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# Verification of Operational Weather Prediction Models December 2016 to February 2017

**Mariken Homleid and Frank Thomas Tveter**

Juvvasshøe. Photo: Ketil Isaksen

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## More information...

Verification results are also available on internal web pages

- http://metcoop.smhi.se/ - MetCoOp verification portal
- http://verif/vmap/ - timeseries and windroses - on Google map

## Models

The following models are verified in this report.

| | |
|---|---|
| ECMWF | Global model (IFS) at the European Centre for Medium-Range Weather Forecasts. From 26 January 2010 horizontal resolution approximately $16 \times 16$ $km^2$. From 8 March 2016 cycle 41r2 with horizontal resolution about $9km$. ECMWF is available about 5 hours later than models run at MET. |
| AROME-Norway | HARMONIE cycle 37h1.1 with AROME physics and non-hydrostatic dynamics, horizontal resolution defined by a $2.5 \times 2.5$ $km^2$ grid. Experimental since 25 October 2012, replacing Harmonie2.5 from 26 February 2013, on Yr from 1 October 2013. |
| AROME-MetCoOp (AM25) | HARMONIE with AROME physics, horizontal resolution defined by a $2.5 \times 2.5$ $km^2$ grid on same domain as AROME-Norway. Run in cooperation with Swedish Meteorological and Hydrological Institute (SMHI). Experimental with cycle 38h1.1 since 9 December 2013, operational since 12 March 2014, cycle 38h1.2 since 8 December 2014. |
| AROME-Arctic (AA25) | HARMONIE with AROME physics, horizontal resolution defined by a $2.5 \times 2.5$ $km^2$ grid, same domain size as AROME-MetCoOp. Experimental with cycle 38h1.2 since 15 October 2015, on Yr from 14 December 2016. |
| MetCoOp ensemble system (MEPSctrl) | MEPS has 10 ensemble members, only member 0, the control, is verified in this report. MEPS is based on HARMONIE cycle 40h1.1 with AROME physics and non-hydrostatic dynamics, horizontal resolution defined by a $2.5 \times 2.5$ $km^2$ grid. Experimental since 25 May 2016. Operational status since 8 November 2016. |

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.

## Post processed forecasts

Most of the raw model data are post processed before being published on Yr.

For 2m temperature, the raw data is first adjusted to a fine scale (500 m) topography applying a vertical temperature gradient of -1.6 degrees pr. 100 m. The "height corrected" 2m temperature forecasts (PPHC) are in a next step adapted to observations by a Kalman filter at all observing stations. The Kalman filter corrections are interpolated horizontally to the 500 m grid by kriging, using weights which decrease with increasing distance from the observing stations, both horizontally and vertically. The interpolated Kalman filter corrections are finally added to the heigth corrected field, giving PPKF.

10 m wind speed is statistically post processed to represent maximum wind speed 10m last hour, and called PP.

The precipitation forecasts are post processed by a neighbourhood method giving a median field. This field is used to determine the precipitation symbol on Yr.

ECMWF provides probabilistic forecasts based on a 51 member ensemble system at 30 km resolution. Consensus forecasts (ECens) are calibrated (ECensPP) before being presented on Yr.

## The HARMONIE system

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 used at MET. More documentation is available on http://www.cnrm.meteo.fr/gmapdoc/ and http://hirlam.org/. A change log for HARMONIE AROME is found on https://metcoop.smhi.se/dokuwiki/nwp/metcoop/changelog/start.

### 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.

### 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.

### 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 will benefit from the possibility of running 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. The orography is taken from gtopo30.

"SURFEX Scientific Documentation" and "User's Guide" are available on http://www.cnrm.meteo.fr/surfex/

## Data assimilation

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

### 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 and 18 UTC as there are very few snow depth observations at 00, 03, 09, 12, 15 and 21.

The Sea Surface Temperature (SST) and Sea Ice Concentration (SIC) 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. SST and SIC for the Baltic Sea have since 26 November 2015 been taken from the ocean model HIROMB run at SMHI.

The surface temperature over sea ice was taken from the boundary model and remained unchanged through the forecast. A simple thermodynamical sea ice scheme (SICE) giving prognostic sea ice temperatures in 4 fixed layers was introduced 26 November 2015.

### Upper air analysis

MEPS runs three dimensional variational (3D VAR) data assimilation using conventional observations from synop stations, ships, radiosondes and aircrafts and AMSU-A and AMSU-B/MHS data from polar orbiting NOAA and METOP satellites. GNSS were introduced 17 February 2015, radar reflectivities 16 June 2015 and IASI data 26 November 2015.

## Boundary fields

MEPS gets its boundary values (1-hourly) from the ECMWF model at approximately 16 km resolution, and has currently 65 vertical levels. None of the HARMONIE configurations at MET have applied digital filter initialization (DFI).

## Verification measures

All model forecasts in this report are verified against observations by interpolating (linear) 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.

### 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 | $\Big(\frac{1}{n}\sum_{i=1}^{n}(f_i - o_i - \mathsf{ME})^2\Big)^{1/2}$ | 0 to $\infty$ | 0 |
| Root Mean Square Error | RMSE | $\Big(\frac{1}{n}\sum_{i=1}^{n}(f_i - o_i)^2\Big)^{1/2}$ | 0 to $\infty$ | 0 |
| Correlation | COR | $\frac{\frac{1}{n}\sum_{i=1}^{n}(f_i - \bar{f})(o_i - \bar{o})}{\mathsf{SD}(f)\mathsf{SD}(o)}$ | $-1$ to 1 | 1 |

In the formula for COR the following definitions are used

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

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

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

### 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 | $c$ | $d$ |

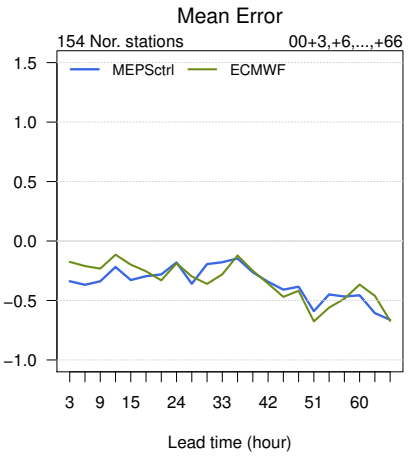
Verification statistics for such forecasts are listed in the following table

| 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) |
| Heidke skill score | HSS | $\frac{(a+d)/n-ssf}{1-ssf}$ | $-\infty$ to 1 | 1 (0 = no skill) |

In the formula for ETS $ar = (a+b)(a+c)/n$.
In the formula for HSS the score for the standard forecast $ssf = [(a+b)(a+c)+(b+d)(c+d)]/n^2$.

## Observations

All observations come from Klimadatavarehuset at MET. Only synop stations are used. The model wind speed is verified against mean wind observations, FF. The post processed wind speed is intended to represent maximum wind speed 10m last hour, and is verified against FX.


Mean Error
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MEPSctrl
ECMWF
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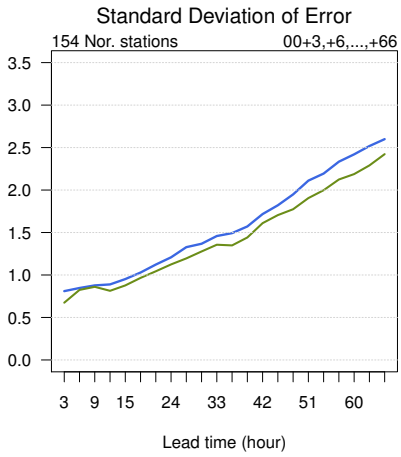
3 9 15 24 33 42 51 60
Lead time (hour)


Standard Deviation of Error
154 Nor. stations
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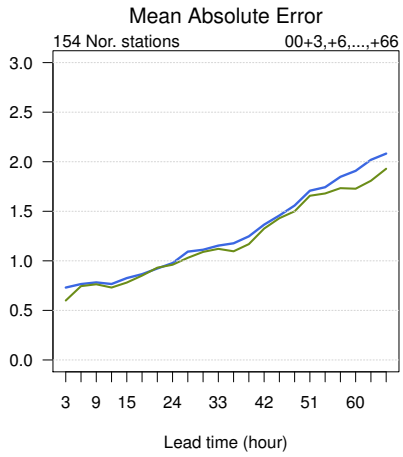
3 9 15 24 33 42 51 60
Lead time (hour)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0.5
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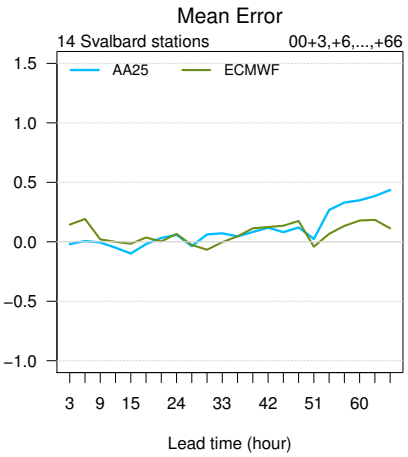
Lead time (hour)


Mean Error
14 Svalbard stations
00+3,+6,...,+66
AA25
ECMWF
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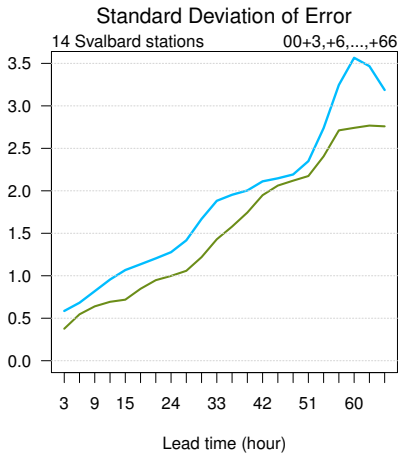
−0.5
−1.0
3 9 15 24 33 42 51 60
Lead time (hour)


Standard Deviation of Error
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00+3,+6,...,+66
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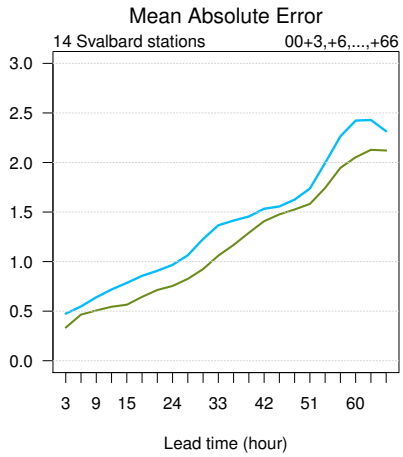
2.5
2.0
1.5
1.0
0.5
0.0
3 9 15 24 33 42 51 60
Lead time (hour)


Mean Absolute Error
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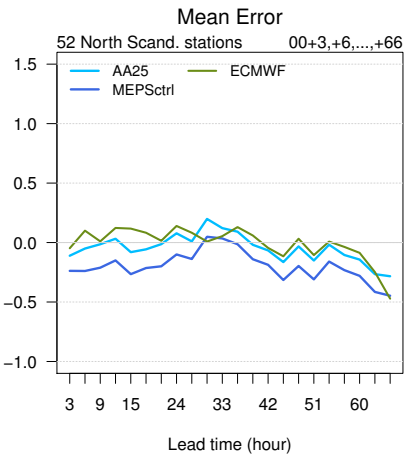
1.0
0.5
0.0
3 9 15 24 33 42 51 60
Lead time (hour)


Mean Error
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00+3,+6,...,+66
AA25
ECMWF
MEPSctrl
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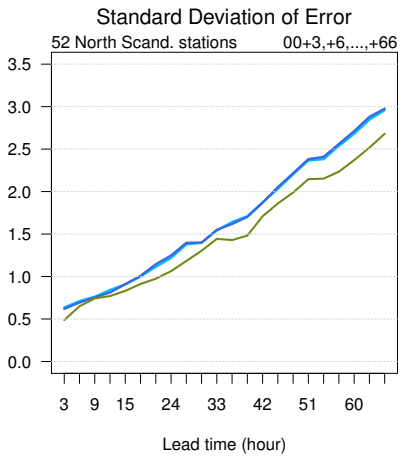
1.0
0.5
0.0
−0.5
−1.0
3 9 15 24 33 42 51 60
Lead time (hour)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1.5
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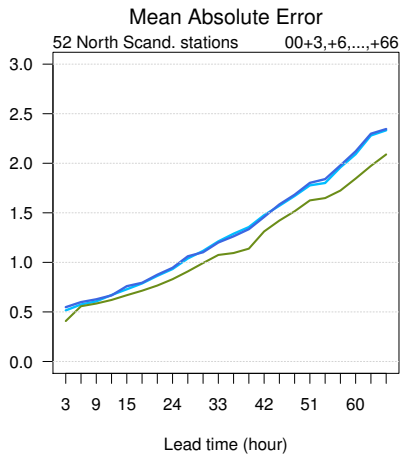
0.0
3 9 15 24 33 42 51 60
Lead time (hour)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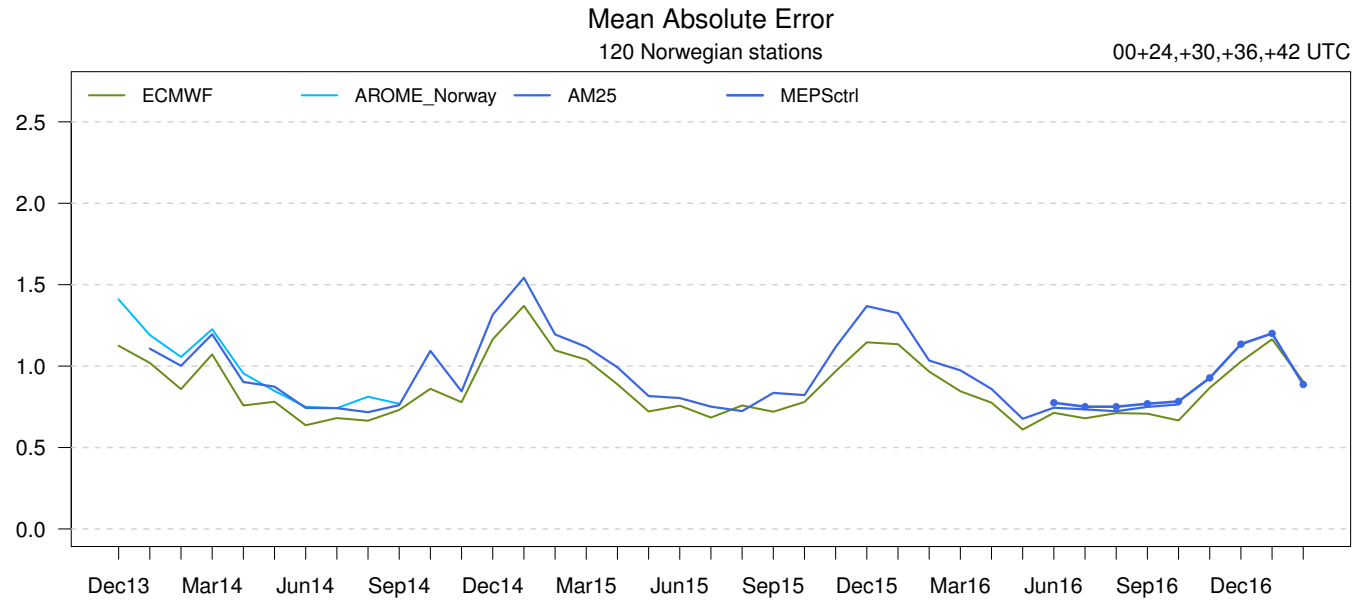
1.5
1.0
0.5
0.0
3 9 15 24 33 42 51 60
Lead time (hour)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ECMWF
AROME_Norway
AM25
MEPSctrl
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1.5
1.0
0.5
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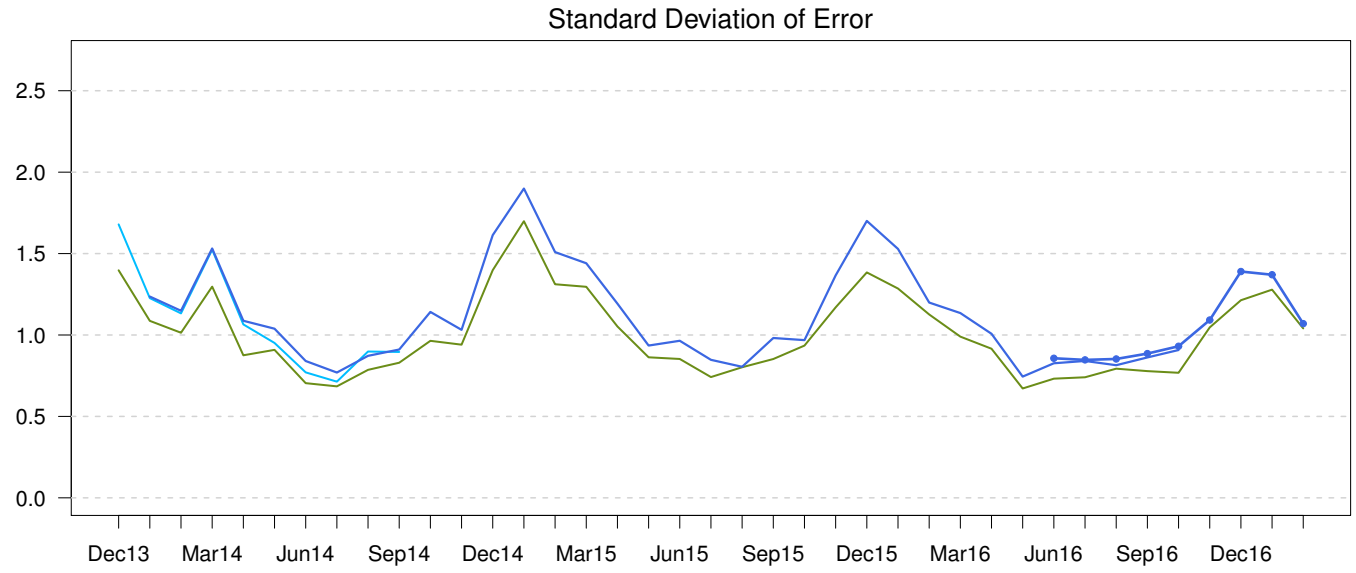
Mar14
Jun14
Sep14
Dec14
Mar15
Jun15
Sep15
Dec15
Mar16
Jun16
Sep16
Dec16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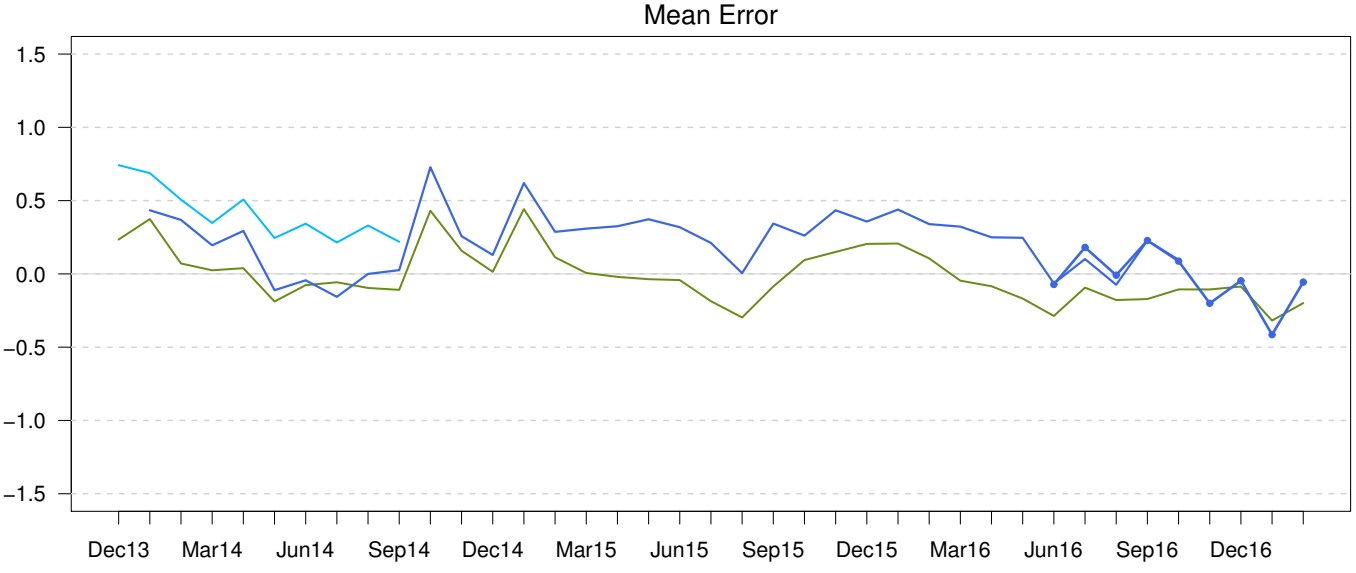
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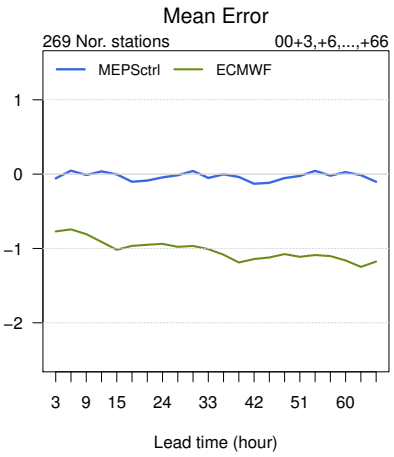
Mean Error
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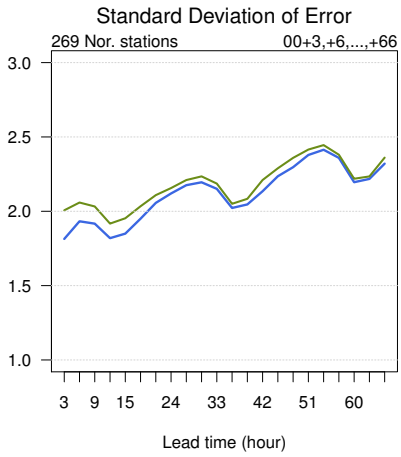
MEPSctrl
ECMWF
1
0
−1
−2
3 9 15 24 33 42 51 60
Lead time (hour)


Standard Deviation of Error
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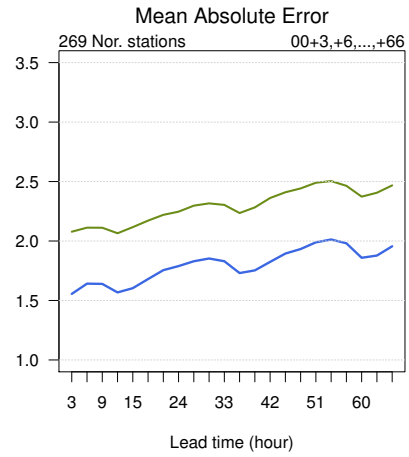
2.0
1.5
1.0
3 9 15 24 33 42 51 60
Lead time (hour)


Mean Absolute Error
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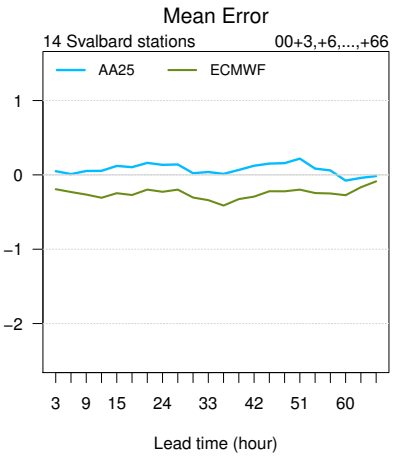
2.5
2.0
1.5
1.0
3 9 15 24 33 42 51 60
Lead time (hour)


Mean Error
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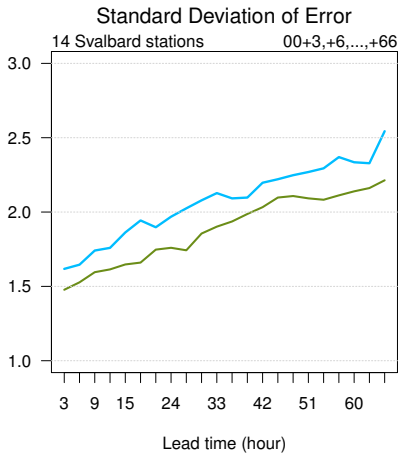
AA25
ECMWF
1
0
−1
−2
3 9 15 24 33 42 51 60
Lead time (hour)


Standard Deviation of Error
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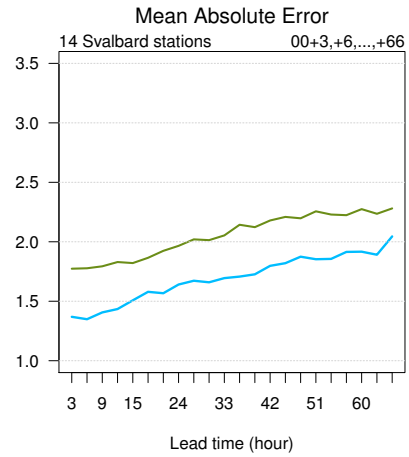
2.5
2.0
1.5
1.0
3 9 15 24 33 42 51 60
Lead time (hour)


Mean Absolute Error
14 Svalbard stations
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2.5
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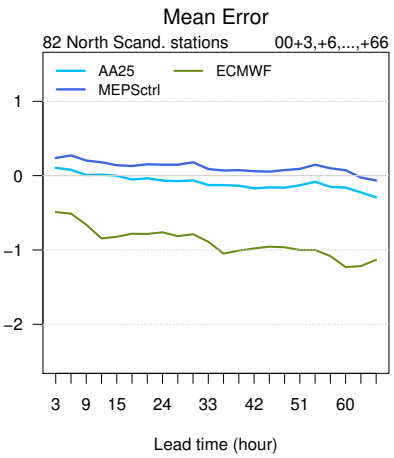
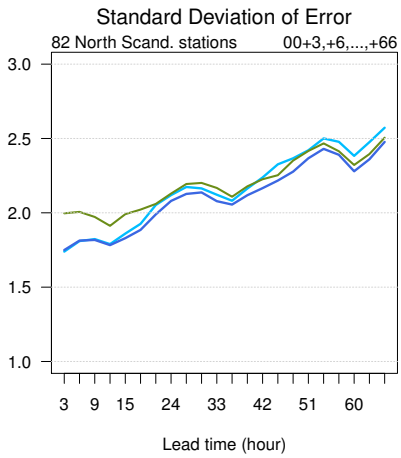
1.5
1.0
3 9 15 24 33 42 51 60
Lead time (hour)


Mean Error
82 North Scand. stations
00+3,+6,...,+66
AA25
ECMWF
MEPSctrl
1
0
−1
−2
3 9 15 24 33 42 51 60
Lead time (hour)


Standard Deviation of Error
82 North Scand. stations
00+3,+6,...,+66
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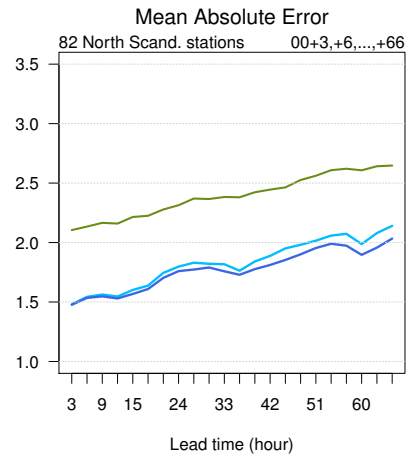
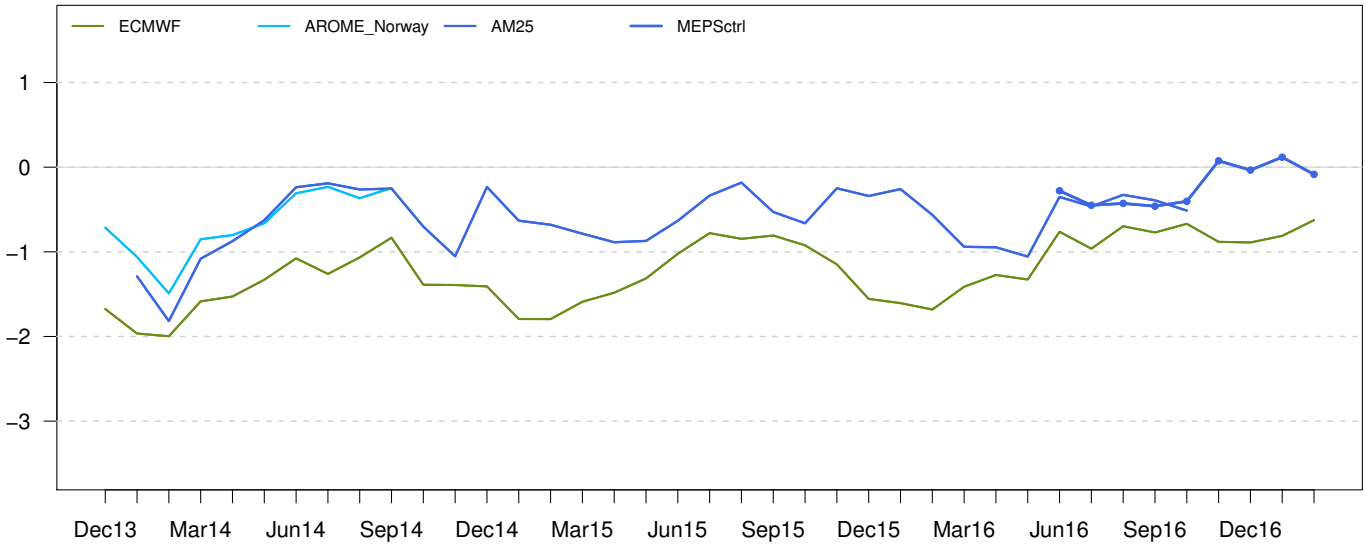
2.5
2.0
1.5
1.0
3 9 15 24 33 42 51 60
Lead time (hour)

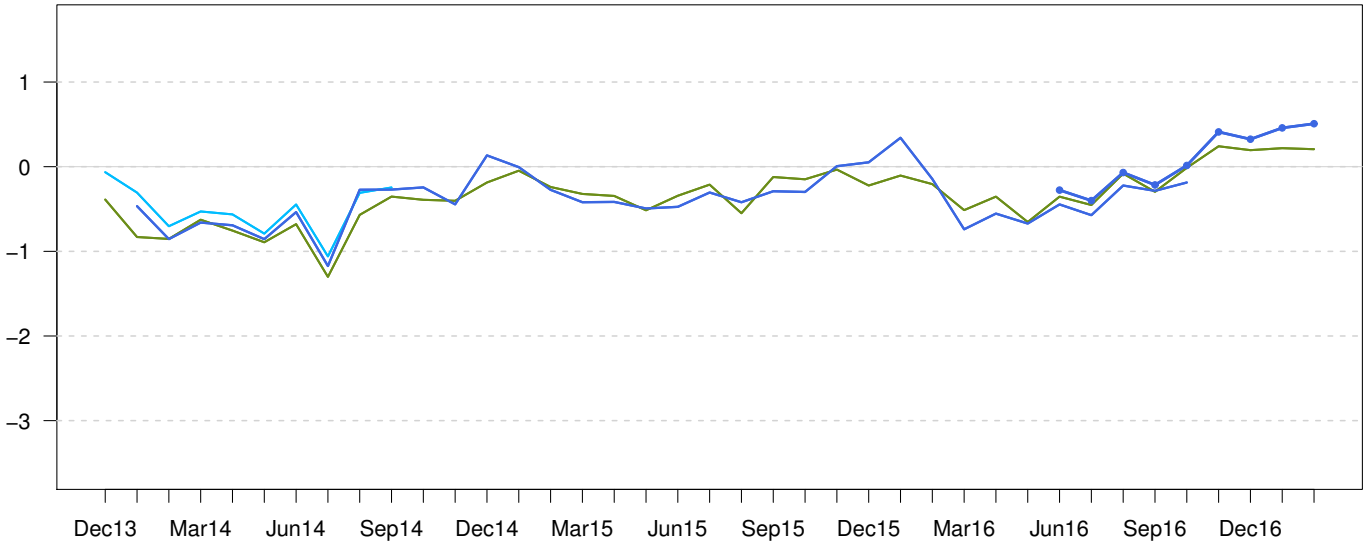

Mean Absolute Error
82 North Scand. stations
00+3,+6,...,+66
3.5
3.0
2.5
2.0
1.5
1.0
3 9 15 24 33 42 51 60
Lead time (hour)

## Mean Error

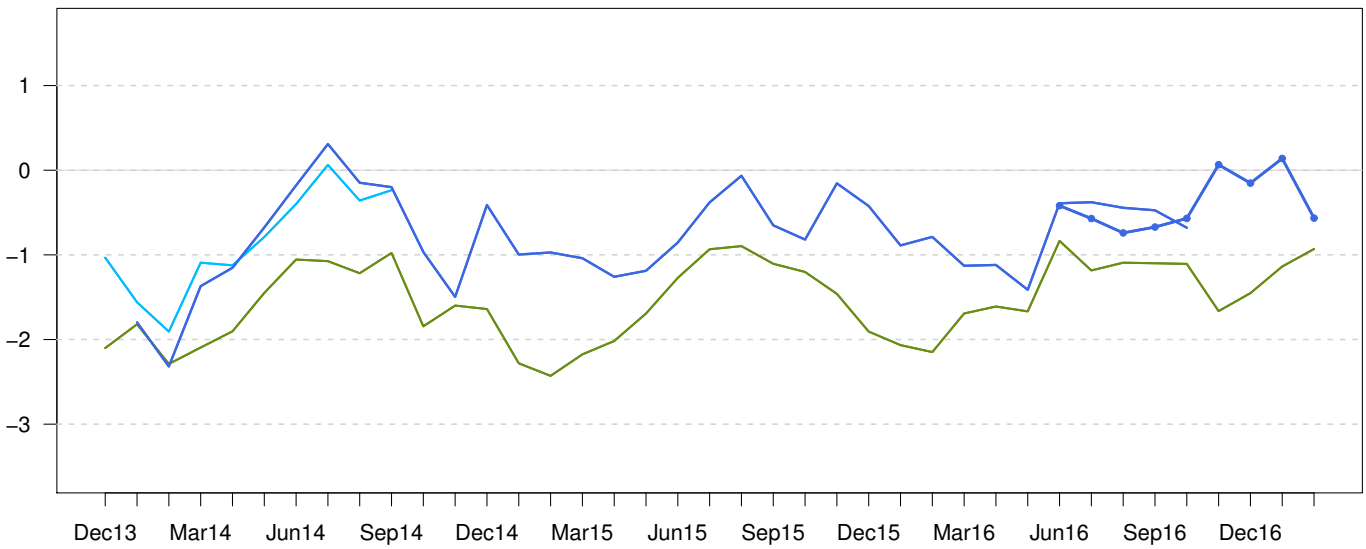
166 Norwegian stations 00+24,+30,+36,+42 UTC




40 Norwegian coastal stations

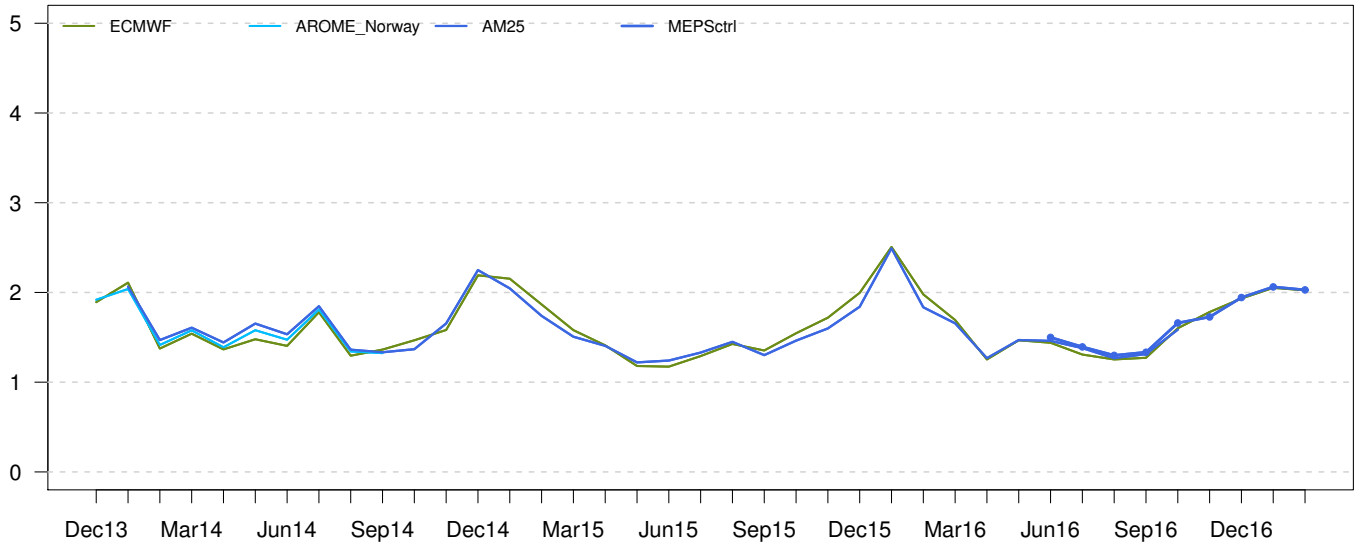



52 Norwegian inland stations

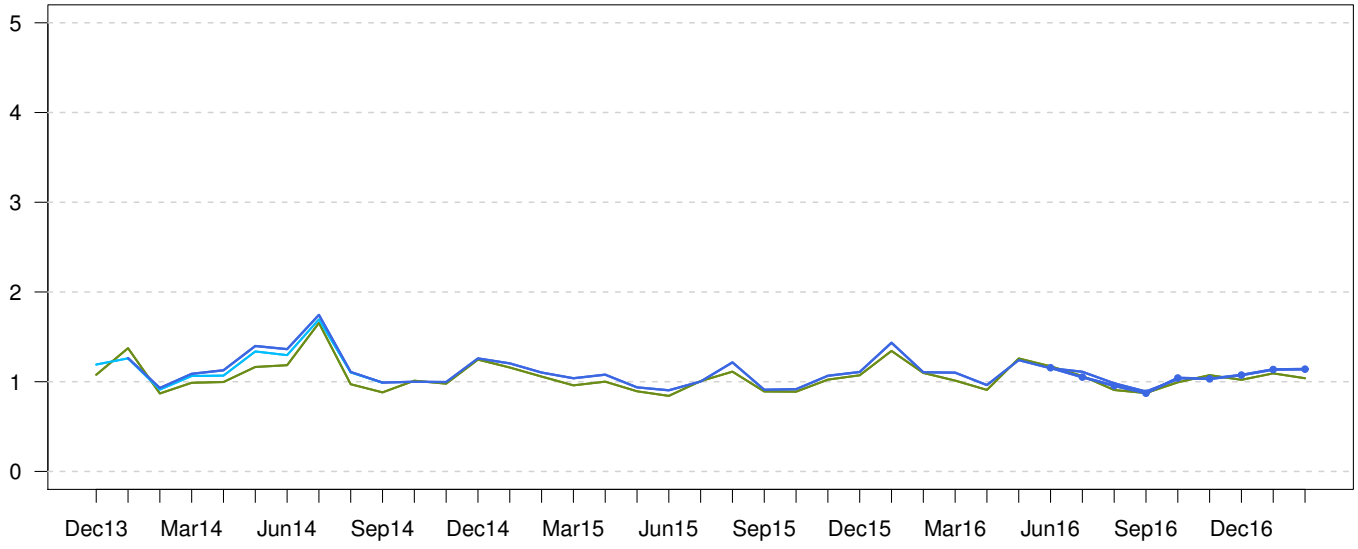


Standard Deviation of Error

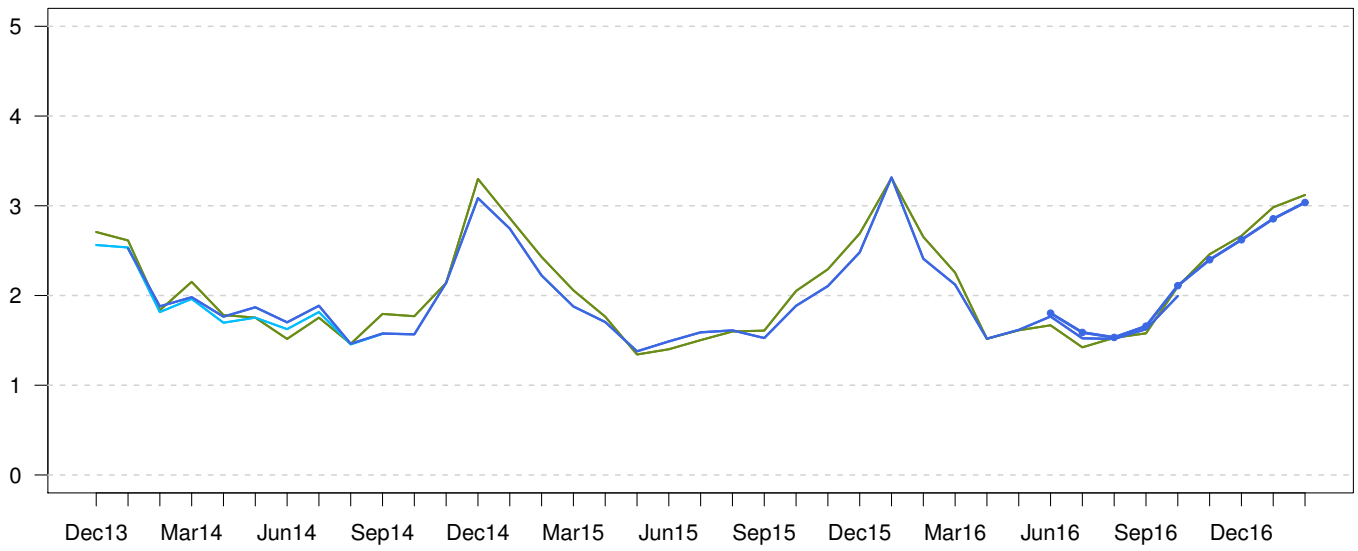
166 Norwegian stations 00+24,+30,+36,+42 UTC




40 Norwegian coastal stations

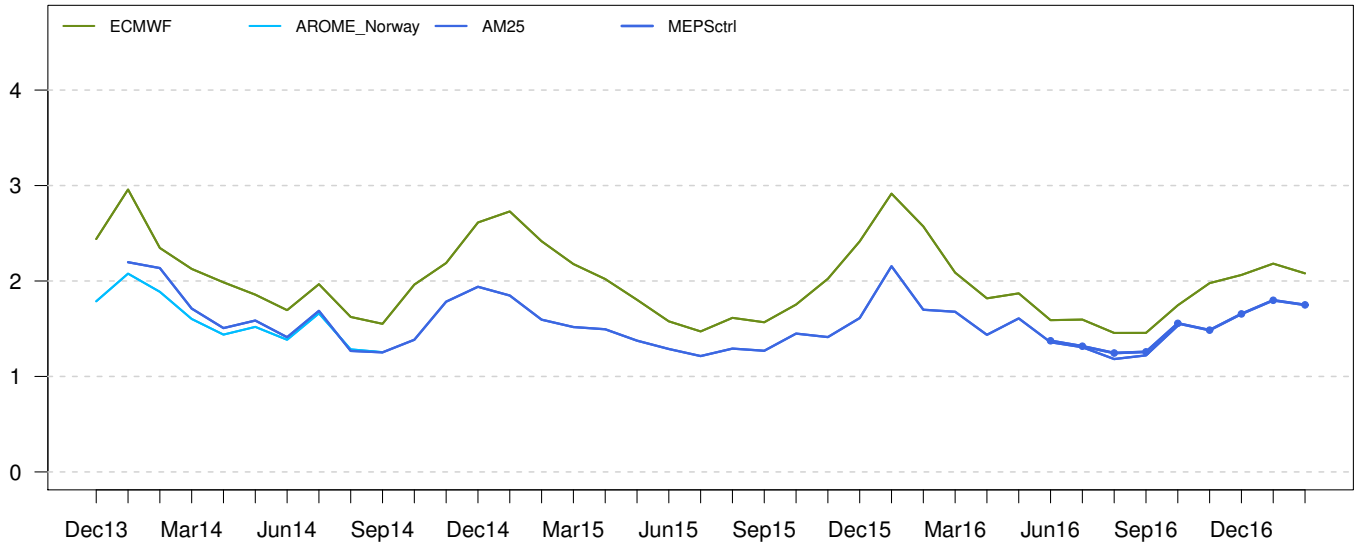



52 Norwegian inland stations

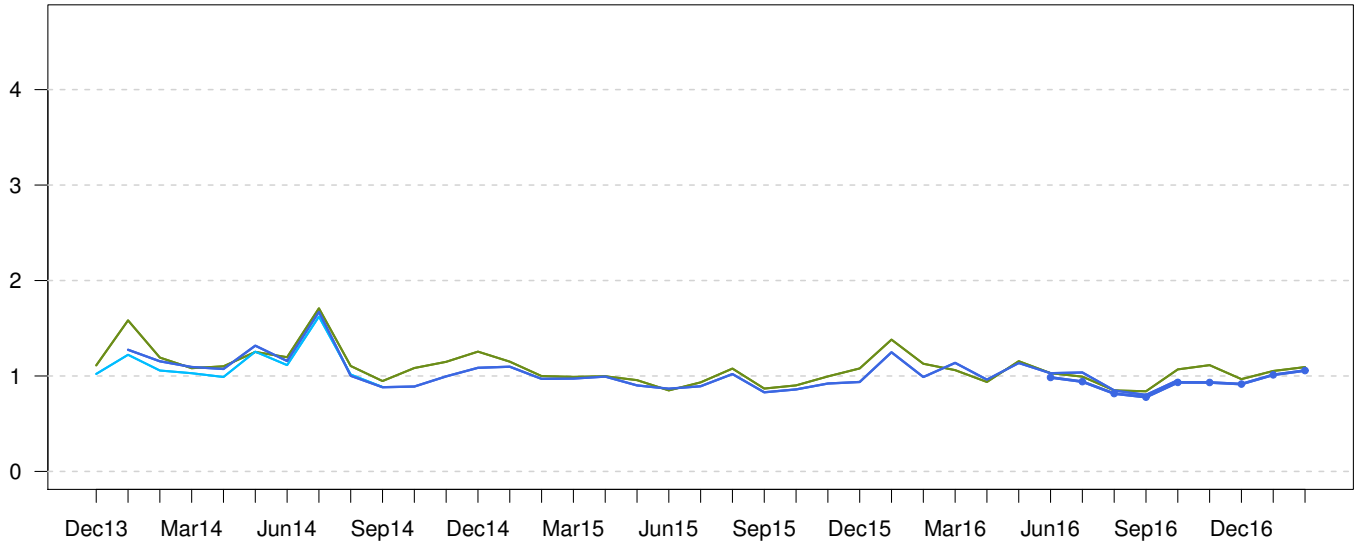


Mean Absolute Error

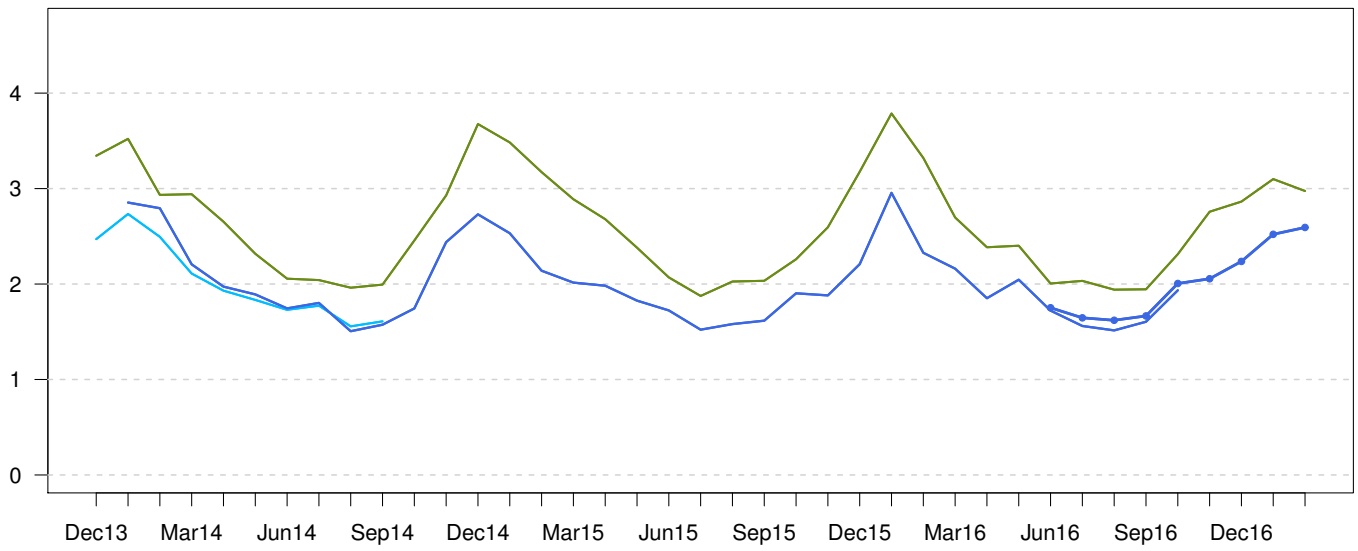
166 Norwegian stations 00+24,+30,+36,+42 UTC




40 Norwegian coastal stations

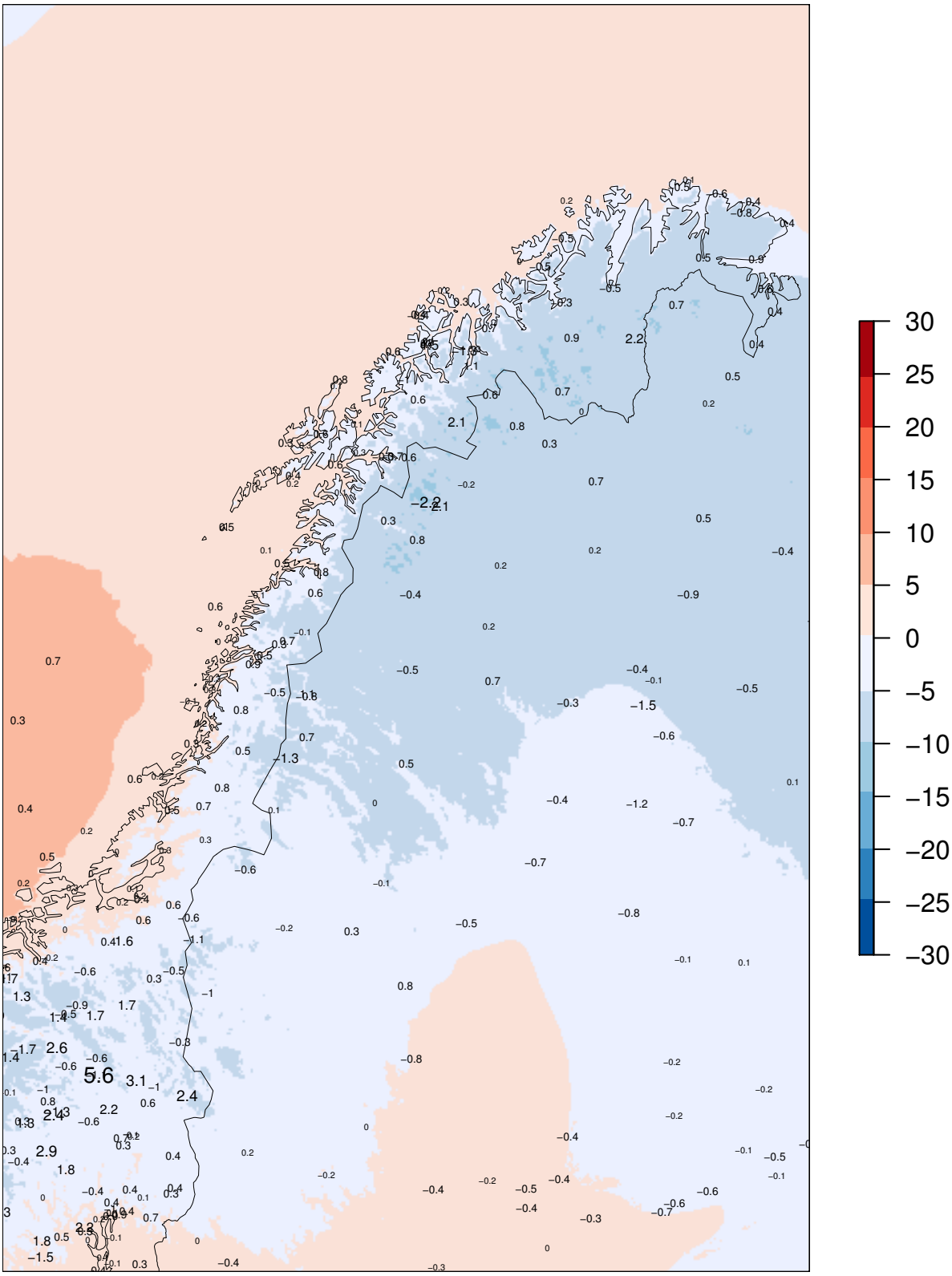



52 Norwegian inland stations



# MEPSctrl 00+12

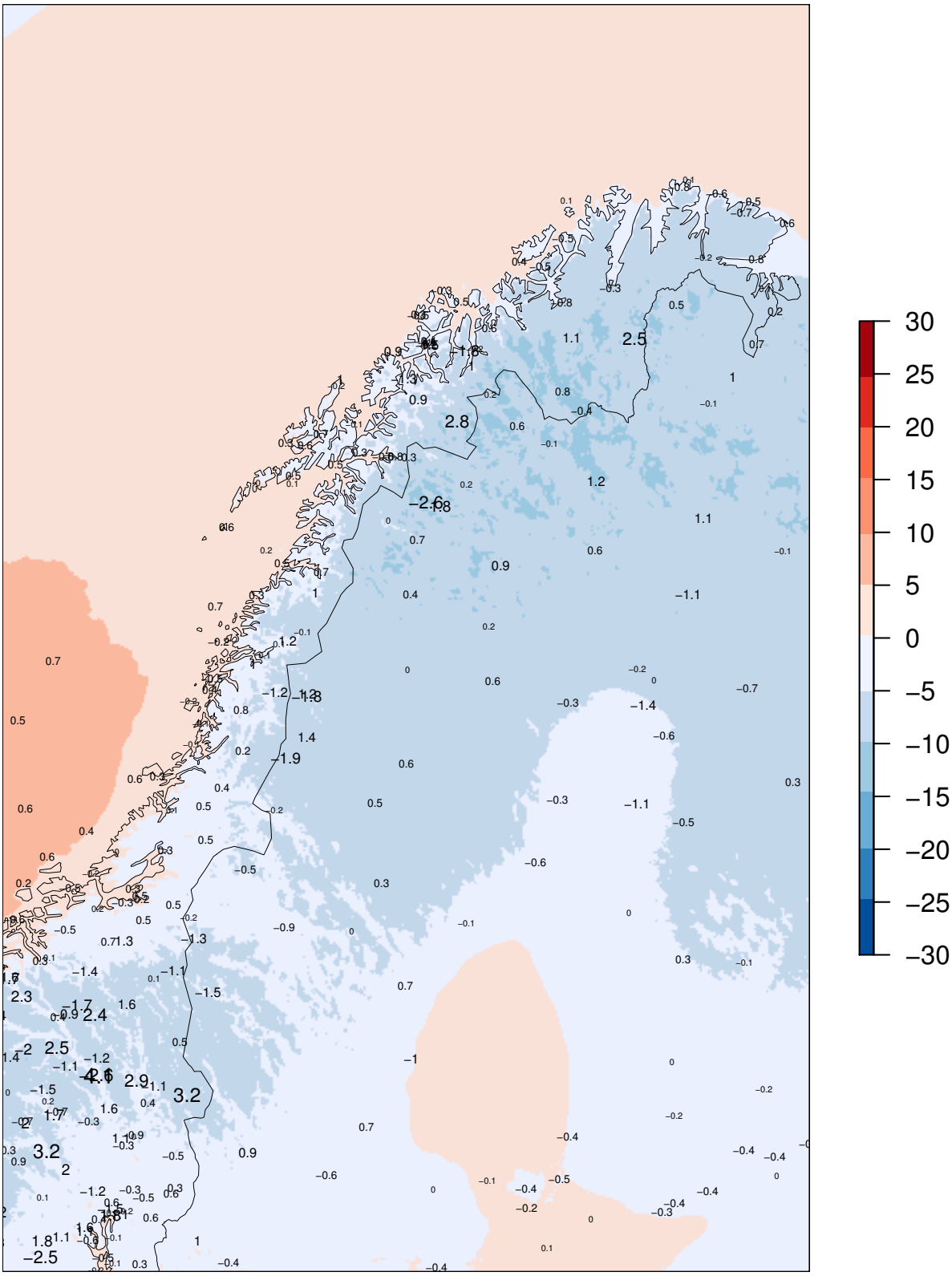
ME at observing sites
(numbers in black)




Model "climatology" 01.12.2016 – 28.02.2017

# MEPSctrl 00+24

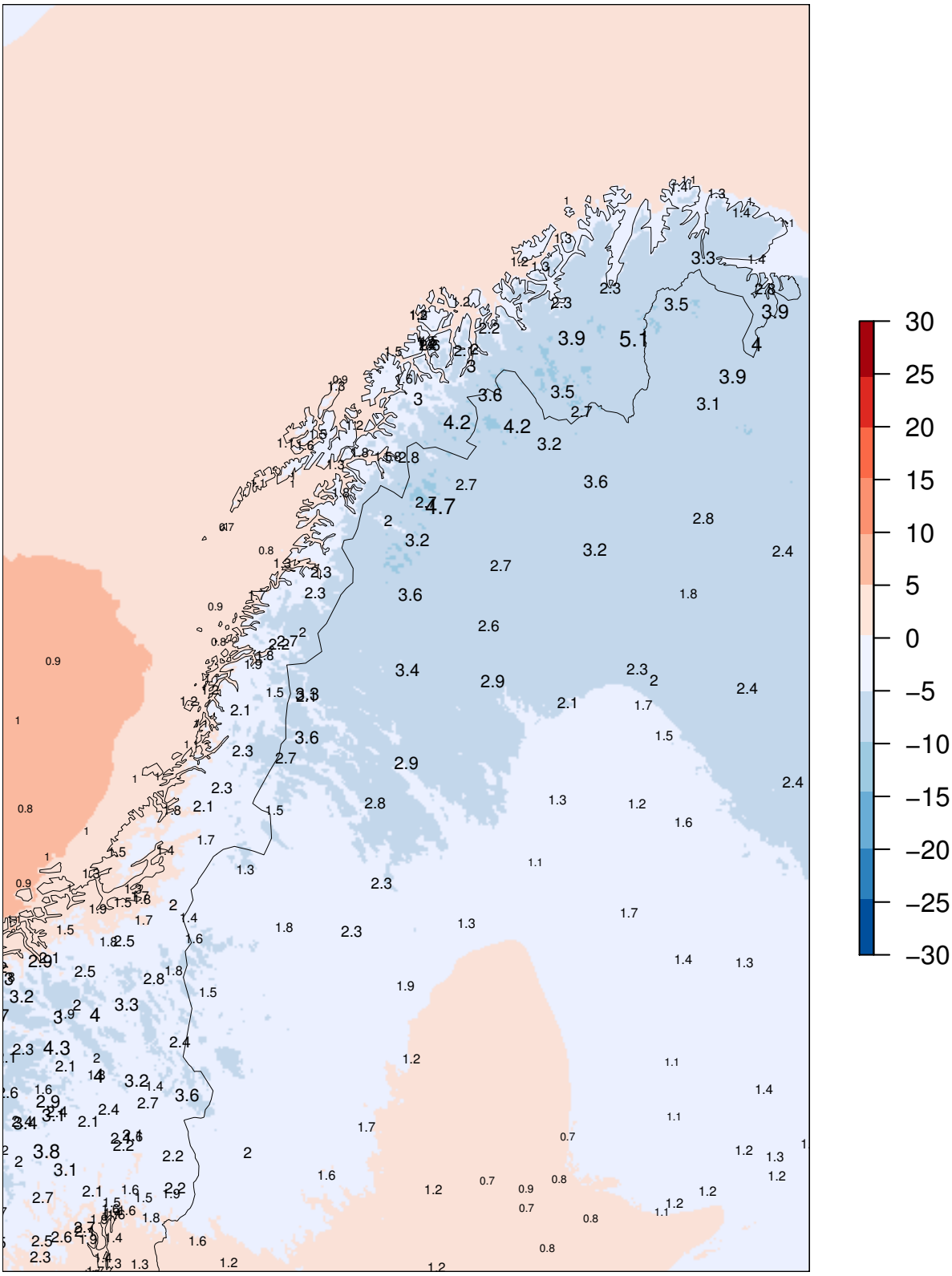
ME at observing sites
(numbers in black)




Model "climatology" 01.12.2016 – 28.02.2017

# MEPSctrl 00+12

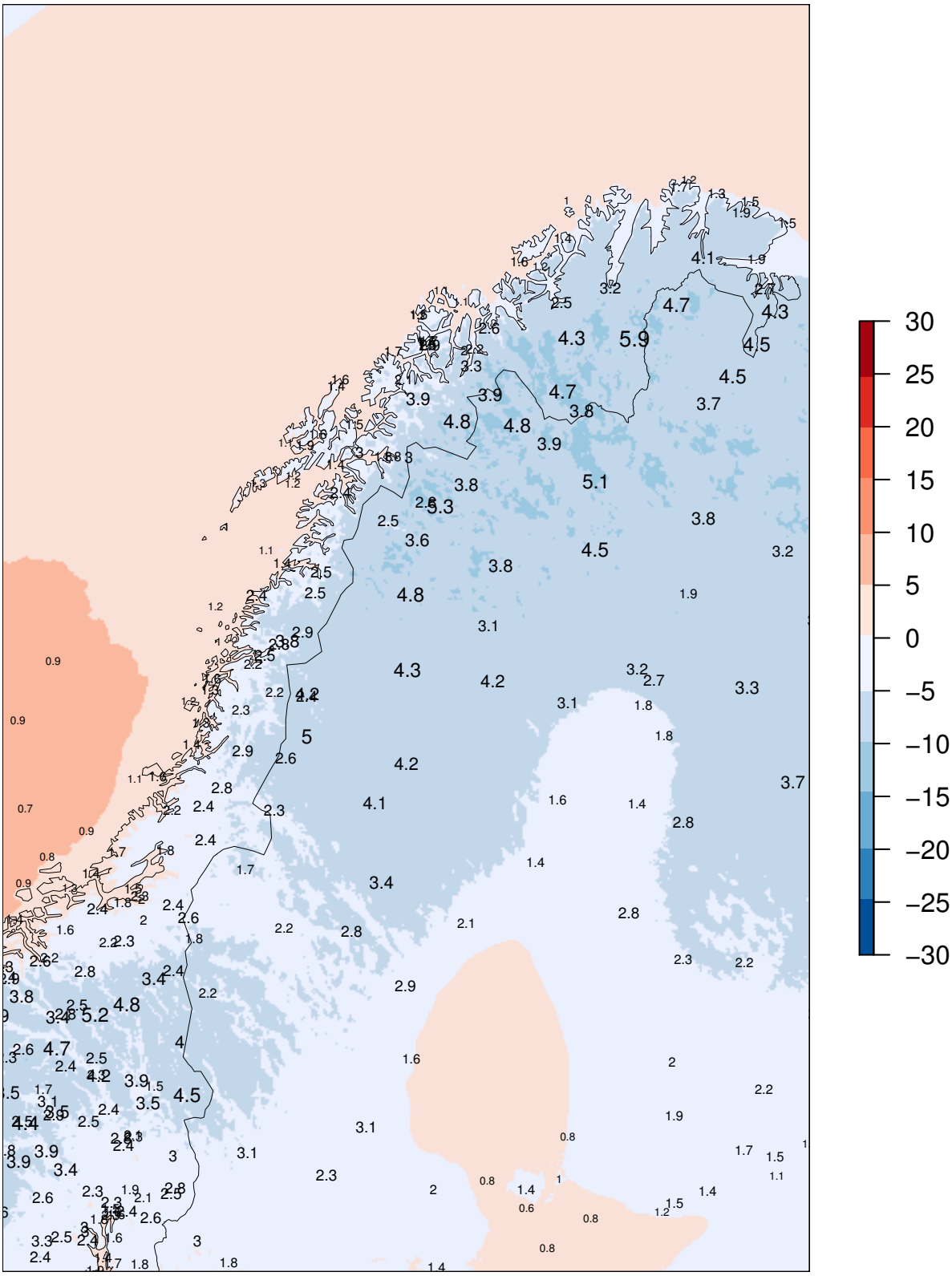
SDE at observing sites
(numbers in black)




Model "climatology" 01.12.2016 – 28.02.2017

MEPSctrl 00+24

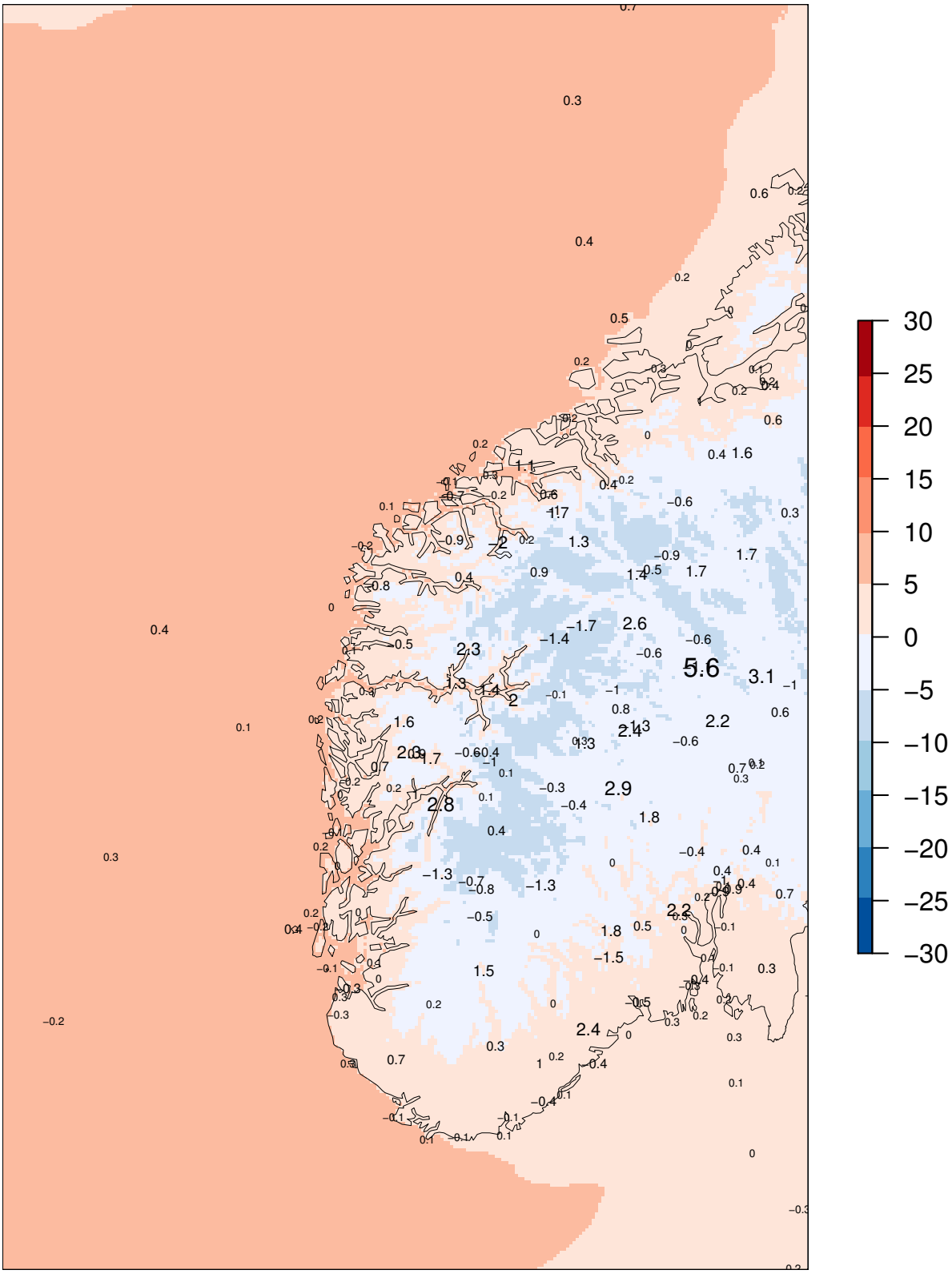
SDE at observing sites
(numbers in black)




Model "climatology" 01.12.2016 – 28.02.2017

MEPSctrl 00+12

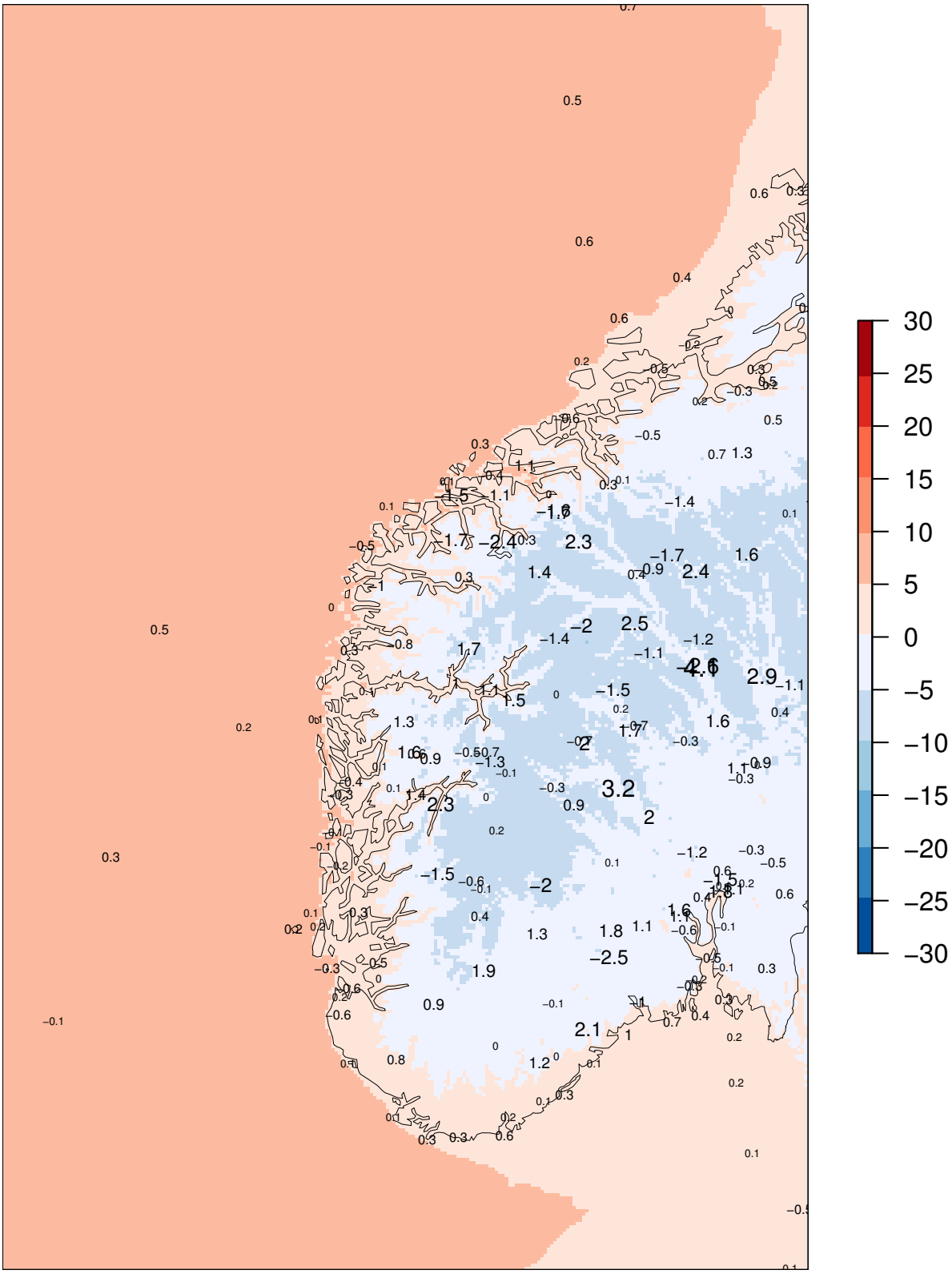
ME at observing sites
(numbers in black)




Model "climatology" 01.12.2016 – 28.02.2017

MEPSctrl 00+24

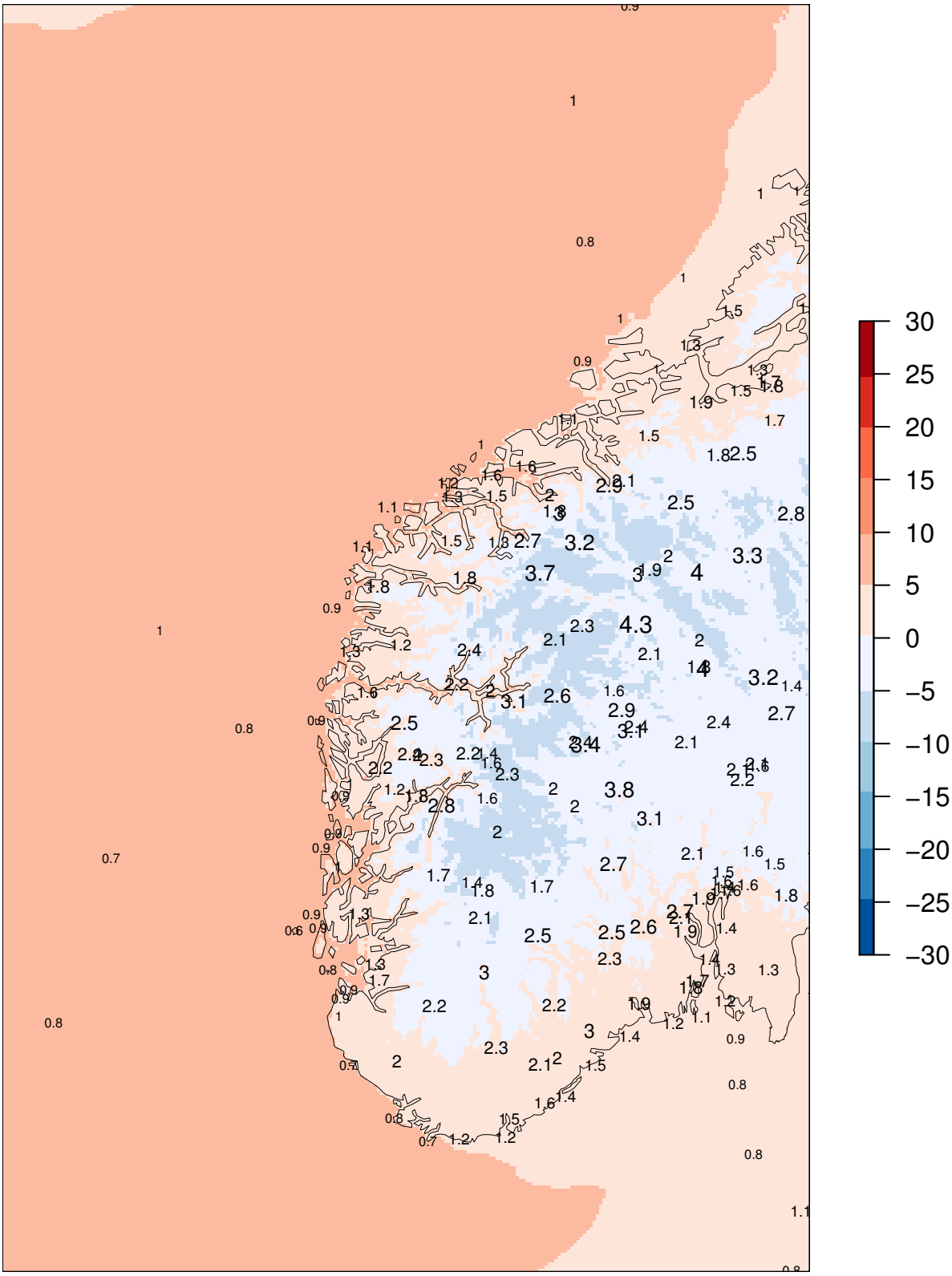
ME at observing sites
(numbers in black)




Model "climatology" 01.12.2016 – 28.02.2017

# MEPSctrl 00+12

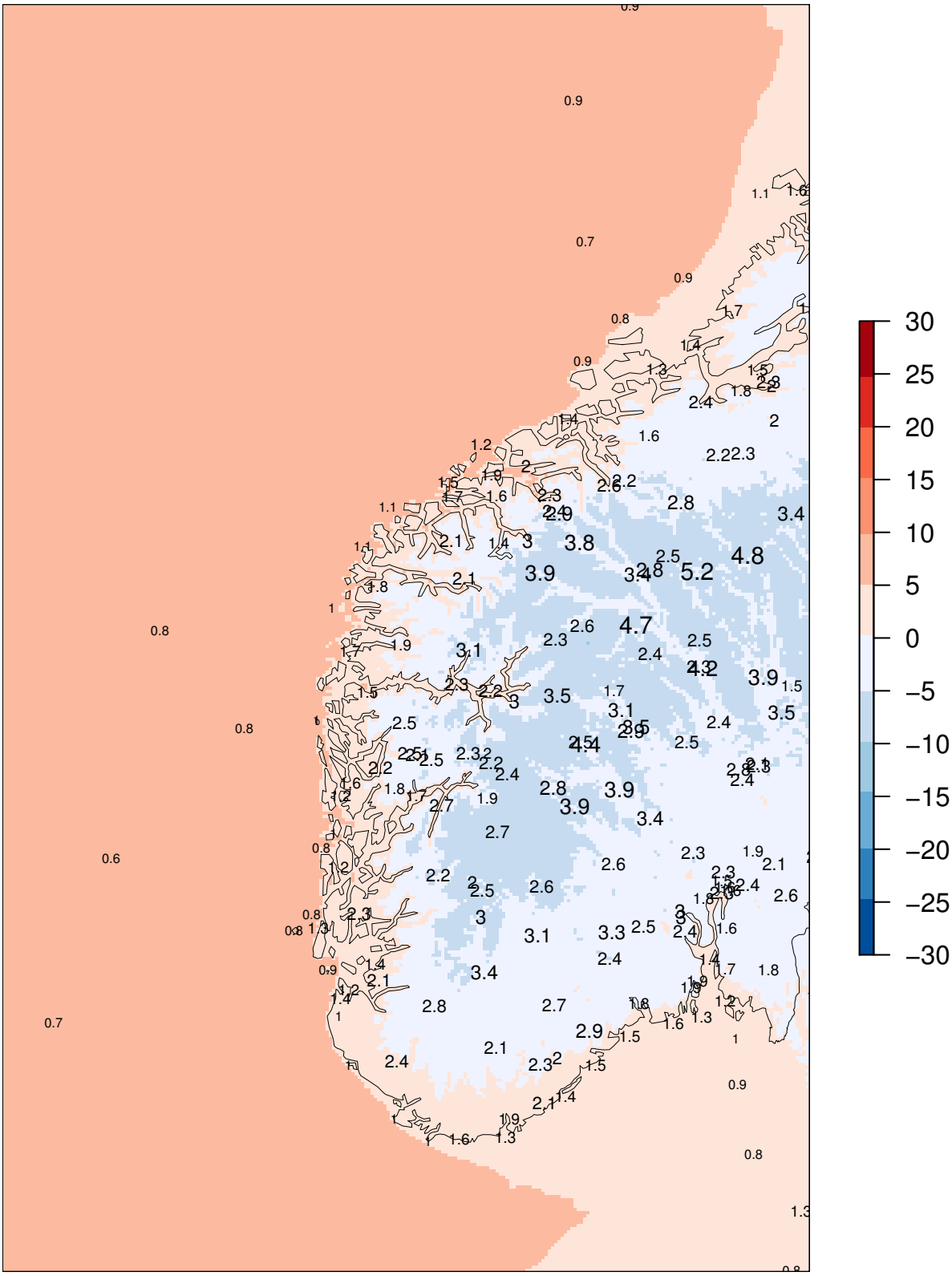
SDE at observing sites
(numbers in black)




Model "climatology" 01.12.2016 – 28.02.2017

MEPSctrl 00+24

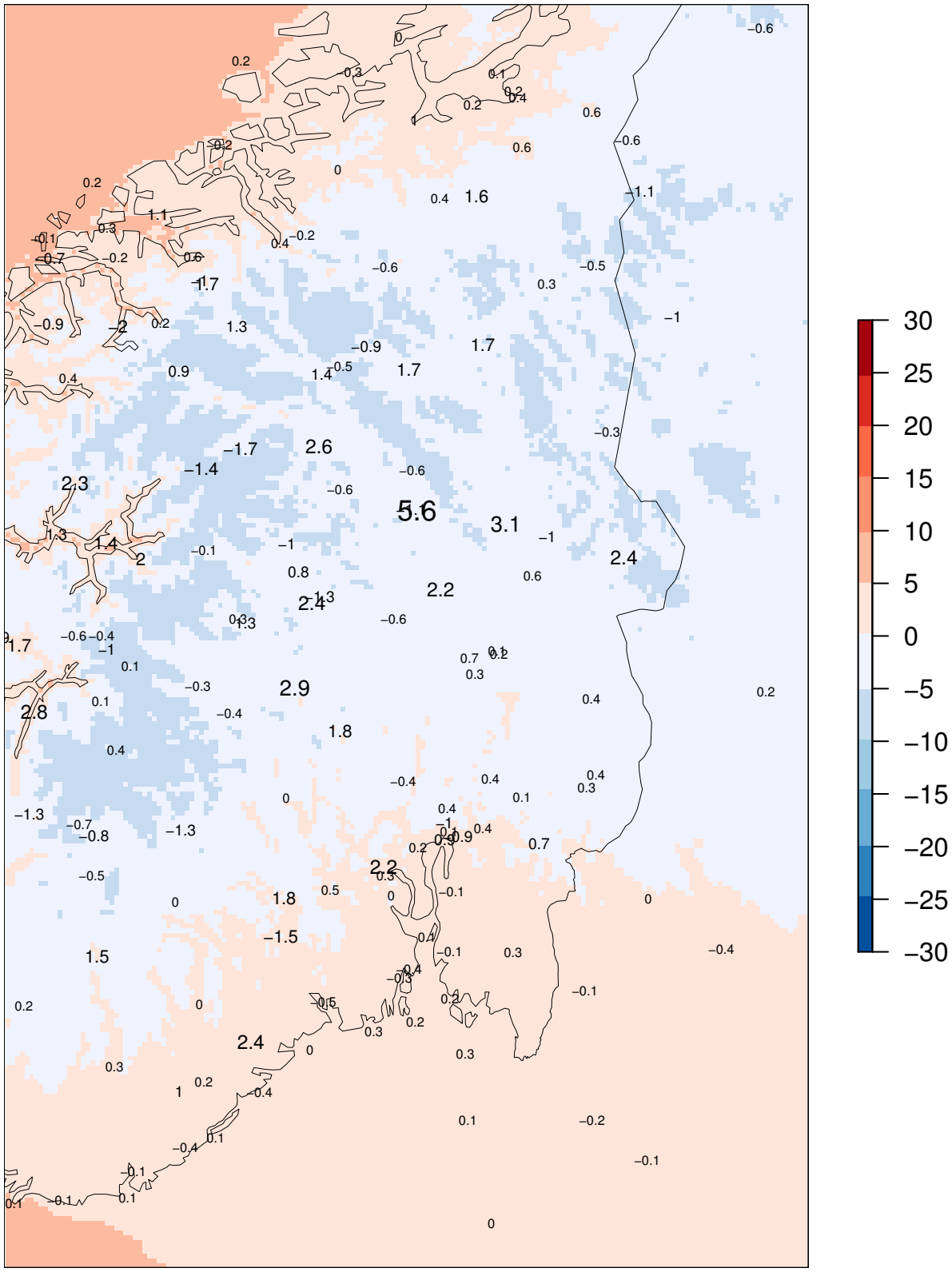
SDE at observing sites
(numbers in black)




Model "climatology" 01.12.2016 – 28.02.2017

MEPSctrl 00+12

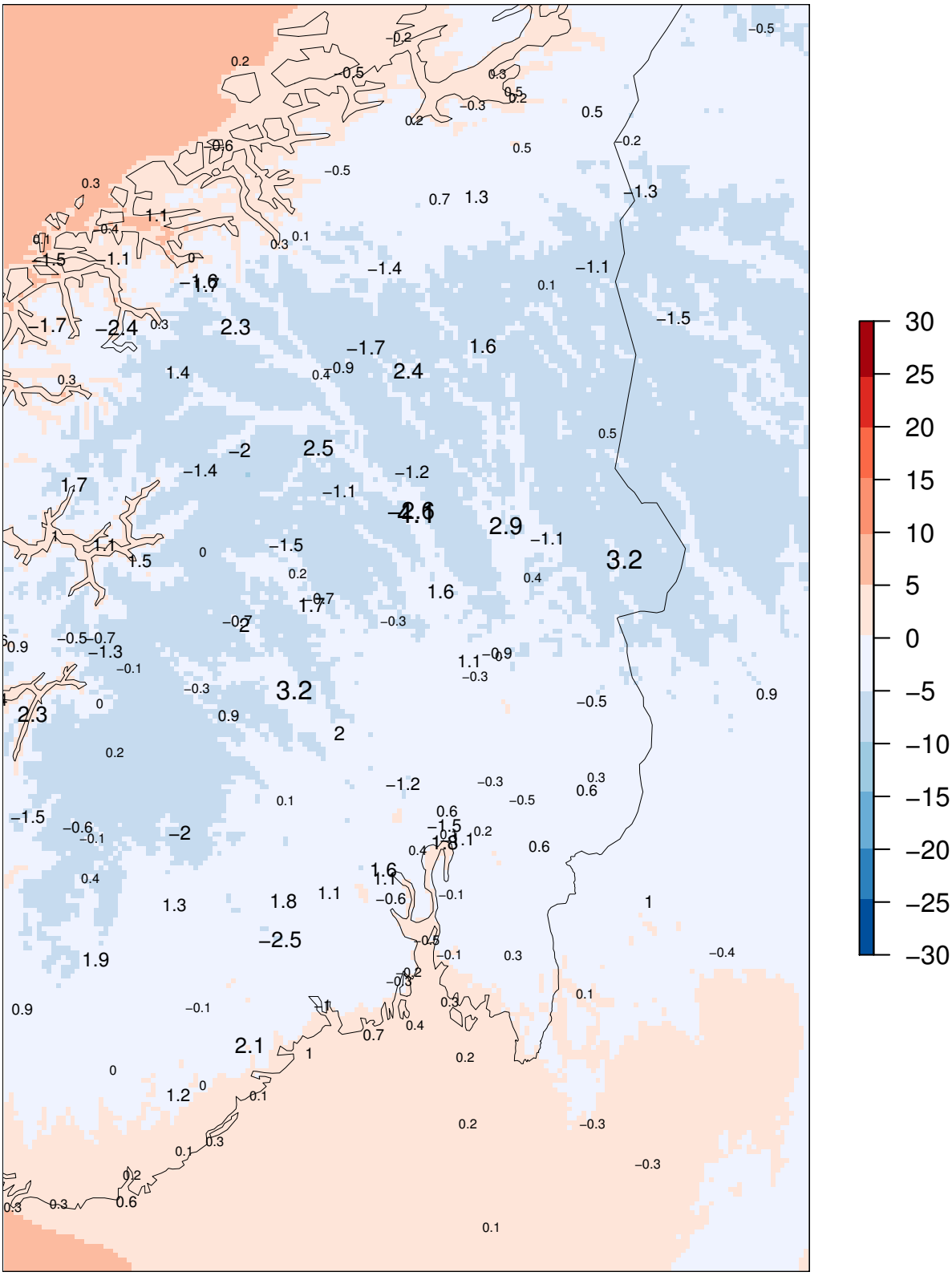
ME at observing sites
(numbers in black)




Model "climatology" 01.12.2016 – 28.02.2017

MEPSctrl 00+24

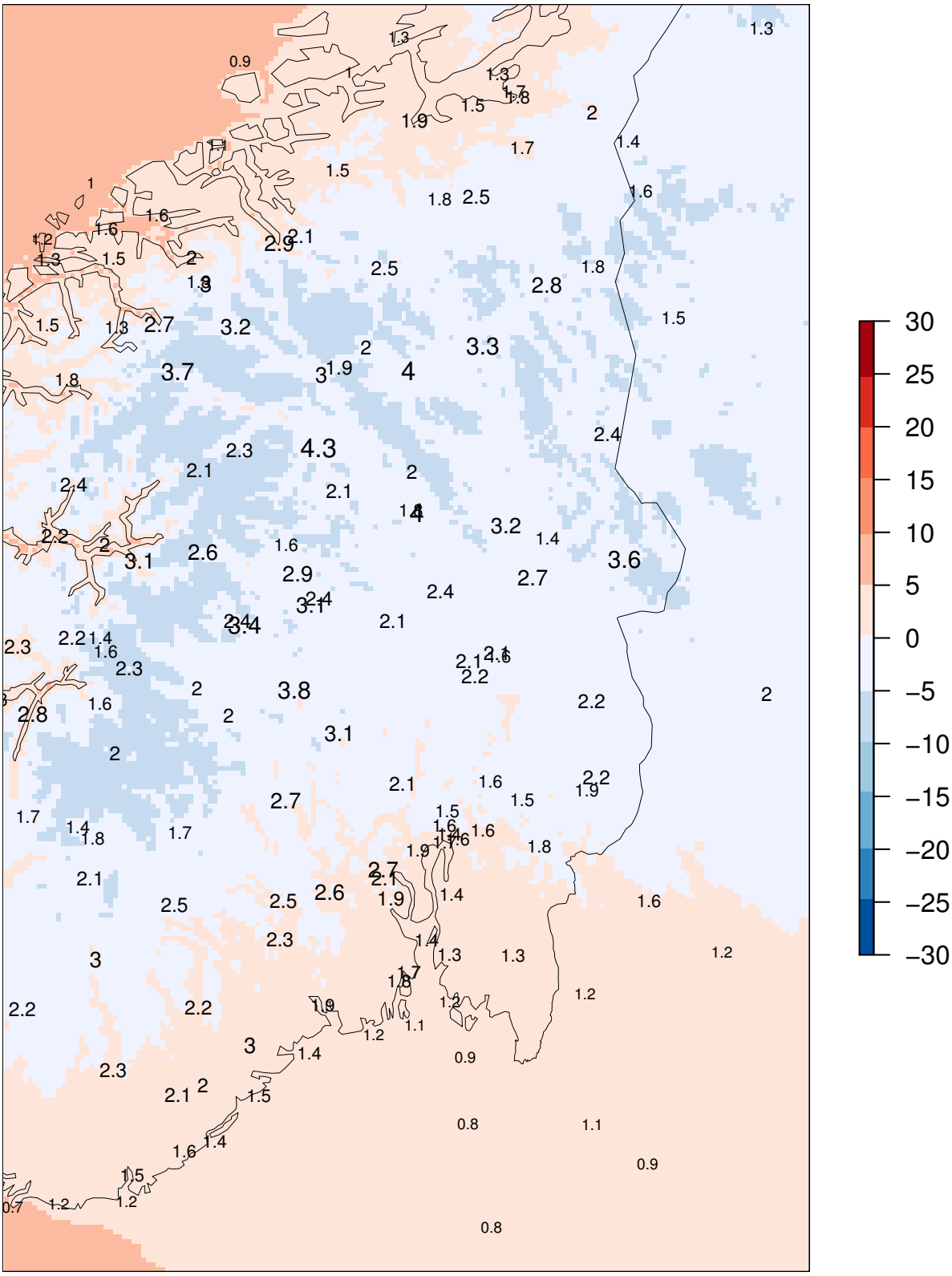
ME at observing sites
(numbers in black)




Model "climatology" 01.12.2016 – 28.02.2017

MEPSctrl 00+12

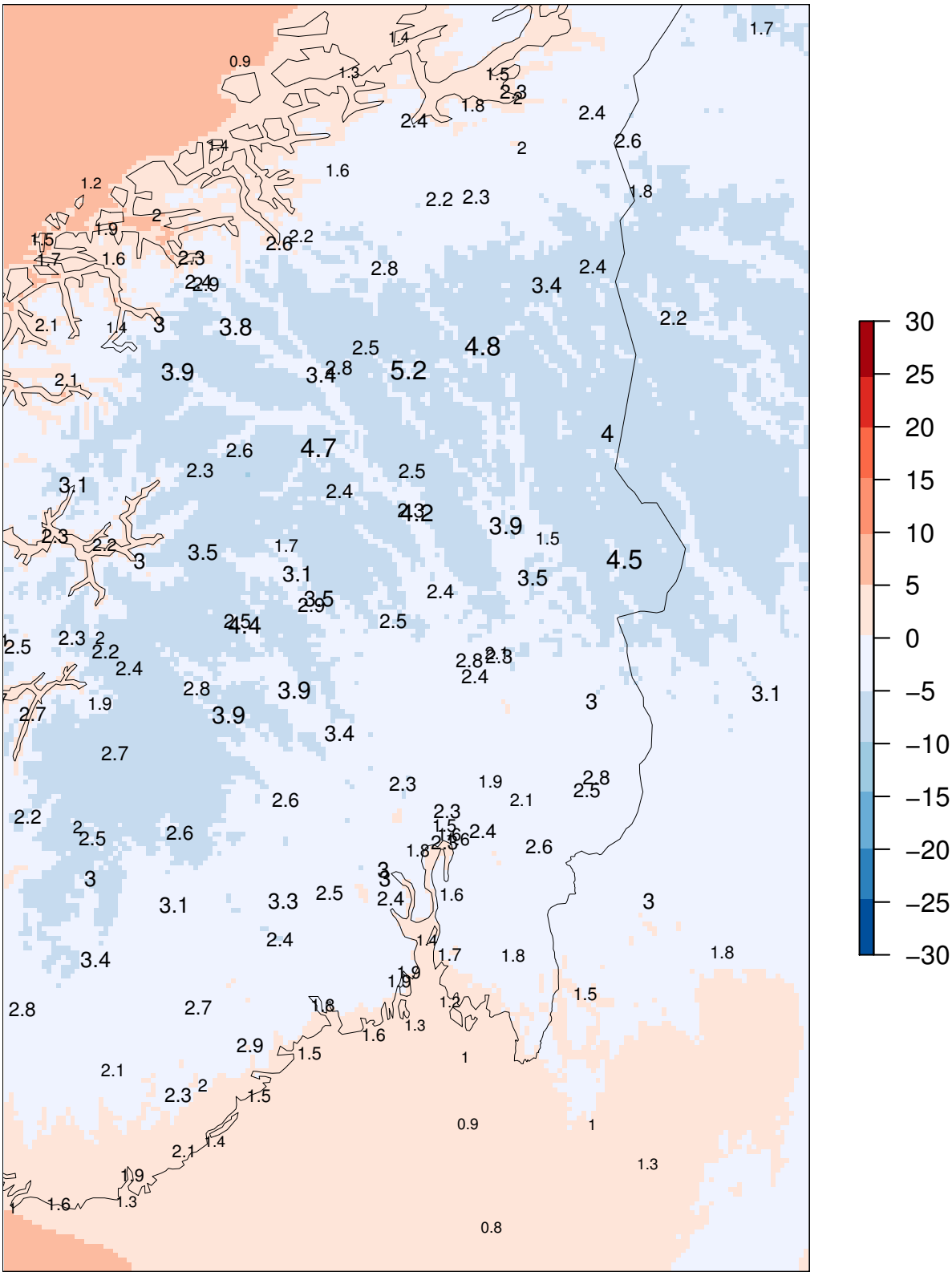
SDE at observing sites
(numbers in black)




Model "climatology" 01.12.2016 – 28.02.2017

MEPSctrl 00+24

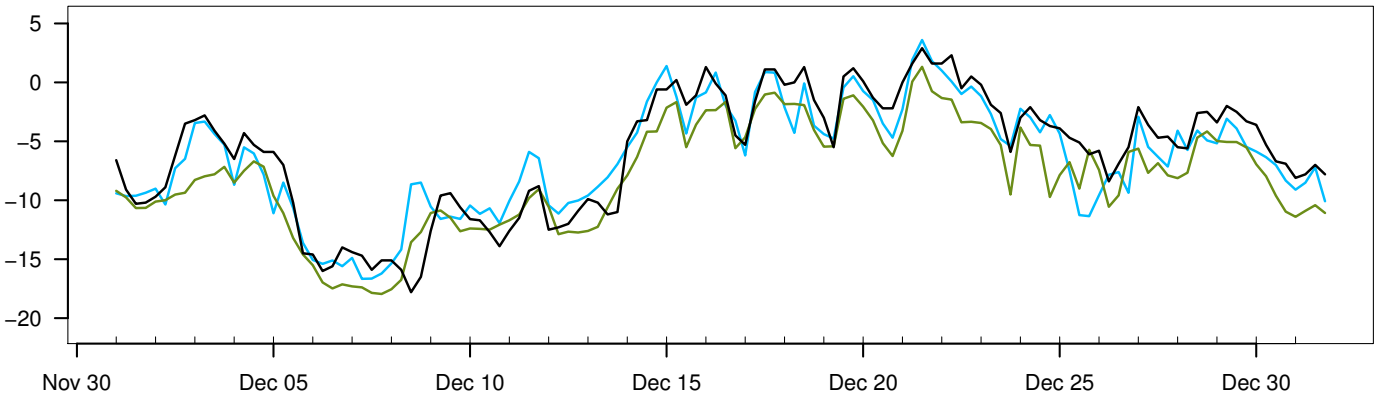
SDE at observing sites
(numbers in black)



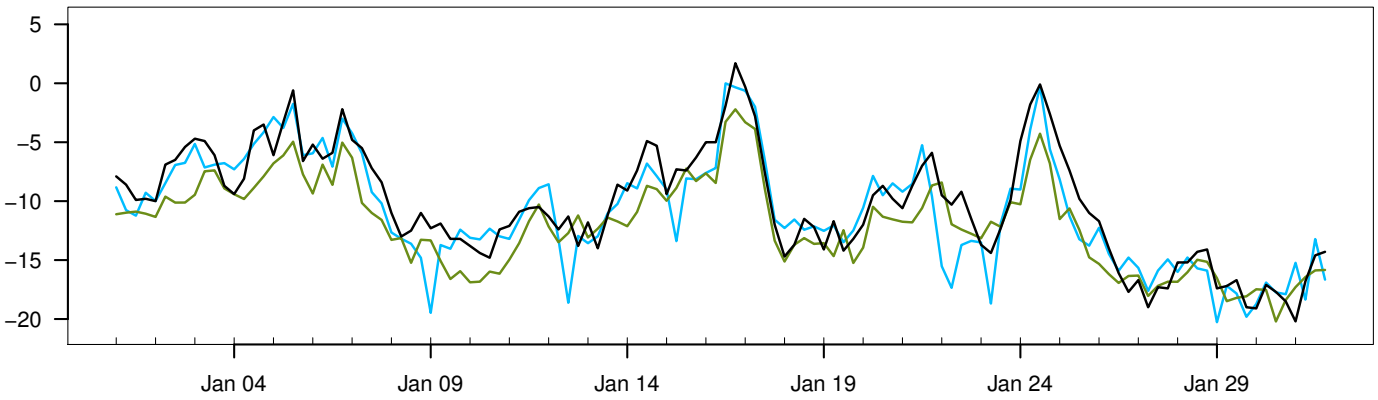

Model "climatology" 01.12.2016 – 28.02.2017

SVALBARD LUFTHAVN

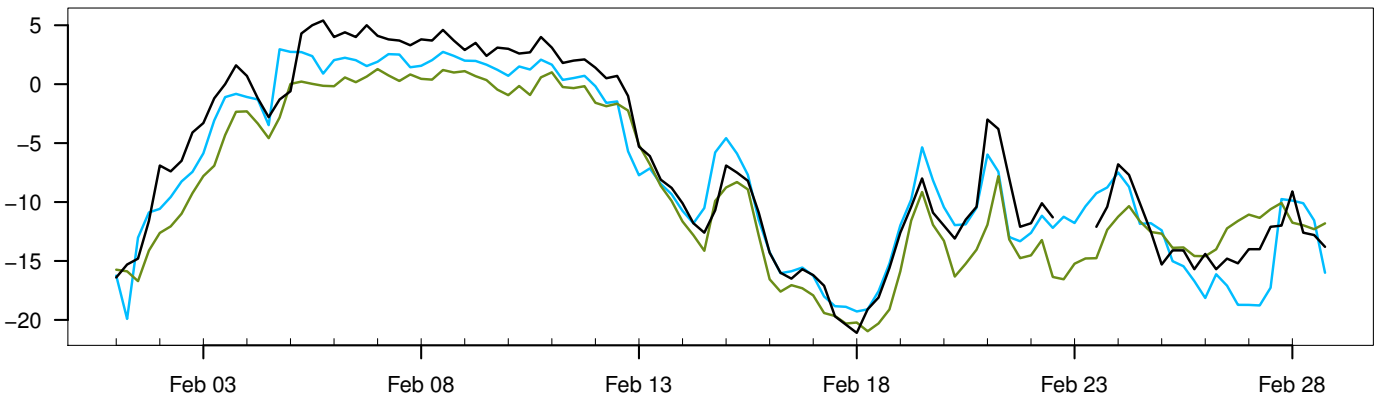
01.12.2016 – 31.12.2016




01.01.2017 – 31.01.2017




01.02.2017 – 28.02.2017



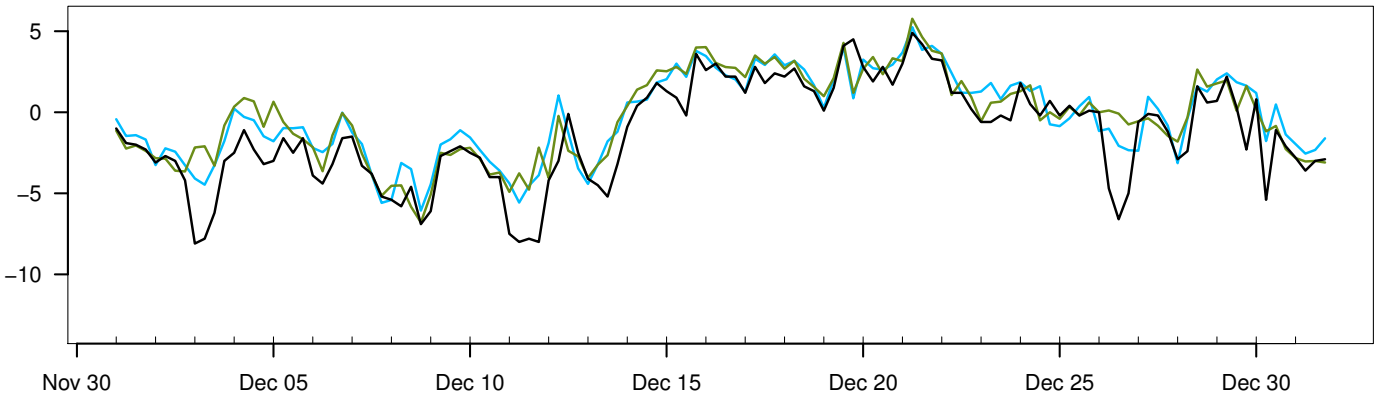

01.12.2016 – 28.02.2017

| | Min | Mean | Max | Std | N |
|---|---|---|---|---|---|
| synop: 00,06,12,18 | −21.1 | −7.7 | 5.4 | 6.2 | 357 |
| AA25: 12+18,+24,+30,+36 | −20.3 | −8.3 | 3.6 | 5.9 | 360 |
| ECMWF: 12+18,+24,+30,+36 | −21 | −9.7 | 1.3 | 5.4 | 360 |

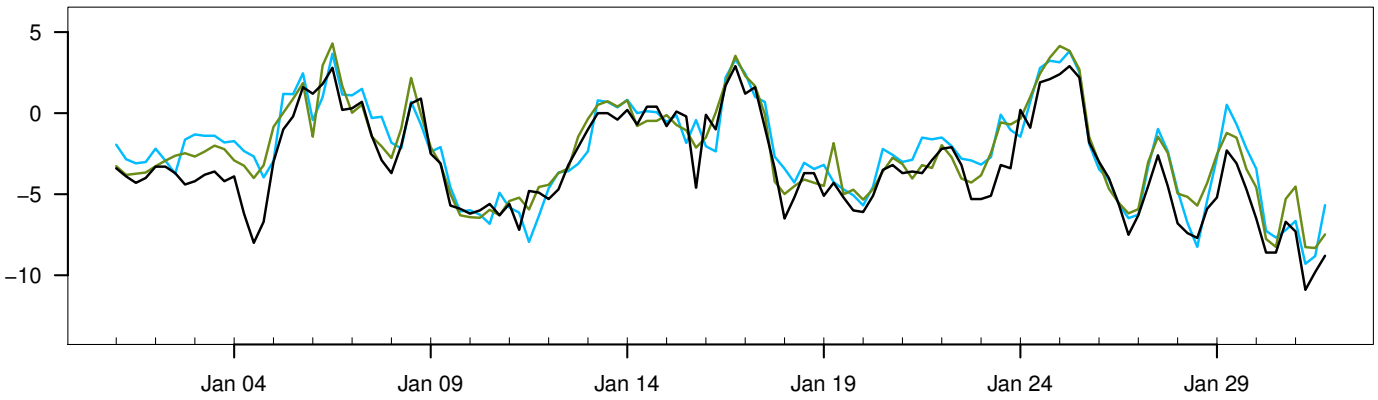
| | ME | SDE | RMSE | MAE | Max.abs.err. | N |
|---|---|---|---|---|---|---|
| AA25 – synop | −0.6 | 2.1 | 2.2 | 1.7 | 9.2 | 357 |
| ECMWF – synop | −1.9 | 1.9 | 2.7 | 2.3 | 8.9 | 357 |

BJØRNØYA

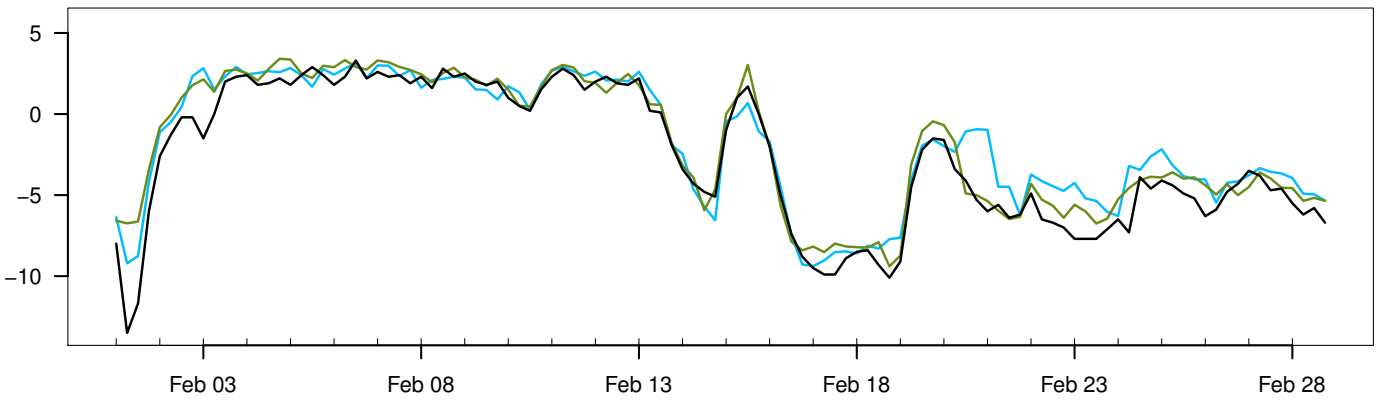
01.12.2016 – 31.12.2016




01.01.2017 – 31.01.2017




01.02.2017 – 28.02.2017

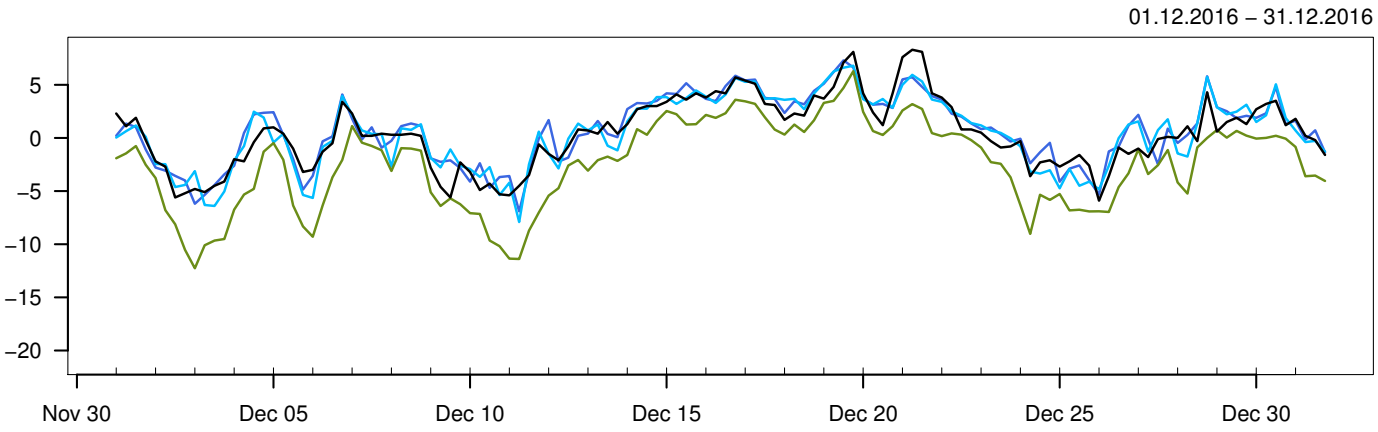


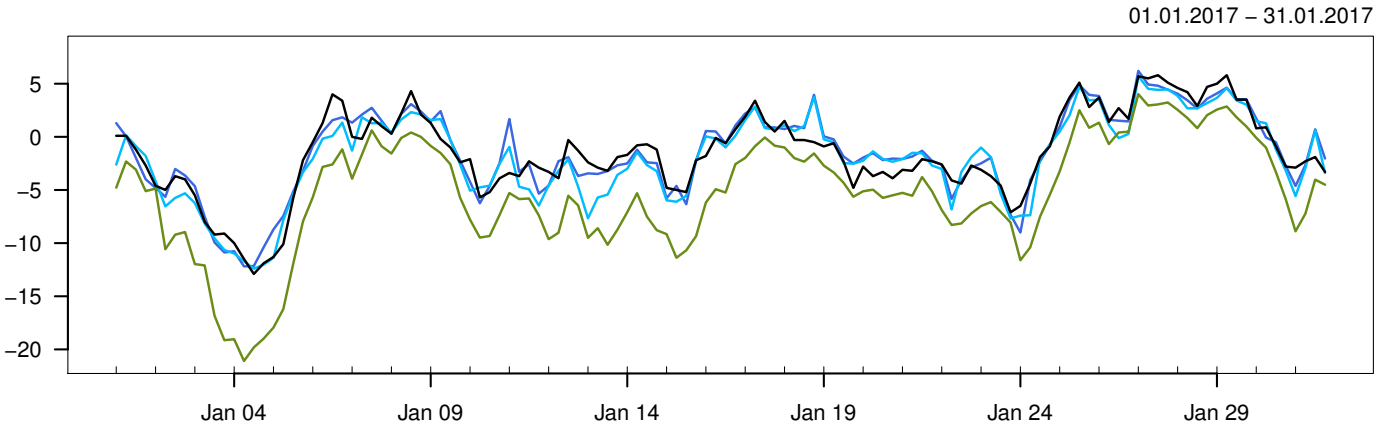

01.12.2016 – 28.02.2017

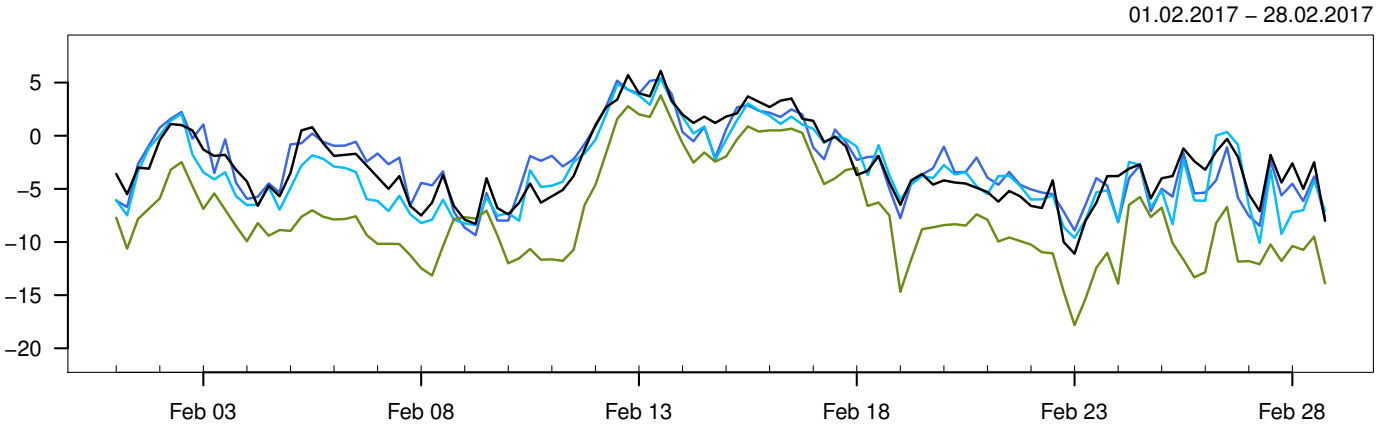
| | Min | Mean | Max | Std | N |
|---|---|---|---|---|---|
| synop: 00,06,12,18 | −13.5 | −2.4 | 4.9 | 3.6 | 360 |
| AA25: 12+18,+24,+30,+36 | −9.4 | −1.5 | 5.2 | 3.2 | 360 |
| ECMWF: 12+18,+24,+30,+36 | −9.4 | −1.6 | 5.8 | 3.3 | 360 |

| | ME | SDE | RMSE | MAE | Max.abs.err. | N |
|---|---|---|---|---|---|---|
| AA25 – synop | 0.9 | 1.3 | 1.6 | 1.2 | 5.3 | 360 |
| ECMWF – synop | 0.8 | 1.3 | 1.5 | 1 | 6.8 | 360 |

TROMSØ



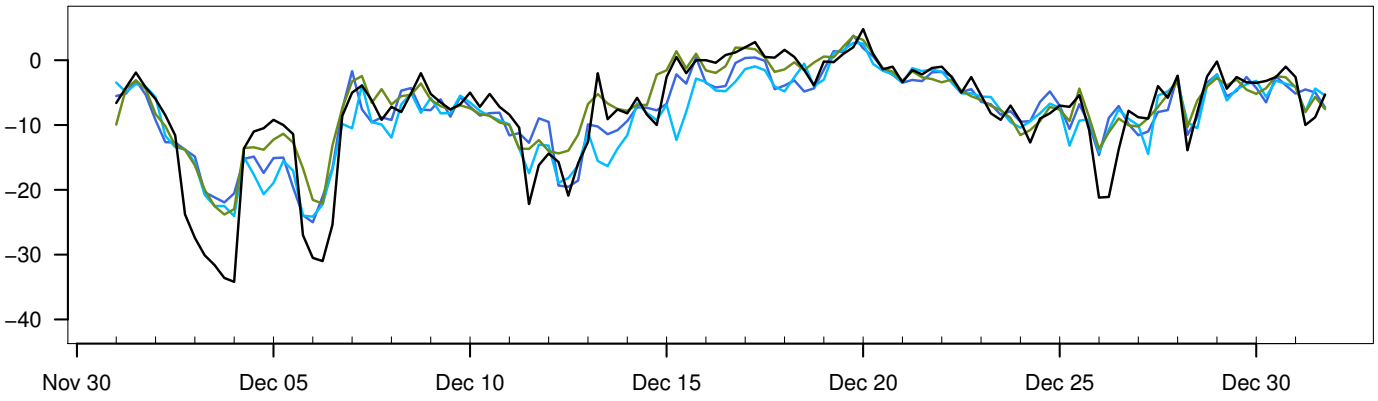

01.12.2016 – 28.02.2017

| | Min | Mean | Max | Std | N |
|---|---|---|---|---|---|
| synop: 00,06,12,18 | −12.9 | −1.2 | 8.3 | 3.8 | 360 |
| MEPSctrl: 12+18,+24,+30,+36 | −12.2 | −1.1 | 7.3 | 3.8 | 360 |
| AA25: 12+18,+24,+30,+36 | −12.4 | −1.6 | 6.8 | 4 | 360 |
| ECMWF: 12+18,+24,+30,+36 | −21.1 | −5 | 6.3 | 5.1 | 360 |

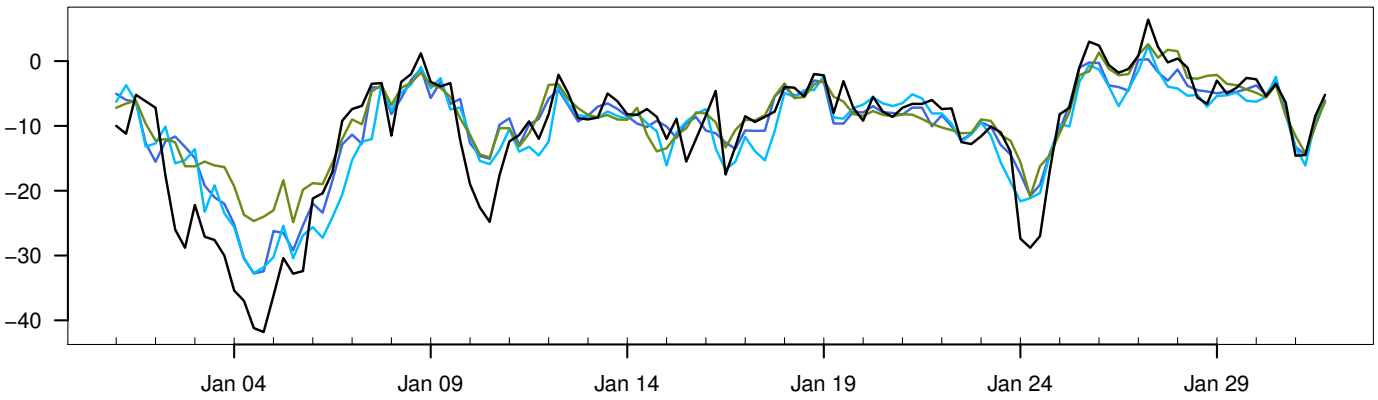
| | ME | SDE | RMSE | MAE | Max.abs.err. | N |
|---|---|---|---|---|---|---|
| MEPSctrl – synop | 0.2 | 1.4 | 1.4 | 1.1 | 5.1 | 360 |
| AA25 – synop | −0.3 | 1.5 | 1.5 | 1.2 | 5.3 | 360 |
| ECMWF – synop | −3.8 | 2.1 | 4.3 | 3.8 | 10.9 | 360 |

KAUTOKEINO

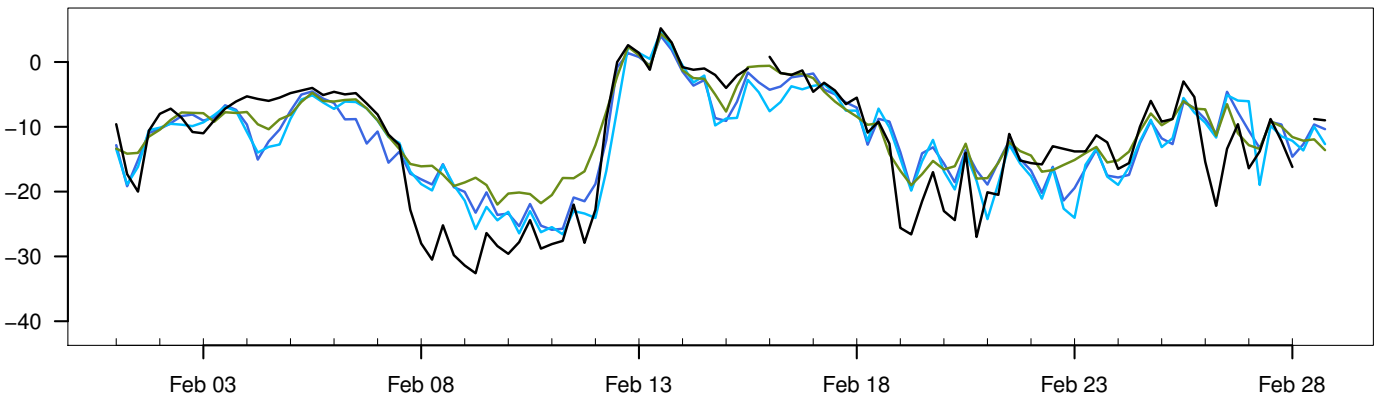
01.12.2016 – 31.12.2016




01.01.2017 – 31.01.2017




01.02.2017 – 28.02.2017

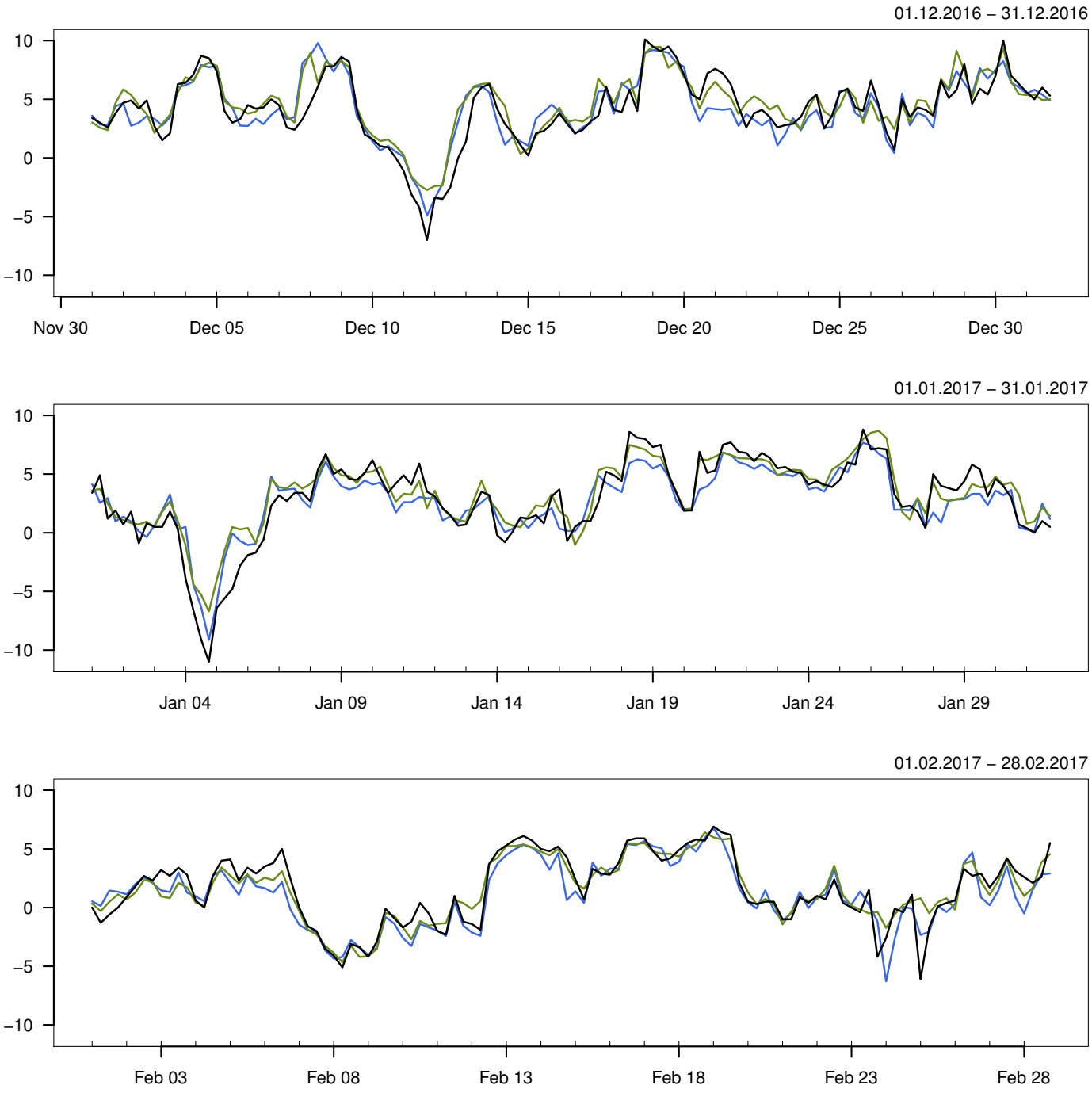



01.12.2016 – 28.02.2017

| | Min | Mean | Max | Std | N |
|---|---|---|---|---|---|
| synop: 00,06,12,18 | −41.8 | −10.3 | 6.4 | 9.4 | 358 |
| MEPSctrl: 12+18,+24,+30,+36 | −32.8 | −9.8 | 4 | 6.7 | 360 |
| AA25: 12+18,+24,+30,+36 | −32.7 | −10.5 | 4.7 | 7.1 | 360 |
| ECMWF: 12+18,+24,+30,+36 | −24.9 | −8.8 | 4.3 | 6 | 360 |

| | ME | SDE | RMSE | MAE | Max.abs.err. | N |
|---|---|---|---|---|---|---|
| MEPSctrl – synop | 0.4 | 4.4 | 4.4 | 3.3 | 15.6 | 358 |
| AA25 – synop | −0.3 | 4.6 | 4.6 | 3.5 | 13.6 | 358 |
| ECMWF – synop | 1.5 | 4.5 | 4.7 | 3.2 | 17.8 | 358 |

ØRLAND III



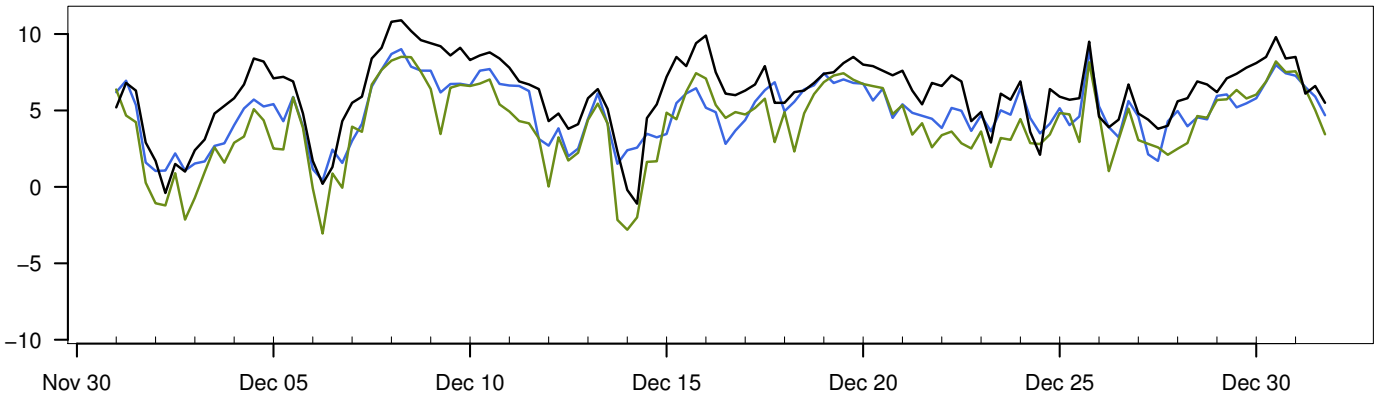

01.12.2016 – 28.02.2017

| | Min | Mean | Max | Std | N |
|---|---|---|---|---|---|
| synop: 00,06,12,18 | −11 | 2.9 | 10.1 | 3.3 | 360 |
| MEPSctrl: 12+18,+24,+30,+36 | −9.1 | 2.7 | 9.8 | 3 | 360 |
| ECMWF: 12+18,+24,+30,+36 | −6.7 | 3.2 | 9.5 | 2.9 | 360 |

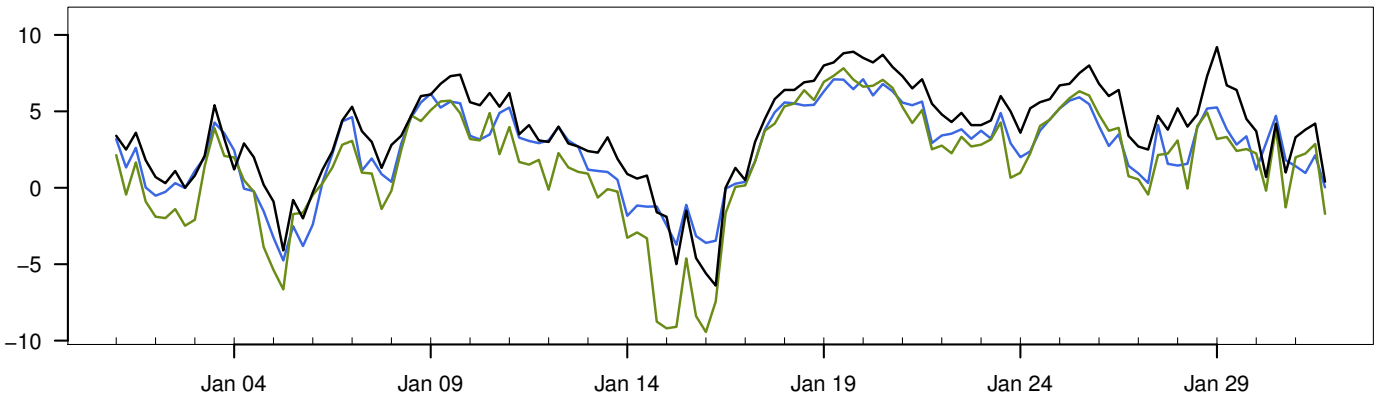
| | ME | SDE | RMSE | MAE | Max.abs.err. | N |
|---|---|---|---|---|---|---|
| MEPSctrl – synop | −0.2 | 1.4 | 1.4 | 1 | 4.8 | 360 |
| ECMWF – synop | 0.3 | 1.2 | 1.3 | 0.9 | 6.9 | 360 |

BERGEN – FLORIDA

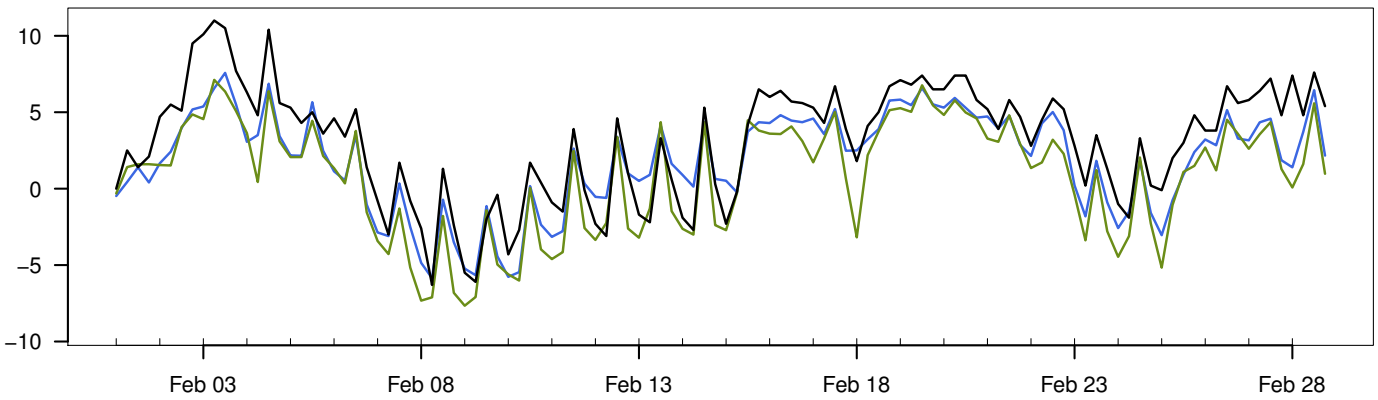
01.12.2016 – 31.12.2016




01.01.2017 – 31.01.2017




01.02.2017 – 28.02.2017



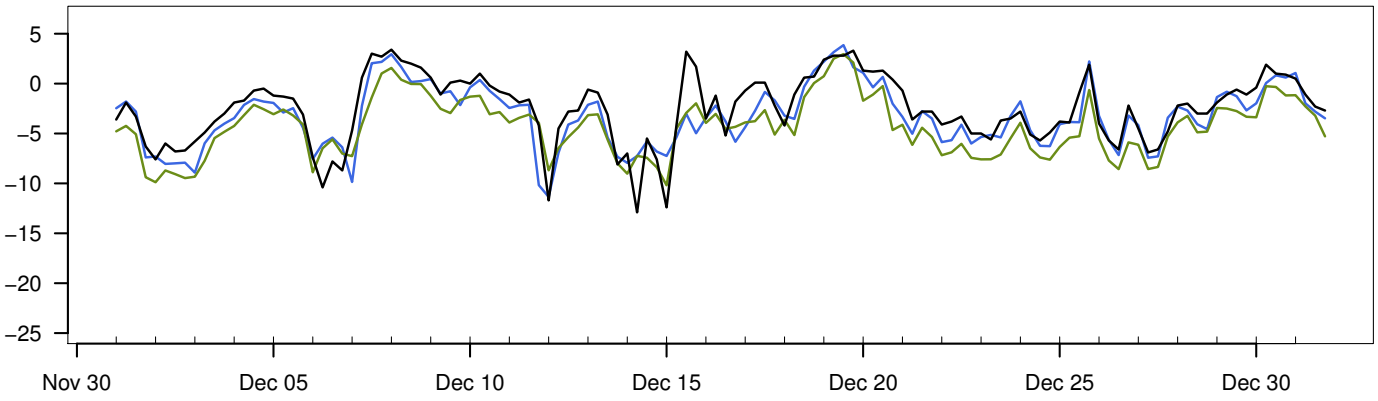

01.12.2016 – 28.02.2017

| | Min | Mean | Max | Std | N |
|---|---|---|---|---|---|
| synop: 00,06,12,18 | −6.4 | 4.4 | 11 | 3.4 | 360 |
| MEPSctrl: 12+18,+24,+30,+36 | −5.9 | 3.1 | 9 | 3 | 360 |
| ECMWF: 12+18,+24,+30,+36 | −9.4 | 2.2 | 8.5 | 3.6 | 360 |

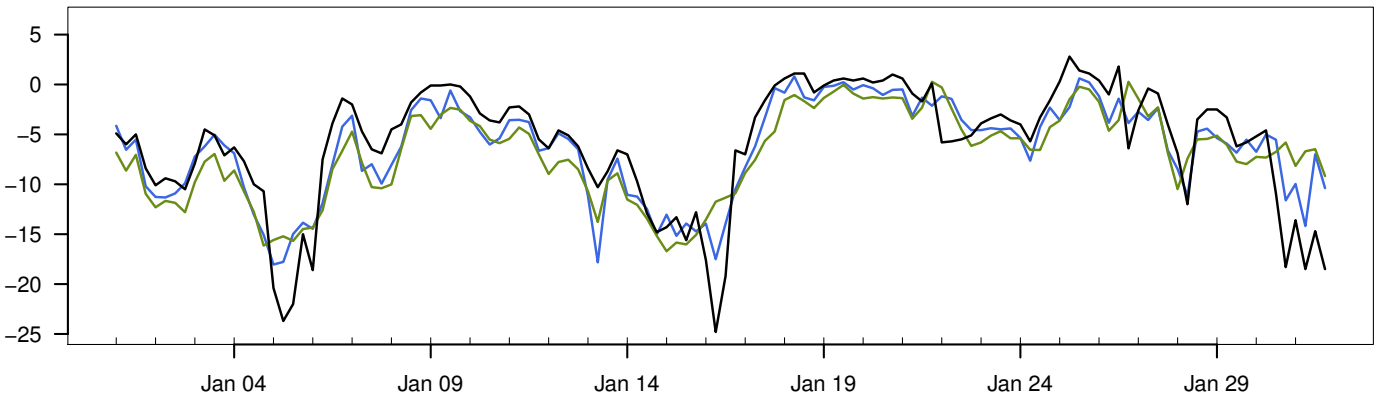
| | ME | SDE | RMSE | MAE | Max.abs.err. | N |
|---|---|---|---|---|---|---|
| MEPSctrl – synop | −1.2 | 1.4 | 1.8 | 1.6 | 6 | 360 |
| ECMWF – synop | −2.1 | 1.3 | 2.5 | 2.2 | 7.3 | 360 |

FINSEVATN

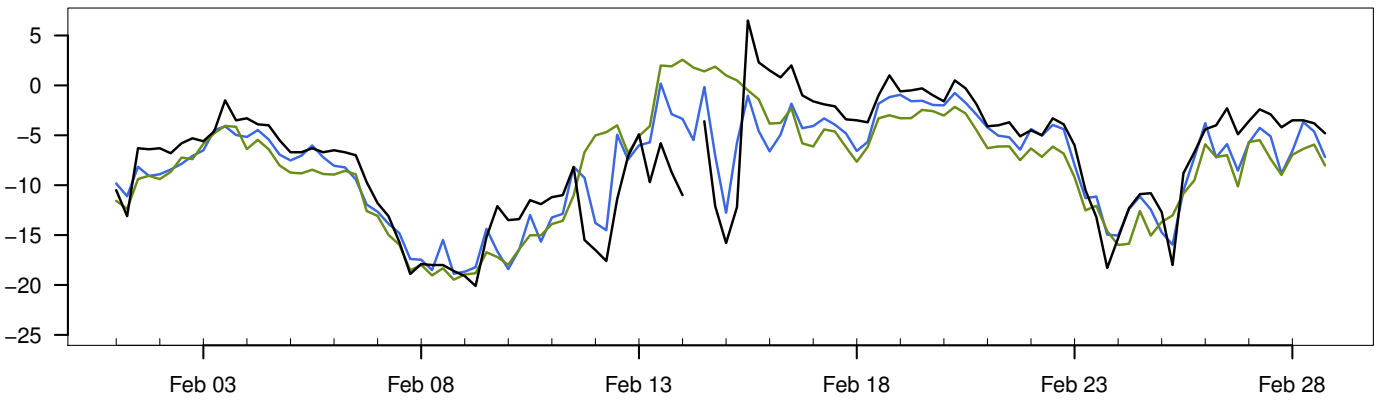
01.12.2016 – 31.12.2016




01.01.2017 – 31.01.2017




01.02.2017 – 28.02.2017



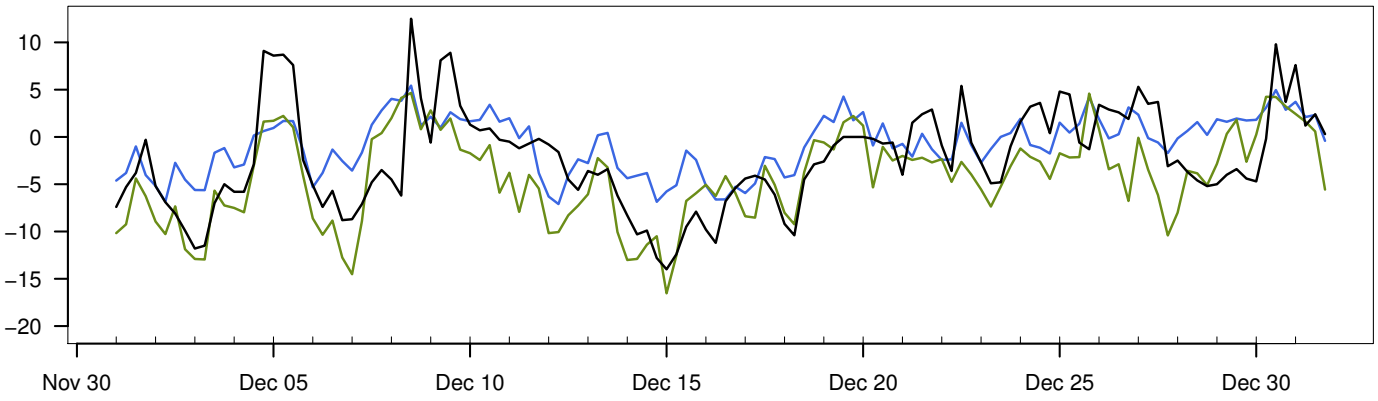

01.12.2016 – 28.02.2017

| | Min | Mean | Max | Std | N |
|---|---|---|---|---|---|
| synop: 00,06,12,18 | −24.8 | −5.2 | 6.5 | 5.5 | 359 |
| MEPSctrl: 12+18,+24,+30,+36 | −18.9 | −5.8 | 3.9 | 4.7 | 360 |
| ECMWF: 12+18,+24,+30,+36 | −19.5 | −6.4 | 3 | 4.6 | 360 |

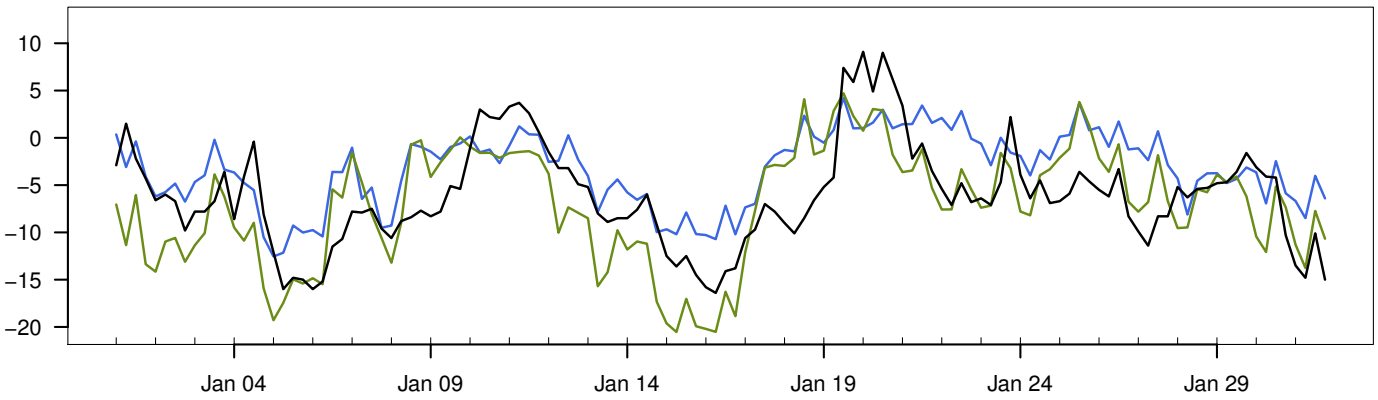
| | ME | SDE | RMSE | MAE | Max.abs.err. | N |
|---|---|---|---|---|---|---|
| MEPSctrl – synop | −0.7 | 2.4 | 2.5 | 1.8 | 8.1 | 359 |
| ECMWF – synop | −1.3 | 3.4 | 3.7 | 2.8 | 16.8 | 359 |

NESBYEN – TODOKK

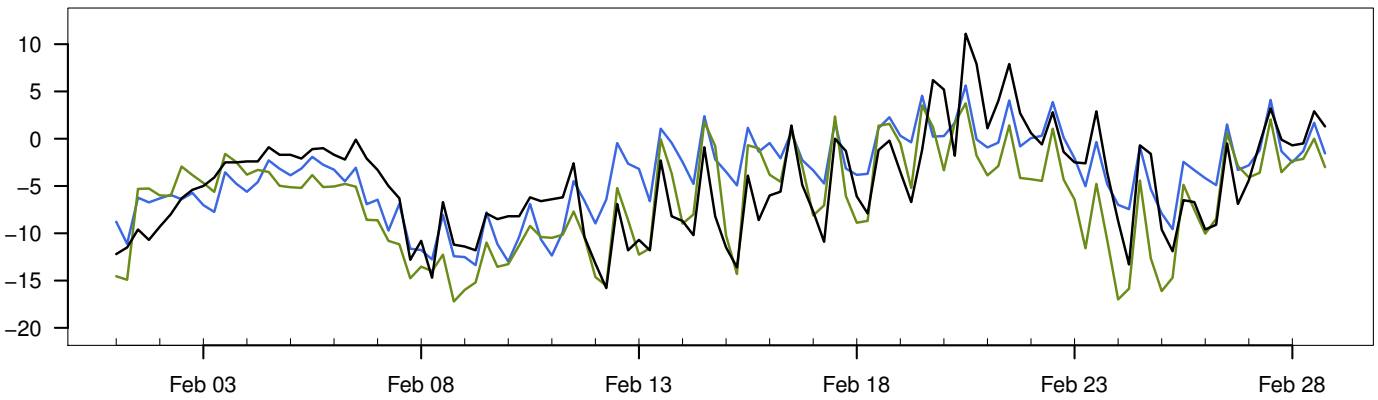
01.12.2016 – 31.12.2016




01.01.2017 – 31.01.2017




01.02.2017 – 28.02.2017



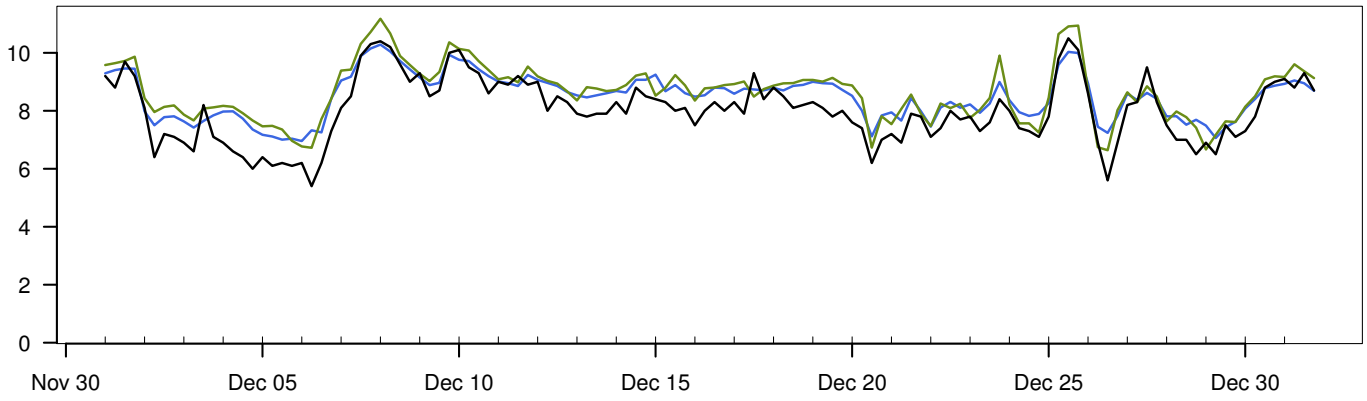

01.12.2016 – 28.02.2017

| | Min | Mean | Max | Std | N |
|---|---|---|---|---|---|
| synop: 00,06,12,18 | −16.4 | −4.3 | 12.5 | 5.6 | 360 |
| MEPSctrl: 12+18,+24,+30,+36 | −13.4 | −2.6 | 5.6 | 4 | 360 |
| ECMWF: 12+18,+24,+30,+36 | −20.5 | −5.9 | 4.7 | 5.5 | 360 |

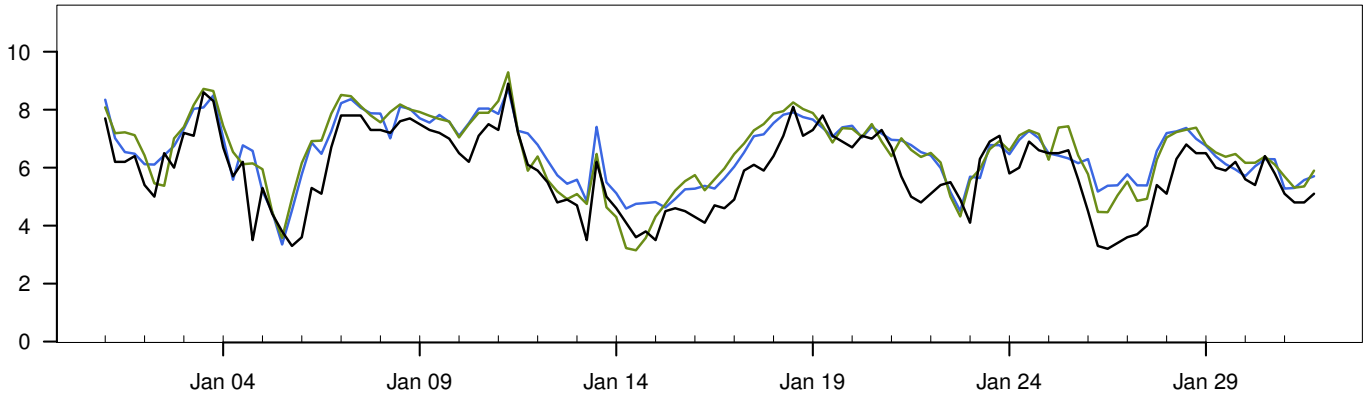
| | ME | SDE | RMSE | MAE | Max.abs.err. | N |
|---|---|---|---|---|---|---|
| MEPSctrl – synop | 1.7 | 4 | 4.4 | 3.7 | 10.8 | 360 |
| ECMWF – synop | −1.6 | 4.1 | 4.4 | 3.7 | 12.8 | 360 |

EKOFISK

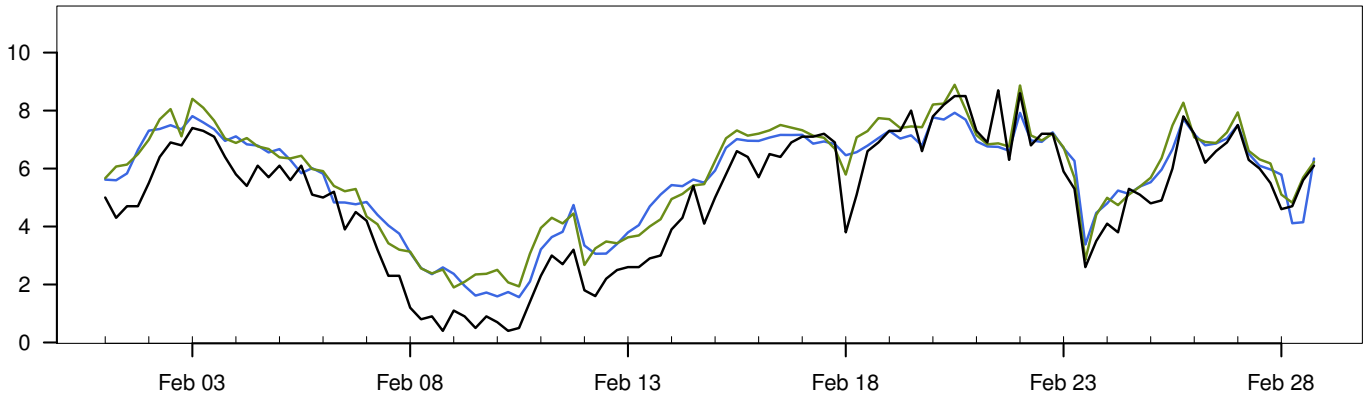
01.12.2016 – 31.12.2016




01.01.2017 – 31.01.2017




01.02.2017 – 28.02.2017

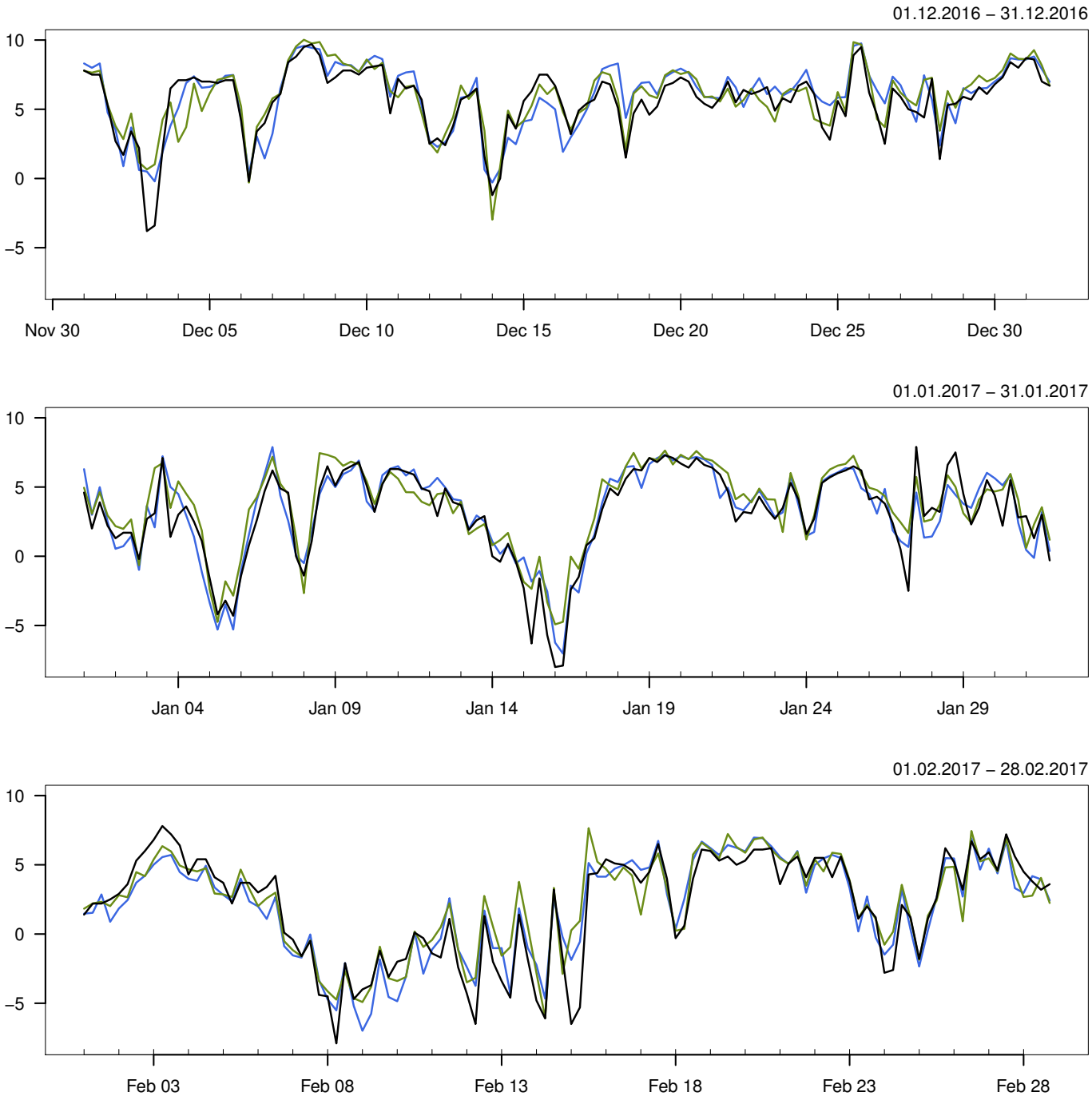



01.12.2016 – 28.02.2017

| | Min | Mean | Max | Std | N |
|---|---|---|---|---|---|
| synop: 00,06,12,18 | 0.4 | 6.3 | 10.5 | 2 | 360 |
| MEPSctrl: 12+18,+24,+30,+36 | 1.6 | 6.9 | 10.3 | 1.7 | 360 |
| ECMWF: 12+18,+24,+30,+36 | 1.9 | 7 | 11.2 | 1.8 | 360 |

| | ME | SDE | RMSE | MAE | Max.abs.err. | N |
|---|---|---|---|---|---|---|
| MEPSctrl – synop | 0.6 | 0.6 | 0.9 | 0.7 | 3.1 | 360 |
| ECMWF – synop | 0.7 | 0.6 | 0.9 | 0.8 | 2.6 | 360 |

SOLA



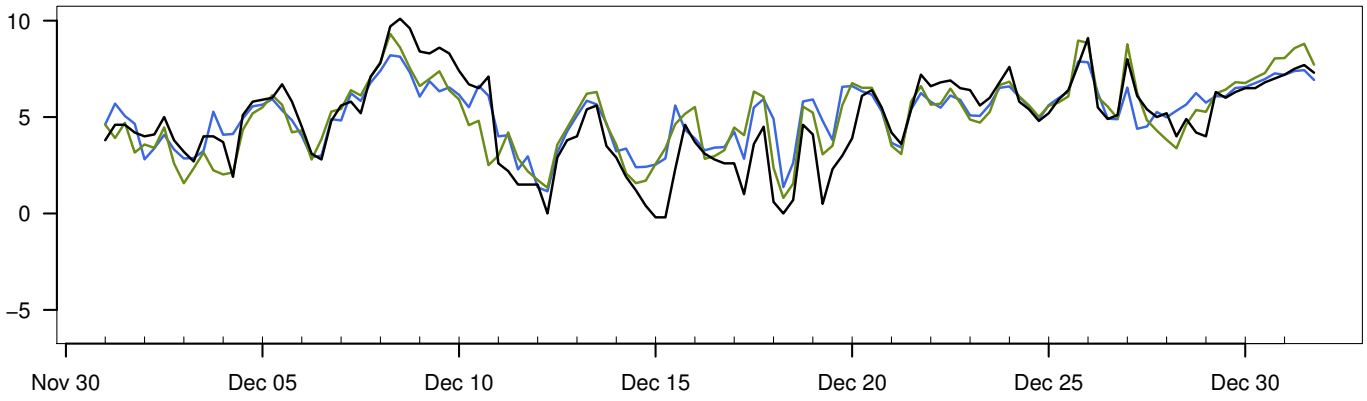

01.12.2016 – 28.02.2017

| | Min | Mean | Max | Std | N |
|---|---|---|---|---|---|
| synop: 00,06,12,18 | −8 | 3.6 | 9.7 | 3.5 | 360 |
| MEPSctrl: 12+18,+24,+30,+36 | −7 | 3.8 | 9.8 | 3.4 | 360 |
| ECMWF: 12+18,+24,+30,+36 | −6 | 4 | 10 | 3.2 | 360 |

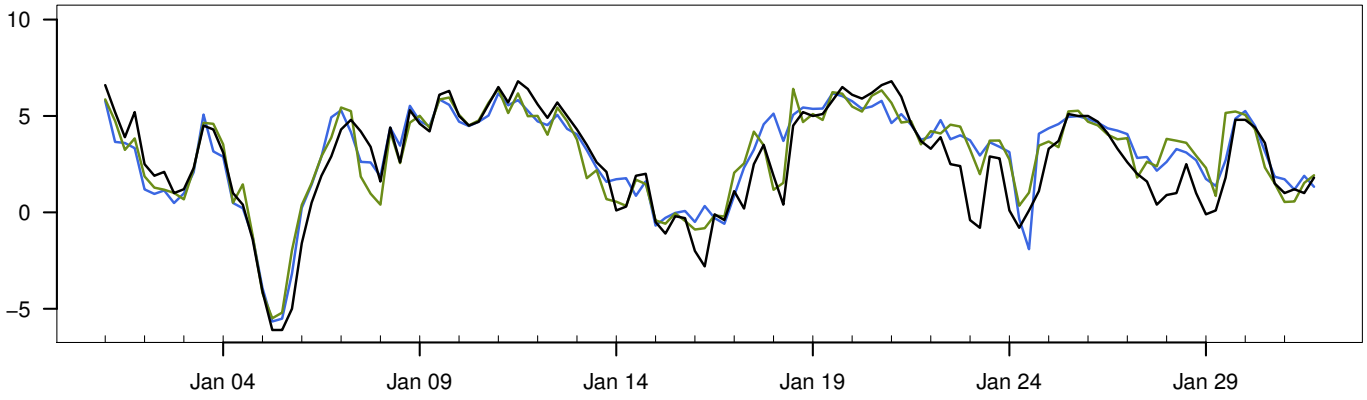
| | ME | SDE | RMSE | MAE | Max.abs.err. | N |
|---|---|---|---|---|---|---|
| MEPSctrl – synop | 0.1 | 1.3 | 1.3 | 0.9 | 4.7 | 360 |
| ECMWF – synop | 0.4 | 1.3 | 1.3 | 1 | 6.8 | 360 |

FÆRDER FYR

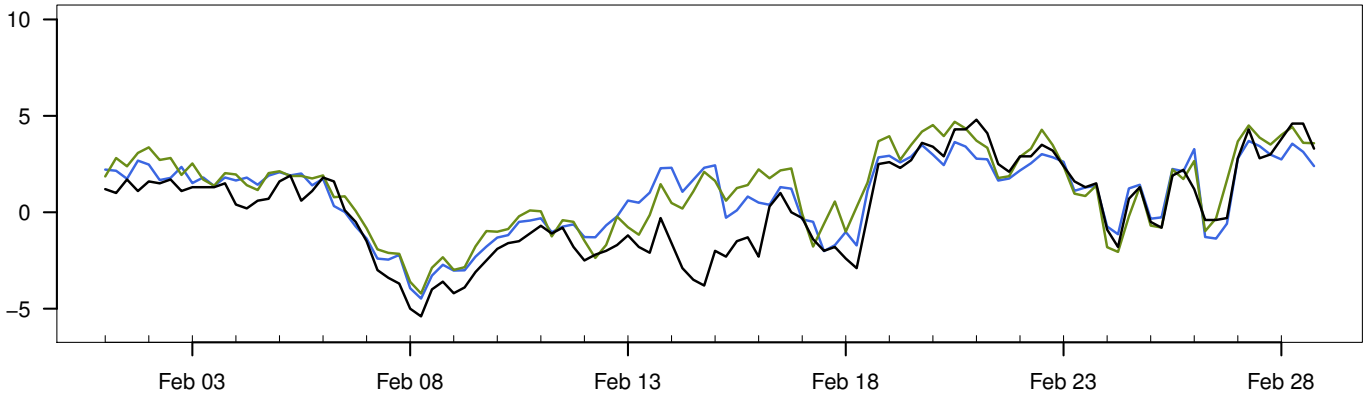
01.12.2016 – 31.12.2016




01.01.2017 – 31.01.2017




01.02.2017 – 28.02.2017



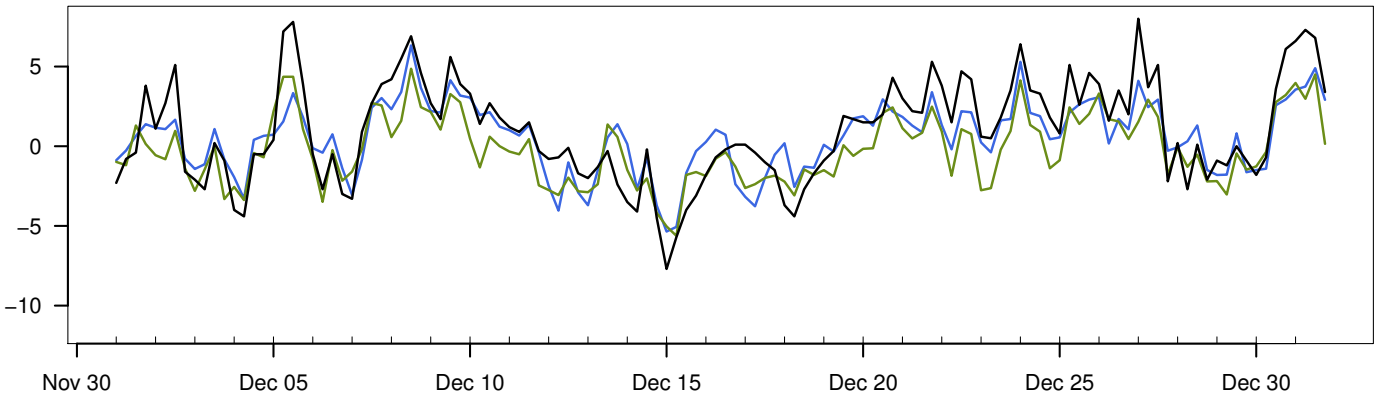

01.12.2016 – 28.02.2017

| | Min | Mean | Max | Std | N |
|---|---|---|---|---|---|
| synop: 00,06,12,18 | −6.1 | 2.6 | 10.1 | 3.1 | 360 |
| MEPSctrl: 12+18,+24,+30,+36 | −5.7 | 3 | 8.2 | 2.6 | 360 |
| ECMWF: 12+18,+24,+30,+36 | −5.5 | 3.1 | 9.3 | 2.7 | 360 |

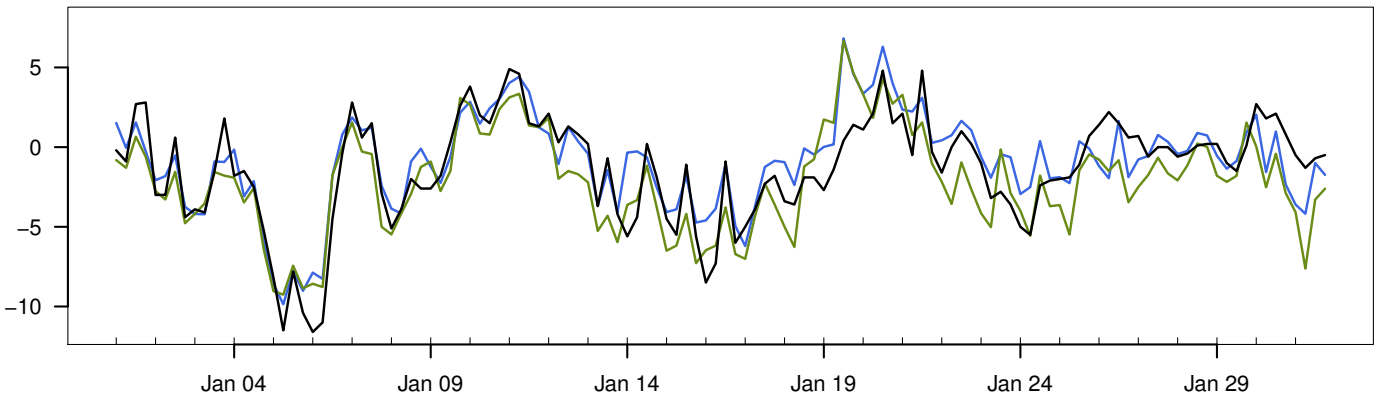
| | ME | SDE | RMSE | MAE | Max.abs.err. | N |
|---|---|---|---|---|---|---|
| MEPSctrl – synop | 0.4 | 1.2 | 1.3 | 0.9 | 6.1 | 360 |
| ECMWF – synop | 0.4 | 1.2 | 1.3 | 1 | 5.9 | 360 |

OSLO – BLINDERN

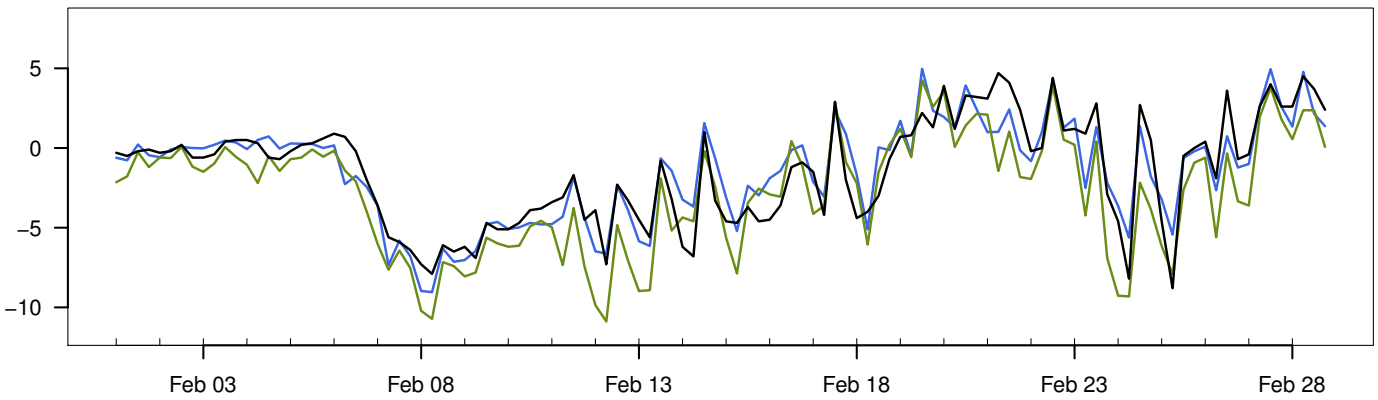
01.12.2016 – 31.12.2016




01.01.2017 – 31.01.2017



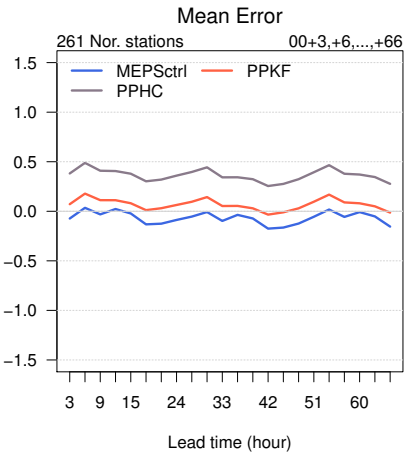

01.02.2017 – 28.02.2017

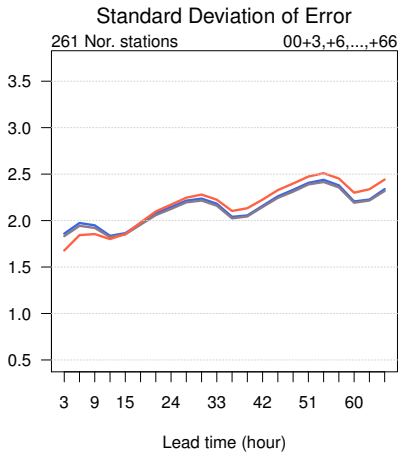


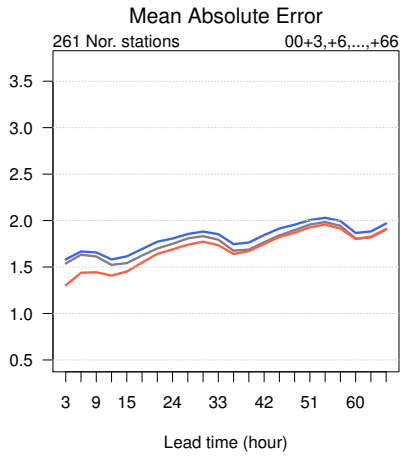

01.12.2016 – 28.02.2017

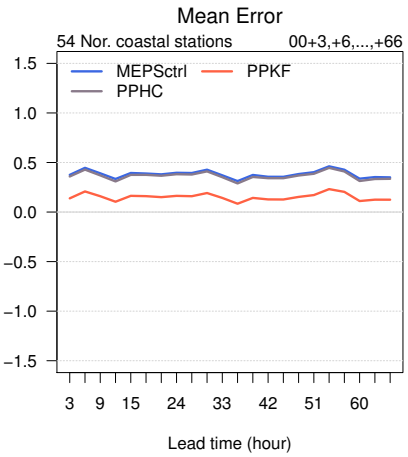
| | Min | Mean | Max | Std | N |
|---|---|---|---|---|---|
| synop: 00,06,12,18 | −11.6 | −0.6 | 8 | 3.4 | 360 |
| MEPSctrl: 12+18,+24,+30,+36 | −9.9 | −0.6 | 6.8 | 2.9 | 360 |
| ECMWF: 12+18,+24,+30,+36 | −10.9 | −1.7 | 6.7 | 3.2 | 360 |

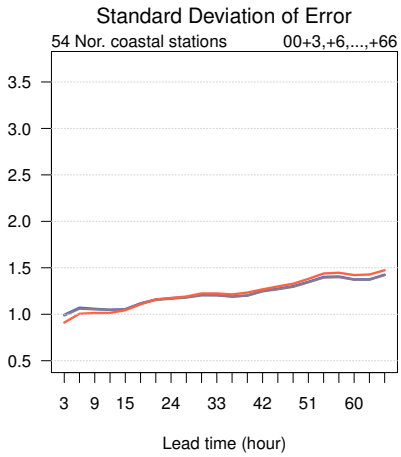
| | ME | SDE | RMSE | MAE | Max.abs.err. | N |
|---|---|---|---|---|---|---|
| MEPSctrl – synop | 0 | 1.7 | 1.7 | 1.3 | 6.4 | 360 |
| ECMWF – synop | −1.1 | 1.8 | 2.1 | 1.7 | 6.5 | 360 |

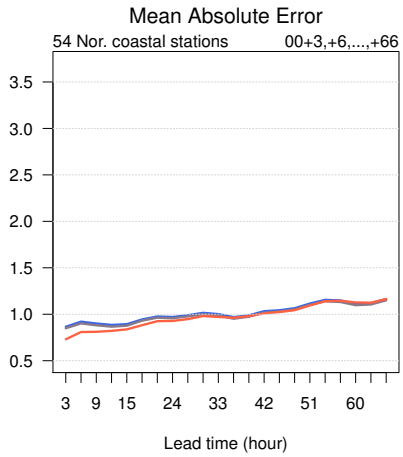

Mean Error
261 Nor. stations
00+3,+6,...,+66
MEPSctrl
PPKF
PPHC
1.5
1.0
0.5
0.0
−0.5
−1.0
−1.5
3 9 15 24 33 42 51 60
Lead time (hour)

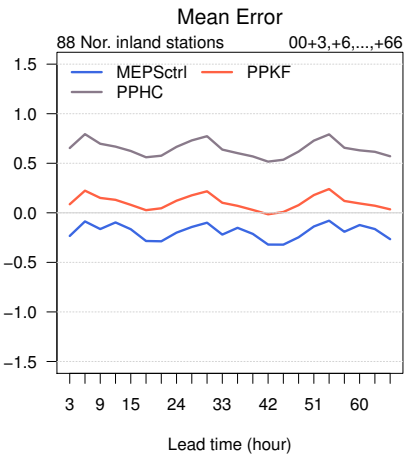

Standard Deviation of Error
261 Nor. stations
00+3,+6,...,+66
3.5
3.0
2.5
2.0
1.5
1.0
0.5
3 9 15 24 33 42 51 60
Lead time (hour)

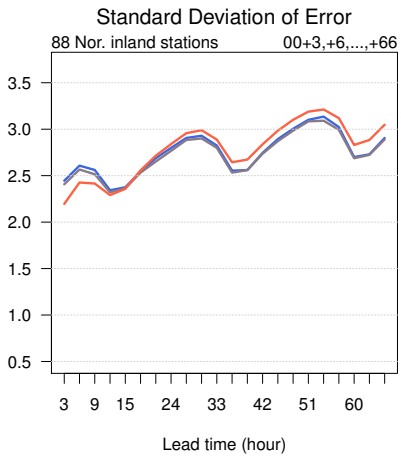

Mean Absolute Error
261 Nor. stations
00+3,+6,...,+66
3.5
3.0
2.5
2.0
1.5
1.0
0.5
3 9 15 24 33 42 51 60
Lead time (hour)

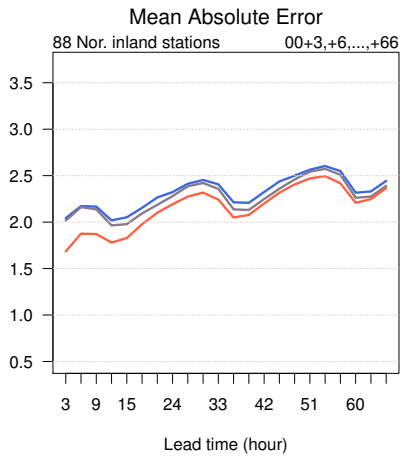

Mean Error
54 Nor. coastal stations
00+3,+6,...,+66
MEPSctrl
PPKF
PPHC
1.5
1.0
0.5
0.0
−0.5
−1.0
−1.5
3 9 15 24 33 42 51 60
Lead time (hour)


Standard Deviation of Error
54 Nor. coastal stations
00+3,+6,...,+66
3.5
3.0
2.5
2.0
1.5
1.0
0.5
3 9 15 24 33 42 51 60
Lead time (hour)


Mean Absolute Error
54 Nor. coastal stations
00+3,+6,...,+66
3.5
3.0
2.5
2.0
1.5
1.0
0.5
3 9 15 24 33 42 51 60
Lead time (hour)

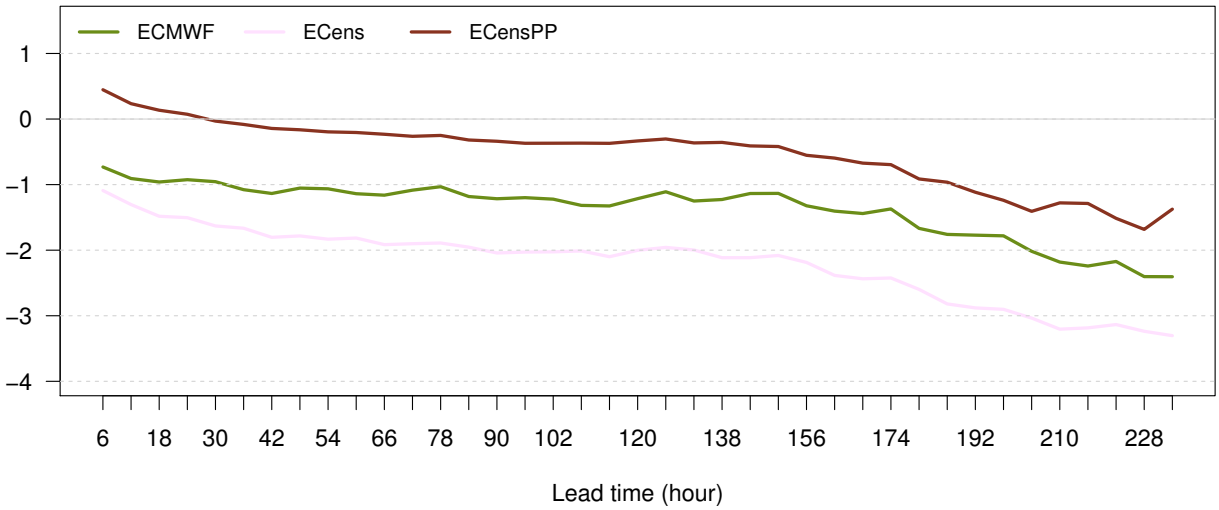

Mean Error
88 Nor. inland stations
00+3,+6,...,+66
MEPSctrl
PPKF
PPHC
1.5
1.0
0.5
0.0
−0.5
−1.0
−1.5
3 9 15 24 33 42 51 60
Lead time (hour)


Standard Deviation of Error
88 Nor. inland stations
00+3,+6,...,+66
3.5
3.0
2.5
2.0
1.5
1.0
0.5
3 9 15 24 33 42 51 60
Lead time (hour)

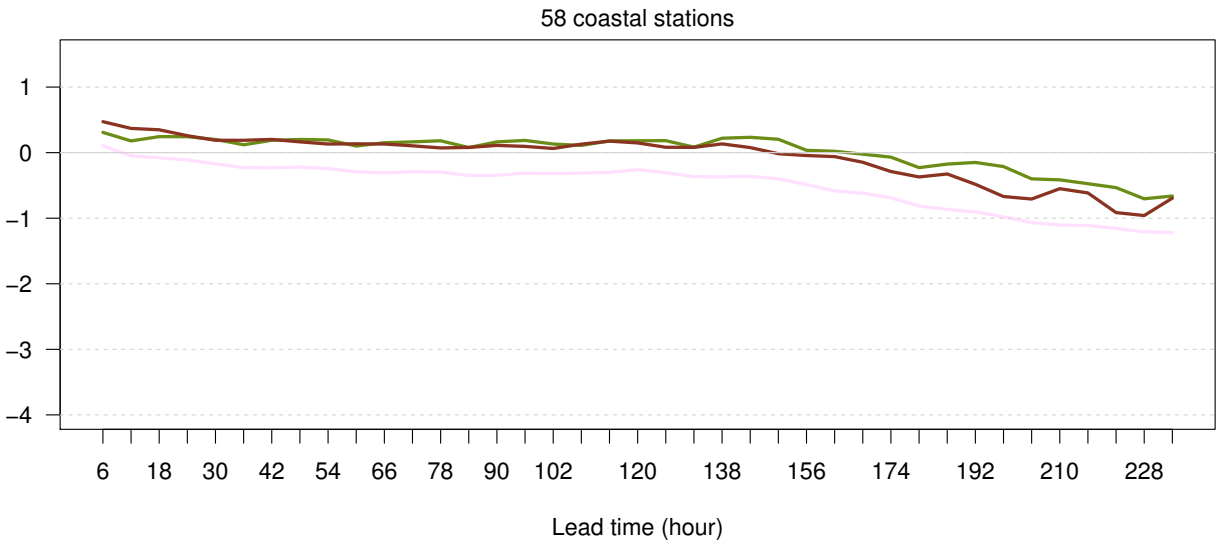

Mean Absolute Error
88 Nor. inland stations
00+3,+6,...,+66
3.5
3.0
2.5
2.0
1.5
1.0
0.5
3 9 15 24 33 42 51 60
Lead time (hour)

## Mean Error

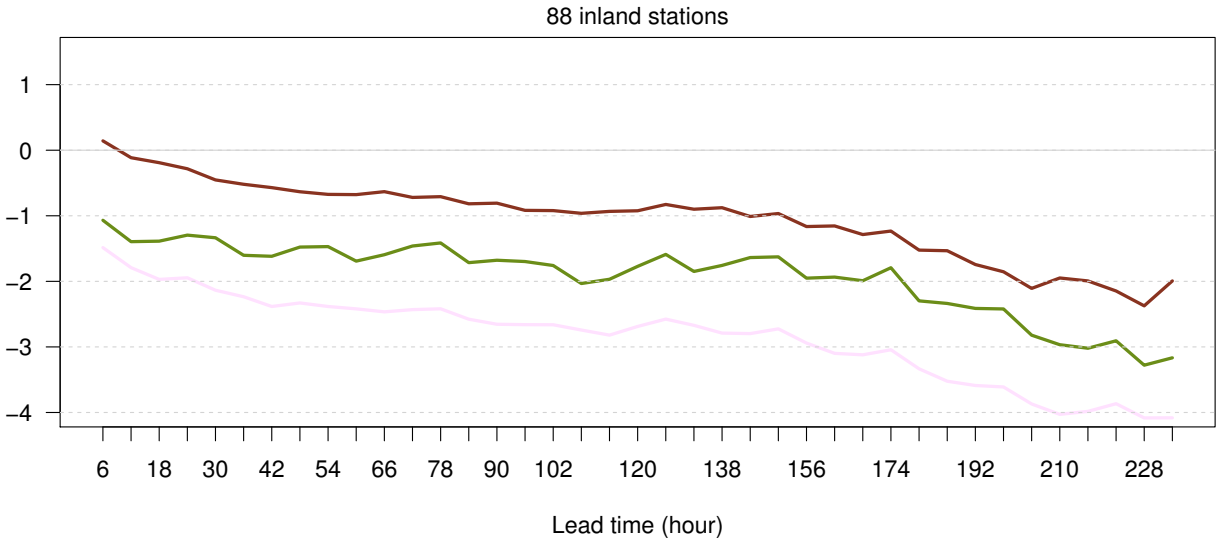
269 Norwegian stations




58 coastal stations

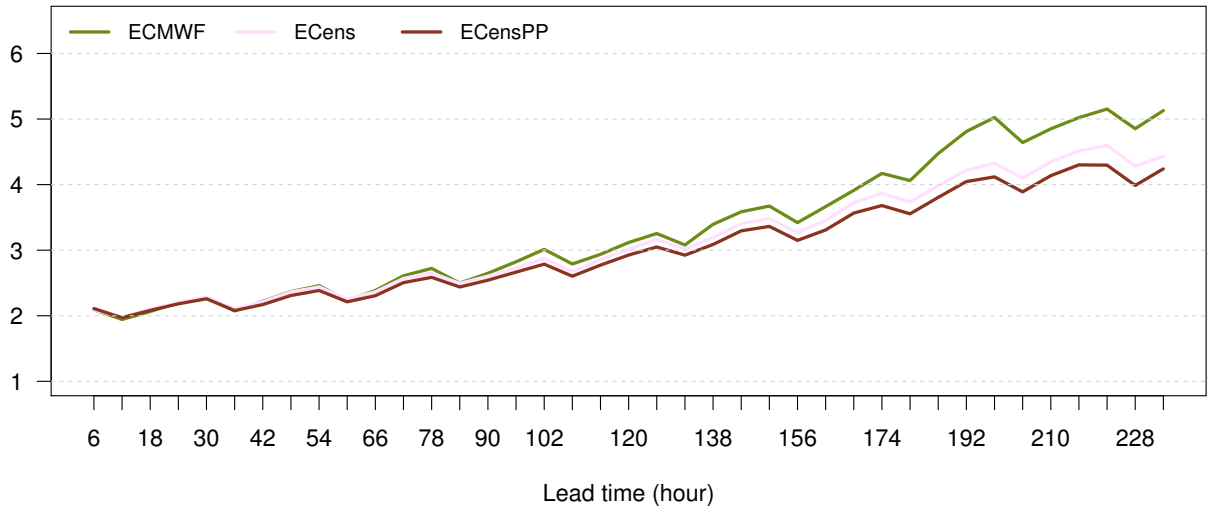



88 inland stations

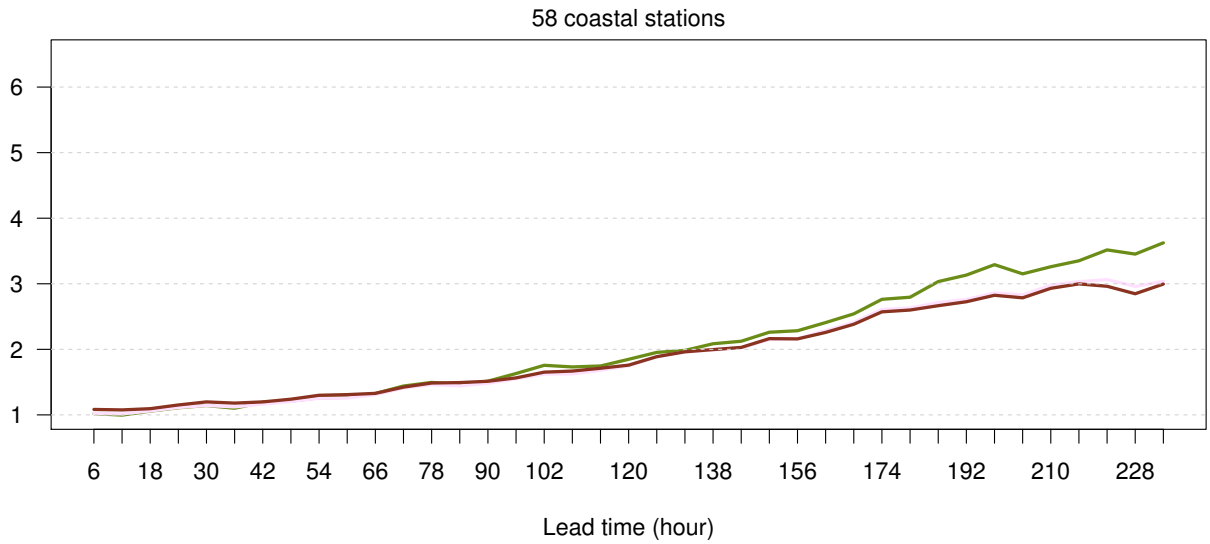


Standard Deviation of Error

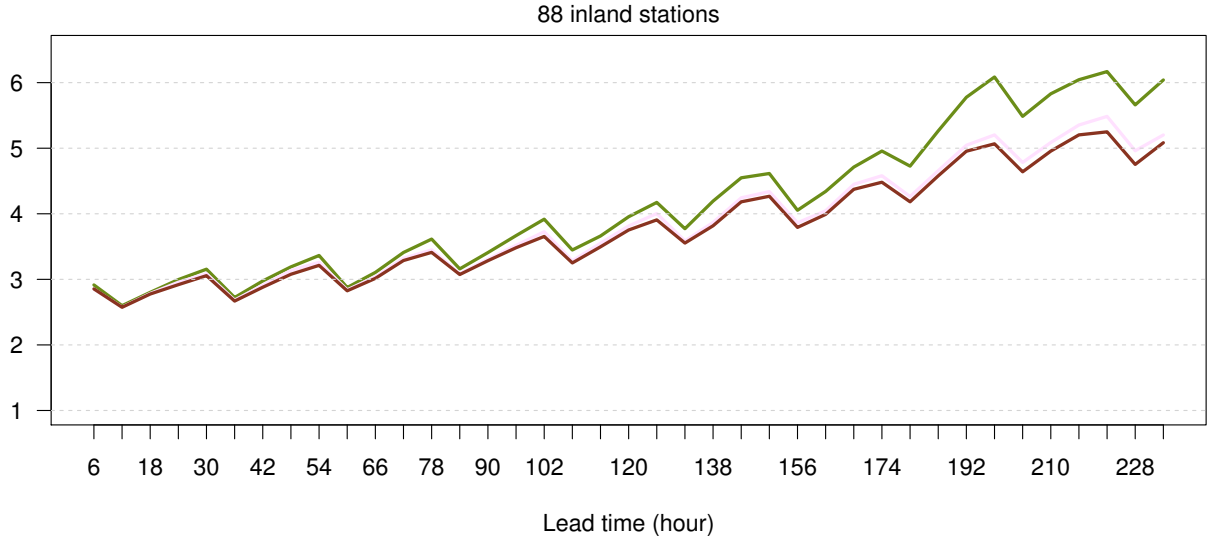
269 Norwegian stations




58 coastal stations

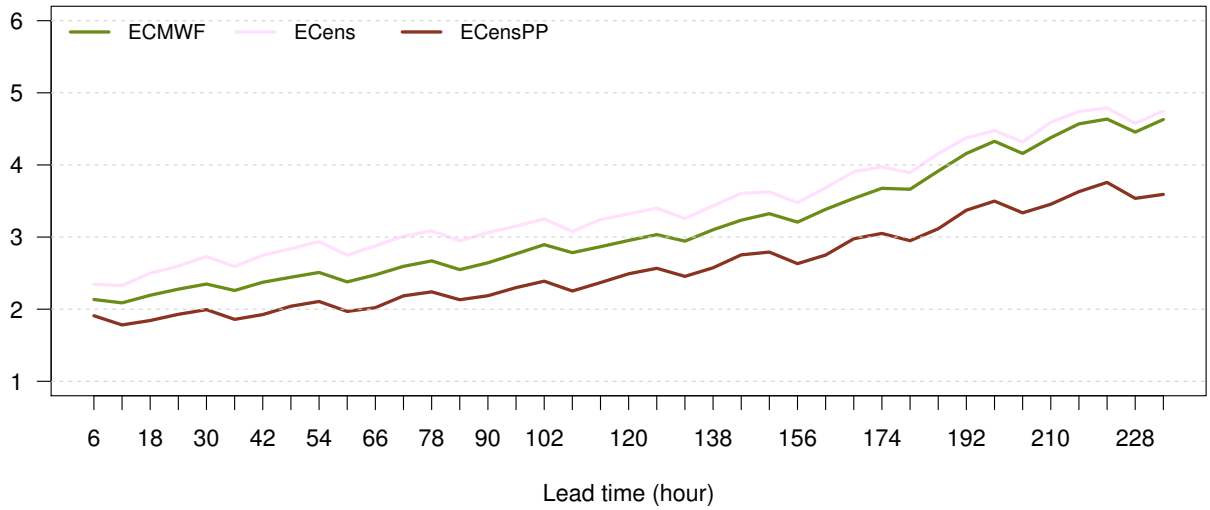



88 inland stations

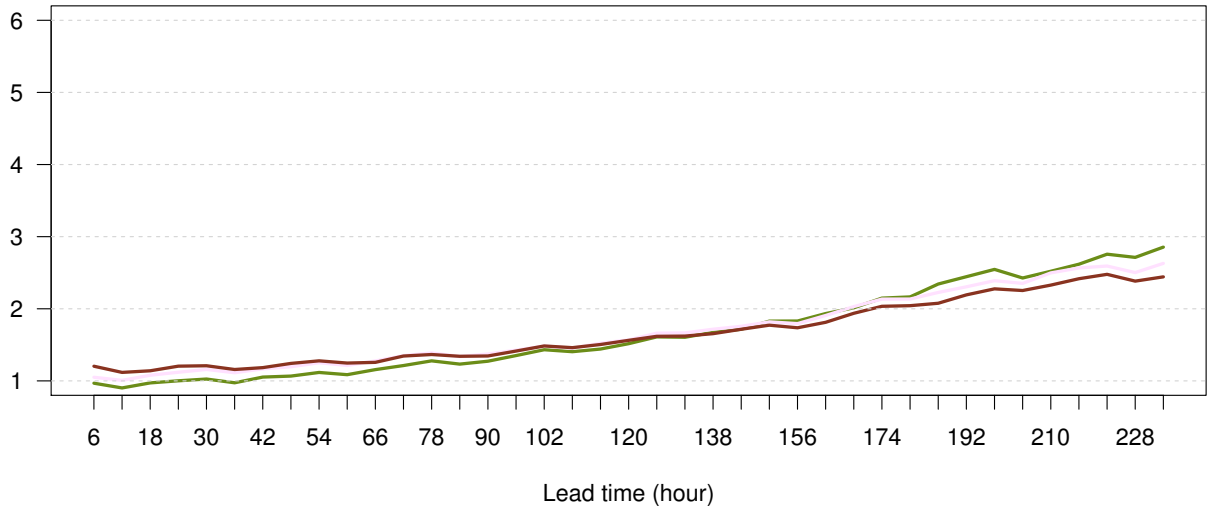


Mean Absolute Error

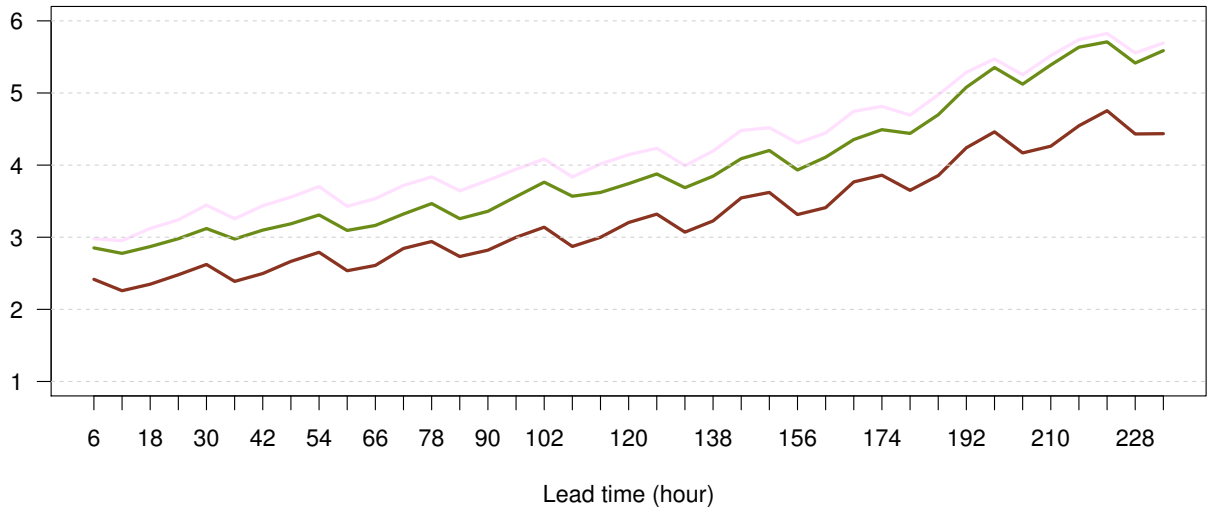
269 Norwegian stations



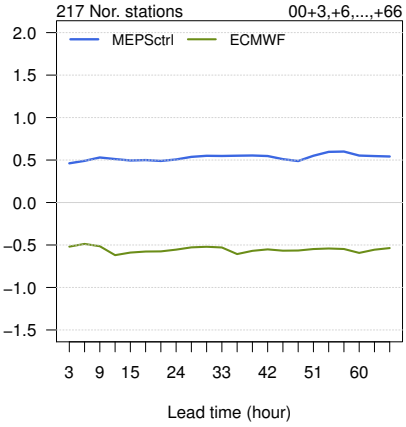

58 coastal stations



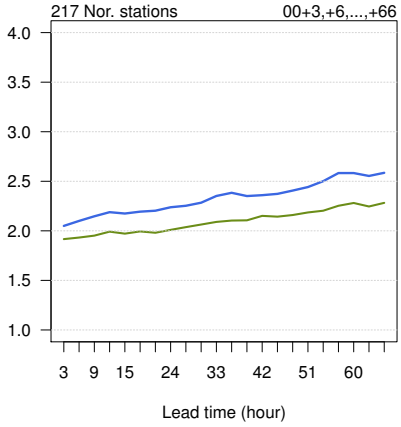

88 inland stations



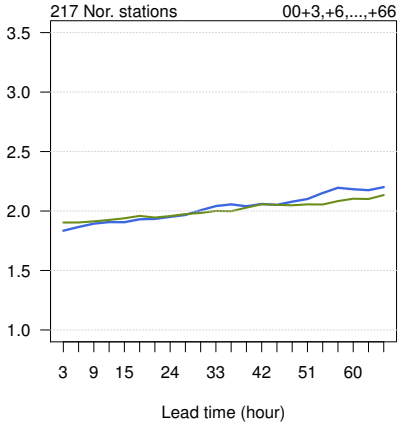
Mean Error



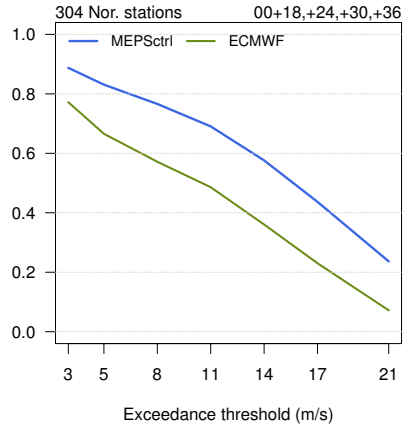

Standard Deviation of Error



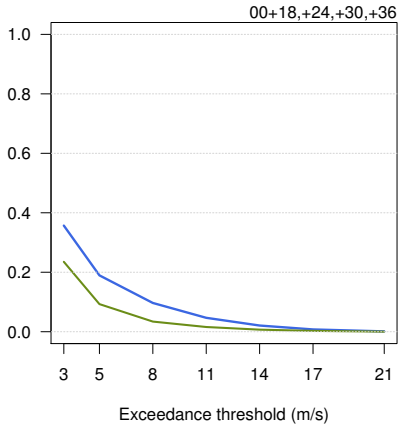

Mean Absolute Error



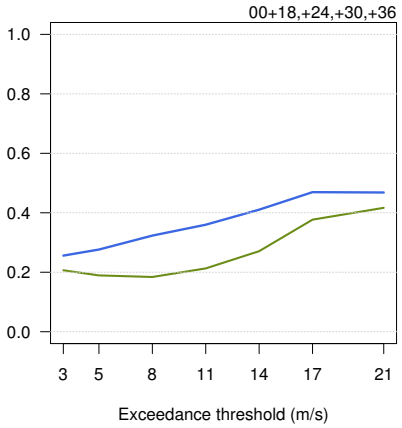

Hit Rate



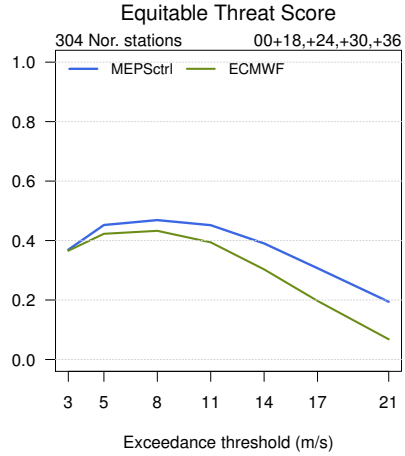

False Alarm Rate



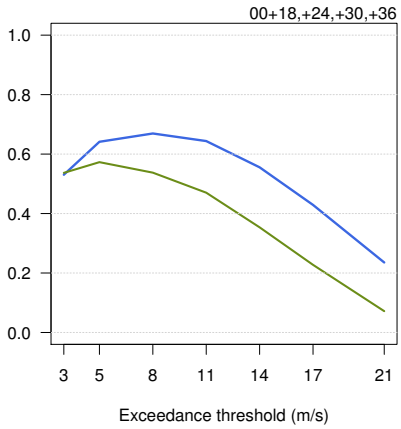

False Alarm Ratio



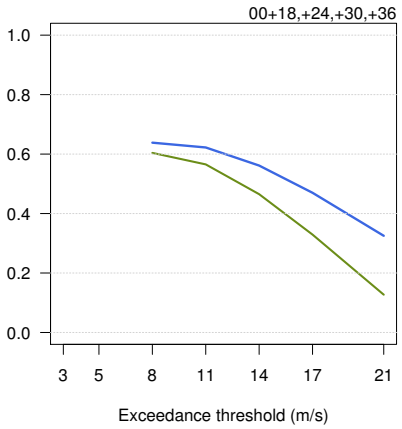

Equitable Threat Score



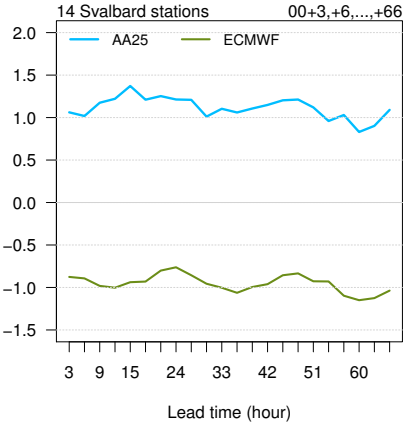

Hansen−Kuiper Skill Score



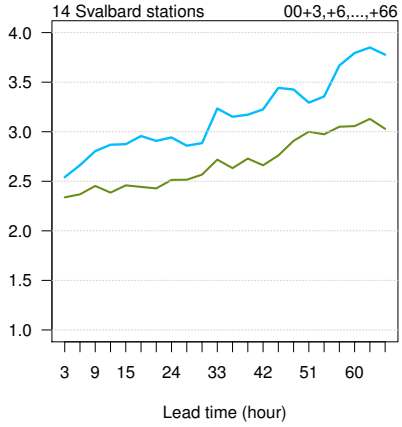

Heidke Skill Score



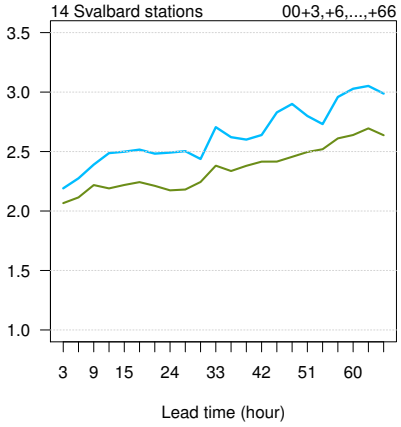
Mean Error



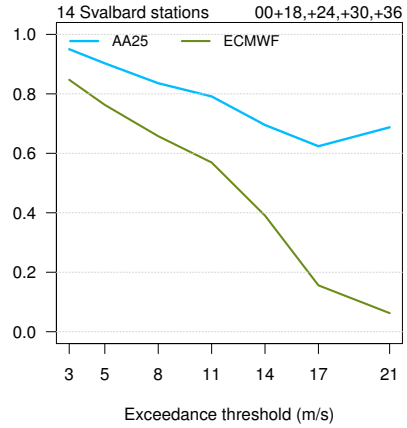

Standard Deviation of Error



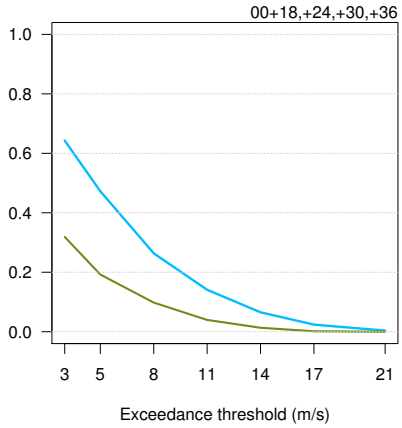

Mean Absolute Error



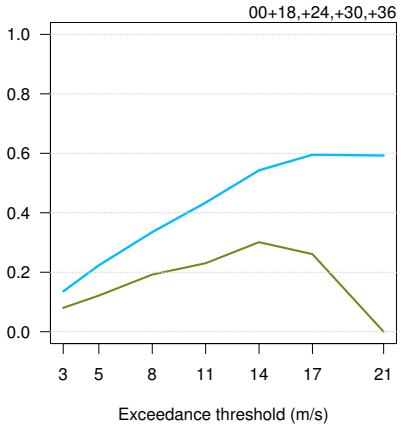

Hit Rate



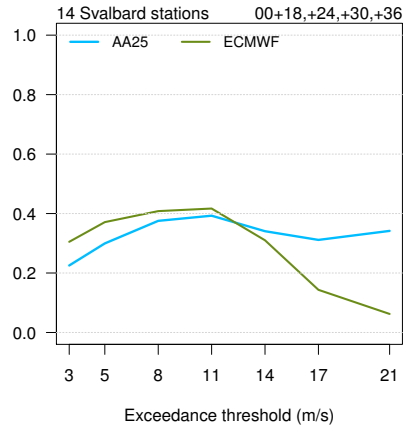

False Alarm Rate



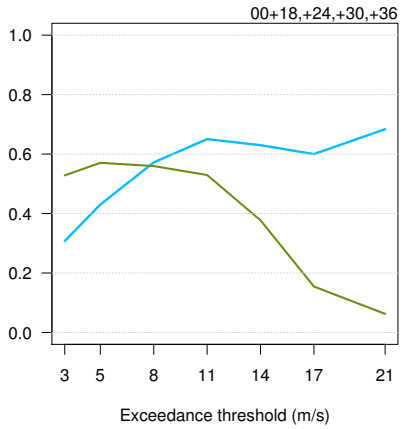

False Alarm Ratio



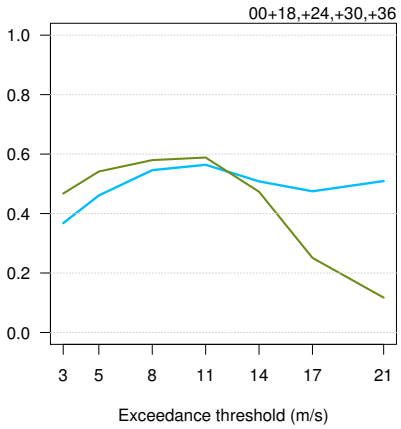

Equitable Threat Score



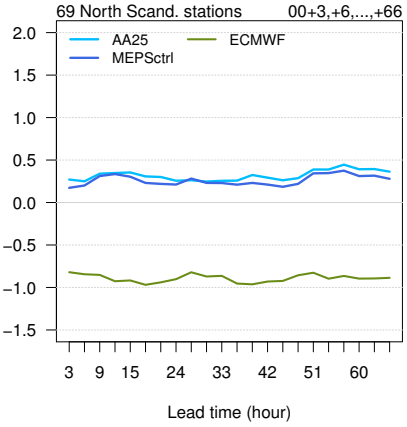

Hansen−Kuiper Skill Score



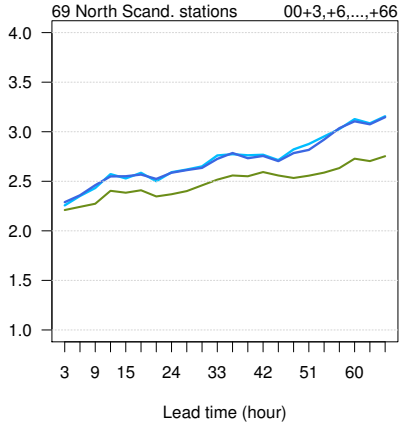

Heidke Skill Score



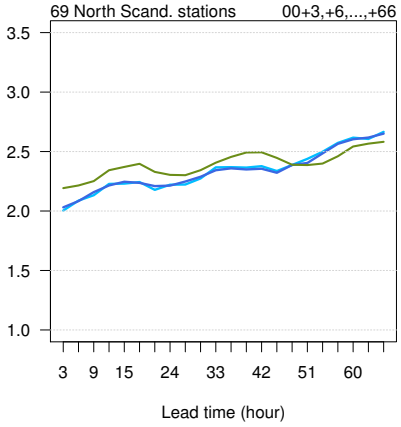
Mean Error



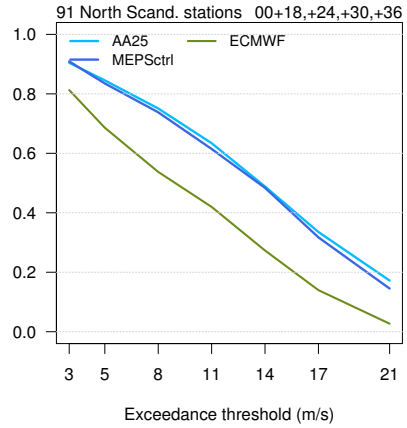

Standard Deviation of Error



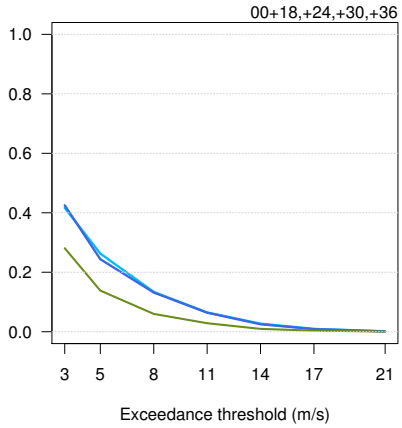

Mean Absolute Error



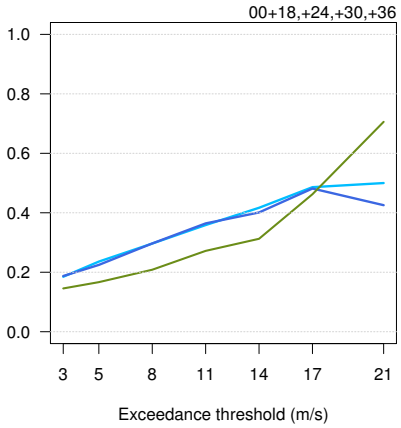

Hit Rate



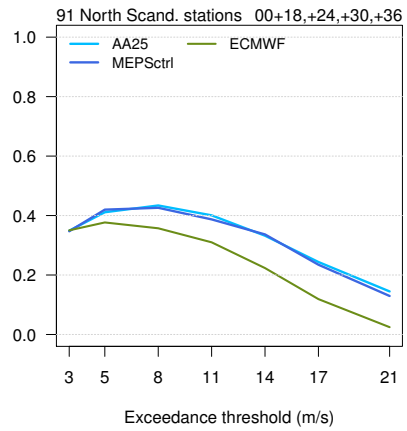

False Alarm Rate



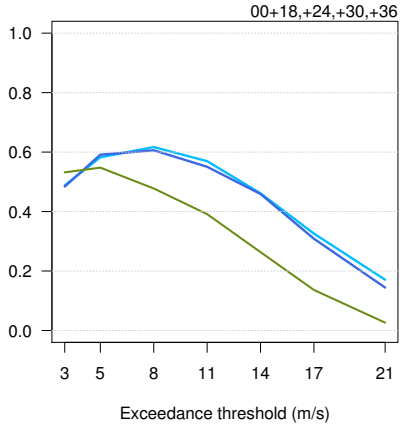

False Alarm Ratio



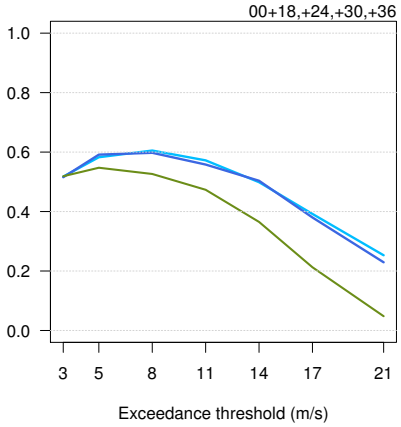

Equitable Threat Score




Hansen−Kuiper Skill Score

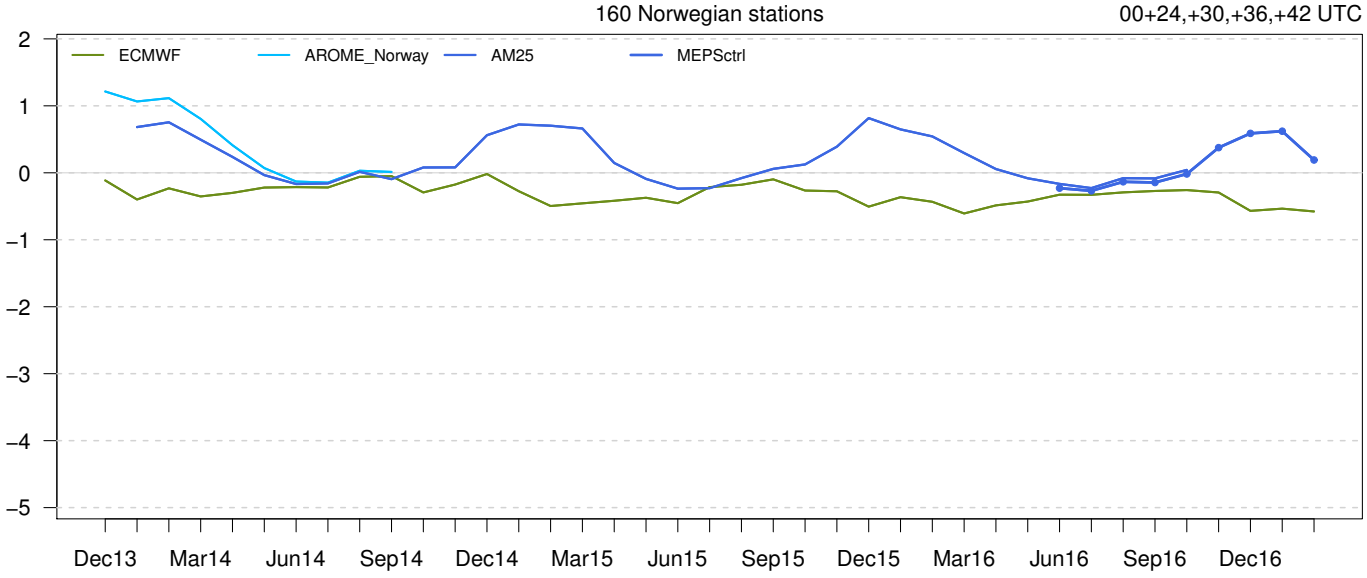



Heidke Skill Score

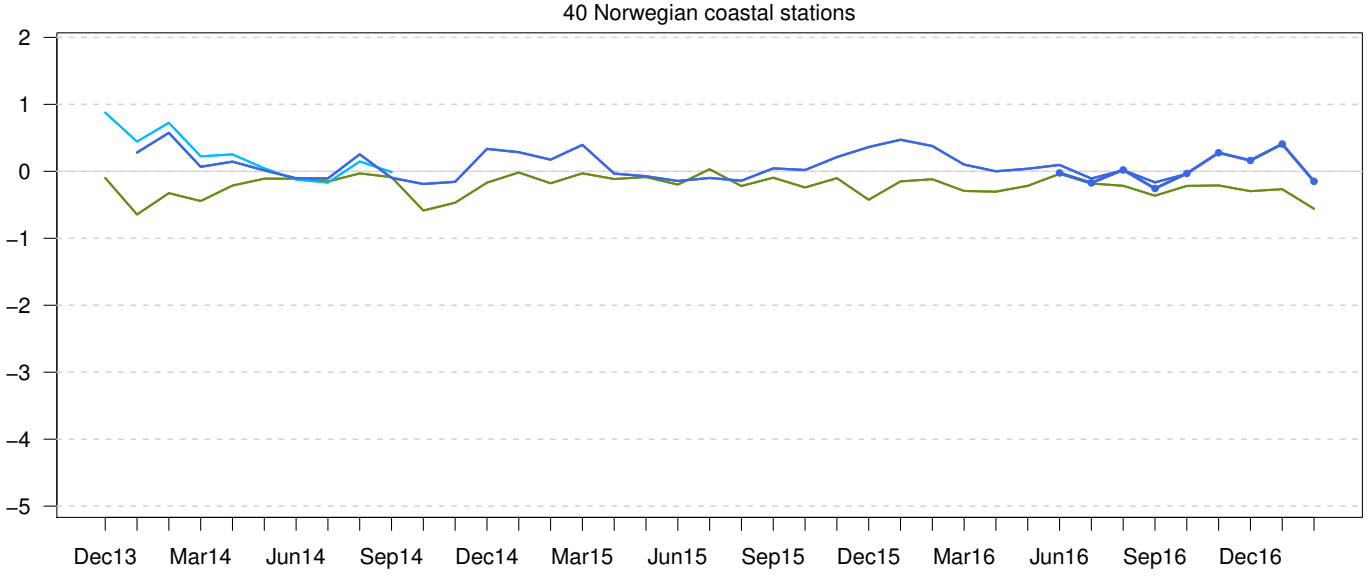


## Mean Error

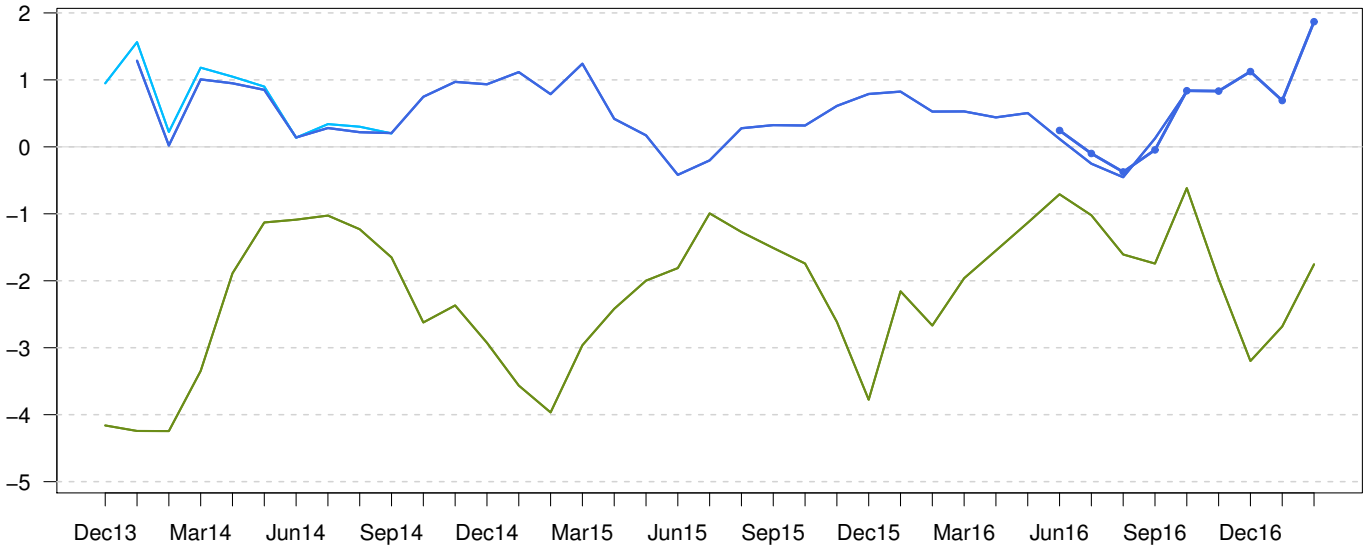
160 Norwegian stations 00+24,+30,+36,+42 UTC




40 Norwegian coastal stations

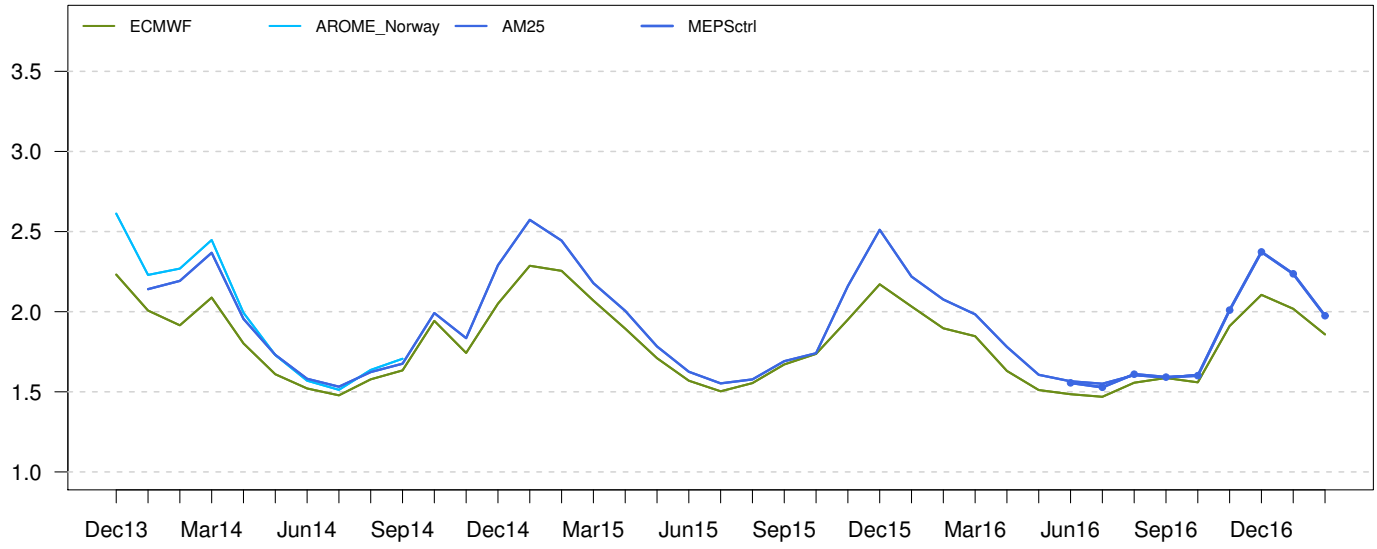



5 Norwegian mountainous stations

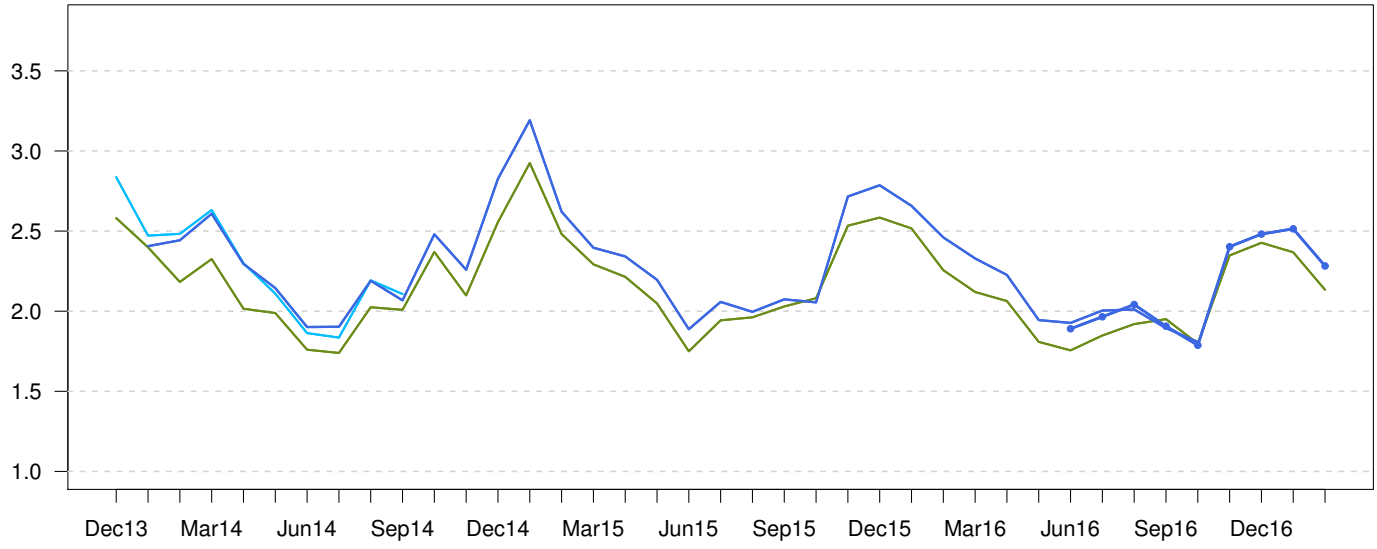


Standard Deviation of Error

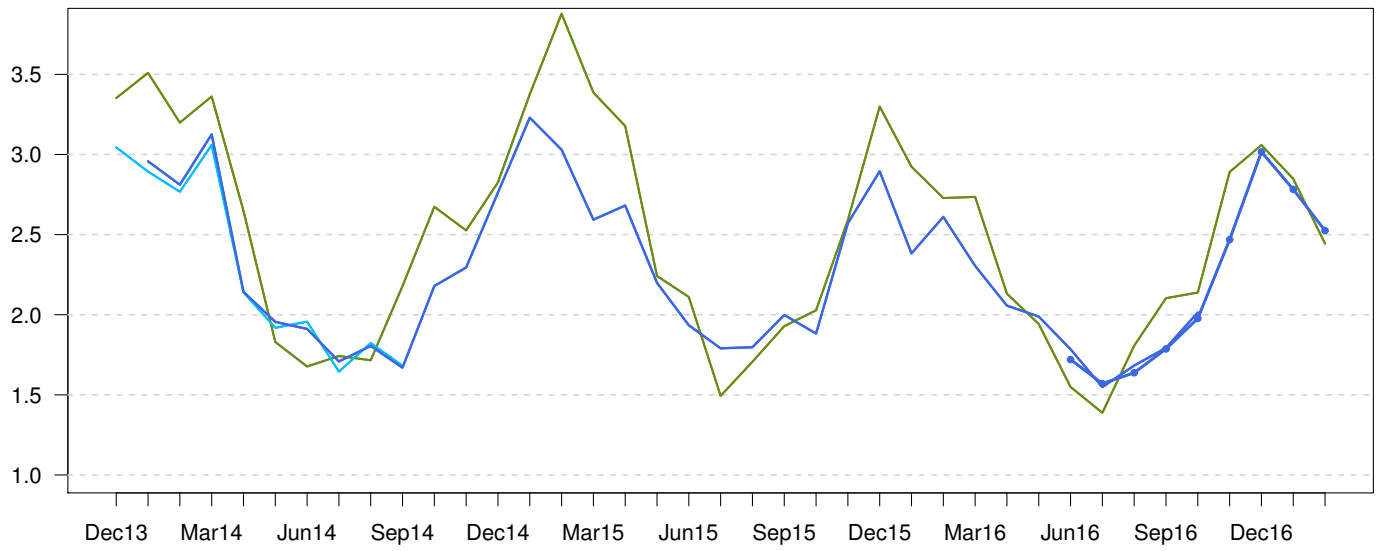
160 Norwegian stations 00+24,+30,+36,+42 UTC




40 Norwegian coastal stations

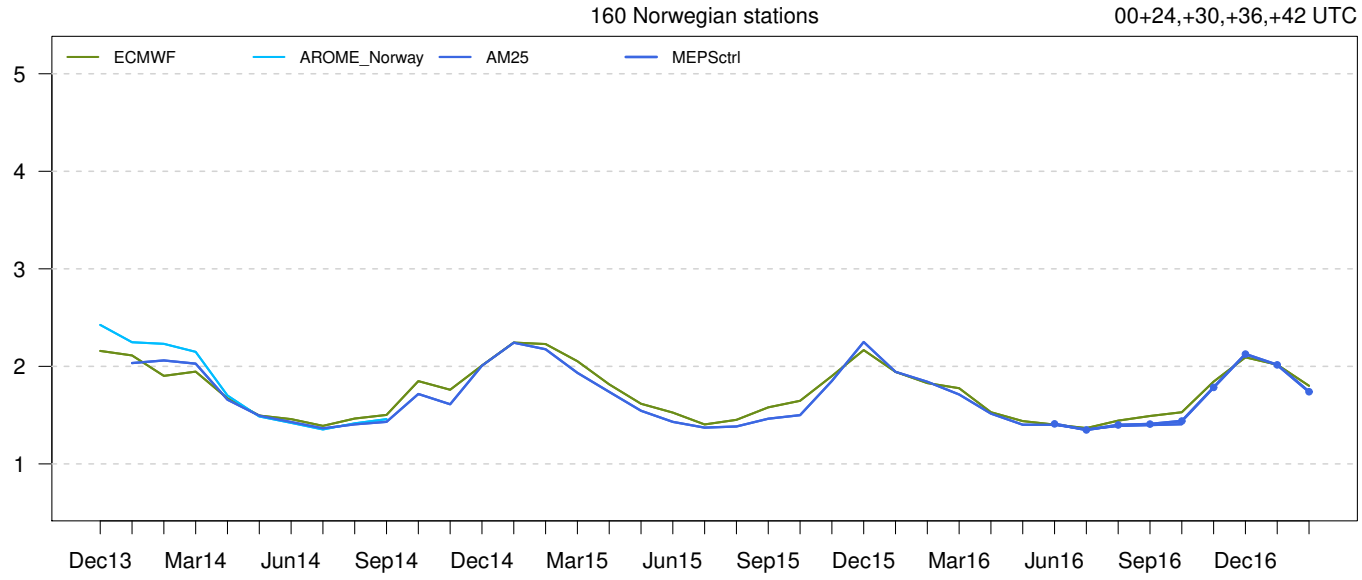



5 Norwegian mountainous stations

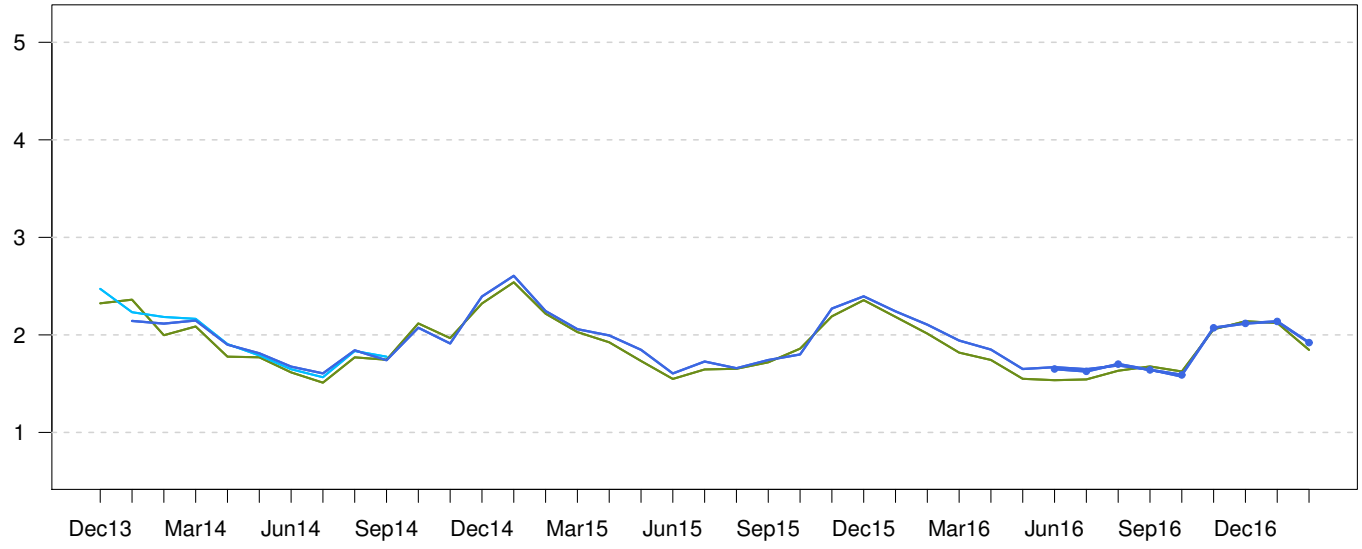


Mean Absolute Error

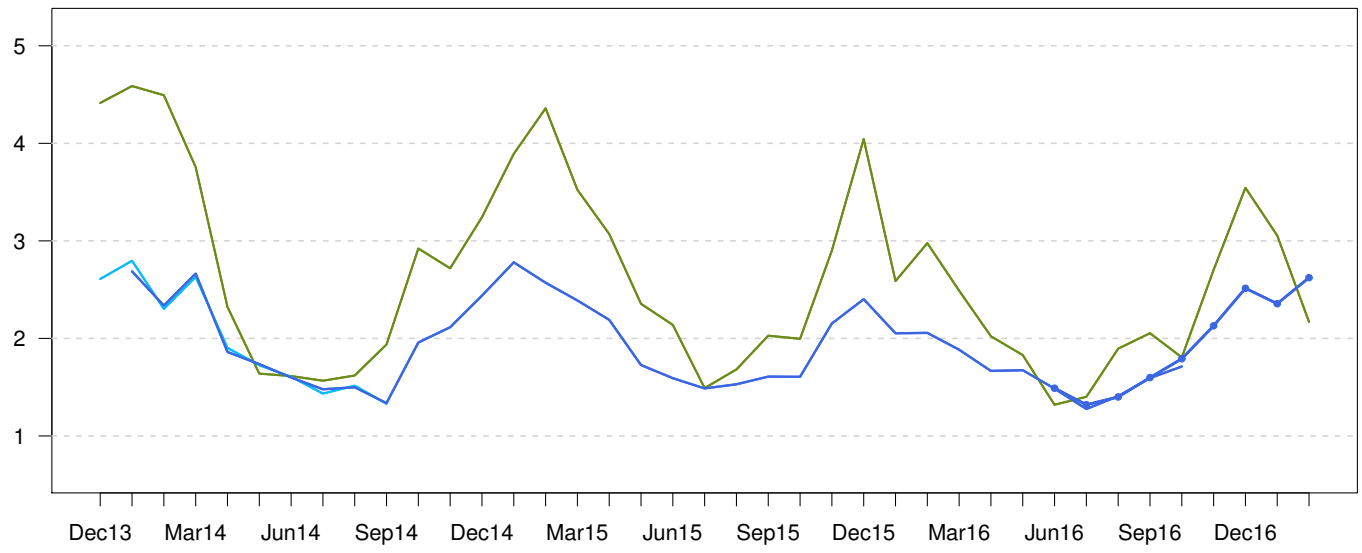
160 Norwegian stations 00+24,+30,+36,+42 UTC




40 Norwegian coastal stations

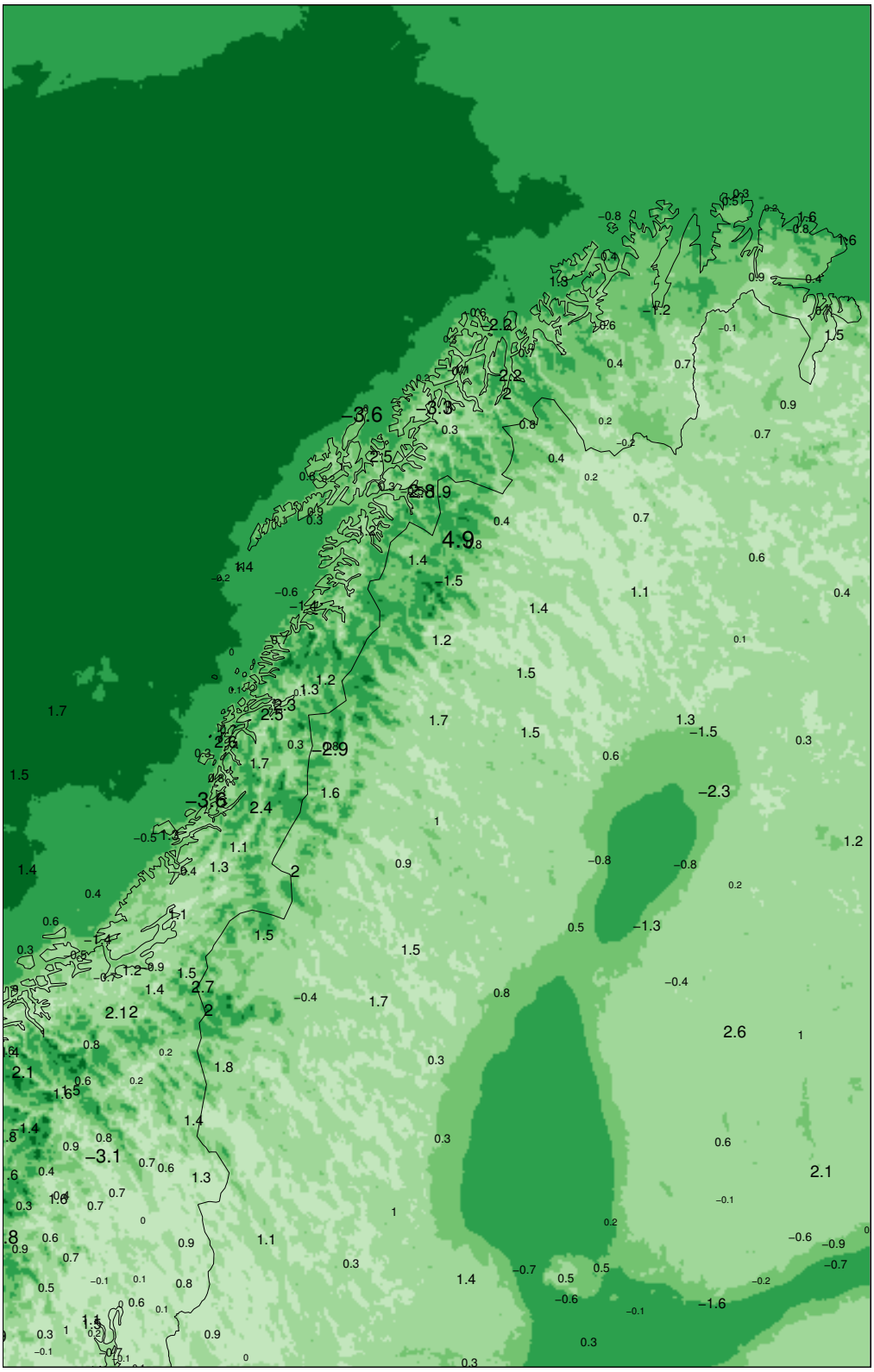



5 Norwegian mountainous stations



MEPSctrl 00+12

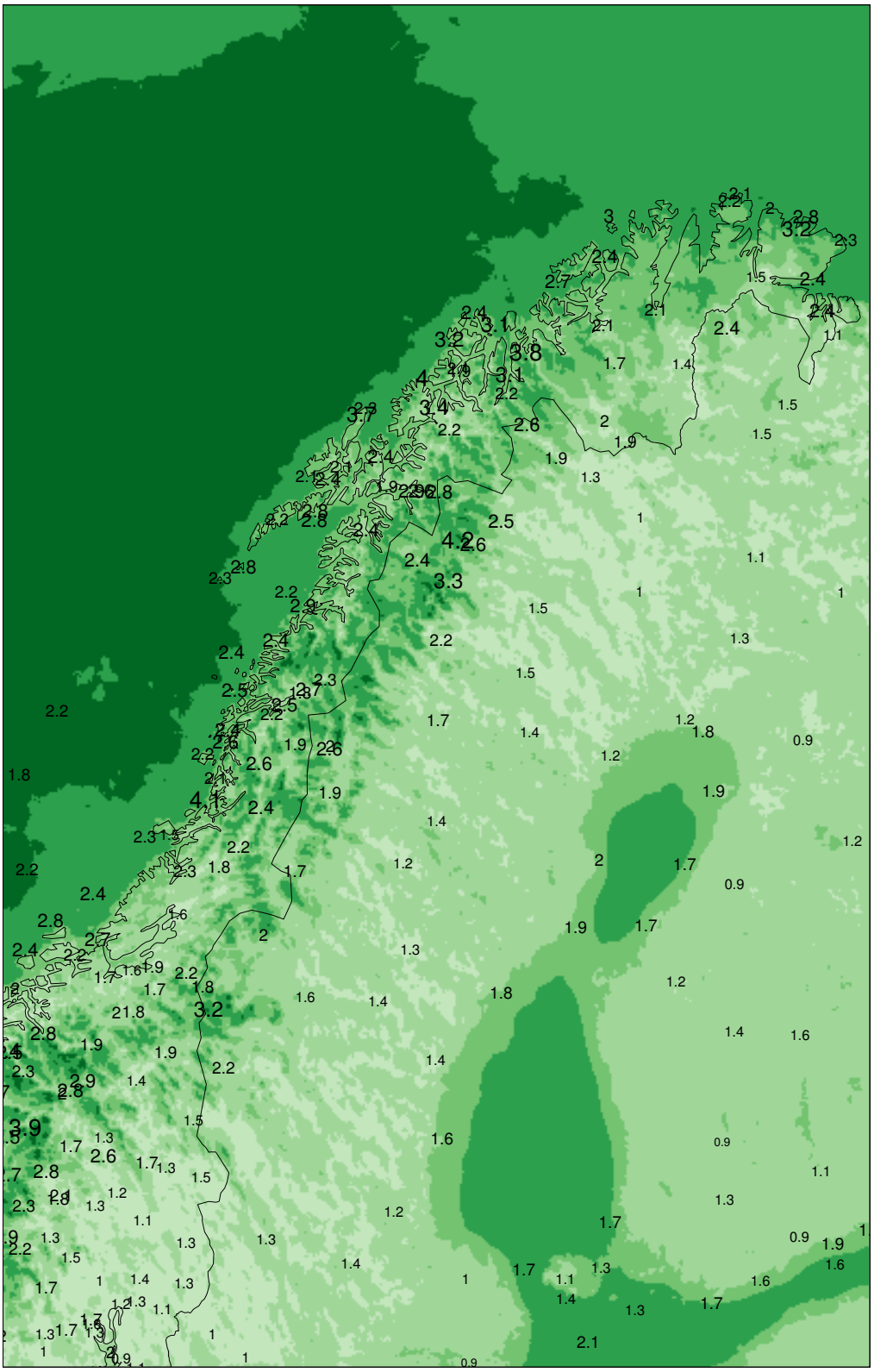
ME at observing sites
(numbers in black)




Model "climatology" 01.12.2016 – 28.02.2017

MEPSctrl 00+12

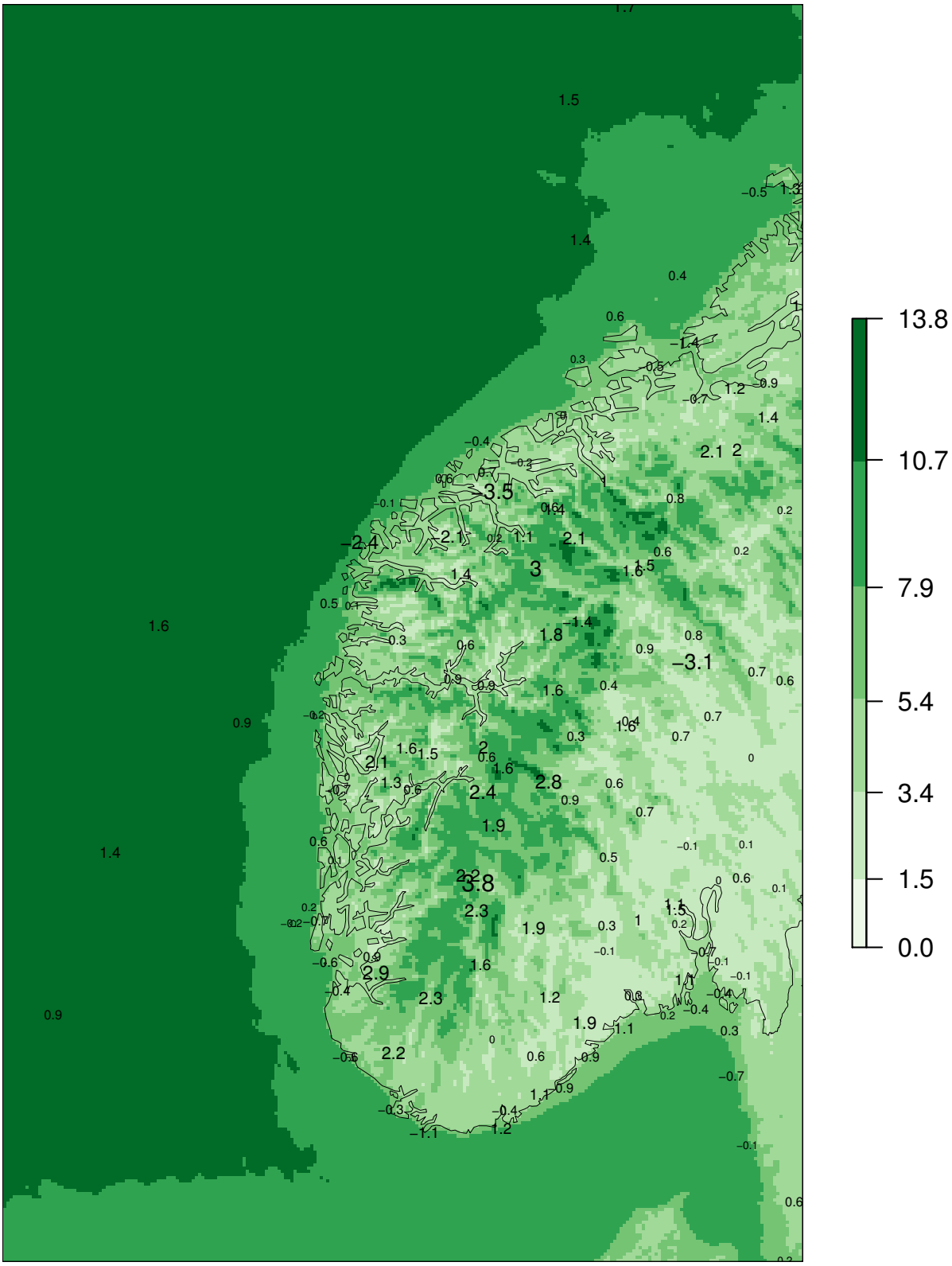
SDE at observing sites
(numbers in black)




Model "climatology" 01.12.2016 – 28.02.2017

MEPSctrl 00+12

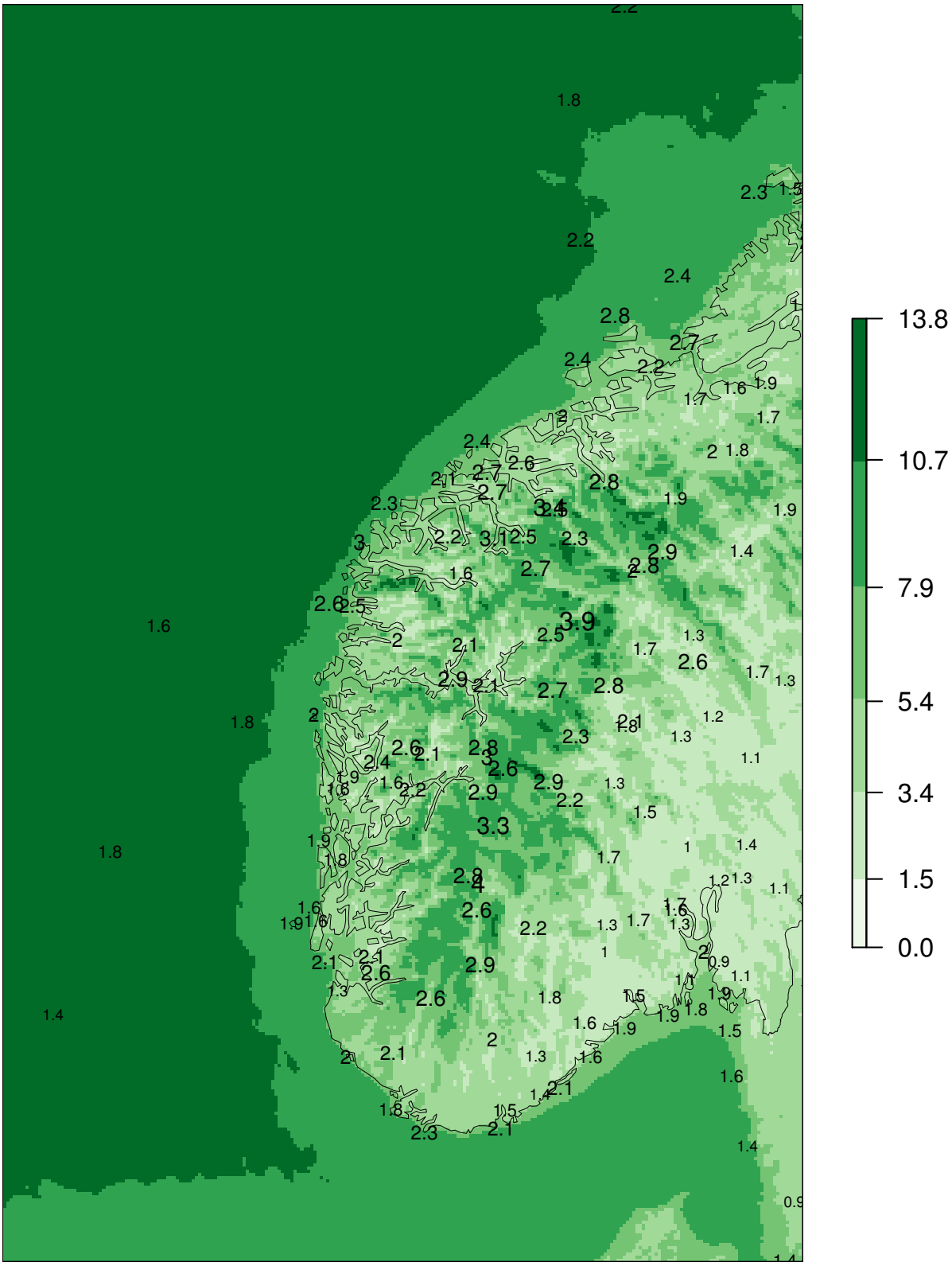
ME at observing sites
(numbers in black)




Model "climatology" 01.12.2016 – 28.02.2017

MEPSctrl 00+12

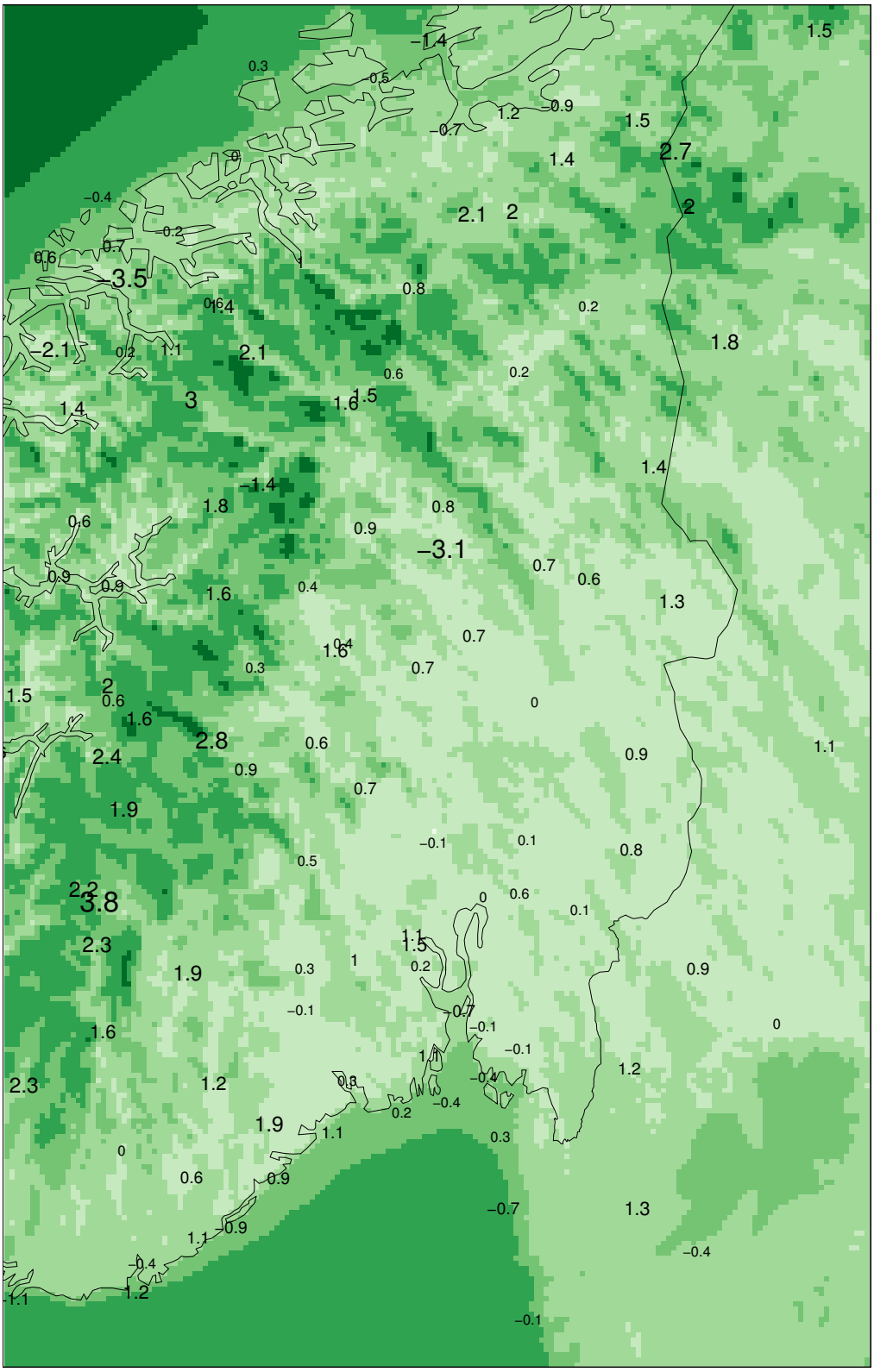
SDE at observing sites
(numbers in black)




Model "climatology" 01.12.2016 – 28.02.2017

MEPSctrl 00+12

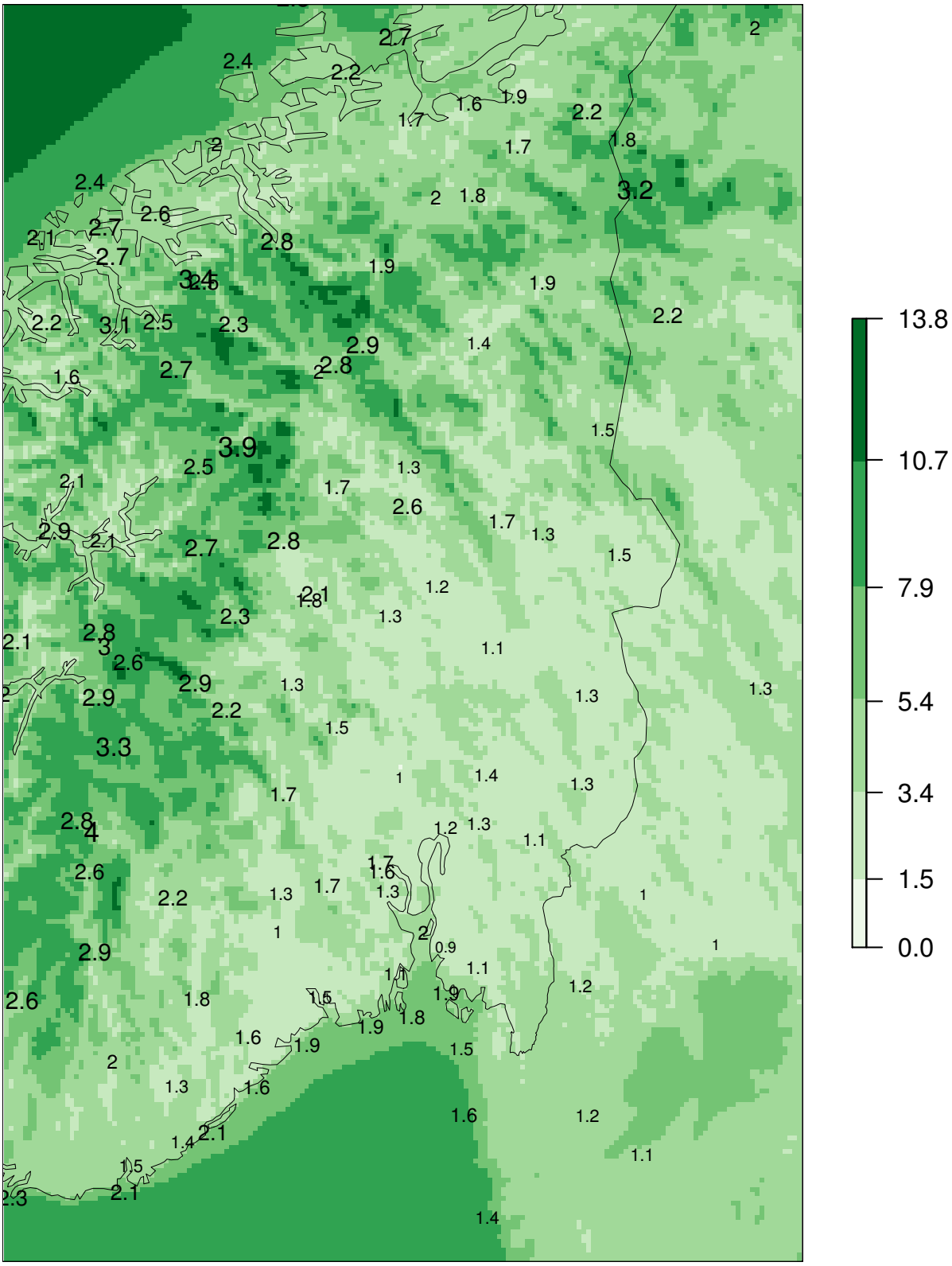
ME at observing sites
(numbers in black)




Model "climatology" 01.12.2016 – 28.02.2017

MEPSctrl 00+12

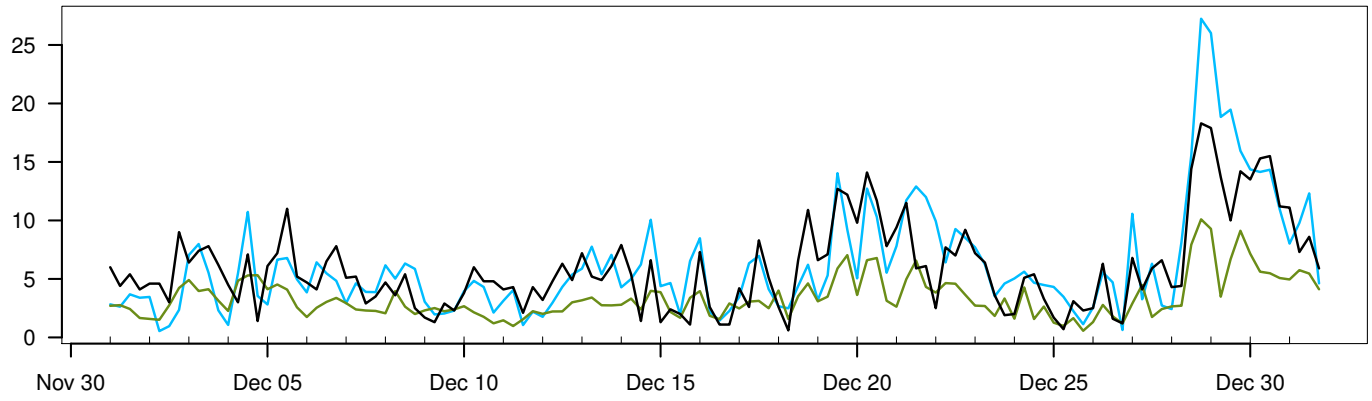
SDE at observing sites
(numbers in black)



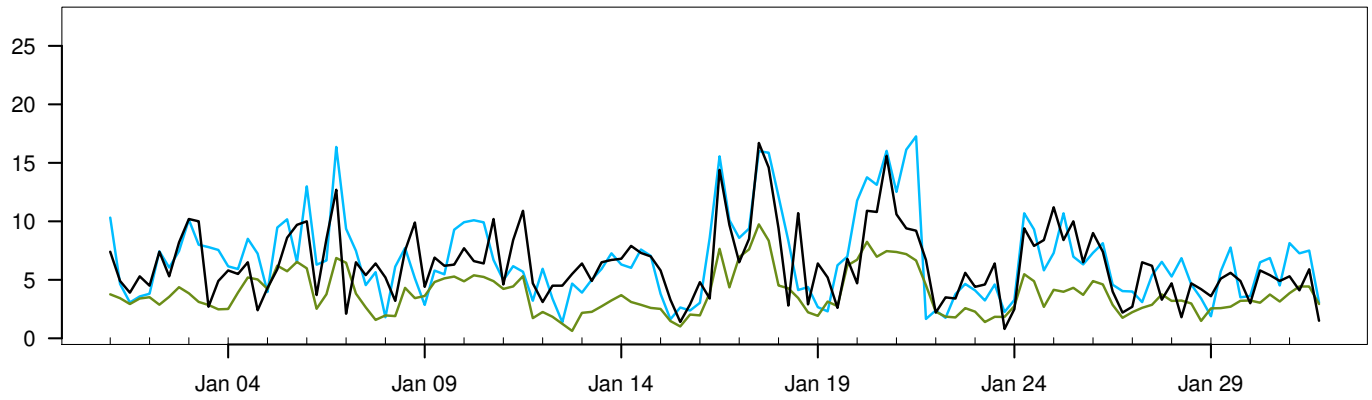

Model "climatology" 01.12.2016 – 28.02.2017

SVALBARD LUFTHAVN

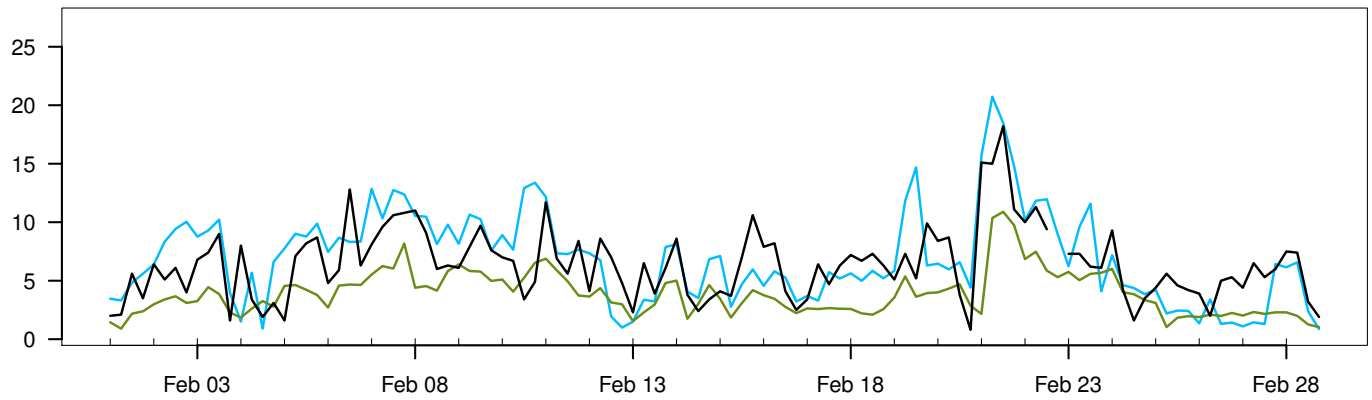
01.12.2016 – 31.12.2016




01.01.2017 – 31.01.2017




01.02.2017 – 28.02.2017



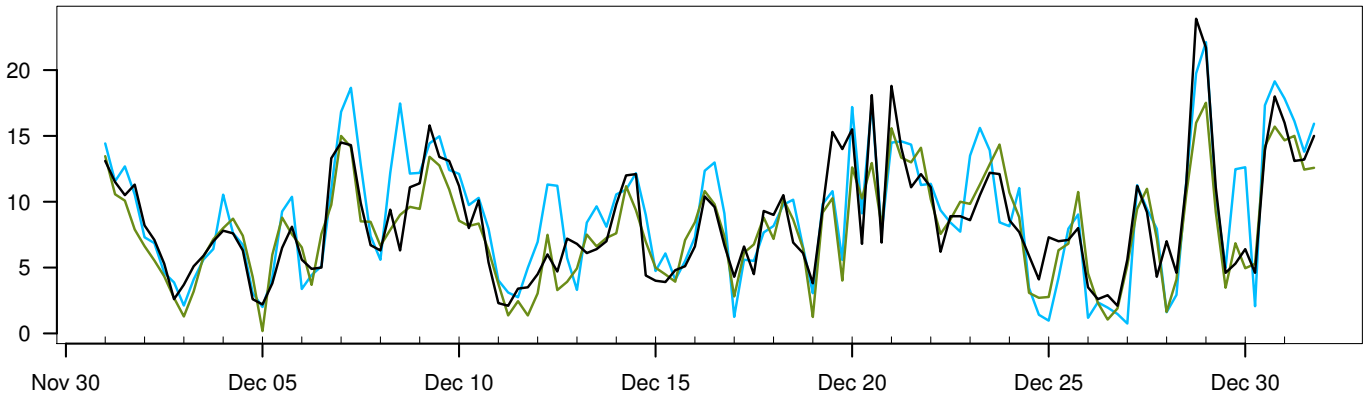

01.12.2016 – 28.02.2017

| | Min | Mean | Max | Std | N |
|---|---|---|---|---|---|
| synop: 00,06,12,18 | 0.6 | 6.2 | 18.3 | 3.3 | 359 |
| AA25: 12+18,+24,+30,+36 | 0.5 | 6.6 | 27.2 | 4.1 | 360 |
| ECMWF: 12+18,+24,+30,+36 | 0.6 | 3.7 | 10.9 | 1.8 | 360 |

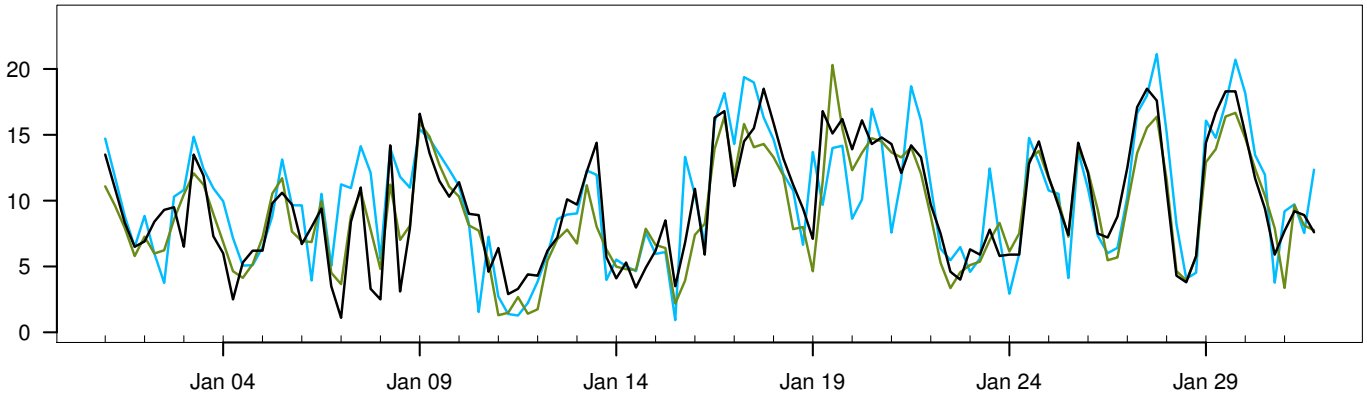
| | ME | SDE | RMSE | MAE | Max.abs.err. | N |
|---|---|---|---|---|---|---|
| AA25 – synop | 0.4 | 2.8 | 2.8 | 2.1 | 9.5 | 359 |
| ECMWF – synop | –2.5 | 2.4 | 3.5 | 2.9 | 12.9 | 359 |

BJØRNØYA

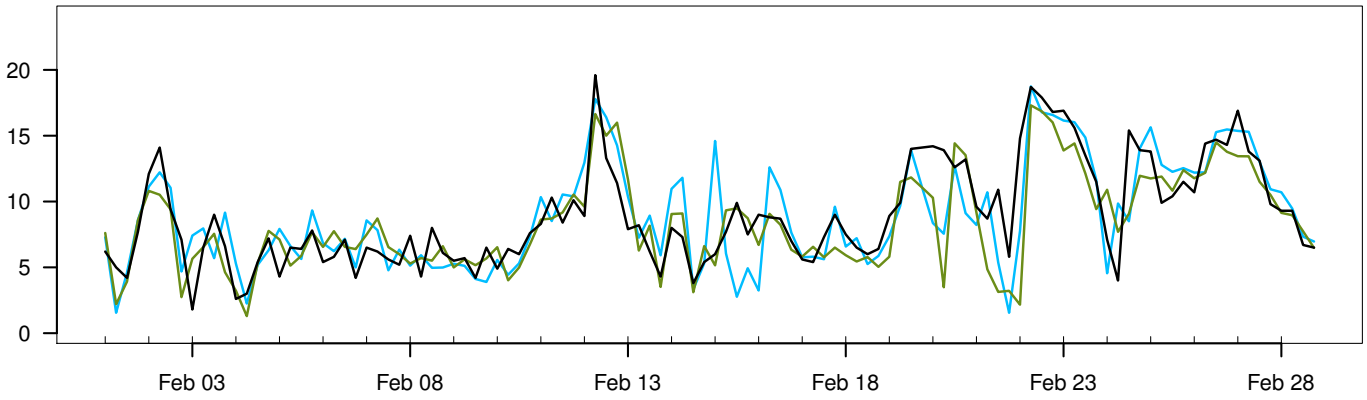
01.12.2016 – 31.12.2016




01.01.2017 – 31.01.2017




01.02.2017 – 28.02.2017

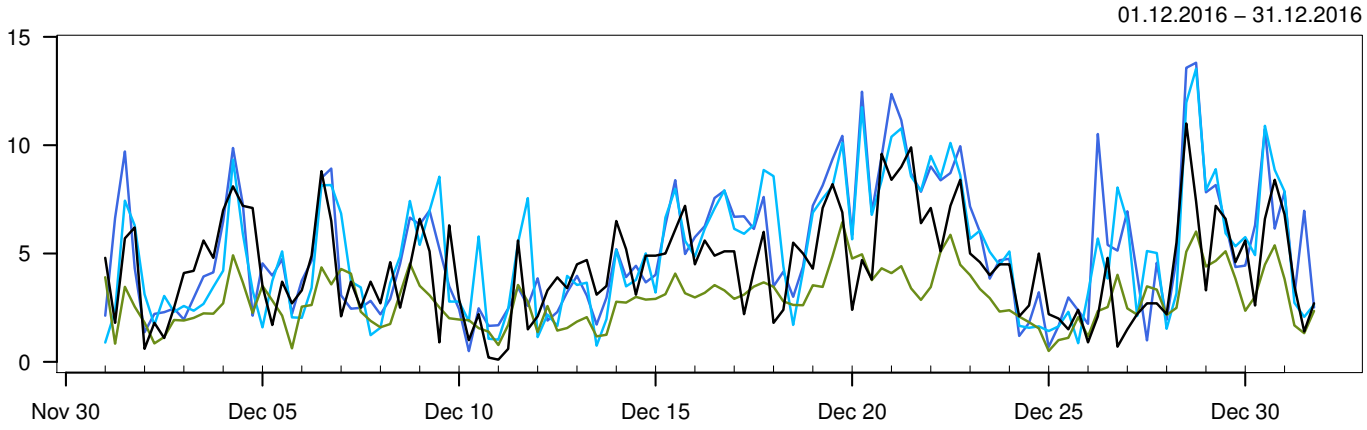


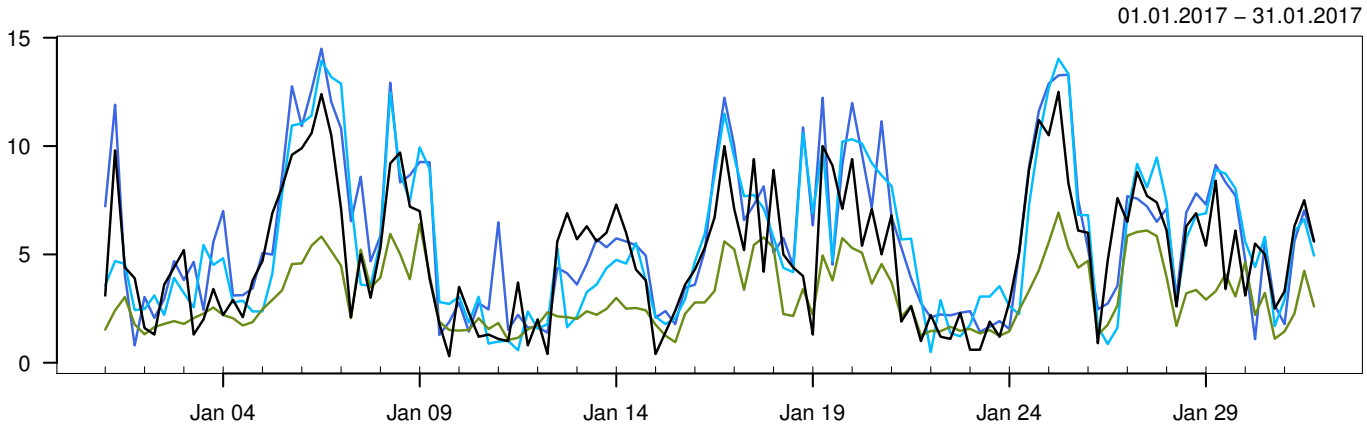

01.12.2016 – 28.02.2017

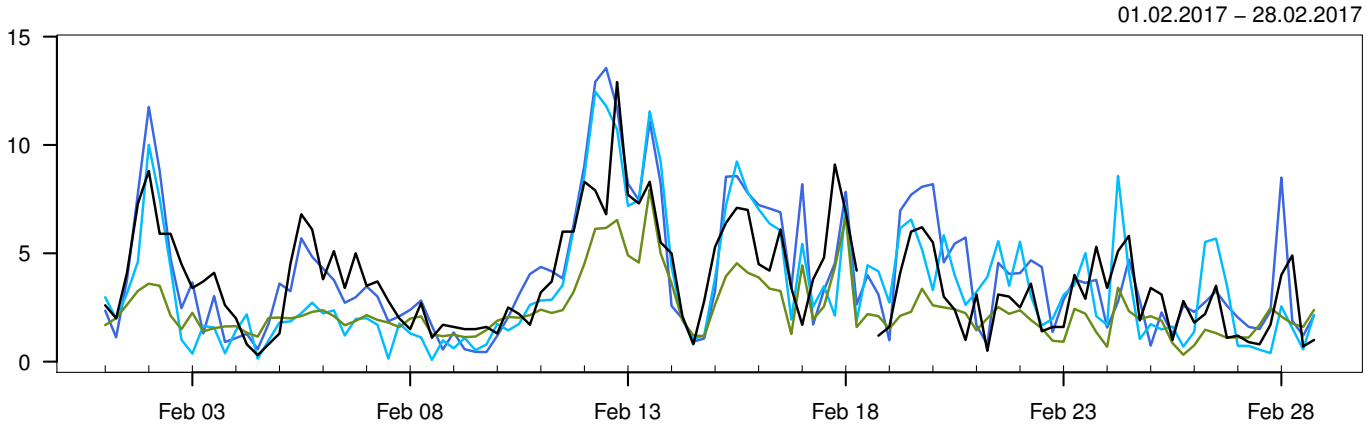
| | Min | Mean | Max | Std | N |
|---|---|---|---|---|---|
| synop: 00,06,12,18 | 1.1 | 9 | 23.9 | 4.2 | 360 |
| AA25: 12+18,+24,+30,+36 | 0.8 | 9.3 | 22.1 | 4.5 | 360 |
| ECMWF: 12+18,+24,+30,+36 | 0.2 | 8.4 | 20.3 | 3.9 | 360 |

| | ME | SDE | RMSE | MAE | Max.abs.err. | N |
|---|---|---|---|---|---|---|
| AA25 – synop | 0.3 | 2.8 | 2.8 | 2 | 11.2 | 360 |
| ECMWF – synop | –0.6 | 2.2 | 2.3 | 1.7 | 12.6 | 360 |

TROMSØ



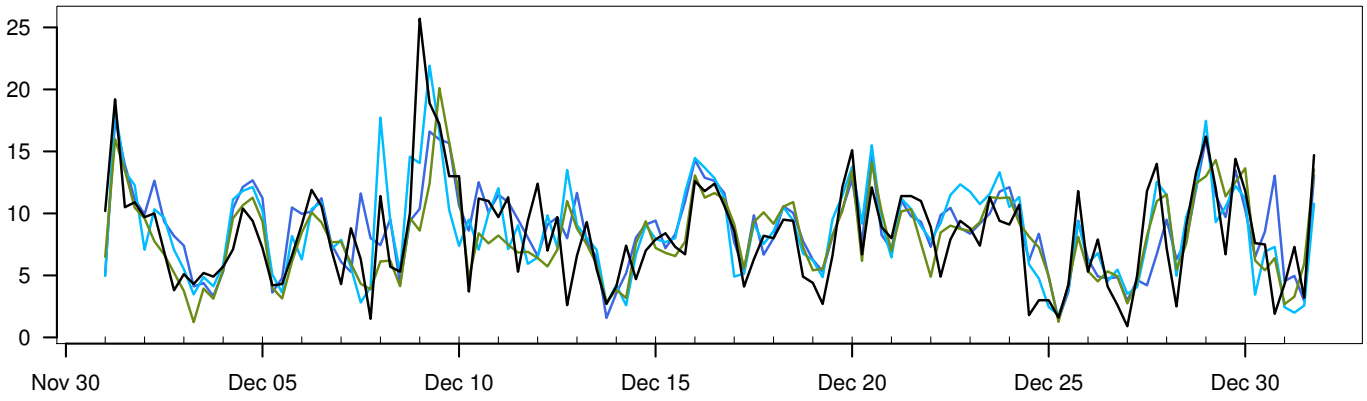

01.12.2016 – 28.02.2017

| | Min | Mean | Max | Std | N |
|---|---|---|---|---|---|
| synop: 00,06,12,18 | 0.1 | 4.4 | 12.9 | 2.6 | 359 |
| MEPSctrl: 12+18,+24,+30,+36 | 0.4 | 5.1 | 14.5 | 3.2 | 360 |
| AA25: 12+18,+24,+30,+36 | 0.1 | 4.7 | 14 | 3.2 | 360 |
| ECMWF: 12+18,+24,+30,+36 | 0.3 | 2.8 | 7.9 | 1.4 | 360 |

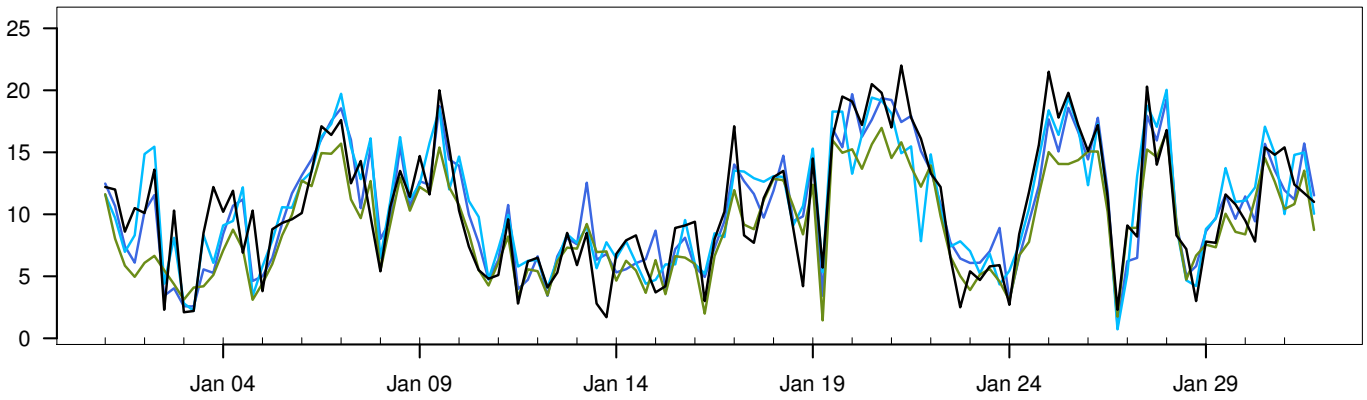
| | ME | SDE | RMSE | MAE | Max.abs.err. | N |
|---|---|---|---|---|---|---|
| MEPSctrl – synop | 0.7 | 2.1 | 2.2 | 1.6 | 8.4 | 359 |
| AA25 – synop | 0.4 | 2.3 | 2.3 | 1.8 | 7.6 | 359 |
| ECMWF – synop | −1.6 | 1.9 | 2.5 | 1.9 | 7.4 | 359 |

SLETTNES FYR

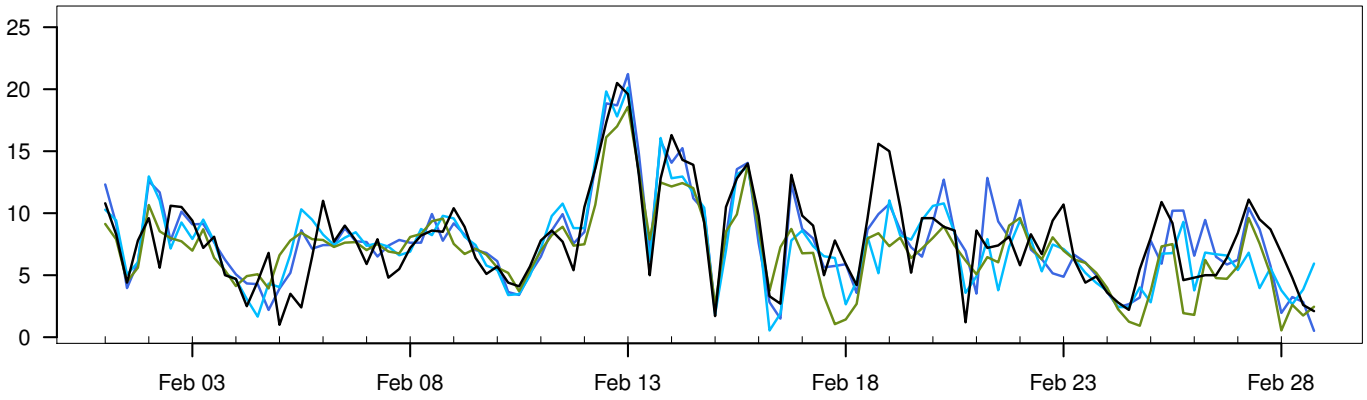
01.12.2016 – 31.12.2016




01.01.2017 – 31.01.2017




01.02.2017 – 28.02.2017



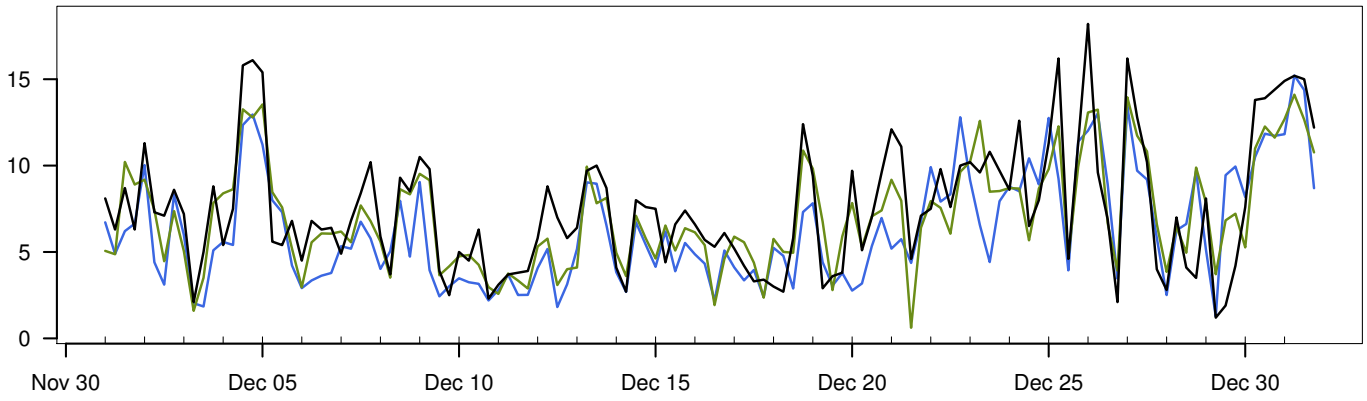

01.12.2016 – 28.02.2017

| | Min | Mean | Max | Std | N |
|---|---|---|---|---|---|
| synop: 00,06,12,18 | 0.9 | 8.9 | 25.7 | 4.5 | 360 |
| MEPSctrl: 12+18,+24,+30,+36 | 0.5 | 9.1 | 21.2 | 4.1 | 360 |
| AA25: 12+18,+24,+30,+36 | 0.5 | 9 | 21.9 | 4.3 | 360 |
| ECMWF: 12+18,+24,+30,+36 | 0.5 | 8.1 | 20.1 | 3.6 | 360 |

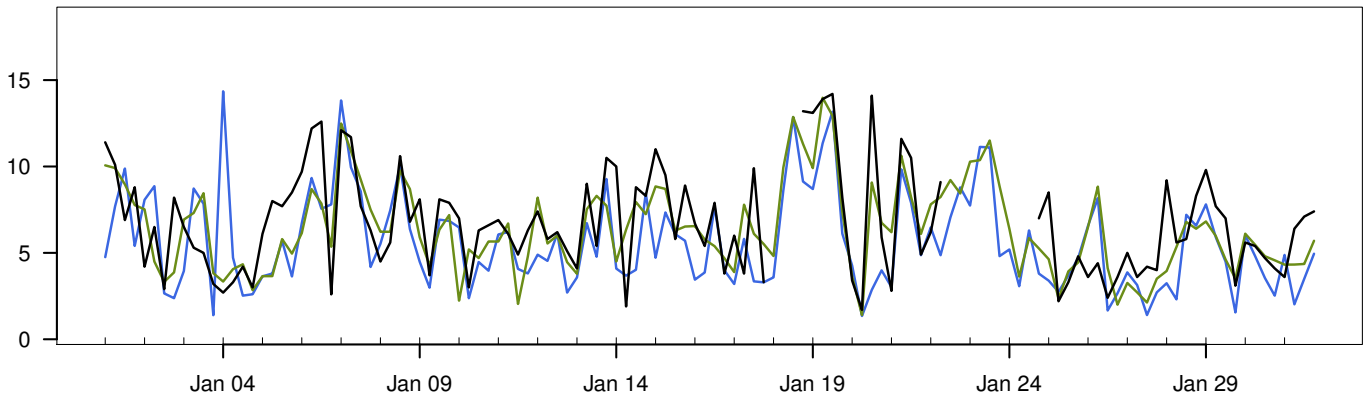
| | ME | SDE | RMSE | MAE | Max.abs.err. | N |
|---|---|---|---|---|---|---|
| MEPSctrl – synop | 0.2 | 2.7 | 2.7 | 2 | 15.3 | 360 |
| AA25 – synop | 0.1 | 2.8 | 2.8 | 2.1 | 11.6 | 360 |
| ECMWF – synop | −0.8 | 2.7 | 2.8 | 2.1 | 17.1 | 360 |

ØRLAND III

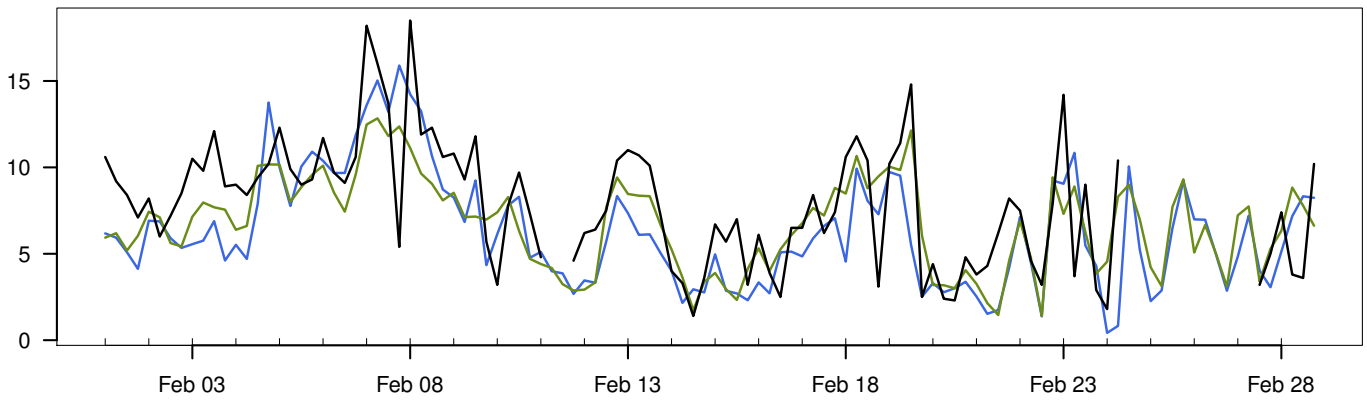
01.12.2016 – 31.12.2016




01.01.2017 – 31.01.2017




01.02.2017 – 28.02.2017



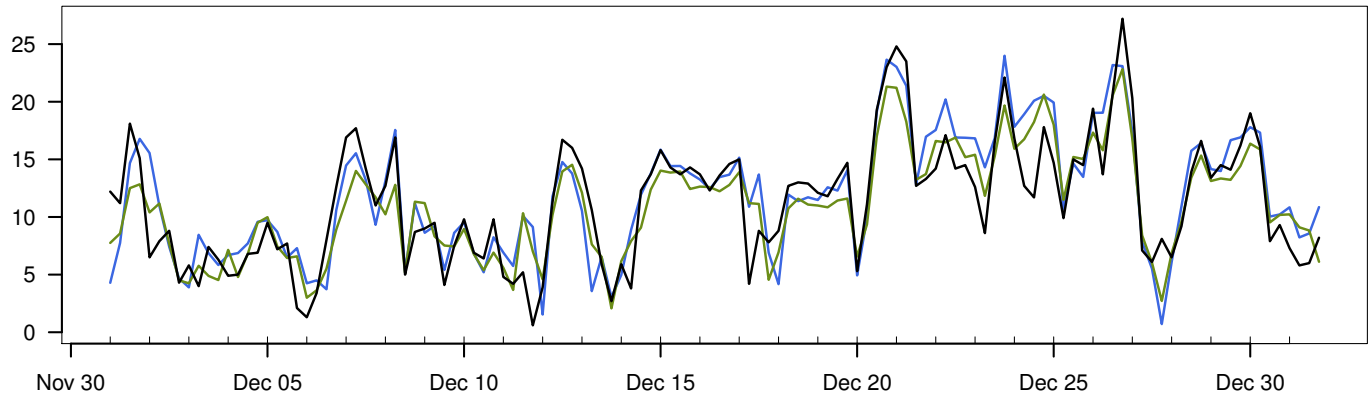

01.12.2016 – 28.02.2017

| | Min | Mean | Max | Std | N |
|---|---|---|---|---|---|
| synop: 00,06,12,18 | 1.2 | 7.4 | 18.5 | 3.5 | 334 |
| MEPSctrl: 12+18,+24,+30,+36 | 0.4 | 6.1 | 15.9 | 3.1 | 360 |
| ECMWF: 12+18,+24,+30,+36 | 0.6 | 6.7 | 14.1 | 2.8 | 360 |

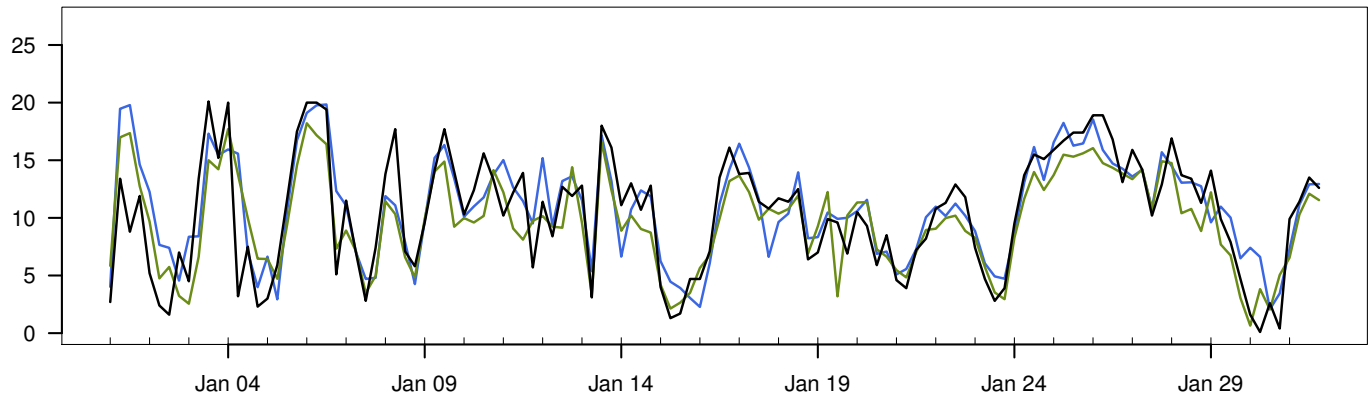
| | ME | SDE | RMSE | MAE | Max.abs.err. | N |
|---|---|---|---|---|---|---|
| MEPSctrl – synop | −1.3 | 2.7 | 3 | 2.3 | 11.7 | 334 |
| ECMWF – synop | −0.7 | 2.2 | 2.3 | 1.8 | 7.4 | 334 |

YTTERØYANE FYR

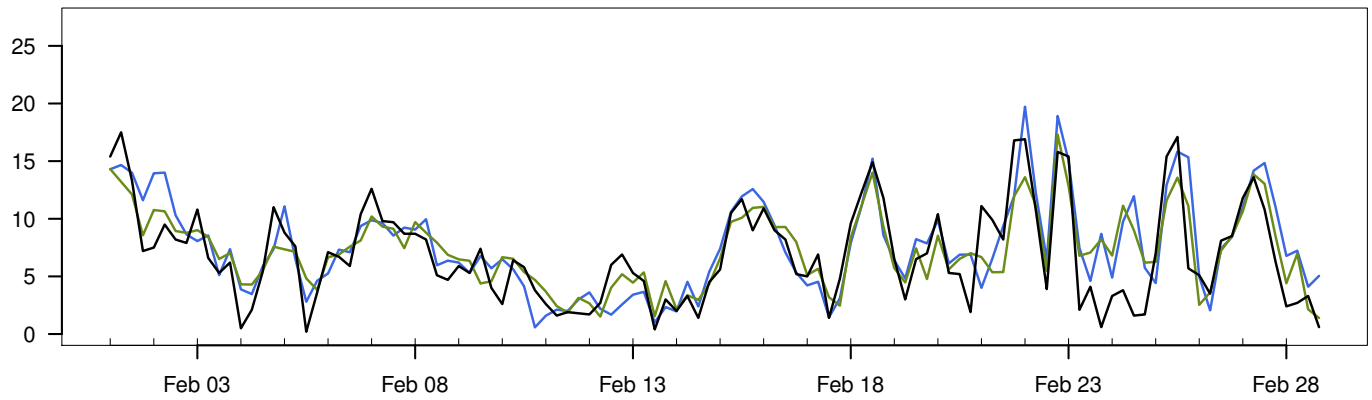
01.12.2016 – 31.12.2016




01.01.2017 – 31.01.2017




01.02.2017 – 28.02.2017



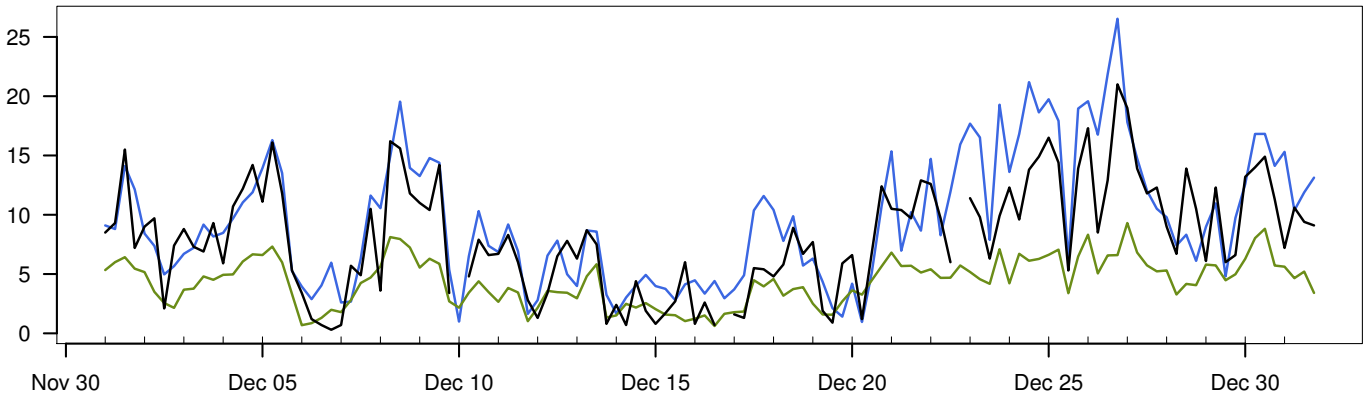

01.12.2016 – 28.02.2017

| | Min | Mean | Max | Std | N |
|---|---|---|---|---|---|
| synop: 00,06,12,18 | 0.1 | 9.6 | 27.2 | 5.2 | 360 |
| MEPSctrl: 12+18,+24,+30,+36 | 0.6 | 10.2 | 24 | 4.9 | 360 |
| ECMWF: 12+18,+24,+30,+36 | 0.7 | 9.4 | 22.8 | 4.3 | 360 |

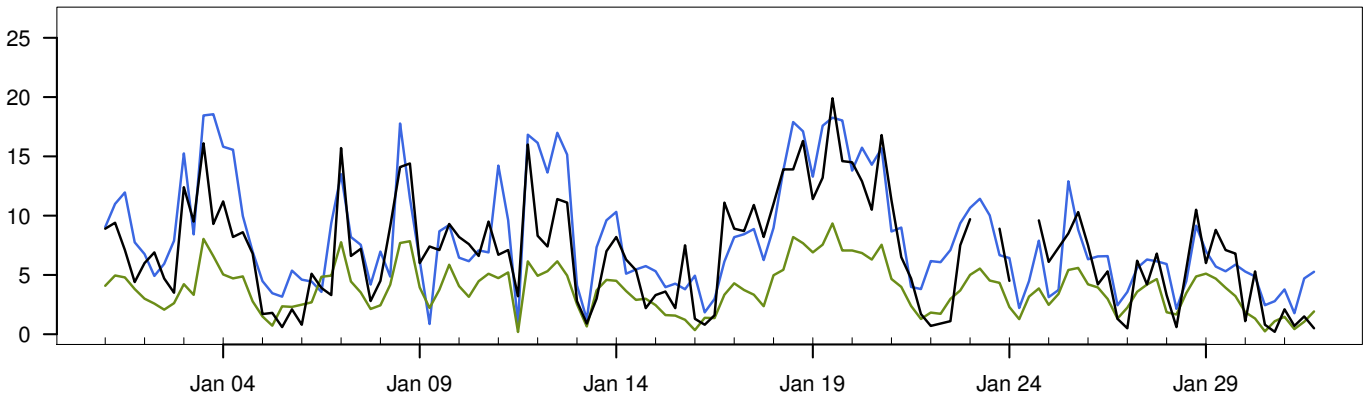
| | ME | SDE | RMSE | MAE | Max.abs.err. | N |
|---|---|---|---|---|---|---|
| MEPSctrl – synop | 0.6 | 2.8 | 2.9 | 2.1 | 12.4 | 360 |
| ECMWF – synop | –0.2 | 2.6 | 2.6 | 2 | 10.5 | 360 |

FINSEVATN

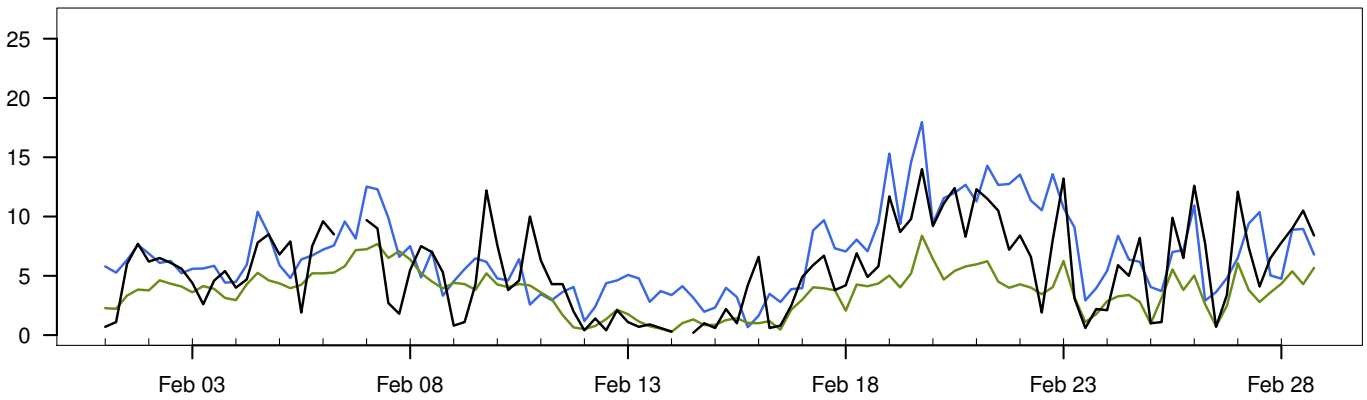
01.12.2016 – 31.12.2016




01.01.2017 – 31.01.2017




01.02.2017 – 28.02.2017

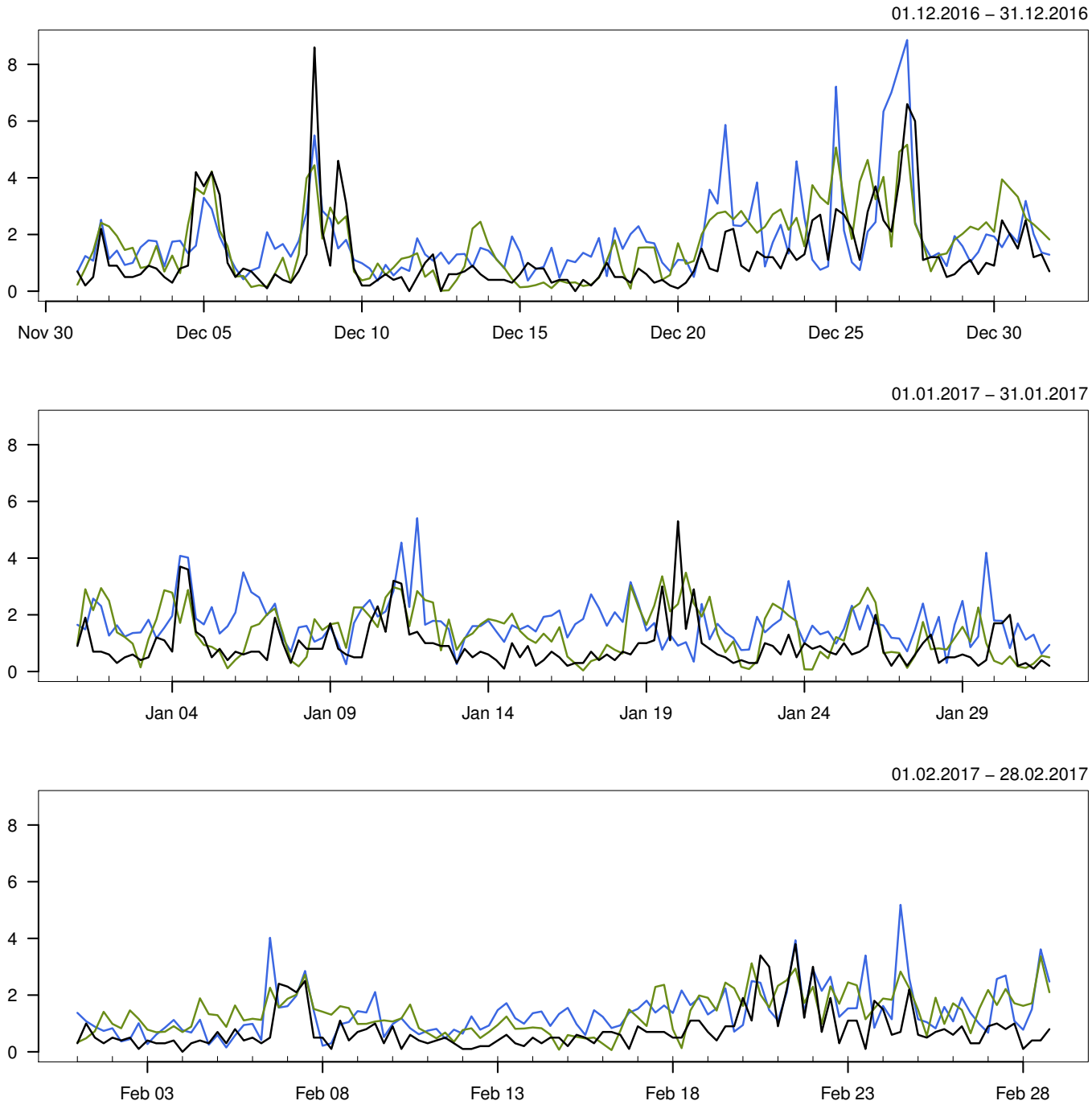



01.12.2016 – 28.02.2017

| | Min | Mean | Max | Std | N |
|---|---|---|---|---|---|
| synop: 00,06,12,18 | 0.2 | 6.9 | 21 | 4.4 | 350 |
| MEPSctrl: 12+18,+24,+30,+36 | 0.7 | 8.2 | 26.5 | 4.7 | 360 |
| ECMWF: 12+18,+24,+30,+36 | 0.2 | 4 | 9.3 | 1.9 | 360 |

| | ME | SDE | RMSE | MAE | Max.abs.err. | N |
|---|---|---|---|---|---|---|
| MEPSctrl – synop | 1.3 | 2.9 | 3.2 | 2.5 | 9.4 | 350 |
| ECMWF – synop | –2.9 | 3 | 4.2 | 3.3 | 14.4 | 350 |

NESBYEN – TODOKK



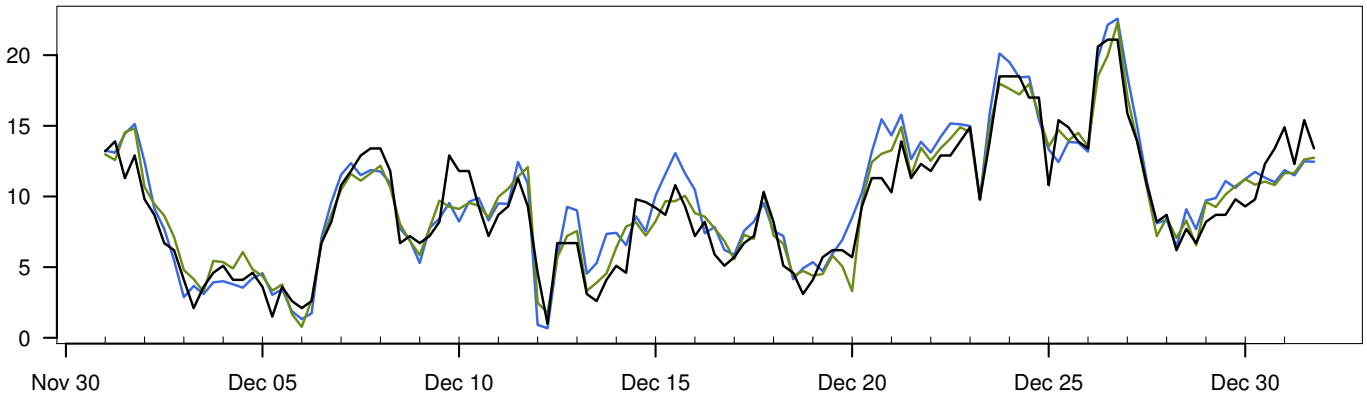

01.12.2016 – 28.02.2017

| | Min | Mean | Max | Std | N |
|---|---|---|---|---|---|
| synop: 00,06,12,18 | 0 | 1 | 8.6 | 1 | 360 |
| MEPSctrl: 12+18,+24,+30,+36 | 0.2 | 1.7 | 8.9 | 1.1 | 360 |
| ECMWF: 12+18,+24,+30,+36 | 0 | 1.5 | 5.2 | 1 | 360 |

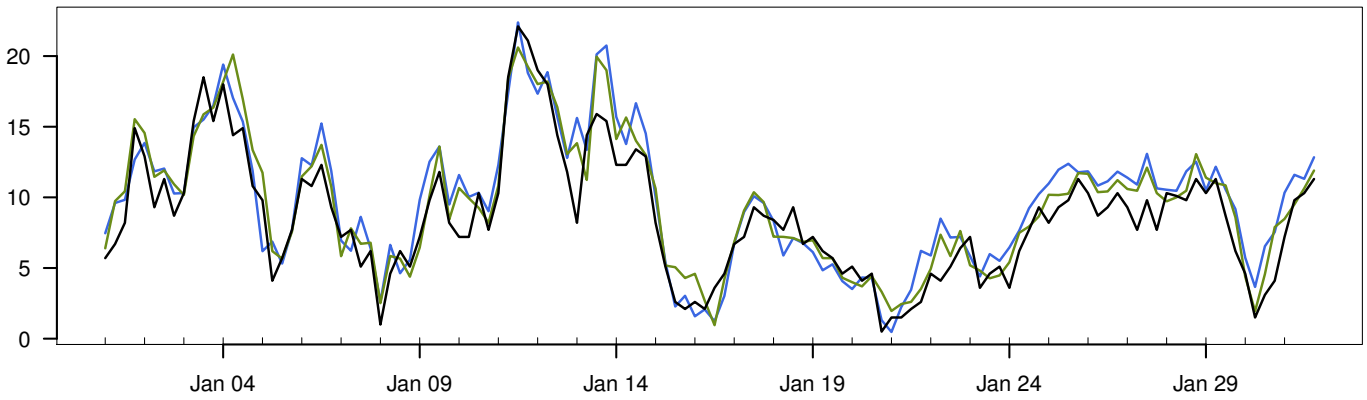
| | ME | SDE | RMSE | MAE | Max.abs.err. | N |
|---|---|---|---|---|---|---|
| MEPSctrl – synop | 0.7 | 1.1 | 1.3 | 0.9 | 4.9 | 360 |
| ECMWF – synop | 0.5 | 0.9 | 1 | 0.8 | 4.2 | 360 |

EKOFISK

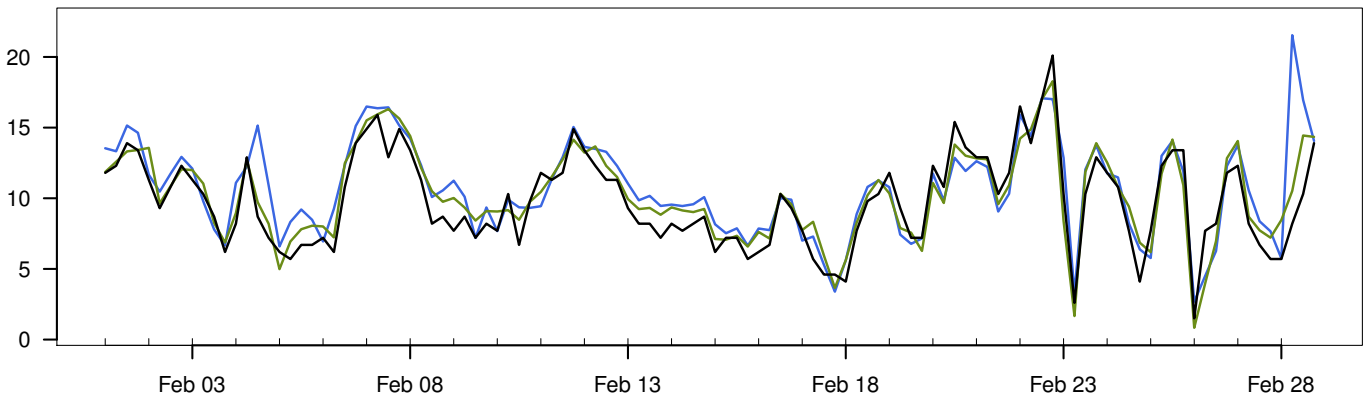
01.12.2016 – 31.12.2016




01.01.2017 – 31.01.2017




01.02.2017 – 28.02.2017

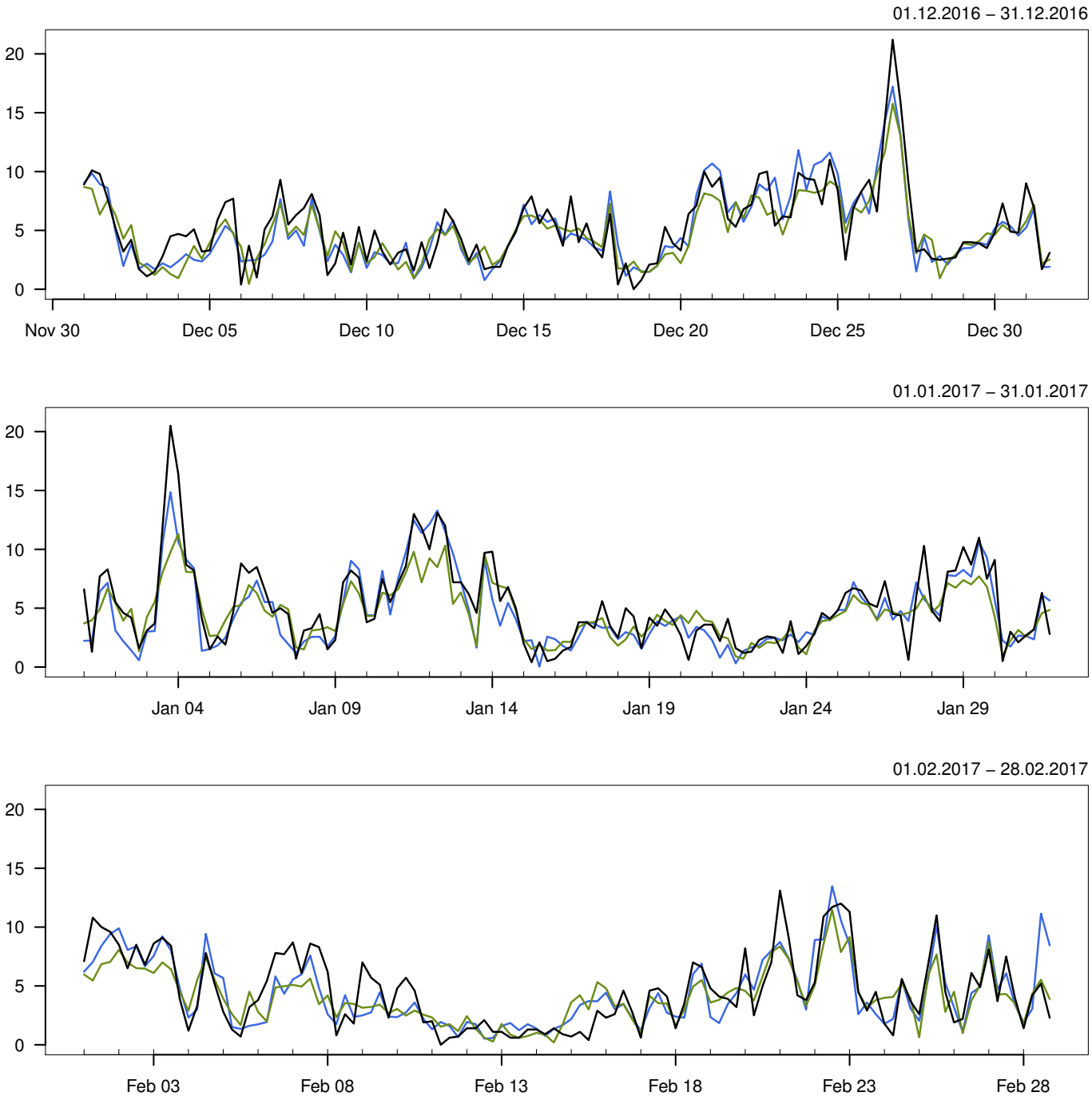



01.12.2016 – 28.02.2017

| | Min | Mean | Max | Std | N |
|---|---|---|---|---|---|
| synop: 00,06,12,18 | 0.5 | 9.2 | 22.1 | 4.1 | 360 |
| MEPSctrl: 12+18,+24,+30,+36 | 0.5 | 10.1 | 22.6 | 4.2 | 360 |
| ECMWF: 12+18,+24,+30,+36 | 0.8 | 9.7 | 22.3 | 4 | 360 |

| | ME | SDE | RMSE | MAE | Max.abs.err. | N |
|---|---|---|---|---|---|---|
| MEPSctrl – synop | 0.8 | 1.8 | 2 | 1.5 | 13.3 | 360 |
| ECMWF – synop | 0.5 | 1.4 | 1.5 | 1.2 | 5.7 | 360 |

SOLA



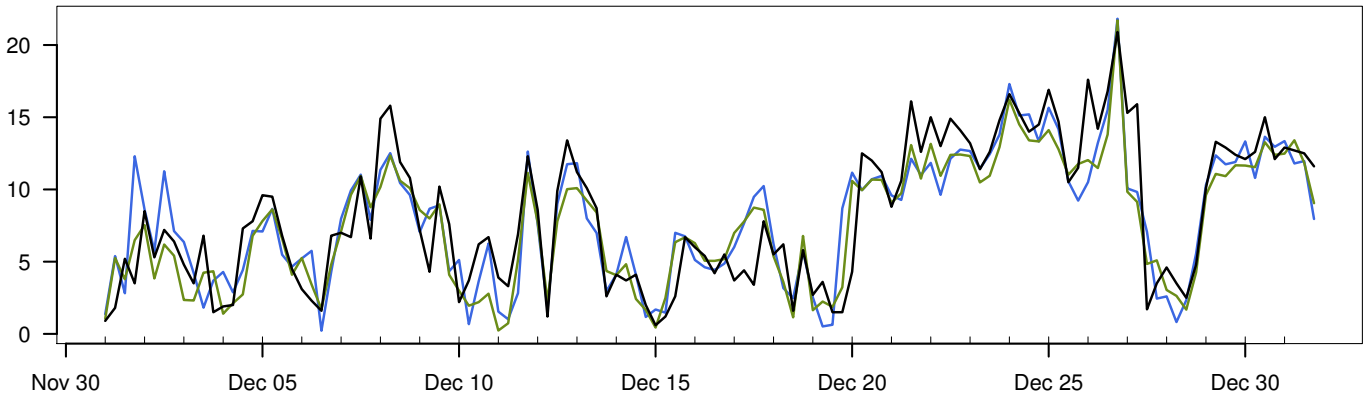

01.12.2016 – 28.02.2017

| | Min | Mean | Max | Std | N |
|---|---|---|---|---|---|
| synop: 00,06,12,18 | 0 | 5 | 21.2 | 3.3 | 360 |
| MEPSctrl: 12+18,+24,+30,+36 | 0 | 4.7 | 17.2 | 3 | 360 |
| ECMWF: 12+18,+24,+30,+36 | 0.2 | 4.5 | 15.8 | 2.4 | 360 |

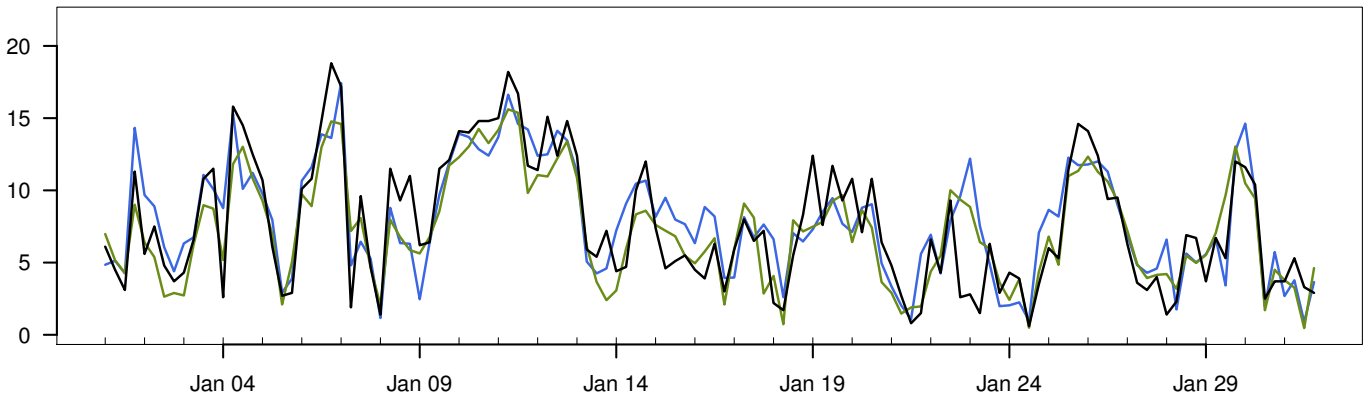
| | ME | SDE | RMSE | MAE | Max.abs.err. | N |
|---|---|---|---|---|---|---|
| MEPSctrl – synop | −0.4 | 1.7 | 1.7 | 1.3 | 6.2 | 360 |
| ECMWF – synop | −0.5 | 1.7 | 1.8 | 1.4 | 10.8 | 360 |

FÆRDER FYR

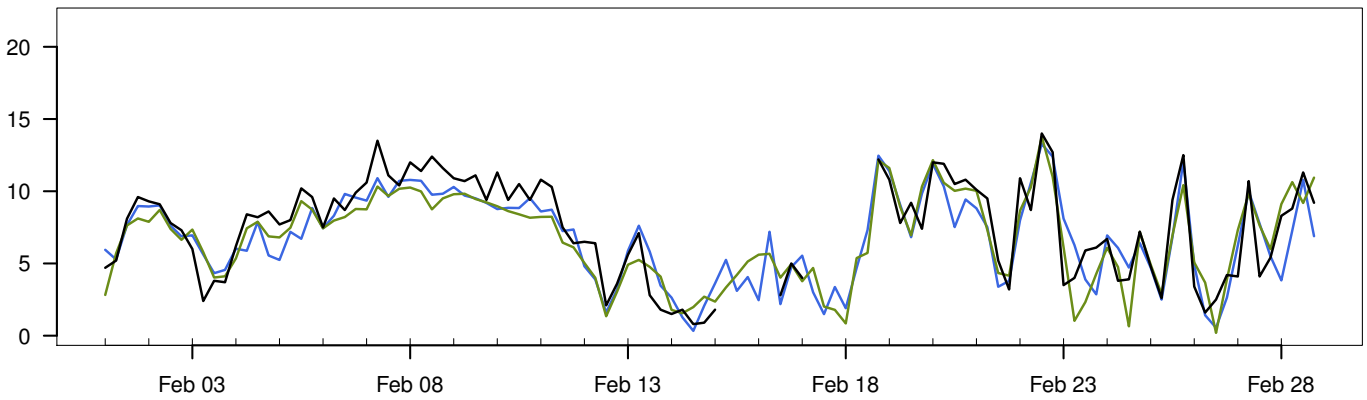
01.12.2016 – 31.12.2016




01.01.2017 – 31.01.2017



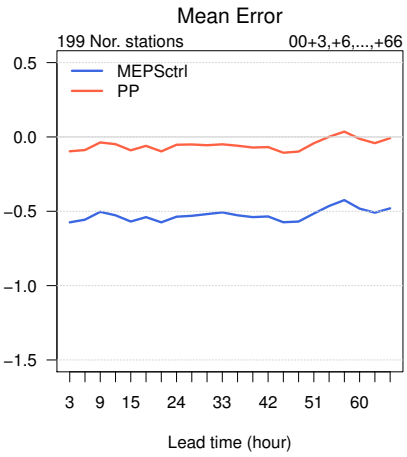

01.02.2017 – 28.02.2017

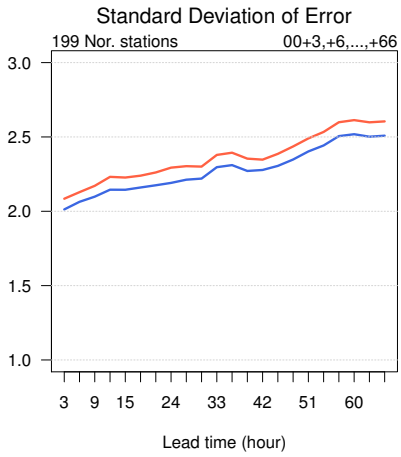


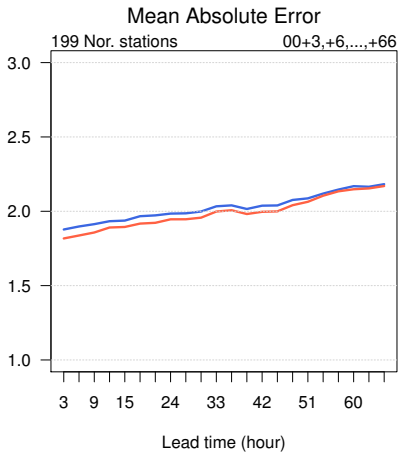

01.12.2016 – 28.02.2017

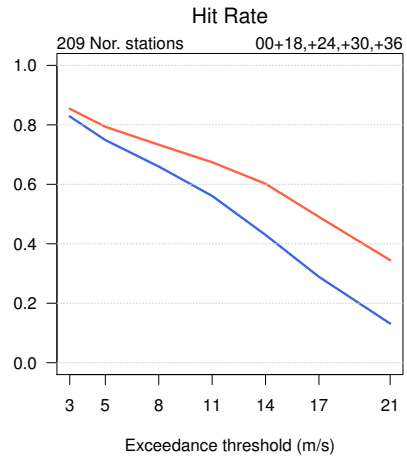
| | Min | Mean | Max | Std | N |
|---|---|---|---|---|---|
| synop: 00,06,12,18 | 0.6 | 7.8 | 20.9 | 4.3 | 350 |
| MEPSctrl: 12+18,+24,+30,+36 | 0.2 | 7.5 | 21.8 | 3.8 | 360 |
| ECMWF: 12+18,+24,+30,+36 | 0.2 | 7.2 | 21.7 | 3.7 | 360 |

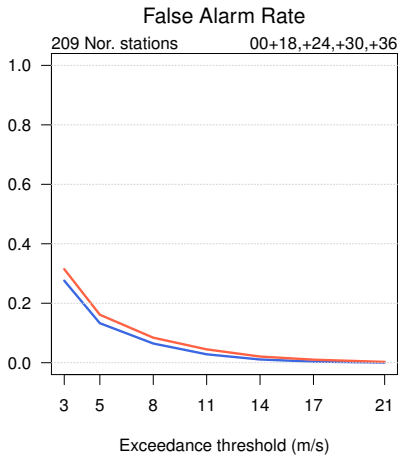
| | ME | SDE | RMSE | MAE | Max.abs.err. | N |
|---|---|---|---|---|---|---|
| MEPSctrl – synop | –0.1 | 2.3 | 2.3 | 1.7 | 9.4 | 350 |
| ECMWF – synop | –0.5 | 2 | 2 | 1.6 | 6.8 | 350 |

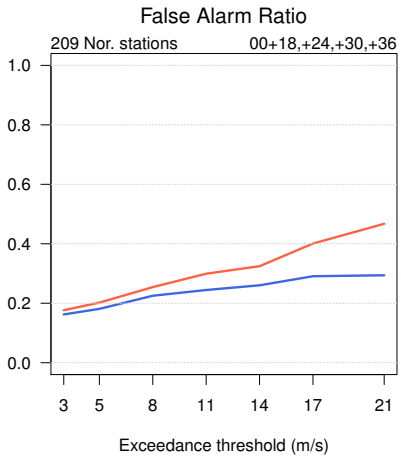

Mean Error
199 Nor. stations
00+3,+6,...,+66
MEPSctrl
PP
0.5
0.0
−0.5
−1.0
−1.5
3 9 15 24 33 42 51 60
Lead time (hour)

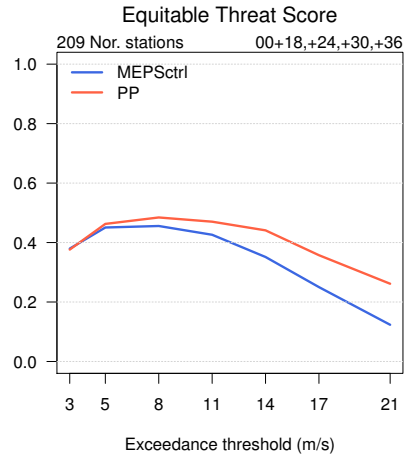

Standard Deviation of Error
199 Nor. stations
00+3,+6,...,+66
3.0
2.5
2.0
1.5
1.0
3 9 15 24 33 42 51 60
Lead time (hour)

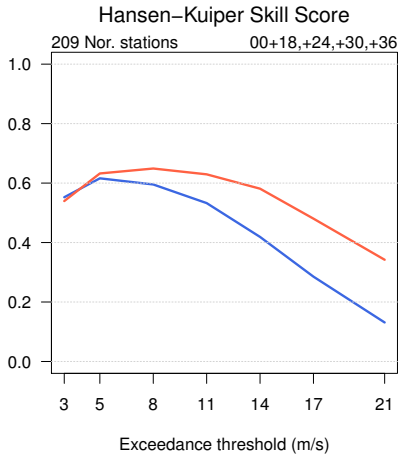

Mean Absolute Error
199 Nor. stations
00+3,+6,...,+66
3.0
2.5
2.0
1.5
1.0
3 9 15 24 33 42 51 60
Lead time (hour)

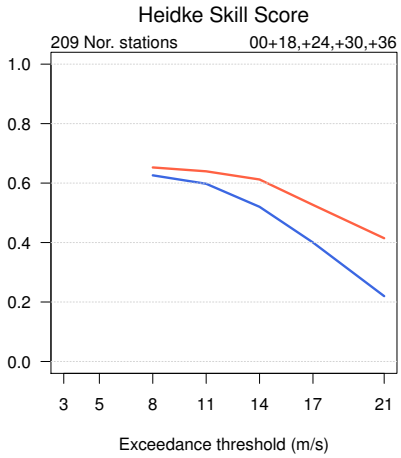

Hit Rate
209 Nor. stations
00+18,+24,+30,+36
1.0
0.8
0.6
0.4
0.2
0.0
3 5 8 11 14 17 21
Exceedance threshold (m/s)


False Alarm Rate
209 Nor. stations
00+18,+24,+30,+36
1.0
0.8
0.6
0.4
0.2
0.0
3 5 8 11 14 17 21
Exceedance threshold (m/s)

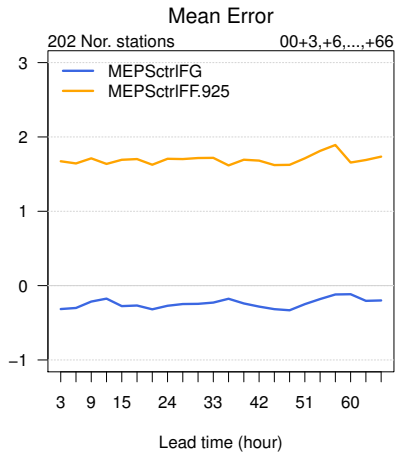

False Alarm Ratio
209 Nor. stations
00+18,+24,+30,+36
1.0
0.8
0.6
0.4
0.2
0.0
3 5 8 11 14 17 21
Exceedance threshold (m/s)

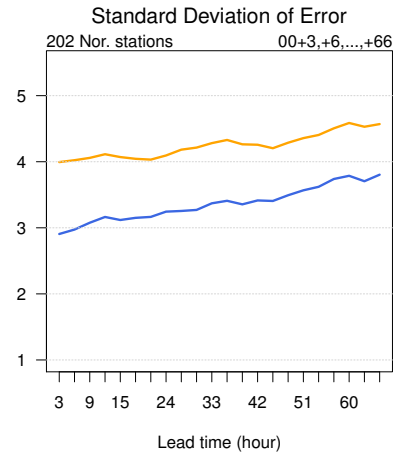

Equitable Threat Score
209 Nor. stations
00+18,+24,+30,+36
MEPSctrl
PP
1.0
0.8
0.6
0.4
0.2
0.0
3 5 8 11 14 17 21
Exceedance threshold (m/s)

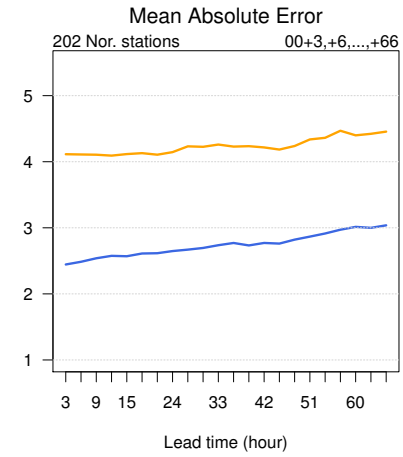

Hansen−Kuiper Skill Score
209 Nor. stations
00+18,+24,+30,+36
1.0
0.8
0.6
0.4
0.2
0.0
3 5 8 11 14 17 21
Exceedance threshold (m/s)

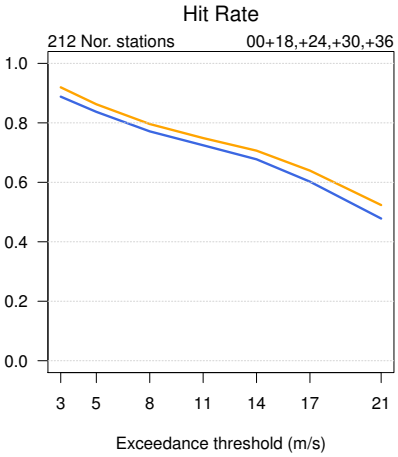

Heidke Skill Score
209 Nor. stations
00+18,+24,+30,+36
1.0
0.8
0.6
0.4
0.2
0.0
3 5 8 11 14 17 21
Exceedance threshold (m/s)

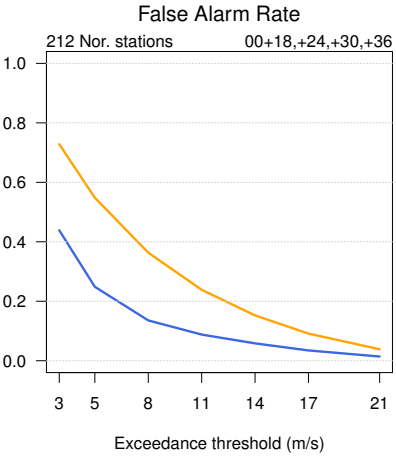
# Wind gust (FG) and wind speed in 925 hpa (FF.925)

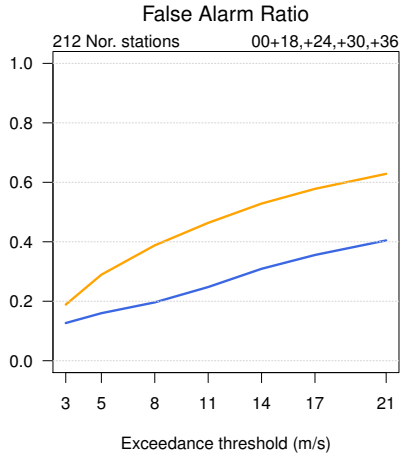


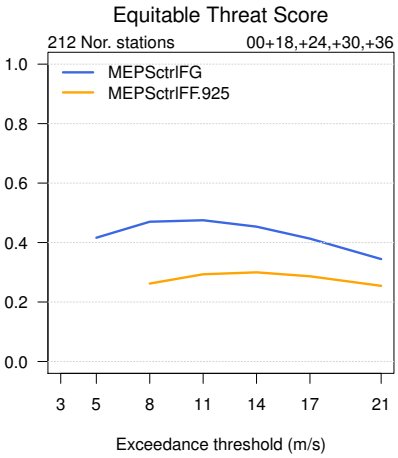



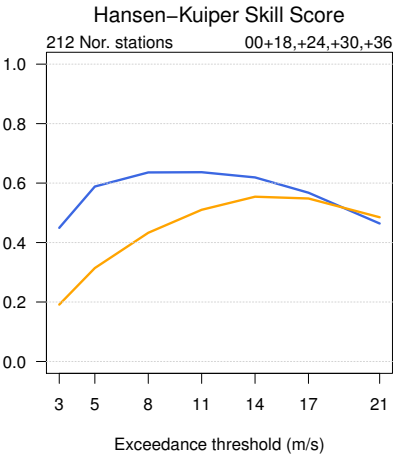



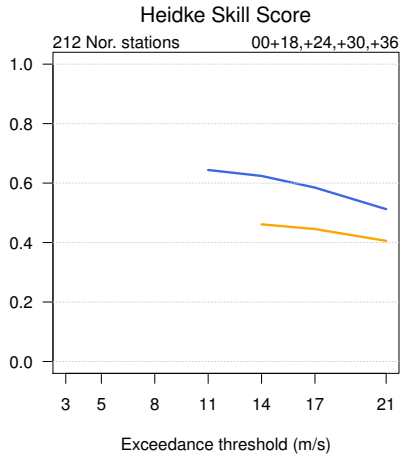



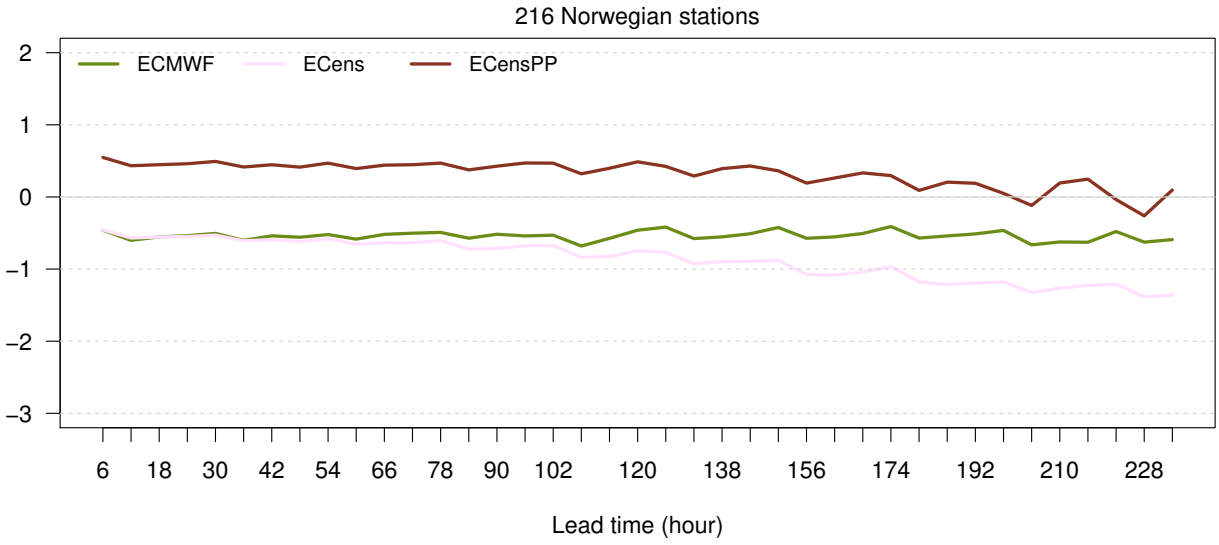



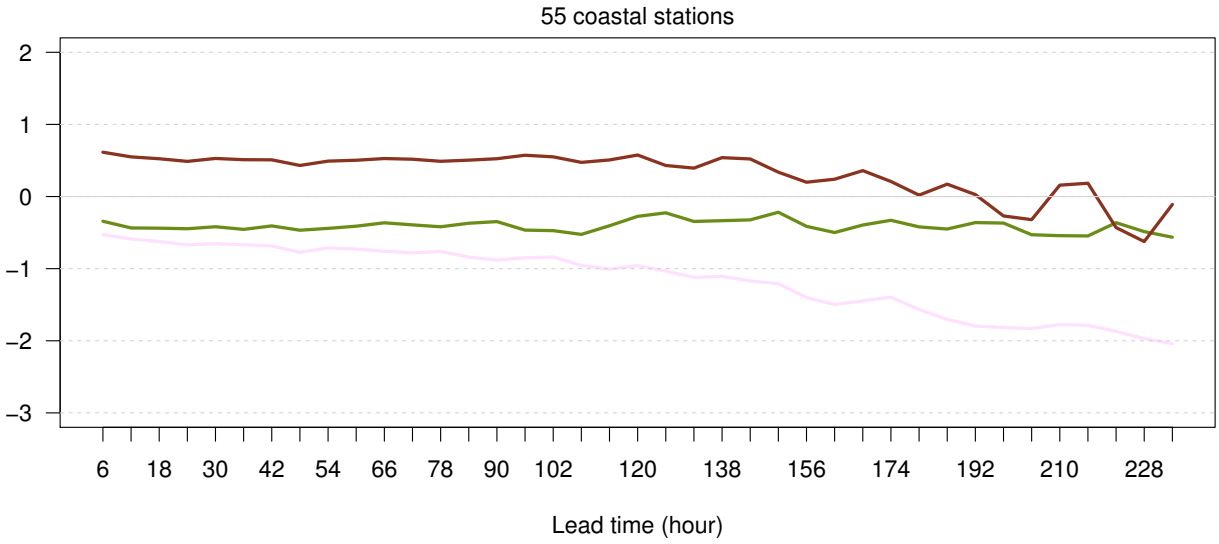



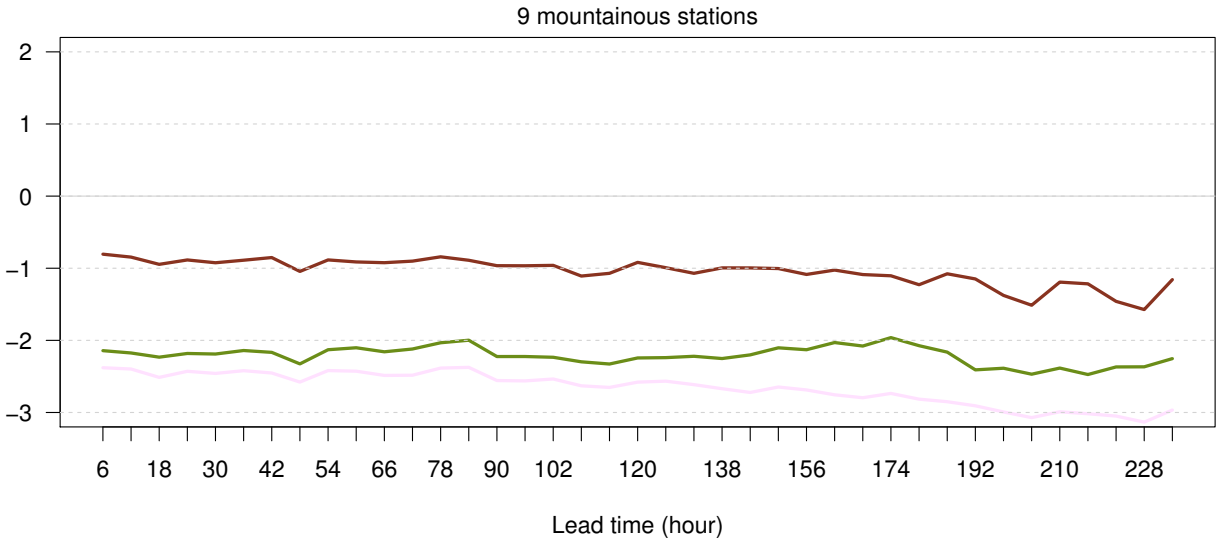



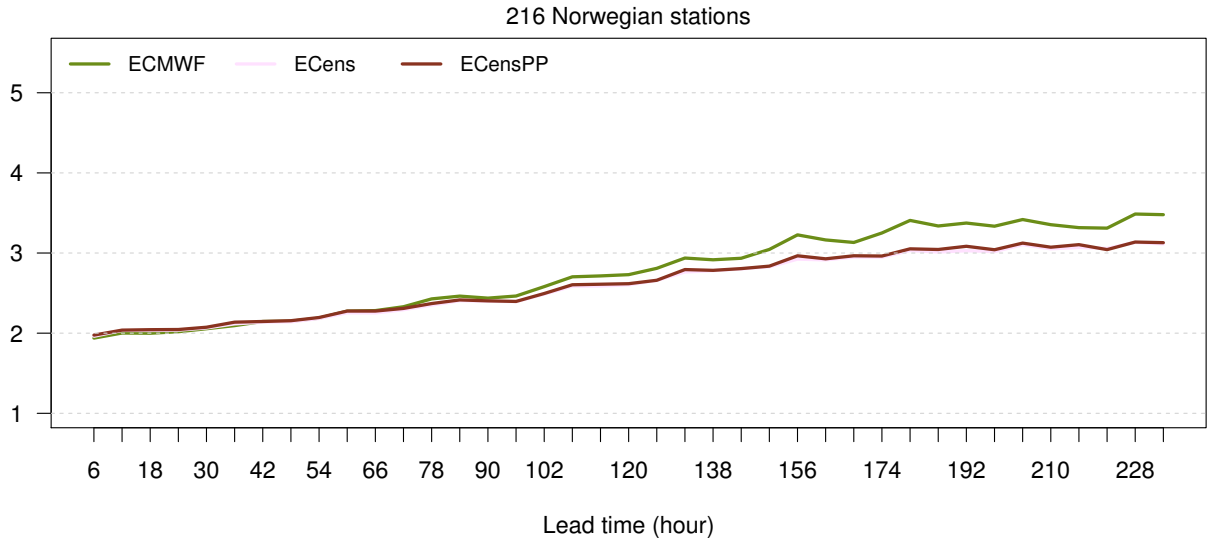
## Mean Error

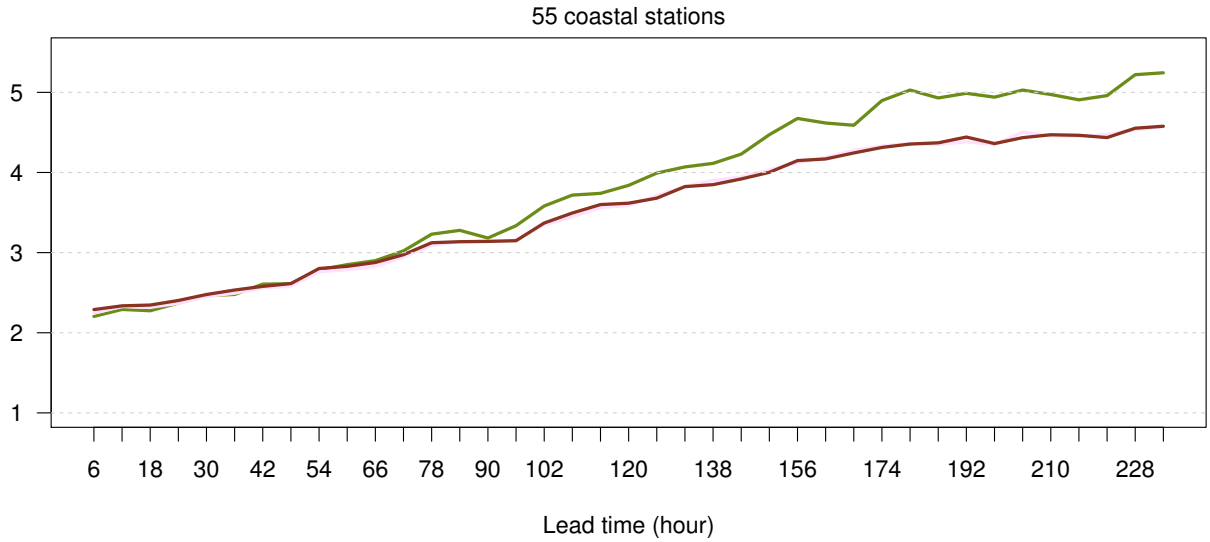

216 Norwegian stations
ECMWF
ECens
ECensPP
2
1
0
−1
−2
−3
6 18 30 42 54 66 78 90 102 120 138 156 174 192 210 228
Lead time (hour)

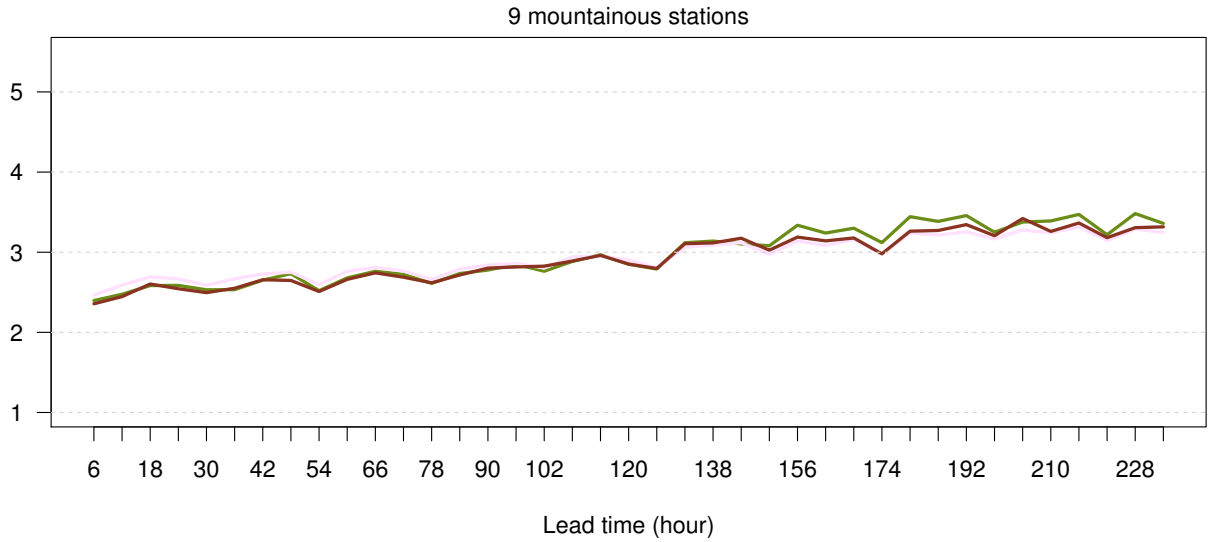

55 coastal stations
2
1
0
−1
−2
−3
6 18 30 42 54 66 78 90 102 120 138 156 174 192 210 228
Lead time (hour)


9 mountainous stations
2
1
0
−1
−2
−3
6 18 30 42 54 66 78 90 102 120 138 156 174 192 210 228
Lead time (hour)

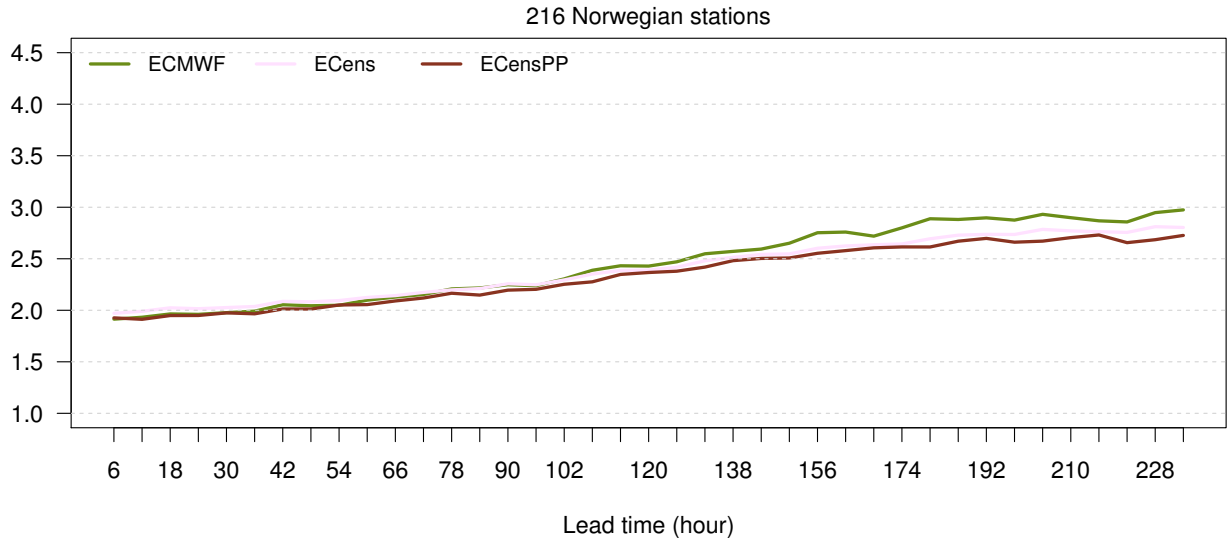
Standard Deviation of Error

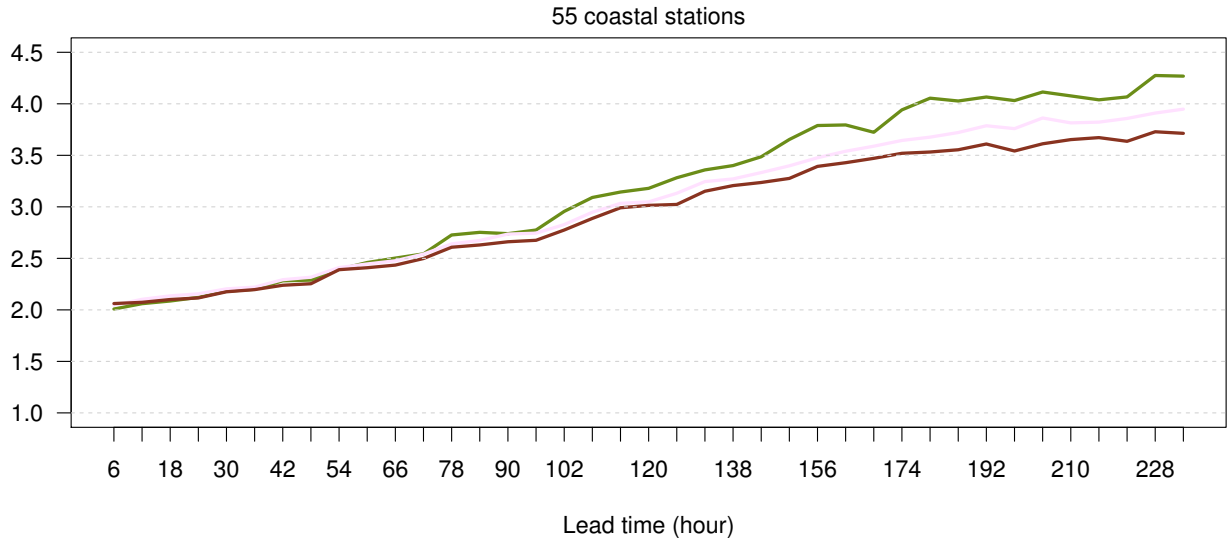


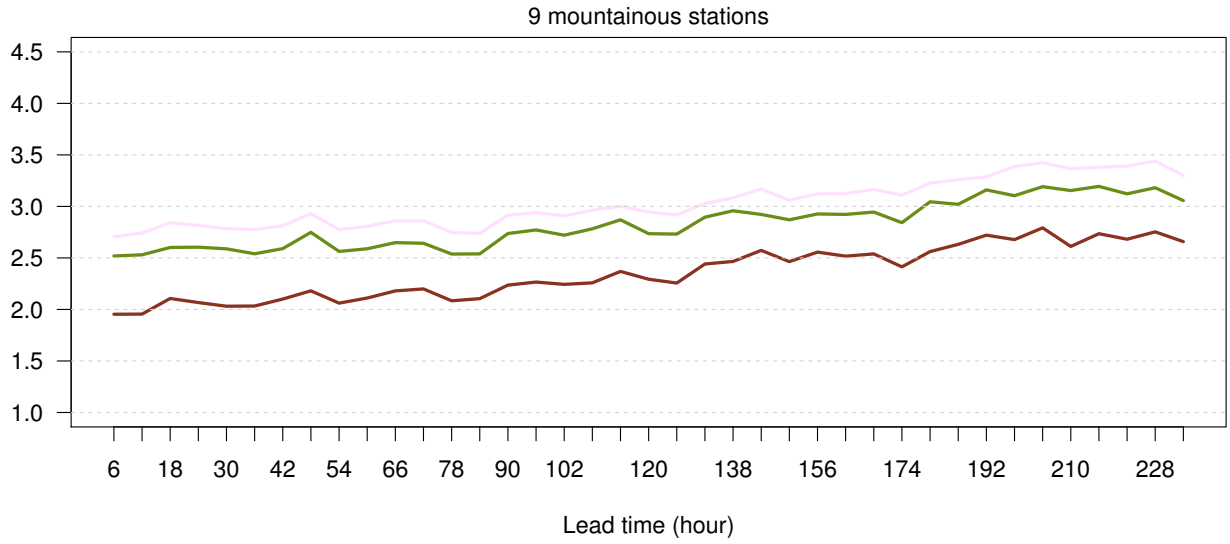



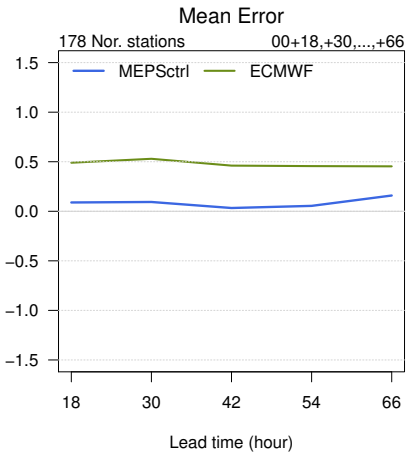



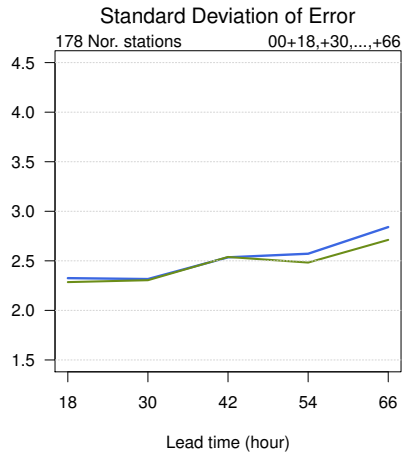
## Mean Absolute Error

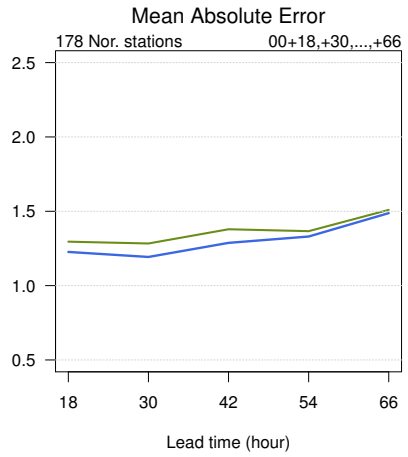


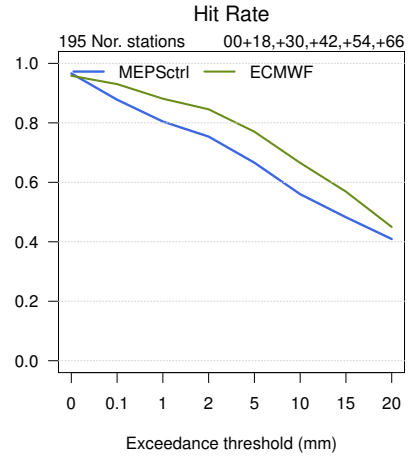



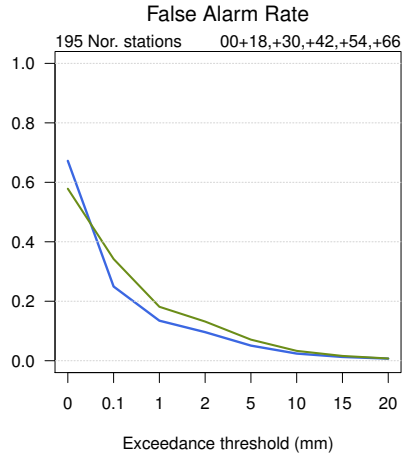



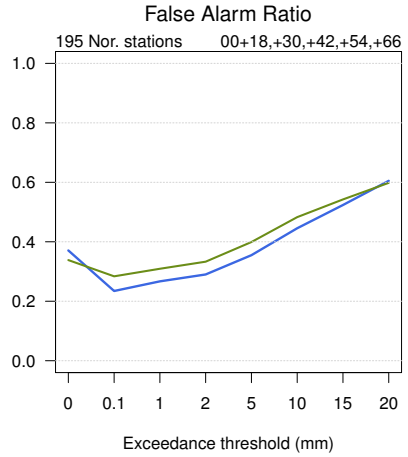

Mean Error
178 Nor. stations
00+18,+30,...,+66
MEPSctrl
ECMWF
1.5
1.0
0.5
0.0
−0.5
−1.0
−1.5
18
30
42
54
66
Lead time (hour)

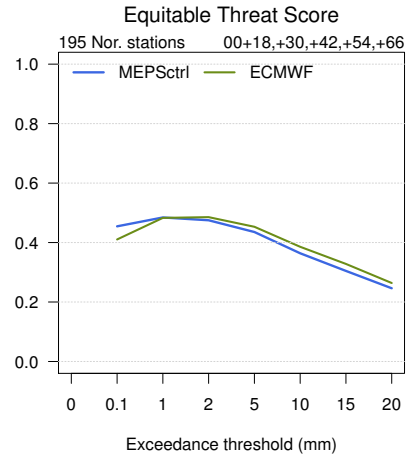

Standard Deviation of Error
178 Nor. stations
00+18,+30,...,+66
4.5
4.0
3.5
3.0
2.5
2.0
1.5
18
30
42
54
66
Lead time (hour)

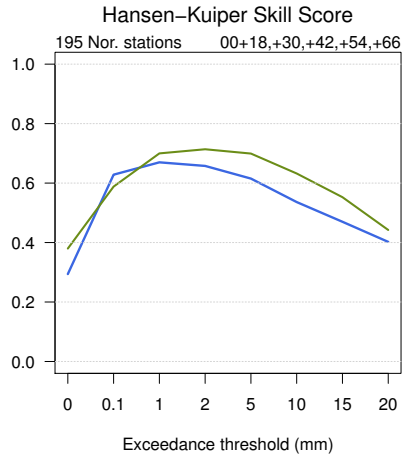

Mean Absolute Error
178 Nor. stations
00+18,+30,...,+66
2.5
2.0
1.5
1.0
0.5
18
30
42
54
66
Lead time (hour)

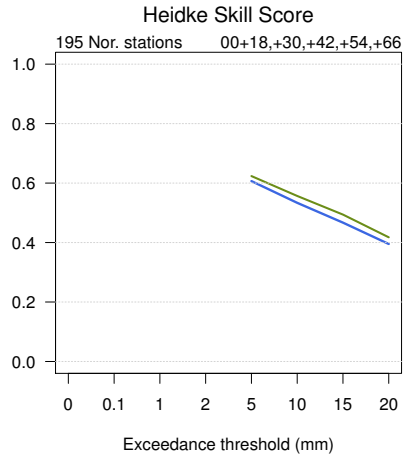

Hit Rate
195 Nor. stations
00+18,+30,+42,+54,+66
MEPSctrl
ECMWF
1.0
0.8
0.6
0.4
0.2
0.0
0
0.1
1
2
5
10
15
20
Exceedance threshold (mm)


False Alarm Rate
195 Nor. stations
00+18,+30,+42,+54,+66
1.0
0.8
0.6
0.4
0.2
0.0
0
0.1
1
2
5
10
15
20
Exceedance threshold (mm)


False Alarm Ratio
195 Nor. stations
00+18,+30,+42,+54,+66
1.0
0.8
0.6
0.4
0.2
0.0
0
0.1
1
2
5
10
15
20
Exceedance threshold (mm)

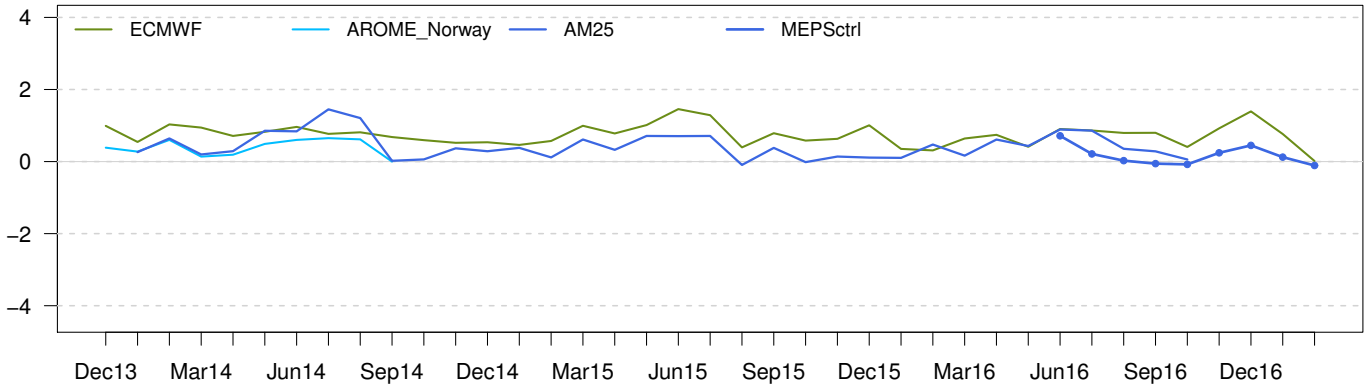

Equitable Threat Score
195 Nor. stations
00+18,+30,+42,+54,+66
MEPSctrl
ECMWF
1.0
0.8
0.6
0.4
0.2
0.0
0
0.1
1
2
5
10
15
20
Exceedance threshold (mm)


Hansen−Kuiper Skill Score
195 Nor. stations
00+18,+30,+42,+54,+66
1.0
0.8
0.6
0.4
0.2
0.0
0
0.1
1
2
5
10
15
20
Exceedance threshold (mm)

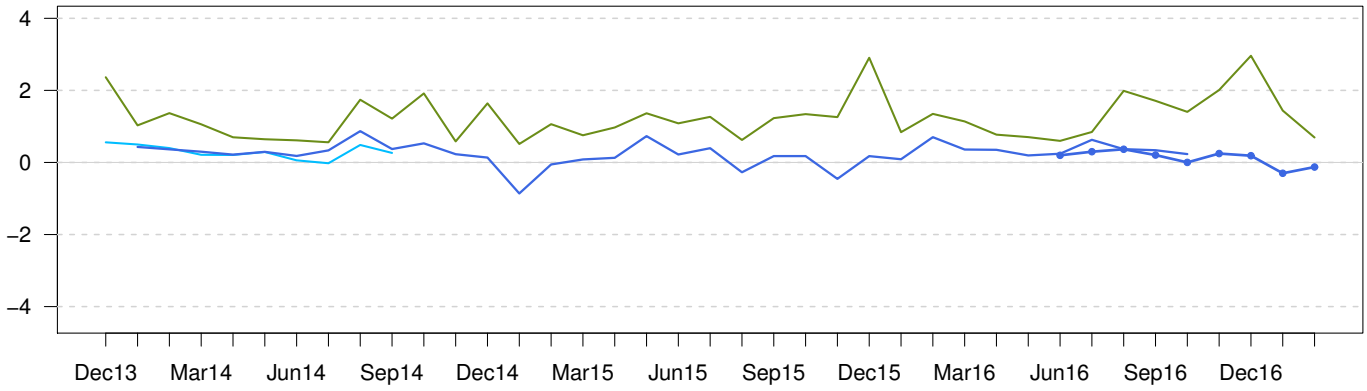

Heidke Skill Score
195 Nor. stations
00+18,+30,+42,+54,+66
1.0
0.8
0.6
0.4
0.2
0.0
0
0.1
1
2
5
10
15
20
Exceedance threshold (mm)

## Mean Error

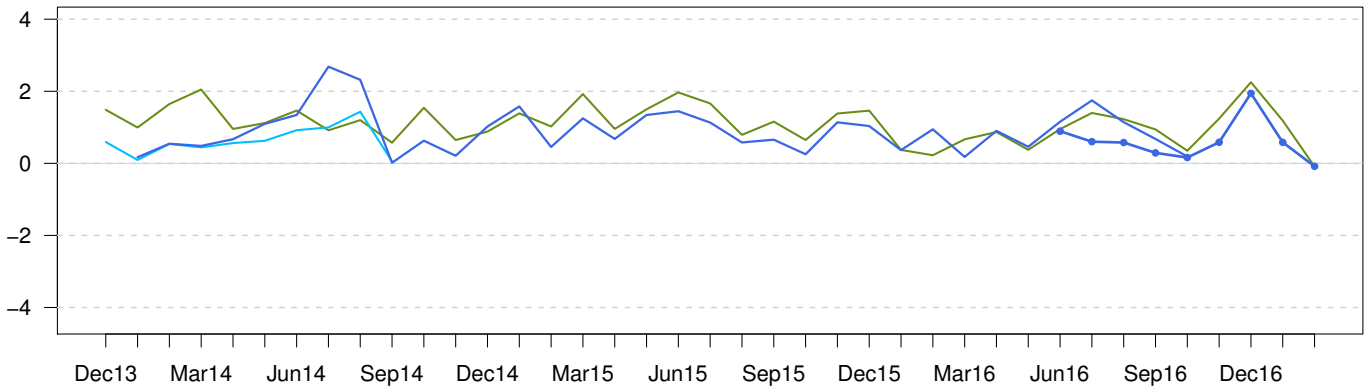
110 Norwegian stations 00+30 UTC



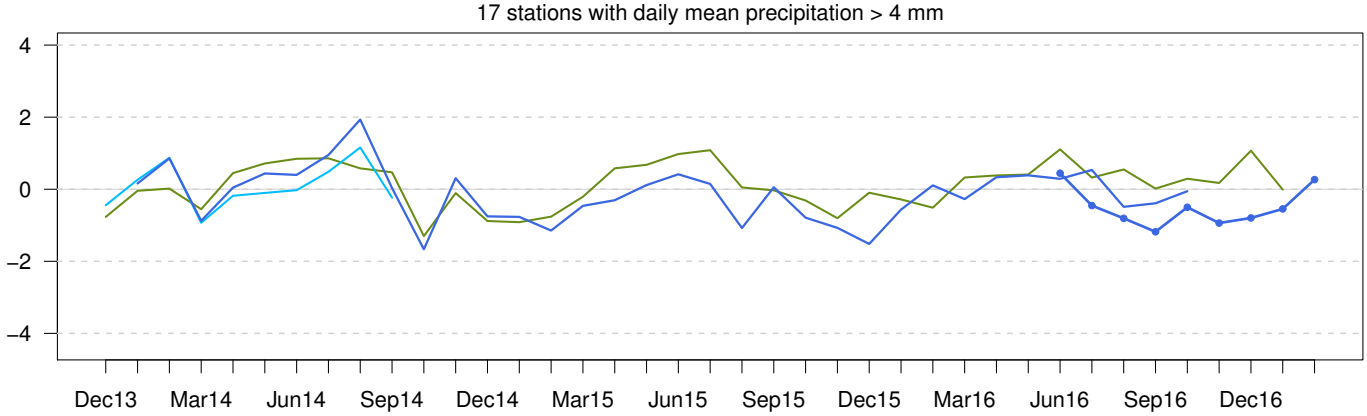

14 coastal stations



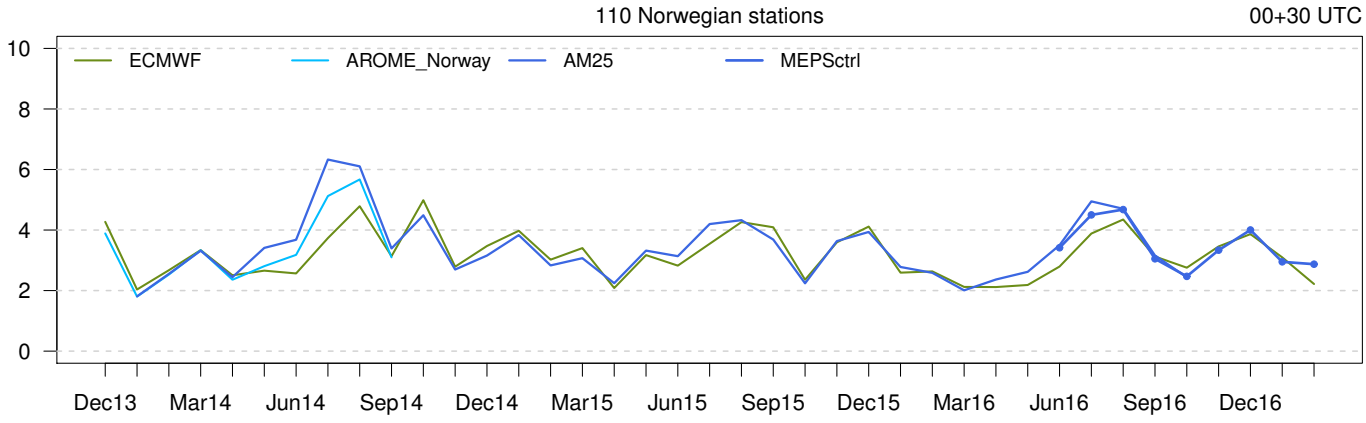

38 stations more than 500 m above sea level

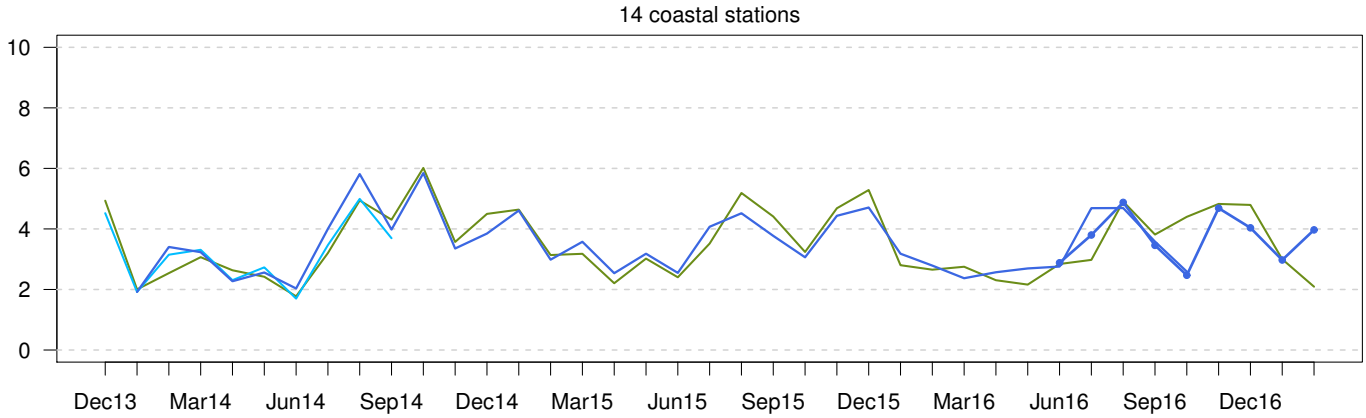


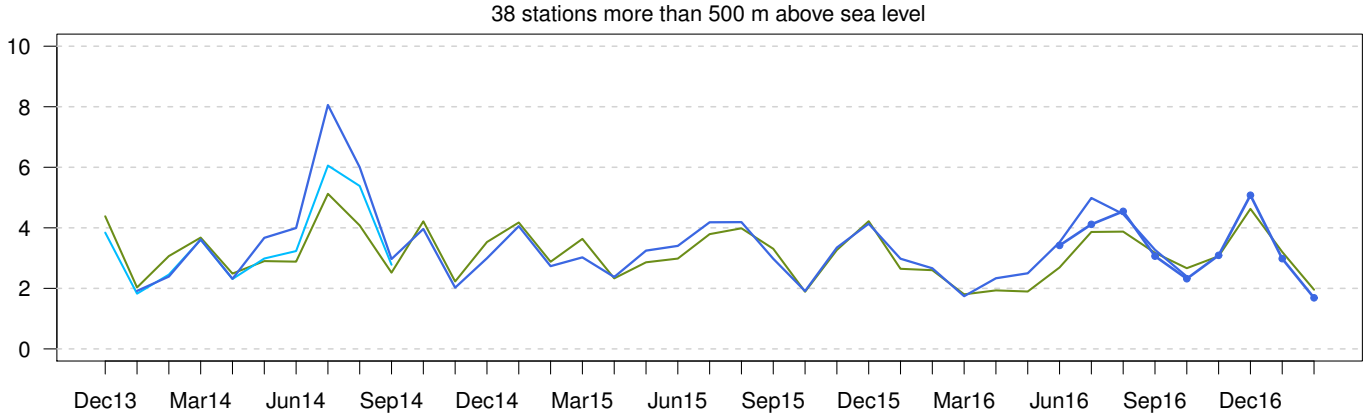

17 stations with daily mean precipitation > 4 mm

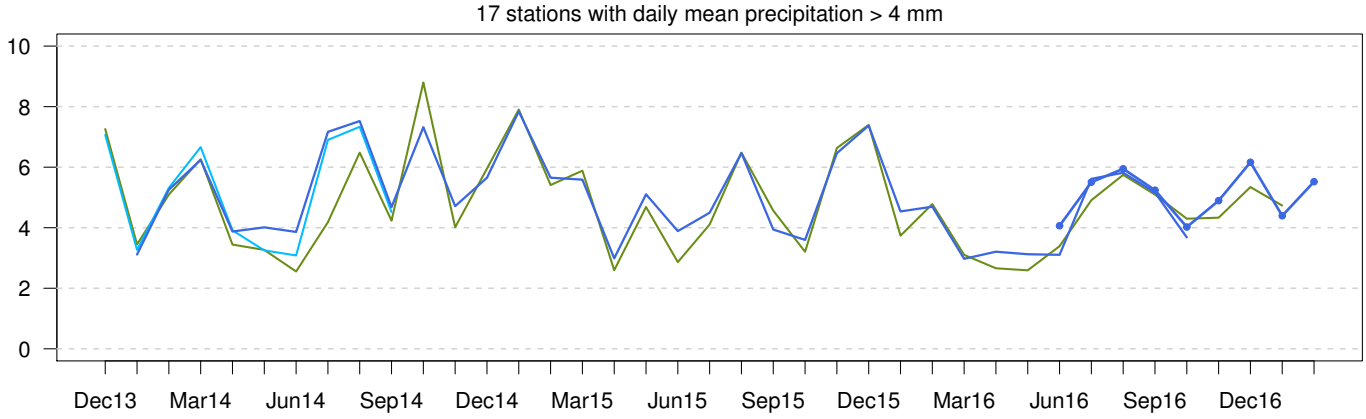


Standard Deviation of Error



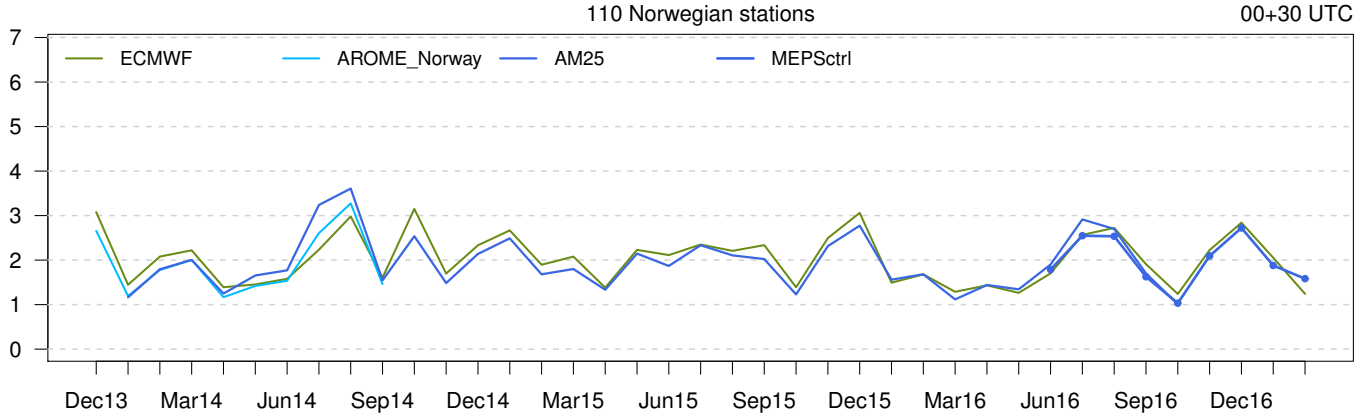



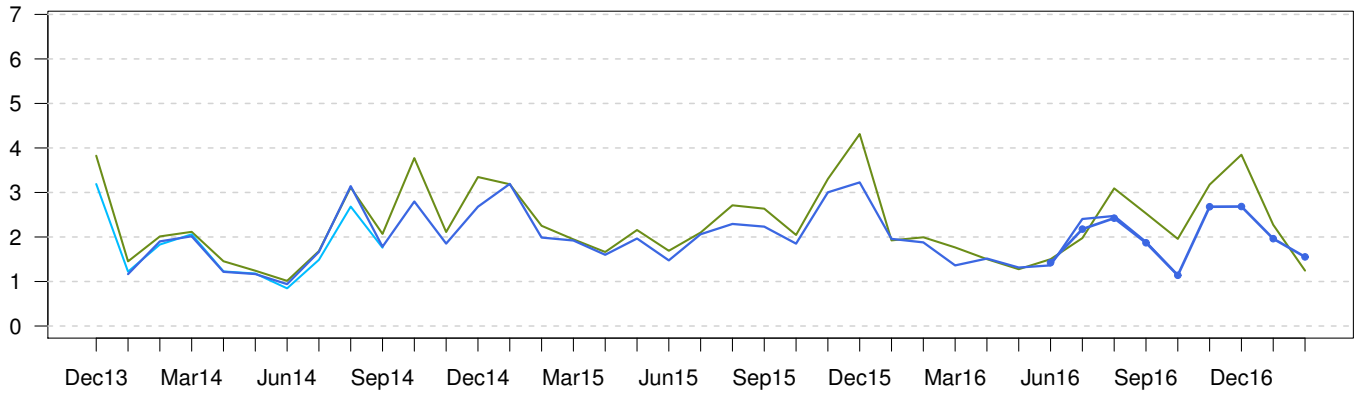



## Mean Absolute Error

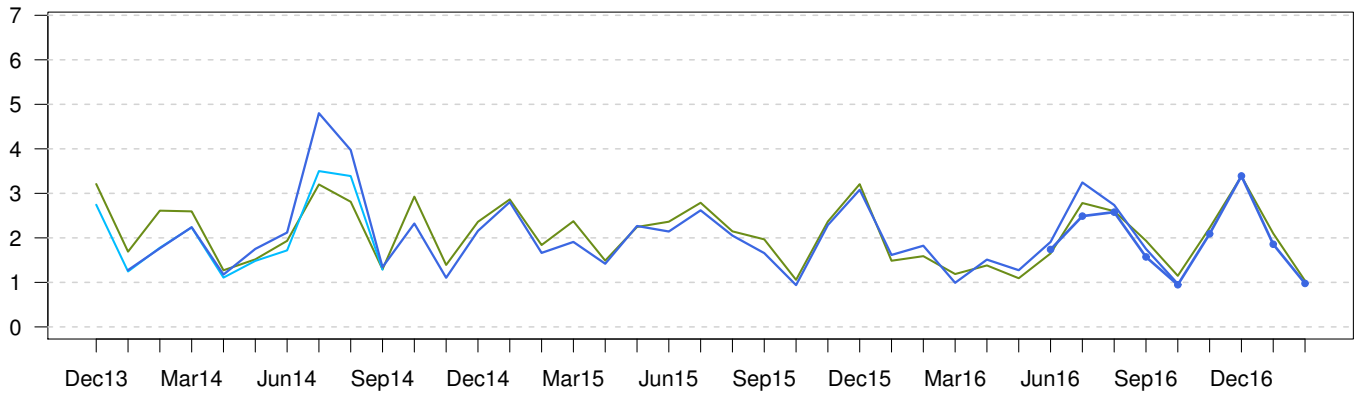
110 Norwegian stations 00+30 UTC



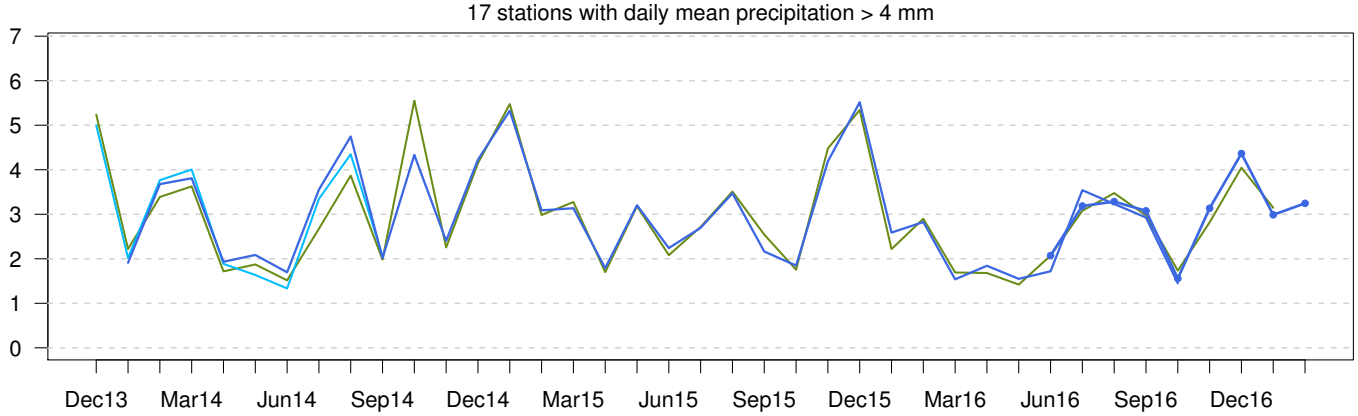

14 coastal stations




38 stations more than 500 m above sea level

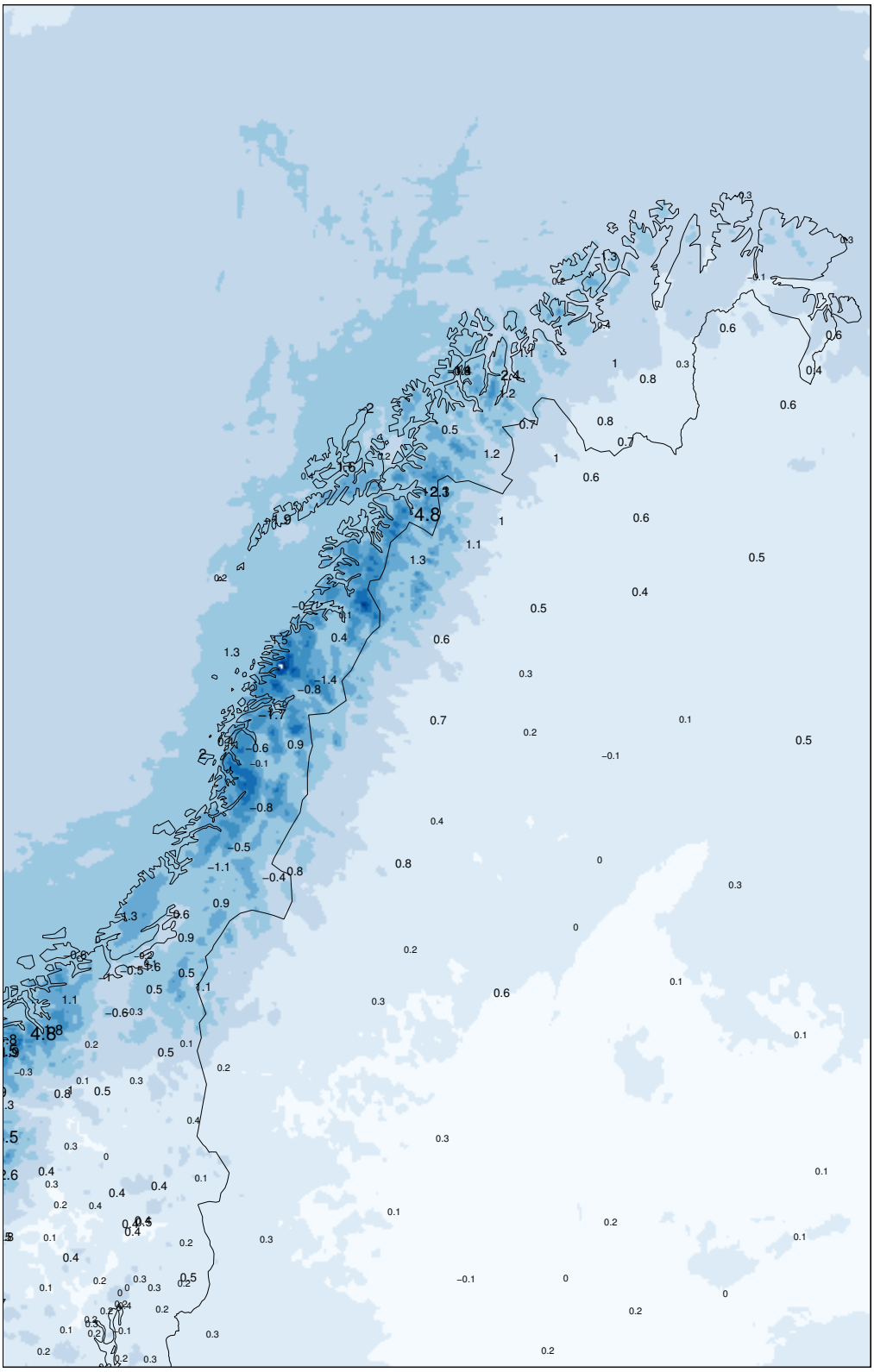



17 stations with daily mean precipitation > 4 mm



# MEPSctrl 00+30

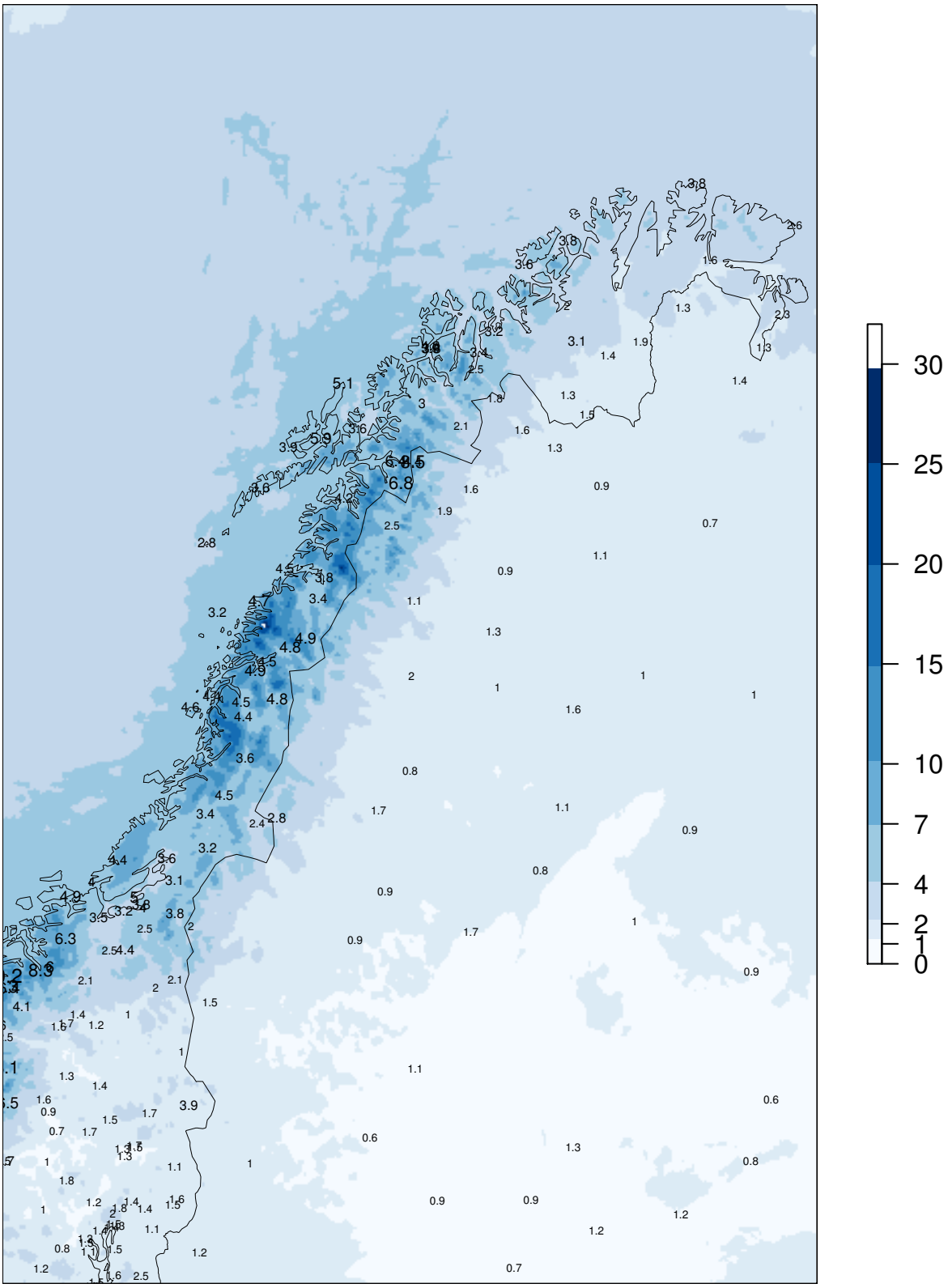
ME at observing sites
(numbers in black)




Model "climatology" 01.12.2016 – 28.02.2017

# MEPSctrl 00+30

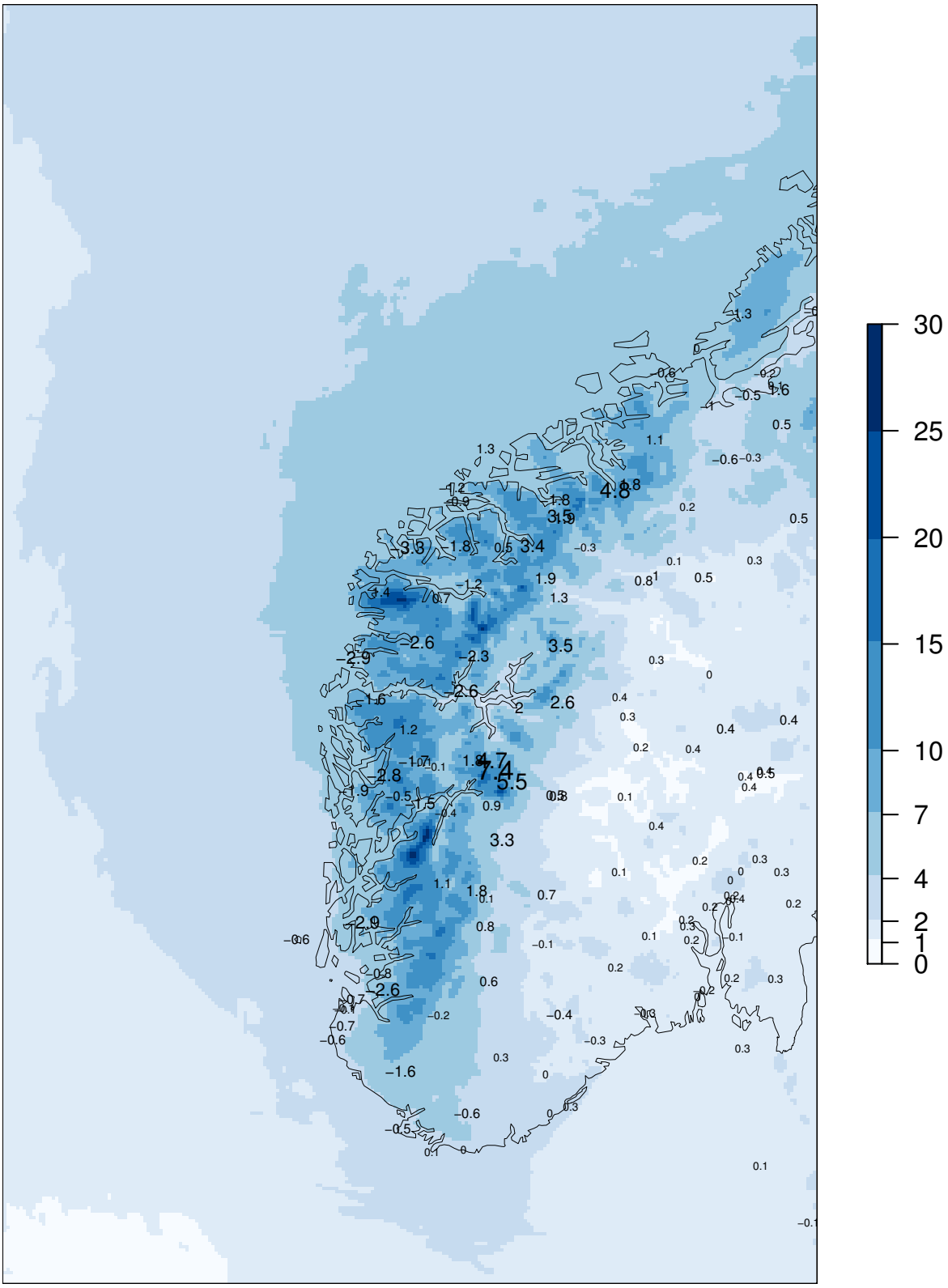
SDE at observing sites
(numbers in black)




Model "climatology" 01.12.2016 – 28.02.2017

# MEPSctrl 00+30

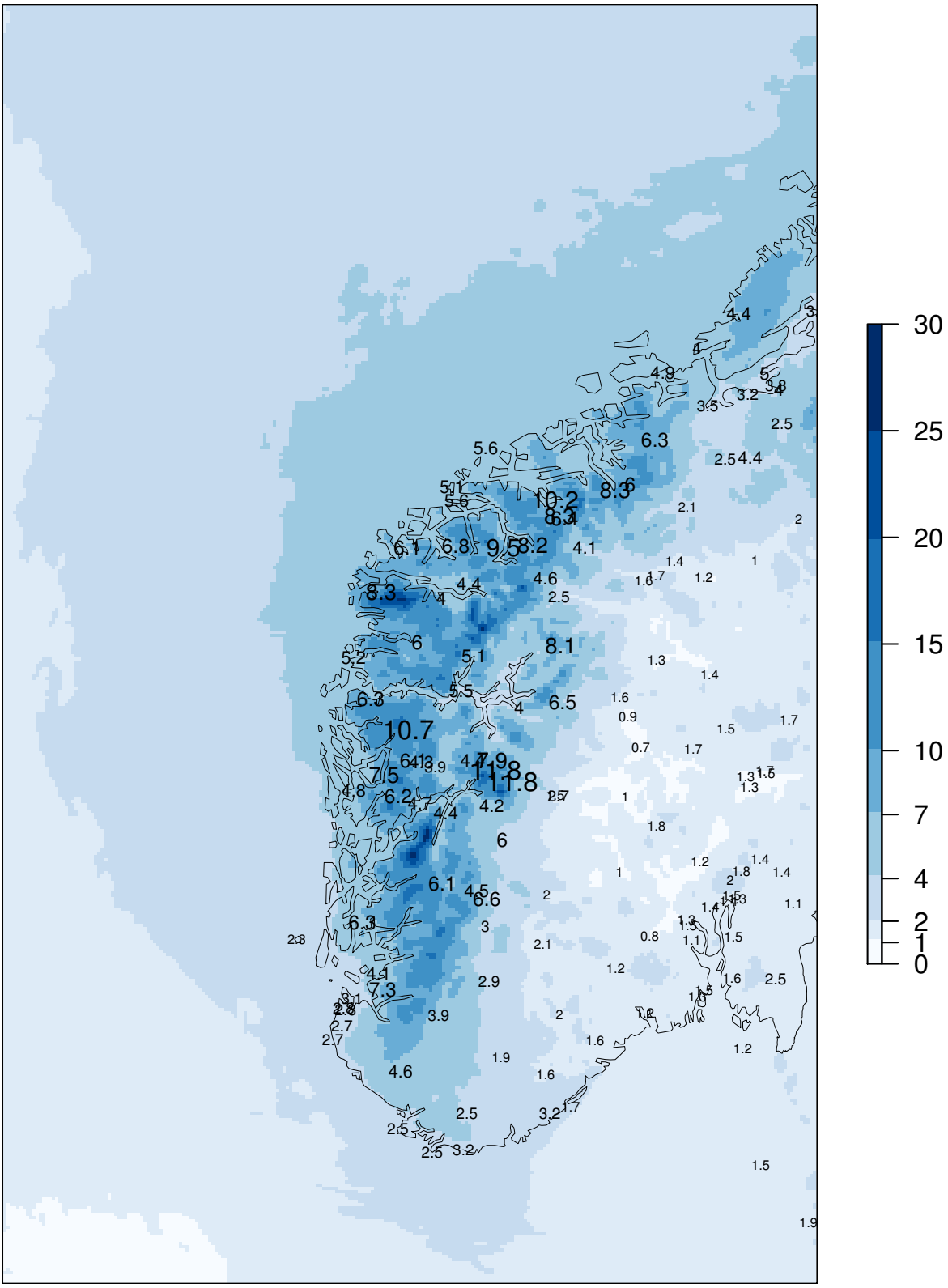
ME at observing sites
(numbers in black)




Model "climatology" 01.12.2016 – 28.02.2017

MEPSctrl 00+30

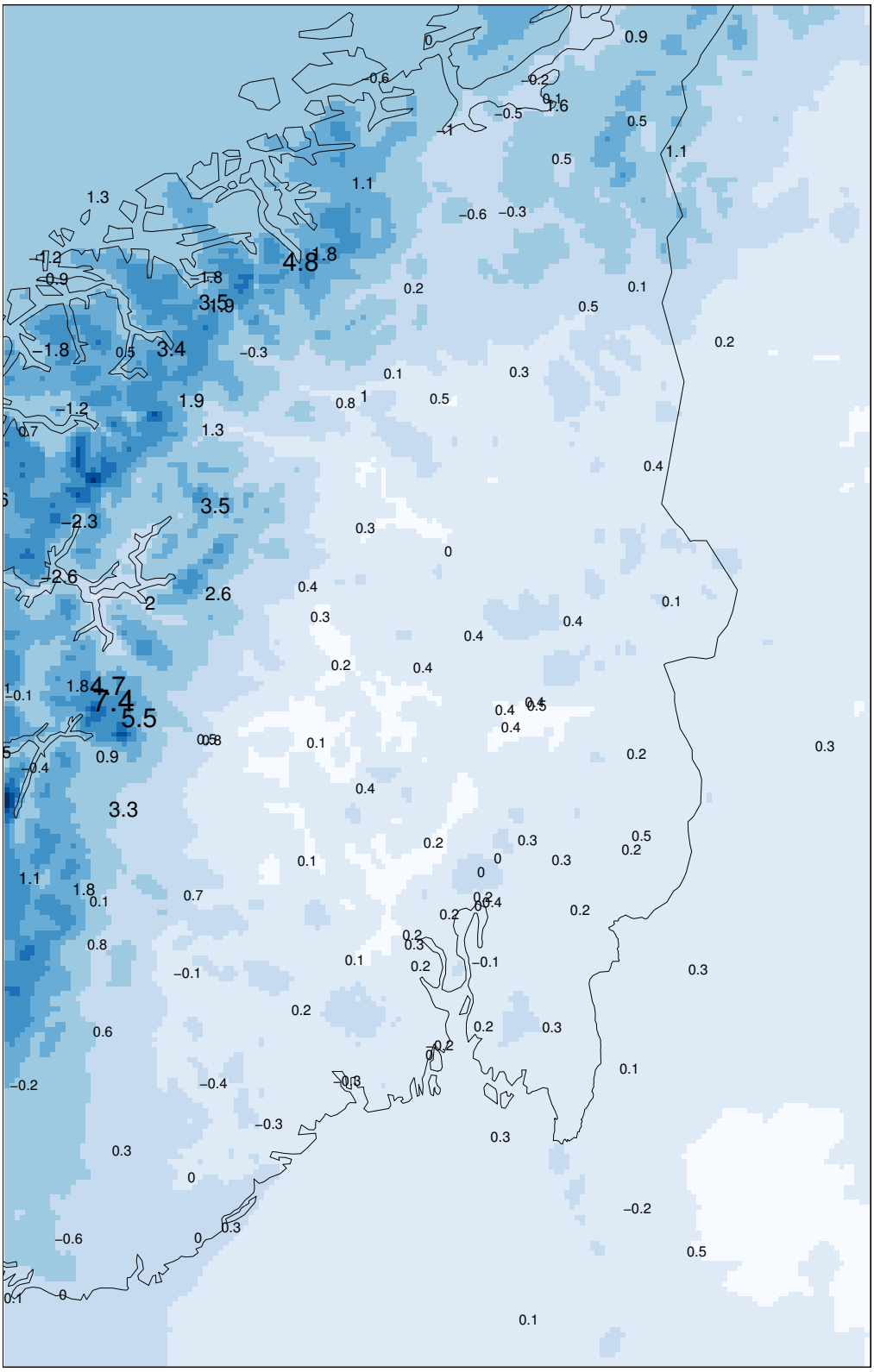
SDE at observing sites
(numbers in black)




Model "climatology" 01.12.2016 – 28.02.2017

MEPSctrl 00+30

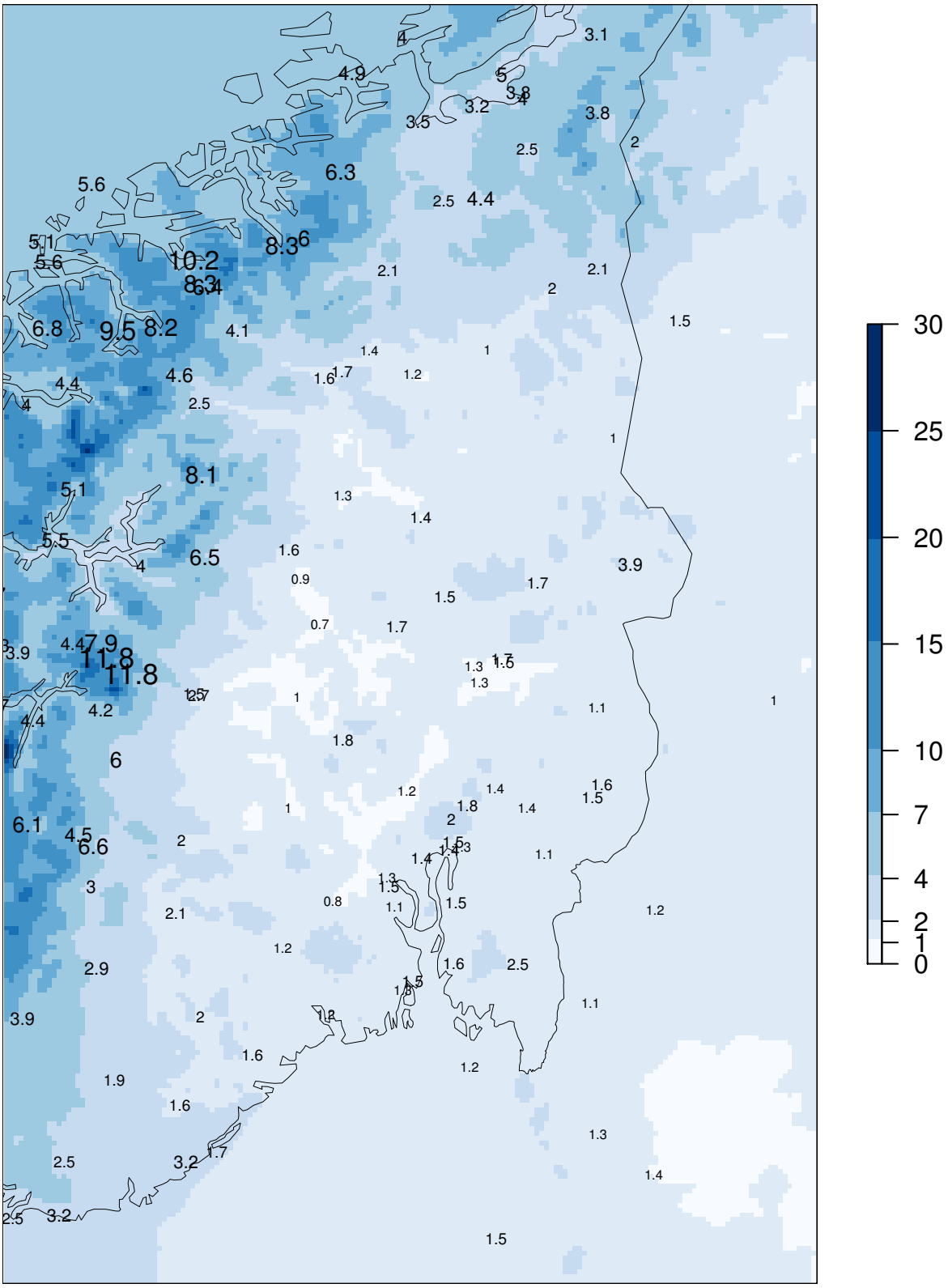
ME at observing sites
(numbers in black)




Model "climatology" 01.12.2016 – 28.02.2017

MEPSctrl 00+30

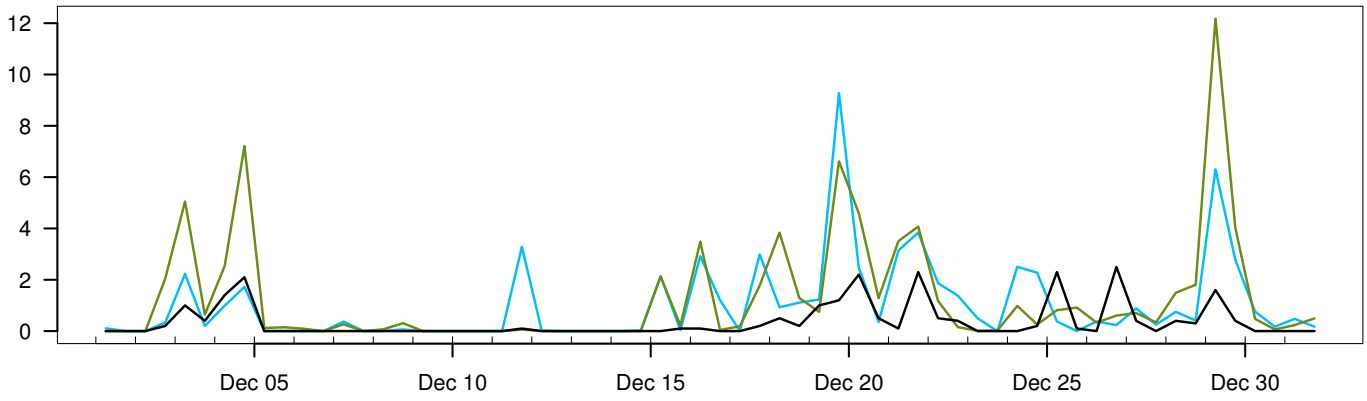
SDE at observing sites
(numbers in black)



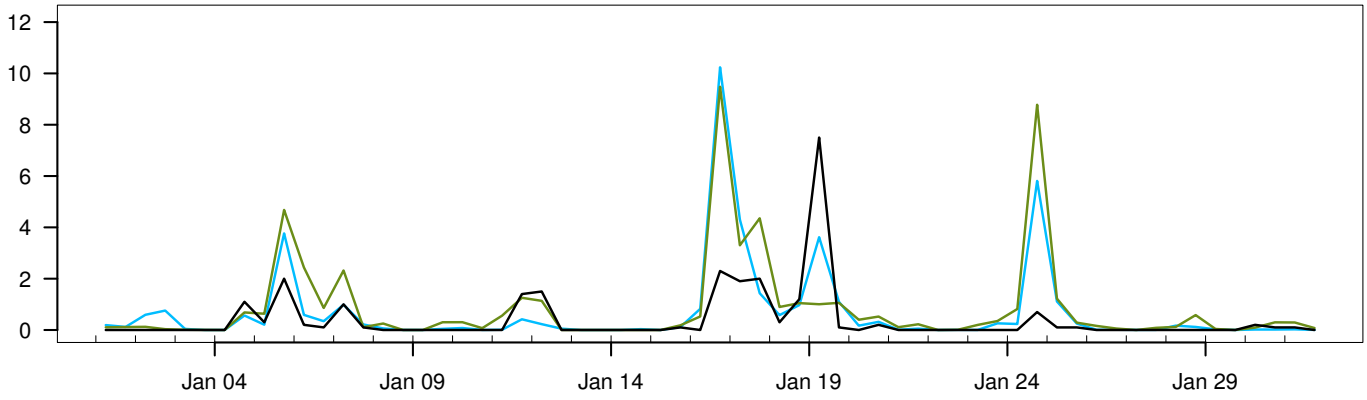

Model "climatology" 01.12.2016 – 28.02.2017

SVALBARD LUFTHAVN

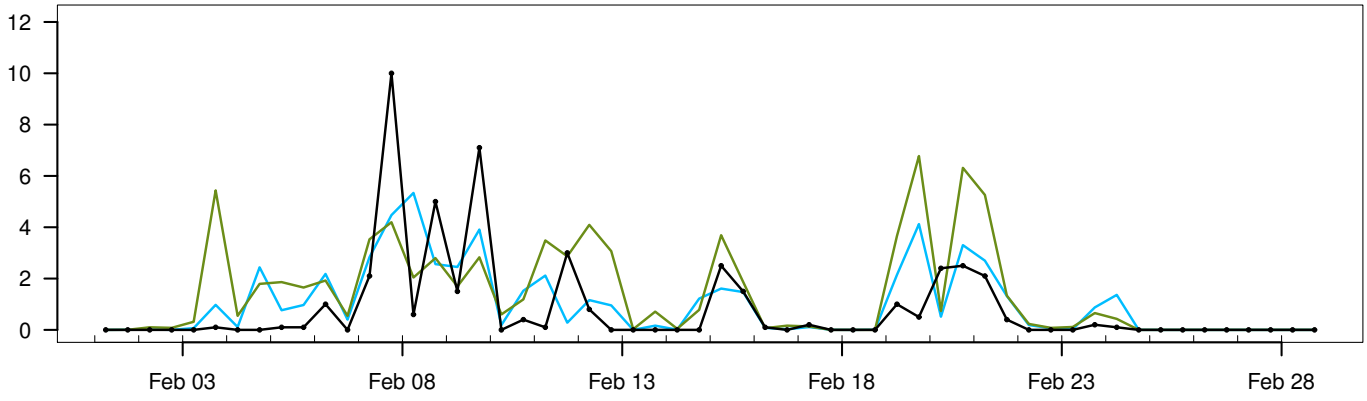
01.12.2016 – 31.12.2016




01.01.2017 – 31.01.2017




01.02.2017 – 28.02.2017



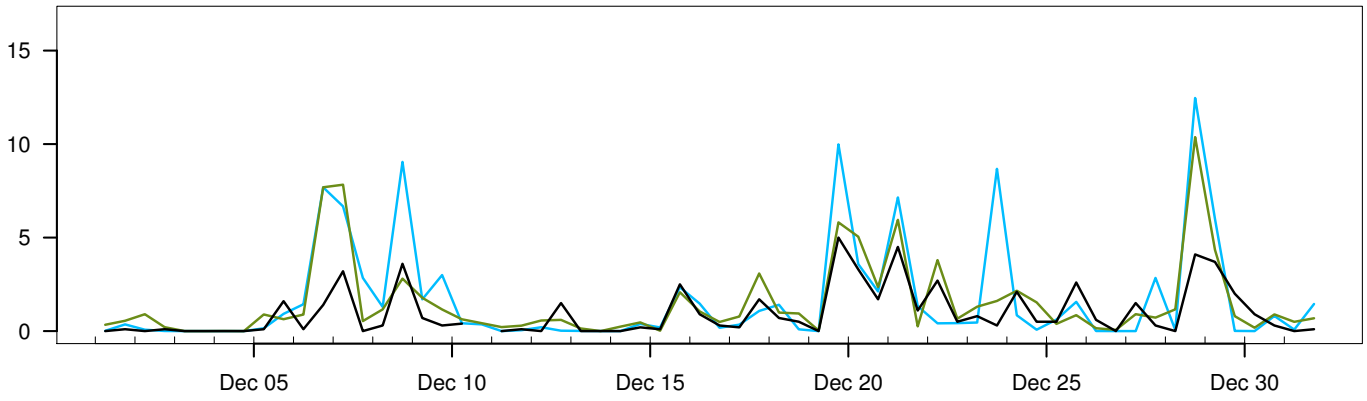

01.12.2016 – 28.02.2017

| | Min | Mean | Max | Std | N |
|---|---|---|---|---|---|
| synop: 06,18 | 0 | 0.5 | 10 | 1.3 | 180 |
| AA25: 12+18,+30 | 0 | 0.9 | 10.2 | 1.6 | 180 |
| ECMWF: 12+18,+30 | 0 | 1.2 | 12.2 | 2 | 180 |

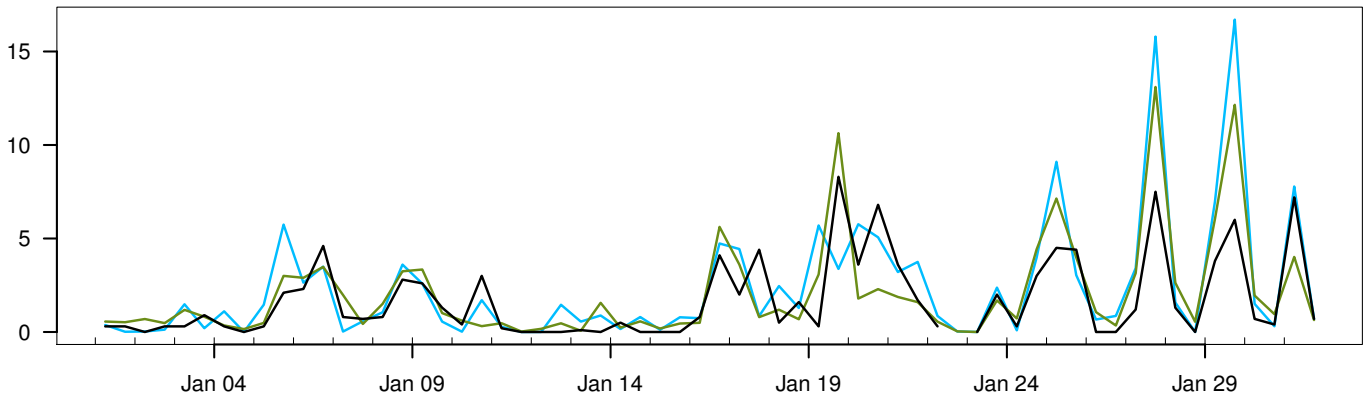
| | ME | SDE | RMSE | MAE | Max.abs.err. | N |
|---|---|---|---|---|---|---|
| AA25 – synop | 0.4 | 1.4 | 1.5 | 0.7 | 8.1 | 180 |
| ECMWF – synop | 0.7 | 1.8 | 1.9 | 0.9 | 10.6 | 180 |

BJØRNØYA

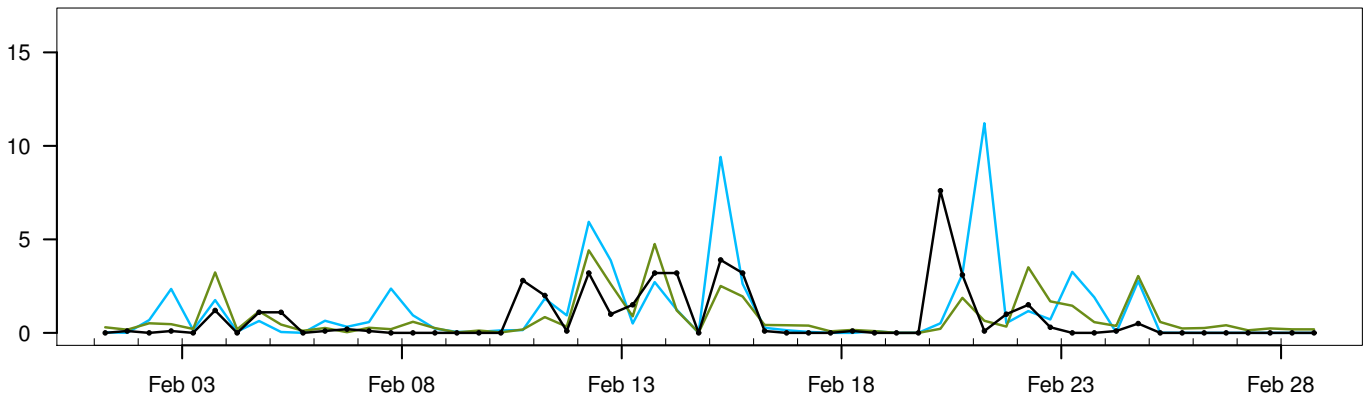
01.12.2016 – 31.12.2016




01.01.2017 – 31.01.2017




01.02.2017 – 28.02.2017



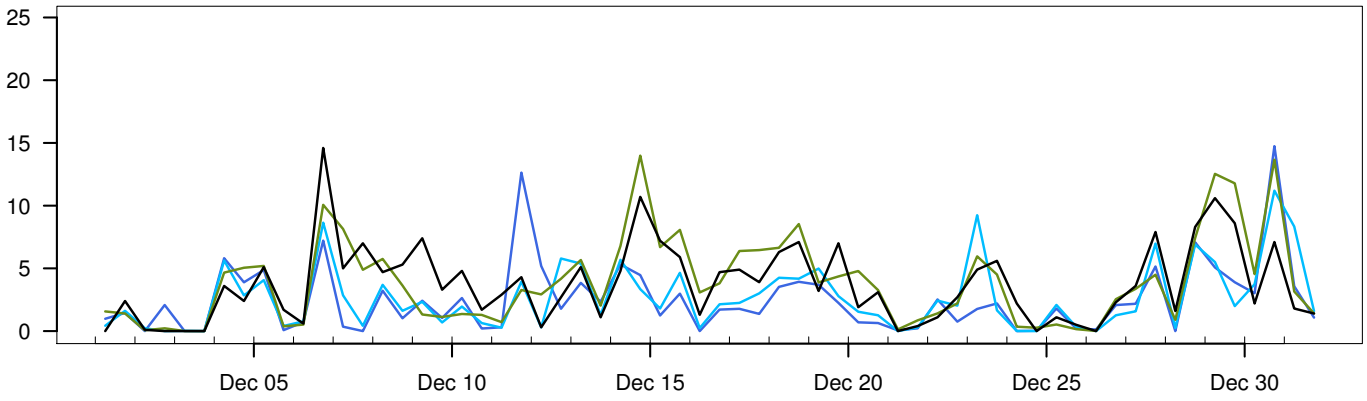

01.12.2016 – 28.02.2017

| | Min | Mean | Max | Std | N |
|---|---|---|---|---|---|
| synop: 06,18 | 0 | 1.2 | 8.3 | 1.7 | 178 |
| AA25: 12+18,+30 | 0 | 1.8 | 16.7 | 2.9 | 180 |
| ECMWF: 12+18,+30 | 0 | 1.5 | 13.1 | 2.2 | 180 |

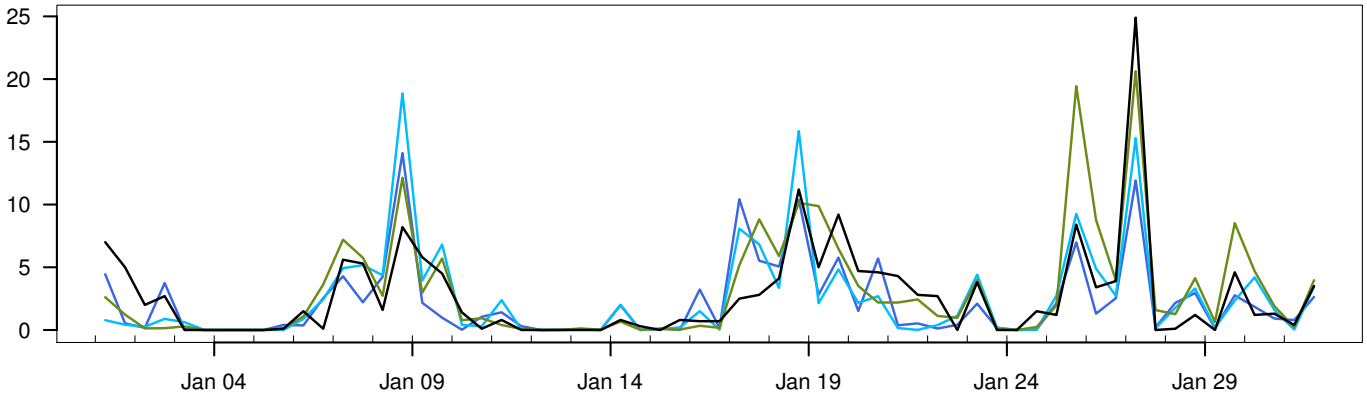
| | ME | SDE | RMSE | MAE | Max.abs.err. | N |
|---|---|---|---|---|---|---|
| AA25 – synop | 0.6 | 2.2 | 2.3 | 1.2 | 11.1 | 178 |
| ECMWF – synop | 0.3 | 1.5 | 1.5 | 0.9 | 7.4 | 178 |

TROMSØ

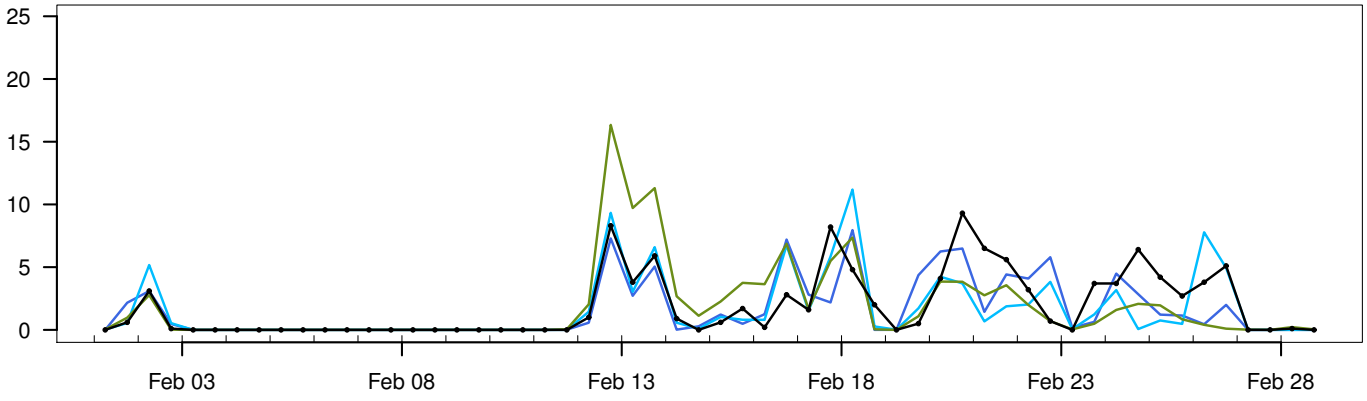
01.12.2016 – 31.12.2016




01.01.2017 – 31.01.2017




01.02.2017 – 28.02.2017



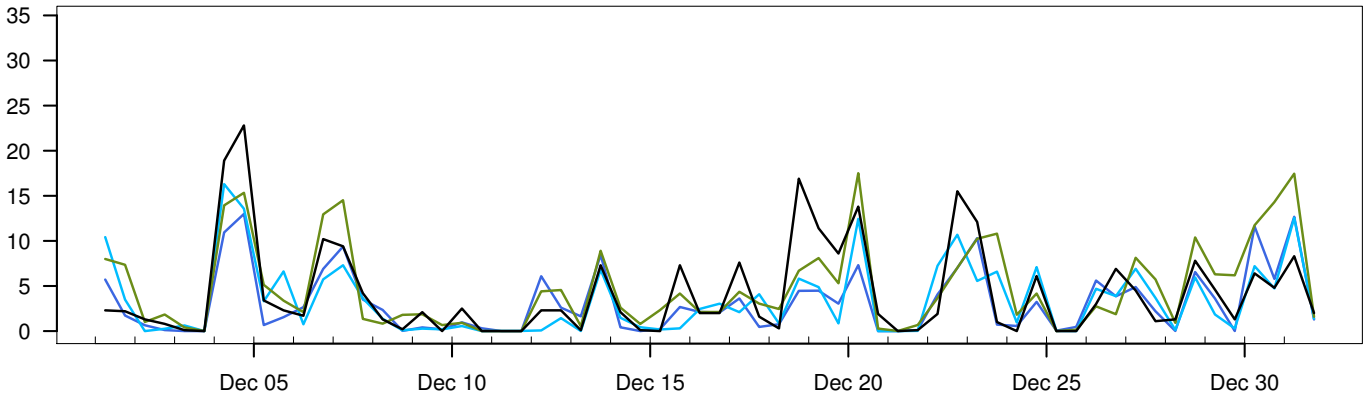

01.12.2016 – 28.02.2017

| | Min | Mean | Max | Std | N |
|---|---|---|---|---|---|
| synop: 06,18 | 0 | 2.8 | 24.9 | 3.3 | 180 |
| MEPSctrl: 12+18,+30 | 0 | 2.1 | 14.7 | 2.8 | 180 |
| AA25: 12+18,+30 | 0 | 2.3 | 18.8 | 3.1 | 180 |
| ECMWF: 12+18,+30 | 0 | 3 | 20.6 | 3.8 | 180 |

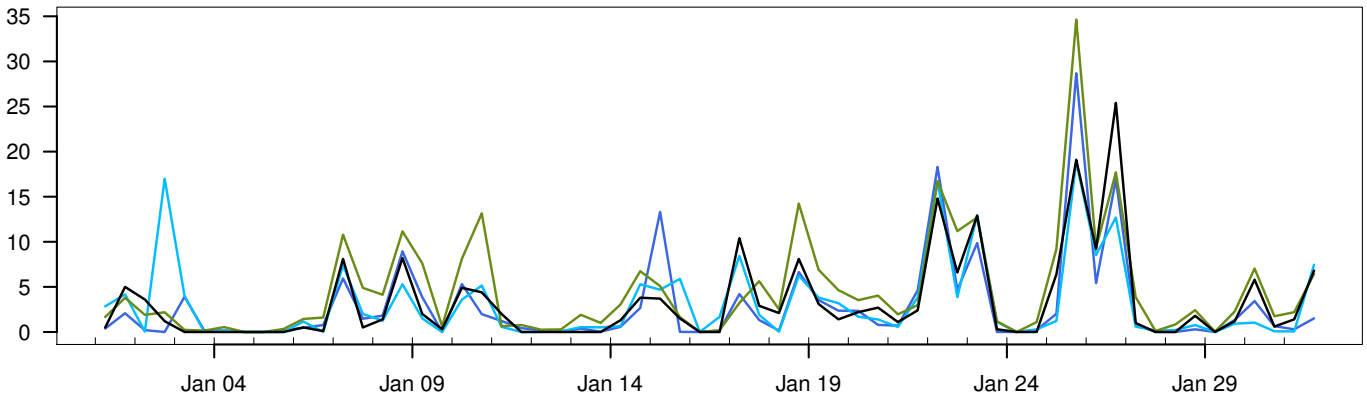
| | ME | SDE | RMSE | MAE | Max.abs.err. | N |
|---|---|---|---|---|---|---|
| MEPSctrl – synop | –0.7 | 2.6 | 2.7 | 1.8 | 13 | 180 |
| AA25 – synop | –0.5 | 2.5 | 2.6 | 1.6 | 10.6 | 180 |
| ECMWF – synop | 0.2 | 2.3 | 2.3 | 1.5 | 11 | 180 |

BODØ VI

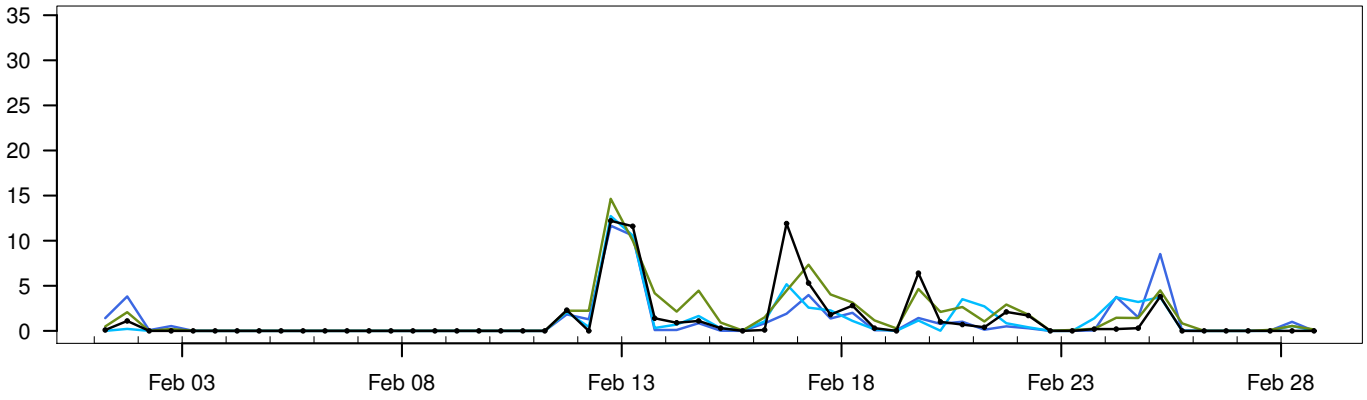
01.12.2016 – 31.12.2016




01.01.2017 – 31.01.2017




01.02.2017 – 28.02.2017

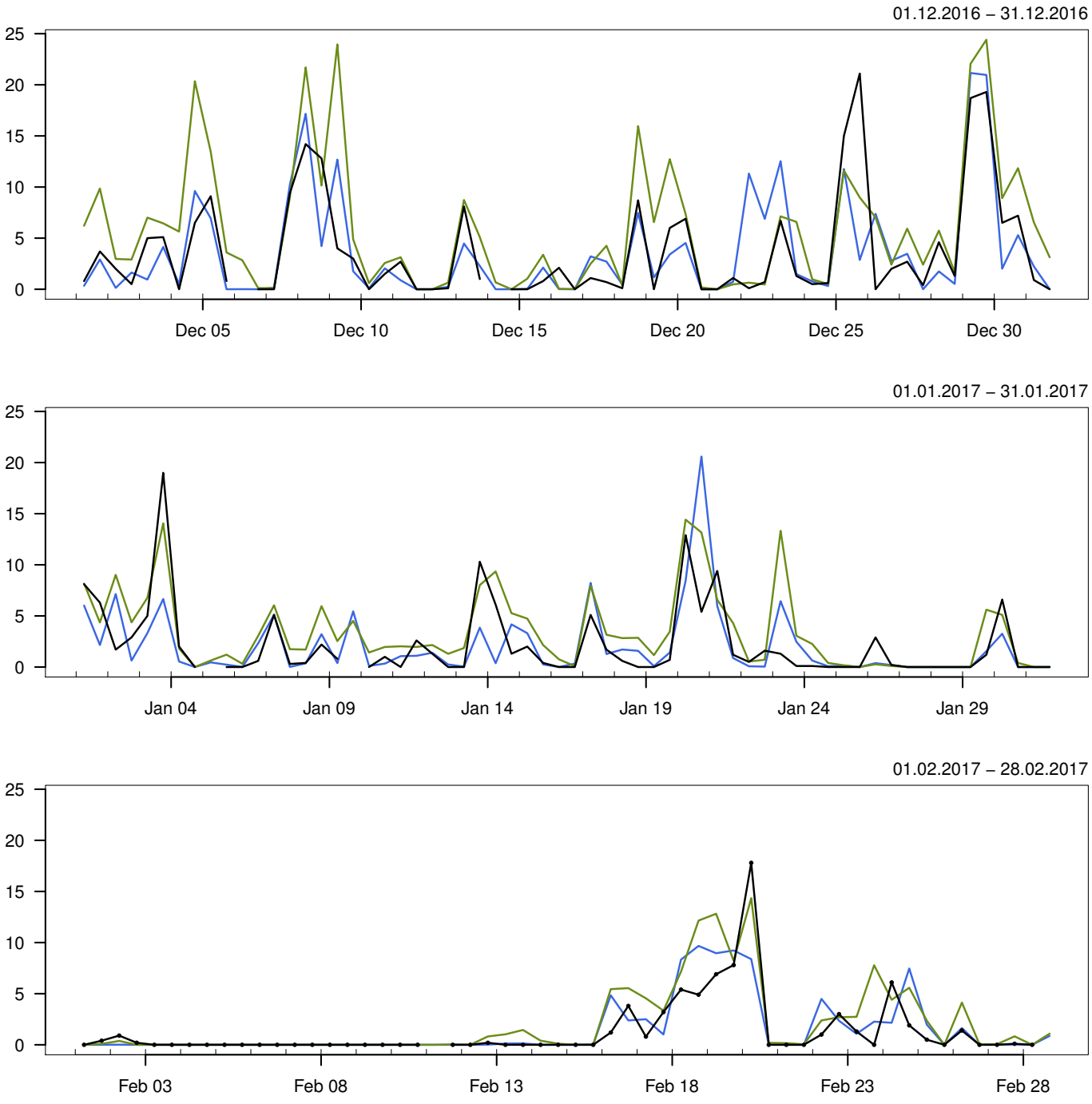



01.12.2016 – 28.02.2017

| | Min | Mean | Max | Std | N |
|---|---|---|---|---|---|
| synop: 06,18 | 0 | 3 | 25.4 | 4.6 | 180 |
| MEPSctrl: 12+18,+30 | 0 | 2.4 | 28.7 | 4 | 180 |
| AA25: 12+18,+30 | 0 | 2.6 | 18.9 | 3.9 | 180 |
| ECMWF: 12+18,+30 | 0 | 3.8 | 34.6 | 4.9 | 180 |

| | ME | SDE | RMSE | MAE | Max.abs.err. | N |
|---|---|---|---|---|---|---|
| MEPSctrl – synop | –0.6 | 2.7 | 2.7 | 1.5 | 12.4 | 180 |
| AA25 – synop | –0.4 | 2.8 | 2.8 | 1.5 | 15.8 | 180 |
| ECMWF – synop | 0.8 | 2.9 | 3 | 1.8 | 15.5 | 180 |

ØRLAND III



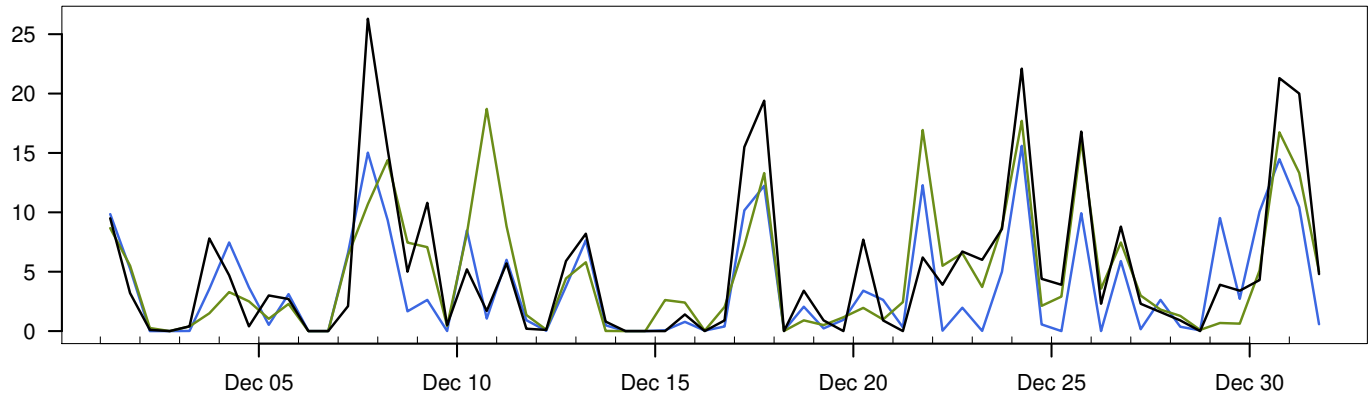

01.12.2016 – 28.02.2017

| | Min | Mean | Max | Std | N |
|---|---|---|---|---|---|
| synop: 06,18 | 0 | 2.5 | 21.1 | 4.2 | 174 |
| MEPSctrl: 12+18,+30 | 0 | 2.4 | 21.2 | 4 | 180 |
| ECMWF: 12+18,+30 | 0 | 3.8 | 24.4 | 5 | 180 |

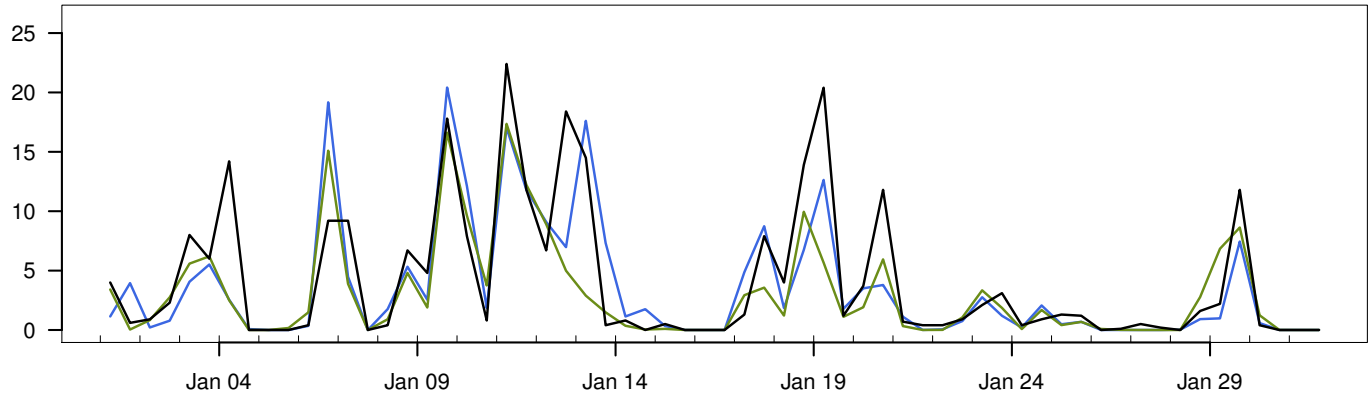
| | ME | SDE | RMSE | MAE | Max.abs.err. | N |
|---|---|---|---|---|---|---|
| MEPSctrl – synop | 0 | 3.2 | 3.2 | 1.6 | 18.2 | 174 |
| ECMWF – synop | 1.5 | 3.1 | 3.4 | 2 | 20 | 174 |

BERGEN – FLORIDA

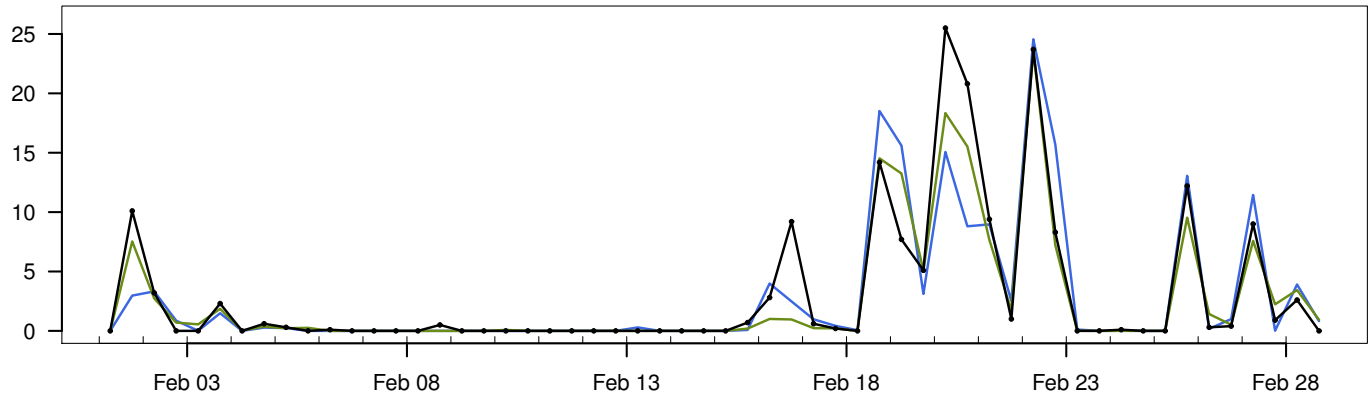
01.12.2016 – 31.12.2016




01.01.2017 – 31.01.2017




01.02.2017 – 28.02.2017

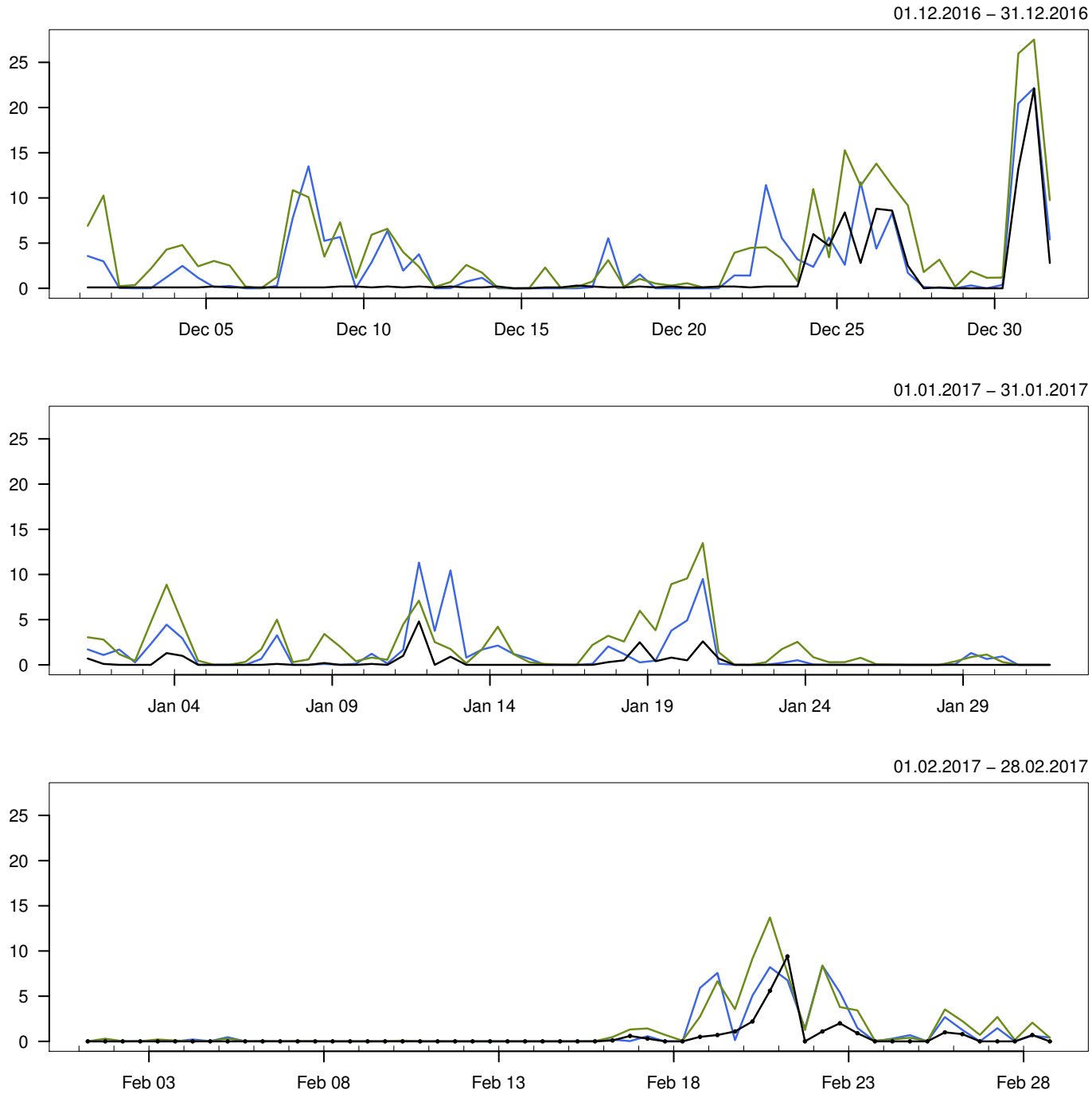



01.12.2016 – 28.02.2017

| | Min | Mean | Max | Std | N |
|---|---|---|---|---|---|
| synop: 06,18 | 0 | 4.2 | 26.3 | 6.1 | 180 |
| MEPSctrl: 12+18,+30 | 0 | 3.4 | 24.6 | 5.1 | 180 |
| ECMWF: 12+18,+30 | 0 | 3.5 | 23.6 | 4.9 | 180 |

| | ME | SDE | RMSE | MAE | Max.abs.err. | N |
|---|---|---|---|---|---|---|
| MEPSctrl – synop | –0.8 | 3.4 | 3.5 | 2.1 | 12 | 180 |
| ECMWF – synop | –0.7 | 3.4 | 3.5 | 1.8 | 17 | 180 |

LÆRDAL IV



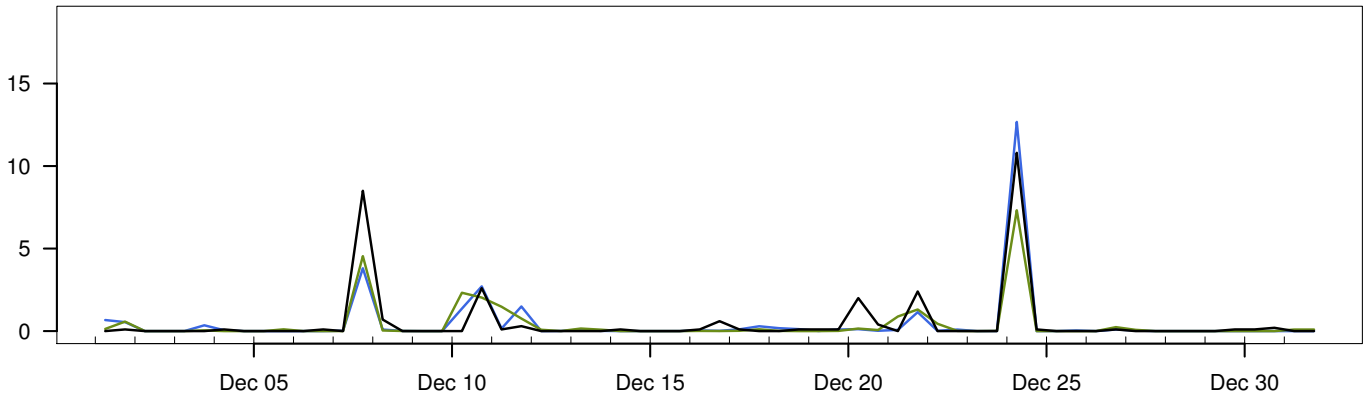

01.12.2016 – 28.02.2017

| | Min | Mean | Max | Std | N |
|---|---|---|---|---|---|
| synop: 06,18 | 0 | 0.7 | 22.1 | 2.4 | 180 |
| MEPSctrl: 12+18,+30 | 0 | 1.8 | 22.2 | 3.4 | 180 |
| ECMWF: 12+18,+30 | 0 | 2.6 | 27.5 | 4.2 | 180 |

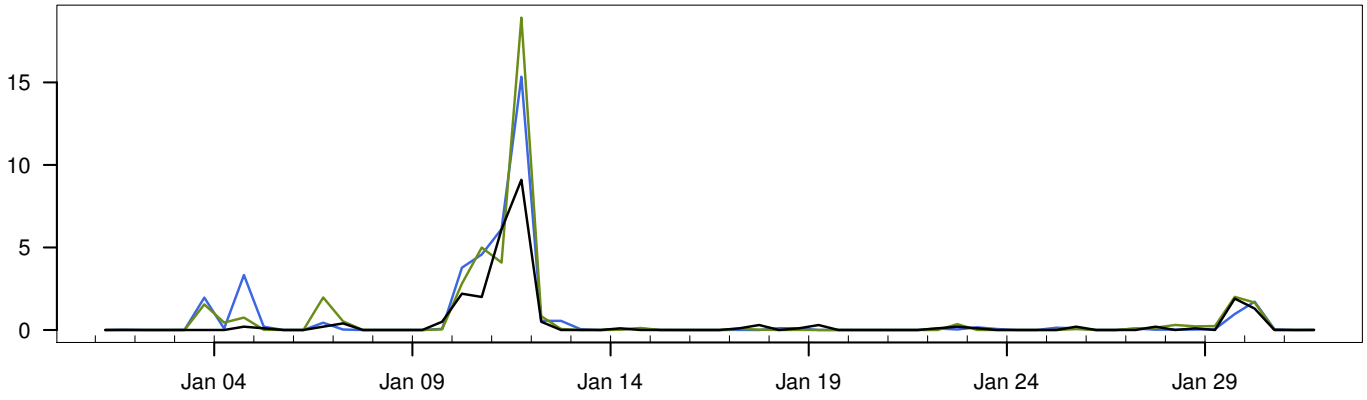
| | ME | SDE | RMSE | MAE | Max.abs.err. | N |
|---|---|---|---|---|---|---|
| MEPSctrl – synop | 1 | 2.4 | 2.6 | 1.3 | 13.4 | 180 |
| ECMWF – synop | 1.9 | 2.7 | 3.3 | 1.9 | 12.8 | 180 |

GARDERMOEN

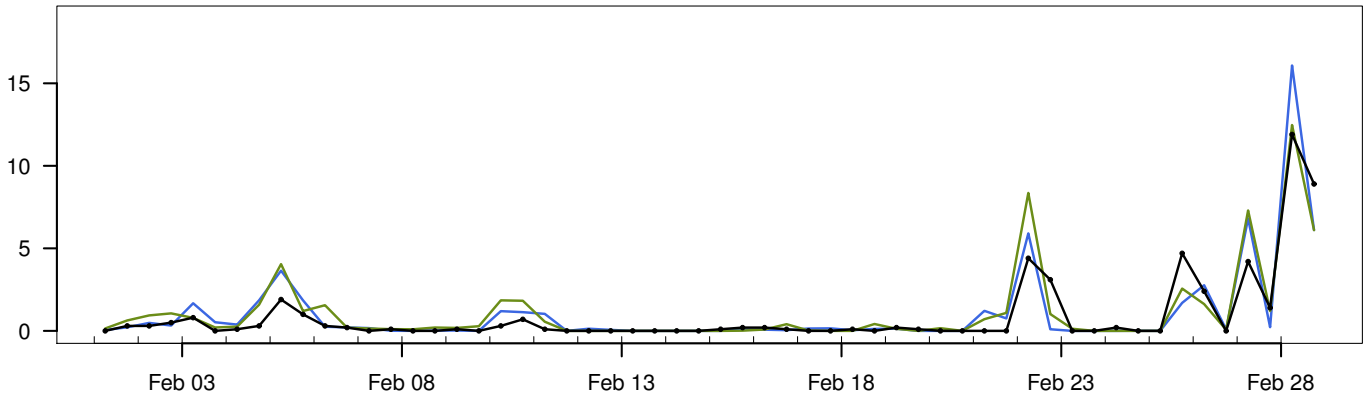
01.12.2016 – 31.12.2016




01.01.2017 – 31.01.2017




01.02.2017 – 28.02.2017



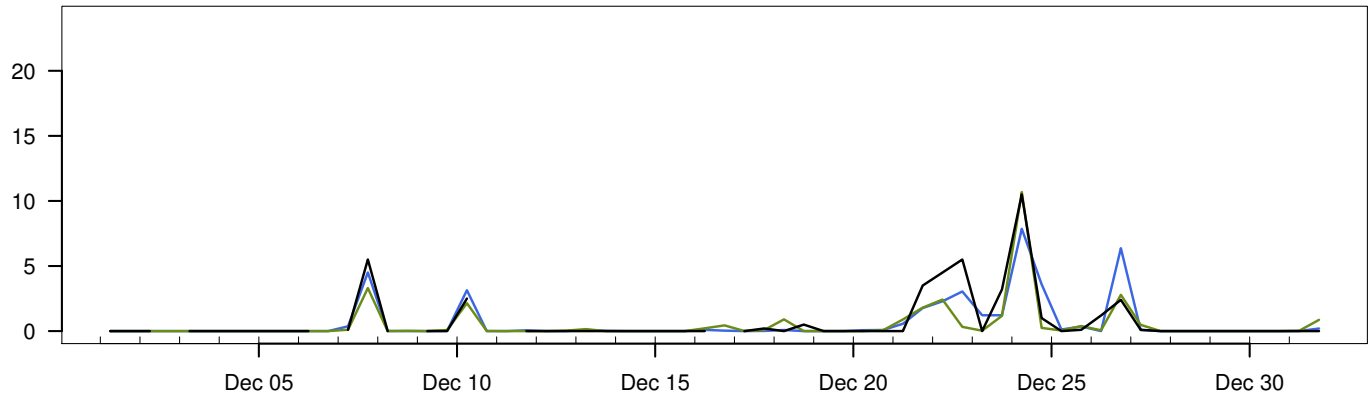

01.12.2016 – 28.02.2017

| | Min | Mean | Max | Std | N |
|---|---|---|---|---|---|
| synop: 06,18 | 0 | 0.6 | 11.9 | 1.8 | 180 |
| MEPSctrl: 12+18,+30 | 0 | 0.7 | 16.1 | 2.2 | 180 |
| ECMWF: 12+18,+30 | 0 | 0.7 | 18.9 | 2.1 | 180 |

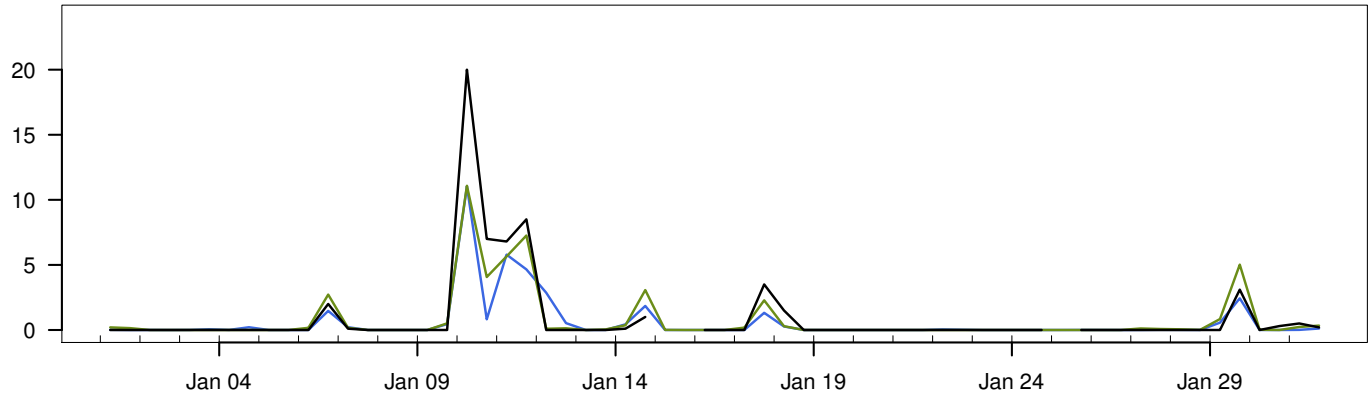
| | ME | SDE | RMSE | MAE | Max.abs.err. | N |
|---|---|---|---|---|---|---|
| MEPSctrl – synop | 0.1 | 1 | 1 | 0.4 | 6.2 | 180 |
| ECMWF – synop | 0.1 | 1.1 | 1.1 | 0.4 | 9.8 | 180 |

NELAUG

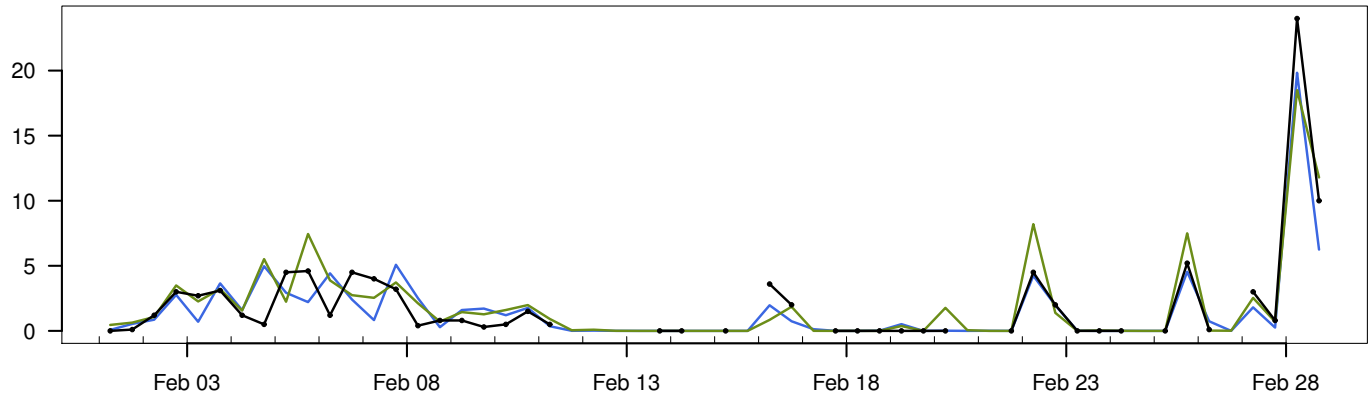
01.12.2016 – 31.12.2016




01.01.2017 – 31.01.2017




01.02.2017 – 28.02.2017




01.12.2016 – 28.02.2017

| | Min | Mean | Max | Std | N |
|---|---|---|---|---|---|
| synop: 06,18 | 0 | 1.2 | 24 | 3 | 160 |
| MEPSctrl: 12+18,+30 | 0 | 0.9 | 19.8 | 2.2 | 180 |
| ECMWF: 12+18,+30 | 0 | 1 | 18.5 | 2.4 | 180 |

| | ME | SDE | RMSE | MAE | Max.abs.err. | N |
|---|---|---|---|---|---|---|
| MEPSctrl – synop | −0.2 | 1.4 | 1.4 | 0.6 | 9 | 160 |
| ECMWF – synop | −0.1 | 1.3 | 1.3 | 0.6 | 8.9 | 160 |