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Verification of Operational Weather Prediction Models December 2024 to February 2025

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Kvaløya, Troms. Photo: Gunnar Noer

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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

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 prediction 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 prediction 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 Institute (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 ensemble runs. 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.

The MEPS 10 m wind speed forecast 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 hirlam.github.io/HarmonieSystemDocumentation/dev/, www.accord-nwp.org and www.cnrm.meteo.fr/gmapdoc/.

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. Mode-S EHS, AMSU-A and MHS from METOP-C satellite were introduced June 2020, METOP-C IASI (deactivation of METOP-A IASI), June 2021, radar radial wind observations and German radars, June 2022.

Boundary fields

MEPS gets its boundary values (1-hourly) from the ECMWF model at approximately 9 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 frost.met.no. 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 underestimates the temperature for all the different groups of stations, while MEPSctrl and AA25 slightly overestimates the temperature. Still, the errors are small, indicating that the timing of the temperature changes is generally good. The temperature forecast from MEPSctrl 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.

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

Wind speed is challenging to evaluate. MEPSctrl 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. AA25 performs about as well as ECMWF for the Svalbard stations, with AA25 having a tendency to overforecast the wind speed while ECMWF generally underetimates it. The threshold scores indicate that wind speed is better forecast for lower than for higher wind speeds for all models. The post-processing of wind speed shows a small effect in the mean error and mean absolute error, while the other scores show almost identical results for MEPSctrl and YrPP.

Precipitation also shows varying results, depending on the amount and location. On average ECMWF has more precipitation than MEPSctrl, but the difference is small. Both have more errors for both very small and very high amounts, than for precipitation in the mid range.

For temperature and wind, the monthly scores for the last three years show that the models generally perform better during summer months than during winter. A possible cause is that storm activity is challenging to predict accurately, and that there are often more storms with high wind speeds during fall and winter than during summer. Precipitation does not have clear seasonal patterns. Convective cases that are challenging to predict may occur with different frequency for different months and years. A challenge with verification of precipitation that occurs during winter is the undercatchment of observed snow. This is the case when there is strong wind in combination with snow, which is often the case especially in Northern Norway and in the mountainous areas in Southern Norway. It is suspected that the models are too dry in the coastal and fjord areas, but the undercatchment leads to cases where the observations give an impression that there is better fit in the models with regards to precipitation than what is actually the case. AA25 and MEPSctrl show very similar results, which is expected since both are HARMONIE models with AROME physics and a horizontal resolution defined by a 2.5×2.5 km^2 grid.

Case studies by forecasters

Case 1. Christmas snow

This case illustrates, as shown several times before, an instance of the NWP models not capturing precipitation sufficiently. In the morning hours of December 24th there was nothing in the models indicating a snowfall in Oslo and the surrounding areas. Despite this, the region received about 3 centimeters of snow in a few hours from around 08 UTC. Figure 1 shows a large area where the radar registered precipitation, while neither the MEPSctrl nor the ECMWF model predicted snow.

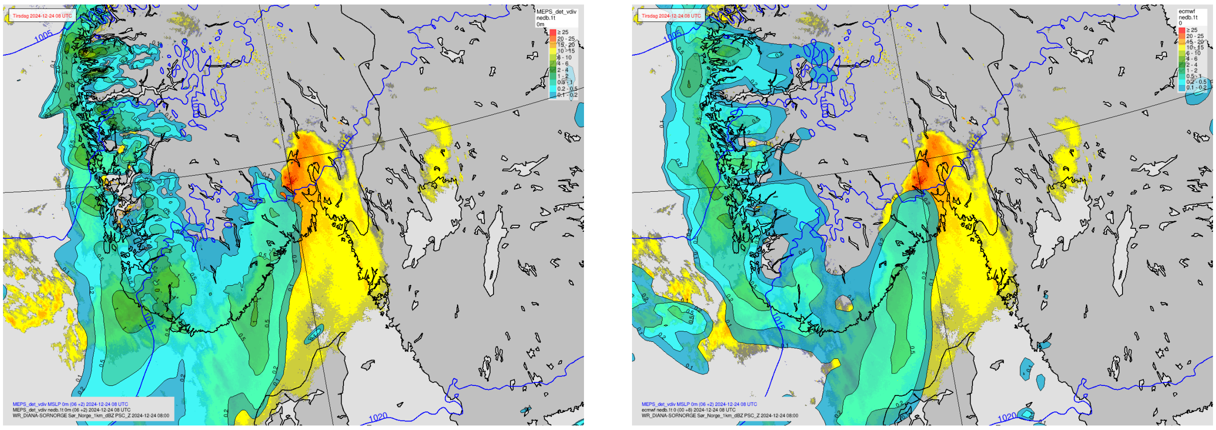


Figure 1: Radar image of precipitation (yellow and orange) together with 1-hour precipitation at 08 UTC on December 24th from MEPSctrl (left) and ECMWF (right) in blue/green.

It is well known that sometimes frontal systems approaching from the west partly or completely dry out when moving over the mountains in southern Norway before reactivating on the other side. This seems to be the case in this scenario. NWP models often struggle with the timing and location of this reactivating process, which in turn can cause large discrepancies between observed and forecasted precipitation. As a forecaster it is important to be aware of the potential impact of reactivating fronts in this region, although it can be difficult to give precise forecasts when the models are inaccurate.

Especially in aviation forecasting an unannounced snowfall like this could have a large impact. From METAR observations at Oslo University Hospital - Ullevål at the time of the snowfall it was reported that at one point the visibility was as low as 600 meters and the cloud base was at 200 ft. This did not coincide with the issued TAF (Terminal Aerodrome Forecast) valid at that time, as it had not taken into account the sudden snowfall. The consequences of underforecasting of snowfall events like this could in a worst-case scenario be quite large and costly.

Case 2. Unusual lightning case

On the evening of January 6th more than 120 lightning strikes were registered on the coast of south-western Norway in just a few hours (figure 2). Winter lightning in itself is not an unusual event, however, this case was special in that the lightning did not result from the traditional convective airmasses approaching from the sea in the west, but rather moving over land from southeast.

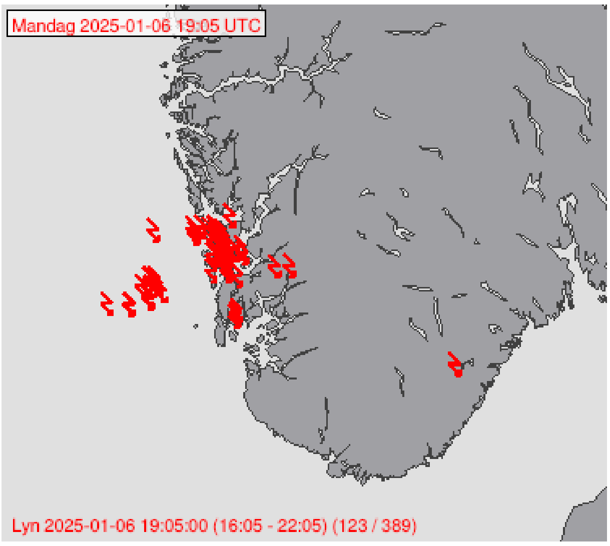


Figure 2: Registered lightning strikes in south-western Norway on the evening of January 6th between 16:05 and 22:05 UTC. Each red lightning bolt symbol indicates the location of a lightning strike.

A very deep low pressure system (close to 950 hPa) located in the North Sea (figure 3) caused strong winds and vertical wind shear over much of Rogaland and Hordaland, providing favorable conditions for lightning activity. However, this was not well captured by the models.

The traditional indexes used by the forecasters at MET Norway to identify areas with potential for strong convective activity (K-index, Showalter index, Sweat index, Total totals and the SMHI lightning index) did not give clear indications for the case on January 6th, although the SMHI lightning index gave some vague indications (figure 4). In cases like these, the role of the forecaster becomes even more important than usual, and the use of radar and satellite imagery becomes crucial in monitoring the location of convective areas as the situation develops.

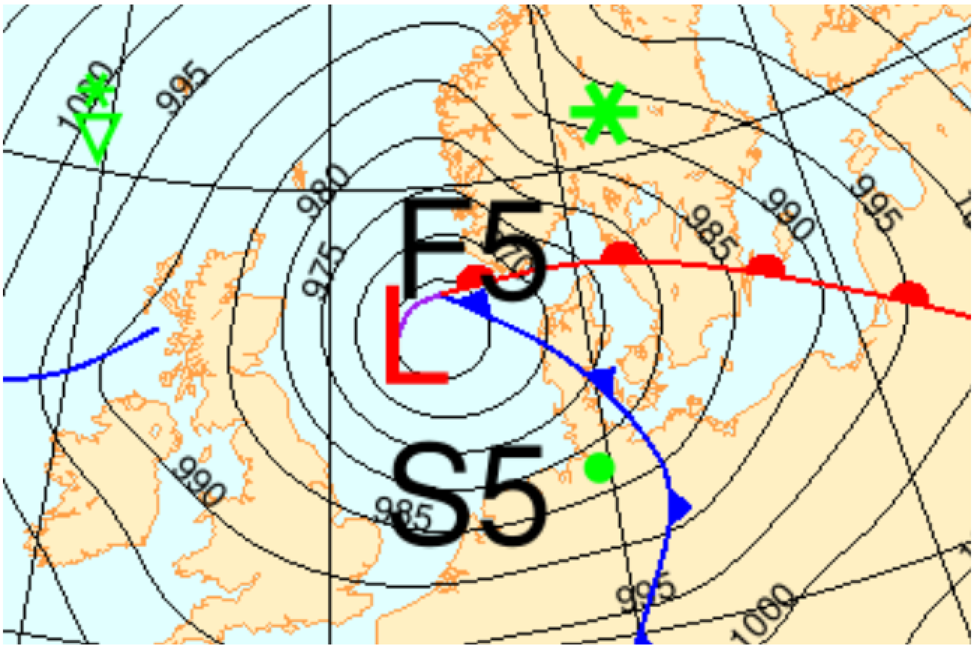


Figure 3: The low pressure system in the North Sea and connected frontal systems, taken from the official analysis from MET Norway at 18 UTC January 6th 2025.

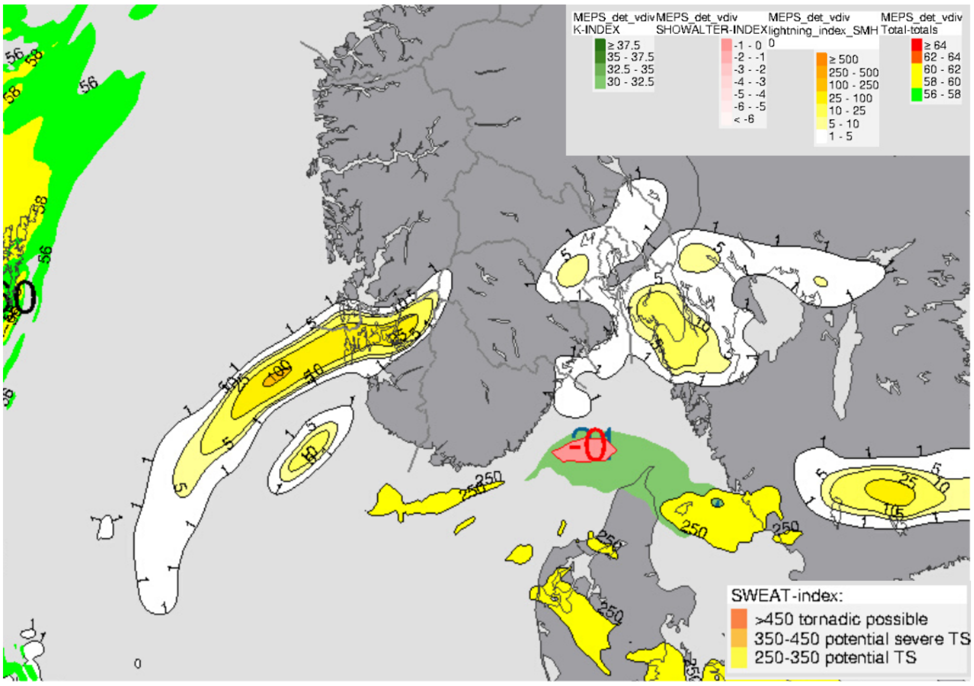


Figure 4: Indexes used at MET Norway to monitor convective activity: K-index, Showalter index, Sweat index, Total totals and the SMHI lightning index. Pictured is data from 18 UTC (06 UTC+12) from MEPSctrl on January 6th.

Case 3. Synoptic uncertainty

Generally, the precision in the MEPSctrl and AA25 models for MSLP is seen as quite good, although slightly behind the ECMWF model in skill scores (pages 18 and 19). Mesoscale features such as polar lows are usually forecasted well on 18 to 24 hours lead time with a positional error of less than 50 km for the low pressure center. For longer lead times, however, the quality is poorer, and this winter there have been an unusually high number of reports concerning uncertainty in the MSLP.

One such event occurred on the 20th of January. The 12 UTC runs from both MEPSctrl and AA25 on the 17th of January indicated a severe polar low on the Finnmark coast, and as conditions were favorable for a development, this was acted upon with a weather alert for a polar low hitting the coast of Northern Norway at the evening of the 20th. However, subsequent runs rapidly changed the position of the low (figure 5), to such an extent that it did have little impact on the area, and the warning had to be canceled.

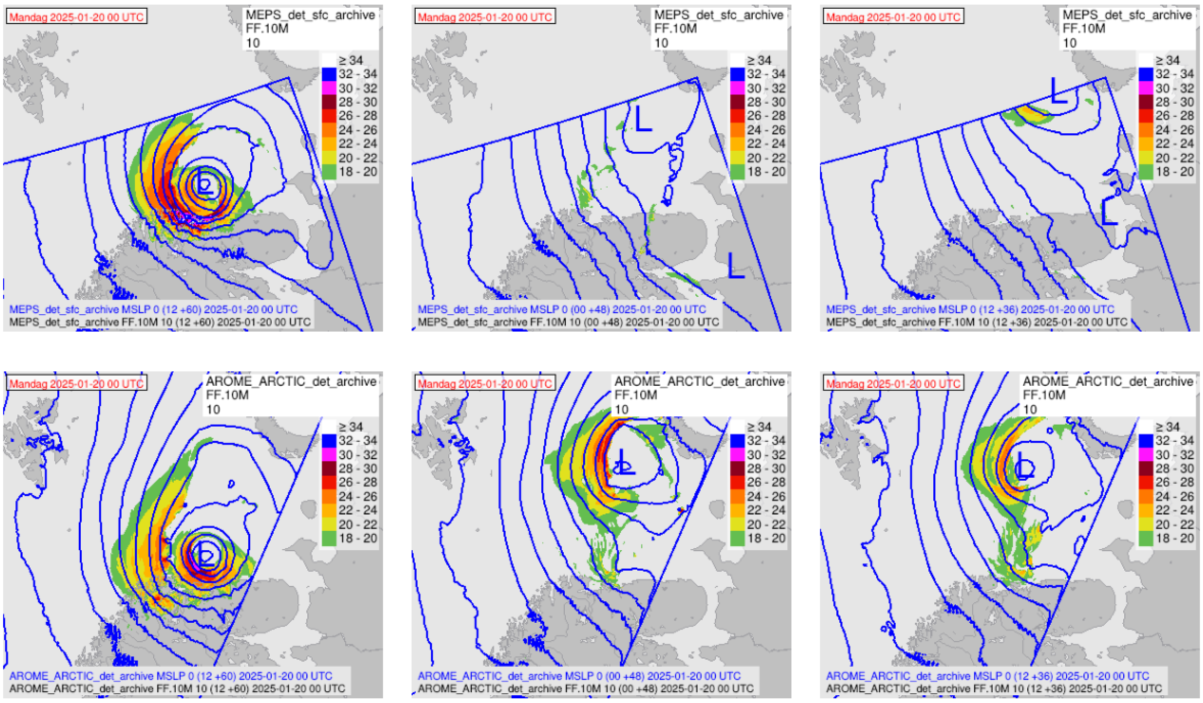


Figure 5: The forecast for 00 UTC on the 20th of January from MEPSctrl (top row) and AA25 (bottom row) with 60hrs (left), 48 hrs (middle) and 36 hrs (right) lead times. The MSLP is shown in blue lines, colored shading indicates 10 m wind speed in m/s.

Other events this season were reported with a positional error of 130 to 180 km at 18 hours lead time, which is more than usual for these types of weather events.

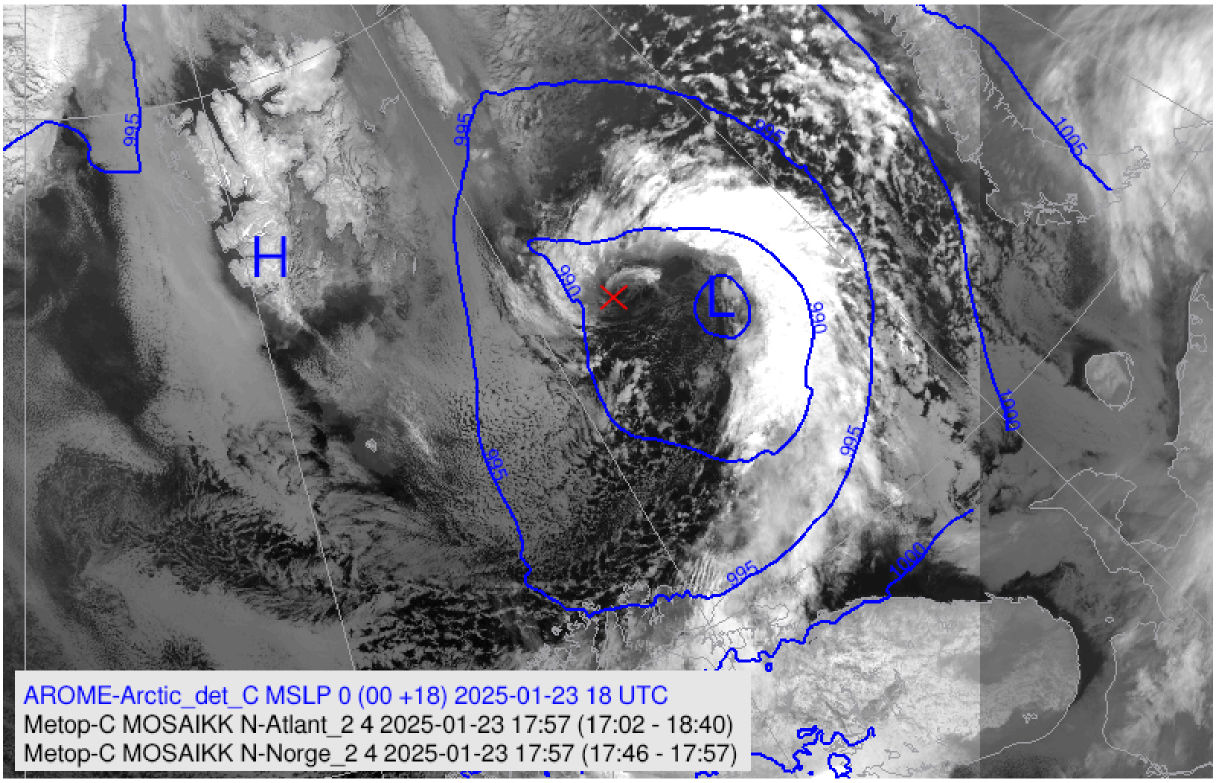
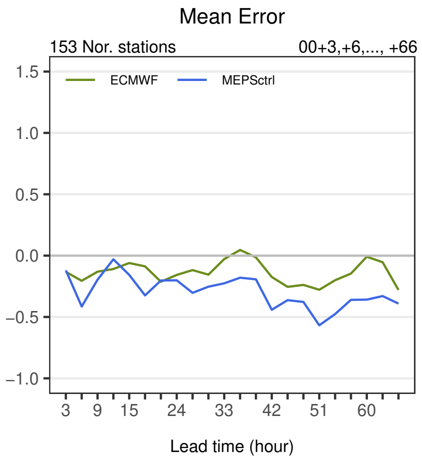
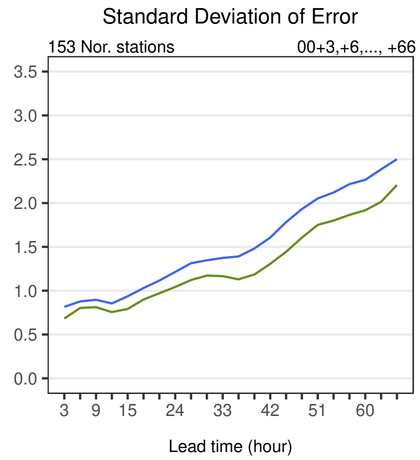


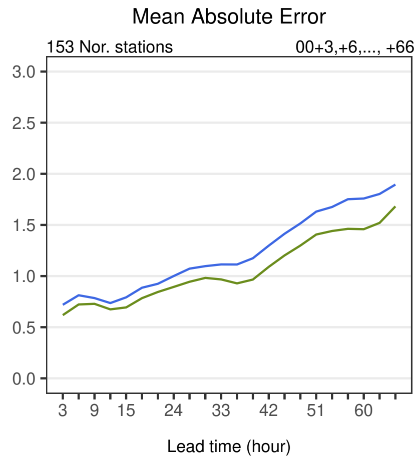
Figure 6: A satellite image showing a low pressure system in the central Barents sea, with the center indicated with a red cross. The prognosis for MSLP (blue lines) from the control run of the AROME-Arctic with 18hrs lead time had in this case a positional error of about 177 km.

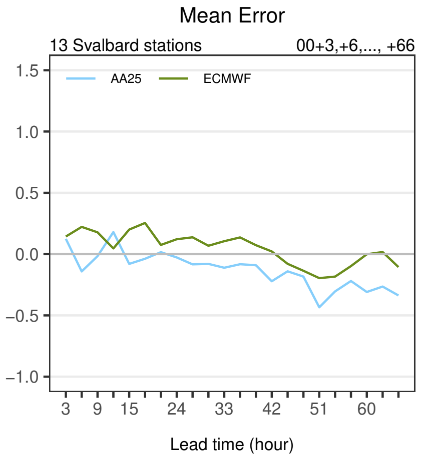
While it is not uncommon with a spread of 100-200 km in the position of the center of mesoscale lows within the ensemble of e.g. the MEPS model runs, usually the positional error in the control run of such systems are in the order of 50-100 km at 18 hours lead time.

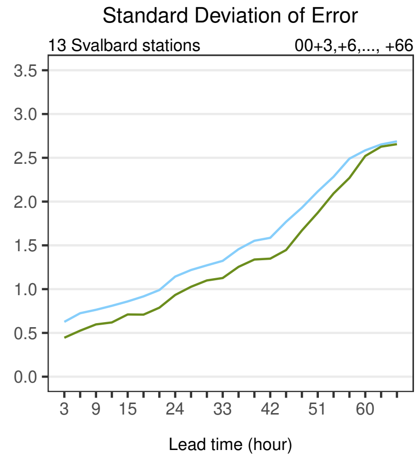
Summarized statistics

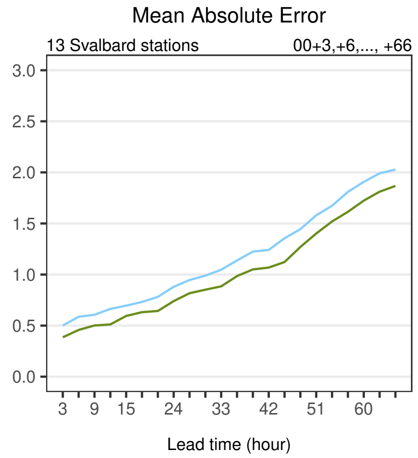

Mean Error
153 Nor. stations
00+3,+6,..., +66
ECMWF
MEPSctrl
Lead time (hour)


Standard Deviation of Error
153 Nor. stations
00+3,+6,..., +66
Lead time (hour)


Mean Absolute Error
153 Nor. stations
00+3,+6,..., +66
Lead time (hour)


Mean Error
13 Svalbard stations
00+3,+6,..., +66
AA25
ECMWF
Lead time (hour)


Standard Deviation of Error
13 Svalbard stations
00+3,+6,..., +66
Lead time (hour)


Mean Absolute Error
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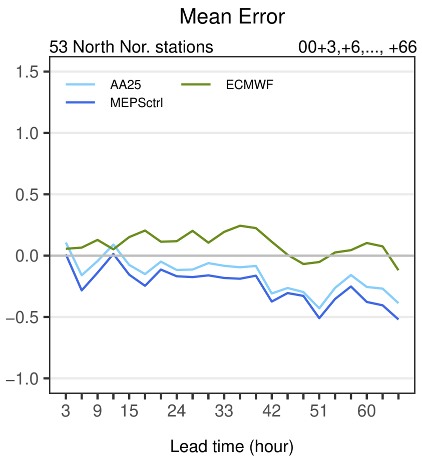
Lead time (hour)


Mean Error
53 North Nor. stations
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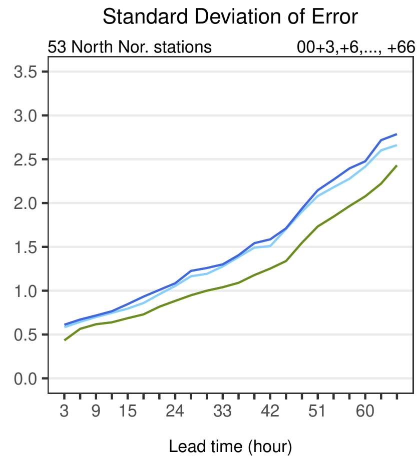
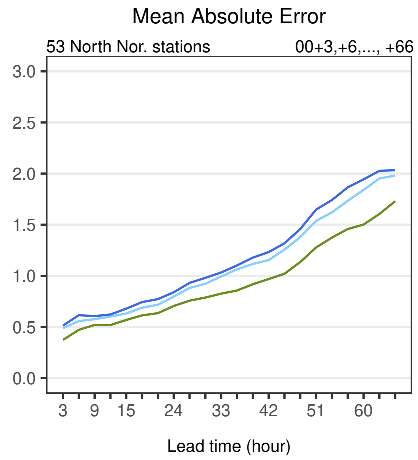
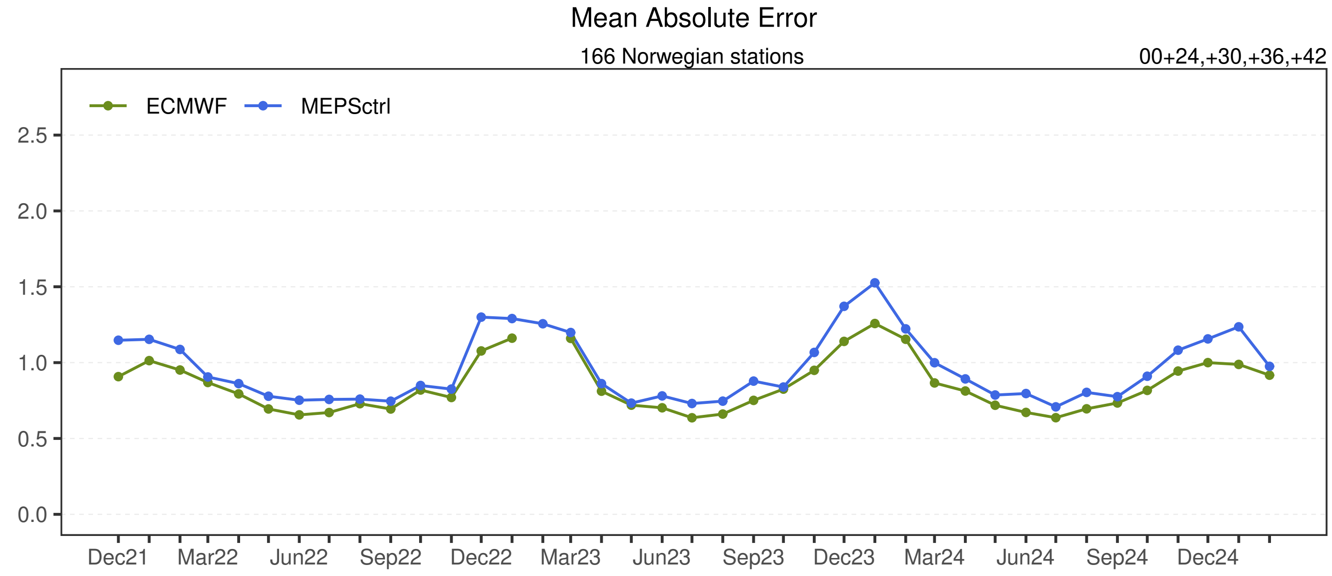
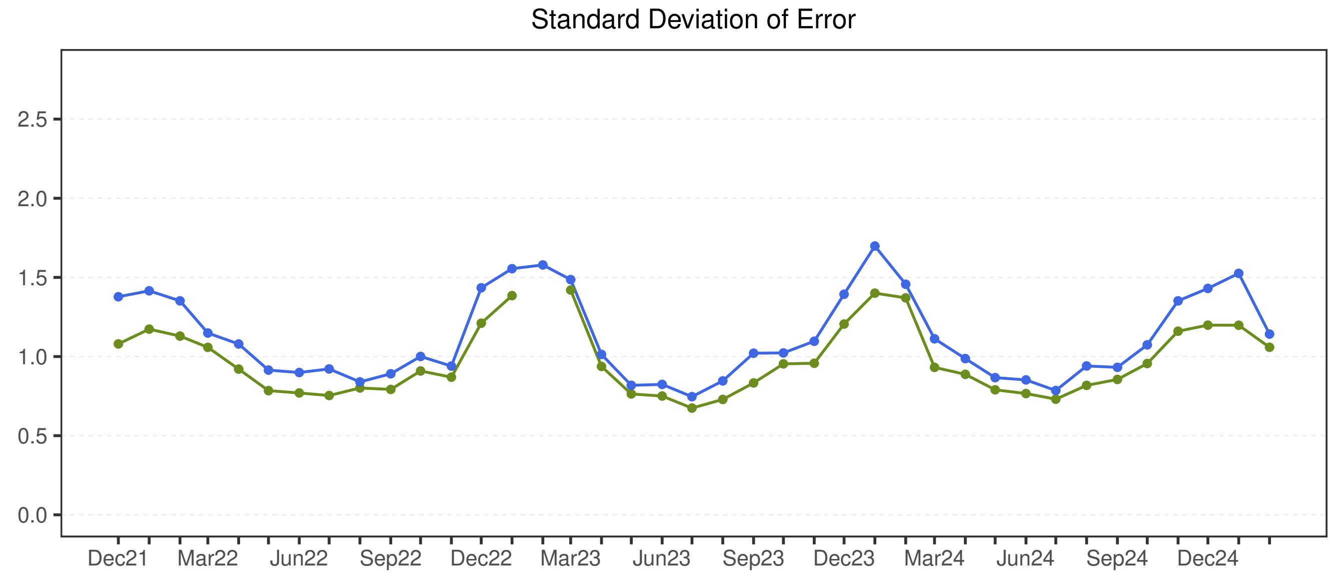
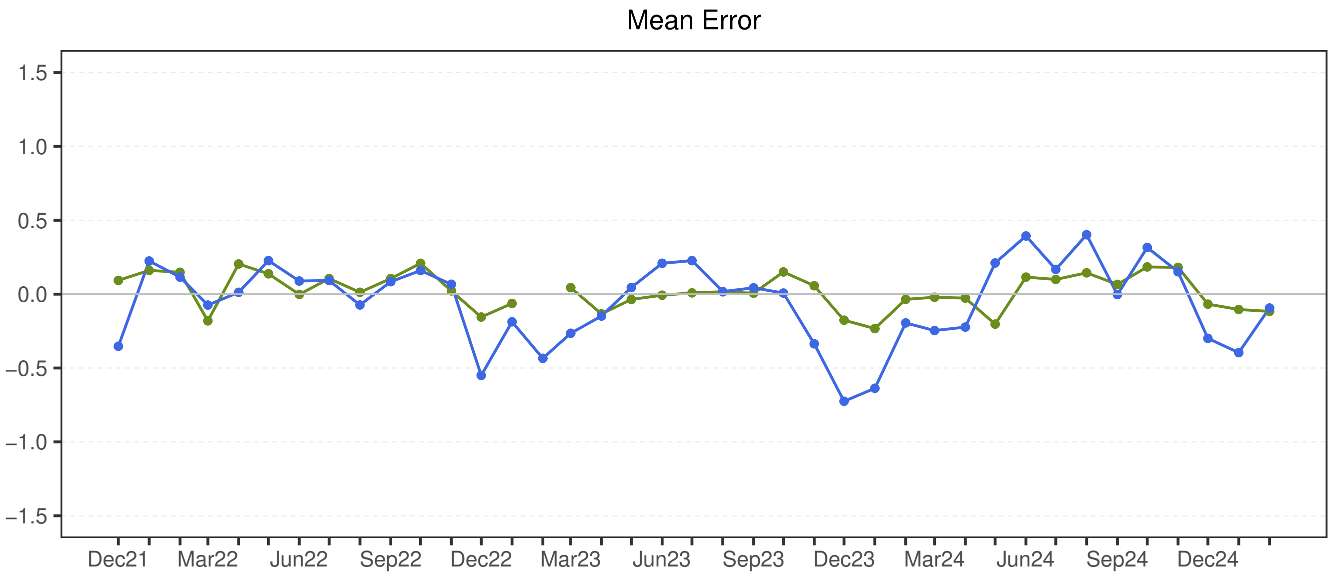
AA25
ECMWF
MEPSctrl
Lead time (hour)


Standard Deviation of Error
53 North Nor. stations
00+3,+6,..., +66
Lead time (hour)


Mean Absolute Error
53 North Nor. stations
00+3,+6,..., +66
Lead time (hour)


Mean Absolute Error
166 Norwegian stations
00+24,+30,+36,+42
ECMWF
MEPSctrl
2.5
2.0
1.5
1.0
0.5
0.0
Dec21
Mar22
Jun22
Sep22
Dec22
Mar23
Jun23
Sep23
Dec23
Mar24
Jun24
Sep24
Dec24


Standard Deviation of Error
2.5
2.0
1.5
1.0
0.5
0.0
Dec21
Mar22
Jun22
Sep22
Dec22
Mar23
Jun23
Sep23
Dec23
Mar24
Jun24
Sep24
Dec24


Mean Error
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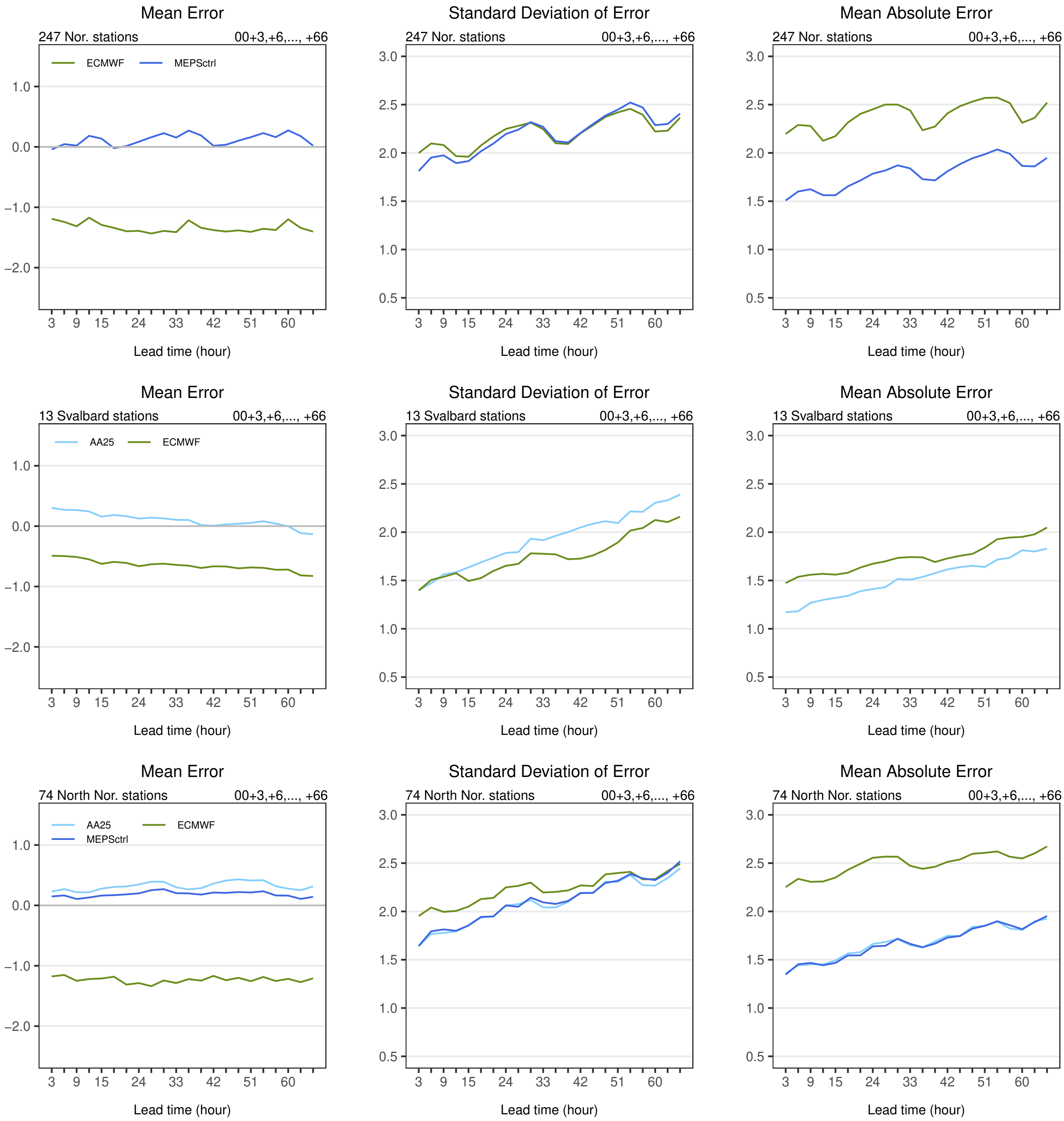
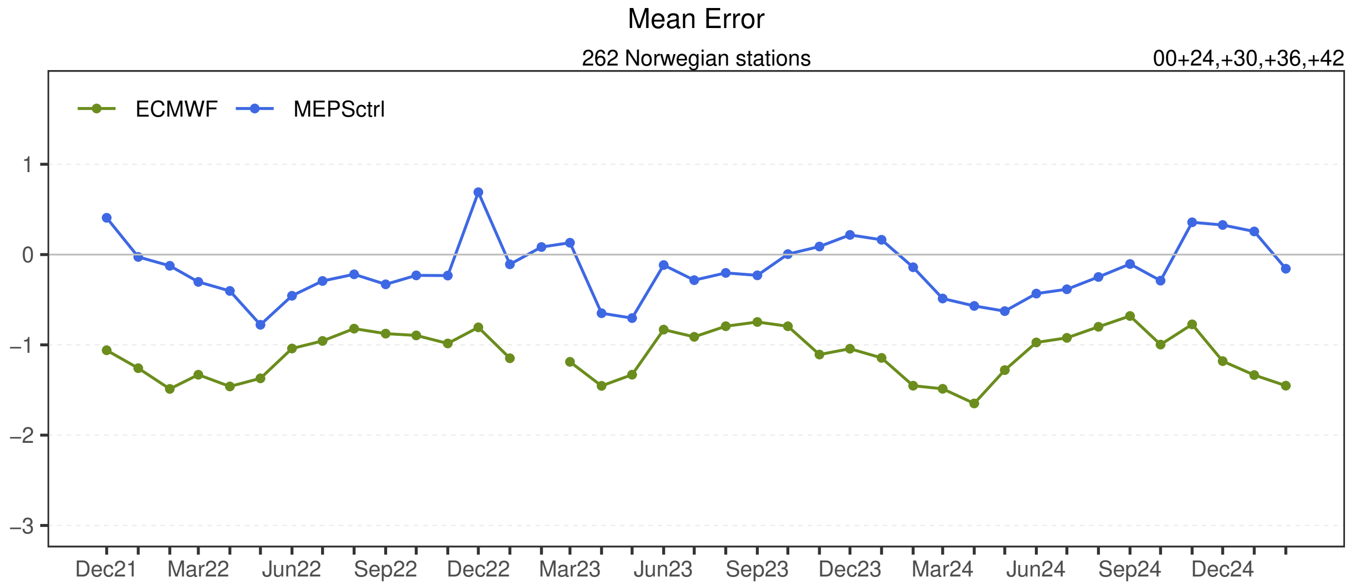
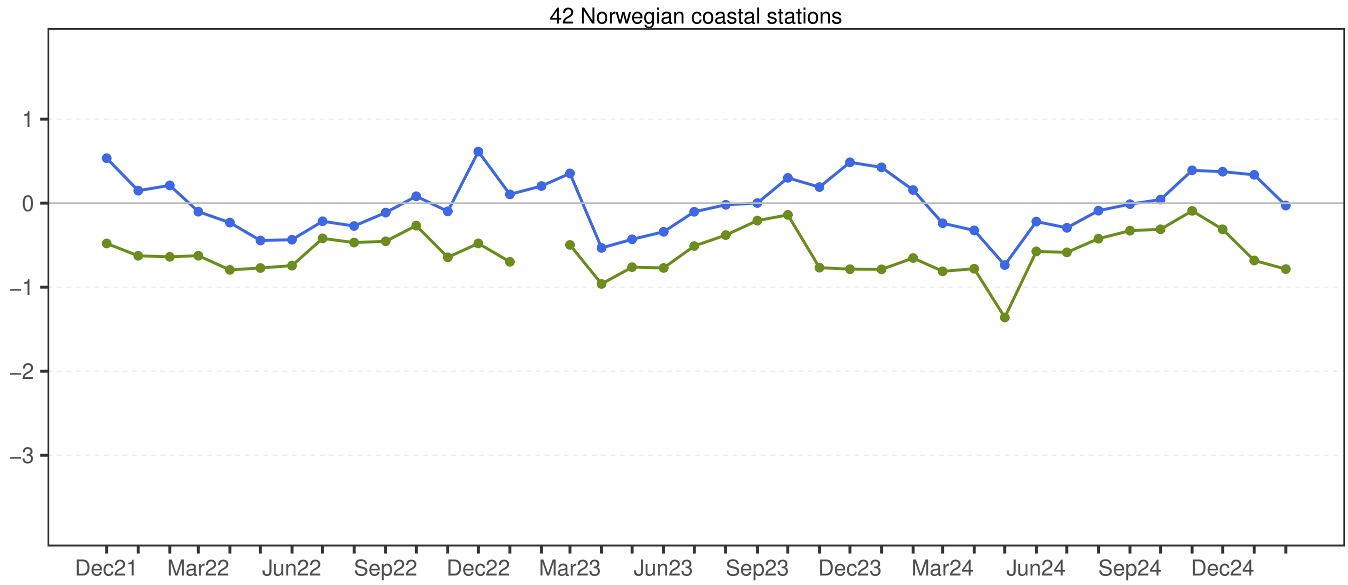
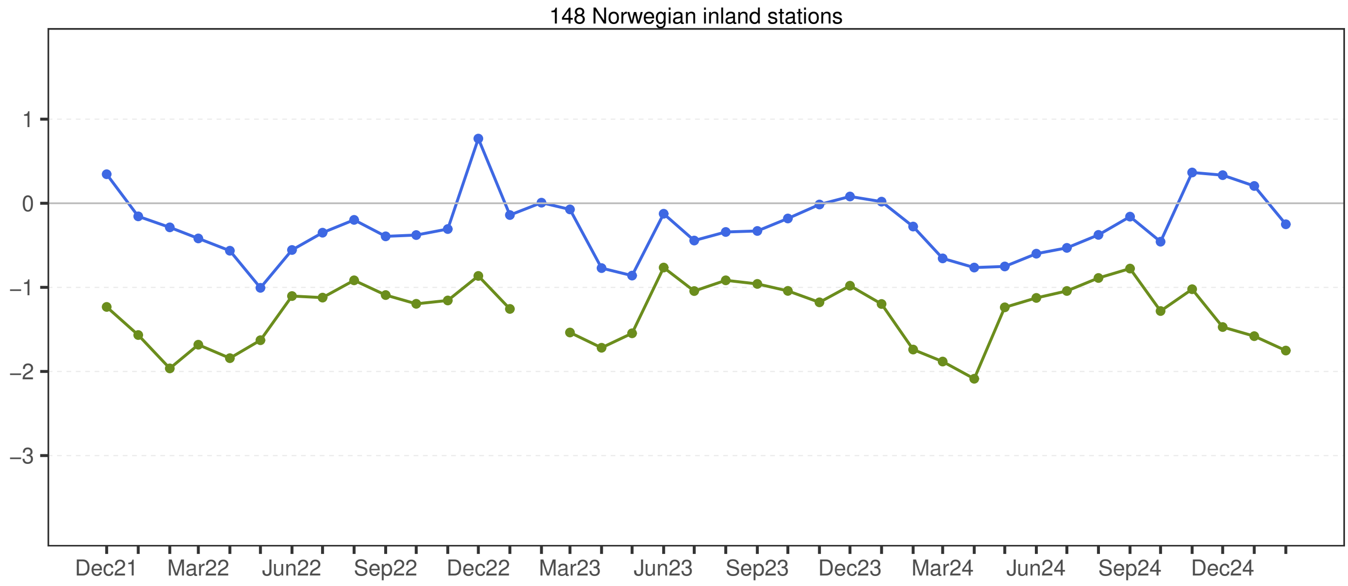
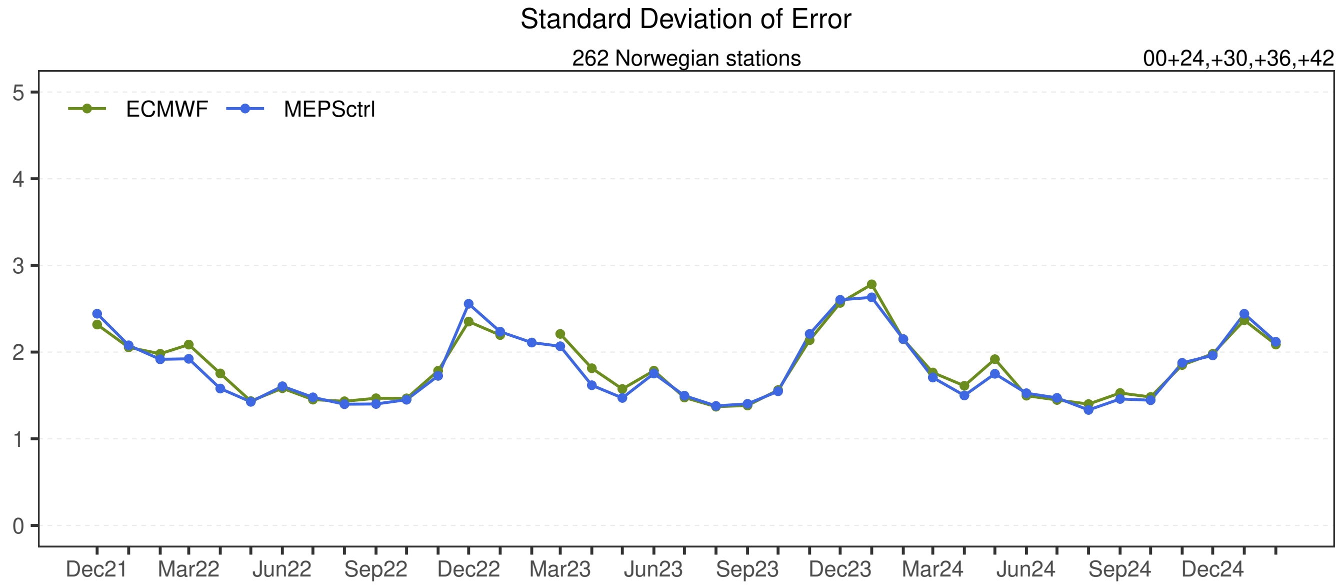
1.0
0.5
0.0
−0.5
−1.0
−1.5
Dec21
Mar22
Jun22
Sep22
Dec22
Mar23
Jun23
Sep23
Dec23
Mar24
Jun24
Sep24
Dec24

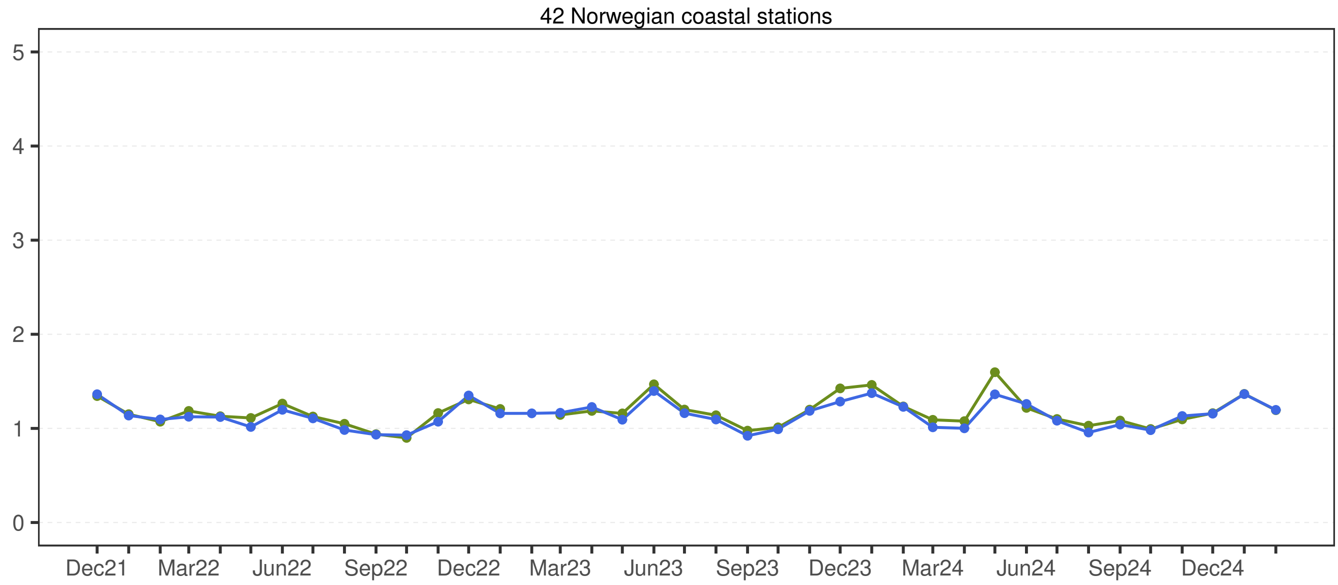

Mean Error
247 Nor. stations
00+3,+6,..., +66
ECMWF
MEPSctrl
1.0
0.0
−1.0
−2.0
3 9 15 24 33 42 51 60
Lead time (hour)
Standard Deviation of Error
247 Nor. stations
00+3,+6,..., +66
3.0
2.5
2.0
1.5
1.0
0.5
3 9 15 24 33 42 51 60
Lead time (hour)
Mean Absolute Error
247 Nor. stations
00+3,+6,..., +66
3.0
2.5
2.0
1.5
1.0
0.5
3 9 15 24 33 42 51 60
Lead time (hour)
Mean Error
13 Svalbard stations
00+3,+6,..., +66
AA25
ECMWF
1.0
0.0
−1.0
−2.0
3 9 15 24 33 42 51 60
Lead time (hour)
Standard Deviation of Error
13 Svalbard stations
00+3,+6,..., +66
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
13 Svalbard stations
00+3,+6,..., +66
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
74 North Nor. stations
00+3,+6,..., +66
AA25
ECMWF
MEPSctrl
1.0
0.0
−1.0
−2.0
3 9 15 24 33 42 51 60
Lead time (hour)
Standard Deviation of Error
74 North Nor. stations
00+3,+6,..., +66
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
74 North Nor. stations
00+3,+6,..., +66
3.0
2.5
2.0
1.5
1.0
0.5
3 9 15 24 33 42 51 60
Lead time (hour)

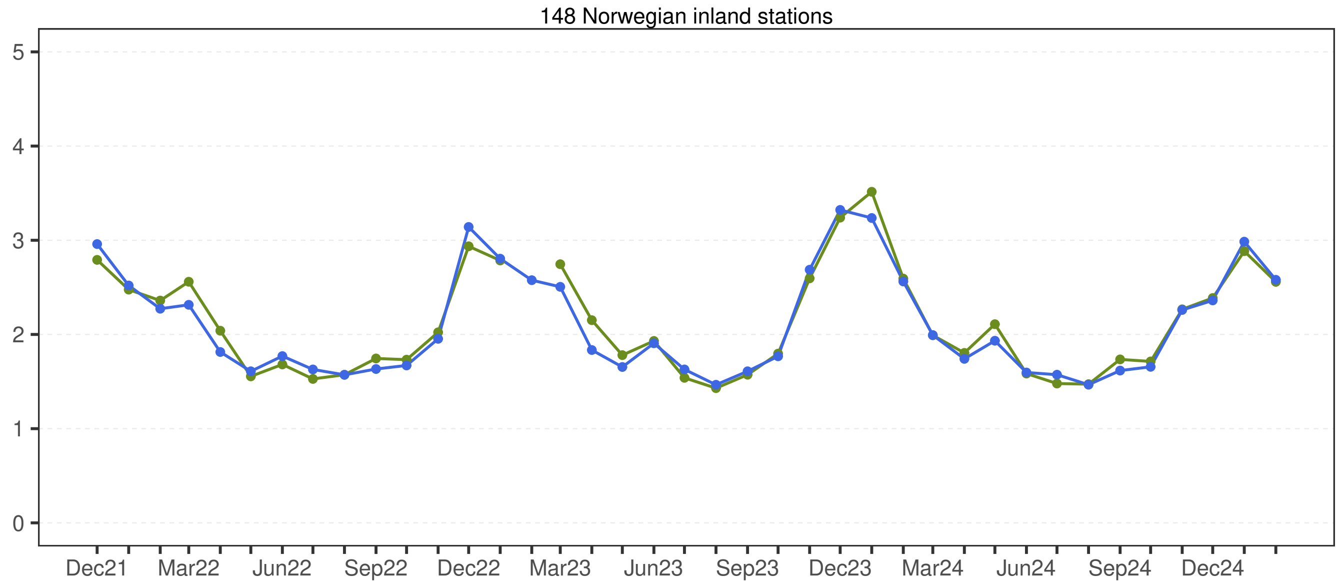

Mean Error
262 Norwegian stations
00+24,+30,+36,+42
ECMWF
MEPSctrl
1
0
−1
−2
−3
Dec21
Mar22
Jun22
Sep22
Dec22
Mar23
Jun23
Sep23
Dec23
Mar24
Jun24
Sep24
Dec24

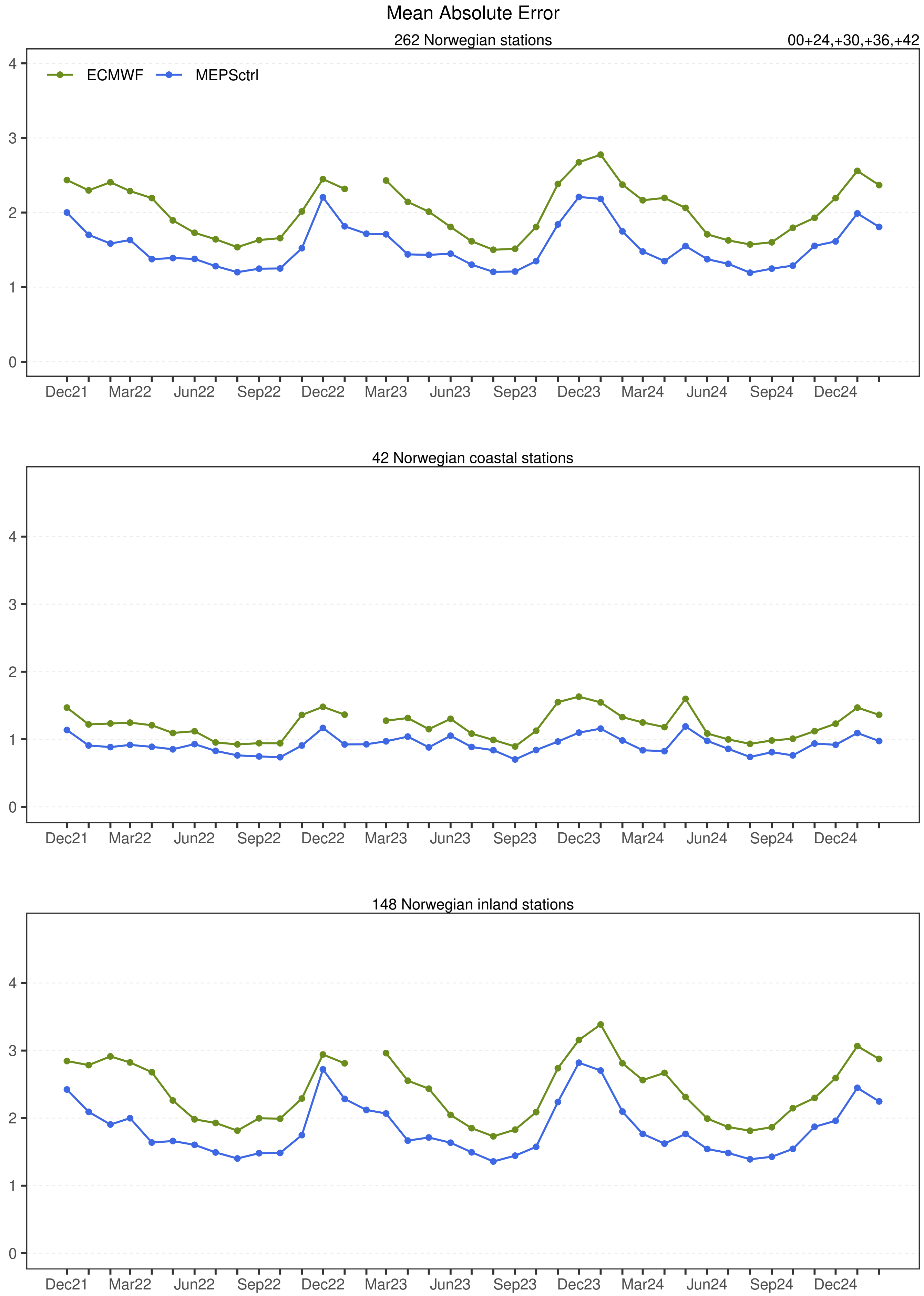

42 Norwegian coastal stations
1
0
−1
−2
−3
Dec21
Mar22
Jun22
Sep22
Dec22
Mar23
Jun23
Sep23
Dec23
Mar24
Jun24
Sep24
Dec24


148 Norwegian inland stations
1
0
−1
−2
−3
Dec21
Mar22
Jun22
Sep22
Dec22
Mar23
Jun23
Sep23
Dec23
Mar24
Jun24
Sep24
Dec24


Standard Deviation of Error
262 Norwegian stations
00+24,+30,+36,+42
ECMWF
MEPSctrl
0
1
2
3
4
5
Dec21
Mar22
Jun22
Sep22
Dec22
Mar23
Jun23
Sep23
Dec23
Mar24
Jun24
Sep24
Dec24


42 Norwegian coastal stations
0
1
2
3
4
5
Dec21
Mar22
Jun22
Sep22
Dec22
Mar23
Jun23
Sep23
Dec23
Mar24
Jun24
Sep24
Dec24

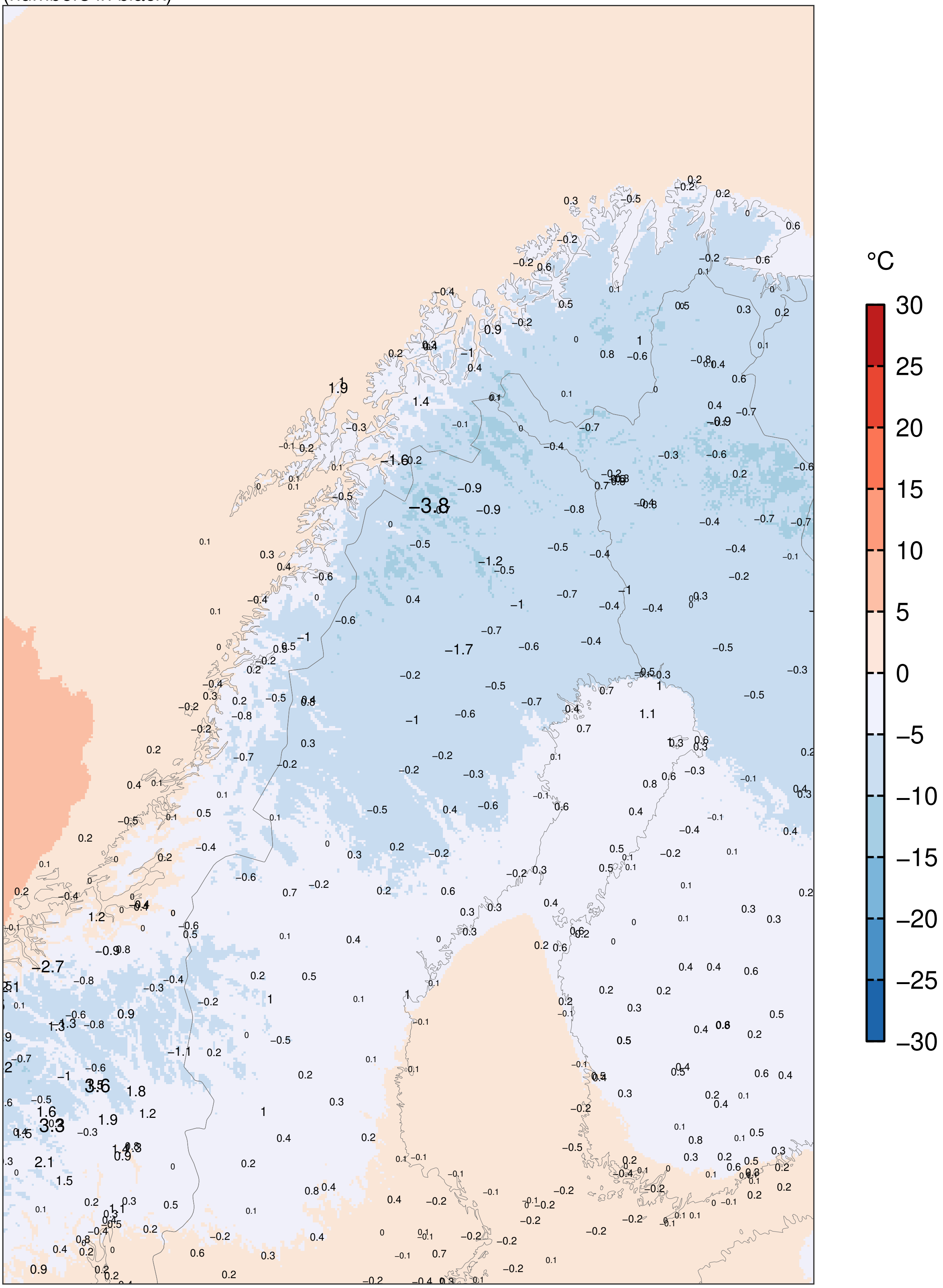

148 Norwegian inland stations
0
1
2
3
4
5
Dec21
Mar22
Jun22
Sep22
Dec22
Mar23
Jun23
Sep23
Dec23
Mar24
Jun24
Sep24
Dec24



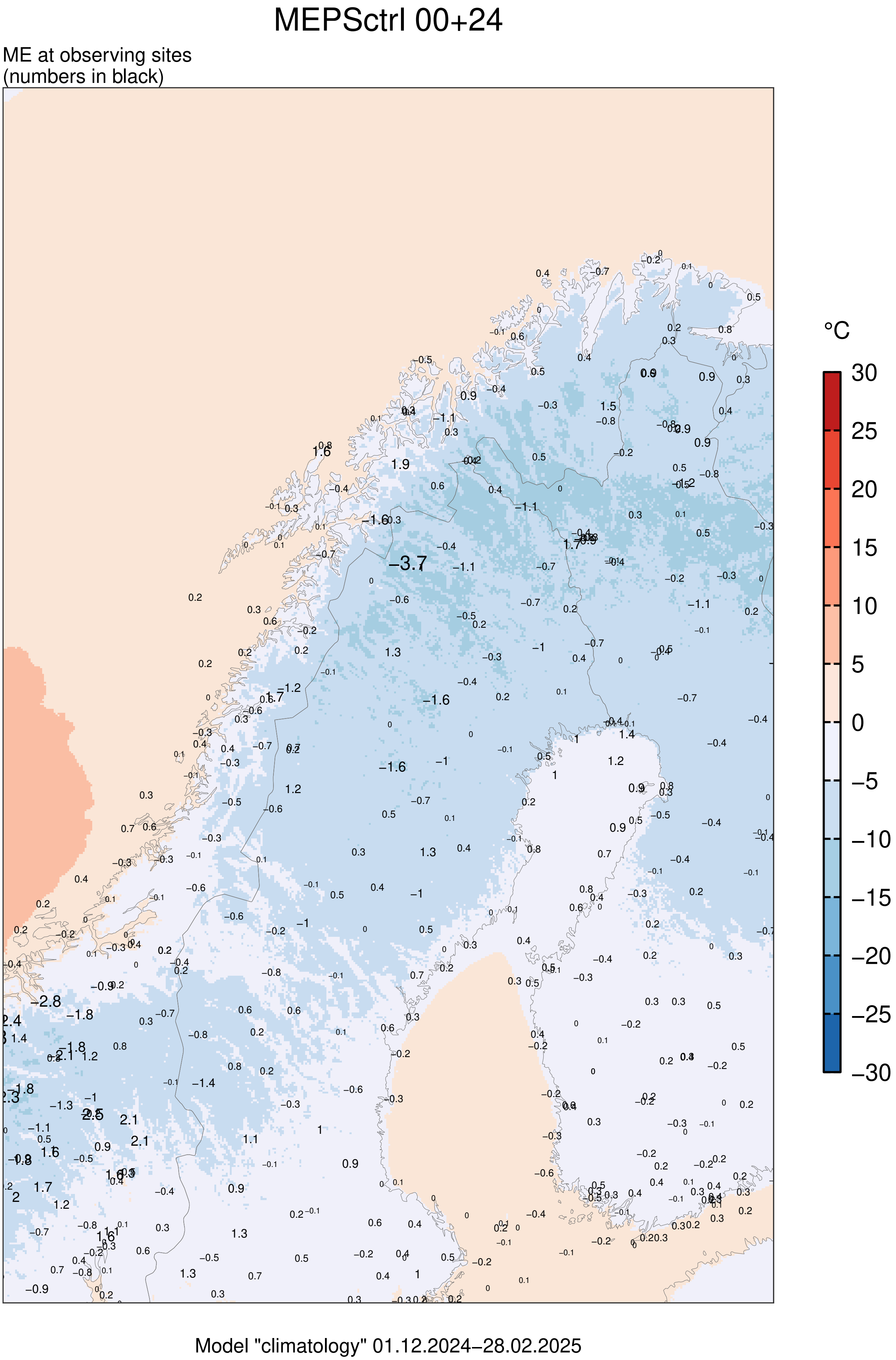
Mean Absolute Error
262 Norwegian stations
00+24,+30,+36,+42
ECMWF
MEPSctrl
42 Norwegian coastal stations
148 Norwegian inland stations
Dec21
Mar22
Jun22
Sep22
Dec22
Mar23
Jun23
Sep23
Dec23
Mar24
Jun24
Sep24
Dec24

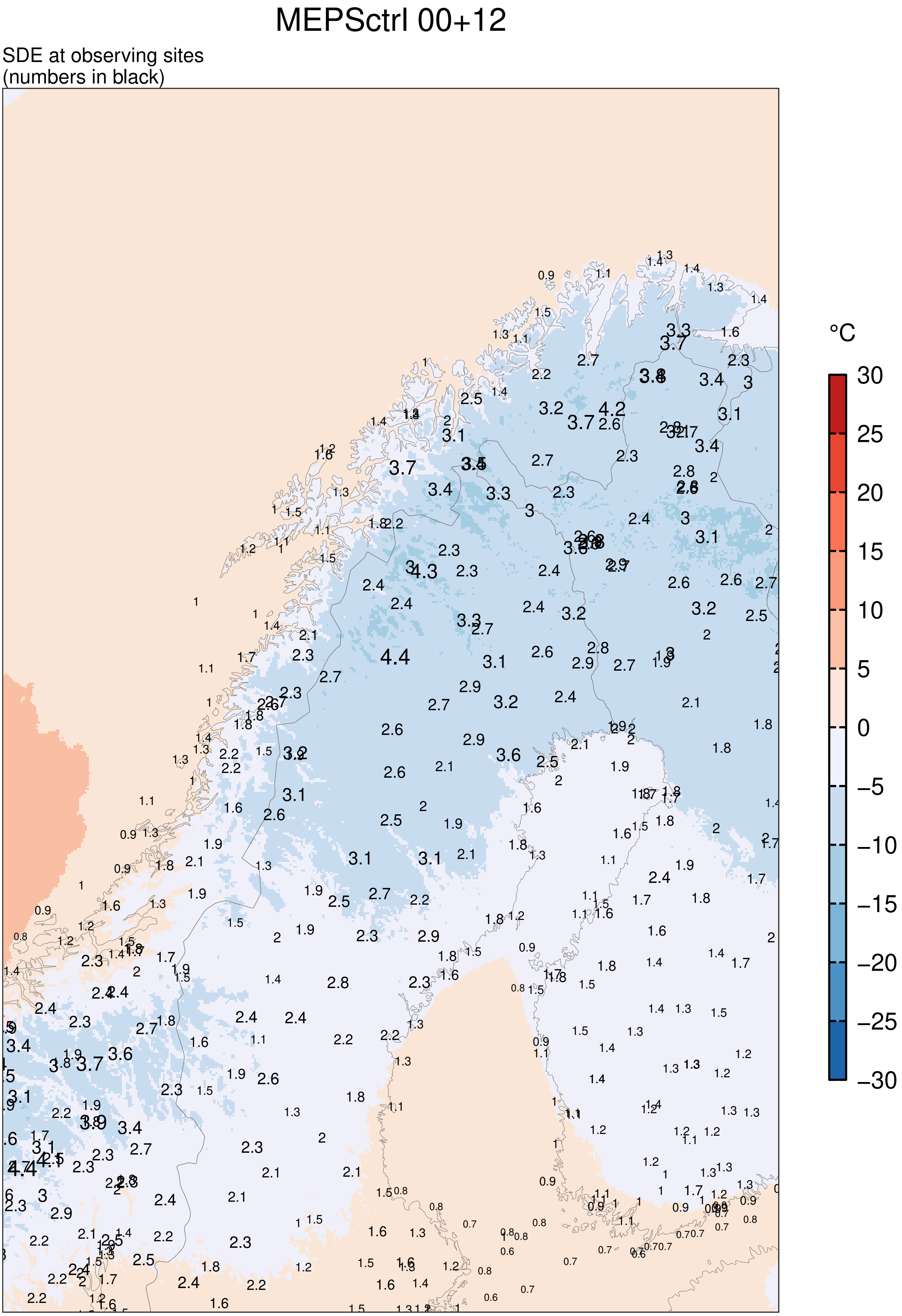
MEPSctrl 00+12

ME at observing sites
(numbers in black)



Model "climatology" 01.12.2024–28.02.2025

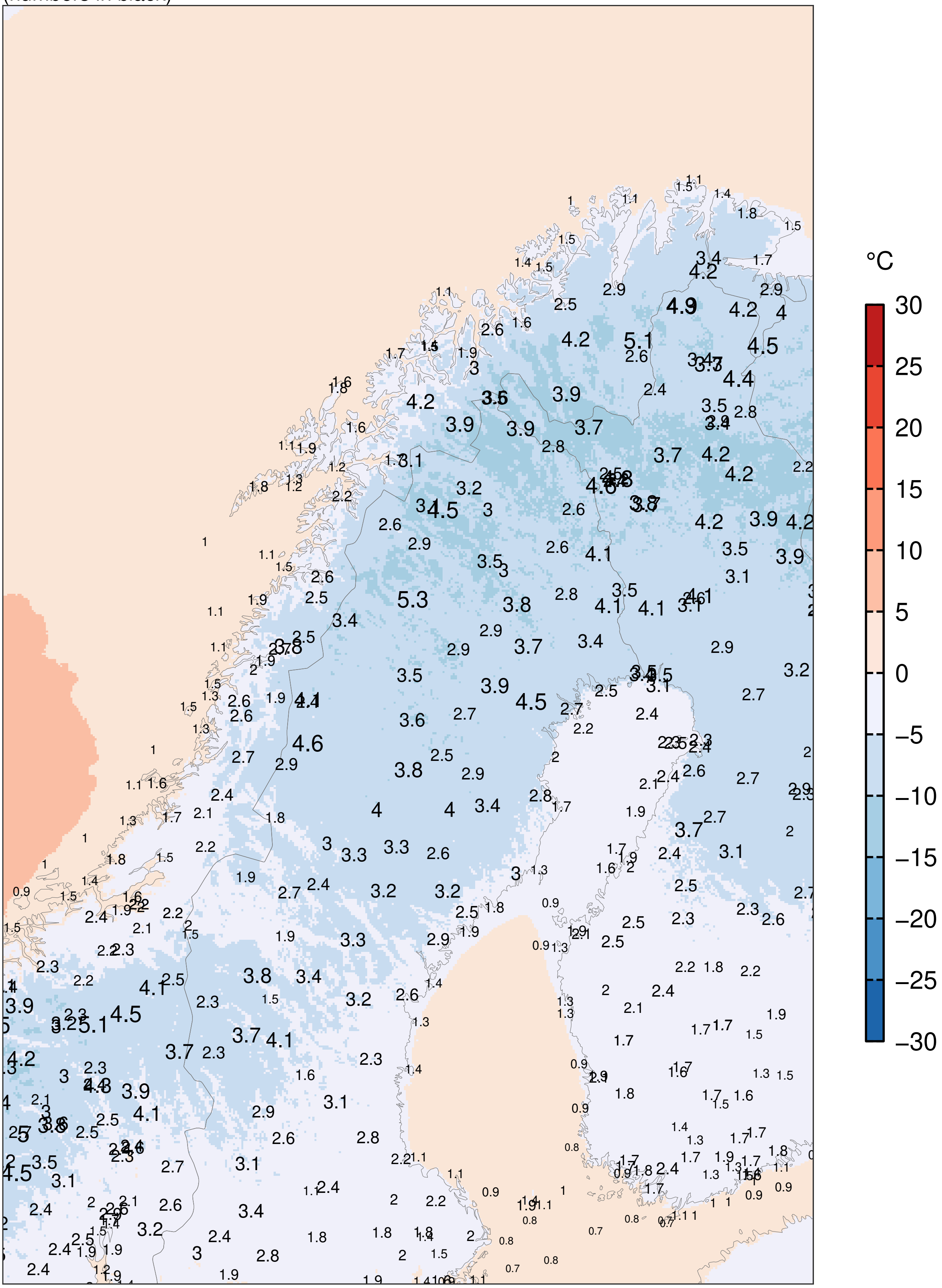

MEPSctrl 00+24
ME at observing sites
(numbers in black)
°C
30
25
20
15
10
5
0
–5
–10
–15
–20
–25
–30
Model "climatology" 01.12.2024–28.02.2025



Model "climatology" 01.12.2024–28.02.2025

MEPSctrl 00+24

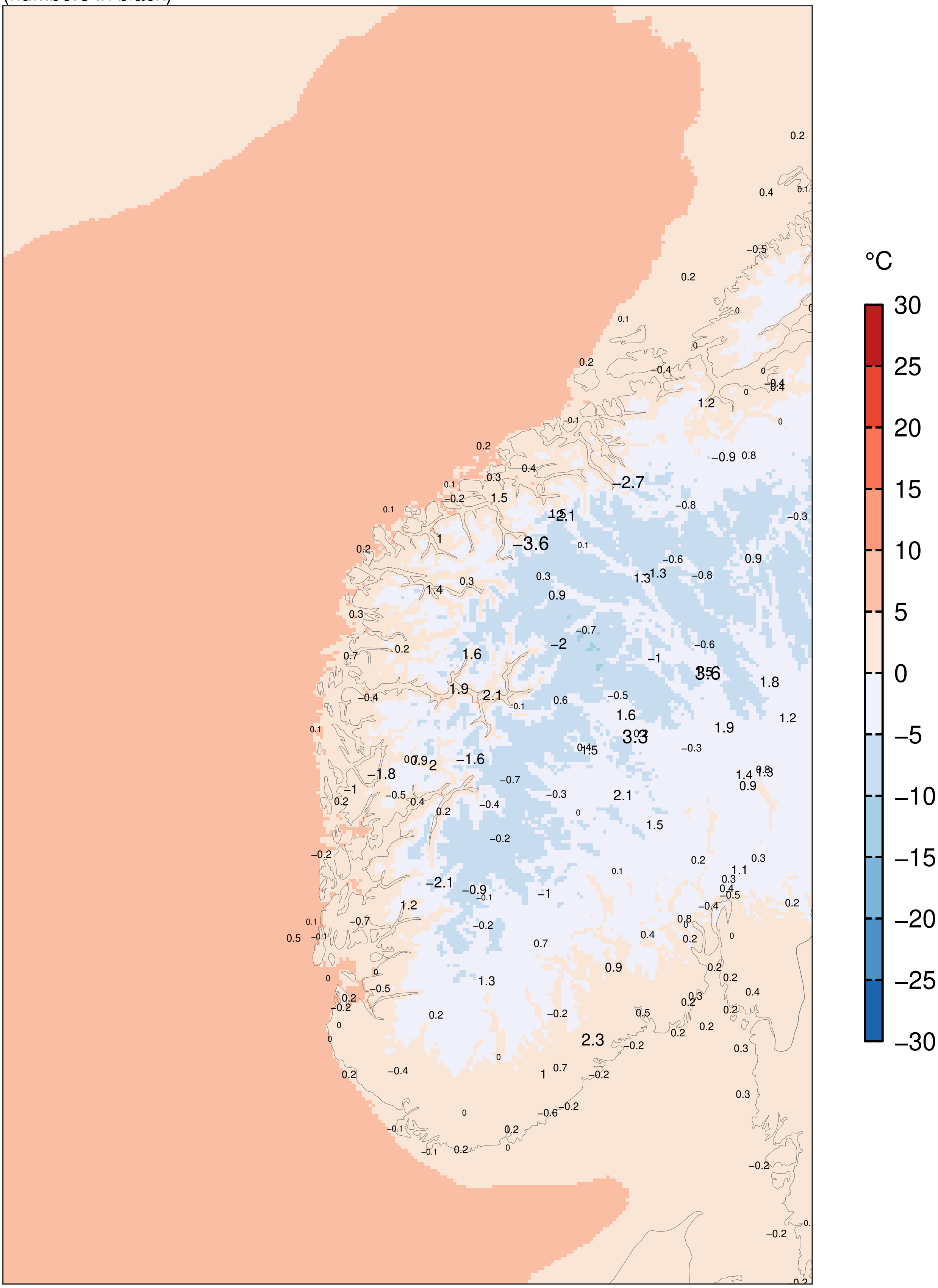
SDE at observing sites
(numbers in black)



Model "climatology" 01.12.2024–28.02.2025

MEPSctrl 00+12

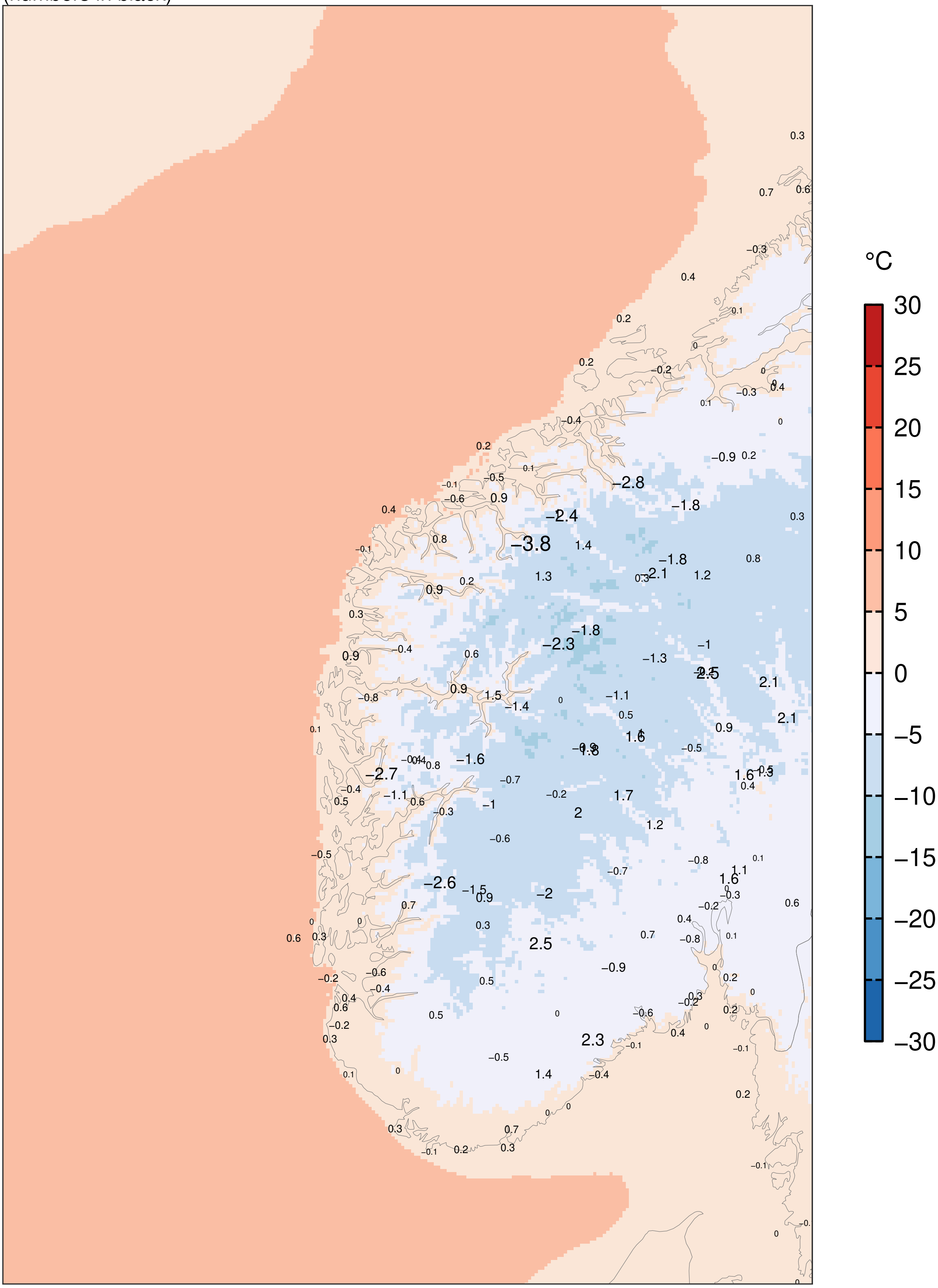
ME at observing sites
(numbers in black)



Model "climatology" 01.12.2024–28.02.2025

MEPSctrl 00+24

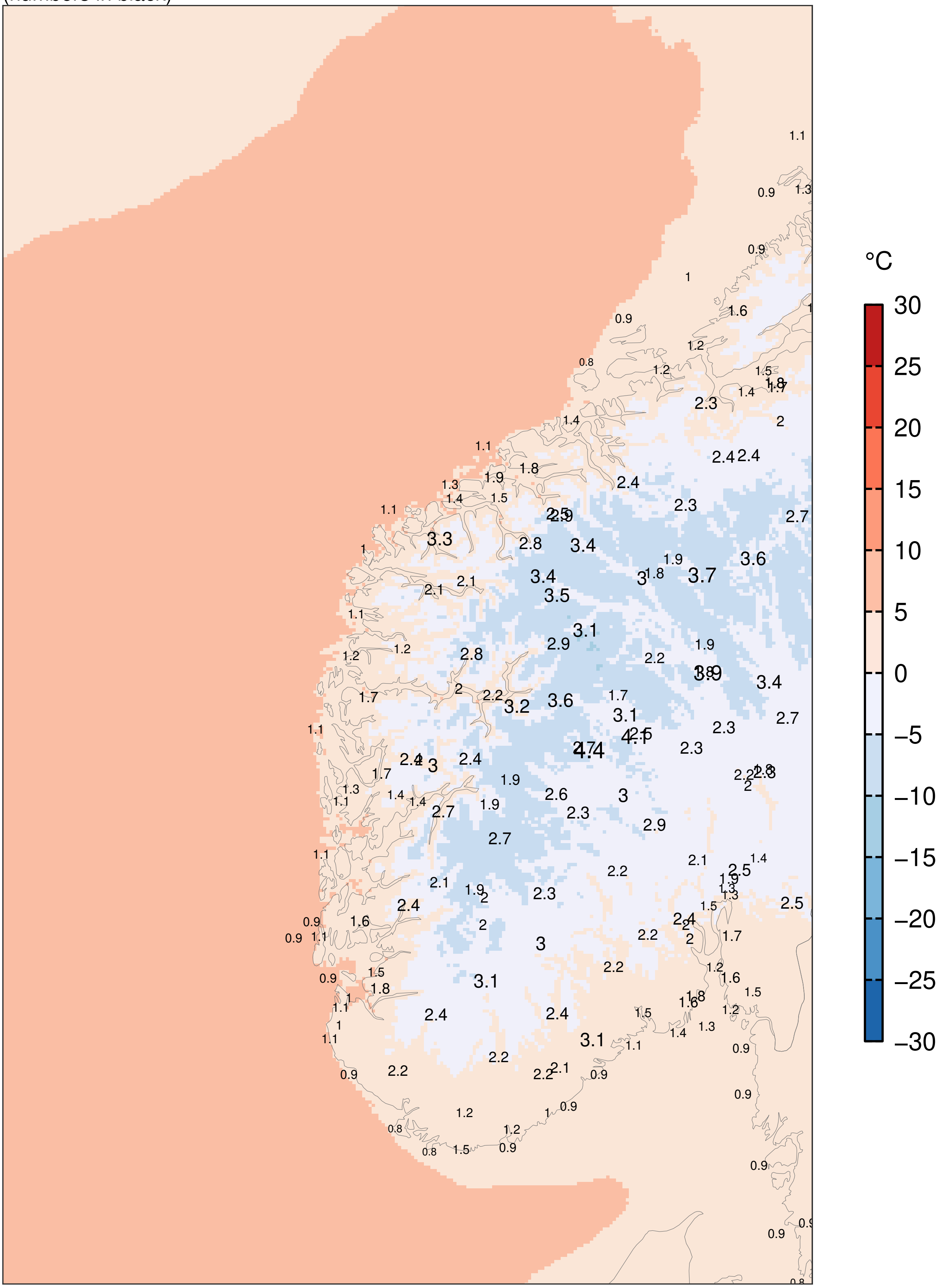
ME at observing sites
(numbers in black)



Model "climatology" 01.12.2024–28.02.2025

MEPSctrl 00+12

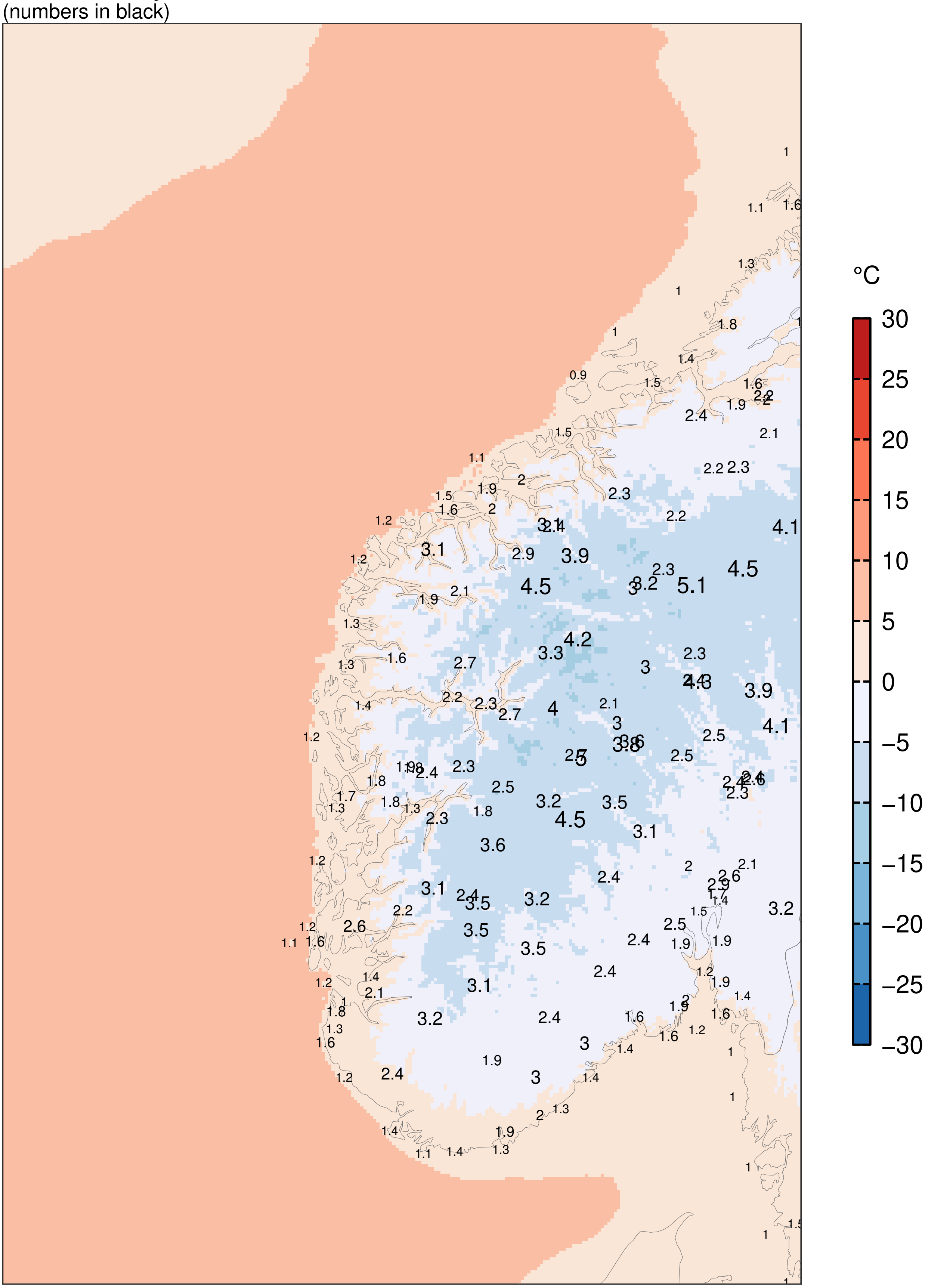
SDE at observing sites
(numbers in black)



Model "climatology" 01.12.2024–28.02.2025

MEPSctrl 00+24

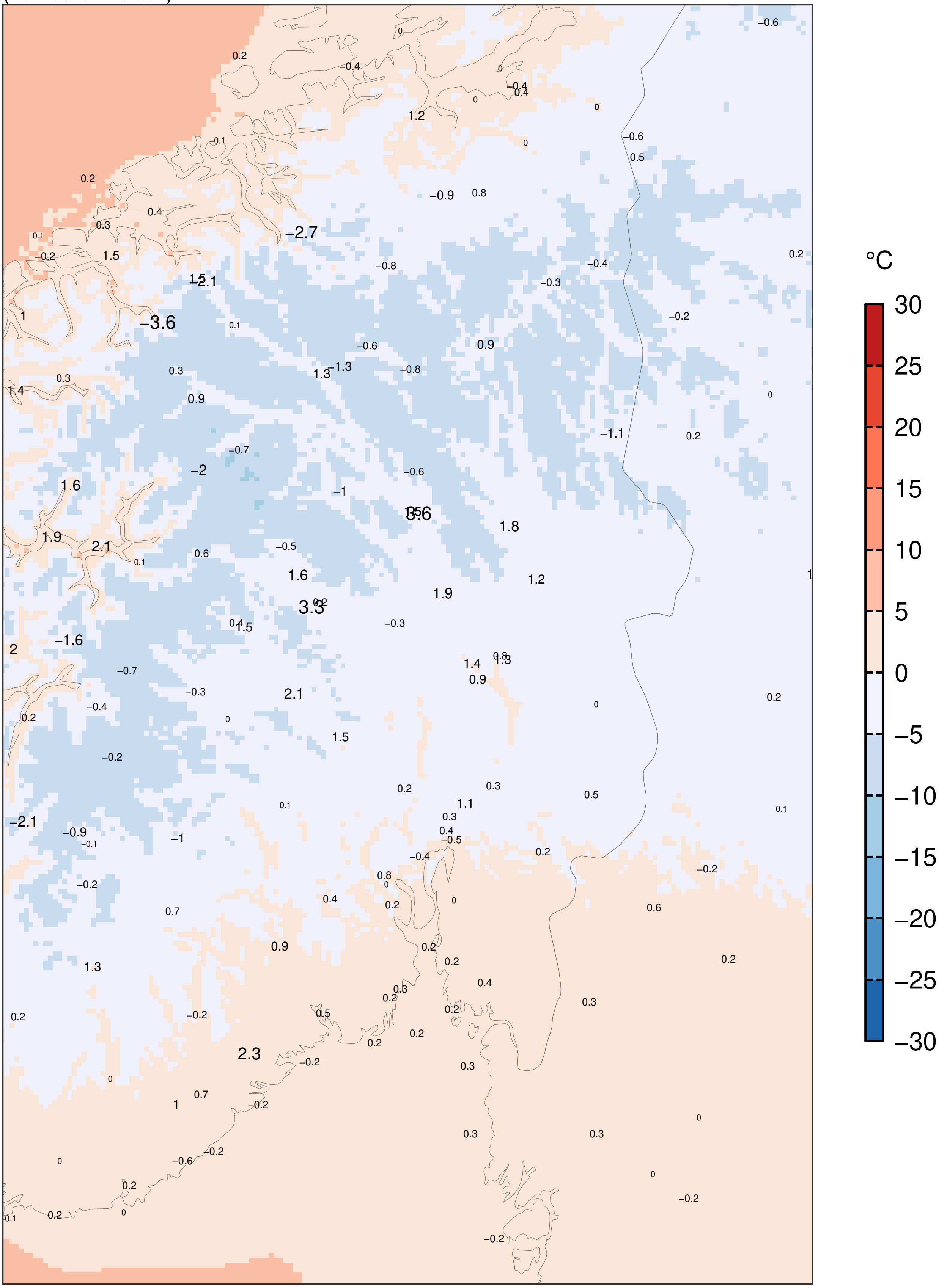
SDE at observing sites
(numbers in black)



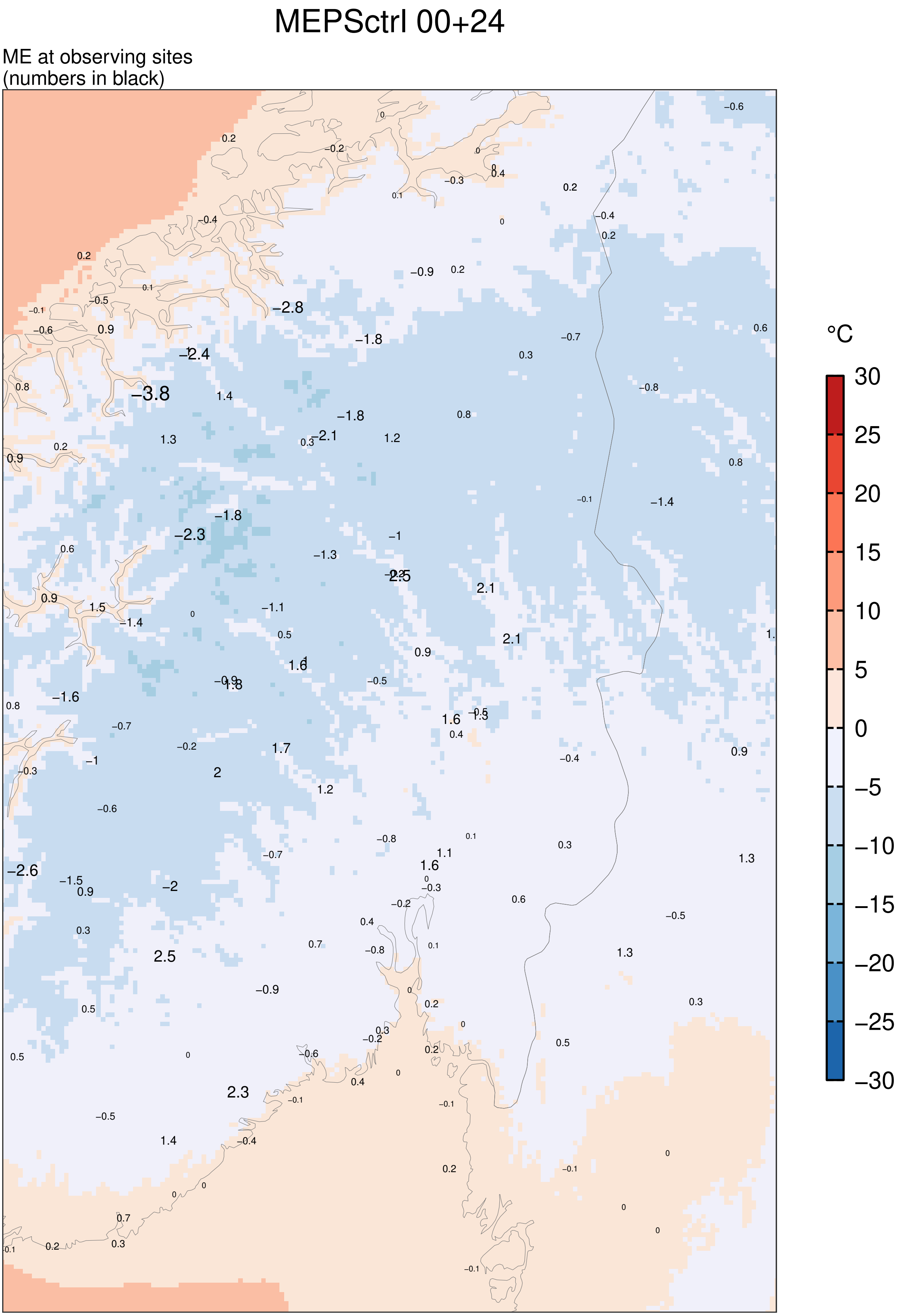
Model "climatology" 01.12.2024–28.02.2025

MEPSctrl 00+12

ME at observing sites
(numbers in black)



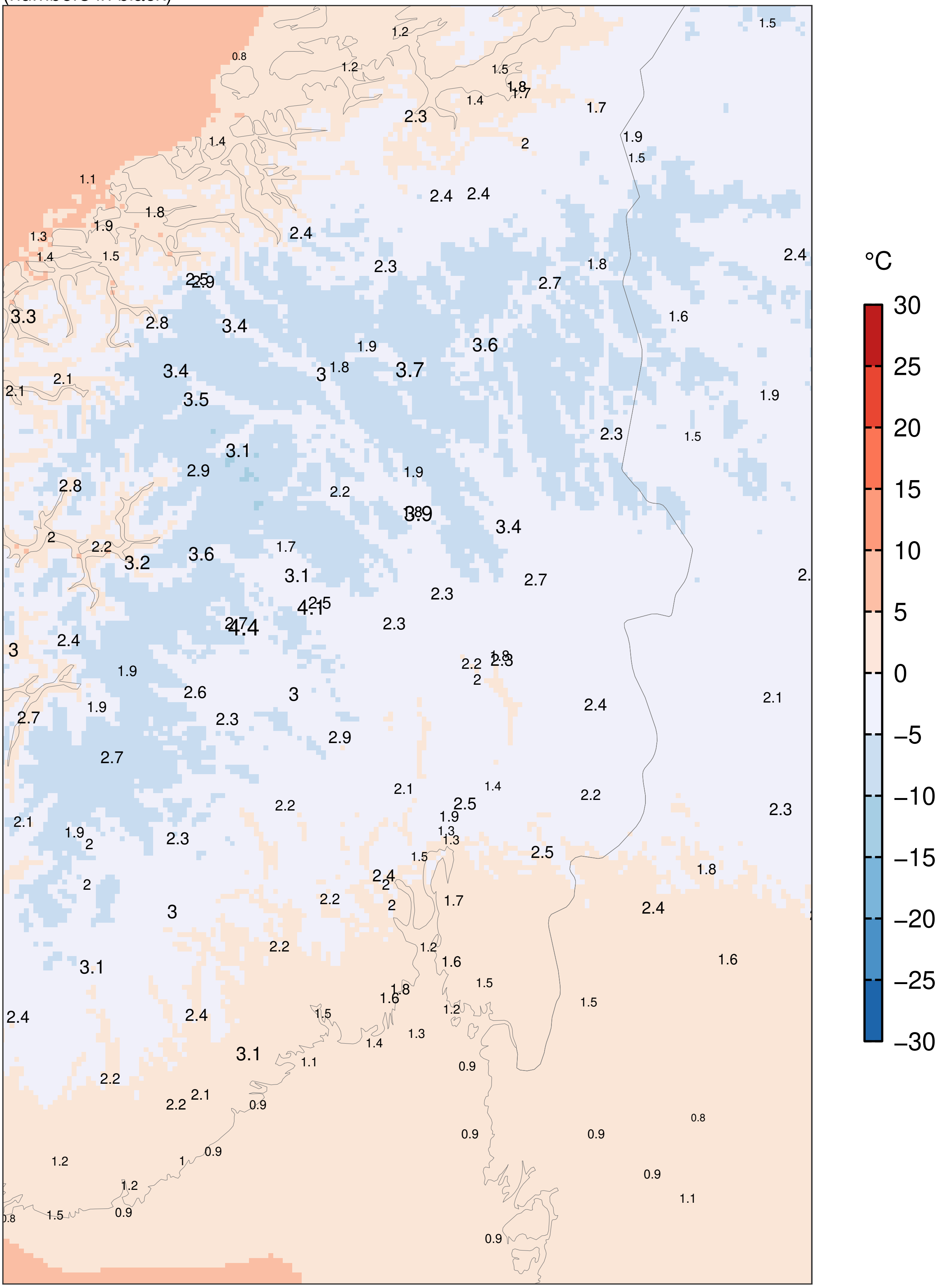
Model "climatology" 01.12.2024–28.02.2025



Model "climatology" 01.12.2024–28.02.2025

MEPSctrl 00+12

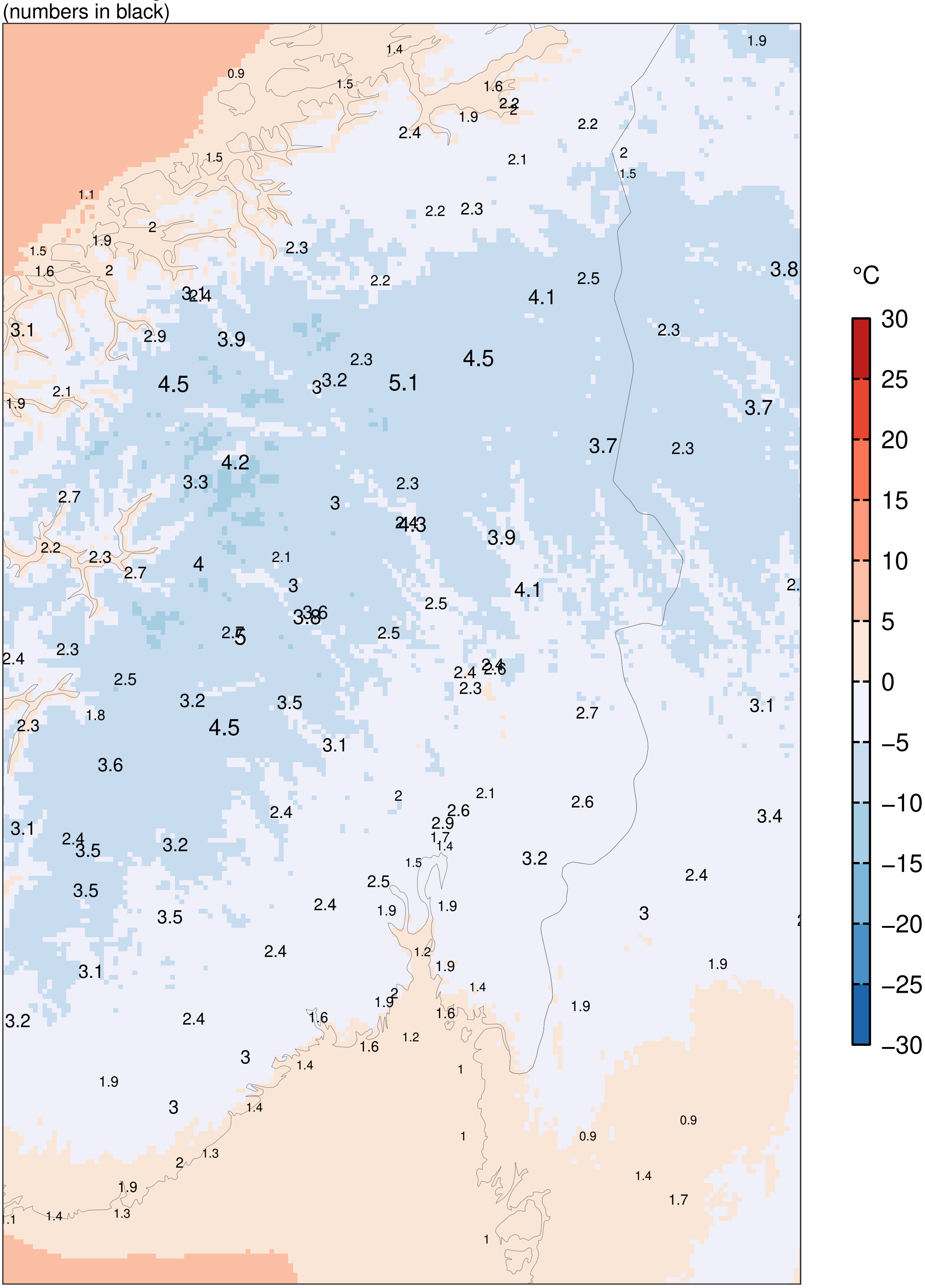
SDE at observing sites
(numbers in black)



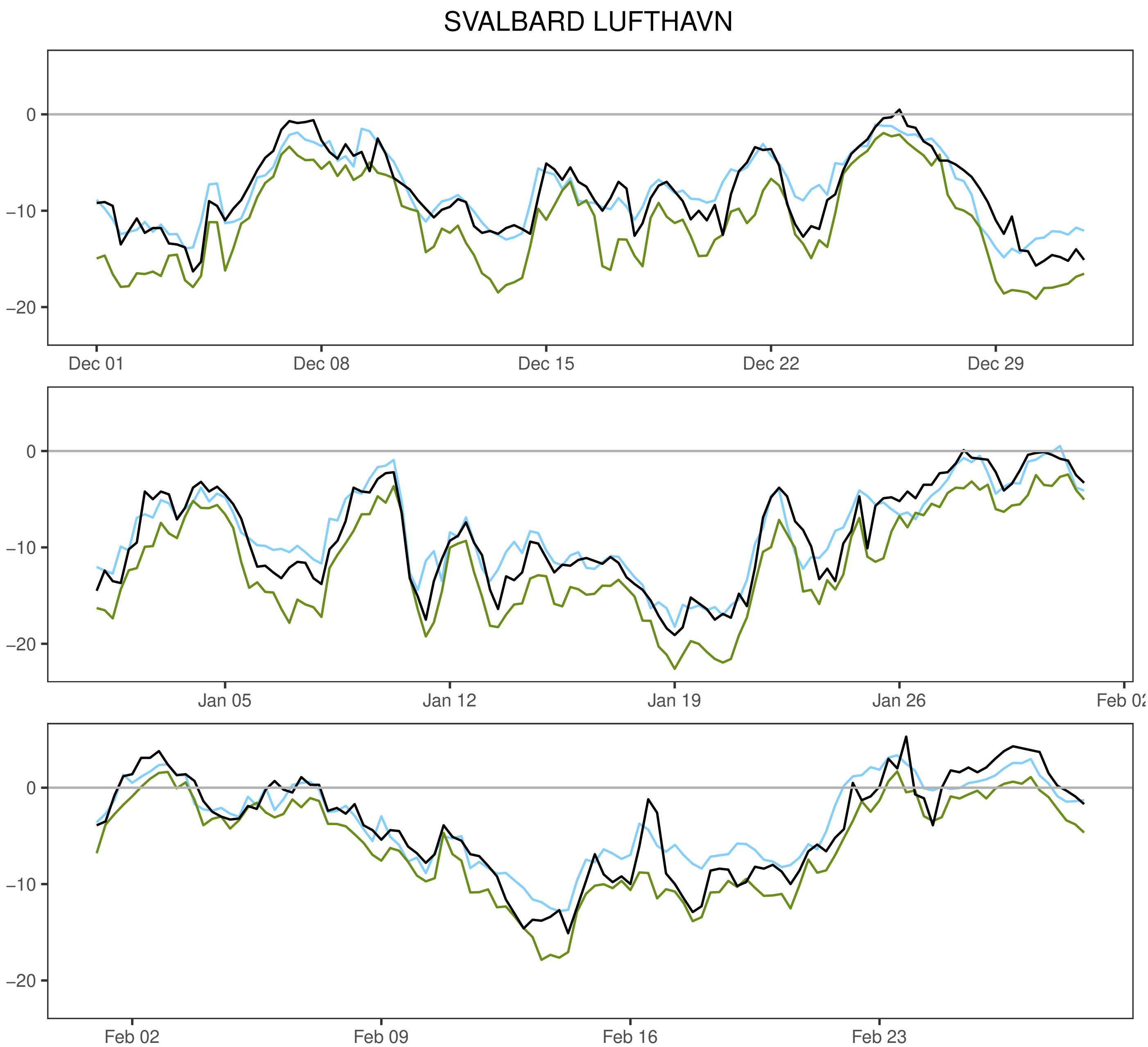
Model "climatology" 01.12.2024–28.02.2025

MEPSctrl 00+24

SDE at observing sites
(numbers in black)

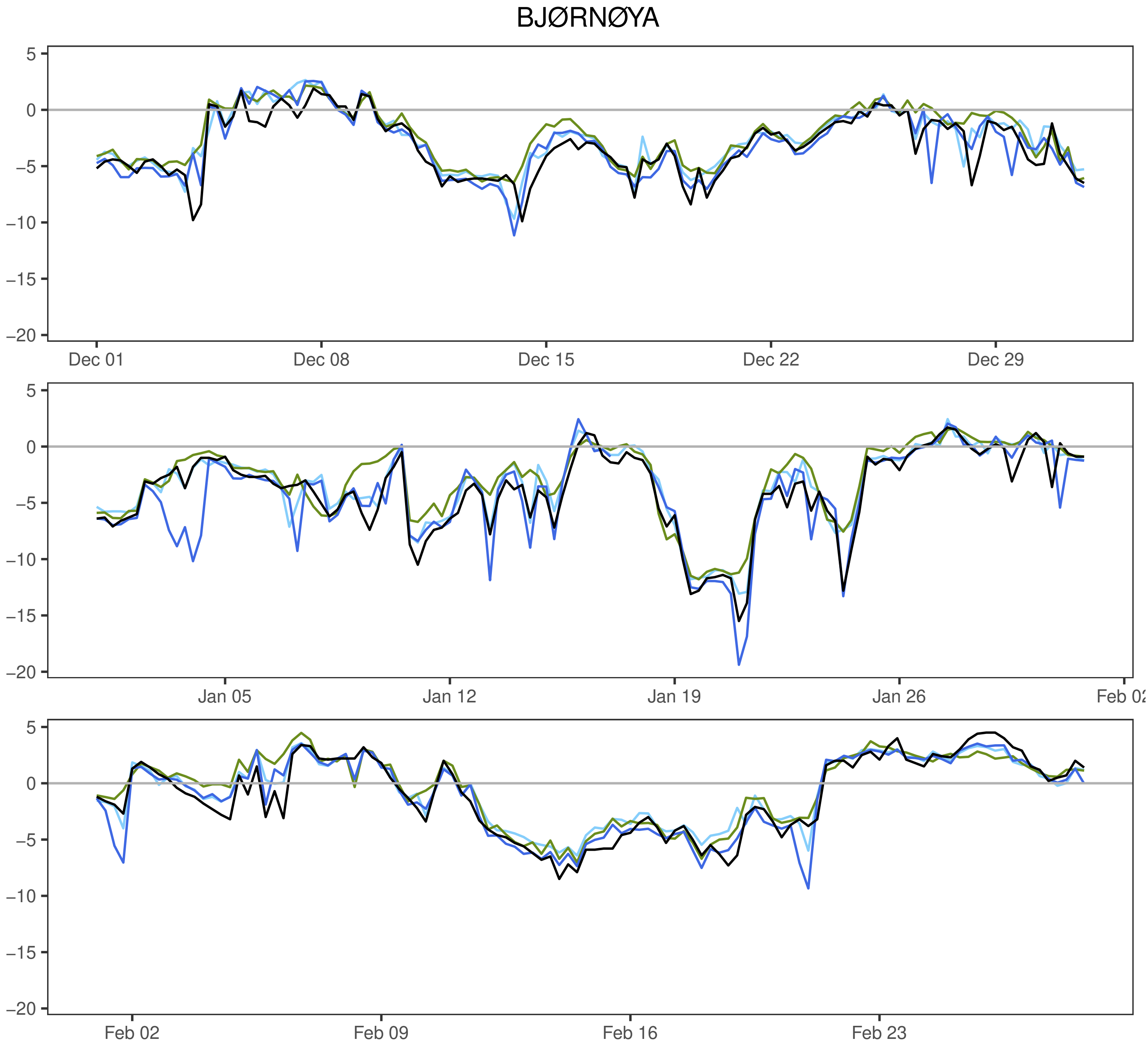


Model "climatology" 01.12.2024–28.02.2025



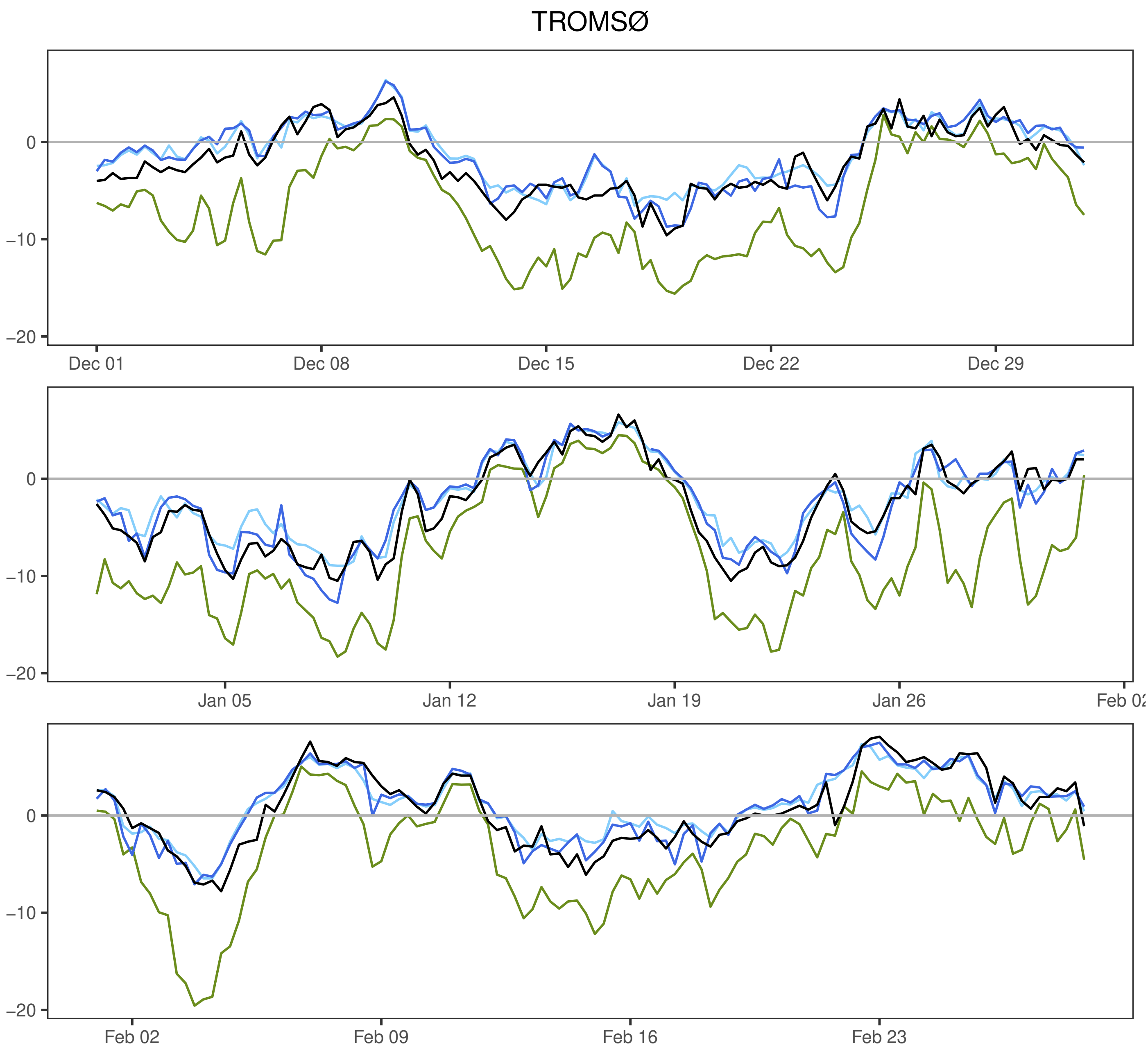
	Min	Mean	Max	Std	N
synop: 00,06,12,18	−19.1	−7.1	5.3	5.3	360
AA25: 12+18,+24,+30,+36	−18.2	−6.7	3.4	4.7	360
ECMWF: 12+18,+24,+30,+36	−22.6	−9.8	1.7	5.7	360

	ME	SDE	RMSE	MAE	Max.abs.err	N
AA25 – synop	0.4	1.8	1.8	1.4	6.1	360
ECMWF – synop	−2.7	1.6	3.2	2.7	8.9	360



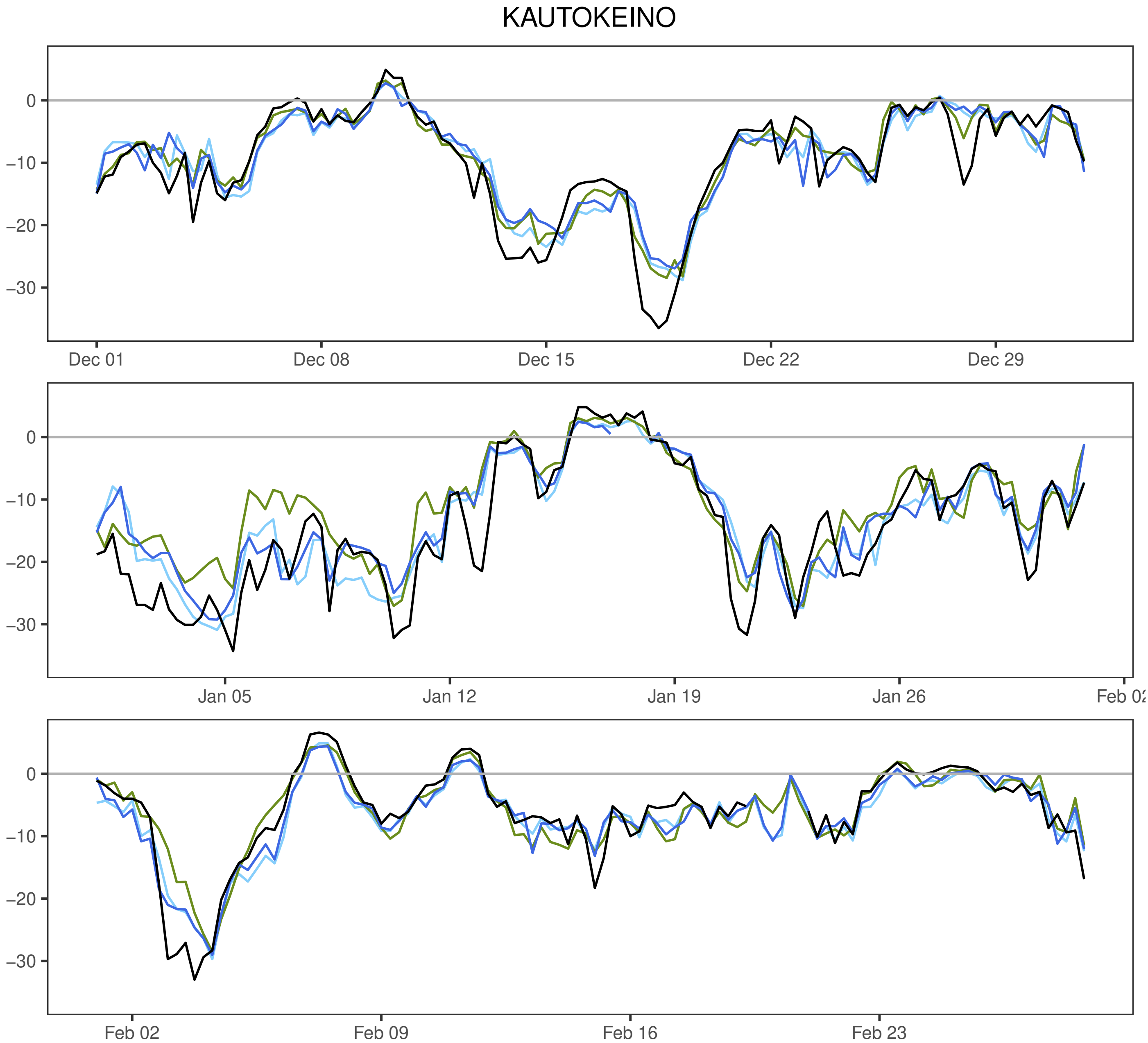
	Min	Mean	Max	Std	N
synop: 00,06,12,18	−15.5	−2.8	4.5	3.5	360
MEPSctrl: 12+18,+24,+30,+36	−19.4	−2.9	3.5	3.7	356
AA25: 12+18,+24,+30,+36	−13.1	−2.3	3.6	3.1	360
ECMWF: 12+18,+24,+30,+36	−11.8	−1.9	4.5	3.1	360

	ME	SDE	RMSE	MAE	Max.abs.err	N
MEPSctrl – synop	−0.1	1.5	1.5	1.0	8.4	356
AA25 – synop	0.5	1.2	1.3	0.9	6.4	356
ECMWF – synop	0.9	1.3	1.6	1.1	6.4	356



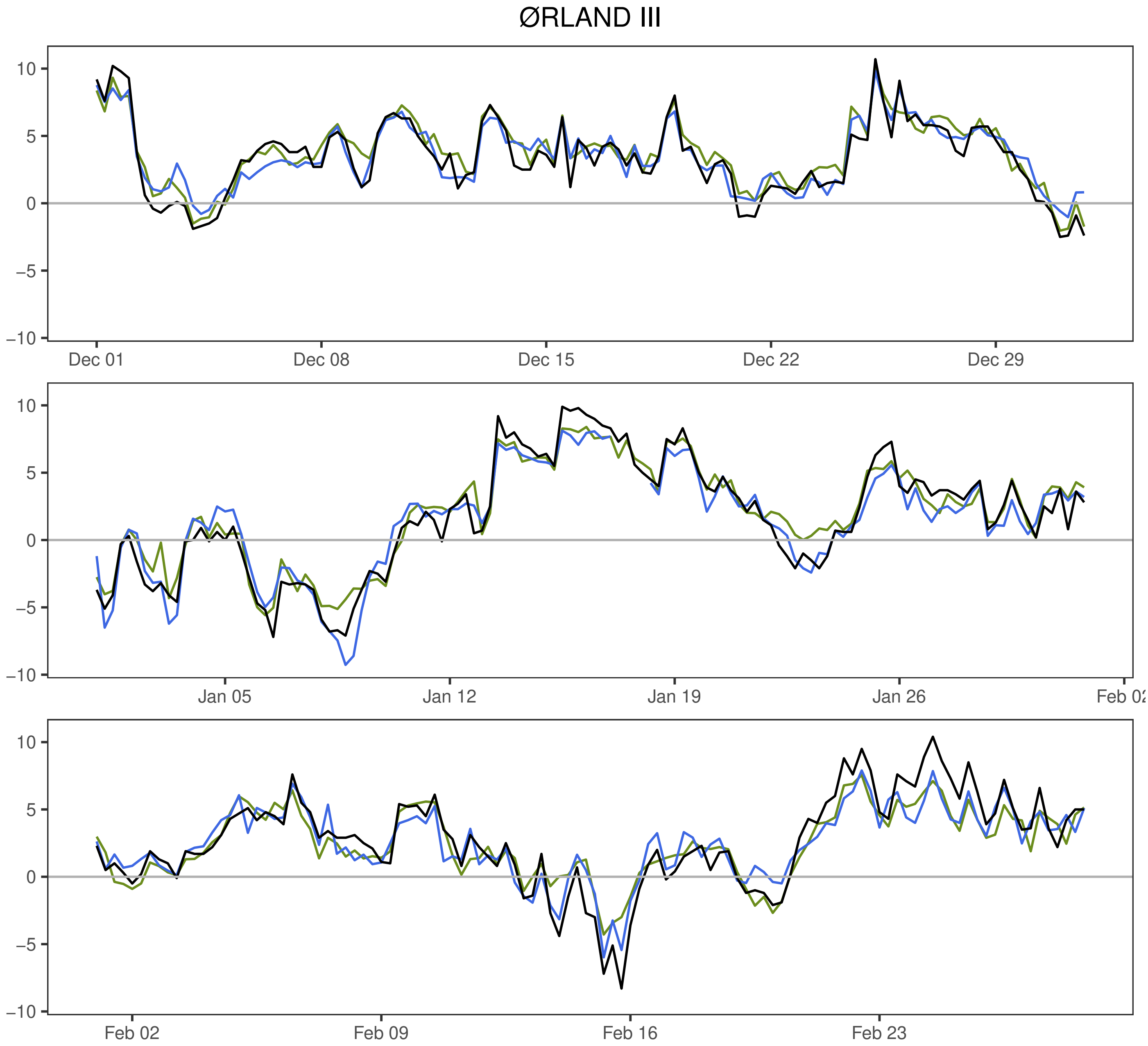
	Min	Mean	Max	Std	N
synop: 00,06,12,18	−10.5	−1.4	8.1	4.2	360
MEPSctrl: 12+18,+24,+30,+36	−12.8	−1.0	7.5	4.2	356
AA25: 12+18,+24,+30,+36	−9.0	−0.7	7.4	3.6	360
ECMWF: 12+18,+24,+30,+36	−19.6	−6.1	5.0	6.0	360

	ME	SDE	RMSE	MAE	Max.abs.err	N
MEPSctrl – synop	0.5	1.5	1.5	1.2	5.2	356
AA25 – synop	0.8	1.4	1.6	1.2	4.8	356
ECMWF – synop	−4.7	2.8	5.5	4.7	13.9	356



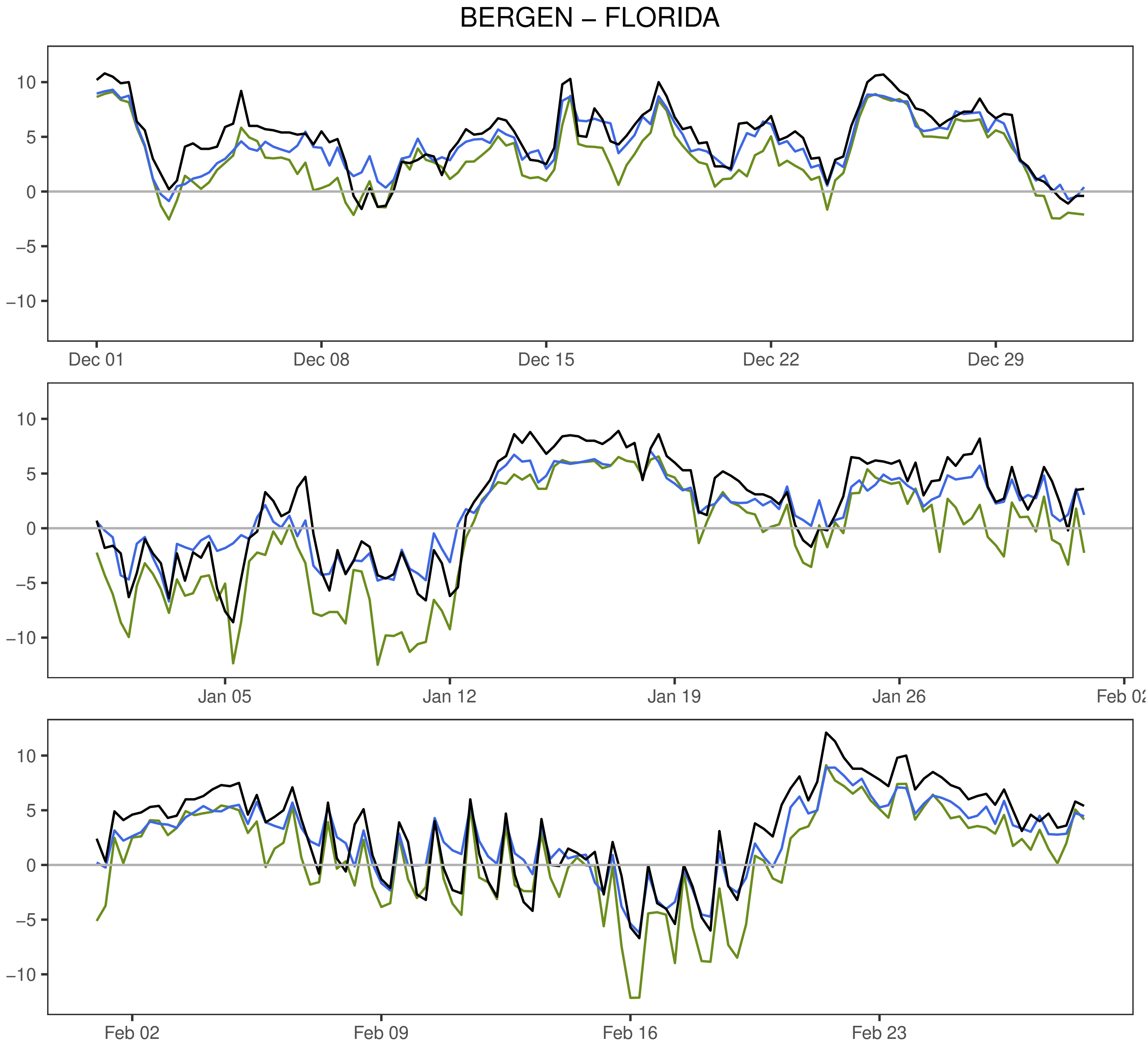
	Min	Mean	Max	Std	N
synop: 00,06,12,18	−36.5	−10.3	6.6	9.5	355
MEPSctrl: 12+18,+24,+30,+36	−29.3	−9.7	4.4	7.7	356
AA25: 12+18,+24,+30,+36	−30.9	−10.0	4.9	8.1	360
ECMWF: 12+18,+24,+30,+36	−28.5	−8.9	4.6	7.5	360

	ME	SDE	RMSE	MAE	Max.abs.err	N
MEPSctrl – synop	0.7	3.9	3.9	2.8	14.7	351
AA25 – synop	0.3	3.9	3.9	2.9	13.0	351
ECMWF – synop	1.4	4.0	4.2	2.9	17.6	351



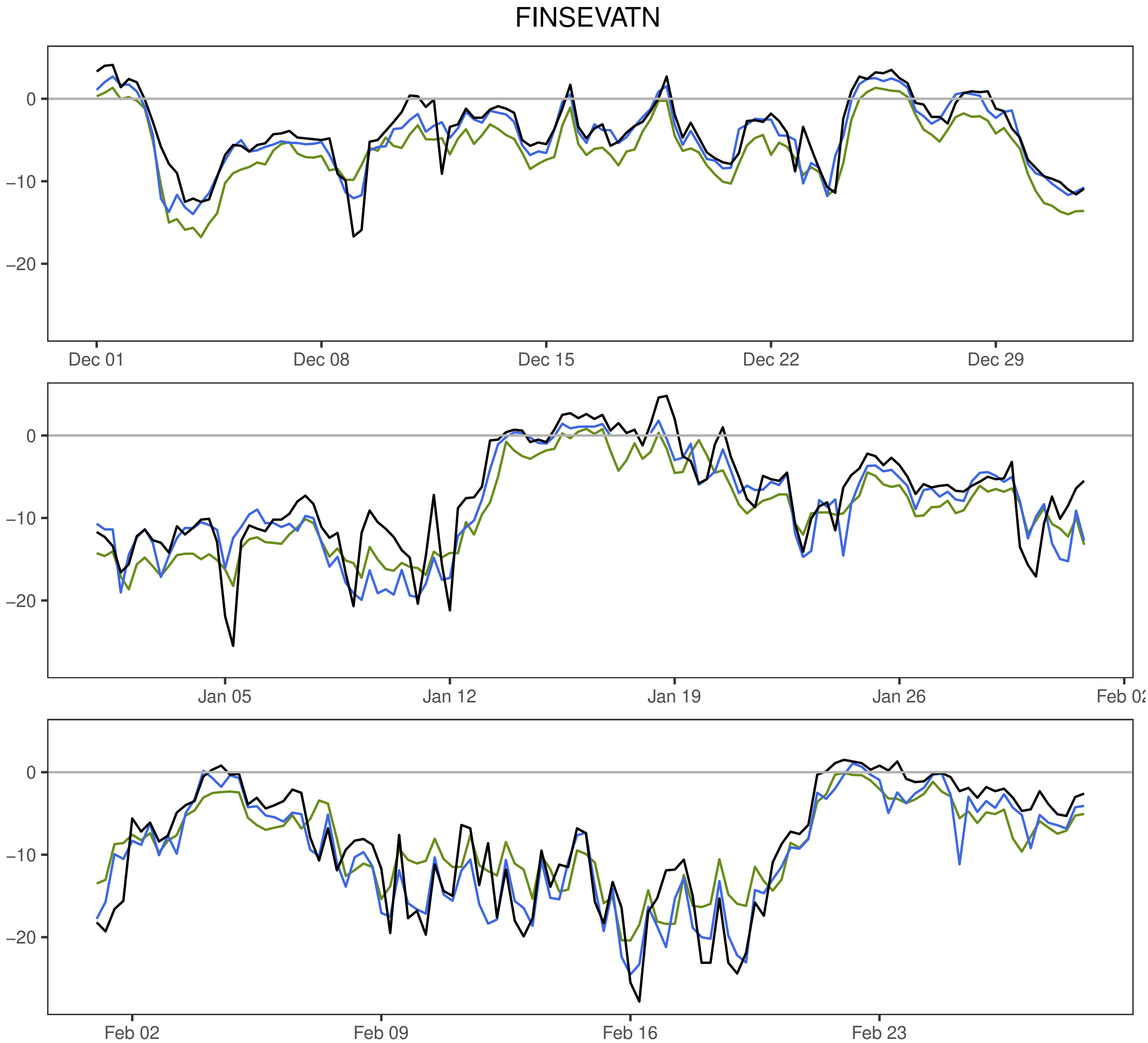
	Min	Mean	Max	Std	N
synop: 00,06,12,18	−8.3	2.6	10.7	3.6	360
MEPSctrl: 12+18,+24,+30,+36	−9.3	2.5	9.8	3.1	356
ECMWF: 12+18,+24,+30,+36	−5.6	2.8	10.2	3.0	360

	ME	SDE	RMSE	MAE	Max.abs.err	N
MEPSctrl – synop	0.0	1.2	1.2	1.0	3.5	356
ECMWF – synop	0.2	1.2	1.2	0.9	5.3	356



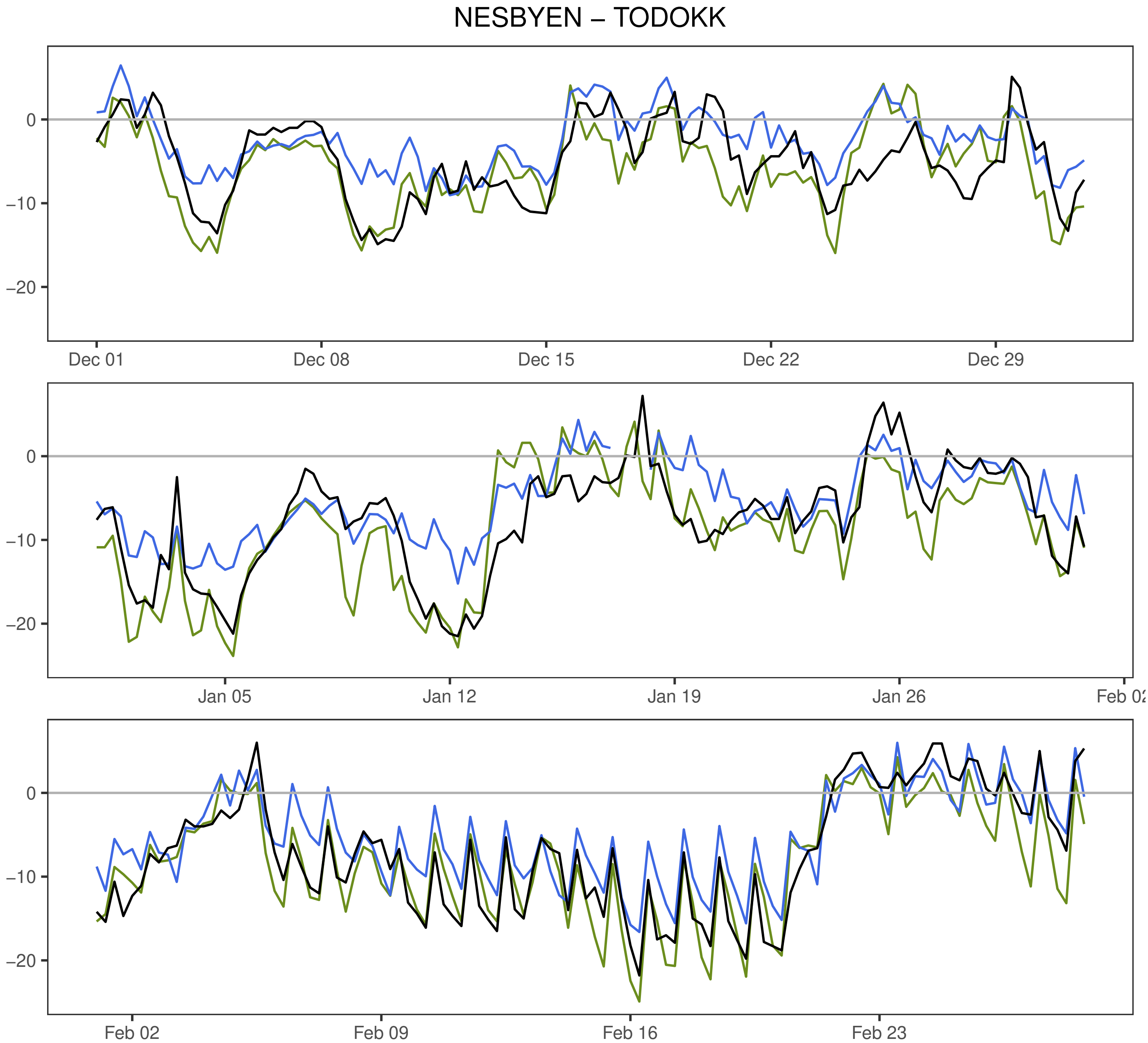
	Min	Mean	Max	Std	N
synop: 00,06,12,18	−8.6	3.4	12.1	4.2	360
MEPSctrl: 12+18,+24,+30,+36	−6.7	2.8	9.3	3.3	356
ECMWF: 12+18,+24,+30,+36	−12.5	1.0	9.1	4.5	360

	ME	SDE	RMSE	MAE	Max.abs.err	N
MEPSctrl – synop	−0.6	1.6	1.8	1.4	7.2	356
ECMWF – synop	−2.4	1.6	2.9	2.5	8.2	356



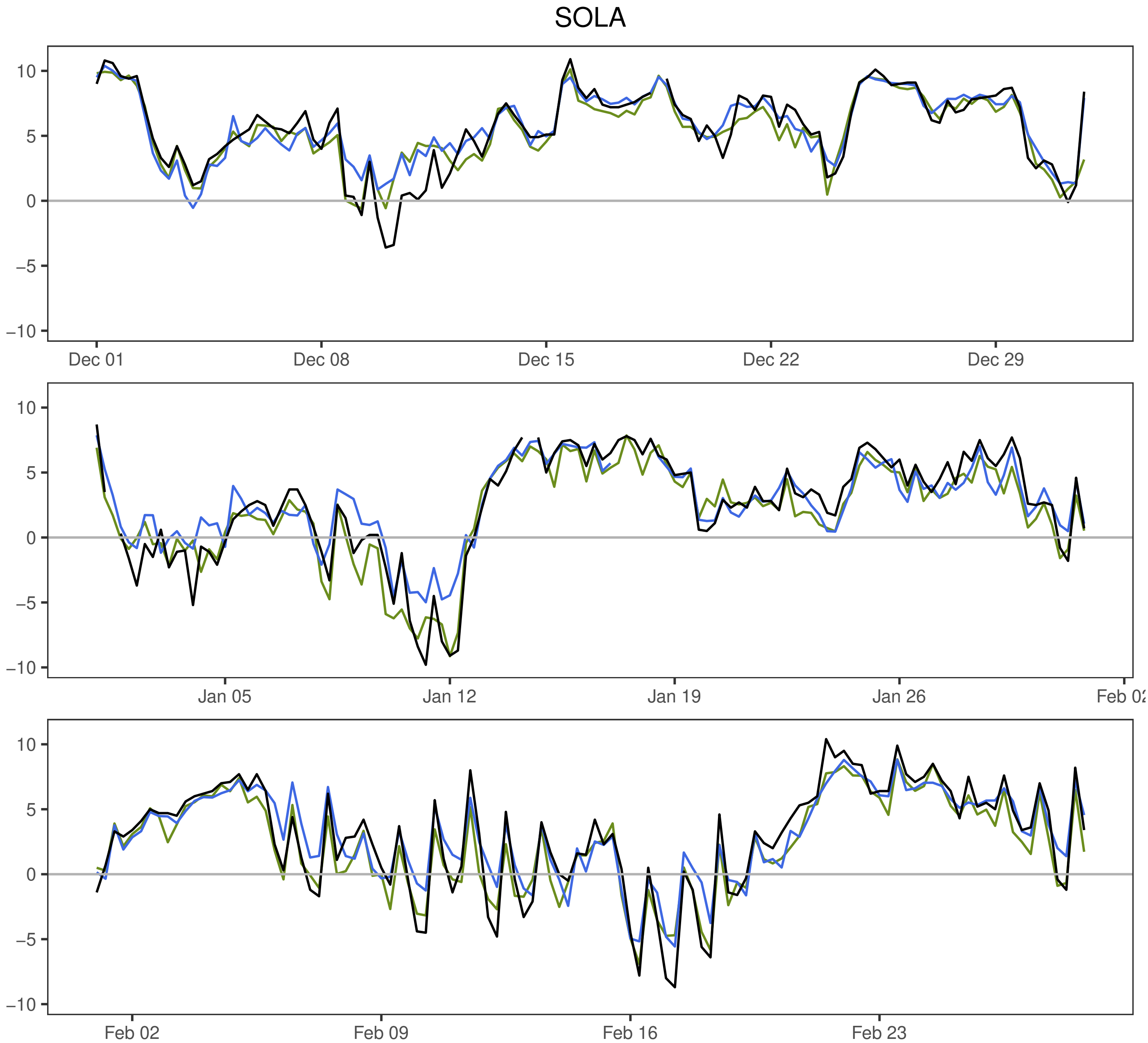
	Min	Mean	Max	Std	N
synop: 00,06,12,18	−27.8	−6.6	4.8	6.3	360
MEPSctrl: 12+18,+24,+30,+36	−24.5	−7.6	2.7	6.0	356
ECMWF: 12+18,+24,+30,+36	−20.4	−8.1	1.3	5.0	360

	ME	SDE	RMSE	MAE	Max.abs.err	N
MEPSctrl – synop	−0.9	2.5	2.7	1.9	13.1	356
ECMWF – synop	−1.5	3.1	3.4	3.0	9.3	356



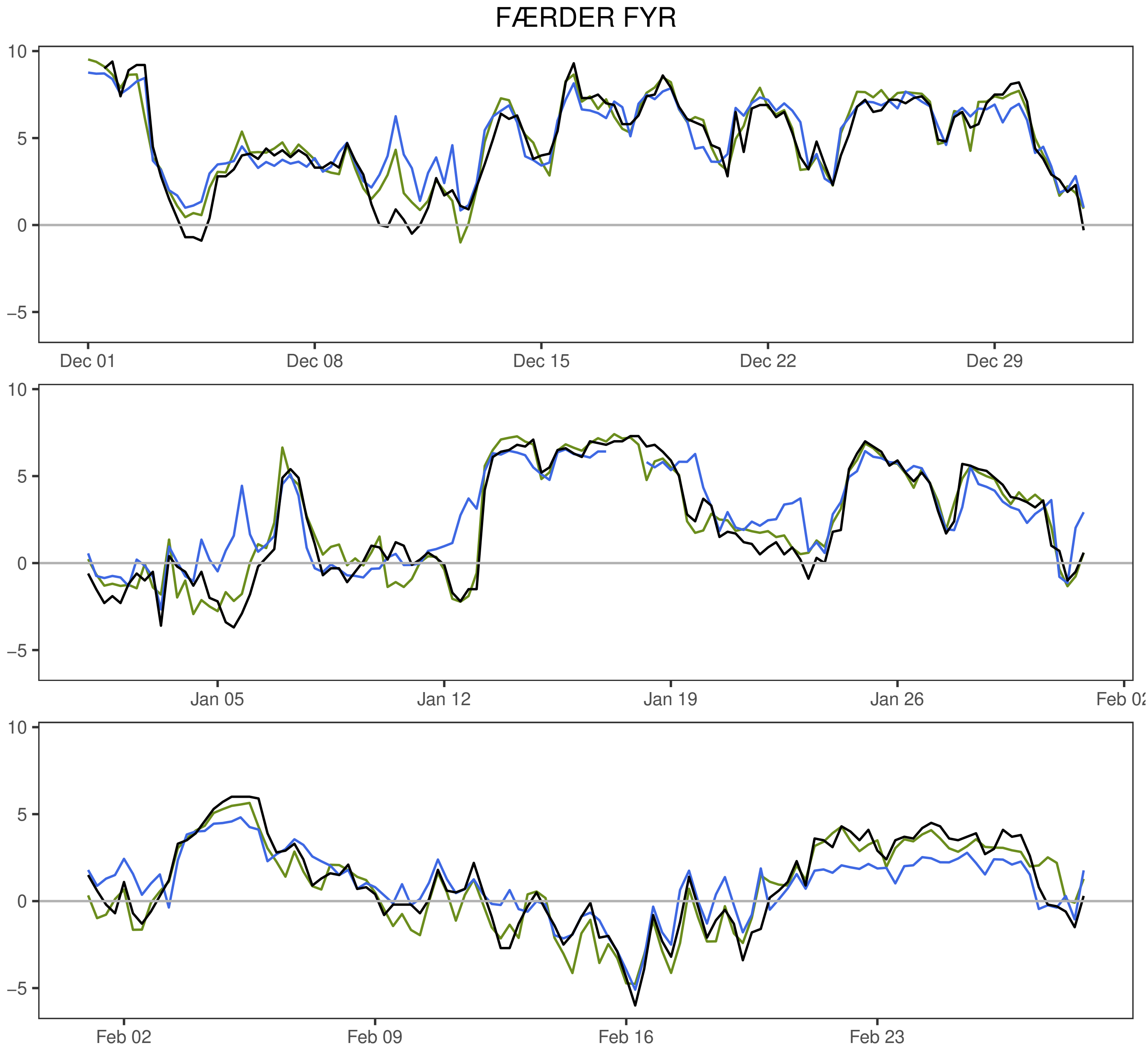
	Min	Mean	Max	Std	N
synop: 00,06,12,18	–21.8	–6.6	7.2	6.3	360
MEPSctrl: 12+18,+24,+30,+36	–16.6	–4.4	6.5	4.8	356
ECMWF: 12+18,+24,+30,+36	–24.9	–7.7	4.3	6.4	360

	ME	SDE	RMSE	MAE	Max.abs.err	N
MEPSctrl – synop	2.3	3.5	4.2	3.4	10.4	356
ECMWF – synop	–1.1	3.5	3.7	2.9	11.9	356



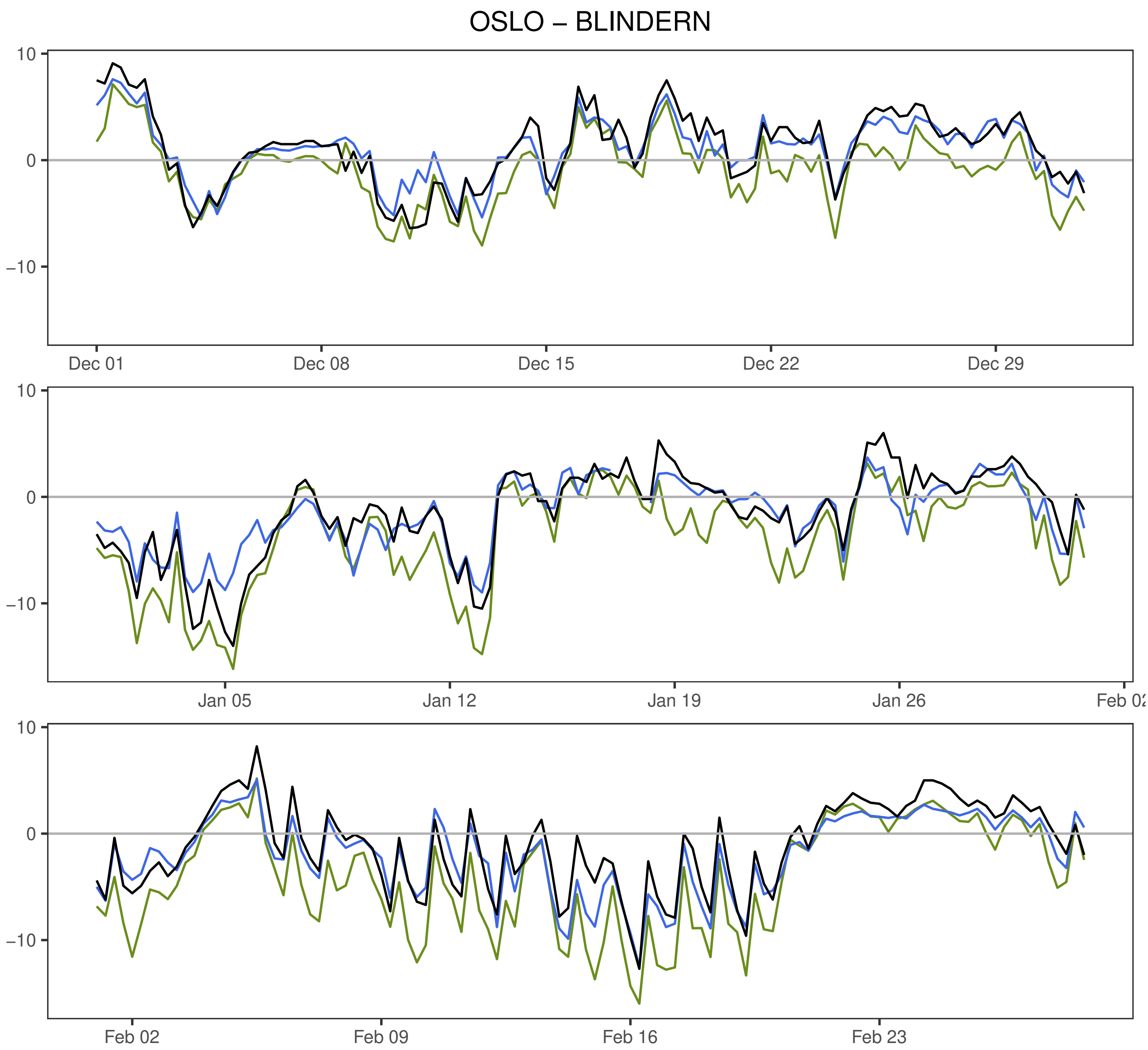
	Min	Mean	Max	Std	N
synop: 00,06,12,18	−9.8	3.7	10.9	4.0	357
MEPSctrl: 12+18,+24,+30,+36	−5.6	3.9	10.4	3.2	356
ECMWF: 12+18,+24,+30,+36	−9.1	3.3	10.1	3.7	360

	ME	SDE	RMSE	MAE	Max.abs.err	N
MEPSctrl − synop	0.2	1.5	1.5	1.1	5.9	353
ECMWF − synop	−0.4	1.3	1.4	1.0	5.2	353



	Min	Mean	Max	Std	N
synop: 00,06,12,18	–6.0	2.8	9.4	3.2	359
MEPSctrl: 12+18,+24,+30,+36	–5.1	3.0	8.8	2.7	356
ECMWF: 12+18,+24,+30,+36	–4.8	2.8	9.5	3.2	360

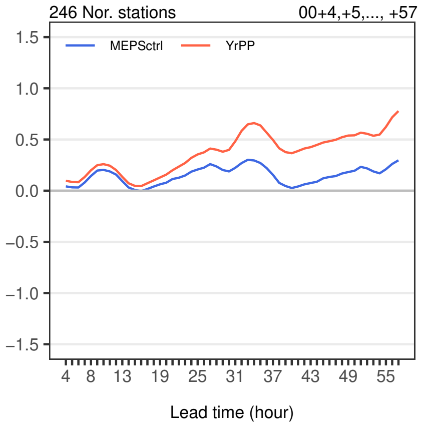
	ME	SDE	RMSE	MAE	Max.abs.err	N
MEPSctrl – synop	0.3	1.4	1.4	1.0	7.3	355
ECMWF – synop	0.1	0.9	0.9	0.7	3.4	355



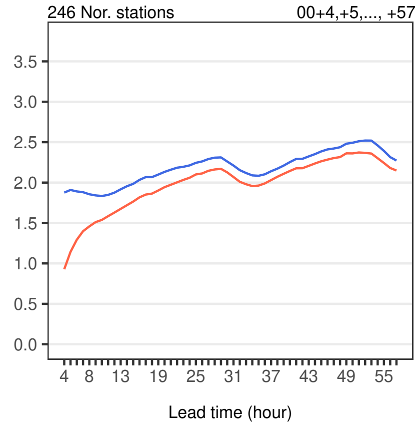
	Min	Mean	Max	Std	N
synop: 00,06,12,18	–14.0	–0.5	9.1	4.1	360
MEPSctrl: 12+18,+24,+30,+36	–12.5	–0.9	7.6	3.5	356
ECMWF: 12+18,+24,+30,+36	–16.2	–2.9	7.1	4.6	360

	ME	SDE	RMSE	MAE	Max.abs.err	N
MEPSctrl – synop	–0.3	1.6	1.6	1.3	6.8	356
ECMWF – synop	–2.4	1.7	3.0	2.5	9.1	356

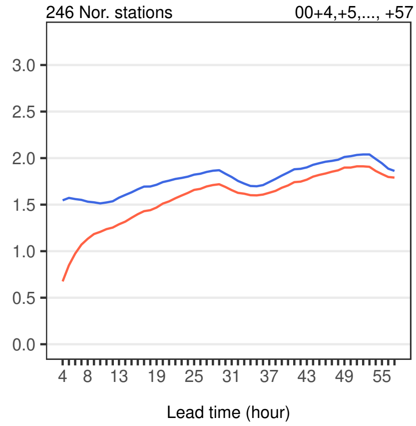
Mean Error



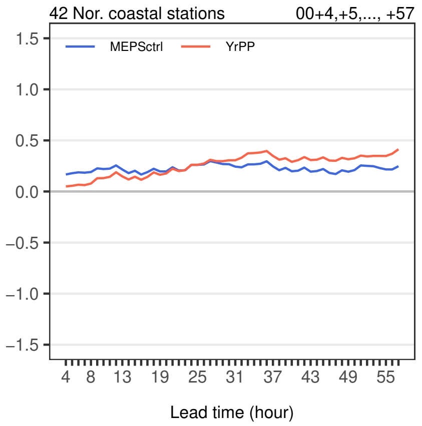
Standard Deviation of Error



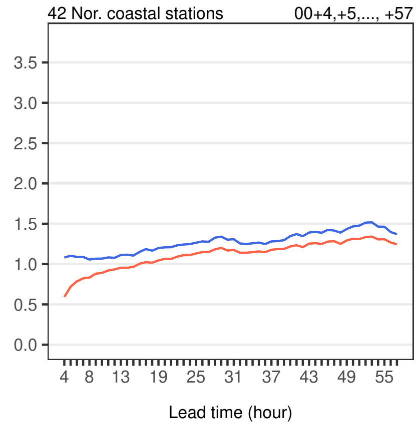
Mean Absolute Error



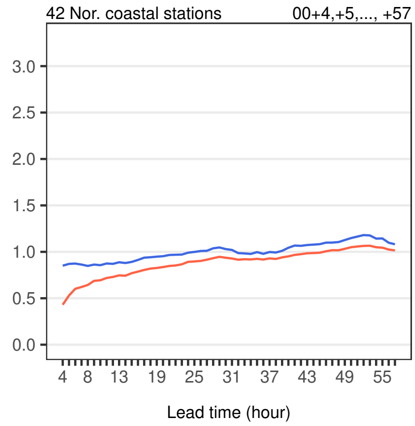
Mean Error



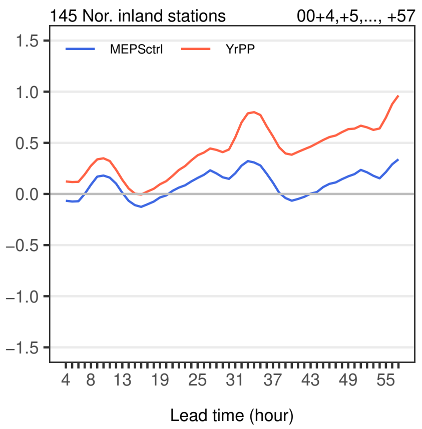
Standard Deviation of Error



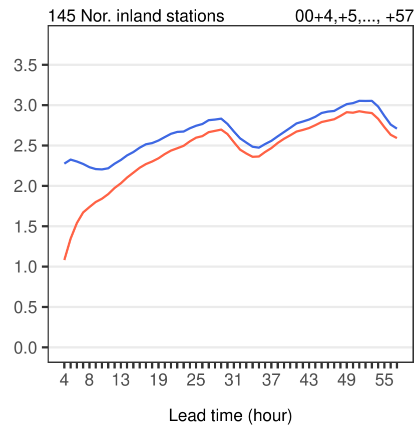
Mean Absolute Error



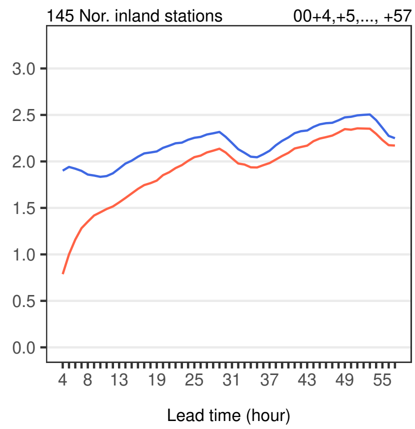
Mean Error

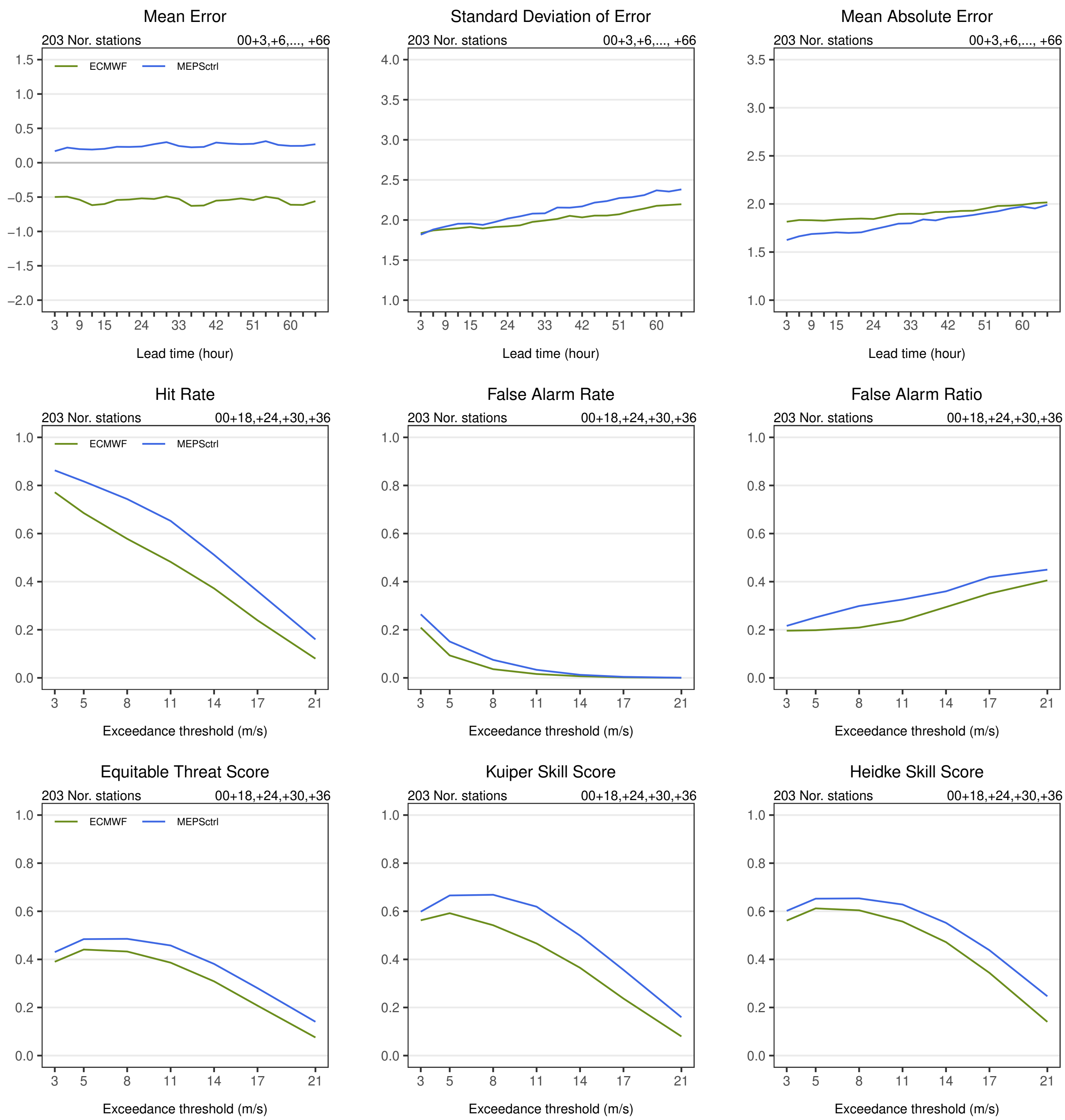


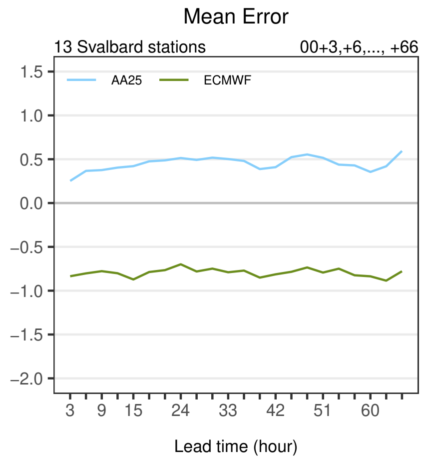
Standard Deviation of Error

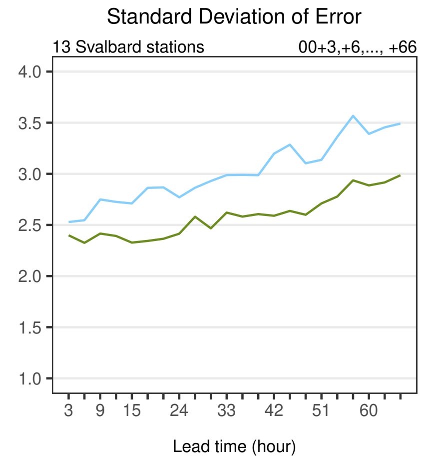


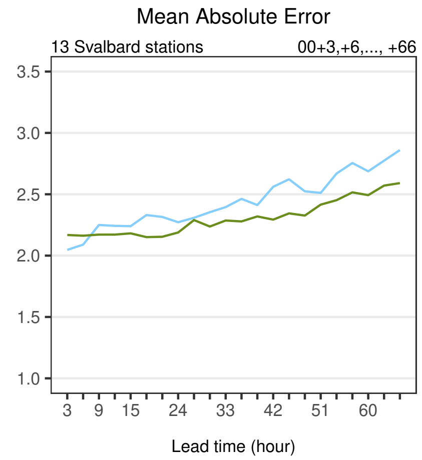
Mean Absolute Error

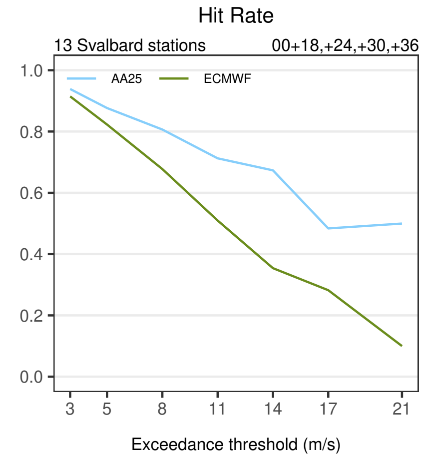


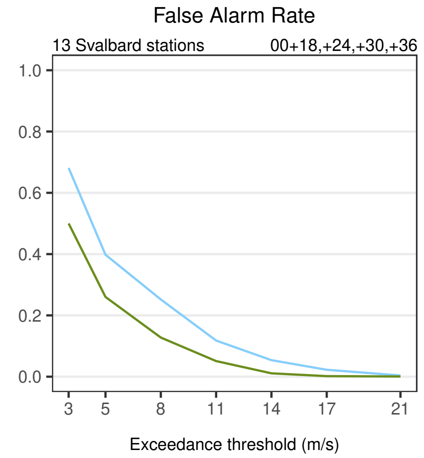

Mean Error
Standard Deviation of Error
Mean Absolute Error
203 Nor. stations
00+3,+6,..., +66
ECMWF
MEPSctrl
Lead time (hour)
Hit Rate
False Alarm Rate
False Alarm Ratio
00+18,+24,+30,+36
Exceedance threshold (m/s)
Equitable Threat Score
Kuiper Skill Score
Heidke Skill Score

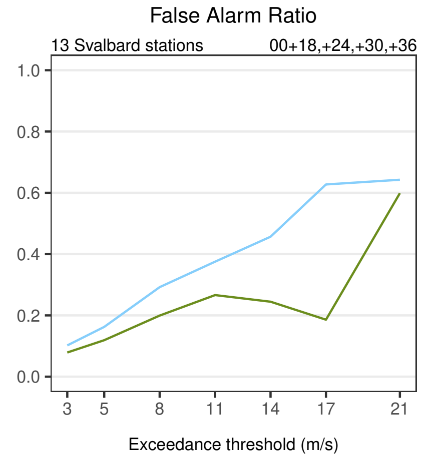

Mean Error
13 Svalbard stations
00+3,+6,..., +66
AA25
ECMWF
Lead time (hour)

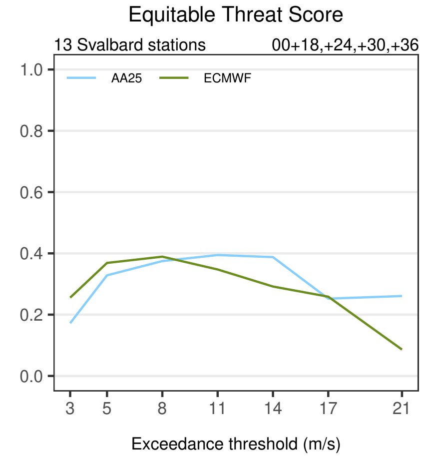

Standard Deviation of Error
13 Svalbard stations
00+3,+6,..., +66
Lead time (hour)

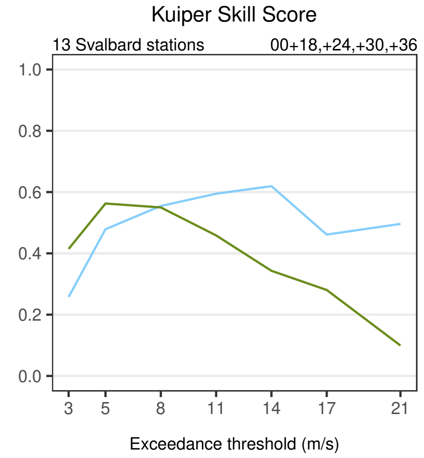

Mean Absolute Error
13 Svalbard stations
00+3,+6,..., +66
Lead time (hour)

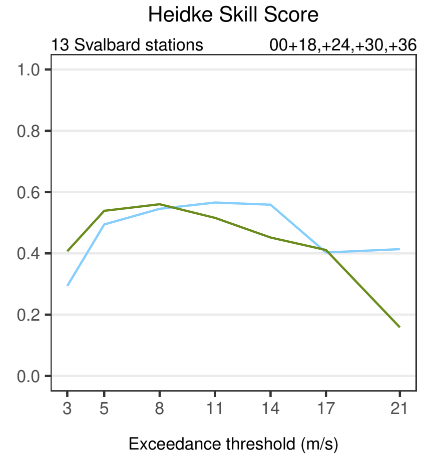

Hit Rate
13 Svalbard stations
00+18,+24,+30,+36
AA25
ECMWF
Exceedance threshold (m/s)

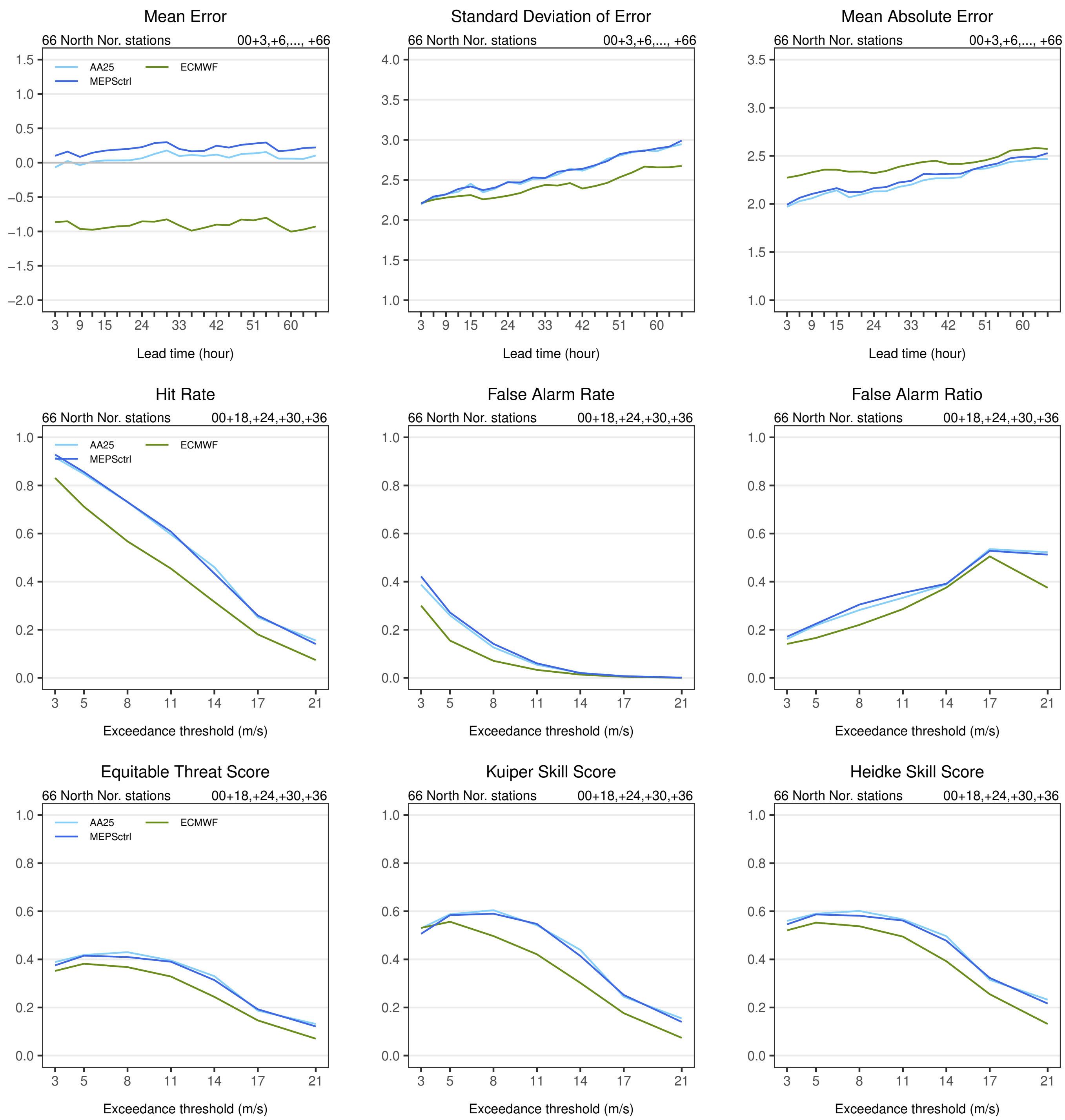

False Alarm Rate
13 Svalbard stations
00+18,+24,+30,+36
Exceedance threshold (m/s)

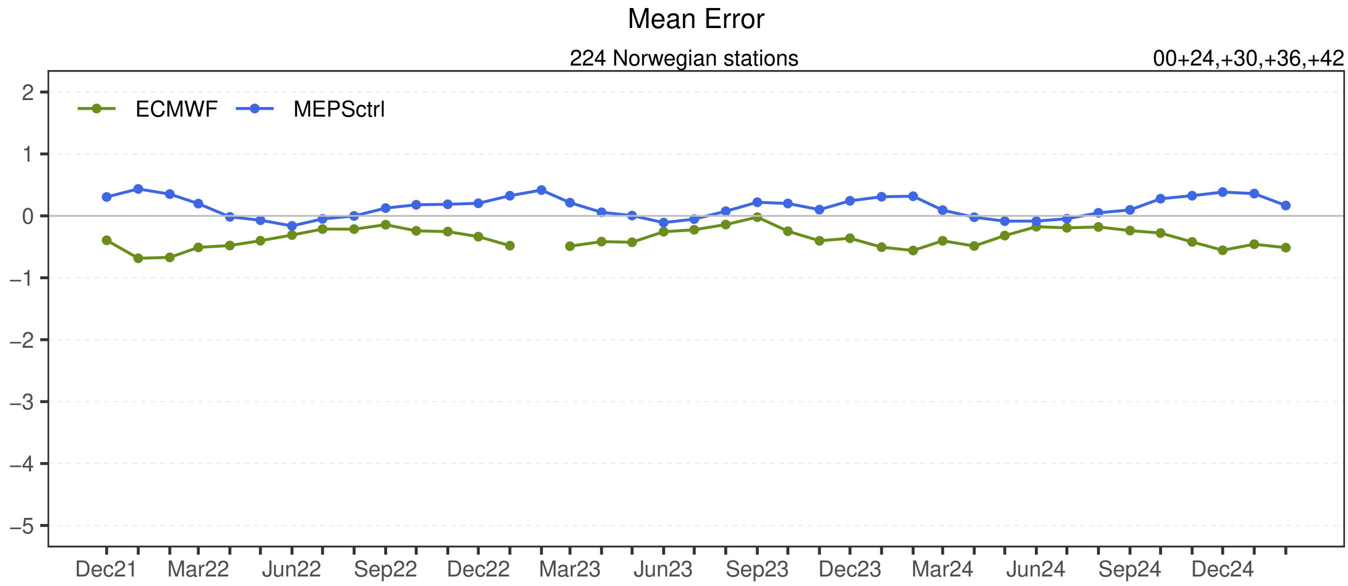

False Alarm Ratio
13 Svalbard stations
00+18,+24,+30,+36
Exceedance threshold (m/s)

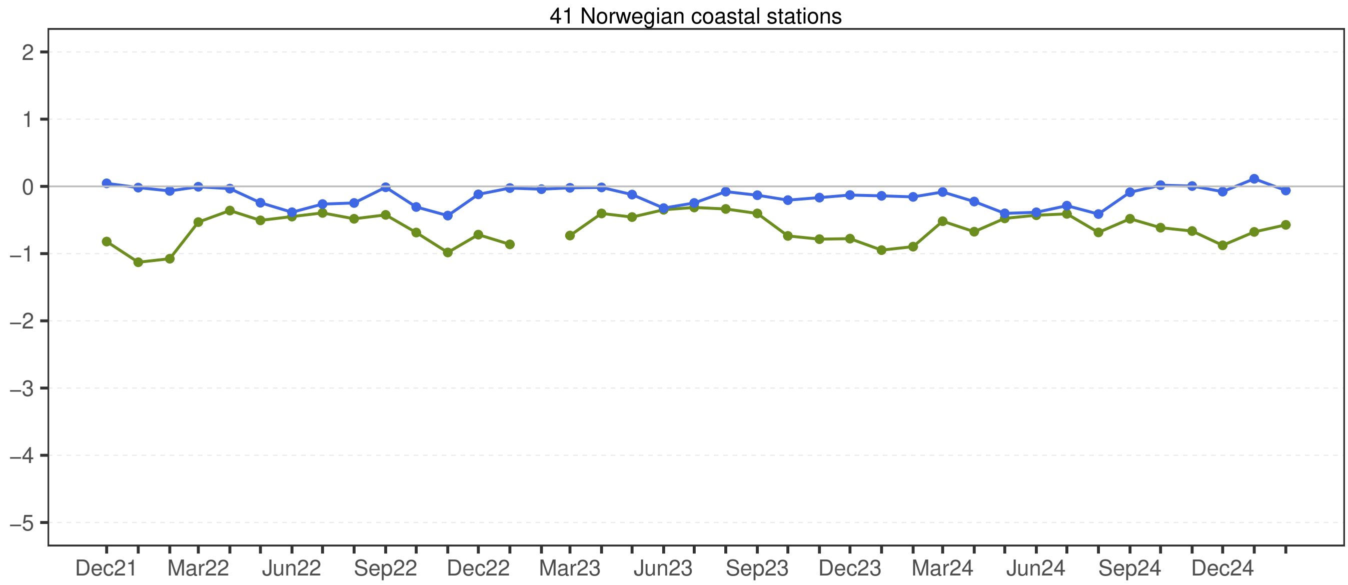

Equitable Threat Score
13 Svalbard stations
00+18,+24,+30,+36
AA25
ECMWF
Exceedance threshold (m/s)

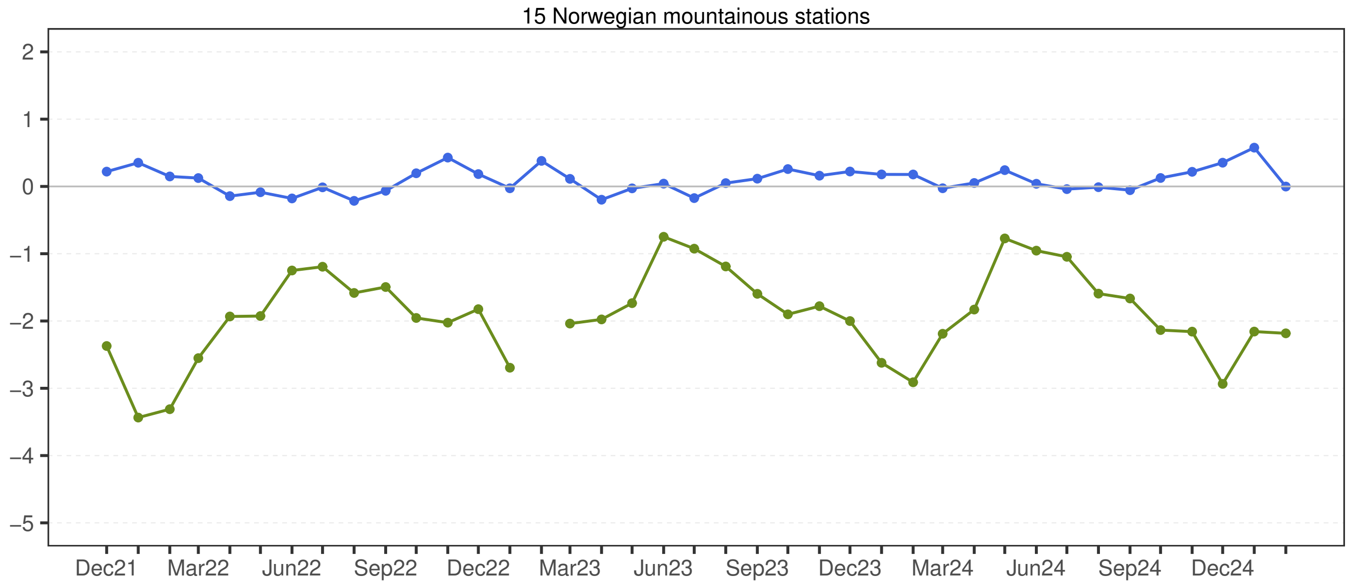

Kuiper Skill Score
13 Svalbard stations
00+18,+24,+30,+36
Exceedance threshold (m/s)

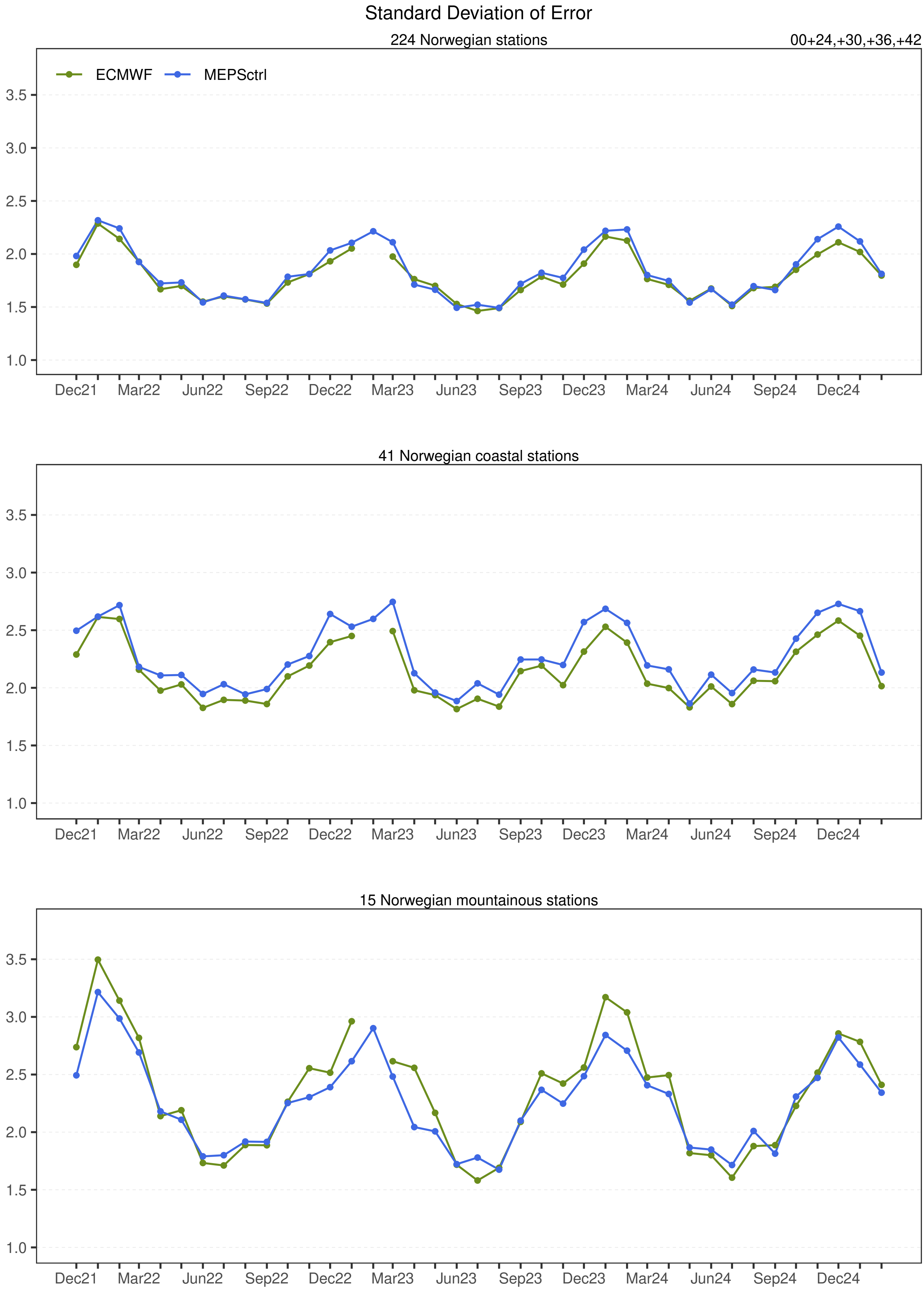

Heidke Skill Score
13 Svalbard stations
00+18,+24,+30,+36
Exceedance threshold (m/s)

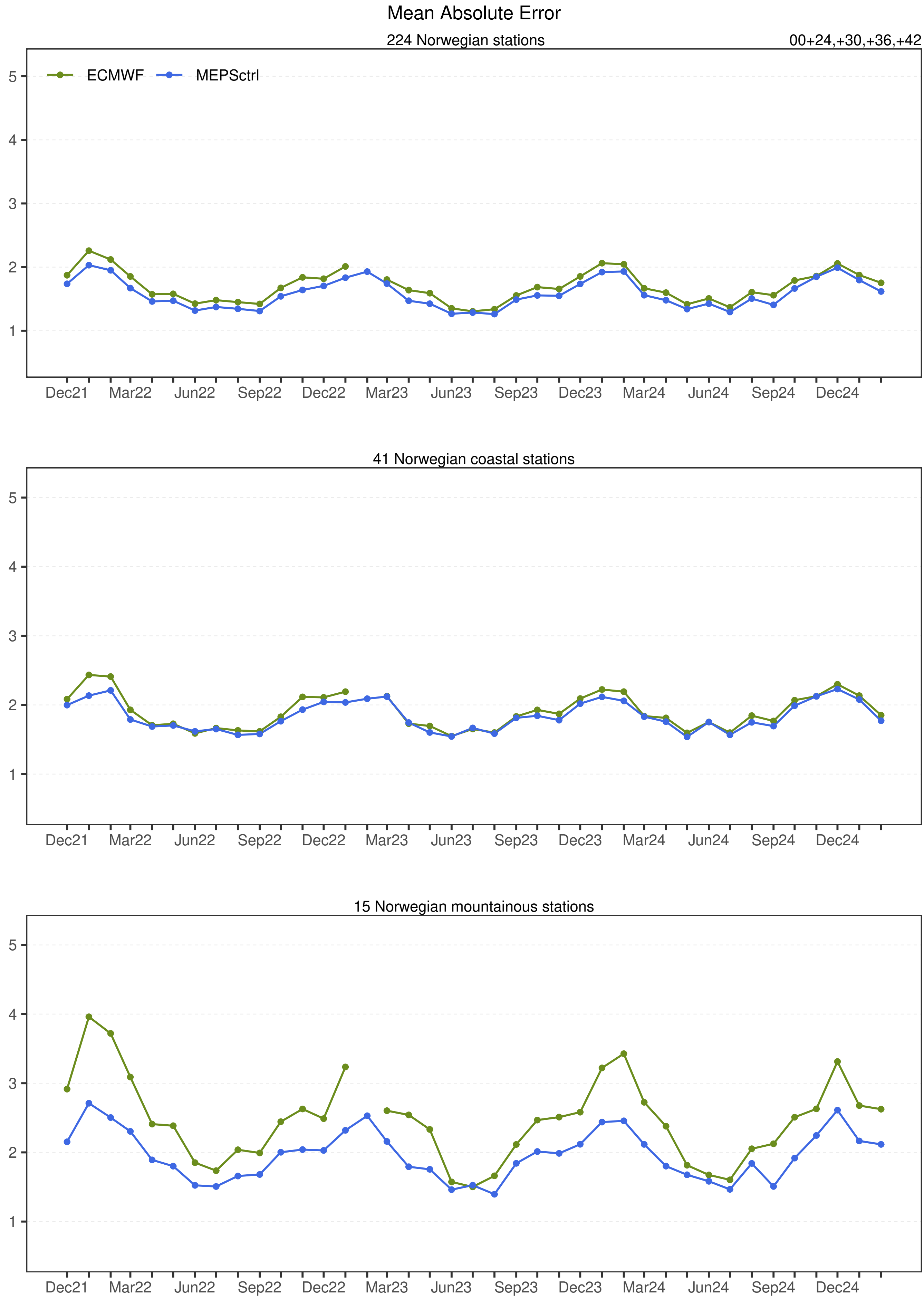

Mean Error
66 North Nor. stations
00+3,+6,..., +66
AA25
MEPSctrl
ECMWF
Lead time (hour)
Standard Deviation of Error
66 North Nor. stations
00+3,+6,..., +66
Lead time (hour)
Mean Absolute Error
66 North Nor. stations
00+3,+6,..., +66
Lead time (hour)
Hit Rate
66 North Nor. stations
00+18,+24,+30,+36
AA25
MEPSctrl
ECMWF
Exceedance threshold (m/s)
False Alarm Rate
66 North Nor. stations
00+18,+24,+30,+36
Exceedance threshold (m/s)
False Alarm Ratio
66 North Nor. stations
00+18,+24,+30,+36
Exceedance threshold (m/s)
Equitable Threat Score
66 North Nor. stations
00+18,+24,+30,+36
AA25
MEPSctrl
ECMWF
Exceedance threshold (m/s)
Kuiper Skill Score
66 North Nor. stations
00+18,+24,+30,+36
Exceedance threshold (m/s)
Heidke Skill Score
66 North Nor. stations
00+18,+24,+30,+36
Exceedance threshold (m/s)


Mean Error
224 Norwegian stations
00+24,+30,+36,+42
ECMWF
MEPSctrl
2
1
0
−1
−2
−3
−4
−5
Dec21 Mar22 Jun22 Sep22 Dec22 Mar23 Jun23 Sep23 Dec23 Mar24 Jun24 Sep24 Dec24


41 Norwegian coastal stations
2
1
0
−1
−2
−3
−4
−5
Dec21 Mar22 Jun22 Sep22 Dec22 Mar23 Jun23 Sep23 Dec23 Mar24 Jun24 Sep24 Dec24


15 Norwegian mountainous stations
2
1
0
−1
−2
−3
−4
−5
Dec21 Mar22 Jun22 Sep22 Dec22 Mar23 Jun23 Sep23 Dec23 Mar24 Jun24 Sep24 Dec24

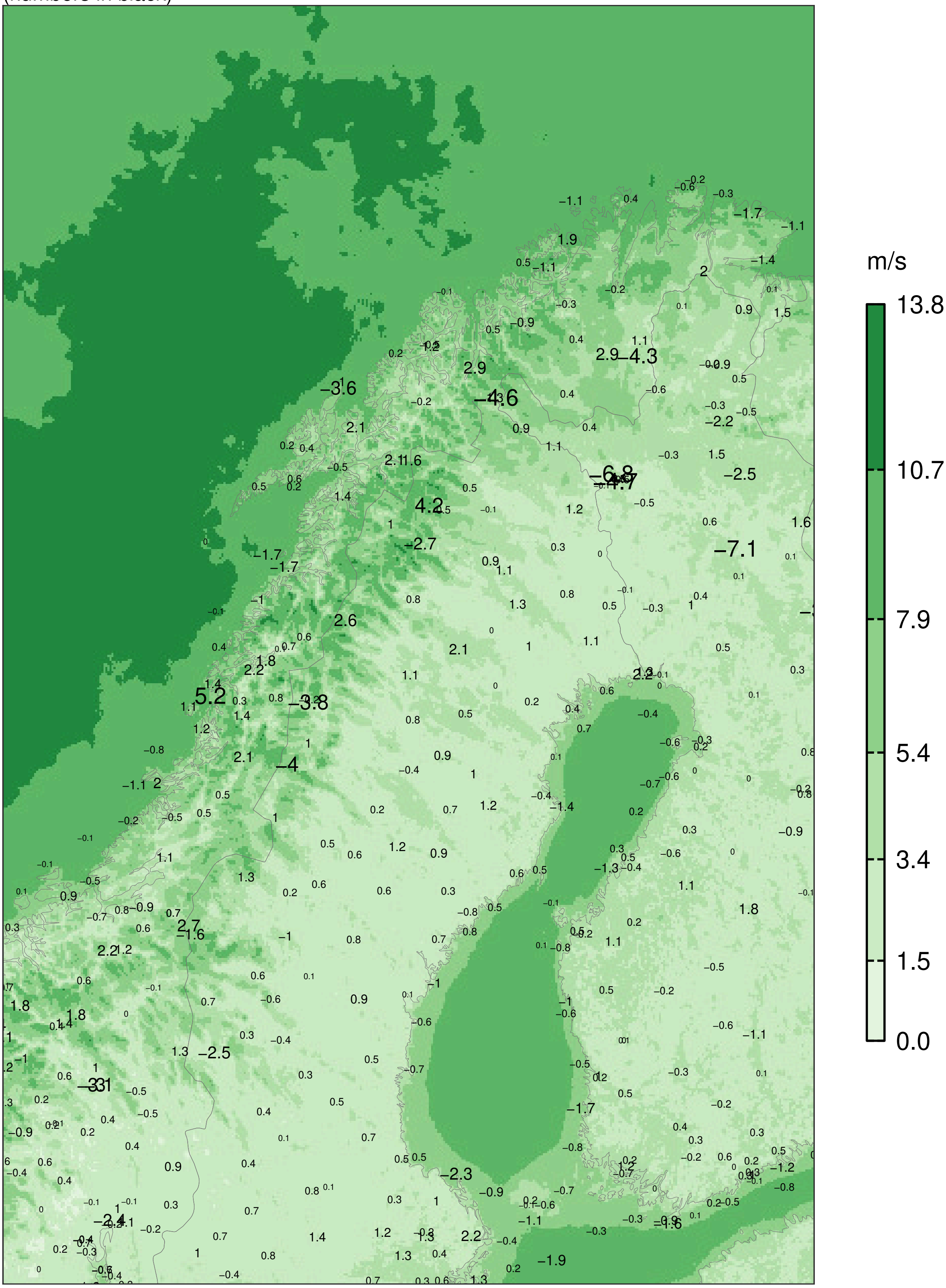

Standard Deviation of Error
224 Norwegian stations
00+24,+30,+36,+42
ECMWF
MEPSctrl
3.5
3.0
2.5
2.0
1.5
1.0
Dec21
Mar22
Jun22
Sep22
Dec22
Mar23
Jun23
Sep23
Dec23
Mar24
Jun24
Sep24
Dec24
41 Norwegian coastal stations
15 Norwegian mountainous stations



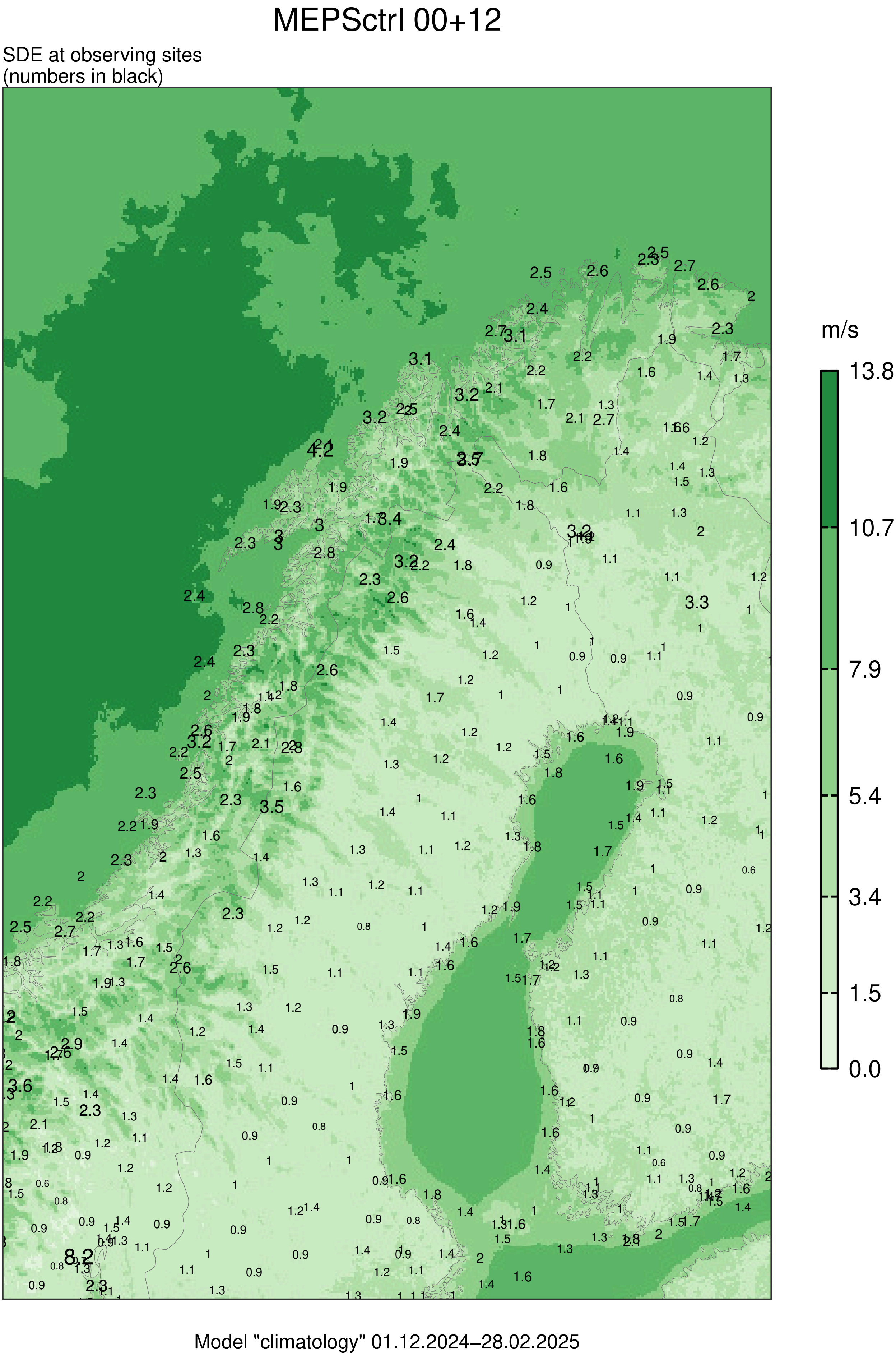
Mean Absolute Error
224 Norwegian stations
00+24,+30,+36,+42
ECMWF
MEPSctrl
5
4
3
2
1
Dec21
Mar22
Jun22
Sep22
Dec22
Mar23
Jun23
Sep23
Dec23
Mar24
Jun24
Sep24
Dec24
41 Norwegian coastal stations
15 Norwegian mountainous stations

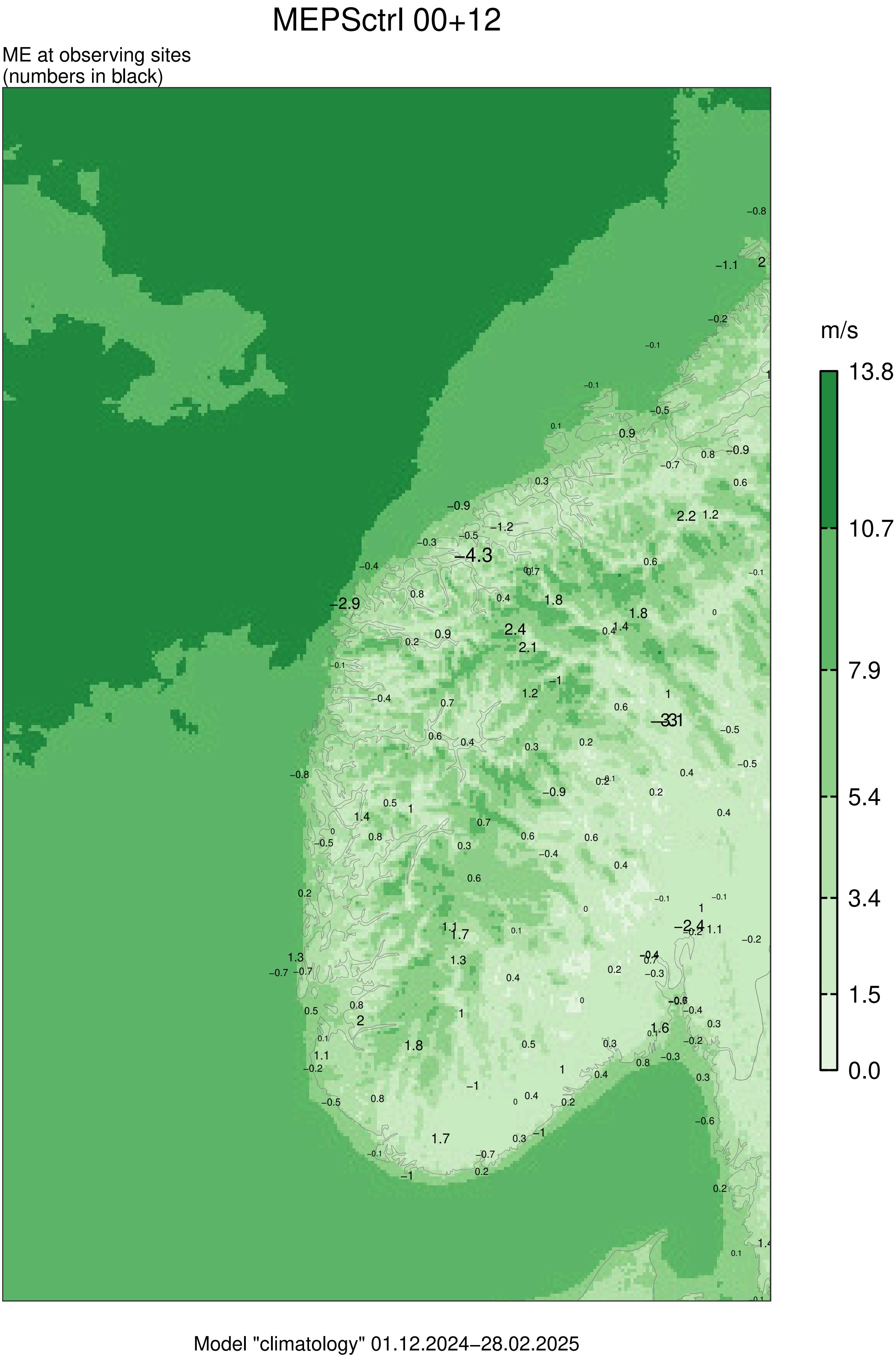
MEPSctrl 00+12

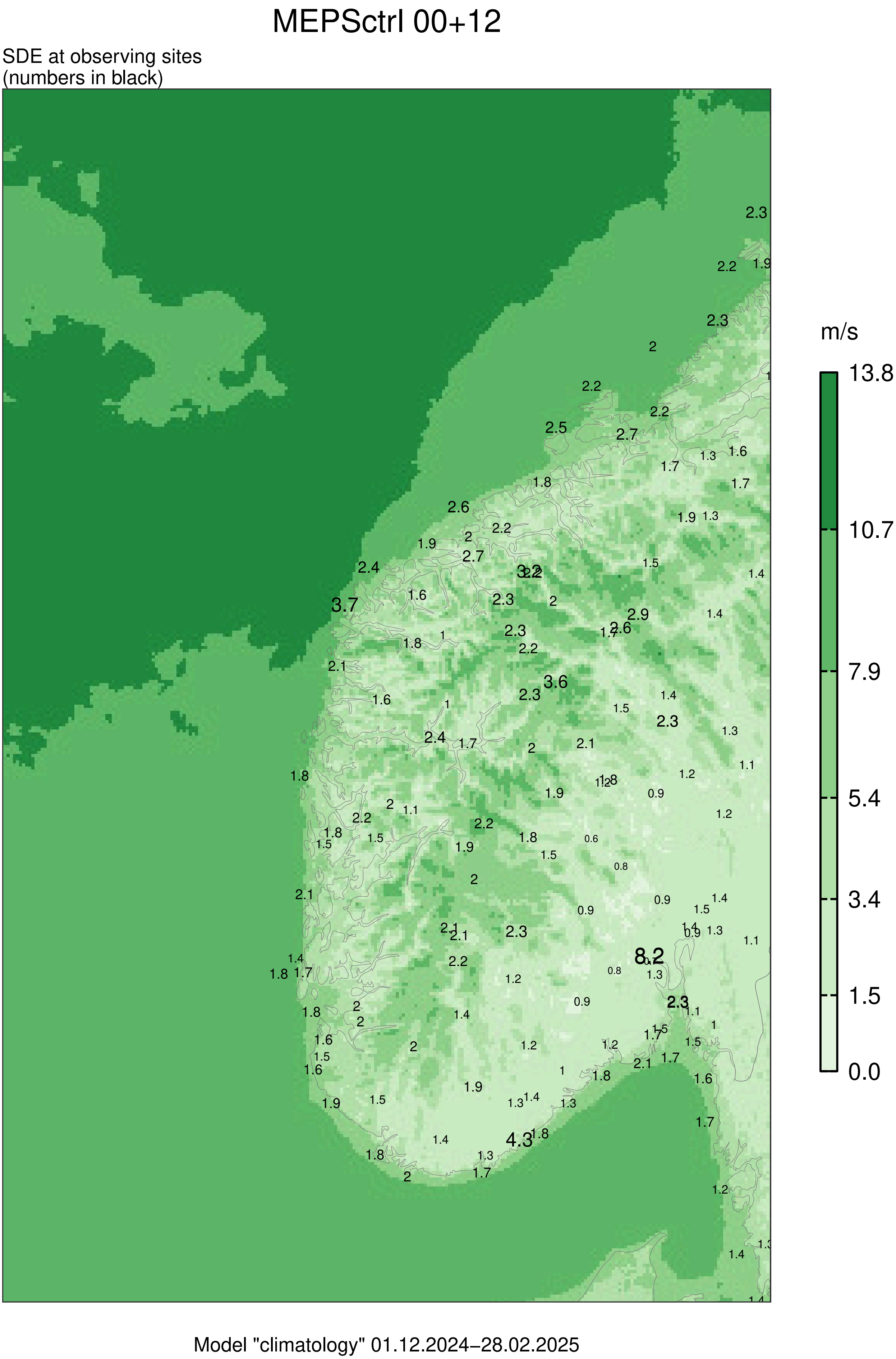
ME at observing sites
(numbers in black)

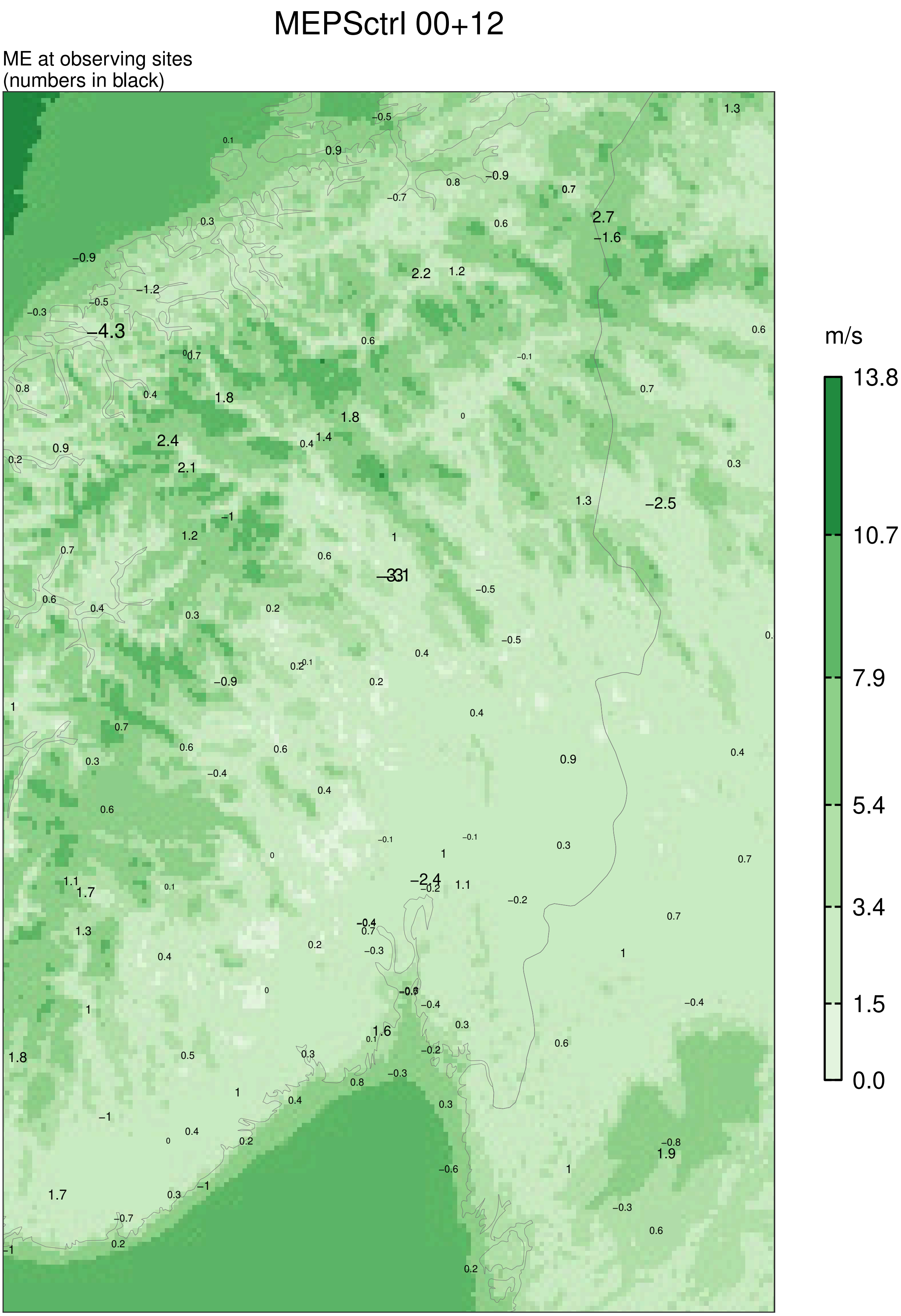


Model "climatology" 01.12.2024–28.02.2025

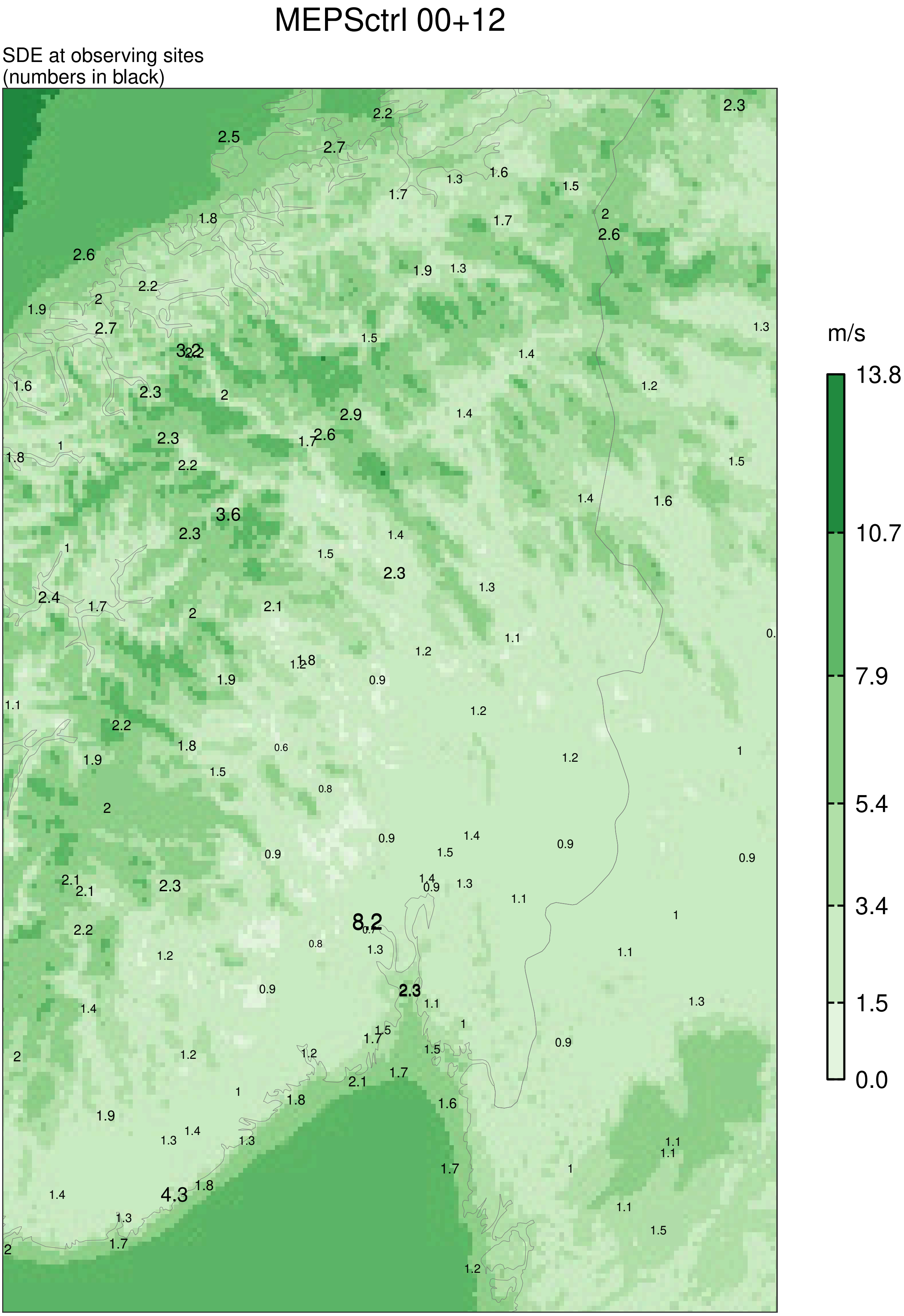

MEPSctrl 00+12
SDE at observing sites
(numbers in black)
m/s
13.8
10.7
7.9
5.4
3.4
1.5
0.0
Model "climatology" 01.12.2024–28.02.2025


MEPSctrl 00+12
ME at observing sites
(numbers in black)
m/s
13.8
10.7
7.9
5.4
3.4
1.5
0.0
Model "climatology" 01.12.2024–28.02.2025

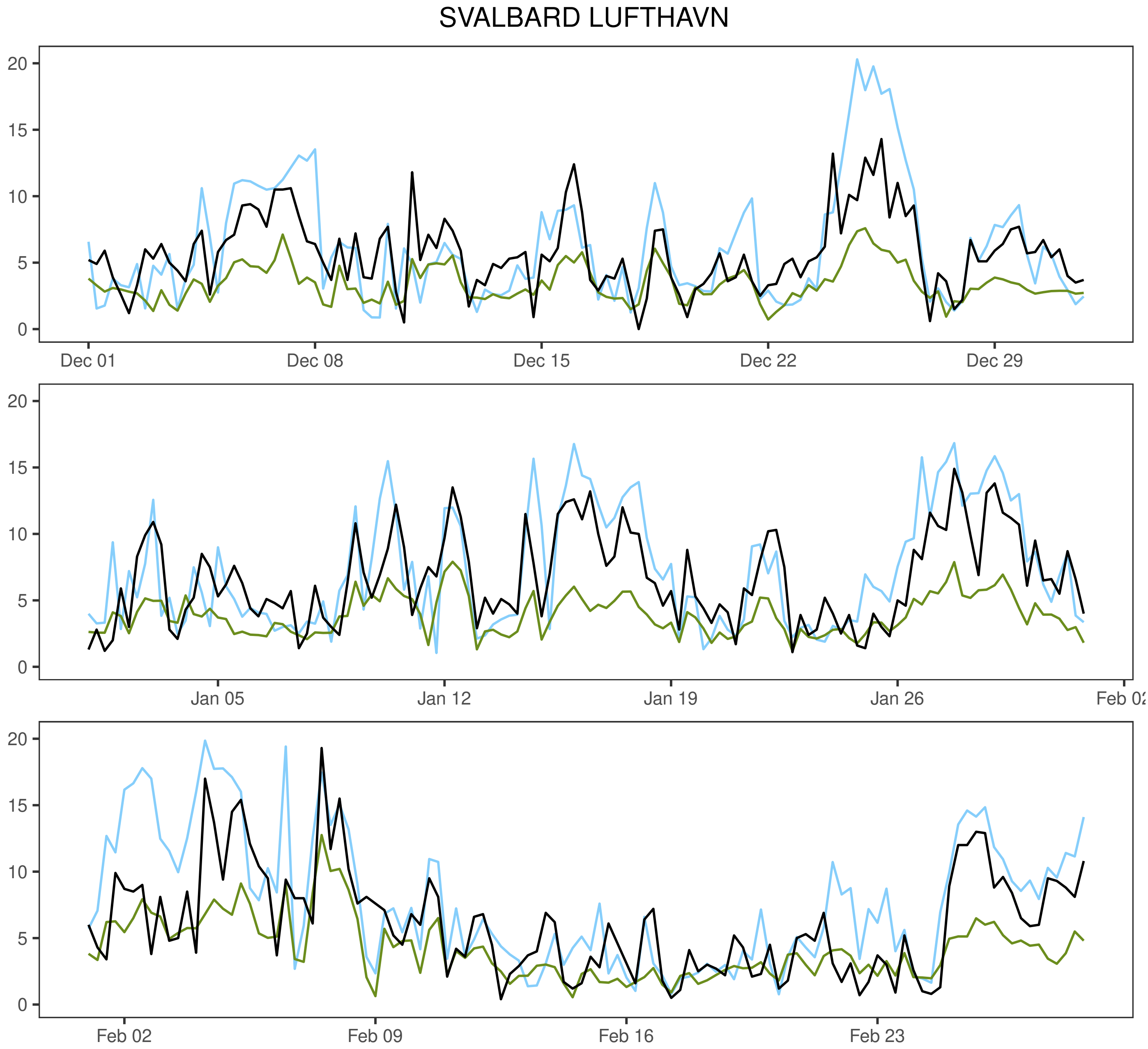

MEPSctrl 00+12
SDE at observing sites
(numbers in black)
m/s
13.8
10.7
7.9
5.4
3.4
1.5
0.0
Model "climatology" 01.12.2024–28.02.2025



Model "climatology" 01.12.2024–28.02.2025

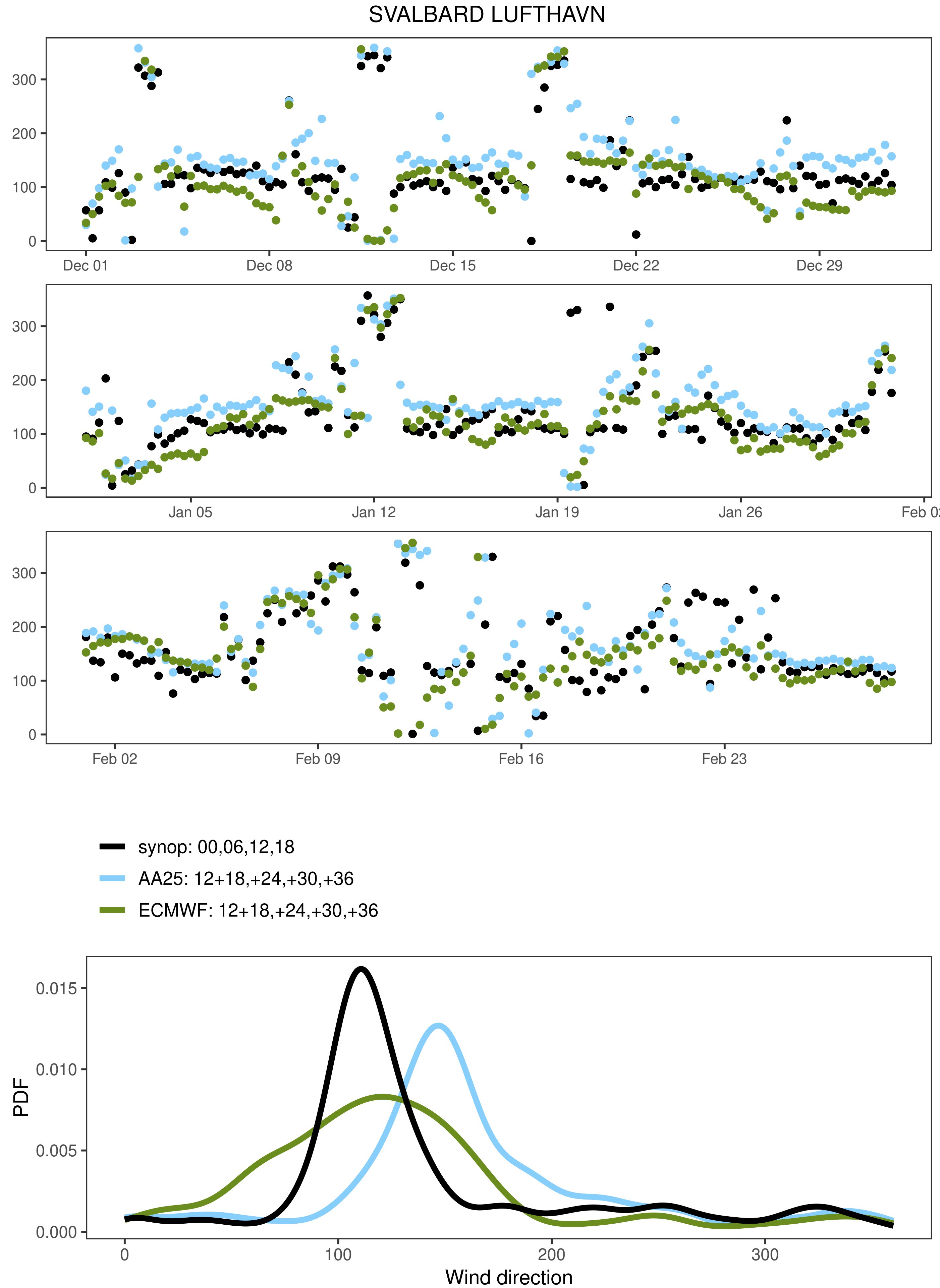


Model "climatology" 01.12.2024–28.02.2025

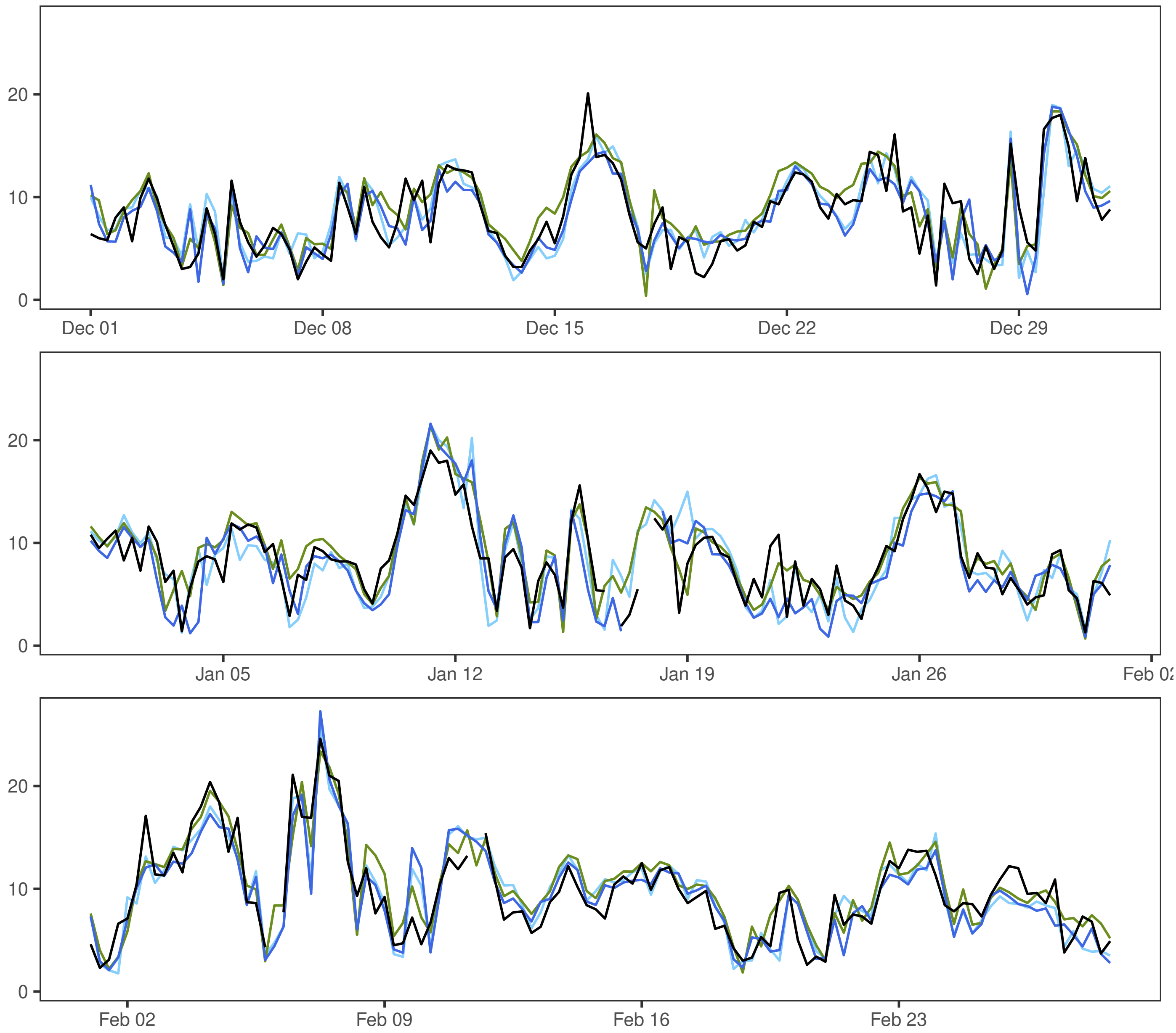


	Min	Mean	Max	Std	N
synop: 00,06,12,18	0.0	6.2	19.3	3.4	360
AA25: 12+18,+24,+30,+36	0.8	7.1	20.3	4.6	360
ECMWF: 12+18,+24,+30,+36	0.5	3.8	12.8	1.8	360

	ME	SDE	RMSE	MAE	Max.abs.err	N
AA25 – synop	0.9	3.1	3.3	2.5	13.2	360
ECMWF – synop	−2.3	2.4	3.3	2.7	10.2	360

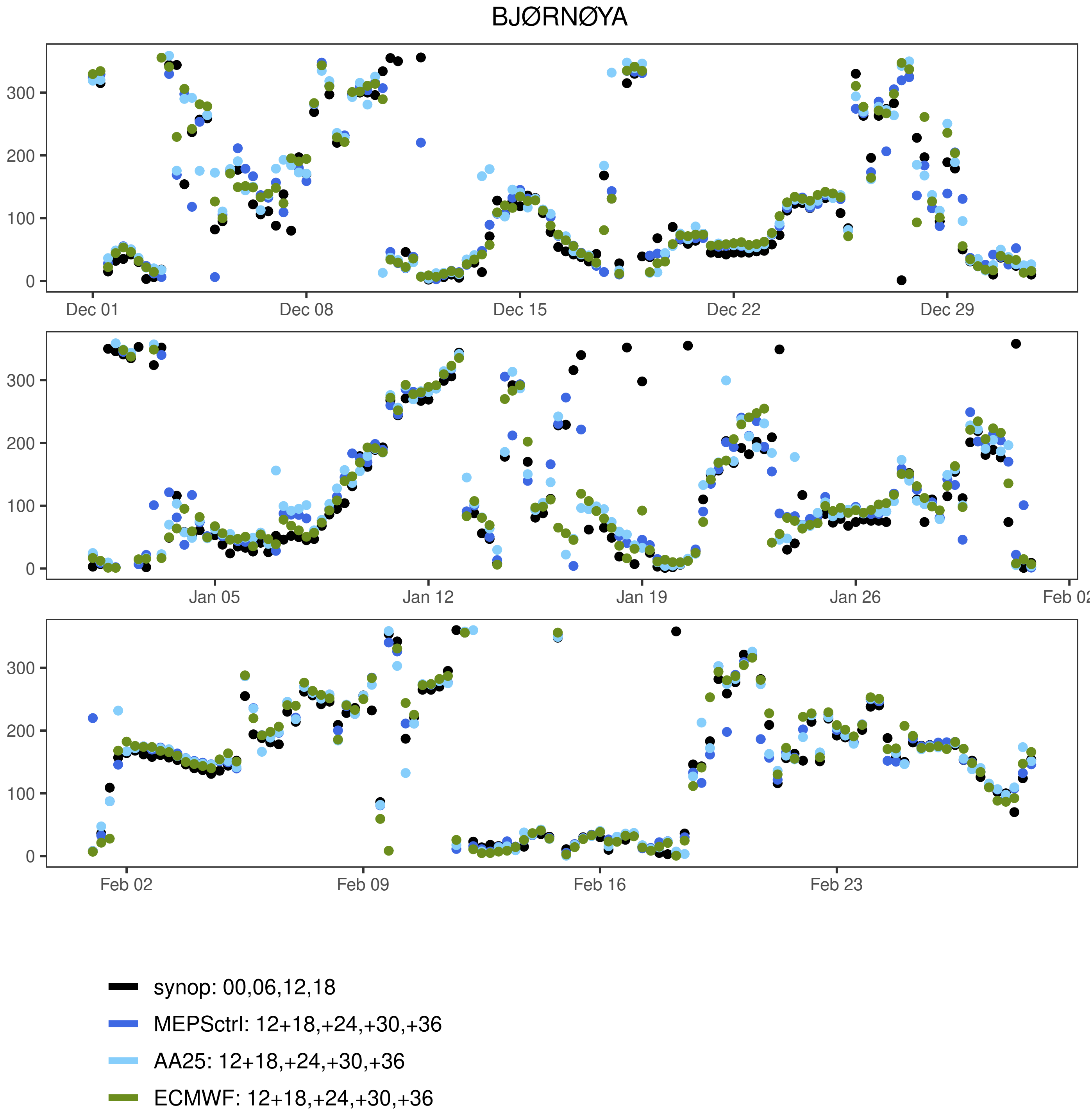

SVALBARD LUFTHAVN
300
200
100
0
Dec 01
Dec 08
Dec 15
Dec 22
Dec 29
Jan 05
Jan 12
Jan 19
Jan 26
Feb 02
Feb 09
Feb 16
Feb 23
synop: 00,06,12,18
AA25: 12+18,+24,+30,+36
ECMWF: 12+18,+24,+30,+36
PDF
0.015
0.010
0.005
0.000
0
100
200
300
Wind direction

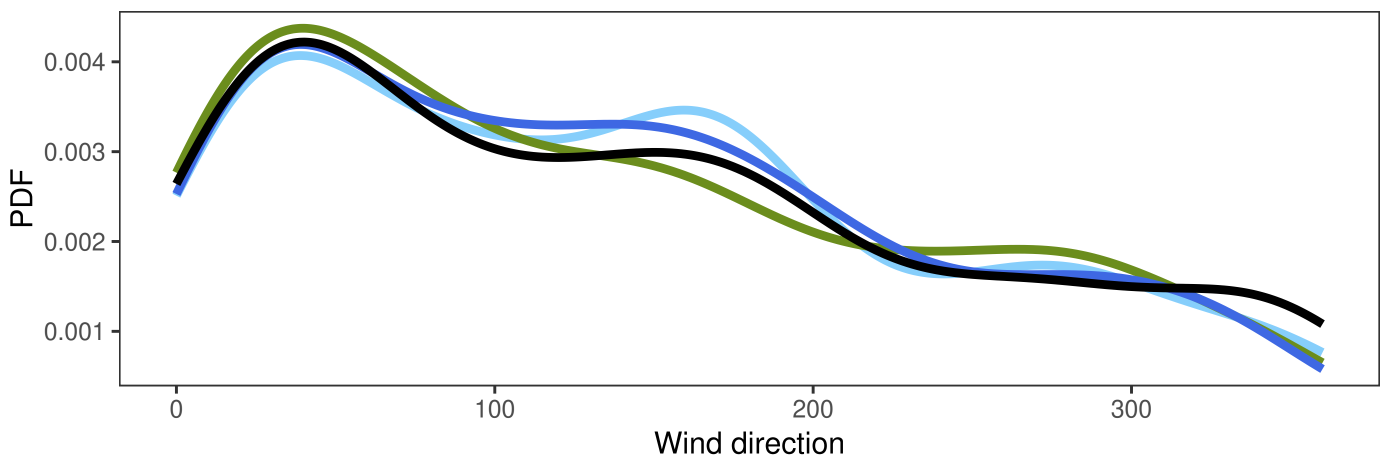
BJØRNØYA

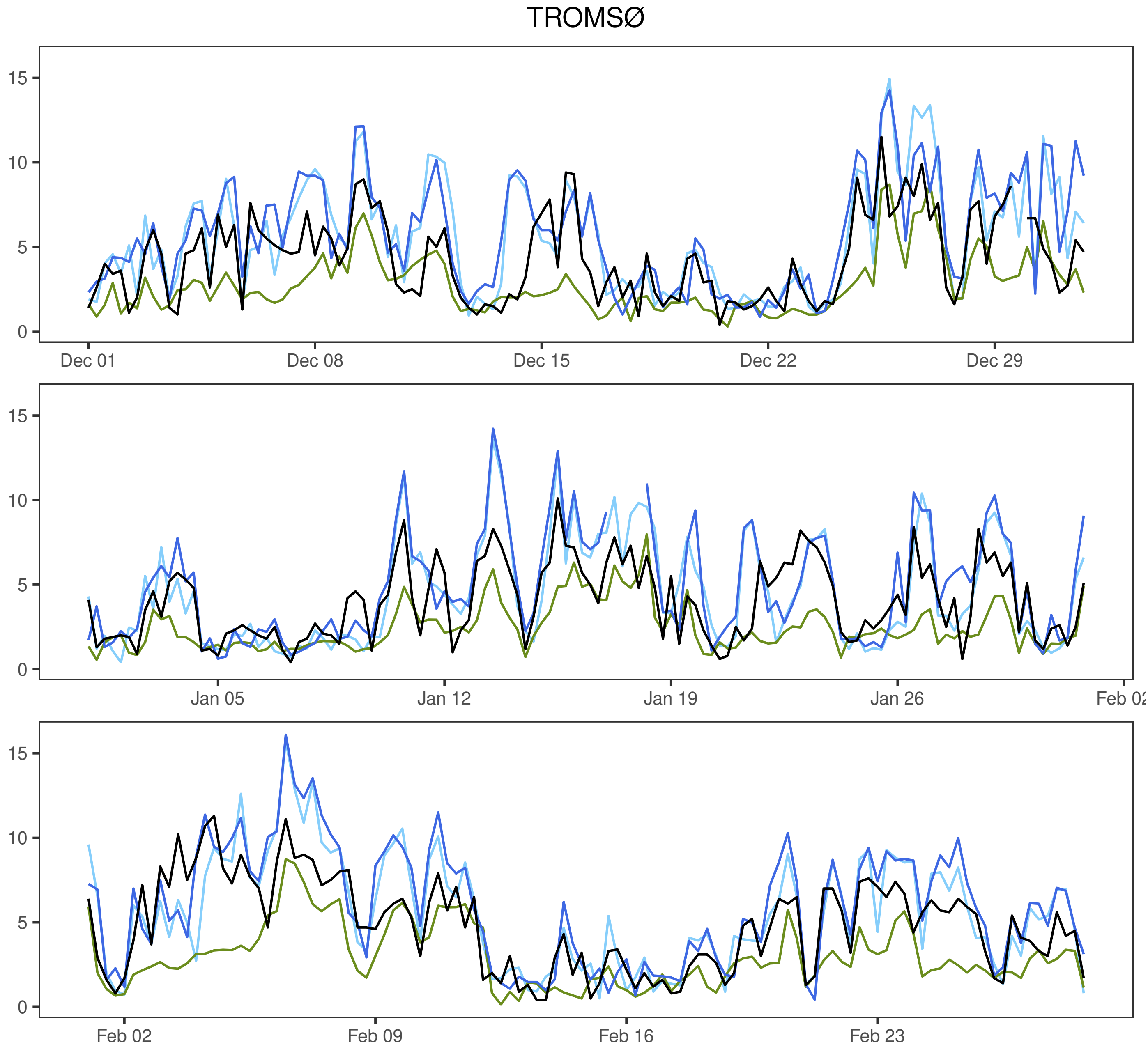


	Min	Mean	Max	Std	N
synop: 00,06,12,18	1.3	8.7	24.6	4.1	356
MEPSctrl: 12+18,+24,+30,+36	0.6	8.4	27.3	4.2	356
AA25: 12+18,+24,+30,+36	1.3	8.8	26.1	4.2	360
ECMWF: 12+18,+24,+30,+36	0.4	9.4	23.4	3.9	360

	ME	SDE	RMSE	MAE	Max.abs.err	N
MEPSctrl – synop	–0.3	2.4	2.4	1.8	8.0	353
AA25 – synop	0.0	2.4	2.4	1.8	9.6	353
ECMWF – synop	0.6	2.0	2.0	1.6	6.0	353

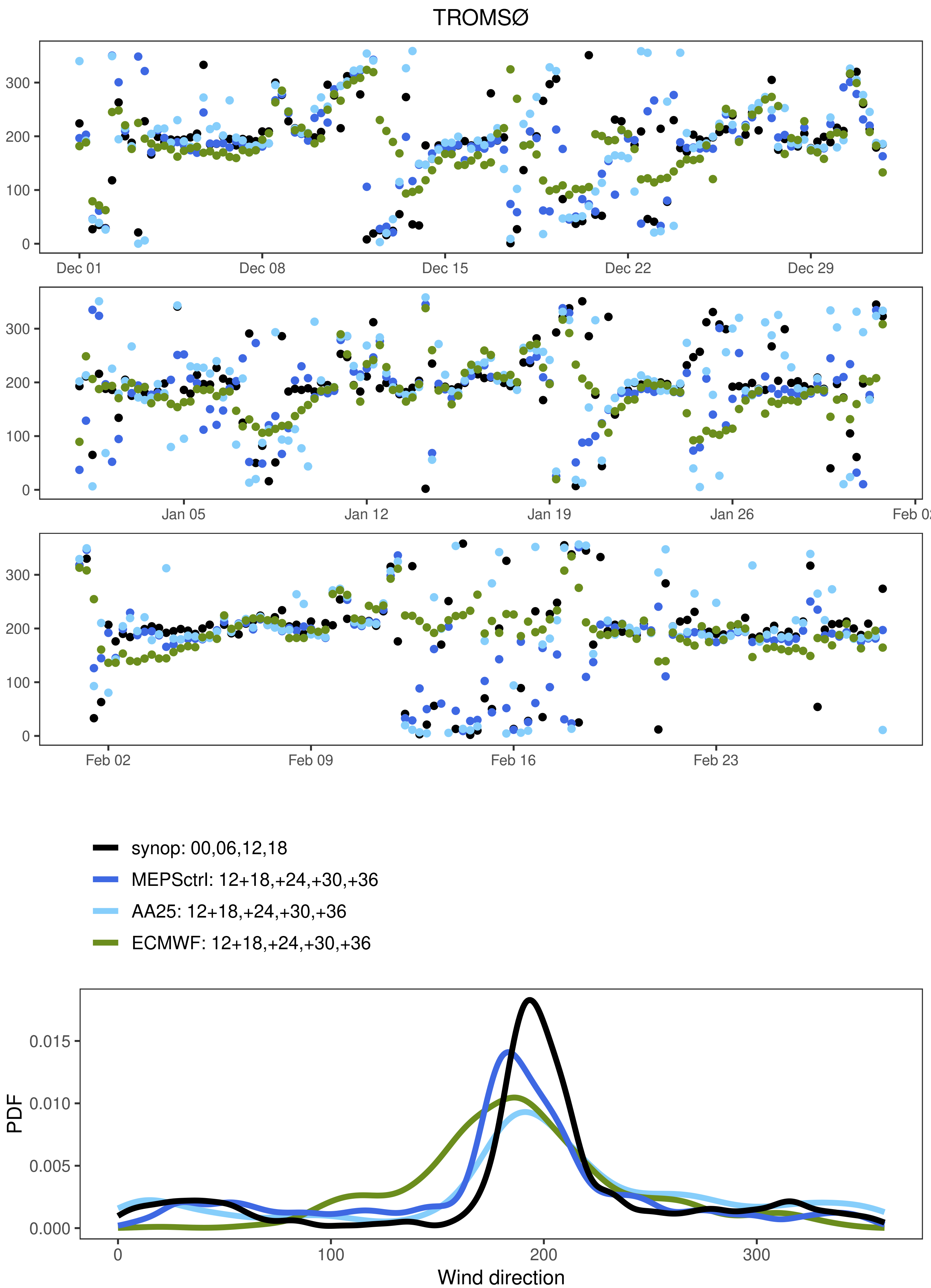

BJØRNØYA
300
200
100
0
Dec 01
Dec 08
Dec 15
Dec 22
Dec 29
Jan 05
Jan 12
Jan 19
Jan 26
Feb 02
Feb 09
Feb 16
Feb 23
synop: 00,06,12,18
MEPSctrl: 12+18,+24,+30,+36
AA25: 12+18,+24,+30,+36
ECMWF: 12+18,+24,+30,+36

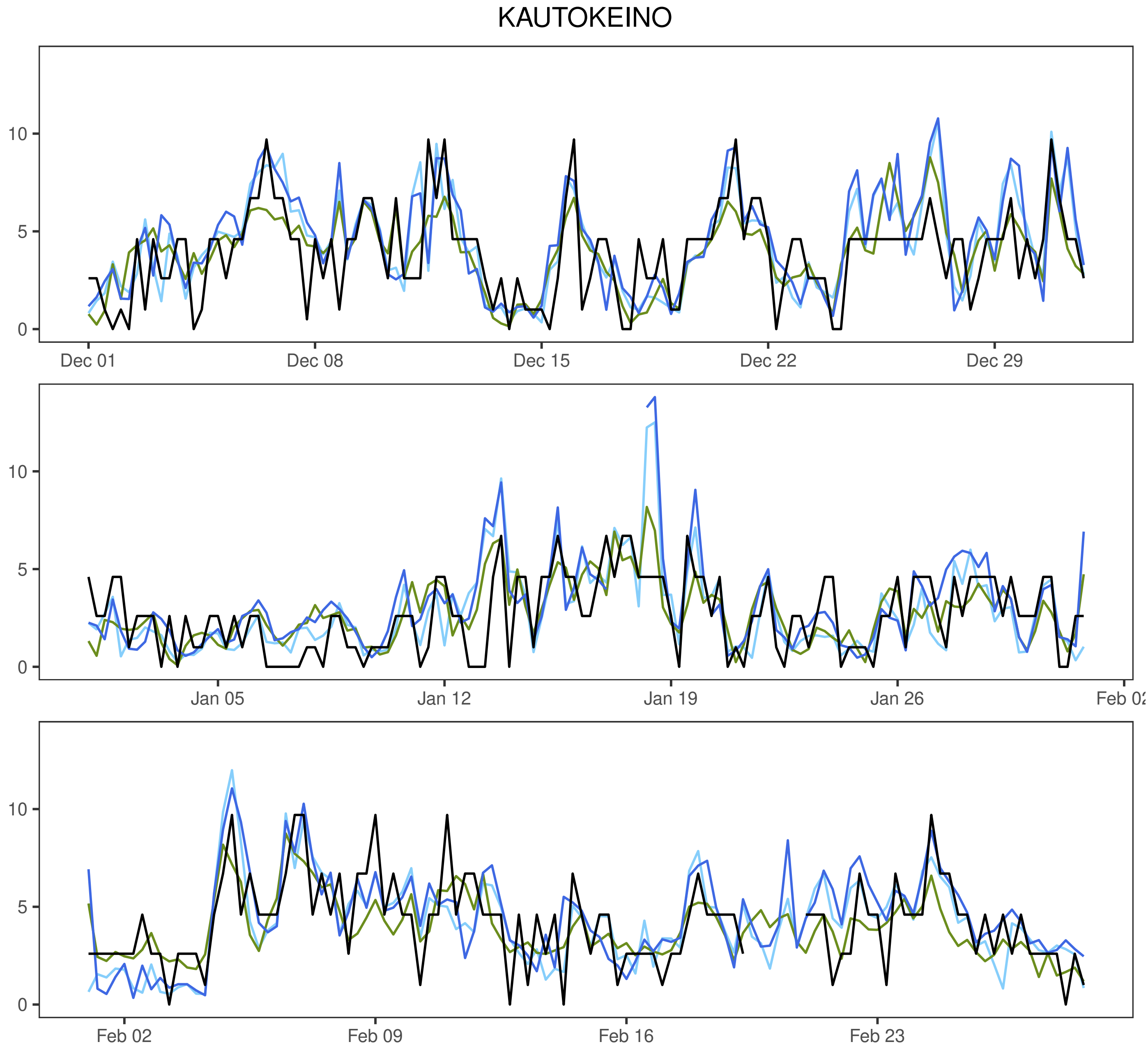

PDF
0.004
0.003
0.002
0.001
0
100
200
300
Wind direction



	Min	Mean	Max	Std	N
synop: 00,06,12,18	0.4	4.4	11.5	2.5	359
MEPSctrl: 12+18,+24,+30,+36	0.4	5.5	16.1	3.3	356
AA25: 12+18,+24,+30,+36	0.4	5.2	15.8	3.3	360
ECMWF: 12+18,+24,+30,+36	0.1	2.7	8.7	1.7	360

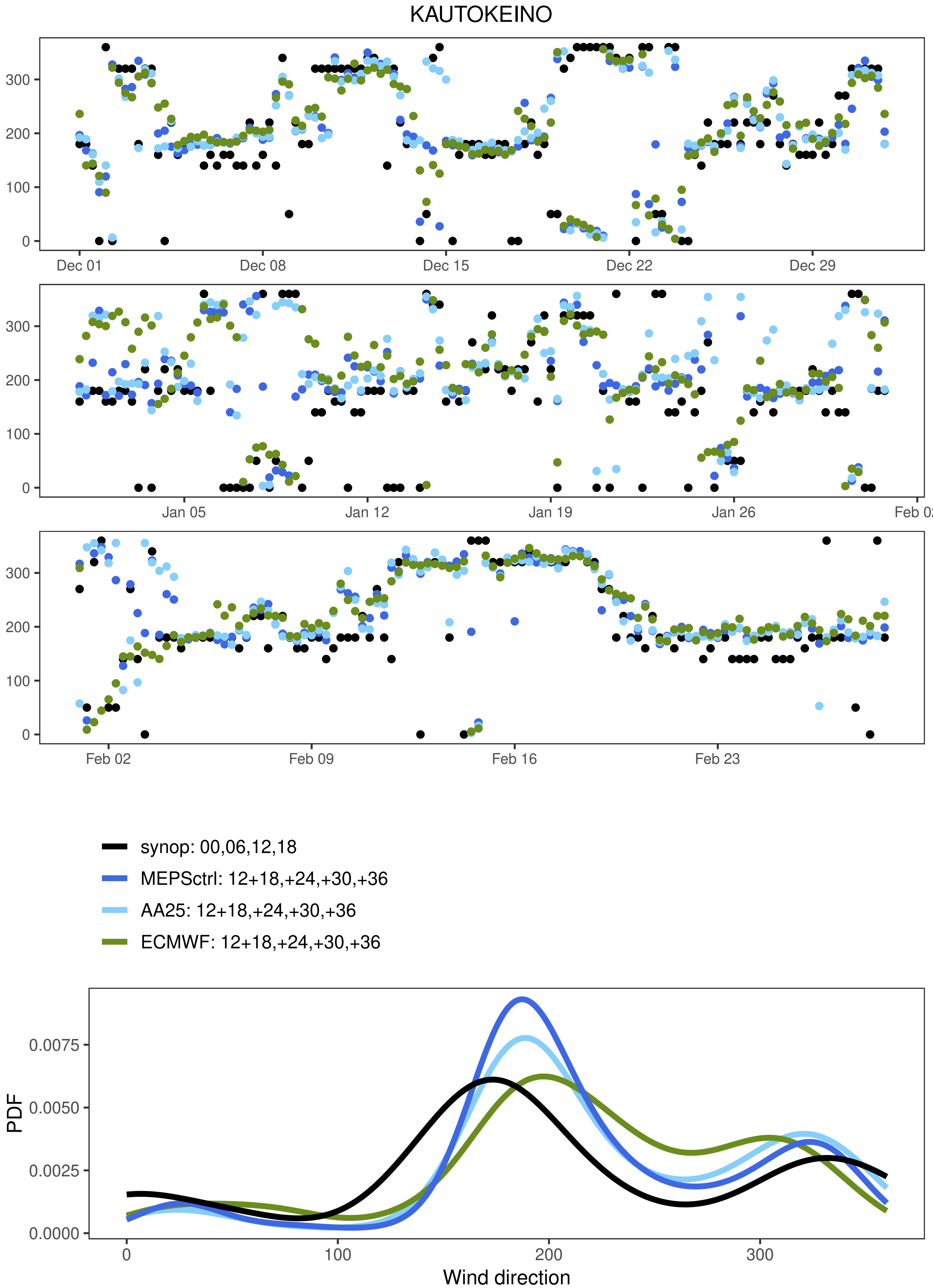
	ME	SDE	RMSE	MAE	Max.abs.err	N
MEPSctrl – synop	1.2	2.1	2.4	1.8	7.6	355
AA25 – synop	0.8	2.1	2.2	1.7	8.1	355
ECMWF – synop	−1.6	1.9	2.5	1.9	8.0	355

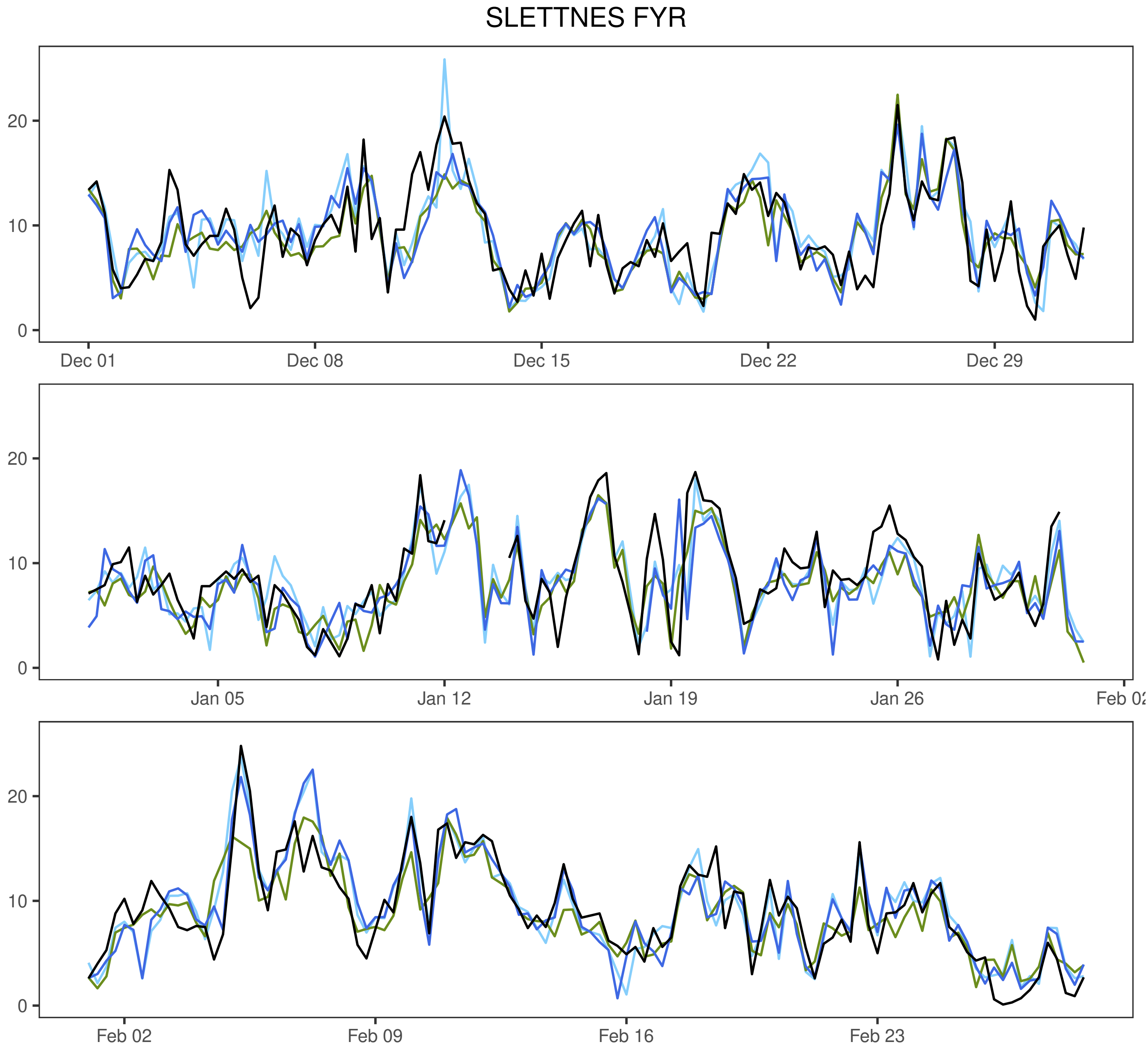

TROMSØ
300
200
100
0
Dec 01
Dec 08
Dec 15
Dec 22
Dec 29
Jan 05
Jan 12
Jan 19
Jan 26
Feb 02
Feb 09
Feb 16
Feb 23
synop: 00,06,12,18
MEPSctrl: 12+18,+24,+30,+36
AA25: 12+18,+24,+30,+36
ECMWF: 12+18,+24,+30,+36
PDF
0.015
0.010
0.005
0.000
0
100
200
300
Wind direction



	Min	Mean	Max	Std	N
synop: 00,06,12,18	0.0	3.5	9.7	2.3	355
MEPSctrl: 12+18,+24,+30,+36	0.3	4.1	13.8	2.5	356
AA25: 12+18,+24,+30,+36	0.2	3.8	12.5	2.4	360
ECMWF: 12+18,+24,+30,+36	0.1	3.5	8.8	1.8	360

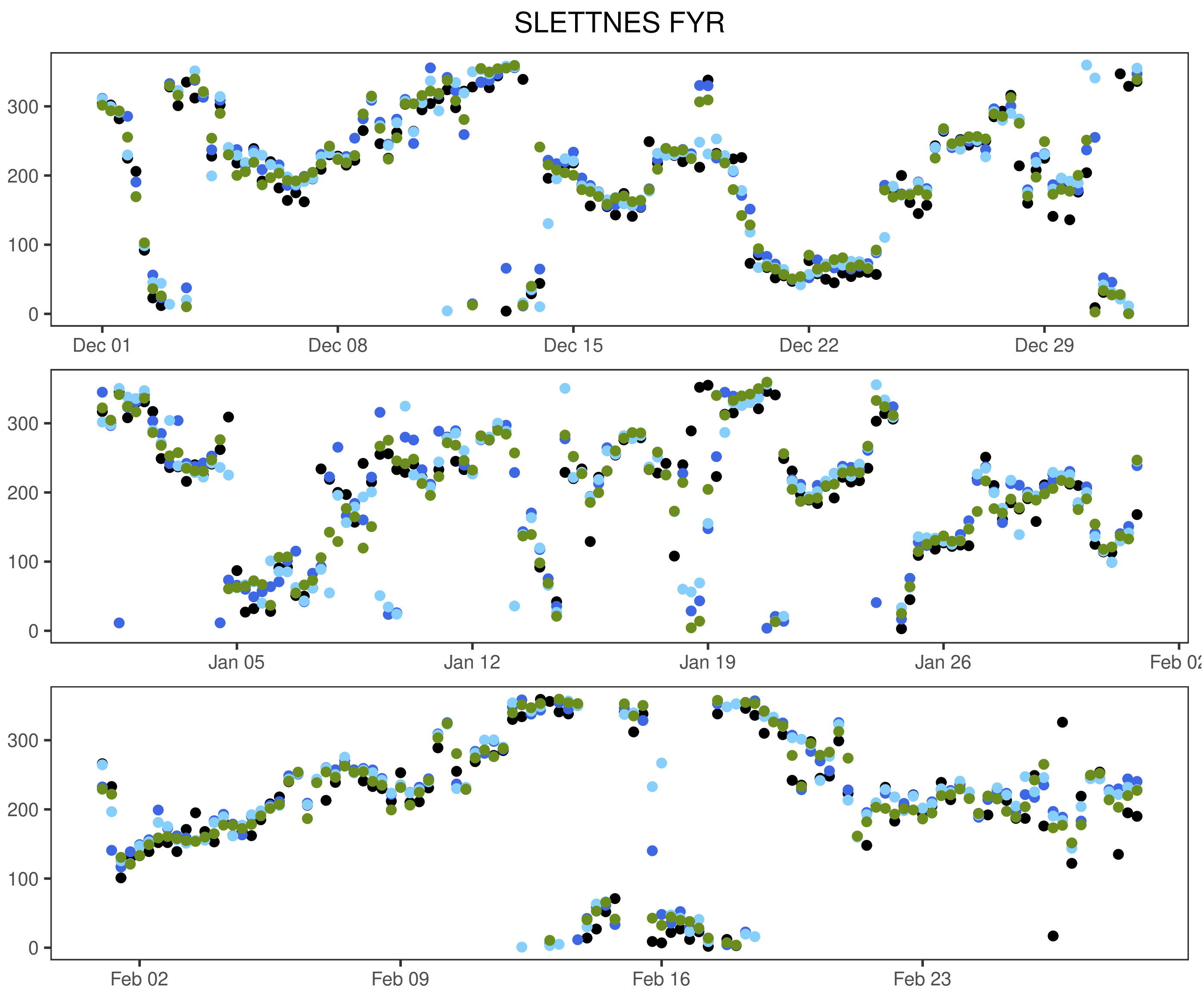
	ME	SDE	RMSE	MAE	Max.abs.err	N
MEPSctrl – synop	0.5	2.1	2.2	1.6	9.2	351
AA25 – synop	0.2	2.0	2.0	1.5	7.9	351
ECMWF – synop	0.0	1.7	1.7	1.3	5.5	351

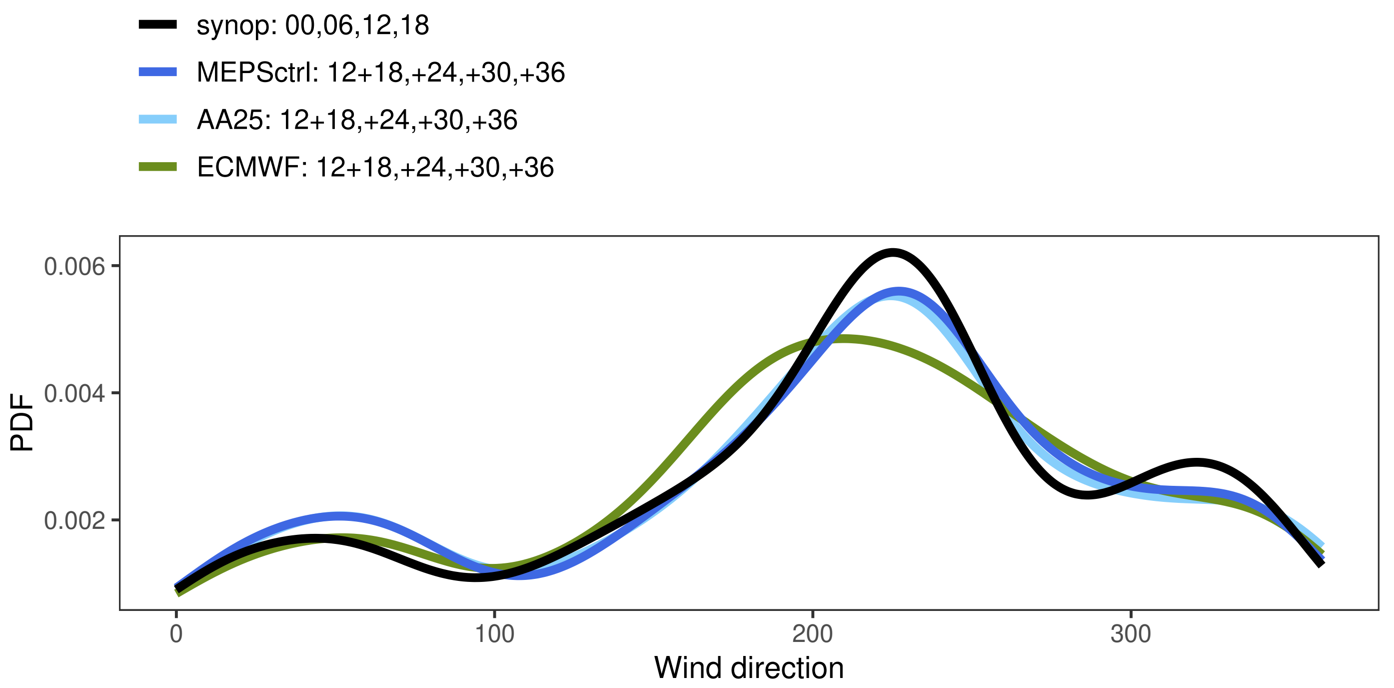

KAUTOKEINO
0
100
200
300
Dec 01
Dec 08
Dec 15
Dec 22
Dec 29
Jan 05
Jan 12
Jan 19
Jan 26
Feb 02
Feb 09
Feb 16
Feb 23
synop: 00,06,12,18
MEPSctrl: 12+18,+24,+30,+36
AA25: 12+18,+24,+30,+36
ECMWF: 12+18,+24,+30,+36
PDF
0.0000
0.0025
0.0050
0.0075
Wind direction

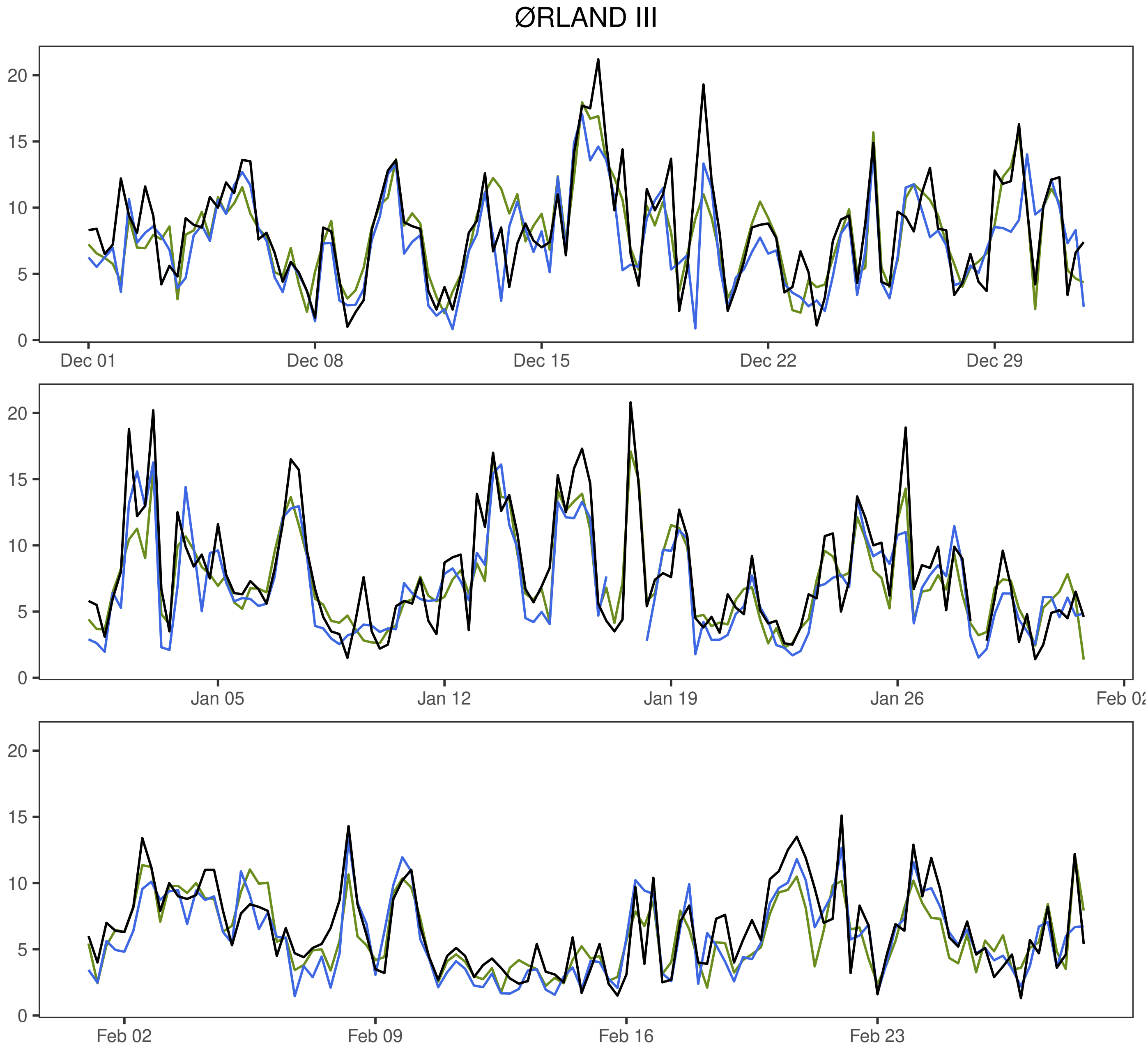


	Min	Mean	Max	Std	N
synop: 00,06,12,18	0.1	8.9	24.8	4.4	351
MEPSctrl: 12+18,+24,+30,+36	0.7	8.9	22.5	4.1	356
AA25: 12+18,+24,+30,+36	1.1	9.1	25.9	4.3	360
ECMWF: 12+18,+24,+30,+36	0.5	8.4	22.5	3.6	360

	ME	SDE	RMSE	MAE	Max.abs.err	N
MEPSctrl – synop	–0.1	2.9	2.9	2.1	14.9	347
AA25 – synop	0.1	2.7	2.7	2.0	10.3	347
ECMWF – synop	–0.5	2.6	2.6	2.0	9.2	347

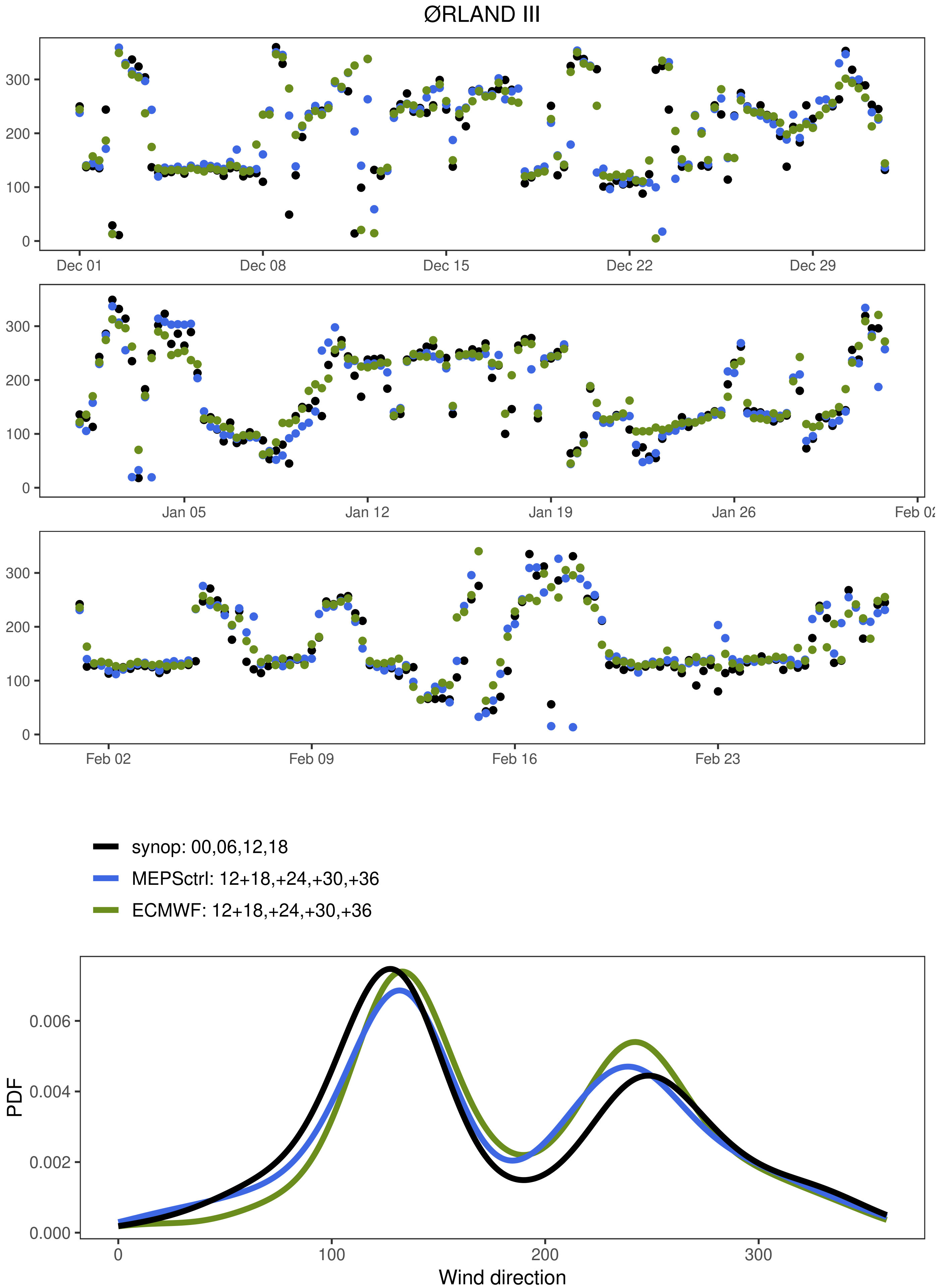

SLETTNES FYR
0
100
200
300
Dec 01
Dec 08
Dec 15
Dec 22
Dec 29
Jan 05
Jan 12
Jan 19
Jan 26
Feb 02
Feb 09
Feb 16
Feb 23

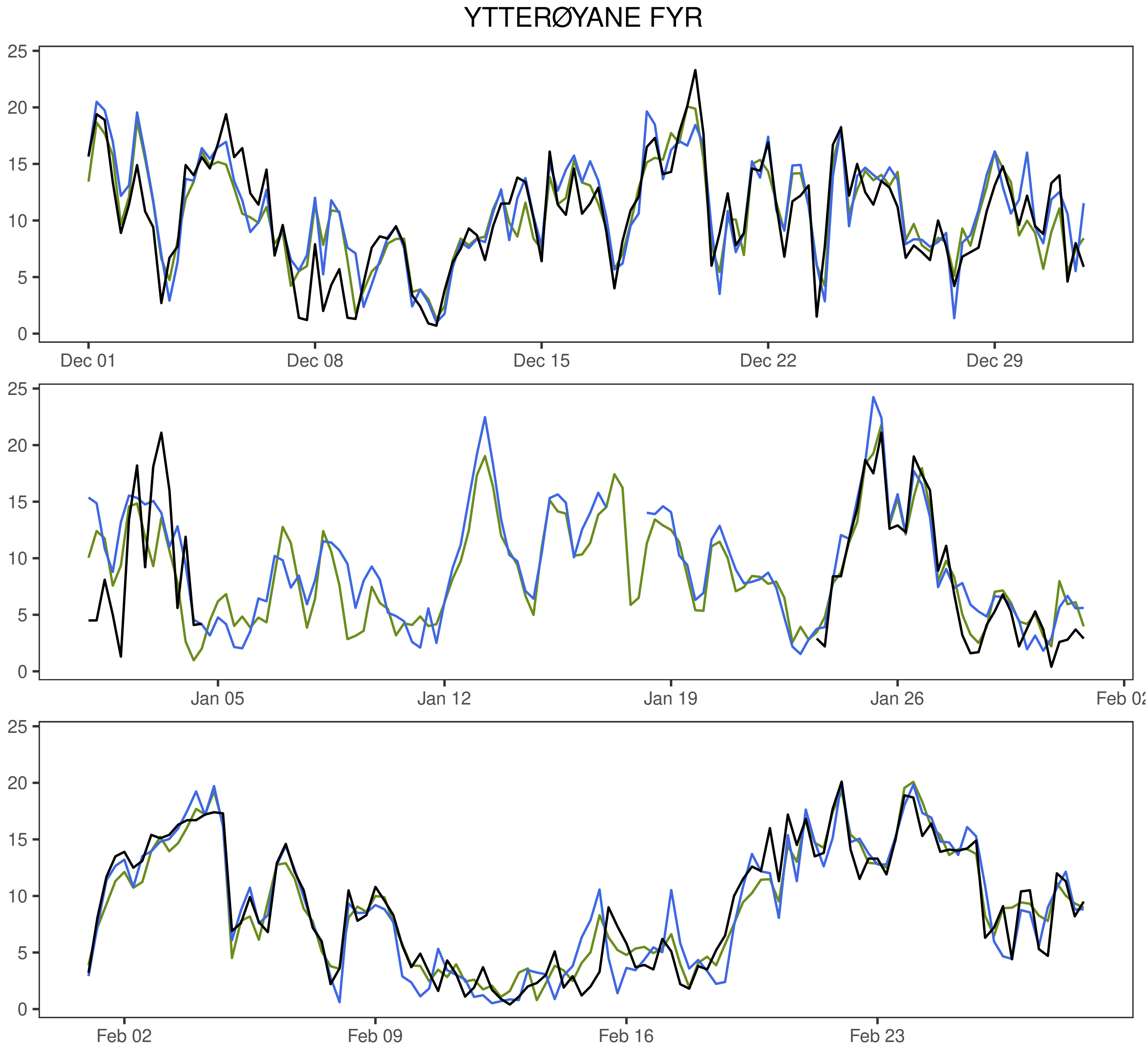

synop: 00,06,12,18
MEPSctrl: 12+18,+24,+30,+36
AA25: 12+18,+24,+30,+36
ECMWF: 12+18,+24,+30,+36
PDF
0.002
0.004
0.006
0
100
200
300
Wind direction



	Min	Mean	Max	Std	N
synop: 00,06,12,18	1.0	7.6	21.2	3.9	359
MEPSctrl: 12+18,+24,+30,+36	0.8	6.7	17.1	3.4	356
ECMWF: 12+18,+24,+30,+36	1.4	7.1	18.0	3.2	360

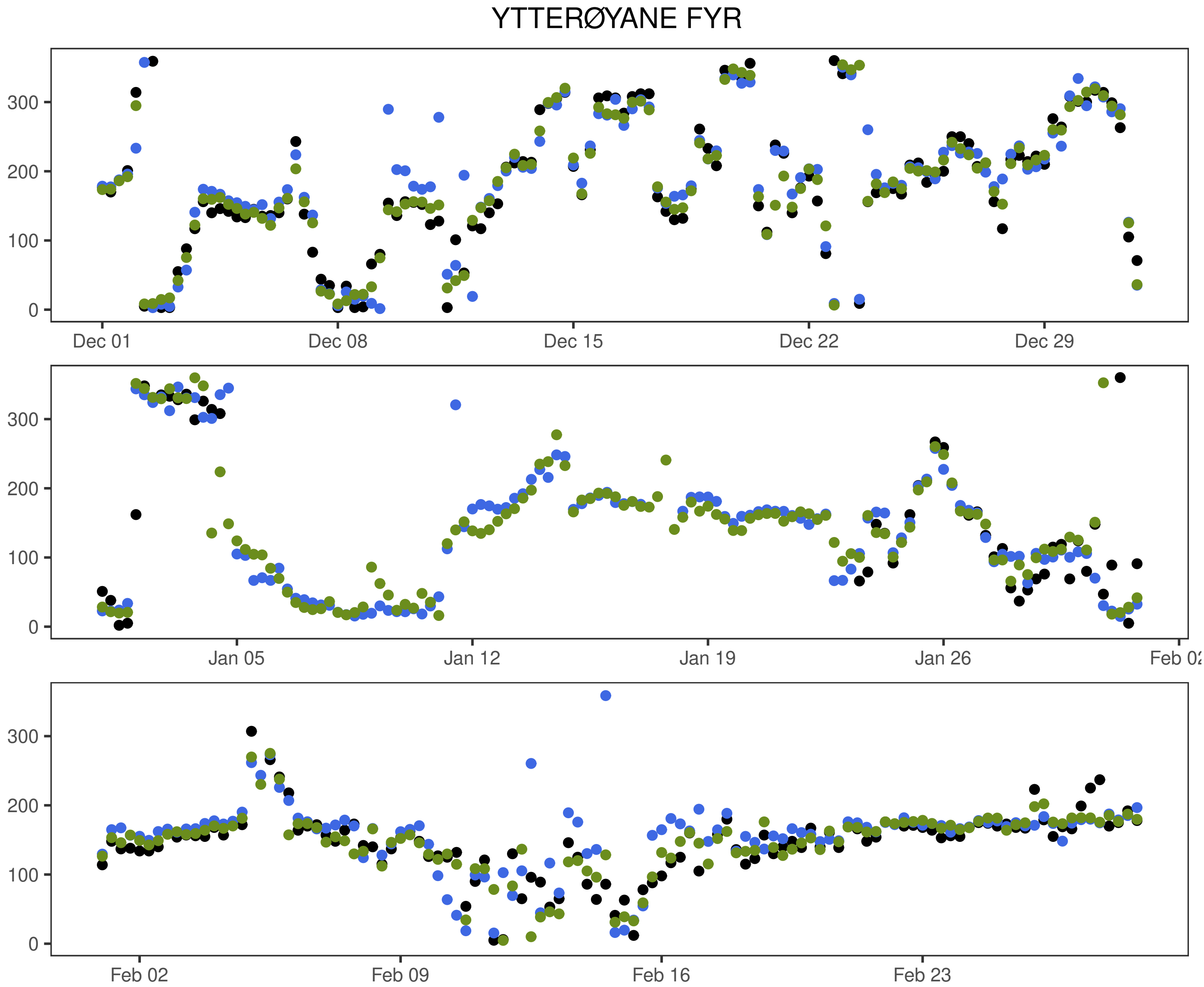
	ME	SDE	RMSE	MAE	Max.abs.err	N
MEPSctrl – synop	–0.8	2.2	2.3	1.7	11.2	355
ECMWF – synop	–0.5	2.0	2.1	1.6	8.4	355

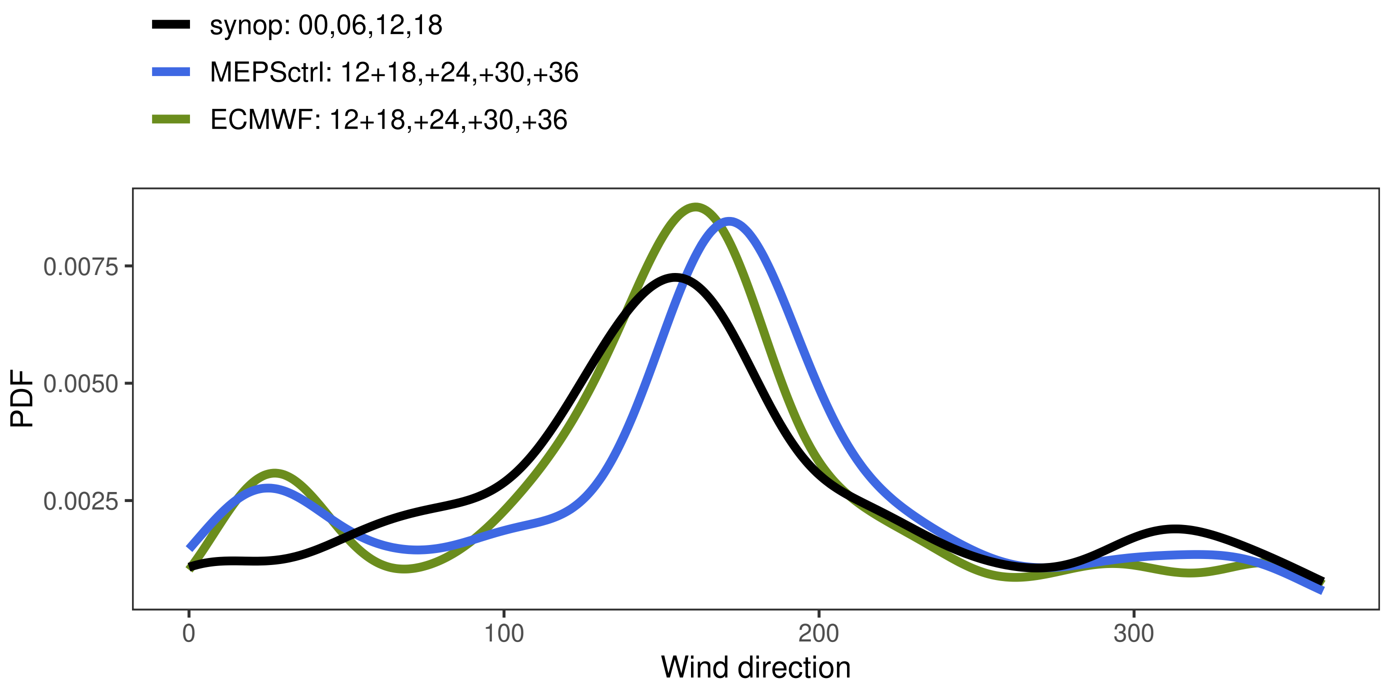

ØRLAND III
Dec 01
Dec 08
Dec 15
Dec 22
Dec 29
Jan 05
Jan 12
Jan 19
Jan 26
Feb 02
Feb 09
Feb 16
Feb 23
synop: 00,06,12,18
MEPSctrl: 12+18,+24,+30,+36
ECMWF: 12+18,+24,+30,+36
PDF
Wind direction

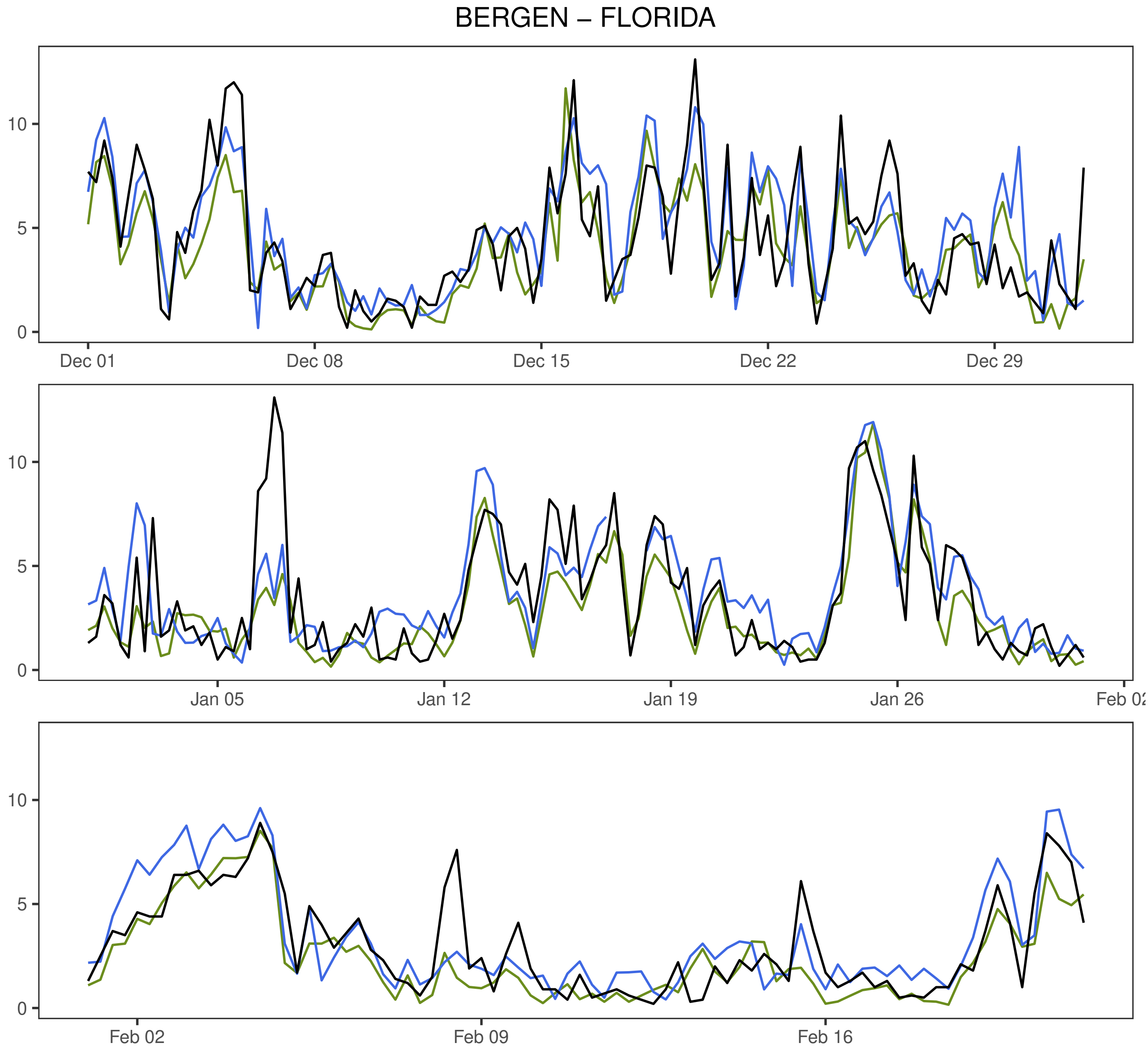


	Min	Mean	Max	Std	N
synop: 00,06,12,18	0.4	9.6	23.3	5.3	285
MEPSctrl: 12+18,+24,+30,+36	0.5	9.8	24.2	5.0	356
ECMWF: 12+18,+24,+30,+36	0.8	9.5	21.8	4.6	360

	ME	SDE	RMSE	MAE	Max.abs.err	N
MEPSctrl – synop	0.5	2.7	2.8	2.0	11.9	285
ECMWF – synop	0.1	2.3	2.3	1.8	9.3	285

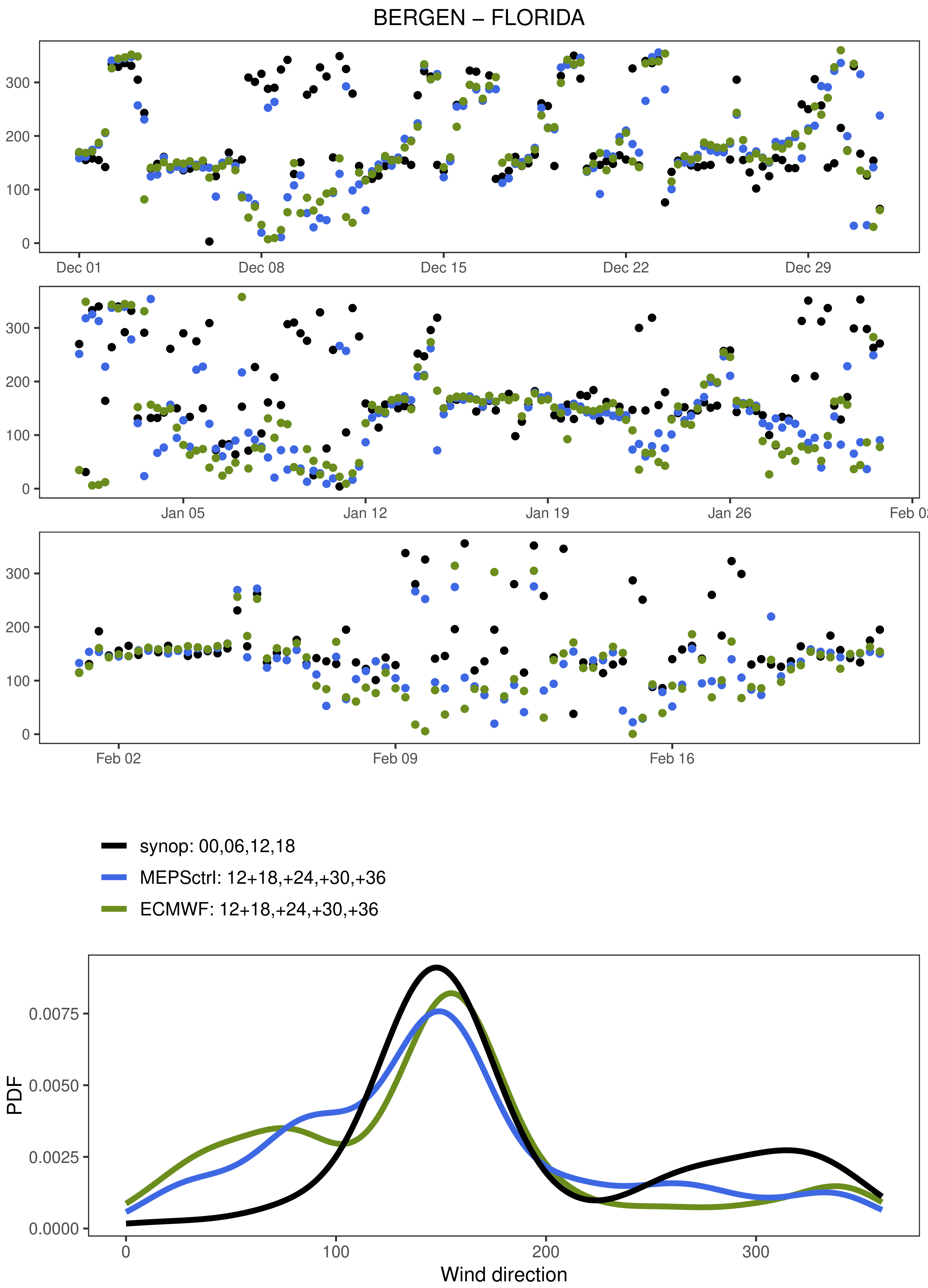

YTTERØYANE FYR
300
200
100
0
Dec 01
Dec 08
Dec 15
Dec 22
Dec 29
Jan 05
Jan 12
Jan 19
Jan 26
Feb 02
Feb 09
Feb 16
Feb 23

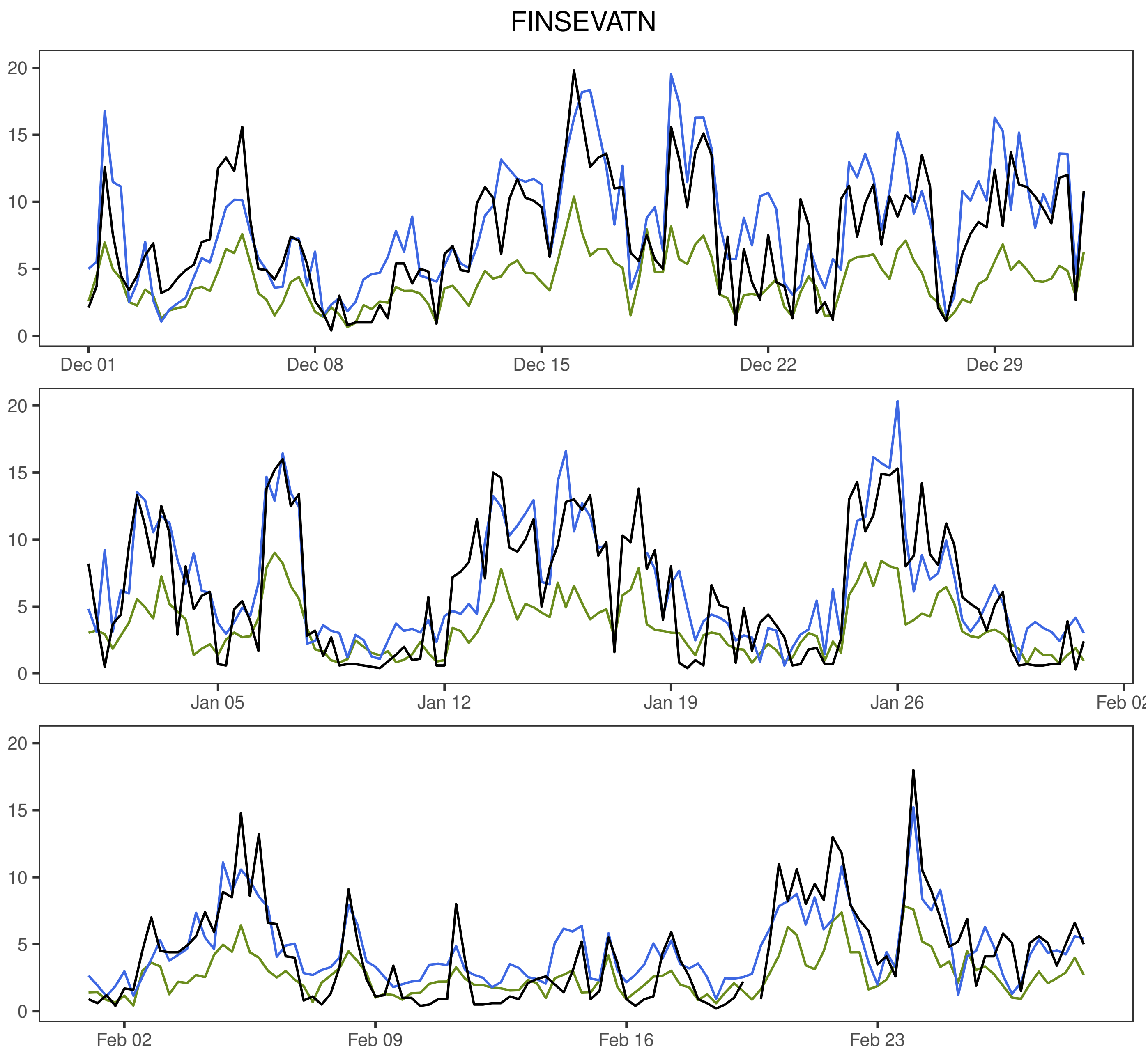

synop: 00,06,12,18
MEPSctrl: 12+18,+24,+30,+36
ECMWF: 12+18,+24,+30,+36
PDF
0.0075
0.0050
0.0025
0
100
200
300
Wind direction



	Min	Mean	Max	Std	N
synop: 00,06,12,18	0.2	3.7	13.1	2.9	330
MEPSctrl: 12+18,+24,+30,+36	0.2	4.0	11.9	2.7	326
ECMWF: 12+18,+24,+30,+36	0.1	3.1	11.9	2.4	330

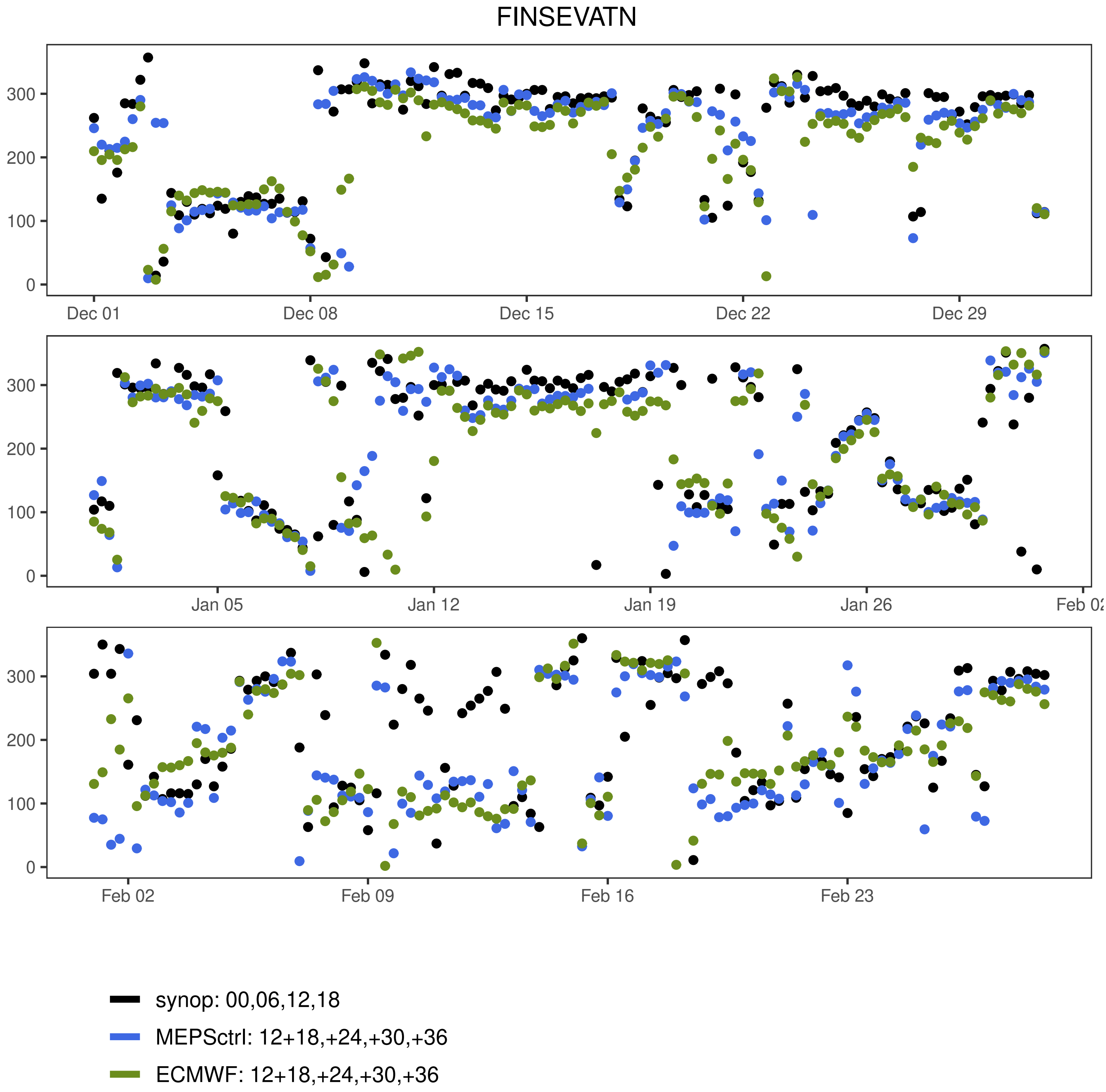
	ME	SDE	RMSE	MAE	Max.abs.err	N
MEPSctrl – synop	0.3	1.9	1.9	1.4	9.6	326
ECMWF – synop	−0.6	1.7	1.8	1.2	10.0	326

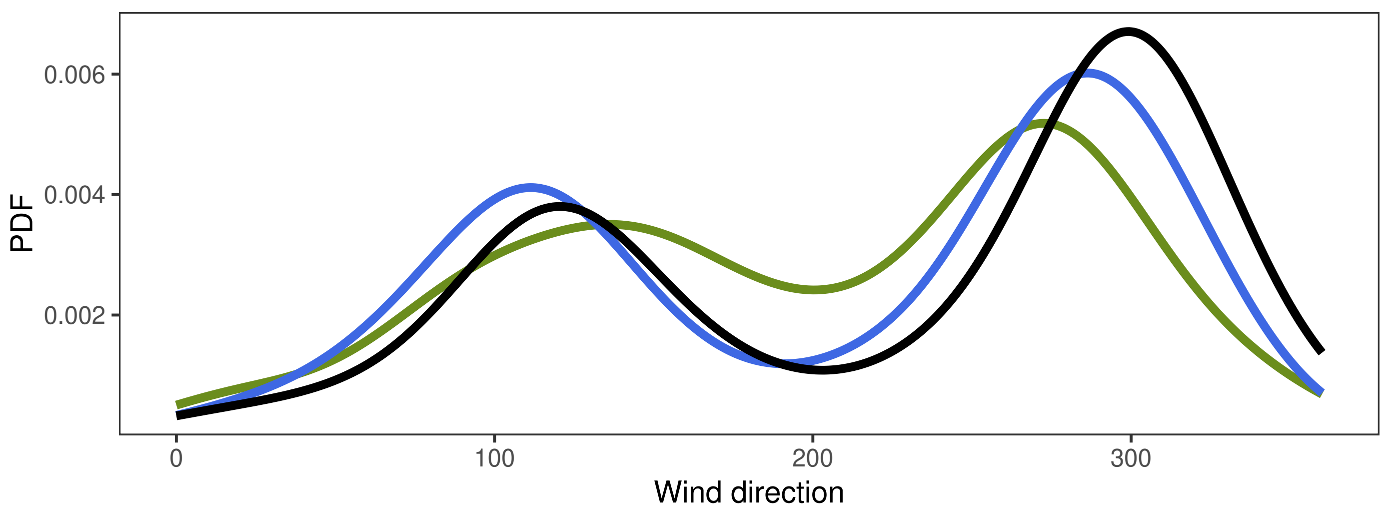

BERGEN – FLORIDA
300
200
100
0
Dec 01
Dec 08
Dec 15
Dec 22
Dec 29
Jan 05
Jan 12
Jan 19
Jan 26
Feb 02
Feb 09
Feb 16
synop: 00,06,12,18
MEPSctrl: 12+18,+24,+30,+36
ECMWF: 12+18,+24,+30,+36
PDF
0.0075
0.0050
0.0025
0.0000
Wind direction

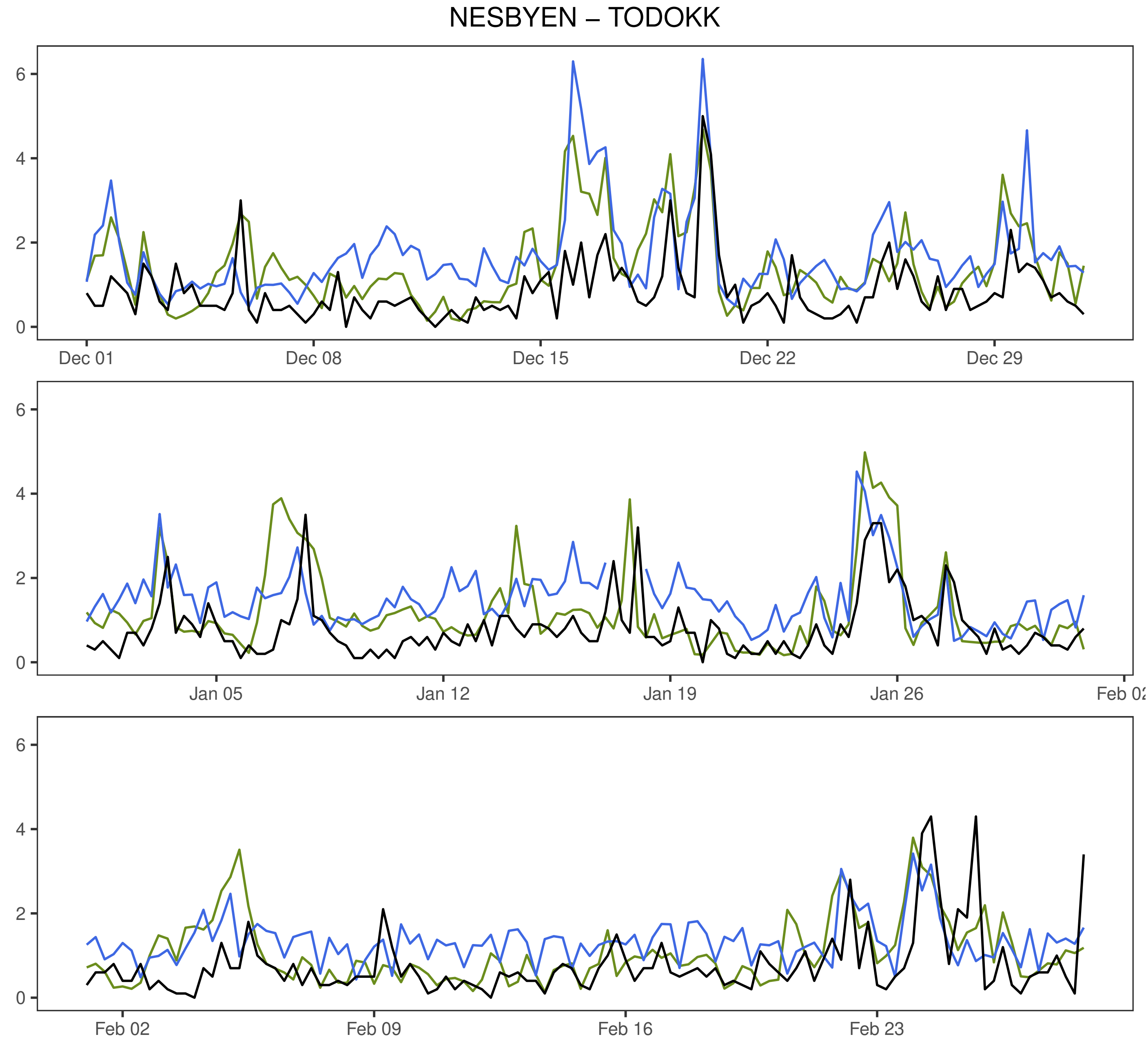


	Min	Mean	Max	Std	N
synop: 00,06,12,18	0.2	6.0	19.8	4.4	359
MEPSctrl: 12+18,+24,+30,+36	0.6	6.6	20.3	4.2	356
ECMWF: 12+18,+24,+30,+36	0.4	3.4	10.4	1.9	360

	ME	SDE	RMSE	MAE	Max.abs.err	N
MEPSctrl – synop	0.6	2.5	2.6	2.0	8.7	355
ECMWF – synop	–2.6	2.9	3.9	3.0	10.4	355

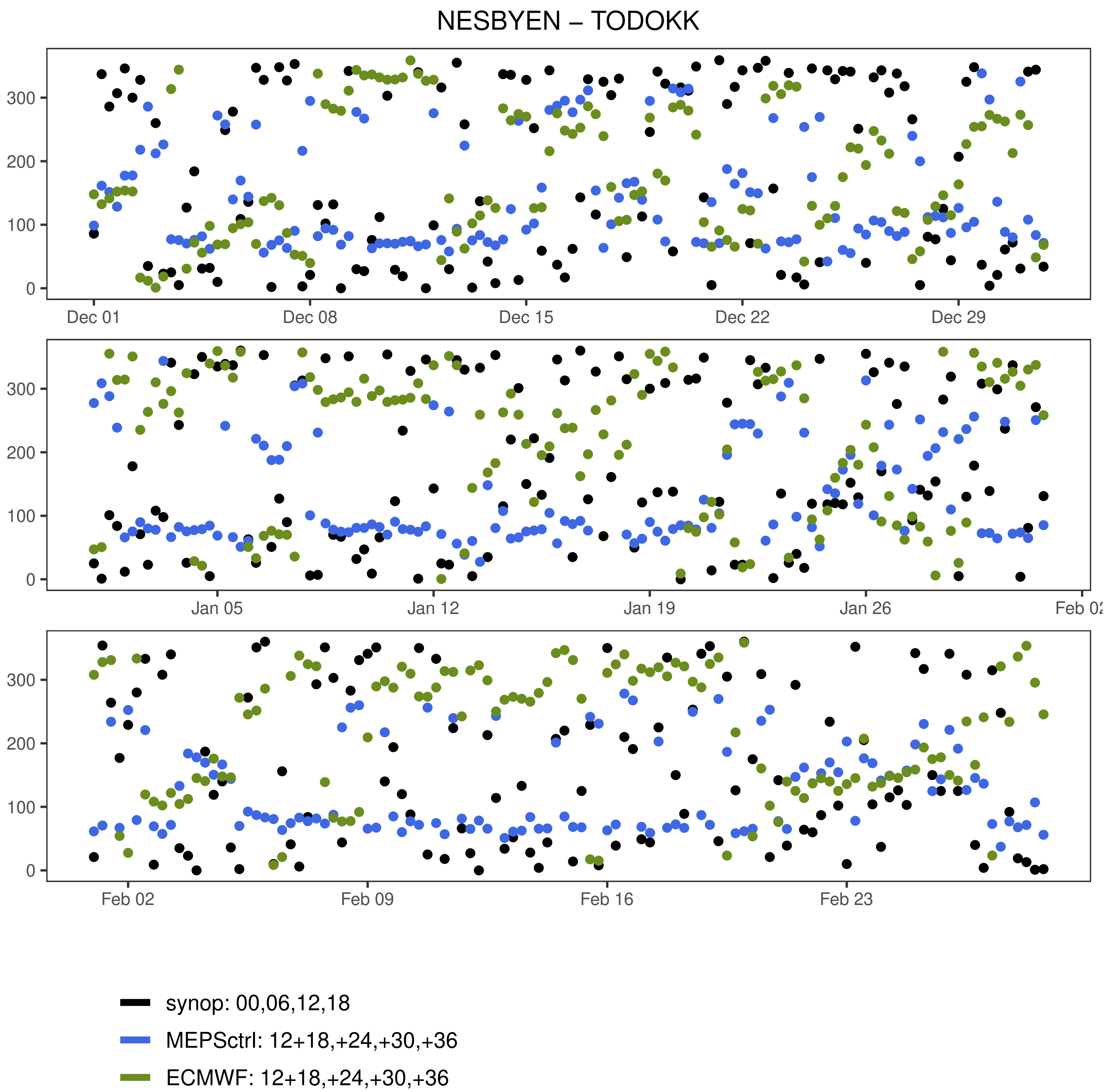

FINSEVATN
300
200
100
0
Dec 01
Dec 08
Dec 15
Dec 22
Dec 29
Jan 05
Jan 12
Jan 19
Jan 26
Feb 02
Feb 09
Feb 16
Feb 23
synop: 00,06,12,18
MEPSctrl: 12+18,+24,+30,+36
ECMWF: 12+18,+24,+30,+36

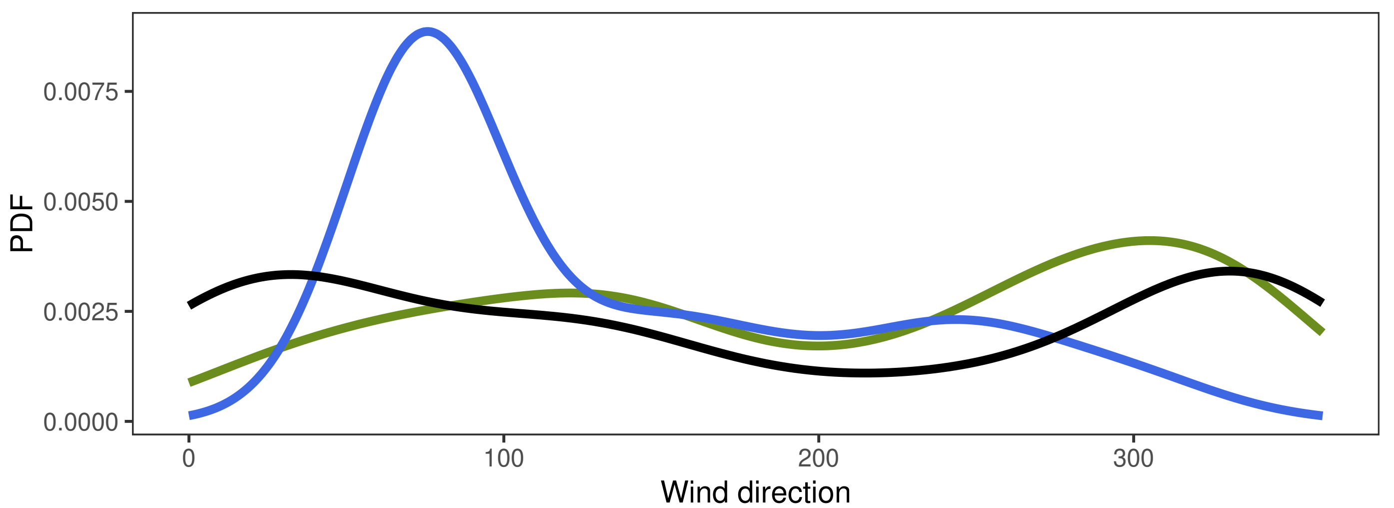

PDF
0.006
0.004
0.002
0
100
200
300
Wind direction

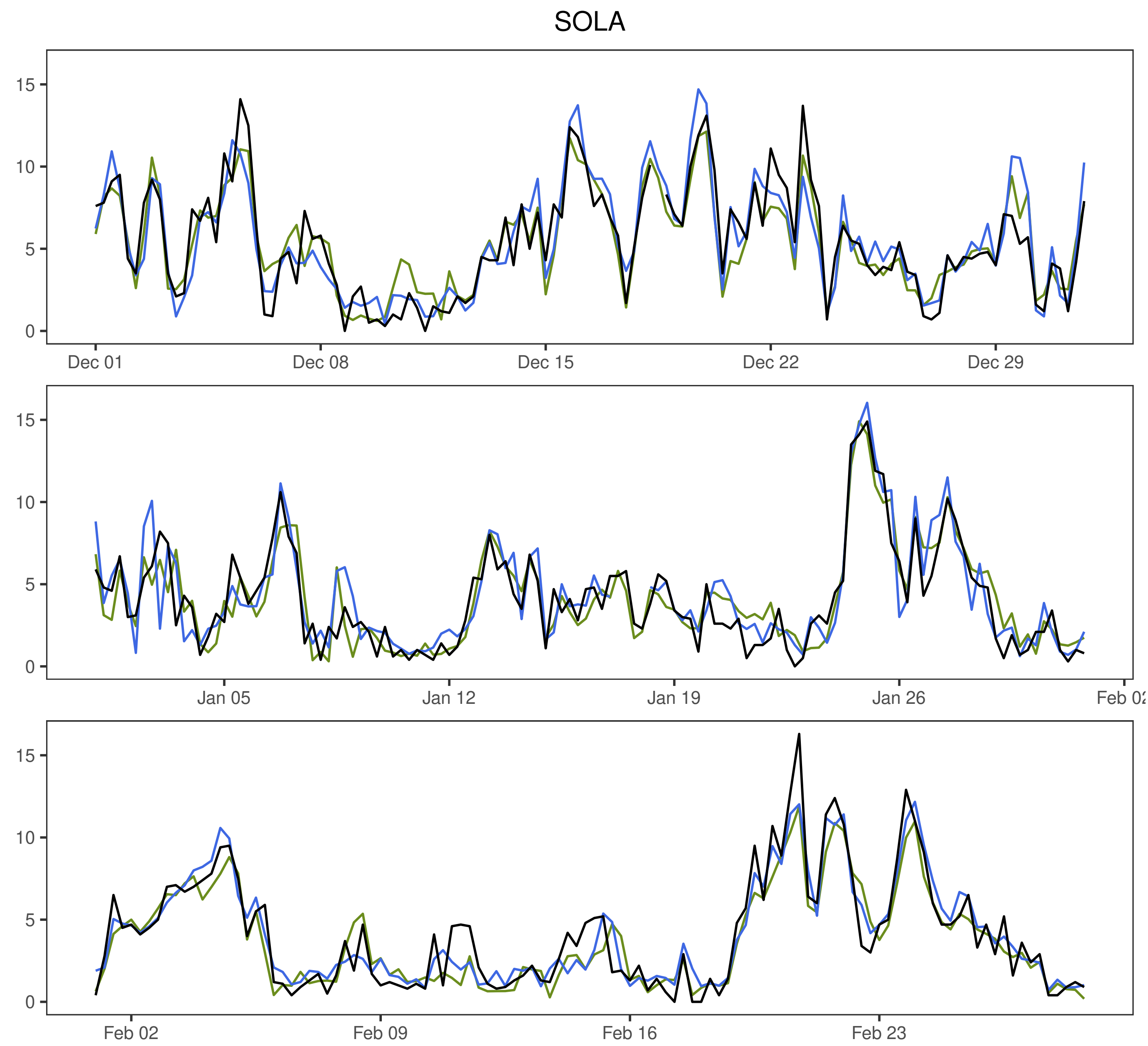


	Min	Mean	Max	Std	N
synop: 00,06,12,18	0.0	0.8	5.0	0.7	360
MEPSctrl: 12+18,+24,+30,+36	0.4	1.5	6.4	0.8	356
ECMWF: 12+18,+24,+30,+36	0.1	1.2	5.0	0.9	360

	ME	SDE	RMSE	MAE	Max.abs.err	N
MEPSctrl – synop	0.7	0.8	1.1	0.9	5.3	356
ECMWF – synop	0.4	0.8	0.9	0.6	3.5	356

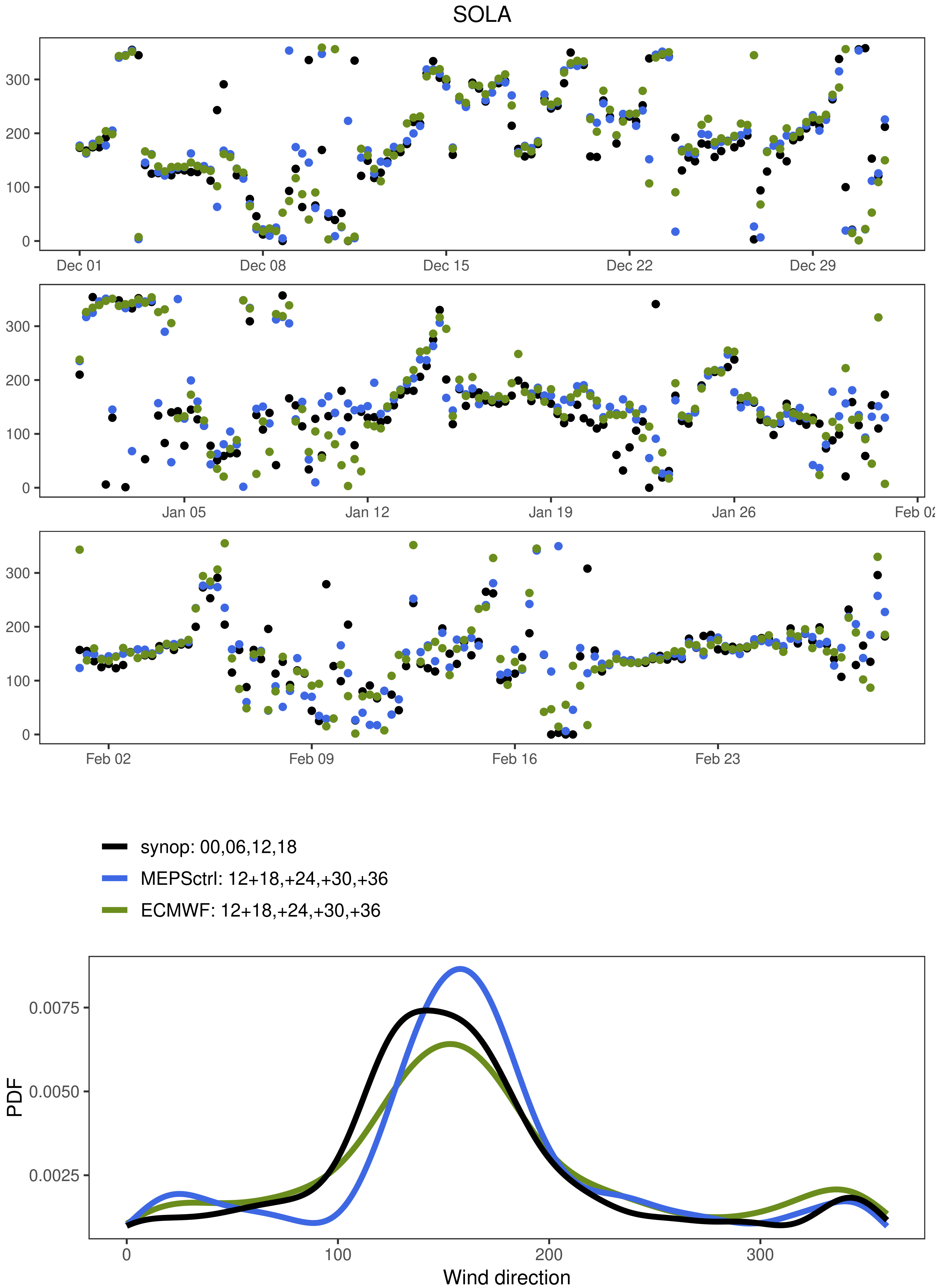

NESBYEN – TODOKK
300
200
100
0
Dec 01
Dec 08
Dec 15
Dec 22
Dec 29
Jan 05
Jan 12
Jan 19
Jan 26
Feb 02
Feb 09
Feb 16
Feb 23
synop: 00,06,12,18
MEPSctrl: 12+18,+24,+30,+36
ECMWF: 12+18,+24,+30,+36

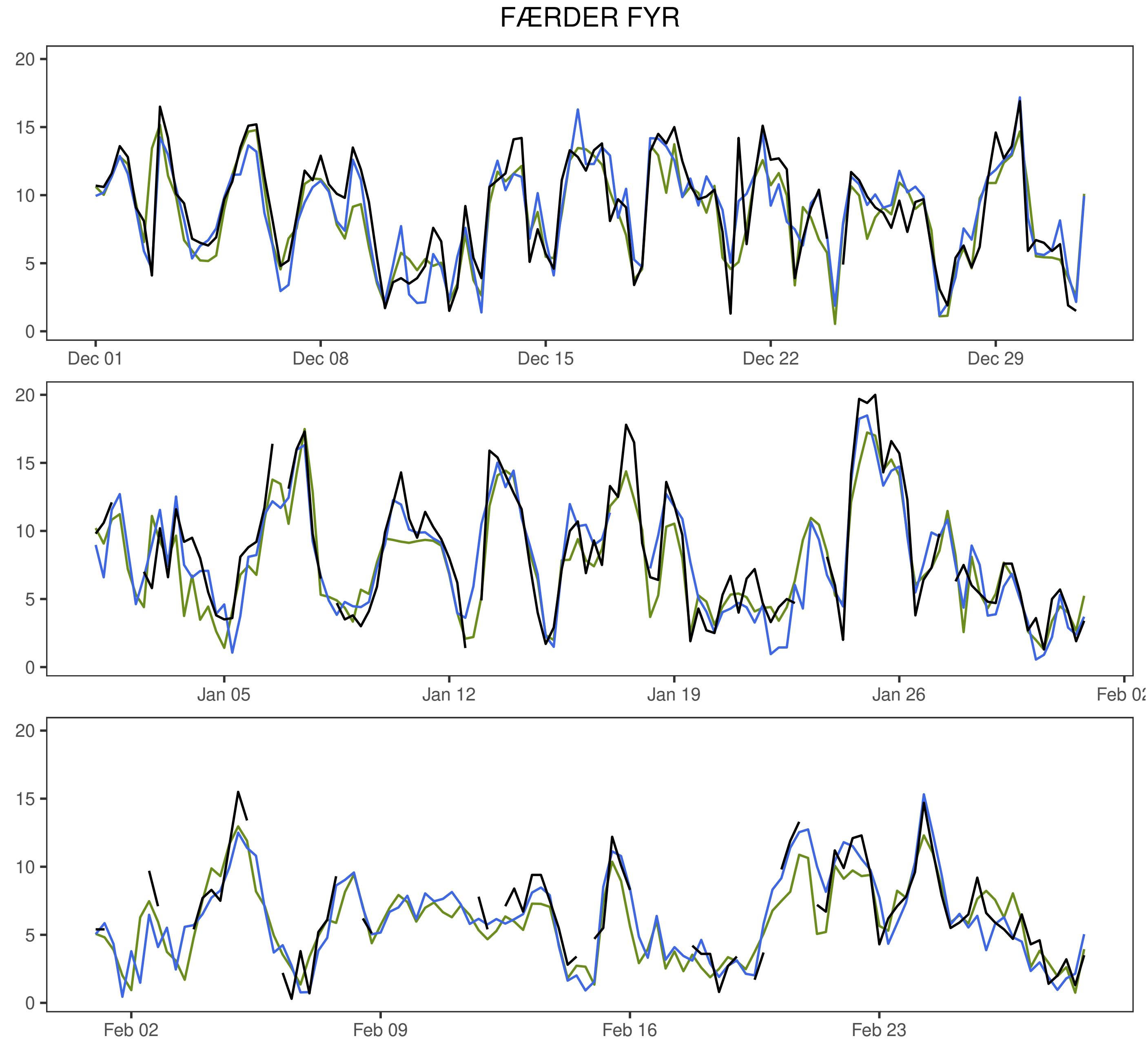

PDF
0.0075
0.0050
0.0025
0.0000
0
100
200
300
Wind direction



	Min	Mean	Max	Std	N
synop: 00,06,12,18	0.0	4.6	16.3	3.3	359
MEPSctrl: 12+18,+24,+30,+36	0.4	4.7	16.0	3.3	356
ECMWF: 12+18,+24,+30,+36	0.2	4.4	14.9	3.0	360

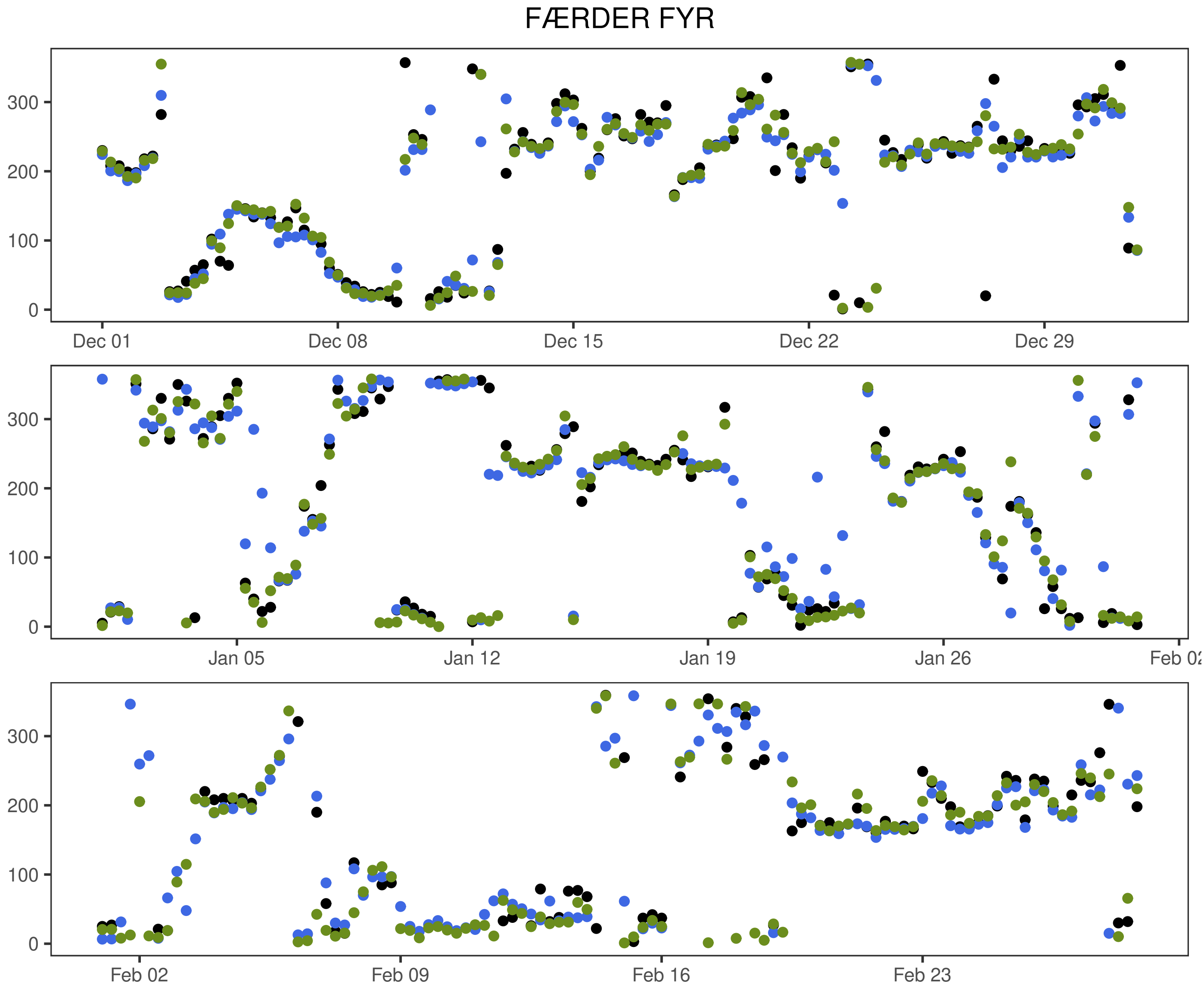
	ME	SDE	RMSE	MAE	Max.abs.err	N
MEPSctrl – synop	0.1	1.5	1.5	1.1	5.9	355
ECMWF – synop	−0.1	1.4	1.4	1.1	4.6	355


SOLA
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
0.0075
0.0050
0.0025
0
100
200
300
Wind direction

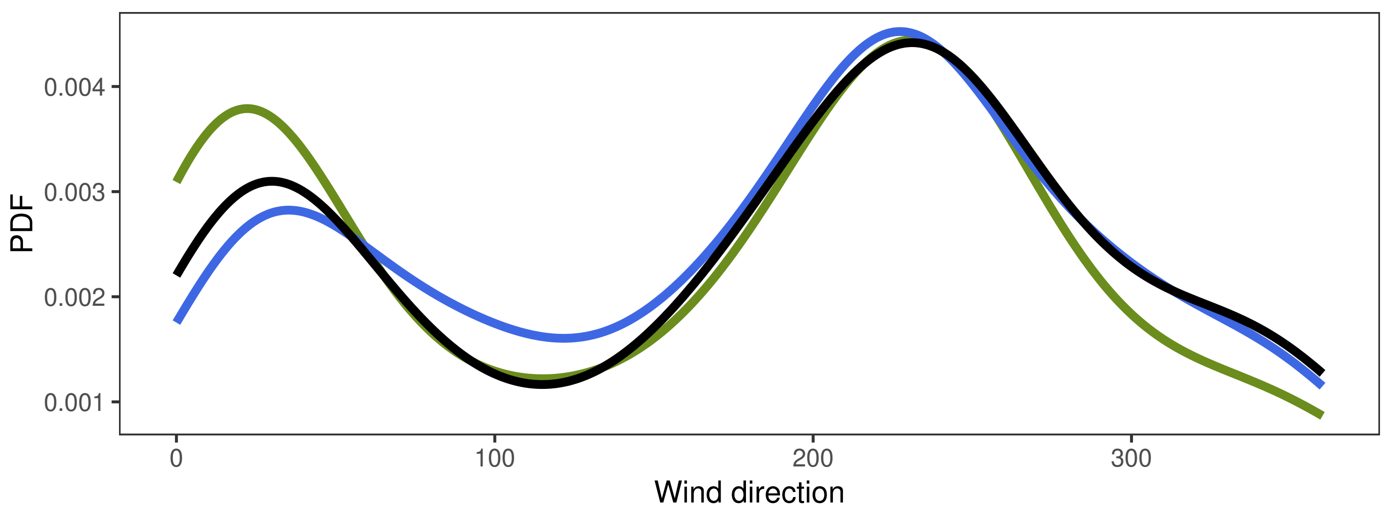


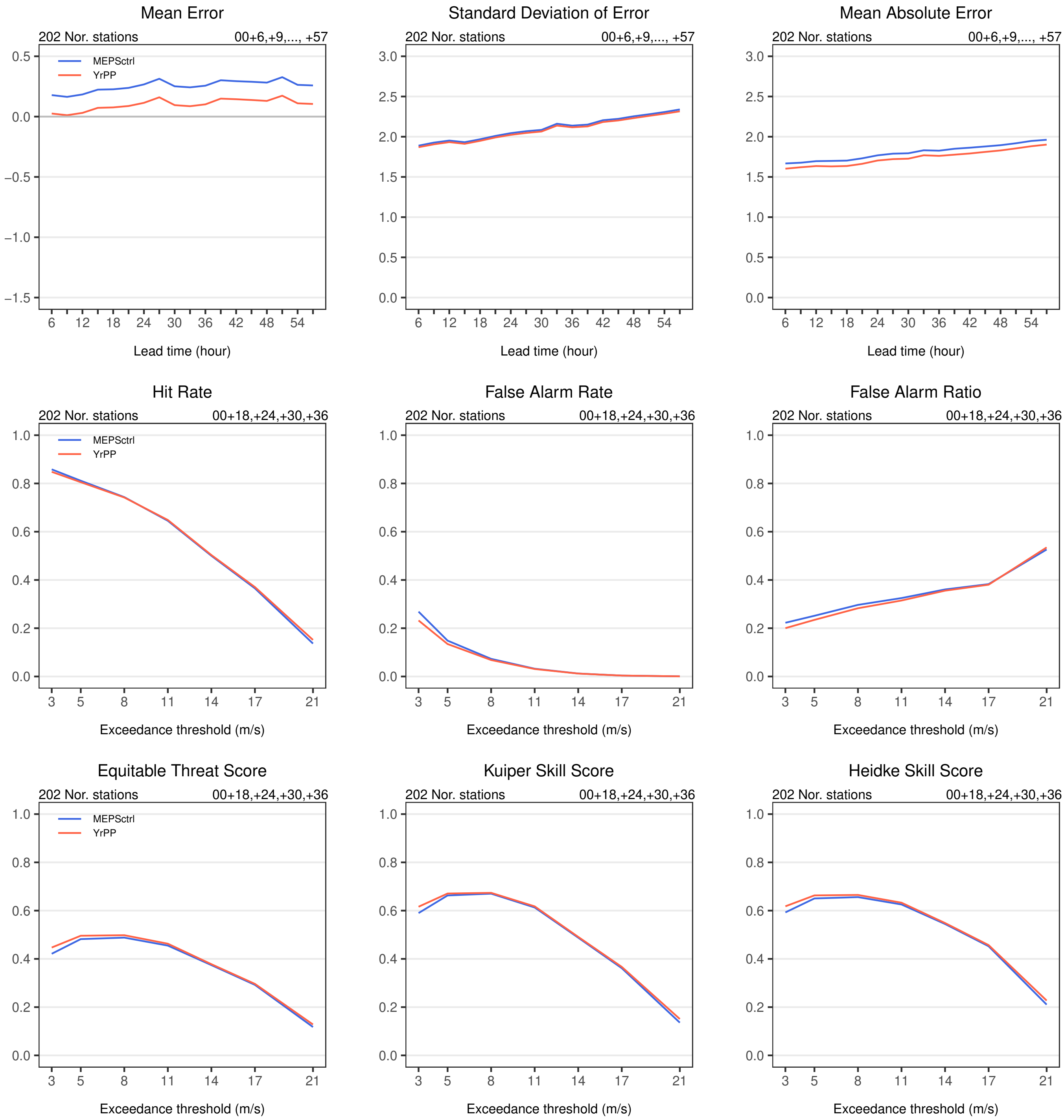
	Min	Mean	Max	Std	N
synop: 00,06,12,18	0.3	8.1	20.0	4.1	318
MEPSctrl: 12+18,+24,+30,+36	0.4	7.6	18.5	3.8	356
ECMWF: 12+18,+24,+30,+36	0.5	7.4	17.5	3.5	360

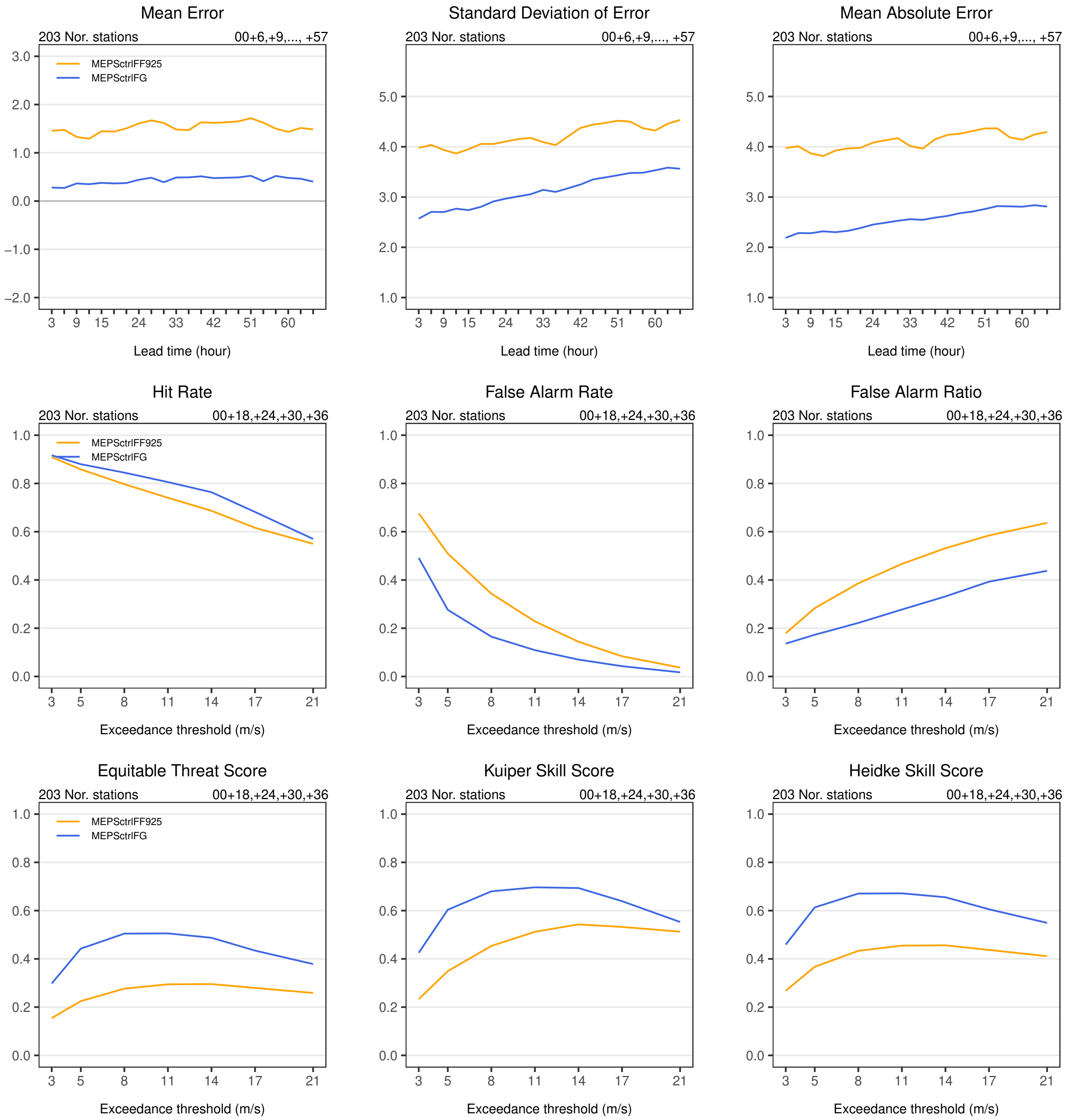
	ME	SDE	RMSE	MAE	Max.abs.err	N
MEPSctrl – synop	–0.3	1.8	1.8	1.4	5.8	314
ECMWF – synop	–0.6	1.8	1.9	1.5	9.3	314

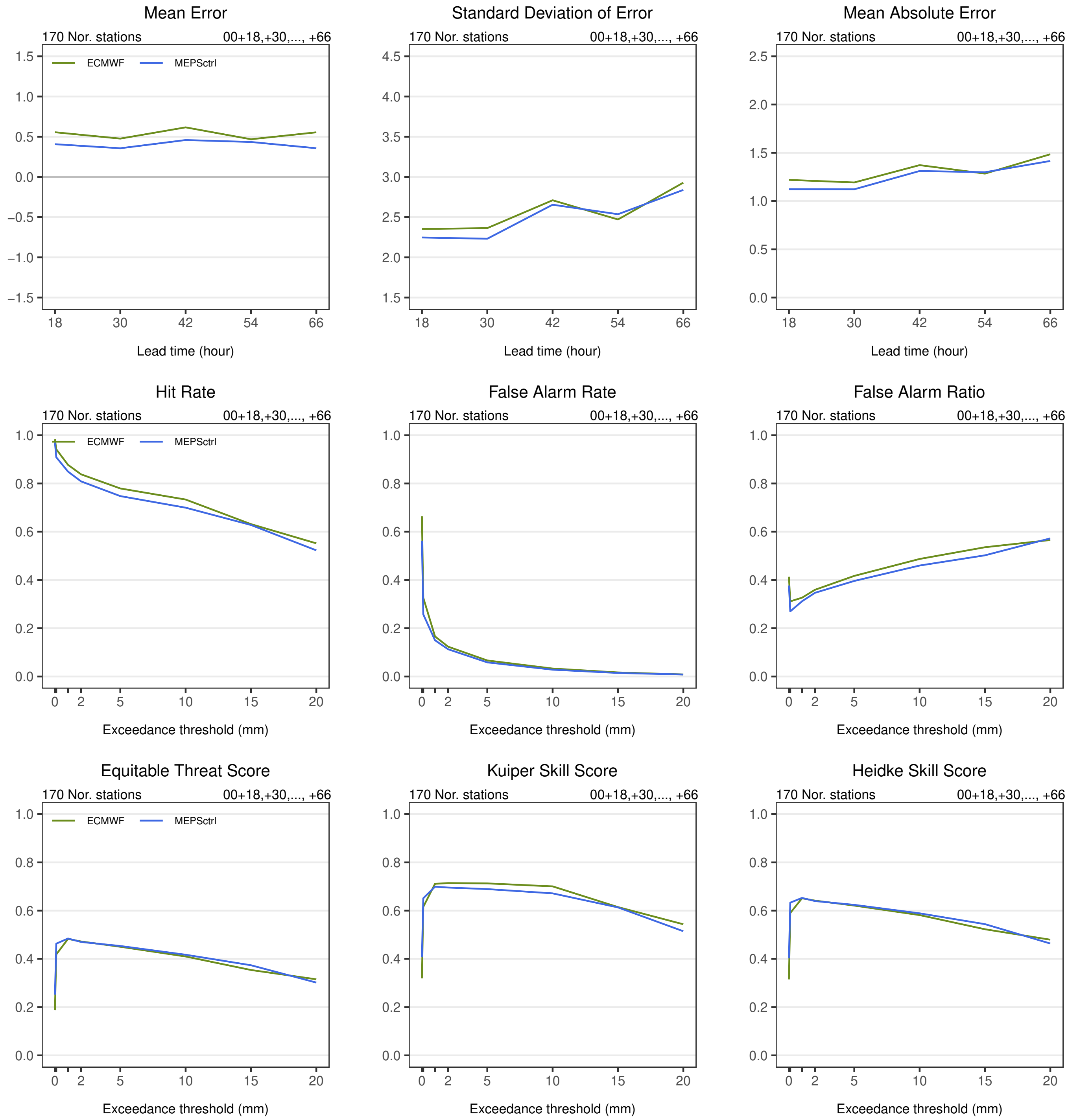


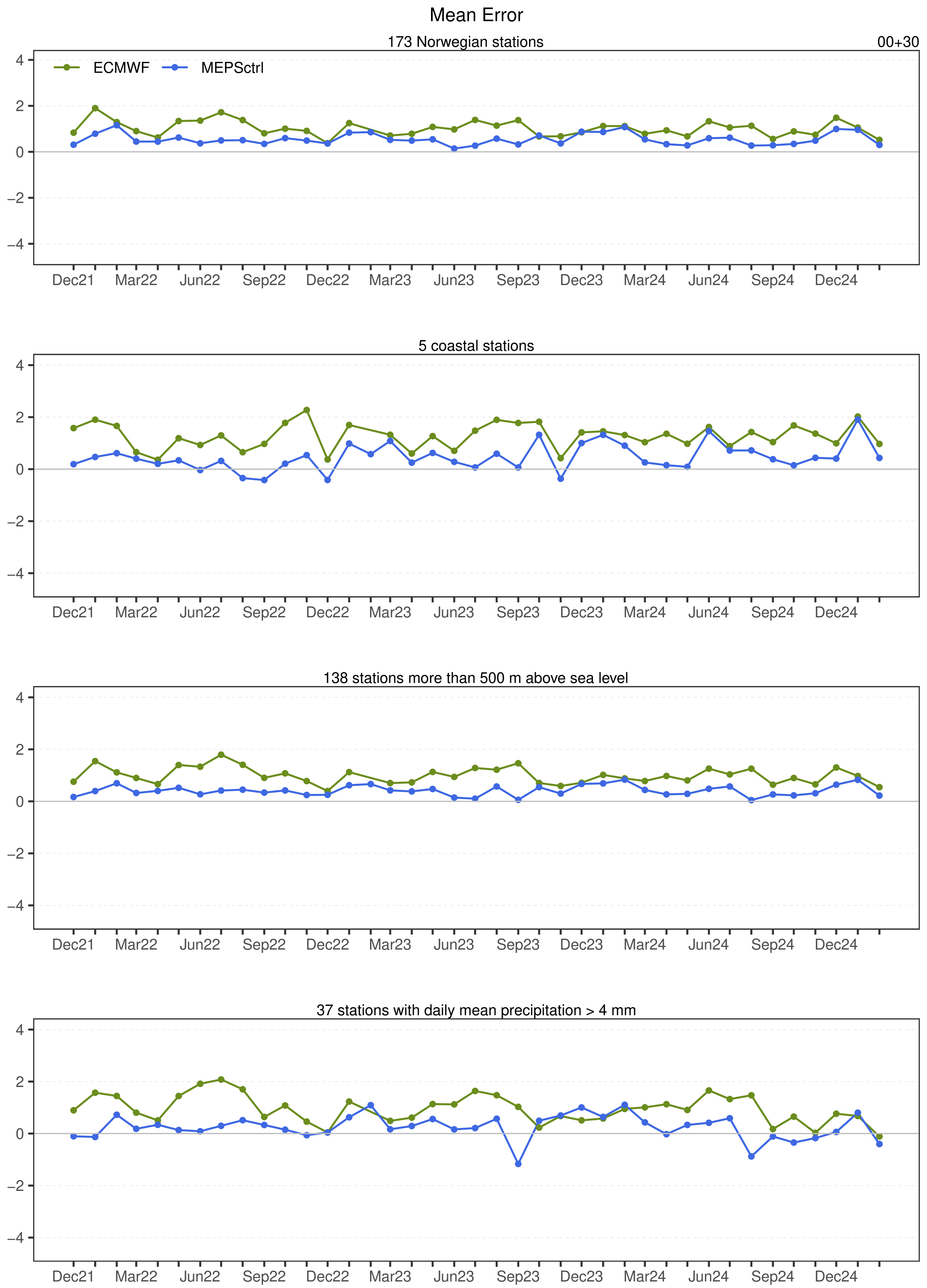
- synop: 00,06,12,18
- MEPSctrl: 12+18,+24,+30,+36
- ECMWF: 12+18,+24,+30,+36

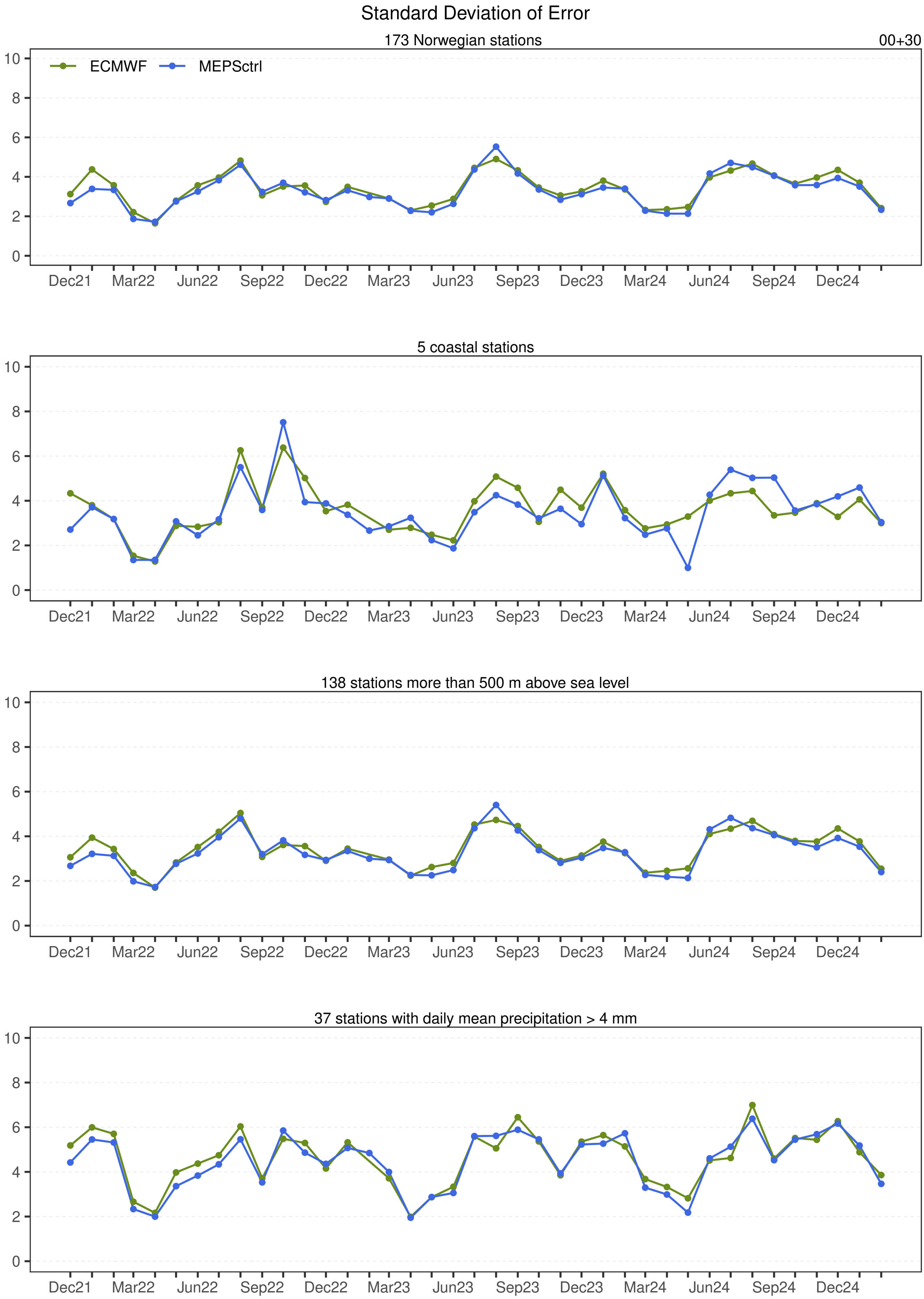


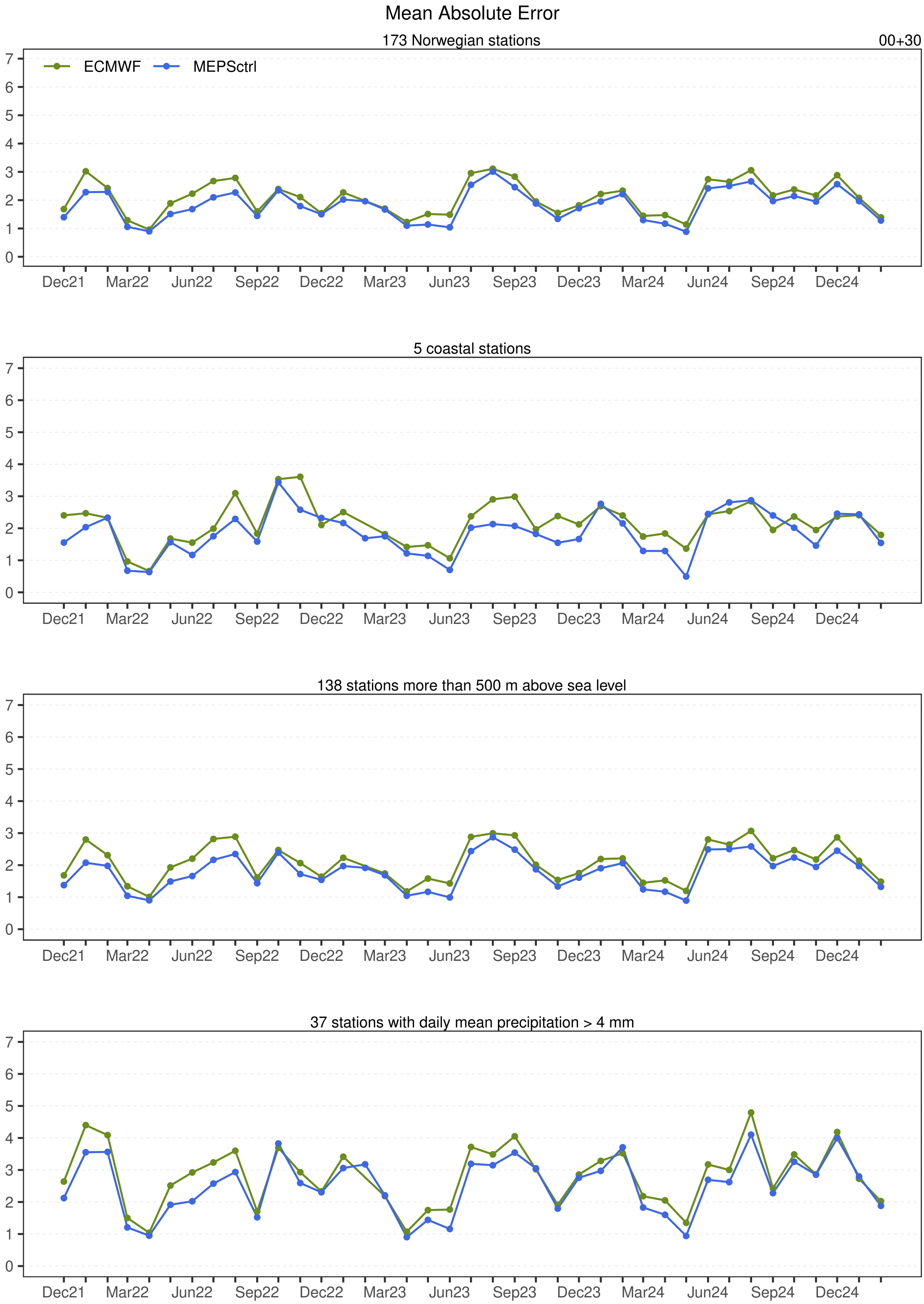

Mean Error
202 Nor. stations
00+6,+9,..., +57
MEPSctrl
YrPP
0.5
0.0
−0.5
−1.0
−1.5
6 12 18 24 30 36 42 48 54
Lead time (hour)
Standard Deviation of Error
202 Nor. stations
00+6,+9,..., +57
3.0
2.5
2.0
1.5
1.0
0.5
0.0
6 12 18 24 30 36 42 48 54
Lead time (hour)
Mean Absolute Error
202 Nor. stations
00+6,+9,..., +57
3.0
2.5
2.0
1.5
1.0
0.5
0.0
6 12 18 24 30 36 42 48 54
Lead time (hour)
Hit Rate
202 Nor. stations
00+18,+24,+30,+36
MEPSctrl
YrPP
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
202 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
202 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
202 Nor. stations
00+18,+24,+30,+36
MEPSctrl
YrPP
1.0
0.8
0.6
0.4
0.2
0.0
3 5 8 11 14 17 21
Exceedance threshold (m/s)
Kuiper Skill Score
202 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
202 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)

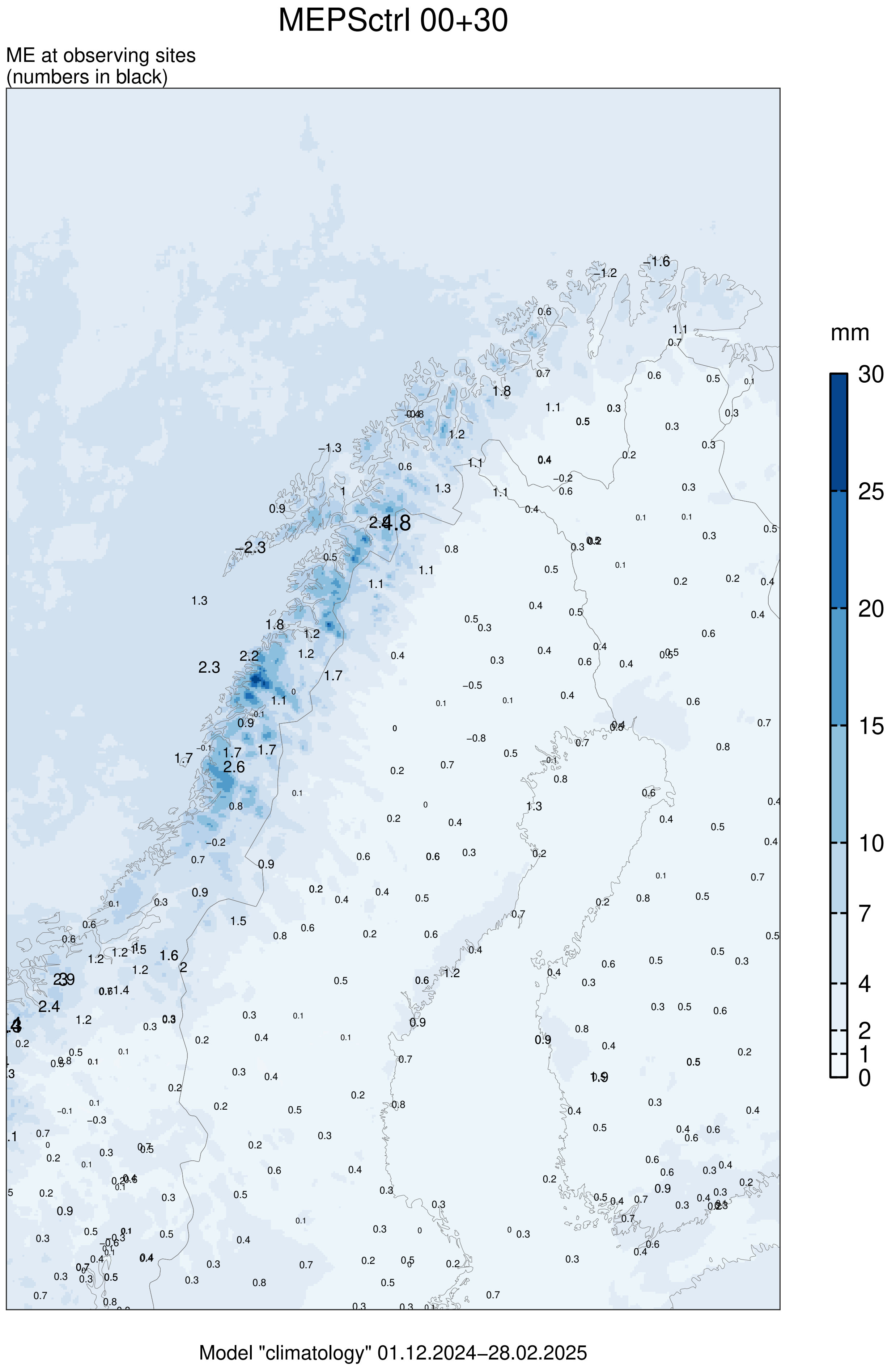

Mean Error
203 Nor. stations
00+6,+9,..., +57
MEPSctrlFF925
MEPSctrlFG
Lead time (hour)
Standard Deviation of Error
203 Nor. stations
00+6,+9,..., +57
Lead time (hour)
Mean Absolute Error
203 Nor. stations
00+6,+9,..., +57
Lead time (hour)
Hit Rate
203 Nor. stations
00+18,+24,+30,+36
MEPSctrlFF925
MEPSctrlFG
Exceedance threshold (m/s)
False Alarm Rate
203 Nor. stations
00+18,+24,+30,+36
Exceedance threshold (m/s)
False Alarm Ratio
203 Nor. stations
00+18,+24,+30,+36
Exceedance threshold (m/s)
Equitable Threat Score
203 Nor. stations
00+18,+24,+30,+36
MEPSctrlFF925
MEPSctrlFG
Exceedance threshold (m/s)
Kuiper Skill Score
203 Nor. stations
00+18,+24,+30,+36
Exceedance threshold (m/s)
Heidke Skill Score
203 Nor. stations
00+18,+24,+30,+36
Exceedance threshold (m/s)


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


Mean Error
173 Norwegian stations
00+30
ECMWF
MEPSctrl
5 coastal stations
138 stations more than 500 m above sea level
37 stations with daily mean precipitation > 4 mm
4
2
0
−2
−4
Dec21
Mar22
Jun22
Sep22
Dec22
Mar23
Jun23
Sep23
Dec23
Mar24
Jun24
Sep24
Dec24

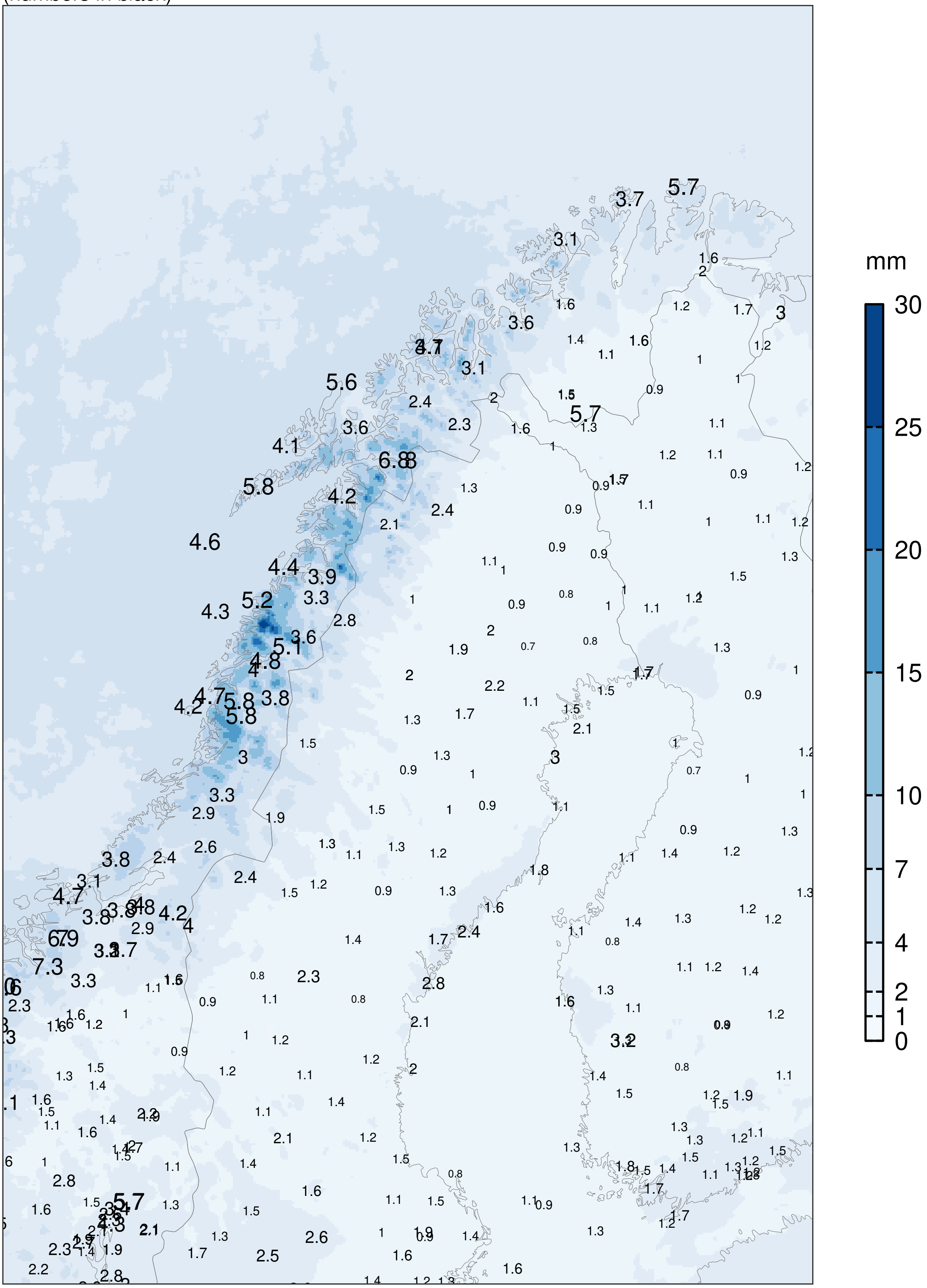

Standard Deviation of Error
173 Norwegian stations
00+30
ECMWF
MEPSctrl
0
2
4
6
8
10
Dec21
Mar22
Jun22
Sep22
Dec22
Mar23
Jun23
Sep23
Dec23
Mar24
Jun24
Sep24
Dec24
5 coastal stations
138 stations more than 500 m above sea level
37 stations with daily mean precipitation > 4 mm


Mean Absolute Error
173 Norwegian stations
00+30
ECMWF
MEPSctrl
5 coastal stations
138 stations more than 500 m above sea level
37 stations with daily mean precipitation > 4 mm
0 1 2 3 4 5 6 7
Dec21 Mar22 Jun22 Sep22 Dec22 Mar23 Jun23 Sep23 Dec23 Mar24 Jun24 Sep24 Dec24

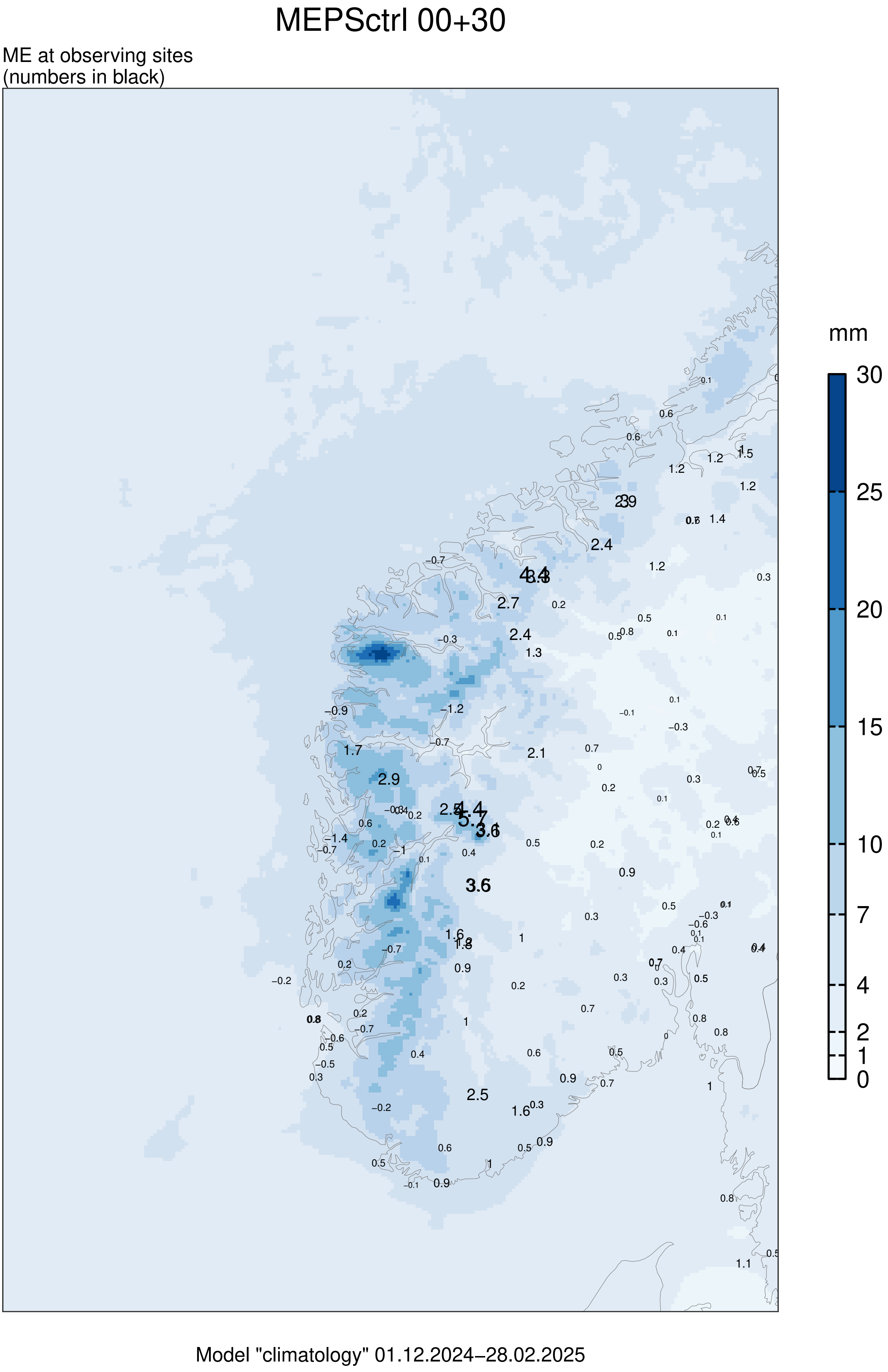

MEPSctrl 00+30
ME at observing sites
(numbers in black)
mm
30
25
20
15
10
7
4
2
1
0
Model "climatology" 01.12.2024–28.02.2025

MEPSctrl 00+30

SDE at observing sites
(numbers in black)

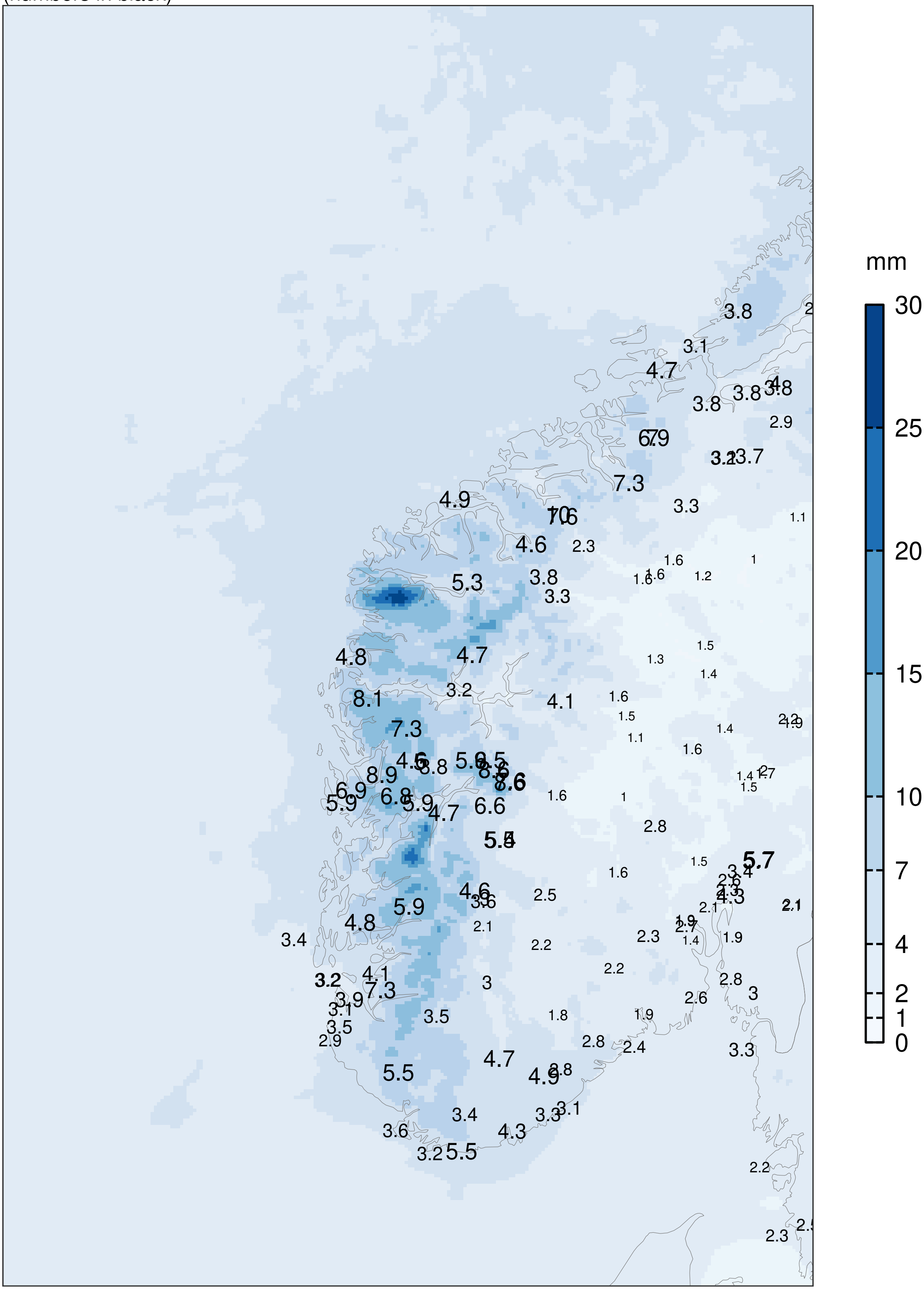


Model "climatology" 01.12.2024–28.02.2025


MEPSctrl 00+30
ME at observing sites
(numbers in black)
mm
30
25
20
15
10
7
4
2
1
0
Model "climatology" 01.12.2024–28.02.2025

MEPSctrl 00+30

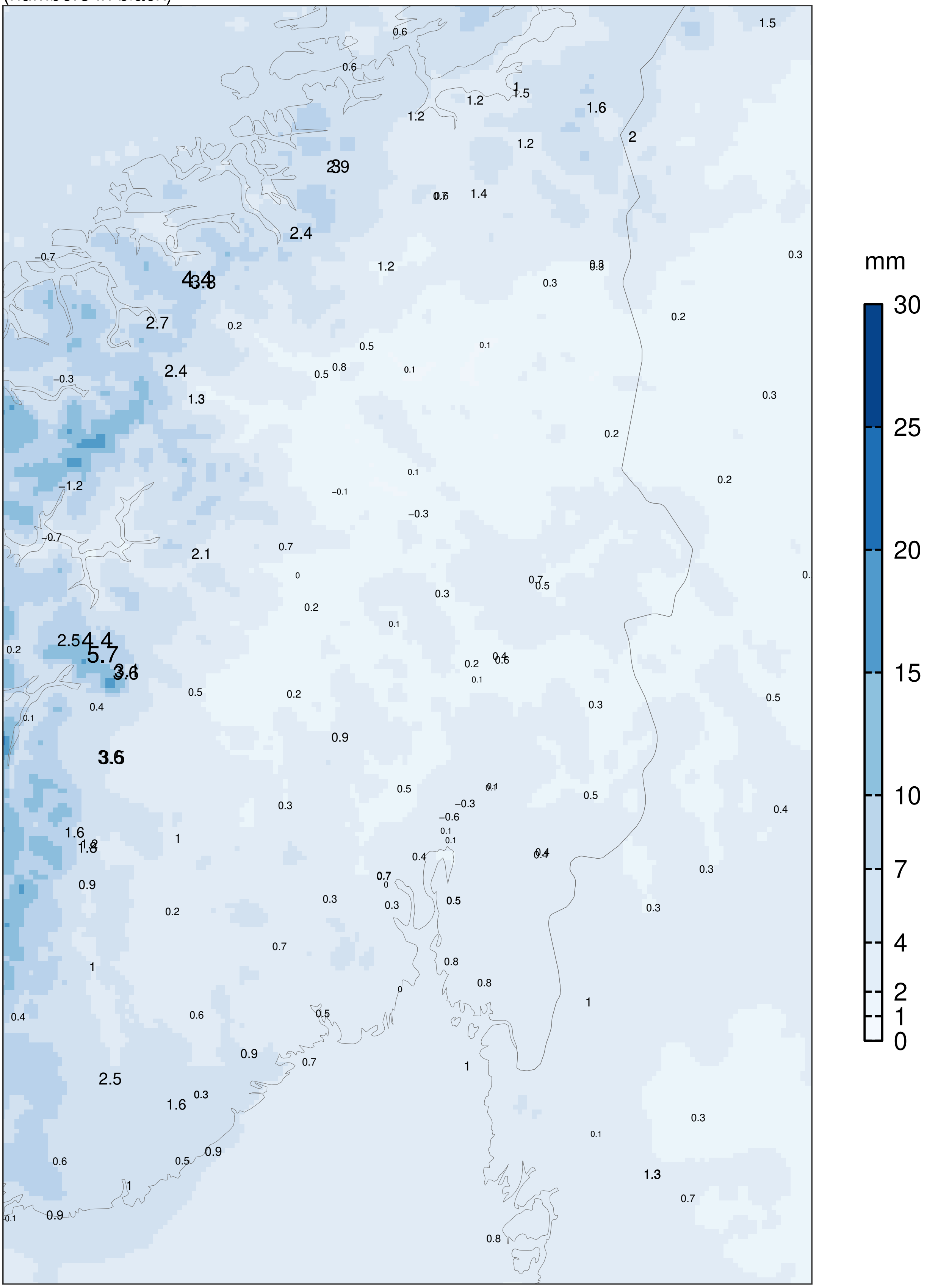
SDE at observing sites
(numbers in black)



Model "climatology" 01.12.2024–28.02.2025

MEPSctrl 00+30

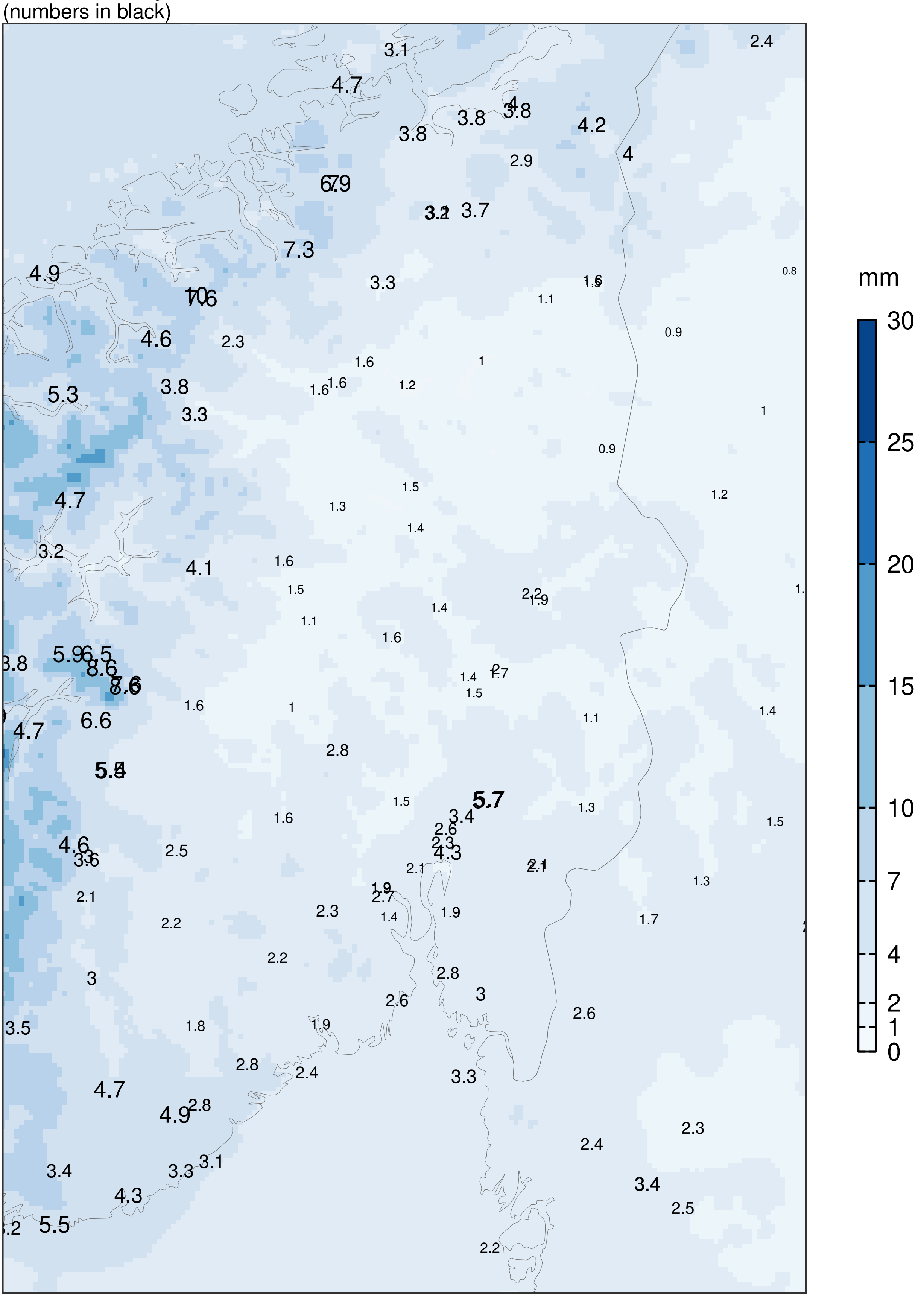
ME at observing sites
(numbers in black)



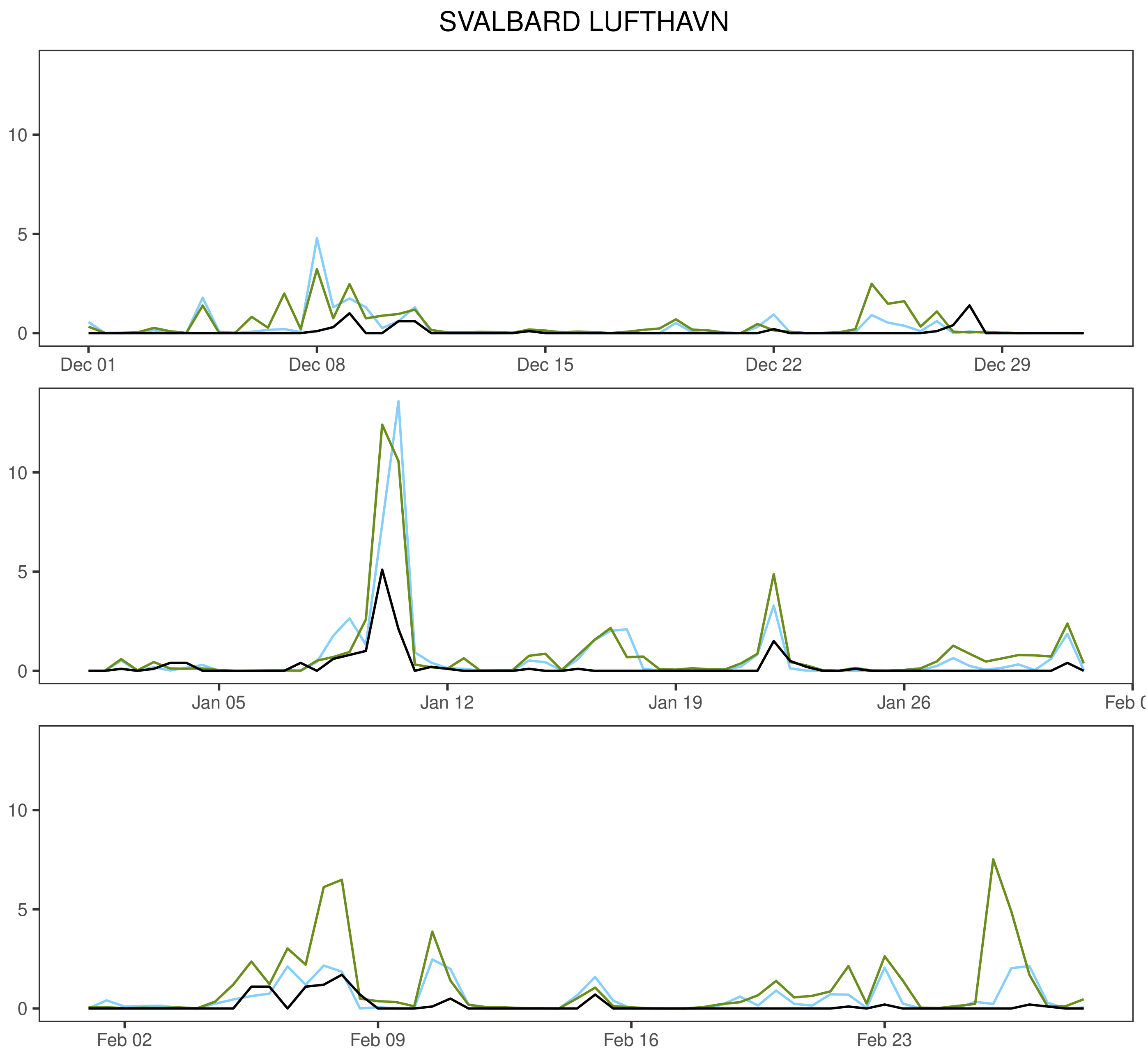
Model "climatology" 01.12.2024–28.02.2025

MEPSctrl 00+30

SDE at observing sites
(numbers in black)

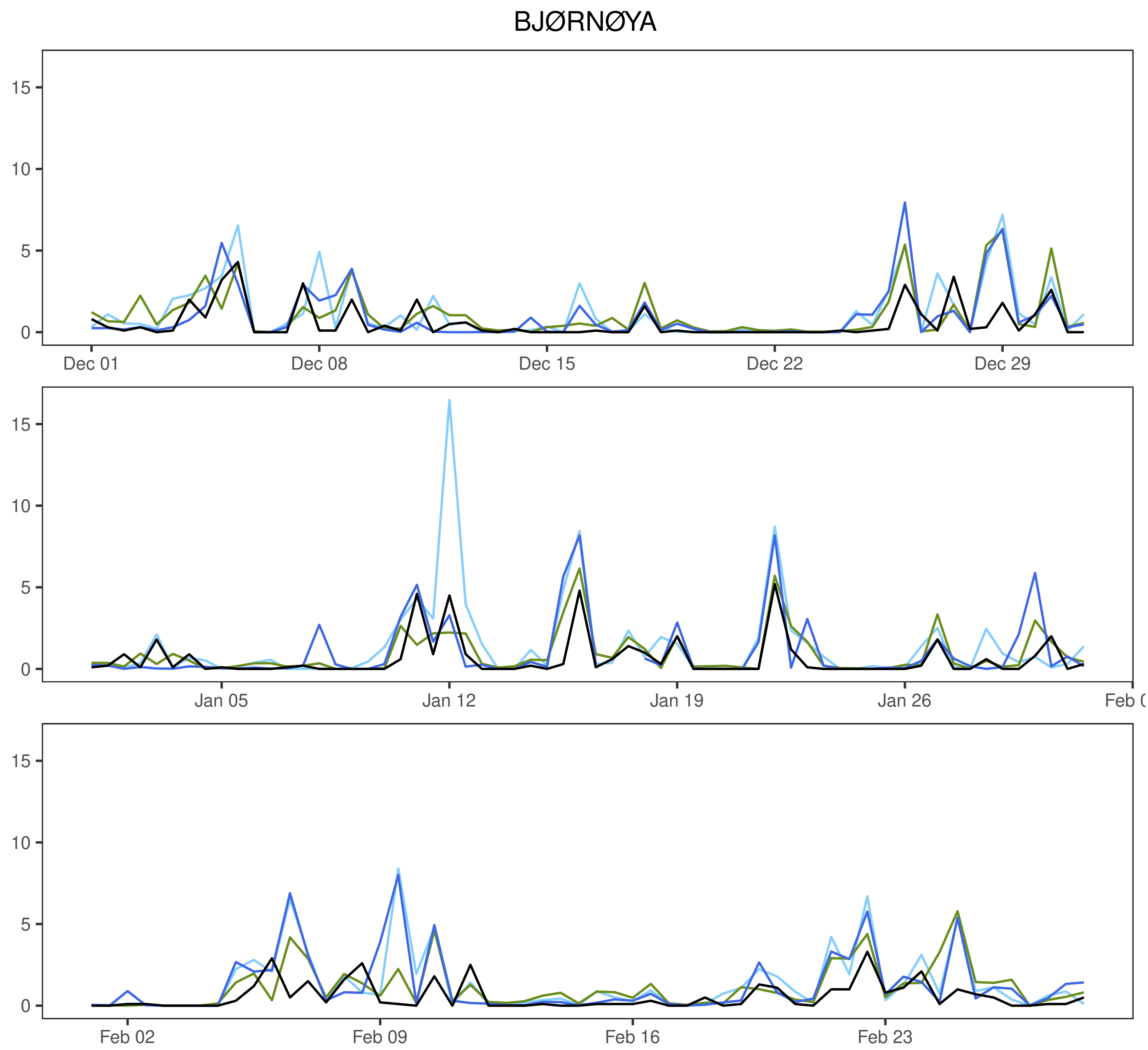


Model "climatology" 01.12.2024–28.02.2025



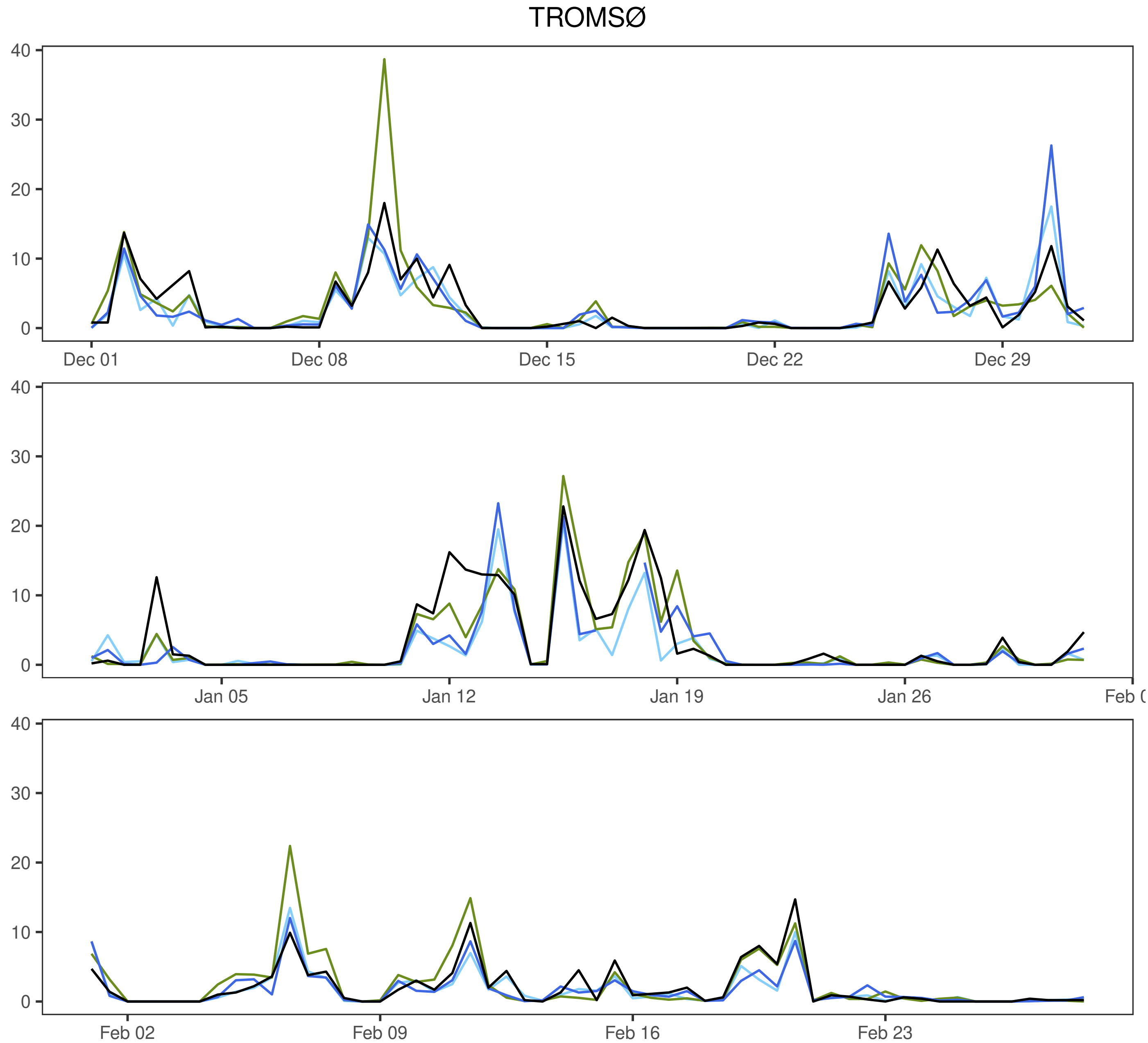
	Min	Mean	Max	Std	N
synop: 06,18	0.0	0.2	5.1	0.5	180
AA25: 12+18,+30	0.0	0.5	13.6	1.3	180
ECMWF: 12+18,+30	0.0	0.8	12.4	1.6	180

	ME	SDE	RMSE	MAE	Max.abs.err	N
AA25 – synop	0.4	1.1	1.1	0.4	11.5	180
ECMWF – synop	0.6	1.3	1.4	0.7	8.5	180



	Min	Mean	Max	Std	N
synop: 06,12,18	0.0	0.6	5.2	1.0	181
MEPSctrl: 12+18,+30	0.0	1.1	8.2	1.8	178
AA25: 12+18,+30	0.0	1.3	16.5	2.1	180
ECMWF: 12+18,+30	0.0	1.0	6.2	1.4	180

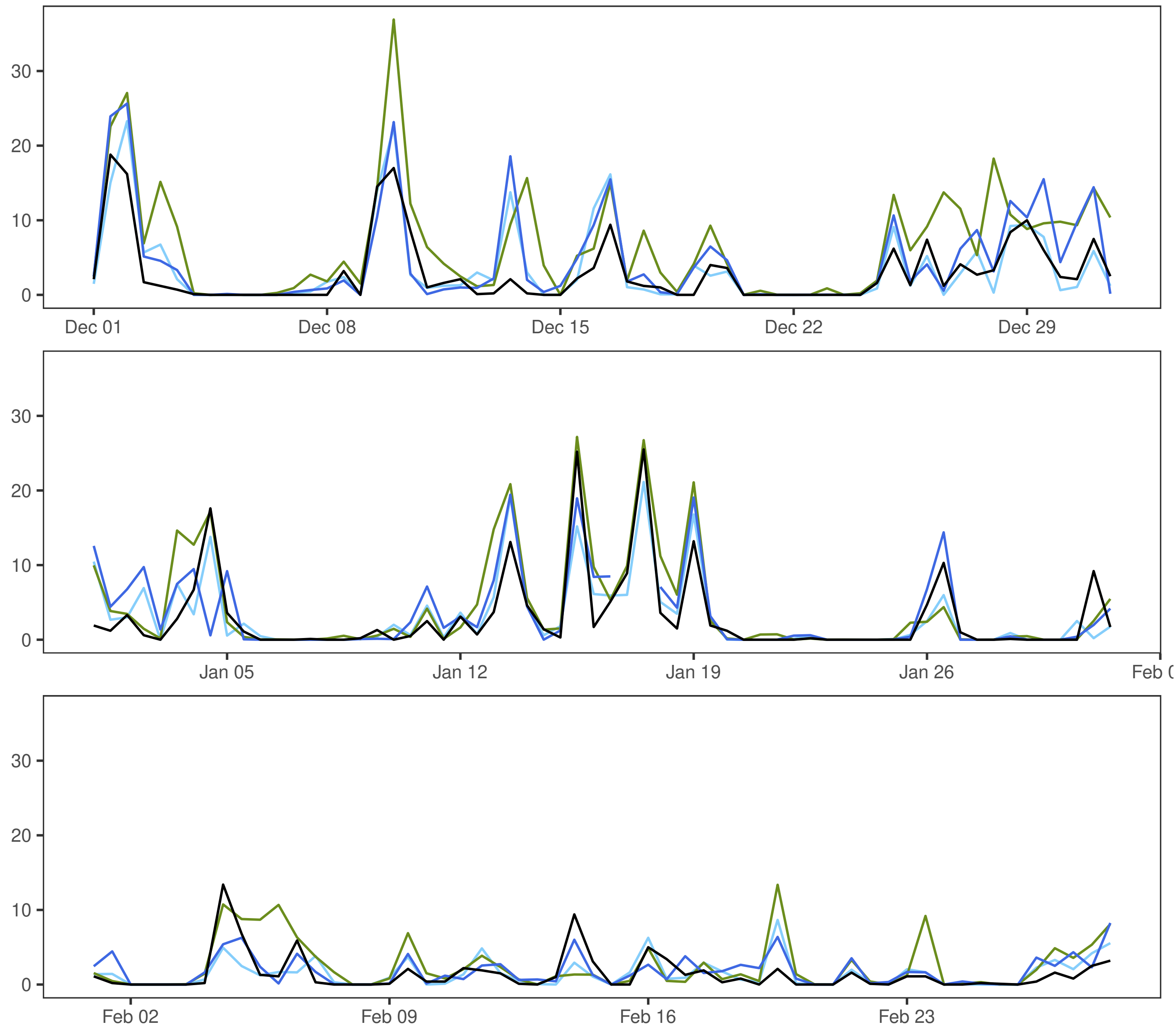
	ME	SDE	RMSE	MAE	Max.abs.err	N
MEPSctrl – synop	0.5	1.4	1.5	0.8	7.9	178
AA25 – synop	0.7	1.6	1.8	0.9	12.0	178
ECMWF – synop	0.4	1.1	1.2	0.7	5.0	178



	Min	Mean	Max	Std	N
synop: 06,18	0.0	2.8	22.8	4.4	180
MEPSctrl: 12+18,+30	0.0	2.3	26.3	4.1	178
AA25: 12+18,+30	0.0	2.1	20.4	3.6	180
ECMWF: 12+18,+30	0.0	2.9	38.7	5.2	180

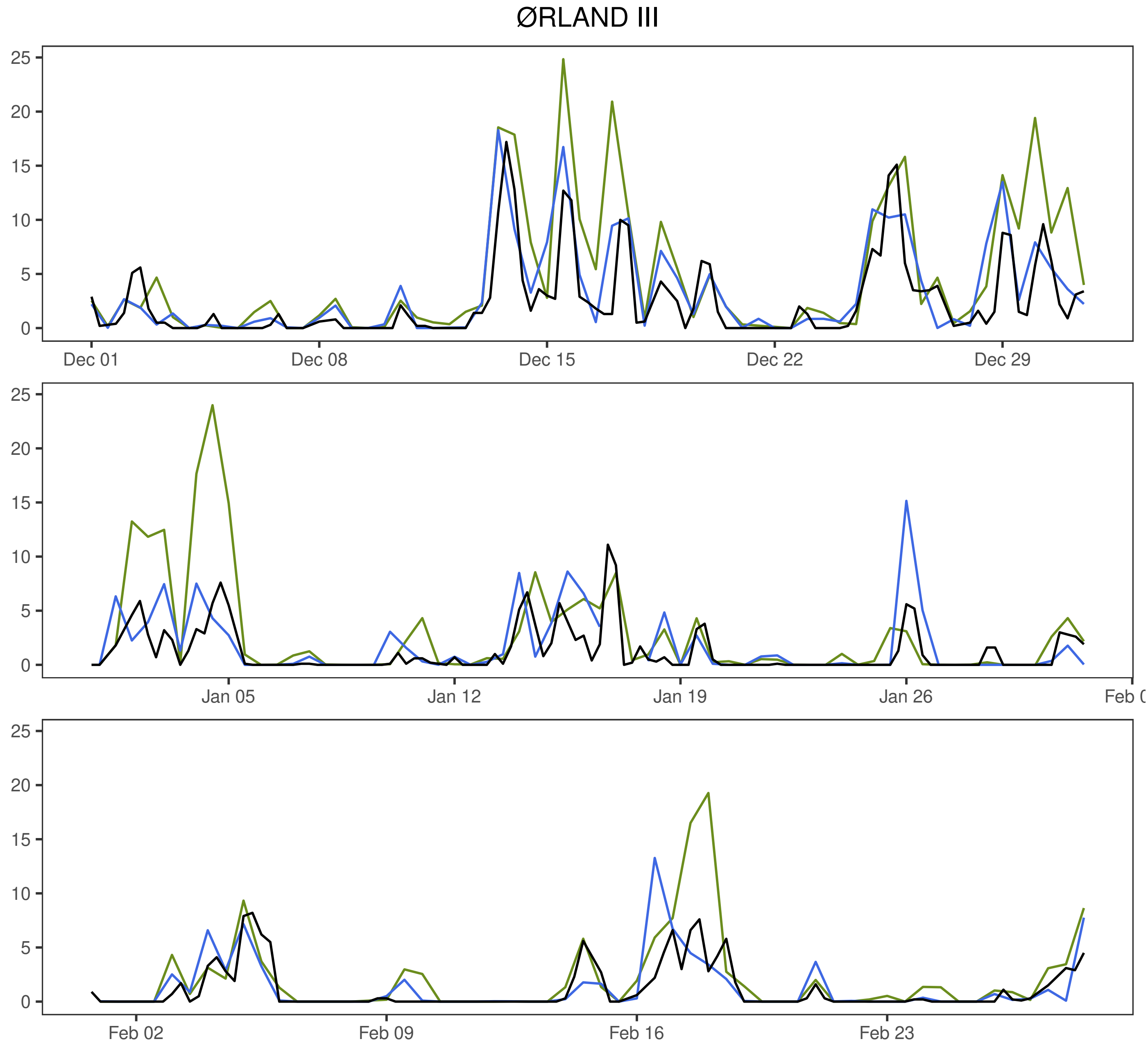
	ME	SDE	RMSE	MAE	Max.abs.err	N
MEPSctrl – synop	–0.4	3.0	3.0	1.5	14.5	178
AA25 – synop	–0.7	2.7	2.7	1.4	13.5	178
ECMWF – synop	0.1	2.9	2.9	1.4	20.7	178

REIPÅ



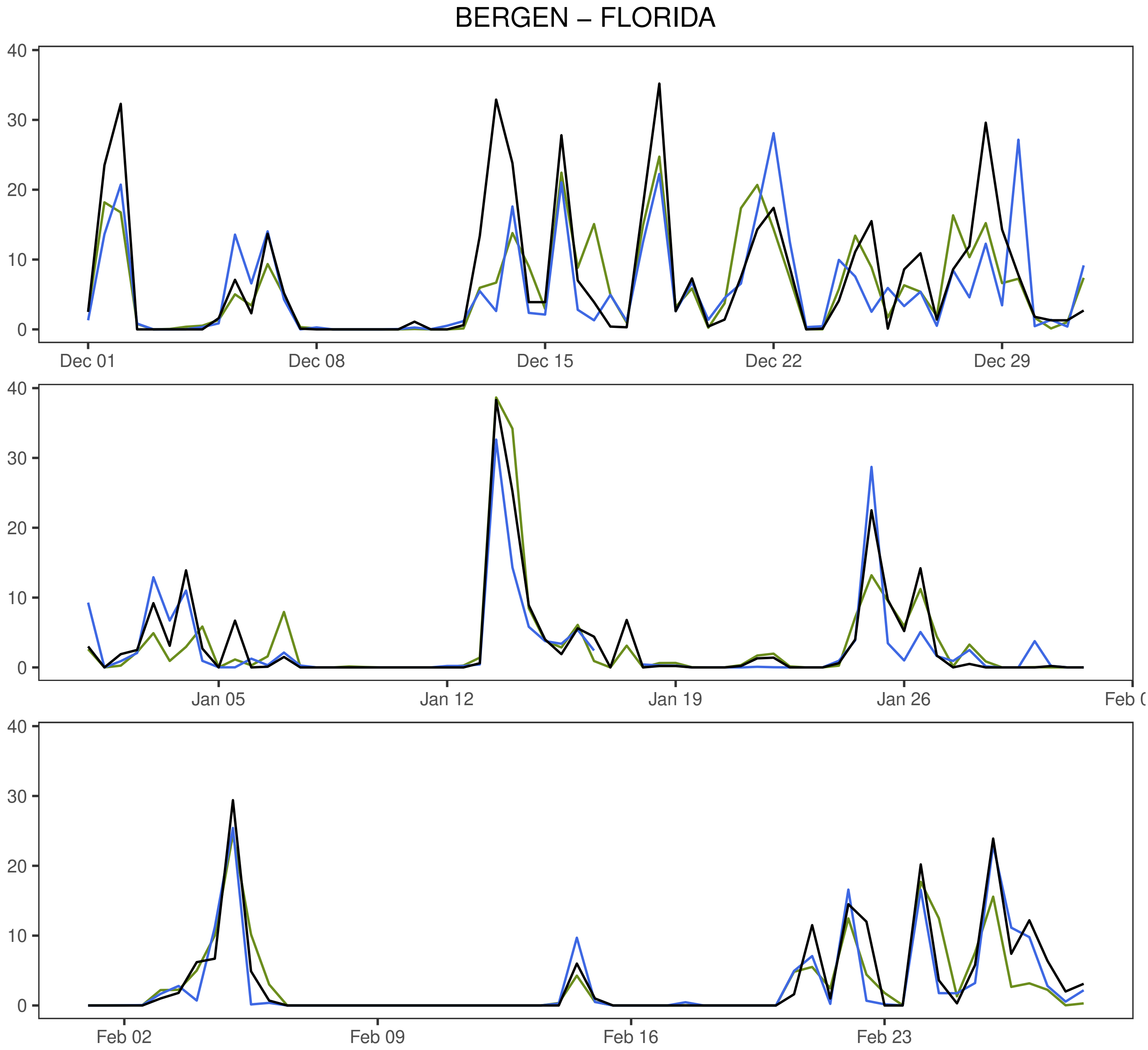
	Min	Mean	Max	Std	N
synop: 06,18	0.0	2.5	25.5	4.4	180
MEPSctrl: 12+18,+30	0.0	3.4	25.6	5.1	178
AA25: 12+18,+30	0.0	2.8	23.3	4.5	180
ECMWF: 12+18,+30	0.0	4.6	36.9	6.3	180

	ME	SDE	RMSE	MAE	Max.abs.err	N
MEPSctrl – synop	1.0	3.2	3.4	1.9	17.0	178
AA25 – synop	0.3	2.6	2.7	1.5	11.7	178
ECMWF – synop	2.1	3.9	4.4	2.5	19.9	178



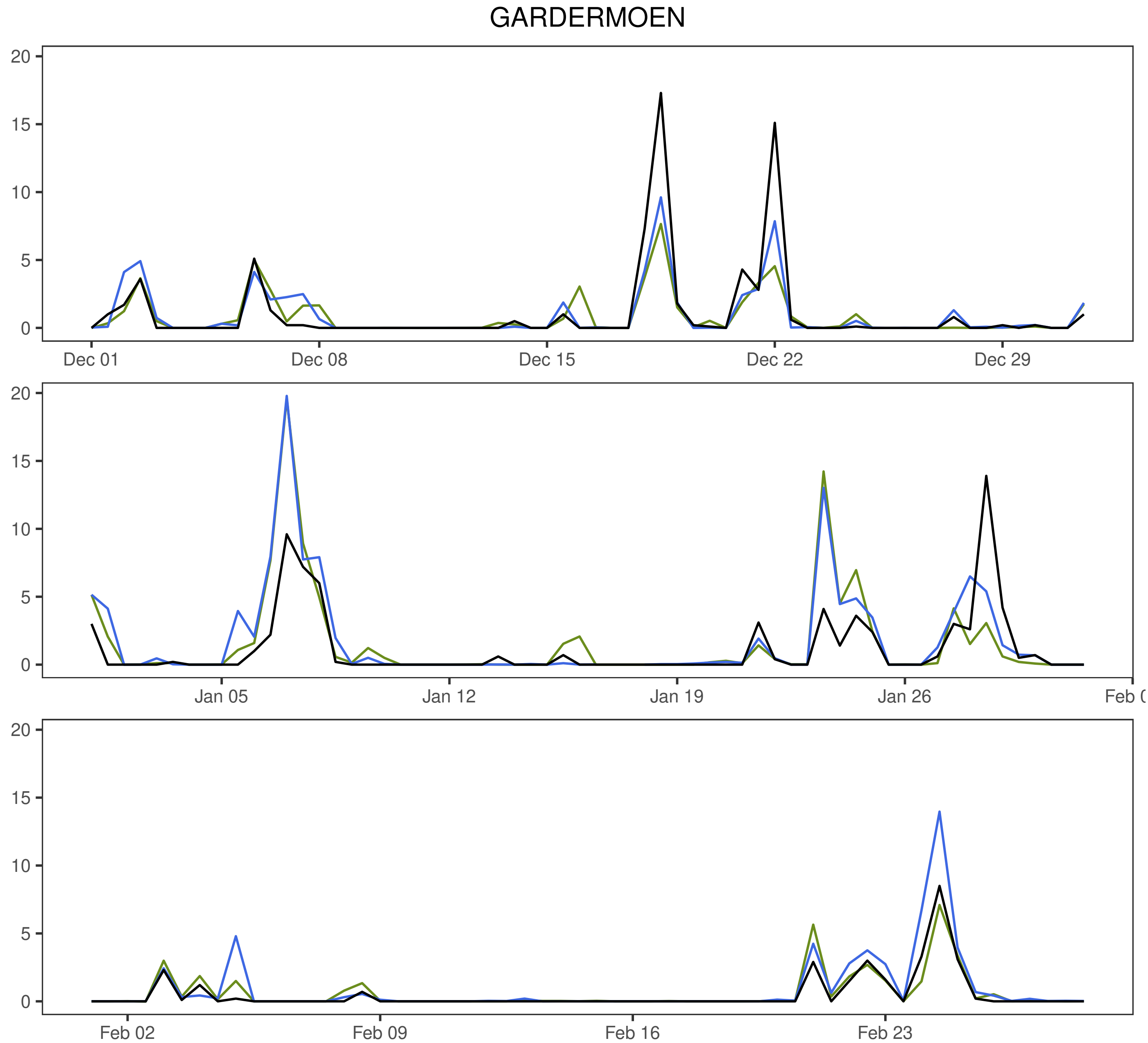
	Min	Mean	Max	Std	N
synop: 00,06,12,18	0.0	1.7	17.2	2.8	337
MEPSctrl: 12+18,+30	0.0	2.2	18.3	3.5	178
ECMWF: 12+18,+30	0.0	3.3	24.8	5.2	180

	ME	SDE	RMSE	MAE	Max.abs.err	N
MEPSctrl – synop	0.6	2.2	2.2	1.2	11.1	178
ECMWF – synop	1.7	3.6	4.0	1.9	19.6	178



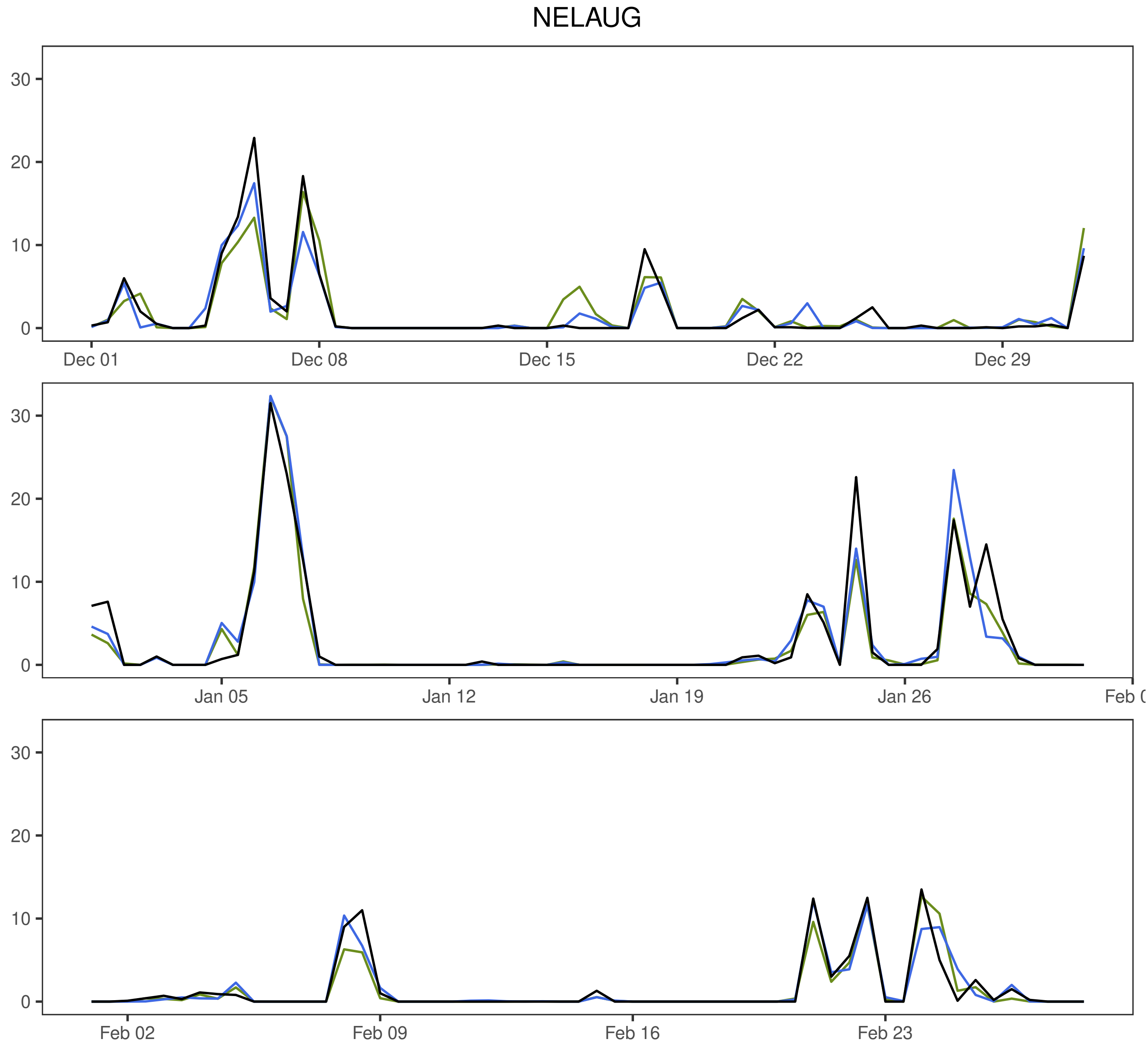
	Min	Mean	Max	Std	N
synop: 06,18	0.0	4.6	38.3	7.9	180
MEPSctrl: 12+18,+30	0.0	3.8	32.6	6.5	178
ECMWF: 12+18,+30	0.0	4.0	38.7	6.4	180

	ME	SDE	RMSE	MAE	Max.abs.err	N
MEPSctrl – synop	–0.8	4.5	4.6	2.3	30.3	178
ECMWF – synop	–0.6	4.1	4.1	2.1	26.2	178



	Min	Mean	Max	Std	N
synop: 06,18	0.0	0.9	17.3	2.5	180
MEPSctrl: 12+18,+30	0.0	1.2	19.8	2.7	178
ECMWF: 12+18,+30	0.0	1.0	19.6	2.4	180

	ME	SDE	RMSE	MAE	Max.abs.err	N
MEPSctrl – synop	0.3	1.8	1.8	0.7	10.2	178
ECMWF – synop	0.1	1.9	1.9	0.7	10.8	178



	Min	Mean	Max	Std	N
synop: 06,18	0.0	2.1	31.5	5.0	180
MEPSctrl: 12+18,+30	0.0	2.1	32.4	4.8	178
ECMWF: 12+18,+30	0.0	2.0	32.3	4.5	180

	ME	SDE	RMSE	MAE	Max.abs.err	N
MEPSctrl – synop	–0.1	1.8	1.8	0.8	11.1	178
ECMWF – synop	–0.2	1.8	1.8	0.8	10.0	178