Norwegian Meteorological Institute

MET info 22/2015 Meteorology

Verification of Experimental and Operational Weather Prediction Models March to May 2015

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Photo: Ingrid Våset

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 Post processed models

Most of the raw model data are post processed before being published on Yr. The models AM25 and H8 are statisticly post processed to represent the 10m max mean wind speed. After post processing, these models are called AM25_PP and H8_PP.
For 2m temperature, the raw data is first interpolated to a 500m grid and then Kalman filtered. These model fields are called AM25.KF and H8.KF.
The precipitation data is post processed by using a neighbourhood method. Through the method, a median value is obtained. This field, called AM25.median is used to determine the precipitation symbol at Yr.
For long term forecast, an ensemble of 51 members run at ECMWF is used to obtain a probabilistic forecast. These fields are called EC_UKAL_KONSENSUS and EC_UKAL_MEDIAN for the consensus and median forecast, respectively. If the probablistic forecast is calibrated before it is published on Yr, it is called EC_KAL_...

The deterministic model just called ECMWF, is also shown in the long term forecast graphs.

3 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/.

3.1 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.

3.2 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.

3.3 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/

3.4 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.

3.4.1 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.

3.4.2 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.

3.5 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).

4 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.

4.1 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

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

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

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

4.2 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 $ar = (a+b)(a+c)/n$.

4.3 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.

5 Norway

5.1 Comments to verification results

Mean Sea Level Pressure:
Slight increase in bias for AM25, compared with the winter season, which still has the highest bias amongst the models. ECMWF still the best model for MSLP, while AM25 has the second lowest MAE.

Wind speed:

Mean wind speed:
More diurnal variations in the bias during spring, than in the winter. Not so much diurnal variation for AM25. Negative bias for ECMWF. The Hirlam models have negative biases during daytime and positive biases in the night. AM25 has a postive bias, but only of about $0.25ms^{-1}$. AM25 scores better than the rest of the models in ETS. AM25 also has considerably more events above $21ms^{-1}$ compared with the rest of the models, still too few compared with the observations.

Max mean wind speed:
The post processed version of AM25 is generally underestimating the max mean wind speed. H8_PP has a smaller bias, but AM25 scores highest for ETS.

Wind gust:
The wind gust from AM25 is generally too low, while the wind gust from H8 is similarly too high. The 925hPa wind is quite similar in both models. MAE is considerably lower for the wind gust than the 925hPa wind. The wind gust scores better for all thresholds except the highest, were the 925hPa wind is slightly better.

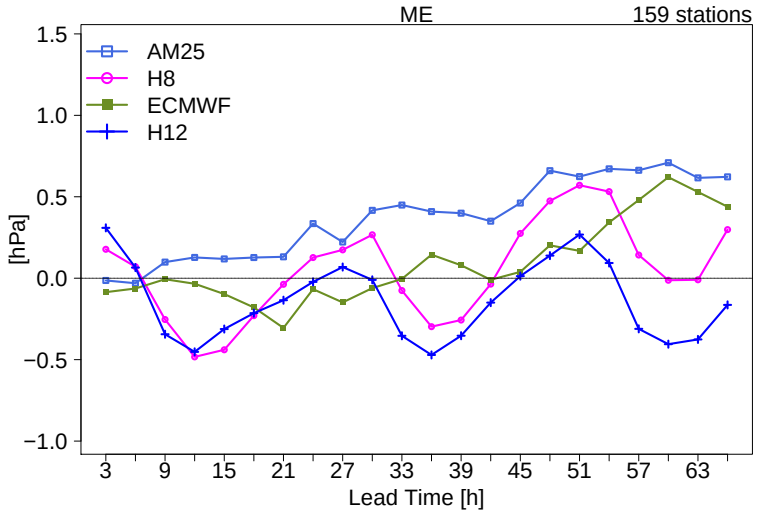
Temperature 2m:
All models have a cold bias during the spring of 2015. H12 has the smallest bias. ECMWF and AM25 also have a cold trend, and end up at around -1°C after 63h. For ECMWF this is actually an improvement from the winter season. While for AM25 it decrease in score. SDE is reduced for all models, compared with the winter season. MAE is also in general reduced, but the reduction is largest for ECMWF. In total H12 is the model with the lowest MAE for the spring.

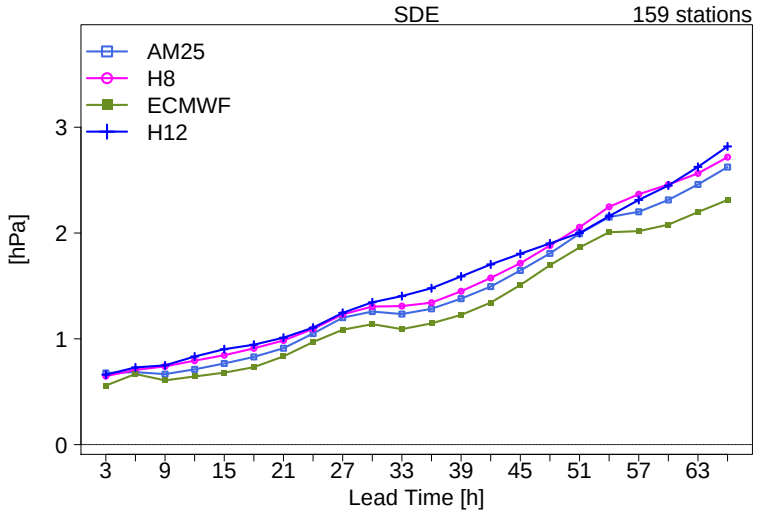
Post processed temperature:
Hardly any bias in temperature after post processing. MAE is a bit reduced, few differences between H8.KF and AM25.KF.

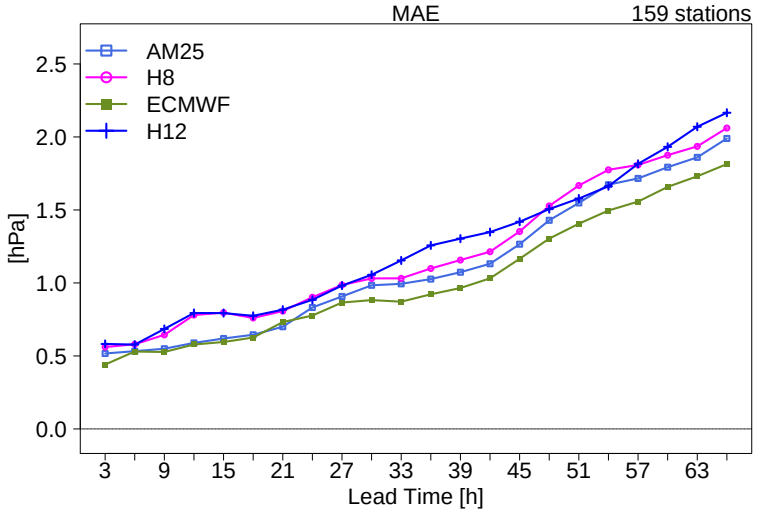
Daily precipitation:
Positive biases for all models, except AM25.median. ECMWF has the highest bias, while AM25 has the smallest bias and the lowest MAE. HR is highest for ECMWF for thresholds up to 25mm/day. For thresholds above this, AM25 has the highest HR. AM25.median has the lowest FAR up to 25mm/day, and the highest ETS for thresholds below 8mm/day. ECMWF has the highest ETS between 8-25mm/day. Above 25mm/day AM25 has the highest score. This is seen again in the multiple contingency table, where AM25.median has the highest number correct in

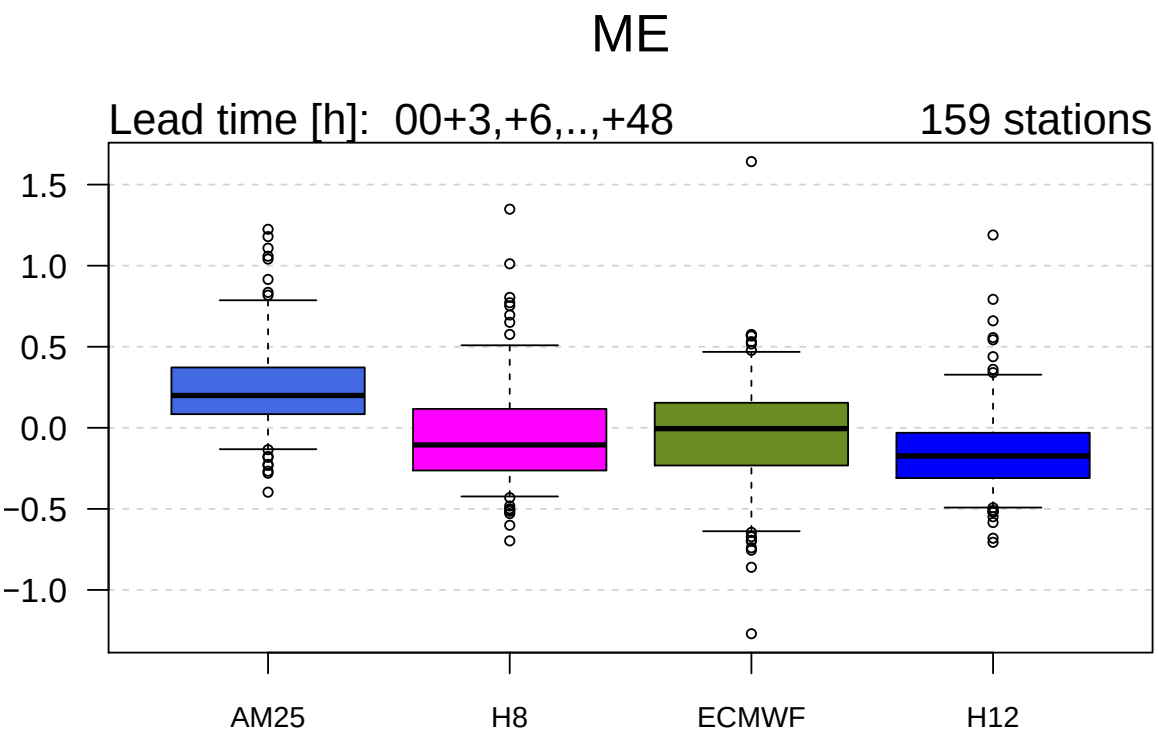
the lowest category, ECMWF rules the middle categories, while AM25 wins in the >50mm/day category.

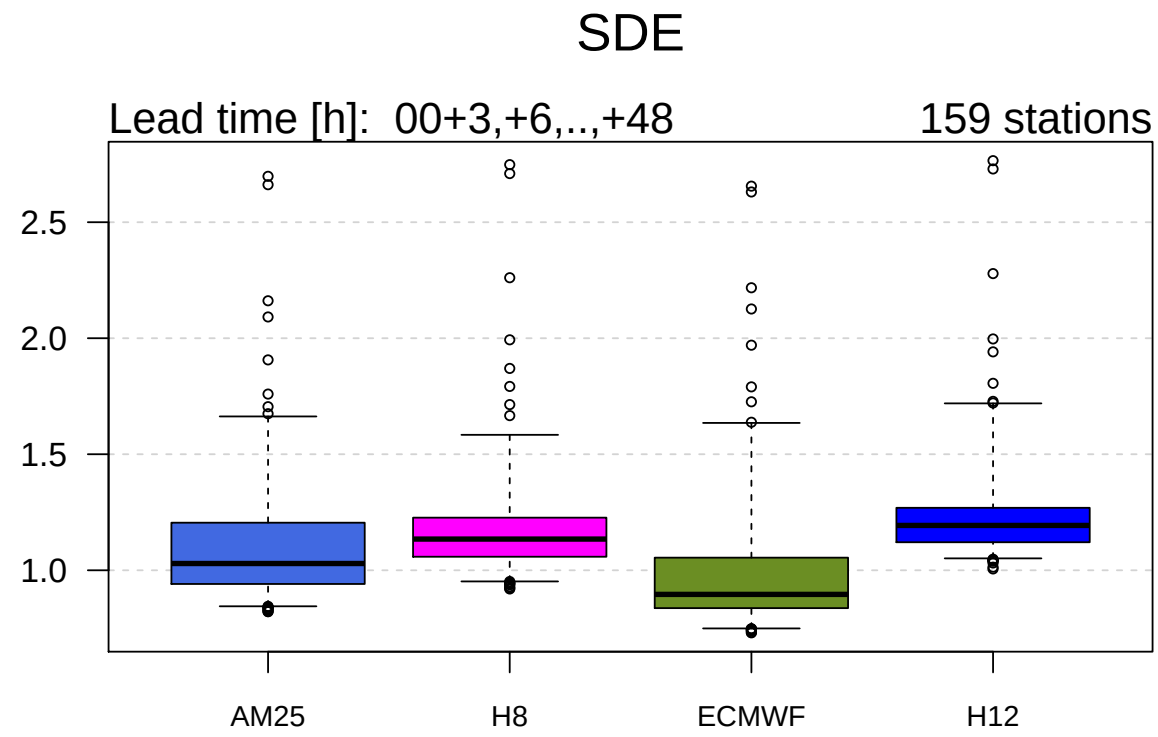
5.2 Pressure and variables at pressure levels



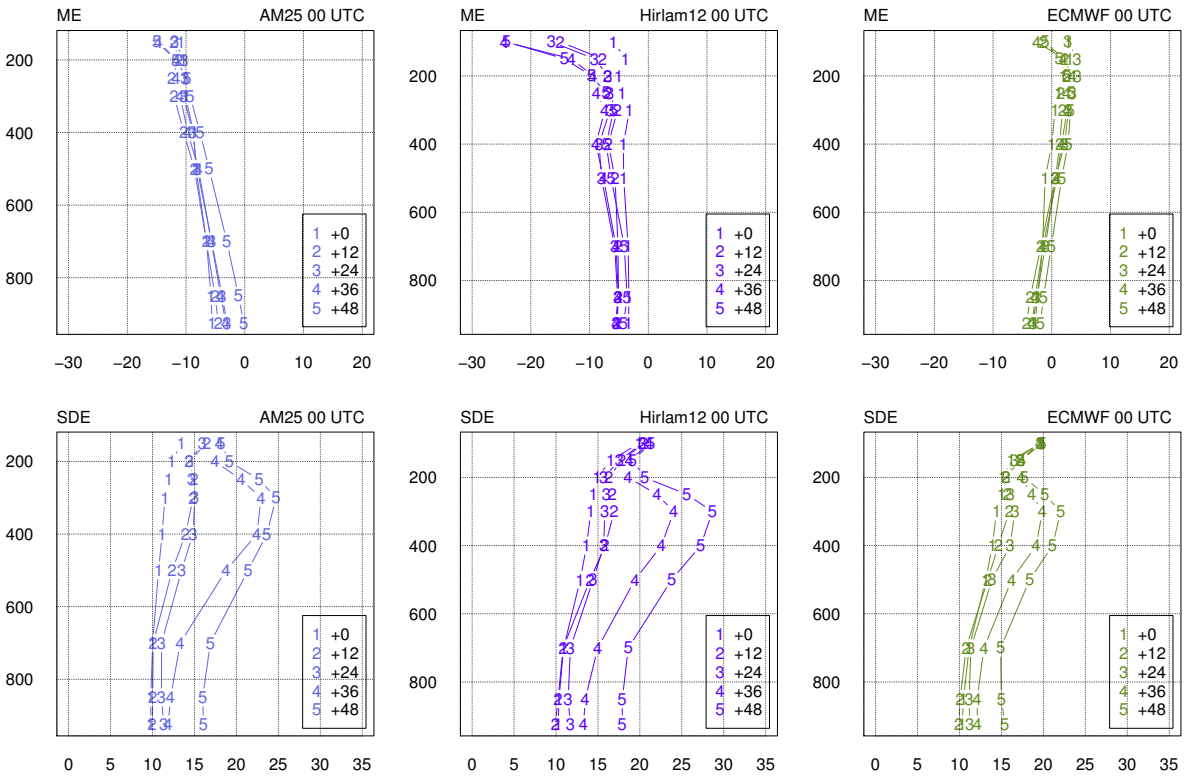




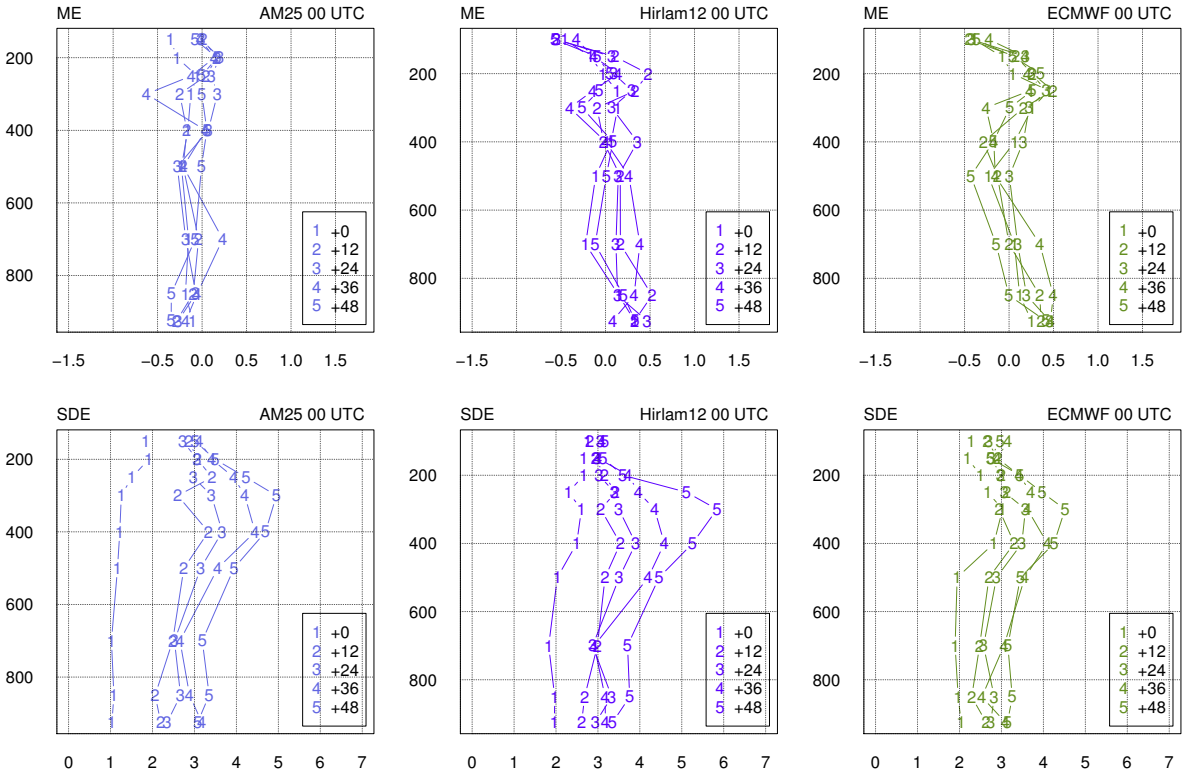

ME
Lead time [h]: 00+3,+6,..,+48
159 stations
1.5
1.0
0.5
0.0
−0.5
−1.0
AM25
H8
ECMWF
H12

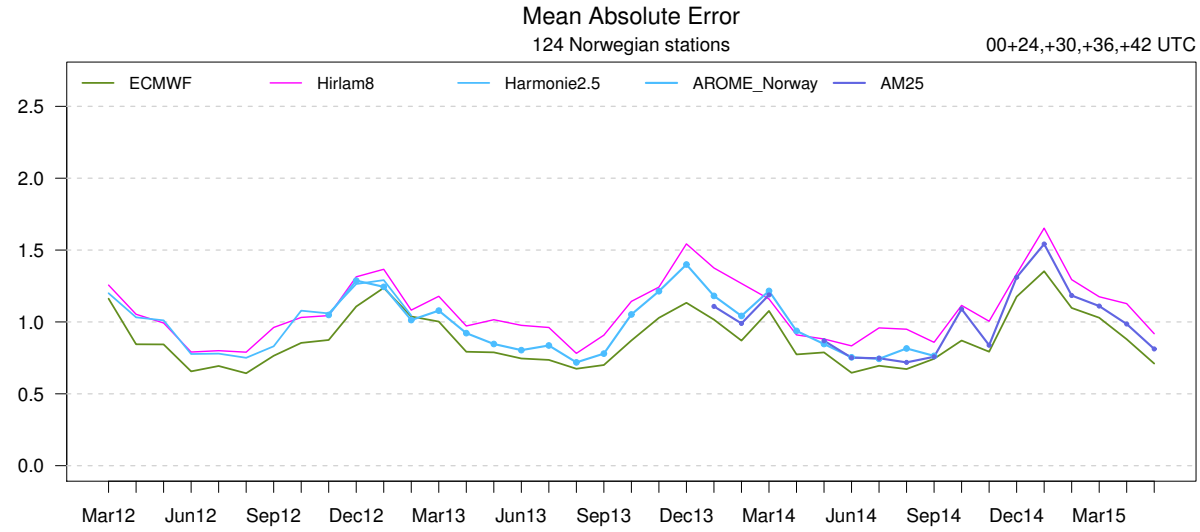

SDE
Lead time [h]: 00+3,+6,..,+48
159 stations
2.5
2.0
1.5
1.0
AM25
H8
ECMWF
H12

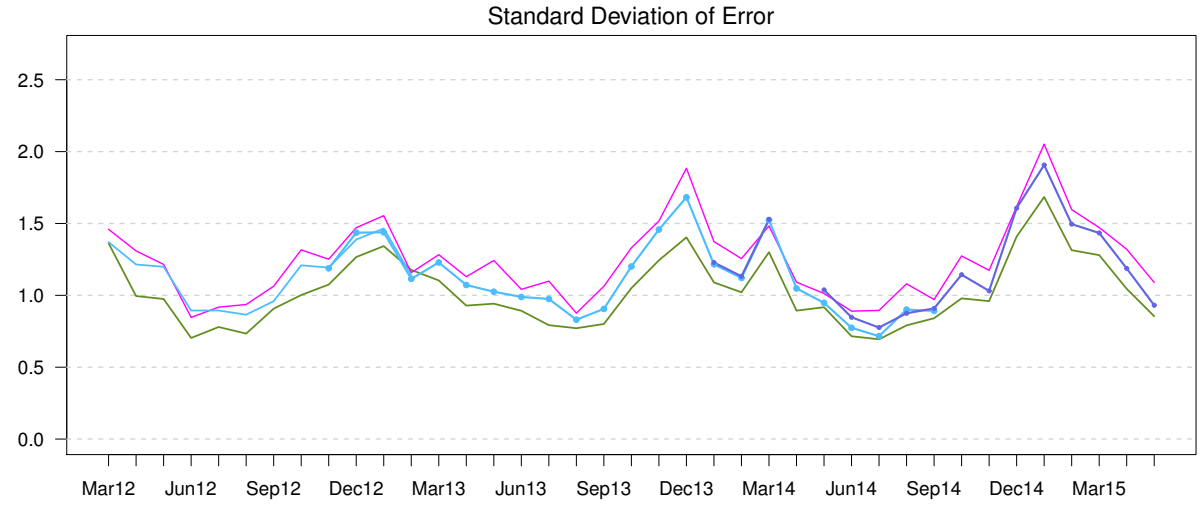
Geopotential height at 3 Norwegian stations

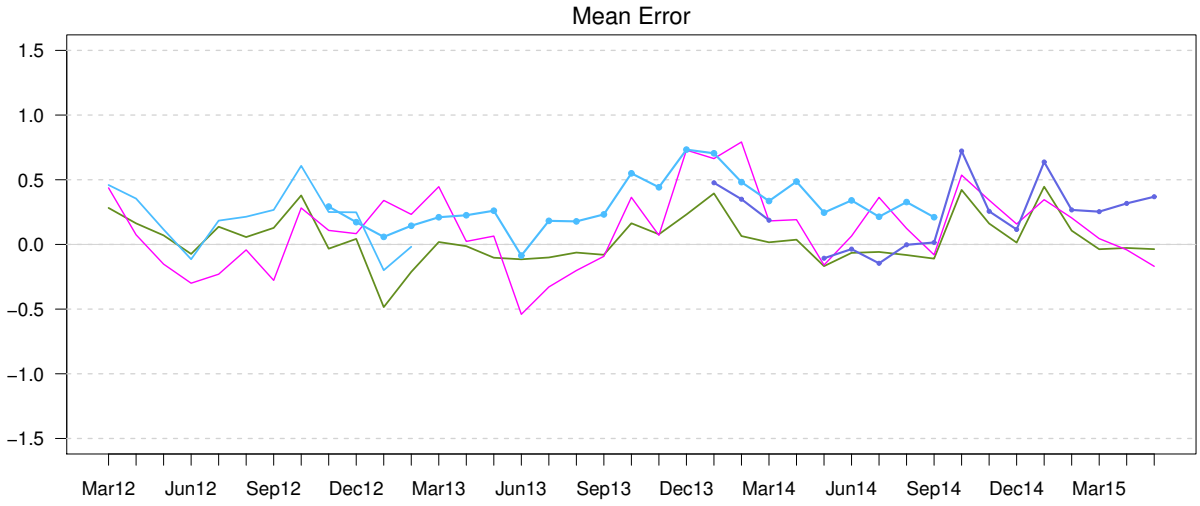


Wind speed at 3 Norwegian stations

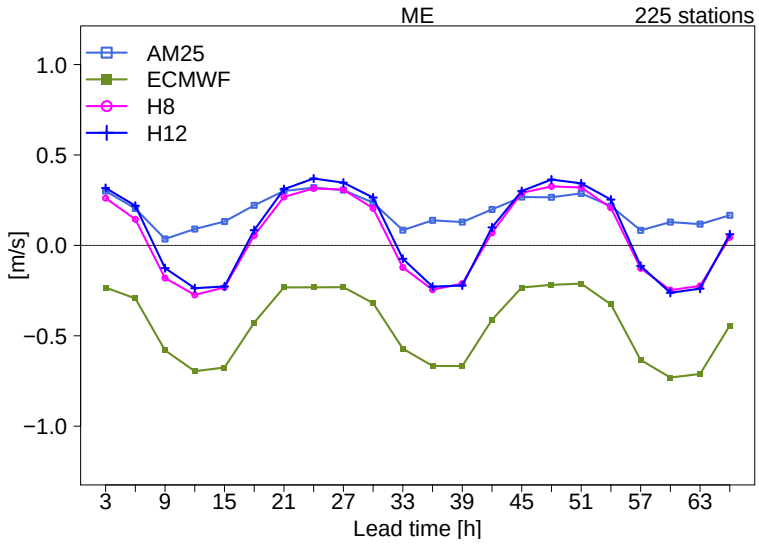


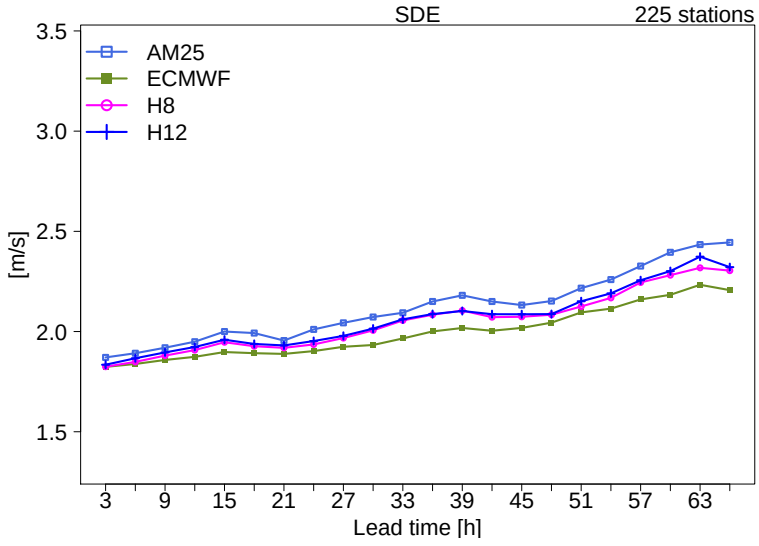

Mean Absolute Error
124 Norwegian stations
00+24,+30,+36,+42 UTC
ECMWF
Hirlam8
Harmonie2.5
AROME_Norway
AM25
2.5
2.0
1.5
1.0
0.5
0.0
Mar12
Jun12
Sep12
Dec12
Mar13
Jun13
Sep13
Dec13
Mar14
Jun14
Sep14
Dec14
Mar15

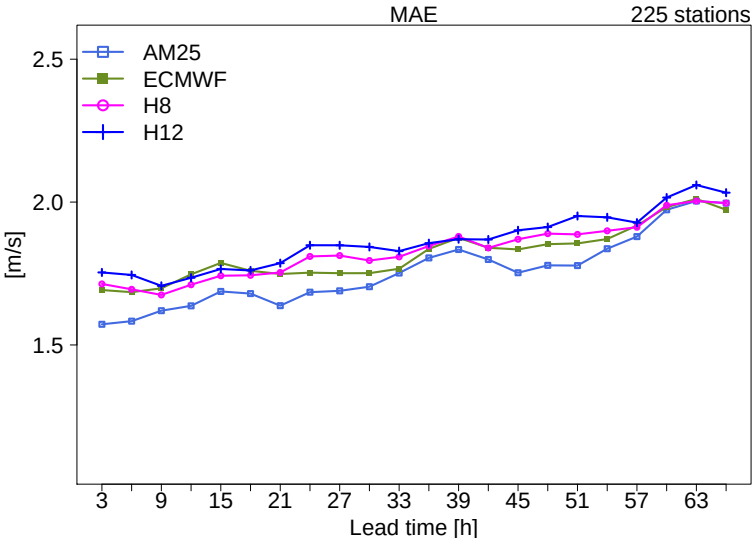

Standard Deviation of Error
2.5
2.0
1.5
1.0
0.5
0.0
Mar12
Jun12
Sep12
Dec12
Mar13
Jun13
Sep13
Dec13
Mar14
Jun14
Sep14
Dec14
Mar15

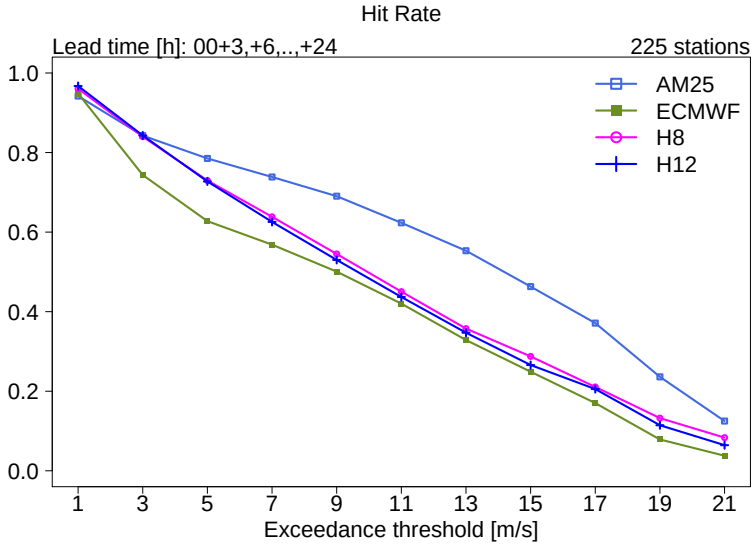

Mean Error
1.5
1.0
0.5
0.0
−0.5
−1.0
−1.5
Mar12
Jun12
Sep12
Dec12
Mar13
Jun13
Sep13
Dec13
Mar14
Jun14
Sep14
Dec14
Mar15

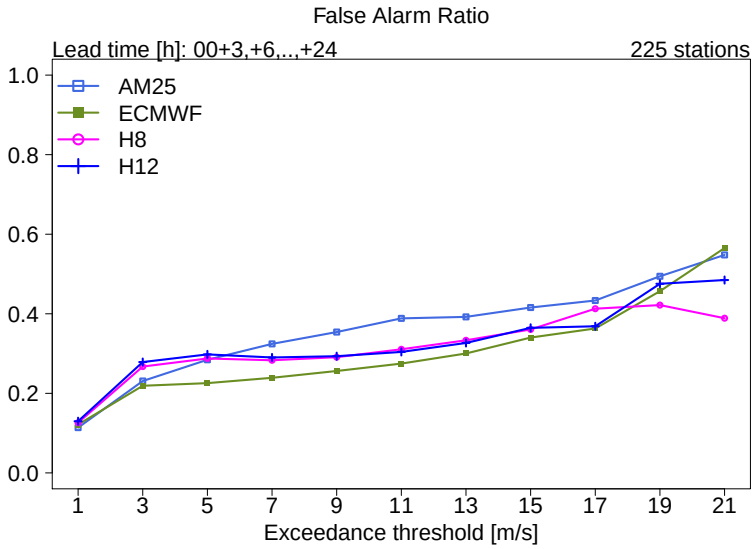
5.3 Wind Speed 10m

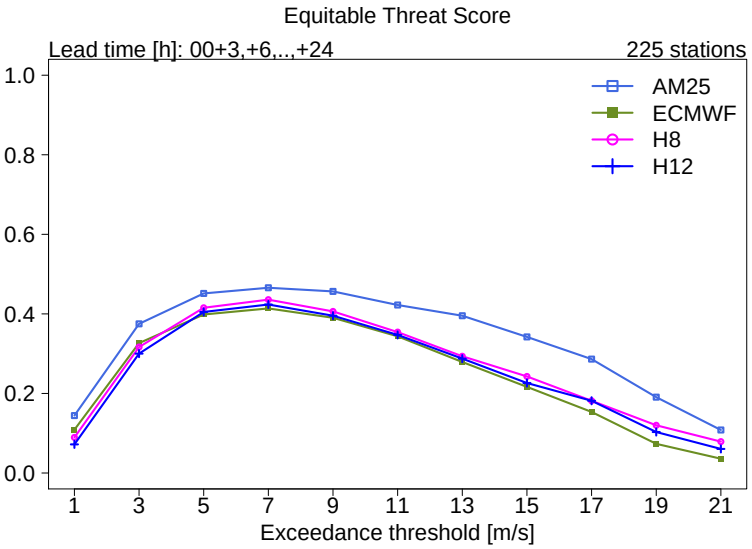


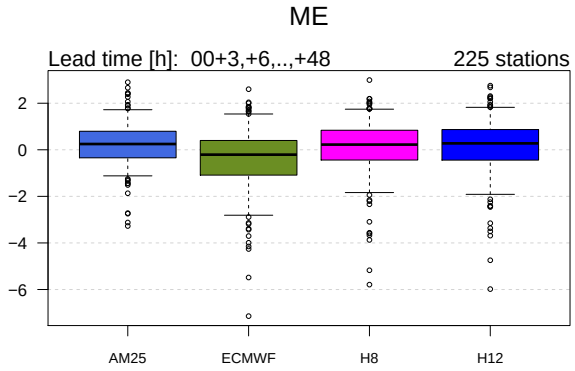


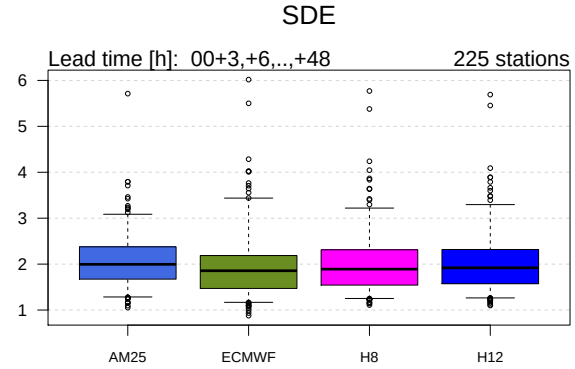



Hit Rate
Lead time [h]: 00+3,+6,..,+24
225 stations
AM25
ECMWF
H8
H12
1.0
0.8
0.6
0.4
0.2
0.0
1 3 5 7 9 11 13 15 17 19 21
Exceedance threshold [m/s]


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]	91207	26226	45	1	0	117479
(3,11]	41157	109523	6379	184	21	157264
(11,17]	295	6356	7553	1013	232	15449
(17,21]	12	133	527	450	227	1349
(21,Inf]	0	15	41	64	65	185
Sum	132671	142253	14545	1712	545	291726

H8 — **OBS**

	[0,3]	(3,11]	(11,17]	(17,21]	(21,Inf]	Sum
[0,3]	82042	26082	218	12	1	108355
(3,11]	50563	112612	8368	588	189	172320
(11,17]	65	3512	5647	806	192	10222
(17,21]	1	43	301	284	123	752
(21,Inf]	0	4	11	22	40	77
Sum	132671	142253	14545	1712	545	291726

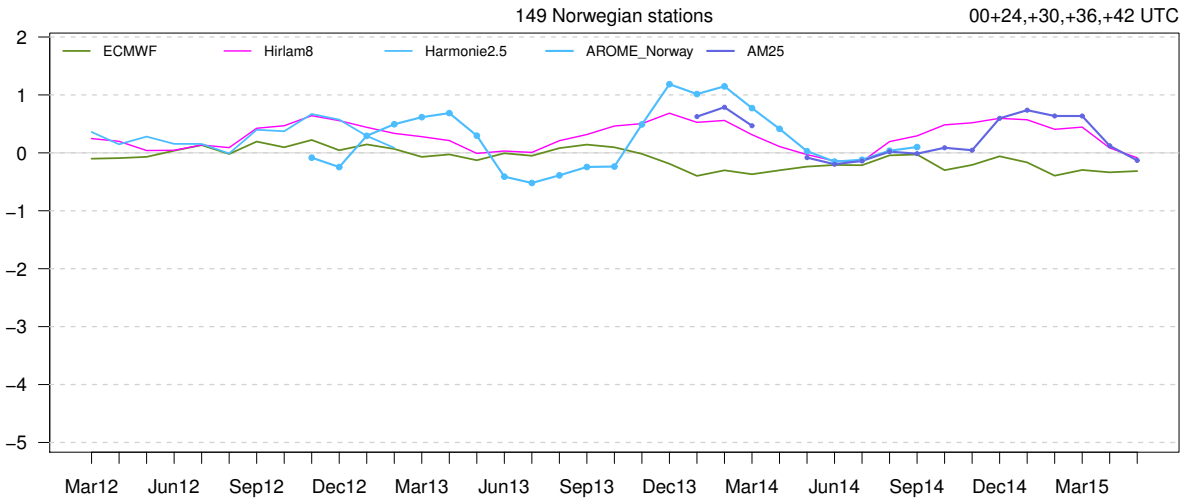
ECMWF — **OBS**

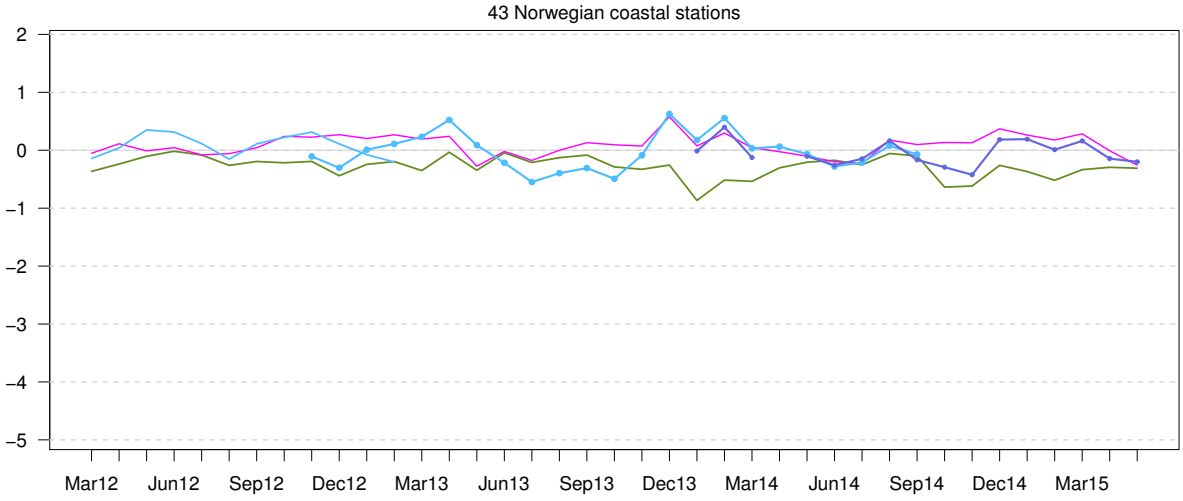
	[0,3]	(3,11]	(11,17]	(17,21]	(21,Inf]	Sum
[0,3]	98631	40611	768	123	43	140176
(3,11]	34007	98787	8272	550	148	141764
(11,17]	33	2800	5279	808	201	9121
(17,21]	0	51	214	218	134	617
(21,Inf]	0	4	12	13	19	48
Sum	132671	142253	14545	1712	545	291726

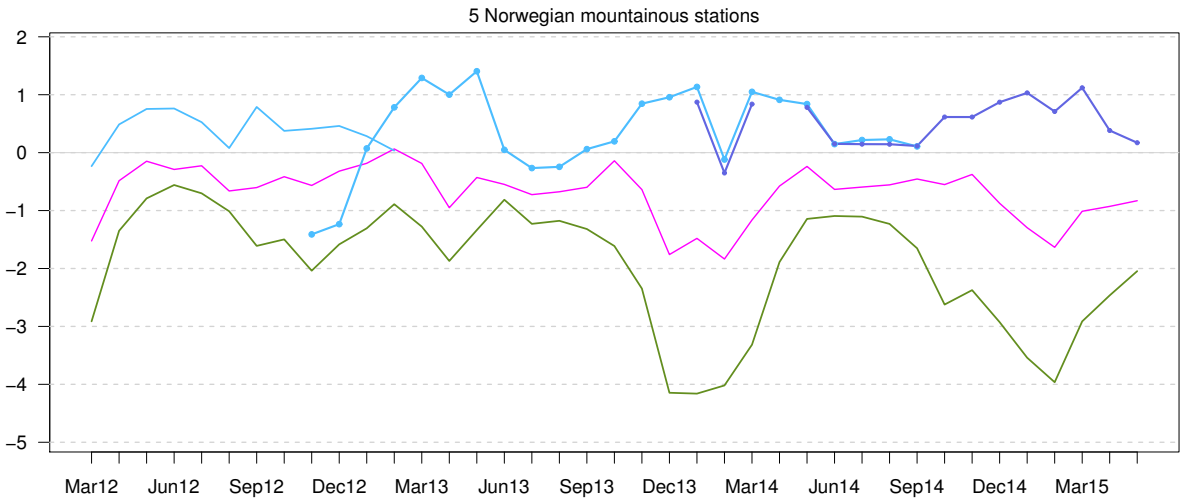
H12 — **OBS**

	[0,3]	(3,11]	(11,17]	(17,21]	(21,Inf]	Sum
[0,3]	79360	25474	176	6	0	105016
(3,11]	53266	113341	8676	630	171	176084
(11,17]	44	3393	5409	774	221	9841
(17,21]	1	41	271	276	119	708
(21,Inf]	0	4	13	26	34	77
Sum	132671	142253	14545	1712	545	291726

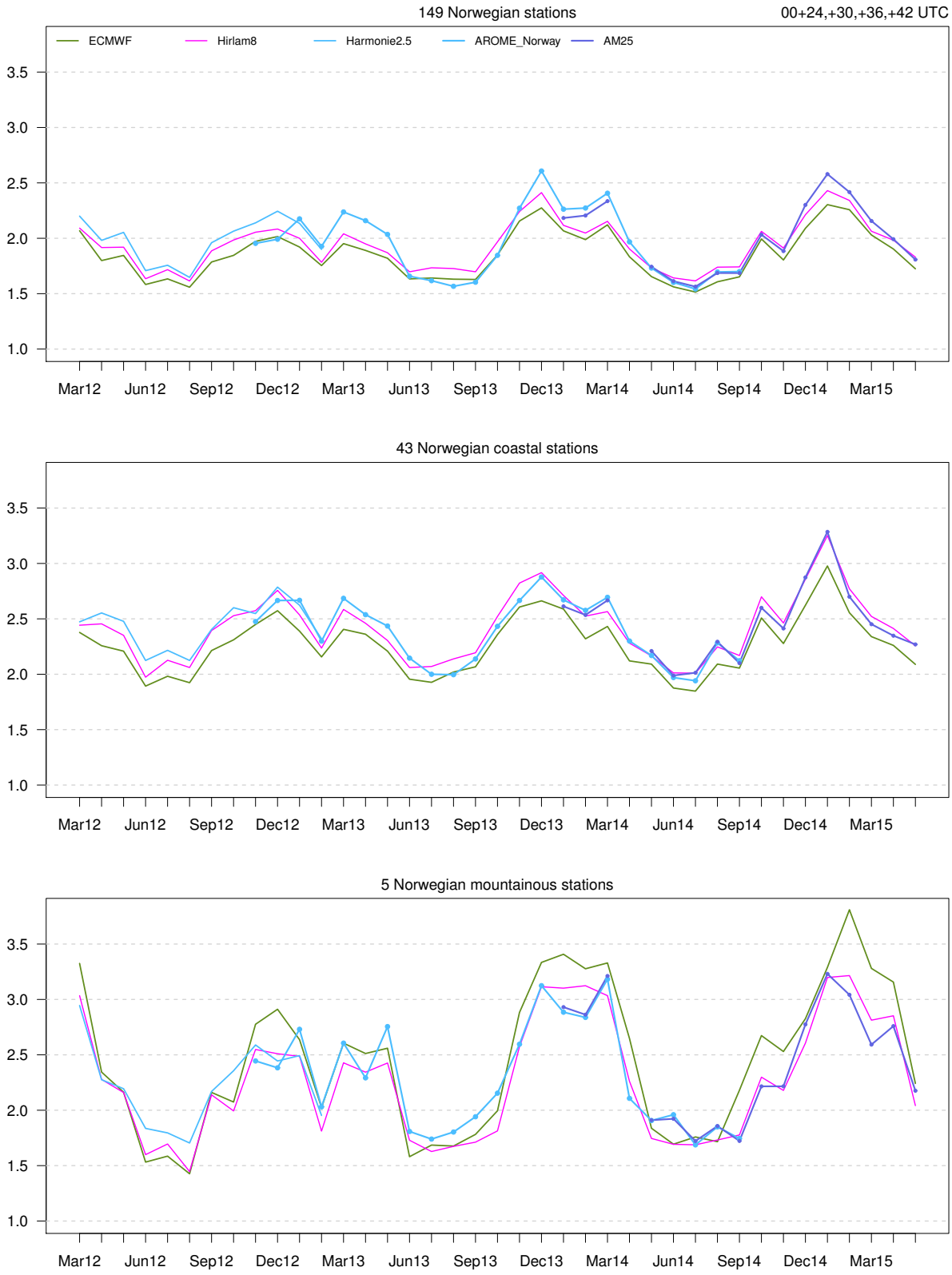
Mean Error


149 Norwegian stations
00+24,+30,+36,+42 UTC
ECMWF
Hirlam8
Harmonie2.5
AROME_Norway
AM25
2
1
0
−1
−2
−3
−4
−5
Mar12
Jun12
Sep12
Dec12
Mar13
Jun13
Sep13
Dec13
Mar14
Jun14
Sep14
Dec14
Mar15


43 Norwegian coastal stations
2
1
0
−1
−2
−3
−4
−5
Mar12
Jun12
Sep12
Dec12
Mar13
Jun13
Sep13
Dec13
Mar14
Jun14
Sep14
Dec14
Mar15

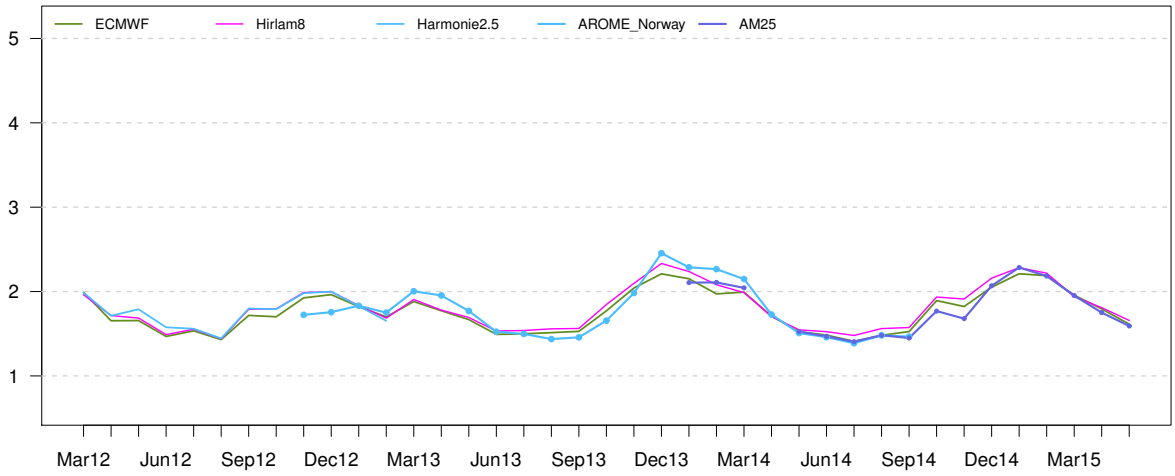

5 Norwegian mountainous stations
2
1
0
−1
−2
−3
−4
−5
Mar12
Jun12
Sep12
Dec12
Mar13
Jun13
Sep13
Dec13
Mar14
Jun14
Sep14
Dec14
Mar15

Standard Deviation of Error

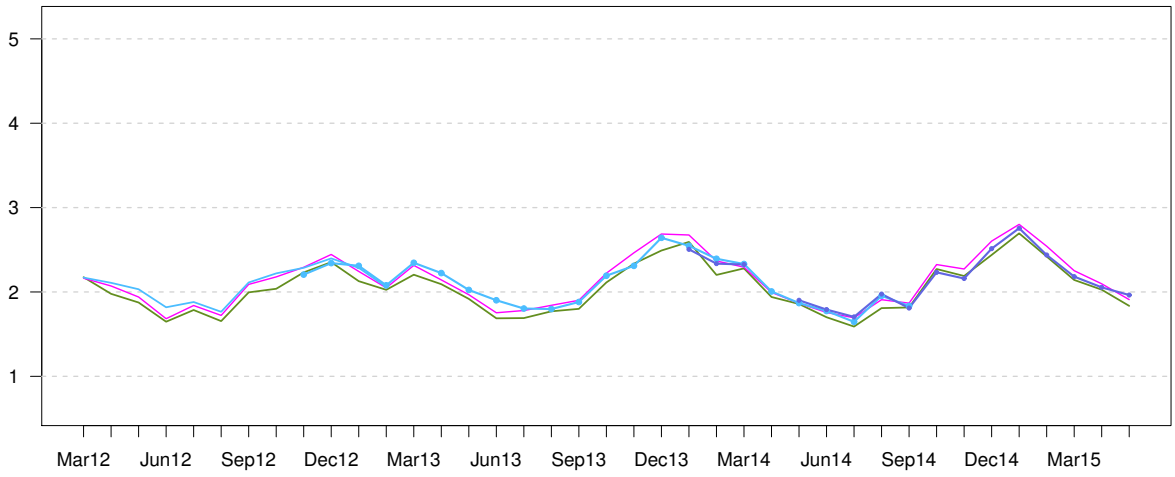


Mean Absolute Error

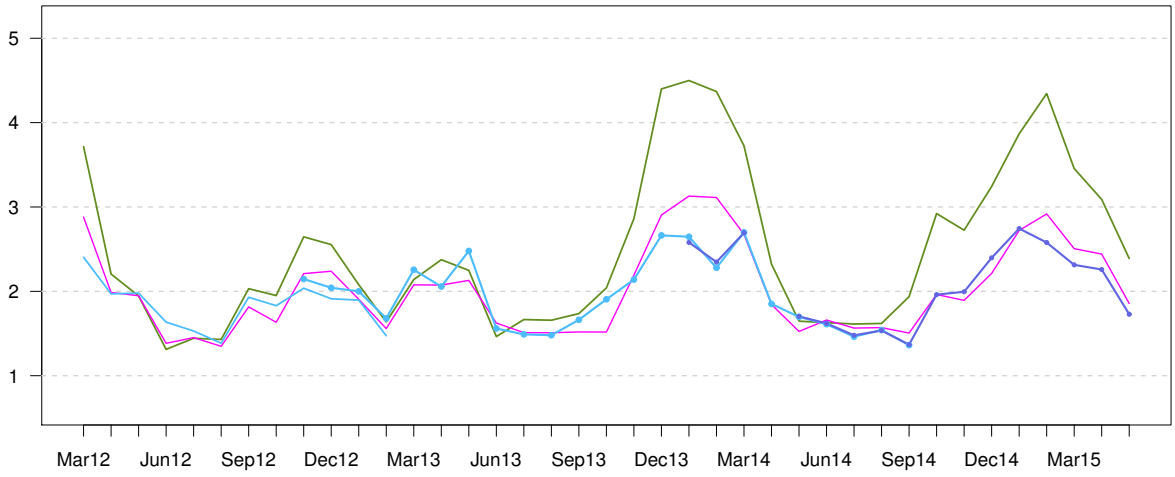
149 Norwegian stations 00+24,+30,+36,+42 UTC



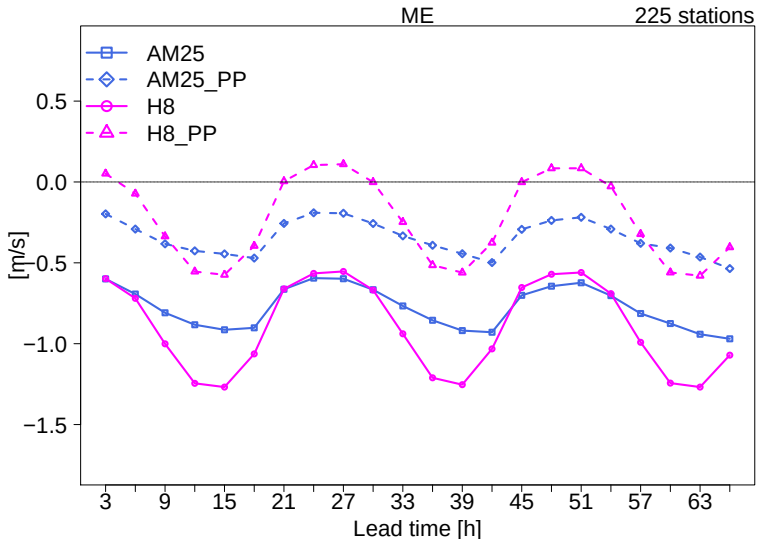
43 Norwegian coastal stations

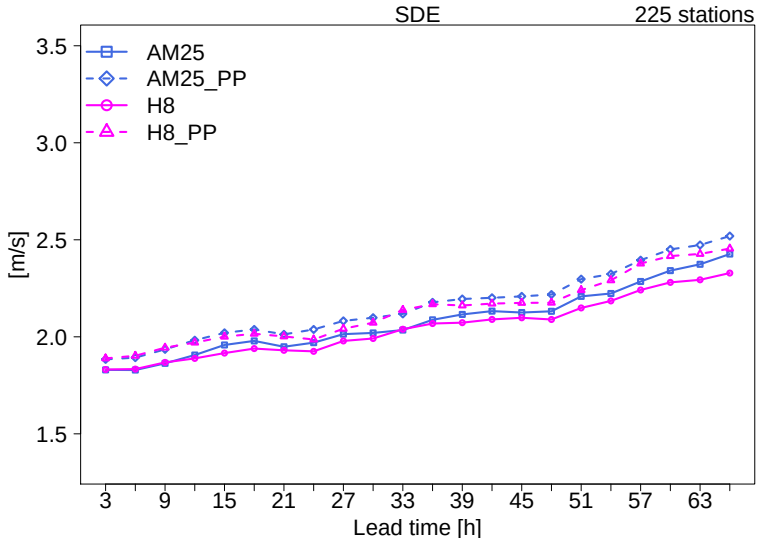


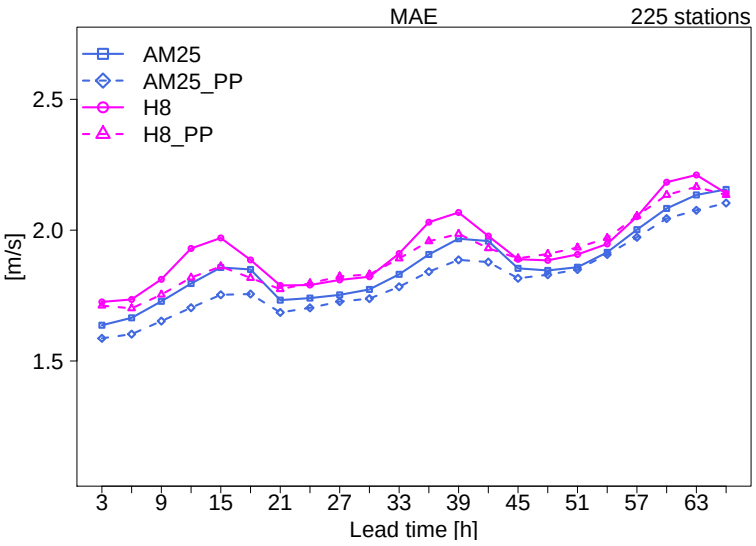
5 Norwegian mountainous stations

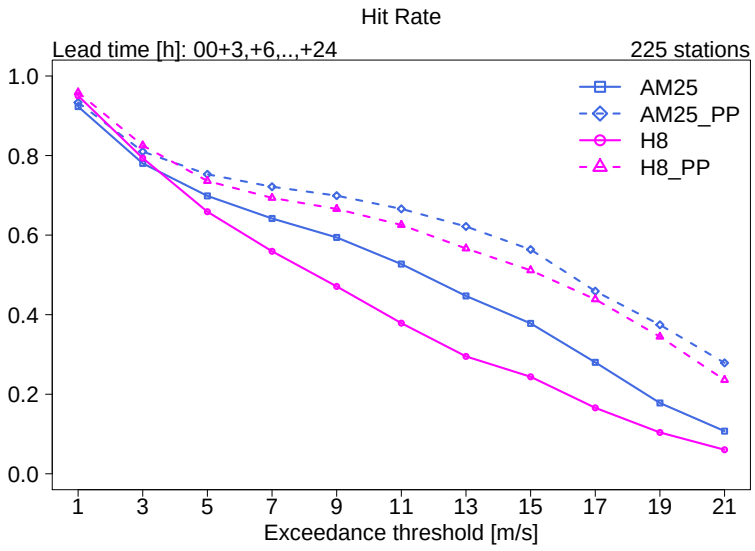


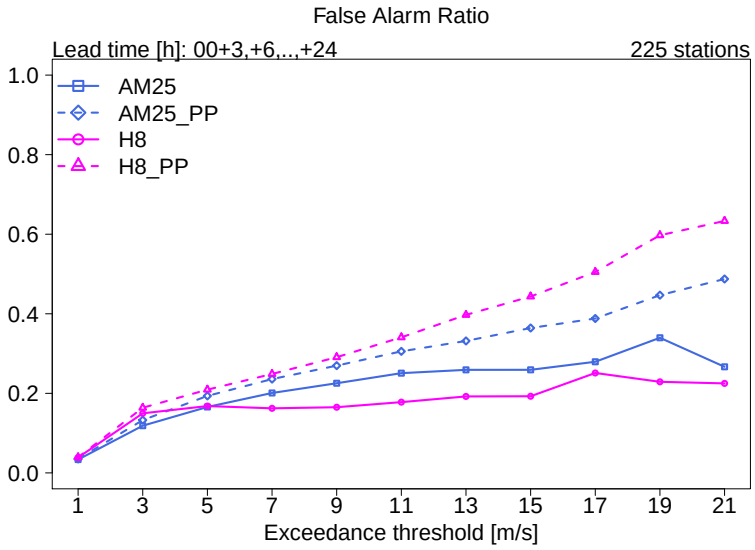
5.4 Max Mean Wind Speed 10m

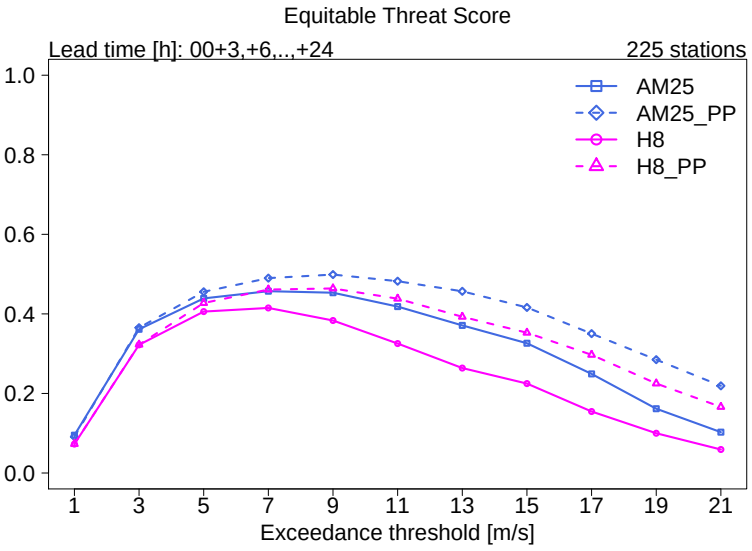


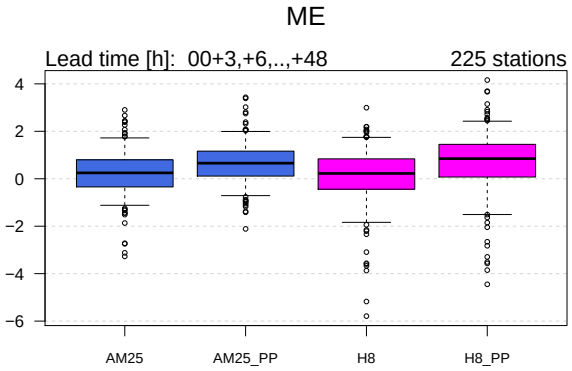


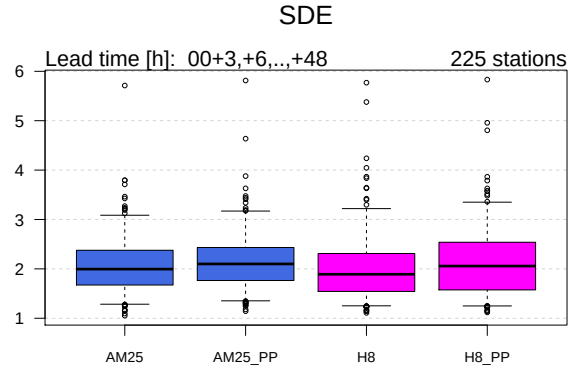



Hit Rate
Lead time [h]: 00+3,+6,..,+24
225 stations
AM25
AM25_PP
H8
H8_PP
1.0
0.8
0.6
0.4
0.2
0.0
1
3
5
7
9
11
13
15
17
19
21
Exceedance threshold [m/s]


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]





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]	69705	41985	134	1	0	111825
(3,11]	20614	116540	10954	386	46	148540
(11,17]	85	4168	8362	1786	495	14896
(17,21]	0	74	361	500	374	1309
(21,Inf]	0	4	24	46	107	181
Sum	90404	162771	19835	2719	1022	276751

AM25_PP

OBS

	[0,3]	(3,11]	(11,17]	(17,21]	(21,Inf]	Sum
[0,3]	66063	36337	92	1	0	102493
(3,11]	24193	119404	7958	213	19	151787
(11,17]	148	6854	10756	1488	334	19580
(17,21]	0	160	930	813	387	2290
(21,Inf]	0	16	99	204	282	601
Sum	90404	162771	19835	2719	1022	276751

H8

OBS

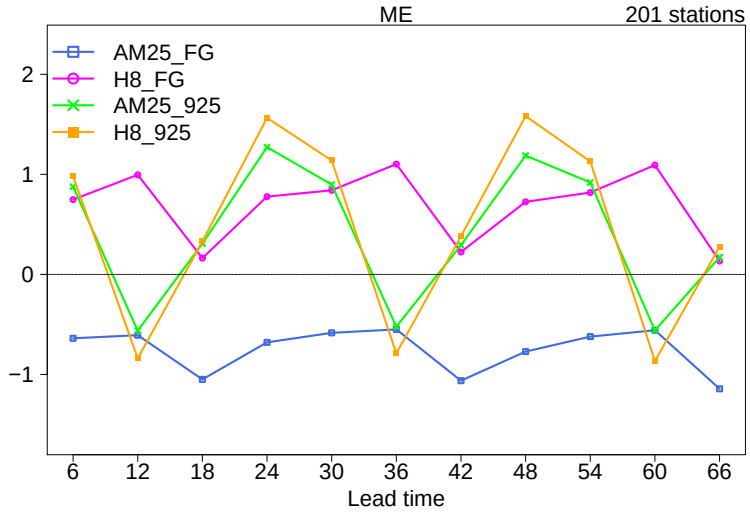
	[0,3]	(3,11]	(11,17]	(17,21]	(21,Inf]	Sum
[0,3]	62753	38748	366	24	3	101894
(3,11]	27631	121913	13206	841	338	163929
(11,17]	20	2088	6069	1515	406	10098
(17,21]	0	21	187	322	221	751
(21,Inf]	0	1	7	17	54	79
Sum	90404	162771	19835	2719	1022	276751

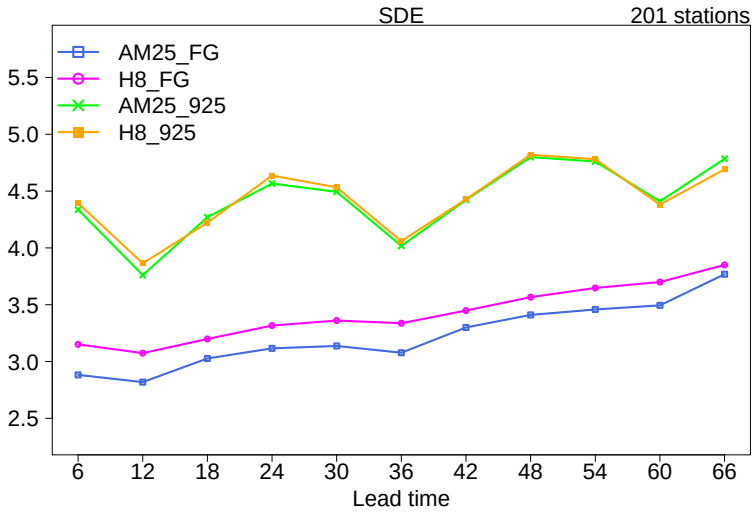
H8_PP

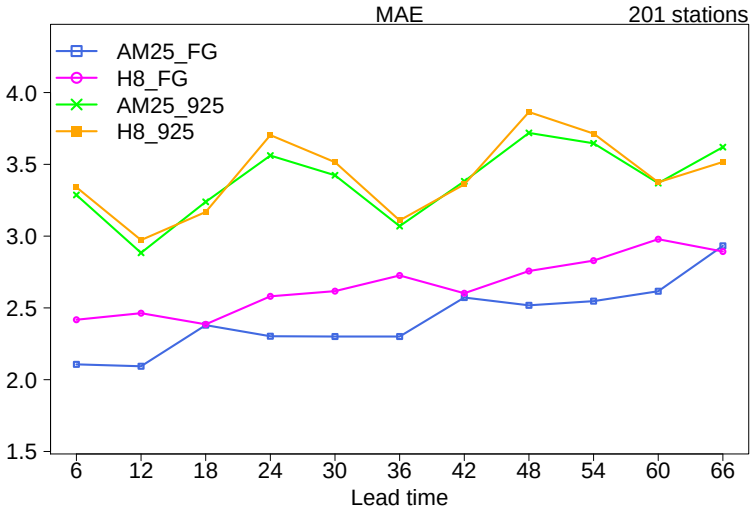
OBS

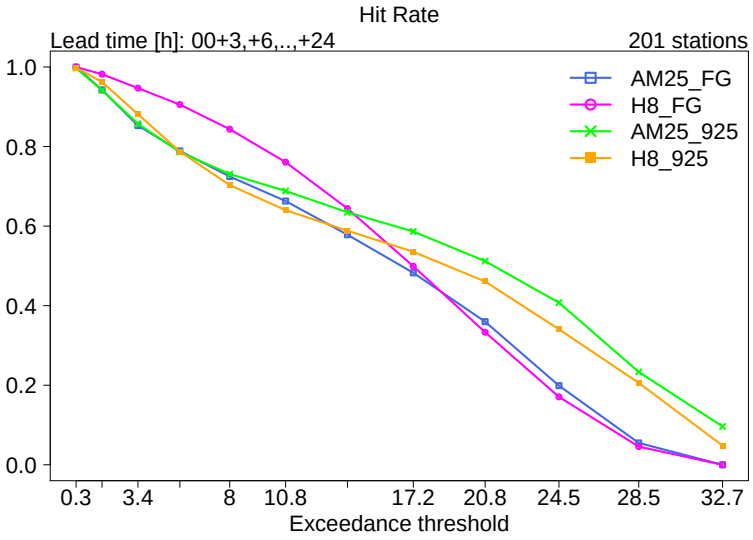
	[0,3]	(3,11]	(11,17]	(17,21]	(21,Inf]	Sum
[0,3]	58738	32957	222	7	0	91924
(3,11]	31556	121812	8242	479	185	162274
(11,17]	109	7790	9837	1109	313	19158
(17,21]	1	195	1392	849	283	2720
(21,Inf]	0	17	142	275	241	675
Sum	90404	162771	19835	2719	1022	276751

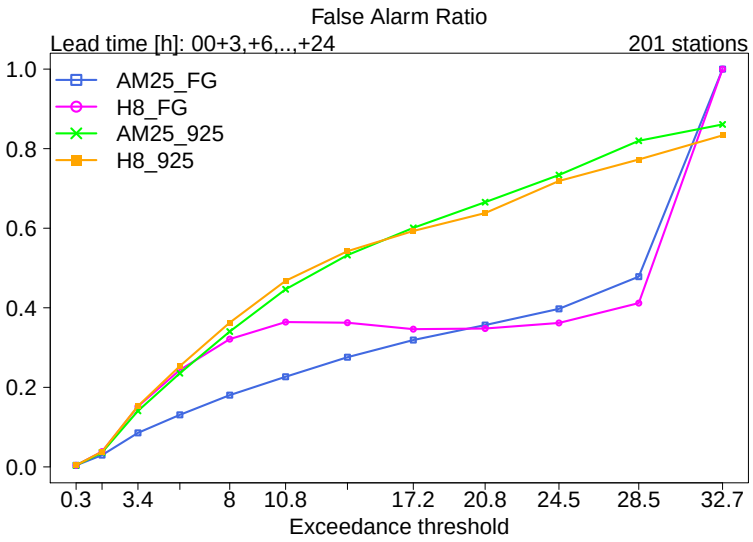
5.5 Wind gust

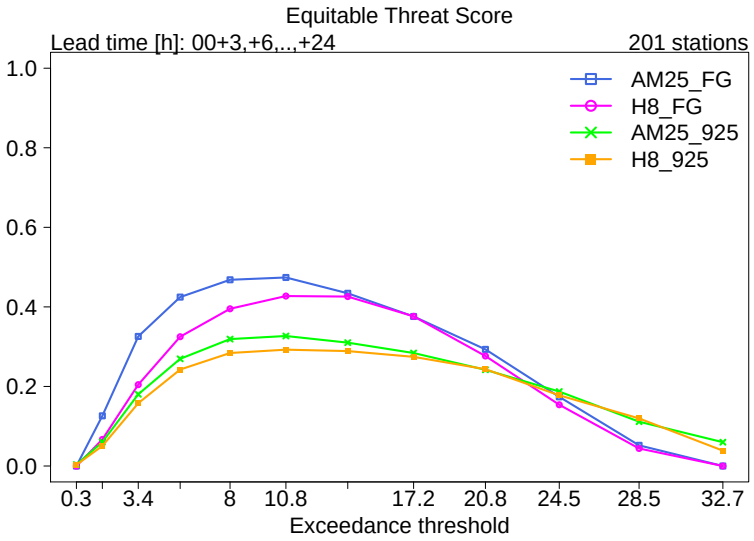

ME
201 stations
AM25_FG
H8_FG
AM25_925
H8_925
2
1
0
−1
6
12
18
24
30
36
42
48
54
60
66
Lead time


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

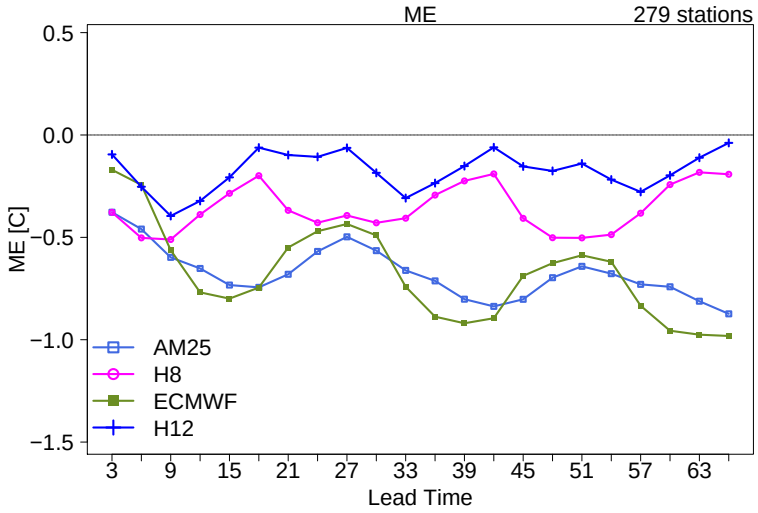

MAE
201 stations
AM25_FG
H8_FG
AM25_925
H8_925
4.0
3.5
3.0
2.5
2.0
1.5
6
12
18
24
30
36
42
48
54
60
66
Lead time

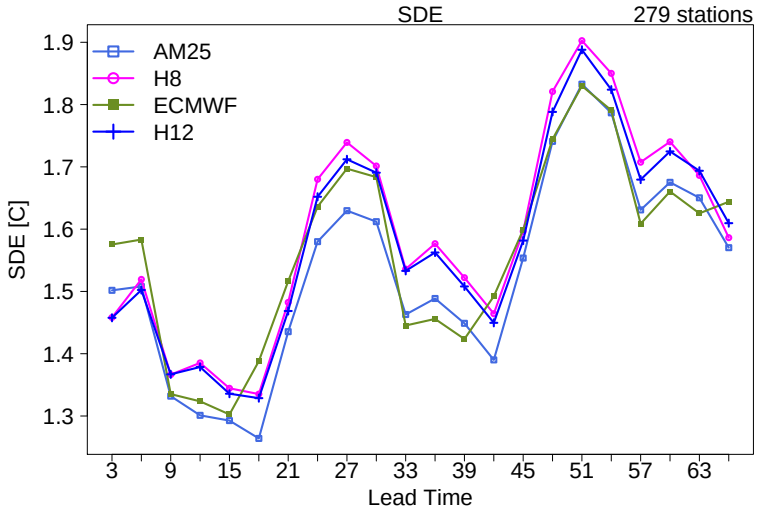

Hit Rate
Lead time [h]: 00+3,+6,..,+24
201 stations
AM25_FG
H8_FG
AM25_925
H8_925
1.0
0.8
0.6
0.4
0.2
0.0
0.3
3.4
8
10.8
17.2
20.8
24.5
28.5
32.7
Exceedance threshold

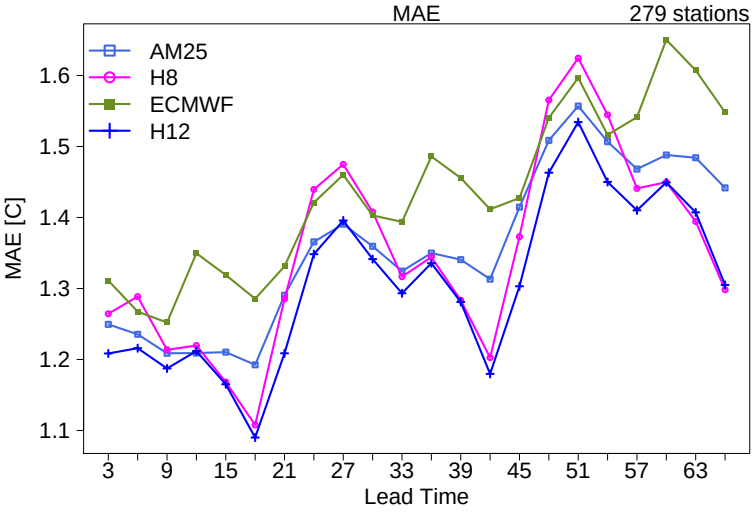

False Alarm Ratio
Lead time [h]: 00+3,+6,..,+24
201 stations
AM25_FG
H8_FG
AM25_925
H8_925
1.0
0.8
0.6
0.4
0.2
0.0
0.3
3.4
8
10.8
17.2
20.8
24.5
28.5
32.7
Exceedance threshold

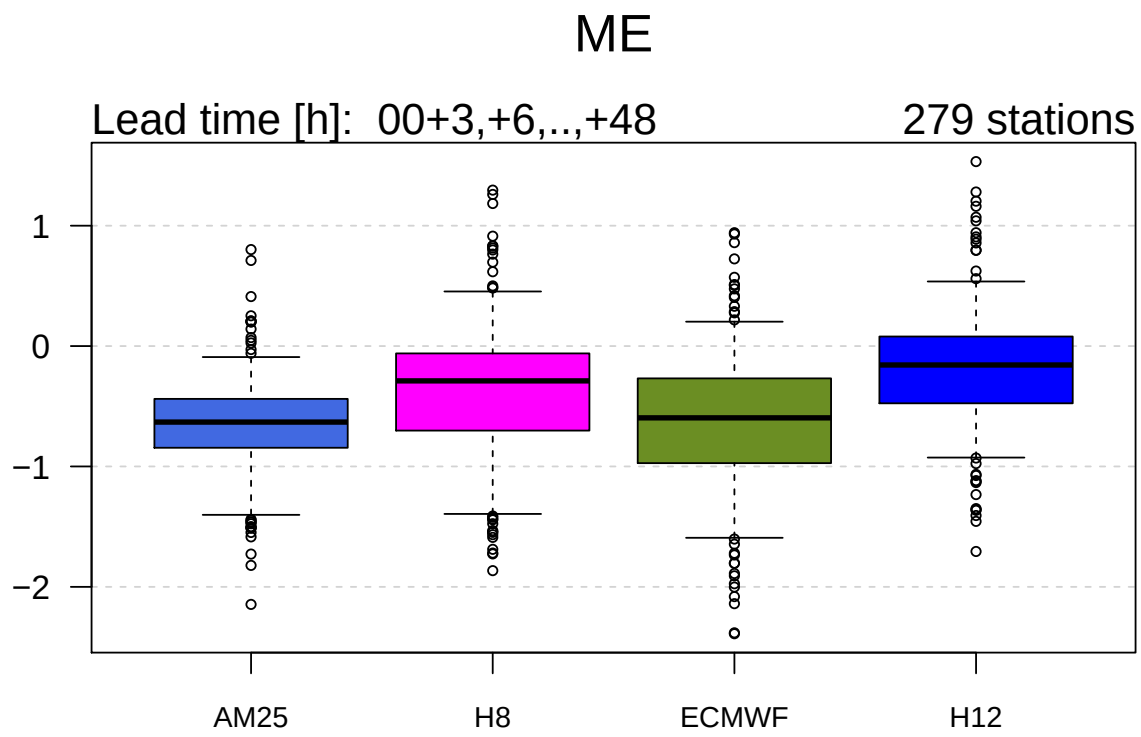

Equitable Threat Score
Lead time [h]: 00+3,+6,..,+24
201 stations
AM25_FG
H8_FG
AM25_925
H8_925
1.0
0.8
0.6
0.4
0.2
0.0
0.3
3.4
8
10.8
17.2
20.8
24.5
28.5
32.7
Exceedance threshold

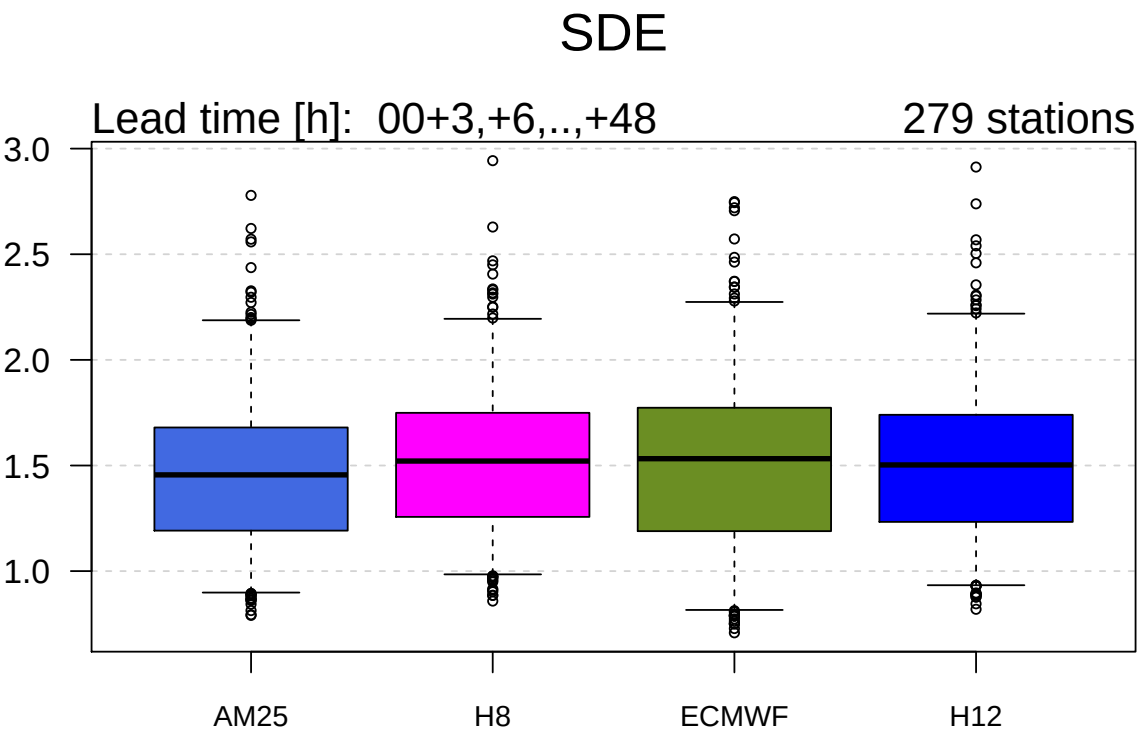
5.6 Temperature 2m







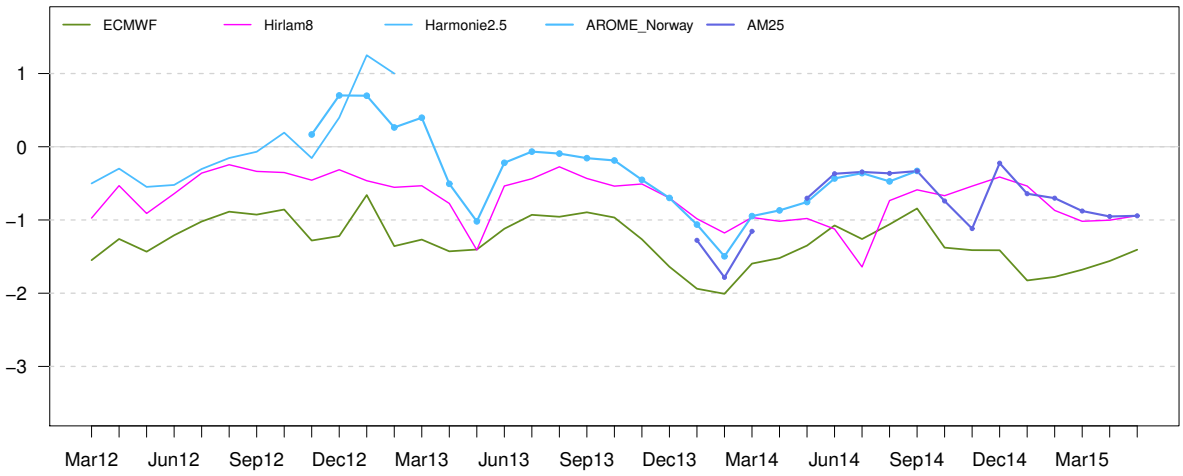

ME
Lead time [h]: 00+3,+6,..,+48
279 stations
1
0
−1
−2
AM25
H8
ECMWF
H12


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

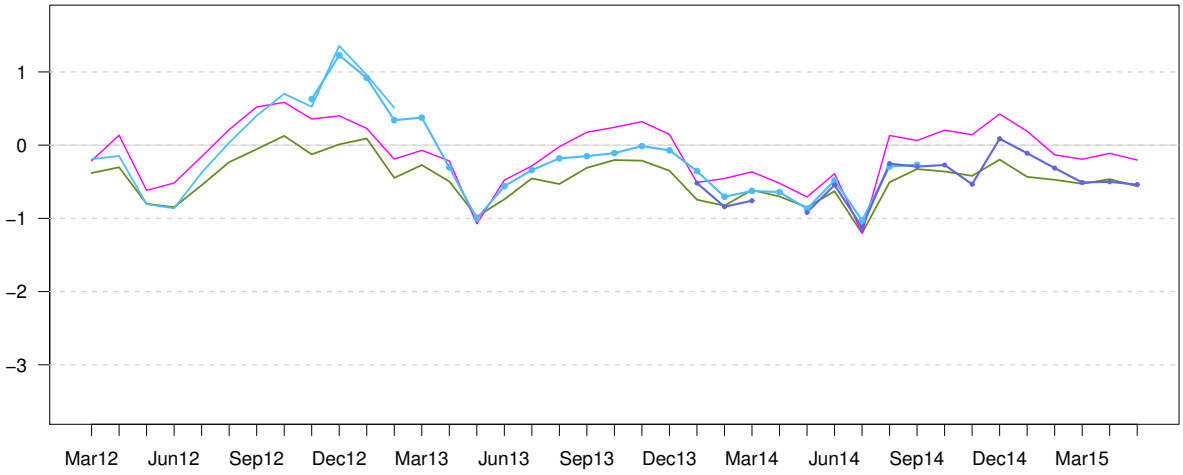
Mean Error

153 Norwegian stations

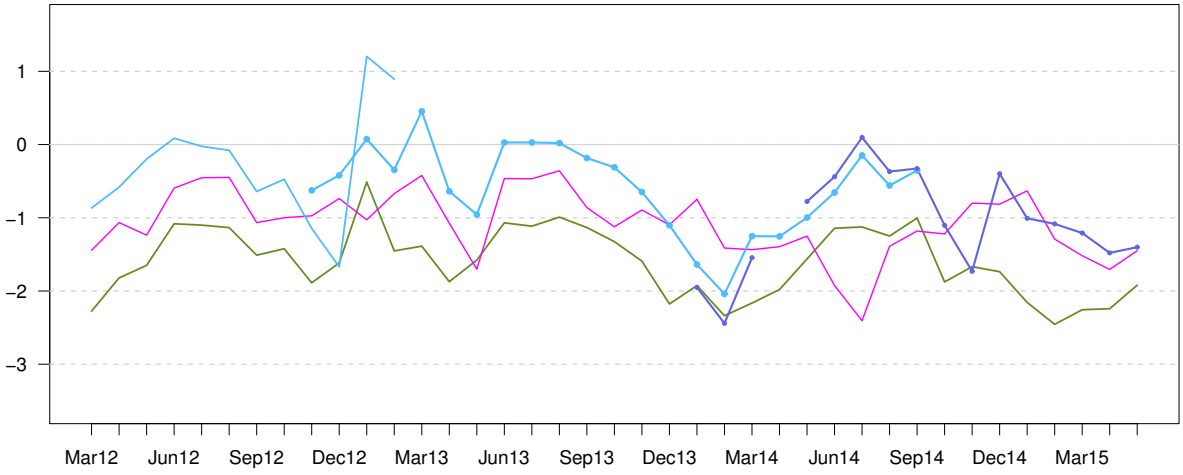
00+24,+30,+36,+42 UTC



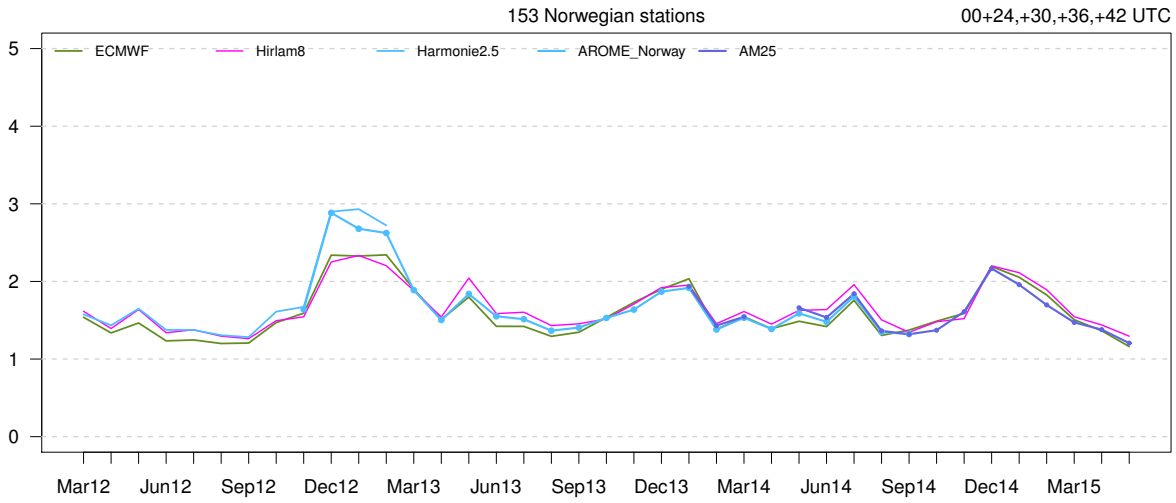
43 Norwegian coastal stations

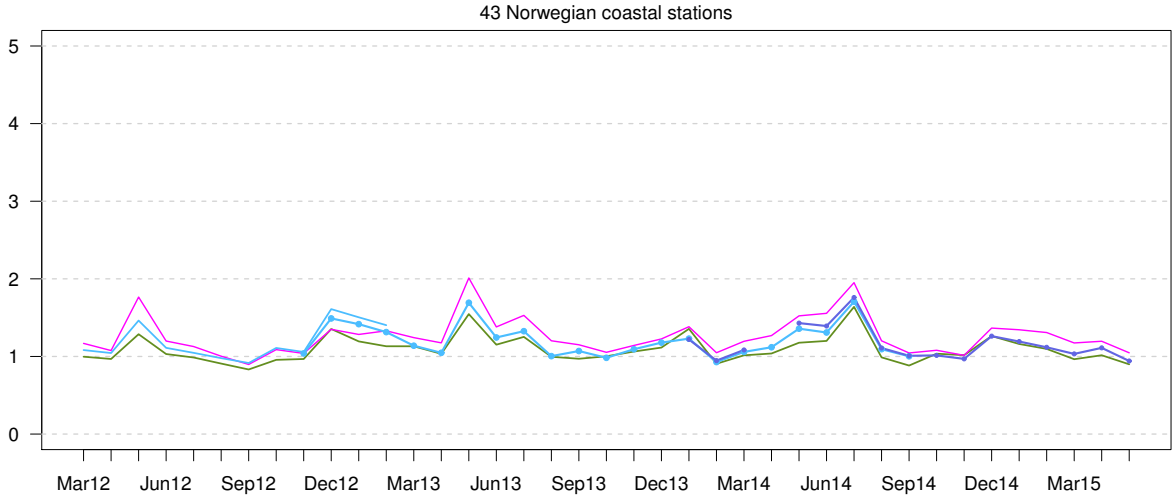


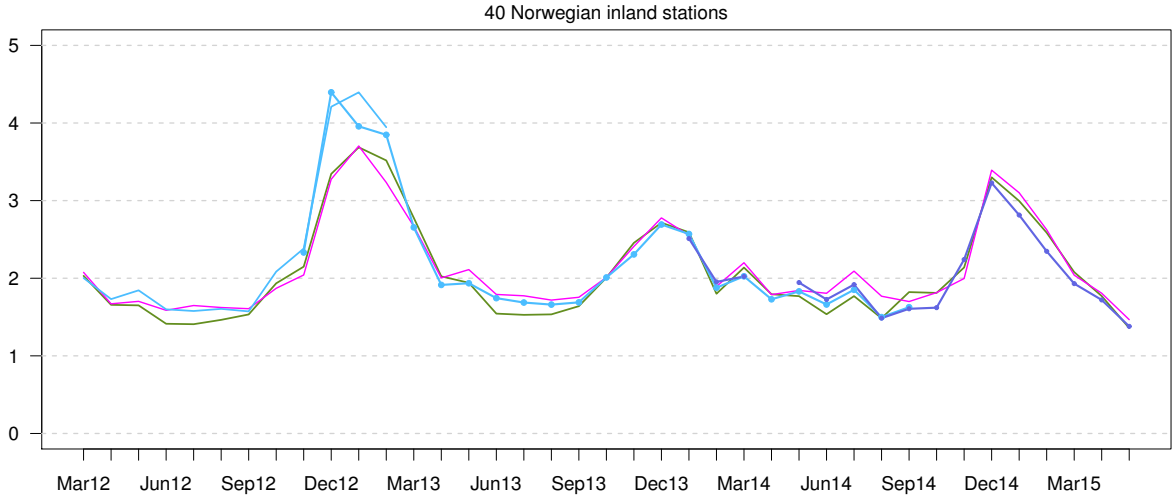
40 Norwegian inland stations



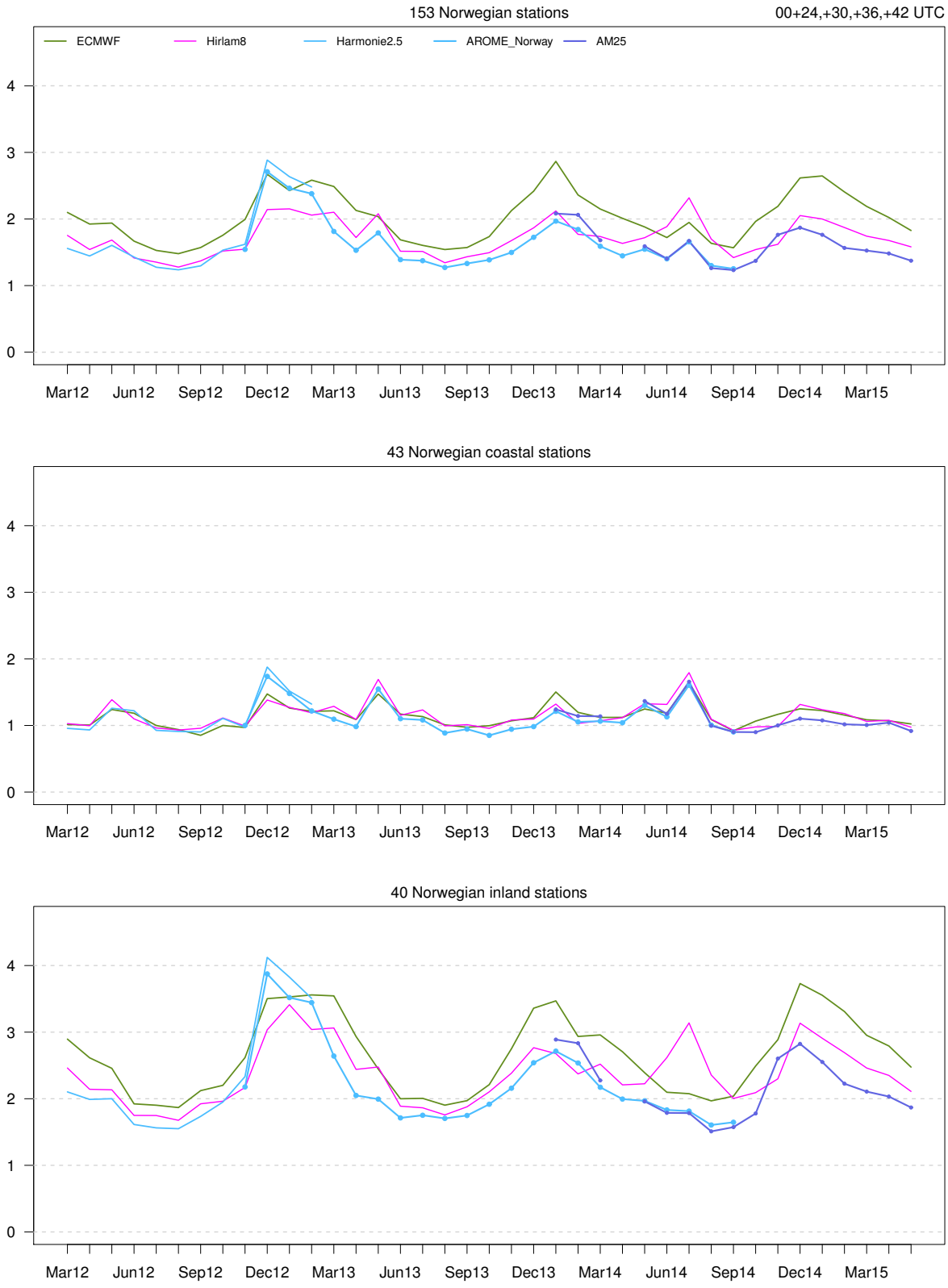
Standard Deviation of Error



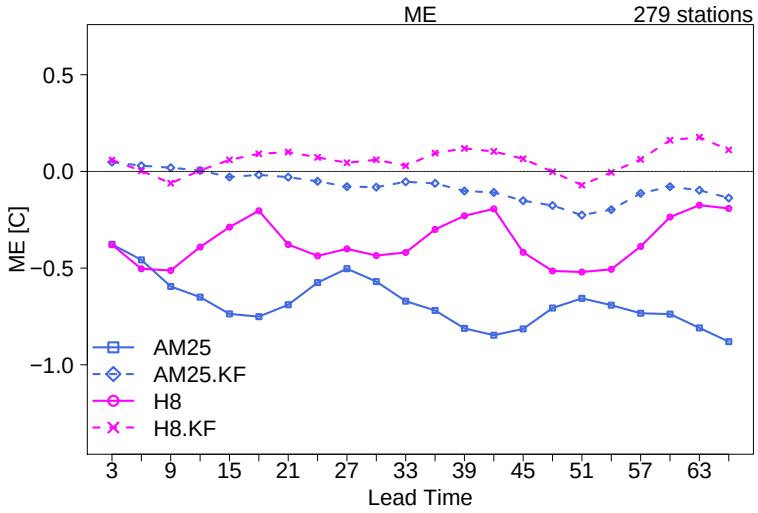


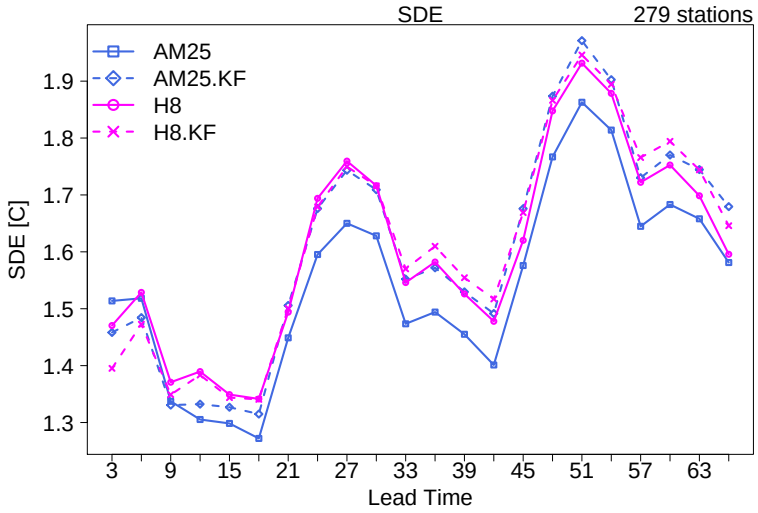


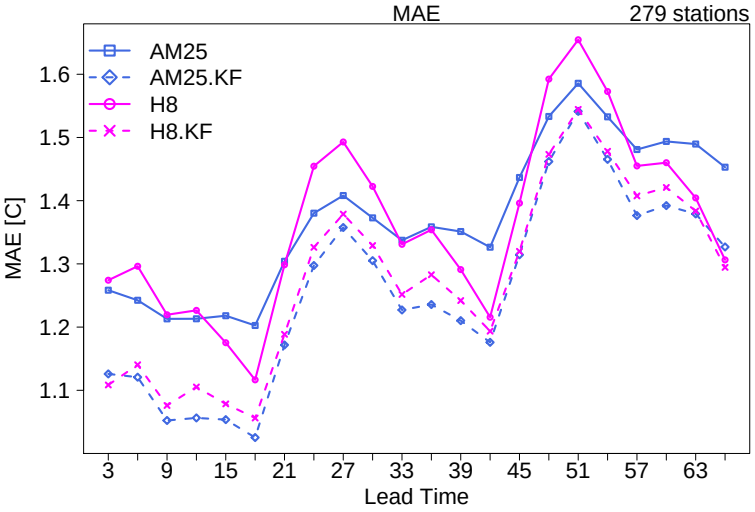
Mean Absolute Error

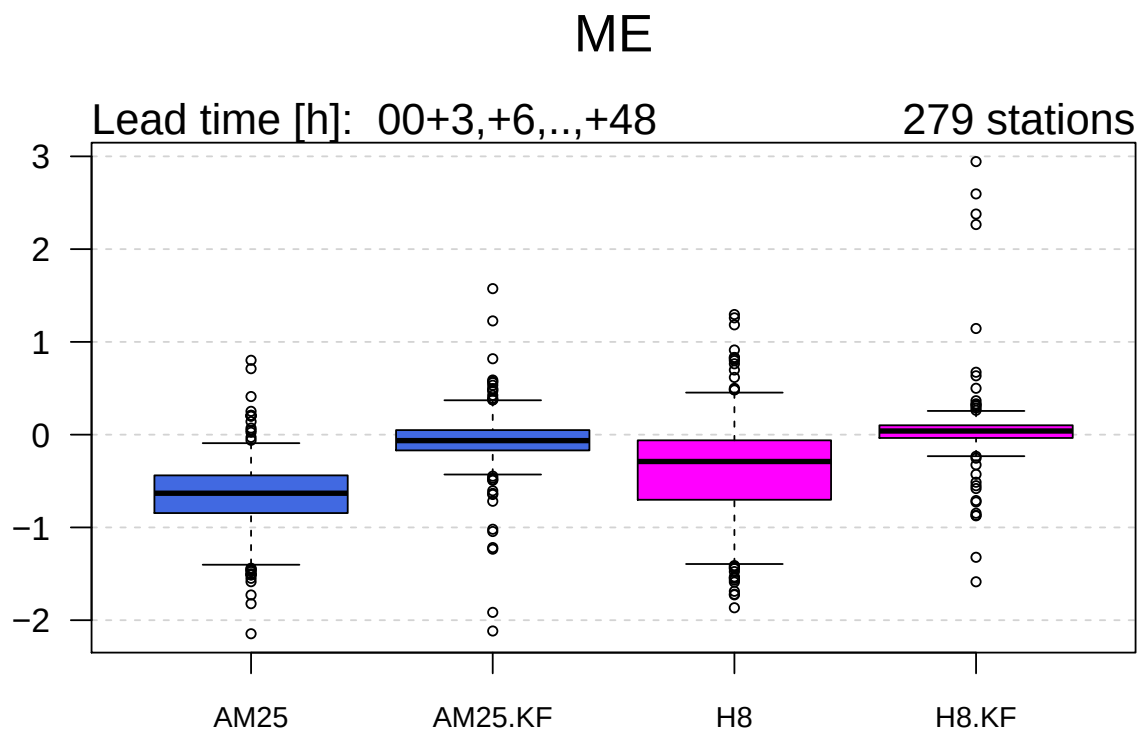


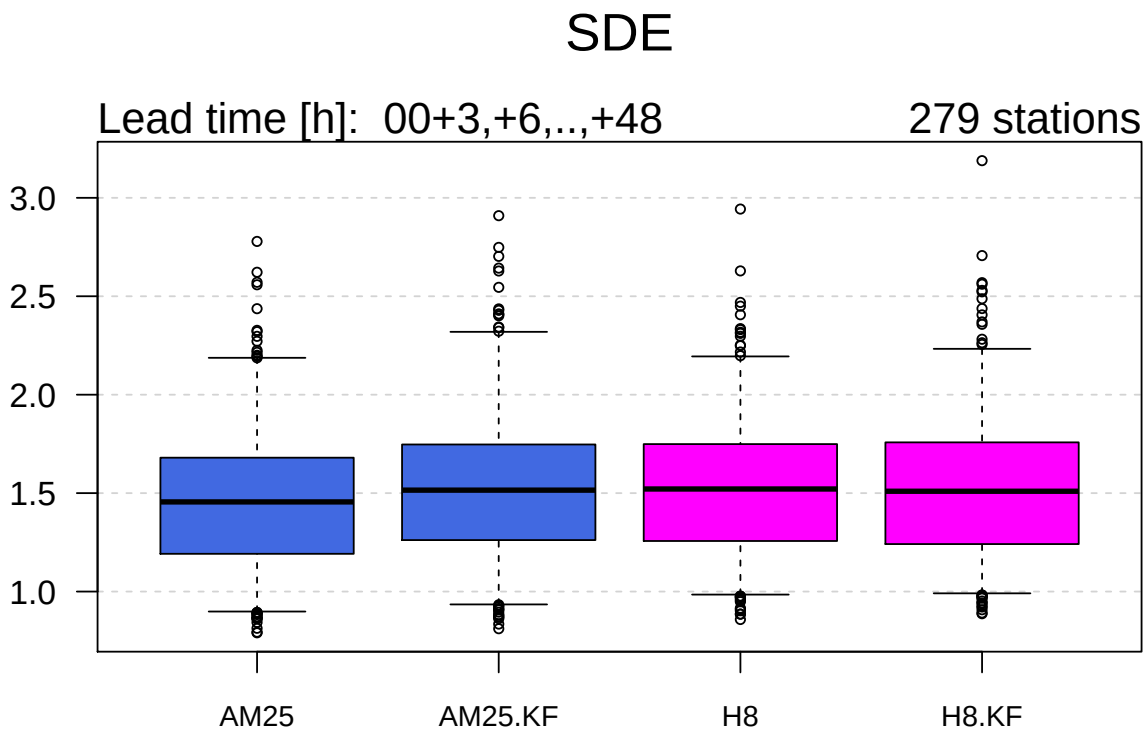
5.7 Post processed temperature 2m



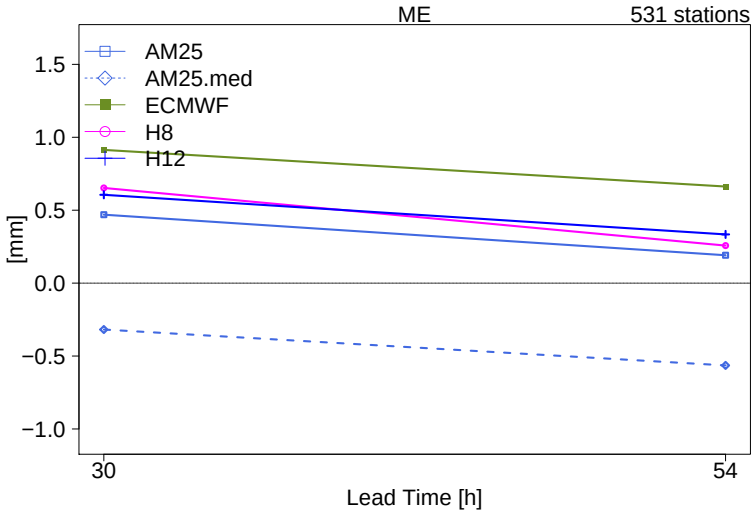


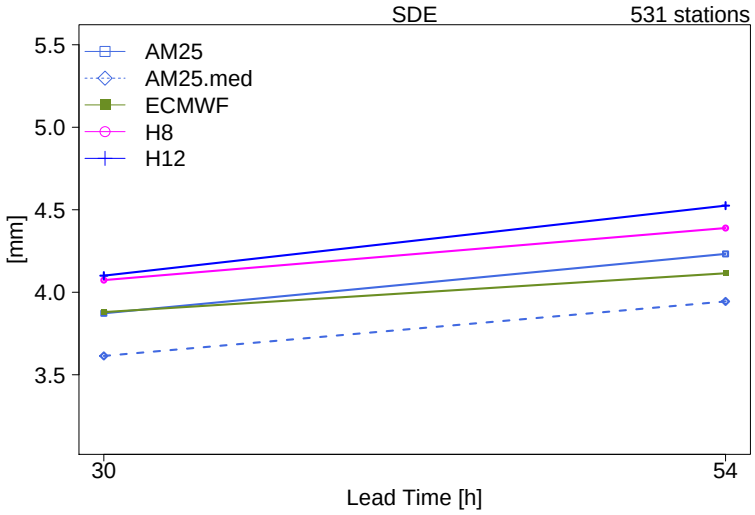


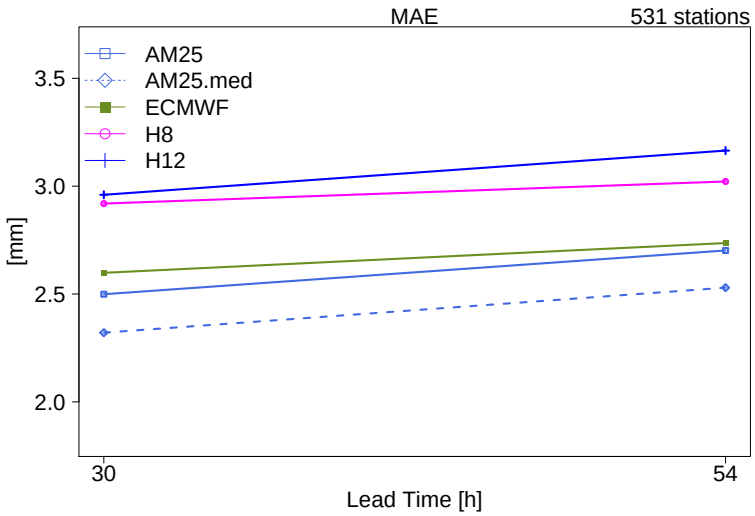

ME
Lead time [h]: 00+3,+6,..,+48
279 stations
3
2
1
0
−1
−2
AM25
AM25.KF
H8
H8.KF

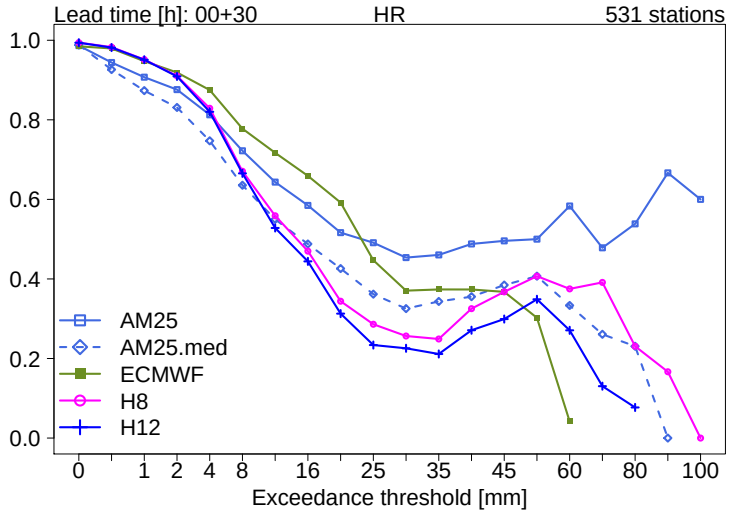

SDE
Lead time [h]: 00+3,+6,..,+48
279 stations
3.0
2.5
2.0
1.5
1.0
AM25
AM25.KF
H8
H8.KF

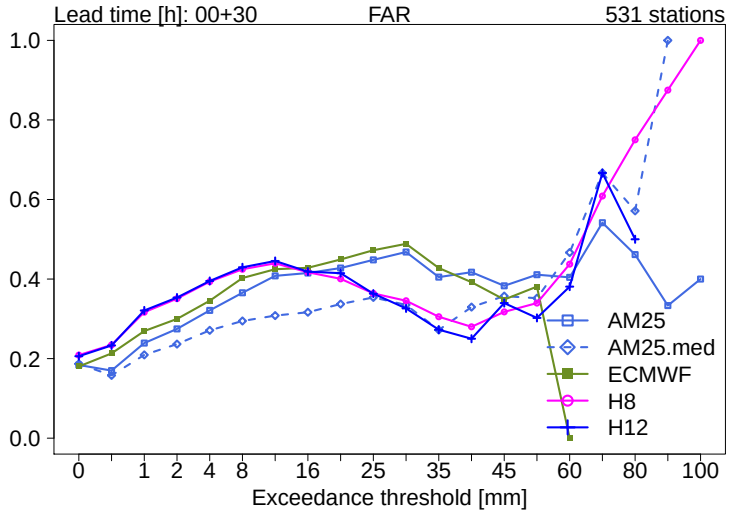
5.8 Daily precipitation

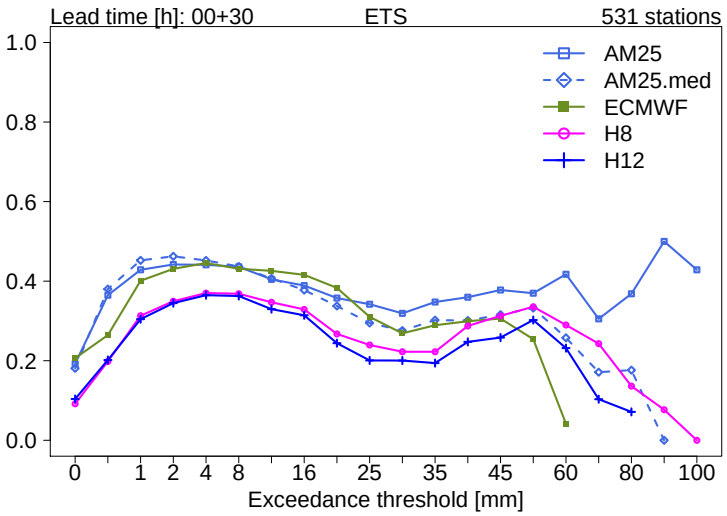


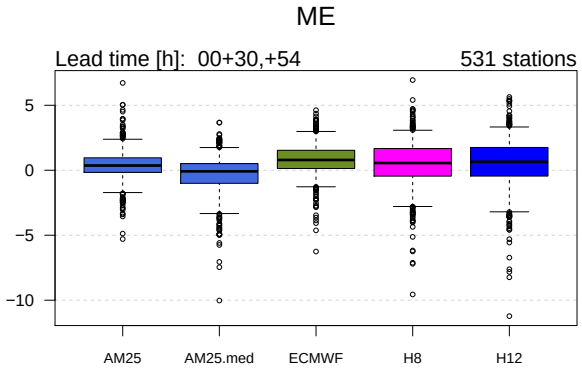


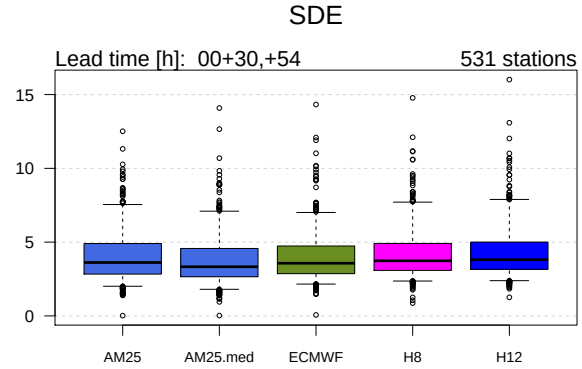



Lead time [h]: 00+30
HR
531 stations
1.0
0.8
0.6
0.4
0.2
0.0
AM25
AM25.med
ECMWF
H8
H12
0 1 2 4 8 16 25 35 45 60 80 100
Exceedance threshold [mm]


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]	10943	2948	76	4	0	13971
(0.1,5]	8160	20809	4116	81	2	33168
(5,20]	665	6121	10016	1158	9	17969
(20,50]	35	124	729	940	75	1903
(50,Inf]	2	2	8	47	84	143
Sum	19805	30004	14945	2230	170	67154

AM25.med

	OBS					
	[0,0.1]	(0.1,5]	(5,20]	(20,50]	(50,Inf]	Sum
[0,0.1]	11777	3698	120	4	0	15599
(0.1,5]	7629	21880	5276	133	2	34920
(5,20]	369	4365	9134	1323	23	15214
(20,50]	28	61	411	740	74	1314
(50,Inf]	2	0	4	30	71	107
Sum	19805	30004	14945	2230	170	67154

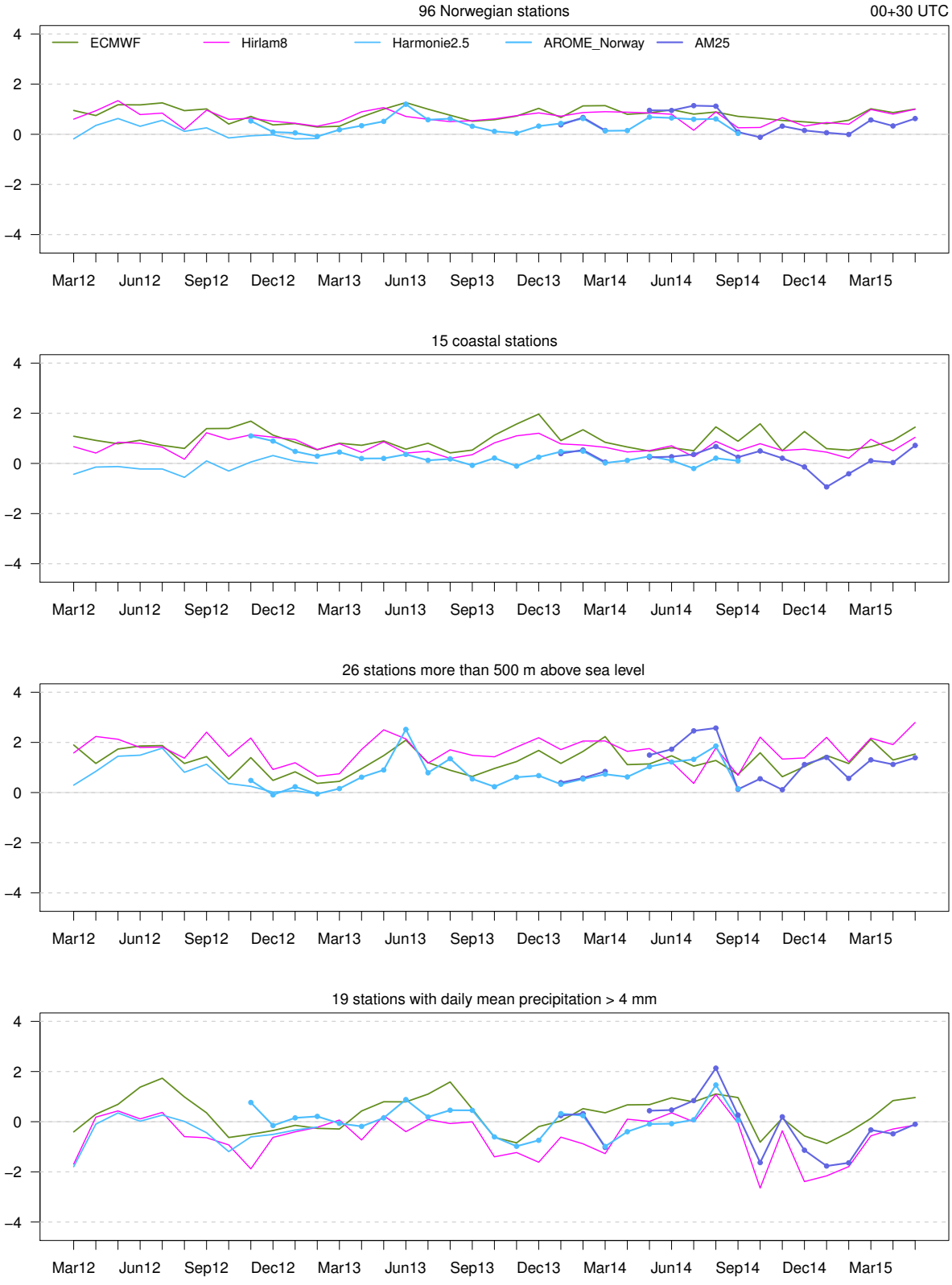
ECMWF

	OBS					
	[0,0.1]	(0.1,5]	(5,20]	(20,50]	(50,Inf]	Sum
[0,0.1]	7705	1204	17	2	0	8928
(0.1,5]	11457	21158	3102	53	2	35772
(5,20]	606	7562	10817	1027	11	20023
(20,50]	35	79	1007	1123	97	2341
(50,Inf]	2	1	2	25	60	90
Sum	19805	30004	14945	2230	170	67154

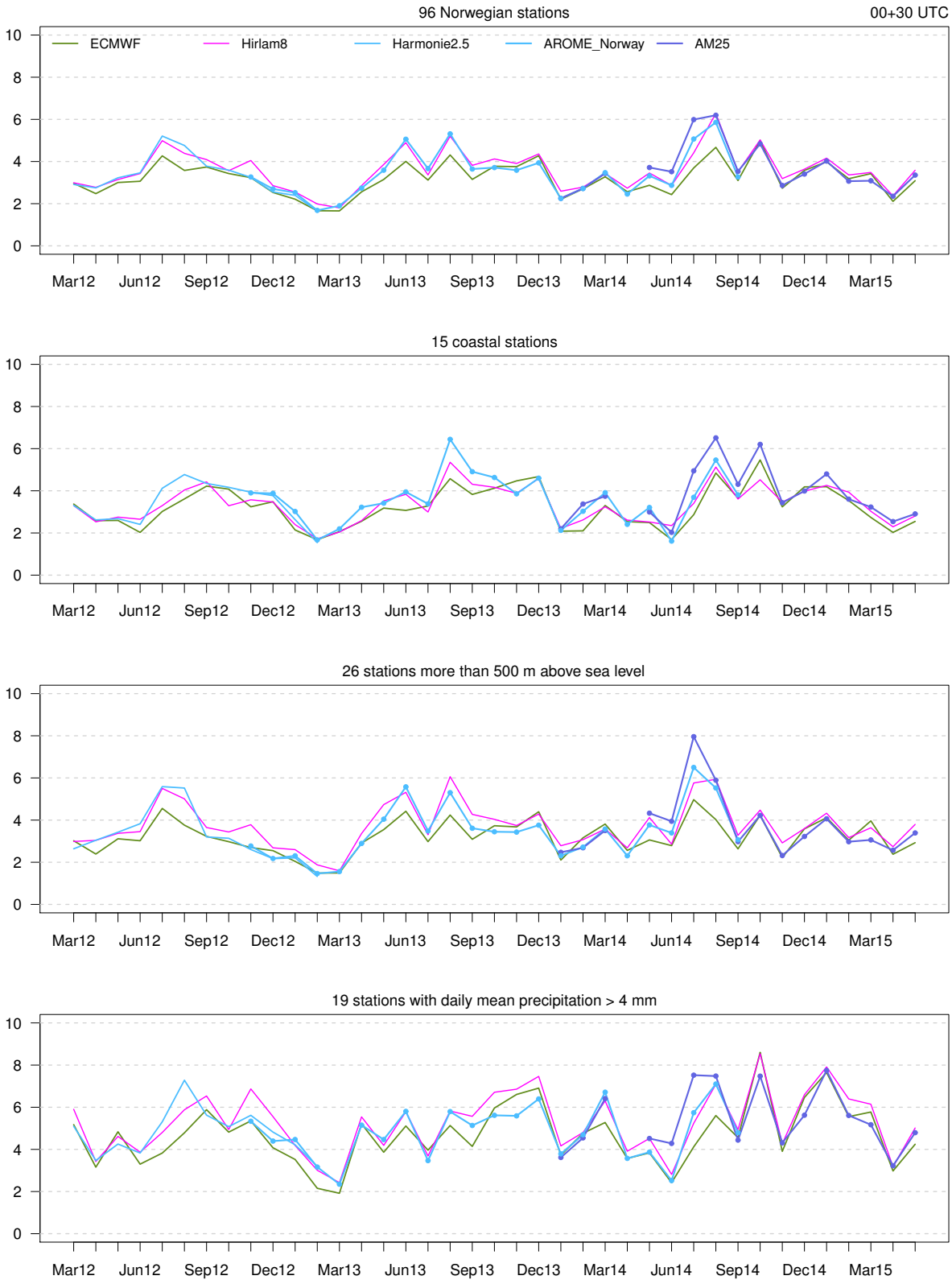
H8

	OBS					
	[0,0.1]	(0.1,5]	(5,20]	(20,50]	(50,Inf]	Sum
[0,0.1]	5865	994	20	2	0	6881
(0.1,5]	12979	20989	4280	98	2	38348
(5,20]	937	7953	10281	1517	18	20706
(20,50]	23	66	361	587	79	1116
(50,Inf]	1	2	3	26	71	103
Sum	19805	30004	14945	2230	170	67154

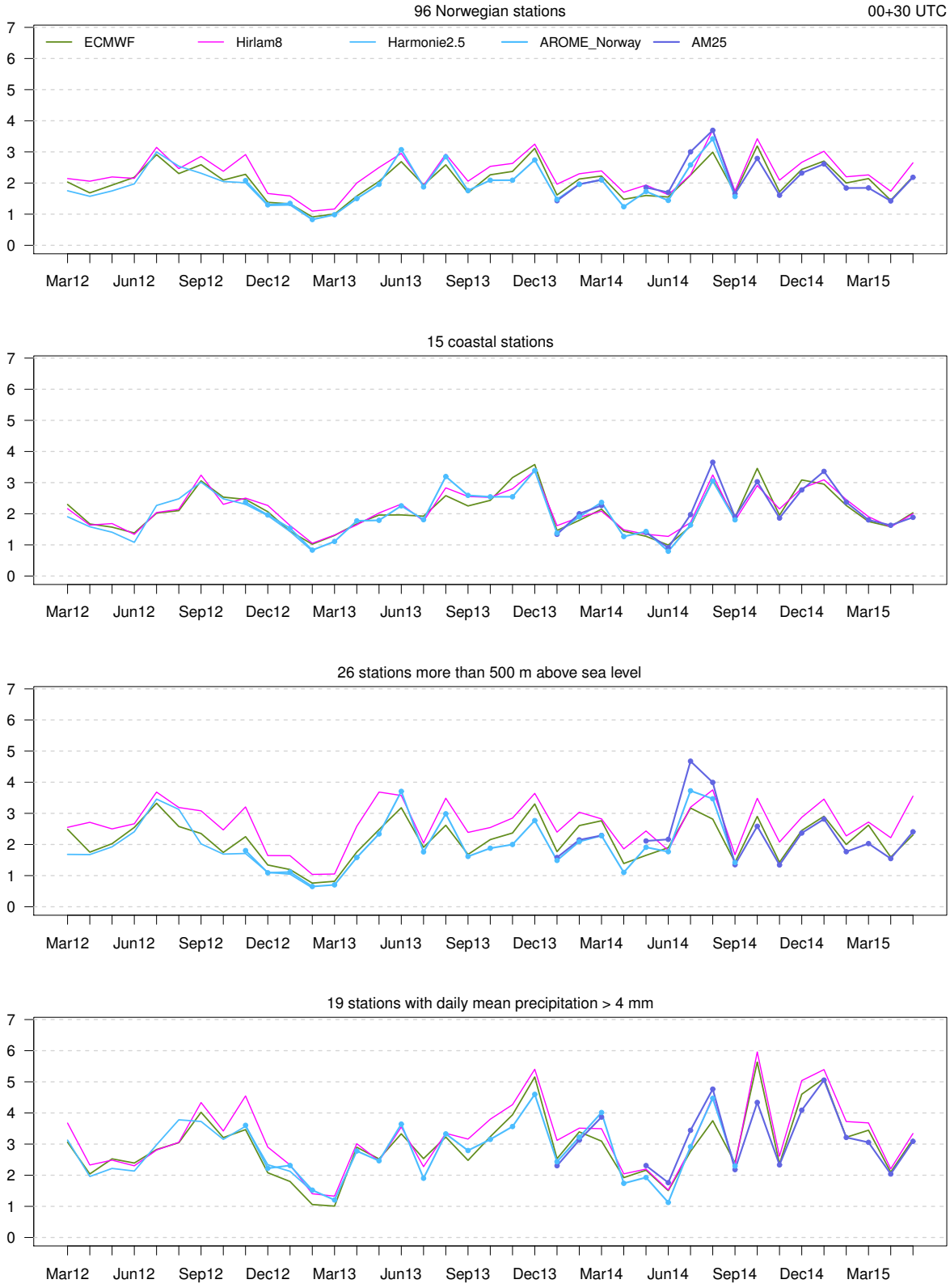
Mean Error


96 Norwegian stations
00+30 UTC
ECMWF
Hirlam8
Harmonie2.5
AROME_Norway
AM25
15 coastal stations
26 stations more than 500 m above sea level
19 stations with daily mean precipitation > 4 mm
4
2
0
−2
−4
Mar12
Jun12
Sep12
Dec12
Mar13
Jun13
Sep13
Dec13
Mar14
Jun14
Sep14
Dec14
Mar15

Standard Deviation of Error



Mean Absolute Error



6 Eastern Norway

6.1 Comments to the verification results

Snow-day in South-East Norway March 26

The public forecast on Yr.no was misleading.

A warm front approached from the south, with warm moist air overlaying the established cold air in the region.

The cold layer below 5000ft is well represented in the profiles from Gardermoen and Rygge, with the warm air sliding on top. AROME-MetCoOp seems to be slightly warmer near the surface than the Hirlam models.

The two temperature plots show values AROME-MetCoOp before and after post-processing of 2m-temperature, compared to SYNOP observations in the area near Oslo. Before post-processing the 2m-tempertature is 1-2 °C higher than the observations. The post-processing raises the temperature by some 1-2°C, and is thereby pulling the forecast further away from what is observed.

Combined with a symbol algorithm that is based heavily on T2m, this produced a forecast of some 20-40 mm rain, while in reality we saw 20-40 cm snow. This error in forecasted/post-processed 2m-temperature lasted for 2-3 days prior to the event, and this short period is not visible in the overall statistics for temperature. However, for the forecasts issued for this particular day, it was of great importance.

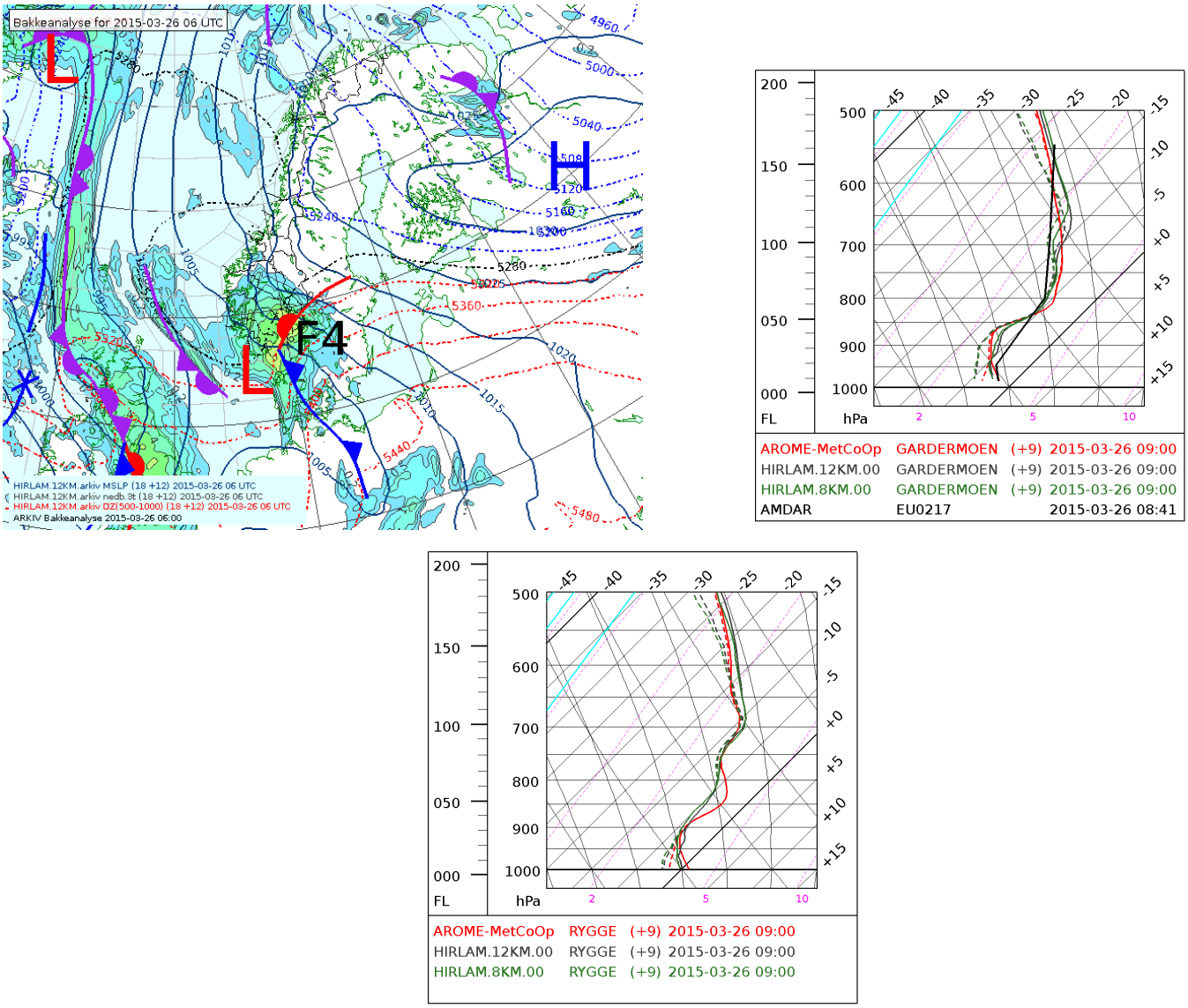


Figure 1: Figures from the March 26 case. Topleft: Forecasters analysis of the synoptic situation. Topright: Vertical profile from Gardermoen. Bottom: Vertical profile from Rygge.

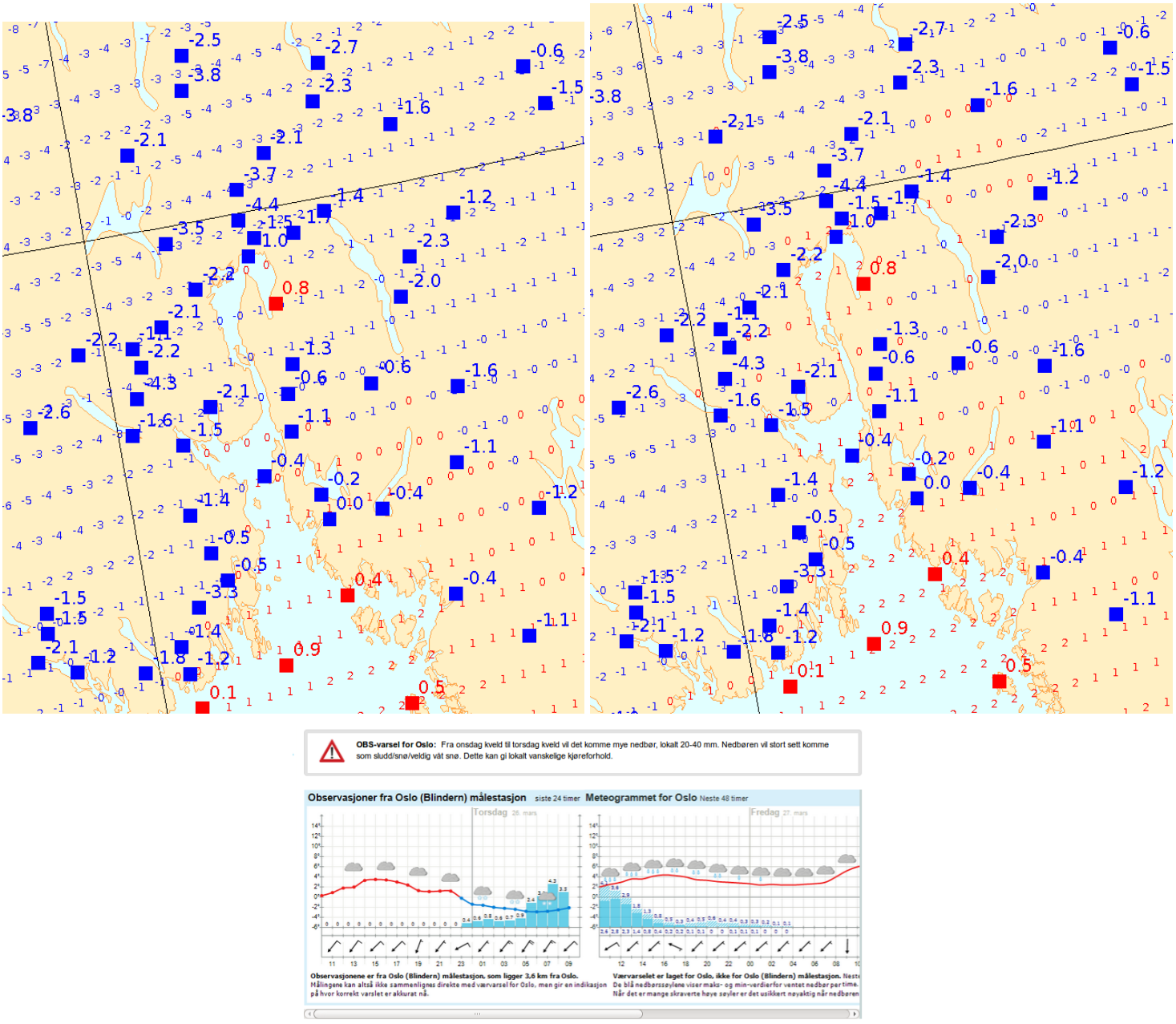
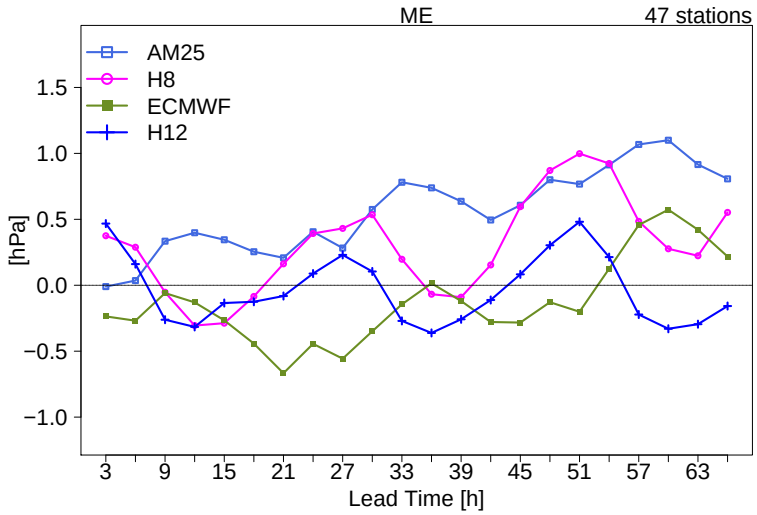
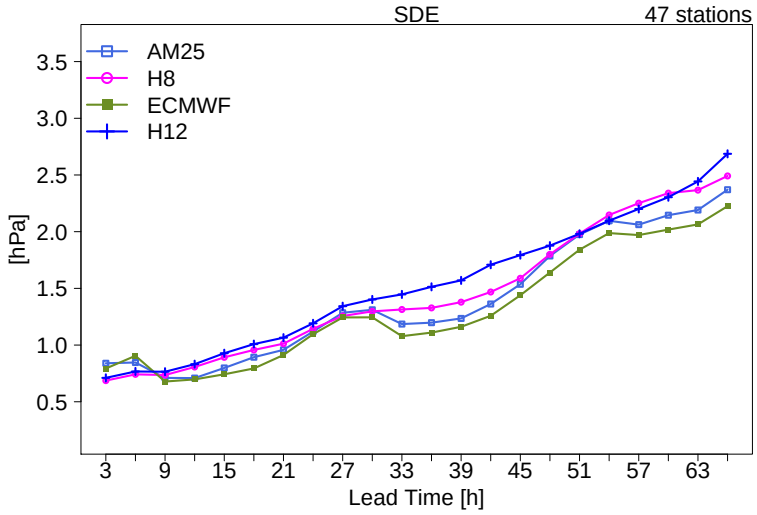
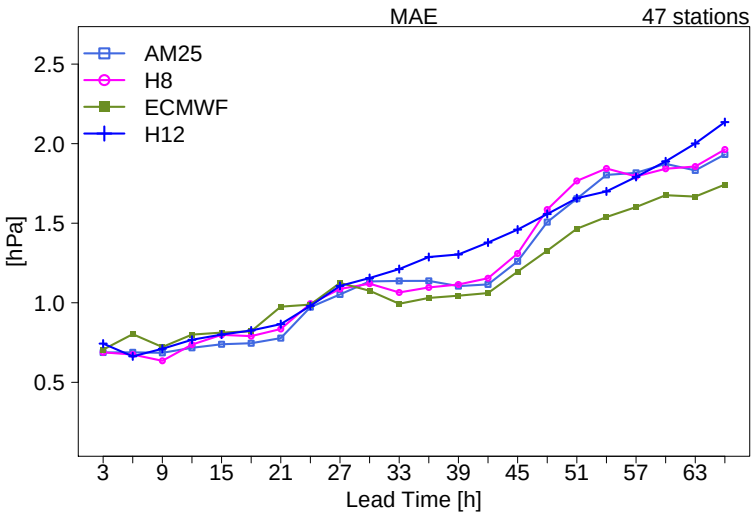


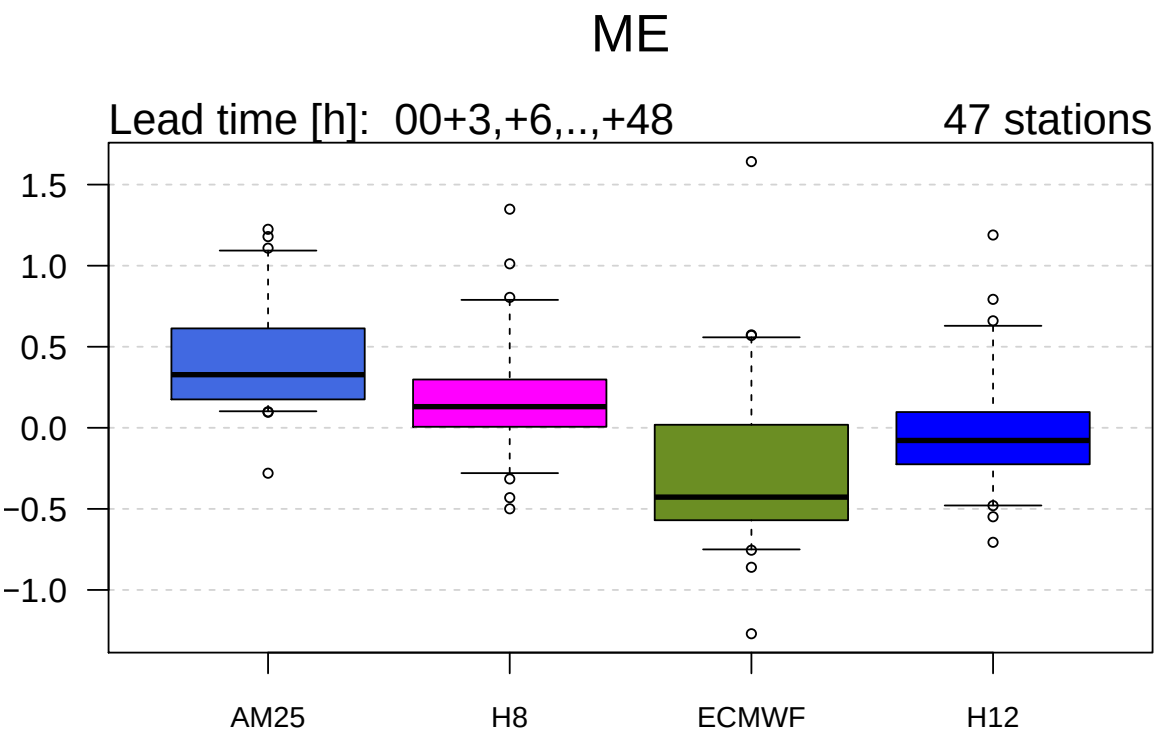
Figure 2: Figures from the March 26 case. Topleft: Forecasted values from AROME (raw) and observations. Topright: Forecasted values from AROME (post processed) and observations. Bottom: Forecast from Yr.

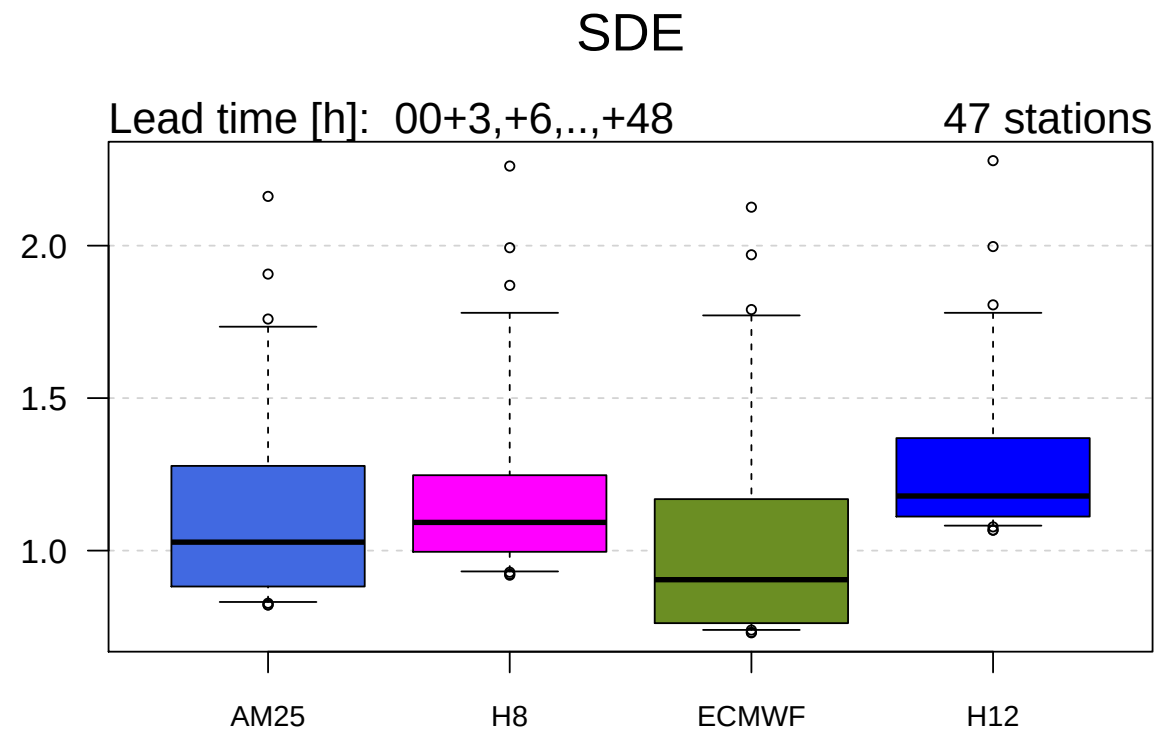
6.2 Pressure


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

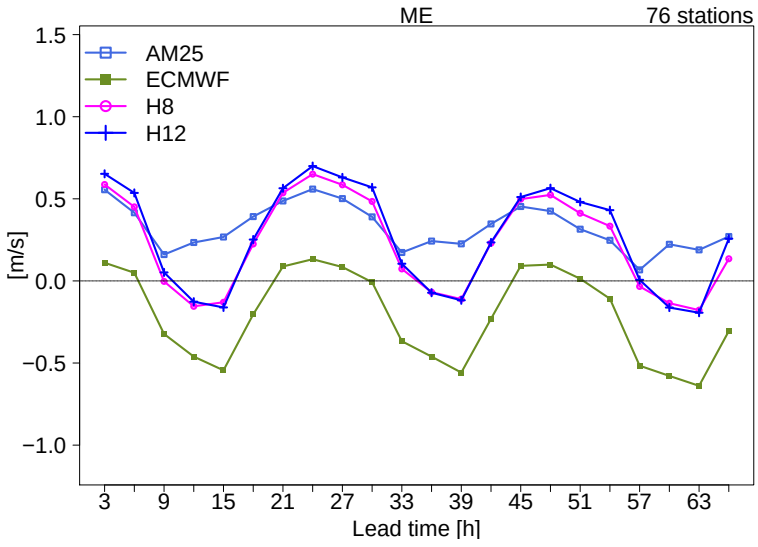

SDE
47 stations
AM25
H8
ECMWF
H12
[hPa]
3.5
3.0
2.5
2.0
1.5
1.0
0.5
3
9
15
21
27
33
39
45
51
57
63
Lead Time [h]

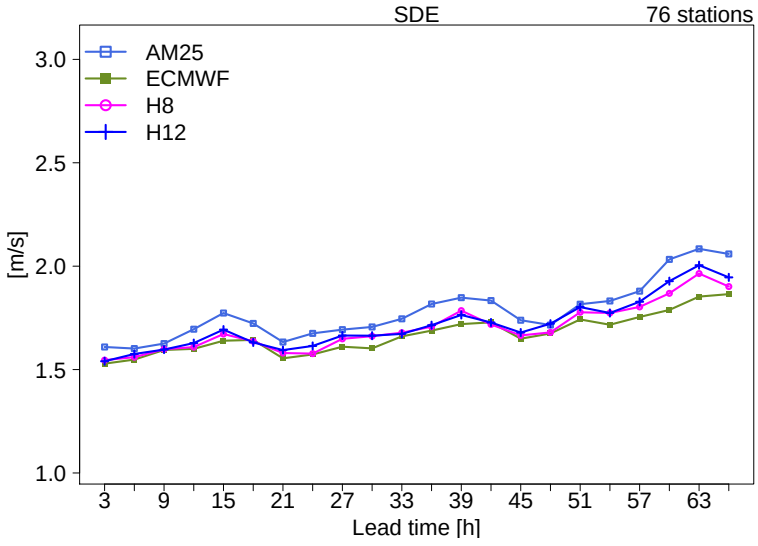

MAE
47 stations
AM25
H8
ECMWF
H12
[hPa]
2.5
2.0
1.5
1.0
0.5
3
9
15
21
27
33
39
45
51
57
63
Lead Time [h]

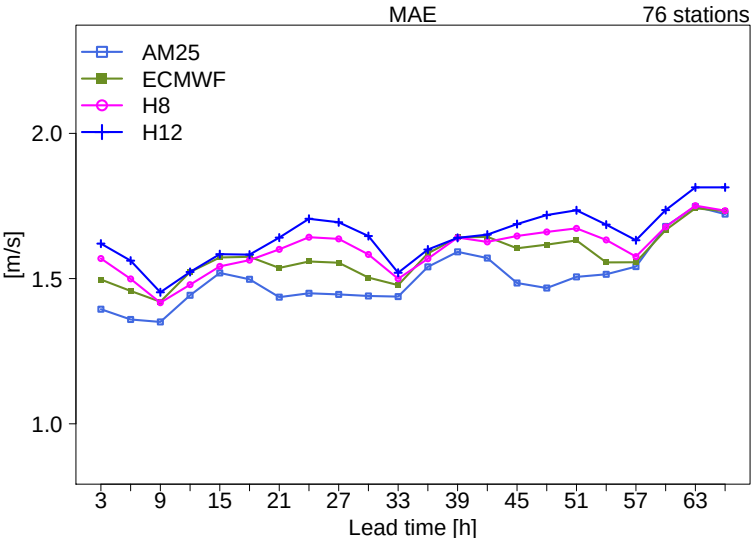

ME
Lead time [h]: 00+3,+6,..,+48
47 stations
1.5
1.0
0.5
0.0
−0.5
−1.0
AM25
H8
ECMWF
H12

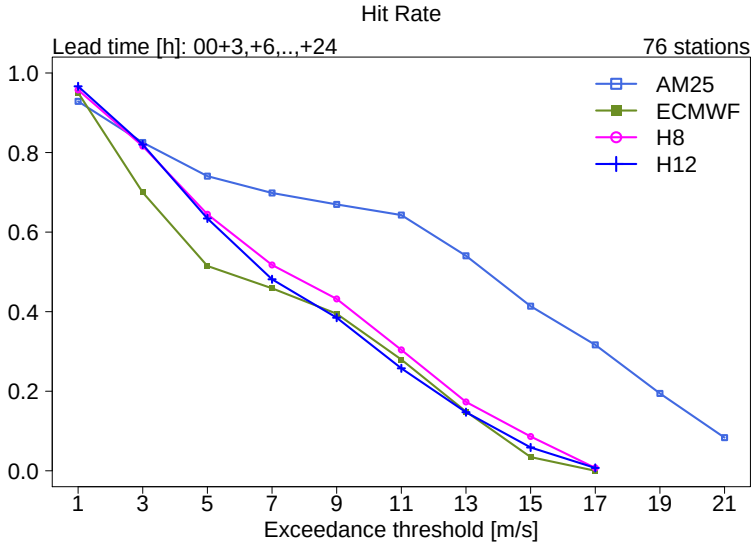

SDE
Lead time [h]: 00+3,+6,..,+48
47 stations
2.0
1.5
1.0
AM25
H8
ECMWF
H12

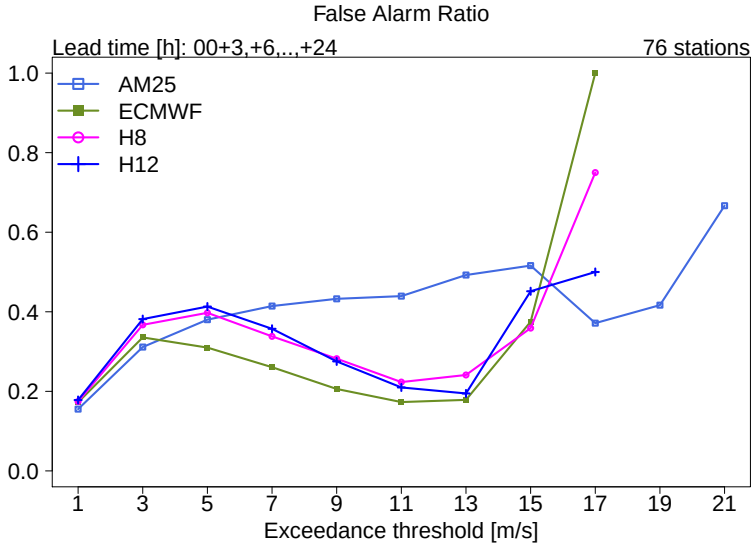
6.3 Wind Speed 10m

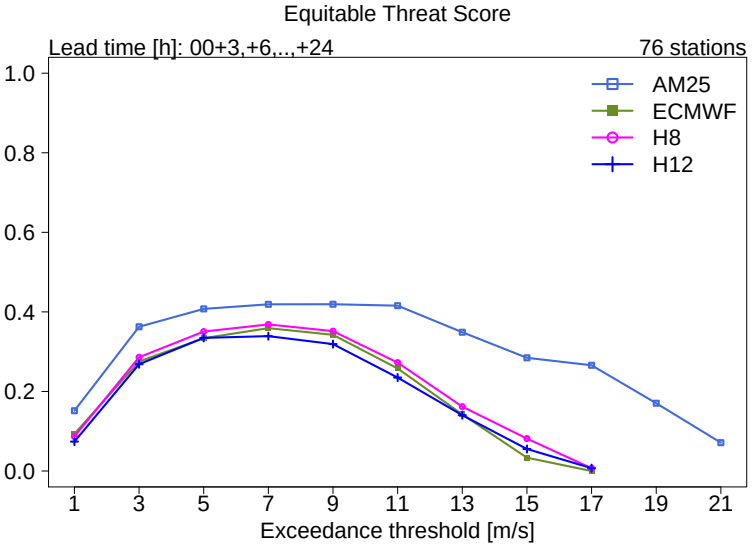


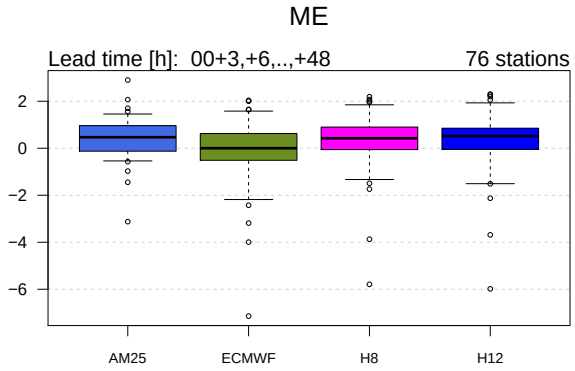


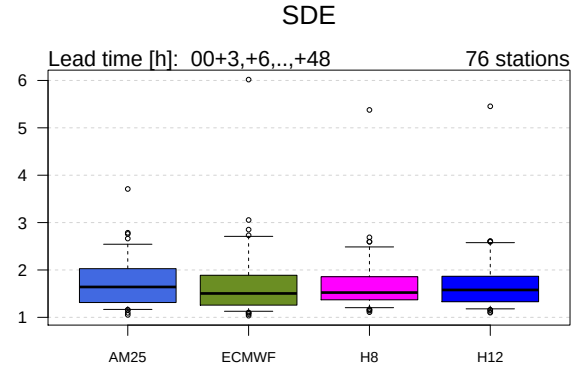



Hit Rate
Lead time [h]: 00+3,+6,..,+24
76 stations
AM25
ECMWF
H8
H12
1.0
0.8
0.6
0.4
0.2
0.0
1 3 5 7 9 11 13 15 17 19 21
Exceedance threshold [m/s]


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]	40042	7788	10	1	0	47841
(3,11]	15840	30683	1019	32	0	47574
(11,17]	75	1262	1340	127	38	2842
(17,21]	0	19	34	30	33	116
(21,Inf]	0	2	1	6	4	13
Sum	55957	39754	2404	196	75	98386

H8

OBS

	[0,3]	(3,11]	(11,17]	(17,21]	(21,Inf]	Sum
[0,3]	35427	7832	89	7	0	43355
(3,11]	20530	31682	1600	147	75	54034
(11,17]	0	240	712	41	0	993
(17,21]	0	0	3	1	0	4
(21,Inf]	0	0	0	0	0	0
Sum	55957	39754	2404	196	75	98386

ECMWF

OBS

	[0,3]	(3,11]	(11,17]	(17,21]	(21,Inf]	Sum
[0,3]	40834	12446	342	99	40	53761
(3,11]	15123	27135	1401	61	35	43755
(11,17]	0	173	660	36	0	869
(17,21]	0	0	1	0	0	1
(21,Inf]	0	0	0	0	0	0
Sum	55957	39754	2404	196	75	98386

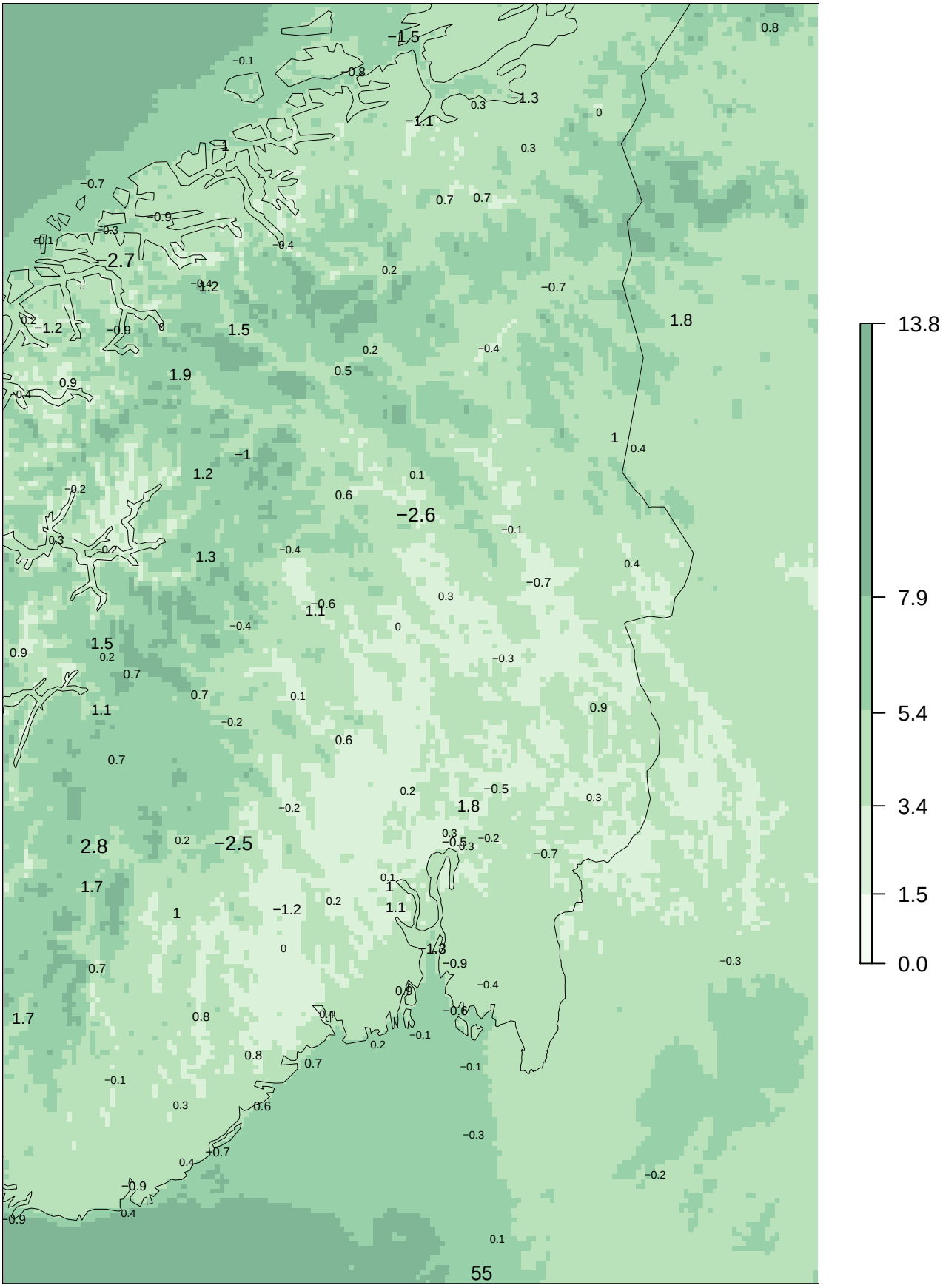
H12

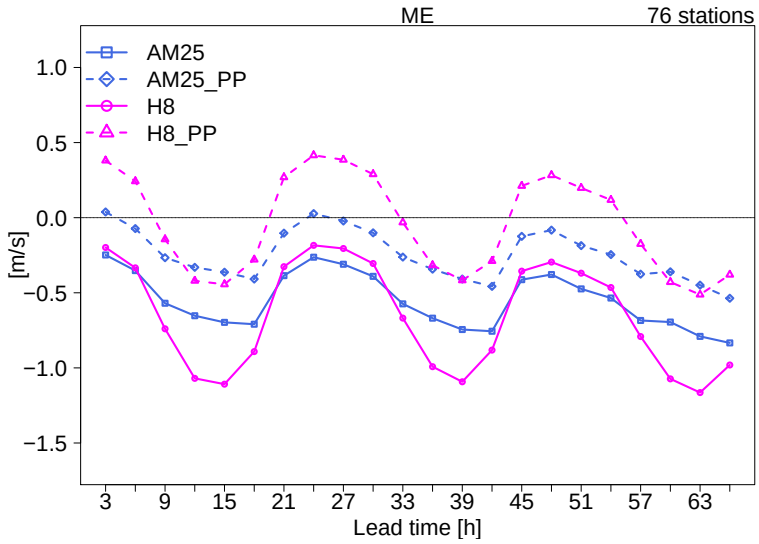
OBS

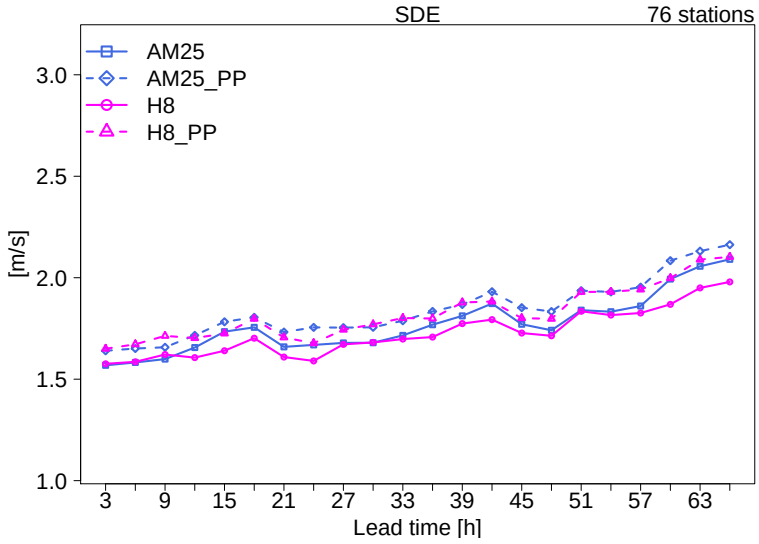
	[0,3]	(3,11]	(11,17]	(17,21]	(21,Inf]	Sum
[0,3]	34093	7597	81	6	0	41777
(3,11]	21864	31956	1725	151	75	55771
(11,17]	0	201	596	38	0	835
(17,21]	0	0	2	1	0	3
(21,Inf]	0	0	0	0	0	0
Sum	55957	39754	2404	196	75	98386

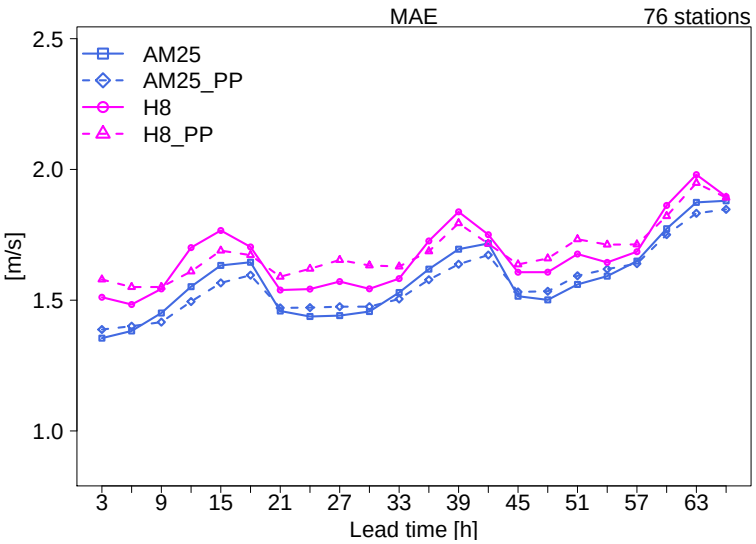
AM25 00+12

ME at observing sites forecast means 01.03.2015 − 31.05.2015



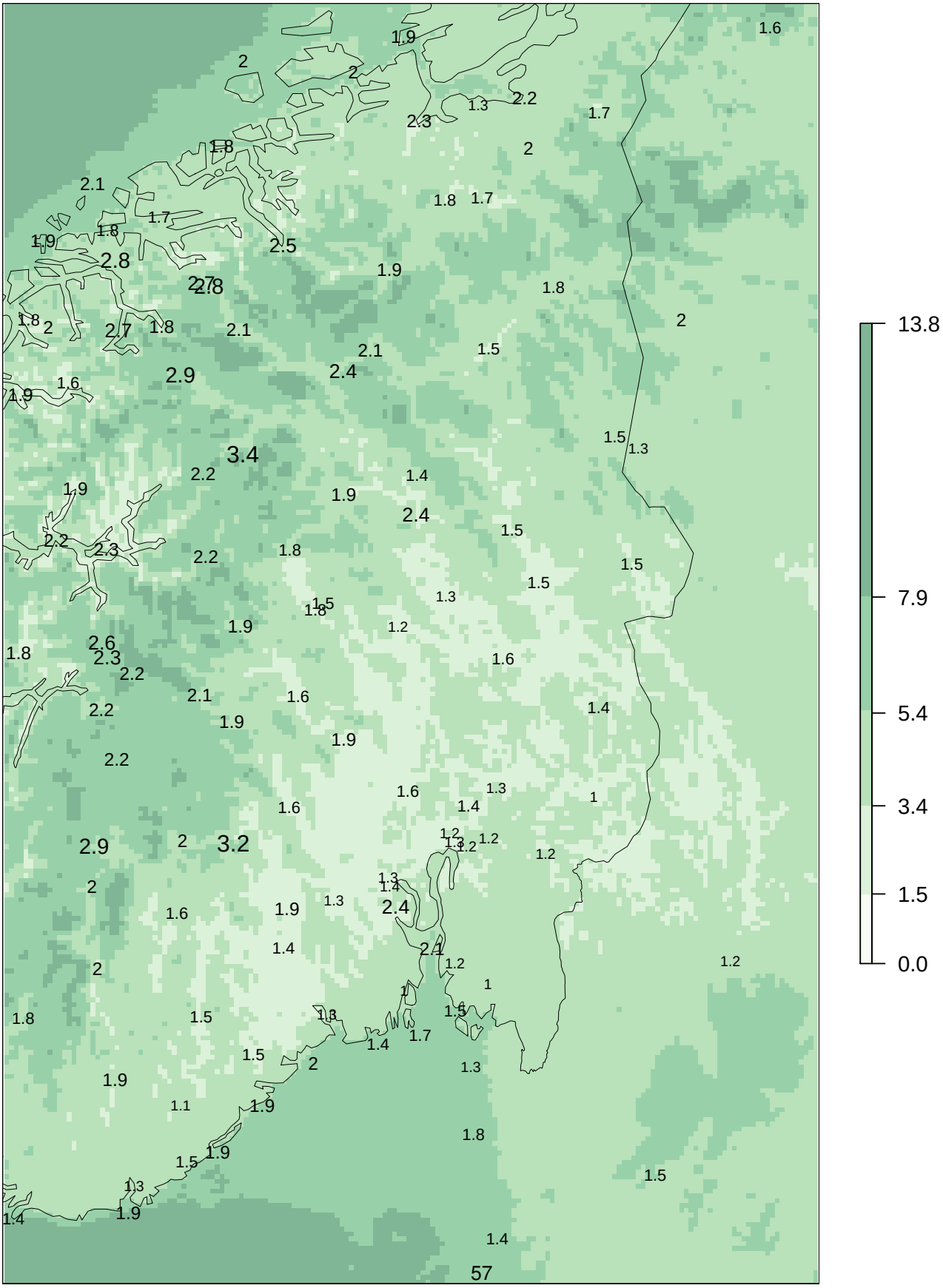

ME
76 stations
AM25
AM25_PP
H8
H8_PP
1.0
0.5
0.0
−0.5
−1.0
−1.5
[m/s]
3
9
15
21
27
33
39
45
51
57
63
Lead time [h]

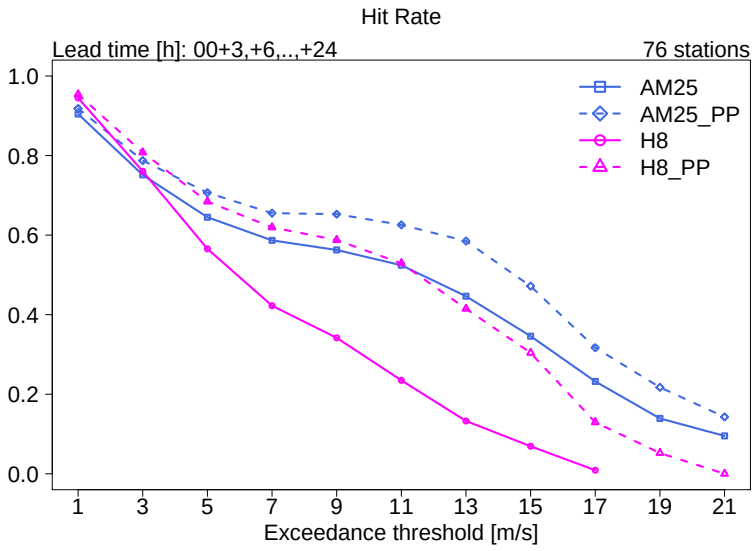

SDE
76 stations
AM25
AM25_PP
H8
H8_PP
3.0
2.5
2.0
1.5
1.0
[m/s]
3
9
15
21
27
33
39
45
51
57
63
Lead time [h]

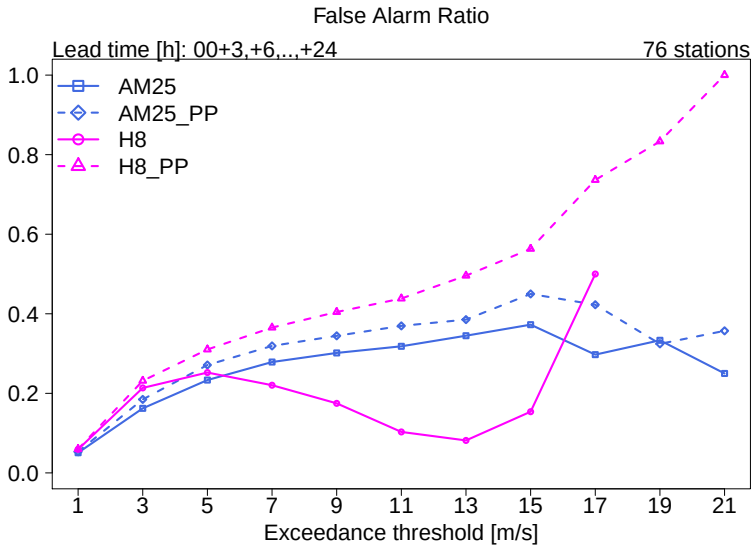

MAE
76 stations
AM25
AM25_PP
H8
H8_PP
2.5
2.0
1.5
1.0
[m/s]
3
9
15
21
27
33
39
45
51
57
63
Lead time [h]

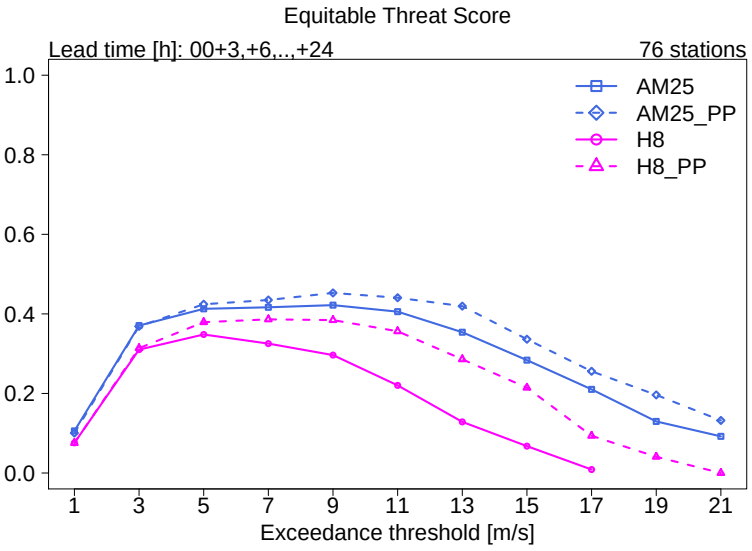
AM25 00+12

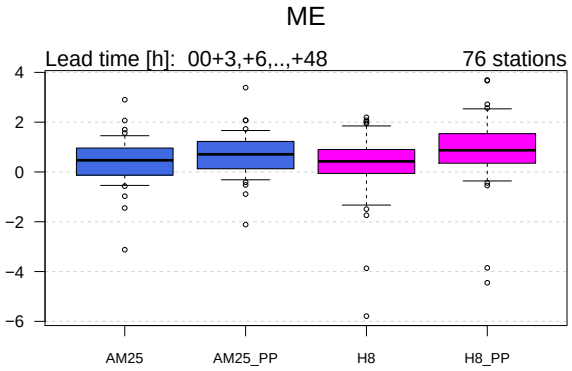
SDE at observing sites forecast means 01.03.2015 − 31.05.2015

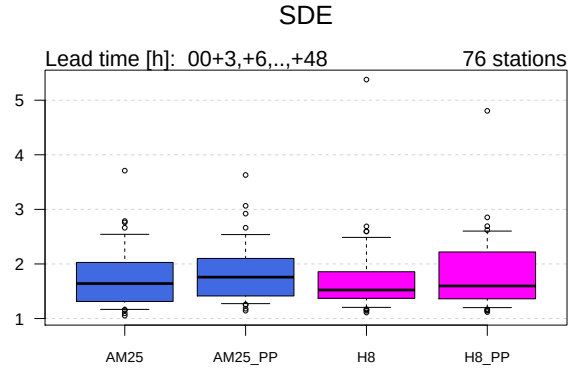



Hit Rate
Lead time [h]: 00+3,+6,..,+24
76 stations
AM25
AM25_PP
H8
H8_PP
1.0
0.8
0.6
0.4
0.2
0.0
1 3 5 7 9 11 13 15 17 19 21
Exceedance threshold [m/s]


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]	31860	14131	37	1	0	46029
(3,11]	8243	35887	1939	75	0	46144
(11,17]	24	961	1600	209	71	2865
(17,21]	0	14	29	32	44	119
(21,Inf]	0	1	1	1	9	12
Sum	40127	50994	3606	318	124	95169

AM25_PP

OBS

	[0,3]	(3,11]	(11,17]	(17,21]	(21,Inf]	Sum
[0,3]	29967	12141	19	1	0	42128
(3,11]	10112	37420	1552	60	0	49144
(11,17]	48	1402	1967	194	53	3664
(17,21]	0	30	65	58	58	211
(21,Inf]	0	1	3	5	13	22
Sum	40127	50994	3606	318	124	95169

H8

OBS

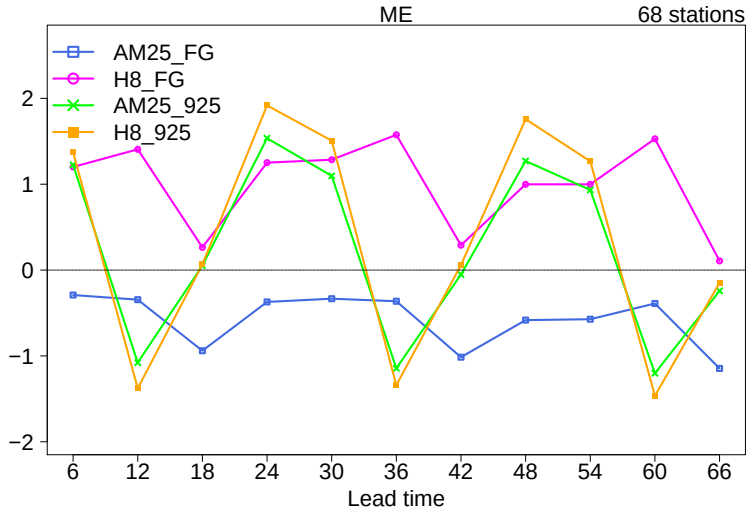
	[0,3]	(3,11]	(11,17]	(17,21]	(21,Inf]	Sum
[0,3]	28274	13155	167	17	0	41613
(3,11]	11853	37710	2646	209	122	52540
(11,17]	0	129	791	90	2	1012
(17,21]	0	0	2	2	0	4
(21,Inf]	0	0	0	0	0	0
Sum	40127	50994	3606	318	124	95169

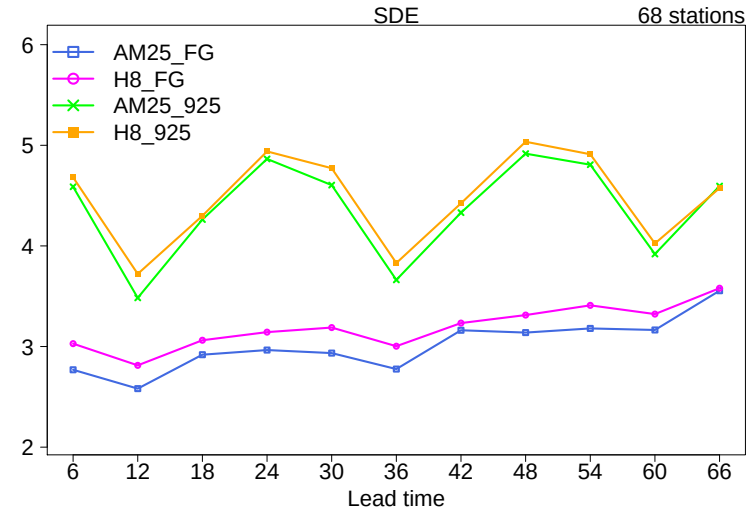
H8_PP

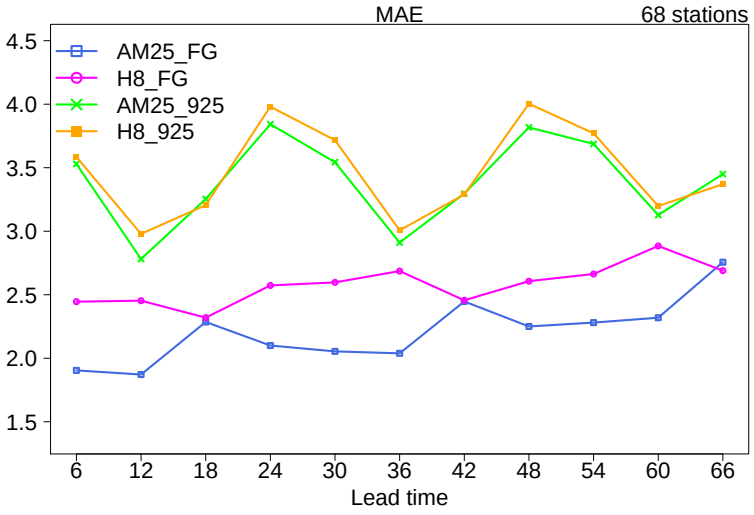
OBS

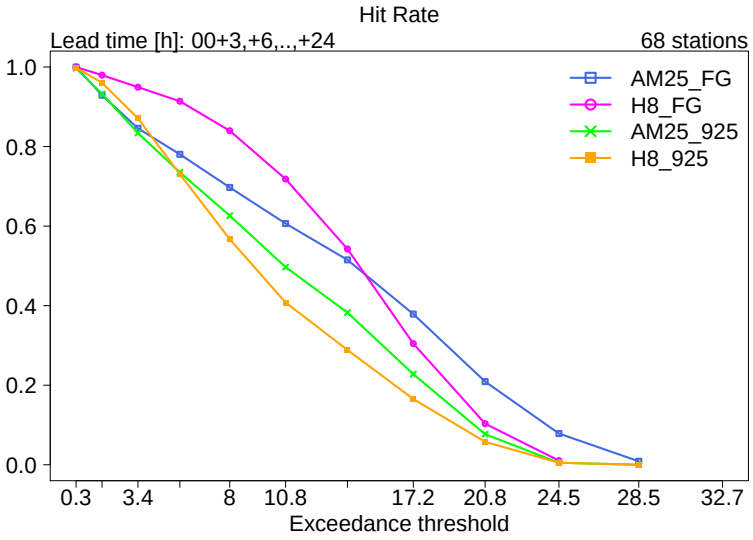
	[0,3]	(3,11]	(11,17]	(17,21]	(21,Inf]	Sum
[0,3]	26249	10701	90	5	0	37045
(3,11]	13842	38593	1602	175	98	54310
(11,17]	36	1680	1781	83	24	3604
(17,21]	0	19	132	54	2	207
(21,Inf]	0	1	1	1	0	3
Sum	40127	50994	3606	318	124	95169

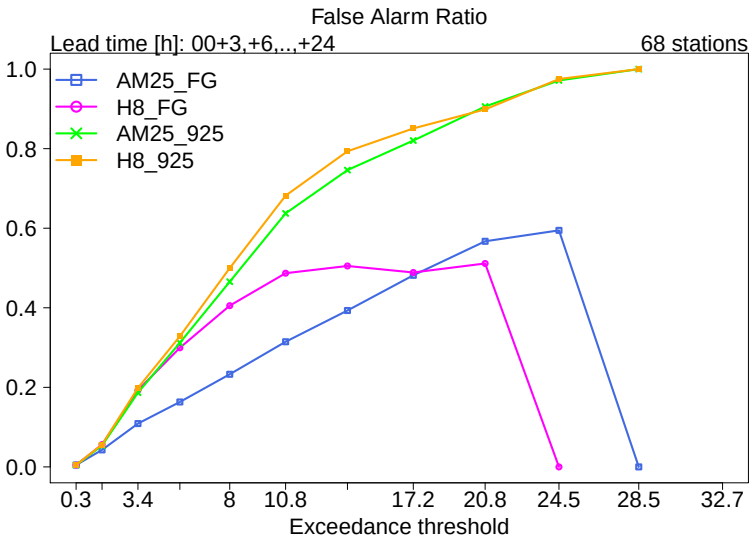
6.4 Wind gust

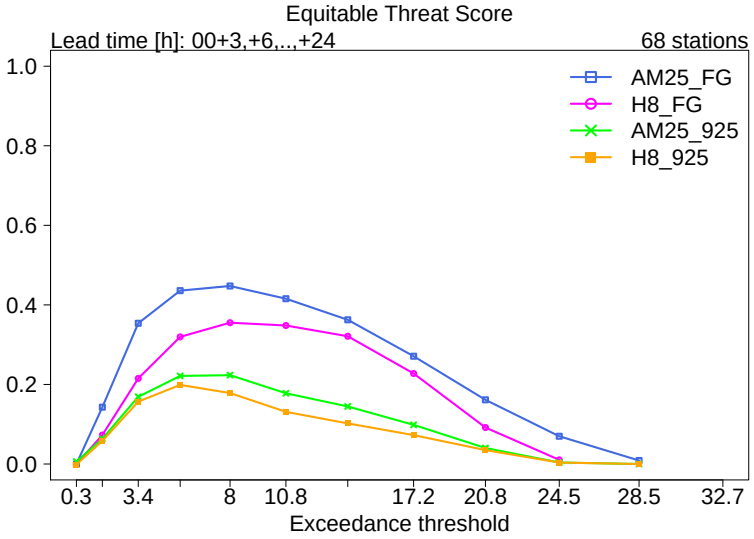

ME
68 stations
AM25_FG
H8_FG
AM25_925
H8_925
2
1
0
−1
−2
6
12
18
24
30
36
42
48
54
60
66
Lead time


SDE
68 stations
AM25_FG
H8_FG
AM25_925
H8_925
6
5
4
3
2
6
12
18
24
30
36
42
48
54
60
66
Lead time

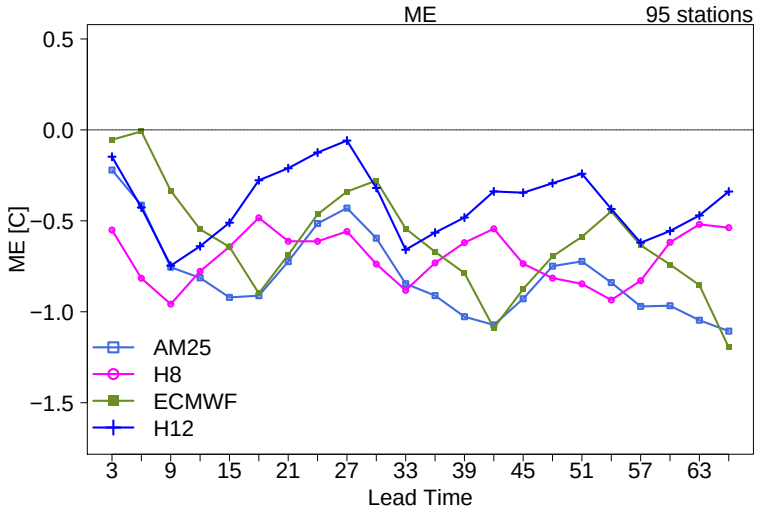

MAE
68 stations
AM25_FG
H8_FG
AM25_925
H8_925
4.5
4.0
3.5
3.0
2.5
2.0
1.5
6
12
18
24
30
36
42
48
54
60
66
Lead time

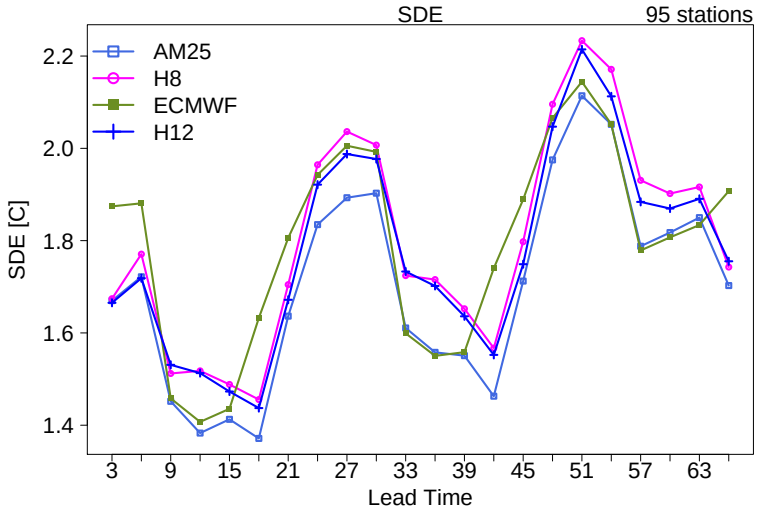

Hit Rate
Lead time [h]: 00+3,+6,..,+24
68 stations
AM25_FG
H8_FG
AM25_925
H8_925
1.0
0.8
0.6
0.4
0.2
0.0
0.3
3.4
8
10.8
17.2
20.8
24.5
28.5
32.7
Exceedance threshold

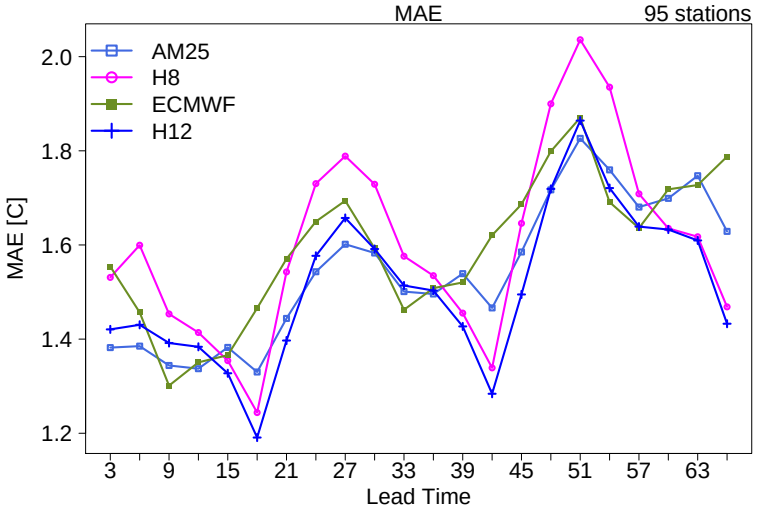

False Alarm Ratio
Lead time [h]: 00+3,+6,..,+24
68 stations
AM25_FG
H8_FG
AM25_925
H8_925
1.0
0.8
0.6
0.4
0.2
0.0
0.3
3.4
8
10.8
17.2
20.8
24.5
28.5
32.7
Exceedance threshold

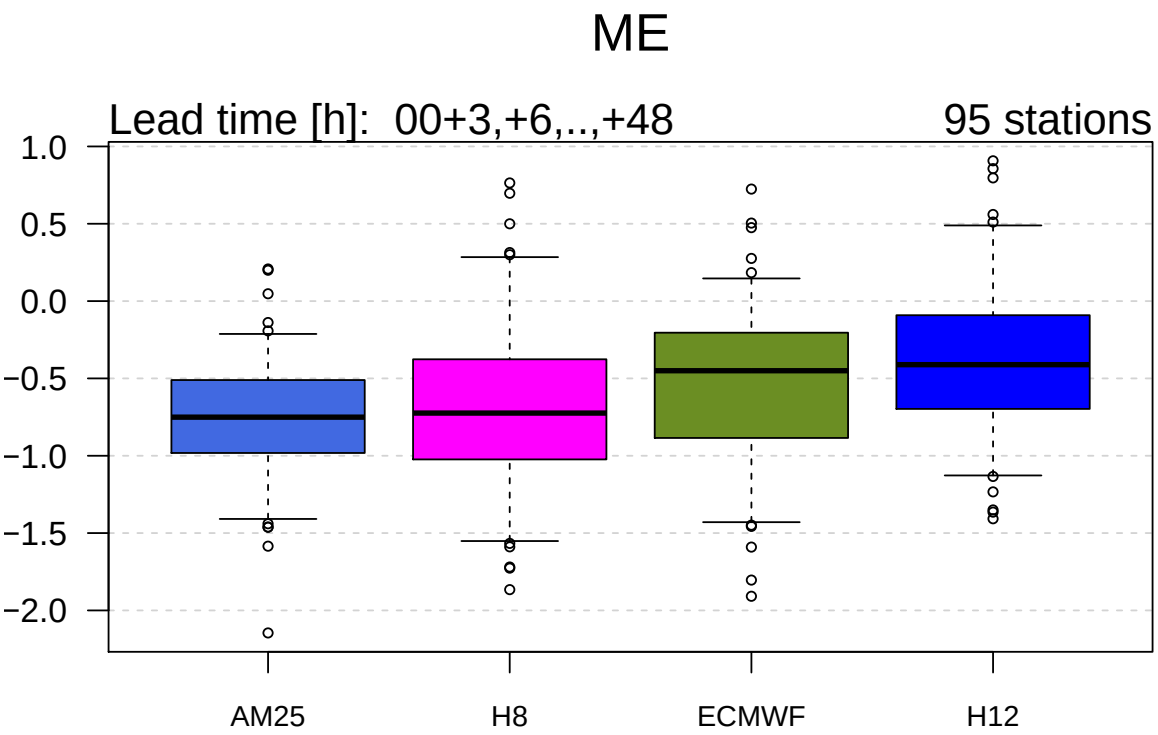

Equitable Threat Score
Lead time [h]: 00+3,+6,..,+24
68 stations
AM25_FG
H8_FG
AM25_925
H8_925
1.0
0.8
0.6
0.4
0.2
0.0
0.3
3.4
8
10.8
17.2
20.8
24.5
28.5
32.7
Exceedance threshold

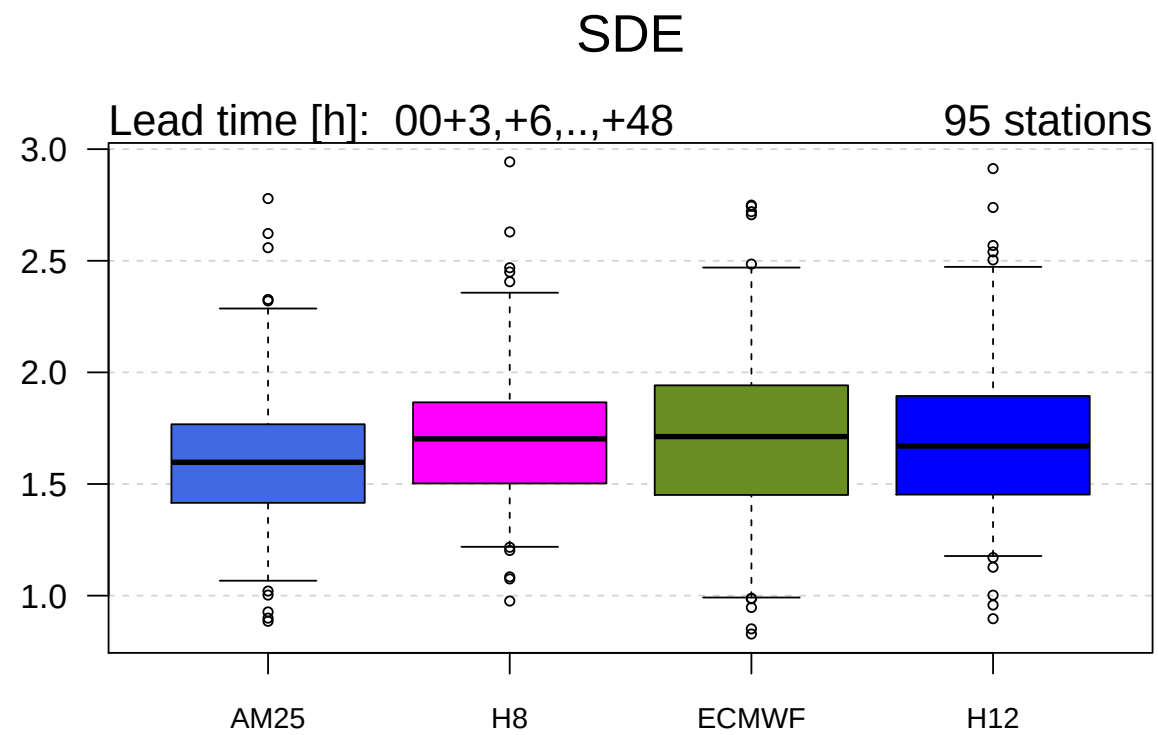
6.5 Temperature 2m





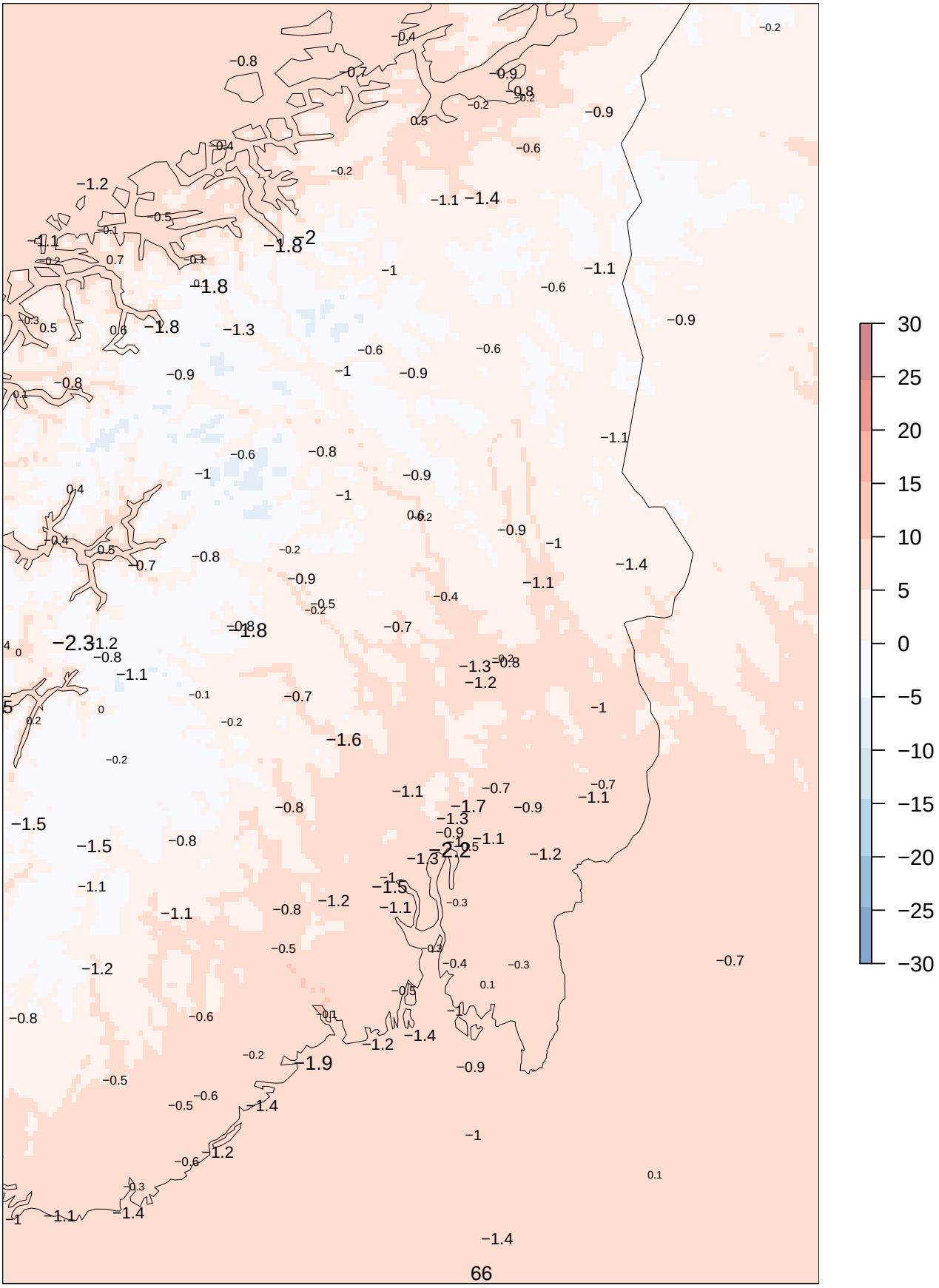



ME
Lead time [h]: 00+3,+6,..,+48
95 stations
1.0
0.5
0.0
−0.5
−1.0
−1.5
−2.0
AM25
H8
ECMWF
H12


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

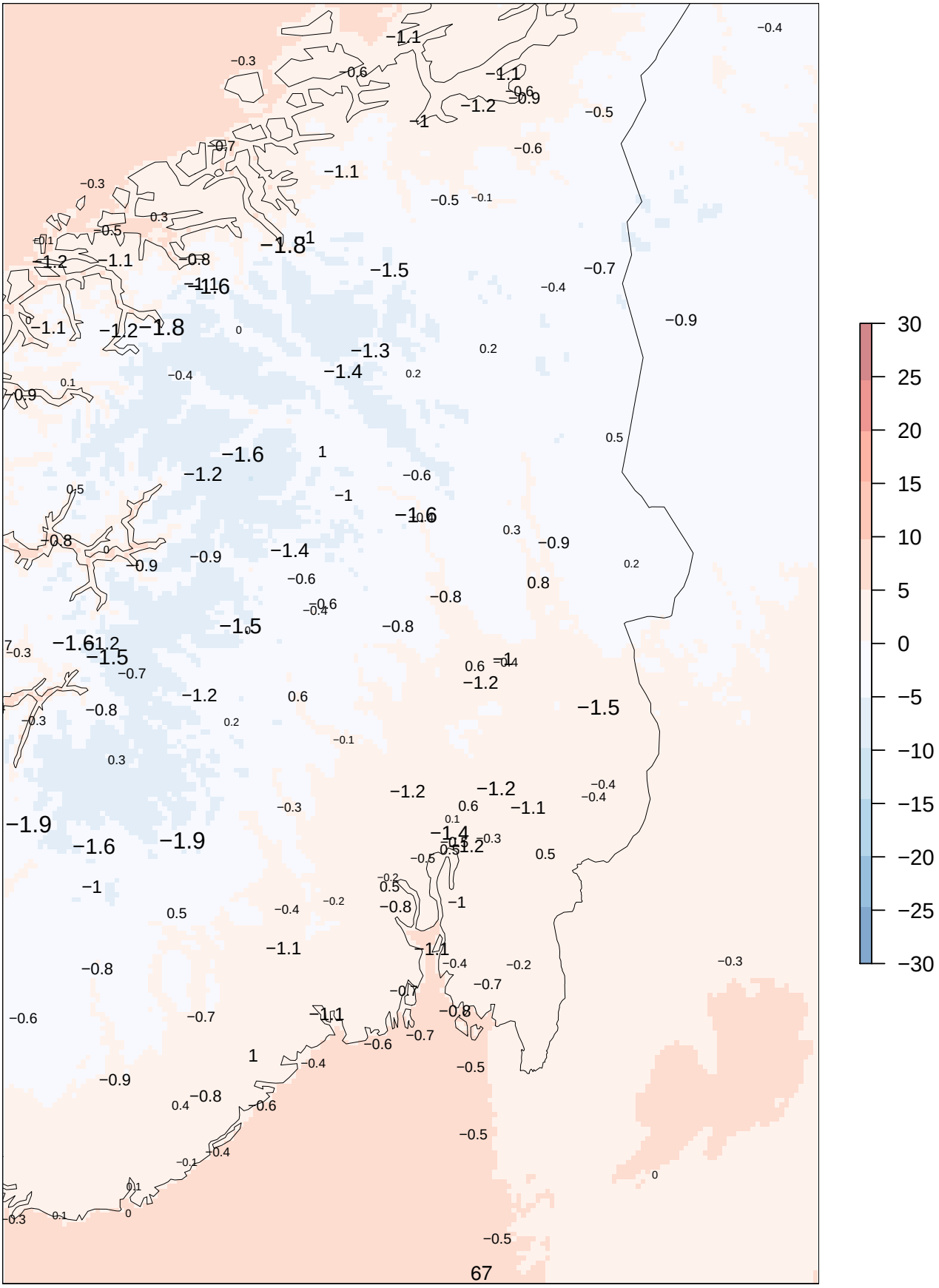
AM25 00+12

ME at observing sites forecast means 01.03.2015 − 31.05.2015



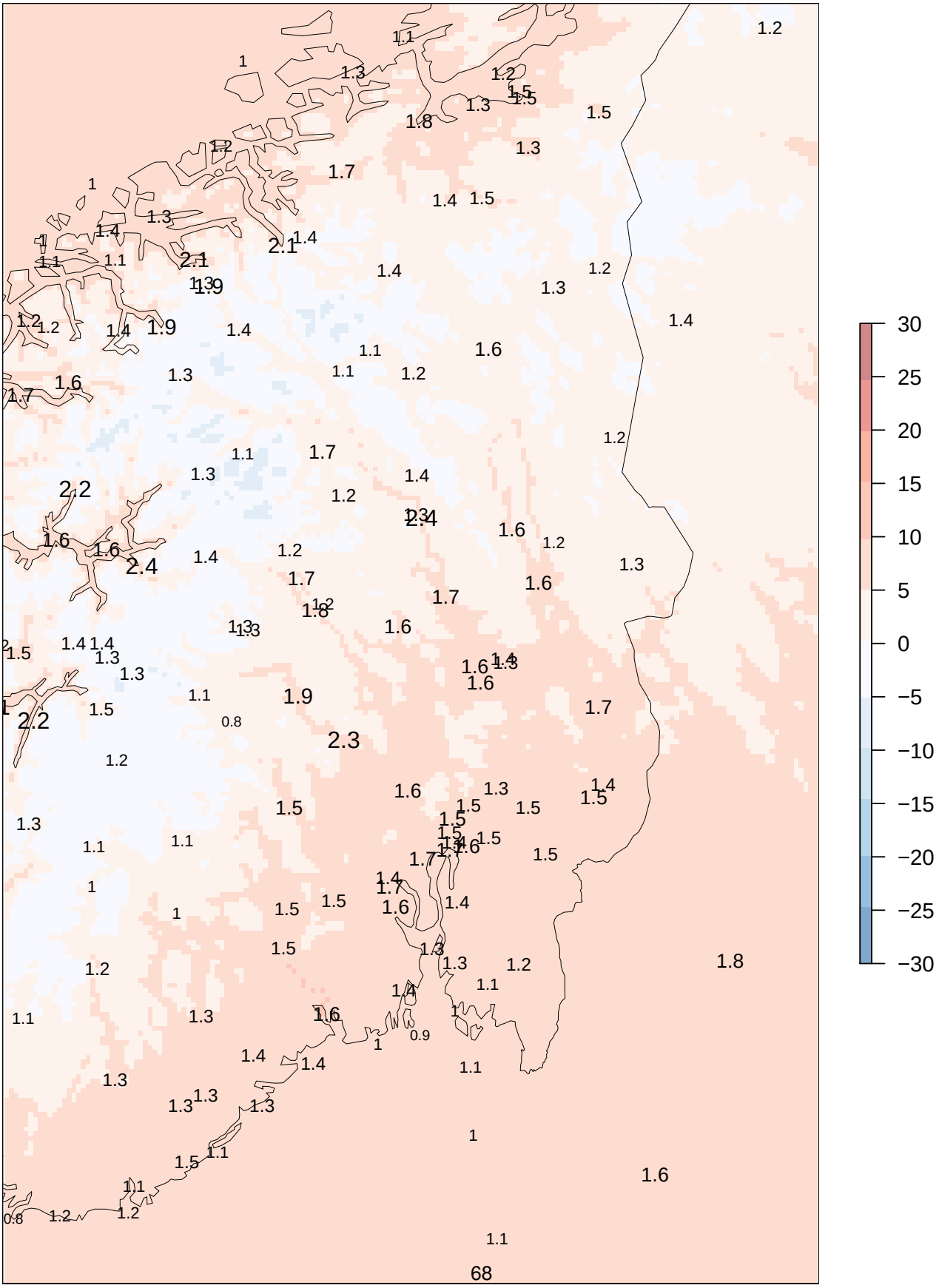
AM25 00+24

ME at observing sites forecast means 01.03.2015 − 31.05.2015



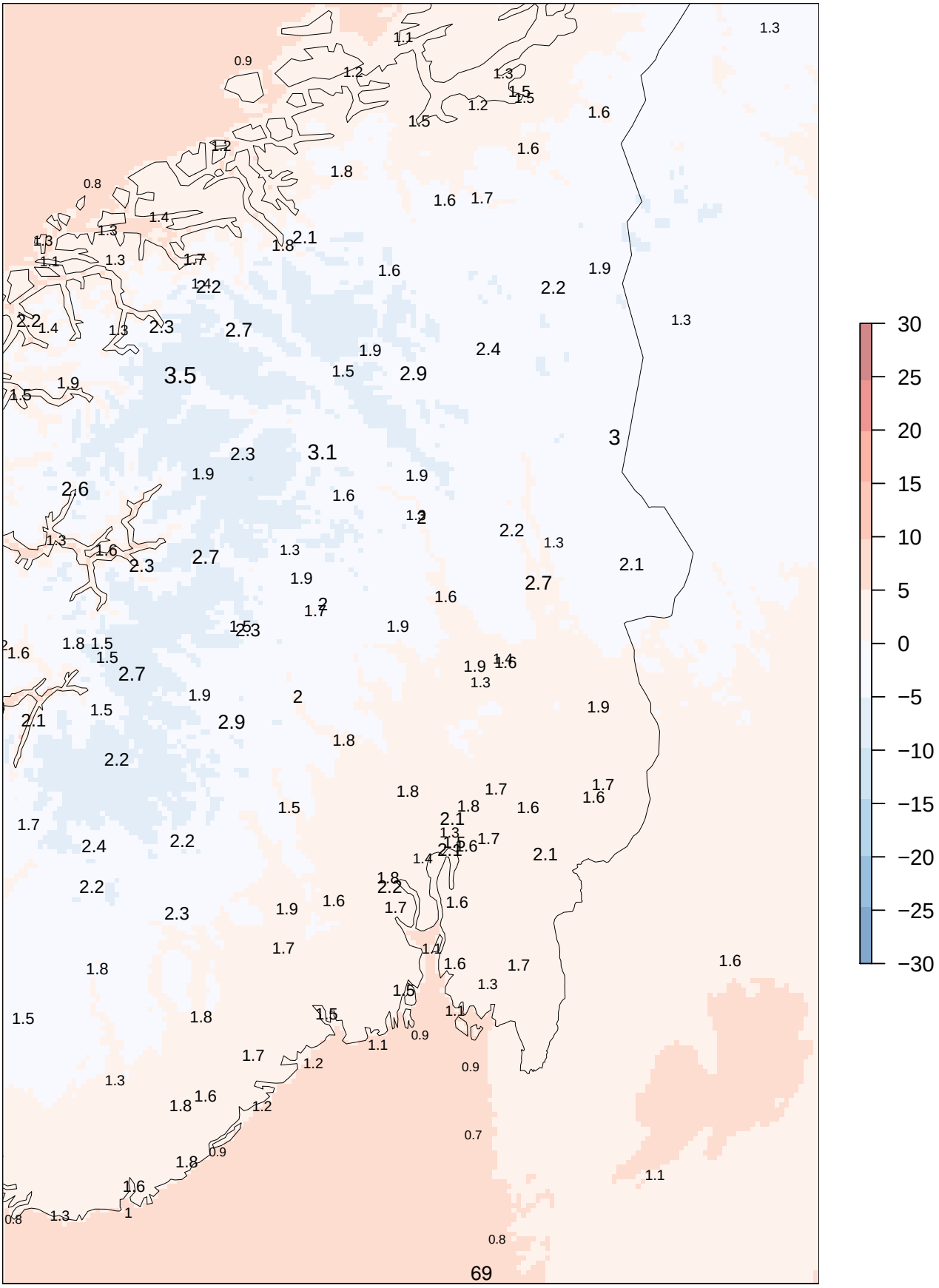
AM25 00+12

SDE at observing sites forecast means 01.03.2015 − 31.05.2015

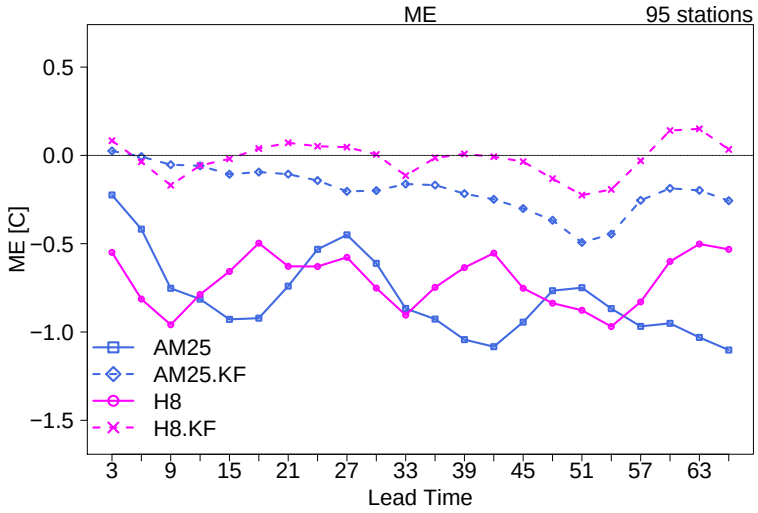


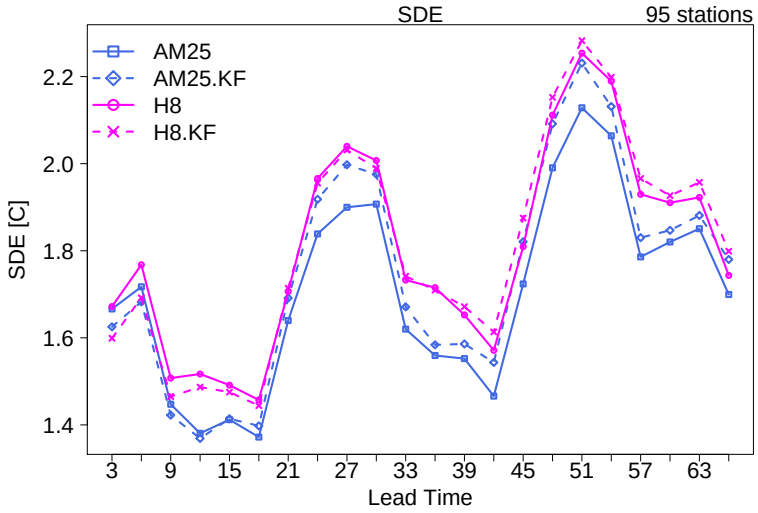
AM25 00+24

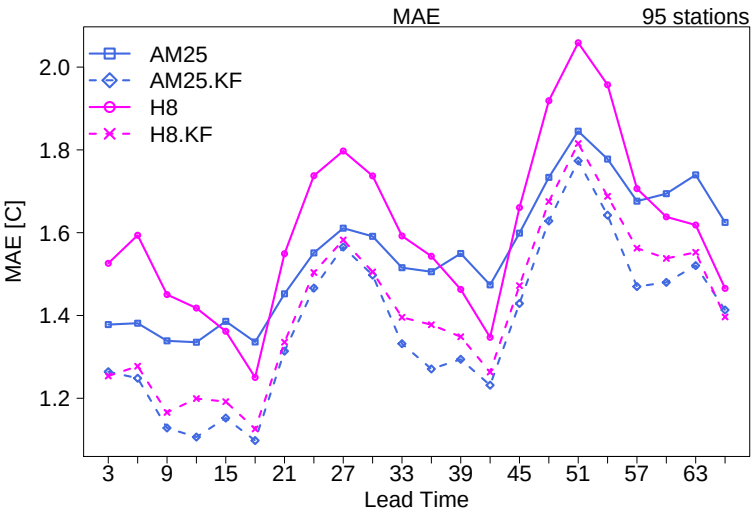
SDE at observing sites forecast means 01.03.2015 − 31.05.2015

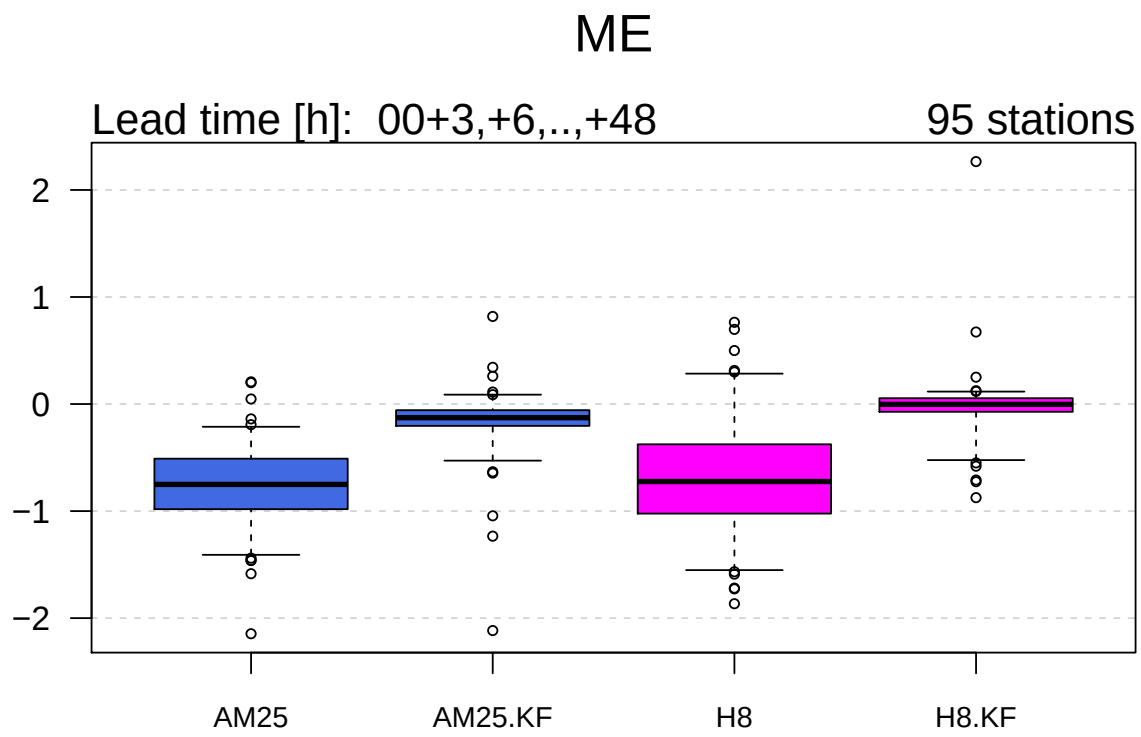


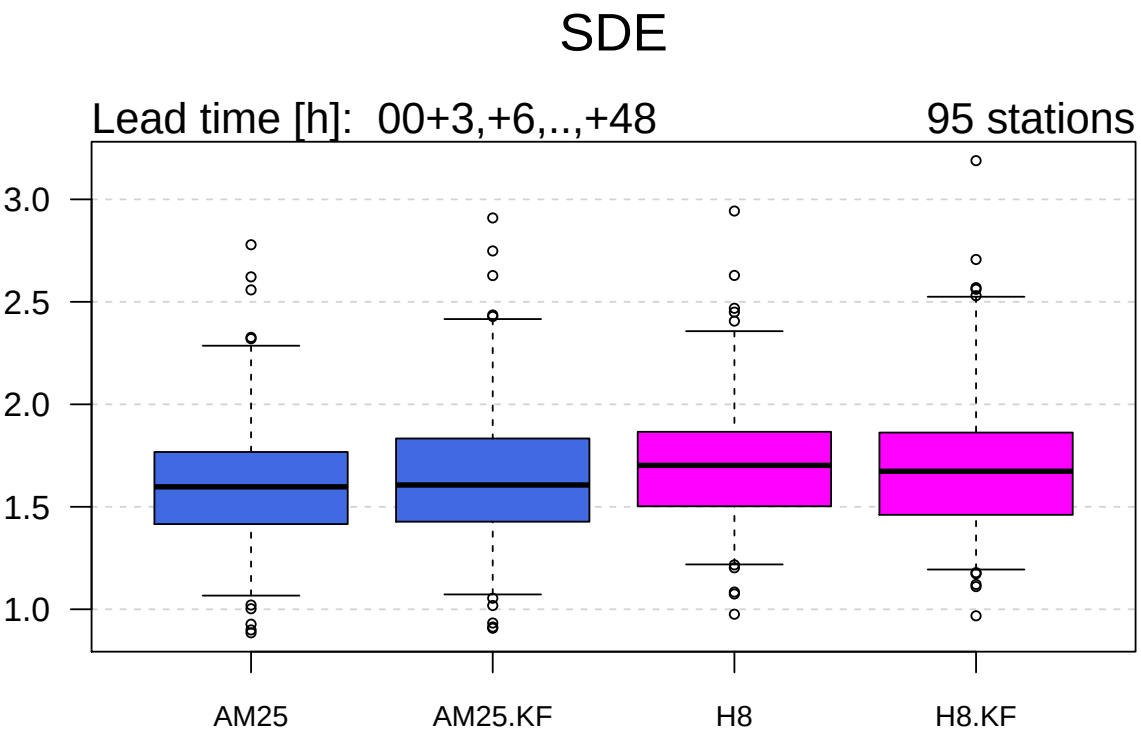
6.6 Post processed temperature 2m



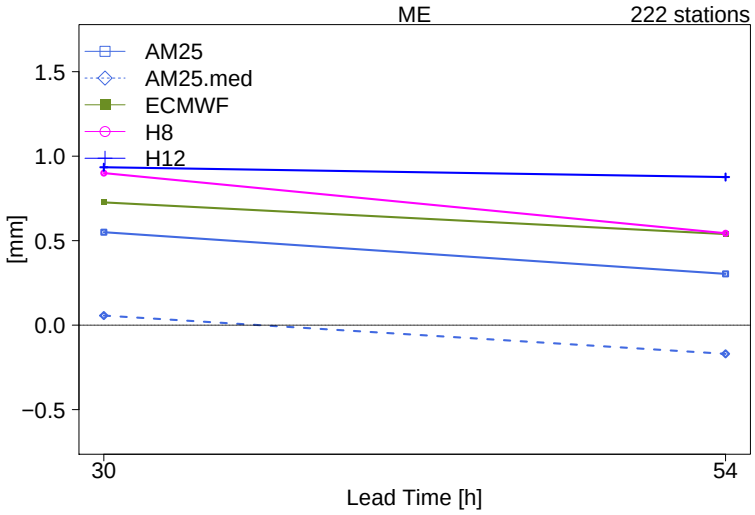


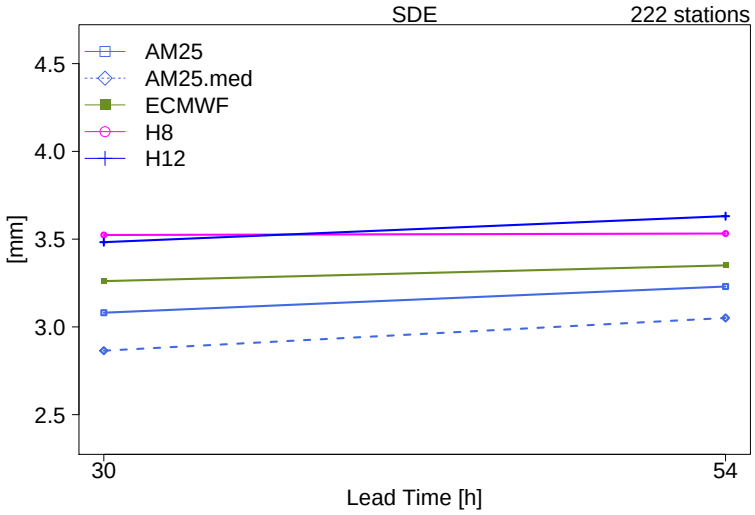


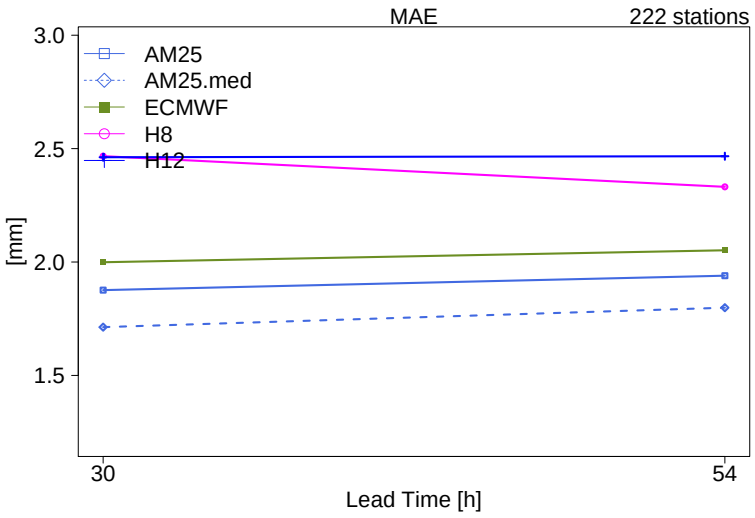

ME
Lead time [h]: 00+3,+6,..,+48
95 stations
2
1
0
−1
−2
AM25
AM25.KF
H8
H8.KF

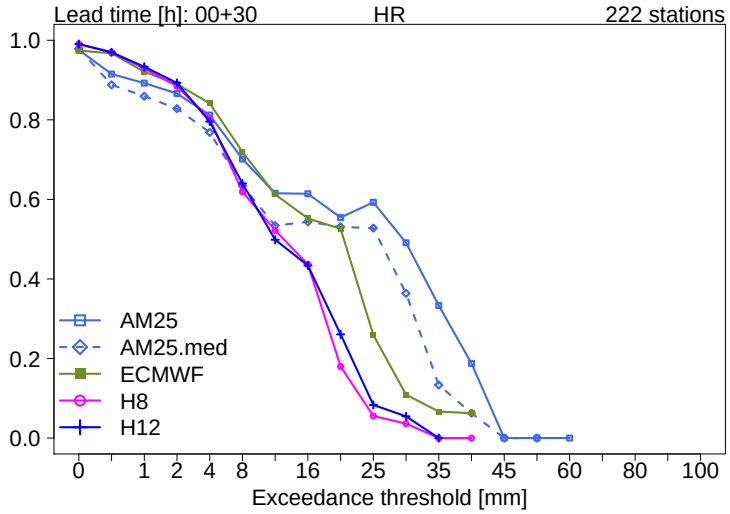

SDE
Lead time [h]: 00+3,+6,..,+48
95 stations
3.0
2.5
2.0
1.5
1.0
AM25
AM25.KF
H8
H8.KF

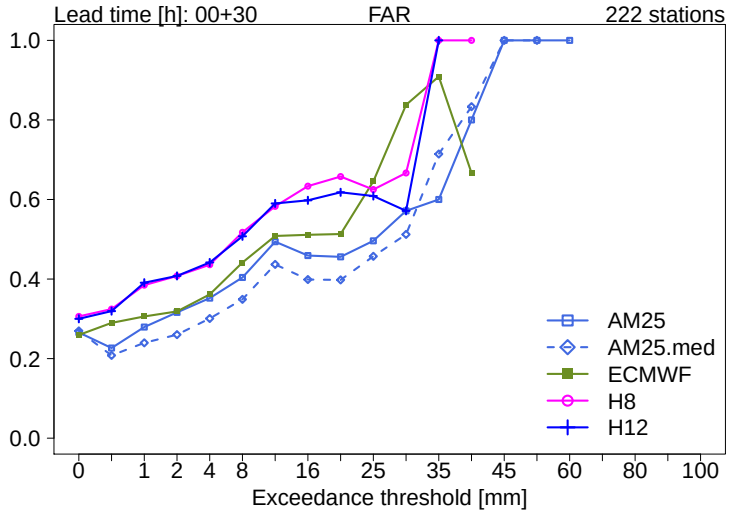
6.7 Daily precipitation

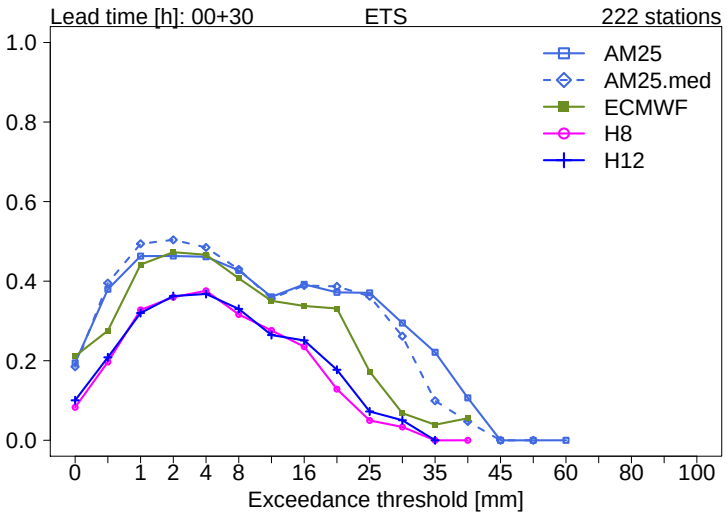


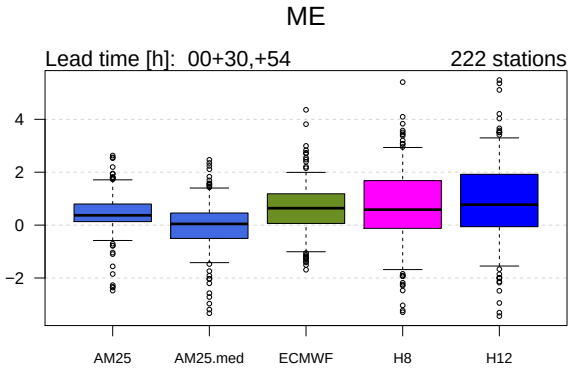


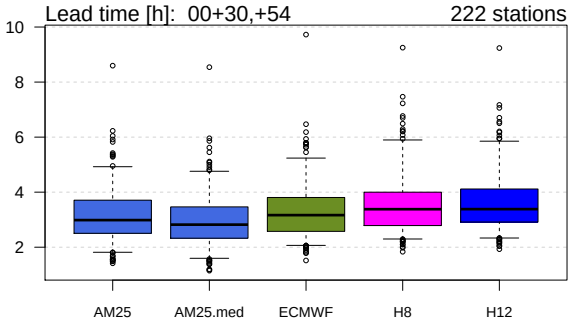



Lead time [h]: 00+30
HR
222 stations
1.0
0.8
0.6
0.4
0.2
0.0
AM25
AM25.med
ECMWF
H8
H12
0 1 2 4 8 16 25 35 45 60 80 100
Exceedance threshold [mm]


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]	7055	1498	30	2	0	8585
(0.1,5]	3854	7677	1225	14	2	12772
(5,20]	272	1950	3093	166	0	5481
(20,50]	17	24	124	166	2	333
(50,Inf]	0	0	0	4	0	4
Sum	11198	11149	4472	352	4	27175

AM25.med — **OBS**

	[0,0.1]	(0.1,5]	(5,20]	(20,50]	(50,Inf]	Sum
[0,0.1]	7585	1916	56	2	0	9559
(0.1,5]	3445	7755	1495	20	2	12717
(5,20]	149	1464	2827	174	0	4614
(20,50]	19	14	94	155	2	284
(50,Inf]	0	0	0	1	0	1
Sum	11198	11149	4472	352	4	27175

ECMWF — **OBS**

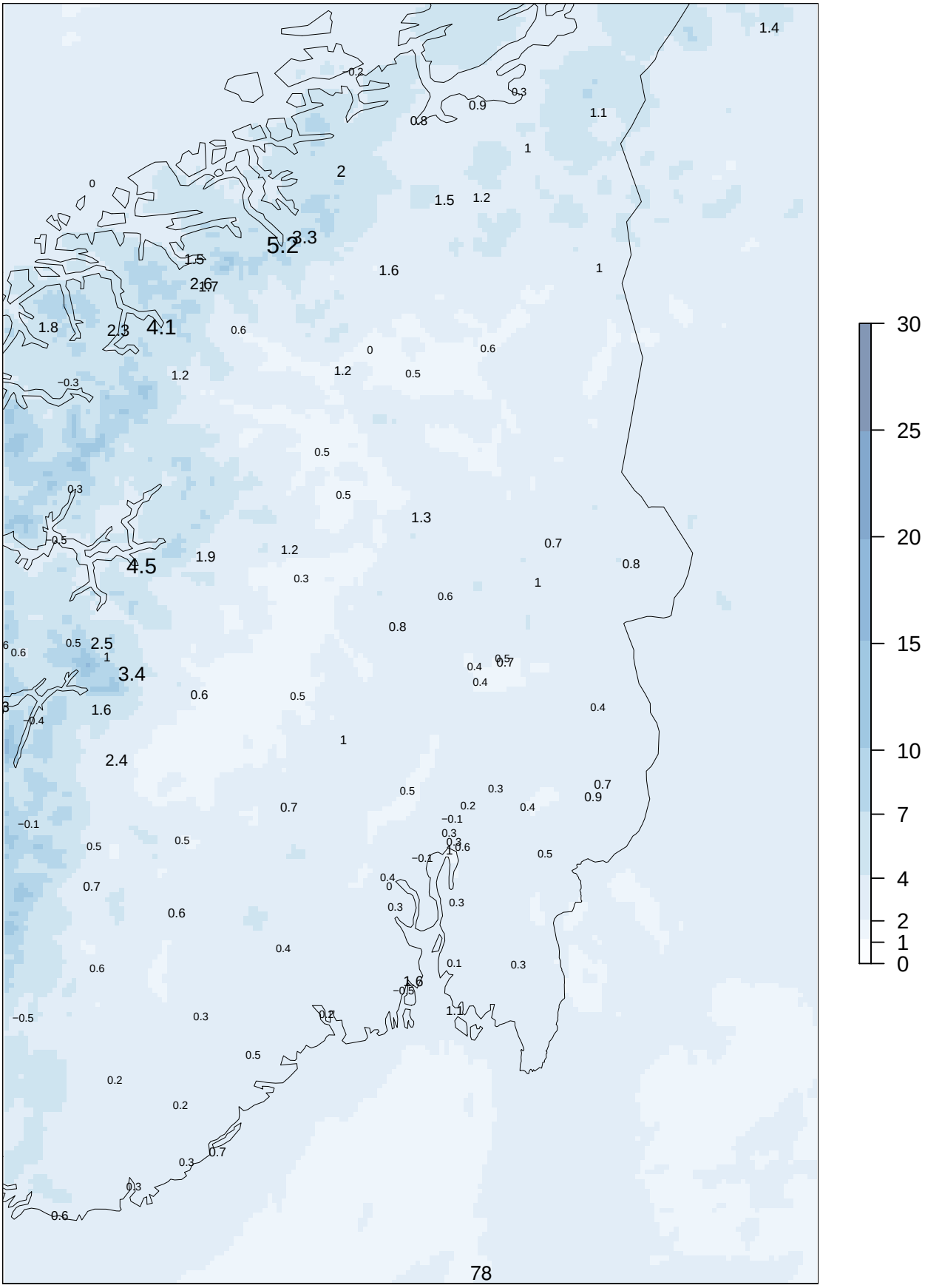
	[0,0.1]	(0.1,5]	(5,20]	(20,50]	(50,Inf]	Sum
[0,0.1]	5071	678	8	2	0	5759
(0.1,5]	5843	8405	1164	15	2	15429
(5,20]	265	2031	3118	167	0	5581
(20,50]	19	35	182	168	2	406
(50,Inf]	0	0	0	0	0	0
Sum	11198	11149	4472	352	4	27175

H8 — **OBS**

	[0,0.1]	(0.1,5]	(5,20]	(20,50]	(50,Inf]	Sum
[0,0.1]	3889	596	9	2	0	4496
(0.1,5]	6929	7956	1376	20	2	16283
(5,20]	369	2571	3029	272	2	6243
(20,50]	11	26	58	58	0	153
(50,Inf]	0	0	0	0	0	0
Sum	11198	11149	4472	352	4	27175

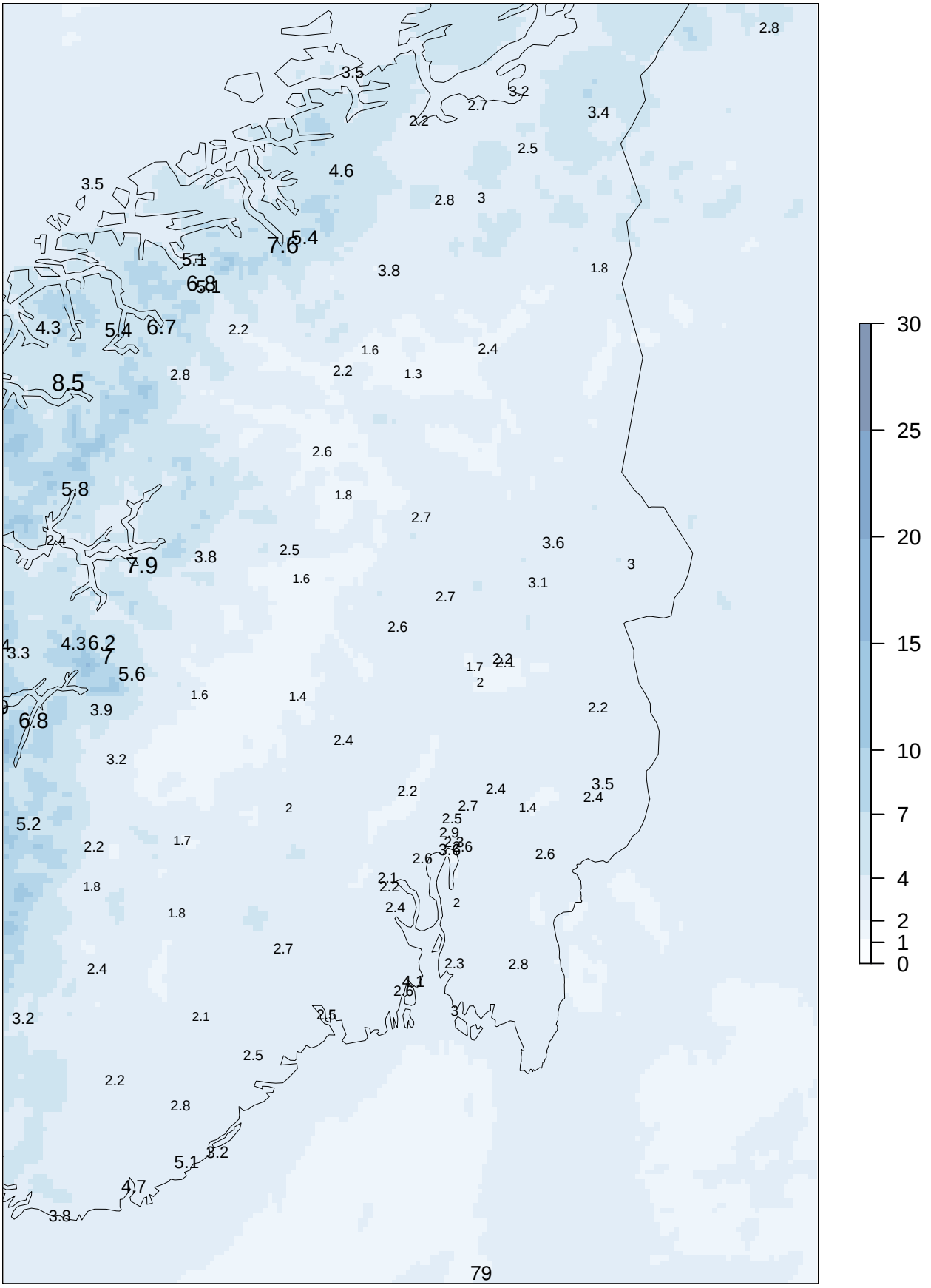
AM25 00+30

ME at observing sites forecast means 01.03.2015 − 31.05.2015



AM25 00+30

SDE at observing sites forecast means 01.03.2015 − 31.05.2015



7 Western Norway

7.1 Comments to the verification results

Wind speed 10 m:
For the period 1st of March 2015 to 31th of May 2015 Arome, Hirlam12 and Hirlam8 have a small positive bias in wind speed during night time and a small negative bias in the afternoon. ECMWF has a negative bias at both day time and night times. Arome scores best for wind speeds below $20ms^{-1}$ and Hirlam 8 scores best for wind speeds above $20ms^{-1}$.

Max mean wind speed 10 m:
For Max Mean Wind Speed, both Arome and Hirlam8 have a negative bias. After postprocessing both Arome and Hirlam8 have small negative biases. For max mean wind speed Arome scores better for wind speeds below $15ms^{-1}$, while Arome and Hirlam are equal above $15ms^{-1}$.

Wind gust:
For wind gust Arome has a negative bias around $1ms^{-1}$, while Hirlam8 has a positive bias between 0.5 and 1 ms^{-1} . If we look at wind speed at 925 hPa (which is often used as an estimate of wind gust), there are only minor differences in bias between the Arome and Hirlam8. Both have a positive bias around $1ms^{-1}$ at midnight and a negative bias around $1ms^{-1}$ around noon.

Wind gust from Arome scores best for wind speeds below $15ms^{-1}$, while Hirlam8 scores better for stronger wind gust. Wind gust from Arome and Hirlam8 score better than wind speed at 925 hPa for wind gust below $25ms^{-1}$, while wind speed at 925 hPa score better for wind gust above $25ms^{-1}$.

Temperature 2m:
For temperature Hirlam12, Hirlam8, Arome and ECMWF all have a negative bias. Both Arome and ECMWF have an increasing negative bias with lead time. After post-processing both Arome and Hirlam8 have almost no bias.

Precipitation:
For precipitation Arome, Hirlam8 and Hirlam12 have almost no bias, while ECMWF have a positive bias. Arome scores best for both light and heavy precipitation, while ECMWF scores better for precipitation between 5 and 30 mm pr 24 hours.

Case VV: Fog over the North Sea:
On June 11-12, AROME has a large area with fog over the North Sea, while satellite images show no fog.

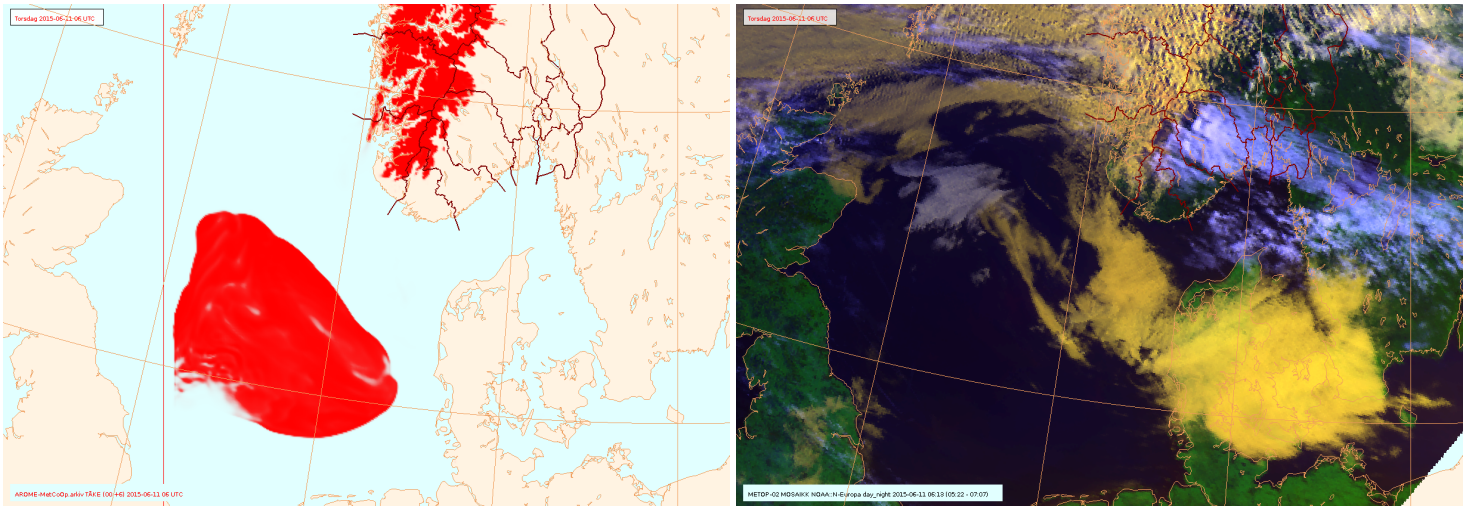
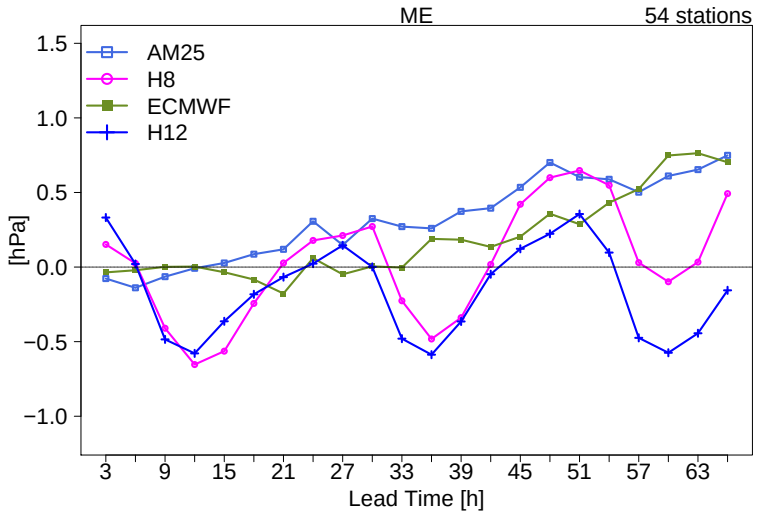
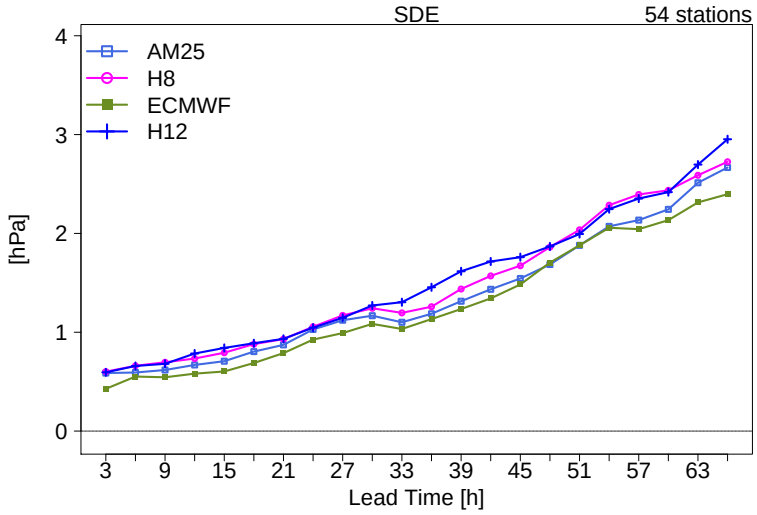
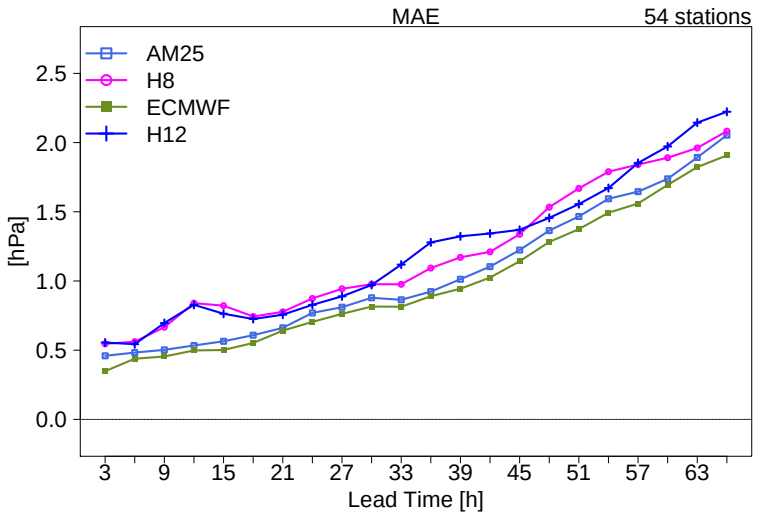


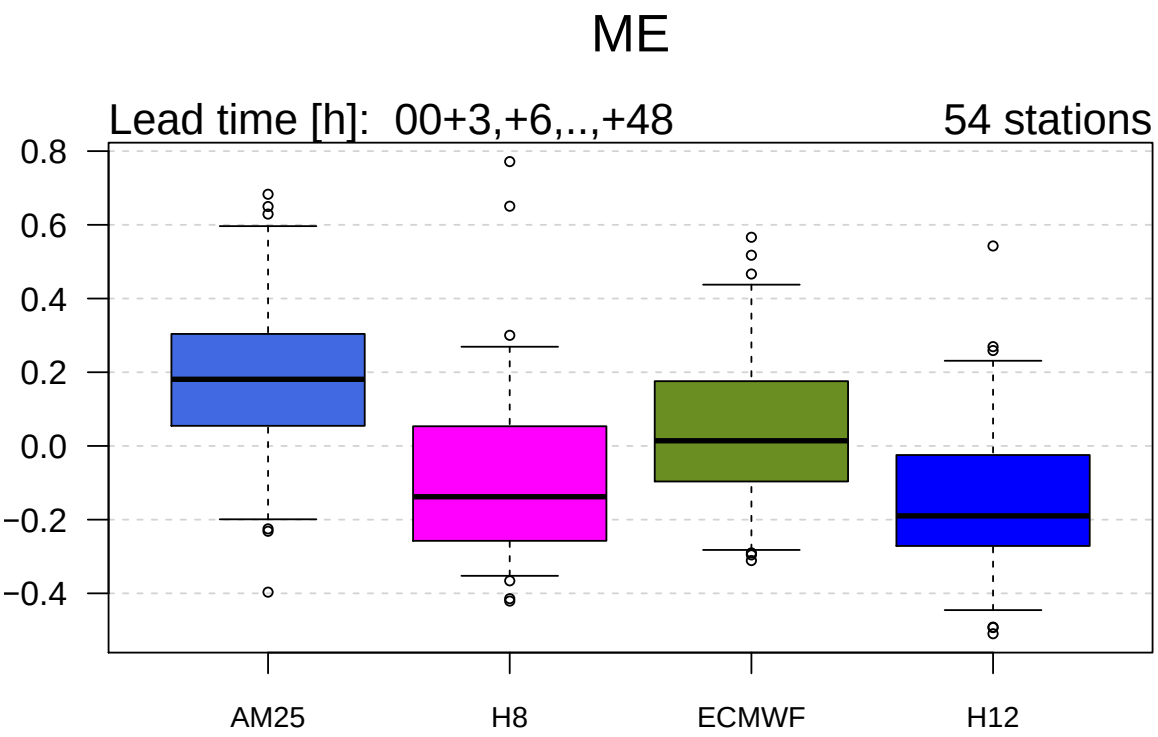
Figure 3: Figures from the June 11 at 06 UTC. Left: Fog from AROME. Right: Satellite image.

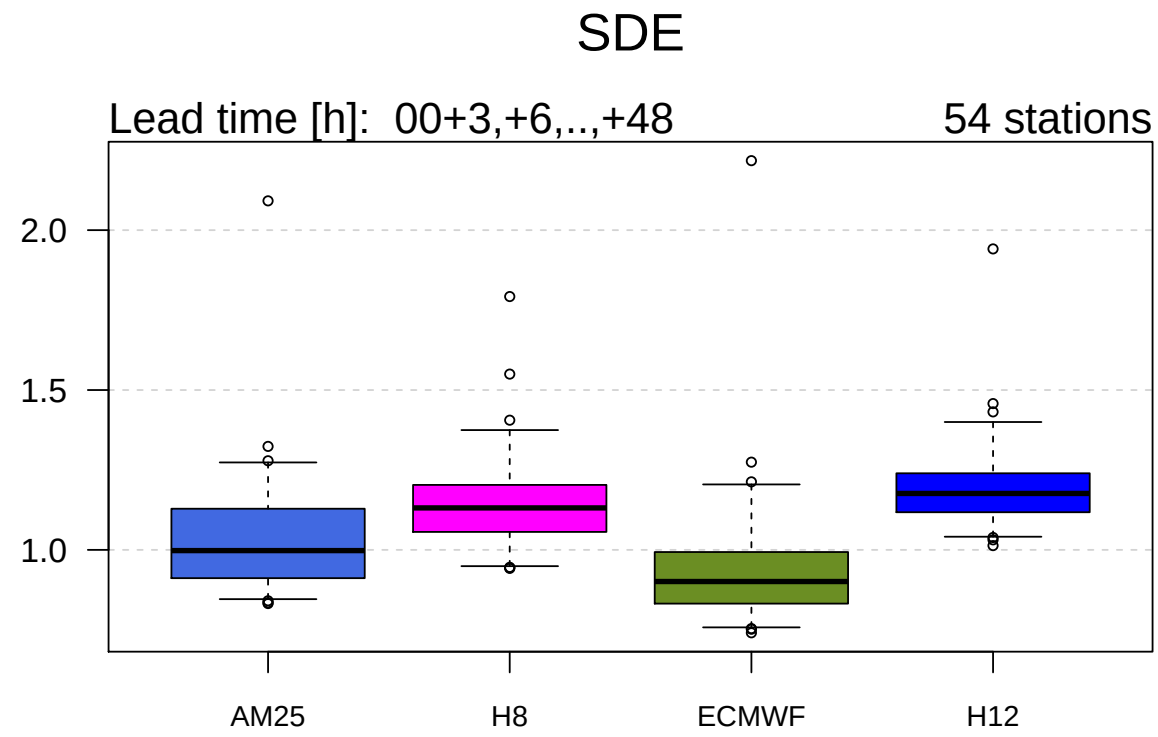
7.2 Pressure


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

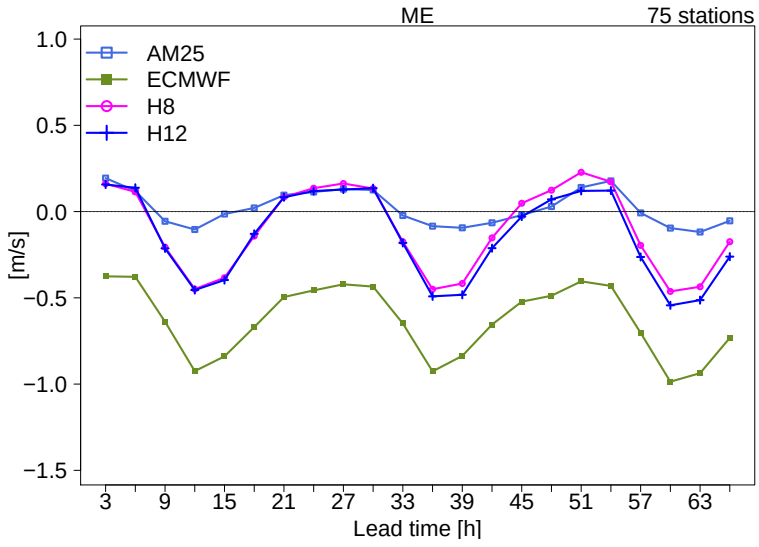

SDE
54 stations
AM25
H8
ECMWF
H12
[hPa]
4
3
2
1
0
3
9
15
21
27
33
39
45
51
57
63
Lead Time [h]

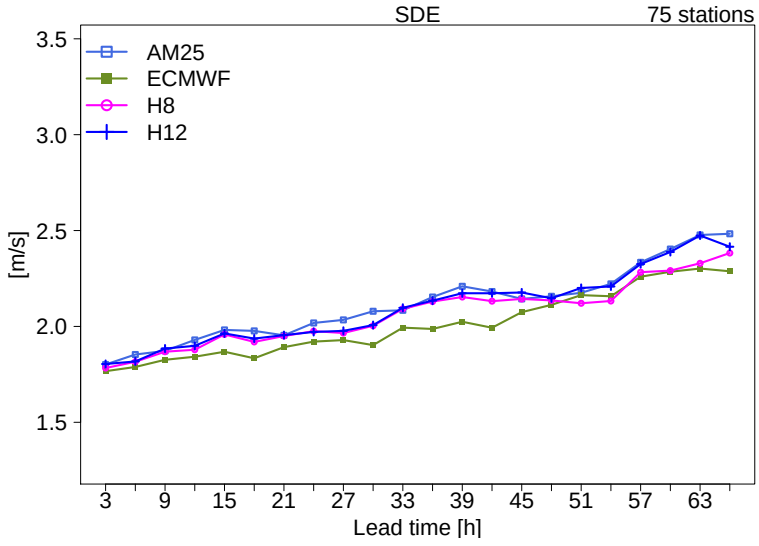

MAE
54 stations
AM25
H8
ECMWF
H12
[hPa]
2.5
2.0
1.5
1.0
0.5
0.0
3
9
15
21
27
33
39
45
51
57
63
Lead Time [h]

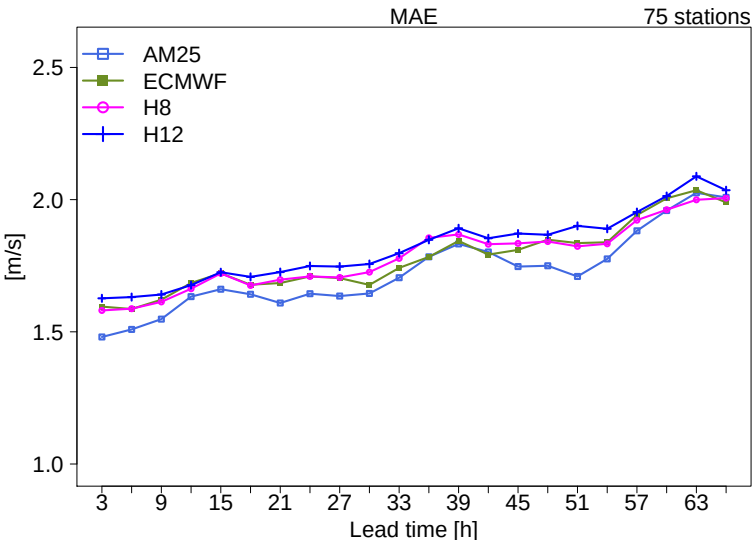

ME
Lead time [h]: 00+3,+6,..,+48
54 stations
0.8
0.6
0.4
0.2
0.0
−0.2
−0.4
AM25
H8
ECMWF
H12

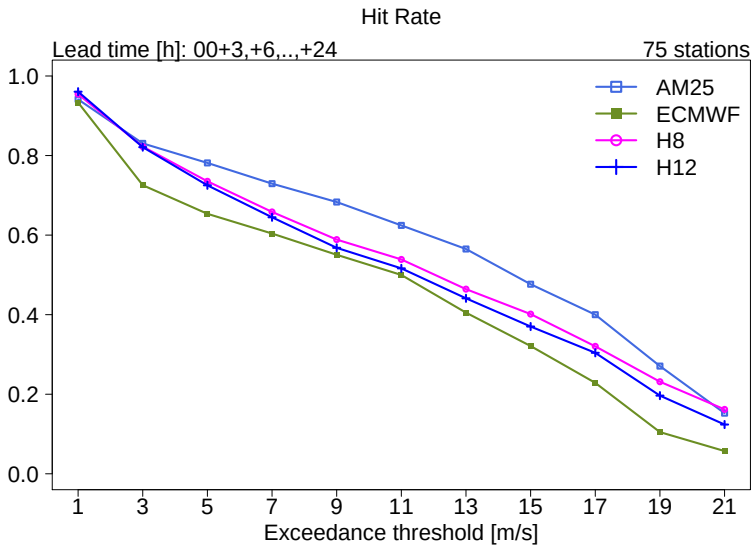

SDE
Lead time [h]: 00+3,+6,..,+48
54 stations
2.0
1.5
1.0
AM25
H8
ECMWF
H12

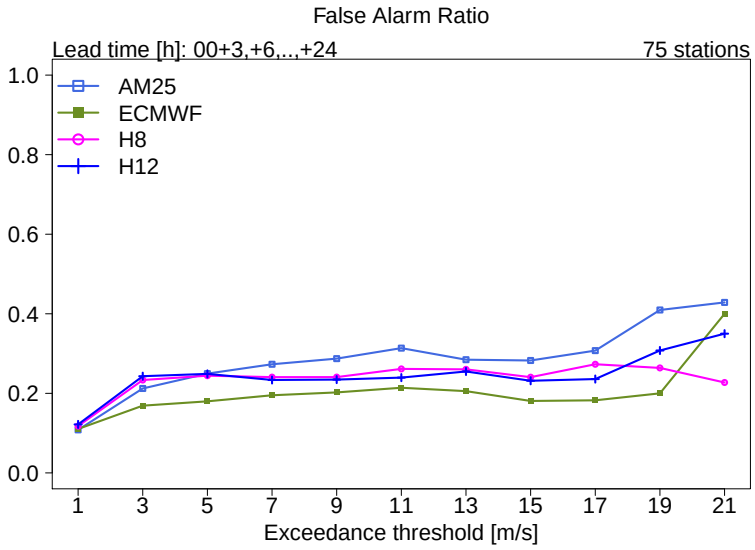
7.3 Wind Speed 10m

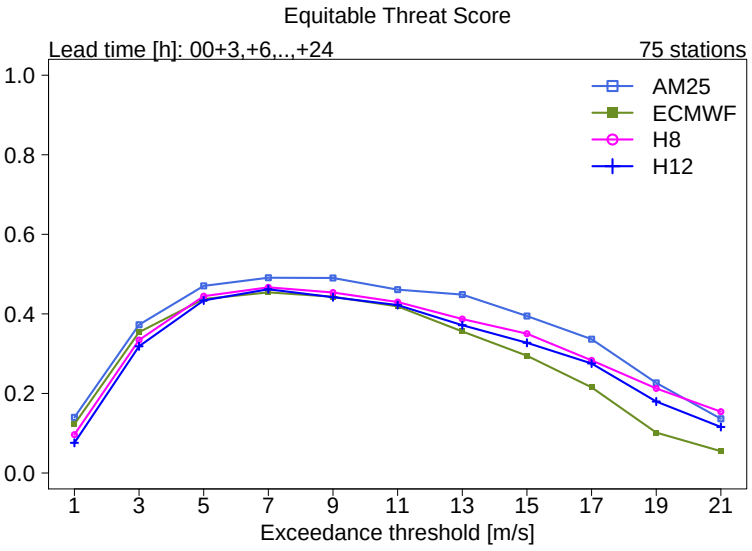


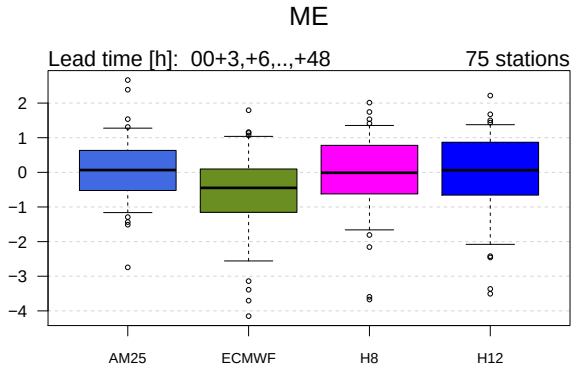


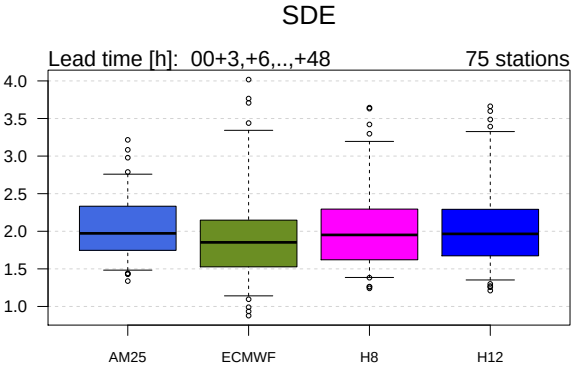



Hit Rate
Lead time [h]: 00+3,+6,..,+24
75 stations
AM25
ECMWF
H8
H12
1.0
0.8
0.6
0.4
0.2
0.0
1 3 5 7 9 11 13 15 17 19 21
Exceedance threshold [m/s]


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]	29585	9966	21	0	0	39572
(3,11]	12602	37398	2468	51	1	52520
(11,17]	75	1746	2789	478	86	5174
(17,21]	4	19	157	219	112	511
(21,Inf]	0	1	7	23	28	59
Sum	42266	49130	5442	771	227	97836

H8

OBS

	[0,3]	(3,11]	(11,17]	(17,21]	(21,Inf]	Sum
[0,3]	27778	10142	106	5	1	38032
(3,11]	14470	37727	2792	146	14	55149
(11,17]	17	1250	2430	434	98	4229
(17,21]	1	10	112	178	84	385
(21,Inf]	0	1	2	8	30	41
Sum	42266	49130	5442	771	227	97836

ECMWF

OBS

	[0,3]	(3,11]	(11,17]	(17,21]	(21,Inf]	Sum
[0,3]	33819	15289	282	22	3	49415
(3,11]	8440	32895	2836	162	18	44351
(11,17]	7	934	2259	470	105	3775
(17,21]	0	9	64	112	91	276
(21,Inf]	0	3	1	5	10	19
Sum	42266	49130	5442	771	227	97836

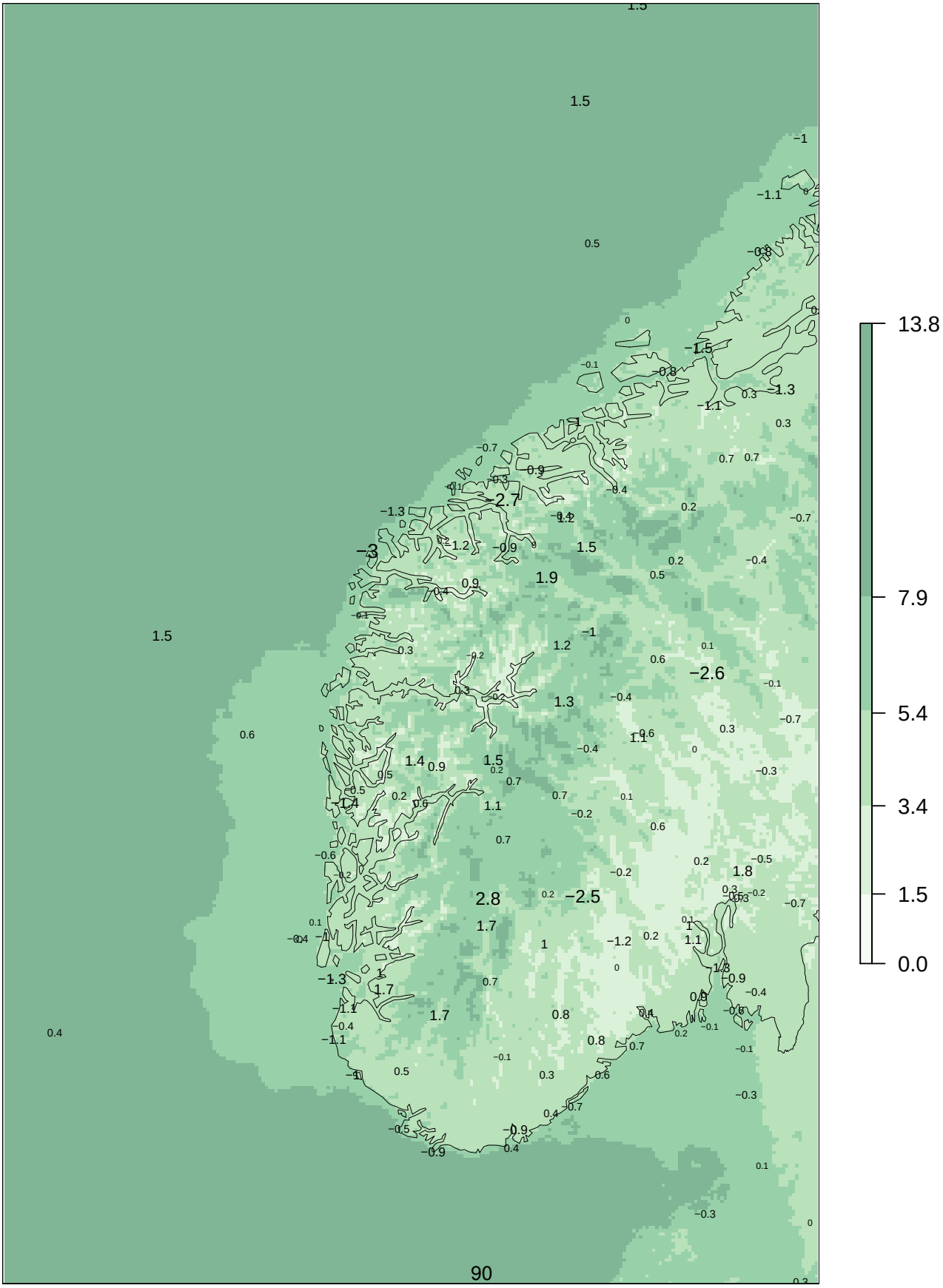
H12

OBS

	[0,3]	(3,11]	(11,17]	(17,21]	(21,Inf]	Sum
[0,3]	27293	10264	82	0	0	37639
(3,11]	14963	37751	2961	174	17	55866
(11,17]	9	1106	2306	423	105	3949
(17,21]	1	9	91	164	81	346
(21,Inf]	0	0	2	10	24	36
Sum	42266	49130	5442	771	227	97836

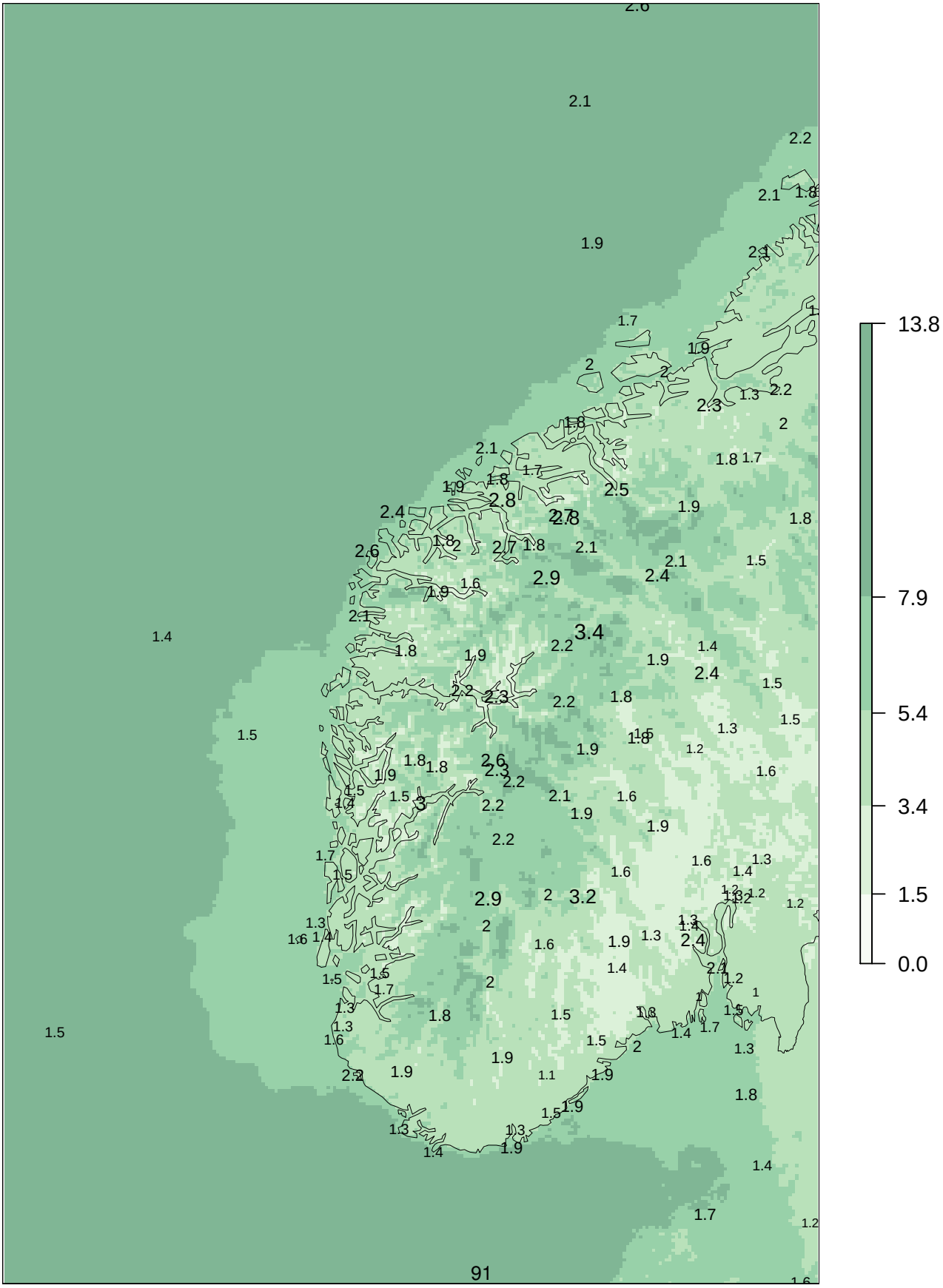
AM25 00+12

ME at observing sites forecast means 01.03.2015 − 31.05.2015

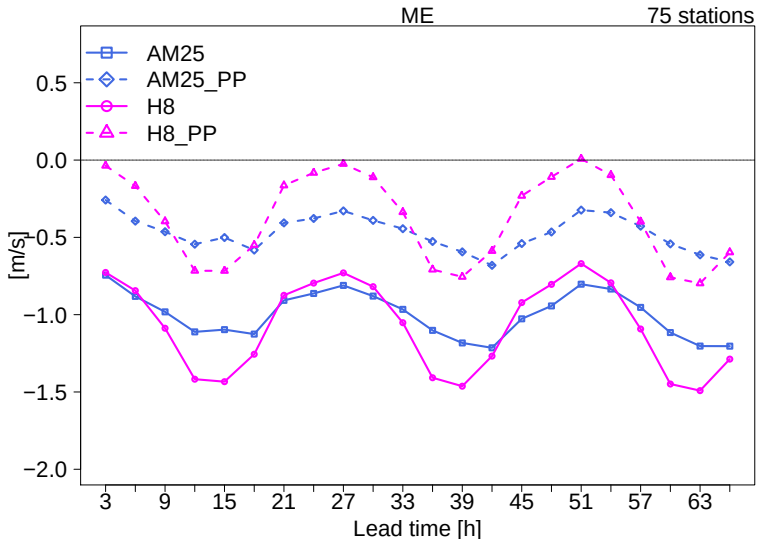


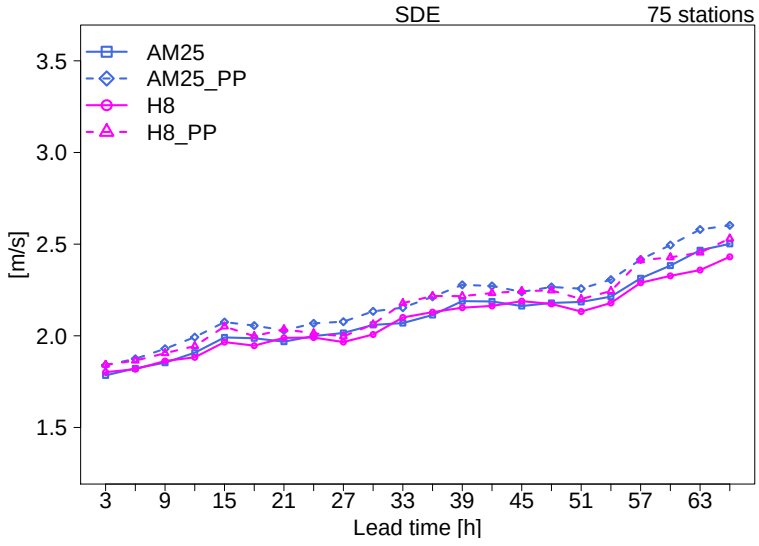
AM25 00+12

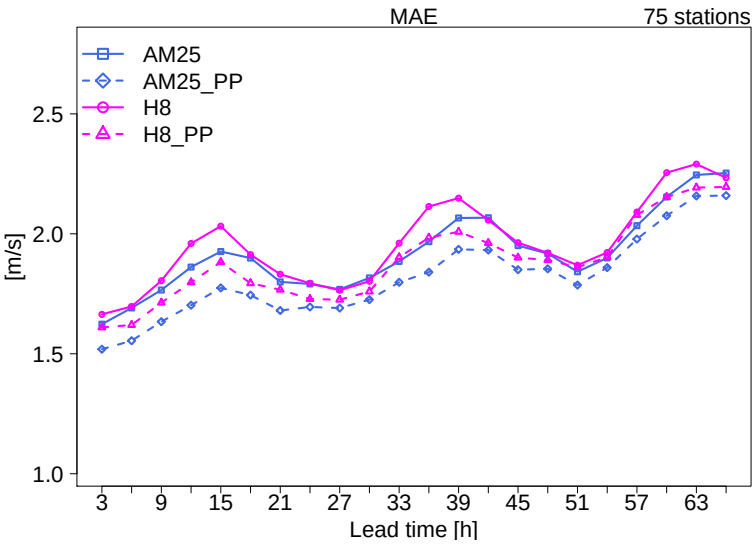
SDE at observing sites forecast means 01.03.2015 − 31.05.2015

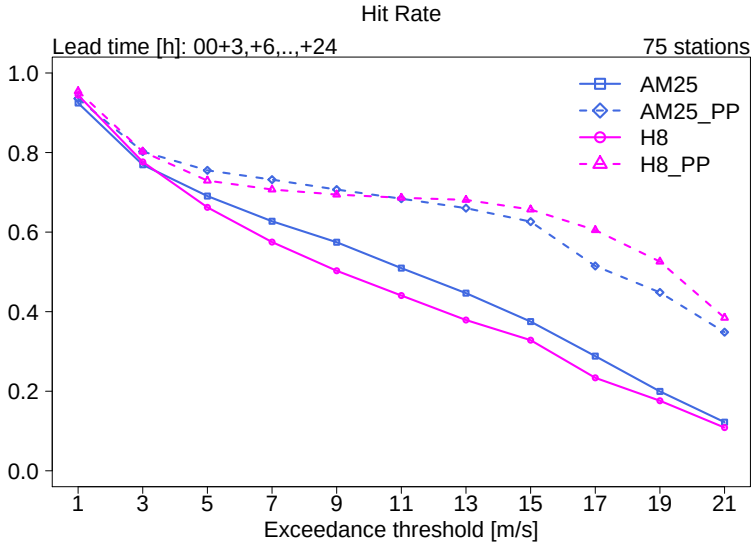


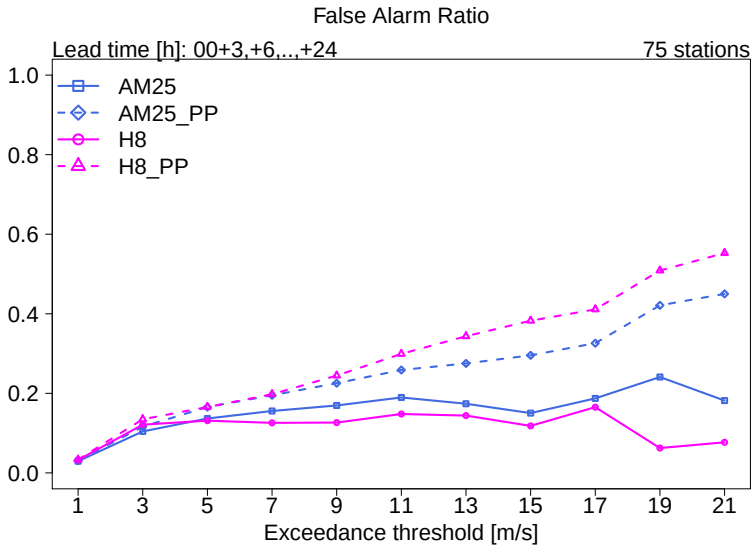
7.4 Max Mean Wind Speed 10m

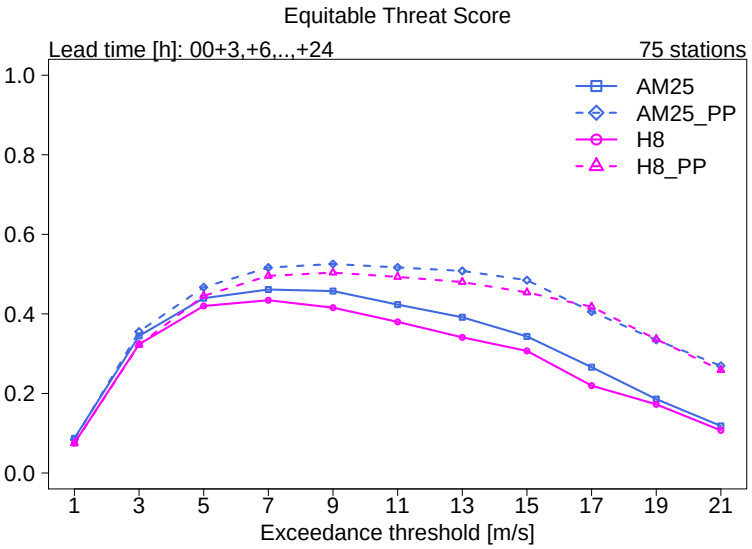




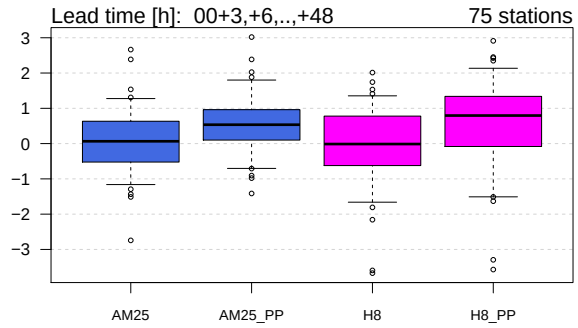



Hit Rate
Lead time [h]: 00+3,+6,..,+24
75 stations
AM25
AM25_PP
H8
H8_PP
1.0
0.8
0.6
0.4
0.2
0.0
1 3 5 7 9 11 13 15 17 19 21
Exceedance threshold [m/s]

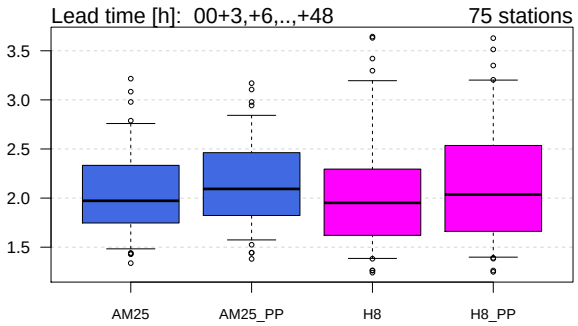

False Alarm Ratio
Lead time [h]: 00+3,+6,..,+24
75 stations
AM25
AM25_PP
H8
H8_PP
1.0
0.8
0.6
0.4
0.2
0.0
1 3 5 7 9 11 13 15 17 19 21
Exceedance threshold [m/s]


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]

ME



SDE



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]	22163	15821	65	0	0	38049
(3,11]	6164	39906	4481	147	11	50709
(11,17]	23	1087	2963	835	201	5109
(17,21]	0	12	100	214	189	515
(21,Inf]	0	0	1	19	43	63
Sum	28350	56826	7610	1215	444	94445

AM25_PP

OBS

	[0,3]	(3,11]	(11,17]	(17,21]	(21,Inf]	Sum
[0,3]	21089	13534	52	0	0	34675
(3,11]	7222	41054	3029	67	5	51377
(11,17]	39	2206	4122	646	115	7128
(17,21]	0	32	379	396	174	981
(21,Inf]	0	0	28	106	150	284
Sum	28350	56826	7610	1215	444	94445

H8

OBS

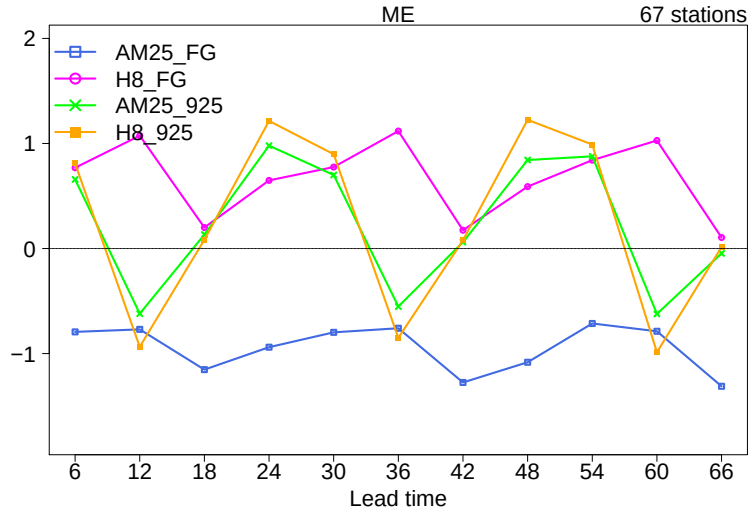
	[0,3]	(3,11]	(11,17]	(17,21]	(21,Inf]	Sum
[0,3]	20772	14938	166	7	3	35886
(3,11]	7574	41131	4839	239	38	53821
(11,17]	4	753	2531	791	215	4294
(17,21]	0	4	73	173	150	400
(21,Inf]	0	0	1	5	38	44
Sum	28350	56826	7610	1215	444	94445

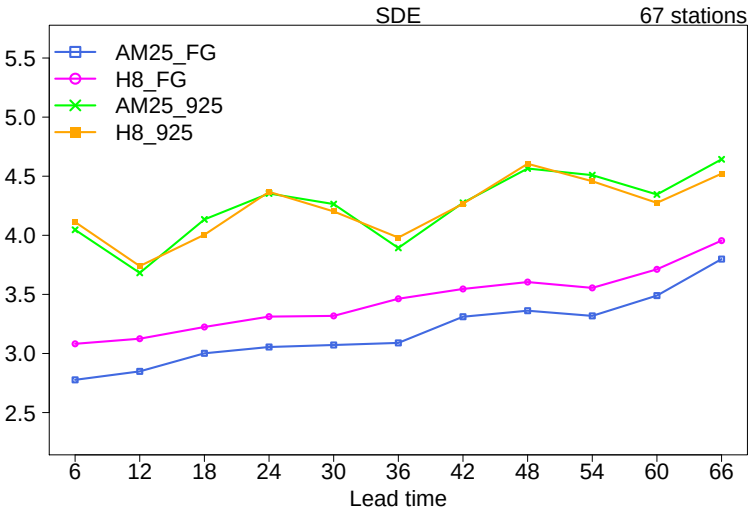
H8_PP

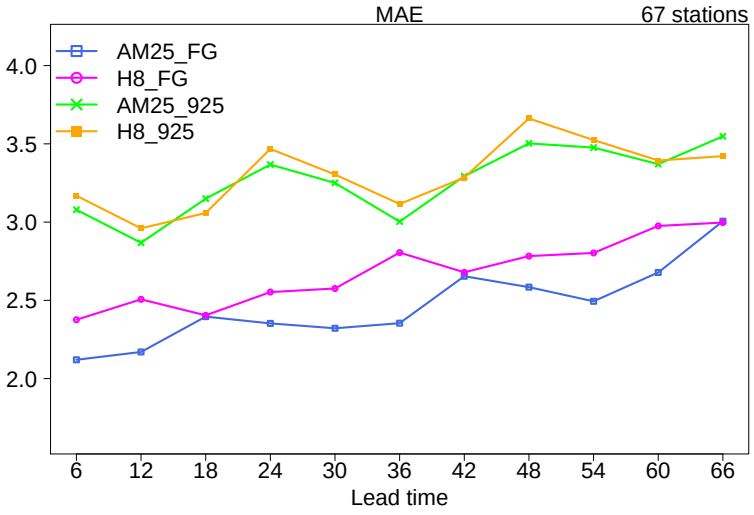
OBS

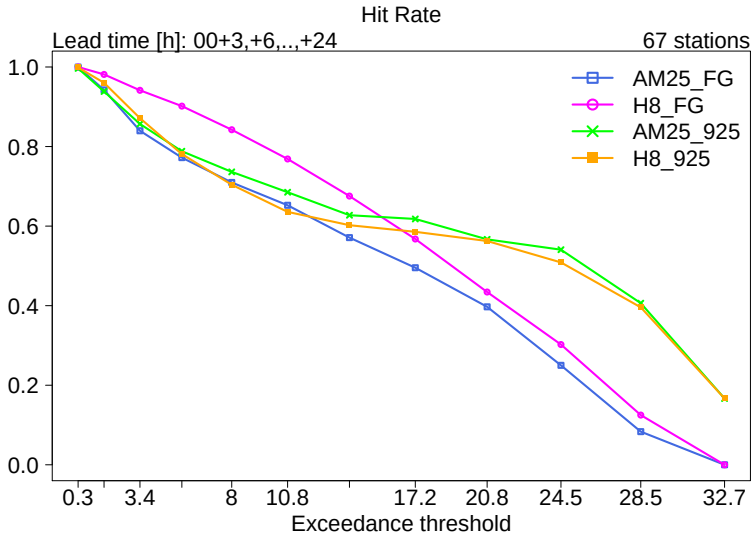
	[0,3]	(3,11]	(11,17]	(17,21]	(21,Inf]	Sum
[0,3]	19648	13157	113	2	0	32920
(3,11]	8676	40817	2864	102	24	52483
(11,17]	25	2787	3996	471	73	7352
(17,21]	1	61	584	490	184	1320
(21,Inf]	0	4	53	150	163	370
Sum	28350	56826	7610	1215	444	94445

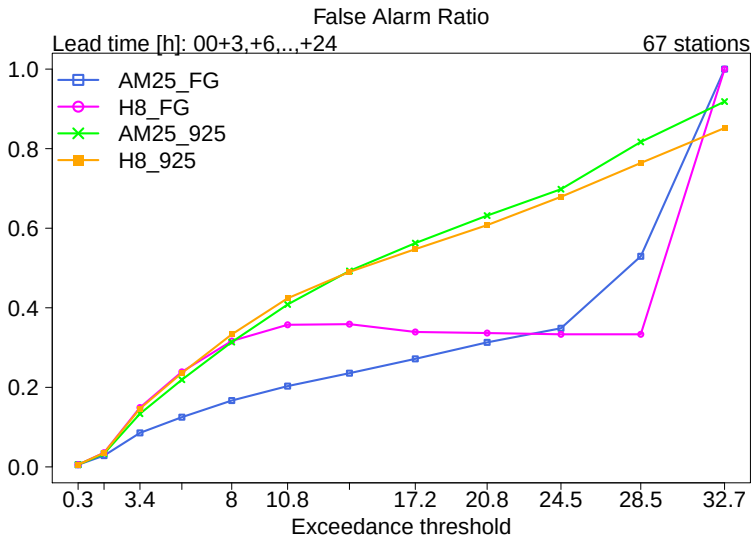
7.5 Wind gust

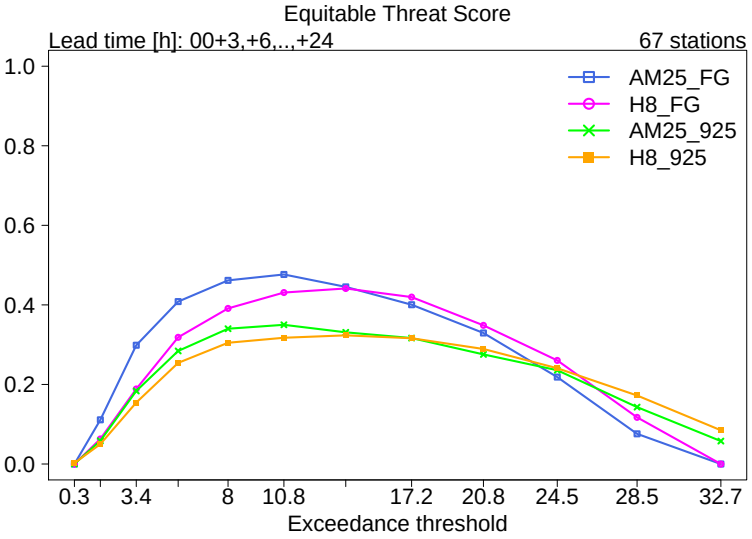

ME
67 stations
AM25_FG
H8_FG
AM25_925
H8_925
2
1
0
−1
6
12
18
24
30
36
42
48
54
60
66
Lead time


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

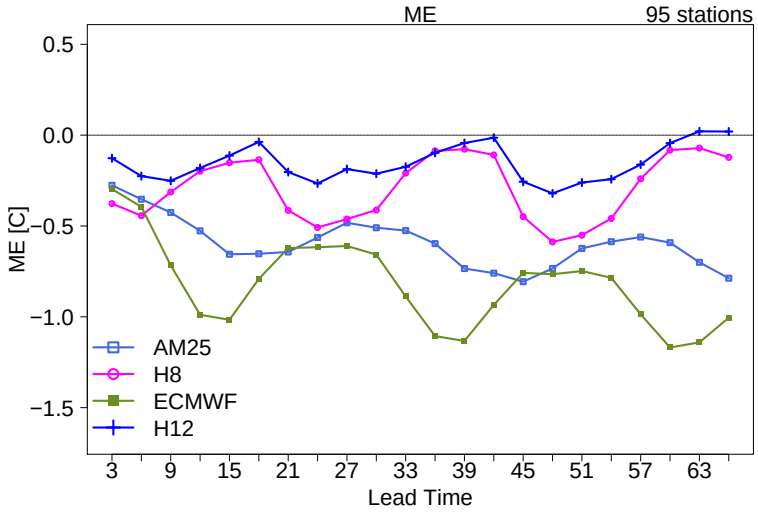

MAE
67 stations
AM25_FG
H8_FG
AM25_925
H8_925
4.0
3.5
3.0
2.5
2.0
6
12
18
24
30
36
42
48
54
60
66
Lead time

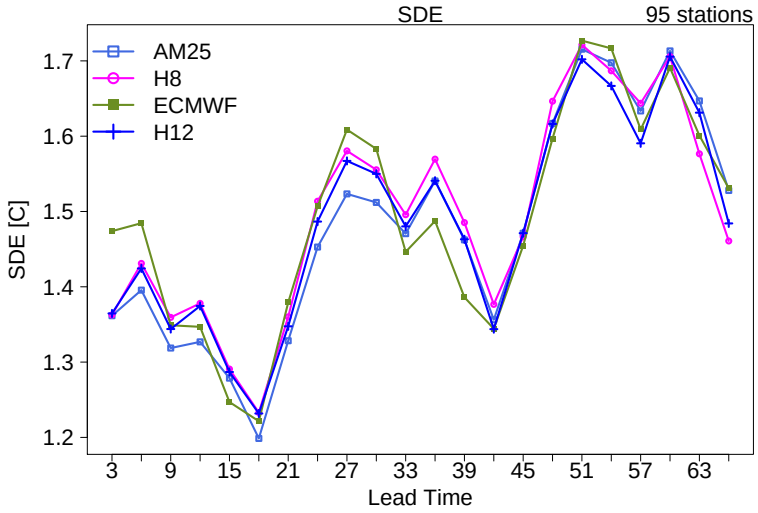

Hit Rate
Lead time [h]: 00+3,+6,..,+24
67 stations
AM25_FG
H8_FG
AM25_925
H8_925
1.0
0.8
0.6
0.4
0.2
0.0
0.3
3.4
8
10.8
17.2
20.8
24.5
28.5
32.7
Exceedance threshold

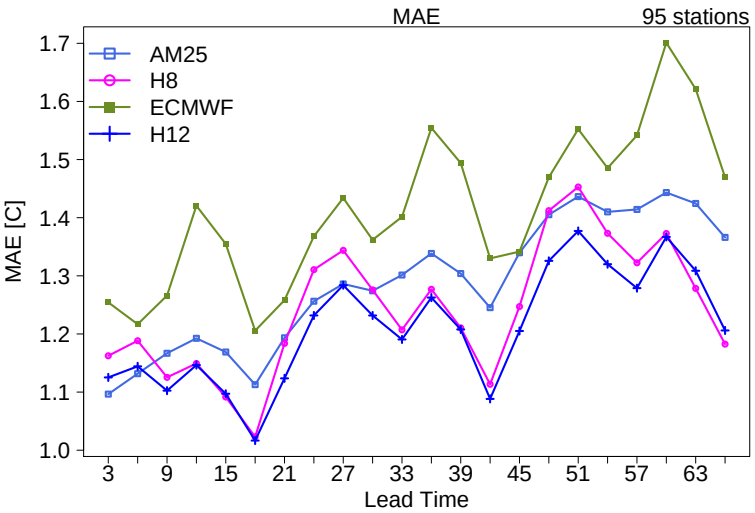

False Alarm Ratio
Lead time [h]: 00+3,+6,..,+24
67 stations
AM25_FG
H8_FG
AM25_925
H8_925
1.0
0.8
0.6
0.4
0.2
0.0
0.3
3.4
8
10.8
17.2
20.8
24.5
28.5
32.7
Exceedance threshold

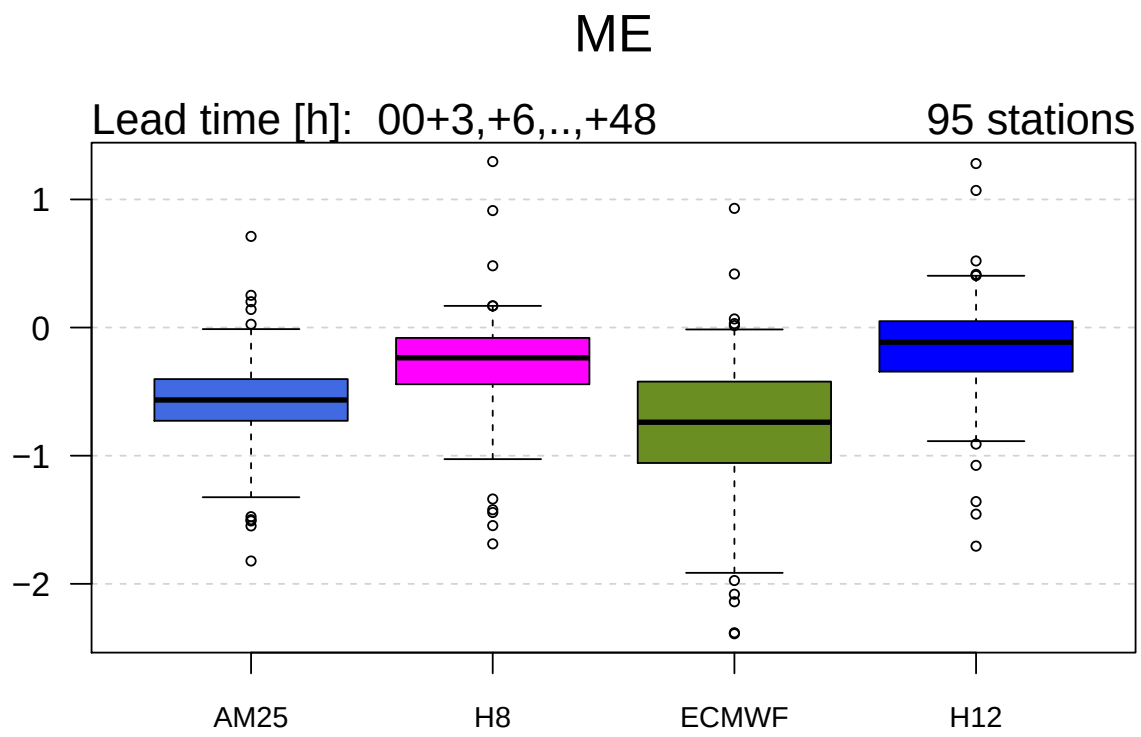

Equitable Threat Score
Lead time [h]: 00+3,+6,..,+24
67 stations
AM25_FG
H8_FG
AM25_925
H8_925
1.0
0.8
0.6
0.4
0.2
0.0
0.3
3.4
8
10.8
17.2
20.8
24.5
28.5
32.7
Exceedance threshold

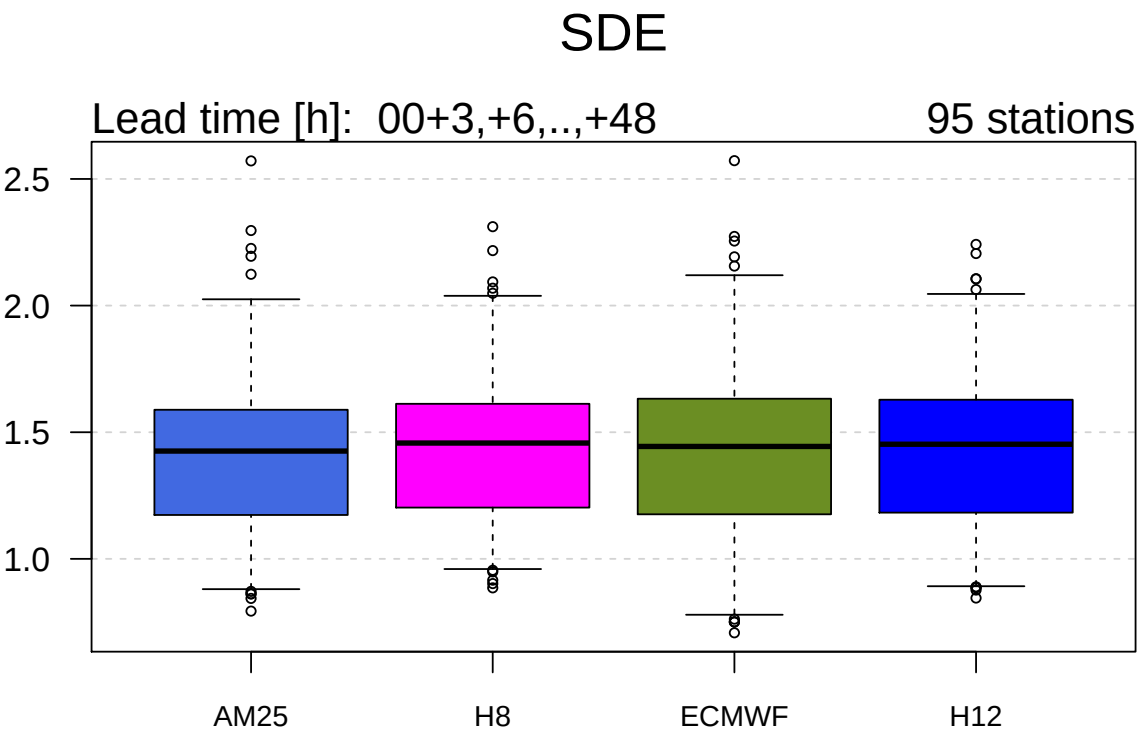
7.6 Temperature 2m





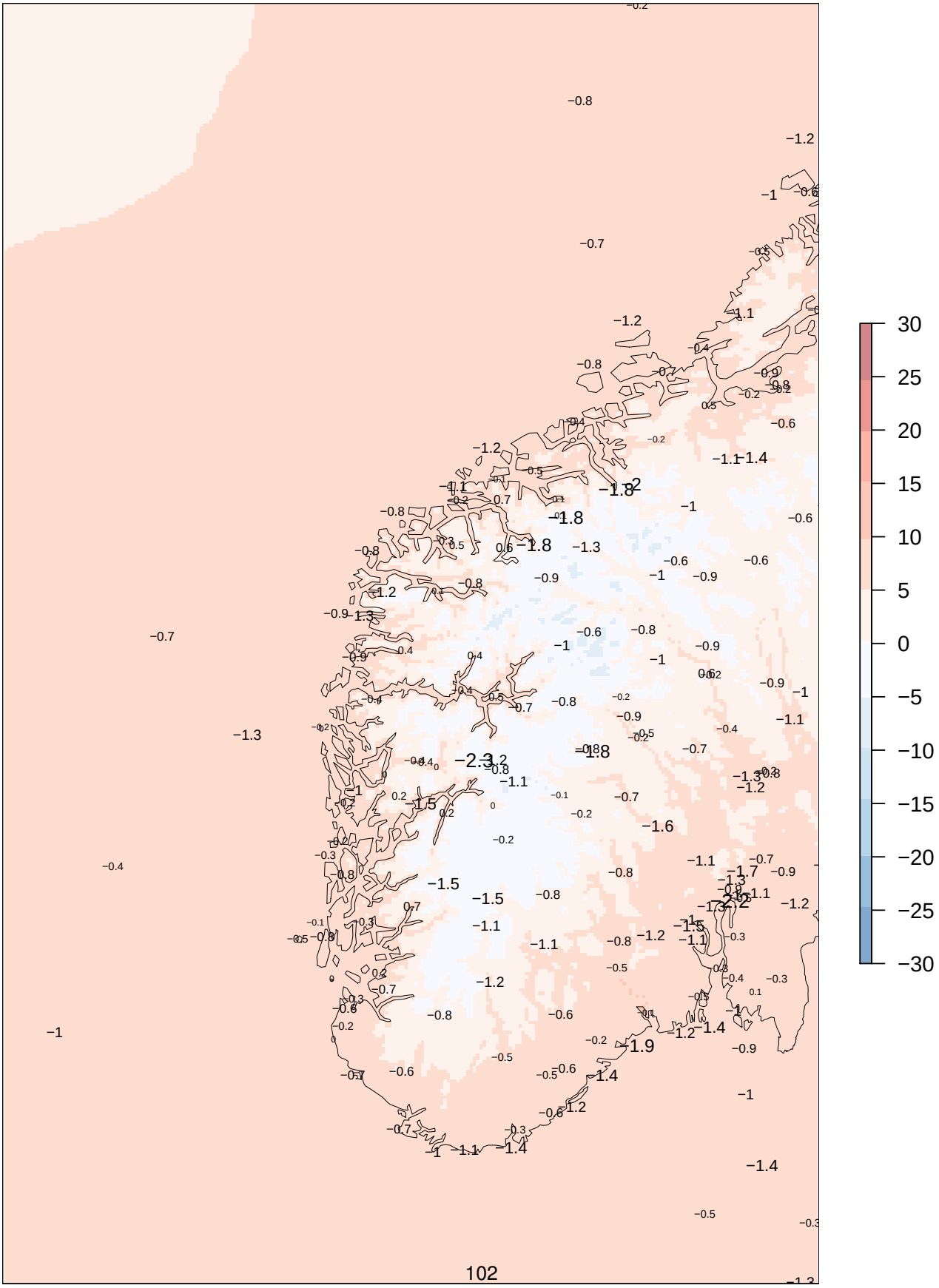



ME
Lead time [h]: 00+3,+6,..,+48
95 stations
1
0
−1
−2
AM25
H8
ECMWF
H12


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

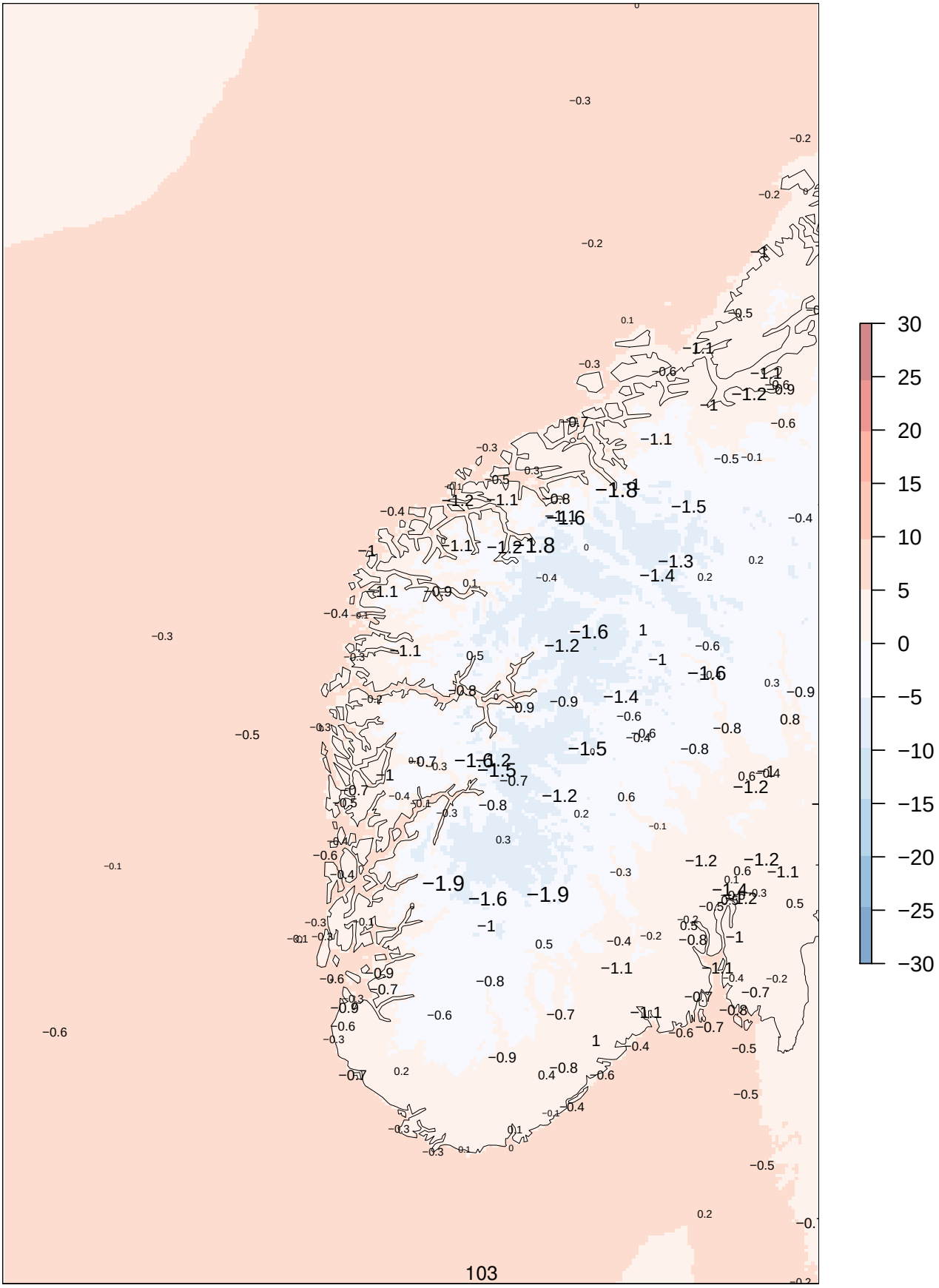
AM25 00+12

ME at observing sites forecast means 01.03.2015 − 31.05.2015



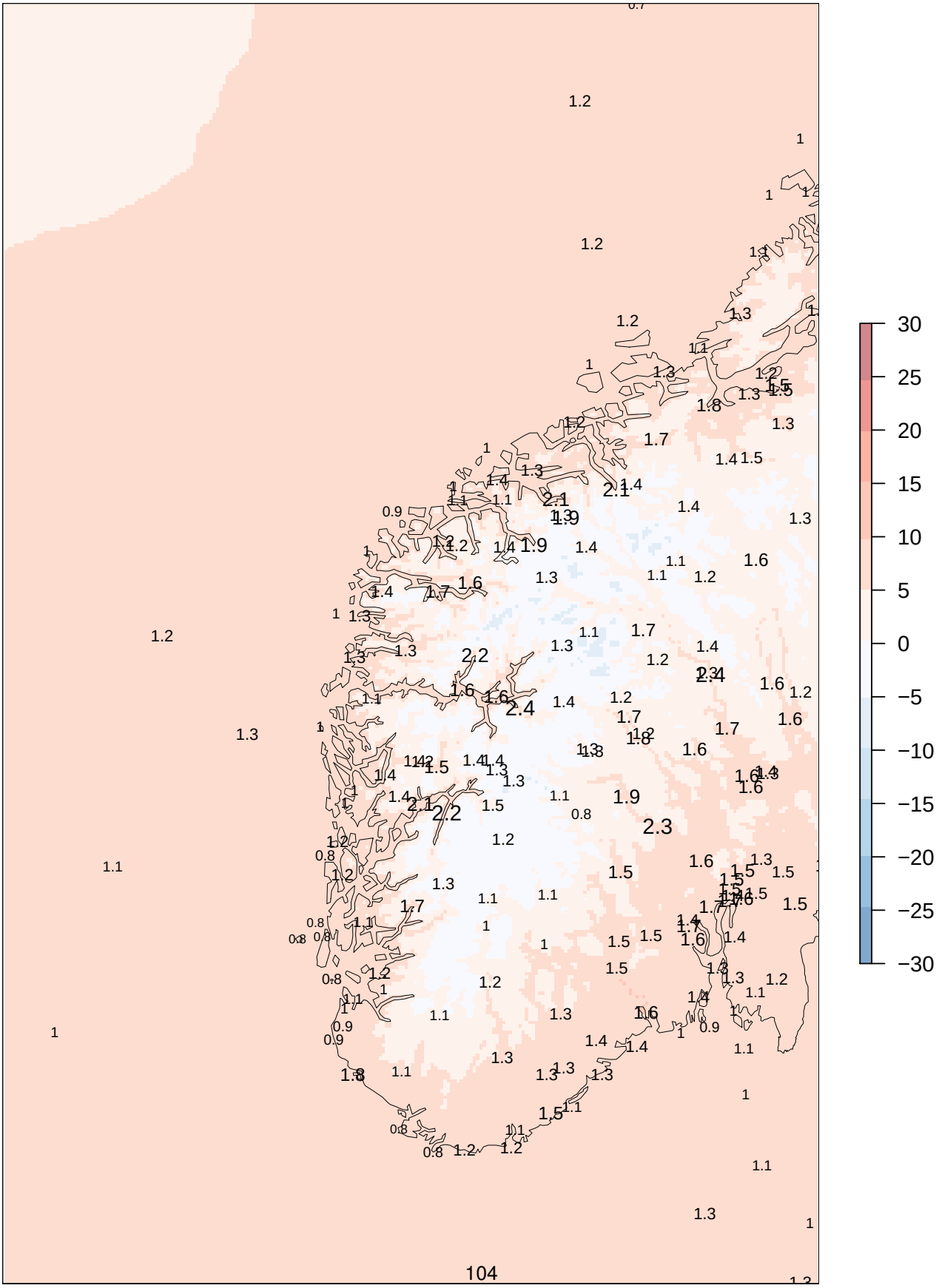
AM25 00+24

ME at observing sites forecast means 01.03.2015 − 31.05.2015



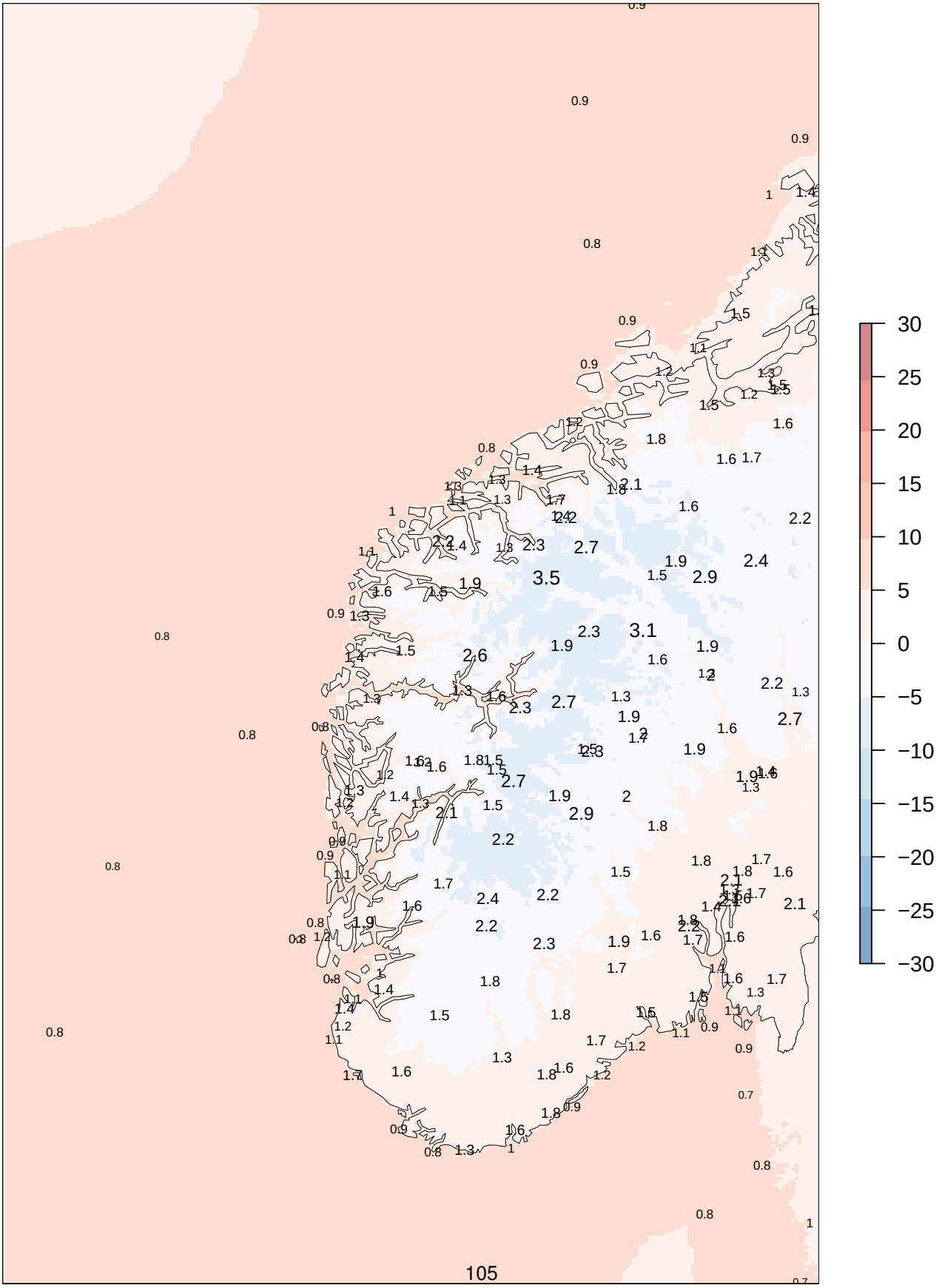
AM25 00+12

SDE at observing sites forecast means 01.03.2015 − 31.05.2015

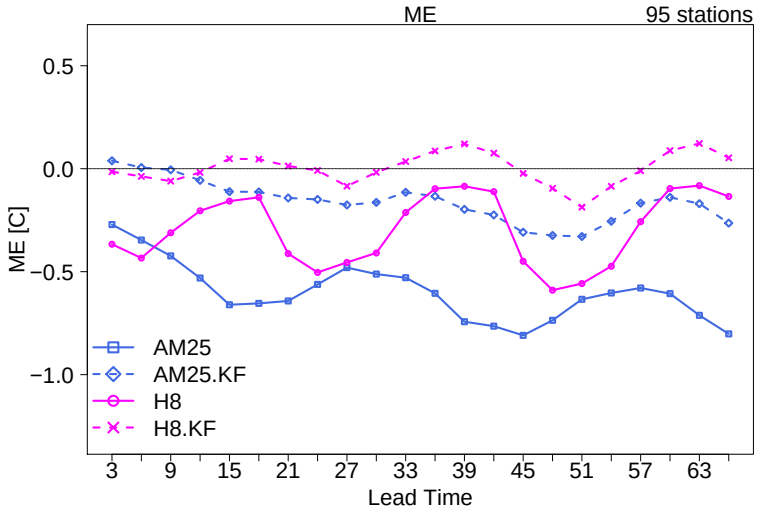


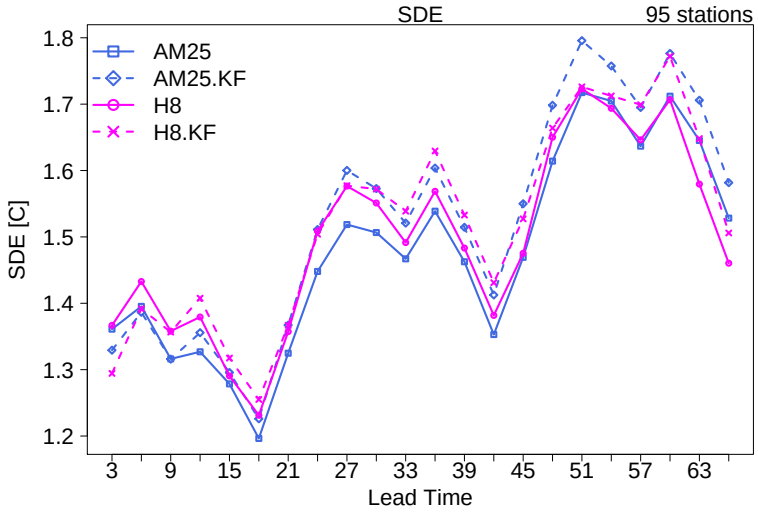
AM25 00+24

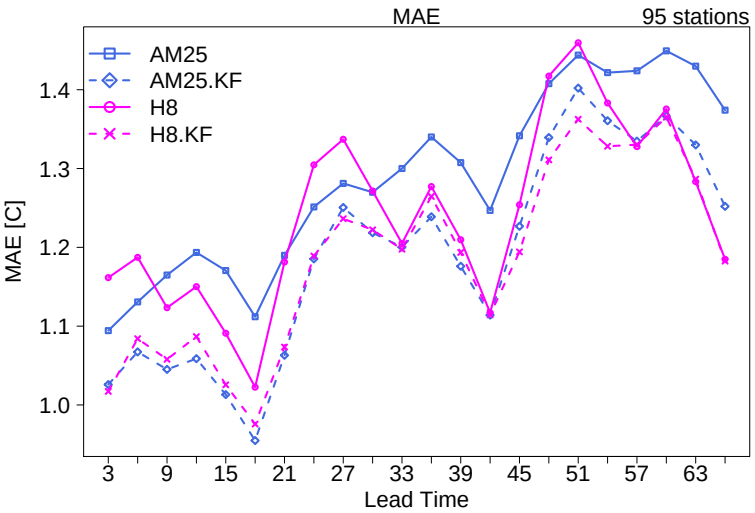
SDE at observing sites forecast means 01.03.2015 − 31.05.2015

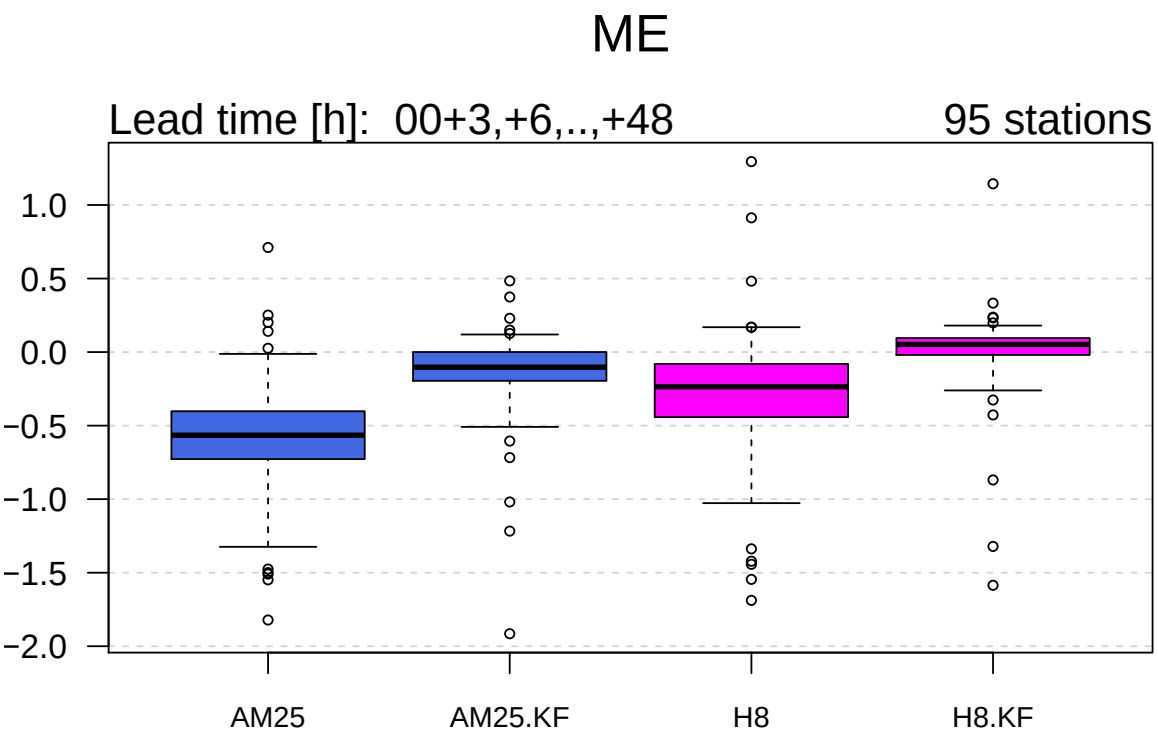


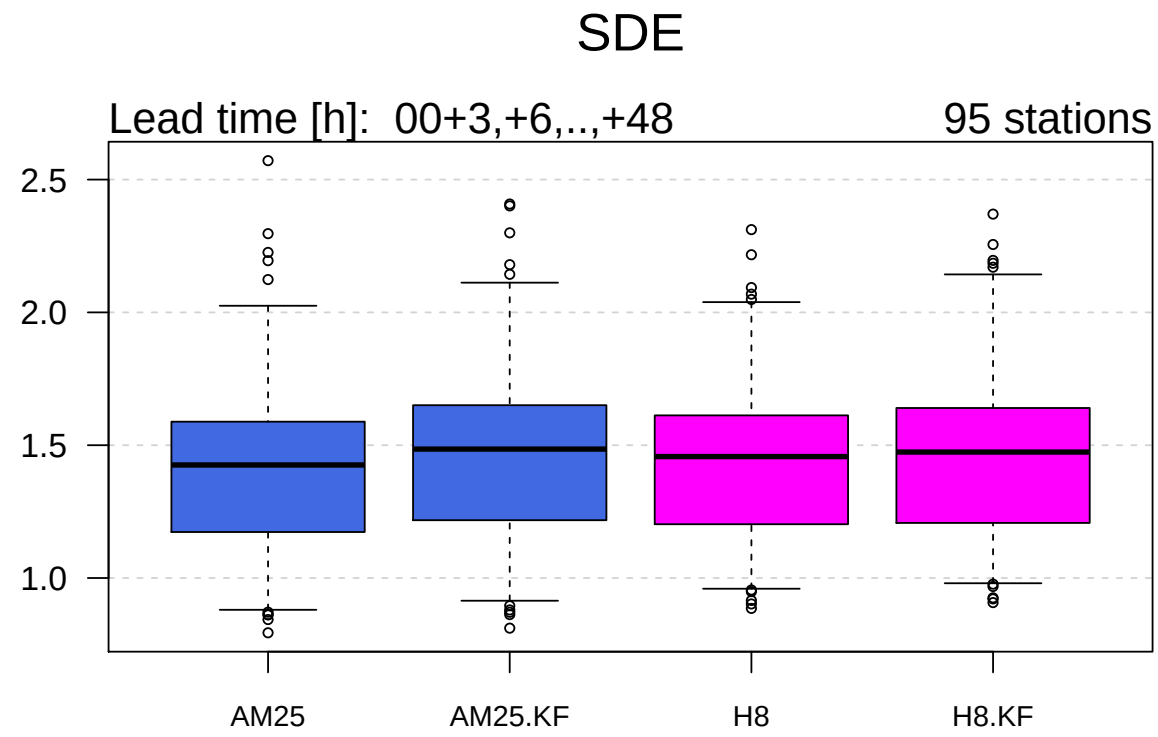
7.7 Post processed temperature 2m



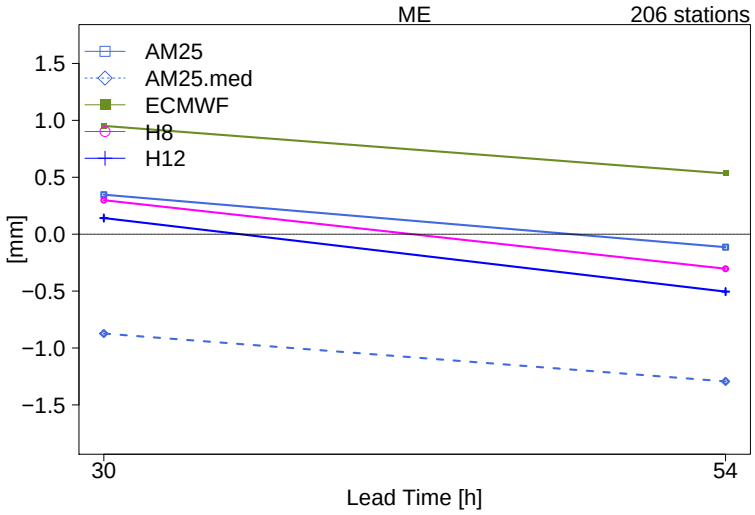


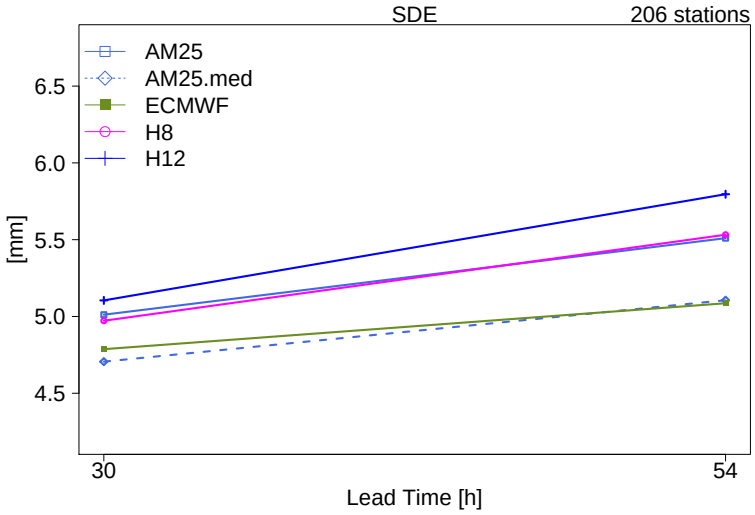


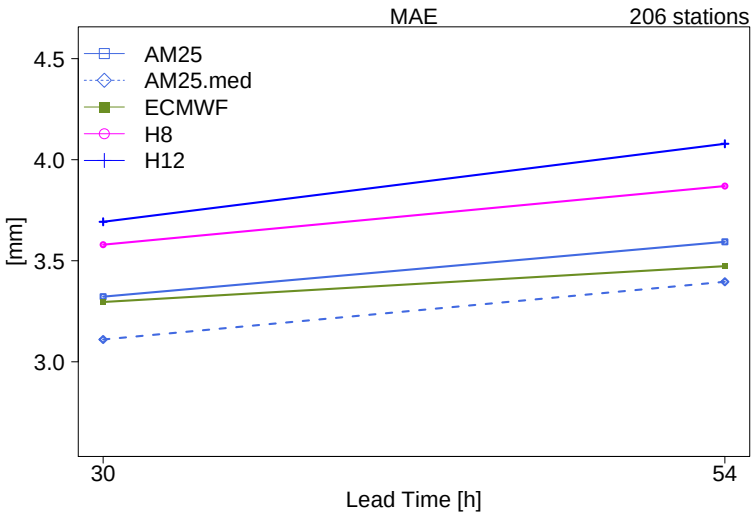

ME
Lead time [h]: 00+3,+6,..,+48
95 stations
1.0
0.5
0.0
−0.5
−1.0
−1.5
−2.0
AM25
AM25.KF
H8
H8.KF

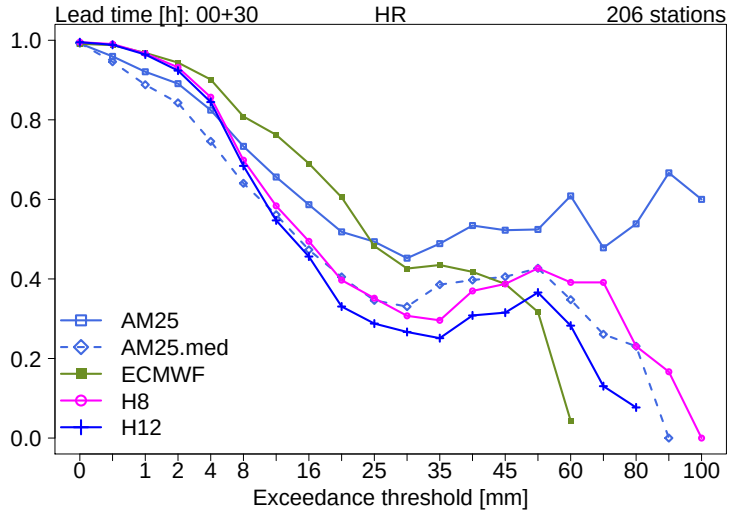

SDE
Lead time [h]: 00+3,+6,..,+48
95 stations
2.5
2.0
1.5
1.0
AM25
AM25.KF
H8
H8.KF

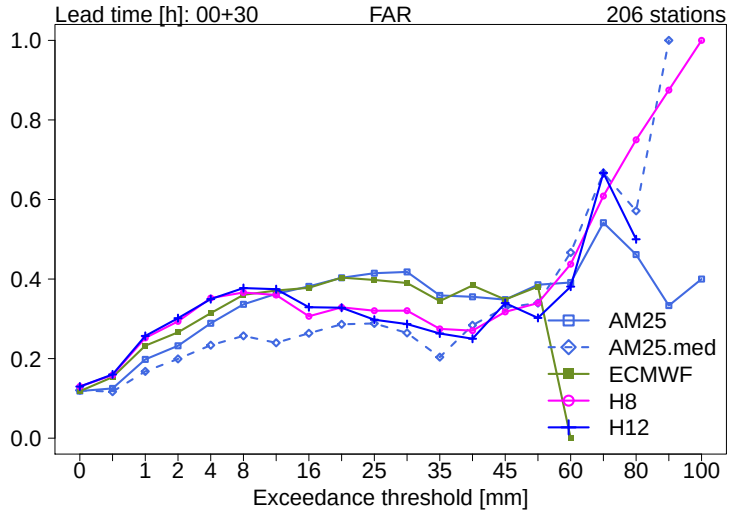
7.8 Daily precipitation

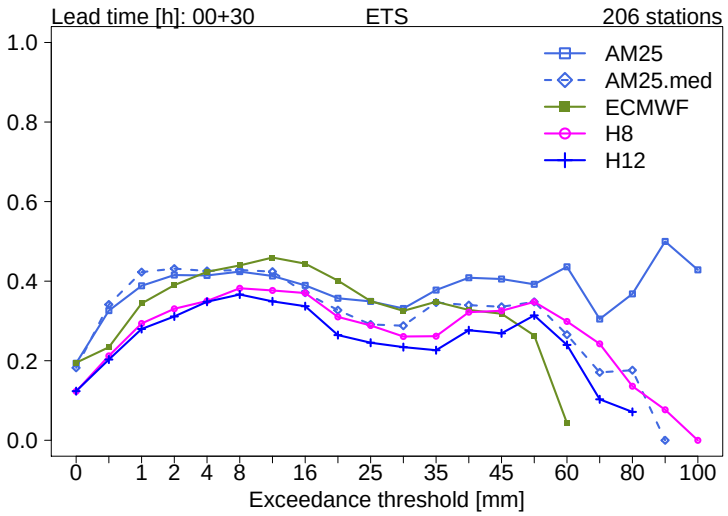


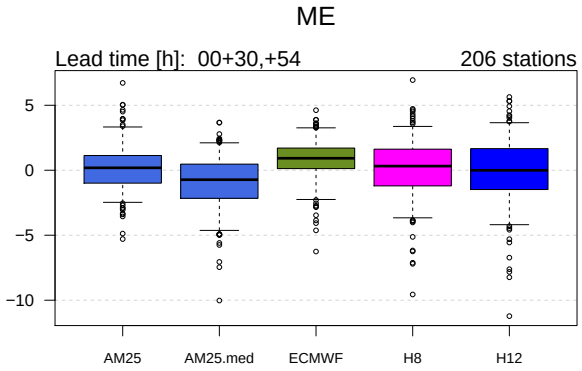


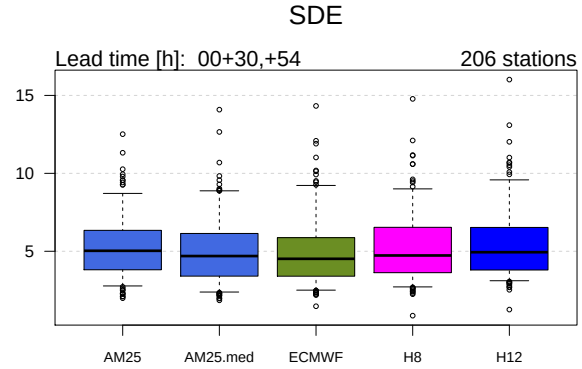



Lead time [h]: 00+30
HR
206 stations
1.0
0.8
0.6
0.4
0.2
0.0
AM25
AM25.med
ECMWF
H8
H12
0 1 2 4 8 16 25 35 45 60 80 100
Exceedance threshold [mm]


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]	2539	967	30	2	0	3538
(0.1,5]	2552	8047	2120	61	0	12780
(5,20]	279	2815	5099	827	8	9028
(20,50]	14	88	461	672	72	1307
(50,Inf]	2	2	8	42	84	138
Sum	5386	11919	7718	1604	164	26791

AM25.med — OBS

	[0,0.1]	(0.1,5]	(5,20]	(20,50]	(50,Inf]	Sum
[0,0.1]	2745	1200	46	2	0	3993
(0.1,5]	2491	8797	2845	103	0	14236
(5,20]	139	1883	4604	980	23	7629
(20,50]	9	39	219	490	70	827
(50,Inf]	2	0	4	29	71	106
Sum	5386	11919	7718	1604	164	26791

ECMWF — OBS

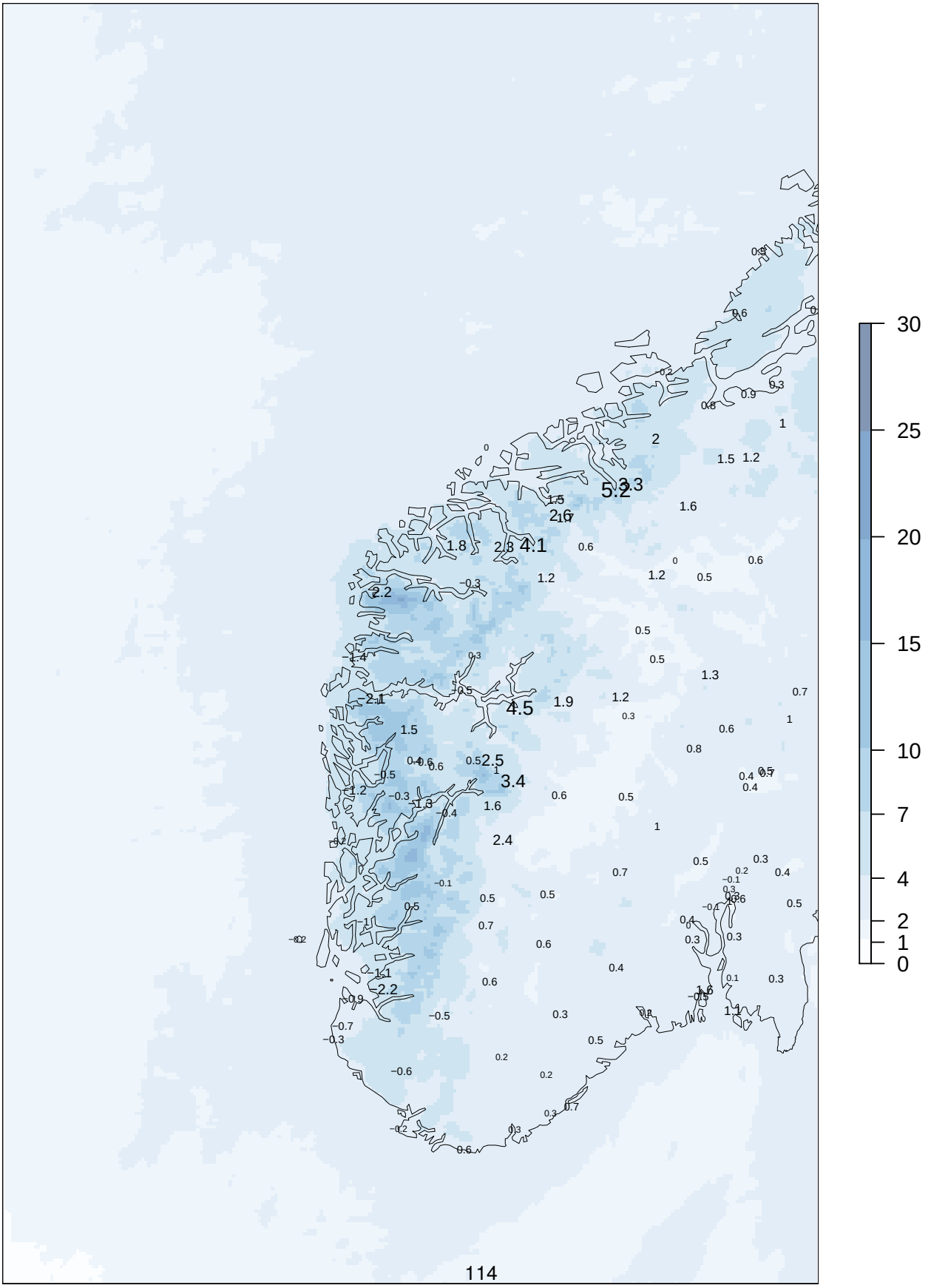
	[0,0.1]	(0.1,5]	(5,20]	(20,50]	(50,Inf]	Sum
[0,0.1]	1715	309	5	0	0	2029
(0.1,5]	3441	7829	1366	28	0	12664
(5,20]	215	3752	5765	760	11	10503
(20,50]	13	28	580	791	93	1505
(50,Inf]	2	1	2	25	60	90
Sum	5386	11919	7718	1604	164	26791

H8 — OBS

	[0,0.1]	(0.1,5]	(5,20]	(20,50]	(50,Inf]	Sum
[0,0.1]	1457	268	5	0	0	1730
(0.1,5]	3512	7938	2058	71	0	13579
(5,20]	405	3683	5415	1047	16	10566
(20,50]	11	28	237	460	77	813
(50,Inf]	1	2	3	26	71	103
Sum	5386	11919	7718	1604	164	26791

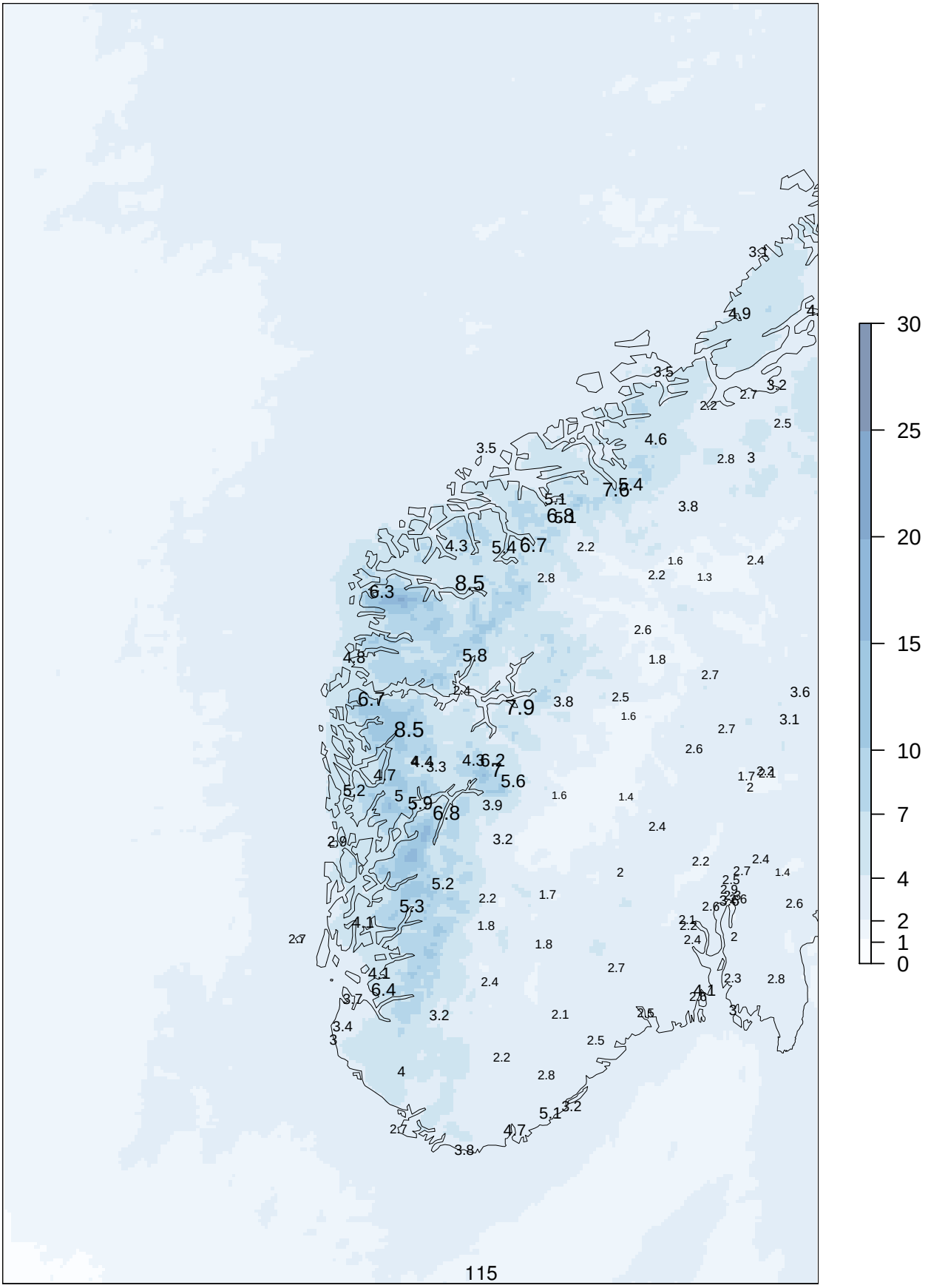
AM25 00+30

ME at observing sites forecast means 01.03.2015 − 31.05.2015



AM25 00+30

SDE at observing sites forecast means 01.03.2015 − 31.05.2015



8 Northern Norway

8.1 Comments to the verification results

Case VNN: Complex topography, Arome 2.5km and preciptiation distribution

Episode with heavy precipitation in Vest-Finnmark May 23-24 2015

Synoptic situation: Slow moving system with semi-stationary occlusion front.
Feature: Heavy precipitation, 9 observations with 20-45mm/24h. Several "seasonal" records.

Model AROME 18Z 15.05.24
Max values: 105mm/24h (raw) 70mm/24h (pp-max) 55mm/24h (pp-median)
Max values lowland (<200m): 55mm/24h (estimated with topography mask.)

Comparing model with observations (mainly in lowland) shows that the model overall underpredicted the amounts. However, the model have much more precipitation at higher elevations, where we have no observations.

It is important to compare the precipitation fields with elevation masks in complex terrain, it is otherwise easy to overpredict the amounts in lower, habitated areas. Current postprossessing that smooth precipitation fields (pp-median, pp-max) may sometimes give a better estimates compared to observations. Unfortunately there are a lot a variations between cases, due to topography and precipitation distribution, so it is hard to tell if one of the precip-fields is generally better than the others. Comparing them all, including elevation mask and/or habitated areas is a common practise among experienced forecasters.

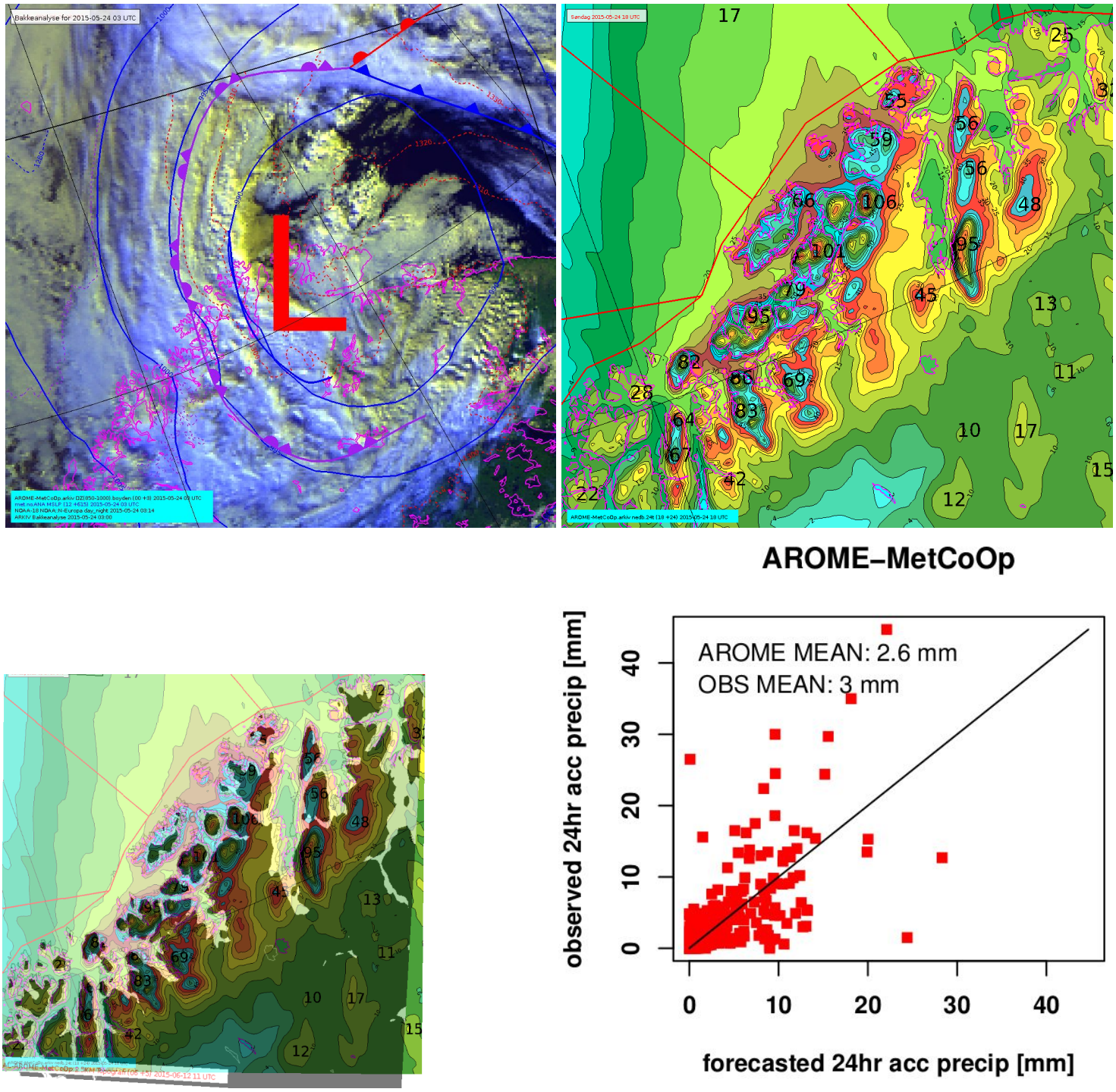
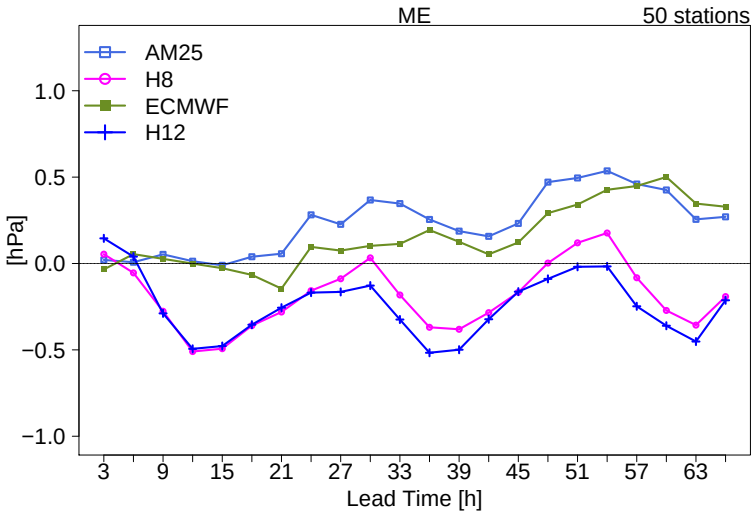
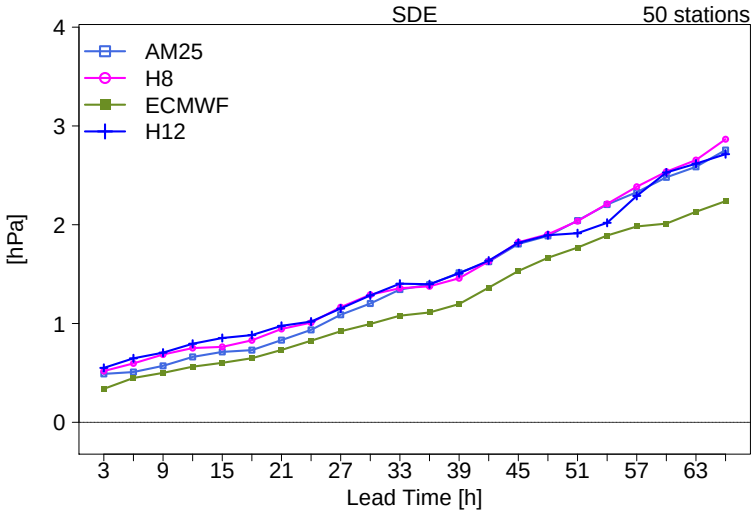
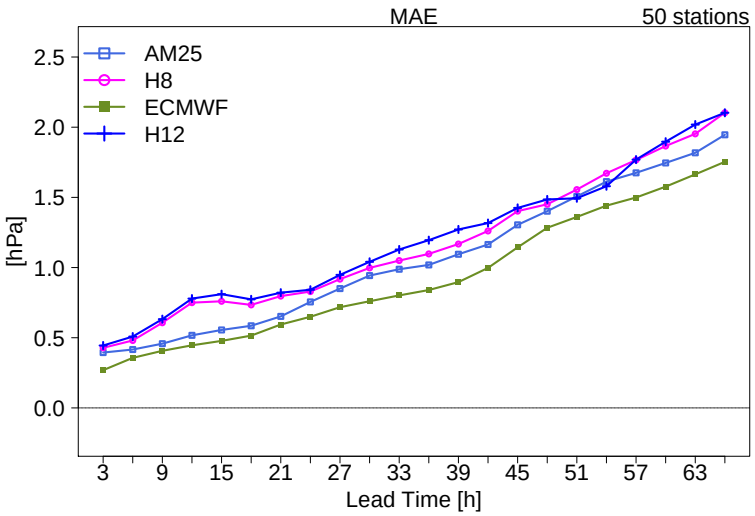


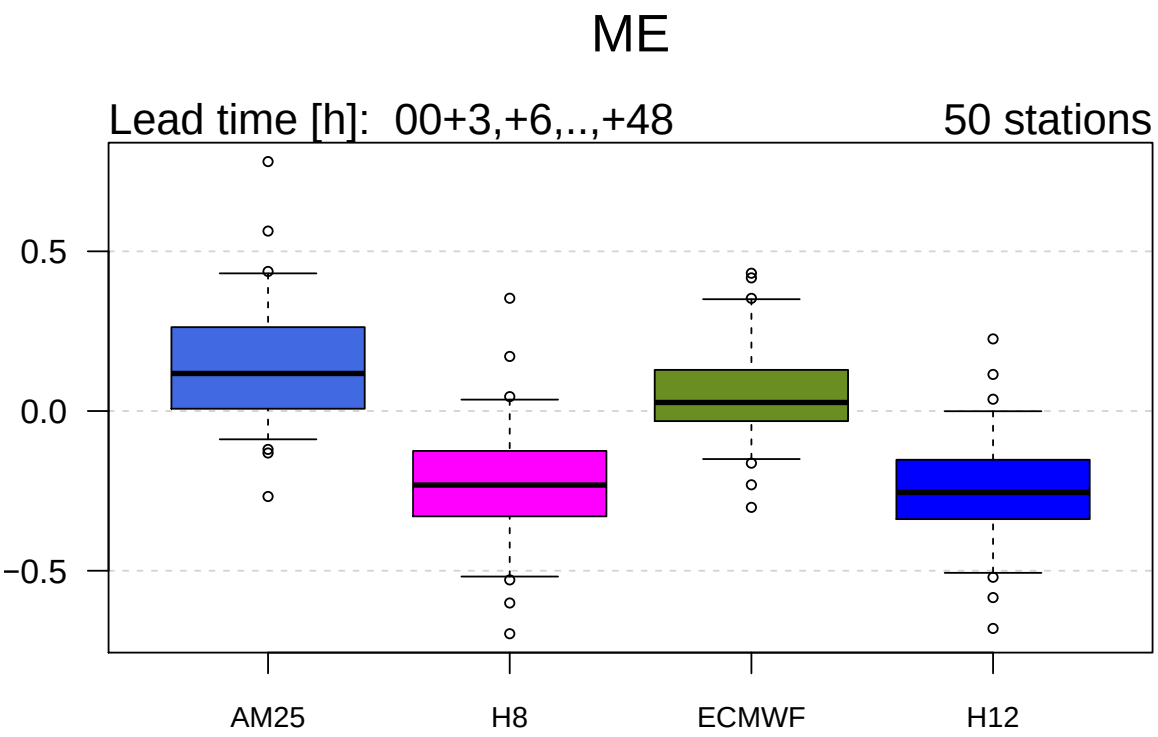
Figure 4: Figures from the heavy precipitation event May 23-24. Topleft: Satellite image and forecasters analysis showing the synoptic situation. Topright: Accumulated 24h-precipitation field from AROME. Bottomleft: Max values lowland estimated with topography mask. Bottomright: Scatterplot of observed and forecasted 24h-precipitation.

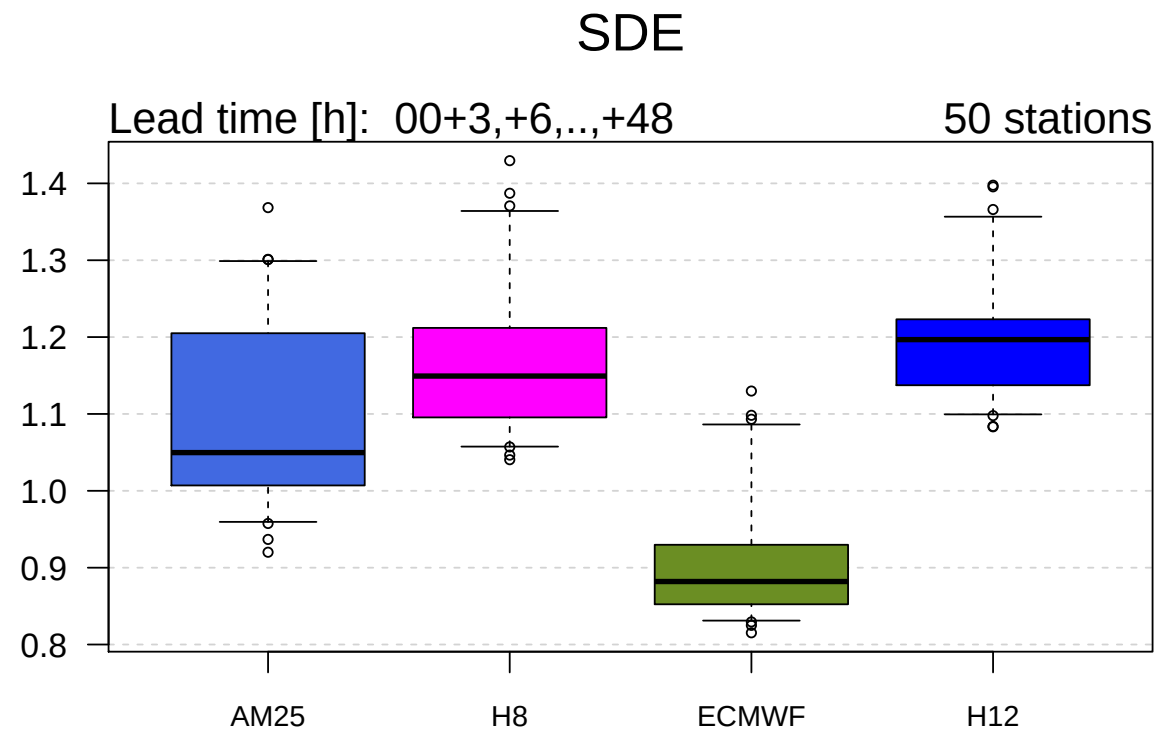
8.2 Pressure


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

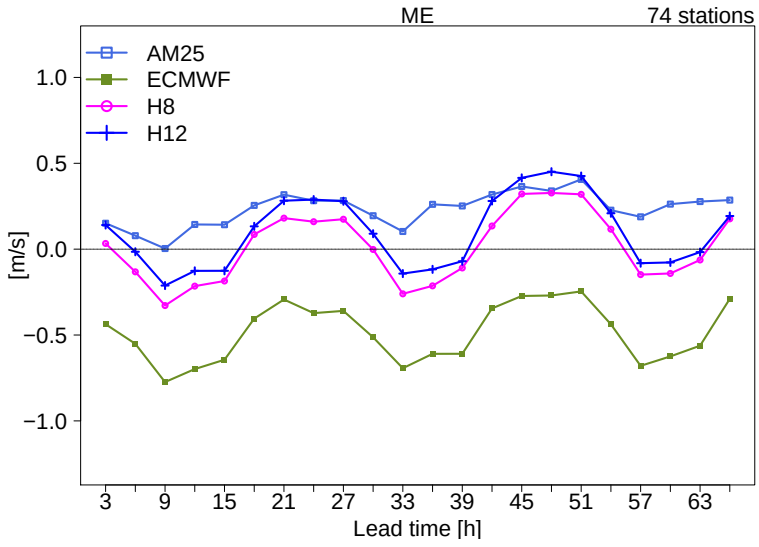

SDE
50 stations
AM25
H8
ECMWF
H12
4
3
2
1
0
[hPa]
3
9
15
21
27
33
39
45
51
57
63
Lead Time [h]

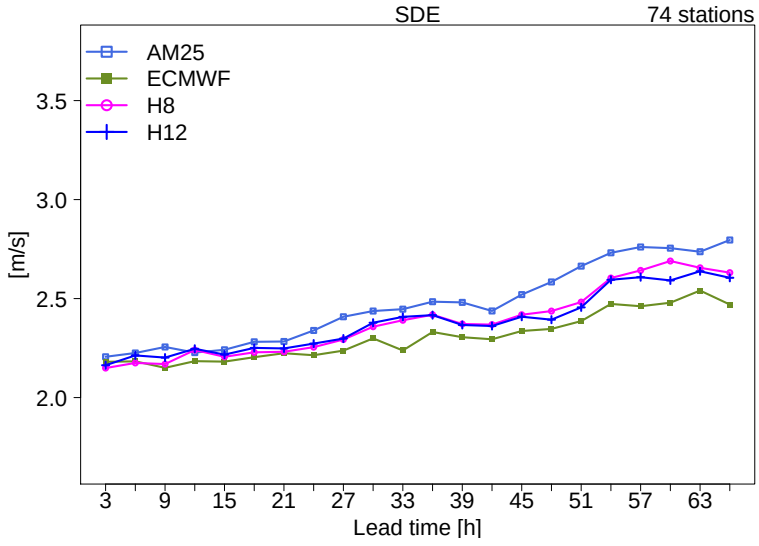

MAE
50 stations
AM25
H8
ECMWF
H12
2.5
2.0
1.5
1.0
0.5
0.0
[hPa]
3
9
15
21
27
33
39
45
51
57
63
Lead Time [h]

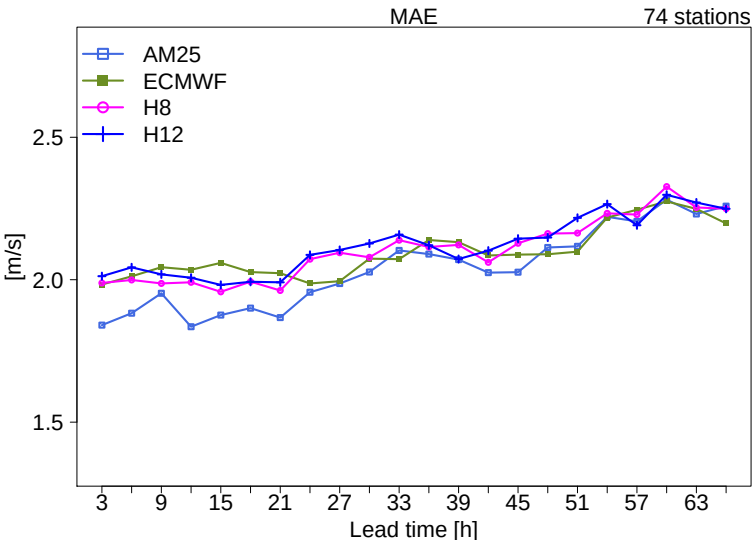

ME
Lead time [h]: 00+3,+6,..,+48
50 stations
0.5
0.0
−0.5
AM25
H8
ECMWF
H12

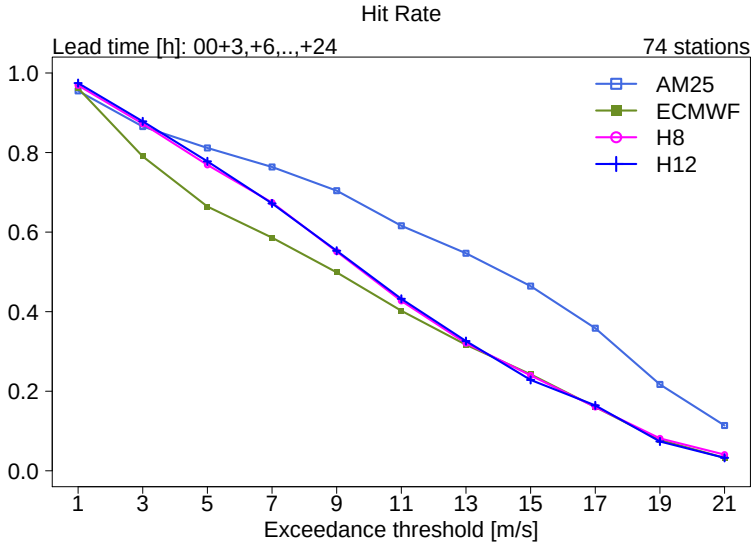

SDE
Lead time [h]: 00+3,+6,..,+48
50 stations
1.4
1.3
1.2
1.1
1.0
0.9
0.8
AM25
H8
ECMWF
H12

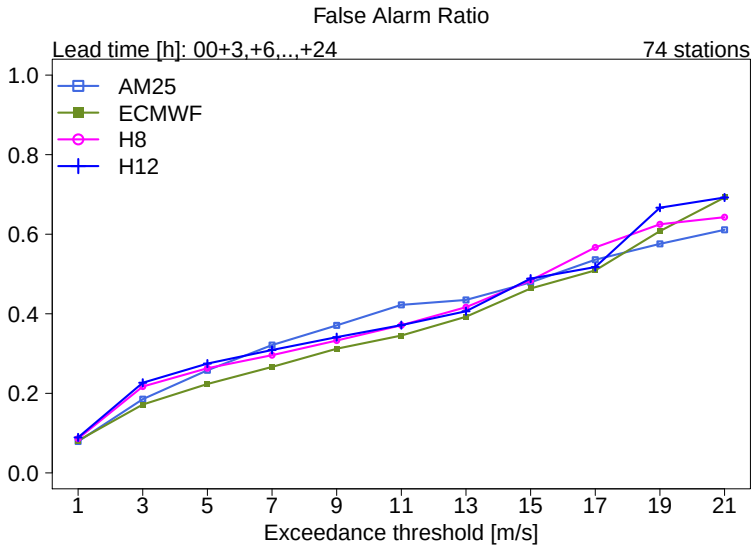
8.3 Wind Speed 10m

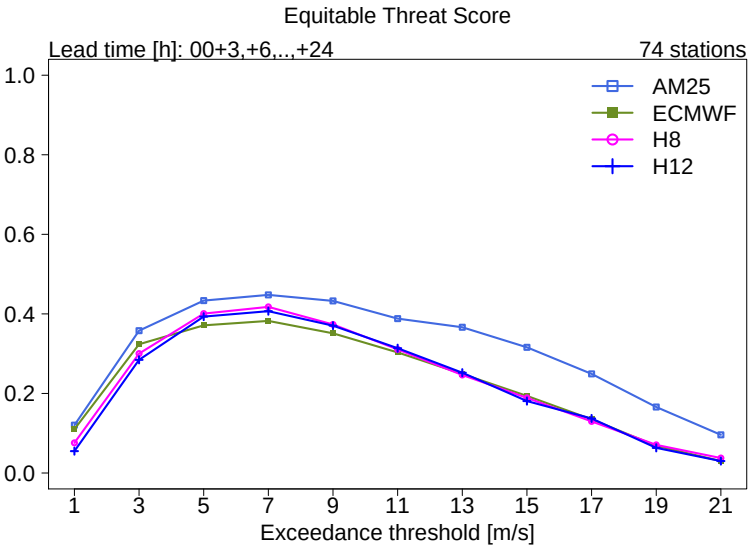


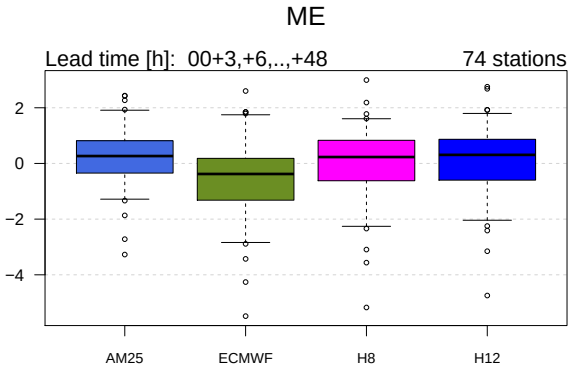


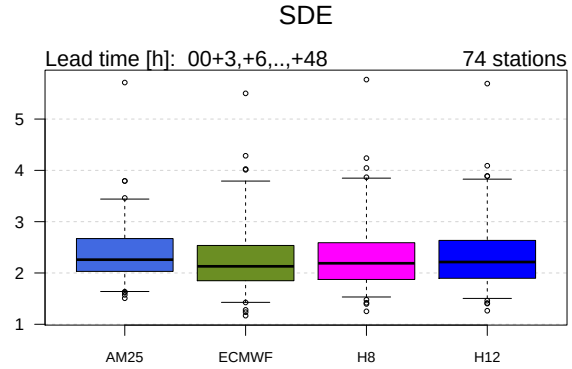



Hit Rate
Lead time [h]: 00+3,+6,..,+24
74 stations
AM25
ECMWF
H8
H12
1.0
0.8
0.6
0.4
0.2
0.0
1 3 5 7 9 11 13 15 17 19 21
Exceedance threshold [m/s]


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]	21580	8472	14	0	0	30066
(3,11]	12715	41442	2892	101	20	57170
(11,17]	145	3348	3424	408	108	7433
(17,21]	8	95	336	201	82	722
(21,Inf]	0	12	33	35	33	113
Sum	34448	53369	6699	745	243	95504

H8 vs **OBS**

	[0,3]	(3,11]	(11,17]	(17,21]	(21,Inf]	Sum
[0,3]	18837	8108	23	0	0	26968
(3,11]	15563	43203	3976	295	100	63137
(11,17]	48	2022	2505	331	94	5000
(17,21]	0	33	186	105	39	363
(21,Inf]	0	3	9	14	10	36
Sum	34448	53369	6699	745	243	95504

ECMWF vs **OBS**

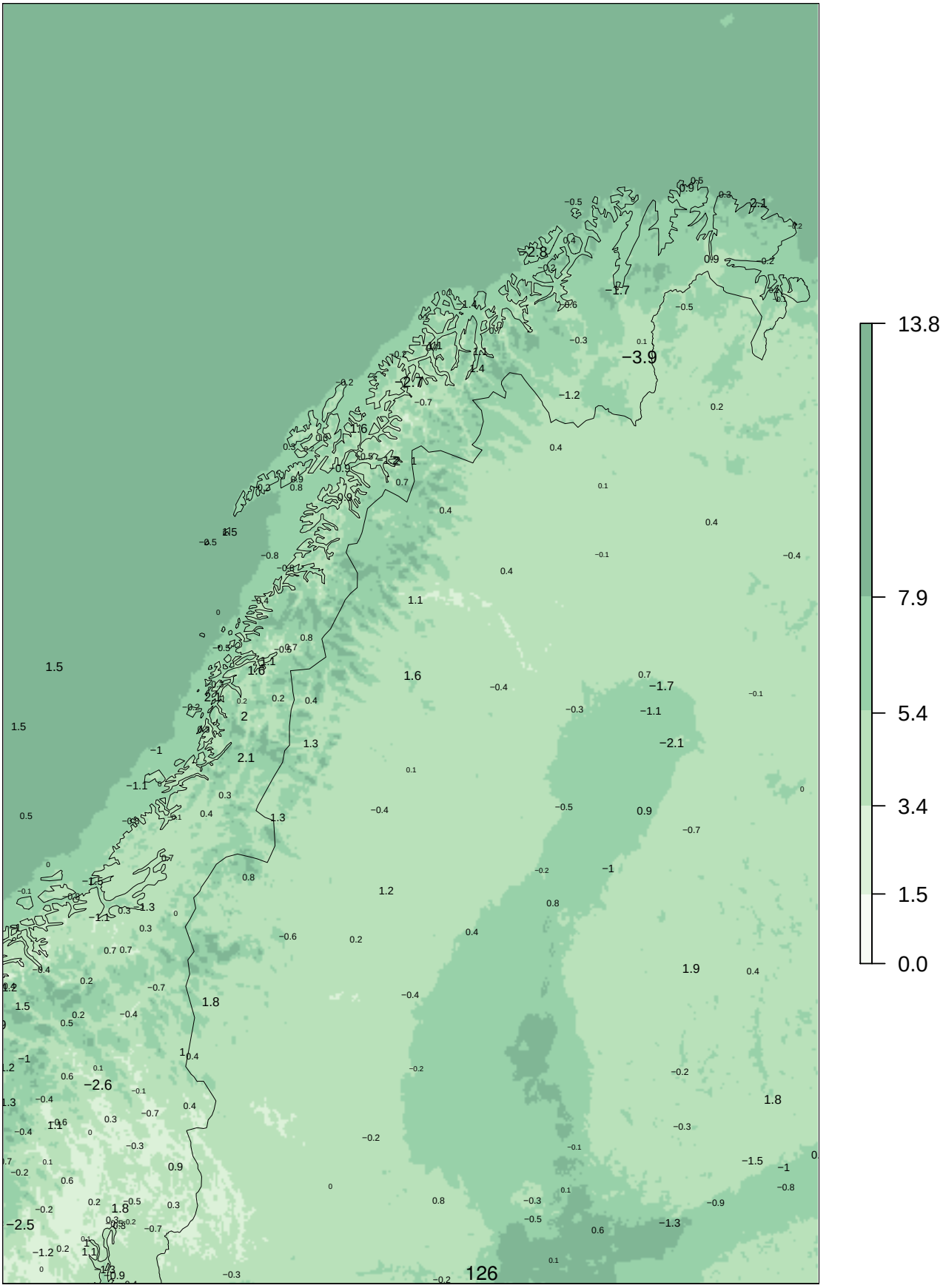
	[0,3]	(3,11]	(11,17]	(17,21]	(21,Inf]	Sum
[0,3]	23978	12876	144	2	0	37000
(3,11]	10444	38757	4035	327	95	53658
(11,17]	26	1693	2360	302	96	4477
(17,21]	0	42	149	106	43	340
(21,Inf]	0	1	11	8	9	29
Sum	34448	53369	6699	745	243	95504

H12 vs **OBS**

	[0,3]	(3,11]	(11,17]	(17,21]	(21,Inf]	Sum
[0,3]	17974	7613	13	0	0	25600
(3,11]	16439	43634	3990	305	79	64447
(11,17]	35	2086	2507	313	116	5057
(17,21]	0	32	178	111	38	359
(21,Inf]	0	4	11	16	10	41
Sum	34448	53369	6699	745	243	95504

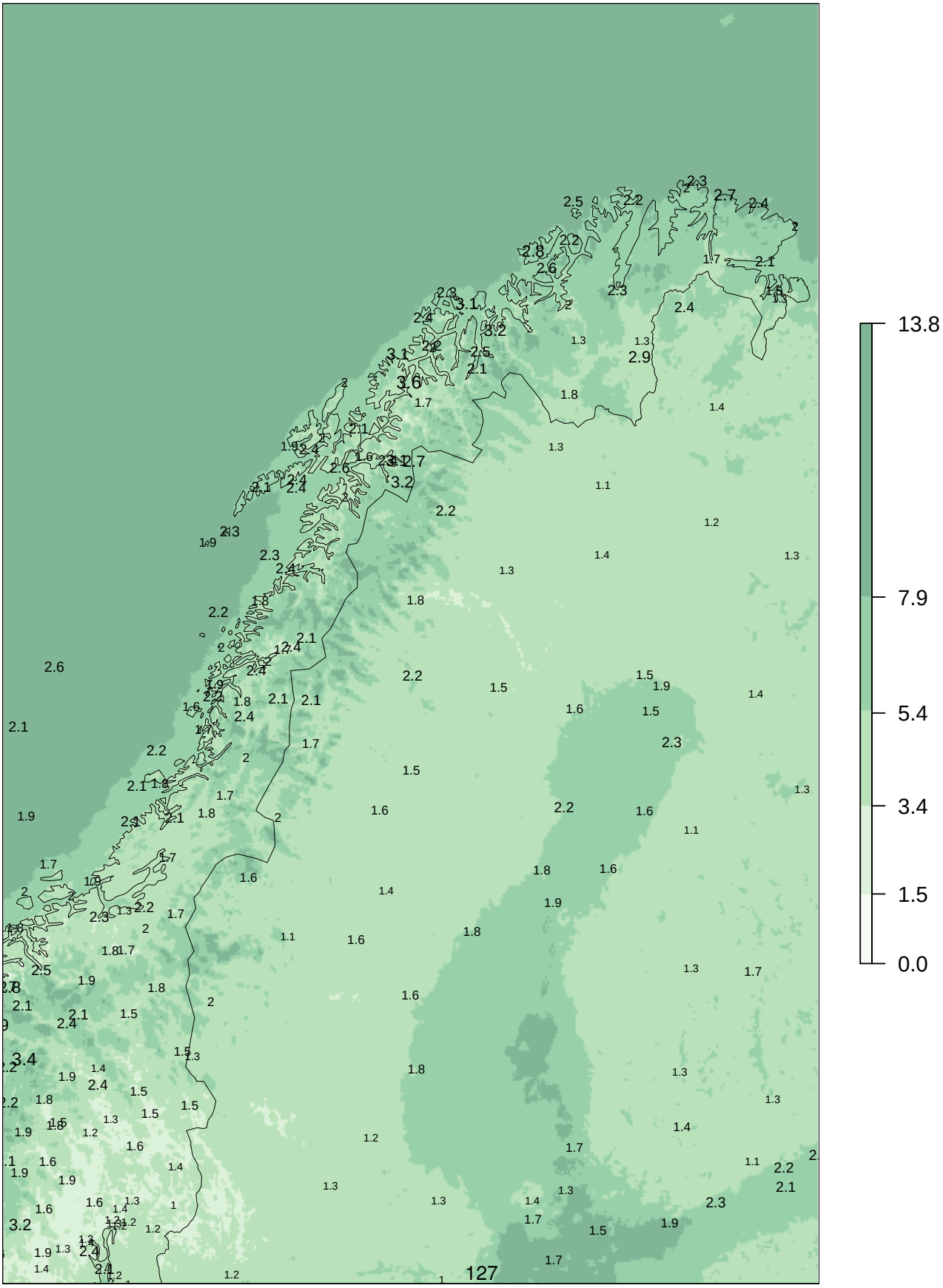
AM25 00+12

ME at observing sites forecast means 01.03.2015 − 31.05.2015

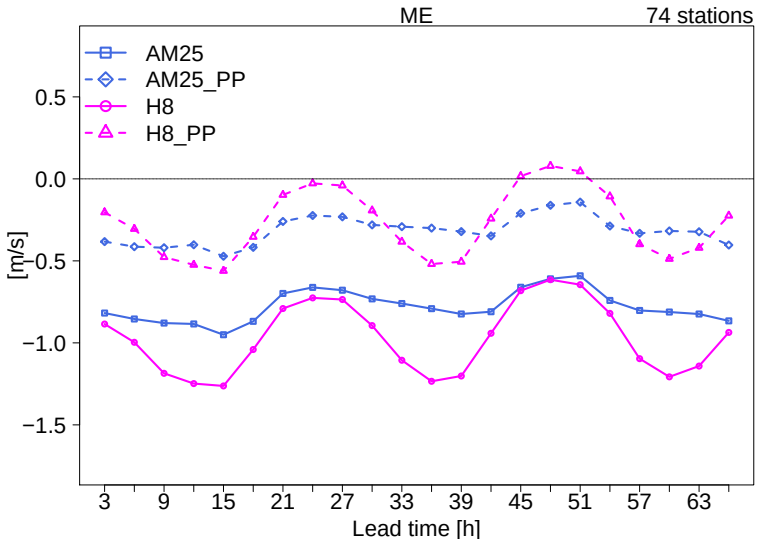


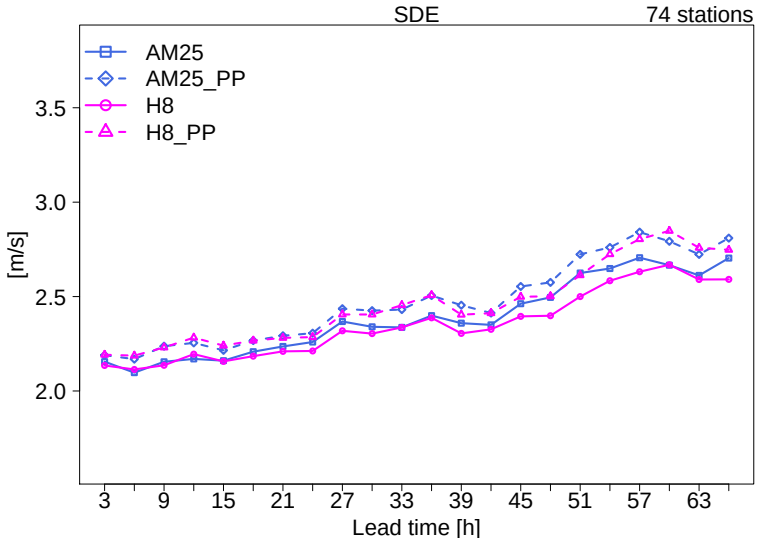
AM25 00+12

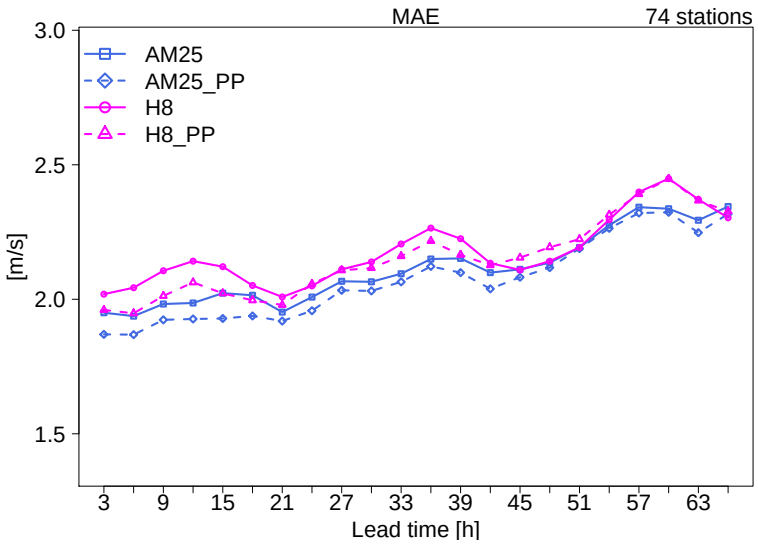
SDE at observing sites forecast means 01.03.2015 − 31.05.2015

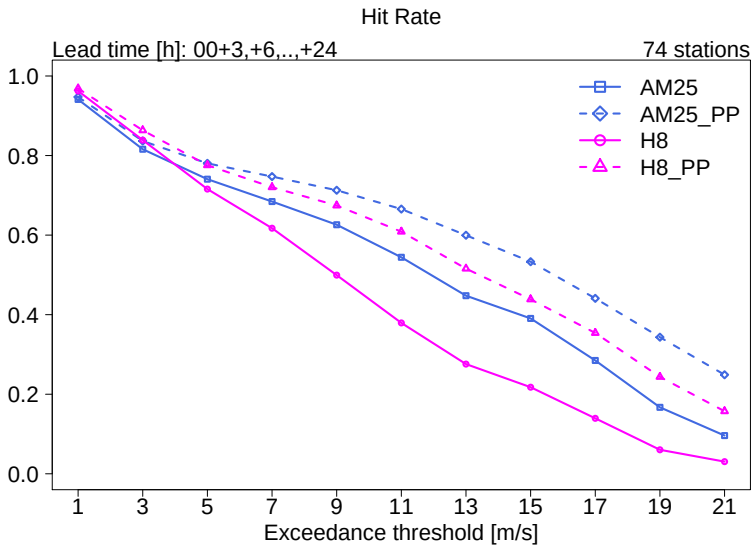


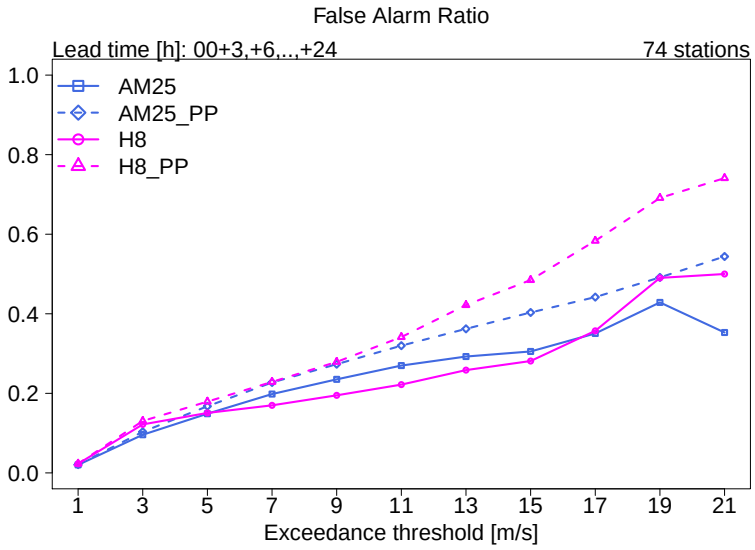
8.4 Max Mean Wind Speed 10m

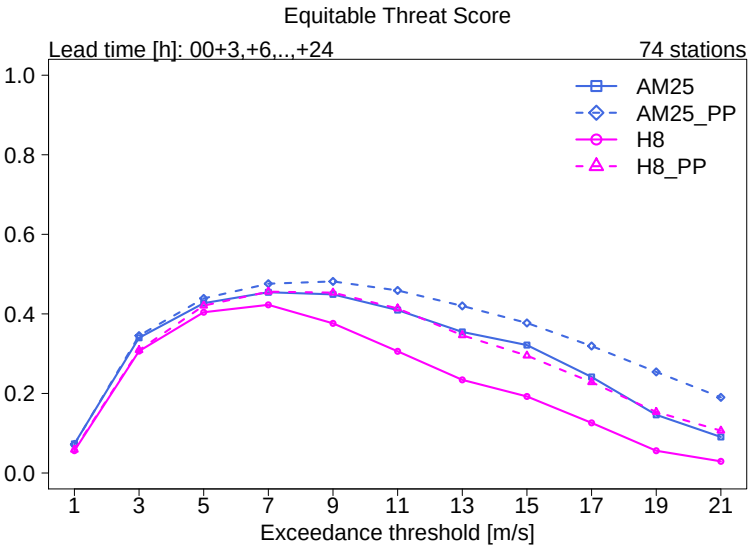


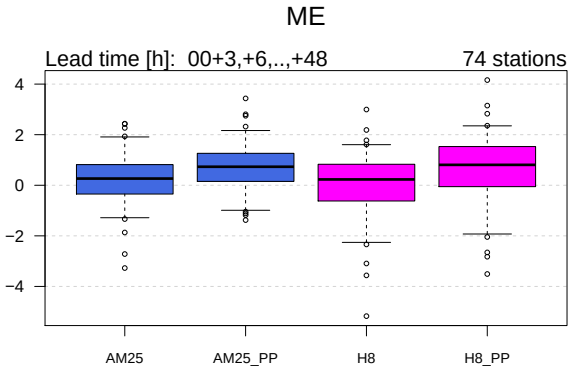


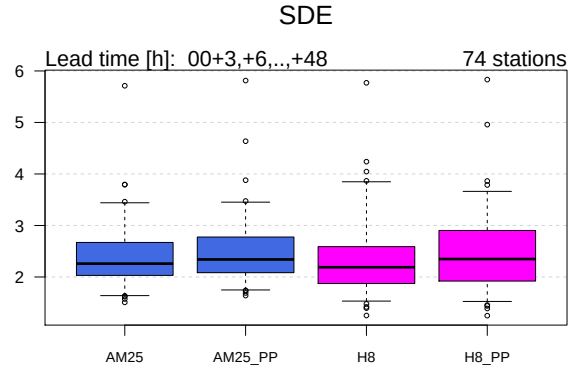



Hit Rate
Lead time [h]: 00+3,+6,..,+24
74 stations
AM25
AM25_PP
H8
H8_PP
1.0
0.8
0.6
0.4
0.2
0.0
1 3 5 7 9 11 13 15 17 19 21
Exceedance threshold [m/s]


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]	15682	12033	32	0	0	27747
(3,11]	6207	40747	4534	164	35	51687
(11,17]	38	2120	3799	742	223	6922
(17,21]	0	48	232	254	141	675
(21,Inf]	0	3	22	26	55	106
Sum	21927	54951	8619	1186	454	87137

AM25_PP

OBS

	[0,3]	(3,11]	(11,17]	(17,21]	(21,Inf]	Sum
[0,3]	15007	10662	21	0	0	25690
(3,11]	6859	40930	3377	86	14	51266
(11,17]	61	3246	4667	648	166	8788
(17,21]	0	98	486	359	155	1098
(21,Inf]	0	15	68	93	119	295
Sum	21927	54951	8619	1186	454	87137

H8

OBS

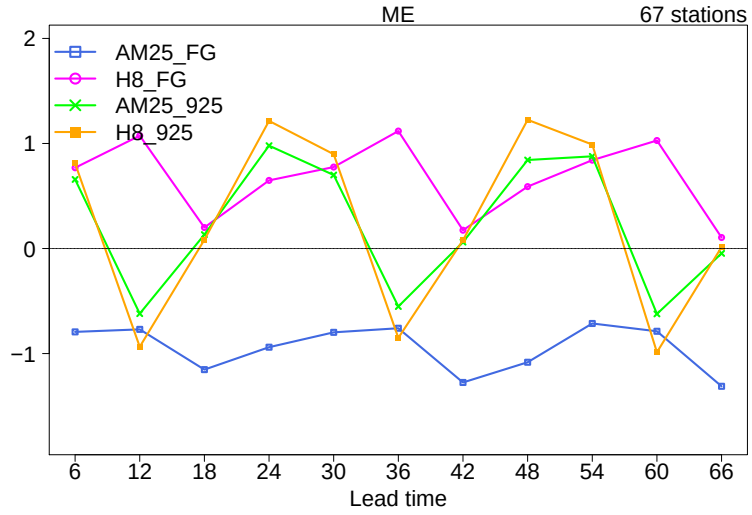
	[0,3]	(3,11]	(11,17]	(17,21]	(21,Inf]	Sum
[0,3]	13707	10655	33	0	0	24395
(3,11]	8204	43072	5721	393	178	57568
(11,17]	16	1206	2747	634	189	4792
(17,21]	0	17	112	147	71	347
(21,Inf]	0	1	6	12	16	35
Sum	21927	54951	8619	1186	454	87137

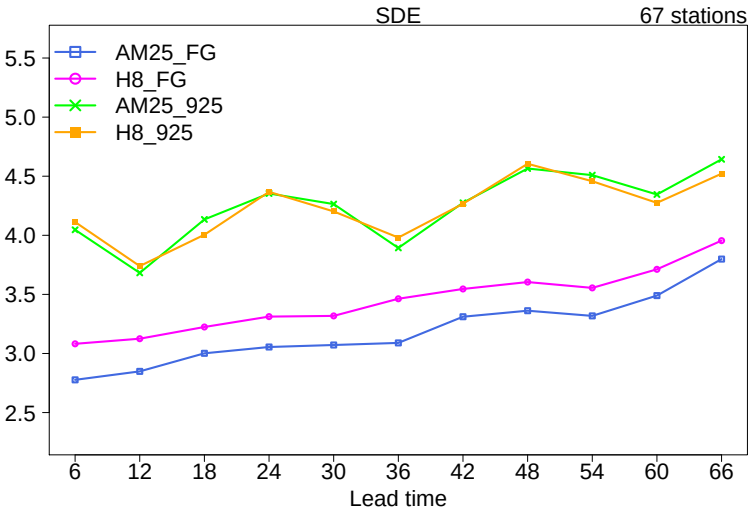
H8_PP

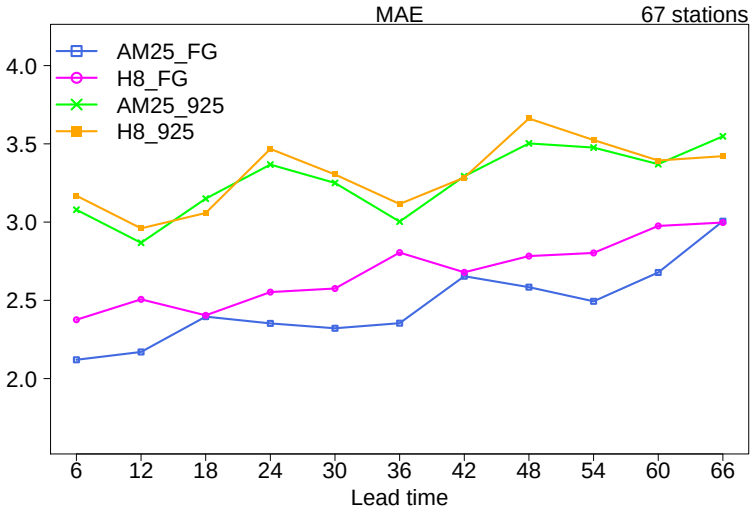
OBS

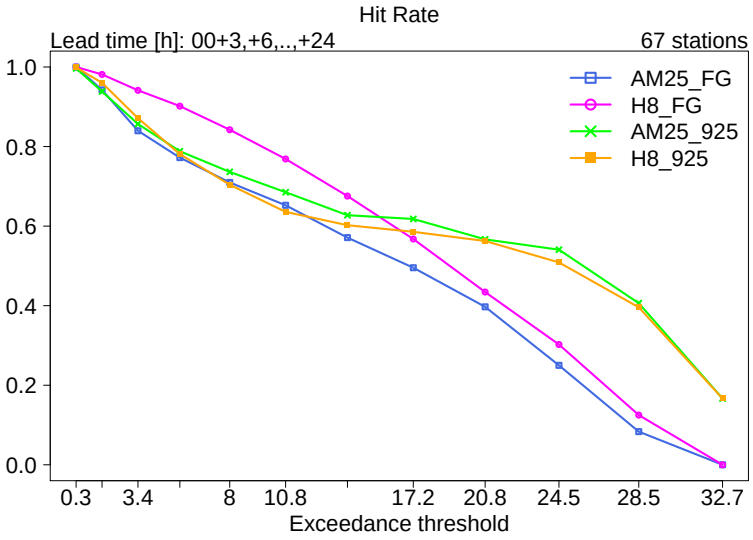
	[0,3]	(3,11]	(11,17]	(17,21]	(21,Inf]	Sum
[0,3]	12841	9099	19	0	0	21959
(3,11]	9038	42402	3776	202	63	55481
(11,17]	48	3323	4060	555	216	8202
(17,21]	0	115	676	305	97	1193
(21,Inf]	0	12	88	124	78	302
Sum	21927	54951	8619	1186	454	87137

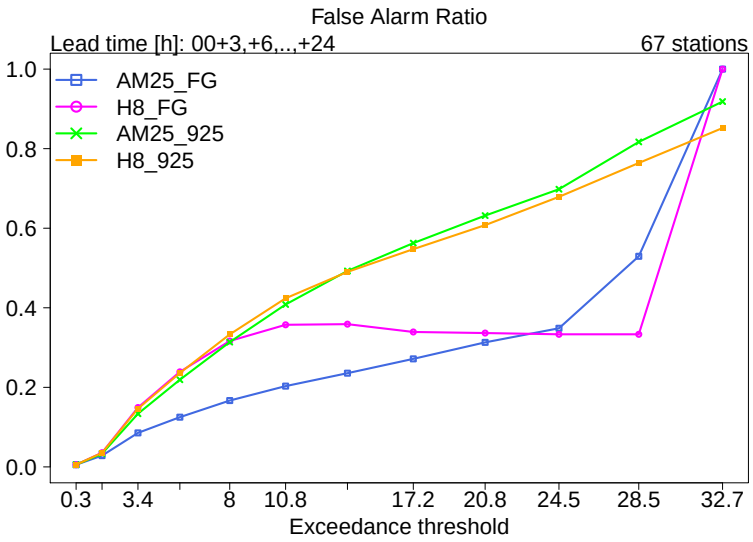
8.5 Wind gust

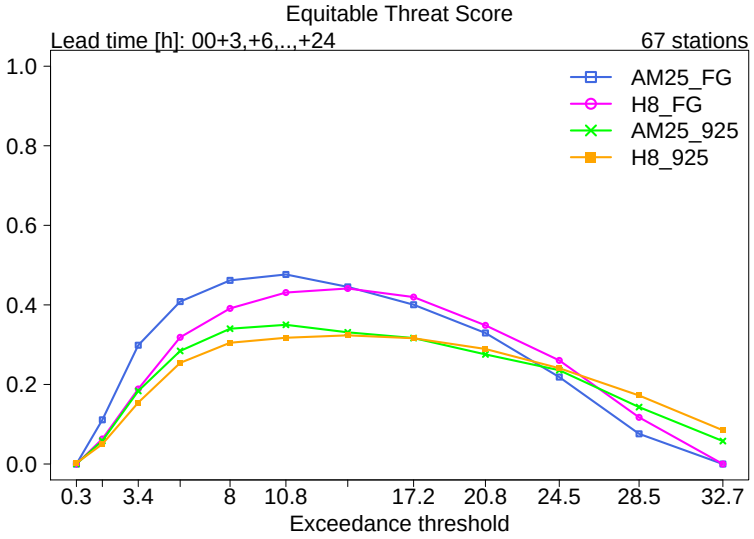

ME
67 stations
AM25_FG
H8_FG
AM25_925
H8_925
2
1
0
−1
6
12
18
24
30
36
42
48
54
60
66
Lead time


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

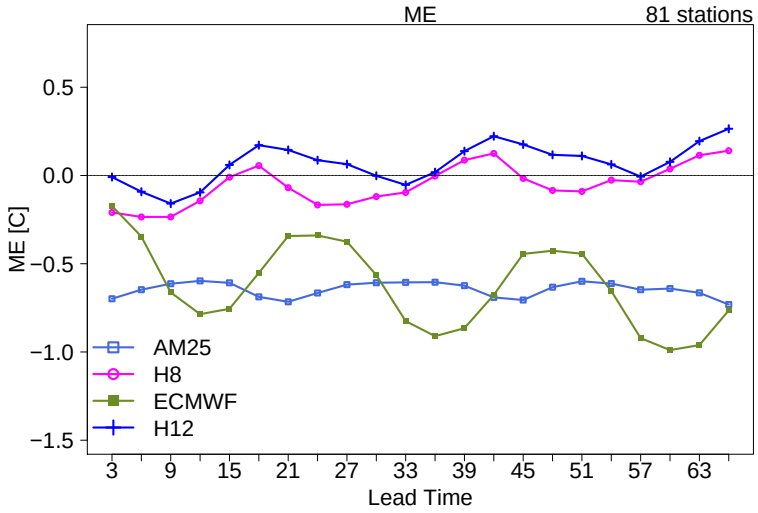

MAE
67 stations
AM25_FG
H8_FG
AM25_925
H8_925
4.0
3.5
3.0
2.5
2.0
6
12
18
24
30
36
42
48
54
60
66
Lead time

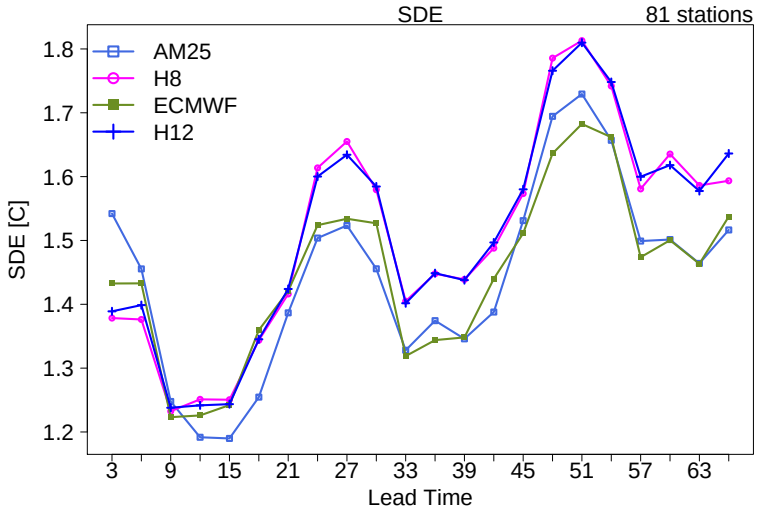

Hit Rate
Lead time [h]: 00+3,+6,..,+24
67 stations
AM25_FG
H8_FG
AM25_925
H8_925
1.0
0.8
0.6
0.4
0.2
0.0
0.3
3.4
8
10.8
17.2
20.8
24.5
28.5
32.7
Exceedance threshold

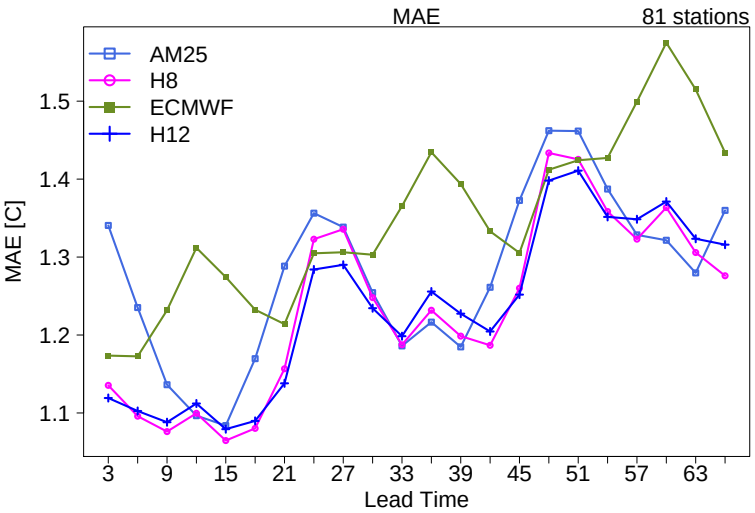

False Alarm Ratio
Lead time [h]: 00+3,+6,..,+24
67 stations
AM25_FG
H8_FG
AM25_925
H8_925
1.0
0.8
0.6
0.4
0.2
0.0
0.3
3.4
8
10.8
17.2
20.8
24.5
28.5
32.7
Exceedance threshold

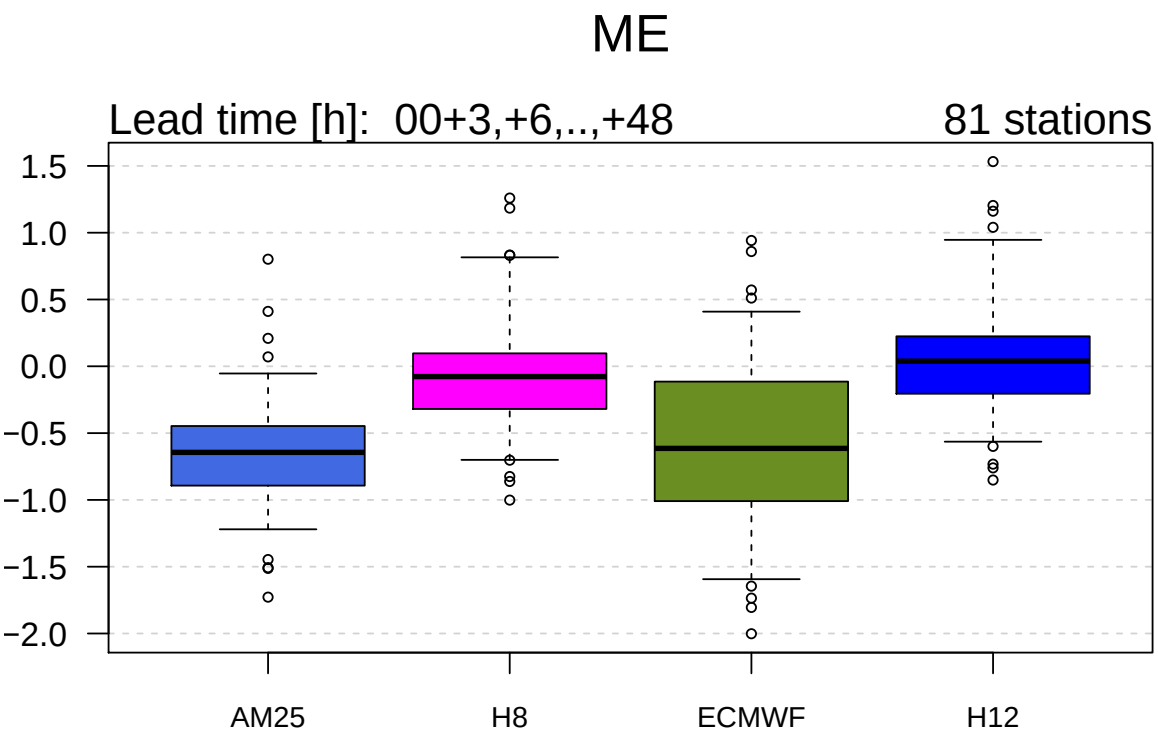

Equitable Threat Score
Lead time [h]: 00+3,+6,..,+24
67 stations
AM25_FG
H8_FG
AM25_925
H8_925
1.0
0.8
0.6
0.4
0.2
0.0
0.3
3.4
8
10.8
17.2
20.8
24.5
28.5
32.7
Exceedance threshold

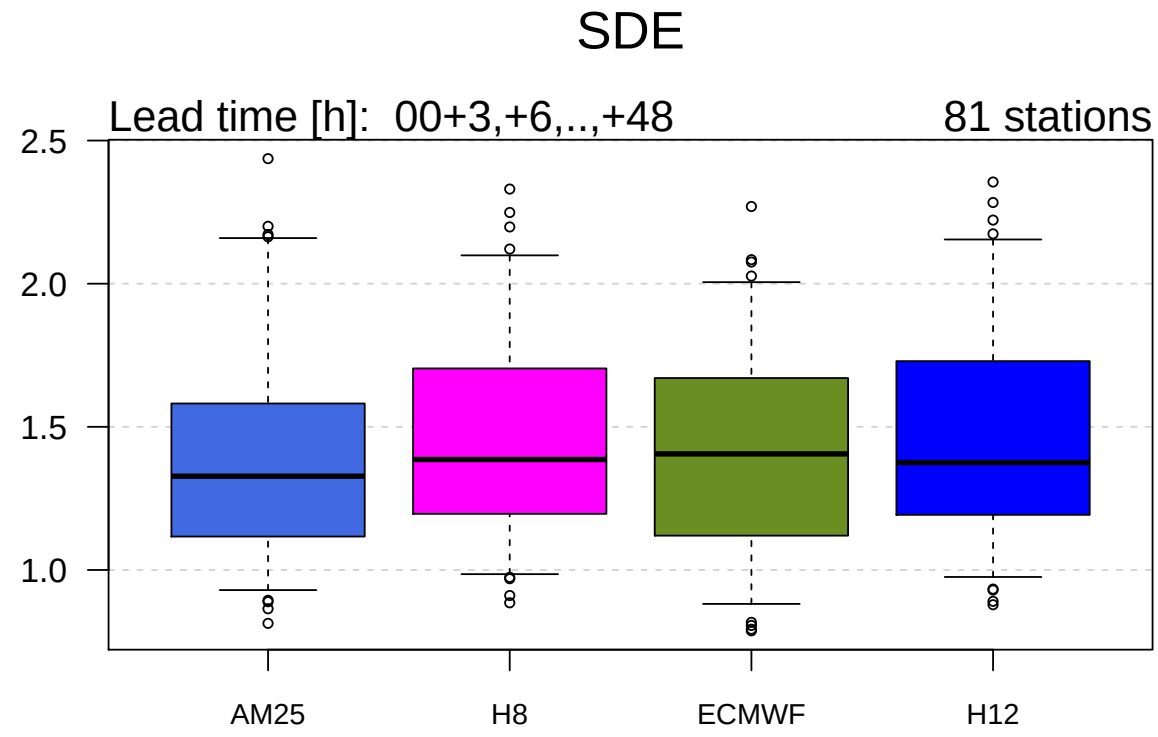
8.6 Temperature 2m





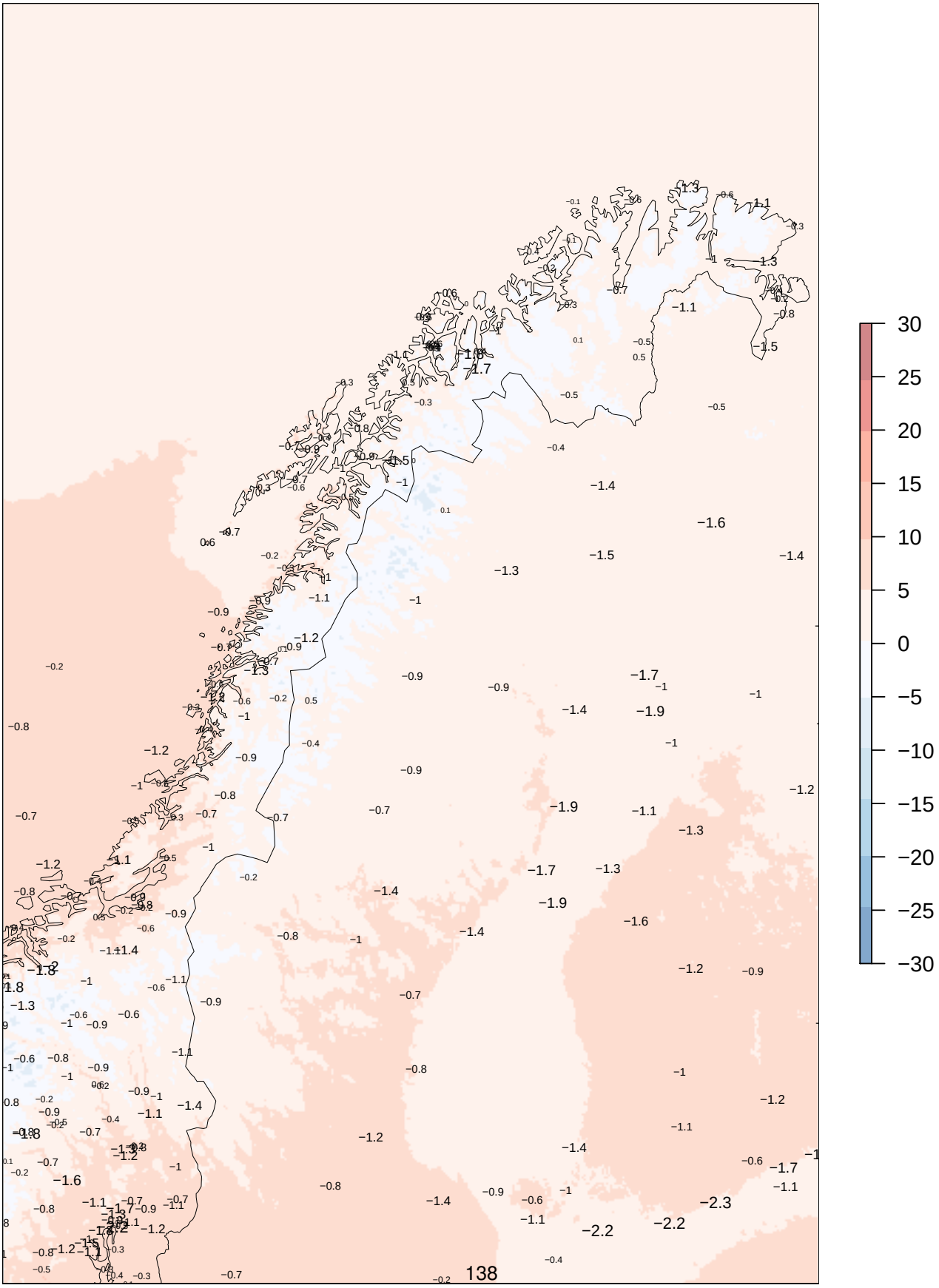



ME
Lead time [h]: 00+3,+6,..,+48
81 stations
1.5
1.0
0.5
0.0
−0.5
−1.0
−1.5
−2.0
AM25
H8
ECMWF
H12


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

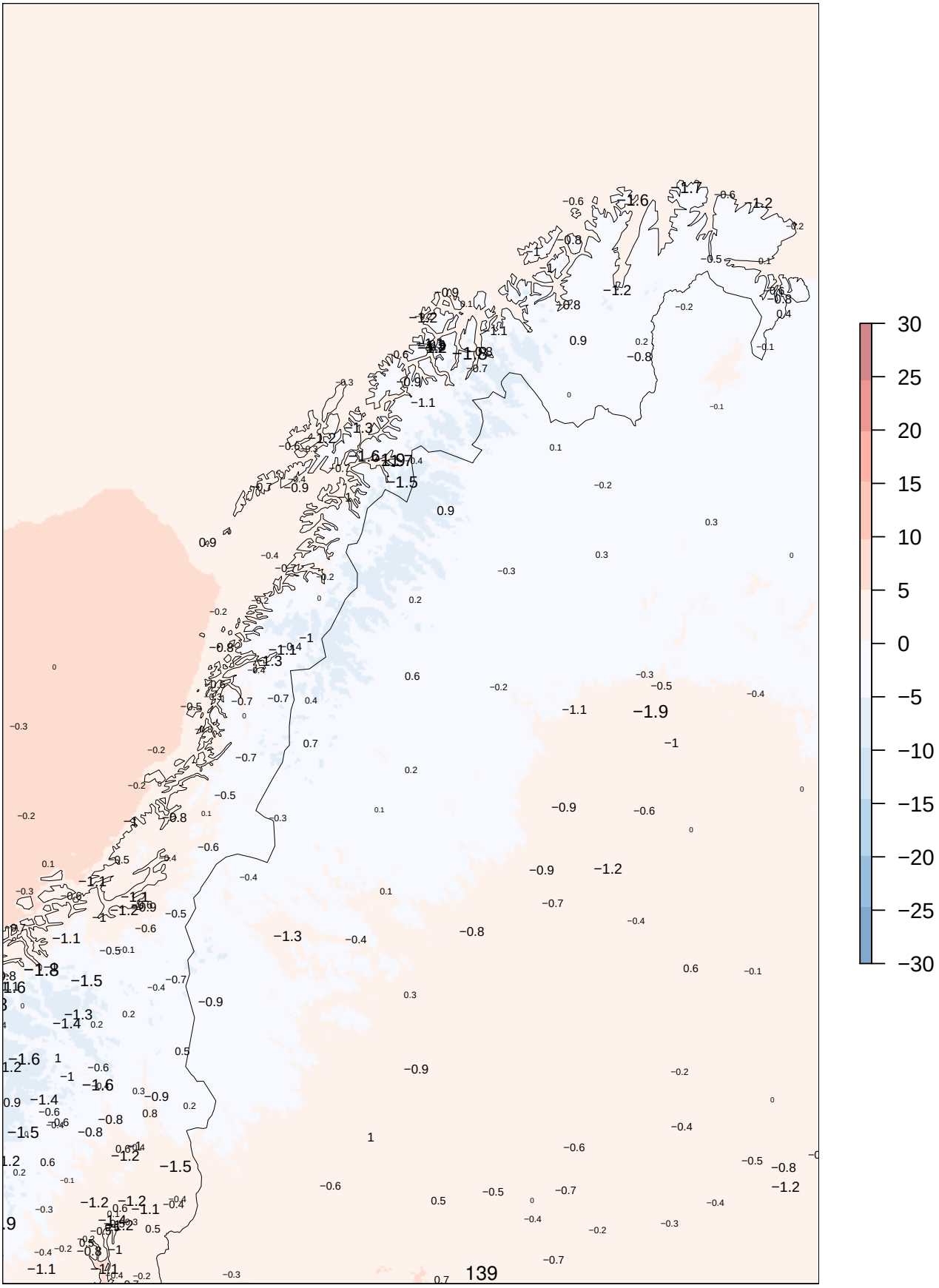
AM25 00+12

ME at observing sites forecast means 01.03.2015 − 31.05.2015



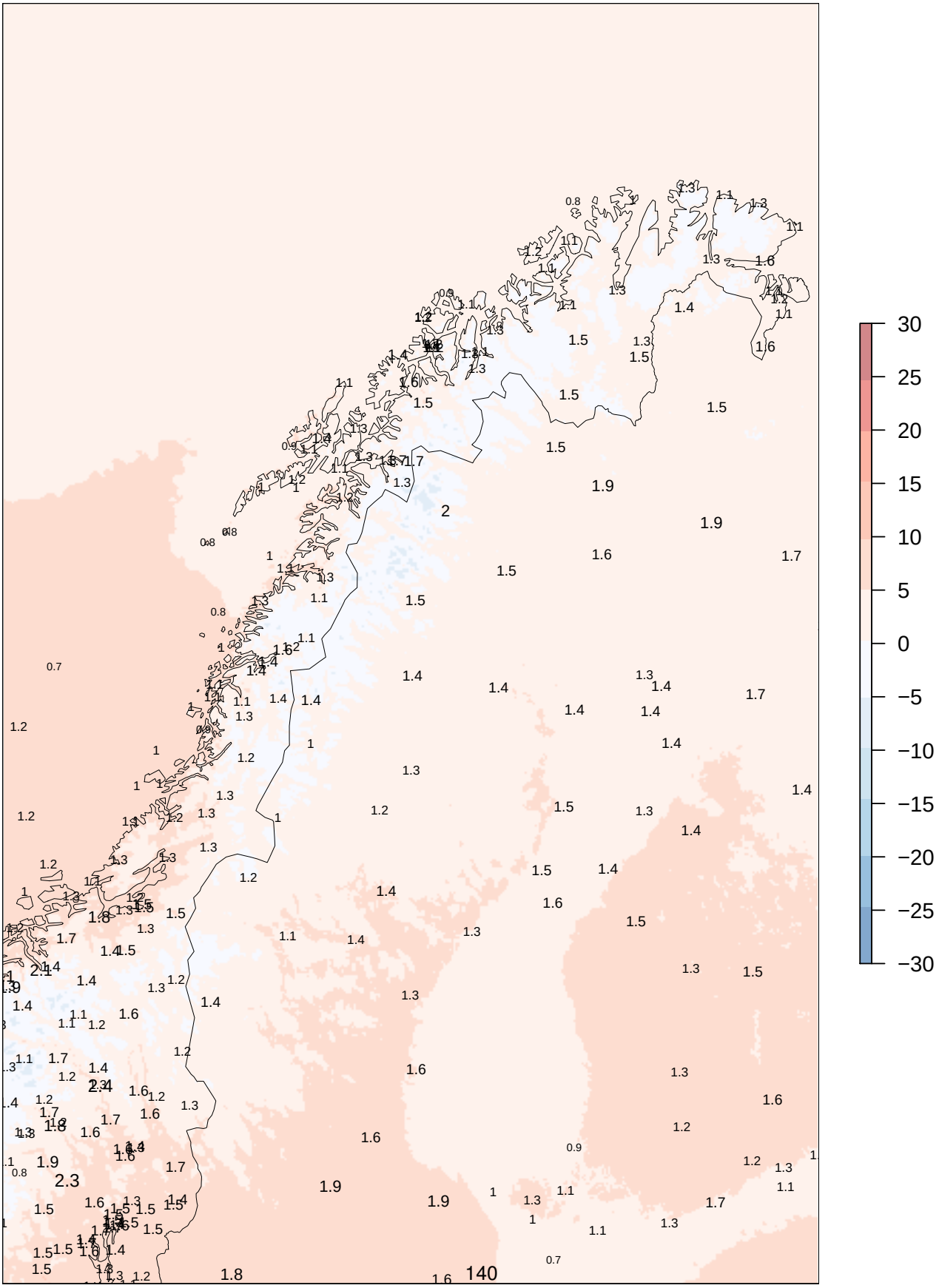
AM25 00+24

ME at observing sites forecast means 01.03.2015 − 31.05.2015



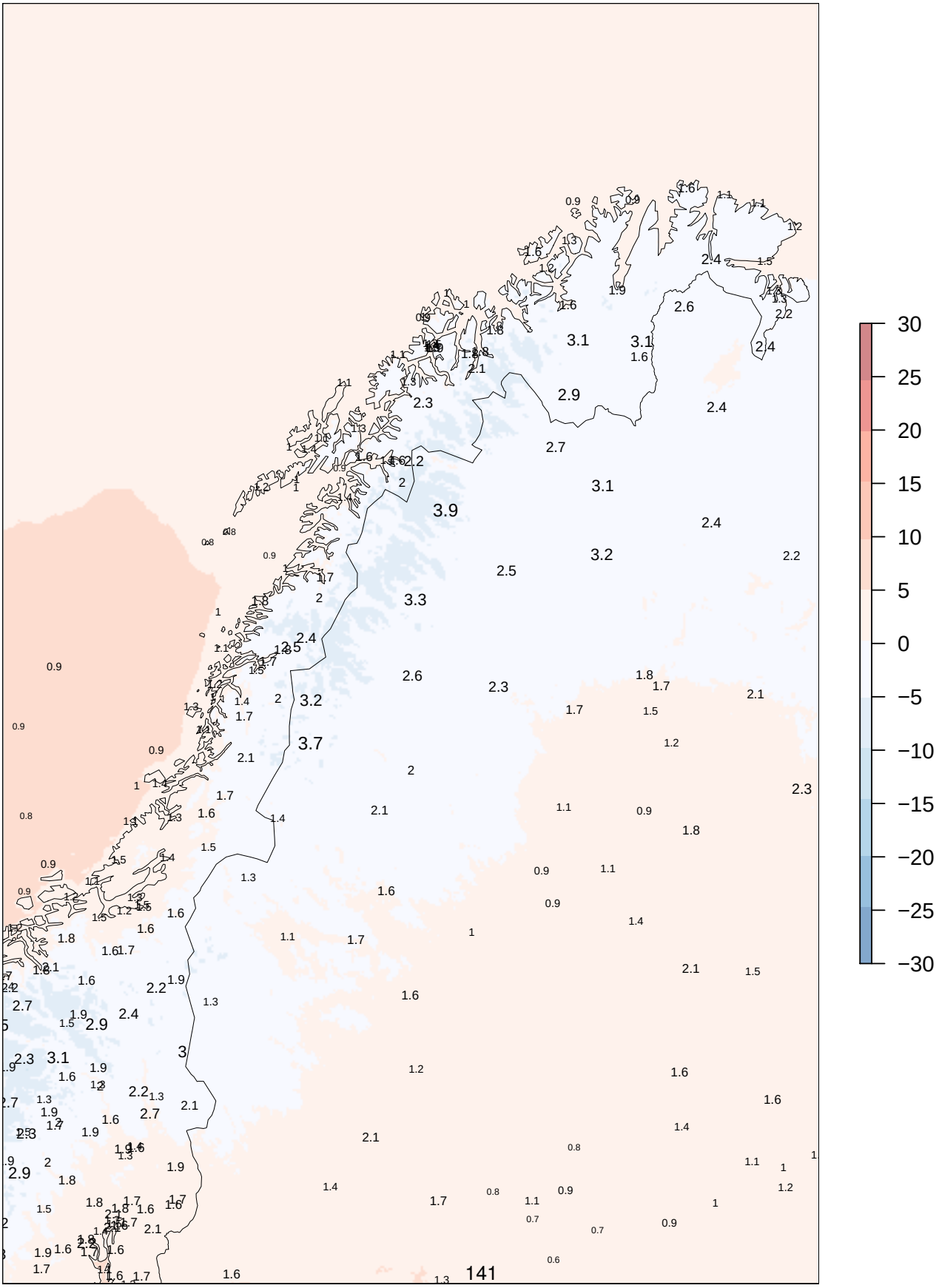
AM25 00+12

SDE at observing sites forecast means 01.03.2015 − 31.05.2015

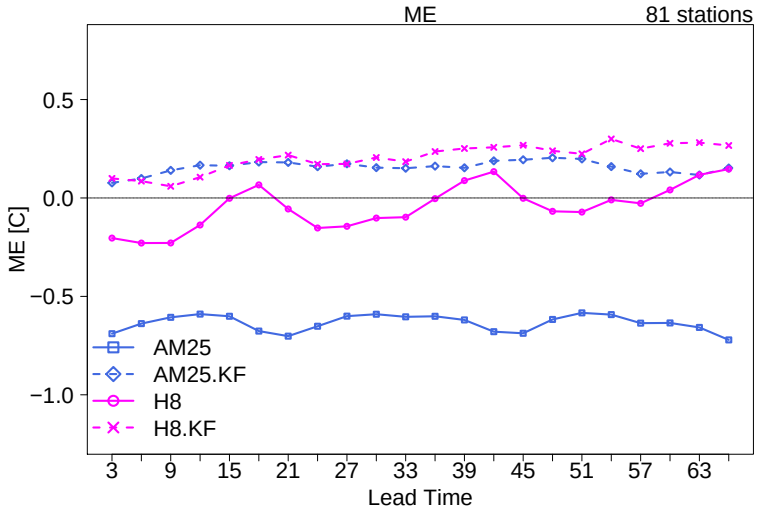


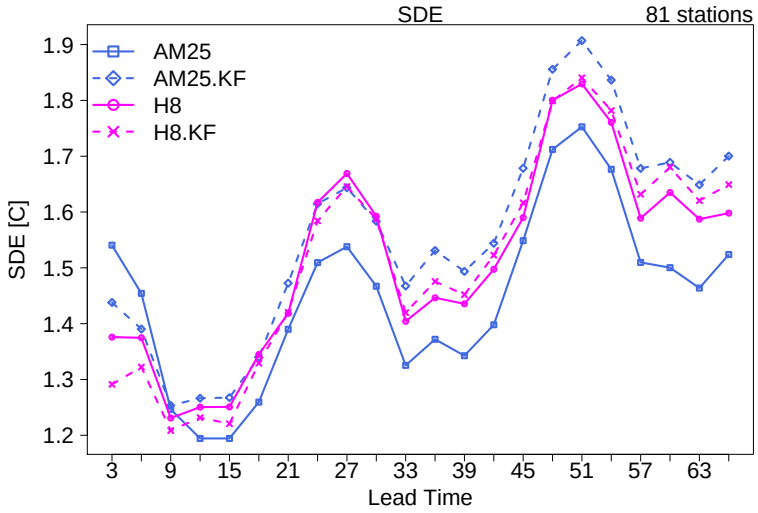
AM25 00+24

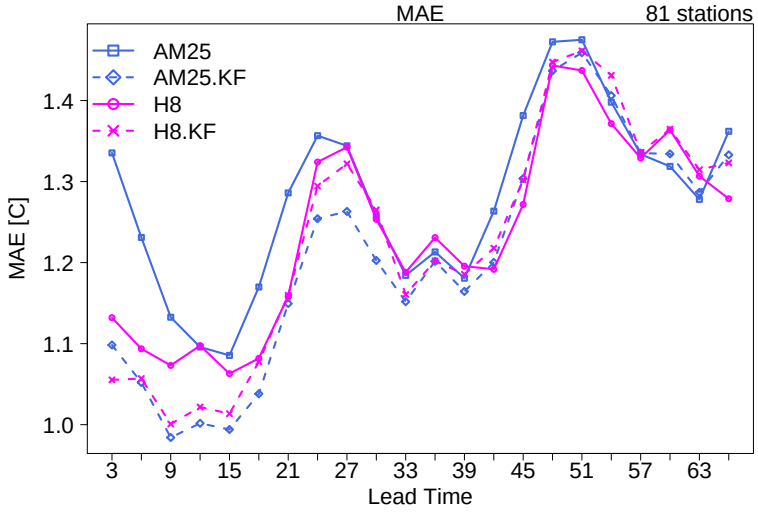
SDE at observing sites forecast means 01.03.2015 − 31.05.2015

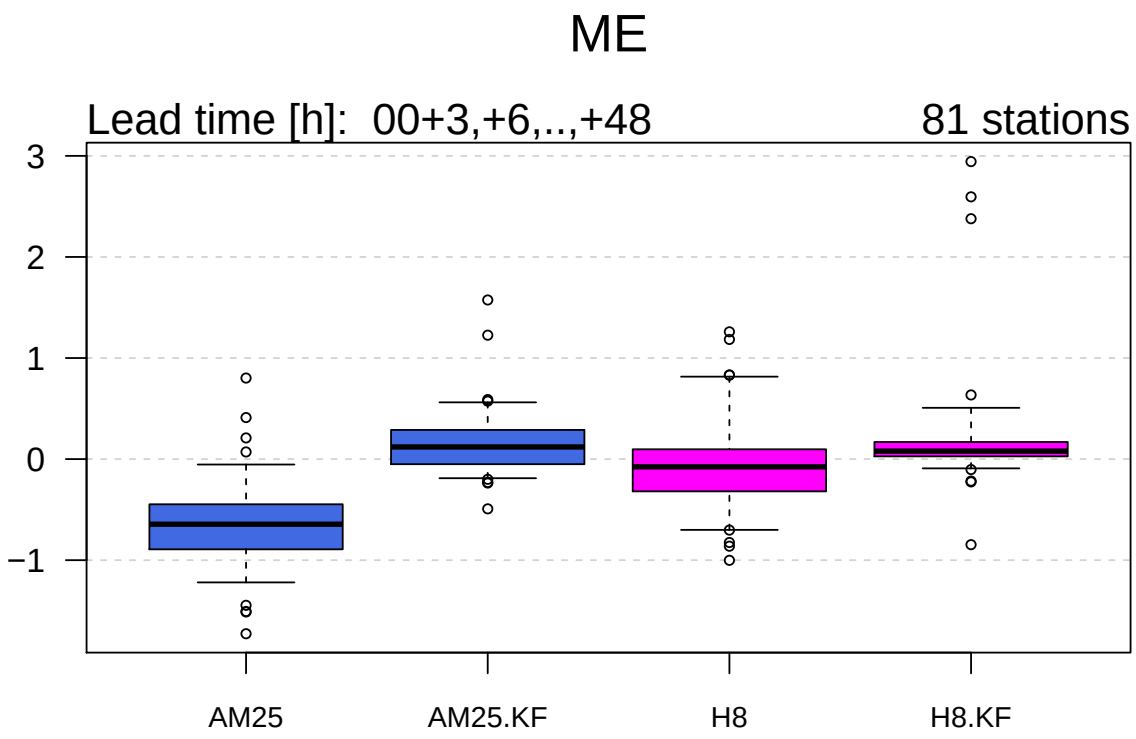


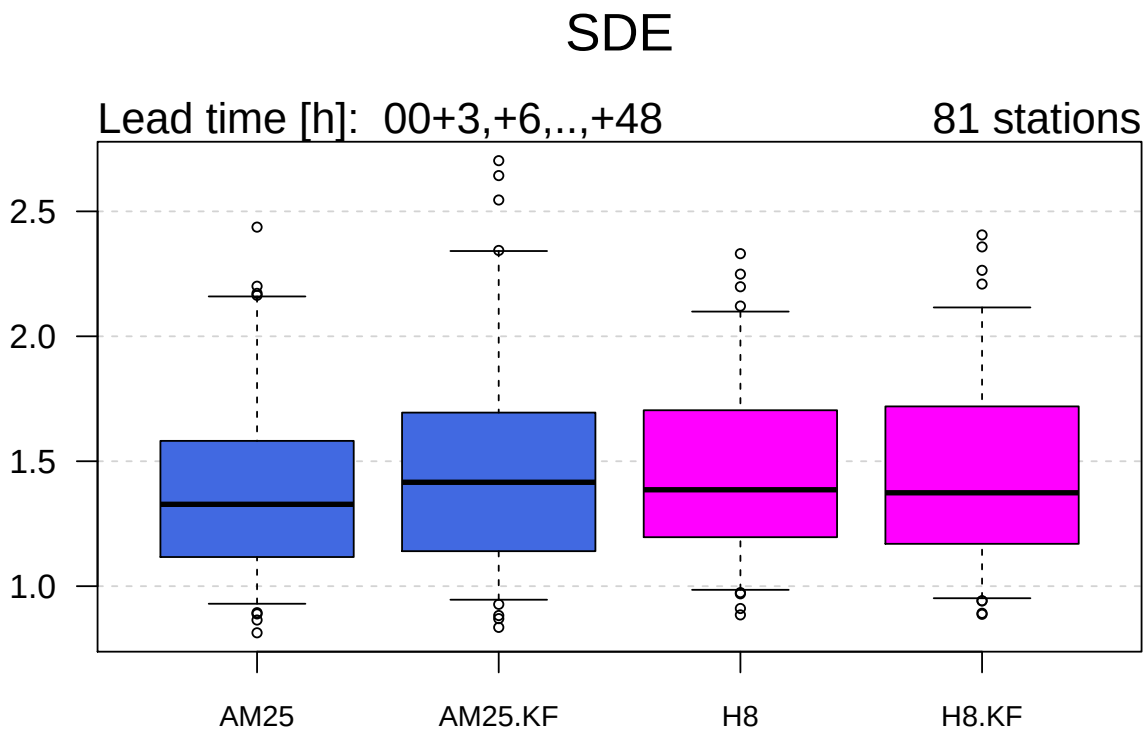
8.7 Post processed temperature 2m



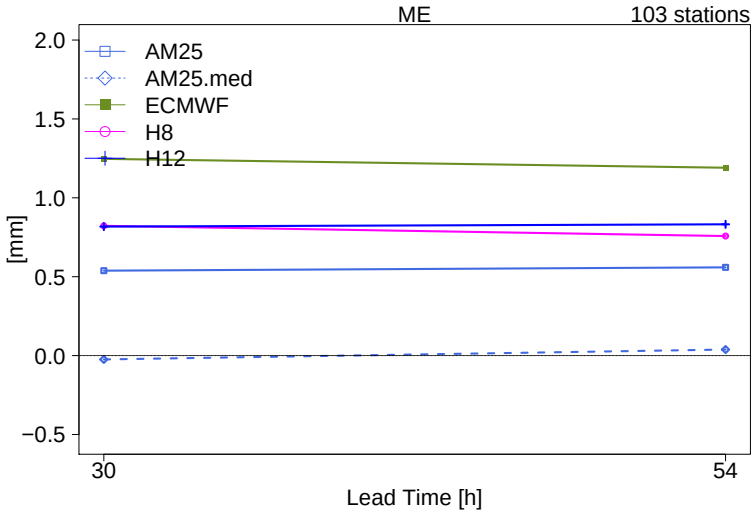


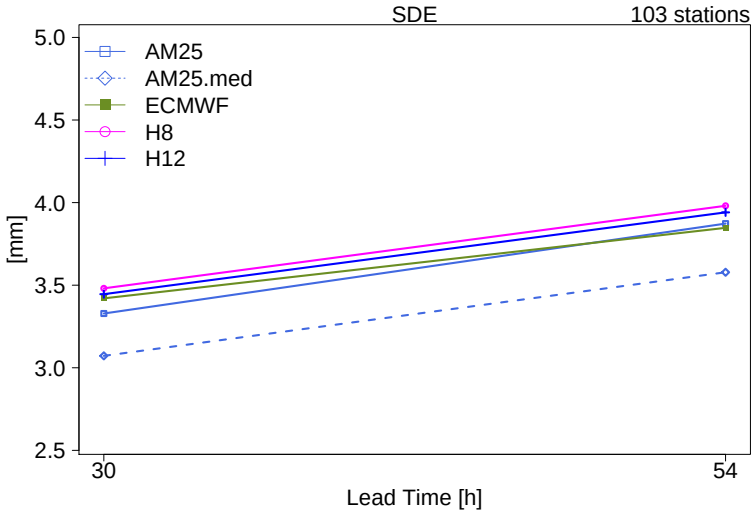


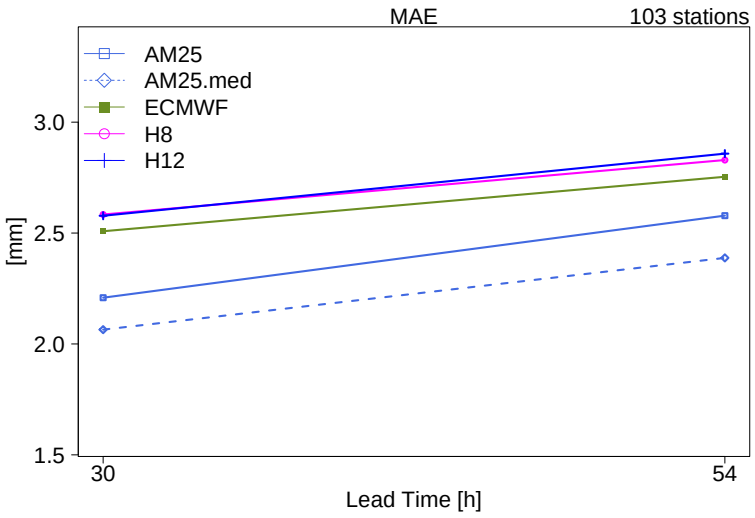

ME
Lead time [h]: 00+3,+6,..,+48
81 stations
3
2
1
0
−1
AM25
AM25.KF
H8
H8.KF

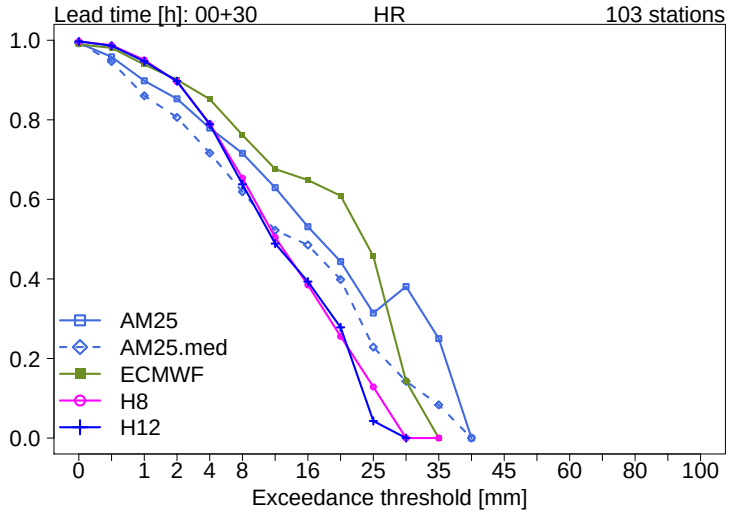

SDE
Lead time [h]: 00+3,+6,..,+48
81 stations
2.5
2.0
1.5
1.0
AM25
AM25.KF
H8
H8.KF

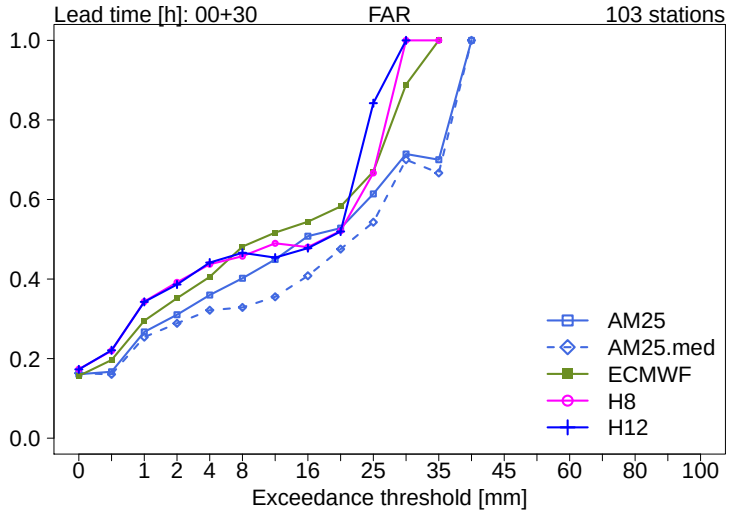
8.8 Daily precipitation

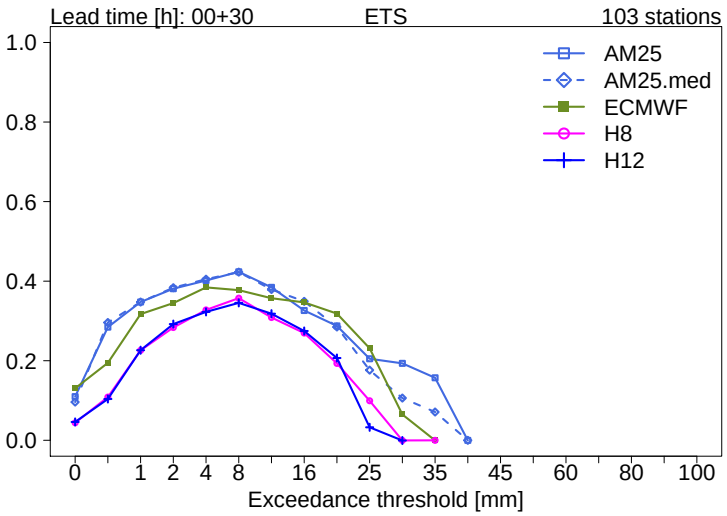


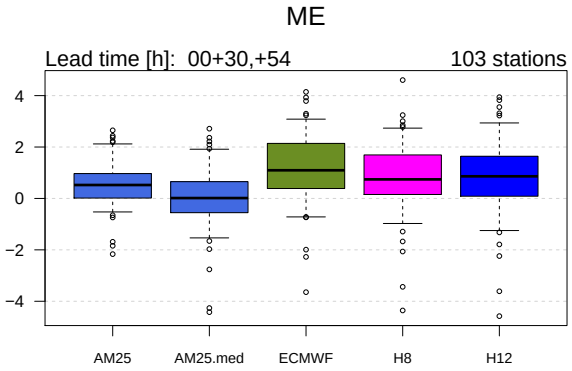


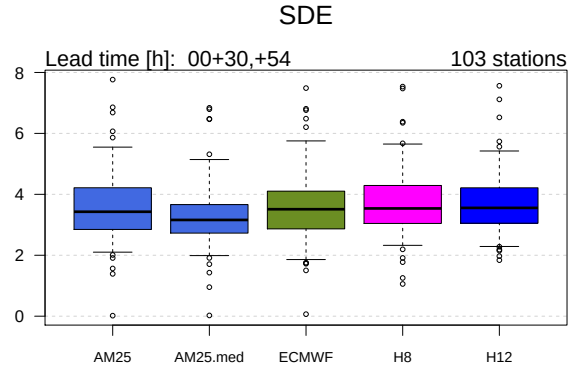



Lead time [h]: 00+30
HR
103 stations
1.0
0.8
0.6
0.4
0.2
0.0
AM25
AM25.med
ECMWF
H8
H12
0 1 2 4 8 16 25 35 45 60 80 100
Exceedance threshold [mm]


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]	1349	483	16	0	0	1848
(0.1,5]	1754	5085	771	6	0	7616
(5,20]	114	1356	1824	165	1	3460
(20,50]	4	12	144	102	1	263
(50,Inf]	0	0	0	1	0	1
Sum	3221	6936	2755	274	2	13188

AM25.med

	OBS					
	[0,0.1]	(0.1,5]	(5,20]	(20,50]	(50,Inf]	Sum
[0,0.1]	1447	582	18	0	0	2047
(0.1,5]	1693	5328	936	10	0	7967
(5,20]	81	1018	1703	169	0	2971
(20,50]	0	8	98	95	2	203
(50,Inf]	0	0	0	0	0	0
Sum	3221	6936	2755	274	2	13188

ECMWF

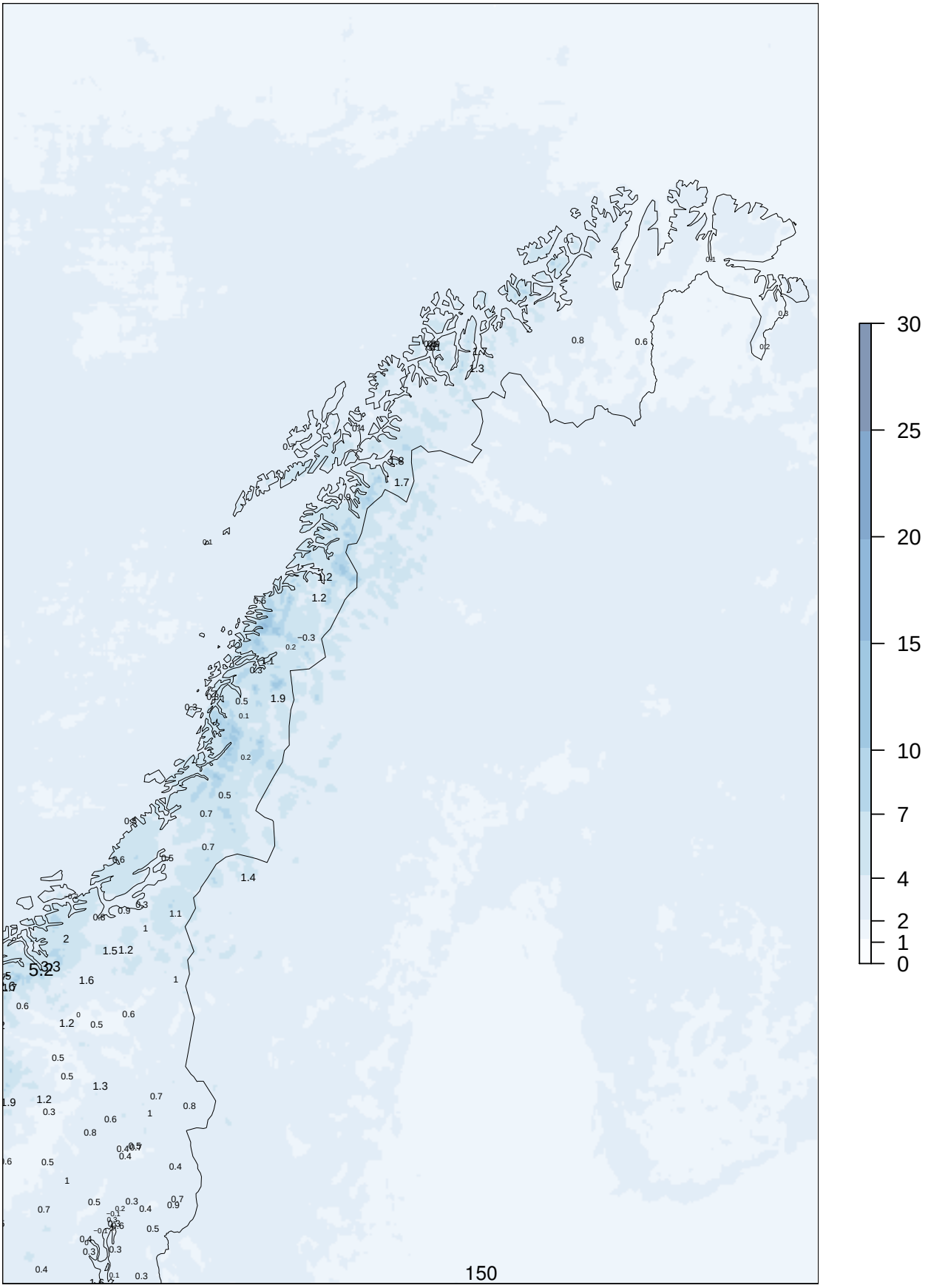
	OBS					
	[0,0.1]	(0.1,5]	(5,20]	(20,50]	(50,Inf]	Sum
[0,0.1]	919	217	4	0	0	1140
(0.1,5]	2173	4924	572	10	0	7679
(5,20]	126	1779	1934	100	0	3939
(20,50]	3	16	245	164	2	430
(50,Inf]	0	0	0	0	0	0
Sum	3221	6936	2755	274	2	13188

H8

	OBS					
	[0,0.1]	(0.1,5]	(5,20]	(20,50]	(50,Inf]	Sum
[0,0.1]	519	130	6	0	0	655
(0.1,5]	2538	5095	846	7	0	8486
(5,20]	163	1699	1837	198	0	3897
(20,50]	1	12	66	69	2	150
(50,Inf]	0	0	0	0	0	0
Sum	3221	6936	2755	274	2	13188

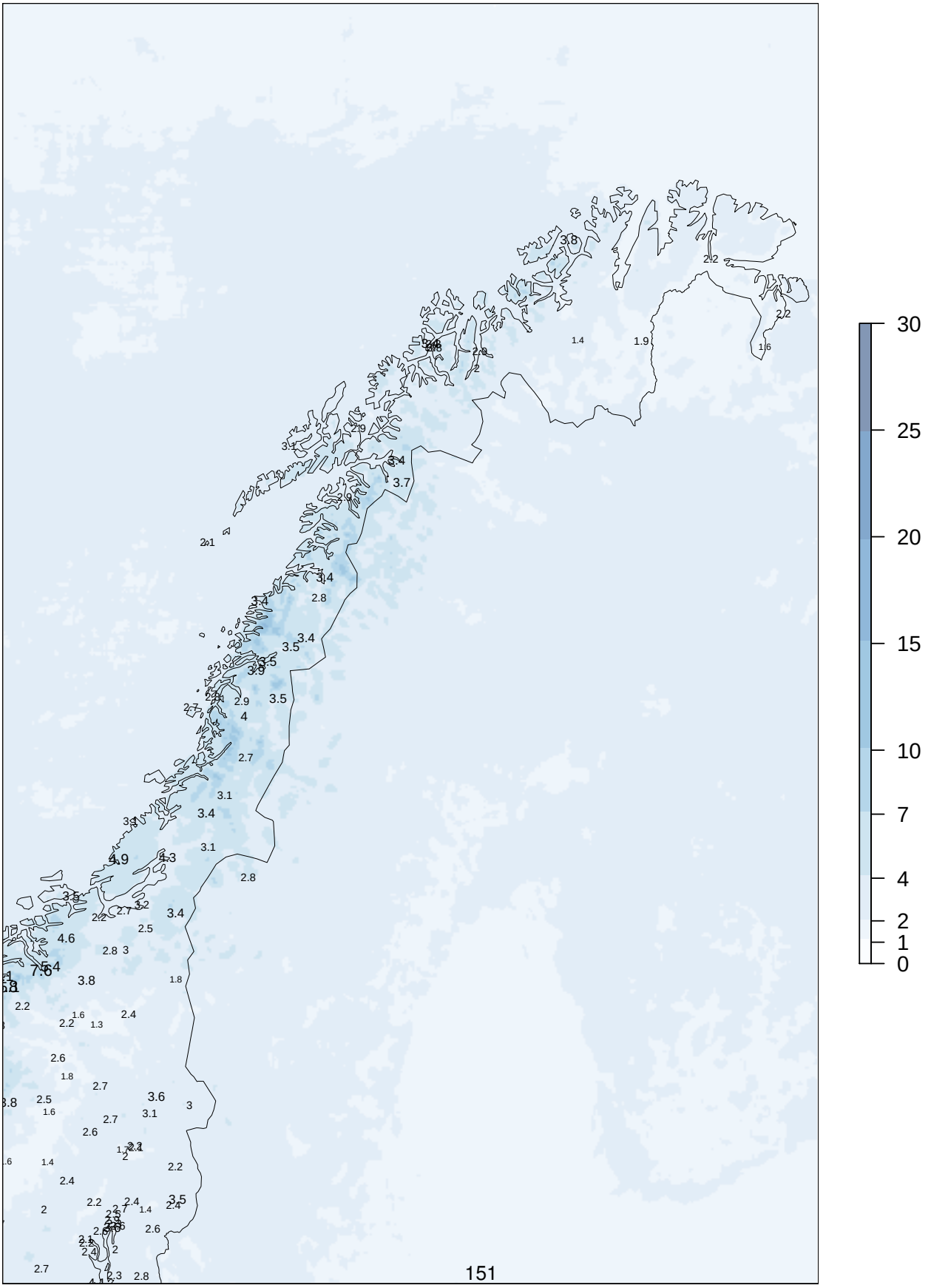
AM25 00+30

ME at observing sites forecast means 01.03.2015 − 31.05.2015



AM25 00+30

SDE at observing sites forecast means 01.03.2015 − 31.05.2015



9 Long term forecast

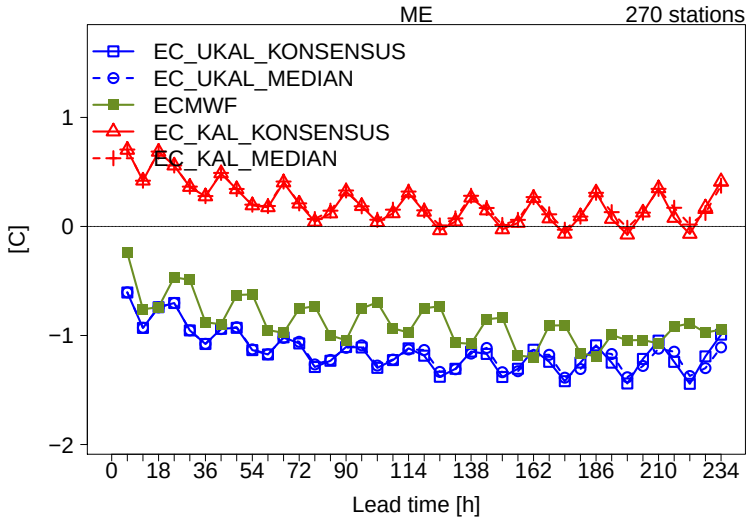
9.1 Comments to the verification results

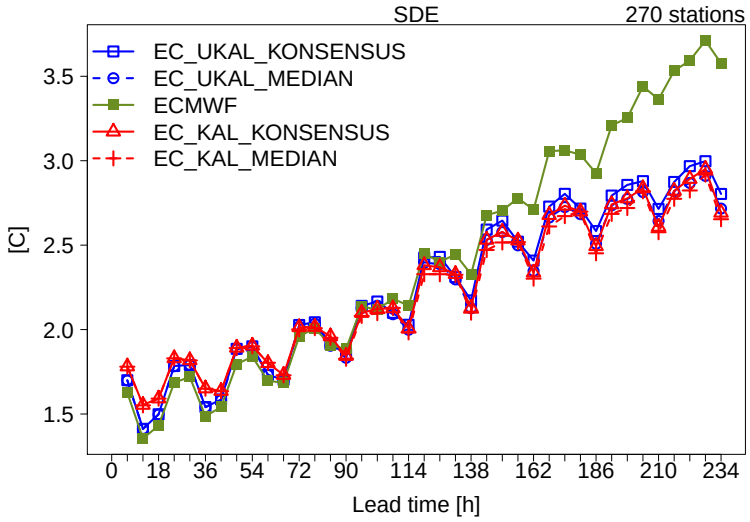
Temperature 2m:
Negative bias with a slight cold trend for both the deterministic ECMWF and also the uncalibrated probabilistic forecast. A small positive bias for the calibrated forecast. This is a clear improvement from the winter season.
SDE is also significantly reduced compared with the winter. Still small differences between the deterministic ECMWF and probabilistic forecast up to 160h, where SDE is increased for the deterministic forecast. There is a clear improvement from calibration in MAE for all lead times. Actually, the uncalibrated probabilistic forecast has higher MAE than the deterministic forecast up to around 138h. MAE is also reduced compared with the winter season.

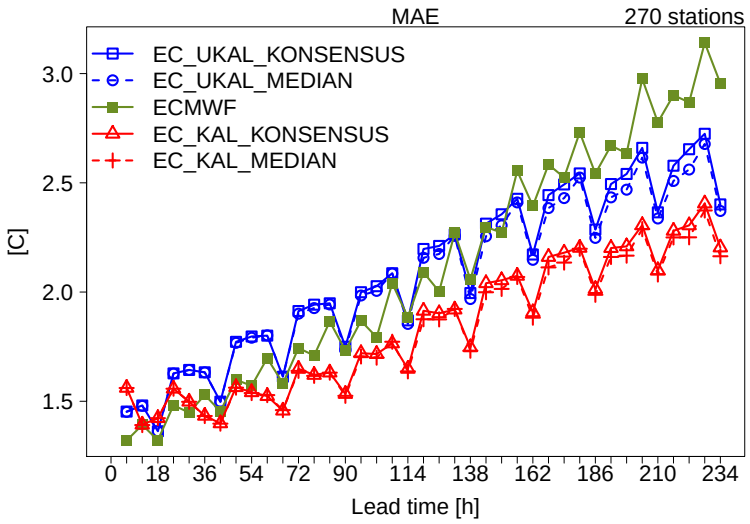
Wind speed 10m:
Negative biases for both deterministic and probabilistic forecast. Clear diurnal variations, with the most bias during daytime. SDE and MAE clearly lower for the probabilistic forecast after around 100h. ETS is quite similar for both forecasts after 72h, and after 216h, the probabilistic forecast is slightly better for low thresholds. Still the overall score is low.

Precipitation:
Small positive bias for the deterministic forecast. Mostly negative bias for the probabilistic forecast, with a clear dry trend. Median drier than the consensus forecast. SDE and MAE higher for the deterministic forecast after around 100h. The deterministic forecast scores better at ETS for the first part of the long term forecast. At 222 and 234, the overall score is very low for both forecast, yet the probabilistic forecast is slightly better at lower threshold and ECMWF is slightly better at higher threshold.

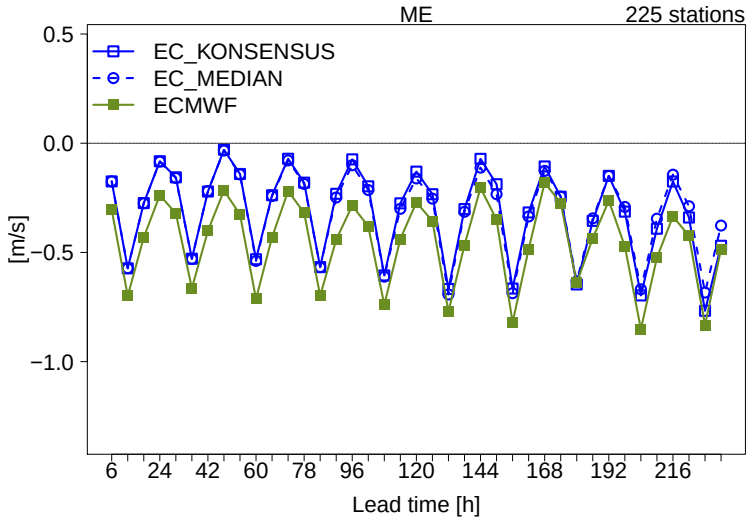
9.2 Temperature 2m

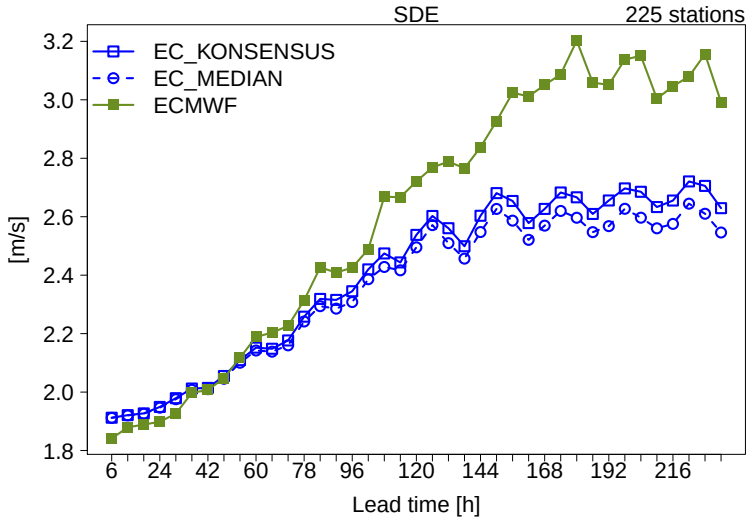


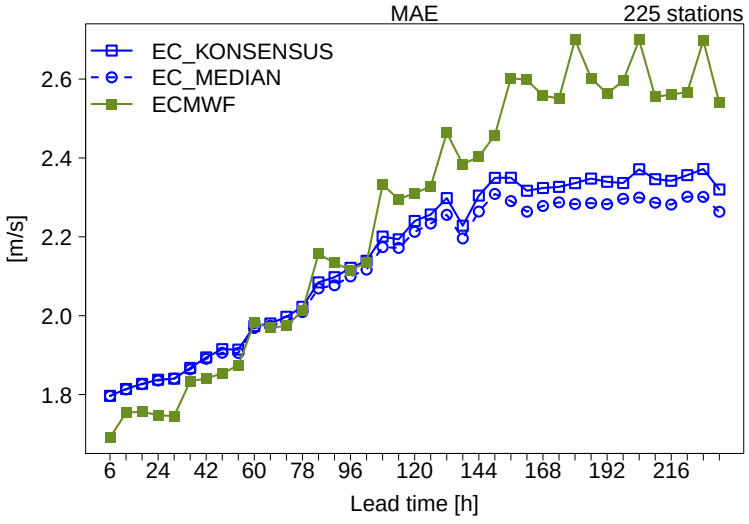


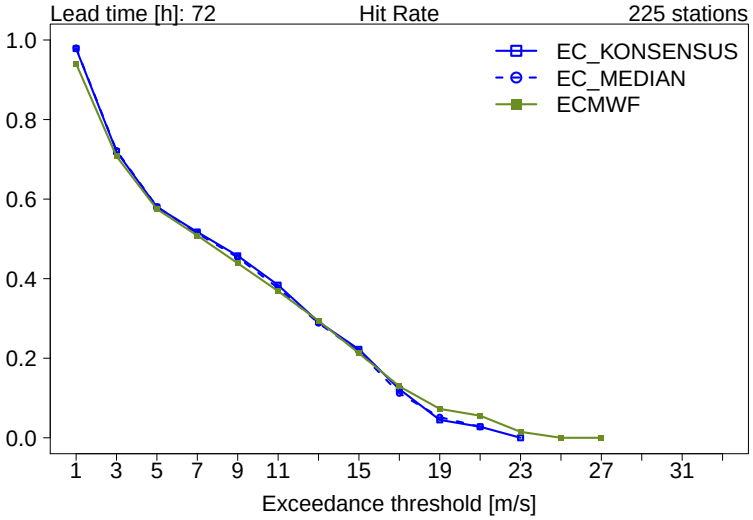


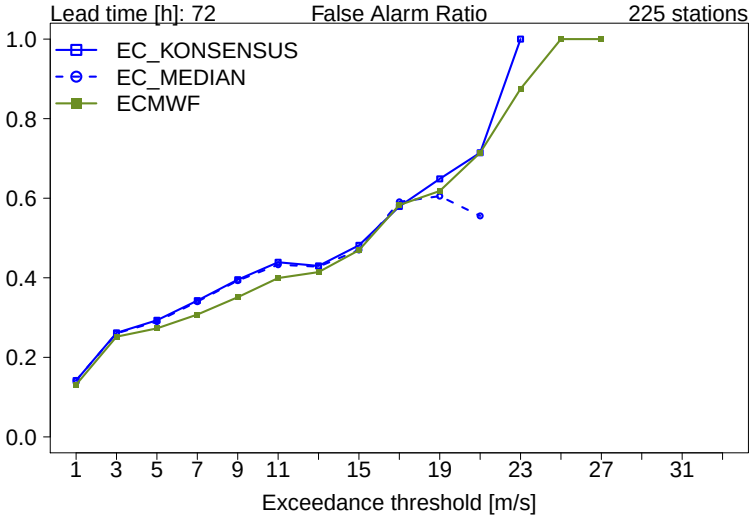
9.3 Wind Speed 10m

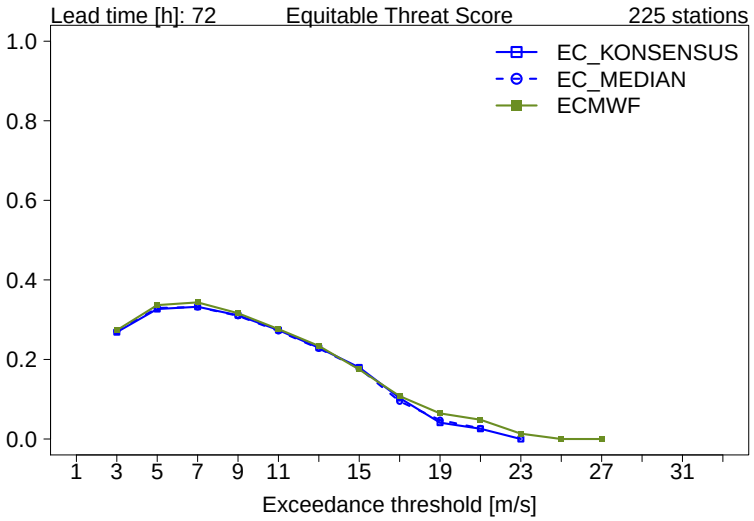


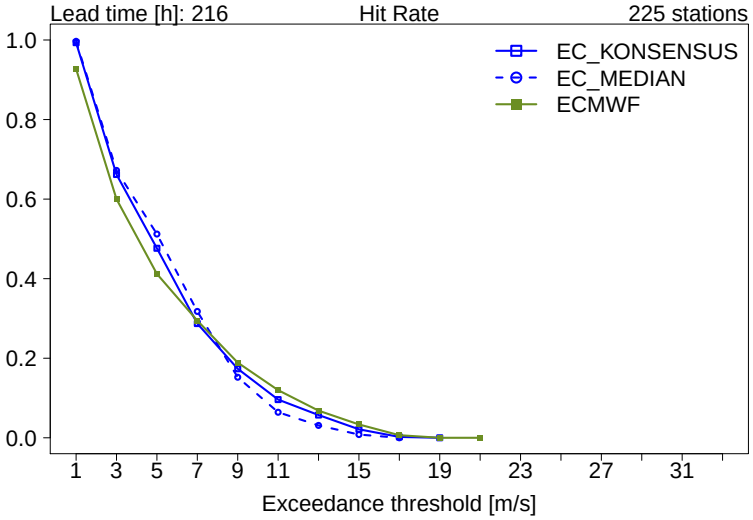


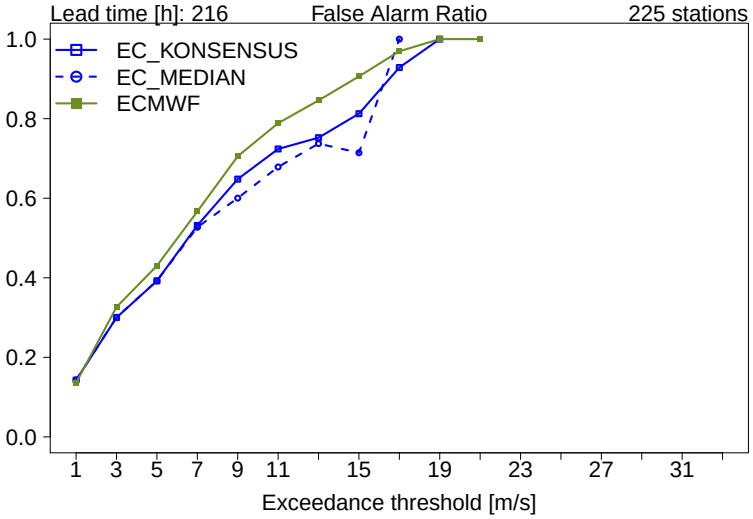


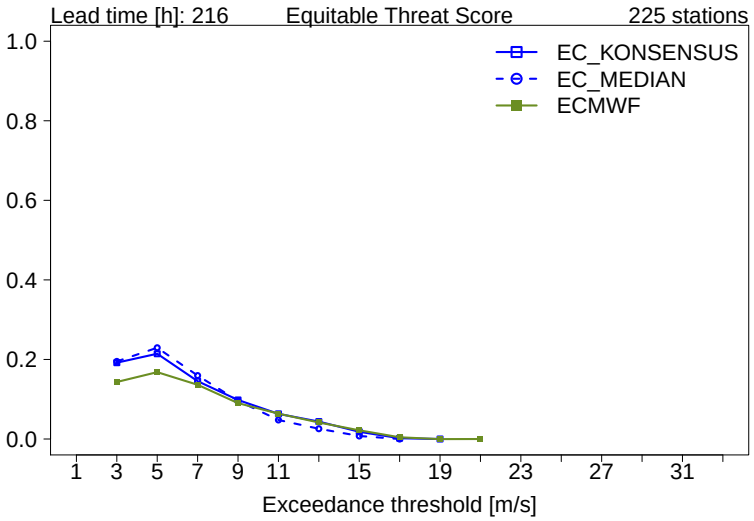

Lead time [h]: 72
Hit Rate
225 stations
EC_KONSENSUS
EC_MEDIAN
ECMWF
1.0
0.8
0.6
0.4
0.2
0.0
1 3 5 7 9 11 15 19 23 27 31
Exceedance threshold [m/s]


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]

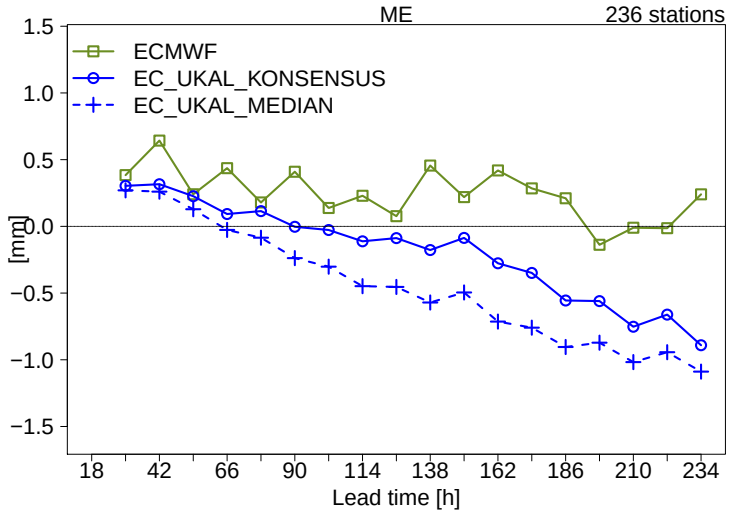

Lead time [h]: 72
Equitable Threat Score
225 stations
EC_KONSENSUS
EC_MEDIAN
ECMWF
1.0
0.8
0.6
0.4
0.2
0.0
1 3 5 7 9 11 15 19 23 27 31
Exceedance threshold [m/s]

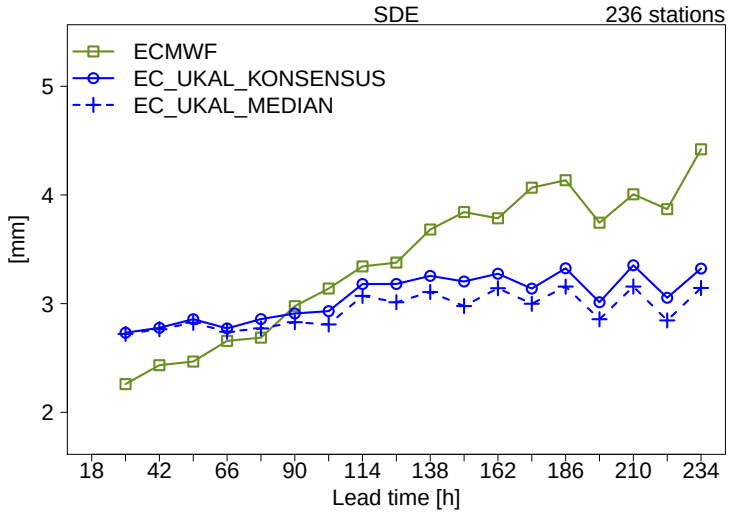

Lead time [h]: 216
Hit Rate
225 stations
EC_KONSENSUS
EC_MEDIAN
ECMWF
1.0
0.8
0.6
0.4
0.2
0.0
1 3 5 7 9 11 15 19 23 27 31
Exceedance threshold [m/s]

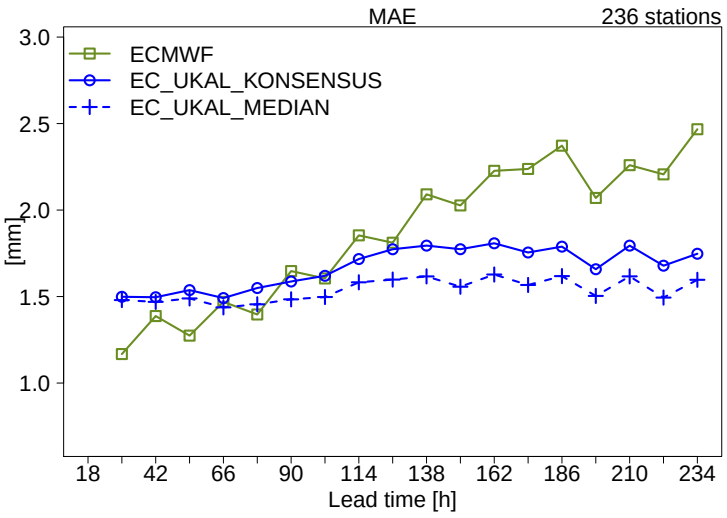

Lead time [h]: 216
False Alarm Ratio
225 stations
EC_KONSENSUS
EC_MEDIAN
ECMWF
1.0
0.8
0.6
0.4
0.2
0.0
1 3 5 7 9 11 15 19 23 27 31
Exceedance threshold [m/s]

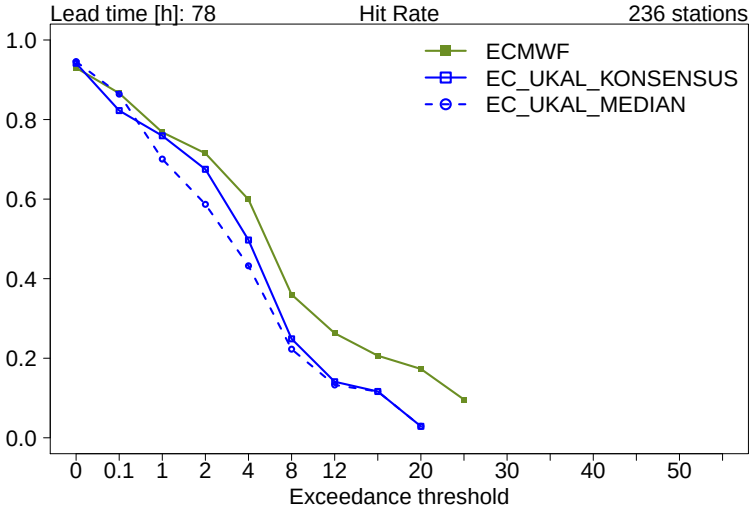

Lead time [h]: 216
Equitable Threat Score
225 stations
EC_KONSENSUS
EC_MEDIAN
ECMWF
1.0
0.8
0.6
0.4
0.2
0.0
1 3 5 7 9 11 15 19 23 27 31
Exceedance threshold [m/s]

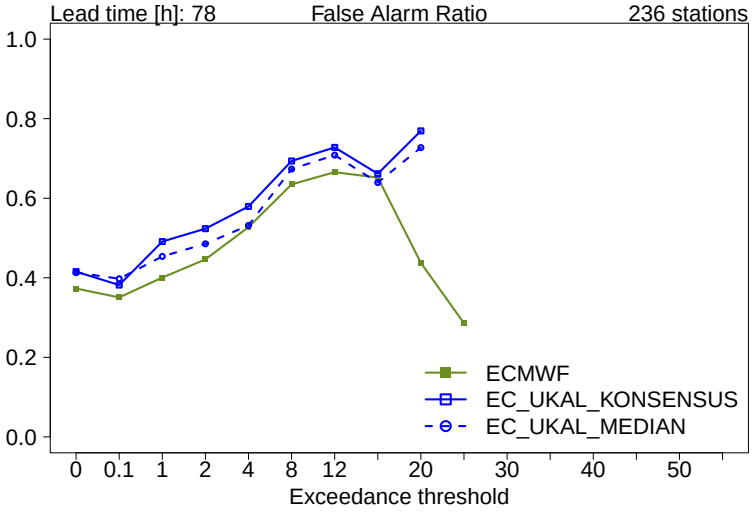
9.4 12h Precipitation

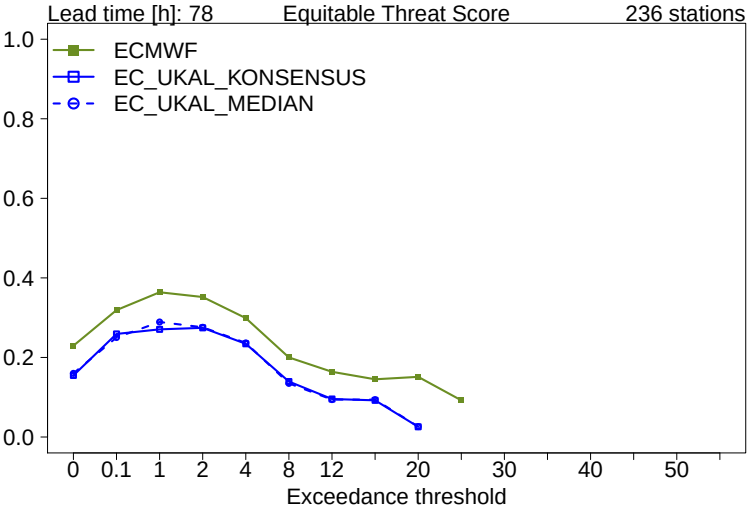


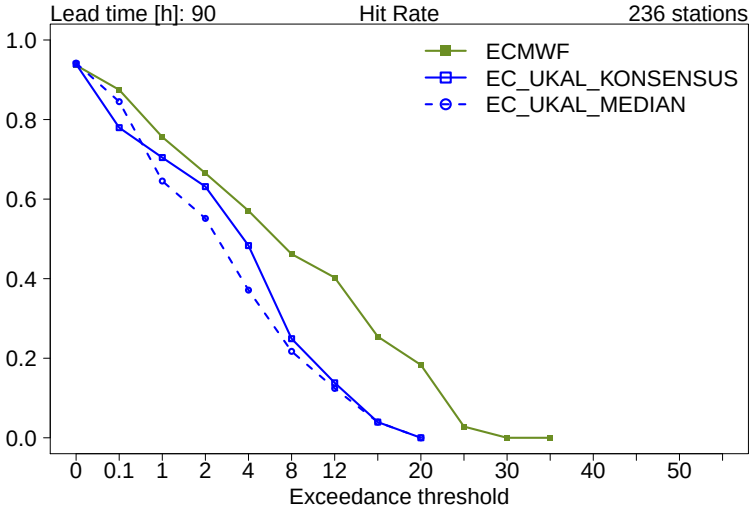


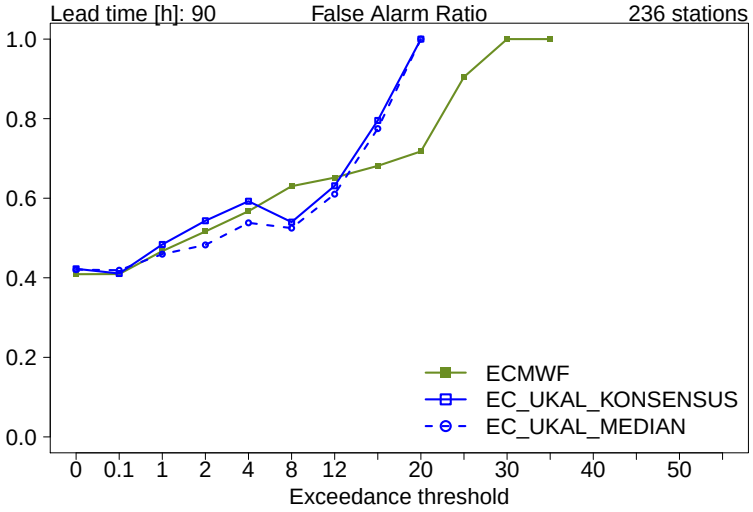


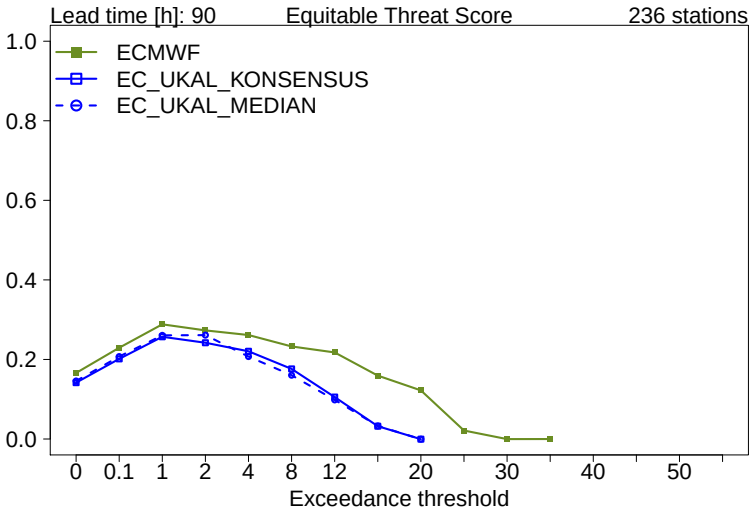

Lead time [h]: 78
Hit Rate
236 stations
ECMWF
EC_UKAL_KONSENSUS
EC_UKAL_MEDIAN
1.0
0.8
0.6
0.4
0.2
0.0
0 0.1 1 2 4 8 12 20 30 40 50
Exceedance threshold

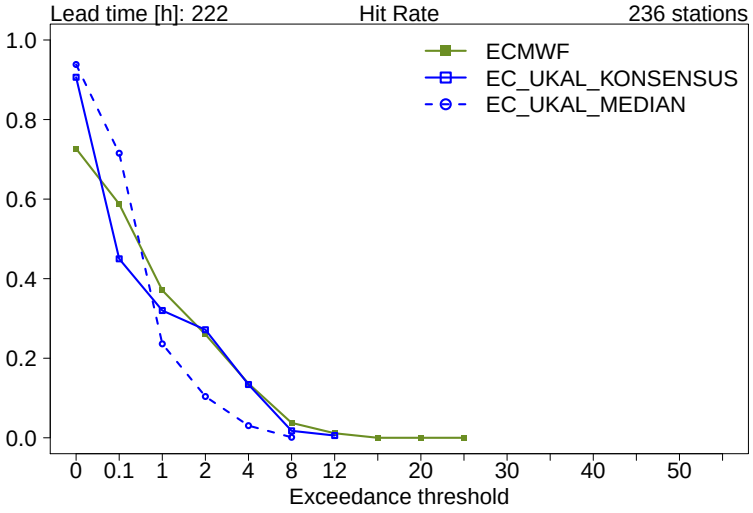

Lead time [h]: 78
False Alarm Ratio
236 stations
ECMWF
EC_UKAL_KONSENSUS
EC_UKAL_MEDIAN
1.0
0.8
0.6
0.4
0.2
0.0
0 0.1 1 2 4 8 12 20 30 40 50
Exceedance threshold

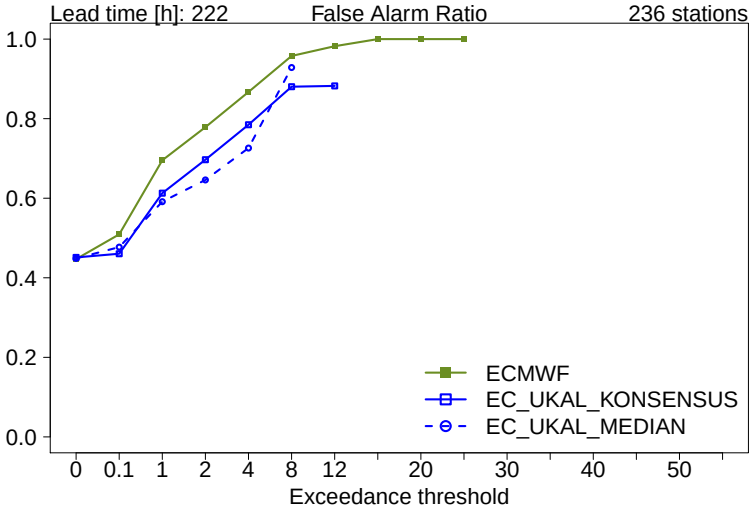

Lead time [h]: 78
Equitable Threat Score
236 stations
ECMWF
EC_UKAL_KONSENSUS
EC_UKAL_MEDIAN
1.0
0.8
0.6
0.4
0.2
0.0
0 0.1 1 2 4 8 12 20 30 40 50
Exceedance threshold

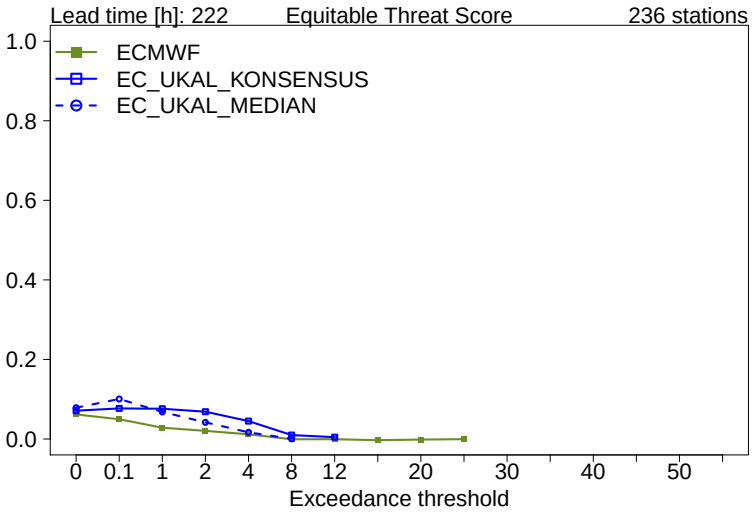

Lead time [h]: 90
Hit Rate
236 stations
ECMWF
EC_UKAL_KONSENSUS
EC_UKAL_MEDIAN
1.0
0.8
0.6
0.4
0.2
0.0
0 0.1 1 2 4 8 12 20 30 40 50
Exceedance threshold

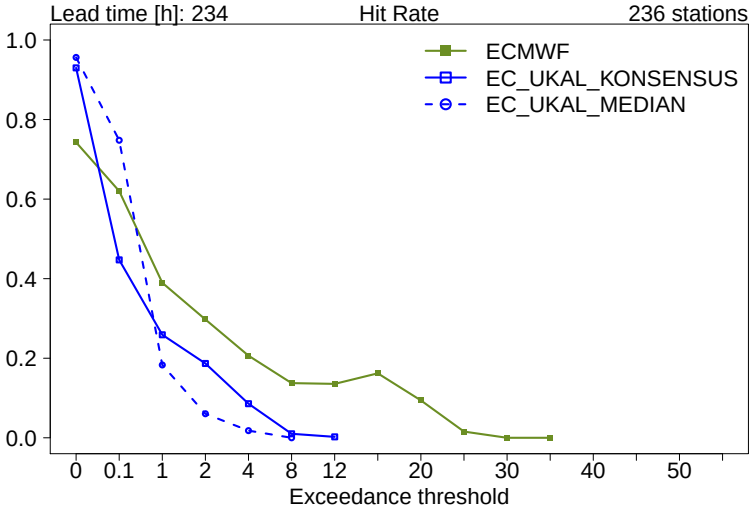

Lead time [h]: 90
False Alarm Ratio
236 stations
ECMWF
EC_UKAL_KONSENSUS
EC_UKAL_MEDIAN
1.0
0.8
0.6
0.4
0.2
0.0
0 0.1 1 2 4 8 12 20 30 40 50
Exceedance threshold

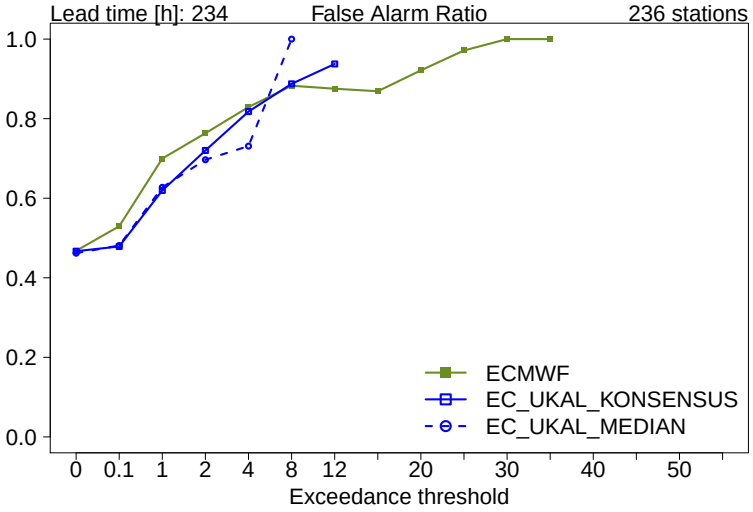

Lead time [h]: 90
Equitable Threat Score
236 stations
ECMWF
EC_UKAL_KONSENSUS
EC_UKAL_MEDIAN
1.0
0.8
0.6
0.4
0.2
0.0
0 0.1 1 2 4 8 12 20 30 40 50
Exceedance threshold

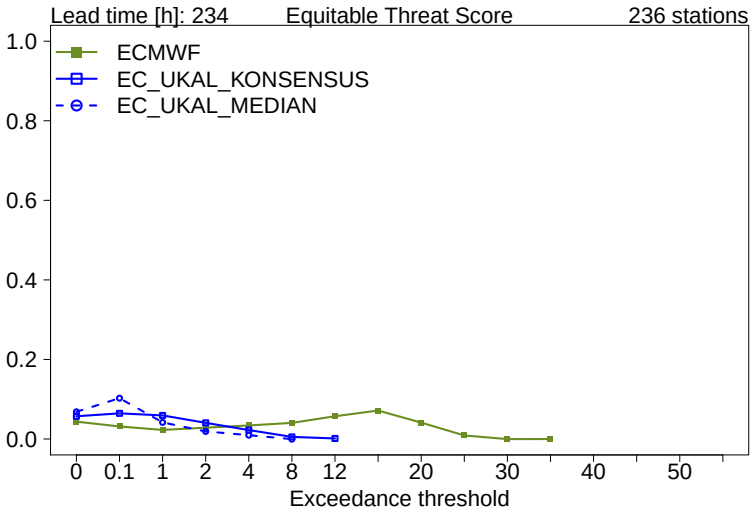

Lead time [h]: 222
Hit Rate
236 stations
ECMWF
EC_UKAL_KONSENSUS
EC_UKAL_MEDIAN
1.0
0.8
0.6
0.4
0.2
0.0
0 0.1 1 2 4 8 12 20 30 40 50
Exceedance threshold


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

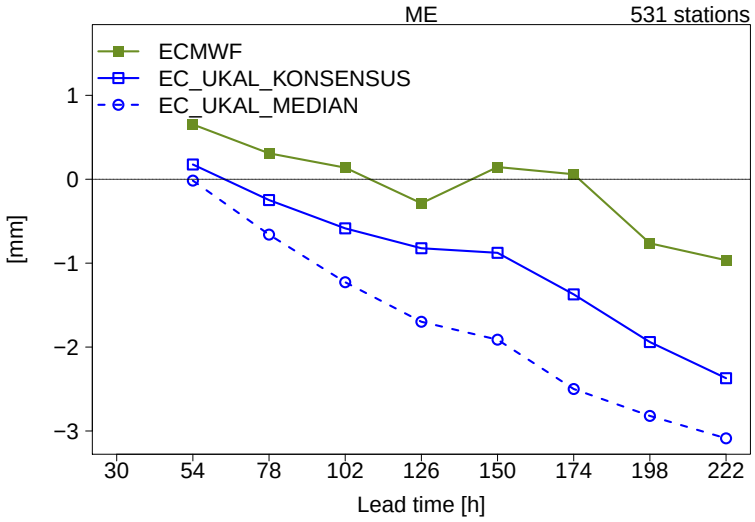

Lead time [h]: 222
Equitable Threat Score
236 stations
ECMWF
EC_UKAL_KONSENSUS
EC_UKAL_MEDIAN
1.0
0.8
0.6
0.4
0.2
0.0
0 0.1 1 2 4 8 12 20 30 40 50
Exceedance threshold

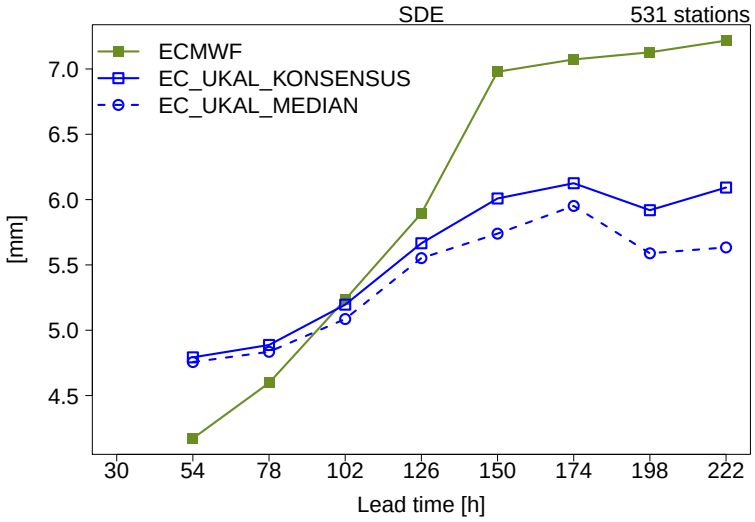

Lead time [h]: 234
Hit Rate
236 stations
ECMWF
EC_UKAL_KONSENSUS
EC_UKAL_MEDIAN
1.0
0.8
0.6
0.4
0.2
0.0
0 0.1 1 2 4 8 12 20 30 40 50
Exceedance threshold

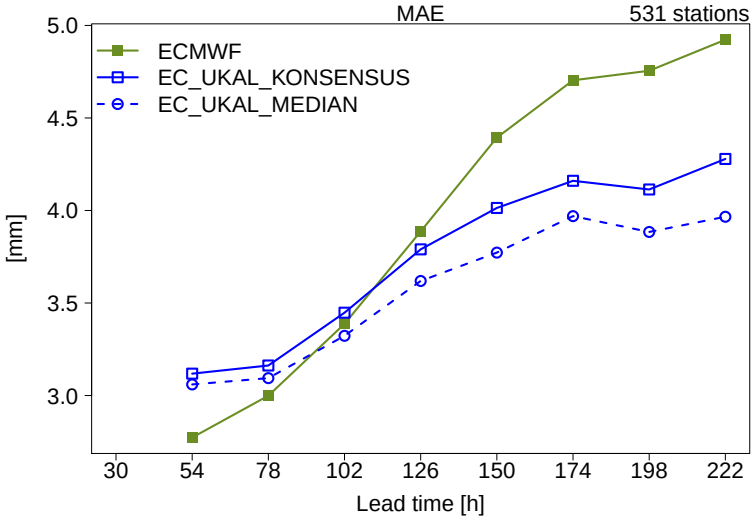

Lead time [h]: 234
False Alarm Ratio
236 stations
ECMWF
EC_UKAL_KONSENSUS
EC_UKAL_MEDIAN
1.0
0.8
0.6
0.4
0.2
0.0
0 0.1 1 2 4 8 12 20 30 40 50
Exceedance threshold

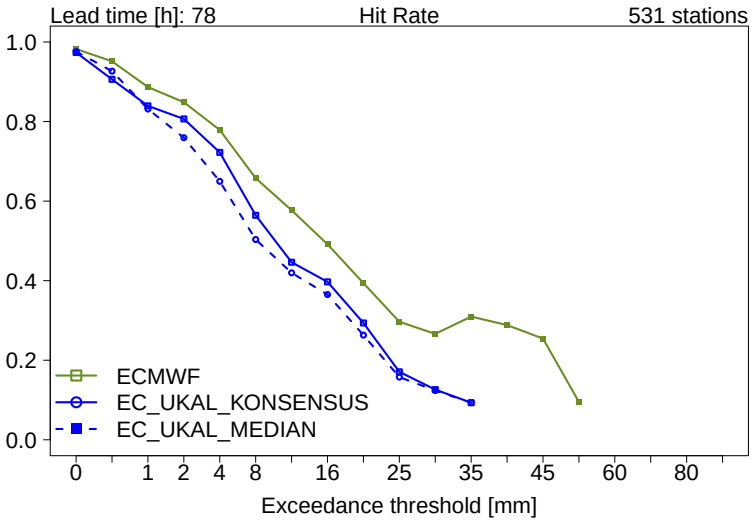

Lead time [h]: 234
Equitable Threat Score
236 stations
ECMWF
EC_UKAL_KONSENSUS
EC_UKAL_MEDIAN
1.0
0.8
0.6
0.4
0.2
0.0
0 0.1 1 2 4 8 12 20 30 40 50
Exceedance threshold

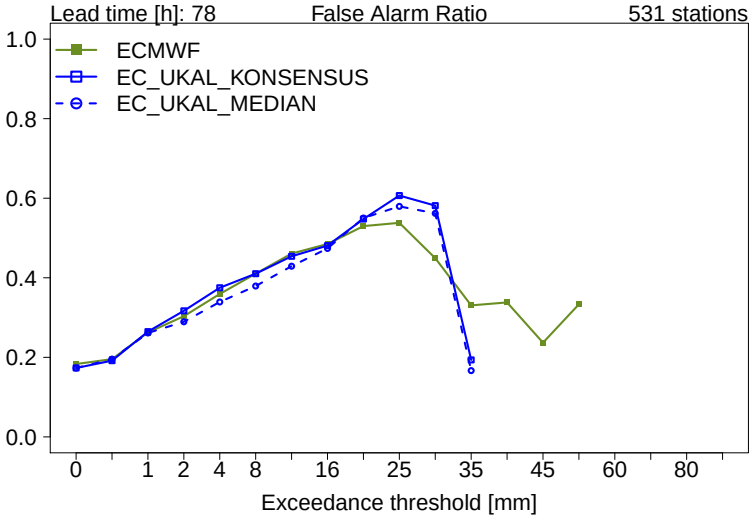
9.5 24h Precipitation

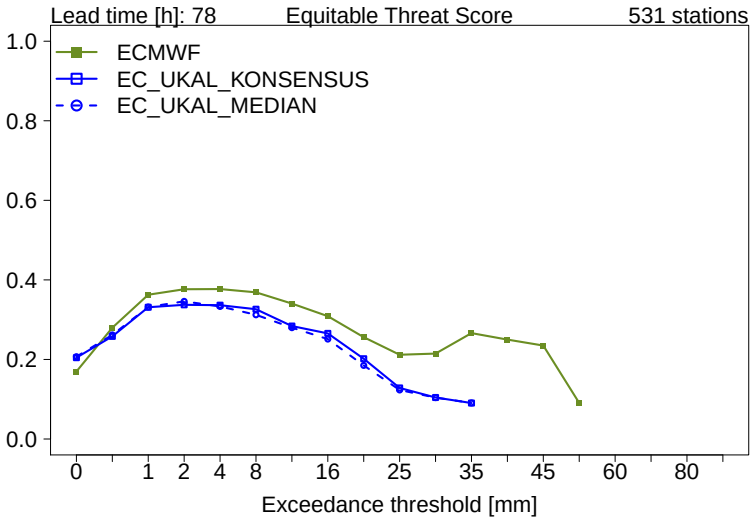


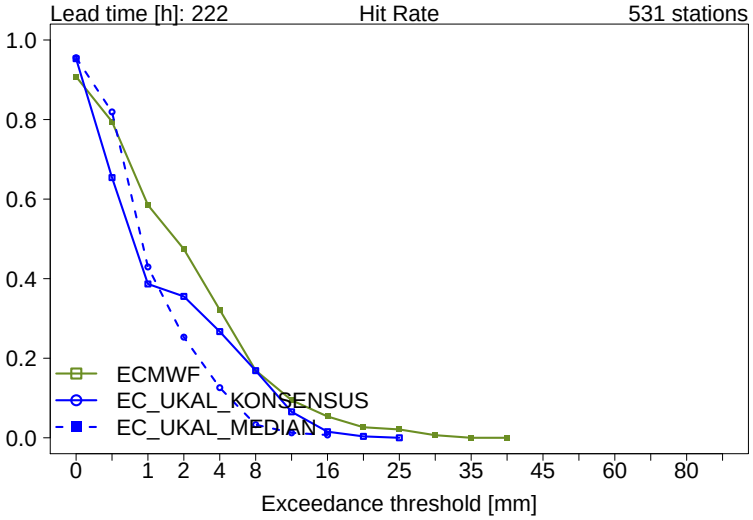


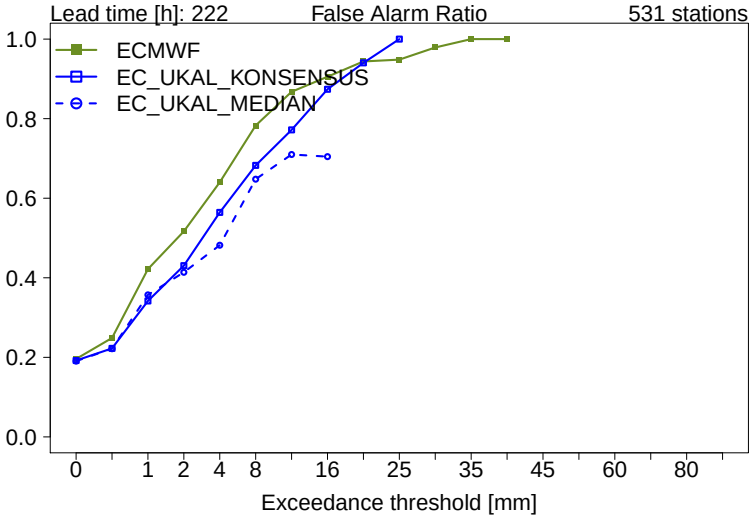


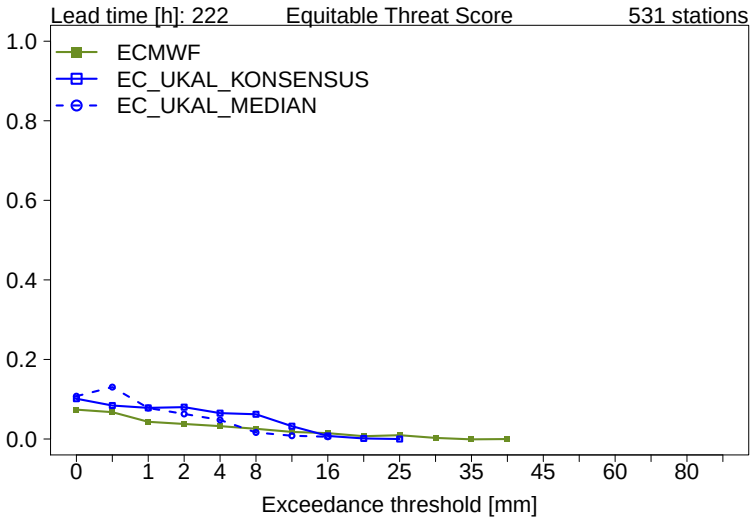

Lead time [h]: 78
Hit Rate
531 stations
1.0
0.8
0.6
0.4
0.2
0.0
ECMWF
EC_UKAL_KONSENSUS
EC_UKAL_MEDIAN
0 1 2 4 8 16 25 35 45 60 80
Exceedance threshold [mm]


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]

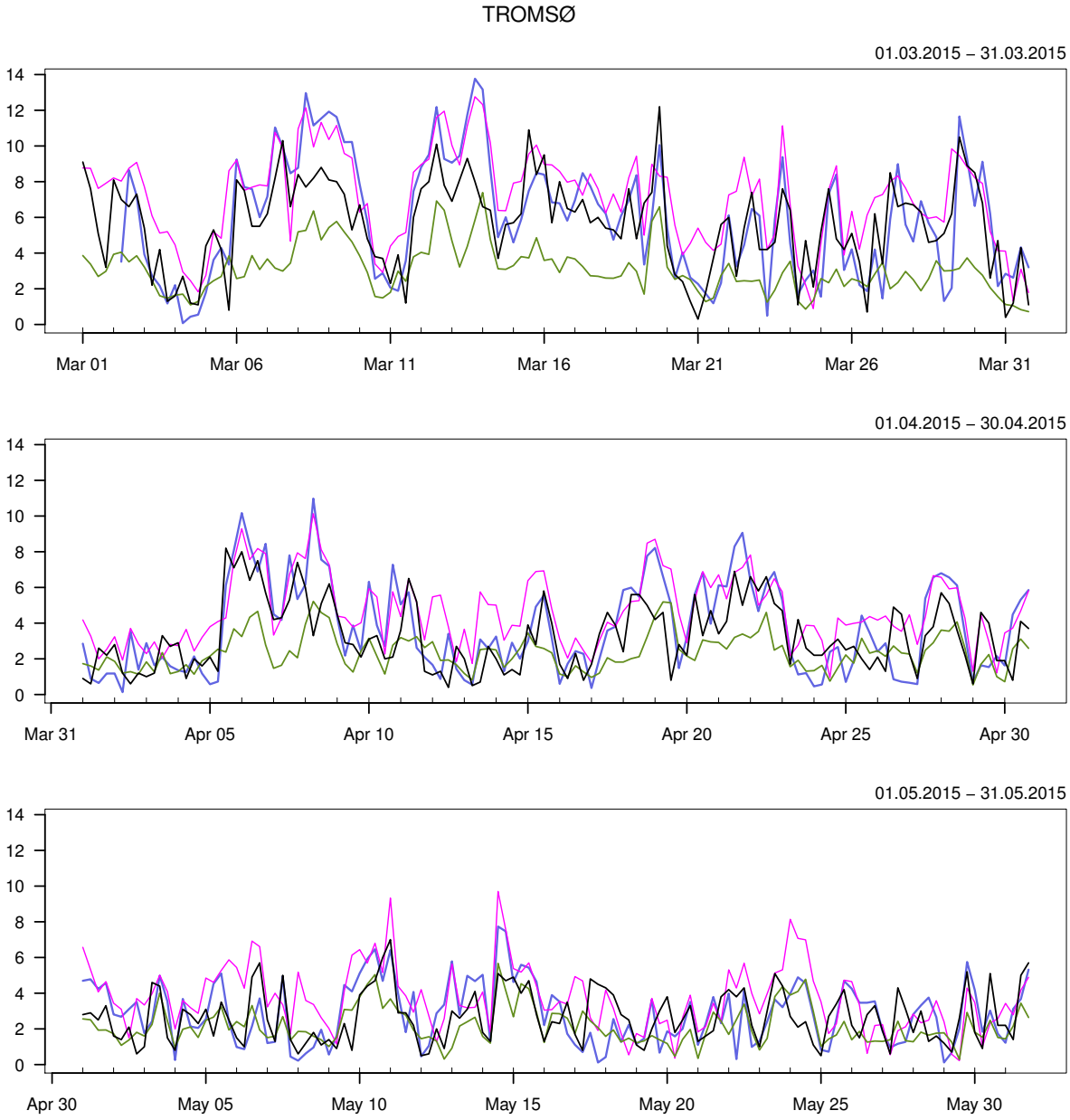

Lead time [h]: 222
Hit Rate
531 stations
1.0
0.8
0.6
0.4
0.2
0.0
ECMWF
EC_UKAL_KONSENSUS
EC_UKAL_MEDIAN
0 1 2 4 8 16 25 35 45 60 80
Exceedance threshold [mm]


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]

10 Appendix

10.1 10m Wind speed

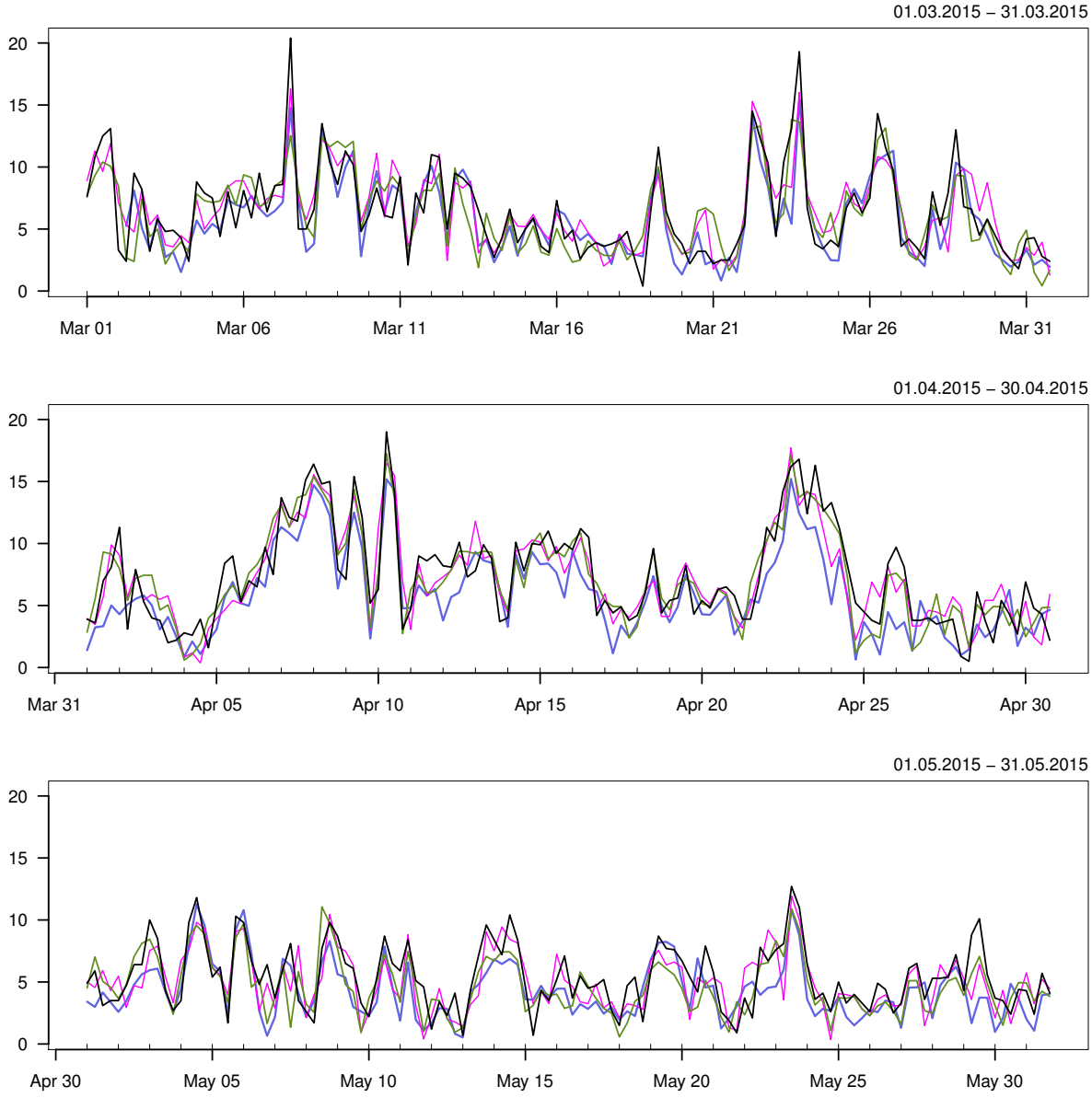


01.03.2015 – 31.05.2015

	Min	Mean	Max	Std	N
synop: 00,06,12,18	0.3	3.8	12.2	2.4	368
AM25: 12+18,+24,+30,+36	0.1	4.2	13.8	2.9	363
Hirlam8: 12+18,+24,+30,+36	0.2	5.2	12.8	2.6	368
ECMWF: 12+18,+24,+30,+36	0.3	2.5	7.4	1.2	368

	ME	SDE	RMSE	MAE	Max.abs.err.	N
AM25 – synop	0.3	1.9	1.9	1.5	7.7	363
Hirlam8 – synop	1.3	1.8	2.2	1.8	7.8	368
ECMWF – synop	–1.3	1.8	2.3	1.7	7.4	368

ØRLAND

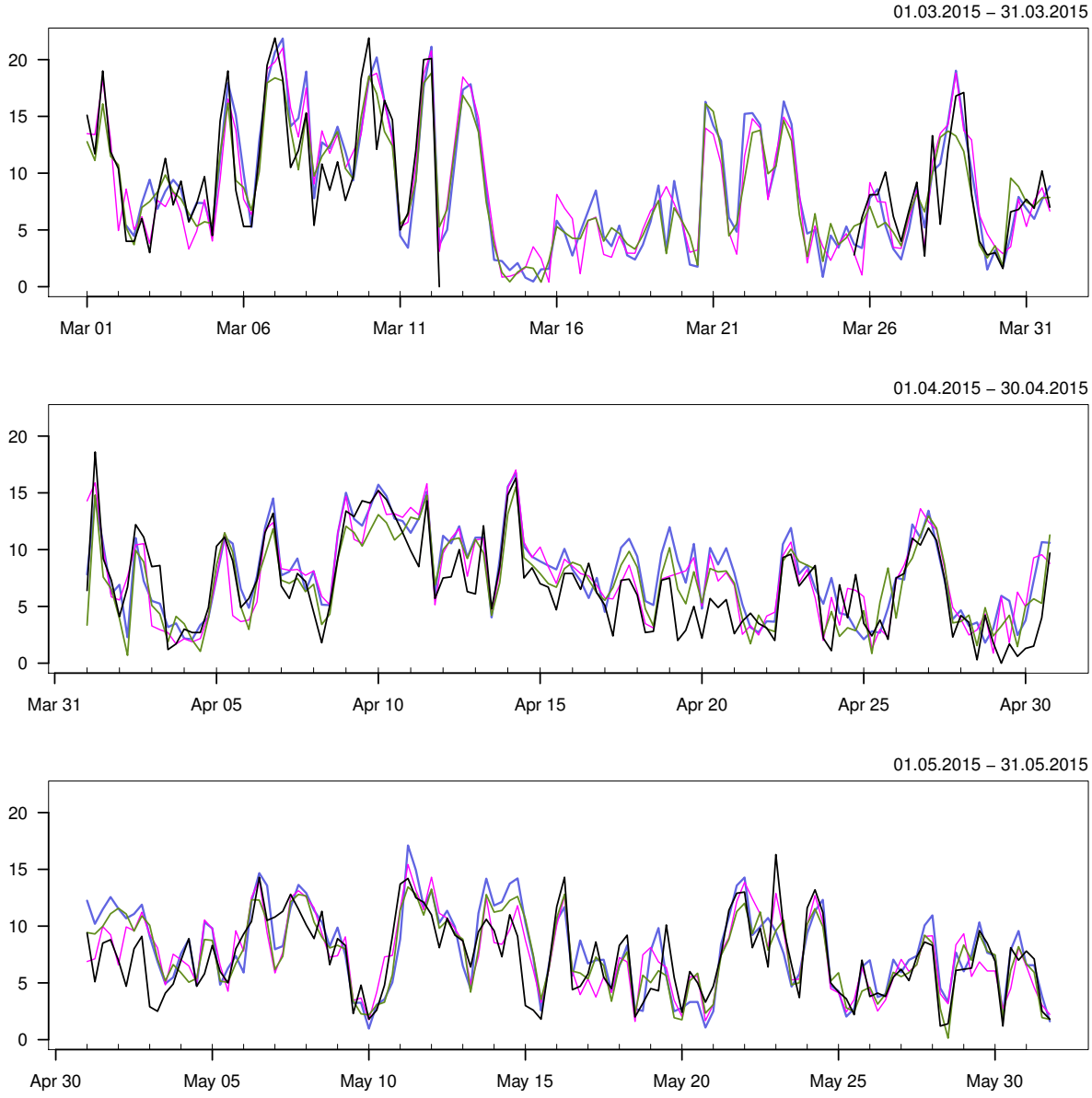


01.03.2015 – 31.05.2015

	Min	Mean	Max	Std	N
synop: 00,06,12,18	0.4	6.4	20.4	3.5	368
AM25: 12+18,+24,+30,+36	0.5	5.3	15.5	3	363
Hirlam8: 12+18,+24,+30,+36	0.4	6.3	17.7	3.2	368
ECMWF: 12+18,+24,+30,+36	0.4	6	17.2	3.3	368

	ME	SDE	RMSE	MAE	Max.abs.err.	N
AM25 – synop	−1.1	1.9	2.2	1.7	8.2	363
Hirlam8 – synop	−0.1	1.9	1.9	1.5	5.2	368
ECMWF – synop	−0.4	1.9	1.9	1.5	7.9	368

YTTERØYANE FYR

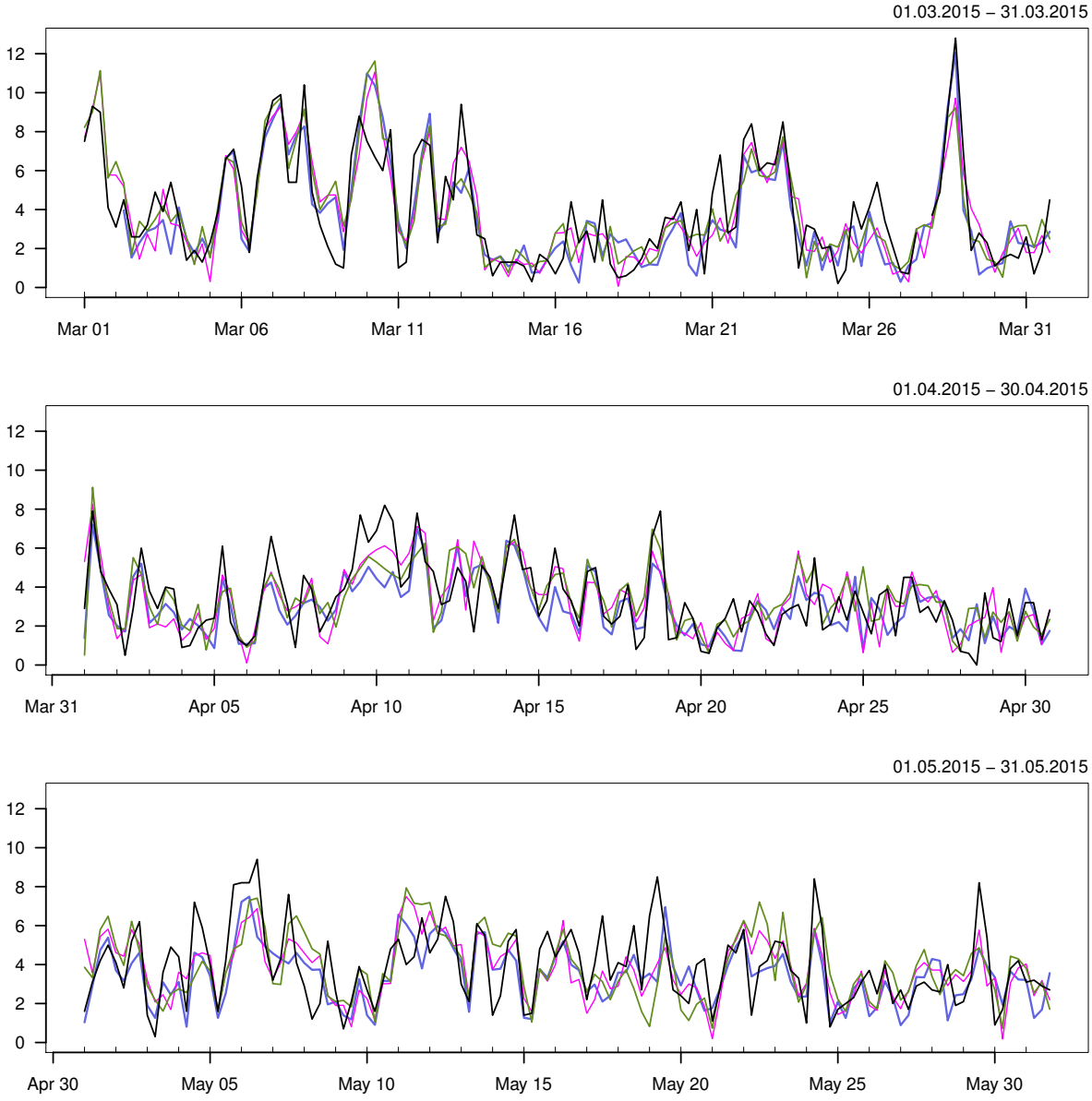


01.03.2015 – 31.05.2015

	Min	Mean	Max	Std	N
synop: 00,06,12,18	0	7.7	21.9	4.3	316
AM25: 12+18,+24,+30,+36	0.5	8.2	21.9	4.3	363
Hirlam8: 12+18,+24,+30,+36	0.4	8	21	4.2	368
ECMWF: 12+18,+24,+30,+36	0.1	7.7	18.8	3.9	368

	ME	SDE	RMSE	MAE	Max.abs.err.	N
AM25 – synop	0.8	2.5	2.6	2.1	8.1	311
Hirlam8 – synop	0.5	2.4	2.5	1.9	8	316
ECMWF – synop	0.2	2.3	2.3	1.8	7.7	316

BERGEN – FLORIDA

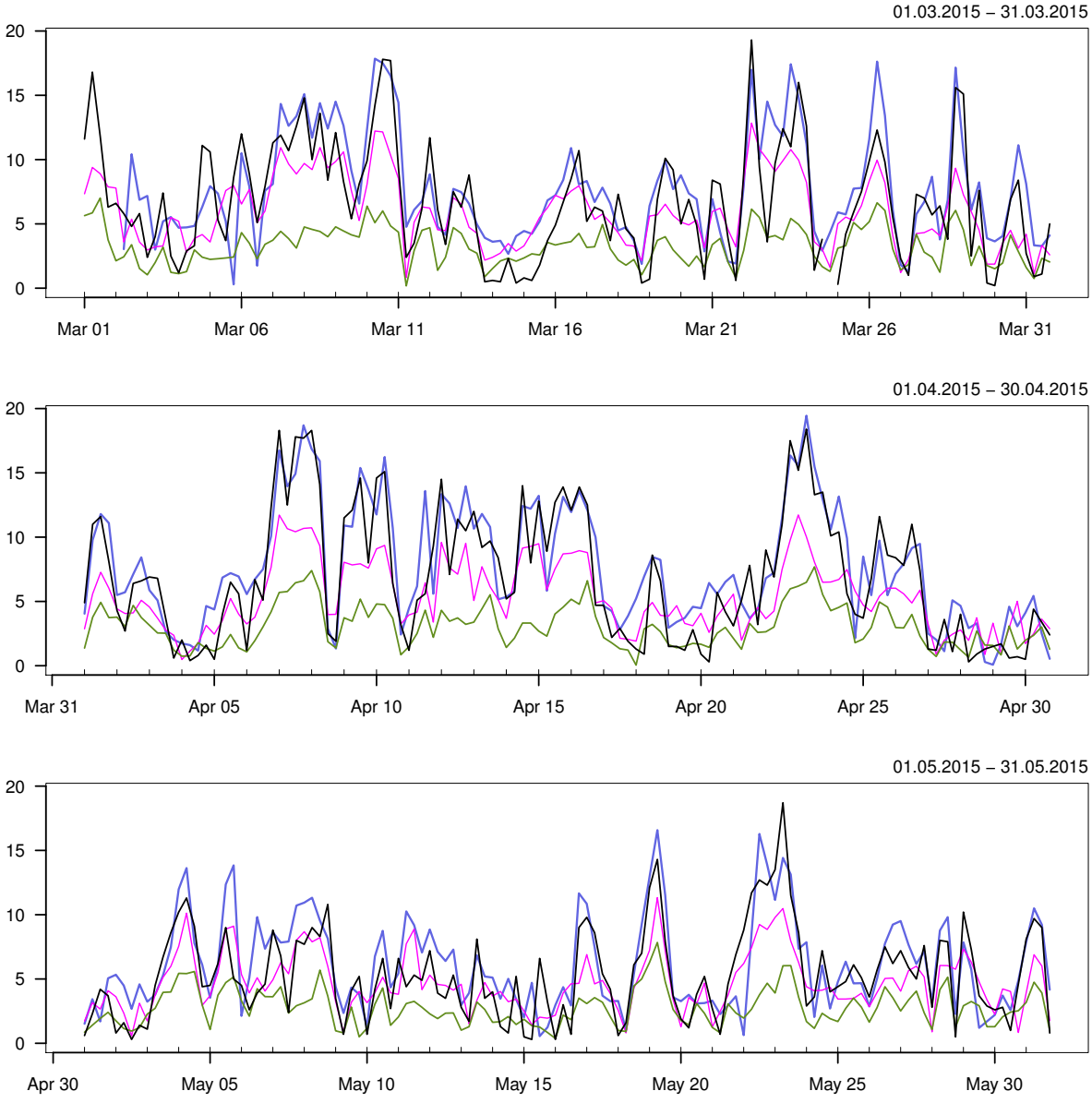


01.03.2015 – 31.05.2015

	Min	Mean	Max	Std	N
synop: 00,06,12,18	0	3.7	12.8	2.2	367
AM25: 12+18,+24,+30,+36	0.2	3.3	12.1	1.9	363
Hirlam8: 12+18,+24,+30,+36	0.1	3.6	11.1	2	368
ECMWF: 12+18,+24,+30,+36	0.5	3.8	11.6	2	368

	ME	SDE	RMSE	MAE	Max.abs.err.	N
AM25 – synop	–0.4	1.4	1.5	1.2	5.4	362
Hirlam8 – synop	–0.1	1.5	1.5	1.2	4.7	367
ECMWF – synop	0	1.6	1.6	1.2	5.7	367

FINSEVATN

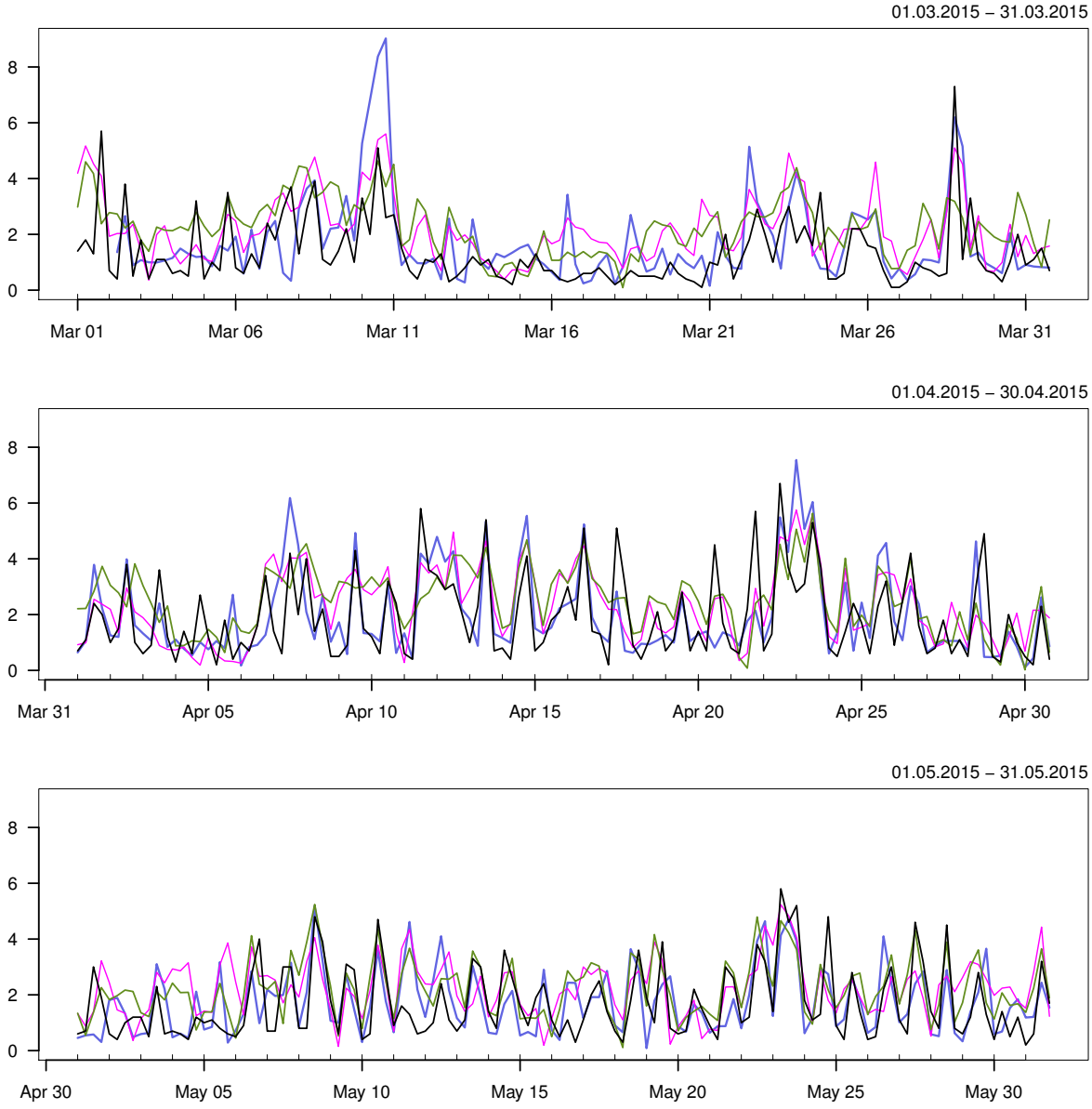


01.03.2015 – 31.05.2015

	Min	Mean	Max	Std	N
synop: 00,06,12,18	0.2	6.4	19.3	4.4	367
AM25: 12+18,+24,+30,+36	0.1	7.2	19.4	4.2	363
Hirlam8: 12+18,+24,+30,+36	0.5	5.3	12.8	2.6	368
ECMWF: 12+18,+24,+30,+36	0	3	7.8	1.5	368

	ME	SDE	RMSE	MAE	Max.abs.err.	N
AM25 – synop	0.9	2.5	2.6	2.1	10.9	362
Hirlam8 – synop	−1	2.7	2.9	2.3	8.4	367
ECMWF – synop	−3.3	3.3	4.7	3.6	13.2	367

NESBYEN

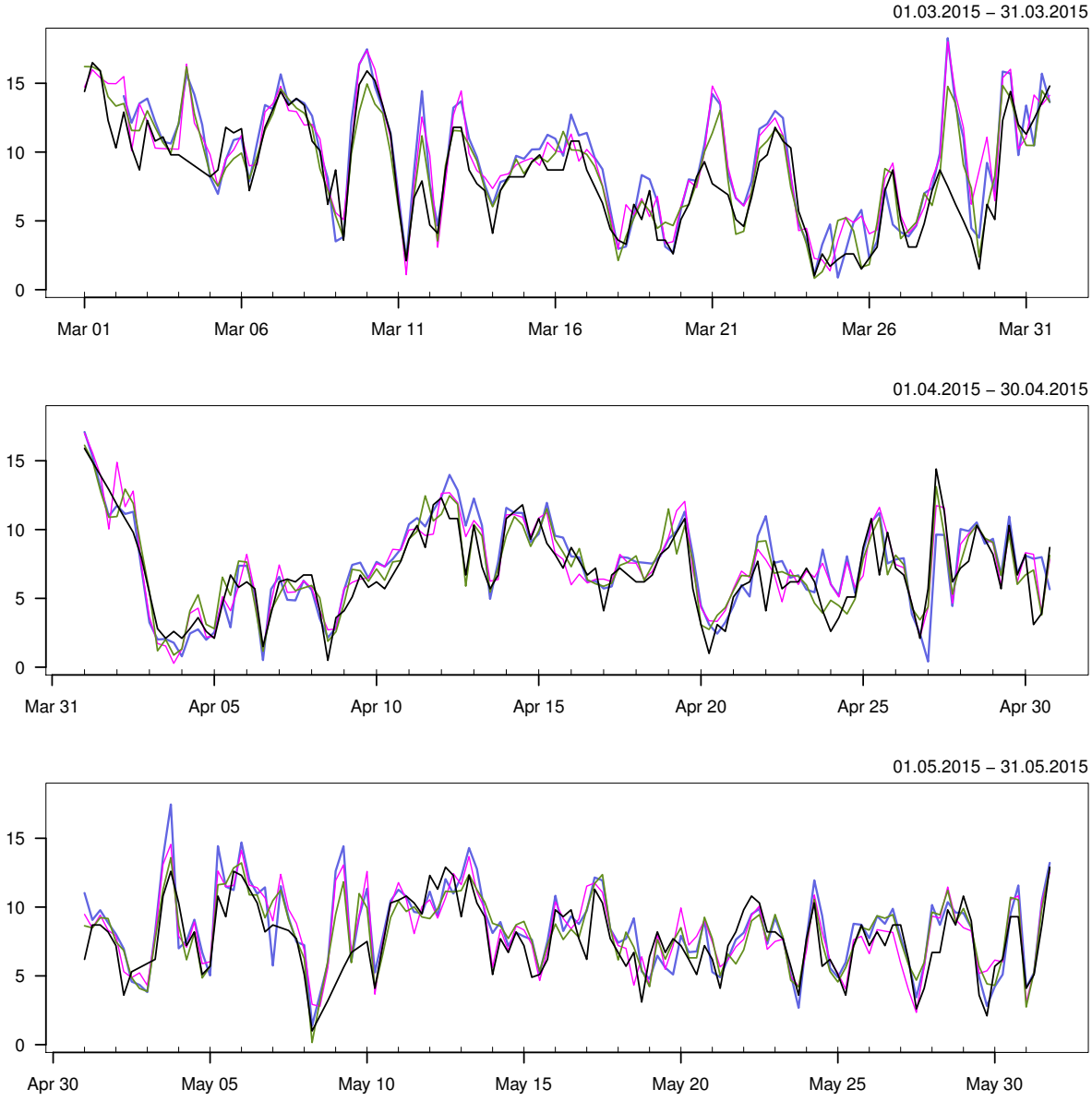


01.03.2015 – 31.05.2015

	Min	Mean	Max	Std	N
synop: 00,06,12,18	0.1	1.6	7.3	1.3	368
AM25: 12+18,+24,+30,+36	0.1	1.8	9	1.4	363
Hirlam8: 12+18,+24,+30,+36	0.2	2.2	5.8	1.2	368
ECMWF: 12+18,+24,+30,+36	0	2.3	5.6	1.1	368

	ME	SDE	RMSE	MAE	Max.abs.err.	N
AM25 – synop	0.2	1.2	1.2	0.9	6.4	363
Hirlam8 – synop	0.6	1.2	1.3	1.1	3.4	368
ECMWF – synop	0.7	1.2	1.4	1.1	4.1	368

EKOFISK

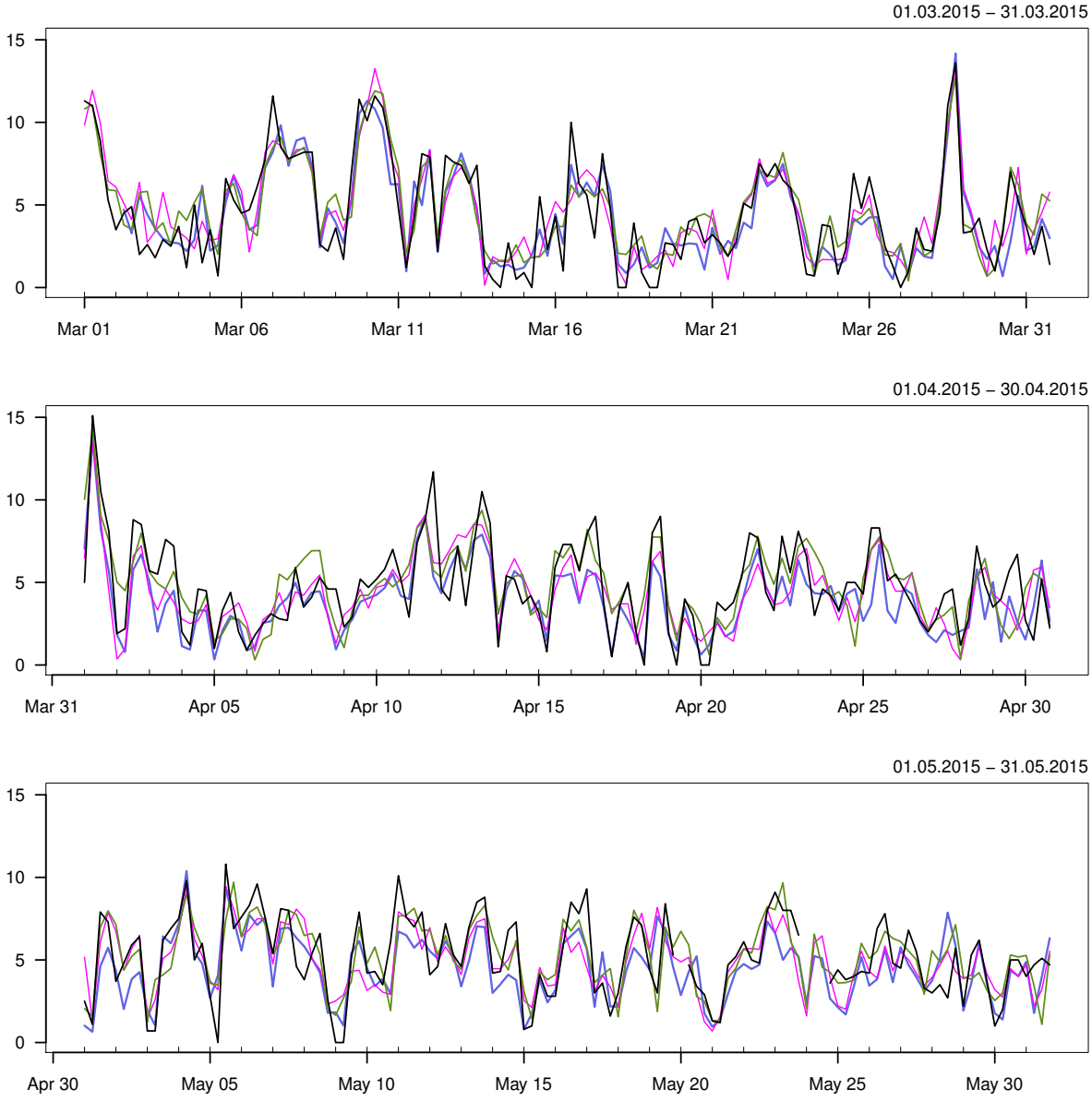


01.03.2015 – 31.05.2015

	Min	Mean	Max	Std	N
synop: 00,06,12,18	0.5	7.6	16.5	3.2	368
AM25: 12+18,+24,+30,+36	0.4	8.4	18.3	3.5	363
Hirlam8: 12+18,+24,+30,+36	0.3	8.4	18	3.4	368
ECMWF: 12+18,+24,+30,+36	0.2	8.1	16.2	3.2	368

	ME	SDE	RMSE	MAE	Max.abs.err.	N
AM25 – synop	0.9	2	2.1	1.5	10.8	363
Hirlam8 – synop	0.8	1.8	2	1.4	10.5	368
ECMWF – synop	0.5	1.6	1.7	1.2	7.3	368

SOLA

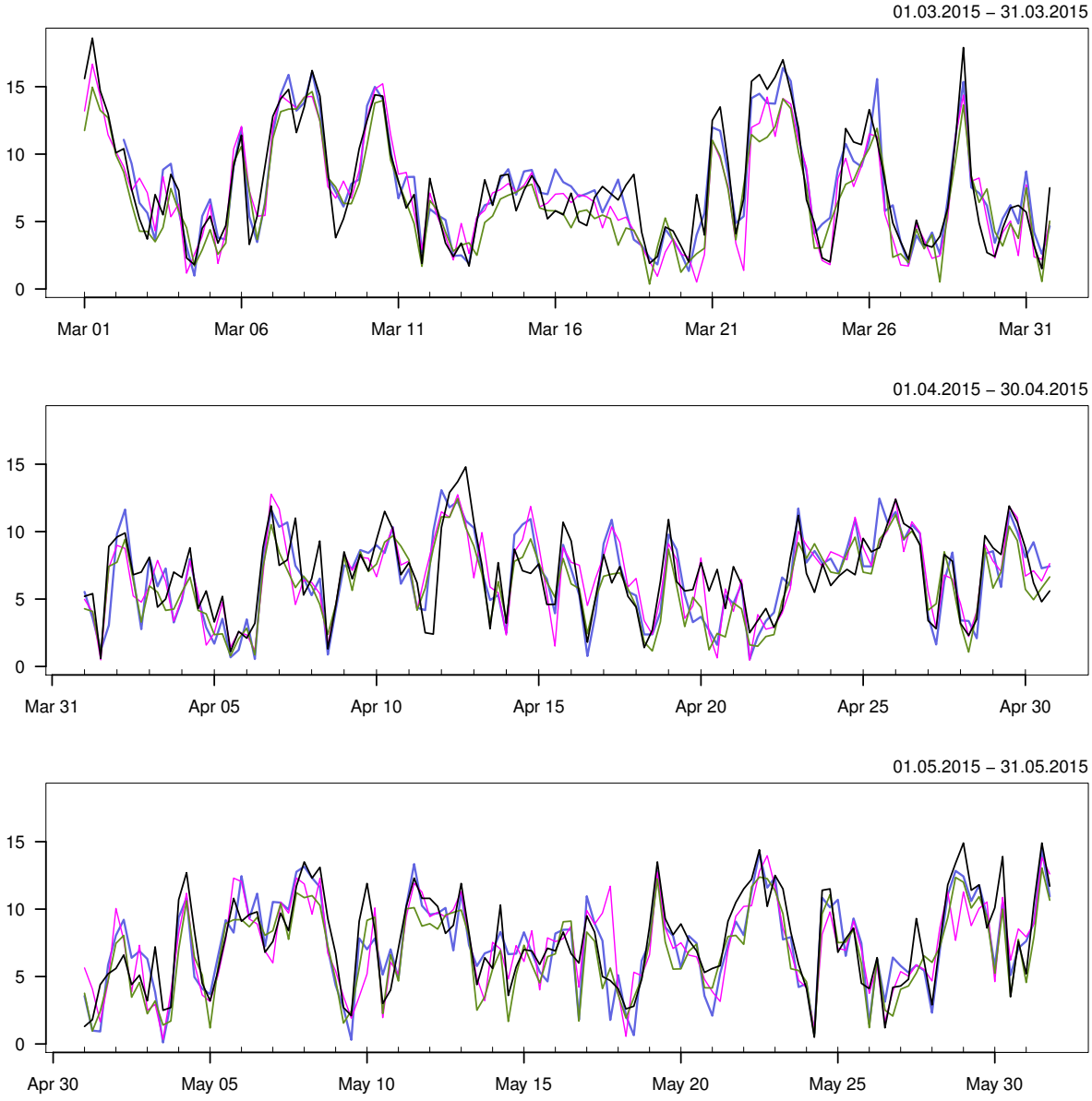


01.03.2015 – 31.05.2015

	Min	Mean	Max	Std	N
synop: 00,06,12,18	0	4.8	15.1	2.8	364
AM25: 12+18,+24,+30,+36	0.3	4.2	14.2	2.3	363
Hirlam8: 12+18,+24,+30,+36	0.1	4.7	13.5	2.3	368
ECMWF: 12+18,+24,+30,+36	0.3	5	14.3	2.3	368

	ME	SDE	RMSE	MAE	Max.abs.err.	N
AM25 – synop	–0.5	1.6	1.6	1.3	6.4	359
Hirlam8 – synop	–0.1	1.7	1.7	1.3	5.5	364
ECMWF – synop	0.2	1.6	1.7	1.3	6	364

FERDER FYR

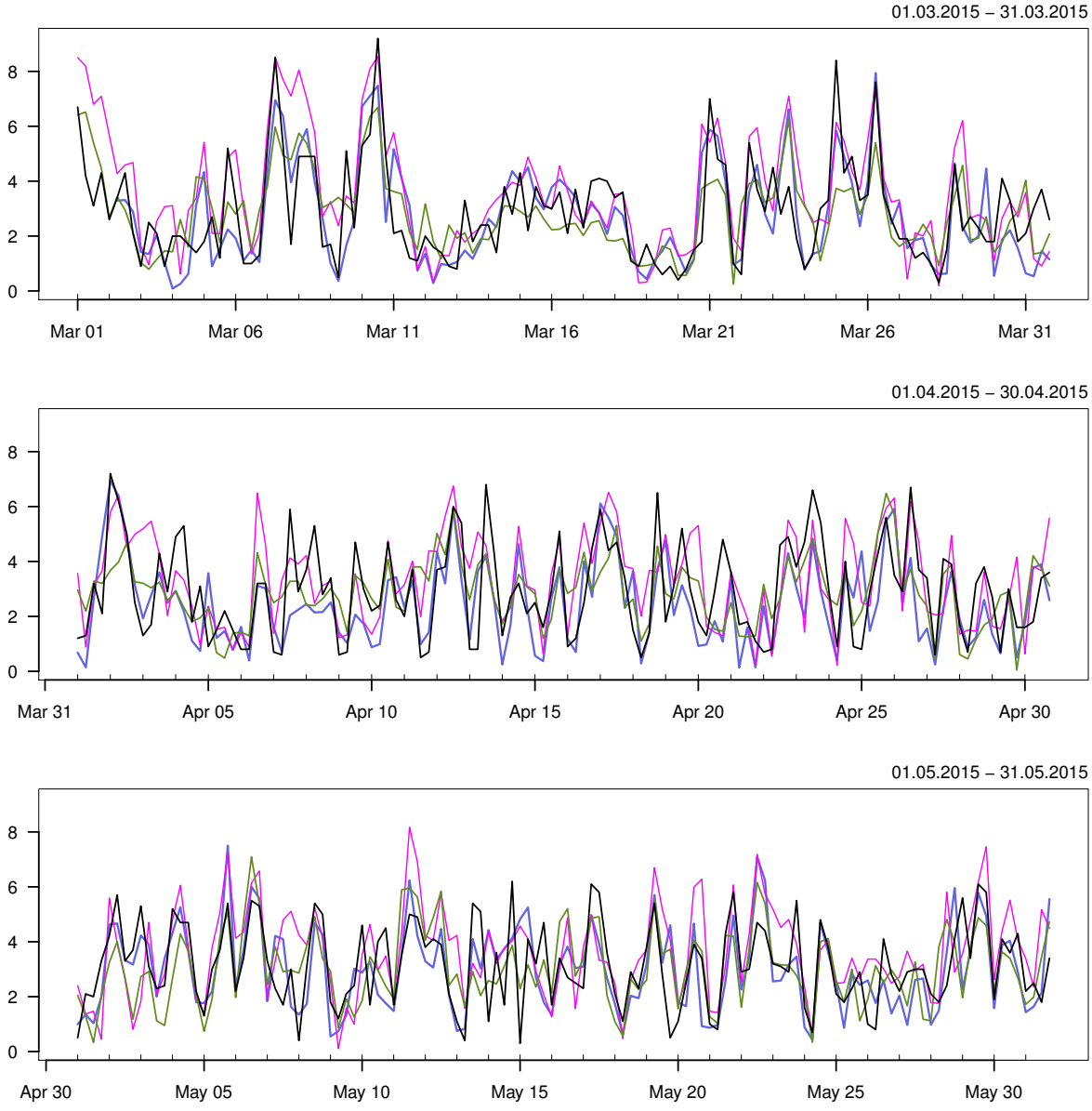


01.03.2015 – 31.05.2015

	Min	Mean	Max	Std	N
synop: 00,06,12,18	0.5	7.4	18.6	3.6	368
AM25: 12+18,+24,+30,+36	0.1	7.2	16.4	3.5	363
Hirlam8: 12+18,+24,+30,+36	0.3	7	16.7	3.4	368
ECMWF: 12+18,+24,+30,+36	0.4	6.5	15	3.2	368

	ME	SDE	RMSE	MAE	Max.abs.err.	N
AM25 – synop	–0.1	1.9	1.9	1.5	7.6	363
Hirlam8 – synop	–0.4	2.1	2.1	1.6	7	368
ECMWF – synop	–0.8	1.7	1.9	1.5	6.4	368

OSLO – BLINDERN

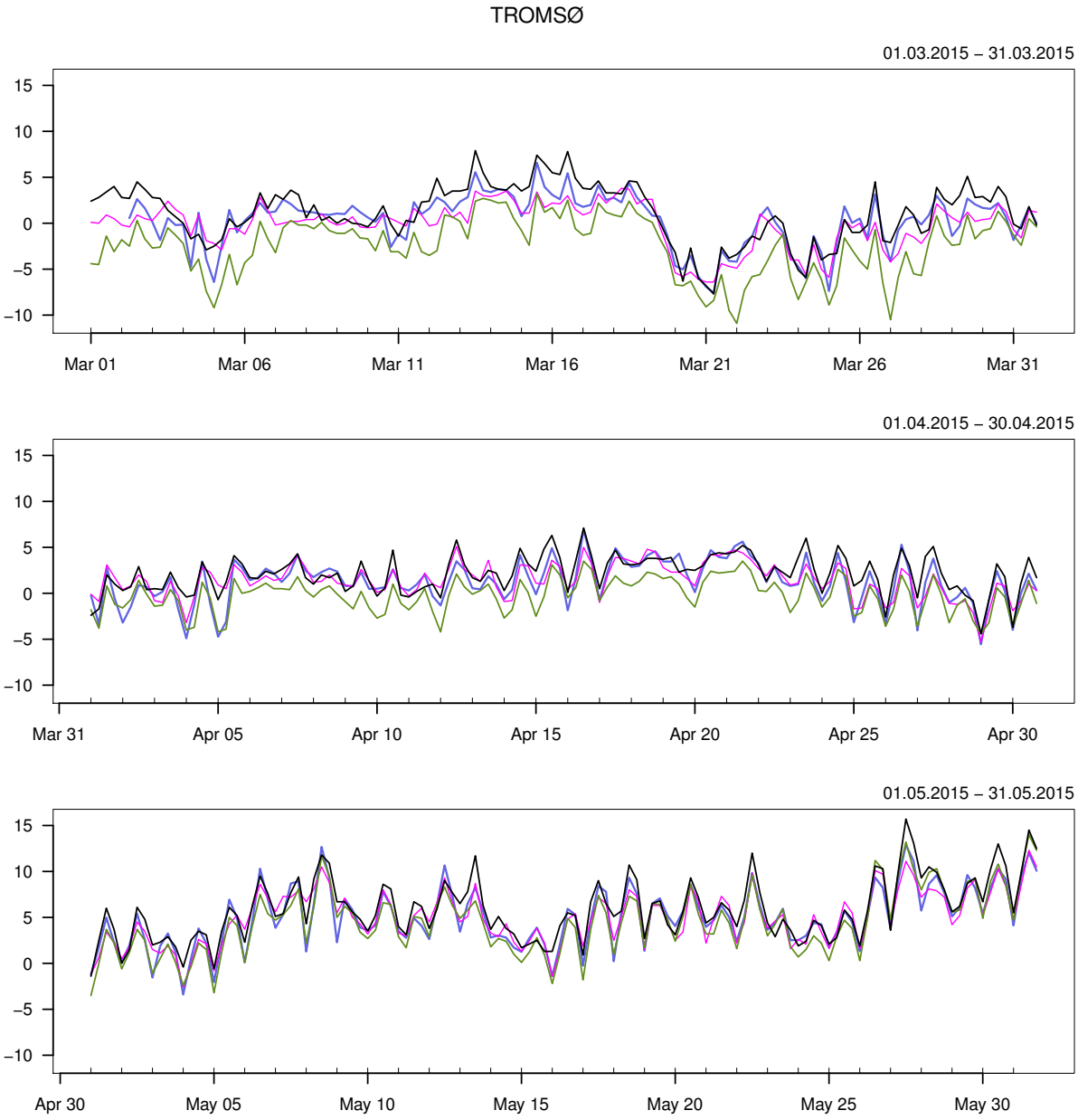


01.03.2015 – 31.05.2015

	Min	Mean	Max	Std	N
synop: 00,06,12,18	0.3	3	9.2	1.7	368
AM25: 12+18,+24,+30,+36	0.1	2.7	7.9	1.6	363
Hirlam8: 12+18,+24,+30,+36	0.1	3.5	8.5	1.8	368
ECMWF: 12+18,+24,+30,+36	0	2.9	7.1	1.3	368

	ME	SDE	RMSE	MAE	Max.abs.err.	N
AM25 – synop	–0.3	1.3	1.4	1	4.5	363
Hirlam8 – synop	0.5	1.6	1.7	1.3	5.4	368
ECMWF – synop	–0.1	1.4	1.4	1.1	4.7	368

10.2 Temperature 2m

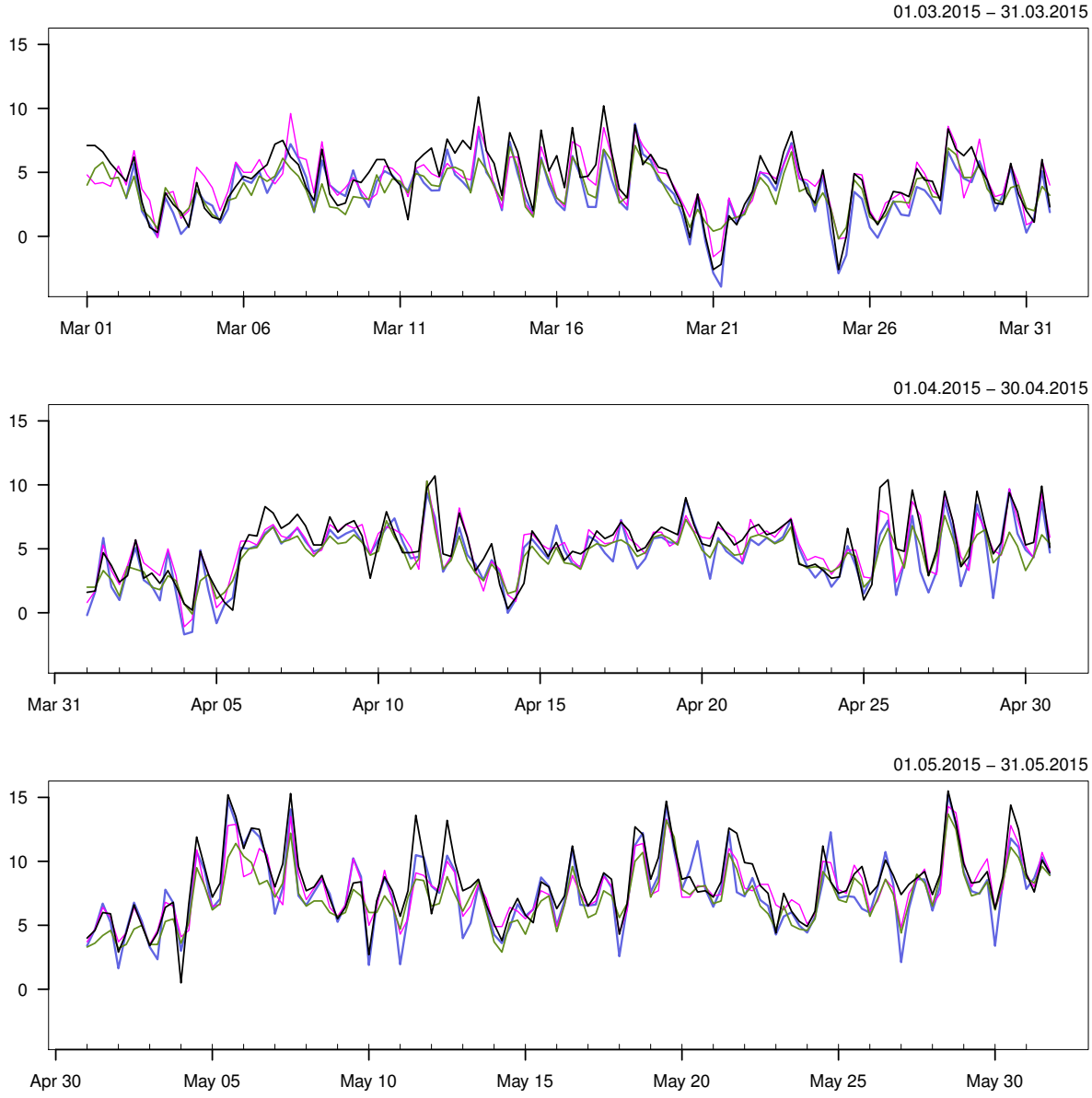


01.03.2015 – 31.05.2015

	Min	Mean	Max	Std	N
synop: 00,06,12,18	−7.7	3	15.7	3.5	368
AM25: 12+18,+24,+30,+36	−7.6	2.2	12.9	3.5	363
Hirlam8: 12+18,+24,+30,+36	−6.4	2.1	12.3	3.3	368
ECMWF: 12+18,+24,+30,+36	−10.9	0.6	14	4.2	368

	ME	SDE	RMSE	MAE	Max.abs.err.	N
AM25 – synop	−0.8	1.3	1.5	1.2	4.9	363
Hirlam8 – synop	−1	1.4	1.7	1.3	5	368
ECMWF – synop	−2.4	1.6	2.9	2.4	8.4	368

ØRLAND

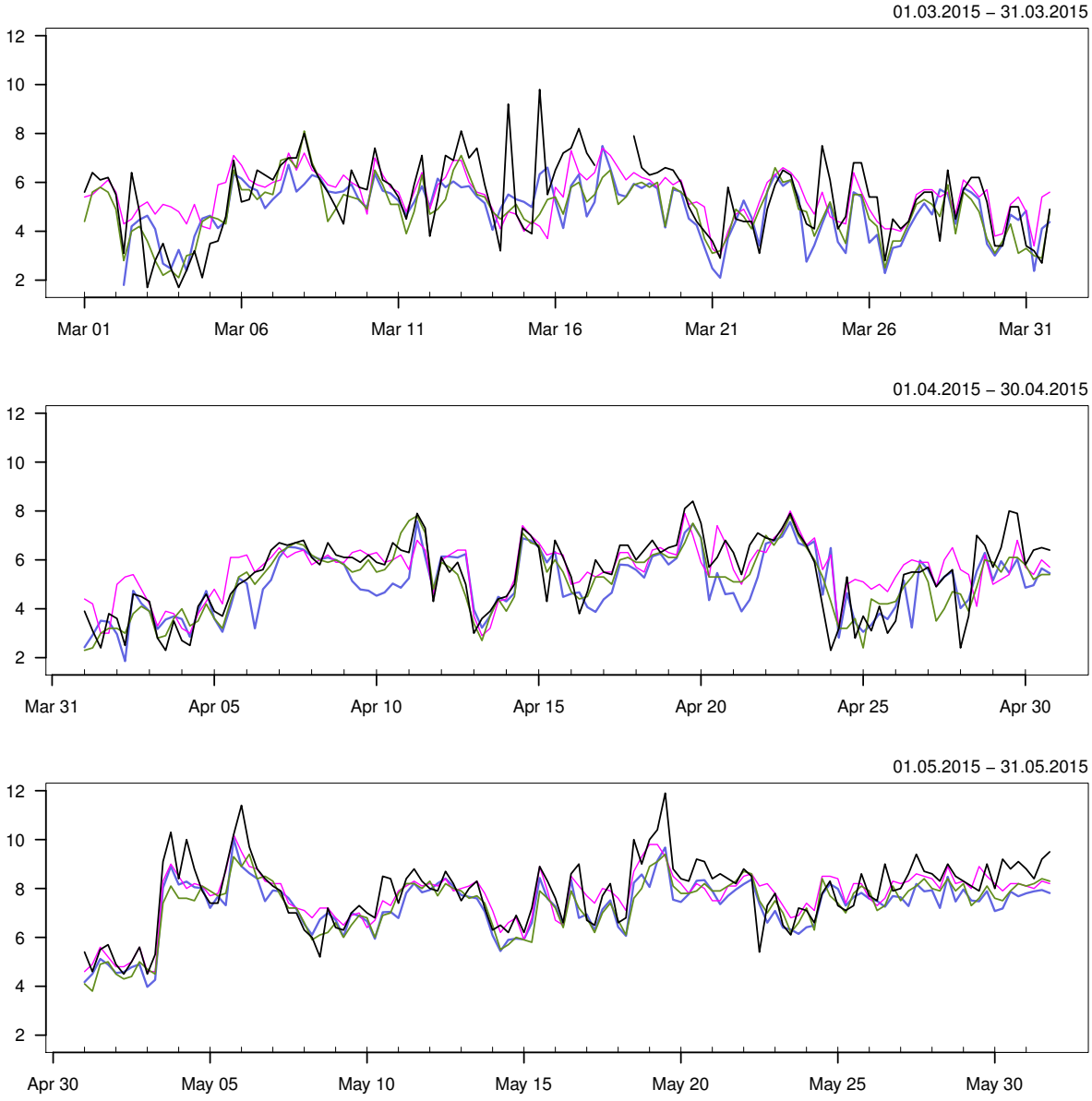


01.03.2015 – 31.05.2015

	Min	Mean	Max	Std	N
synop: 00,06,12,18	−2.6	6	15.5	3	368
AM25: 12+18,+24,+30,+36	−3.9	5.2	15.2	3	363
Hirlam8: 12+18,+24,+30,+36	−1.6	5.7	14.3	2.6	368
ECMWF: 12+18,+24,+30,+36	−0.2	5.1	13.7	2.4	368

	ME	SDE	RMSE	MAE	Max.abs.err.	N
AM25 – synop	−0.7	1.2	1.4	1.1	5.3	363
Hirlam8 – synop	−0.3	1.2	1.3	1	4.5	368
ECMWF – synop	−0.9	1.2	1.5	1.2	5	368

YTTERØYANE FYR



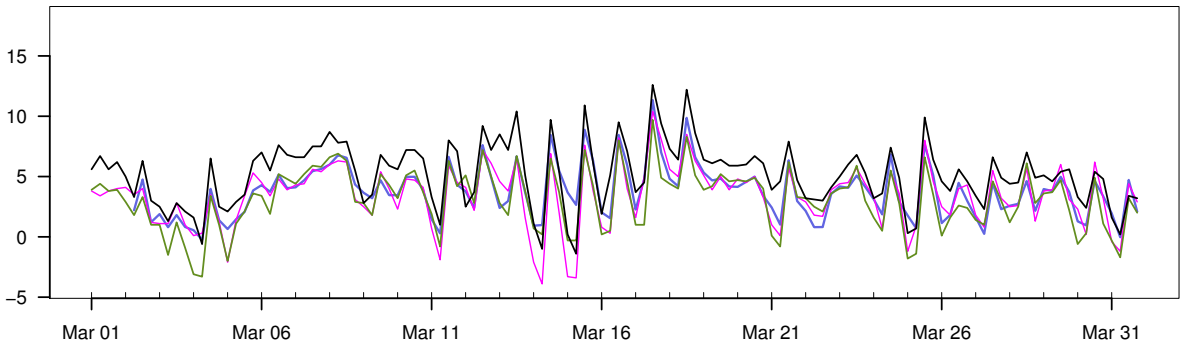
01.03.2015 – 31.05.2015

	Min	Mean	Max	Std	N
synop: 00,06,12,18	1.7	6.2	11.9	1.9	364
AM25: 12+18,+24,+30,+36	1.8	5.7	10	1.6	363
Hirlam8: 12+18,+24,+30,+36	2.9	6.3	10.2	1.5	368
ECMWF: 12+18,+24,+30,+36	2.1	5.8	9.4	1.6	368

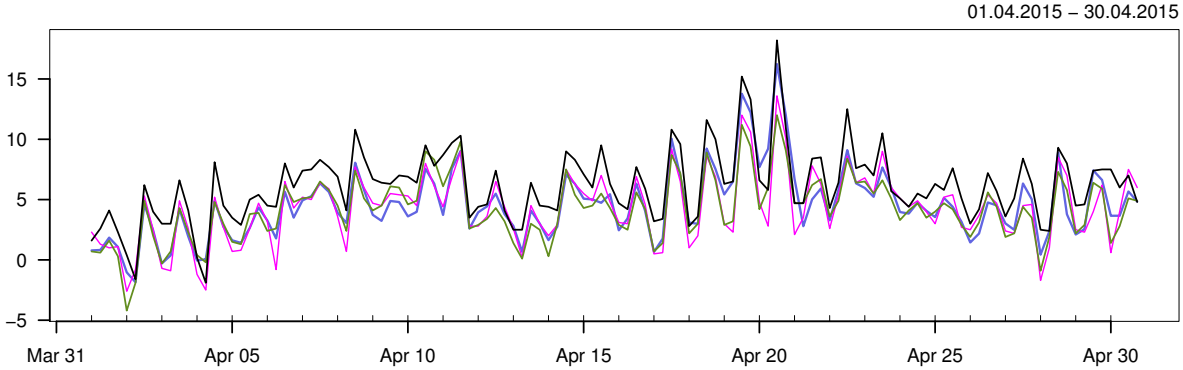
	ME	SDE	RMSE	MAE	Max.abs.err.	N
AM25 – synop	−0.5	0.9	1.1	0.8	4.2	359
Hirlam8 – synop	0	1	1	0.7	5.6	364
ECMWF – synop	−0.4	0.9	1	0.7	5.1	364

BERGEN – FLORIDA

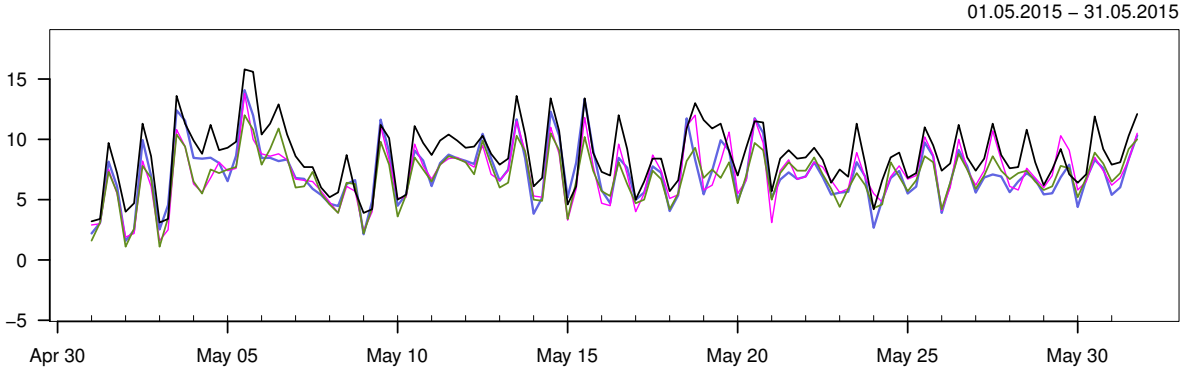
01.03.2015 – 31.03.2015



01.04.2015 – 30.04.2015



01.05.2015 – 31.05.2015

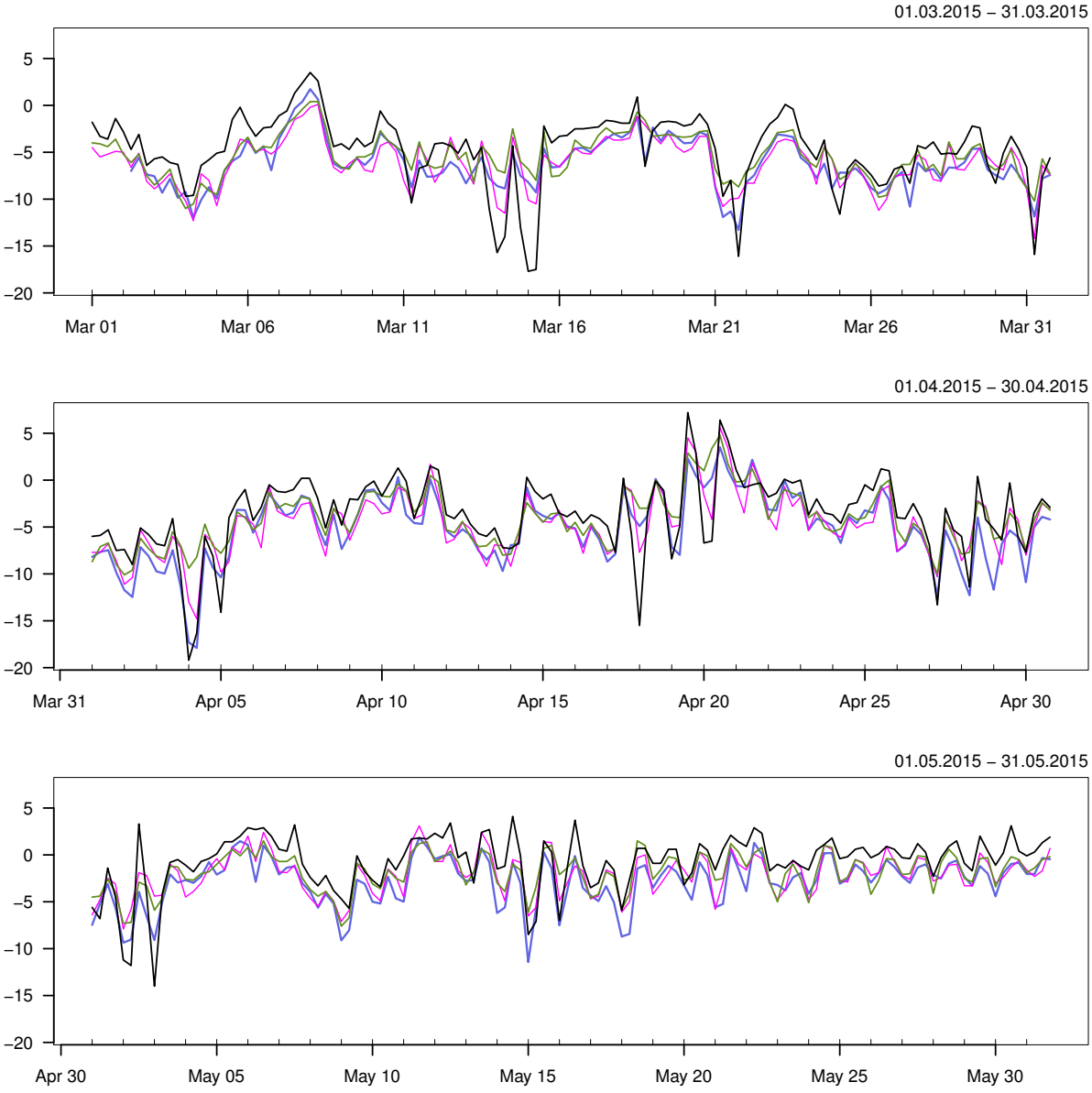


01.03.2015 – 31.05.2015

	Min	Mean	Max	Std	N
synop: 00,06,12,18	−1.9	6.7	18.2	3.1	368
AM25: 12+18,+24,+30,+36	−1.9	5.2	16.2	2.9	363
Hirlam8: 12+18,+24,+30,+36	−3.9	4.9	13.8	3	368
ECMWF: 12+18,+24,+30,+36	−4.2	4.7	12	2.9	368

	ME	SDE	RMSE	MAE	Max.abs.err.	N
AM25 – synop	−1.5	1.3	2	1.7	6.2	363
Hirlam8 – synop	−1.7	1.2	2.1	1.8	6.9	368
ECMWF – synop	−1.9	1.2	2.3	2	6.2	368

FINSEVATN

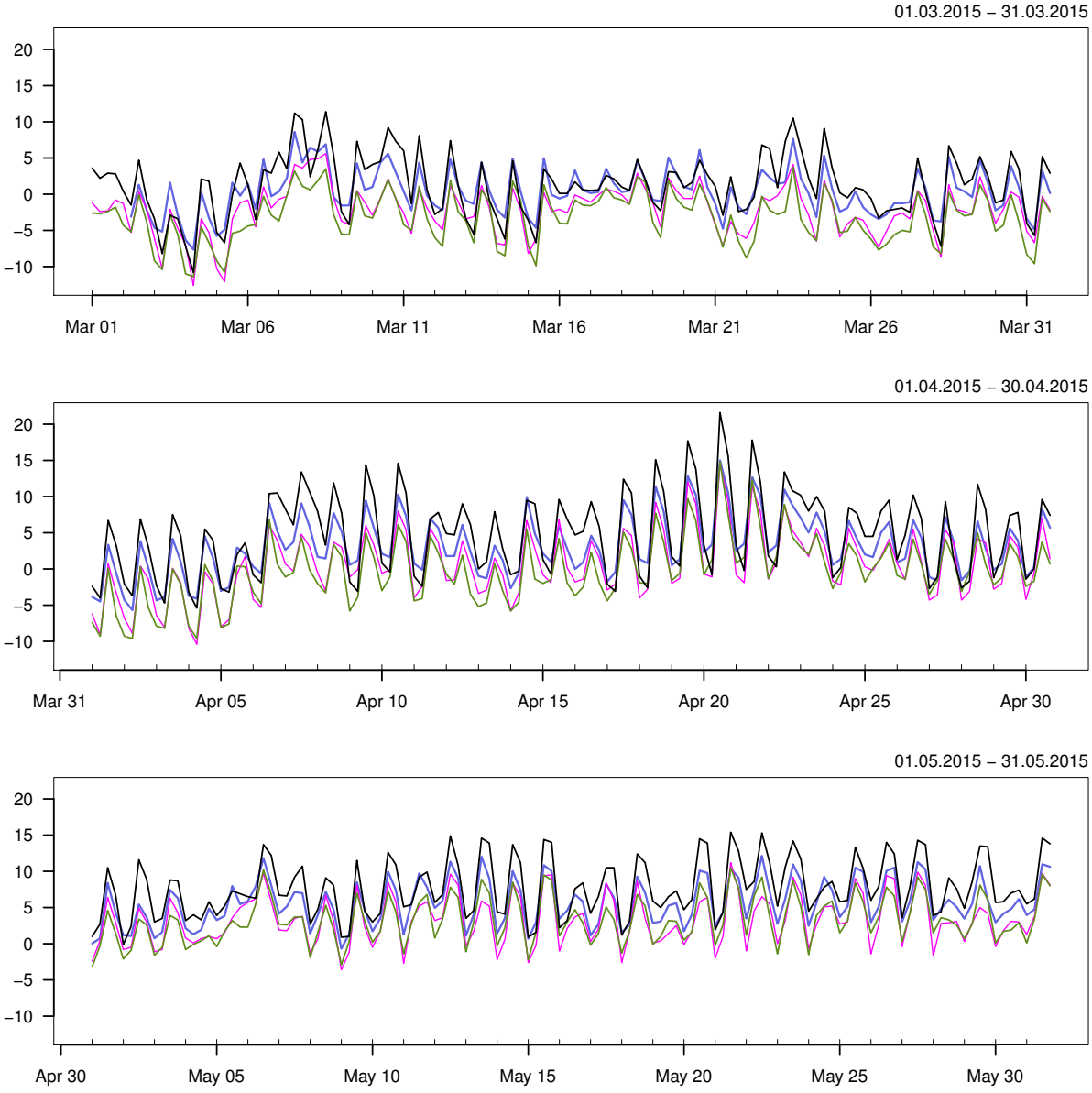


01.03.2015 – 31.05.2015

	Min	Mean	Max	Std	N
synop: 00,06,12,18	−19.2	−3	7.2	4	368
AM25: 12+18,+24,+30,+36	−17.9	−4.7	3.5	3.4	363
Hirlam8: 12+18,+24,+30,+36	−14.8	−4.3	5.6	3.2	368
ECMWF: 12+18,+24,+30,+36	−11	−3.8	4.8	2.9	368

	ME	SDE	RMSE	MAE	Max.abs.err.	N
AM25 – synop	−1.7	2.1	2.7	2.3	10.6	363
Hirlam8 – synop	−1.3	2.2	2.5	2.1	9.6	368
ECMWF – synop	−0.7	2.4	2.6	1.9	12.5	368

NESBYEN

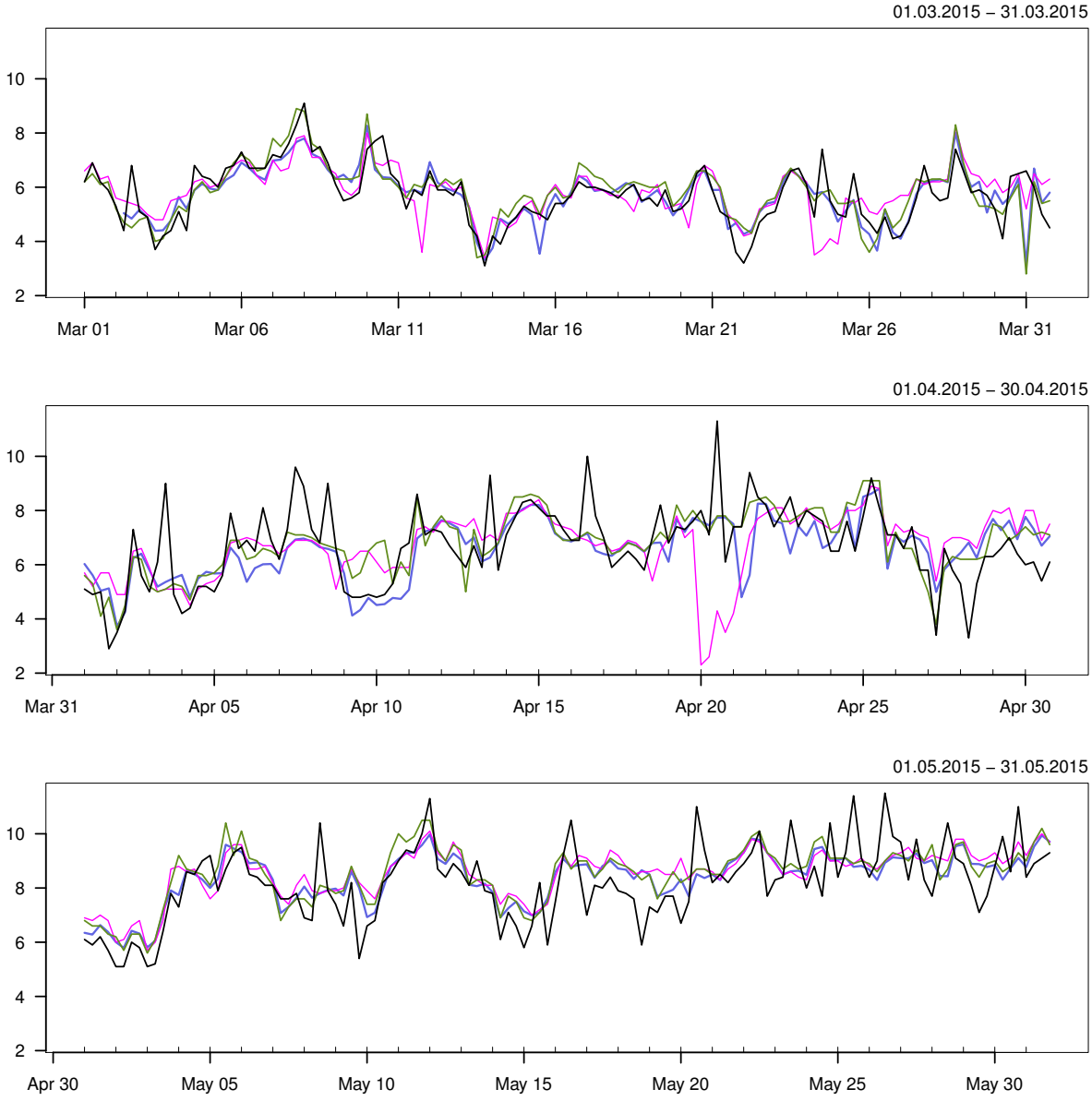


01.03.2015 – 31.05.2015

	Min	Mean	Max	Std	N
synop: 00,06,12,18	−10.8	4.6	21.6	5.5	368
AM25: 12+18,+24,+30,+36	−7.7	3.1	15	4.2	363
Hirlam8: 12+18,+24,+30,+36	−12.6	0.6	14.6	4.5	368
ECMWF: 12+18,+24,+30,+36	−11.4	0	14.8	4.6	368

	ME	SDE	RMSE	MAE	Max.abs.err.	N
AM25 – synop	−1.5	2.2	2.7	2.2	7.3	363
Hirlam8 – synop	−4	2.2	4.6	4.1	9.2	368
ECMWF – synop	−4.6	2.4	5.2	4.7	10.8	368

EKOFISK

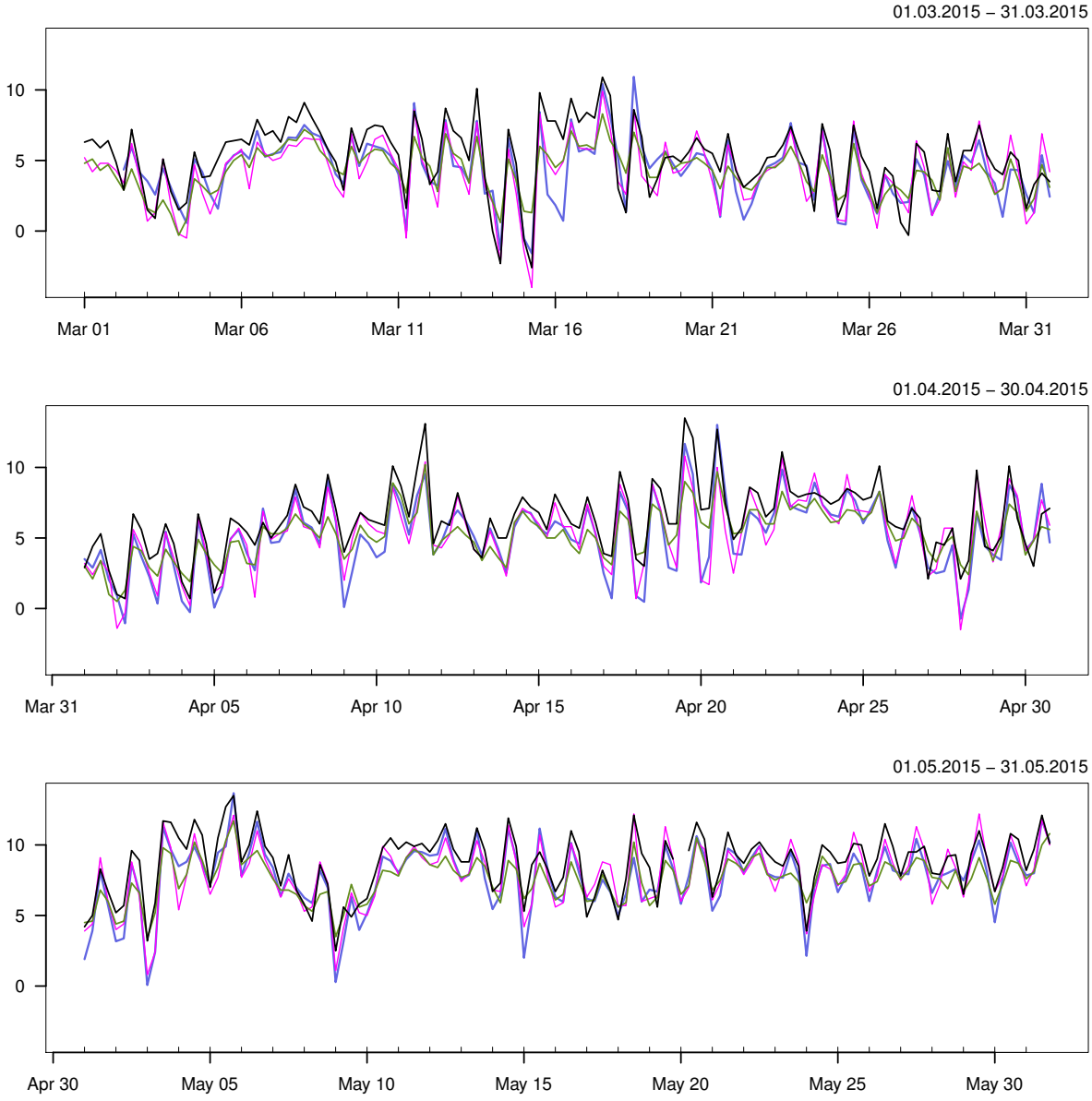


01.03.2015 – 31.05.2015

	Min	Mean	Max	Std	N
synop: 00,06,12,18	2.9	6.9	11.5	1.7	368
AM25: 12+18,+24,+30,+36	3.2	6.9	10	1.5	363
Hirlam8: 12+18,+24,+30,+36	2.3	7	10.1	1.5	368
ECMWF: 12+18,+24,+30,+36	2.8	7.1	10.5	1.5	368

	ME	SDE	RMSE	MAE	Max.abs.err.	N
AM25 – synop	0	1	1	0.7	3.8	363
Hirlam8 – synop	0.2	1.1	1.2	0.8	7	368
ECMWF – synop	0.2	0.9	0.9	0.7	3.9	368

SOLA

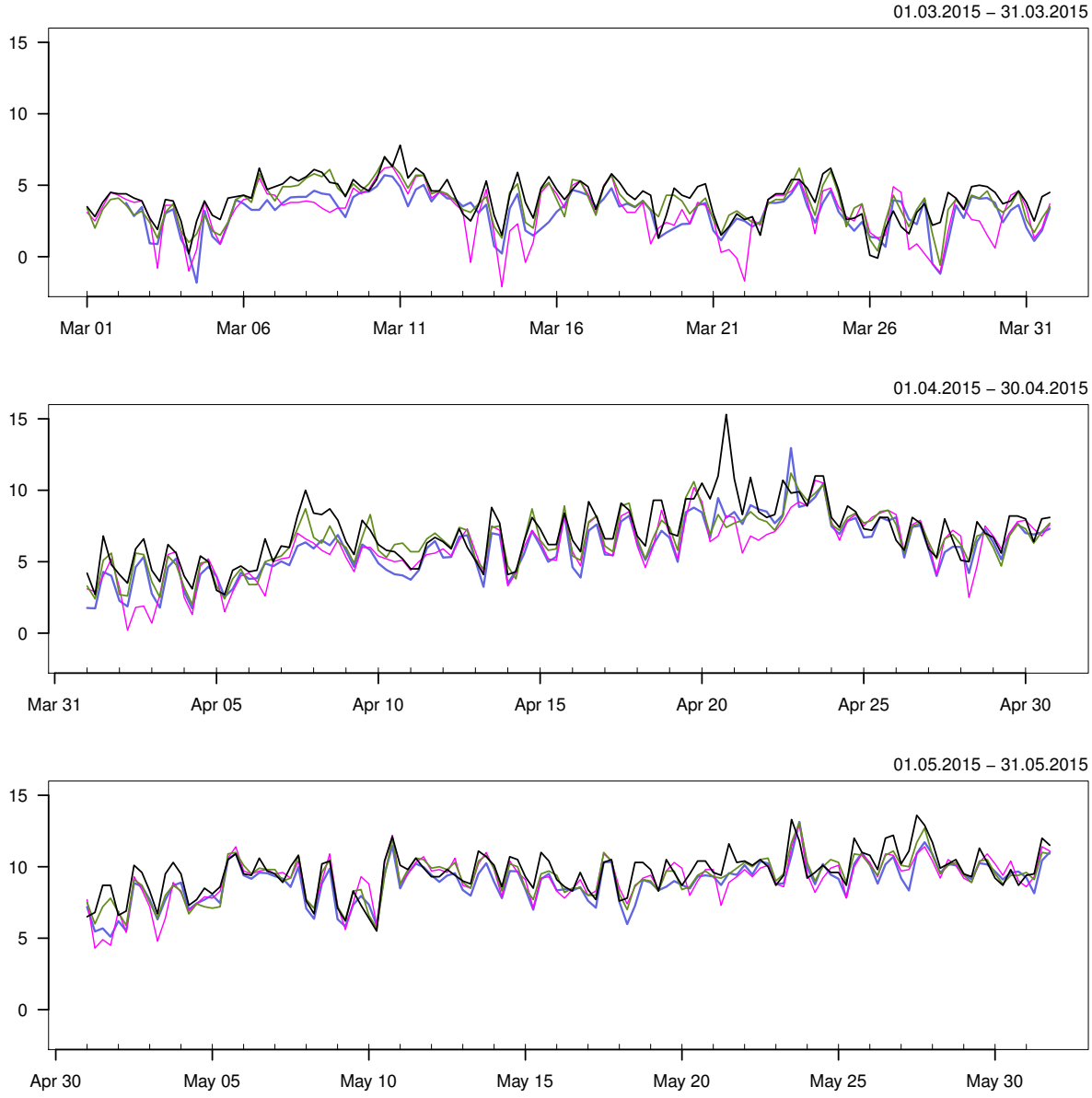


01.03.2015 – 31.05.2015

	Min	Mean	Max	Std	N
synop: 00,06,12,18	−2.6	6.7	13.5	2.8	367
AM25: 12+18,+24,+30,+36	−1.6	5.7	13.7	2.8	363
Hirlam8: 12+18,+24,+30,+36	−4	5.8	12.2	2.8	368
ECMWF: 12+18,+24,+30,+36	−0.3	5.7	11.7	2.2	368

	ME	SDE	RMSE	MAE	Max.abs.err.	N
AM25 – synop	−1	1.2	1.6	1.3	6	362
Hirlam8 – synop	−0.9	1.2	1.5	1.2	5.4	367
ECMWF – synop	−1	1.2	1.5	1.3	4.5	367

FERDER FYR

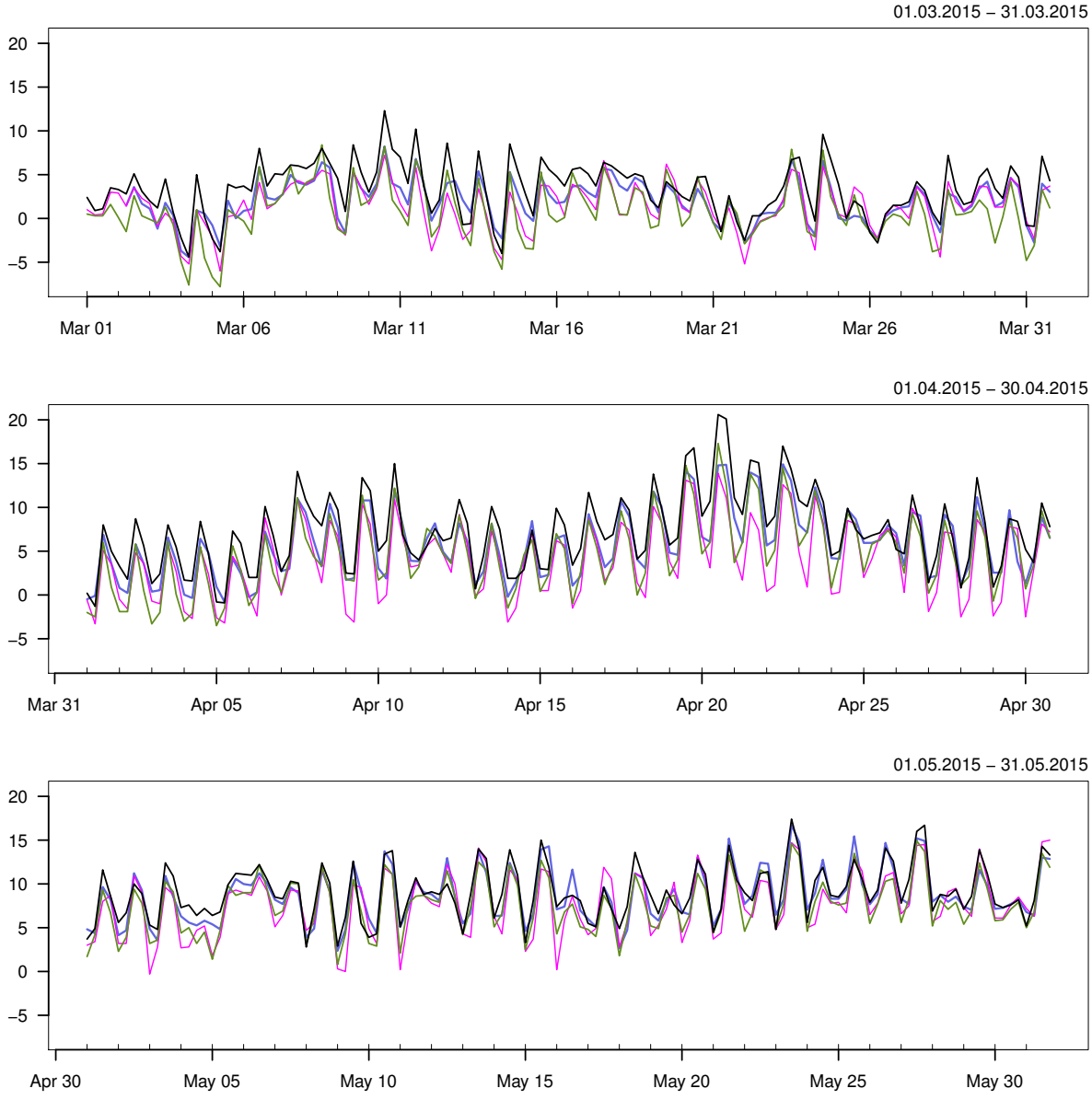


01.03.2015 – 31.05.2015

	Min	Mean	Max	Std	N
synop: 00,06,12,18	−0.1	6.9	15.3	2.8	368
AM25: 12+18,+24,+30,+36	−1.8	6	13.1	2.9	363
Hirlam8: 12+18,+24,+30,+36	−2.1	6.1	13	3.1	368
ECMWF: 12+18,+24,+30,+36	−0.6	6.5	13.1	2.8	368

	ME	SDE	RMSE	MAE	Max.abs.err.	N
AM25 – synop	−0.9	1	1.3	1	7.2	363
Hirlam8 – synop	−0.8	1.2	1.5	1.1	7.1	368
ECMWF – synop	−0.4	0.9	0.9	0.7	7.9	368

OSLO – BLINDERN

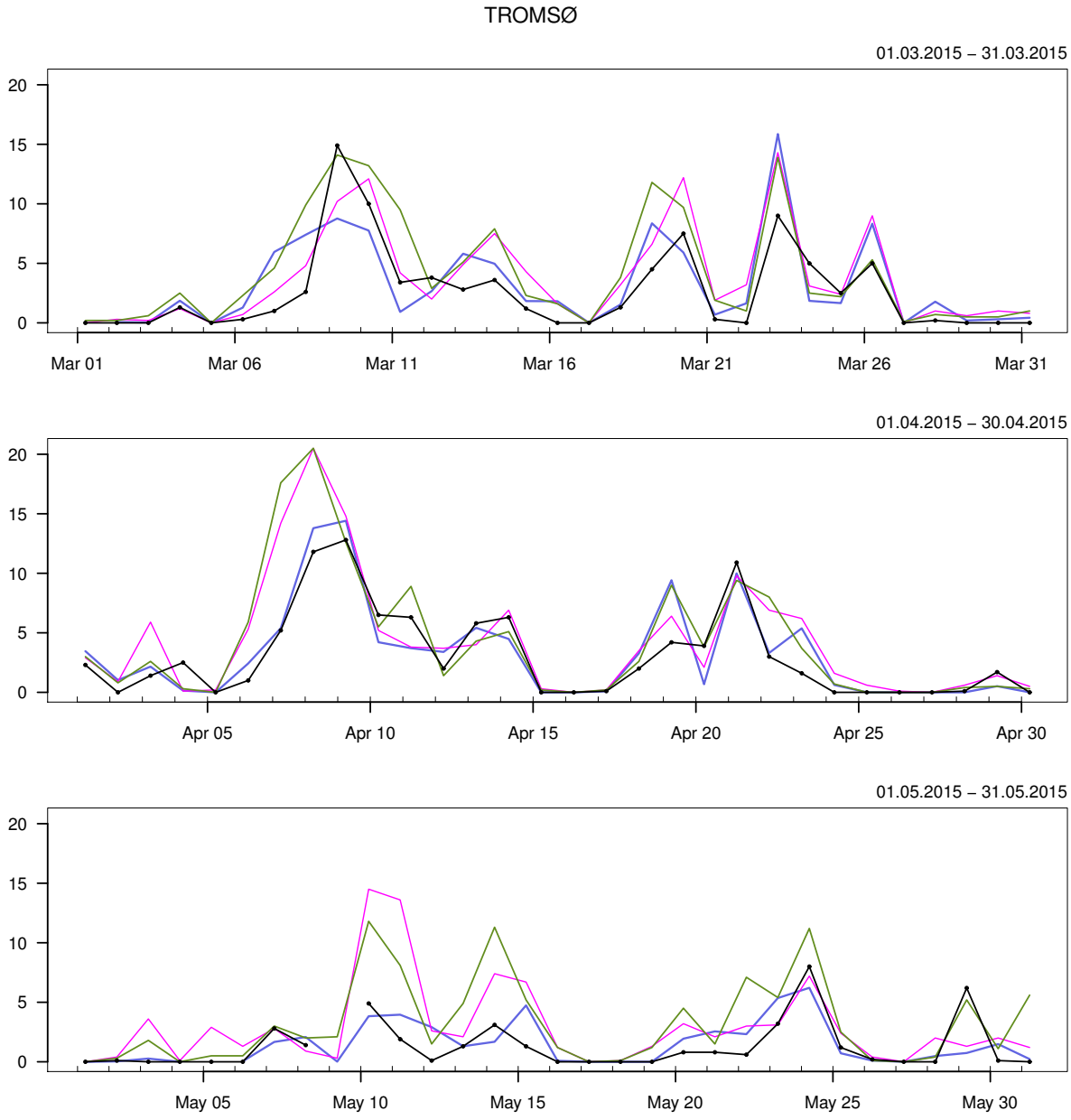


01.03.2015 – 31.05.2015

	Min	Mean	Max	Std	N
synop: 00,06,12,18	−4.4	6.6	20.6	4.3	368
AM25: 12+18,+24,+30,+36	−4.4	5.5	16.7	4.2	363
Hirlam8: 12+18,+24,+30,+36	−6	4.4	15	4.5	368
ECMWF: 12+18,+24,+30,+36	−7.8	4.4	17.3	4.6	368

	ME	SDE	RMSE	MAE	Max.abs.err.	N
AM25 – synop	−1.1	1.5	1.8	1.5	5.8	363
Hirlam8 – synop	−2.2	2	3	2.4	9.2	368
ECMWF – synop	−2.2	1.6	2.7	2.3	7.5	368

10.3 Daily precipitation

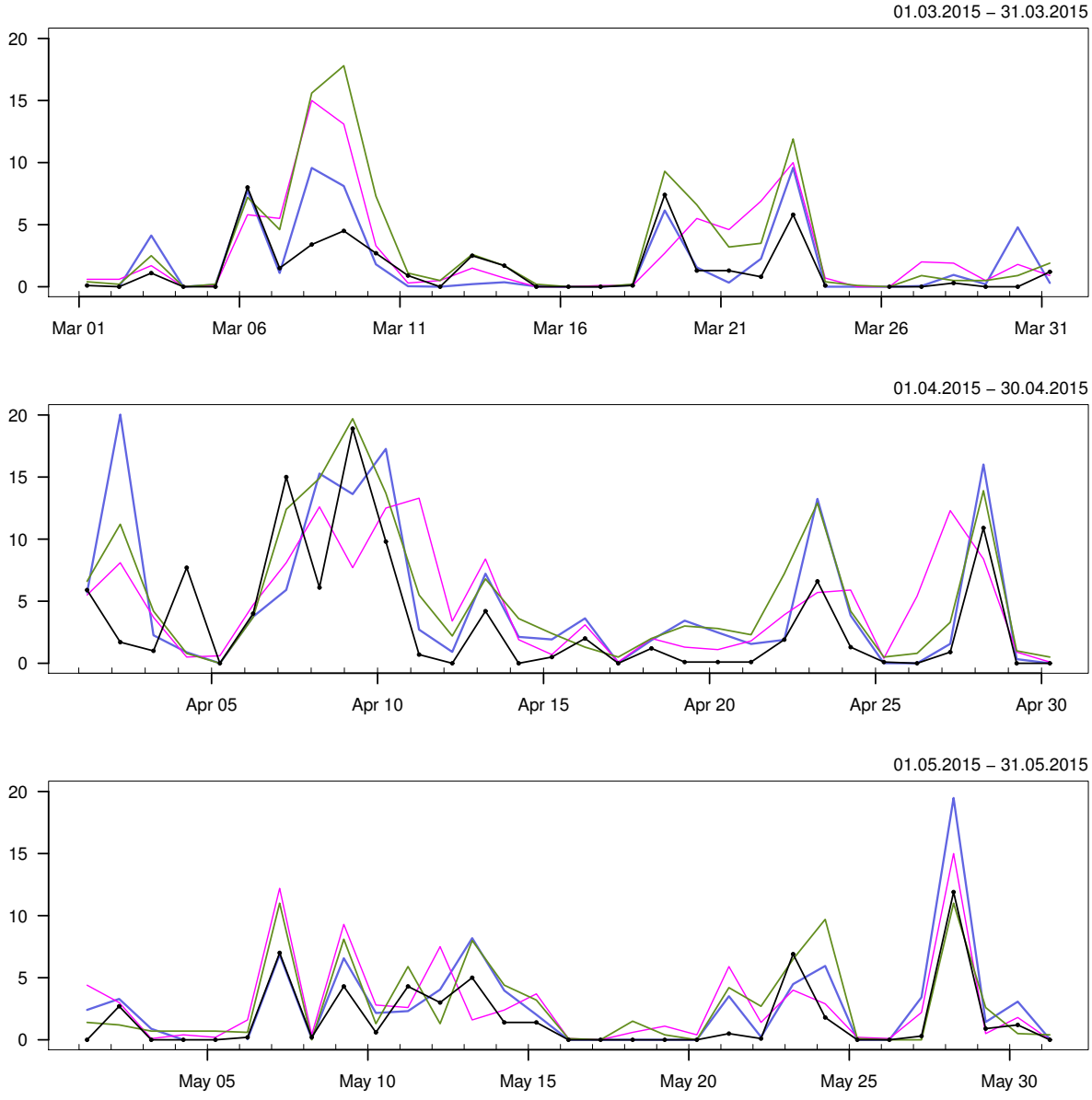


01.03.2015 – 31.05.2015

	Min	Mean	Max	Std	N
synop: 06	0	2.3	14.9	3.3	91
AM25: 00+30	0	2.7	15.9	3.4	90
Hirlam8: 00+30	0	3.6	20.5	4.2	92
ECMWF: 00+30	0	3.9	20.5	4.5	92

	ME	SDE	RMSE	MAE	Max.abs.err.	N
AM25 – synop	0.4	2	2.1	1.3	6.9	89
Hirlam8 – synop	1.4	2.6	3	1.9	11.7	91
ECMWF – synop	1.6	2.7	3.1	2	12.4	91

BODØ

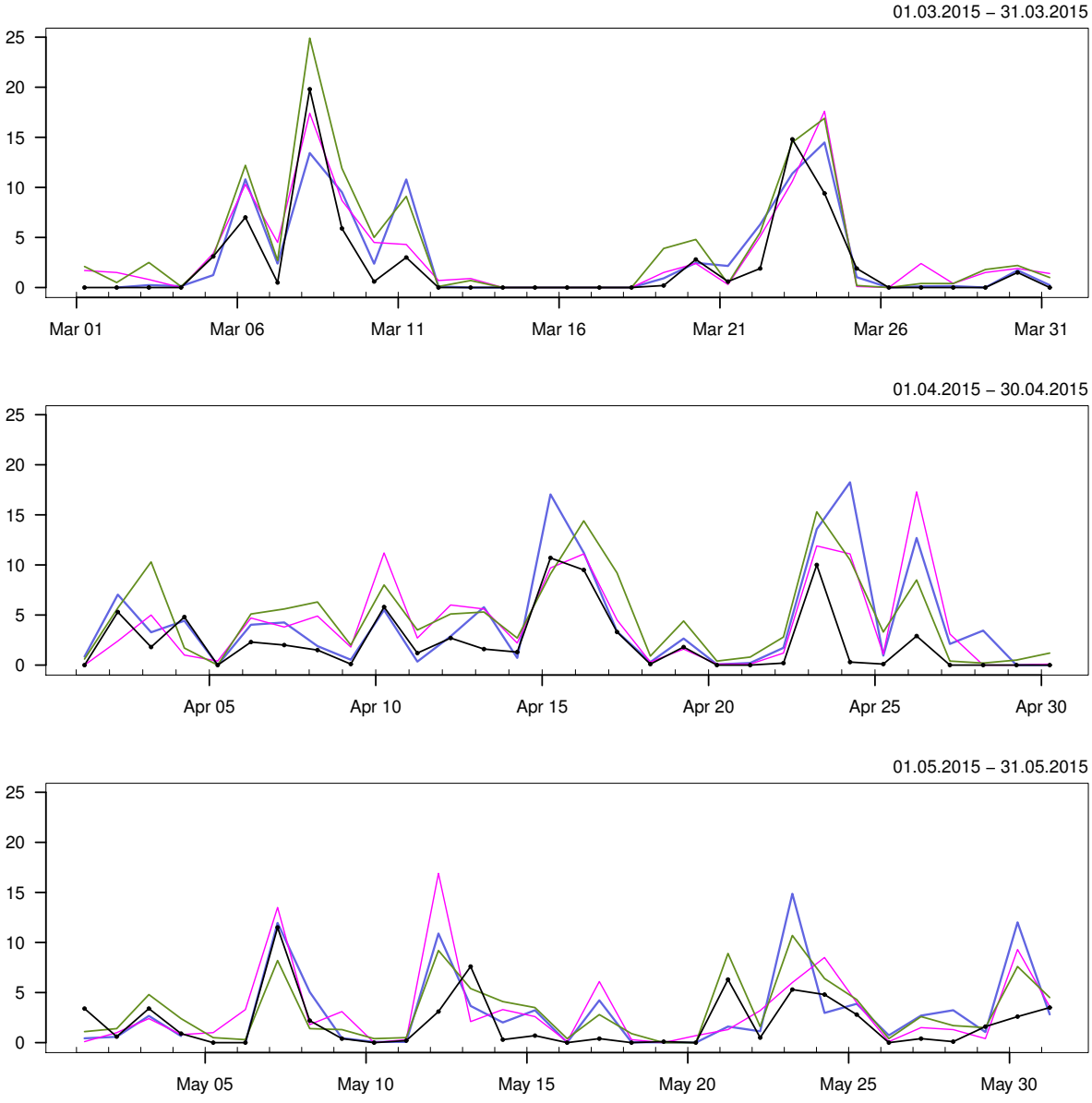


01.03.2015 – 31.05.2015

	Min	Mean	Max	Std	N
synop: 06	0	2.2	18.9	3.5	91
AM25: 00+30	0	3.3	20	4.6	90
Hirlam8: 00+30	0	3.5	15	4	92
ECMWF: 00+30	0	3.8	19.7	4.7	92

	ME	SDE	RMSE	MAE	Max.abs.err.	N
AM25 – synop	1.1	3.2	3.4	1.9	18.3	89
Hirlam8 – synop	1.3	3.5	3.7	2.4	12.6	91
ECMWF – synop	1.7	2.9	3.3	2.1	13.3	91

ØRLAND

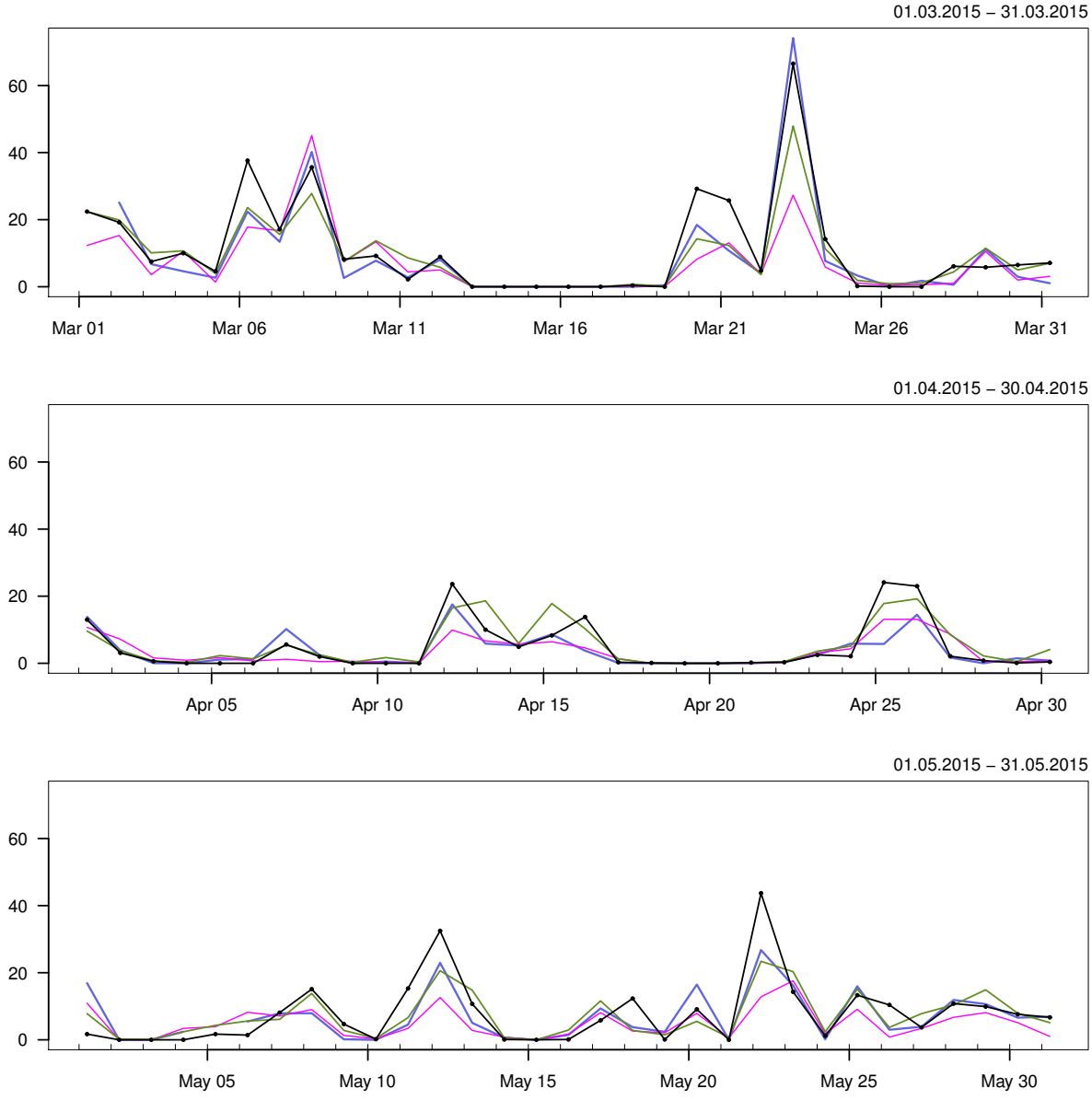


01.03.2015 – 31.05.2015

	Min	Mean	Max	Std	N
synop: 06	0	2.2	19.8	3.6	92
AM25: 00+30	0	3.5	18.3	4.6	90
Hirlam8: 00+30	0	3.6	17.6	4.4	92
ECMWF: 00+30	0	4	24.9	4.6	92

	ME	SDE	RMSE	MAE	Max.abs.err.	N
AM25 – synop	1.2	3.2	3.5	1.9	18	90
Hirlam8 – synop	1.3	3.1	3.4	2.1	14.4	92
ECMWF – synop	1.8	2.4	3	2.1	10.2	92

BERGEN – FLORIDA

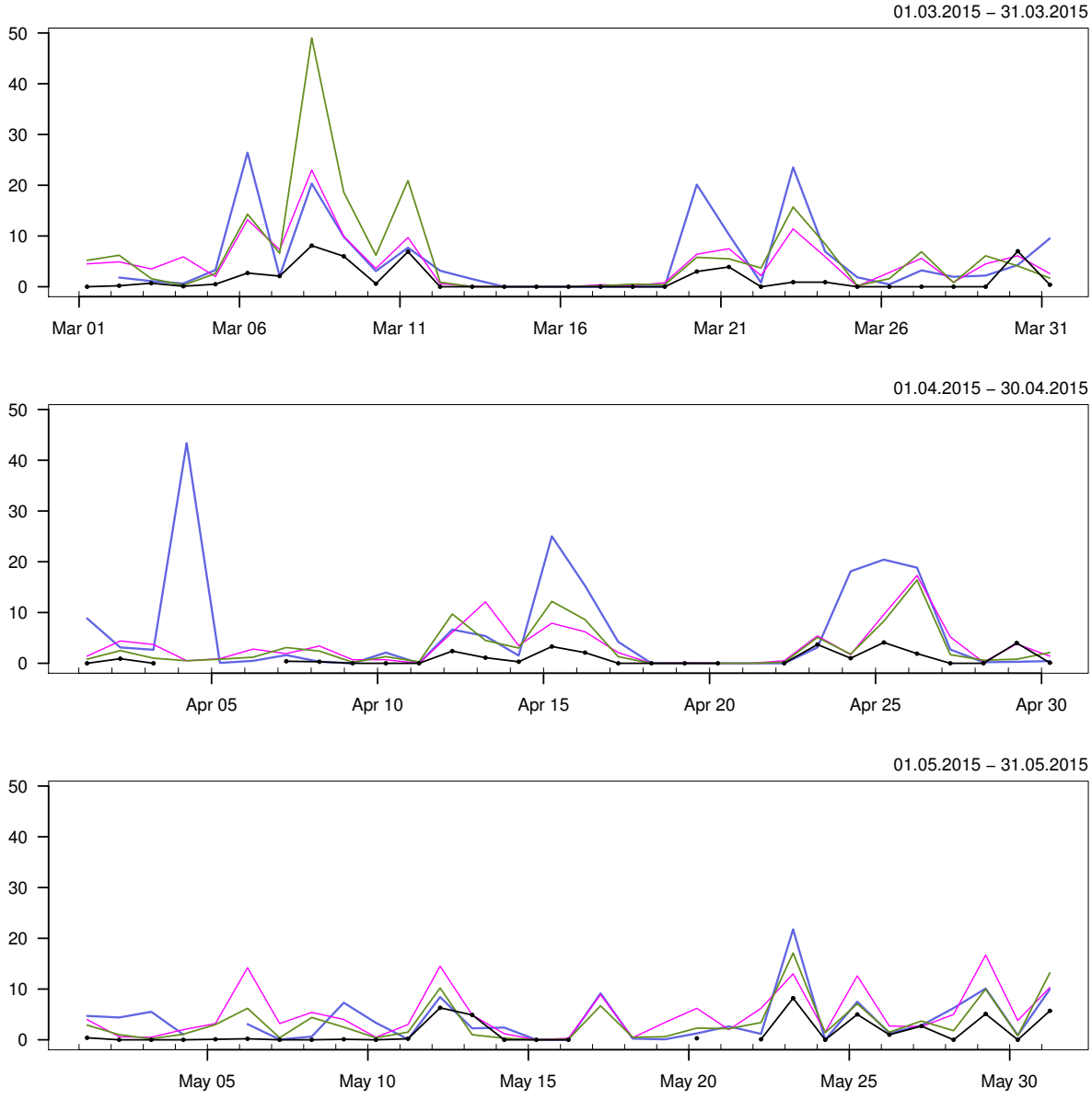


01.03.2015 – 31.05.2015

	Min	Mean	Max	Std	N
synop: 06	0	7.9	66.5	11.4	92
AM25: 00+30	0	6.6	74.1	10.3	90
Hirlam8: 00+30	0	5.3	45.1	6.8	92
ECMWF: 00+30	0	7.3	47.9	8.2	92

	ME	SDE	RMSE	MAE	Max.abs.err.	N
AM25 – synop	–1.3	5.3	5.4	3.3	18.3	90
Hirlam8 – synop	–2.6	7.4	7.8	4.3	39.2	92
ECMWF – synop	–0.6	5.2	5.3	3.2	20.3	92

LÆRDAL

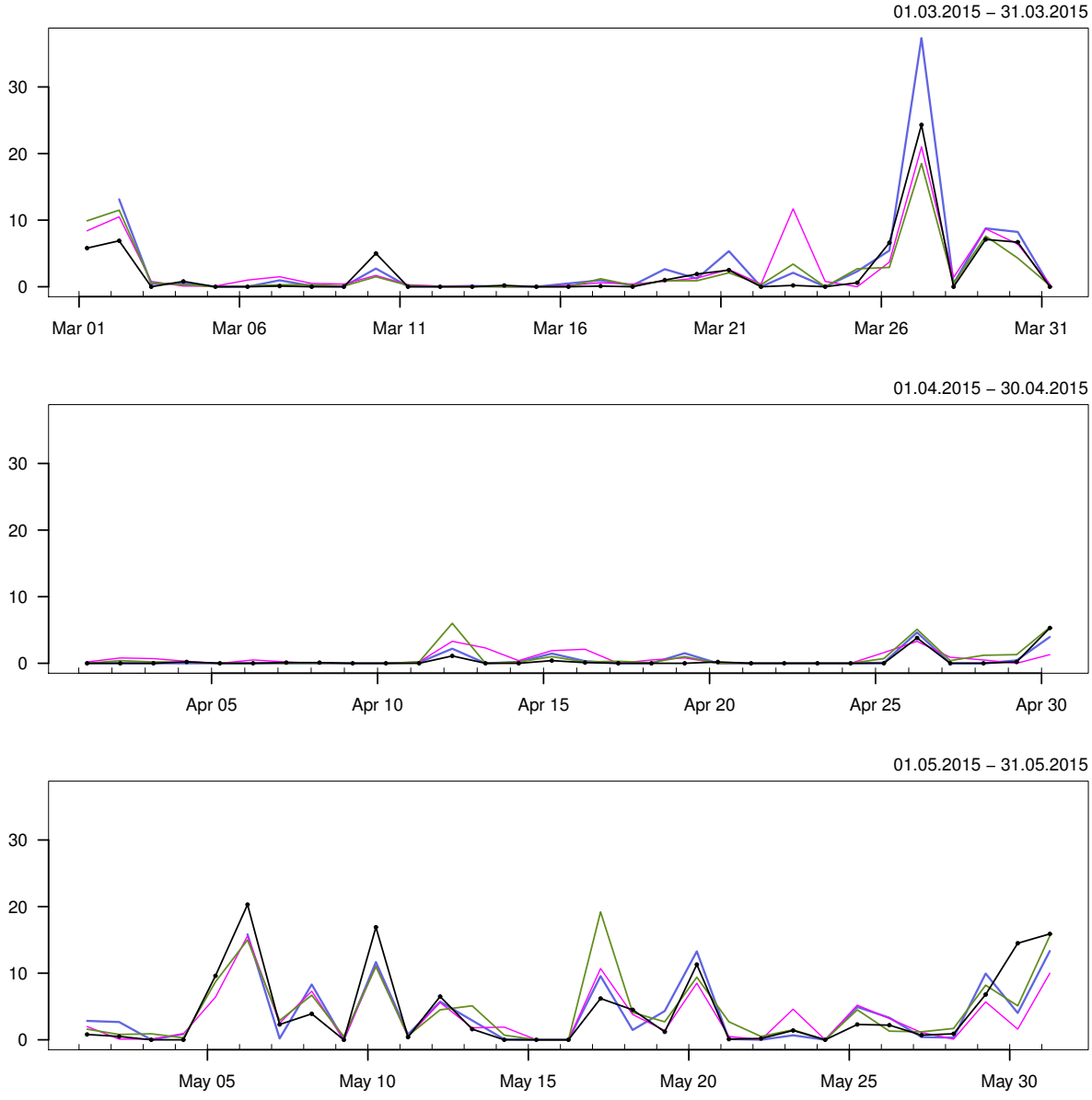


01.03.2015 – 31.05.2015

	Min	Mean	Max	Std	N
synop: 06	0	1.3	8.2	2.2	84
AM25: 00+30	0	5.2	43.4	7.7	90
Hirlam8: 00+30	0	4.4	23	4.6	92
ECMWF: 00+30	0	4.3	49	6.7	92

	ME	SDE	RMSE	MAE	Max.abs.err.	N
AM25 – synop	3.7	5.8	6.9	3.9	23.7	82
Hirlam8 – synop	3.3	3.5	4.8	3.3	15.4	84
ECMWF – synop	3.2	5.6	6.4	3.4	40.9	84

GARDERMOEN

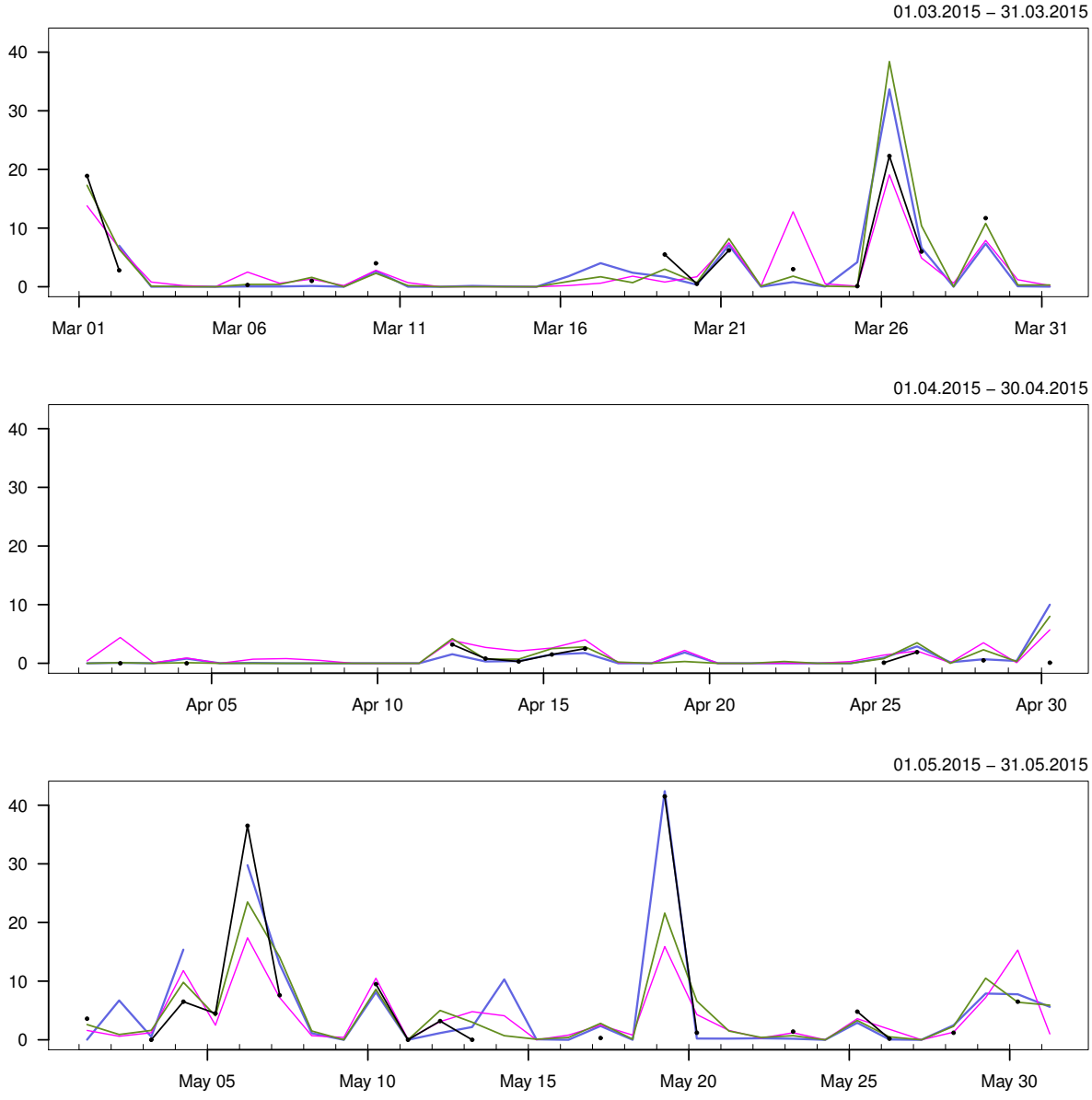


01.03.2015 – 31.05.2015

	Min	Mean	Max	Std	N
synop: 06	0	2.3	24.3	4.7	92
AM25: 00+30	0	2.5	37.3	5.2	90
Hirlam8: 00+30	0	2.4	21	3.8	92
ECMWF: 00+30	0	2.5	19.2	4.2	92

	ME	SDE	RMSE	MAE	Max.abs.err.	N
AM25 – synop	0.3	2.3	2.4	1.1	13	90
Hirlam8 – synop	0.1	2.5	2.5	1.3	12.9	92
ECMWF – synop	0.2	2.4	2.4	1.2	13	92

NELAUG



01.03.2015 – 31.05.2015

	Min	Mean	Max	Std	N
synop: 06	0	5.3	41.5	9	42
AM25: 00+30	0	2.9	42.4	6.9	90
Hirlam8: 00+30	0	2.7	19.1	4.2	92
ECMWF: 00+30	0	3	38.4	5.9	92

	ME	SDE	RMSE	MAE	Max.abs.err.	N
AM25 – synop	0.6	3.5	3.6	2.3	11.4	40
Hirlam8 – synop	0	5.9	5.9	3.3	25.6	42
ECMWF – synop	0.5	5	5.1	2.7	19.9	42