Norwegian Meteorological Institute

MET info 17/2014 Meteorology

# Verification of Experimental and Operational Weather Prediction Models June to August 2014

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# 1 Models

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

| | |
|---|---|
| EC | Global model (IFS) at the ECMWF. From 26 January 2010 resolution $T1279$ or approximately $16 \times 16\ km^2$ horizontally. Available resolution for verification at MET is $0.125°$ latitude and longitude. Number of vertical levels increased from $L91$ to $L137$ 25 June 2013. |
| Hirlam12 (H12) | Version 7.1, horizontal resolution defined by a $12 \times 12\ km^2$ grid since 13 February 2008. |
| Hirlam8 (H8) | Version 7.1, horizontal resolution defined by a $8 \times 8\ km^2$ grid since 13 February 2008. |
| Harmonie5.5 | HARMONIE cycle 36h1.3 with ALARO physics run on a $5.5 \times 5.5\ km^2$ grid from 4 May 2011 to 15 January 2013. |
| Harmonie2.5 | HARMONIE cycle 36h1.3 with AROME physics run on a $2.5 \times 2.5\ km^2$ grid from 4 May 2011 to 26 February 2013. |
| AROME-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 $\infty$ | 0 |
| Mean Absolute Error | MAE | $\frac{1}{n} \sum_{i=1}^{n} \mid f_i - o_i \mid$ | 0 to $\infty$ | 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 $\infty$ | 0 |
| Root Mean Square Error | RMSE | $\left( \frac{1}{n} \sum_{i=1}^{n}(f_i - o_i)^2 \right)^{1/2}$ | 0 to $\infty$ | 0 |
| Correlation | COR | $\frac{\frac{1}{n}\sum_{i=1}^{n}(f_i - \bar{f})(o_i - \bar{o})}{SD(f)SD(o)}$ | $-1$ to 1 | 1 |

In the formula for COR the following definitions are used

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

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

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

## 3.2 Forecasts of categorical variables

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

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

Verification statistics for such forecasts are listed in the following table

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

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

## 3.3 Observations

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

## 3.4 Changes since last report

- Post processed fields from AM25 added
- ECMWF deterministic model availiable on higher resolution

# 4 Norway

## 4.1 Comments to verification results

MSLP:
For pressure, ECMWF is still in the lead. The AROME models score alomst as good as ECMWF, but AROME-Norway has a larger bias. The Hirlam models are no longer maintained and the errors have grown for these models.

10m wind speed:
There is a clear diurnal cycle in the bias for the Hirlam models, with about $0.5ms^{-1}$ too weak winds during day, and the opposite during night. The ECMWF model still has the lowest SDE, but the AROME models have the lowest MAE.

AROME has the highest hit rate (HR) for values up to $17ms^{-1}$. For the highest threshold, AM25, H8 and H12 score best. The Hirlam models have a higher false alarm ratio (FAR) than the other models for the lowest thresholds. For the highest thresholds both H8 and AROME have high FAR, while ECMWF and AM25 have relatively low FAR. At equitable threat score (ETS), AROME and AM25 are tied for best up to $17ms^{-1}$. AM25 and the Hirlam models have the highest score for thresholds above $19ms^{-1}$.

Looking at the distribution, all models have too few values above the two lowest category. This goes especially for H8, however H8 is also the model with the best score for the highest category.

Max Mean Wind Speed:
After post processing, the wind speeds are generally higher, but still do not match the observed max mean wind, except H8_PP during nighttime. Both AROME models are about $-0.5ms^{-1}$ off.

As seen in earlier reports, H8_PP has high HR and FAR. The post processed AROME models score alike in ETS. Above 11 m/s, H8_PP also score just as high as the post processed AROME models.

Wind gust:
AROME has the least bias. AM25 has about $0.5ms^{-1}$ too weak winds. In general H8 has too strong winds, but a clear diurnal cycle, with almost no bias in the afternoon and $1ms^{-1}$ too strong winds around noon. The 925hPa winds are too weak in the day, and a little too strong during the night. AROME score best in ETS up to $24.5ms^{-1}$, AM25 is about just as good up to $17.2ms^{-1}$. For the highest values, the 925hPa wind is best.

Temperature 2m:

AM25 has the lowest bias of the models. The Hirlam models are no longer maintained and this is perhaps most evident in the temperature, they now have a large cold bias. ECMWF has a clear diurnal cycle in the bias, too cold during daytime and too warm during nights. The Hirlam models have a high MAE. ECMWF and the AROME models have almost the same MAE.

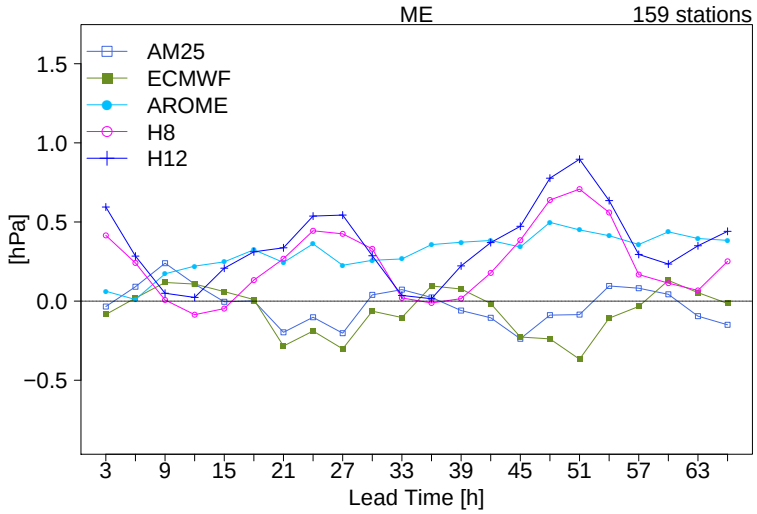
The post processing did not change much for the AROME models, but the MAE is a little reduced. The post processing has the best effect for H8, since the model was very off to begin with.

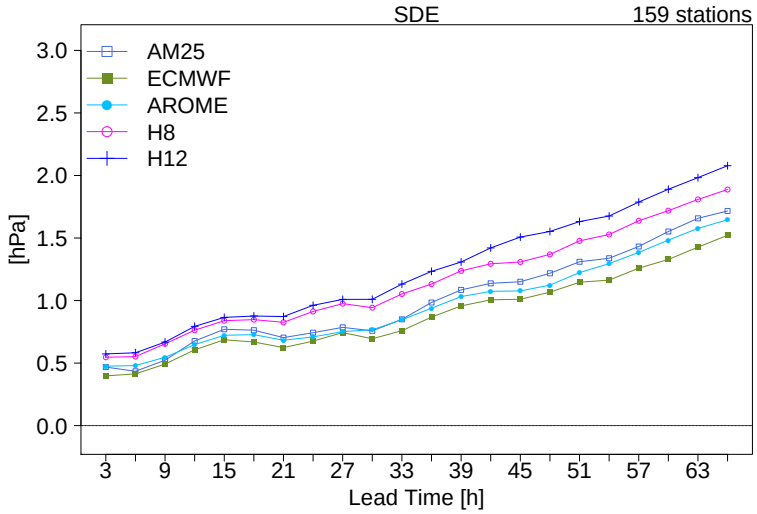
Daily precipitation:
AM25 has the most precipitation of the models, in general around 1.5mm above observed values. ECMWF and AROME both have a positive bias around 0.8mm. The Hirlam models have almost no bias. The post processed median values have a negative bias between -1 and -1.5mm.

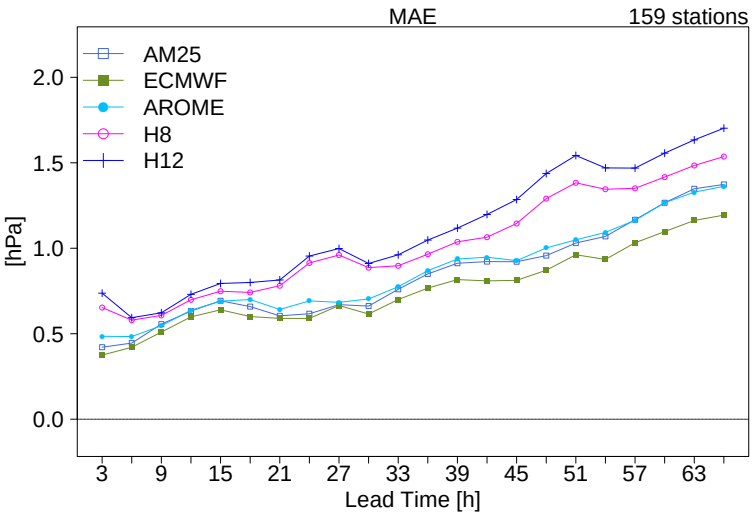
The median values have the lowest HR, while ECMWF has the highest HR for the lowest thresholds. Above 12mm the AROME models have the highest HR. FAR is high for almost all models except the median values. Above 8mm the ECMWF model also has lower FAR than the other raw models. The AROME models and median fields have the highest ETS below 2mm. ECMWF is the best model for moderate thresholds between 4-25 mm. Above this, AROME and AM25 scores better.

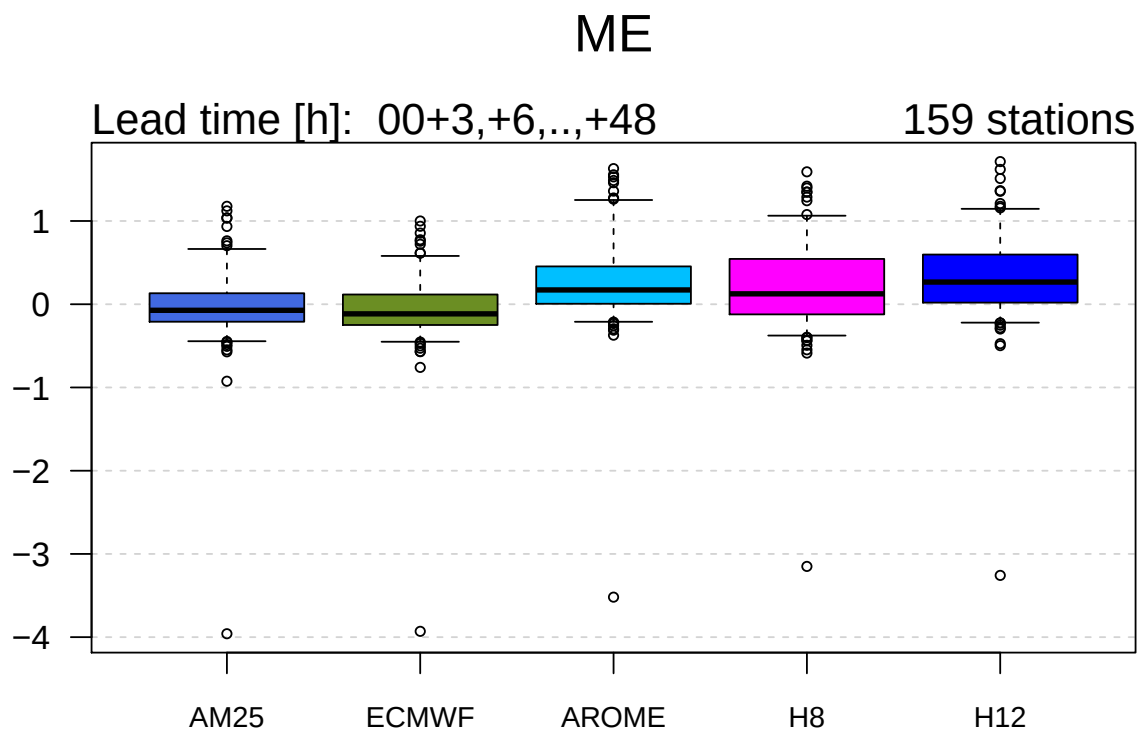
It is worth noticing that AM25 has over twice as much events above 50mm, as the observed events. AM25 has 263 events in this category, but only in 13 of these cases was it observed. While AM25.med had only 6, yet it was observed in 4 of these cases.

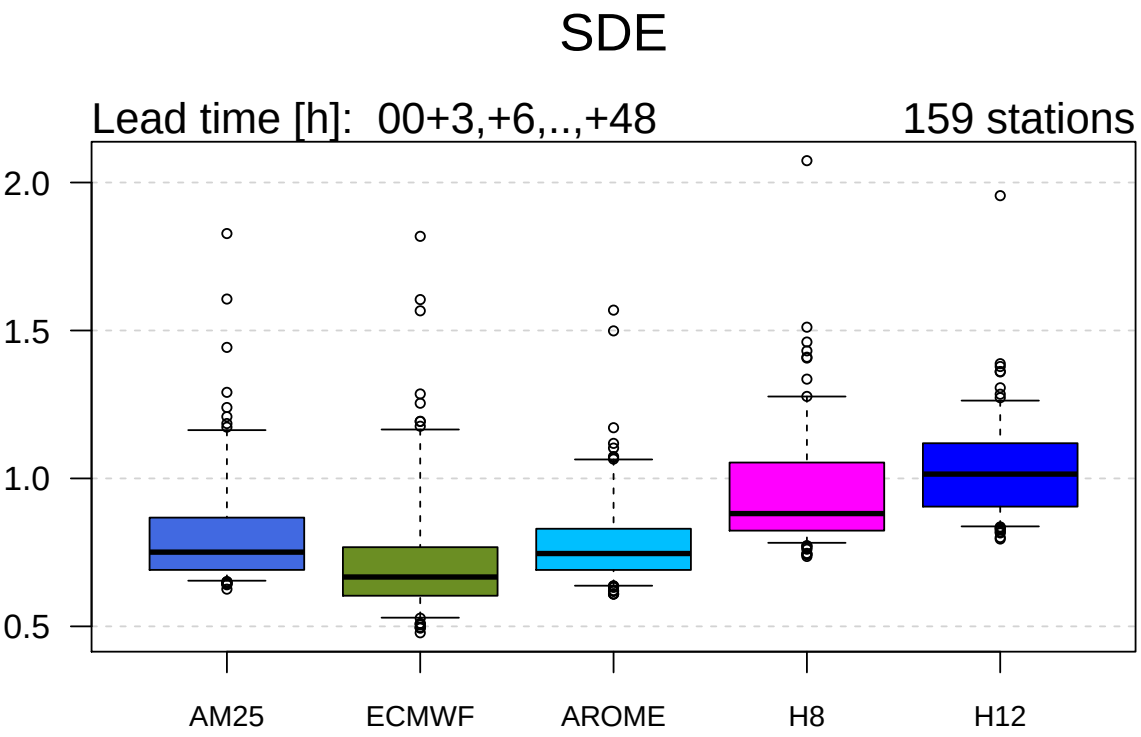
## 4.2 Pressure and variables at pressure levels



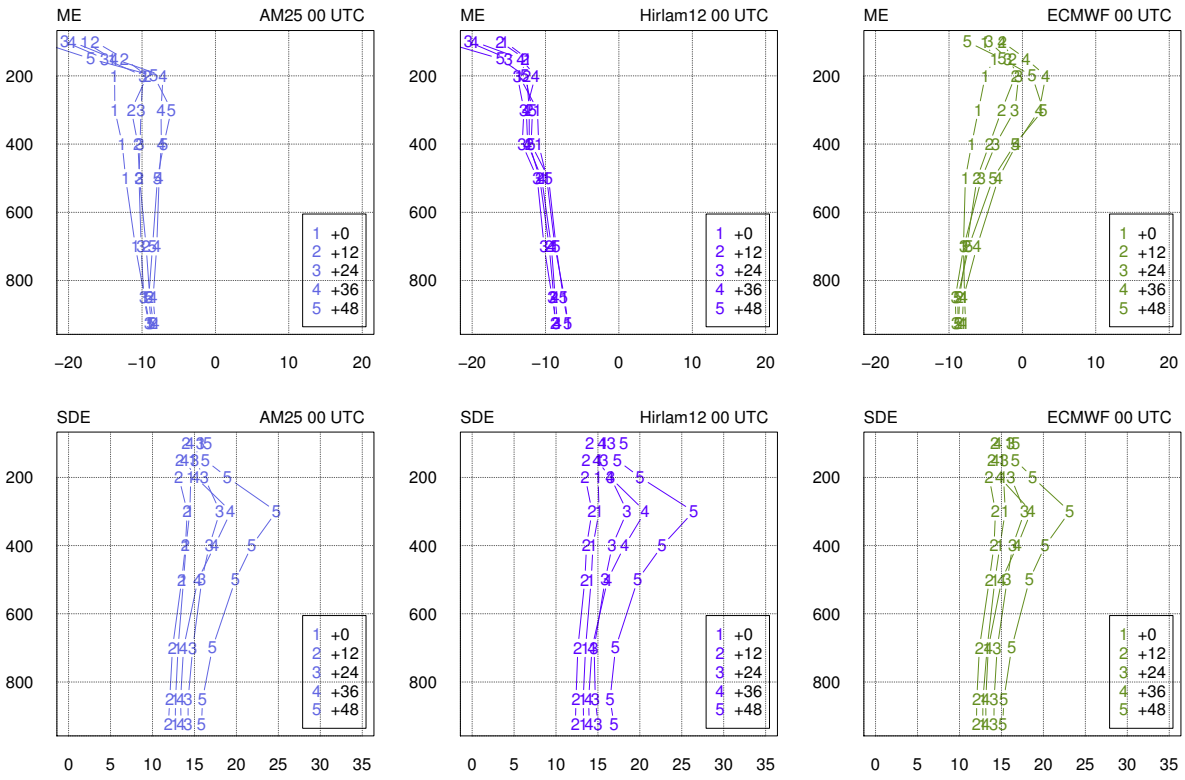



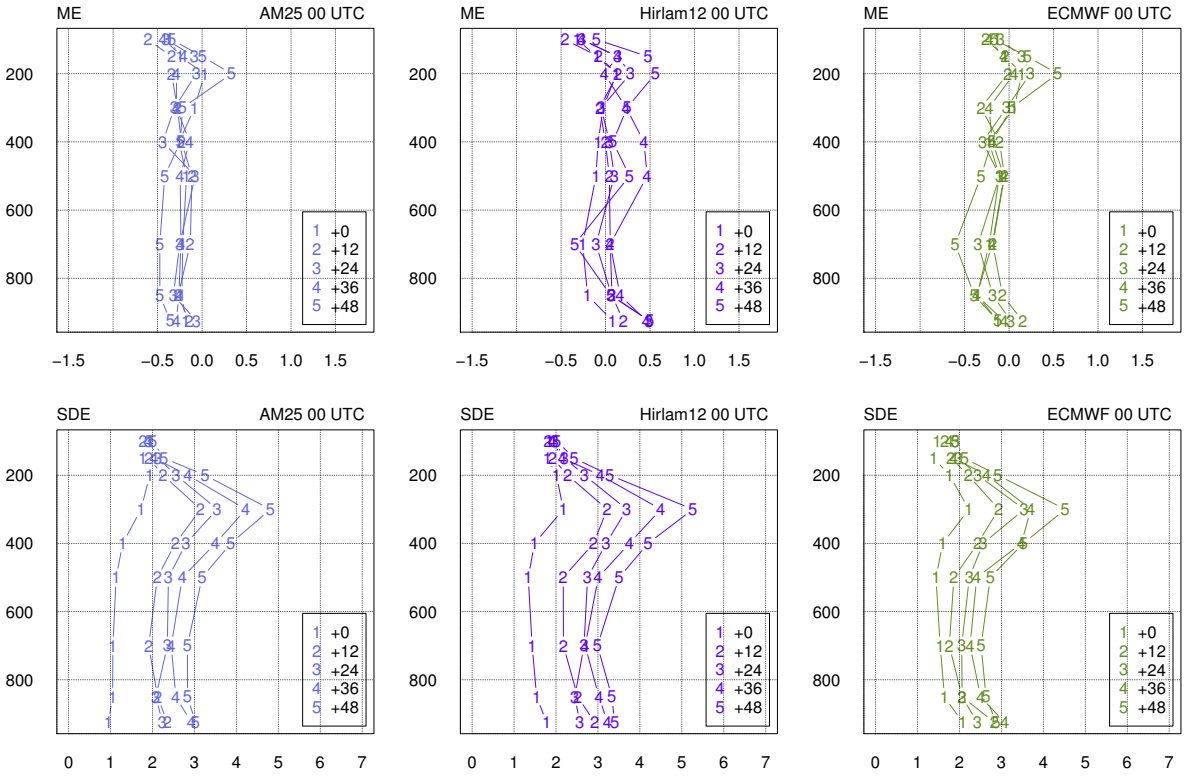

ME
Lead time [h]: 00+3,+6,..,+48
159 stations
1
0
−1
−2
−3
−4
AM25
ECMWF
AROME
H8
H12

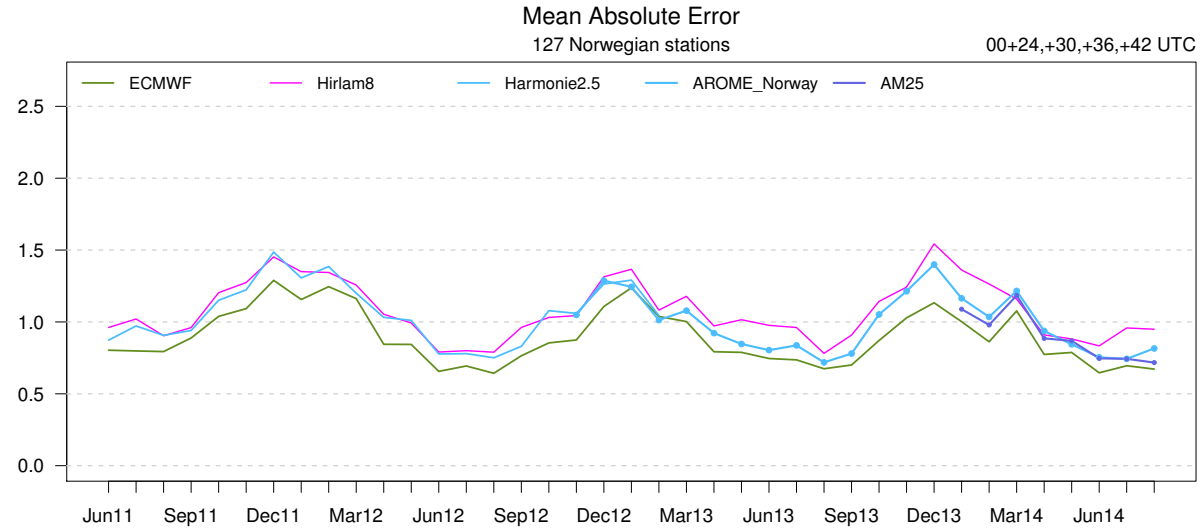

SDE
Lead time [h]: 00+3,+6,..,+48
159 stations
2.0
1.5
1.0
0.5
AM25
ECMWF
AROME
H8
H12

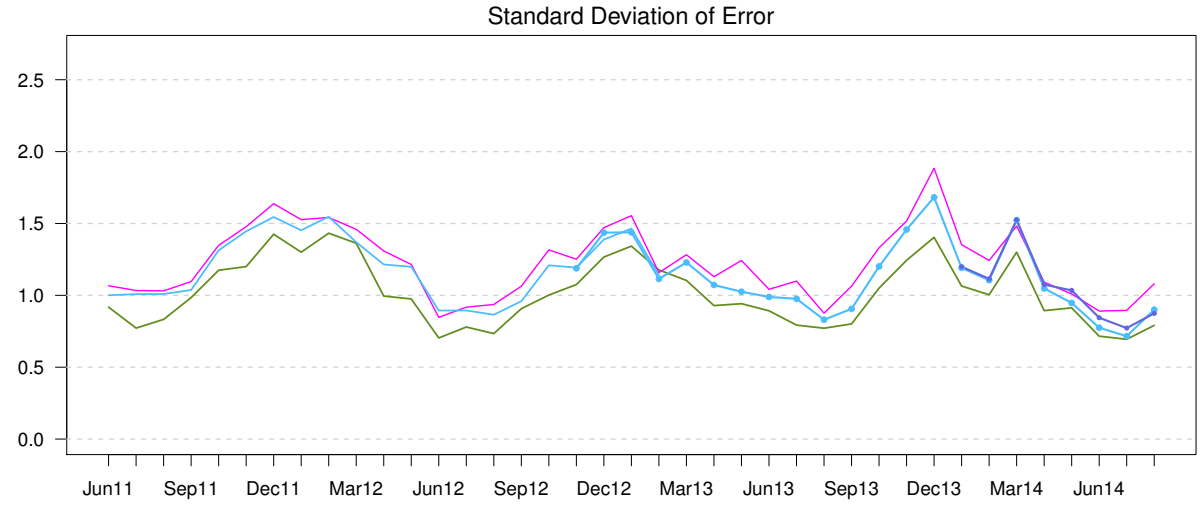
Geopotential height at 4 Norwegian stations

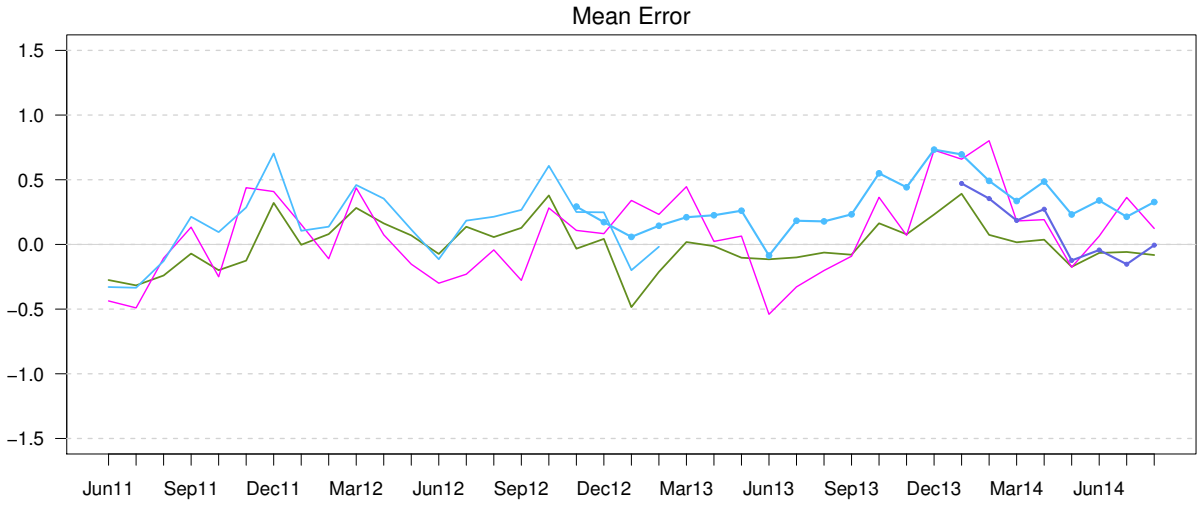



Wind speed at 4 Norwegian stations

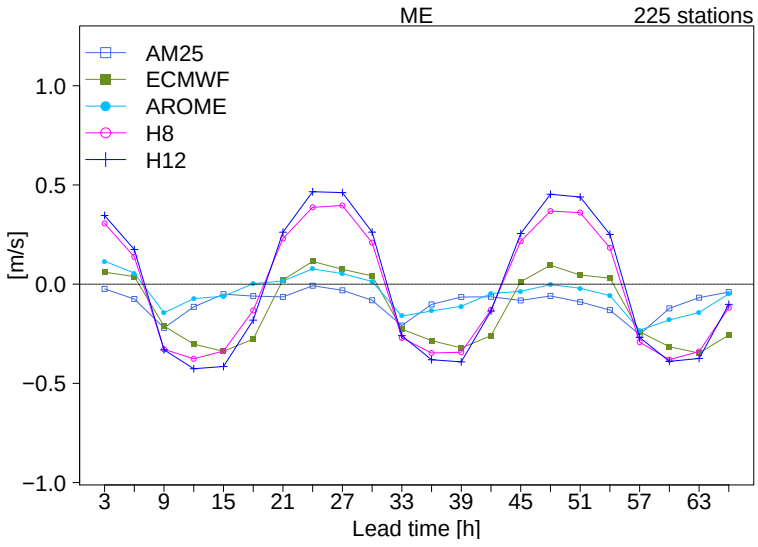


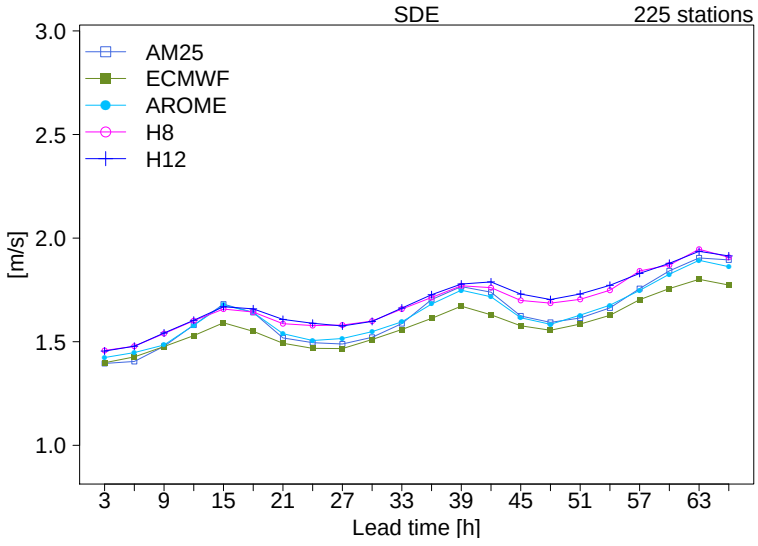

Mean Absolute Error
127 Norwegian stations
00+24,+30,+36,+42 UTC
ECMWF
Hirlam8
Harmonie2.5
AROME_Norway
AM25
2.5
2.0
1.5
1.0
0.5
0.0
Jun11
Sep11
Dec11
Mar12
Jun12
Sep12
Dec12
Mar13
Jun13
Sep13
Dec13
Mar14
Jun14

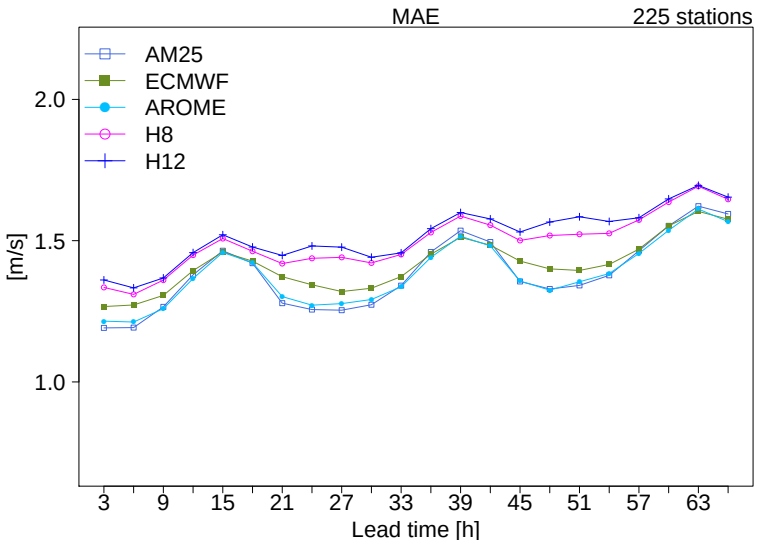

Standard Deviation of Error
2.5
2.0
1.5
1.0
0.5
0.0
Jun11
Sep11
Dec11
Mar12
Jun12
Sep12
Dec12
Mar13
Jun13
Sep13
Dec13
Mar14
Jun14

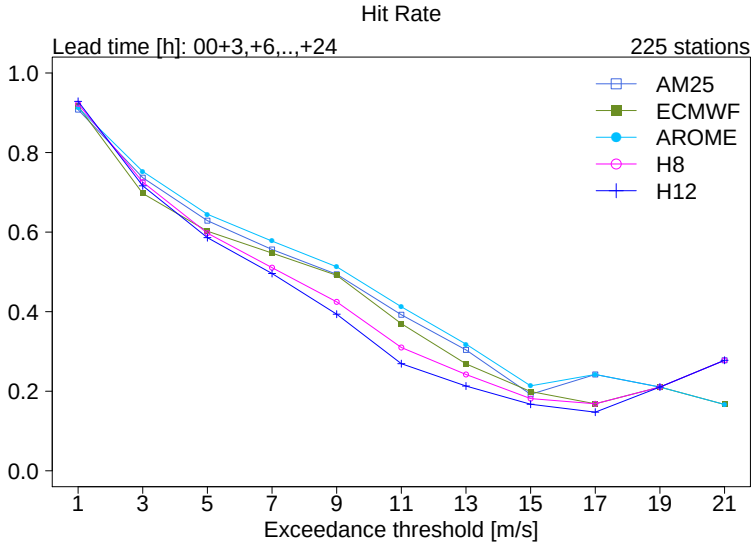

Mean Error
1.5
1.0
0.5
0.0
−0.5
−1.0
−1.5
Jun11
Sep11
Dec11
Mar12
Jun12
Sep12
Dec12
Mar13
Jun13
Sep13
Dec13
Mar14
Jun14

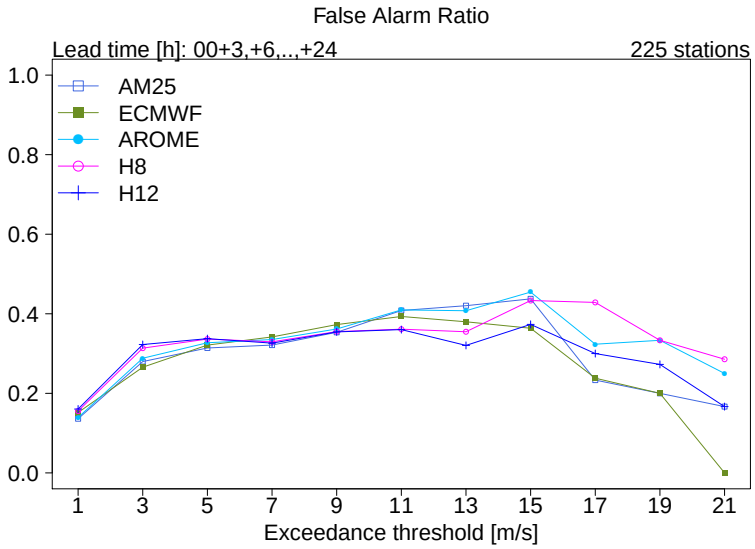
## 4.3 Wind Speed 10m

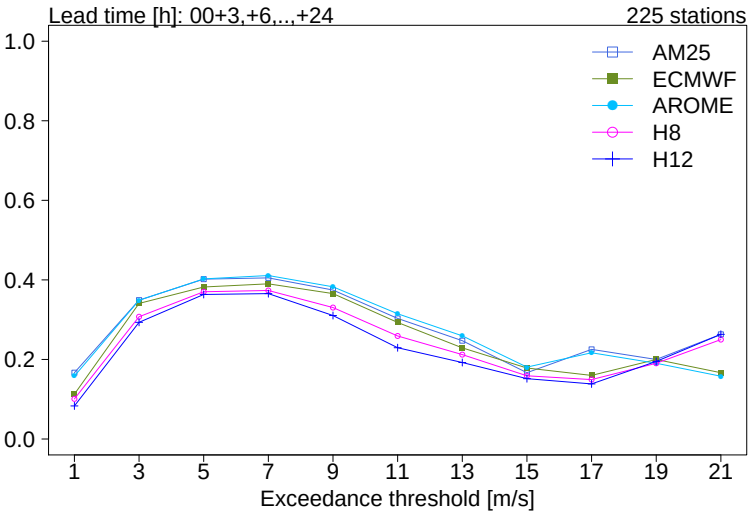


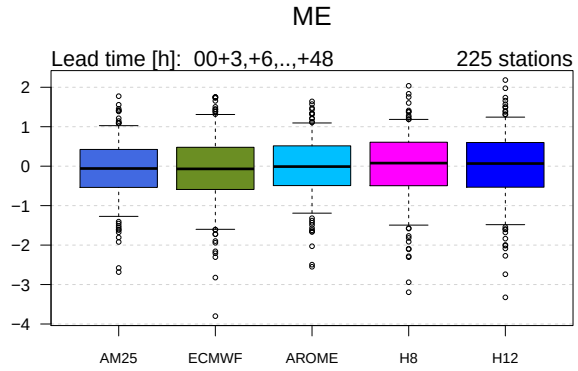



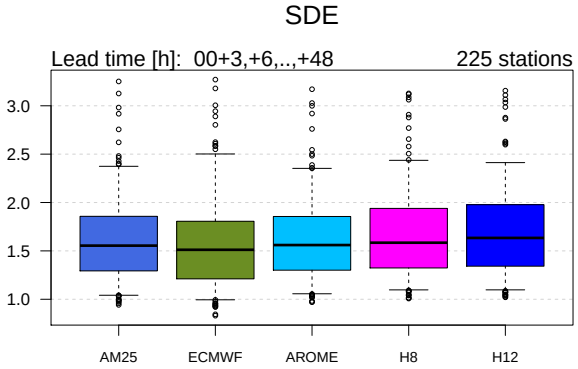




Hit Rate
Lead time [h]: 00+3,+6,..,+24
225 stations
AM25
ECMWF
AROME
H8
H12
1.0
0.8
0.6
0.4
0.2
0.0
1 3 5 7 9 11 13 15 17 19 21
Exceedance threshold [m/s]


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


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




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

**AM25** — OBS

| | [0,3] | (3,11] | (11,17] | (17,21] | (21,Inf] | Sum |
|---|---|---|---|---|---|---|
| [0,3] | 129266 | 34270 | 44 | 0 | 0 | 163580 |
| (3,11] | 36373 | 86146 | 2747 | 34 | 4 | 125304 |
| (11,17] | 62 | 1204 | 1496 | 102 | 18 | 2882 |
| (17,21] | 1 | 2 | 13 | 16 | 9 | 41 |
| (21,Inf] | 0 | 0 | 0 | 2 | 5 | 7 |
| Sum | 165702 | 121622 | 4300 | 154 | 36 | 291814 |

**H8** — OBS

| | [0,3] | (3,11] | (11,17] | (17,21] | (21,Inf] | Sum |
|---|---|---|---|---|---|---|
| [0,3] | 121847 | 35587 | 97 | 1 | 0 | 157532 |
| (3,11] | 43800 | 85226 | 2987 | 59 | 9 | 132081 |
| (11,17] | 55 | 805 | 1201 | 79 | 14 | 2154 |
| (17,21] | 0 | 3 | 15 | 13 | 5 | 36 |
| (21,Inf] | 0 | 1 | 0 | 2 | 8 | 11 |
| Sum | 165702 | 121622 | 4300 | 154 | 36 | 291814 |

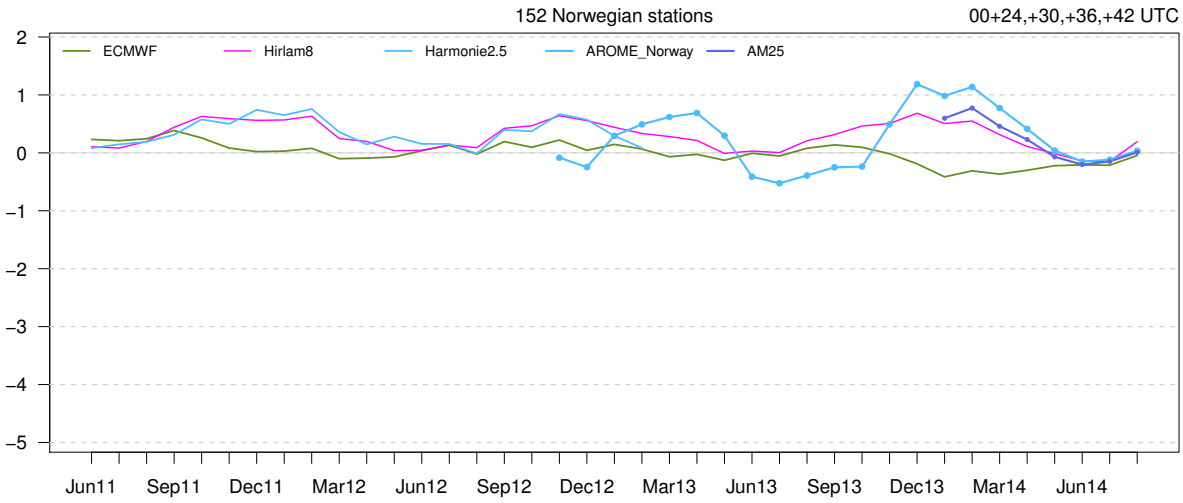
**ECMWF** — OBS

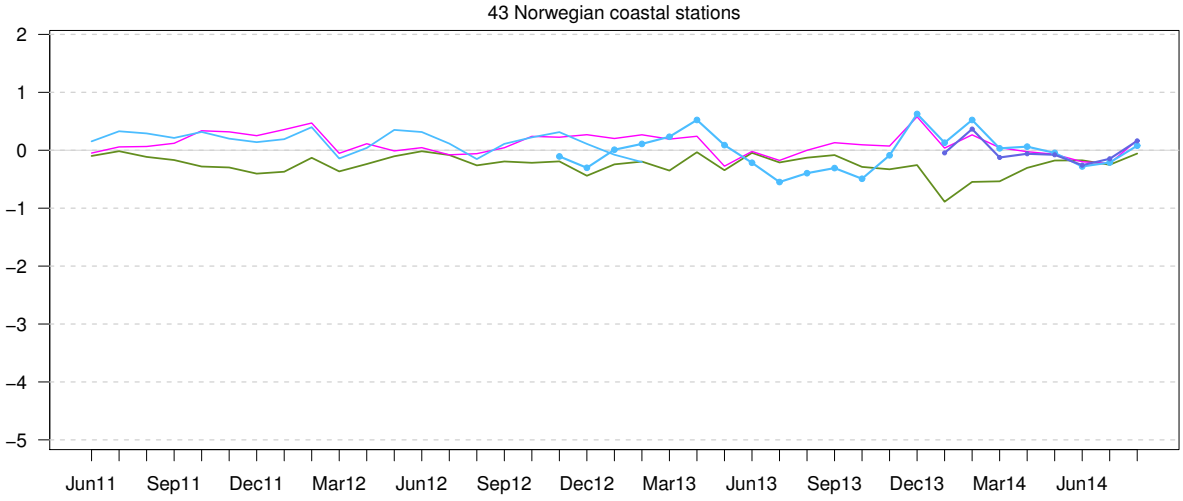
| | [0,3] | (3,11] | (11,17] | (17,21] | (21,Inf] | Sum |
|---|---|---|---|---|---|---|
| [0,3] | 133195 | 38797 | 167 | 11 | 2 | 172172 |
| (3,11] | 32469 | 81739 | 2644 | 41 | 7 | 116900 |
| (11,17] | 38 | 1084 | 1482 | 92 | 13 | 2709 |
| (17,21] | 0 | 2 | 7 | 10 | 9 | 28 |
| (21,Inf] | 0 | 0 | 0 | 0 | 5 | 5 |
| Sum | 165702 | 121622 | 4300 | 154 | 36 | 291814 |

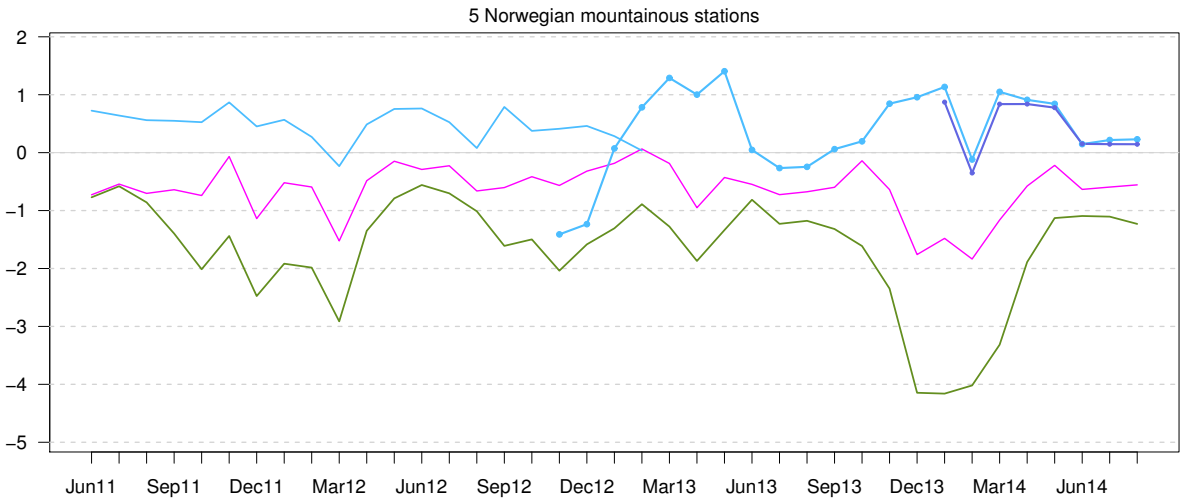
**AROME** — OBS

| | [0,3] | (3,11] | (11,17] | (17,21] | (21,Inf] | Sum |
|---|---|---|---|---|---|---|
| [0,3] | 127266 | 32742 | 41 | 0 | 0 | 160049 |
| (3,11] | 38377 | 87662 | 2711 | 36 | 3 | 128789 |
| (11,17] | 59 | 1212 | 1536 | 102 | 19 | 2928 |
| (17,21] | 0 | 6 | 12 | 13 | 11 | 42 |
| (21,Inf] | 0 | 0 | 0 | 3 | 3 | 6 |
| Sum | 165702 | 121622 | 4300 | 154 | 36 | 291814 |

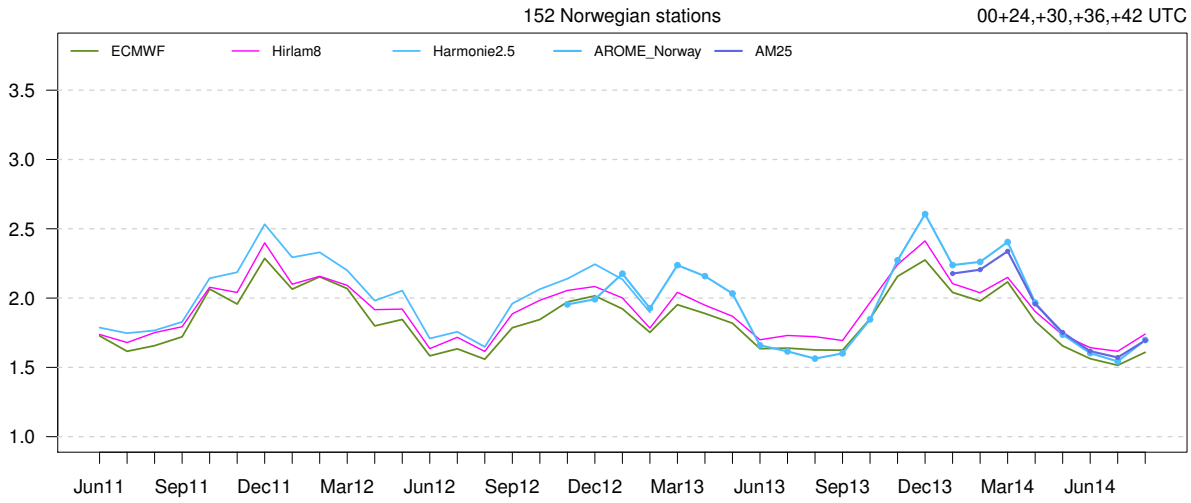
# Mean Error

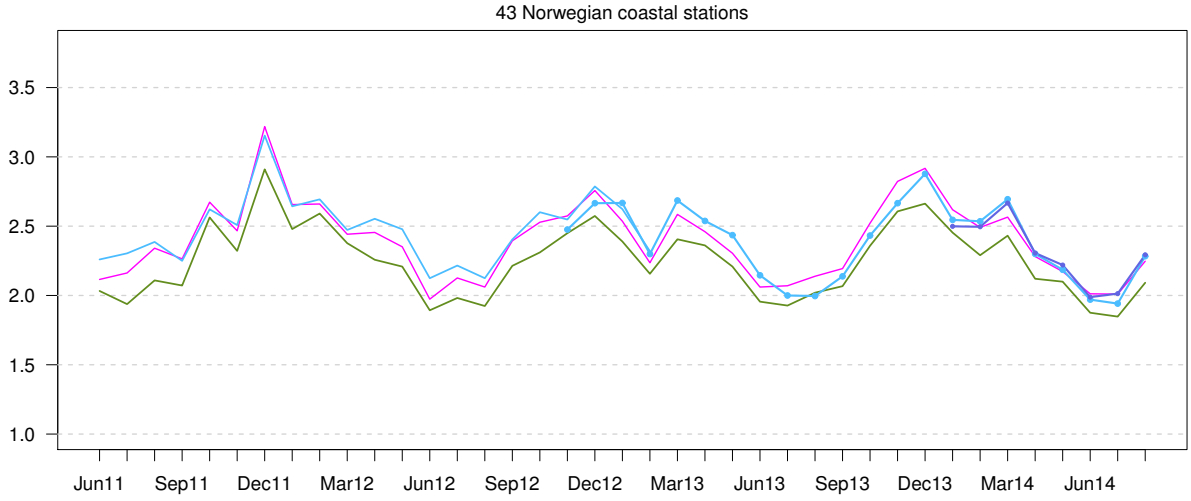

152 Norwegian stations
00+24,+30,+36,+42 UTC
ECMWF
Hirlam8
Harmonie2.5
AROME_Norway
AM25
2
1
0
−1
−2
−3
−4
−5
Jun11
Sep11
Dec11
Mar12
Jun12
Sep12
Dec12
Mar13
Jun13
Sep13
Dec13
Mar14
Jun14

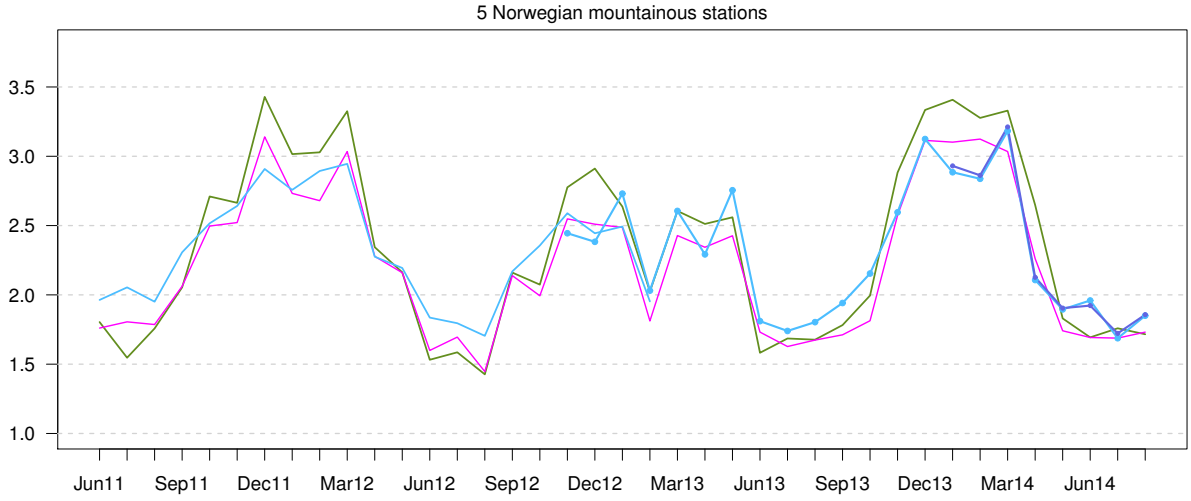

43 Norwegian coastal stations
2
1
0
−1
−2
−3
−4
−5
Jun11
Sep11
Dec11
Mar12
Jun12
Sep12
Dec12
Mar13
Jun13
Sep13
Dec13
Mar14
Jun14


5 Norwegian mountainous stations
2
1
0
−1
−2
−3
−4
−5
Jun11
Sep11
Dec11
Mar12
Jun12
Sep12
Dec12
Mar13
Jun13
Sep13
Dec13
Mar14
Jun14

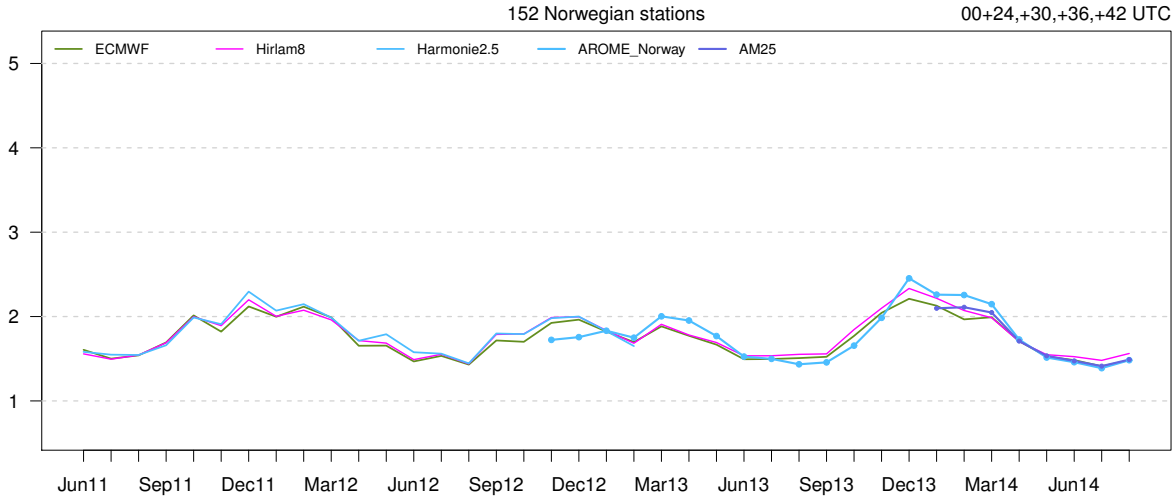
Standard Deviation of Error

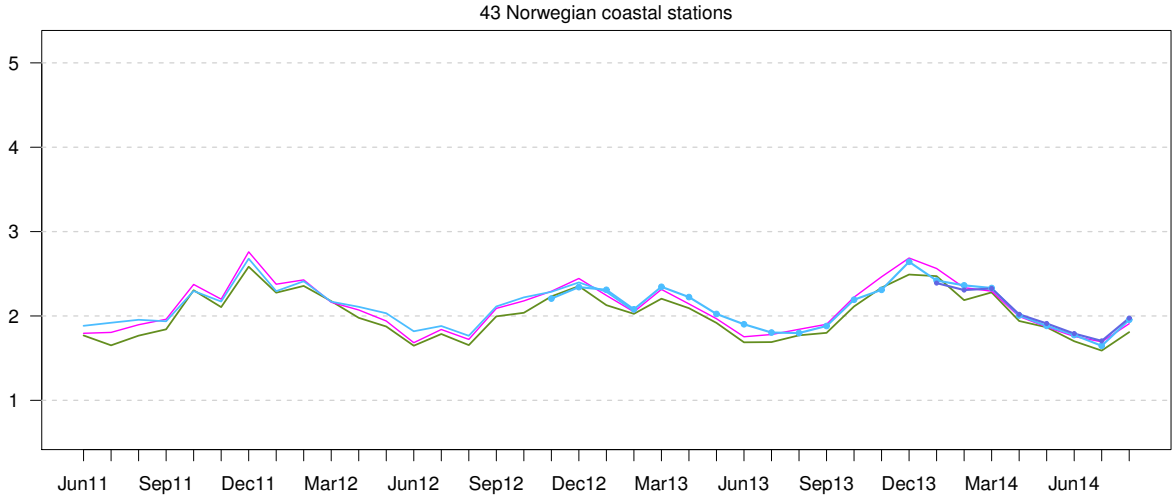


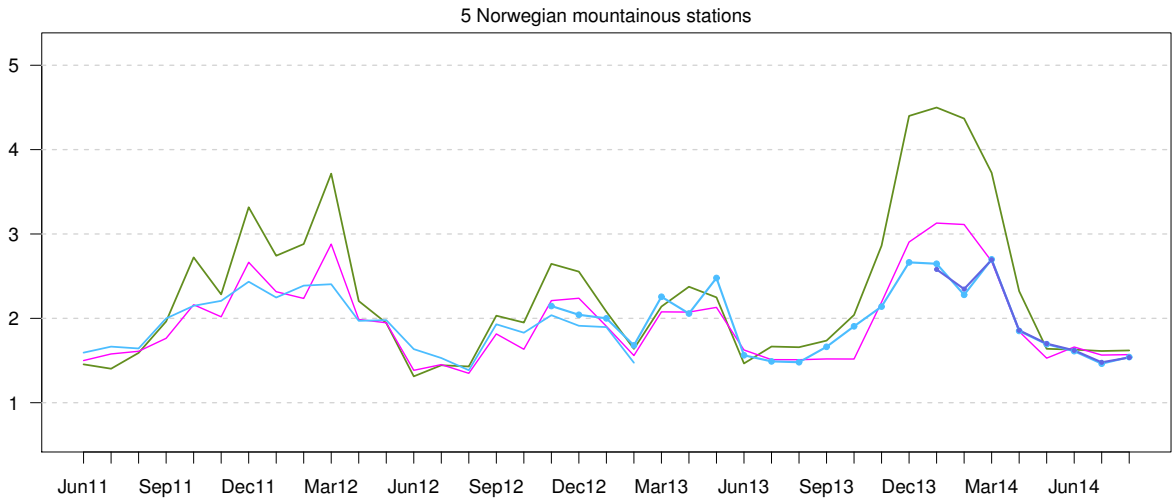



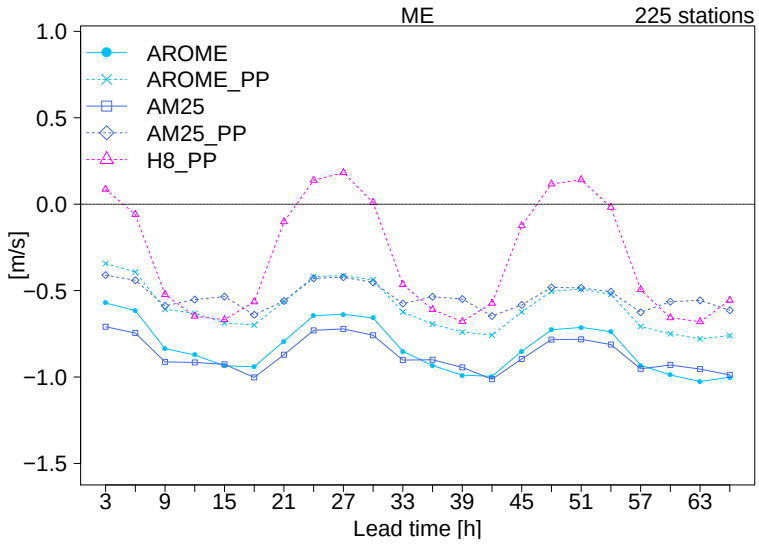
Mean Absolute Error

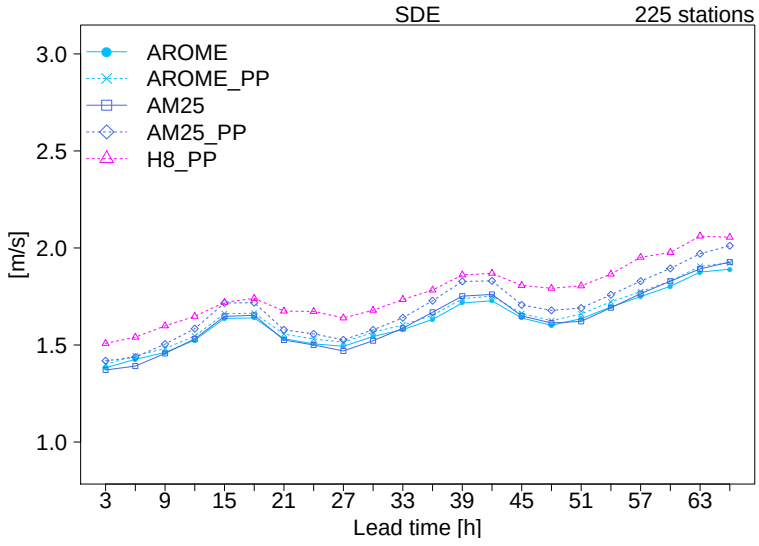


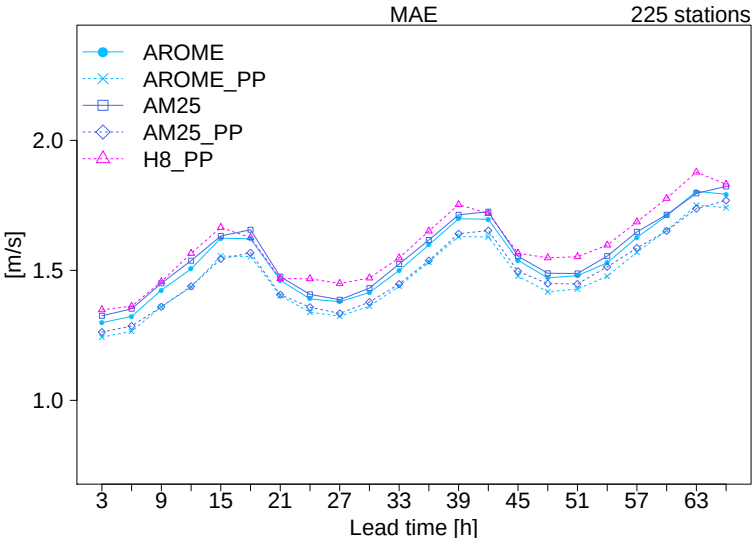



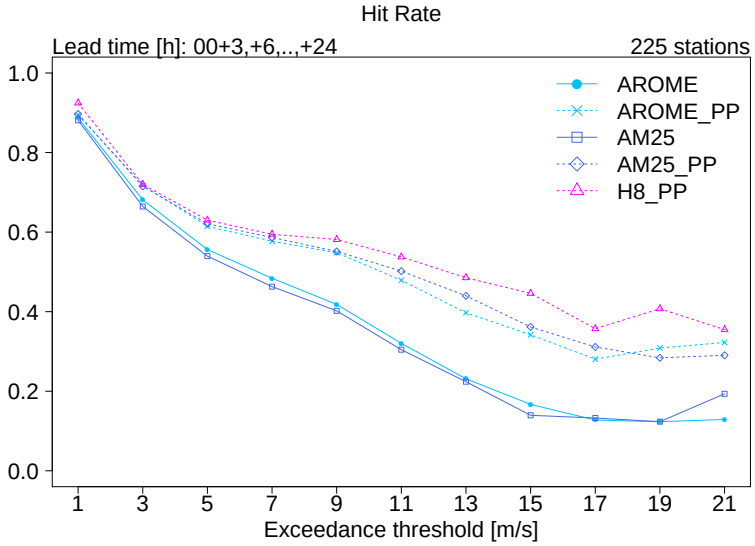



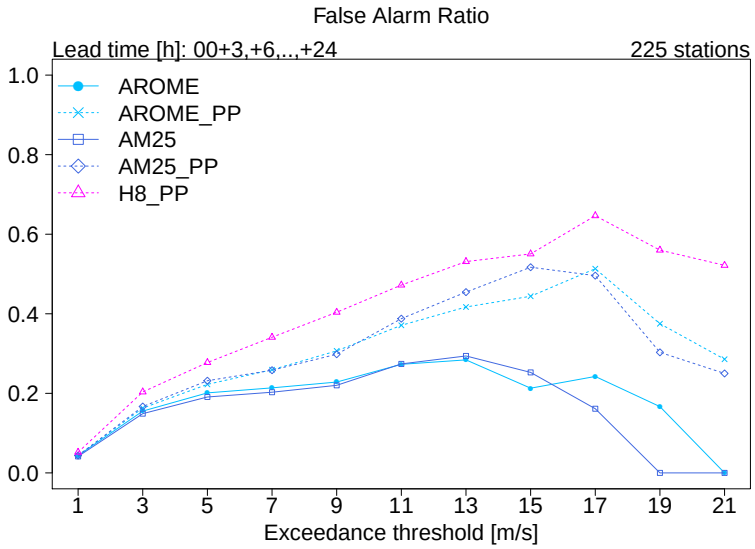
## 4.4 Max Mean Wind Speed 10m

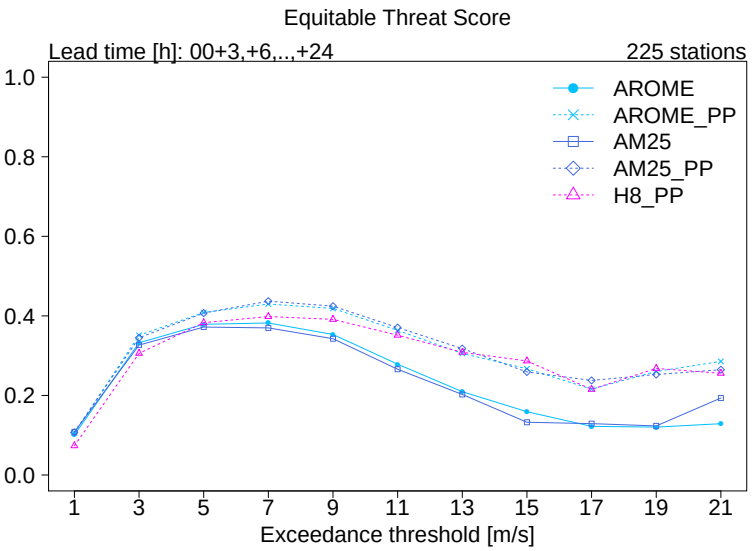


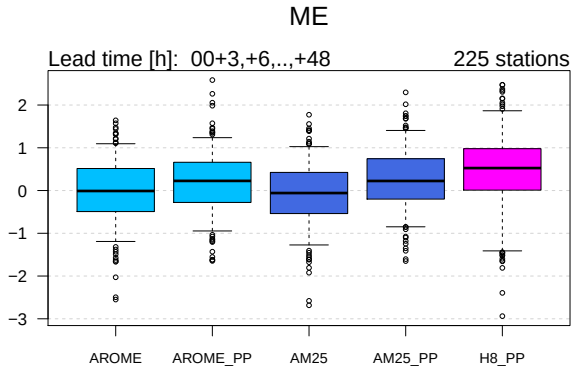



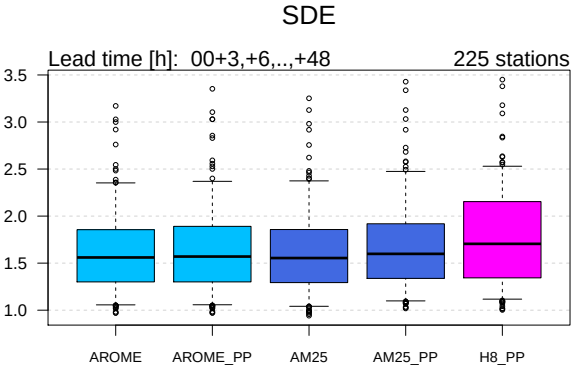




Hit Rate
Lead time [h]: 00+3,+6,..,+24
225 stations
AROME
AROME_PP
AM25
AM25_PP
H8_PP
1.0
0.8
0.6
0.4
0.2
0.0
1 3 5 7 9 11 13 15 17 19 21
Exceedance threshold [m/s]


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


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




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

**AM25** — **OBS**

| | [0,3] | (3,11] | (11,17] | (17,21] | (21,Inf] | Sum |
|---|---|---|---|---|---|---|
| [0,3] | 97286 | 52595 | 113 | 0 | 0 | 149994 |
| (3,11] | 18284 | 93016 | 4780 | 103 | 12 | 116195 |
| (11,17] | 48 | 821 | 1750 | 211 | 30 | 2860 |
| (17,21] | 0 | 3 | 9 | 17 | 13 | 42 |
| (21,Inf] | 0 | 0 | 0 | 0 | 7 | 7 |
| Sum | 115618 | 146435 | 6652 | 331 | 62 | 269098 |

**AM25_PP** — **OBS**

| | [0,3] | (3,11] | (11,17] | (17,21] | (21,Inf] | Sum |
|---|---|---|---|---|---|---|
| [0,3] | 93107 | 44677 | 78 | 0 | 0 | 137862 |
| (3,11] | 22428 | 99459 | 3519 | 59 | 5 | 125470 |
| (11,17] | 74 | 2282 | 2949 | 198 | 27 | 5530 |
| (17,21] | 9 | 15 | 103 | 69 | 18 | 214 |
| (21,Inf] | 0 | 2 | 3 | 5 | 12 | 22 |
| Sum | 115618 | 146435 | 6652 | 331 | 62 | 269098 |

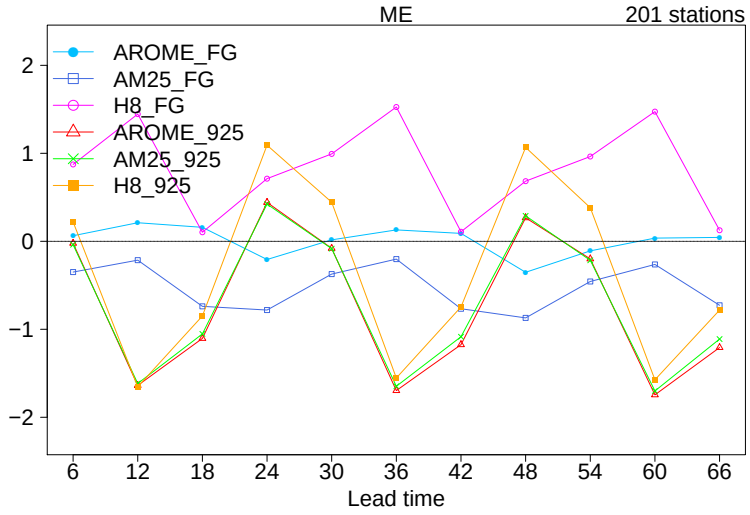
**AROME** — **OBS**

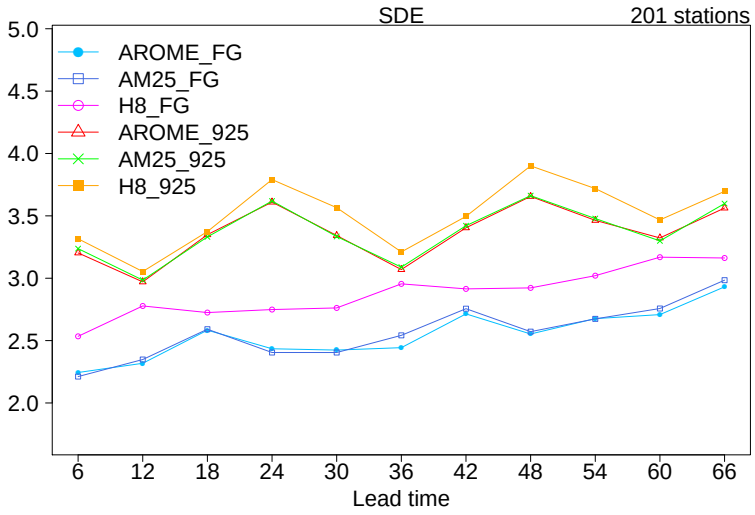
| | [0,3] | (3,11] | (11,17] | (17,21] | (21,Inf] | Sum |
|---|---|---|---|---|---|---|
| [0,3] | 96083 | 50466 | 99 | 0 | 0 | 146648 |
| (3,11] | 19487 | 95151 | 4748 | 107 | 10 | 119503 |
| (11,17] | 48 | 814 | 1794 | 211 | 33 | 2900 |
| (17,21] | 0 | 4 | 11 | 12 | 14 | 41 |
| (21,Inf] | 0 | 0 | 0 | 1 | 5 | 6 |
| Sum | 115618 | 146435 | 6652 | 331 | 62 | 269098 |

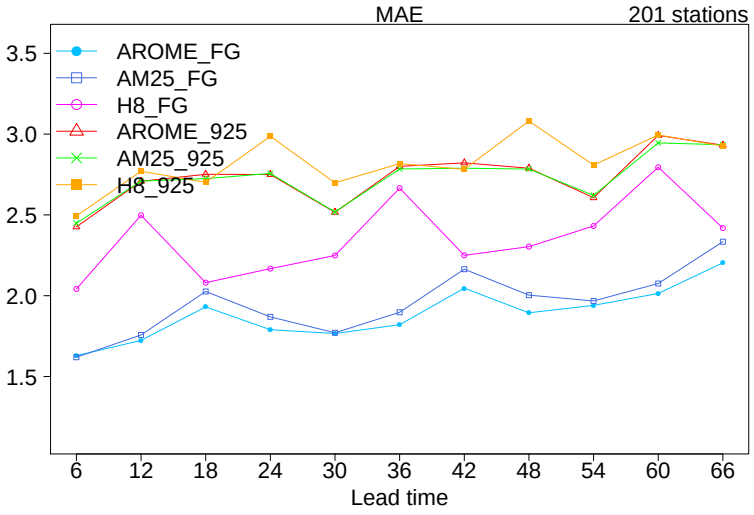
**AROME_PP** — **OBS**

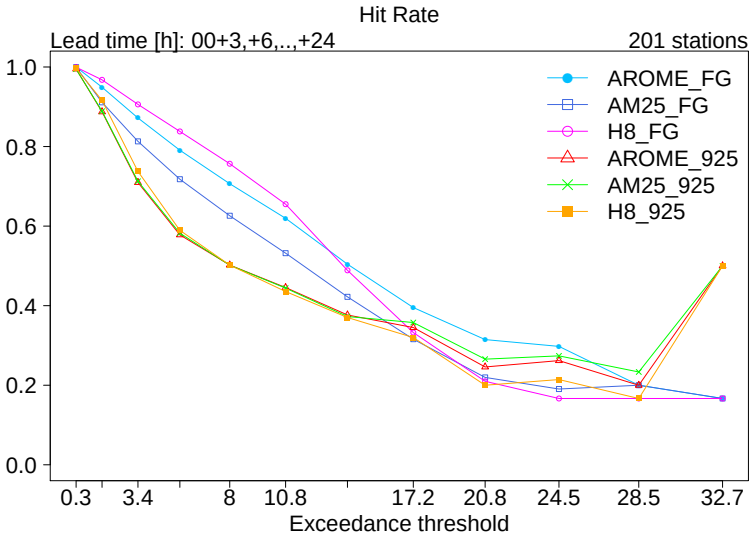
| | [0,3] | (3,11] | (11,17] | (17,21] | (21,Inf] | Sum |
|---|---|---|---|---|---|---|
| [0,3] | 93875 | 44804 | 75 | 0 | 0 | 138754 |
| (3,11] | 21666 | 99694 | 3750 | 60 | 4 | 125174 |
| (11,17] | 74 | 1917 | 2737 | 210 | 27 | 4965 |
| (17,21] | 3 | 20 | 86 | 57 | 19 | 185 |
| (21,Inf] | 0 | 0 | 4 | 4 | 12 | 20 |
| Sum | 115618 | 146435 | 6652 | 331 | 62 | 269098 |

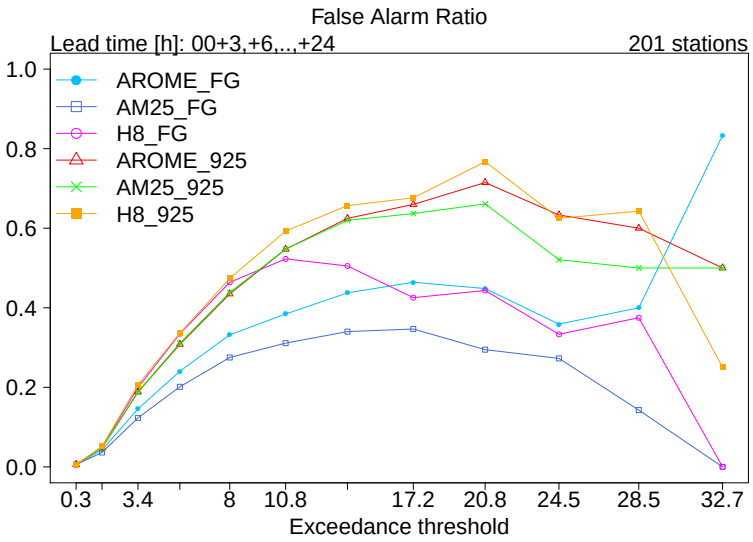
## 4.5 Wind gust

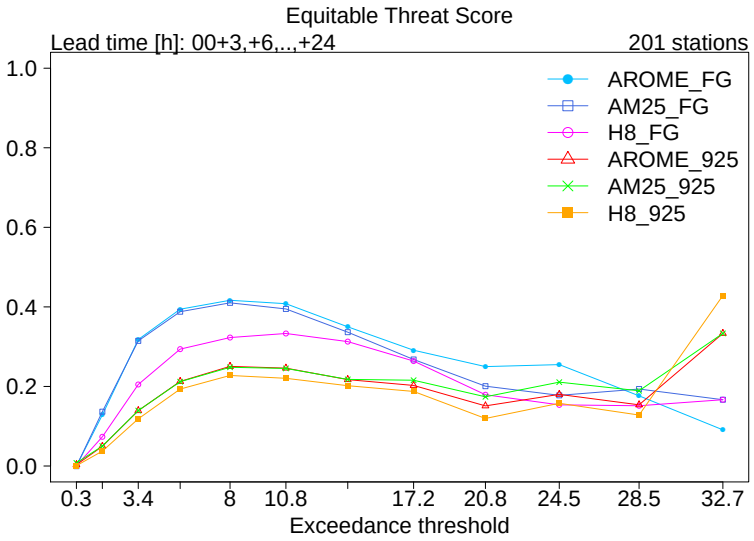

ME
201 stations
AROME_FG
AM25_FG
H8_FG
AROME_925
AM25_925
H8_925
2
1
0
−1
−2
6
12
18
24
30
36
42
48
54
60
66
Lead time


SDE
201 stations
AROME_FG
AM25_FG
H8_FG
AROME_925
AM25_925
H8_925
5.0
4.5
4.0
3.5
3.0
2.5
2.0
6
12
18
24
30
36
42
48
54
60
66
Lead time

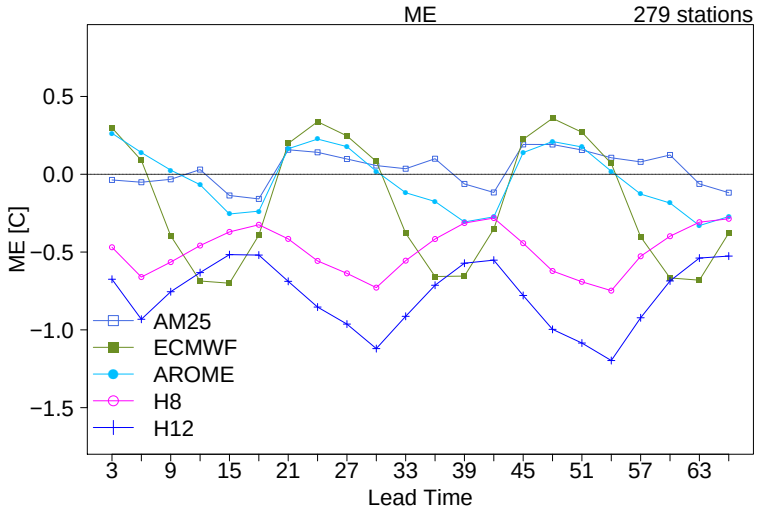

MAE
201 stations
AROME_FG
AM25_FG
H8_FG
AROME_925
AM25_925
H8_925
3.5
3.0
2.5
2.0
1.5
6
12
18
24
30
36
42
48
54
60
66
Lead time

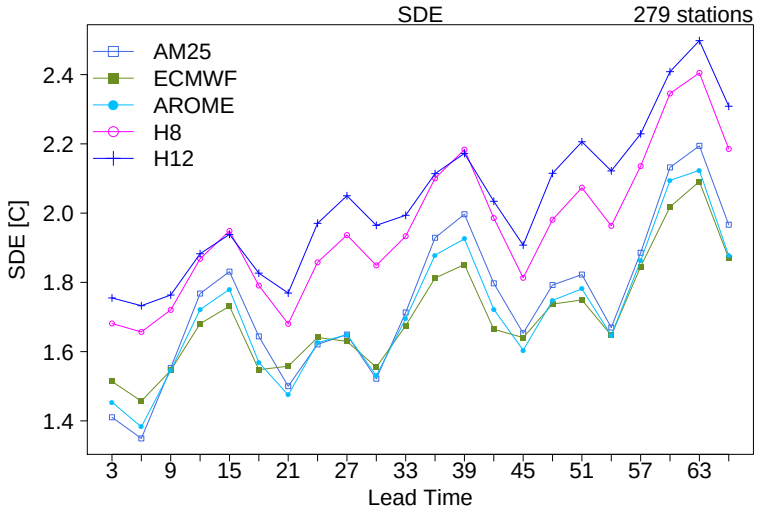

Hit Rate
Lead time [h]: 00+3,+6,..,+24
201 stations
1.0
0.8
0.6
0.4
0.2
0.0
AROME_FG
AM25_FG
H8_FG
AROME_925
AM25_925
H8_925
0.3
3.4
8
10.8
17.2
20.8
24.5
28.5
32.7
Exceedance threshold

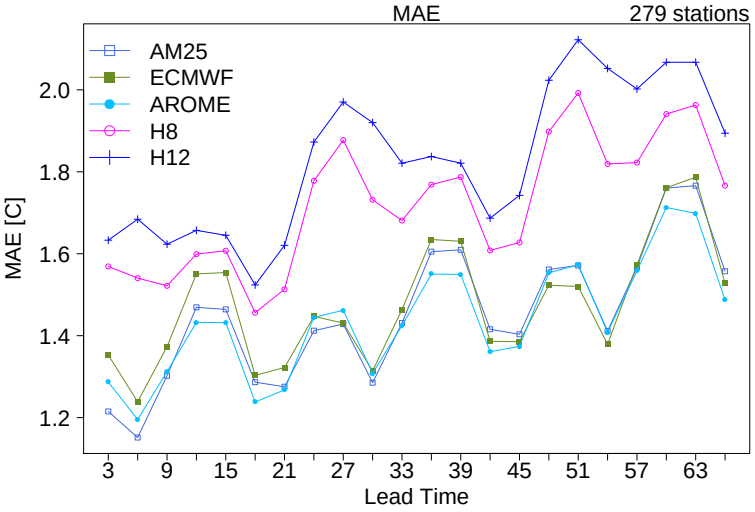

False Alarm Ratio
Lead time [h]: 00+3,+6,..,+24
201 stations
1.0
0.8
0.6
0.4
0.2
0.0
AROME_FG
AM25_FG
H8_FG
AROME_925
AM25_925
H8_925
0.3
3.4
8
10.8
17.2
20.8
24.5
28.5
32.7
Exceedance threshold

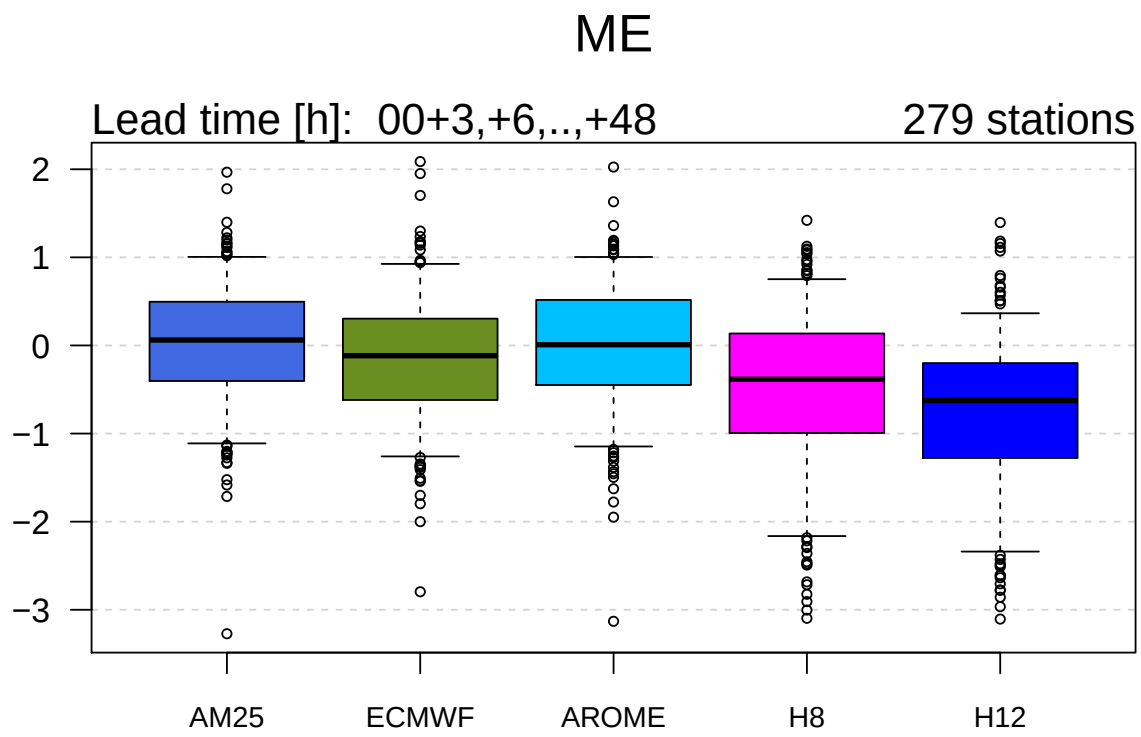

Equitable Threat Score
Lead time [h]: 00+3,+6,..,+24
201 stations
1.0
0.8
0.6
0.4
0.2
0.0
AROME_FG
AM25_FG
H8_FG
AROME_925
AM25_925
H8_925
0.3
3.4
8
10.8
17.2
20.8
24.5
28.5
32.7
Exceedance threshold

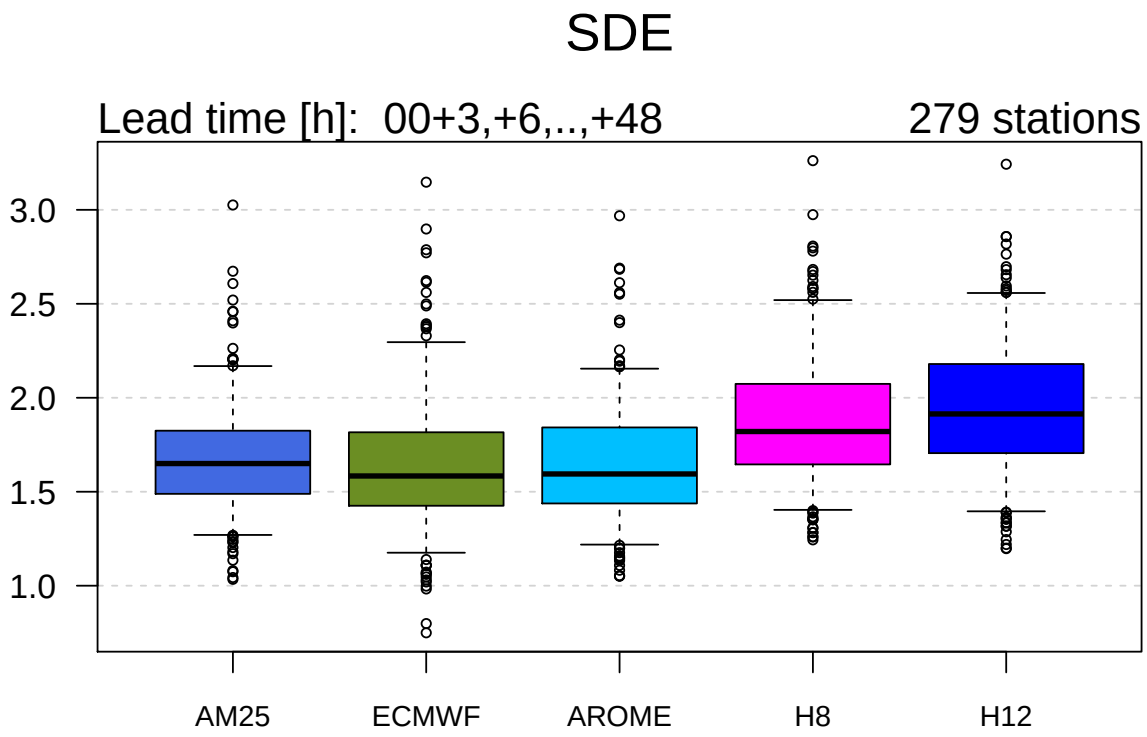
## 4.6 Temperature 2m



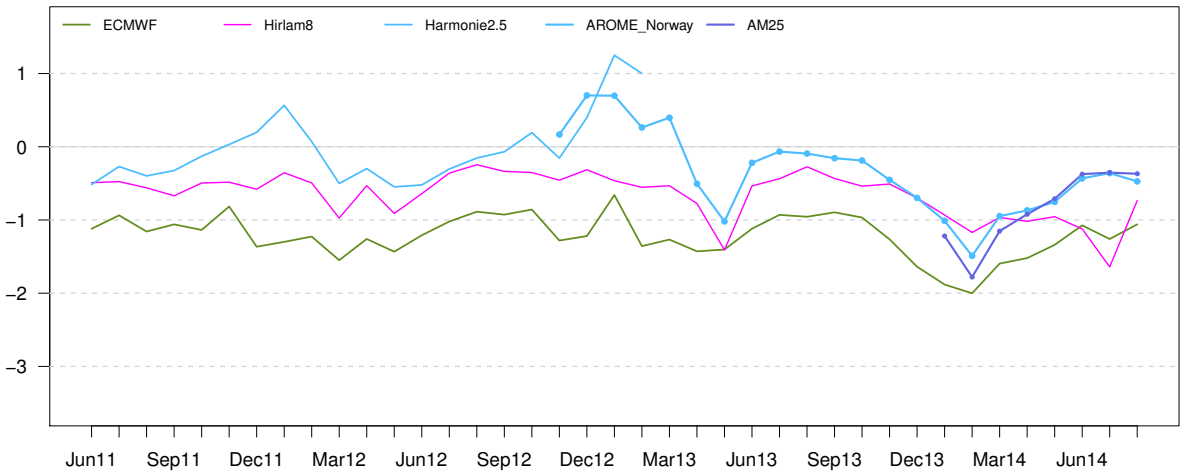

ME
Lead time [h]: 00+3,+6,..,+48
279 stations
2
1
0
−1
−2
−3
AM25
ECMWF
AROME
H8
H12


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

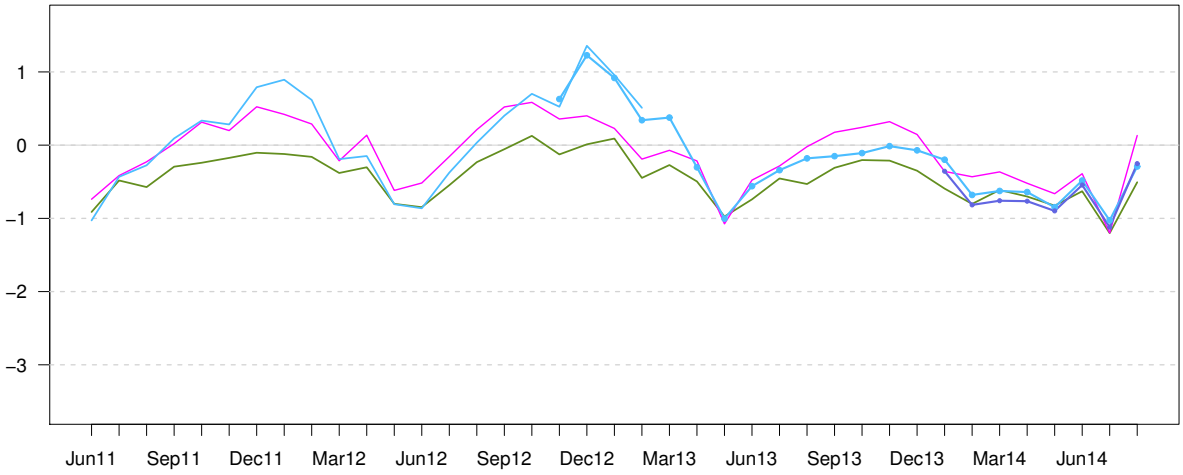
# Mean Error

156 Norwegian stations

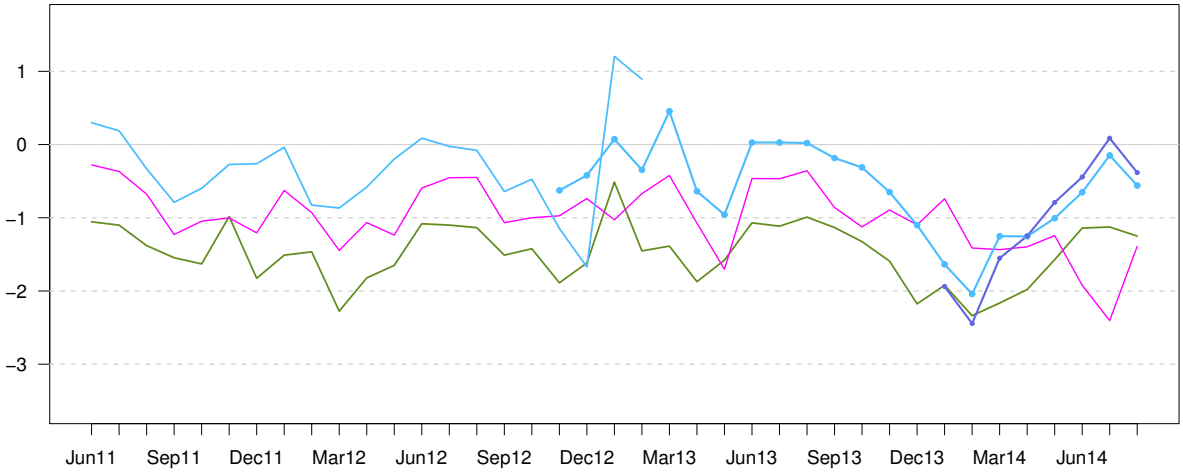
00+24,+30,+36,+42 UTC



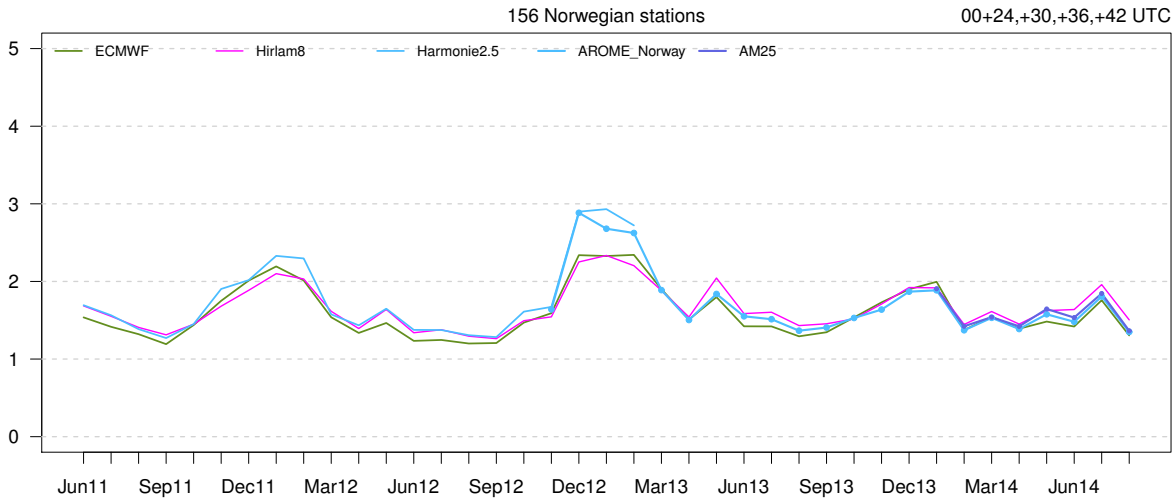

43 Norwegian coastal stations

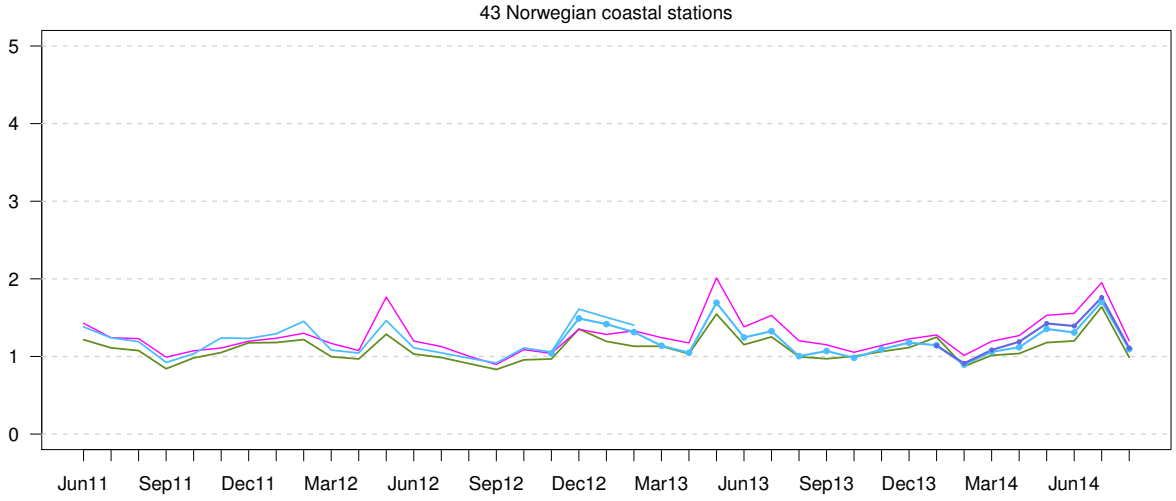


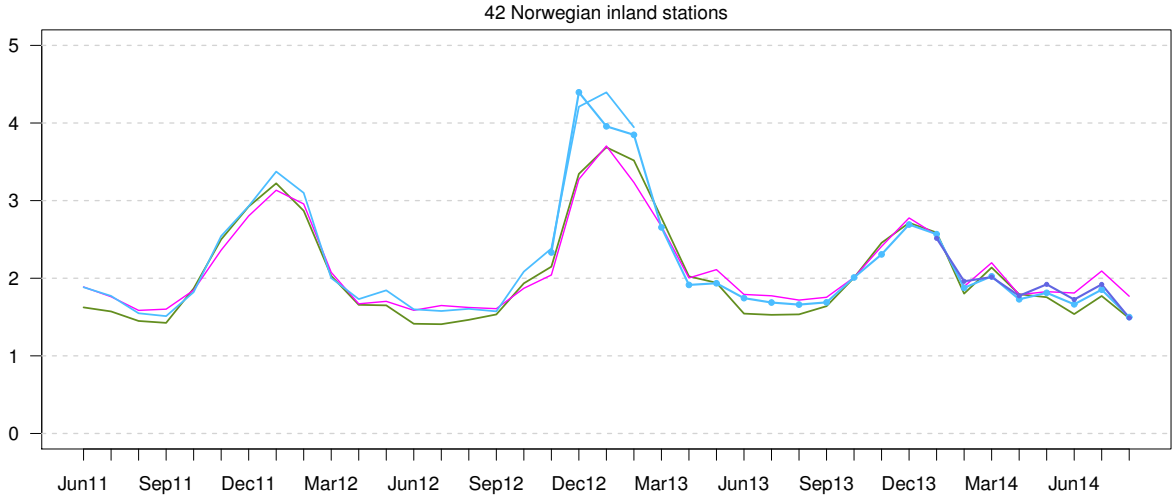

42 Norwegian inland stations



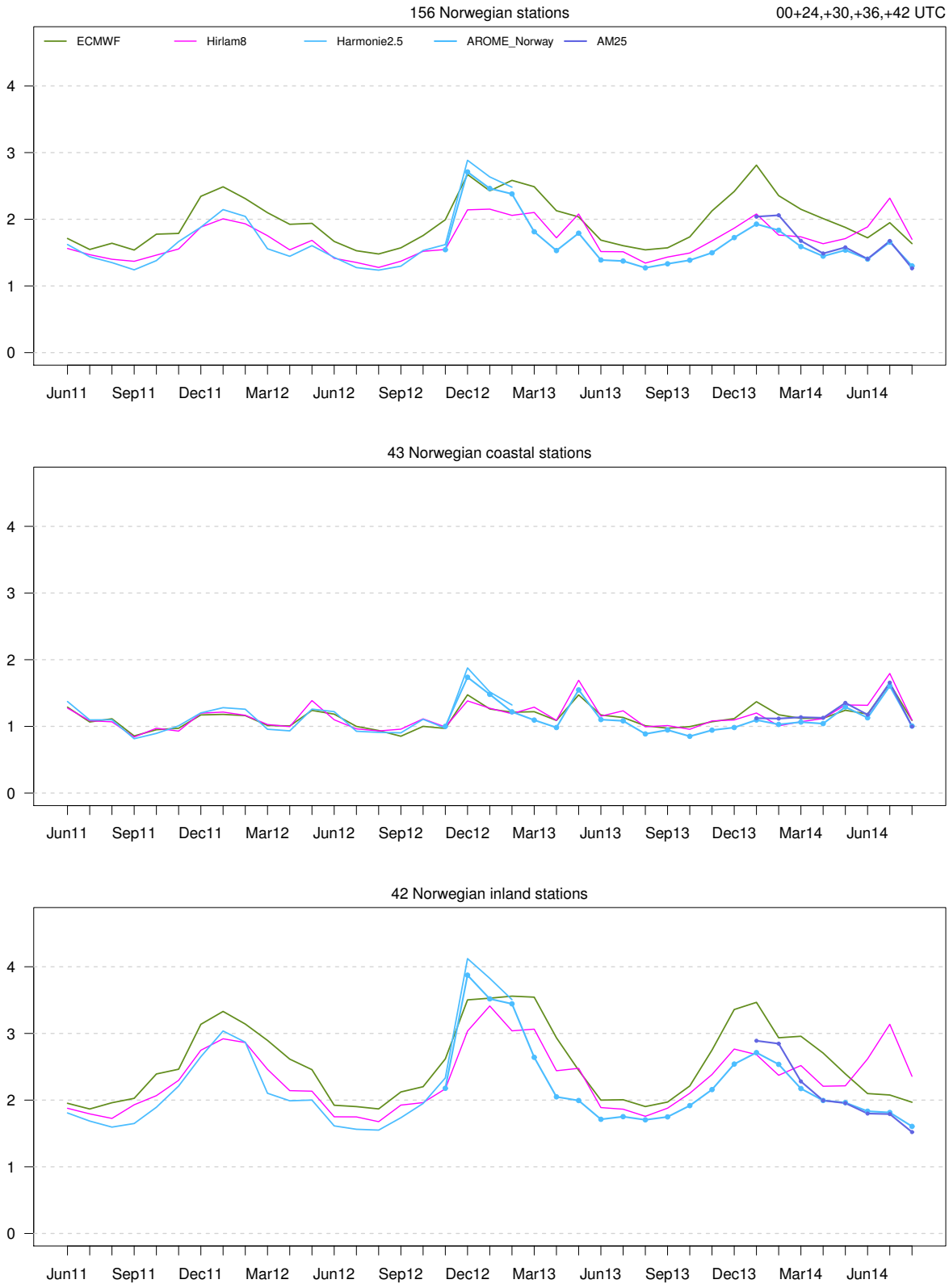
Standard Deviation of Error



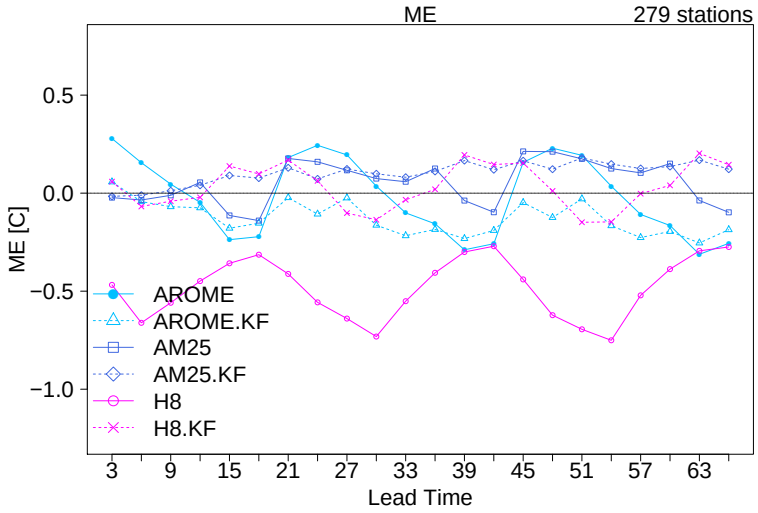



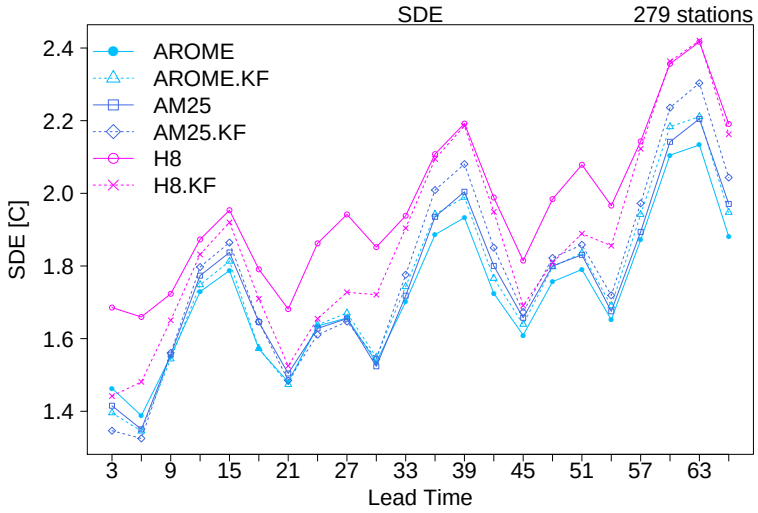



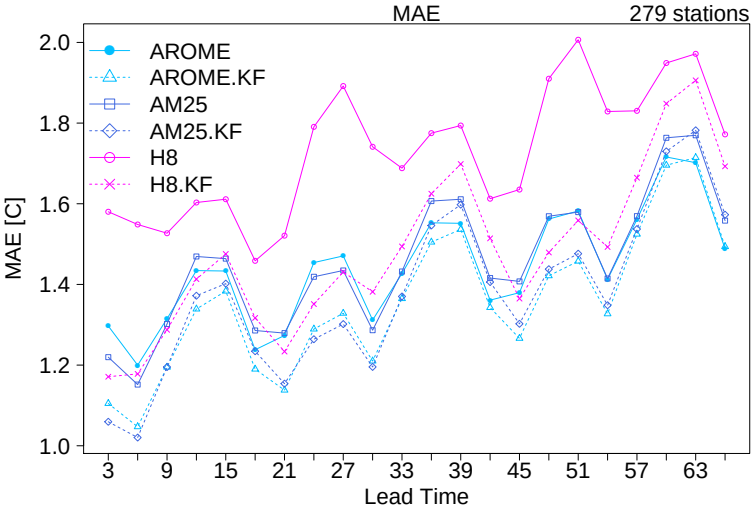
Mean Absolute Error

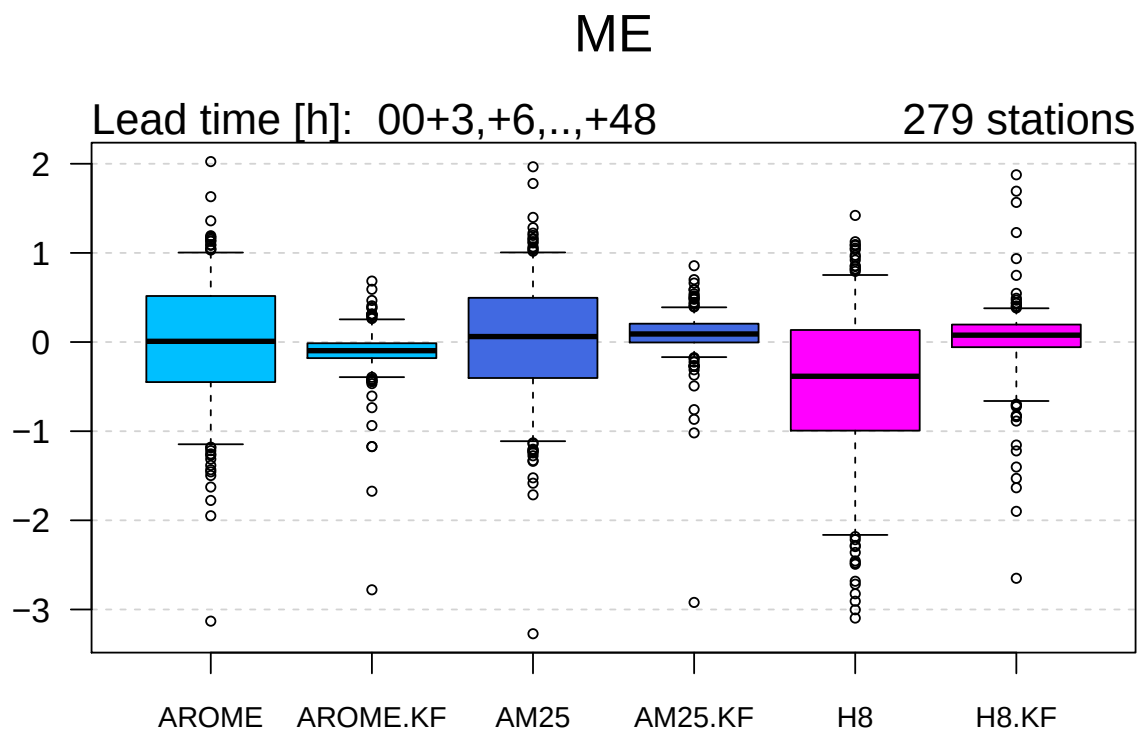


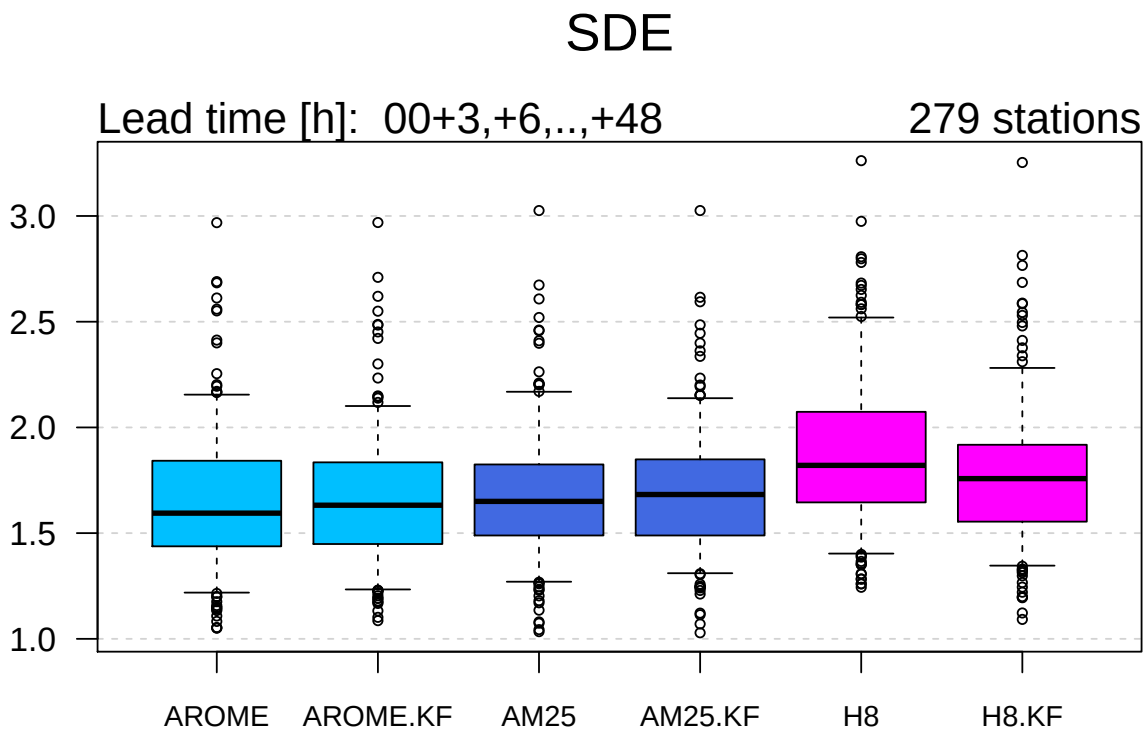
## 4.7 Post processed temperature 2m



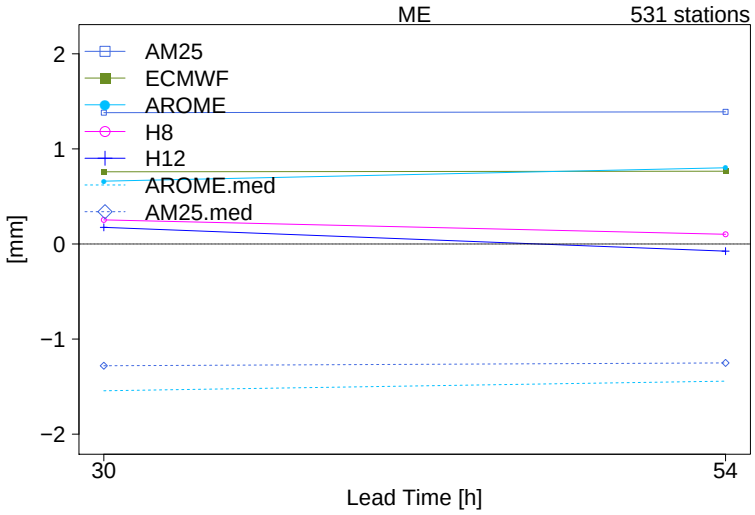



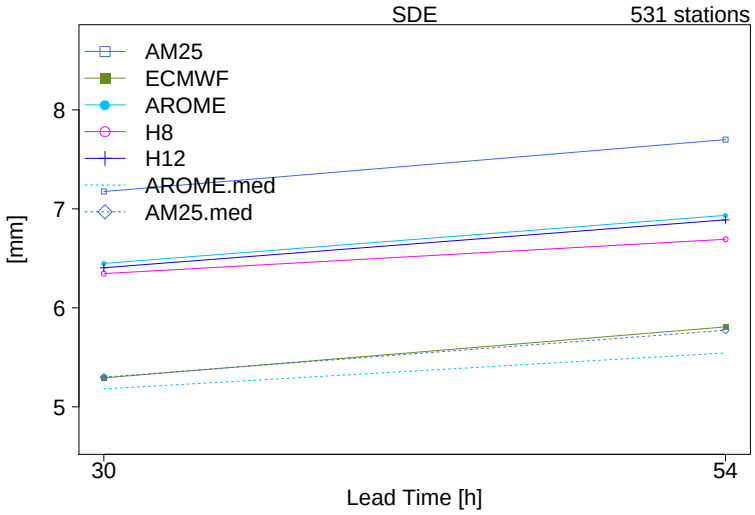



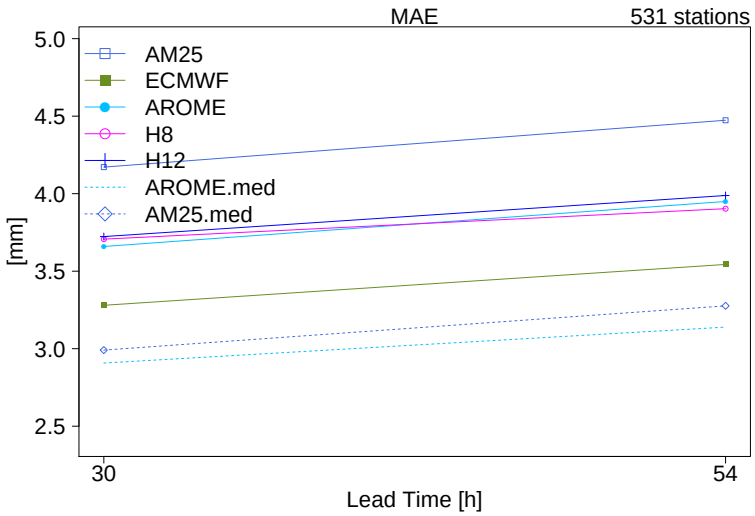

ME
Lead time [h]: 00+3,+6,..,+48
279 stations
2
1
0
−1
−2
−3
AROME
AROME.KF
AM25
AM25.KF
H8
H8.KF

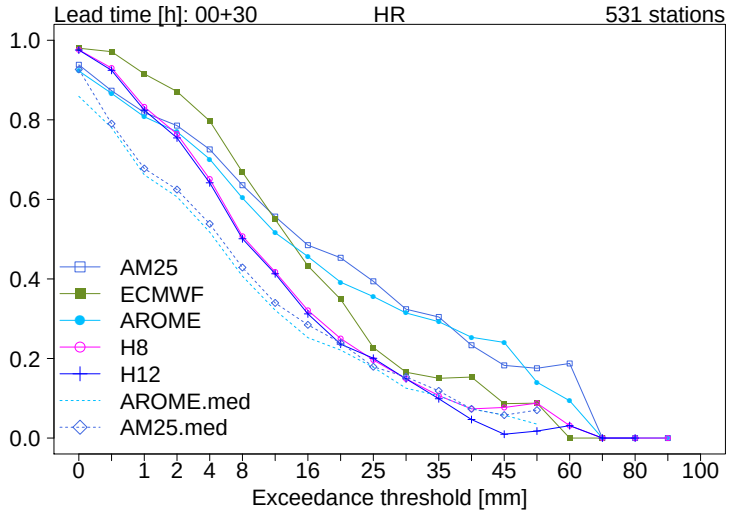

SDE
Lead time [h]: 00+3,+6,..,+48
279 stations
3.0
2.5
2.0
1.5
1.0
AROME
AROME.KF
AM25
AM25.KF
H8
H8.KF

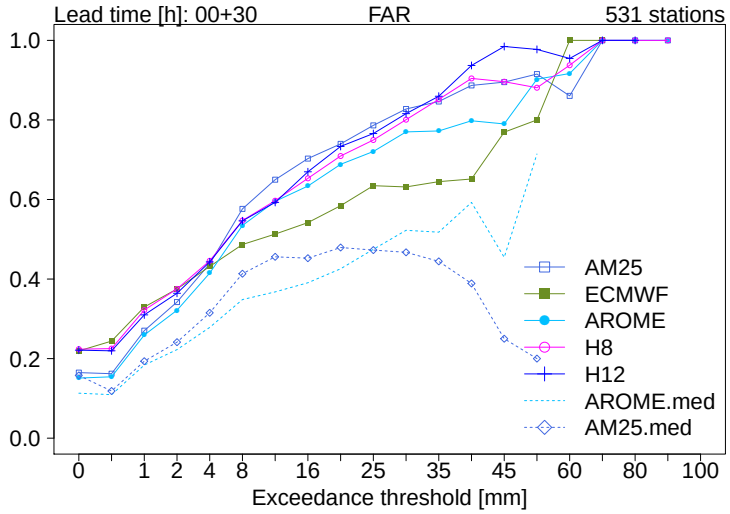
## 4.8 Daily precipitation

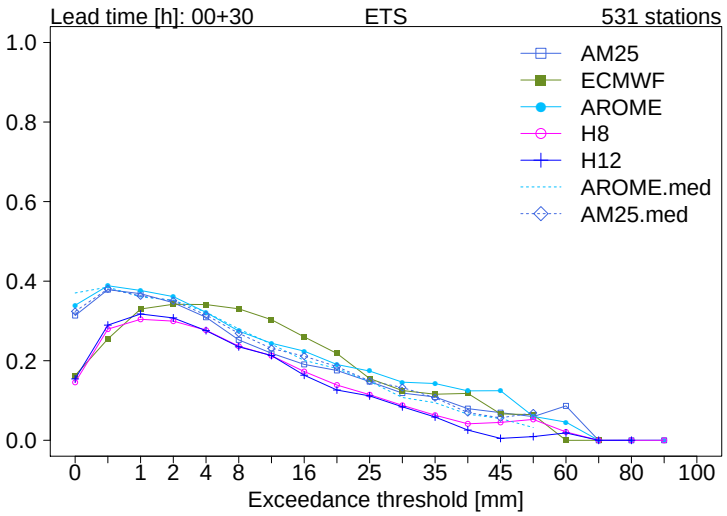


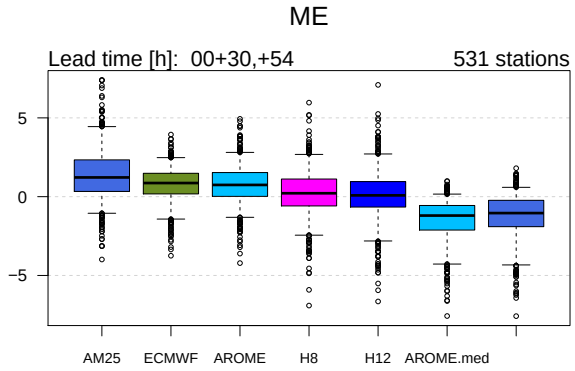



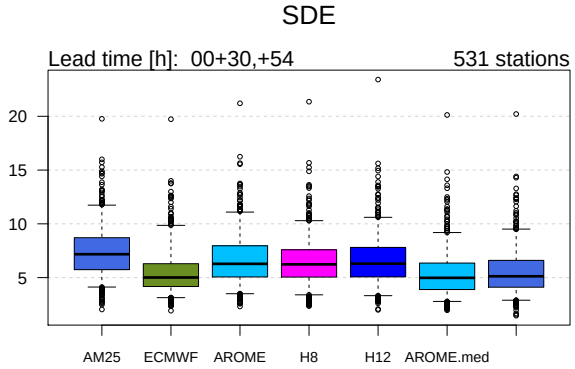




Lead time [h]: 00+30
HR
531 stations
1.0
0.8
0.6
0.4
0.2
0.0
AM25
ECMWF
AROME
H8
H12
AROME.med
AM25.med
0
1
2
4
8
16
25
35
45
60
80
100
Exceedance threshold [mm]


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




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

**AM25**

| OBS | [0,0.1] | (0.1,5] | (5,20] | (20,50] | (50,Inf] | Sum |
|---|---|---|---|---|---|---|
| [0,0.1] | 14872 | 5557 | 594 | 41 | 2 | 21066 |
| (0.1,5] | 6275 | 15048 | 3893 | 338 | 5 | 25559 |
| (5,20] | 1191 | 7805 | 6561 | 938 | 37 | 16532 |
| (20,50] | 151 | 1097 | 1849 | 893 | 59 | 4049 |
| (50,Inf] | 6 | 51 | 91 | 102 | 13 | 263 |
| Sum | 22495 | 29558 | 12988 | 2312 | 116 | 67469 |

**AM25.med**

| OBS | [0,0.1] | (0.1,5] | (5,20] | (20,50] | (50,Inf] | Sum |
|---|---|---|---|---|---|---|
| [0,0.1] | 17635 | 8747 | 1156 | 91 | 2 | 27631 |
| (0.1,5] | 4464 | 16802 | 6030 | 588 | 20 | 27904 |
| (5,20] | 377 | 3858 | 5276 | 1128 | 47 | 10686 |
| (20,50] | 19 | 151 | 526 | 503 | 43 | 1242 |
| (50,Inf] | 0 | 0 | 0 | 2 | 4 | 6 |
| Sum | 22495 | 29558 | 12988 | 2312 | 116 | 67469 |

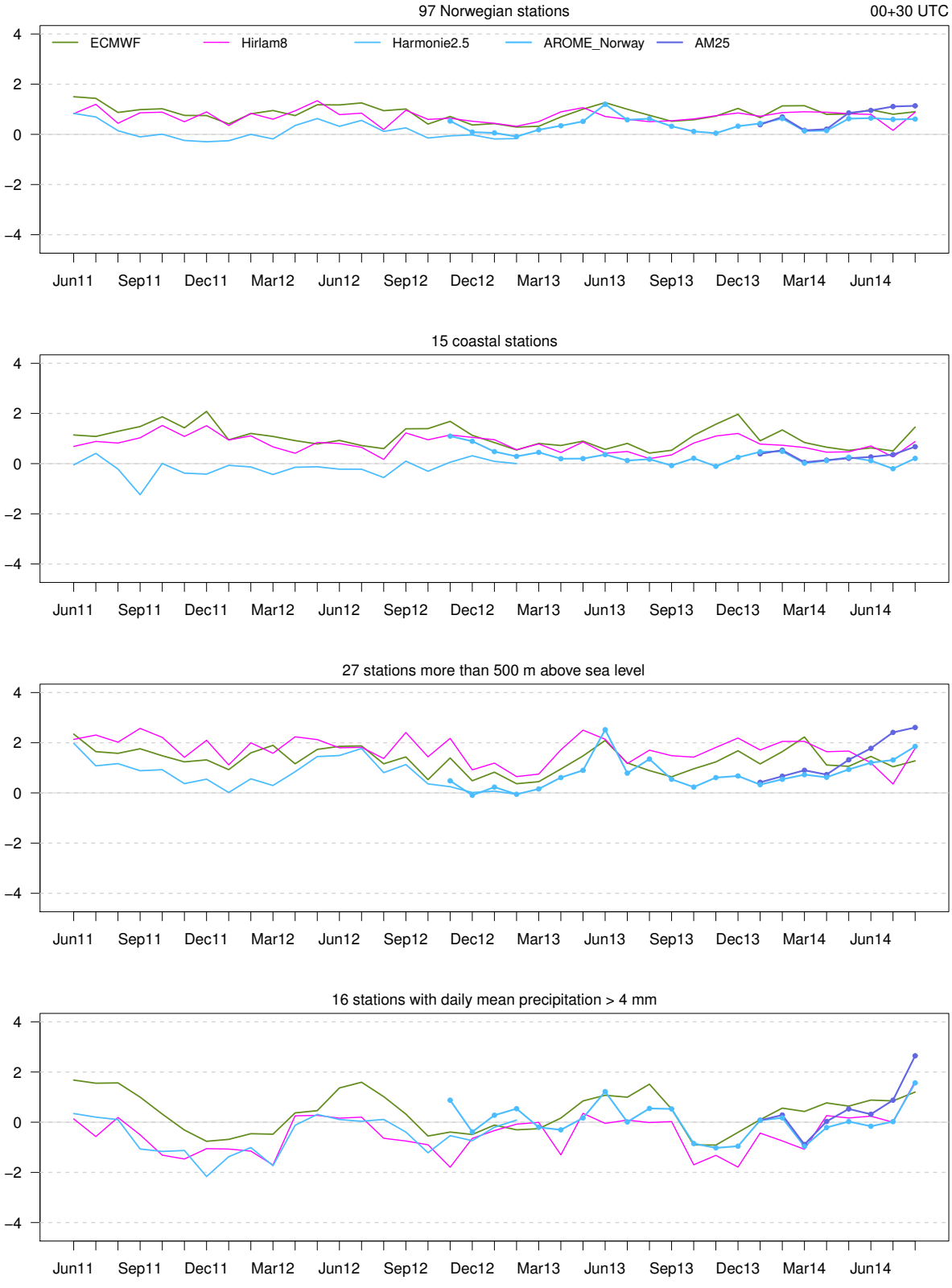
**ECMWF**

| OBS | [0,0.1] | (0.1,5] | (5,20] | (20,50] | (50,Inf] | Sum |
|---|---|---|---|---|---|---|
| [0,0.1] | 8398 | 1343 | 74 | 9 | 0 | 9824 |
| (0.1,5] | 12947 | 19112 | 3641 | 203 | 5 | 35908 |
| (5,20] | 1134 | 8845 | 8328 | 1361 | 37 | 19705 |
| (20,50] | 16 | 255 | 925 | 717 | 67 | 1980 |
| (50,Inf] | 0 | 3 | 20 | 22 | 7 | 52 |
| Sum | 22495 | 29558 | 12988 | 2312 | 116 | 67469 |

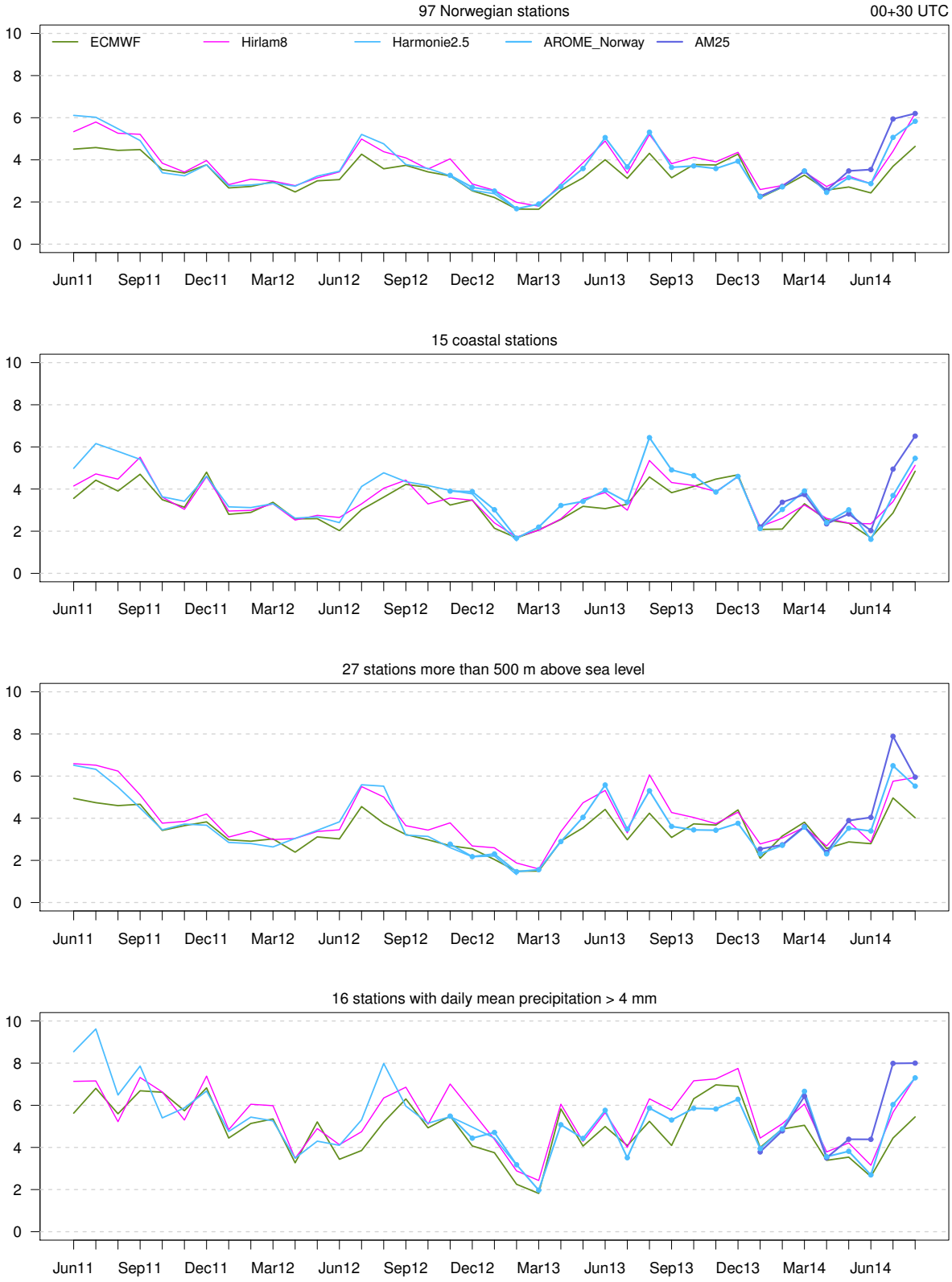
**AROME**

| OBS | [0,0.1] | (0.1,5] | (5,20] | (20,50] | (50,Inf] | Sum |
|---|---|---|---|---|---|---|
| [0,0.1] | 15200 | 5714 | 556 | 48 | 1 | 21519 |
| (0.1,5] | 6220 | 16151 | 4239 | 321 | 9 | 26940 |
| (5,20] | 985 | 6988 | 6658 | 1056 | 30 | 15717 |
| (20,50] | 87 | 691 | 1477 | 797 | 61 | 3113 |
| (50,Inf] | 3 | 14 | 58 | 90 | 15 | 180 |
| Sum | 22495 | 29558 | 12988 | 2312 | 116 | 67469 |

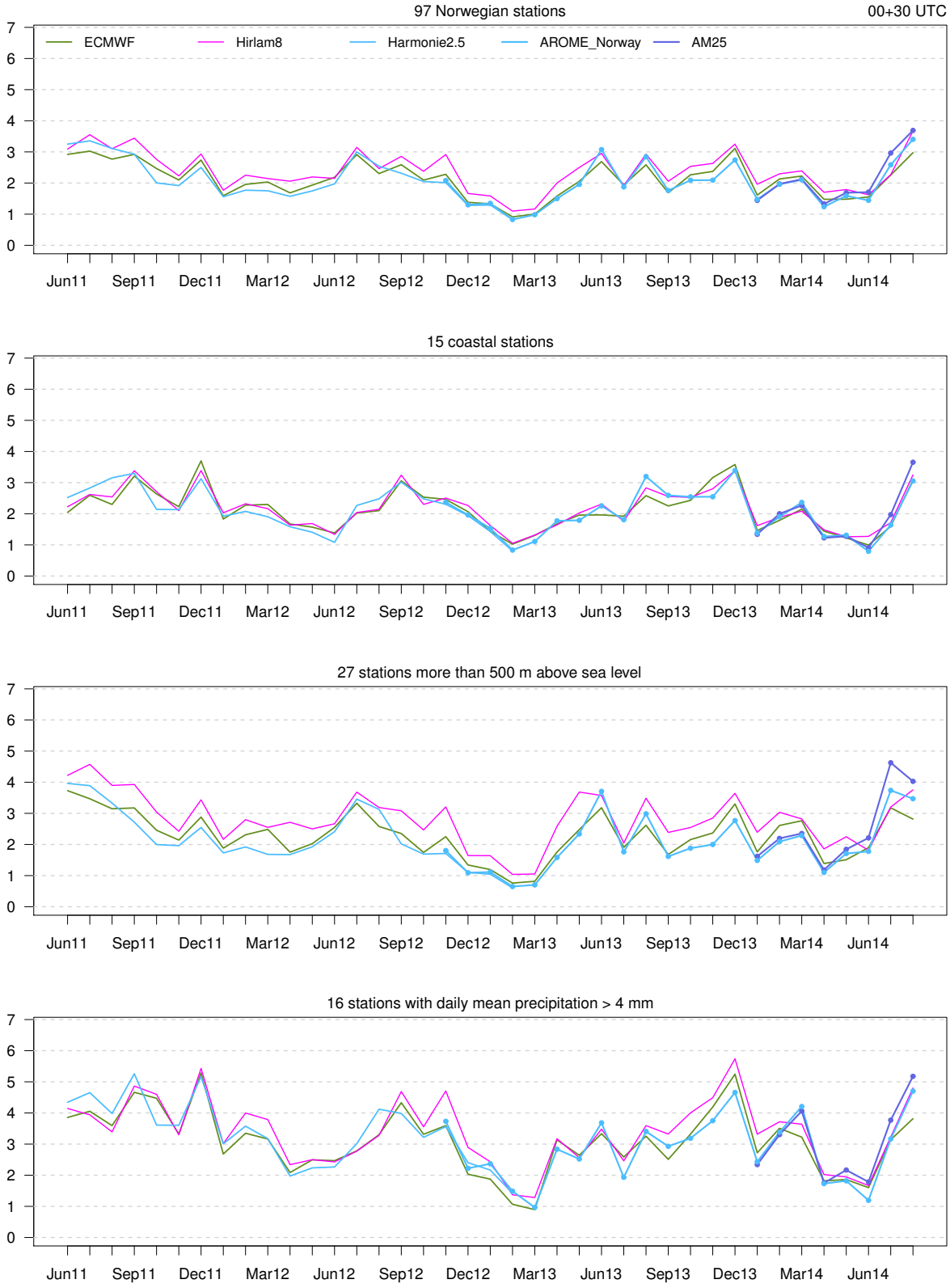
## Mean Error


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
Jun11
Sep11
Dec11
Mar12
Jun12
Sep12
Dec12
Mar13
Jun13
Sep13
Dec13
Mar14
Jun14

Standard Deviation of Error

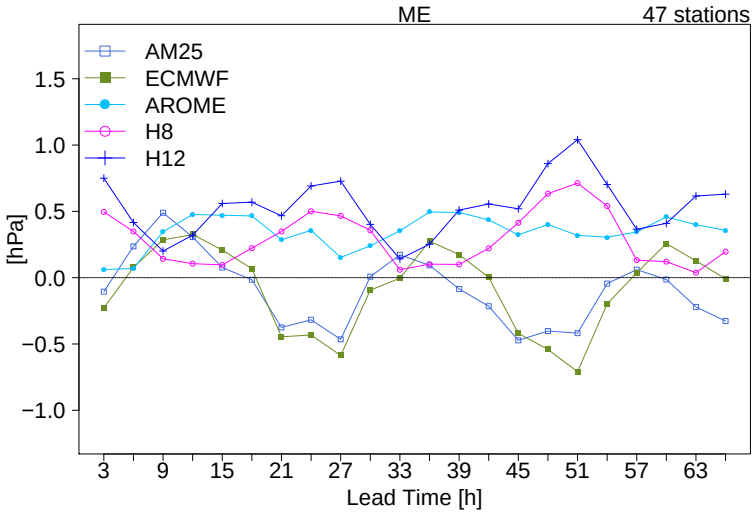


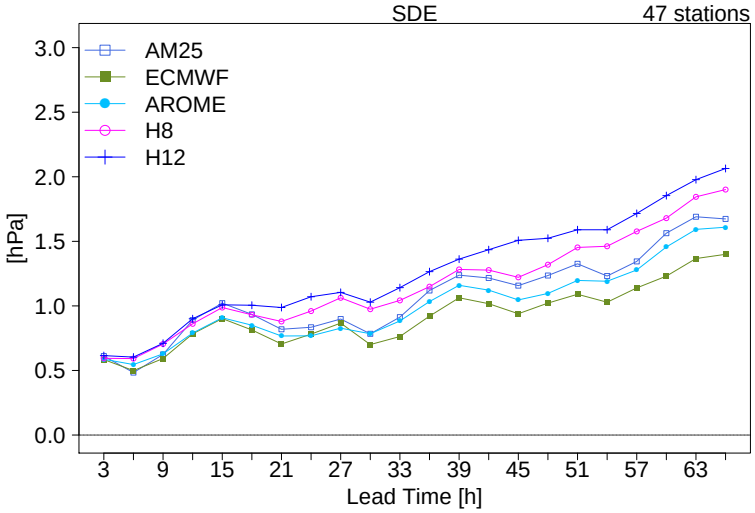
Mean Absolute Error

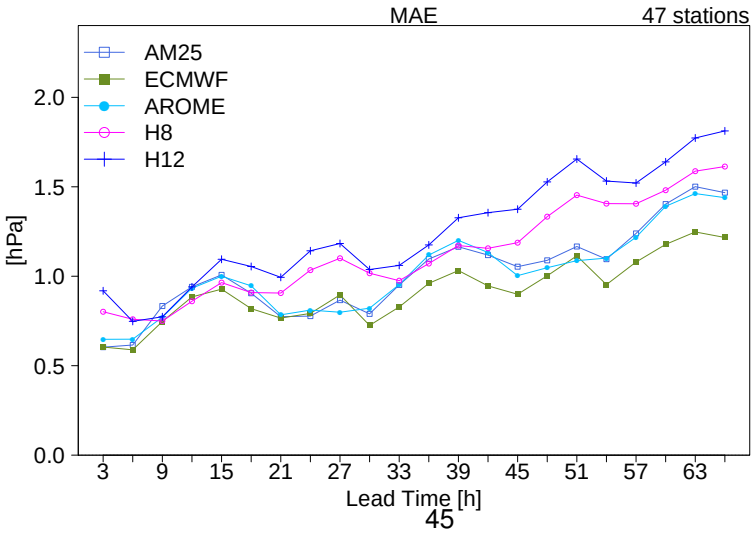


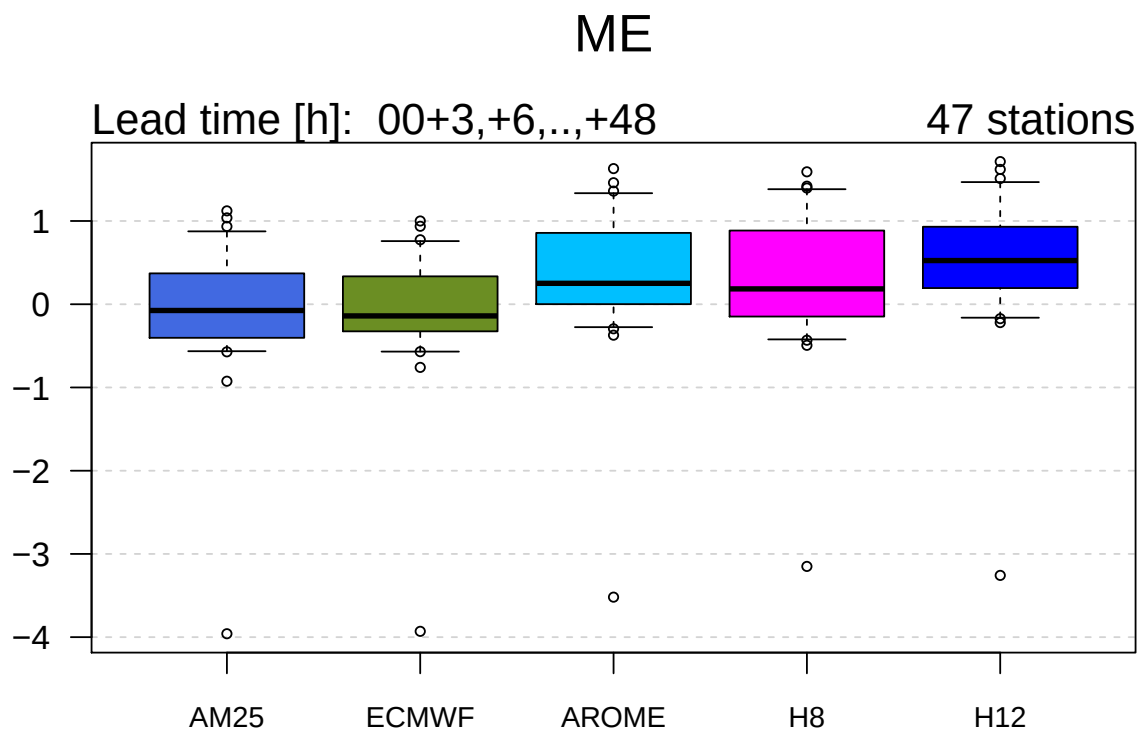
# 5 Eastern Norway

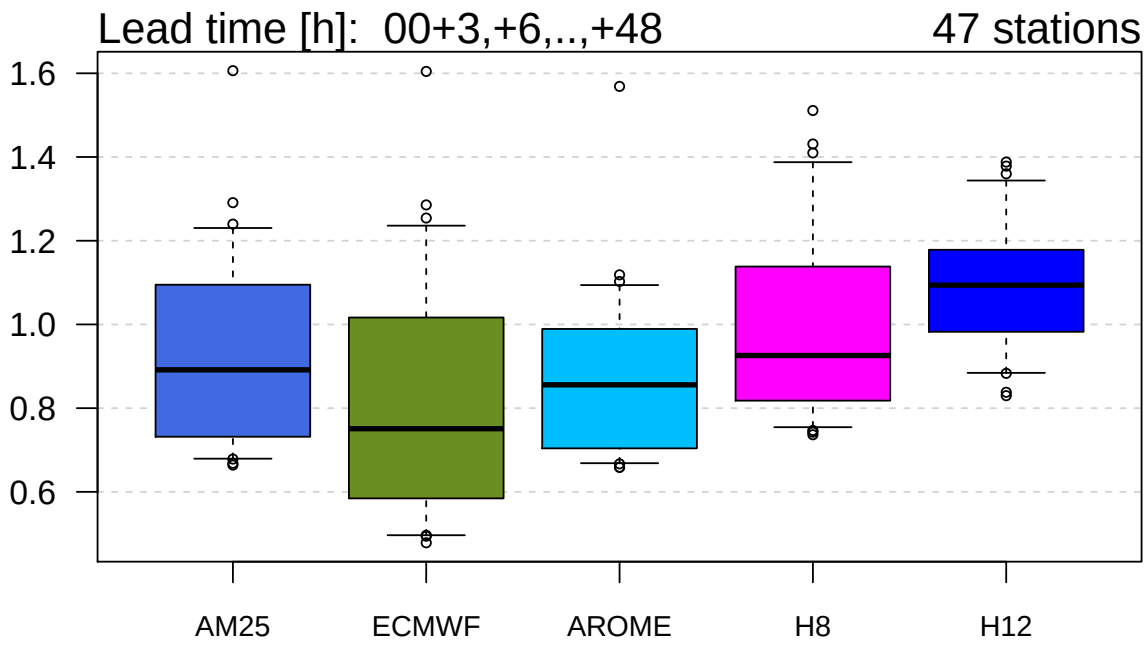
## 5.1 Pressure



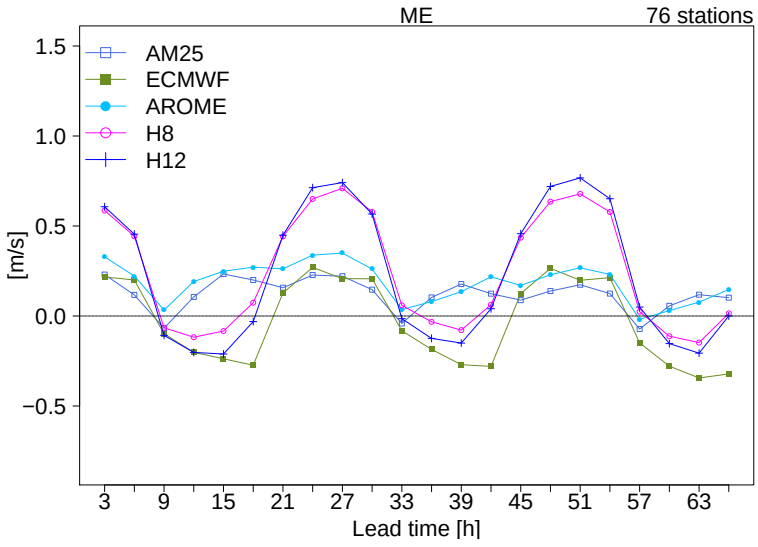



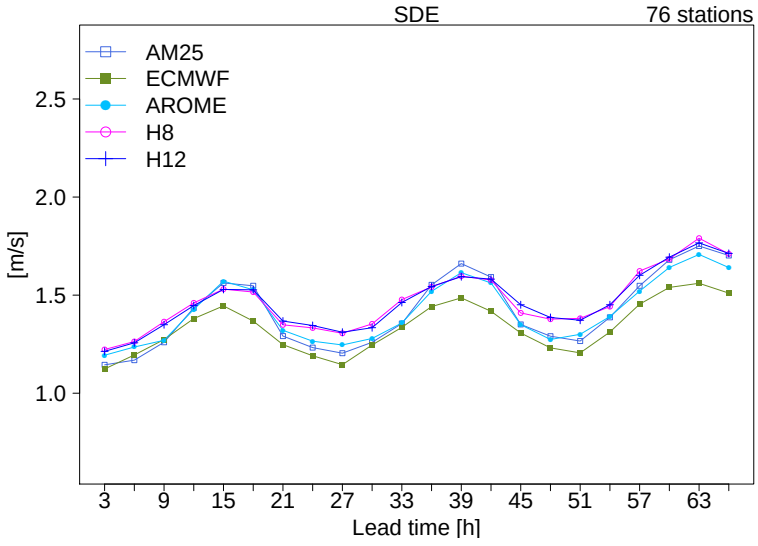



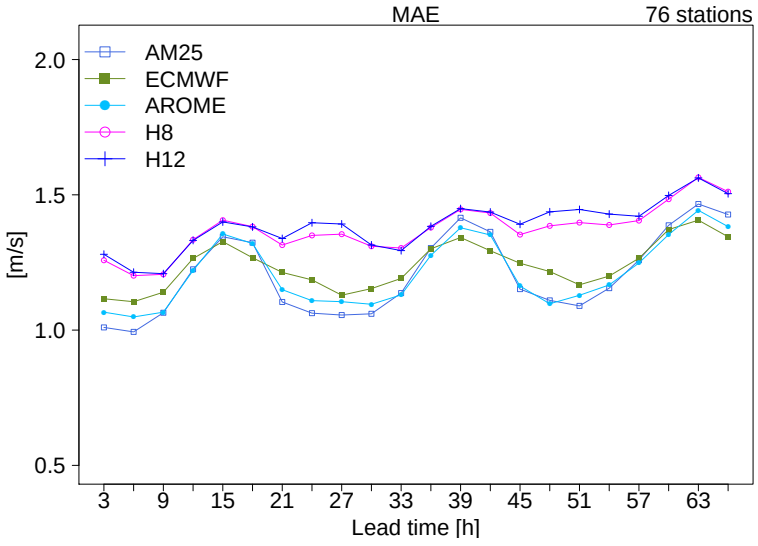

ME
Lead time [h]: 00+3,+6,..,+48
47 stations
1
0
−1
−2
−3
−4
AM25
ECMWF
AROME
H8
H12

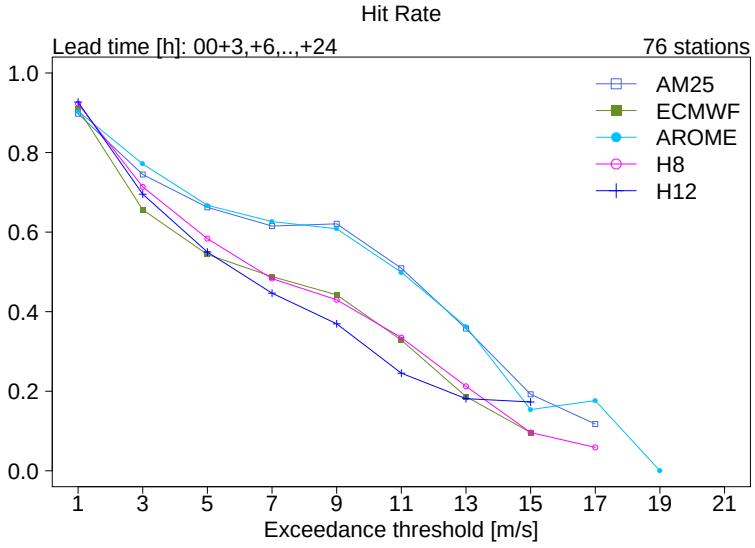

SDE
Lead time [h]: 00+3,+6,..,+48
47 stations
1.6
1.4
1.2
1.0
0.8
0.6
AM25
ECMWF
AROME
H8
H12

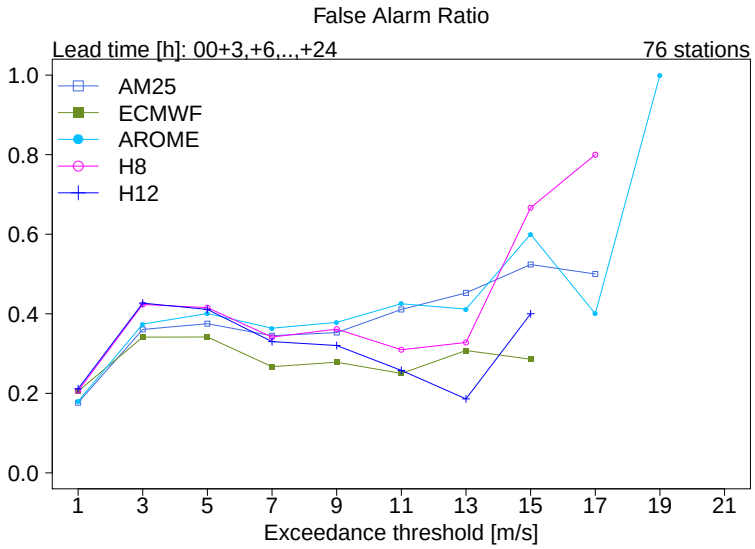
## 5.2 Wind Speed 10m

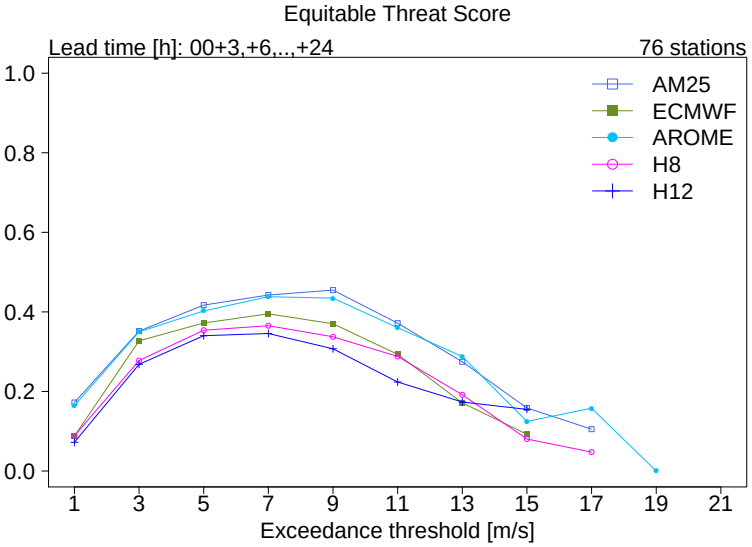


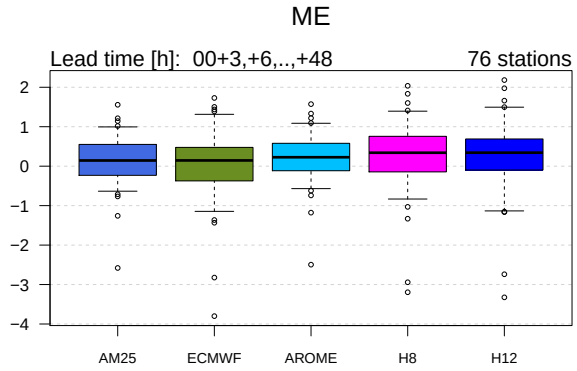



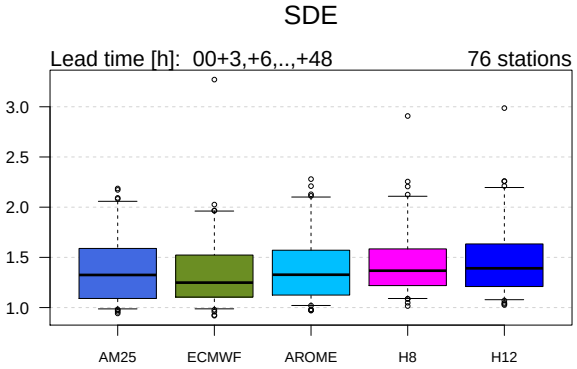




Hit Rate
Lead time [h]: 00+3,+6,..,+24
76 stations
AM25
ECMWF
AROME
H8
H12
1.0
0.8
0.6
0.4
0.2
0.0
1 3 5 7 9 11 13 15 17 19 21
Exceedance threshold [m/s]


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


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




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

**AM25** — **OBS**

| | [0,3] | (3,11] | (11,17] | (17,21] | (21,Inf] | Sum |
|---|---|---|---|---|---|---|
| [0,3] | 52401 | 8424 | 5 | 0 | 0 | 60830 |
| (3,11] | 13212 | 21782 | 490 | 4 | 1 | 35489 |
| (11,17] | 5 | 338 | 461 | 21 | 6 | 831 |
| (17,21] | 0 | 0 | 3 | 1 | 1 | 5 |
| (21,Inf] | 0 | 0 | 0 | 0 | 0 | 0 |
| Sum | 65618 | 30544 | 959 | 26 | 8 | 97155 |

**H8** — **OBS**

| | [0,3] | (3,11] | (11,17] | (17,21] | (21,Inf] | Sum |
|---|---|---|---|---|---|---|
| [0,3] | 48163 | 9085 | 23 | 1 | 0 | 57272 |
| (3,11] | 17453 | 21308 | 624 | 16 | 6 | 39407 |
| (11,17] | 2 | 150 | 308 | 9 | 1 | 470 |
| (17,21] | 0 | 1 | 4 | 0 | 1 | 6 |
| (21,Inf] | 0 | 0 | 0 | 0 | 0 | 0 |
| Sum | 65618 | 30544 | 959 | 26 | 8 | 97155 |

**ECMWF** — **OBS**

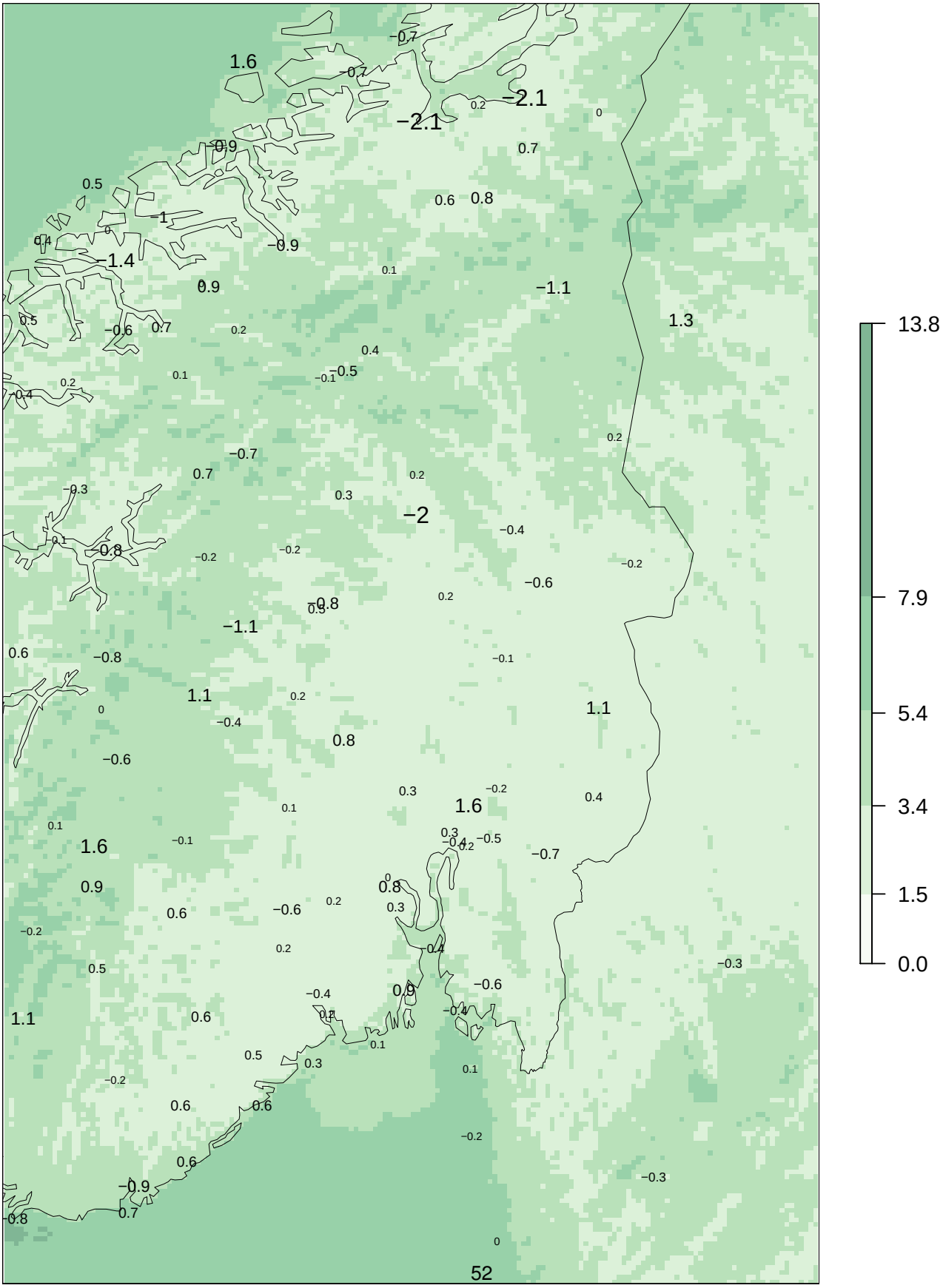
| | [0,3] | (3,11] | (11,17] | (17,21] | (21,Inf] | Sum |
|---|---|---|---|---|---|---|
| [0,3] | 54780 | 10969 | 98 | 10 | 2 | 65859 |
| (3,11] | 10838 | 19450 | 555 | 5 | 2 | 30850 |
| (11,17] | 0 | 125 | 306 | 11 | 4 | 446 |
| (17,21] | 0 | 0 | 0 | 0 | 0 | 0 |
| (21,Inf] | 0 | 0 | 0 | 0 | 0 | 0 |
| Sum | 65618 | 30544 | 959 | 26 | 8 | 97155 |

**AROME** — **OBS**

| | [0,3] | (3,11] | (11,17] | (17,21] | (21,Inf] | Sum |
|---|---|---|---|---|---|---|
| [0,3] | 51276 | 7605 | 7 | 0 | 0 | 58888 |
| (3,11] | 14337 | 22597 | 504 | 6 | 2 | 37446 |
| (11,17] | 5 | 342 | 446 | 19 | 4 | 816 |
| (17,21] | 0 | 0 | 2 | 1 | 2 | 5 |
| (21,Inf] | 0 | 0 | 0 | 0 | 0 | 0 |
| Sum | 65618 | 30544 | 959 | 26 | 8 | 97155 |

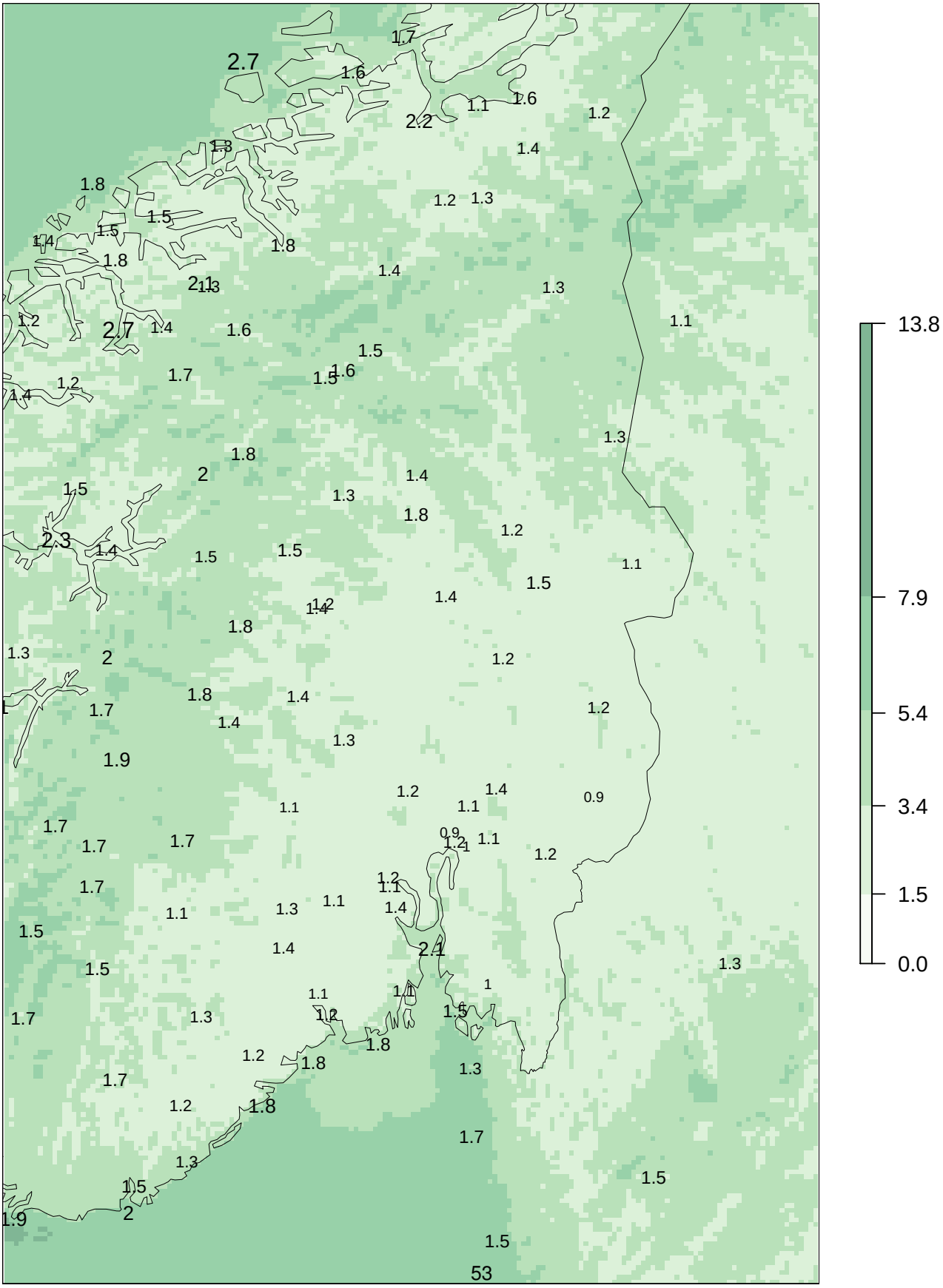
# AM25 00+12

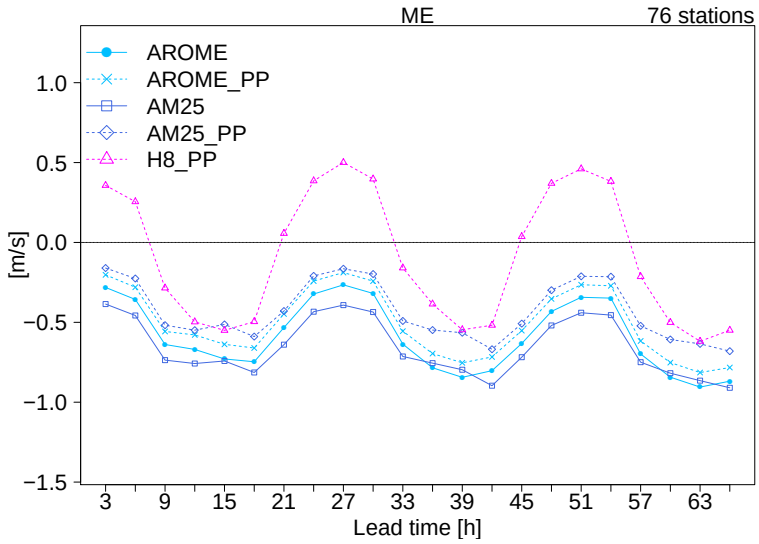
ME at observing sites forecast means 01.06.2014 − 31.08.2014

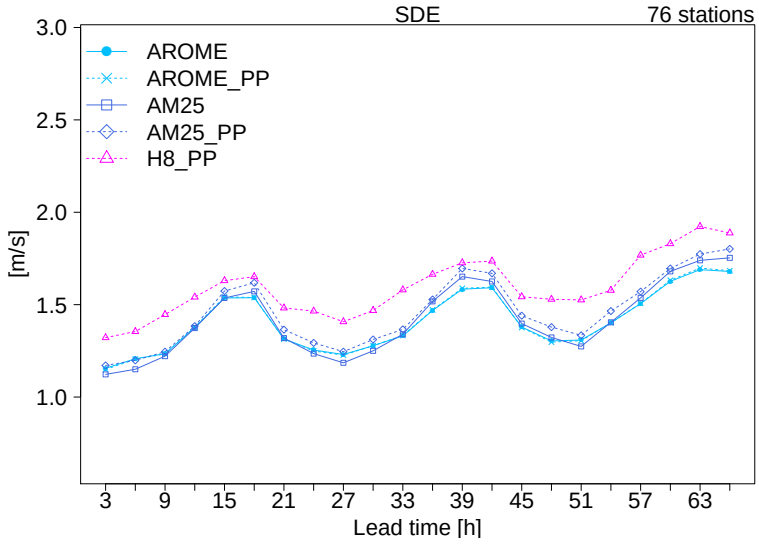


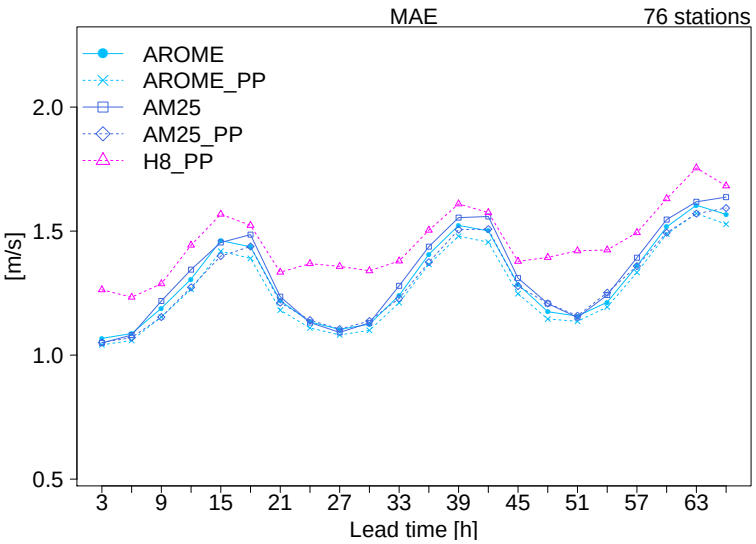
# AM25 00+12

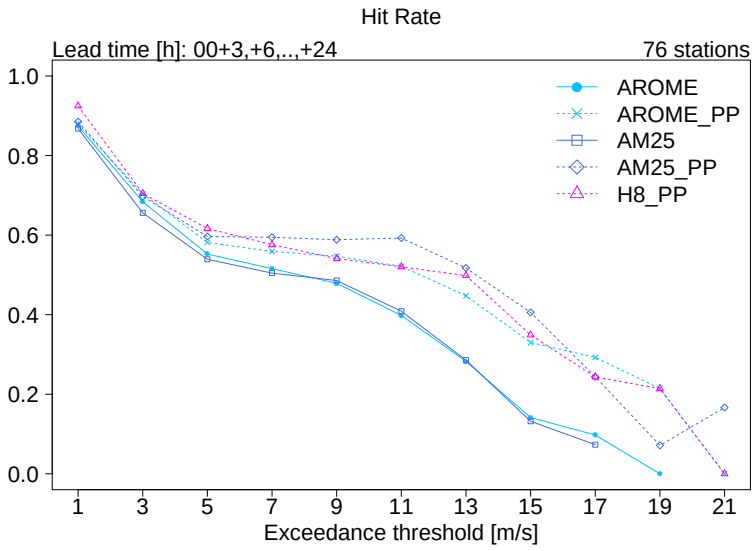
SDE at observing sites forecast means 01.06.2014 − 31.08.2014

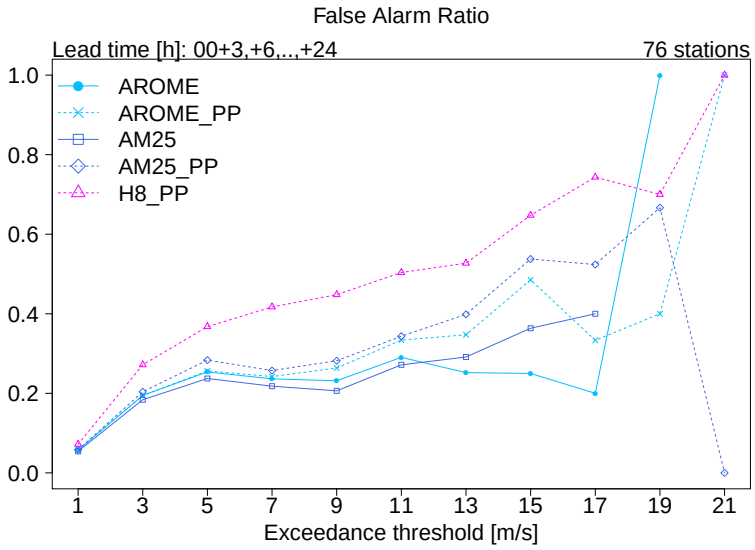


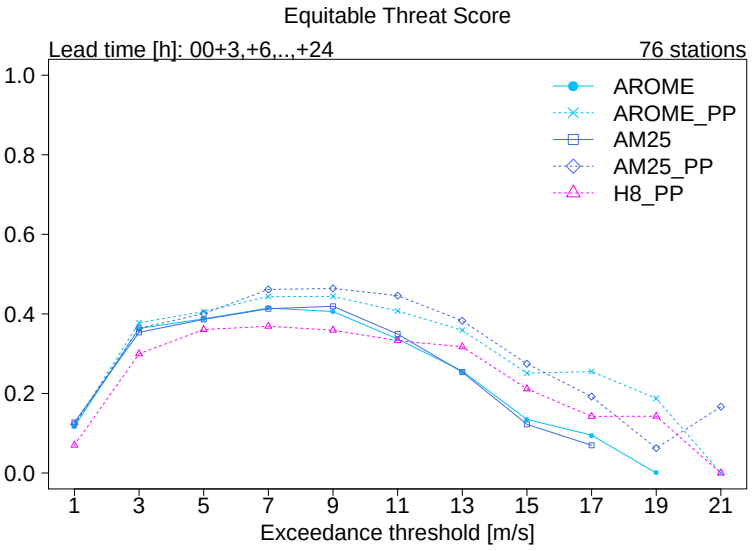

ME
76 stations
AROME
AROME_PP
AM25
AM25_PP
H8_PP
[m/s]
1.0
0.5
0.0
−0.5
−1.0
−1.5
3
9
15
21
27
33
39
45
51
57
63
Lead time [h]

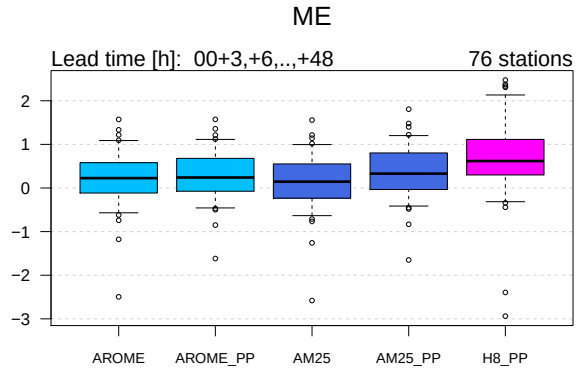

SDE
76 stations
AROME
AROME_PP
AM25
AM25_PP
H8_PP
[m/s]
3.0
2.5
2.0
1.5
1.0
3
9
15
21
27
33
39
45
51
57
63
Lead time [h]

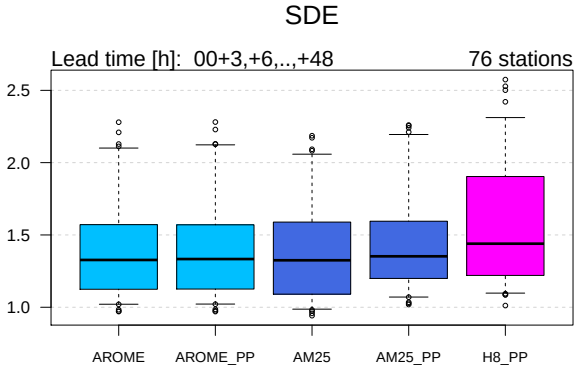

MAE
76 stations
AROME
AROME_PP
AM25
AM25_PP
H8_PP
[m/s]
2.0
1.5
1.0
0.5
3
9
15
21
27
33
39
45
51
57
63
Lead time [h]


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


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


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




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

**AM25** vs **OBS**

| | [0,3] | (3,11] | (11,17] | (17,21] | (21,Inf] | Sum |
|---|---|---|---|---|---|---|
| [0,3] | 40344 | 15443 | 22 | 0 | 0 | 55809 |
| (3,11] | 6557 | 26229 | 886 | 12 | 2 | 33686 |
| (11,17] | 2 | 221 | 542 | 56 | 9 | 830 |
| (17,21] | 0 | 0 | 2 | 3 | 1 | 6 |
| (21,Inf] | 0 | 0 | 0 | 0 | 0 | 0 |
| Sum | 46903 | 41893 | 1452 | 71 | 12 | 90331 |

**AM25_PP** vs **OBS**

| | [0,3] | (3,11] | (11,17] | (17,21] | (21,Inf] | Sum |
|---|---|---|---|---|---|---|
| [0,3] | 38959 | 13563 | 12 | 0 | 0 | 52534 |
| (3,11] | 7939 | 27849 | 658 | 8 | 1 | 36455 |
| (11,17] | 5 | 479 | 763 | 51 | 7 | 1305 |
| (17,21] | 0 | 2 | 19 | 11 | 3 | 35 |
| (21,Inf] | 0 | 0 | 0 | 1 | 1 | 2 |
| Sum | 46903 | 41893 | 1452 | 71 | 12 | 90331 |

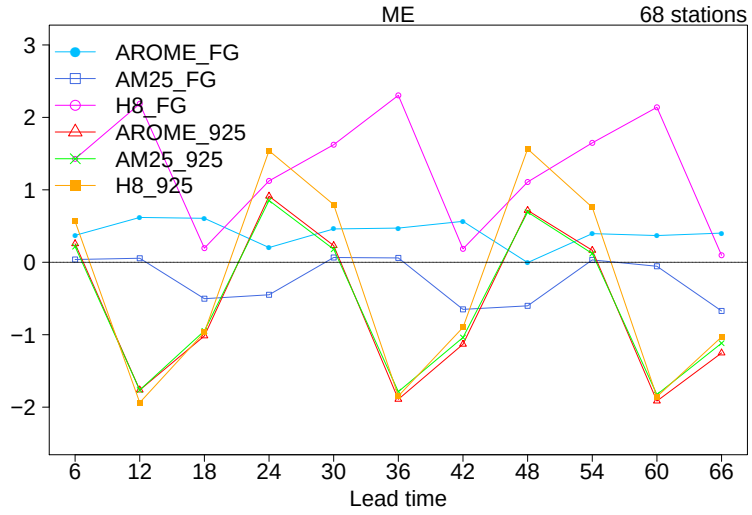
**AROME** vs **OBS**

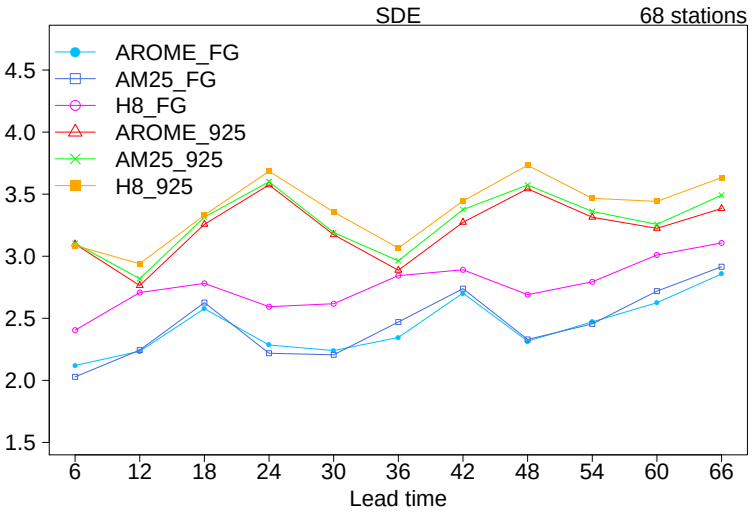
| | [0,3] | (3,11] | (11,17] | (17,21] | (21,Inf] | Sum |
|---|---|---|---|---|---|---|
| [0,3] | 39673 | 14308 | 19 | 0 | 0 | 54000 |
| (3,11] | 7227 | 27352 | 914 | 15 | 3 | 35511 |
| (11,17] | 3 | 233 | 518 | 54 | 7 | 815 |
| (17,21] | 0 | 0 | 1 | 2 | 2 | 5 |
| (21,Inf] | 0 | 0 | 0 | 0 | 0 | 0 |
| Sum | 46903 | 41893 | 1452 | 71 | 12 | 90331 |

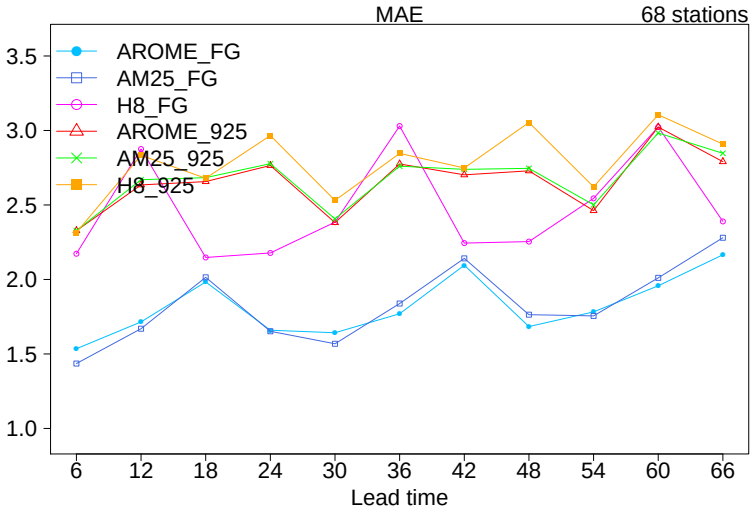
**AROME_PP** vs **OBS**

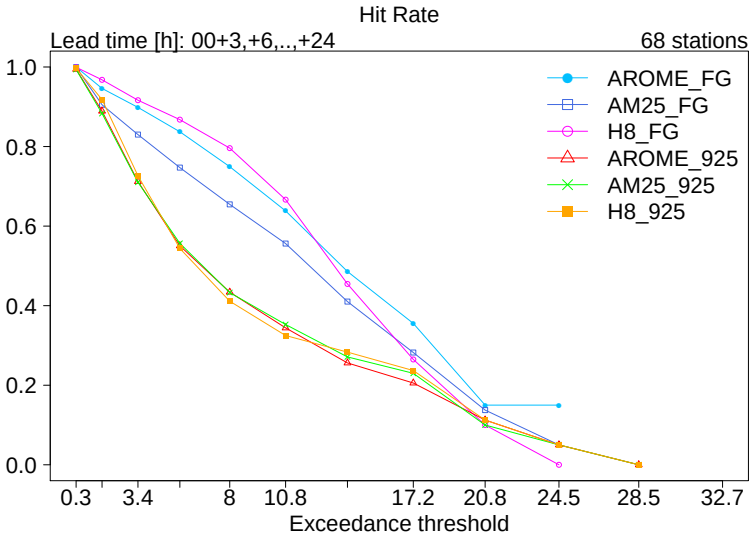
| | [0,3] | (3,11] | (11,17] | (17,21] | (21,Inf] | Sum |
|---|---|---|---|---|---|---|
| [0,3] | 39448 | 13444 | 13 | 0 | 0 | 52905 |
| (3,11] | 7452 | 28075 | 755 | 13 | 1 | 36296 |
| (11,17] | 3 | 372 | 671 | 44 | 8 | 1098 |
| (17,21] | 0 | 2 | 12 | 14 | 3 | 31 |
| (21,Inf] | 0 | 0 | 1 | 0 | 0 | 1 |
| Sum | 46903 | 41893 | 1452 | 71 | 12 | 90331 |

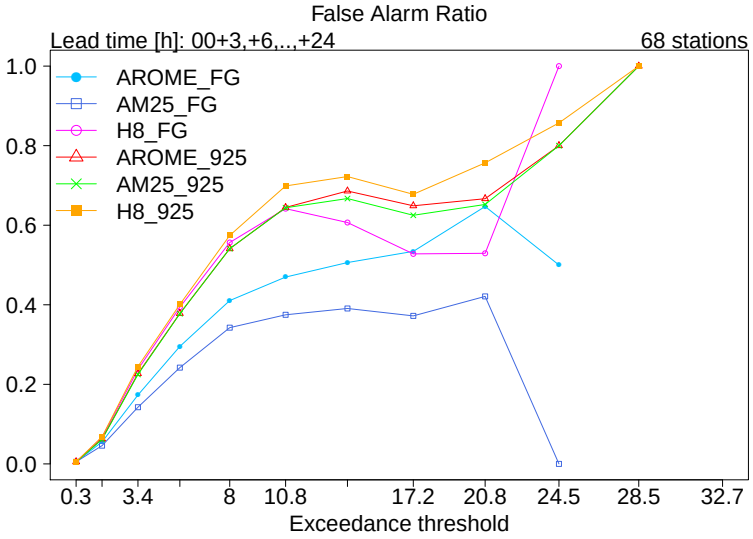
## 5.3 Wind gust

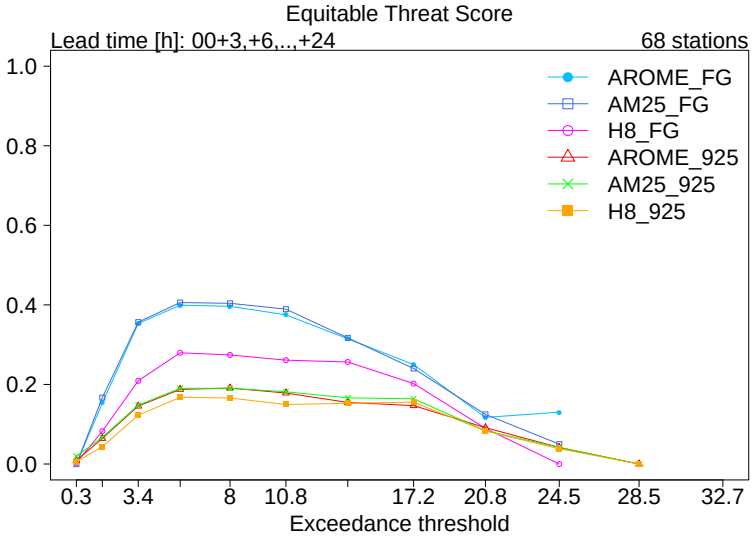

ME
68 stations
AROME_FG
AM25_FG
H8_FG
AROME_925
AM25_925
H8_925
3
2
1
0
−1
−2
6
12
18
24
30
36
42
48
54
60
66
Lead time


SDE
68 stations
AROME_FG
AM25_FG
H8_FG
AROME_925
AM25_925
H8_925
4.5
4.0
3.5
3.0
2.5
2.0
1.5
6
12
18
24
30
36
42
48
54
60
66
Lead time

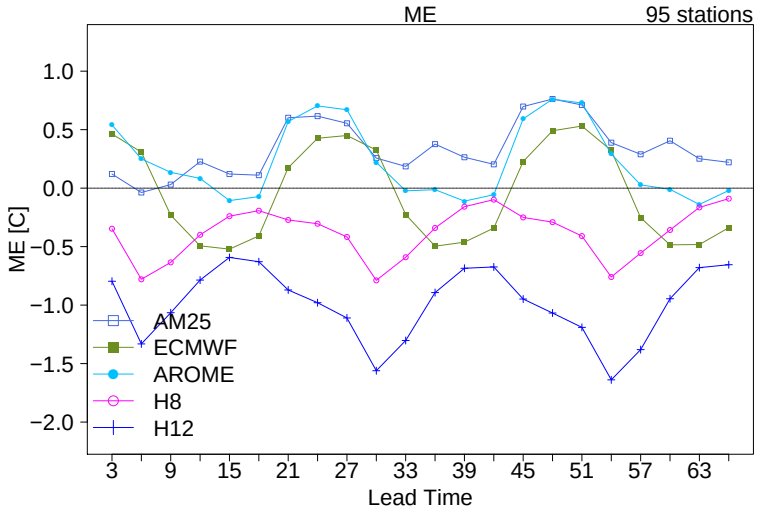

MAE
68 stations
AROME_FG
AM25_FG
H8_FG
AROME_925
AM25_925
H8_925
3.5
3.0
2.5
2.0
1.5
1.0
6
12
18
24
30
36
42
48
54
60
66
Lead time

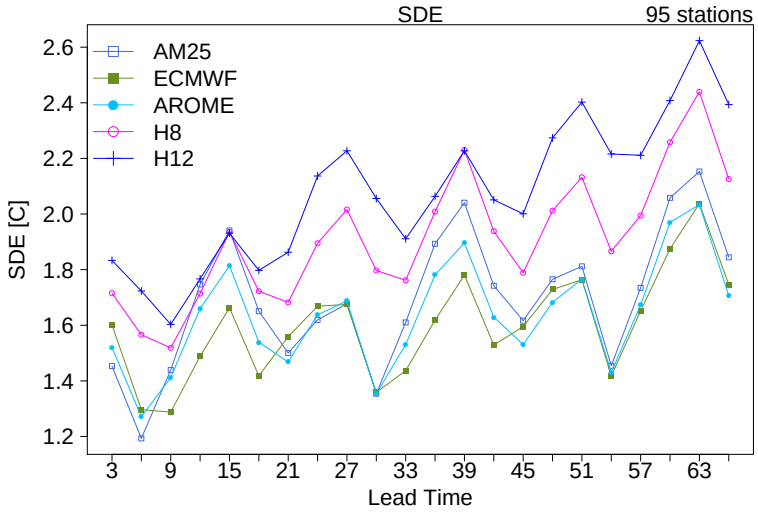

Hit Rate
Lead time [h]: 00+3,+6,..,+24
68 stations
AROME_FG
AM25_FG
H8_FG
AROME_925
AM25_925
H8_925
1.0
0.8
0.6
0.4
0.2
0.0
0.3
3.4
8
10.8
17.2
20.8
24.5
28.5
32.7
Exceedance threshold

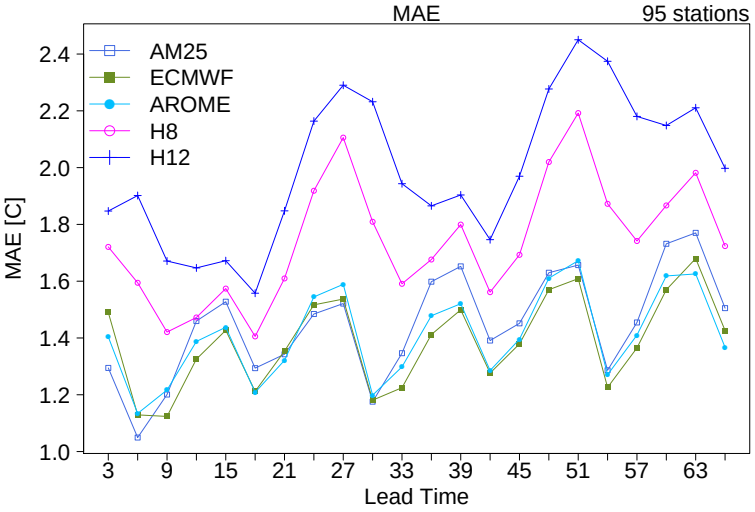

False Alarm Ratio
Lead time [h]: 00+3,+6,..,+24
68 stations
AROME_FG
AM25_FG
H8_FG
AROME_925
AM25_925
H8_925
1.0
0.8
0.6
0.4
0.2
0.0
0.3
3.4
8
10.8
17.2
20.8
24.5
28.5
32.7
Exceedance threshold

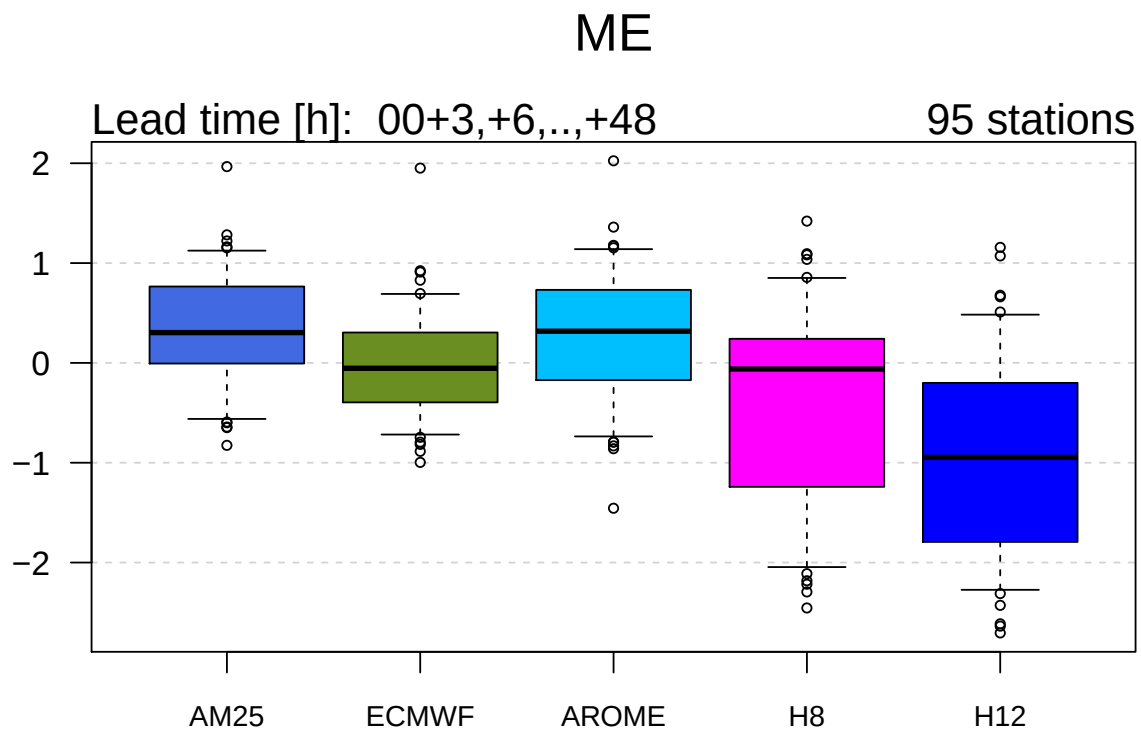

Equitable Threat Score
Lead time [h]: 00+3,+6,..,+24
68 stations
AROME_FG
AM25_FG
H8_FG
AROME_925
AM25_925
H8_925
1.0
0.8
0.6
0.4
0.2
0.0
0.3
3.4
8
10.8
17.2
20.8
24.5
28.5
32.7
Exceedance threshold

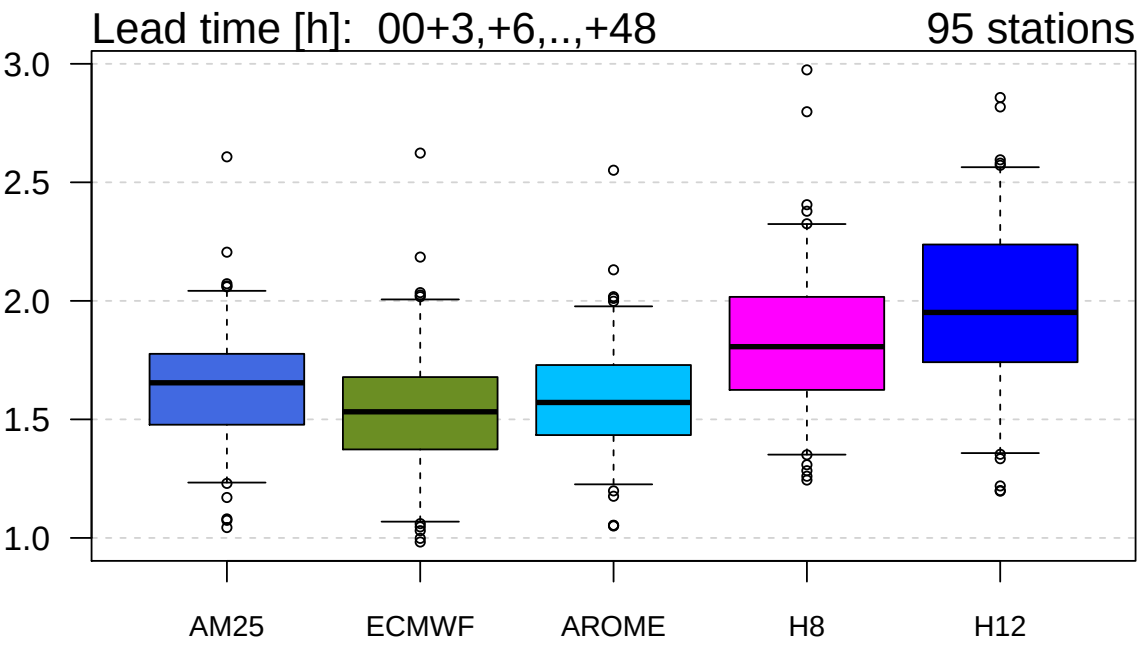
## 5.4 Temperature 2m



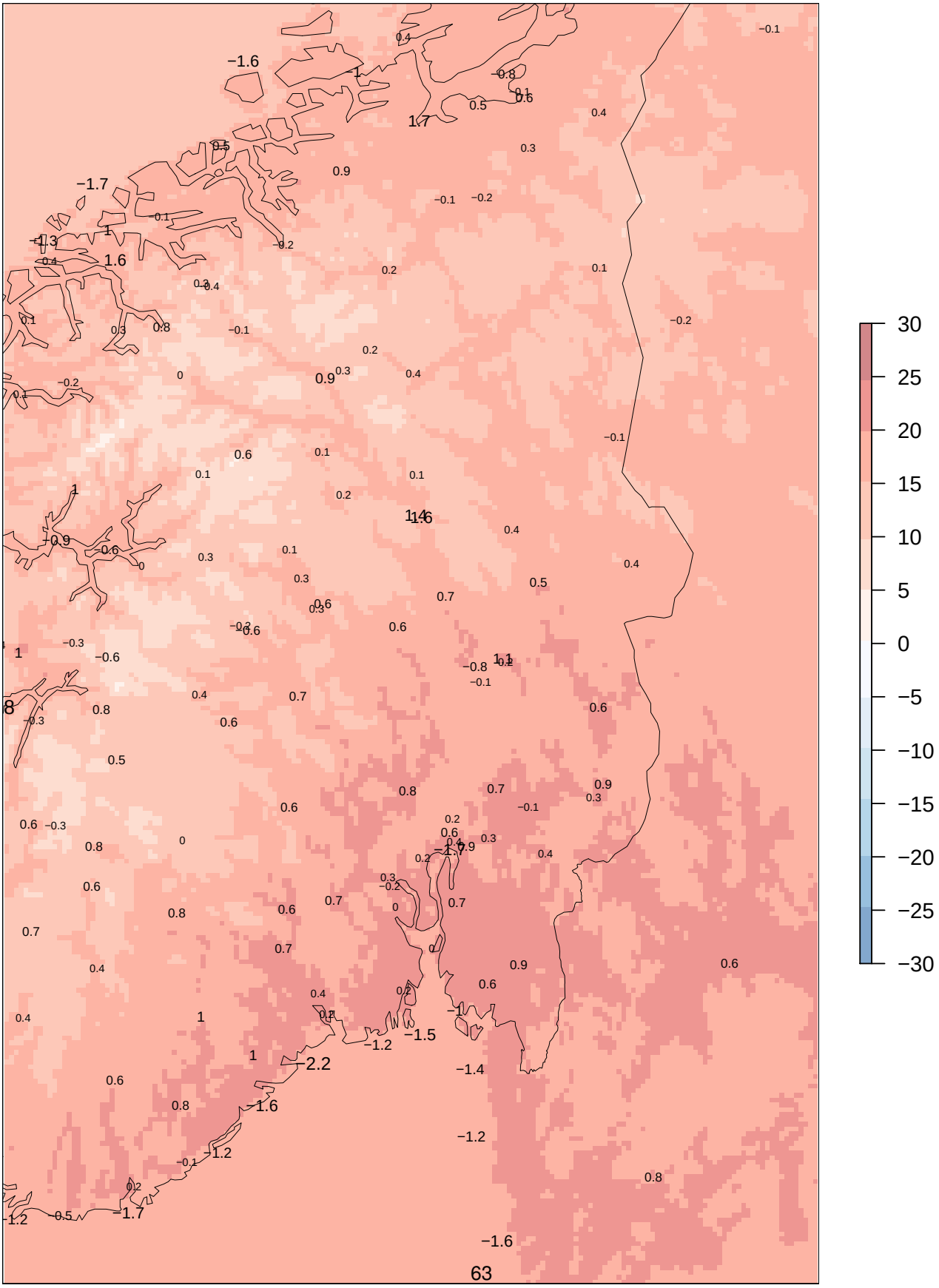




ME
Lead time [h]: 00+3,+6,..,+48
95 stations
2
1
0
−1
−2
AM25
ECMWF
AROME
H8
H12


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

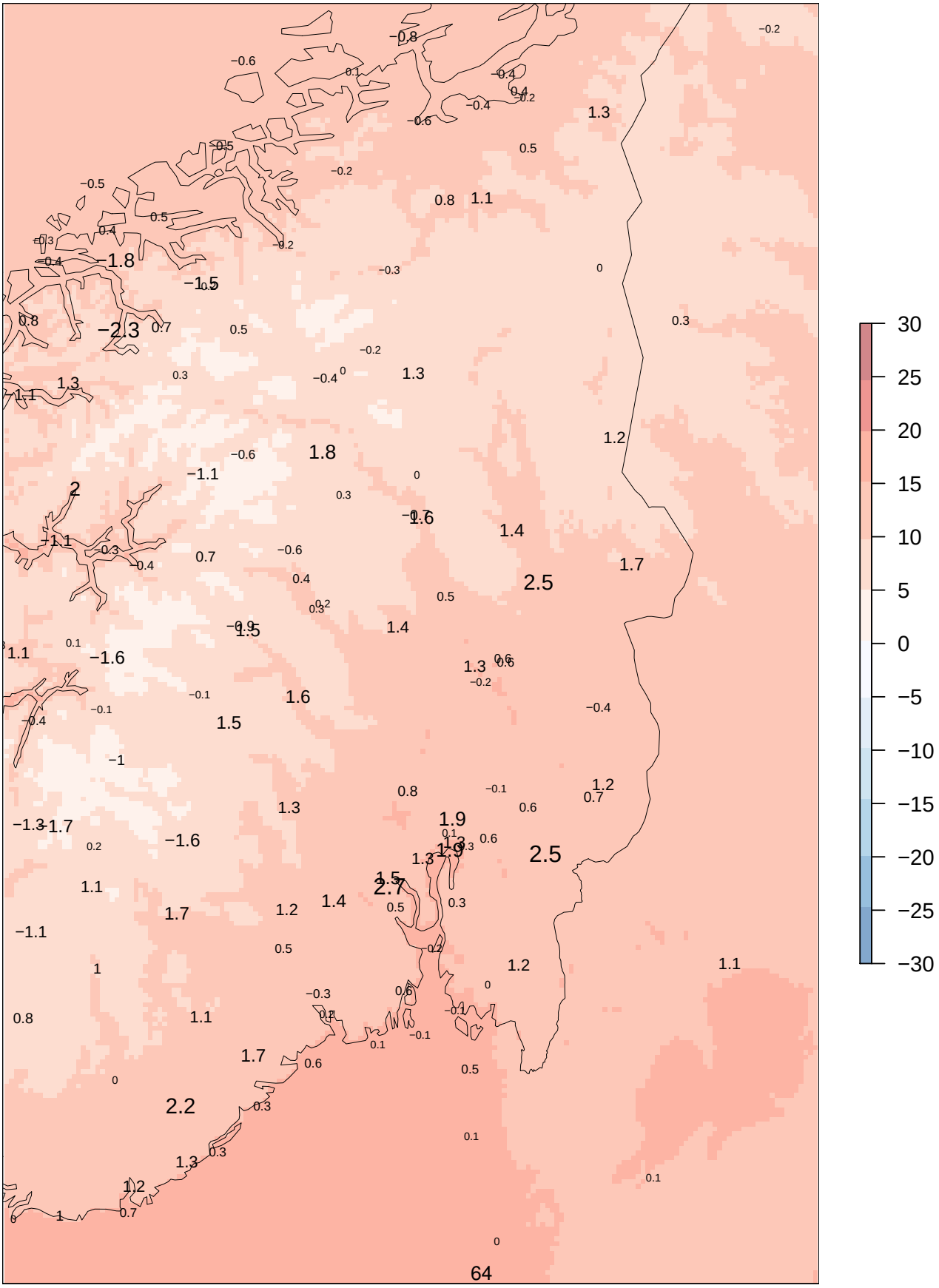
# AM25 00+12

ME at observing sites forecast means 01.06.2014 − 31.08.2014



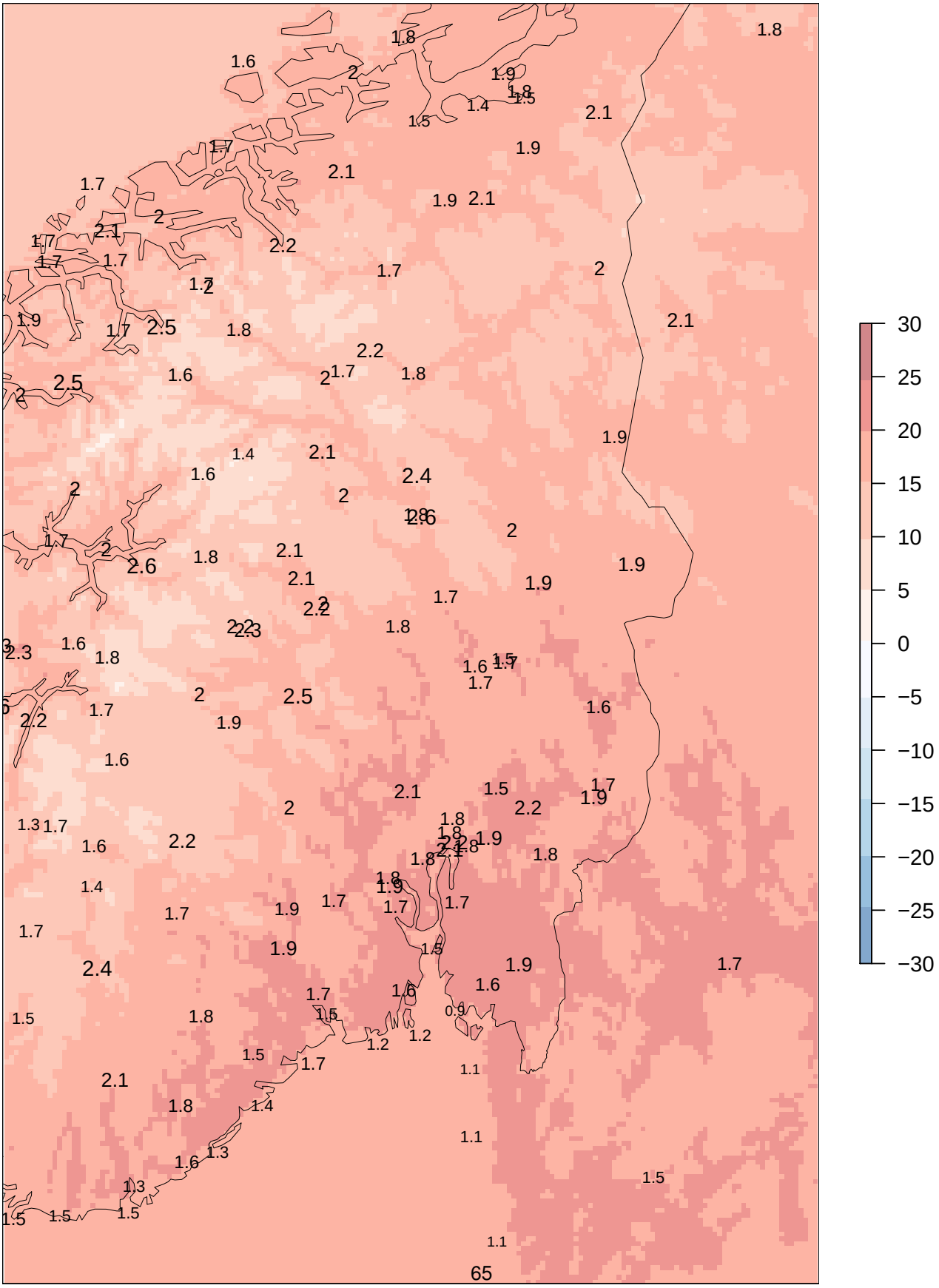
# AM25 00+24

ME at observing sites forecast means 01.06.2014 − 31.08.2014



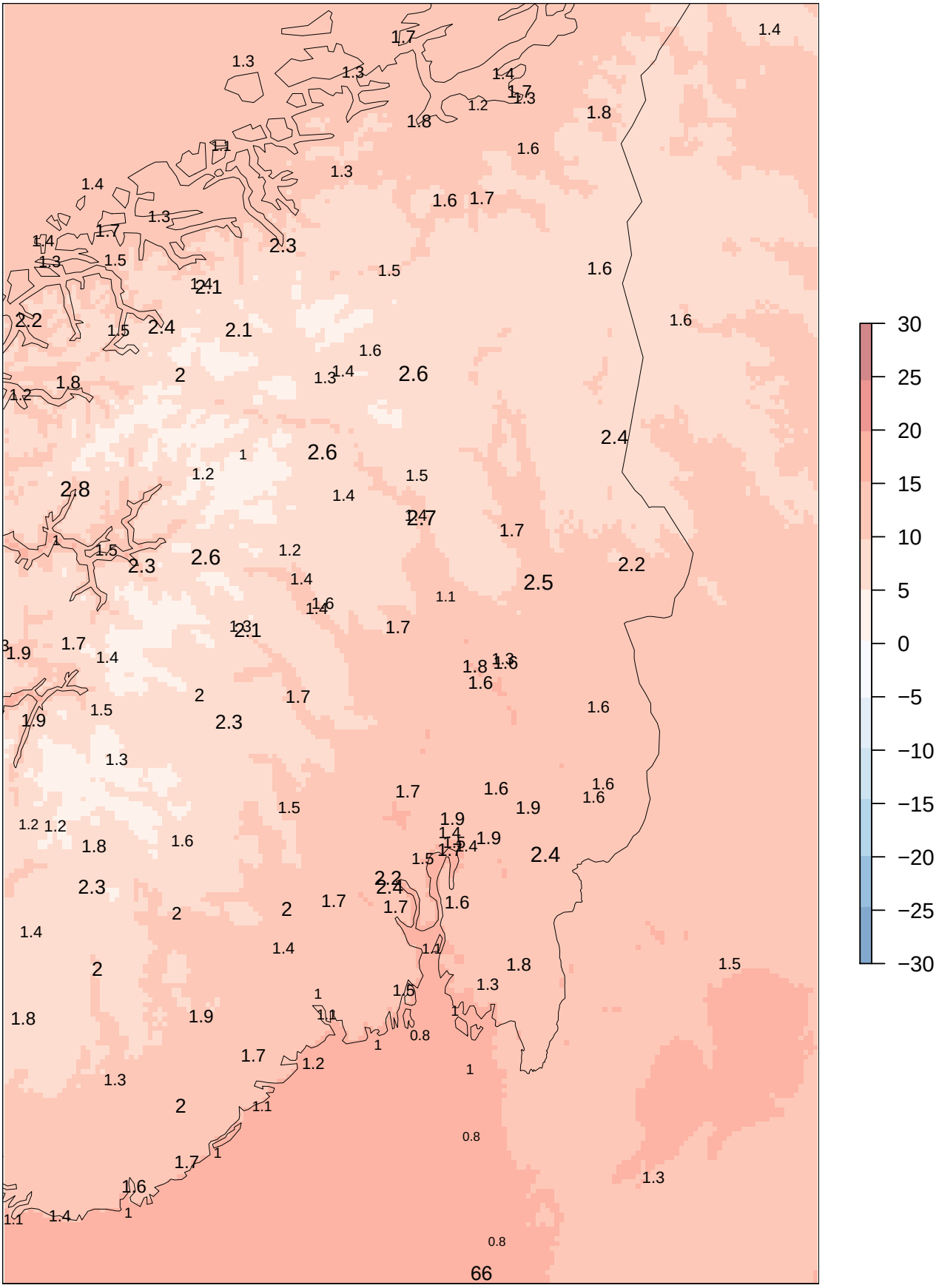
# AM25 00+12

SDE at observing sites forecast means 01.06.2014 − 31.08.2014

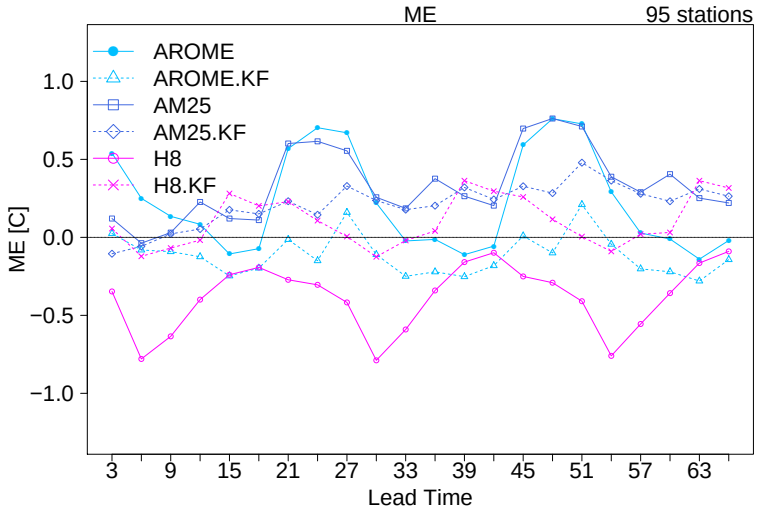


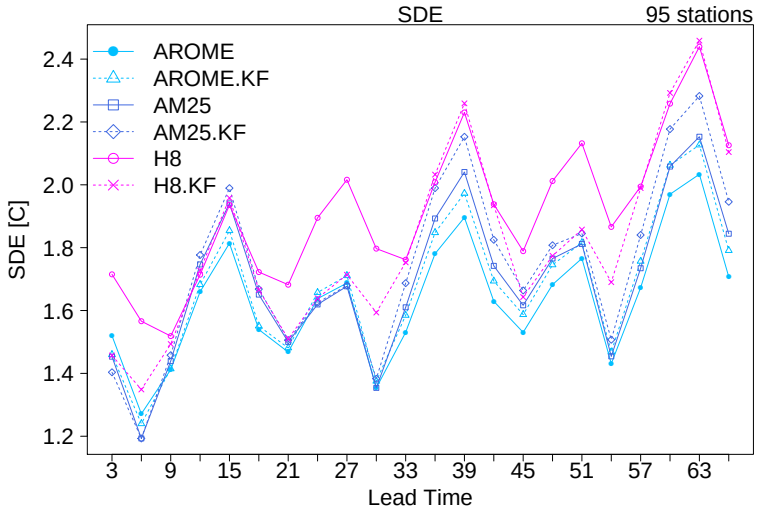
# AM25 00+24

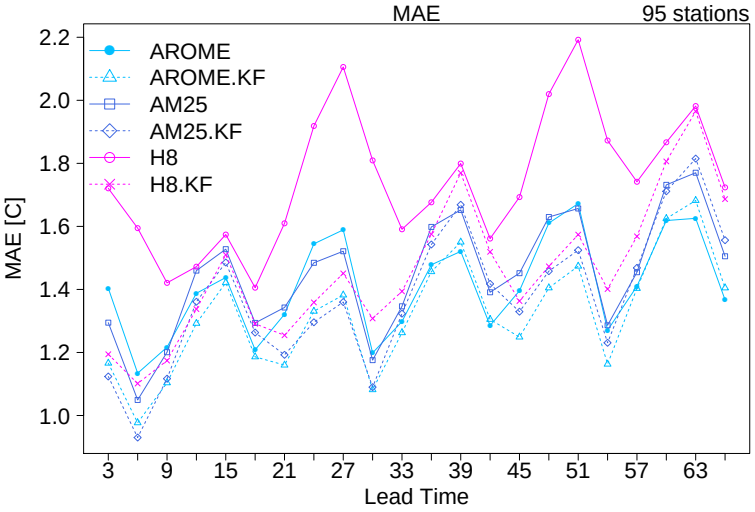
SDE at observing sites forecast means 01.06.2014 − 31.08.2014

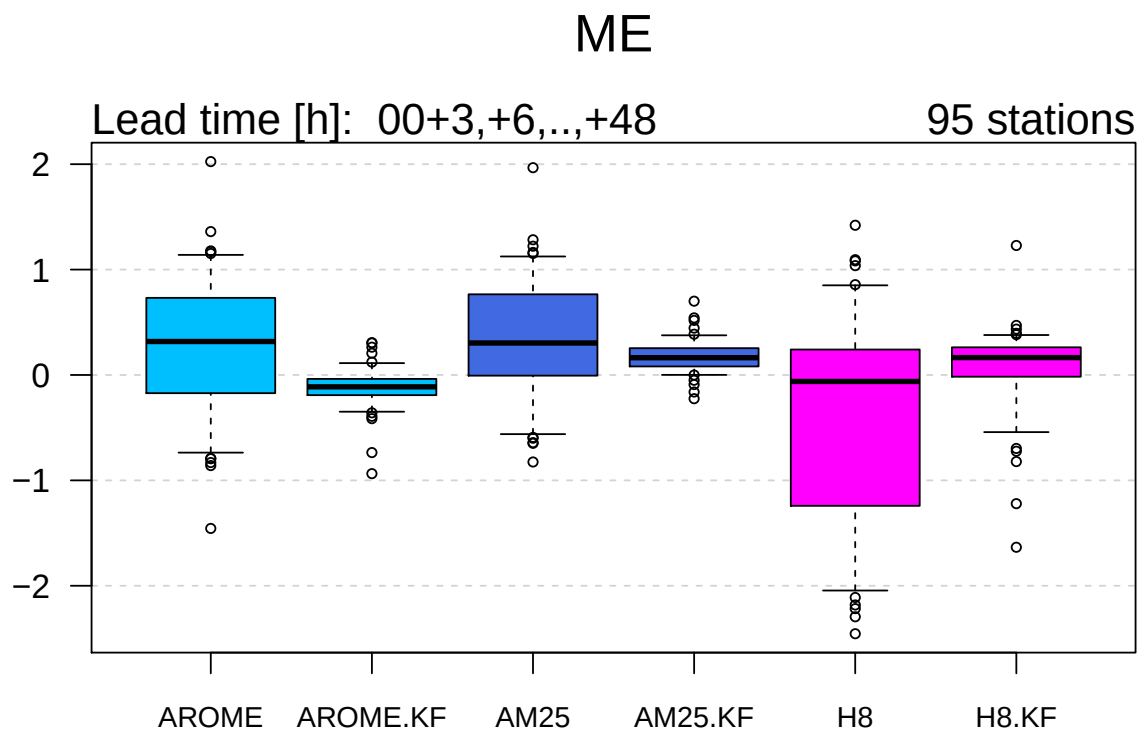


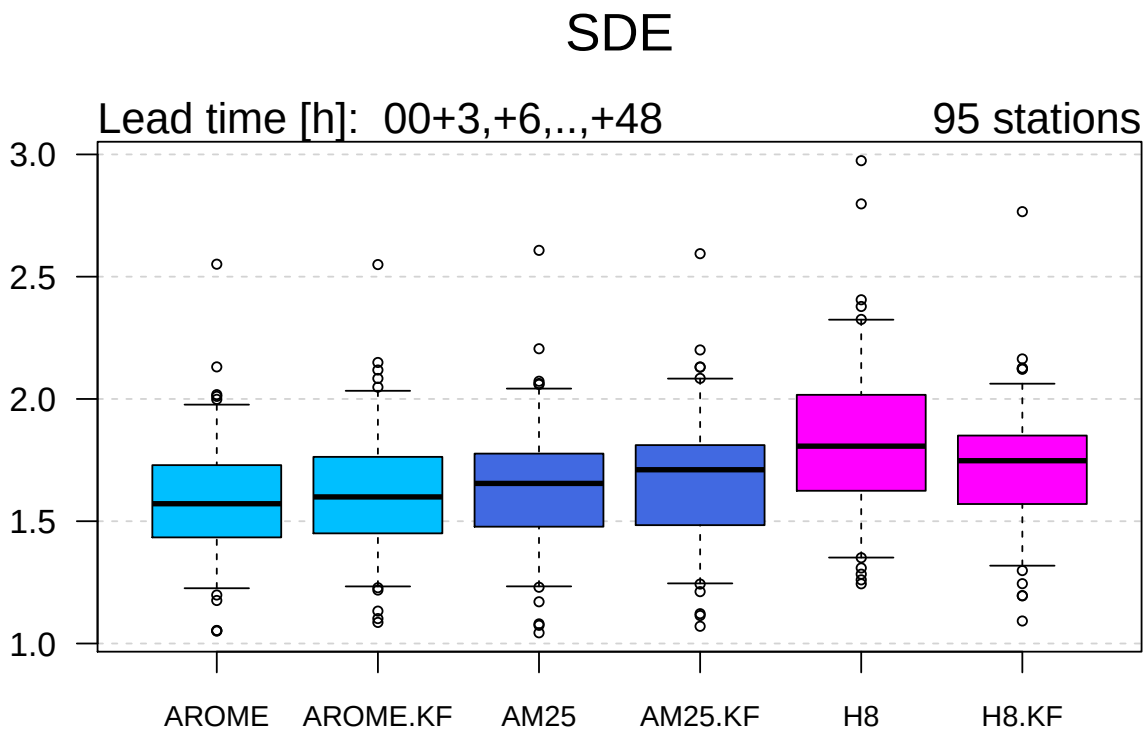
## 5.5 Post processed temperature 2m



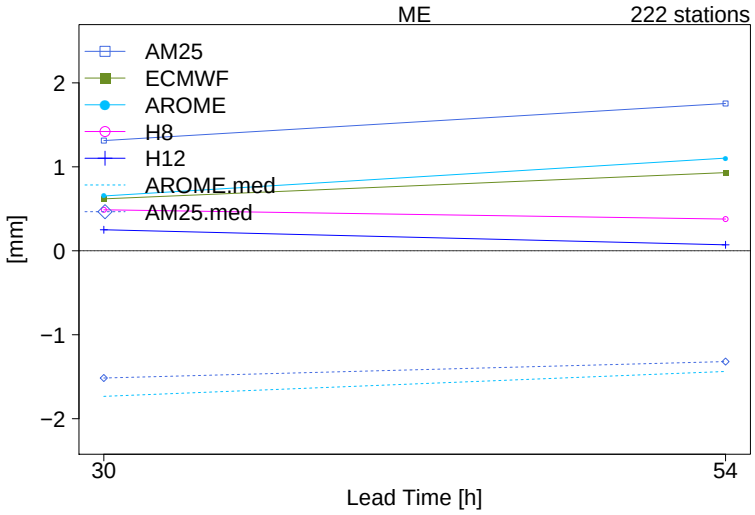



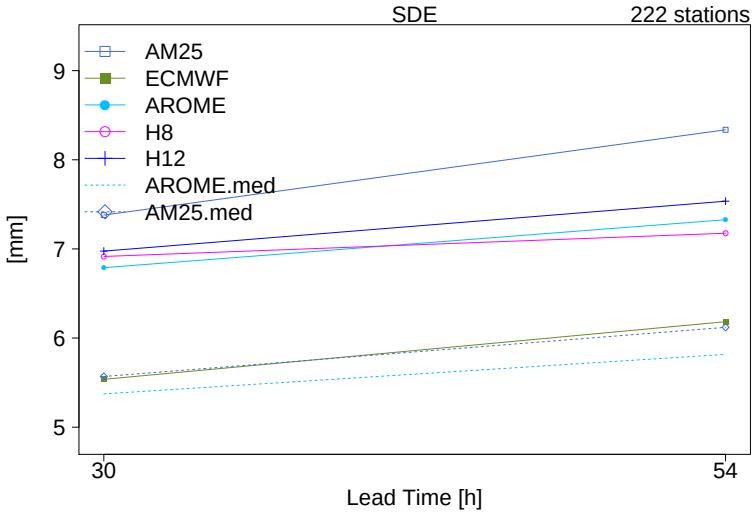



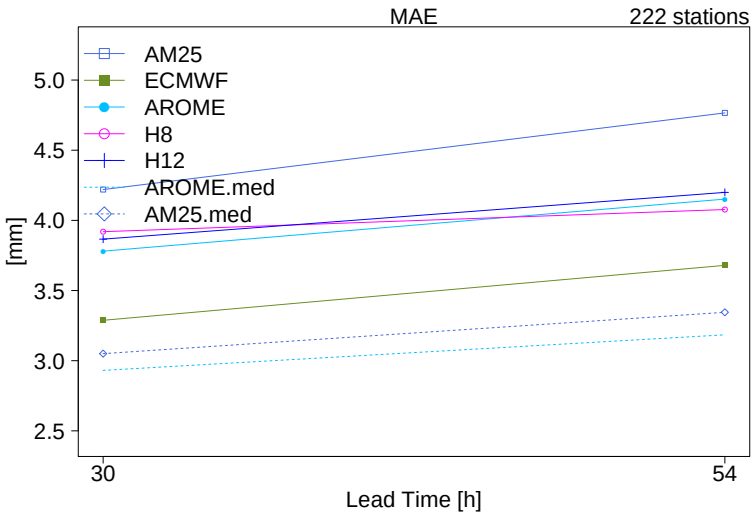

ME
Lead time [h]: 00+3,+6,..,+48
95 stations
2
1
0
−1
−2
AROME
AROME.KF
AM25
AM25.KF
H8
H8.KF

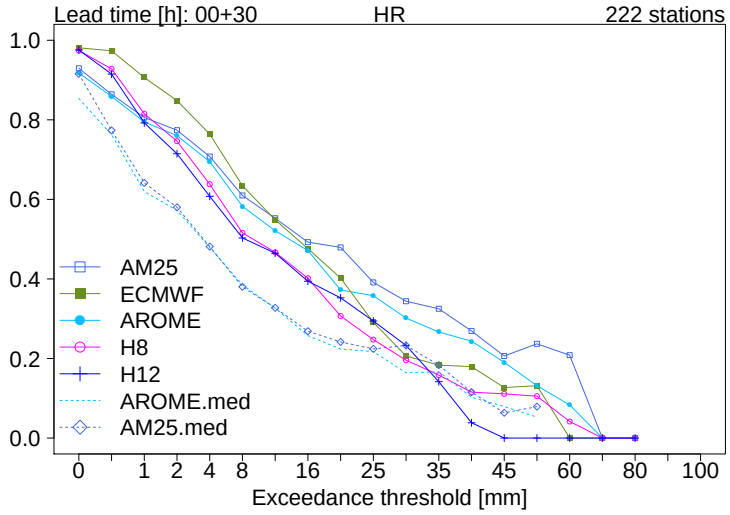

SDE
Lead time [h]: 00+3,+6,..,+48
95 stations
3.0
2.5
2.0
1.5
1.0
AROME
AROME.KF
AM25
AM25.KF
H8
H8.KF

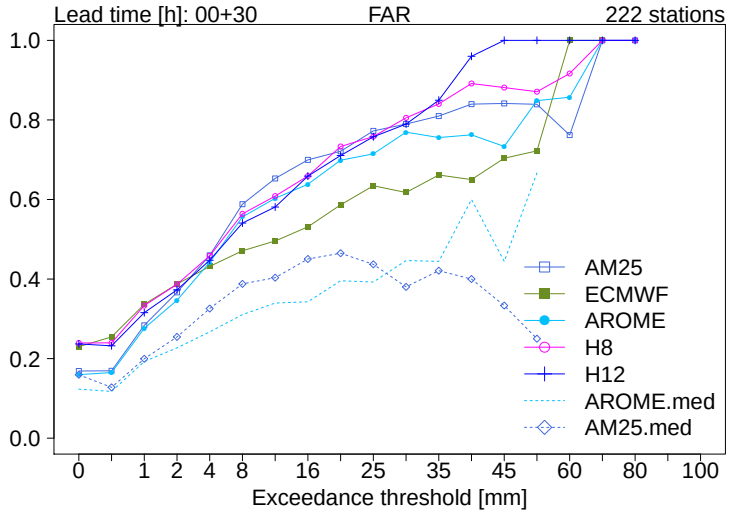
## 5.6 Daily precipitation

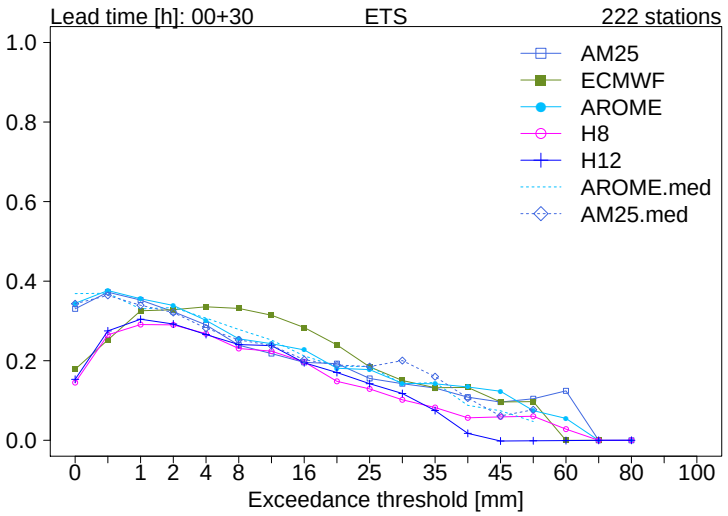


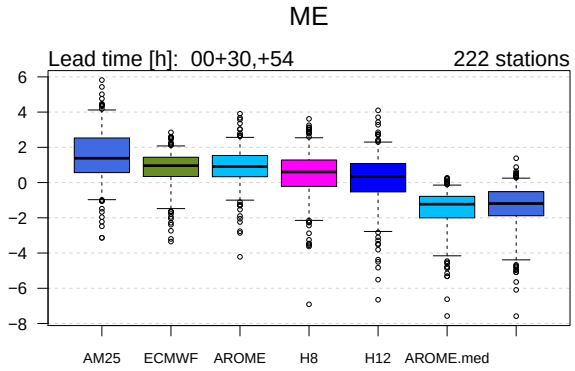



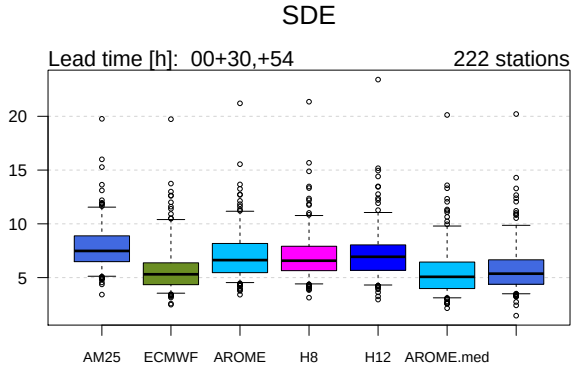




Lead time [h]: 00+30
HR
222 stations
1.0
0.8
0.6
0.4
0.2
0.0
AM25
ECMWF
AROME
H8
H12
AROME.med
AM25.med
0
1
2
4
8
16
25
35
45
60
80
100
Exceedance threshold [mm]


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




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

**AM25**

**OBS**

| | [0,0.1] | (0.1,5] | (5,20] | (20,50] | (50,Inf] | Sum |
|---|---|---|---|---|---|---|
| [0,0.1] | 6826 | 2427 | 285 | 10 | 0 | 9548 |
| (0.1,5] | 2745 | 6097 | 1687 | 127 | 3 | 10659 |
| (5,20] | 564 | 3560 | 2687 | 356 | 28 | 7195 |
| (20,50] | 77 | 455 | 818 | 415 | 37 | 1802 |
| (50,Inf] | 4 | 33 | 41 | 42 | 10 | 130 |
| Sum | 10216 | 12572 | 5518 | 950 | 78 | 29334 |

**AM25.med**

**OBS**

| | [0,0.1] | (0.1,5] | (5,20] | (20,50] | (50,Inf] | Sum |
|---|---|---|---|---|---|---|
| [0,0.1] | 8054 | 3868 | 579 | 31 | 0 | 12532 |
| (0.1,5] | 1965 | 7139 | 2745 | 231 | 15 | 12095 |
| (5,20] | 187 | 1491 | 1979 | 467 | 31 | 4155 |
| (20,50] | 10 | 74 | 215 | 220 | 29 | 548 |
| (50,Inf] | 0 | 0 | 0 | 1 | 3 | 4 |
| Sum | 10216 | 12572 | 5518 | 950 | 78 | 29334 |

**ECMWF**

**OBS**

| | [0,0.1] | (0.1,5] | (5,20] | (20,50] | (50,Inf] | Sum |
|---|---|---|---|---|---|---|
| [0,0.1] | 3821 | 568 | 22 | 1 | 0 | 4412 |
| (0.1,5] | 5841 | 8278 | 1676 | 62 | 3 | 15860 |
| (5,20] | 545 | 3593 | 3315 | 508 | 23 | 7984 |
| (20,50] | 9 | 130 | 491 | 369 | 45 | 1044 |
| (50,Inf] | 0 | 3 | 14 | 10 | 7 | 34 |
| Sum | 10216 | 12572 | 5518 | 950 | 78 | 29334 |

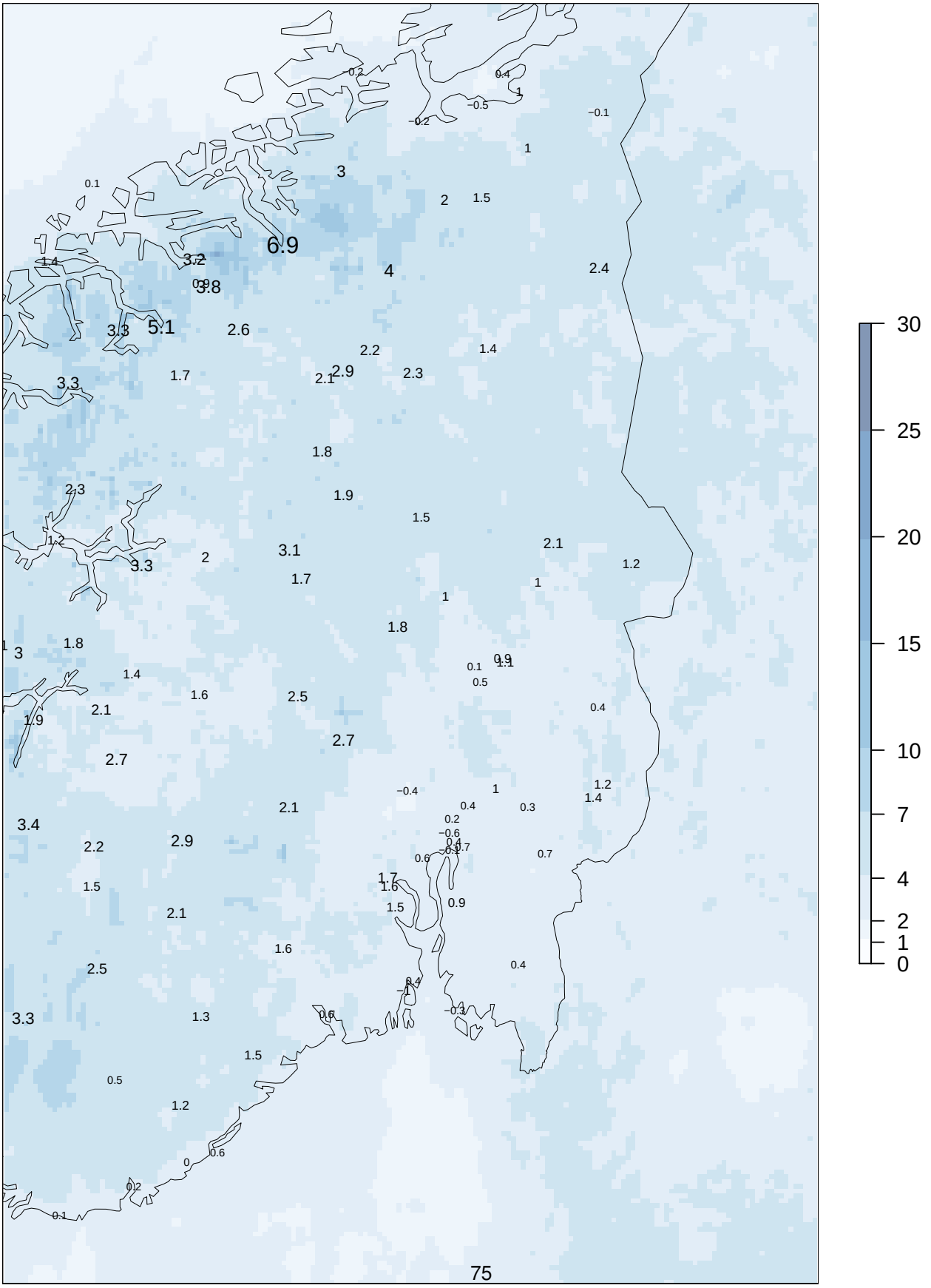
**AROME**

**OBS**

| | [0,0.1] | (0.1,5] | (5,20] | (20,50] | (50,Inf] | Sum |
|---|---|---|---|---|---|---|
| [0,0.1] | 6939 | 2561 | 254 | 17 | 1 | 9772 |
| (0.1,5] | 2747 | 6492 | 1786 | 109 | 5 | 11139 |
| (5,20] | 486 | 3188 | 2792 | 435 | 23 | 6924 |
| (20,50] | 43 | 325 | 673 | 347 | 40 | 1428 |
| (50,Inf] | 1 | 6 | 13 | 42 | 9 | 71 |
| Sum | 10216 | 12572 | 5518 | 950 | 78 | 29334 |

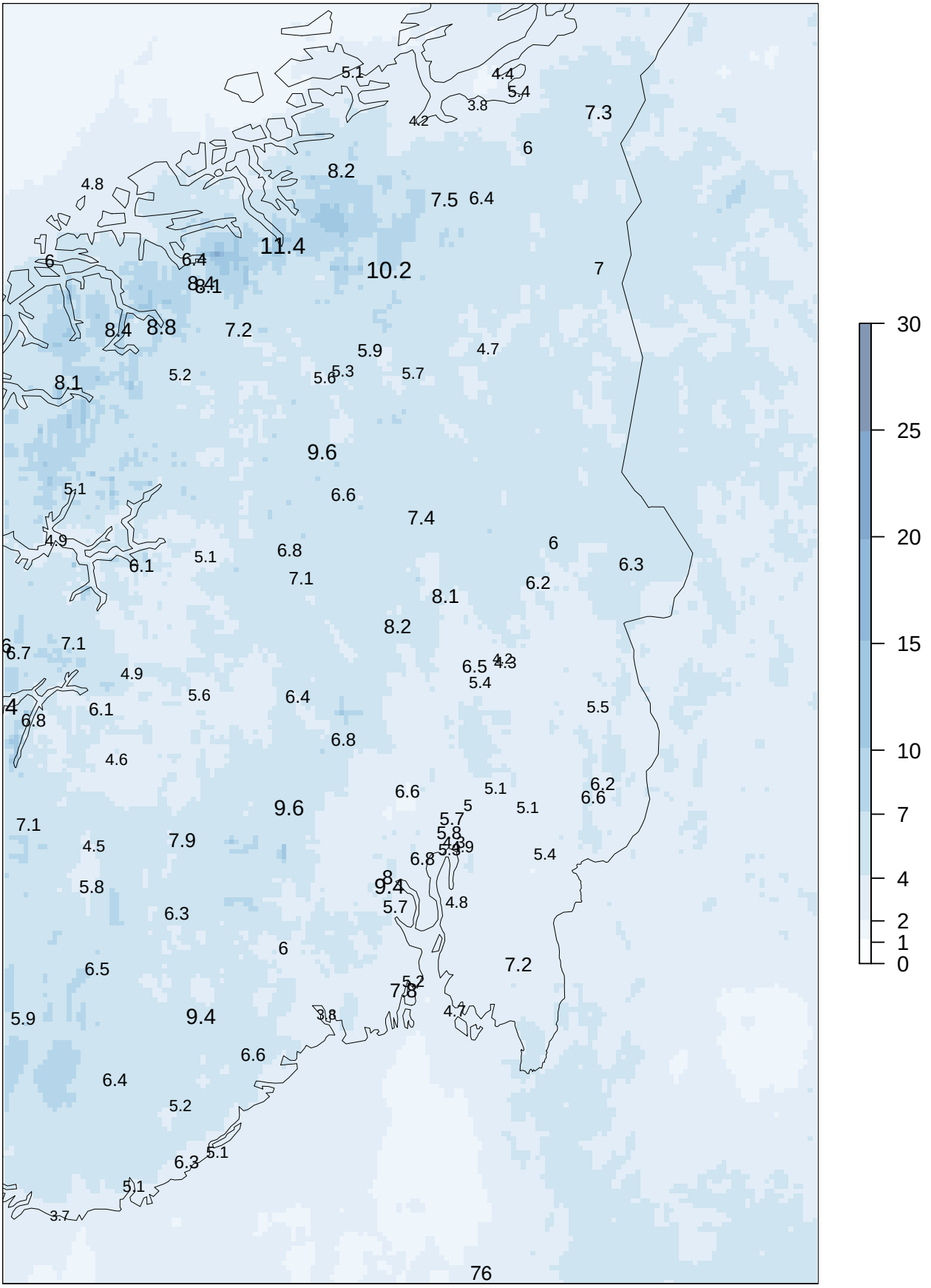
# AM25 00+30

ME at observing sites forecast means 01.06.2014 − 31.08.2014



# AM25 00+30

SDE at observing sites forecast means 01.06.2014 − 31.08.2014



# 6 Western Norway

## 6.1 Comments to the verification results

Wind speed 10 m:
For the period 1st of June to 31st of August 2014, both AROME and AM25 have a small negative bias in wind speed. The Hirlam models and ECMWF have 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. AM25 and AROME score best for all wind speeds, except for wind speed above $20ms^{-1}$.

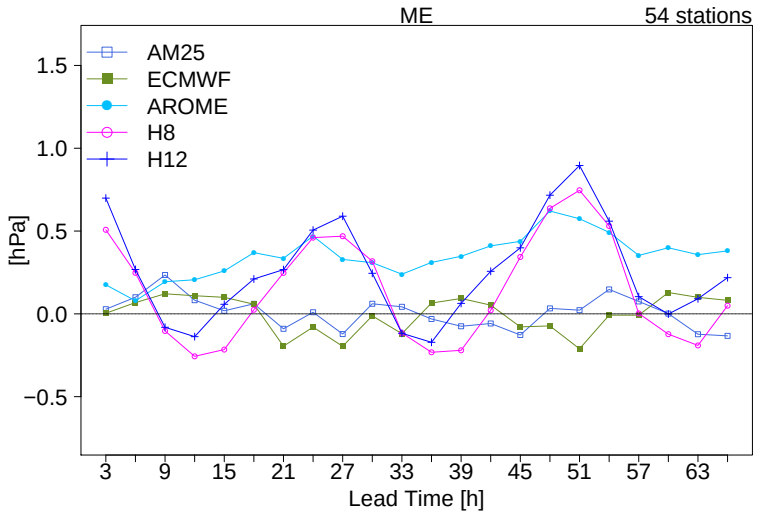
Max mean wind speed 10 m:
For Max Mean Wind Speed, both AM25 and AROME have a negative bias. After post processing the bias is about $-0.5ms^{-1}$ for both AROME models. Hirlam 8 km has also a strong diurnal variation, and scores better than the AROME models during nighttime.

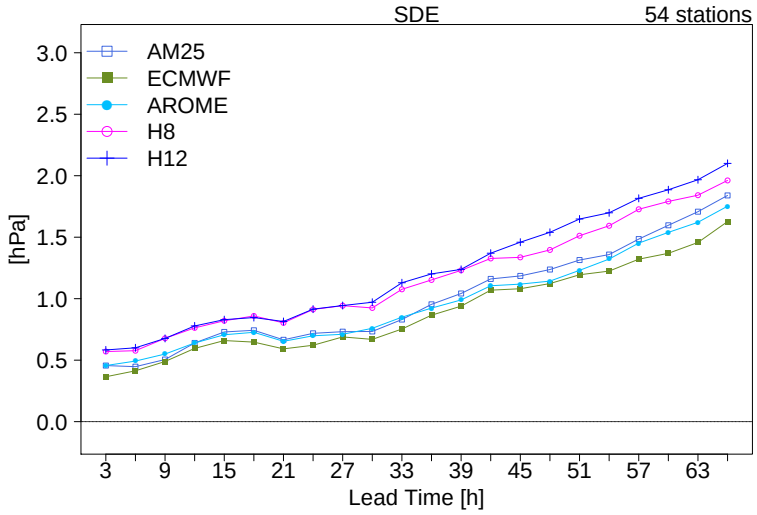
Wind gust:
For wind gust the AROME models have a negative bias, while Hirlam 8 km has a positive bias. The bias is smaller for AROME (about $-0.2ms^{-1}$) than for AM25 (about $-0.9ms^{-1}$). If we look at wind speed at 925 hPa (which often is used as an estimate of wind gust), there are only minor differences in bias between the AROME models and Hirlam 8 km. The wind at 925 hPa scores better for the strongest winds than wind gust.

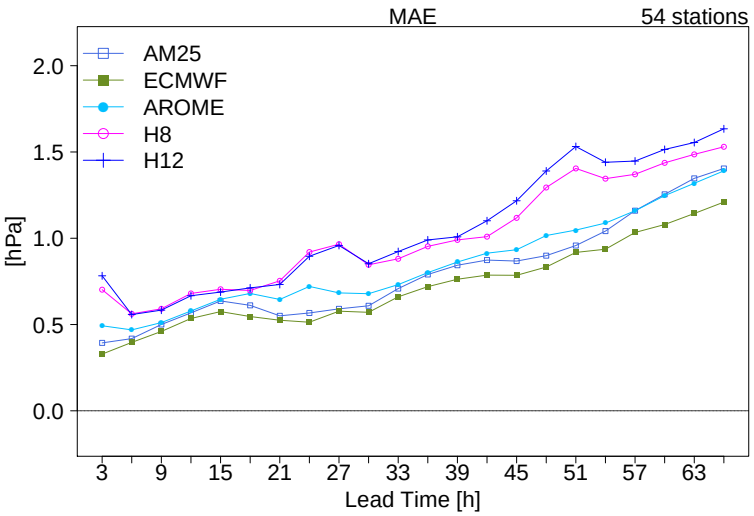
Temperature 2m:
For temperature all models have a diurnal variation. There is almost no bias during nighttime and a negative bias during daytime. After post processing the bias is small and positive for Hirlam8 km and AM25, while AROME has a small negative bias.

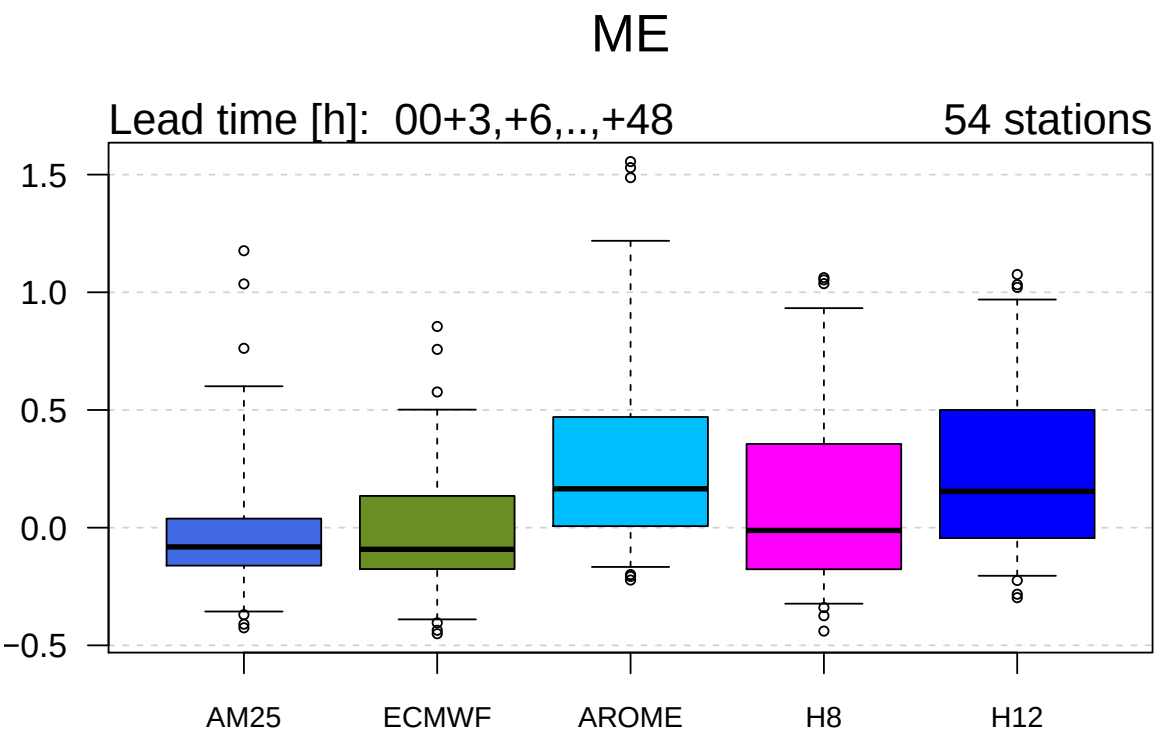
Precipitation:
For precipitation ECWMF and the AROME models have positive bias, while Hirlam 12 and 8 km have almost no bias. For light and heavy precipitation AM25 and AROME are the best models, while ECMWF is better for 24-hour precipitation between 5 and 20 mm. AROME is slightly better than AM25. After post processing AM25 and AROME have a negative bias around 1.5mm.

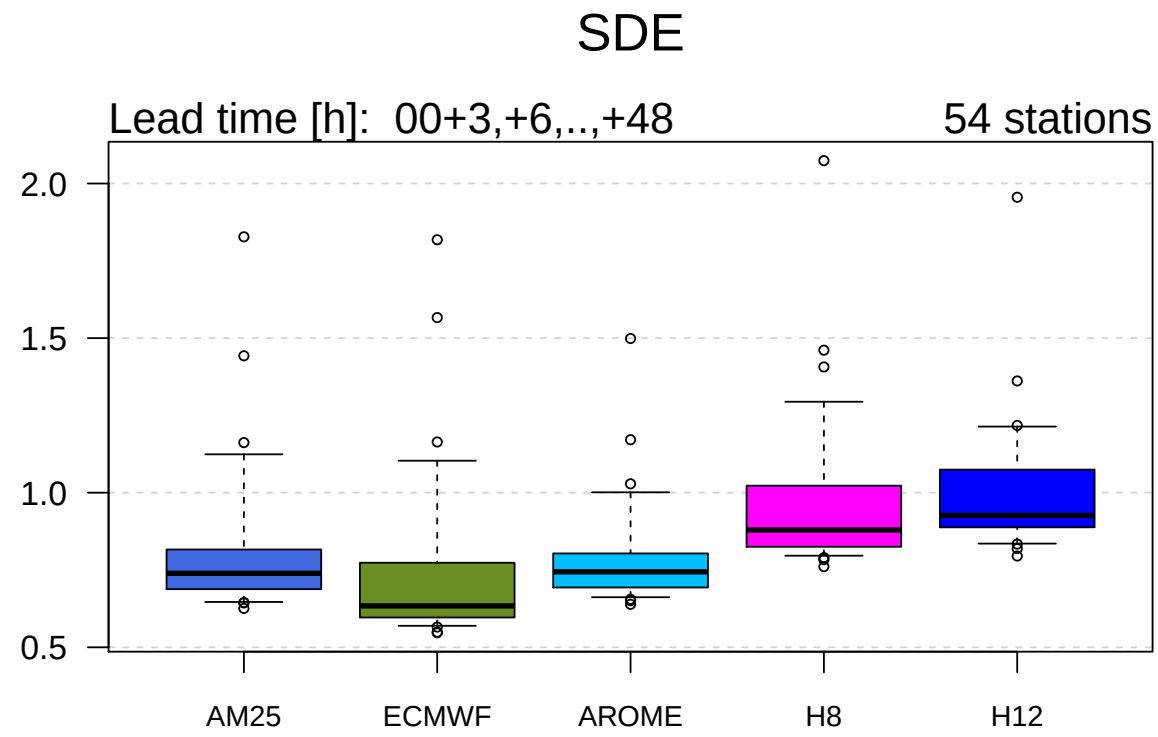
## 6.2 Pressure


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

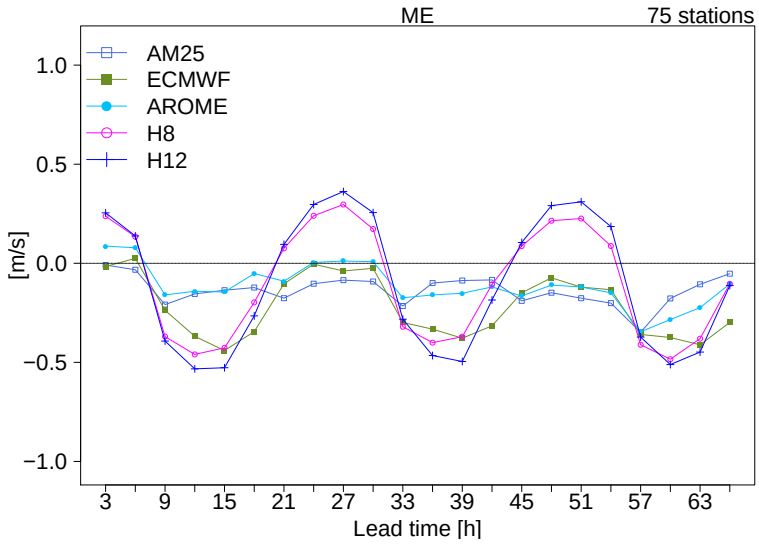

SDE
54 stations
AM25
ECMWF
AROME
H8
H12
[hPa]
3.0
2.5
2.0
1.5
1.0
0.5
0.0
3
9
15
21
27
33
39
45
51
57
63
Lead Time [h]

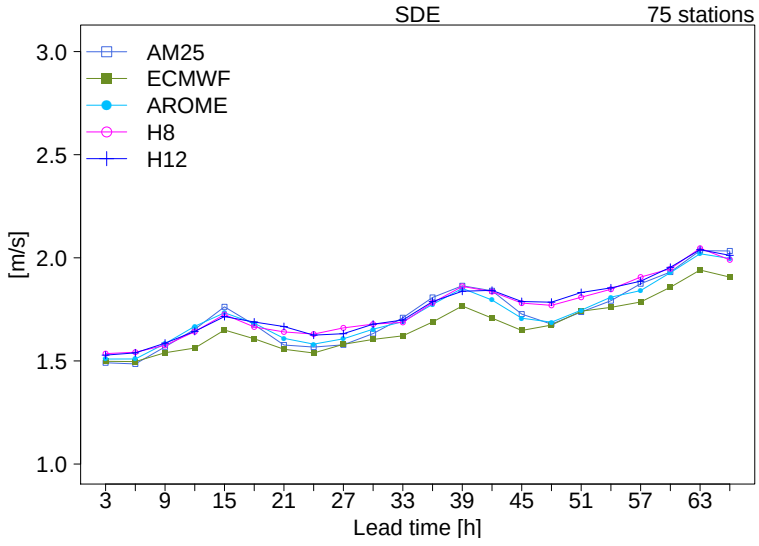

MAE
54 stations
AM25
ECMWF
AROME
H8
H12
[hPa]
2.0
1.5
1.0
0.5
0.0
3
9
15
21
27
33
39
45
51
57
63
Lead Time [h]

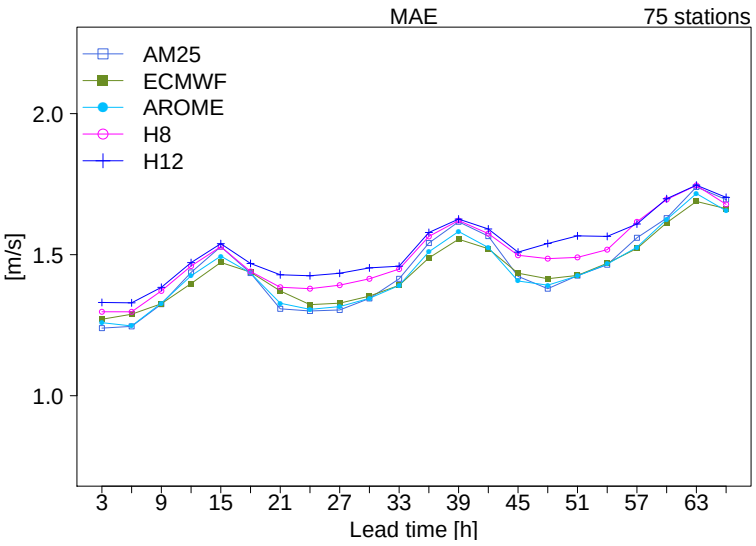

ME
Lead time [h]: 00+3,+6,..,+48
54 stations
1.5
1.0
0.5
0.0
−0.5
AM25
ECMWF
AROME
H8
H12

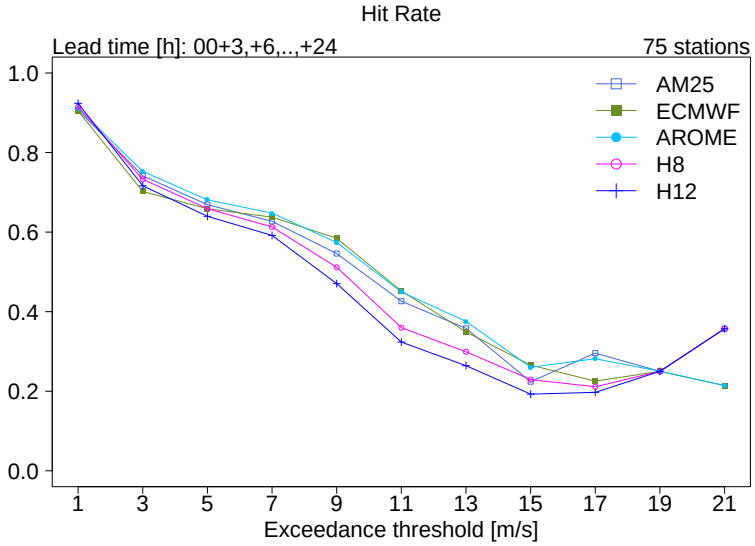

SDE
Lead time [h]: 00+3,+6,..,+48
54 stations
2.0
1.5
1.0
0.5
AM25
ECMWF
AROME
H8
H12

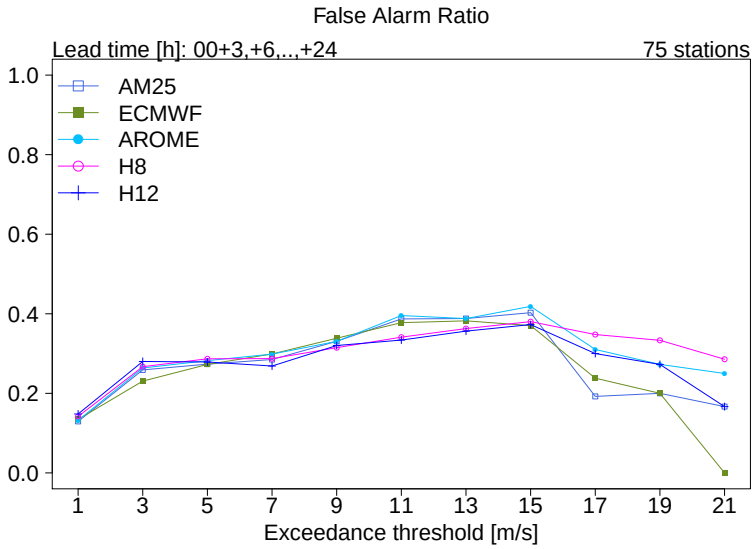
## 6.3 Wind Speed 10m

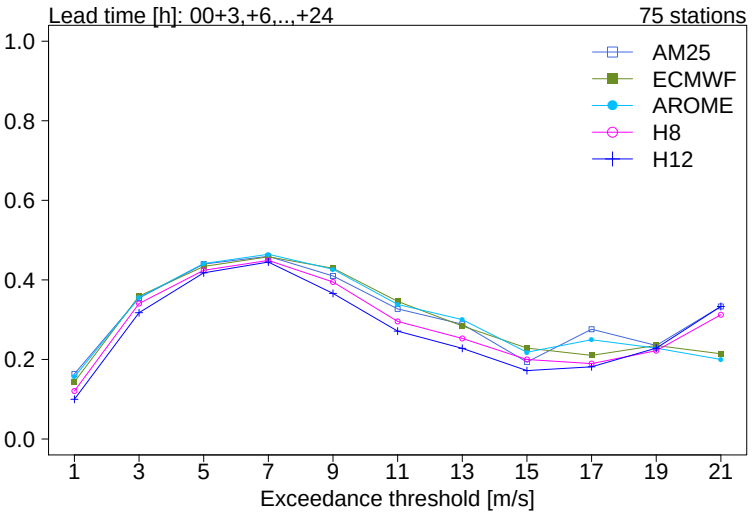


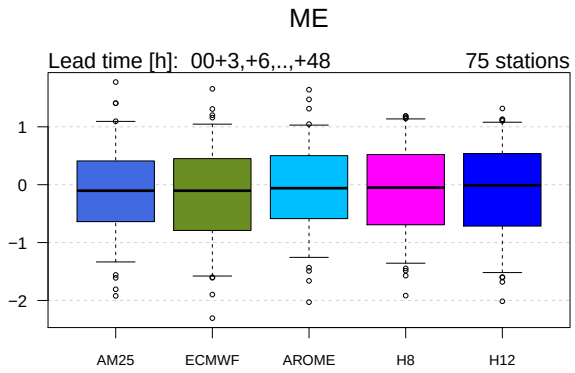



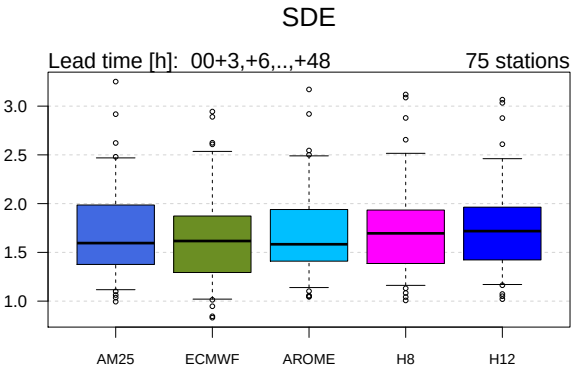




Hit Rate
Lead time [h]: 00+3,+6,..,+24
75 stations
AM25
ECMWF
AROME
H8
H12
1.0
0.8
0.6
0.4
0.2
0.0
1 3 5 7 9 11 13 15 17 19 21
Exceedance threshold [m/s]


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


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




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

**AM25** — **OBS**

| | [0,3] | (3,11] | (11,17] | (17,21] | (21,Inf] | Sum |
|---|---|---|---|---|---|---|
| [0,3] | 41376 | 12005 | 11 | 0 | 0 | 53392 |
| (3,11] | 11737 | 29864 | 1361 | 21 | 3 | 42986 |
| (11,17] | 55 | 612 | 809 | 76 | 12 | 1564 |
| (17,21] | 1 | 2 | 10 | 15 | 8 | 36 |
| (21,Inf] | 0 | 0 | 0 | 2 | 5 | 7 |
| Sum | 53169 | 42483 | 2191 | 114 | 28 | 97985 |

**H8** — **OBS**

| | [0,3] | (3,11] | (11,17] | (17,21] | (21,Inf] | Sum |
|---|---|---|---|---|---|---|
| [0,3] | 40458 | 12234 | 43 | 0 | 0 | 52735 |
| (3,11] | 12665 | 29791 | 1435 | 34 | 3 | 43928 |
| (11,17] | 46 | 455 | 702 | 65 | 13 | 1281 |
| (17,21] | 0 | 2 | 11 | 13 | 4 | 30 |
| (21,Inf] | 0 | 1 | 0 | 2 | 8 | 11 |
| Sum | 53169 | 42483 | 2191 | 114 | 28 | 97985 |

**ECMWF** — **OBS**

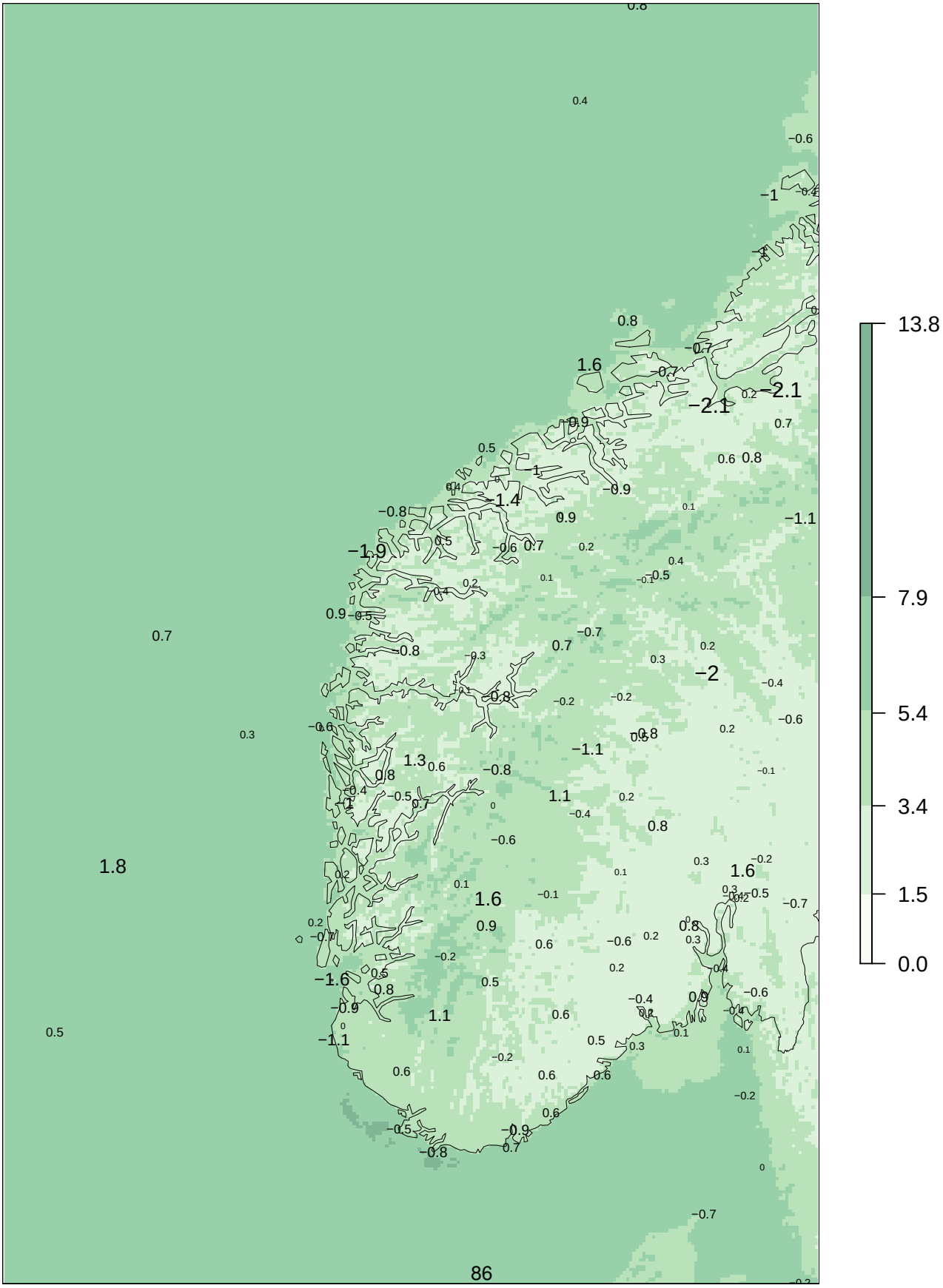
| | [0,3] | (3,11] | (11,17] | (17,21] | (21,Inf] | Sum |
|---|---|---|---|---|---|---|
| [0,3] | 43525 | 13643 | 35 | 1 | 0 | 57204 |
| (3,11] | 9610 | 28186 | 1227 | 28 | 5 | 39056 |
| (11,17] | 34 | 652 | 922 | 75 | 9 | 1692 |
| (17,21] | 0 | 2 | 7 | 10 | 9 | 28 |
| (21,Inf] | 0 | 0 | 0 | 0 | 5 | 5 |
| Sum | 53169 | 42483 | 2191 | 114 | 28 | 97985 |

**AROME** — **OBS**

| | [0,3] | (3,11] | (11,17] | (17,21] | (21,Inf] | Sum |
|---|---|---|---|---|---|---|
| [0,3] | 41022 | 11676 | 14 | 0 | 0 | 52712 |
| (3,11] | 12095 | 30183 | 1332 | 22 | 1 | 43633 |
| (11,17] | 52 | 619 | 836 | 77 | 15 | 1599 |
| (17,21] | 0 | 5 | 9 | 12 | 9 | 35 |
| (21,Inf] | 0 | 0 | 0 | 3 | 3 | 6 |
| Sum | 53169 | 42483 | 2191 | 114 | 28 | 97985 |

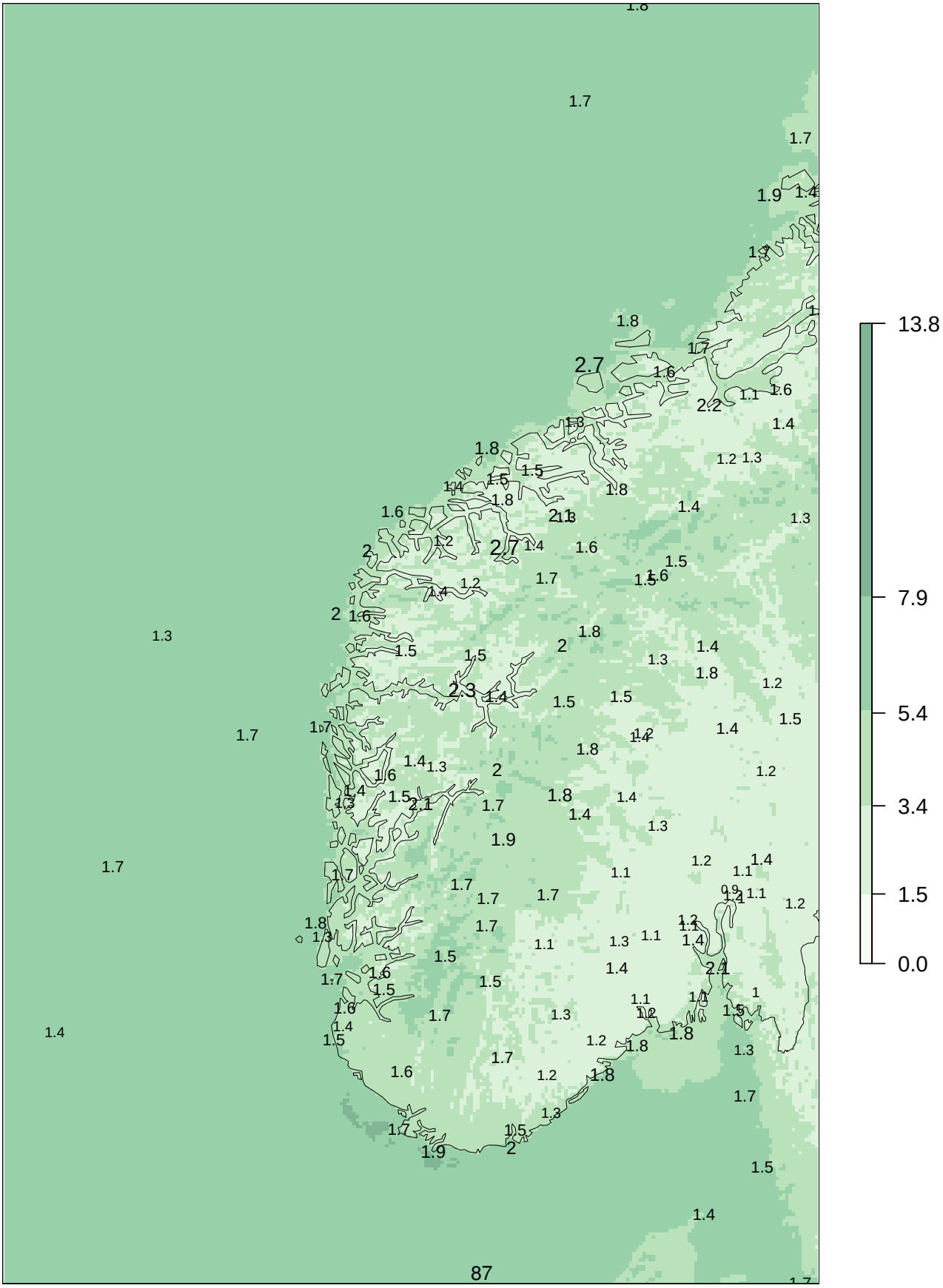
# AM25 00+12

ME at observing sites forecast means 01.06.2014 − 31.08.2014

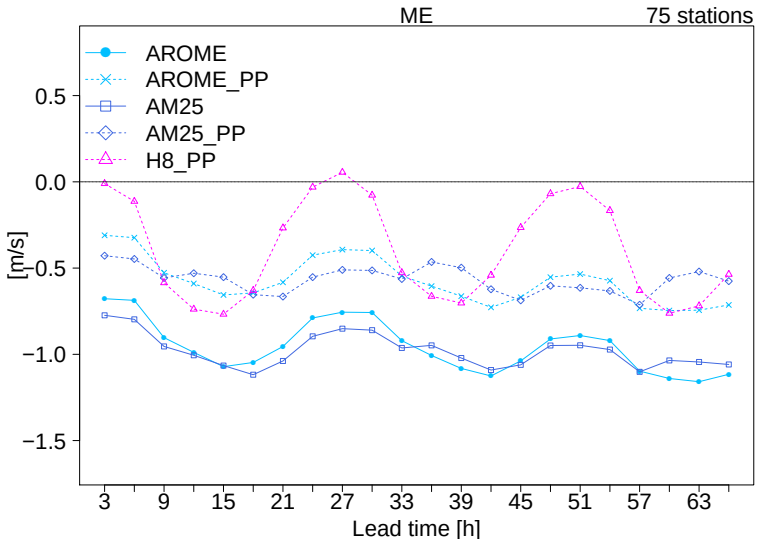


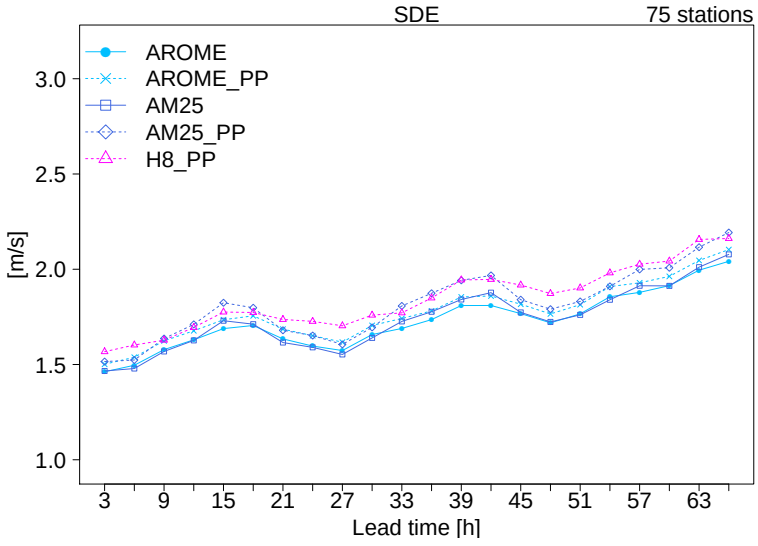
# AM25 00+12

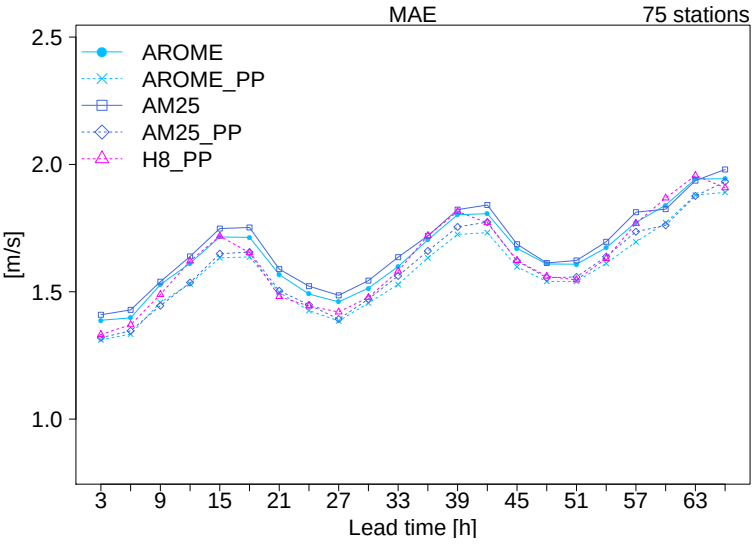
SDE at observing sites forecast means 01.06.2014 − 31.08.2014

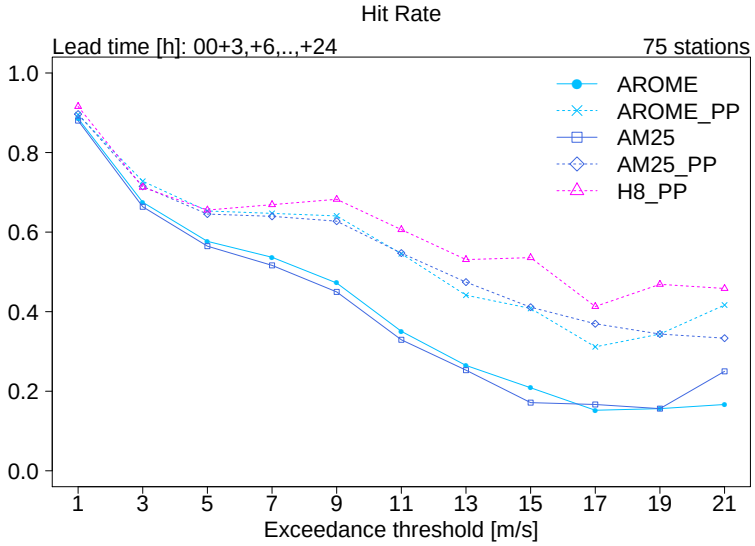


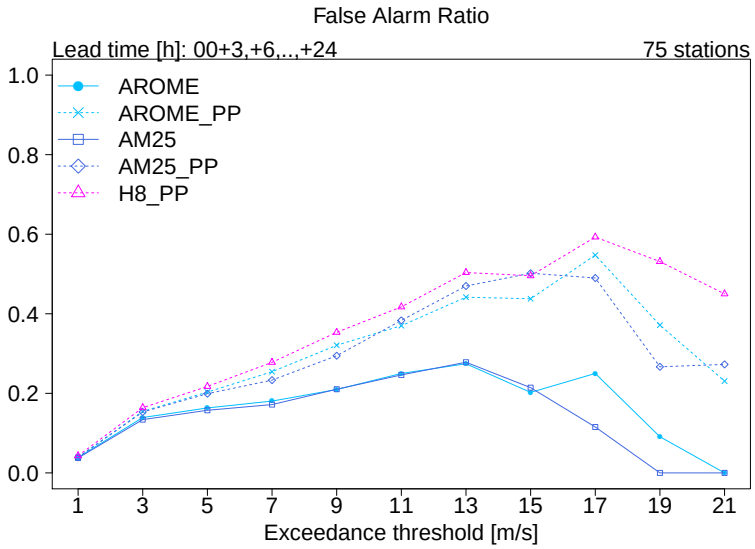
## 6.4 Max Mean Wind Speed 10m

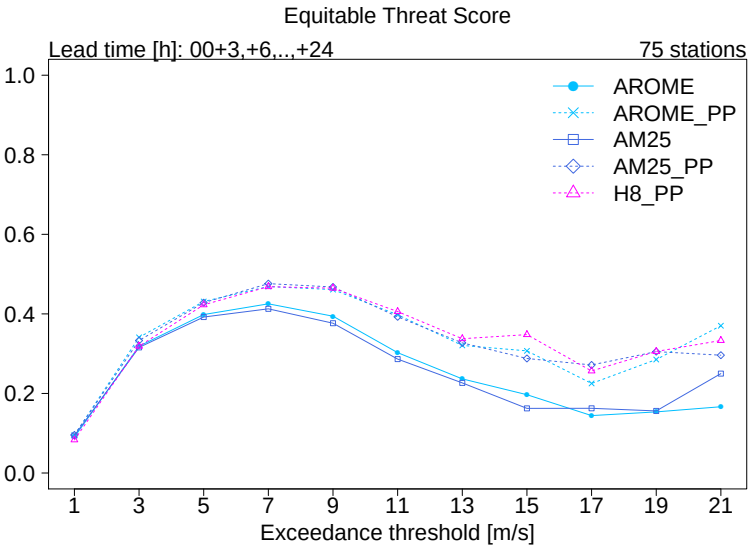


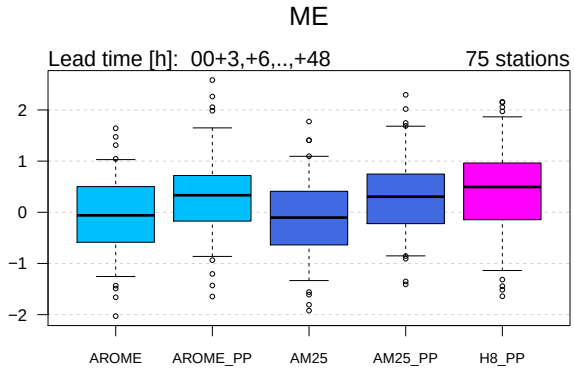



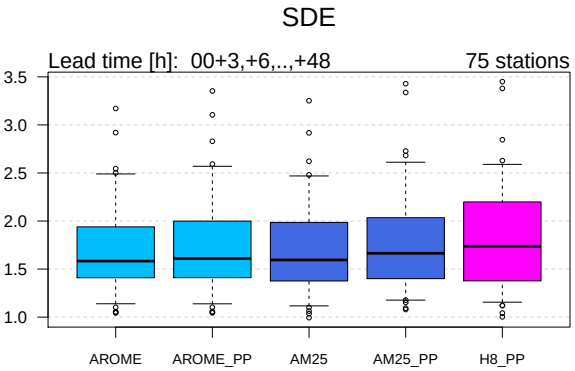




Hit Rate
Lead time [h]: 00+3,+6,..,+24
75 stations
AROME
AROME_PP
AM25
AM25_PP
H8_PP
1.0
0.8
0.6
0.4
0.2
0.0
1 3 5 7 9 11 13 15 17 19 21
Exceedance threshold [m/s]


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


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




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

**AM25** vs **OBS**

| | [0,3] | (3,11] | (11,17] | (17,21] | (21,Inf] | Sum |
|---|---|---|---|---|---|---|
| [0,3] | 31421 | 19380 | 43 | 0 | 0 | 50844 |
| (3,11] | 5930 | 33041 | 2425 | 67 | 8 | 41471 |
| (11,17] | 45 | 405 | 937 | 147 | 21 | 1555 |
| (17,21] | 0 | 3 | 7 | 14 | 12 | 36 |
| (21,Inf] | 0 | 0 | 0 | 0 | 7 | 7 |
| Sum | 37396 | 52829 | 3412 | 228 | 48 | 93913 |

**AM25_PP** vs **OBS**

| | [0,3] | (3,11] | (11,17] | (17,21] | (21,Inf] | Sum |
|---|---|---|---|---|---|---|
| [0,3] | 29905 | 16417 | 33 | 0 | 0 | 46355 |
| (3,11] | 7416 | 35149 | 1658 | 38 | 2 | 44263 |
| (11,17] | 66 | 1248 | 1636 | 128 | 20 | 3098 |
| (17,21] | 9 | 13 | 82 | 58 | 15 | 177 |
| (21,Inf] | 0 | 2 | 3 | 4 | 11 | 20 |
| Sum | 37396 | 52829 | 3412 | 228 | 48 | 93913 |

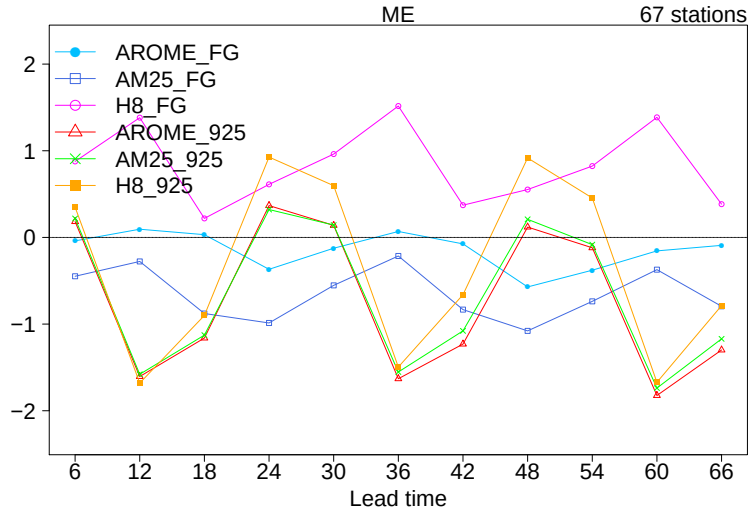
**AROME** vs **OBS**

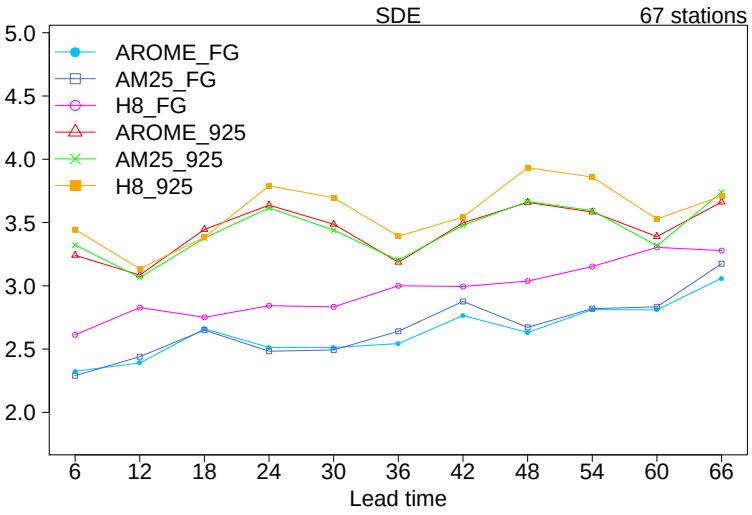
| | [0,3] | (3,11] | (11,17] | (17,21] | (21,Inf] | Sum |
|---|---|---|---|---|---|---|
| [0,3] | 31147 | 18929 | 34 | 0 | 0 | 50110 |
| (3,11] | 6204 | 33502 | 2395 | 69 | 5 | 42175 |
| (11,17] | 45 | 394 | 975 | 148 | 26 | 1588 |
| (17,21] | 0 | 4 | 8 | 10 | 12 | 34 |
| (21,Inf] | 0 | 0 | 0 | 1 | 5 | 6 |
| Sum | 37396 | 52829 | 3412 | 228 | 48 | 93913 |

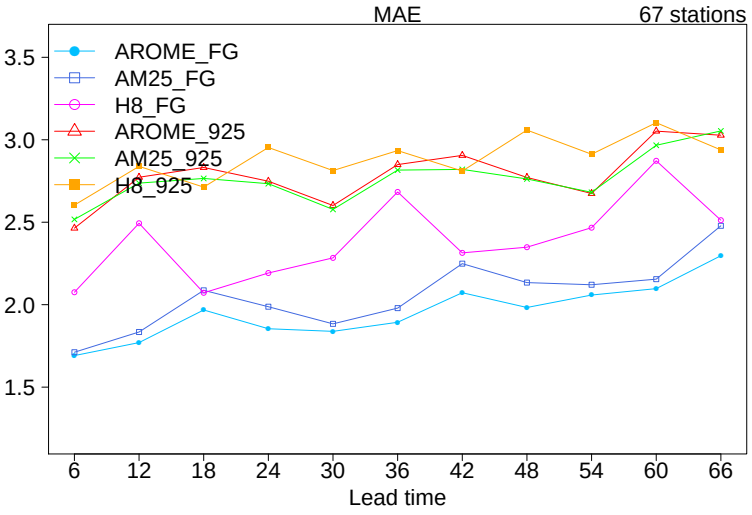
**AROME_PP** vs **OBS**

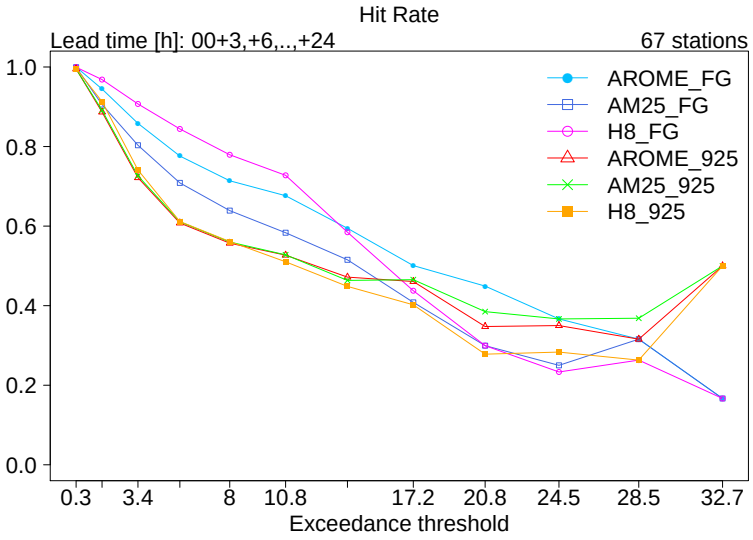
| | [0,3] | (3,11] | (11,17] | (17,21] | (21,Inf] | Sum |
|---|---|---|---|---|---|---|
| [0,3] | 29792 | 15870 | 25 | 0 | 0 | 45687 |
| (3,11] | 7530 | 35823 | 1738 | 34 | 1 | 45126 |
| (11,17] | 71 | 1118 | 1575 | 147 | 19 | 2930 |
| (17,21] | 3 | 18 | 71 | 43 | 16 | 151 |
| (21,Inf] | 0 | 0 | 3 | 4 | 12 | 19 |
| Sum | 37396 | 52829 | 3412 | 228 | 48 | 93913 |

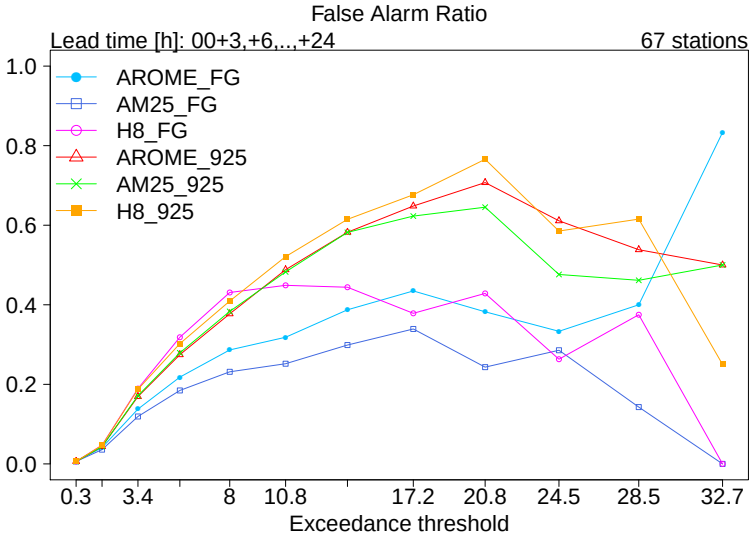
## 6.5 Wind gust

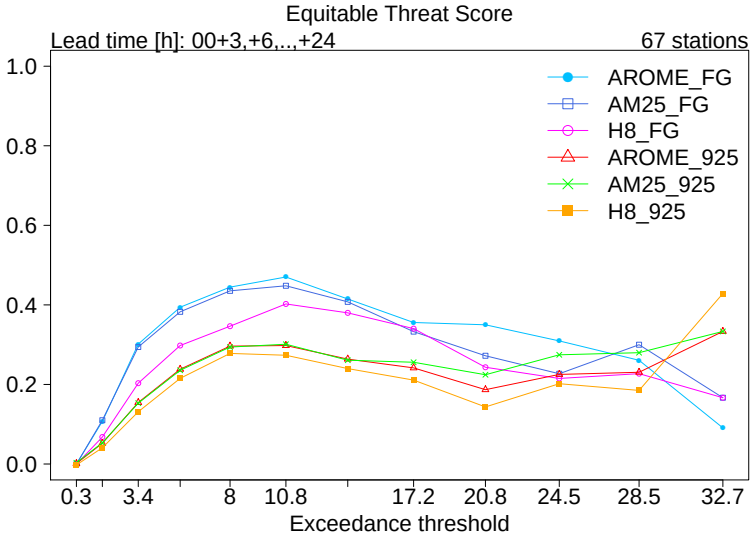

ME
67 stations
AROME_FG
AM25_FG
H8_FG
AROME_925
AM25_925
H8_925
2
1
0
−1
−2
6
12
18
24
30
36
42
48
54
60
66
Lead time


SDE
67 stations
AROME_FG
AM25_FG
H8_FG
AROME_925
AM25_925
H8_925
5.0
4.5
4.0
3.5
3.0
2.5
2.0
6
12
18
24
30
36
42
48
54
60
66
Lead time

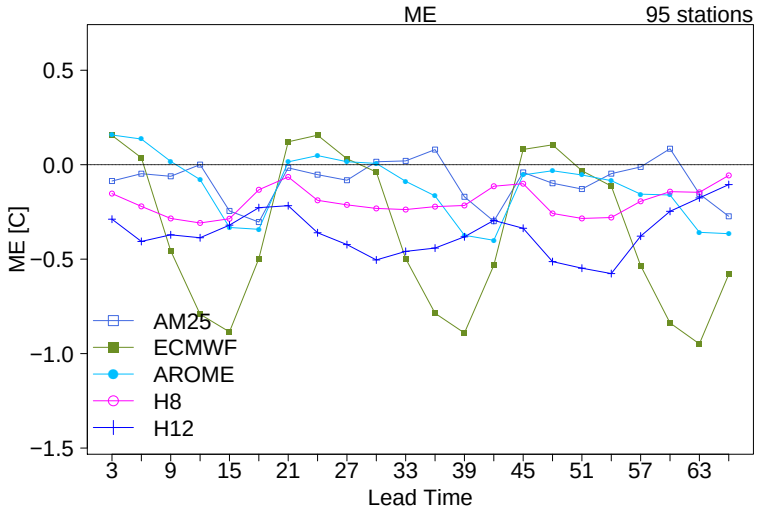

MAE
67 stations
AROME_FG
AM25_FG
H8_FG
AROME_925
AM25_925
H8_925
3.5
3.0
2.5
2.0
1.5
6
12
18
24
30
36
42
48
54
60
66
Lead time

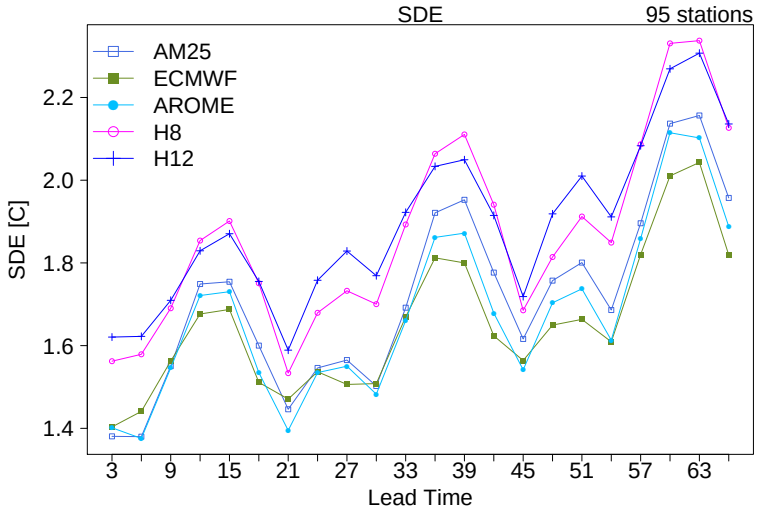

Hit Rate
Lead time [h]: 00+3,+6,..,+24
67 stations
AROME_FG
AM25_FG
H8_FG
AROME_925
AM25_925
H8_925
1.0
0.8
0.6
0.4
0.2
0.0
0.3
3.4
8
10.8
17.2
20.8
24.5
28.5
32.7
Exceedance threshold

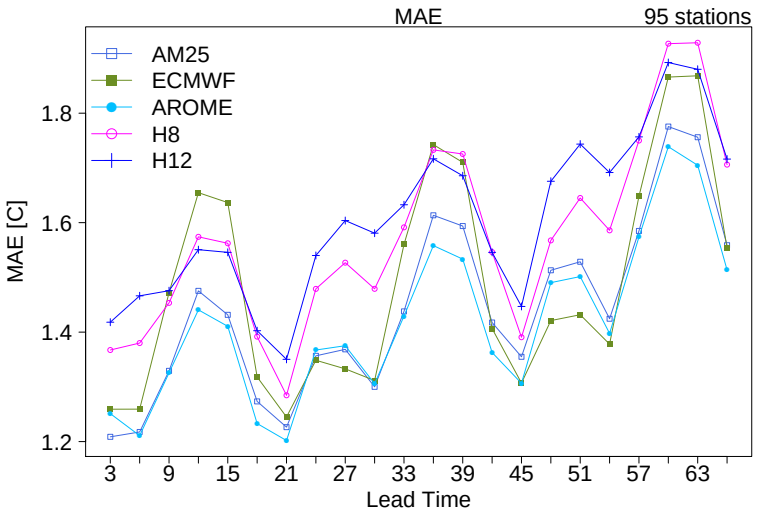

False Alarm Ratio
Lead time [h]: 00+3,+6,..,+24
67 stations
AROME_FG
AM25_FG
H8_FG
AROME_925
AM25_925
H8_925
1.0
0.8
0.6
0.4
0.2
0.0
0.3
3.4
8
10.8
17.2
20.8
24.5
28.5
32.7
Exceedance threshold

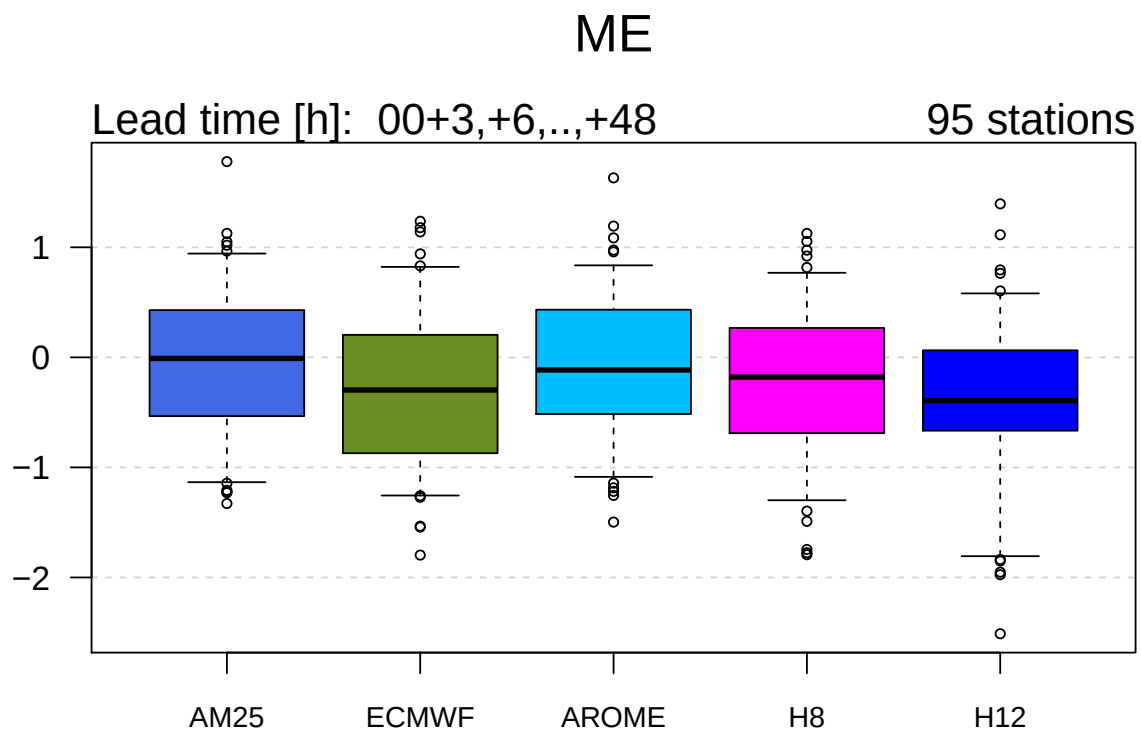

Equitable Threat Score
Lead time [h]: 00+3,+6,..,+24
67 stations
AROME_FG
AM25_FG
H8_FG
AROME_925
AM25_925
H8_925
1.0
0.8
0.6
0.4
0.2
0.0
0.3
3.4
8
10.8
17.2
20.8
24.5
28.5
32.7
Exceedance threshold

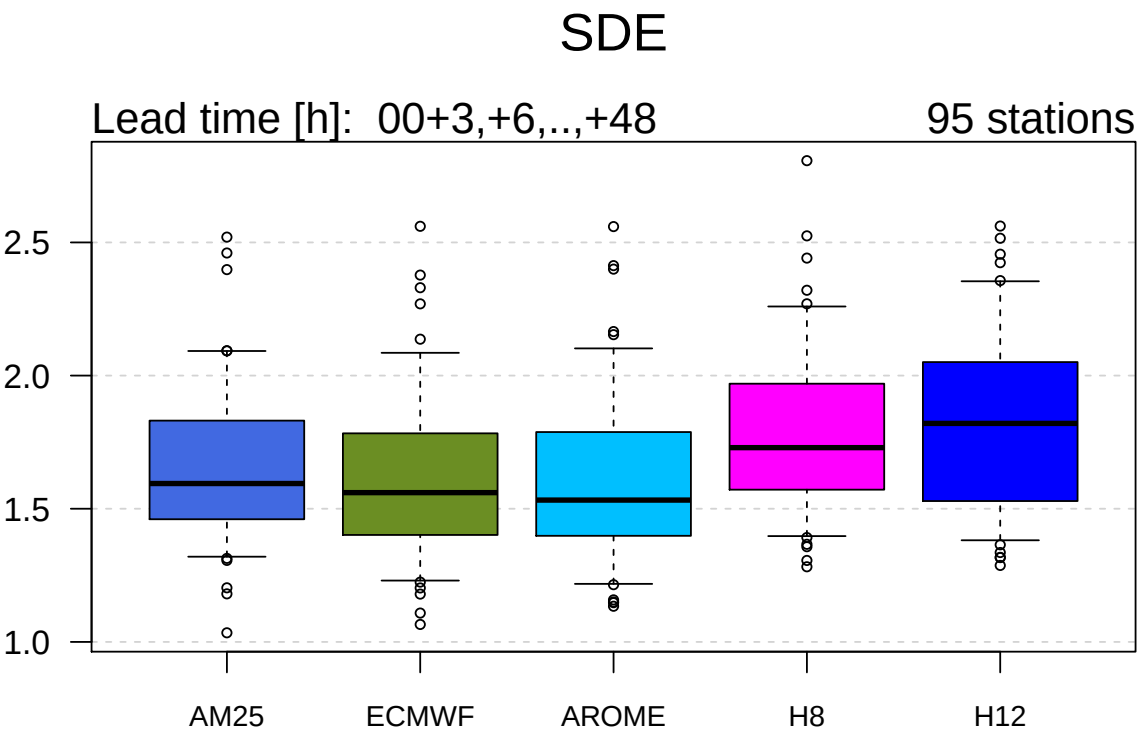
## 6.6 Temperature 2m



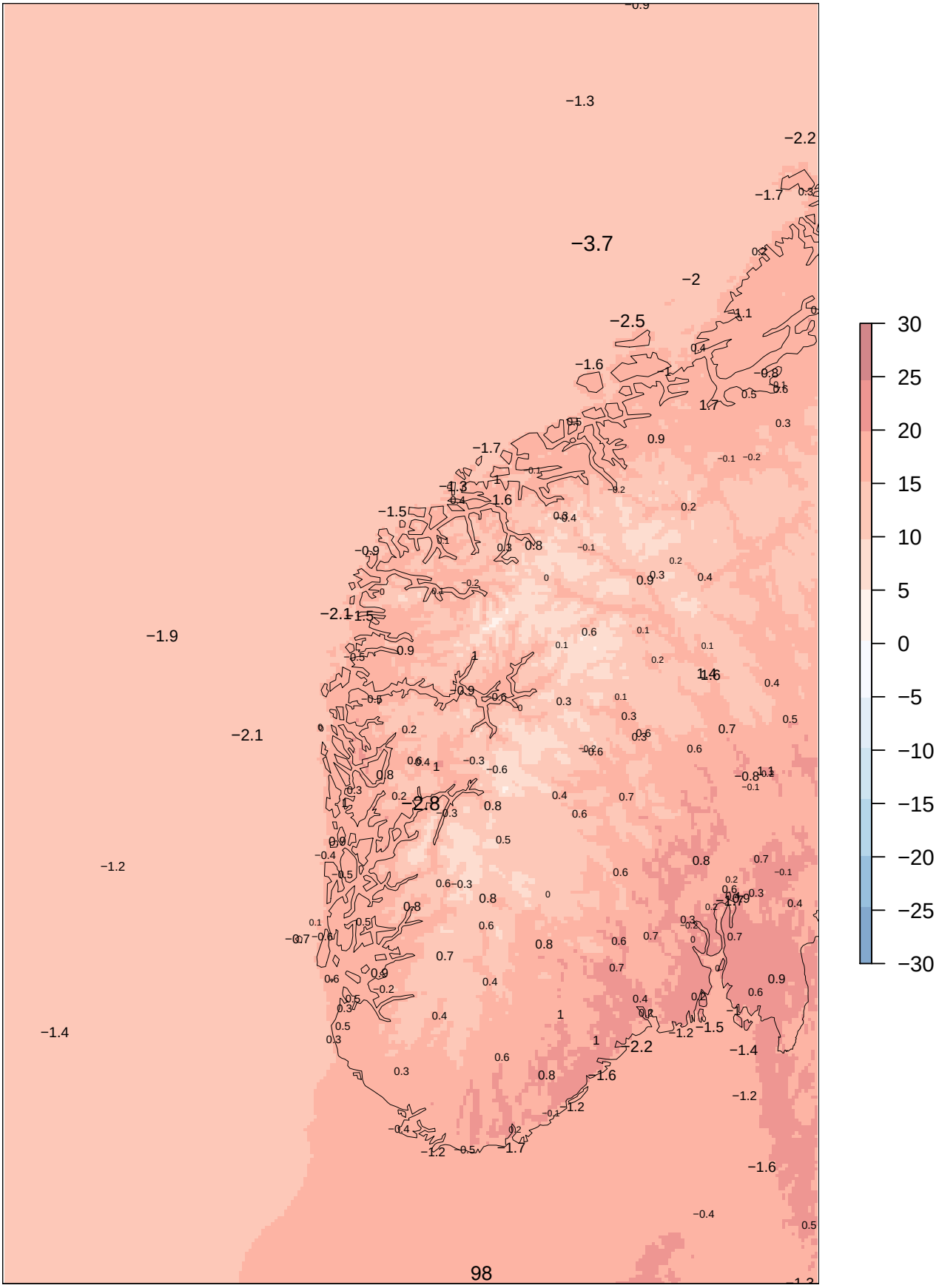




ME
Lead time [h]: 00+3,+6,..,+48
95 stations
1
0
−1
−2
AM25
ECMWF
AROME
H8
H12


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

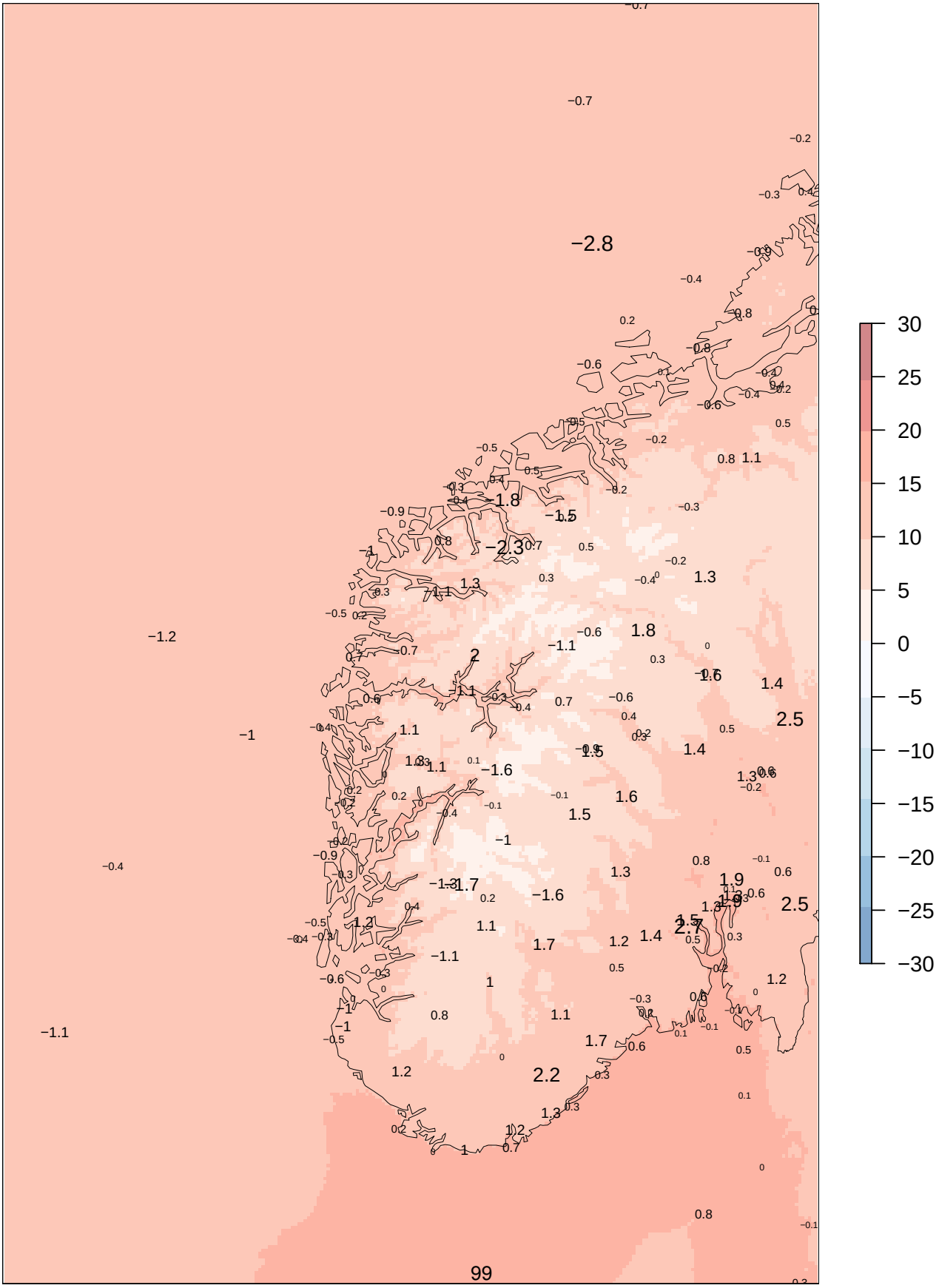
# AM25 00+12

ME at observing sites forecast means 01.06.2014 − 31.08.2014



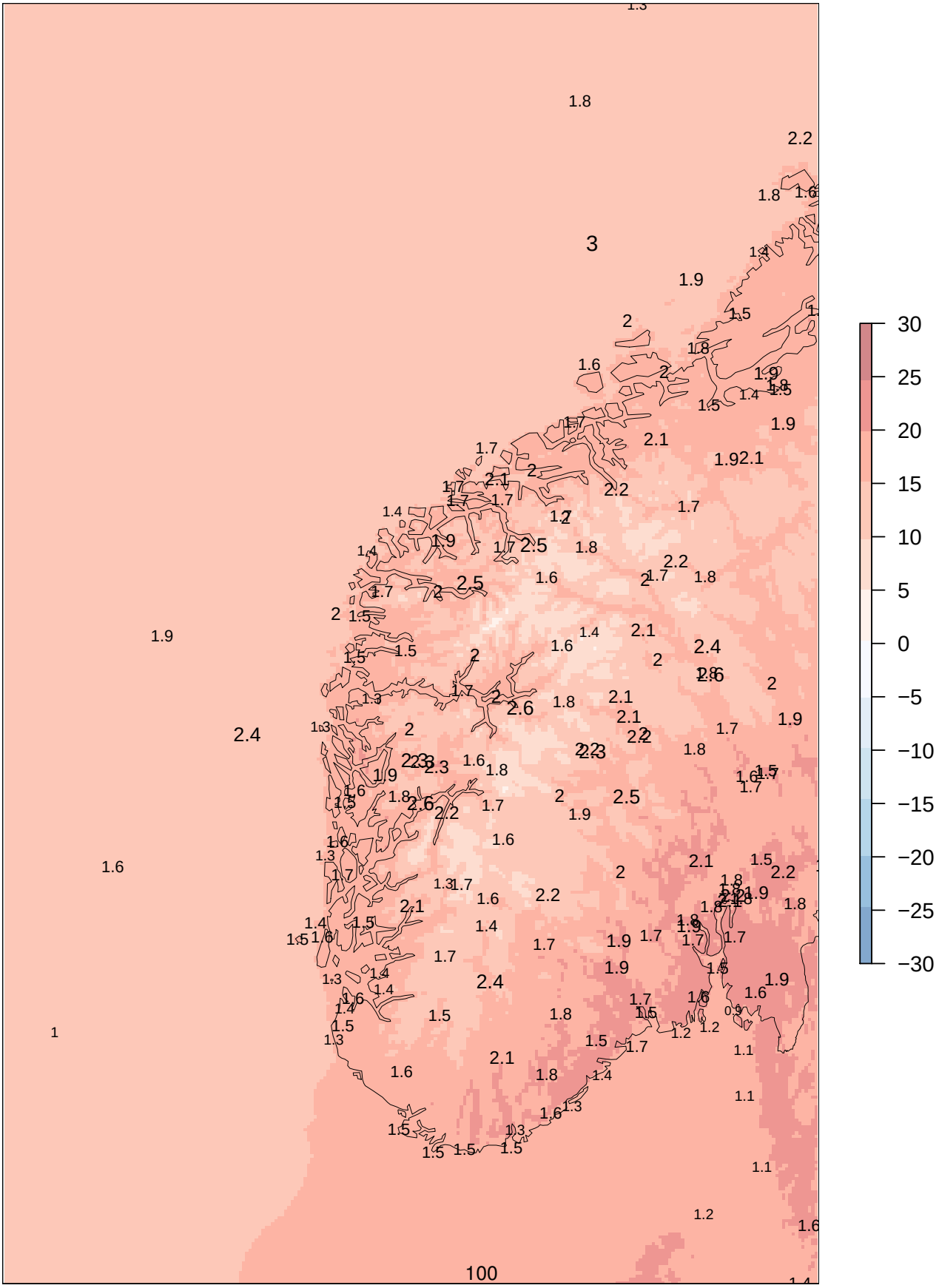
# AM25 00+24

ME at observing sites forecast means 01.06.2014 − 31.08.2014



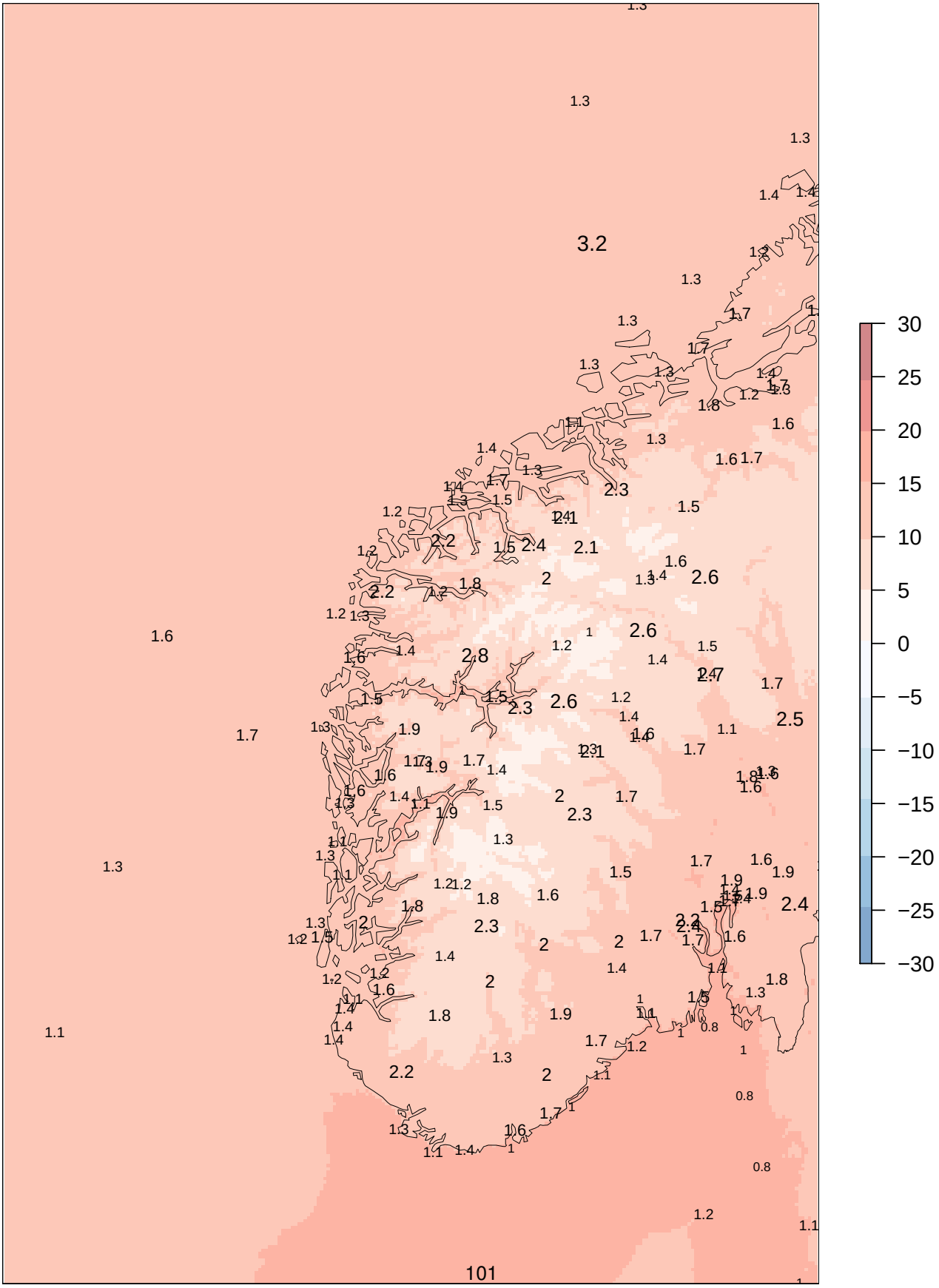
# AM25 00+12

SDE at observing sites forecast means 01.06.2014 − 31.08.2014

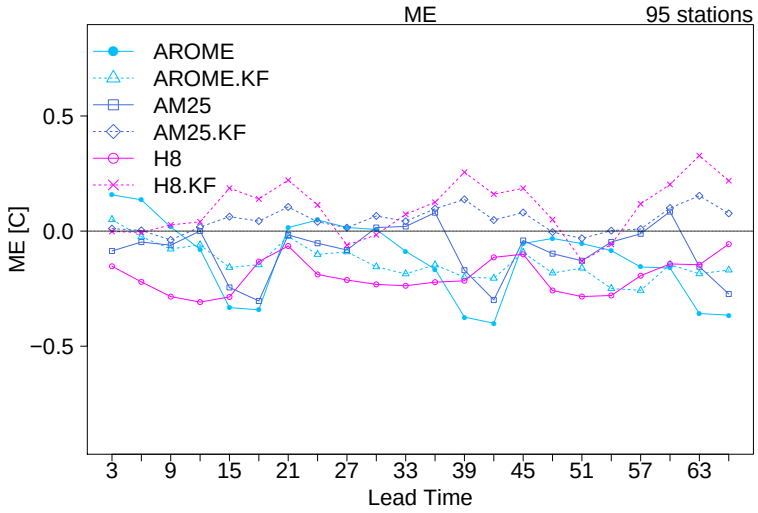


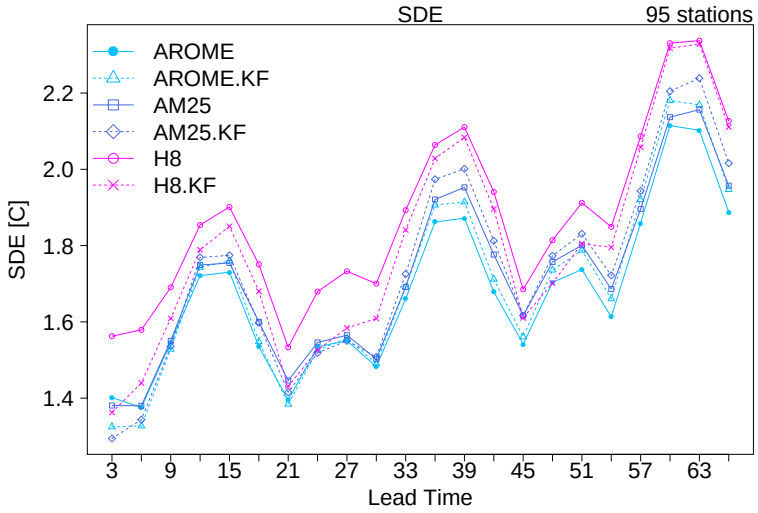
# AM25 00+24

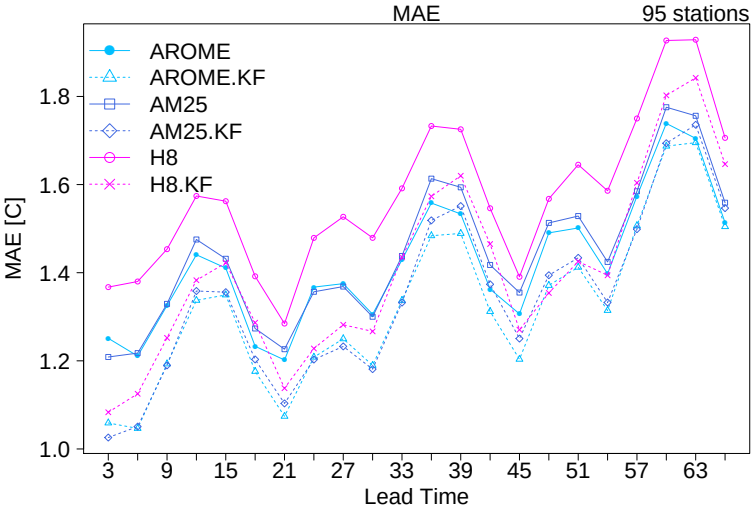
SDE at observing sites forecast means 01.06.2014 − 31.08.2014

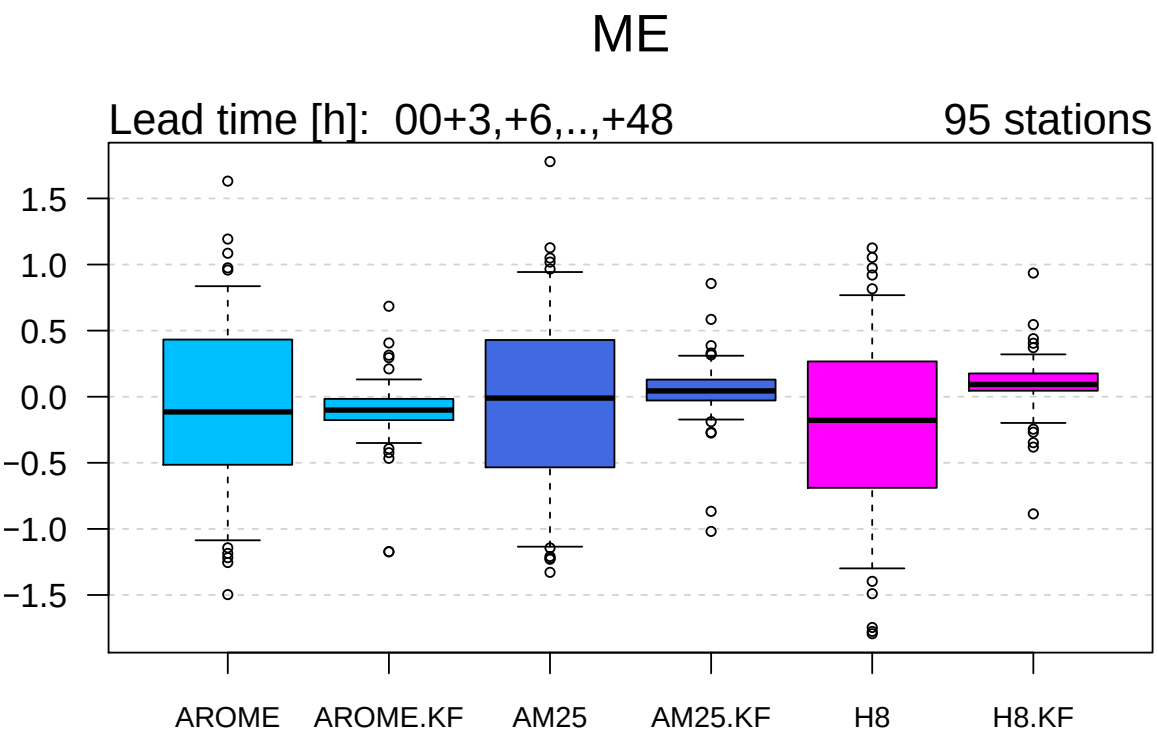


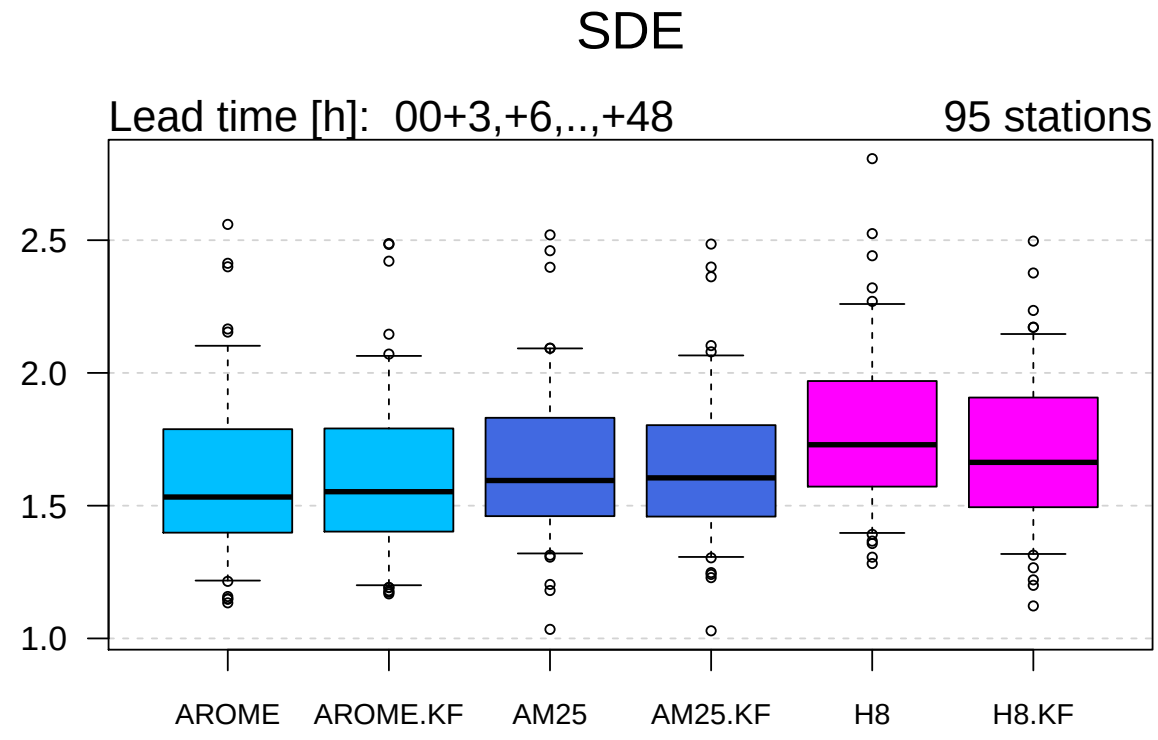
## 6.7 Post processed temperature 2m



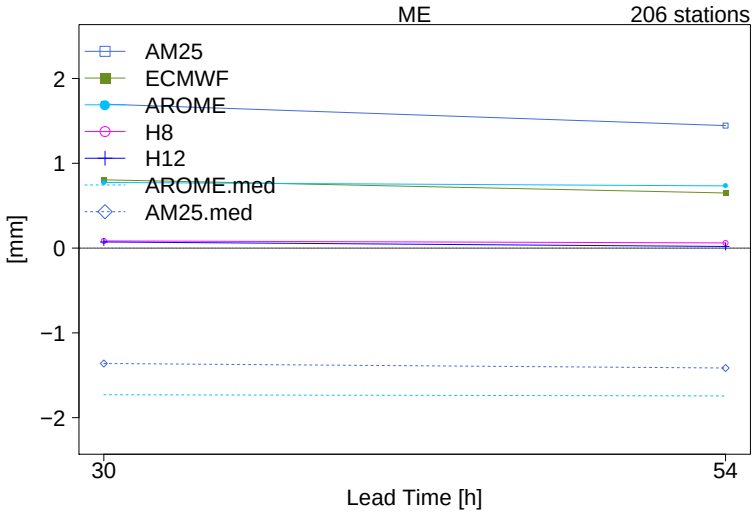



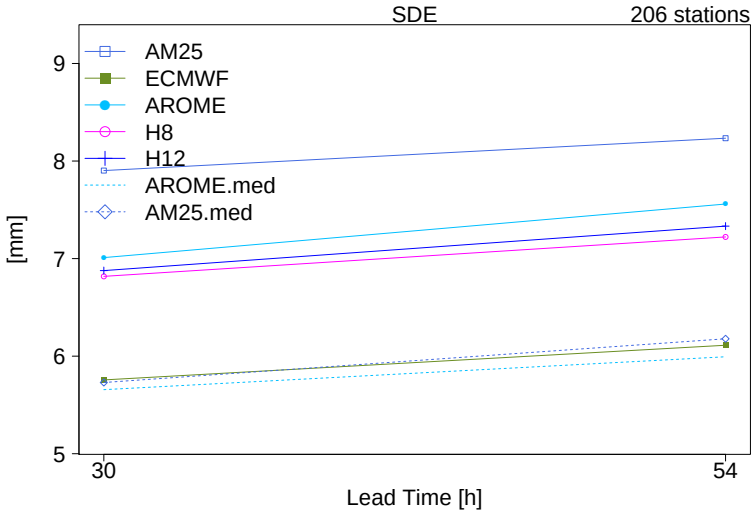



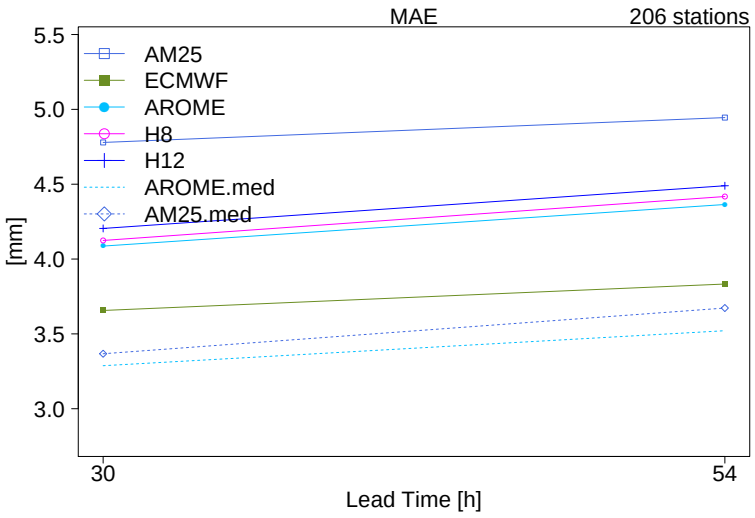

ME
Lead time [h]: 00+3,+6,..,+48
95 stations
1.5
1.0
0.5
0.0
−0.5
−1.0
−1.5
AROME
AROME.KF
AM25
AM25.KF
H8
H8.KF

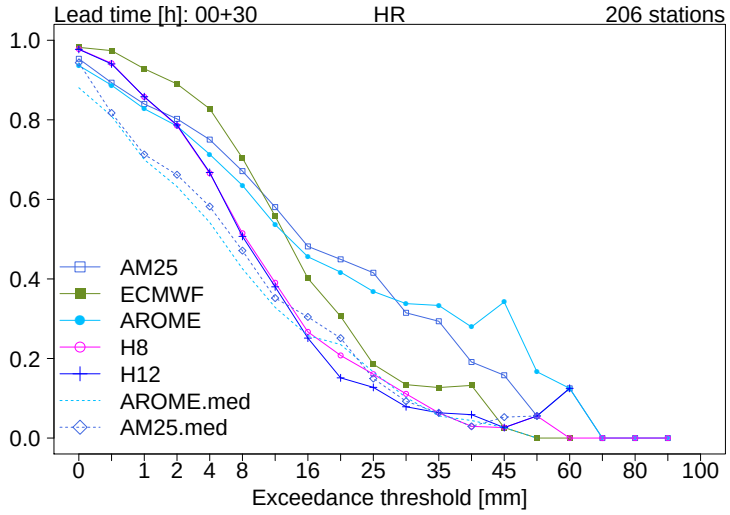

SDE
Lead time [h]: 00+3,+6,..,+48
95 stations
2.5
2.0
1.5
1.0
AROME
AROME.KF
AM25
AM25.KF
H8
H8.KF

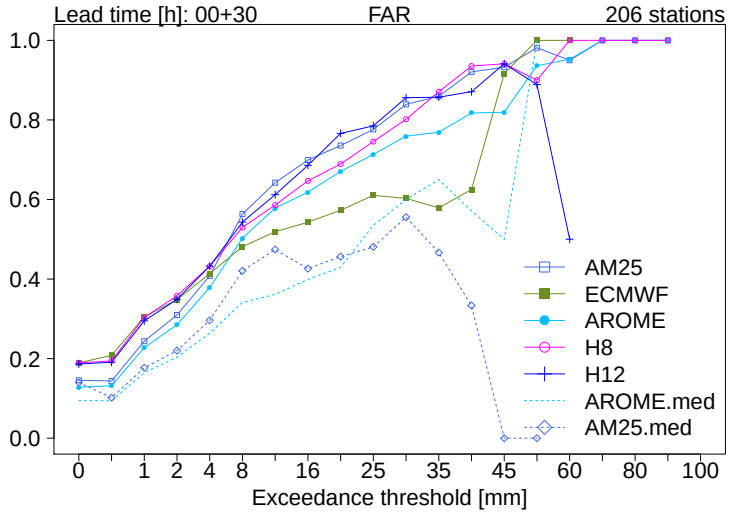
## 6.8 Daily precipitation

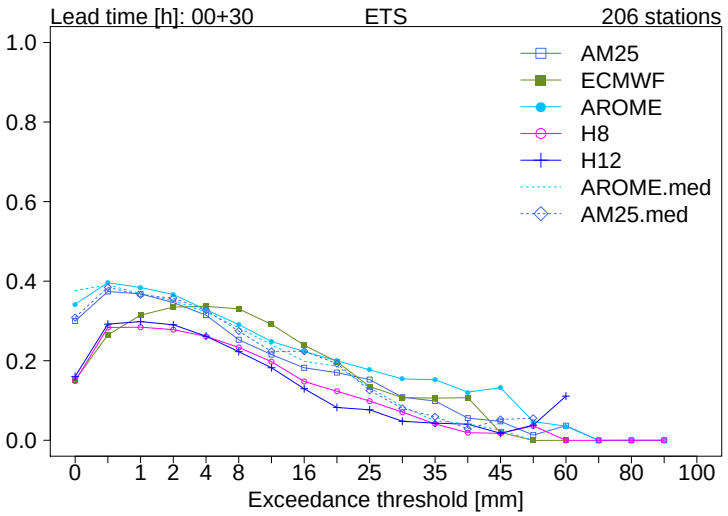


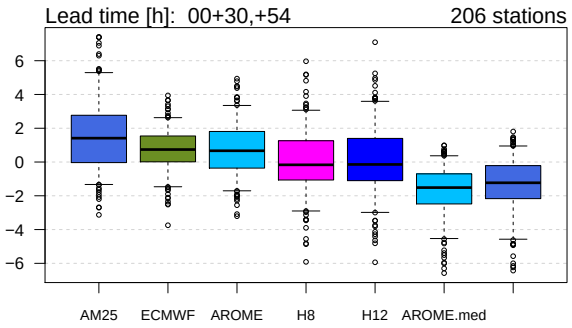




Lead time [h]: 00+30
HR
206 stations
1.0
0.8
0.6
0.4
0.2
0.0
AM25
ECMWF
AROME
H8
H12
AROME.med
AM25.med
0
1
2
4
8
16
25
35
45
60
80
100
Exceedance threshold [mm]

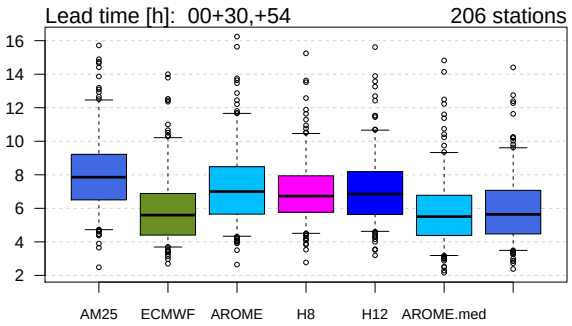

Lead time [h]: 00+30
FAR
206 stations
1.0
0.8
0.6
0.4
0.2
0.0
AM25
ECMWF
AROME
H8
H12
AROME.med
AM25.med
0
1
2
4
8
16
25
35
45
60
80
100
Exceedance threshold [mm]


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

ME




SDE




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

**AM25**

| | OBS | | | | | |
|---|---|---|---|---|---|---|
| | [0,0.1] | (0.1,5] | (5,20] | (20,50] | (50,Inf] | Sum |
| [0,0.1] | 4747 | 1917 | 232 | 27 | 2 | 6925 |
| (0.1,5] | 2309 | 6052 | 1637 | 175 | 2 | 10175 |
| (5,20] | 469 | 3262 | 3013 | 509 | 9 | 7262 |
| (20,50] | 54 | 537 | 879 | 436 | 20 | 1926 |
| (50,Inf] | 2 | 15 | 49 | 55 | 3 | 124 |
| Sum | 7581 | 11783 | 5810 | 1202 | 36 | 26412 |

**AM25.med**

| | OBS | | | | | |
|---|---|---|---|---|---|---|
| | [0,0.1] | (0.1,5] | (5,20] | (20,50] | (50,Inf] | Sum |
| [0,0.1] | 5748 | 3099 | 446 | 55 | 2 | 9350 |
| (0.1,5] | 1684 | 6828 | 2516 | 314 | 5 | 11347 |
| (5,20] | 144 | 1799 | 2577 | 568 | 15 | 5103 |
| (20,50] | 5 | 57 | 271 | 264 | 13 | 610 |
| (50,Inf] | 0 | 0 | 0 | 1 | 1 | 2 |
| Sum | 7581 | 11783 | 5810 | 1202 | 36 | 26412 |

**ECMWF**

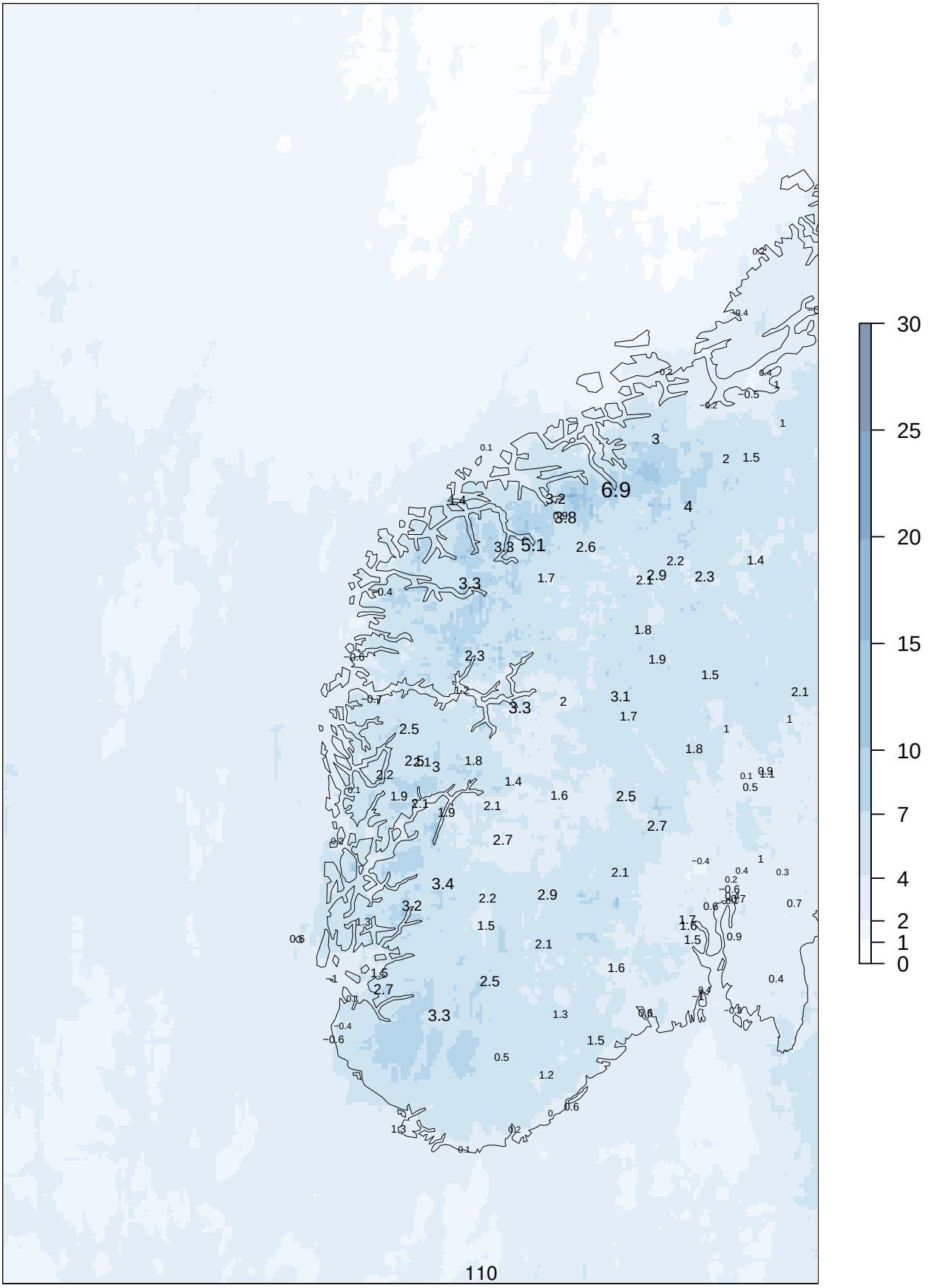
| | OBS | | | | | |
|---|---|---|---|---|---|---|
| | [0,0.1] | (0.1,5] | (5,20] | (20,50] | (50,Inf] | Sum |
| [0,0.1] | 2719 | 431 | 44 | 7 | 0 | 3201 |
| (0.1,5] | 4424 | 7297 | 1446 | 120 | 2 | 13289 |
| (5,20] | 431 | 3947 | 3950 | 748 | 14 | 9090 |
| (20,50] | 7 | 108 | 364 | 315 | 20 | 814 |
| (50,Inf] | 0 | 0 | 6 | 12 | 0 | 18 |
| Sum | 7581 | 11783 | 5810 | 1202 | 36 | 26412 |

**AROME**

| | OBS | | | | | |
|---|---|---|---|---|---|---|
| | [0,0.1] | (0.1,5] | (5,20] | (20,50] | (50,Inf] | Sum |
| [0,0.1] | 4929 | 1930 | 217 | 29 | 0 | 7105 |
| (0.1,5] | 2252 | 6672 | 1852 | 187 | 4 | 10967 |
| (5,20] | 368 | 2862 | 3007 | 534 | 7 | 6778 |
| (20,50] | 30 | 313 | 690 | 405 | 20 | 1458 |
| (50,Inf] | 2 | 6 | 44 | 47 | 5 | 104 |
| Sum | 7581 | 11783 | 5810 | 1202 | 36 | 26412 |

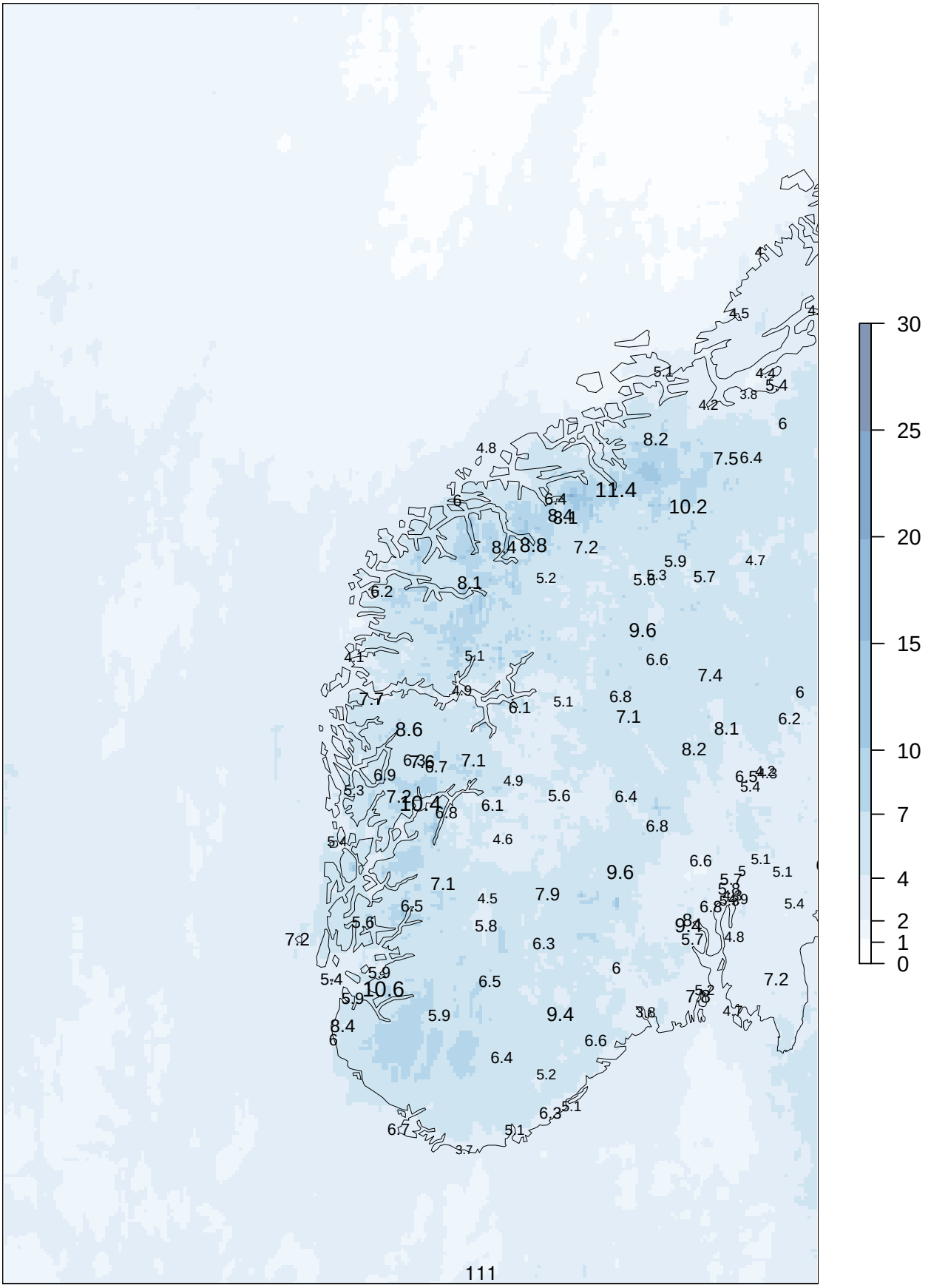
# AM25 00+30

ME at observing sites forecast means 01.06.2014 − 31.08.2014



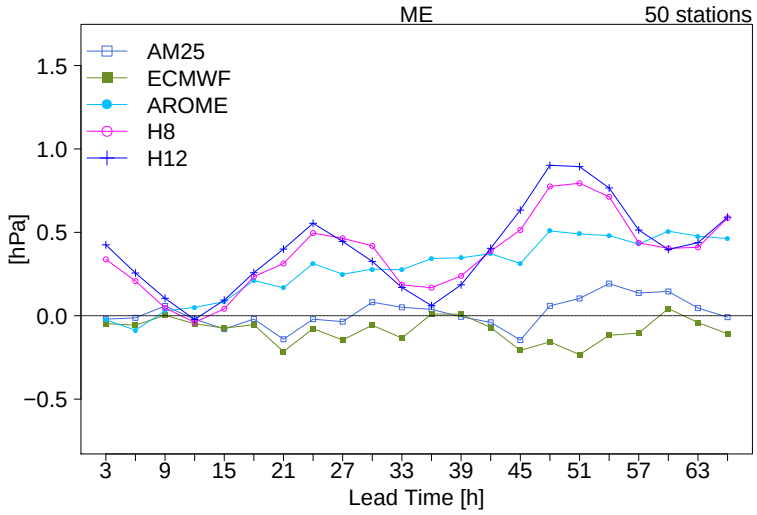
# AM25 00+30

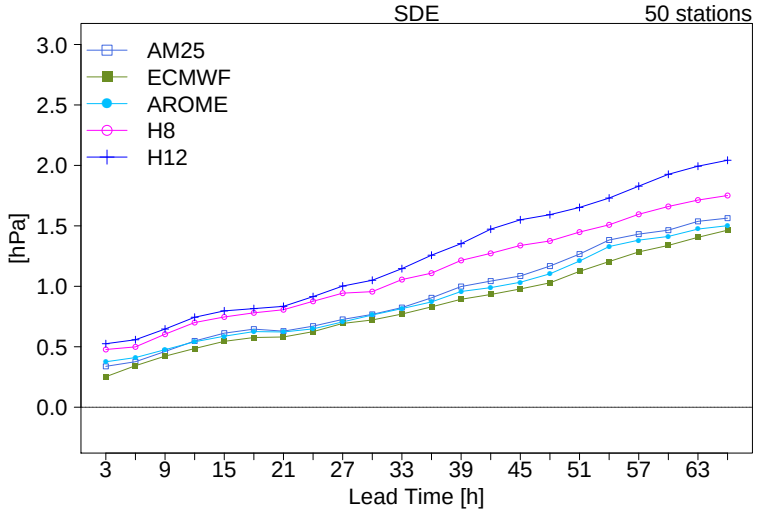
SDE at observing sites forecast means 01.06.2014 − 31.08.2014

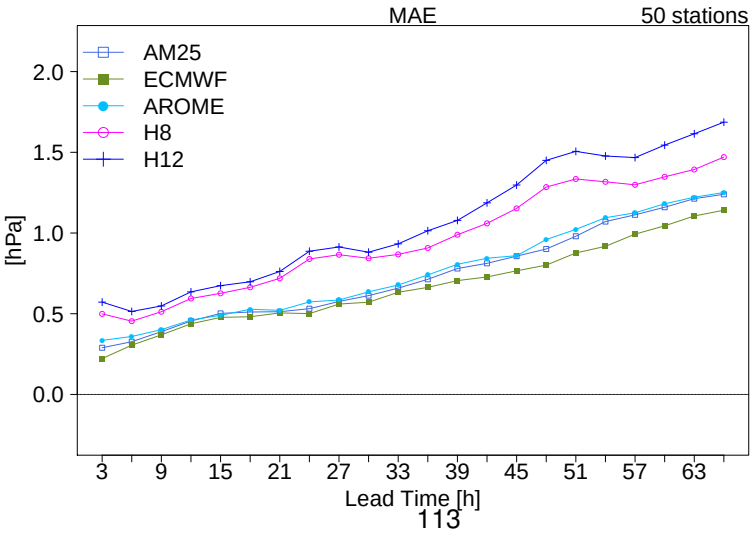


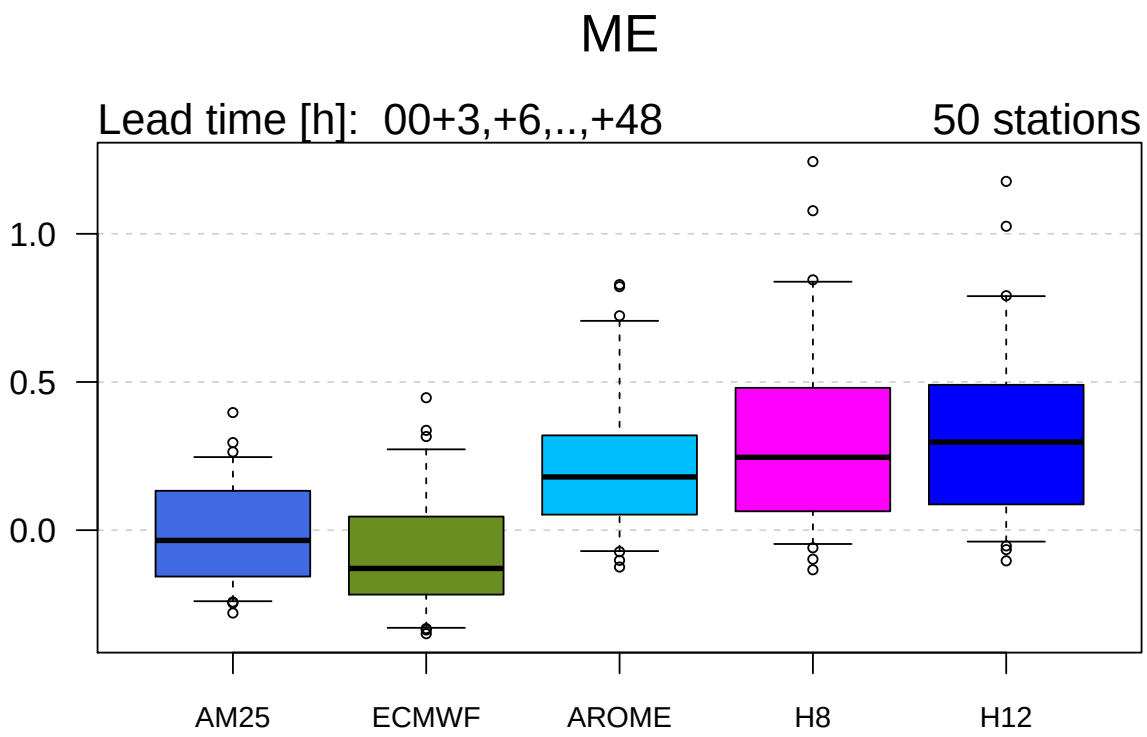
# 7 Northern Norway

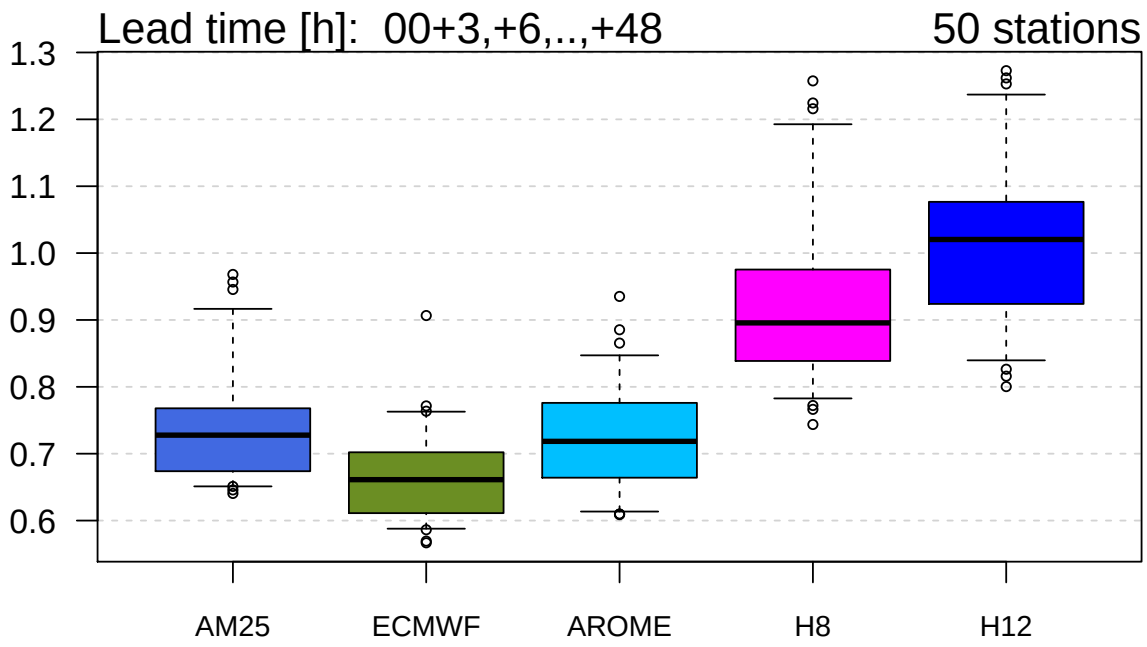
## 7.1 Pressure



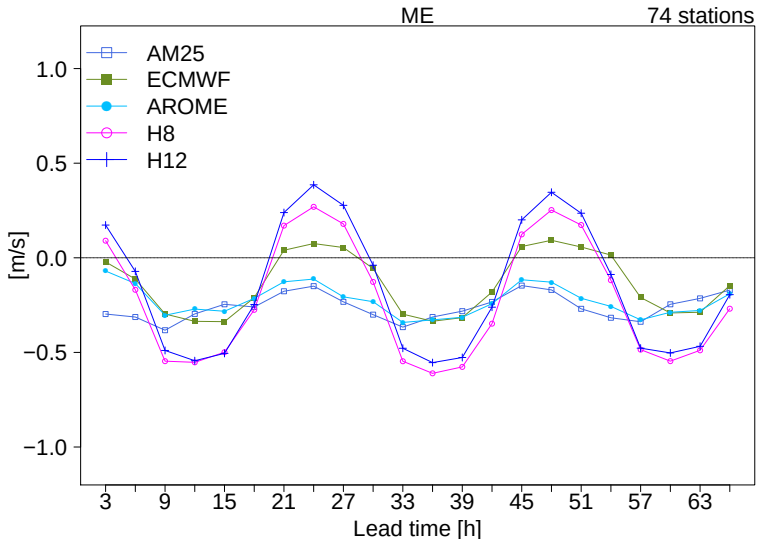



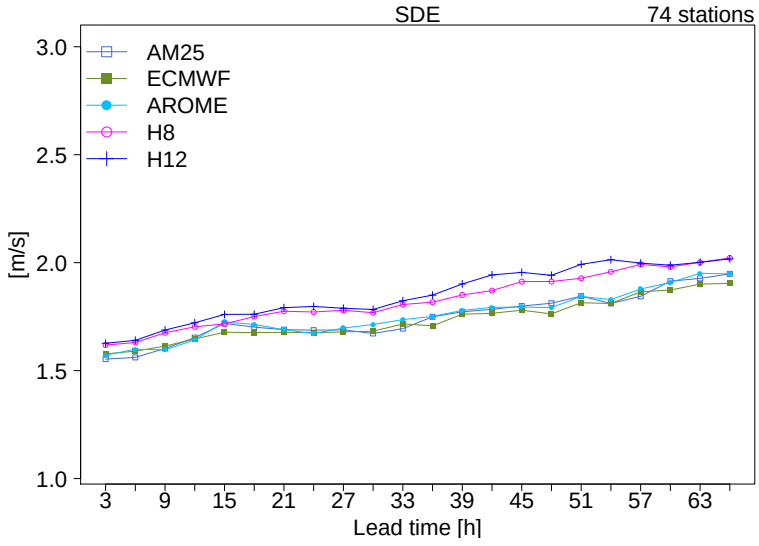



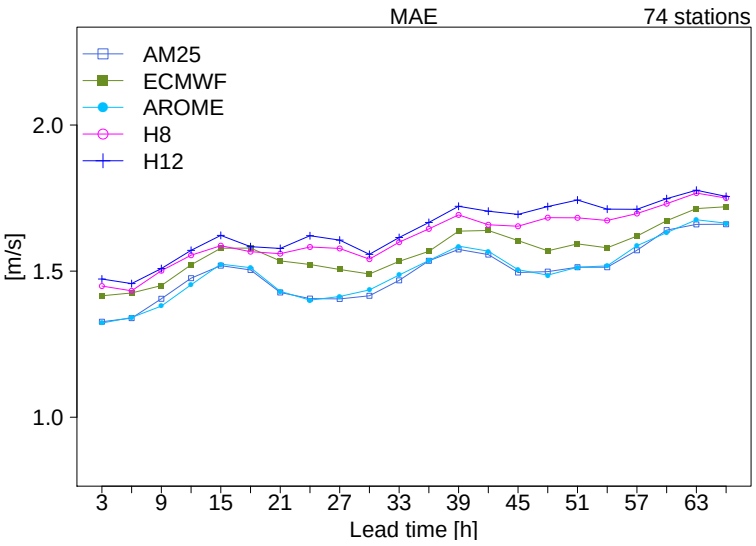

ME
Lead time [h]: 00+3,+6,..,+48
50 stations
1.0
0.5
0.0
AM25
ECMWF
AROME
H8
H12

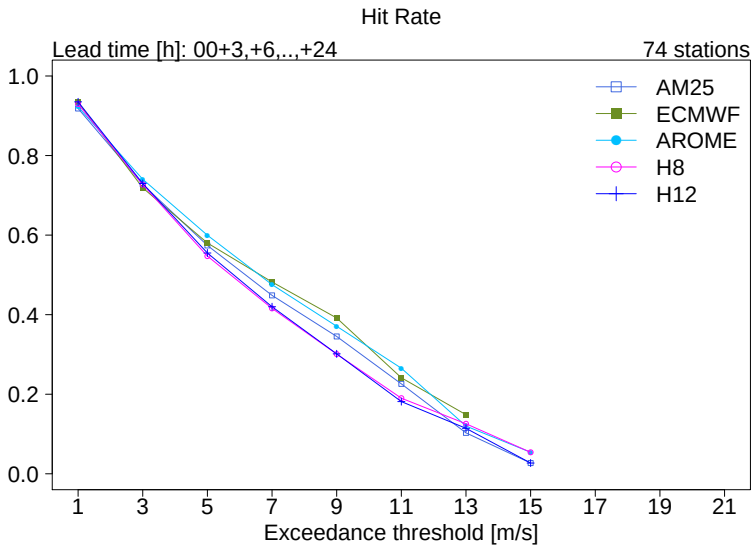

SDE
Lead time [h]: 00+3,+6,..,+48
50 stations
1.3
1.2
1.1
1.0
0.9
0.8
0.7
0.6
AM25
ECMWF
AROME
H8
H12

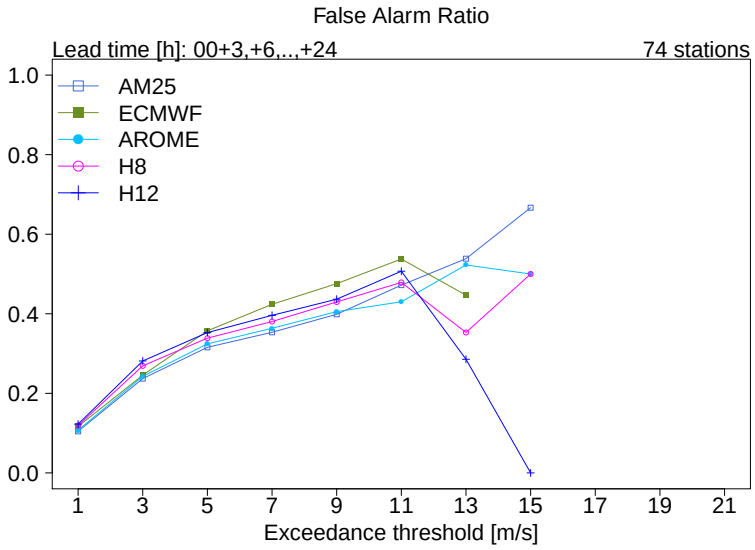
## 7.2 Wind Speed 10m

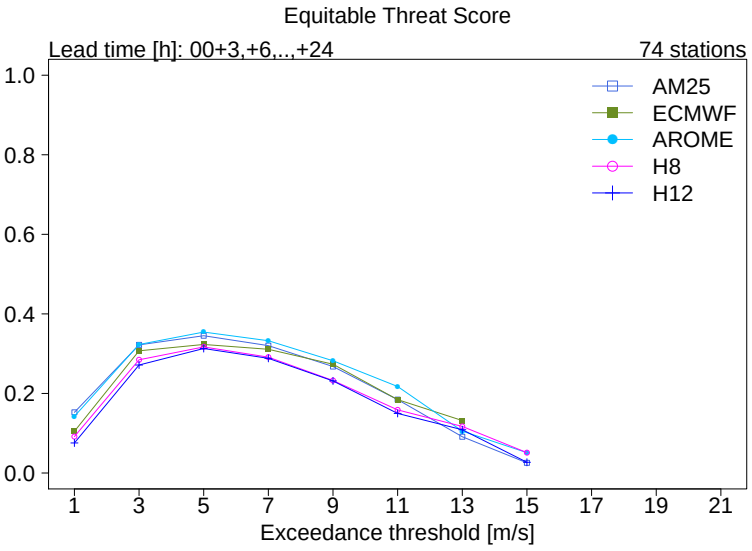


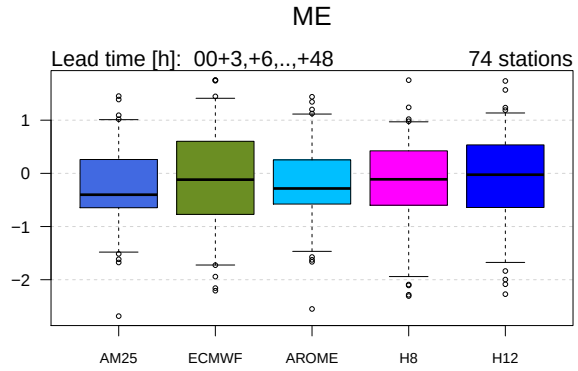



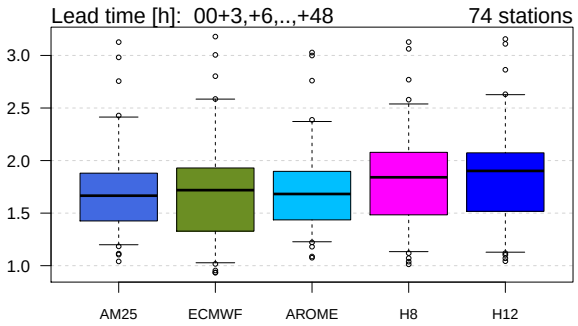




Hit Rate
Lead time [h]: 00+3,+6,..,+24
74 stations
AM25
ECMWF
AROME
H8
H12
1.0
0.8
0.6
0.4
0.2
0.0
1 3 5 7 9 11 13 15 17 19 21
Exceedance threshold [m/s]


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


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




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

74 stations

**AM25**

| | OBS | | | | | |
|---|---|---|---|---|---|---|
| | [0,3] | (3,11] | (11,17] | (17,21] | (21,Inf] | Sum |
| [0,3] | 35489 | 13841 | 28 | 0 | 0 | 49358 |
| (3,11] | 11424 | 34500 | 896 | 9 | 0 | 46829 |
| (11,17] | 2 | 254 | 226 | 5 | 0 | 487 |
| (17,21] | 0 | 0 | 0 | 0 | 0 | 0 |
| (21,Inf] | 0 | 0 | 0 | 0 | 0 | 0 |
| Sum | 46915 | 48595 | 1150 | 14 | 0 | 96674 |

**H8**

| | OBS | | | | | |
|---|---|---|---|---|---|---|
| | [0,3] | (3,11] | (11,17] | (17,21] | (21,Inf] | Sum |
| [0,3] | 33226 | 14268 | 31 | 0 | 0 | 47525 |
| (3,11] | 13682 | 34127 | 928 | 9 | 0 | 48746 |
| (11,17] | 7 | 200 | 191 | 5 | 0 | 403 |
| (17,21] | 0 | 0 | 0 | 0 | 0 | 0 |
| (21,Inf] | 0 | 0 | 0 | 0 | 0 | 0 |
| Sum | 46915 | 48595 | 1150 | 14 | 0 | 96674 |

**ECMWF**

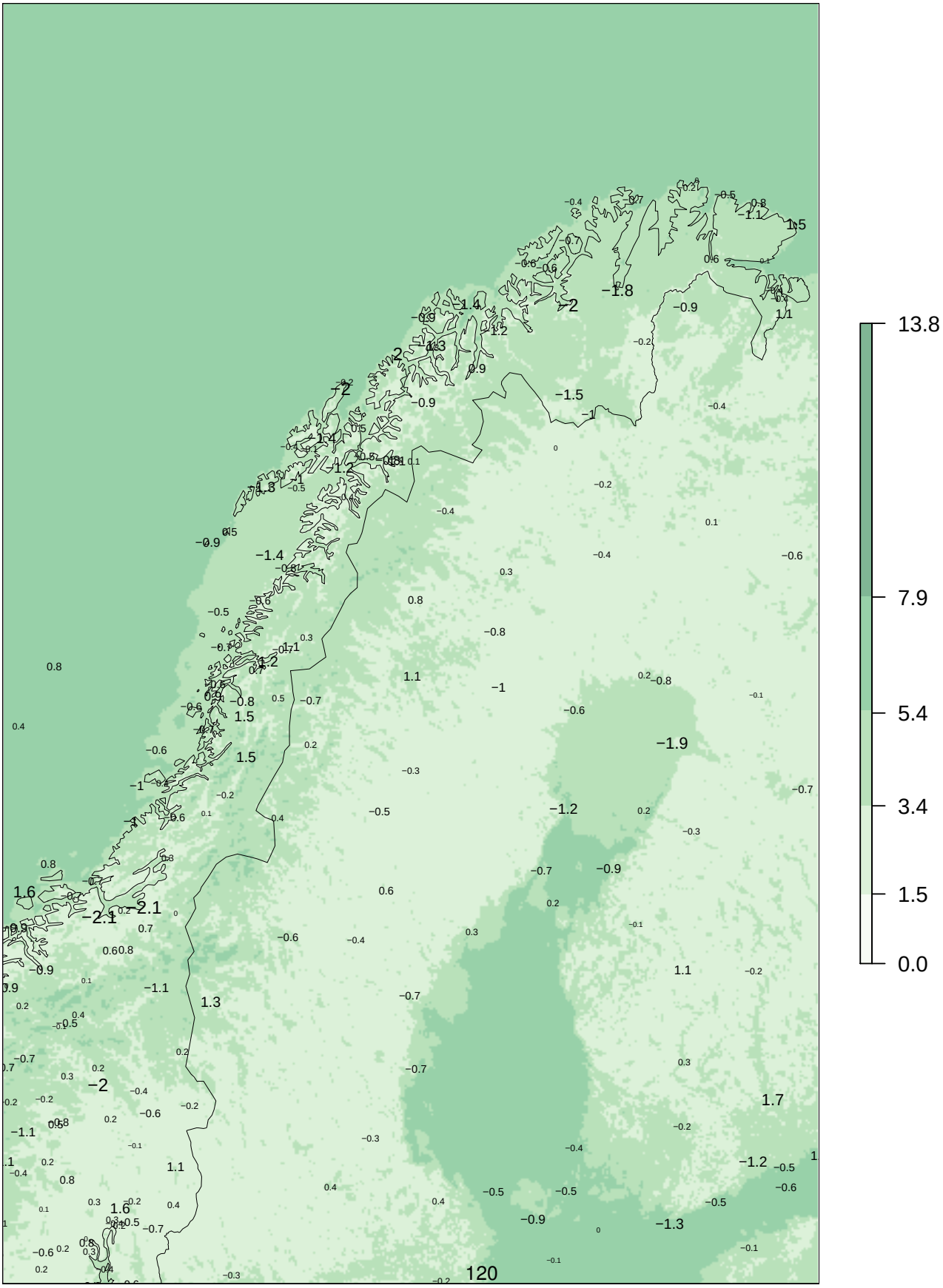
| | OBS | | | | | |
|---|---|---|---|---|---|---|
| | [0,3] | (3,11] | (11,17] | (17,21] | (21,Inf] | Sum |
| [0,3] | 34890 | 14185 | 34 | 0 | 0 | 49109 |
| (3,11] | 12021 | 34103 | 862 | 8 | 0 | 46994 |
| (11,17] | 4 | 307 | 254 | 6 | 0 | 571 |
| (17,21] | 0 | 0 | 0 | 0 | 0 | 0 |
| (21,Inf] | 0 | 0 | 0 | 0 | 0 | 0 |
| Sum | 46915 | 48595 | 1150 | 14 | 0 | 96674 |

**AROME**

| | OBS | | | | | |
|---|---|---|---|---|---|---|
| | [0,3] | (3,11] | (11,17] | (17,21] | (21,Inf] | Sum |
| [0,3] | 34968 | 13461 | 20 | 0 | 0 | 48449 |
| (3,11] | 11945 | 34882 | 875 | 8 | 0 | 47710 |
| (11,17] | 2 | 251 | 254 | 6 | 0 | 513 |
| (17,21] | 0 | 1 | 1 | 0 | 0 | 2 |
| (21,Inf] | 0 | 0 | 0 | 0 | 0 | 0 |
| Sum | 46915 | 48595 | 1150 | 14 | 0 | 96674 |

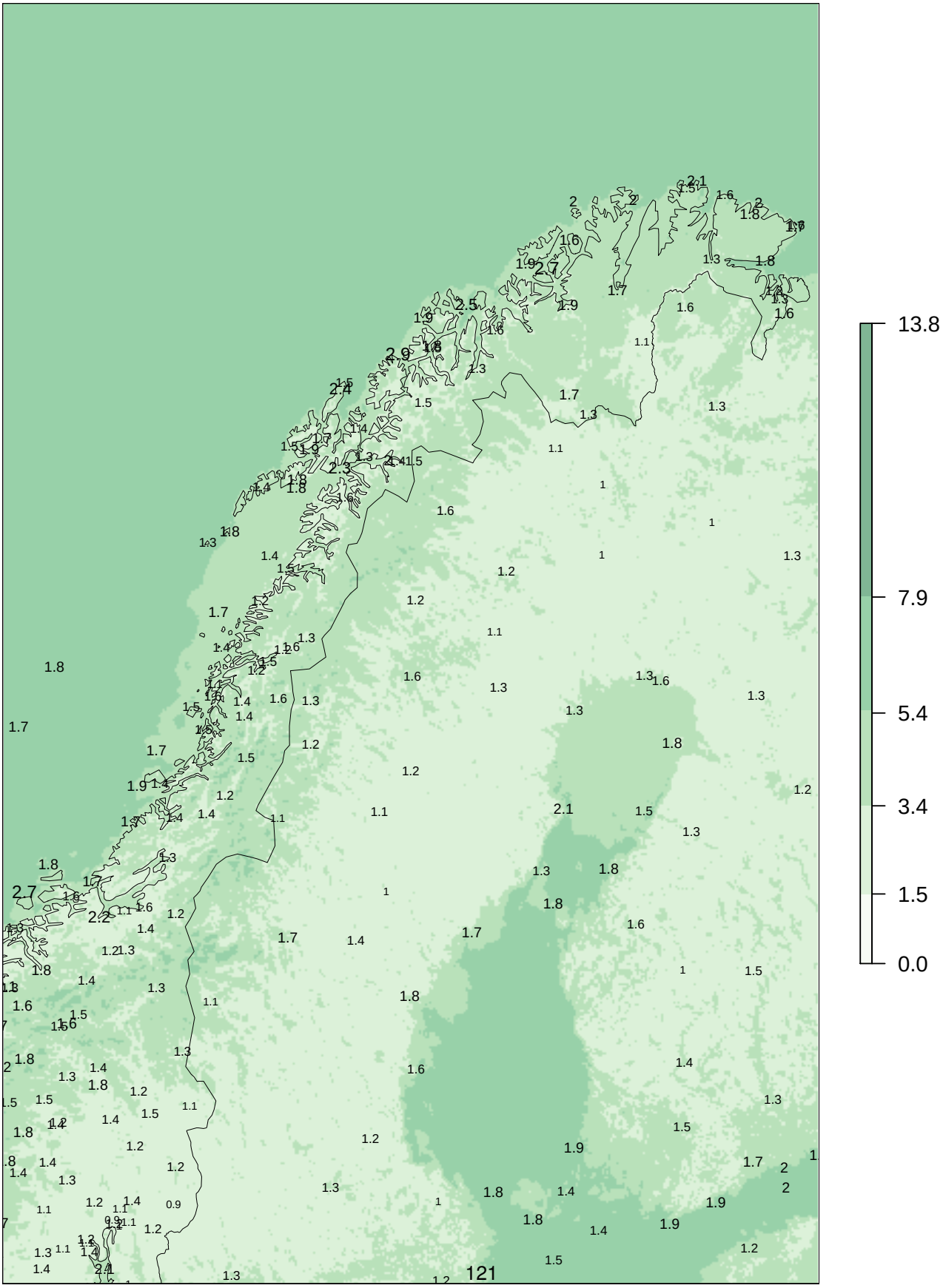
# AM25 00+12

ME at observing sites forecast means 01.06.2014 − 31.08.2014

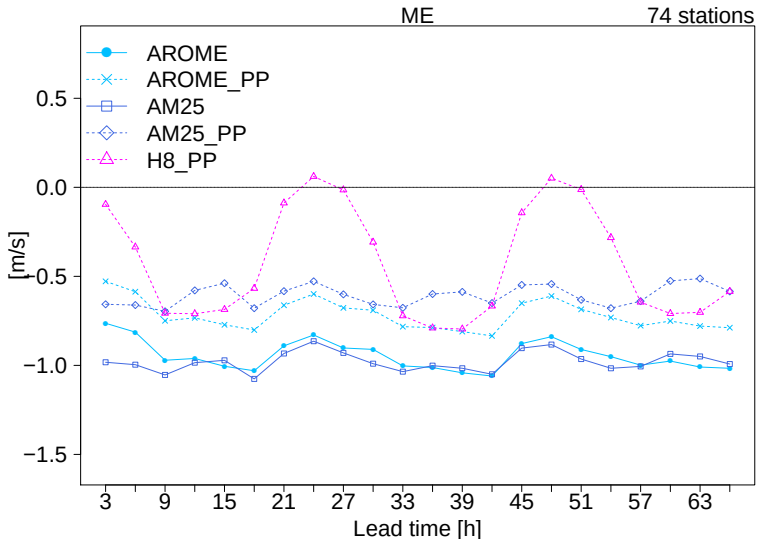


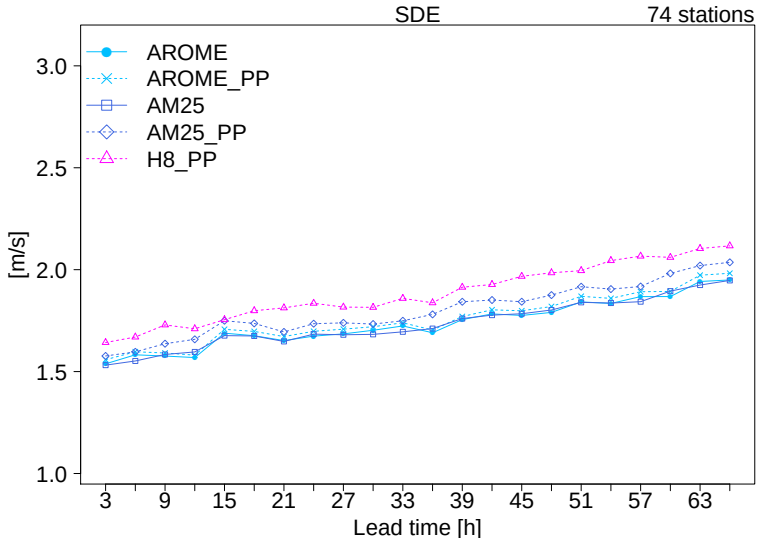
# AM25 00+12

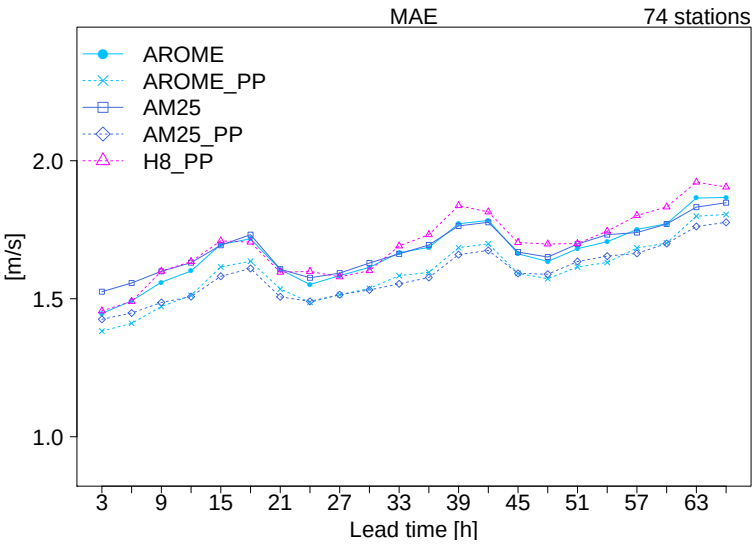
SDE at observing sites forecast means 01.06.2014 − 31.08.2014

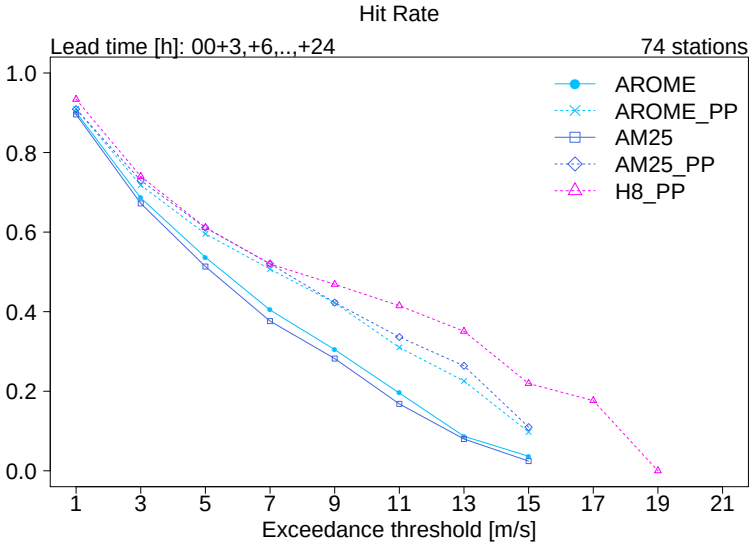


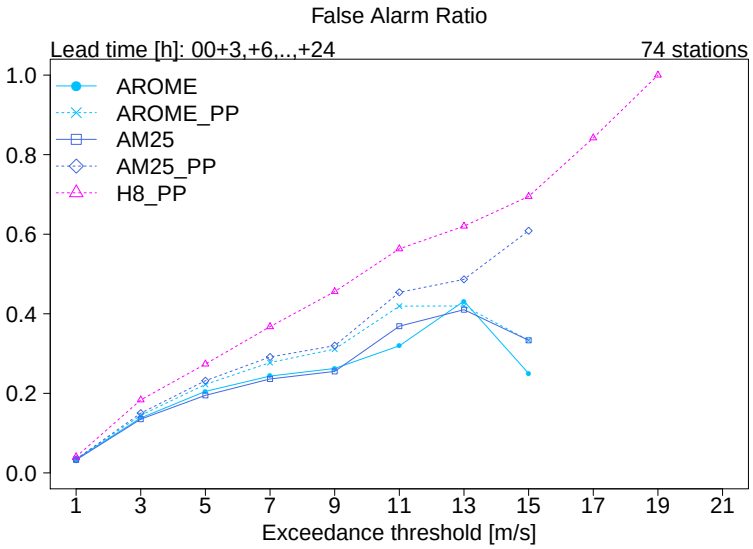
## 7.3 Max Mean Wind Speed 10m

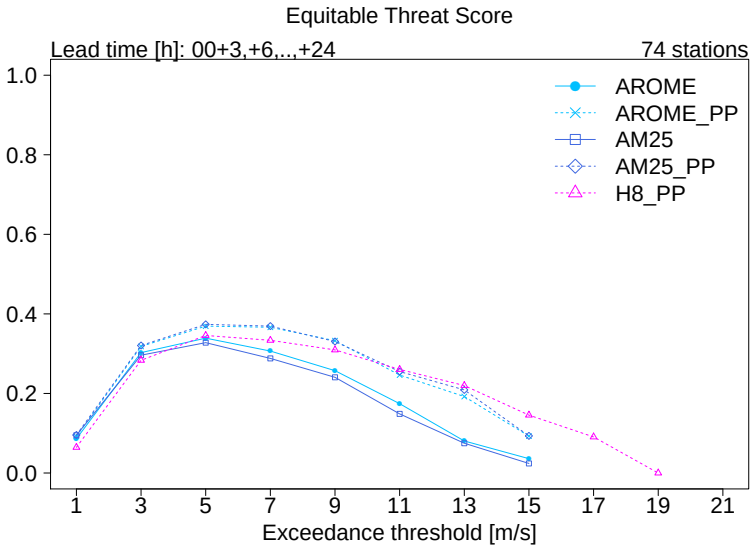


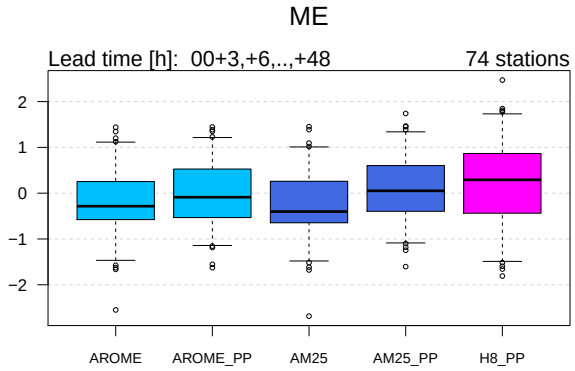



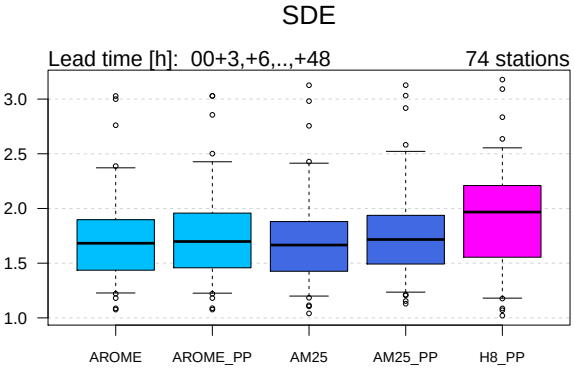




Hit Rate
Lead time [h]: 00+3,+6,..,+24
74 stations
AROME
AROME_PP
AM25
AM25_PP
H8_PP
1.0
0.8
0.6
0.4
0.2
0.0
1 3 5 7 9 11 13 15 17 19 21
Exceedance threshold [m/s]


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


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




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

**AM25**

| OBS | [0,3] | (3,11] | (11,17] | (17,21] | (21,Inf] | Sum |
|---|---|---|---|---|---|---|
| [0,3] | 25521 | 17772 | 48 | 0 | 0 | 43341 |
| (3,11] | 5797 | 33746 | 1469 | 24 | 2 | 41038 |
| (11,17] | 1 | 195 | 271 | 8 | 0 | 475 |
| (17,21] | 0 | 0 | 0 | 0 | 0 | 0 |
| (21,Inf] | 0 | 0 | 0 | 0 | 0 | 0 |
| Sum | 31319 | 51713 | 1788 | 32 | 2 | 84854 |

**AM25_PP**

| OBS | [0,3] | (3,11] | (11,17] | (17,21] | (21,Inf] | Sum |
|---|---|---|---|---|---|---|
| [0,3] | 24243 | 14697 | 33 | 0 | 0 | 38973 |
| (3,11] | 7073 | 36461 | 1203 | 13 | 2 | 44752 |
| (11,17] | 3 | 555 | 550 | 19 | 0 | 1127 |
| (17,21] | 0 | 0 | 2 | 0 | 0 | 2 |
| (21,Inf] | 0 | 0 | 0 | 0 | 0 | 0 |
| Sum | 31319 | 51713 | 1788 | 32 | 2 | 84854 |

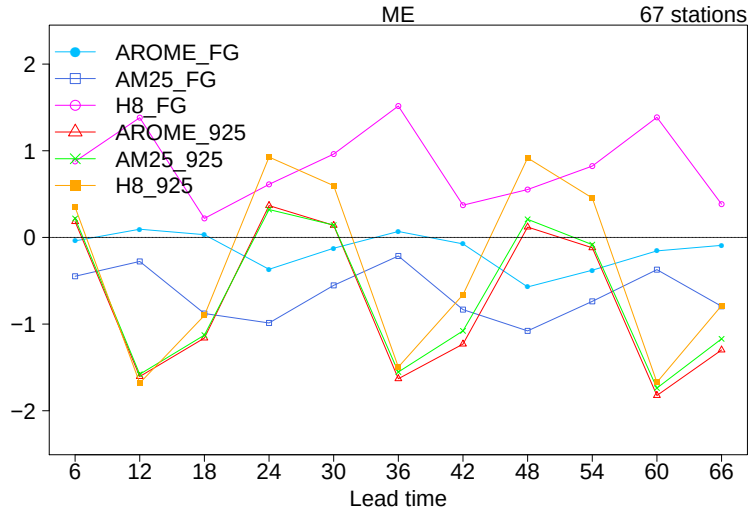
**AROME**

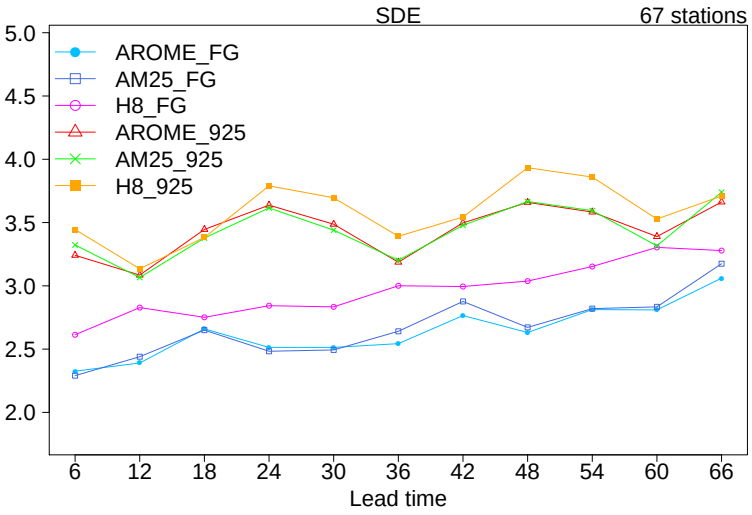
| OBS | [0,3] | (3,11] | (11,17] | (17,21] | (21,Inf] | Sum |
|---|---|---|---|---|---|---|
| [0,3] | 25263 | 17229 | 46 | 0 | 0 | 42538 |
| (3,11] | 6056 | 34297 | 1439 | 23 | 2 | 41817 |
| (11,17] | 0 | 187 | 301 | 9 | 0 | 497 |
| (17,21] | 0 | 0 | 2 | 0 | 0 | 2 |
| (21,Inf] | 0 | 0 | 0 | 0 | 0 | 0 |
| Sum | 31319 | 51713 | 1788 | 32 | 2 | 84854 |

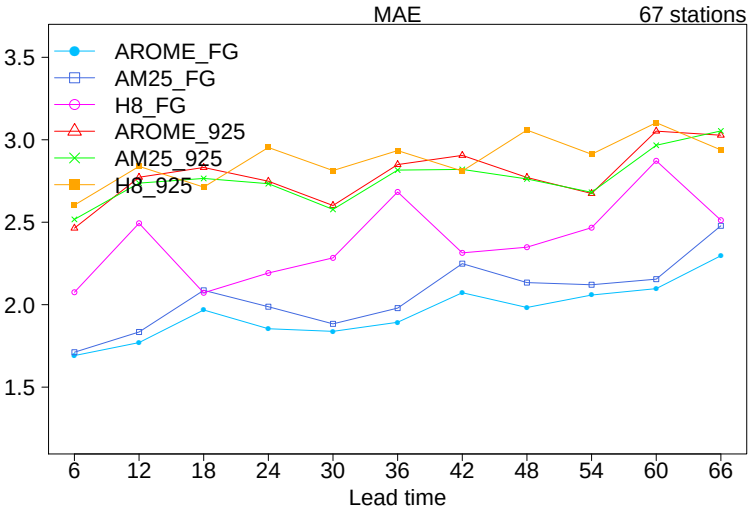
**AROME_PP**

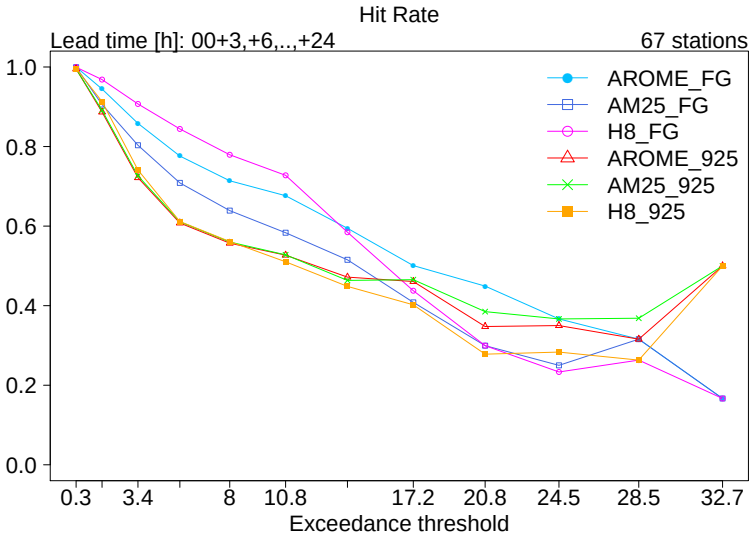
| OBS | [0,3] | (3,11] | (11,17] | (17,21] | (21,Inf] | Sum |
|---|---|---|---|---|---|---|
| [0,3] | 24635 | 15490 | 37 | 0 | 0 | 40162 |
| (3,11] | 6684 | 35796 | 1257 | 13 | 2 | 43752 |
| (11,17] | 0 | 427 | 491 | 19 | 0 | 937 |
| (17,21] | 0 | 0 | 3 | 0 | 0 | 3 |
| (21,Inf] | 0 | 0 | 0 | 0 | 0 | 0 |
| Sum | 31319 | 51713 | 1788 | 32 | 2 | 84854 |

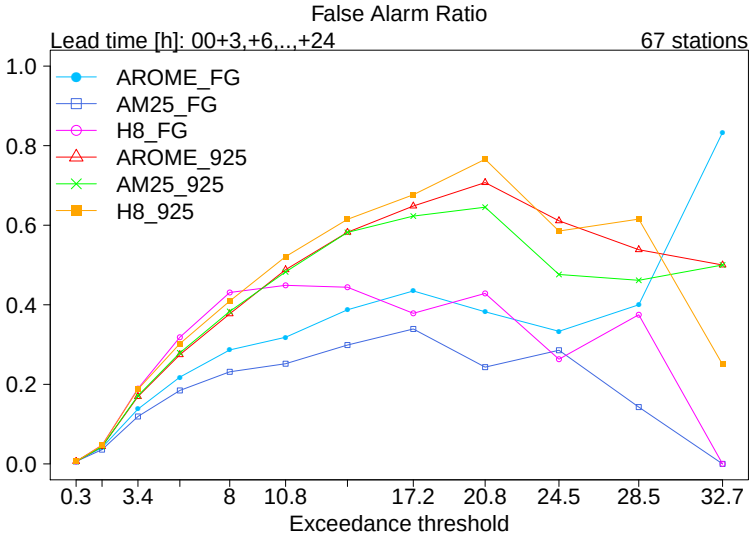
## 7.4 Wind gust

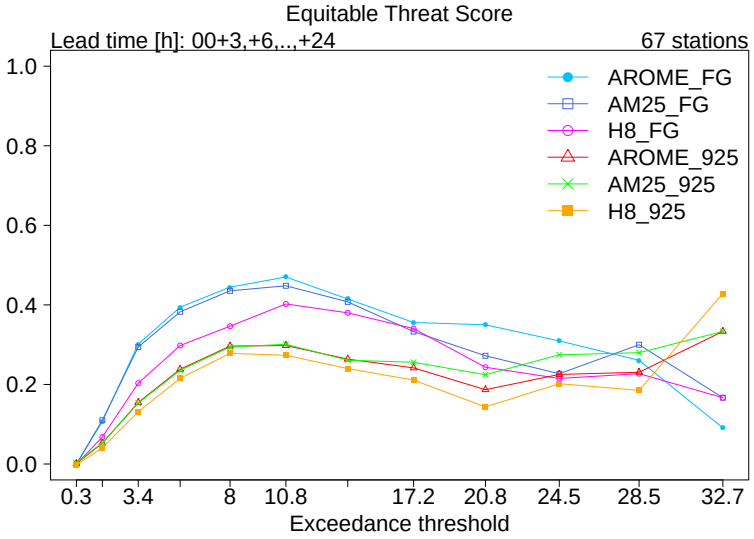

ME
67 stations
AROME_FG
AM25_FG
H8_FG
AROME_925
AM25_925
H8_925
2
1
0
−1
−2
6
12
18
24
30
36
42
48
54
60
66
Lead time


SDE
67 stations
AROME_FG
AM25_FG
H8_FG
AROME_925
AM25_925
H8_925
5.0
4.5
4.0
3.5
3.0
2.5
2.0
6
12
18
24
30
36
42
48
54
60
66
Lead time

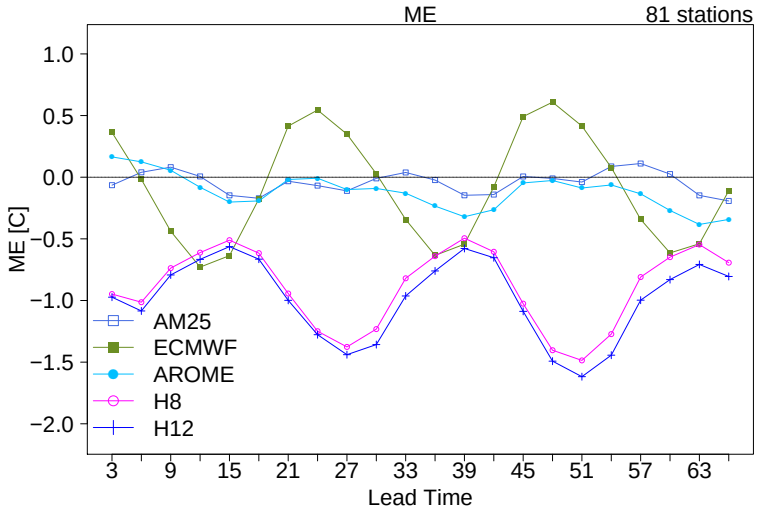

MAE
67 stations
AROME_FG
AM25_FG
H8_FG
AROME_925
AM25_925
H8_925
3.5
3.0
2.5
2.0
1.5
6
12
18
24
30
36
42
48
54
60
66
Lead time

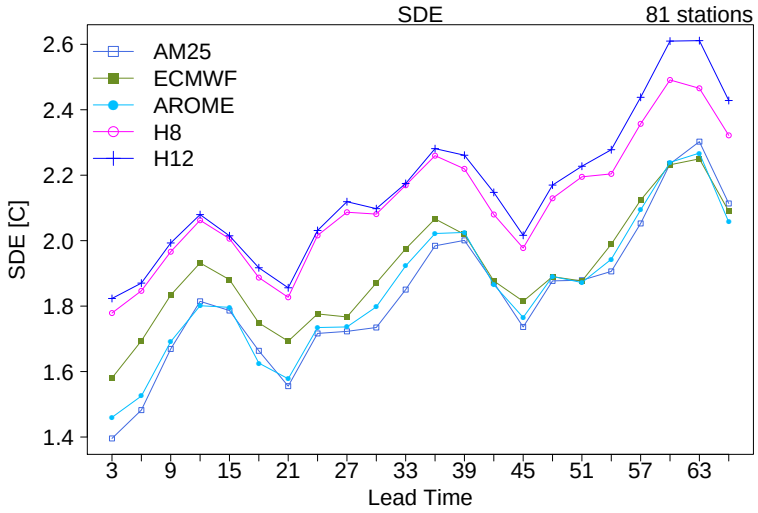

Hit Rate
Lead time [h]: 00+3,+6,..,+24
67 stations
AROME_FG
AM25_FG
H8_FG
AROME_925
AM25_925
H8_925
1.0
0.8
0.6
0.4
0.2
0.0
0.3
3.4
8
10.8
17.2
20.8
24.5
28.5
32.7
Exceedance threshold

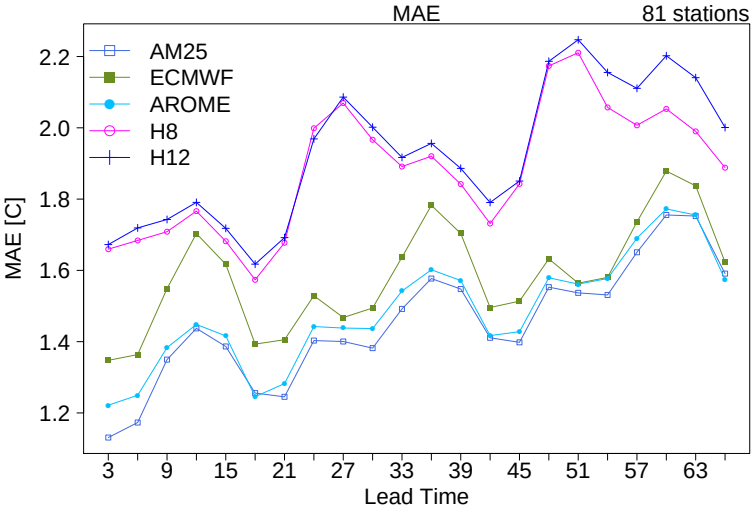

False Alarm Ratio
Lead time [h]: 00+3,+6,..,+24
67 stations
AROME_FG
AM25_FG
H8_FG
AROME_925
AM25_925
H8_925
1.0
0.8
0.6
0.4
0.2
0.0
0.3
3.4
8
10.8
17.2
20.8
24.5
28.5
32.7
Exceedance threshold

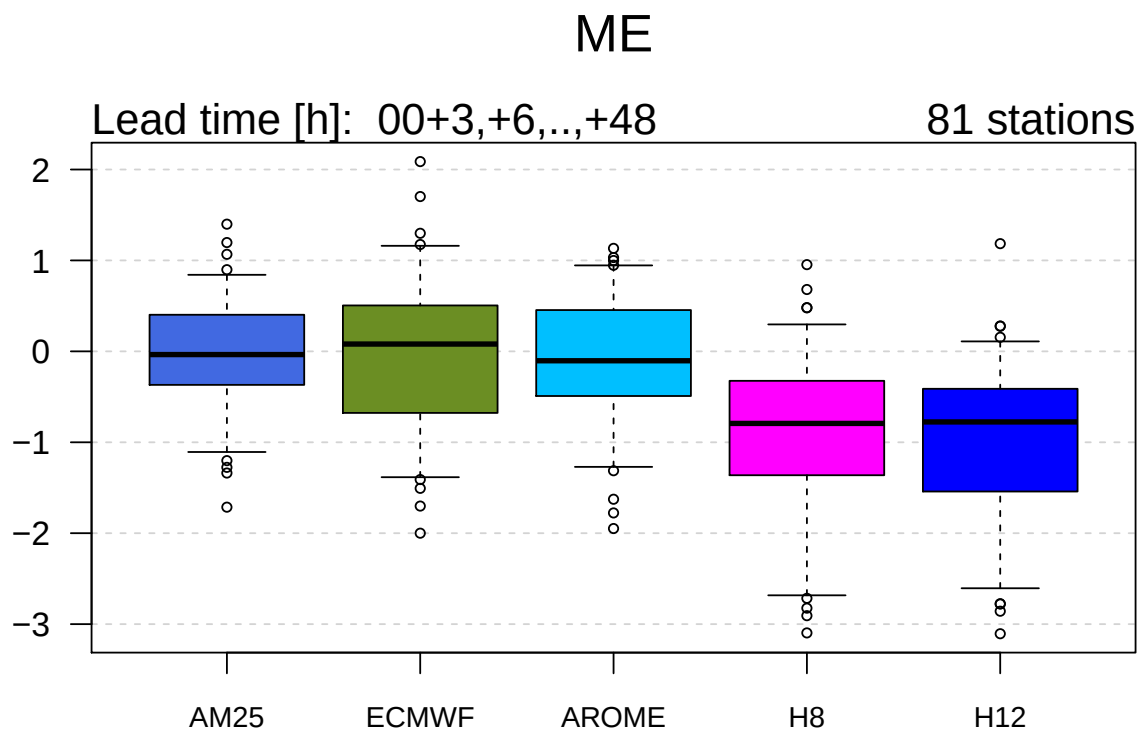

Equitable Threat Score
Lead time [h]: 00+3,+6,..,+24
67 stations
AROME_FG
AM25_FG
H8_FG
AROME_925
AM25_925
H8_925
1.0
0.8
0.6
0.4
0.2
0.0
0.3
3.4
8
10.8
17.2
20.8
24.5
28.5
32.7
Exceedance threshold

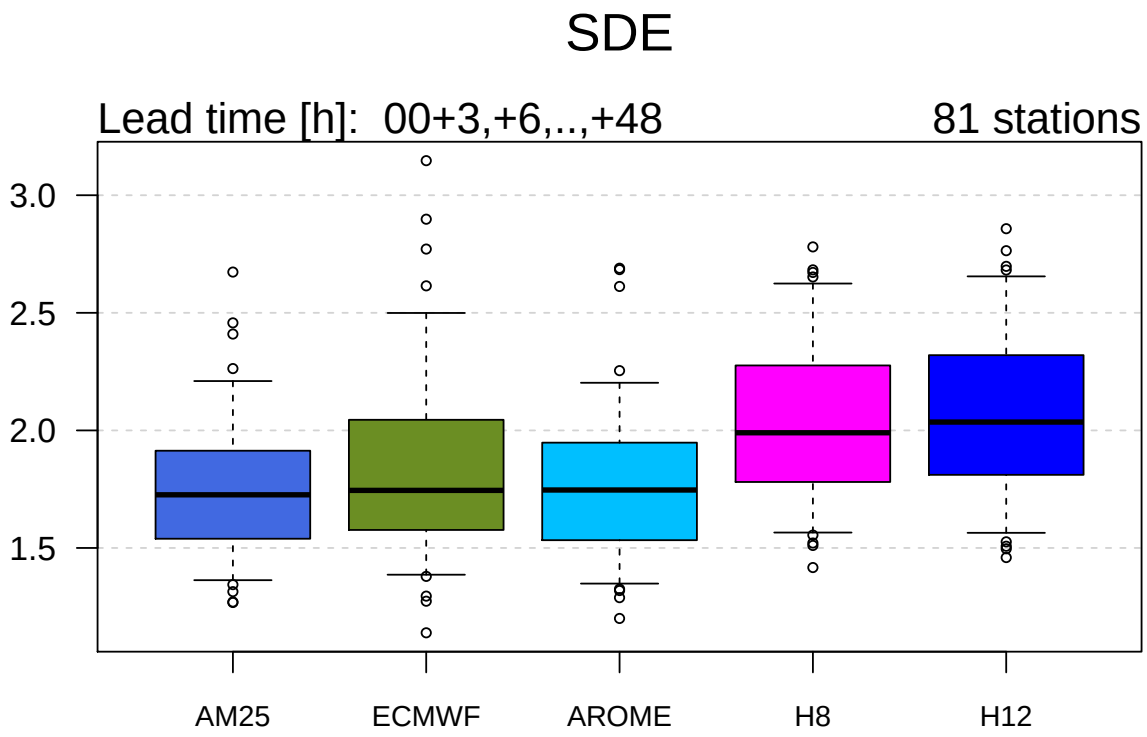
## 7.5 Temperature 2m



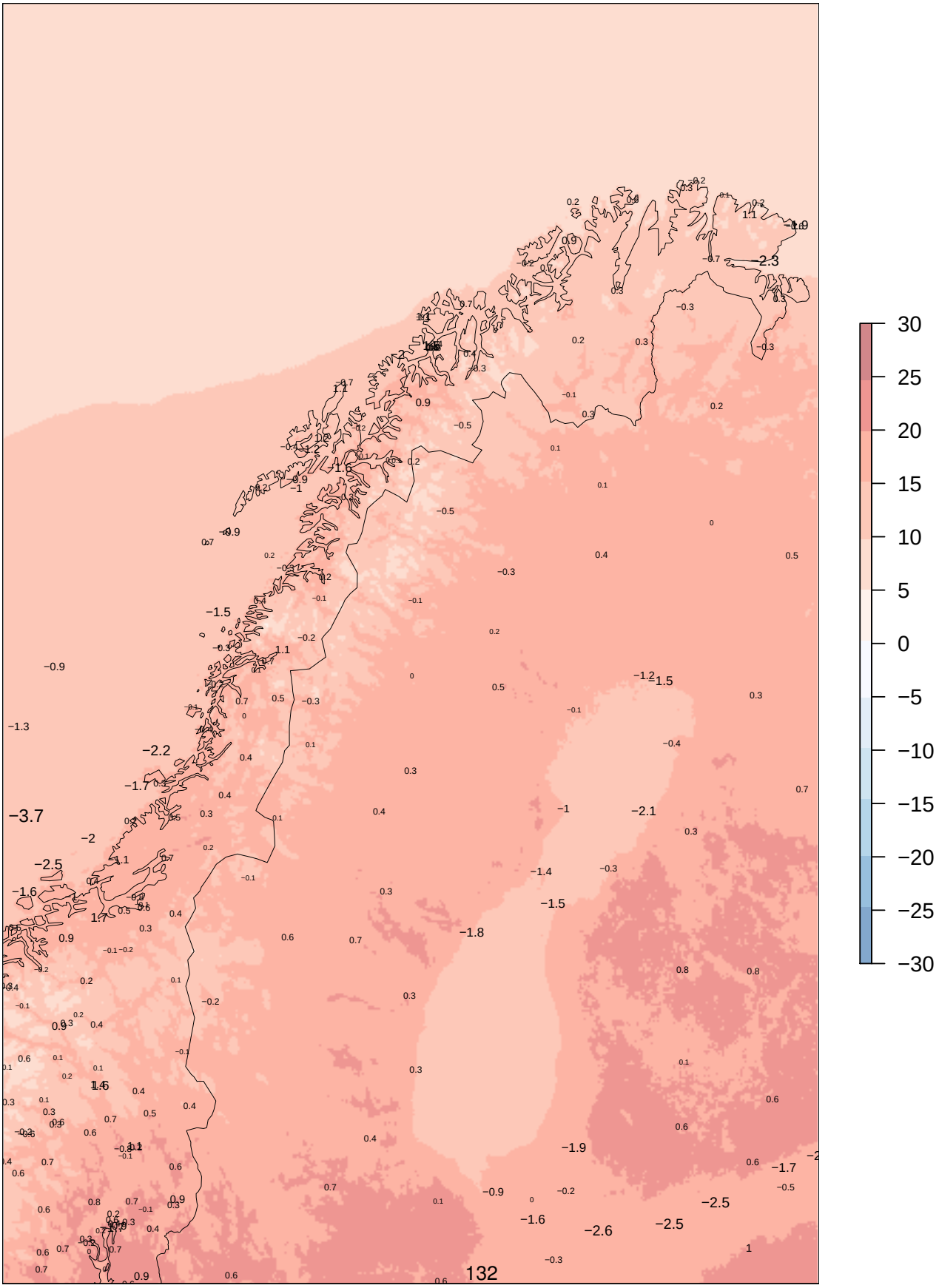




ME
Lead time [h]: 00+3,+6,..,+48
81 stations
2
1
0
−1
−2
−3
AM25
ECMWF
AROME
H8
H12


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

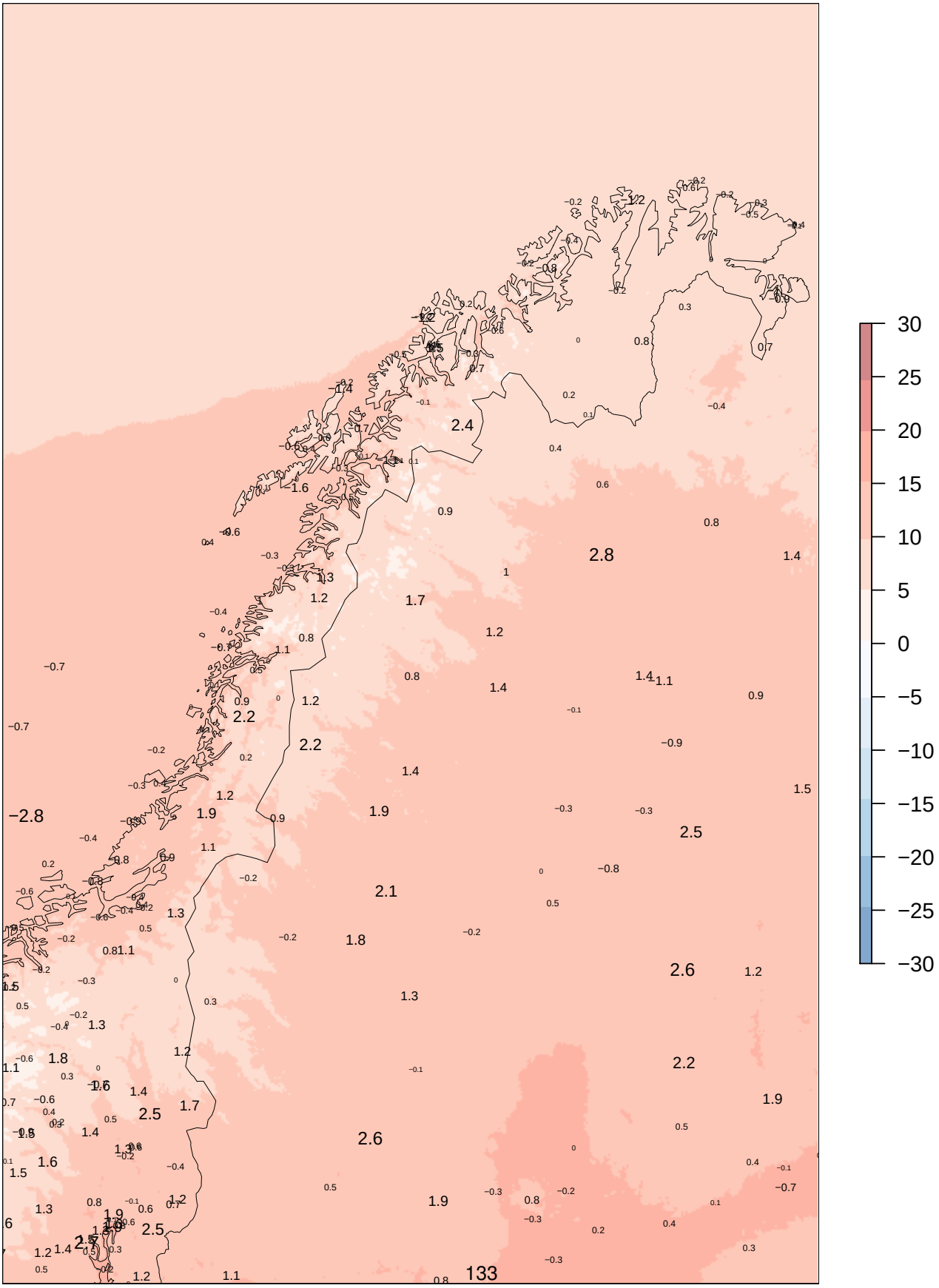
# AM25 00+12

ME at observing sites forecast means 01.06.2014 − 31.08.2014



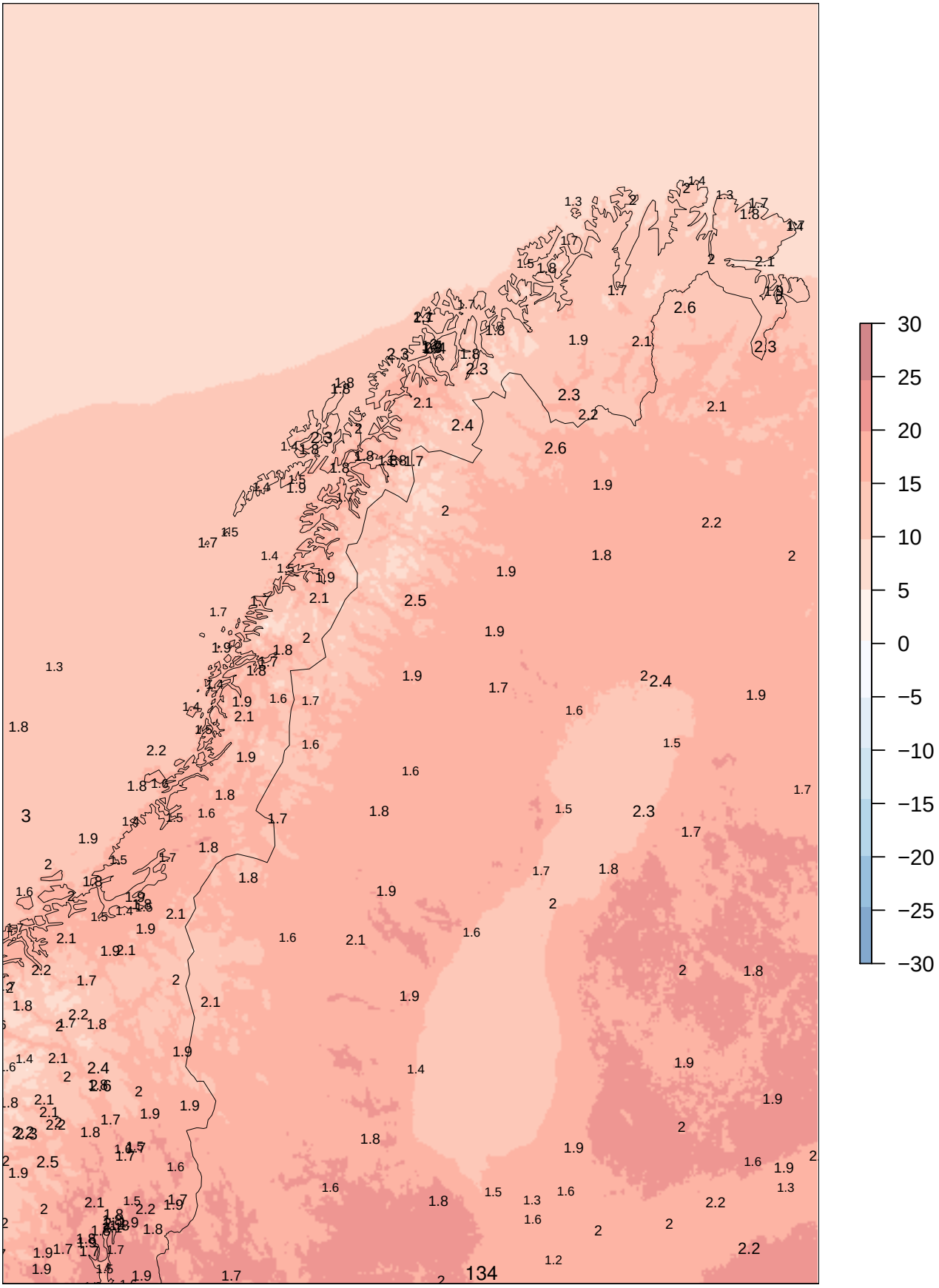
# AM25 00+24

ME at observing sites forecast means 01.06.2014 − 31.08.2014



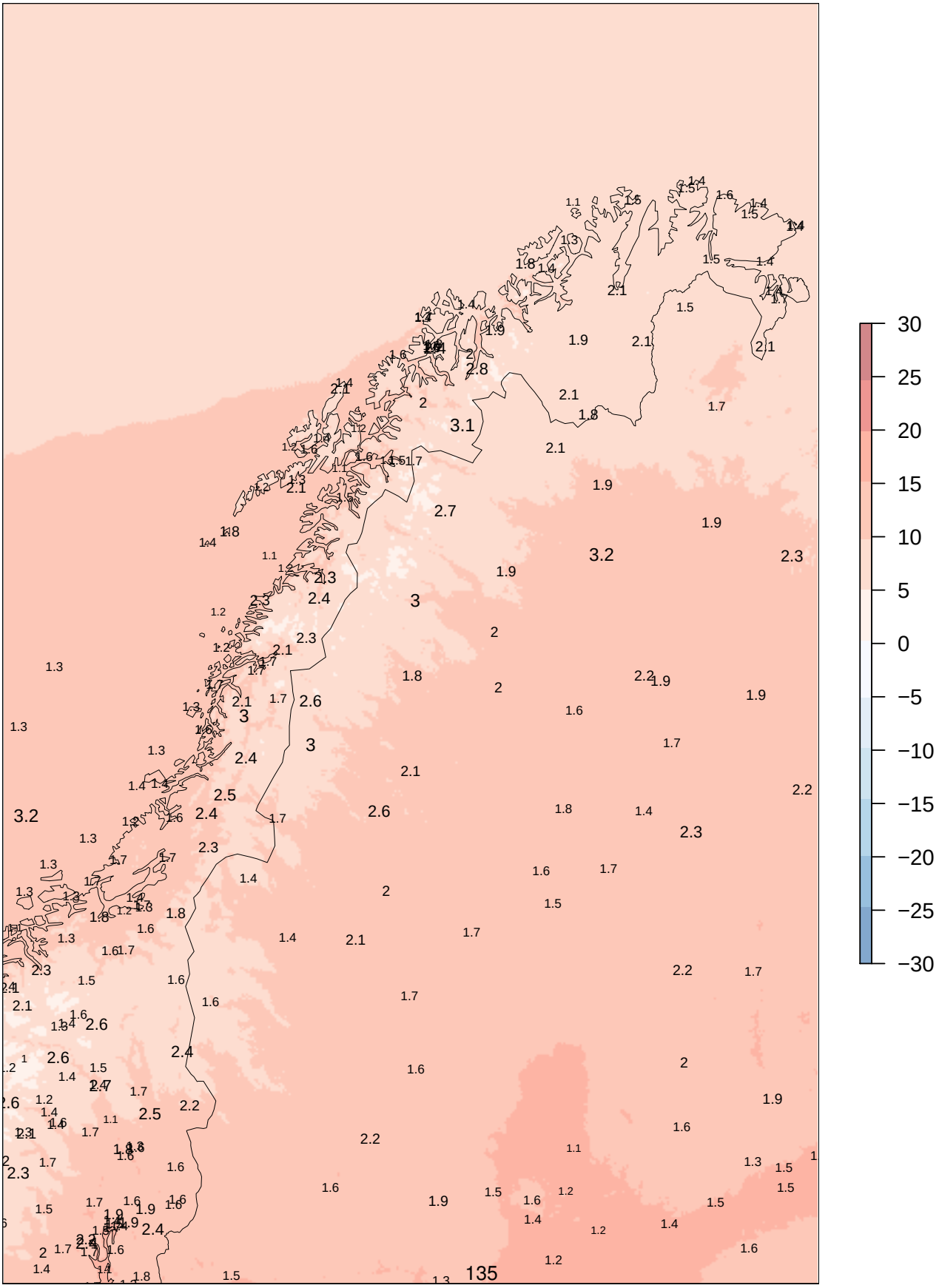
# AM25 00+12

SDE at observing sites forecast means 01.06.2014 − 31.08.2014

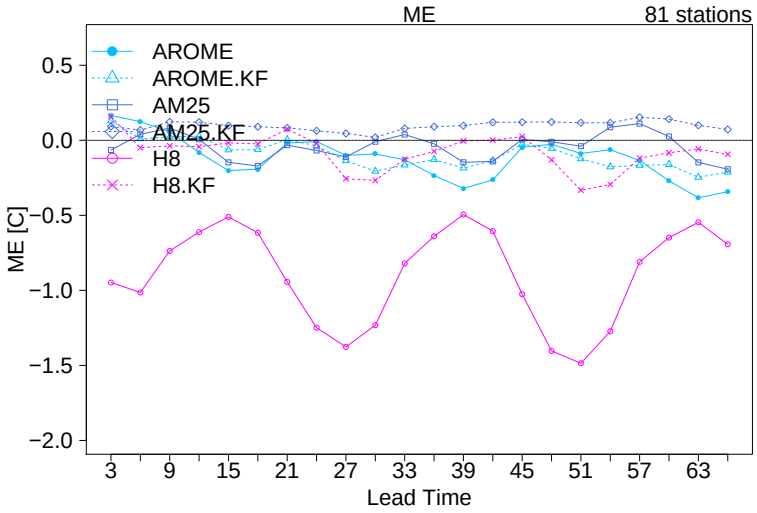


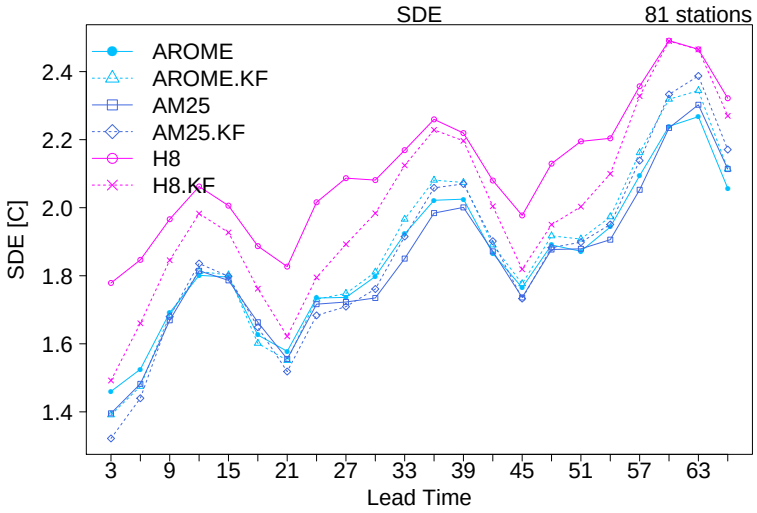
# AM25 00+24

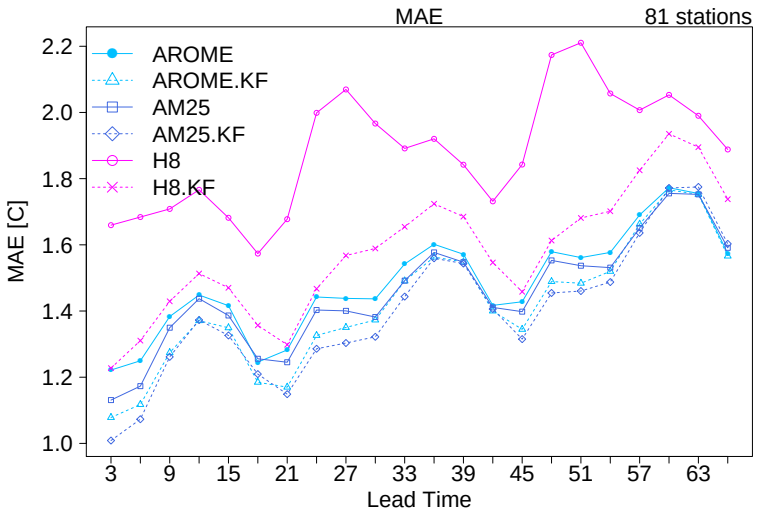
SDE at observing sites forecast means 01.06.2014 − 31.08.2014

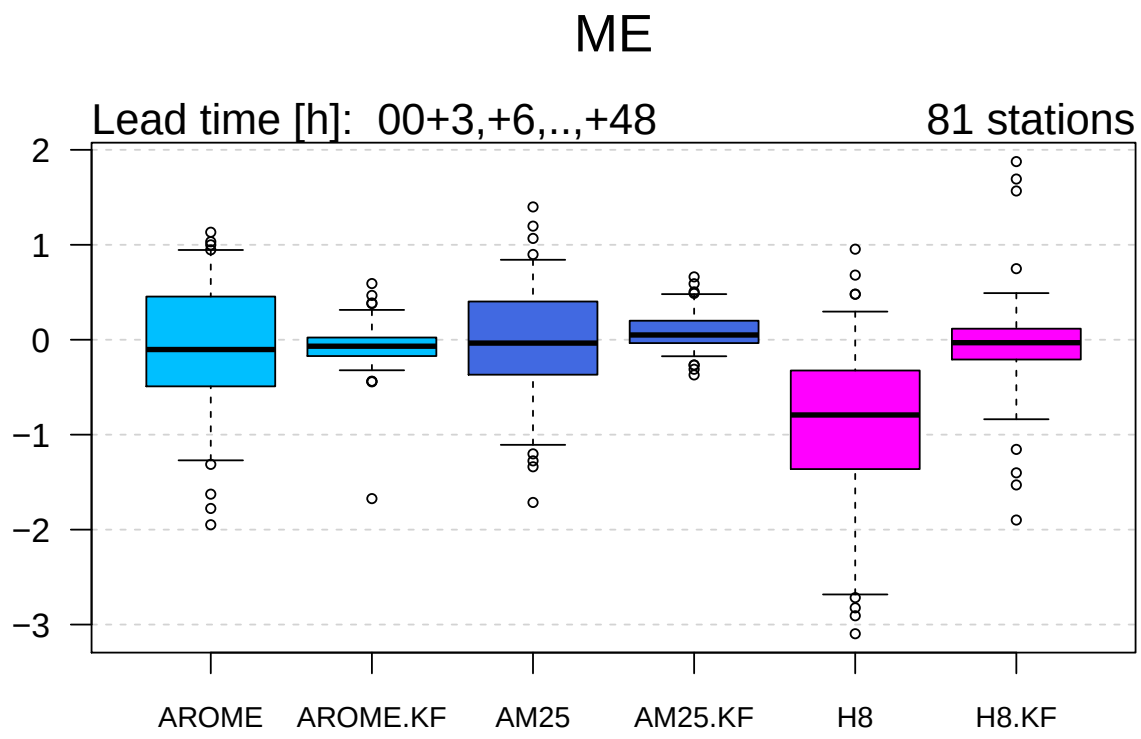


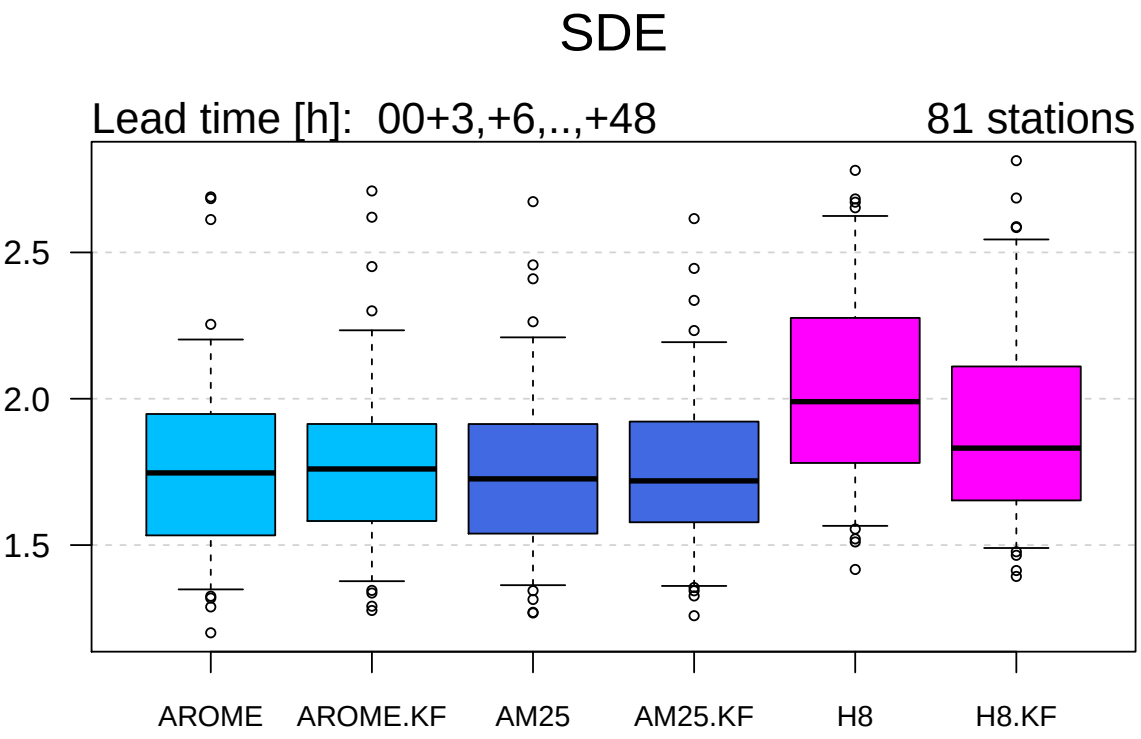
## 7.6 Post processed temperature 2m



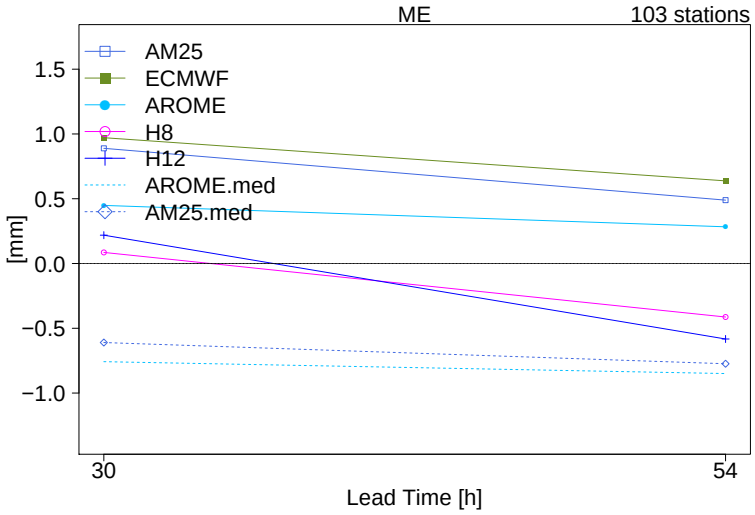



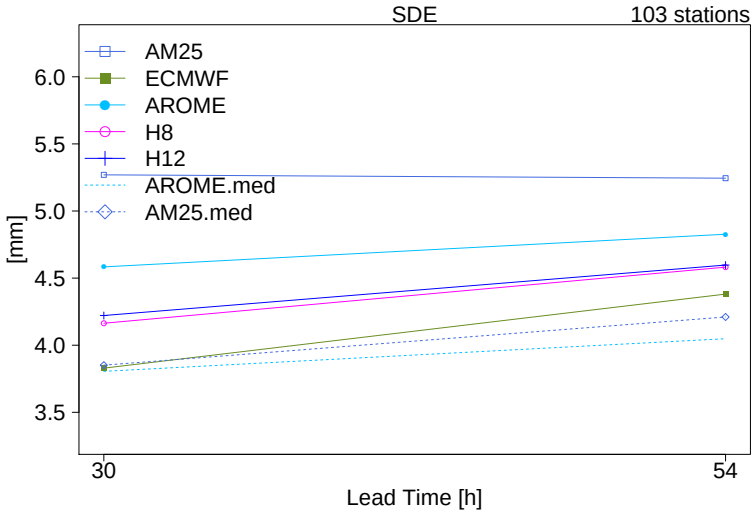



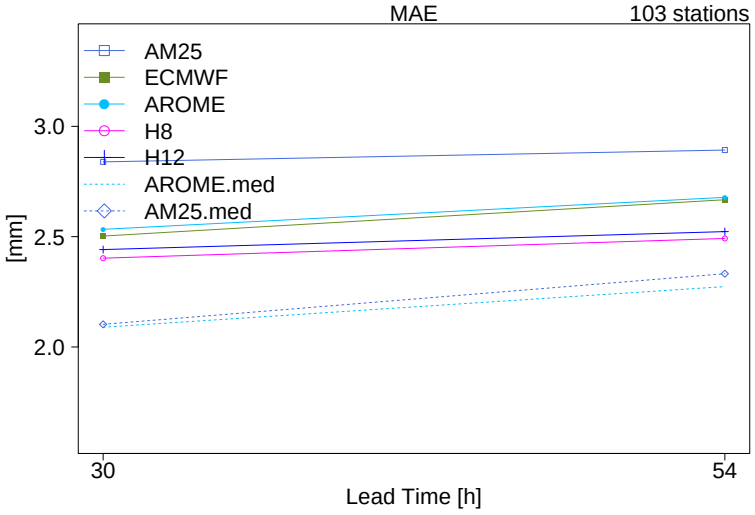

ME
Lead time [h]: 00+3,+6,..,+48
81 stations
2
1
0
−1
−2
−3
AROME
AROME.KF
AM25
AM25.KF
H8
H8.KF

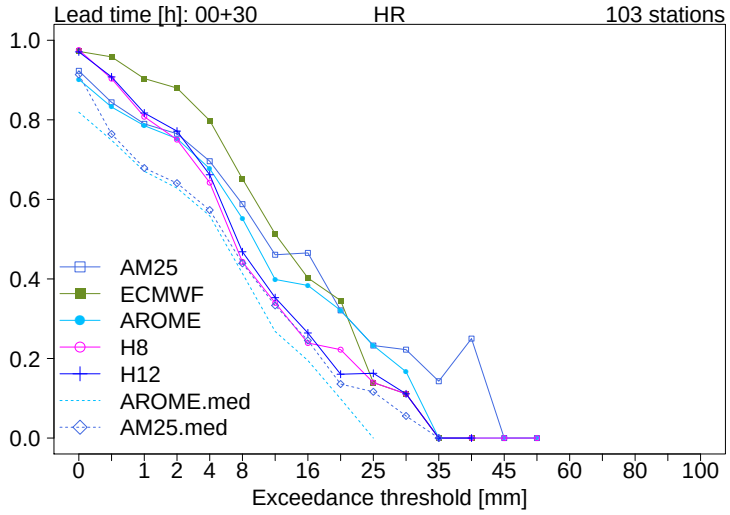

SDE
Lead time [h]: 00+3,+6,..,+48
81 stations
2.5
2.0
1.5
AROME
AROME.KF
AM25
AM25.KF
H8
H8.KF

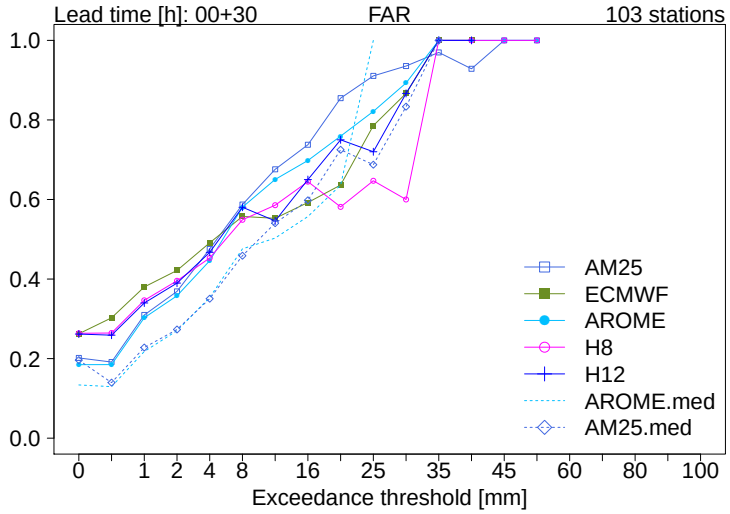
## 7.7 Daily precipitation

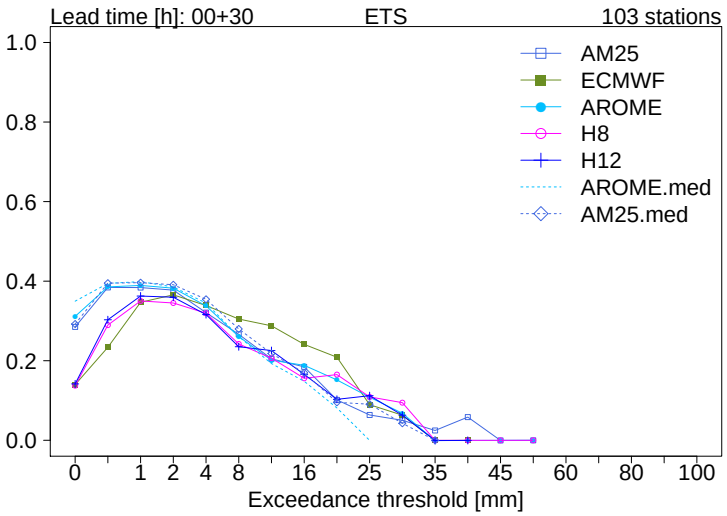


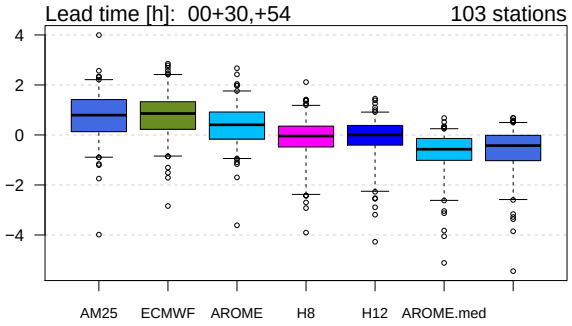




Lead time [h]: 00+30
HR
103 stations
1.0
0.8
0.6
0.4
0.2
0.0
AM25
ECMWF
AROME
H8
H12
AROME.med
AM25.med
0
1
2
4
8
16
25
35
45
60
80
100
Exceedance threshold [mm]

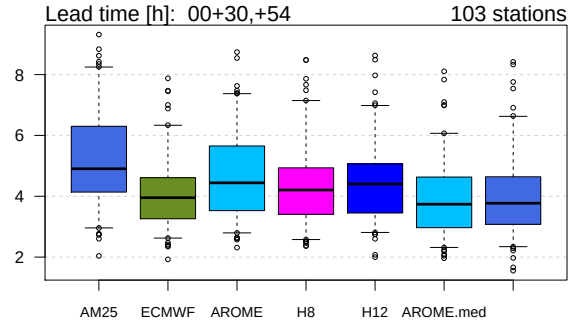

Lead time [h]: 00+30
FAR
103 stations
1.0
0.8
0.6
0.4
0.2
0.0
AM25
ECMWF
AROME
H8
H12
AROME.med
AM25.med
0
1
2
4
8
16
25
35
45
60
80
100
Exceedance threshold [mm]


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

ME




SDE




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

**AM25**

| OBS | [0,0.1] | (0.1,5] | (5,20] | (20,50] | (50,Inf] | Sum |
|---|---|---|---|---|---|---|
| [0,0.1] | 3299 | 1213 | 77 | 4 | 0 | 4593 |
| (0.1,5] | 1221 | 2899 | 569 | 36 | 0 | 4725 |
| (5,20] | 158 | 983 | 861 | 73 | 0 | 2075 |
| (20,50] | 20 | 105 | 152 | 42 | 2 | 321 |
| (50,Inf] | 0 | 3 | 1 | 5 | 0 | 9 |
| Sum | 4698 | 5203 | 1660 | 160 | 2 | 11723 |

**AM25.med**

| OBS | [0,0.1] | (0.1,5] | (5,20] | (20,50] | (50,Inf] | Sum |
|---|---|---|---|---|---|---|
| [0,0.1] | 3833 | 1780 | 131 | 5 | 0 | 5749 |
| (0.1,5] | 815 | 2835 | 769 | 43 | 0 | 4462 |
| (5,20] | 46 | 568 | 720 | 93 | 1 | 1428 |
| (20,50] | 4 | 20 | 40 | 19 | 1 | 84 |
| (50,Inf] | 0 | 0 | 0 | 0 | 0 | 0 |
| Sum | 4698 | 5203 | 1660 | 160 | 2 | 11723 |

**ECMWF**

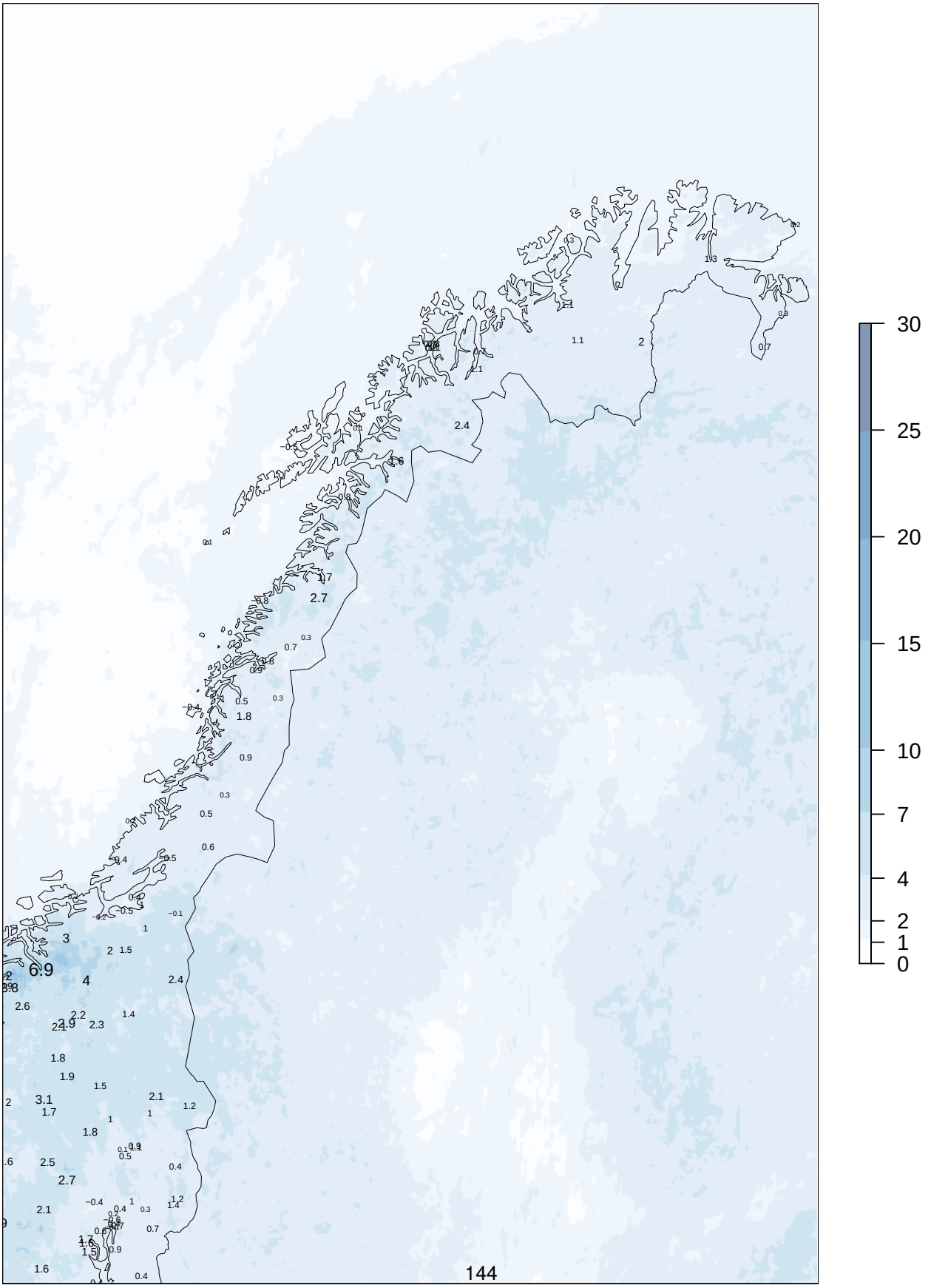
| OBS | [0,0.1] | (0.1,5] | (5,20] | (20,50] | (50,Inf] | Sum |
|---|---|---|---|---|---|---|
| [0,0.1] | 1858 | 344 | 8 | 1 | 0 | 2211 |
| (0.1,5] | 2682 | 3537 | 519 | 21 | 0 | 6759 |
| (5,20] | 158 | 1305 | 1063 | 105 | 0 | 2631 |
| (20,50] | 0 | 17 | 70 | 33 | 2 | 122 |
| (50,Inf] | 0 | 0 | 0 | 0 | 0 | 0 |
| Sum | 4698 | 5203 | 1660 | 160 | 2 | 11723 |

**AROME**

| OBS | [0,0.1] | (0.1,5] | (5,20] | (20,50] | (50,Inf] | Sum |
|---|---|---|---|---|---|---|
| [0,0.1] | 3332 | 1223 | 85 | 2 | 0 | 4642 |
| (0.1,5] | 1221 | 2987 | 601 | 25 | 0 | 4834 |
| (5,20] | 131 | 938 | 859 | 87 | 0 | 2015 |
| (20,50] | 14 | 53 | 114 | 45 | 1 | 227 |
| (50,Inf] | 0 | 2 | 1 | 1 | 1 | 5 |
| Sum | 4698 | 5203 | 1660 | 160 | 2 | 11723 |

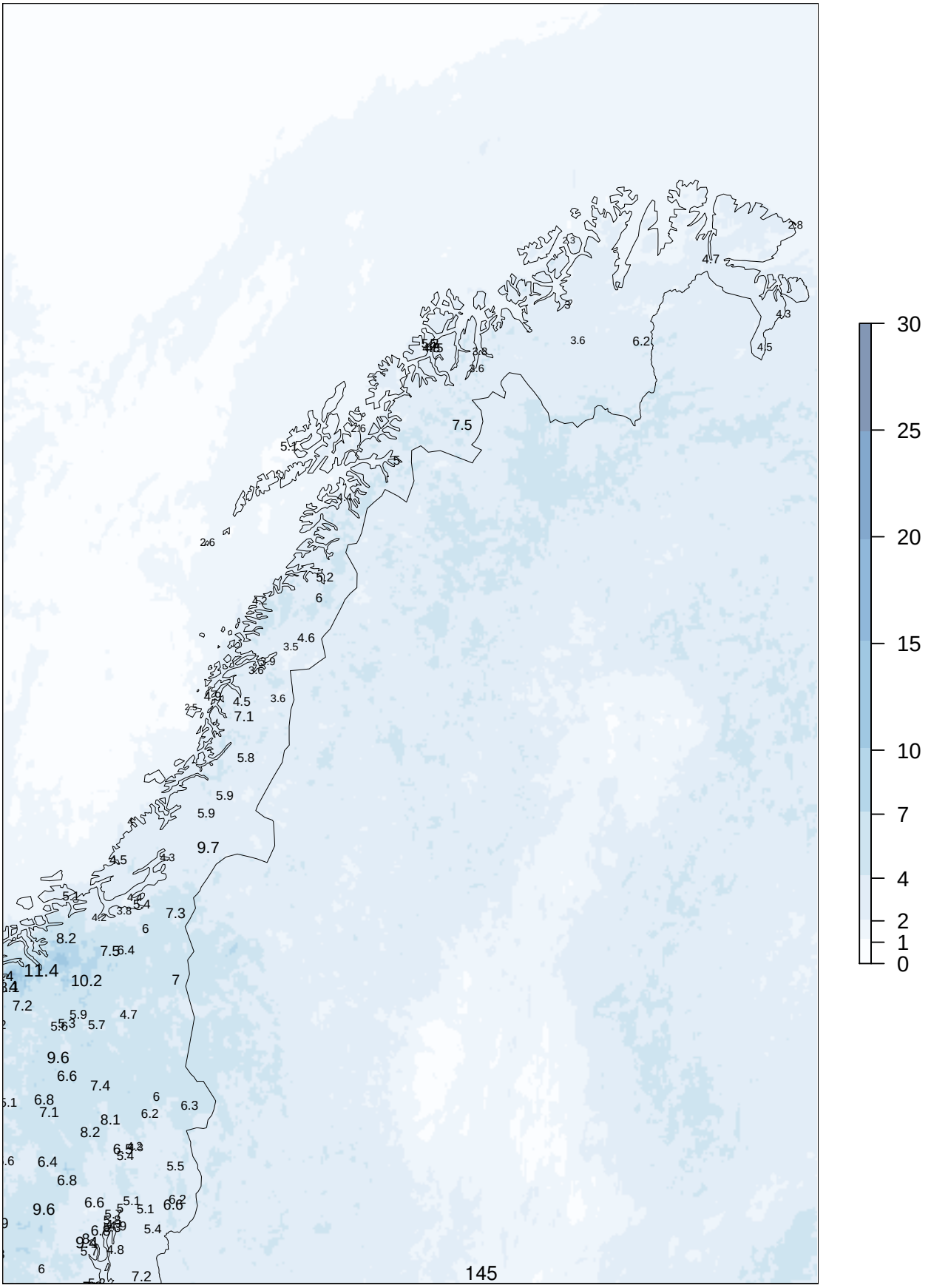
# AM25 00+30

ME at observing sites forecast means 01.06.2014 − 31.08.2014



# AM25 00+30

SDE at observing sites forecast means 01.06.2014 − 31.08.2014



# 8 Long term forecast

Temperature 2m:
The bias has a smaller diurnal cycle after the calibration, yet in general the calibrated long term forecast is a little too warm. The uncalibrated forecast is very similar to the deterministic forecast and is in general a bit too cold. Compared with the spring forecast, the uncalibrated and deterministic forecast have improved much. However, the calibrated forecast scores very close to that of the spring. After 114h the SDE and MAE increase much more rapid for the deterministic forecast than for the probabilistic forecasts.

Wind speed 10m:
The bias is lower in the probabilistic forecast than the deterministic forecast. Still a clear diurnal cycle with too weak winds during day and too strong winds during night. After 144h, there are small differences between the probabilistic and deterministic forecasts. However, the SDE grows faster for the deterministic forecast, resulting in a larger MAE for the this forecast.

At 72h there is little difference between the probabilistic and deterministic forecasts for the threshold scores HR, FAR, and ETS. The deterministic forecast has values above $15ms^{-1}$ (the probabilistic does not), but misses on these, so the score is the same.

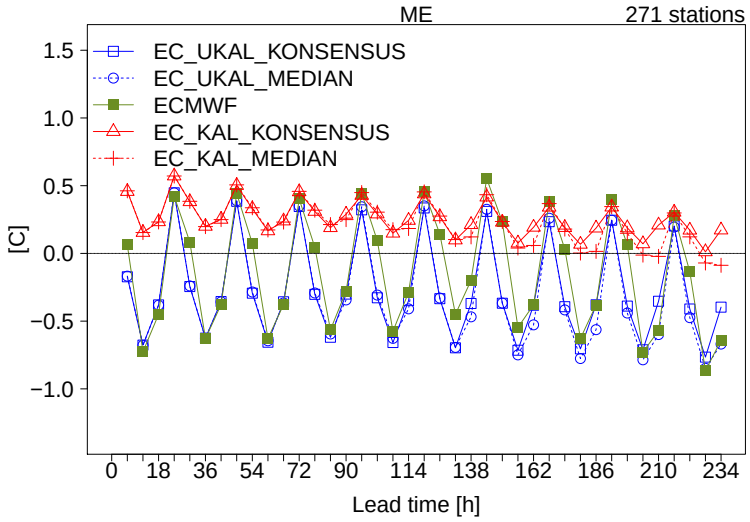
At 216h, the probabilistic forecast score better than the deterministic forecast for the weak wind speeds, but have no values above $13ms^{-1}$. There are low skills for both forecasts.

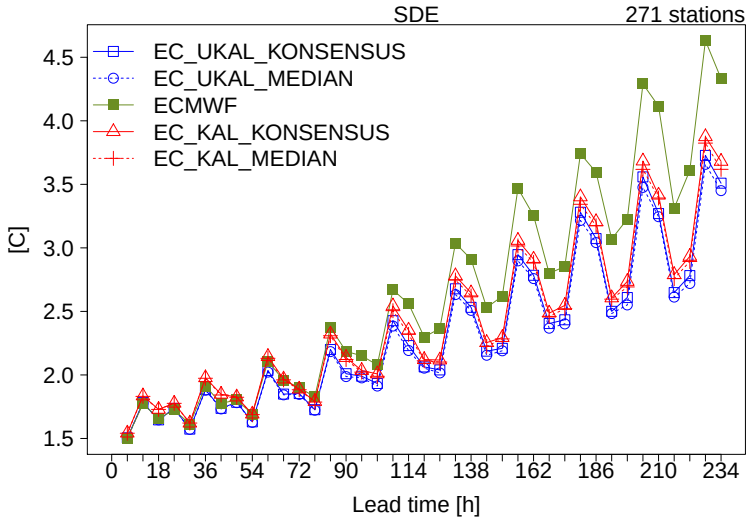
Precipitation:
Low bias in general, but clear diurnal variation in the deterministic forecast. There is a clear dry trend in the probabilistic forecasts. Almost constant SDE with lead time for the probabilistic forecasts. Increasing SDE for the deterministic forecast. Few differences between the calibrated and the uncalibrated forecast.

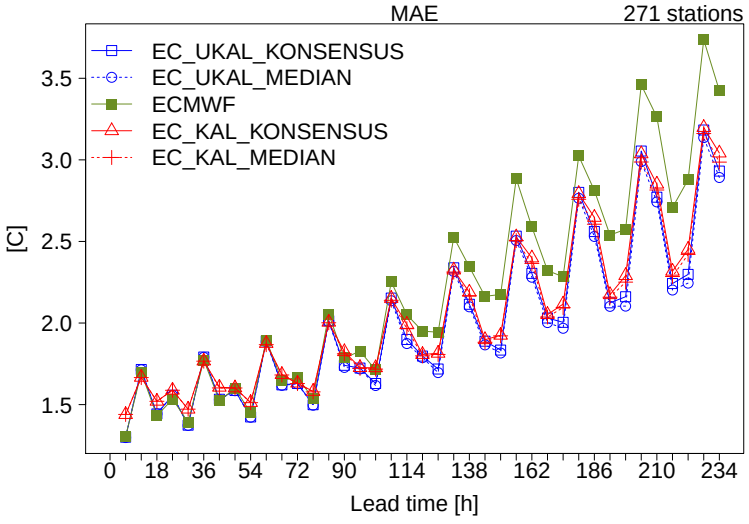
The deterministic forecast scores better than the probabilistic forecast in ETS for all thresholds at 78h (nighttime). At daytime (90h) the ETS is the same for both the probabilistic and deterministic up to 8mm. Above this threshold, the deterministic forecast scores better.

There is very little skill in the forecast at 222h and 234h. The 24h precipitation forecasts are very similar to the 12h forecasts.

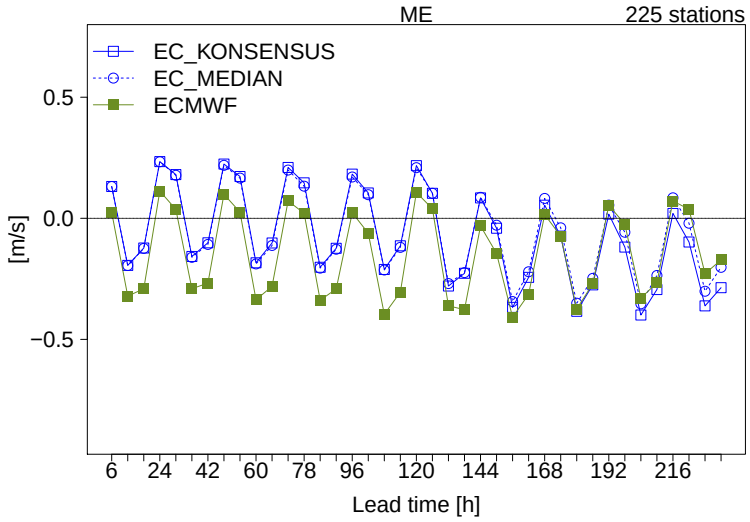
## 8.1 Temperature 2m

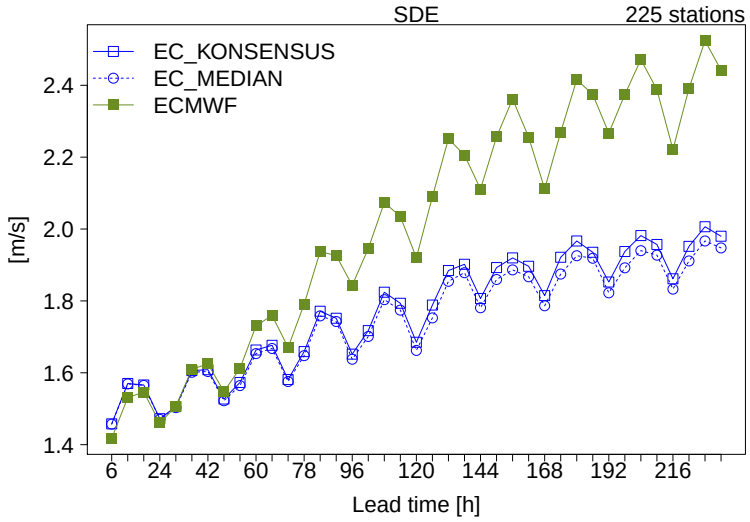


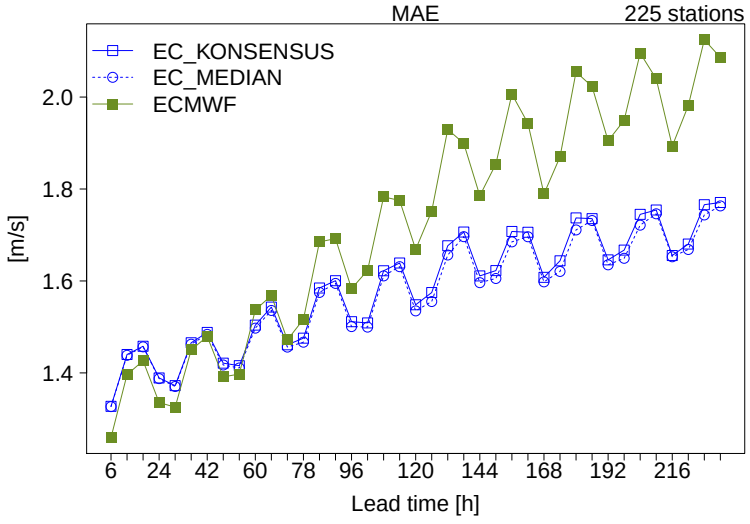



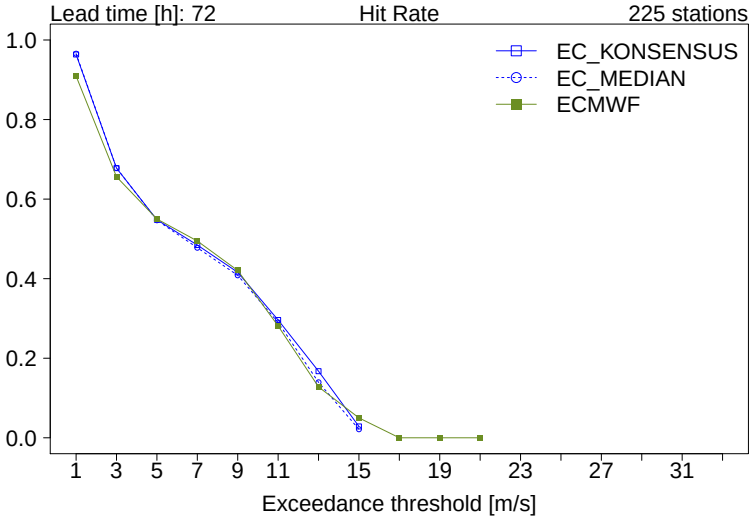



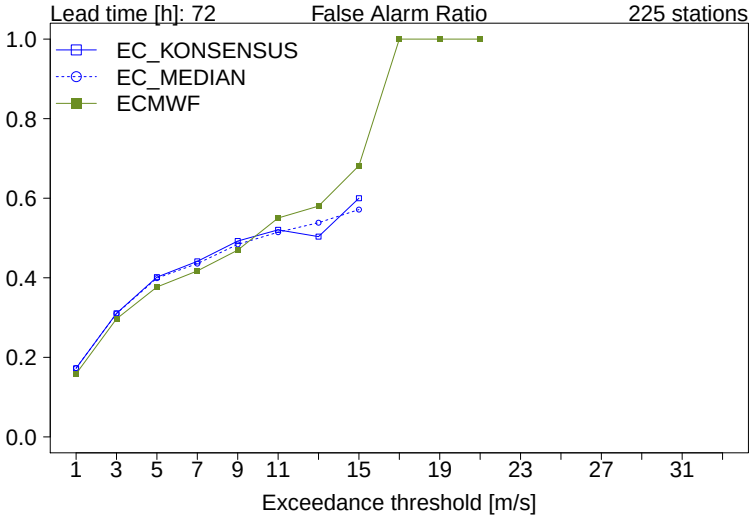
## 8.2 Wind Speed 10m

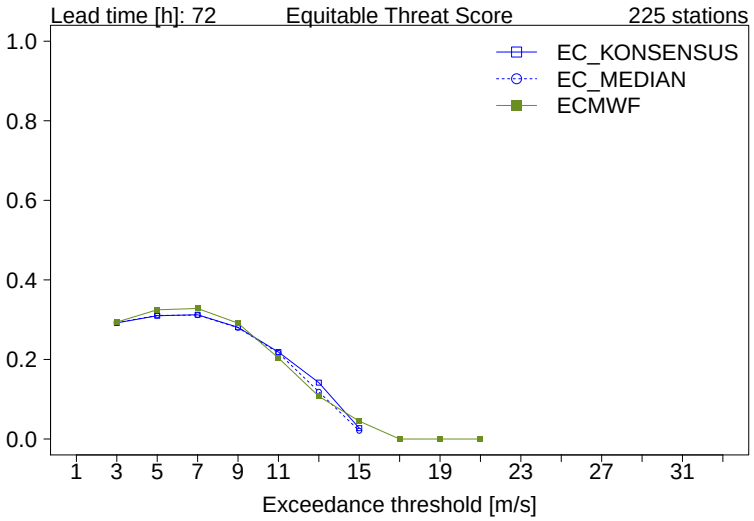


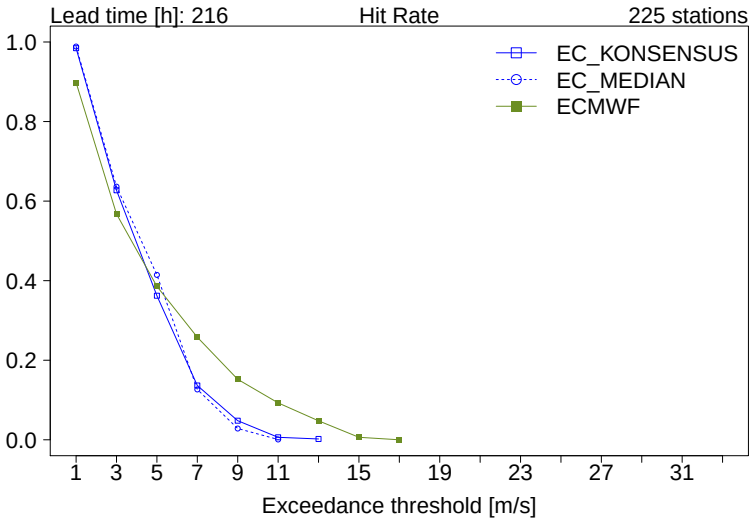



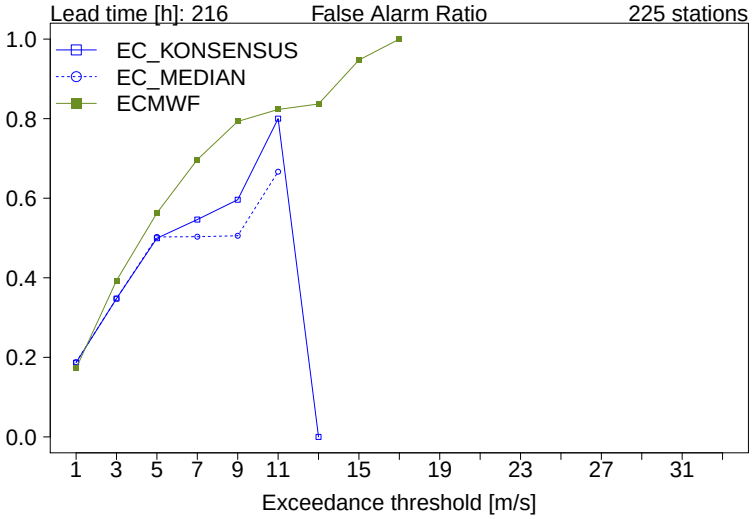



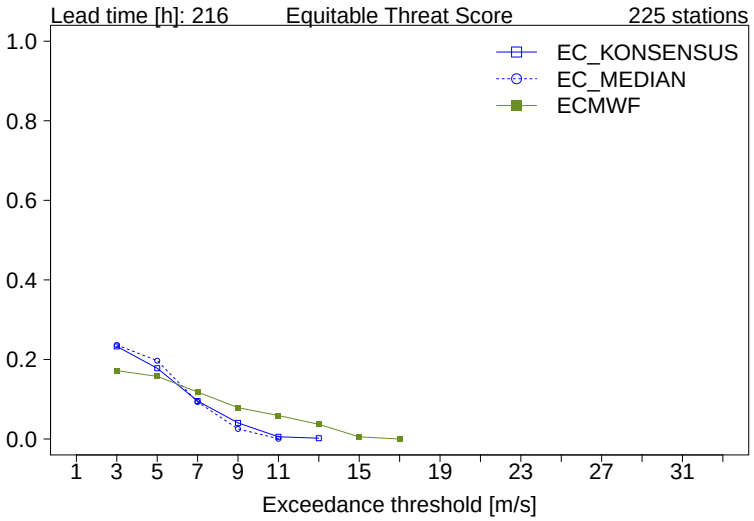

Lead time [h]: 72
Hit Rate
225 stations
EC_KONSENSUS
EC_MEDIAN
ECMWF
1.0
0.8
0.6
0.4
0.2
0.0
1 3 5 7 9 11 15 19 23 27 31
Exceedance threshold [m/s]


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]

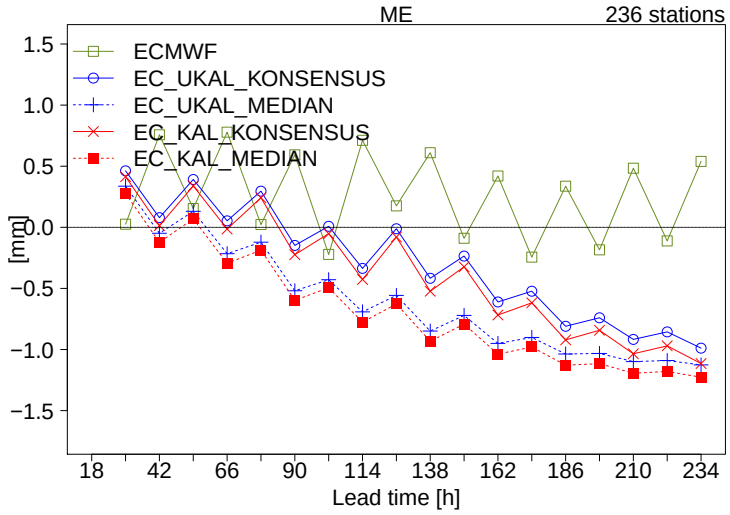

Lead time [h]: 72
Equitable Threat Score
225 stations
EC_KONSENSUS
EC_MEDIAN
ECMWF
1.0
0.8
0.6
0.4
0.2
0.0
1 3 5 7 9 11 15 19 23 27 31
Exceedance threshold [m/s]

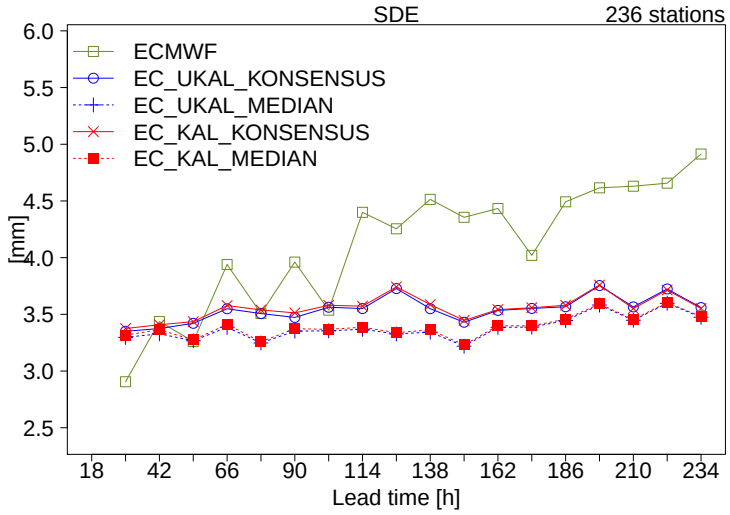

Lead time [h]: 216
Hit Rate
225 stations
EC_KONSENSUS
EC_MEDIAN
ECMWF
1.0
0.8
0.6
0.4
0.2
0.0
1 3 5 7 9 11 15 19 23 27 31
Exceedance threshold [m/s]

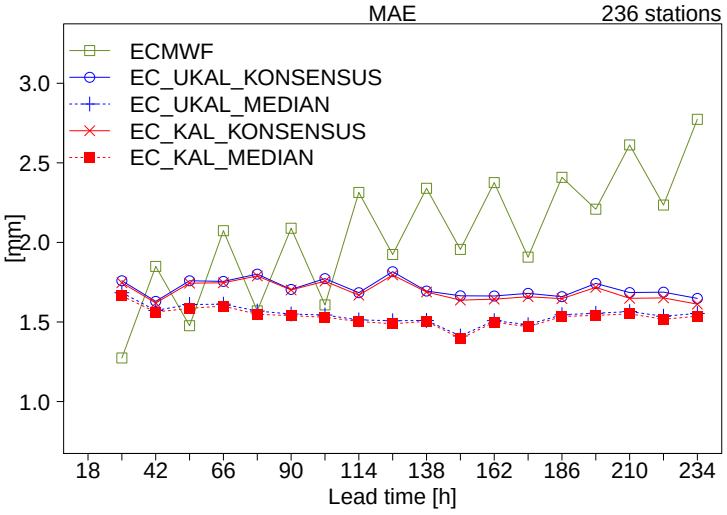

Lead time [h]: 216
False Alarm Ratio
225 stations
EC_KONSENSUS
EC_MEDIAN
ECMWF
1.0
0.8
0.6
0.4
0.2
0.0
1 3 5 7 9 11 15 19 23 27 31
Exceedance threshold [m/s]

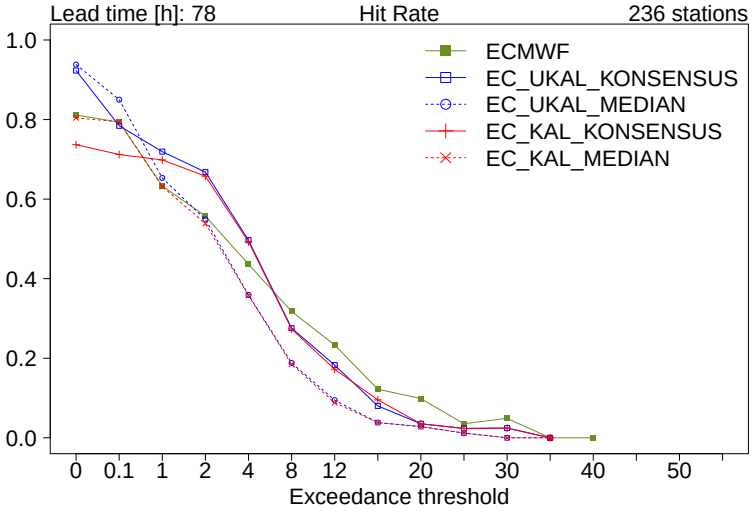

Lead time [h]: 216
Equitable Threat Score
225 stations
EC_KONSENSUS
EC_MEDIAN
ECMWF
1.0
0.8
0.6
0.4
0.2
0.0
1 3 5 7 9 11 15 19 23 27 31
Exceedance threshold [m/s]

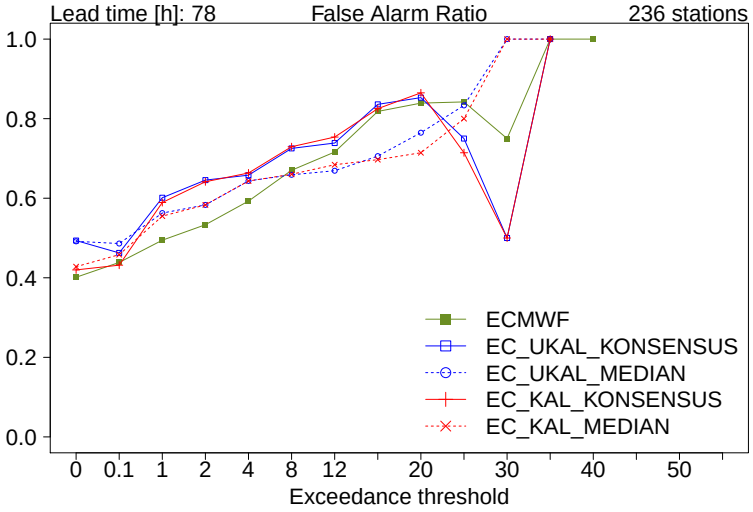
## 8.3 12h Precipitation

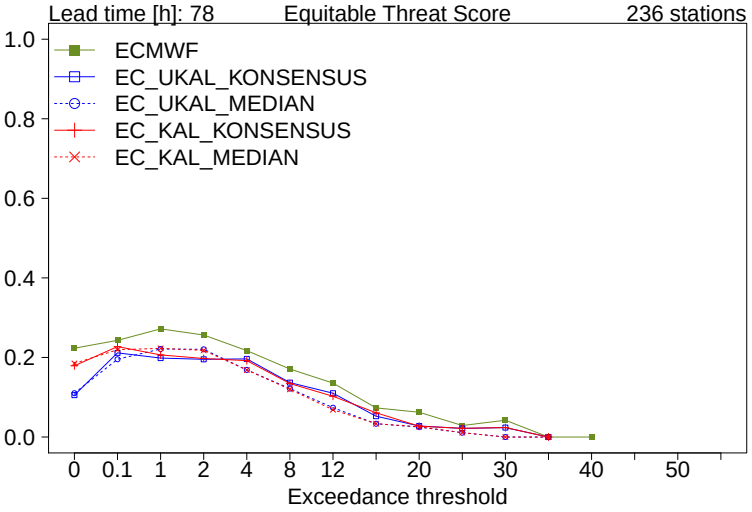


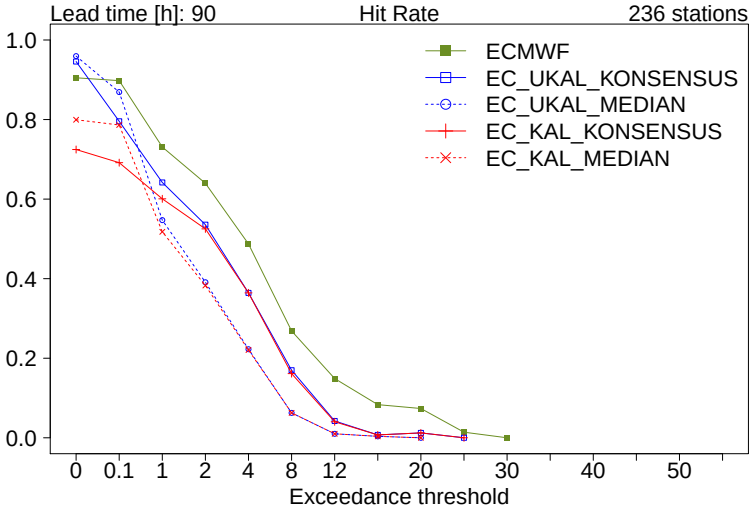




Lead time [h]: 78
Hit Rate
236 stations
ECMWF
EC_UKAL_KONSENSUS
EC_UKAL_MEDIAN
EC_KAL_KONSENSUS
EC_KAL_MEDIAN
1.0
0.8
0.6
0.4
0.2
0.0
0 0.1 1 2 4 8 12 20 30 40 50
Exceedance threshold


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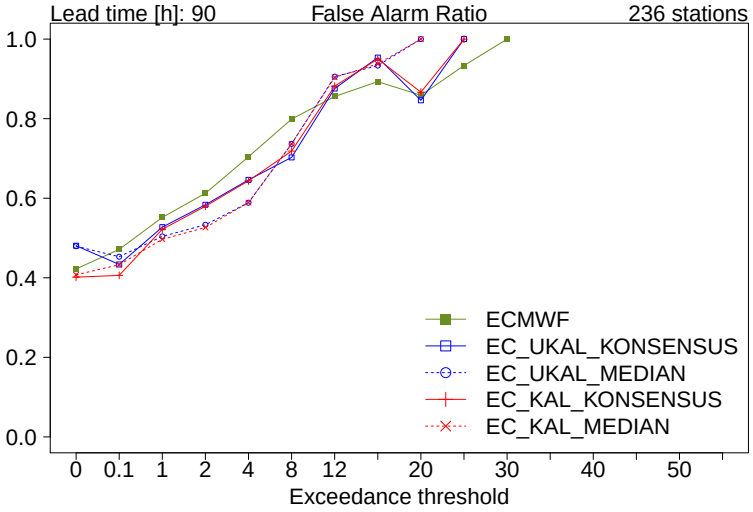
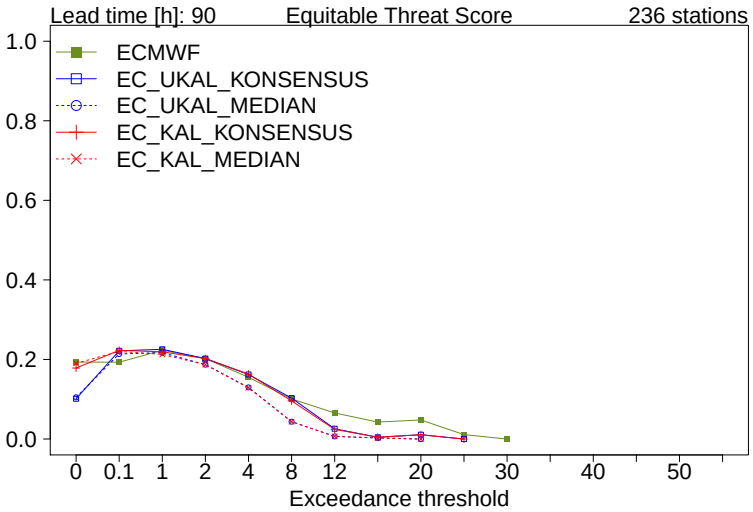
0.8
0.6
0.4
0.2
0.0
0 0.1 1 2 4 8 12 20 30 40 50
Exceedance threshold


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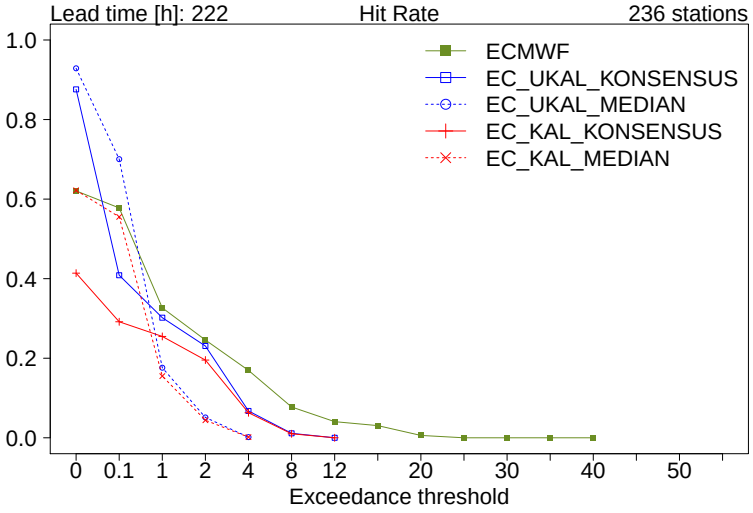
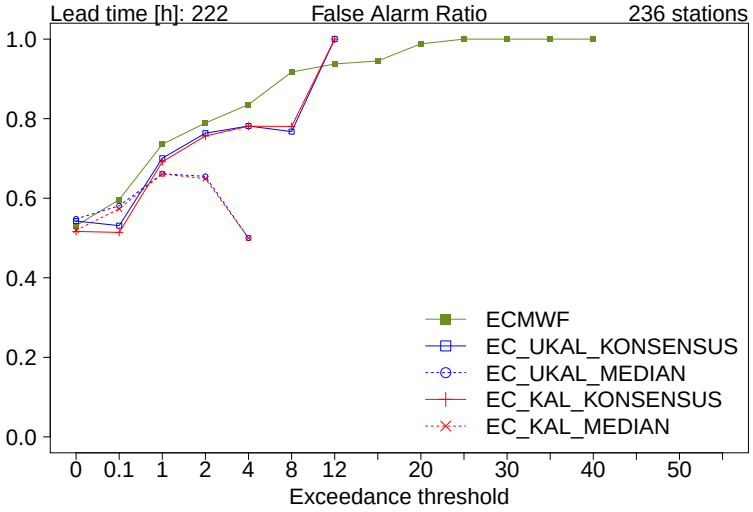
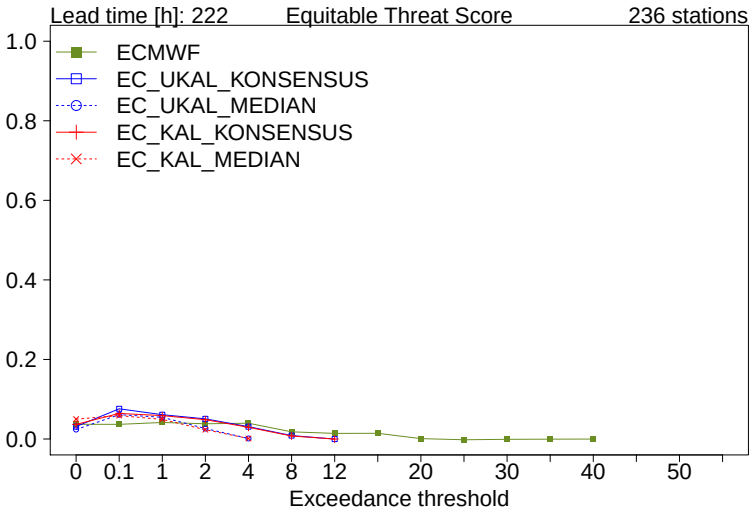
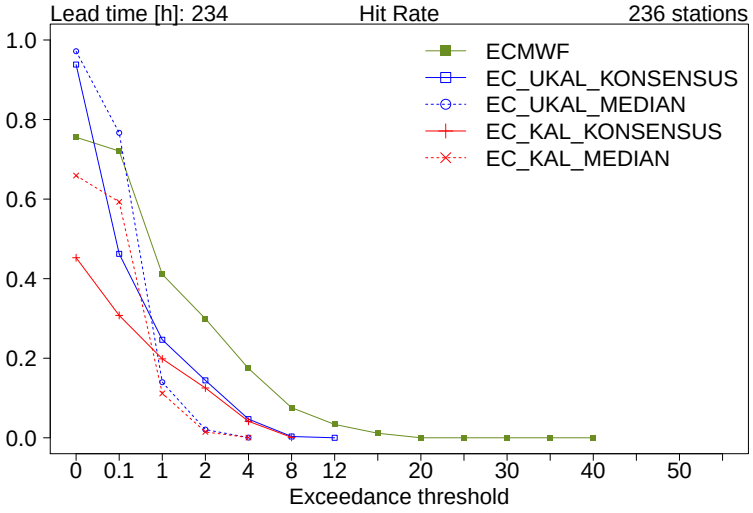
0.8
0.6
0.4
0.2
0.0
0 0.1 1 2 4 8 12 20 30 40 50
Exceedance threshold


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


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


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


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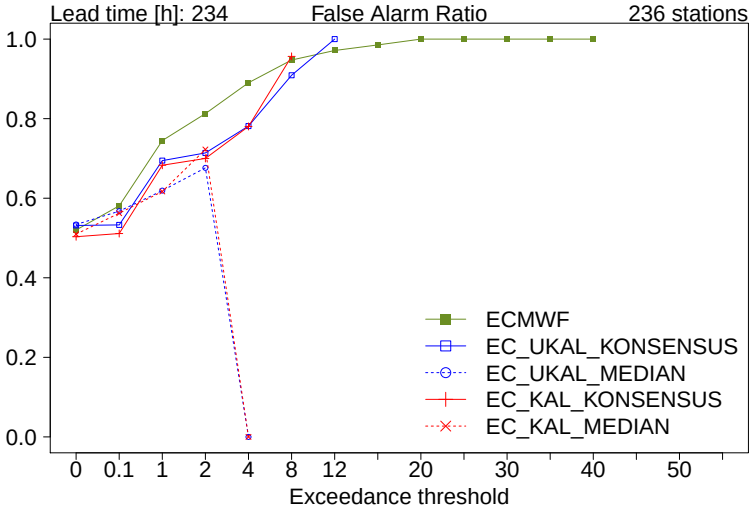
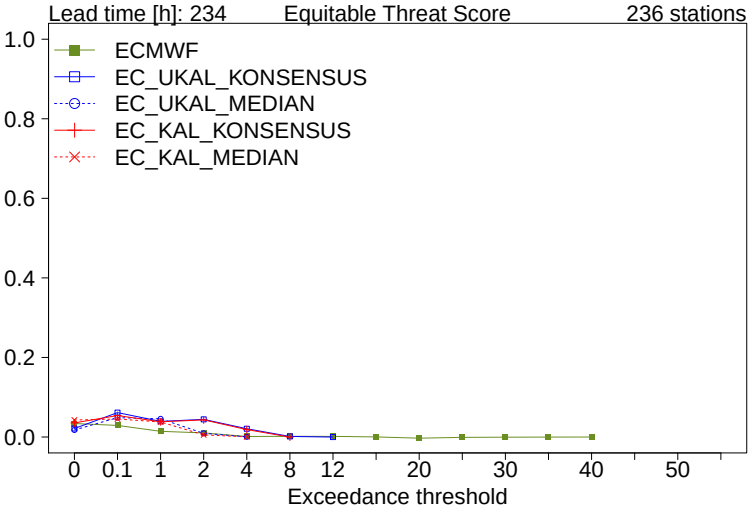
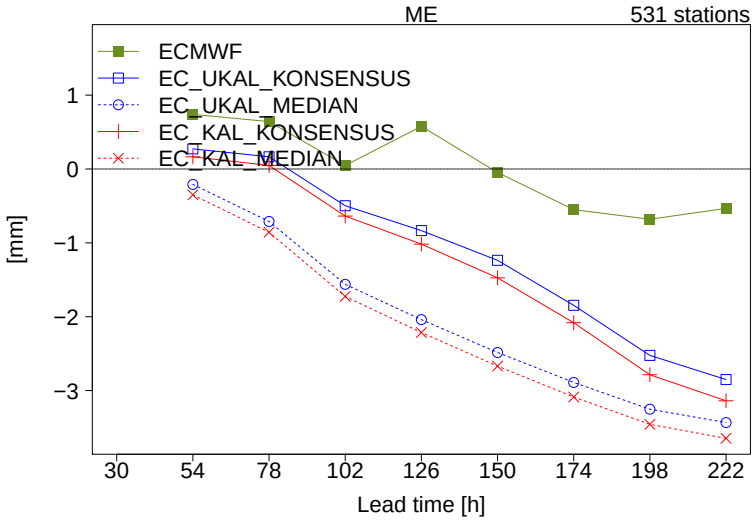
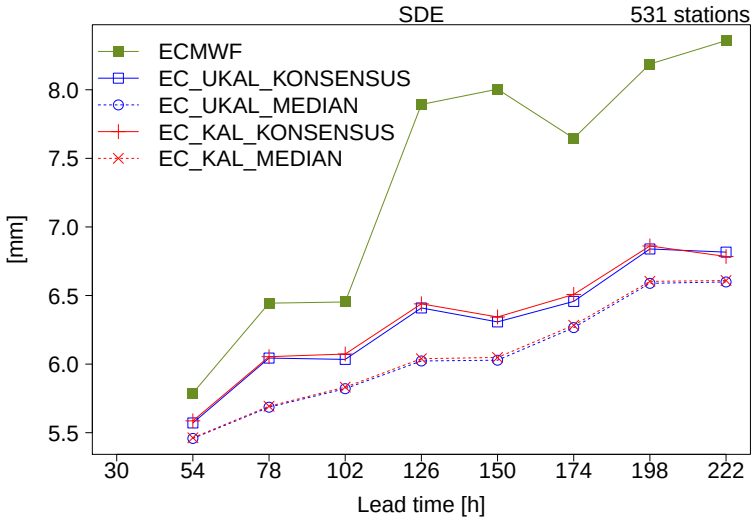
EC_UKAL_MEDIAN
EC_KAL_KONSENSUS
EC_KAL_MEDIAN
0 0.1 1 2 4 8 12 20 30 40 50
Exceedance threshold

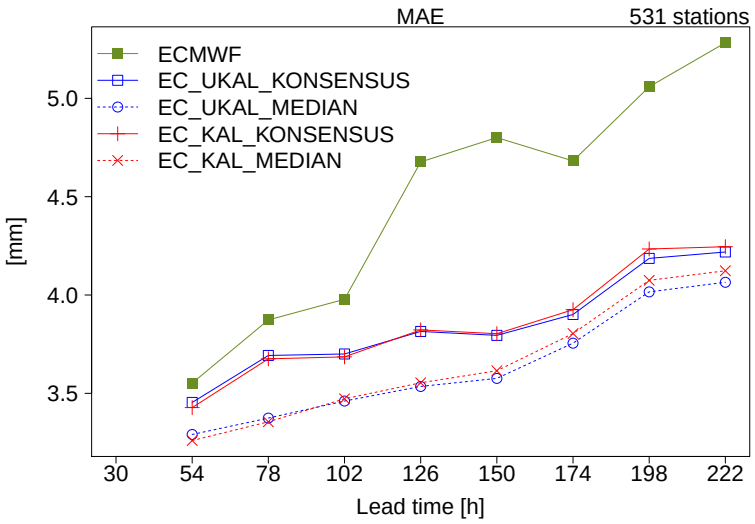

Lead time [h]: 234
False Alarm Ratio
236 stations
1.0
0.8
0.6
0.4
0.2
0.0
ECMWF
EC_UKAL_KONSENSUS
EC_UKAL_MEDIAN
EC_KAL_KONSENSUS
EC_KAL_MEDIAN
0 0.1 1 2 4 8 12 20 30 40 50
Exceedance threshold

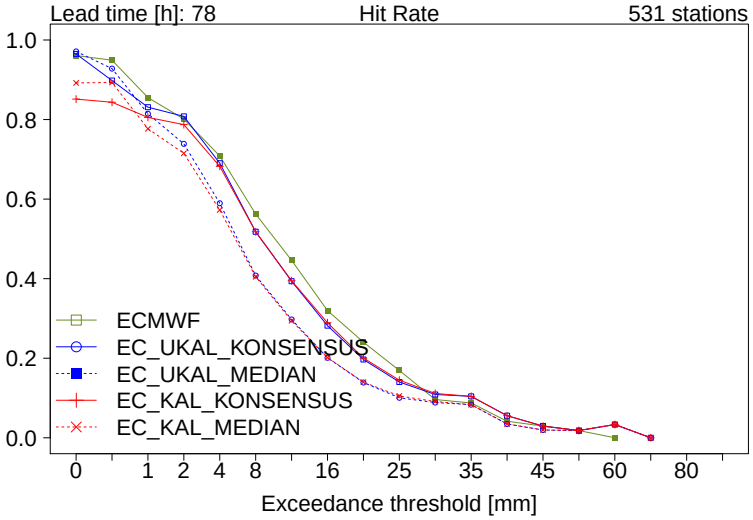

Lead time [h]: 234
Equitable Threat Score
236 stations
1.0
0.8
0.6
0.4
0.2
0.0
ECMWF
EC_UKAL_KONSENSUS
EC_UKAL_MEDIAN
EC_KAL_KONSENSUS
EC_KAL_MEDIAN
0 0.1 1 2 4 8 12 20 30 40 50
Exceedance threshold

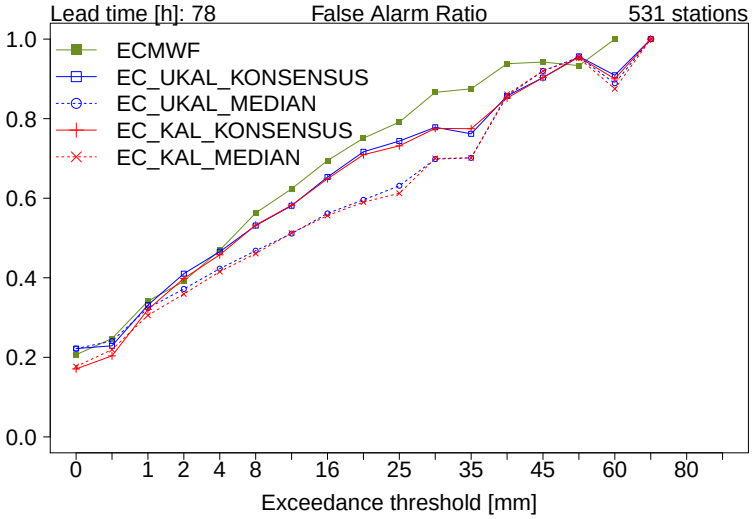
## 8.4 24h Precipitation

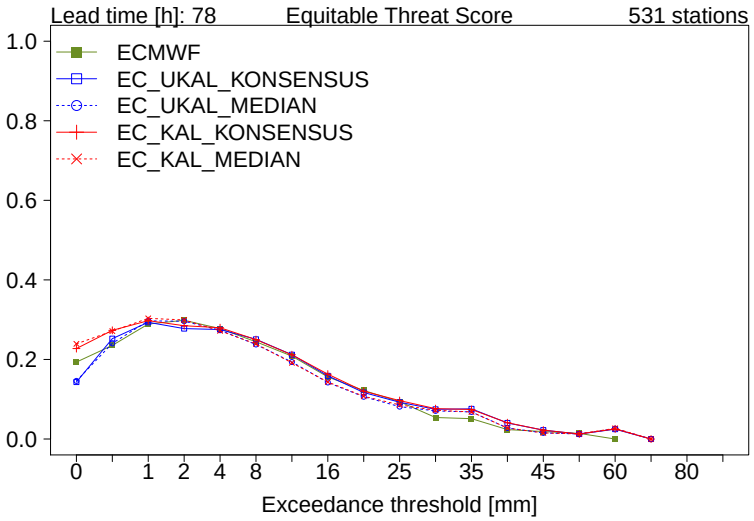


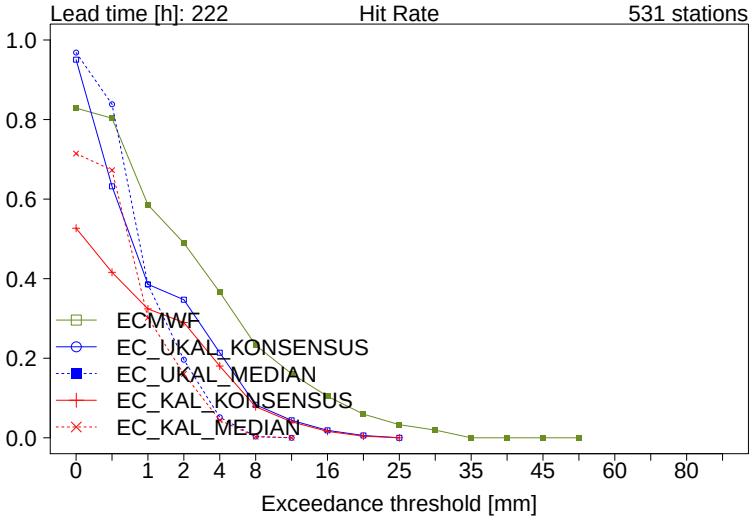



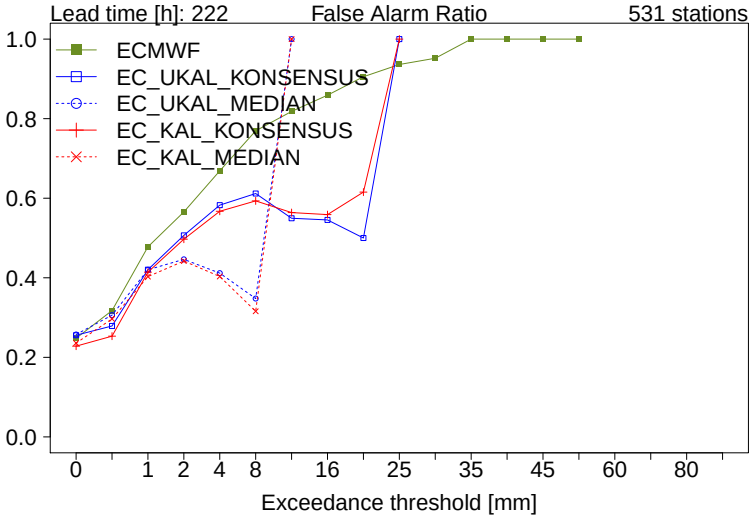



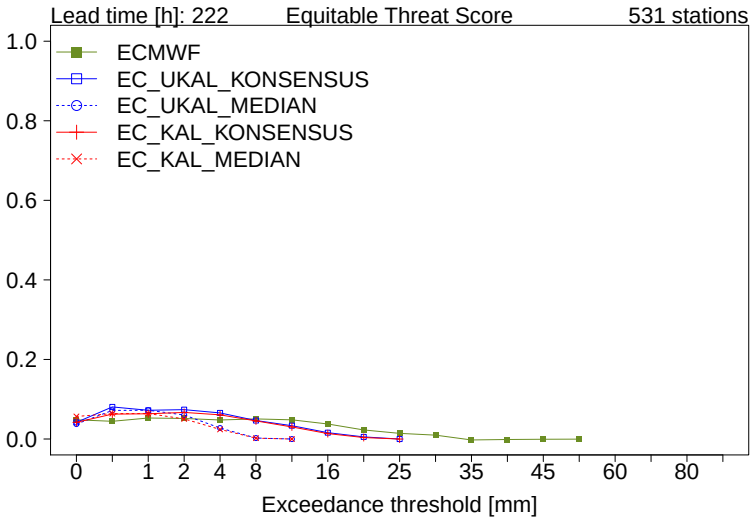

Lead time [h]: 78
Hit Rate
531 stations
1.0
0.8
0.6
0.4
0.2
0.0
ECMWF
EC_UKAL_KONSENSUS
EC_UKAL_MEDIAN
EC_KAL_KONSENSUS
EC_KAL_MEDIAN
0 1 2 4 8 16 25 35 45 60 80
Exceedance threshold [mm]


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
EC_KAL_KONSENSUS
EC_KAL_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
EC_KAL_KONSENSUS
EC_KAL_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
EC_KAL_KONSENSUS
EC_KAL_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
EC_KAL_KONSENSUS
EC_KAL_MEDIAN
0 1 2 4 8 16 25 35 45 60 80
Exceedance threshold [mm]

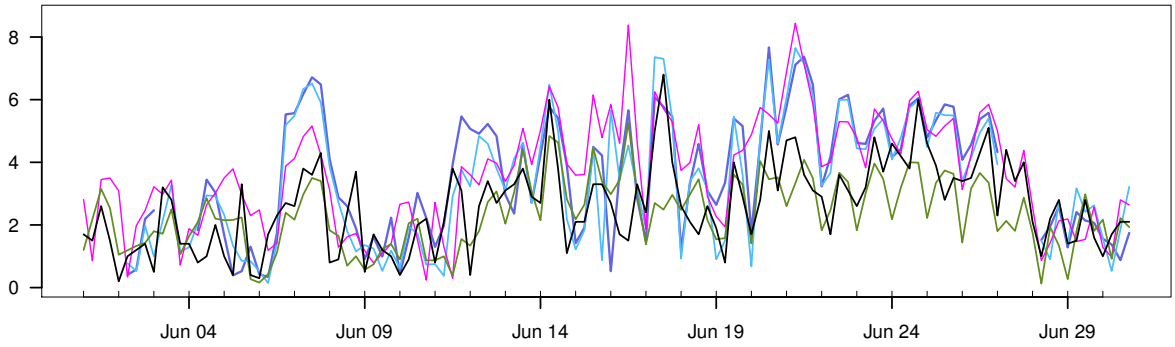

Lead time [h]: 222
Equitable Threat Score
531 stations
1.0
0.8
0.6
0.4
0.2
0.0
ECMWF
EC_UKAL_KONSENSUS
EC_UKAL_MEDIAN
EC_KAL_KONSENSUS
EC_KAL_MEDIAN
0 1 2 4 8 16 25 35 45 60 80
Exceedance threshold [mm]

# 9 Appendix

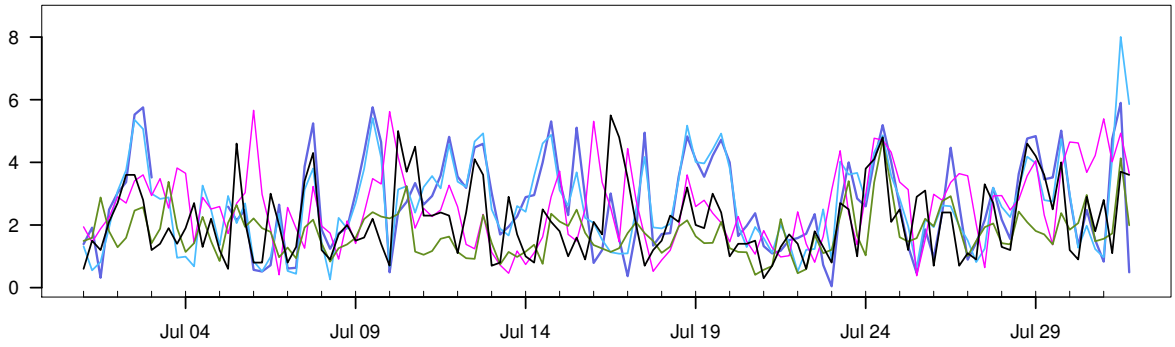
## 9.1 10m Wind speed

TROMSØ

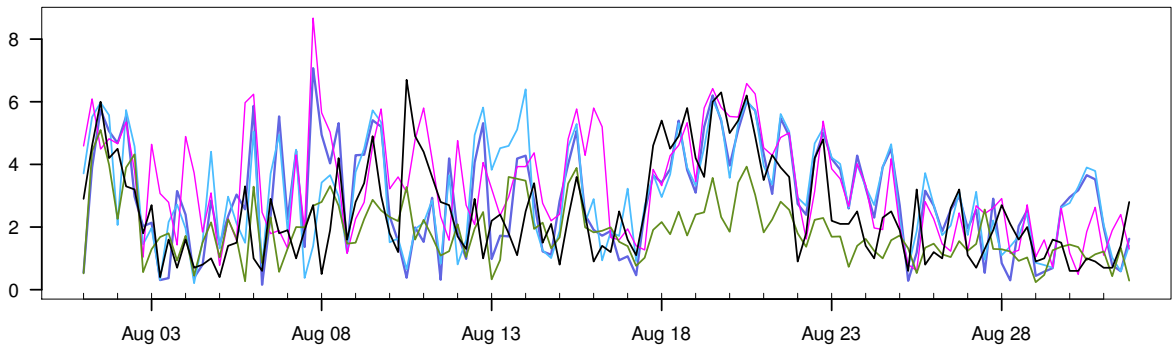
01.06.2014 – 30.06.2014




01.07.2014 – 31.07.2014




01.08.2014 – 31.08.2014

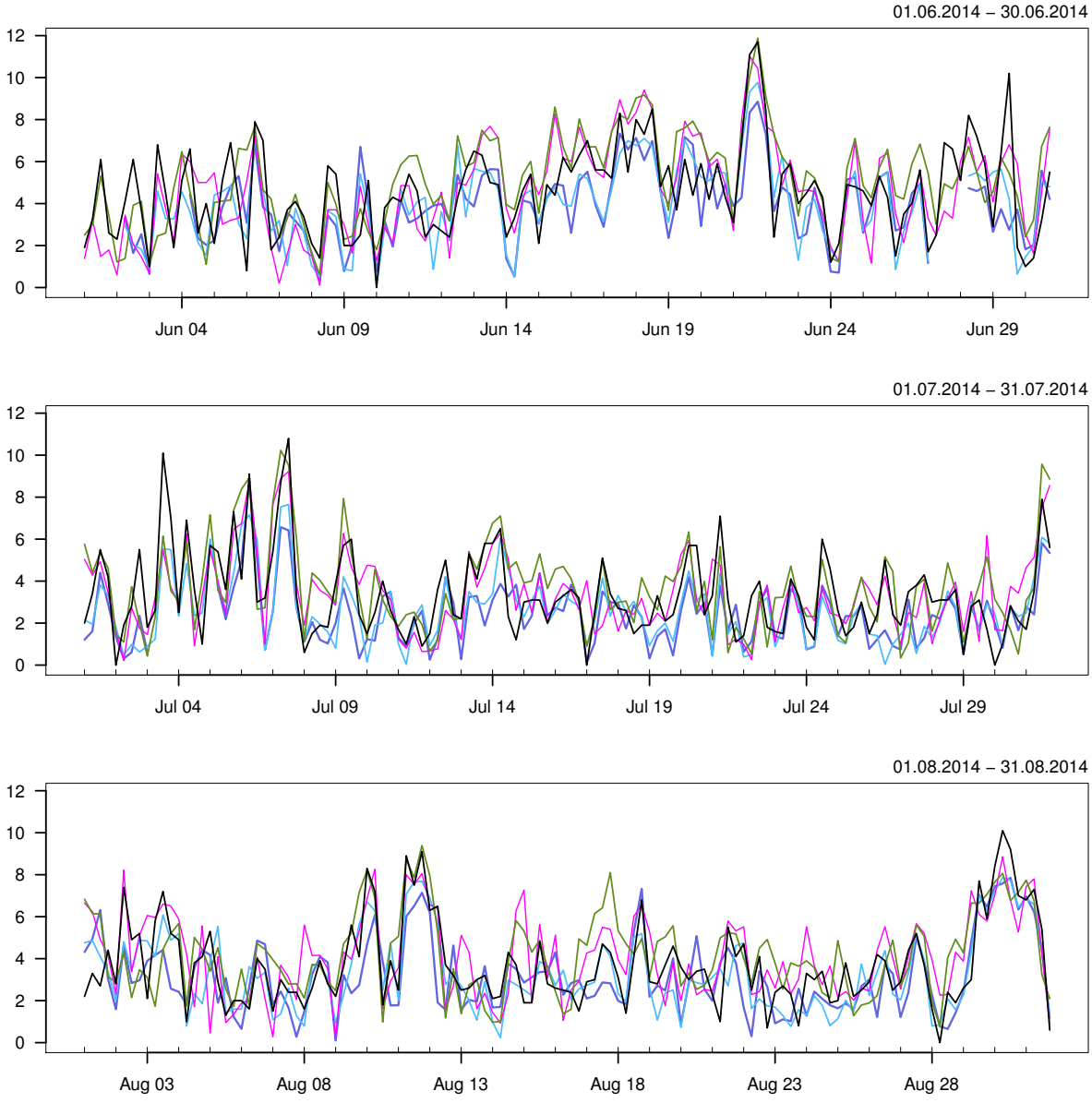



01.06.2014 – 31.08.2014

| | Min | Mean | Max | Std | N |
|---|---|---|---|---|---|
| synop: 00,06,12,18 | 0.2 | 2.4 | 6.8 | 1.4 | 368 |
| AM25: 12+18,+24,+30,+36 | 0 | 3.1 | 7.7 | 1.7 | 347 |
| AROME_Norway: 12+18,+24,+30,+36 | 0.1 | 3 | 8 | 1.7 | 359 |
| Hirlam8: 12+18,+24,+30,+36 | 0.2 | 3.1 | 8.7 | 1.6 | 368 |
| ECMWF: 12+18,+24,+30,+36 | 0.1 | 2 | 5.3 | 1 | 368 |

| | ME | SDE | RMSE | MAE | Max.abs.err. | N |
|---|---|---|---|---|---|---|
| AM25 – synop | 0.6 | 1.5 | 1.7 | 1.3 | 6.3 | 347 |
| AROME_Norway – synop | 0.6 | 1.5 | 1.6 | 1.3 | 6 | 359 |
| Hirlam8 – synop | 0.8 | 1.5 | 1.7 | 1.3 | 6.9 | 368 |
| ECMWF – synop | –0.4 | 1.2 | 1.3 | 1 | 4.4 | 368 |

ØRLAND

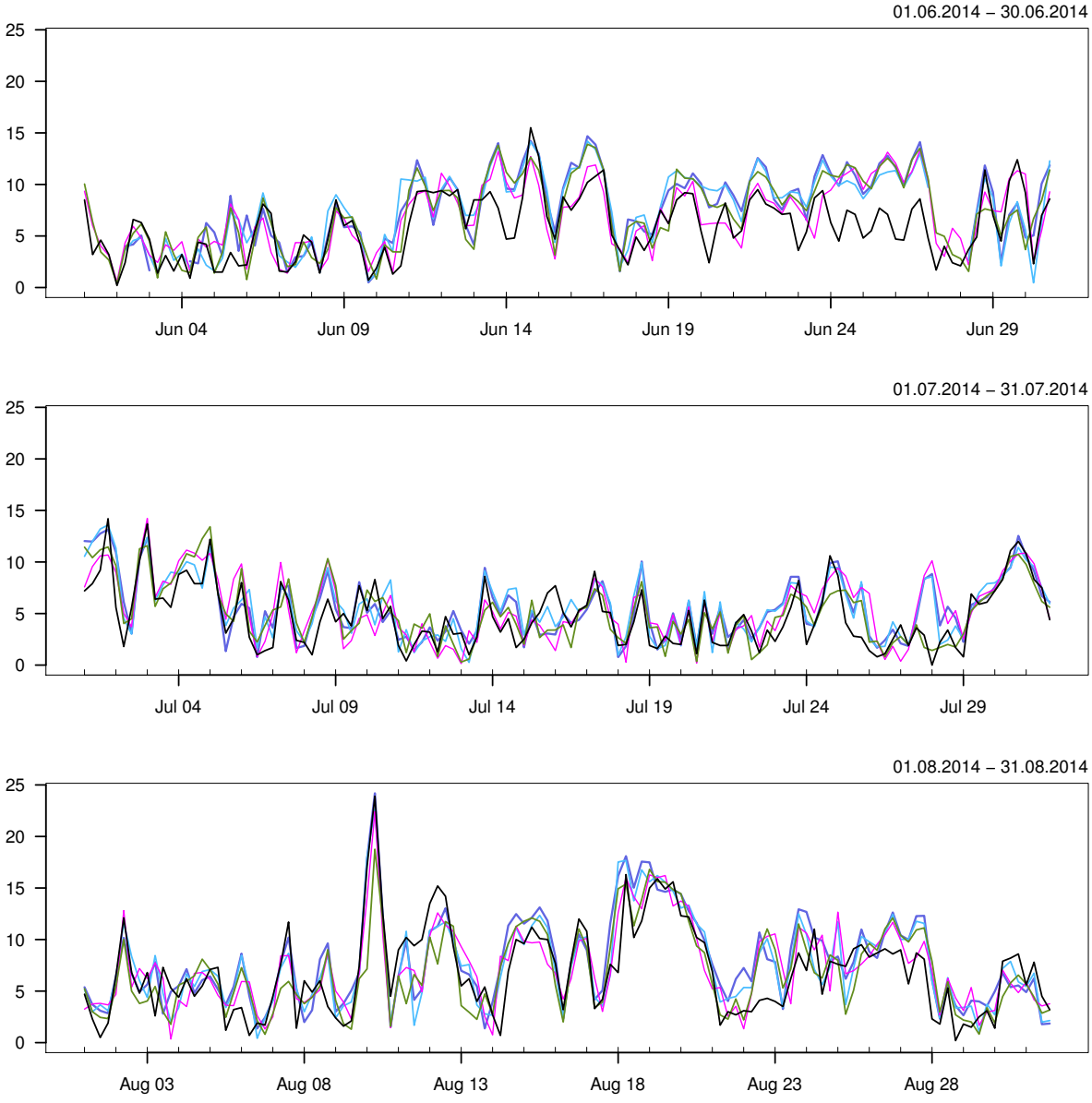



01.06.2014 – 31.08.2014

| | Min | Mean | Max | Std | N |
|---|---|---|---|---|---|
| synop: 00,06,12,18 | 0 | 3.9 | 11.7 | 2.1 | 368 |
| AM25: 12+18,+24,+30,+36 | 0.1 | 3.1 | 8.9 | 1.8 | 347 |
| AROME_Norway: 12+18,+24,+30,+36 | 0 | 3.3 | 9.8 | 1.9 | 359 |
| Hirlam8: 12+18,+24,+30,+36 | 0.1 | 4 | 11 | 2.1 | 368 |
| ECMWF: 12+18,+24,+30,+36 | 0.3 | 4.3 | 11.9 | 2.1 | 368 |

| | ME | SDE | RMSE | MAE | Max.abs.err. | N |
|---|---|---|---|---|---|---|
| AM25 – synop | −0.7 | 1.5 | 1.6 | 1.3 | 7.5 | 347 |
| AROME_Norway – synop | −0.6 | 1.4 | 1.5 | 1.2 | 6 | 359 |
| Hirlam8 – synop | 0.1 | 1.7 | 1.7 | 1.3 | 5.4 | 368 |
| ECMWF – synop | 0.4 | 1.7 | 1.7 | 1.3 | 5.8 | 368 |

YTTERØYANE FYR

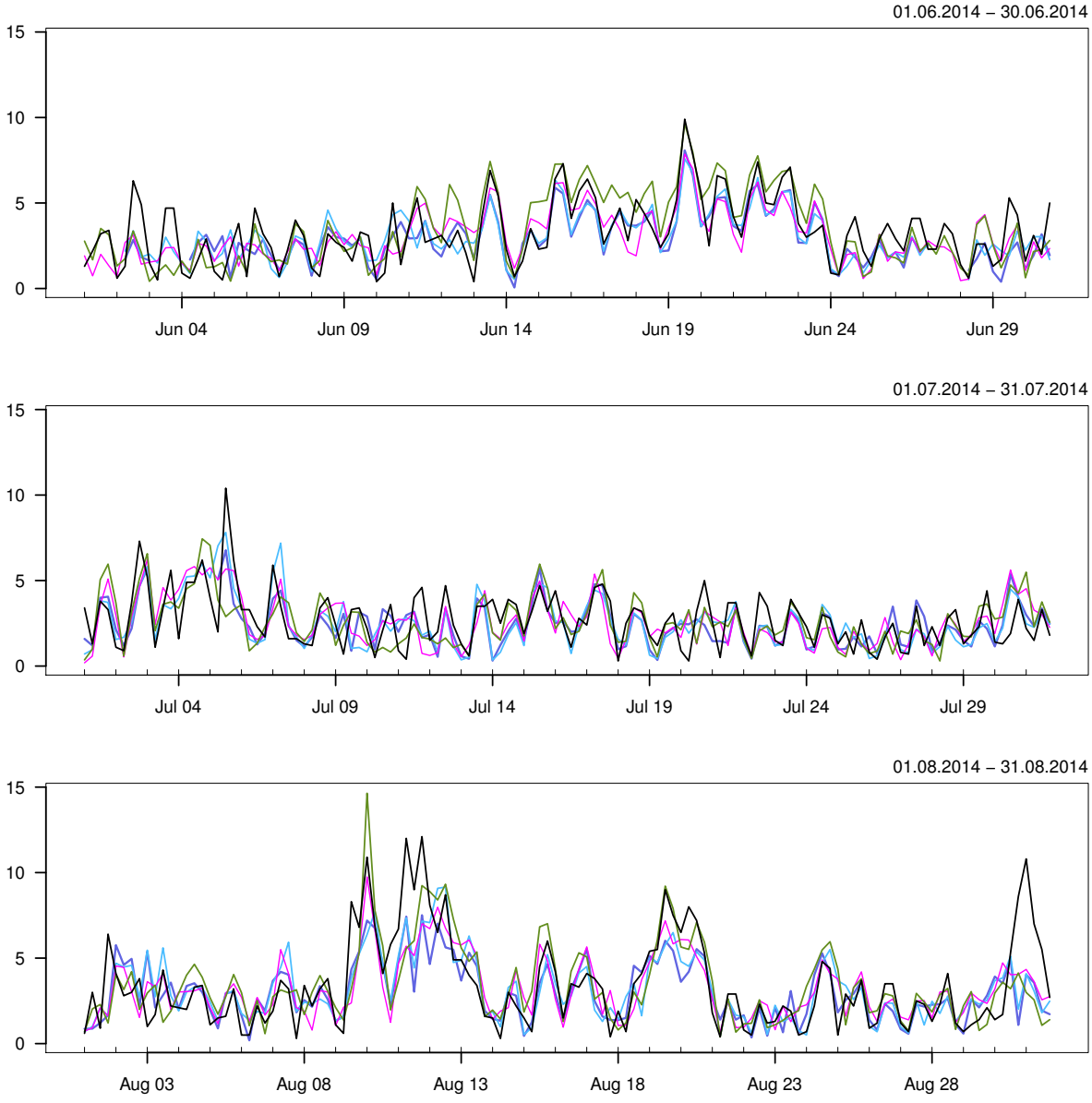



01.06.2014 – 31.08.2014

| | Min | Mean | Max | Std | N |
|---|---|---|---|---|---|
| synop: 00,06,12,18 | 0 | 5.9 | 23.9 | 3.6 | 368 |
| AM25: 12+18,+24,+30,+36 | 0.5 | 7.1 | 24.2 | 3.8 | 347 |
| AROME_Norway: 12+18,+24,+30,+36 | 0.3 | 7 | 22.6 | 3.7 | 359 |
| Hirlam8: 12+18,+24,+30,+36 | 0.1 | 6.5 | 22.4 | 3.5 | 368 |
| ECMWF: 12+18,+24,+30,+36 | 0.3 | 6.4 | 18.8 | 3.6 | 368 |

| | ME | SDE | RMSE | MAE | Max.abs.err. | N |
|---|---|---|---|---|---|---|
| AM25 – synop | 1.2 | 2.4 | 2.7 | 2.1 | 9.4 | 347 |
| AROME_Norway – synop | 1 | 2.3 | 2.6 | 1.9 | 10.7 | 359 |
| Hirlam8 – synop | 0.7 | 2.4 | 2.5 | 1.9 | 10.1 | 368 |
| ECMWF – synop | 0.6 | 2.5 | 2.6 | 2 | 10 | 368 |

BERGEN – FLORIDA



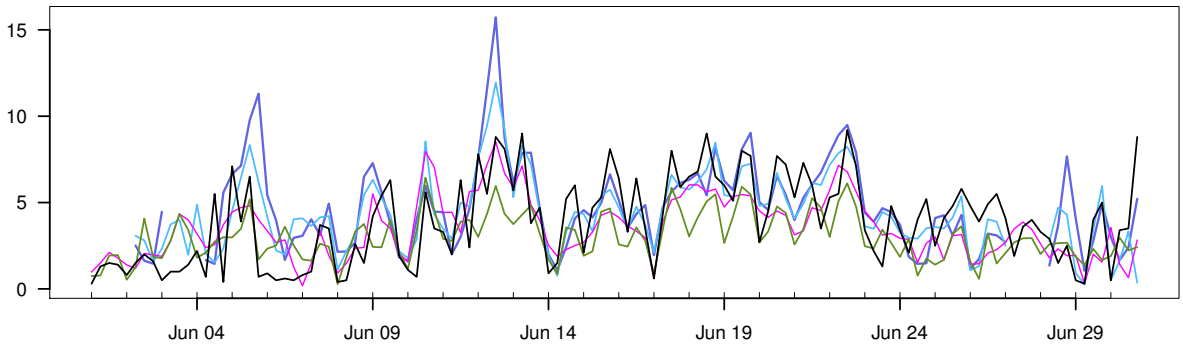

01.06.2014 – 31.08.2014

| | Min | Mean | Max | Std | N |
|---|---|---|---|---|---|
| synop: 00,06,12,18 | 0.3 | 3.1 | 12.1 | 2.1 | 368 |
| AM25: 12+18,+24,+30,+36 | 0.1 | 2.8 | 8.1 | 1.5 | 347 |
| AROME_Norway: 12+18,+24,+30,+36 | 0.3 | 2.9 | 9.2 | 1.6 | 359 |
| Hirlam8: 12+18,+24,+30,+36 | 0.2 | 3 | 9.8 | 1.6 | 368 |
| ECMWF: 12+18,+24,+30,+36 | 0.3 | 3.2 | 14.6 | 2 | 368 |

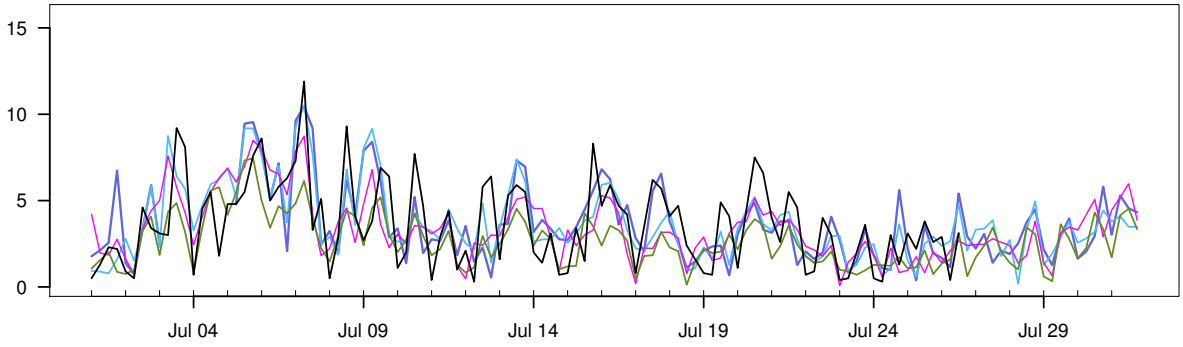
| | ME | SDE | RMSE | MAE | Max.abs.err. | N |
|---|---|---|---|---|---|---|
| AM25 – synop | −0.4 | 1.5 | 1.5 | 1.1 | 7.5 | 347 |
| AROME_Norway – synop | −0.3 | 1.5 | 1.5 | 1.1 | 6.7 | 359 |
| Hirlam8 – synop | −0.2 | 1.5 | 1.5 | 1.2 | 6.5 | 368 |
| ECMWF – synop | 0 | 1.6 | 1.6 | 1.2 | 7.8 | 368 |

FINSEVATN

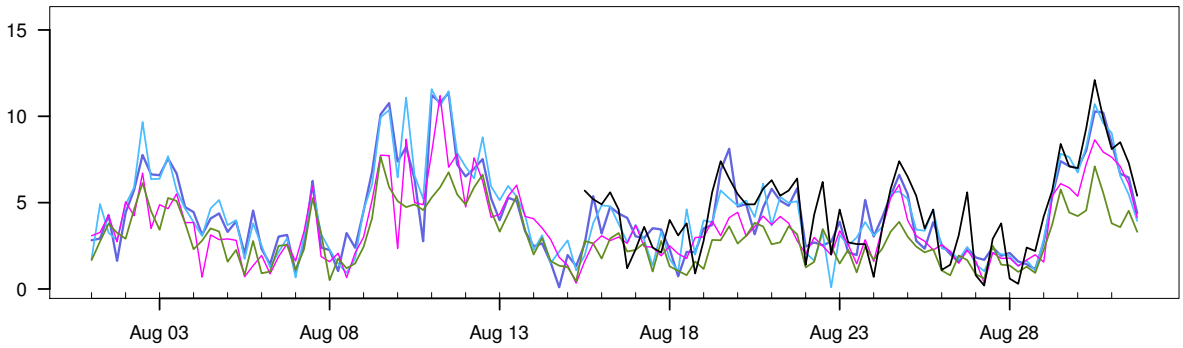
01.06.2014 – 30.06.2014




01.07.2014 – 31.07.2014




01.08.2014 – 31.08.2014

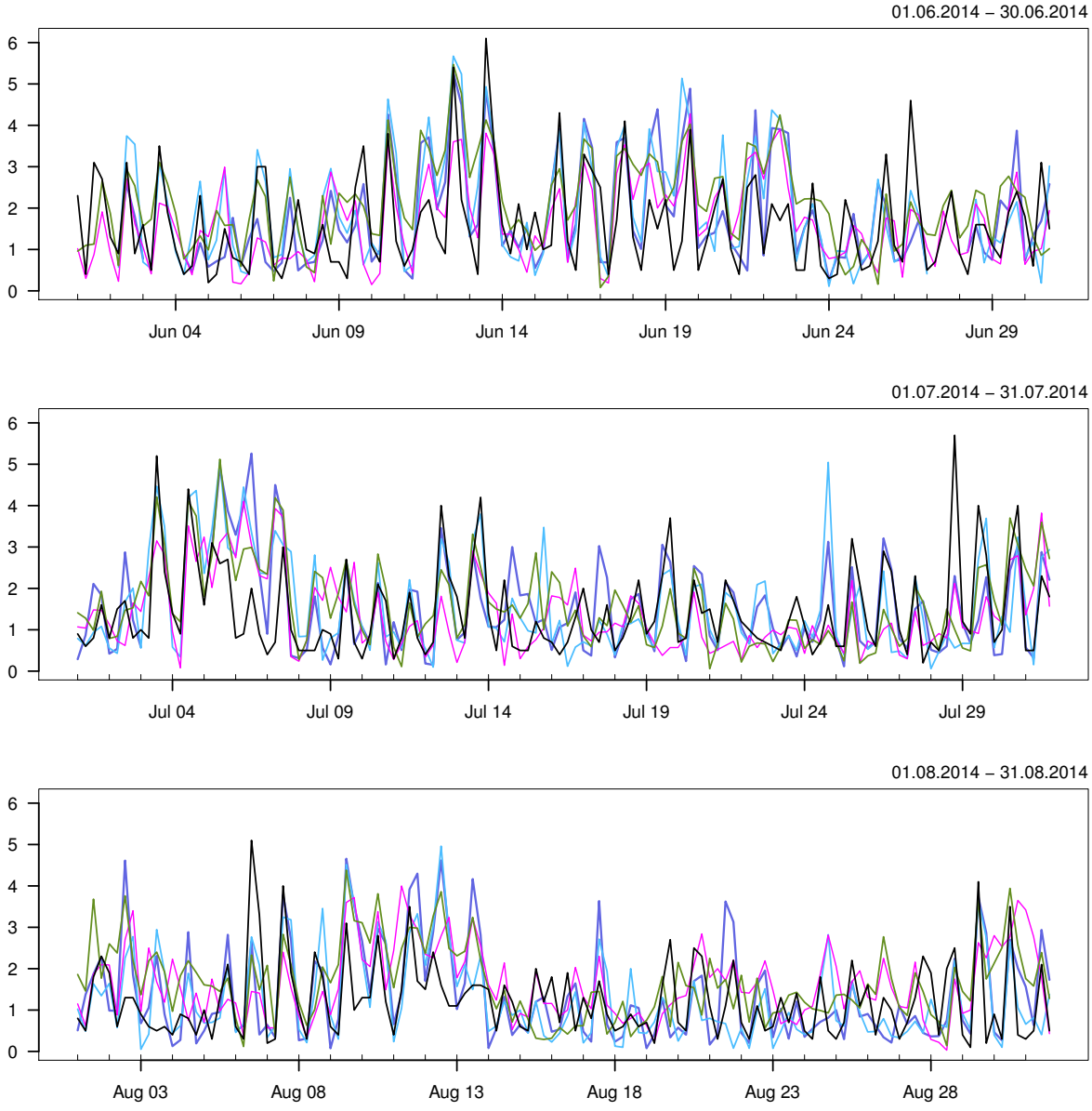



01.06.2014 – 31.08.2014

| | Min | Mean | Max | Std | N |
|---|---|---|---|---|---|
| synop: 00,06,12,18 | 0.2 | 3.9 | 12.1 | 2.5 | 289 |
| AM25: 12+18,+24,+30,+36 | 0.1 | 4.2 | 15.7 | 2.5 | 347 |
| AROME_Norway: 12+18,+24,+30,+36 | 0.1 | 4.2 | 11.9 | 2.3 | 359 |
| Hirlam8: 12+18,+24,+30,+36 | 0.1 | 3.5 | 11.2 | 1.9 | 368 |
| ECMWF: 12+18,+24,+30,+36 | 0.1 | 2.9 | 7.7 | 1.5 | 368 |

| | ME | SDE | RMSE | MAE | Max.abs.err. | N |
|---|---|---|---|---|---|---|
| AM25 – synop | 0.2 | 2.2 | 2.2 | 1.6 | 10.6 | 268 |
| AROME_Norway – synop | 0.1 | 1.9 | 1.9 | 1.5 | 8.4 | 280 |
| Hirlam8 – synop | −0.5 | 1.9 | 2 | 1.6 | 6 | 289 |
| ECMWF – synop | −1.2 | 1.9 | 2.2 | 1.8 | 6.4 | 289 |

NESBYEN



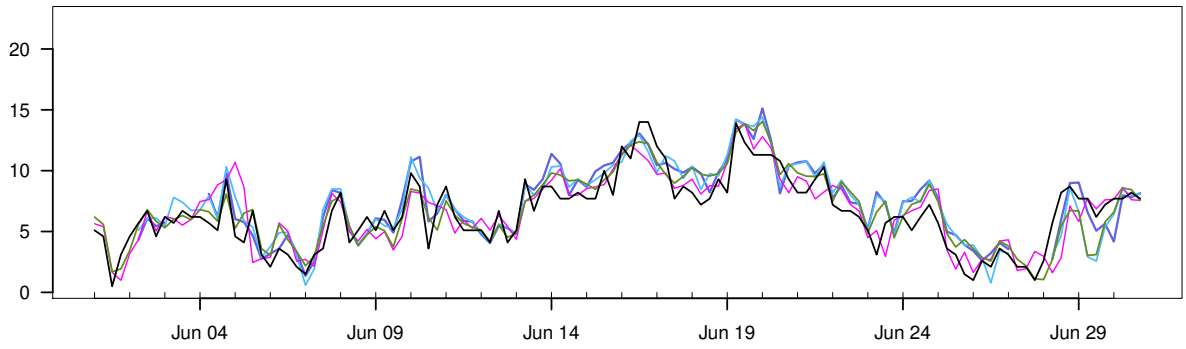

01.06.2014 – 31.08.2014

| | Min | Mean | Max | Std | N |
|---|---|---|---|---|---|
| synop: 00,06,12,18 | 0.1 | 1.4 | 6.1 | 1.1 | 368 |
| AM25: 12+18,+24,+30,+36 | 0.1 | 1.5 | 5.3 | 1.2 | 347 |
| AROME_Norway: 12+18,+24,+30,+36 | 0.1 | 1.6 | 5.7 | 1.2 | 359 |
| Hirlam8: 12+18,+24,+30,+36 | 0 | 1.6 | 4.3 | 0.9 | 368 |
| ECMWF: 12+18,+24,+30,+36 | 0.1 | 1.8 | 5.5 | 1 | 368 |

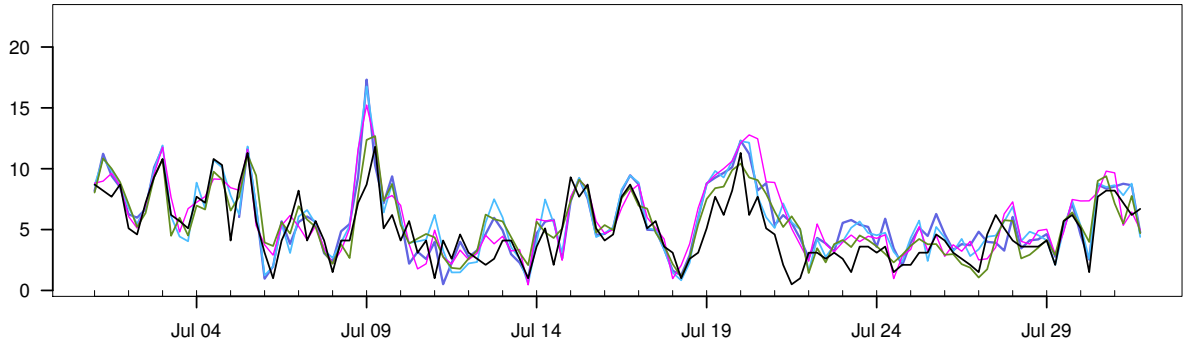
| | ME | SDE | RMSE | MAE | Max.abs.err. | N |
|---|---|---|---|---|---|---|
| AM25 – synop | 0.1 | 1.1 | 1.1 | 0.8 | 3.8 | 347 |
| AROME_Norway – synop | 0.2 | 1.1 | 1.1 | 0.8 | 5.1 | 359 |
| Hirlam8 – synop | 0.1 | 1.1 | 1.1 | 0.8 | 3.6 | 368 |
| ECMWF – synop | 0.4 | 1.1 | 1.1 | 0.9 | 4.7 | 368 |

EKOFISK

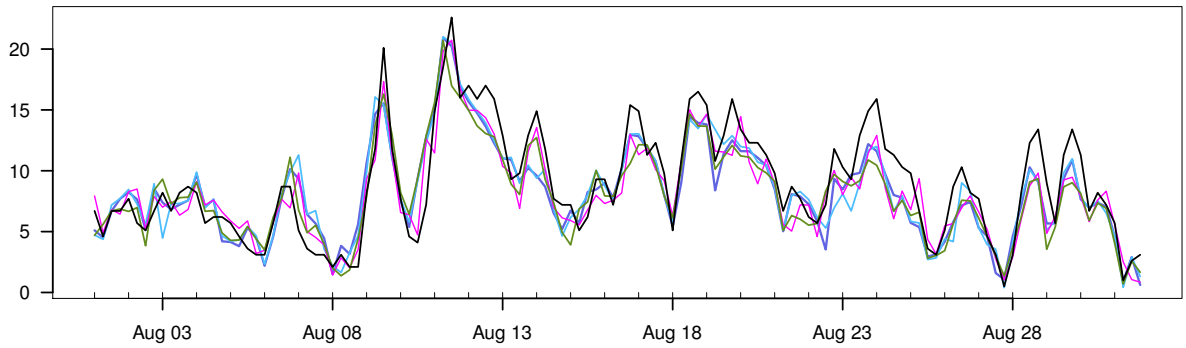
01.06.2014 – 30.06.2014




01.07.2014 – 31.07.2014




01.08.2014 – 31.08.2014

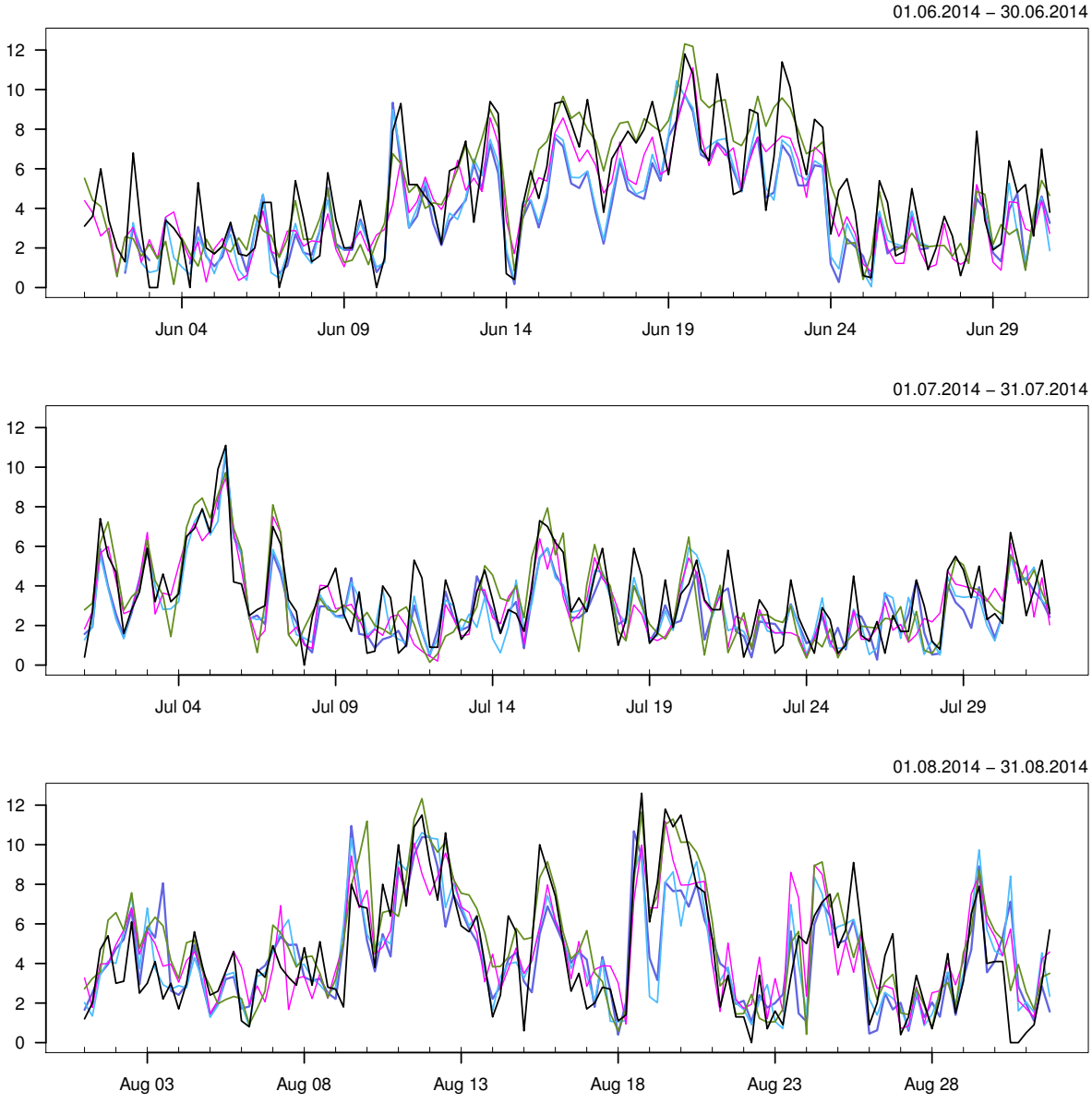



01.06.2014 – 31.08.2014

| | Min | Mean | Max | Std | N |
|---|---|---|---|---|---|
| synop: 00,06,12,18 | 0.5 | 6.8 | 22.6 | 3.8 | 368 |
| AM25: 12+18,+24,+30,+36 | 0.5 | 7.1 | 20.9 | 3.4 | 347 |
| AROME_Norway: 12+18,+24,+30,+36 | 0.4 | 7.2 | 21 | 3.4 | 359 |
| Hirlam8: 12+18,+24,+30,+36 | 0.5 | 6.9 | 20.7 | 3.3 | 368 |
| ECMWF: 12+18,+24,+30,+36 | 0.7 | 6.8 | 20.7 | 3.3 | 368 |

| | ME | SDE | RMSE | MAE | Max.abs.err. | N |
|---|---|---|---|---|---|---|
| AM25 – synop | 0.2 | 1.9 | 1.9 | 1.5 | 8.6 | 347 |
| AROME_Norway – synop | 0.3 | 2 | 2 | 1.5 | 8.1 | 359 |
| Hirlam8 – synop | 0.1 | 1.9 | 1.9 | 1.5 | 6.6 | 368 |
| ECMWF – synop | 0 | 1.8 | 1.8 | 1.4 | 5.7 | 368 |

SOLA



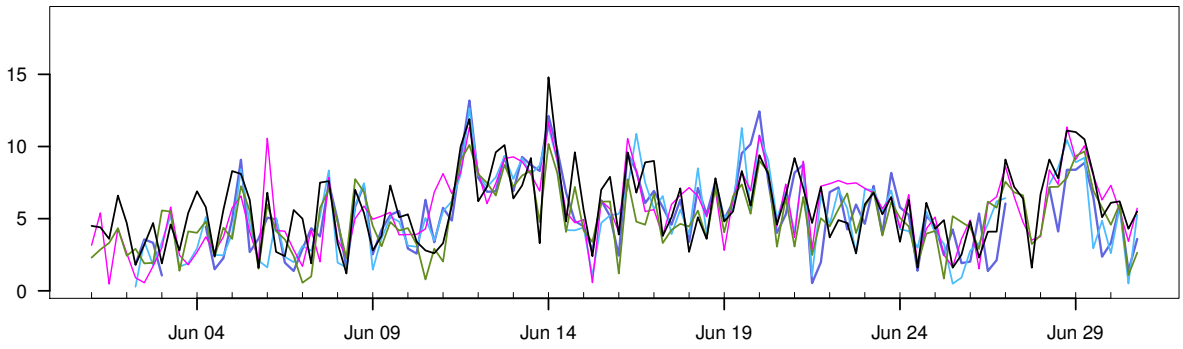

01.06.2014 – 31.08.2014

| | Min | Mean | Max | Std | N |
|---|---|---|---|---|---|
| synop: 00,06,12,18 | 0 | 4.2 | 12.6 | 2.7 | 368 |
| AM25: 12+18,+24,+30,+36 | 0.2 | 3.7 | 10.9 | 2.2 | 347 |
| AROME_Norway: 12+18,+24,+30,+36 | 0 | 3.8 | 10.9 | 2.4 | 359 |
| Hirlam8: 12+18,+24,+30,+36 | 0.2 | 4 | 11.2 | 2.3 | 368 |
| ECMWF: 12+18,+24,+30,+36 | 0.1 | 4.4 | 12.3 | 2.8 | 368 |

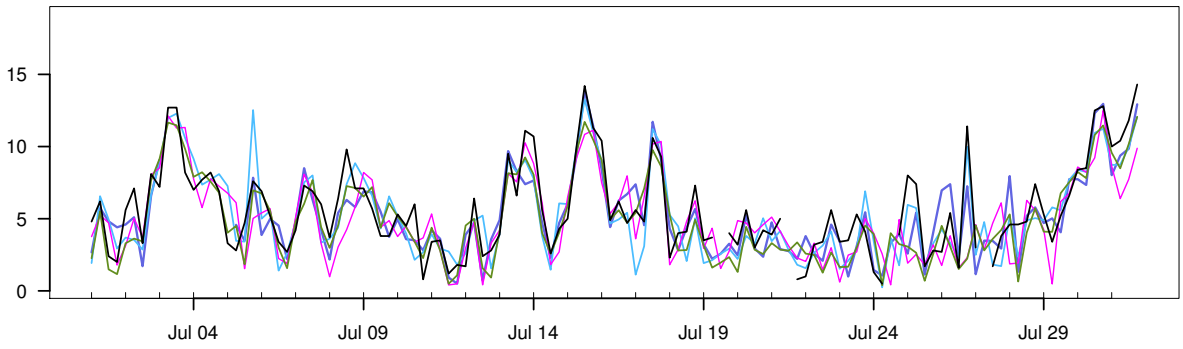
| | ME | SDE | RMSE | MAE | Max.abs.err. | N |
|---|---|---|---|---|---|---|
| AM25 – synop | −0.6 | 1.6 | 1.7 | 1.3 | 7.1 | 347 |
| AROME_Norway – synop | −0.5 | 1.6 | 1.7 | 1.3 | 8.4 | 359 |
| Hirlam8 – synop | −0.2 | 1.6 | 1.6 | 1.3 | 5.7 | 368 |
| ECMWF – synop | 0.2 | 1.6 | 1.6 | 1.3 | 5.2 | 368 |

FERDER FYR

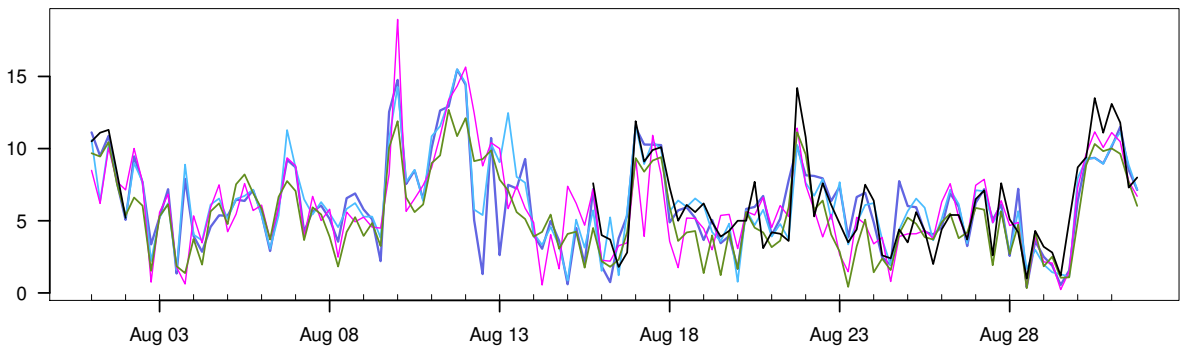
01.06.2014 – 30.06.2014




01.07.2014 – 31.07.2014




01.08.2014 – 31.08.2014



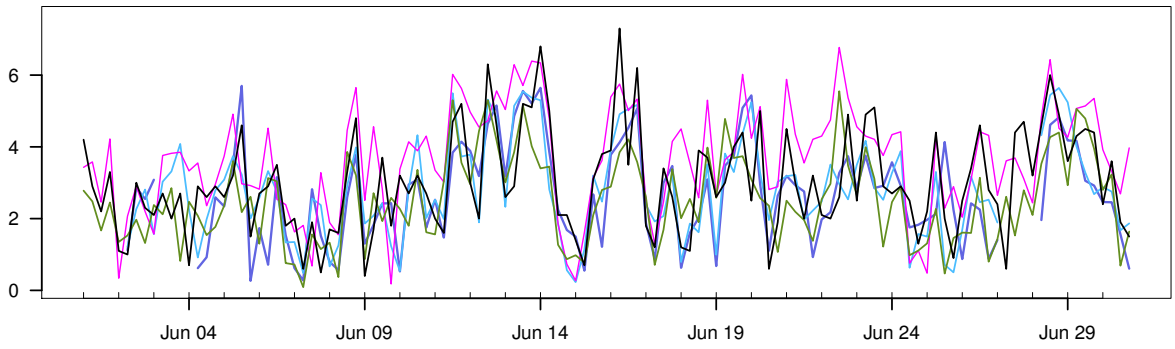

01.06.2014 – 31.08.2014

| | Min | Mean | Max | Std | N |
|---|---|---|---|---|---|
| synop: 00,06,12,18 | 0.5 | 5.8 | 14.8 | 2.9 | 310 |
| AM25: 12+18,+24,+30,+36 | 0.4 | 5.6 | 15.5 | 2.9 | 347 |
| AROME_Norway: 12+18,+24,+30,+36 | 0.2 | 5.6 | 15.5 | 3 | 359 |
| Hirlam8: 12+18,+24,+30,+36 | 0.2 | 5.5 | 18.9 | 2.9 | 368 |
| ECMWF: 12+18,+24,+30,+36 | 0.3 | 5.1 | 12.7 | 2.7 | 368 |

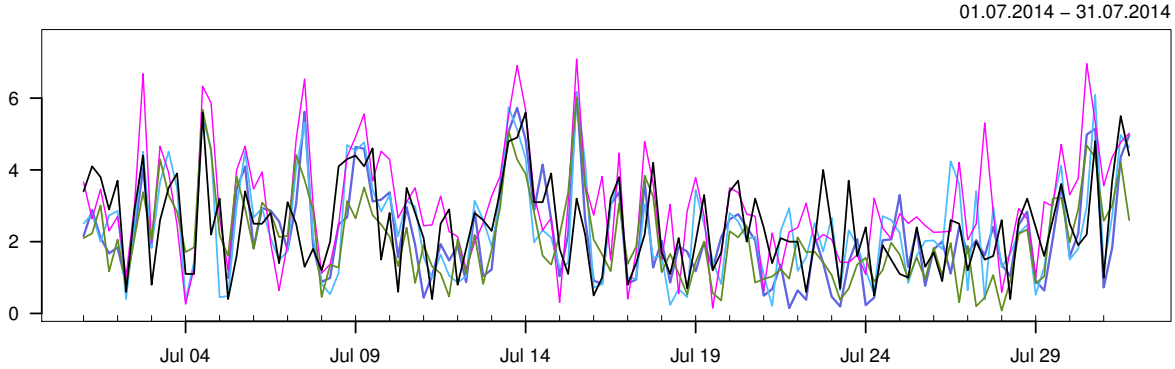
| | ME | SDE | RMSE | MAE | Max.abs.err. | N |
|---|---|---|---|---|---|---|
| AM25 – synop | −0.3 | 1.9 | 1.9 | 1.5 | 5.4 | 289 |
| AROME_Norway – synop | −0.4 | 1.8 | 1.9 | 1.4 | 5.4 | 301 |
| Hirlam8 – synop | −0.4 | 2 | 2.1 | 1.6 | 9.1 | 310 |
| ECMWF – synop | −0.8 | 1.7 | 1.9 | 1.4 | 9.2 | 310 |

OSLO – BLINDERN

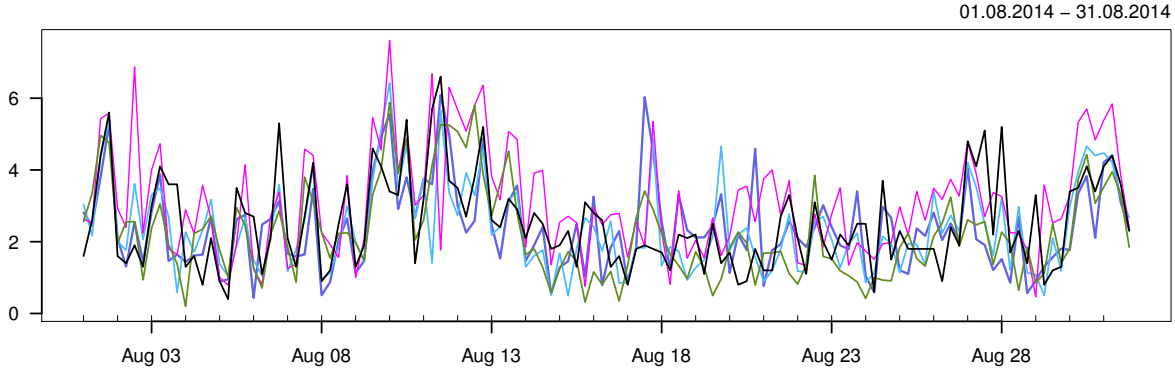
01.06.2014 – 30.06.2014




01.07.2014 – 31.07.2014




01.08.2014 – 31.08.2014

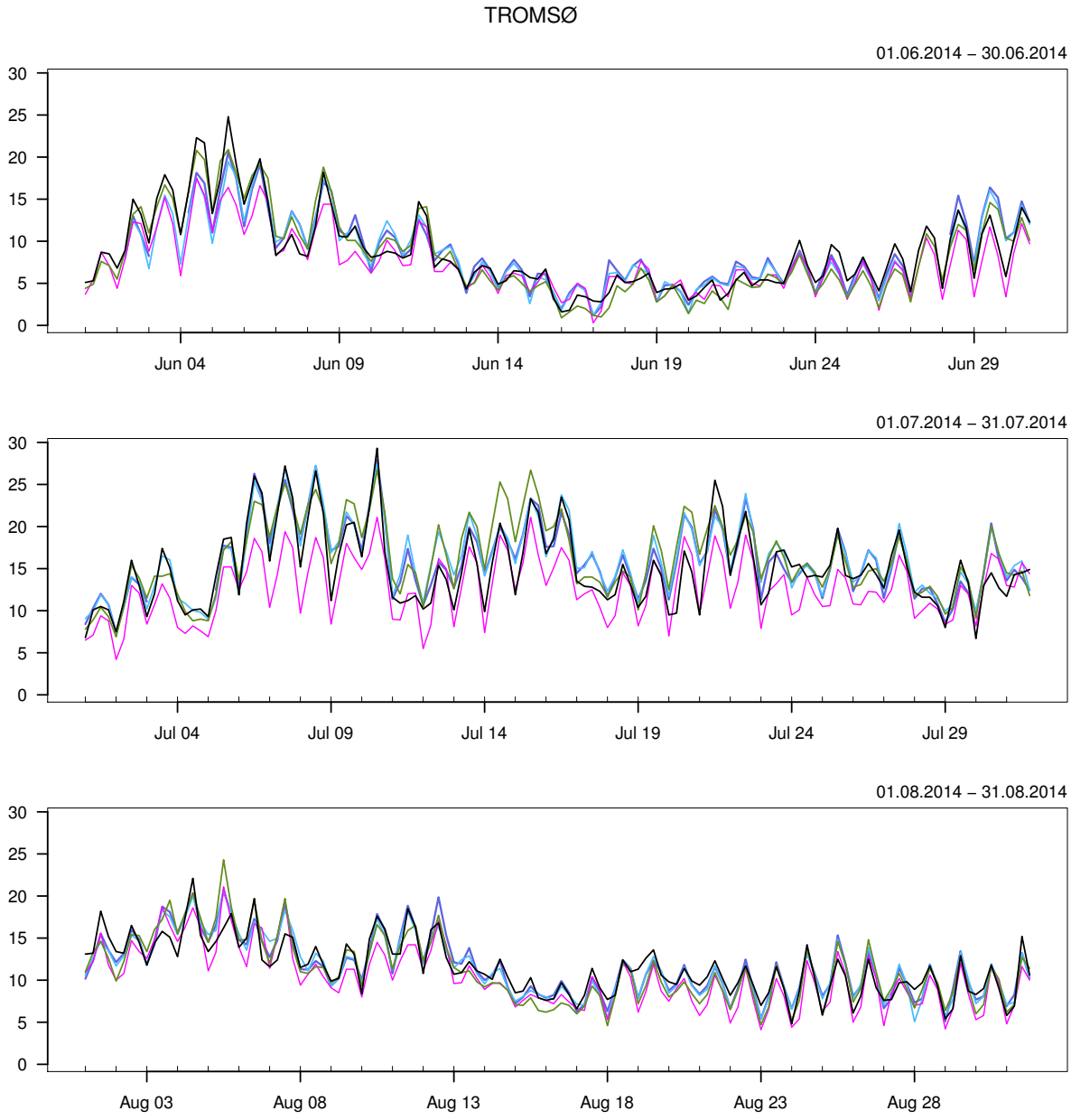



01.06.2014 – 31.08.2014

| | Min | Mean | Max | Std | N |
|---|---|---|---|---|---|
| synop: 00,06,12,18 | 0.4 | 2.6 | 7.3 | 1.3 | 368 |
| AM25: 12+18,+24,+30,+36 | 0.1 | 2.4 | 6.2 | 1.3 | 347 |
| AROME_Norway: 12+18,+24,+30,+36 | 0.2 | 2.5 | 6.4 | 1.3 | 359 |
| Hirlam8: 12+18,+24,+30,+36 | 0.2 | 3.2 | 7.6 | 1.5 | 368 |
| ECMWF: 12+18,+24,+30,+36 | 0.1 | 2.3 | 6 | 1.2 | 368 |

| | ME | SDE | RMSE | MAE | Max.abs.err. | N |
|---|---|---|---|---|---|---|
| AM25 – synop | −0.2 | 1.1 | 1.2 | 0.9 | 4.3 | 347 |
| AROME_Norway – synop | −0.1 | 1.1 | 1.1 | 0.8 | 4.3 | 359 |
| Hirlam8 – synop | 0.6 | 1.3 | 1.5 | 1.1 | 5.2 | 368 |
| ECMWF – synop | −0.4 | 1.2 | 1.2 | 1 | 3.4 | 368 |

## 9.2 Temperature 2m

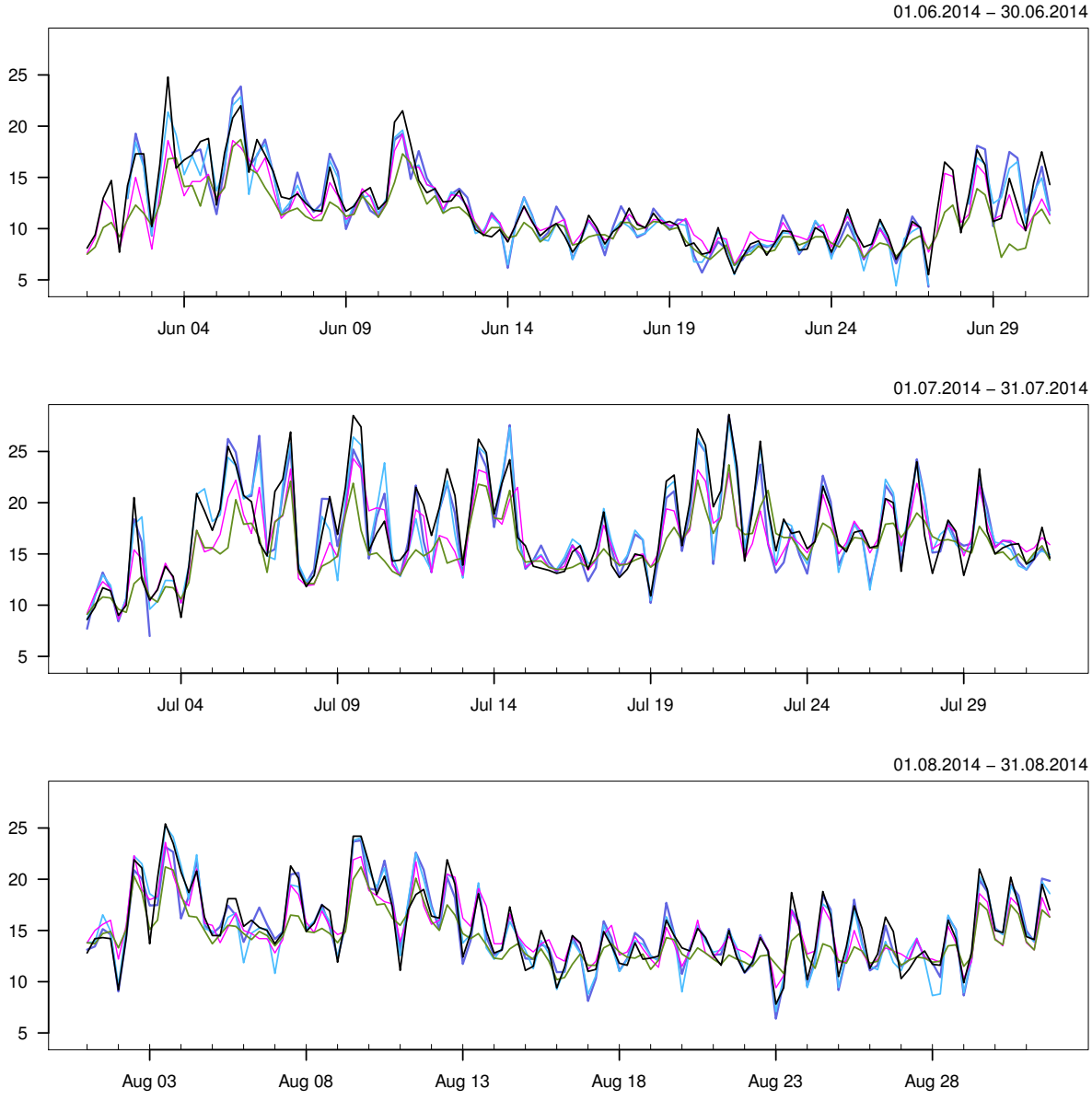



01.06.2014 – 31.08.2014

| | Min | Mean | Max | Std | N |
|---|---|---|---|---|---|
| synop: 00,06,12,18 | 1.6 | 11.8 | 29.3 | 5 | 368 |
| AM25: 12+18,+24,+30,+36 | 1.2 | 12.2 | 27.9 | 5 | 347 |
| AROME_Norway: 12+18,+24,+30,+36 | 1.2 | 12.2 | 27.5 | 5.1 | 359 |
| Hirlam8: 12+18,+24,+30,+36 | 0.3 | 10.2 | 21.1 | 4.2 | 368 |
| ECMWF: 12+18,+24,+30,+36 | 0.9 | 11.9 | 26.7 | 5.5 | 368 |

| | ME | SDE | RMSE | MAE | Max.abs.err. | N |
|---|---|---|---|---|---|---|
| AM25 – synop | 0.4 | 1.8 | 1.8 | 1.4 | 6.1 | 347 |
| AROME_Norway – synop | 0.3 | 1.9 | 1.9 | 1.4 | 7.8 | 359 |
| Hirlam8 – synop | −1.6 | 2.1 | 2.6 | 2 | 8.4 | 368 |
| ECMWF – synop | 0.2 | 2.1 | 2.1 | 1.6 | 8.1 | 368 |

ØRLAND



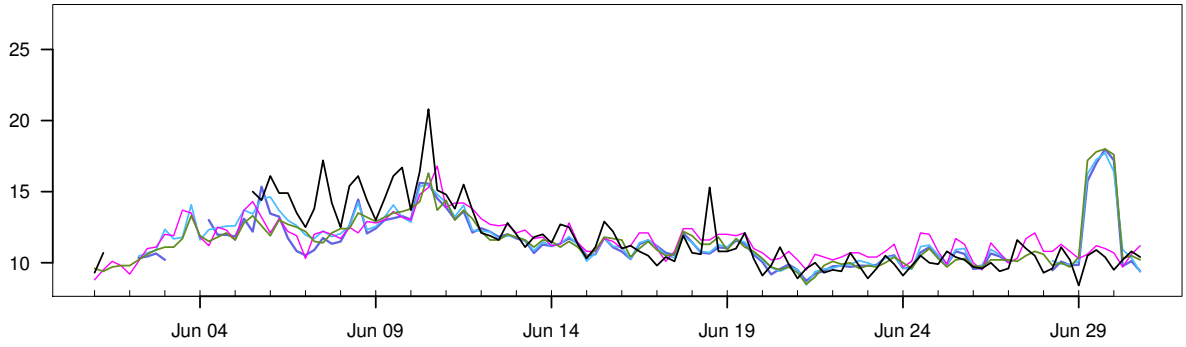

01.06.2014 – 31.08.2014

| | Min | Mean | Max | Std | N |
|---|---|---|---|---|---|
| synop: 00,06,12,18 | 5.5 | 14.9 | 28.6 | 4.5 | 368 |
| AM25: 12+18,+24,+30,+36 | 4.3 | 14.8 | 28.5 | 4.5 | 347 |
| AROME_Norway: 12+18,+24,+30,+36 | 4.4 | 14.8 | 28 | 4.5 | 359 |
| Hirlam8: 12+18,+24,+30,+36 | 6.5 | 14.4 | 24.3 | 3.6 | 368 |
| ECMWF: 12+18,+24,+30,+36 | 6.4 | 13.5 | 23.7 | 3.3 | 368 |

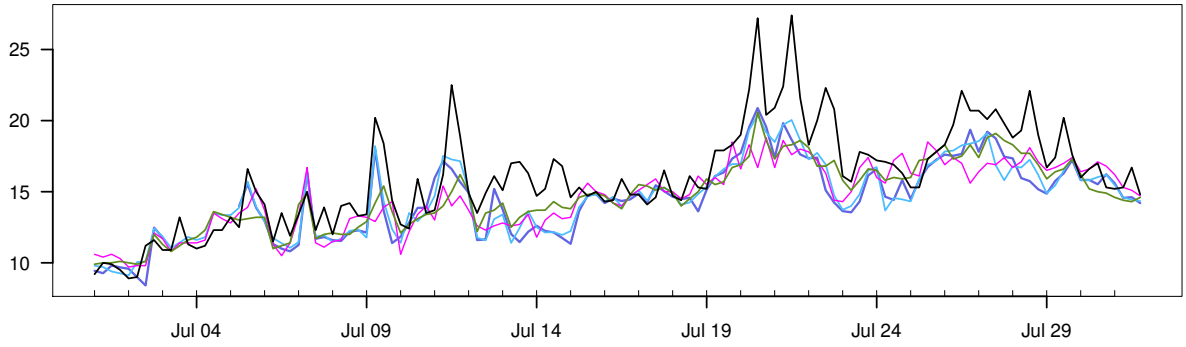
| | ME | SDE | RMSE | MAE | Max.abs.err. | N |
|---|---|---|---|---|---|---|
| AM25 – synop | −0.1 | 1.6 | 1.6 | 1.1 | 10.4 | 347 |
| AROME_Norway – synop | −0.2 | 1.6 | 1.6 | 1.1 | 8.8 | 359 |
| Hirlam8 – synop | −0.5 | 1.8 | 1.9 | 1.4 | 6.8 | 368 |
| ECMWF – synop | −1.4 | 2.2 | 2.6 | 1.9 | 10.1 | 368 |

YTTERØYANE FYR

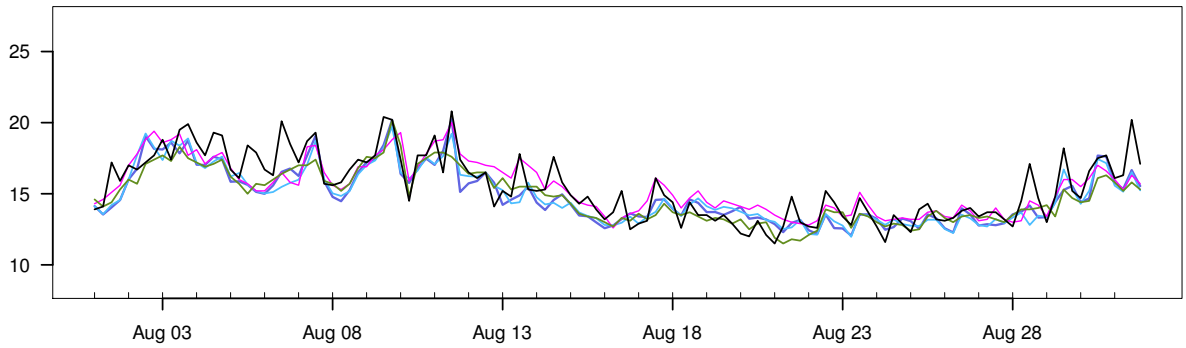
01.06.2014 – 30.06.2014




01.07.2014 – 31.07.2014




01.08.2014 – 31.08.2014

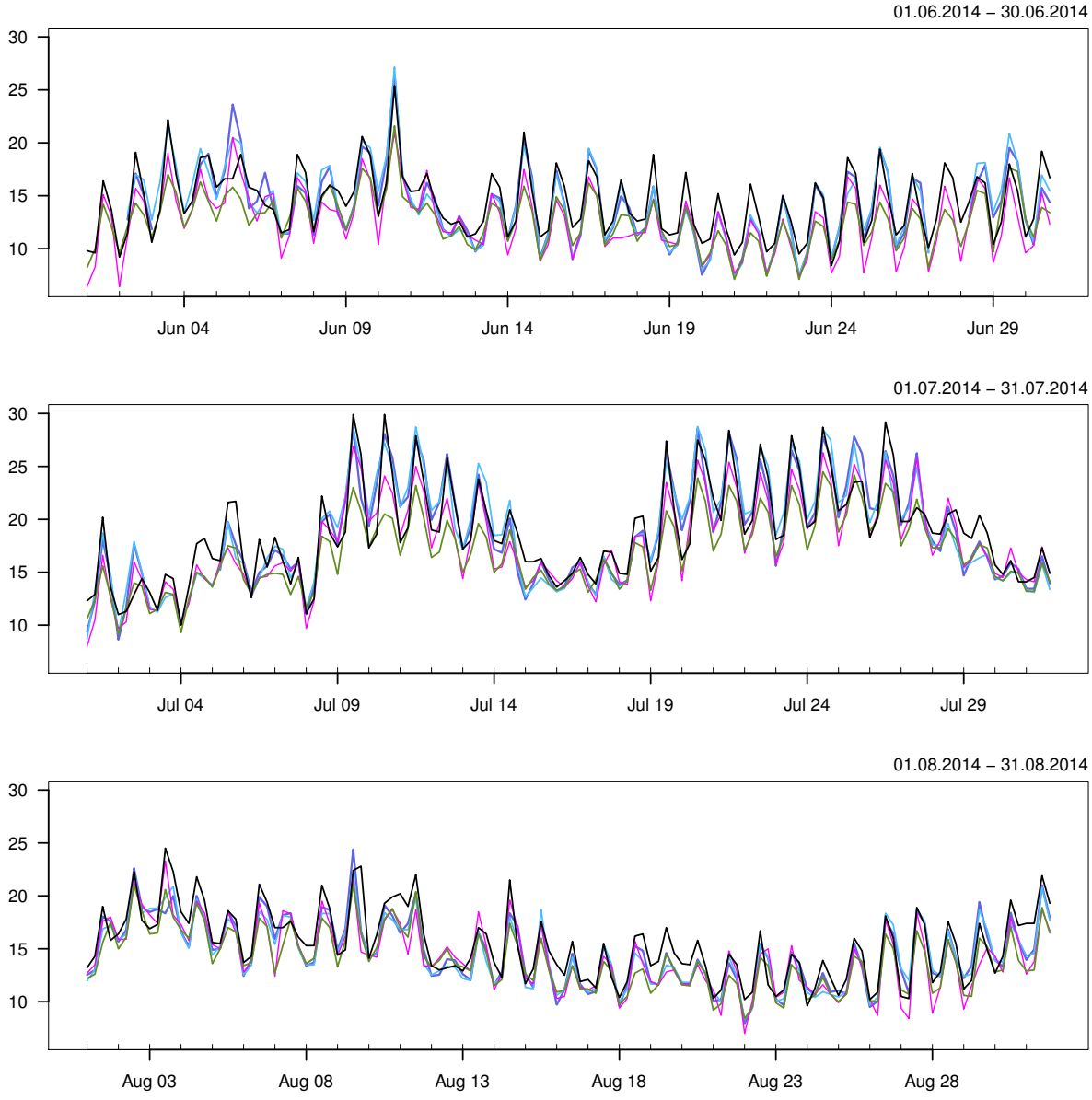



01.06.2014 – 31.08.2014

| | Min | Mean | Max | Std | N |
|---|---|---|---|---|---|
| synop: 00,06,12,18 | 8.4 | 14.5 | 27.4 | 3.3 | 352 |
| AM25: 12+18,+24,+30,+36 | 8.4 | 13.7 | 20.9 | 2.6 | 347 |
| AROME_Norway: 12+18,+24,+30,+36 | 8.4 | 13.8 | 20.4 | 2.5 | 359 |
| Hirlam8: 12+18,+24,+30,+36 | 8.8 | 13.9 | 20 | 2.5 | 368 |
| ECMWF: 12+18,+24,+30,+36 | 8.5 | 13.7 | 20.6 | 2.5 | 368 |

| | ME | SDE | RMSE | MAE | Max.abs.err. | N |
|---|---|---|---|---|---|---|
| AM25 – synop | −0.9 | 1.8 | 2 | 1.4 | 8.8 | 338 |
| AROME_Norway – synop | −0.8 | 1.7 | 1.9 | 1.3 | 7.4 | 346 |
| Hirlam8 – synop | −0.5 | 1.9 | 1.9 | 1.3 | 10.5 | 352 |
| ECMWF – synop | −0.8 | 1.7 | 1.9 | 1.2 | 9.1 | 352 |

BERGEN – FLORIDA

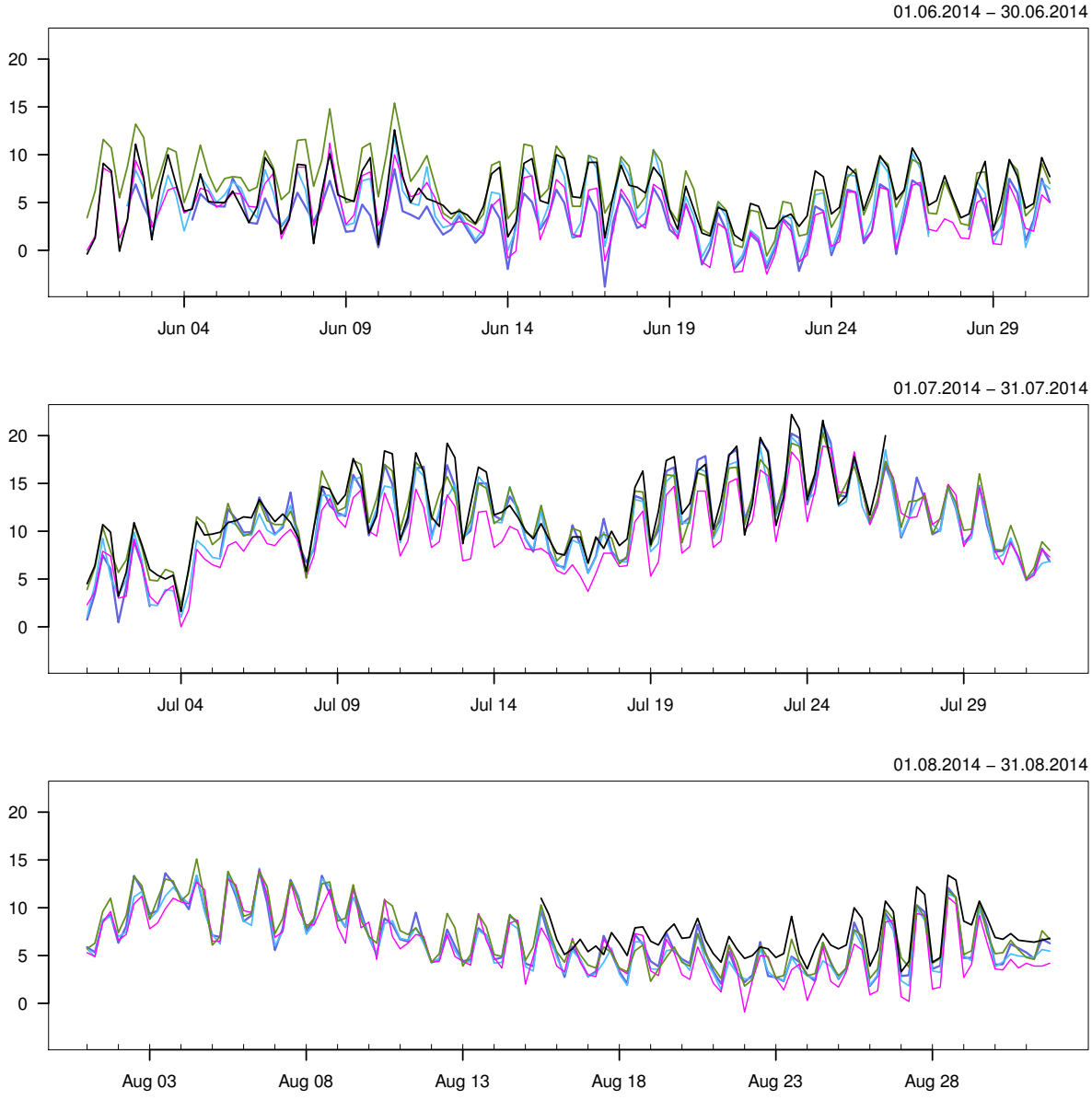



01.06.2014 – 31.08.2014

| | Min | Mean | Max | Std | N |
|---|---|---|---|---|---|
| synop: 00,06,12,18 | 8.4 | 16.2 | 29.9 | 4.2 | 368 |
| AM25: 12+18,+24,+30,+36 | 7.3 | 15.9 | 28.6 | 4.4 | 347 |
| AROME_Norway: 12+18,+24,+30,+36 | 7.3 | 15.9 | 28.8 | 4.4 | 359 |
| Hirlam8: 12+18,+24,+30,+36 | 6.4 | 14.9 | 26.9 | 4.1 | 368 |
| ECMWF: 12+18,+24,+30,+36 | 7.1 | 14.5 | 24.5 | 3.4 | 368 |

| | ME | SDE | RMSE | MAE | Max.abs.err. | N |
|---|---|---|---|---|---|---|
| AM25 – synop | −0.4 | 1.7 | 1.8 | 1.4 | 7 | 347 |
| AROME_Norway – synop | −0.4 | 1.8 | 1.8 | 1.5 | 6.3 | 359 |
| Hirlam8 – synop | −1.3 | 1.6 | 2.1 | 1.7 | 8.1 | 368 |
| ECMWF – synop | −1.7 | 1.6 | 2.3 | 1.9 | 9.4 | 368 |

FINSEVATN

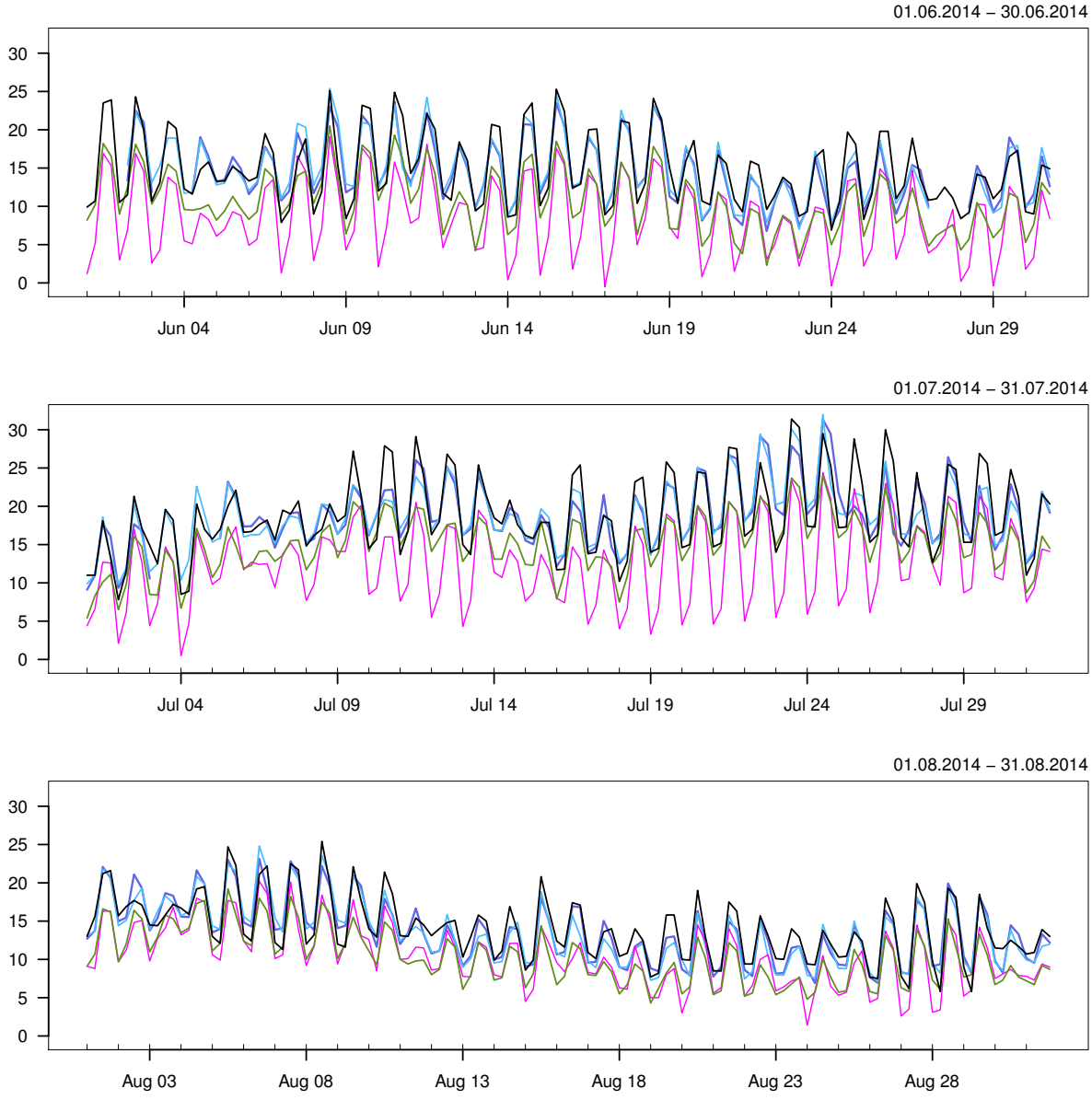



01.06.2014 – 31.08.2014

| | Min | Mean | Max | Std | N |
|---|---|---|---|---|---|
| synop: 00,06,12,18 | −0.4 | 8.3 | 22.2 | 4.4 | 289 |
| AM25: 12+18,+24,+30,+36 | −3.8 | 7.3 | 21.2 | 4.7 | 347 |
| AROME_Norway: 12+18,+24,+30,+36 | −1.6 | 7.4 | 20.8 | 4.3 | 359 |
| Hirlam8: 12+18,+24,+30,+36 | −2.5 | 6.6 | 18.9 | 4.2 | 368 |
| ECMWF: 12+18,+24,+30,+36 | −0.6 | 8.5 | 20.3 | 4 | 368 |

| | ME | SDE | RMSE | MAE | Max.abs.err. | N |
|---|---|---|---|---|---|---|
| AM25 – synop | −1.7 | 1.6 | 2.4 | 2 | 6.1 | 268 |
| AROME_Norway – synop | −1.4 | 1.4 | 2 | 1.7 | 5.6 | 280 |
| Hirlam8 – synop | −2.3 | 1.6 | 2.7 | 2.4 | 6.2 | 289 |
| ECMWF – synop | −0.1 | 1.8 | 1.8 | 1.5 | 6 | 289 |

NESBYEN

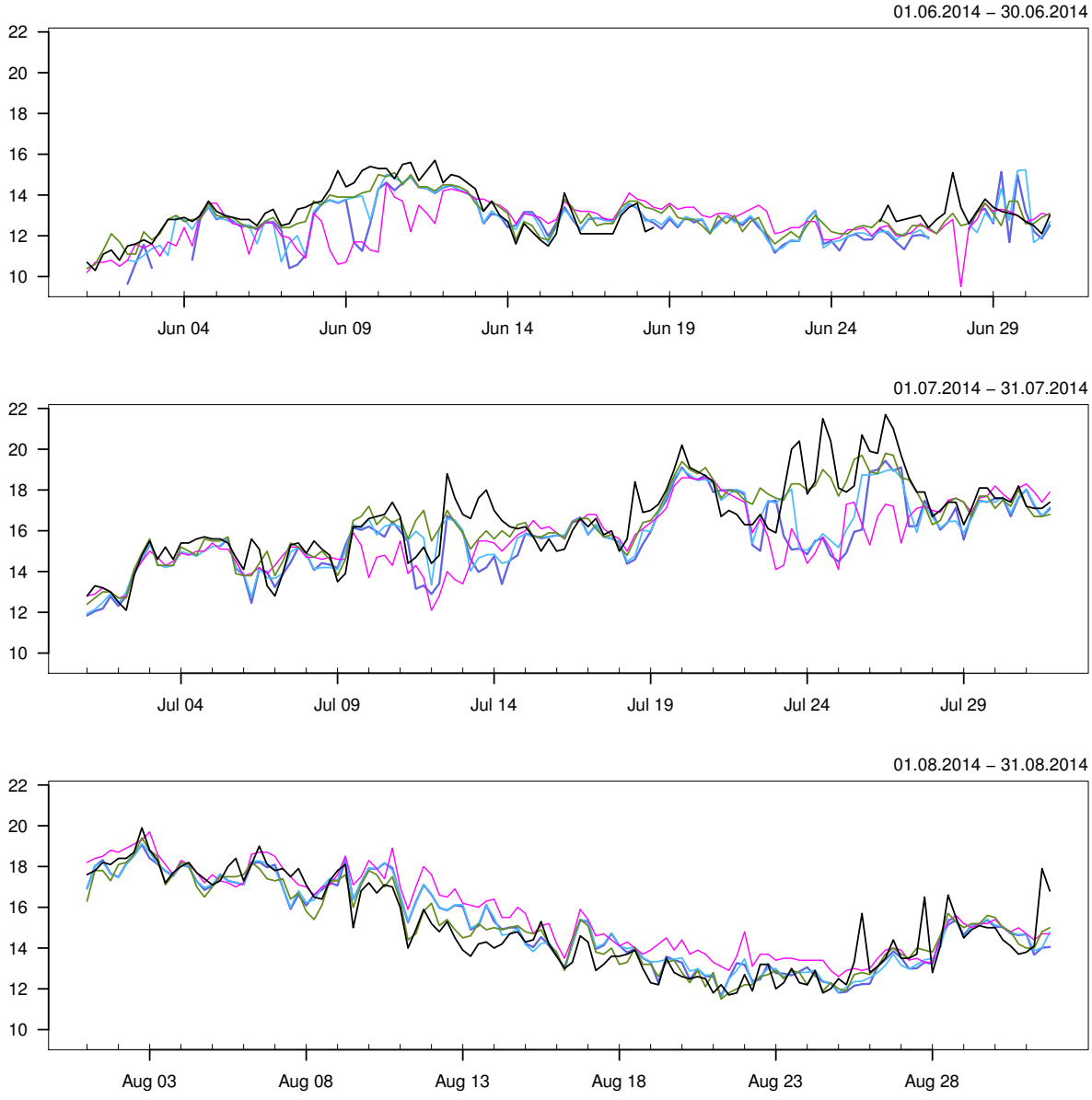



01.06.2014 – 31.08.2014

| | Min | Mean | Max | Std | N |
|---|---|---|---|---|---|
| synop: 00,06,12,18 | 5.8 | 15.9 | 31.4 | 5.2 | 368 |
| AM25: 12+18,+24,+30,+36 | 6.8 | 15.6 | 31.3 | 4.8 | 347 |
| AROME_Norway: 12+18,+24,+30,+36 | 7 | 15.7 | 32 | 4.8 | 359 |
| Hirlam8: 12+18,+24,+30,+36 | −0.5 | 10.4 | 24.4 | 5.2 | 368 |
| ECMWF: 12+18,+24,+30,+36 | 2.3 | 12 | 24 | 4.3 | 368 |

| | ME | SDE | RMSE | MAE | Max.abs.err. | N |
|---|---|---|---|---|---|---|
| AM25 – synop | −0.4 | 2.2 | 2.2 | 1.7 | 9.4 | 347 |
| AROME_Norway – synop | −0.3 | 2.2 | 2.2 | 1.7 | 7.1 | 359 |
| Hirlam8 – synop | −5.5 | 2.4 | 6 | 5.5 | 12.3 | 368 |
| ECMWF – synop | −3.9 | 2.3 | 4.5 | 4 | 9.3 | 368 |

EKOFISK



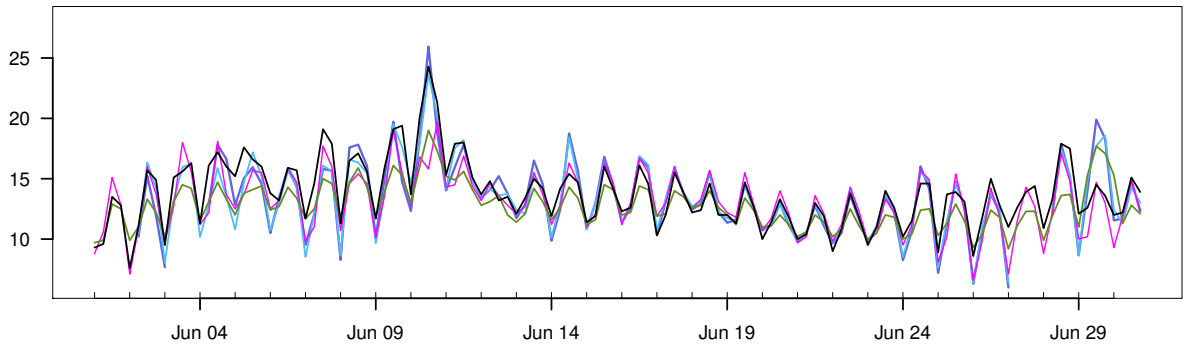

01.06.2014 – 31.08.2014

| | Min | Mean | Max | Std | N |
|---|---|---|---|---|---|
| synop: 00,06,12,18 | 10.3 | 15.1 | 21.7 | 2.3 | 341 |
| AM25: 12+18,+24,+30,+36 | 9.6 | 14.6 | 19.4 | 2.1 | 347 |
| AROME_Norway: 12+18,+24,+30,+36 | 10.7 | 14.7 | 19.1 | 2.1 | 359 |
| Hirlam8: 12+18,+24,+30,+36 | 9.5 | 14.7 | 19.7 | 2.1 | 368 |
| ECMWF: 12+18,+24,+30,+36 | 10.4 | 14.8 | 19.8 | 2.1 | 368 |

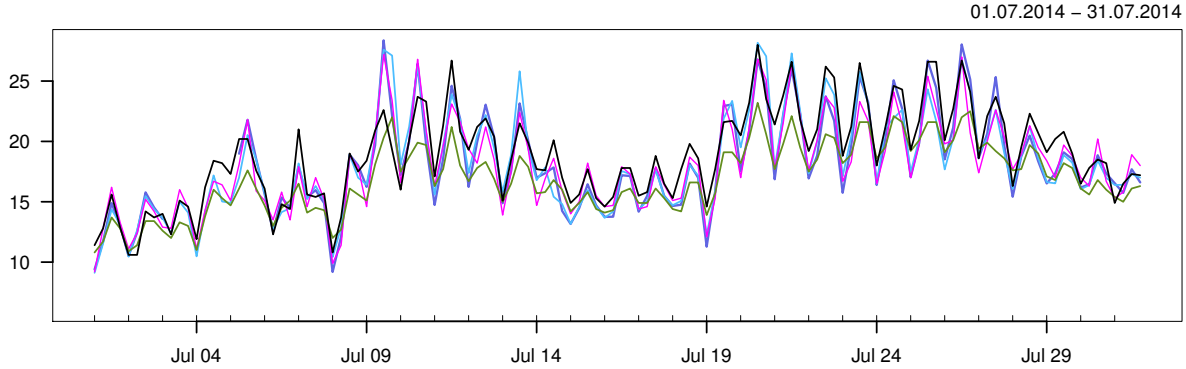
| | ME | SDE | RMSE | MAE | Max.abs.err. | N |
|---|---|---|---|---|---|---|
| AM25 – synop | −0.4 | 1.3 | 1.3 | 0.9 | 5.9 | 320 |
| AROME_Norway – synop | −0.3 | 1.1 | 1.1 | 0.8 | 5.6 | 332 |
| Hirlam8 – synop | −0.3 | 1.5 | 1.5 | 1.1 | 5.8 | 341 |
| ECMWF – synop | −0.1 | 0.8 | 0.8 | 0.6 | 3.1 | 341 |

SOLA

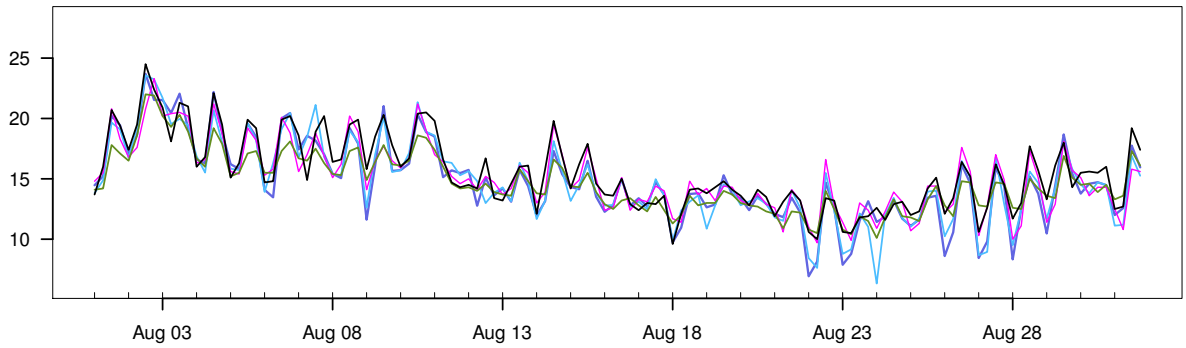
01.06.2014 – 30.06.2014




01.07.2014 – 31.07.2014




01.08.2014 – 31.08.2014

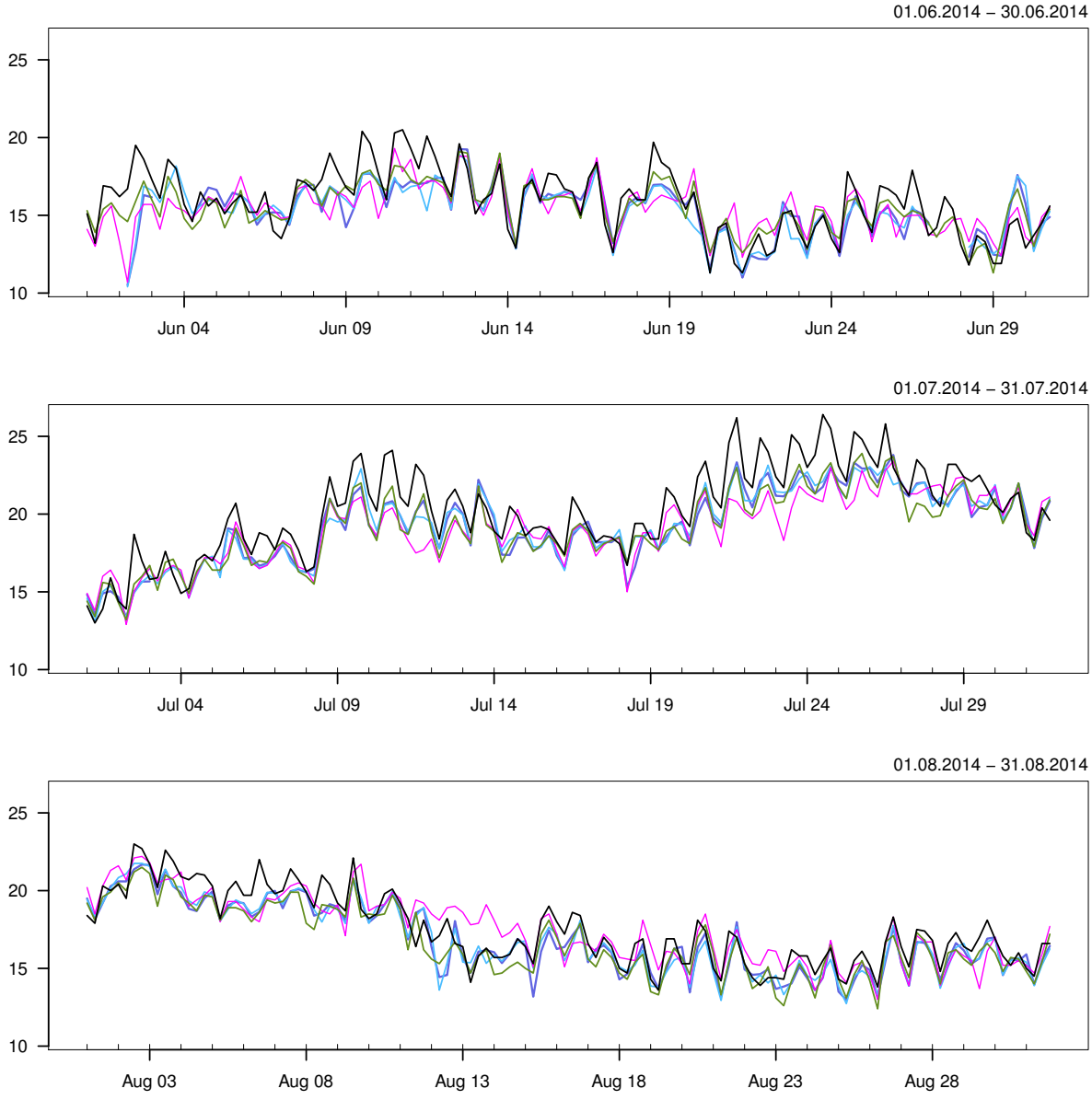



01.06.2014 – 31.08.2014

| | Min | Mean | Max | Std | N |
|---|---|---|---|---|---|
| synop: 00,06,12,18 | 7.6 | 16.1 | 28 | 3.9 | 368 |
| AM25: 12+18,+24,+30,+36 | 6 | 15.5 | 28.4 | 4.1 | 347 |
| AROME_Norway: 12+18,+24,+30,+36 | 6.3 | 15.5 | 28.2 | 4 | 359 |
| Hirlam8: 12+18,+24,+30,+36 | 6.6 | 15.4 | 27.2 | 3.7 | 368 |
| ECMWF: 12+18,+24,+30,+36 | 9.2 | 14.8 | 23.2 | 3 | 368 |

| | ME | SDE | RMSE | MAE | Max.abs.err. | N |
|---|---|---|---|---|---|---|
| AM25 – synop | −0.7 | 1.5 | 1.6 | 1.2 | 5.8 | 347 |
| AROME_Norway – synop | −0.6 | 1.5 | 1.6 | 1.2 | 7.8 | 359 |
| Hirlam8 – synop | −0.6 | 1.4 | 1.6 | 1.2 | 8.5 | 368 |
| ECMWF – synop | −1.3 | 1.5 | 2 | 1.6 | 5.6 | 368 |

FERDER FYR



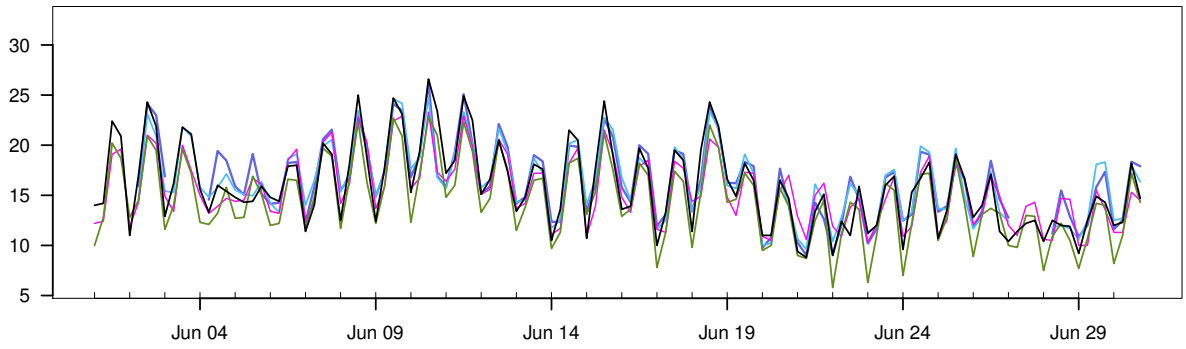

01.06.2014 – 31.08.2014

| | Min | Mean | Max | Std | N |
|---|---|---|---|---|---|
| synop: 00,06,12,18 | 11.3 | 17.9 | 26.4 | 3.1 | 368 |
| AM25: 12+18,+24,+30,+36 | 10.5 | 17.2 | 23.8 | 2.7 | 347 |
| AROME_Norway: 12+18,+24,+30,+36 | 10.4 | 17.2 | 23.1 | 2.7 | 359 |
| Hirlam8: 12+18,+24,+30,+36 | 10.7 | 17.3 | 23.4 | 2.5 | 368 |
| ECMWF: 12+18,+24,+30,+36 | 11.3 | 17.1 | 23.9 | 2.5 | 368 |

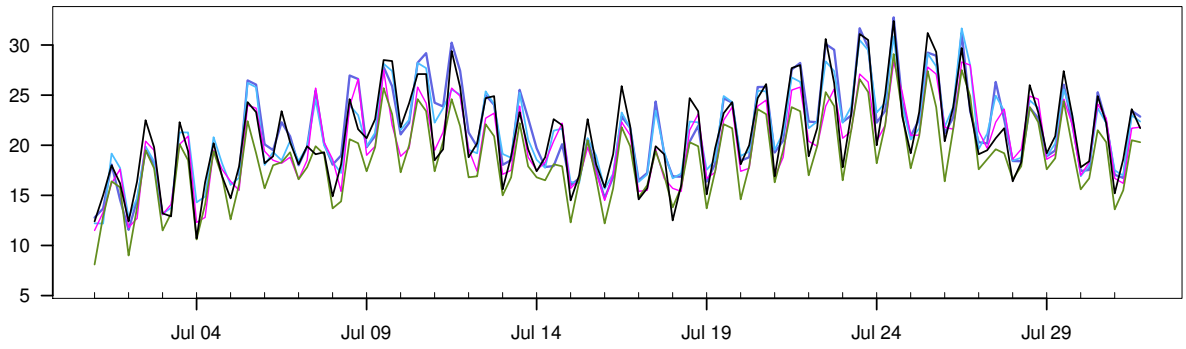
| | ME | SDE | RMSE | MAE | Max.abs.err. | N |
|---|---|---|---|---|---|---|
| AM25 – synop | −0.8 | 1.2 | 1.4 | 1.1 | 6.6 | 347 |
| AROME_Norway – synop | −0.8 | 1.2 | 1.4 | 1.1 | 6.3 | 359 |
| Hirlam8 – synop | −0.6 | 1.5 | 1.6 | 1.2 | 6 | 368 |
| ECMWF – synop | −0.8 | 1 | 1.3 | 1 | 3.8 | 368 |

OSLO – BLINDERN

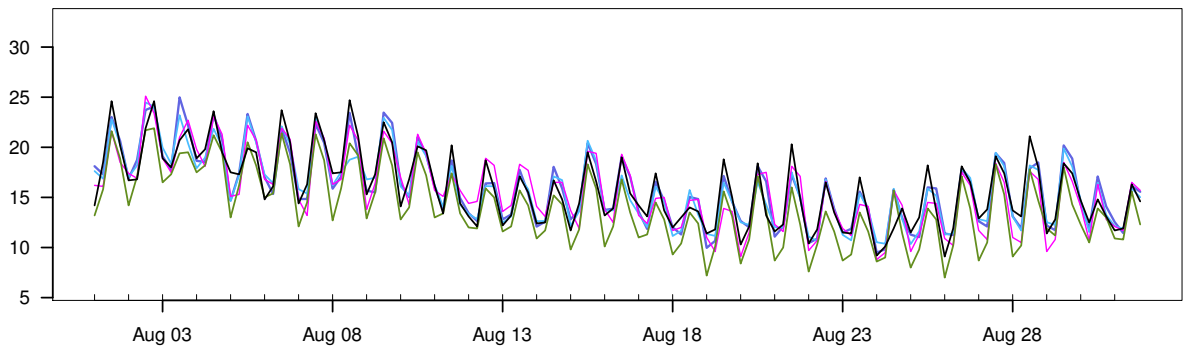
01.06.2014 – 30.06.2014




01.07.2014 – 31.07.2014




01.08.2014 – 31.08.2014

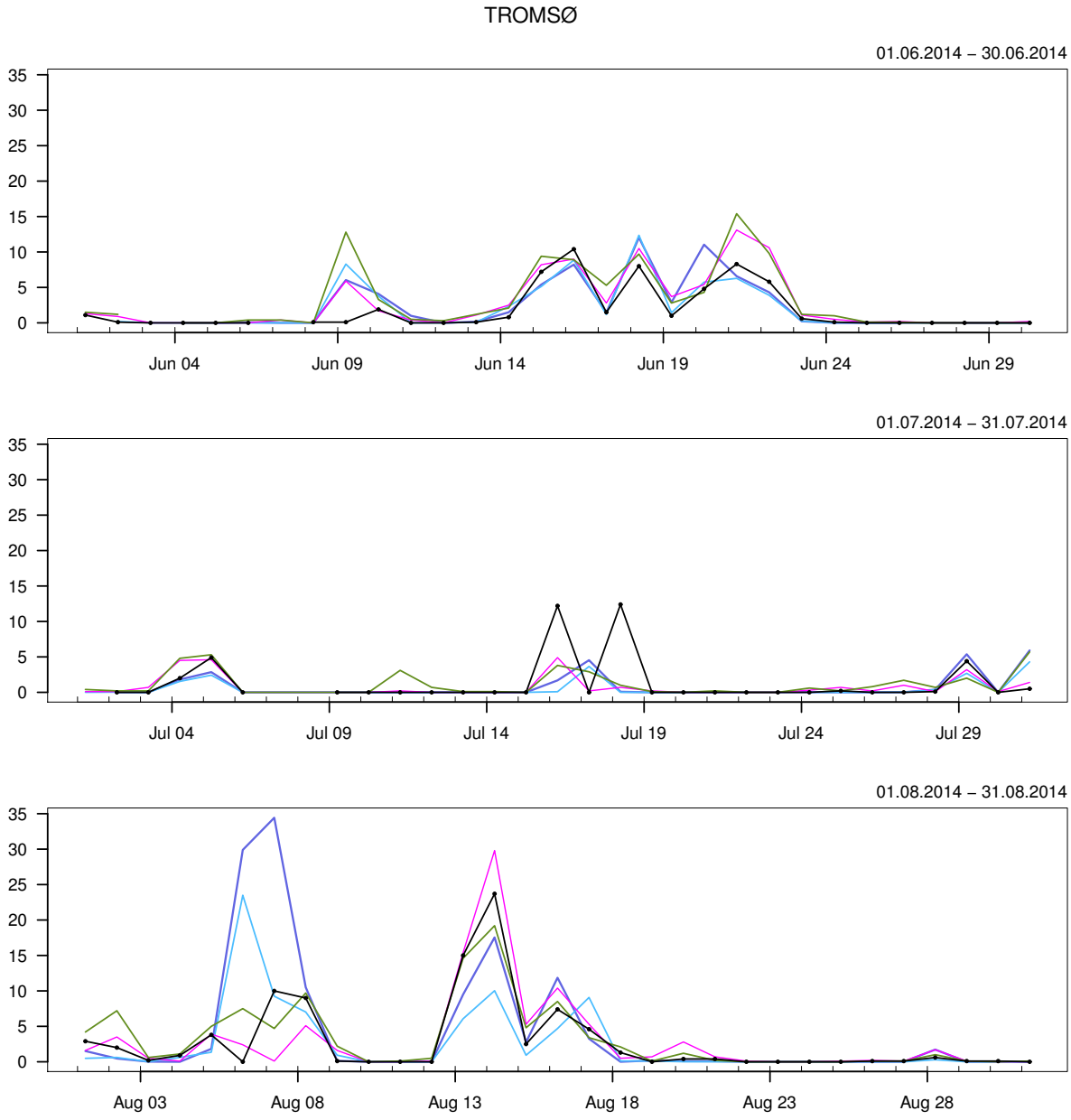



01.06.2014 – 31.08.2014

| | Min | Mean | Max | Std | N |
|---|---|---|---|---|---|
| synop: 00,06,12,18 | 8.8 | 17.6 | 32.4 | 4.8 | 368 |
| AM25: 12+18,+24,+30,+36 | 9 | 18 | 32.8 | 4.7 | 347 |
| AROME_Norway: 12+18,+24,+30,+36 | 9.6 | 17.9 | 31.7 | 4.5 | 359 |
| Hirlam8: 12+18,+24,+30,+36 | 8.8 | 17.1 | 28.3 | 4.3 | 368 |
| ECMWF: 12+18,+24,+30,+36 | 5.8 | 15.8 | 29.1 | 4.4 | 368 |

| | ME | SDE | RMSE | MAE | Max.abs.err. | N |
|---|---|---|---|---|---|---|
| AM25 – synop | 0.3 | 1.7 | 1.8 | 1.3 | 6.5 | 347 |
| AROME_Norway – synop | 0.2 | 1.6 | 1.7 | 1.2 | 6.6 | 359 |
| Hirlam8 – synop | −0.5 | 1.9 | 2 | 1.6 | 6.7 | 368 |
| ECMWF – synop | −1.8 | 1.4 | 2.3 | 2 | 5.5 | 368 |

## 9.3 Daily precipitation

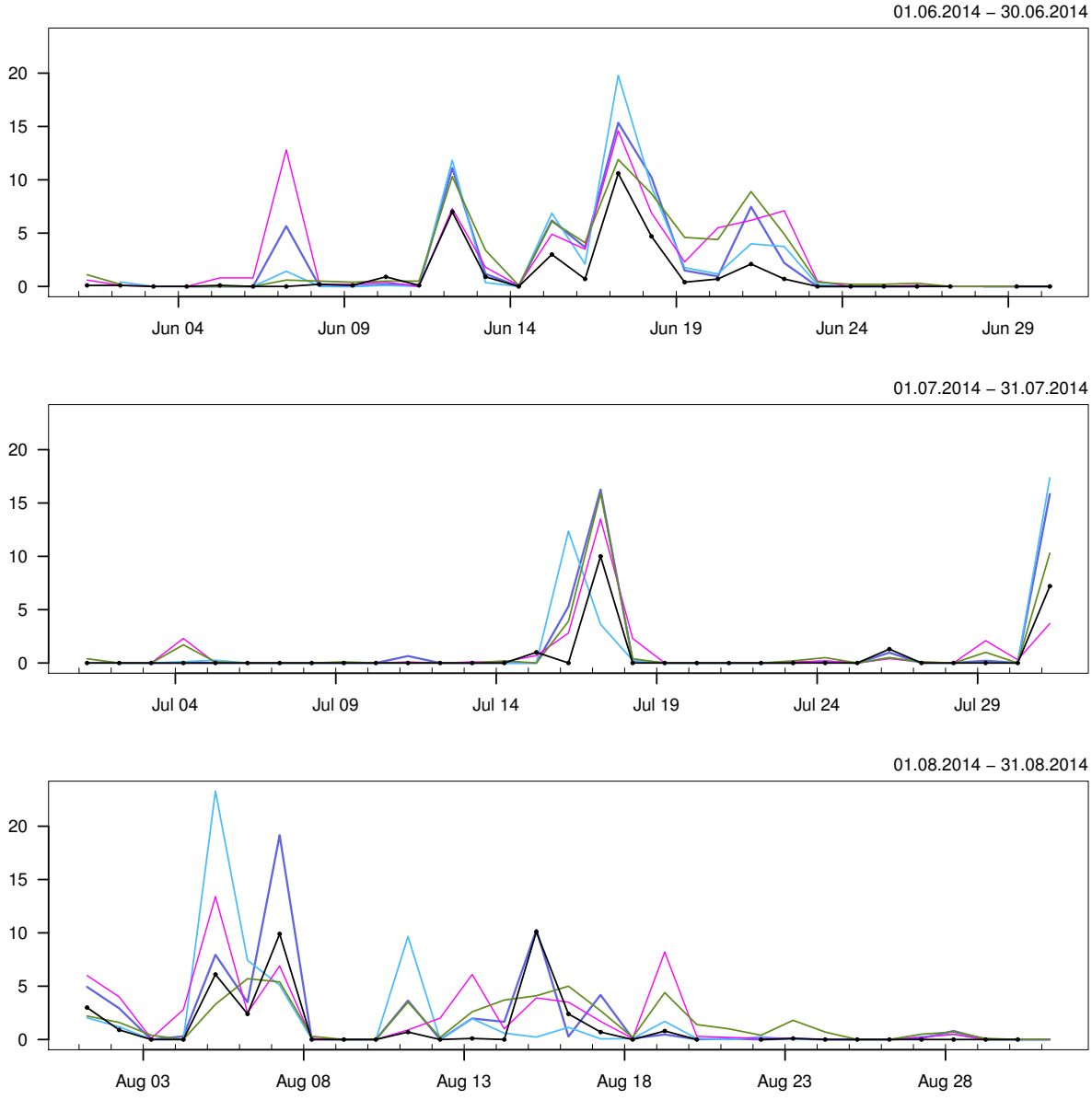



01.06.2014 – 31.08.2014

| | Min | Mean | Max | Std | N |
|---|---|---|---|---|---|
| synop: 06 | 0 | 2 | 23.7 | 4.1 | 88 |
| AM25: 00+30 | 0 | 2.4 | 34.4 | 5.7 | 88 |
| AROME_Norway: 00+30 | 0 | 1.7 | 23.5 | 3.6 | 90 |
| Hirlam8: 00+30 | 0 | 2.1 | 29.8 | 4.3 | 92 |
| ECMWF: 00+30 | 0 | 2.5 | 19.2 | 3.9 | 91 |

| | ME | SDE | RMSE | MAE | Max.abs.err. | N |
|---|---|---|---|---|---|---|
| AM25 – synop | 0.5 | 4.9 | 4.9 | 1.8 | 29.9 | 85 |
| AROME_Norway – synop | –0.3 | 3.9 | 3.9 | 1.5 | 23.5 | 86 |
| Hirlam8 – synop | 0.2 | 2.4 | 2.4 | 1.1 | 11.7 | 88 |
| ECMWF – synop | 0.6 | 2.7 | 2.8 | 1.4 | 12.7 | 87 |

BODØ

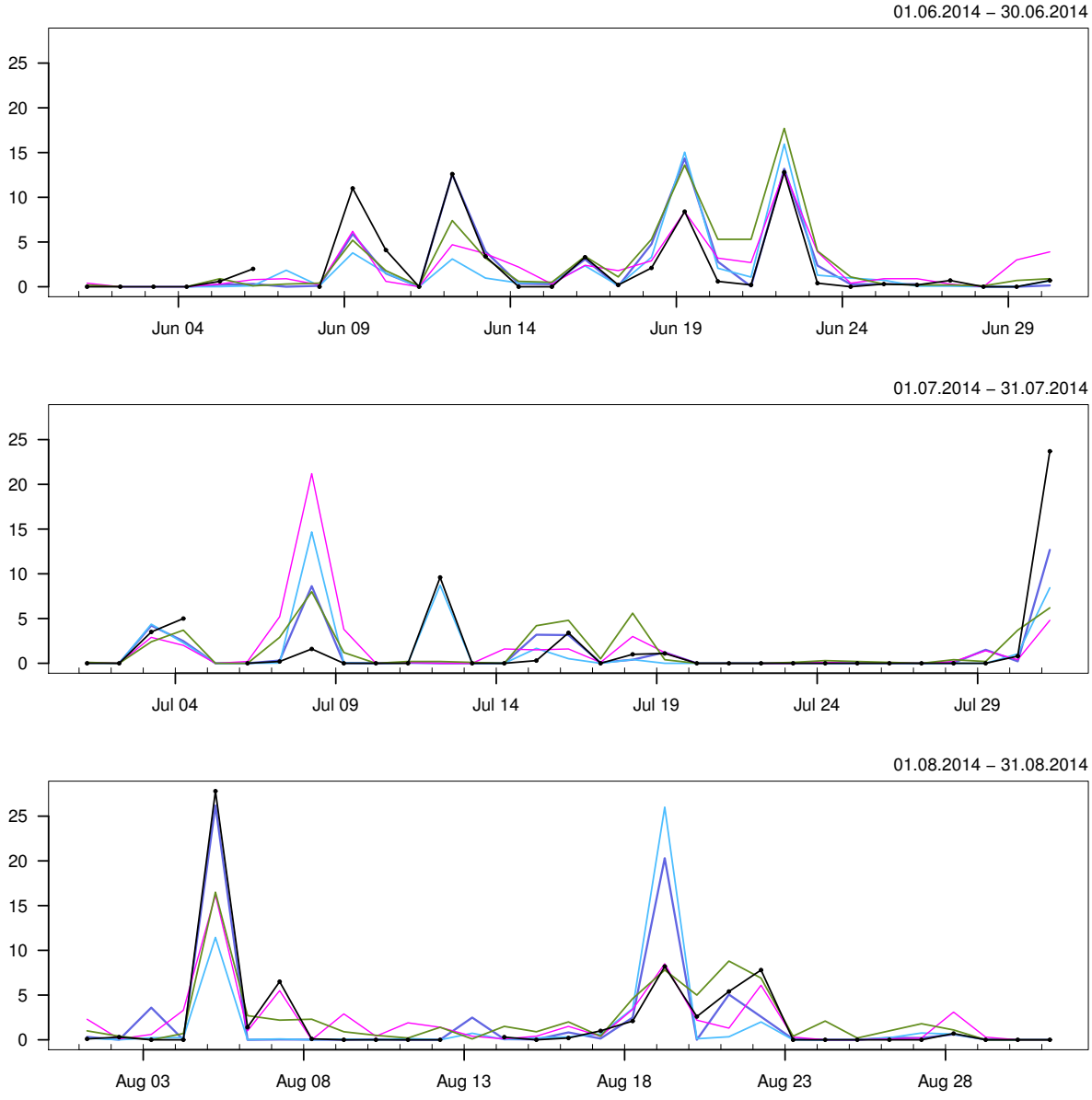



01.06.2014 – 31.08.2014

| | Min | Mean | Max | Std | N |
|---|---|---|---|---|---|
| synop: 06 | 0 | 1 | 10.6 | 2.4 | 89 |
| AM25: 00+30 | 0 | 1.9 | 19.2 | 4.1 | 88 |
| AROME_Norway: 00+30 | 0 | 1.7 | 23.3 | 4.3 | 90 |
| Hirlam8: 00+30 | 0 | 1.8 | 14.6 | 3.3 | 92 |
| ECMWF: 00+30 | 0 | 1.8 | 15.9 | 3 | 91 |

| | ME | SDE | RMSE | MAE | Max.abs.err. | N |
|---|---|---|---|---|---|---|
| AM25 – synop | 0.9 | 2.1 | 2.3 | 1 | 9.3 | 85 |
| AROME_Norway – synop | 0.7 | 3.3 | 3.4 | 1.4 | 17.2 | 87 |
| Hirlam8 – synop | 0.9 | 2.3 | 2.5 | 1.2 | 12.8 | 89 |
| ECMWF – synop | 0.8 | 1.9 | 2 | 1.2 | 6.8 | 88 |

ØRLAND



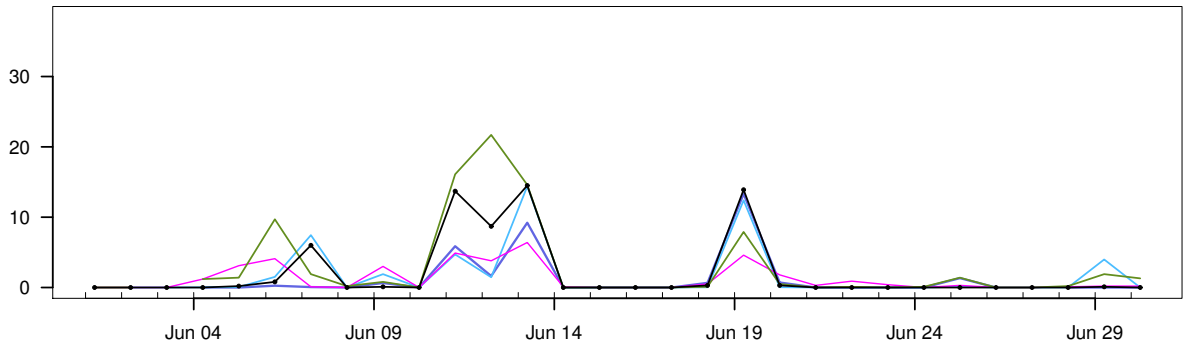

01.06.2014 – 31.08.2014

| | Min | Mean | Max | Std | N |
|---|---|---|---|---|---|
| synop: 06 | 0 | 2 | 27.8 | 4.6 | 89 |
| AM25: 00+30 | 0 | 1.9 | 26.2 | 4.5 | 88 |
| AROME_Norway: 00+30 | 0 | 1.6 | 26 | 4.1 | 90 |
| Hirlam8: 00+30 | 0 | 2 | 21.2 | 3.4 | 92 |
| ECMWF: 00+30 | 0 | 2.2 | 17.7 | 3.4 | 91 |

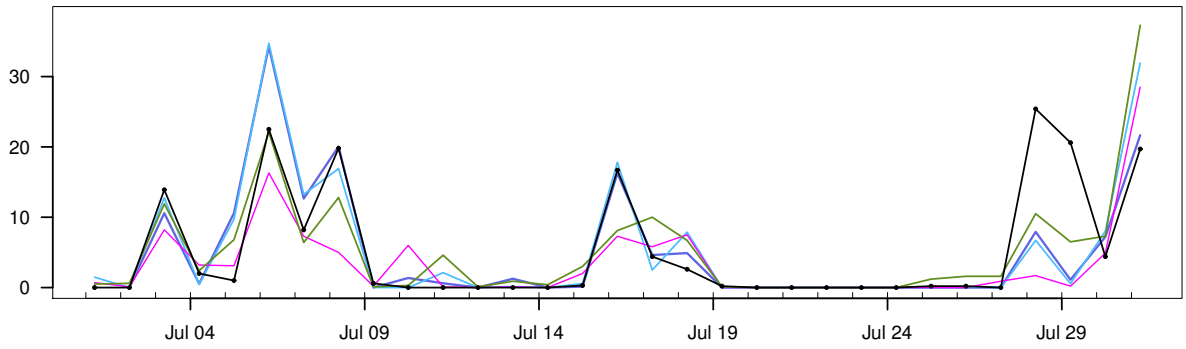
| | ME | SDE | RMSE | MAE | Max.abs.err. | N |
|---|---|---|---|---|---|---|
| AM25 – synop | −0.1 | 2.7 | 2.7 | 1.2 | 12.1 | 85 |
| AROME_Norway – synop | −0.4 | 3.9 | 3.9 | 1.6 | 17.8 | 87 |
| Hirlam8 – synop | 0 | 3.8 | 3.8 | 1.7 | 19.6 | 89 |
| ECMWF – synop | 0.2 | 3.2 | 3.2 | 1.7 | 17.5 | 88 |

BERGEN – FLORIDA

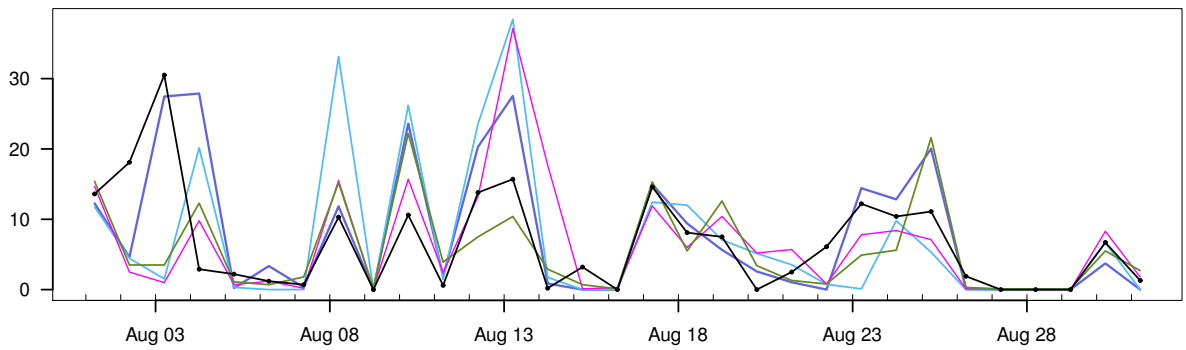
01.06.2014 – 30.06.2014




01.07.2014 – 31.07.2014




01.08.2014 – 31.08.2014

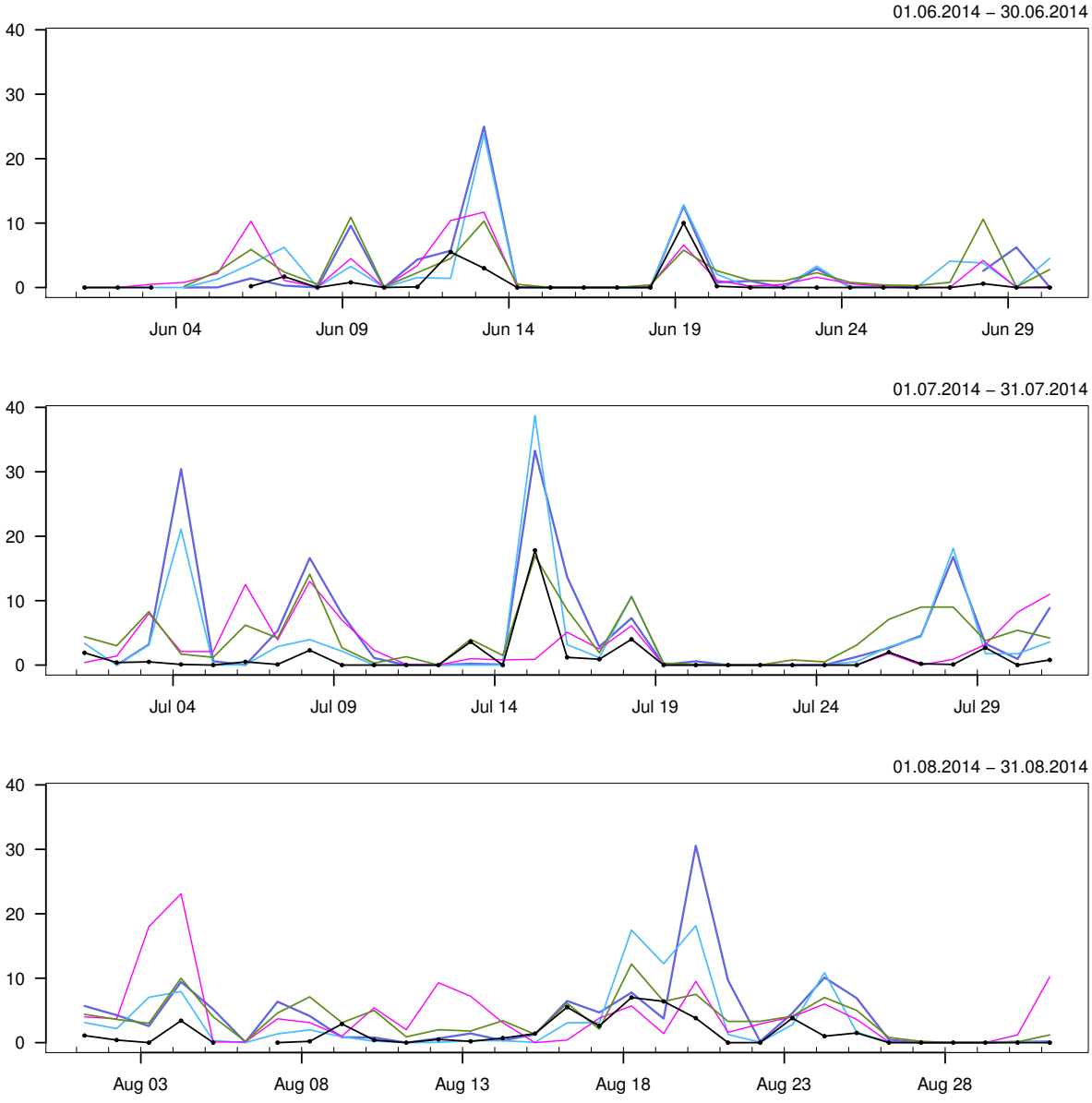



01.06.2014 – 31.08.2014

| | Min | Mean | Max | Std | N |
|---|---|---|---|---|---|
| synop: 06 | 0 | 4.6 | 30.5 | 7.1 | 92 |
| AM25: 00+30 | 0 | 5 | 34.3 | 8.1 | 88 |
| AROME_Norway: 00+30 | 0 | 4.9 | 38.4 | 8.7 | 90 |
| Hirlam8: 00+30 | 0 | 3.8 | 37.1 | 6.2 | 92 |
| ECMWF: 00+30 | 0 | 4.7 | 37.3 | 6.8 | 91 |

| | ME | SDE | RMSE | MAE | Max.abs.err. | N |
|---|---|---|---|---|---|---|
| AM25 – synop | 0.1 | 5.4 | 5.4 | 2.6 | 25 | 88 |
| AROME_Norway – synop | 0.2 | 7 | 7 | 3.4 | 29 | 90 |
| Hirlam8 – synop | −0.8 | 6.5 | 6.6 | 3.3 | 29.5 | 92 |
| ECMWF – synop | 0 | 5.6 | 5.6 | 3.1 | 27 | 91 |

LÆRDAL

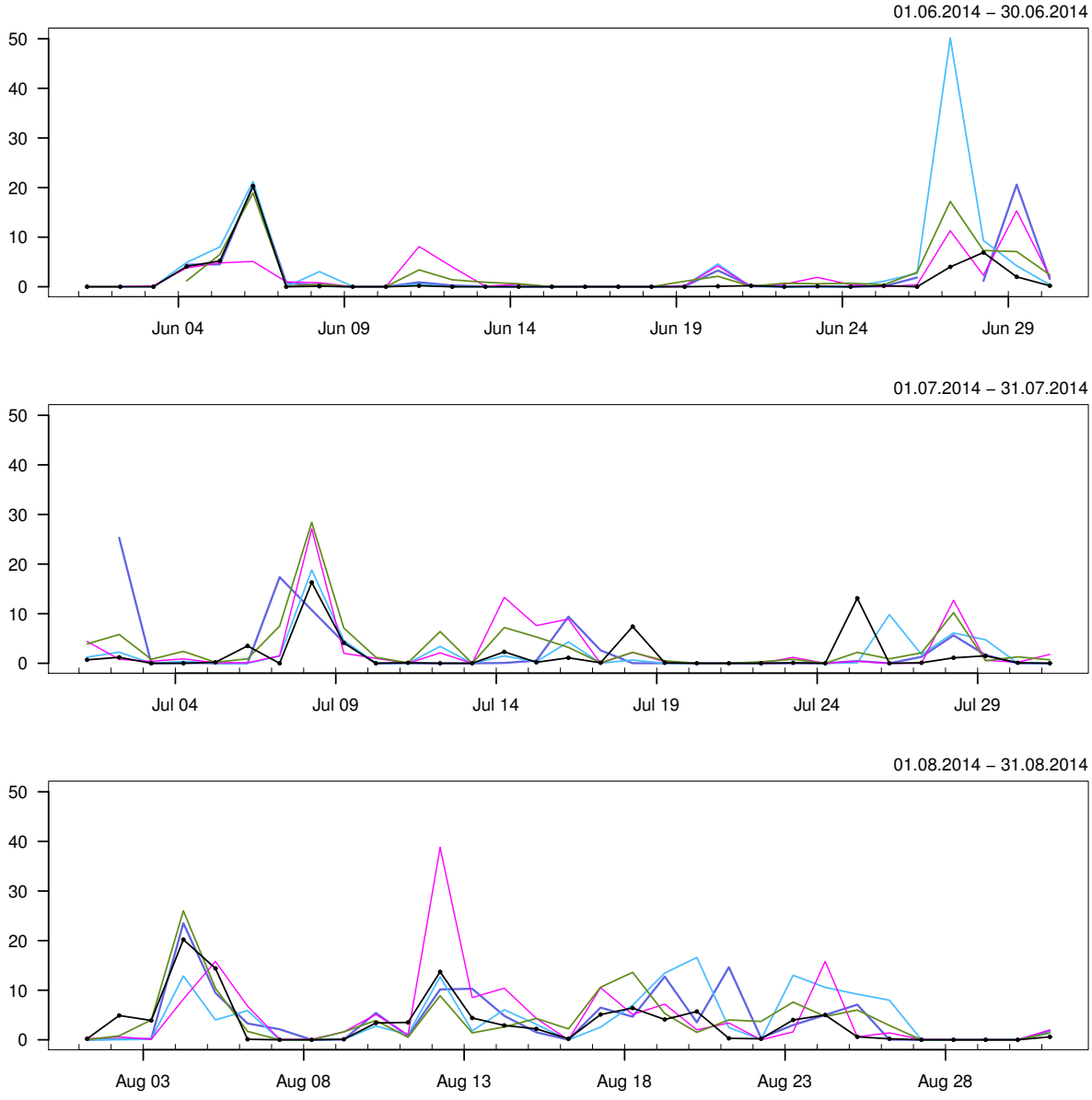



01.06.2014 – 31.08.2014

| | Min | Mean | Max | Std | N |
|---|---|---|---|---|---|
| synop: 06 | 0 | 1.2 | 17.8 | 2.6 | 89 |
| AM25: 00+30 | 0 | 4.1 | 33.3 | 6.9 | 88 |
| AROME_Norway: 00+30 | 0 | 3.2 | 38.7 | 6.3 | 90 |
| Hirlam8: 00+30 | 0 | 3.1 | 23.1 | 4.3 | 92 |
| ECMWF: 00+30 | 0 | 3.5 | 16.9 | 3.6 | 91 |

| | ME | SDE | RMSE | MAE | Max.abs.err. | N |
|---|---|---|---|---|---|---|
| AM25 – synop | 3.1 | 5.9 | 6.7 | 3.3 | 30.3 | 85 |
| AROME_Norway – synop | 2.1 | 4.8 | 5.3 | 2.5 | 21 | 87 |
| Hirlam8 – synop | 2 | 4.7 | 5.1 | 2.9 | 19.7 | 89 |
| ECMWF – synop | 2.4 | 2.9 | 3.8 | 2.5 | 11.8 | 88 |

GARDERMOEN

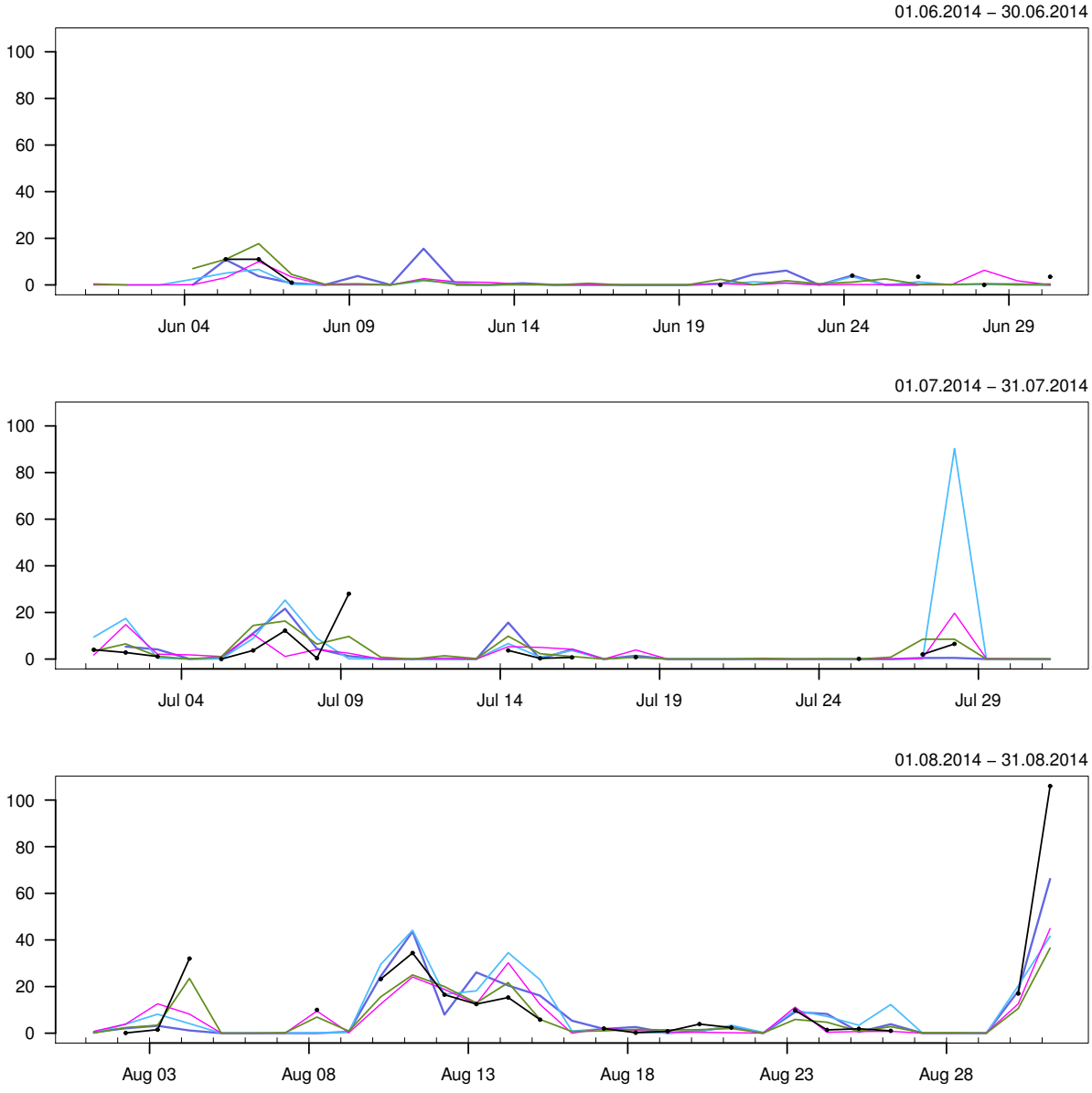



01.06.2014 – 31.08.2014

| | Min | Mean | Max | Std | N |
|---|---|---|---|---|---|
| synop: 06 | 0 | 2.2 | 20.3 | 4.3 | 92 |
| AM25: 00+30 | 0 | 3.1 | 25.3 | 5.6 | 88 |
| AROME_Norway: 00+30 | 0 | 3.4 | 50.1 | 6.8 | 90 |
| Hirlam8: 00+30 | 0 | 3.3 | 38.8 | 6 | 92 |
| ECMWF: 00+30 | 0 | 3.4 | 28.4 | 5.2 | 91 |

| | ME | SDE | RMSE | MAE | Max.abs.err. | N |
|---|---|---|---|---|---|---|
| AM25 – synop | 0.8 | 4.9 | 4.9 | 2.3 | 24.1 | 88 |
| AROME_Norway – synop | 1.2 | 6 | 6.1 | 2.5 | 46.1 | 90 |
| Hirlam8 – synop | 1.1 | 5 | 5.2 | 2.8 | 25.1 | 92 |
| ECMWF – synop | 1.2 | 3.4 | 3.5 | 2.2 | 13.2 | 91 |

NELAUG




01.06.2014 – 31.08.2014

| | Min | Mean | Max | Std | N |
|---|---|---|---|---|---|
| synop: 06 | 0 | 9 | 106 | 17.3 | 44 |
| AM25: 00+30 | 0 | 4.4 | 66.2 | 9.9 | 88 |
| AROME_Norway: 00+30 | 0 | 5.4 | 90.3 | 12.8 | 90 |
| Hirlam8: 00+30 | 0 | 3.6 | 44.9 | 7.2 | 92 |
| ECMWF: 00+30 | 0 | 3.9 | 36.5 | 6.8 | 91 |

| | ME | SDE | RMSE | MAE | Max.abs.err. | N |
|---|---|---|---|---|---|---|
| AM25 – synop | −1 | 10.1 | 10.2 | 5.7 | 39.8 | 43 |
| AROME_Norway – synop | 1.7 | 18.3 | 18.4 | 8.7 | 83.8 | 44 |
| Hirlam8 – synop | −1.8 | 12 | 12.1 | 6.4 | 61.1 | 44 |
| ECMWF – synop | −1.5 | 11.6 | 11.7 | 5 | 69.5 | 44 |