Norwegian
Meteorological
Institute

MET info

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Meteorology

Verification of Experimental and Operational Weather Prediction Models March 2014 to June 2014

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Photo: Kjell Juvland

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 0.25° 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-Norway (AROME)	HARMONIE cycle 37h1.1 with AROME physics run on a $2.5 \times 2.5\ km^2$ grid on a larger domain than Harmonie2.5; experimental since 25 October 2012, replacing Harmonie2.5 from 26 February 2013.
AROME-MetCoOp (AM25)	HARMONIE cycle 38h1.1 with AROME physics run on a $2.5 \times 2.5\ km^2$ grid on same domain as AROME-Norway; experimental since 9 December 2013.

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

2 HARMONIE, AROME-Norway and AROME-MetCoOp

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

2.1 ALARO-0 physics

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

2.2 AROME physics

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

2.3 SURFEX as surface model

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

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

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

2.4 Data assimilation

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

2.4.1 Surface analysis

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

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

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

2.4.2 Upper air analysis

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

2.5 Boundaries and initialization of upper air fields

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

AROME-Norway and AROME-MetCoOp get their boundary values (1-hourly) from the ECMWF model at approximately 16 km resolution. They have currently 65 vertical levels. AROME-Norway do no upper air assimilation, the upper air fields are initialized from ECMWF forecasts each cycle. None of the HARMONIE configurations at MET have applied digital filter initialization (DFI).

3 Verification measures

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

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

3.1 Forecasts of continuous variables

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

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

In the formula for COR the following definitions are used

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

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

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

3.2 Forecasts of categorical variables

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

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

Verification statistics for such forecasts are listed in the following table

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

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

3.3 Observations

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

3.4 Changes since last report

- Verification of wind gust added for 25 March to 31 May, verified against observed wind gust, FG.
- AROME-Norway median for precipitation corrected. Errors in previous reports.
- Lead time back to +66h. Only +48h was available for the winter report.

4 Norway

4.1 Comments to verification results

MSLP:
AM25 has a lower bias compared with AROME. ECMWF still has the lowest SDE for most lead times. Small differences between the AROME models in SDE. Small differences also in MAE, but ECMWF is still the best model for mean sea level pressure.

Wind speed:
The AROME models generally have too much wind, while ECMWF has too little compared with the observations. In total, the bias in the Hirlam models is close to zero, but diurnal variations are large. Too weak winds during daytime and too strong during the nights.

HR is high for the AROME models, but so is also the FAR. The AROME models have the highest ETS. There are no large differences between the two AROME models, but AM25 scores a little better for low thresholds, while AROME is the best for high thresholds (>$11ms^{-1}$).

After the post processing, H8_PP and AROME_PP both still have too weak winds compared with the max mean wind speed. HR is increased for both models after post processing. As is the FAR, but the increase is significantly larger for H8_PP than AROME_PP. For ETS, AROME_PP has the highest score for all thresholds, but the increase in score due to post processing is larger for H8.

Wind gust:
For the wind gust two different variables for AROME, AM25, and H8, are used, the gust (FG) and wind speed in the 925hPa layer. Both commonly used to forecast wind gust. The verification period is between 25 march to 31 May. There are clear differences in the scores for gust and 925hPa wind. The 925hPa winds are generally too weak during the day and too strong during the night. The bias in gust varies more, but shows the opposite pattern with higher wind speed during the day and weaker during night. AROME_FG has the least bias, while AM25_FG is generally too weak, compared with the observations. The 925hPa winds have a higher SDE and MAE than the gust variables. AROME_FG has the lowest MAE.

The 925hPa winds have a lower HR for thresholds less than $17.2ms^{-1}$, than the FG winds. But higher HR for higher wind speeds. AROME_FG has the highest HR of the FG for thresholds above $10.8ms^{-1}$, but also the highest FAR above $13.9ms^{-1}$. Due to a significantly higher FAR, the 925hPa winds score lower on the ETS than the FG winds for most thresholds. AROME_FG stands out as the best model and variable for wind gust in the ETS score.

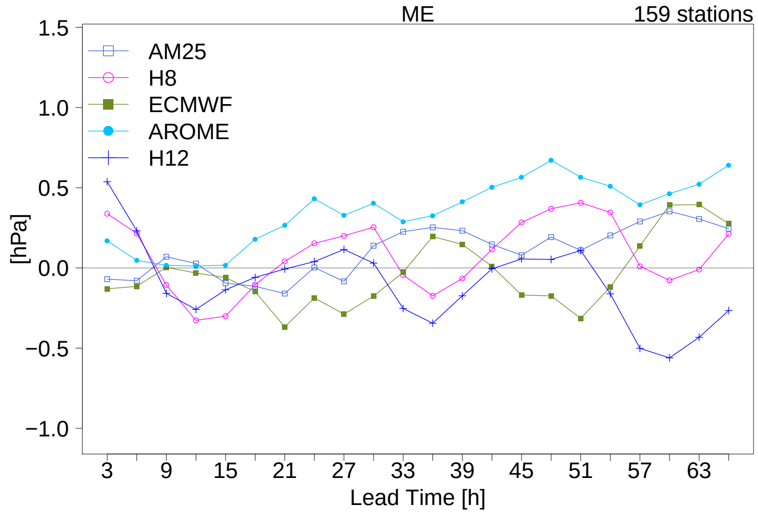
Temperature:
As with the winter temperature forecast, the spring forecasts have been too cold compared with the observations. There are diurnal variations for most models, in ME, but specially in SDE. AM25 has a bias of around $-0.5\,^{\circ}\mathrm{C}$, and is colder than AROME during nighttime. ECMWF has the largest diurnal variations in ME, but no cold trend, as seen in earlier reports. AM25 has a higher SDE than AROME, which results in a higher MAE. AROME has the lowest MAE the first 15 hours, and is tied with H8 for the rest.

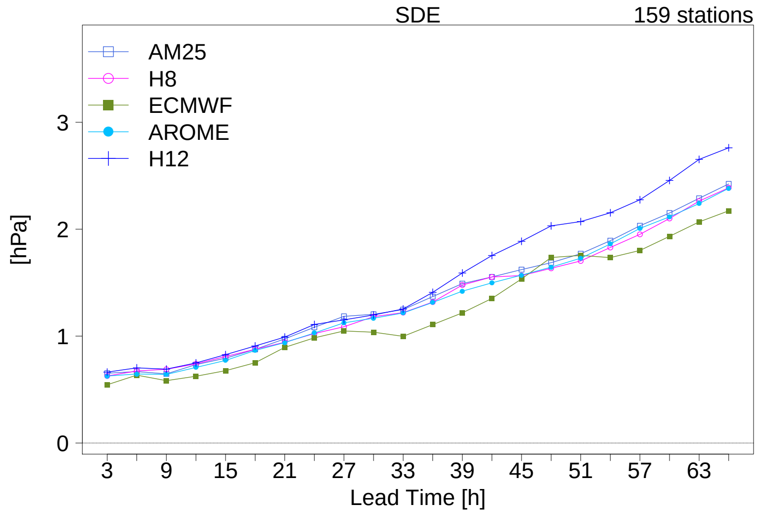
The post processed temperatures have reduced bias compared with the model data. AROME.KF has the least bias during daytime, and a small cold trend. Similar to the winter period, H8.KF has the lowest bias. For the first 24h AROME.KF has lower SDE than AROME. AROME.KF has the lowest MAE.

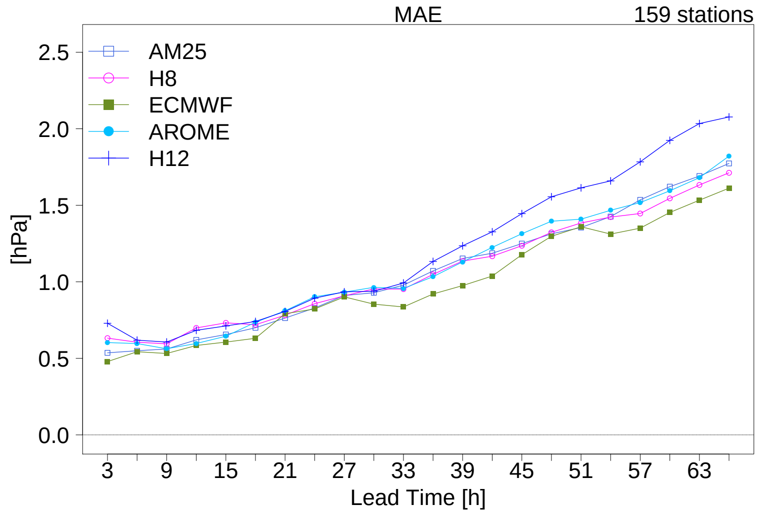
Precipitation:
All models have too much precipitation compared with the observations for the spring. The exception is the AROME.med. There could be undercatchment in the observations, so normally the models should have a small positive bias. ECMWF has the highest bias.

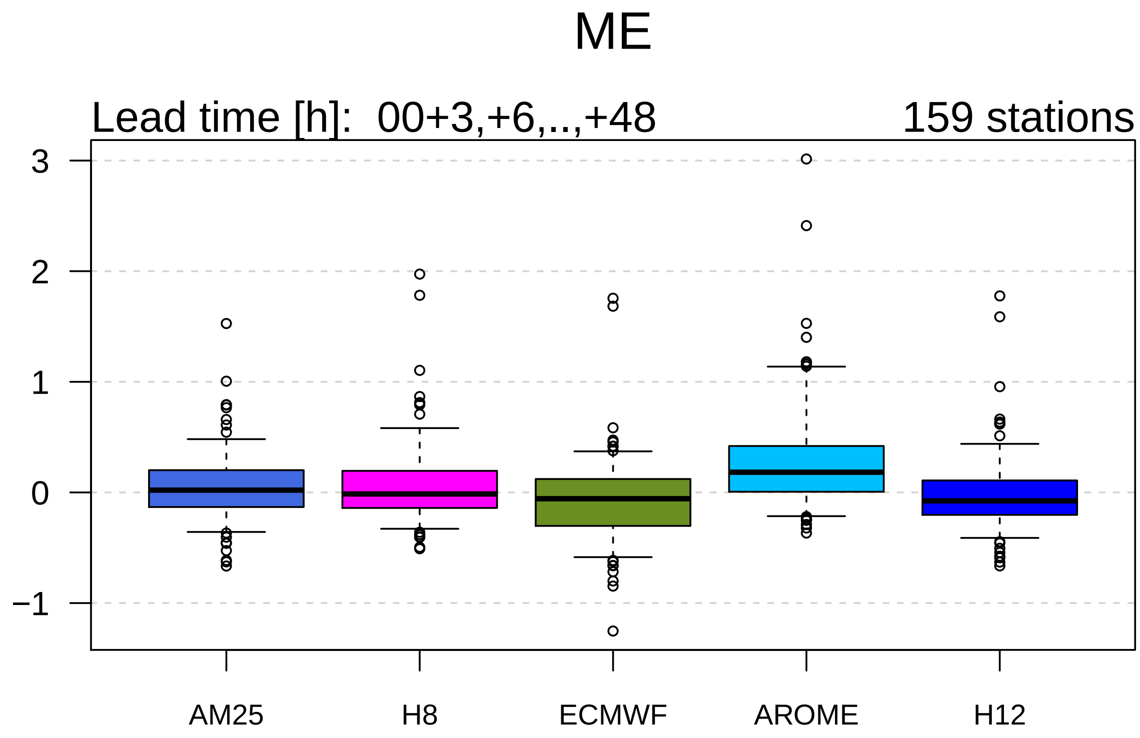
ECMWF has the highest HR for thresholds lower than 25mm. Above this, the AROME models score significantly better than the rest. The AROME models have low FAR below 12mm, AROME.med the lowest up to 25mm. AROME.med has the highest ETS score up to 35mm. For the heaviest precipitation (above 35mm) the raw data from the AROME models scores highest. No large differences between AROME and AM25.

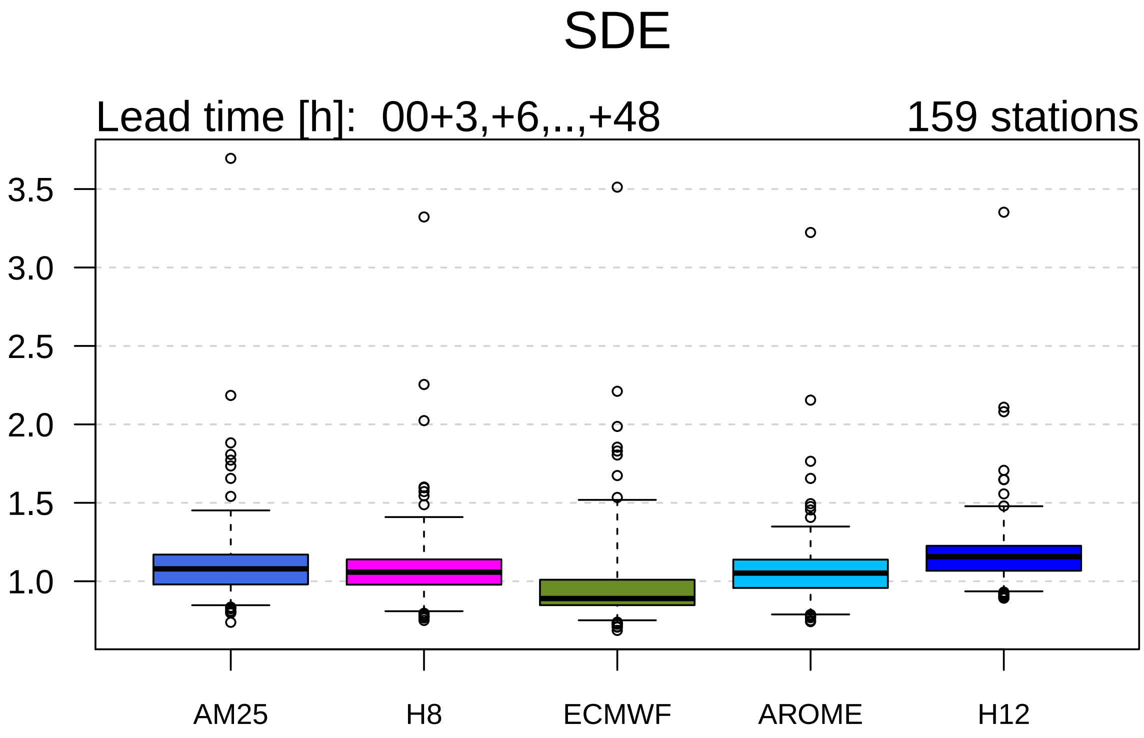
4.2 Pressure and variables at pressure levels



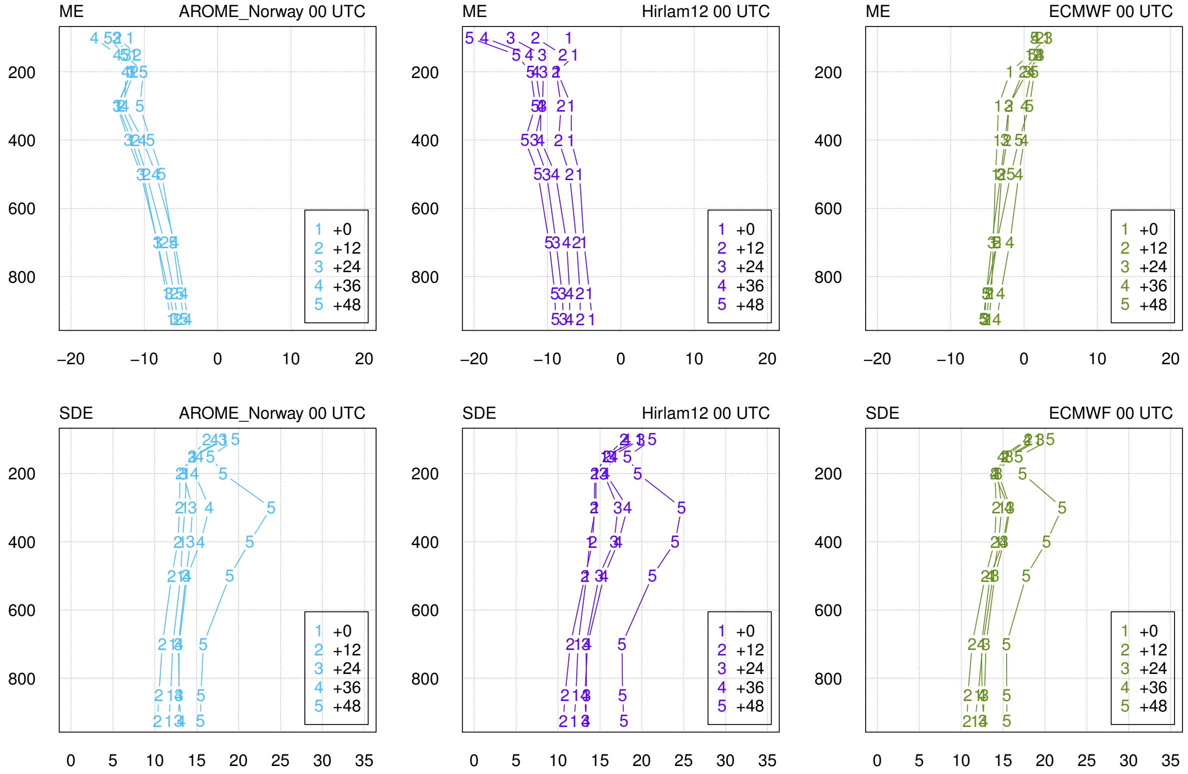




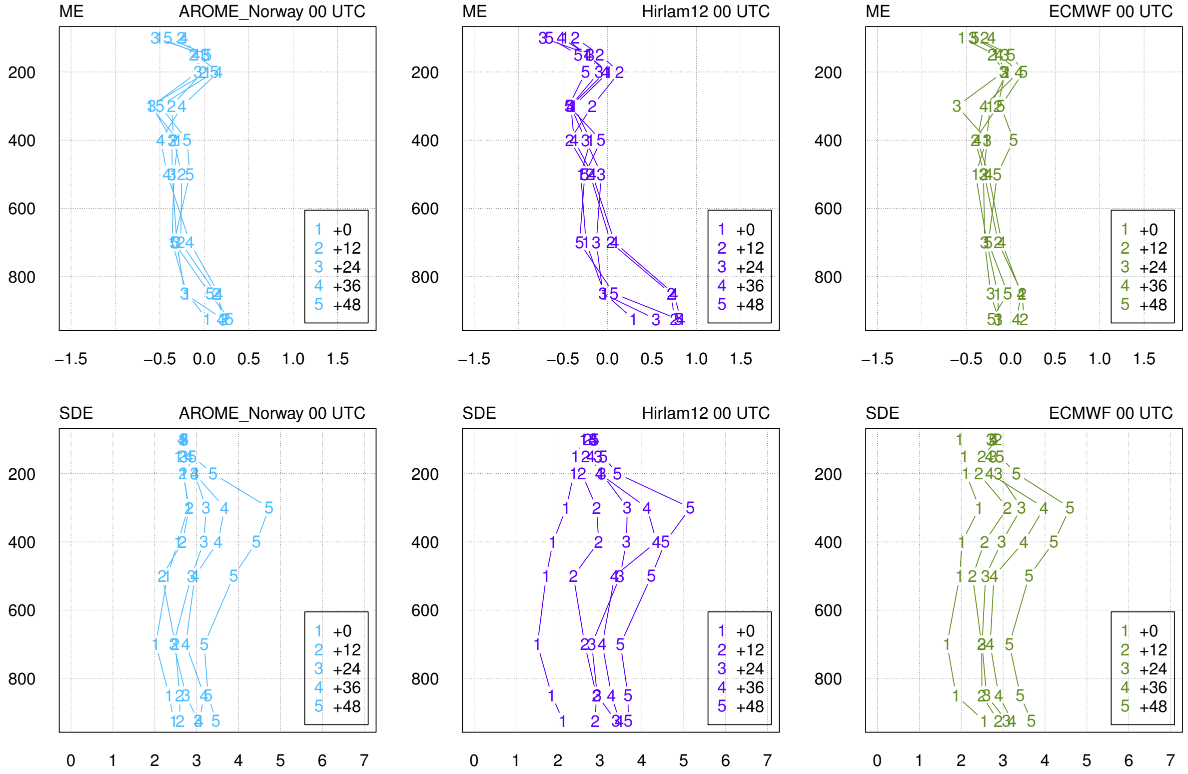

ME
Lead time [h]: 00+3,+6,..,+48
159 stations
3
2
1
0
−1
AM25
H8
ECMWF
AROME
H12

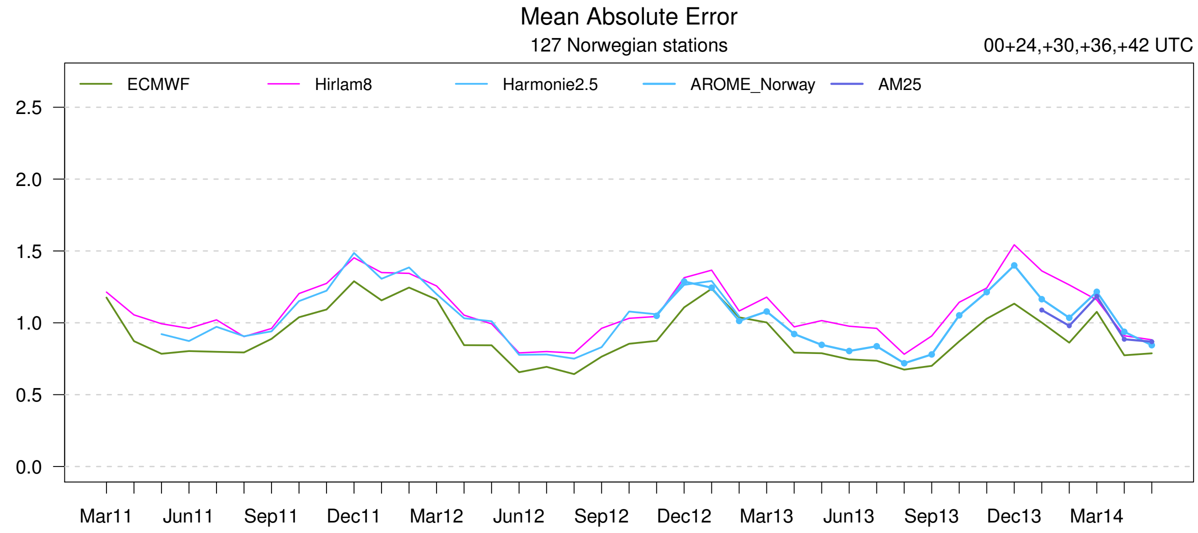

SDE
Lead time [h]: 00+3,+6,..,+48
159 stations
3.5
3.0
2.5
2.0
1.5
1.0
AM25
H8
ECMWF
AROME
H12

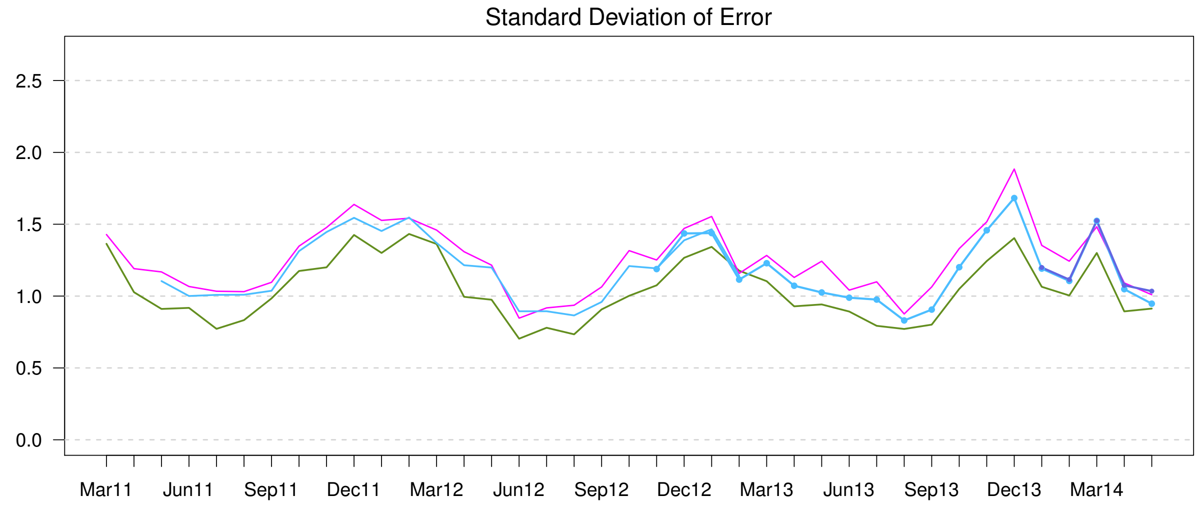
Geopotential height at 4 Norwegian stations



Wind speed at 4 Norwegian stations




Mean Absolute Error
127 Norwegian stations
00+24,+30,+36,+42 UTC
ECMWF
Hirlam8
Harmonie2.5
AROME_Norway
AM25
2.5
2.0
1.5
1.0
0.5
0.0
Mar11
Jun11
Sep11
Dec11
Mar12
Jun12
Sep12
Dec12
Mar13
Jun13
Sep13
Dec13
Mar14


Standard Deviation of Error
2.5
2.0
1.5
1.0
0.5
0.0
Mar11
Jun11
Sep11
Dec11
Mar12
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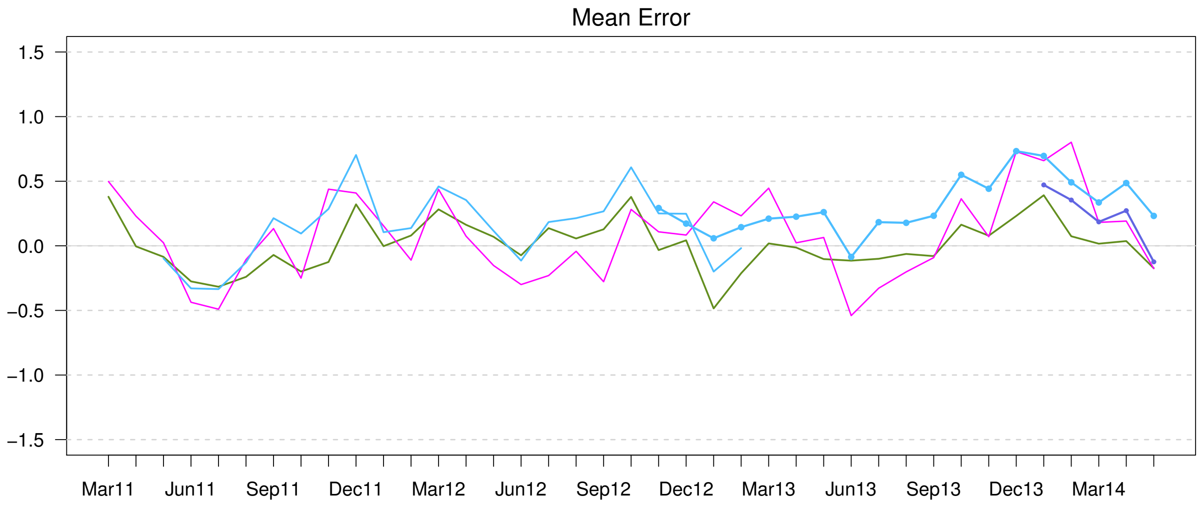
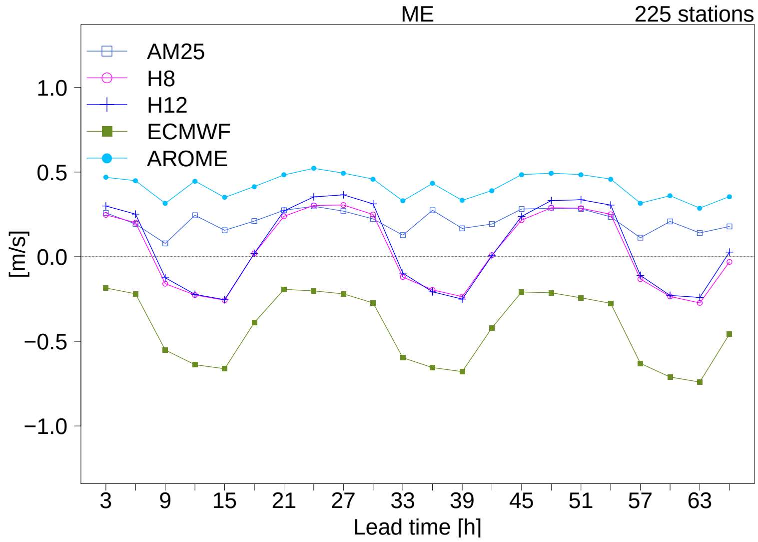
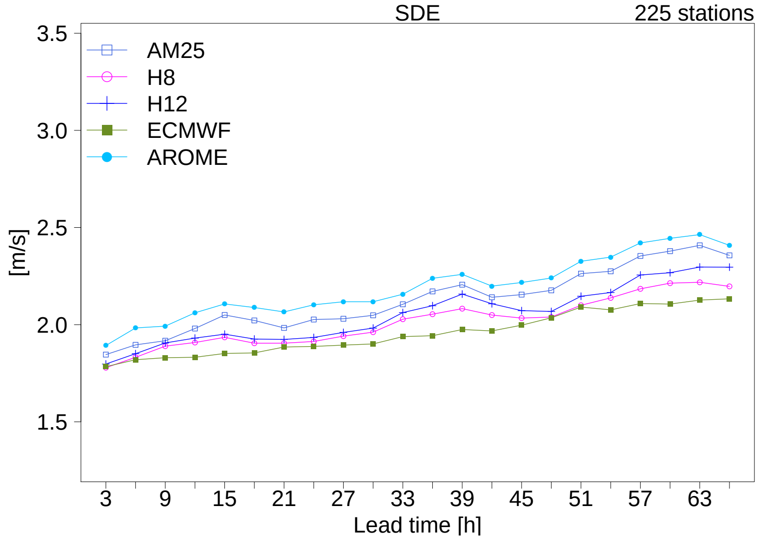
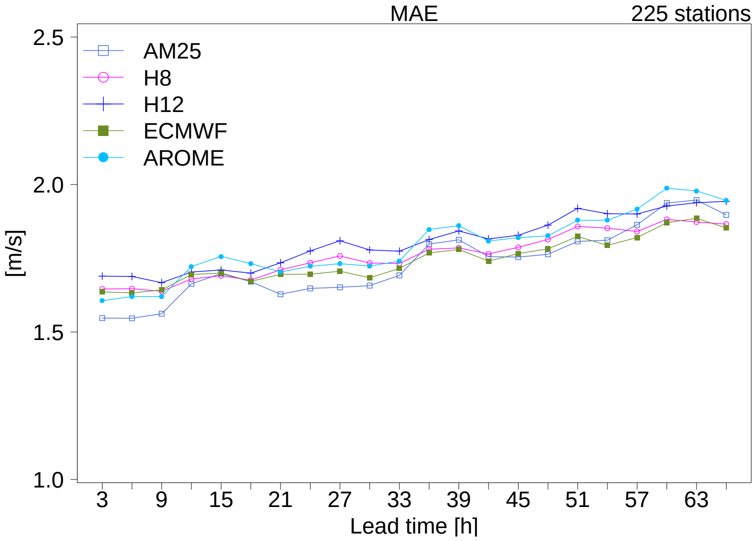
Sep12
Dec12
Mar13
Jun13
Sep13
Dec13
Mar14

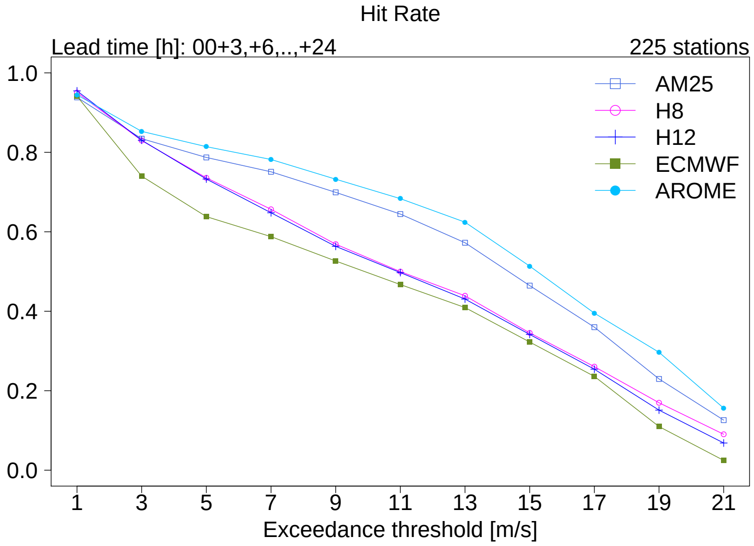

Mean Error
1.5
1.0
0.5
0.0
−0.5
−1.0
−1.5
Mar11
Jun11
Sep11
Dec11
Mar12
Jun12
Sep12
Dec12
Mar13
Jun13
Sep13
Dec13
Mar14

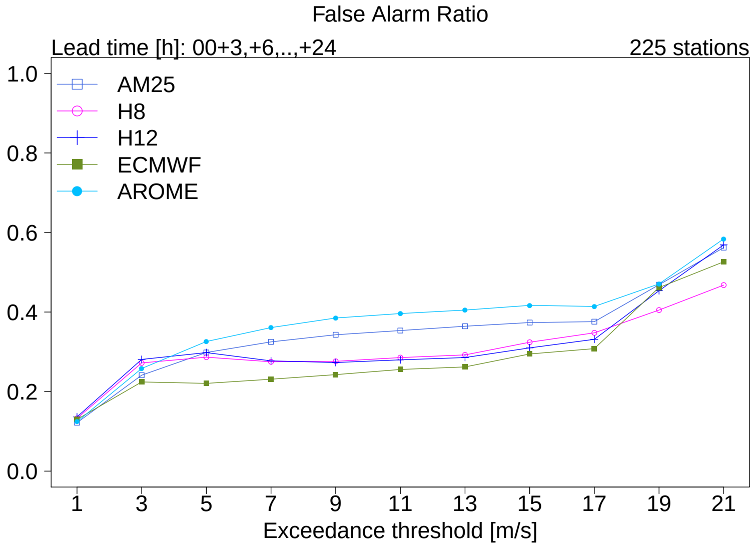
4.3 Wind Speed 10m

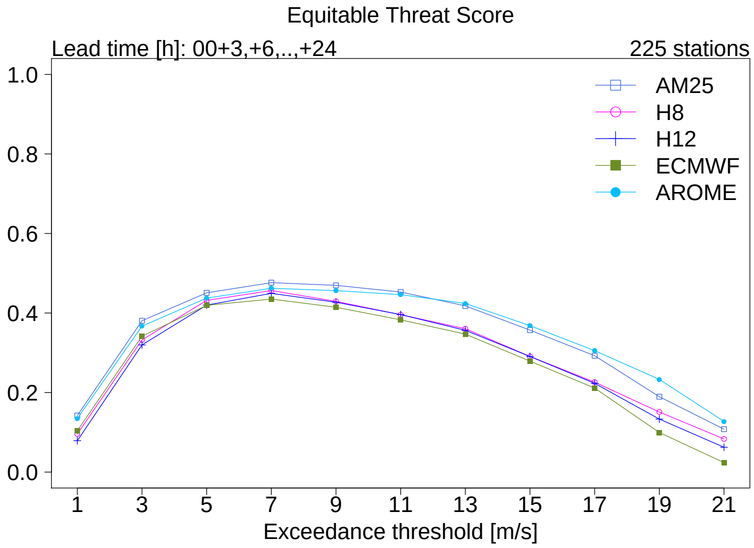




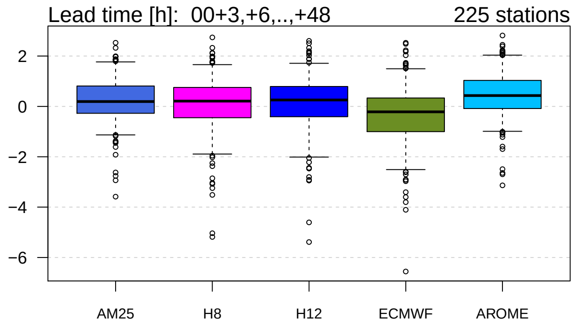



Hit Rate
Lead time [h]: 00+3,+6,..,+24
225 stations
1.0
0.8
0.6
0.4
0.2
0.0
1
3
5
7
9
11
13
15
17
19
21
Exceedance threshold [m/s]
AM25
H8
H12
ECMWF
AROME

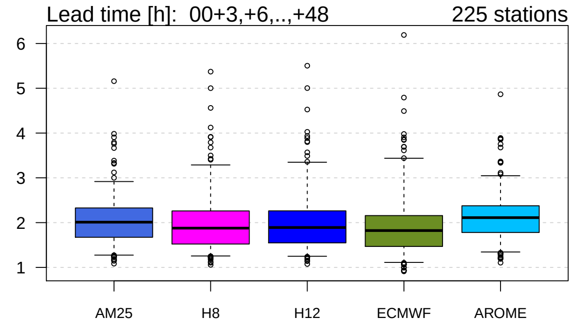

False Alarm Ratio
Lead time [h]: 00+3,+6,..,+24
225 stations
1.0
0.8
0.6
0.4
0.2
0.0
1
3
5
7
9
11
13
15
17
19
21
Exceedance threshold [m/s]
AM25
H8
H12
ECMWF
AROME


Equitable Threat Score
Lead time [h]: 00+3,+6,..,+24
225 stations
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]
AM25
H8
H12
ECMWF
AROME

ME



SDE



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

OBS

AM25

	[0,3]	(3,11]	(11,17]	(17,21]	(21,Inf]	Sum
[0,3]	97950	25600	101	5	2	123658
(3,11]	40178	99493	5821	247	67	145806
(11,17]	334	5908	7712	1181	337	15472
(17,21]	2	101	447	553	232	1335
(21,Inf]	0	7	41	64	89	201
Sum	138464	131109	14122	2050	727	286472

OBS

H8

	[0,3]	(3,11]	(11,17]	(17,21]	(21,Inf]	Sum
[0,3]	91211	25861	187	8	1	117268
(3,11]	47153	101681	7649	593	240	157316
(11,17]	98	3529	5937	991	265	10820
(17,21]	2	37	328	426	160	953
(21,Inf]	0	1	21	32	61	115
Sum	138464	131109	14122	2050	727	286472

OBS

ECMWF

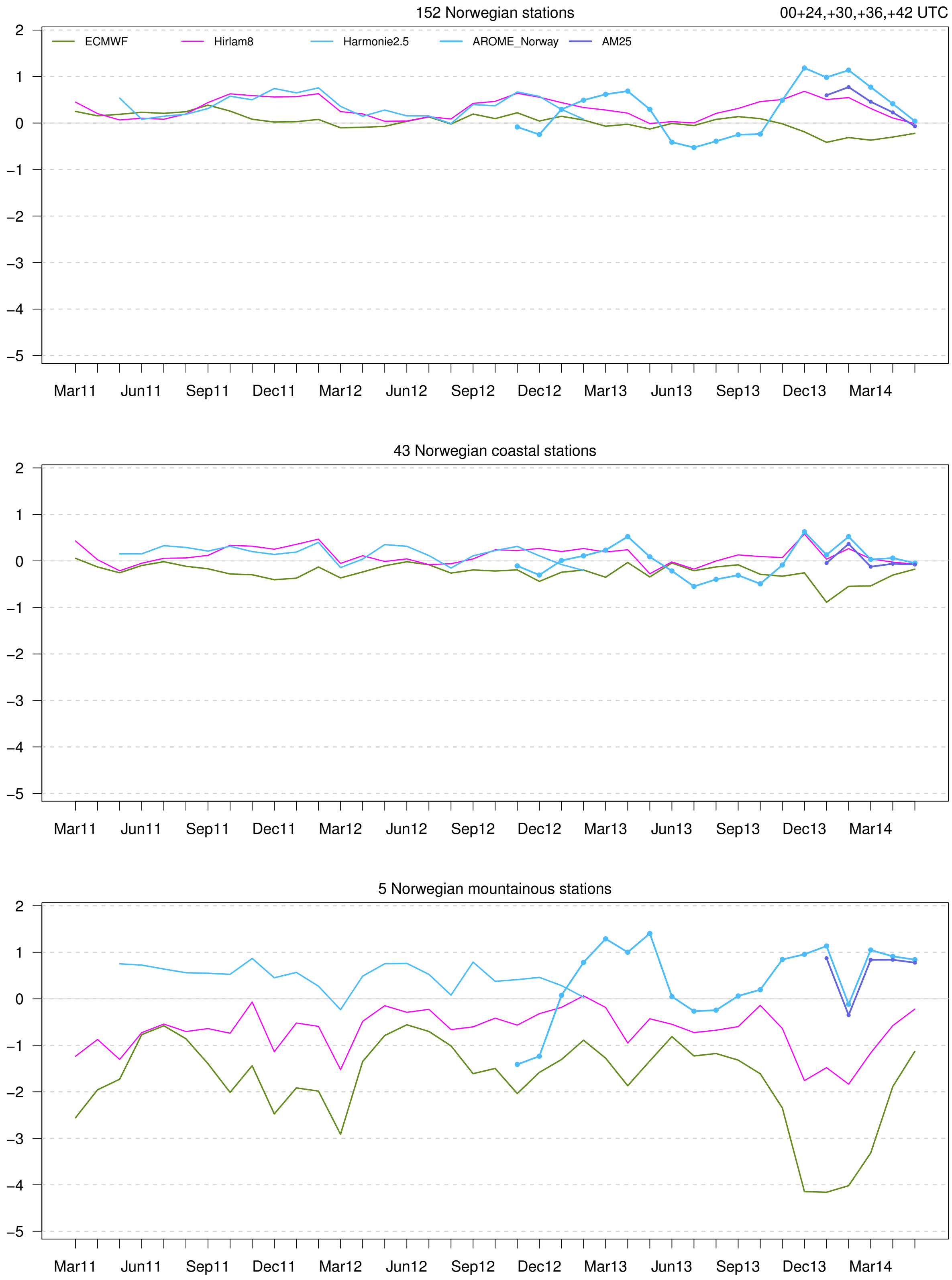
	[0,3]	(3,11]	(11,17]	(17,21]	(21,Inf]	Sum
[0,3]	106325	38819	718	123	59	146044
(3,11]	32071	89516	7705	460	91	129843
(11,17]	68	2735	5435	1088	373	9699
(17,21]	0	38	252	372	179	841
(21,Inf]	0	1	12	7	25	45
Sum	138464	131109	14122	2050	727	286472

OBS

AROME

	[0,3]	(3,11]	(11,17]	(17,21]	(21,Inf]	Sum
[0,3]	93454	22823	94	4	3	116378
(3,11]	44508	100902	5252	221	45	150928
(11,17]	496	7227	8166	1146	334	17369
(17,21]	6	143	563	594	244	1550
(21,Inf]	0	14	47	85	101	247
Sum	138464	131109	14122	2050	727	286472

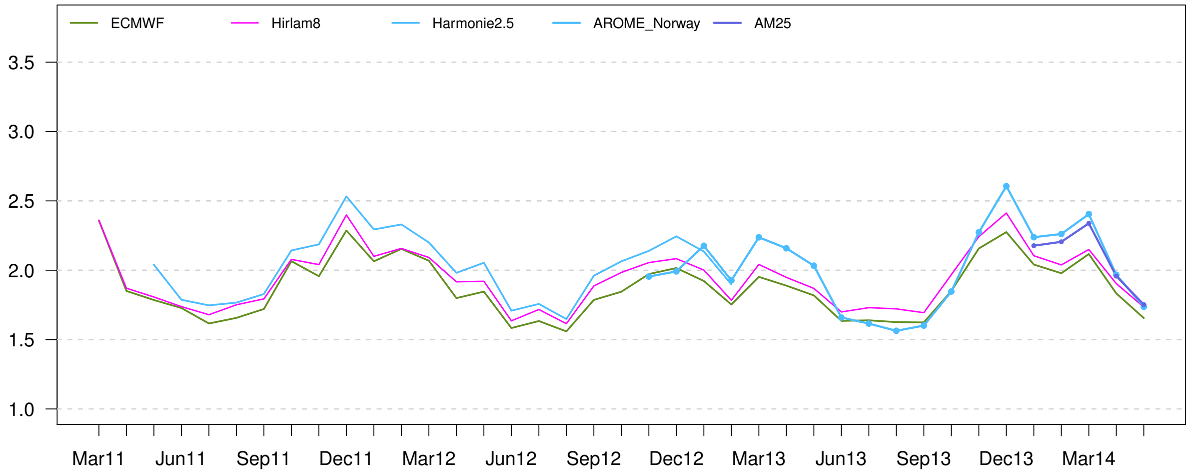
Mean Error


152 Norwegian stations
00+24,+30,+36,+42 UTC
ECMWF
Hirlam8
Harmonie2.5
AROME_Norway
AM25
2
1
0
−1
−2
−3
−4
−5
Mar11
Jun11
Sep11
Dec11
Mar12
Jun12
Sep12
Dec12
Mar13
Jun13
Sep13
Dec13
Mar14
43 Norwegian coastal stations
5 Norwegian mountainous stations

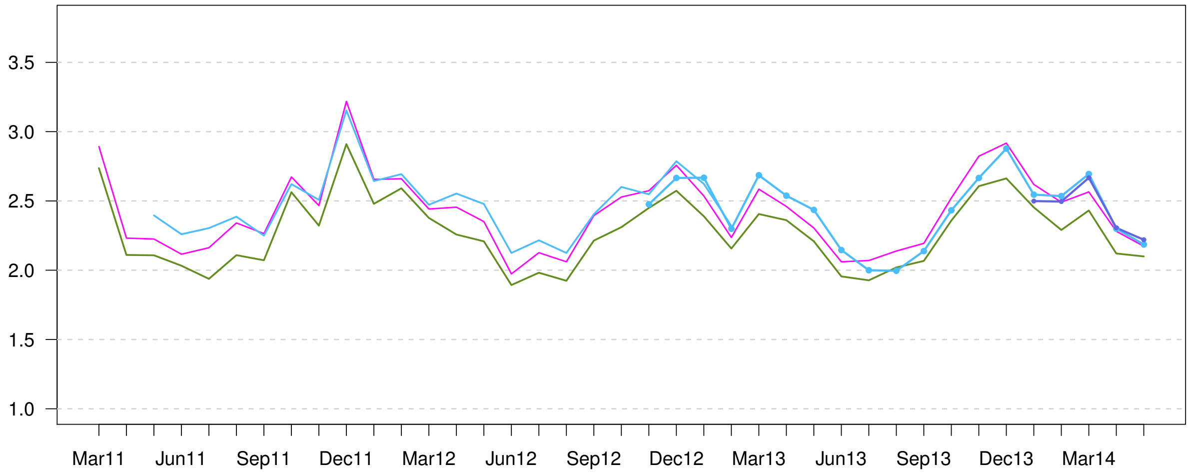
Standard Deviation of Error

152 Norwegian stations

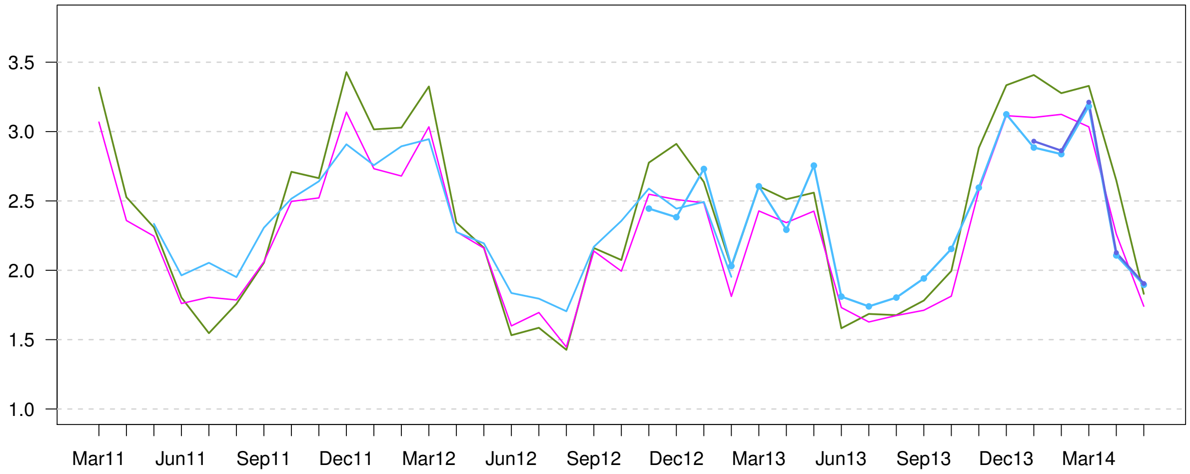
00+24,+30,+36,+42 UTC



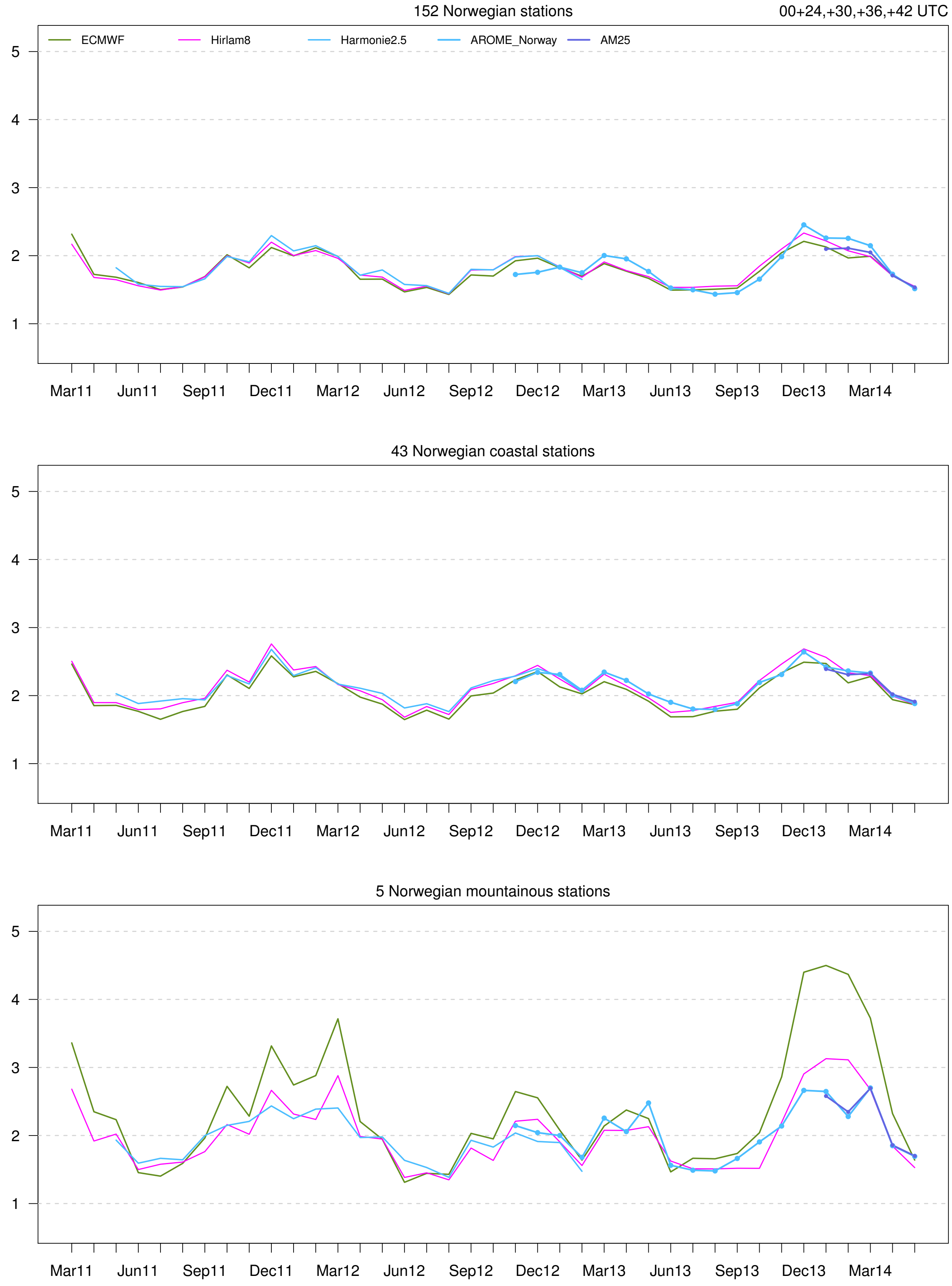
43 Norwegian coastal stations



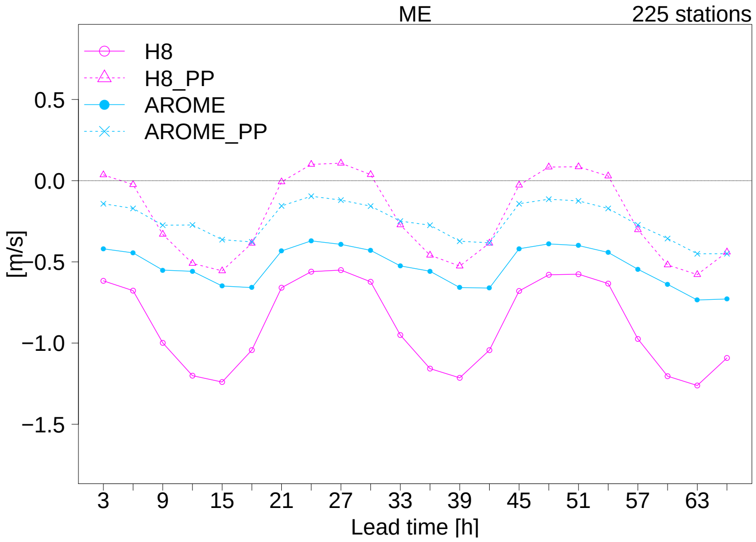
5 Norwegian mountainous stations

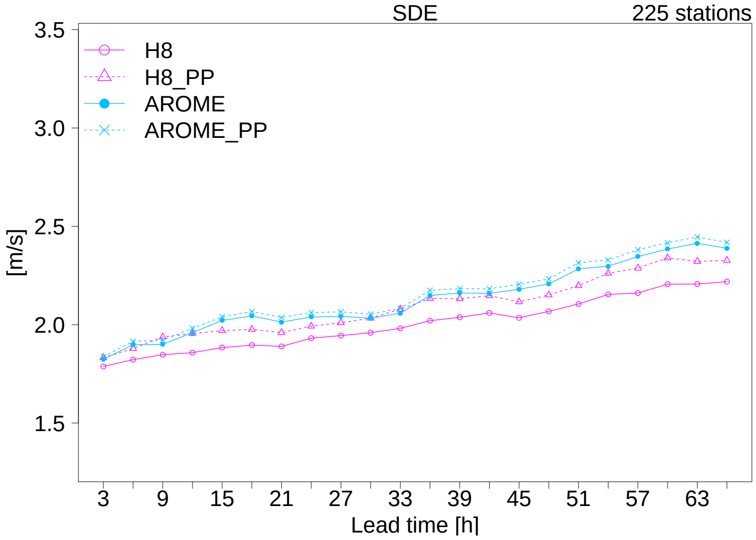


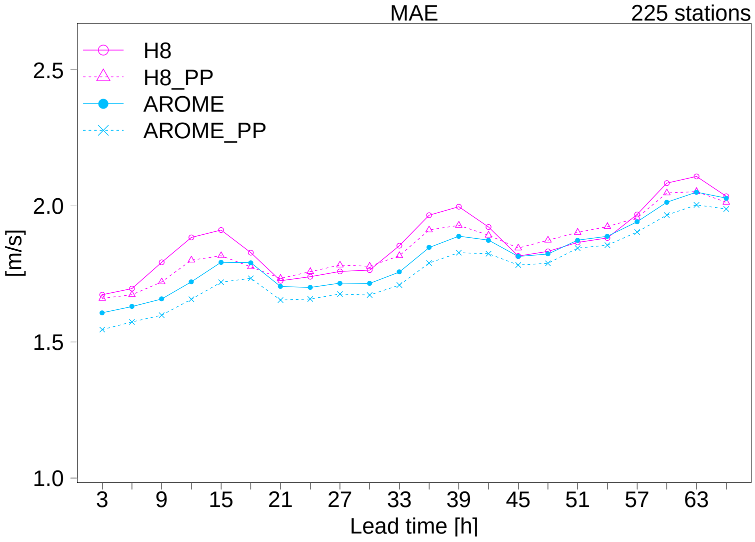
Mean Absolute Error

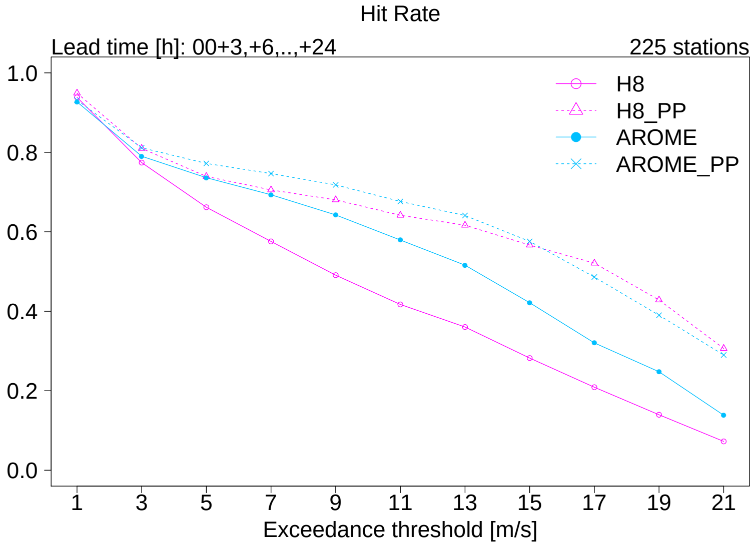


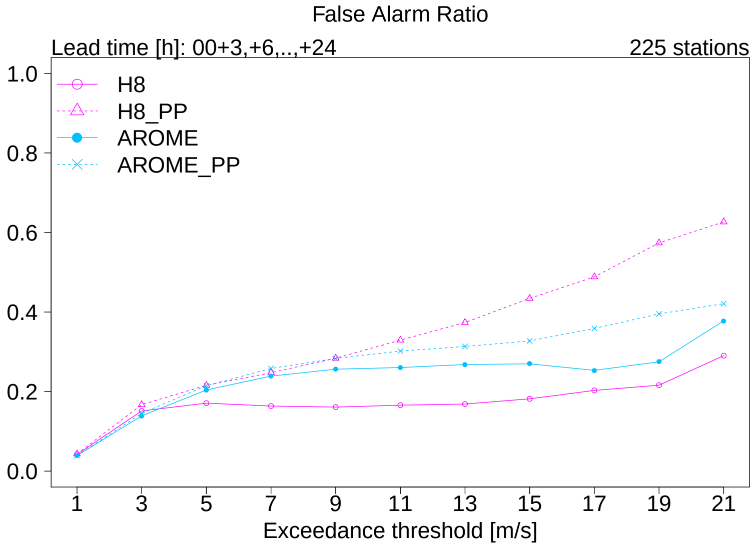
4.4 Max Mean Wind Speed 10m

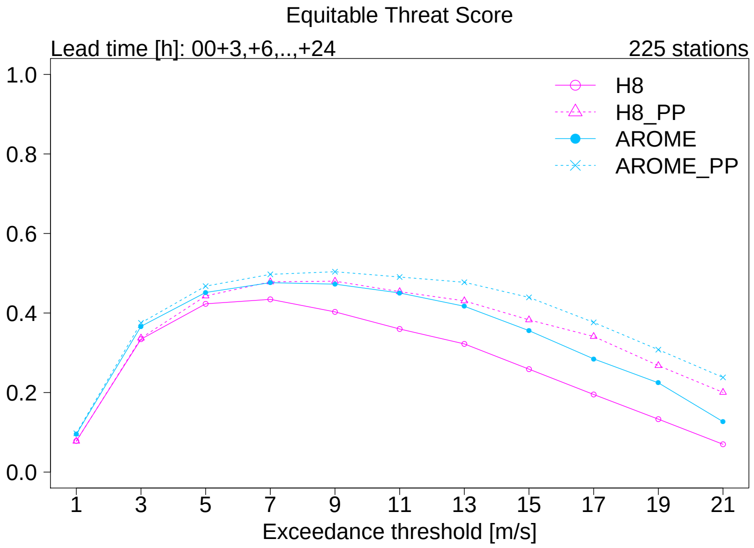


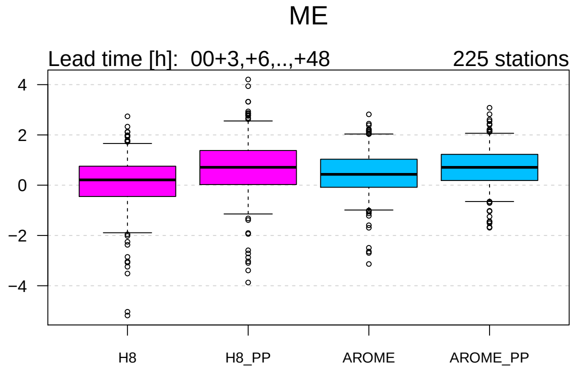


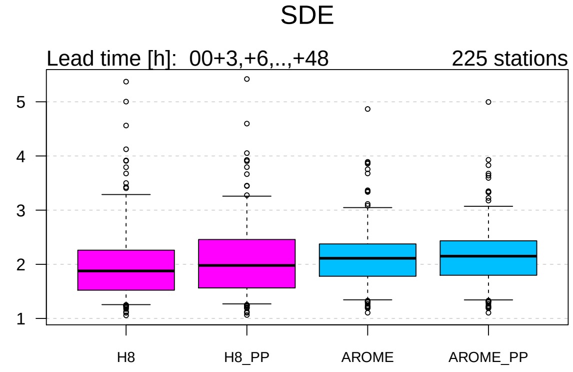



Hit Rate
Lead time [h]: 00+3,+6,..,+24
225 stations
H8
H8_PP
AROME
AROME_PP
1.0
0.8
0.6
0.4
0.2
0.0
1
3
5
7
9
11
13
15
17
19
21
Exceedance threshold [m/s]


False Alarm Ratio
Lead time [h]: 00+3,+6,..,+24
225 stations
H8
H8_PP
AROME
AROME_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
H8
H8_PP
AROME
AROME_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

OBS

H8

	[0,3]	(3,11]	(11,17]	(17,21]	(21,Inf]	Sum
[0,3]	69799	39633	290	14	3	109739
(3,11]	25090	109739	12072	862	410	148173
(11,17]	60	2103	6419	1618	429	10629
(17,21]	2	11	187	453	295	948
(21,Inf]	0	0	14	21	80	115
Sum	94951	151486	18982	2968	1217	269604

OBS

H8_PP

	[0,3]	(3,11]	(11,17]	(17,21]	(21,Inf]	Sum
[0,3]	65562	33447	146	1	3	99159
(3,11]	29236	110404	7649	498	185	147972
(11,17]	139	7436	9318	1028	383	18304
(17,21]	12	190	1711	1004	290	3207
(21,Inf]	2	9	158	437	356	962
Sum	94951	151486	18982	2968	1217	269604

OBS

AROME

	[0,3]	(3,11]	(11,17]	(17,21]	(21,Inf]	Sum
[0,3]	71770	37197	153	7	3	109130
(3,11]	23000	109497	9266	405	83	142251
(11,17]	179	4706	9186	1839	586	16496
(17,21]	2	79	350	660	392	1483
(21,Inf]	0	7	27	57	153	244
Sum	94951	151486	18982	2968	1217	269604

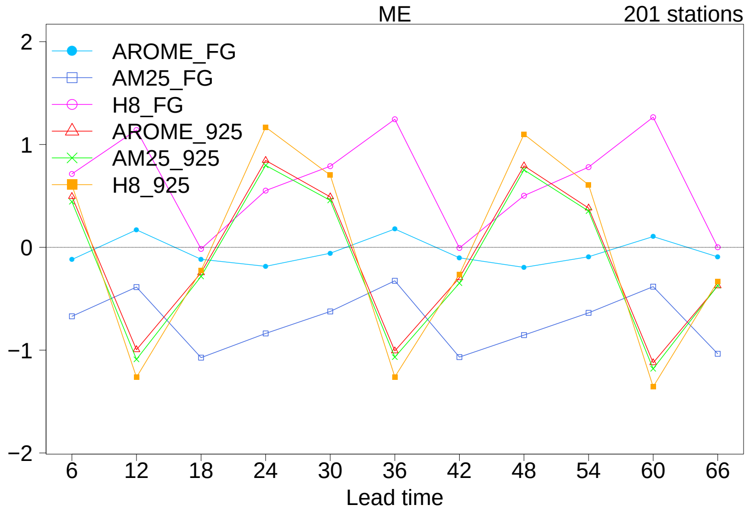
OBS

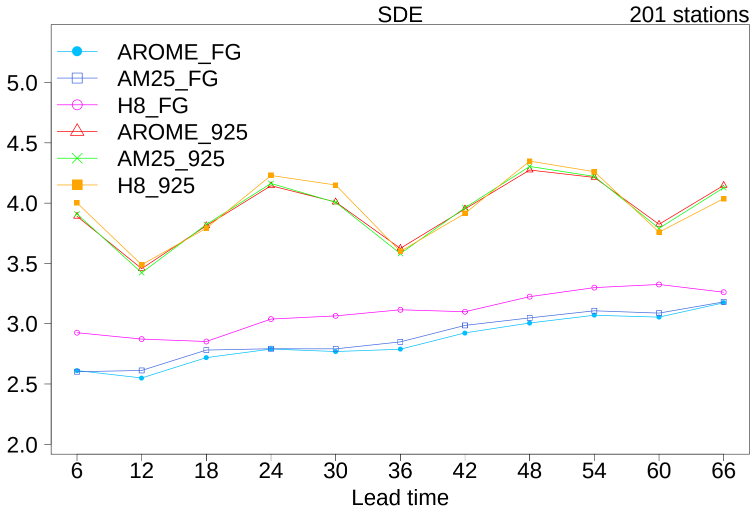
AROME_PP

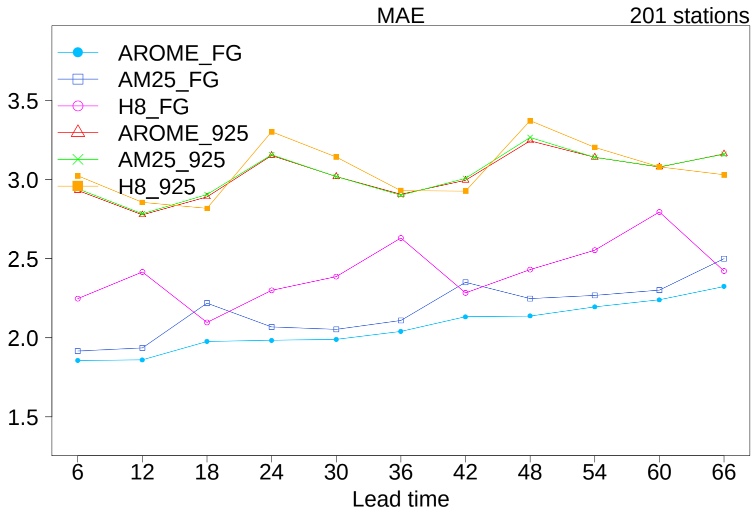
	[0,3]	(3,11]	(11,17]	(17,21]	(21,Inf]	Sum
[0,3]	70025	33524	117	4	3	103673
(3,11]	24724	111110	7350	260	40	143484
(11,17]	196	6708	10523	1487	454	19368
(17,21]	6	134	947	1021	400	2508
(21,Inf]	0	10	45	196	320	571
Sum	94951	151486	18982	2968	1217	269604

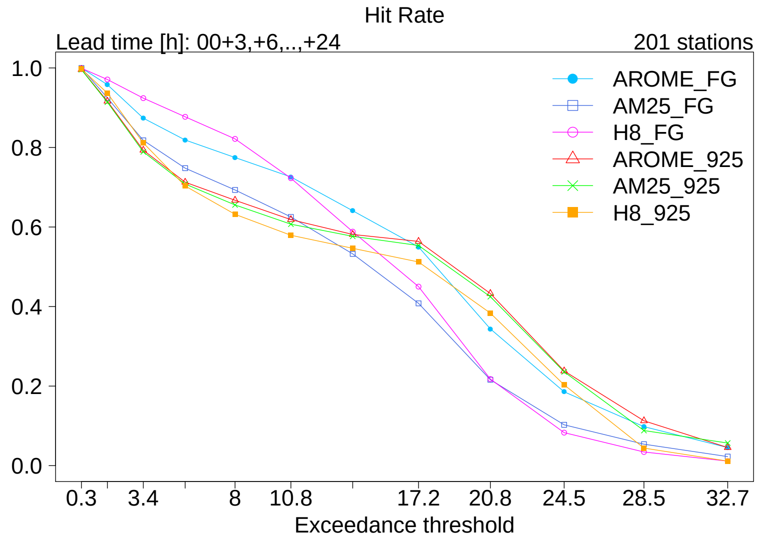
4.5 Wind gust

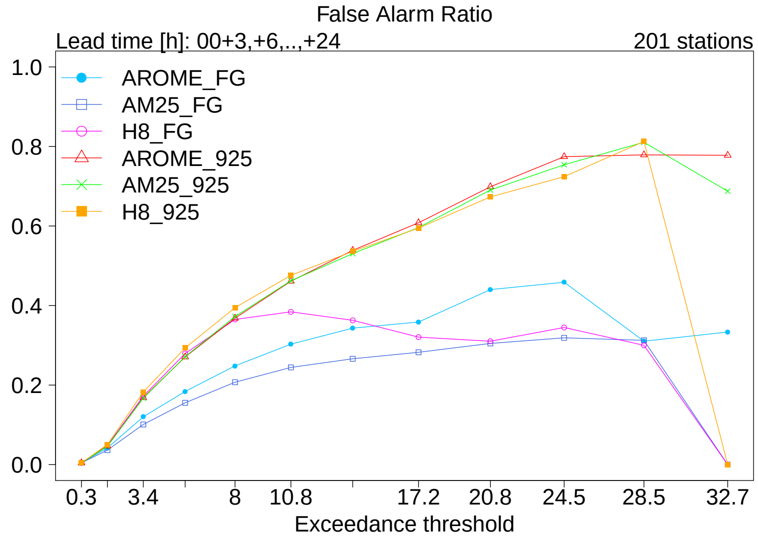
4.5.1 25 March - 31 May

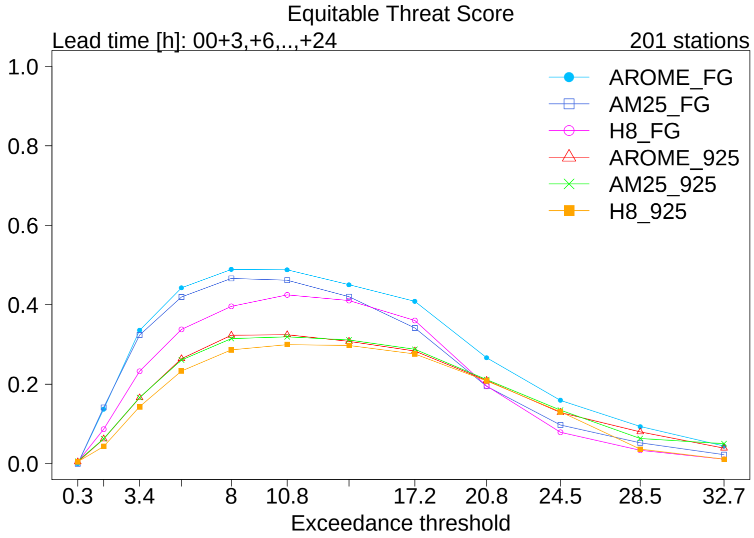




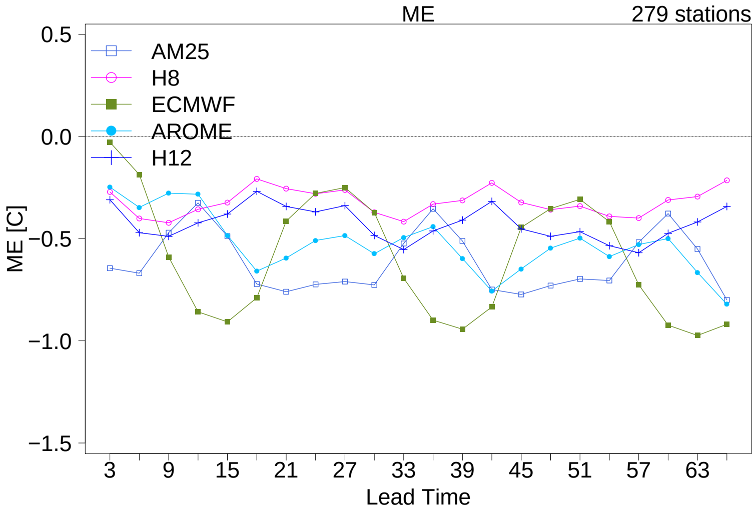


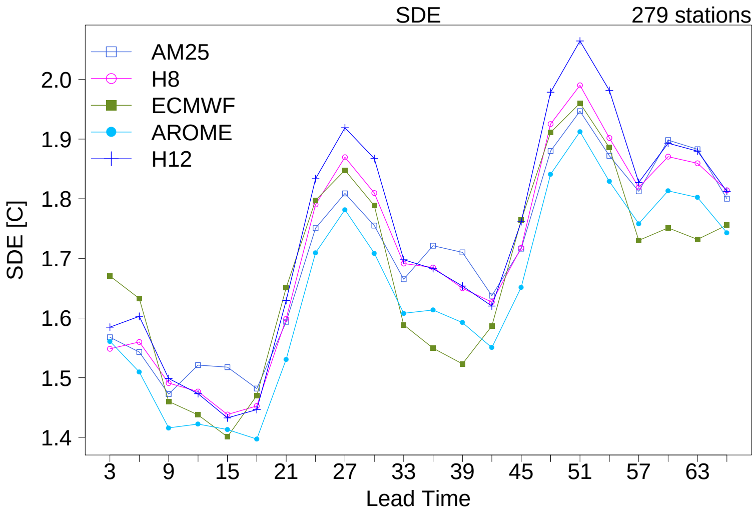

Hit Rate
Lead time [h]: 00+3,+6,..,+24
201 stations
AROME_FG
AM25_FG
H8_FG
AROME_925
AM25_925
H8_925
1.0
0.8
0.6
0.4
0.2
0.0
0.3
3.4
8
10.8
17.2
20.8
24.5
28.5
32.7
Exceedance threshold

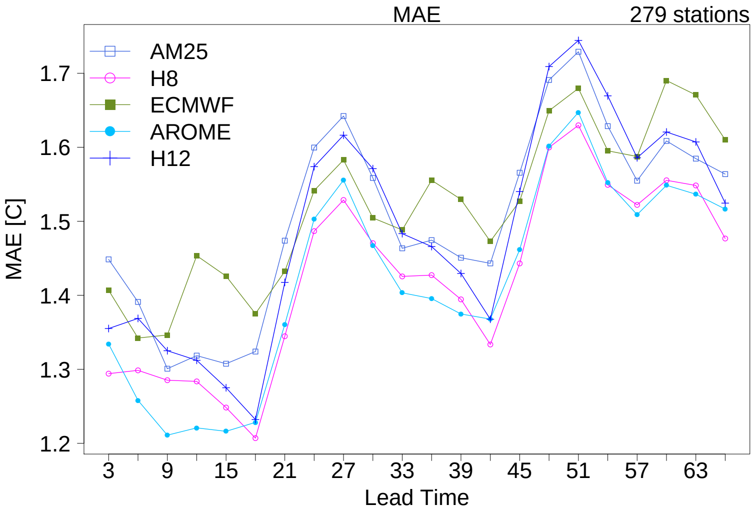

False Alarm Ratio
Lead time [h]: 00+3,+6,..,+24
201 stations
AROME_FG
AM25_FG
H8_FG
AROME_925
AM25_925
H8_925
1.0
0.8
0.6
0.4
0.2
0.0
0.3
3.4
8
10.8
17.2
20.8
24.5
28.5
32.7
Exceedance threshold

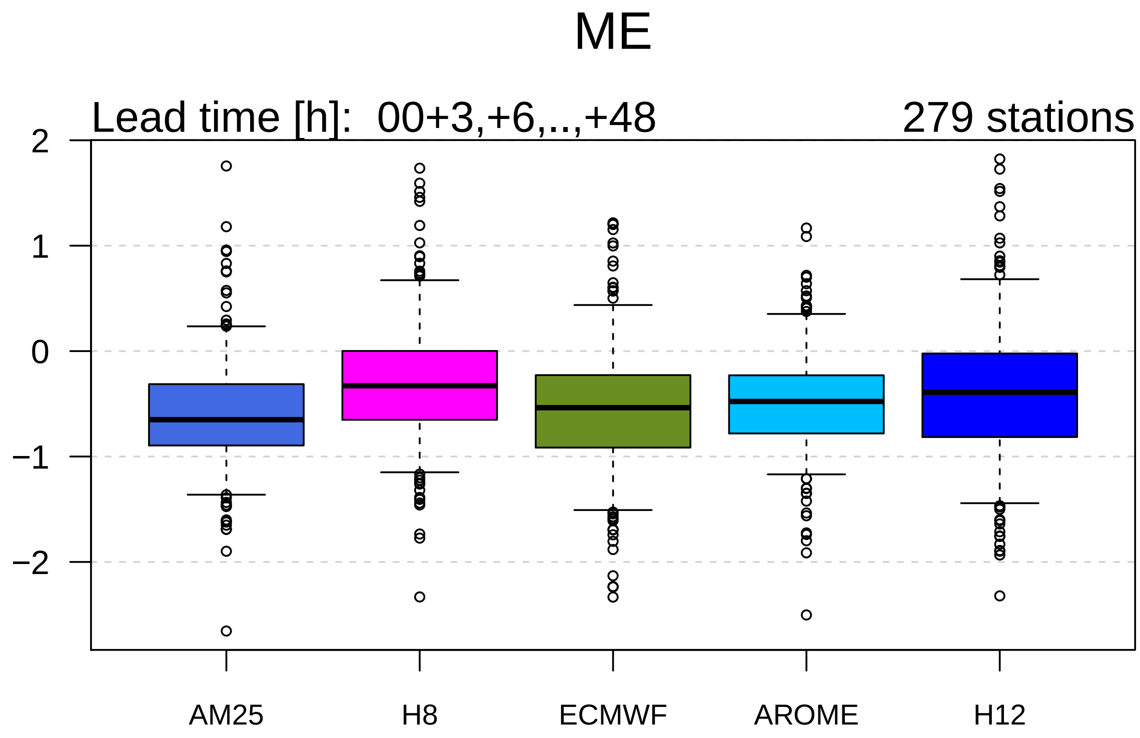

Equitable Threat Score
Lead time [h]: 00+3,+6,..,+24
201 stations
AROME_FG
AM25_FG
H8_FG
AROME_925
AM25_925
H8_925
1.0
0.8
0.6
0.4
0.2
0.0
0.3
3.4
8
10.8
17.2
20.8
24.5
28.5
32.7
Exceedance threshold

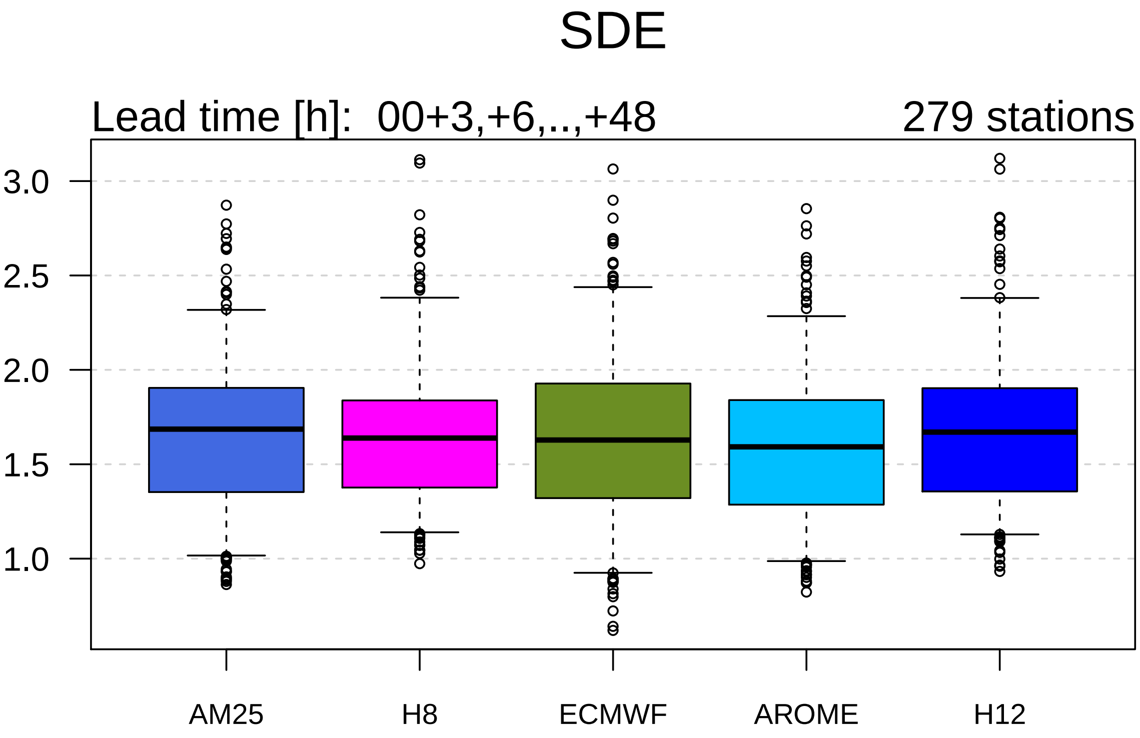
4.6 Temperature 2m







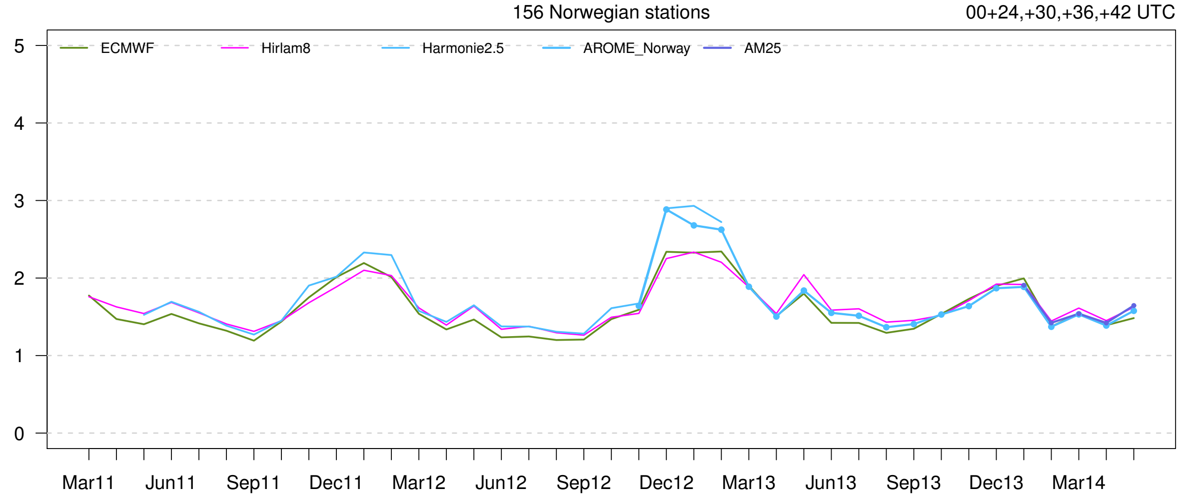

ME
Lead time [h]: 00+3,+6,..,+48
279 stations
2
1
0
−1
−2
AM25
H8
ECMWF
AROME
H12

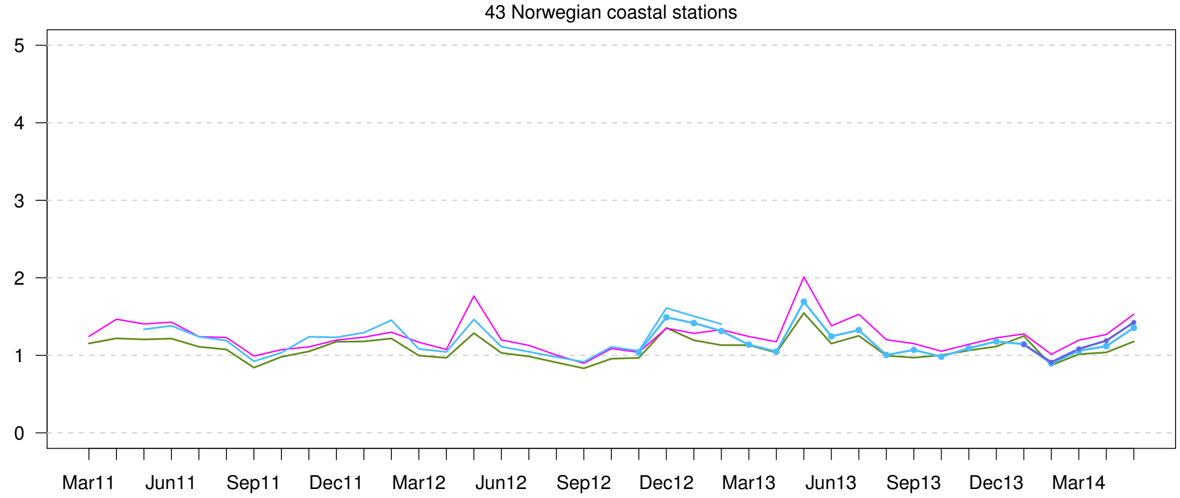

SDE
Lead time [h]: 00+3,+6,..,+48
279 stations
3.0
2.5
2.0
1.5
1.0
AM25
H8
ECMWF
AROME
H12

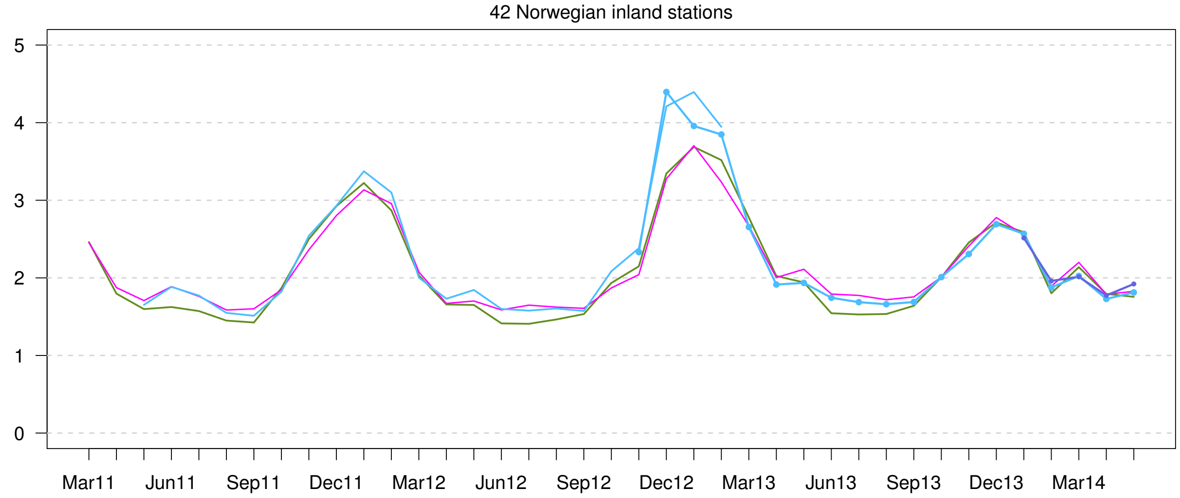
Mean Error


156 Norwegian stations
00+24,+30,+36,+42 UTC
ECMWF
Hirlam8
Harmonie2.5
AROME_Norway
AM25
1
0
−1
−2
−3
Mar11
Jun11
Sep11
Dec11
Mar12
Jun12
Sep12
Dec12
Mar13
Jun13
Sep13
Dec13
Mar14
43 Norwegian coastal stations
42 Norwegian inland stations

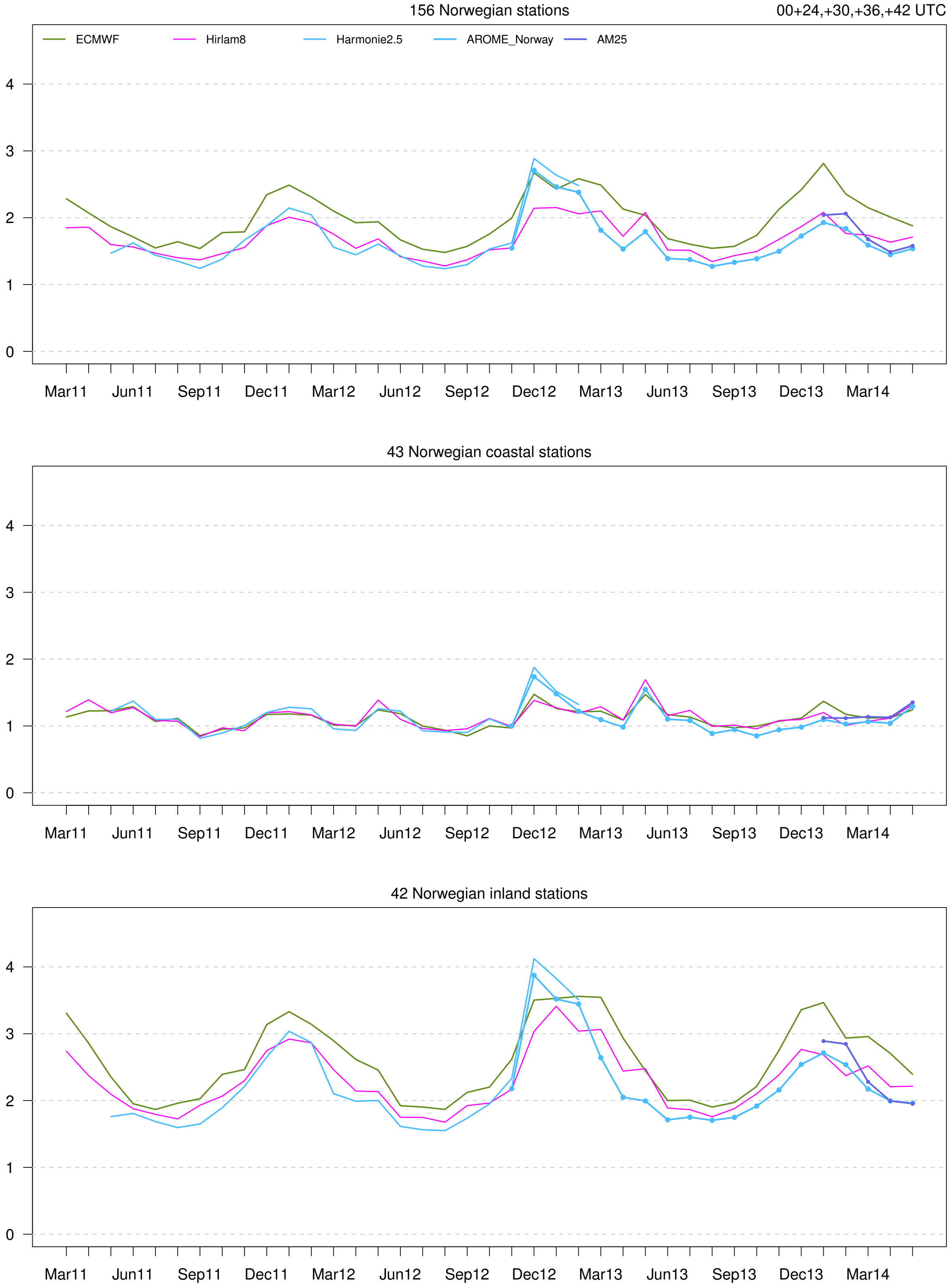
Standard Deviation of Error



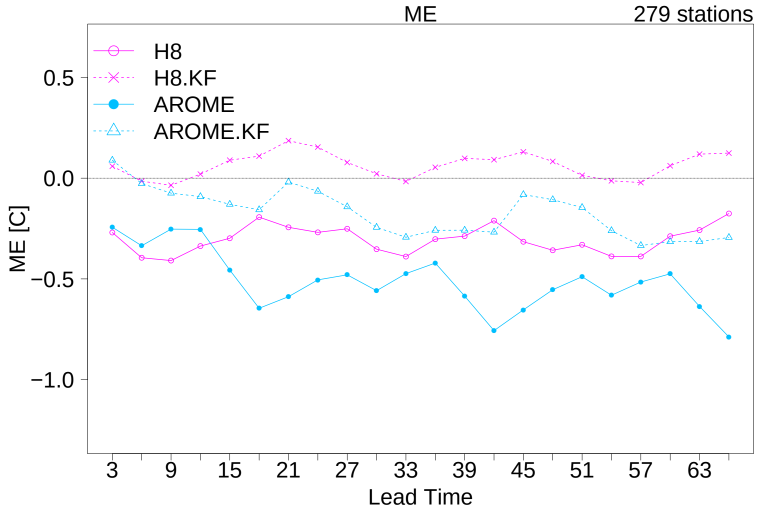


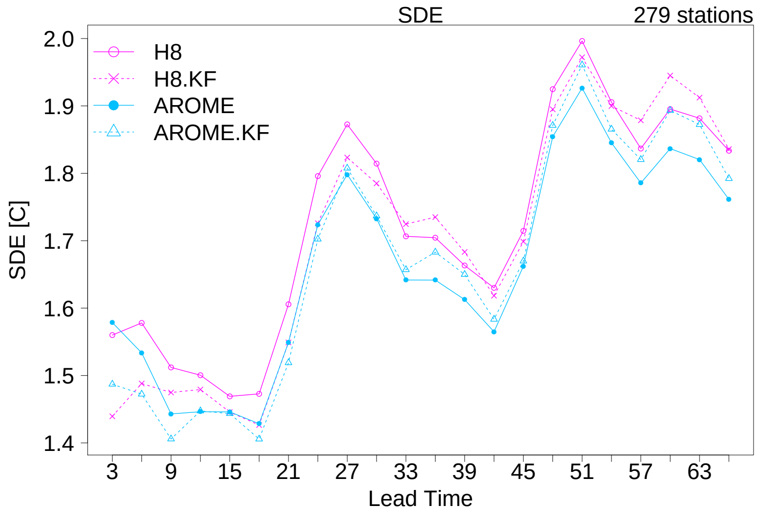


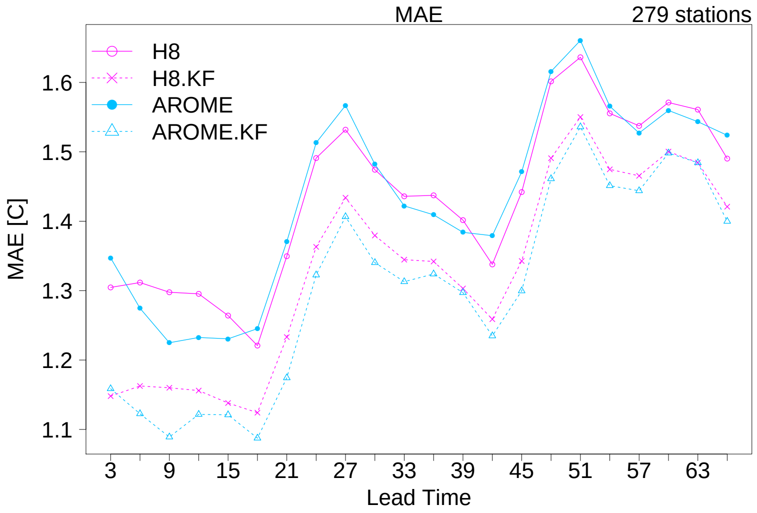
Mean Absolute Error

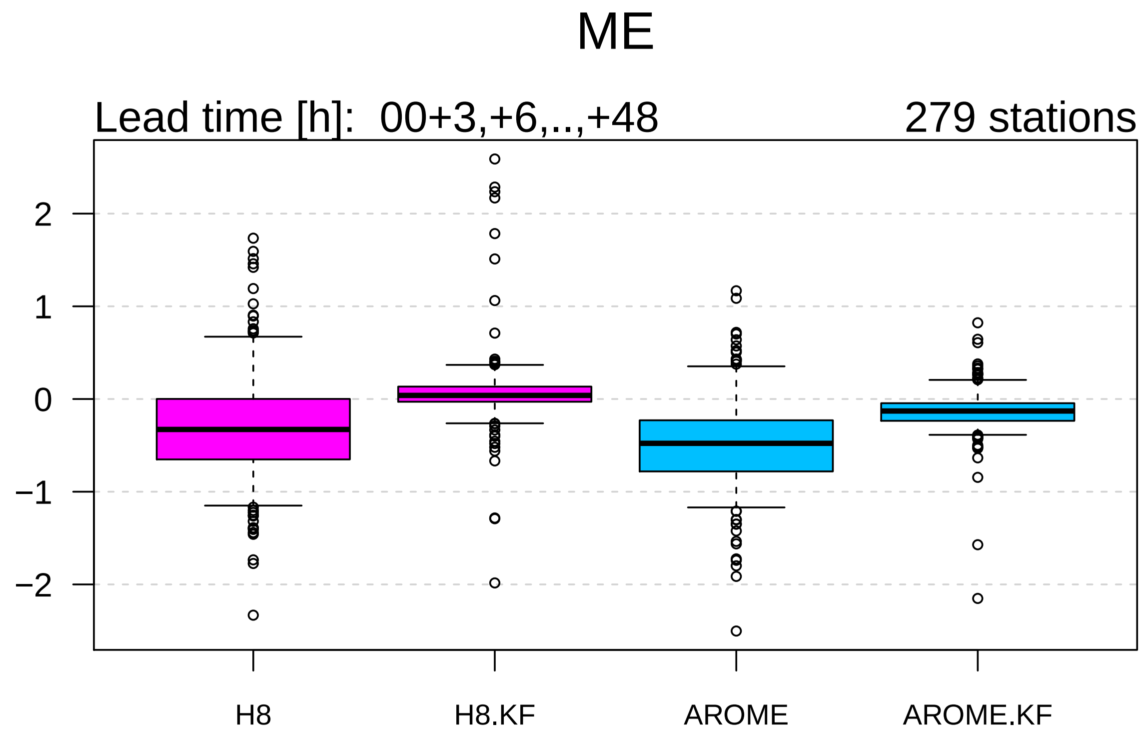


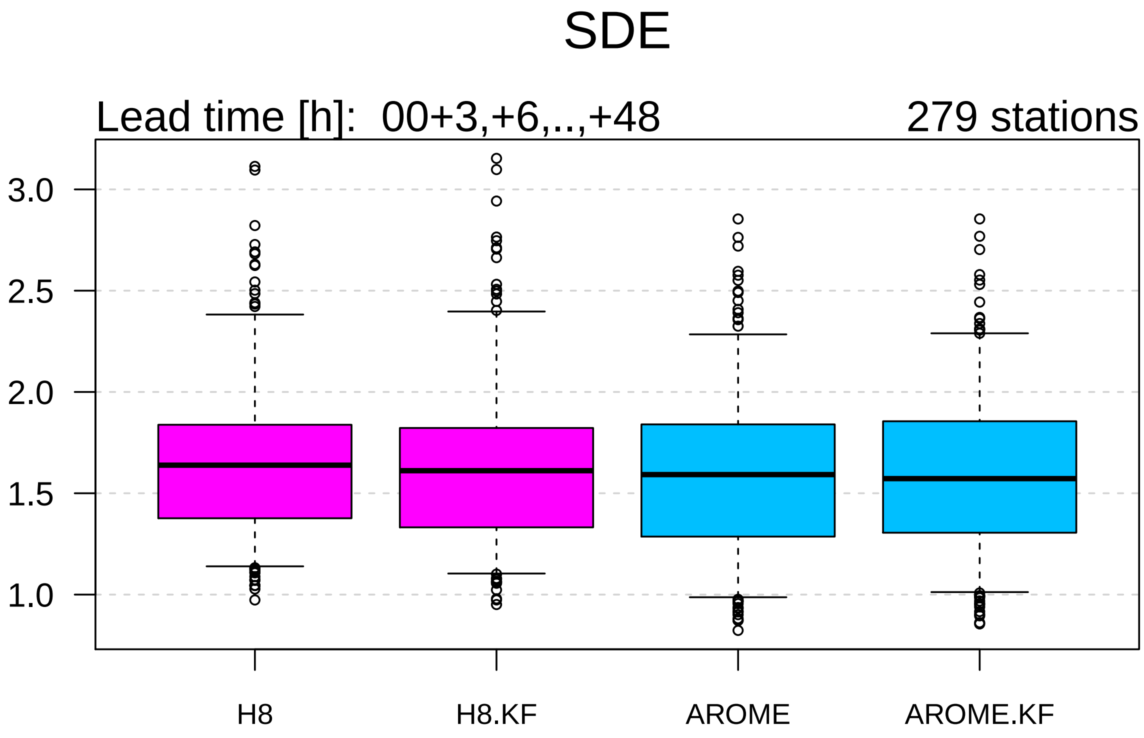
4.7 Post processed temperature 2m



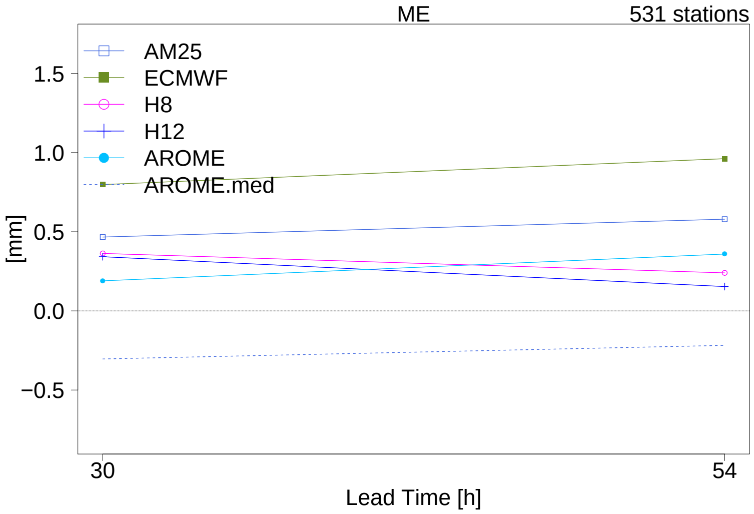


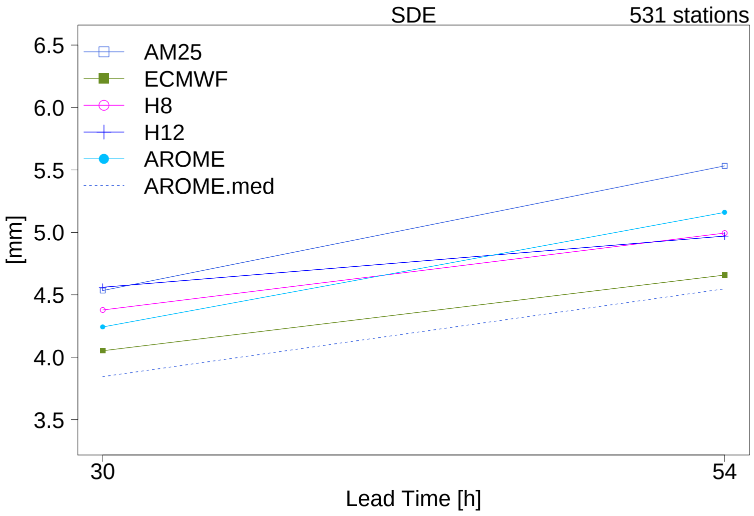


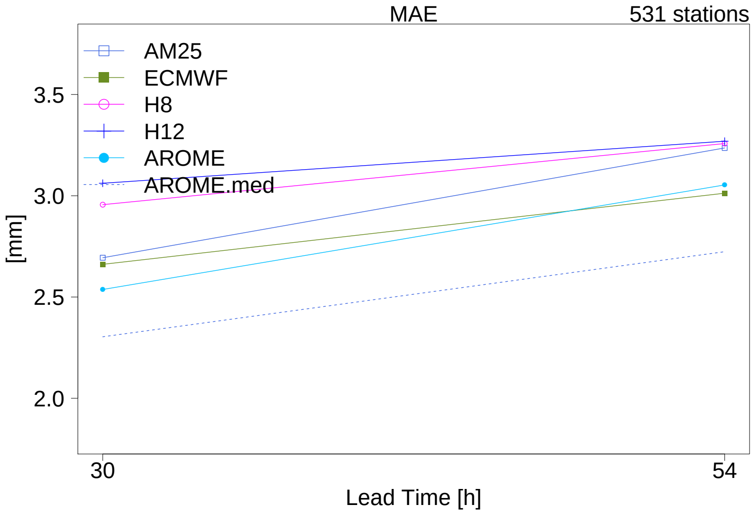

ME
Lead time [h]: 00+3,+6,..,+48
279 stations
2
1
0
−1
−2
H8
H8.KF
AROME
AROME.KF

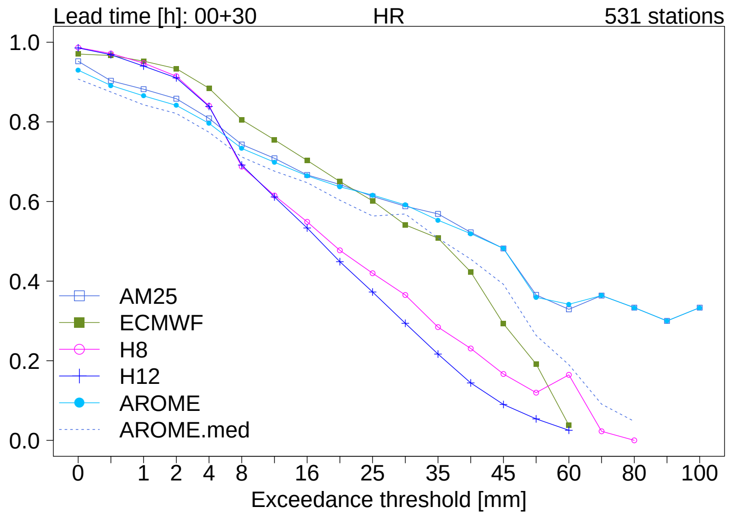

SDE
Lead time [h]: 00+3,+6,..,+48
279 stations
3.0
2.5
2.0
1.5
1.0
H8
H8.KF
AROME
AROME.KF

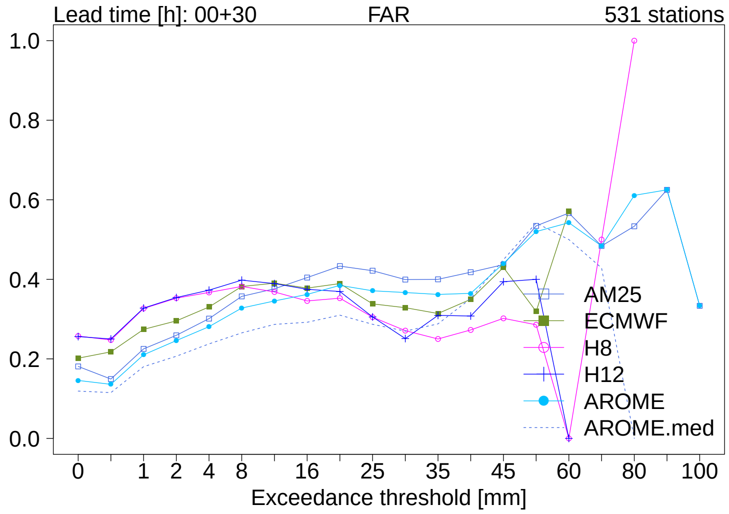
4.8 Daily precipitation

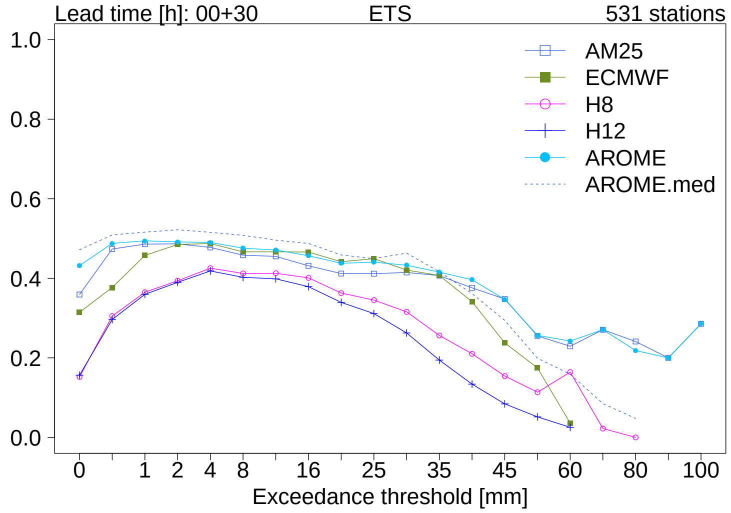


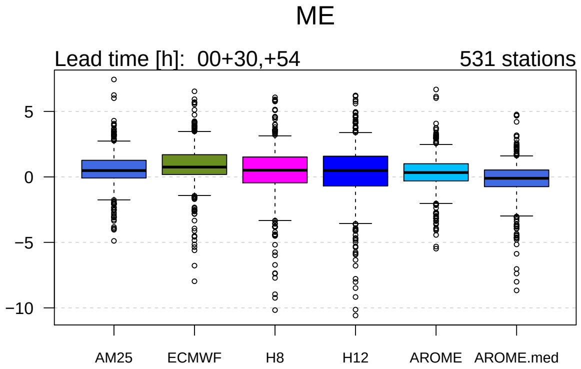


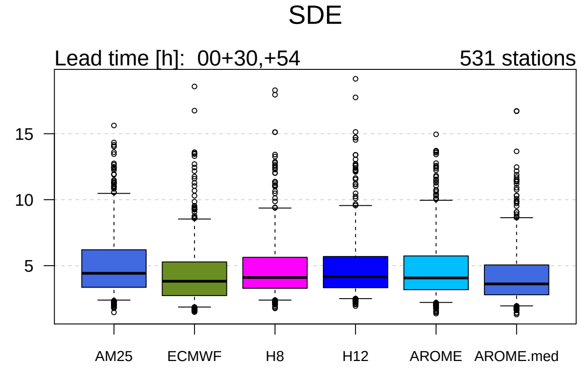



Lead time [h]: 00+30
HR
531 stations
1.0
0.8
0.6
0.4
0.2
0.0
AM25
ECMWF
H8
H12
AROME
AROME.med
0
1
2
4
8
16
25
35
45
60
80
100
Exceedance threshold [mm]


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





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

OBS

AM25

	[0,0.1]	(0.1,5]	(5,20]	(20,50]	(50,Inf]	Sum
[0,0.1]	16846	4066	177	8	0	21097
(0.1,5]	5716	15863	3223	78	2	24882
(5,20]	562	5063	7674	960	32	14291
(20,50]	40	284	1127	1227	200	2878
(50,Inf]	3	19	23	104	99	248
Sum	23167	25295	12224	2377	333	63396

OBS

H8

	[0,0.1]	(0.1,5]	(5,20]	(20,50]	(50,Inf]	Sum
[0,0.1]	10426	1366	61	5	0	11858
(0.1,5]	11903	17399	3177	80	0	32559
(5,20]	807	6406	8388	1397	58	17056
(20,50]	31	119	597	886	250	1883
(50,Inf]	0	5	1	9	25	40
Sum	23167	25295	12224	2377	333	63396

OBS

ECMWF

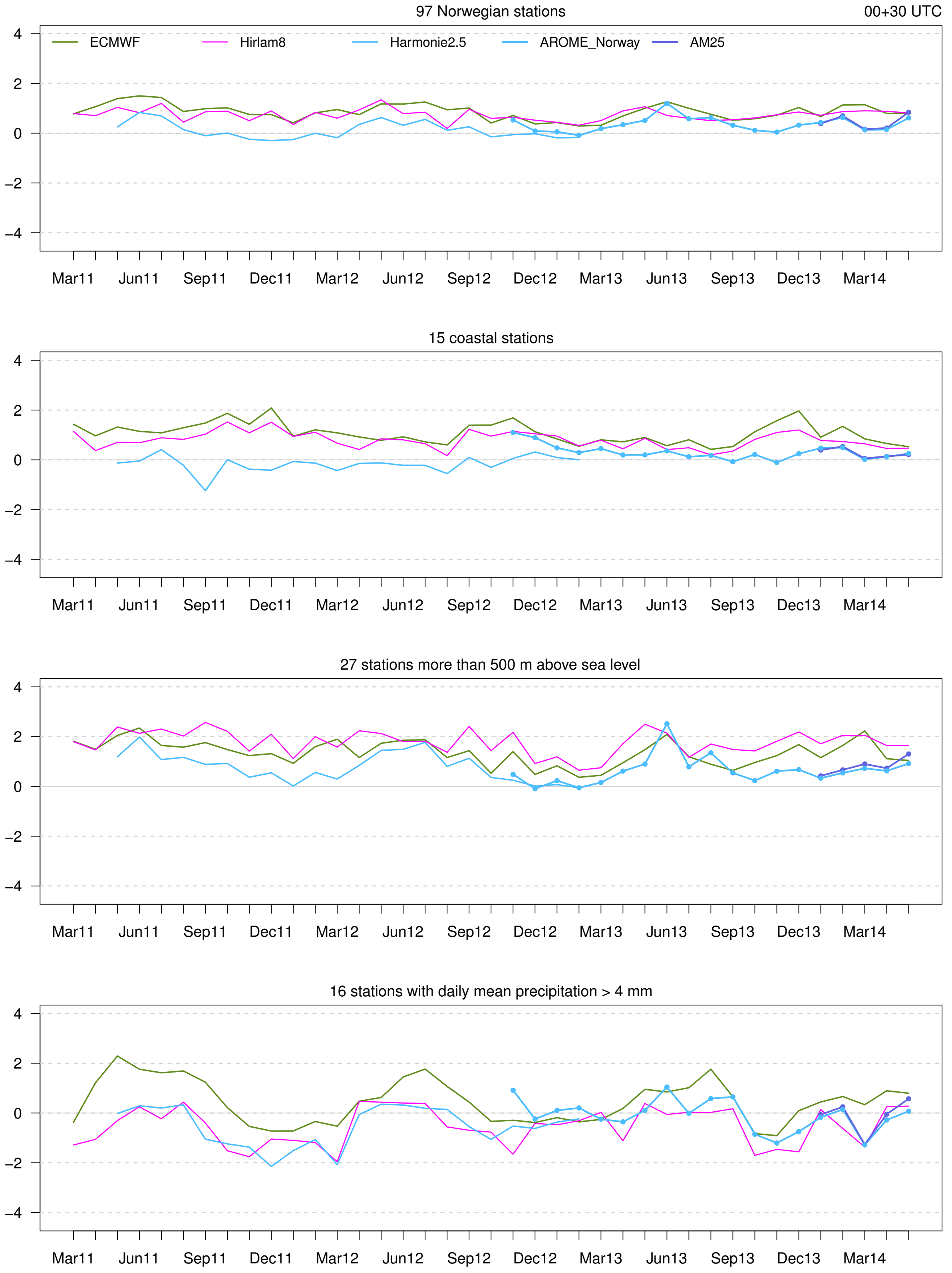
	[0,0.1]	(0.1,5]	(5,20]	(20,50]	(50,Inf]	Sum
[0,0.1]	12501	1525	37	3	0	14066
(0.1,5]	10118	16999	2114	25	0	29256
(5,20]	532	6596	8979	946	15	17068
(20,50]	16	174	1091	1369	259	2909
(50,Inf]	0	1	3	34	59	97
Sum	23167	25295	12224	2377	333	63396

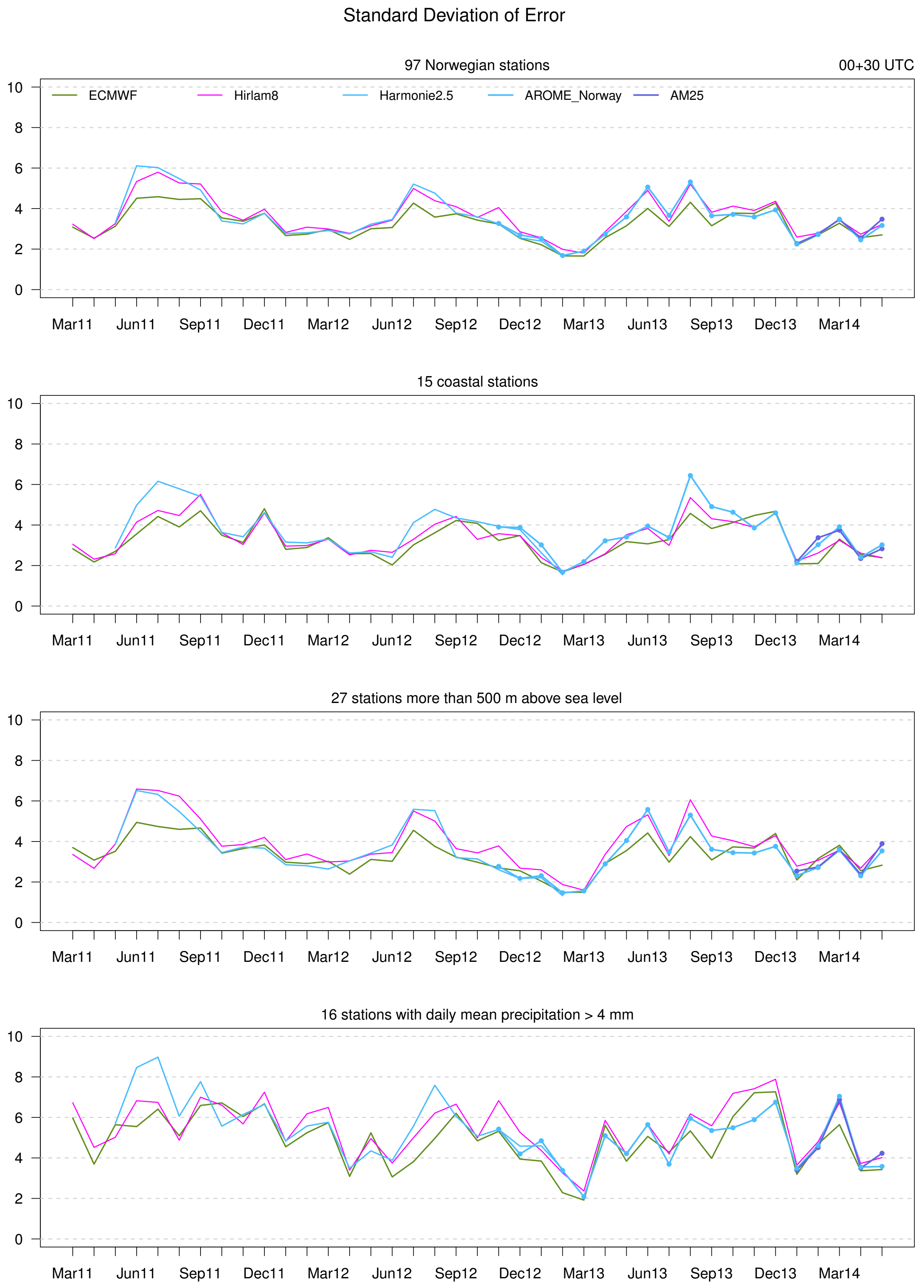
OBS

AROME

	[0,0.1]	(0.1,5]	(5,20]	(20,50]	(50,Inf]	Sum
[0,0.1]	17267	4415	188	7	0	21877
(0.1,5]	5417	16079	3295	81	2	24874
(5,20]	456	4595	7704	949	34	13738
(20,50]	23	198	1018	1237	198	2674
(50,Inf]	4	8	19	103	99	233
Sum	23167	25295	12224	2377	333	63396

Mean Error


97 Norwegian stations
00+30 UTC
ECMWF
Hirlam8
Harmonie2.5
AROME_Norway
AM25
15 coastal stations
27 stations more than 500 m above sea level
16 stations with daily mean precipitation > 4 mm
4
2
0
−2
−4
Mar11
Jun11
Sep11
Dec11
Mar12
Jun12
Sep12
Dec12
Mar13
Jun13
Sep13
Dec13
Mar14



Standard Deviation of Error

97 Norwegian stations

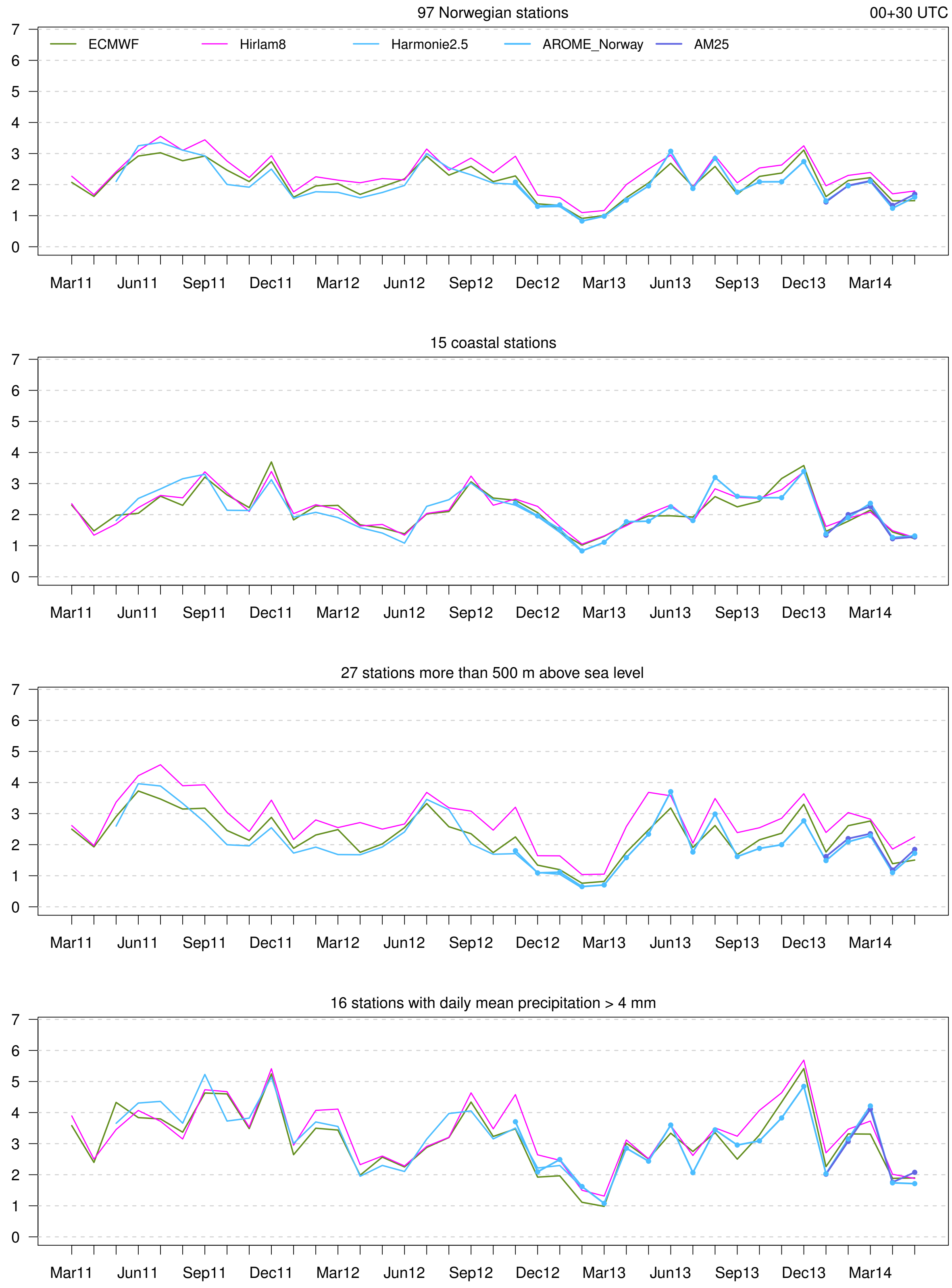
00+30 UTC

15 coastal stations

27 stations more than 500 m above sea level

16 stations with daily mean precipitation > 4 mm

Mean Absolute Error



5 Eastern Norway

5.1 Comments to the verification results

MSLP
MAE and SDE grow by a factor 2-3 with increasing prognosis length, but the errors are relatively small, 2-3 hPa. It is worth noticing that MAE and SDE for the AROME models seem to be smaller than for ECMWF the first 24hrs of the prognosis, while ECMWF is better towards the end.

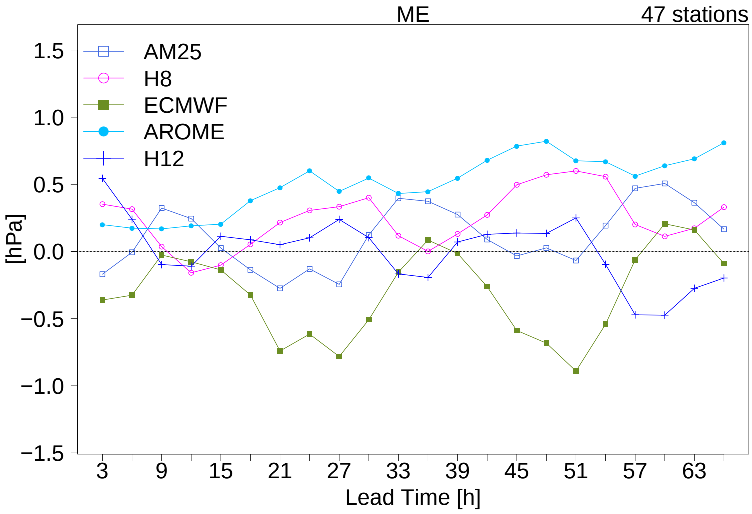
10 m wind (FF)
Arome-MetCoOp and Arome-Norway overestimate the mean wind over eastern Norway, but the values are relatively small $(1 - 3ms^{-1})$. The geographical distribution of errors is uneven, large errors in the mountain and relatively large along the coast, less in the inland stations. Hit Rate (HR) and False Alarm Ratio (FAR) are significantly higher for the AROME models than for Hirlam and ECMWF, especially for large values. The ETS, however, shows that the AROME models have better overall scores for all wind speeds, and significantly better than the coarser models for wind speeds higher than $10ms^{-1}$.

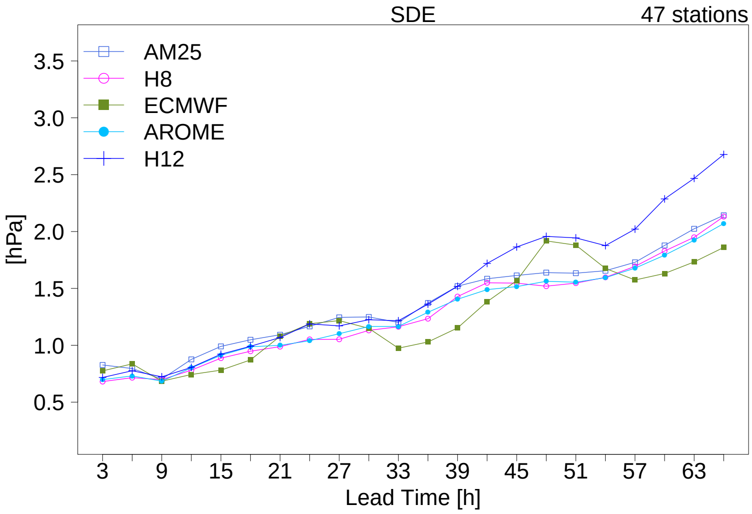
Hirlam and ECMWF are not able to predict the highest wind speeds $(17 - 21ms^{-1})$, while the AROME models forecast roughly half the observed occurrences.

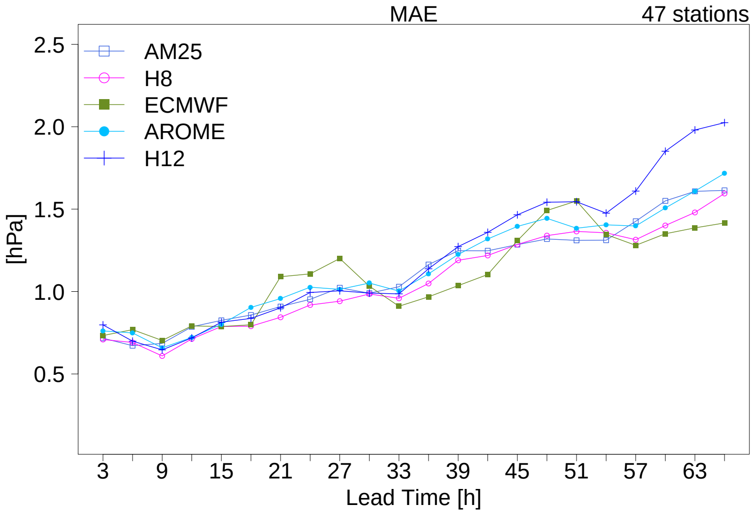
Post processing increases the quality of the forecasts for all wind speeds, more so towards the highest wind speeds.

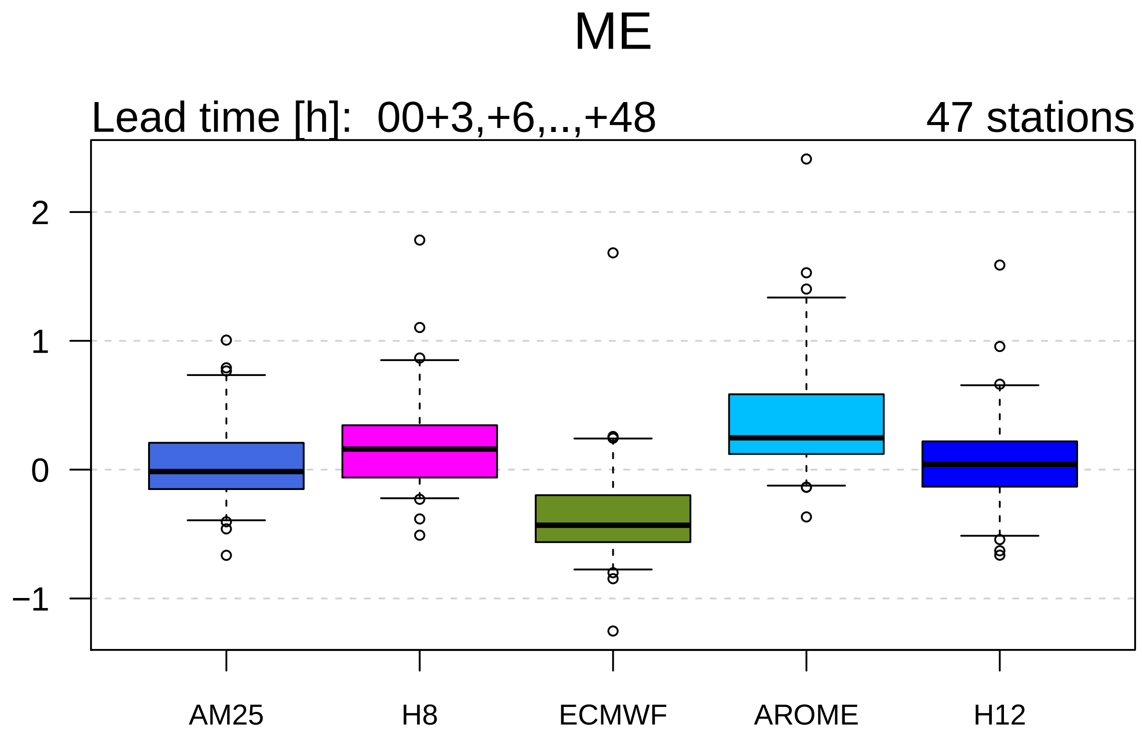
The predicted Wind Gusts from Arome and Hirlam seem to give less Mean Errors and SDE than wind from 925hPa. The AROME models score slightly better than Hirlam.

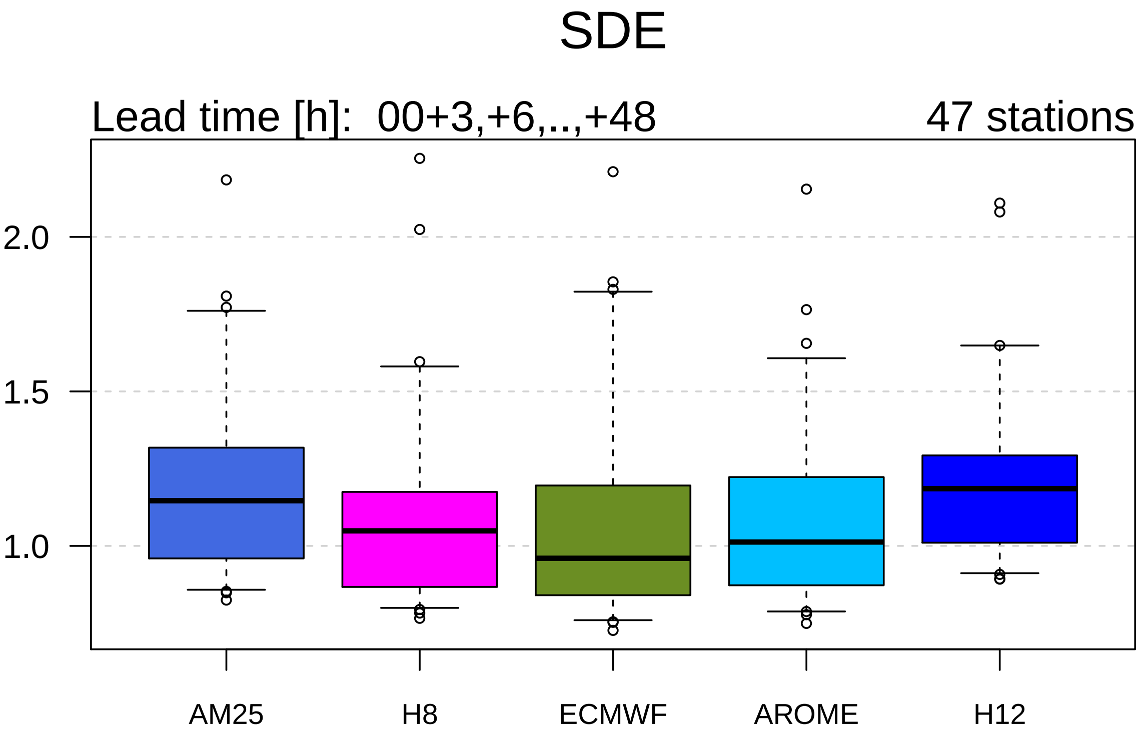
5.2 Pressure


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

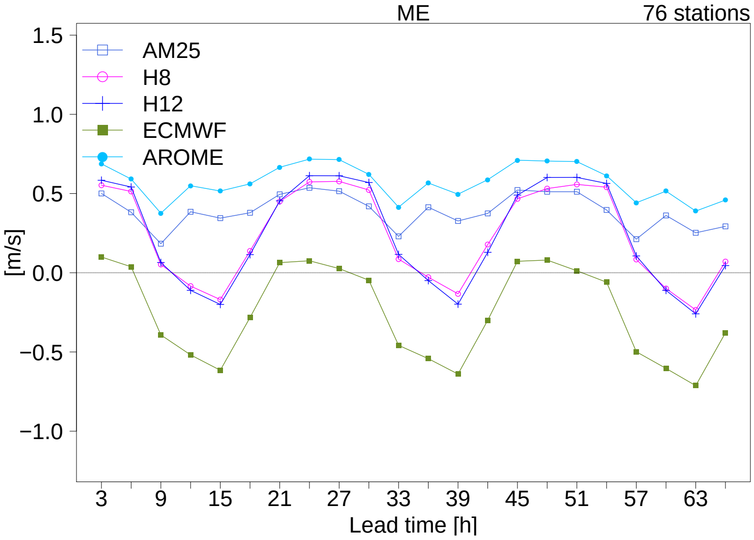

SDE
47 stations
AM25
H8
ECMWF
AROME
H12
[hPa]
3.5
3.0
2.5
2.0
1.5
1.0
0.5
3
9
15
21
27
33
39
45
51
57
63
Lead Time [h]

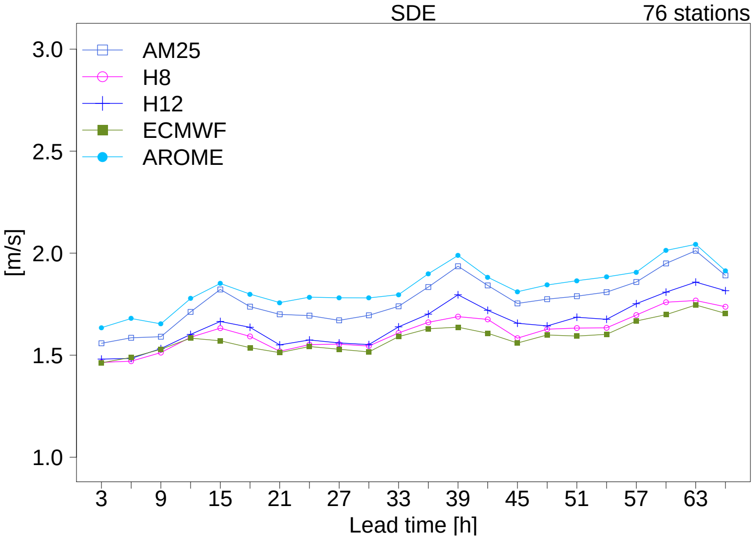

MAE
47 stations
AM25
H8
ECMWF
AROME
H12
[hPa]
2.5
2.0
1.5
1.0
0.5
3
9
15
21
27
33
39
45
51
57
63
Lead Time [h]

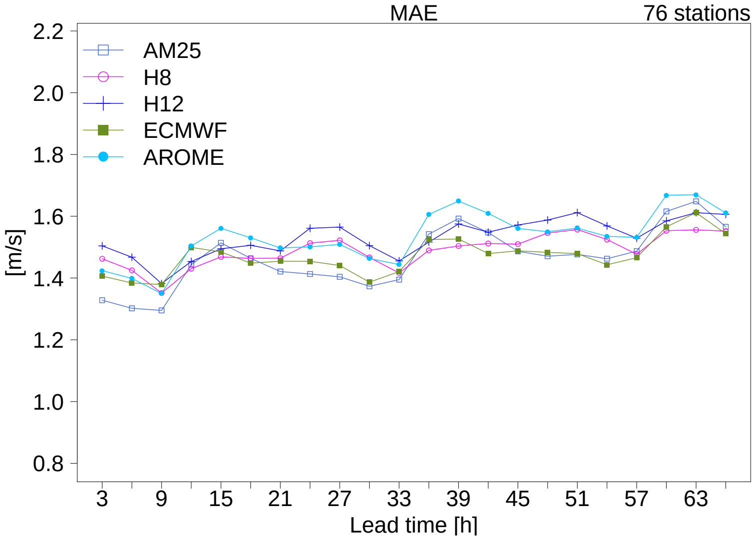

ME
Lead time [h]: 00+3,+6,..,+48
47 stations
2
1
0
−1
AM25
H8
ECMWF
AROME
H12

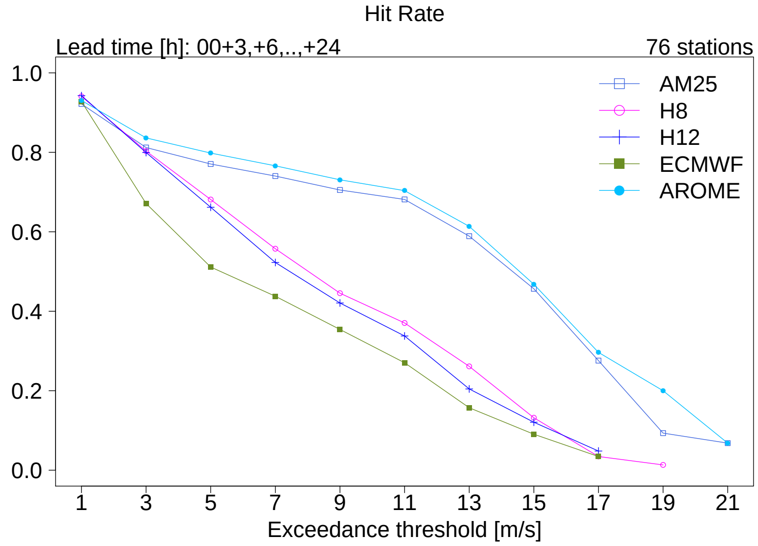

SDE
Lead time [h]: 00+3,+6,..,+48
47 stations
2.0
1.5
1.0
AM25
H8
ECMWF
AROME
H12

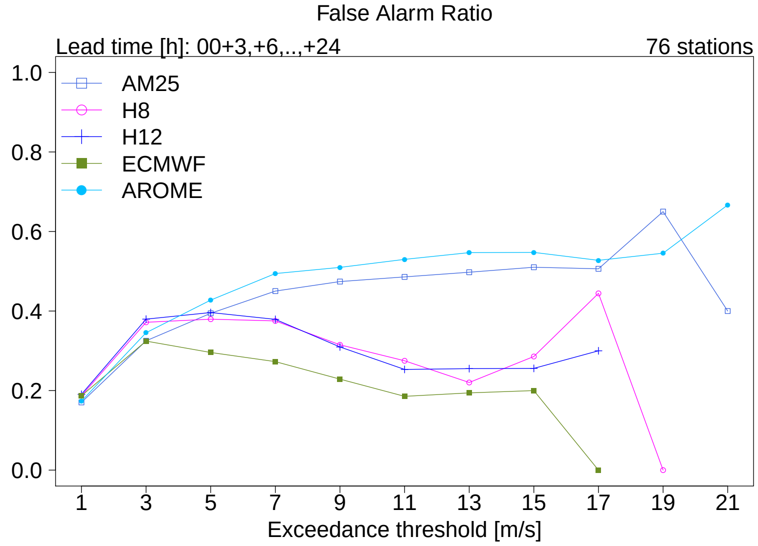
5.3 Wind Speed 10m

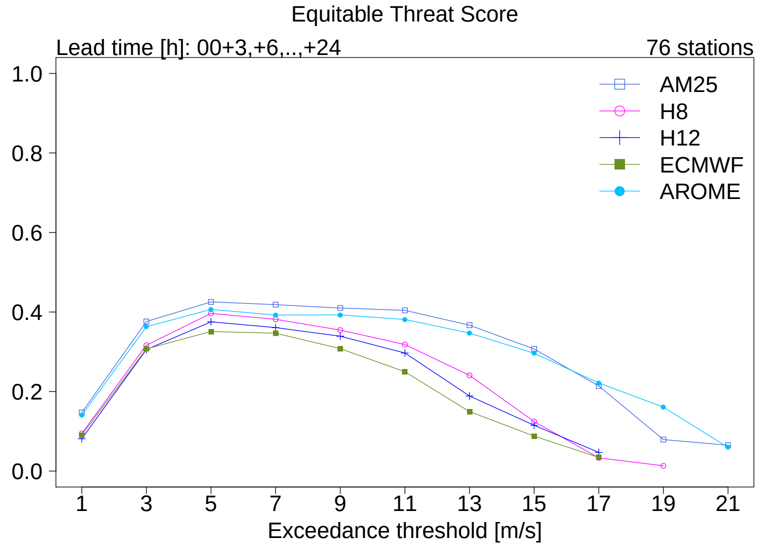


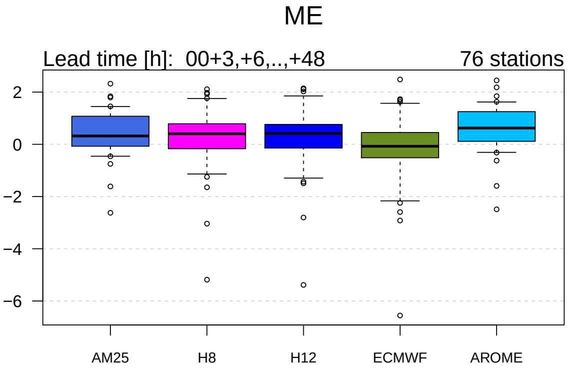


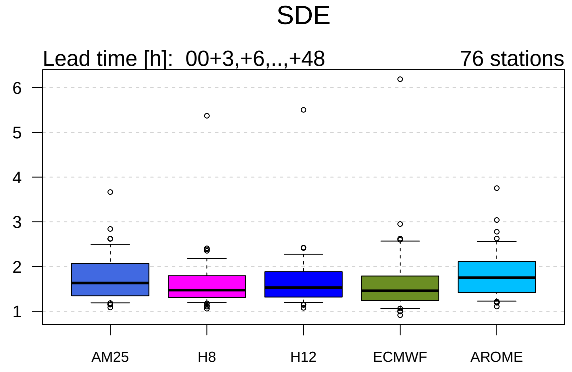



Hit Rate
Lead time [h]: 00+3,+6,..,+24
76 stations
AM25
H8
H12
ECMWF
AROME
1.0
0.8
0.6
0.4
0.2
0.0
1
3
5
7
9
11
13
15
17
19
21
Exceedance threshold [m/s]


False Alarm Ratio
Lead time [h]: 00+3,+6,..,+24
76 stations
AM25
H8
H12
ECMWF
AROME
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
H8
H12
ECMWF
AROME
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

OBS

AM25

	[0,3]	(3,11]	(11,17]	(17,21]	(21,Inf]	Sum
[0,3]	44472	7222	8	0	0	51702
(3,11]	14745	26453	651	31	9	41889
(11,17]	94	1215	1097	129	48	2583
(17,21]	1	27	31	39	27	125
(21,Inf]	0	1	0	2	4	7
Sum	59312	34918	1787	201	88	96306

OBS

H8

	[0,3]	(3,11]	(11,17]	(17,21]	(21,Inf]	Sum
[0,3]	41274	7326	45	3	0	48648
(3,11]	18037	27275	1093	115	74	46594
(11,17]	1	315	643	77	12	1048
(17,21]	0	2	6	6	2	16
(21,Inf]	0	0	0	0	0	0
Sum	59312	34918	1787	201	88	96306

OBS

ECMWF

	[0,3]	(3,11]	(11,17]	(17,21]	(21,Inf]	Sum
[0,3]	47383	12060	272	81	54	59850
(3,11]	11928	22712	1038	57	28	35763
(11,17]	1	146	477	59	4	687
(17,21]	0	0	0	4	2	6
(21,Inf]	0	0	0	0	0	0
Sum	59312	34918	1787	201	88	96306

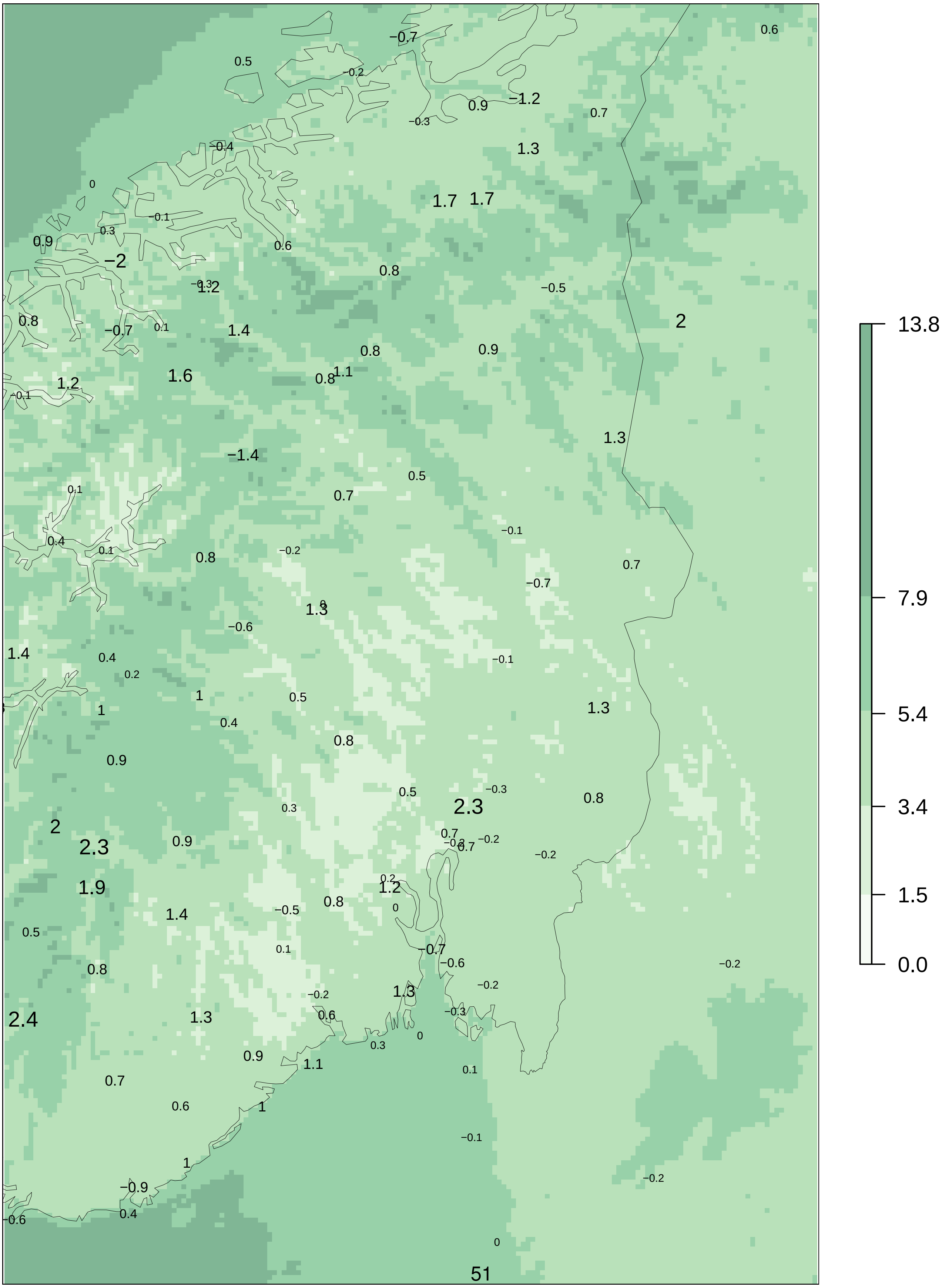
OBS

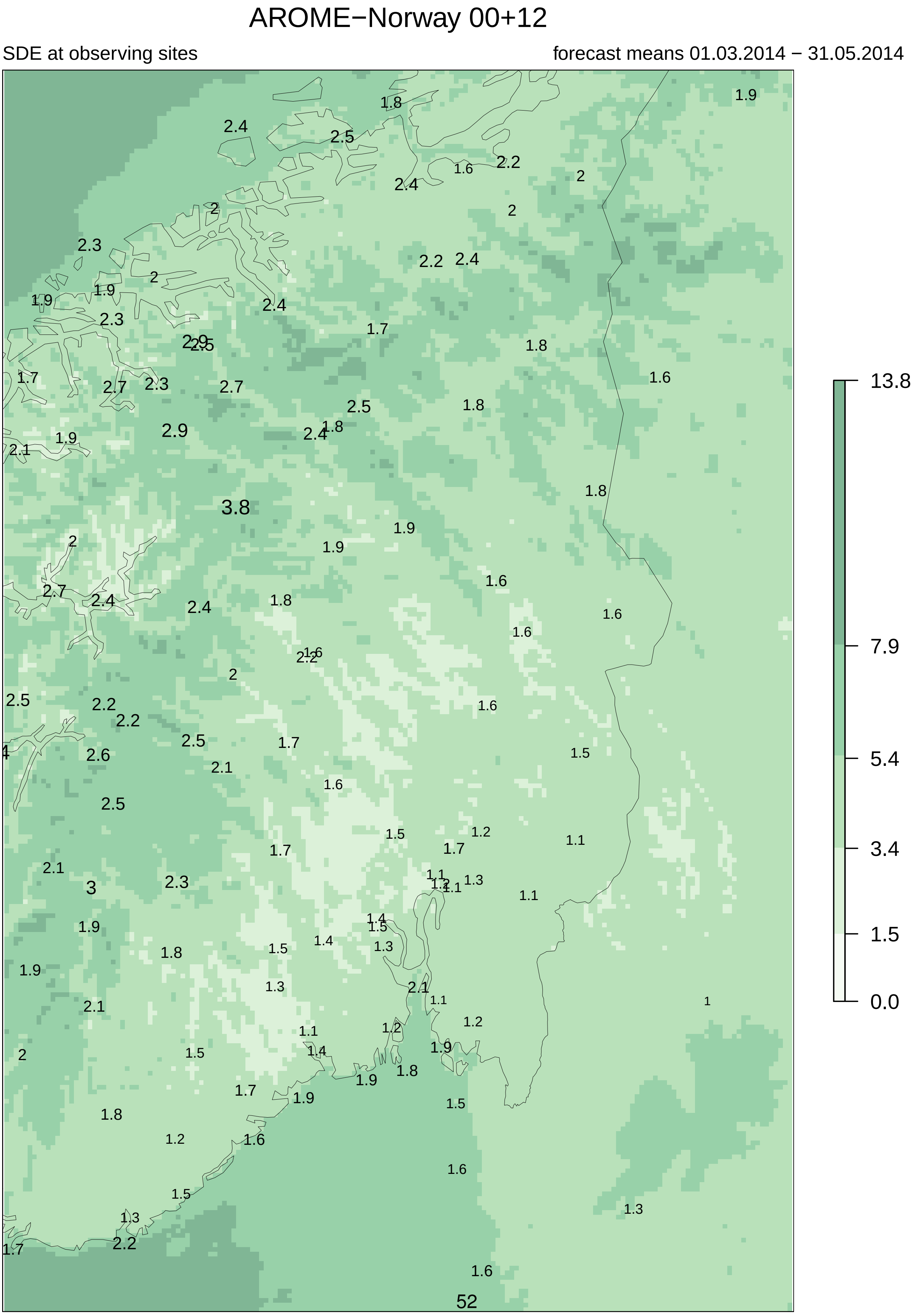
AROME

	[0,3]	(3,11]	(11,17]	(17,21]	(21,Inf]	Sum
[0,3]	42549	6236	6	0	0	48791
(3,11]	16621	27177	616	31	9	44454
(11,17]	139	1465	1124	125	48	2901
(17,21]	3	37	38	40	28	146
(21,Inf]	0	3	3	5	3	14
Sum	59312	34918	1787	201	88	96306

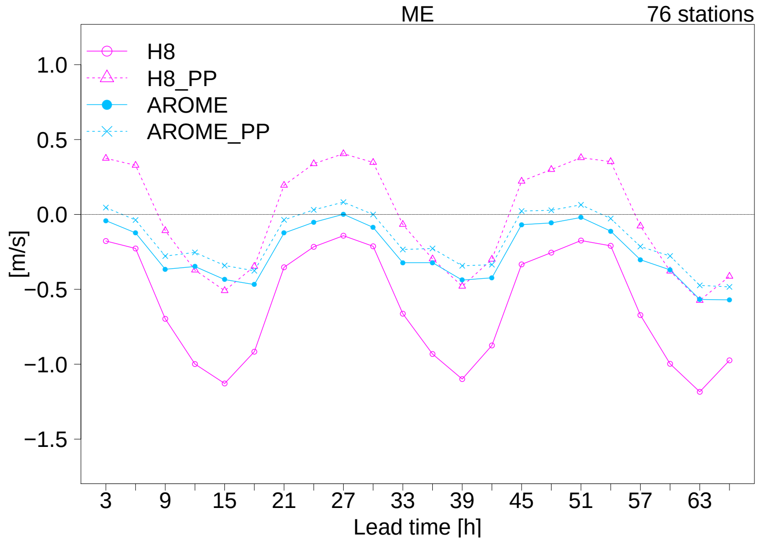
AROME−Norway 00+12

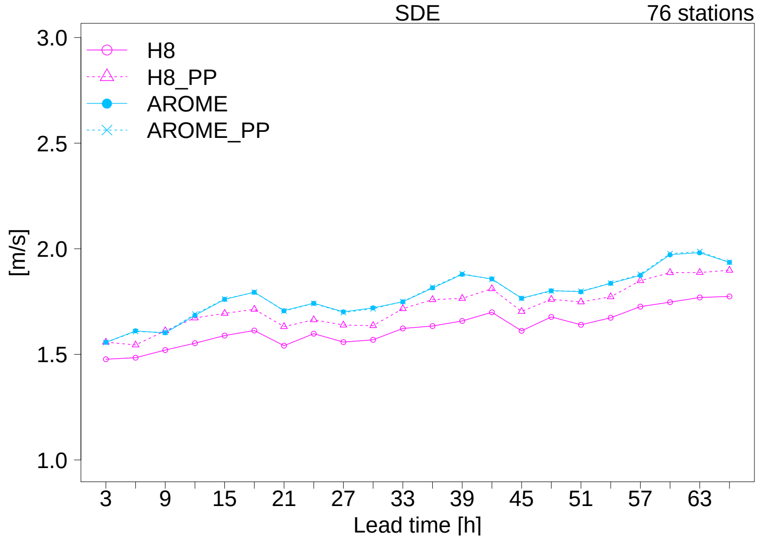
ME at observing sites forecast means 01.03.2014 − 31.05.2014

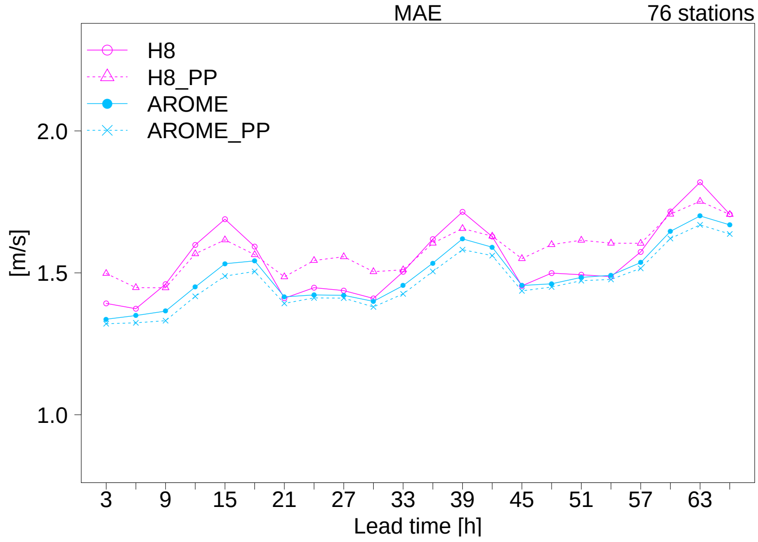


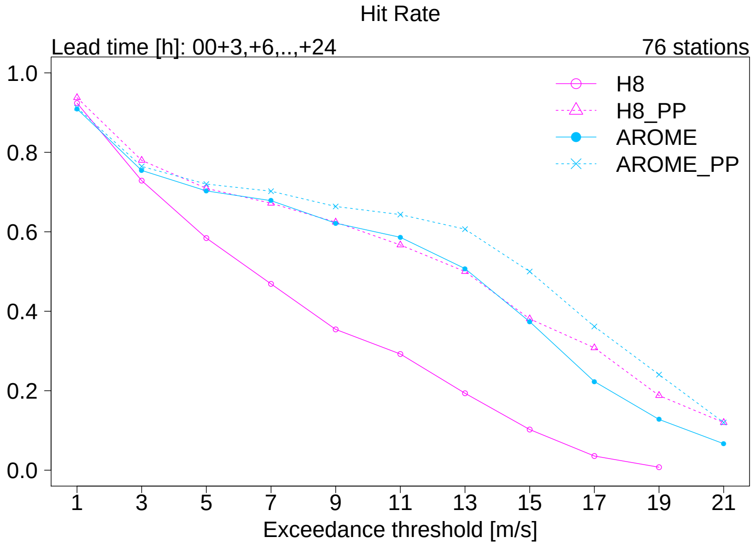

AROME−Norway 00+12
SDE at observing sites
forecast means 01.03.2014 − 31.05.2014
13.8
7.9
5.4
3.4
1.5
0.0
52

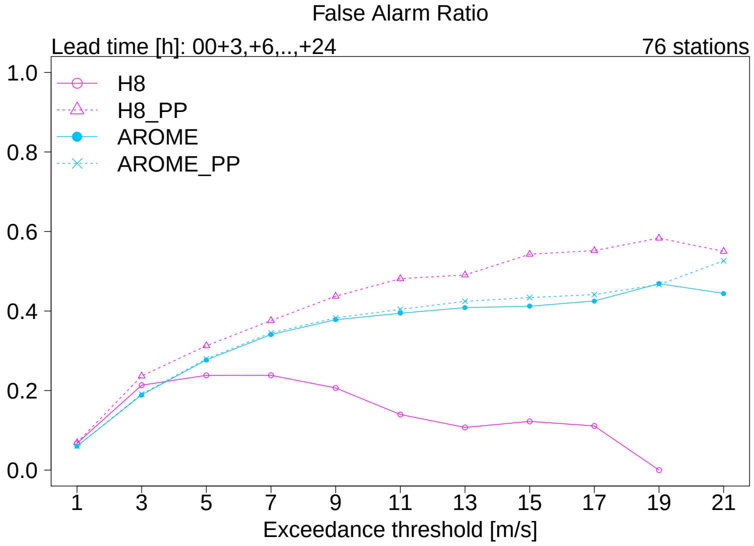
5.4 Max Mean Wind Speed 10m

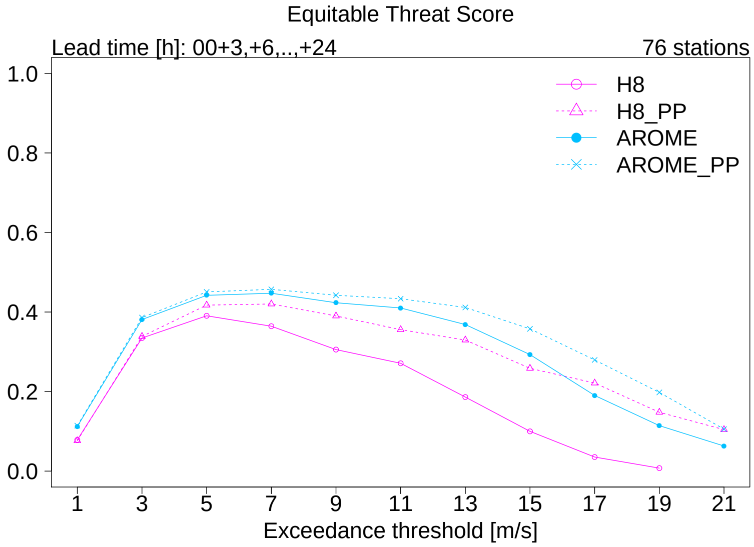


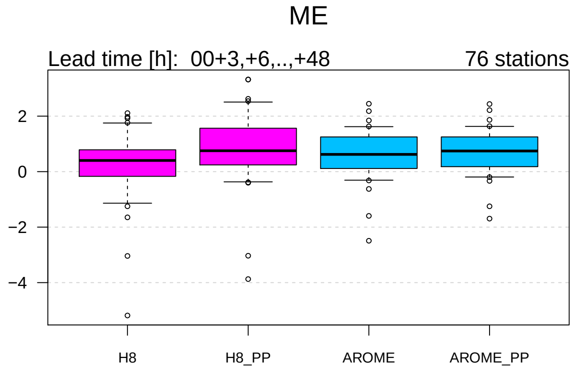


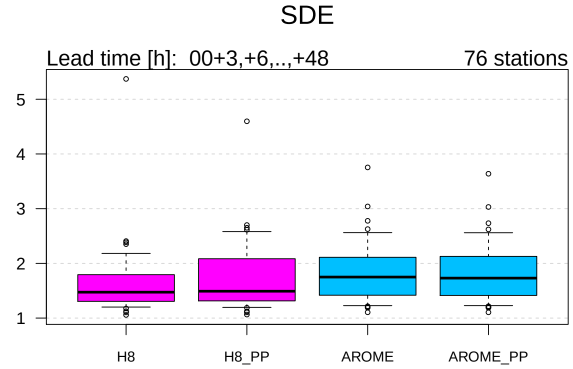



Hit Rate
Lead time [h]: 00+3,+6,..,+24
76 stations
1.0
0.8
0.6
0.4
0.2
0.0
1
3
5
7
9
11
13
15
17
19
21
Exceedance threshold [m/s]
H8
H8_PP
AROME
AROME_PP


False Alarm Ratio
Lead time [h]: 00+3,+6,..,+24
76 stations
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]
H8
H8_PP
AROME
AROME_PP


Equitable Threat Score
Lead time [h]: 00+3,+6,..,+24
76 stations
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]
H8
H8_PP
AROME
AROME_PP





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

76 stations

OBS

H8

	[0,3]	(3,11]	(11,17]	(17,21]	(21,Inf]	Sum
[0,3]	32972	13051	67	10	0	46100
(3,11]	9954	32328	1861	157	124	44424
(11,17]	0	167	737	123	21	1048
(17,21]	0	0	3	8	5	16
(21,Inf]	0	0	0	0	0	0
Sum	42926	45546	2668	298	150	91588

OBS

H8_PP

	[0,3]	(3,11]	(11,17]	(17,21]	(21,Inf]	Sum
[0,3]	30863	10676	20	0	0	41559
(3,11]	12028	33244	1113	140	103	46628
(11,17]	35	1605	1396	50	23	3109
(17,21]	0	21	135	92	10	258
(21,Inf]	0	0	4	16	14	34
Sum	42926	45546	2668	298	150	91588

OBS

AROME

	[0,3]	(3,11]	(11,17]	(17,21]	(21,Inf]	Sum
[0,3]	34005	11955	14	0	0	45974
(3,11]	8875	32432	1238	66	13	42624
(11,17]	45	1126	1384	186	95	2836
(17,21]	1	30	30	44	35	140
(21,Inf]	0	3	2	2	7	14
Sum	42926	45546	2668	298	150	91588

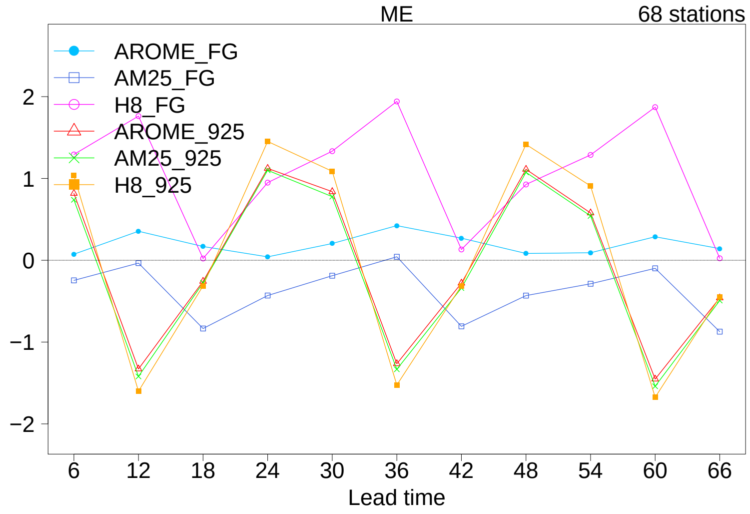
OBS

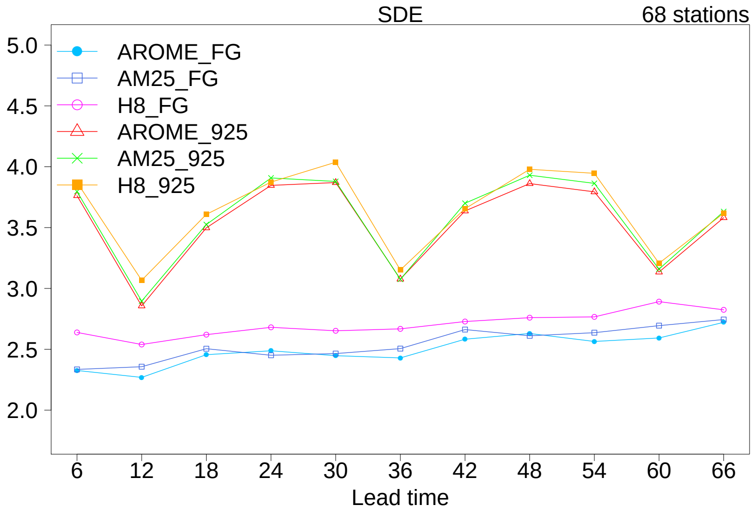
AROME_PP

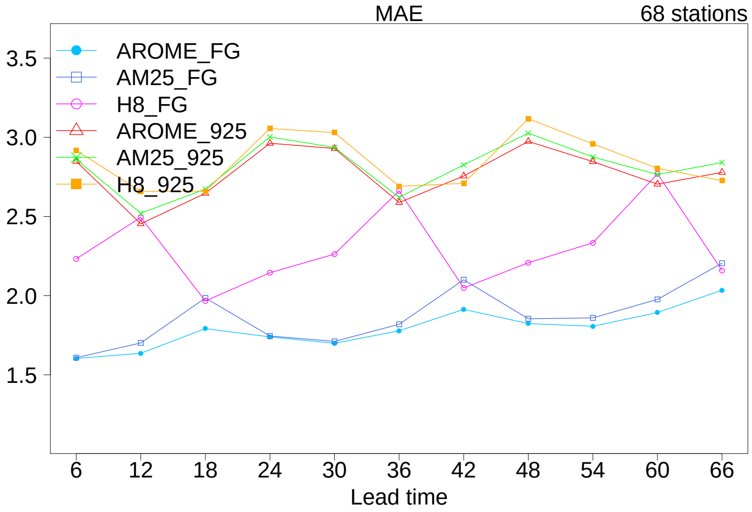
	[0,3]	(3,11]	(11,17]	(17,21]	(21,Inf]	Sum
[0,3]	33774	11462	11	0	0	45247
(3,11]	9106	32742	1092	51	10	43001
(11,17]	45	1307	1478	158	84	3072
(17,21]	1	32	84	78	40	235
(21,Inf]	0	3	3	11	16	33
Sum	42926	45546	2668	298	150	91588

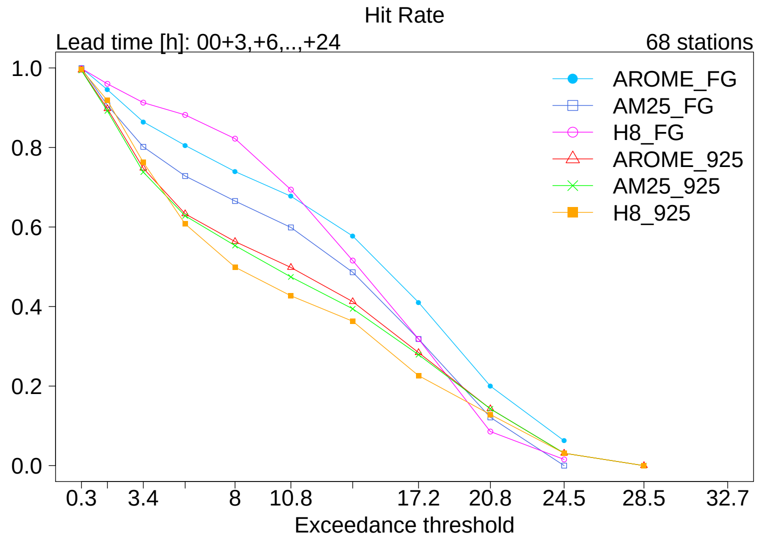
5.5 Wind gust

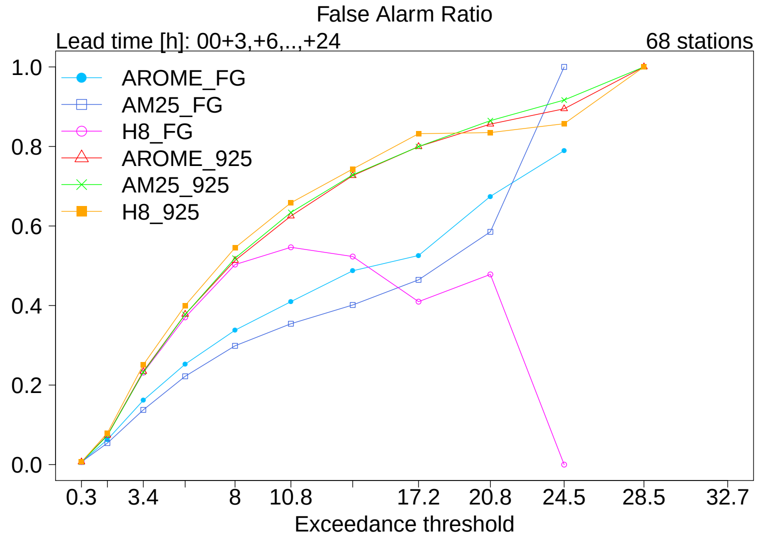
5.5.1 25 March - 31 May

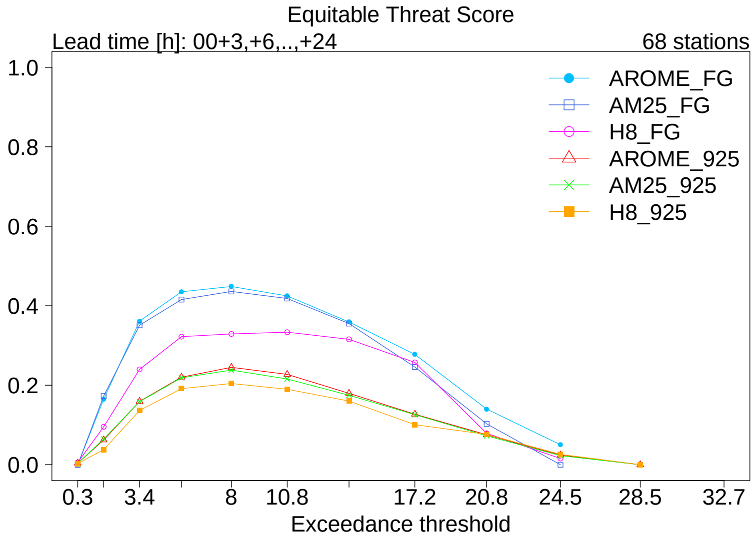




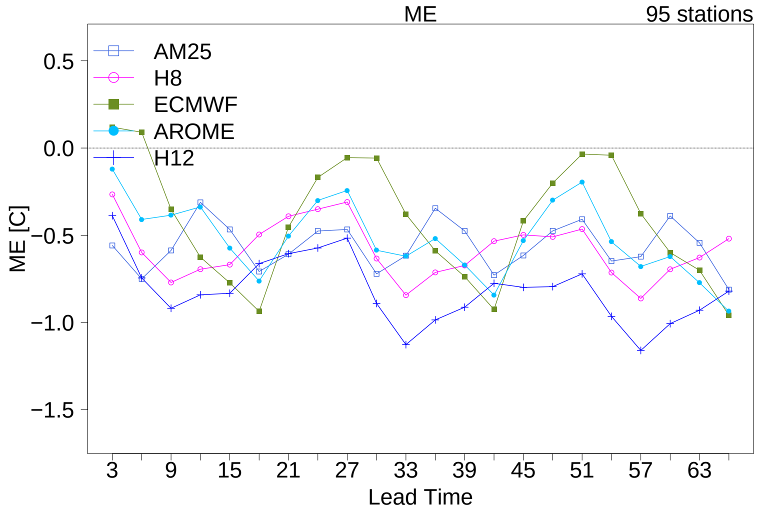


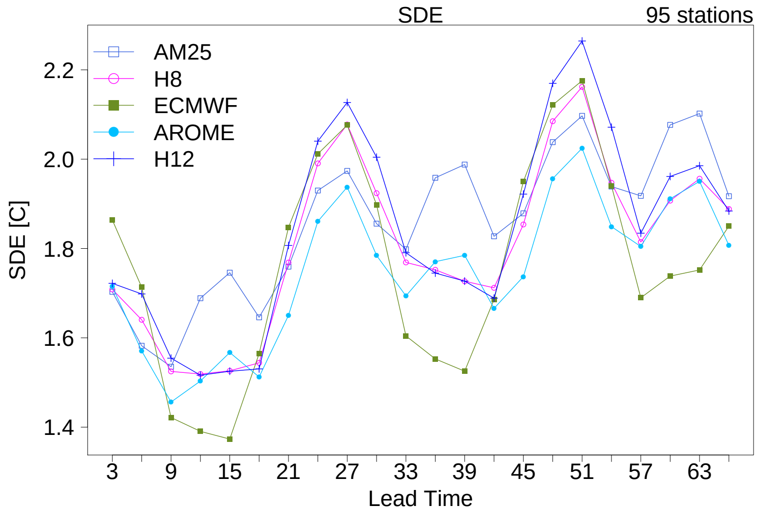

Hit Rate
Lead time [h]: 00+3,+6,..,+24
68 stations
1.0
0.8
0.6
0.4
0.2
0.0
0.3
3.4
8
10.8
17.2
20.8
24.5
28.5
32.7
Exceedance threshold
AROME_FG
AM25_FG
H8_FG
AROME_925
AM25_925
H8_925

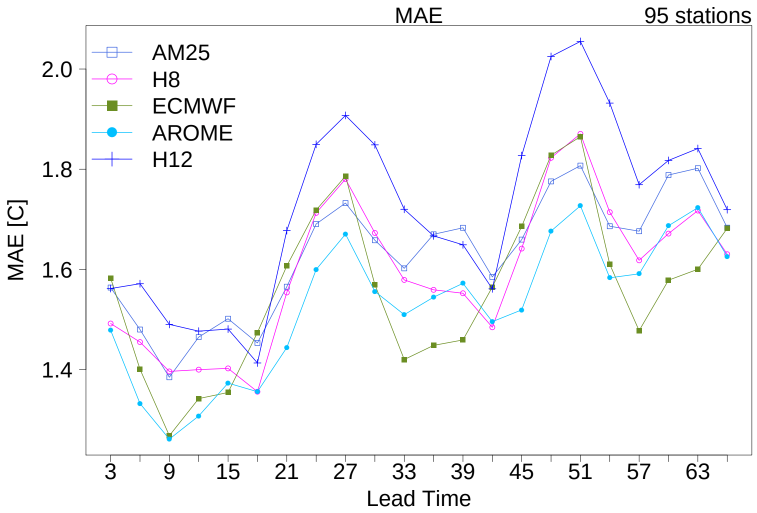

False Alarm Ratio
Lead time [h]: 00+3,+6,..,+24
68 stations
1.0
0.8
0.6
0.4
0.2
0.0
0.3
3.4
8
10.8
17.2
20.8
24.5
28.5
32.7
Exceedance threshold
AROME_FG
AM25_FG
H8_FG
AROME_925
AM25_925
H8_925

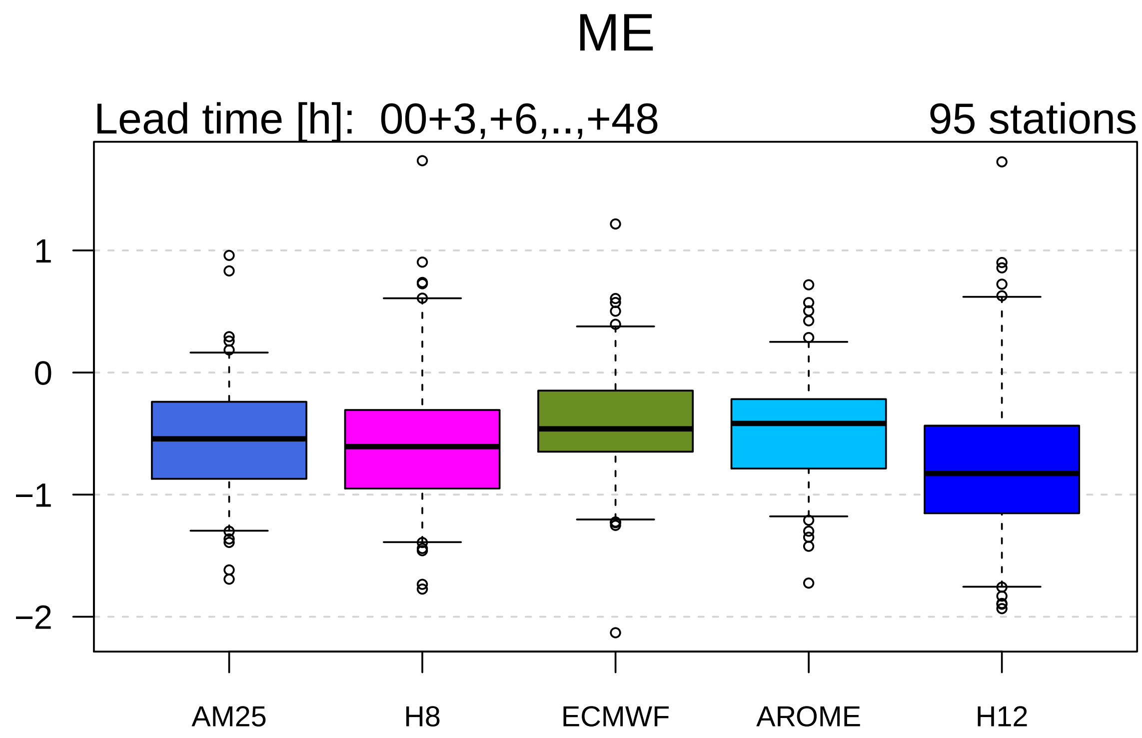

Equitable Threat Score
Lead time [h]: 00+3,+6,..,+24
68 stations
1.0
0.8
0.6
0.4
0.2
0.0
0.3
3.4
8
10.8
17.2
20.8
24.5
28.5
32.7
Exceedance threshold
AROME_FG
AM25_FG
H8_FG
AROME_925
AM25_925
H8_925

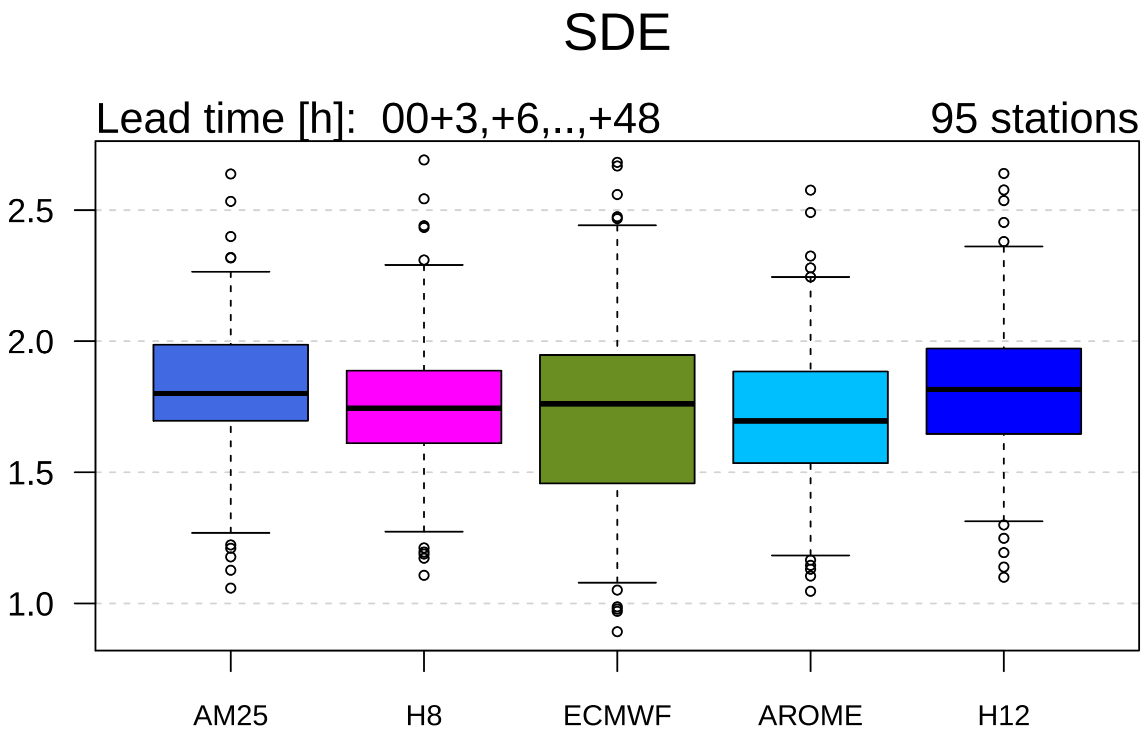
5.6 Temperature 2m







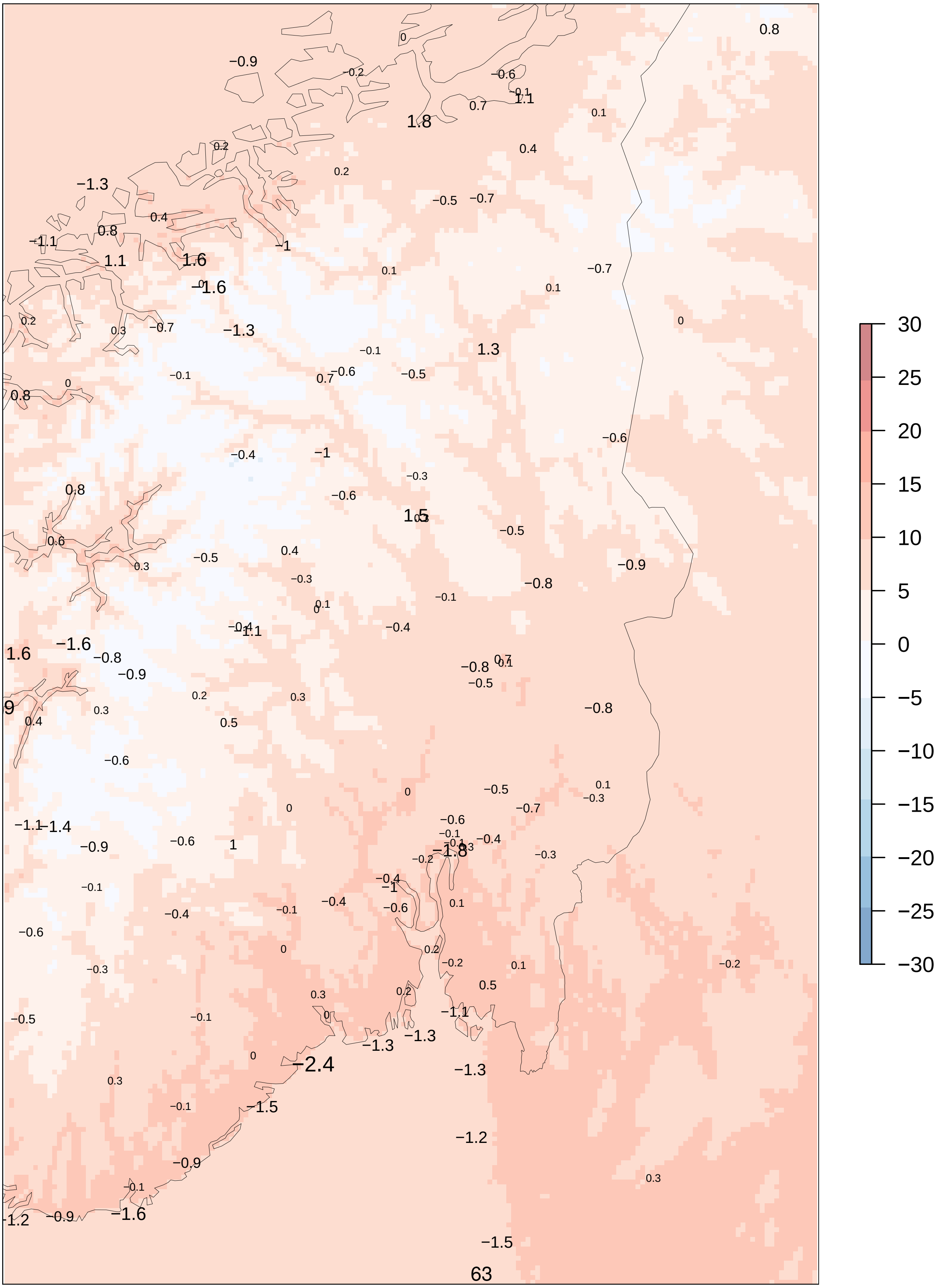

ME
Lead time [h]: 00+3,+6,..,+48
95 stations
1
0
−1
−2
AM25
H8
ECMWF
AROME
H12


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

AROME−Norway 00+12

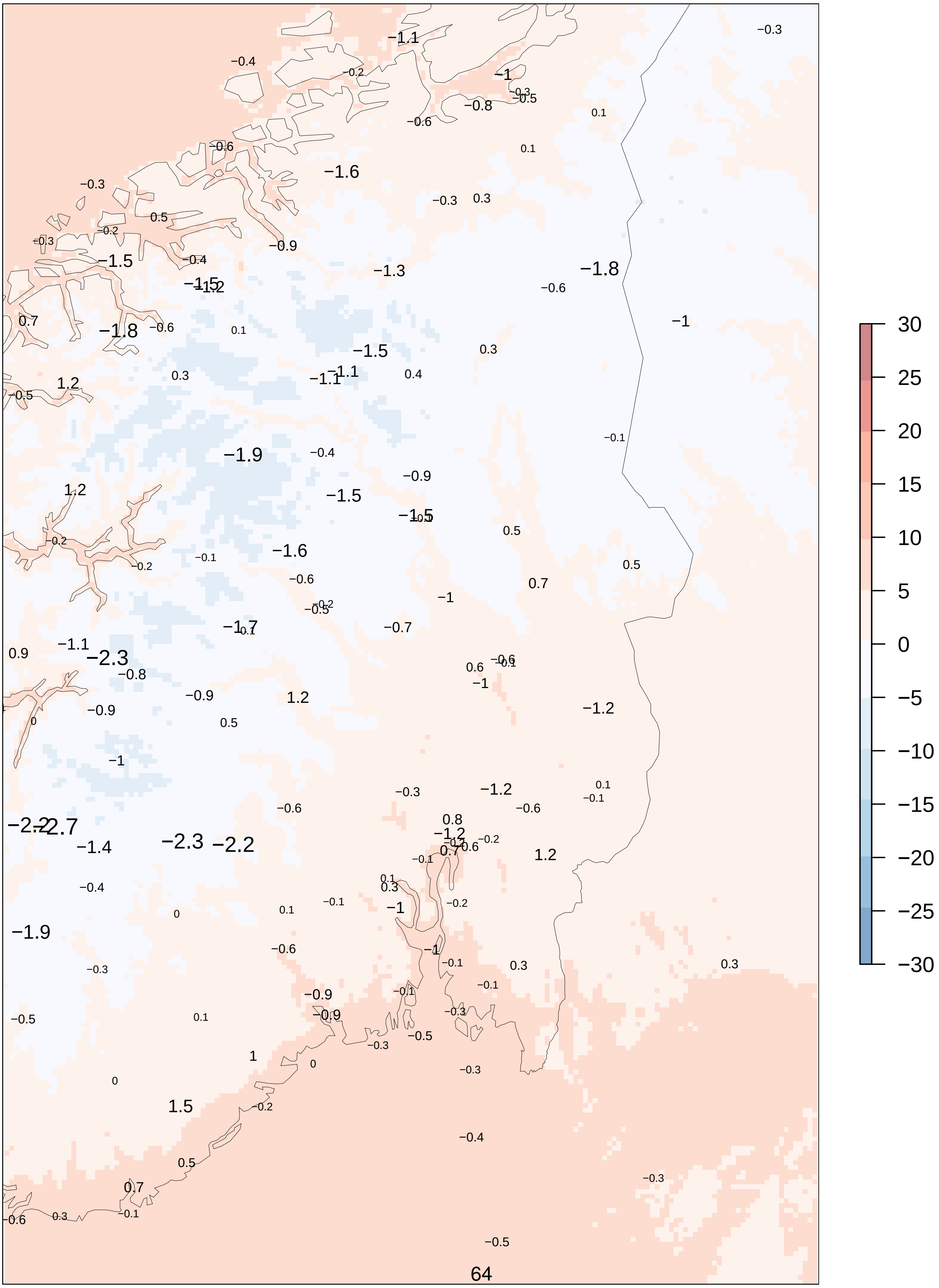
ME at observing sites

forecast means 01.03.2014 − 31.05.2014



AROME−Norway 00+24

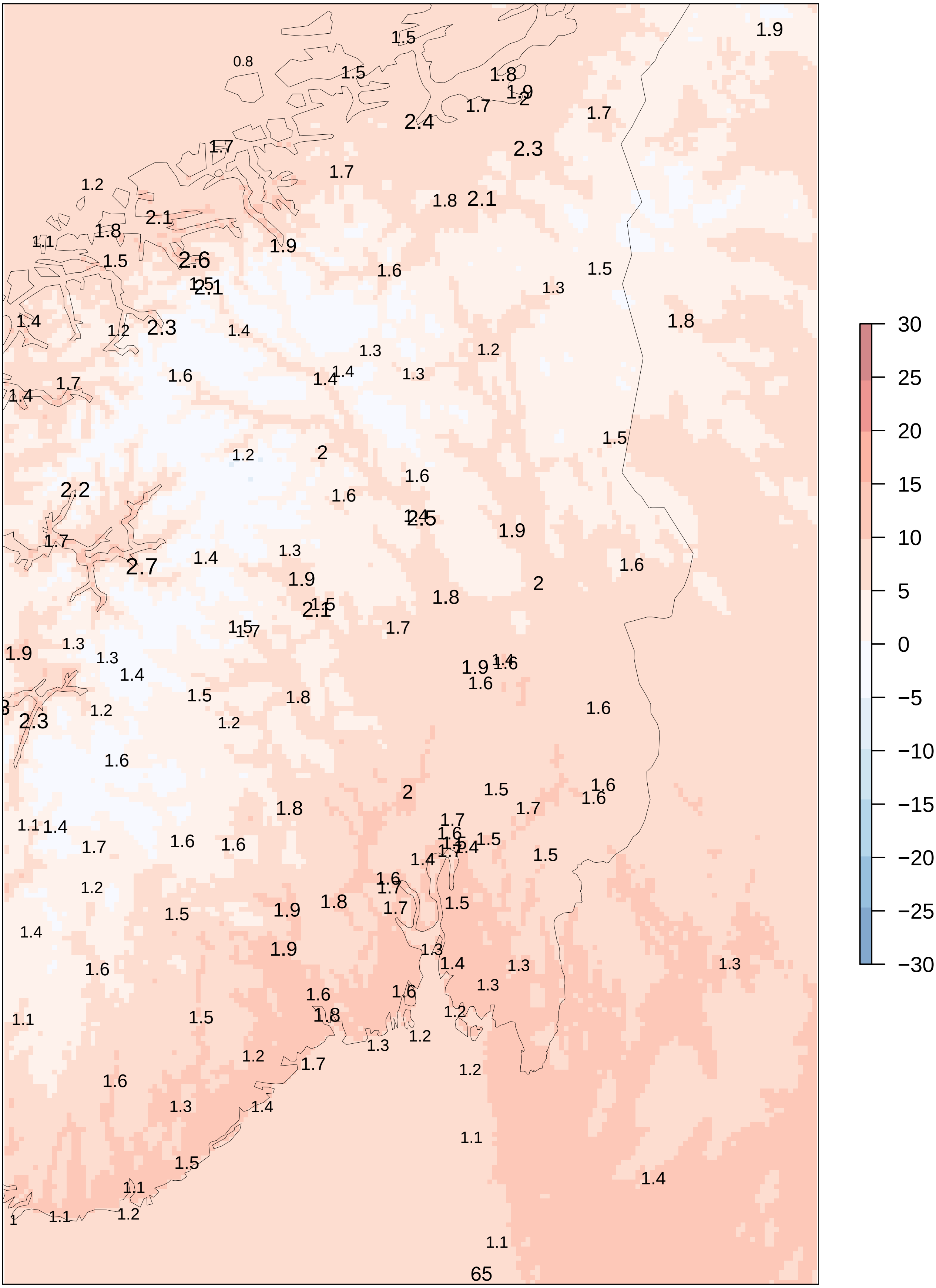
ME at observing sites forecast means 01.03.2014 − 31.05.2014

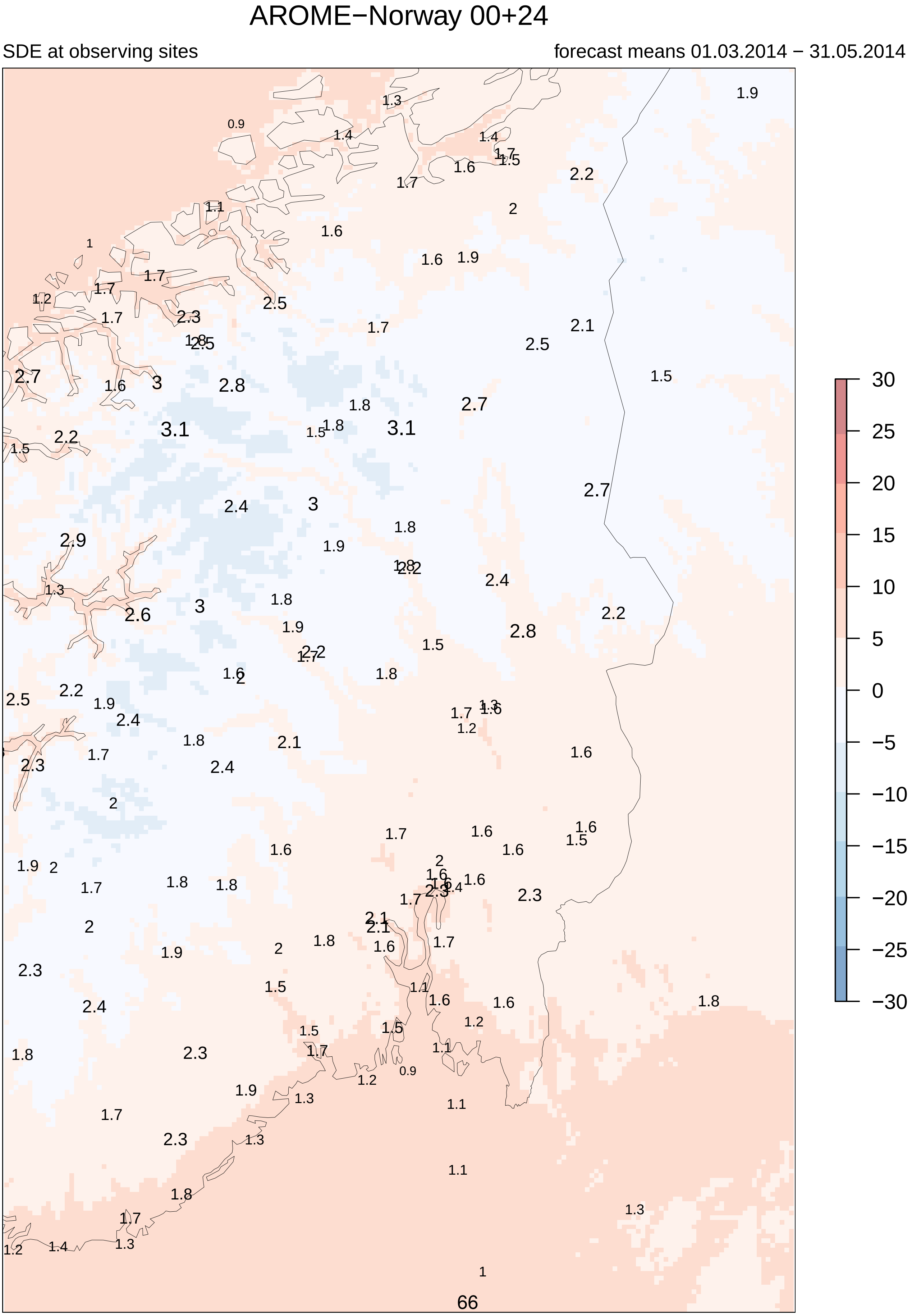


AROME−Norway 00+12

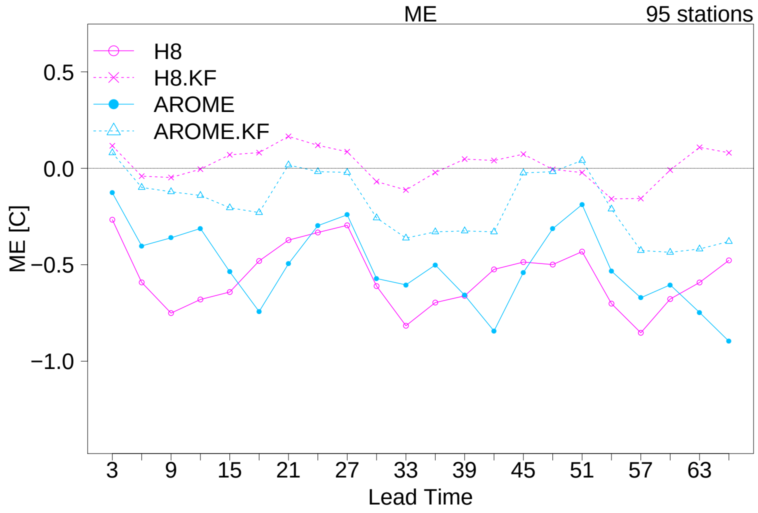
SDE at observing sites

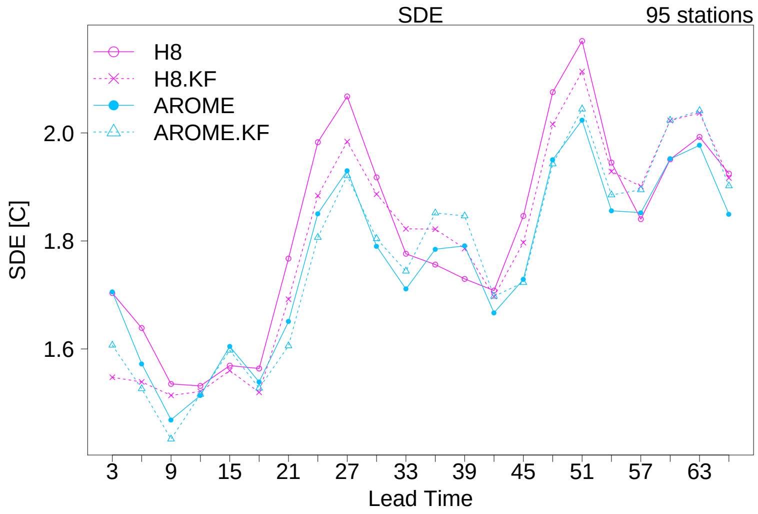
forecast means 01.03.2014 − 31.05.2014

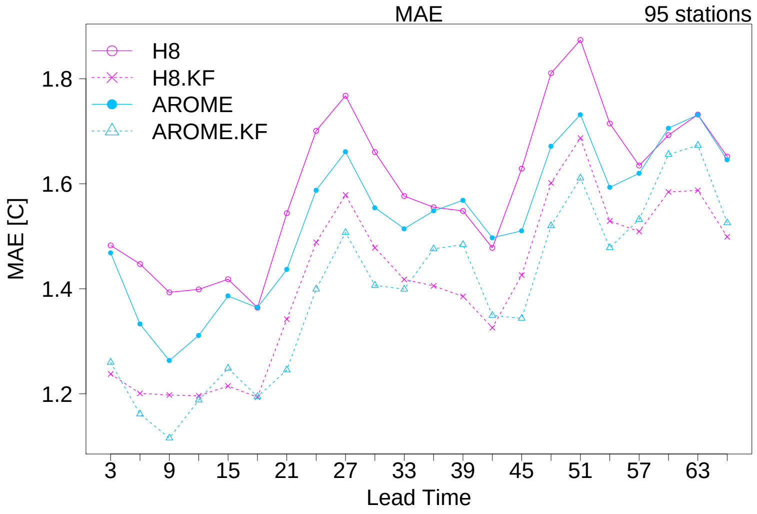


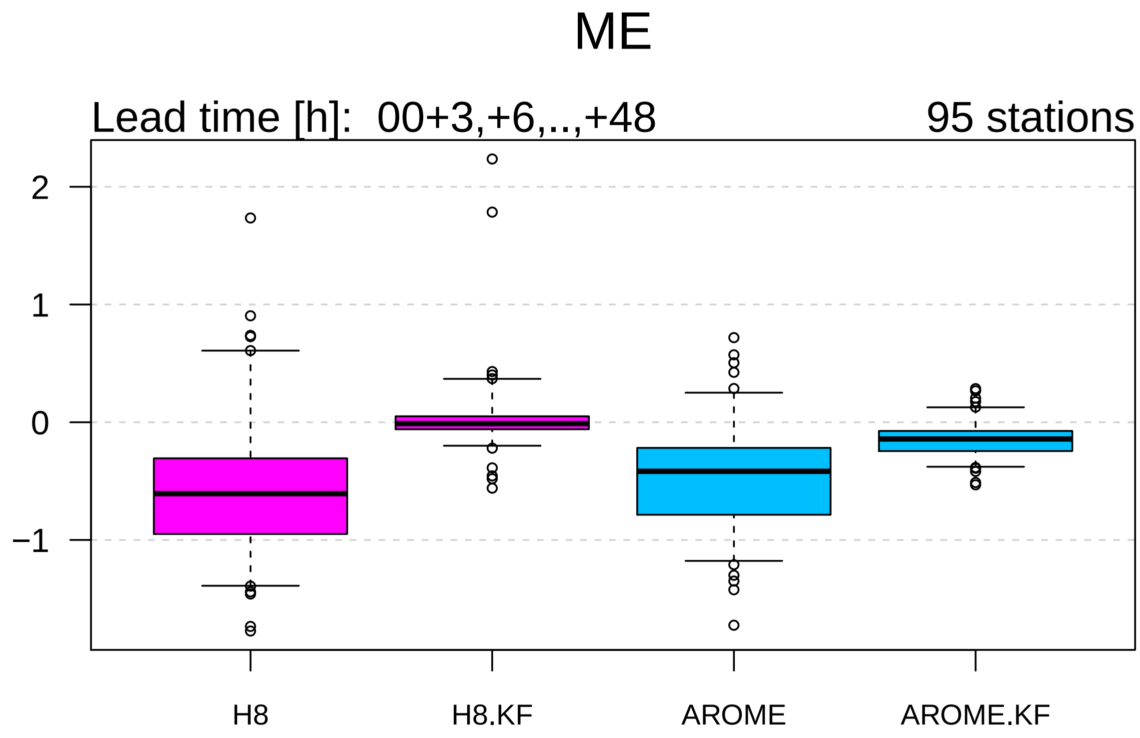

AROME−Norway 00+24
SDE at observing sites
forecast means 01.03.2014 − 31.05.2014
30
25
20
15
10
5
0
−5
−10
−15
−20
−25
−30

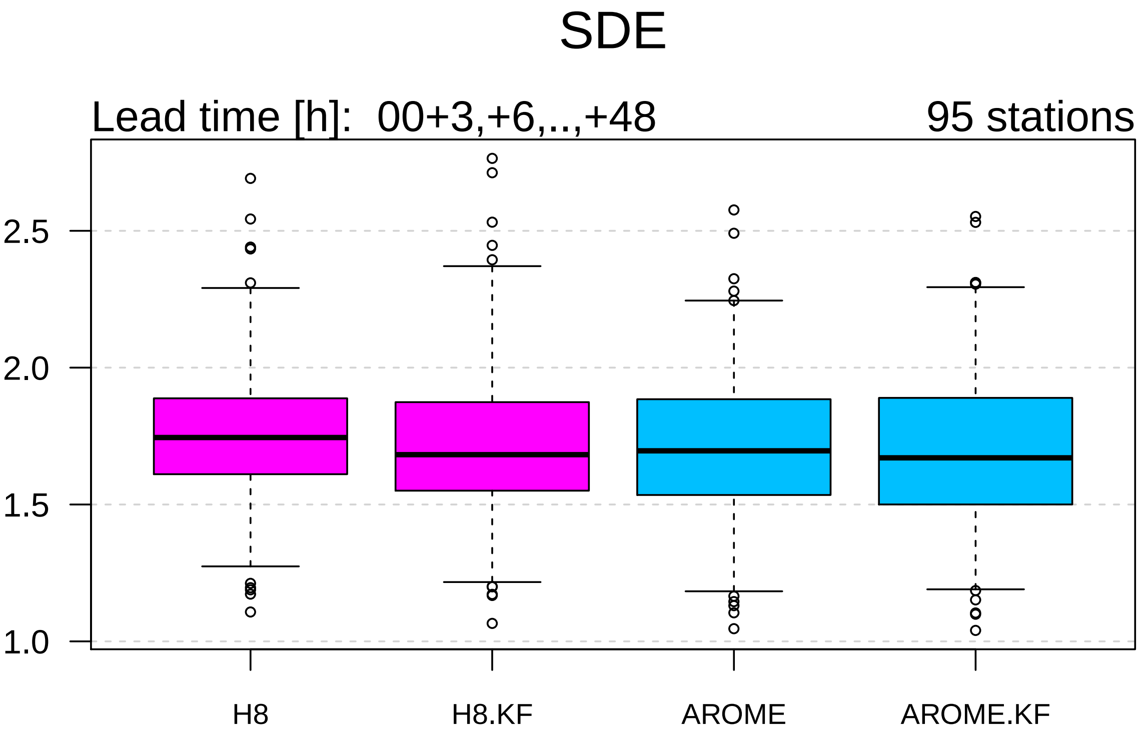
5.7 Post processed temperature 2m



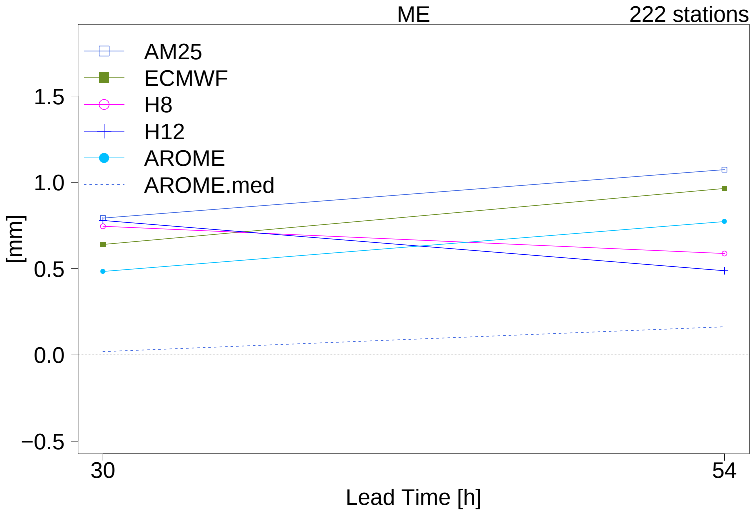


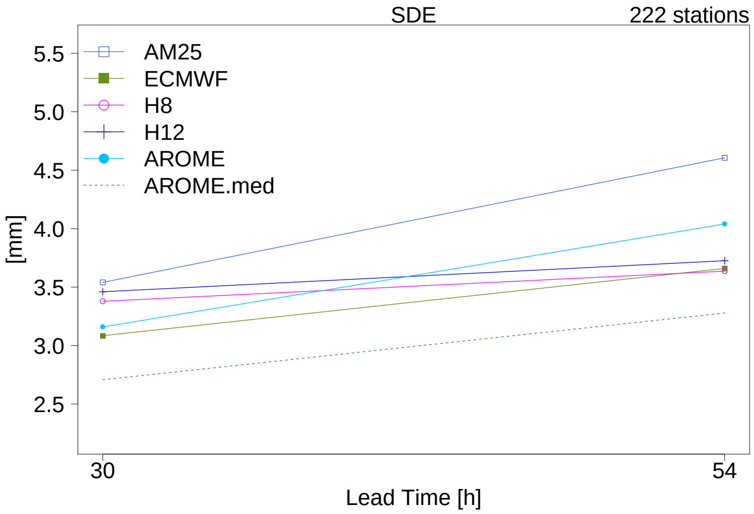


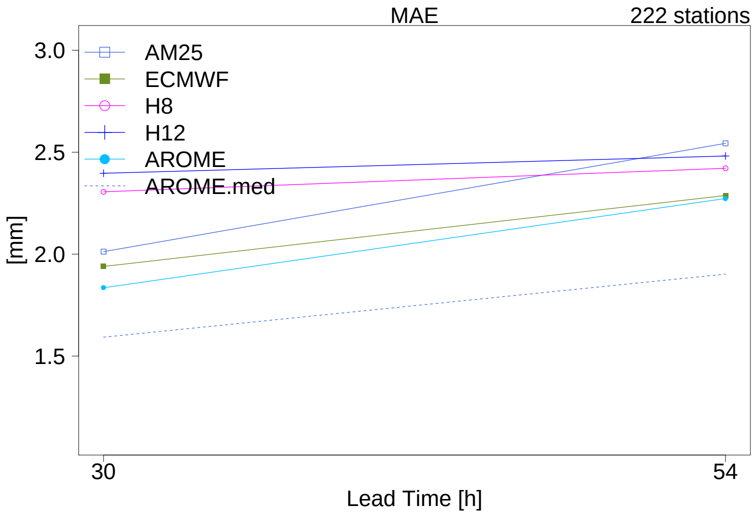

ME
Lead time [h]: 00+3,+6,..,+48
95 stations
2
1
0
−1
H8
H8.KF
AROME
AROME.KF

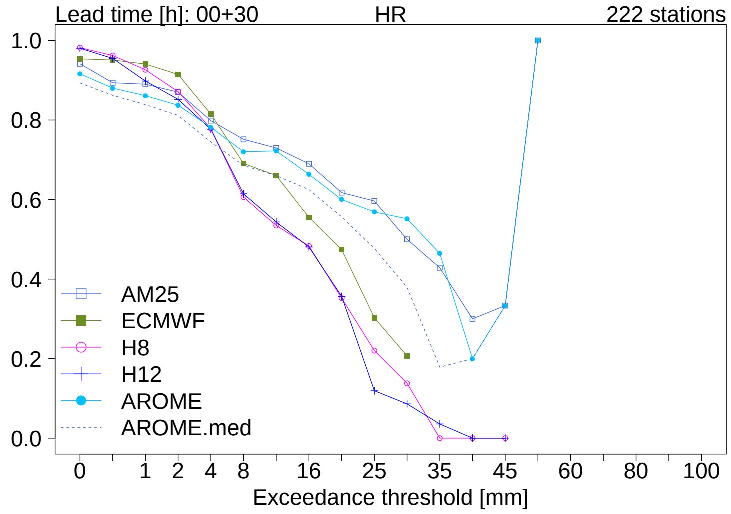

SDE
Lead time [h]: 00+3,+6,..,+48
95 stations
2.5
2.0
1.5
1.0
H8
H8.KF
AROME
AROME.KF

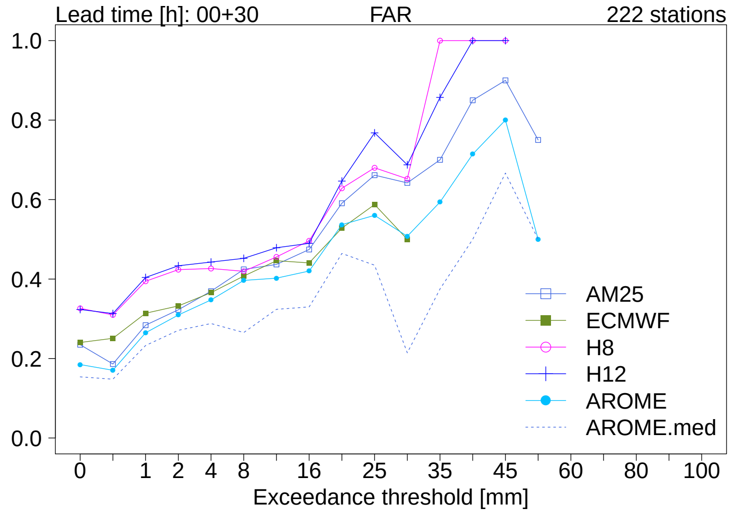
5.8 Daily precipitation

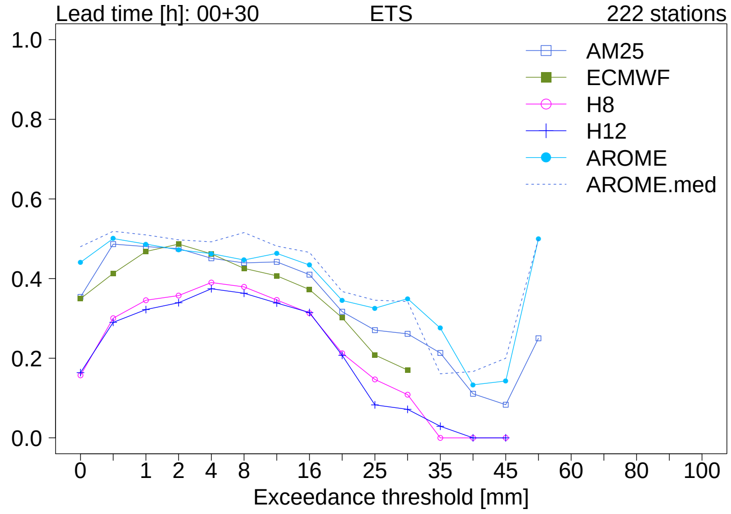


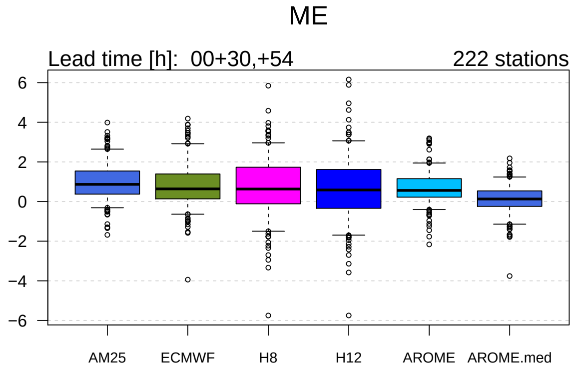


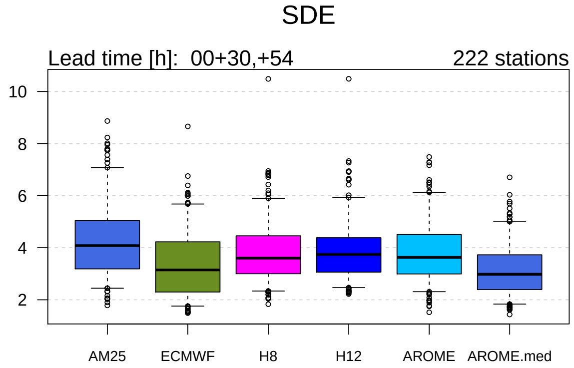



Lead time [h]: 00+30
HR
222 stations
1.0
0.8
0.6
0.4
0.2
0.0
AM25
ECMWF
H8
H12
AROME
AROME.med
0
1
2
4
8
16
25
35
45
60
80
100
Exceedance threshold [mm]


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





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

OBS

AM25

	[0,0.1]	(0.1,5]	(5,20]	(20,50]	(50,Inf]	Sum
[0,0.1]	8840	1494	59	4	0	10397
(0.1,5]	2672	6249	969	8	0	9898
(5,20]	201	1976	2334	194	0	4705
(20,50]	14	119	359	242	1	735
(50,Inf]	0	9	2	2	1	14
Sum	11727	9847	3723	450	2	25749

OBS

H8

	[0,0.1]	(0.1,5]	(5,20]	(20,50]	(50,Inf]	Sum
[0,0.1]	5697	612	39	2	0	6350
(0.1,5]	5703	7141	1172	20	0	14036
(5,20]	322	2059	2328	328	2	5039
(20,50]	5	34	184	100	0	323
(50,Inf]	0	1	0	0	0	1
Sum	11727	9847	3723	450	2	25749

OBS

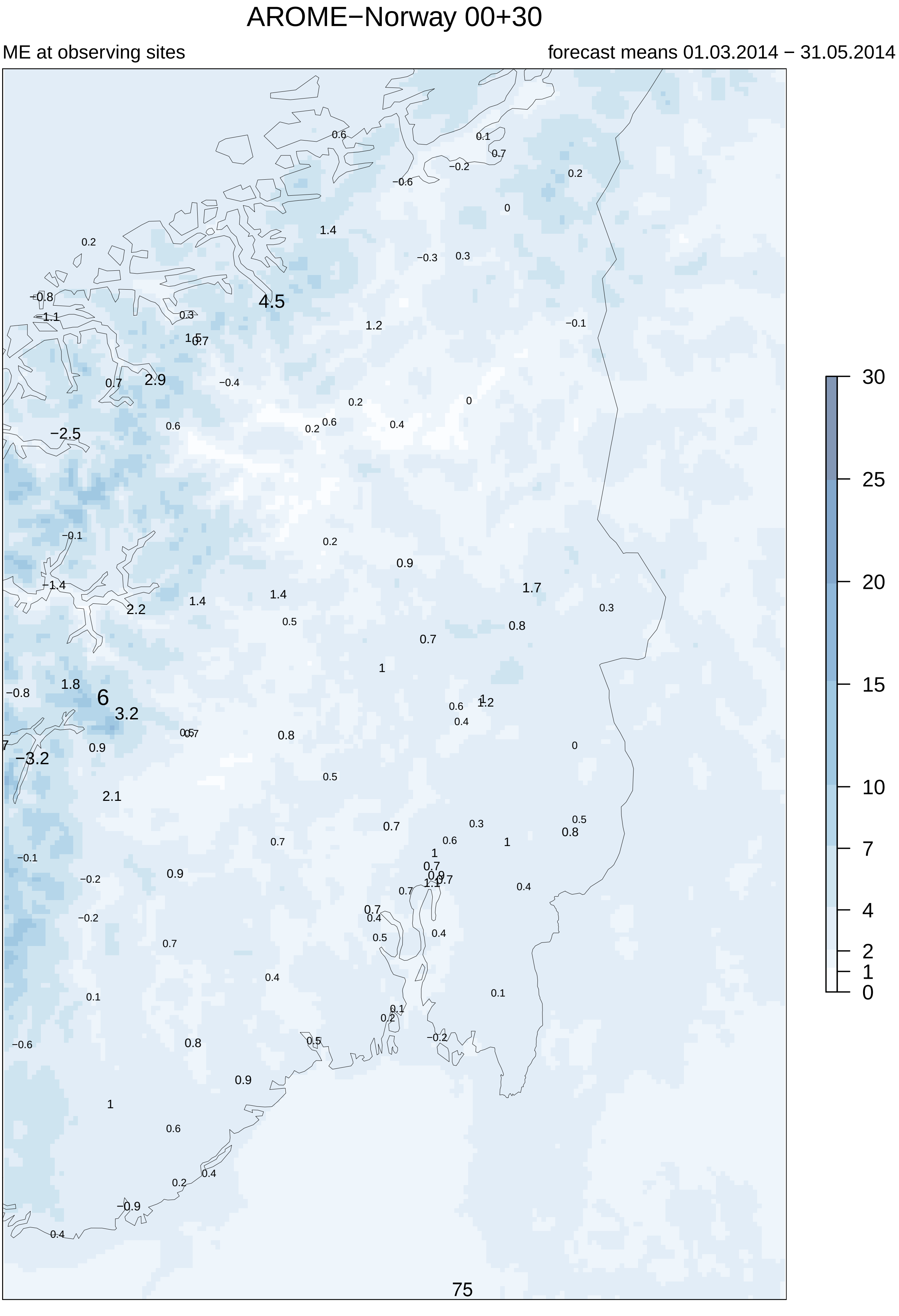
ECMWF

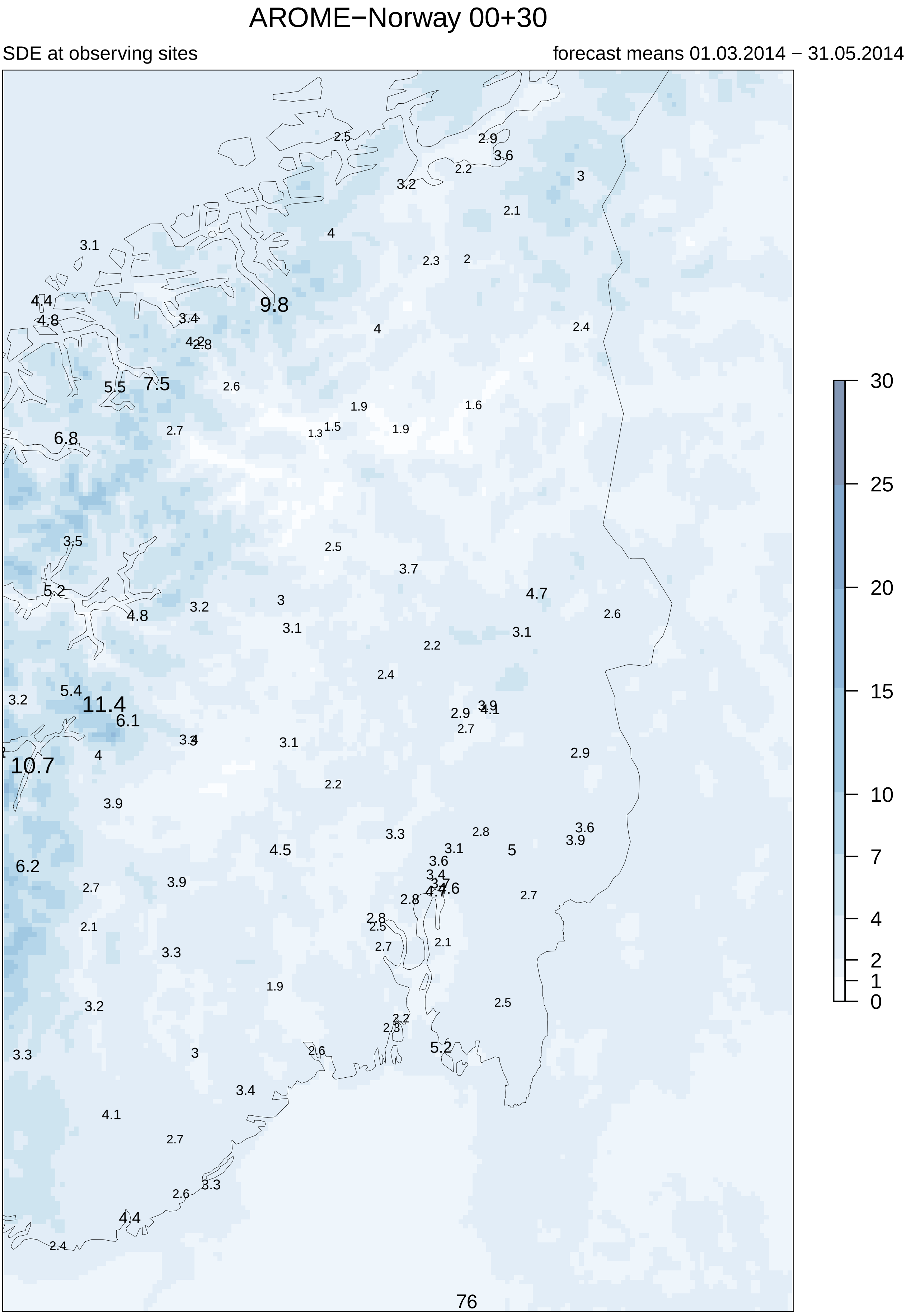
	[0,0.1]	(0.1,5]	(5,20]	(20,50]	(50,Inf]	Sum
[0,0.1]	7223	720	21	0	0	7964
(0.1,5]	4304	7080	949	11	0	12344
(5,20]	197	1985	2529	235	0	4946
(20,50]	3	62	224	204	2	495
(50,Inf]	0	0	0	0	0	0
Sum	11727	9847	3723	450	2	25749

OBS

AROME

	[0,0.1]	(0.1,5]	(5,20]	(20,50]	(50,Inf]	Sum
[0,0.1]	9022	1680	81	3	0	10786
(0.1,5]	2537	6370	997	10	0	9914
(5,20]	160	1719	2335	193	0	4407
(20,50]	8	74	309	243	1	635
(50,Inf]	0	4	1	1	1	7
Sum	11727	9847	3723	450	2	25749


AROME−Norway 00+30
ME at observing sites
forecast means 01.03.2014 − 31.05.2014
30
25
20
15
10
7
4
2
1
0


AROME−Norway 00+30
SDE at observing sites
forecast means 01.03.2014 − 31.05.2014
2.5
2.9
3.6
2.2
3
3.2
2.1
4
3.1
2.3
2
4.4
9.8
3.4
4.8
4
2.4
4.2
2.8
5.5
7.5
2.6
1.9
1.6
2.7
1.5
1.3
1.9
6.8
3.5
2.5
3.7
5.2
4.7
3
3.2
4.8
2.6
3.1
3.1
2.2
2.4
5.4
3.2
11.4
3.9
2.9
4.1
6.1
2.7
3.4
3.1
2.9
4
10.7
2.2
3.9
2.8
3.6
3.3
3.1
3.9
4.5
5
6.2
3.6
3.4
2.7
3.9
3.7
2.8
4.4
4.6
2.7
2.8
2.5
2.1
2.7
3.3
1.9
2.5
3.2
2.2
2.3
3.3
3
2.6
5.2
3.4
4.1
2.7
3.3
2.6
4.4
2.4
30
25
20
15
10
7
4
2
1
0

6 Western Norway

6.1 Comments to the verification results

Wind speed 10 m:
For the period 1st of March to 31st of May 2014, AROME has a small positive bias in wind speed. This bias is smaller for AROME MetCoOp than AROME Norway. The Hirlam-models and ECMWF has a clear diurnal variation in bias. Hirlam 12 and 8 km have a positive bias during nighttime and a negative bias during daytime, while ECMWF has a negative bias during both daytime and nighttime. AROME scores best for all wind speeds. Below $11ms^{-1}$ AROME MetCoOp scores slightly better than AROME Norway, while it is the opposite above $11ms^{-1}$.

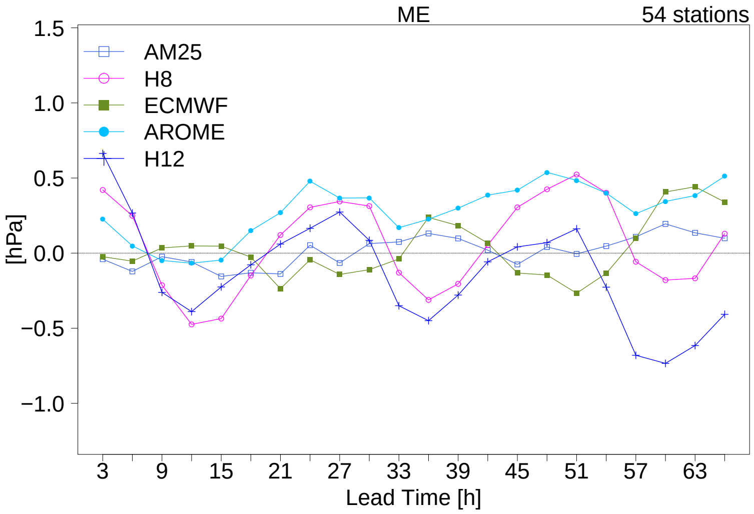
Max mean wind speed 10 m:
For Max Mean Wind Speed, both AROME and Hirlam 8 km have a negative bias. After post-processing the biases are about -0.3 to $-0.4ms^{-1}$ for Hirlam 8 and about -0.2 to $-0.3ms^{-1}$ for AROME. Hirlam 8 also has a stronger diurnal variation.

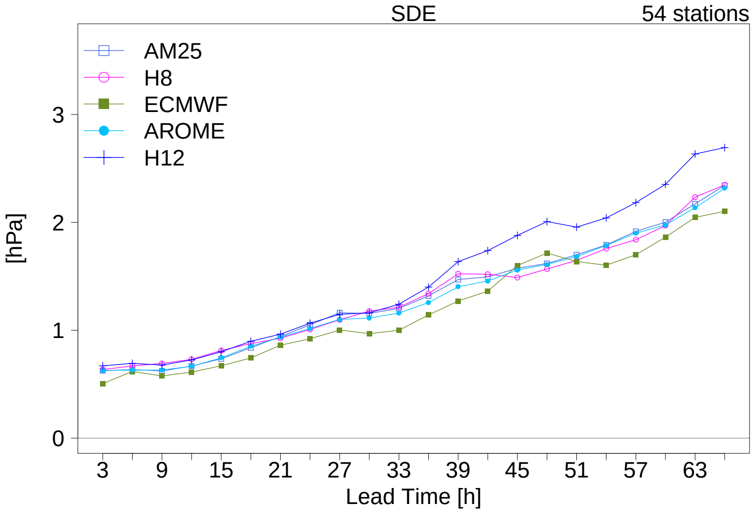
Wind gust:
For wind gust AROME has a negative bias, while Hirlam 8 has a positive bias. The bias is smaller for Arome Norway (about $-0.2ms^{-1}$) than for Arome MetCoOp (about $-0.9ms^{-1}$). If we look at wind speed at 925 hPa (which often is used as an esimate of wind gust), the are only minor differences in bias between AROME and Hirlam 8 km. The wind at 925 hPa scores better for strong winds than wind gust.

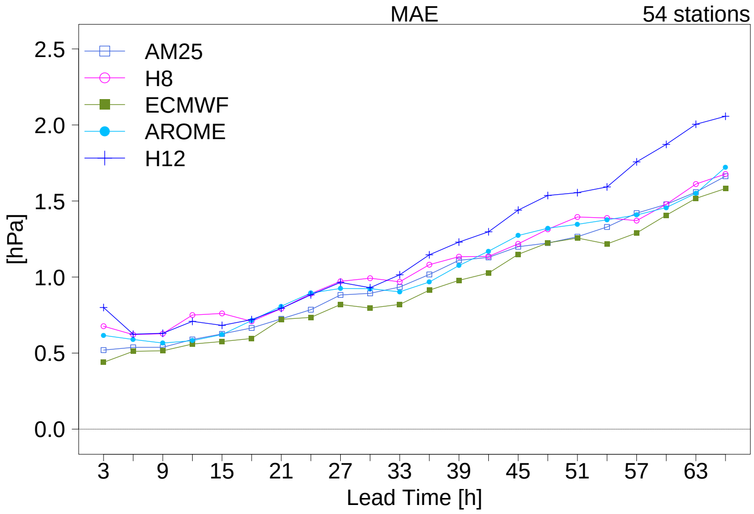
Temperature 2m:
The bias in temperature was negative for all models and has a diurnal variation. For Hirlam and AROME modells, the bias was smaller during daytime, while the bias in ECMWF was smaller during nighttime. After post-processing Hirlam 8 has a small positive bias, while AROME has a small negative bias.

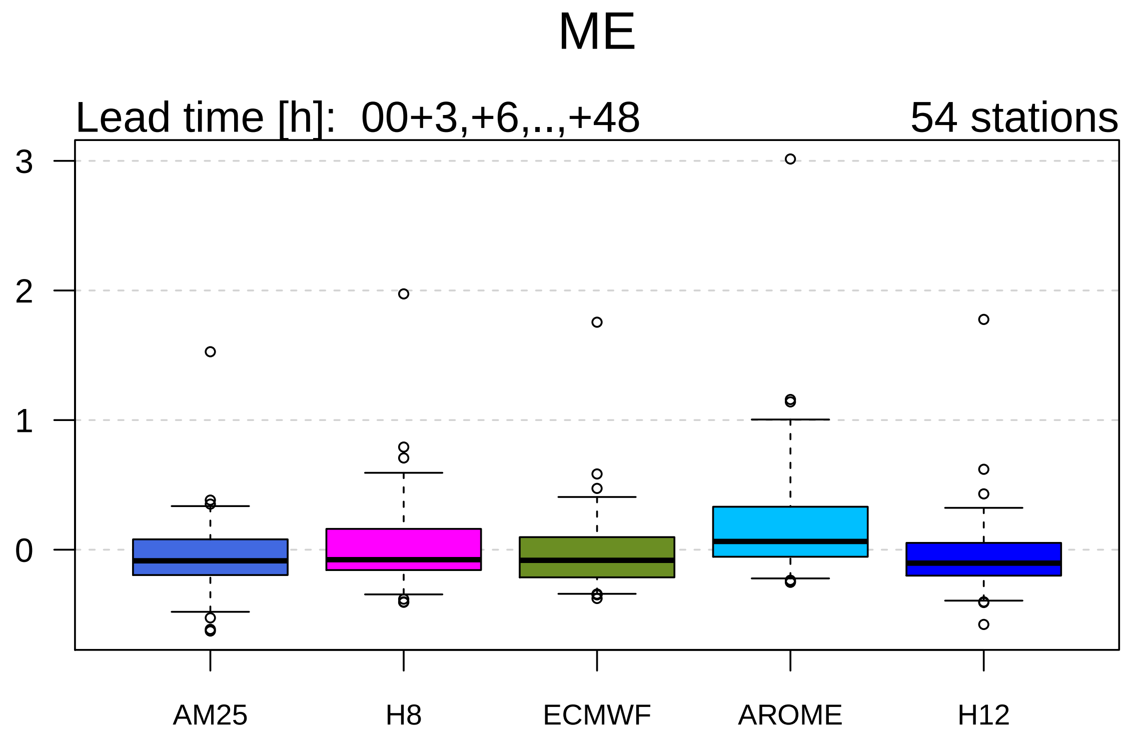
Precipitation:
For precipitation AROME has a small positive bias, while Hirlam has a small negative bias. ECMWF has a larger positive bias, but ECMWF has less errors (SDE and MAE) than both AROME and Hirlam. For light and heavy precipitation, AROME is the best model, while ECMWF is better for 24-hours precipitation between 8 and 35 mm.

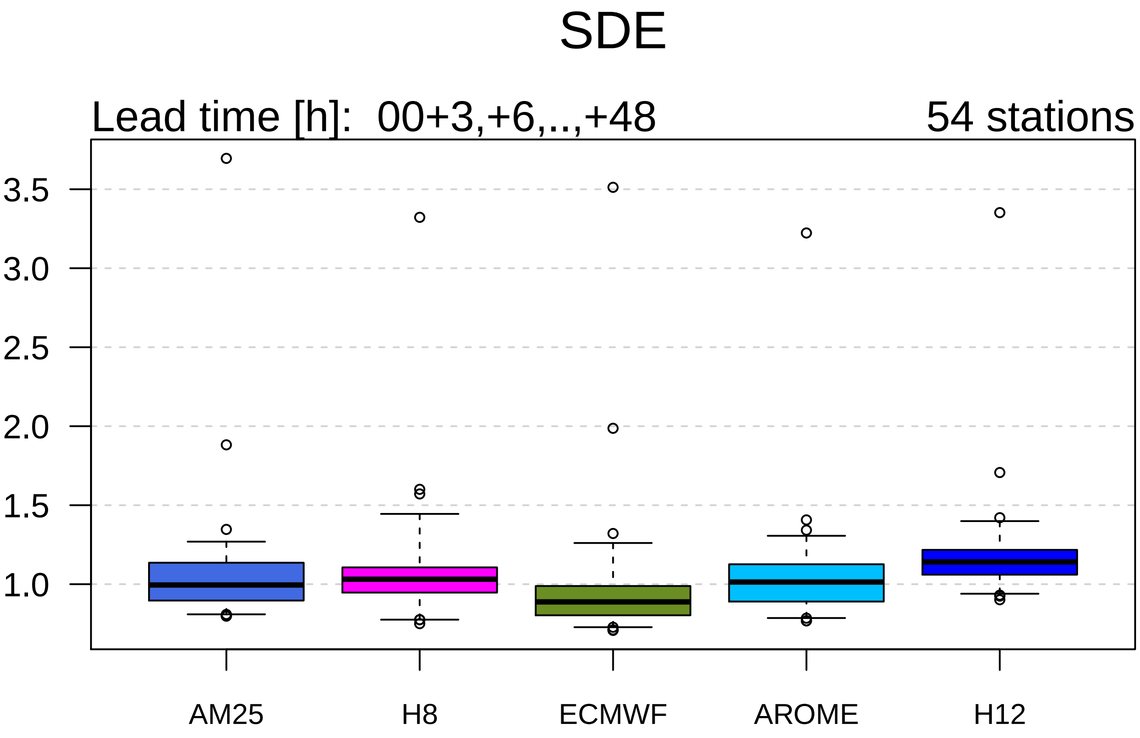
6.2 Pressure


ME
54 stations
AM25
H8
ECMWF
AROME
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]

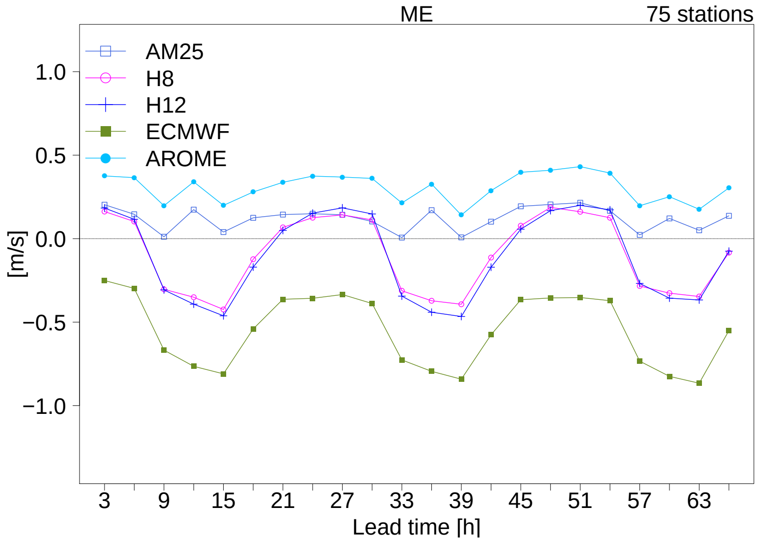

SDE
54 stations
AM25
H8
ECMWF
AROME
H12
[hPa]
3
2
1
0
3
9
15
21
27
33
39
45
51
57
63
Lead Time [h]

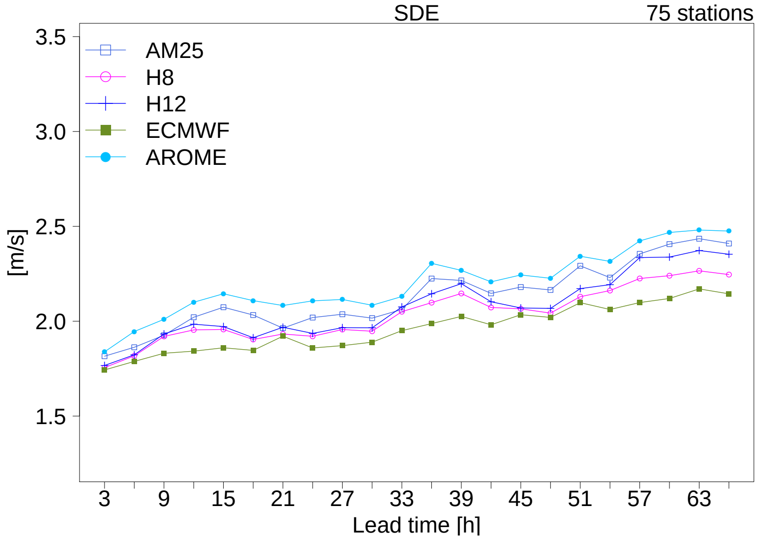

MAE
54 stations
AM25
H8
ECMWF
AROME
H12
[hPa]
2.5
2.0
1.5
1.0
0.5
0.0
3
9
15
21
27
33
39
45
51
57
63
Lead Time [h]

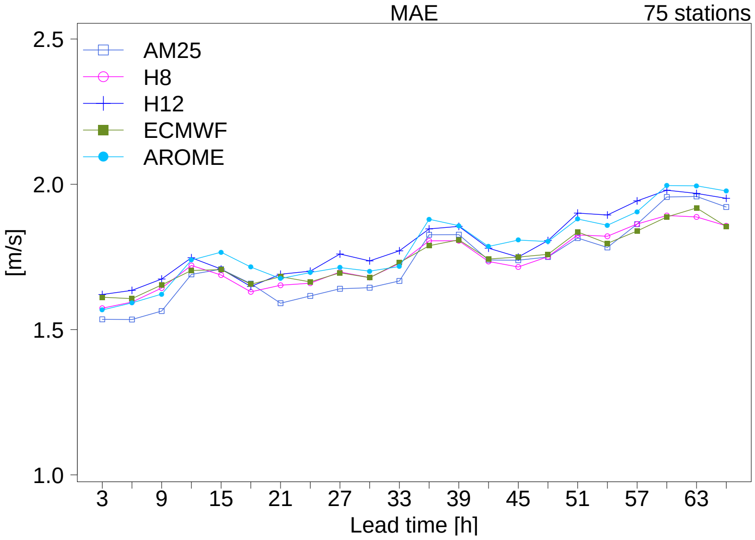

ME
Lead time [h]: 00+3,+6,..,+48
54 stations
3
2
1
0
AM25
H8
ECMWF
AROME
H12

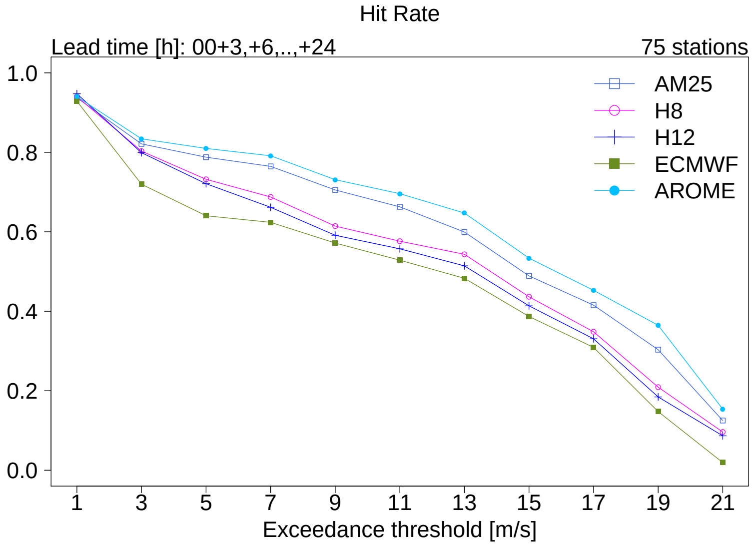

SDE
Lead time [h]: 00+3,+6,..,+48
54 stations
3.5
3.0
2.5
2.0
1.5
1.0
AM25
H8
ECMWF
AROME
H12

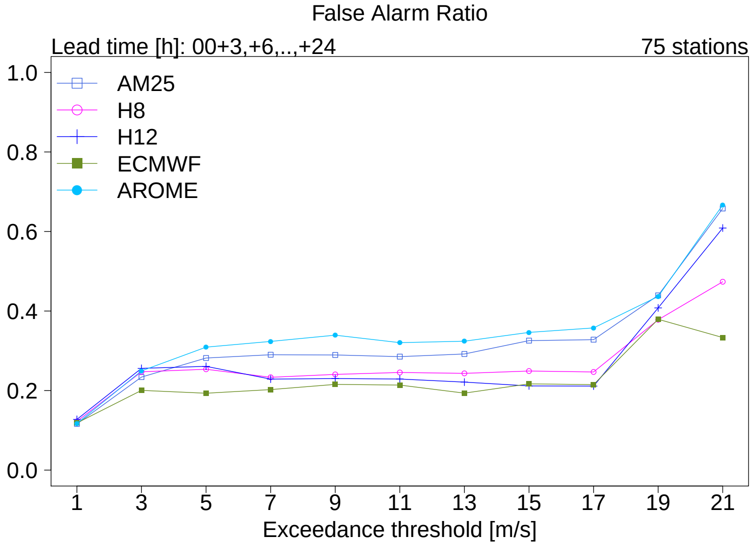
6.3 Wind Speed 10m

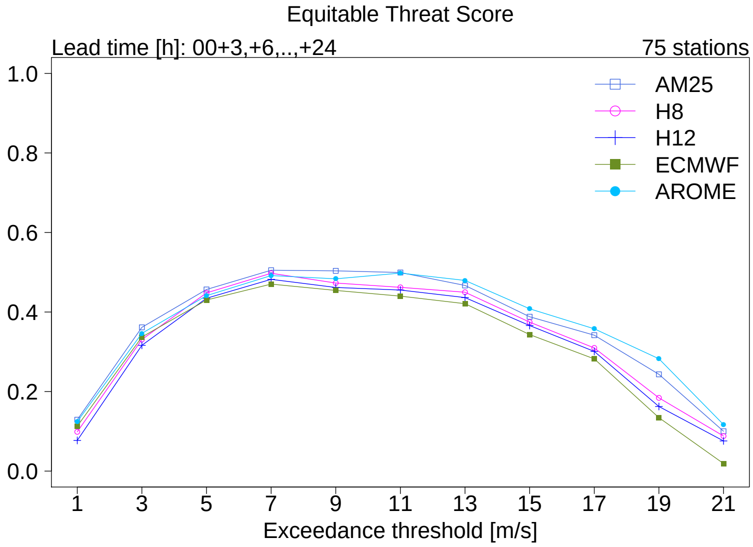


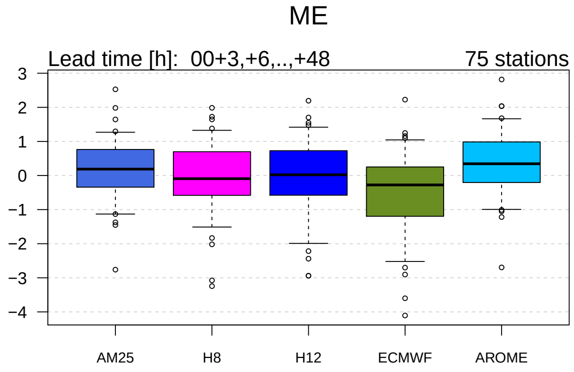


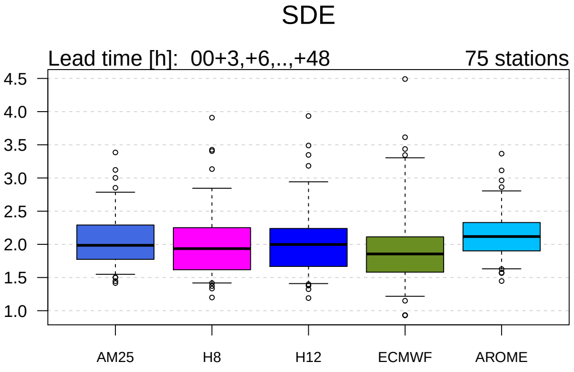



Hit Rate
Lead time [h]: 00+3,+6,..,+24
75 stations
AM25
H8
H12
ECMWF
AROME
1.0
0.8
0.6
0.4
0.2
0.0
1
3
5
7
9
11
13
15
17
19
21
Exceedance threshold [m/s]


False Alarm Ratio
Lead time [h]: 00+3,+6,..,+24
75 stations
AM25
H8
H12
ECMWF
AROME
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
H8
H12
ECMWF
AROME
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]	30980	9689	37	1	1	40708
(3,11]	13230	33430	2132	59	3	48854
(11,17]	76	1755	3013	458	94	5396
(17,21]	1	21	174	249	85	530
(21,Inf]	0	2	11	31	22	66
Sum	44287	44897	5367	798	205	95554

H8

OBS

	[0,3]	(3,11]	(11,17]	(17,21]	(21,Inf]	Sum
[0,3]	30451	10510	87	3	0	41051
(3,11]	13821	33049	2535	139	18	49562
(11,17]	15	1330	2623	428	87	4483
(17,21]	0	8	119	217	87	431
(21,Inf]	0	0	3	11	13	27
Sum	44287	44897	5367	798	205	95554

ECMWF

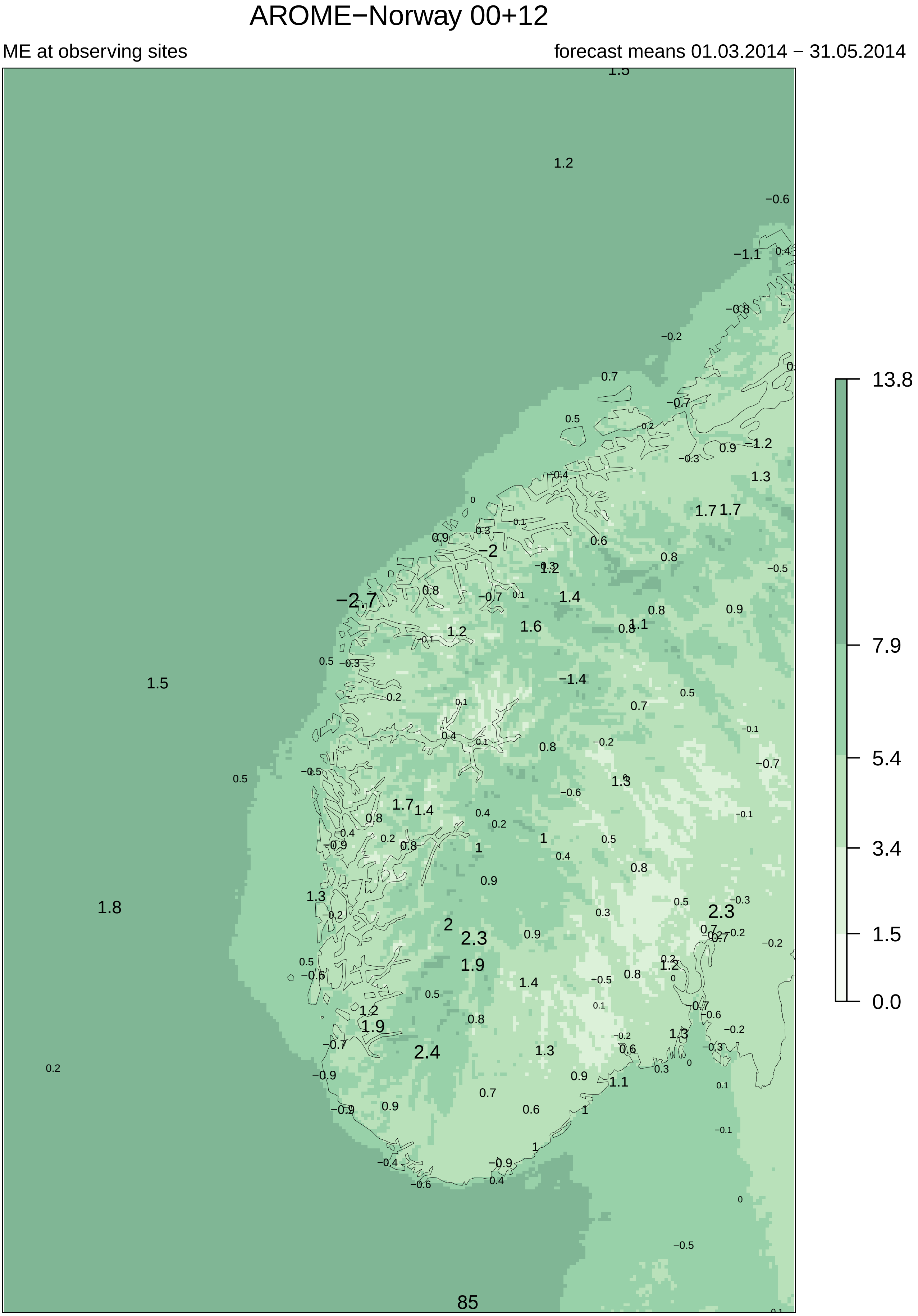
OBS

	[0,3]	(3,11]	(11,17]	(17,21]	(21,Inf]	Sum
[0,3]	34836	14639	293	38	5	49811
(3,11]	9449	29278	2597	129	16	41469
(11,17]	2	974	2390	453	92	3911
(17,21]	0	6	87	176	89	358
(21,Inf]	0	0	0	2	3	5
Sum	44287	44897	5367	798	205	95554

AROME

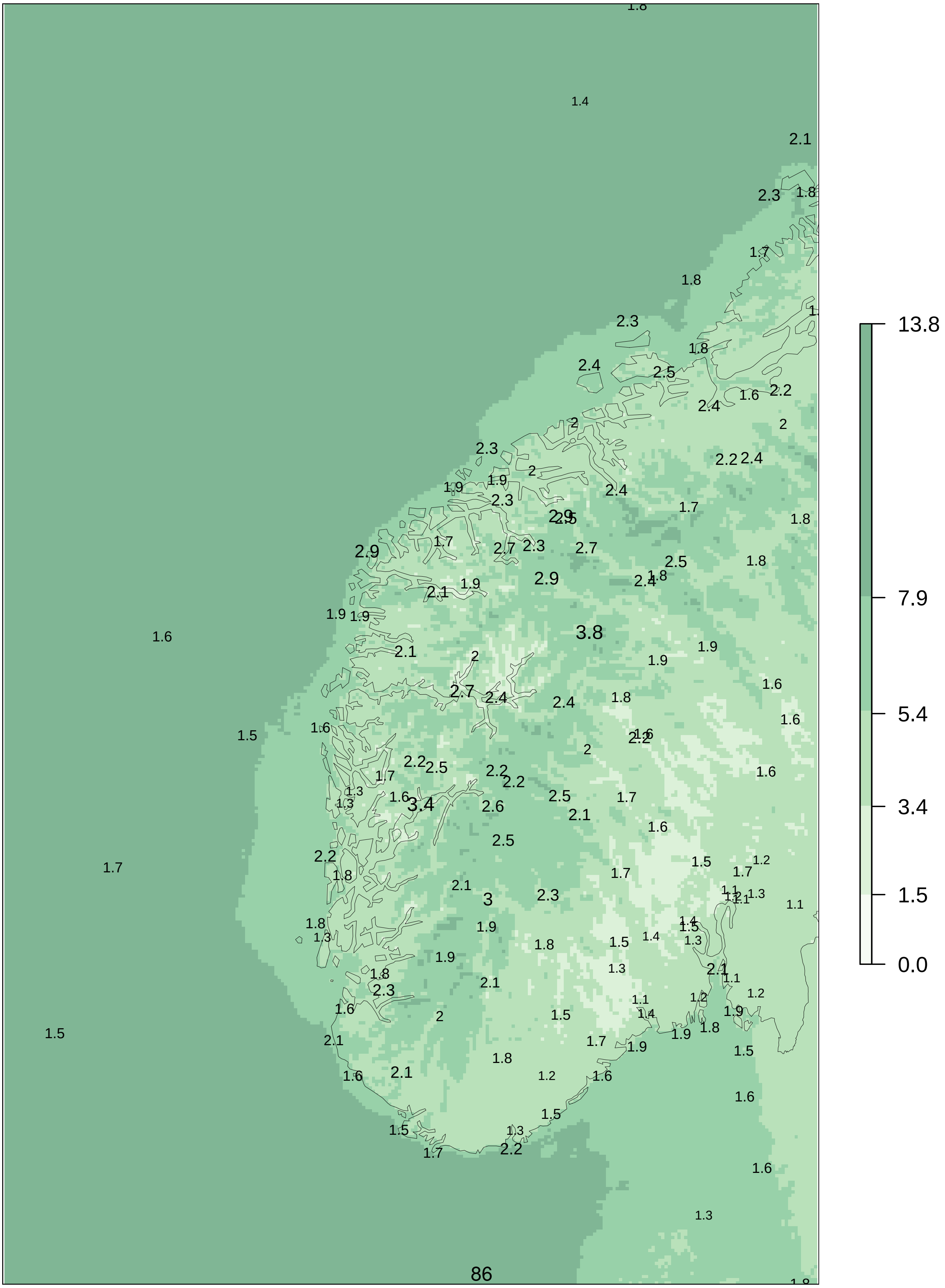
OBS

	[0,3]	(3,11]	(11,17]	(17,21]	(21,Inf]	Sum
[0,3]	29684	8865	39	2	2	38592
(3,11]	14473	33879	1917	51	0	50320
(11,17]	129	2122	3194	436	89	5970
(17,21]	1	28	203	269	90	591
(21,Inf]	0	3	14	40	24	81
Sum	44287	44897	5367	798	205	95554

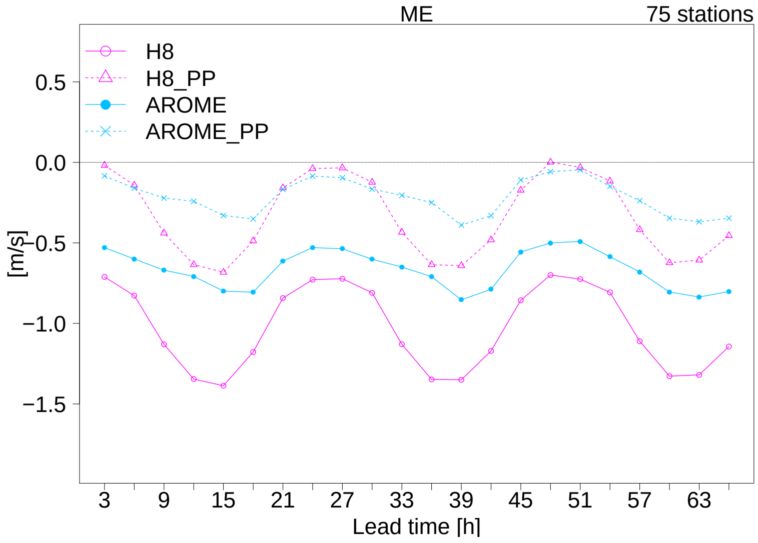

AROME−Norway 00+12
ME at observing sites
forecast means 01.03.2014 − 31.05.2014
13.8
7.9
5.4
3.4
1.5
0.0
85

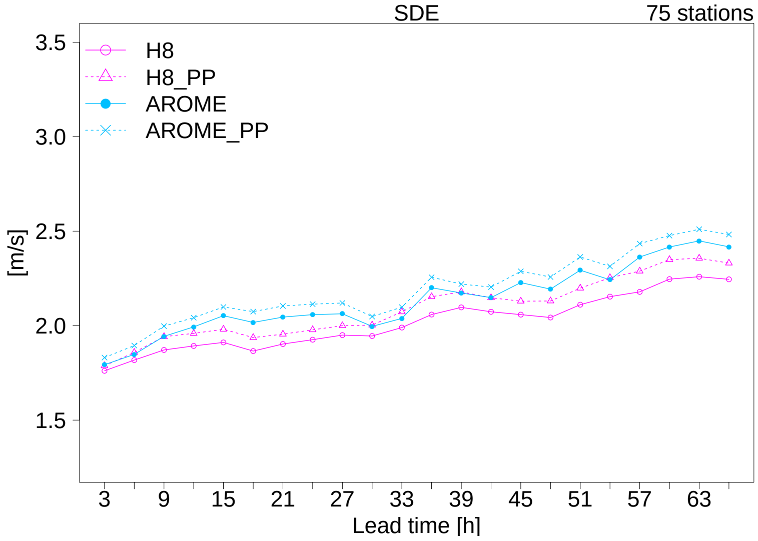
AROME−Norway 00+12

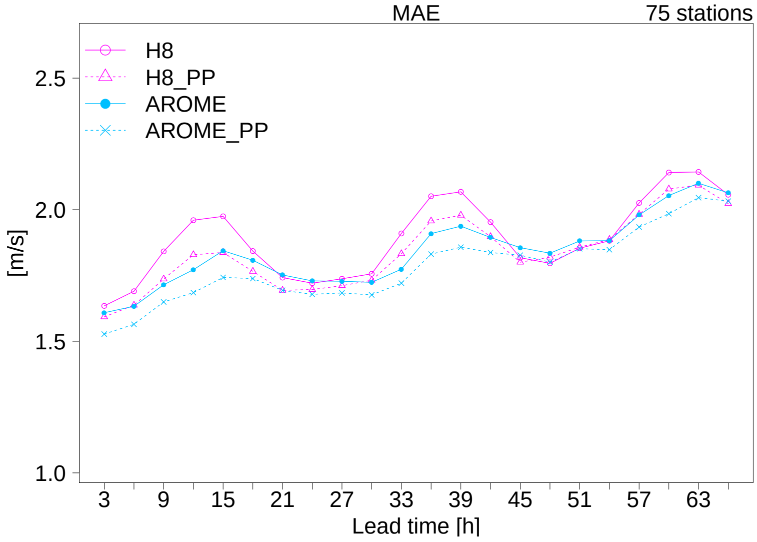
SDE at observing sites forecast means 01.03.2014 − 31.05.2014

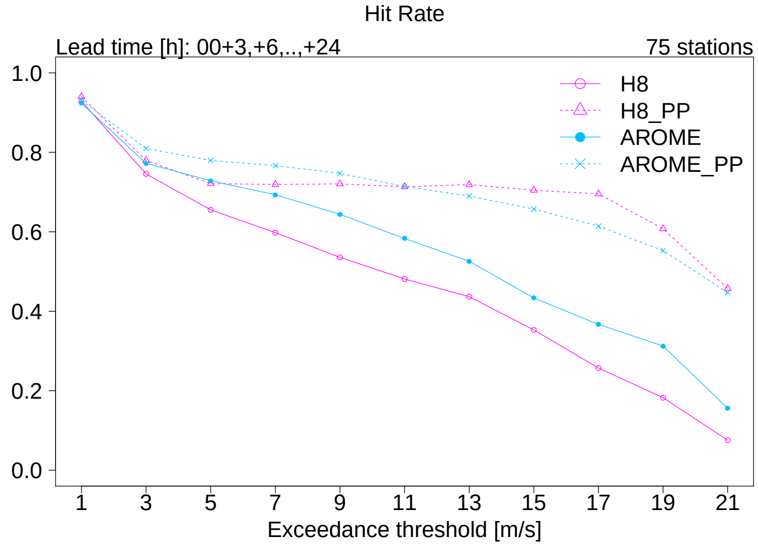


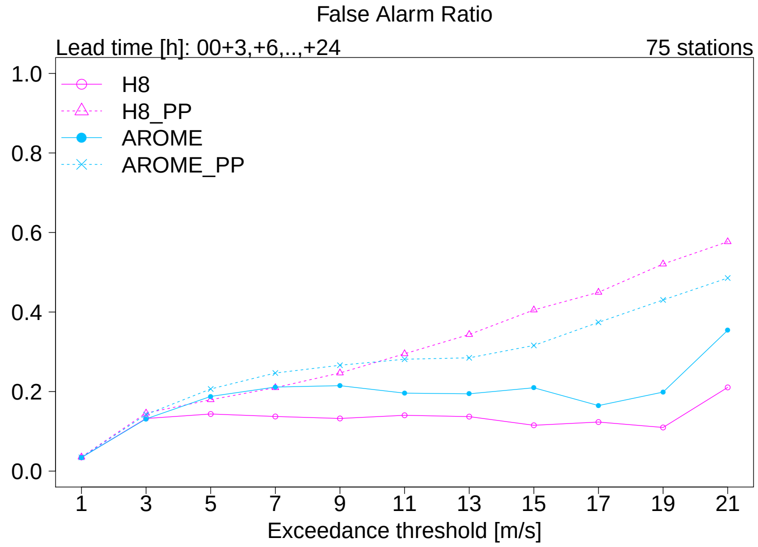
6.4 Max Mean Wind Speed 10m

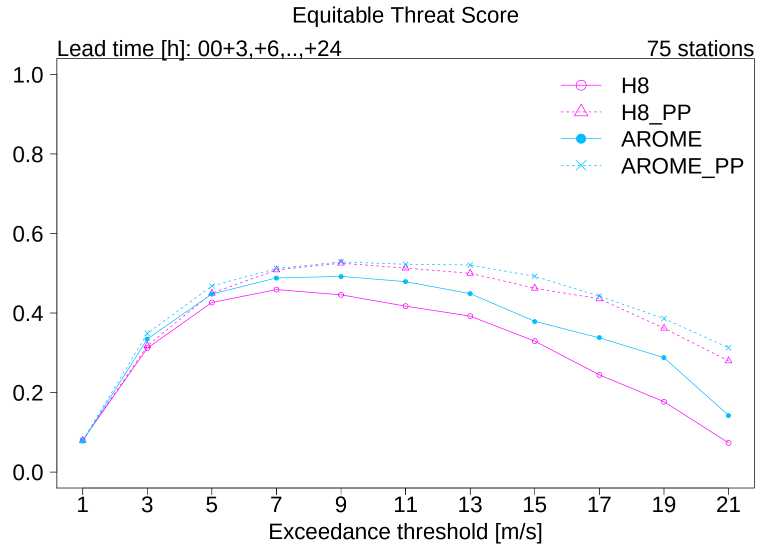


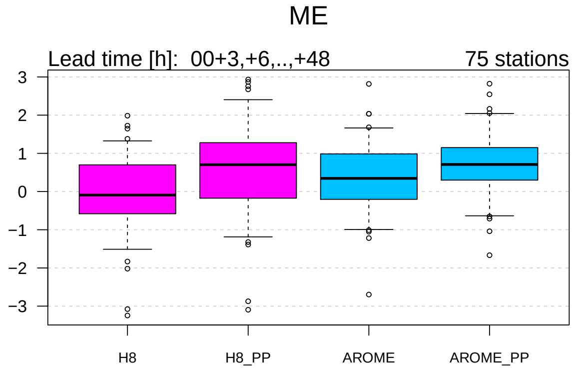


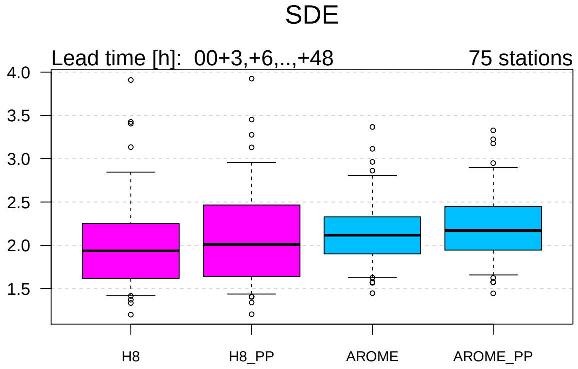



Hit Rate
Lead time [h]: 00+3,+6,..,+24
75 stations
H8
H8_PP
AROME
AROME_PP
1.0
0.8
0.6
0.4
0.2
0.0
1
3
5
7
9
11
13
15
17
19
21
Exceedance threshold [m/s]


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





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

75 stations

OBS

H8

	[0,3]	(3,11]	(11,17]	(17,21]	(21,Inf]	Sum
[0,3]	23193	16294	142	1	1	39631
(3,11]	7403	36618	4300	221	23	48565
(11,17]	9	823	2813	751	187	4583
(17,21]	0	3	51	216	167	437
(21,Inf]	0	0	1	6	20	27
Sum	30605	53738	7307	1195	398	93243

OBS

H8_PP

	[0,3]	(3,11]	(11,17]	(17,21]	(21,Inf]	Sum
[0,3]	21951	14114	71	0	1	36137
(3,11]	8627	36720	2439	80	4	47870
(11,17]	27	2823	3949	391	61	7251
(17,21]	0	77	810	524	161	1572
(21,Inf]	0	4	38	200	171	413
Sum	30605	53738	7307	1195	398	93243

OBS

AROME

	[0,3]	(3,11]	(11,17]	(17,21]	(21,Inf]	Sum
[0,3]	22958	14561	71	6	2	37598
(3,11]	7604	37822	3568	99	4	49097
(11,17]	43	1340	3562	760	178	5883
(17,21]	0	13	101	304	166	584
(21,Inf]	0	2	5	26	48	81
Sum	30605	53738	7307	1195	398	93243

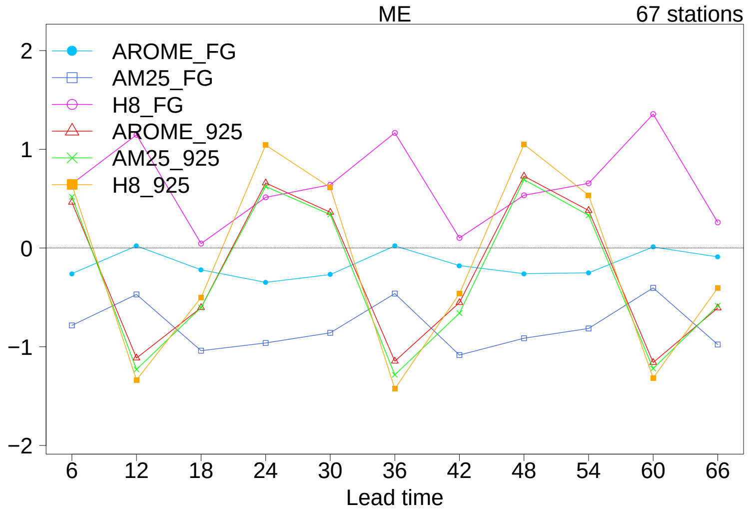
OBS

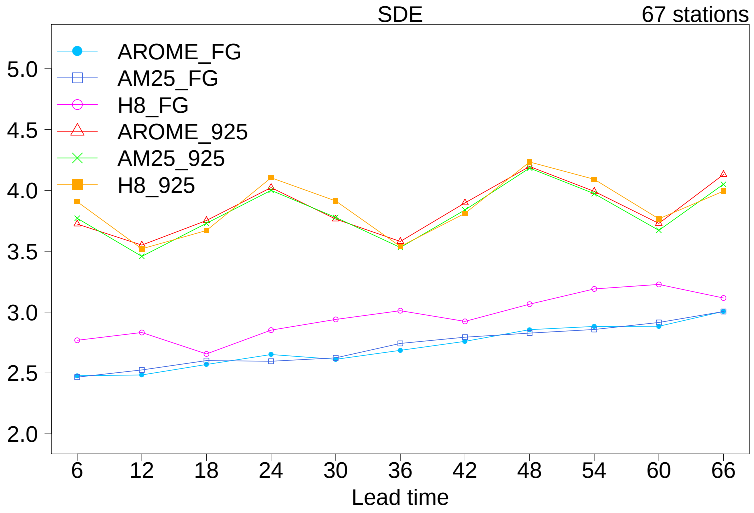
AROME_PP

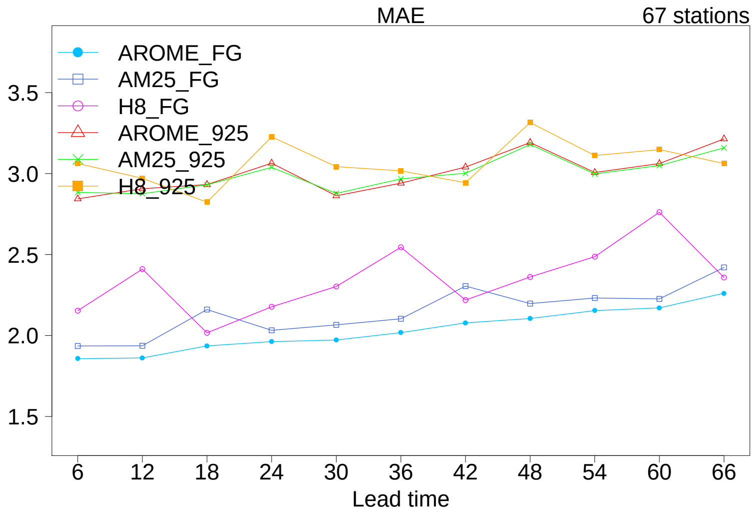
	[0,3]	(3,11]	(11,17]	(17,21]	(21,Inf]	Sum
[0,3]	21870	12268	52	4	2	34196
(3,11]	8685	38867	2494	67	1	50114
(11,17]	50	2551	4222	480	99	7402
(17,21]	0	48	519	502	141	1210
(21,Inf]	0	4	20	142	155	321
Sum	30605	53738	7307	1195	398	93243

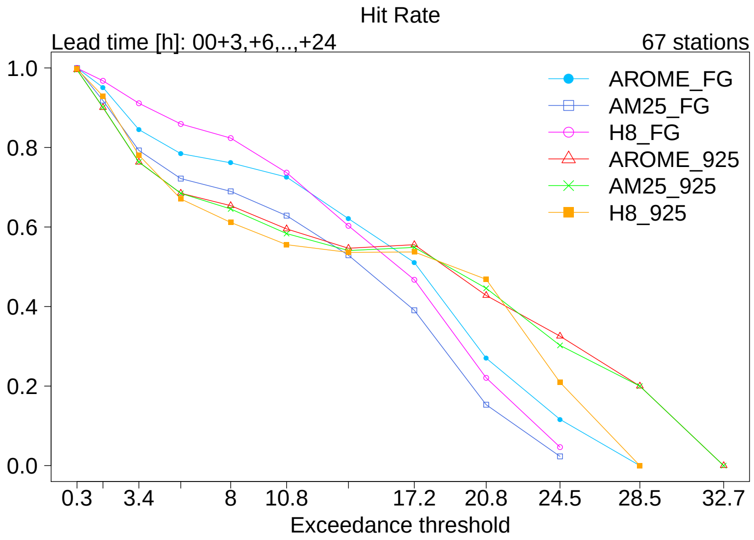
6.5 Wind gust

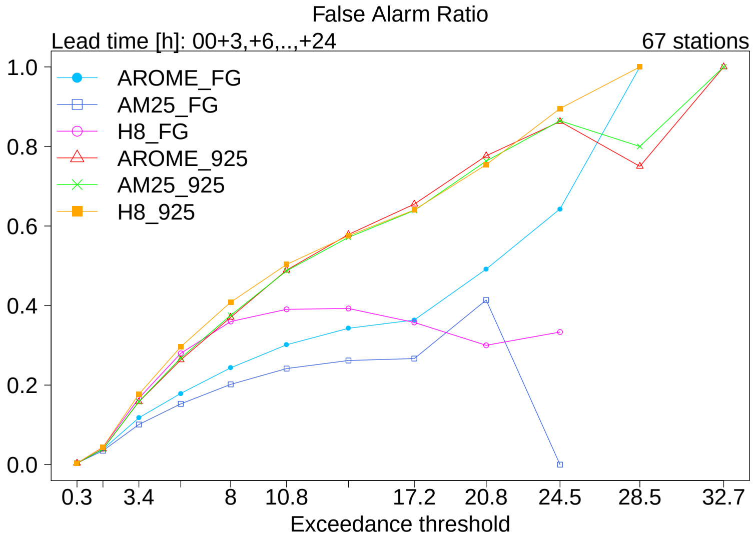
6.5.1 25 March - 31 May

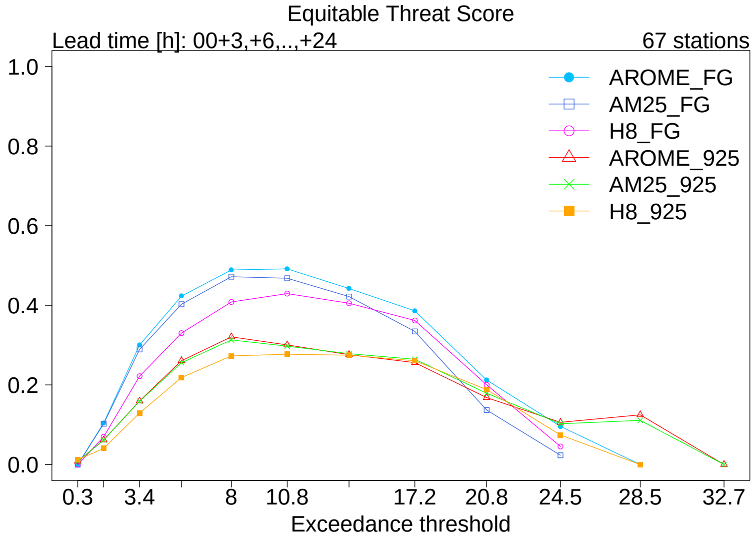




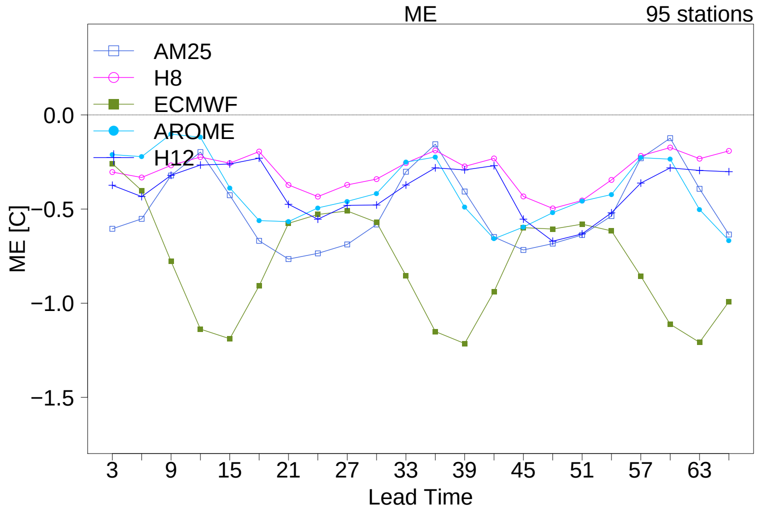


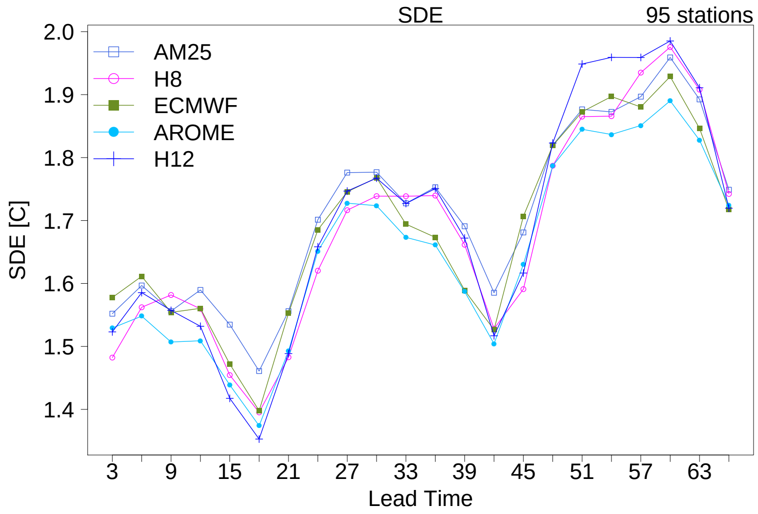

Hit Rate
Lead time [h]: 00+3,+6,..,+24
67 stations
AROME_FG
AM25_FG
H8_FG
AROME_925
AM25_925
H8_925
1.0
0.8
0.6
0.4
0.2
0.0
0.3
3.4
8
10.8
17.2
20.8
24.5
28.5
32.7
Exceedance threshold

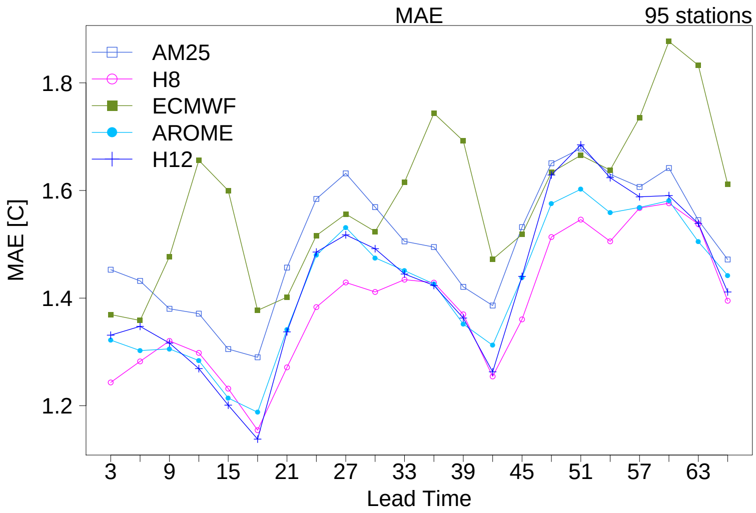

False Alarm Ratio
Lead time [h]: 00+3,+6,..,+24
67 stations
AROME_FG
AM25_FG
H8_FG
AROME_925
AM25_925
H8_925
1.0
0.8
0.6
0.4
0.2
0.0
0.3
3.4
8
10.8
17.2
20.8
24.5
28.5
32.7
Exceedance threshold

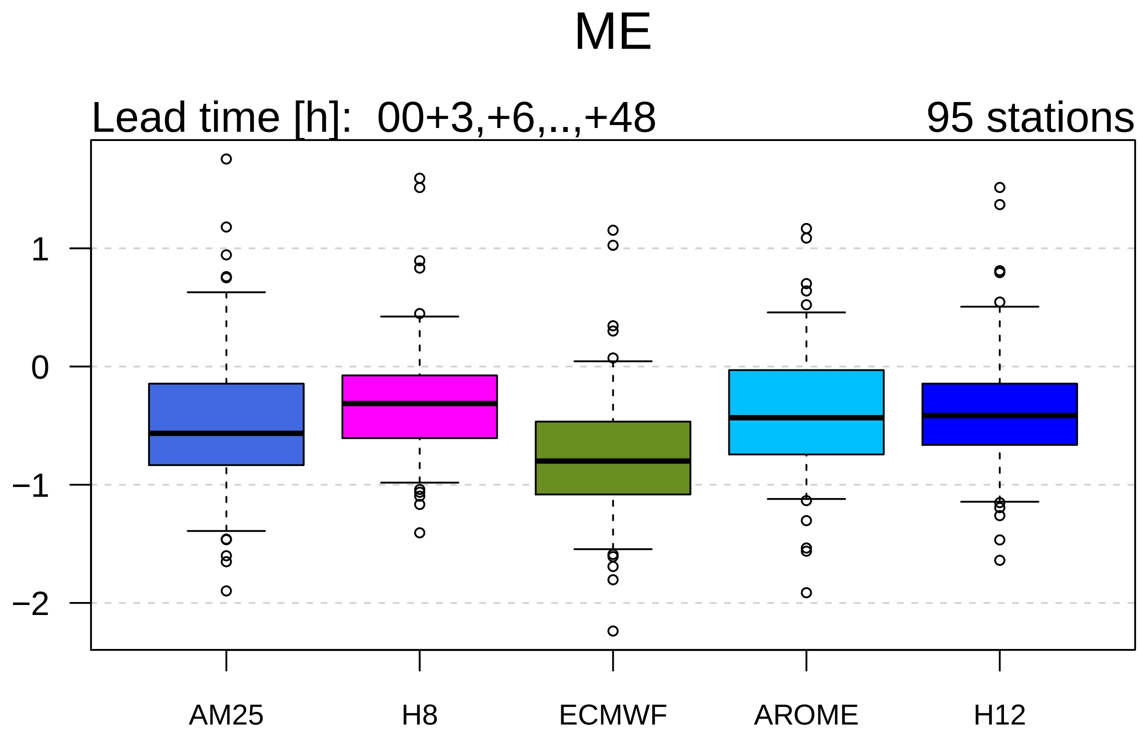

Equitable Threat Score
Lead time [h]: 00+3,+6,..,+24
67 stations
AROME_FG
AM25_FG
H8_FG
AROME_925
AM25_925
H8_925
1.0
0.8
0.6
0.4
0.2
0.0
0.3
3.4
8
10.8
17.2
20.8
24.5
28.5
32.7
Exceedance threshold

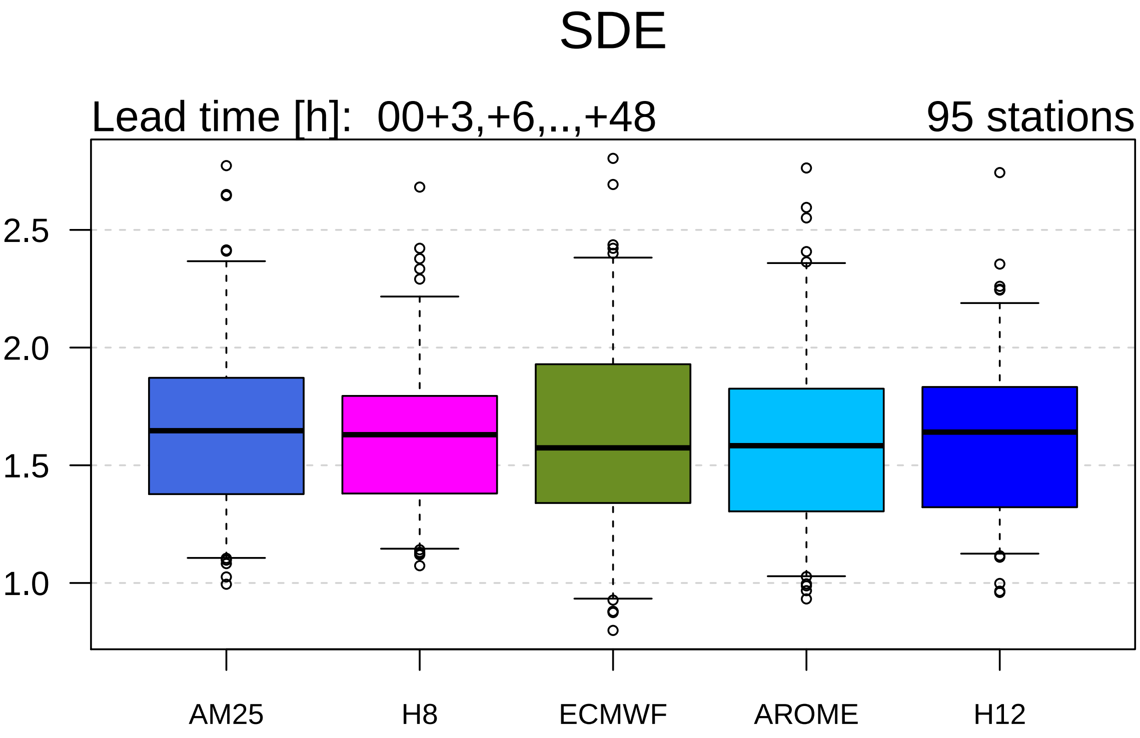
6.6 Temperature 2m





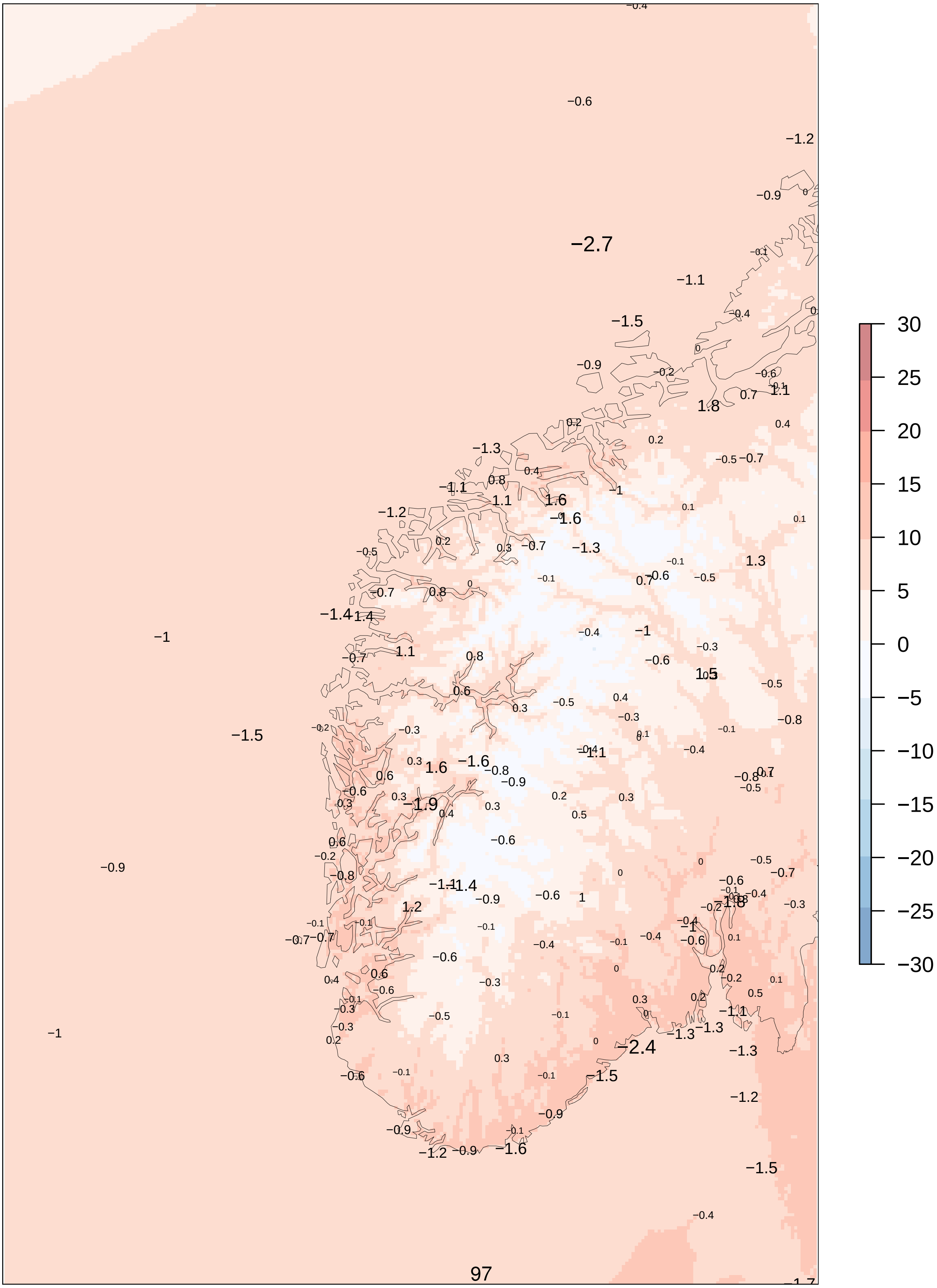



ME
Lead time [h]: 00+3,+6,..,+48
95 stations
1
0
−1
−2
AM25
H8
ECMWF
AROME
H12


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

AROME−Norway 00+12

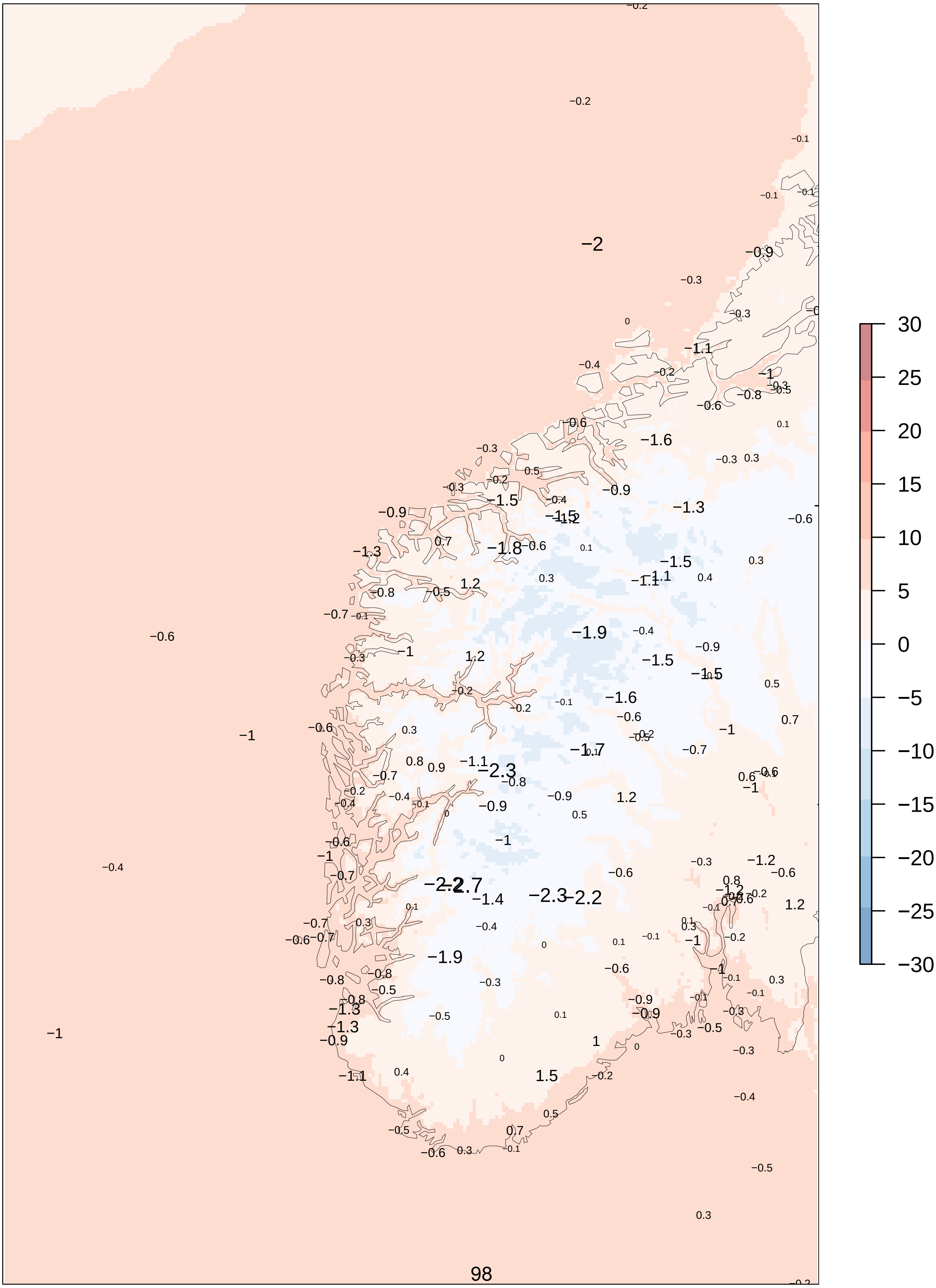
ME at observing sites forecast means 01.03.2014 − 31.05.2014

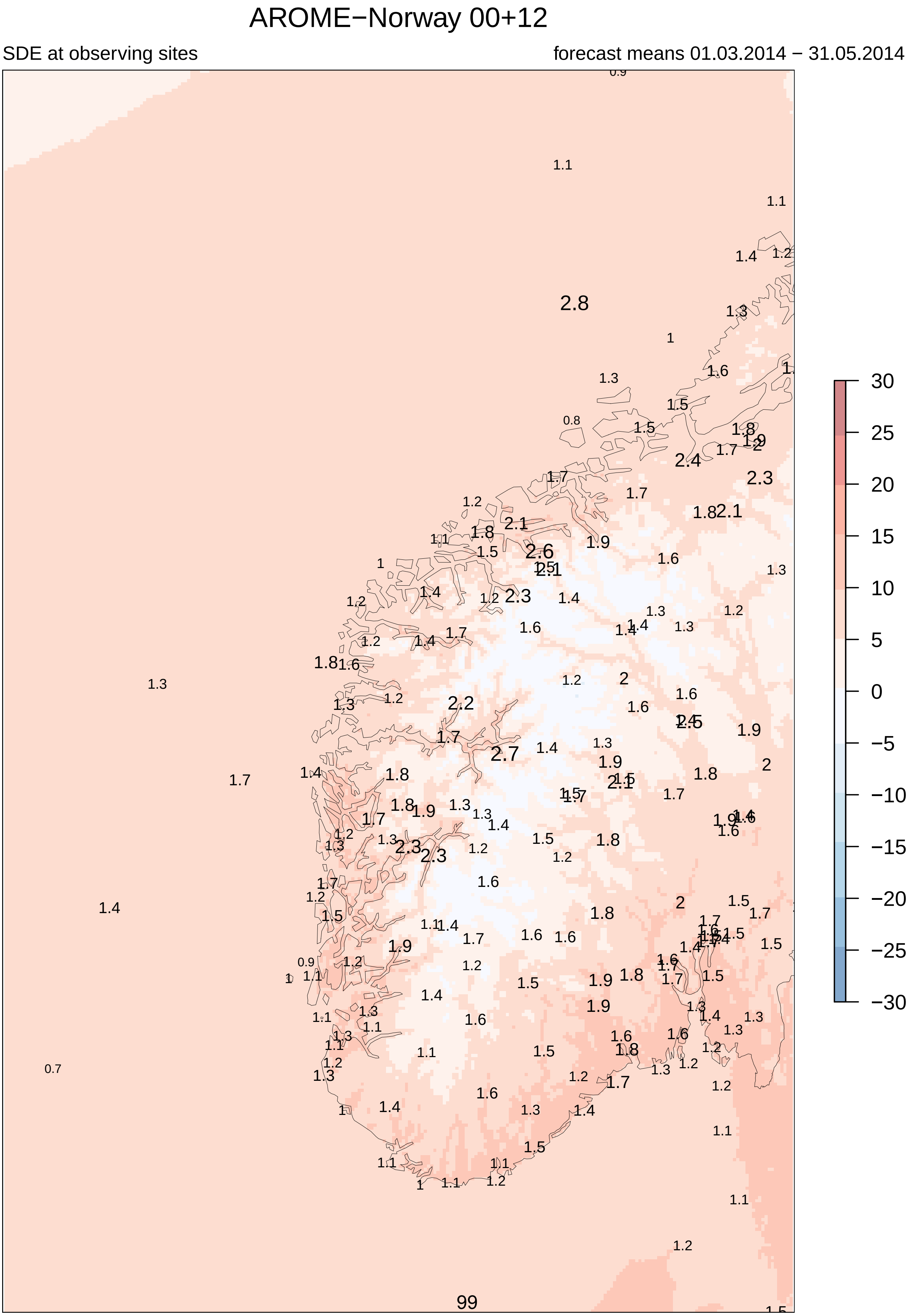


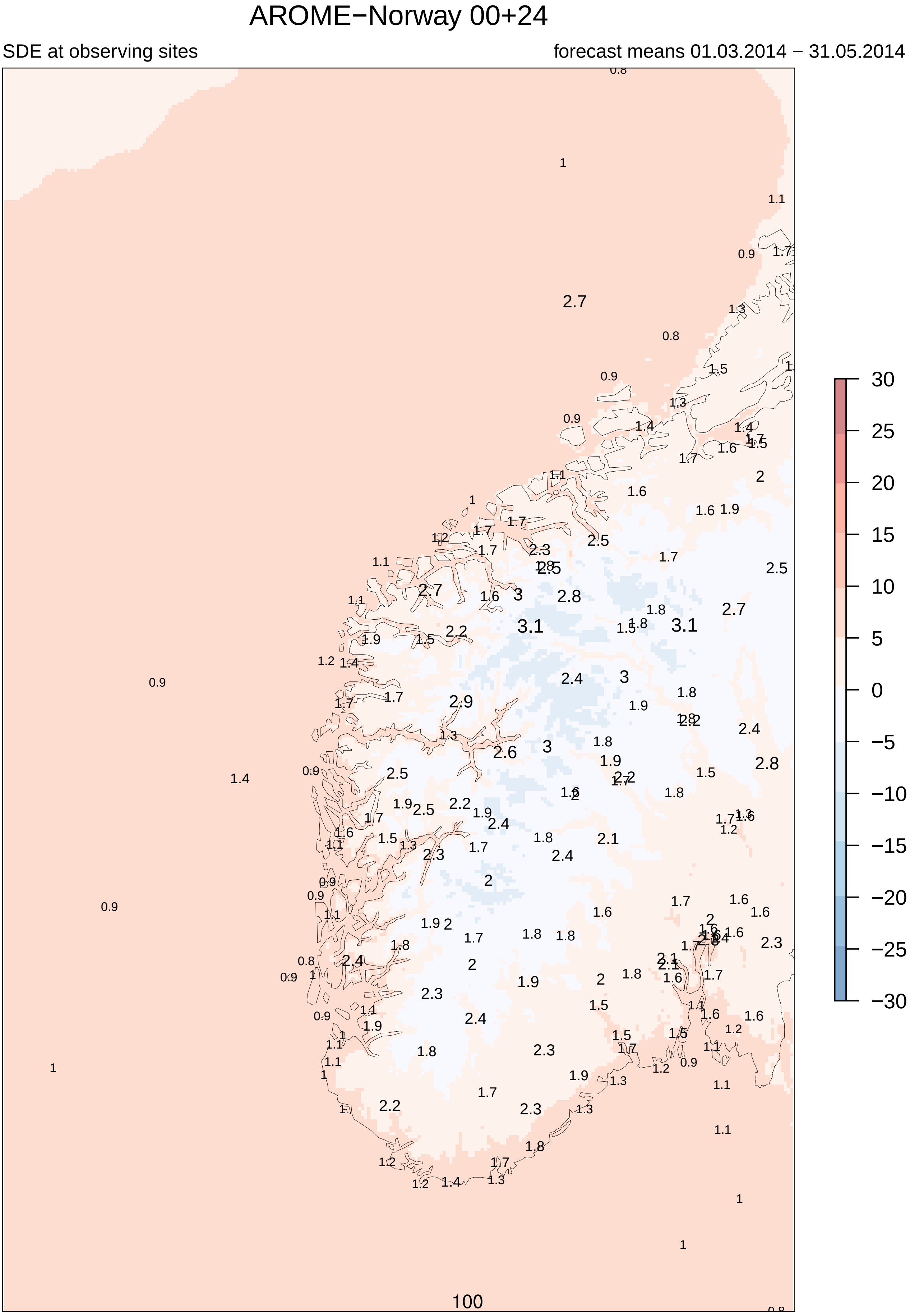
AROME−Norway 00+24

ME at observing sites

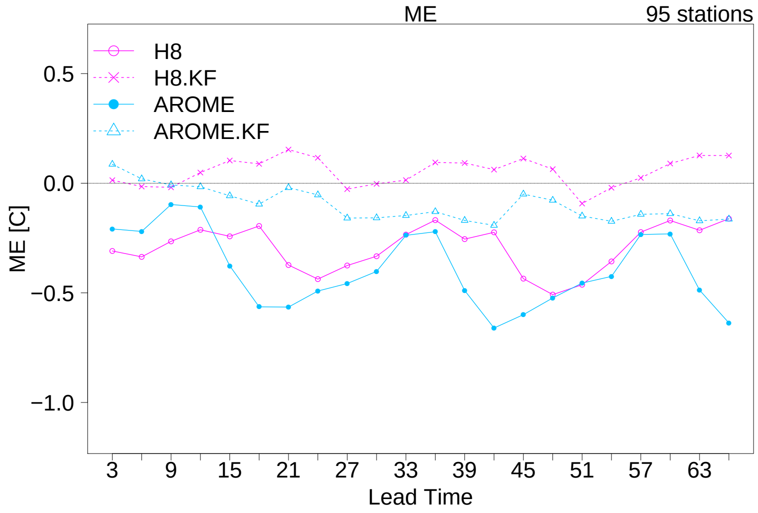
forecast means 01.03.2014 − 31.05.2014

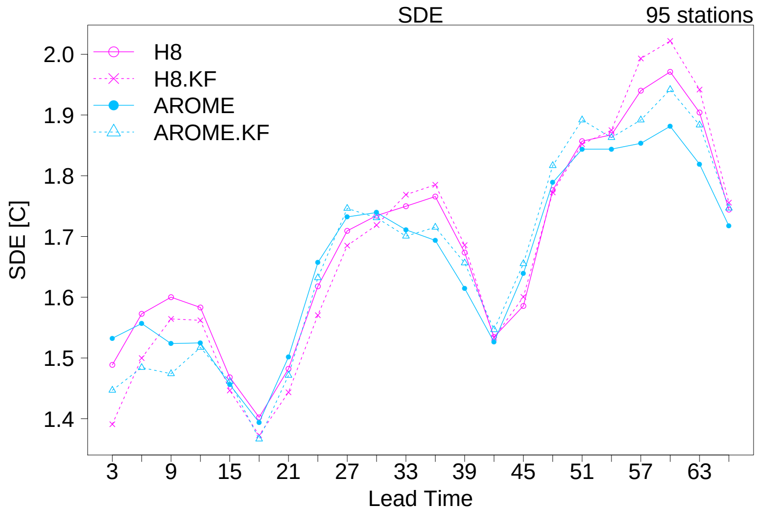


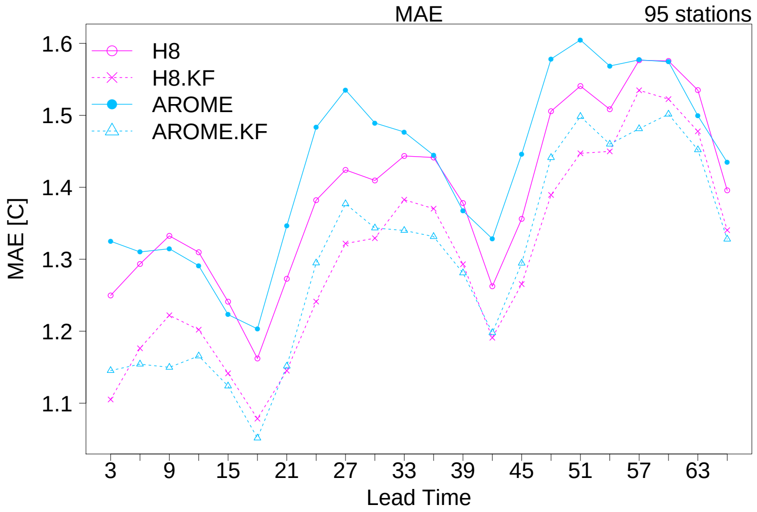

AROME−Norway 00+12
SDE at observing sites
forecast means 01.03.2014 − 31.05.2014
0.9
1.1
1.1
1.4
1.2
2.8
1.3
1
1.6
1.3
1.5
0.8
1.5
1.8
1.9
1.7
2
2.4
2.3
1.7
1.7
1.2
1.8
2.1
2.1
1.1
1.8
1.9
1.5
2.6
1.6
1
2.5
2.1
1.3
1.4
1.2
2.3
1.4
1.2
1.2
1.3
1.4
1.3
1.4
1.6
1.2
1.4
1.7
1.8
1.6
1.3
1.2
2
1.3
1.2
2.2
1.6
1.6
2.5
1.7
1.4
1.9
2.7
1.3
2
1.7
1.4
1.8
1.9
1.8
1.5
2.1
1.7
1.8
1.9
1.3
1.3
1.7
1.9
1.4
1.7
1.4
1.6
1.2
1.3
2.3
2.3
1.2
1.5
1.8
1.3
1.2
1.7
1.6
1.4
1.2
1.5
2
1.8
1.5
1.7
1.1
1.4
1.7
1.6
1.6
1.7
1.6
1.5
1.5
1.9
1.4
0.9
1.2
1.2
1.6
1.7
1
1.1
1.5
1.9
1.8
1.7
1.5
1.4
1.9
1.3
1.1
1.3
1.4
1.6
1.3
1.1
1.3
1.6
1.6
1.2
1.2
1.1
1.5
1.8
1.3
1.2
0.7
1.3
1.2
1.7
1.2
1.1
1.4
1.6
1.3
1.4
1.1
1.5
1.1
1.1
1
1.1
1.2
1.1
1.2
1.5
−30
−25
−20
−15
−10
−5
0
5
10
15
20
25
30

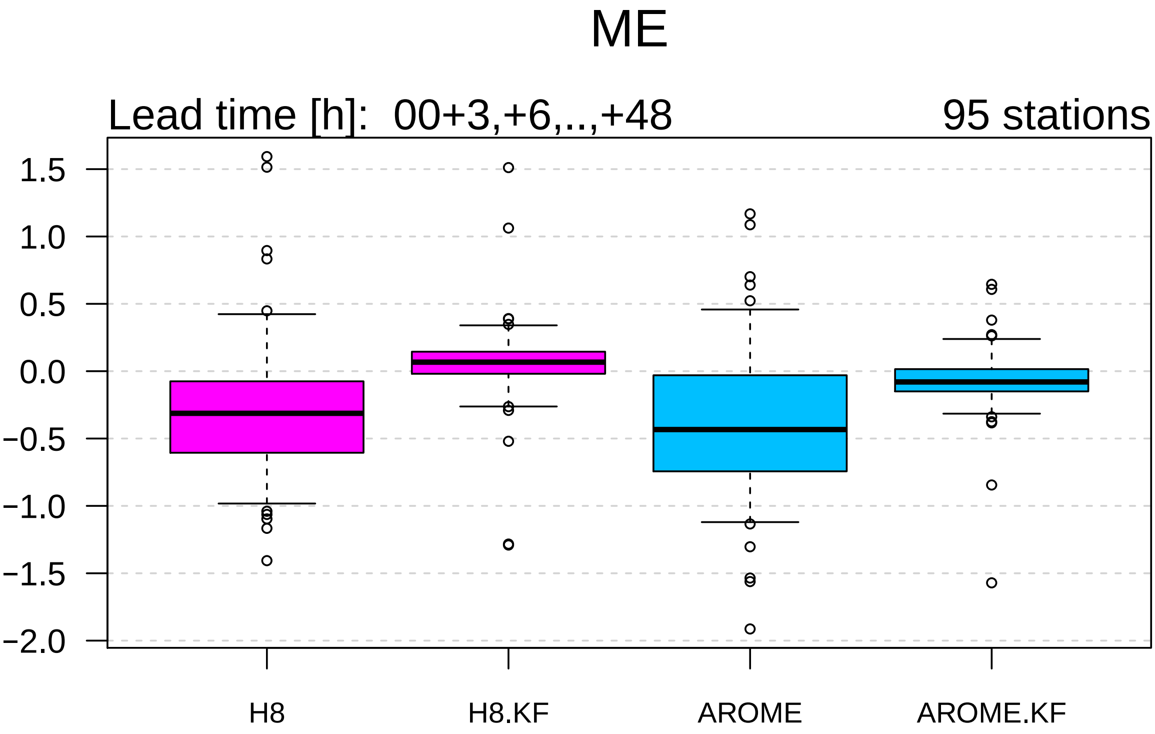

AROME−Norway 00+24
SDE at observing sites
forecast means 01.03.2014 − 31.05.2014
30
25
20
15
10
5
0
−5
−10
−15
−20
−25
−30
100

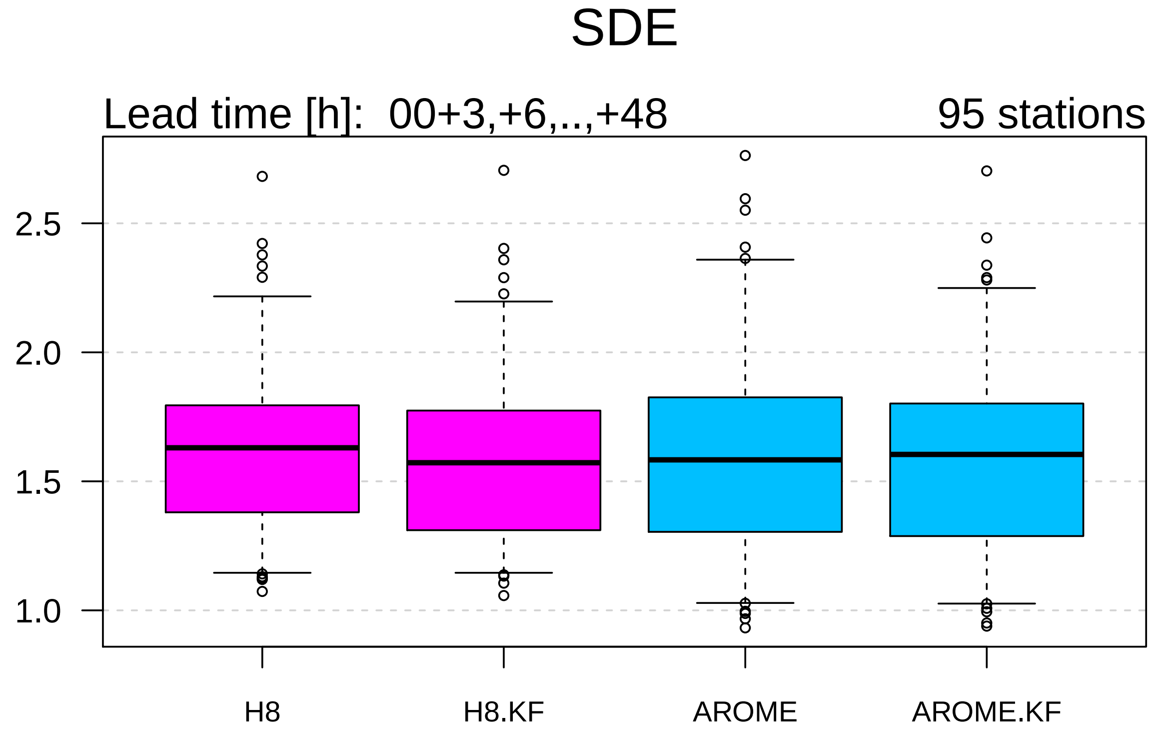
6.7 Post processed temperature 2m



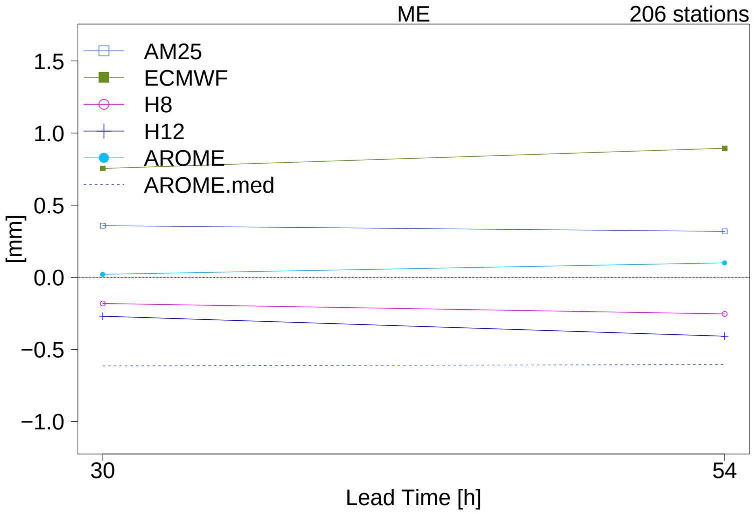


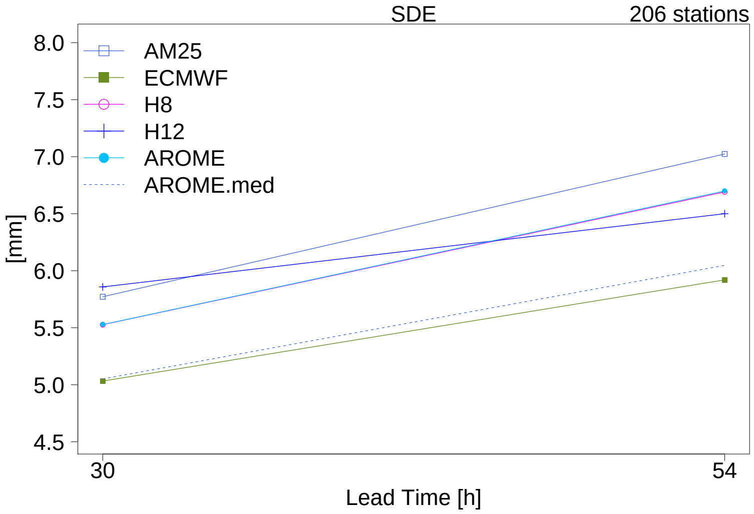


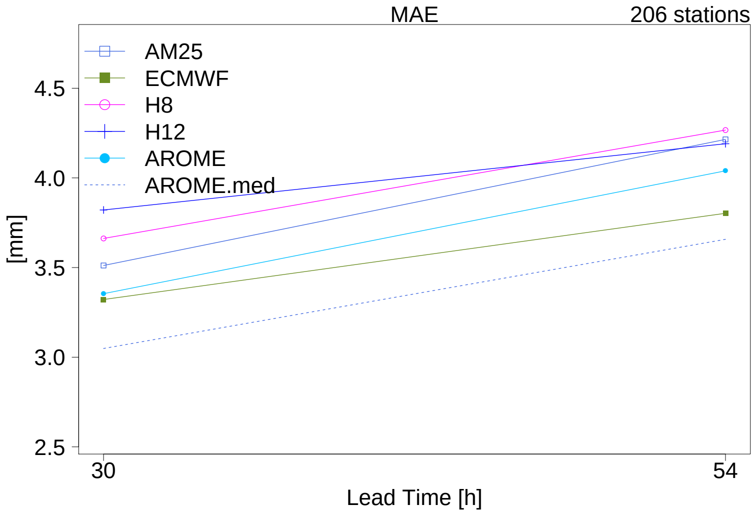

ME
Lead time [h]: 00+3,+6,..,+48
95 stations
1.5
1.0
0.5
0.0
−0.5
−1.0
−1.5
−2.0
H8
H8.KF
AROME
AROME.KF

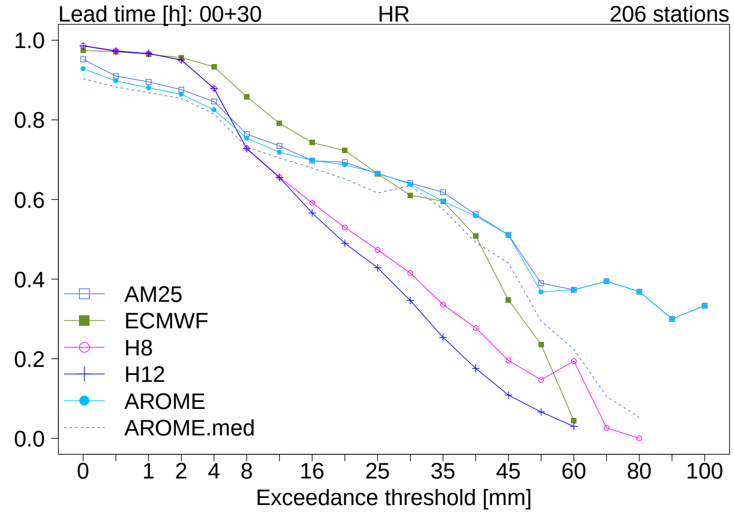

SDE
Lead time [h]: 00+3,+6,..,+48
95 stations
2.5
2.0
1.5
1.0
H8
H8.KF
AROME
AROME.KF

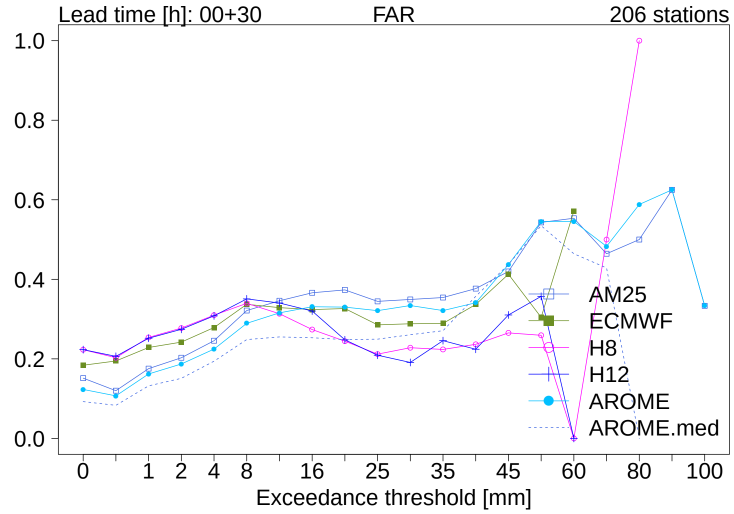
6.8 Daily precipitation

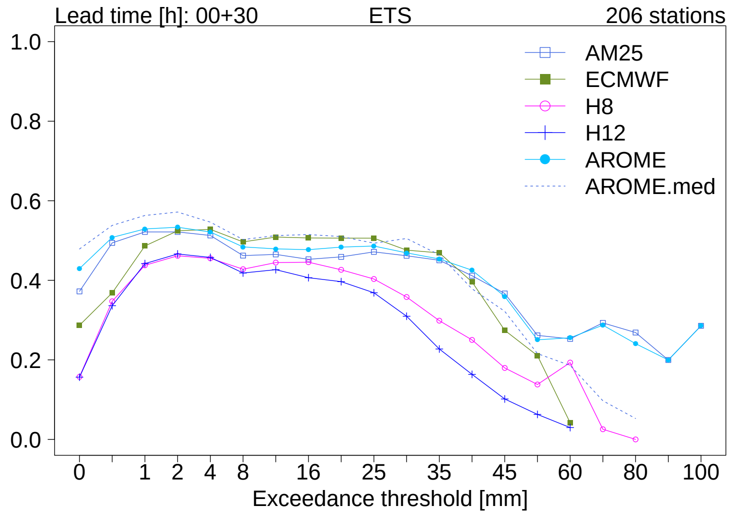


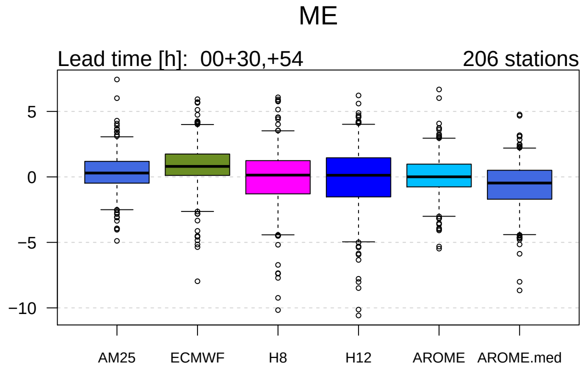


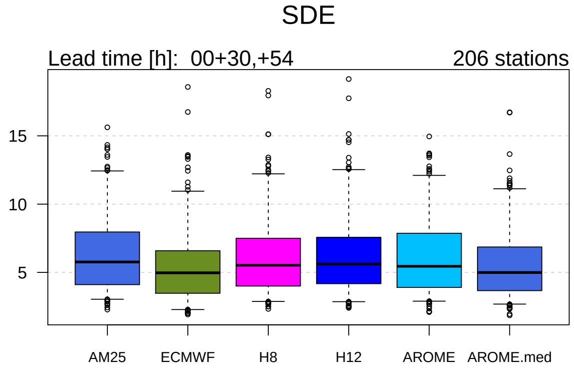



Lead time [h]: 00+30
HR
206 stations
1.0
0.8
0.6
0.4
0.2
0.0
AM25
ECMWF
H8
H12
AROME
AROME.med
0
1
2
4
8
16
25
35
45
60
80
100
Exceedance threshold [mm]


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





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

OBS

AM25

	[0,0.1]	(0.1,5]	(5,20]	(20,50]	(50,Inf]	Sum
[0,0.1]	5752	1576	72	2	0	7402
(0.1,5]	1713	5011	1397	62	2	8185
(5,20]	260	2087	3700	537	21	6605
(20,50]	25	137	609	838	165	1774
(50,Inf]	3	9	16	96	83	207
Sum	7753	8820	5794	1535	271	24173

OBS

H8

	[0,0.1]	(0.1,5]	(5,20]	(20,50]	(50,Inf]	Sum
[0,0.1]	3742	578	18	2	0	4340
(0.1,5]	3693	5364	1316	50	0	10423
(5,20]	294	2802	4158	816	42	8112
(20,50]	24	72	302	658	204	1260
(50,Inf]	0	4	0	9	25	38
Sum	7753	8820	5794	1535	271	24173

OBS

ECMWF

	[0,0.1]	(0.1,5]	(5,20]	(20,50]	(50,Inf]	Sum
[0,0.1]	4035	583	10	2	0	4630
(0.1,5]	3522	5248	656	10	0	9436
(5,20]	183	2902	4501	519	3	8108
(20,50]	13	86	625	970	209	1903
(50,Inf]	0	1	2	34	59	96
Sum	7753	8820	5794	1535	271	24173

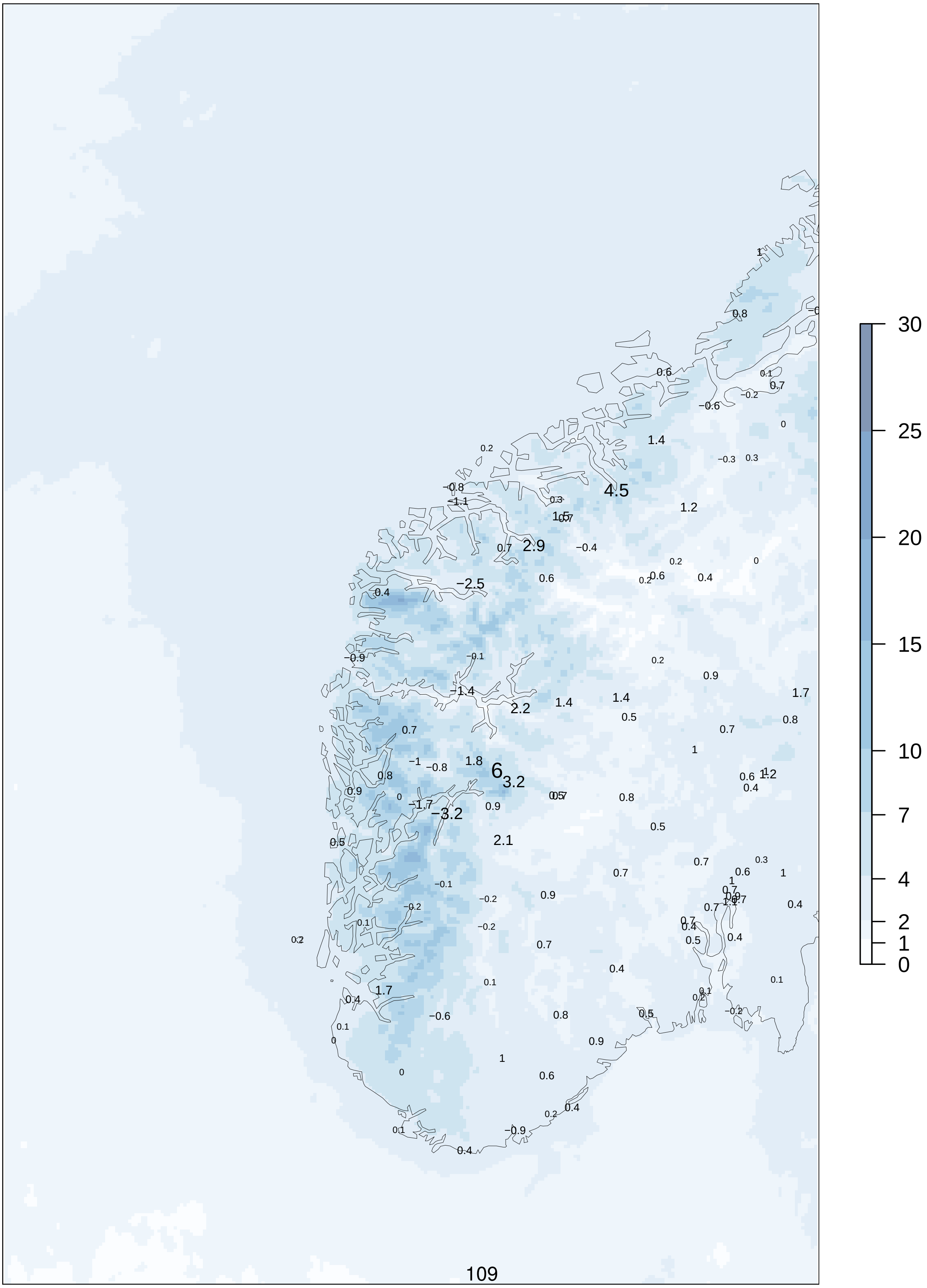
OBS

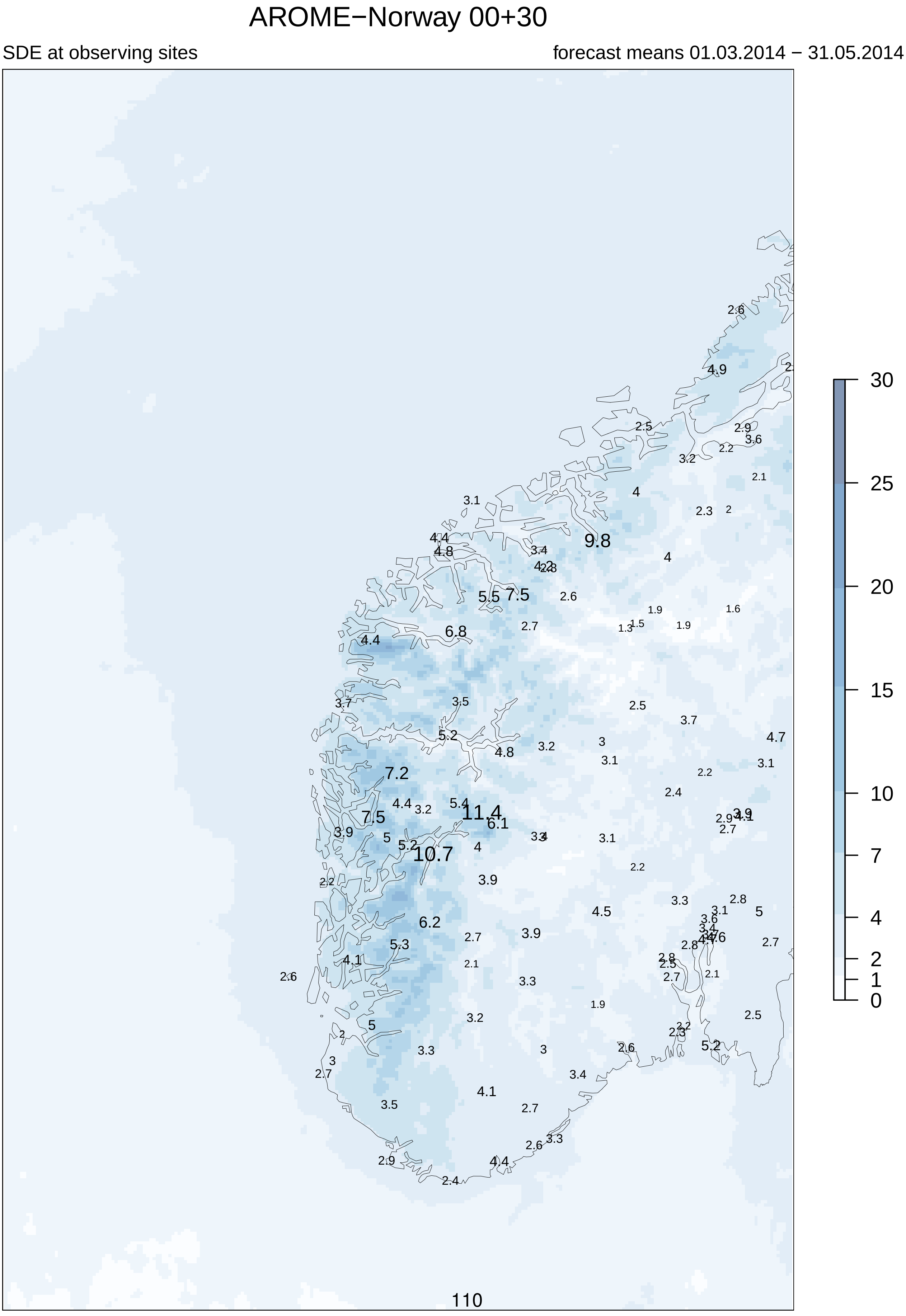
AROME

	[0,0.1]	(0.1,5]	(5,20]	(20,50]	(50,Inf]	Sum
[0,0.1]	5914	1706	68	3	0	7691
(0.1,5]	1620	5087	1449	59	1	8216
(5,20]	201	1919	3700	537	24	6381
(20,50]	14	106	562	841	165	1688
(50,Inf]	4	2	15	95	81	197
Sum	7753	8820	5794	1535	271	24173

AROME−Norway 00+30

ME at observing sites forecast means 01.03.2014 − 31.05.2014




AROME−Norway 00+30
SDE at observing sites
forecast means 01.03.2014 − 31.05.2014
30
25
20
15
10
7
4
2
1
0

7 Northern Norway

7.1 Comments to the verification results

Just as earlier period mean 10m winds from Arome-Norway have a better frequency bias than AM25 (MetCoOp), but compared to observations it still has too few incidents of the two highest wind speed classes. Number of incidents of wind > $17ms^{-1}$ is 1485 (observations), 965 (Arome-Norway) and 808 (Arome-MetCoOp). At max mean wind speed the corresponding number of incidents were 2144 (observations), 908 (Arome-Norway) and 1280 (Arome-Norway-PP). Looking forward to see if the new post processing routine for Arome-MetCoOp will improve that. For max wind it seem only to be the lowest winds (< $3ms^{-1}$) where Arome-Norway-PP overpredicts wind speed.

Interesting to see the new verfication of windgusts, comparing both windgusts at 10 m with the model wind at 925hPa. It supports the forecaster practise to use the wind at 925 hPa as the best estimates at high wind speeds (gust >$24.5ms^{-1}$). As expected, for wind gust below $17ms^{-1}$, the 925 hPa wind overpredicts wind gusts significantly. But it is not used by forecasters at those low wind speeds.

For precipitation Arome MetCoOp is very promising regarding the range >20mm/24h. It seems to predict the highest intensities without overprediction. The well known Arome weakness of shallow winter convection at sea and on the coastline during onshore winds was clearly seen at several occasions. Gunnar Noer wrote an extensive report of a case 22. April.

"The 22 April 2014 case is typical for situations with westerly to northerly flow with a mix of deep and shallow convection over the Norwegian seas, and strong convection associated with orographic lifting across the coast. This is a common weather type in Northern Norway, and it accounts for a major part of the precipitation in the winter time in the region. At present, the Arome models are not sufficiently able to produce precipitation from certain types of convective clouds. The problem is pronounced with shallow convection at sea. There is also a pronounced lag in the models ability to develop precipitation in strong orographic lifting, hence the forecast precipitation is displaced inland." From "A precipitation case from 22.April 2014" by Gunnar Noer.

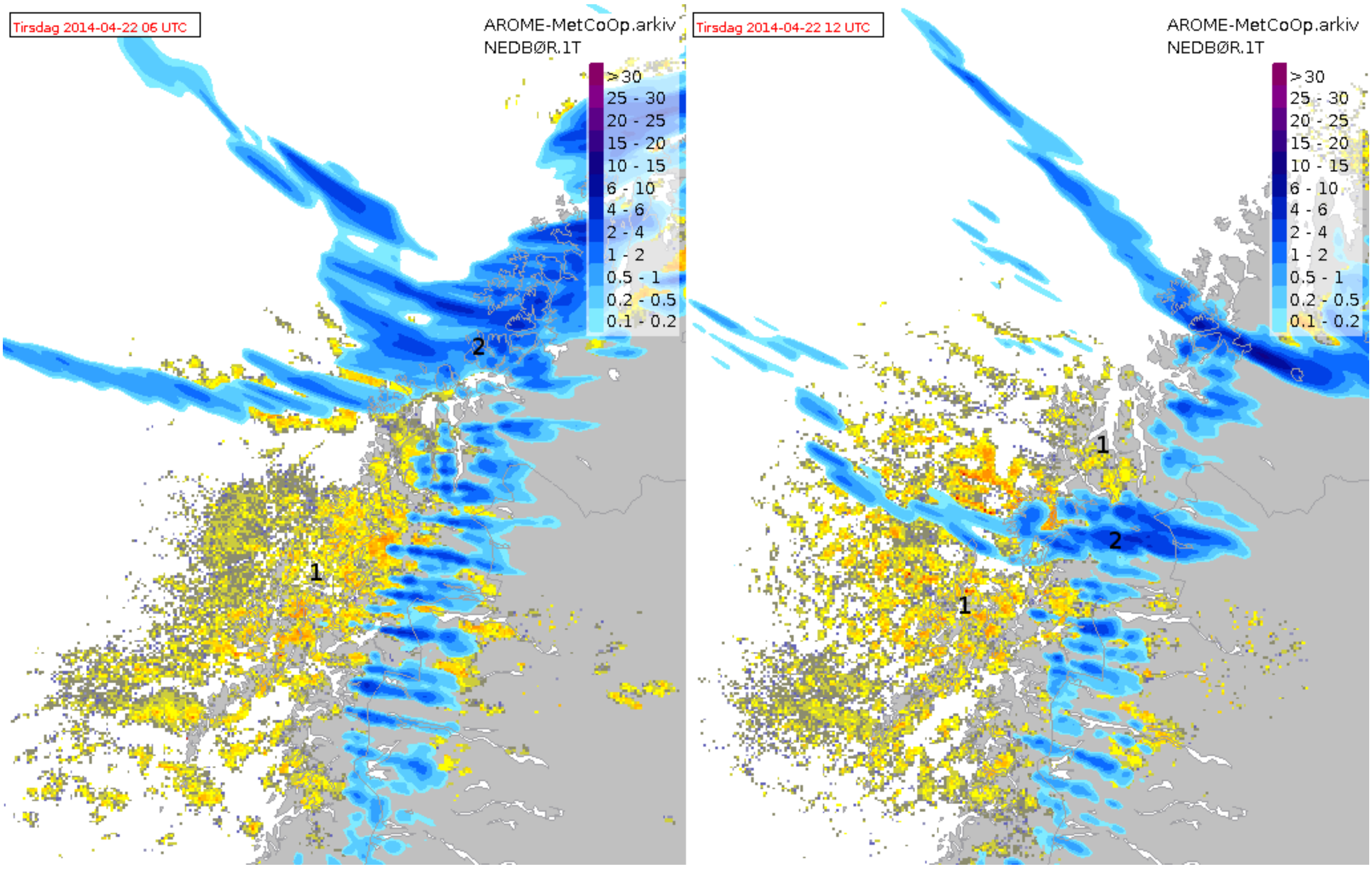
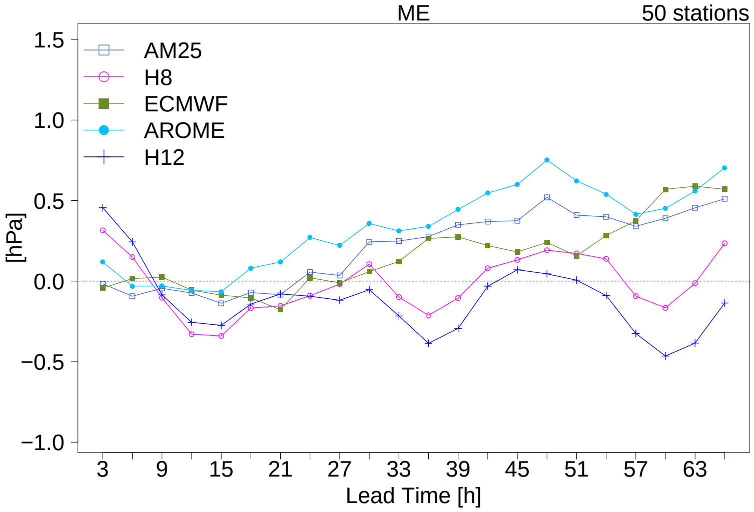
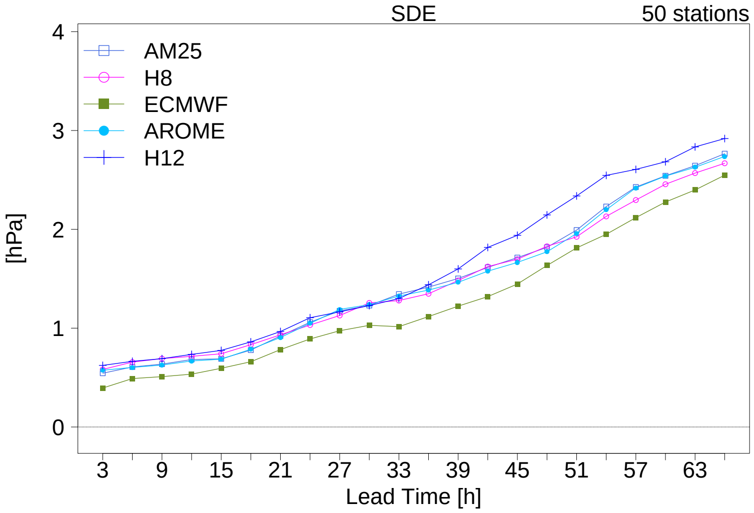
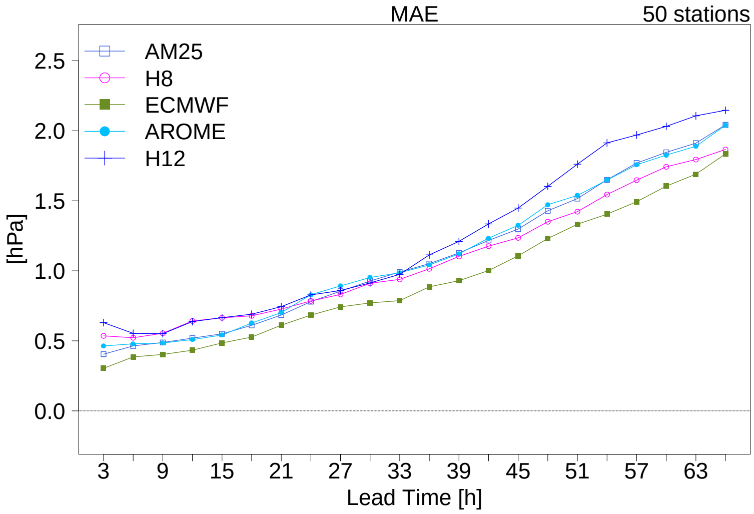


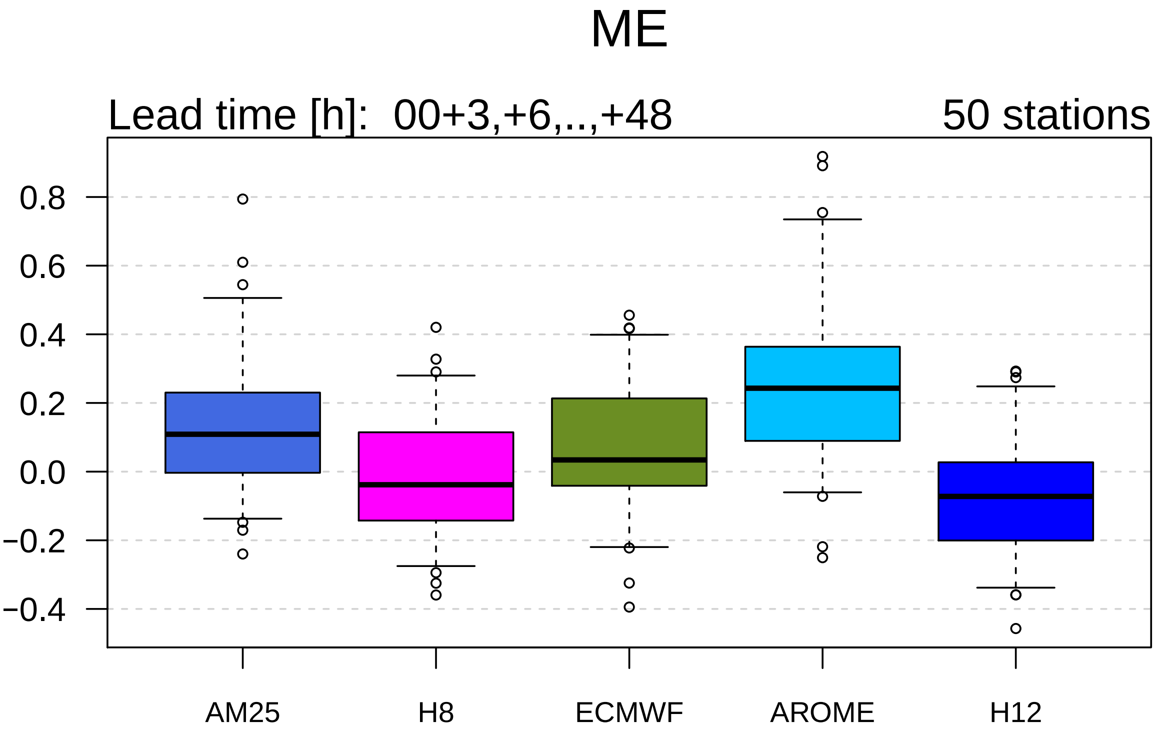
Figure 1: 22.april case

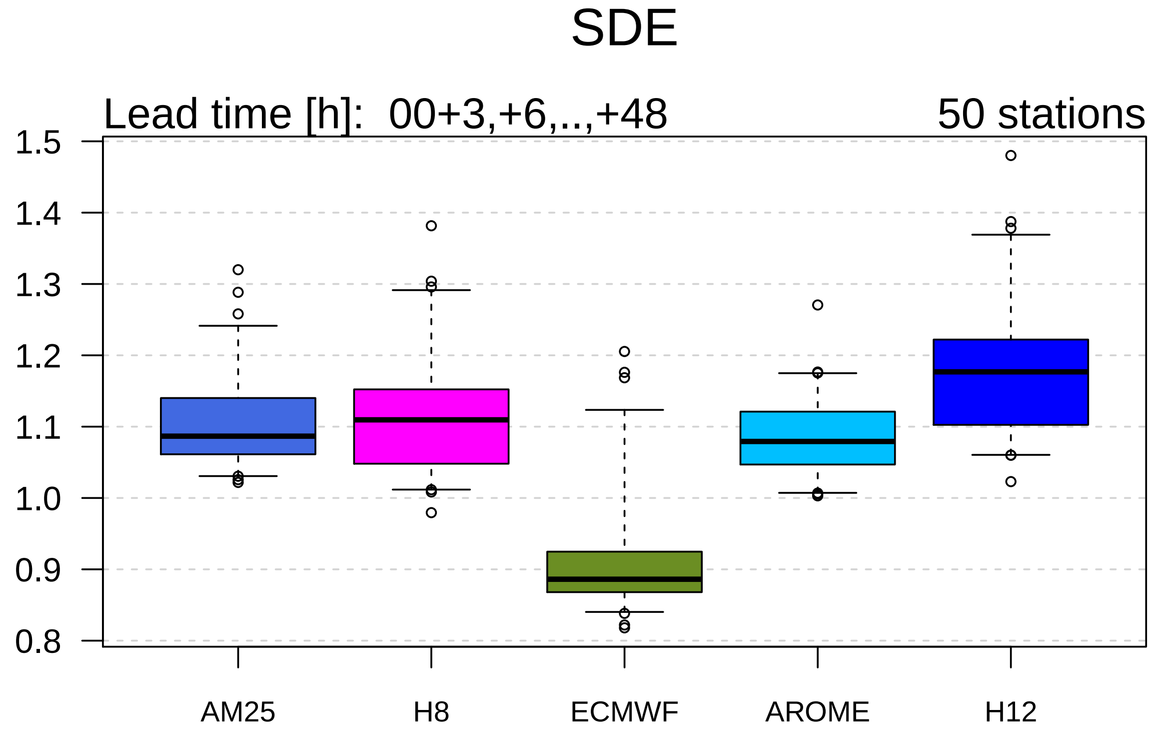
7.2 Pressure


ME
50 stations
AM25
H8
ECMWF
AROME
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]

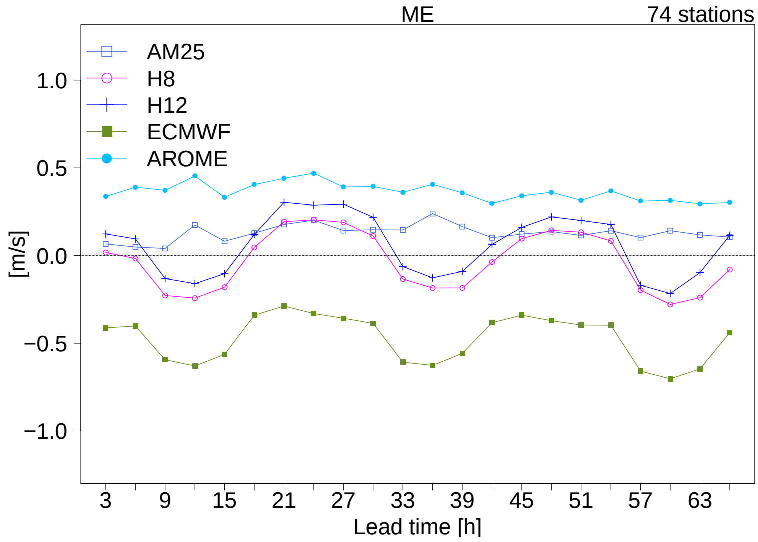

SDE
50 stations
AM25
H8
ECMWF
AROME
H12
[hPa]
4
3
2
1
0
3
9
15
21
27
33
39
45
51
57
63
Lead Time [h]

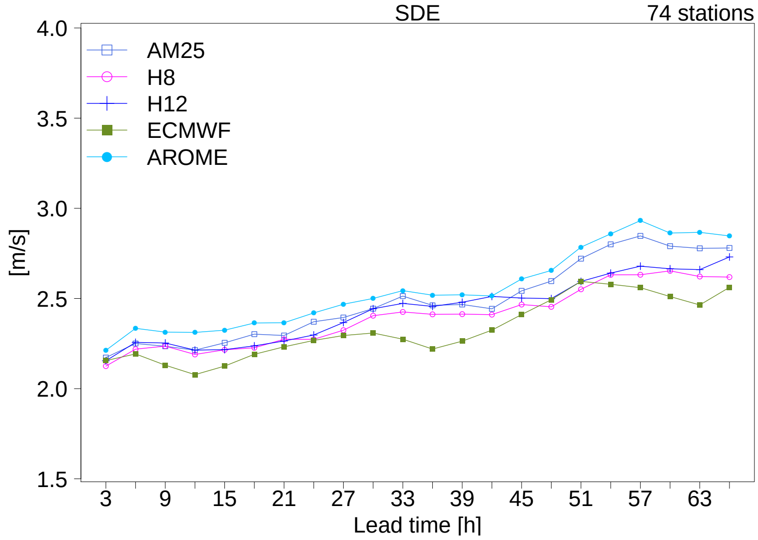

MAE
50 stations
AM25
H8
ECMWF
AROME
H12
[hPa]
2.5
2.0
1.5
1.0
0.5
0.0
3
9
15
21
27
33
39
45
51
57
63
Lead Time [h]

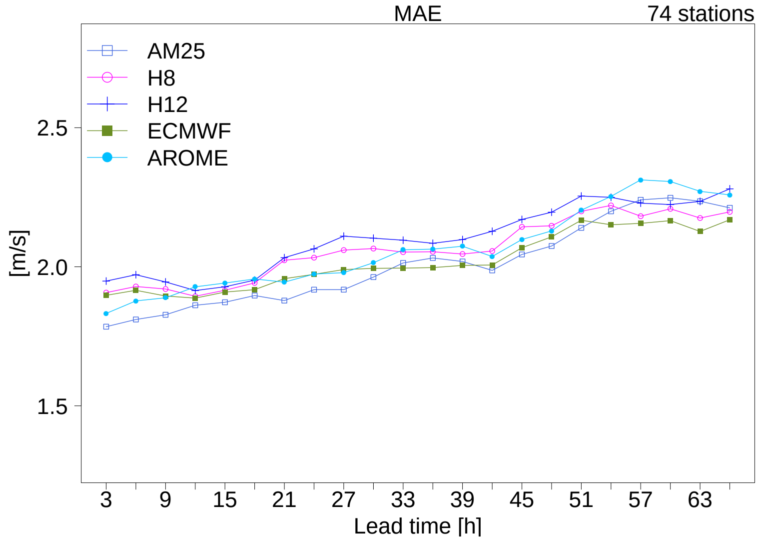

ME
Lead time [h]: 00+3,+6,..,+48
50 stations
0.8
0.6
0.4
0.2
0.0
−0.2
−0.4
AM25
H8
ECMWF
AROME
H12

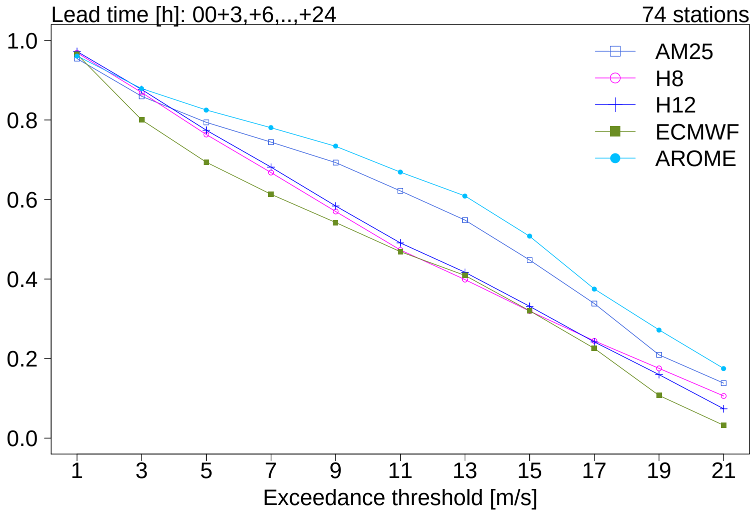

SDE
Lead time [h]: 00+3,+6,..,+48
50 stations
1.5
1.4
1.3
1.2
1.1
1.0
0.9
0.8
AM25
H8
ECMWF
AROME
H12

7.3 Wind Speed 10m

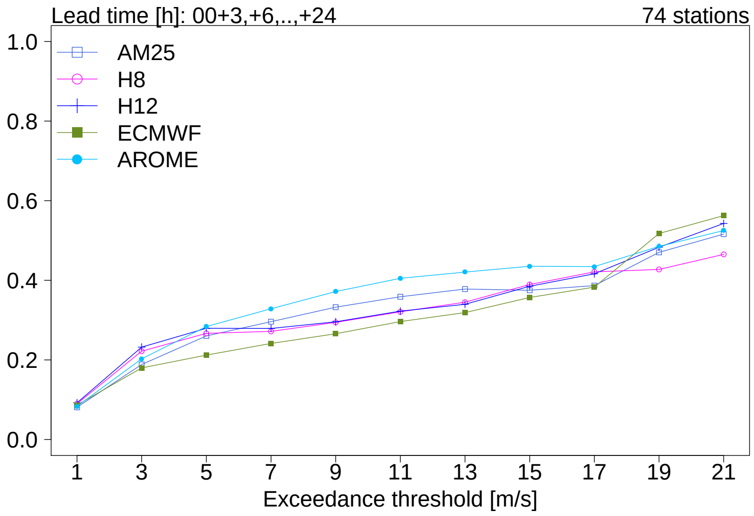




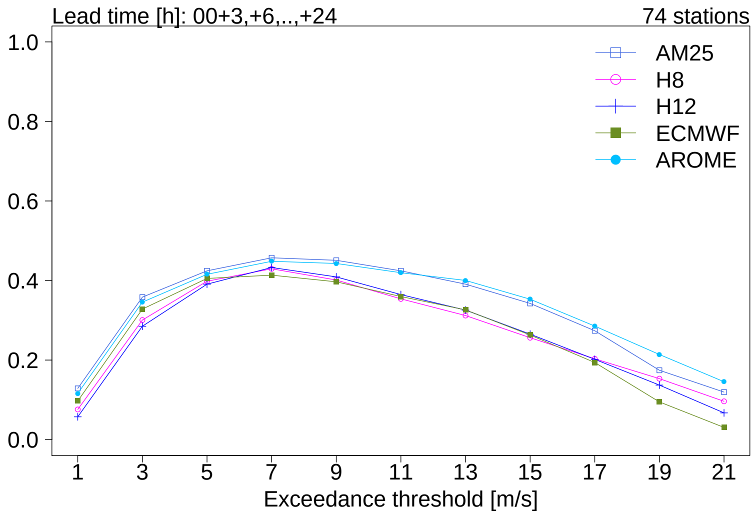




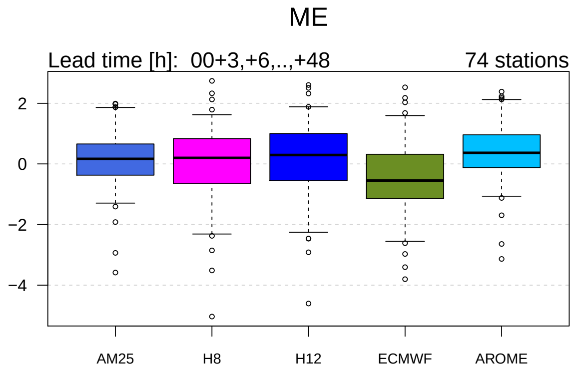
Hit Rate

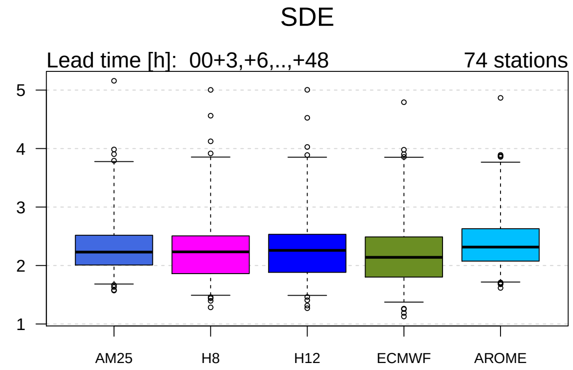


False Alarm Ratio



Equitable Threat Score





Lead time [h]: 00+3,+6,..,+48 UTC 74 stations

OBS

AM25

	[0,3]	(3,11]	(11,17]	(17,21]	(21,Inf]	Sum
[0,3]	22498	8689	56	4	1	31248
(3,11]	12203	39610	3038	157	55	55063
(11,17]	164	2938	3602	594	195	7493
(17,21]	0	53	242	265	120	680
(21,Inf]	0	4	30	31	63	128
Sum	34865	51294	6968	1051	434	94612

OBS

H8

	[0,3]	(3,11]	(11,17]	(17,21]	(21,Inf]	Sum
[0,3]	19486	8025	55	2	1	27569
(3,11]	15295	41357	4021	339	148	61160
(11,17]	82	1884	2671	486	166	5289
(17,21]	2	27	203	203	71	506
(21,Inf]	0	1	18	21	48	88
Sum	34865	51294	6968	1051	434	94612

OBS

ECMWF

	[0,3]	(3,11]	(11,17]	(17,21]	(21,Inf]	Sum
[0,3]	24106	12120	153	4	0	36383
(3,11]	10694	37526	4070	274	47	52611
(11,17]	65	1615	2568	576	277	5101
(17,21]	0	32	165	192	88	477
(21,Inf]	0	1	12	5	22	40
Sum	34865	51294	6968	1051	434	94612

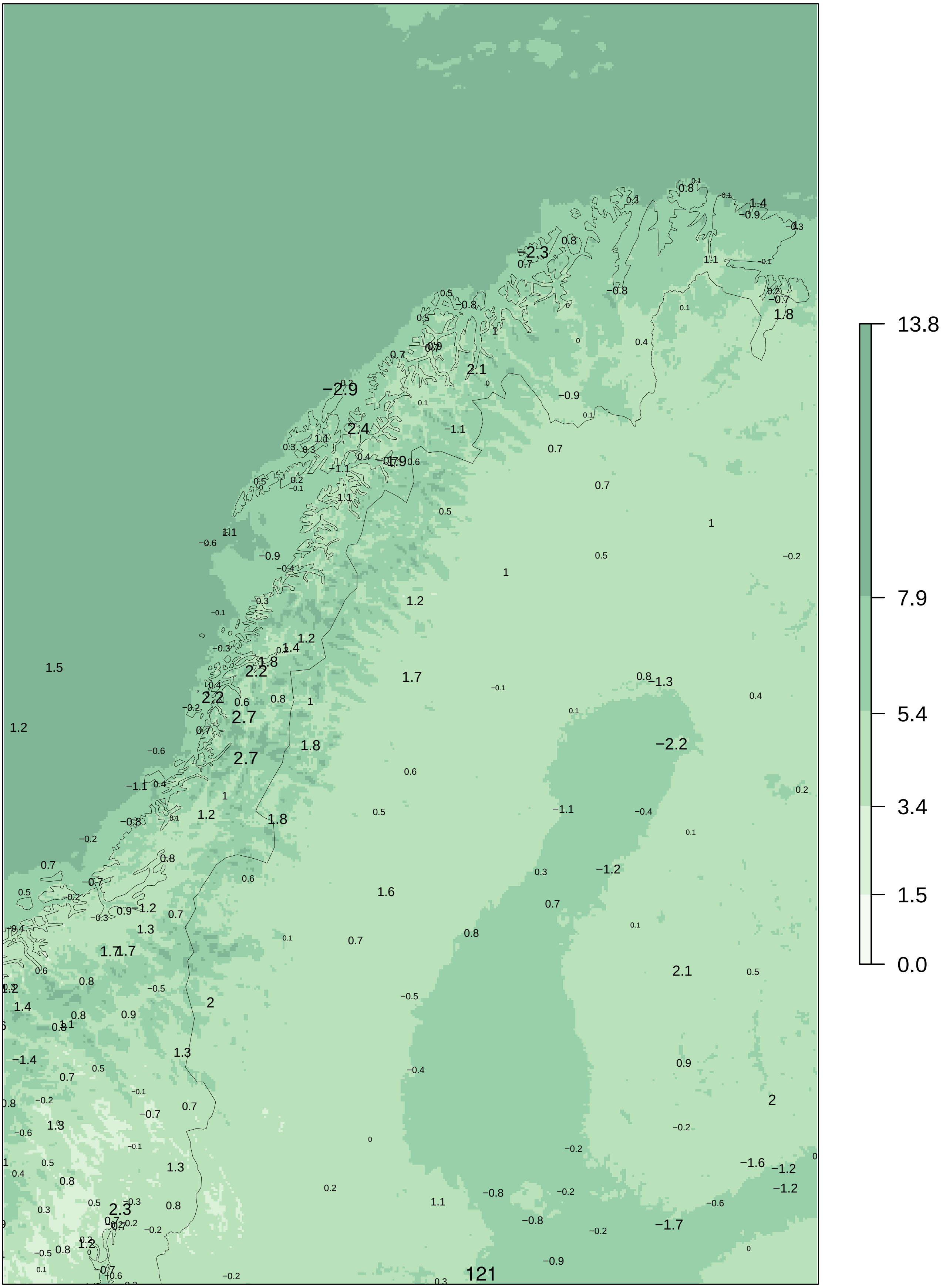
OBS

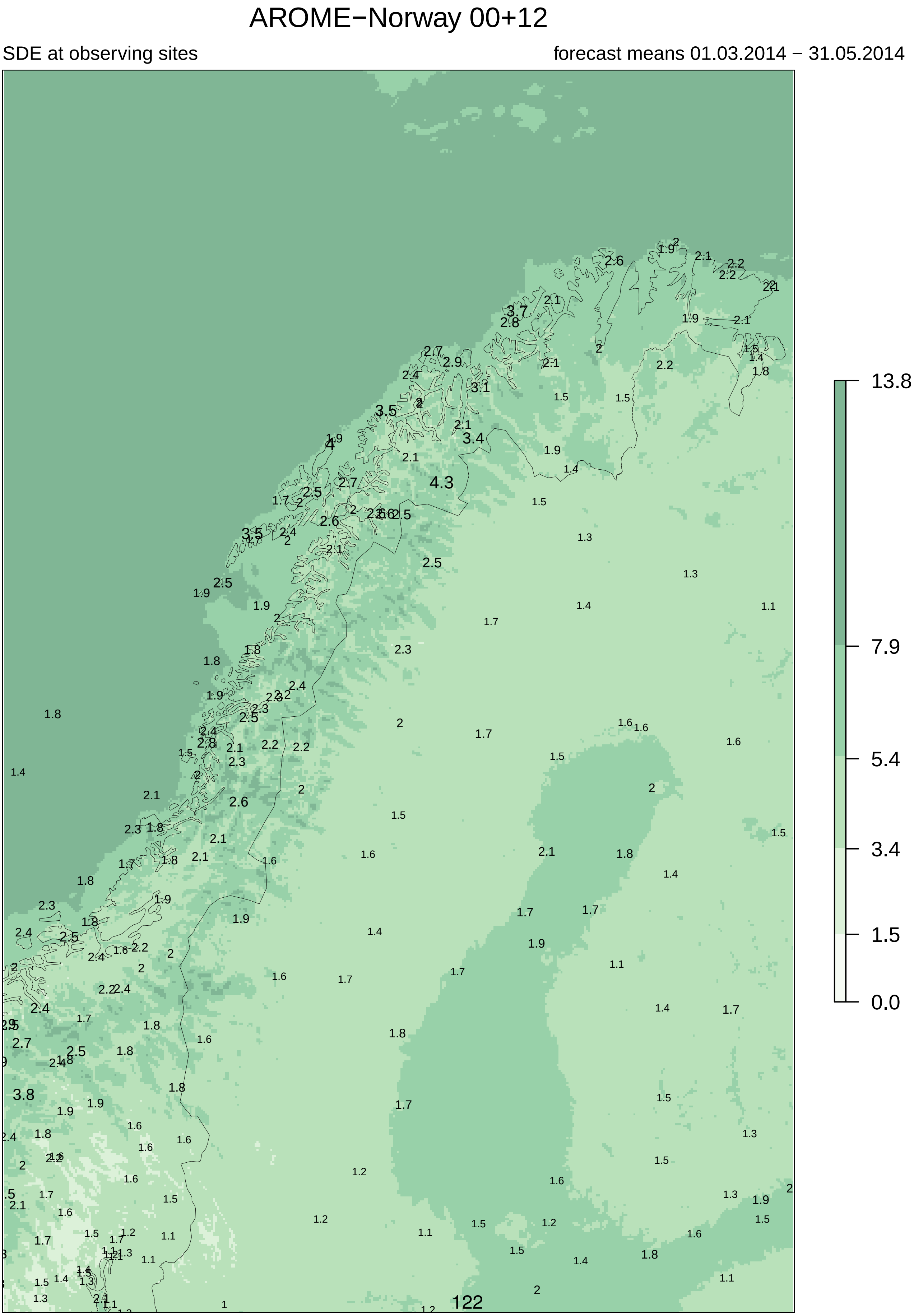
AROME

	[0,3]	(3,11]	(11,17]	(17,21]	(21,Inf]	Sum
[0,3]	21221	7722	49	2	1	28995
(3,11]	13414	39846	2719	139	36	56154
(11,17]	228	3640	3848	585	197	8498
(17,21]	2	78	322	285	126	813
(21,Inf]	0	8	30	40	74	152
Sum	34865	51294	6968	1051	434	94612

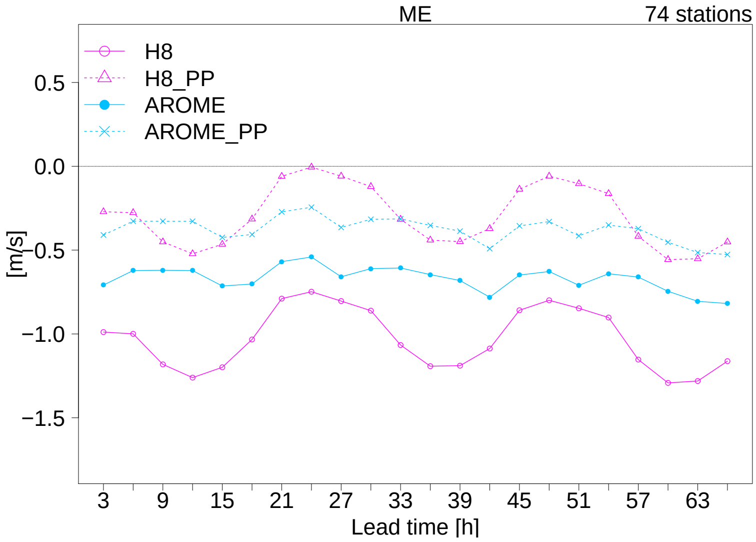
AROME−Norway 00+12

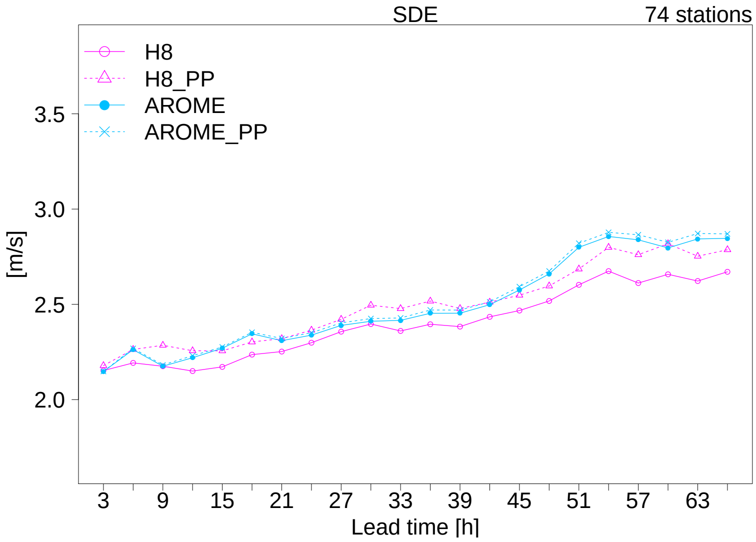
ME at observing sites forecast means 01.03.2014 − 31.05.2014

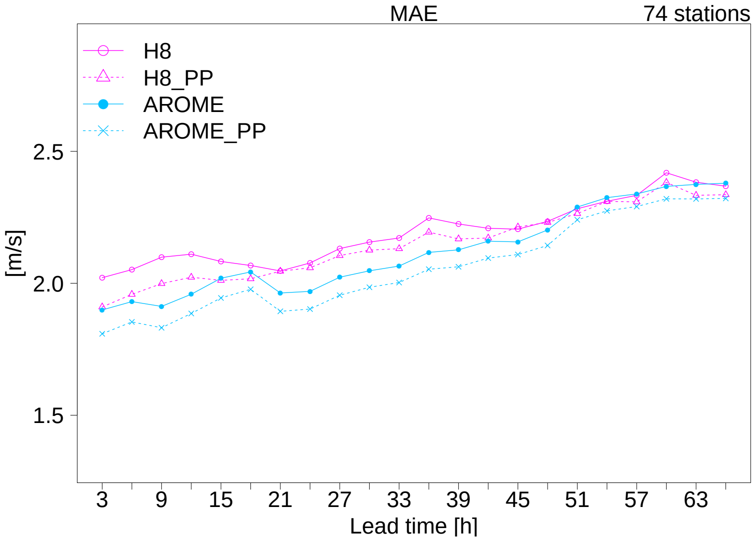


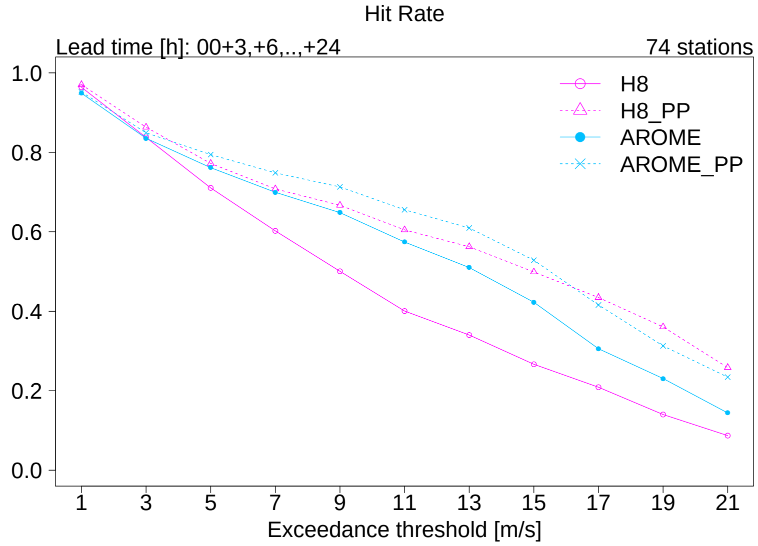

AROME−Norway 00+12
SDE at observing sites
forecast means 01.03.2014 − 31.05.2014
13.8
7.9
5.4
3.4
1.5
0.0

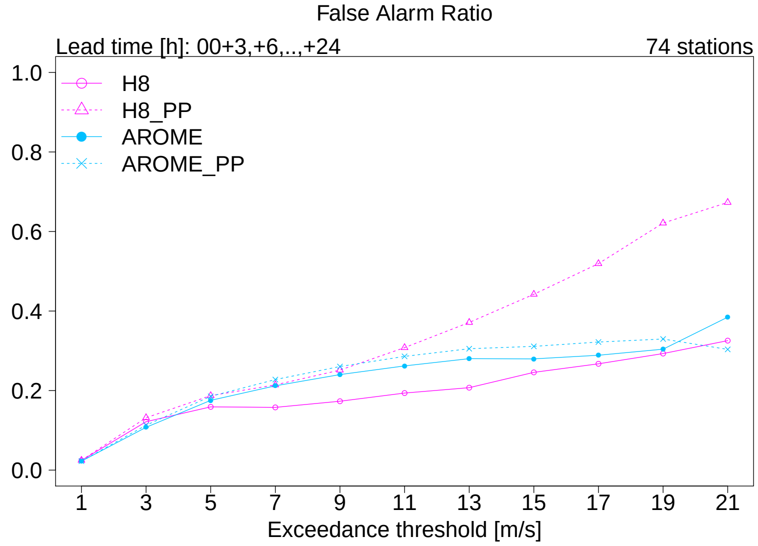
7.4 Max Mean Wind Speed 10m

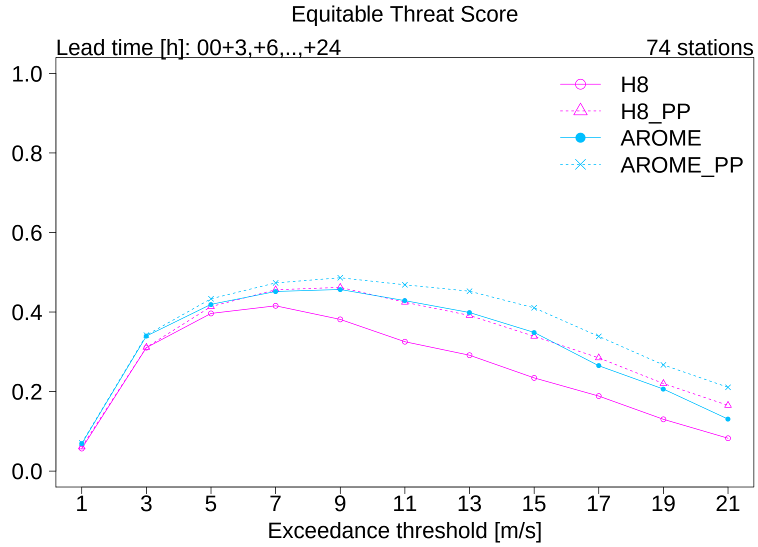


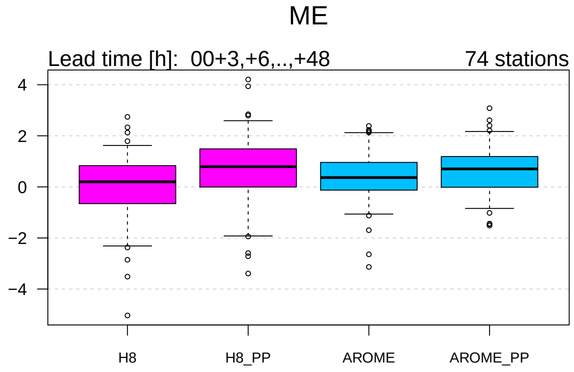


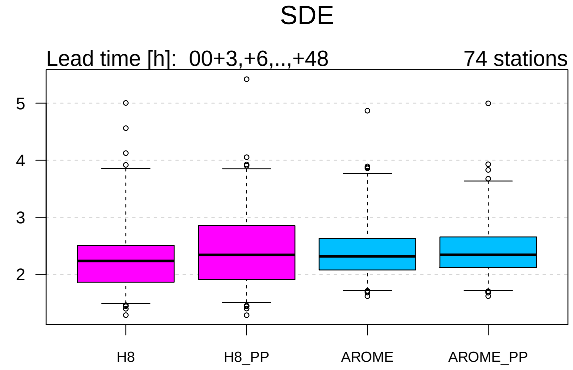



Hit Rate
Lead time [h]: 00+3,+6,..,+24
74 stations
H8
H8_PP
AROME
AROME_PP
1.0
0.8
0.6
0.4
0.2
0.0
1
3
5
7
9
11
13
15
17
19
21
Exceedance threshold [m/s]


False Alarm Ratio
Lead time [h]: 00+3,+6,..,+24
74 stations
H8
H8_PP
AROME
AROME_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
H8
H8_PP
AROME
AROME_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

OBS

		[0,3]	(3,11]	(11,17]	(17,21]	(21,Inf]	Sum
H8	[0,3]	13634	10288	81	3	2	24008
	(3,11]	7733	40793	5911	484	263	55184
	(11,17]	51	1113	2869	744	221	4998
	(17,21]	2	8	133	229	123	495
	(21,Inf]	0	0	13	15	60	88
	Sum	21420	52202	9007	1475	669	84773

OBS

		[0,3]	(3,11]	(11,17]	(17,21]	(21,Inf]	Sum
H8_PP	[0,3]	12748	8657	55	1	2	21463
	(3,11]	8581	40440	4097	278	78	53474
	(11,17]	77	3008	3973	587	299	7944
	(17,21]	12	92	766	388	119	1377
	(21,Inf]	2	5	116	221	171	515
	Sum	21420	52202	9007	1475	669	84773

OBS

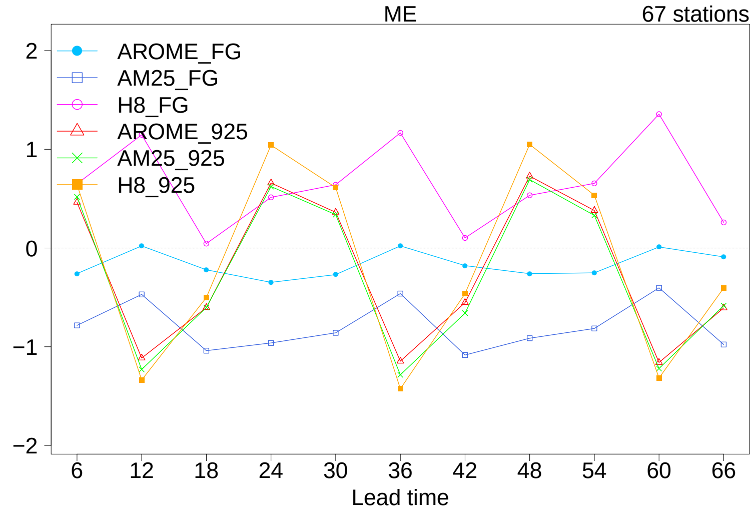
		[0,3]	(3,11]	(11,17]	(17,21]	(21,Inf]	Sum
AROME	[0,3]	14807	10681	68	1	1	25558
	(3,11]	6521	39243	4460	240	66	50530
	(11,17]	91	2240	4240	893	313	7777
	(17,21]	1	36	219	312	191	759
	(21,Inf]	0	2	20	29	98	149
	Sum	21420	52202	9007	1475	669	84773

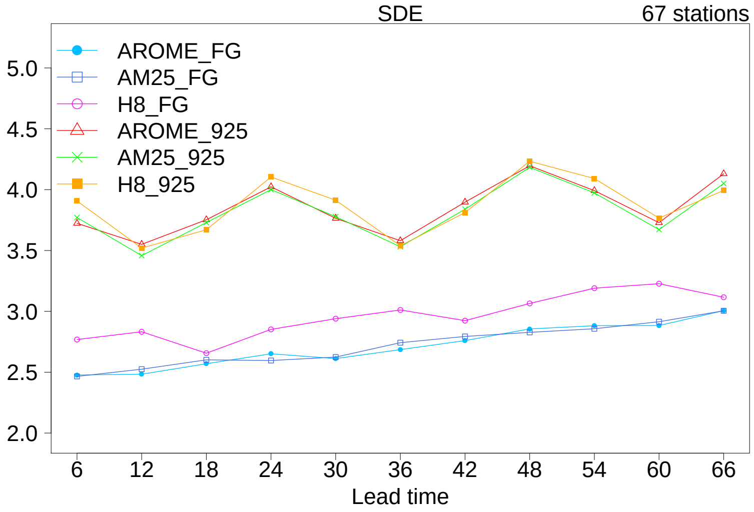
OBS

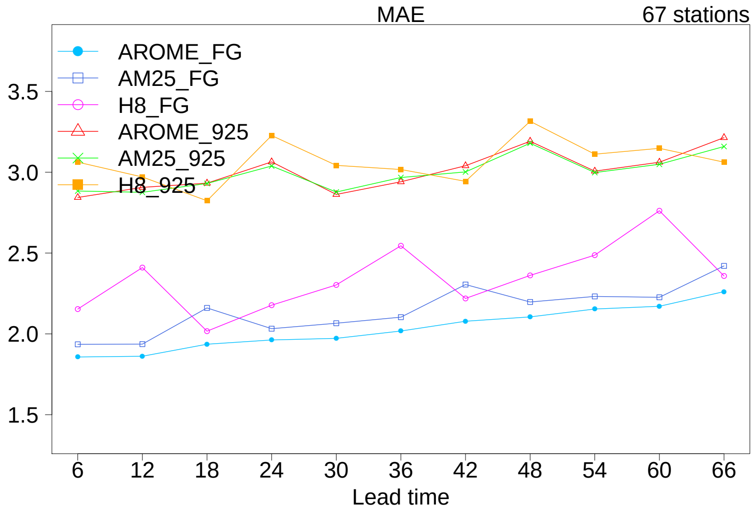
		[0,3]	(3,11]	(11,17]	(17,21]	(21,Inf]	Sum
AROME_PP	[0,3]	14381	9794	54	0	1	24230
	(3,11]	6933	39501	3764	142	29	50369
	(11,17]	101	2850	4823	849	271	8894
	(17,21]	5	54	344	441	219	1063
	(21,Inf]	0	3	22	43	149	217
	Sum	21420	52202	9007	1475	669	84773

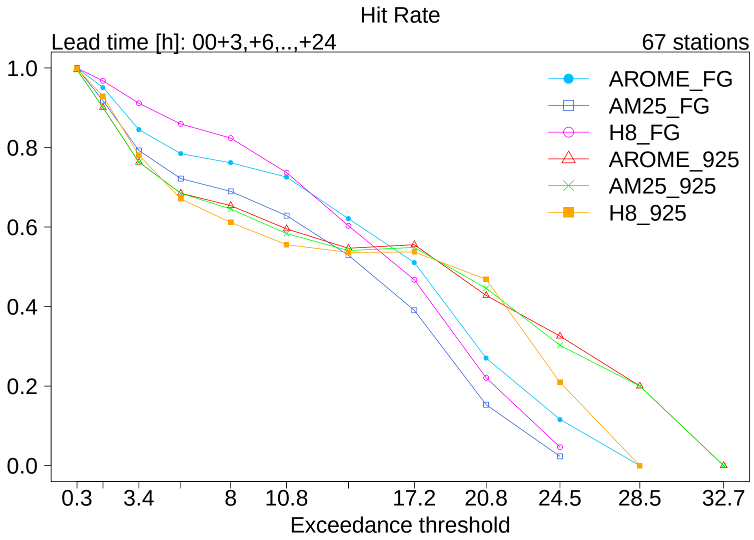
7.5 Wind gust

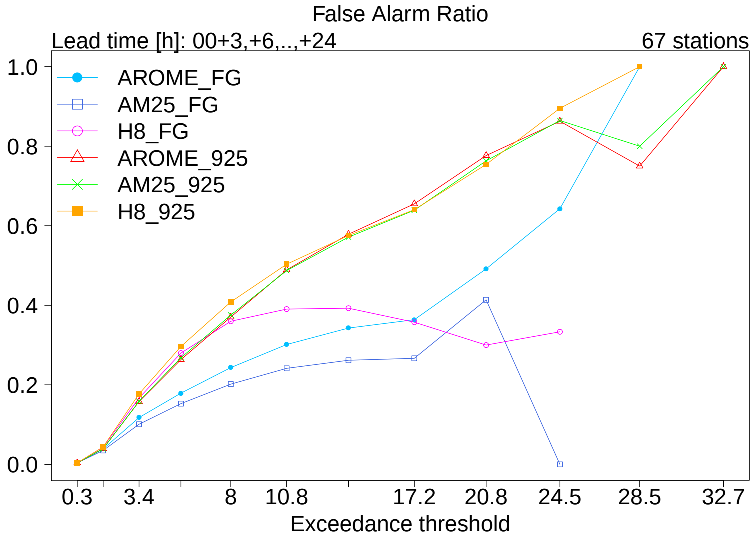
7.5.1 25 March - 31 May

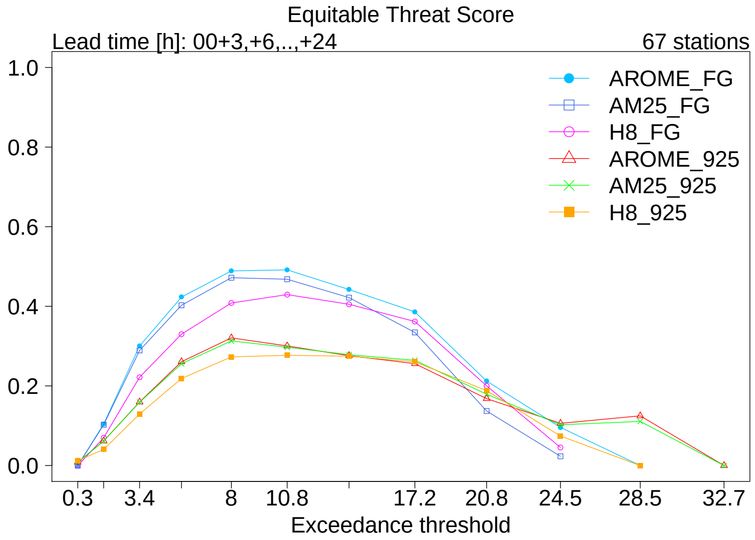




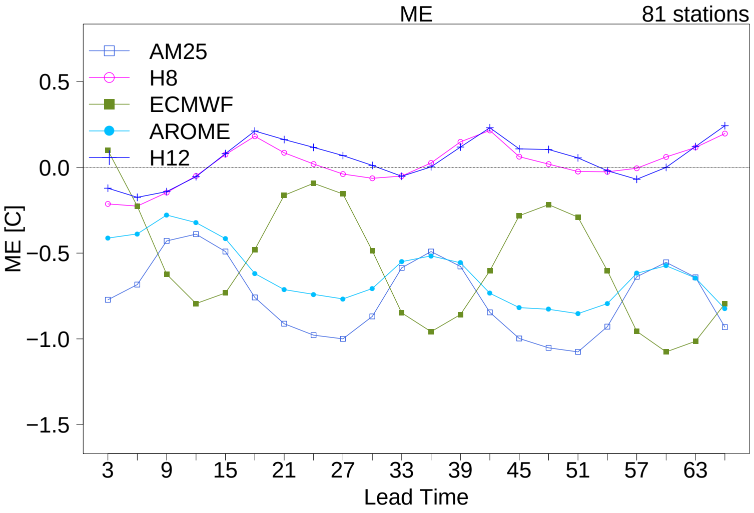


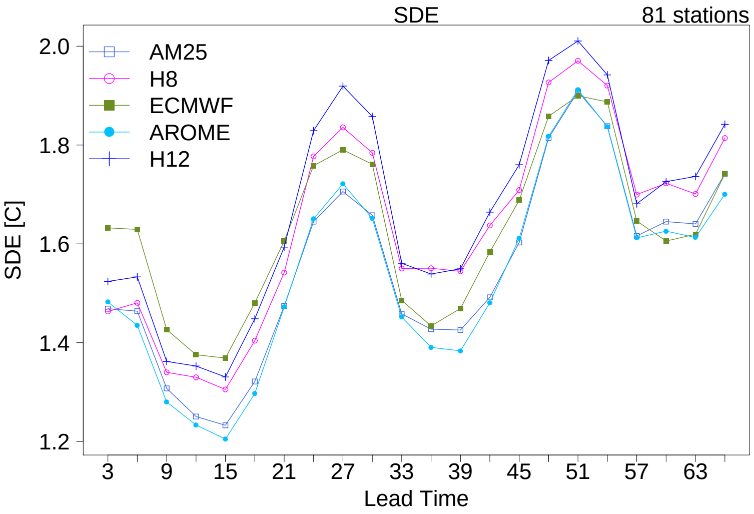

Hit Rate
Lead time [h]: 00+3,+6,..,+24
67 stations
1.0
0.8
0.6
0.4
0.2
0.0
0.3
3.4
8
10.8
17.2
20.8
24.5
28.5
32.7
Exceedance threshold
AROME_FG
AM25_FG
H8_FG
AROME_925
AM25_925
H8_925

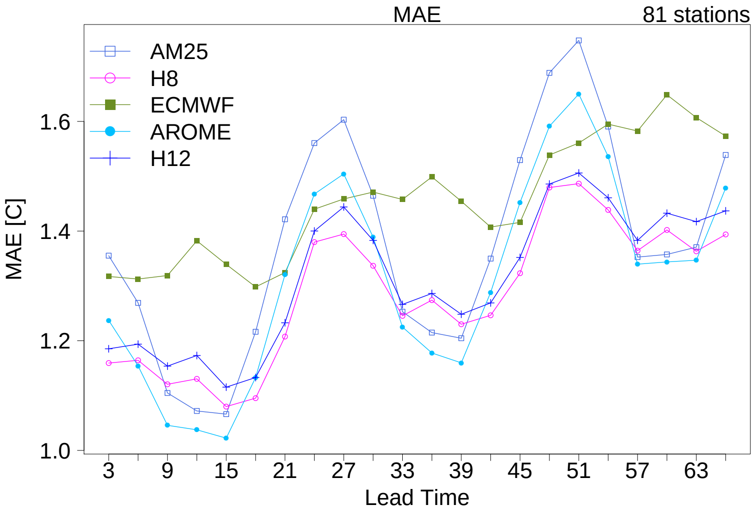

False Alarm Ratio
Lead time [h]: 00+3,+6,..,+24
67 stations
1.0
0.8
0.6
0.4
0.2
0.0
0.3
3.4
8
10.8
17.2
20.8
24.5
28.5
32.7
Exceedance threshold
AROME_FG
AM25_FG
H8_FG
AROME_925
AM25_925
H8_925

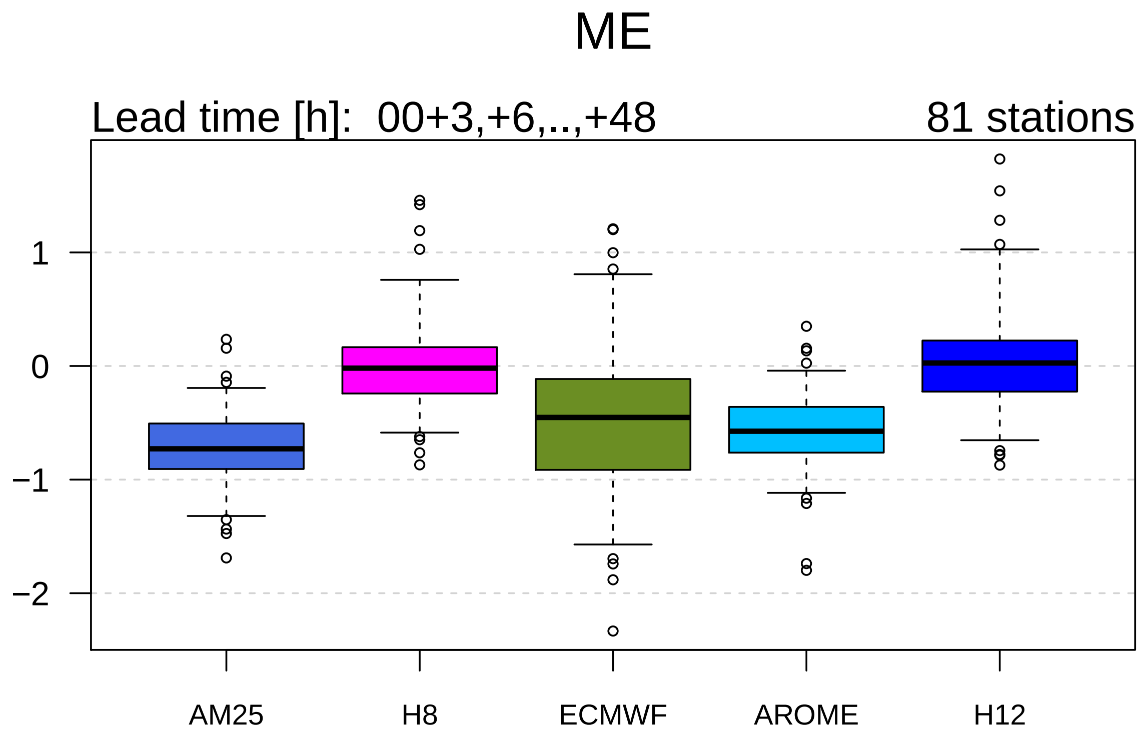

Equitable Threat Score
Lead time [h]: 00+3,+6,..,+24
67 stations
1.0
0.8
0.6
0.4
0.2
0.0
0.3
3.4
8
10.8
17.2
20.8
24.5
28.5
32.7
Exceedance threshold
AROME_FG
AM25_FG
H8_FG
AROME_925
AM25_925
H8_925

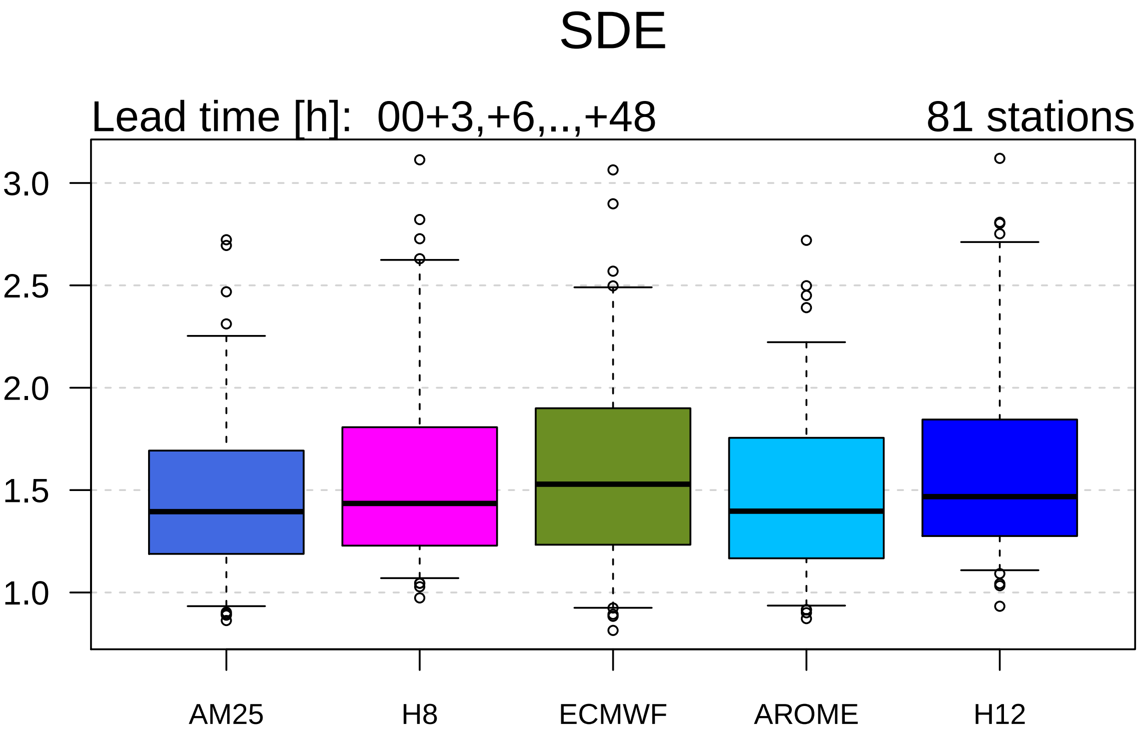
7.6 Temperature 2m





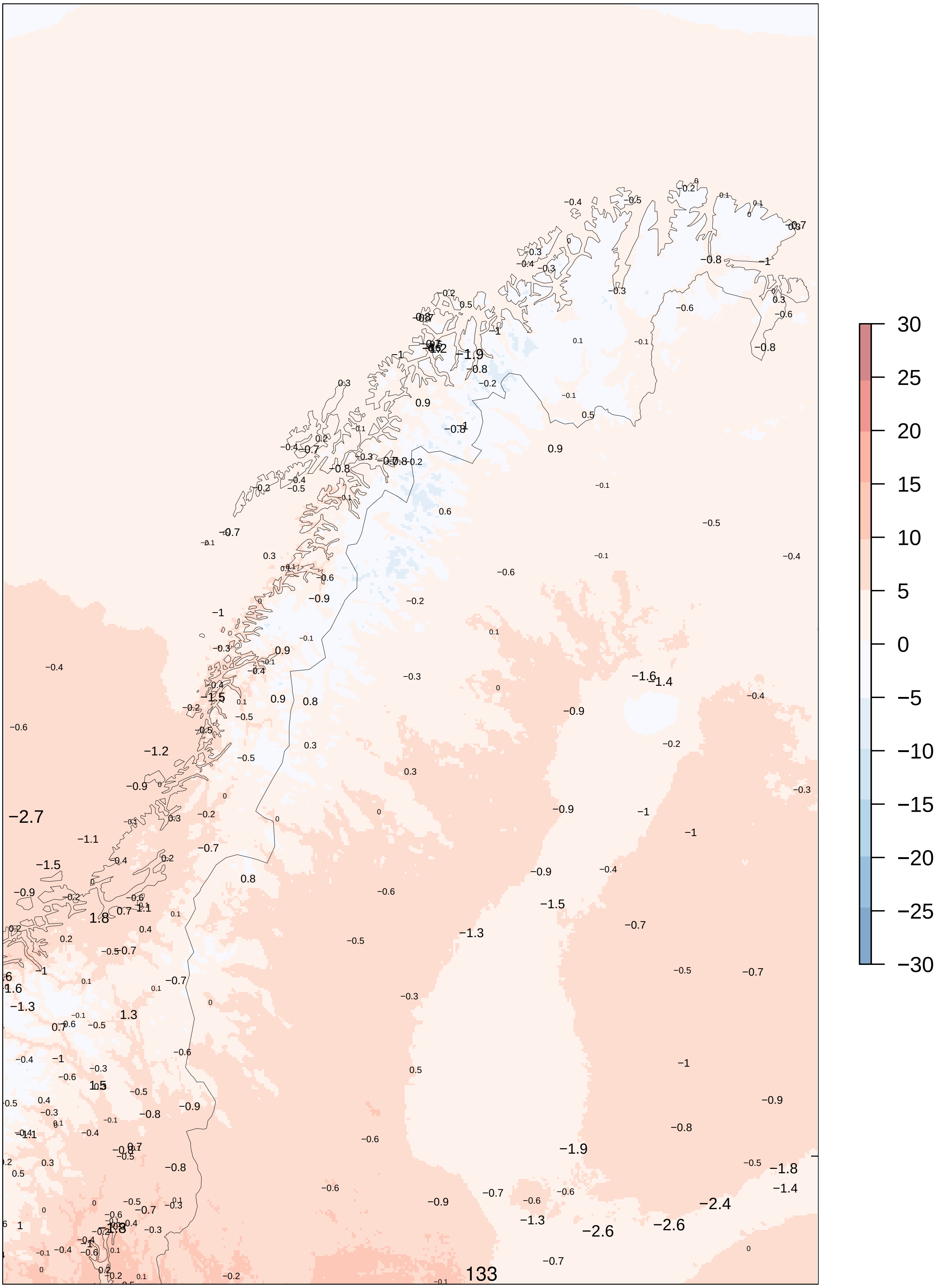


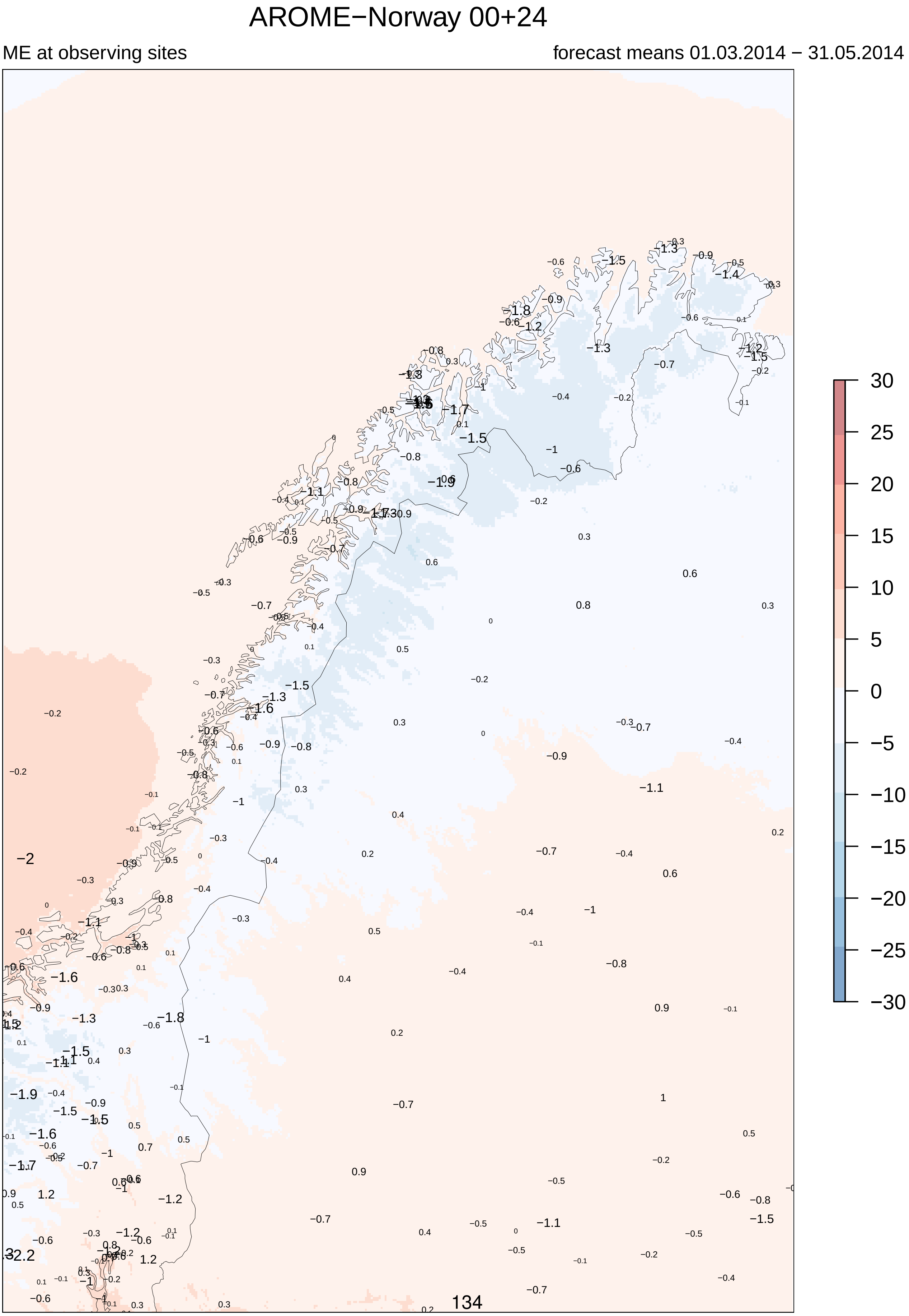

ME
Lead time [h]: 00+3,+6,..,+48
81 stations
1
0
−1
−2
AM25
H8
ECMWF
AROME
H12

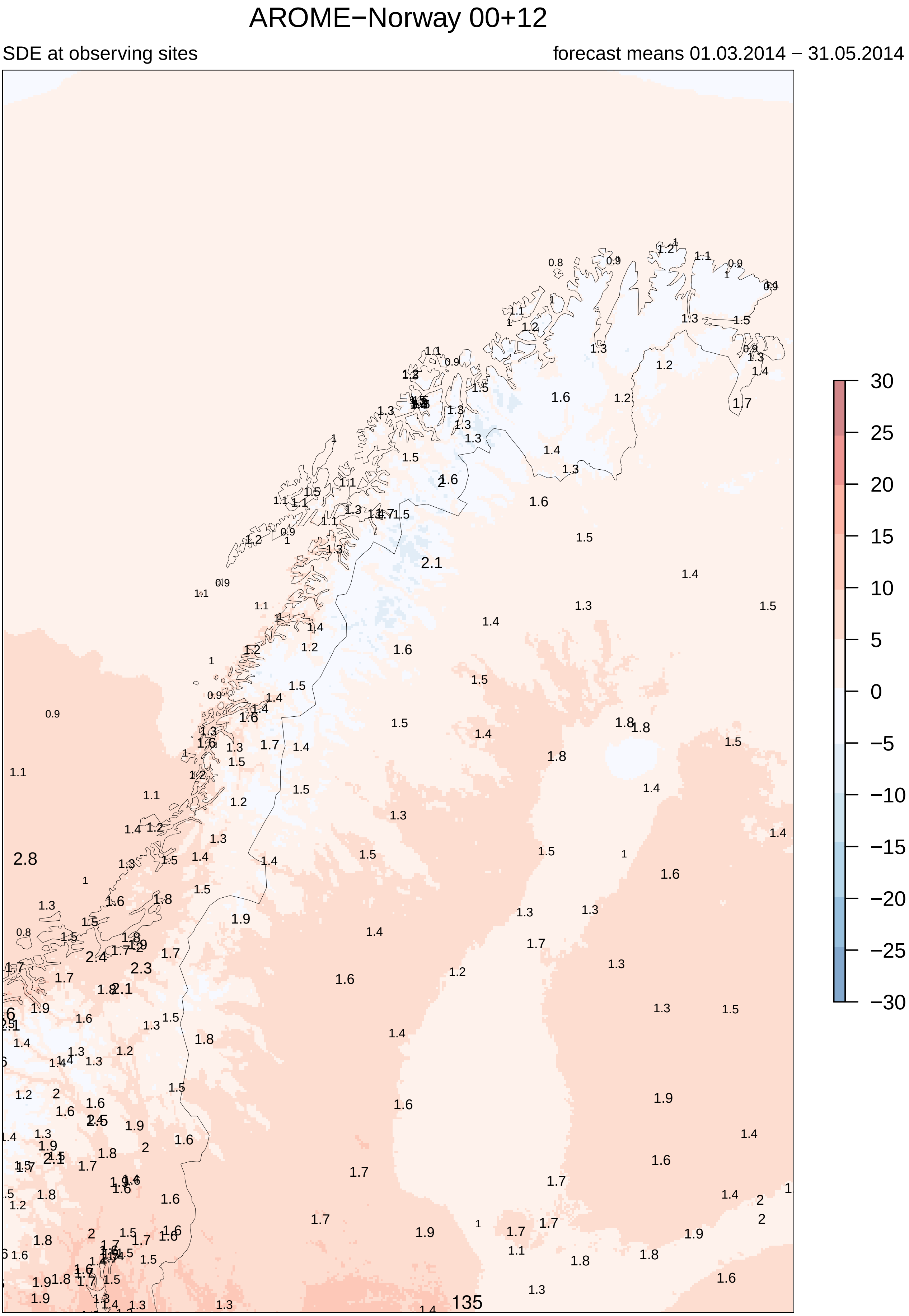

SDE
Lead time [h]: 00+3,+6,..,+48
81 stations
3.0
2.5
2.0
1.5
1.0
AM25
H8
ECMWF
AROME
H12

AROME−Norway 00+12

ME at observing sites forecast means 01.03.2014 − 31.05.2014

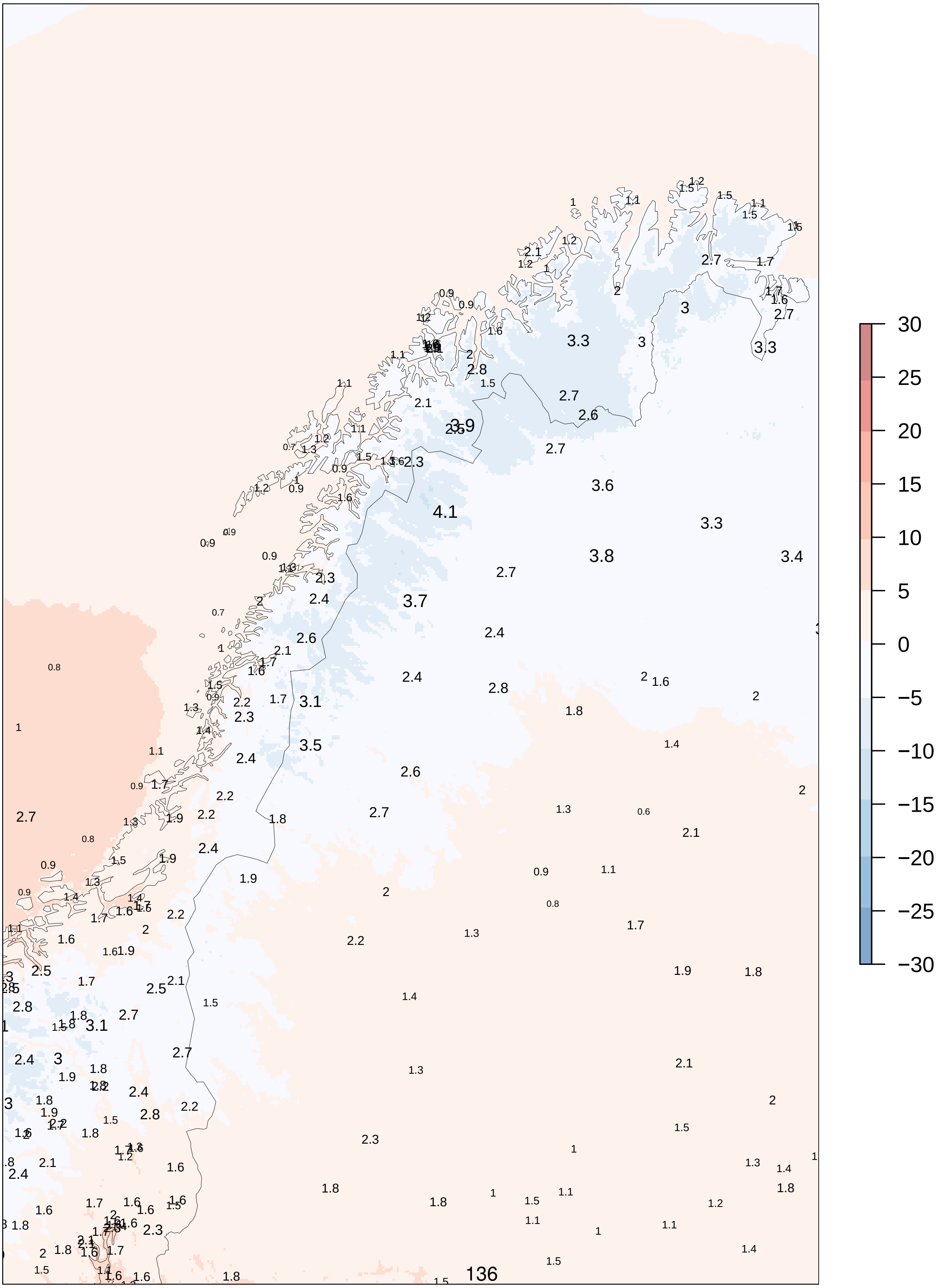



AROME−Norway 00+24
ME at observing sites
forecast means 01.03.2014 − 31.05.2014
30
25
20
15
10
5
0
−5
−10
−15
−20
−25
−30

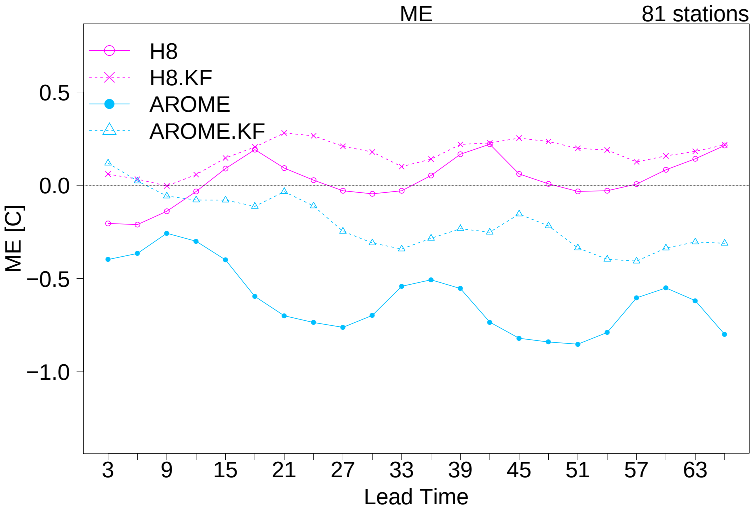

AROME−Norway 00+12
SDE at observing sites
forecast means 01.03.2014 − 31.05.2014
30
25
20
15
10
5
0
−5
−10
−15
−20
−25
−30
2.8
2.1
2.4
2.3
1.9
1.8
1.6
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8

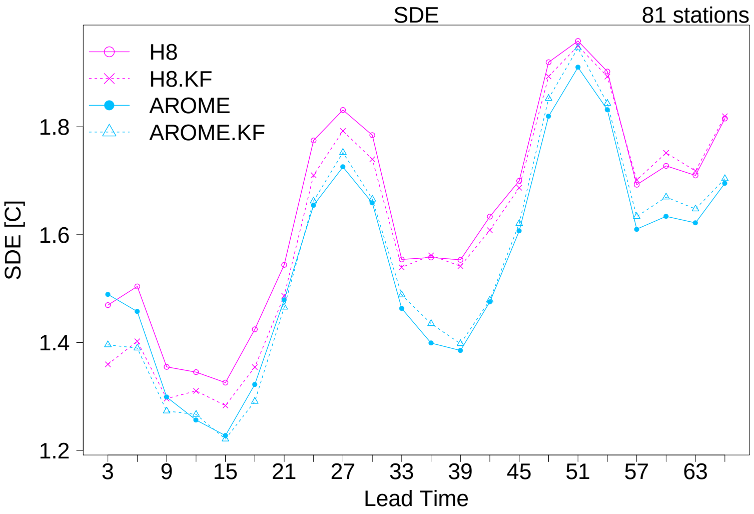
AROME−Norway 00+24

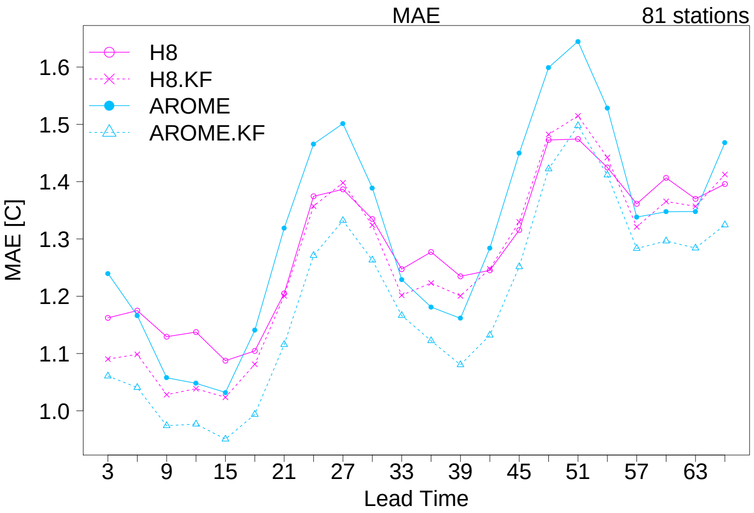
SDE at observing sites forecast means 01.03.2014 − 31.05.2014

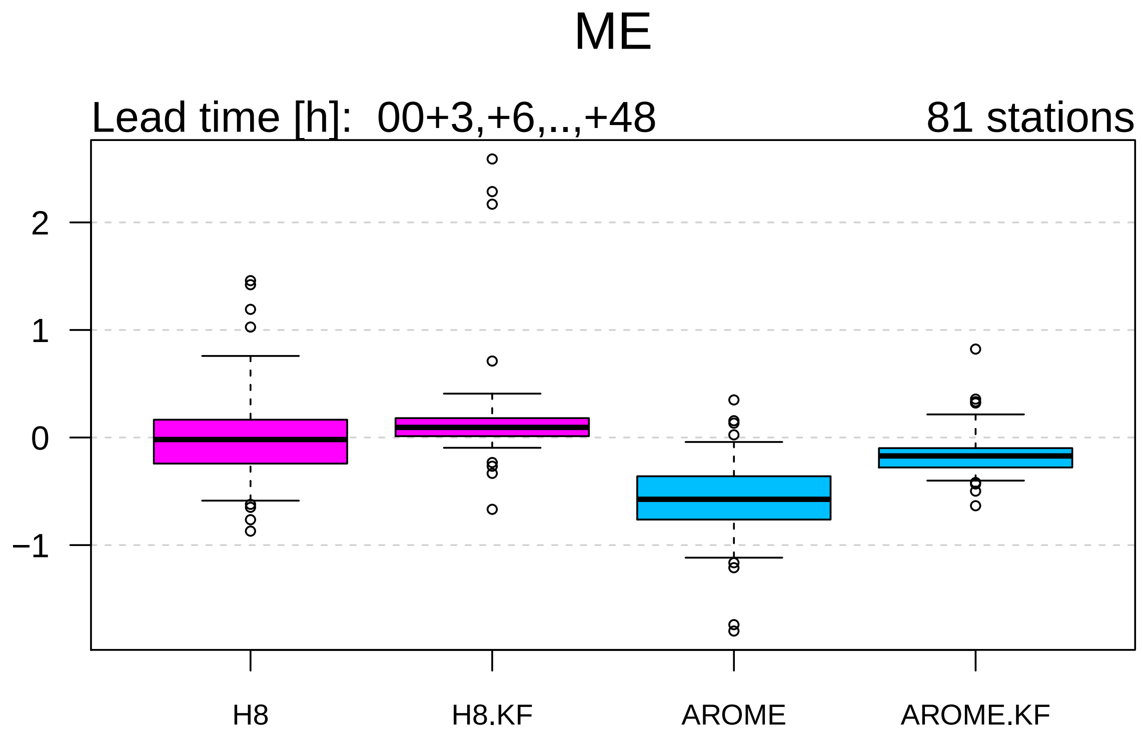


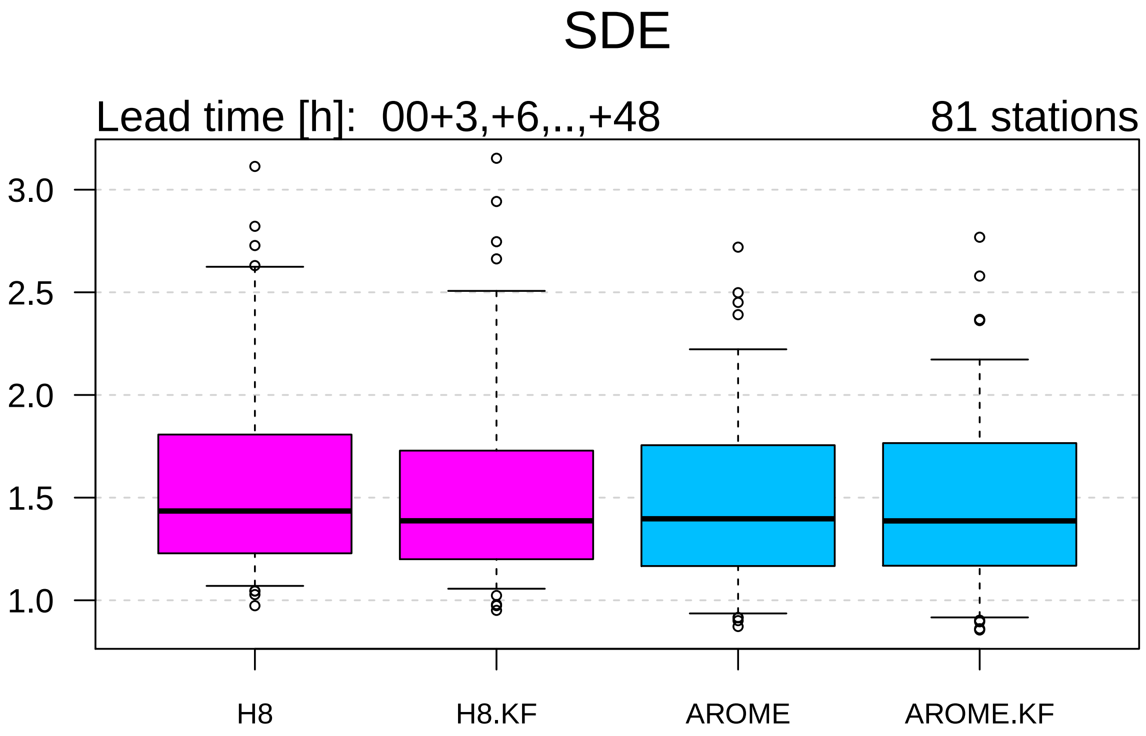
7.7 Post processed temperature 2m



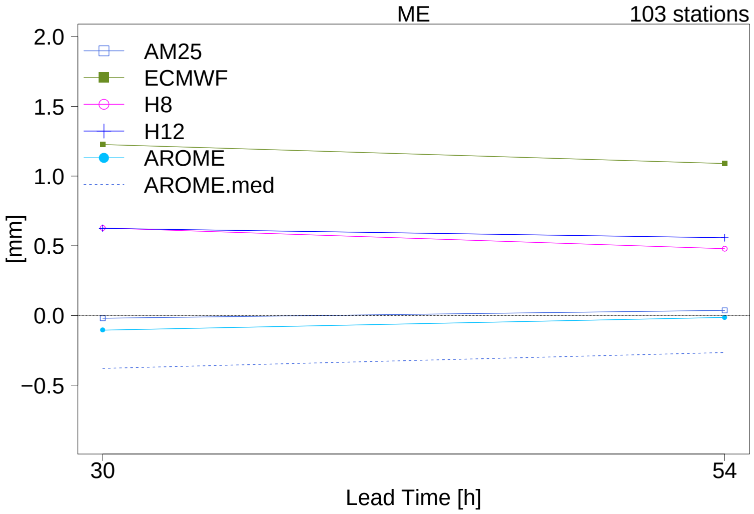


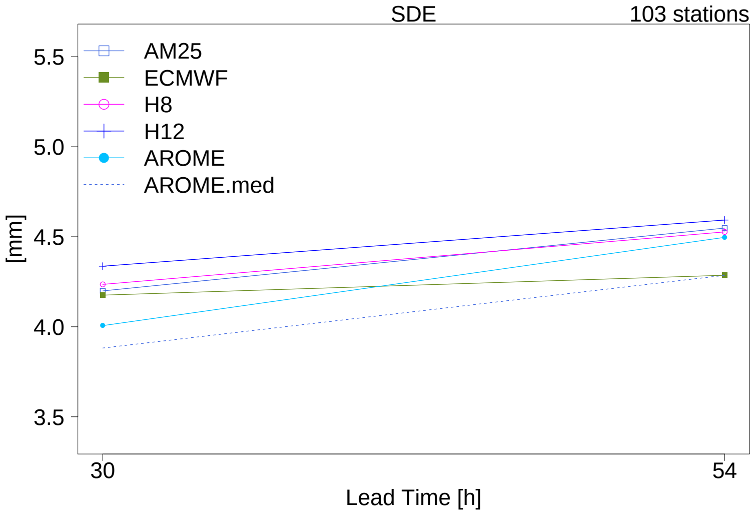


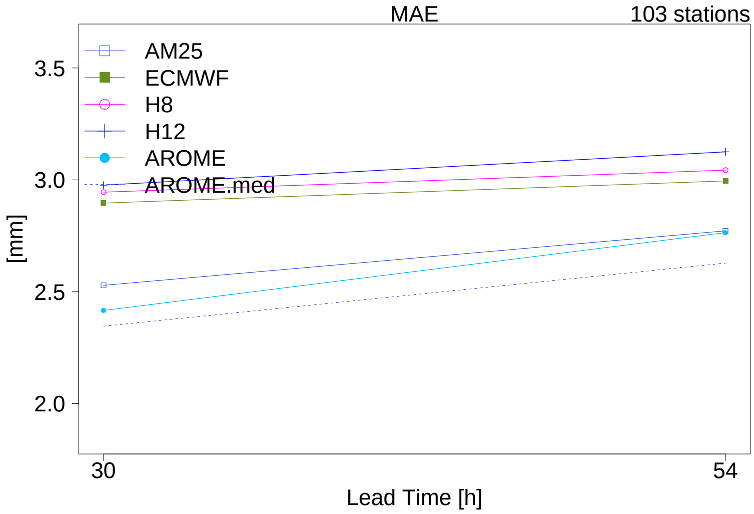

ME
Lead time [h]: 00+3,+6,..,+48
81 stations
2
1
0
−1
H8
H8.KF
AROME
AROME.KF

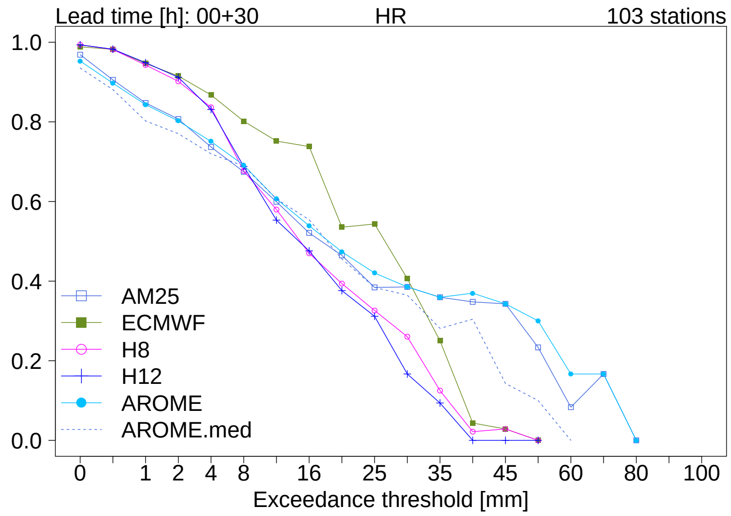

SDE
Lead time [h]: 00+3,+6,..,+48
81 stations
3.0
2.5
2.0
1.5
1.0
H8
H8.KF
AROME
AROME.KF

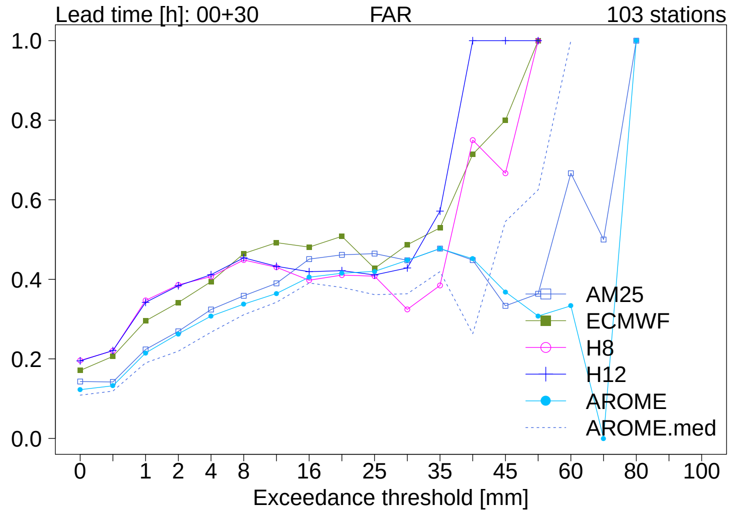
7.8 Daily precipitation

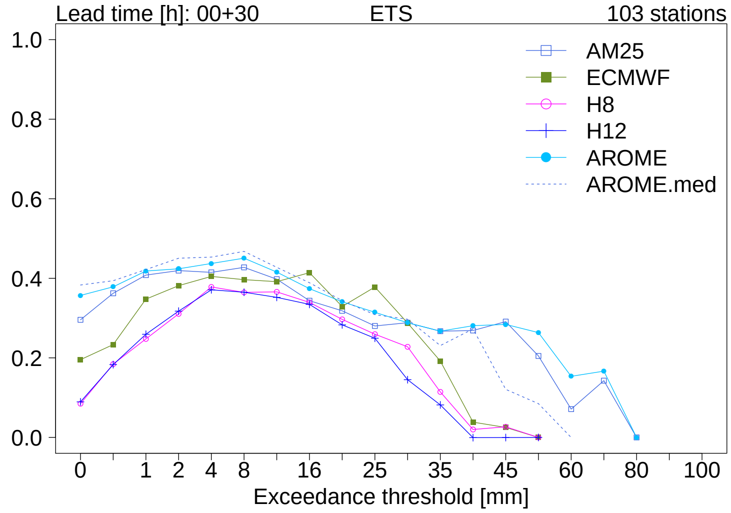


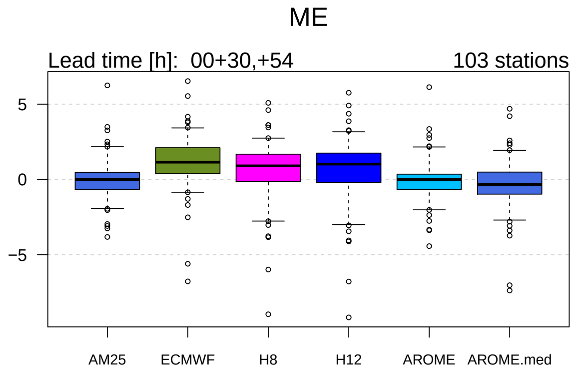


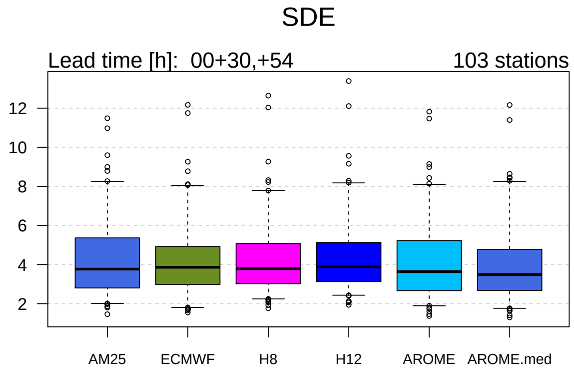



Lead time [h]: 00+30
HR
103 stations
AM25
ECMWF
H8
H12
AROME
AROME.med
1.0
0.8
0.6
0.4
0.2
0.0
0
1
2
4
8
16
25
35
45
60
80
100
Exceedance threshold [mm]


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


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





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

OBS

AM25

	[0,0.1]	(0.1,5]	(5,20]	(20,50]	(50,Inf]	Sum
[0,0.1]	2254	996	46	2	0	3298
(0.1,5]	1331	4603	857	8	0	6799
(5,20]	101	1000	1640	229	11	2981
(20,50]	1	28	159	147	34	369
(50,Inf]	0	1	5	6	15	27
Sum	3687	6628	2707	392	60	13474

OBS

H8

	[0,0.1]	(0.1,5]	(5,20]	(20,50]	(50,Inf]	Sum
[0,0.1]	987	176	4	1	0	1168
(0.1,5]	2507	4894	689	10	0	8100
(5,20]	191	1545	1902	253	14	3905
(20,50]	2	13	111	128	46	300
(50,Inf]	0	0	1	0	0	1
Sum	3687	6628	2707	392	60	13474

OBS

ECMWF

	[0,0.1]	(0.1,5]	(5,20]	(20,50]	(50,Inf]	Sum
[0,0.1]	1243	222	6	1	0	1472
(0.1,5]	2292	4671	509	4	0	7476
(5,20]	152	1709	1949	192	12	4014
(20,50]	0	26	242	195	48	511
(50,Inf]	0	0	1	0	0	1
Sum	3687	6628	2707	392	60	13474

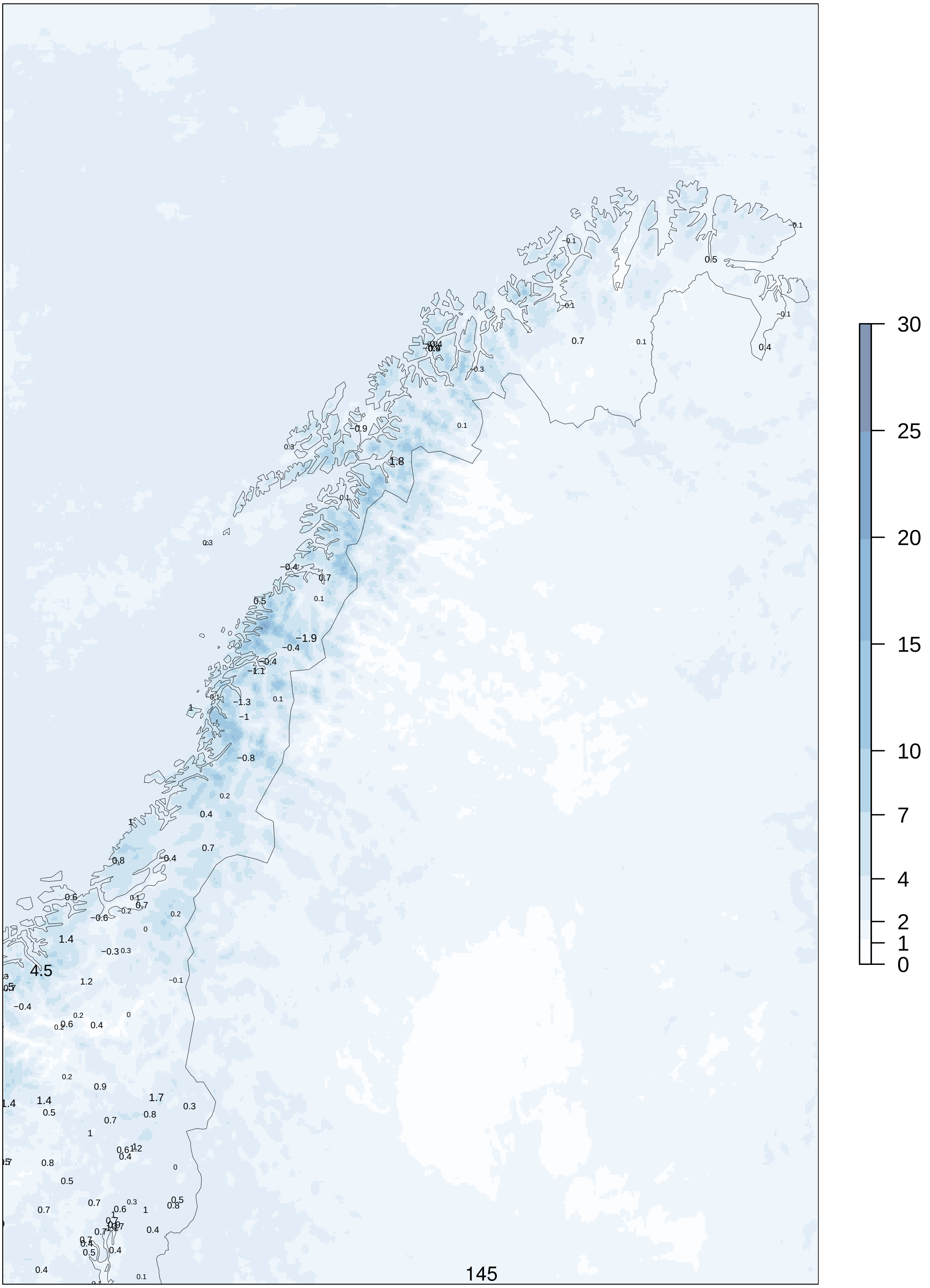
OBS

AROME

	[0,0.1]	(0.1,5]	(5,20]	(20,50]	(50,Inf]	Sum
[0,0.1]	2331	1029	39	1	0	3400
(0.1,5]	1260	4622	849	12	1	6744
(5,20]	95	957	1669	219	10	2950
(20,50]	1	18	147	153	32	351
(50,Inf]	0	2	3	7	17	29
Sum	3687	6628	2707	392	60	13474

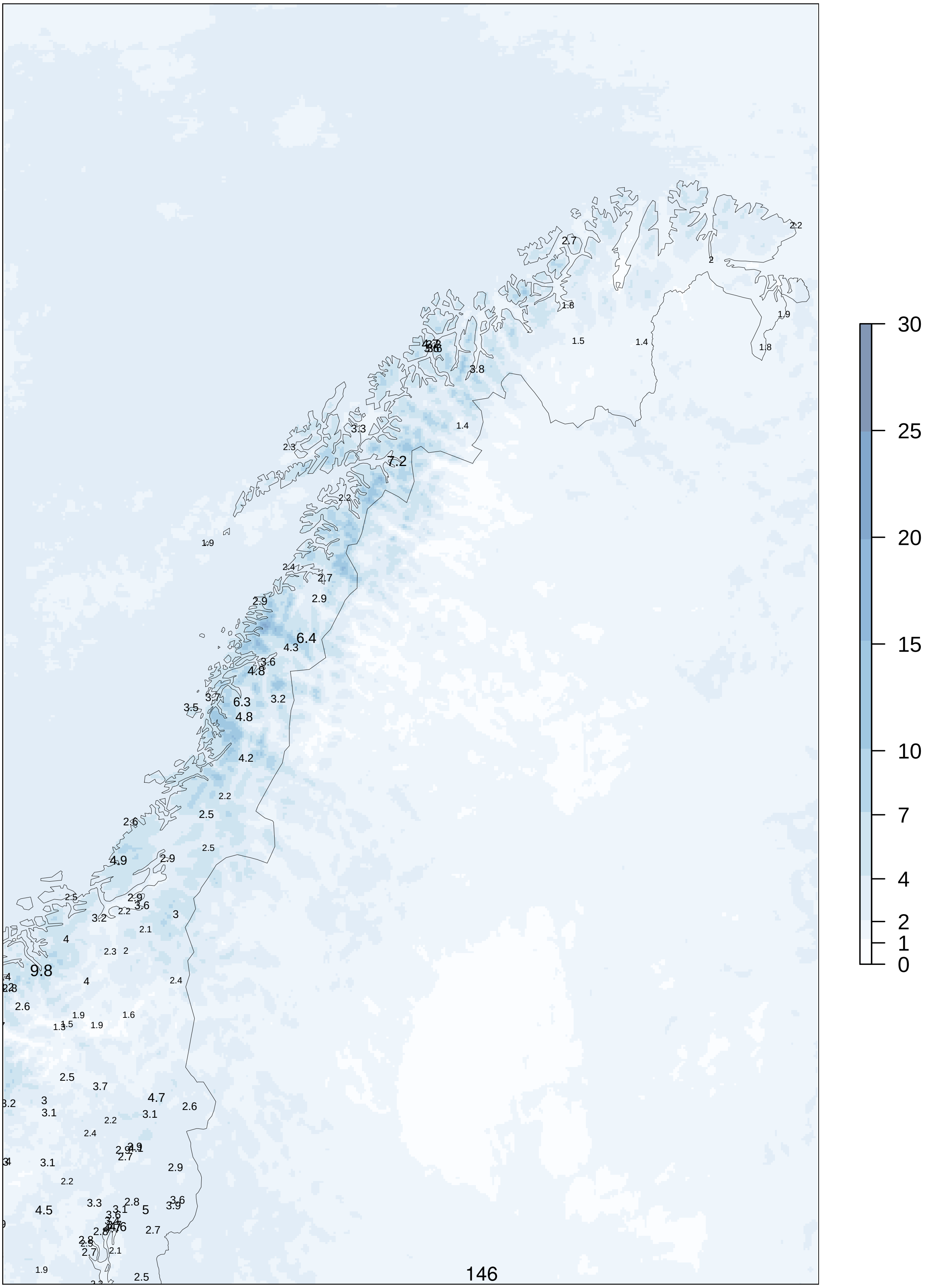
AROME−Norway 00+30

ME at observing sites forecast means 01.03.2014 − 31.05.2014



AROME−Norway 00+30

SDE at observing sites forecast means 01.03.2014 − 31.05.2014



8 Long term forecast

Temperature
The temperature forecasts have been too cold for the deterministic and uncalibrated probabilistic forecast, in general around $-1\,^{\circ}\mathrm{C}$. The calibration reduces the bias, so the forecast issued on Yr had almost no bias, during this period. After 90h, the deterministic forecast had a larger SDE than the probabilistic forecast. There were few differences between the uncalibrated and the calibrated probabilistic forecast in SDE. The MAE was lowest for the calibrated probabilistic forecast. But the differences between the probabilistic forecasts were small, about $0.25\,^{\circ}\mathrm{C}$.

Wind speed
Both the deterministic and probabilistic forecast have a negative bias for wind speed, between 0 to $-0.7ms^{-1}$. Almost no bias during nighttime. The SDE is larger for the deterministic forecast, about $3ms^{-1}$ after 200h. The probabilistic forecast has a SDE of about $2.5ms^{-1}$ after 200h. The deterministic forecast has the lowest MAE for lead times lower than about 78h. After this the MAE is larger for the deterministic forecast.

At 72h, the HR is very similar for both forecasts, but the HR is a bit higher for the probabilistic forecast up to $19ms^{-1}$. The FAR is also somewhat increased for the probabilistic forecast. The ETS show almost the exact same score for both forecasts.

At 216h, the probabilistic forecast has no values above $15ms^{-1}$, so the HR decreases rapidly with increasing thresholds. The decrease is also rapid for the deterministic forecast, but this forecast has at least values up to $25ms^{-1}$. FAR is lower for the probabilistic forecast, than the deterministic. The ETS is low for both forecasts for this lead time, but it is higher for the probabilistic forecast for thresholds below $9ms^{-1}$. Above this, the ETS is highest for the deterministic forecast, mostly because this forecast actually have values above this threshold.

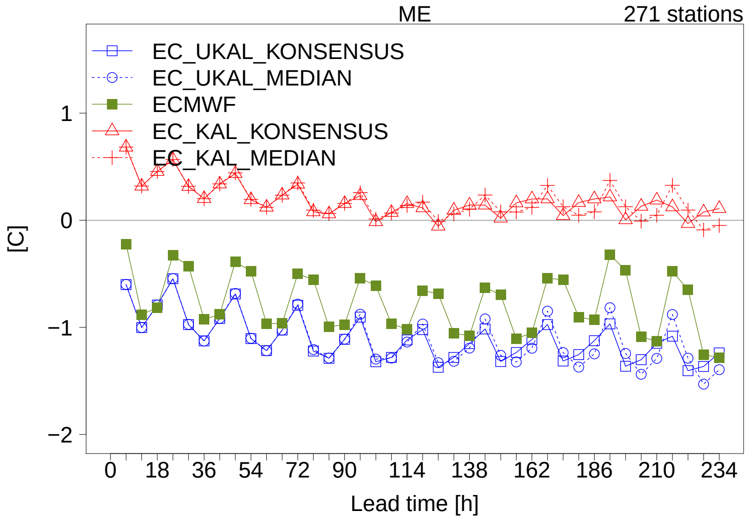
Precipitation
For 12h precipitation there is a clear dry trend in the bias for the probabilistic forecast. The same trend is found in the deterministic forecast before 138h, but at the end of the lead time the forecasts have a wet trend. The underestimation of precipitation in the probabilistic forecast is larger during daytime than nighttime. There are no clear diurnal variations in the deterministic forecast.

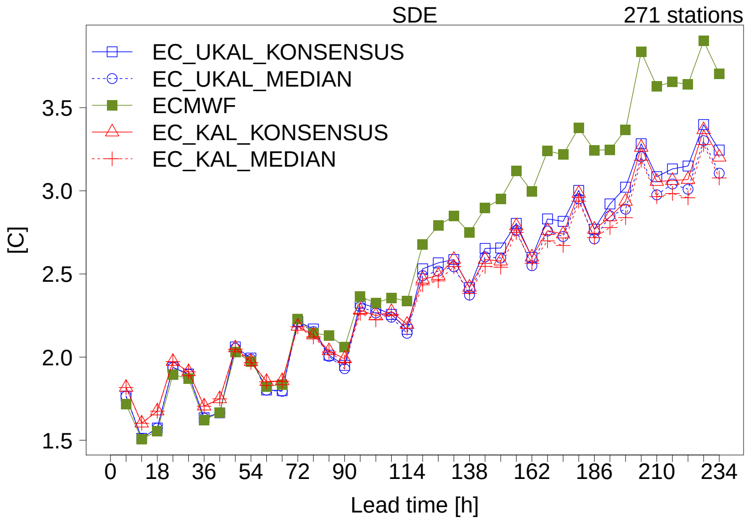
At 78h (nighttime), the highest values of the probabilistic forecast are around 20mm, while the deterministic forecast have values up to 30mm. HR is higher for the deterministic forecast. FAR is high for both forecasts, around 0.4 for 0.1mm. Due to both higher HR and lower FAR, the deterministic forecast scores best on the ETS. At 90h (daytime), both models have higher HR and lower FAR, and highest values are increased with about 5mm. The deterministic forecast still scores best on the ETS.

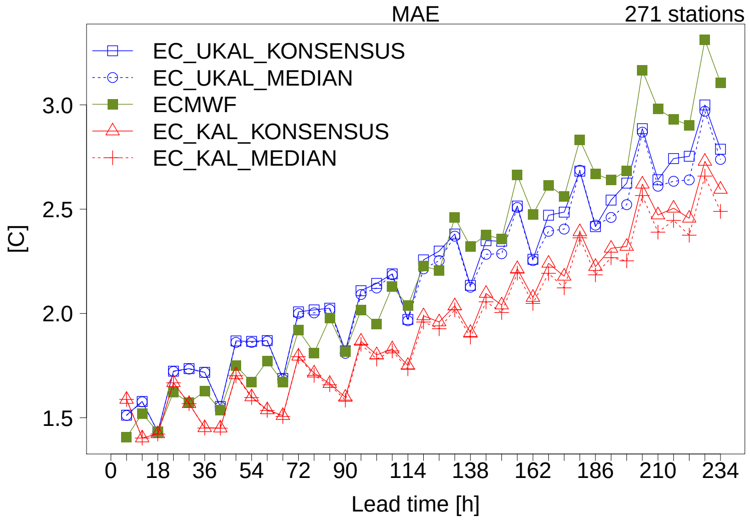
At the end of the lead time, 222h and 234h, the deterministic forecast have almost no skill, due to a very high FAR. The probabilistic forecast scores better on ETS, but has no values above 12mm during nights and 20mm during days.

For 24h precipitation, the picture is much the same. The deterministic forecast is better at lead time 78h, and the probabilistic is better at 222h. The probabilistic forecast does not have values above 25mm at lead time 222h, while the deterministic have values up to 50mm.

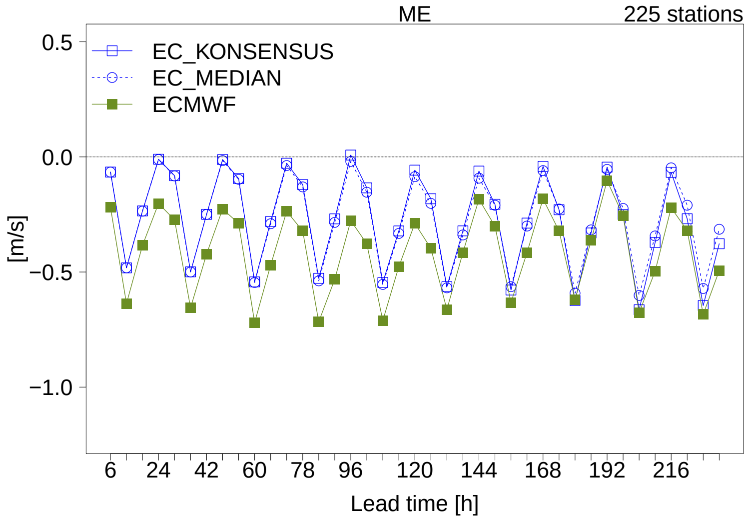
8.1 Temperature 2m

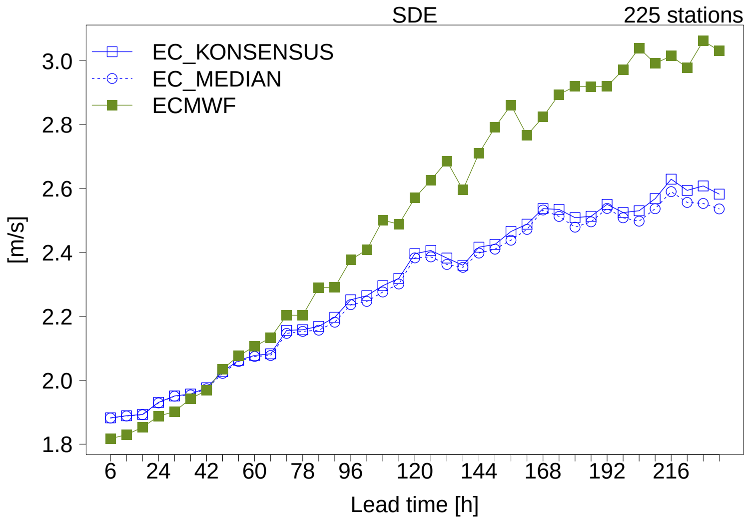


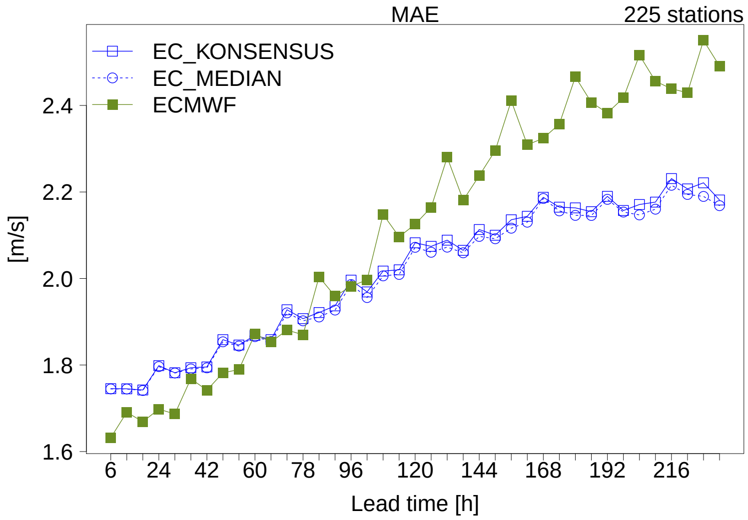


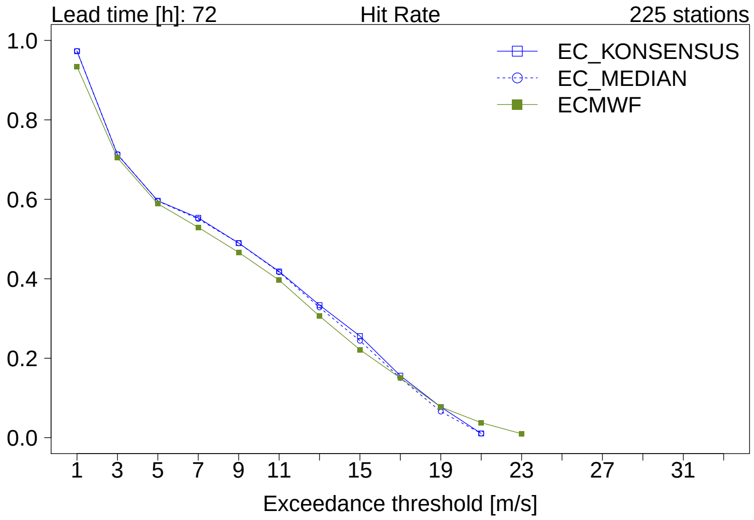


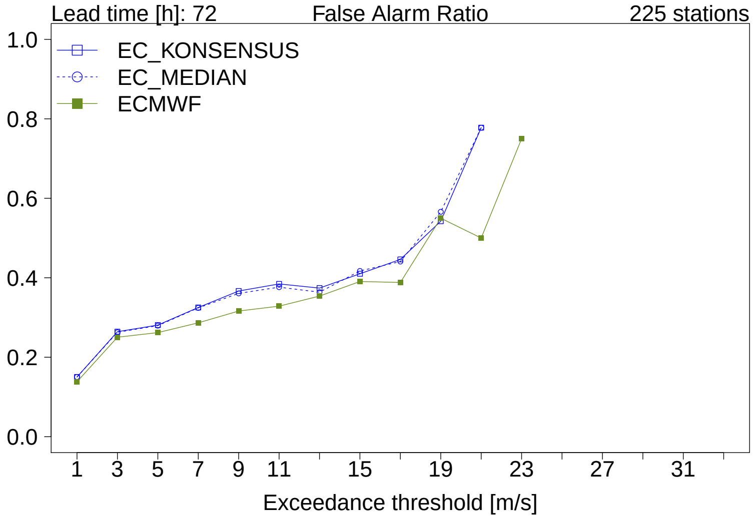
8.2 Wind Speed 10m

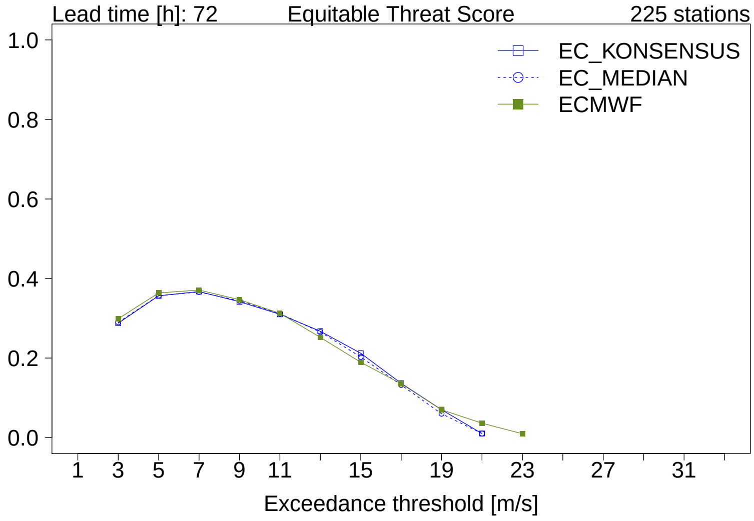


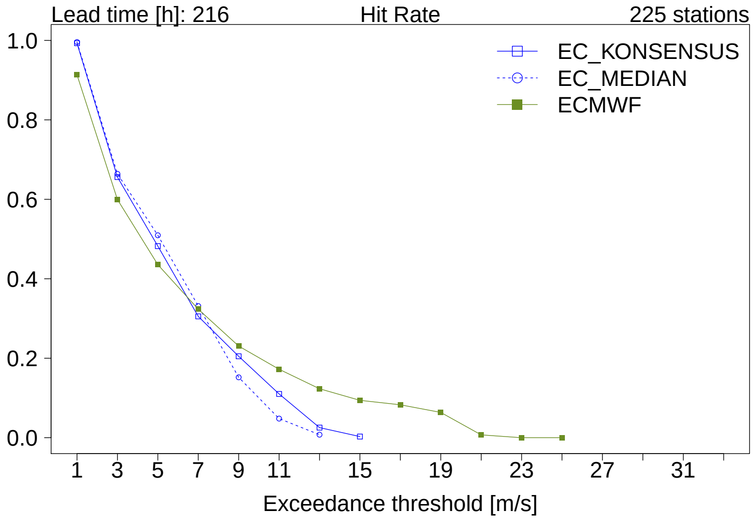


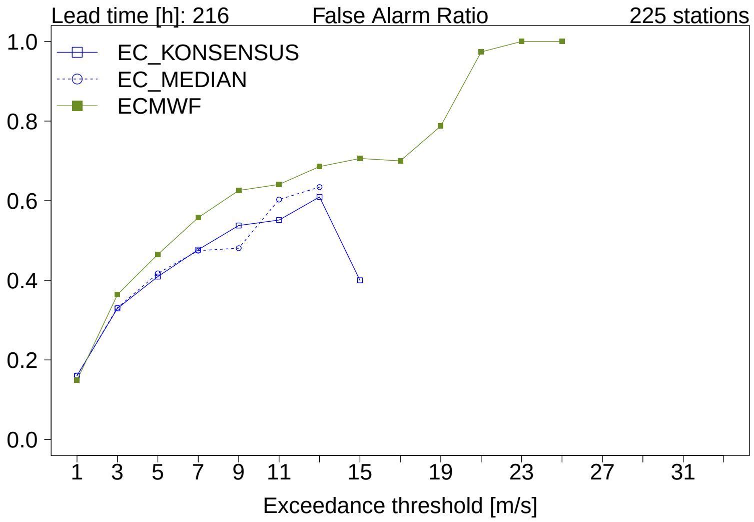


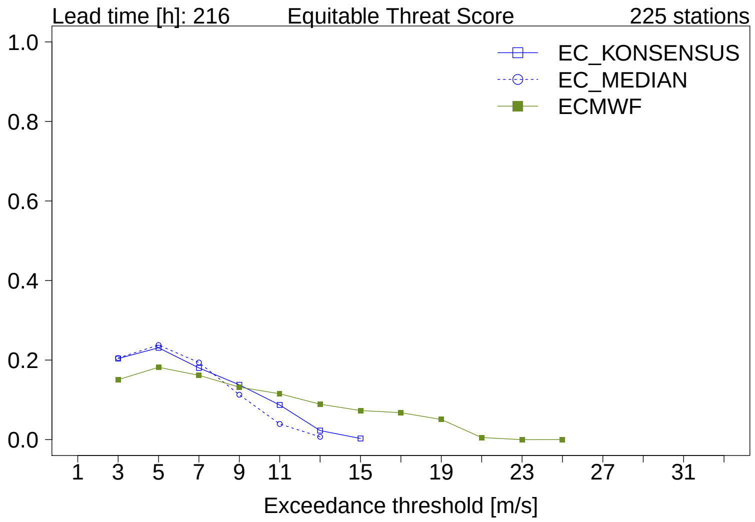

Lead time [h]: 72
Hit Rate
225 stations
EC_KONSENSUS
EC_MEDIAN
ECMWF
1.0
0.8
0.6
0.4
0.2
0.0
1
3
5
7
9
11
15
19
23
27
31
Exceedance threshold [m/s]


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

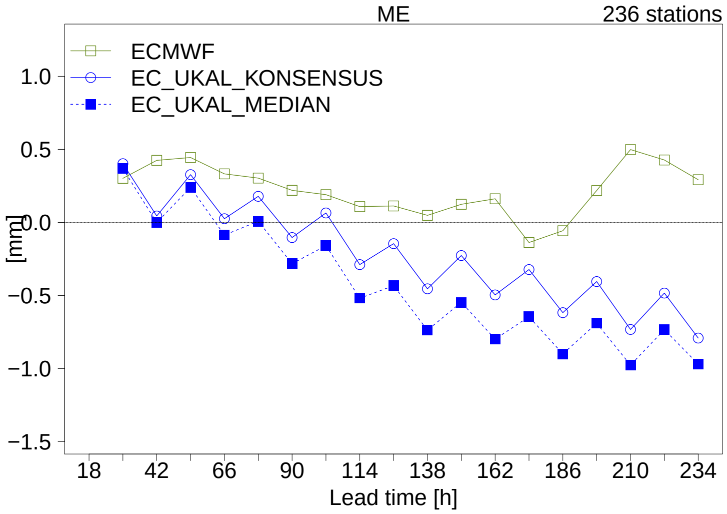

Lead time [h]: 72
Equitable Threat Score
225 stations
EC_KONSENSUS
EC_MEDIAN
ECMWF
1.0
0.8
0.6
0.4
0.2
0.0
1
3
5
7
9
11
15
19
23
27
31
Exceedance threshold [m/s]

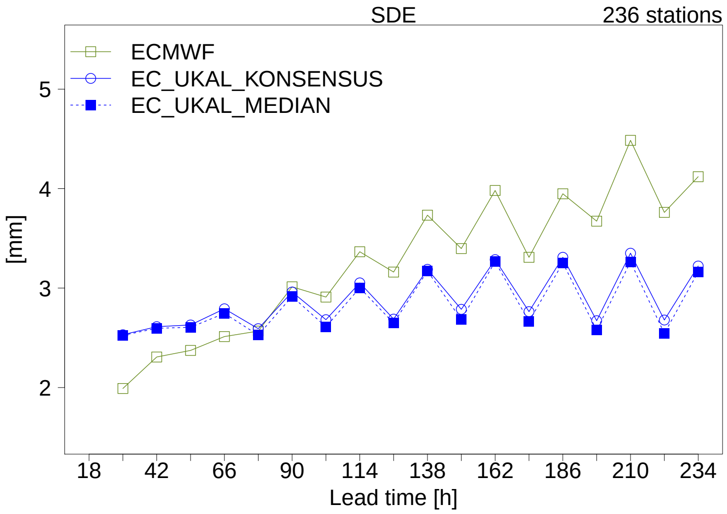

Lead time [h]: 216
Hit Rate
225 stations
EC_KONSENSUS
EC_MEDIAN
ECMWF
1.0
0.8
0.6
0.4
0.2
0.0
1
3
5
7
9
11
15
19
23
27
31
Exceedance threshold [m/s]

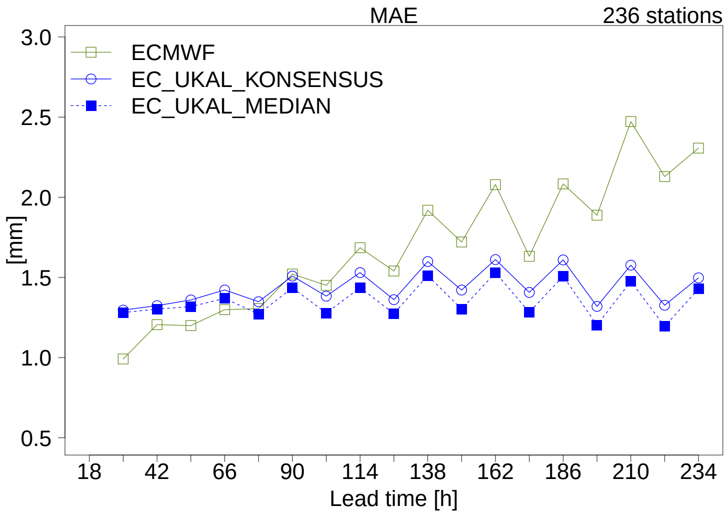

Lead time [h]: 216
False Alarm Ratio
225 stations
EC_KONSENSUS
EC_MEDIAN
ECMWF
1.0
0.8
0.6
0.4
0.2
0.0
1
3
5
7
9
11
15
19
23
27
31
Exceedance threshold [m/s]

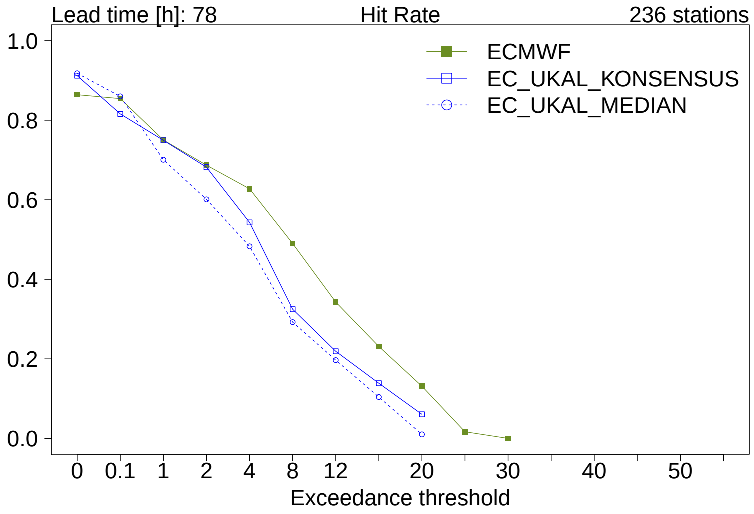

Lead time [h]: 216
Equitable Threat Score
225 stations
EC_KONSENSUS
EC_MEDIAN
ECMWF
1.0
0.8
0.6
0.4
0.2
0.0
1
3
5
7
9
11
15
19
23
27
31
Exceedance threshold [m/s]

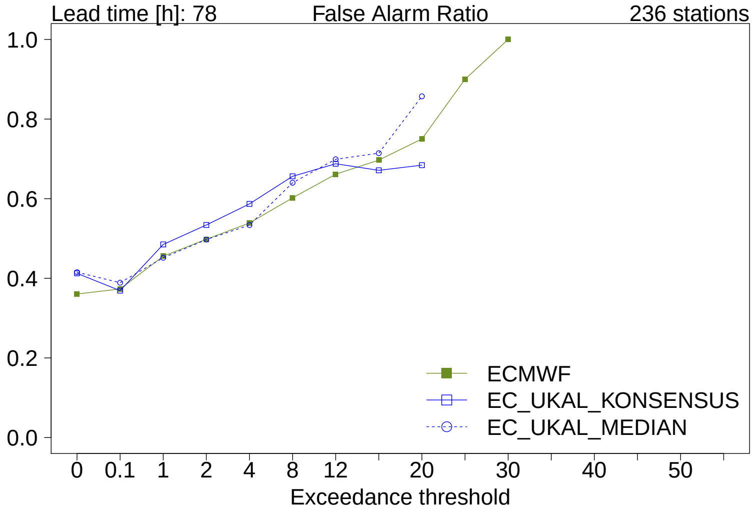
8.3 12h Precipitation

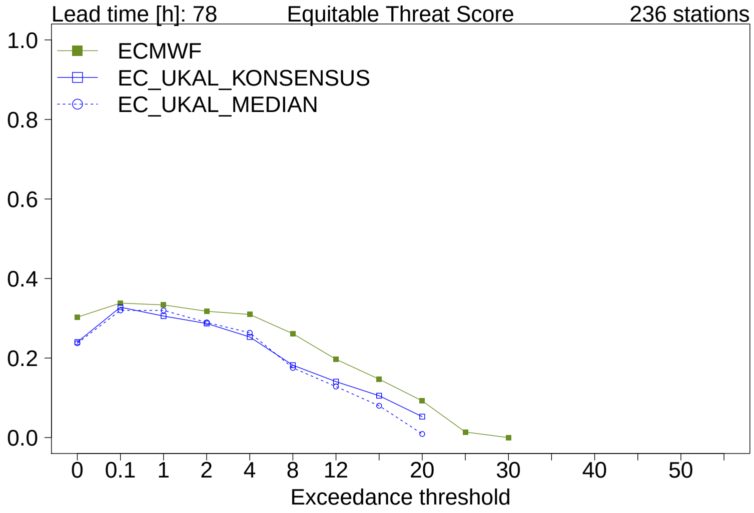


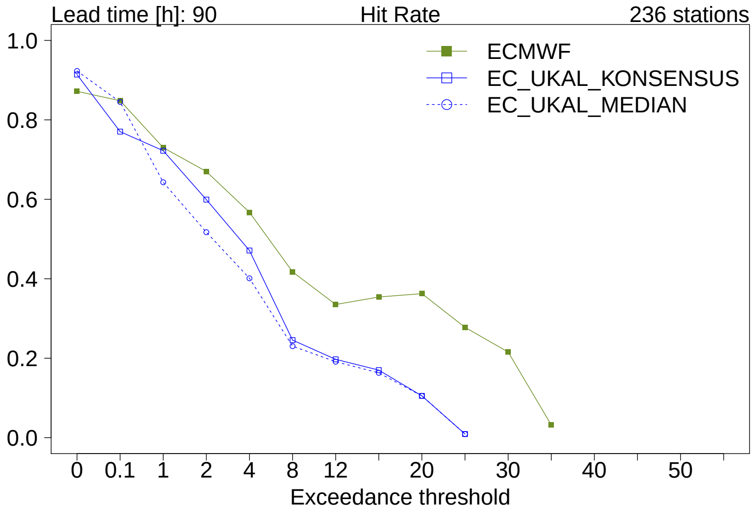


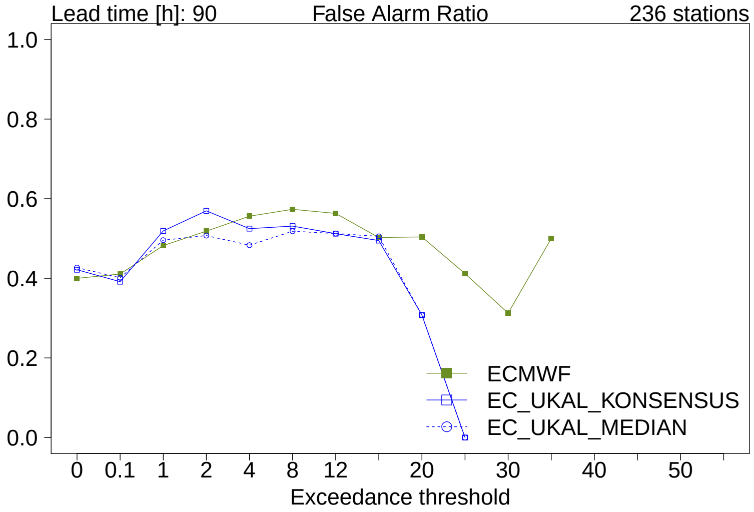


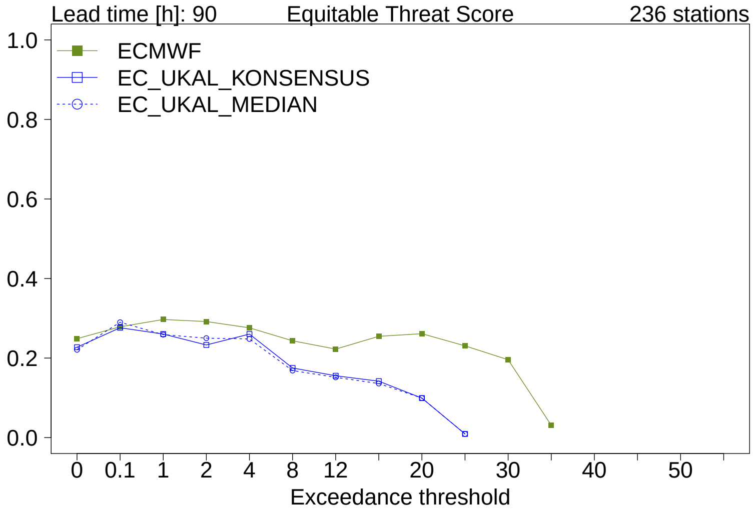

Lead time [h]: 78
Hit Rate
236 stations
ECMWF
EC_UKAL_KONSENSUS
EC_UKAL_MEDIAN
1.0
0.8
0.6
0.4
0.2
0.0
0
0.1
1
2
4
8
12
20
30
40
50
Exceedance threshold

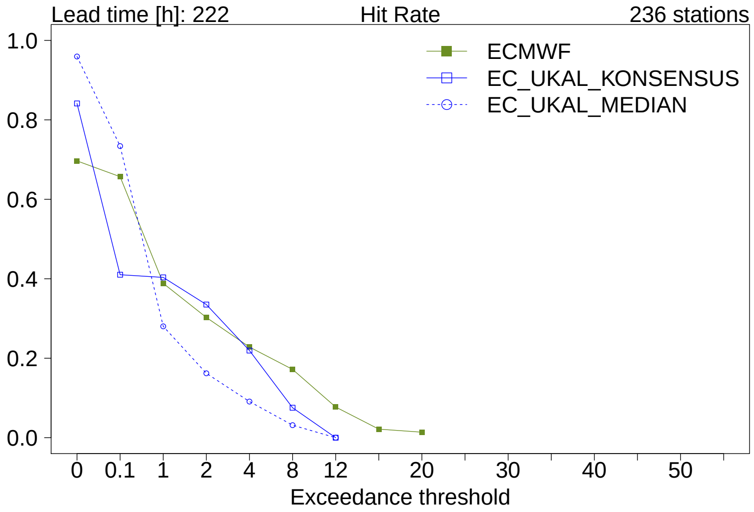

Lead time [h]: 78
False Alarm Ratio
236 stations
ECMWF
EC_UKAL_KONSENSUS
EC_UKAL_MEDIAN
1.0
0.8
0.6
0.4
0.2
0.0
0
0.1
1
2
4
8
12
20
30
40
50
Exceedance threshold

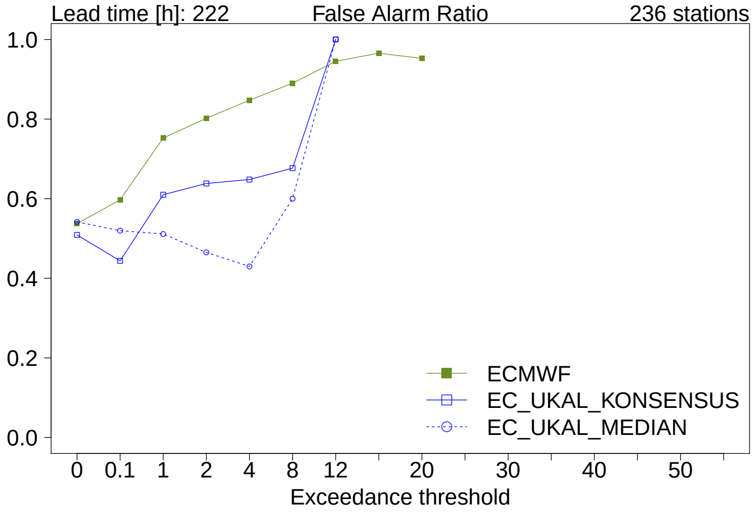

Lead time [h]: 78
Equitable Threat Score
236 stations
ECMWF
EC_UKAL_KONSENSUS
EC_UKAL_MEDIAN
1.0
0.8
0.6
0.4
0.2
0.0
0
0.1
1
2
4
8
12
20
30
40
50
Exceedance threshold

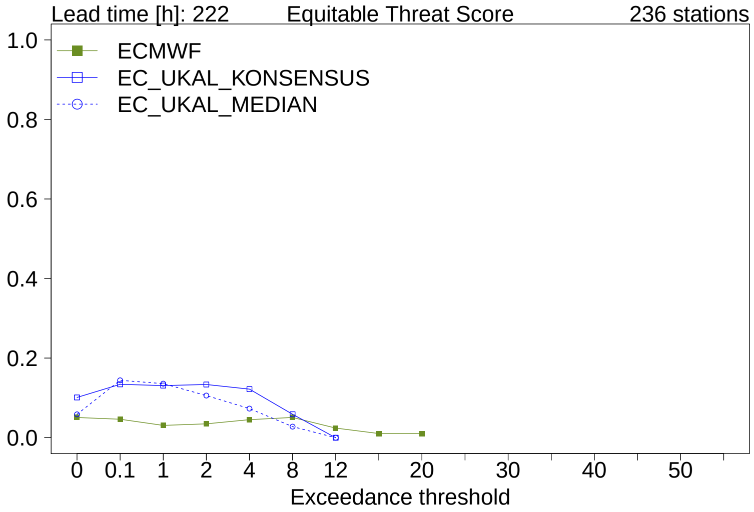

Lead time [h]: 90
Hit Rate
236 stations
ECMWF
EC_UKAL_KONSENSUS
EC_UKAL_MEDIAN
1.0
0.8
0.6
0.4
0.2
0.0
0
0.1
1
2
4
8
12
20
30
40
50
Exceedance threshold

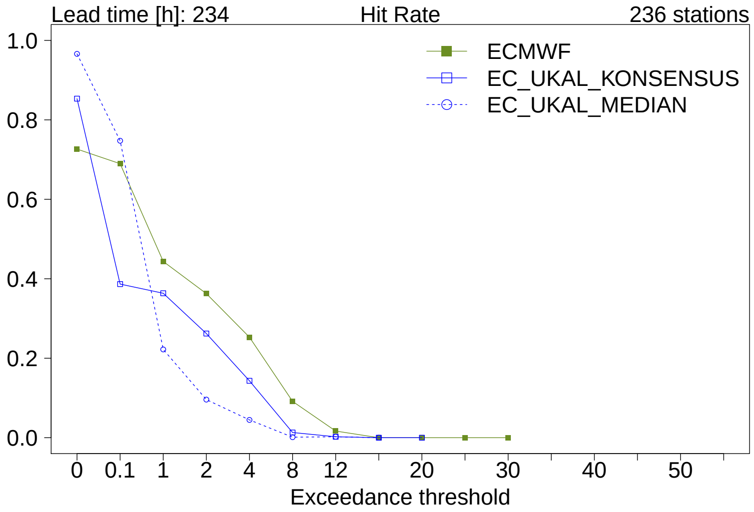

Lead time [h]: 90
False Alarm Ratio
236 stations
ECMWF
EC_UKAL_KONSENSUS
EC_UKAL_MEDIAN
1.0
0.8
0.6
0.4
0.2
0.0
0
0.1
1
2
4
8
12
20
30
40
50
Exceedance threshold

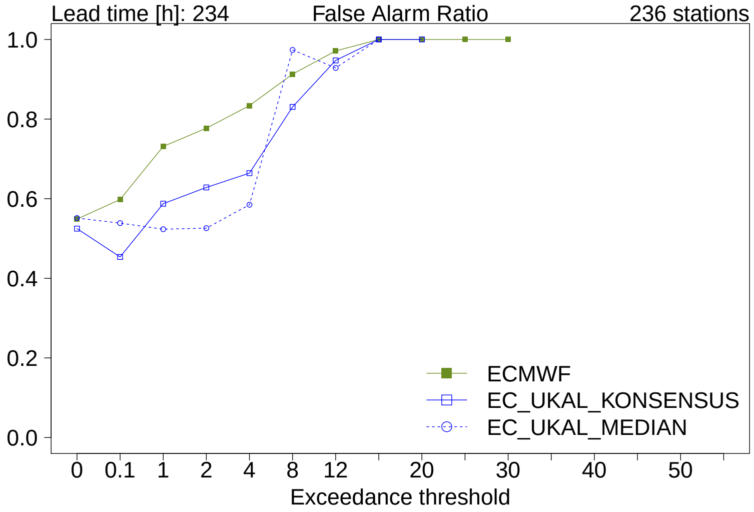

Lead time [h]: 90
Equitable Threat Score
236 stations
ECMWF
EC_UKAL_KONSENSUS
EC_UKAL_MEDIAN
1.0
0.8
0.6
0.4
0.2
0.0
0
0.1
1
2
4
8
12
20
30
40
50
Exceedance threshold

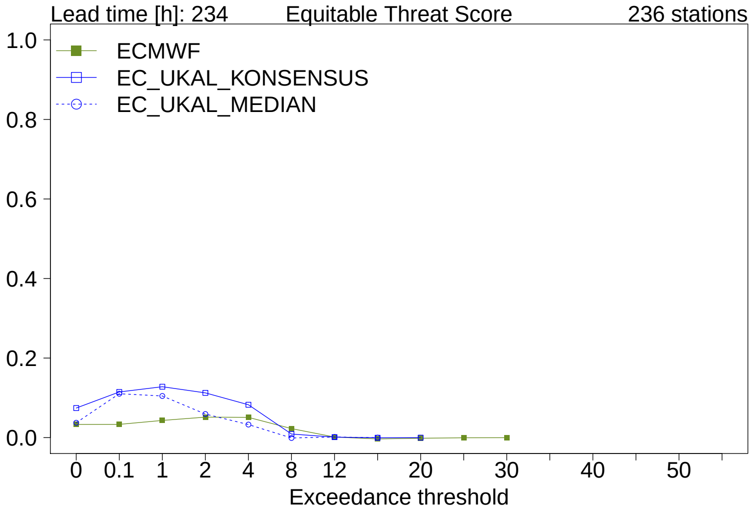

Lead time [h]: 222
Hit Rate
236 stations
ECMWF
EC_UKAL_KONSENSUS
EC_UKAL_MEDIAN
1.0
0.8
0.6
0.4
0.2
0.0
0
0.1
1
2
4
8
12
20
30
40
50
Exceedance threshold


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

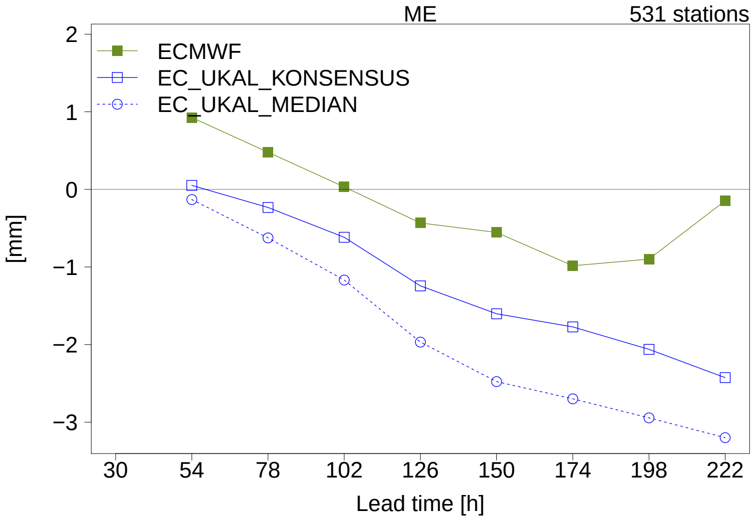

Lead time [h]: 222
Equitable Threat Score
236 stations
ECMWF
EC_UKAL_KONSENSUS
EC_UKAL_MEDIAN
1.0
0.8
0.6
0.4
0.2
0.0
0
0.1
1
2
4
8
12
20
30
40
50
Exceedance threshold

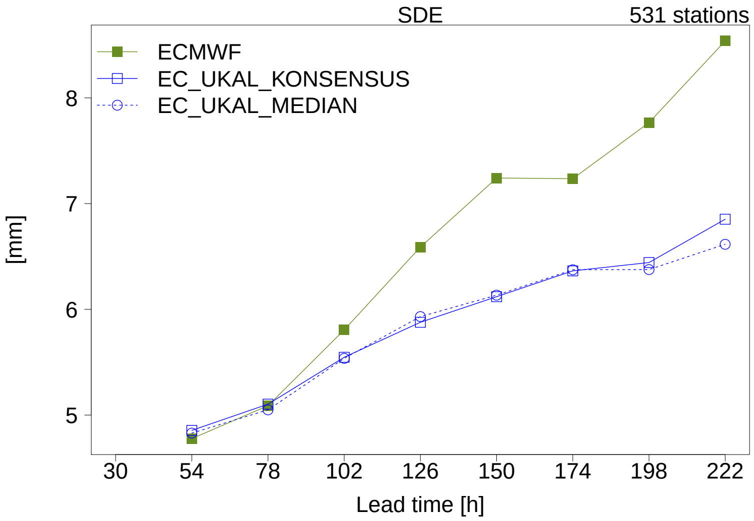

Lead time [h]: 234
Hit Rate
236 stations
ECMWF
EC_UKAL_KONSENSUS
EC_UKAL_MEDIAN
1.0
0.8
0.6
0.4
0.2
0.0
0
0.1
1
2
4
8
12
20
30
40
50
Exceedance threshold

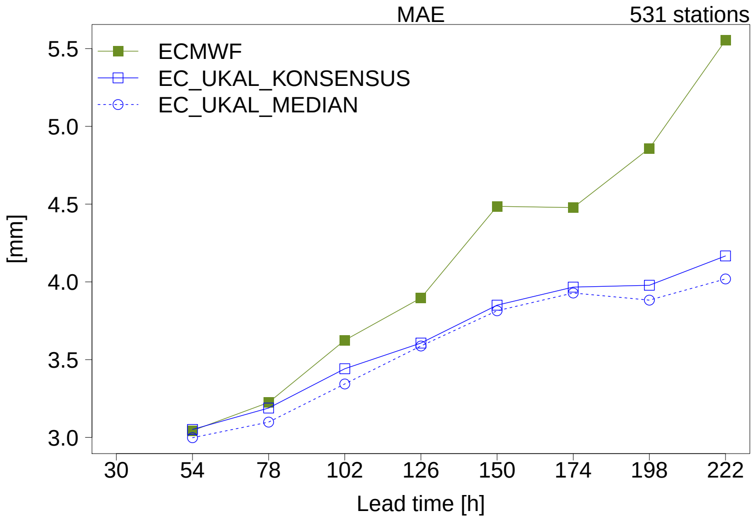

Lead time [h]: 234
False Alarm Ratio
236 stations
ECMWF
EC_UKAL_KONSENSUS
EC_UKAL_MEDIAN
1.0
0.8
0.6
0.4
0.2
0.0
0
0.1
1
2
4
8
12
20
30
40
50
Exceedance threshold

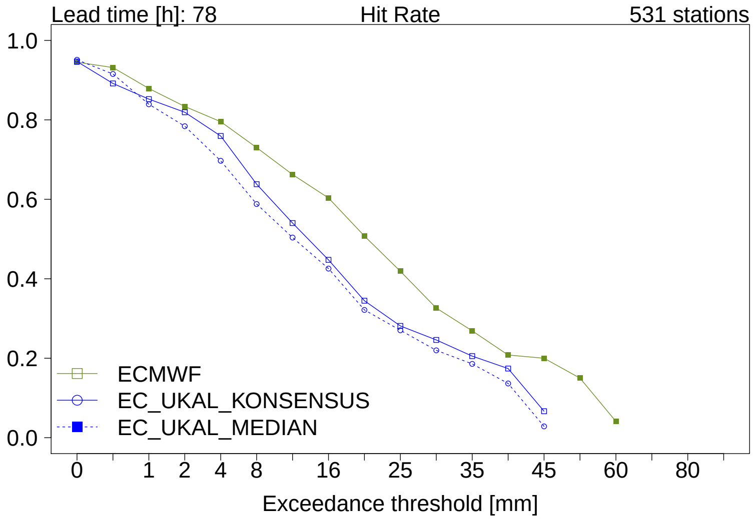

Lead time [h]: 234
Equitable Threat Score
236 stations
ECMWF
EC_UKAL_KONSENSUS
EC_UKAL_MEDIAN
1.0
0.8
0.6
0.4
0.2
0.0
0
0.1
1
2
4
8
12
20
30
40
50
Exceedance threshold

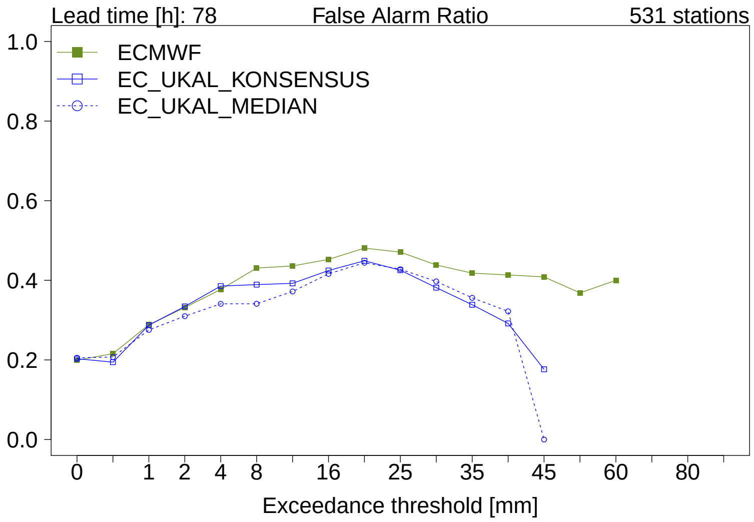
8.4 24h Precipitation

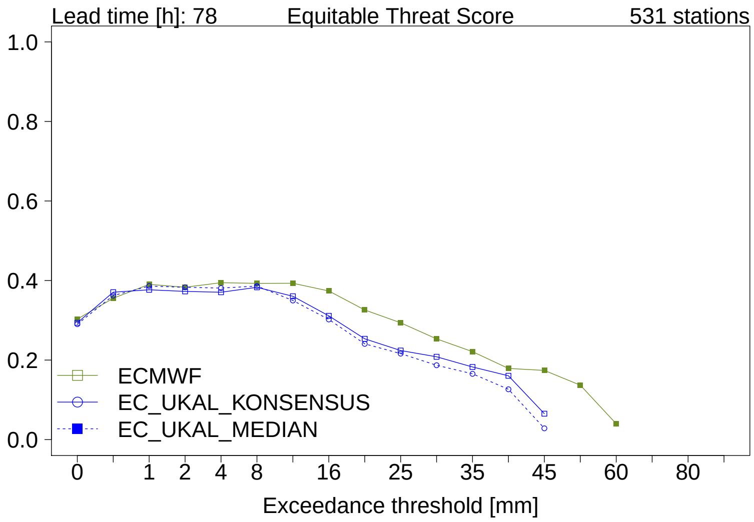


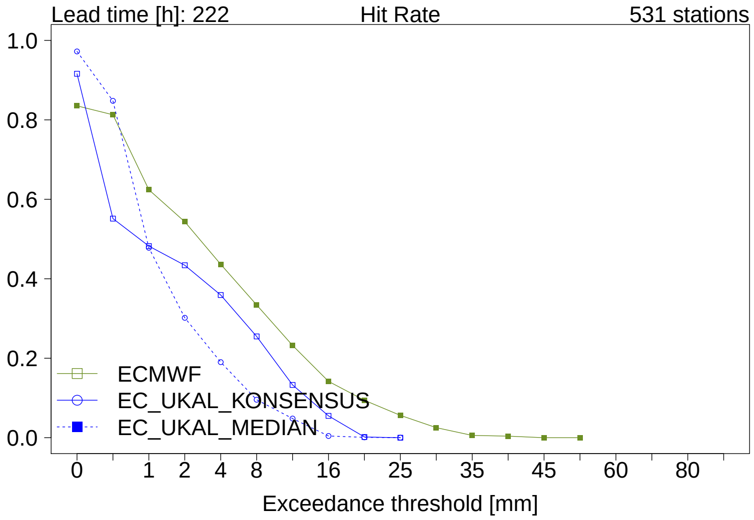


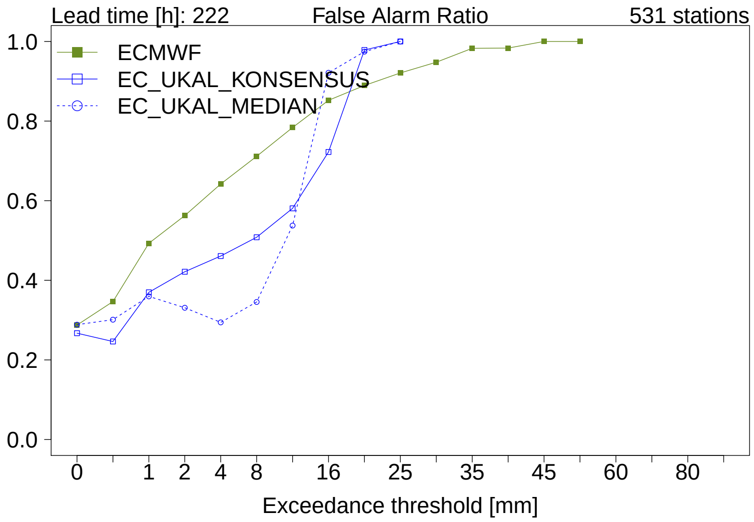


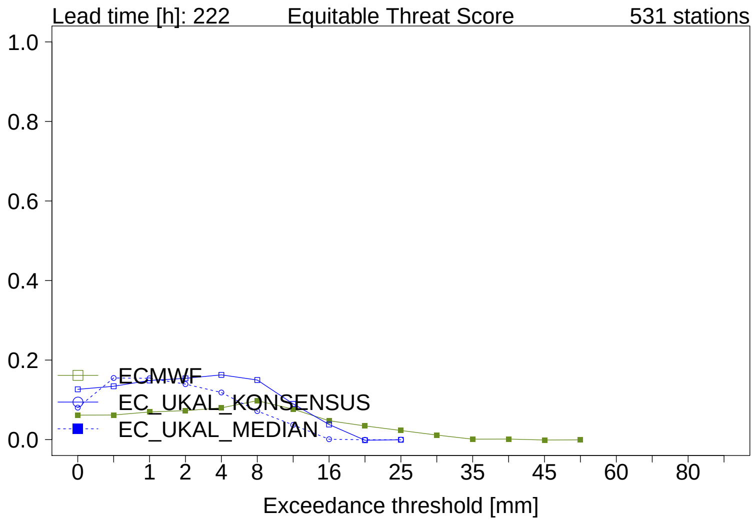

Lead time [h]: 78
Hit Rate
531 stations
1.0
0.8
0.6
0.4
0.2
0.0
ECMWF
EC_UKAL_KONSENSUS
EC_UKAL_MEDIAN
0
1
2
4
8
16
25
35
45
60
80
Exceedance threshold [mm]


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


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

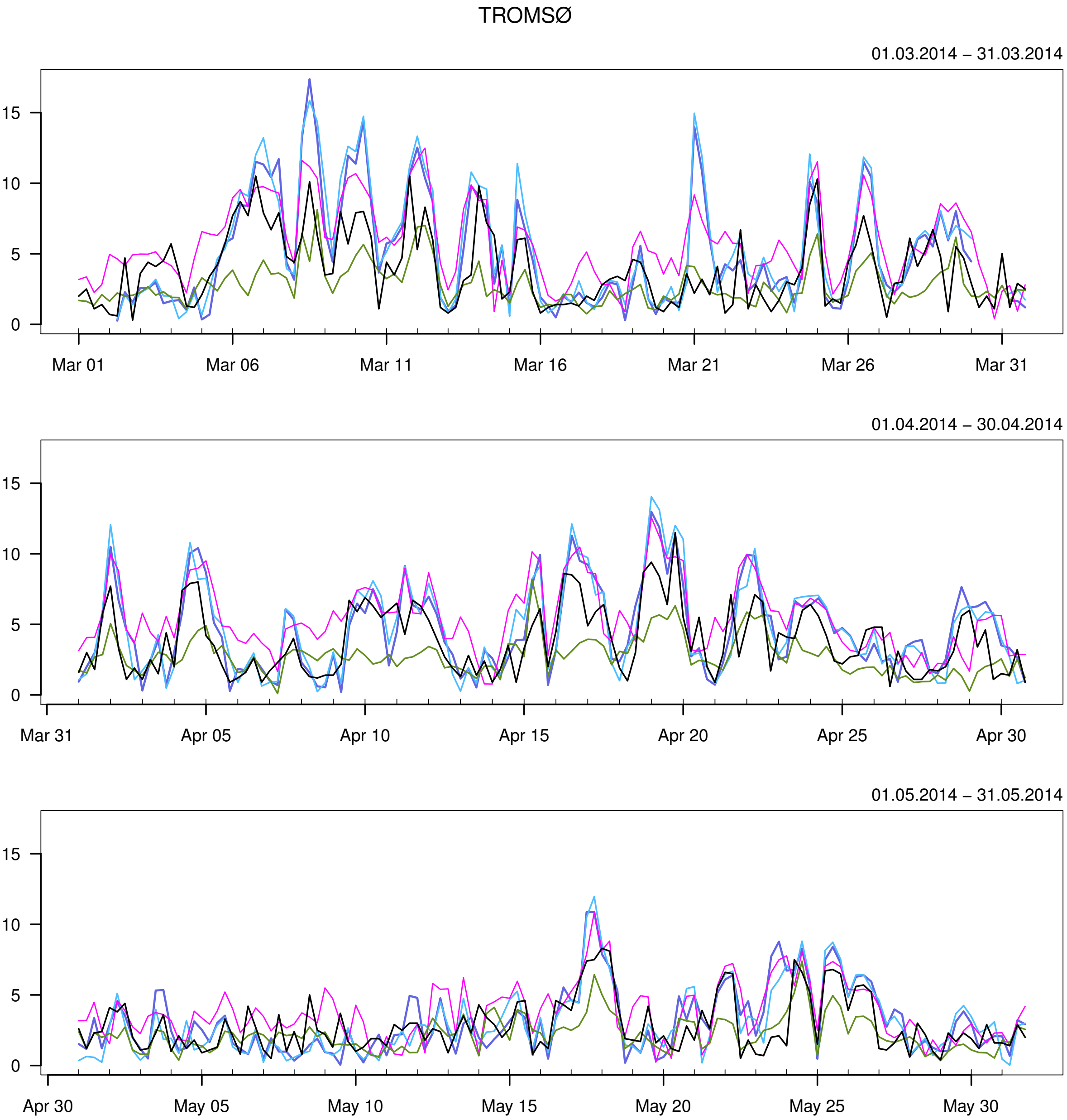

Lead time [h]: 222
Hit Rate
531 stations
1.0
0.8
0.6
0.4
0.2
0.0
ECMWF
EC_UKAL_KONSENSUS
EC_UKAL_MEDIAN
0
1
2
4
8
16
25
35
45
60
80
Exceedance threshold [mm]


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


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

9 Appendix

9.1 10m Wind speed

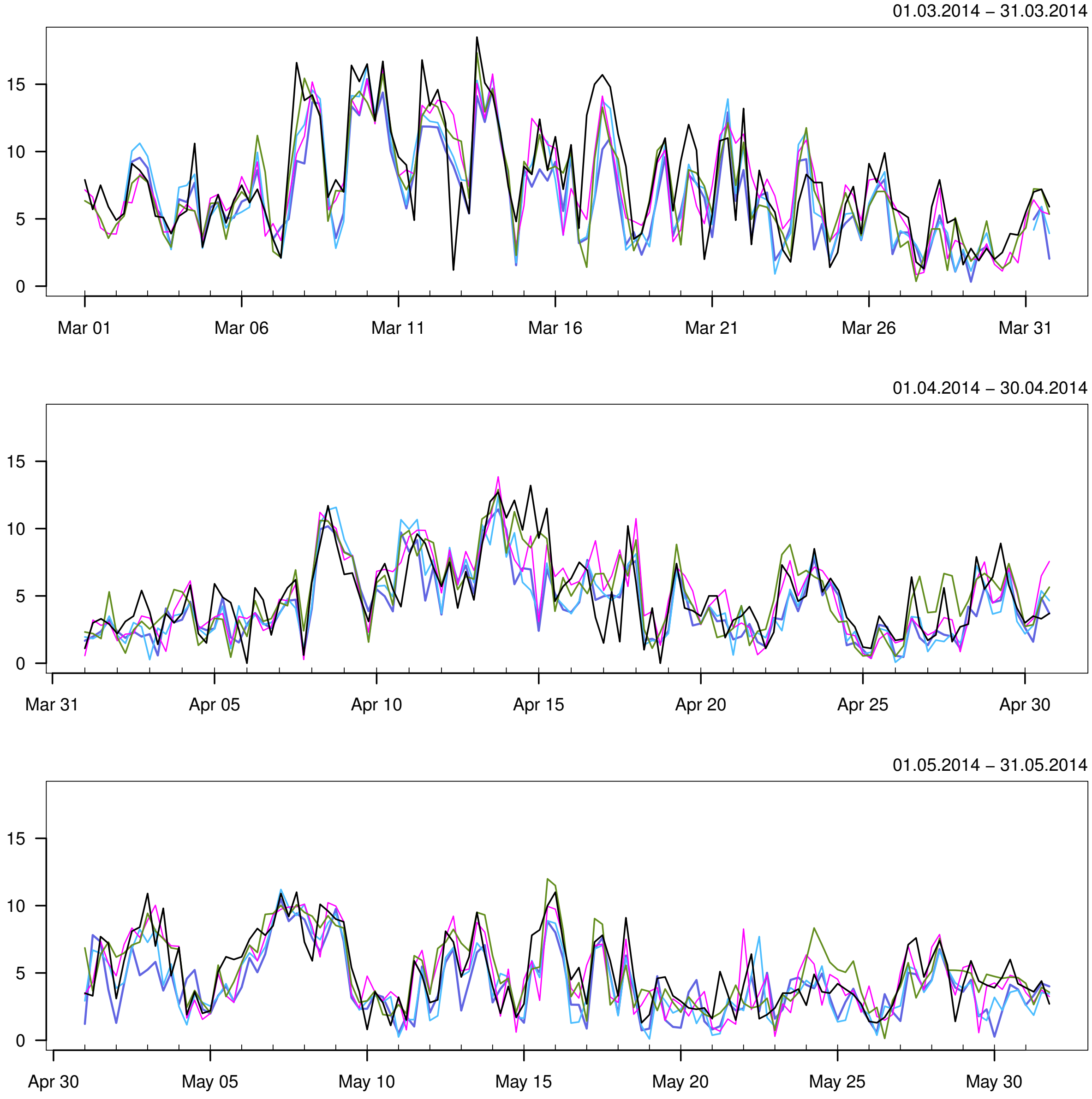


01.03.2014 – 31.03.2014

	Min	Mean	Max	Std	N
synop: 00,06,12,18	0.3	3.5	11.5	2.3	372
AM25: 12+18,+24,+30,+36	0	4.2	17.4	3.2	363
AROME_Norway: 12+18,+24,+30,+36	0	4.4	15.9	3.4	363
Hirlam8: 12+18,+24,+30,+36	0.2	5	12.6	2.6	372
ECMWF: 12+18,+24,+30,+36	0.1	2.6	8.2	1.3	372

	ME	SDE	RMSE	MAE	Max.abs.err.	N
AM25 – synop	0.7	2.1	2.2	1.6	11.8	363
AROME_Norway – synop	0.8	2.2	2.4	1.7	12.8	363
Hirlam8 – synop	1.5	2	2.5	2	7.1	372
ECMWF – synop	−0.9	1.8	2	1.5	7	372

ØRLAND

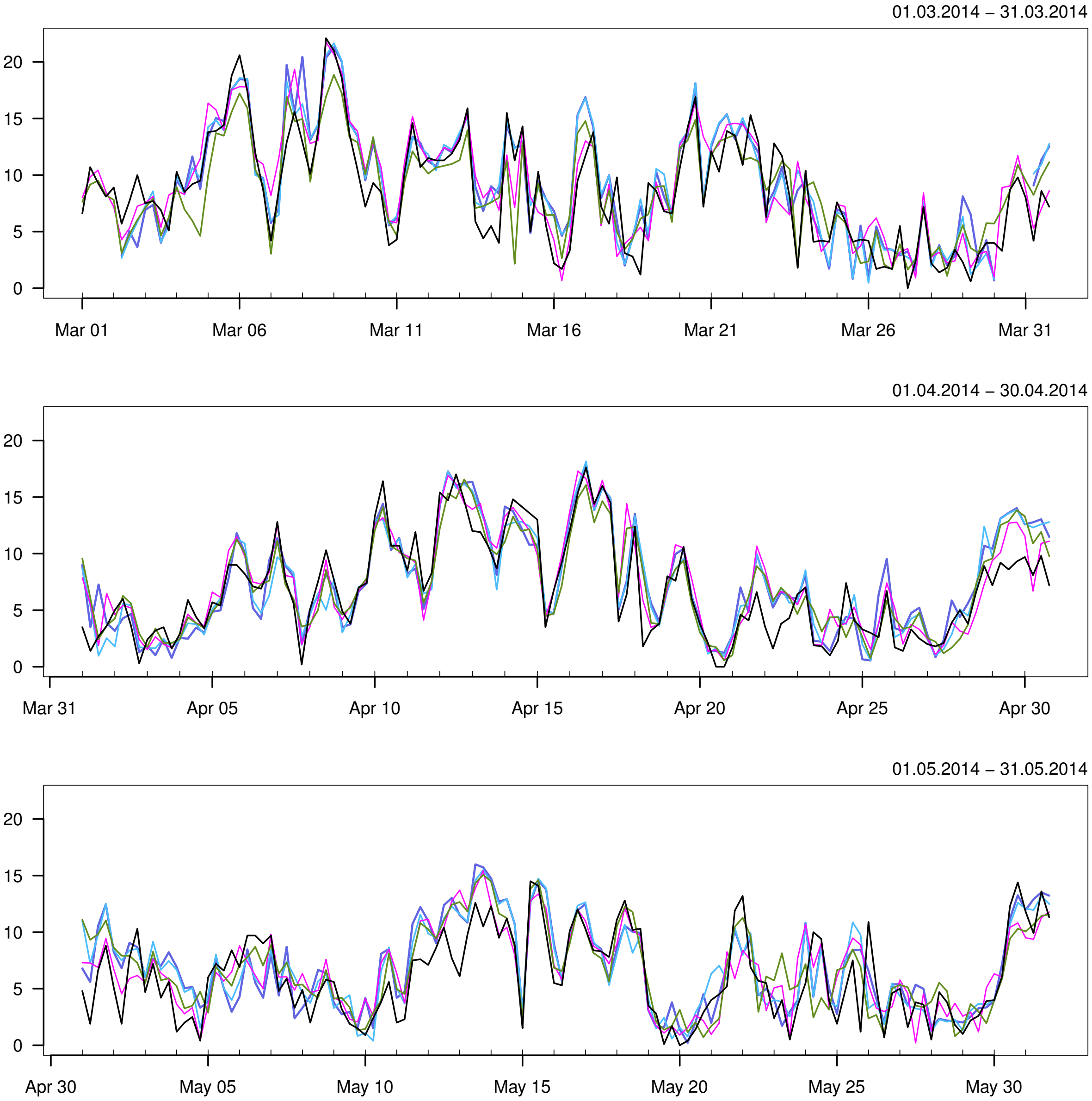


01.03.2014 – 31.03.2014

	Min	Mean	Max	Std	N
synop: 00,06,12,18	0	6	18.5	3.5	372
AM25: 12+18,+24,+30,+36	0.3	5	15.4	3	363
AROME_Norway: 12+18,+24,+30,+36	0.1	5.3	16.3	3.3	363
Hirlam8: 12+18,+24,+30,+36	0.3	5.8	16.2	3.2	372
ECMWF: 12+18,+24,+30,+36	0.1	5.9	17.3	3.2	372

	ME	SDE	RMSE	MAE	Max.abs.err.	N
AM25 – synop	–1	2.1	2.4	1.8	9.2	363
AROME_Norway – synop	–0.8	2.1	2.3	1.7	9	363
Hirlam8 – synop	–0.2	2.1	2.1	1.6	11.5	372
ECMWF – synop	–0.1	2	2	1.5	11.3	372

YTTERØYANE FYR

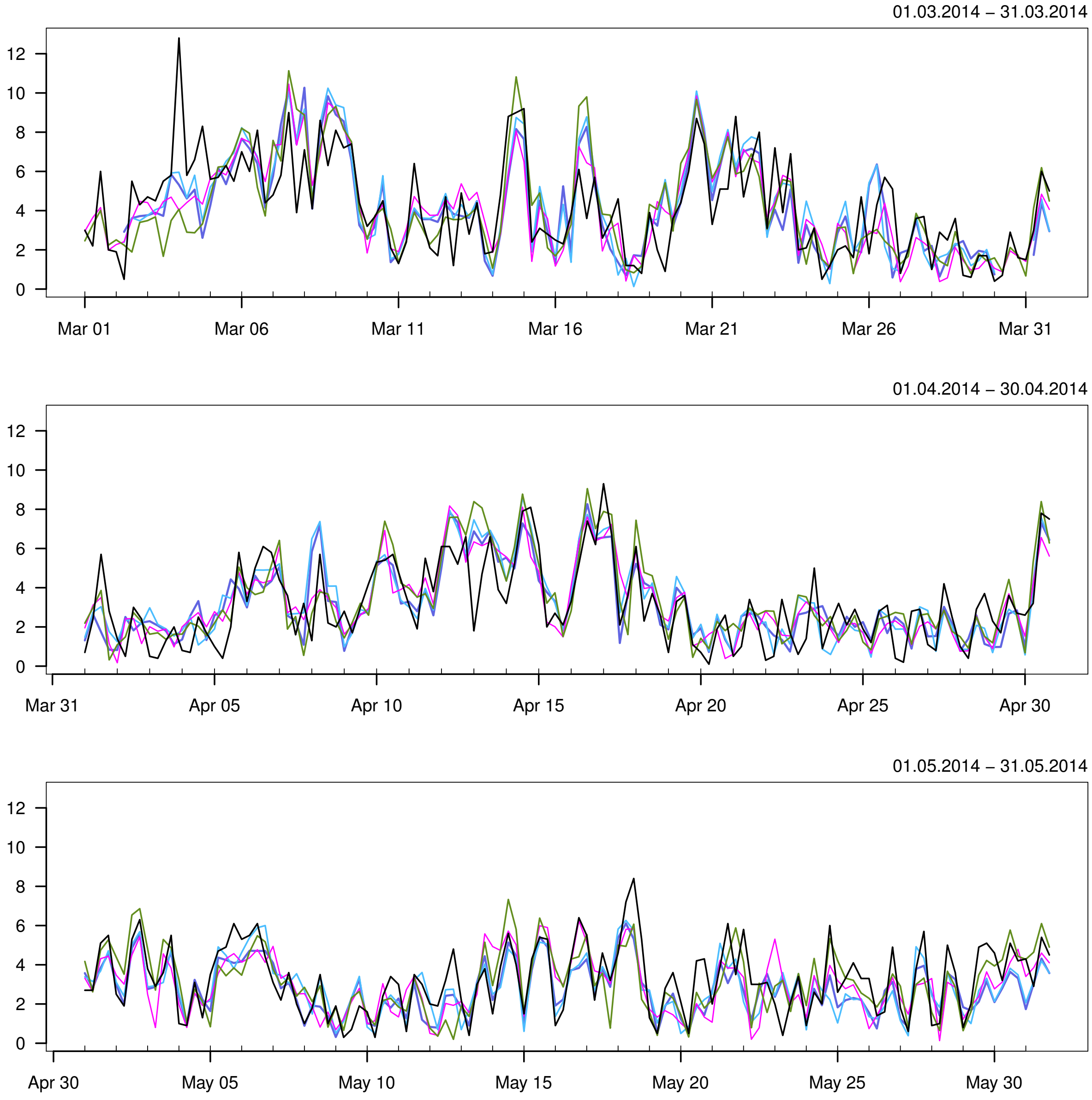


01.03.2014 – 31.03.2014

	Min	Mean	Max	Std	N
— synop: 00,06,12,18	0	7.2	22.1	4.5	372
— AM25: 12+18,+24,+30,+36	0.2	7.9	21.3	4.6	363
— AROME_Norway: 12+18,+24,+30,+36	0.4	7.9	21.7	4.5	363
— Hirlam8: 12+18,+24,+30,+36	0.2	7.8	21.8	4.3	372
— ECMWF: 12+18,+24,+30,+36	0.6	7.6	18.9	4	372

	ME	SDE	RMSE	MAE	Max.abs.err.	N
AM25 – synop	0.7	2.4	2.5	1.9	7.5	363
AROME_Norway – synop	0.7	2.4	2.5	1.9	8.6	363
Hirlam8 – synop	0.5	2.2	2.3	1.7	9.4	372
ECMWF – synop	0.3	2.3	2.4	1.8	9.1	372

BERGEN – FLORIDA

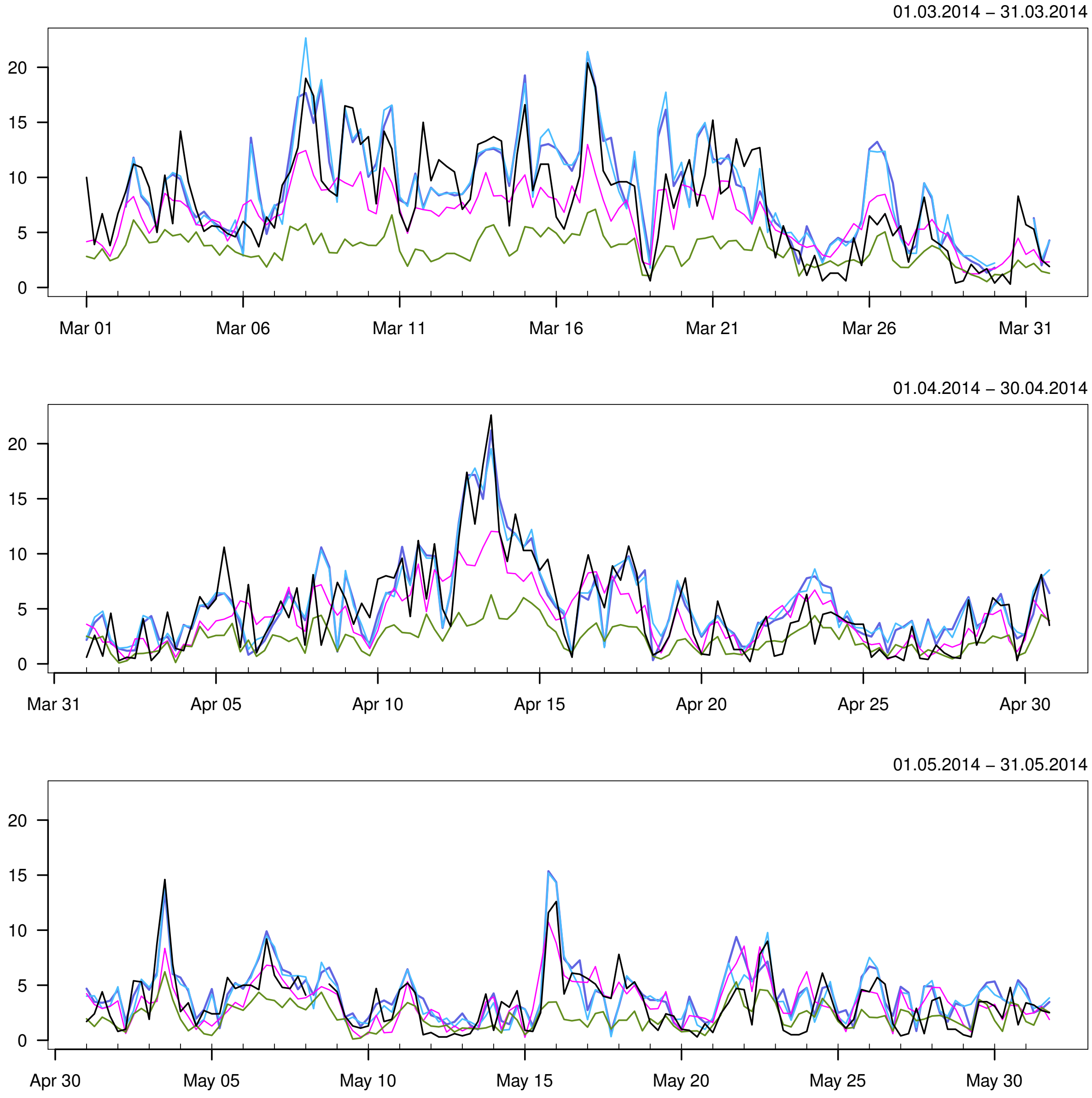


01.03.2014 – 31.03.2014

		Min	Mean	Max	Std	N
—	synop: 00,06,12,18	0.1	3.6	12.8	2.2	372
—	AM25: 12+18,+24,+30,+36	0.3	3.4	10.3	2	363
—	AROME_Norway: 12+18,+24,+30,+36	0.1	3.6	10.2	2.1	363
—	Hirlam8: 12+18,+24,+30,+36	0.1	3.5	10.4	2	372
—	ECMWF: 12+18,+24,+30,+36	0.2	3.6	11.1	2.2	372

	ME	SDE	RMSE	MAE	Max.abs.err.	N
AM25 – synop	−0.2	1.5	1.5	1.2	7.5	363
AROME_Norway – synop	0	1.5	1.5	1.1	6.8	363
Hirlam8 – synop	−0.1	1.5	1.5	1.2	8.8	372
ECMWF – synop	0	1.6	1.6	1.2	8.7	372

FINSEVATN

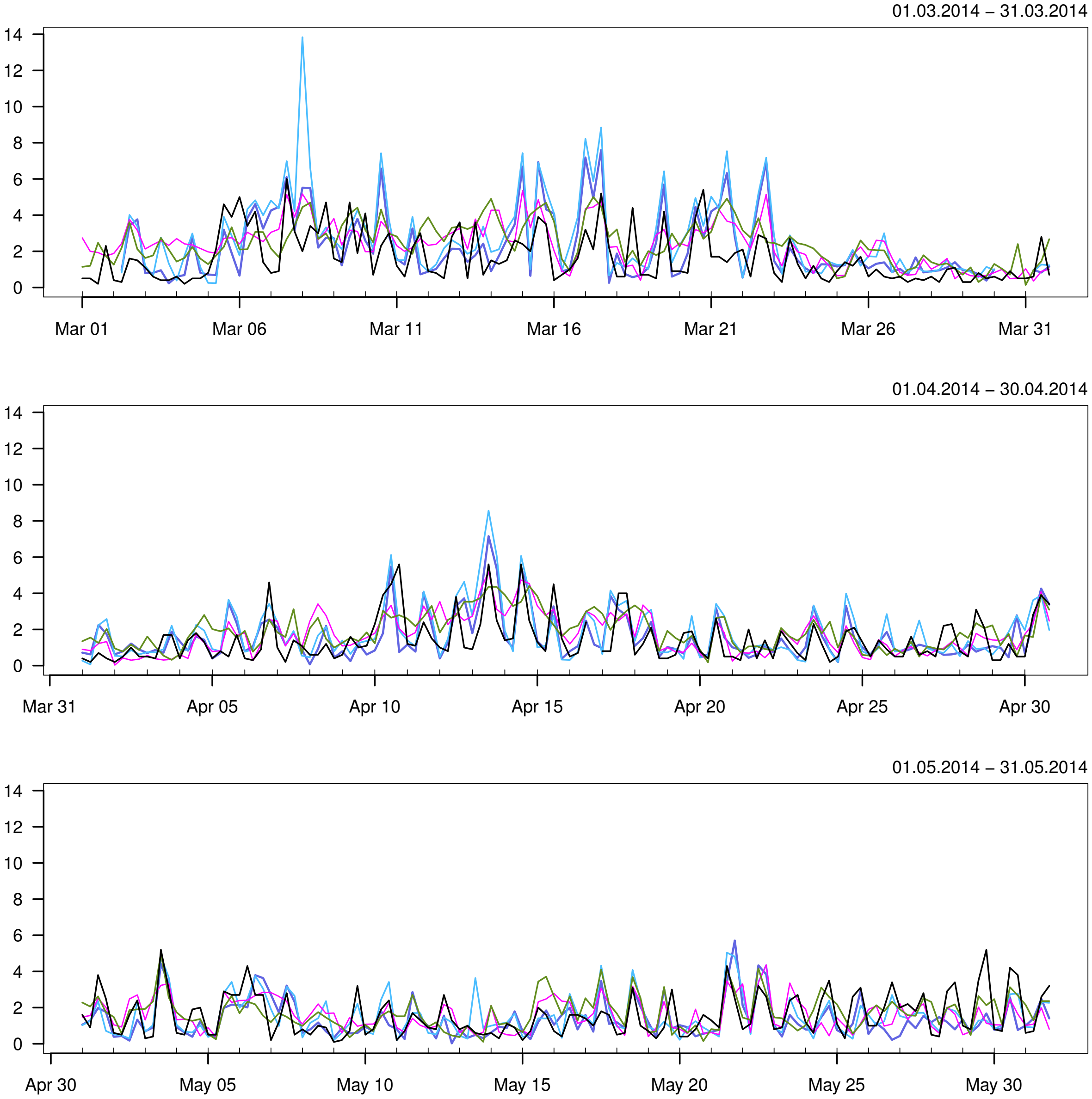


01.03.2014 – 31.03.2014

		Min	Mean	Max	Std	N
—	synop: 00,06,12,18	0.2	5.4	22.6	4.3	370
—	AM25: 12+18,+24,+30,+36	0.3	6.2	21.3	4.1	363
—	AROME_Norway: 12+18,+24,+30,+36	0.3	6.3	22.7	4.2	363
—	Hirlam8: 12+18,+24,+30,+36	0.3	4.8	13	2.7	372
—	ECMWF: 12+18,+24,+30,+36	0.1	2.7	7.1	1.4	372

	ME	SDE	RMSE	MAE	Max.abs.err.	N
AM25 – synop	0.8	2.4	2.6	2	9.2	361
AROME_Norway – synop	0.9	2.4	2.6	2	9.9	361
Hirlam8 – synop	−0.6	2.6	2.7	2	10.6	370
ECMWF – synop	−2.7	3.3	4.3	3.1	16.3	370

NESBYEN

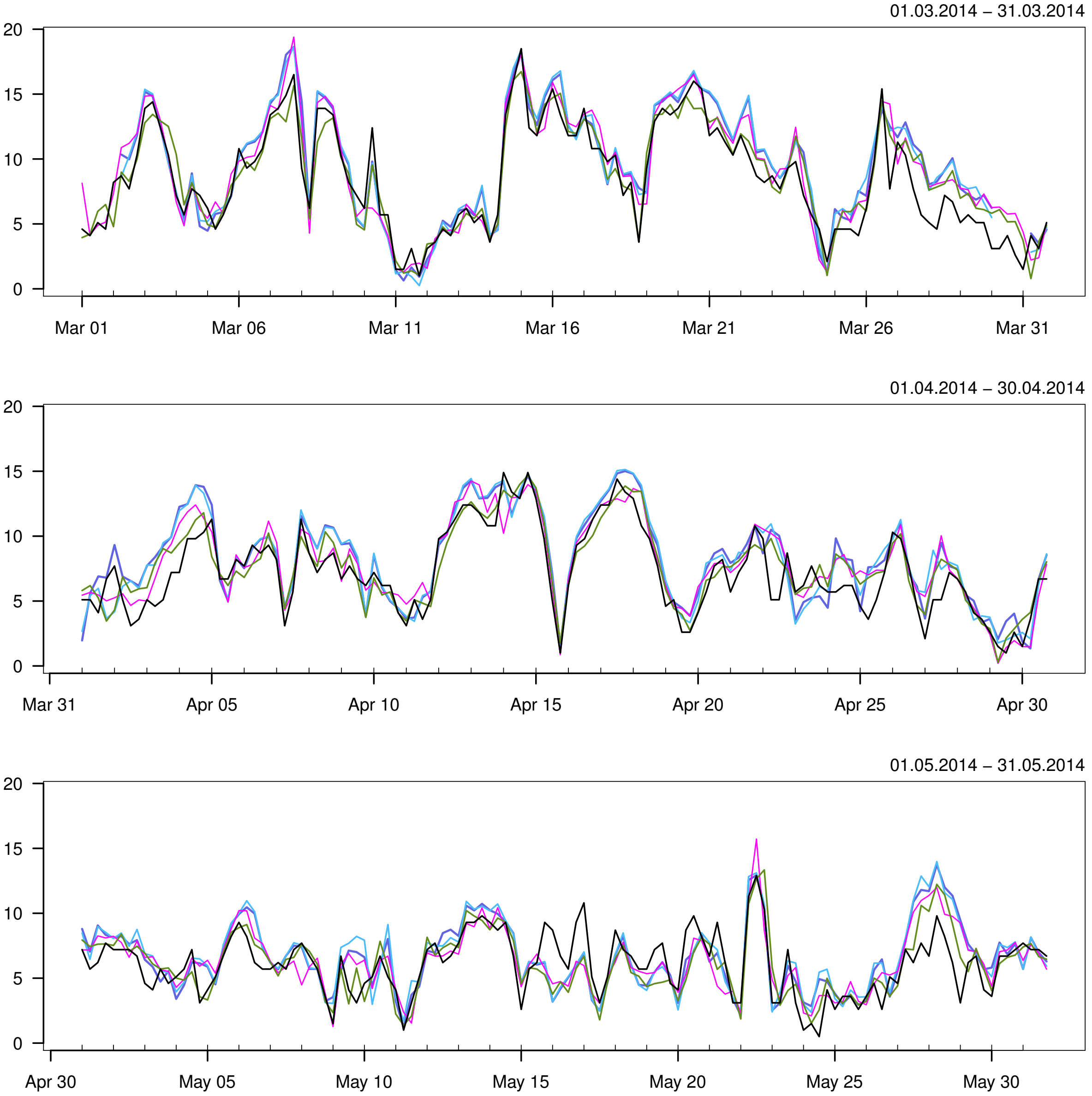


01.03.2014 – 31.03.2014

		Min	Mean	Max	Std	N
—	synop: 00,06,12,18	0.1	1.6	6	1.3	371
—	AM25: 12+18,+24,+30,+36	0	1.7	7.6	1.5	363
—	AROME_Norway: 12+18,+24,+30,+36	0.1	2	13.8	1.7	363
—	Hirlam8: 12+18,+24,+30,+36	0	1.9	5.3	1.1	372
—	ECMWF: 12+18,+24,+30,+36	0.1	2	5	1.1	372

	ME	SDE	RMSE	MAE	Max.abs.err.	N
AM25 – synop	0.1	1.3	1.3	0.9	4.9	362
AROME_Norway – synop	0.5	1.5	1.5	1	11.8	362
Hirlam8 – synop	0.3	1.2	1.2	1	4.1	371
ECMWF – synop	0.5	1.2	1.3	1	3.5	371

EKOFISK

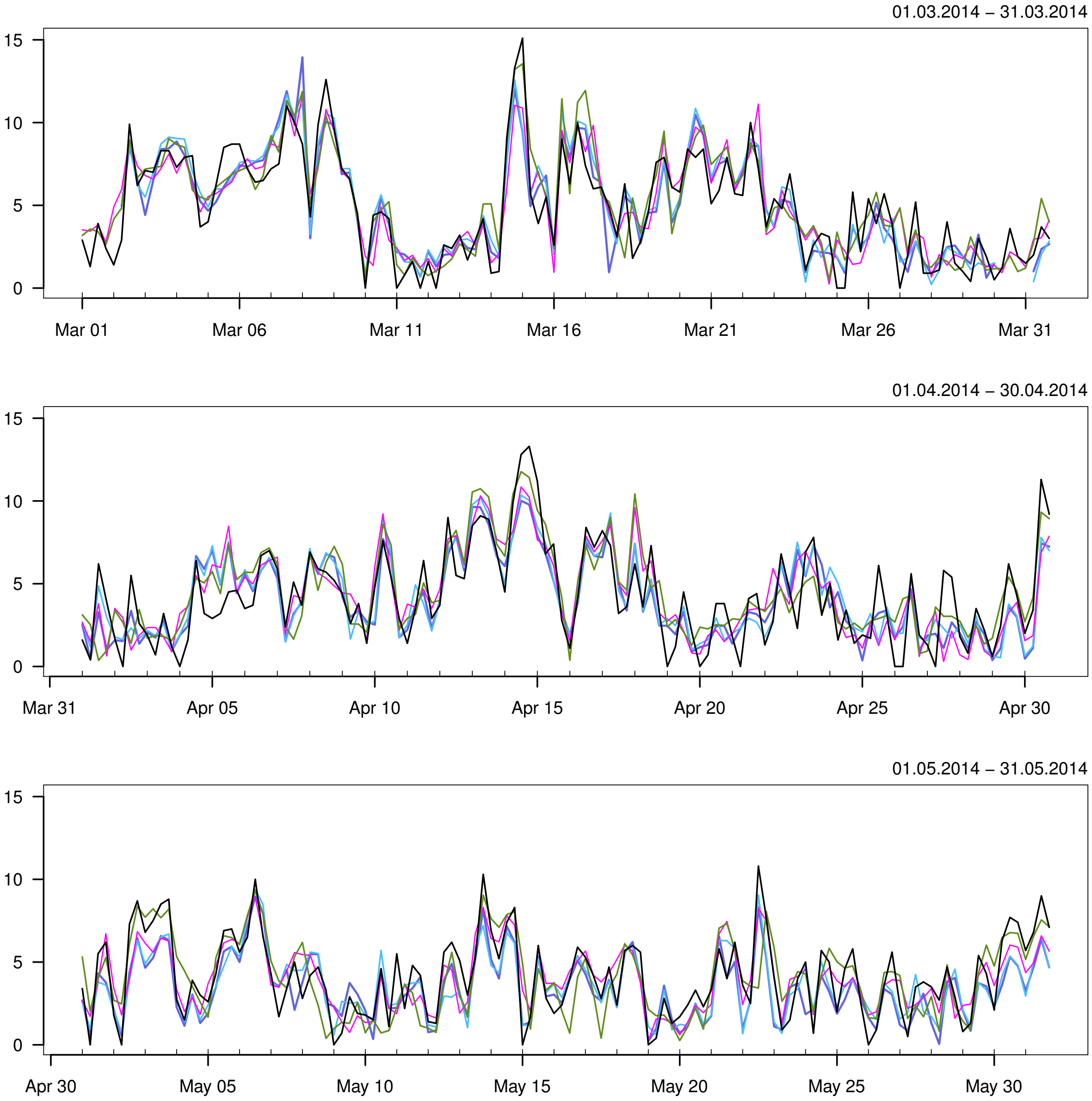


01.03.2014 – 31.03.2014

		Min	Mean	Max	Std	N
—	synop: 00,06,12,18	0.5	7.3	18.5	3.5	372
—	AM25: 12+18,+24,+30,+36	0.6	8.2	18.6	3.7	363
—	AROME_Norway: 12+18,+24,+30,+36	0.3	8.3	18.6	3.8	363
—	Hirlam8: 12+18,+24,+30,+36	0.2	7.8	19.4	3.6	372
—	ECMWF: 12+18,+24,+30,+36	0.3	7.6	16.7	3.4	372

	ME	SDE	RMSE	MAE	Max.abs.err.	N
AM25 – synop	0.8	1.7	1.9	1.5	6.4	363
AROME_Norway – synop	0.8	1.7	1.9	1.5	6	363
Hirlam8 – synop	0.5	1.6	1.7	1.3	6.5	372
ECMWF – synop	0.2	1.5	1.5	1.1	4.9	372

SOLA

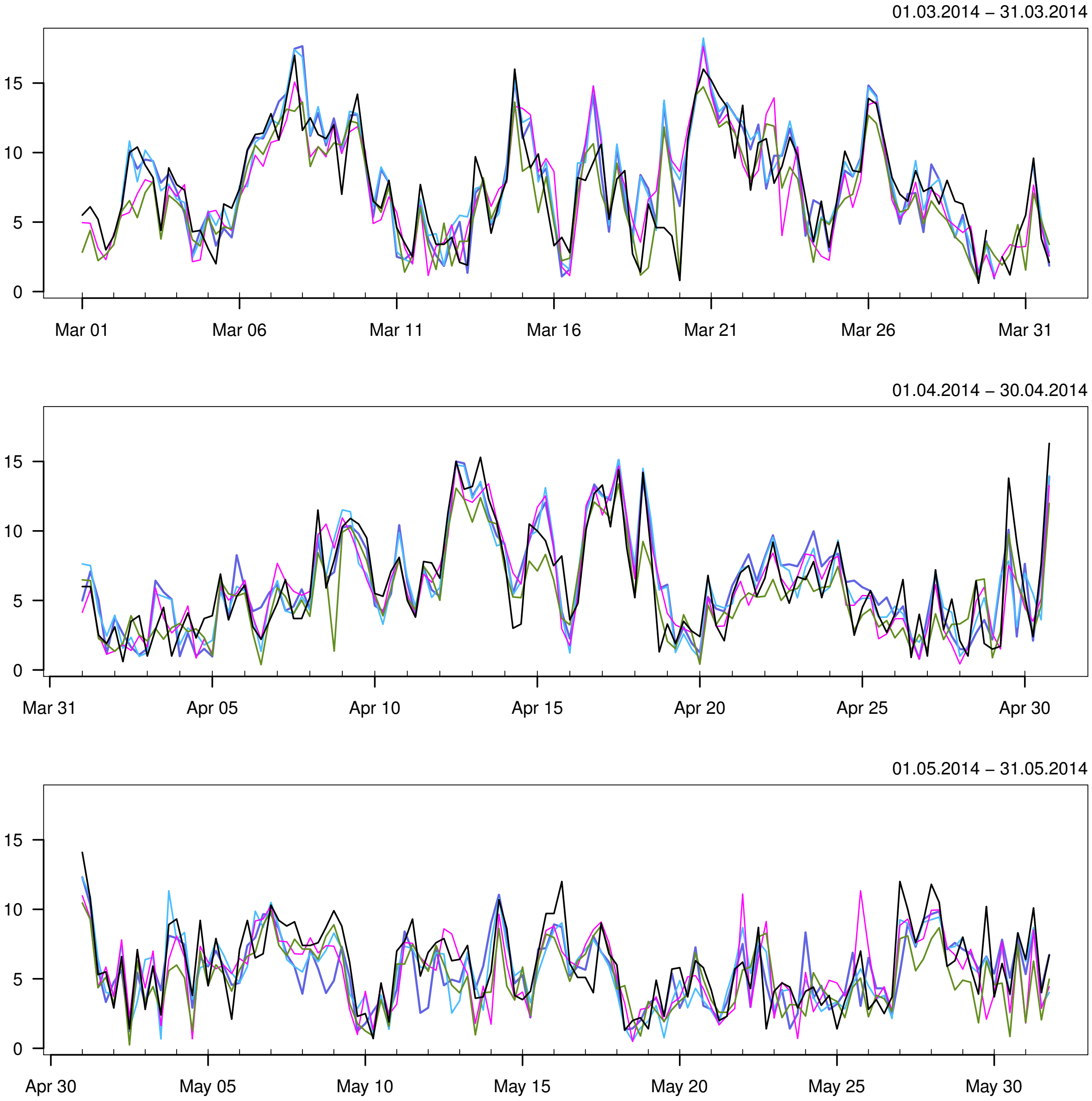


01.03.2014 – 31.03.2014

		Min	Mean	Max	Std	N
—	synop: 00,06,12,18	0	4.5	15.1	3	372
—	AM25: 12+18,+24,+30,+36	0	4.2	13.9	2.6	363
—	AROME_Norway: 12+18,+24,+30,+36	0.2	4.4	12.6	2.7	363
—	Hirlam8: 12+18,+24,+30,+36	0.2	4.5	11.7	2.6	372
—	ECMWF: 12+18,+24,+30,+36	0.3	4.7	13.6	2.8	372

	ME	SDE	RMSE	MAE	Max.abs.err.	N
AM25 – synop	−0.3	1.5	1.6	1.2	5.7	363
AROME_Norway – synop	−0.2	1.5	1.6	1.2	5.6	363
Hirlam8 – synop	0	1.7	1.7	1.3	5.5	372
ECMWF – synop	0.2	1.7	1.7	1.3	7.4	372

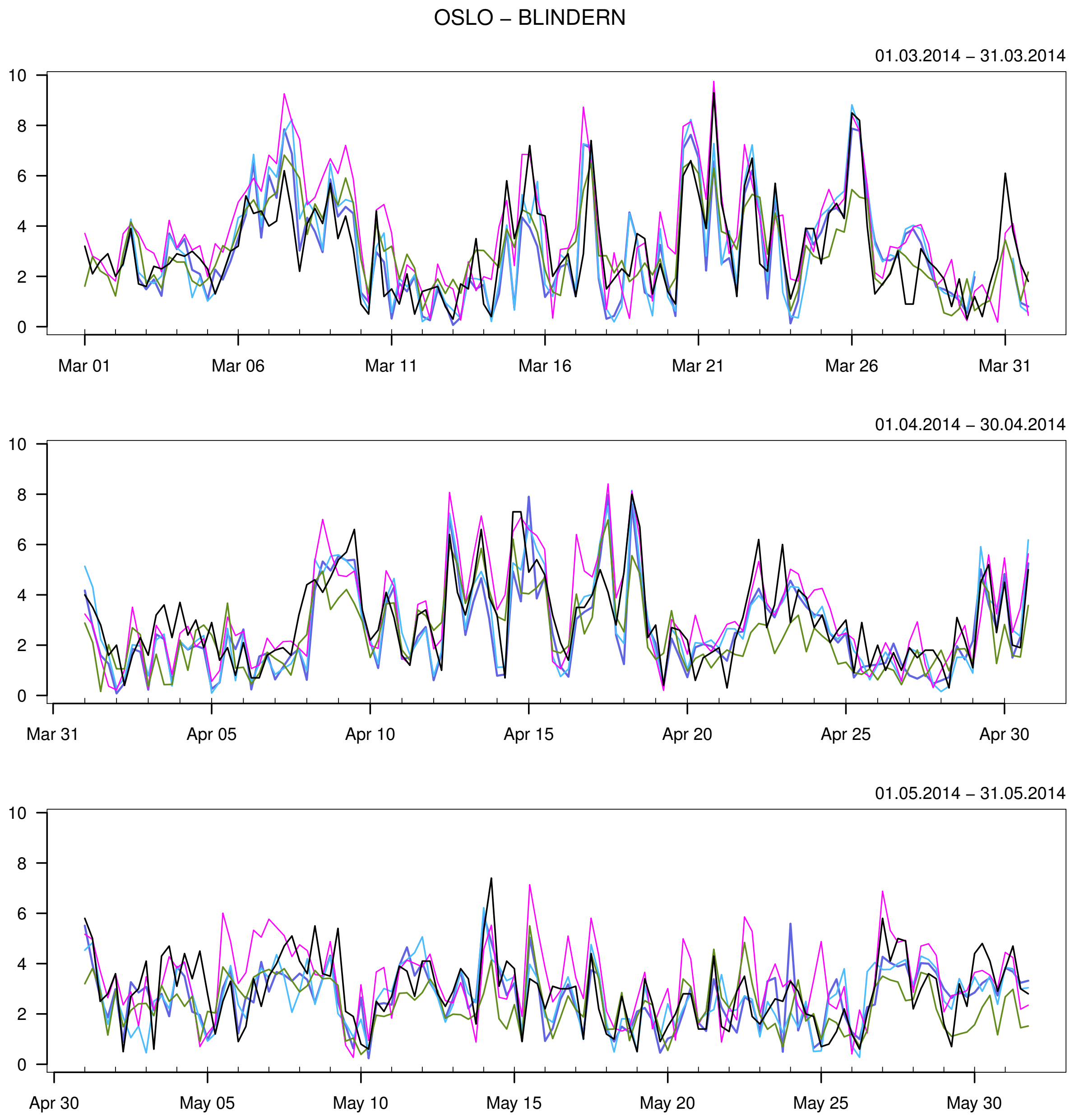
FERDER FYR



01.03.2014 – 31.03.2014

	Min	Mean	Max	Std	N
synop: 00,06,12,18	0.6	6.6	17	3.5	371
AM25: 12+18,+24,+30,+36	0.8	6.7	17.9	3.5	363
AROME_Norway: 12+18,+24,+30,+36	0.5	6.7	18.2	3.5	363
Hirlam8: 12+18,+24,+30,+36	0.4	6.3	17.6	3.4	372
ECMWF: 12+18,+24,+30,+36	0.2	5.8	14.7	3.1	372

	ME	SDE	RMSE	MAE	Max.abs.err.	N
AM25 – synop	0	2	2	1.5	9	362
AROME_Norway – synop	0.1	1.9	1.9	1.5	9.2	362
Hirlam8 – synop	−0.2	2.1	2.1	1.6	8.1	371
ECMWF – synop	−0.8	1.8	2	1.5	7.2	371

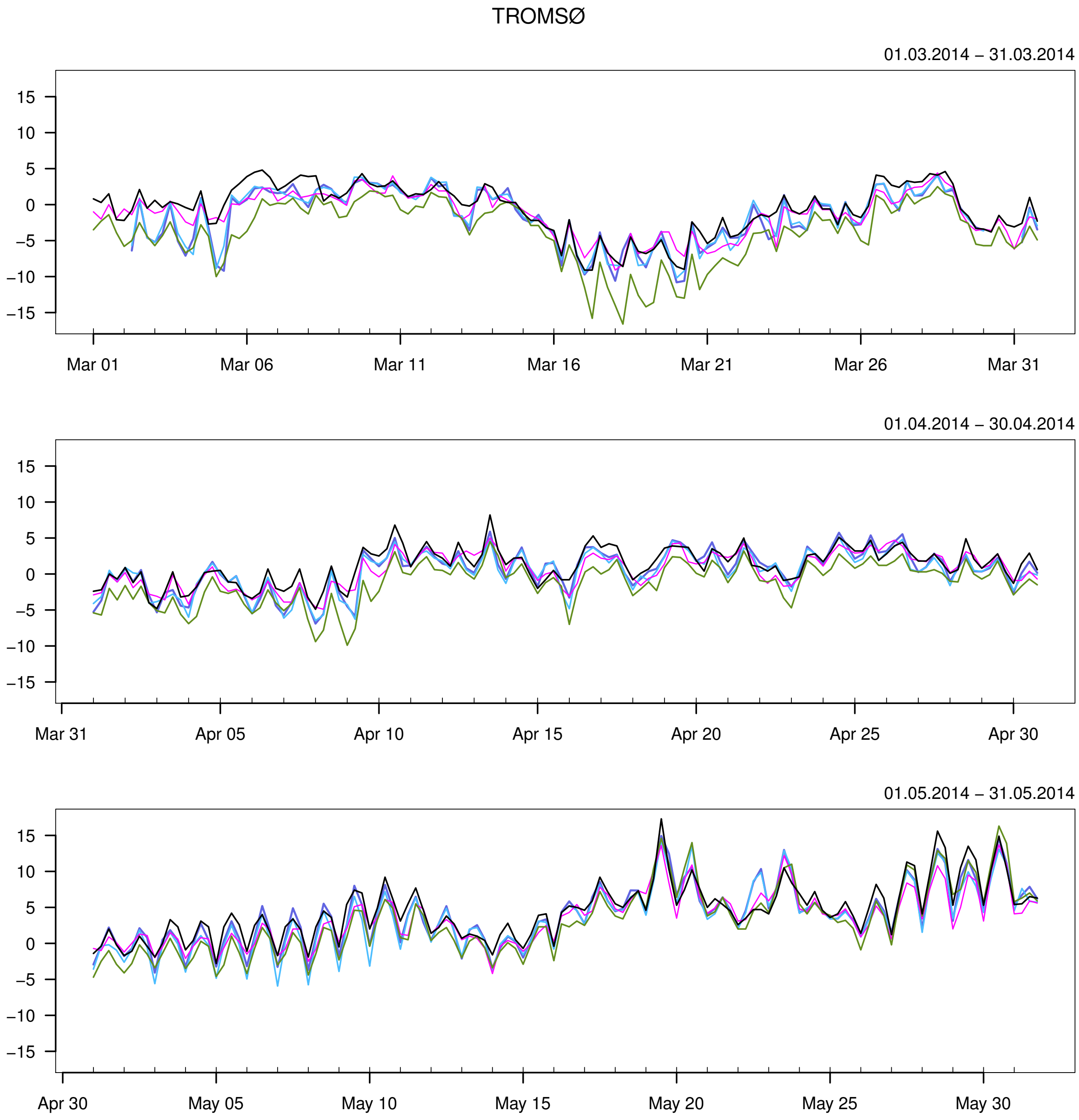

OSLO – BLINDERN

01.03.2014 – 31.03.2014

		Min	Mean	Max	Std	N
—	synop: 00,06,12,18	0.3	3	9.3	1.7	372
—	AM25: 12+18,+24,+30,+36	0.1	2.8	8	1.7	363
—	AROME_Norway: 12+18,+24,+30,+36	0.1	2.9	8.8	1.8	363
—	Hirlam8: 12+18,+24,+30,+36	0.2	3.5	9.8	1.9	372
—	ECMWF: 12+18,+24,+30,+36	0.2	2.6	7	1.4	372

	ME	SDE	RMSE	MAE	Max.abs.err.	N
AM25 – synop	−0.3	1.2	1.2	0.9	4.4	363
AROME_Norway – synop	−0.1	1.2	1.2	0.9	4.4	363
Hirlam8 – synop	0.5	1.3	1.4	1.1	5.8	372
ECMWF – synop	−0.3	1.2	1.3	1	3.8	372

9.2 Temperature 2m

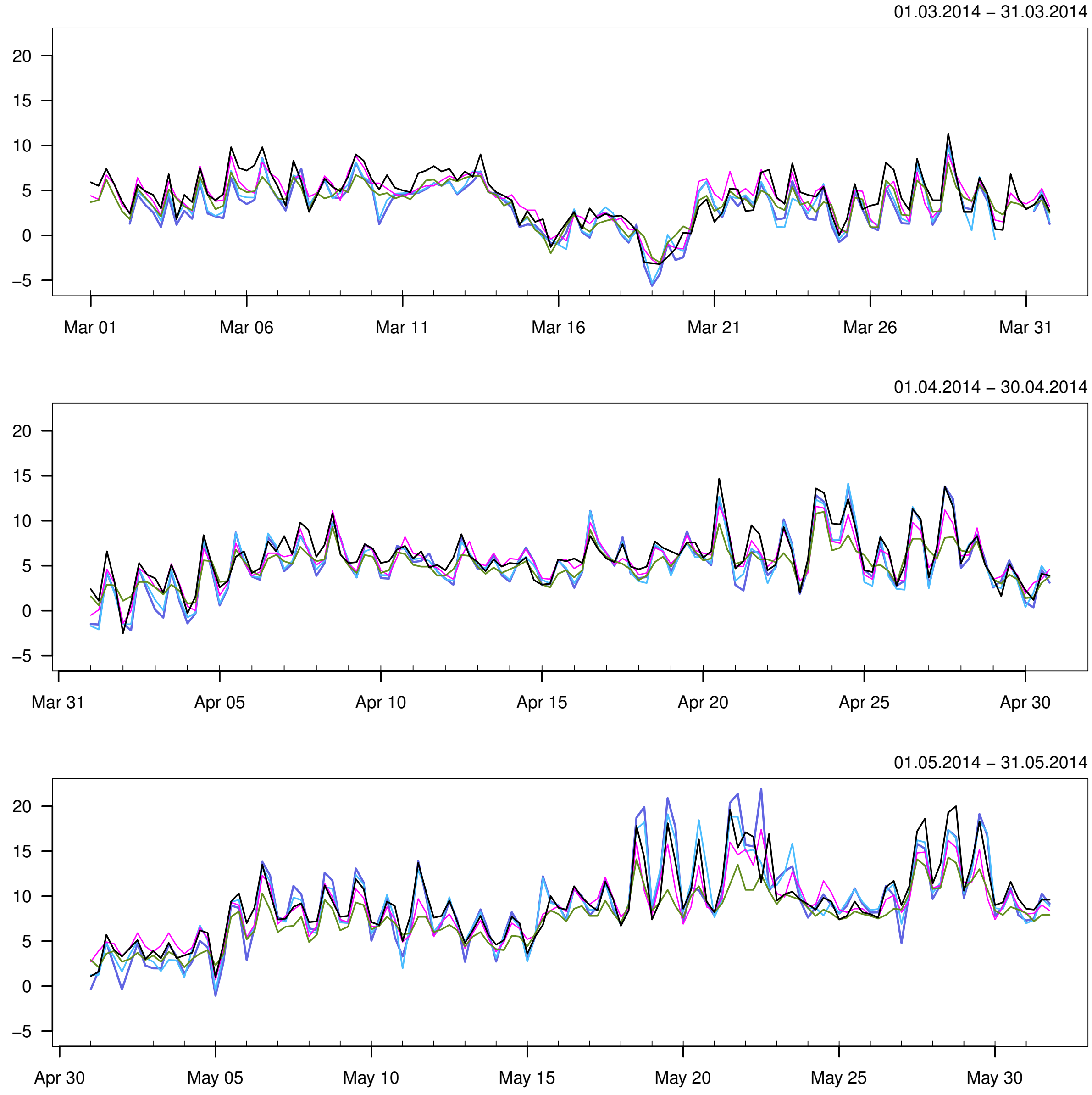


01.03.2014 – 31.05.2014

	Min	Mean	Max	Std	N
— synop: 00,06,12,18	−9.1	1.7	17.3	4	372
— AM25: 12+18,+24,+30,+36	−10.8	1	14.9	4.3	363
— AROME_Norway: 12+18,+24,+30,+36	−10.2	0.8	14.3	4.2	363
— Hirlam8: 12+18,+24,+30,+36	−9.1	0.9	13.7	3.7	372
— ECMWF: 12+18,+24,+30,+36	−16.6	−0.6	16.3	4.9	372

	ME	SDE	RMSE	MAE	Max.abs.err.	N
AM25 – synop	−0.7	1.5	1.7	1.2	9.1	363
AROME_Norway – synop	−1	1.6	1.8	1.4	6.6	363
Hirlam8 – synop	−0.7	1.3	1.5	1.2	5.5	372
ECMWF – synop	−2.3	1.8	2.9	2.5	8.1	372

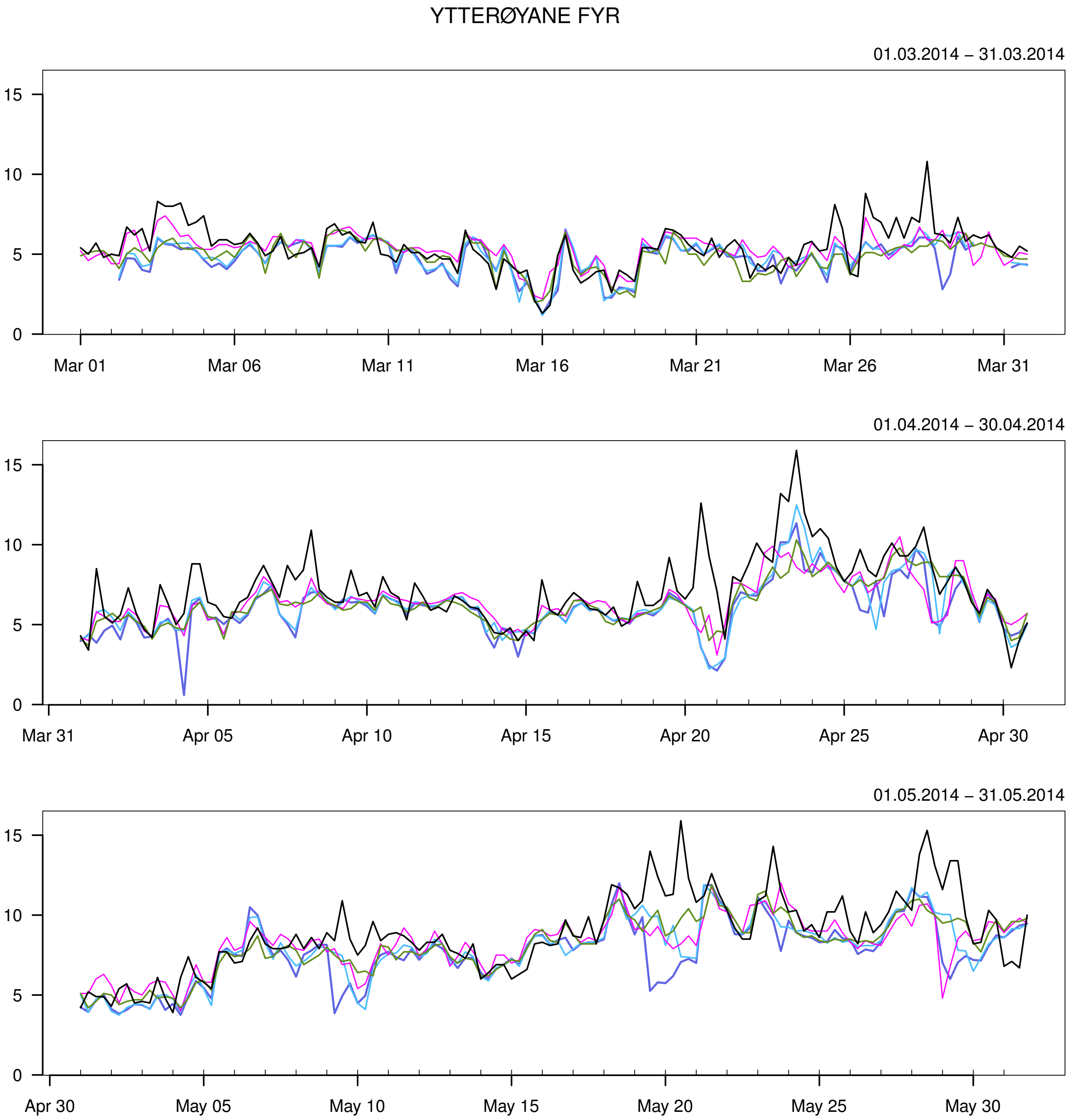
ØRLAND



01.03.2014 – 31.03.2014

	Min	Mean	Max	Std	N
synop: 00,06,12,18	−3.2	6.5	20	3.9	372
AM25: 12+18,+24,+30,+36	−5.6	5.8	22	4.4	363
AROME_Norway: 12+18,+24,+30,+36	−5.3	6	19.1	4.2	363
Hirlam8: 12+18,+24,+30,+36	−3.3	6.1	17.4	3.3	372
ECMWF: 12+18,+24,+30,+36	−3	5.4	14.3	2.9	372

	ME	SDE	RMSE	MAE	Max.abs.err.	N
AM25 – synop	−0.7	1.7	1.8	1.3	10.5	363
AROME_Norway – synop	−0.6	1.4	1.5	1.2	6	363
Hirlam8 – synop	−0.4	1.3	1.4	1	5.9	372
ECMWF – synop	−1.1	1.5	1.9	1.4	8.3	372

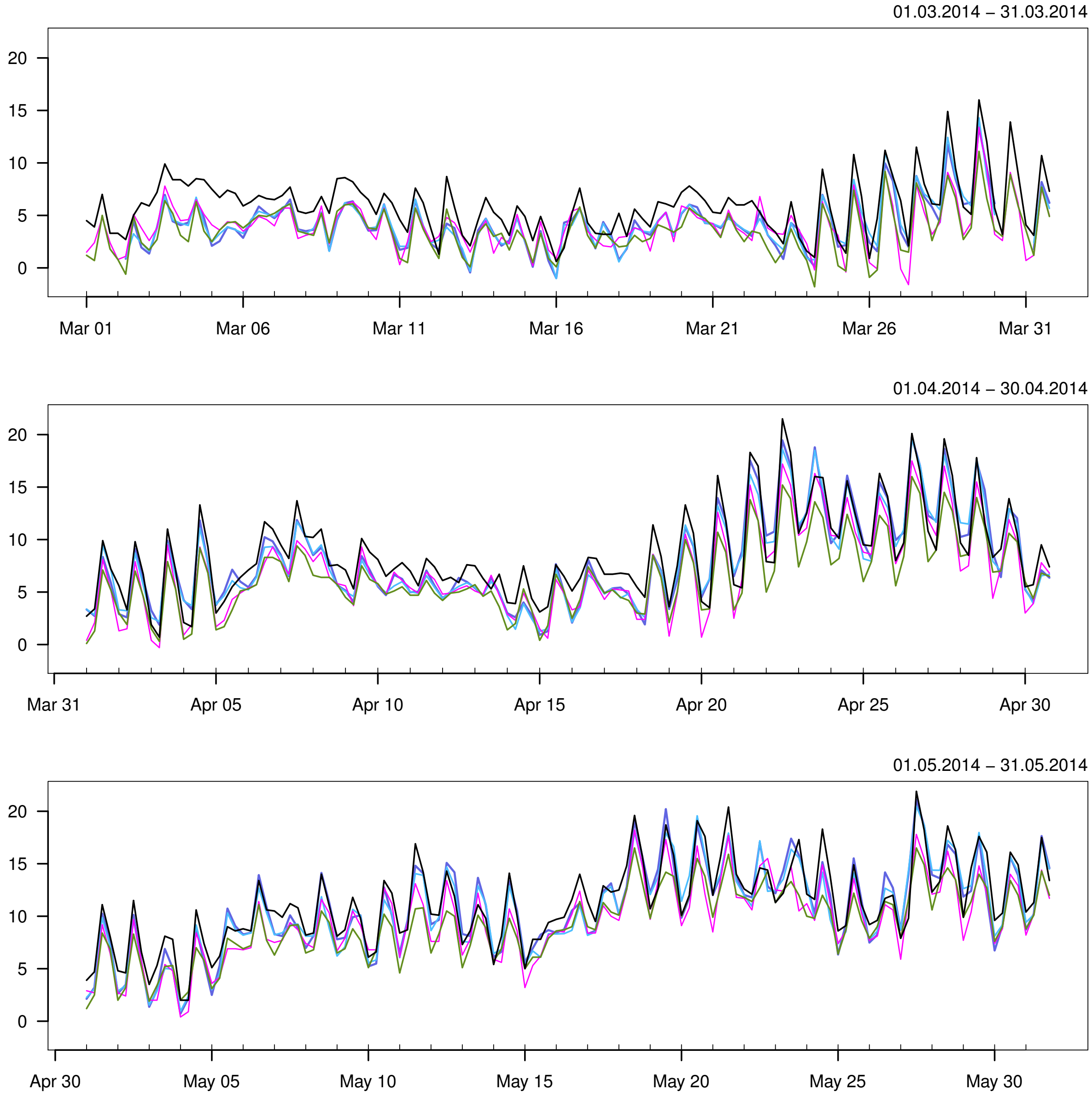


01.03.2014 – 31.03.2014

	Min	Mean	Max	Std	N
synop: 00,06,12,18	1.3	7.1	15.9	2.5	372
AM25: 12+18,+24,+30,+36	0.6	6.1	12	2	363
AROME_Norway: 12+18,+24,+30,+36	1.2	6.4	12.5	2	363
Hirlam8: 12+18,+24,+30,+36	2.2	6.6	12	1.8	372
ECMWF: 12+18,+24,+30,+36	2	6.4	11.9	1.9	372

	ME	SDE	RMSE	MAE	Max.abs.err.	N
AM25 – synop	−1	1.6	1.9	1.3	9	363
AROME_Norway – synop	−0.8	1.4	1.6	1.1	9	363
Hirlam8 – synop	−0.5	1.5	1.6	1	8.1	372
ECMWF – synop	−0.7	1.3	1.5	1	6.5	372

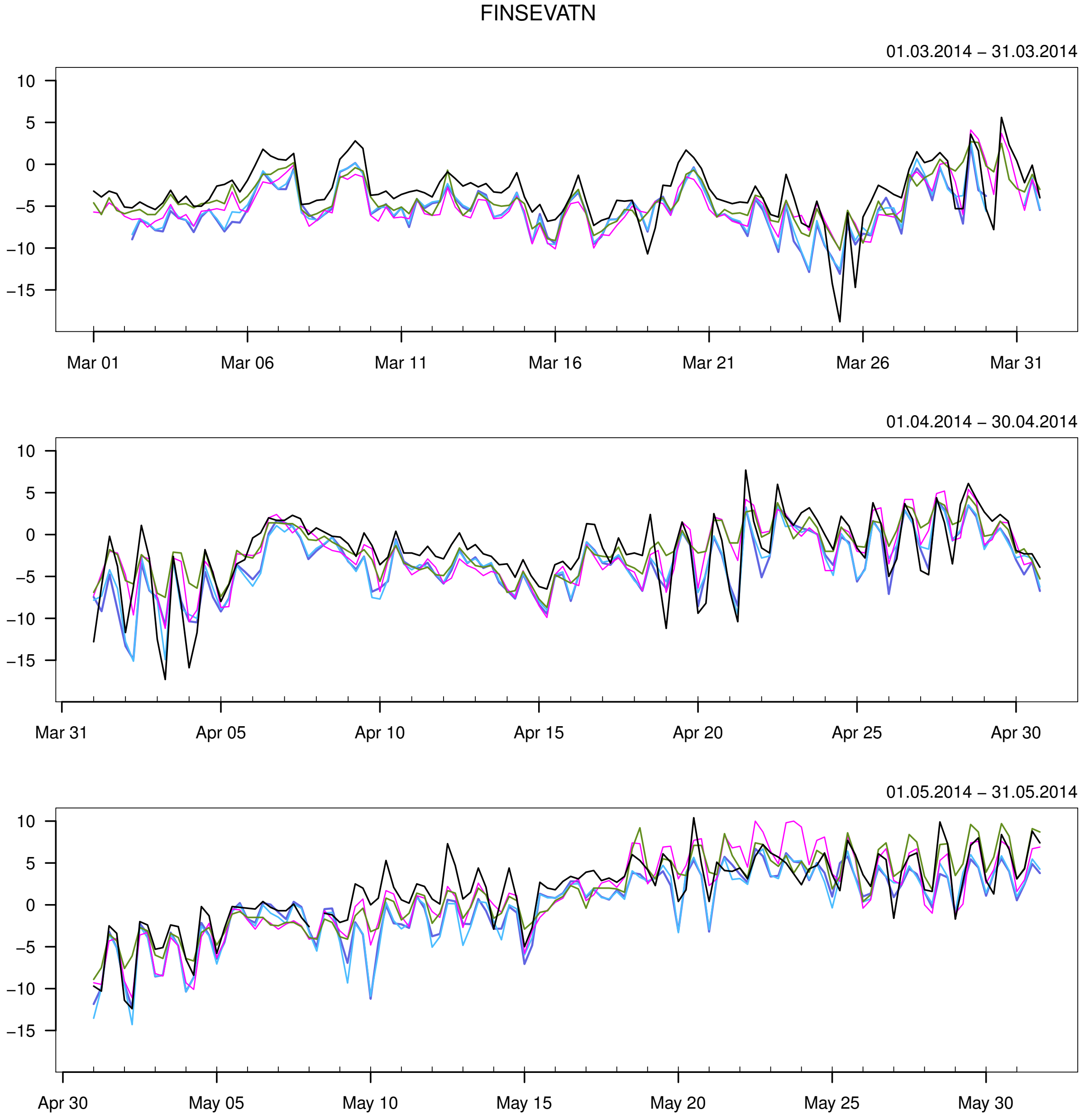
BERGEN – FLORIDA



01.03.2014 – 31.03.2014

	Min	Mean	Max	Std	N
— synop: 00,06,12,18	0.6	8.6	21.9	4.3	372
— AM25: 12+18,+24,+30,+36	−1	7.7	21.1	4.6	363
— AROME_Norway: 12+18,+24,+30,+36	−1	7.6	20.5	4.5	363
— Hirlam8: 12+18,+24,+30,+36	−1.6	6.8	18.2	4.1	372
— ECMWF: 12+18,+24,+30,+36	−1.8	6.4	16.5	3.9	372

	ME	SDE	RMSE	MAE	Max.abs.err.	N
AM25 – synop	−1	1.5	1.8	1.5	5.4	363
AROME_Norway – synop	−1.1	1.5	1.9	1.6	5.1	363
Hirlam8 – synop	−1.8	1.3	2.2	1.9	6.8	372
ECMWF – synop	−2.2	1.3	2.5	2.2	6.3	372

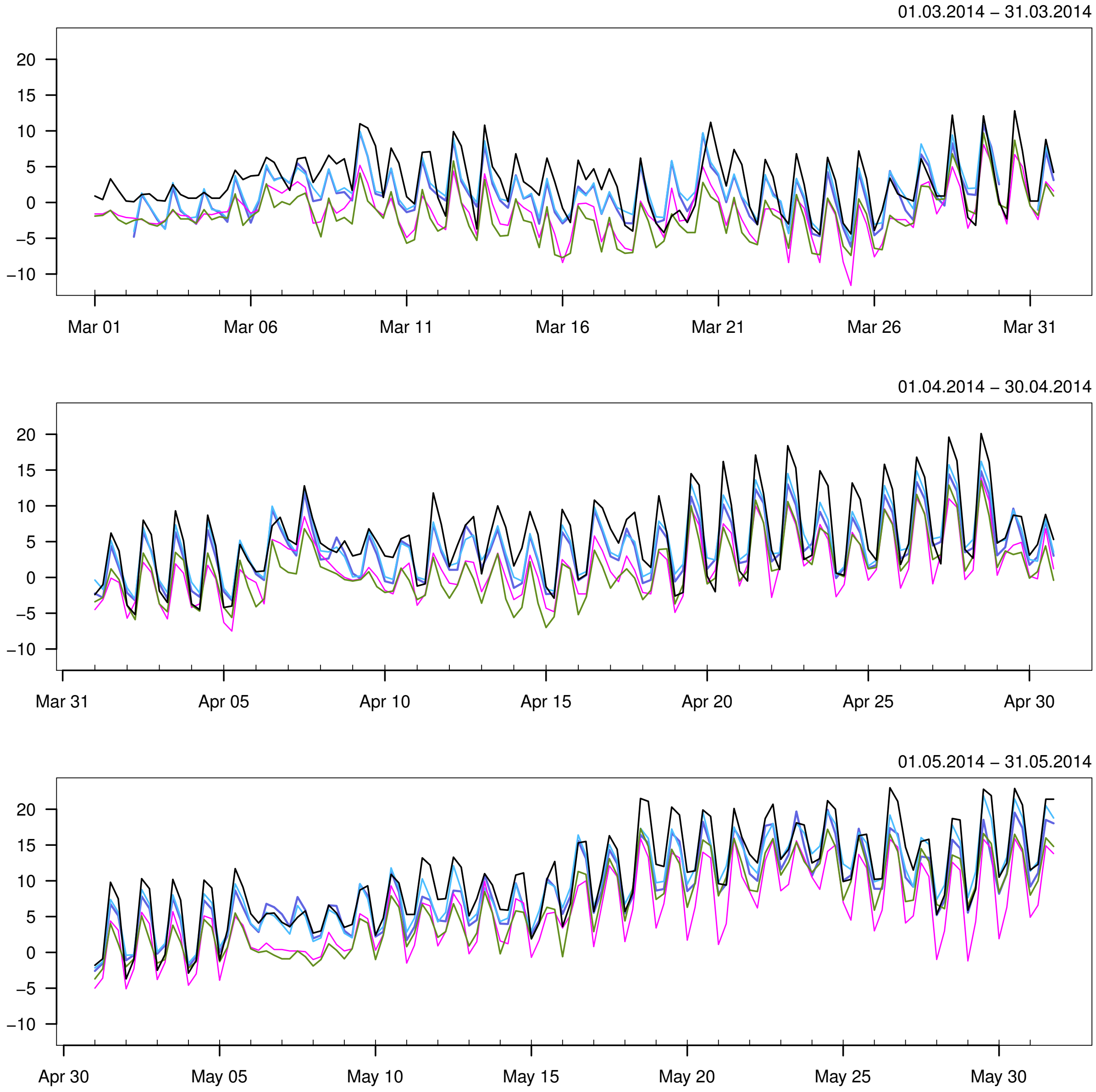


01.03.2014 – 31.03.2014

		Min	Mean	Max	Std	N
—	synop: 00,06,12,18	−18.8	−1.2	10.4	4.5	371
—	AM25: 12+18,+24,+30,+36	−14.9	−3	6.7	4.3	363
—	AROME_Norway: 12+18,+24,+30,+36	−15.1	−3	6.7	4.3	363
—	Hirlam8: 12+18,+24,+30,+36	−11.2	−2.1	10	4.6	372
—	ECMWF: 12+18,+24,+30,+36	−10.2	−1.7	9.7	4.2	372

	ME	SDE	RMSE	MAE	Max.abs.err.	N
AM25 – synop	−1.8	2.1	2.7	2.3	11.2	362
AROME_Norway – synop	−1.7	2.1	2.7	2.3	10.9	362
Hirlam8 – synop	−0.9	2.4	2.6	2.1	8.5	371
ECMWF – synop	−0.4	2.5	2.5	1.9	10.1	371

NESBYEN

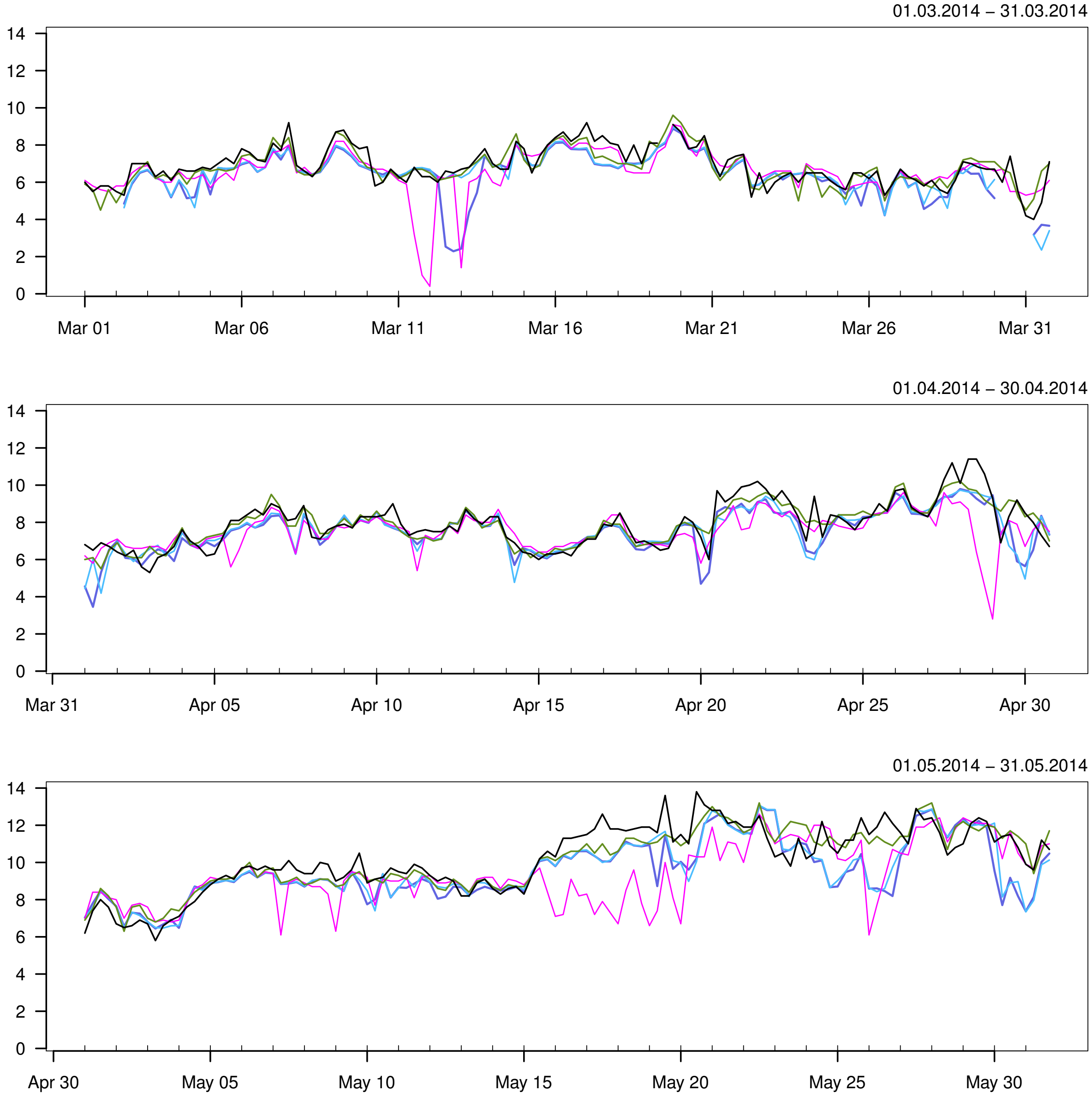


01.03.2014 – 31.03.2014

	Min	Mean	Max	Std	N
— synop: 00,06,12,18	−5.2	6.3	23	6.4	372
— AM25: 12+18,+24,+30,+36	−6.2	4.7	19.9	5.5	363
— AROME_Norway: 12+18,+24,+30,+36	−5.3	5.4	21.9	5.7	363
— Hirlam8: 12+18,+24,+30,+36	−11.6	2	16	5.3	372
— ECMWF: 12+18,+24,+30,+36	−7.7	2	17.3	5.8	372

	ME	SDE	RMSE	MAE	Max.abs.err.	N
AM25 – synop	−1.6	2.2	2.7	2.2	8.7	363
AROME_Norway – synop	−1	2.2	2.4	1.9	7.8	363
Hirlam8 – synop	−4.3	2.3	4.9	4.4	10.6	372
ECMWF – synop	−4.2	2.5	4.9	4.3	10.4	372

EKOFISK

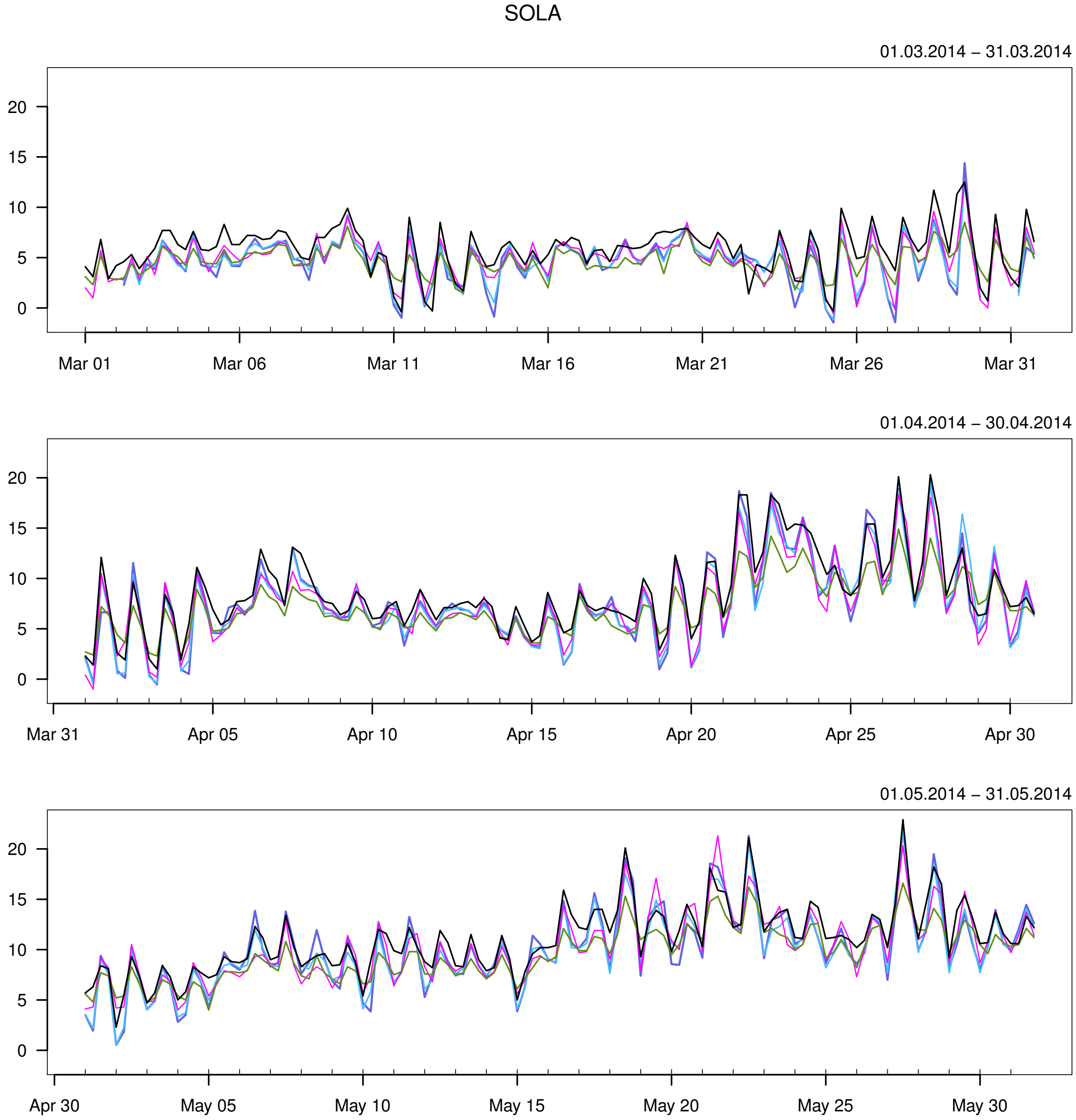


01.03.2014 – 31.05.2014

		Min	Mean	Max	Std	N
—	synop: 00,06,12,18	4	8.3	13.8	2	371
—	AM25: 12+18,+24,+30,+36	2.3	7.8	13	1.9	363
—	AROME_Norway: 12+18,+24,+30,+36	2.4	7.9	13.1	1.8	363
—	Hirlam8: 12+18,+24,+30,+36	0.4	7.8	12.6	1.8	372
—	ECMWF: 12+18,+24,+30,+36	4.5	8.2	13.2	1.9	372

	ME	SDE	RMSE	MAE	Max.abs.err.	N
AM25 – synop	–0.5	1	1.1	0.7	4.3	362
AROME_Norway – synop	–0.4	0.9	1	0.7	4.1	362
Hirlam8 – synop	–0.5	1.3	1.4	0.9	6.5	371
ECMWF – synop	–0.1	0.6	0.6	0.4	2.4	371

SOLA

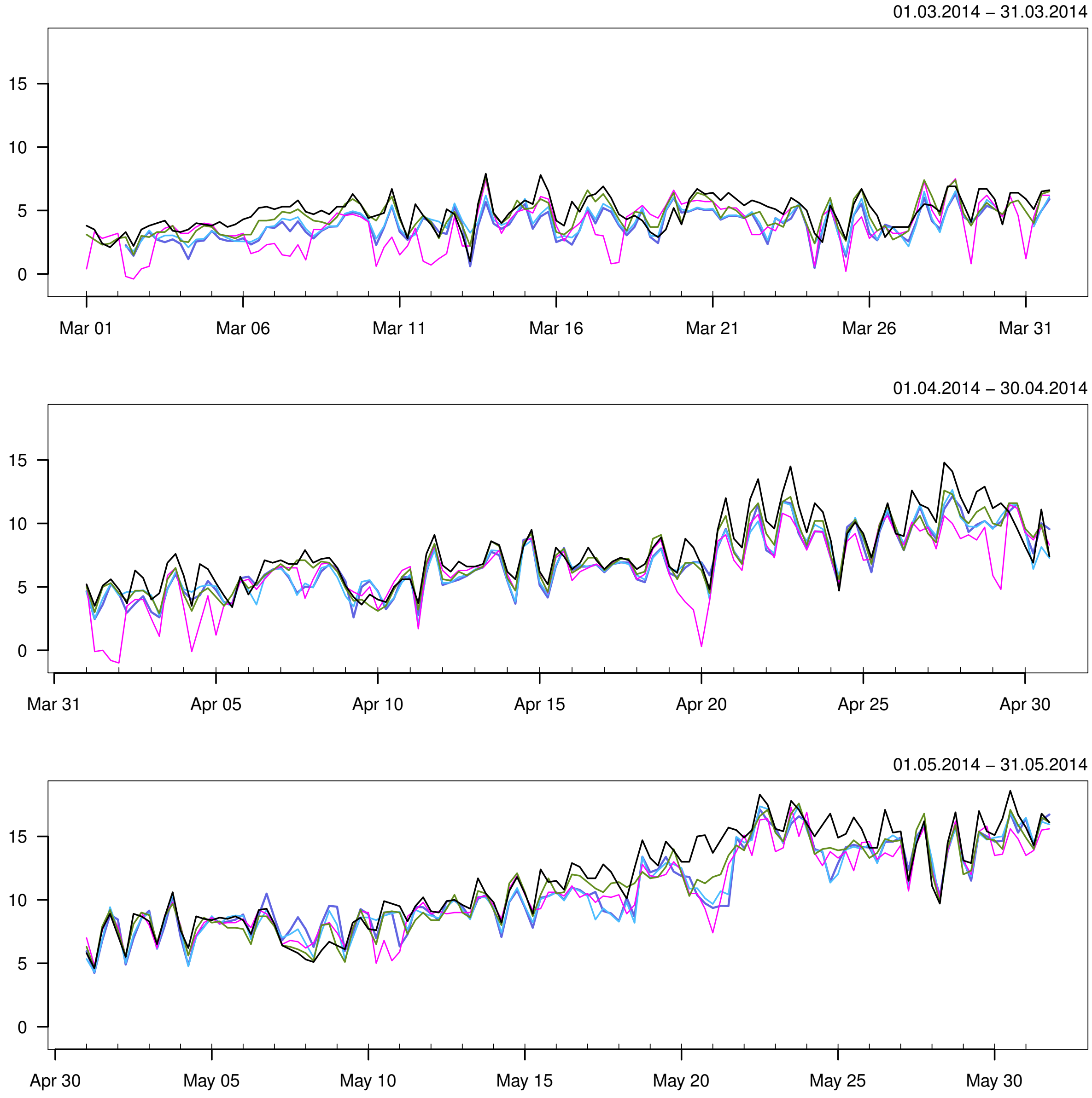


01.03.2014 – 31.03.2014

		Min	Mean	Max	Std	N
—	synop: 00,06,12,18	−0.4	8.5	22.9	3.9	372
—	AM25: 12+18,+24,+30,+36	−1.4	7.6	22.1	4.3	363
—	AROME_Norway: 12+18,+24,+30,+36	−1.2	7.5	21.9	4	363
—	Hirlam8: 12+18,+24,+30,+36	−1	7.6	21.3	3.9	372
—	ECMWF: 12+18,+24,+30,+36	1.5	7.1	16.6	3.1	372

	ME	SDE	RMSE	MAE	Max.abs.err.	N
AM25 – synop	−1	1.4	1.7	1.3	10	363
AROME_Norway – synop	−1.1	1.3	1.7	1.3	9.2	363
Hirlam8 – synop	−0.9	1.2	1.5	1.2	5.4	372
ECMWF – synop	−1.3	1.4	2	1.6	6.3	372

FERDER FYR



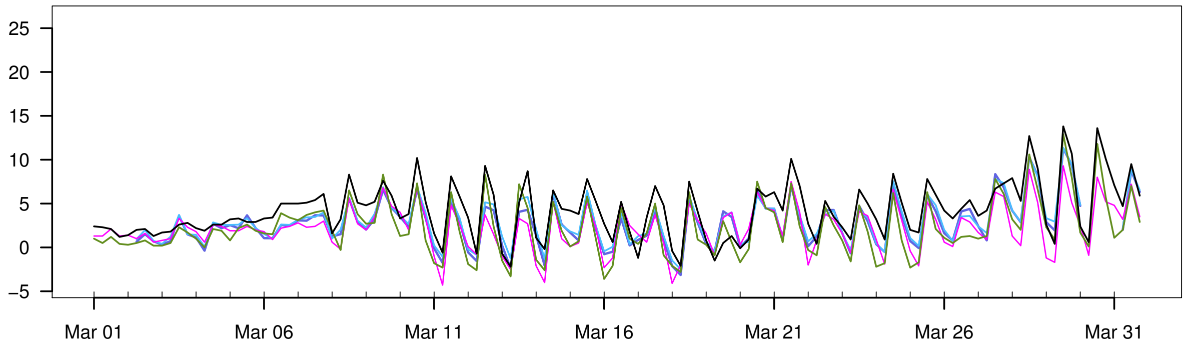
01.03.2014 – 31.05.2014

	Min	Mean	Max	Std	N
synop: 00,06,12,18	1	8	18.6	3.9	372
AM25: 12+18,+24,+30,+36	0.5	7.2	17.1	3.7	363
AROME_Norway: 12+18,+24,+30,+36	1.6	7.3	17.4	3.6	363
Hirlam8: 12+18,+24,+30,+36	−1	6.9	17.3	3.8	372
ECMWF: 12+18,+24,+30,+36	1.5	7.5	17.6	3.6	372

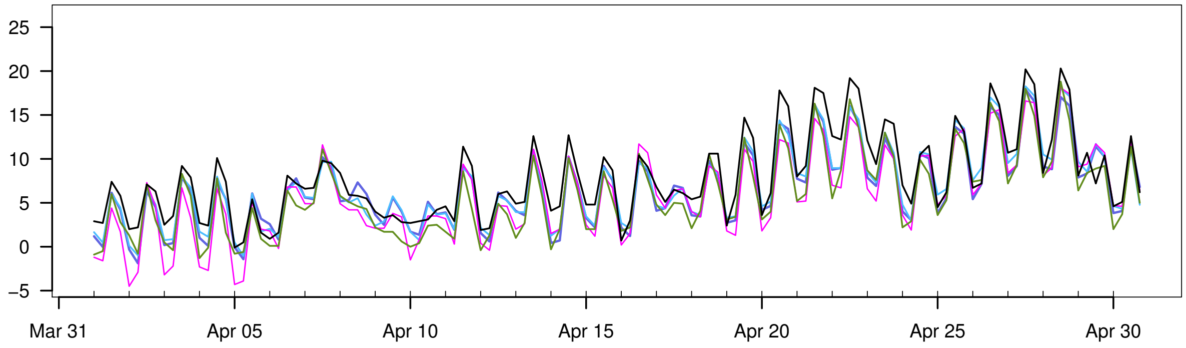
	ME	SDE	RMSE	MAE	Max.abs.err.	N
AM25 – synop	−0.9	1.2	1.5	1.2	6.2	363
AROME_Norway – synop	−0.8	1.1	1.4	1.1	5.4	363
Hirlam8 – synop	−1.1	1.6	2	1.4	6.8	372
ECMWF – synop	−0.5	0.8	1	0.8	3.8	372

OSLO – BLINDERN

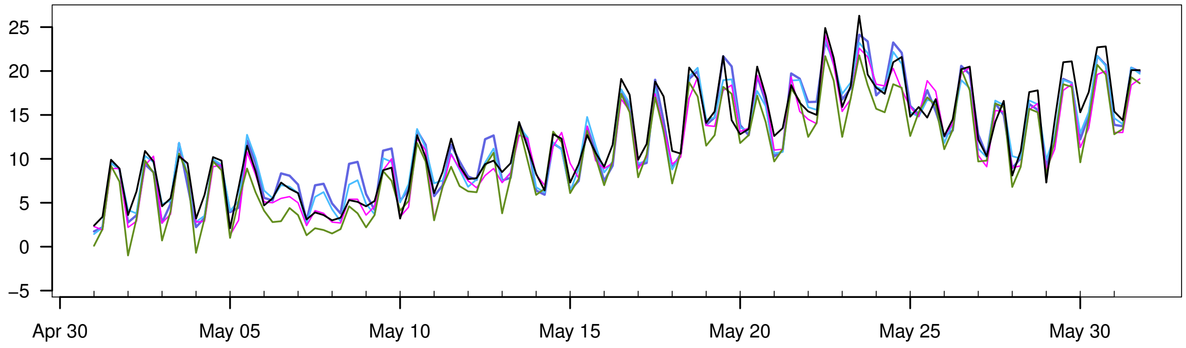
01.03.2014 – 31.03.2014



01.04.2014 – 30.04.2014



01.05.2014 – 31.05.2014

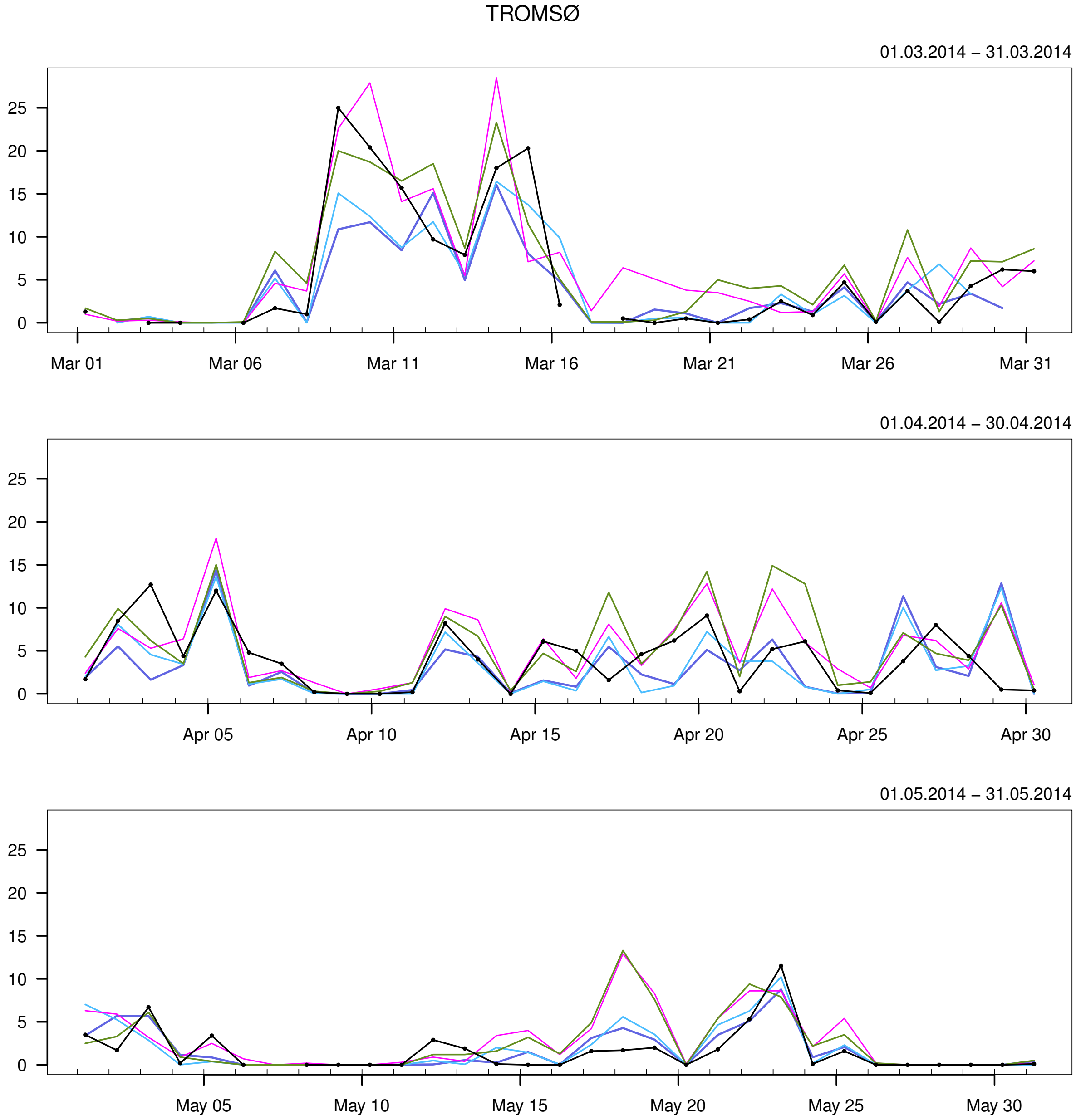


01.03.2014 – 31.05.2014

	Min	Mean	Max	Std	N
synop: 00,06,12,18	−2.2	8.1	26.3	5.7	372
AM25: 12+18,+24,+30,+36	−3.1	7.2	24.1	5.9	363
AROME_Norway: 12+18,+24,+30,+36	−2.5	7.4	23.7	5.7	363
Hirlam8: 12+18,+24,+30,+36	−4.5	6.4	24.1	5.9	372
ECMWF: 12+18,+24,+30,+36	−3.6	6.2	21.8	5.7	372

	ME	SDE	RMSE	MAE	Max.abs.err.	N
AM25 – synop	−0.9	1.7	1.9	1.6	6.1	363
AROME_Norway – synop	−0.8	1.5	1.7	1.4	4.7	363
Hirlam8 – synop	−1.6	1.8	2.4	2	6.6	372
ECMWF – synop	−1.9	1.5	2.4	2.1	7.1	372

9.3 Daily precipitation

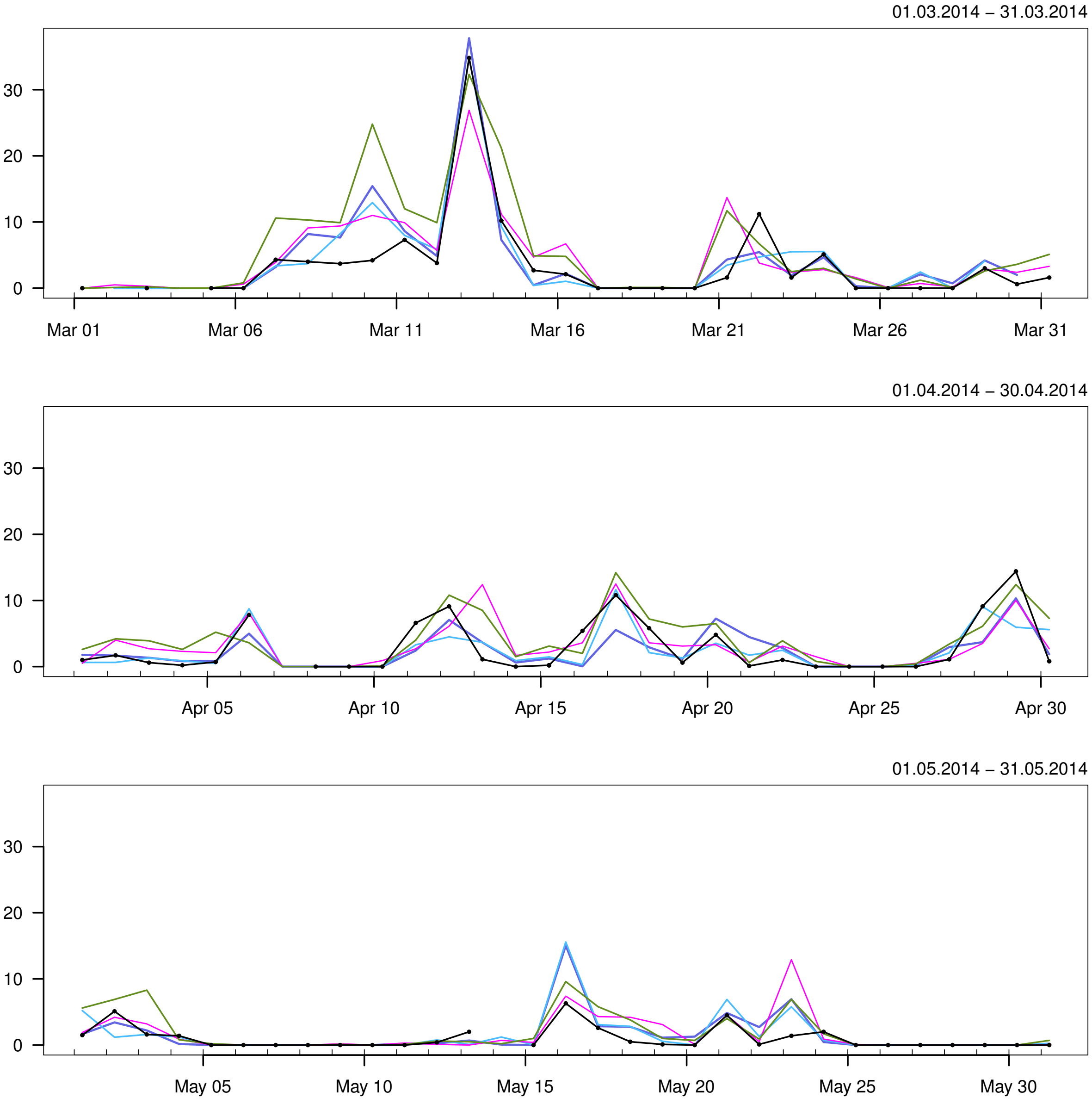


01.03.2014 – 31.03.2014

	Min	Mean	Max	Std	N
— synop: 06	0	3.7	25	5.1	91
— AM25: 00+30	0	2.9	16.1	3.7	92
— AROME_Norway: 00+30	0	3	16.4	4.1	92
— Hirlam8: 00+30	0	4.9	28.5	5.6	95
— ECMWF: 00+30	0	4.7	23.3	5.3	95

	ME	SDE	RMSE	MAE	Max.abs.err.	N
AM25 – synop	–0.8	3.7	3.7	2.3	14.1	89
AROME_Norway – synop	–0.5	3.4	3.4	2.2	11.8	88
Hirlam8 – synop	1.4	3.5	3.7	2.5	13.2	91
ECMWF – synop	1.2	3.4	3.6	2.4	11.6	91

BODØ

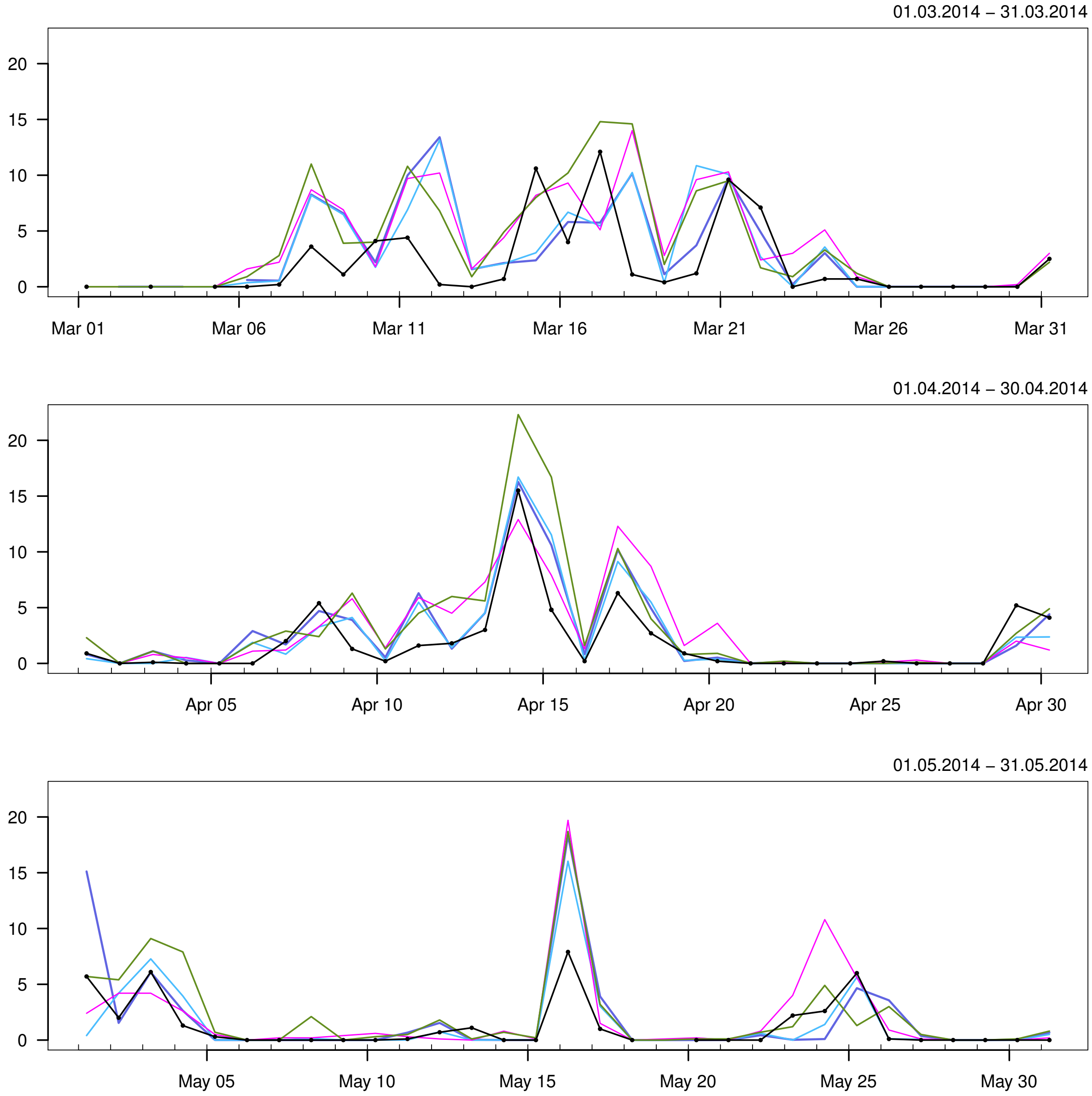


01.03.2014 – 31.03.2014

	Min	Mean	Max	Std	N
— synop: 06	0	2.4	34.8	4.6	91
— AM25: 00+30	0	2.6	37.8	4.8	92
— AROME_Norway: 00+30	0	2.6	34.8	4.7	92
— Hirlam8: 00+30	0	3	26.9	4.3	95
— ECMWF: 00+30	0	3.9	32.3	5.5	95

	ME	SDE	RMSE	MAE	Max.abs.err.	N
AM25 – synop	0.3	2.5	2.5	1.5	11.2	88
AROME_Norway – synop	0.3	2.4	2.4	1.4	9.3	88
Hirlam8 – synop	0.8	3	3.1	1.8	12.1	91
ECMWF – synop	1.7	3.4	3.8	2.3	20.6	91

ØRLAND

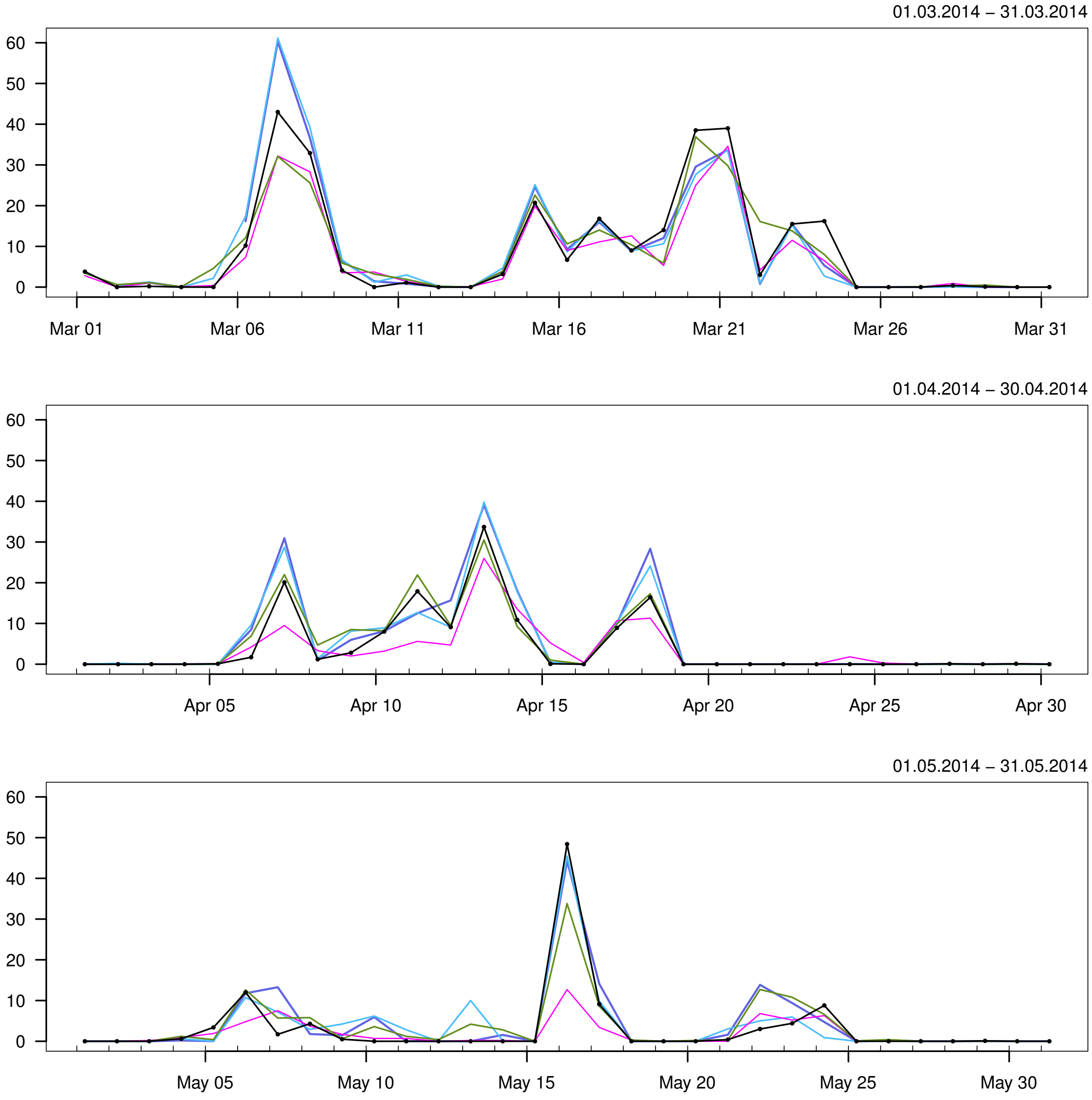


01.03.2014 – 31.03.2014

	Min	Mean	Max	Std	N
synop: 06	0	1.9	15.5	3	92
AM25: 00+30	0	2.8	18.4	4.2	92
AROME_Norway: 00+30	0	2.7	16.7	4.1	92
Hirlam8: 00+30	0	3.1	19.7	4	95
ECMWF: 00+30	0	3.6	22.3	5.1	95

	ME	SDE	RMSE	MAE	Max.abs.err.	N
AM25 – synop	1	3.1	3.2	1.8	13.2	89
AROME_Norway – synop	0.8	3.1	3.2	1.8	13	89
Hirlam8 – synop	1.3	3.1	3.4	2.1	12.9	92
ECMWF – synop	1.8	3.5	4	2.3	13.5	92

BERGEN – FLORIDA

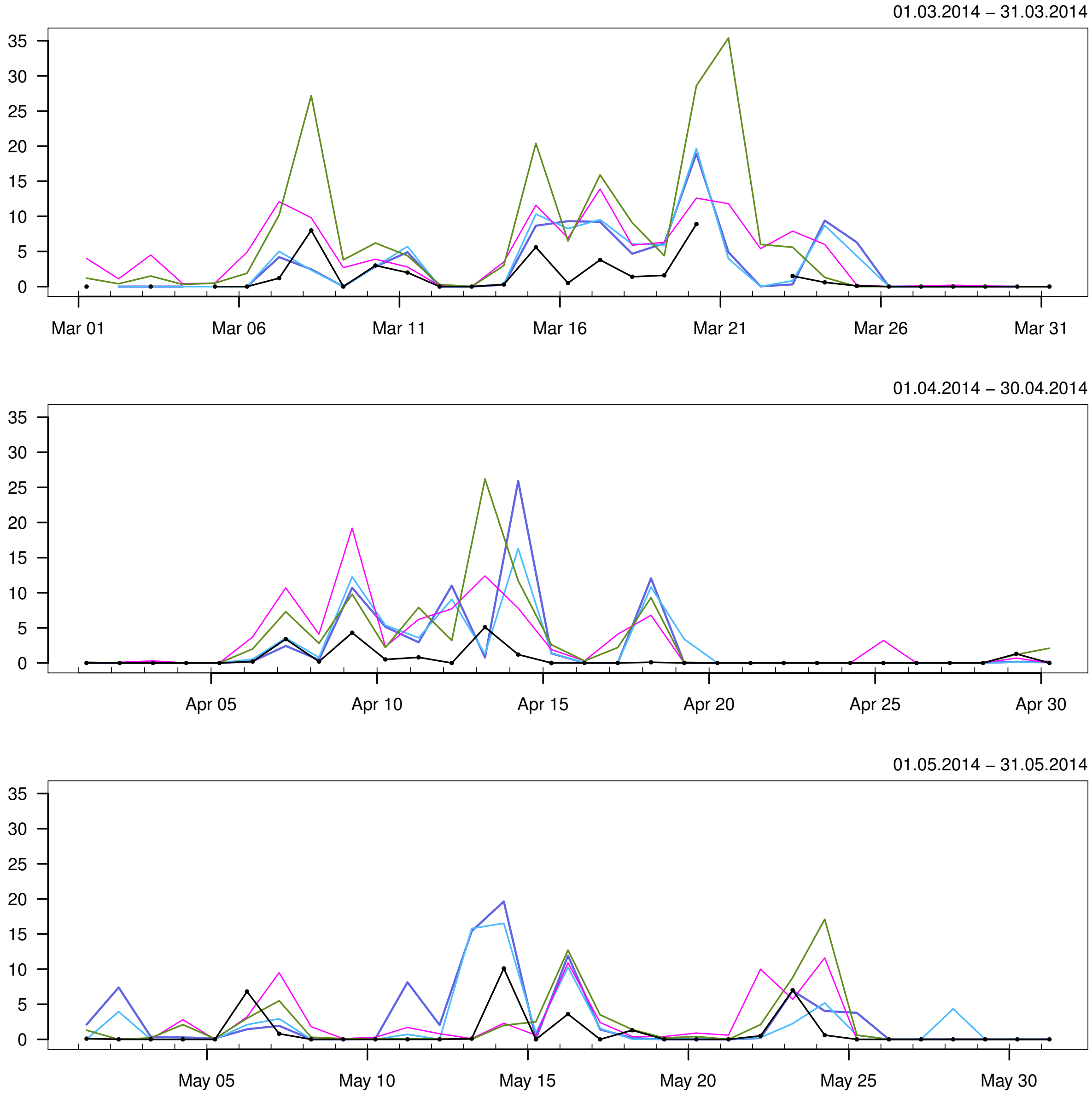


01.03.2014 – 31.05.2014

	Min	Mean	Max	Std	N
synop: 06	0	5.3	48.4	10.4	95
AM25: 00+30	0	6.4	60.3	11.5	92
AROME_Norway: 00+30	0	6.2	61.2	11.4	92
Hirlam8: 00+30	0	4.2	34.6	7.2	95
ECMWF: 00+30	0	5.6	36.9	8.8	95

	ME	SDE	RMSE	MAE	Max.abs.err.	N
AM25 – synop	0.9	3.9	4	2	17.3	92
AROME_Norway – synop	0.8	3.9	4	2.1	18.2	92
Hirlam8 – synop	−1.1	5.1	5.2	2.4	35.7	95
ECMWF – synop	0.2	3.5	3.5	1.8	14.6	95

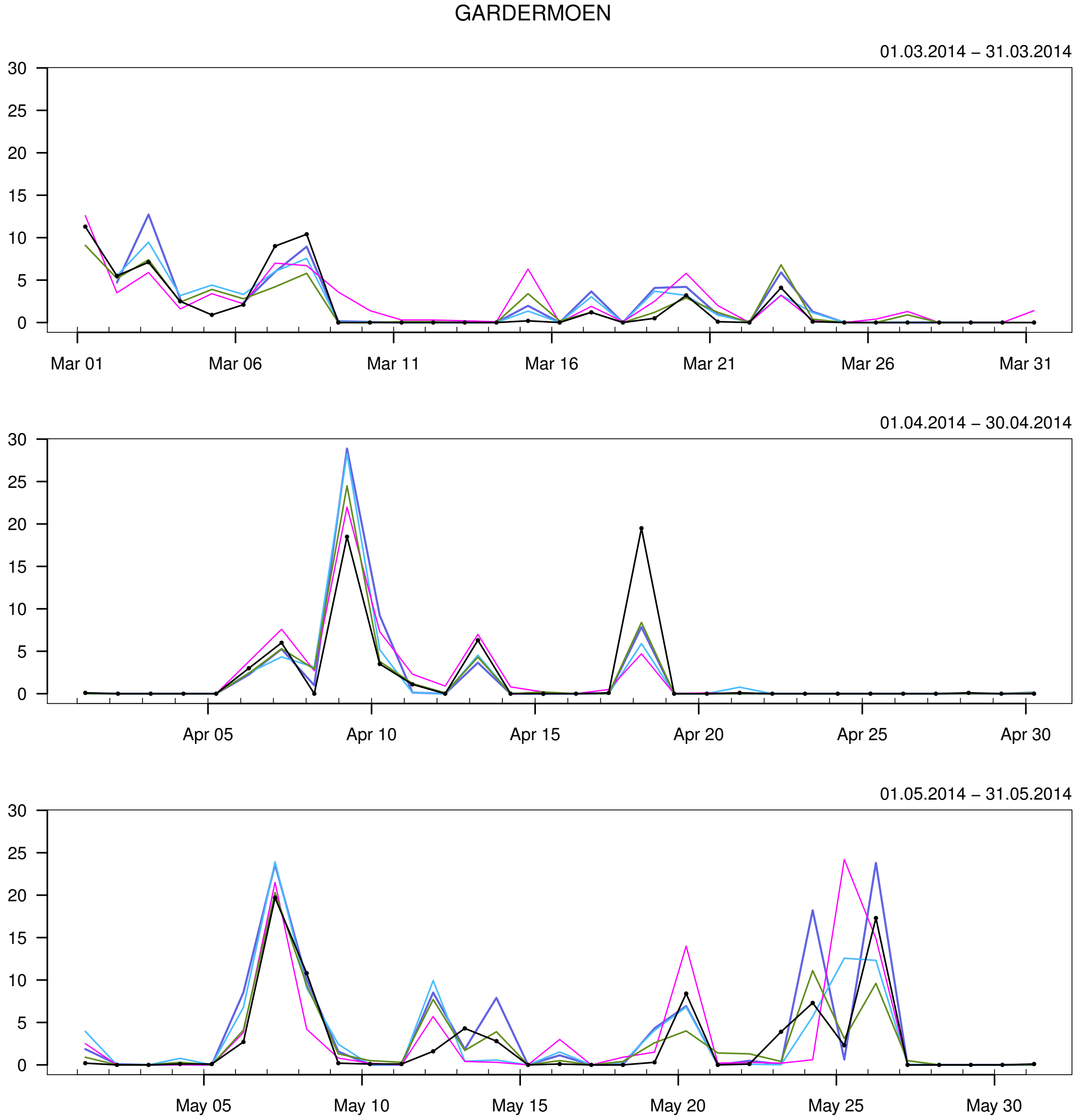
LÆRDAL



01.03.2014 – 31.03.2014

	Min	Mean	Max	Std	N
synop: 06	0	1	10.1	2.1	91
AM25: 00+30	0	2.8	25.9	5	92
AROME_Norway: 00+30	0	2.5	19.7	4.3	92
Hirlam8: 00+30	0	3.2	19.2	4.2	95
ECMWF: 00+30	0	3.8	35.4	6.8	95

	ME	SDE	RMSE	MAE	Max.abs.err.	N
AM25 – synop	1.9	4.4	4.8	2.3	24.7	88
AROME_Norway – synop	1.6	3.7	4	2.1	15.7	88
Hirlam8 – synop	2.2	3.5	4.1	2.5	14.9	91
ECMWF – synop	2.5	4.8	5.4	2.8	21.1	91

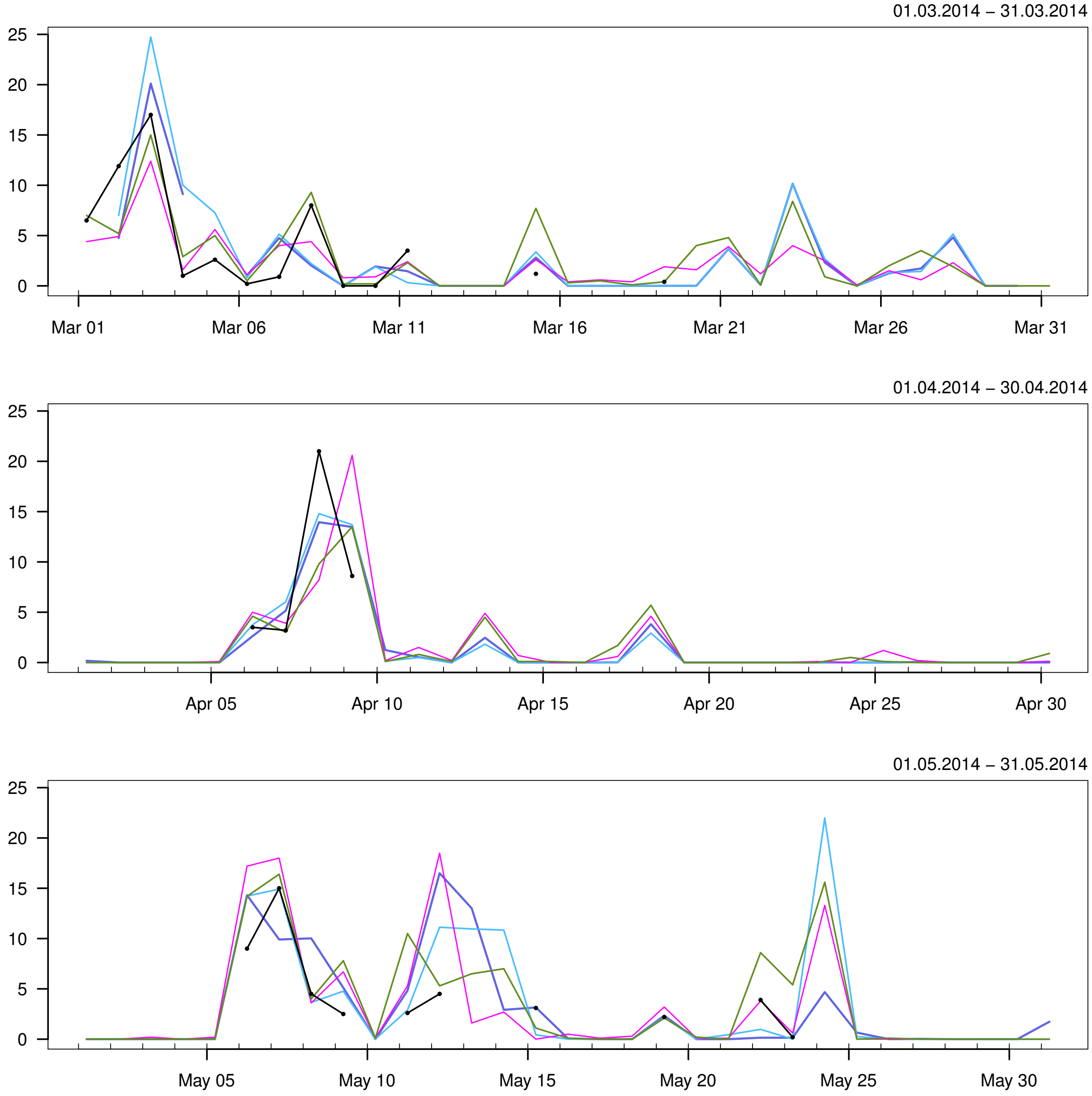


01.03.2014 – 31.03.2014

	Min	Mean	Max	Std	N
synop: 06	0	2.1	19.7	4.4	95
AM25: 00+30	0	2.6	28.9	5.4	92
AROME_Norway: 00+30	0	2.3	28.3	4.6	92
Hirlam8: 00+30	0	2.5	24.2	4.7	95
ECMWF: 00+30	0	2.1	24.5	4	95

	ME	SDE	RMSE	MAE	Max.abs.err.	N
AM25 – synop	0.6	2.7	2.8	1.3	11.7	92
AROME_Norway – synop	0.3	2.7	2.7	1.3	13.6	92
Hirlam8 – synop	0.4	3.3	3.3	1.5	21.9	95
ECMWF – synop	0	2.1	2.1	1	11.1	95

NELAUG



01.03.2014 – 31.03.2014

		Min	Mean	Max	Std	N
—	synop: 06	0	5.1	21	5.5	27
—	AM25: 00+30	0	2.2	20.1	4.2	92
—	AROME_Norway: 00+30	0	2.5	24.7	4.9	92
—	Hirlam8: 00+30	0	2.3	20.6	4.2	95
—	ECMWF: 00+30	0	2.5	16.4	4	95

	ME	SDE	RMSE	MAE	Max.abs.err.	N
AM25 – synop	0.9	4.6	4.7	3.5	12	25
AROME_Norway – synop	1	4	4.1	3.1	9	26
Hirlam8 – synop	0.9	5.2	5.3	3.5	14	27
ECMWF – synop	1.1	4	4.1	2.9	11.2	27