(5,20]	26	679	1486	202	9	2402
(20,50]	0	5	105	178	31	319
(50,Inf]	0	0	0	2	2	4
Sum	4163	5559	2498	407	46	12673

ECMWF

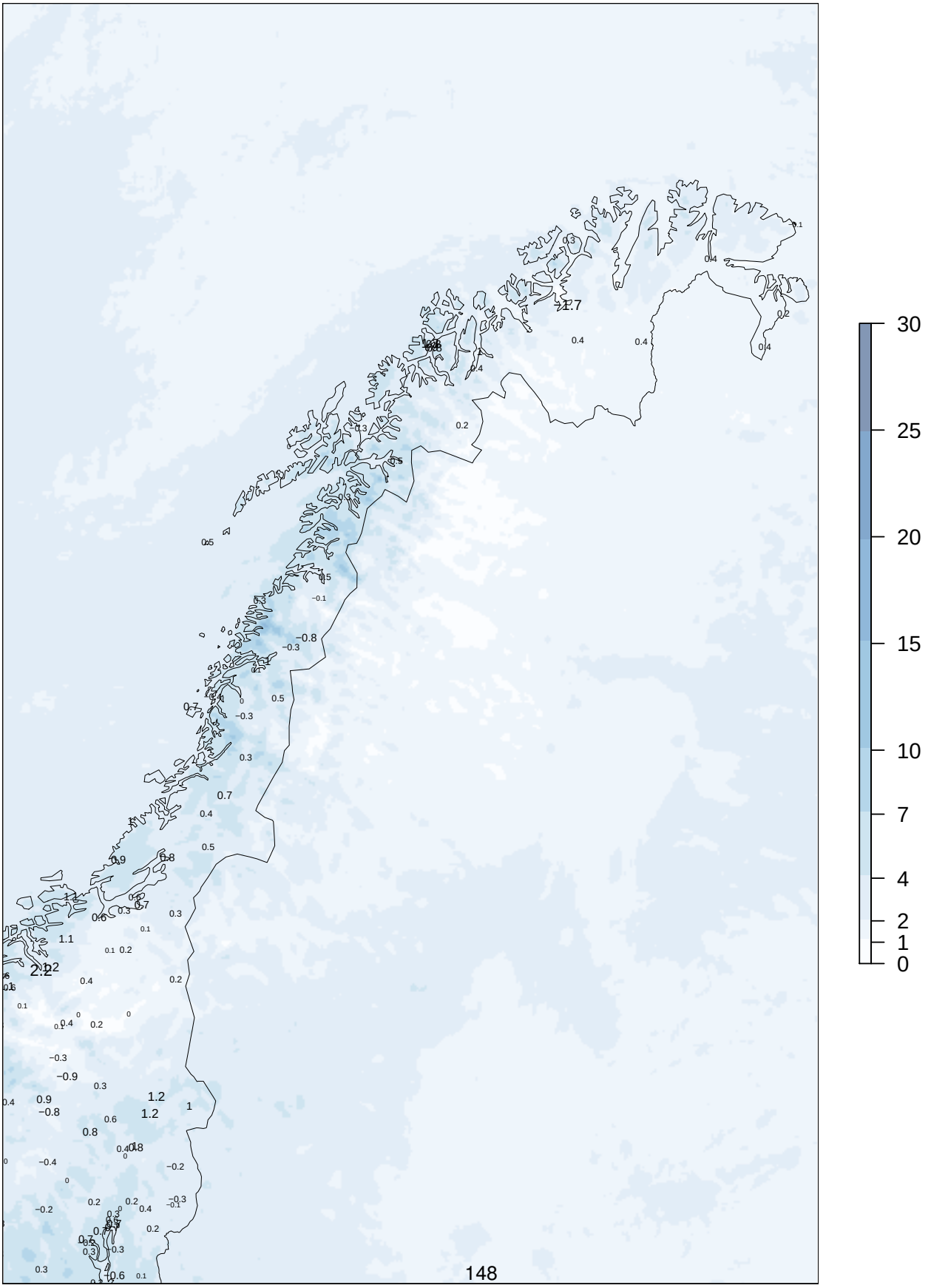
OBS	[0,0.1]	(0.1,5]	(5,20]	(20,50]	(50,Inf]	Sum
[0,0.1]	1960	333	8	0	2	2303
(0.1,5]	2138	3868	461	7	2	6476
(5,20]	65	1339	1828	201	15	3448
(20,50]	0	19	201	199	27	446
(50,Inf]	0	0	0	0	0	0
Sum	4163	5559	2498	407	46	12673

H8

OBS	[0,0.1]	(0.1,5]	(5,20]	(20,50]	(50,Inf]	Sum
[0,0.1]	1849	366	8	1	2	2226
(0.1,5]	2222	4061	851	39	2	7175
(5,20]	92	1125	1552	251	16	3036
(20,50]	0	7	86	116	25	234
(50,Inf]	0	0	1	0	1	2
Sum	4163	5559	2498	407	46	12673

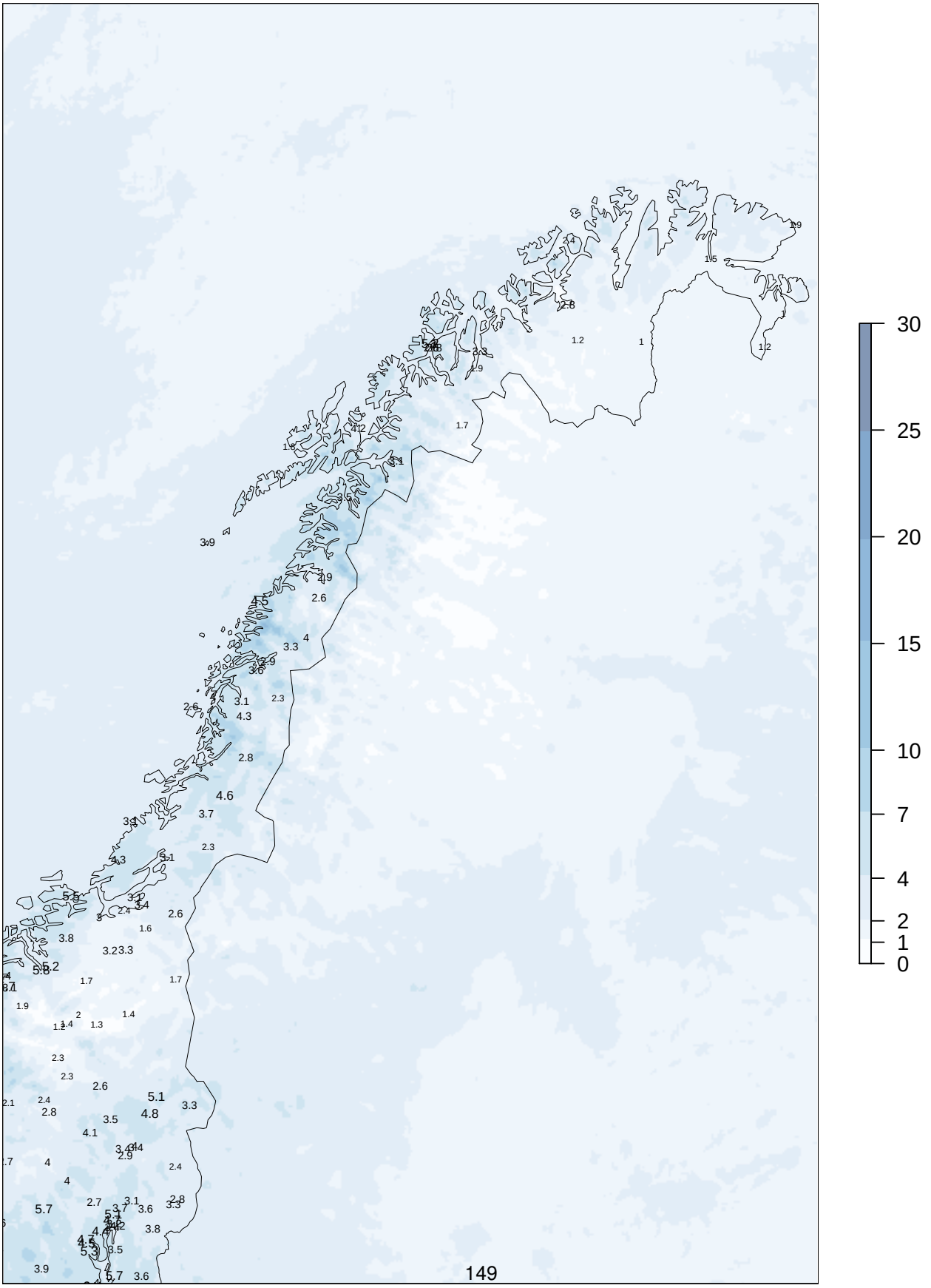
AM25 00+30

ME at observing sites forecast means 01.09.2014 − 30.11.2014



AM25 00+30

SDE at observing sites forecast means 01.09.2014 − 30.11.2014



8 Long term forecast

Temperature 2m:
There is a clear cold bias for all fields. Cold trend up to lead time +100h, then stable at -0.1 to $-0.5\,^{\circ}\mathrm{C}$, $-0.75\,^{\circ}\mathrm{C}$, and -0.9 to $-1.3\,^{\circ}\mathrm{C}$, for calibrated, deterministic and uncalibrated fields, respectively. Clear improvement by using calibrated fields. Small differences between the models in SDE up to 150h, after this the deterministic field has larger SDE than the probabilistic. The calibrated field scores a little better than uncalibrated. The calibrated field has the smallest MAE, with a total error of $2.25\,^{\circ}\mathrm{C}$ for the longest lead times.

Wind speed 10m:
Not much bias compared with the mean wind speed. Deterministic wind generally a little too weak, around $-0.3ms^{-1}$. A smaller negative bias also for the probabilistic field, but with a small trend towards weaker winds. SDE higher for the deterministic forecasts after 78h. The deterministic forecast has a smaller MAE up to 78h, but after this the probabilistic forecast is the best.

Small differences in HR at 72h, but the deterministic forecast has a lower FAR. Small differences also in ETS, but the deterministic forecast scores marginally better. After 216h, the general score is low. The probabilistic forecast score better for thresholds up to $9ms^{-1}$, the deterministic forecast scores best for high threshold.

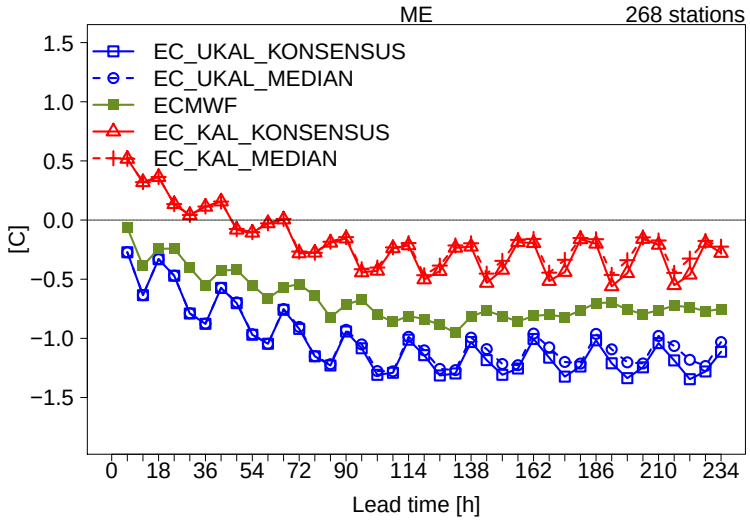
12h precipitation:
Small positive bias in the deterministic forecast. Negative bias, with a clear dry trend for both probabilistic fields. Clear improvement by using a consensus field instead of median. SDE is higher for the deterministic forecast after 72h, and this also go for the MAE.

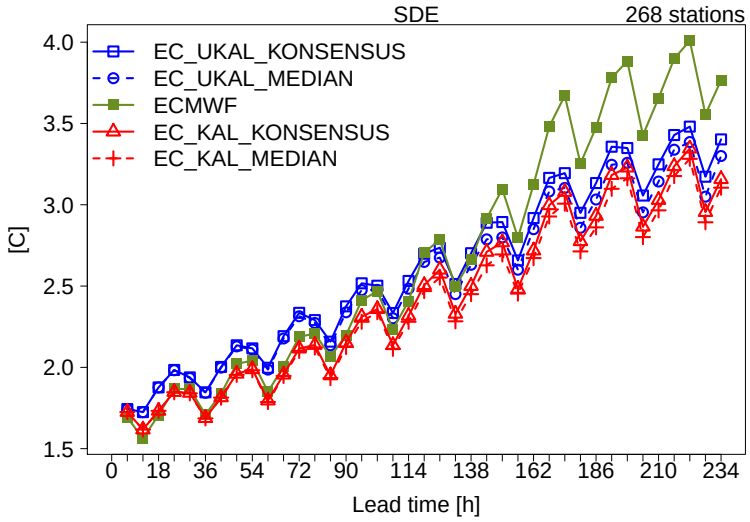
At 72h HR is significantly higher for deterministic forecast for thresholds above 2 mm, and FAR is also lower, so the deterministic forecast scores better in ETS.

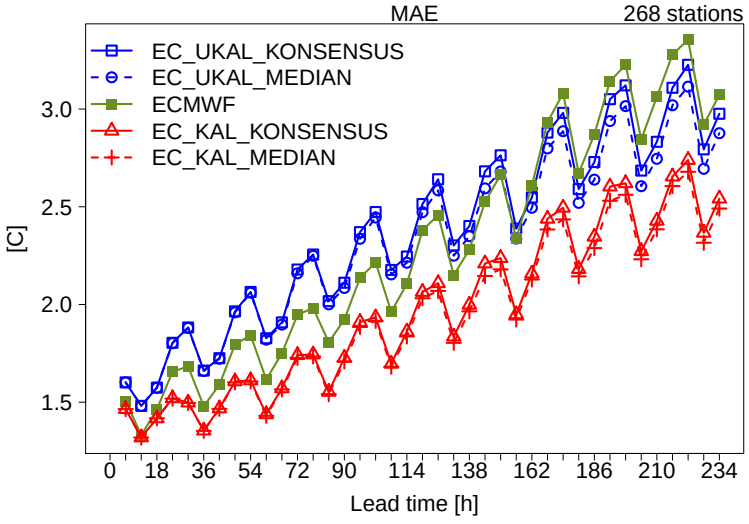
The HRs are more alike after 222h, and the FAR is sky high for the deterministic forecast. The ETS is not high for any model field, but higher for the probabilistic consensus than the others. It should be mentioned that the probabilistic consensus forecast has no events with precipitation above 20mm.

The 24h precipitation is much the same as the 12h precipitation.

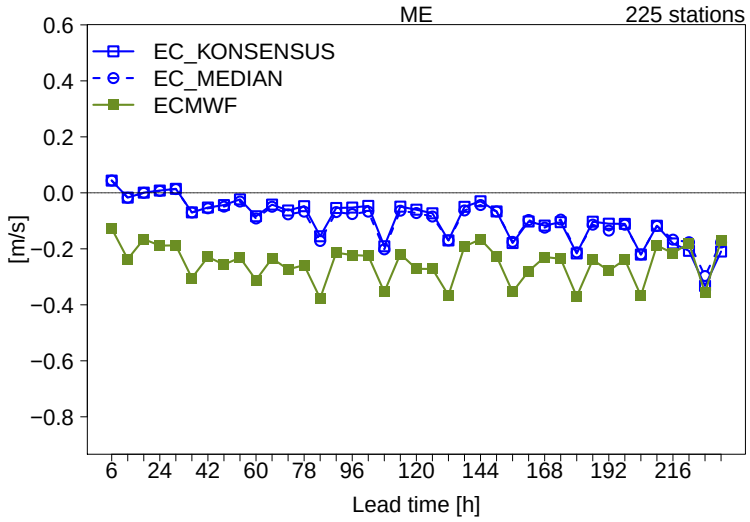
8.1 Temperature 2m

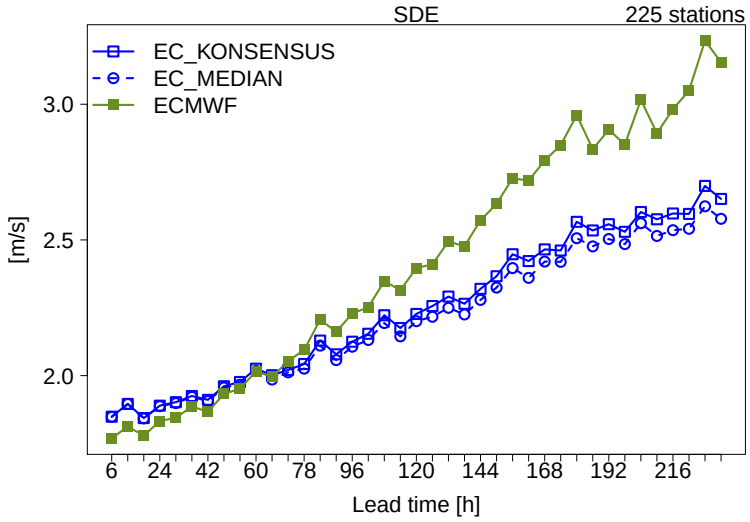


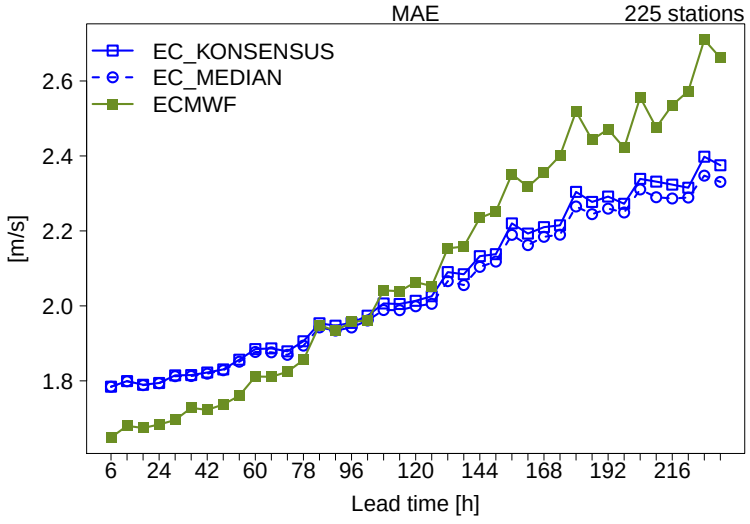


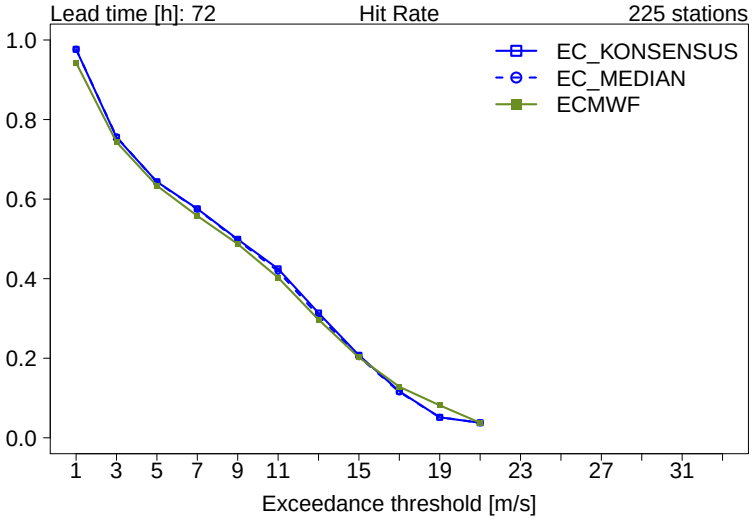


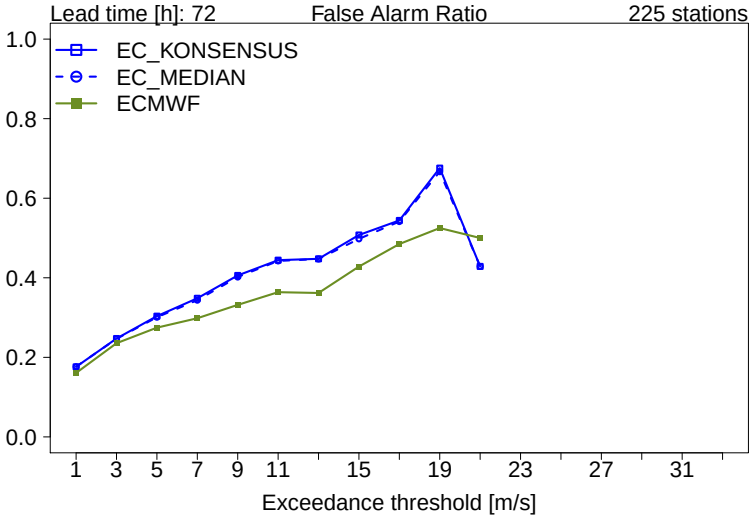
8.2 Wind Speed 10m

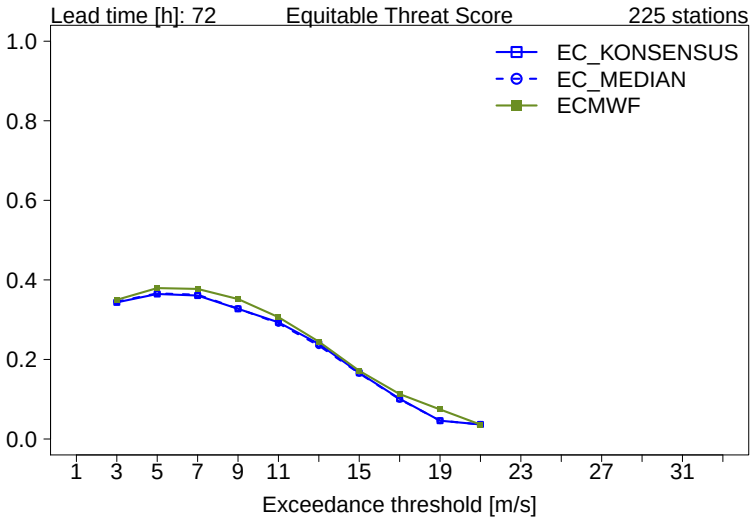


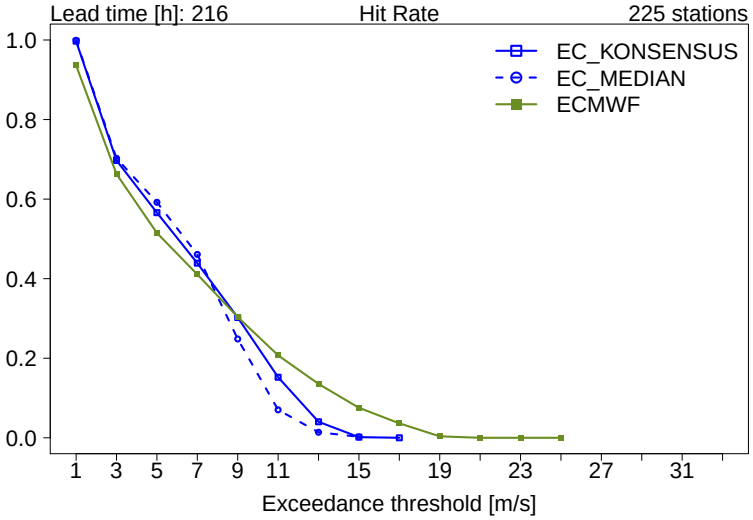


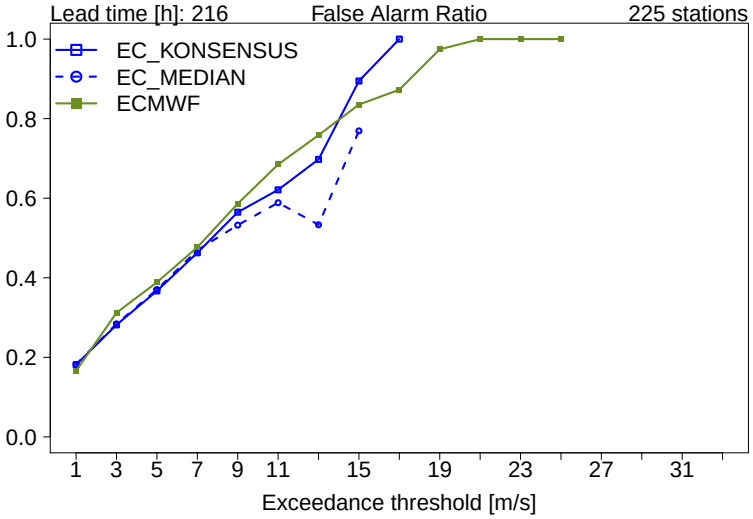


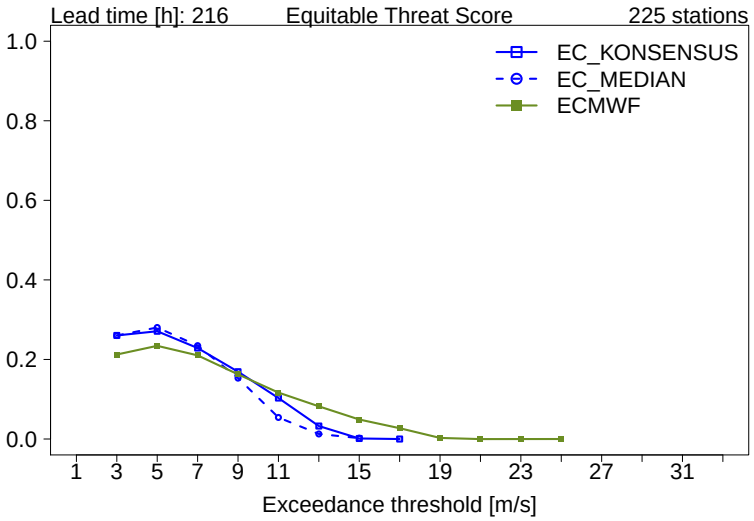

Lead time [h]: 72
Hit Rate
225 stations
EC_KONSENSUS
EC_MEDIAN
ECMWF
1.0
0.8
0.6
0.4
0.2
0.0
1 3 5 7 9 11 15 19 23 27 31
Exceedance threshold [m/s]


Lead time [h]: 72
False Alarm Ratio
225 stations
EC_KONSENSUS
EC_MEDIAN
ECMWF
1.0
0.8
0.6
0.4
0.2
0.0
1 3 5 7 9 11 15 19 23 27 31
Exceedance threshold [m/s]

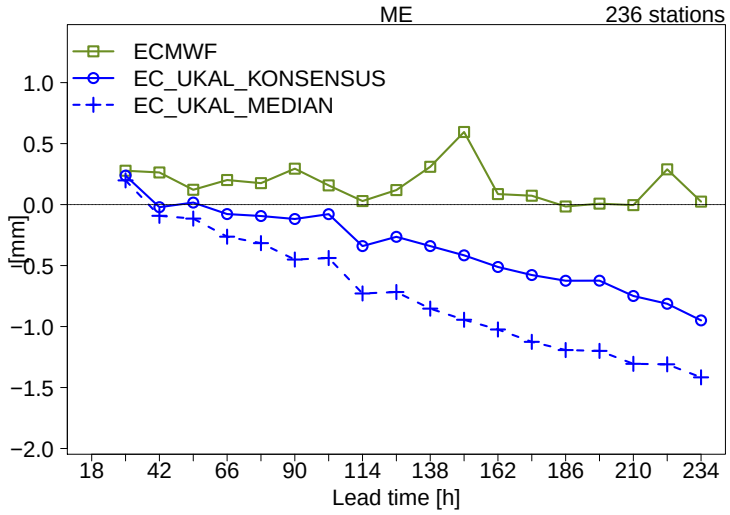

Lead time [h]: 72
Equitable Threat Score
225 stations
EC_KONSENSUS
EC_MEDIAN
ECMWF
1.0
0.8
0.6
0.4
0.2
0.0
1 3 5 7 9 11 15 19 23 27 31
Exceedance threshold [m/s]

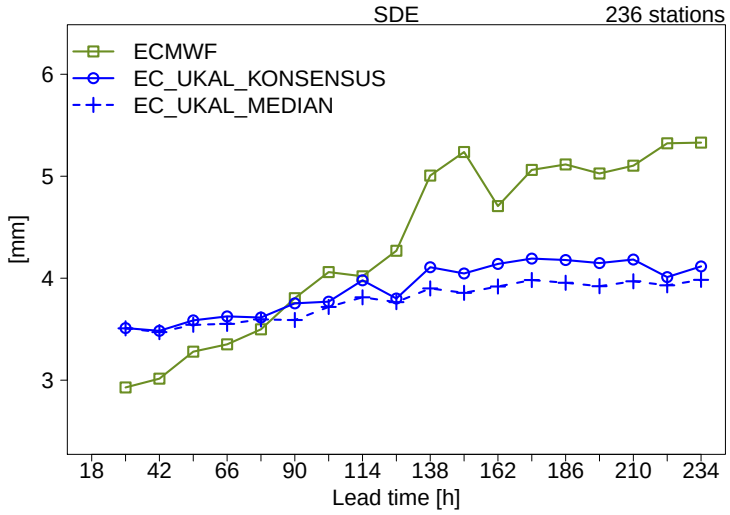

Lead time [h]: 216
Hit Rate
225 stations
EC_KONSENSUS
EC_MEDIAN
ECMWF
1.0
0.8
0.6
0.4
0.2
0.0
1 3 5 7 9 11 15 19 23 27 31
Exceedance threshold [m/s]

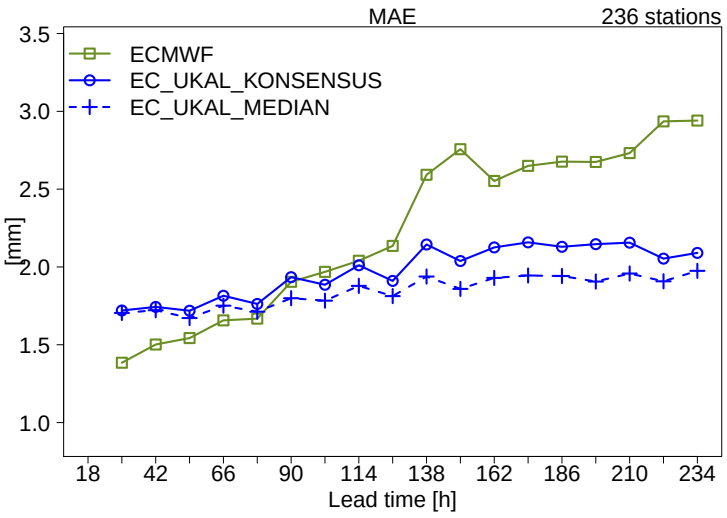

Lead time [h]: 216
False Alarm Ratio
225 stations
EC_KONSENSUS
EC_MEDIAN
ECMWF
1.0
0.8
0.6
0.4
0.2
0.0
1 3 5 7 9 11 15 19 23 27 31
Exceedance threshold [m/s]

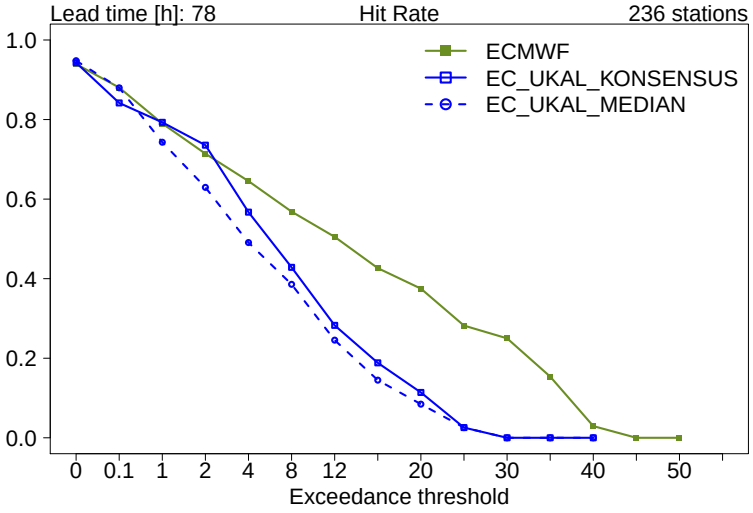

Lead time [h]: 216
Equitable Threat Score
225 stations
EC_KONSENSUS
EC_MEDIAN
ECMWF
1.0
0.8
0.6
0.4
0.2
0.0
1 3 5 7 9 11 15 19 23 27 31
Exceedance threshold [m/s]

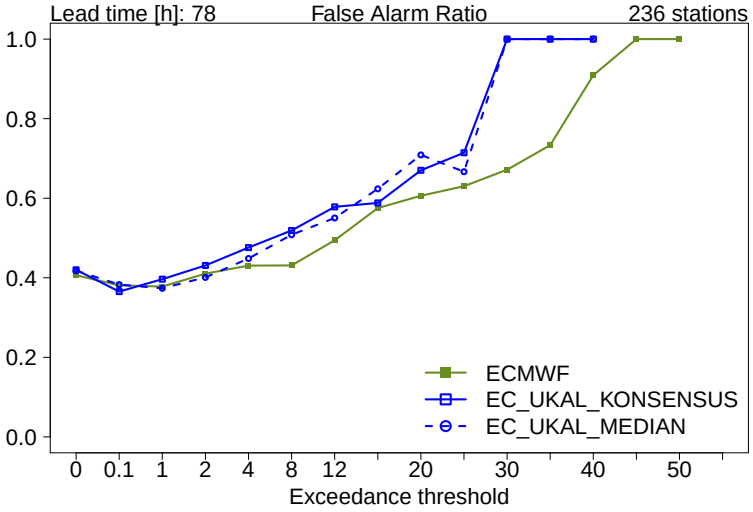
8.3 12h Precipitation

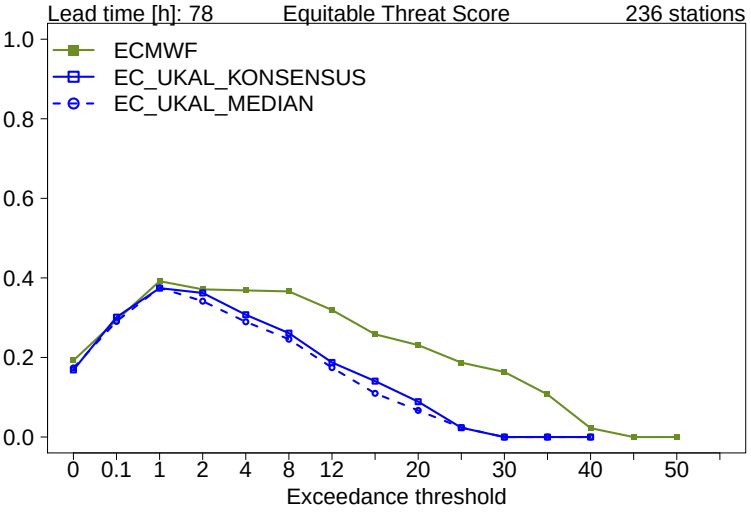


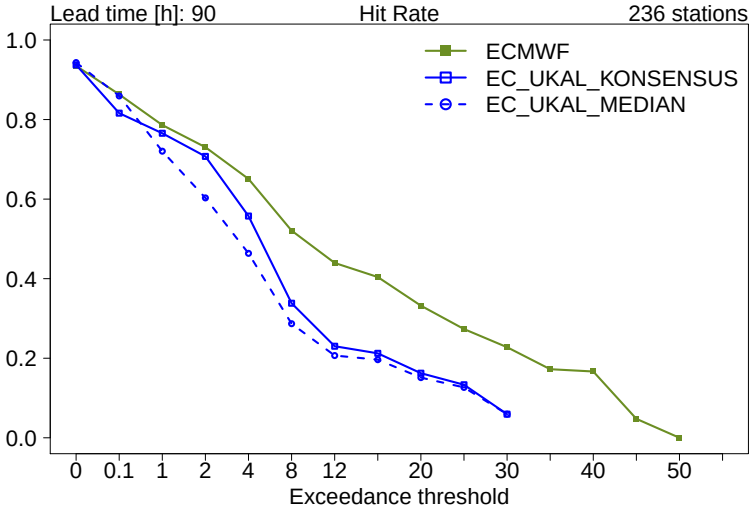


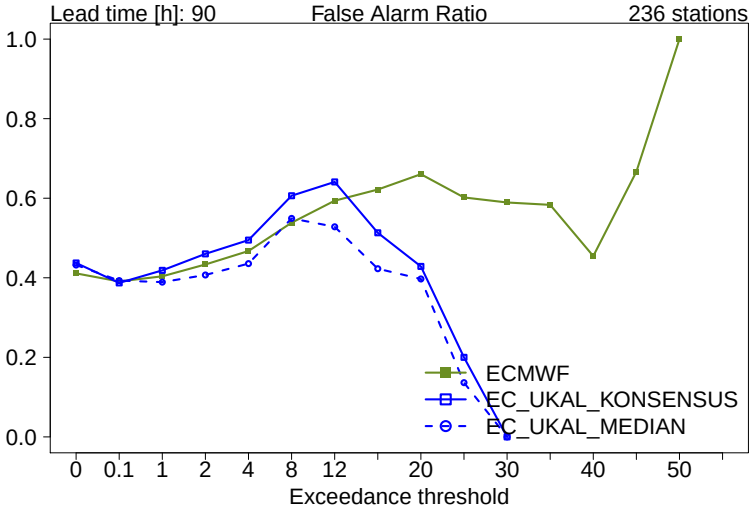


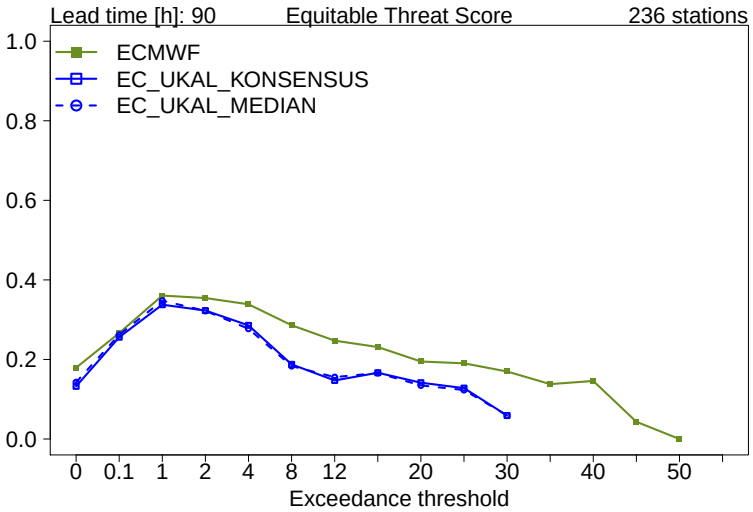

Lead time [h]: 78
Hit Rate
236 stations
ECMWF
EC_UKAL_KONSENSUS
EC_UKAL_MEDIAN
1.0
0.8
0.6
0.4
0.2
0.0
0 0.1 1 2 4 8 12 20 30 40 50
Exceedance threshold

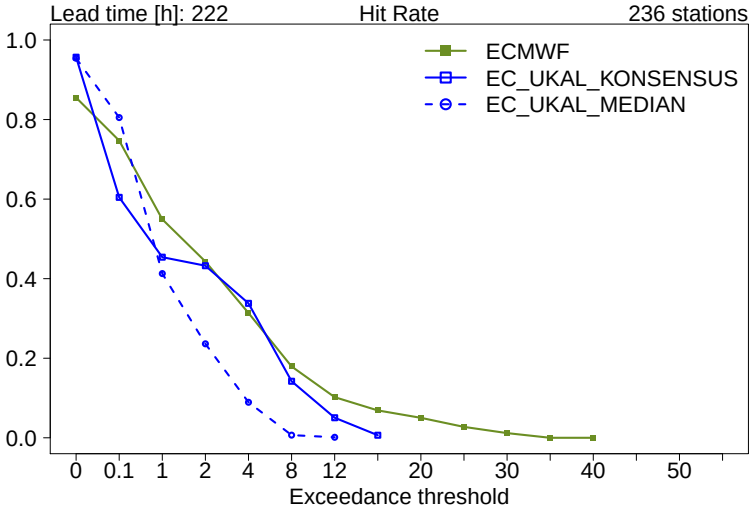

Lead time [h]: 78
False Alarm Ratio
236 stations
ECMWF
EC_UKAL_KONSENSUS
EC_UKAL_MEDIAN
1.0
0.8
0.6
0.4
0.2
0.0
0 0.1 1 2 4 8 12 20 30 40 50
Exceedance threshold

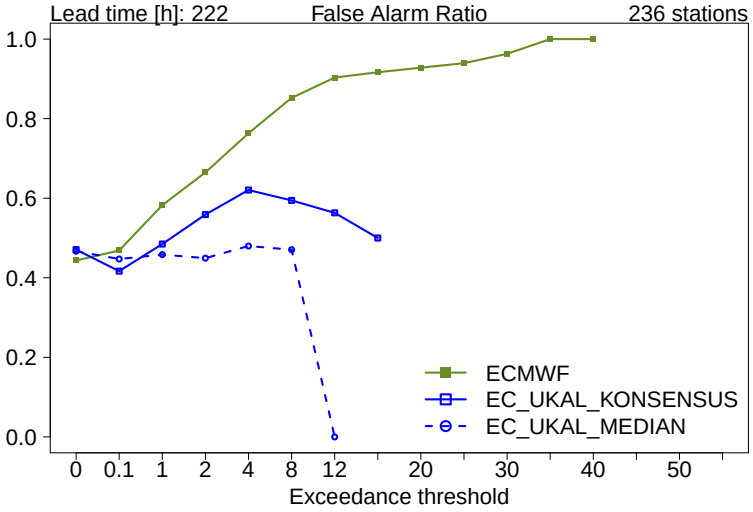

Lead time [h]: 78
Equitable Threat Score
236 stations
ECMWF
EC_UKAL_KONSENSUS
EC_UKAL_MEDIAN
1.0
0.8
0.6
0.4
0.2
0.0
0 0.1 1 2 4 8 12 20 30 40 50
Exceedance threshold

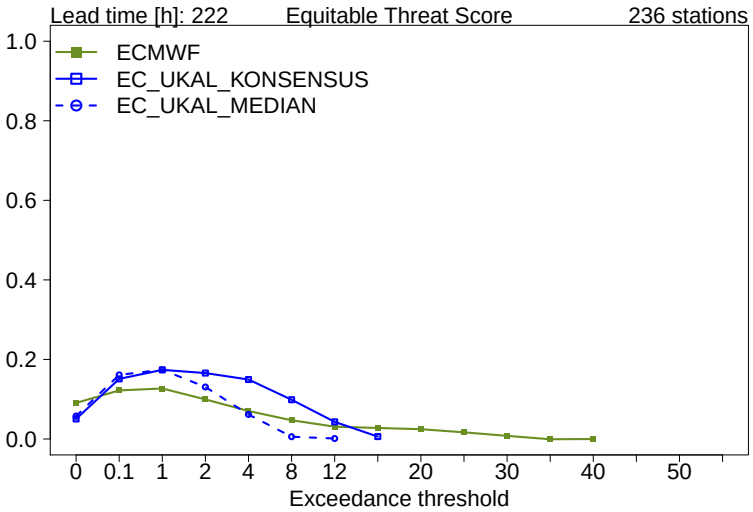

Lead time [h]: 90
Hit Rate
236 stations
ECMWF
EC_UKAL_KONSENSUS
EC_UKAL_MEDIAN
1.0
0.8
0.6
0.4
0.2
0.0
0 0.1 1 2 4 8 12 20 30 40 50
Exceedance threshold

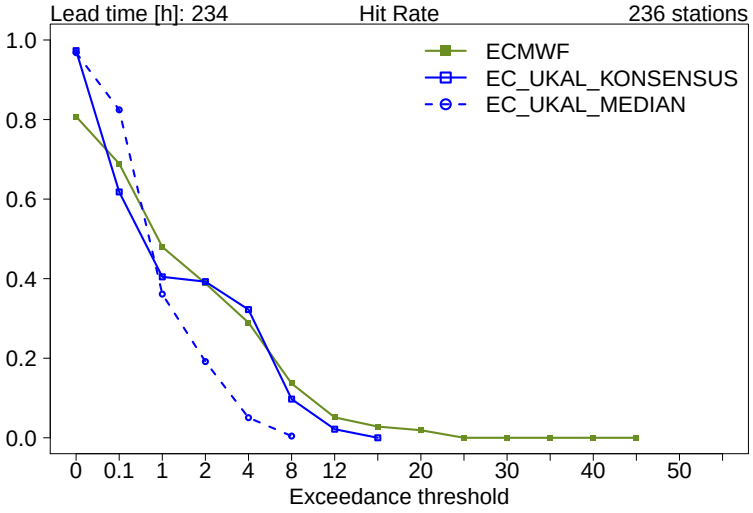

Lead time [h]: 90
False Alarm Ratio
236 stations
ECMWF
EC_UKAL_KONSENSUS
EC_UKAL_MEDIAN
1.0
0.8
0.6
0.4
0.2
0.0
0 0.1 1 2 4 8 12 20 30 40 50
Exceedance threshold

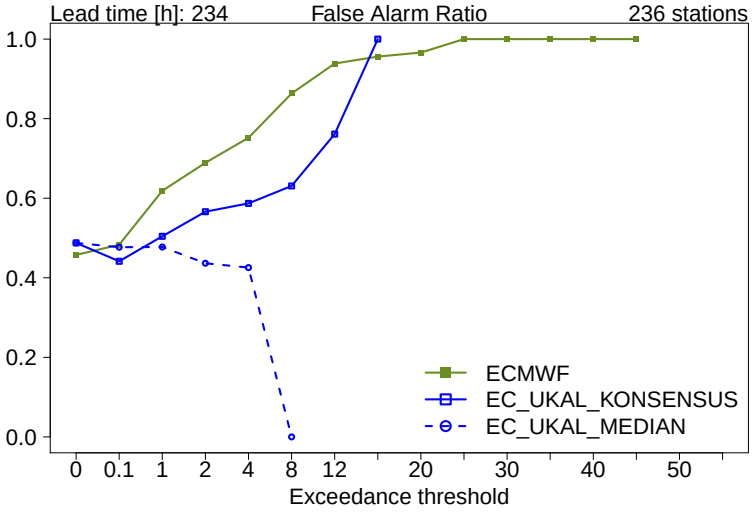

Lead time [h]: 90
Equitable Threat Score
236 stations
ECMWF
EC_UKAL_KONSENSUS
EC_UKAL_MEDIAN
1.0
0.8
0.6
0.4
0.2
0.0
0 0.1 1 2 4 8 12 20 30 40 50
Exceedance threshold

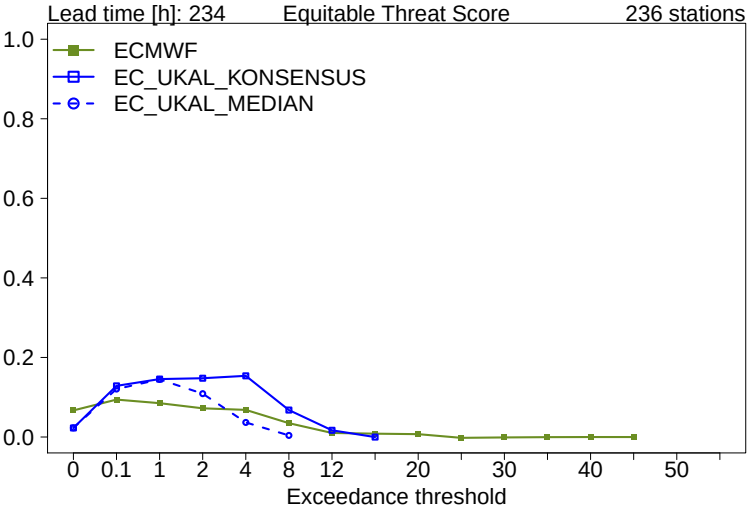

Lead time [h]: 222
Hit Rate
236 stations
ECMWF
EC_UKAL_KONSENSUS
EC_UKAL_MEDIAN
1.0
0.8
0.6
0.4
0.2
0.0
0 0.1 1 2 4 8 12 20 30 40 50
Exceedance threshold


Lead time [h]: 222
False Alarm Ratio
236 stations
ECMWF
EC_UKAL_KONSENSUS
EC_UKAL_MEDIAN
1.0
0.8
0.6
0.4
0.2
0.0
0 0.1 1 2 4 8 12 20 30 40 50
Exceedance threshold

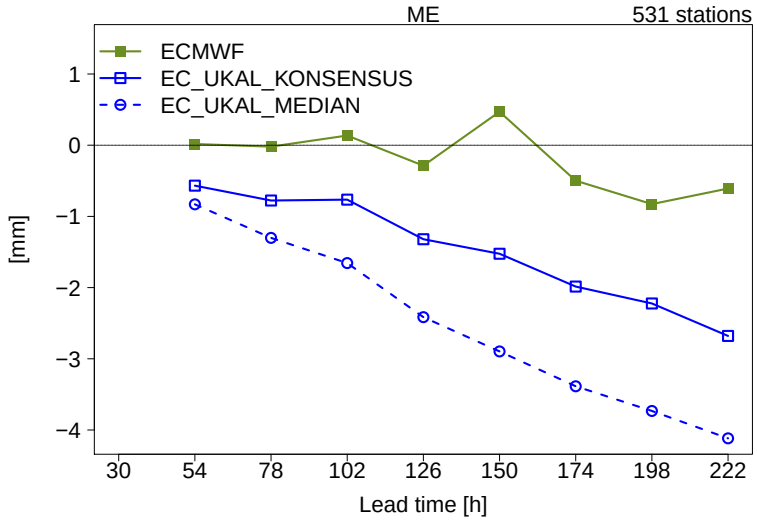

Lead time [h]: 222
Equitable Threat Score
236 stations
ECMWF
EC_UKAL_KONSENSUS
EC_UKAL_MEDIAN
1.0
0.8
0.6
0.4
0.2
0.0
0 0.1 1 2 4 8 12 20 30 40 50
Exceedance threshold

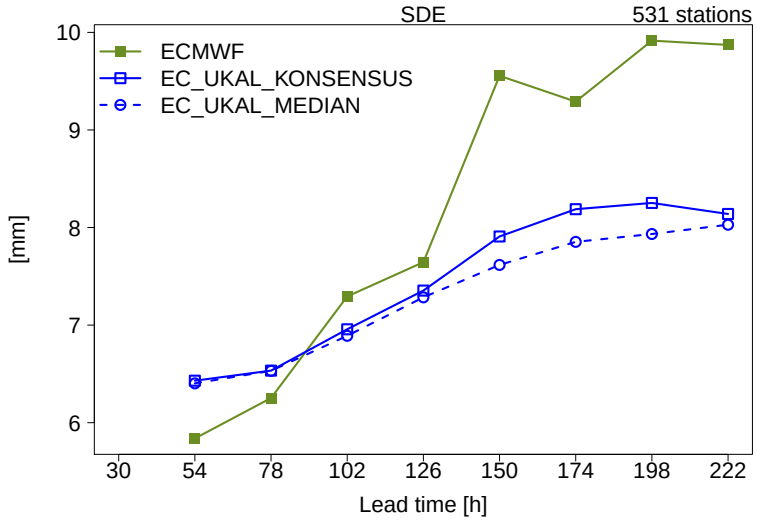

Lead time [h]: 234
Hit Rate
236 stations
ECMWF
EC_UKAL_KONSENSUS
EC_UKAL_MEDIAN
1.0
0.8
0.6
0.4
0.2
0.0
0 0.1 1 2 4 8 12 20 30 40 50
Exceedance threshold

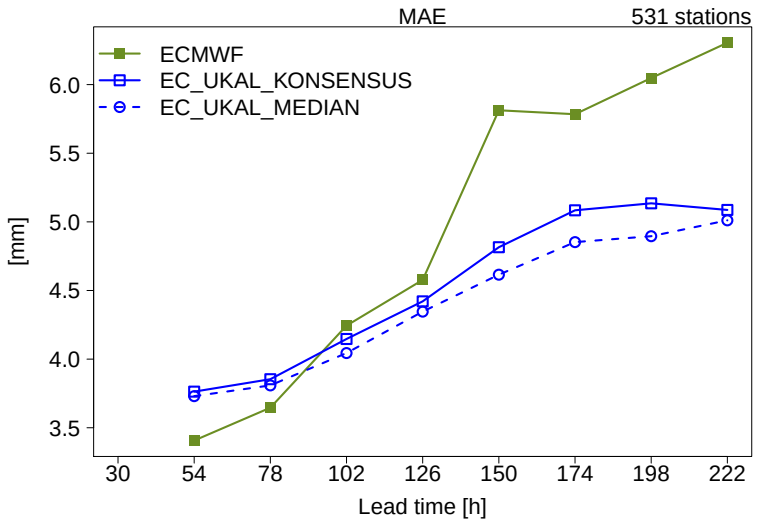

Lead time [h]: 234
False Alarm Ratio
236 stations
ECMWF
EC_UKAL_KONSENSUS
EC_UKAL_MEDIAN
1.0
0.8
0.6
0.4
0.2
0.0
0 0.1 1 2 4 8 12 20 30 40 50
Exceedance threshold

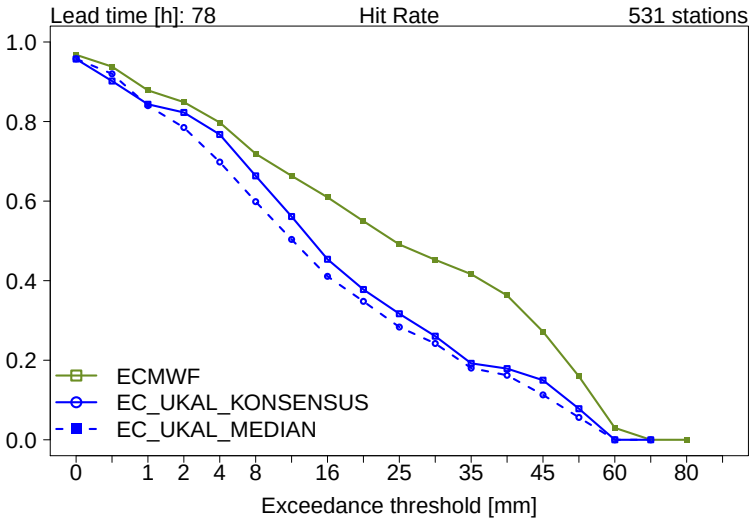

Lead time [h]: 234
Equitable Threat Score
236 stations
ECMWF
EC_UKAL_KONSENSUS
EC_UKAL_MEDIAN
1.0
0.8
0.6
0.4
0.2
0.0
0 0.1 1 2 4 8 12 20 30 40 50
Exceedance threshold

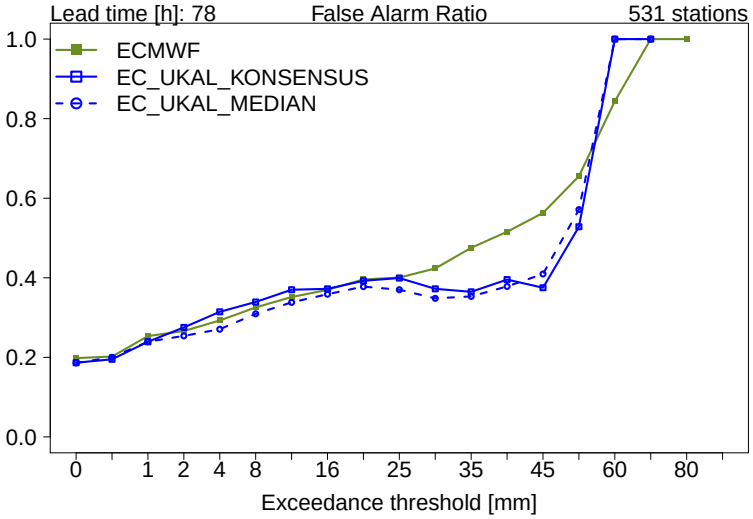
8.4 24h Precipitation

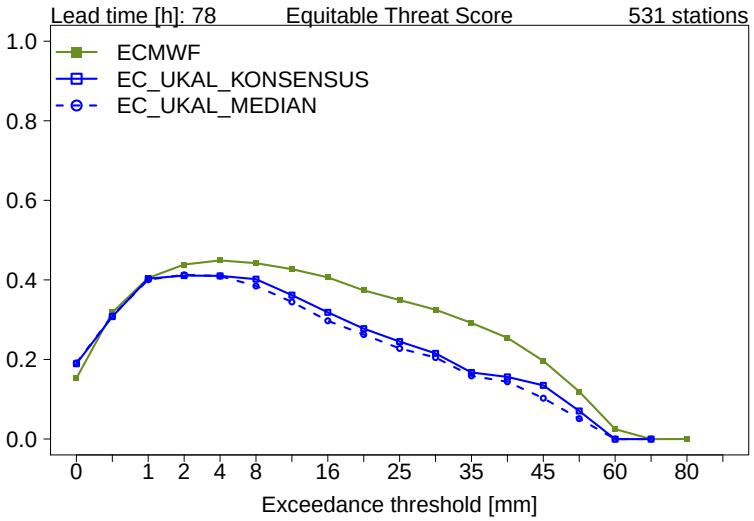


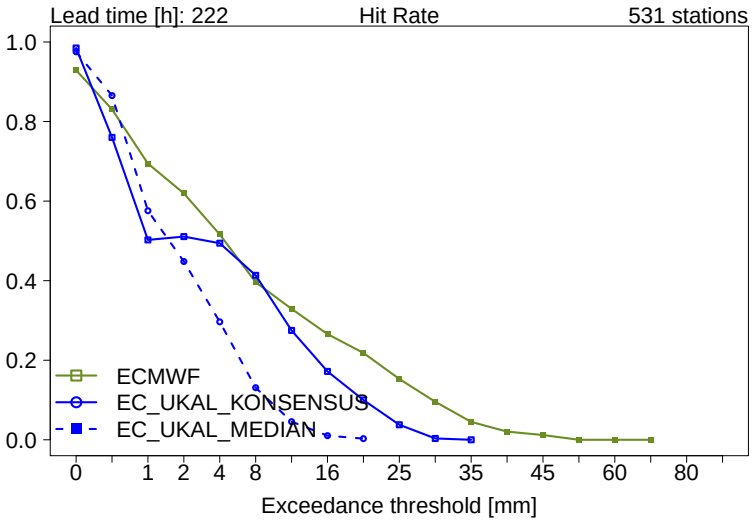


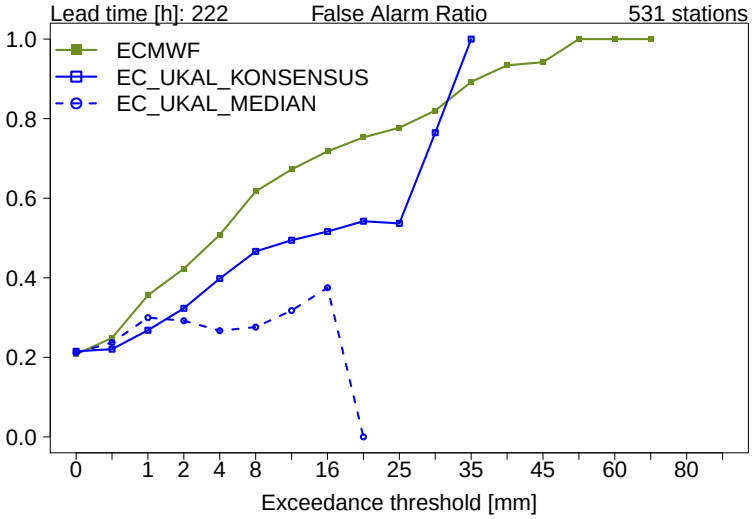


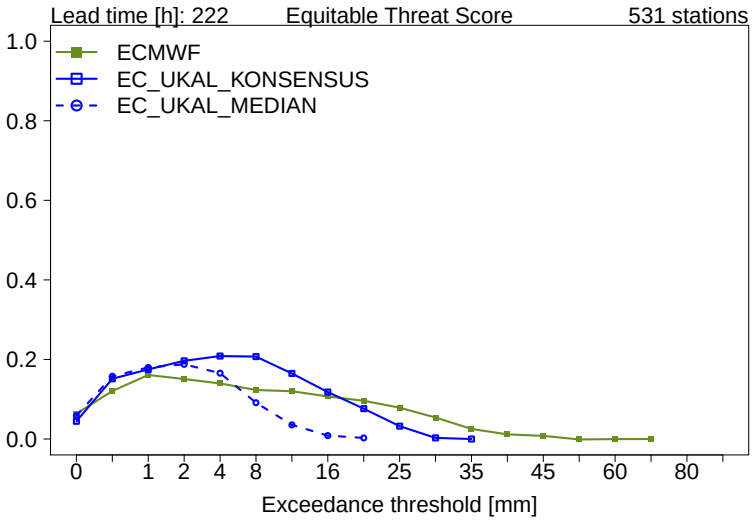

Lead time [h]: 78
Hit Rate
531 stations
1.0
0.8
0.6
0.4
0.2
0.0
ECMWF
EC_UKAL_KONSENSUS
EC_UKAL_MEDIAN
0 1 2 4 8 16 25 35 45 60 80
Exceedance threshold [mm]


Lead time [h]: 78
False Alarm Ratio
531 stations
1.0
0.8
0.6
0.4
0.2
0.0
ECMWF
EC_UKAL_KONSENSUS
EC_UKAL_MEDIAN
0 1 2 4 8 16 25 35 45 60 80
Exceedance threshold [mm]


Lead time [h]: 78
Equitable Threat Score
531 stations
1.0
0.8
0.6
0.4
0.2
0.0
ECMWF
EC_UKAL_KONSENSUS
EC_UKAL_MEDIAN
0 1 2 4 8 16 25 35 45 60 80
Exceedance threshold [mm]

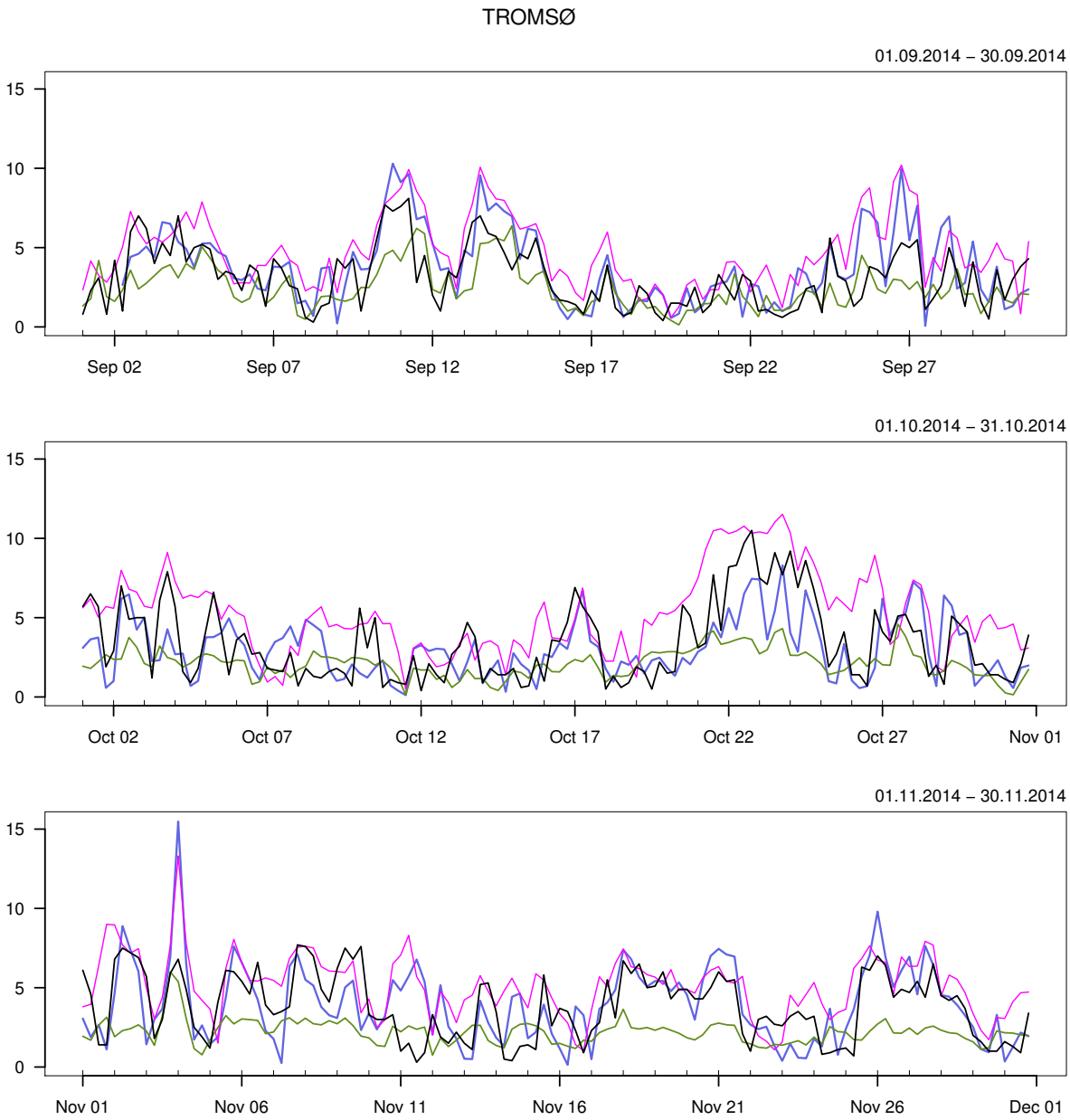

Lead time [h]: 222
Hit Rate
531 stations
1.0
0.8
0.6
0.4
0.2
0.0
ECMWF
EC_UKAL_KONSENSUS
EC_UKAL_MEDIAN
0
1
2
4
8
16
25
35
45
60
80
Exceedance threshold [mm]


Lead time [h]: 222
False Alarm Ratio
531 stations
1.0
0.8
0.6
0.4
0.2
0.0
ECMWF
EC_UKAL_KONSENSUS
EC_UKAL_MEDIAN
0
1
2
4
8
16
25
35
45
60
80
Exceedance threshold [mm]


Lead time [h]: 222
Equitable Threat Score
531 stations
1.0
0.8
0.6
0.4
0.2
0.0
ECMWF
EC_UKAL_KONSENSUS
EC_UKAL_MEDIAN
0
1
2
4
8
16
25
35
45
60
80
Exceedance threshold [mm]

9 Appendix

9.1 10m Wind speed

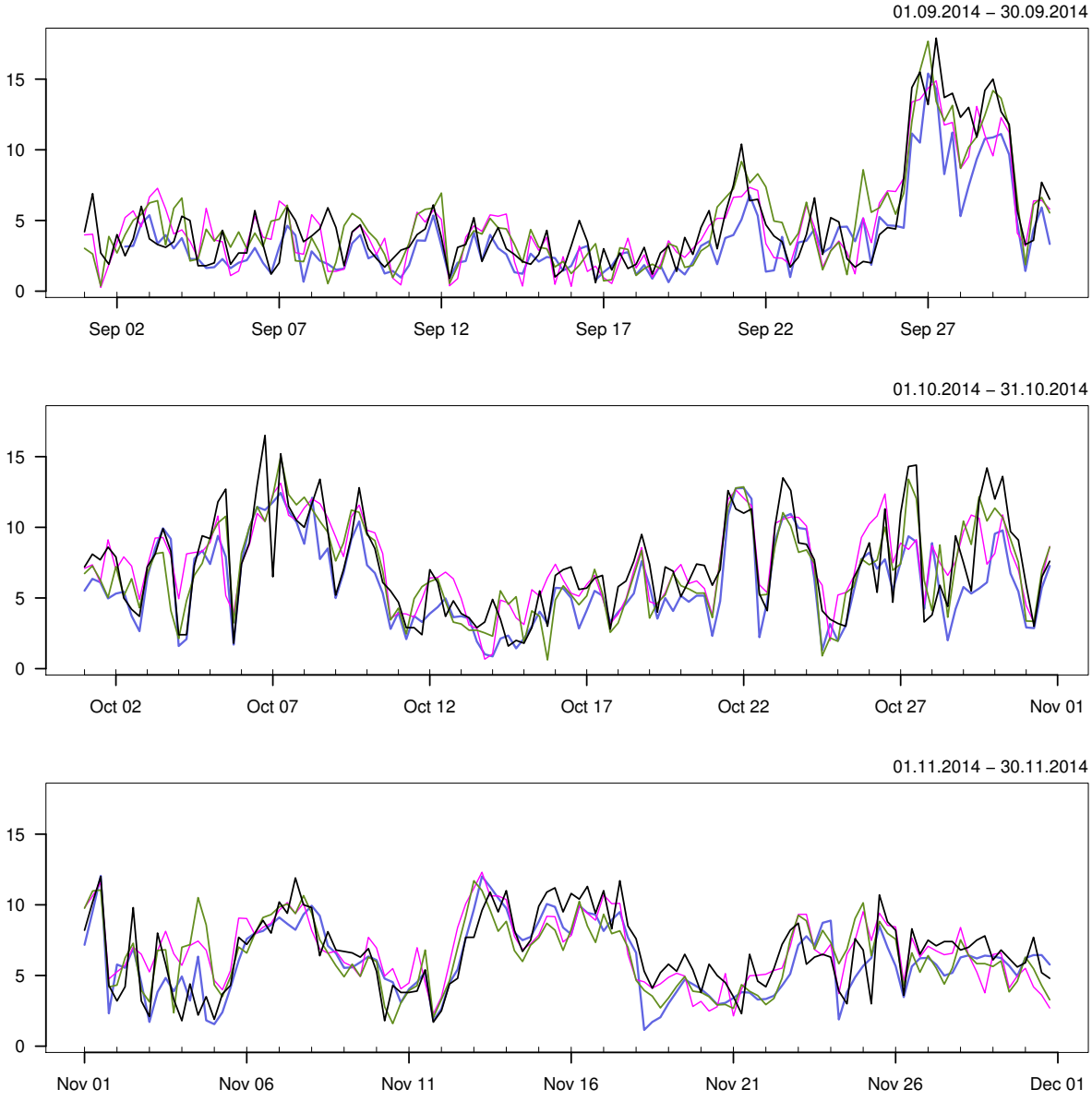


01.09.2014 – 30.11.2014

	Min	Mean	Max	Std	N
synop: 00,06,12,18	0.3	3.5	10.5	2.2	364
AM25: 12+18,+24,+30,+36	0.1	3.6	15.5	2.3	359
Hirlam8: 12+18,+24,+30,+36	0.5	5	13.3	2.2	364
ECMWF: 12+18,+24,+30,+36	0.1	2.3	6.4	1	364

	ME	SDE	RMSE	MAE	Max.abs.err.	N
AM25 – synop	0.1	1.9	1.9	1.5	8.7	359
Hirlam8 – synop	1.6	1.8	2.4	1.9	7.6	364
ECMWF – synop	−1.2	1.8	2.2	1.7	6.9	364

ØRLAND

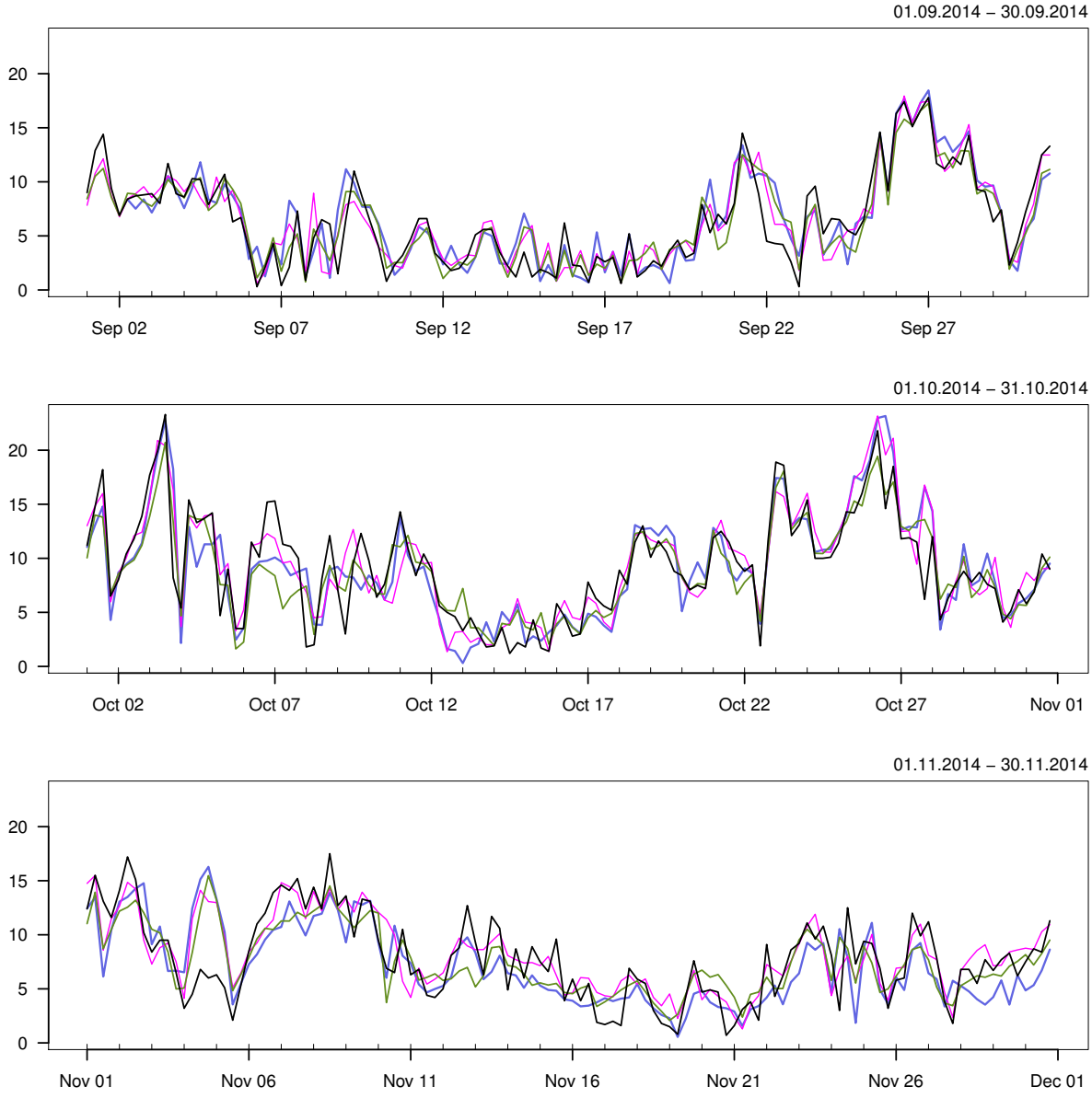


01.09.2014 – 30.11.2014

	Min	Mean	Max	Std	N
synop: 00,06,12,18	0.6	6.2	17.9	3.4	364
AM25: 12+18,+24,+30,+36	0.6	5.3	15.4	3	359
Hirlam8: 12+18,+24,+30,+36	0.3	6.3	14.9	3	364
ECMWF: 12+18,+24,+30,+36	0.4	6.1	17.7	3.1	364

	ME	SDE	RMSE	MAE	Max.abs.err.	N
AM25 – synop	−1	1.8	2	1.5	8.1	359
Hirlam8 – synop	0	2	2	1.6	7.5	364
ECMWF – synop	−0.2	1.9	1.9	1.6	8.3	364

YTTERØYANE FYR

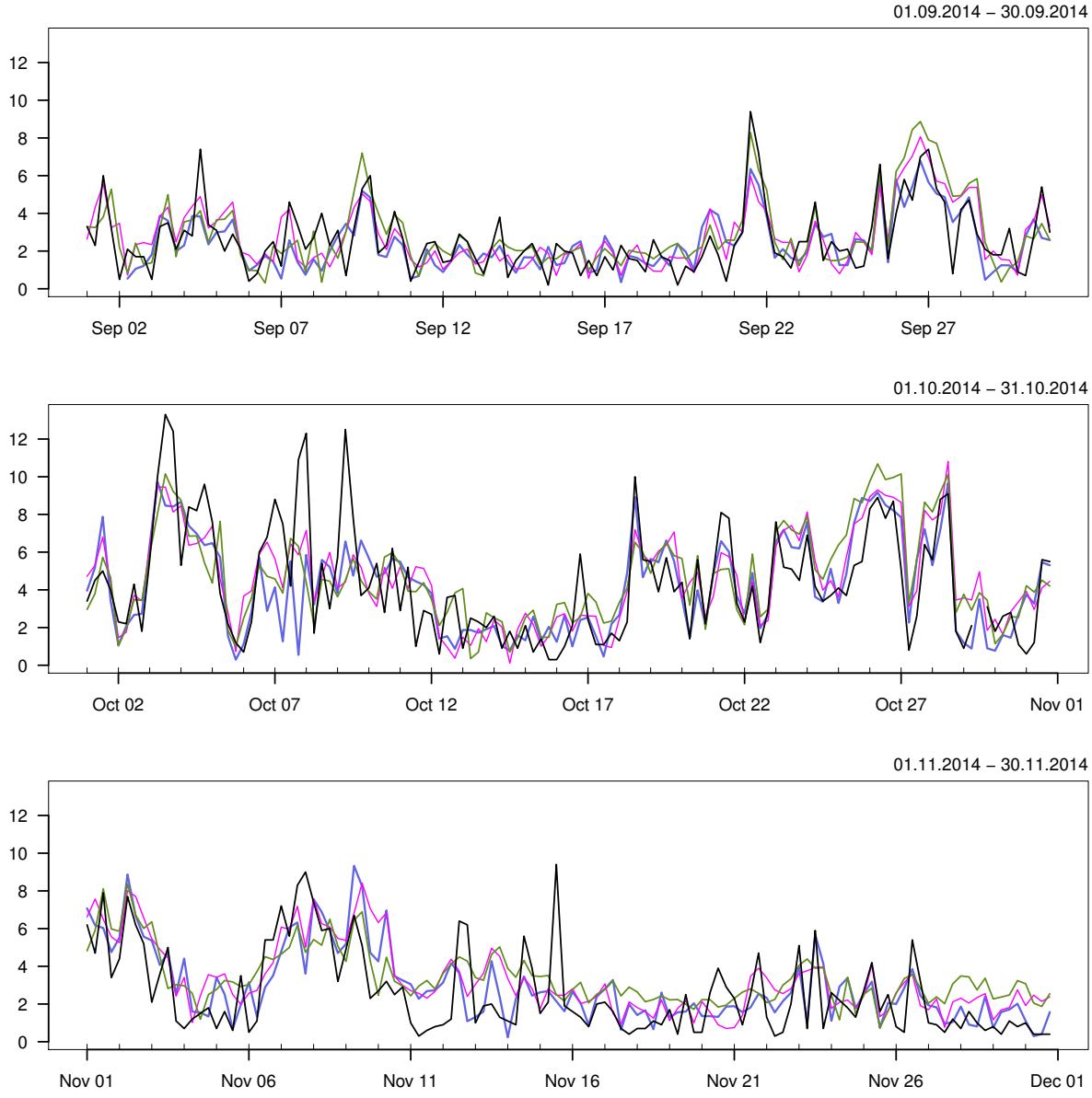


01.09.2014 – 30.11.2014

	Min	Mean	Max	Std	N
synop: 00,06,12,18	0.3	7.9	23.3	4.4	364
AM25: 12+18,+24,+30,+36	0.3	7.6	23.2	4.4	359
Hirlam8: 12+18,+24,+30,+36	0.6	8.1	23.2	4.2	364
ECMWF: 12+18,+24,+30,+36	0.7	7.7	20.7	3.8	364

	ME	SDE	RMSE	MAE	Max.abs.err.	N
AM25 – synop	–0.2	2.6	2.6	1.9	10.4	359
Hirlam8 – synop	0.2	2.2	2.2	1.6	10.6	364
ECMWF – synop	–0.2	2.1	2.1	1.6	9.5	364

BERGEN – FLORIDA

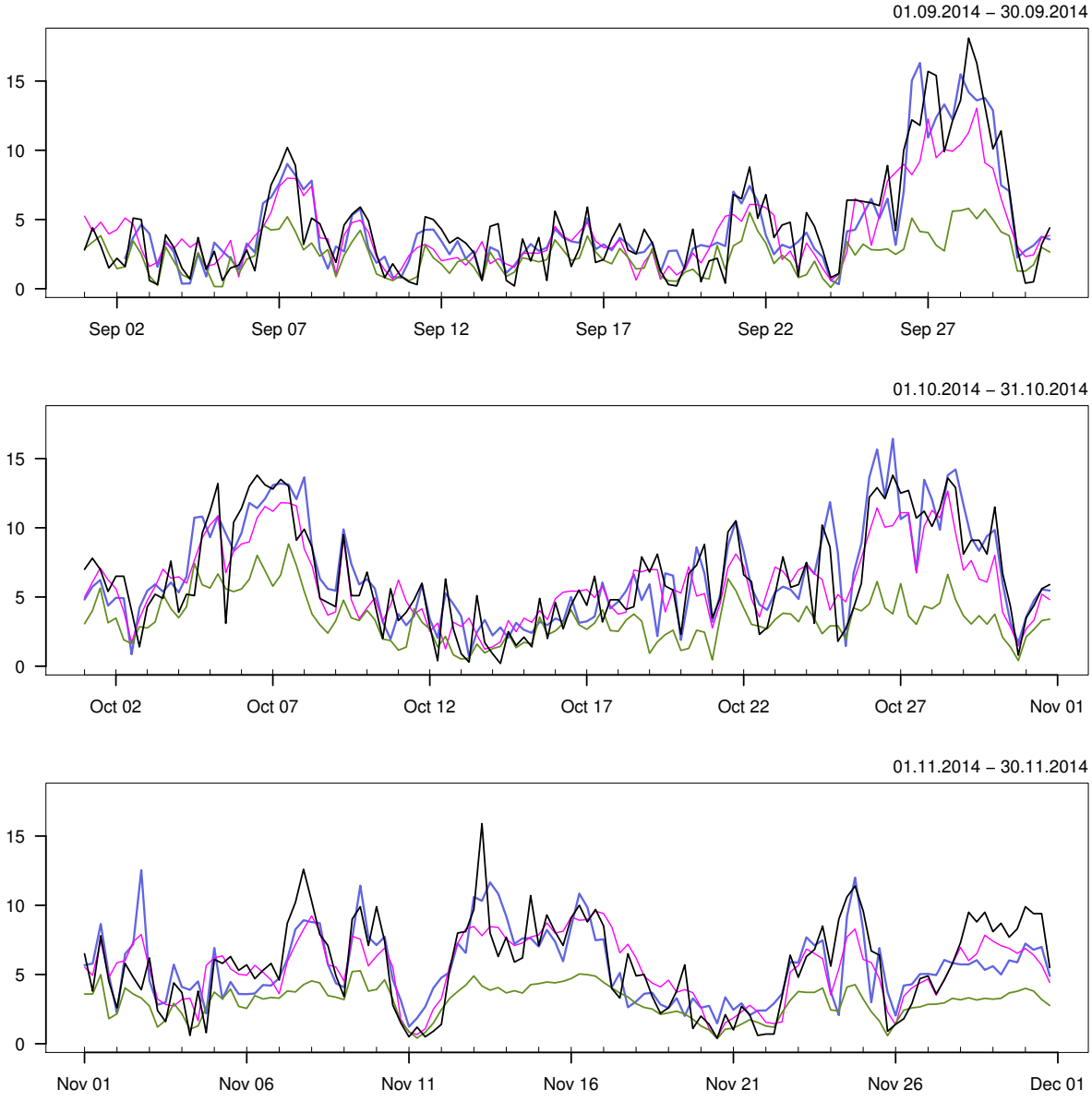


01.09.2014 – 30.11.2014

	Min	Mean	Max	Std	N
synop: 00,06,12,18	0.2	3.2	13.3	2.5	363
AM25: 12+18,+24,+30,+36	0.2	3.2	9.7	2.1	359
Hirlam8: 12+18,+24,+30,+36	0.1	3.6	10.8	2.1	364
ECMWF: 12+18,+24,+30,+36	0.3	3.7	10.7	2.1	364

	ME	SDE	RMSE	MAE	Max.abs.err.	N
AM25 – synop	0	1.7	1.7	1.2	10.4	358
Hirlam8 – synop	0.4	1.7	1.8	1.4	8.1	363
ECMWF – synop	0.5	1.8	1.9	1.5	8	363

FINSEVATN

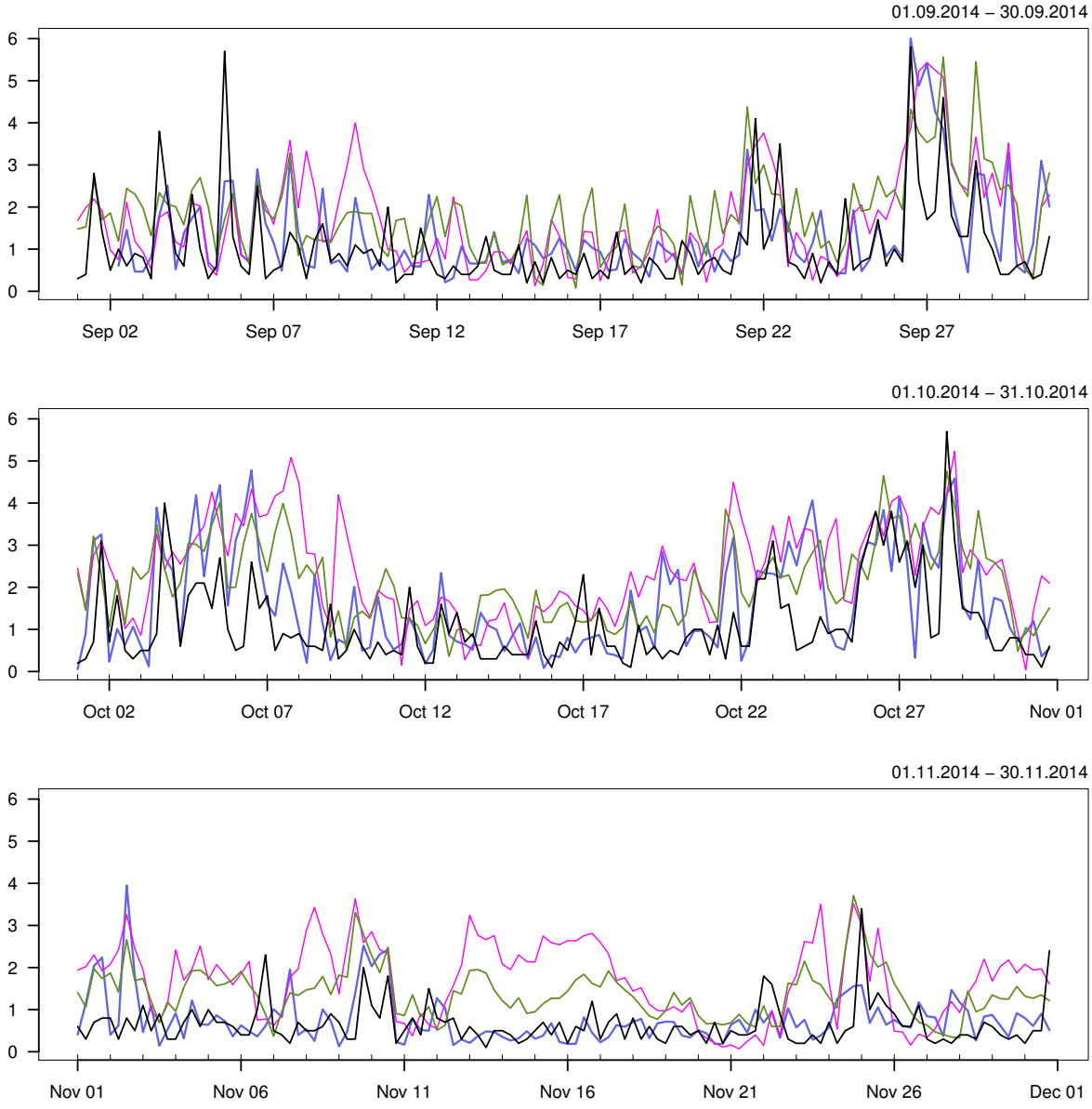


01.09.2014 – 30.11.2014

	Min	Mean	Max	Std	N
synop: 00,06,12,18	0.2	5.6	18.1	3.6	364
AM25: 12+18,+24,+30,+36	0.3	5.6	16.4	3.4	359
Hirlam8: 12+18,+24,+30,+36	0.4	5.2	13	2.7	364
ECMWF: 12+18,+24,+30,+36	0.1	3	8.8	1.5	364

	ME	SDE	RMSE	MAE	Max.abs.err.	N
AM25 – synop	0	2	2	1.5	8.6	359
Hirlam8 – synop	–0.3	1.9	2	1.6	8.1	364
ECMWF – synop	–2.6	2.6	3.7	2.8	12.3	364

NESBYEN

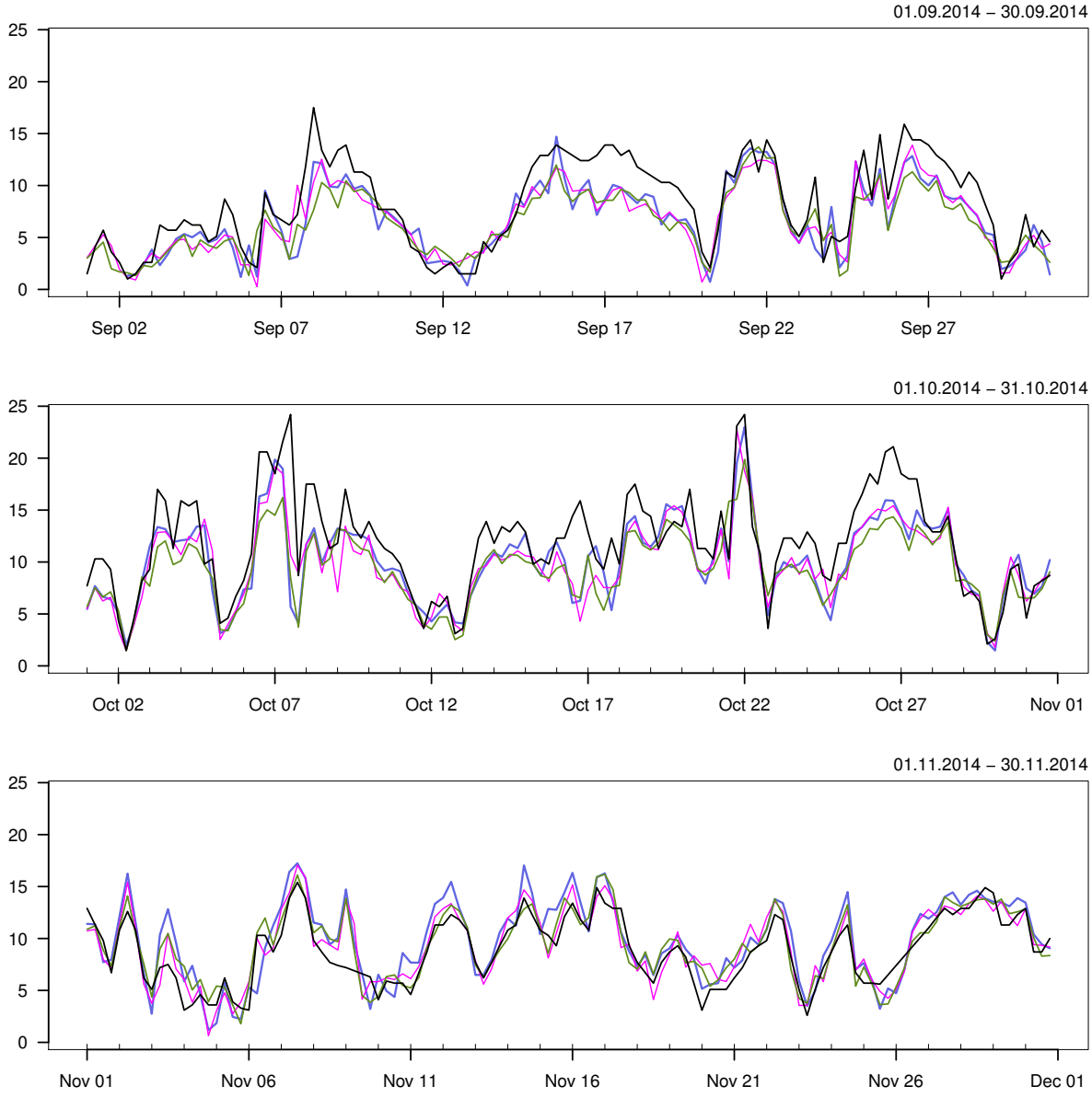


01.09.2014 – 30.11.2014

	Min	Mean	Max	Std	N
synop: 00,06,12,18	0.1	0.9	5.8	0.9	364
AM25: 12+18,+24,+30,+36	0.1	1.2	6	1.1	359
Hirlam8: 12+18,+24,+30,+36	0	1.9	5.4	1.1	364
ECMWF: 12+18,+24,+30,+36	0.1	1.8	5.6	0.9	364

	ME	SDE	RMSE	MAE	Max.abs.err.	N
AM25 – synop	0.3	0.9	0.9	0.7	3.7	359
Hirlam8 – synop	1	1.1	1.5	1.2	4.4	364
ECMWF – synop	0.8	0.9	1.2	1	4	364

EKOFISK

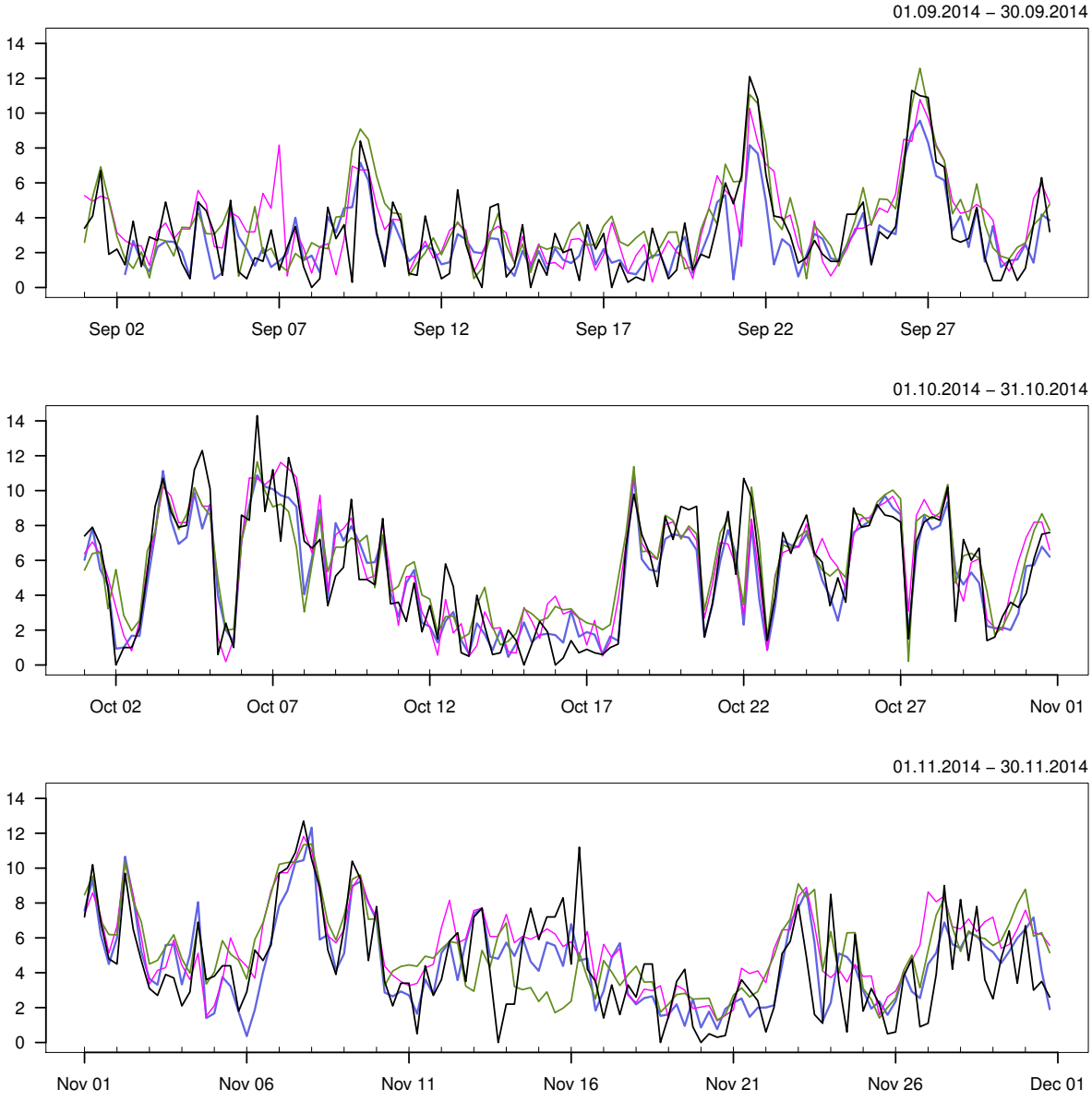


01.09.2014 – 30.11.2014

	Min	Mean	Max	Std	N
synop: 00,06,12,18	1	9.6	24.2	4.4	364
AM25: 12+18,+24,+30,+36	0.4	9	23	4	359
Hirlam8: 12+18,+24,+30,+36	0.3	8.6	22.8	3.8	364
ECMWF: 12+18,+24,+30,+36	1.3	8.4	19.9	3.5	364

	ME	SDE	RMSE	MAE	Max.abs.err.	N
AM25 – synop	−0.7	2.5	2.6	2	18.5	359
Hirlam8 – synop	−1	2.3	2.5	1.9	13.5	364
ECMWF – synop	−1.2	2.5	2.8	2.1	15.8	364

SOLA

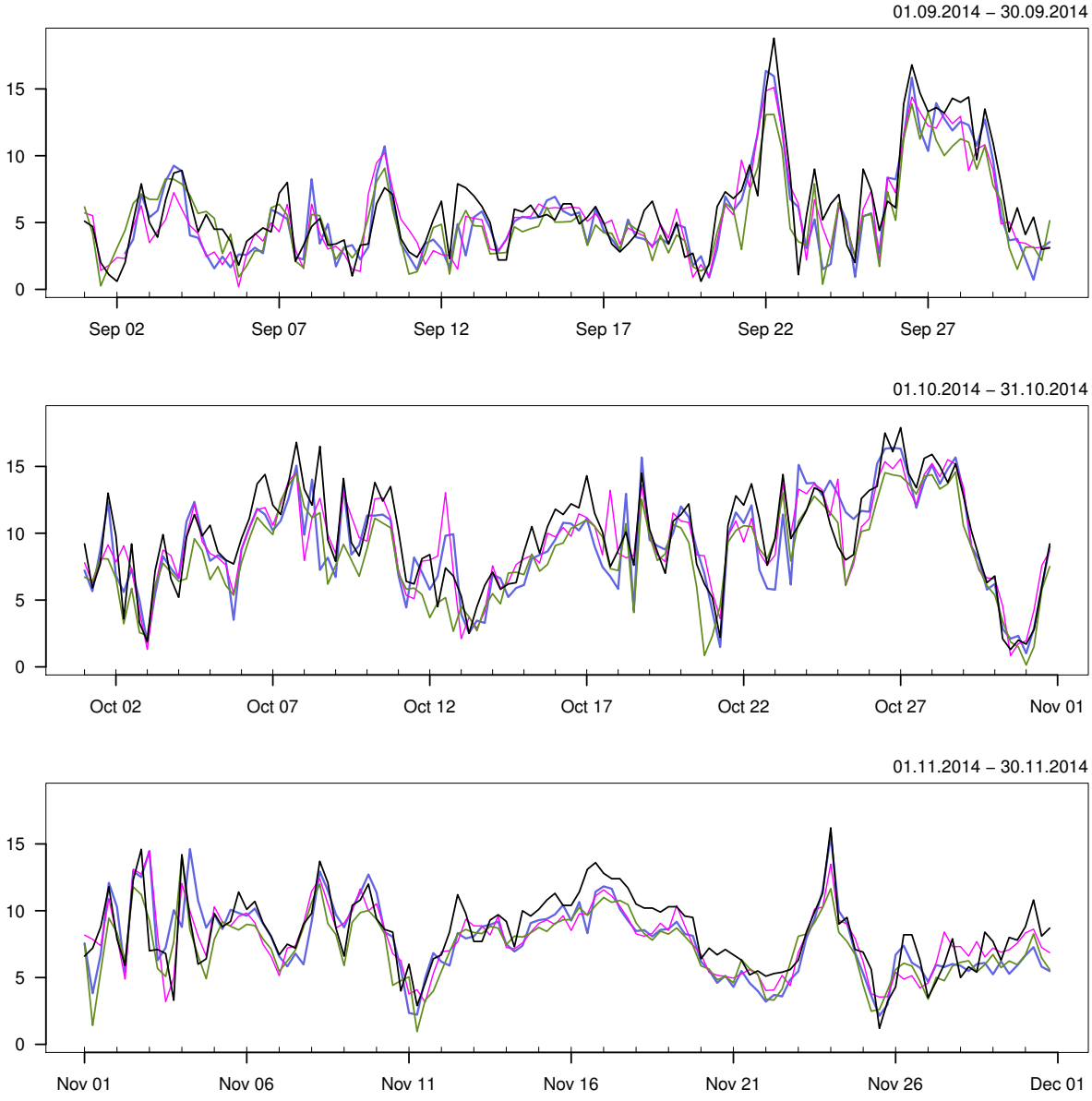


01.09.2014 – 30.11.2014

	Min	Mean	Max	Std	N
synop: 00,06,12,18	0	4.3	14.3	3.1	364
AM25: 12+18,+24,+30,+36	0.4	4.2	12.3	2.7	359
Hirlam8: 12+18,+24,+30,+36	0.2	4.9	11.8	2.7	364
ECMWF: 12+18,+24,+30,+36	0.2	4.9	12.6	2.6	364

	ME	SDE	RMSE	MAE	Max.abs.err.	N
AM25 – synop	–0.1	1.7	1.7	1.2	8.4	359
Hirlam8 – synop	0.6	1.9	2	1.5	7.8	364
ECMWF – synop	0.6	1.9	2	1.5	7.6	364

FERDER FYR

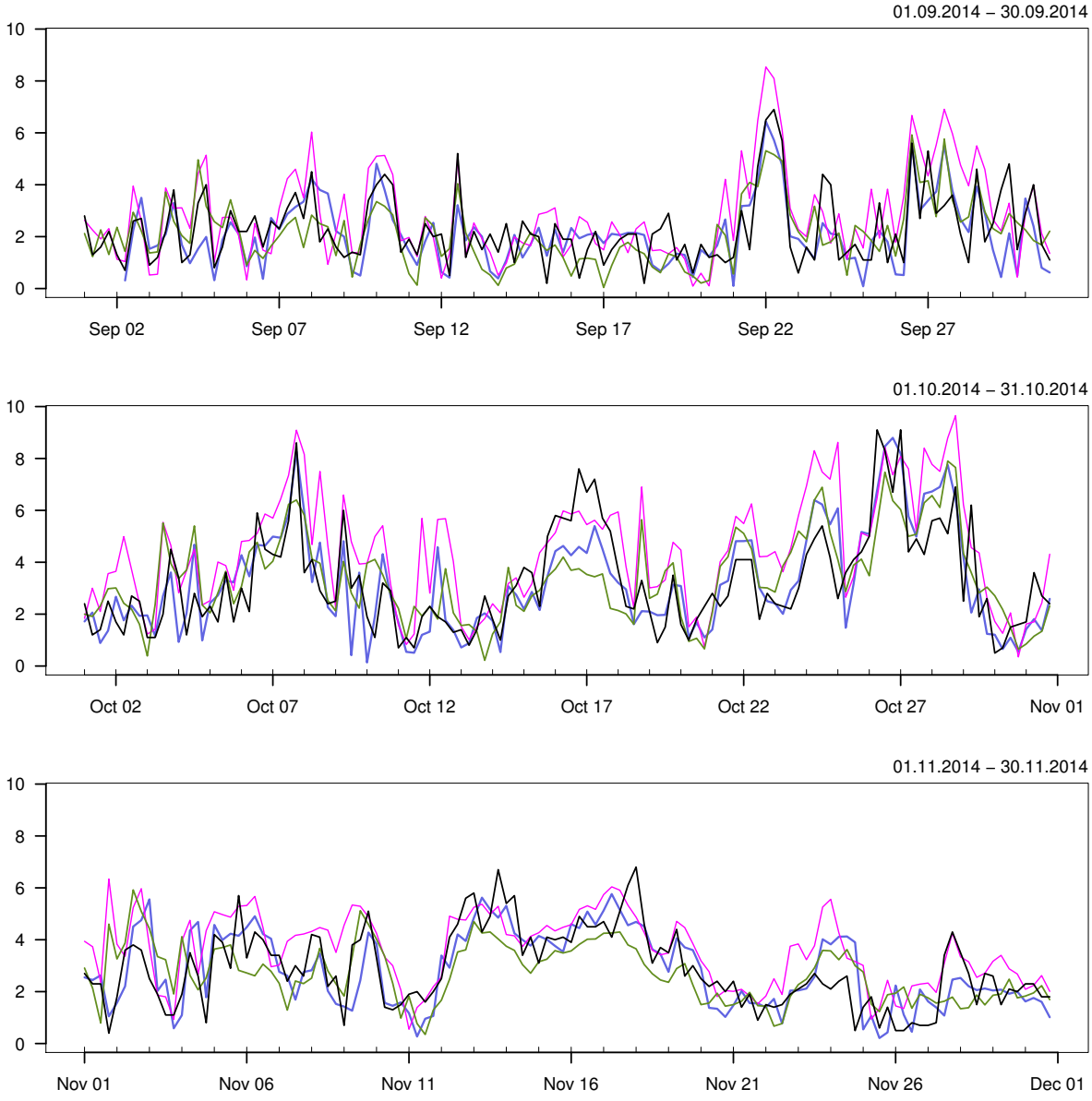


01.09.2014 – 30.11.2014

	Min	Mean	Max	Std	N
synop: 00,06,12,18	0.6	8.1	18.8	3.7	364
AM25: 12+18,+24,+30,+36	0.7	7.5	16.4	3.6	359
Hirlam8: 12+18,+24,+30,+36	0.2	7.6	15.6	3.4	364
ECMWF: 12+18,+24,+30,+36	0.1	6.9	14.6	3.2	364

	ME	SDE	RMSE	MAE	Max.abs.err.	N
AM25 – synop	–0.6	1.9	2	1.5	9.2	359
Hirlam8 – synop	–0.5	1.7	1.8	1.4	7.5	364
ECMWF – synop	–1.2	1.6	2	1.6	5.8	364

OSLO – BLINDERN

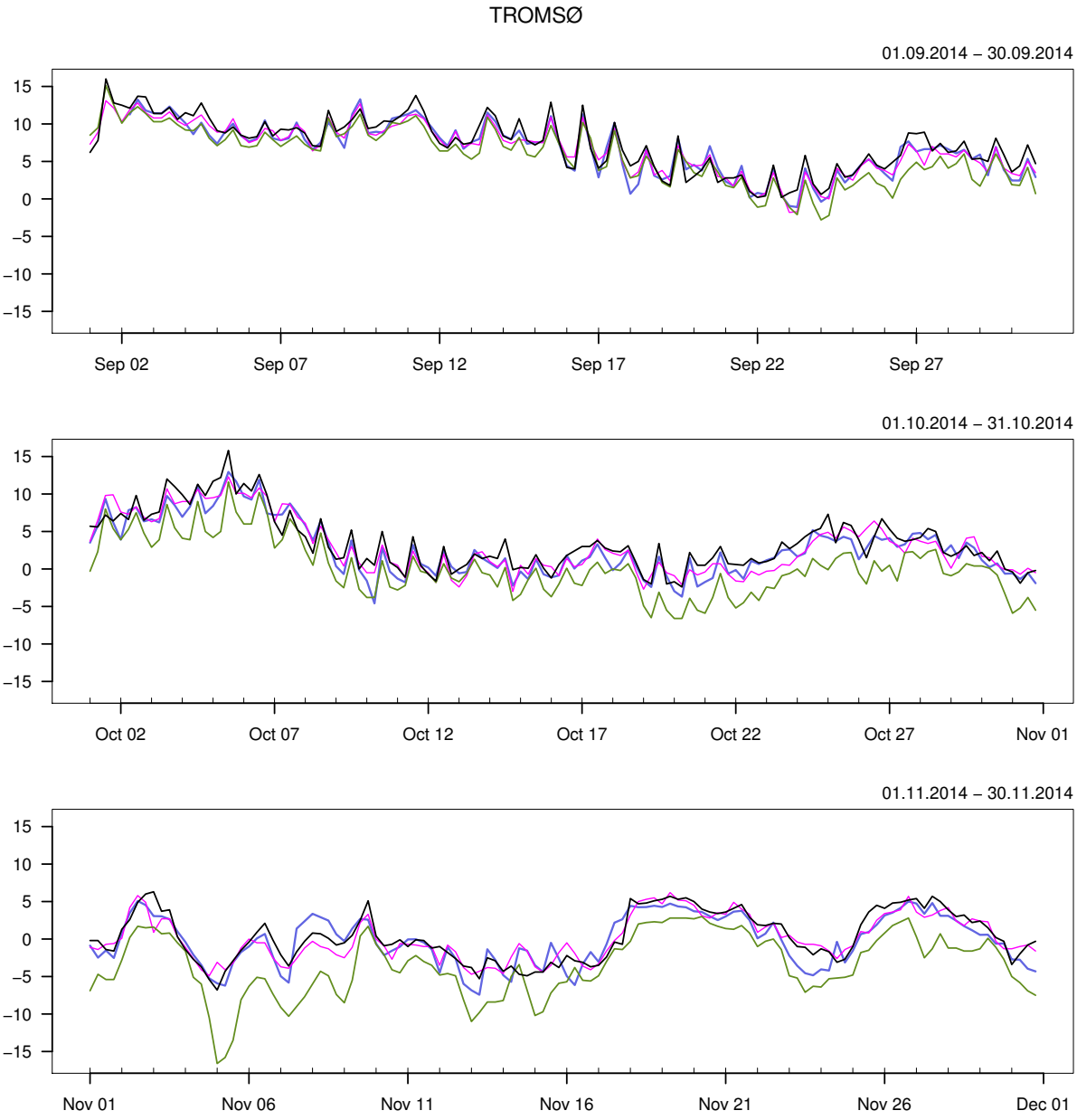


01.09.2014 – 30.11.2014

	Min	Mean	Max	Std	N
synop: 00,06,12,18	0.2	2.8	9.1	1.6	364
AM25: 12+18,+24,+30,+36	0.1	2.7	8.8	1.7	359
Hirlam8: 12+18,+24,+30,+36	0.1	3.6	9.7	1.9	364
ECMWF: 12+18,+24,+30,+36	0	2.7	7.9	1.4	364

	ME	SDE	RMSE	MAE	Max.abs.err.	N
AM25 – synop	–0.1	1.1	1.1	0.9	4.1	359
Hirlam8 – synop	0.8	1.4	1.6	1.2	6	364
ECMWF – synop	–0.1	1.3	1.3	1	4.2	364

9.2 Temperature 2m

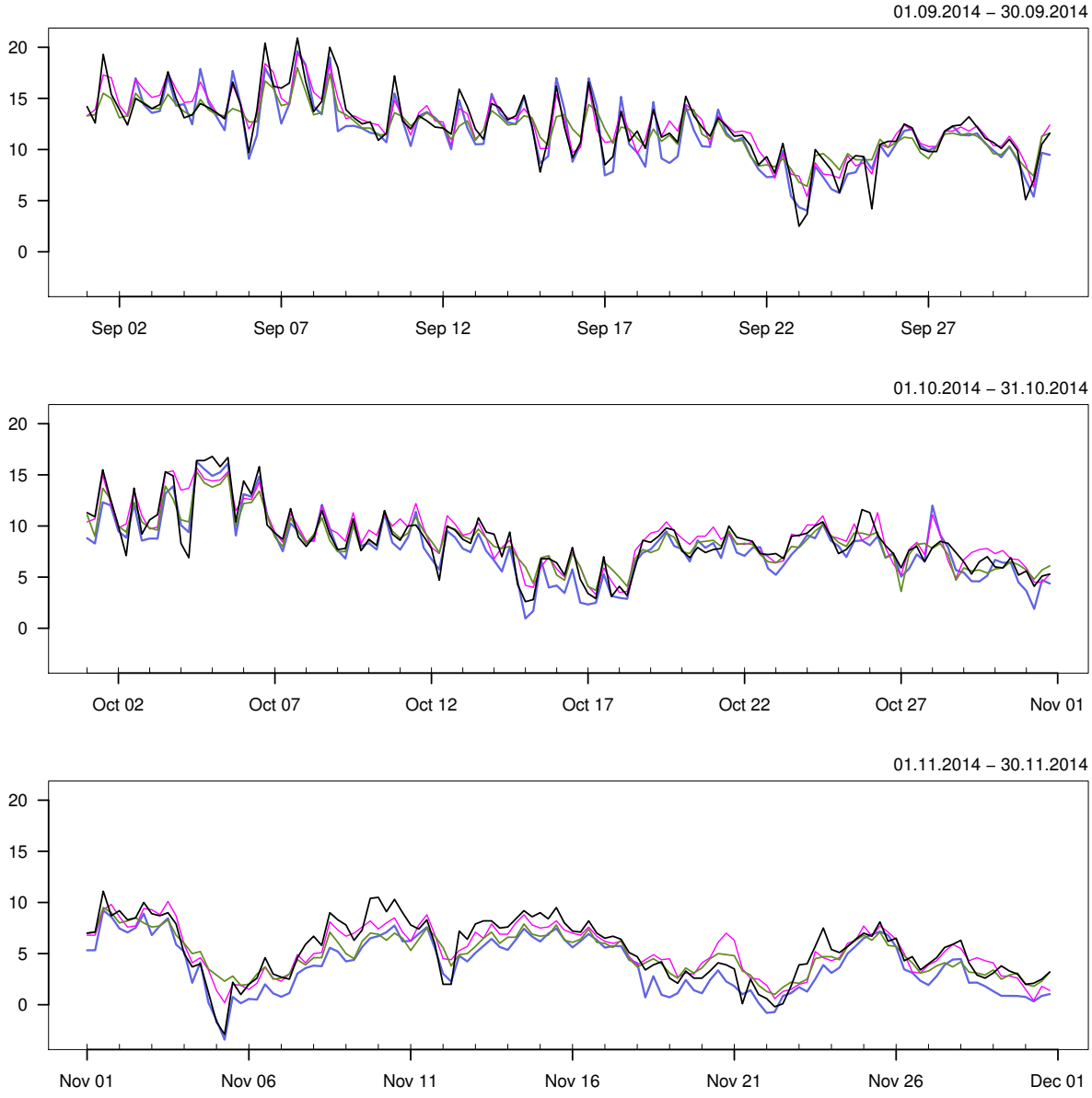


01.09.2014 – 30.11.2014

	Min	Mean	Max	Std	N
synop: 00,06,12,18	−6.8	3.8	16	4.5	364
AM25: 12+18,+24,+30,+36	−7.4	3	13.3	4.4	359
Hirlam8: 12+18,+24,+30,+36	−4.9	3.3	13.1	4.3	364
ECMWF: 12+18,+24,+30,+36	−16.6	0.9	15.1	5.4	364

	ME	SDE	RMSE	MAE	Max.abs.err.	N
AM25 – synop	−0.6	1.4	1.5	1.2	5.1	359
Hirlam8 – synop	−0.5	1.3	1.4	1.1	5.4	364
ECMWF – synop	−2.9	2	3.5	3	11.5	364

ØRLAND

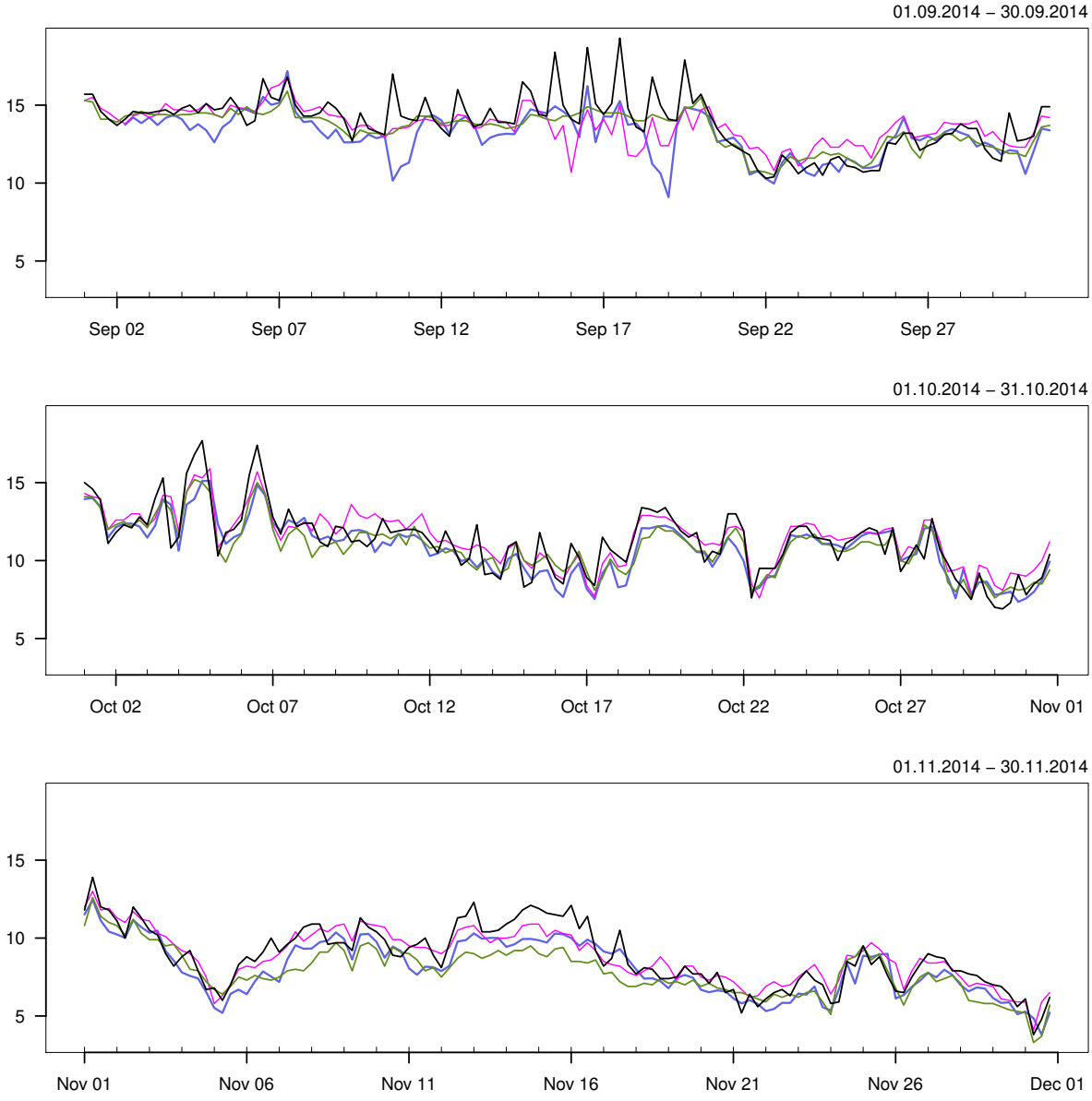


01.09.2014 – 30.11.2014

	Min	Mean	Max	Std	N
synop: 00,06,12,18	−2.9	8.8	20.9	4.1	364
AM25: 12+18,+24,+30,+36	−3.4	7.7	19.6	4.3	359
Hirlam8: 12+18,+24,+30,+36	0.2	8.9	19.4	3.9	364
ECMWF: 12+18,+24,+30,+36	1	8.5	18	3.6	364

	ME	SDE	RMSE	MAE	Max.abs.err.	N
AM25 – synop	−0.9	1.2	1.5	1.3	6.2	359
Hirlam8 – synop	0.2	1.3	1.3	1	6.8	364
ECMWF – synop	−0.3	1.4	1.4	1.1	5.2	364

YTTERØYANE FYR

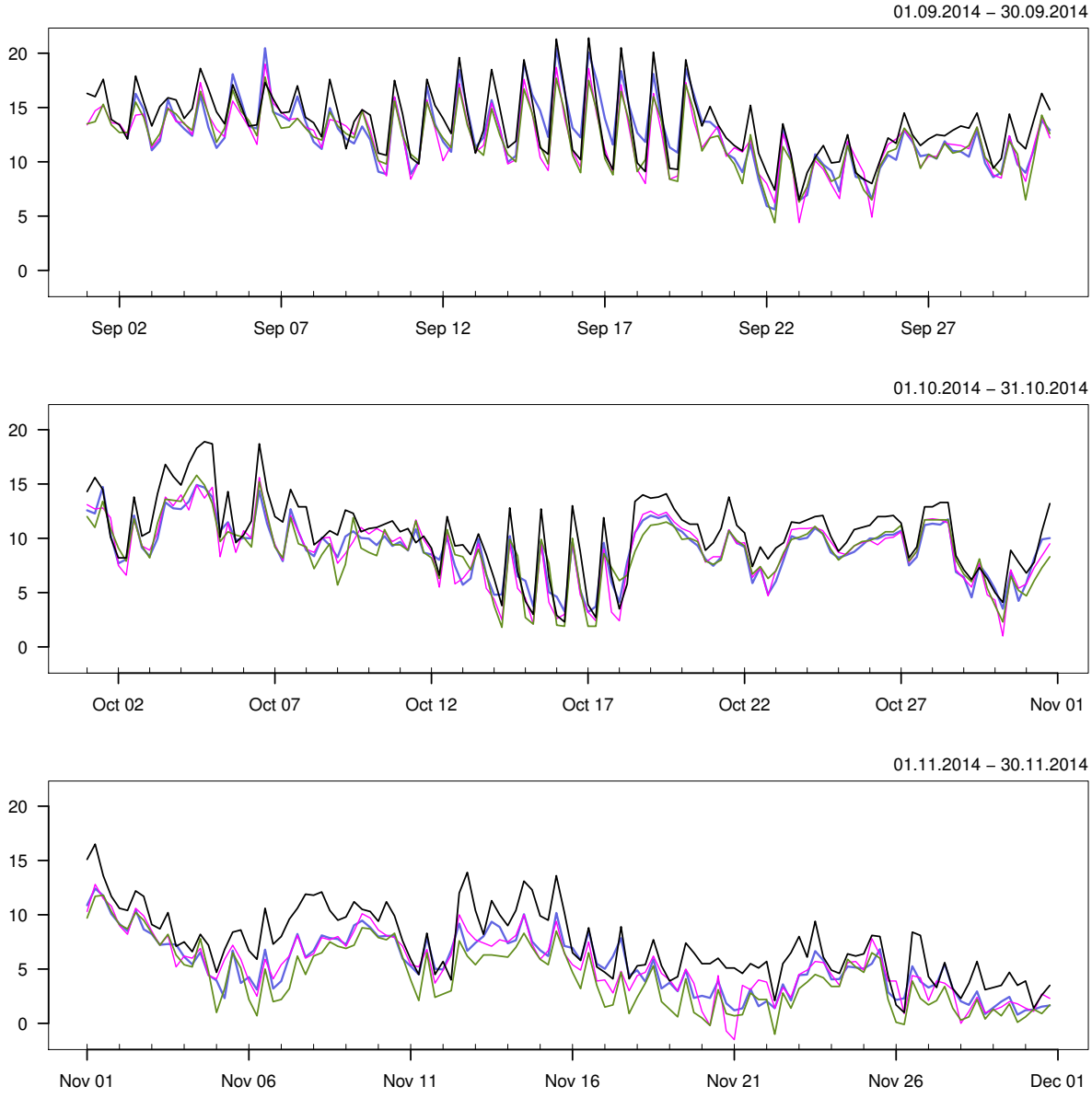


01.09.2014 – 30.11.2014

	Min	Mean	Max	Std	N
synop: 00,06,12,18	3.8	11.3	19.3	2.8	364
AM25: 12+18,+24,+30,+36	3.8	10.6	17.2	2.6	359
Hirlam8: 12+18,+24,+30,+36	4.1	11.3	16.8	2.5	364
ECMWF: 12+18,+24,+30,+36	3.3	10.7	15.9	2.7	364

	ME	SDE	RMSE	MAE	Max.abs.err.	N
AM25 – synop	–0.7	1.1	1.2	0.9	6.8	359
Hirlam8 – synop	0	1.1	1.1	0.8	5.6	364
ECMWF – synop	–0.6	1	1.2	0.9	4.8	364

BERGEN – FLORIDA

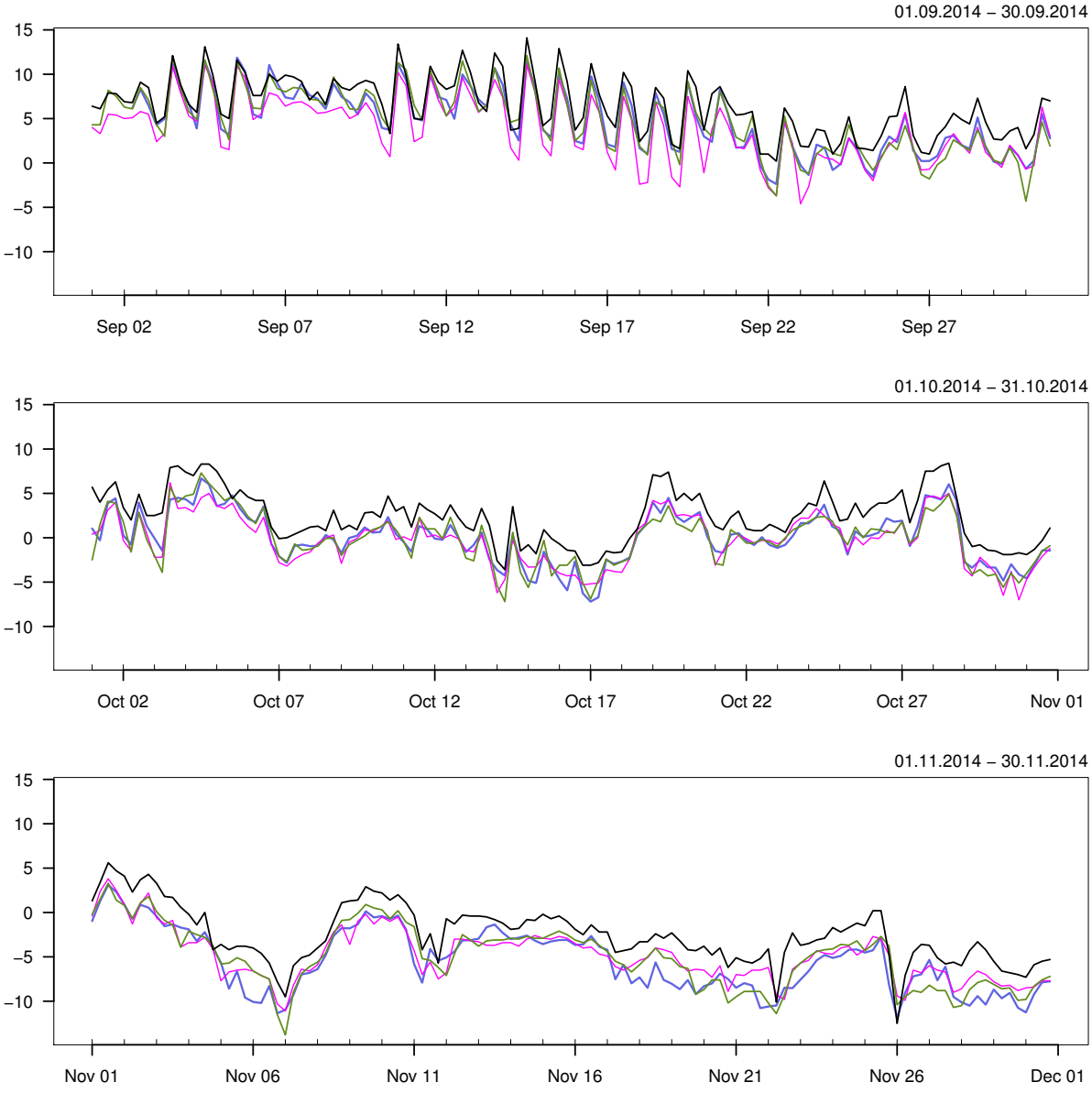


01.09.2014 – 30.11.2014

	Min	Mean	Max	Std	N
synop: 00,06,12,18	1	10.5	21.4	4.1	364
AM25: 12+18,+24,+30,+36	0.8	8.9	20.5	4	359
Hirlam8: 12+18,+24,+30,+36	−1.5	8.8	19	4	364
ECMWF: 12+18,+24,+30,+36	−1	8.4	17.8	4.2	364

	ME	SDE	RMSE	MAE	Max.abs.err.	N
AM25 – synop	−1.5	1.6	2.1	1.8	7.2	359
Hirlam8 – synop	−1.7	1.4	2.2	1.8	6.6	364
ECMWF – synop	−2.1	1.5	2.6	2.2	7.7	364

FINSEVATN

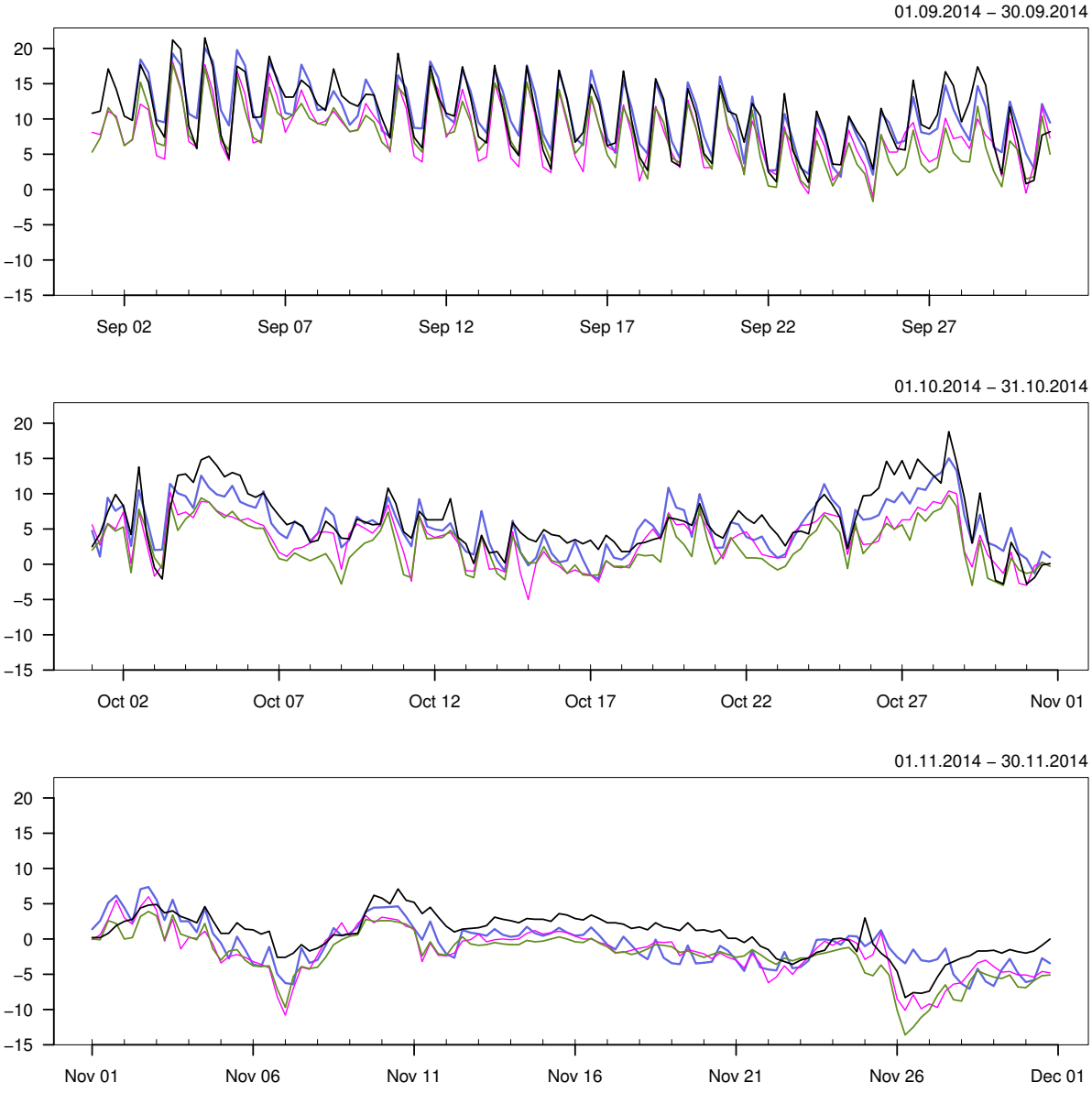


01.09.2014 – 30.11.2014

	Min	Mean	Max	Std	N
synop: 00,06,12,18	−12.5	2.1	14.1	4.8	364
AM25: 12+18,+24,+30,+36	−11.9	−0.3	11.9	5.3	359
Hirlam8: 12+18,+24,+30,+36	−11.1	−0.4	11.1	4.7	364
ECMWF: 12+18,+24,+30,+36	−13.8	−0.1	12.1	5.2	364

	ME	SDE	RMSE	MAE	Max.abs.err.	N
AM25 – synop	−2.3	1.3	2.7	2.4	6.5	359
Hirlam8 – synop	−2.5	1.1	2.8	2.6	6.5	364
ECMWF – synop	−2.2	1.4	2.6	2.3	8.2	364

NESBYEN

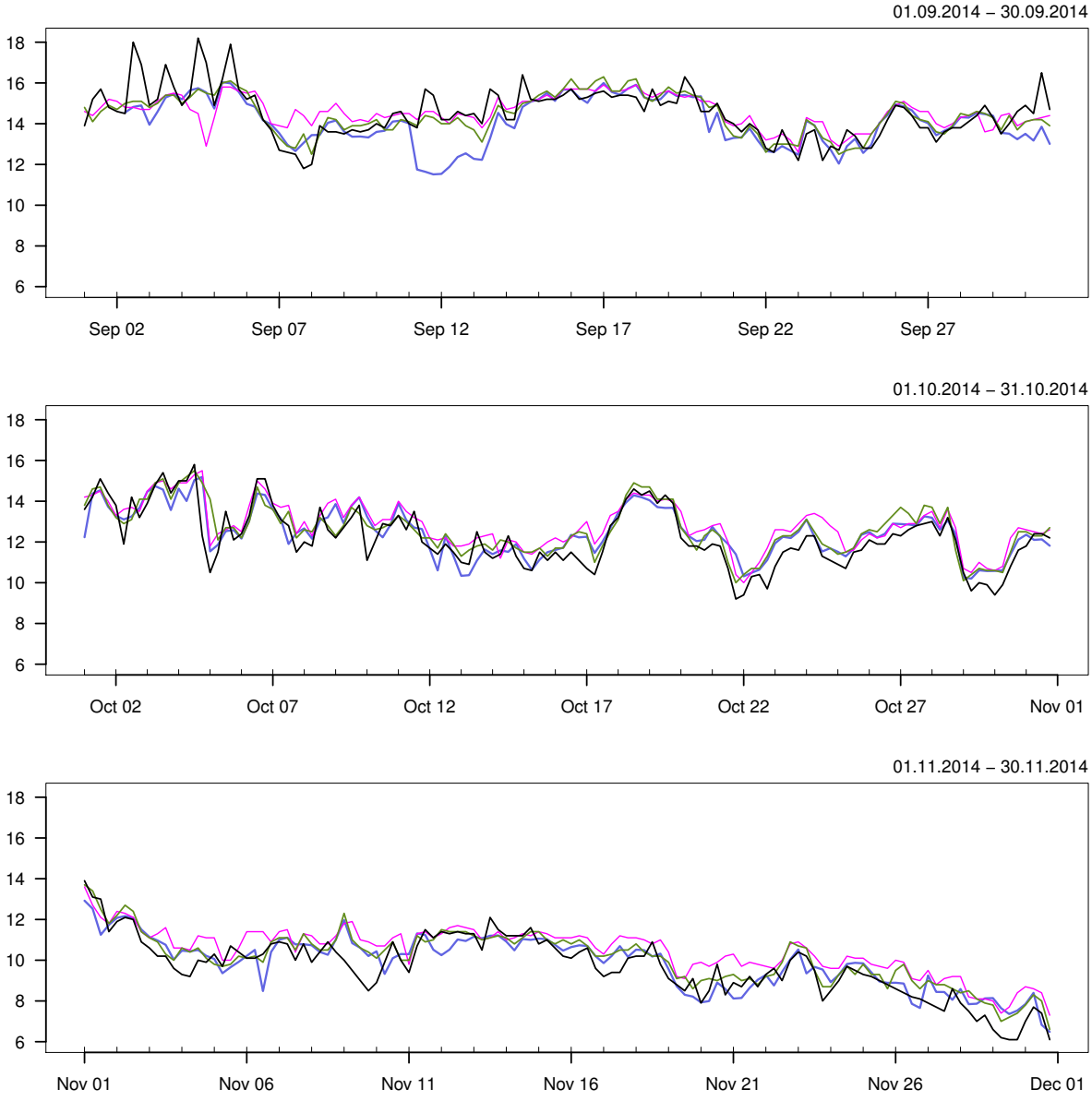


01.09.2014 – 30.11.2014

	Min	Mean	Max	Std	N
synop: 00,06,12,18	−8.3	5.8	21.5	5.8	364
AM25: 12+18,+24,+30,+36	−7.1	5.1	20.1	6	359
Hirlam8: 12+18,+24,+30,+36	−10.8	3.2	18.1	5.4	364
ECMWF: 12+18,+24,+30,+36	−13.6	2.7	17.8	5.4	364

	ME	SDE	RMSE	MAE	Max.abs.err.	N
AM25 – synop	−0.6	2.3	2.4	2	6.1	359
Hirlam8 – synop	−2.6	2.3	3.4	2.9	8.6	364
ECMWF – synop	−3.1	2.2	3.8	3.3	9.5	364

EKOFISK

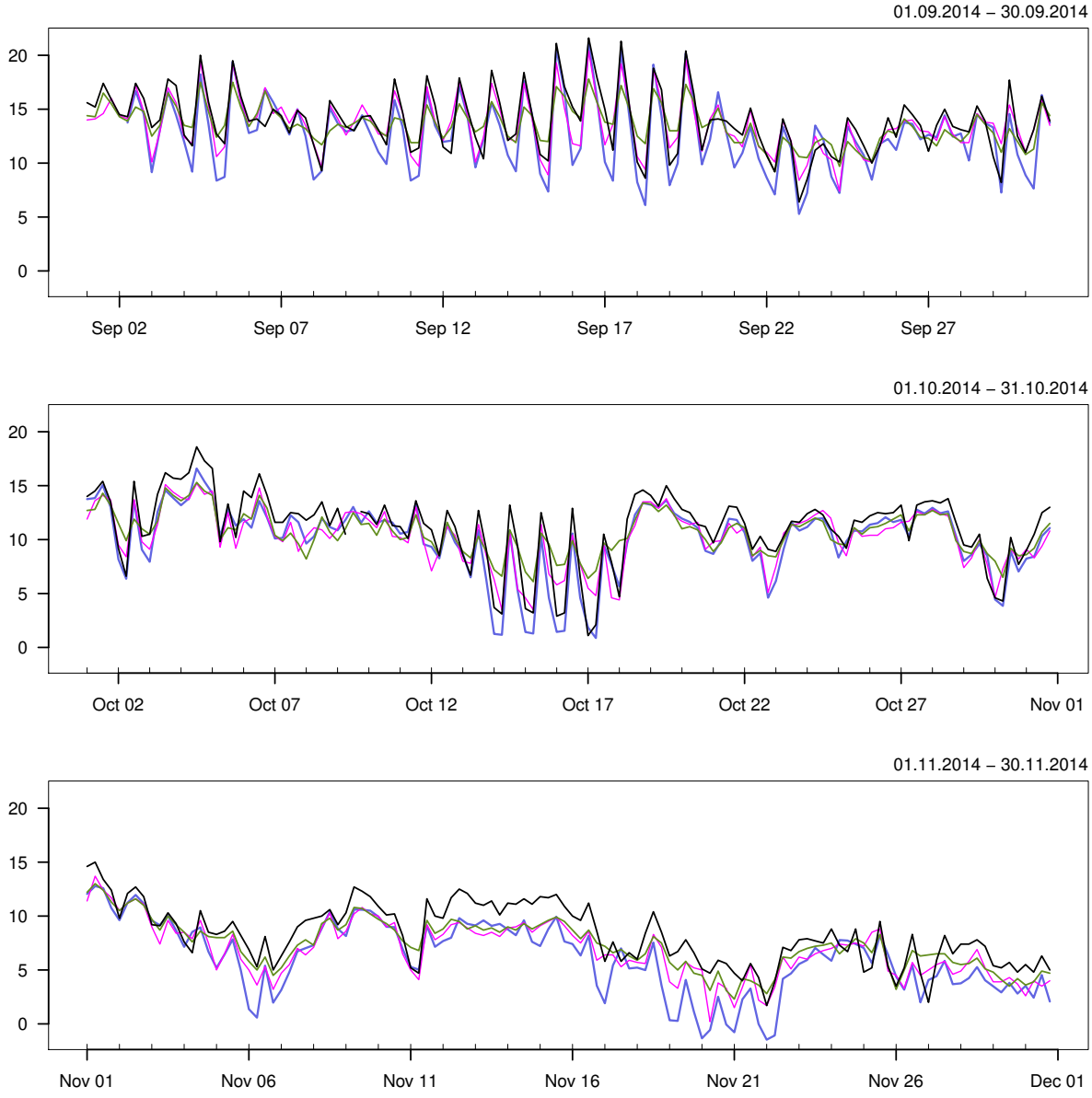


01.09.2014 – 30.11.2014

	Min	Mean	Max	Std	N
synop: 00,06,12,18	6.1	12.2	18.2	2.4	364
AM25: 12+18,+24,+30,+36	6.5	12.1	16	2.1	359
Hirlam8: 12+18,+24,+30,+36	7.3	12.6	15.9	2	364
ECMWF: 12+18,+24,+30,+36	6.6	12.4	16.3	2.1	364

	ME	SDE	RMSE	MAE	Max.abs.err.	N
AM25 – synop	0	0.9	0.9	0.6	4.1	359
Hirlam8 – synop	0.5	0.8	1	0.7	4.1	364
ECMWF – synop	0.2	0.7	0.7	0.6	3.6	364

SOLA

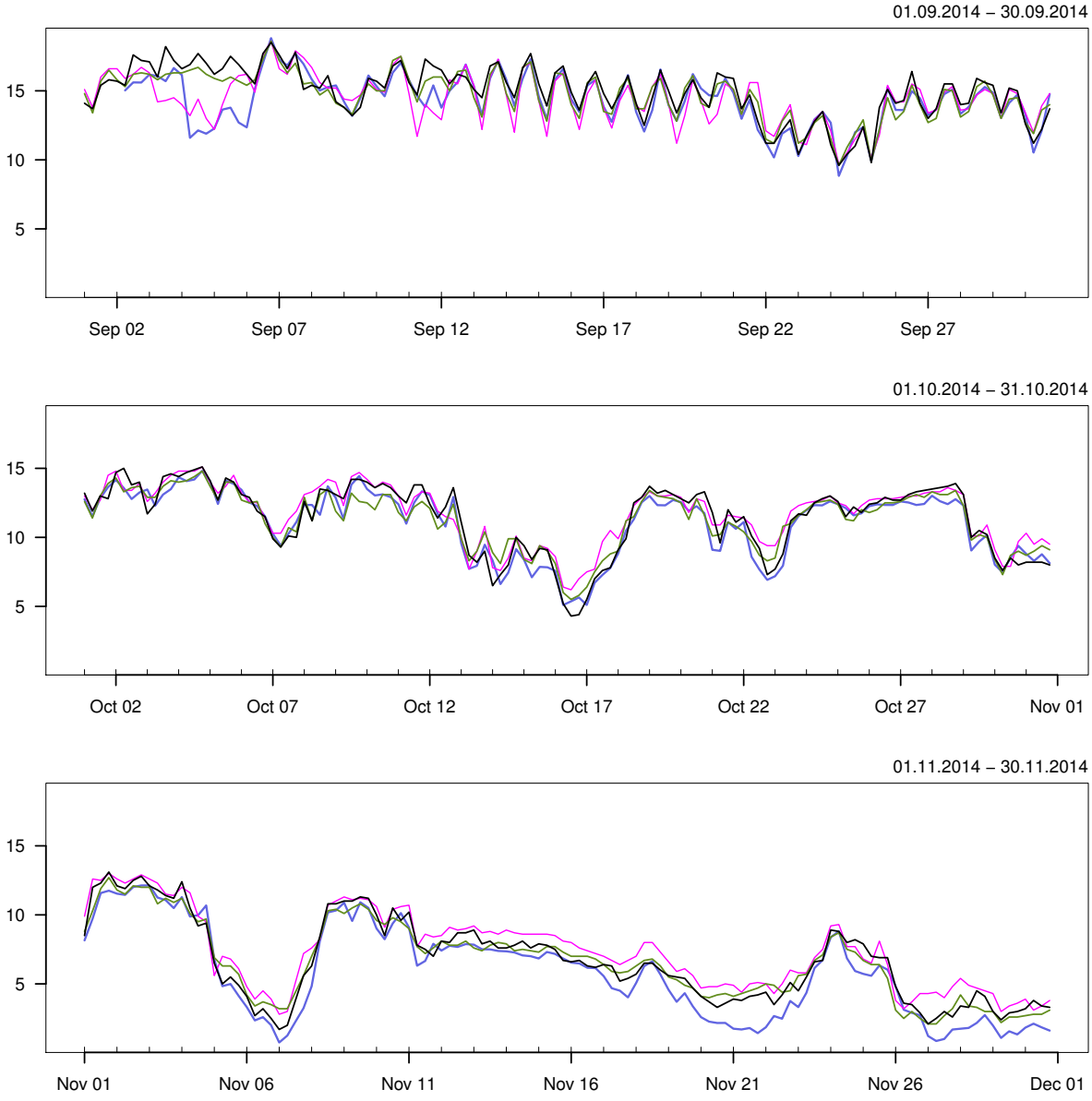


01.09.2014 – 30.11.2014

	Min	Mean	Max	Std	N
synop: 00,06,12,18	1.1	11.1	21.6	3.8	363
AM25: 12+18,+24,+30,+36	−1.5	9.5	21.1	4.2	359
Hirlam8: 12+18,+24,+30,+36	0.2	10.2	20.4	3.7	364
ECMWF: 12+18,+24,+30,+36	2.3	10.5	17.8	3.2	364

	ME	SDE	RMSE	MAE	Max.abs.err.	N
AM25 – synop	−1.5	1.5	2.2	1.7	6.4	358
Hirlam8 – synop	−0.9	1.4	1.7	1.4	4.5	363
ECMWF – synop	−0.6	1.6	1.7	1.4	5.3	363

FERDER FYR

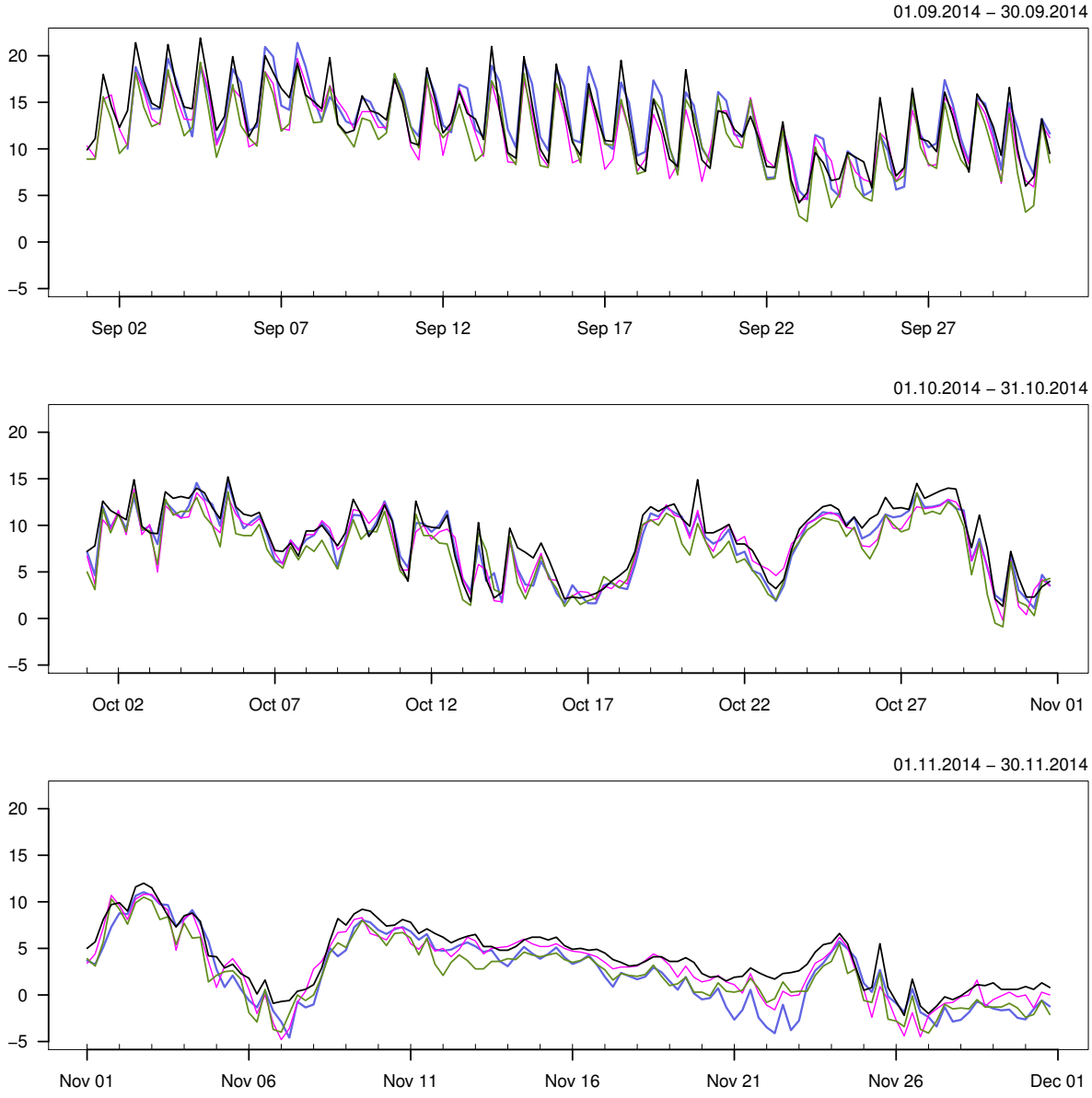


01.09.2014 – 30.11.2014

	Min	Mean	Max	Std	N
synop: 00,06,12,18	1.7	11	18.5	4.2	364
AM25: 12+18,+24,+30,+36	0.8	10.3	18.8	4.3	359
Hirlam8: 12+18,+24,+30,+36	2.8	11.2	18.6	3.7	364
ECMWF: 12+18,+24,+30,+36	2.1	10.9	18.6	4	364

	ME	SDE	RMSE	MAE	Max.abs.err.	N
AM25 – synop	–0.6	1	1.2	0.8	5.6	359
Hirlam8 – synop	0.2	1.1	1.1	0.8	4	364
ECMWF – synop	–0.2	0.7	0.7	0.6	2.4	364

OSLO – BLINDERN

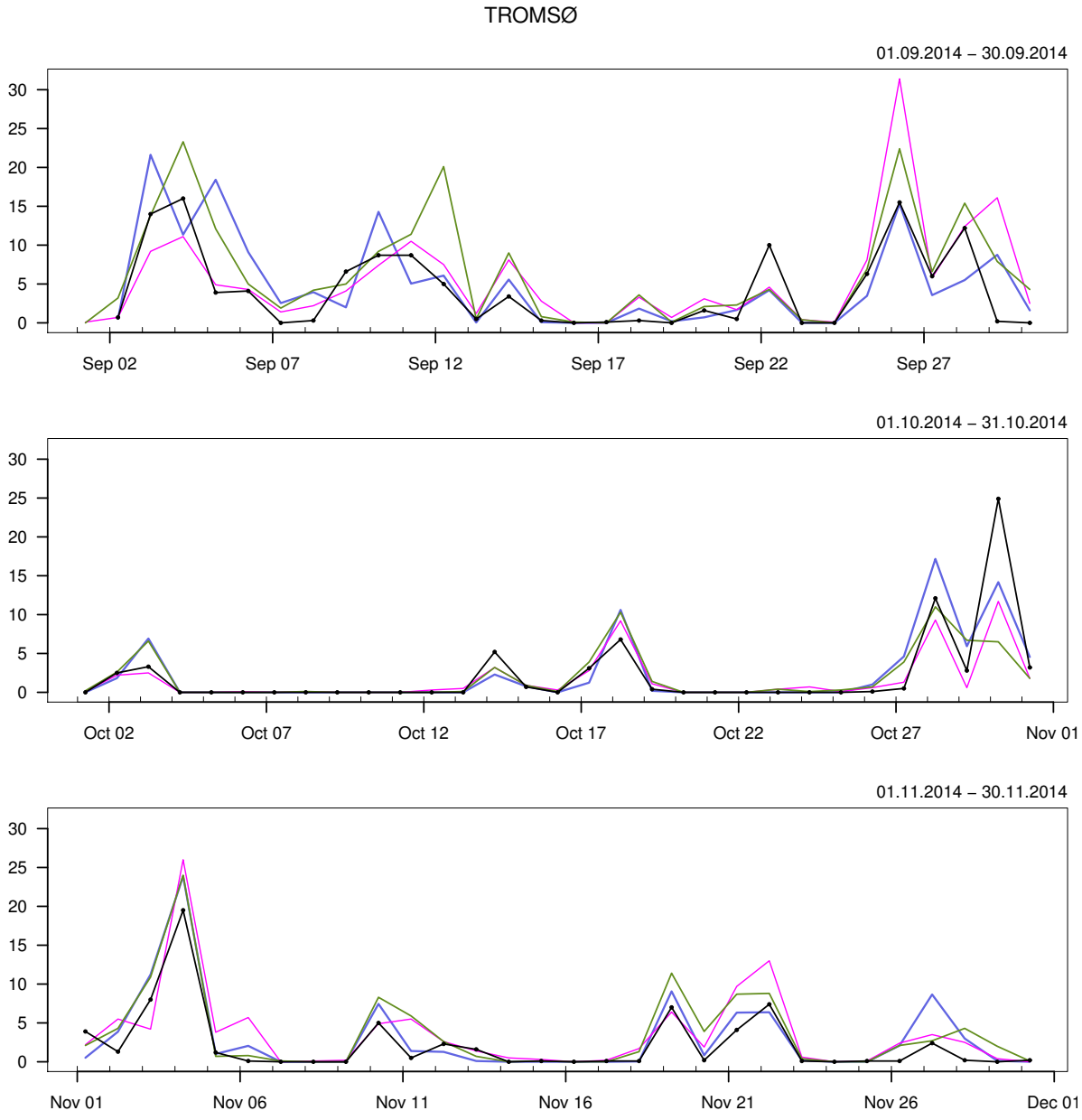


01.09.2014 – 30.11.2014

	Min	Mean	Max	Std	N
synop: 00,06,12,18	−2.2	8.6	21.9	5.1	364
AM25: 12+18,+24,+30,+36	−4.6	7.8	21.4	5.7	359
Hirlam8: 12+18,+24,+30,+36	−4.8	7.7	19.7	5	364
ECMWF: 12+18,+24,+30,+36	−4.1	7	19.3	5.1	364

	ME	SDE	RMSE	MAE	Max.abs.err.	N
AM25 – synop	−0.8	1.5	1.7	1.4	6.2	359
Hirlam8 – synop	−0.9	1.3	1.6	1.2	4.6	364
ECMWF – synop	−1.6	1.2	2	1.7	5	364

9.3 Daily precipitation



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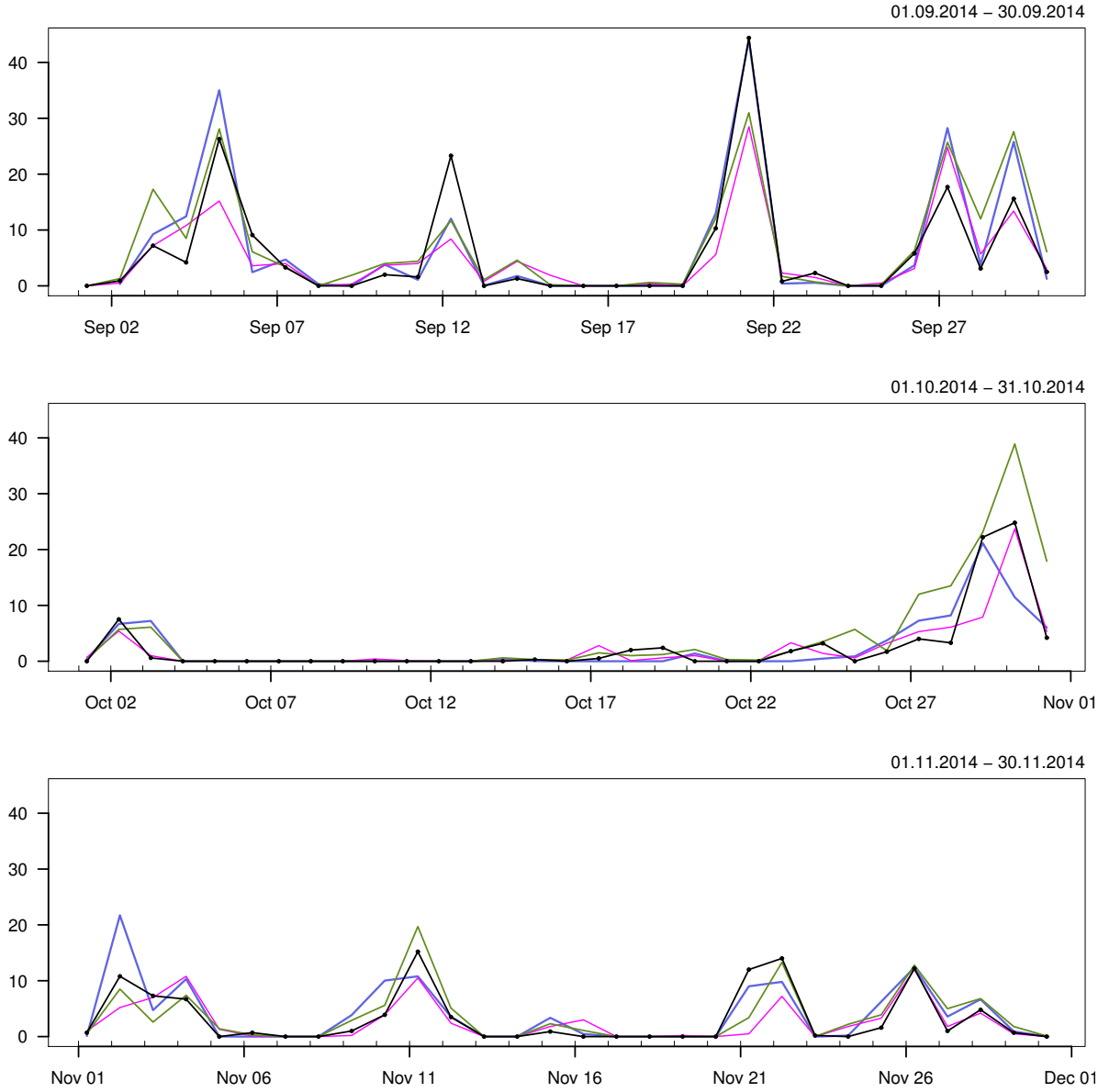
	Min	Mean	Max	Std	N
synop: 06	0	2.8	24.9	4.8	90
AM25: 00+30	0	3.4	23.9	5.2	90
Hirlam8: 00+30	0	3.5	31.4	5.3	91
ECMWF: 00+30	0	4	24	5.5	91

	ME	SDE	RMSE	MAE	Max.abs.err.	N
AM25 – synop	0.6	3.1	3.2	1.8	14.5	90
Hirlam8 – synop	0.7	3.4	3.5	1.8	15.9	90
ECMWF – synop	1.2	3.4	3.6	1.9	18.4	90

BODØ



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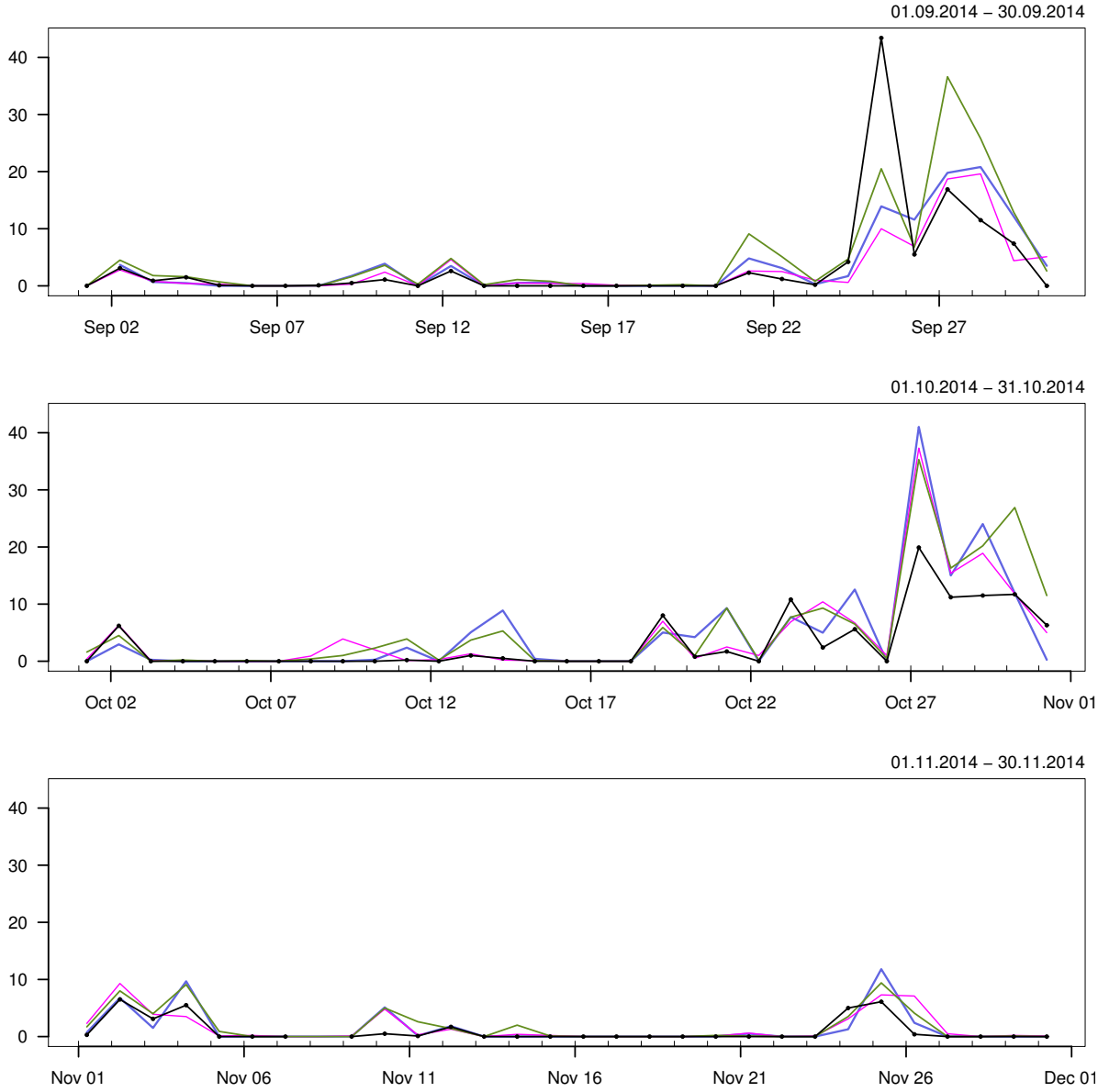
	Min	Mean	Max	Std	N
synop: 06	0	3.9	44.4	7.4	91
AM25: 00+30	0	4.4	44.1	8	90
Hirlam8: 00+30	0	3.3	28.5	5.4	91
ECMWF: 00+30	0	5.1	38.9	8	91

	ME	SDE	RMSE	MAE	Max.abs.err.	N
AM25 – synop	0.4	3.5	3.5	1.9	13.4	90
Hirlam8 – synop	–0.6	3.8	3.8	1.9	15.9	91
ECMWF – synop	1.1	4	4.2	2.3	14.1	91

ØRLAND



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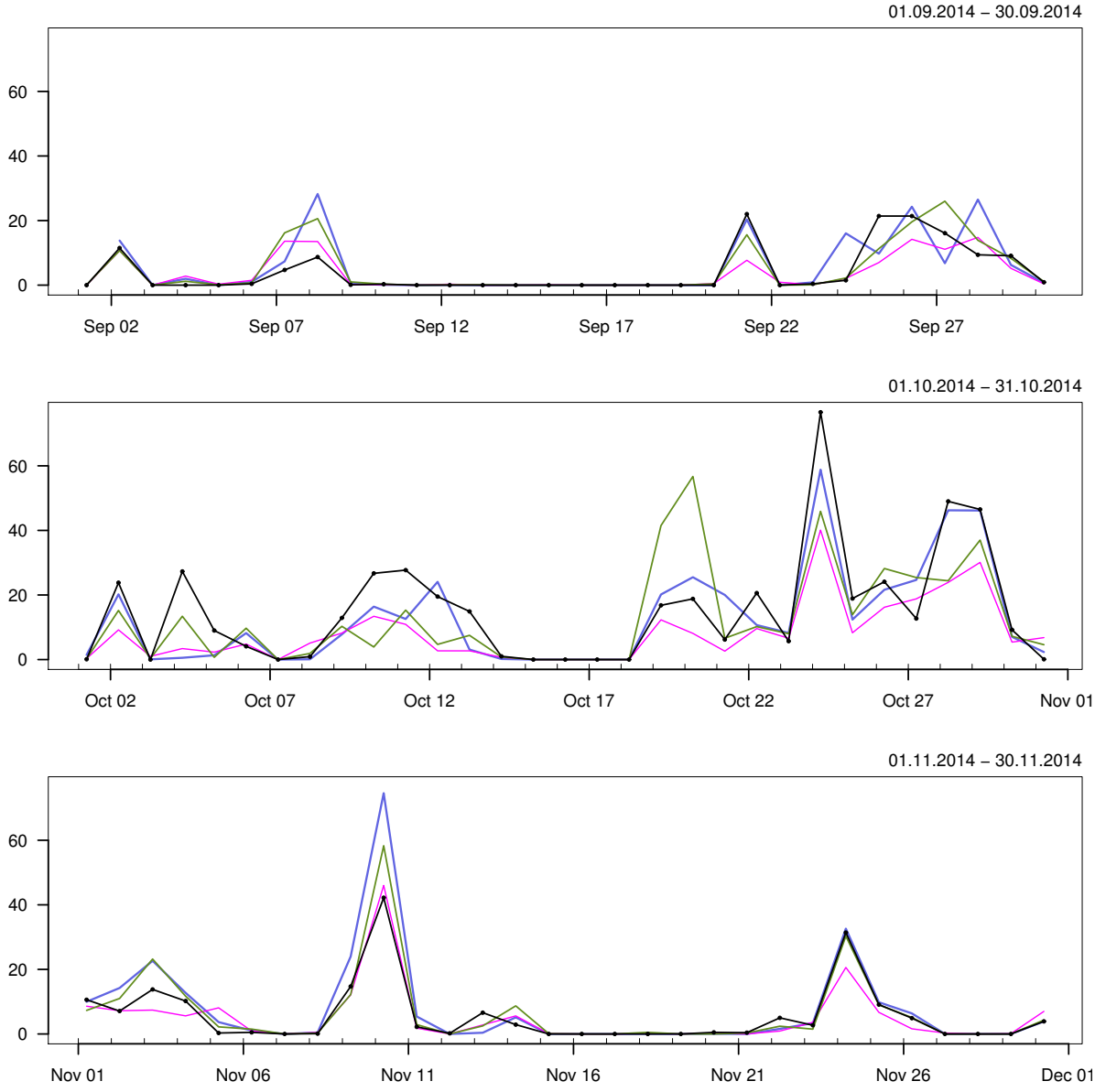
	Min	Mean	Max	Std	N
synop: 06	0	2.5	43.4	5.9	90
AM25: 00+30	0	3.4	41	6.5	90
Hirlam8: 00+30	0	3	37.3	5.7	91
ECMWF: 00+30	0	4.1	36.6	7.3	91

	ME	SDE	RMSE	MAE	Max.abs.err.	N
AM25 – synop	0.8	4.8	4.8	2.1	29.5	89
Hirlam8 – synop	0.5	4.5	4.5	1.6	33.4	90
ECMWF – synop	1.6	4.6	4.8	2.3	22.9	90

BERGEN – FLORIDA



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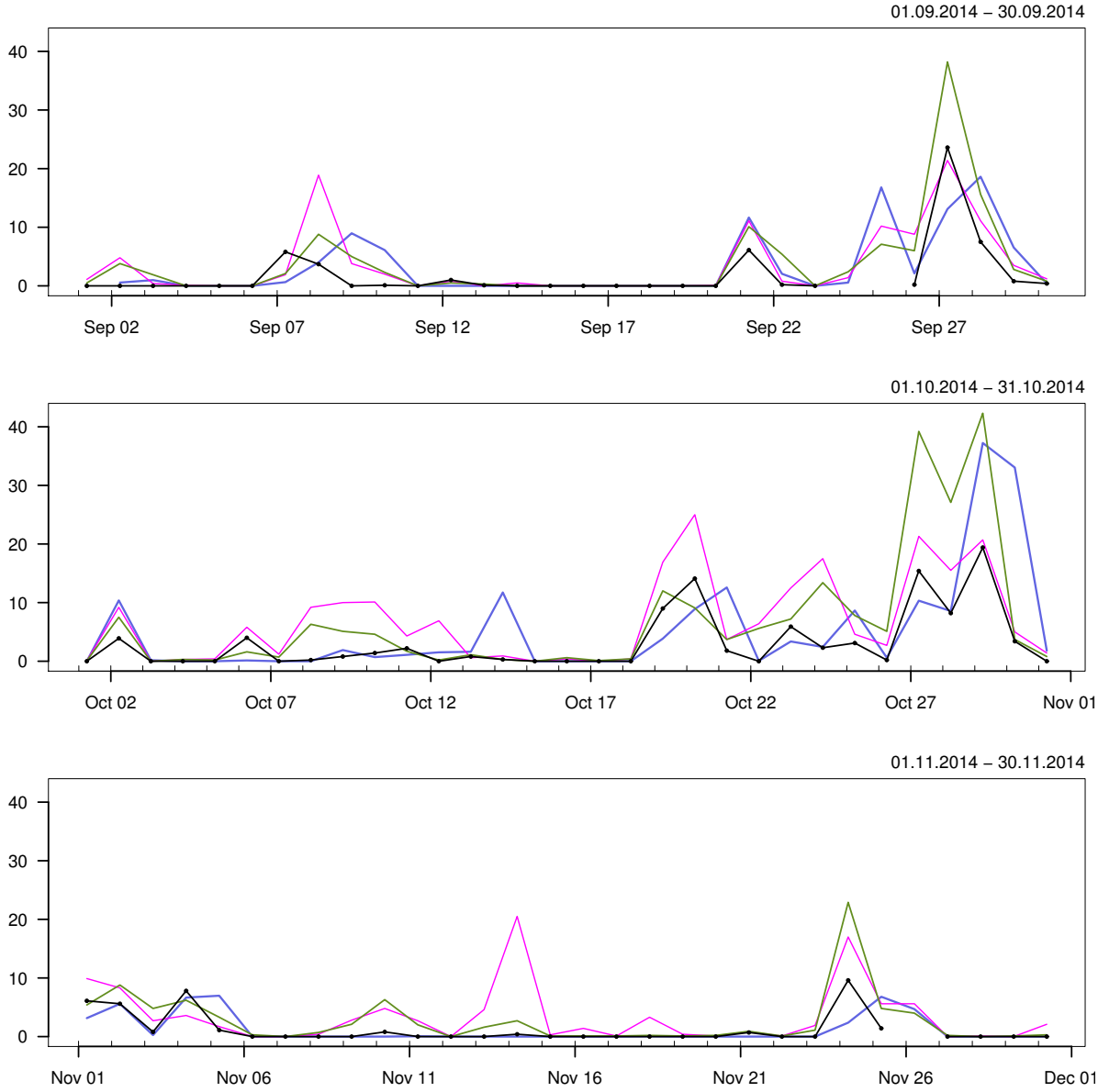
	Min	Mean	Max	Std	N
synop: 06	0	8.5	76.6	13.2	91
AM25: 00+30	0	8.8	74.6	13.7	90
Hirlam8: 00+30	0	5.6	46	8.3	91
ECMWF: 00+30	0	8.1	58.3	12.4	91

	ME	SDE	RMSE	MAE	Max.abs.err.	N
AM25 – synop	0.3	7.3	7.3	3.9	32.4	90
Hirlam8 – synop	–2.9	7.3	7.8	4.3	36.5	91
ECMWF – synop	–0.4	8.4	8.4	4.2	37.9	91

LÆRDAL



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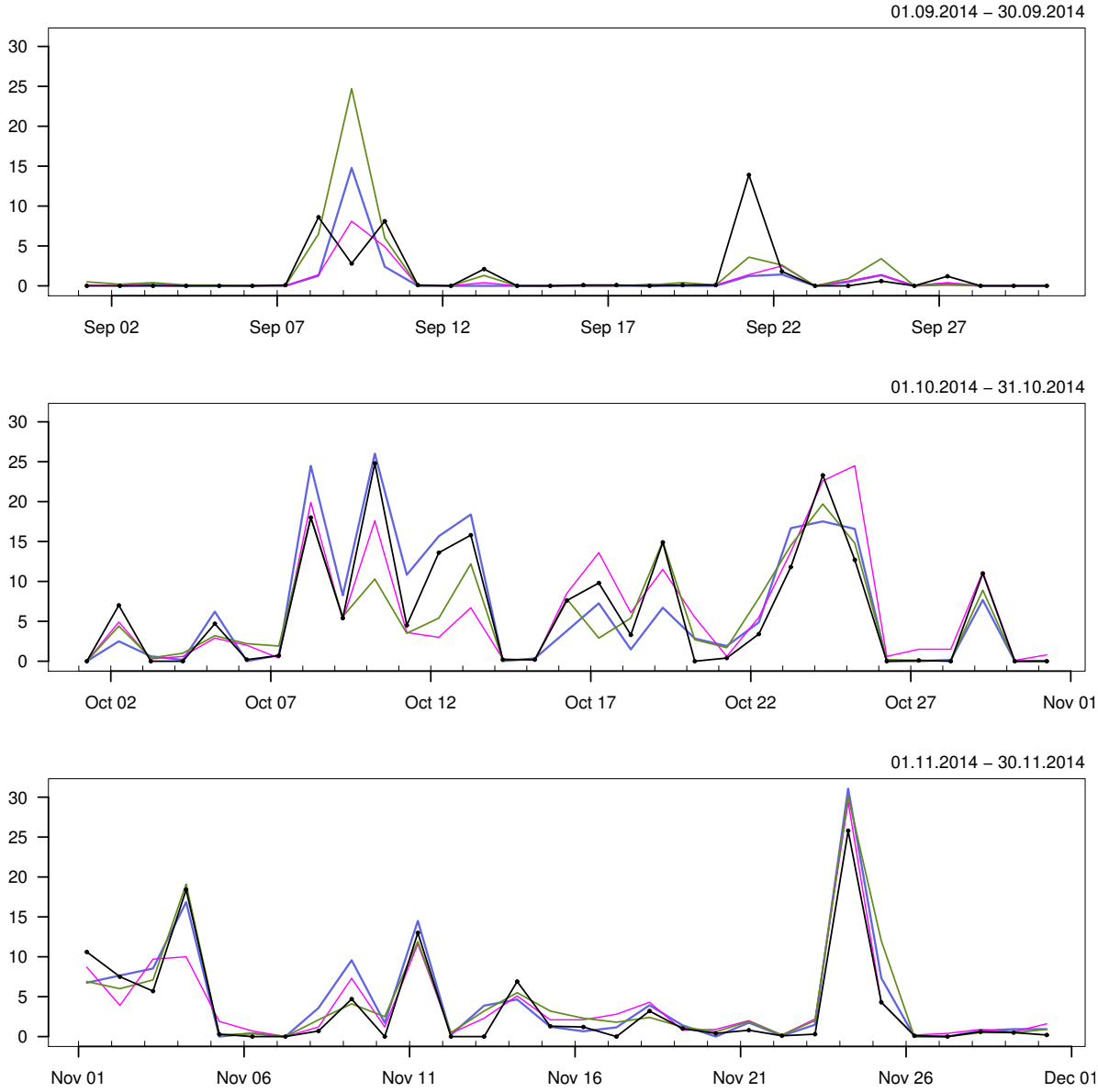
	Min	Mean	Max	Std	N
synop: 06	0	2	23.6	4.3	88
AM25: 00+30	0	3.2	37.2	6.4	90
Hirlam8: 00+30	0	4.6	25	6.2	91
ECMWF: 00+30	0	4.4	42.3	8.1	91

	ME	SDE	RMSE	MAE	Max.abs.err.	N
AM25 – synop	1	5	5.1	2.3	29.6	87
Hirlam8 – synop	2.5	4	4.7	2.7	20.1	88
ECMWF – synop	2.4	4.8	5.3	2.7	23.8	88

GARDERMOEN

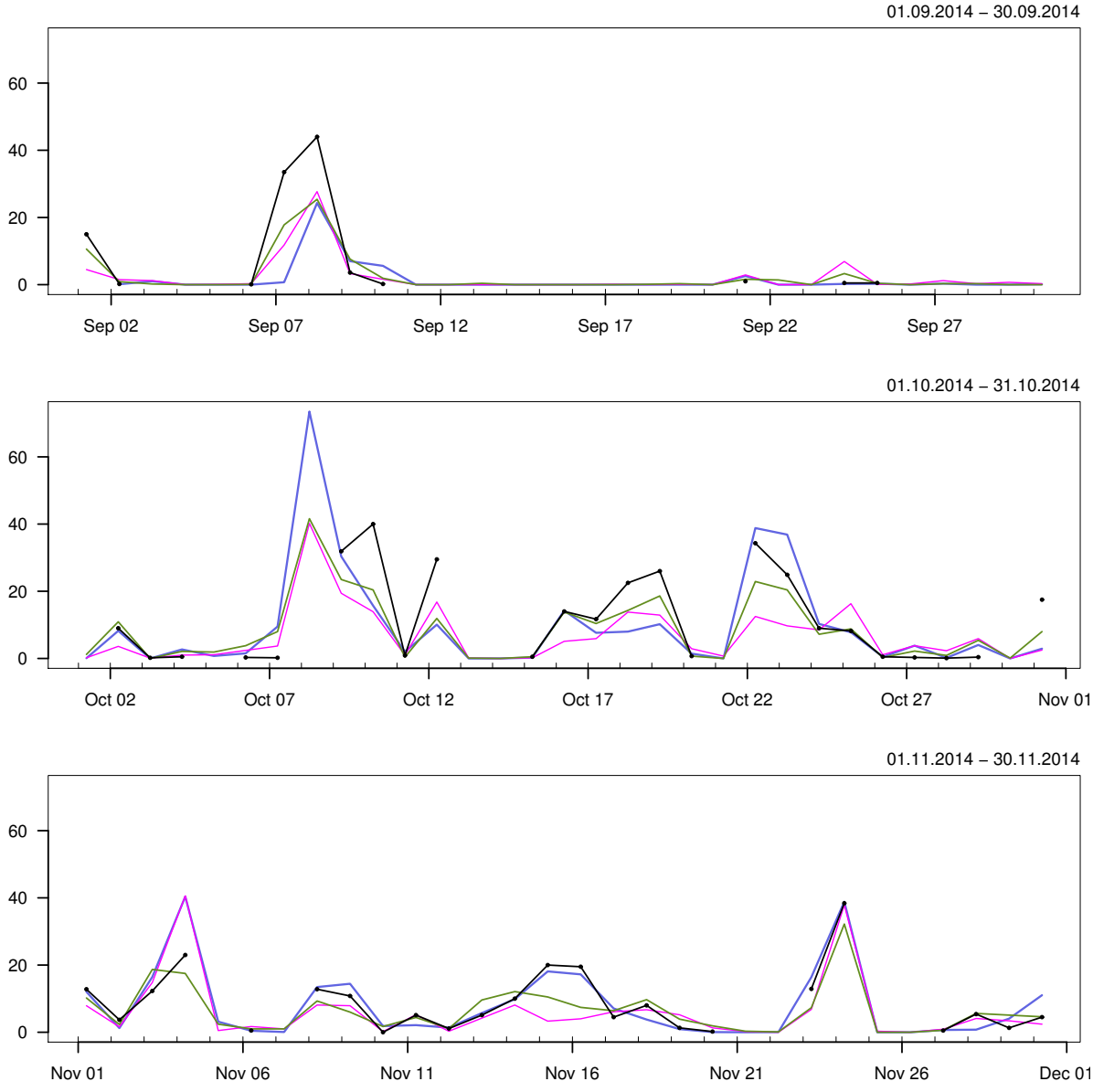


01.09.2014 – 30.11.2014

	Min	Mean	Max	Std	N
synop: 06	0	3.7	25.8	6.2	91
AM25: 00+30	0	4	31.1	6.6	90
Hirlam8: 00+30	0	3.7	29.4	5.8	91
ECMWF: 00+30	0	3.8	30.1	5.9	91

	ME	SDE	RMSE	MAE	Max.abs.err.	N
AM25 – synop	0.2	3.1	3.1	1.7	12.7	90
Hirlam8 – synop	–0.1	3.1	3.1	1.7	12.5	91
ECMWF – synop	0.1	3.6	3.6	1.7	21.9	91

NELAUG



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	Min	Mean	Max	Std	N
synop: 06	0	10.3	44	12.1	58
AM25: 00+30	0	6.5	73.5	11.8	90
Hirlam8: 00+30	0	5	40.6	8.2	91
ECMWF: 00+30	0	5.8	41.6	8	91

	ME	SDE	RMSE	MAE	Max.abs.err.	N
AM25 – synop	–1.3	8.3	8.4	4.6	32.8	57
Hirlam8 – synop	–3.2	8.1	8.7	5.6	26.1	58
ECMWF – synop	–2.1	6.1	6.4	4.2	19.6	58