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Verification of Operational Weather Prediction Models December 2021 to February 2022

Lene Østvand, Mariken Homleid, Gunnar Noer and Frank Thomas Tveter

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More information...

Verification results are also available on internal web pages

- https://metcoop-comm.smhi.se/ and https://metcoop.smhi.se/ - MetCoOp Web Tools - including verification and observation monitoring
- https://harp.smhi.se/ - MetCoOp verification visualized with harp
- http://verif/vmap/ - timeseries and windroses - on Google map
- https://hirlam.org/trac/wiki/CommunicationWithUsers - HARMONIE quarterly reports

About this report

This verification report indicates the quality of the main operational weather forecasting models used at the Norwegian Meteorological Institute for the period indicated. Another purpose of the verification report series is to provide a stable source of information suitable for monitoring longer trends in forecasting quality for interested readers. The report complements the verification and monitoring performed on individual models. Each model is monitored and developed according to the scientific method, where changes are only introduced when they can document a better likely prediction skill. Such documentation is available as research papers, consortium news, and presentations at team-, syndicate- and consortium-meetings. The skill of the forecasting service in severe weather situations is also documented with special emphasis on forecast failures, in order to learn from them and improve the system.

The report includes verification results for 3 Numerical Weather Prediction (NWP) models; MetCoOp ensemble system (MEPS) covering Norway, Sweden, Finland, Denmark and the Baltic states, AROME-Arctic covering Svalbard, Novaja Semlja, Frans Josefs land and the Northern part of Scandinavia and the global ECMWF. The models are further described in the Models section. The variables verified are mean sea level pressure, temperature, wind speed and precipitation. The results are grouped by variable. A short summary of the results and cases studies by forecasters are also included.

Verification results are shown for different groups of stations: Norwegian, Svalbard and North Scandinavian. For temperature there are additional groups with Norwegian coastal and Norwegian inland stations, for wind speed Norwegian coastal and Norwegian mountainous stations, and for precipitation coastal stations, stations more than 500 m above sea level, and stations with daily mean precipitation > 4 mm. For MEPSctrl statistics at the observing sites are also visualized on maps with model climatology. The text size of the statistics increases with the value. Time series with observations and available models are included for selected stations. Post processed variables are compared with MEPSctrl.

Models

The following Numerical Weather Prediction (NWP) models are verified in this report. The verification measures are plotted for each model with the colors indicated in the table below.

ECMWF	Global model (IFS) at the European Centre for Medium-Range Weather Forecasts. From 26 January 2010 horizontal resolution approximately 16×16 km^2. From 8 March 2016 cycle 41r2 with horizontal resolution about 9 km. ECMWF is available about 5 hours later than models run at MET.
MetCoOp ensemble system (MEPSctrl)	MEPS has 30 lagged ensemble members, constructed from 5 members updated hourly and run up to 66 hours. Only member 0, the control, is verified in this report. MEPS is based on HARMONIE with AROME physics and non-hydrostatic dynamics, horizontal resolution defined by a 2.5×2.5 km^2 grid. Experimental with cycle 37h1.1 from November 2012, on Yr since 1 October 2013, operational since March 2014, cycle 38h1.2 from December 2014, cycle 40h1.1 since November 2016 and cycle 43h2.1 from 23 March 2021. MEPS is run in cooperation with Swedish Meteorological and Hydrological Institute (SMHI), Finnish Meteorological Institue (FMI) and Estonian Environment Agency (ESTEA).
AROME-Arctic (AA25)	HARMONIE with AROME physics, horizontal resolution defined by a 2.5×2.5 km^2 grid. Experimental with cycle 38h1.2 from 15 October 2015, on Yr from 14 December 2016, cycle 40h1.1 since June 2017, cycle 43h2.1 since 5 May 2021.

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.

A change log for HARMONIE AROME is available on internal webpages
https://metcoop.smhi.se/dokuwiki/nwp/metcoop/changelog/start.

Post processed forecasts

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

The met nordic temperature forecasts, YrPP in the plots, are post-processed forecasts based on the latest MEPS control run. The MEPS temperature forecasts are first downscaled to 1 km resolution using the model lapse rate in a neighbourhood. The forecasts are then bias corrected using a fine scale 1 km temperature analysis as reference. The temperature analysis is based on multiple data sources using both conventional and citizen observations.

10 m wind speed is post-processed by downscaling to 1 km resolution to better represent local topography, and called YrPP.

YrPP is plotted with the color below.

The HARMONIE system

HARMONIE is the acronym for HIRLAM's meso-scale forecast system (Hirlam Aladin Regional/Meso-scale Operational NWP In Europe). For documentation see
- *The HARMONIE-AROME Model Configuration in the ALADIN-HIRLAM NWP System* by Bengtsson et al. 2017, available at https://doi.org/10.1175/MWR-D-16-0417.1
- *AROME-MetCoOp: A Nordic Convective-Scale Operational Weather Prediction Model* by Müller et al. 2017, available at https://doi.org/10.1175/WAF-D-16-0099.1

More documentation is also available on http://www.cnrm.meteo.fr/gmapdoc/ and http://hirlam.org/.

This section presents some of the main components and setups that are used at MET.

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 and 65 vertical layers, and from April 2015 1.3 km and 90 vertical layers.

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 uses SURFEX in all their configurations. Surface modelling and assimilation 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 UTC as there are very few snow depth observations at 00, 03, 09, 12, 15, 18 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 ocean models run at SMHI; first HIROMB and since 26 April 2017 NEMO.

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, IASI 26 November 2015 and ASCAT 17 March 2016.

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

In the formula for COR the following definitions are used

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

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

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

For wind direction the probability density function (PDF) is used to show the distribution of observed and forecast wind directions. The PDF used here is a kernel density estimate, which is a smoothed version of the histogram.

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. From June 1 2021, both the model wind speed and the post-processed wind speed are verified against mean wind observations, FF. The model wind gust is verified against the observed wind gust, FG. FF and FG are defined as follows:

- FF: Wind speed (10 meters above ground) - defined as the mean value for the last 10 minutes before the time of the observation.
- FG: Gust wind speed (10 m above ground) - defined as highest gust wind speed (3 second mean) the last 10 minutes before the time of the observation.

Summary of the results

Summarized statistics show that ECMWF in general forecasts sea level pressure better than MEPSctrl/AA25, but the errors are small for both.

Temperature is on average better forecast by MEPSctrl/AA25 than ECMWF. ECMWF tends to underestimate the temperature, while AA25 shows too warm forecasts both for Svalbard stations and North Scandinavian stations. MEPSctrl also shows somewhat too warm forecasts for the North Scandinavian stations, but not a clear bias for the Norwegian stations. Still, the errors are small, indicating that the timing of the temperature changes is generally good. The upgrade of MEPS from cycle 40 to cycle 43 in March 2021 was not expected to affect winter temperatures. But since the previous winter, two additional changes have been introduced, to improve the performance in stable situations and to increase the effect of thin ice clouds on the radiation. The first change leads to lower temperatures in stable situations, on average reduced 2m temperature, while the effect of ”the radiation change” is higher temperatures in some situations, on average increased 2m temperature. While both changes have been introduced in MEPS, only the radiation change has been introduced in AROME-Arctic, explaining why AROME-Arctic on average is warmer than MEPS when averaged over North Scandinavian stations. The temperature forecast is further improved by post processing, particularly for the shortest lead times. The improvement is larger for inland stations than coastal stations, which have less variation in temperature and smaller errors than inland stations for both MEPSctrl and post processed forecasts. However, the post processed temperature shows a slightly warm bias. Since the mean absolute error is smaller after post processing, this indicates that MEPSctrl has on average larger errors, but in both directions.

For wind speed and precipitation, a larger number of verification scores is used to assess model quality, including threshold statistics.

The wind speed is challenging to evaluate. MEPSctrl clearly performs better than ECMWF over land, and particularly in the mountains, where ECMWF underestimates the speed considerably as seen in the monthly mean error and mean absolute error. The threshold scores indicate that lower wind speeds are better forecast than higher wind speeds for all models. The near surface wind speeds are affected by the upgrade to cycle 43 both by modifications in the turbulence scheme and by the physiography upgrade. ECOCLIMAP Second Generation has new tree heights and a more ”binary” separation between patch 1 (low vegetation) and 2 (trees). The largest effect of the change is seen at coastal stations with a small increase on average. The probability distribution of wind direction and time series of wind speed and direction reveals systematic errors in e.g. wind direction at some stations, e.g. Svalbard, but also impressing results at many stations, e.g. Sletnes, Ørland and Finsevatn. The post processing of wind speed was changed on 1 June 2021 by downscaling to 1km resolution to better represent local topography. The change implies that the post processed wind speed represents the mean wind speed rather than the maximum mean wind speed as before this change was introduced. The mean error and mean absolute error indicate that post processing improves the wind forecast that MEPSctrl to some extent overestimates, while the other scores show almost identical results for MEPSctrl and YrPP.

Precipitation also shows varying results, depending on the amount and location. ECMWF has on average more precipitation than MEPSctrl. Evaluated by skill scores, both models have more errors for both very small amounts and very high amounts, than precipitation in the mid range. MEPSctrl performs better than ECMWF for small amounts and no precipitation.

The models generally perform better during summer than during winter. A possible cause is that storm activity is challenging to predict accurately, and there are often more storms during fall and winter than during summer. Precipitation is an exception from this trend, as summer often comes with convective cases that are challenging to predict. AA25 and MEPSctrl show very similar results, which is expected since both are HARMONIE with AROME physics, horizontal resolution defined by a 2.5×2.5 km^2 grid.

Case studies by forecasters

Case 1. Wind gust inland 19 January 2022

Figure 1 shows wind gust forecast for MEPSctrl. Table 1 shows observed maximum wind gust for different areas. A yellow warning for high wind gusts (figure 2) from north-west was issued for Wednesday afternoon 19 January to Thursday morning 20 January, with gusts from 19-23 m/s. Higher gusts were expected in the mountains.

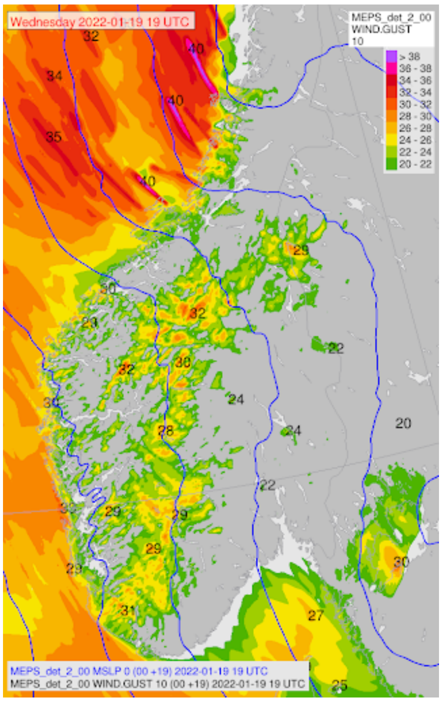


Figure 1: Wind gust forecast for MEPS-ctrl Wednesday 19 January 2022 19 UTC. The numbers are the maximum values from MEPSctrl

Area	**Wind gust (m/s) 19 UTC**
Innlandet	18-31
Oslo	17-24
Viken	19-22, Hemsedal 32
Vestfold og Telemark	17-23, Møsstrand 30
Agder	20-31

Table 1: Observed maximum wind gust for selected areas in the same time period.

Figure 2: Yellow warning for high wind gusts.

Case 2. Precipitation in Trøndelag to Troms 18 January 2022

Table 2 shows the 20 highest values for 24 hour precipitation in Nordland. Figure 3 shows 24 hour precipitation on Wednesday 19 January 06 UTC from MEPSctrl and ECMWF. Tuesday to Wednesday morning high amounts of precipitation were forecast in Nordland and Troms: 30-60 mm during 24 hours, at Helgeland locationwise 60-90 mm. A maximum of 229 mm from stationary precipitation was forecast by MEPSctrl at Saltfjellet. The ECMWF model forecast a maximum of 102 mm.

Toppliste for døgnverdier i Nordland

Viser data for sum(precipitation_amount P1D) for 2022-01-18 06:00 til 2022-01-19 06:00 UTC.
Data er gyldig per 2022-01-20 10:26

	Stasjonsnavn	Fylke	RR	% av normal
1	77230 - MOSJØEN LUFTHAVN (72 moh)	NORDLAND	79.9	46.6%
2	78350 - BARDAL (39 moh)	NORDLAND	79.2	42.2%
3	79220 - SKAMDAL (37 moh)	NORDLAND	73.8	41.7%
4	78370 - BJERKA - VALLA (20 moh)	NORDLAND	63.7	37.2%
5	79700 - STORFORSHEI (110 moh)	NORDLAND	61.3	20.5%
6	86520 - SORTLAND - KLEIVA (14 moh)	NORDLAND	56.7	35.3%
7	78250 - LEIRFJORD (53 moh)	NORDLAND	55.5	28.4%
8	77280 - LAKSFORS (50 moh)	NORDLAND	55.3	35.4%
9	82840 - STYRKESNES - HESTVIKA (27 moh)	NORDLAND	54.5	37.2%
10	78360 - SELJELIA (126 moh)	NORDLAND	52.9	24.0%
11	82650 - VALLJORD (3 moh)	NORDLAND	52.7	32.3%
12	76470 - HØYHOLM (8 moh)	NORDLAND	46.4	26.3%
13	84070 - BJØRKÅSEN (53 moh)	NORDLAND	43.2	31.8%
14	80200 - LURØY (115 moh)	NORDLAND	41.0	14.2%
15	87110 - ANDØYA (10 moh)	NORDLAND	38.3	31.9%
16	82560 - KJERRINGØY - STRANDÅ (20 moh)	NORDLAND	37.8	27.6%
17	85440 - KVITFOSSEN I VÅGAN (3 moh)	NORDLAND	36.5	12.0%
18	79764 - HJARTÅSEN (251 moh)	NORDLAND	35.9	24.0%
19	76530 - TJØTTA (21 moh)	NORDLAND	33.9	26.2%
20	85470 - KONGSMARKA (29 moh)	NORDLAND	33.8	14.2%

Table 2: 24h precipitation in Nordland 18 January 06 UTC to 19 January 06 UTC. The normal referred to in the rightmost column is the monthly normal for each station based on the 1991-2020 reference period.

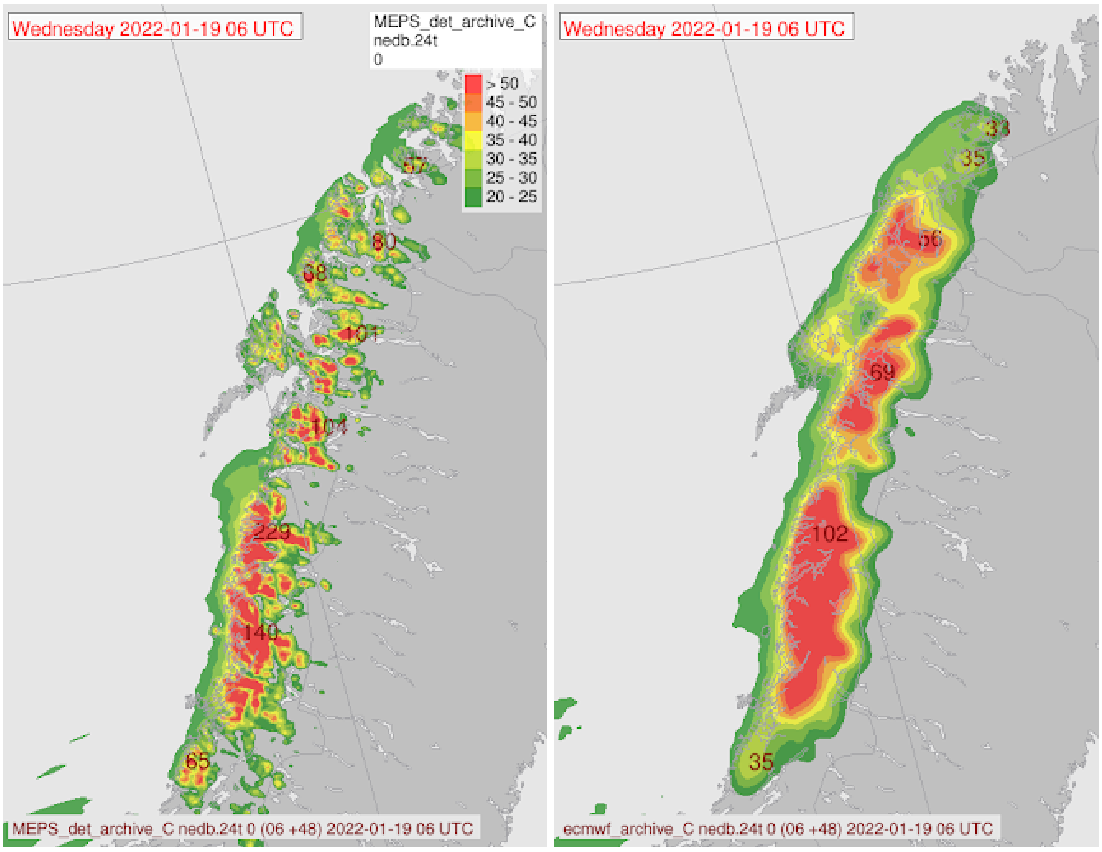


Figure 3: 24h precipitation 19 January 06 UTC from MEPSctrl (left) and ECMWF (right).

Case 3. Precipitation in South of Norway 15 February 2022

Figure 4 shows maximum 24 hour precipitation from models vs observations, from MEPSctrl and ECMWF respectively. MEPSctrl shows slightly too high values, while ECMWF shows somewhat too low values.

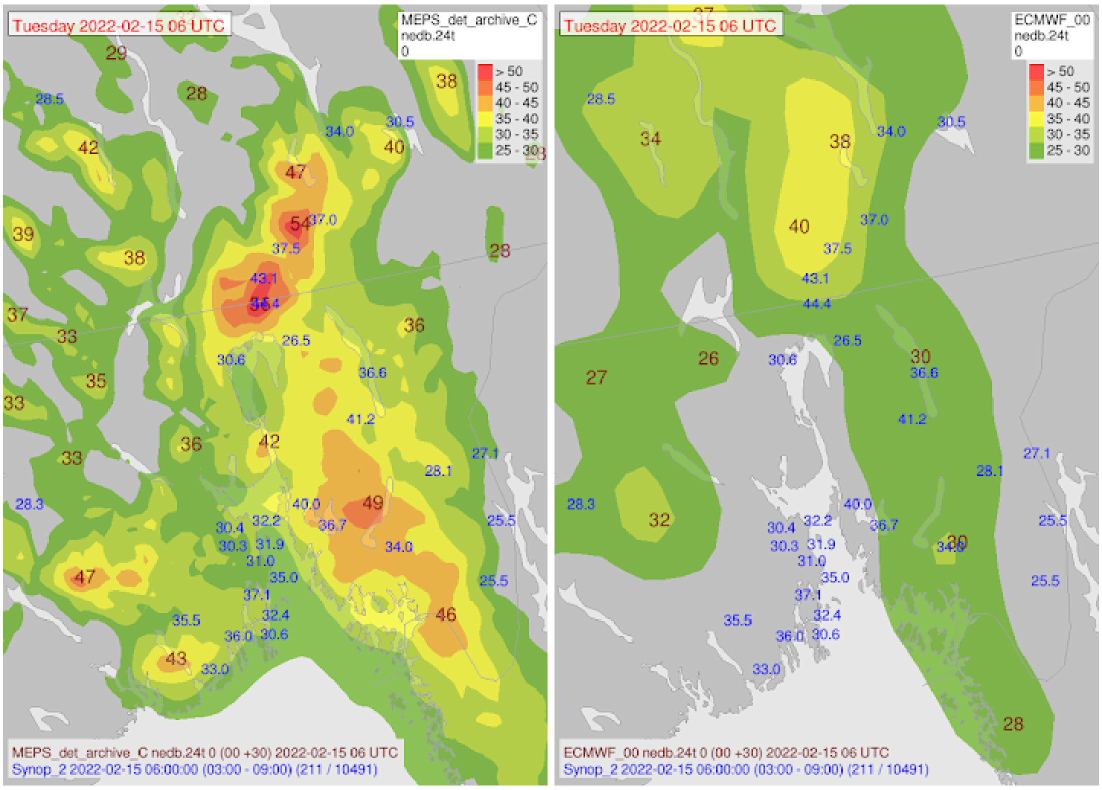
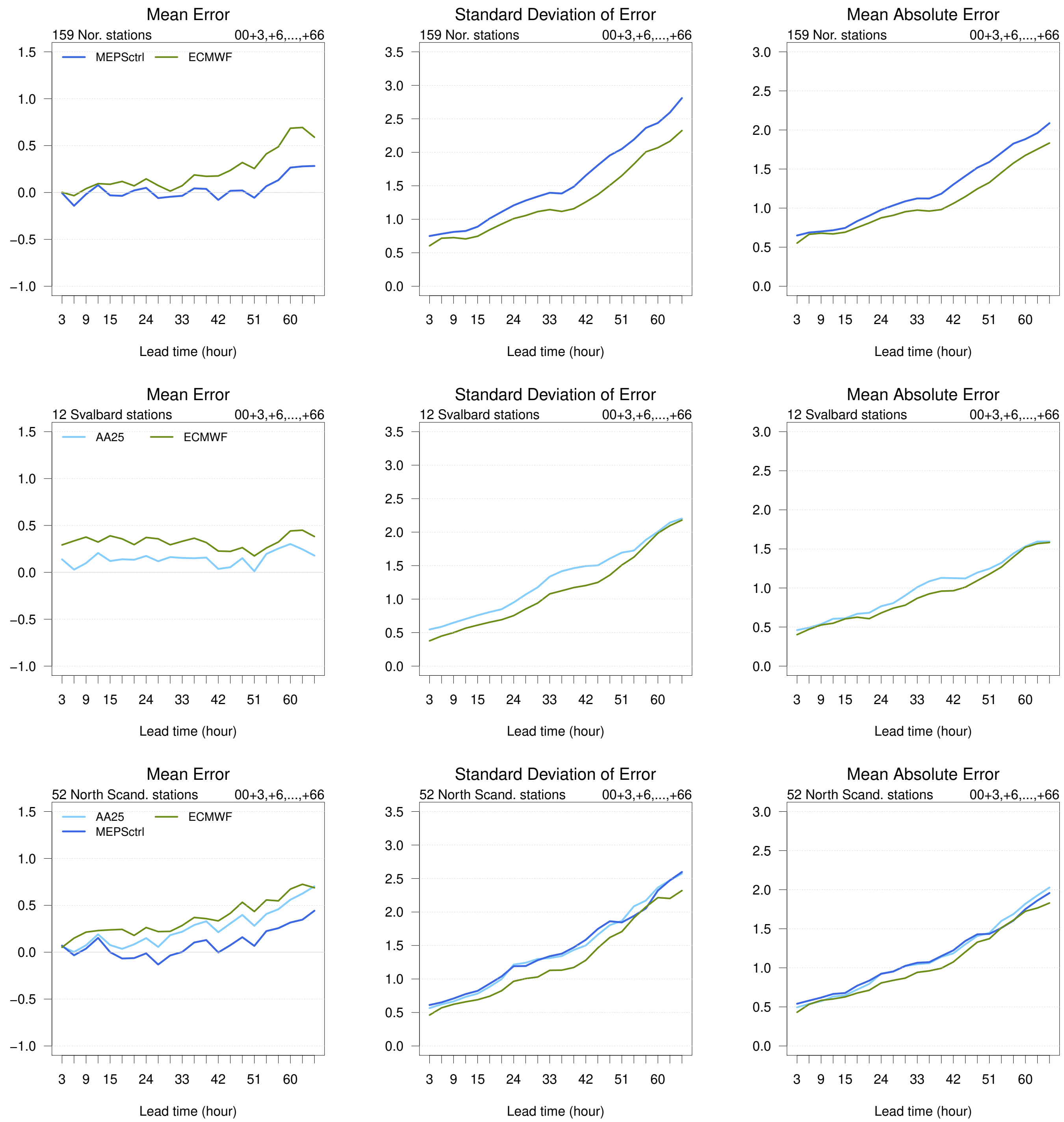


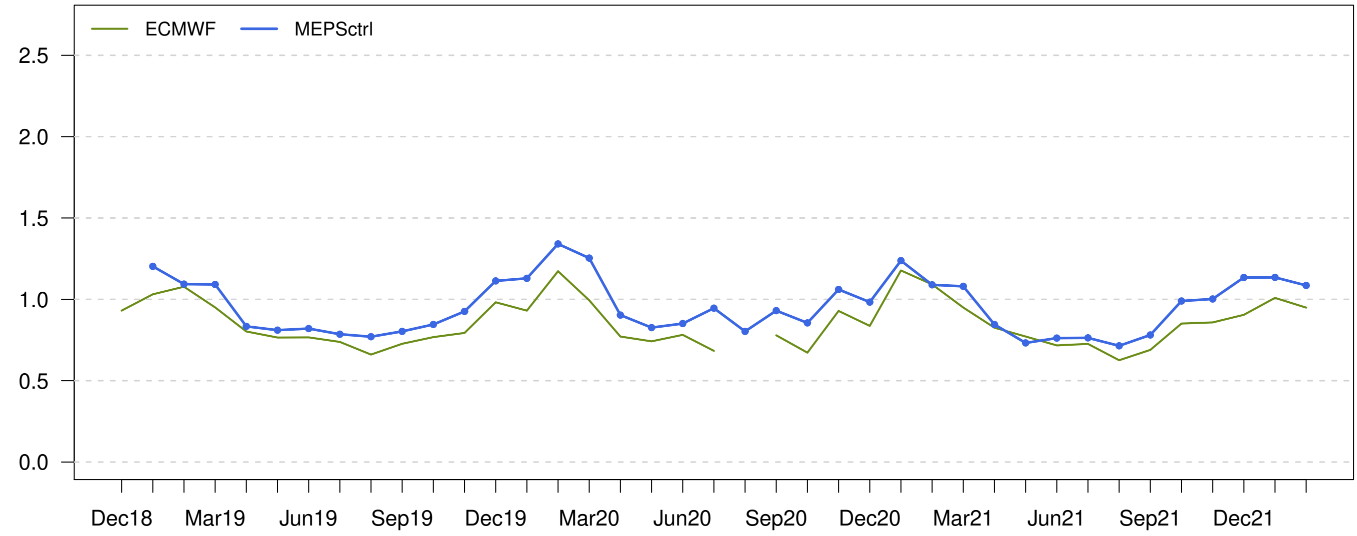
Figure 4: 24h precipitation 15 February 06 UTC from MEPSctrl (left) and ECMWF (right). Maxumum forecast values are shown in red, and 24h observations are shown in blue.

Summarized statistics

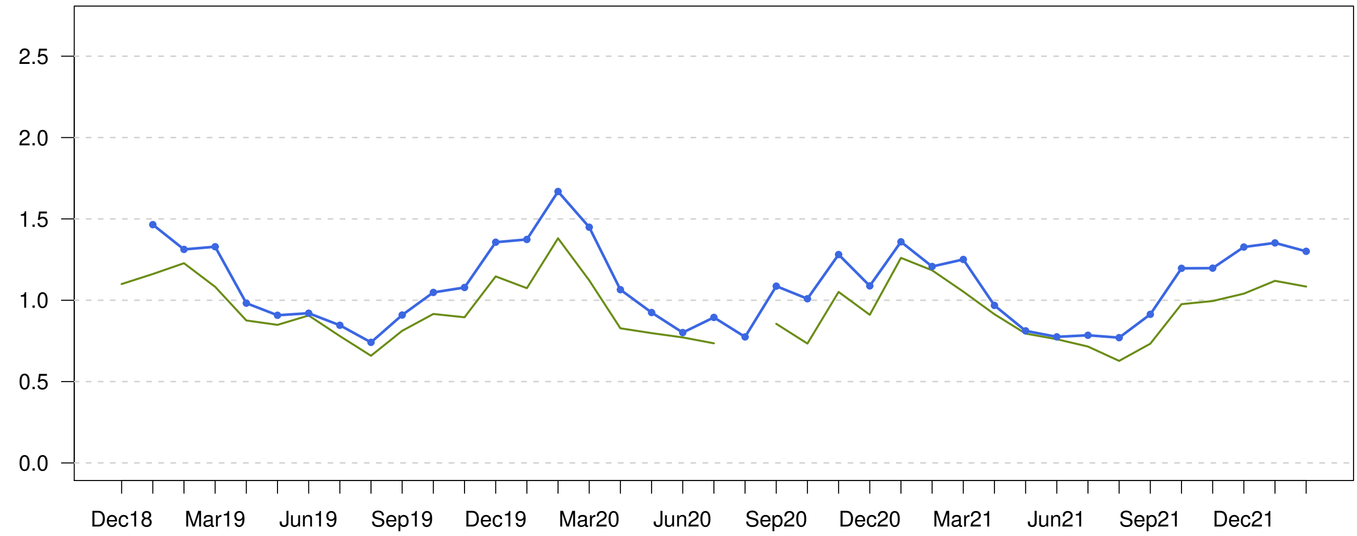

Mean Error
159 Nor. stations
00+3,+6,...,+66
MEPSctrl
ECMWF
Lead time (hour)
Standard Deviation of Error
159 Nor. stations
00+3,+6,...,+66
Lead time (hour)
Mean Absolute Error
159 Nor. stations
00+3,+6,...,+66
Lead time (hour)
Mean Error
12 Svalbard stations
00+3,+6,...,+66
AA25
ECMWF
Lead time (hour)
Standard Deviation of Error
12 Svalbard stations
00+3,+6,...,+66
Lead time (hour)
Mean Absolute Error
12 Svalbard stations
00+3,+6,...,+66
Lead time (hour)
Mean Error
52 North Scand. stations
00+3,+6,...,+66
AA25
ECMWF
MEPSctrl
Lead time (hour)
Standard Deviation of Error
52 North Scand. stations
00+3,+6,...,+66
Lead time (hour)
Mean Absolute Error
52 North Scand. stations
00+3,+6,...,+66
Lead time (hour)

Mean Absolute Error

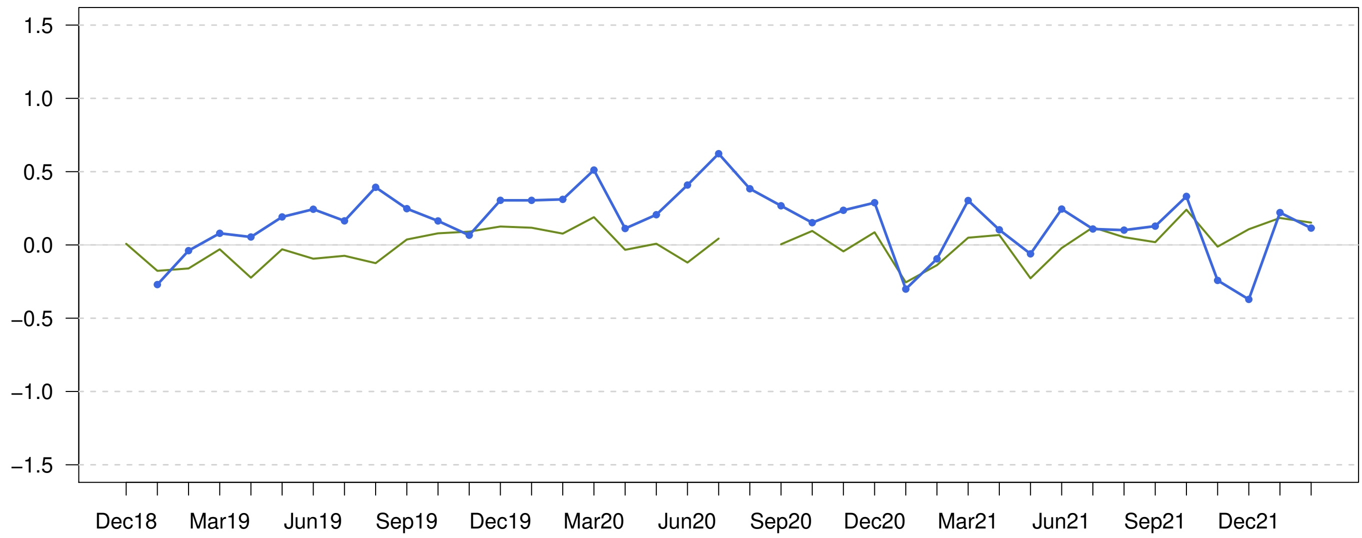
179 Norwegian stations 00+24,+30,+36,+42 UTC

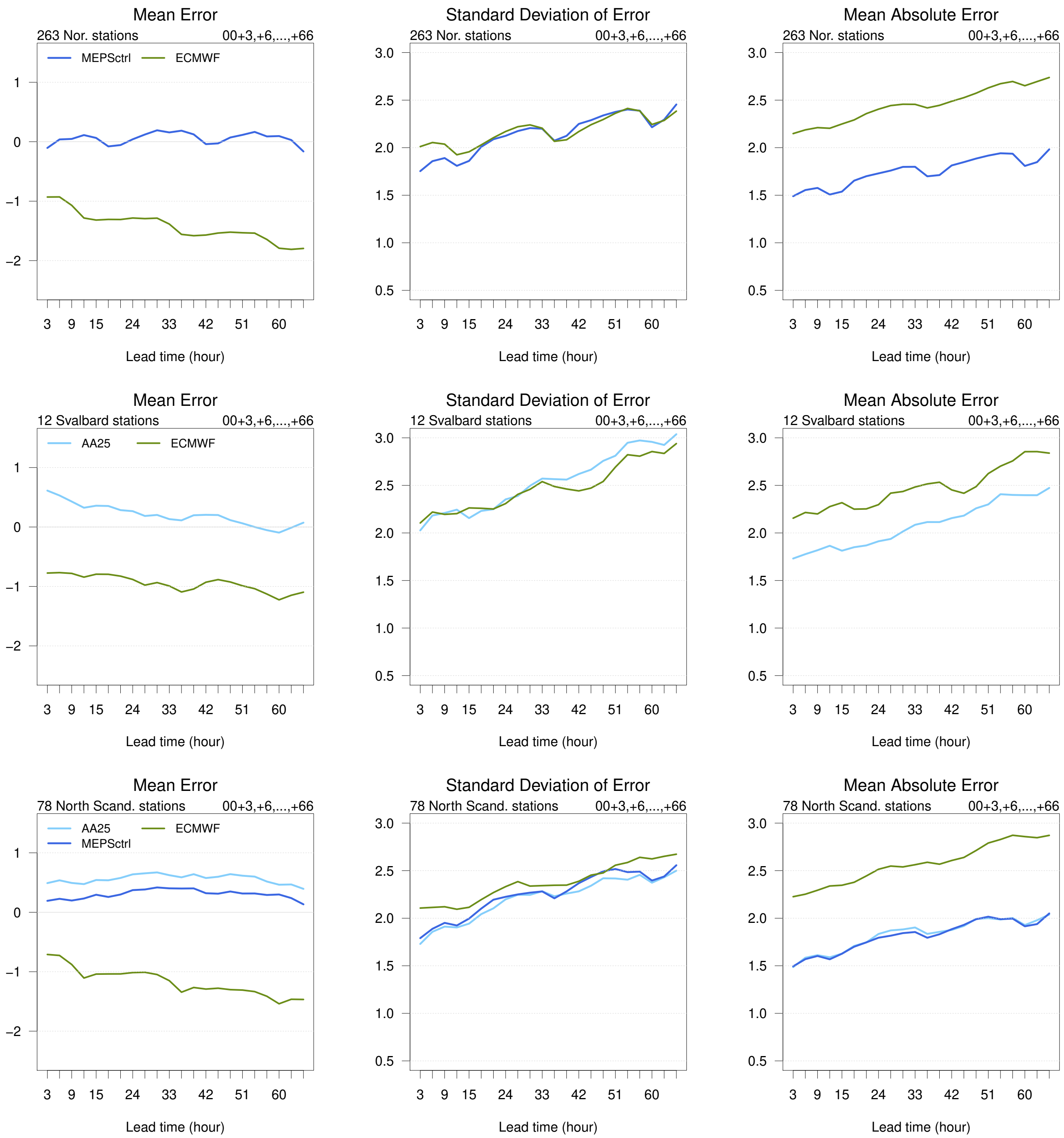


Standard Deviation of Error

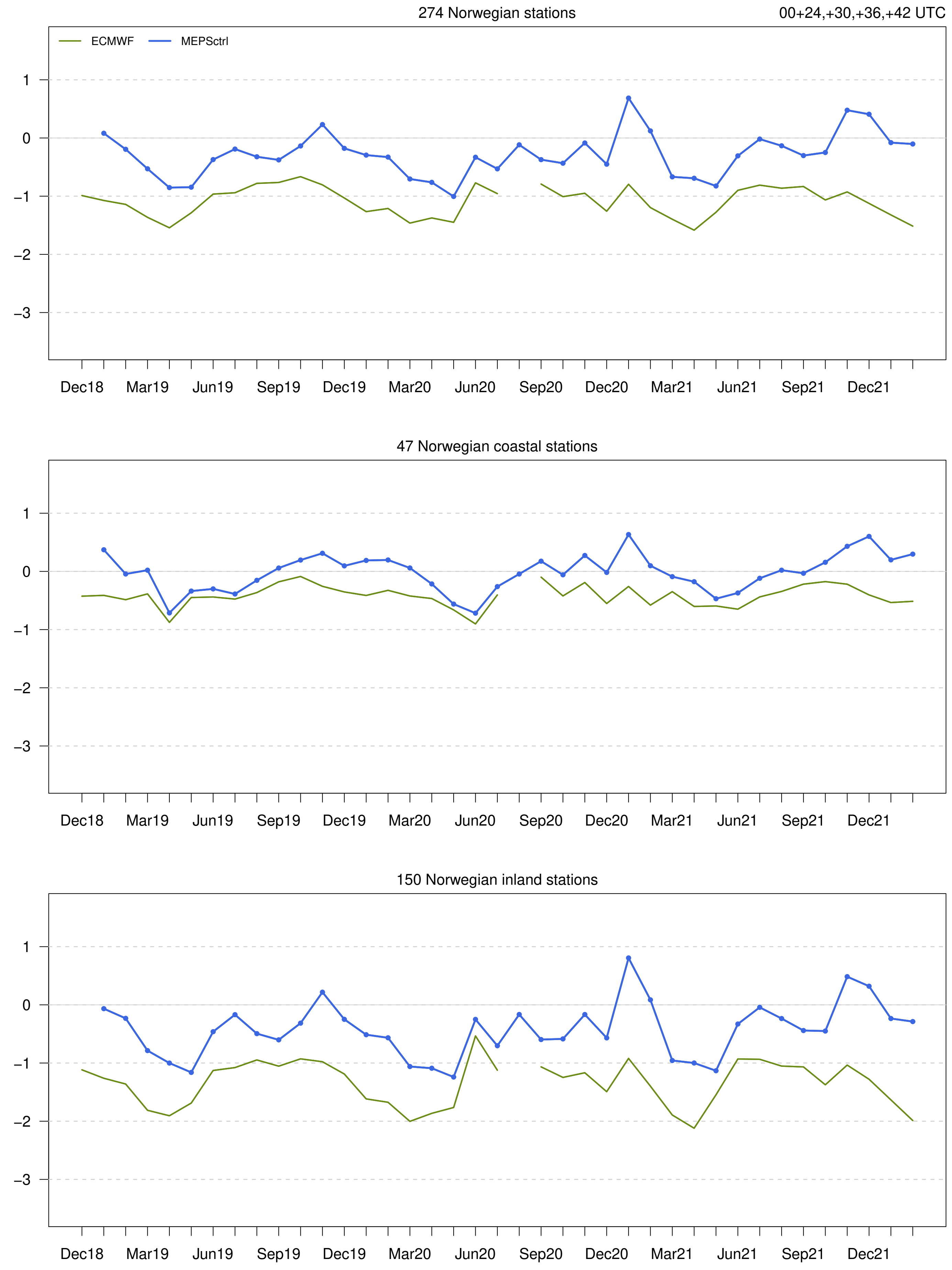


Mean Error



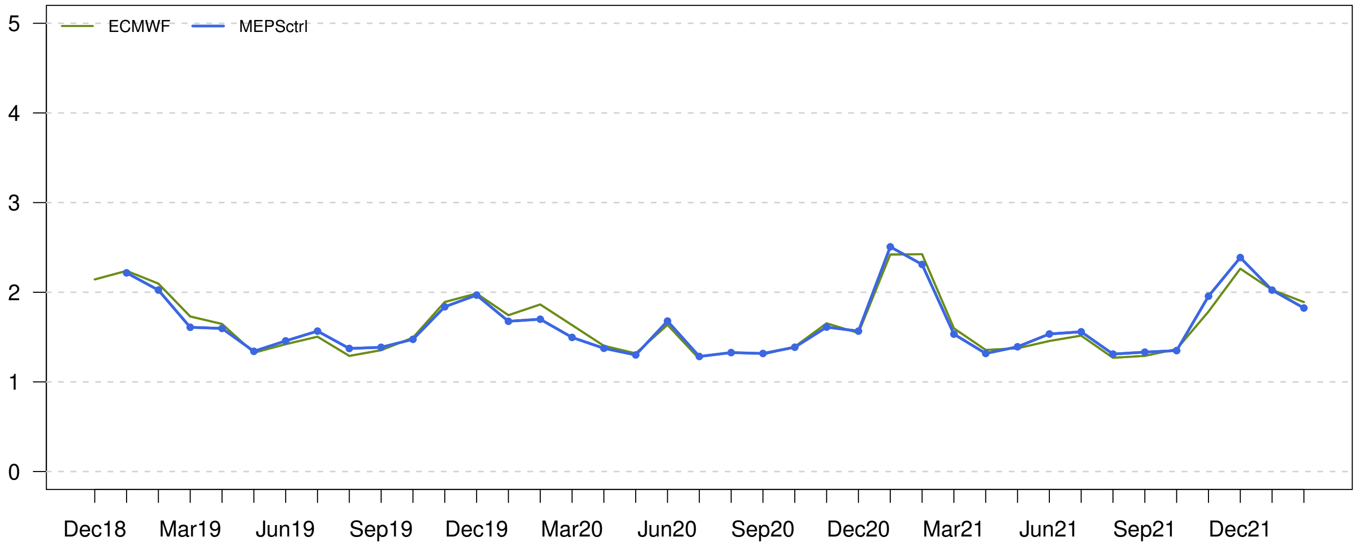

Mean Error
263 Nor. stations
00+3,+6,...,+66
MEPSctrl
ECMWF
Lead time (hour)
Standard Deviation of Error
263 Nor. stations
00+3,+6,...,+66
Lead time (hour)
Mean Absolute Error
263 Nor. stations
00+3,+6,...,+66
Lead time (hour)
Mean Error
12 Svalbard stations
00+3,+6,...,+66
AA25
ECMWF
Lead time (hour)
Standard Deviation of Error
12 Svalbard stations
00+3,+6,...,+66
Lead time (hour)
Mean Absolute Error
12 Svalbard stations
00+3,+6,...,+66
Lead time (hour)
Mean Error
78 North Scand. stations
00+3,+6,...,+66
AA25
ECMWF
MEPSctrl
Lead time (hour)
Standard Deviation of Error
78 North Scand. stations
00+3,+6,...,+66
Lead time (hour)
Mean Absolute Error
78 North Scand. stations
00+3,+6,...,+66
Lead time (hour)

Mean Error

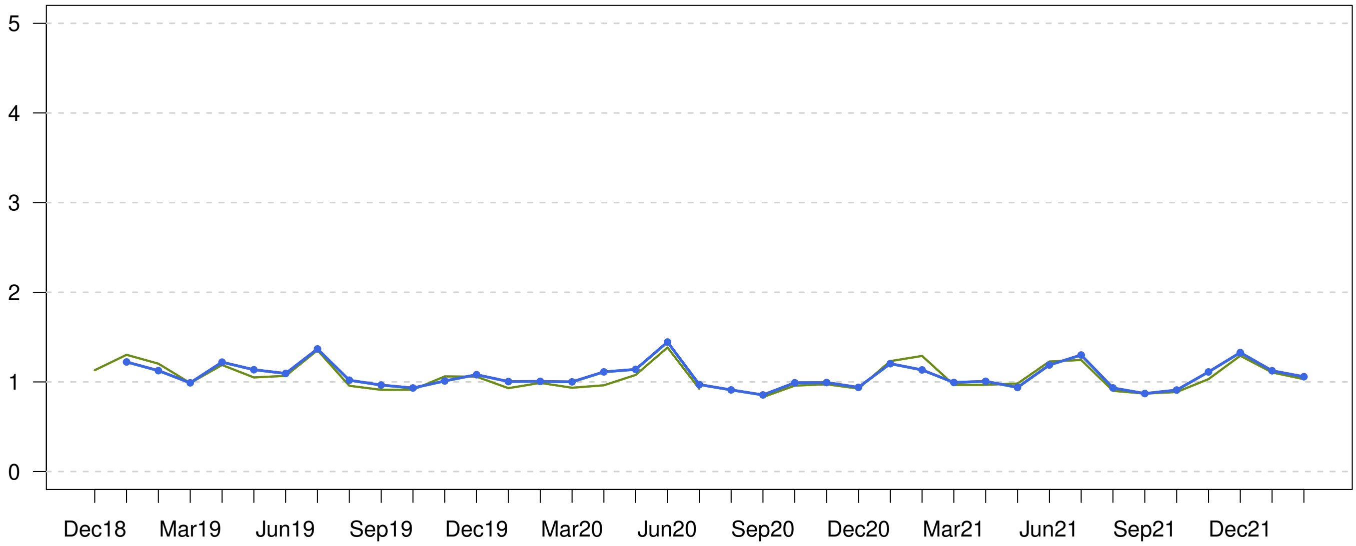

274 Norwegian stations
00+24,+30,+36,+42 UTC
ECMWF
MEPSctrl
1
0
−1
−2
−3
Dec18
Mar19
Jun19
Sep19
Dec19
Mar20
Jun20
Sep20
Dec20
Mar21
Jun21
Sep21
Dec21
47 Norwegian coastal stations
150 Norwegian inland stations

Standard Deviation of Error

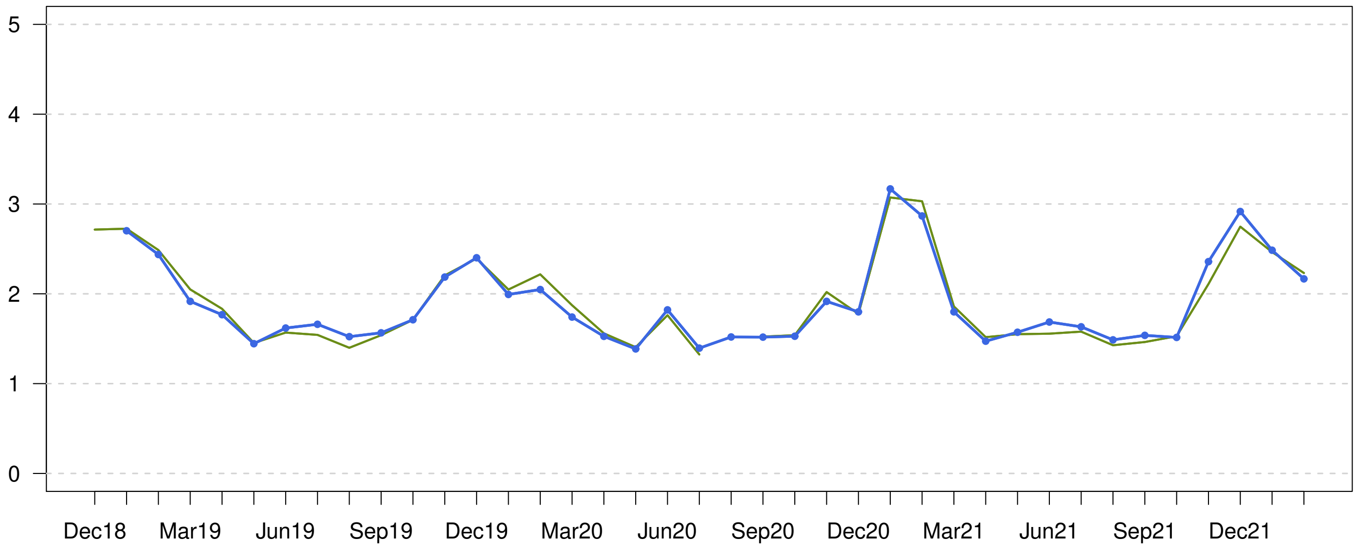
274 Norwegian stations 00+24,+30,+36,+42 UTC



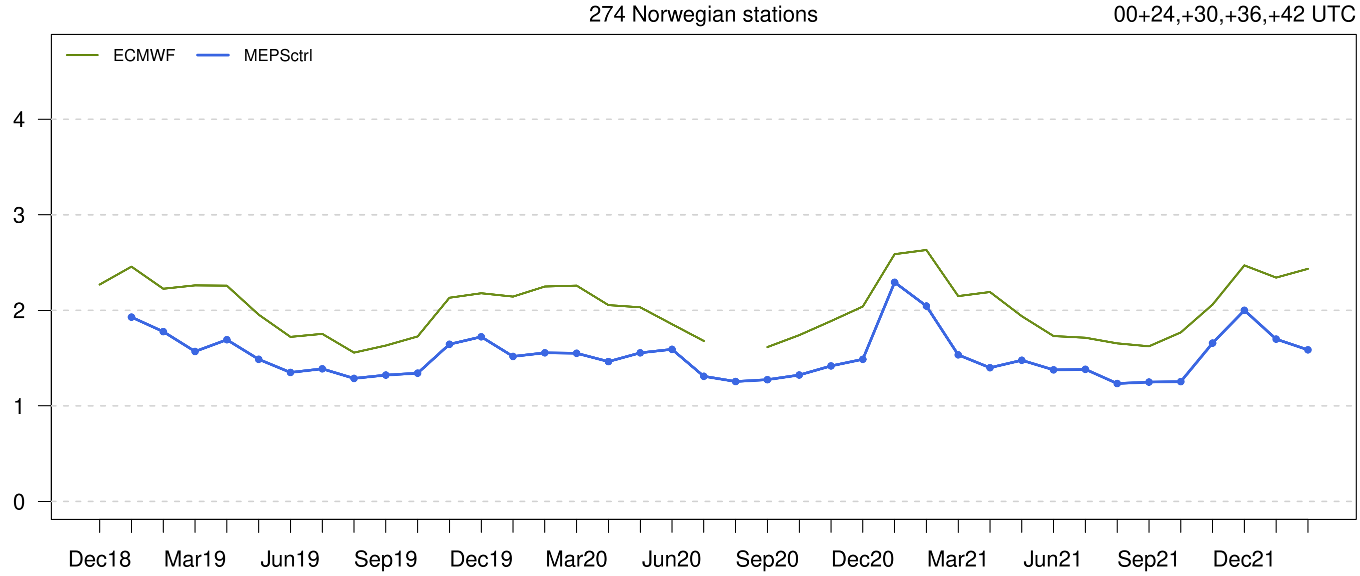
47 Norwegian coastal stations

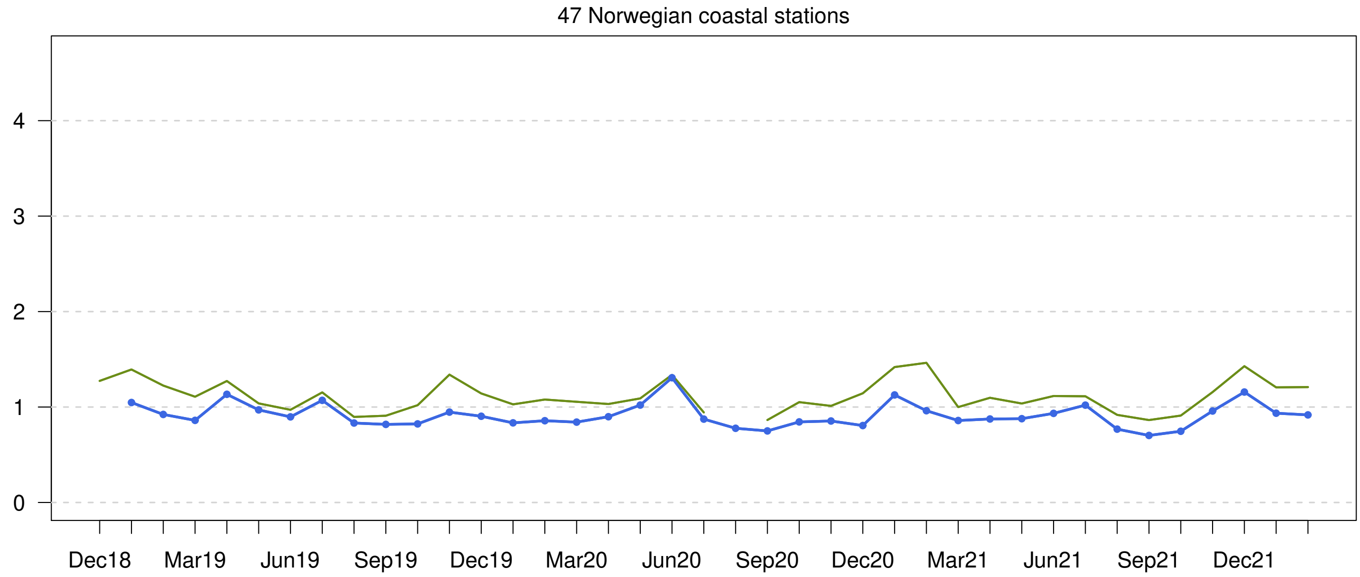


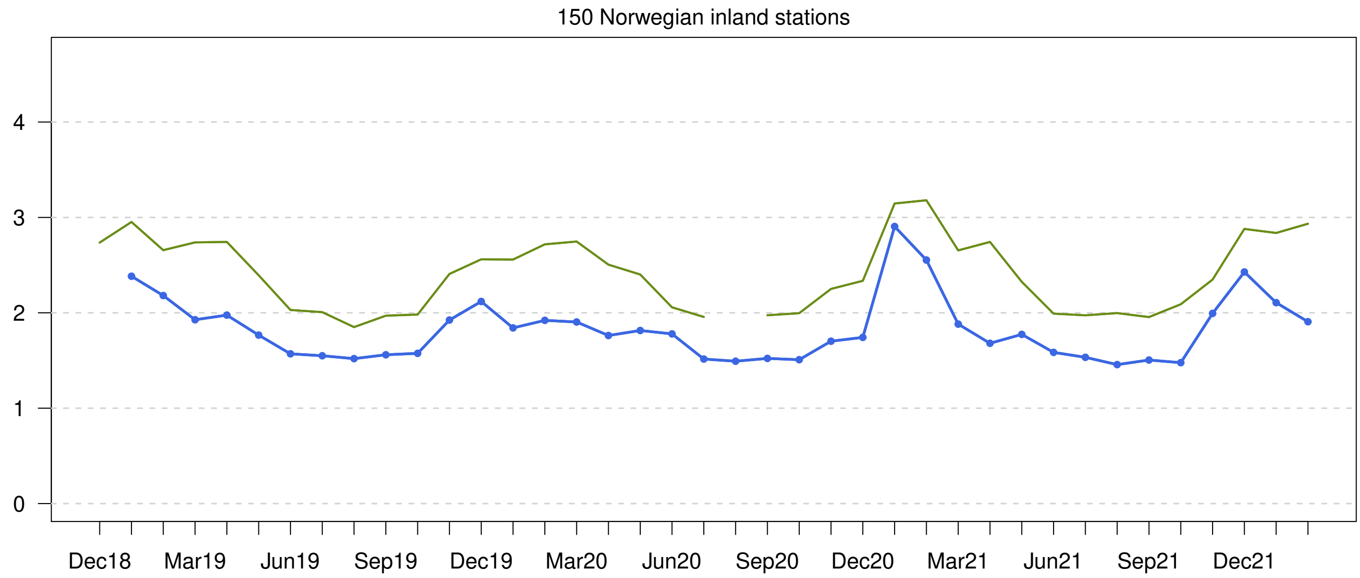
150 Norwegian inland stations

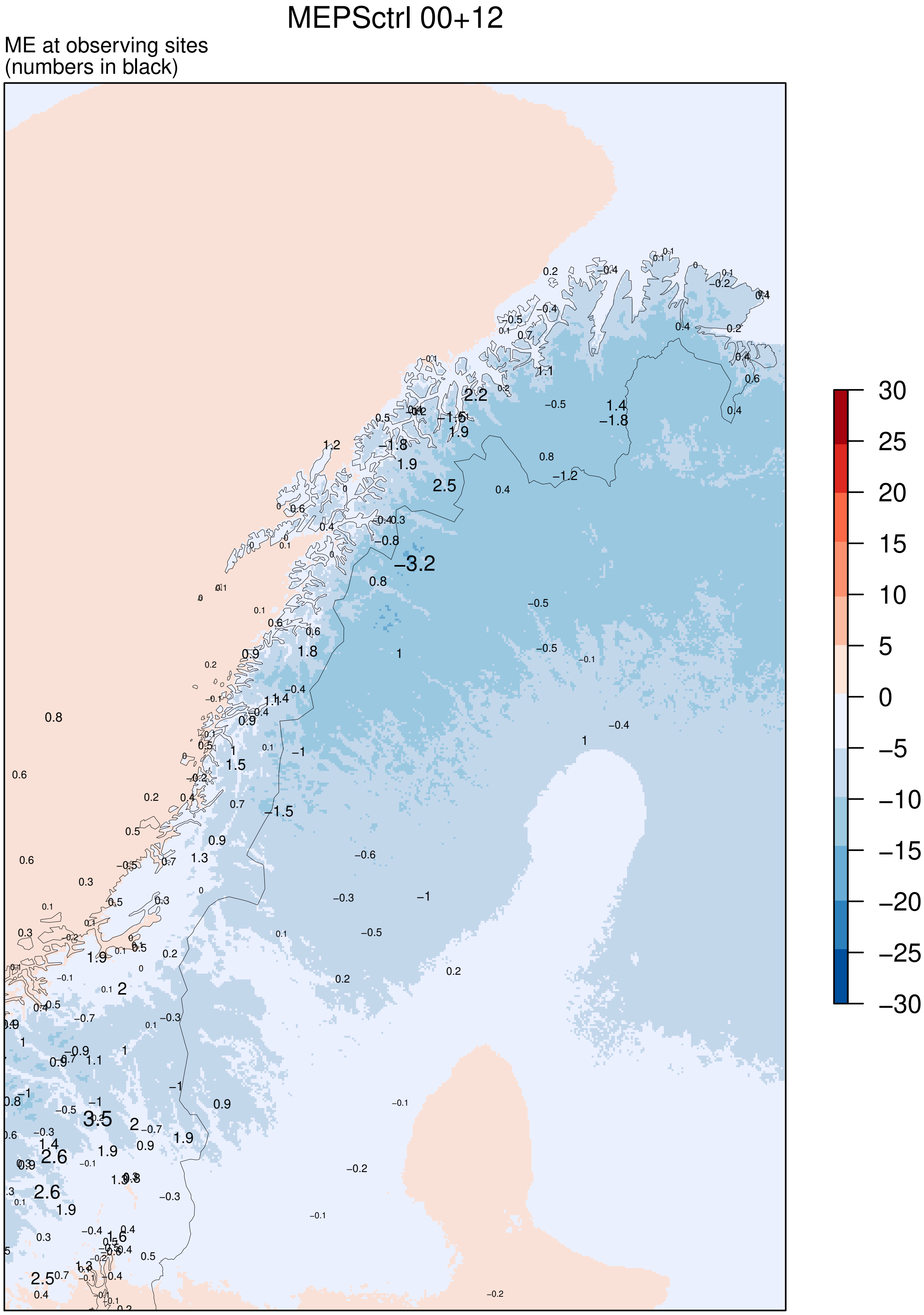


Mean Absolute Error





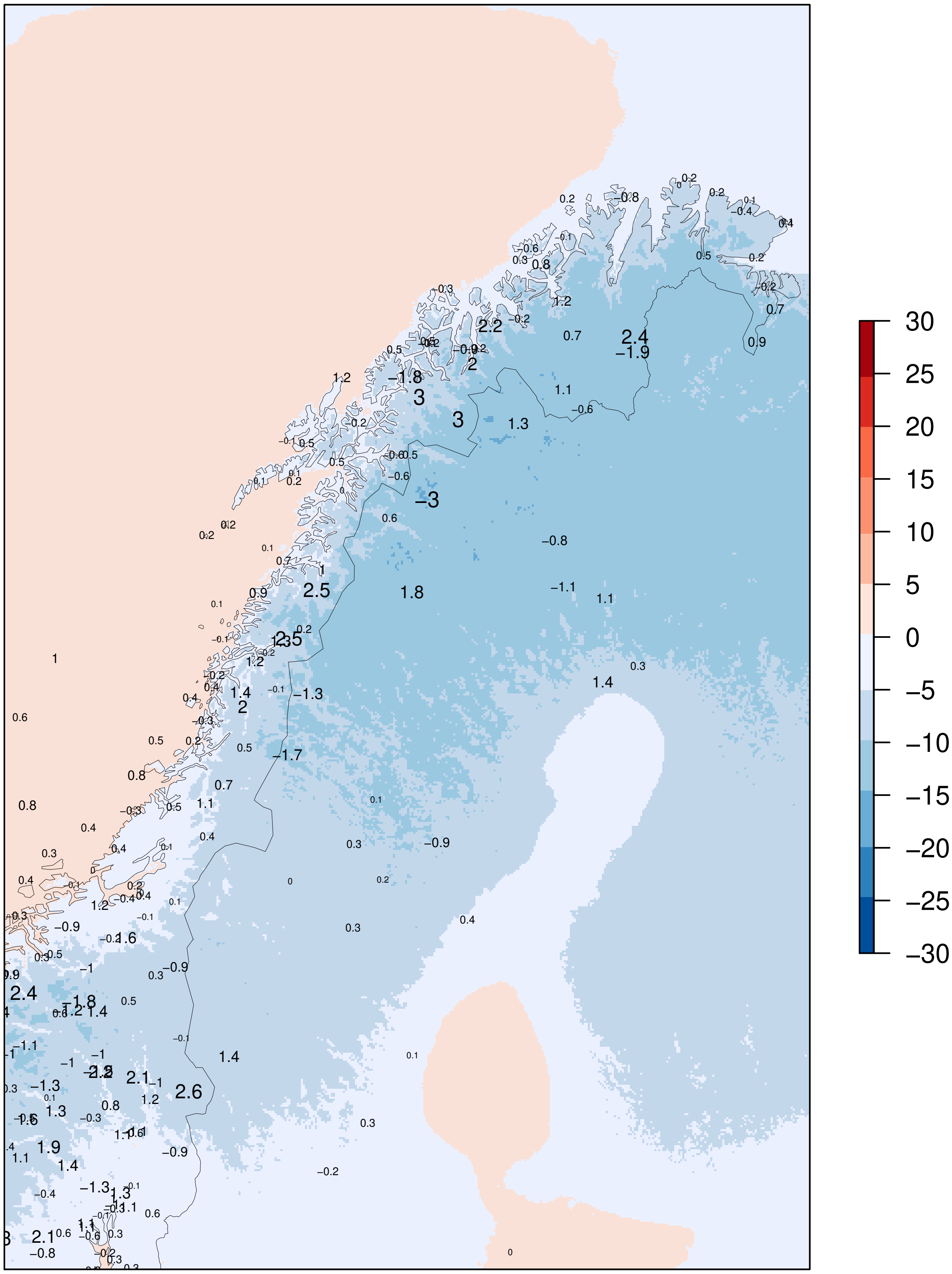




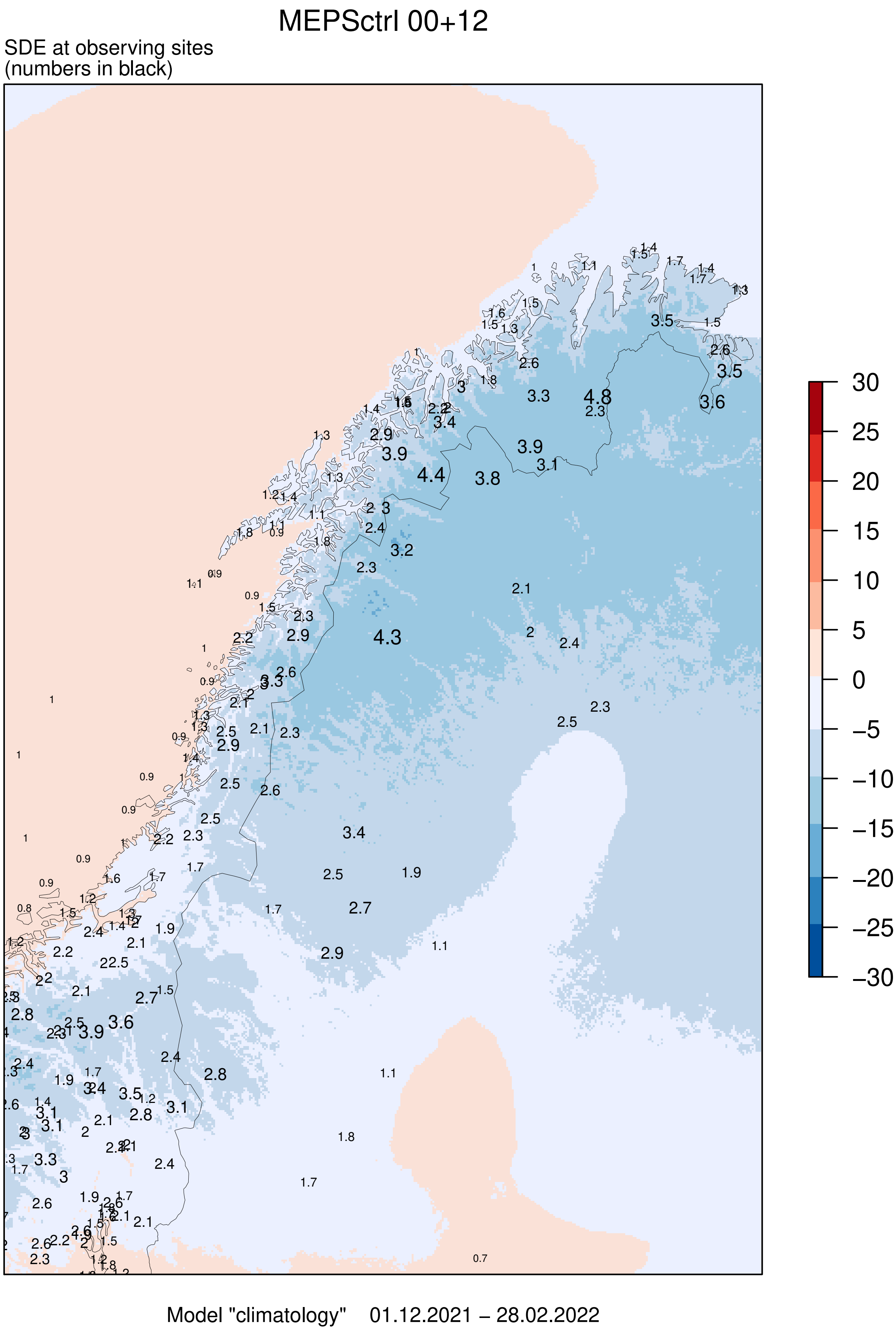
Model "climatology" 01.12.2021 – 28.02.2022

MEPSctrl 00+24

ME at observing sites
(numbers in black)

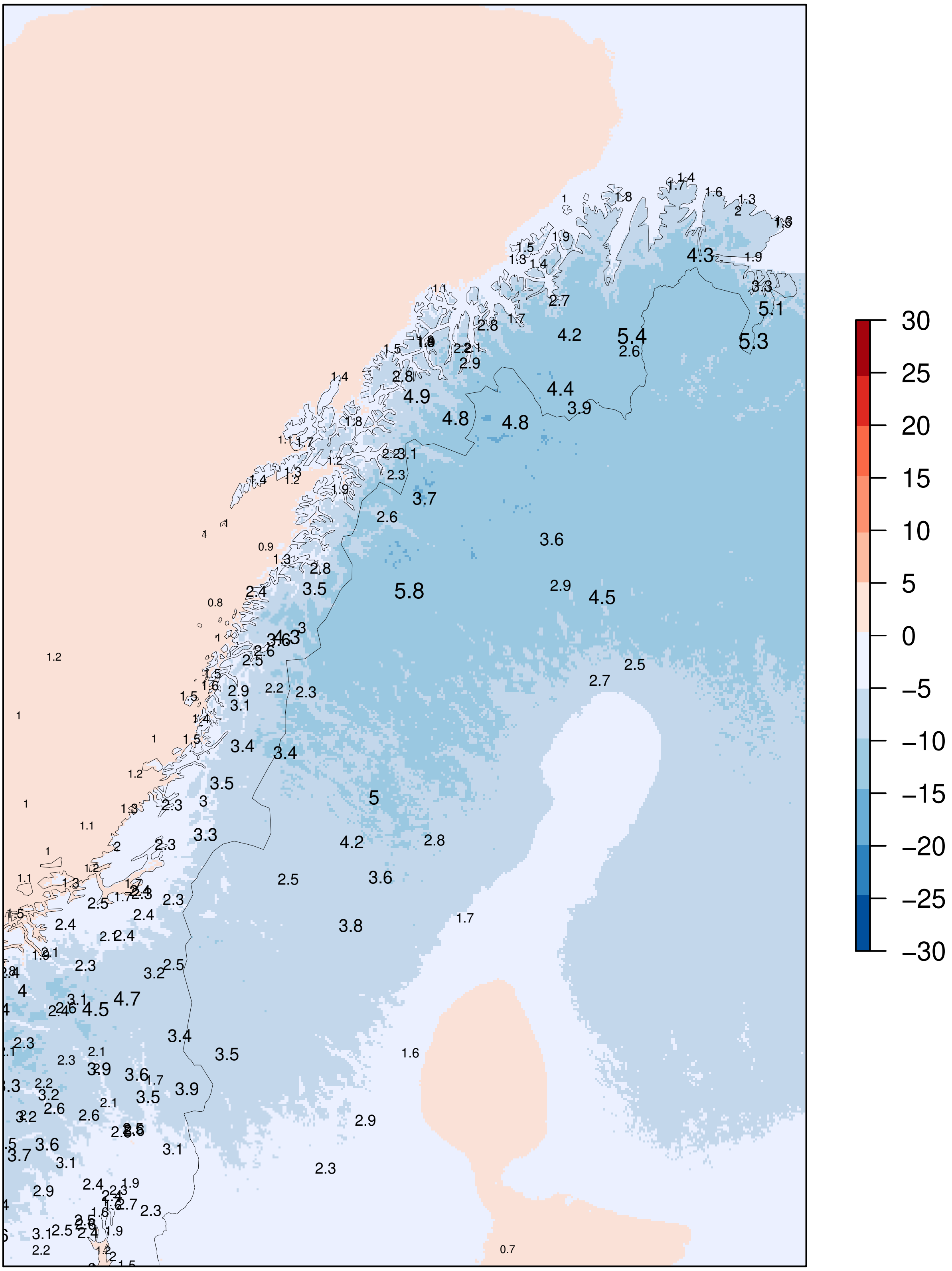


Model "climatology" 01.12.2021 – 28.02.2022


MEPSctrl 00+12
SDE at observing sites
(numbers in black)
30
25
20
15
10
5
0
−5
−10
−15
−20
−25
−30
Model "climatology" 01.12.2021 – 28.02.2022

MEPSctrl 00+24

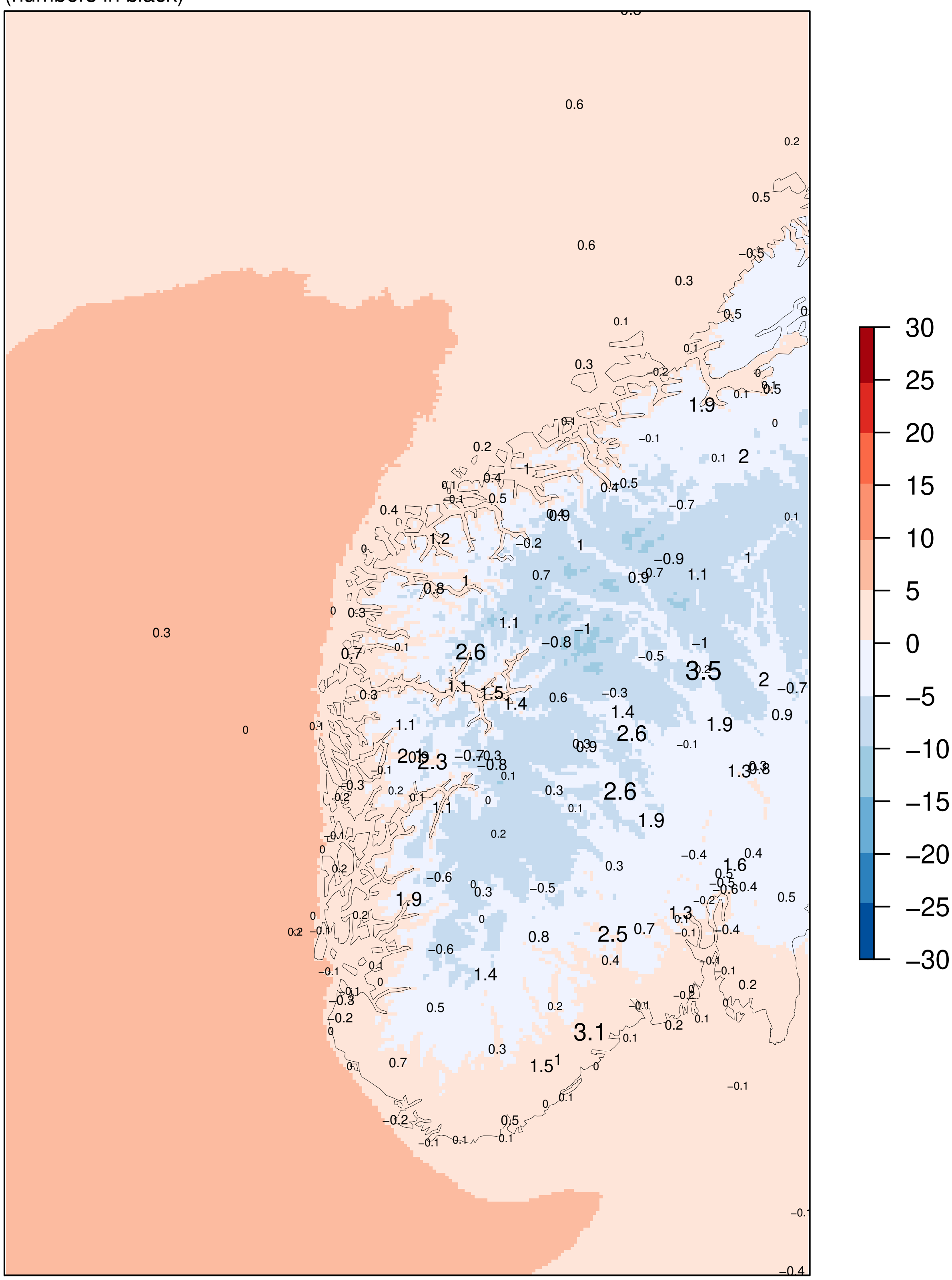
SDE at observing sites
(numbers in black)



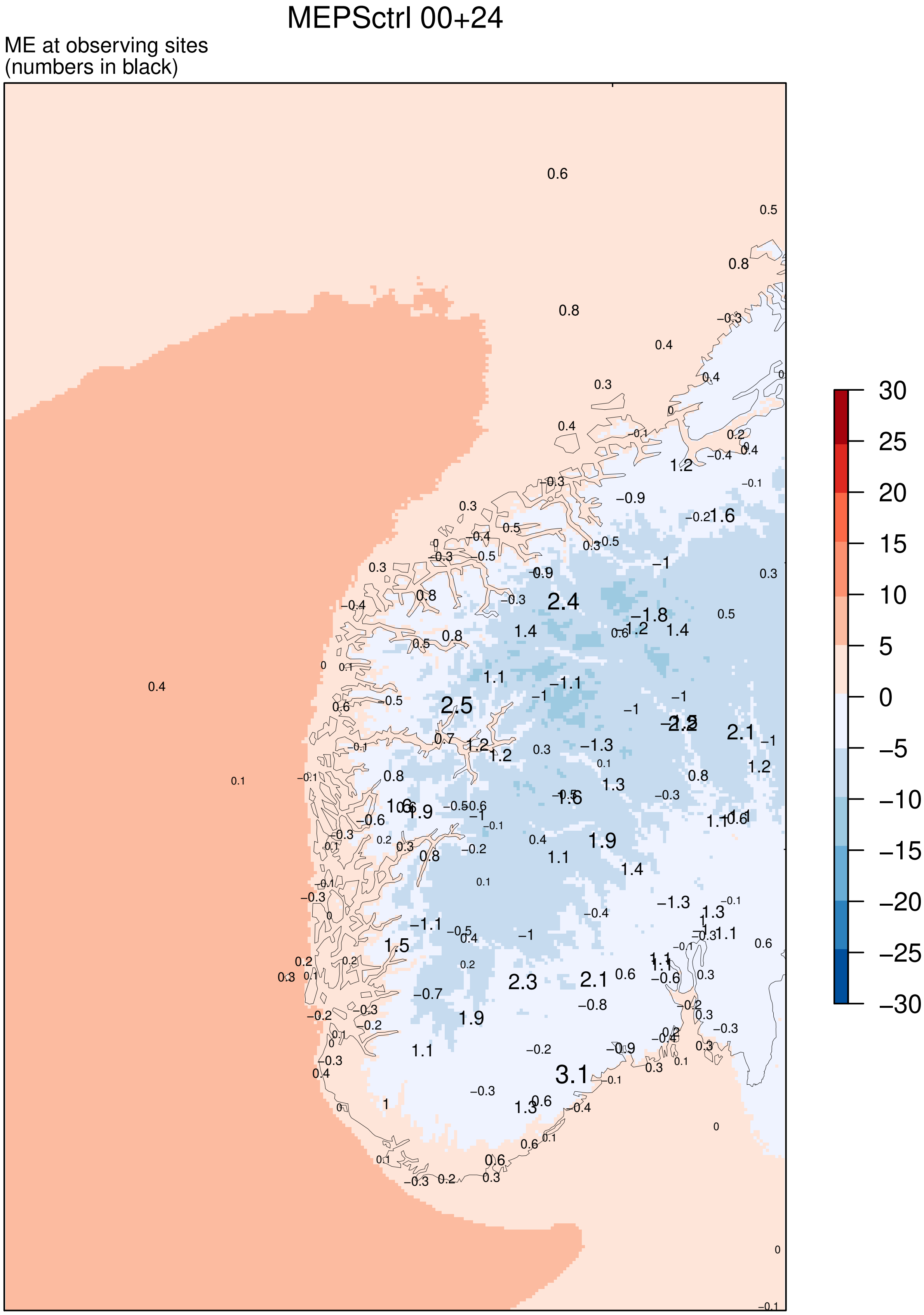
Model "climatology" 01.12.2021 – 28.02.2022

MEPSctrl 00+12

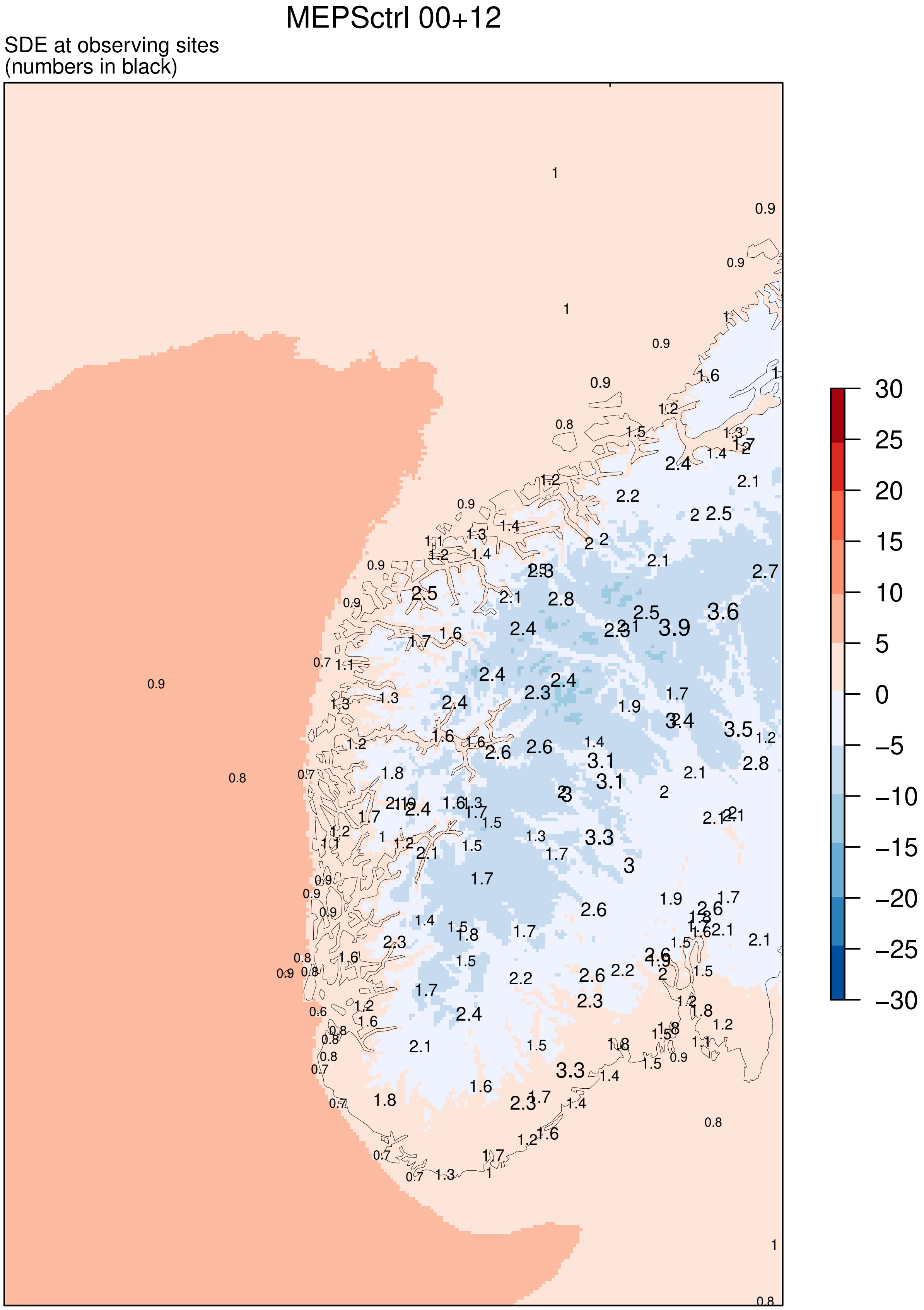
ME at observing sites
(numbers in black)



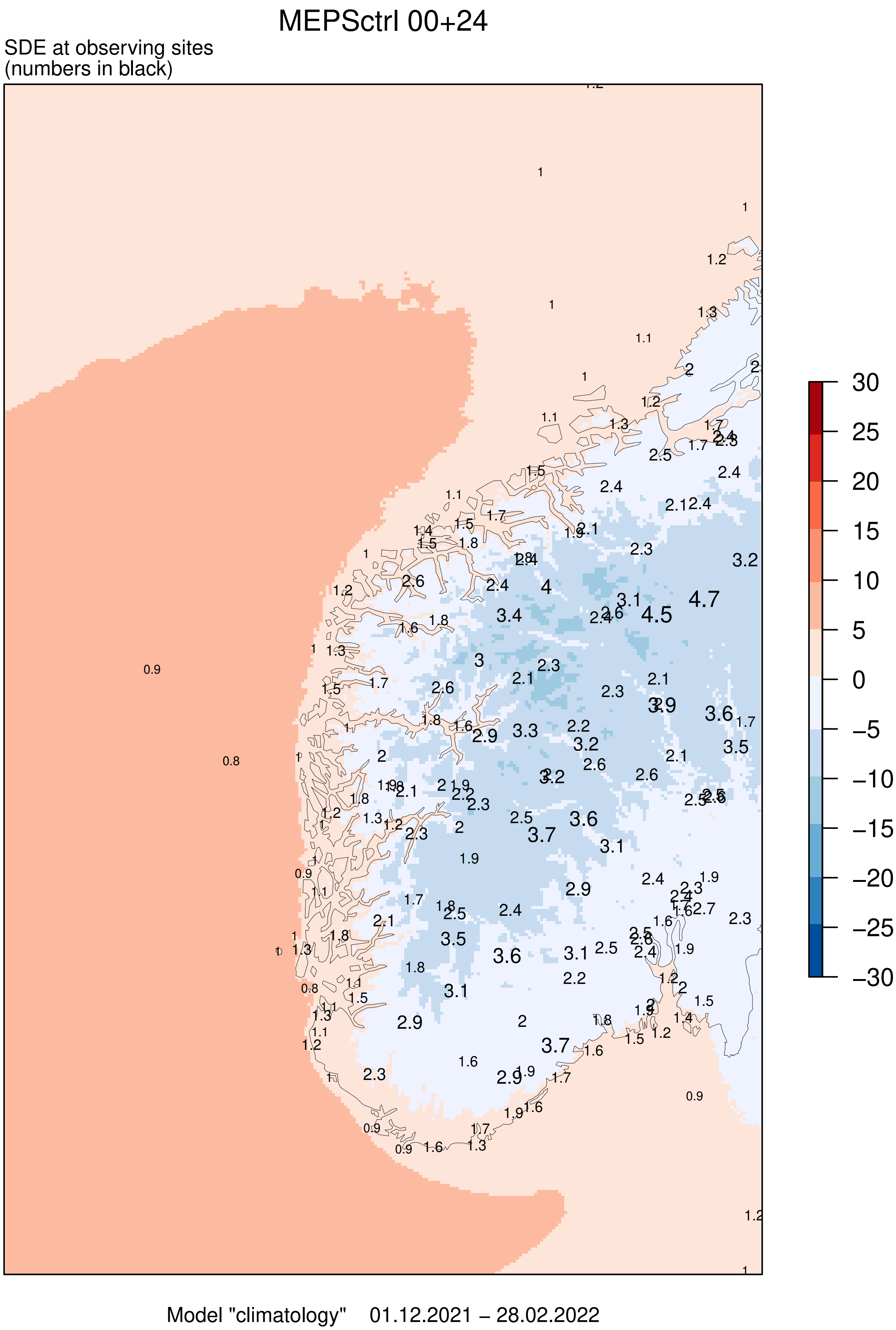
Model "climatology" 01.12.2021 – 28.02.2022



Model "climatology"   01.12.2021 – 28.02.2022

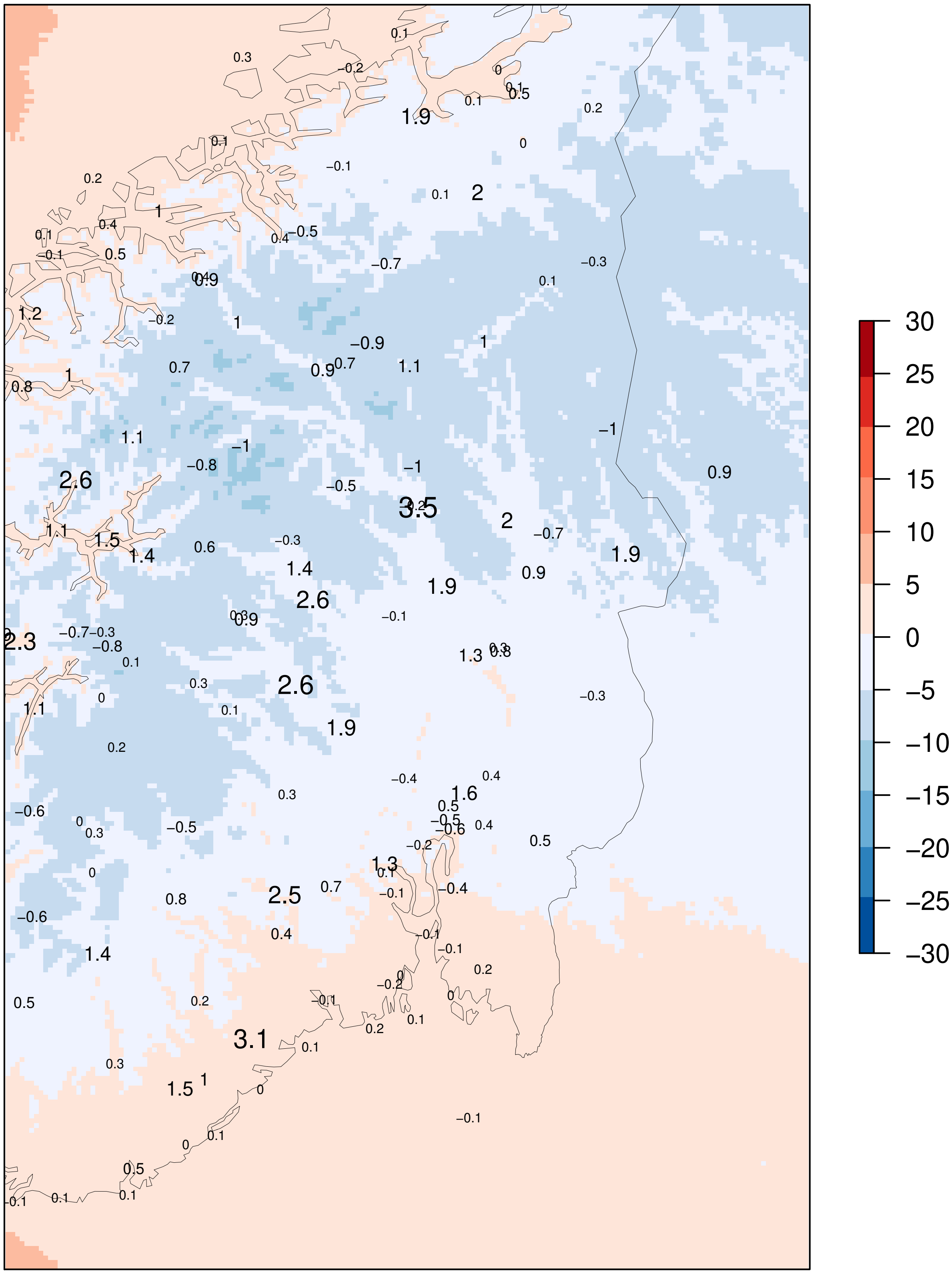


Model "climatology" 01.12.2021 – 28.02.2022


MEPSctrl 00+24
SDE at observing sites
(numbers in black)
30
25
20
15
10
5
0
−5
−10
−15
−20
−25
−30
Model "climatology" 01.12.2021 – 28.02.2022

MEPSctrl 00+12

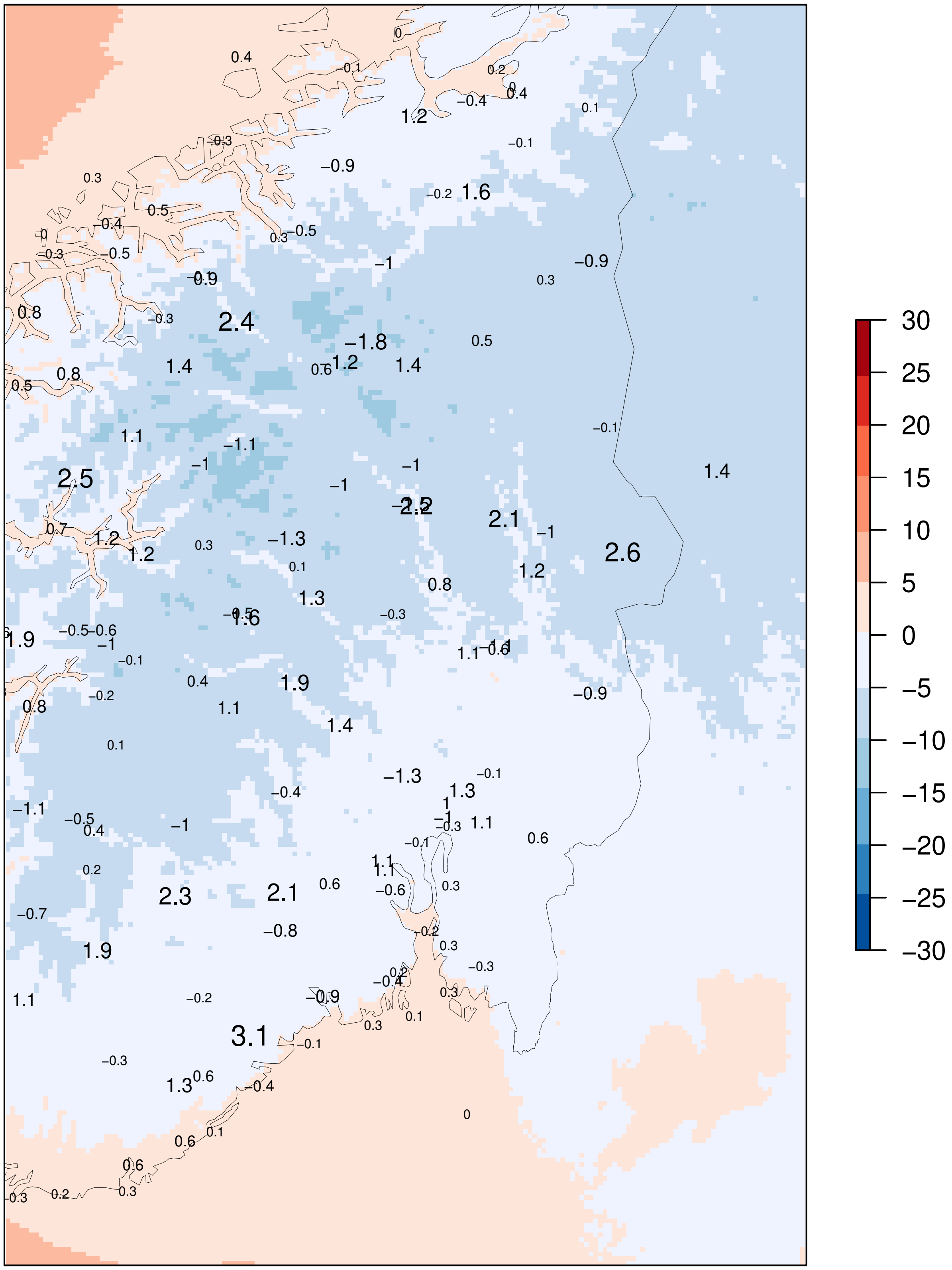
ME at observing sites
(numbers in black)



Model "climatology" 01.12.2021 – 28.02.2022

MEPSctrl 00+24

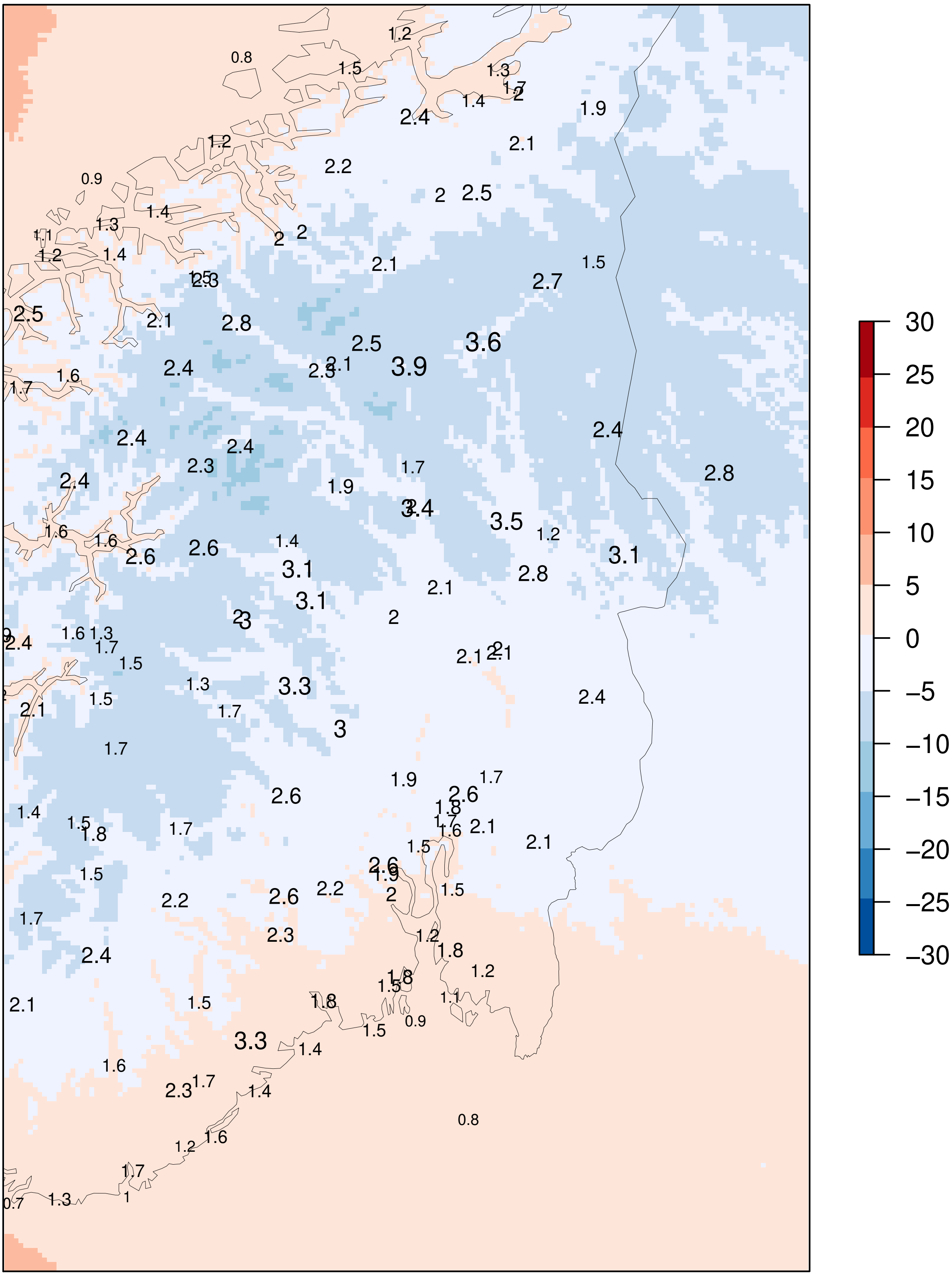
ME at observing sites
(numbers in black)



Model "climatology" 01.12.2021 – 28.02.2022

MEPSctrl 00+12

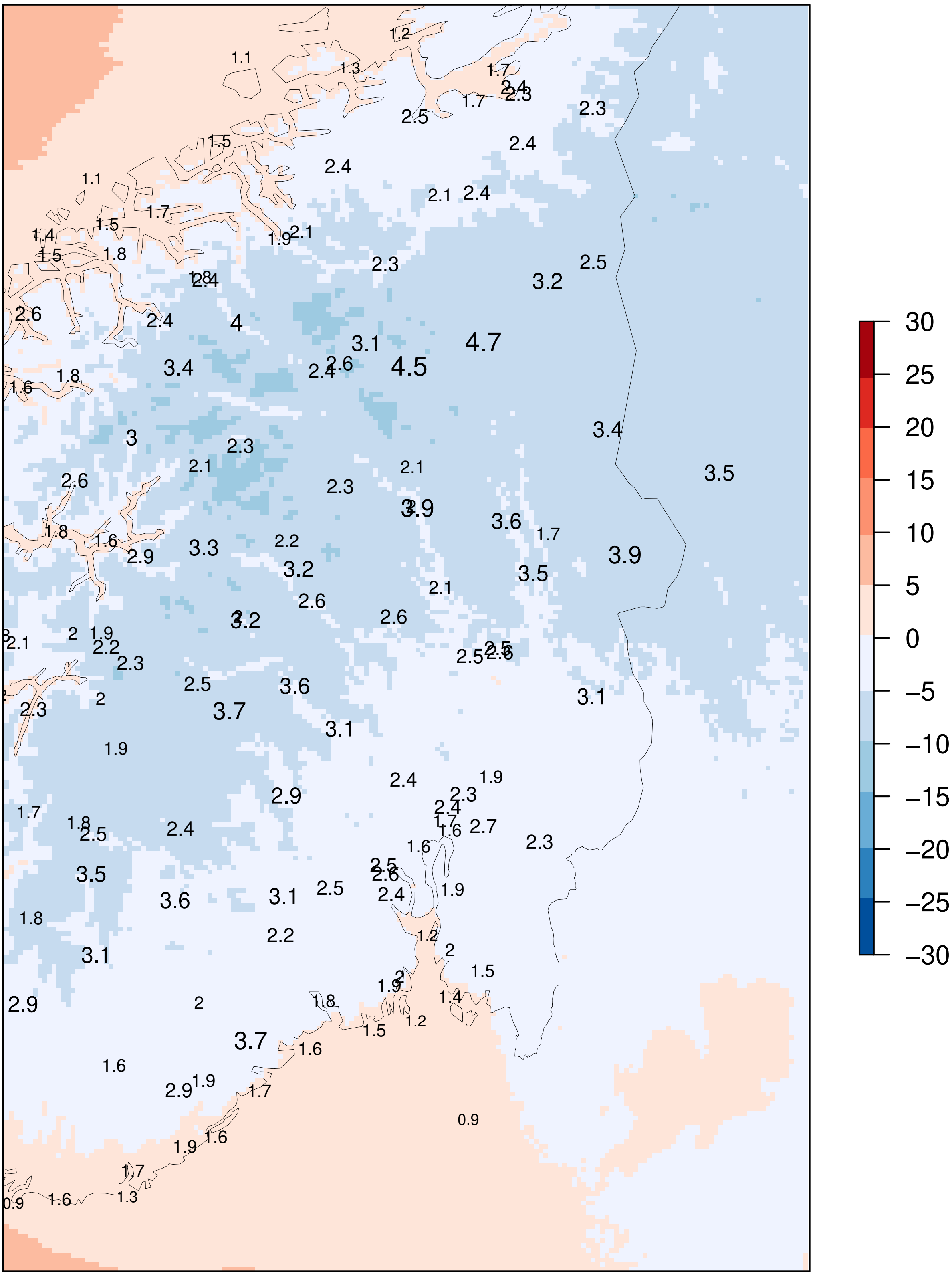
SDE at observing sites
(numbers in black)



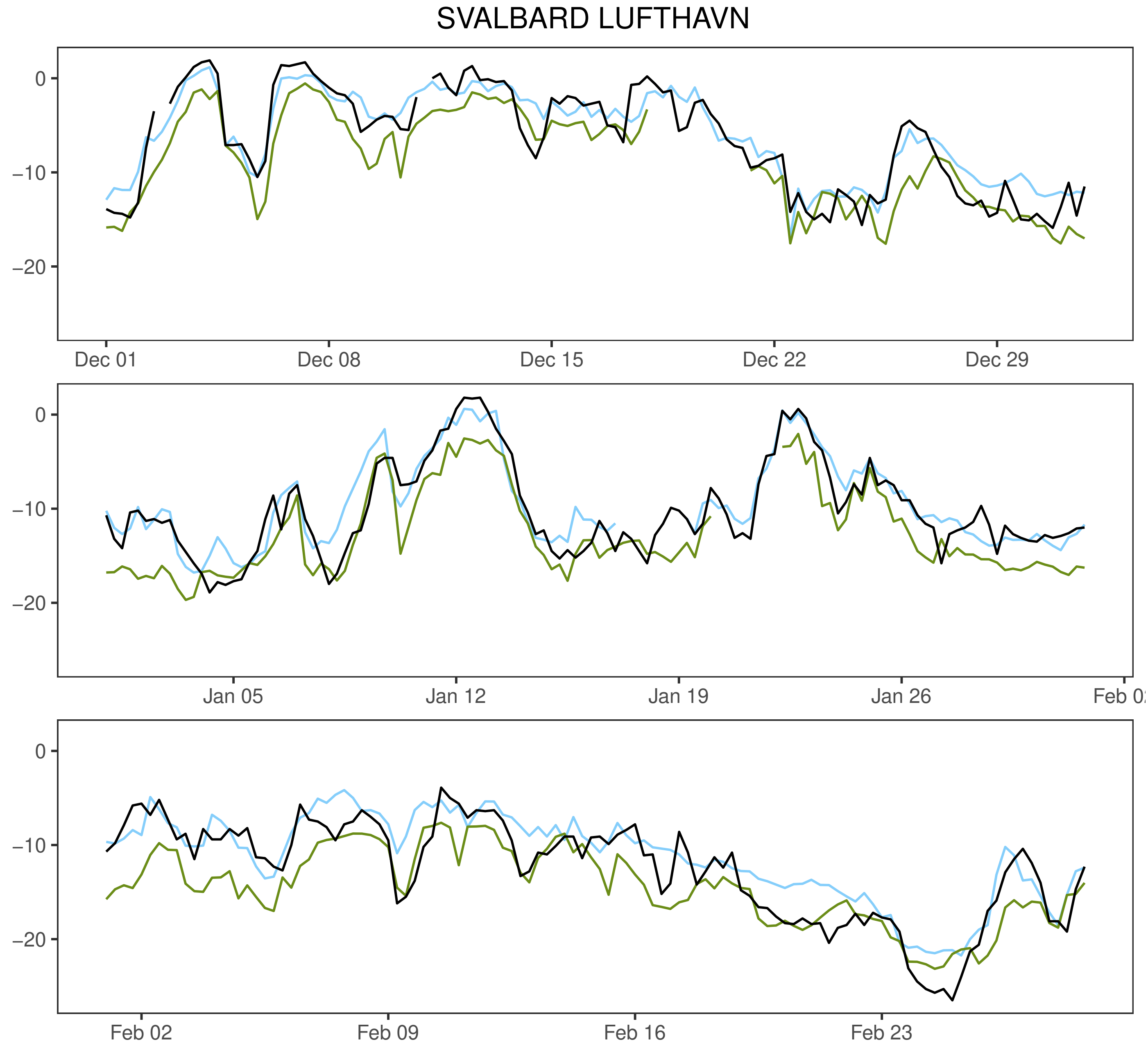
Model "climatology" 01.12.2021 – 28.02.2022

MEPSctrl 00+24

SDE at observing sites
(numbers in black)

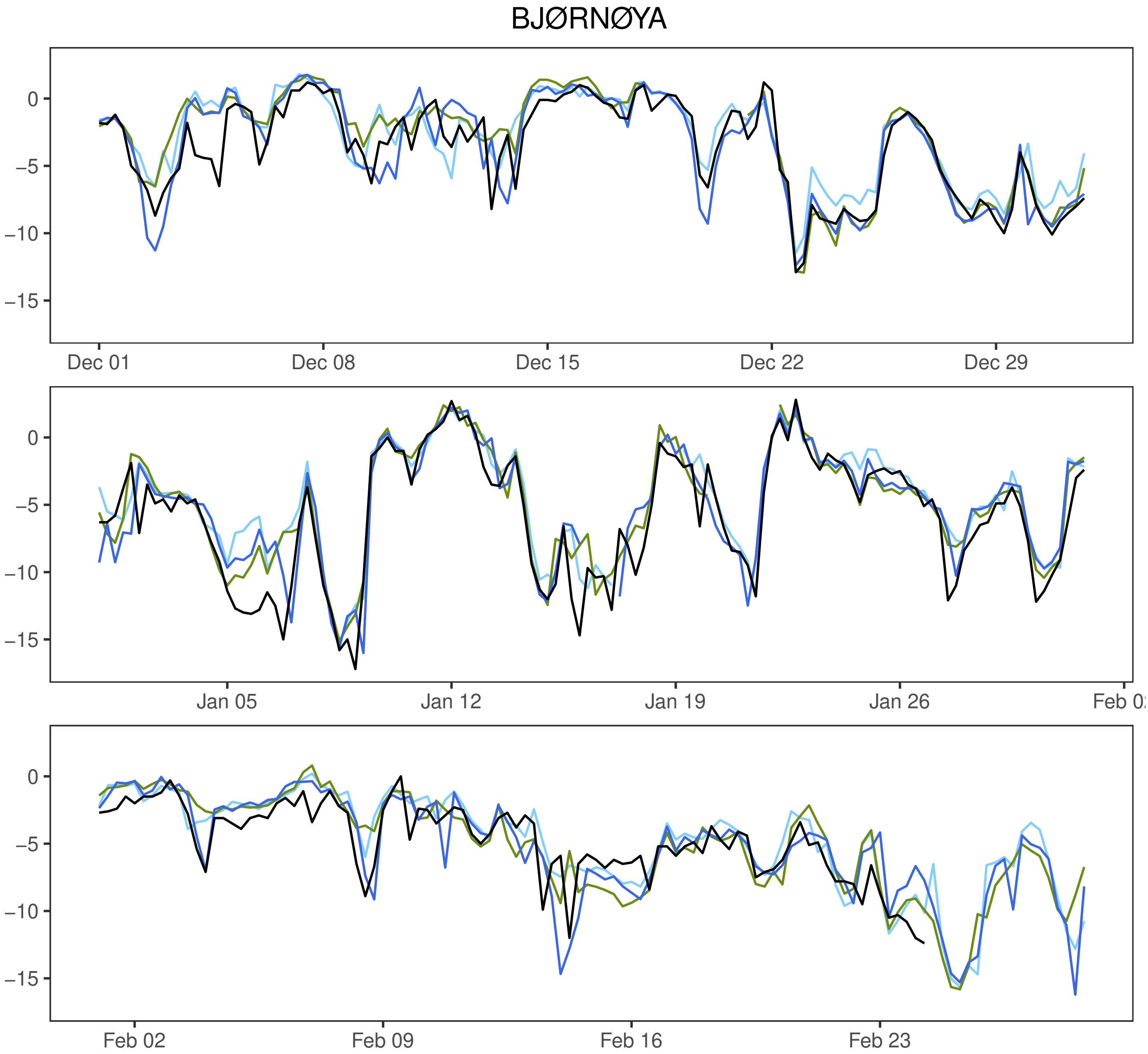


Model "climatology" 01.12.2021 – 28.02.2022



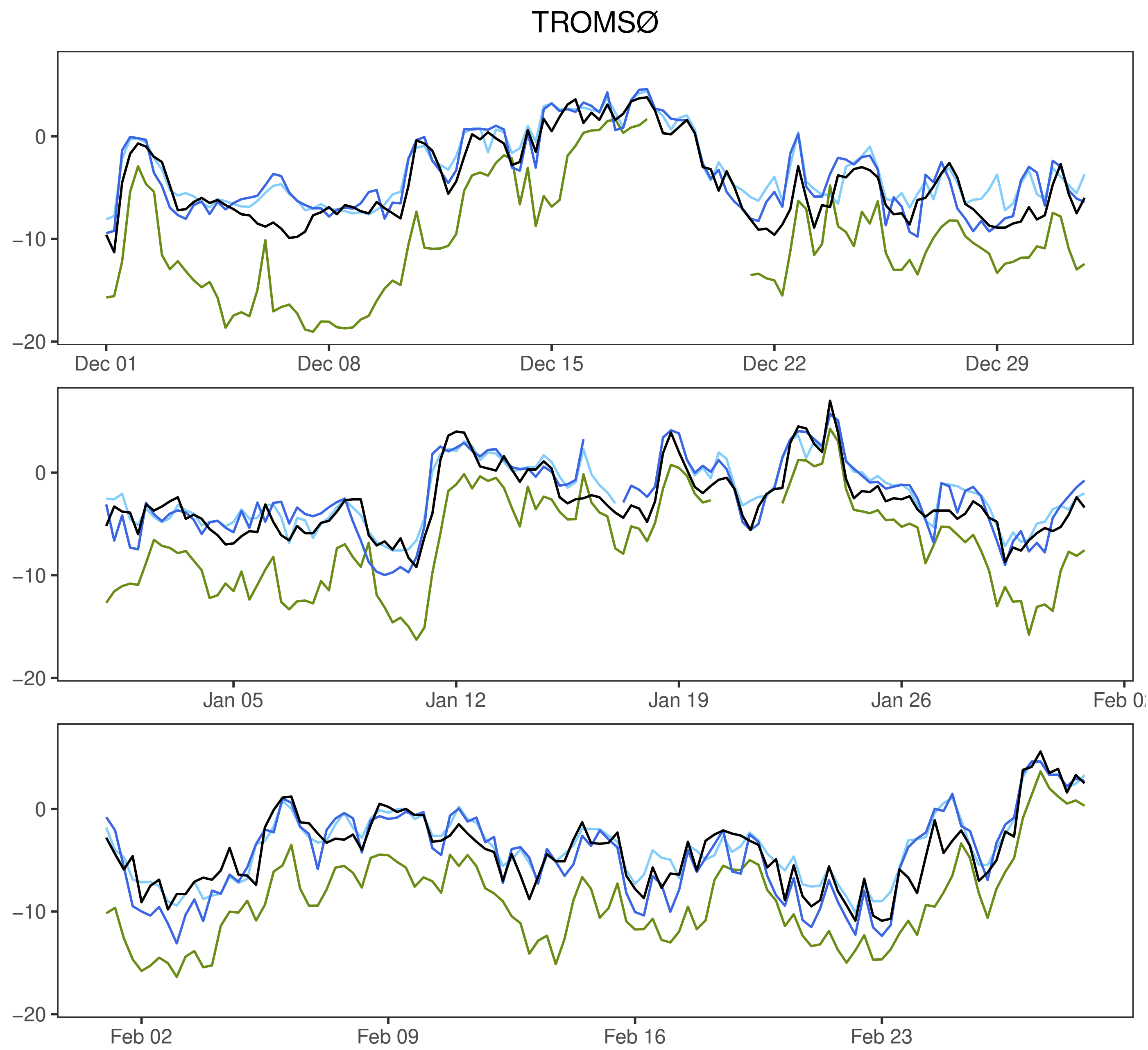
	Min	Mean	Max	Std	N
synop: 00,06,12,18	−26.5	−9.7	1.9	5.8	358
AA25: 12+18,+24,+30,+36	−21.7	−8.8	1.2	5.1	352
ECMWF: 12+18,+24,+30,+36	−23.2	−12.0	−0.5	5.2	340

	ME	SDE	RMSE	MAE	Max.abs.err.	N
AA25−synop	0.8	2.2	2.3	1.8	7.5	330
ECMWF−synop	−2.1	2.4	3.2	2.7	8.8	330



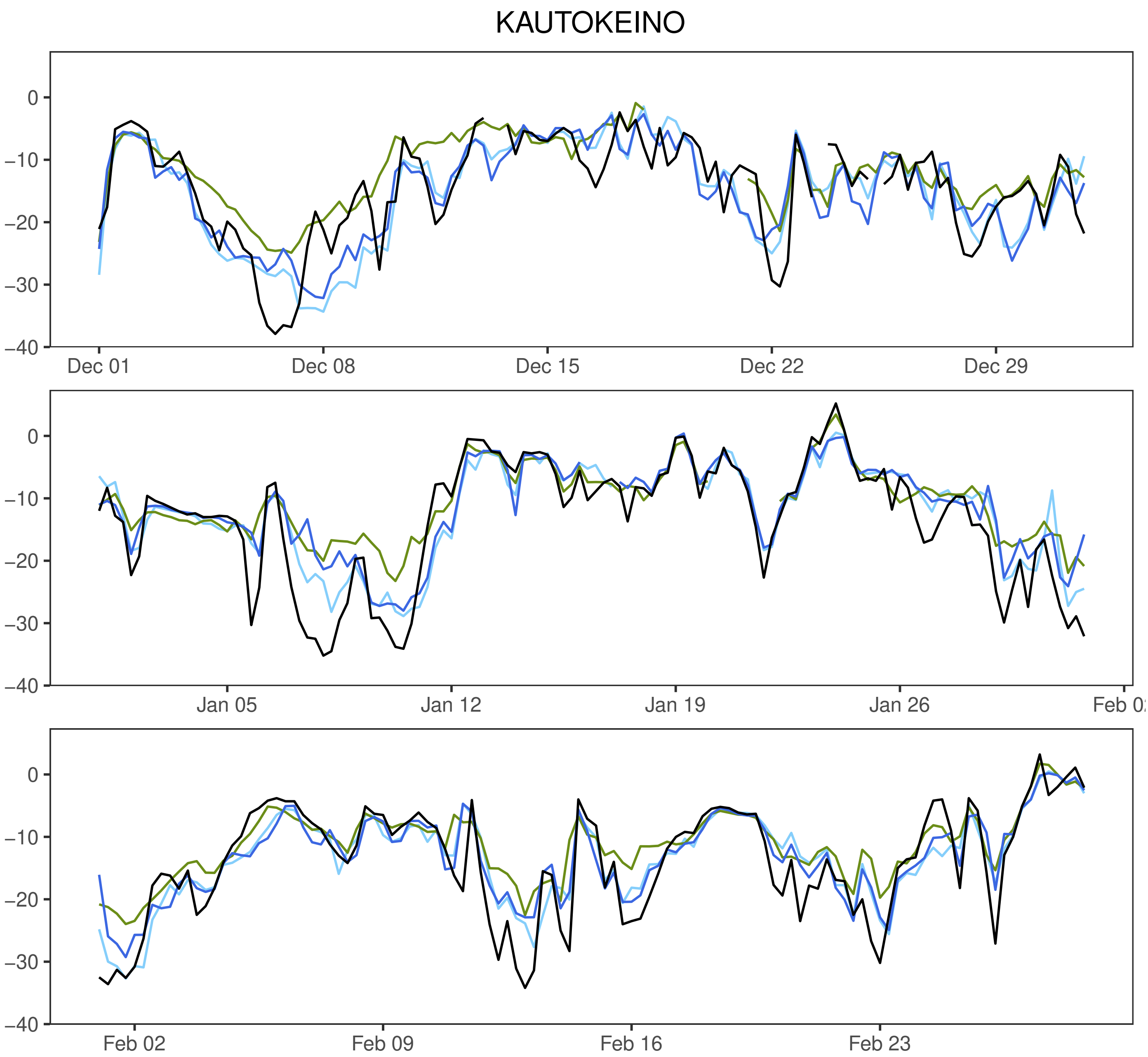
	Min	Mean	Max	Std	N
synop: 00,06,12,18	−17.2	−4.8	2.8	3.9	342
MEPSctrl: 12+18,+24,+30,+36	−16.2	−4.7	2.2	3.9	356
AA25: 12+18,+24,+30,+36	−15.6	−4.1	2.2	3.6	352
ECMWF: 12+18,+24,+30,+36	−15.8	−4.5	2.4	3.9	340

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl−synop	0.4	1.9	2.0	1.4	8.8	310
AA25−synop	1.0	1.7	2.0	1.4	7.9	310
ECMWF−synop	0.7	1.7	1.8	1.3	8.0	310



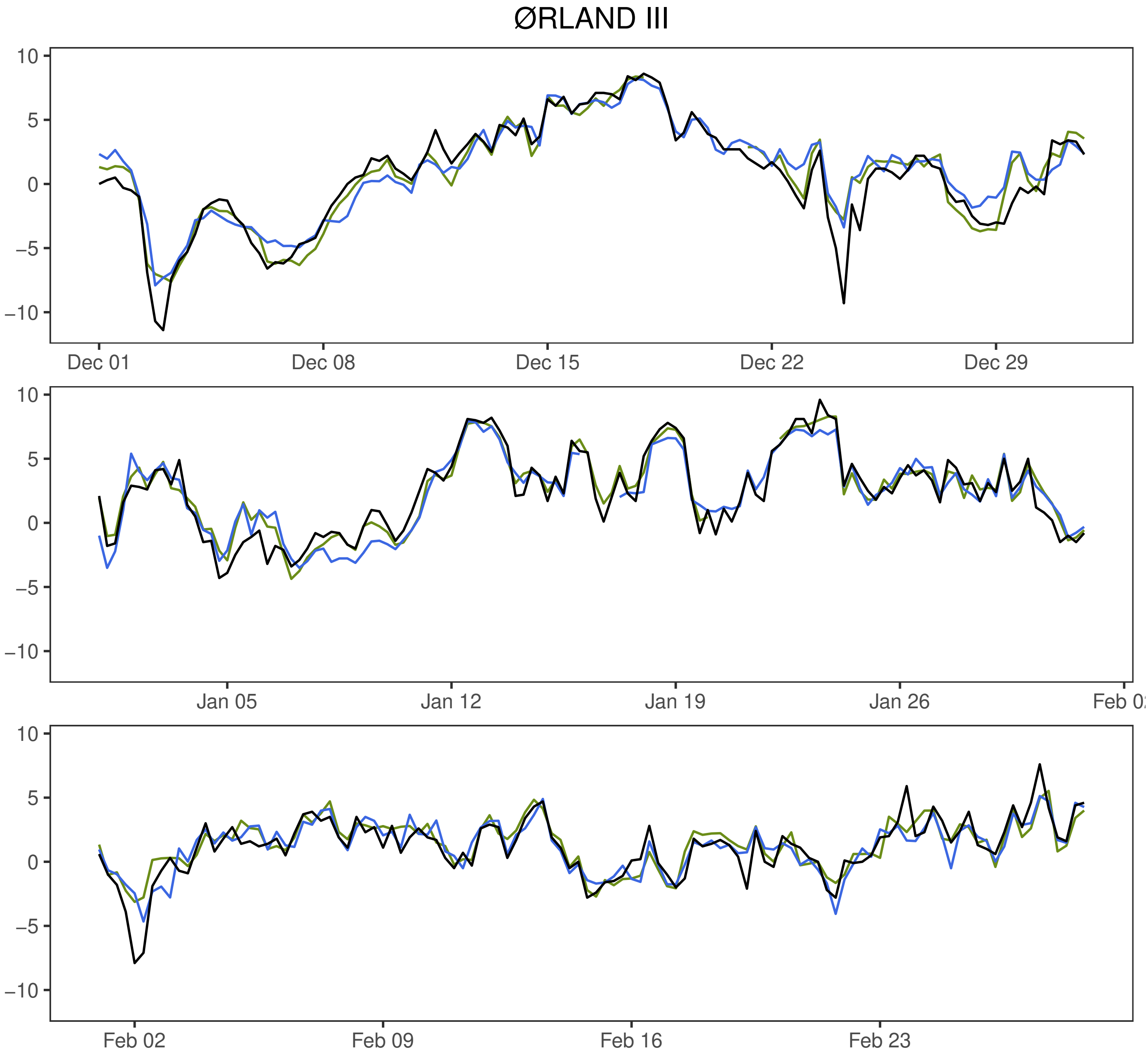
		Min	Mean	Max	Std	N
	synop: 00,06,12,18	−11.3	−3.8	7.0	3.6	360
	MEPSctrl: 12+18,+24,+30,+36	−13.1	−3.5	5.7	4.0	356
	AA25: 12+18,+24,+30,+36	−10.1	−3.0	5.8	3.3	352
	ECMWF: 12+18,+24,+30,+36	−19.0	−8.6	4.3	5.1	340

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl−synop	0.3	1.9	1.9	1.5	5.8	328
AA25−synop	0.8	1.5	1.7	1.3	5.6	328
ECMWF−synop	−4.8	2.5	5.4	4.8	12.0	328



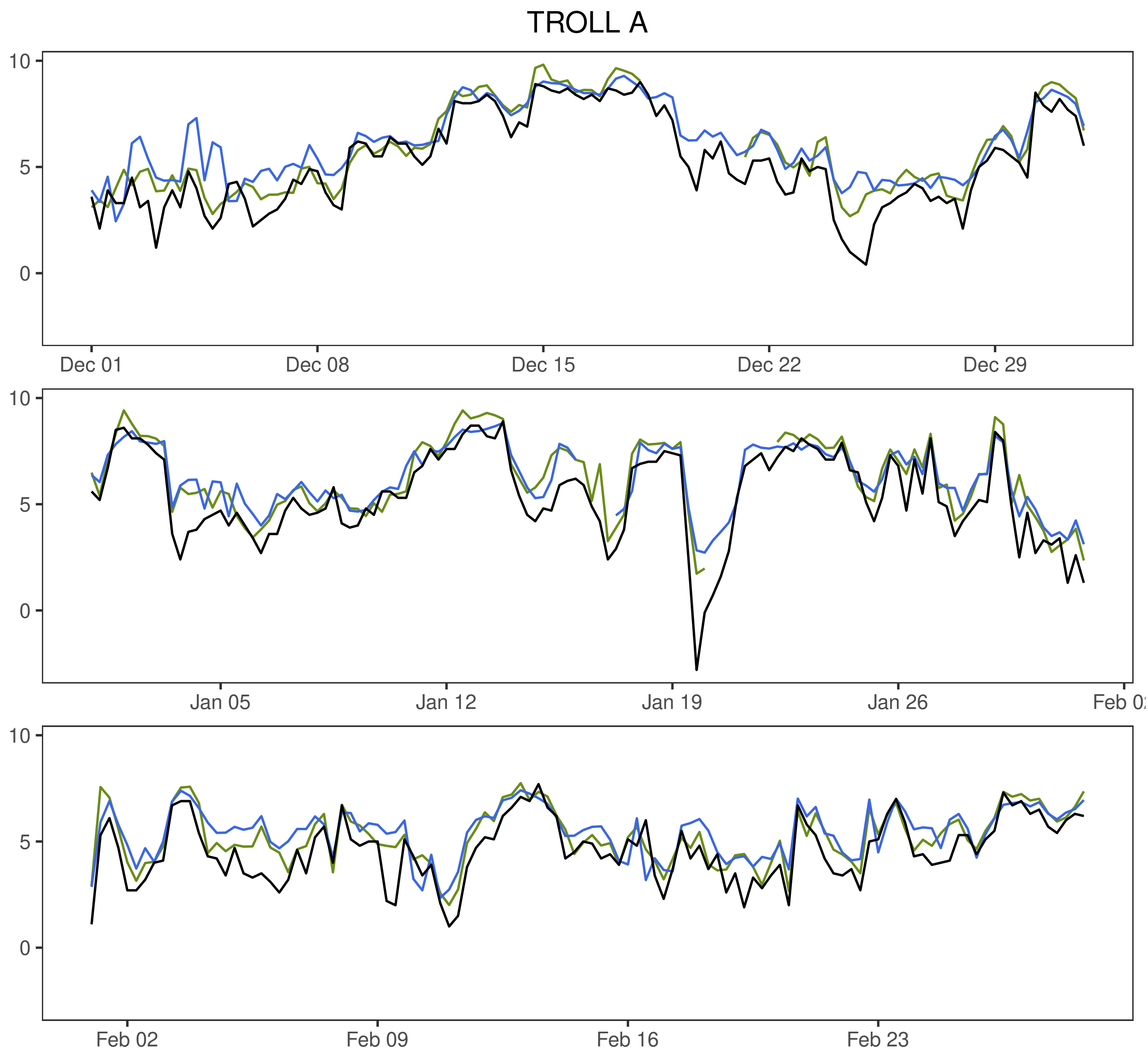
	Min	Mean	Max	Std	N
synop: 00,06,12,18	−37.9	−14.0	5.2	8.9	356
MEPSctrl: 12+18,+24,+30,+36	−32.2	−13.3	0.4	7.1	356
AA25: 12+18,+24,+30,+36	−34.3	−13.7	0.5	7.8	352
ECMWF: 12+18,+24,+30,+36	−24.9	−11.3	3.4	5.6	340

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl−synop	0.8	5.0	5.1	3.7	18.9	324
AA25−synop	0.4	4.8	4.8	3.6	15.5	324
ECMWF−synop	2.9	5.0	5.8	4.1	17.8	324



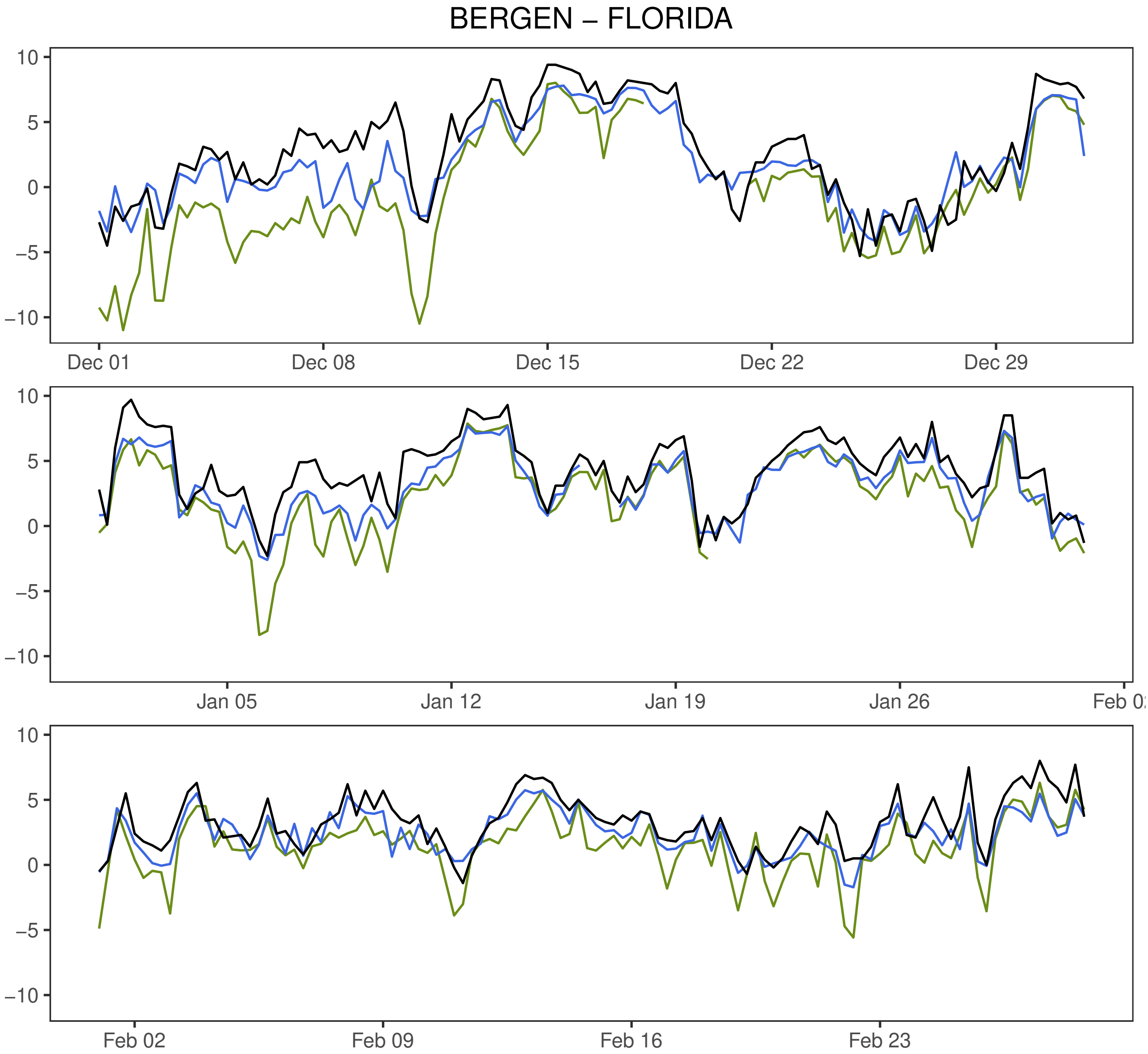
	Min	Mean	Max	Std	N
synop: 00,06,12,18	−11.4	1.4	9.6	3.4	360
MEPSctrl: 12+18,+24,+30,+36	−7.9	1.6	8.2	3.0	356
ECMWF: 12+18,+24,+30,+36	−7.6	1.5	8.4	3.1	340

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl−synop	0.1	1.4	1.4	1.0	5.9	336
ECMWF−synop	0.2	1.2	1.2	0.8	6.5	336



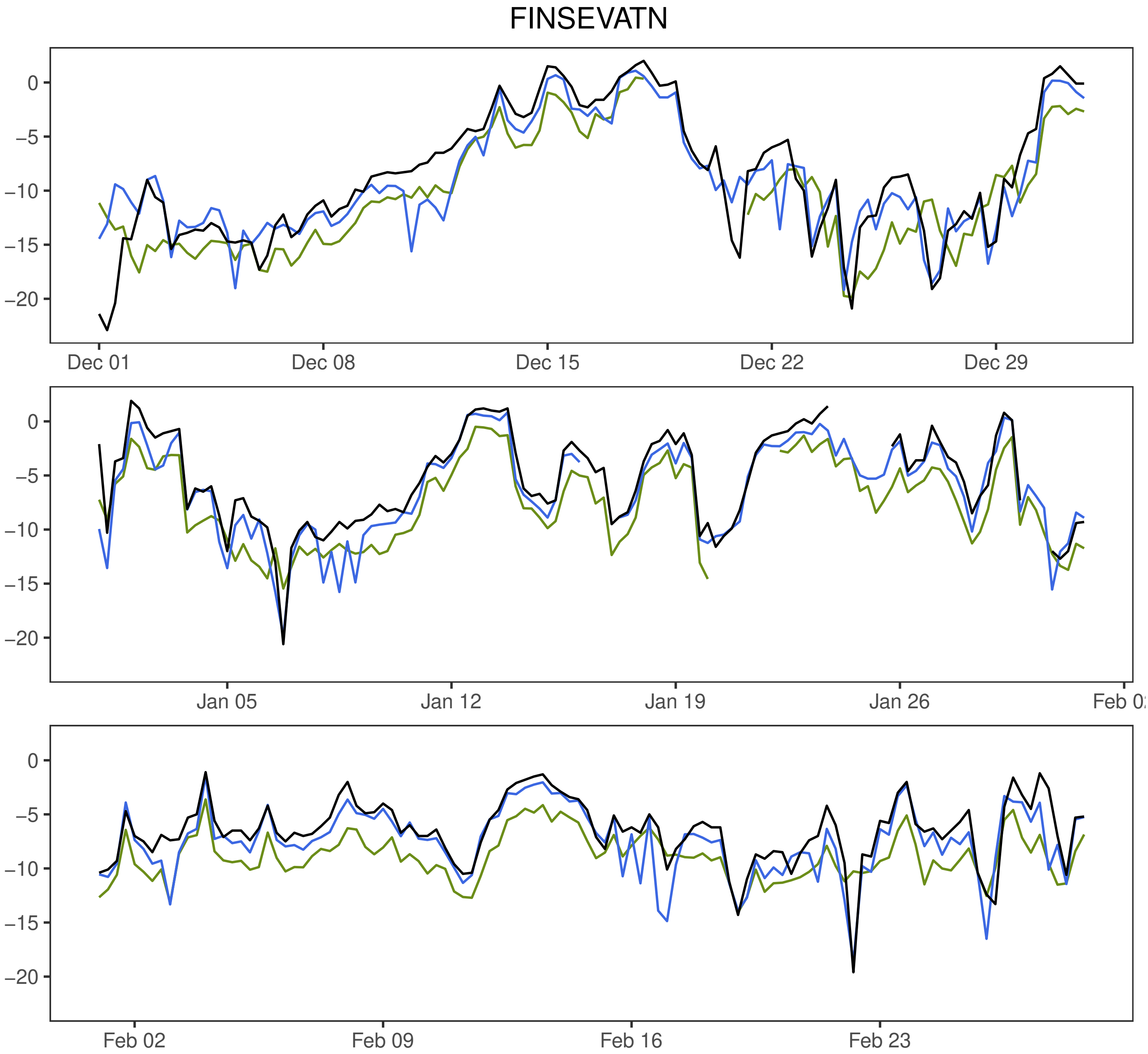
	Min	Mean	Max	Std	N
synop: 00,06,12,18	−2.8	5.1	9.0	2.0	360
MEPSctrl: 12+18,+24,+30,+36	2.3	6.0	9.3	1.5	356
ECMWF: 12+18,+24,+30,+36	1.7	5.8	9.8	1.8	340

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl−synop	0.9	0.9	1.3	1.0	5.6	336
ECMWF−synop	0.7	0.7	1.0	0.8	4.5	336



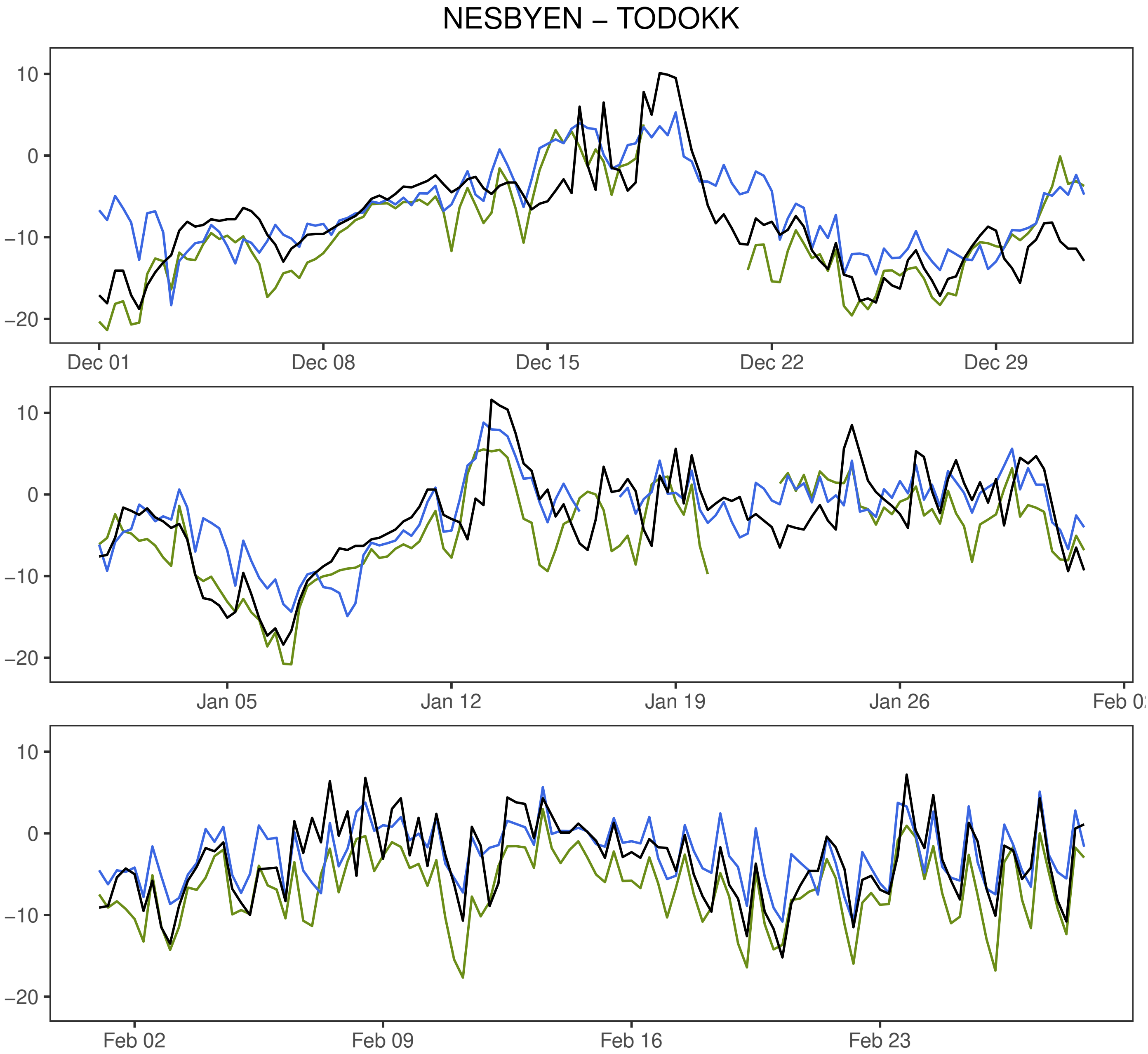
	Min	Mean	Max	Std	N
synop: 00,06,12,18	–5.3	3.4	9.7	3.0	360
MEPSctrl: 12+18,+24,+30,+36	–4.2	2.4	7.8	2.6	356
ECMWF: 12+18,+24,+30,+36	–11.0	1.1	8.0	3.7	340

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl–synop	–1.0	1.3	1.7	1.3	5.3	336
ECMWF–synop	–2.4	1.8	3.0	2.5	8.4	336



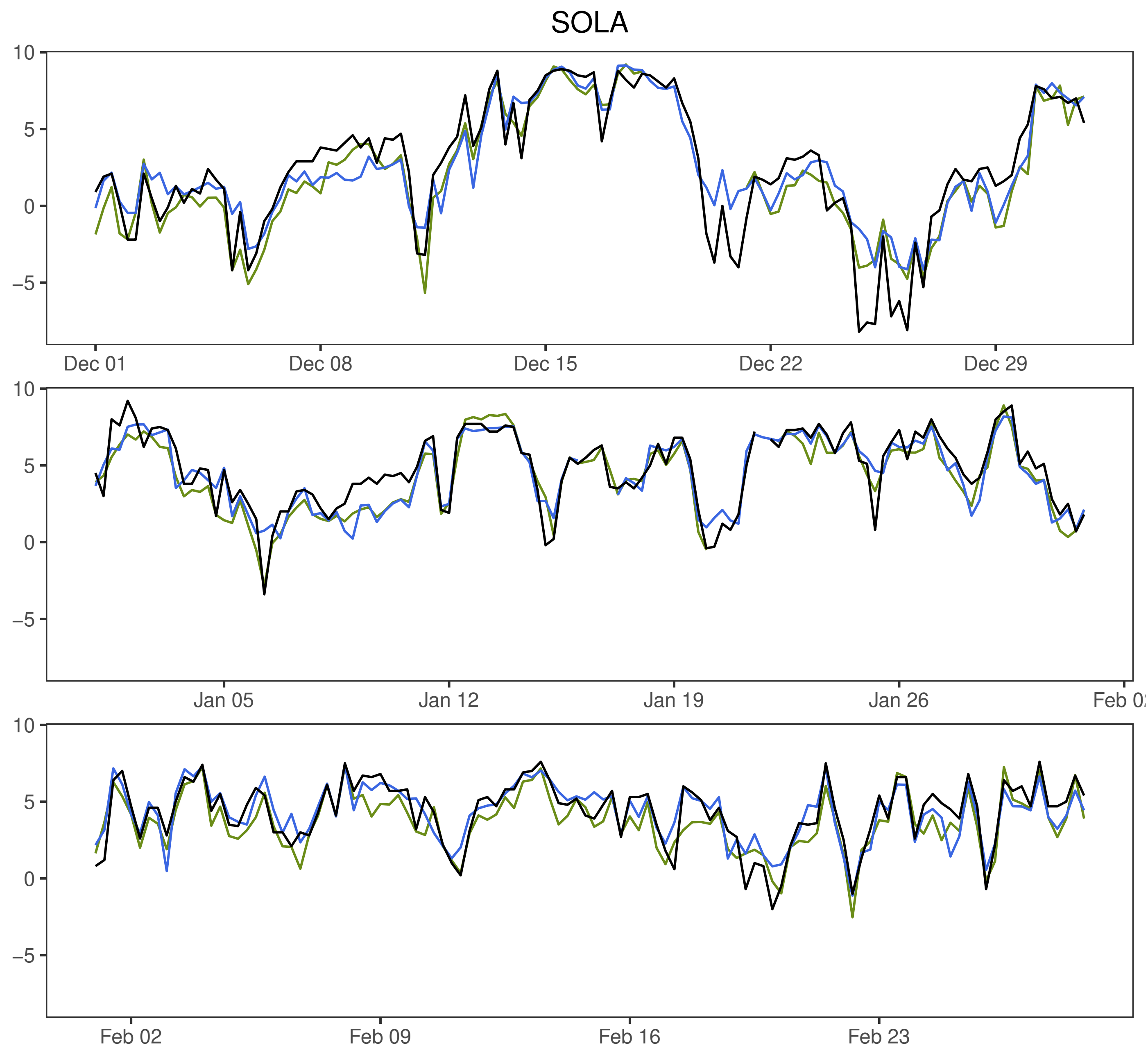
	Min	Mean	Max	Std	N
synop: 00,06,12,18	−22.9	−6.8	2.0	4.8	350
MEPSctrl: 12+18,+24,+30,+36	−19.9	−7.6	1.1	4.5	356
ECMWF: 12+18,+24,+30,+36	−19.9	−8.9	0.4	4.1	340

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl−synop	−0.9	2.0	2.1	1.4	11.0	326
ECMWF−synop	−2.1	2.2	3.1	2.7	10.4	326



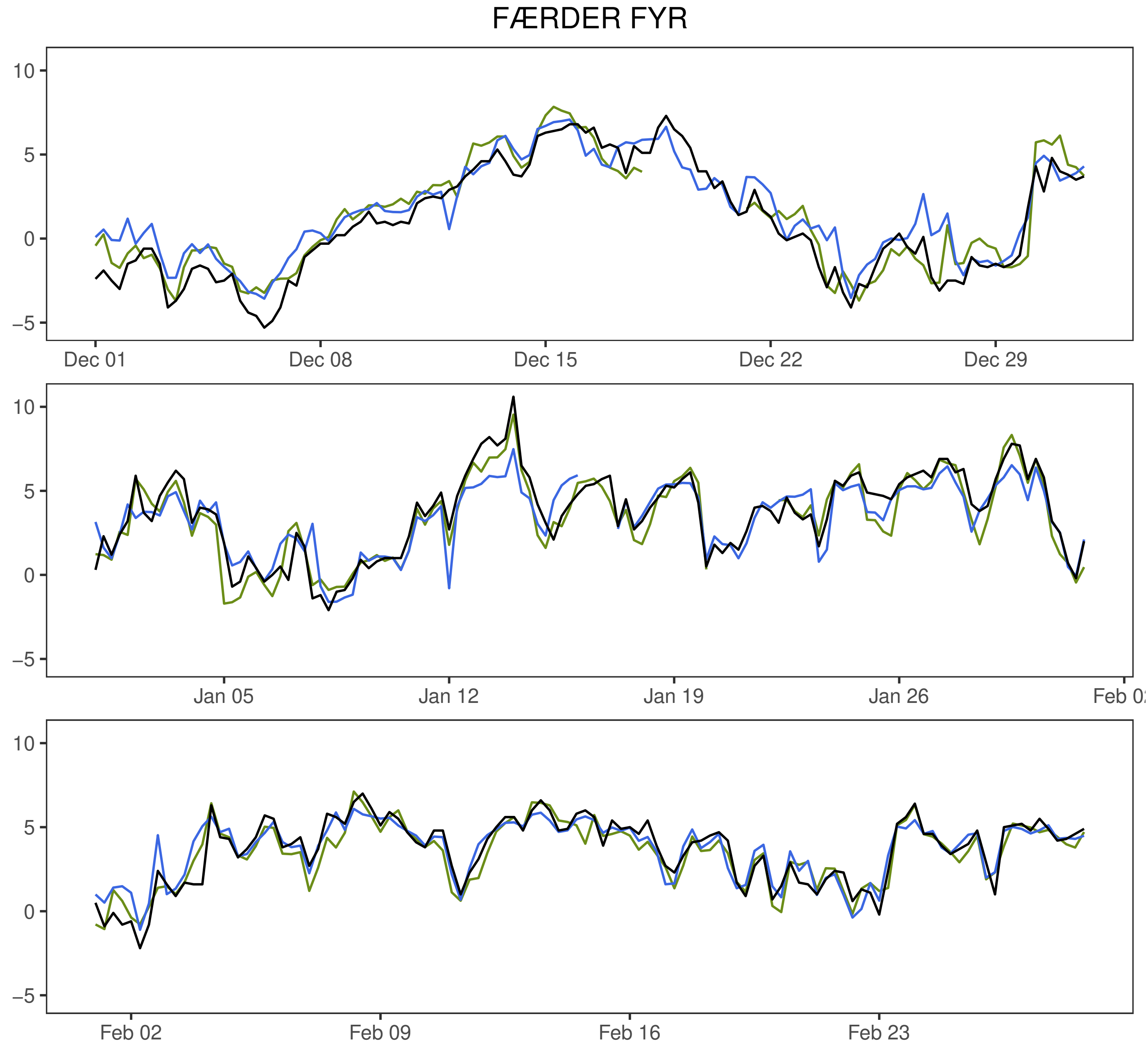
	Min	Mean	Max	Std	N
synop: 00,06,12,18	−18.8	−4.8	11.6	6.1	360
MEPSctrl: 12+18,+24,+30,+36	−18.3	−3.8	8.8	5.0	356
ECMWF: 12+18,+24,+30,+36	−21.4	−7.0	5.5	5.7	340

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl−synop	1.1	3.6	3.8	3.0	10.4	336
ECMWF−synop	−2.0	3.6	4.1	3.4	13.2	336



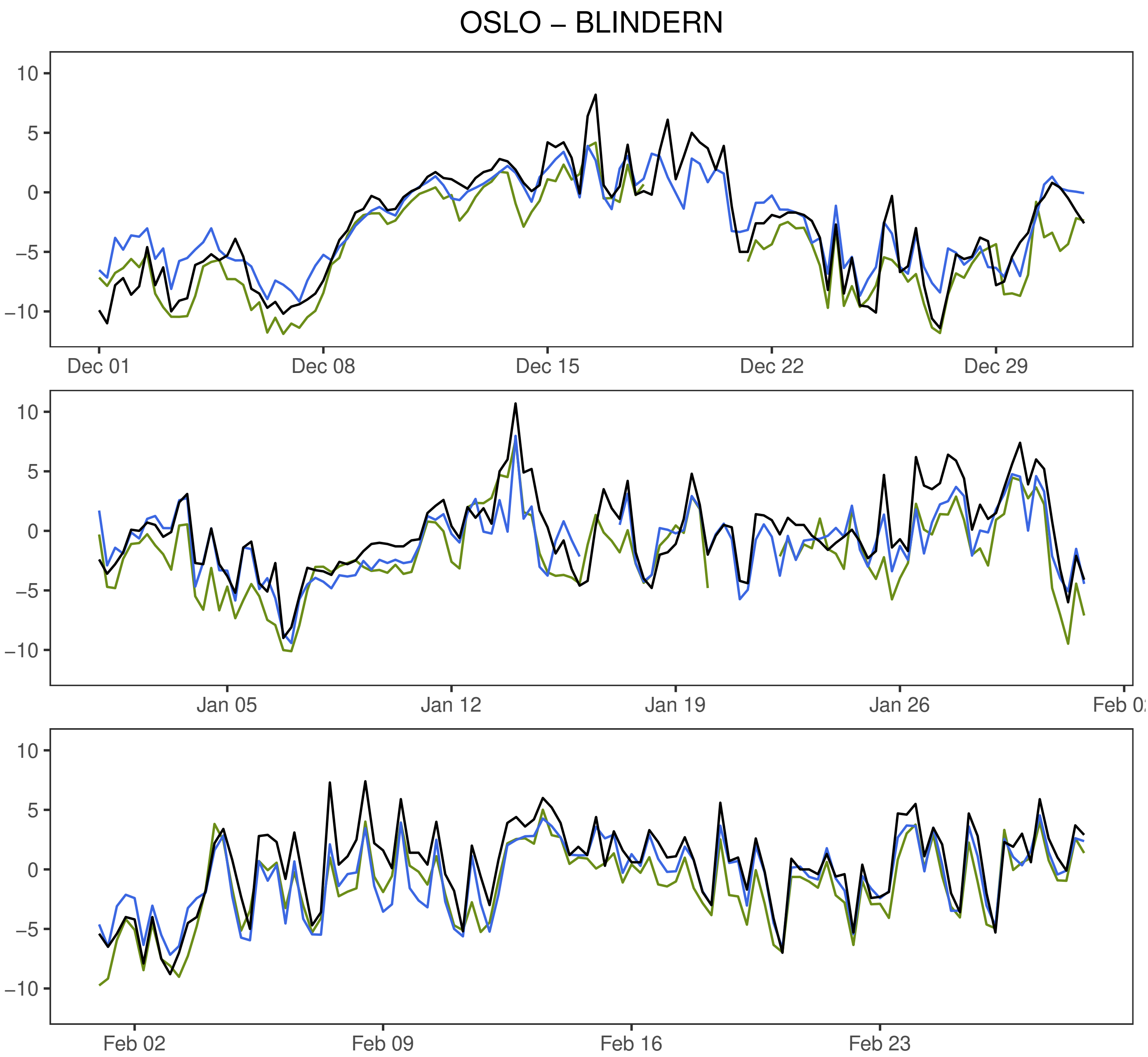
	Min	Mean	Max	Std	N
synop: 00,06,12,18	−8.2	3.8	9.2	3.2	359
MEPSctrl: 12+18,+24,+30,+36	−4.1	3.8	9.1	2.8	356
ECMWF: 12+18,+24,+30,+36	−5.7	3.3	9.2	3.0	340

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl−synop	−0.1	1.3	1.3	1.0	6.7	336
ECMWF−synop	−0.6	1.2	1.3	1.0	4.2	336



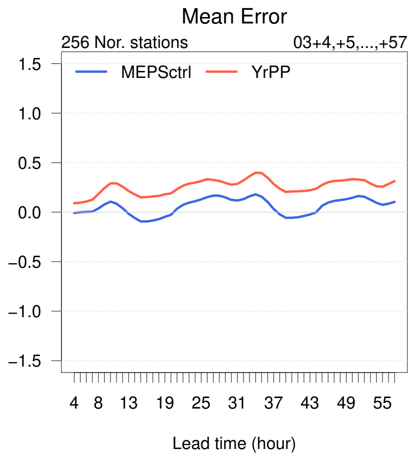
	Min	Mean	Max	Std	N
synop: 00,06,12,18	−5.3	2.7	10.6	3.0	360
MEPSctrl: 12+18,+24,+30,+36	−3.6	2.9	7.5	2.4	356
ECMWF: 12+18,+24,+30,+36	−3.7	2.7	9.5	2.8	340

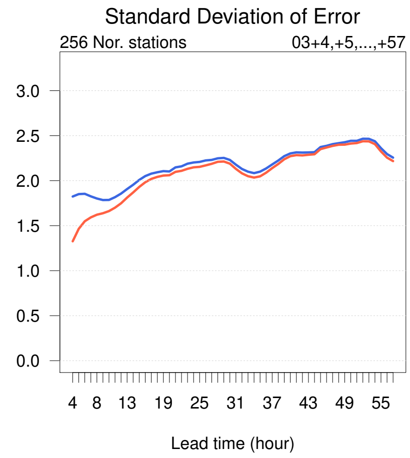
	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl−synop	0.2	1.1	1.1	0.8	4.4	336
ECMWF−synop	0.0	1.0	1.0	0.8	3.6	336

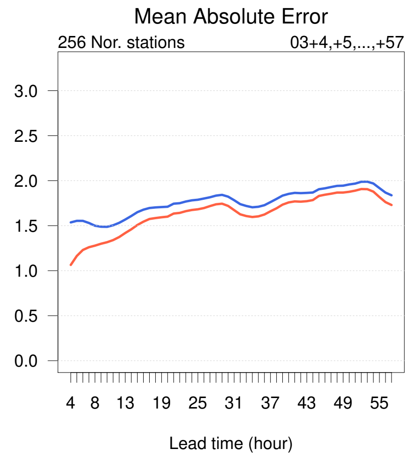


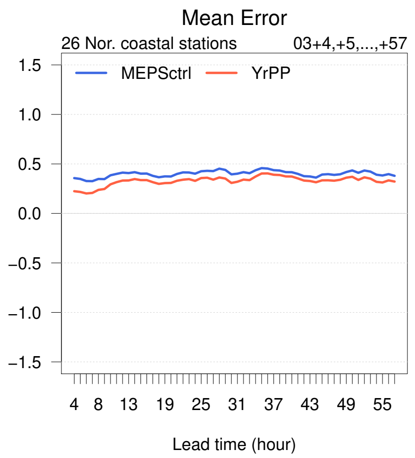
	Min	Mean	Max	Std	N
synop: 00,06,12,18	−11.4	−0.9	10.7	4.1	360
MEPSctrl: 12+18,+24,+30,+36	−9.4	−1.5	8.0	3.2	356
ECMWF: 12+18,+24,+30,+36	−11.9	−2.7	7.7	3.8	340

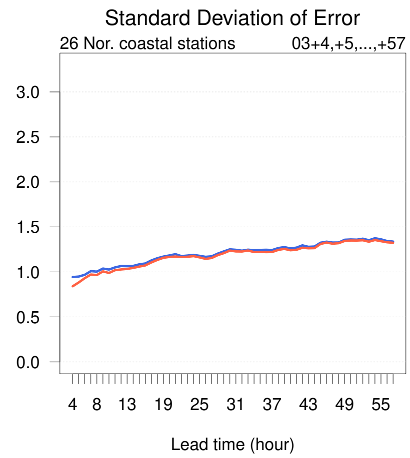
	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl−synop	−0.5	1.8	1.8	1.4	6.1	336
ECMWF−synop	−1.6	1.6	2.3	1.9	6.9	336

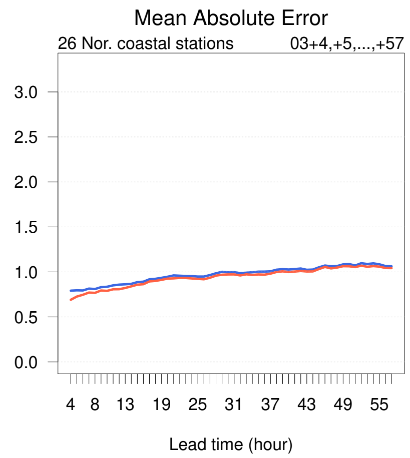

Mean Error
256 Nor. stations
03+4,+5,...,+57
MEPSctrl
YrPP
1.5
1.0
0.5
0.0
−0.5
−1.0
−1.5
4 8 13 19 25 31 37 43 49 55
Lead time (hour)

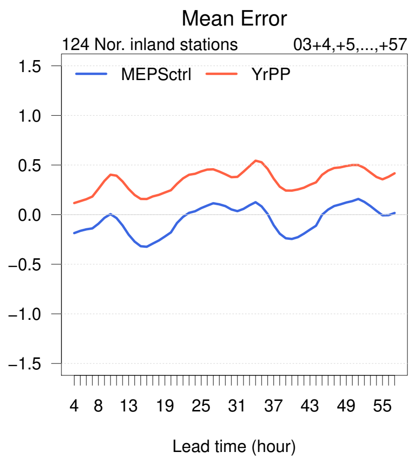

Standard Deviation of Error
256 Nor. stations
03+4,+5,...,+57
3.0
2.5
2.0
1.5
1.0
0.5
0.0
4 8 13 19 25 31 37 43 49 55
Lead time (hour)

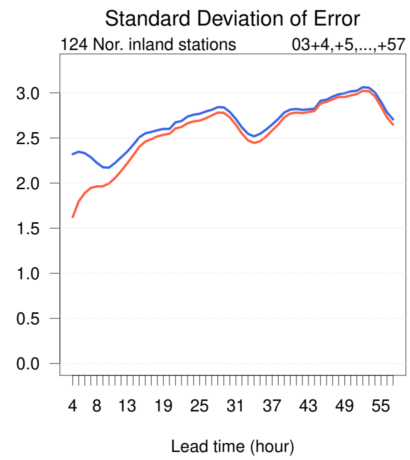

Mean Absolute Error
256 Nor. stations
03+4,+5,...,+57
3.0
2.5
2.0
1.5
1.0
0.5
0.0
4 8 13 19 25 31 37 43 49 55
Lead time (hour)

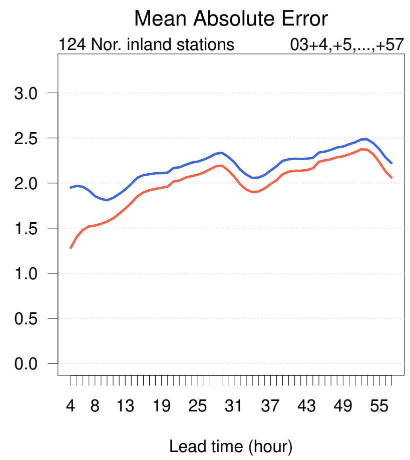

Mean Error
26 Nor. coastal stations
03+4,+5,...,+57
MEPSctrl
YrPP
1.5
1.0
0.5
0.0
−0.5
−1.0
−1.5
4 8 13 19 25 31 37 43 49 55
Lead time (hour)

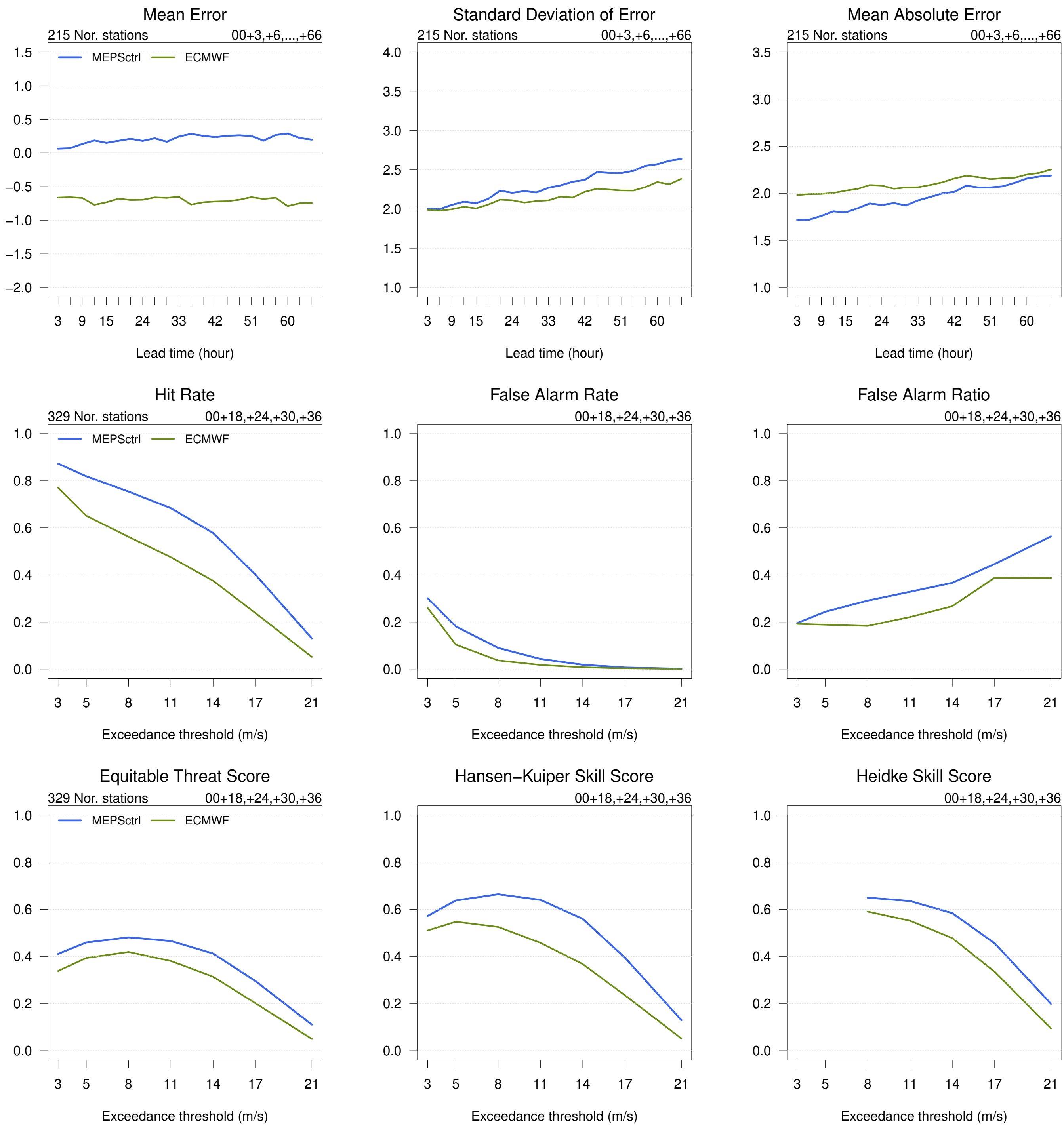

Standard Deviation of Error
26 Nor. coastal stations
03+4,+5,...,+57
3.0
2.5
2.0
1.5
1.0
0.5
0.0
4 8 13 19 25 31 37 43 49 55
Lead time (hour)

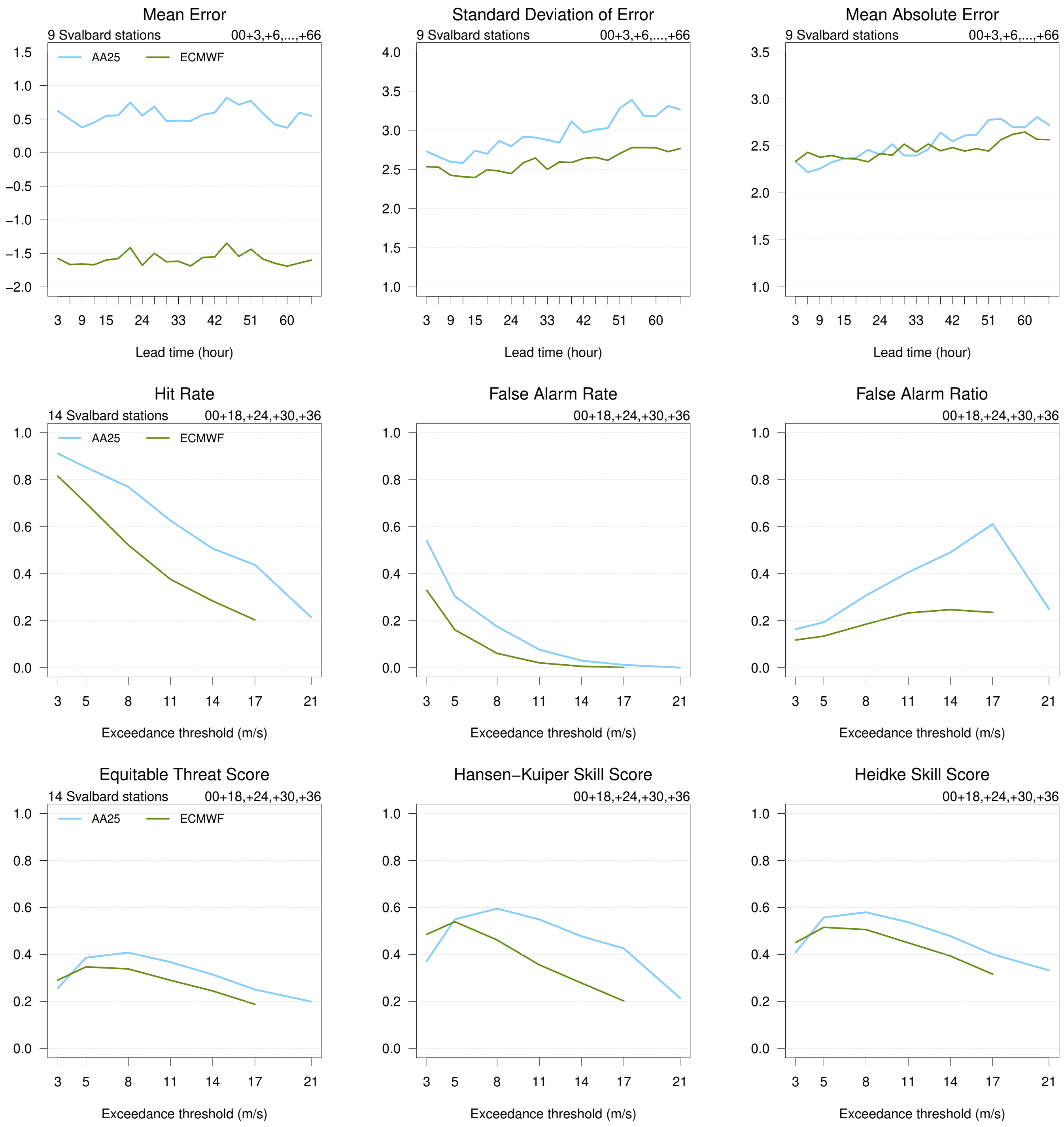

Mean Absolute Error
26 Nor. coastal stations
03+4,+5,...,+57
3.0
2.5
2.0
1.5
1.0
0.5
0.0
4 8 13 19 25 31 37 43 49 55
Lead time (hour)

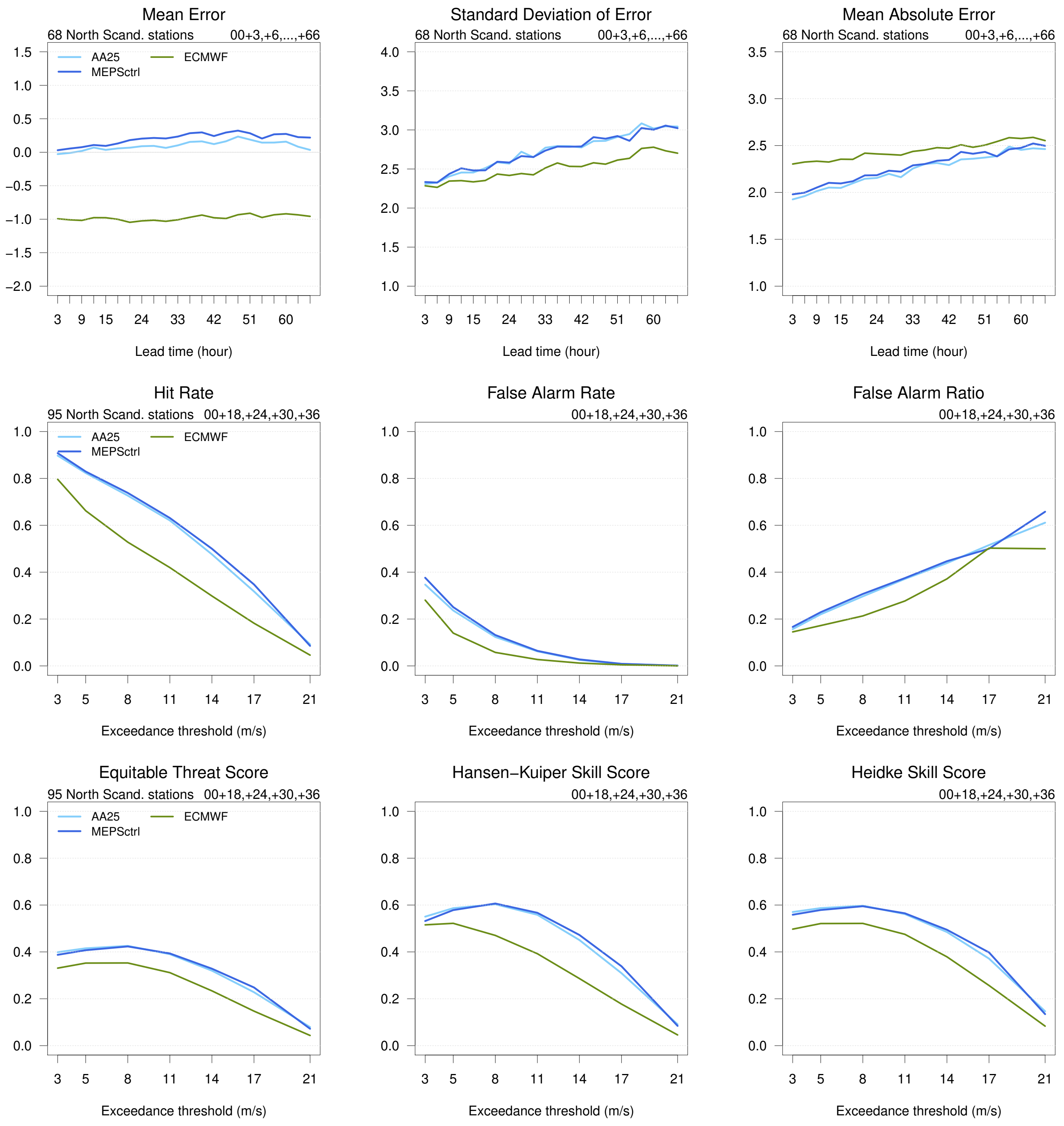

Mean Error
124 Nor. inland stations
03+4,+5,...,+57
MEPSctrl
YrPP
1.5
1.0
0.5
0.0
−0.5
−1.0
−1.5
4 8 13 19 25 31 37 43 49 55
Lead time (hour)


Standard Deviation of Error
124 Nor. inland stations
03+4,+5,...,+57
3.0
2.5
2.0
1.5
1.0
0.5
0.0
4 8 13 19 25 31 37 43 49 55
Lead time (hour)

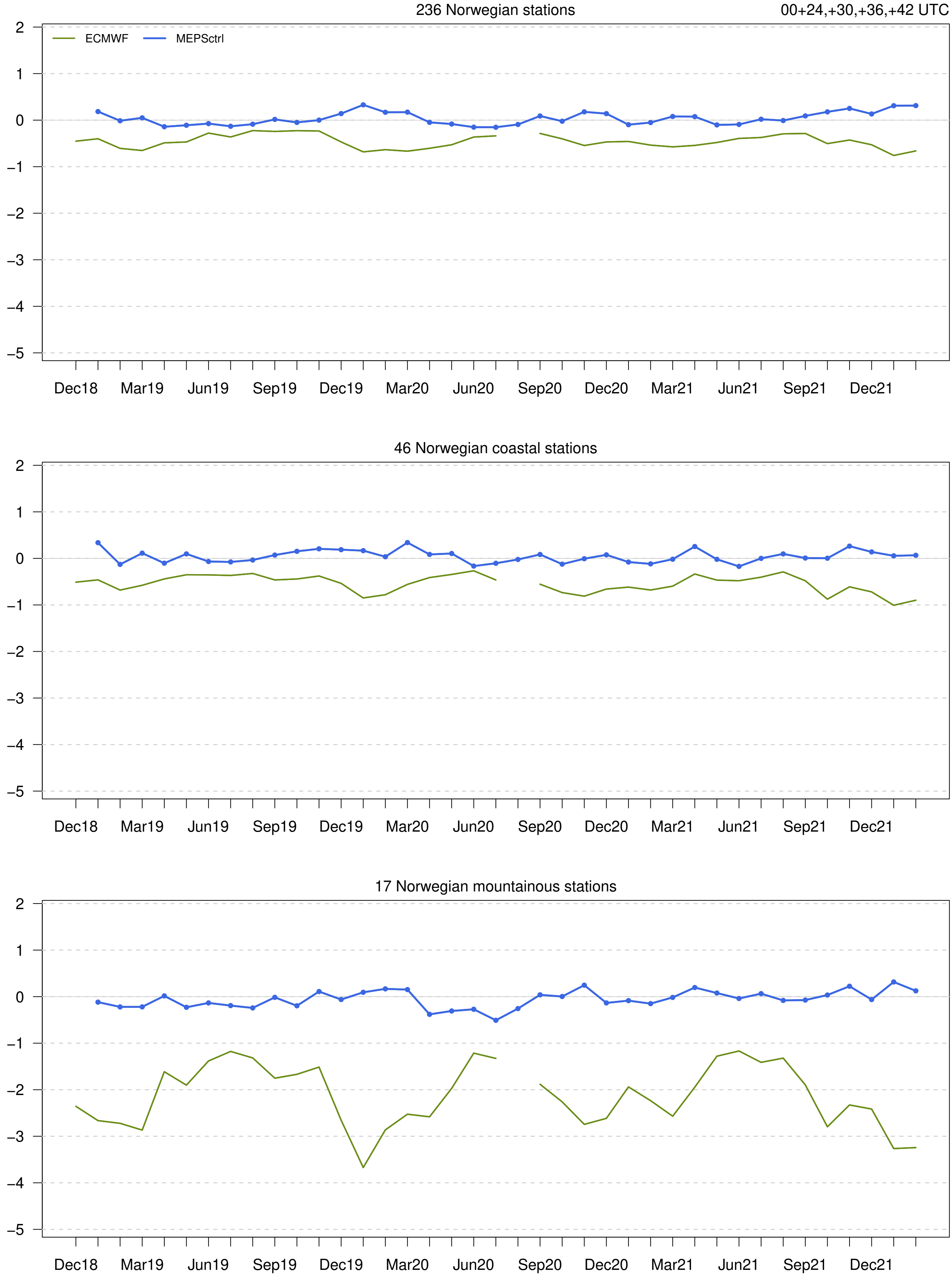

Mean Absolute Error
124 Nor. inland stations
03+4,+5,...,+57
3.0
2.5
2.0
1.5
1.0
0.5
0.0
4 8 13 19 25 31 37 43 49 55
Lead time (hour)


Mean Error
215 Nor. stations
00+3,+6,...,+66
MEPSctrl
ECMWF
Lead time (hour)
Standard Deviation of Error
215 Nor. stations
00+3,+6,...,+66
Lead time (hour)
Mean Absolute Error
215 Nor. stations
00+3,+6,...,+66
Lead time (hour)
Hit Rate
329 Nor. stations
00+18,+24,+30,+36
MEPSctrl
ECMWF
Exceedance threshold (m/s)
False Alarm Rate
00+18,+24,+30,+36
Exceedance threshold (m/s)
False Alarm Ratio
00+18,+24,+30,+36
Exceedance threshold (m/s)
Equitable Threat Score
329 Nor. stations
00+18,+24,+30,+36
MEPSctrl
ECMWF
Exceedance threshold (m/s)
Hansen−Kuiper Skill Score
00+18,+24,+30,+36
Exceedance threshold (m/s)
Heidke Skill Score
00+18,+24,+30,+36
Exceedance threshold (m/s)

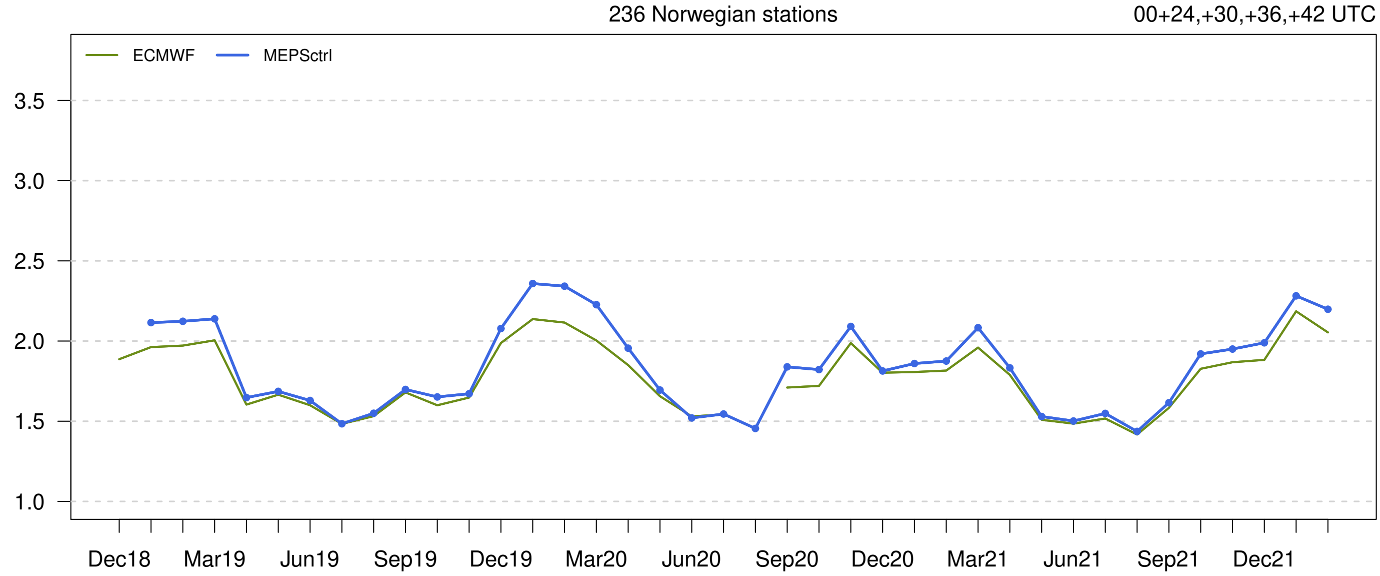

Mean Error
9 Svalbard stations
00+3,+6,...,+66
AA25
ECMWF
Lead time (hour)
Standard Deviation of Error
9 Svalbard stations
00+3,+6,...,+66
Lead time (hour)
Mean Absolute Error
9 Svalbard stations
00+3,+6,...,+66
Lead time (hour)
Hit Rate
14 Svalbard stations
00+18,+24,+30,+36
AA25
ECMWF
Exceedance threshold (m/s)
False Alarm Rate
00+18,+24,+30,+36
Exceedance threshold (m/s)
False Alarm Ratio
00+18,+24,+30,+36
Exceedance threshold (m/s)
Equitable Threat Score
14 Svalbard stations
00+18,+24,+30,+36
AA25
ECMWF
Exceedance threshold (m/s)
Hansen−Kuiper Skill Score
00+18,+24,+30,+36
Exceedance threshold (m/s)
Heidke Skill Score
00+18,+24,+30,+36
Exceedance threshold (m/s)

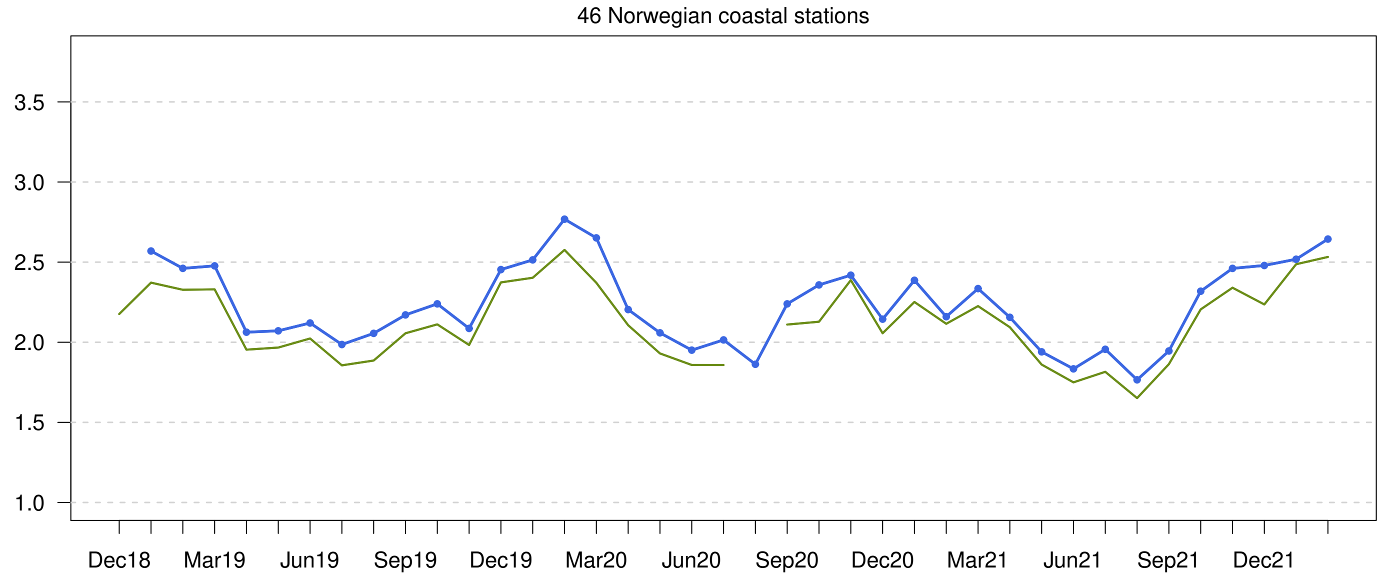

Mean Error
68 North Scand. stations 00+3,+6,...,+66
AA25
MEPSctrl
ECMWF
Lead time (hour)
Standard Deviation of Error
68 North Scand. stations 00+3,+6,...,+66
Lead time (hour)
Mean Absolute Error
68 North Scand. stations 00+3,+6,...,+66
Lead time (hour)
Hit Rate
95 North Scand. stations 00+18,+24,+30,+36
Exceedance threshold (m/s)
False Alarm Rate
00+18,+24,+30,+36
Exceedance threshold (m/s)
False Alarm Ratio
00+18,+24,+30,+36
Exceedance threshold (m/s)
Equitable Threat Score
95 North Scand. stations 00+18,+24,+30,+36
Exceedance threshold (m/s)
Hansen−Kuiper Skill Score
00+18,+24,+30,+36
Exceedance threshold (m/s)
Heidke Skill Score
00+18,+24,+30,+36
Exceedance threshold (m/s)

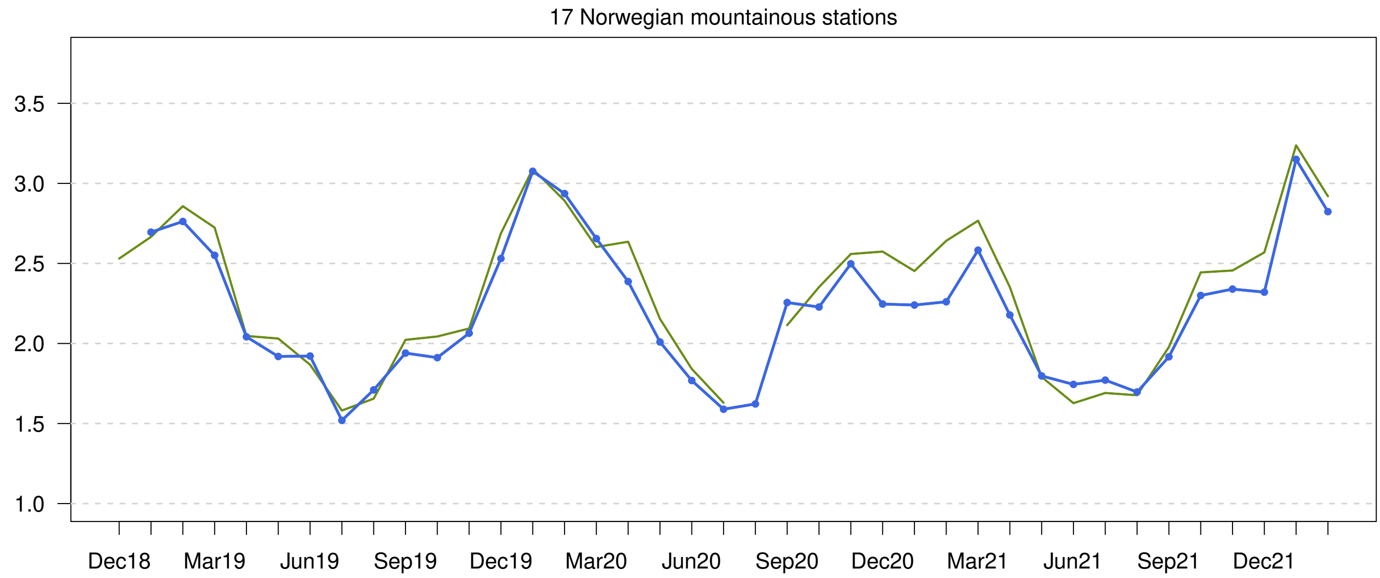
Mean Error

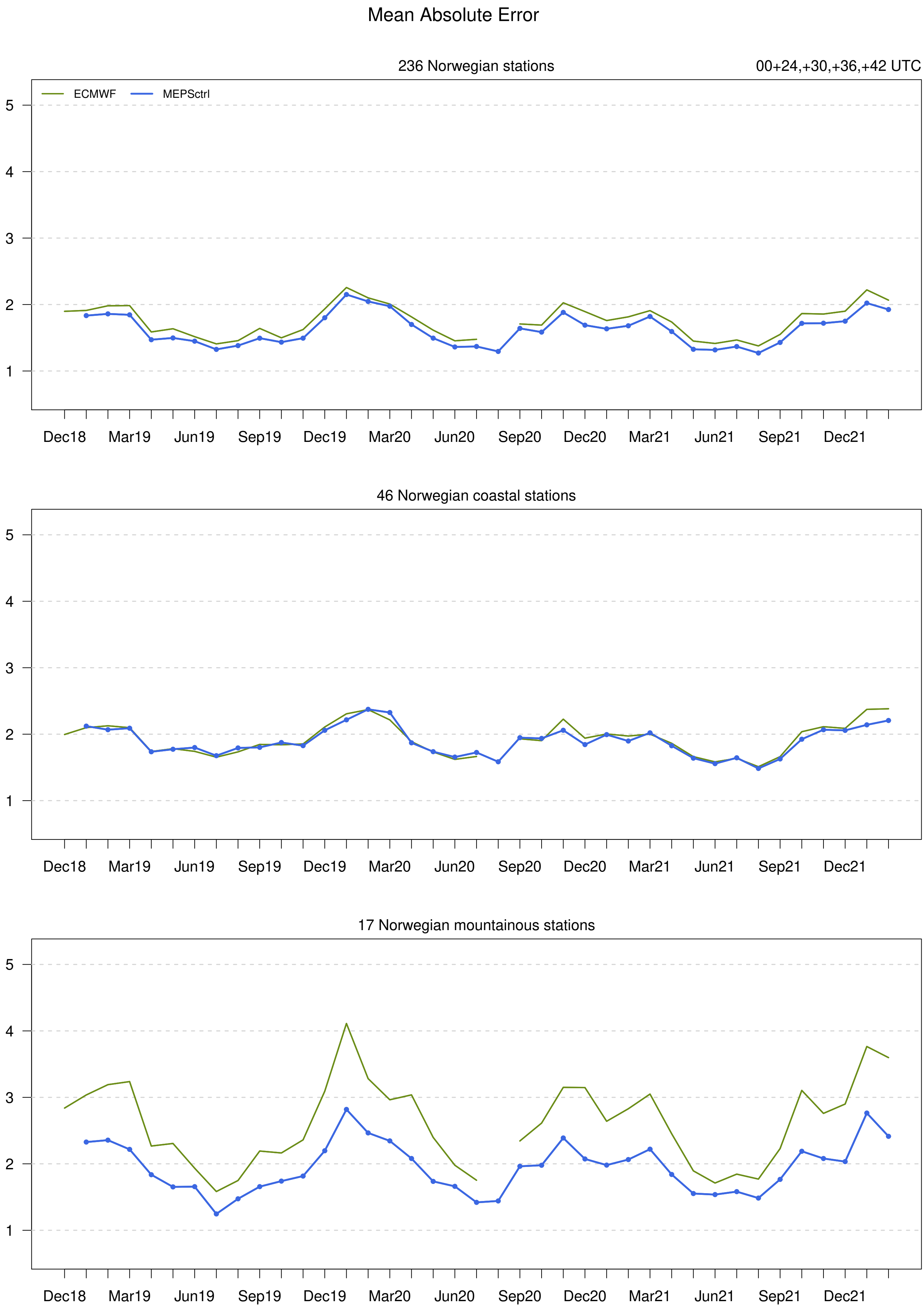

236 Norwegian stations
00+24,+30,+36,+42 UTC
ECMWF
MEPSctrl
2
1
0
−1
−2
−3
−4
−5
Dec18
Mar19
Jun19
Sep19
Dec19
Mar20
Jun20
Sep20
Dec20
Mar21
Jun21
Sep21
Dec21
46 Norwegian coastal stations
17 Norwegian mountainous stations

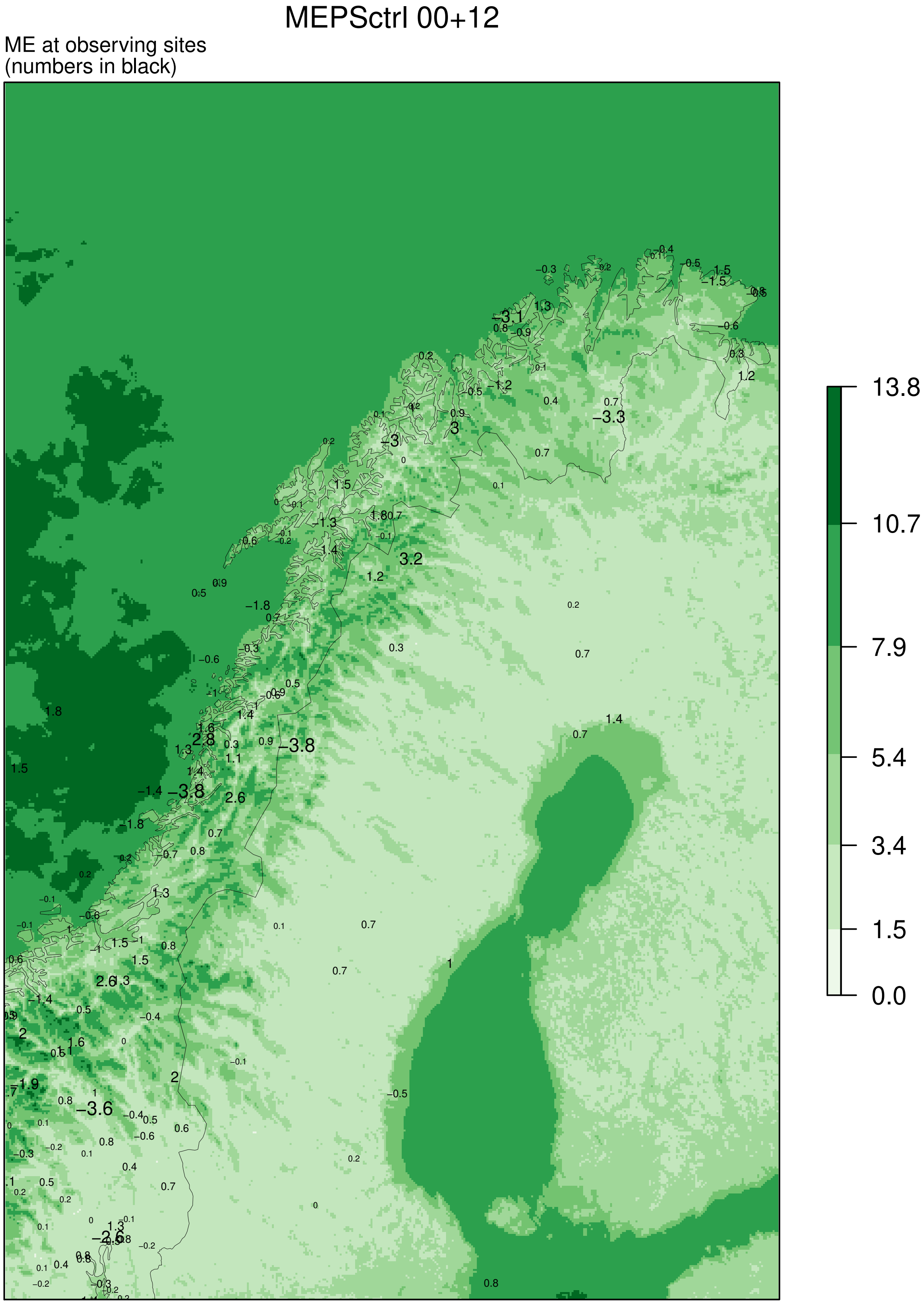
Standard Deviation of Error



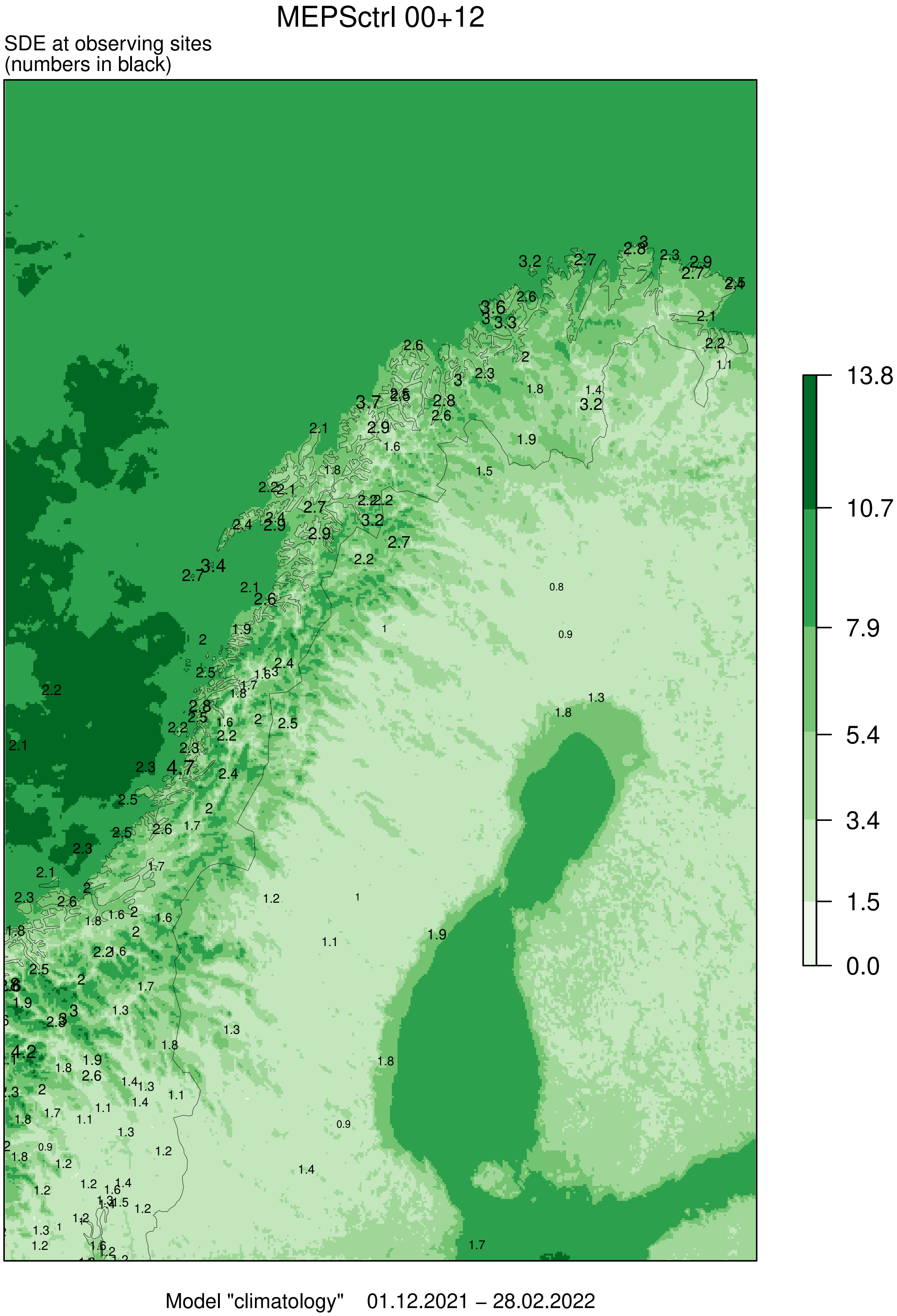





Mean Absolute Error
236 Norwegian stations
00+24,+30,+36,+42 UTC
ECMWF
MEPSctrl
1
2
3
4
5
Dec18
Mar19
Jun19
Sep19
Dec19
Mar20
Jun20
Sep20
Dec20
Mar21
Jun21
Sep21
Dec21
46 Norwegian coastal stations
17 Norwegian mountainous stations

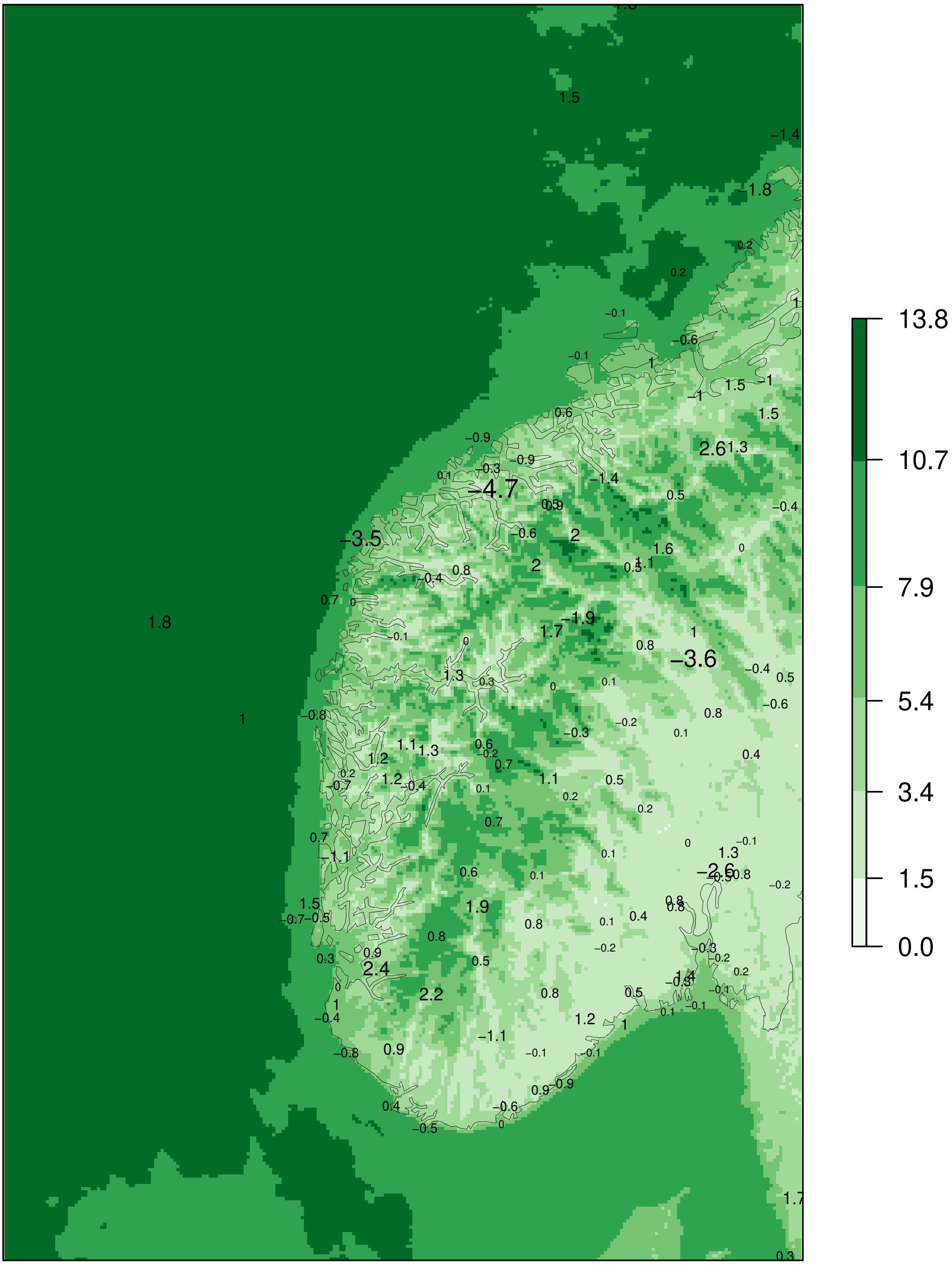


Model "climatology" 01.12.2021 – 28.02.2022


MEPSctrl 00+12
SDE at observing sites
(numbers in black)
13.8
10.7
7.9
5.4
3.4
1.5
0.0
Model "climatology" 01.12.2021 – 28.02.2022

MEPSctrl 00+12

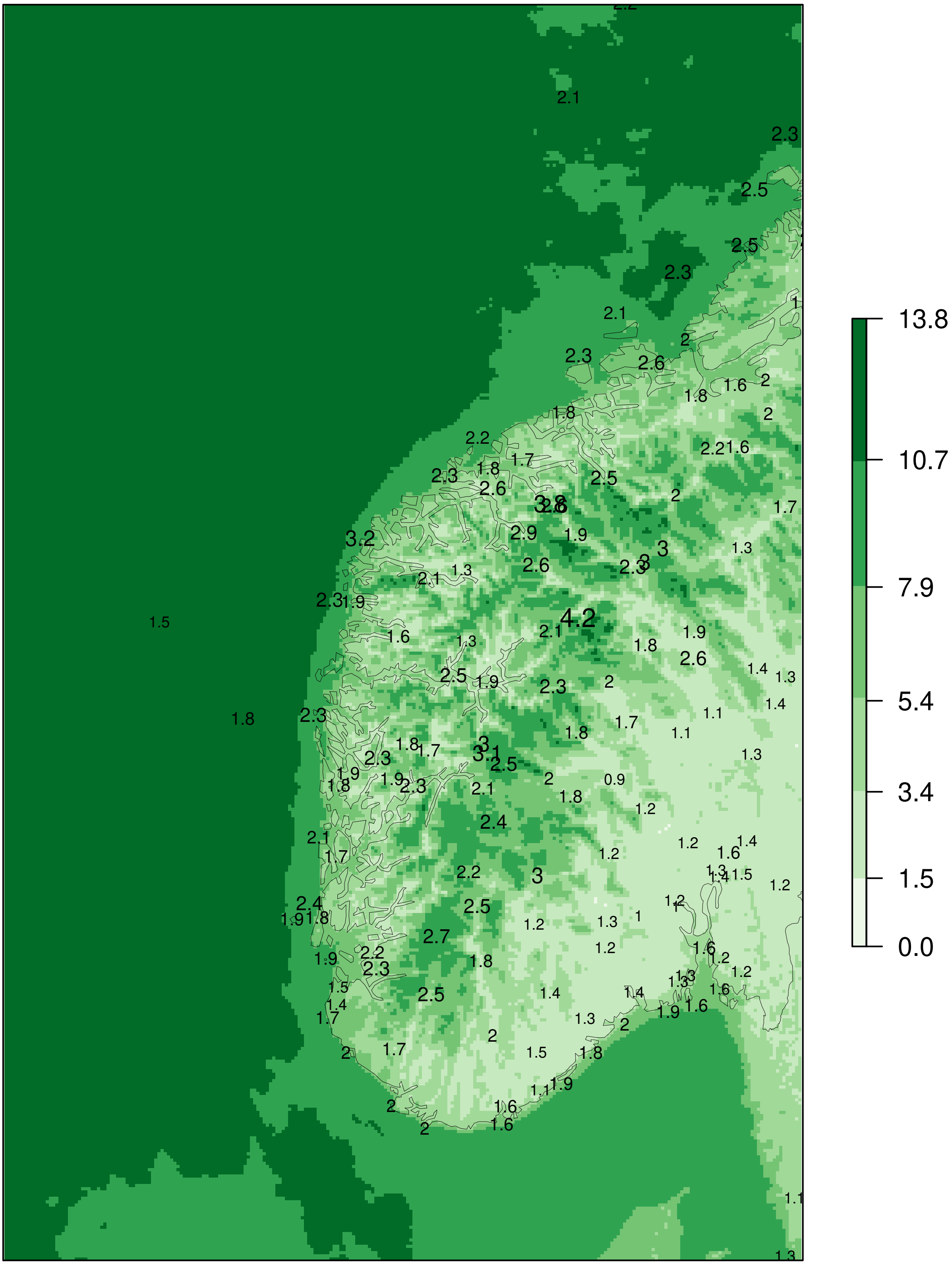
ME at observing sites
(numbers in black)



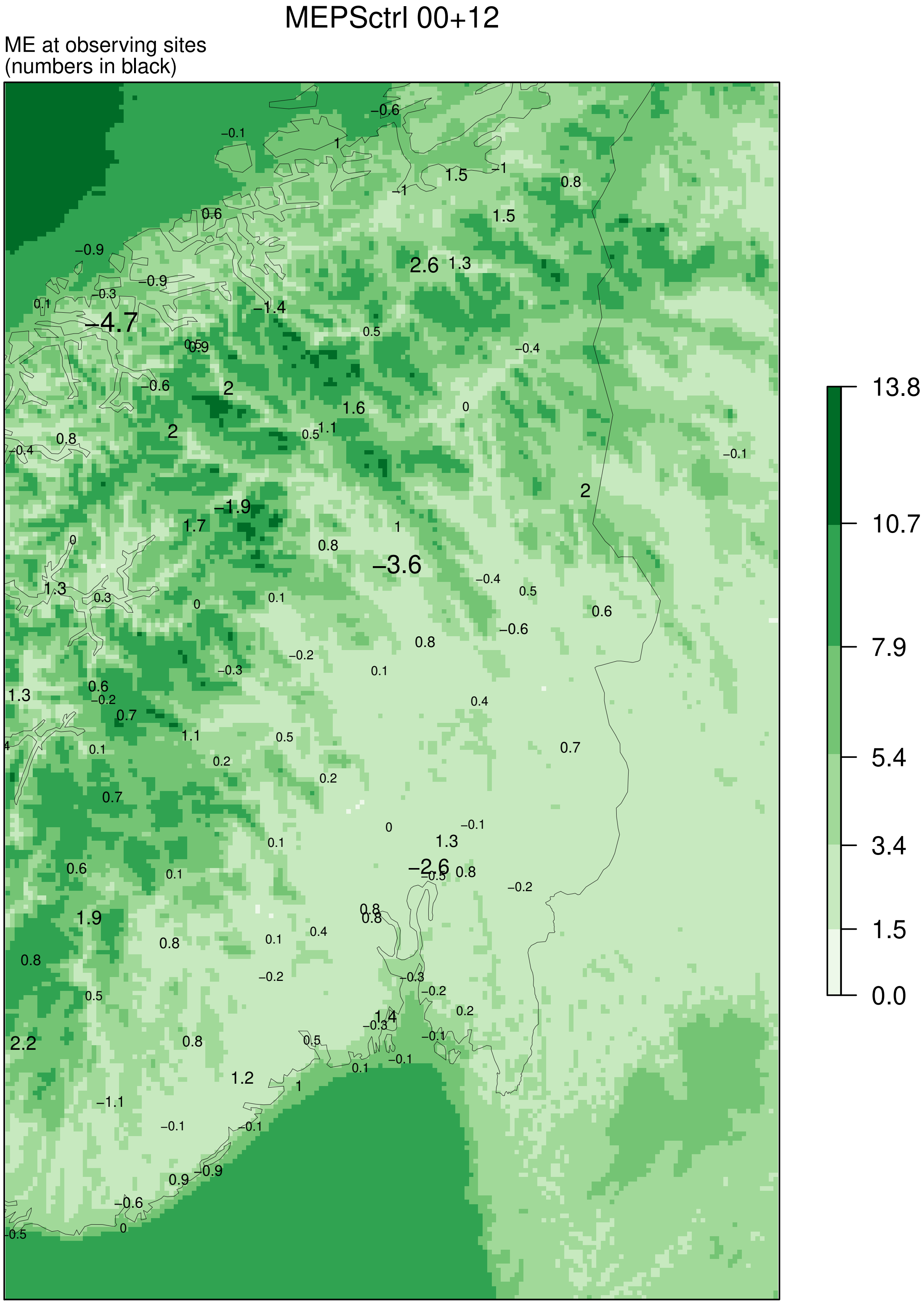
Model "climatology" 01.12.2021 – 28.02.2022

MEPSctrl 00+12

SDE at observing sites
(numbers in black)



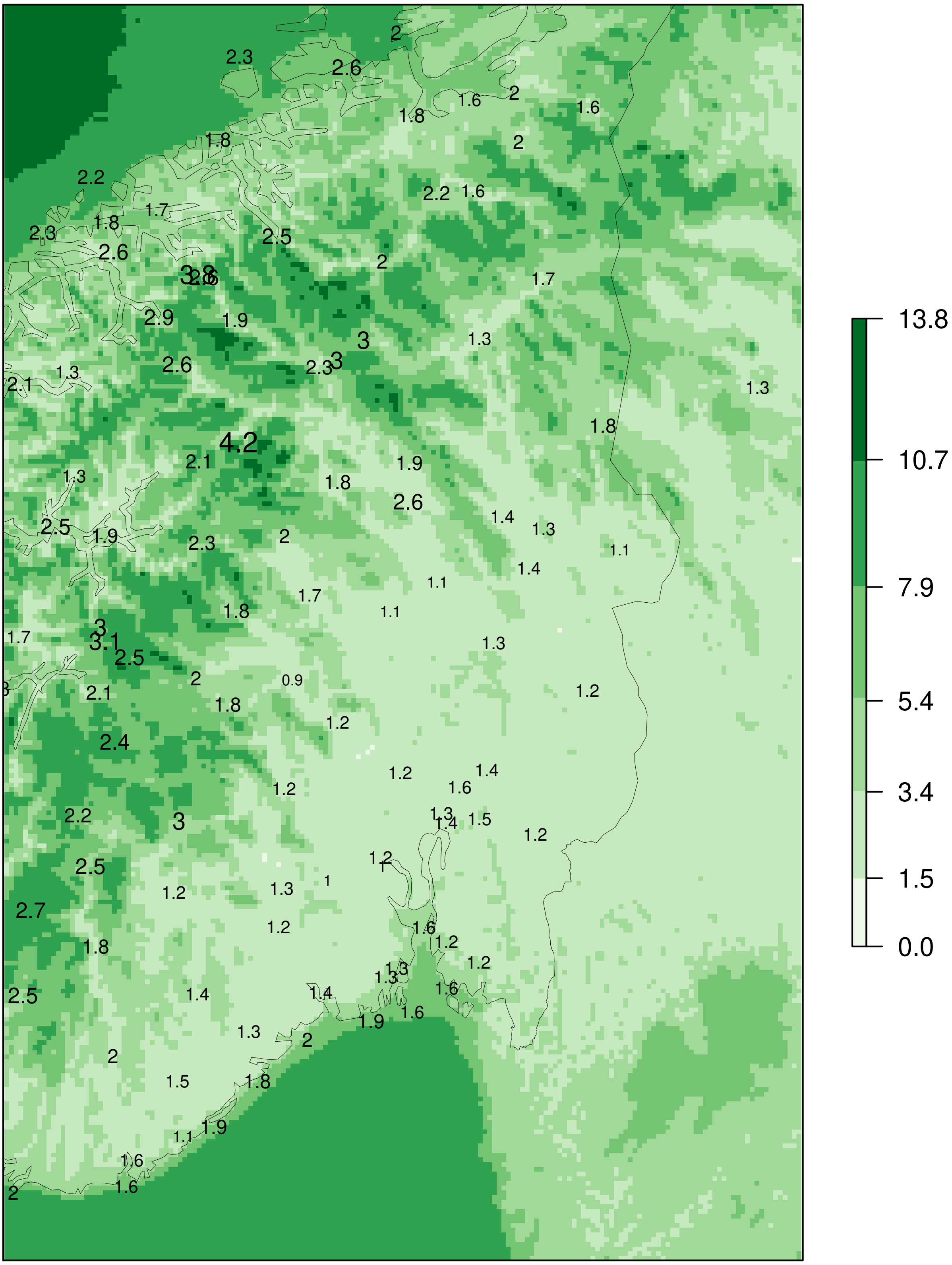
Model "climatology" 01.12.2021 – 28.02.2022



Model "climatology" 01.12.2021 – 28.02.2022

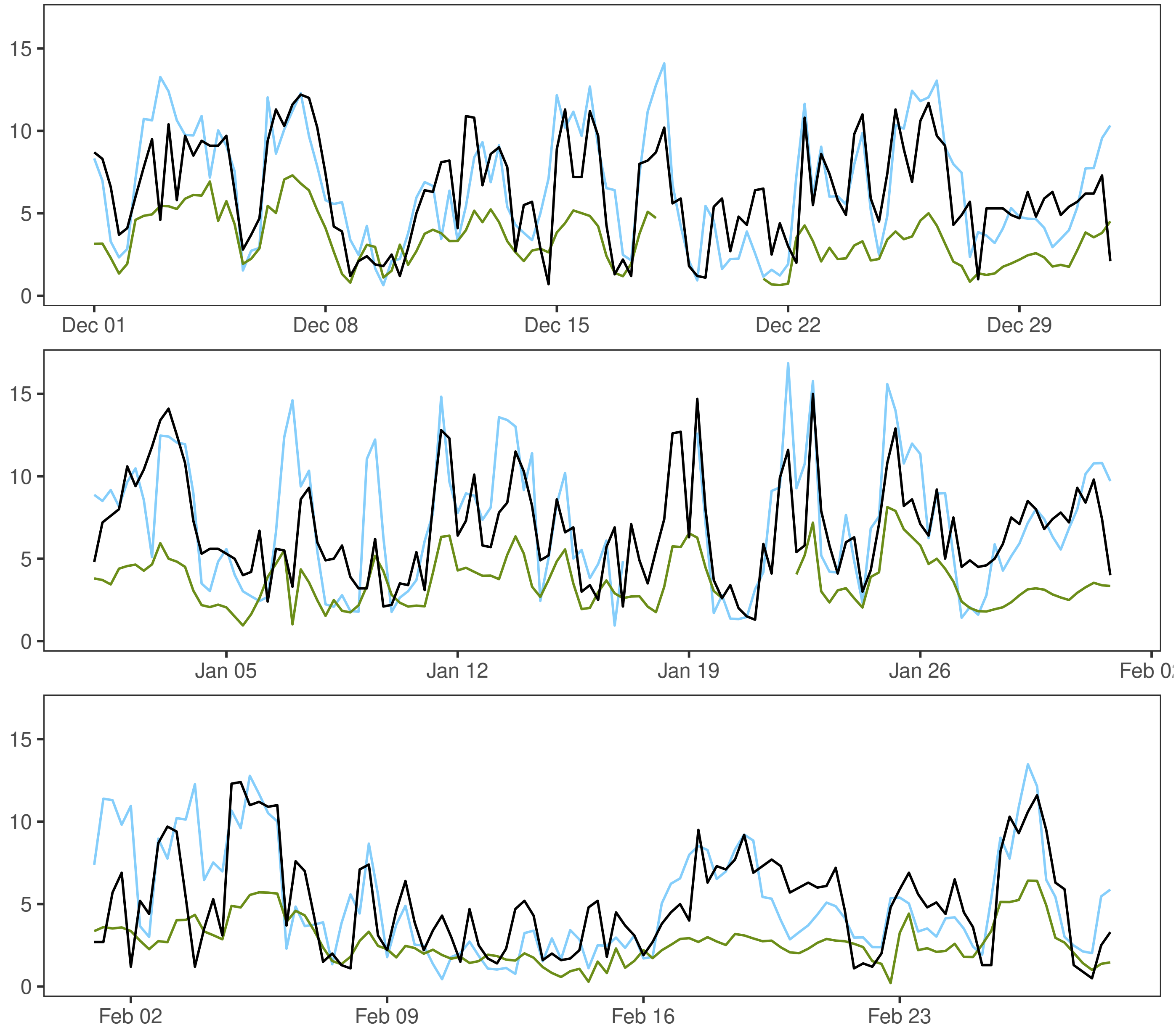
MEPSctrl 00+12

SDE at observing sites
(numbers in black)



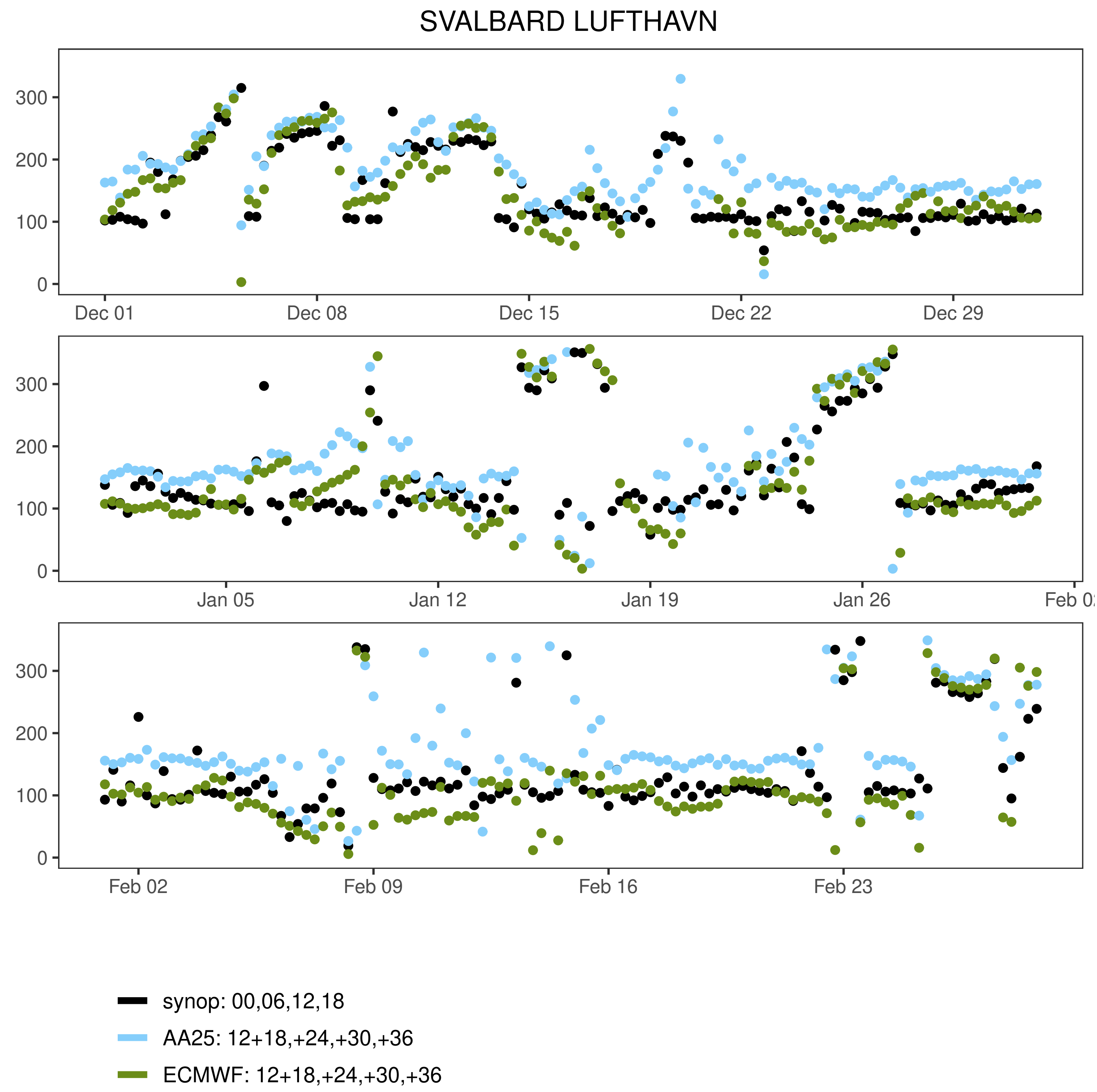
Model "climatology" 01.12.2021 – 28.02.2022

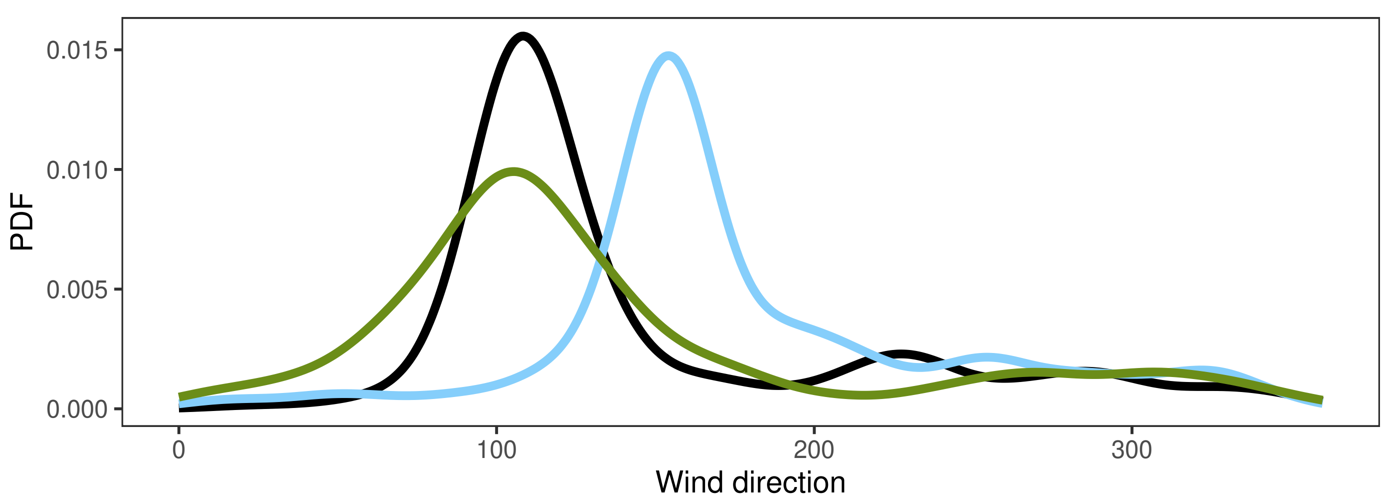
SVALBARD LUFTHAVN

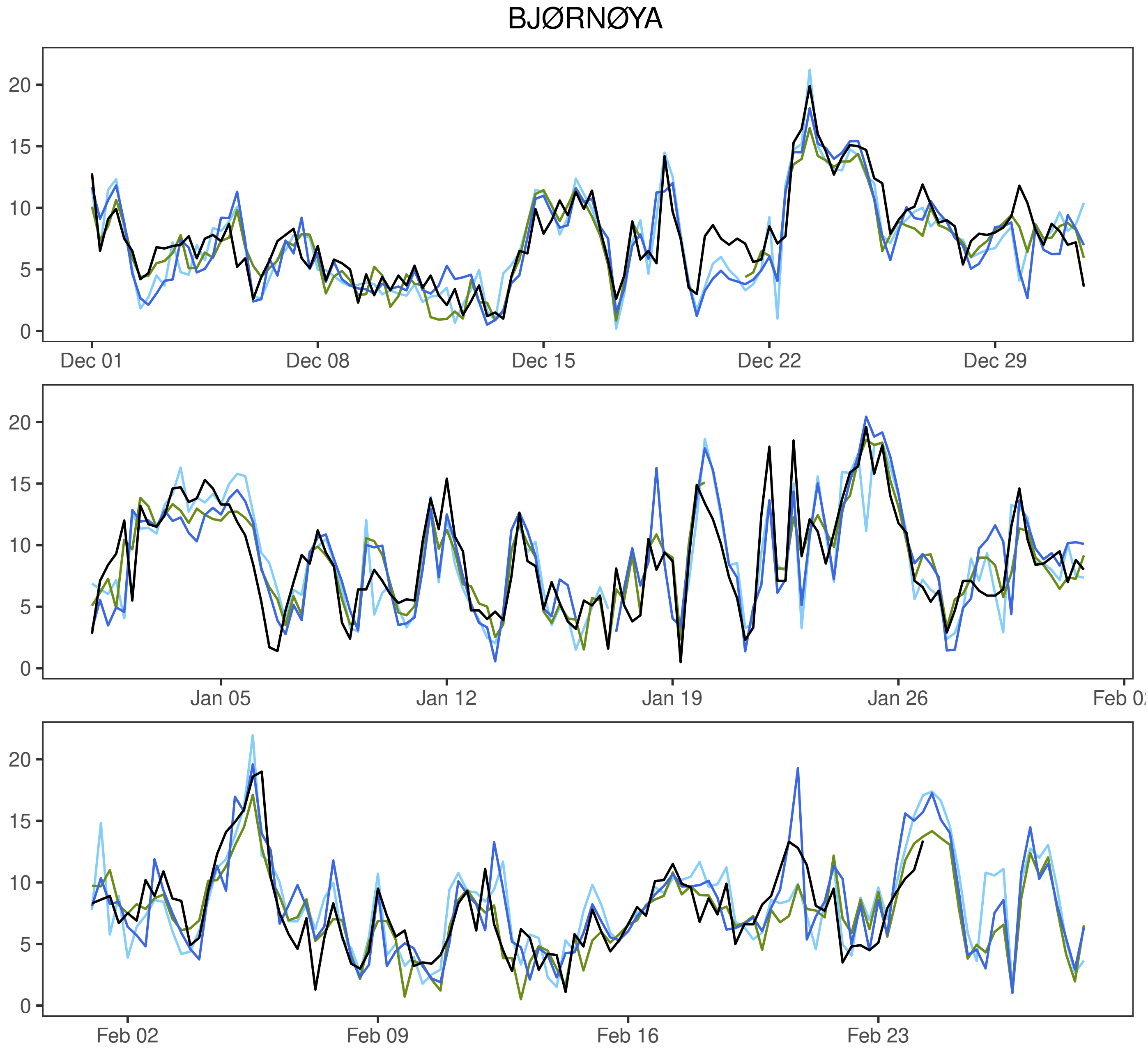


	Min	Mean	Max	Std	N
synop: 00,06,12,18	0.5	6.1	15.0	3.1	360
AA25: 12+18,+24,+30,+36	0.4	6.3	16.9	3.6	352
ECMWF: 12+18,+24,+30,+36	0.2	3.2	8.1	1.5	340

	ME	SDE	RMSE	MAE	Max.abs.err.	N
AA25−synop	0.3	2.6	2.7	2.0	11.3	332
ECMWF−synop	−2.9	2.2	3.6	3.1	9.1	332

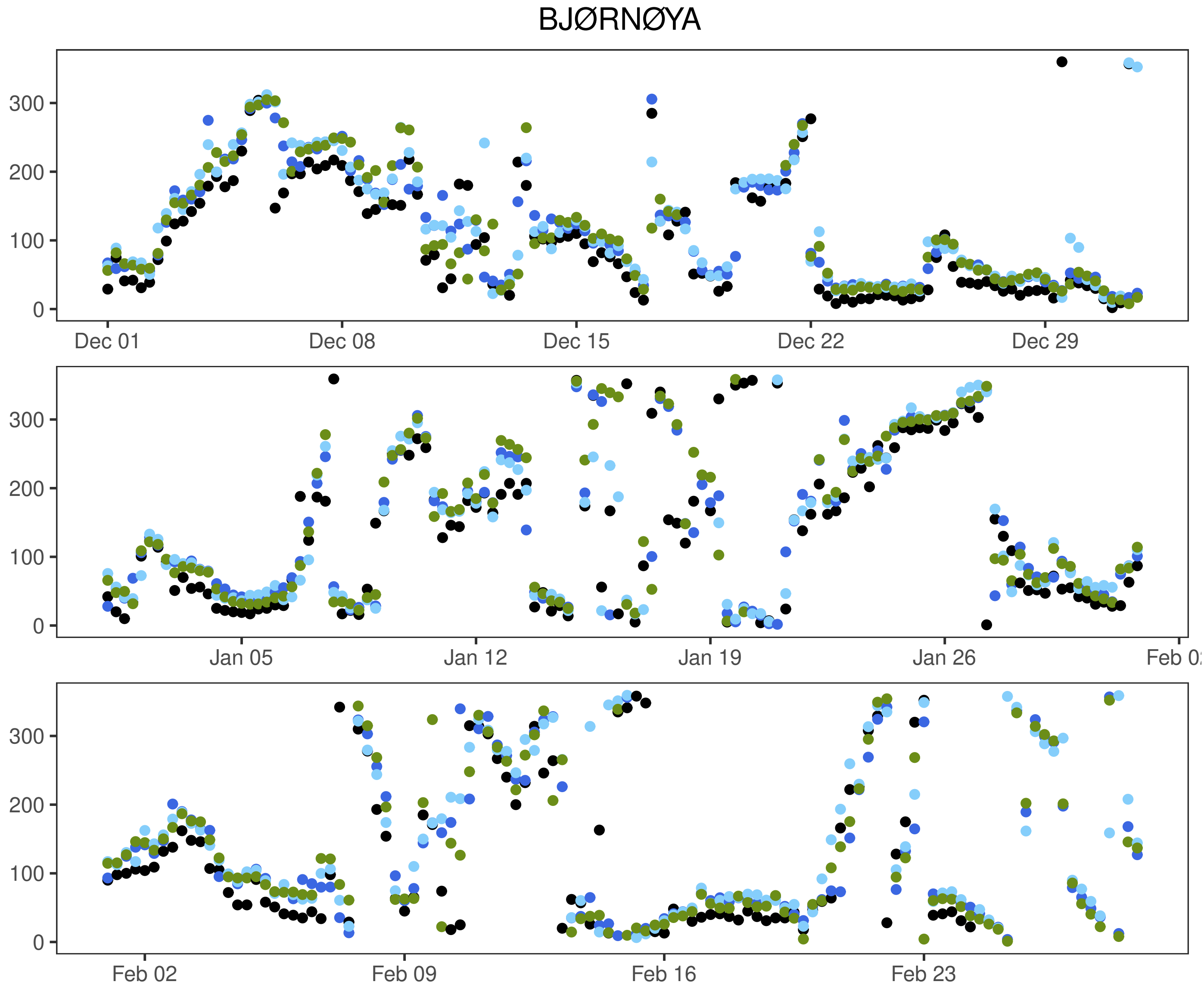

SVALBARD LUFTHAVN
300
200
100
0
Dec 01
Dec 08
Dec 15
Dec 22
Dec 29
Jan 05
Jan 12
Jan 19
Jan 26
Feb 02
Feb 09
Feb 16
Feb 23
synop: 00,06,12,18
AA25: 12+18,+24,+30,+36
ECMWF: 12+18,+24,+30,+36


PDF
0.015
0.010
0.005
0.000
0
100
200
300
Wind direction

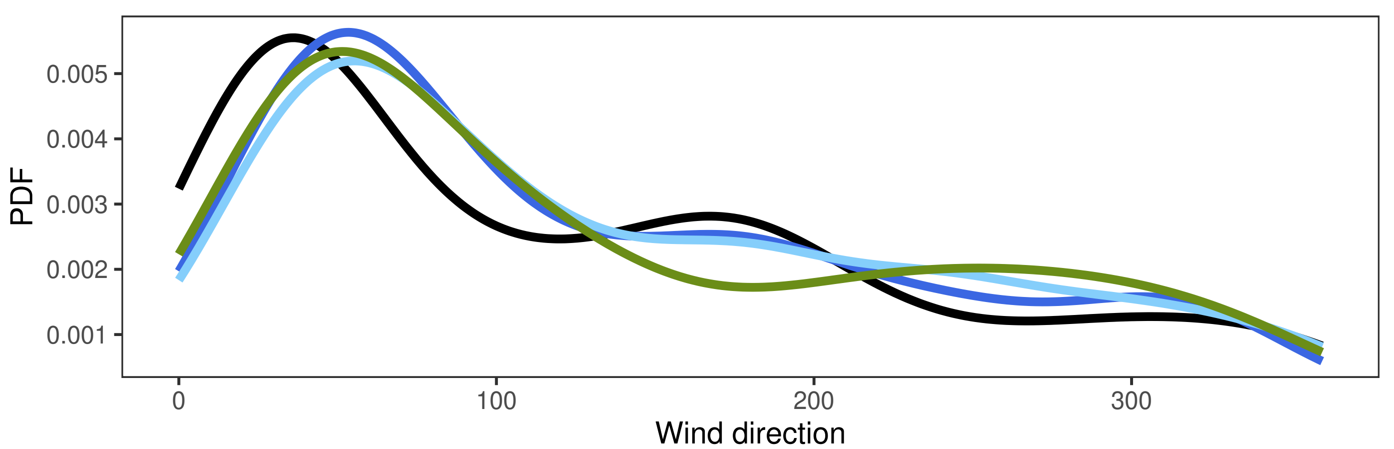


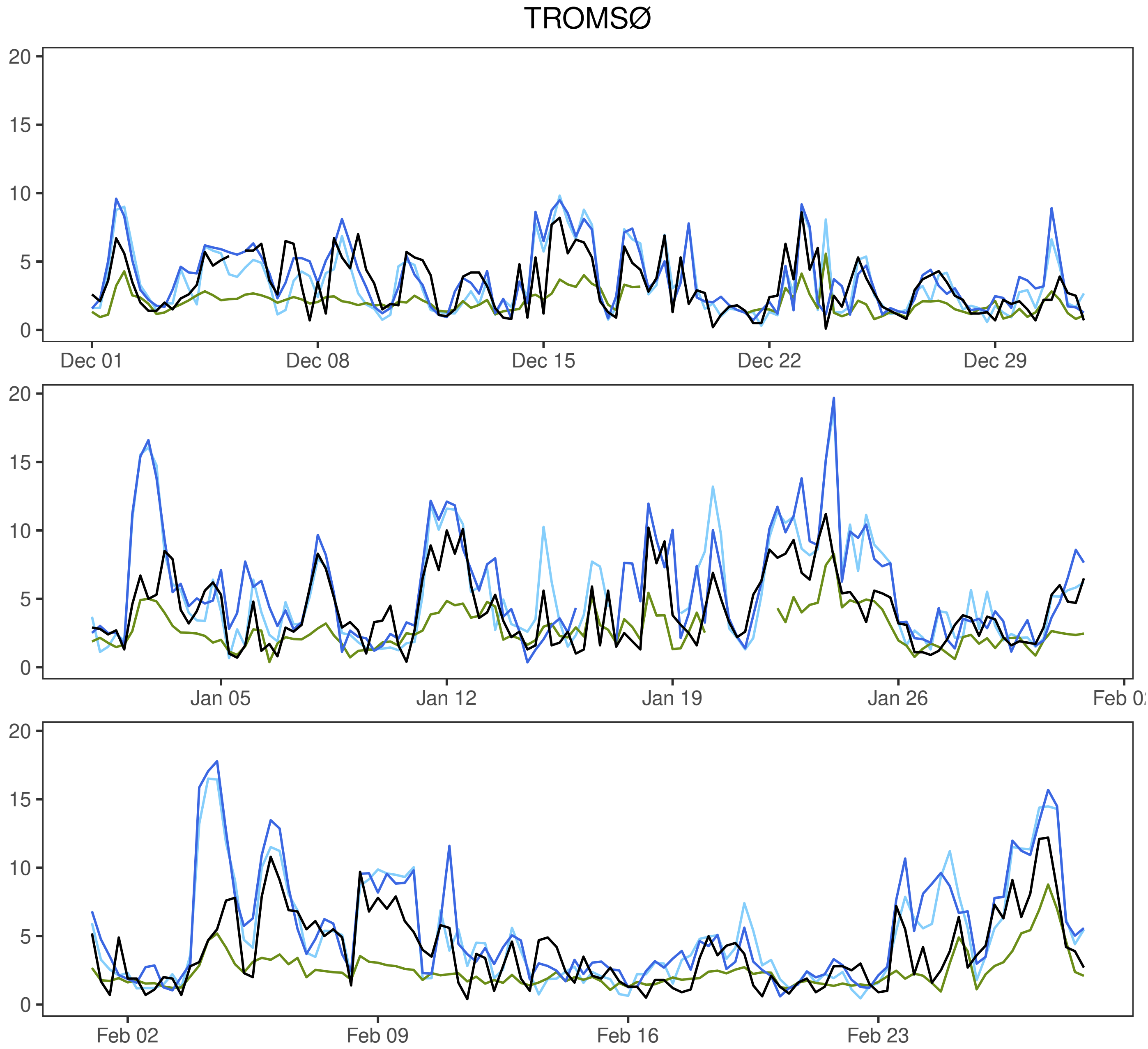
	Min	Mean	Max	Std	N
synop: 00,06,12,18	0.5	8.0	19.9	3.8	342
MEPSctrl: 12+18,+24,+30,+36	0.5	8.0	20.4	4.0	356
AA25: 12+18,+24,+30,+36	0.2	8.1	22.0	4.0	352
ECMWF: 12+18,+24,+30,+36	0.5	7.8	18.6	3.5	340

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl–synop	0.0	2.4	2.4	1.9	7.7	310
AA25–synop	0.0	2.5	2.4	1.9	8.4	310
ECMWF–synop	−0.2	1.9	1.9	1.5	6.2	310



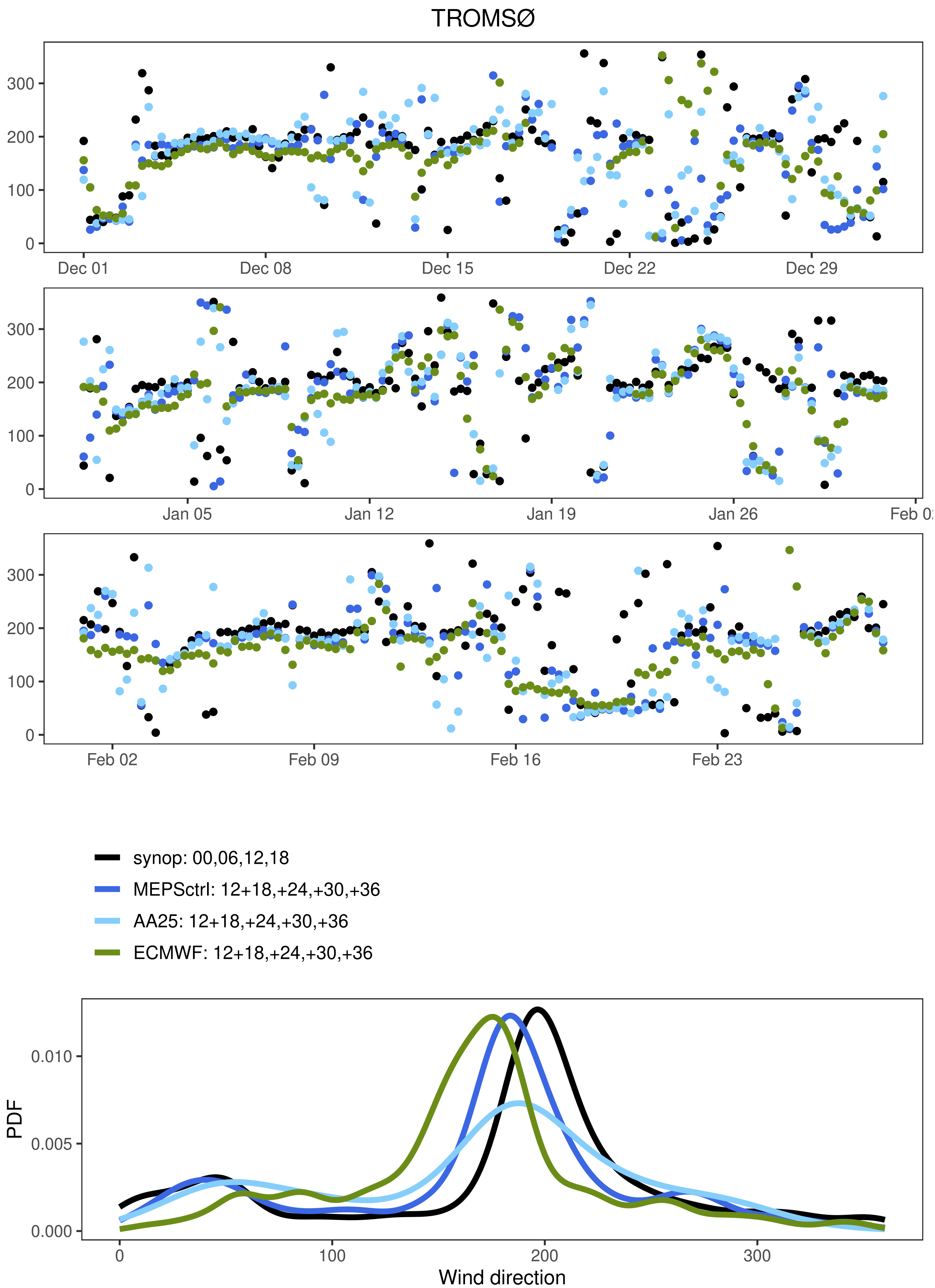
- synop: 00,06,12,18
- MEPSctrl: 12+18,+24,+30,+36
- AA25: 12+18,+24,+30,+36
- ECMWF: 12+18,+24,+30,+36



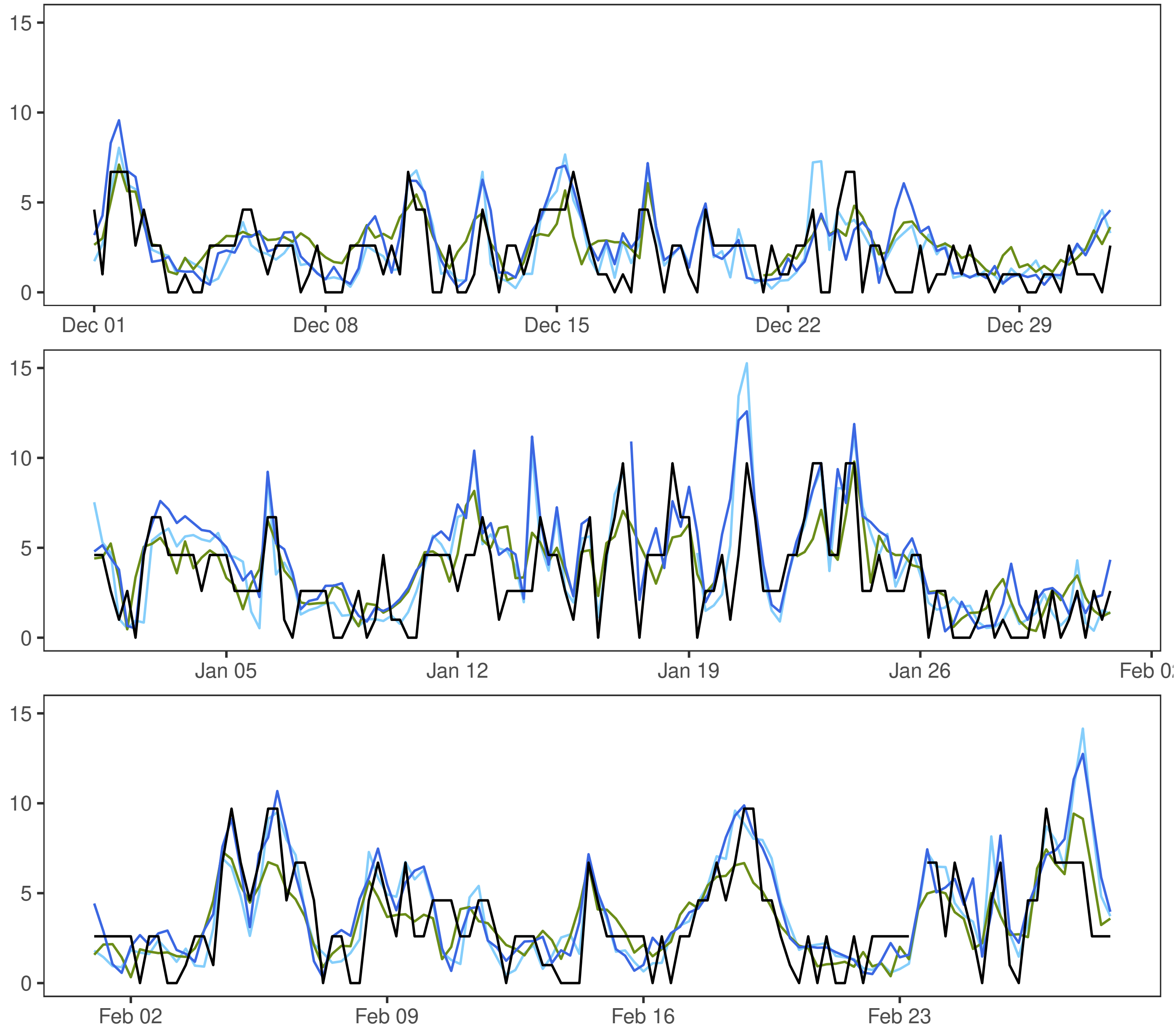


	Min	Mean	Max	Std	N
synop: 00,06,12,18	0.1	3.8	12.2	2.4	359
MEPSctrl: 12+18,+24,+30,+36	0.4	5.0	19.7	3.5	356
AA25: 12+18,+24,+30,+36	0.3	4.6	18.9	3.5	352
ECMWF: 12+18,+24,+30,+36	0.4	2.4	8.8	1.2	340

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl–synop	1.2	2.4	2.7	1.8	12.8	327
AA25–synop	0.9	2.4	2.6	1.7	11.8	327
ECMWF–synop	−1.4	1.8	2.3	1.7	7.5	327

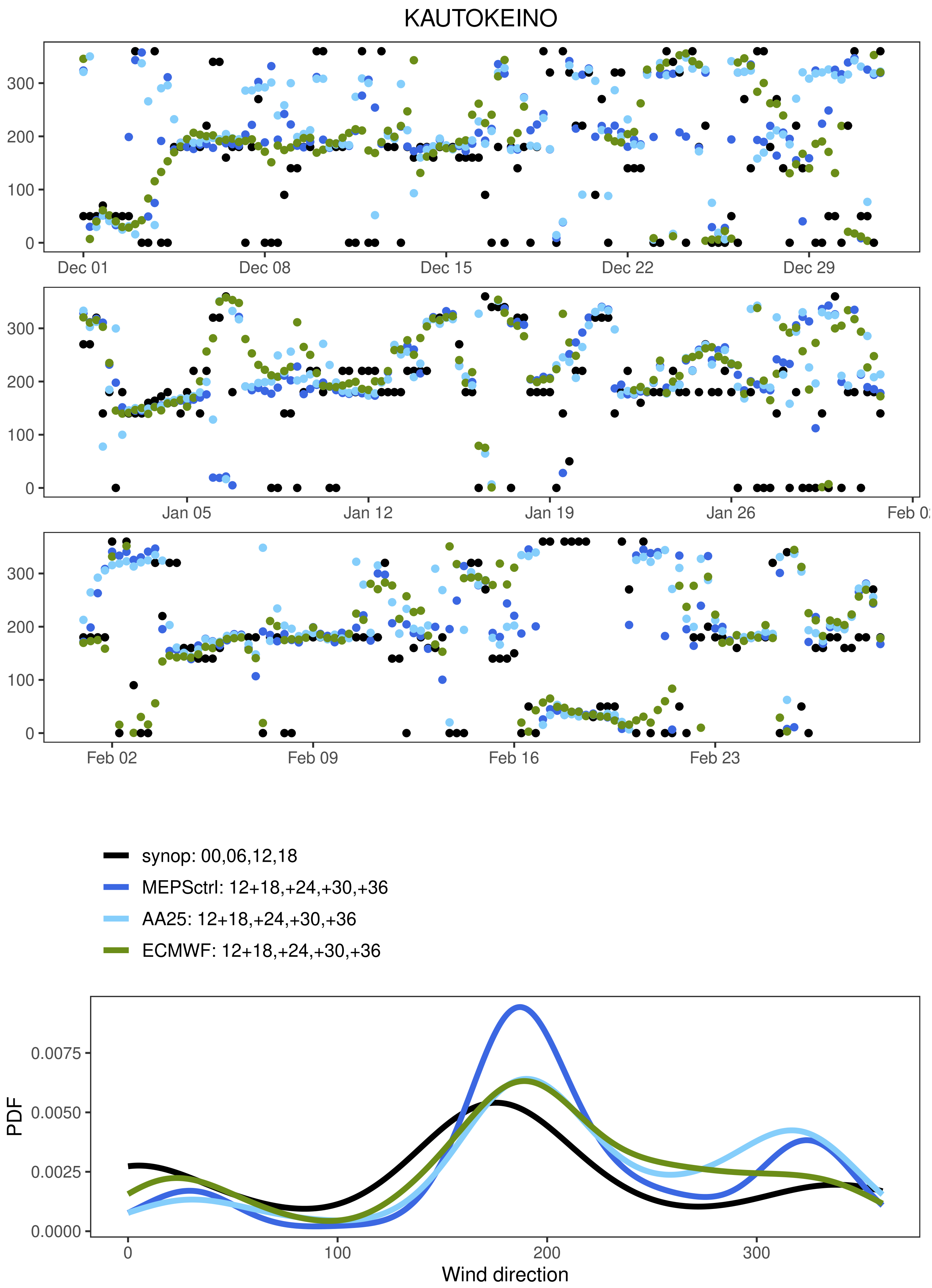

TROMSØ
0
100
200
300
Dec 01
Dec 08
Dec 15
Dec 22
Dec 29
Jan 05
Jan 12
Jan 19
Jan 26
Feb 02
Feb 09
Feb 16
Feb 23
synop: 00,06,12,18
MEPSctrl: 12+18,+24,+30,+36
AA25: 12+18,+24,+30,+36
ECMWF: 12+18,+24,+30,+36
PDF
0.000
0.005
0.010
Wind direction

KAUTOKEINO

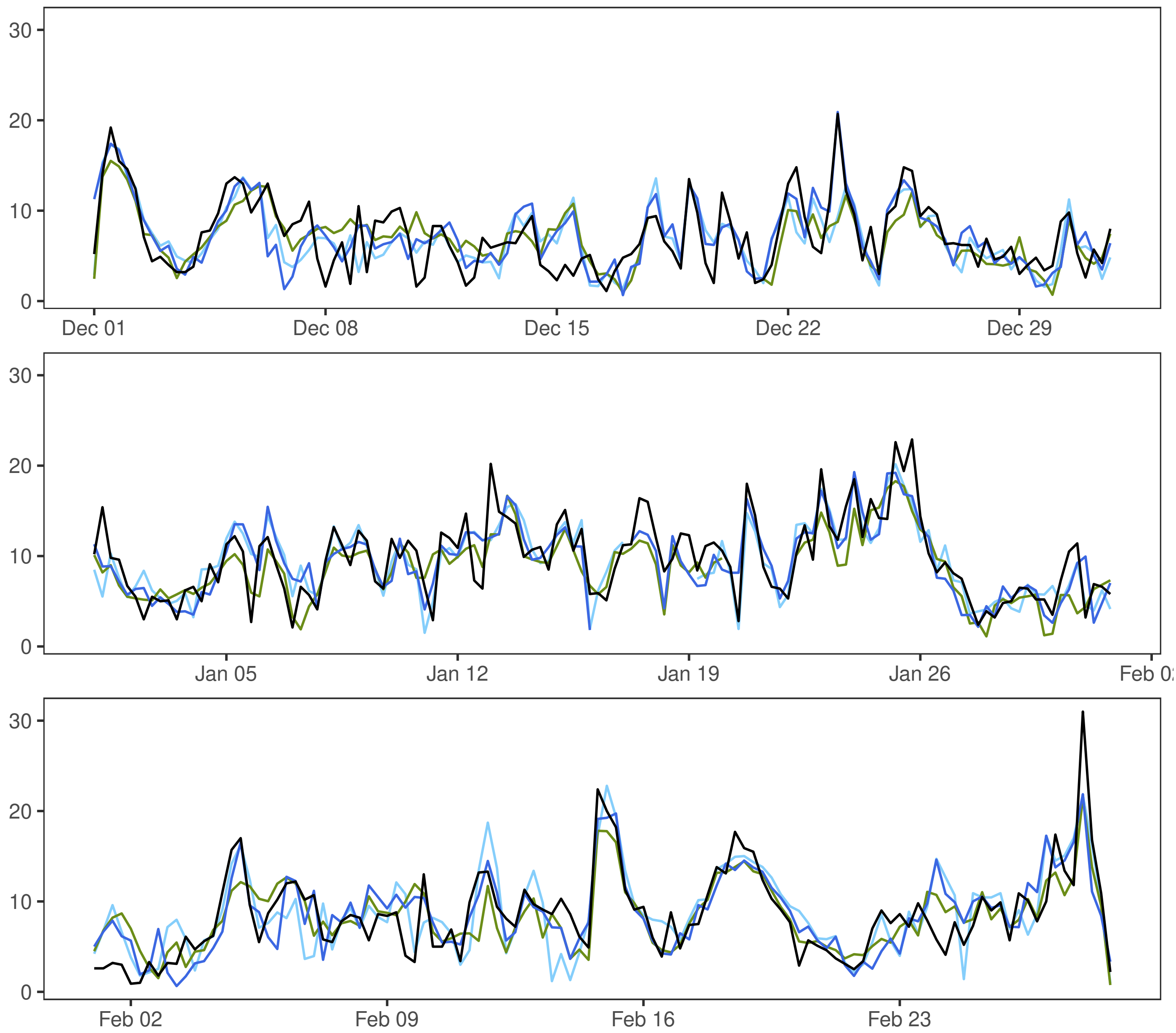


	Min	Mean	Max	Std	N
synop: 00,06,12,18	0.0	3.0	9.7	2.4	359
MEPSctrl: 12+18,+24,+30,+36	0.3	3.8	12.7	2.6	356
AA25: 12+18,+24,+30,+36	0.2	3.4	15.3	2.6	352
ECMWF: 12+18,+24,+30,+36	0.3	3.3	9.8	1.7	340

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl–synop	0.8	1.9	2.0	1.6	8.6	327
AA25–synop	0.4	1.9	1.9	1.5	7.8	327
ECMWF–synop	0.4	1.7	1.8	1.4	5.1	327

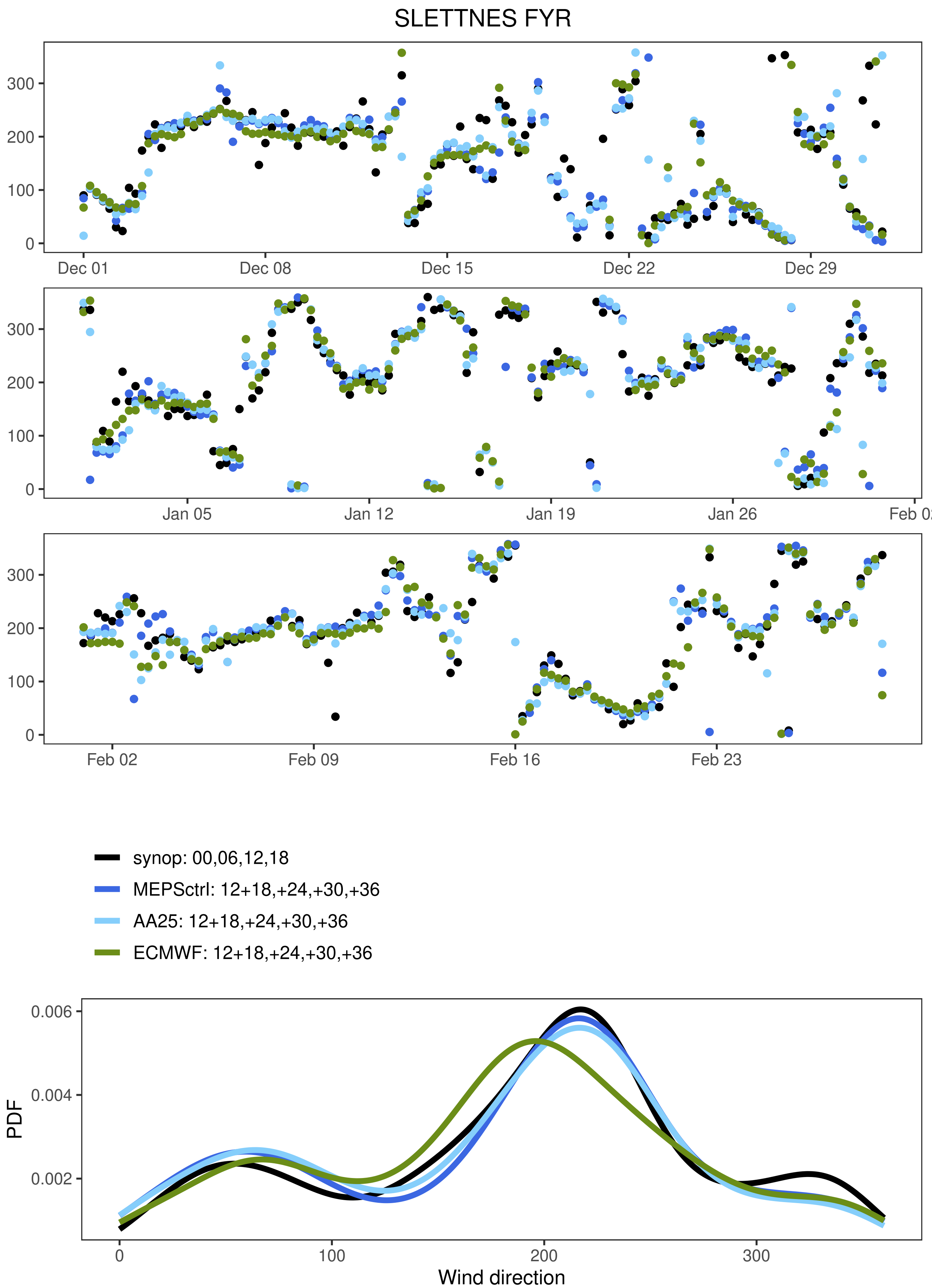

KAUTOKEINO
300
200
100
0
Dec 01
Dec 08
Dec 15
Dec 22
Dec 29
Jan 05
Jan 12
Jan 19
Jan 26
Feb 02
Feb 09
Feb 16
Feb 23
synop: 00,06,12,18
MEPSctrl: 12+18,+24,+30,+36
AA25: 12+18,+24,+30,+36
ECMWF: 12+18,+24,+30,+36
PDF
0.0075
0.0050
0.0025
0.0000
Wind direction

SLETTNES FYR

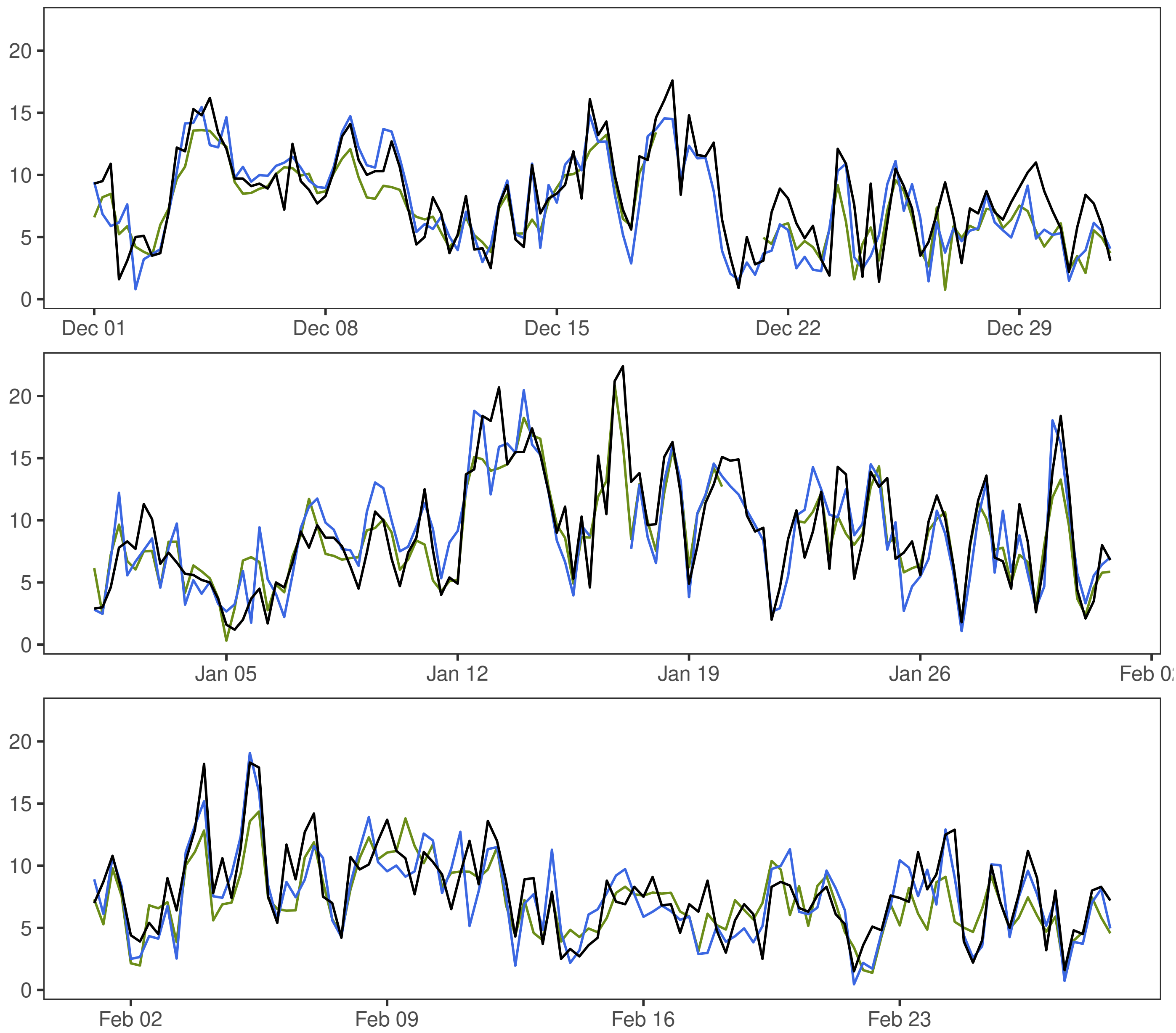


	Min	Mean	Max	Std	N
synop: 00,06,12,18	0.9	8.5	31.0	4.5	360
MEPSctrl: 12+18,+24,+30,+36	0.6	8.4	21.9	4.0	356
AA25: 12+18,+24,+30,+36	1.0	8.4	22.8	4.1	352
ECMWF: 12+18,+24,+30,+36	0.7	8.0	21.5	3.5	340

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl–synop	0.0	2.9	2.9	2.3	9.1	328
AA25–synop	0.0	3.1	3.1	2.3	11.4	328
ECMWF–synop	−0.4	2.8	2.8	2.1	11.9	328

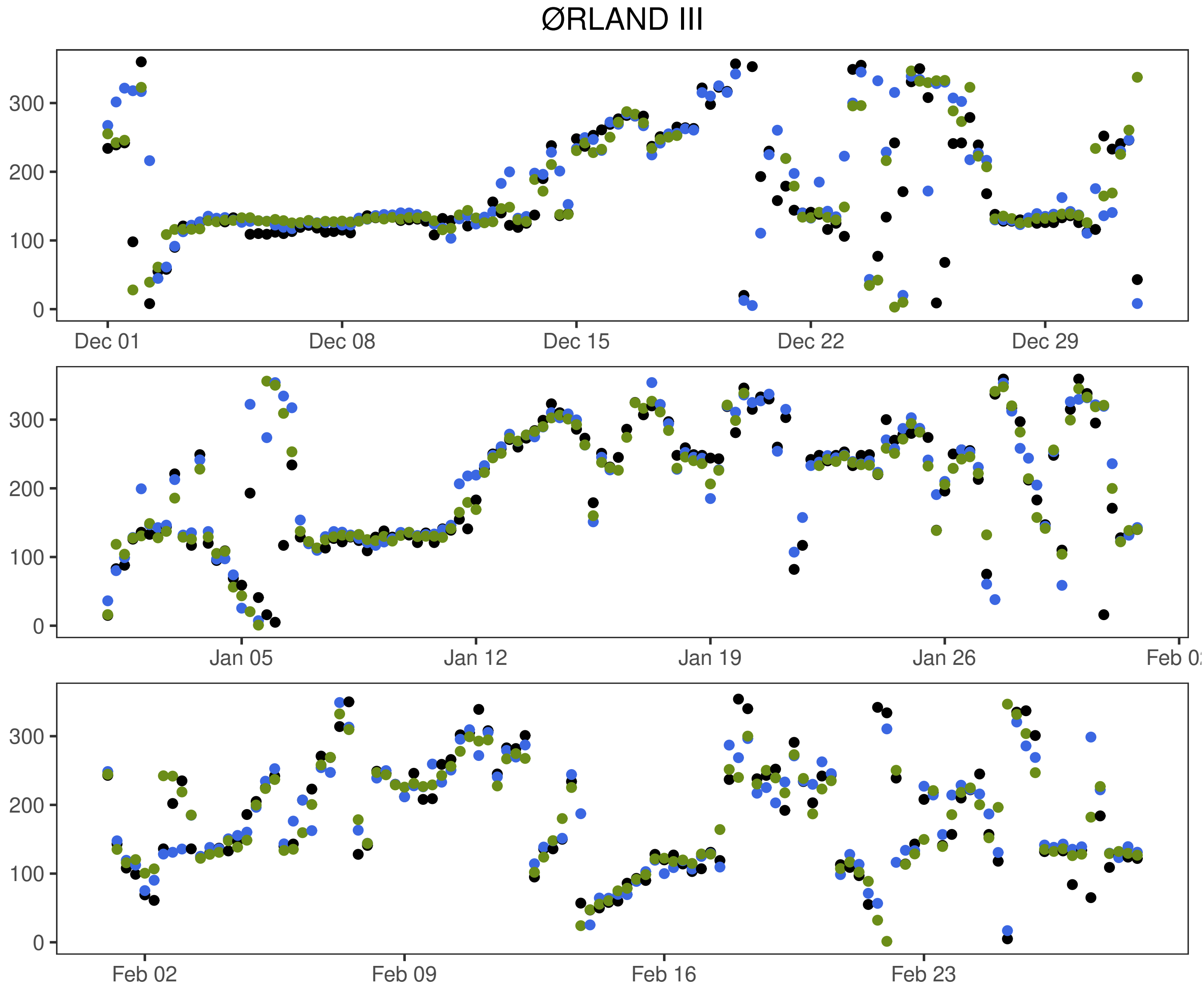

SLETTNES FYR
300
200
100
0
Dec 01
Dec 08
Dec 15
Dec 22
Dec 29
Jan 05
Jan 12
Jan 19
Jan 26
Feb 02
Feb 09
Feb 16
Feb 23
synop: 00,06,12,18
MEPSctrl: 12+18,+24,+30,+36
AA25: 12+18,+24,+30,+36
ECMWF: 12+18,+24,+30,+36
PDF
0.006
0.004
0.002
Wind direction

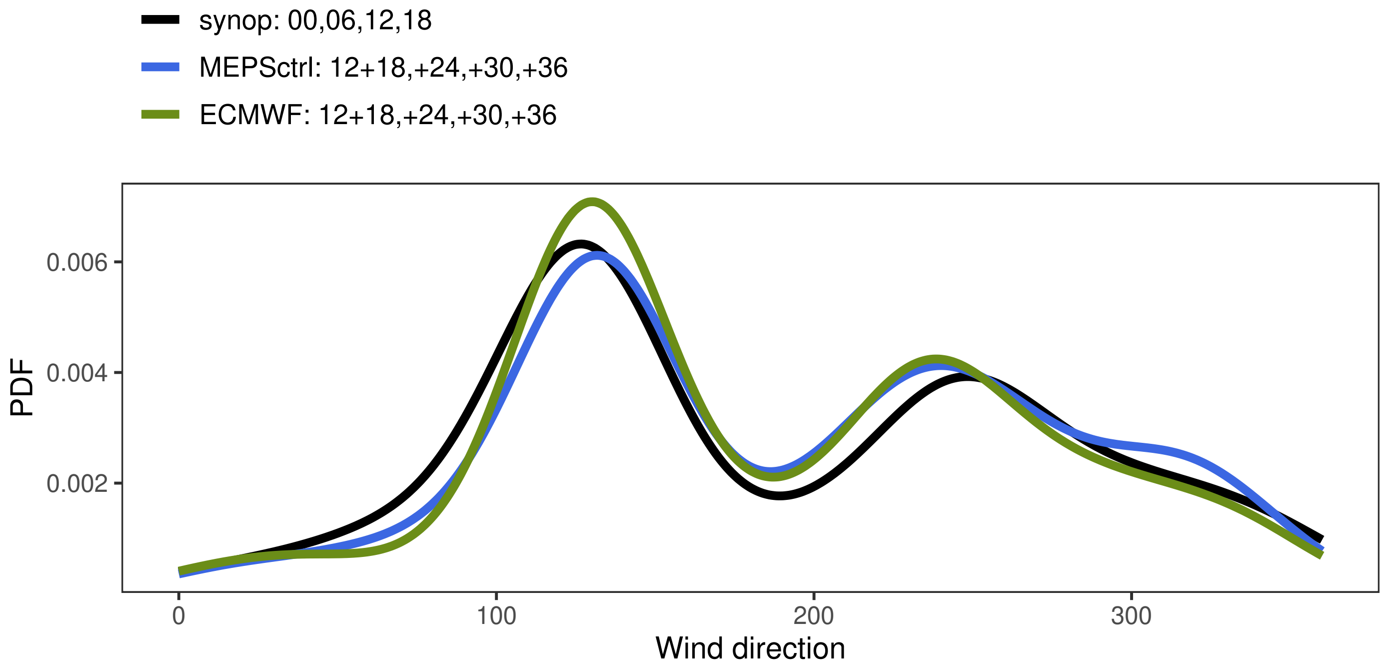
ØRLAND III

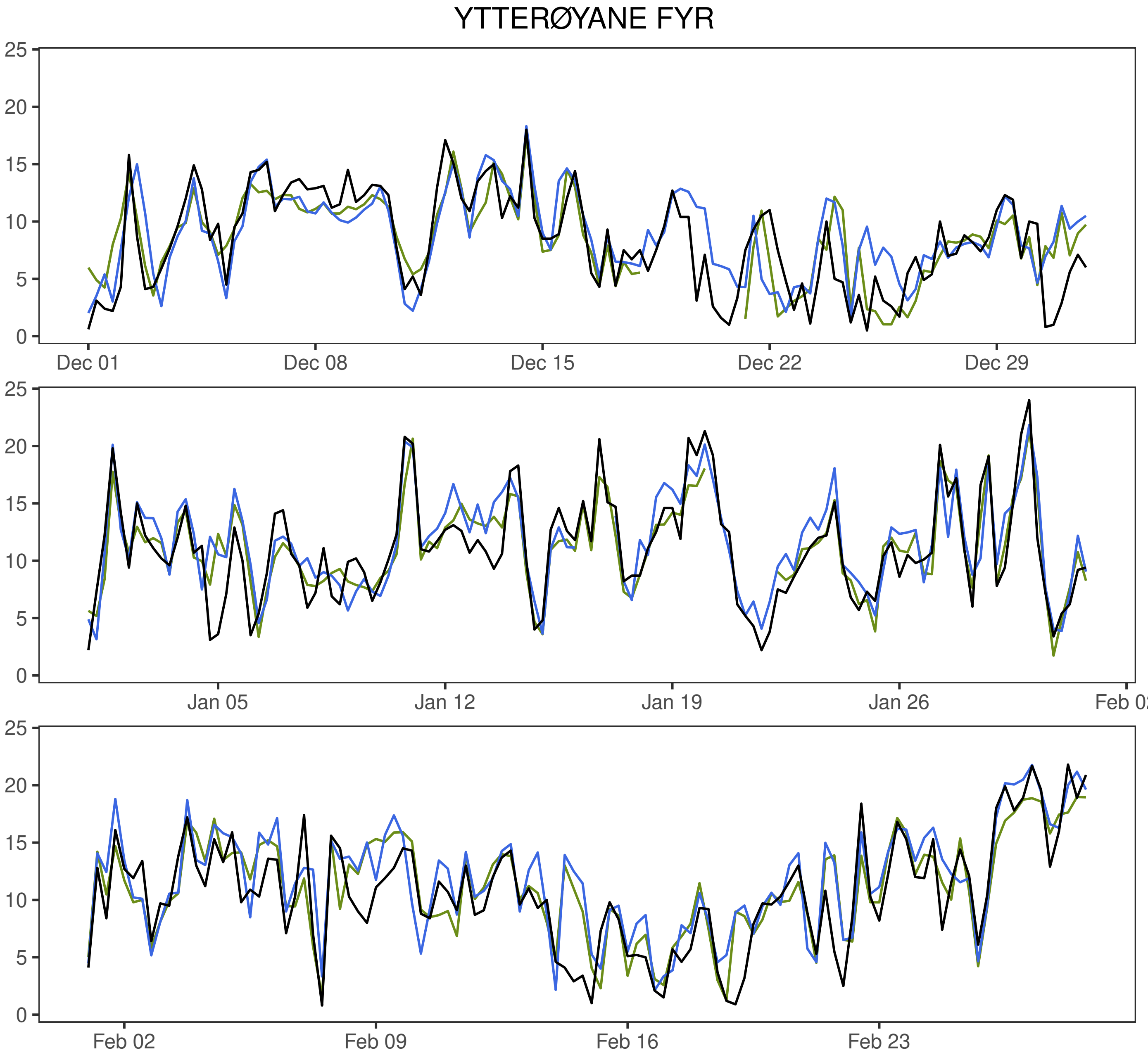


	Min	Mean	Max	Std	N
synop: 00,06,12,18	0.9	8.4	22.4	3.9	360
MEPSctrl: 12+18,+24,+30,+36	0.5	8.0	20.5	3.8	356
ECMWF: 12+18,+24,+30,+36	0.3	7.7	20.9	3.3	340

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl–synop	−0.2	2.3	2.3	1.8	6.9	336
ECMWF–synop	−0.6	2.1	2.2	1.7	8.6	336

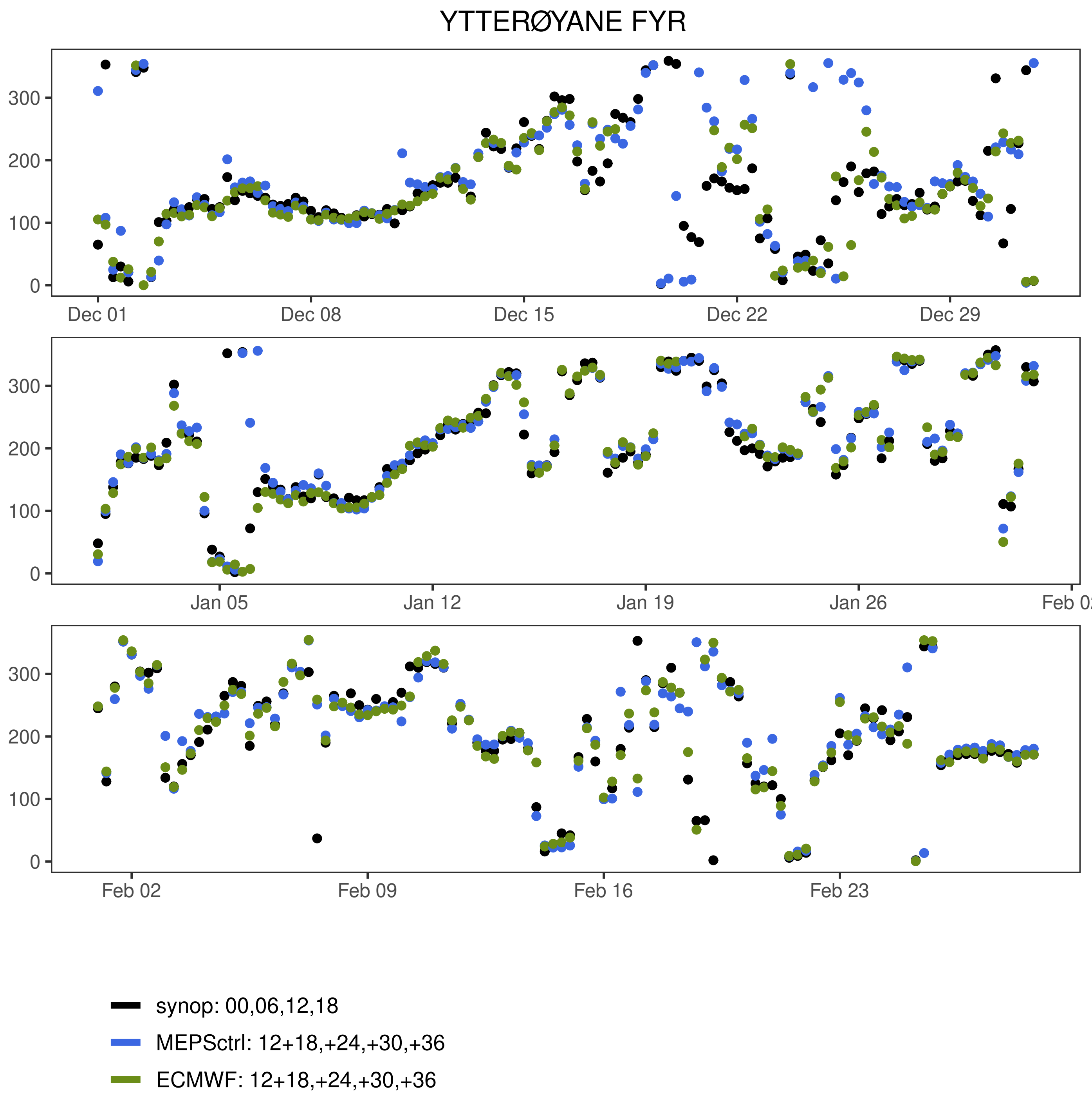

ØRLAND III
300
200
100
0
Dec 01
Dec 08
Dec 15
Dec 22
Dec 29
Jan 05
Jan 12
Jan 19
Jan 26
Feb 02
Feb 09
Feb 16
Feb 23

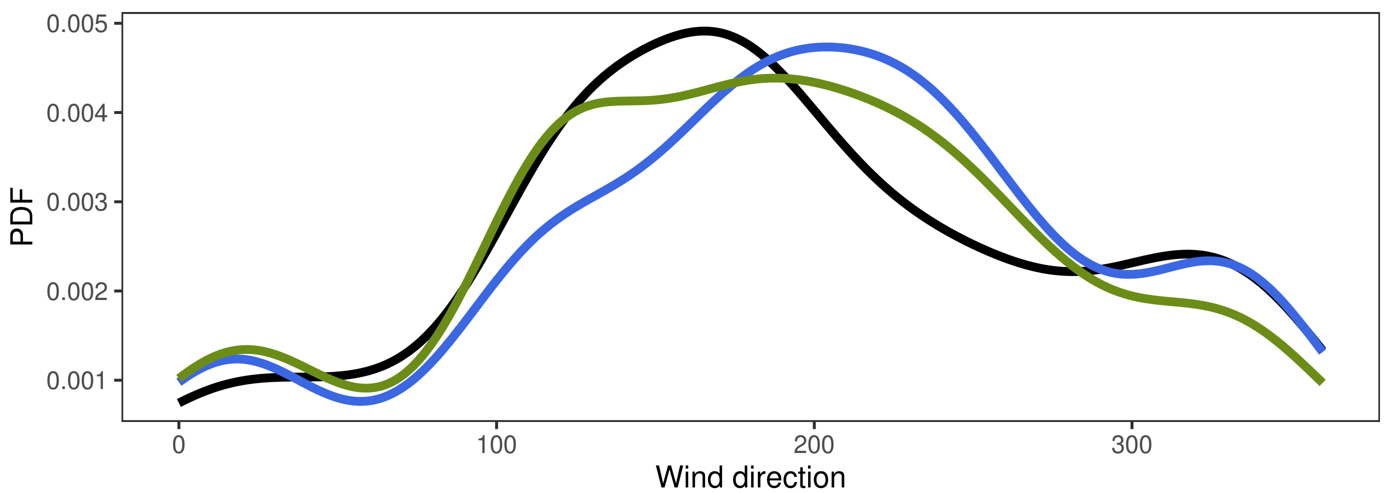

synop: 00,06,12,18
MEPSctrl: 12+18,+24,+30,+36
ECMWF: 12+18,+24,+30,+36
PDF
0.006
0.004
0.002
0
100
200
300
Wind direction

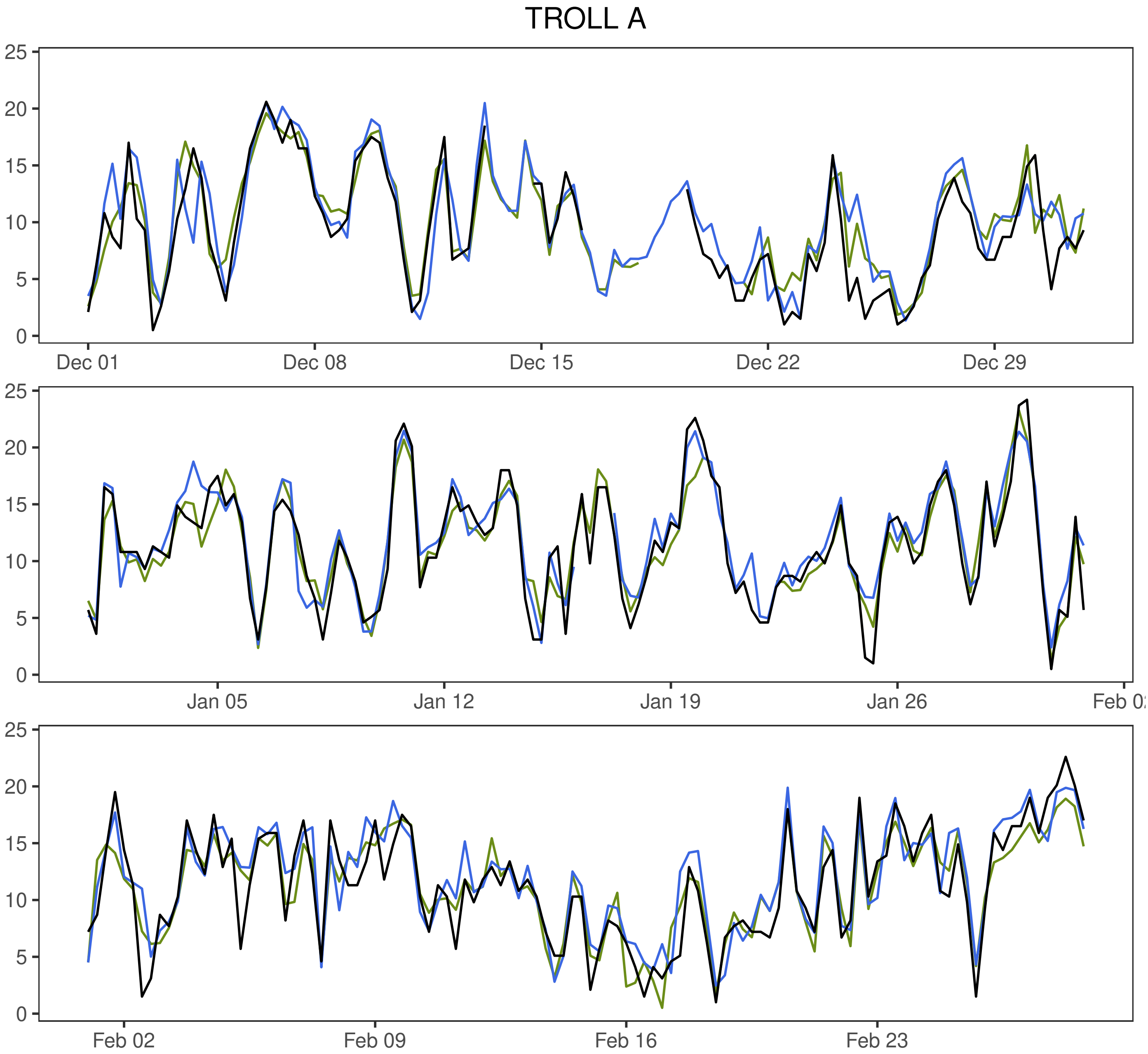


	Min	Mean	Max	Std	N
synop: 00,06,12,18	0.5	10.0	24.0	4.7	360
MEPSctrl: 12+18,+24,+30,+36	1.6	10.7	21.8	4.3	356
ECMWF: 12+18,+24,+30,+36	1.0	10.3	21.4	4.1	340

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl−synop	0.7	2.8	2.9	2.2	9.8	336
ECMWF−synop	0.1	2.6	2.6	1.9	8.9	336

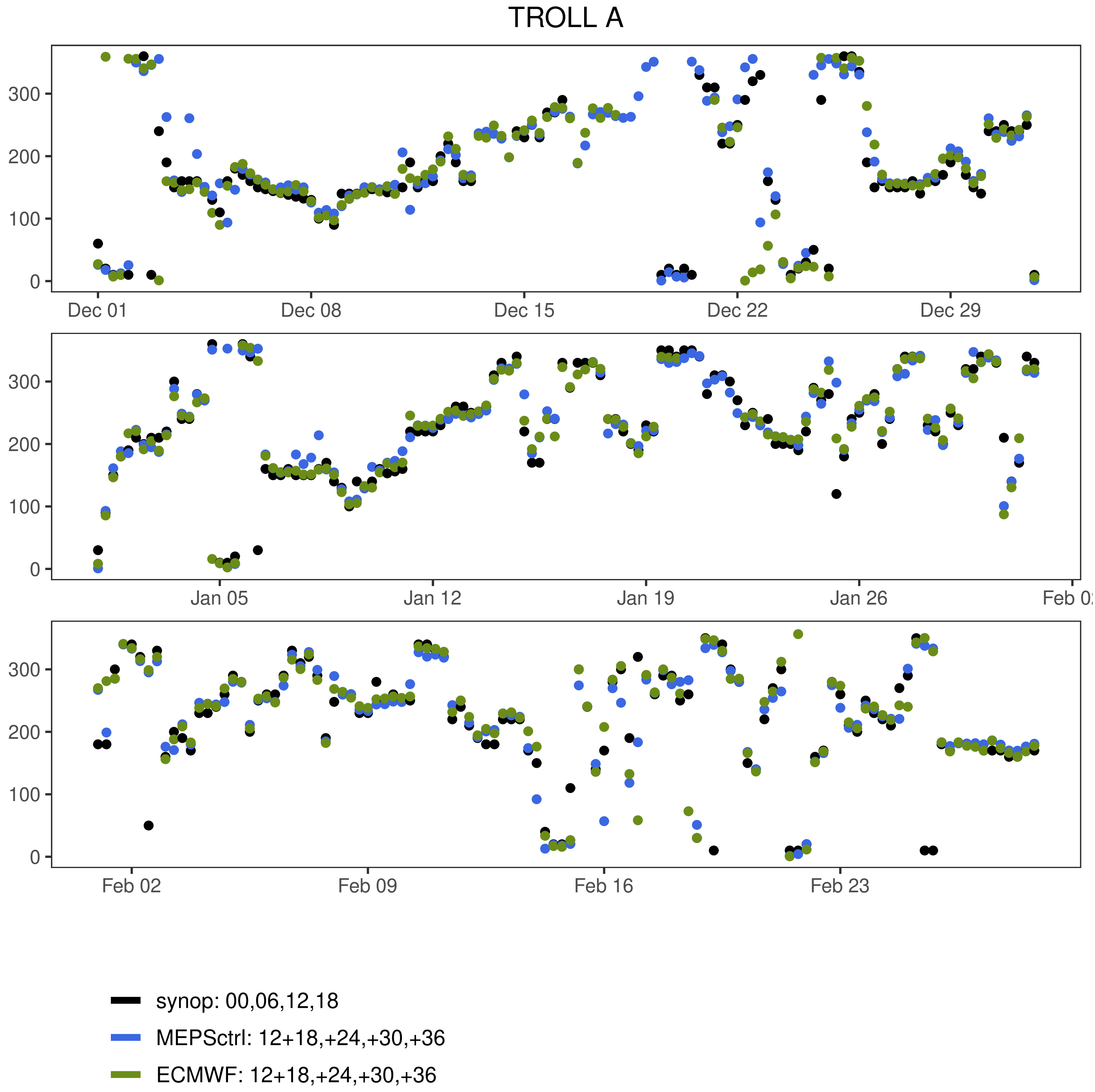

YTTERØYANE FYR
300
200
100
0
Dec 01
Dec 08
Dec 15
Dec 22
Dec 29
Jan 05
Jan 12
Jan 19
Jan 26
Feb 02
Feb 09
Feb 16
Feb 23
synop: 00,06,12,18
MEPSctrl: 12+18,+24,+30,+36
ECMWF: 12+18,+24,+30,+36

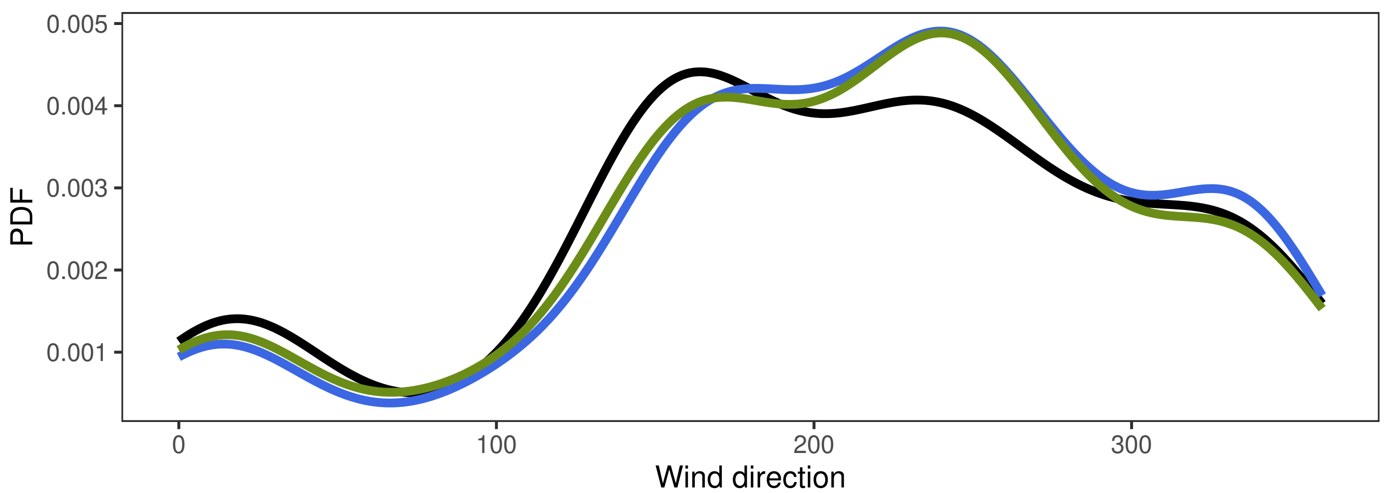

PDF
0.005
0.004
0.003
0.002
0.001
0
100
200
300
Wind direction

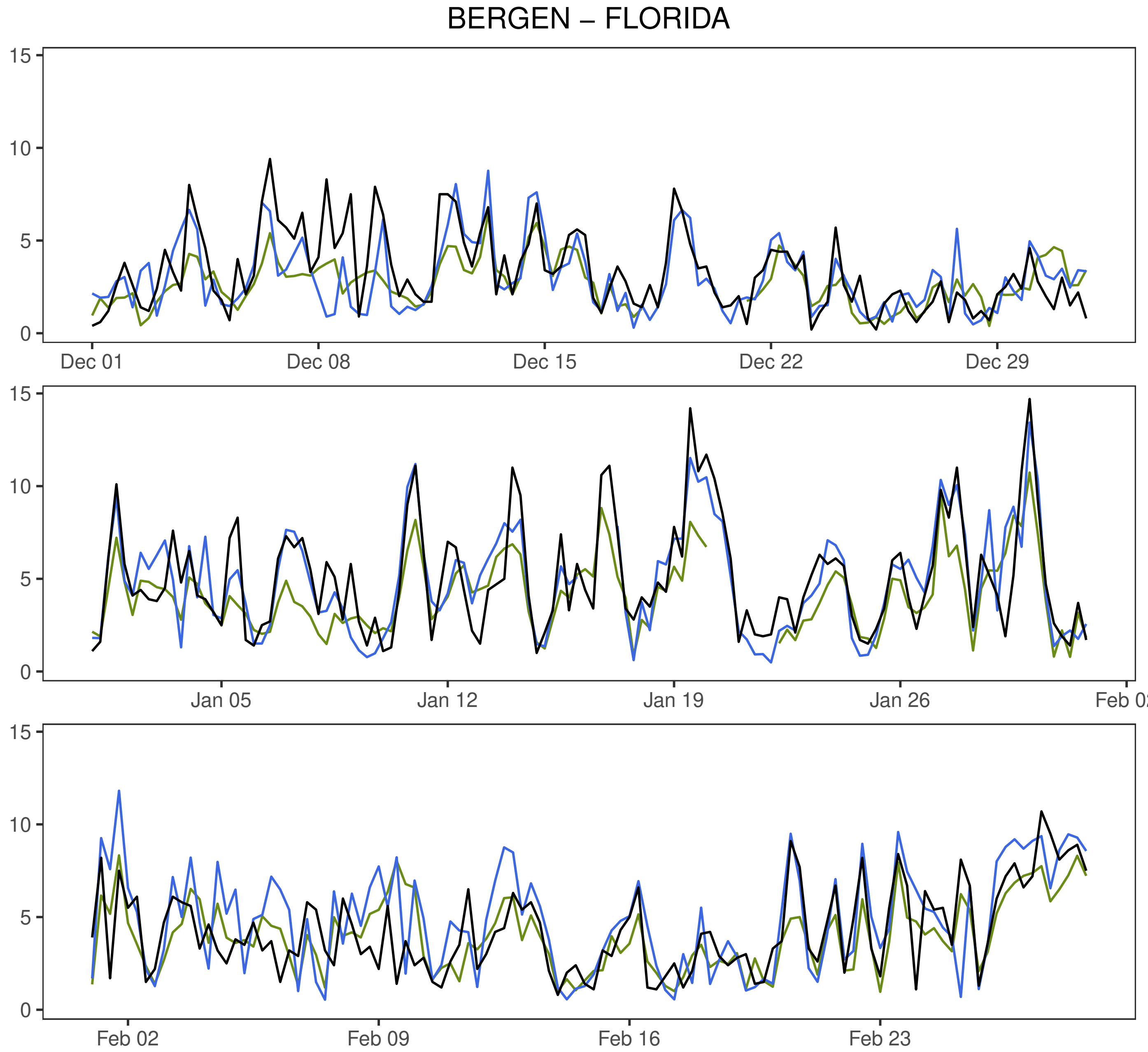


	Min	Mean	Max	Std	N
synop: 00,06,12,18	0.5	10.7	24.2	5.0	343
MEPSctrl: 12+18,+24,+30,+36	1.3	11.3	21.5	4.6	356
ECMWF: 12+18,+24,+30,+36	0.5	11.0	23.3	4.4	340

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl−synop	0.7	2.2	2.3	1.7	9.5	324
ECMWF−synop	0.2	2.0	2.0	1.6	6.9	324

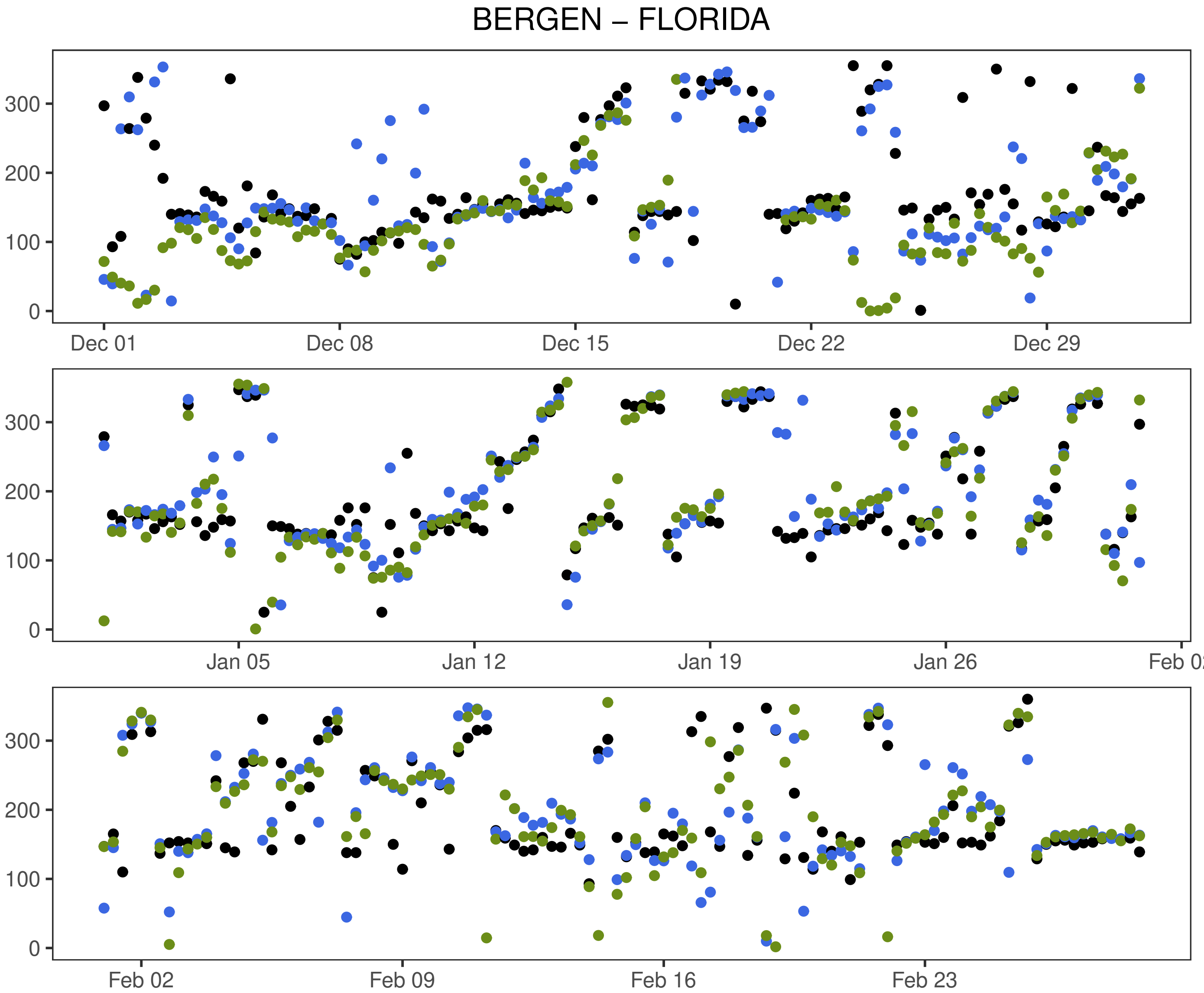

TROLL A
300
200
100
0
Dec 01
Dec 08
Dec 15
Dec 22
Dec 29
Jan 05
Jan 12
Jan 19
Jan 26
Feb 02
Feb 09
Feb 16
Feb 23
synop: 00,06,12,18
MEPSctrl: 12+18,+24,+30,+36
ECMWF: 12+18,+24,+30,+36

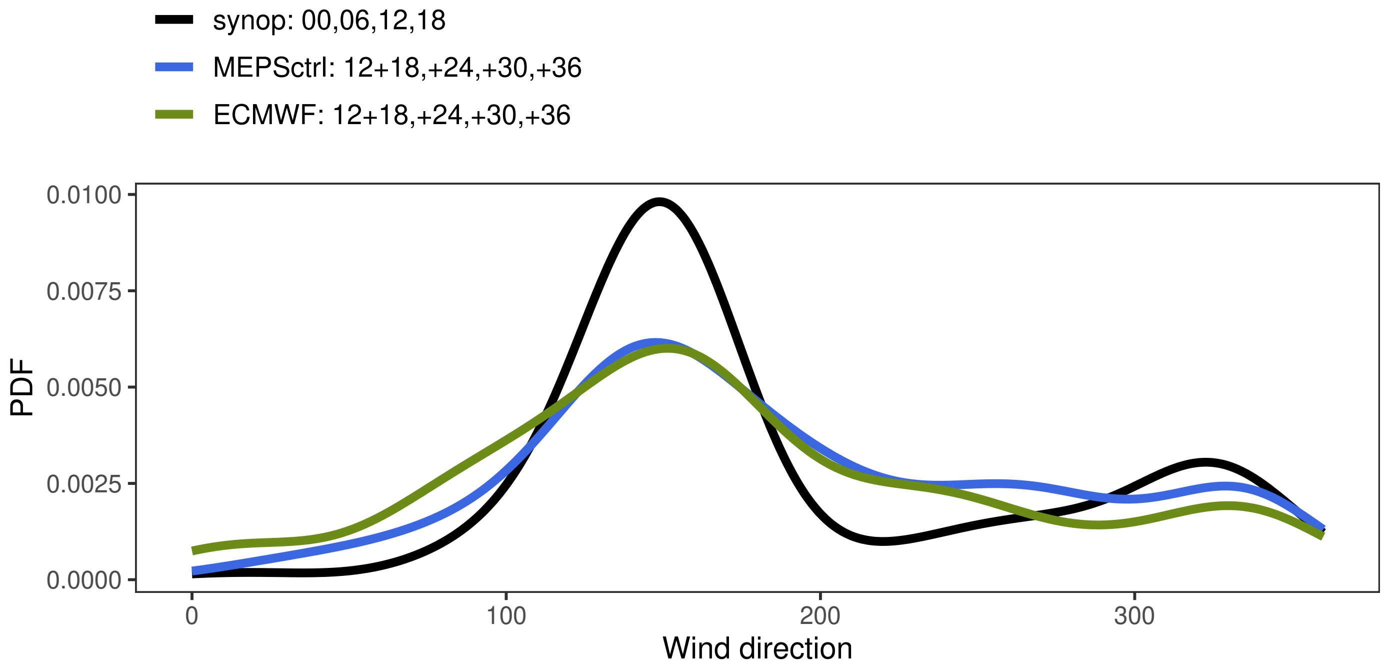

0.005
0.004
0.003
0.002
0.001
PDF
0
100
200
300
Wind direction

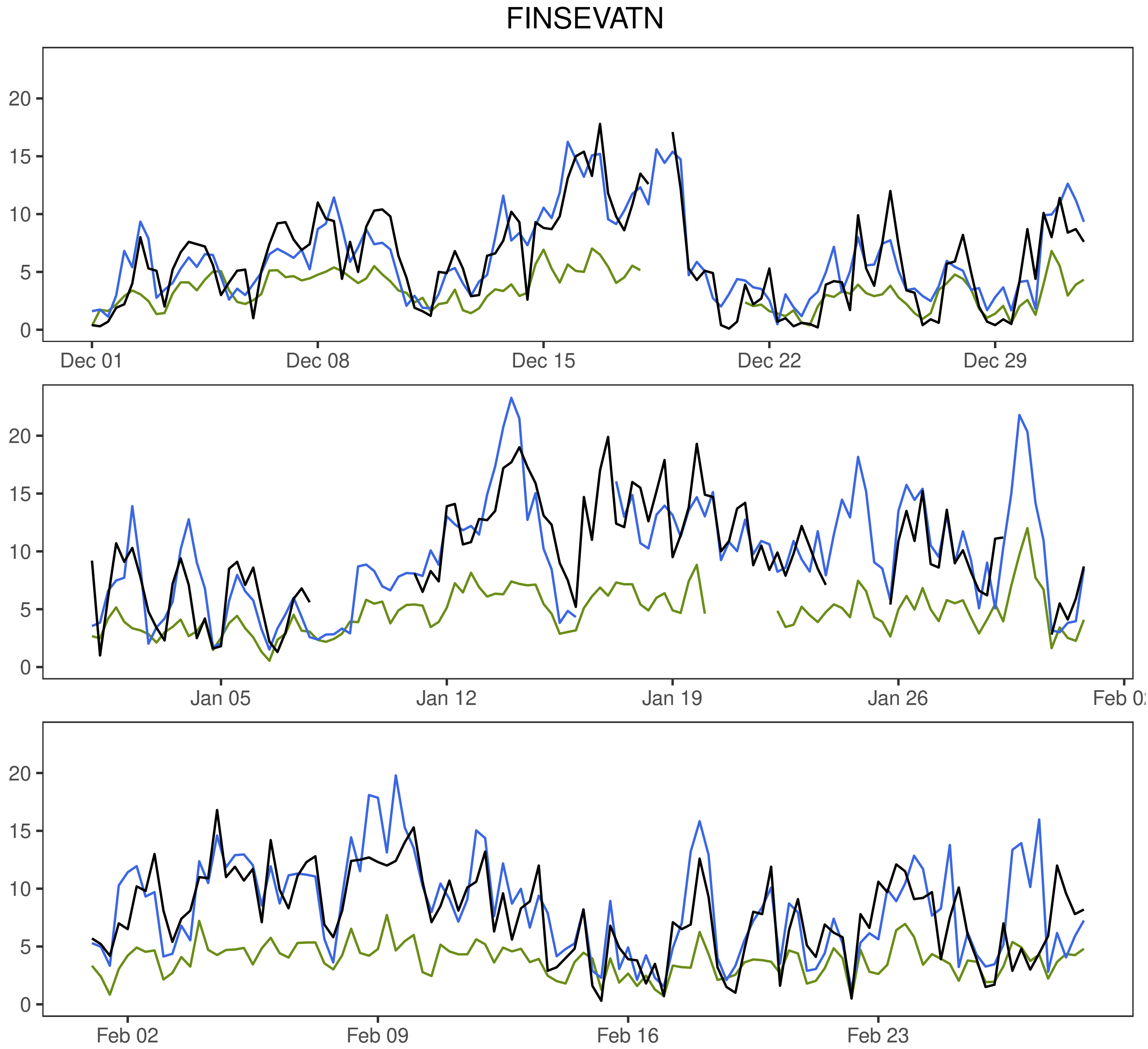


	Min	Mean	Max	Std	N
synop: 00,06,12,18	0.2	4.2	14.7	2.6	360
MEPSctrl: 12+18,+24,+30,+36	0.3	4.2	13.4	2.7	356
ECMWF: 12+18,+24,+30,+36	0.4	3.6	10.7	1.9	340

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl–synop	0.1	1.9	1.9	1.4	7.4	336
ECMWF–synop	–0.6	1.7	1.8	1.4	6.6	336

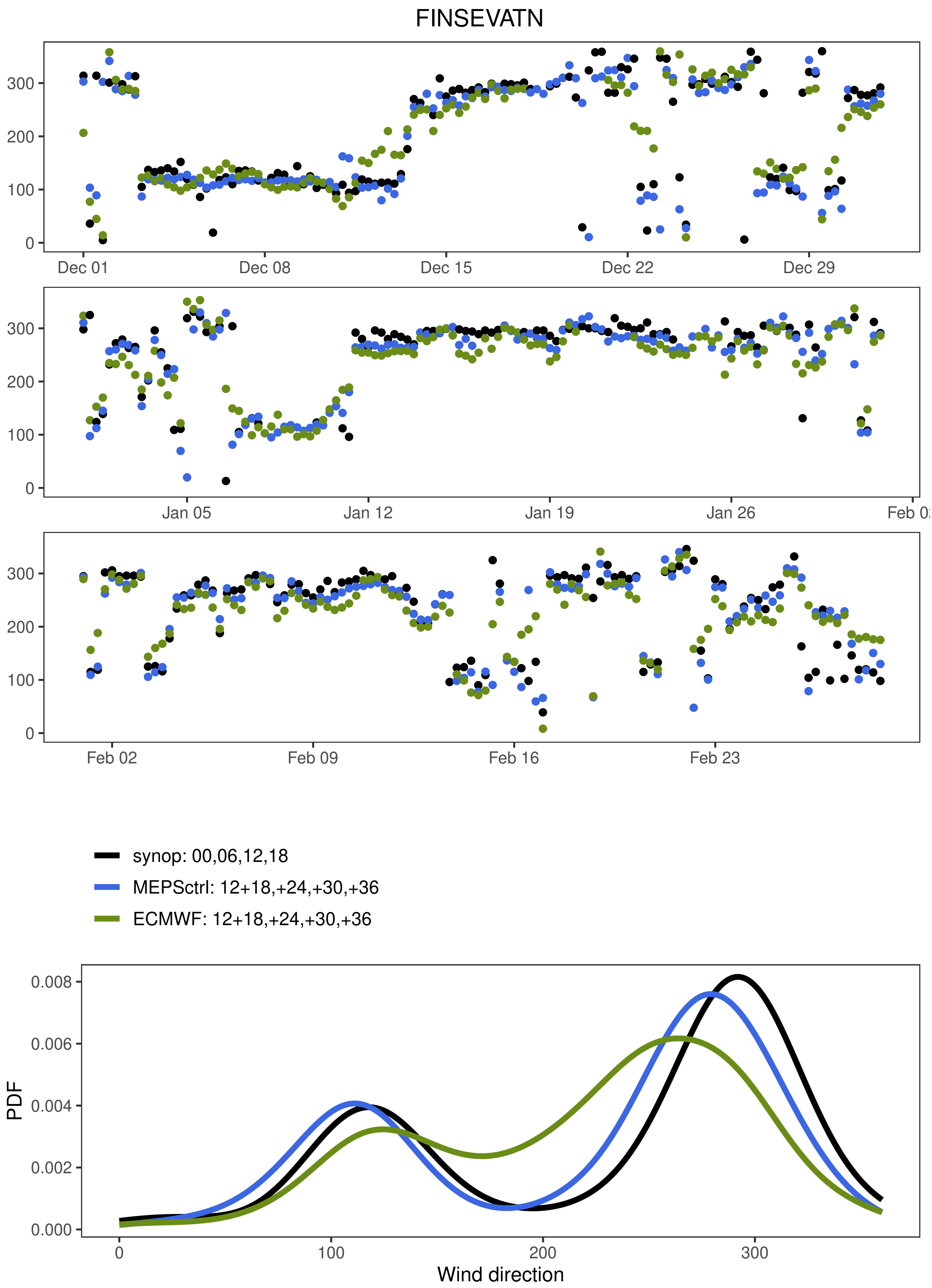

BERGEN – FLORIDA
0
100
200
300
Dec 01
Dec 08
Dec 15
Dec 22
Dec 29
Jan 05
Jan 12
Jan 19
Jan 26
Feb 02
Feb 09
Feb 16
Feb 23

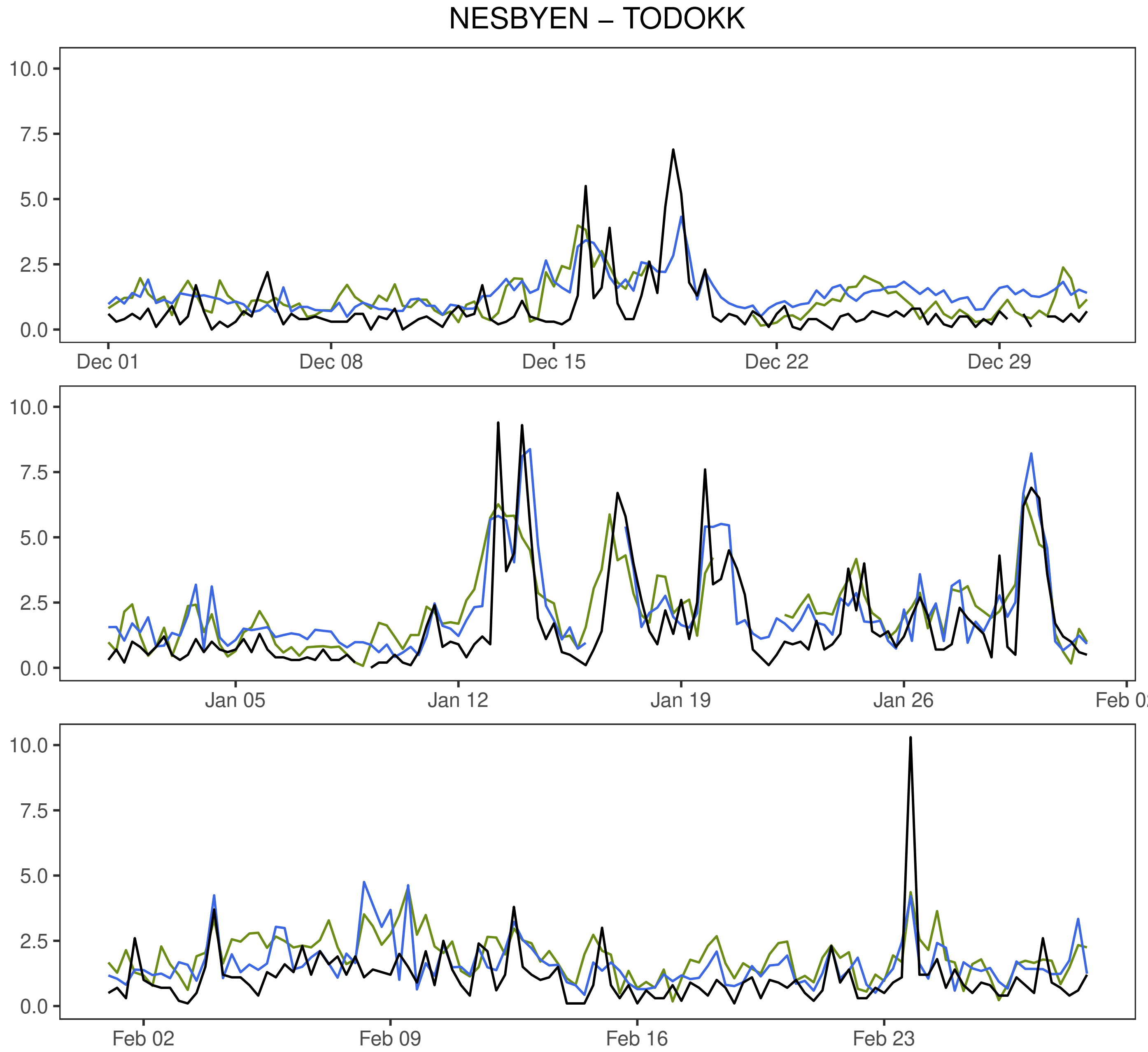

synop: 00,06,12,18
MEPSctrl: 12+18,+24,+30,+36
ECMWF: 12+18,+24,+30,+36
PDF
0.0000
0.0025
0.0050
0.0075
0.0100
0
100
200
300
Wind direction



	Min	Mean	Max	Std	N
synop: 00,06,12,18	0.1	7.7	19.9	4.3	335
MEPSctrl: 12+18,+24,+30,+36	0.5	8.1	23.3	4.4	356
ECMWF: 12+18,+24,+30,+36	0.3	4.0	12.0	1.7	340

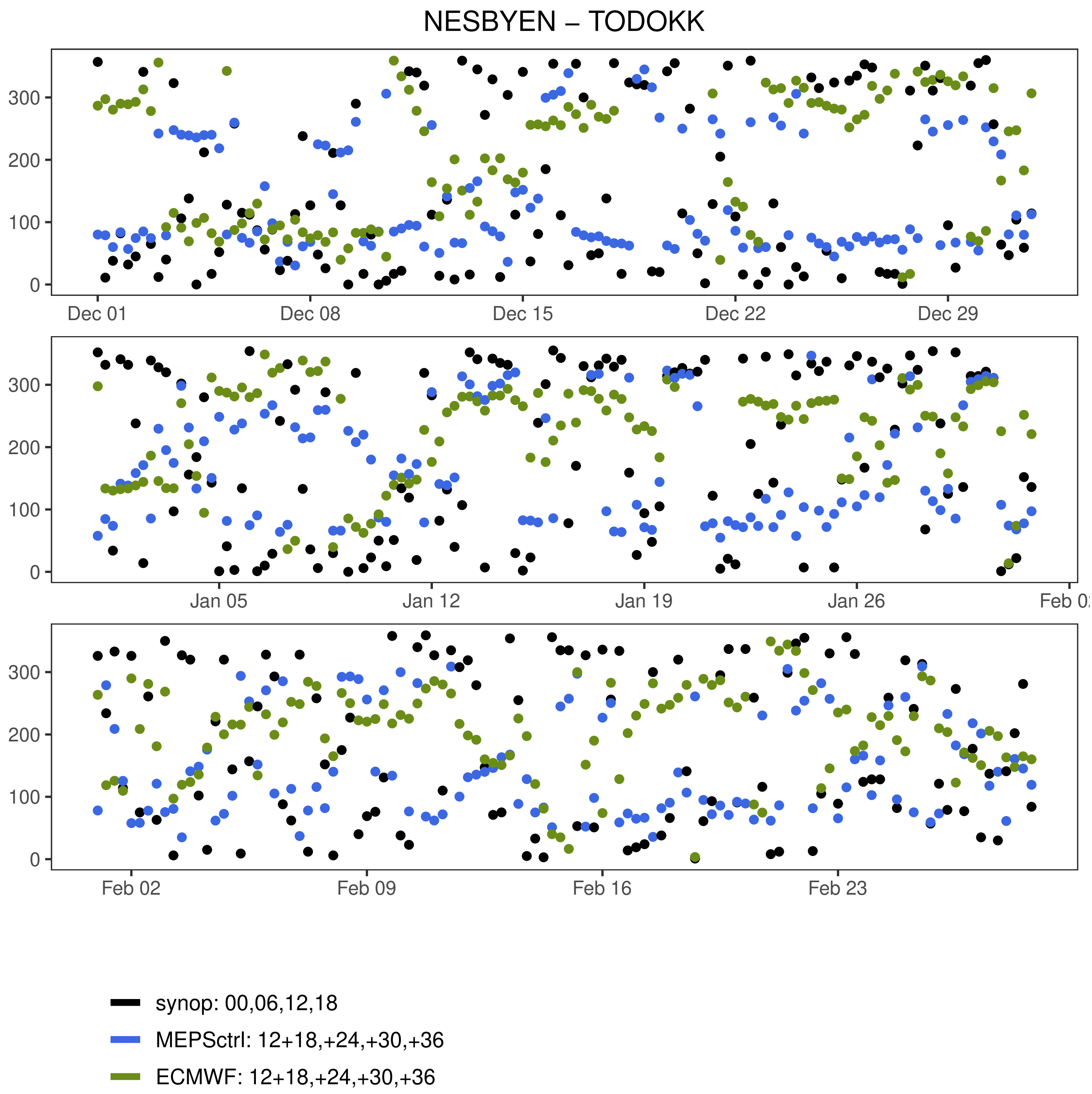
	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl–synop	0.2	2.6	2.6	2.0	11.6	313
ECMWF–synop	−3.7	3.1	4.8	4.0	12.5	313

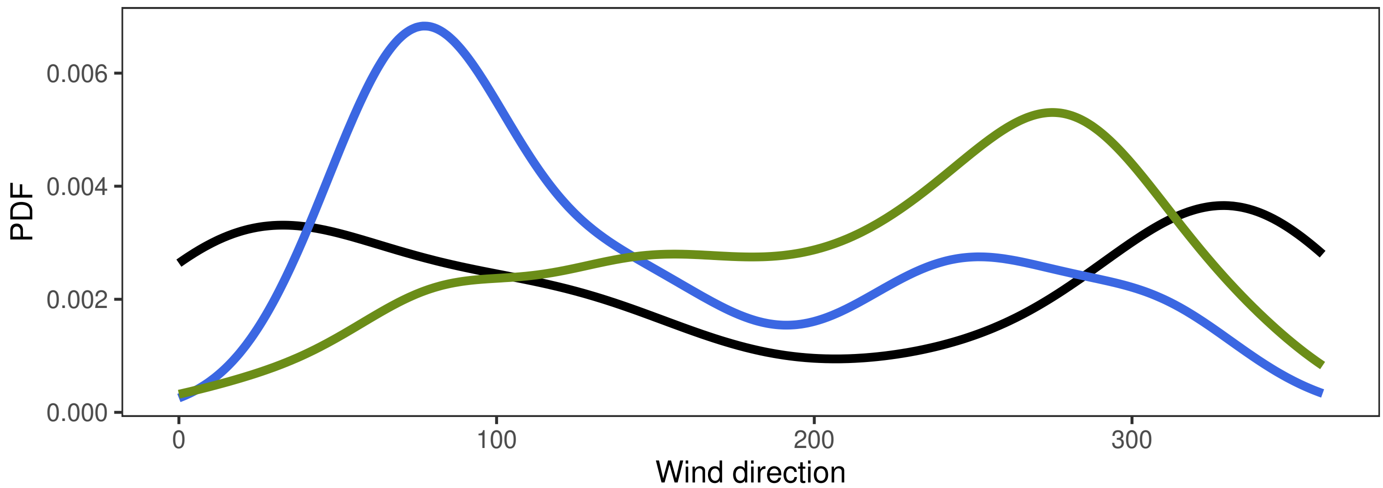

FINSEVATN
300
200
100
0
Dec 01
Dec 08
Dec 15
Dec 22
Dec 29
Jan 05
Jan 12
Jan 19
Jan 26
Feb 02
Feb 09
Feb 16
Feb 23
synop: 00,06,12,18
MEPSctrl: 12+18,+24,+30,+36
ECMWF: 12+18,+24,+30,+36
PDF
0.008
0.006
0.004
0.002
0.000
0
100
200
300
Wind direction

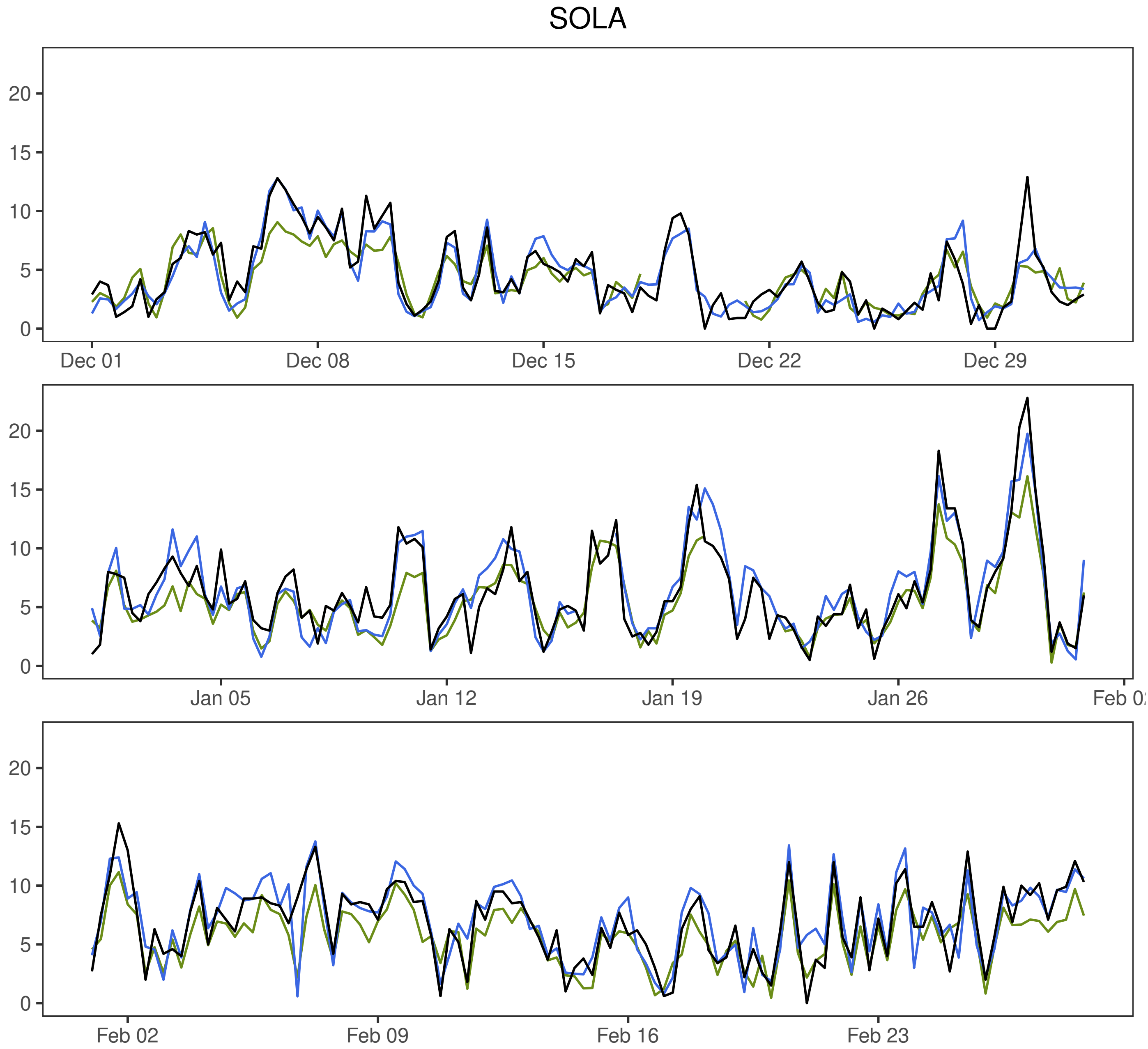


	Min	Mean	Max	Std	N
synop: 00,06,12,18	0.0	1.2	10.3	1.5	357
MEPSctrl: 12+18,+24,+30,+36	0.4	1.7	8.4	1.2	356
ECMWF: 12+18,+24,+30,+36	0.1	1.8	6.6	1.1	340

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl–synop	0.6	0.9	1.1	0.8	6.1	333
ECMWF–synop	0.6	1.0	1.2	0.9	5.9	333

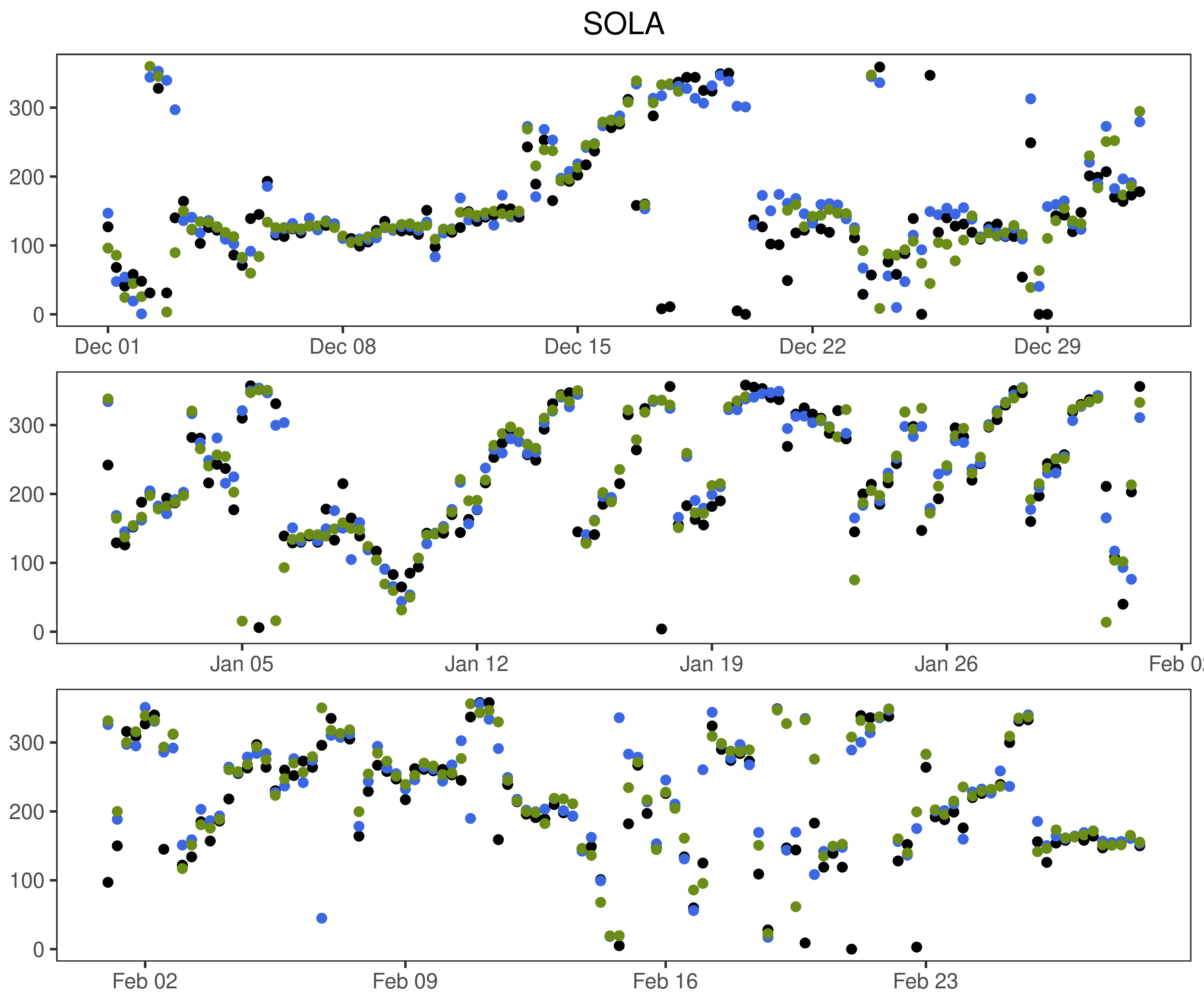

NESBYEN – TODOKK
300
200
100
0
Dec 01
Dec 08
Dec 15
Dec 22
Dec 29
Jan 05
Jan 12
Jan 19
Jan 26
Feb 02
Feb 09
Feb 16
Feb 23
synop: 00,06,12,18
MEPSctrl: 12+18,+24,+30,+36
ECMWF: 12+18,+24,+30,+36


PDF
0.000
0.002
0.004
0.006
0
100
200
300
Wind direction

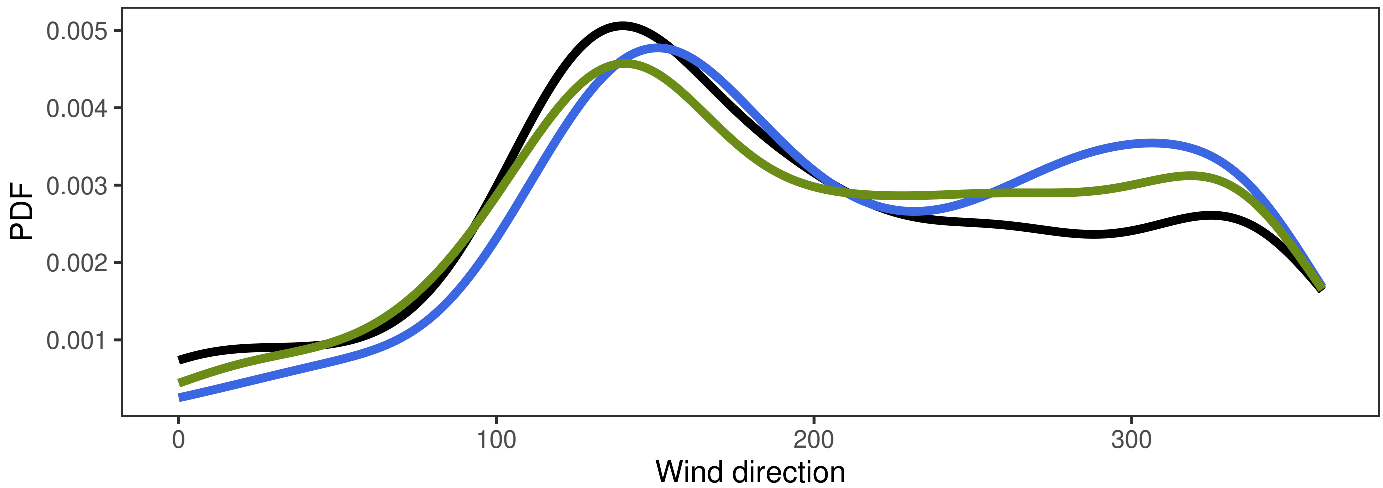


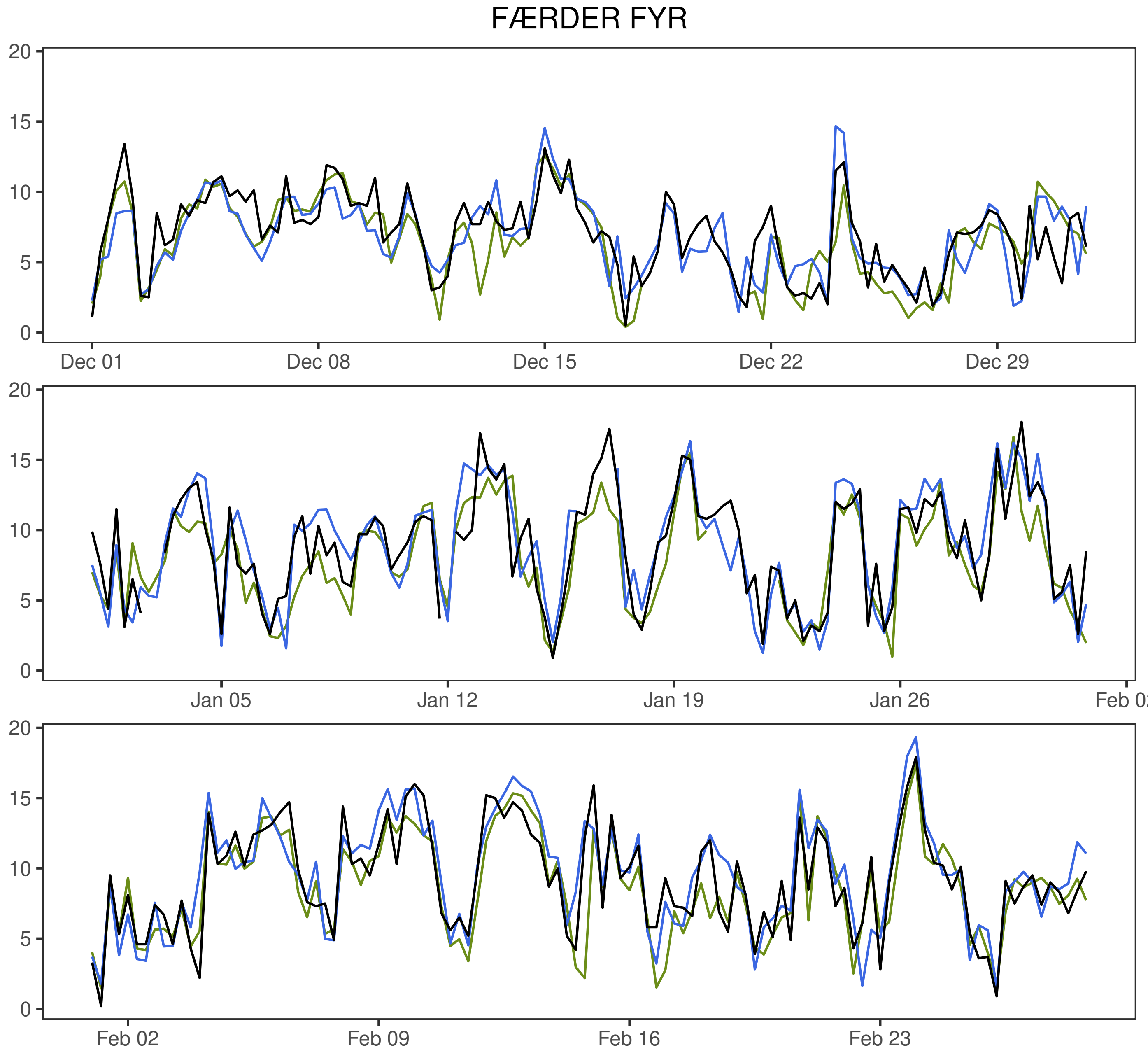
	Min	Mean	Max	Std	N
synop: 00,06,12,18	0.0	5.9	22.8	3.6	360
MEPSctrl: 12+18,+24,+30,+36	0.6	6.0	19.7	3.5	356
ECMWF: 12+18,+24,+30,+36	0.3	5.1	16.1	2.6	340

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl−synop	0.1	1.7	1.7	1.2	8.4	336
ECMWF−synop	−0.8	1.7	1.9	1.4	7.7	336



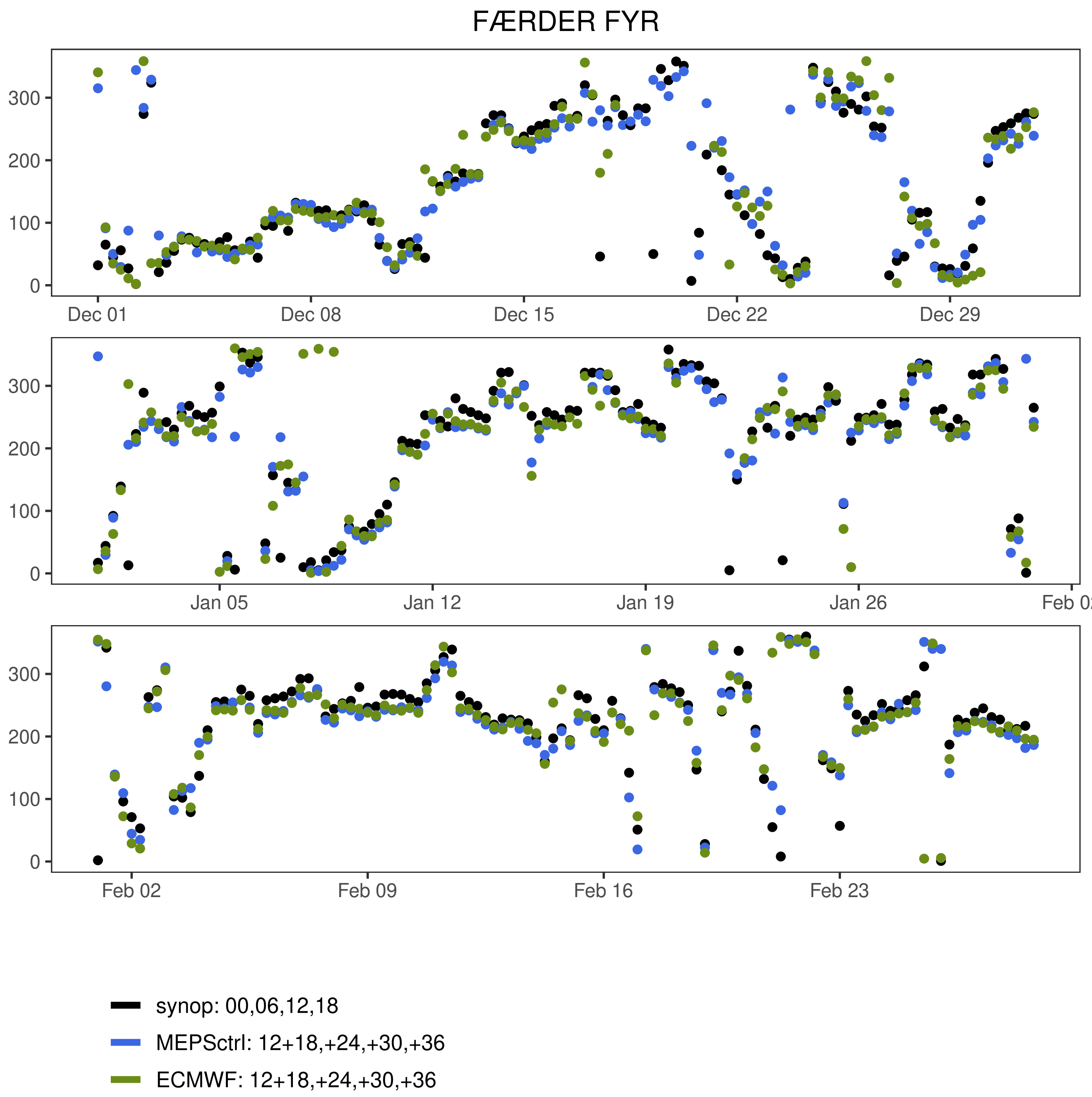
synop: 00,06,12,18
MEPSctrl: 12+18,+24,+30,+36
ECMWF: 12+18,+24,+30,+36

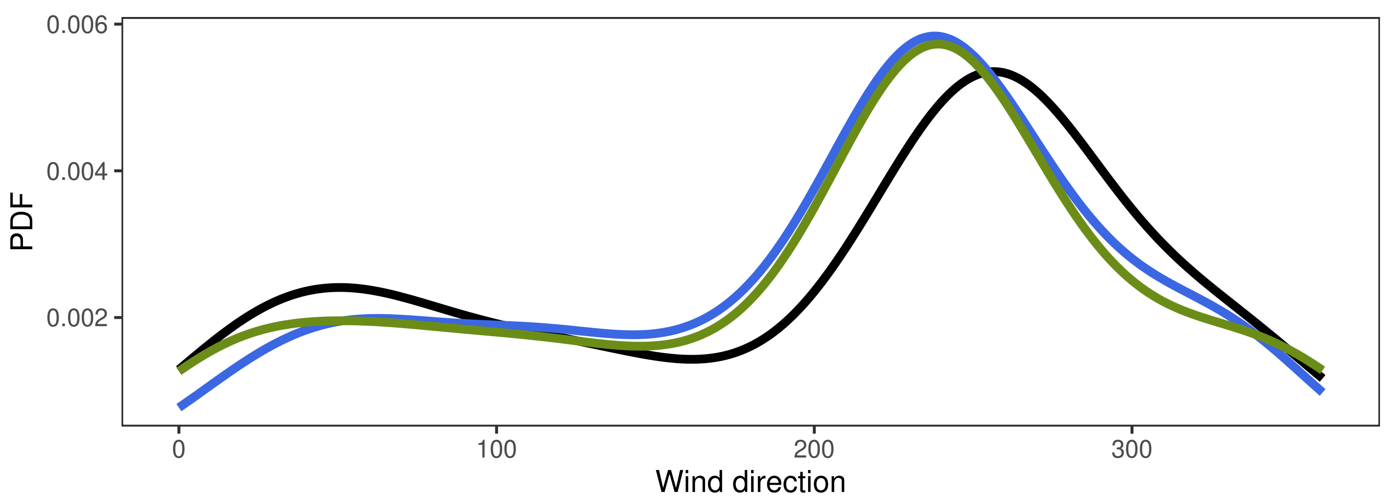


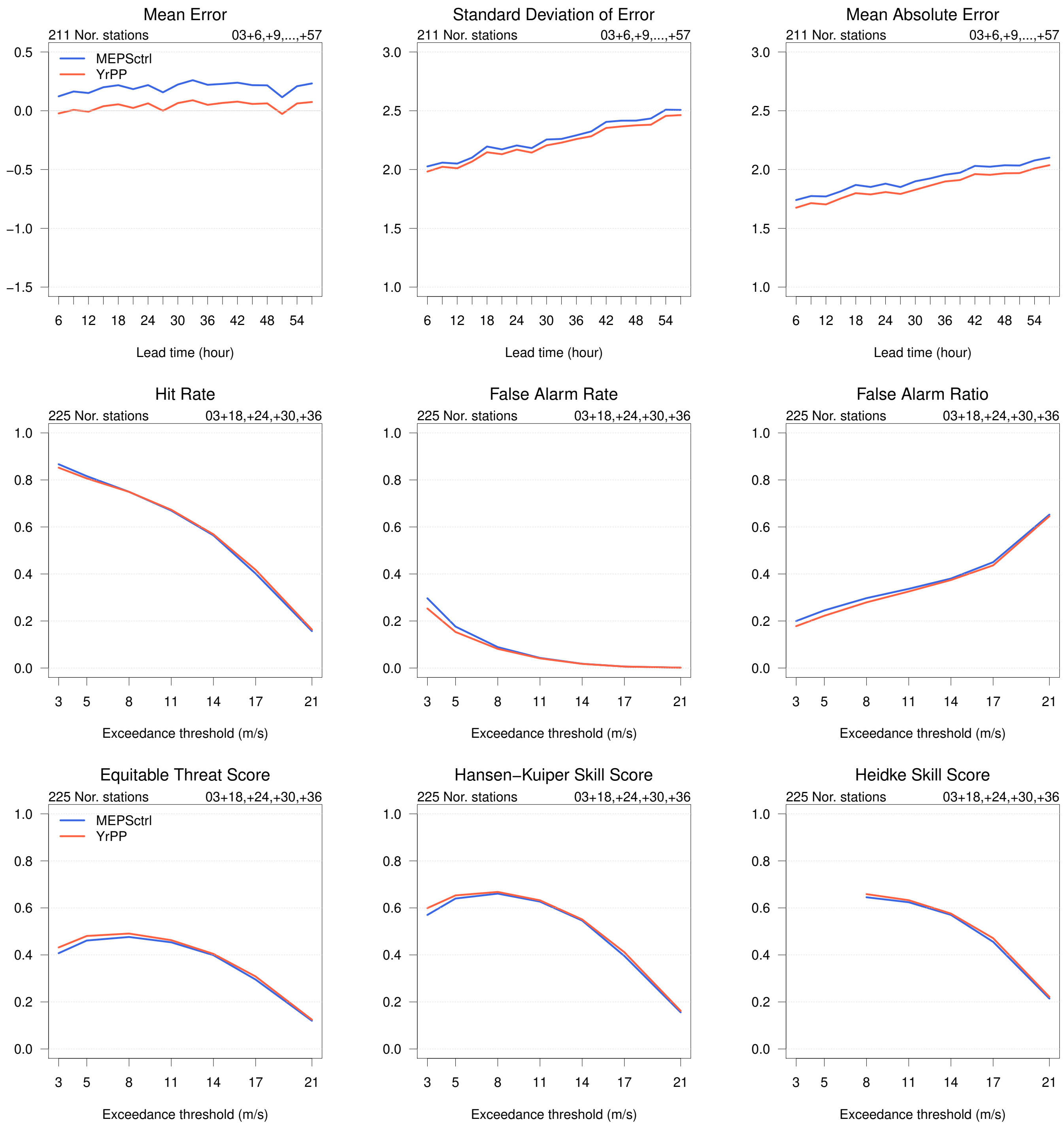


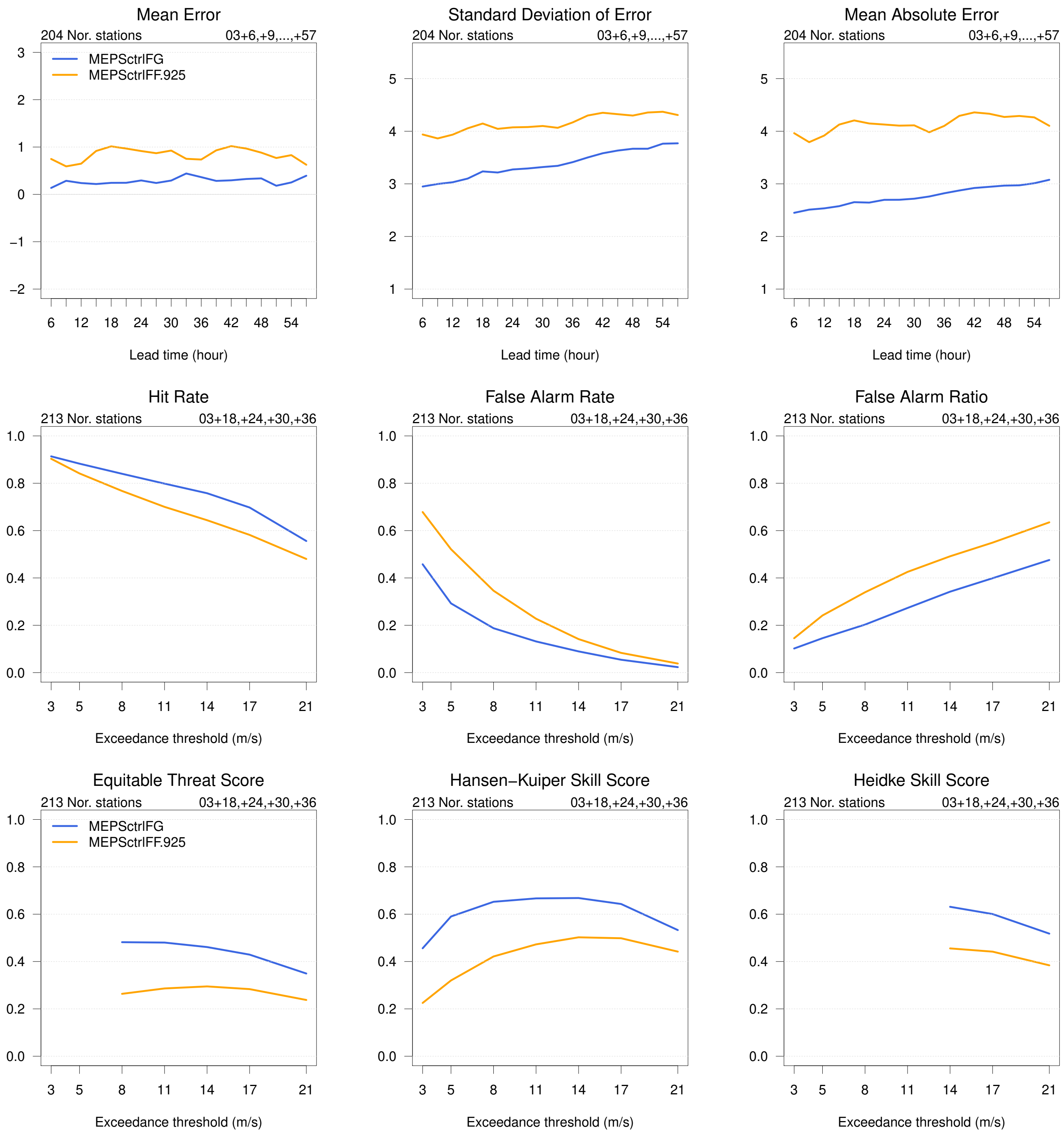
	Min	Mean	Max	Std	N
synop: 00,06,12,18	0.2	8.3	17.9	3.6	357
MEPSctrl: 12+18,+24,+30,+36	1.2	8.4	19.3	3.7	356
ECMWF: 12+18,+24,+30,+36	0.4	7.7	17.4	3.5	340

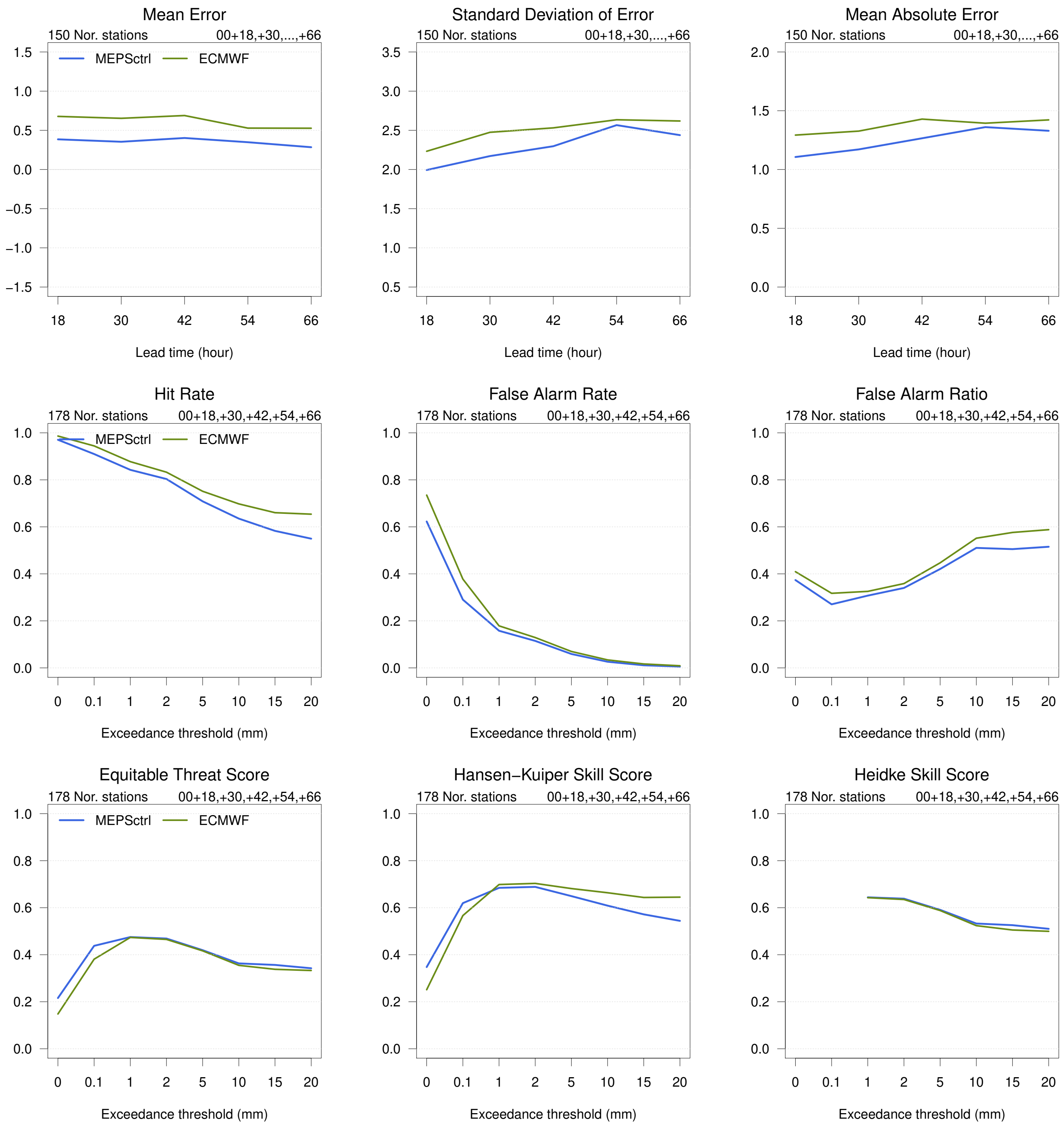
	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl−synop	0.2	2.0	2.0	1.6	7.5	333
ECMWF−synop	−0.6	2.0	2.1	1.6	10.0	333


FÆRDER FYR
300
200
100
0
Dec 01
Dec 08
Dec 15
Dec 22
Dec 29
Jan 05
Jan 12
Jan 19
Jan 26
Feb 02
Feb 09
Feb 16
Feb 23
synop: 00,06,12,18
MEPSctrl: 12+18,+24,+30,+36
ECMWF: 12+18,+24,+30,+36

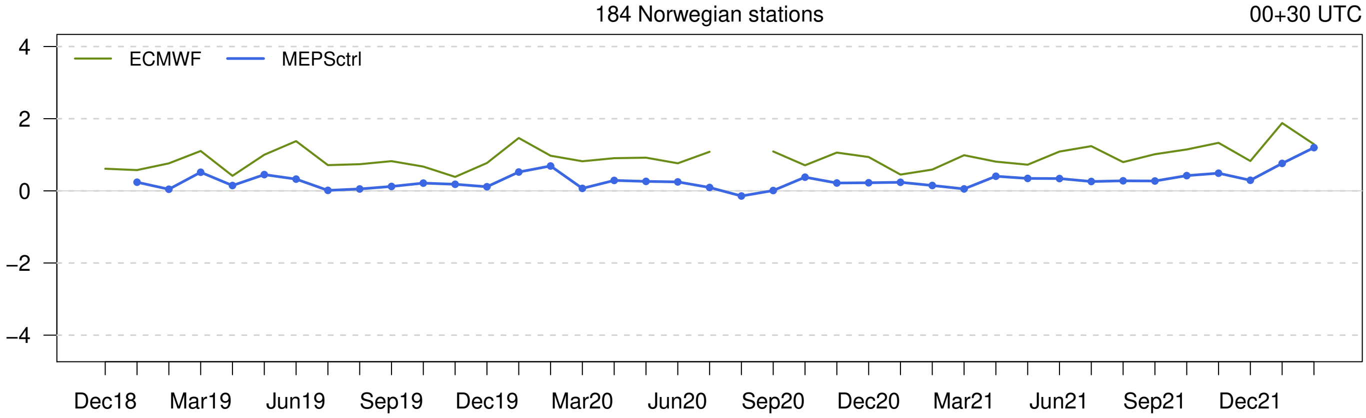

0.006
0.004
0.002
PDF
0
100
200
300
Wind direction

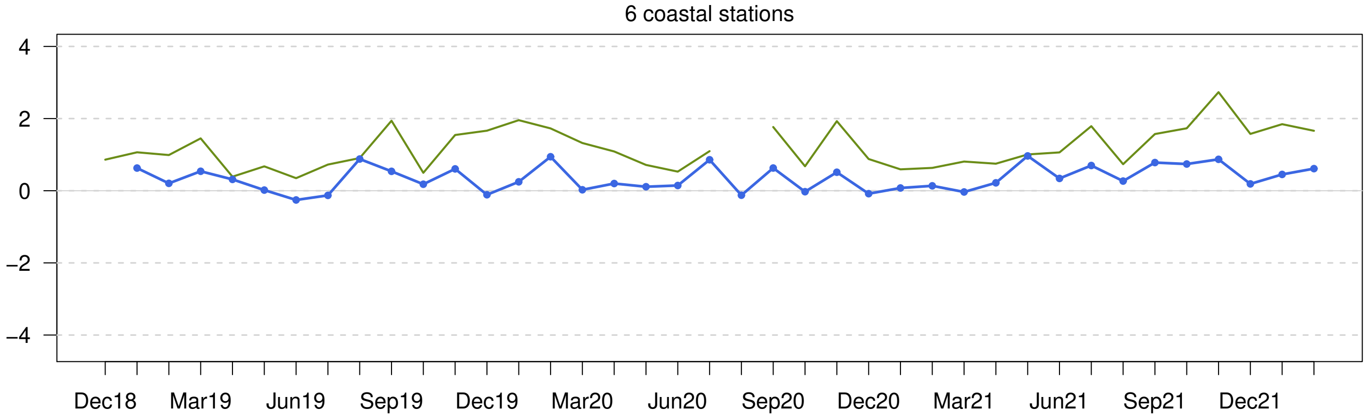

Mean Error
211 Nor. stations
03+6,+9,...,+57
MEPSctrl
YrPP
Lead time (hour)
Standard Deviation of Error
211 Nor. stations
03+6,+9,...,+57
Lead time (hour)
Mean Absolute Error
211 Nor. stations
03+6,+9,...,+57
Lead time (hour)
Hit Rate
225 Nor. stations
03+18,+24,+30,+36
Exceedance threshold (m/s)
False Alarm Rate
225 Nor. stations
03+18,+24,+30,+36
Exceedance threshold (m/s)
False Alarm Ratio
225 Nor. stations
03+18,+24,+30,+36
Exceedance threshold (m/s)
Equitable Threat Score
225 Nor. stations
03+18,+24,+30,+36
MEPSctrl
YrPP
Exceedance threshold (m/s)
Hansen−Kuiper Skill Score
225 Nor. stations
03+18,+24,+30,+36
Exceedance threshold (m/s)
Heidke Skill Score
225 Nor. stations
03+18,+24,+30,+36
Exceedance threshold (m/s)

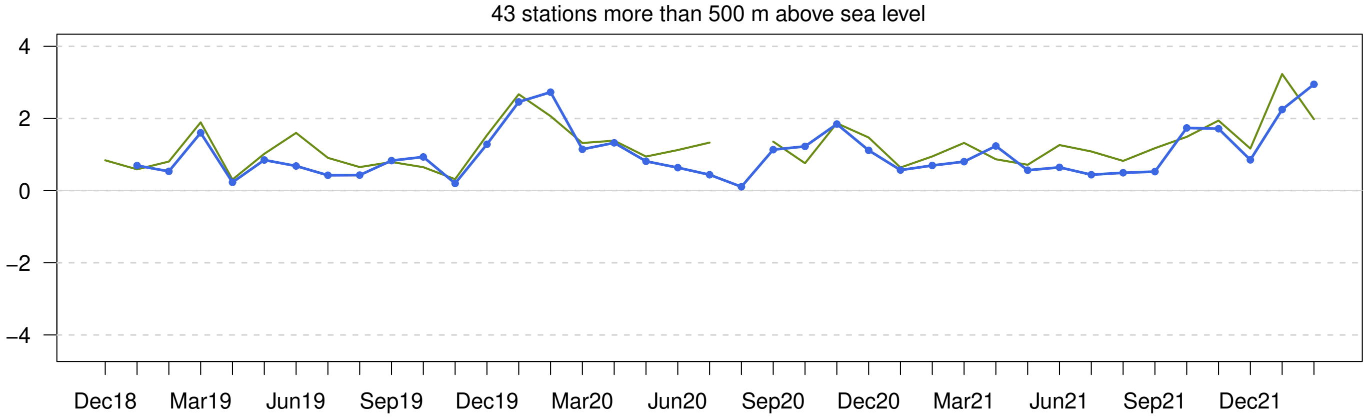

Mean Error
204 Nor. stations
03+6,+9,...,+57
MEPSctrlFG
MEPSctrlFF.925
Lead time (hour)
Standard Deviation of Error
204 Nor. stations
03+6,+9,...,+57
Lead time (hour)
Mean Absolute Error
204 Nor. stations
03+6,+9,...,+57
Lead time (hour)
Hit Rate
213 Nor. stations
03+18,+24,+30,+36
Exceedance threshold (m/s)
False Alarm Rate
213 Nor. stations
03+18,+24,+30,+36
Exceedance threshold (m/s)
False Alarm Ratio
213 Nor. stations
03+18,+24,+30,+36
Exceedance threshold (m/s)
Equitable Threat Score
213 Nor. stations
03+18,+24,+30,+36
MEPSctrlFG
MEPSctrlFF.925
Exceedance threshold (m/s)
Hansen−Kuiper Skill Score
213 Nor. stations
03+18,+24,+30,+36
Exceedance threshold (m/s)
Heidke Skill Score
213 Nor. stations
03+18,+24,+30,+36
Exceedance threshold (m/s)

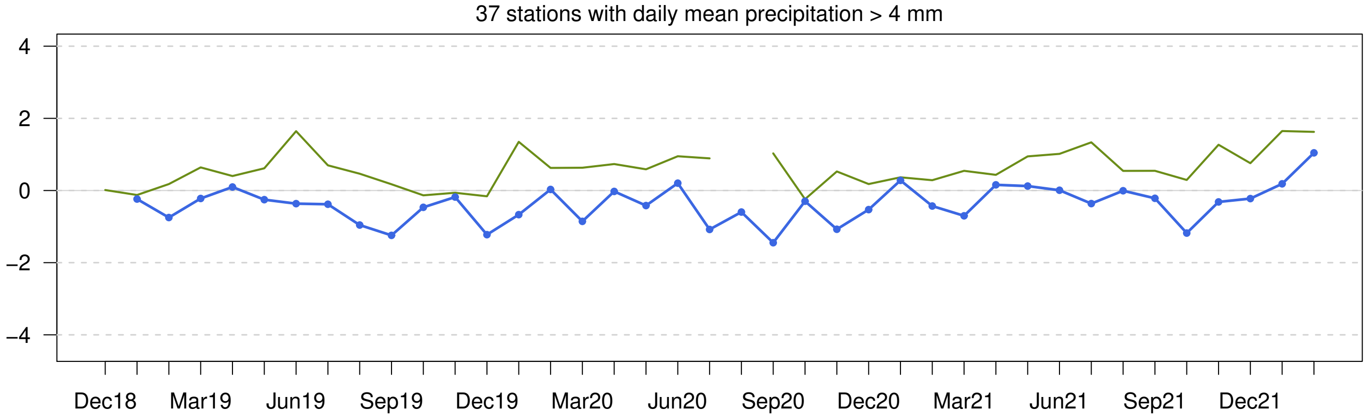

Mean Error
150 Nor. stations
00+18,+30,...,+66
MEPSctrl
ECMWF
Lead time (hour)
Standard Deviation of Error
150 Nor. stations
00+18,+30,...,+66
Lead time (hour)
Mean Absolute Error
150 Nor. stations
00+18,+30,...,+66
Lead time (hour)
Hit Rate
178 Nor. stations
00+18,+30,+42,+54,+66
MEPSctrl
ECMWF
Exceedance threshold (mm)
False Alarm Rate
178 Nor. stations
00+18,+30,+42,+54,+66
Exceedance threshold (mm)
False Alarm Ratio
178 Nor. stations
00+18,+30,+42,+54,+66
Exceedance threshold (mm)
Equitable Threat Score
178 Nor. stations
00+18,+30,+42,+54,+66
MEPSctrl
ECMWF
Exceedance threshold (mm)
Hansen−Kuiper Skill Score
178 Nor. stations
00+18,+30,+42,+54,+66
Exceedance threshold (mm)
Heidke Skill Score
178 Nor. stations
00+18,+30,+42,+54,+66
Exceedance threshold (mm)

Mean Error

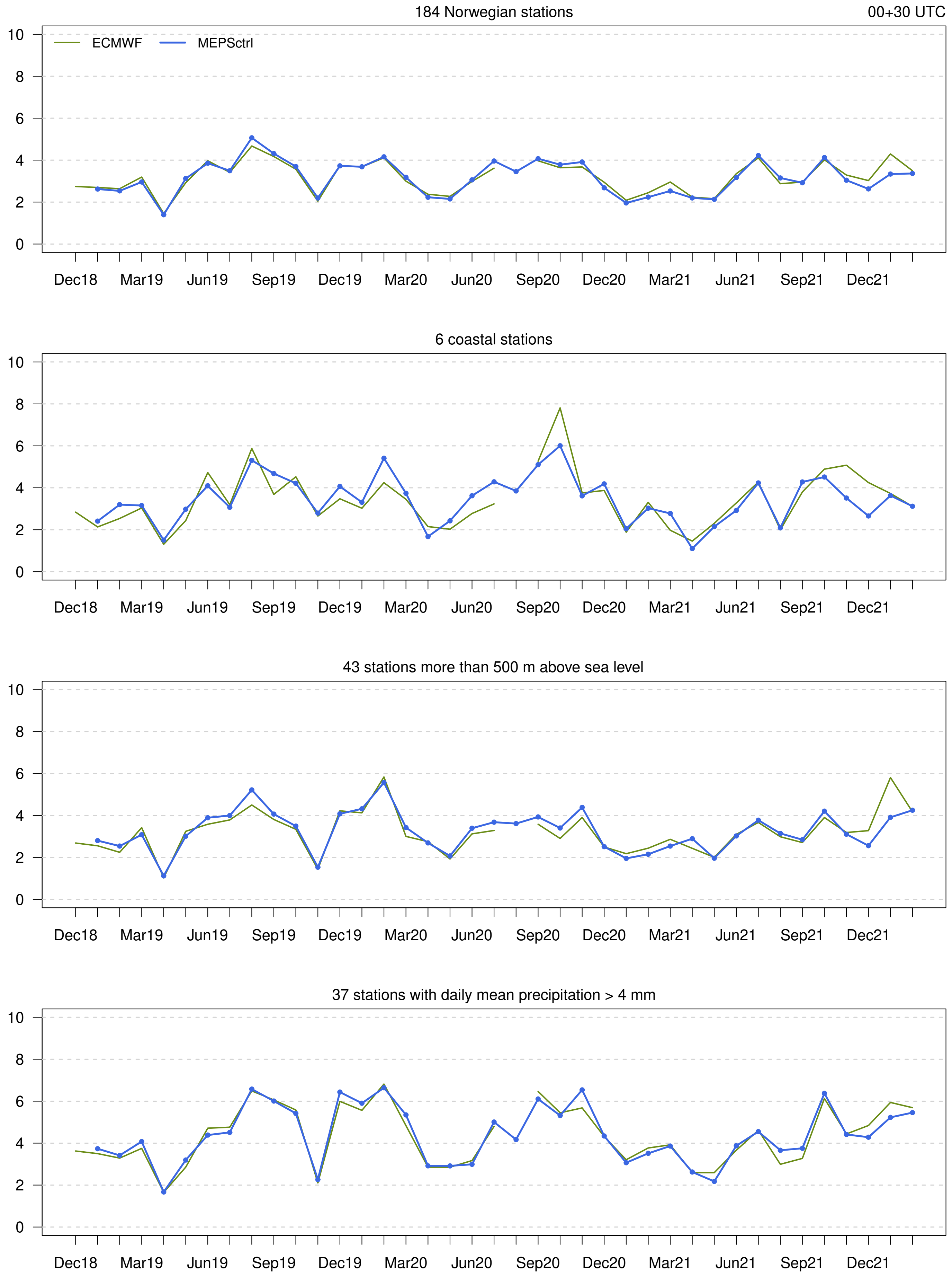

184 Norwegian stations
00+30 UTC
ECMWF
MEPSctrl
4
2
0
−2
−4
Dec18
Mar19
Jun19
Sep19
Dec19
Mar20
Jun20
Sep20
Dec20
Mar21
Jun21
Sep21
Dec21


6 coastal stations
4
2
0
−2
−4
Dec18
Mar19
Jun19
Sep19
Dec19
Mar20
Jun20
Sep20
Dec20
Mar21
Jun21
Sep21
Dec21

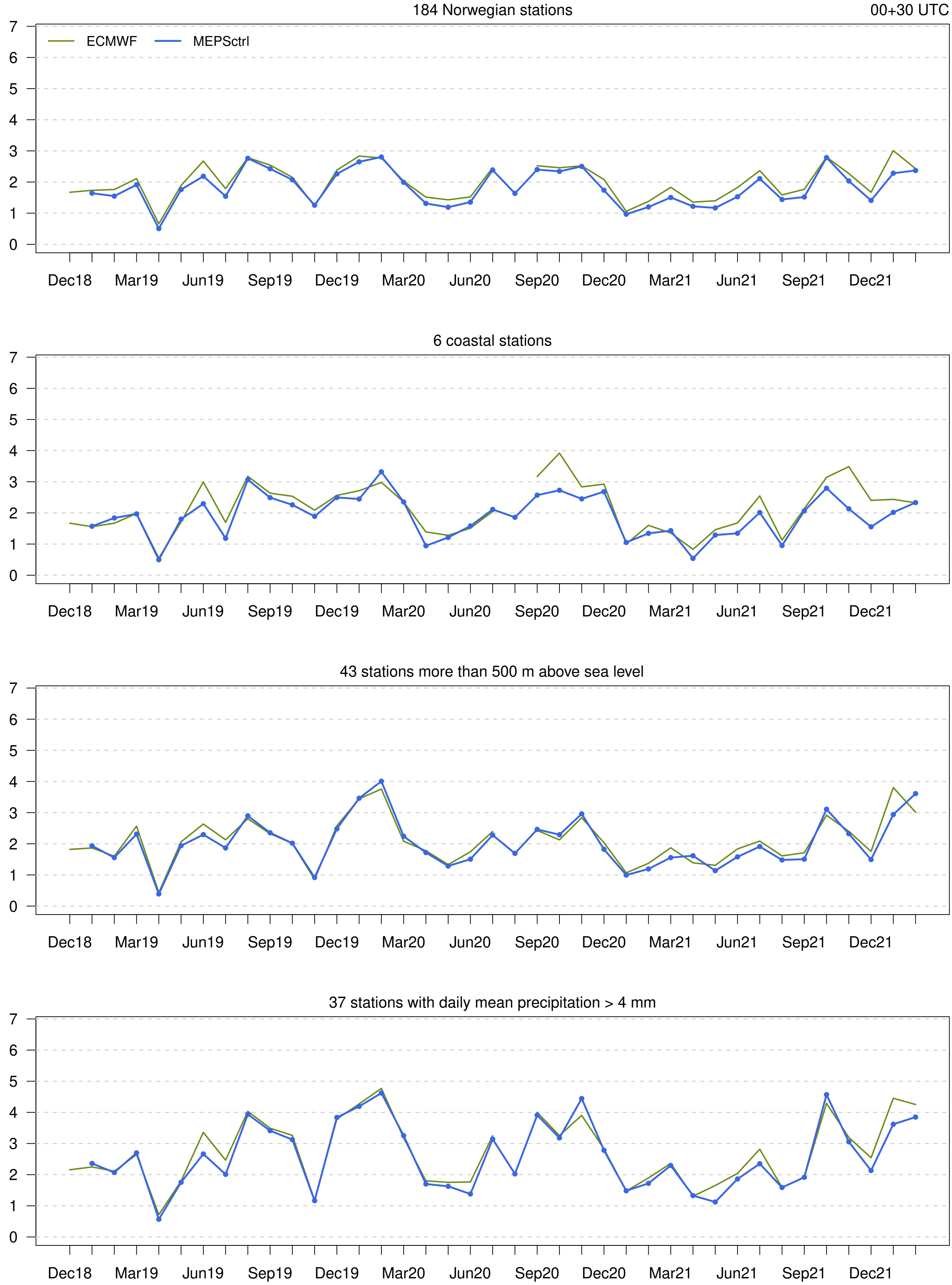

43 stations more than 500 m above sea level
4
2
0
−2
−4
Dec18
Mar19
Jun19
Sep19
Dec19
Mar20
Jun20
Sep20
Dec20
Mar21
Jun21
Sep21
Dec21


37 stations with daily mean precipitation > 4 mm
4
2
0
−2
−4
Dec18
Mar19
Jun19
Sep19
Dec19
Mar20
Jun20
Sep20
Dec20
Mar21
Jun21
Sep21
Dec21

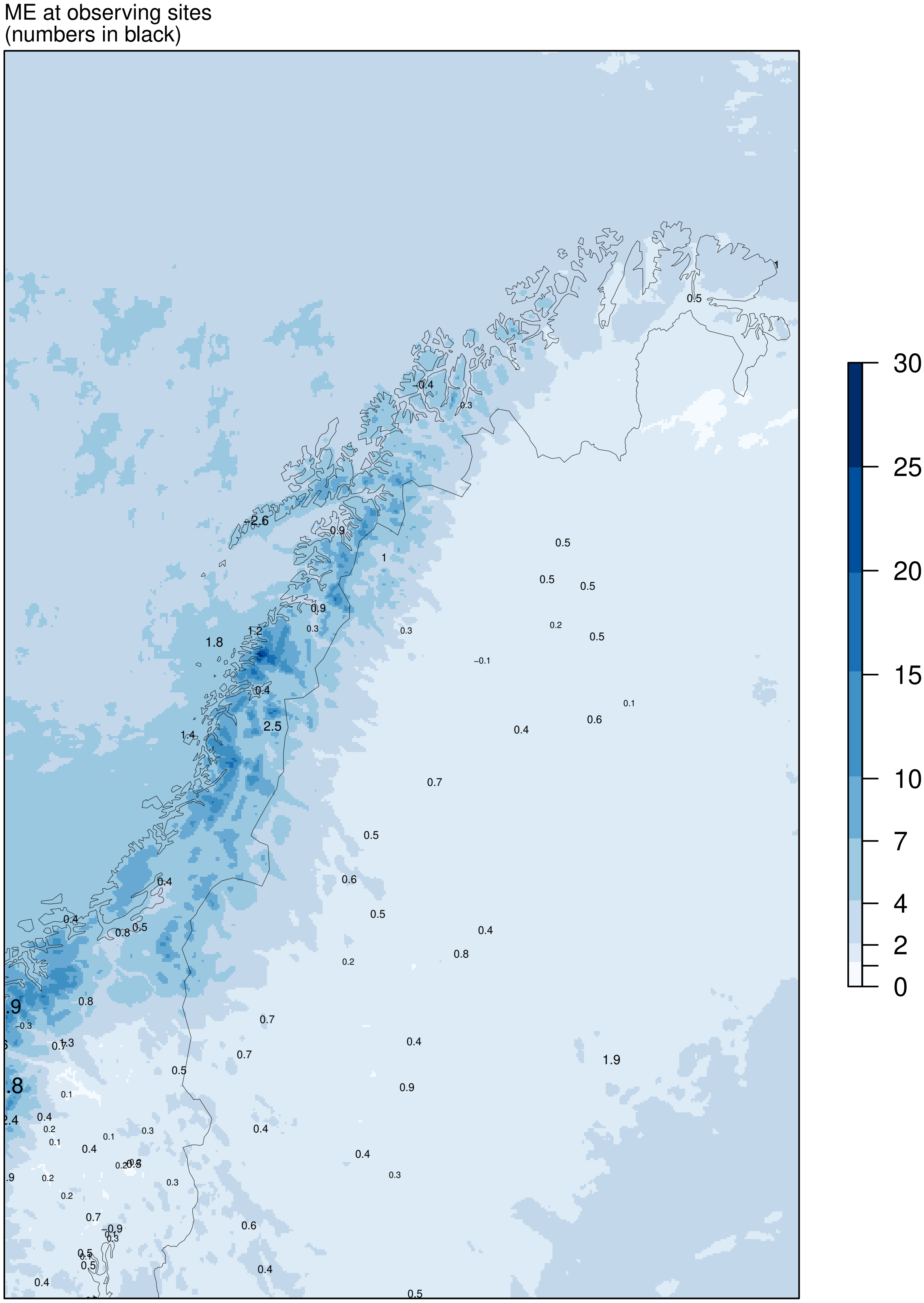
Standard Deviation of Error



Mean Absolute Error



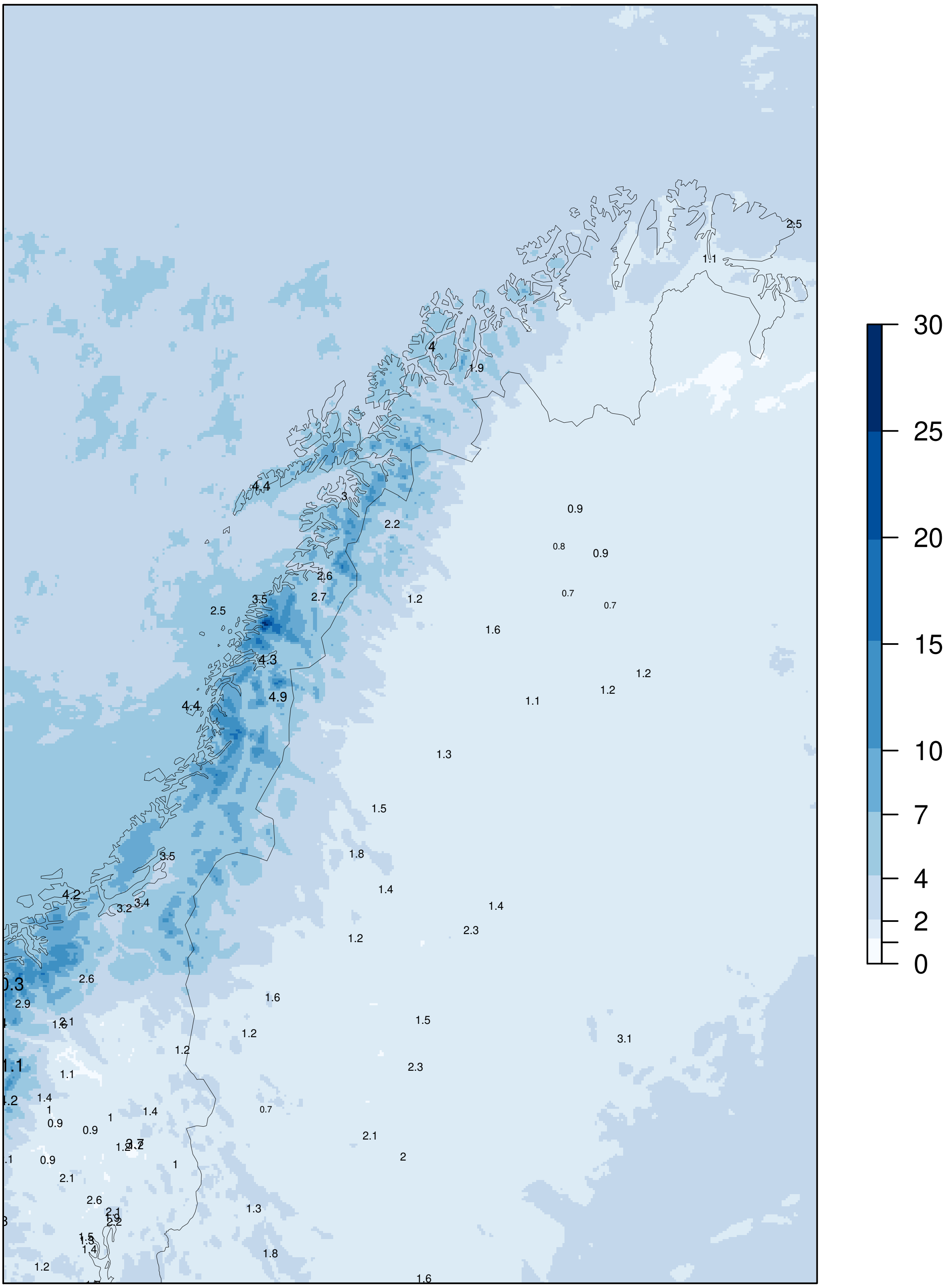
MEPSctrl 00+30



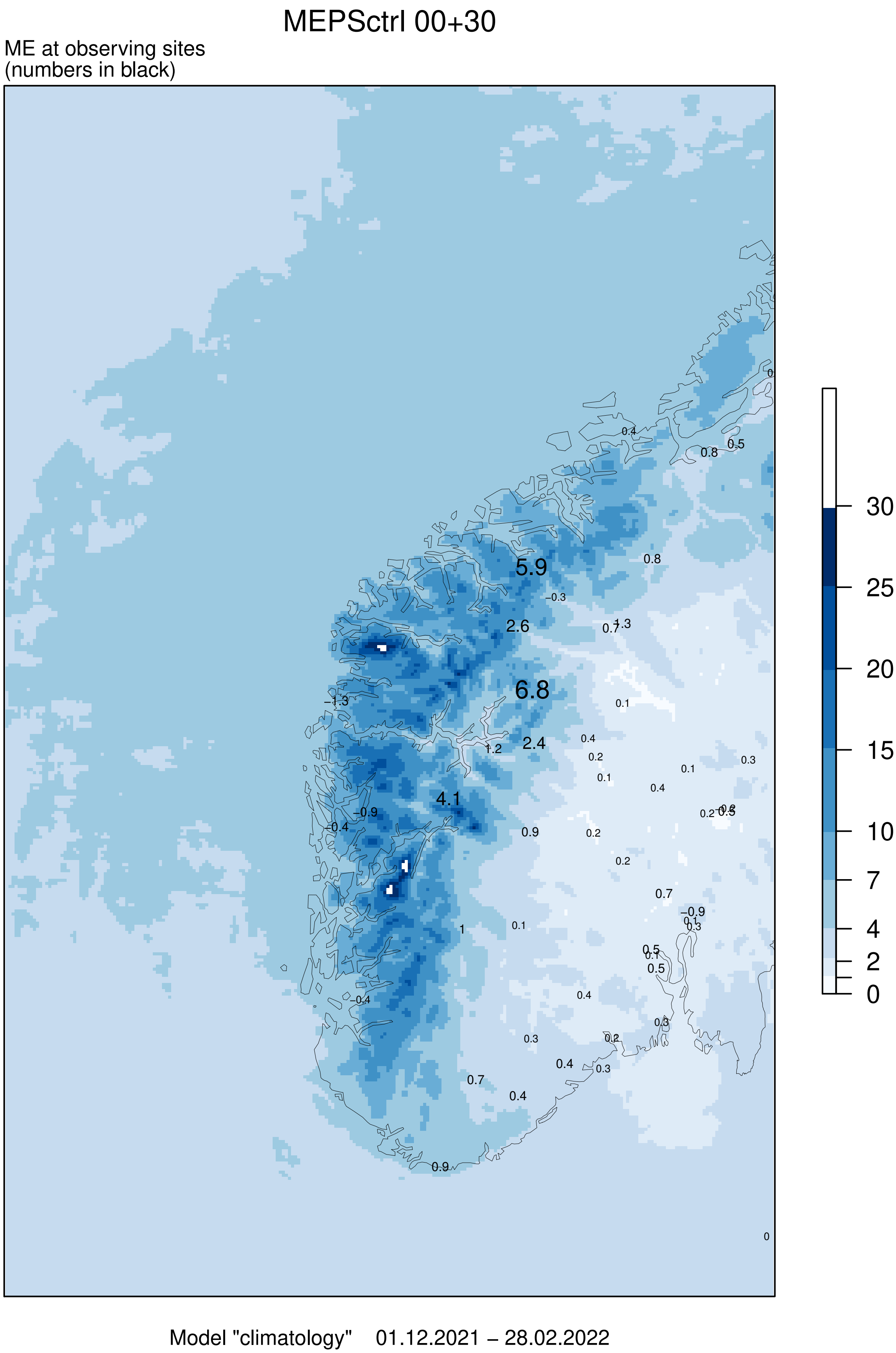
Model "climatology" 01.12.2021 – 28.02.2022

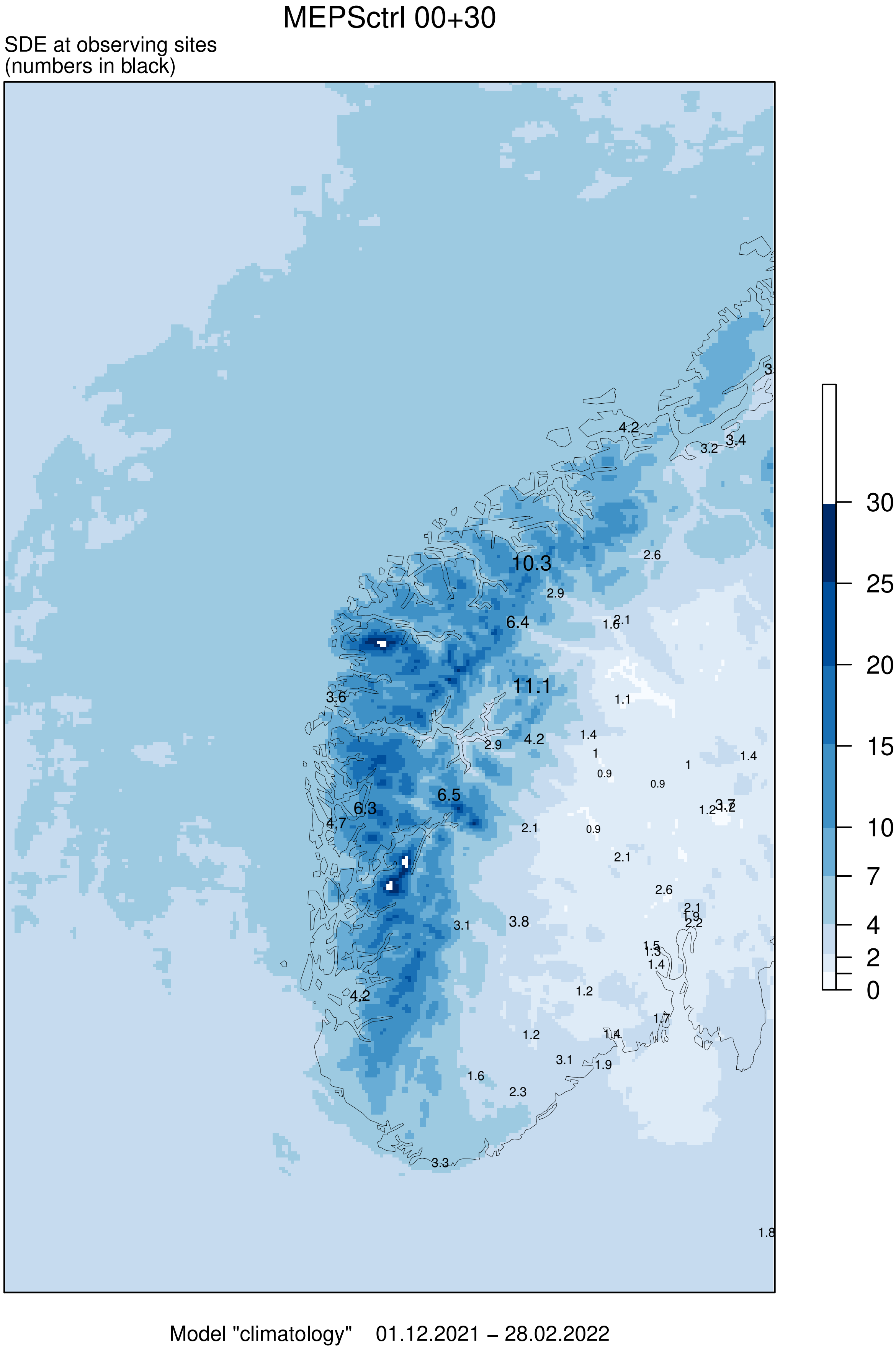
MEPSctrl 00+30

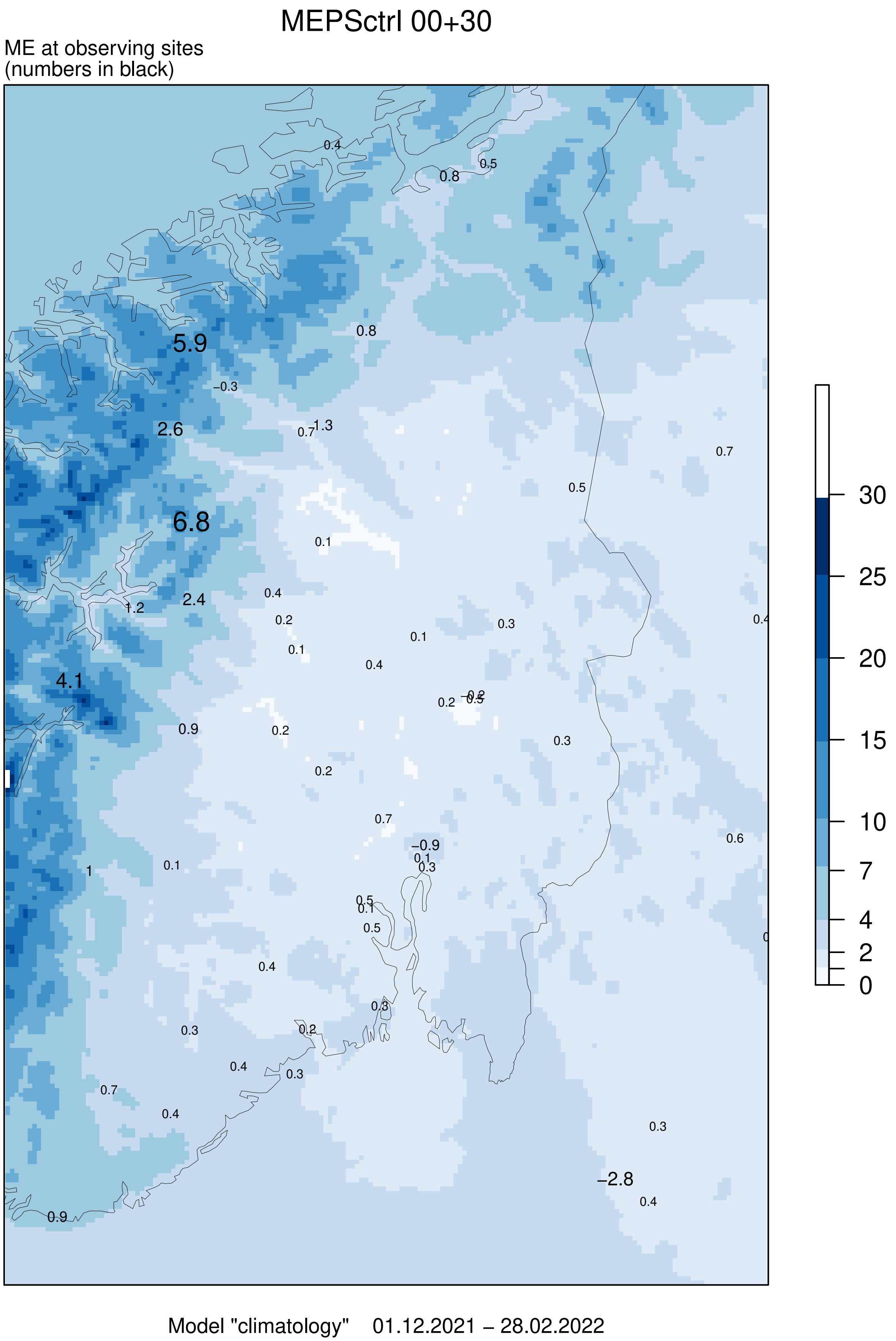
SDE at observing sites
(numbers in black)



Model "climatology" 01.12.2021 – 28.02.2022

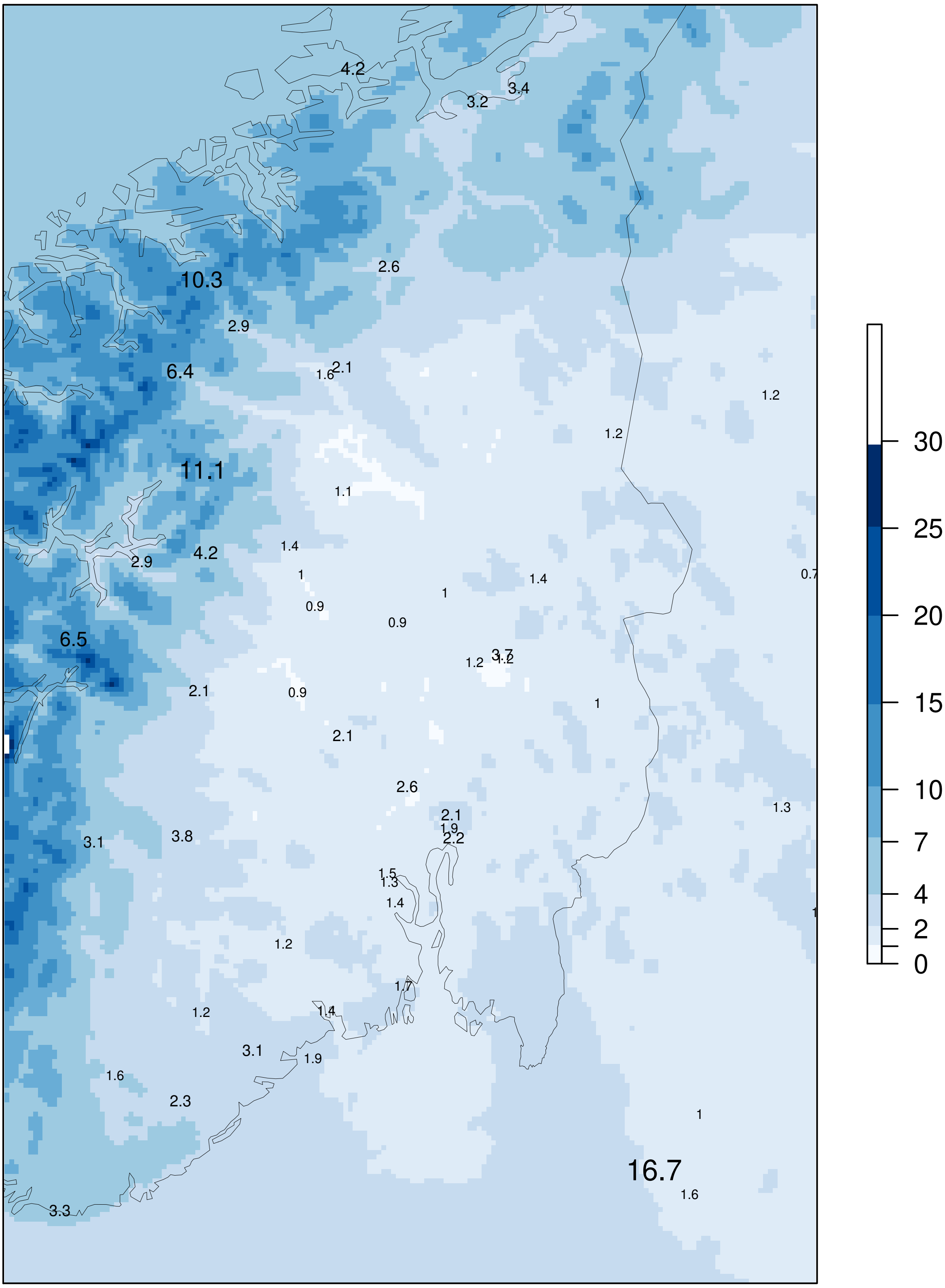

MEPSctrl 00+30
ME at observing sites
(numbers in black)
5.9
2.6
6.8
2.4
4.1
30
25
20
15
10
7
4
2
0
Model "climatology" 01.12.2021 – 28.02.2022


MEPSctrl 00+30
SDE at observing sites
(numbers in black)
30
25
20
15
10
7
4
2
0
Model "climatology" 01.12.2021 – 28.02.2022

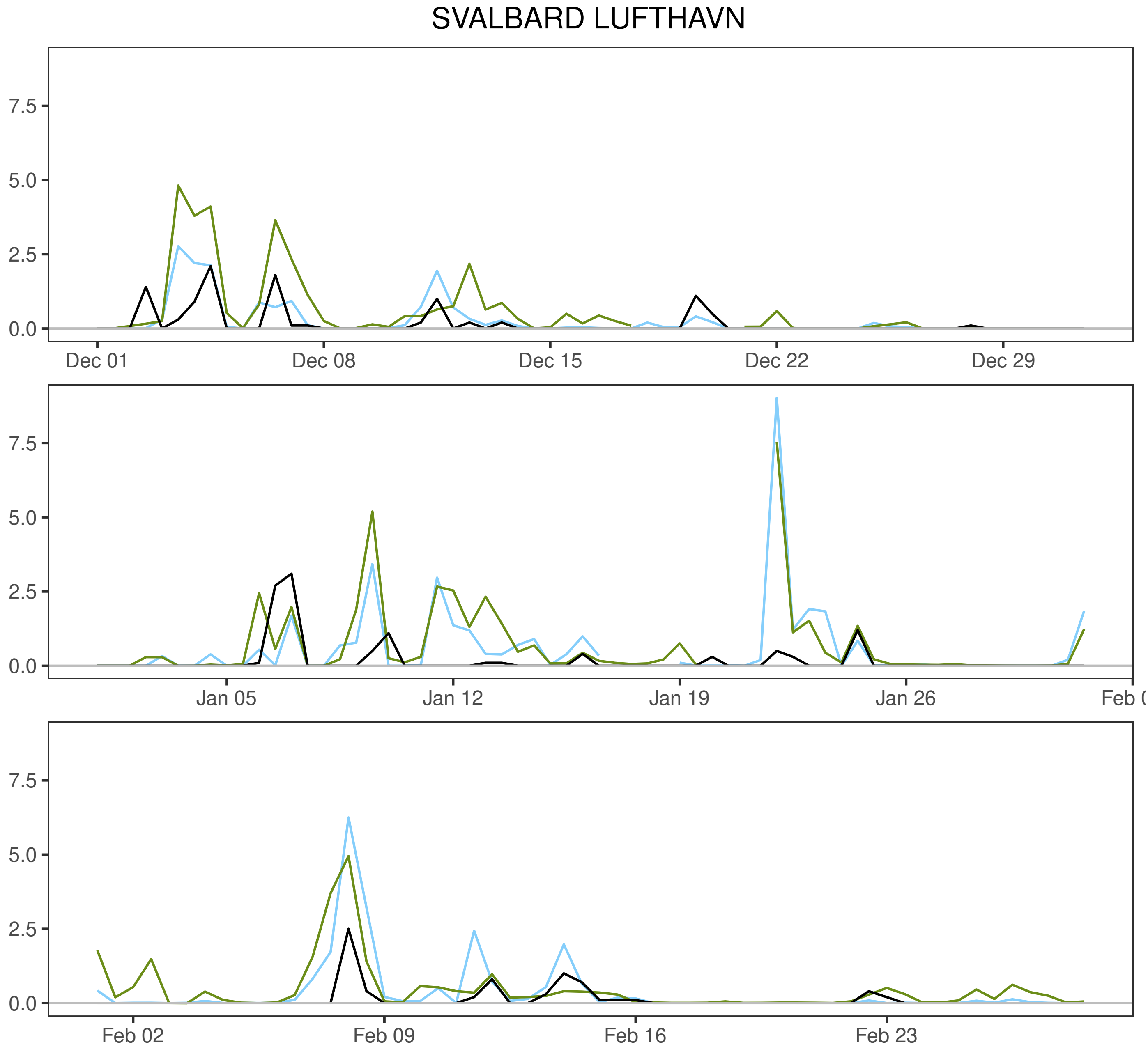

MEPSctrl 00+30
ME at observing sites
(numbers in black)
5.9
2.6
6.8
2.4
1.2
4.1
-2.8
30
25
20
15
10
7
4
2
0
Model "climatology" 01.12.2021 – 28.02.2022

MEPSctrl 00+30

SDE at observing sites
(numbers in black)

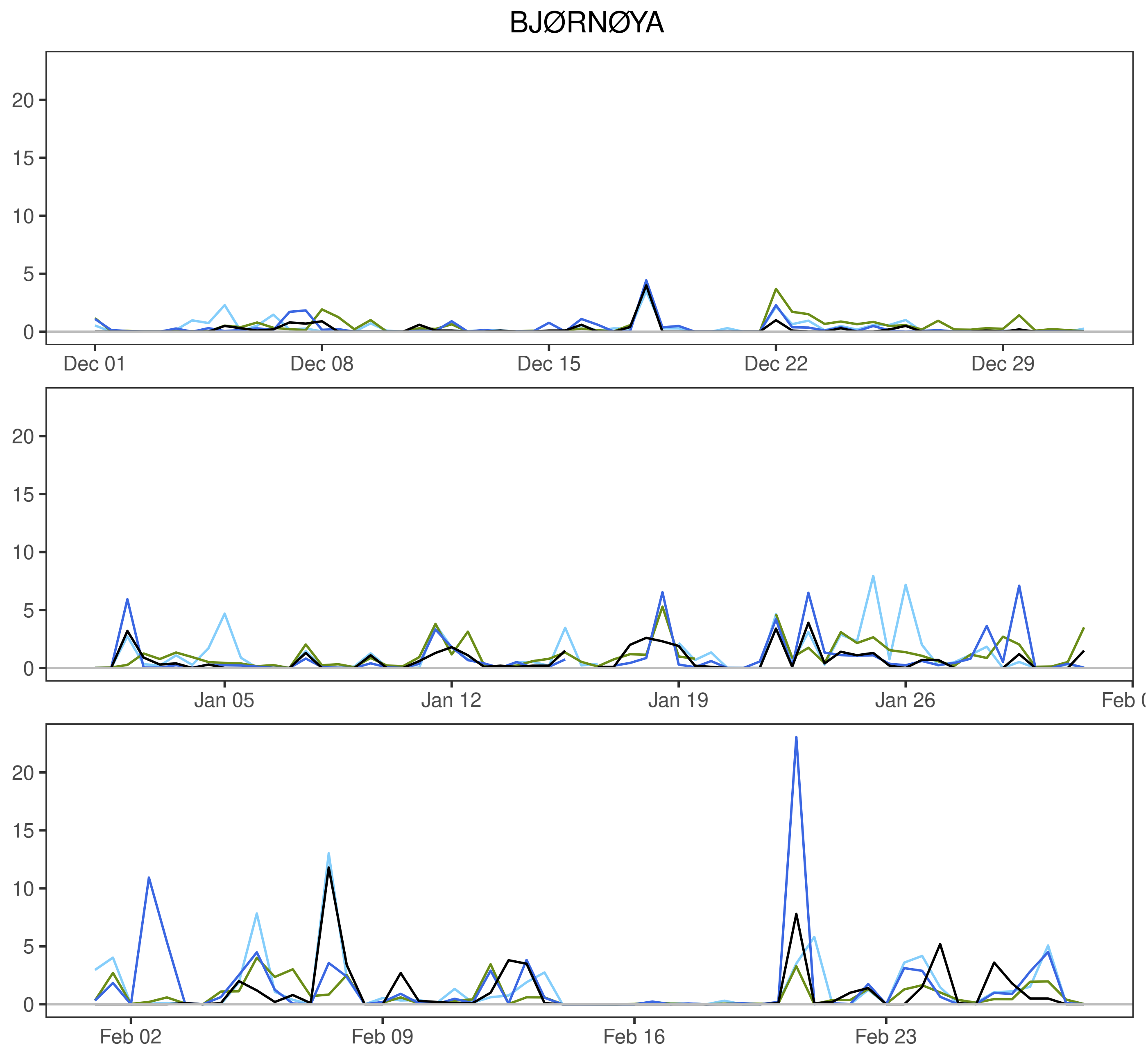


Model "climatology"   01.12.2021 – 28.02.2022



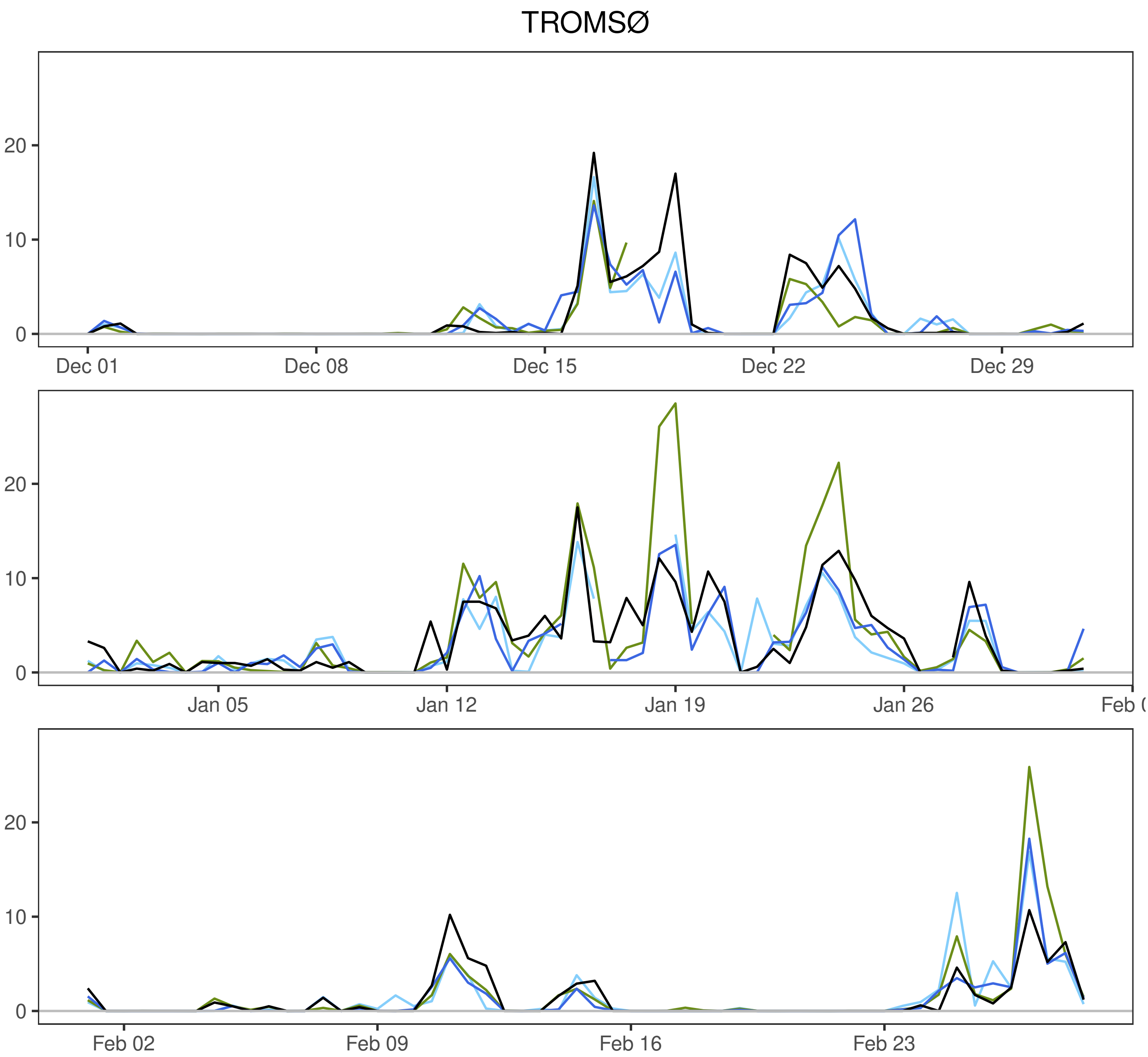
	Min	Mean	Max	Std	N
synop: 06,18	0.0	0.2	3.1	0.5	180
AA25: 12+18,+30	0.0	0.4	9.0	1.0	176
ECMWF: 12+18,+30	0.0	0.6	7.5	1.1	170

	ME	SDE	RMSE	MAE	Max.abs.err.	N
AA25−synop	0.3	1.0	1.0	0.4	8.5	166
ECMWF−synop	0.4	1.0	1.1	0.5	7.0	166



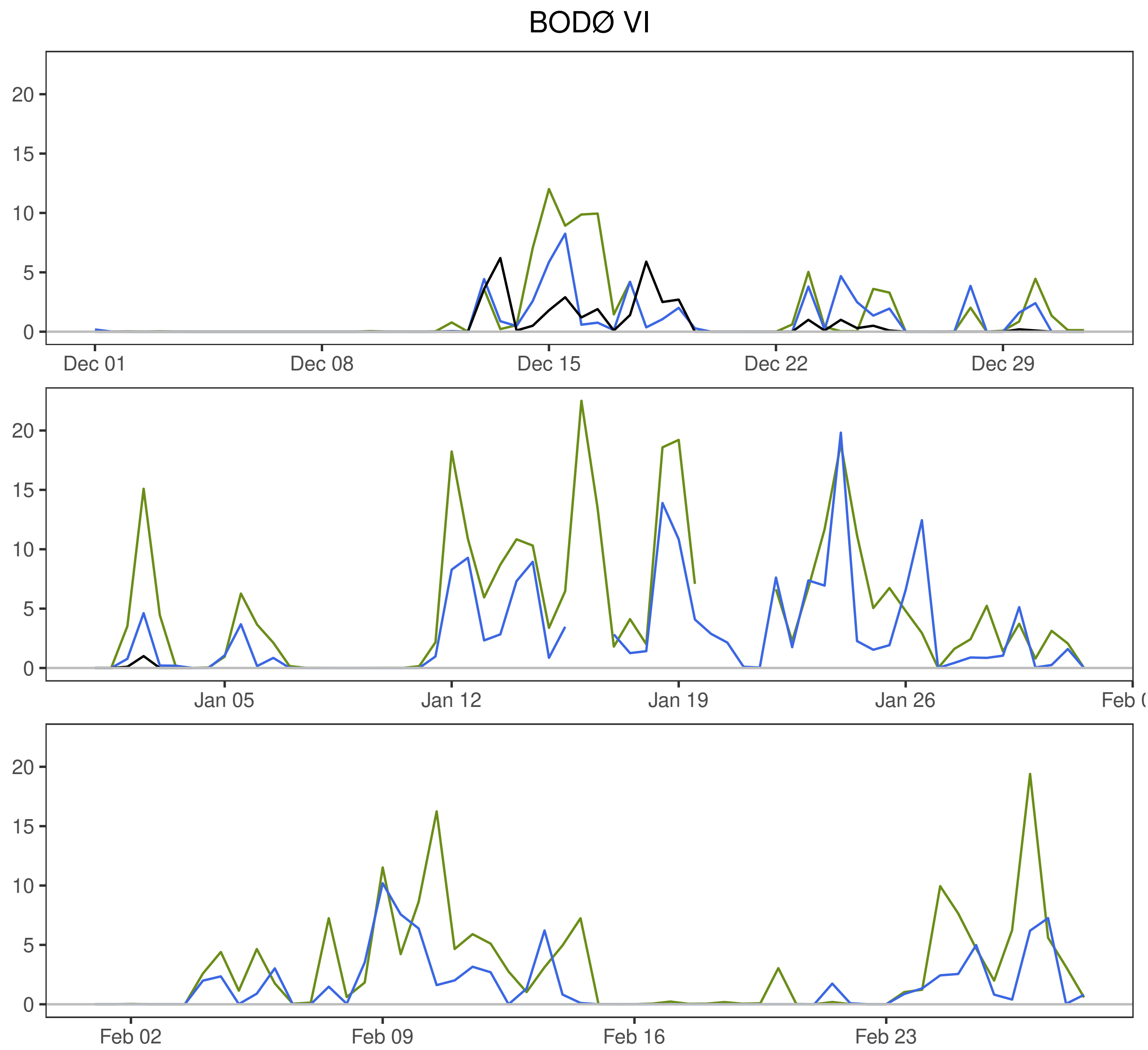
	Min	Mean	Max	Std	N
synop: 06,18	0.0	0.6	11.8	1.4	179
MEPSctrl: 12+18,+30	0.0	0.9	23.0	2.3	178
AA25: 12+18,+30	0.0	0.9	13.0	1.7	176
ECMWF: 12+18,+30	0.0	0.8	5.3	1.0	170

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl−synop	0.3	2.0	2.0	0.8	15.2	164
AA25−synop	0.4	1.5	1.5	0.7	7.2	164
ECMWF−synop	0.2	1.4	1.4	0.7	11.0	164



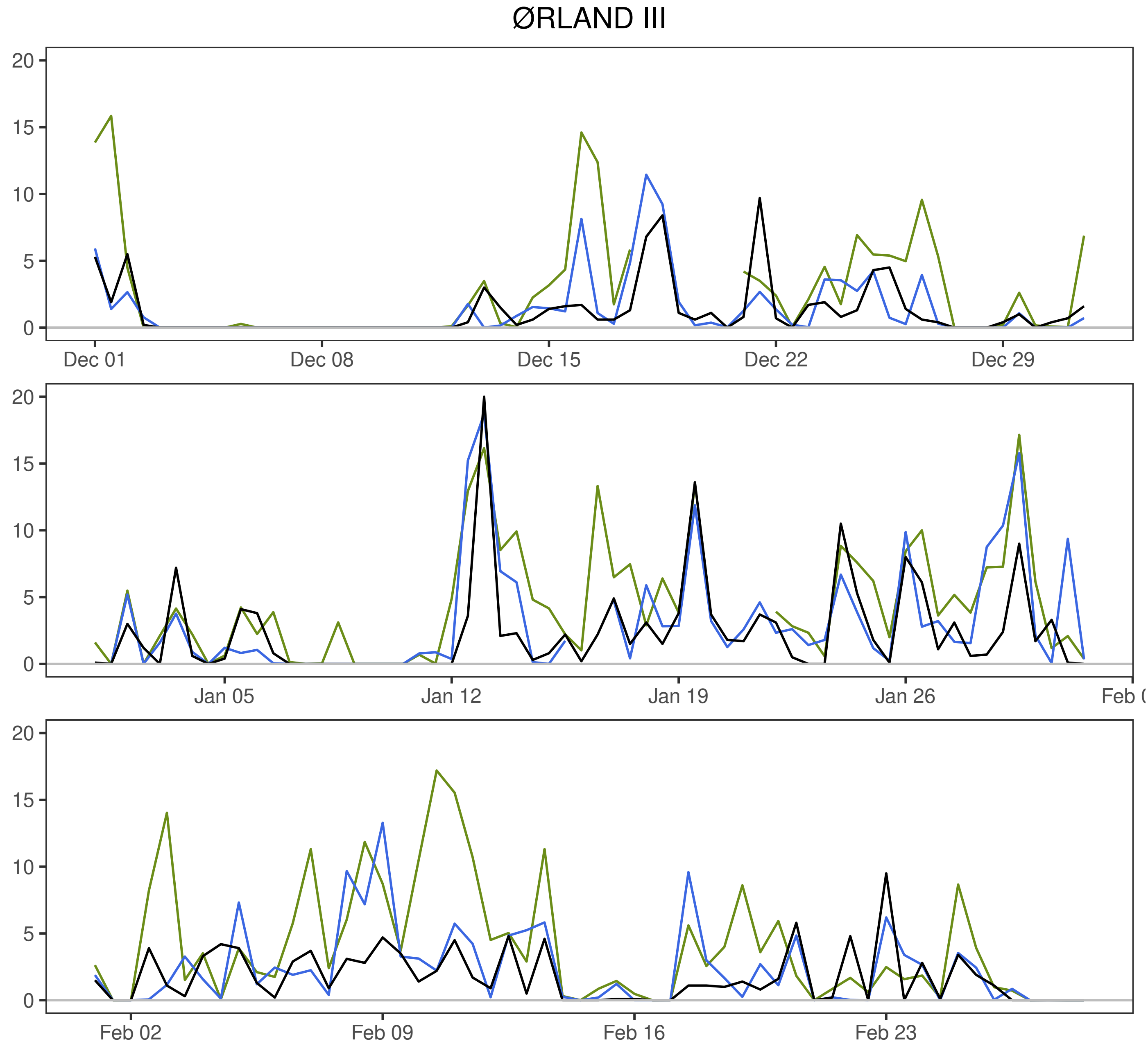
	Min	Mean	Max	Std	N
synop: 06,18	0.0	2.2	19.2	3.7	179
MEPSctrl: 12+18,+30	0.0	1.8	18.3	3.2	178
AA25: 12+18,+30	0.0	1.8	16.8	3.2	176
ECMWF: 12+18,+30	0.0	2.3	28.5	4.9	170

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl−synop	−0.1	1.8	1.8	0.9	7.6	163
AA25−synop	−0.2	1.8	1.8	1.0	7.9	163
ECMWF−synop	0.2	2.7	2.7	1.1	18.9	163



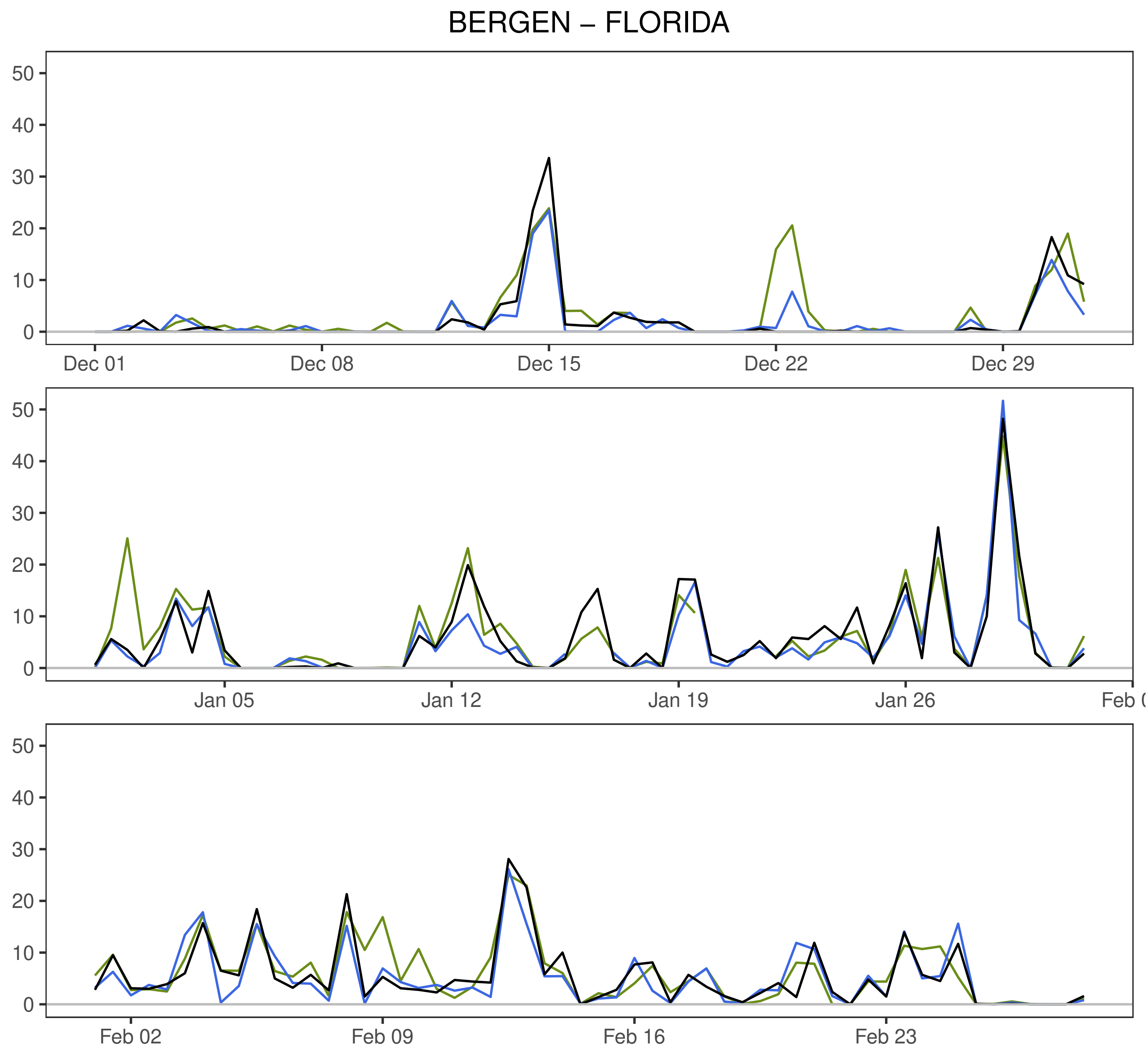
	Min	Mean	Max	Std	N
synop: 06,18	0.0	0.5	6.2	1.2	69
MEPSctrl: 12+18,+30	0.0	1.8	19.8	3.0	178
ECMWF: 12+18,+30	0.0	3.2	22.5	4.7	170

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl–synop	0.5	1.5	1.6	0.7	5.4	63
ECMWF–synop	1.3	3.0	3.2	1.5	14.1	63



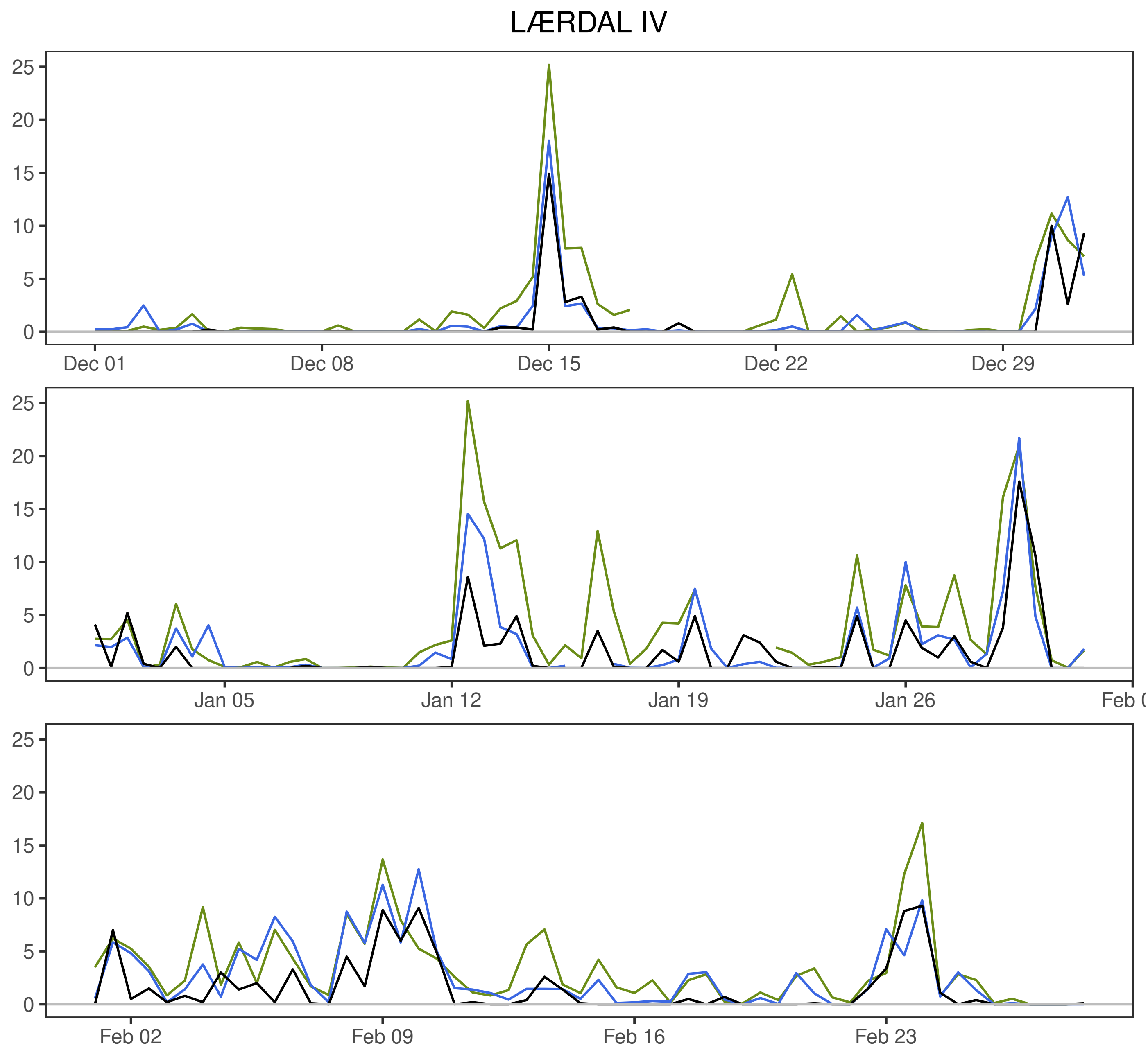
	Min	Mean	Max	Std	N
synop: 06,18	0.0	1.8	20.0	2.7	180
MEPSctrl: 12+18,+30	0.0	2.3	18.7	3.4	178
ECMWF: 12+18,+30	0.0	3.7	17.2	4.3	170

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl−synop	0.5	2.5	2.5	1.4	11.6	168
ECMWF−synop	1.9	3.5	4.0	2.4	15.0	168



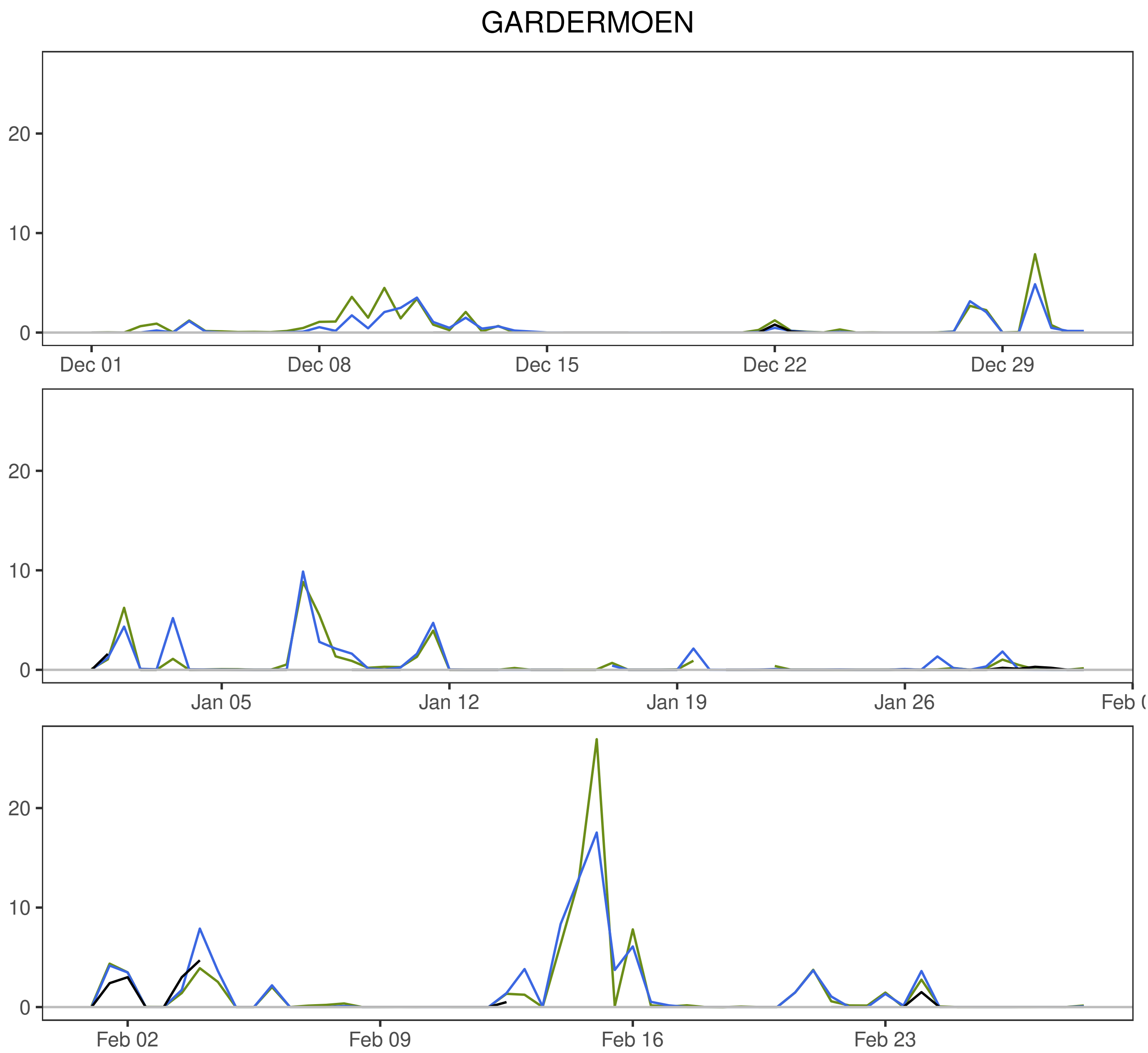
		Min	Mean	Max	Std	N
	synop: 06,18	0.0	4.5	48.2	7.0	180
	MEPSctrl: 12+18,+30	0.0	4.0	51.7	6.3	178
	ECMWF: 12+18,+30	0.0	5.3	44.8	6.9	170

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl–synop	–0.5	2.8	2.8	1.7	12.4	168
ECMWF–synop	0.7	3.9	3.9	2.2	21.6	168



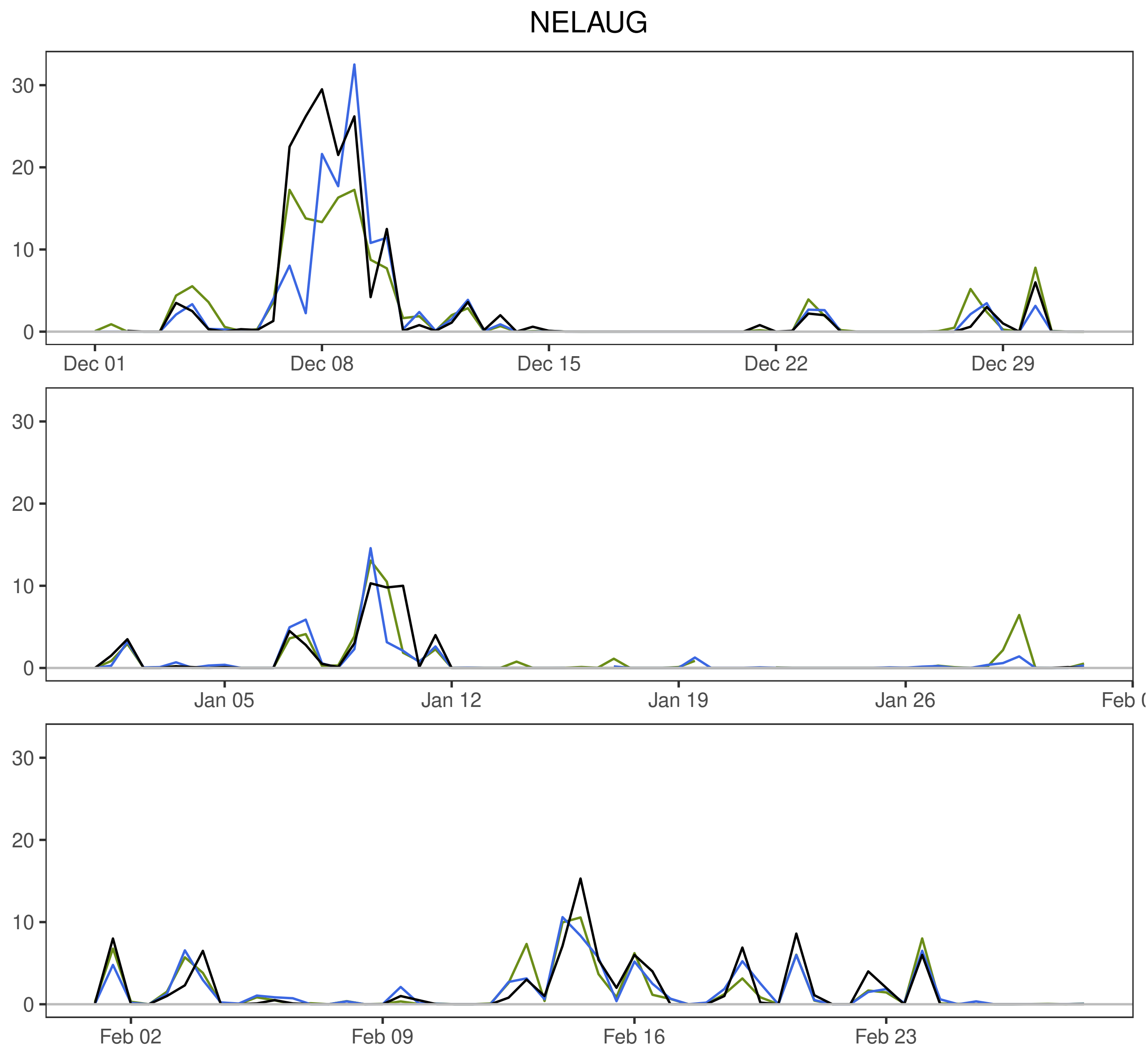
	Min	Mean	Max	Std	N
synop: 06,18	0.0	1.3	17.6	2.8	180
MEPSctrl: 12+18,+30	0.0	1.9	21.7	3.5	178
ECMWF: 12+18,+30	0.0	3.1	25.2	4.5	170

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl−synop	0.7	1.9	2.1	1.1	10.1	168
ECMWF−synop	1.8	2.8	3.3	1.9	16.6	168



	Min	Mean	Max	Std	N
synop: 06,18	0.0	0.1	4.7	0.6	143
MEPSctrl: 12+18,+30	0.0	0.9	17.5	2.2	178
ECMWF: 12+18,+30	0.0	1.0	26.9	2.7	170

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl–synop	0.1	0.5	0.5	0.2	3.2	133
ECMWF–synop	0.1	0.3	0.3	0.2	2.0	133



	Min	Mean	Max	Std	N
synop: 06,18	0.0	1.8	29.5	4.7	179
MEPSctrl: 12+18,+30	0.0	1.5	32.5	3.8	178
ECMWF: 12+18,+30	0.0	1.7	17.3	3.5	170

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl–synop	–0.3	2.7	2.7	1.0	24.0	167
ECMWF–synop	–0.2	2.3	2.3	1.0	16.2	167