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Verification of Operational Weather Prediction Models March to May 2024

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Contents

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

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 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.

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	$\left(\frac{1}{n} \sum_{i=1}^{n}(f_i - o_i - \mathrm{M}E)^2 \right)^{1/2}$	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

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

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

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 forecast 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. MEPSctrl shows a very small underestimation, while AA25 is slightly too warm for the Svalbard stations, and slightly too cold for the North Norwegian stations. Still, the errors are small, indicating that the timing of the temperature changes is generally good. 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.

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 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 maps show that underestimation also applies to coastal stations in strong wind events. The threshold scores indicate that wind speed is better forecast for lower than for higher wind speeds for all models. The mean error indicates a small underestimation of the wind speed after post processing, 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 which this spring had mean errors slightly above 0. Both models have larger errors for both very small amounts and very high amounts, than 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 undercatchment of observed snow. This leads to cases where it may look like the models have too much precipitation, when the reality is that the observation is inaccurate. AA25 and MEPSctrl show very similar results, which is expected since both are HARMONIE with AROME physics and a horizontal resolution defined by a 2.5×2.5 km^2 grid.

Case studies by forecasters

Case 1. Precipitation.

On 25 March, an area of embedded convective clouds gave precipitation in the form of snow over a large area in south eastern Norway. Figure 1 shows a radar image of the area at 12 UTC.

In figure 2 the differences in the model precipitation at 12 UTC for difference lead times (+9, +6, +3) can be seen. There are very small differences in the placement of the precipitation. Figure 3 shows the differences in forecast precipitation from the MetCoOp-nowcasting (MNWC) at 12 UTC for difference lead times (+3, +2, +1).

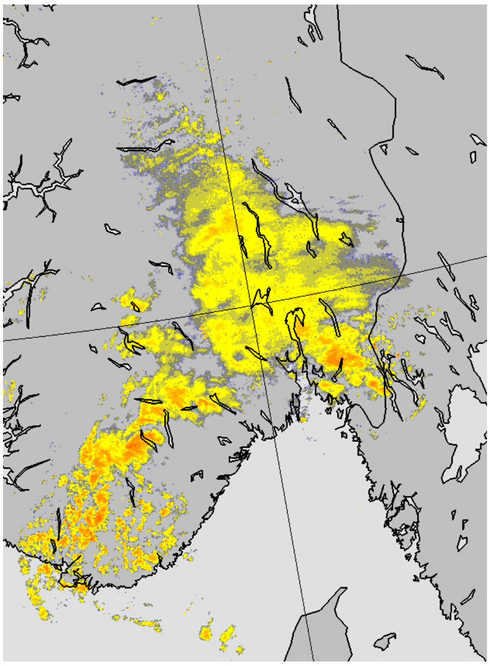


Figure 1: Radar image of preciptitation over southern Norway at 12 UTC on 25 March.

As seen in figure 2, much of the precipitation was not captured by MEPSctrl, especially in the areas around the Oslo Fjord and further north. The more prominent convective cells in the southern part of Norway were captured quite well, but the light snowfall further north and east was not. MNWC is also struggling with capturing the precipitation (figure 3) and shows no major improvements to the operational MEPS model even for lead times of just one hour.

Independently of lead time in the first nine hours the placement of the precipitation remains more or less unchanged. This means that the spin-up was not the cause of error in this case. Rather, it illustrates that there is still a tendency that MEPSctrl (and MNWC) is underforecasting precipitation in certain conditions.

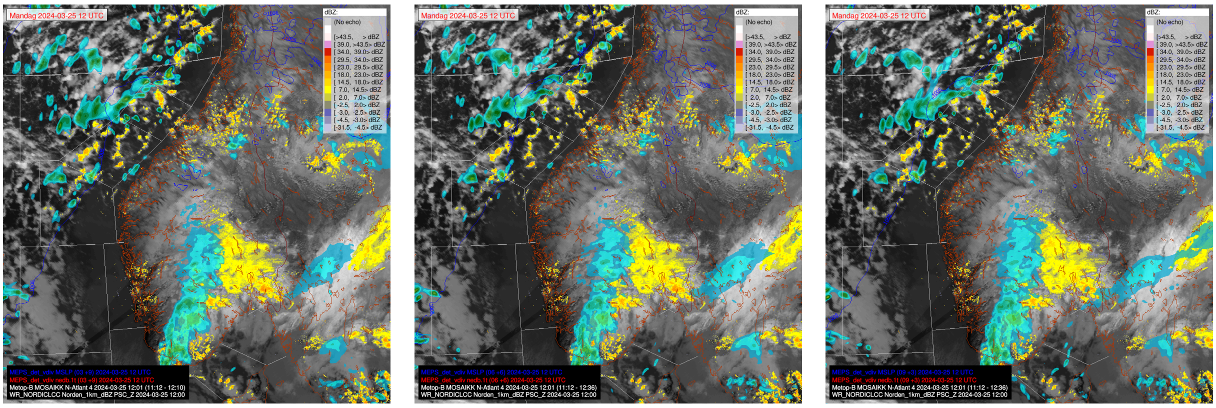


Figure 2: Forecast precipitation (in blue) from MEPSctrl at 12 UTC on 25 March with different lead times, 03+9 (left), 06+6 (middle) and 09+3 (right). The yellow/orange shading is the radar precipitation as seen in figure 1.

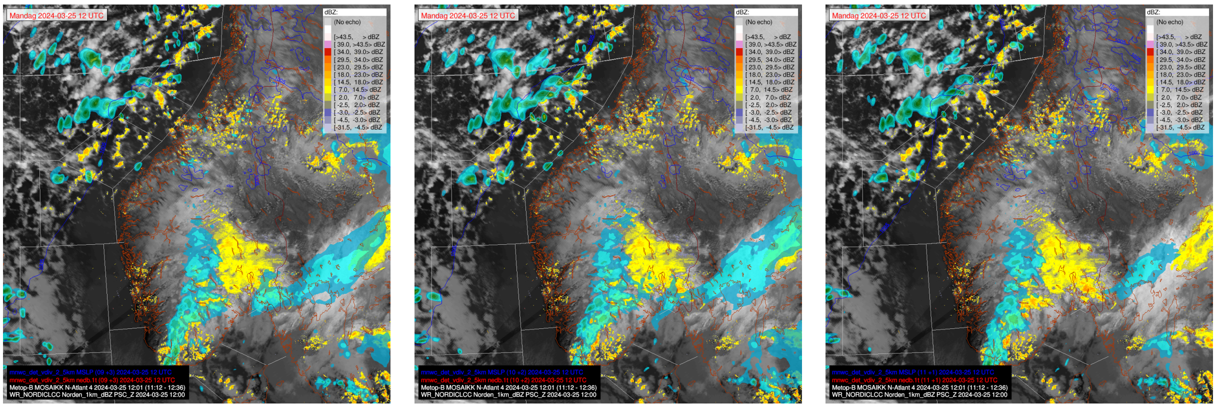


Figure 3: Forecast precipitation (in blue) from the MNWC model at 12 UTC on 25 March with different lead times, 09+3 (left), 10+2 (middle) and 11+1 (right).

Case 2. Missing low clouds.

On 6 May large parts of northern Norway were covered in a widespread stratocumulus cloud cover at around 1000 m. This, however, was not well represented in MEPSctrl and AA25 for parts of Nordland and Troms, causing Yr to forecast nearly cloud free conditions in places like Tromsø (figure 4, left), while the reality was an overcast day (figure 4, right).

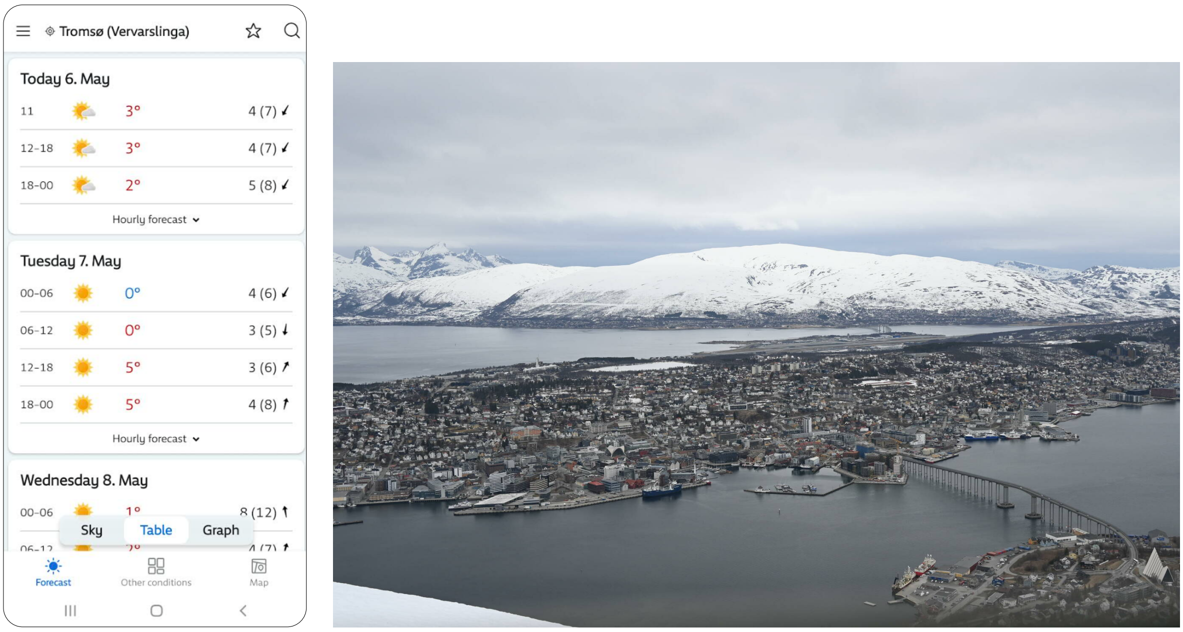


Figure 4: The forecast for Tromsø from Yr (left) and the city of Tromsø seen from the top of Fjellheisen (right).

Also located in the same stratocumulus cloud cover was Andenes. Figure 5 shows the observed and prognostic soundings from Andenes at 00 UTC on 6 May.

The soundings show that while all the models seem to capture a thin cloud layer at around 1000 m (∼3000 ft), they are too dry in the range 3000-5000 ft. None of the models capture the strong inversion correctly. This would explain the forecast shown on Yr. Note also that the MetCoOp-Nowcasting (MNWC) is not performing better than the other models despite having a shorter lead time.

In figure 6 we show the prognostic soundings from Tromsø at 08 and 12 UTC on 6 May. There is no observational sounding to compare them to directly, but it is relatively safe to assume that the sounding from Andenes is comparable. It seems that ECMWF performs better and is more humid in the 3000-5000 ft range than MEPSctrl and AA25 at 08 UTC, while the difference is smaller at 12 UTC, though ECMWF still seems to be performing slightly better.

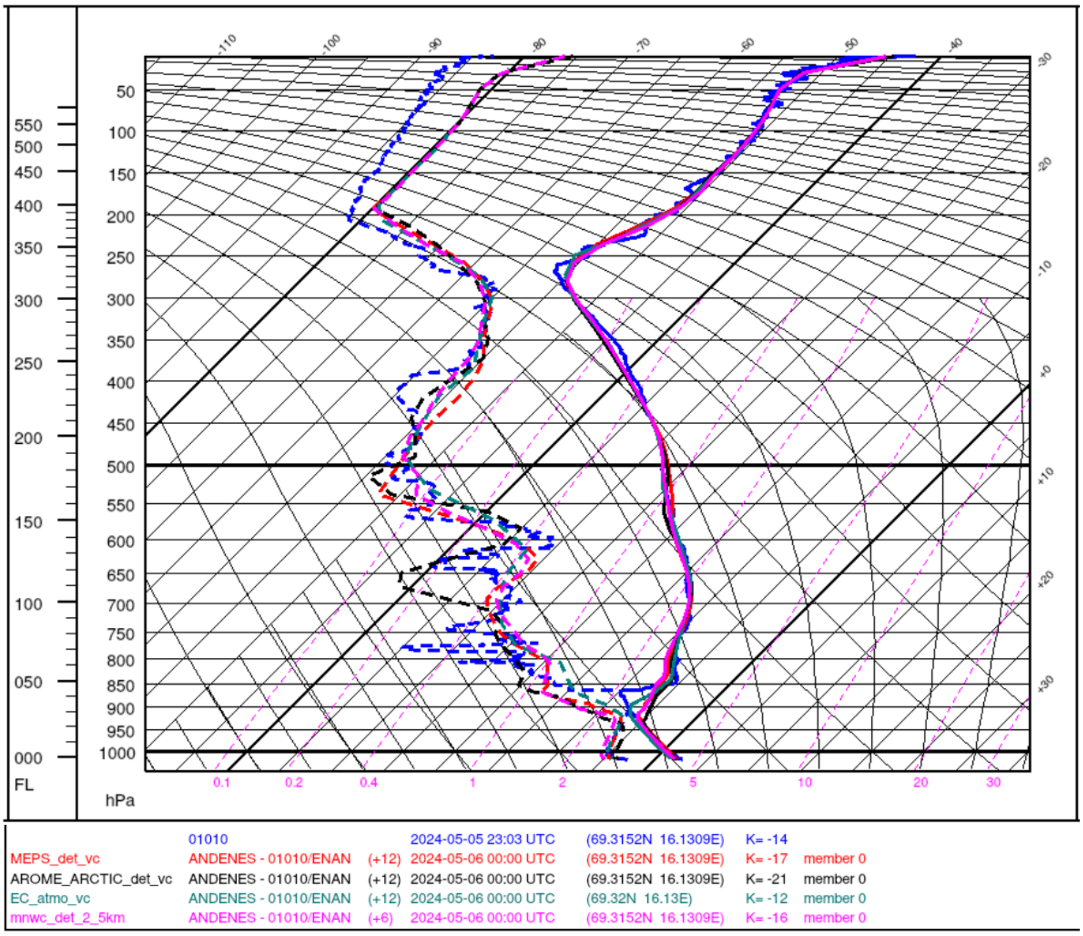


Figure 5: Soundings at Andenes at 00 UTC on 6 May. Observed sounding in blue, prognostic soundings from MEPSctrl (red), AA25 (black), ECMWF (green) and MNWC (magenta).

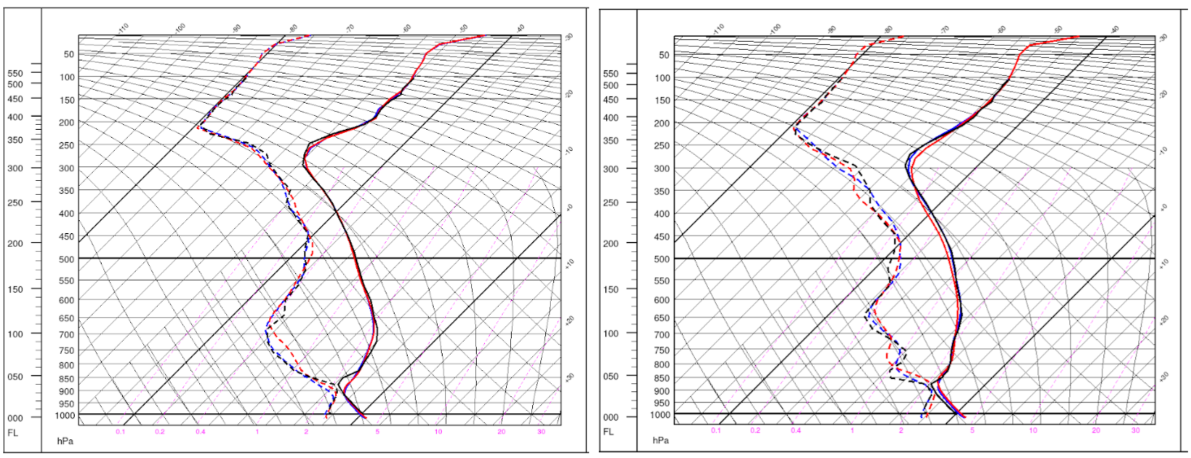


Figure 6: Prognostic soundings from Tromsø at 08 UTC (left) and 12 UTC (right). MEPSctrl in blue, AA25 in red and ECMWF in black.

Case 3. False fog.

May is the start of the fog season, and experiences so far indicate that the problems with excessive fog persists. Generally the prognosis for fog is considered as unreliable.

This case in the North Sea from 6 May illustrates the situation (figure 7). Here the prognostic 2m temperature (T2m) was slightly too low compared to observations (figure 8), and upon reaching saturation, the T2m fell further due to outgoing radiation from the prognosed fog layer. This in turn expanded the fog area further. The sea surface temperature (SST) was 7-9°C in the area. It seems that the reason for the erratic fog was either associated with the radiation at the top of the cloud layer or that the T2m was too much affected by the underlying surface. In any case this event illustrates that there may be an issue with the model physics in the lowest model levels.

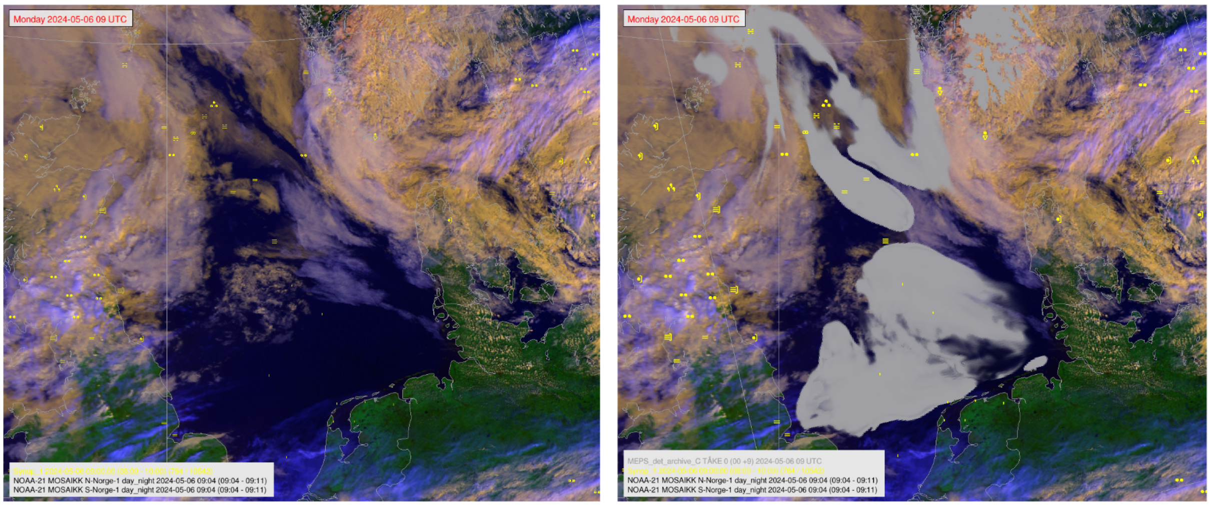


Figure 7: Satellite picture of the North Sea at 09 UTC on 6 May (left) and the forecast fog from MEPSctrl (in grey) at 09 UTC on top of the same satellite image (right).

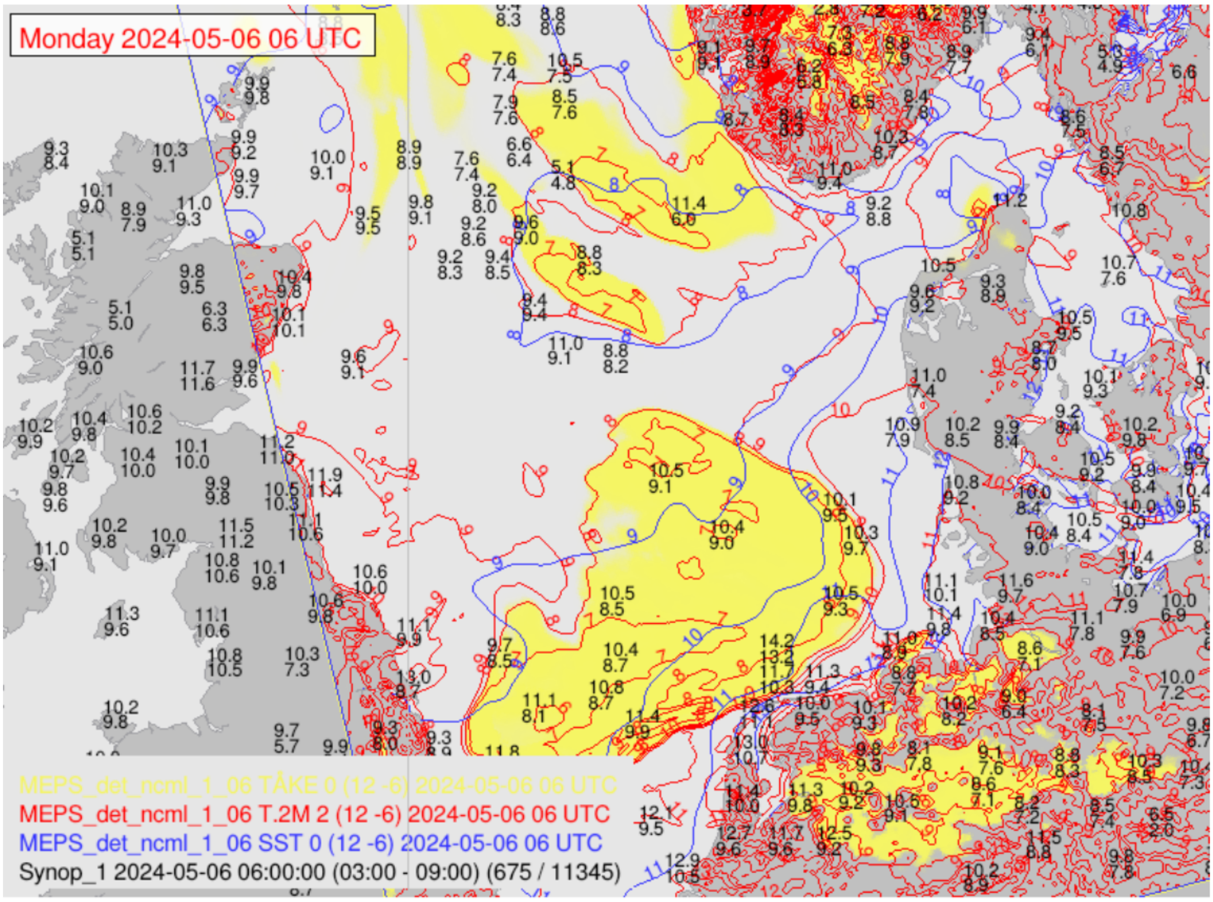
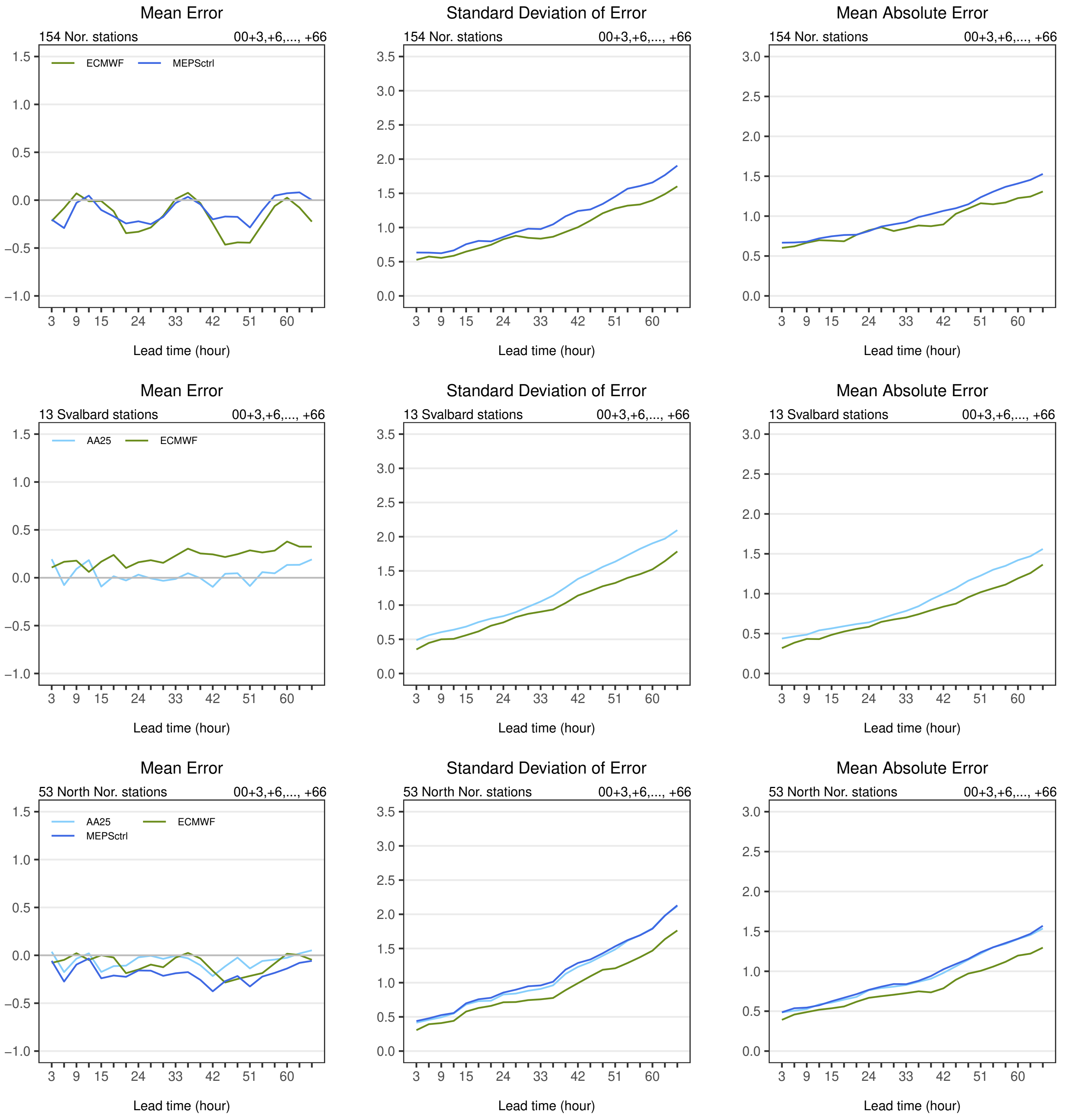
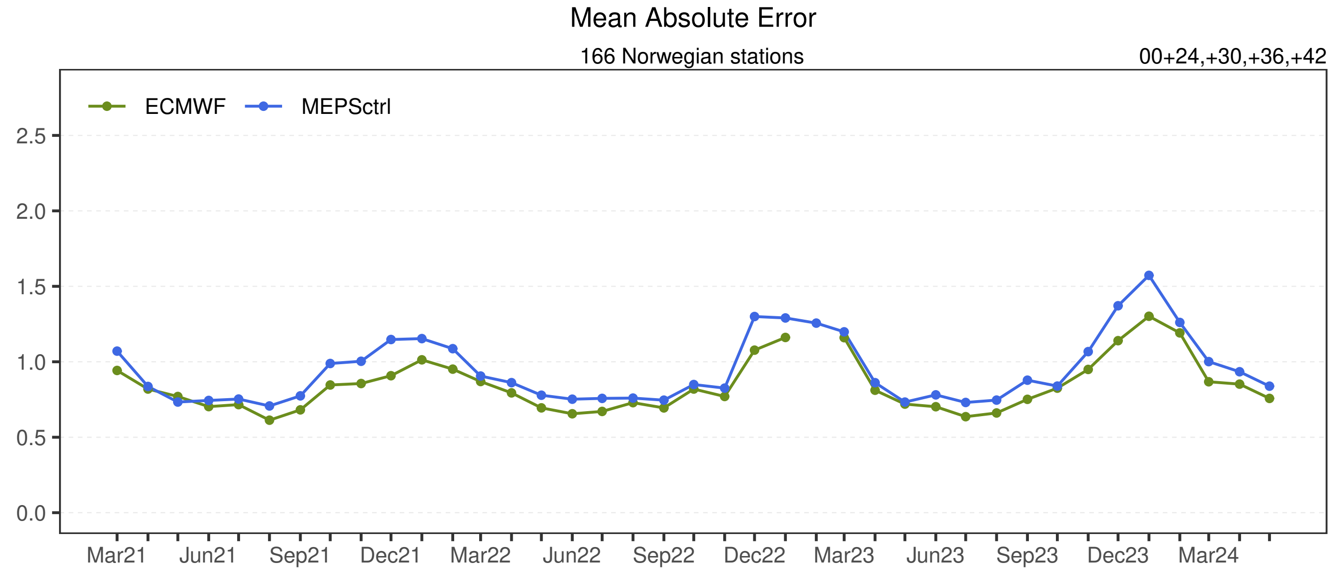


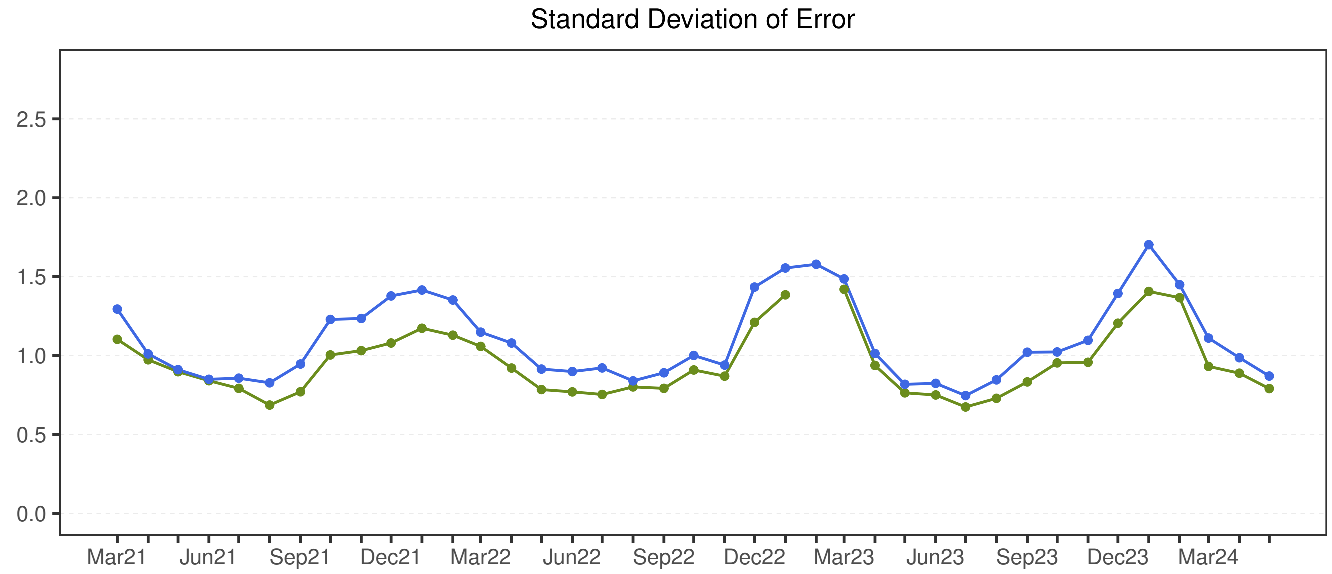
Figure 8: The T2m (red), SST (blue) and the prognostic fog (yellow) plotted against observations of T2m and 2m dew point temperature (black). As can be seen, the prognostic T2m is just slightly too low, but this error is sufficient to set off the chain reaction causing false prognostic fog.

Summarized statistics



Mean Error
154 Nor. stations
00+3,+6,..., +66
ECMWF
MEPSctrl
Lead time (hour)
Standard Deviation of Error
154 Nor. stations
00+3,+6,..., +66
Lead time (hour)
Mean Absolute Error
154 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
13 Svalbard stations
00+3,+6,..., +66
Lead time (hour)
Mean Error
53 North Nor. stations
00+3,+6,..., +66
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
Mar21
Jun21
Sep21
Dec21
Mar22
Jun22
Sep22
Dec22
Mar23
Jun23
Sep23
Dec23
Mar24


Standard Deviation of Error
2.5
2.0
1.5
1.0
0.5
0.0
Mar21
Jun21
Sep21
Dec21
Mar22
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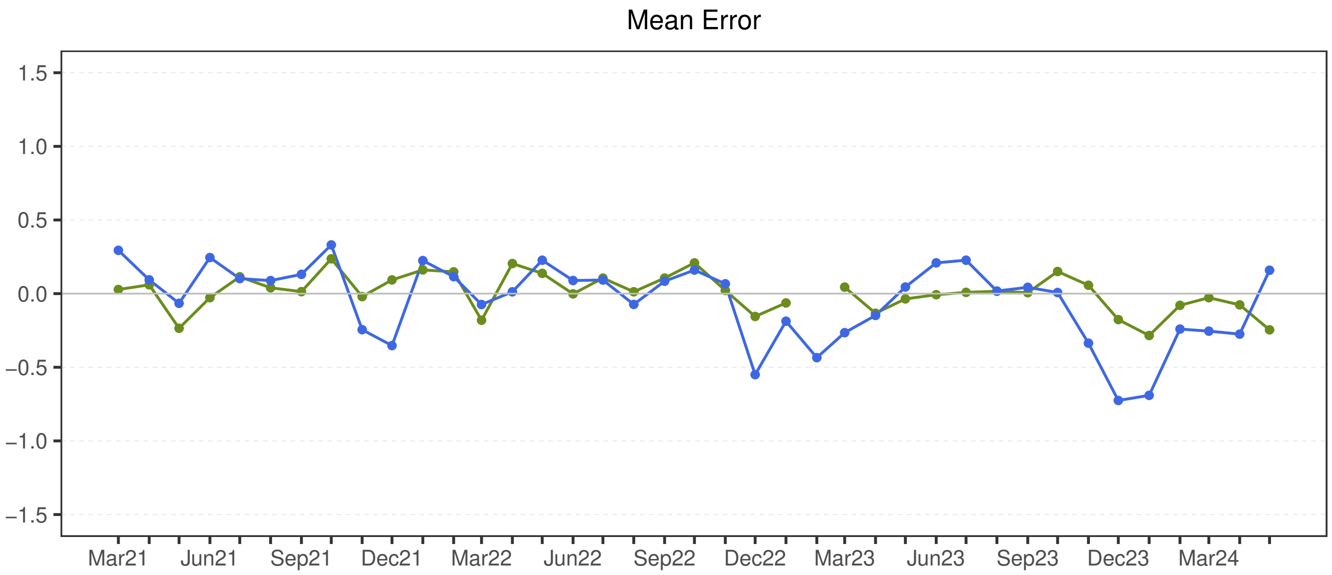
Jun23
Sep23
Dec23
Mar24


Mean Error
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1.0
0.5
0.0
−0.5
−1.0
−1.5
Mar21
Jun21
Sep21
Dec21
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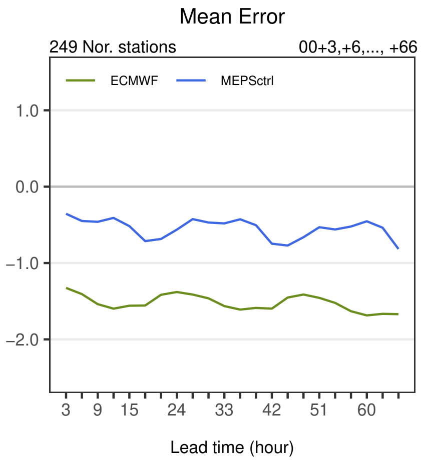
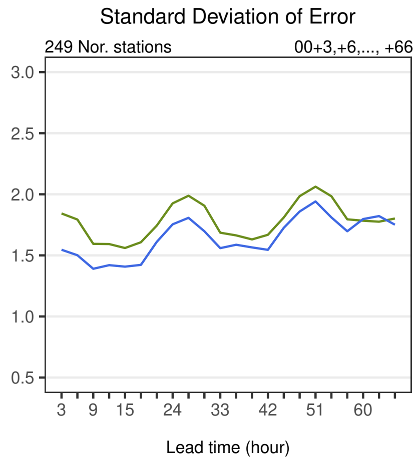
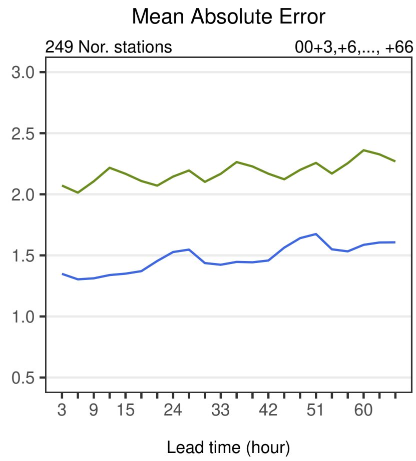
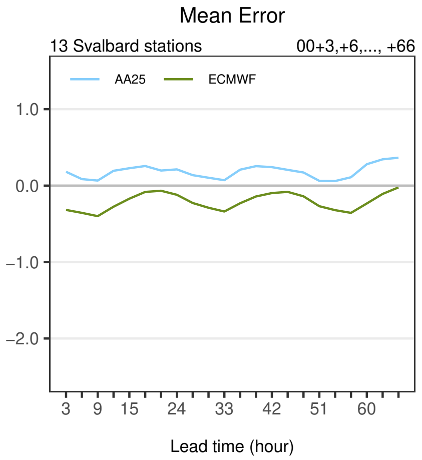
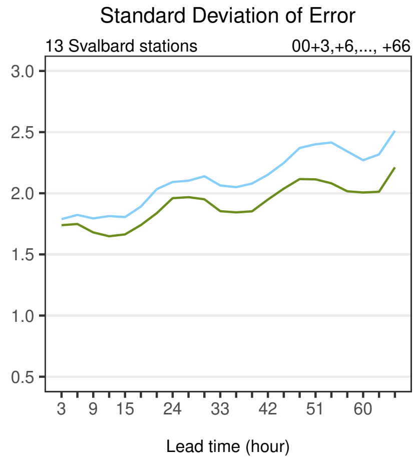
Jun23
Sep23
Dec23
Mar24

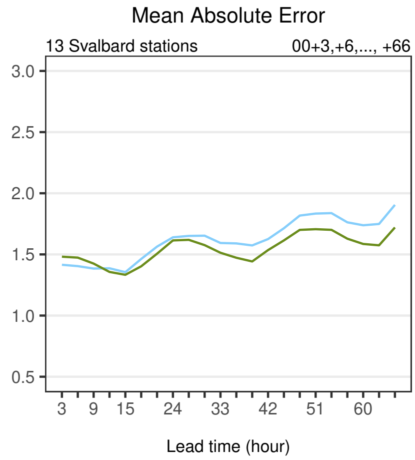

Mean Error
249 Nor. stations
00+3,+6,..., +66
ECMWF
MEPSctrl
1.0
0.0
−1.0
−2.0
3 9 15 24 33 42 51 60
Lead time (hour)

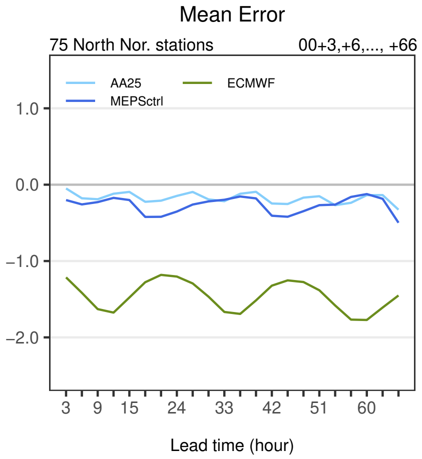

Standard Deviation of Error
249 Nor. stations
00+3,+6,..., +66
3.0
2.5
2.0
1.5
1.0
0.5
3 9 15 24 33 42 51 60
Lead time (hour)

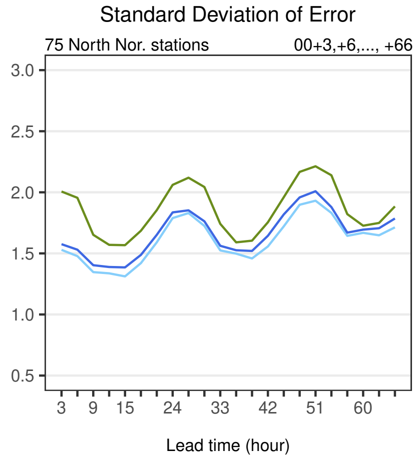

Mean Absolute Error
249 Nor. stations
00+3,+6,..., +66
3.0
2.5
2.0
1.5
1.0
0.5
3 9 15 24 33 42 51 60
Lead time (hour)

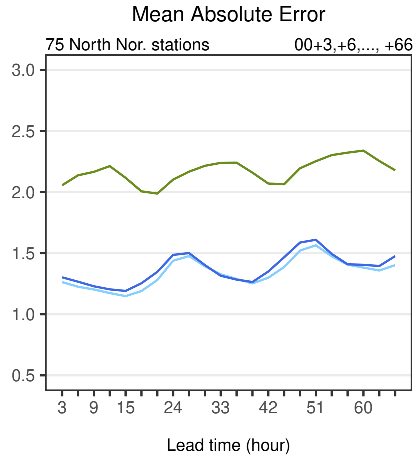

Mean Error
13 Svalbard stations
00+3,+6,..., +66
AA25
ECMWF
1.0
0.0
−1.0
−2.0
3 9 15 24 33 42 51 60
Lead time (hour)

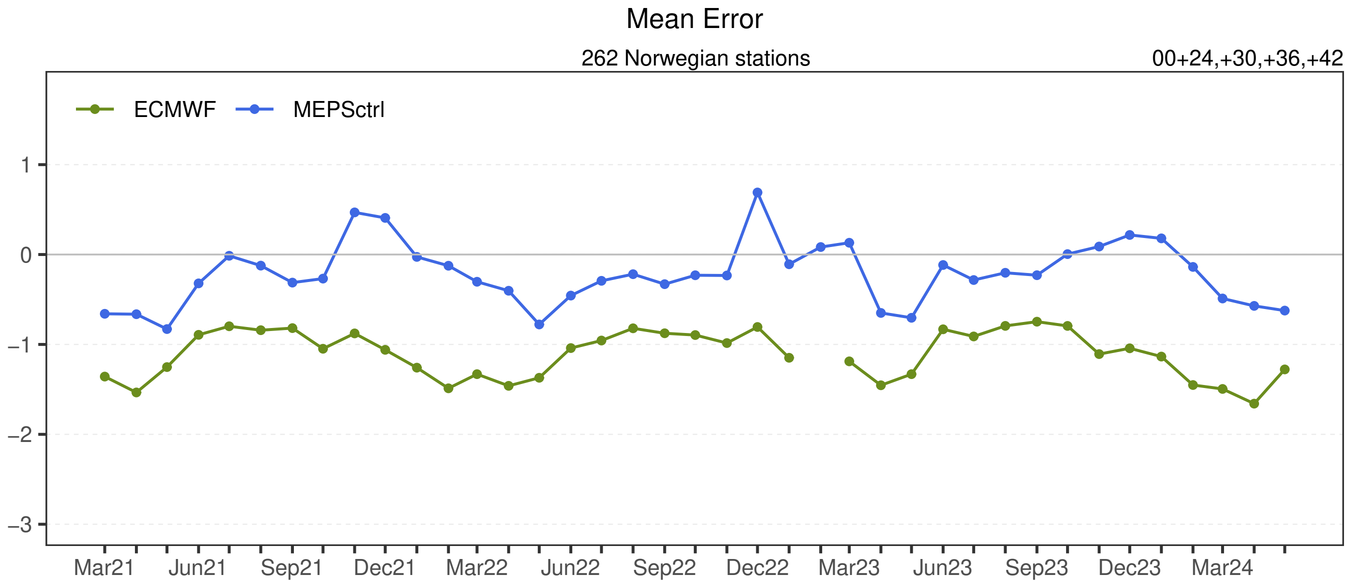

Standard Deviation of Error
13 Svalbard stations
00+3,+6,..., +66
3.0
2.5
2.0
1.5
1.0
0.5
3 9 15 24 33 42 51 60
Lead time (hour)

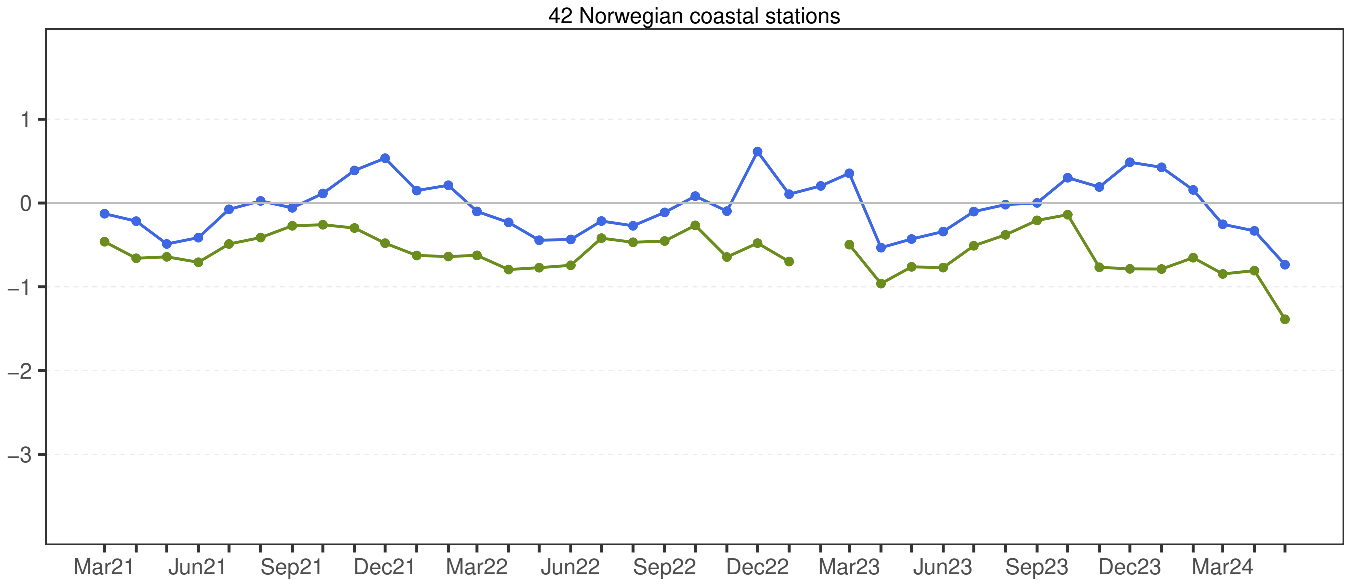

Mean Absolute Error
13 Svalbard stations
00+3,+6,..., +66
3.0
2.5
2.0
1.5
1.0
0.5
3 9 15 24 33 42 51 60
Lead time (hour)

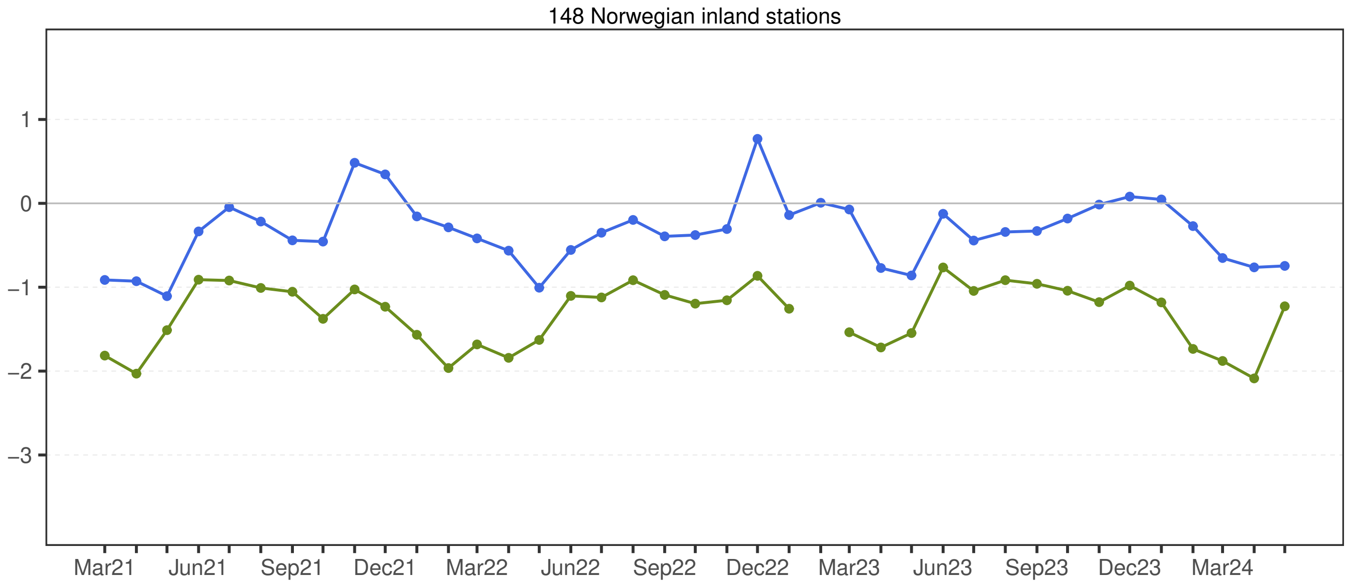

Mean Error
75 North Nor. stations
00+3,+6,..., +66
AA25
ECMWF
MEPSctrl
1.0
0.0
−1.0
−2.0
3 9 15 24 33 42 51 60
Lead time (hour)

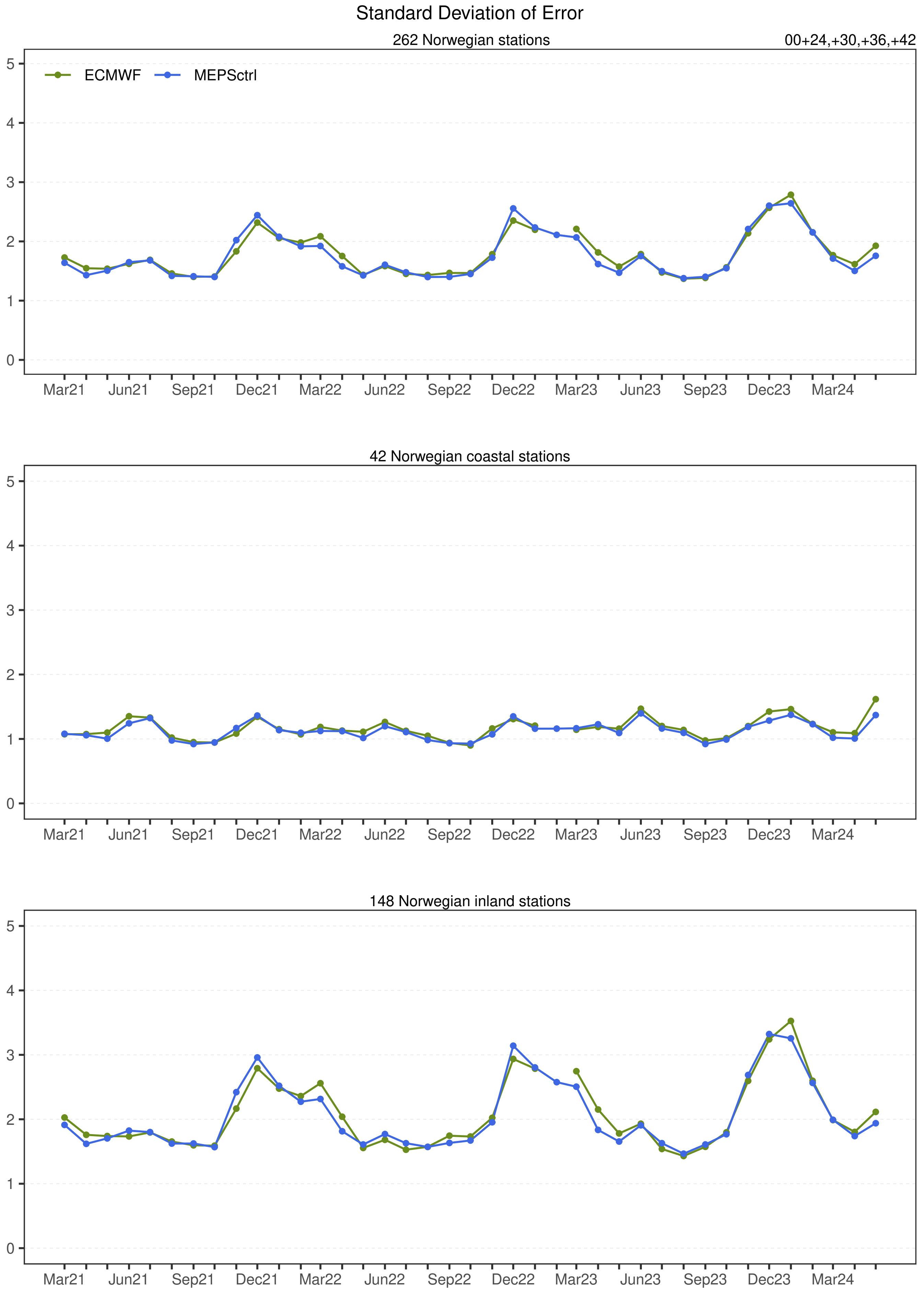

Standard Deviation of Error
75 North Nor. stations
00+3,+6,..., +66
3.0
2.5
2.0
1.5
1.0
0.5
3 9 15 24 33 42 51 60
Lead time (hour)

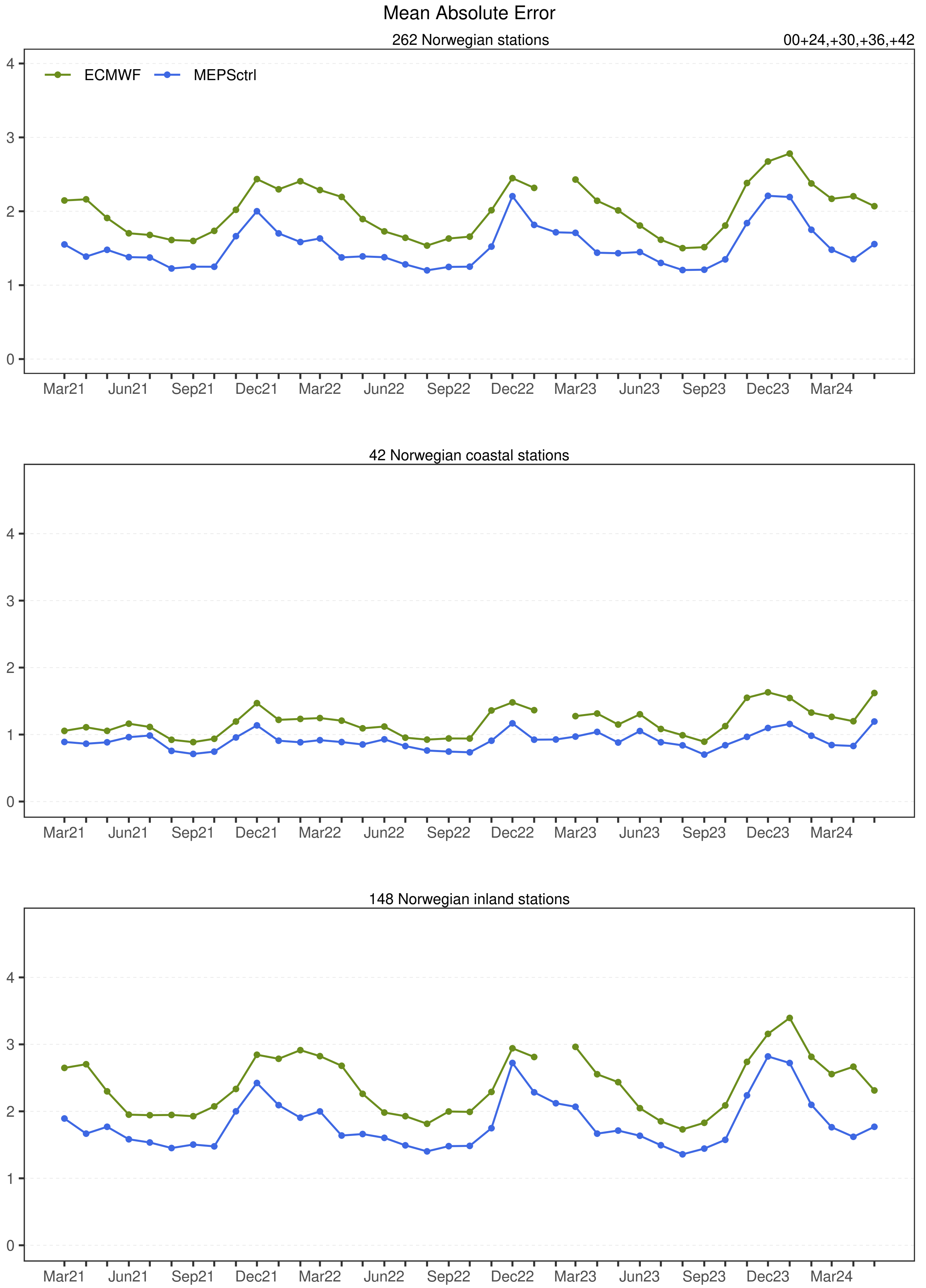

Mean Absolute Error
75 North Nor. stations
00+3,+6,..., +66
3.0
2.5
2.0
1.5
1.0
0.5
3 9 15 24 33 42 51 60
Lead time (hour)


Mean Error
262 Norwegian stations
00+24,+30,+36,+42
ECMWF
MEPSctrl
1
0
−1
−2
−3
Mar21
Jun21
Sep21
Dec21
Mar22
Jun22
Sep22
Dec22
Mar23
Jun23
Sep23
Dec23
Mar24

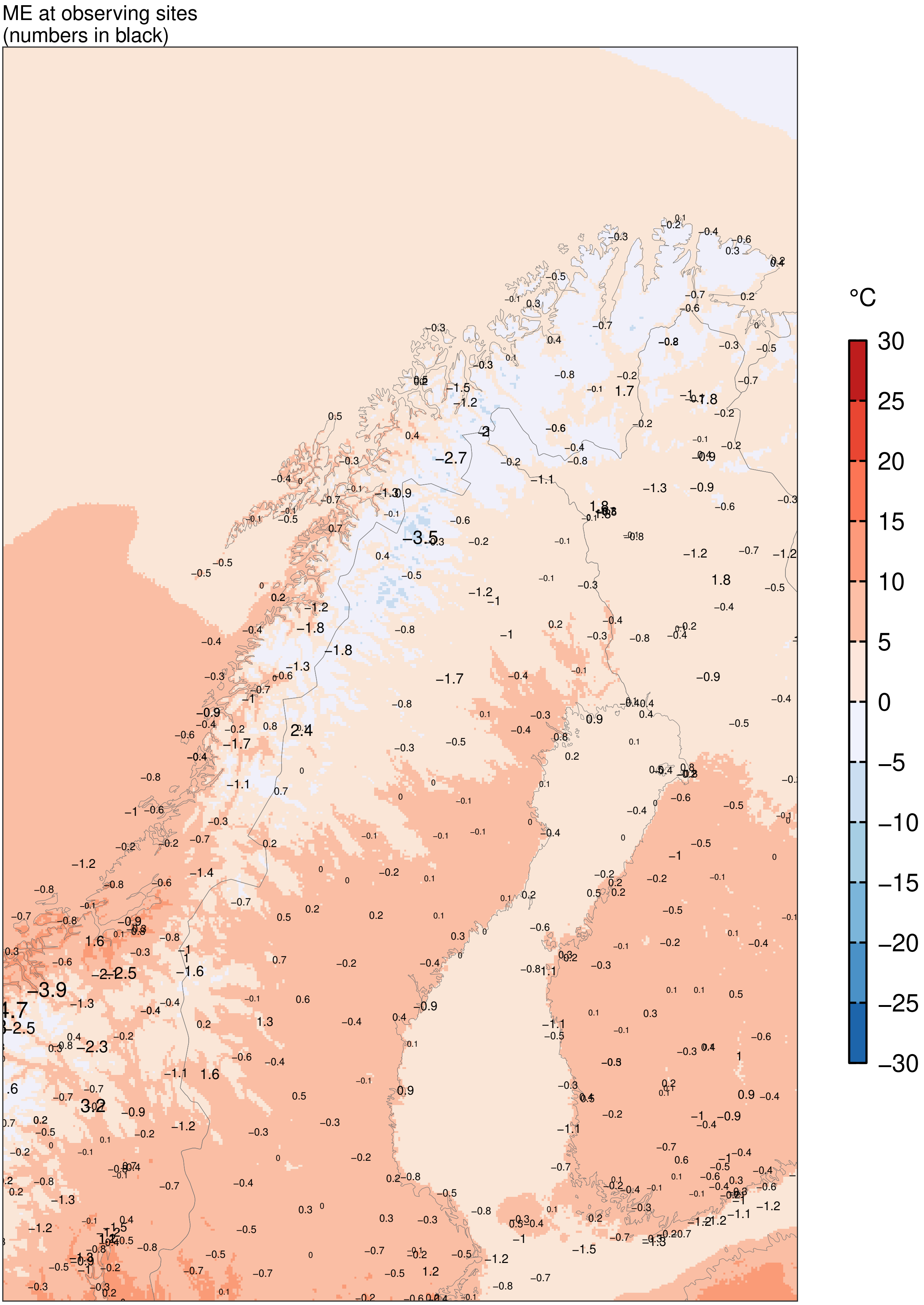

42 Norwegian coastal stations
1
0
−1
−2
−3
Mar21
Jun21
Sep21
Dec21
Mar22
Jun22
Sep22
Dec22
Mar23
Jun23
Sep23
Dec23
Mar24


148 Norwegian inland stations
1
0
−1
−2
−3
Mar21
Jun21
Sep21
Dec21
Mar22
Jun22
Sep22
Dec22
Mar23
Jun23
Sep23
Dec23
Mar24


Standard Deviation of Error
262 Norwegian stations
00+24,+30,+36,+42
ECMWF
MEPSctrl
0
1
2
3
4
5
Mar21 Jun21 Sep21 Dec21 Mar22 Jun22 Sep22 Dec22 Mar23 Jun23 Sep23 Dec23 Mar24
42 Norwegian coastal stations
0
1
2
3
4
5
Mar21 Jun21 Sep21 Dec21 Mar22 Jun22 Sep22 Dec22 Mar23 Jun23 Sep23 Dec23 Mar24
148 Norwegian inland stations
0
1
2
3
4
5
Mar21 Jun21 Sep21 Dec21 Mar22 Jun22 Sep22 Dec22 Mar23 Jun23 Sep23 Dec23 Mar24


Mean Absolute Error
262 Norwegian stations
00+24,+30,+36,+42
ECMWF
MEPSctrl
0
1
2
3
4
Mar21
Jun21
Sep21
Dec21
Mar22
Jun22
Sep22
Dec22
Mar23
Jun23
Sep23
Dec23
Mar24
42 Norwegian coastal stations
148 Norwegian inland stations

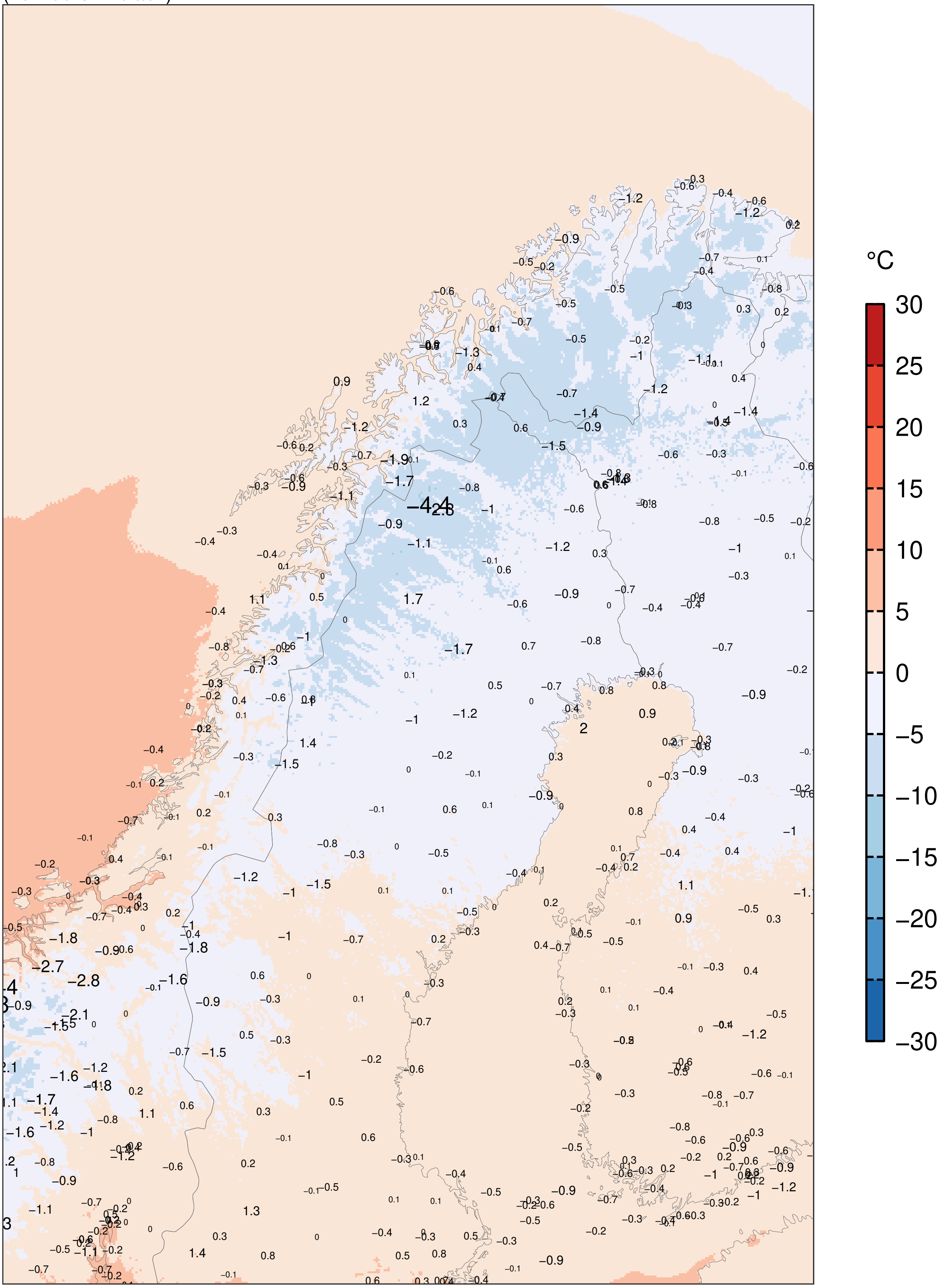
MEPSctrl 00+12



Model "climatology" 01.03.2024–31.05.2024

MEPSctrl 00+24

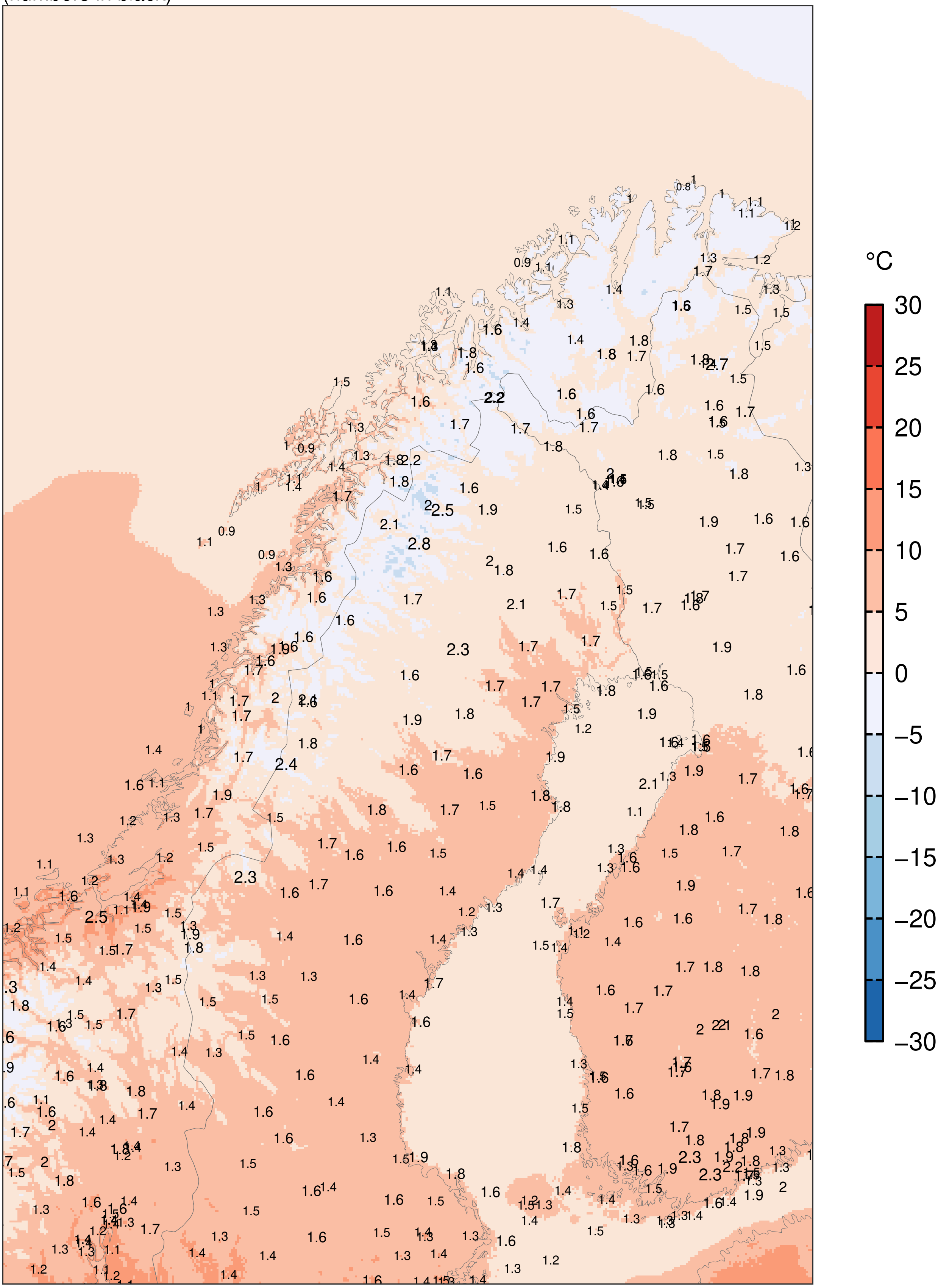
ME at observing sites
(numbers in black)



Model "climatology" 01.03.2024–31.05.2024

MEPSctrl 00+12

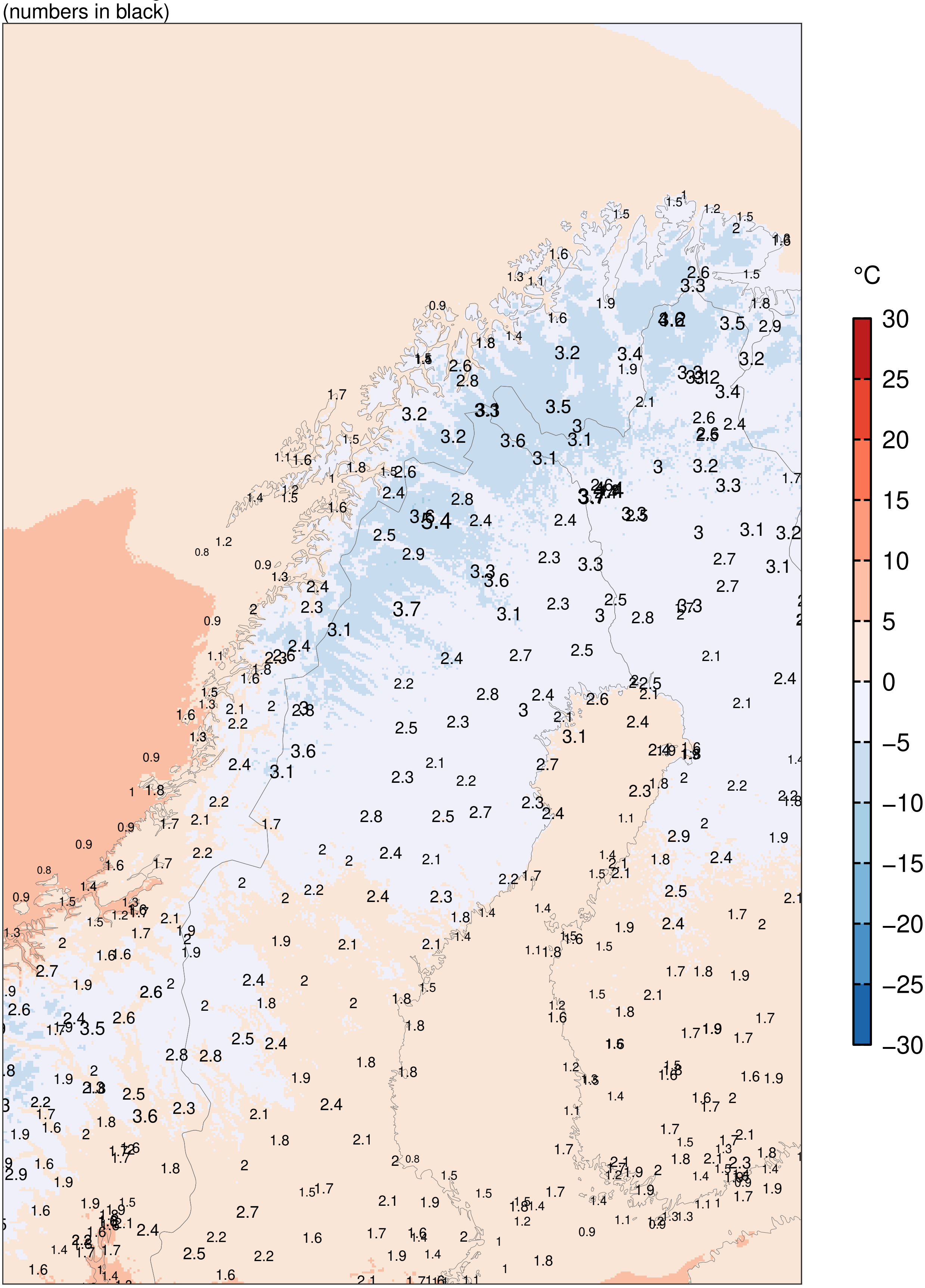
SDE at observing sites
(numbers in black)



Model "climatology" 01.03.2024–31.05.2024

MEPSctrl 00+24

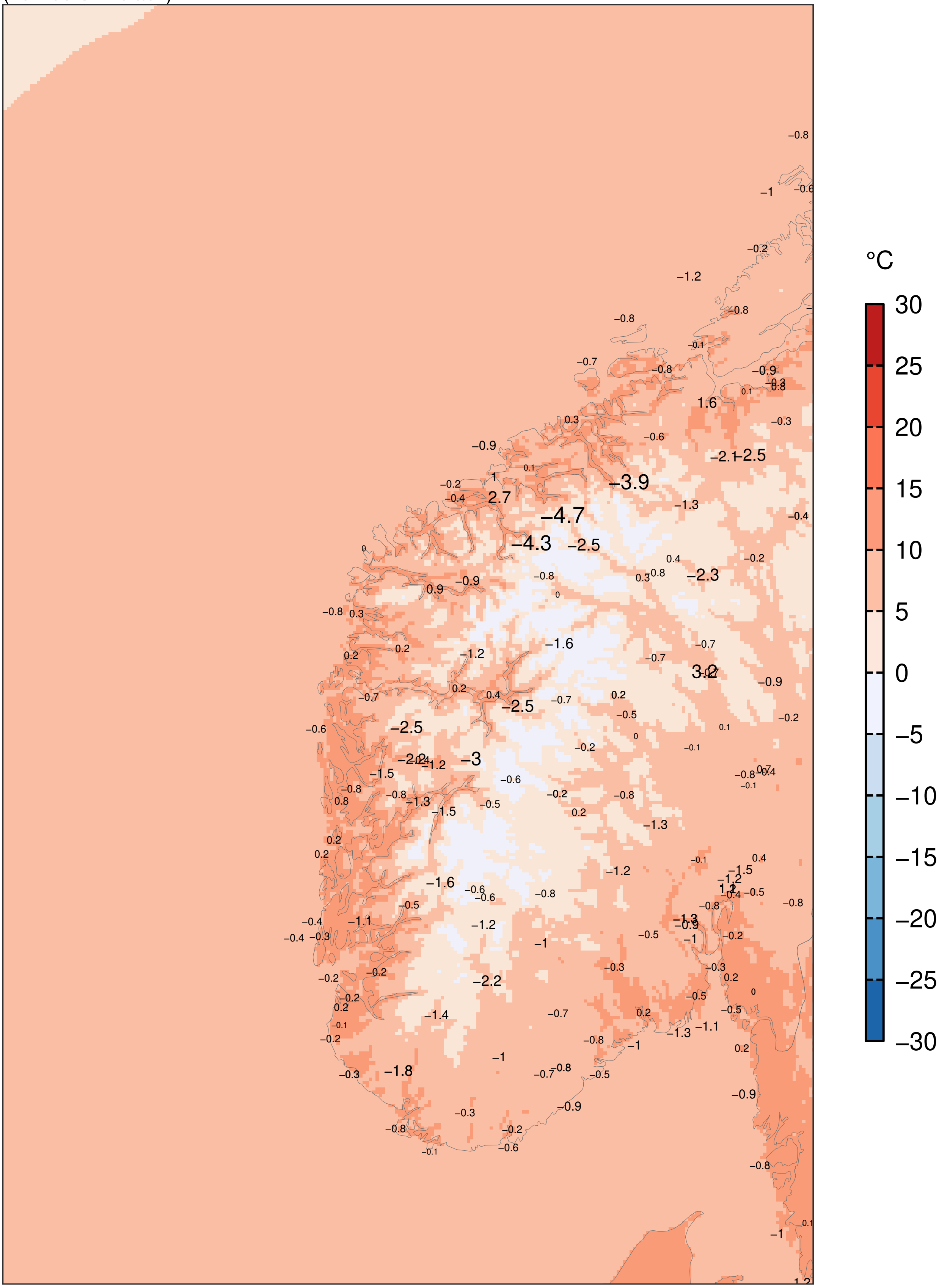
SDE at observing sites
(numbers in black)



Model "climatology" 01.03.2024–31.05.2024

MEPSctrl 00+12

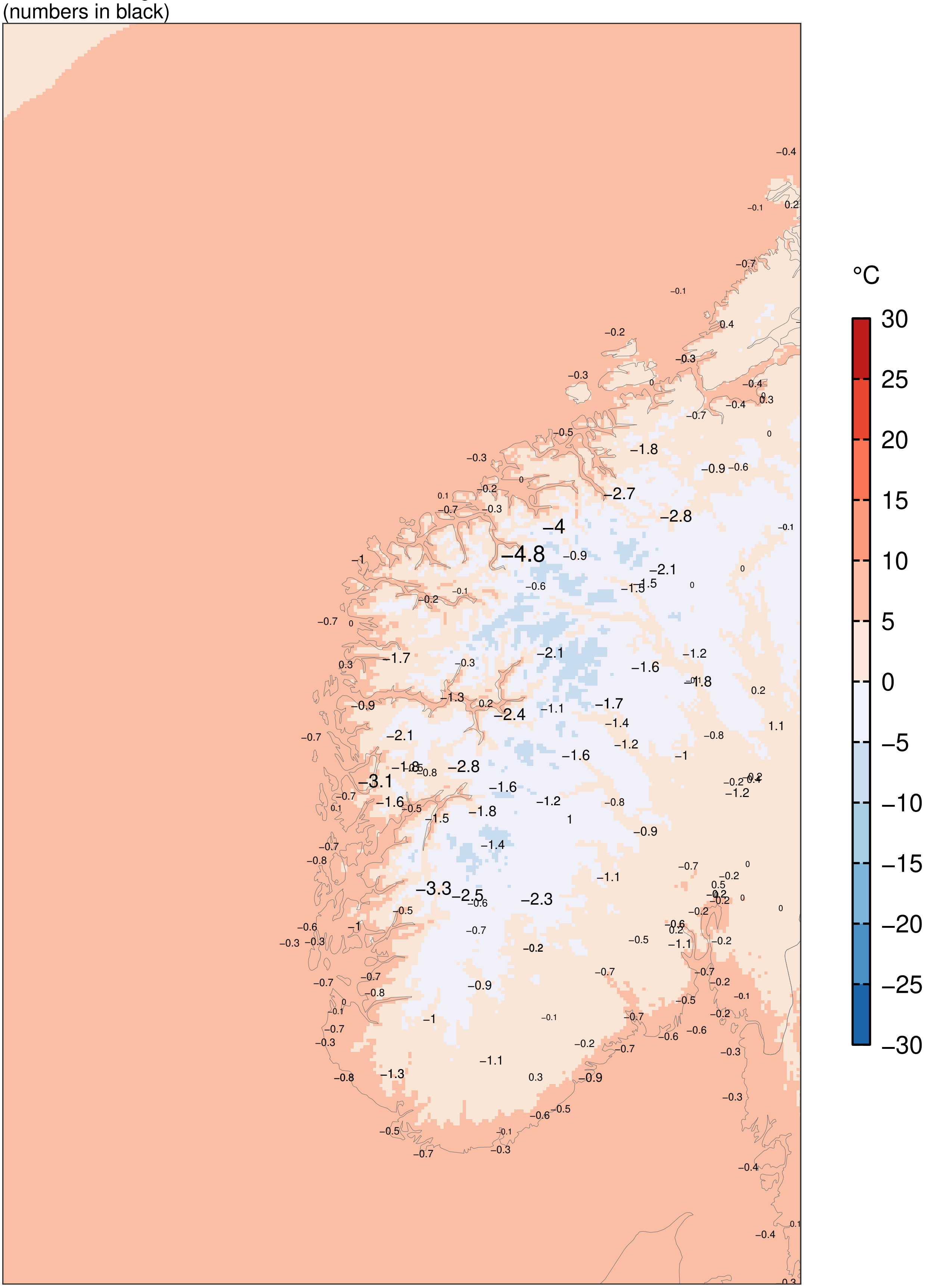
ME at observing sites
(numbers in black)



Model "climatology" 01.03.2024–31.05.2024

MEPSctrl 00+24

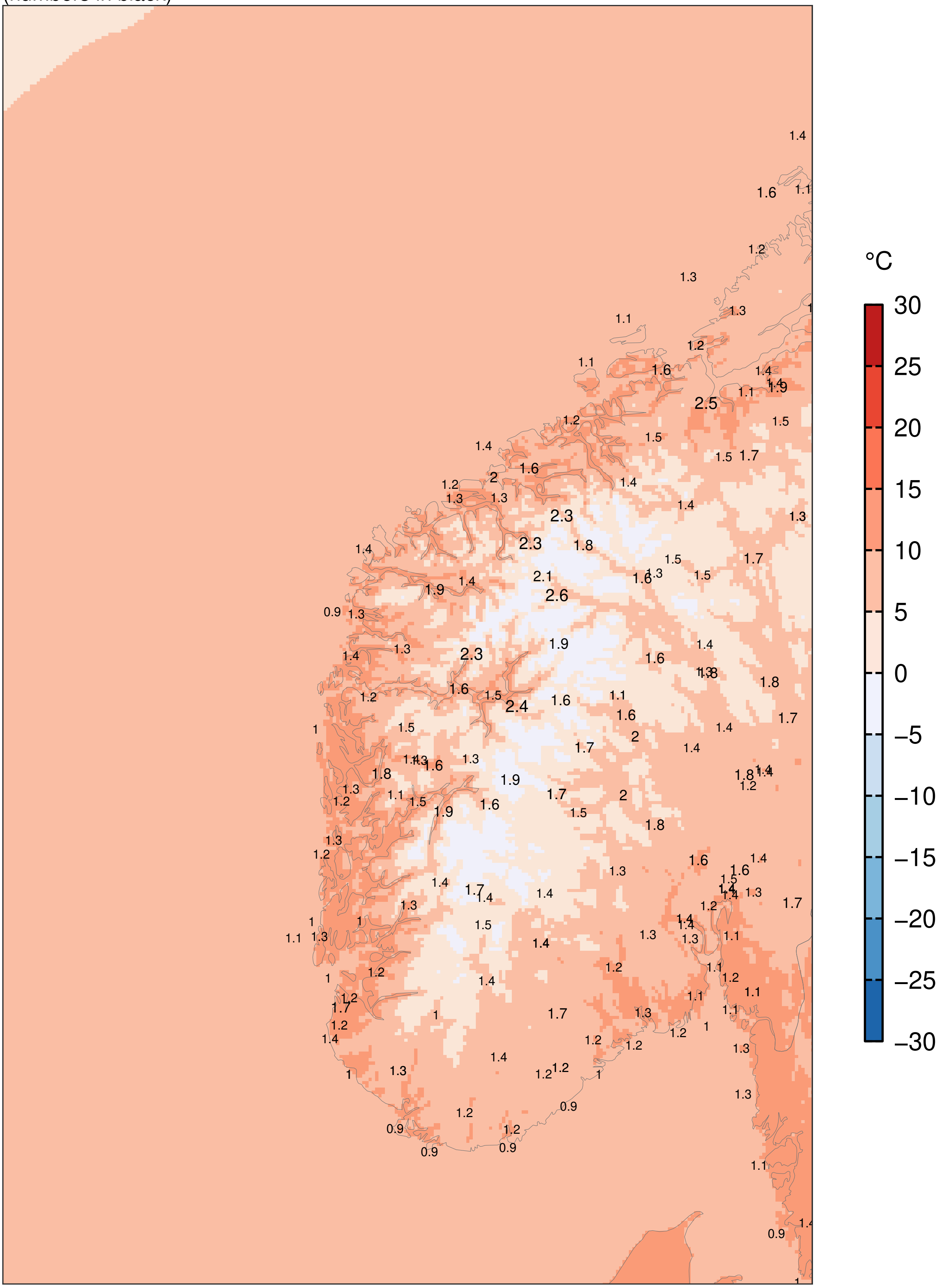
ME at observing sites
(numbers in black)



Model "climatology" 01.03.2024–31.05.2024

MEPSctrl 00+12

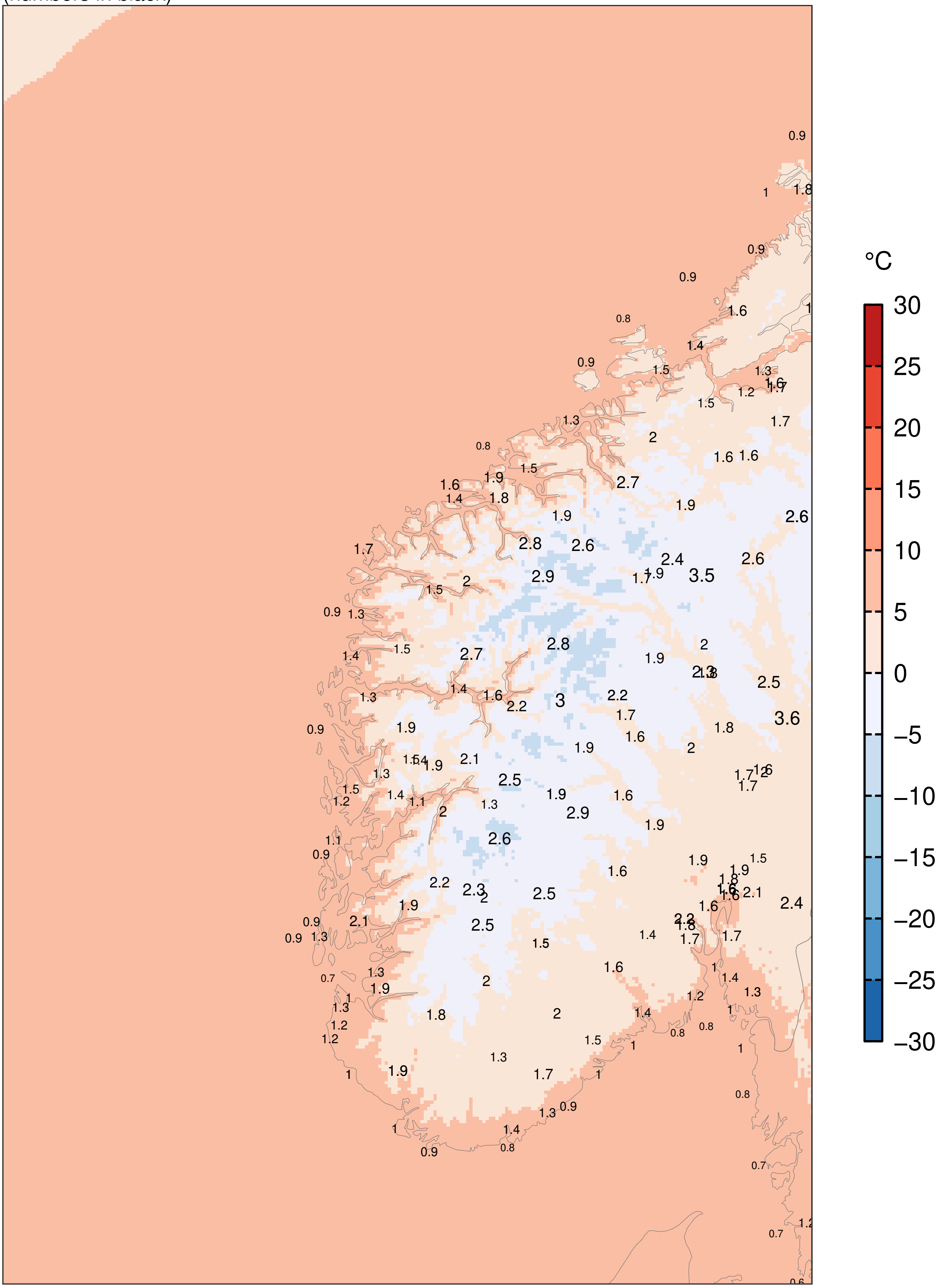
SDE at observing sites
(numbers in black)



Model "climatology" 01.03.2024–31.05.2024

MEPSctrl 00+24

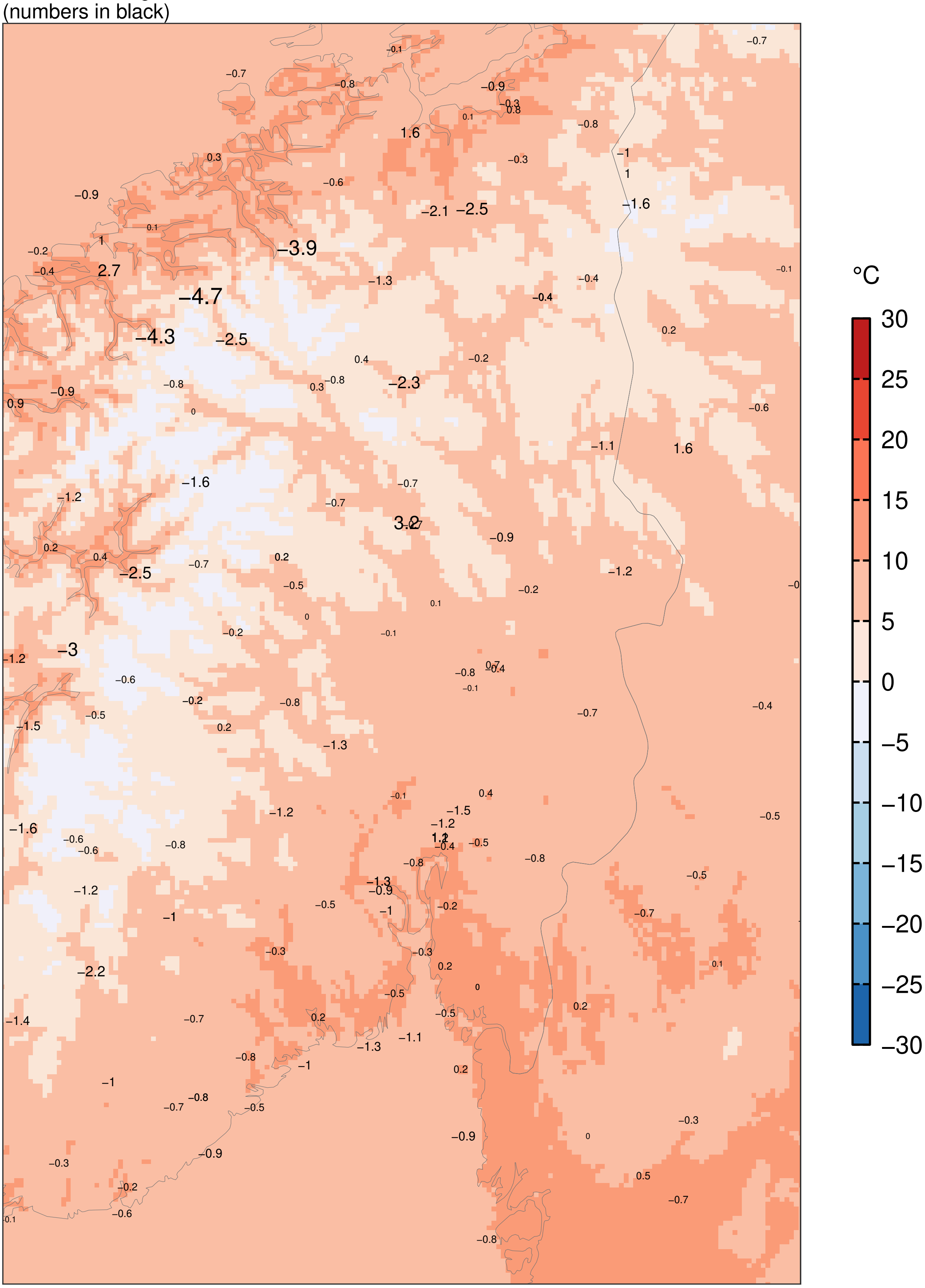
SDE at observing sites
(numbers in black)



Model "climatology" 01.03.2024–31.05.2024

MEPSctrl 00+12

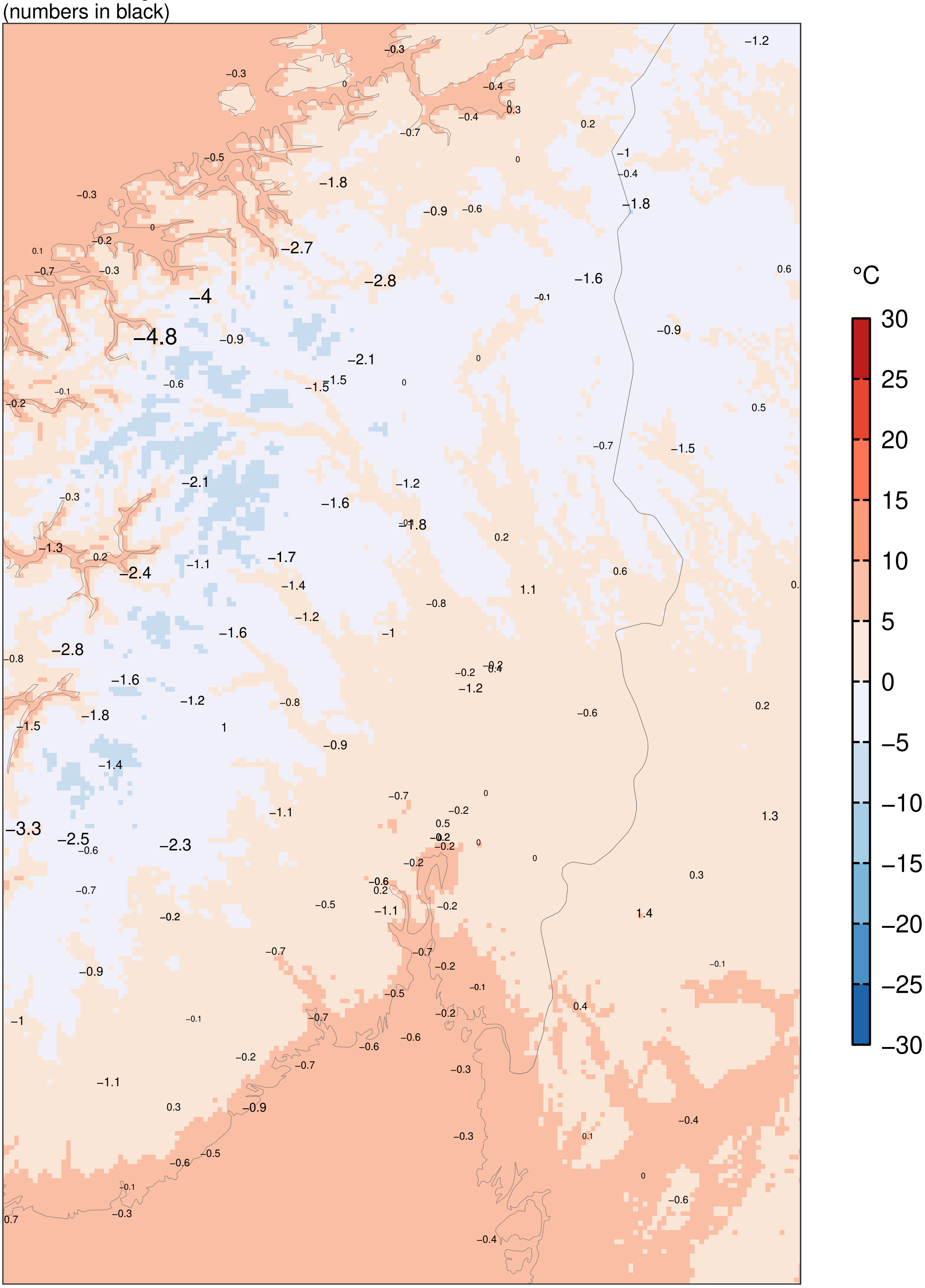
ME at observing sites
(numbers in black)



Model "climatology" 01.03.2024–31.05.2024

MEPSctrl 00+24

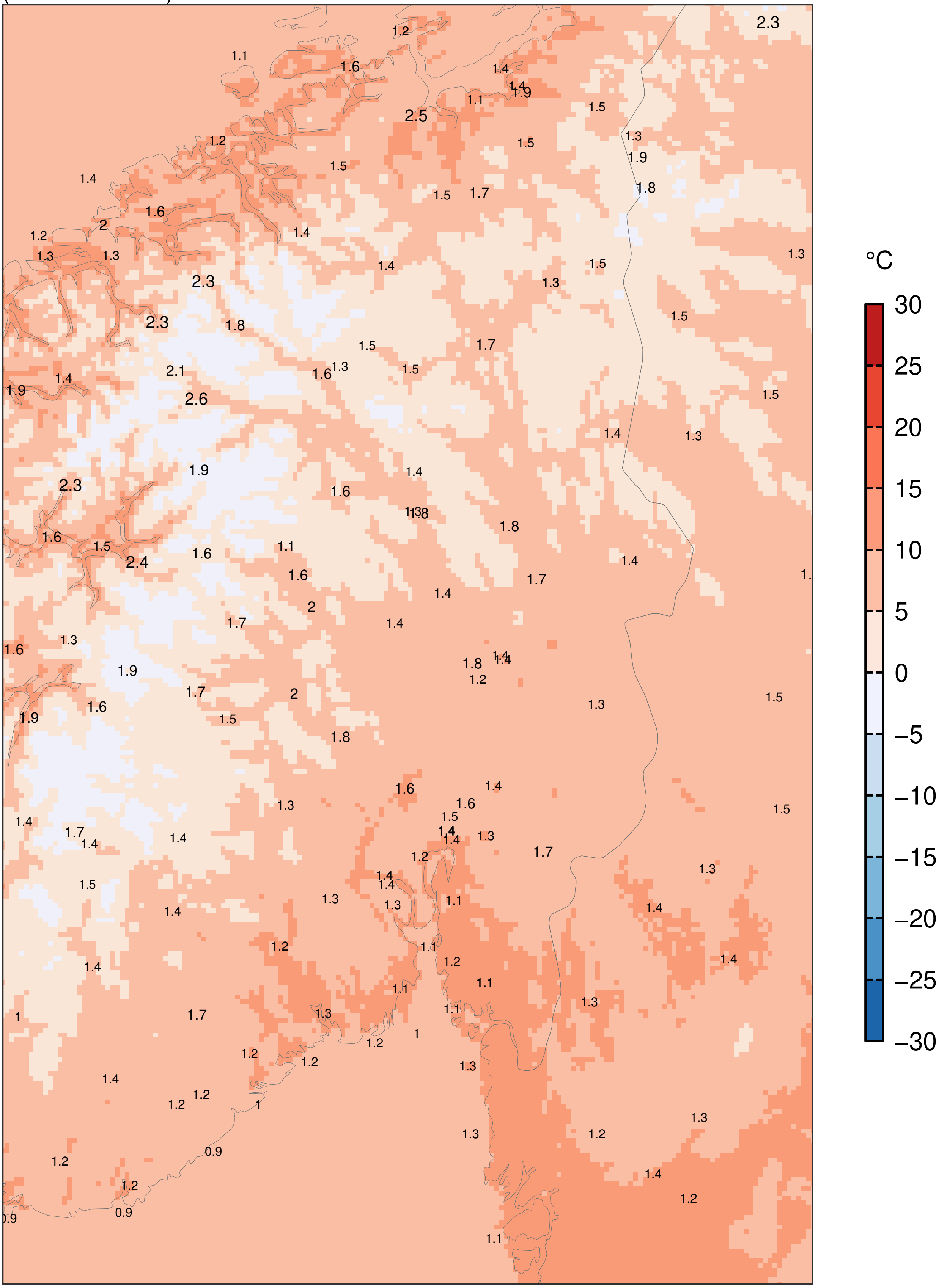
ME at observing sites
(numbers in black)



Model "climatology" 01.03.2024–31.05.2024

MEPSctrl 00+12

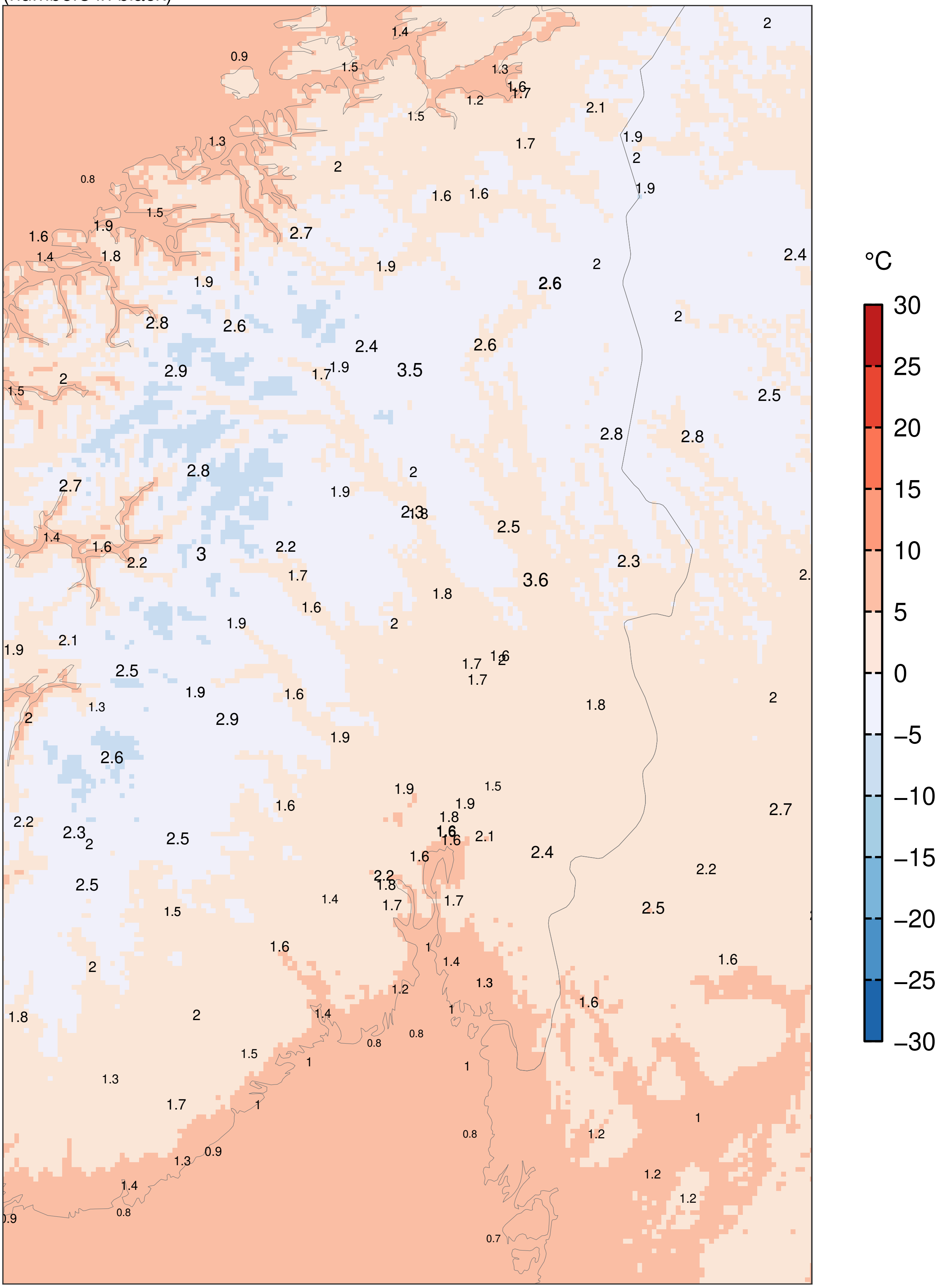
SDE at observing sites
(numbers in black)



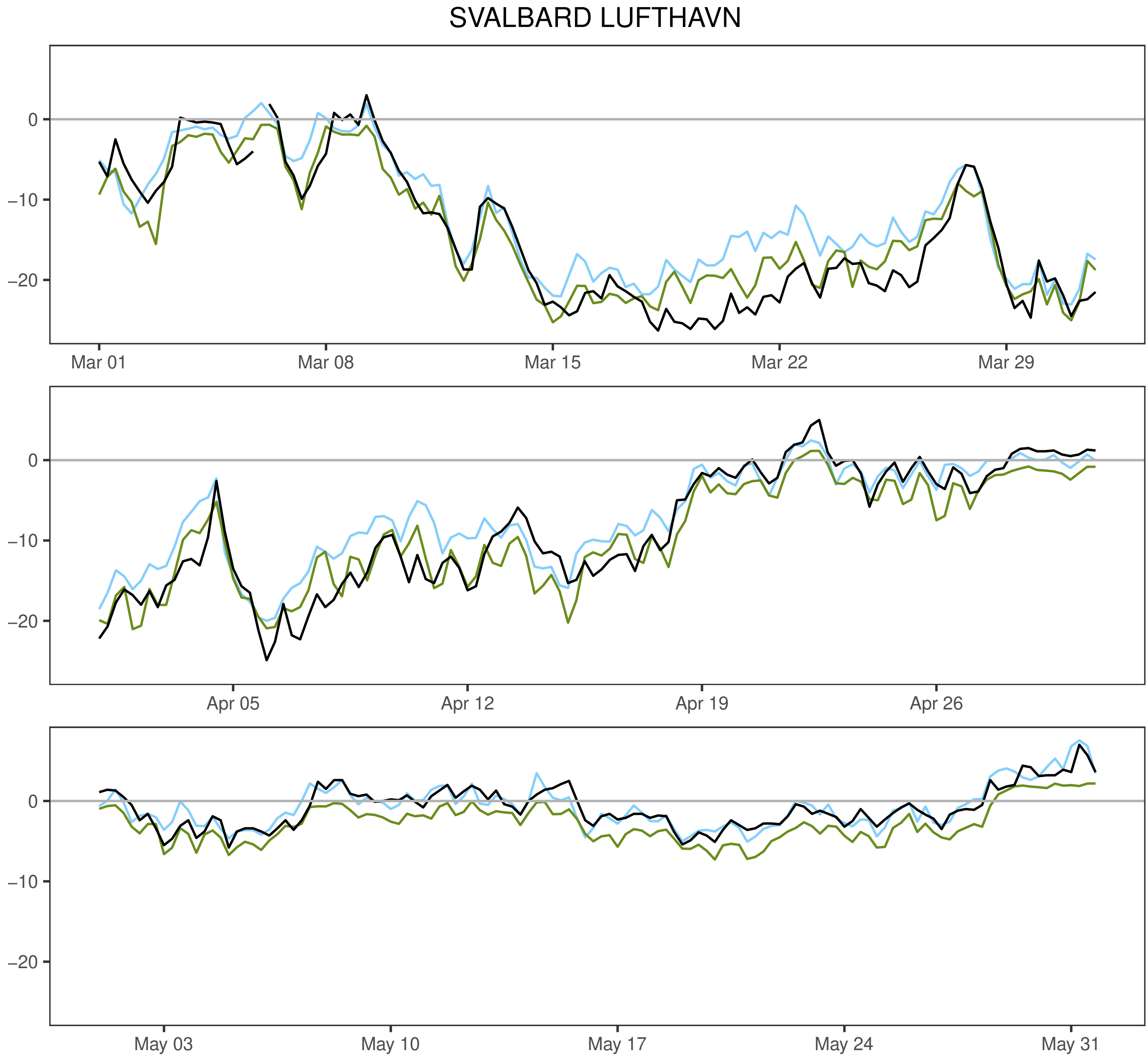
Model "climatology" 01.03.2024–31.05.2024

MEPSctrl 00+24

SDE at observing sites
(numbers in black)

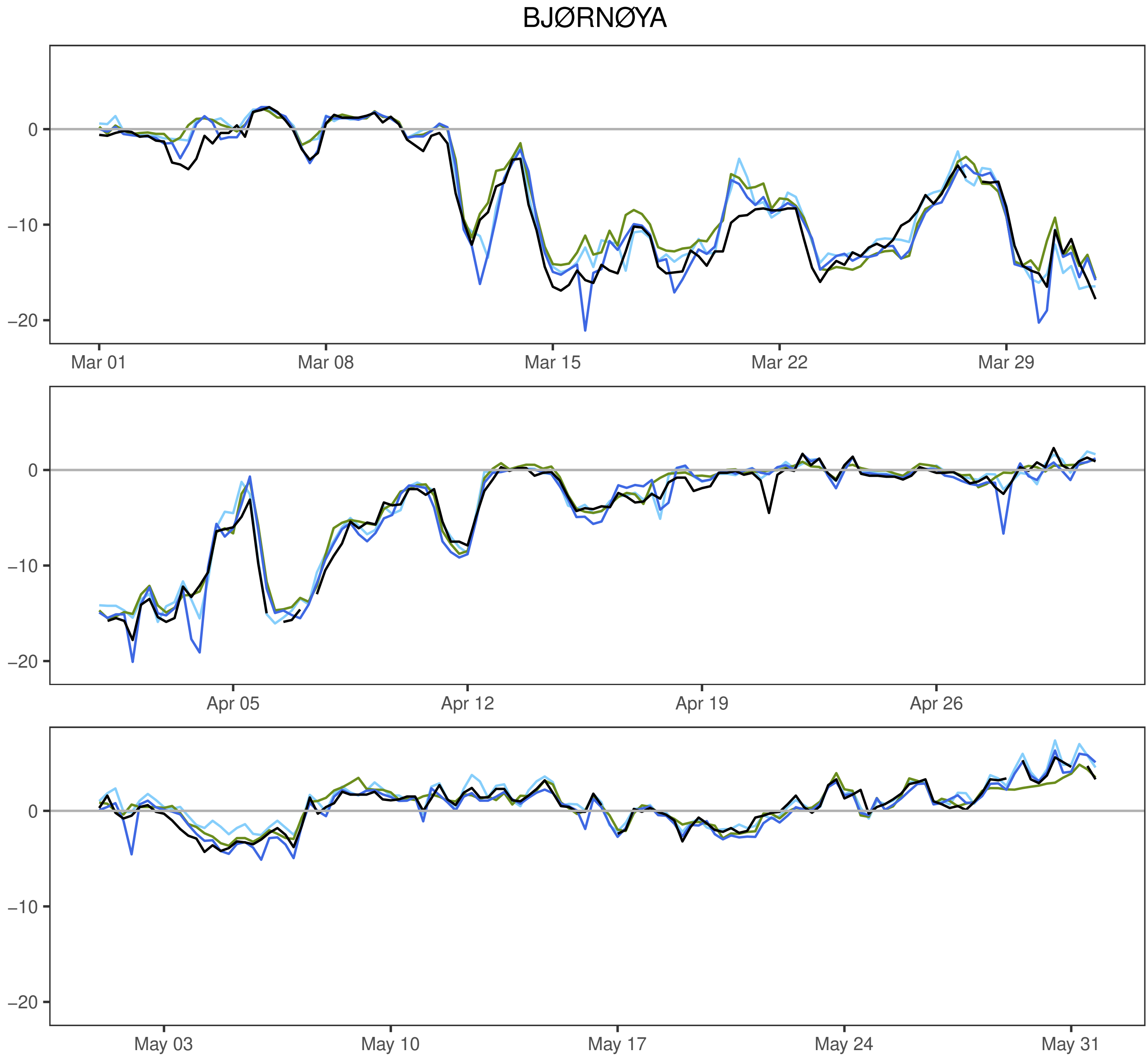


Model "climatology" 01.03.2024–31.05.2024



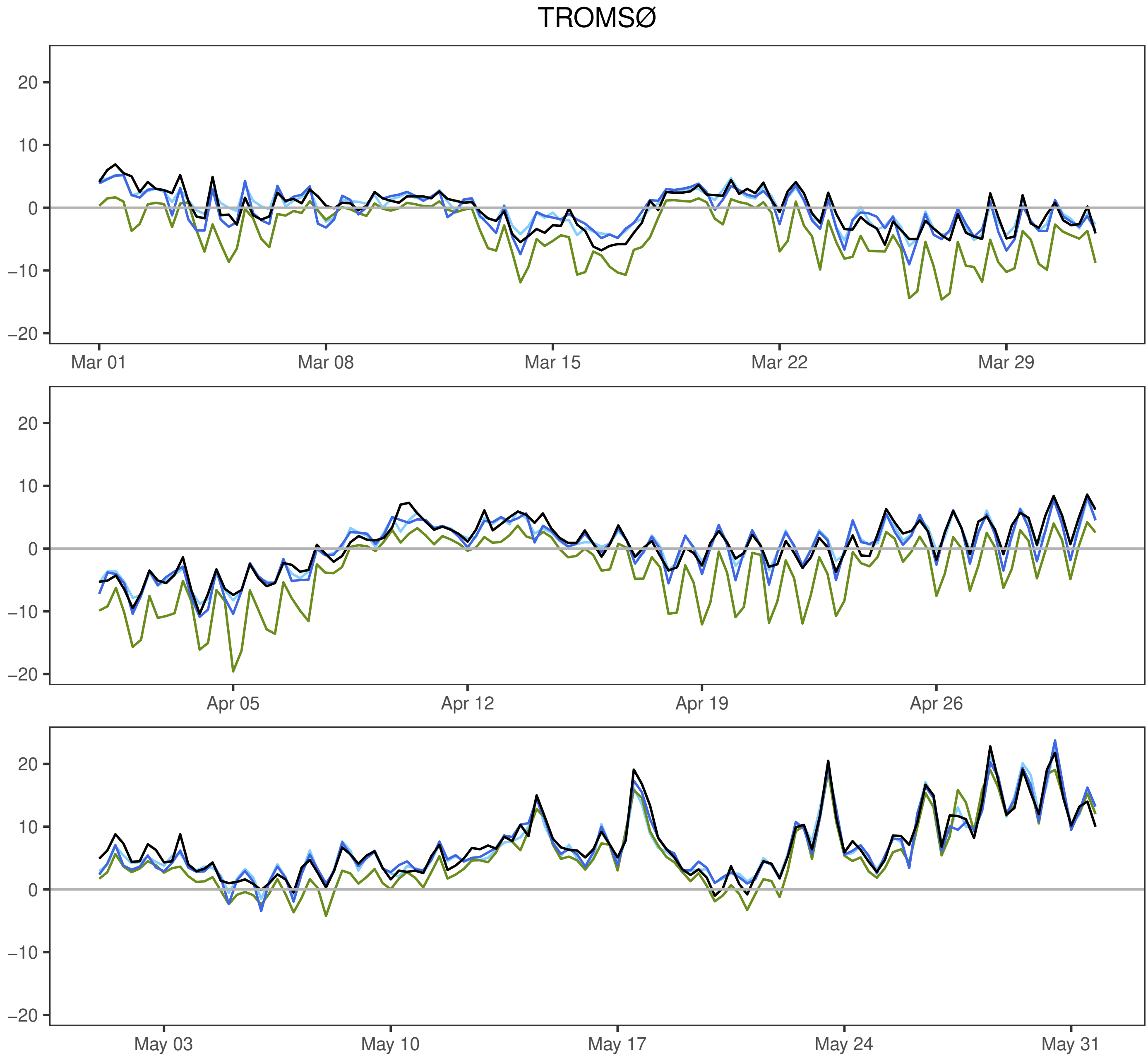
	Min	Mean	Max	Std	N
synop: 00,06,12,18	–26.3	–7.9	7.0	8.7	367
AA25: 12+18,+24,+30,+36	–23.1	–6.5	7.5	7.2	368
ECMWF: 12+18,+24,+30,+36	–25.3	–8.7	2.2	7.4	368

	ME	SDE	RMSE	MAE	Max.abs.err	N
AA25 – synop	1.4	2.7	3.1	2.2	9.5	367
ECMWF – synop	–0.9	2.3	2.5	2.1	6.9	367



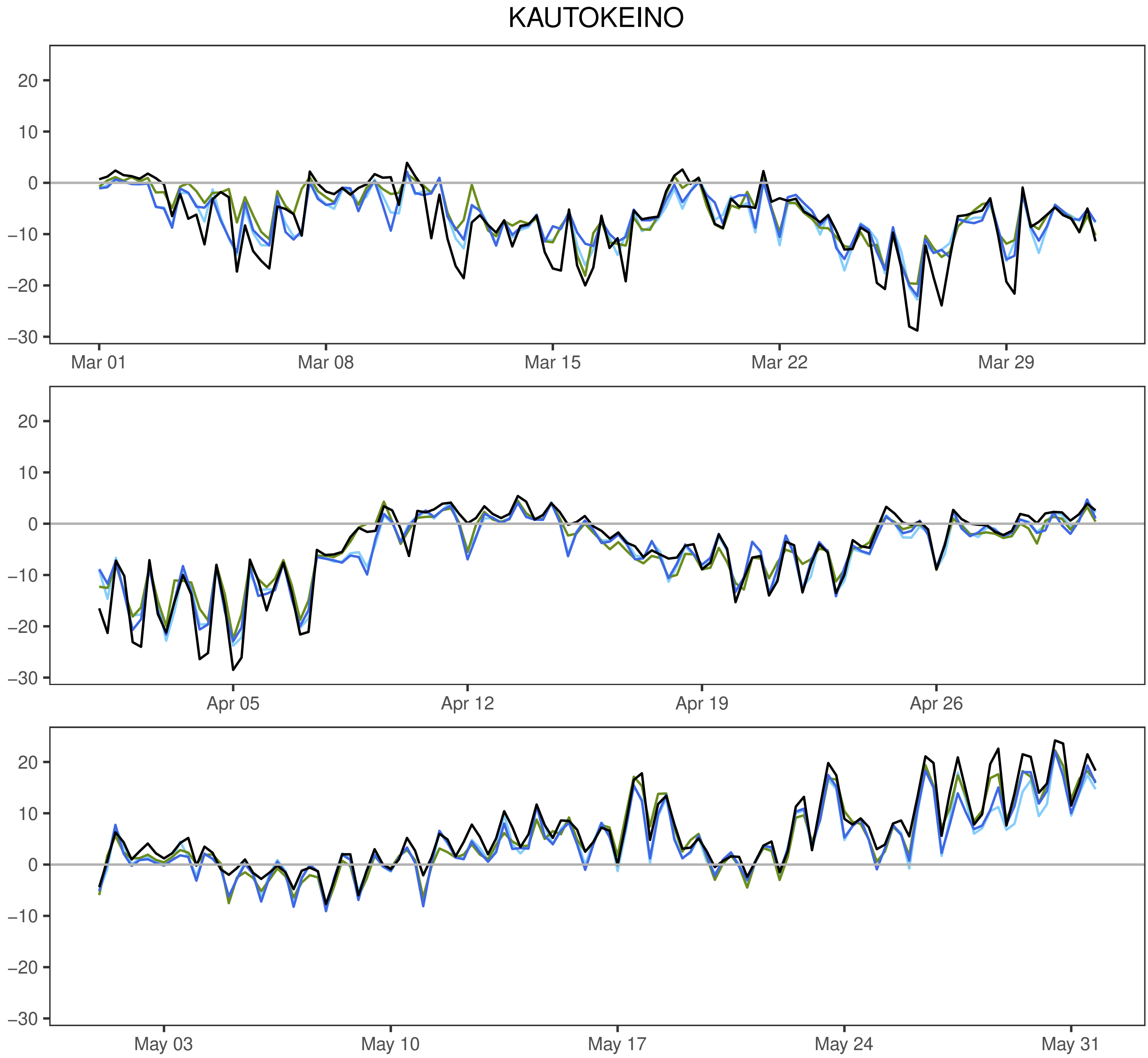
	Min	Mean	Max	Std	N
synop: 00,06,12,18	−17.8	−3.6	5.6	5.8	361
MEPSctrl: 12+18,+24,+30,+36	−21.1	−3.7	6.3	5.9	368
AA25: 12+18,+24,+30,+36	−16.7	−3.2	7.4	5.8	368
ECMWF: 12+18,+24,+30,+36	−15.6	−3.2	4.8	5.4	368

	ME	SDE	RMSE	MAE	Max.abs.err	N
MEPSctrl – synop	0.0	1.4	1.4	0.9	7.0	361
AA25 – synop	0.5	1.1	1.2	0.9	6.0	361
ECMWF – synop	0.5	1.2	1.4	0.9	5.1	361



	Min	Mean	Max	Std	N
synop: 00,06,12,18	−10.4	2.4	22.8	5.4	368
MEPSctrl: 12+18,+24,+30,+36	−10.9	2.1	23.7	5.4	368
AA25: 12+18,+24,+30,+36	−8.8	2.4	23.3	5.1	368
ECMWF: 12+18,+24,+30,+36	−19.6	−0.7	19.1	6.8	368

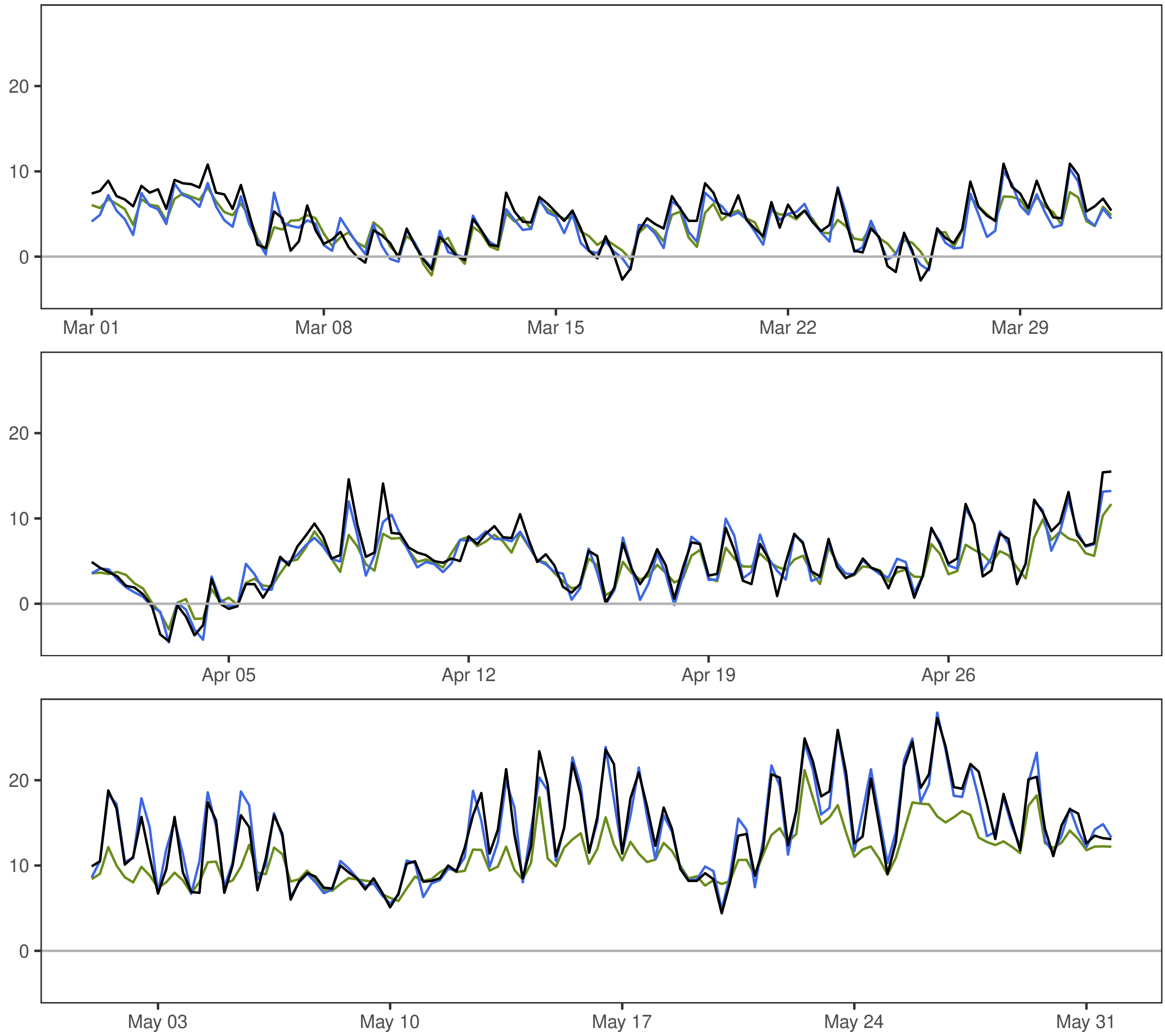
	ME	SDE	RMSE	MAE	Max.abs.err	N
MEPSctrl – synop	−0.3	1.4	1.4	1.1	4.4	368
AA25 – synop	0.0	1.3	1.3	1.0	4.5	368
ECMWF – synop	−3.1	2.3	3.9	3.2	12.2	368



	Min	Mean	Max	Std	N
synop: 00,06,12,18	−28.8	−2.1	24.2	9.4	368
MEPSctrl: 12+18,+24,+30,+36	−22.9	−2.6	22.1	7.8	368
AA25: 12+18,+24,+30,+36	−23.8	−2.7	22.1	7.8	368
ECMWF: 12+18,+24,+30,+36	−22.5	−2.1	22.3	7.8	368

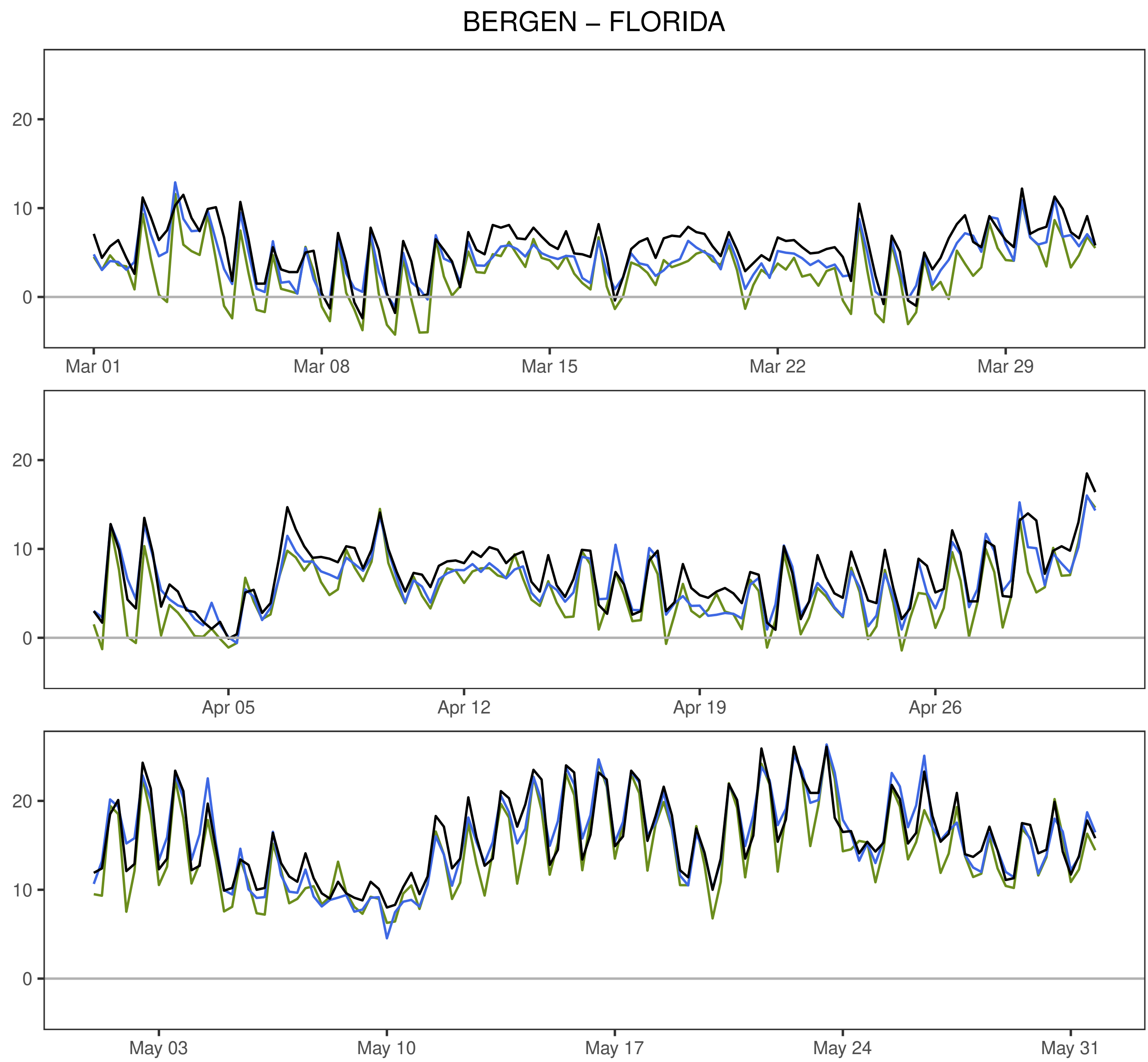
	ME	SDE	RMSE	MAE	Max.abs.err	N
MEPSctrl – synop	−0.6	3.0	3.1	2.2	10.8	368
AA25 – synop	−0.7	2.9	3.0	2.1	11.4	368
ECMWF – synop	0.0	2.9	2.9	2.1	11.3	368

ØRLAND III



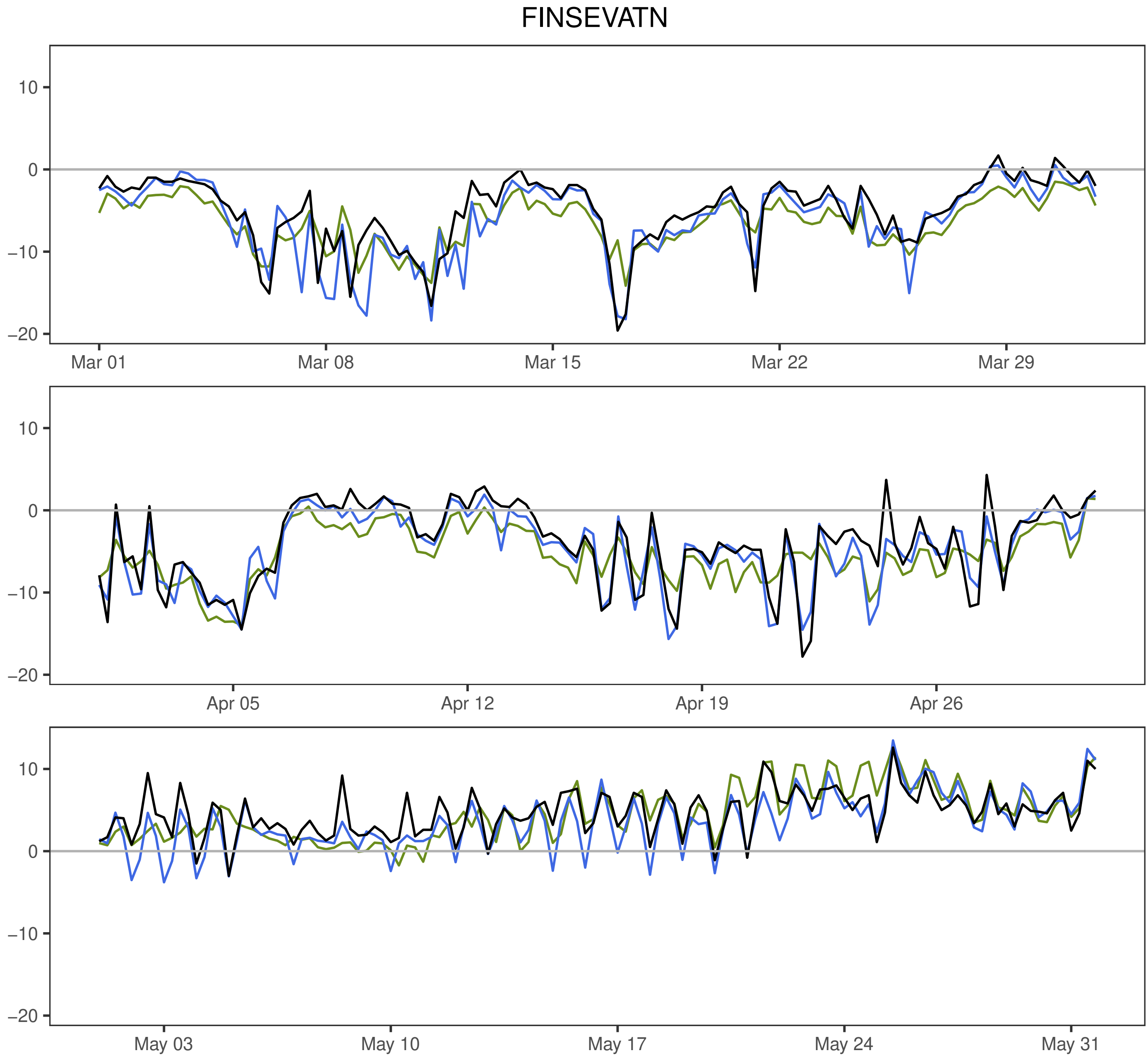
	Min	Mean	Max	Std	N
synop: 00,06,12,18	−4.4	7.8	27.3	6.0	368
MEPSctrl: 12+18,+24,+30,+36	−4.5	7.5	27.9	6.0	368
ECMWF: 12+18,+24,+30,+36	−3.0	6.5	21.2	4.2	368

	ME	SDE	RMSE	MAE	Max.abs.err	N
MEPSctrl – synop	−0.3	1.3	1.3	1.0	4.5	368
ECMWF – synop	−1.3	2.4	2.7	1.8	11.5	368



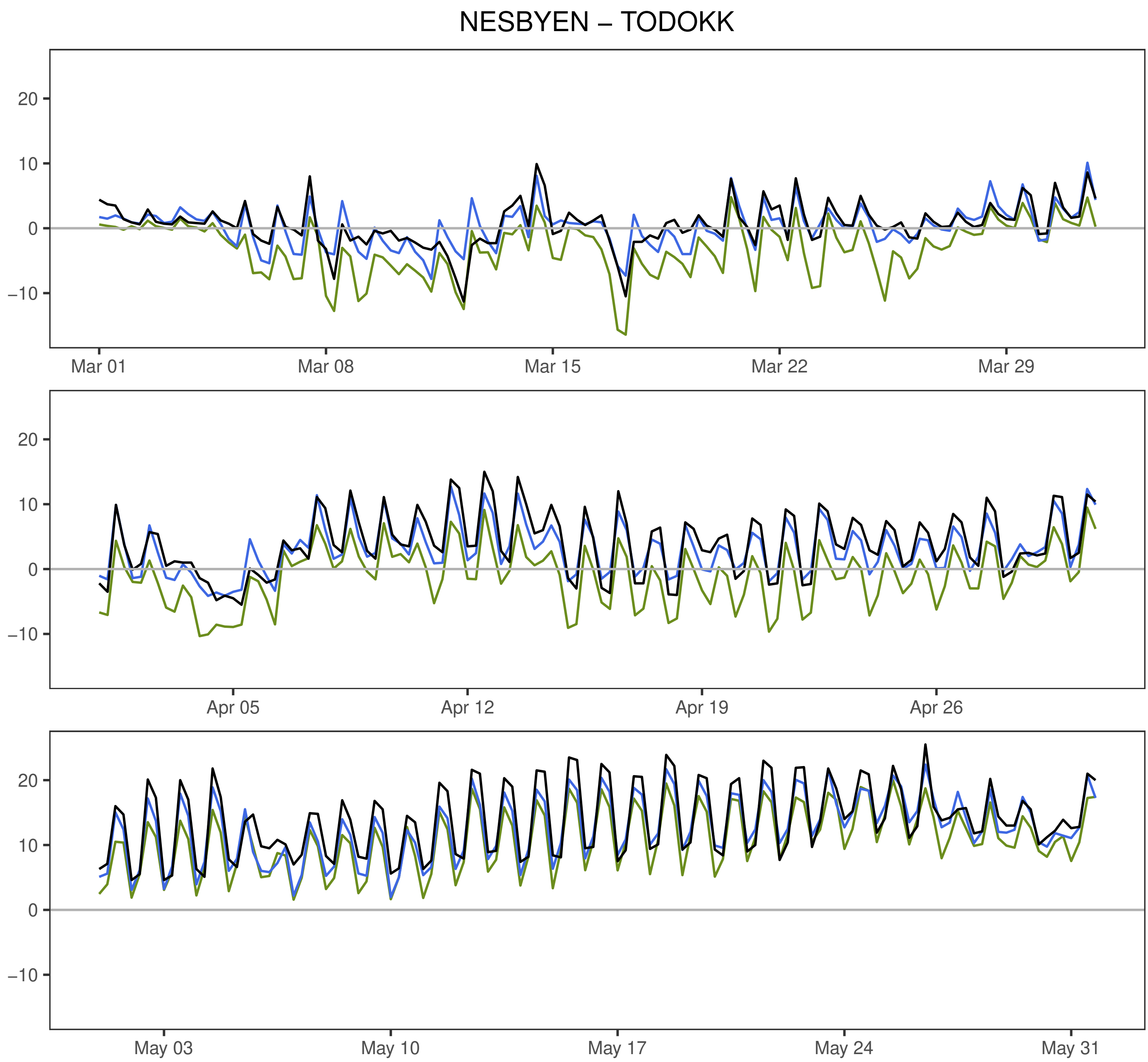
	Min	Mean	Max	Std	N
synop: 00,06,12,18	–2.4	9.5	26.1	5.9	368
MEPSctrl: 12+18,+24,+30,+36	–1.1	8.8	26.4	6.2	368
ECMWF: 12+18,+24,+30,+36	–4.2	7.5	26.3	6.4	368

	ME	SDE	RMSE	MAE	Max.abs.err	N
MEPSctrl – synop	–0.7	1.5	1.7	1.4	5.1	368
ECMWF – synop	–2.0	1.6	2.6	2.2	8.1	368



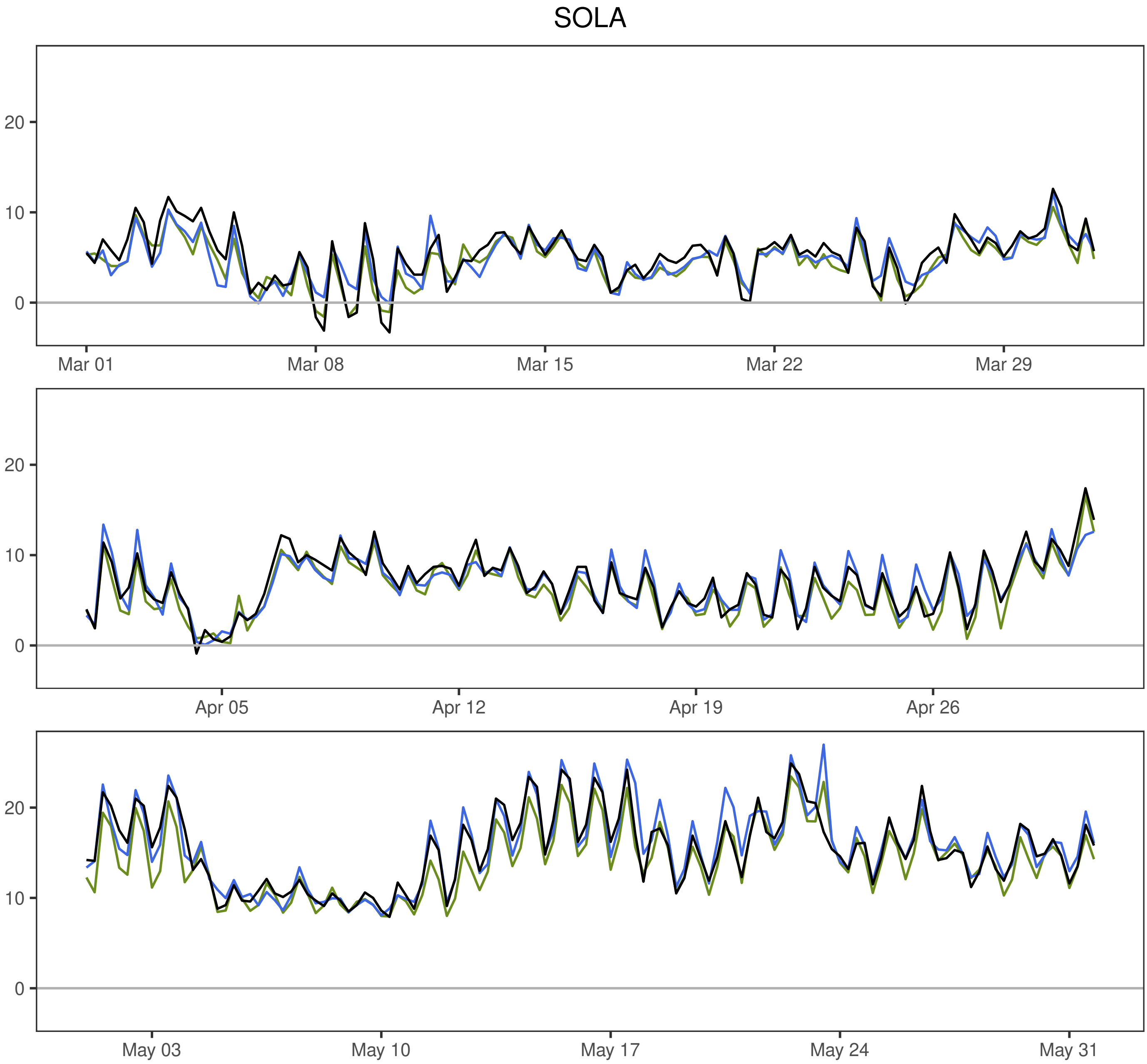
	Min	Mean	Max	Std	N
synop: 00,06,12,18	−19.6	−1.5	12.6	5.9	368
MEPSctrl: 12+18,+24,+30,+36	−18.4	−2.4	13.5	6.0	368
ECMWF: 12+18,+24,+30,+36	−14.2	−2.4	12.8	5.9	368

	ME	SDE	RMSE	MAE	Max.abs.err	N
MEPSctrl – synop	−1.0	2.1	2.3	1.6	10.4	368
ECMWF – synop	−0.9	2.7	2.9	2.3	12.6	368



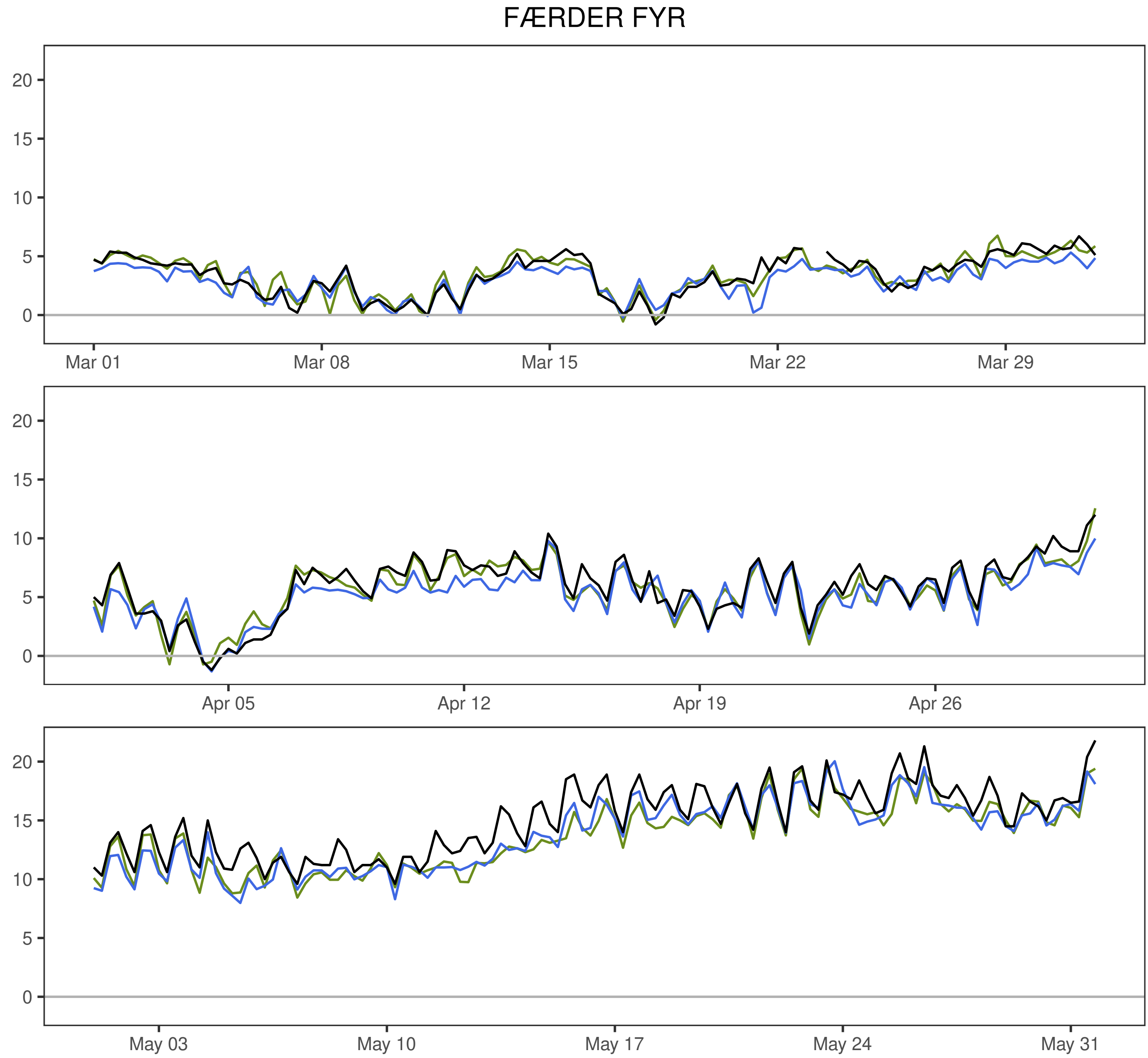
	Min	Mean	Max	Std	N
synop: 00,06,12,18	–11.3	6.2	25.5	7.4	368
MEPSctrl: 12+18,+24,+30,+36	–7.8	5.4	22.4	6.8	368
ECMWF: 12+18,+24,+30,+36	–16.4	2.3	20.0	7.7	368

	ME	SDE	RMSE	MAE	Max.abs.err	N
MEPSctrl – synop	–0.8	2.0	2.1	1.7	7.2	368
ECMWF – synop	–3.9	2.3	4.5	4.0	11.0	368



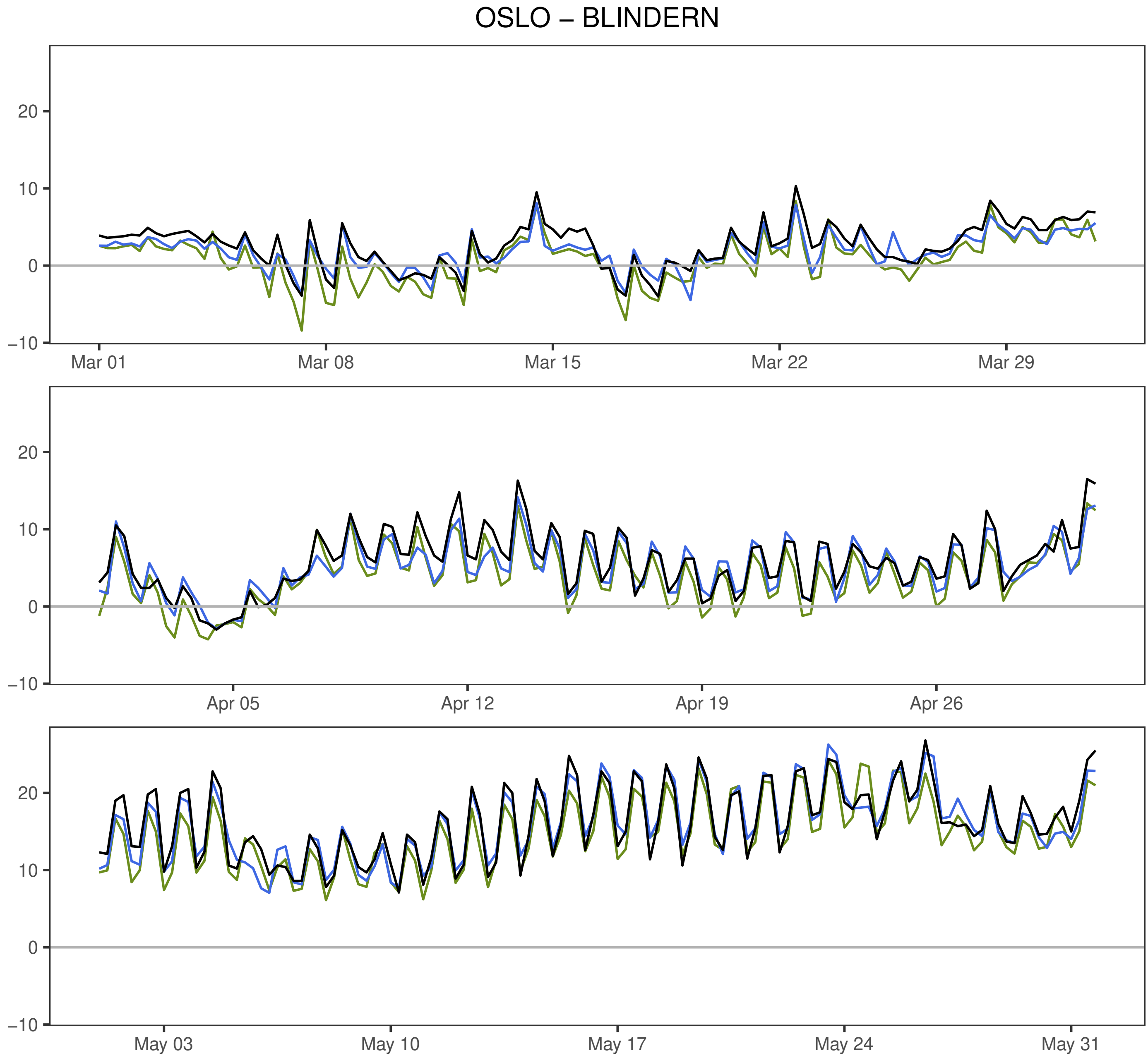
	Min	Mean	Max	Std	N
synop: 00,06,12,18	–3.3	9.2	24.9	5.6	368
MEPSctrl: 12+18,+24,+30,+36	–0.1	9.1	27.0	5.8	368
ECMWF: 12+18,+24,+30,+36	–1.6	8.3	23.4	5.3	368

	ME	SDE	RMSE	MAE	Max.abs.err	N
MEPSctrl – synop	–0.1	1.4	1.4	1.0	9.7	368
ECMWF – synop	–0.9	1.2	1.5	1.2	5.9	368



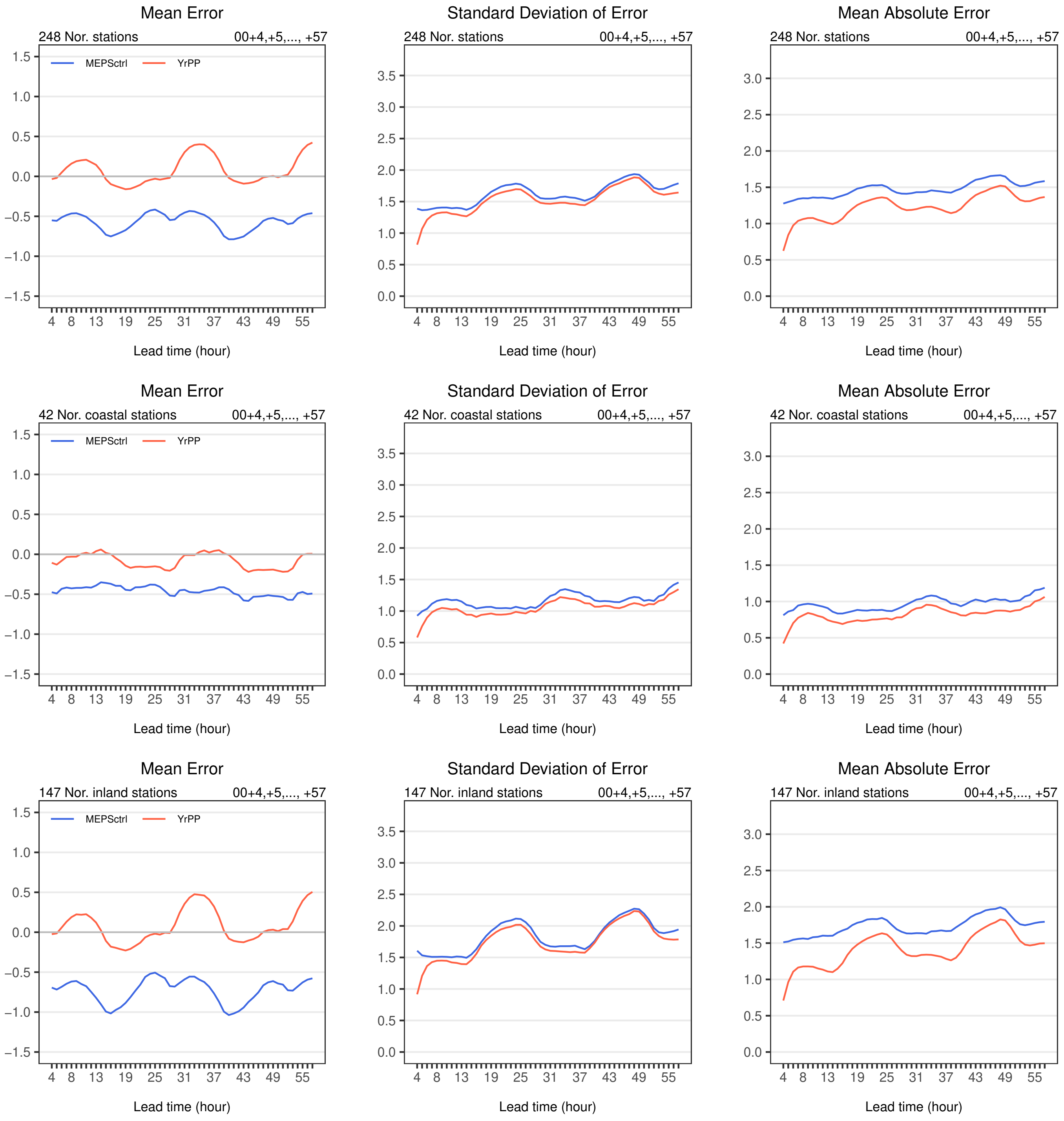
	Min	Mean	Max	Std	N
synop: 00,06,12,18	–1.2	8.1	21.8	5.6	366
MEPSctrl: 12+18,+24,+30,+36	–1.3	7.3	20.0	5.2	368
ECMWF: 12+18,+24,+30,+36	–0.7	7.6	19.7	5.0	368

	ME	SDE	RMSE	MAE	Max.abs.err	N
MEPSctrl – synop	–0.8	1.0	1.3	1.0	4.6	366
ECMWF – synop	–0.5	1.0	1.2	0.8	5.0	366

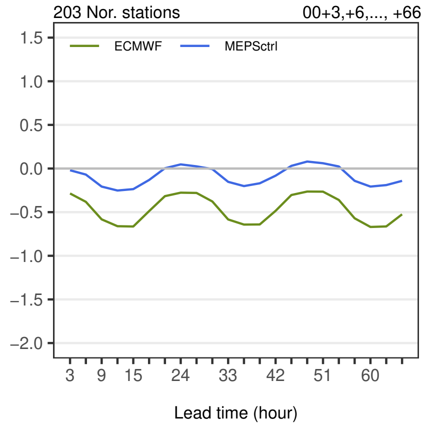


	Min	Mean	Max	Std	N
synop: 00,06,12,18	–4.0	8.2	26.8	7.1	368
MEPSctrl: 12+18,+24,+30,+36	–4.5	7.7	26.3	7.1	368
ECMWF: 12+18,+24,+30,+36	–8.4	6.5	24.2	7.1	368

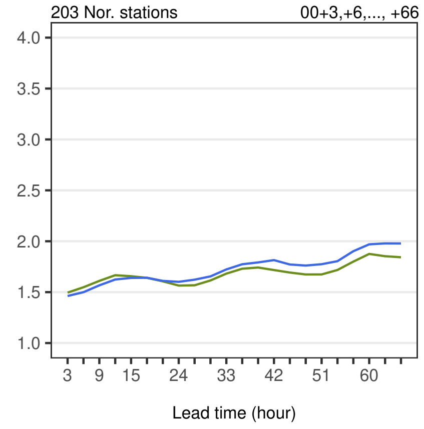
	ME	SDE	RMSE	MAE	Max.abs.err	N
MEPSctrl – synop	–0.5	1.4	1.5	1.2	5.1	368
ECMWF – synop	–1.7	1.4	2.2	1.9	5.5	368


Mean Error
248 Nor. stations
00+4,+5,..., +57
MEPSctrl
YrPP
Lead time (hour)
Standard Deviation of Error
248 Nor. stations
00+4,+5,..., +57
Lead time (hour)
Mean Absolute Error
248 Nor. stations
00+4,+5,..., +57
Lead time (hour)
Mean Error
42 Nor. coastal stations
00+4,+5,..., +57
MEPSctrl
YrPP
Lead time (hour)
Standard Deviation of Error
42 Nor. coastal stations
00+4,+5,..., +57
Lead time (hour)
Mean Absolute Error
42 Nor. coastal stations
00+4,+5,..., +57
Lead time (hour)
Mean Error
147 Nor. inland stations
00+4,+5,..., +57
MEPSctrl
YrPP
Lead time (hour)
Standard Deviation of Error
147 Nor. inland stations
00+4,+5,..., +57
Lead time (hour)
Mean Absolute Error
147 Nor. inland stations
00+4,+5,..., +57
Lead time (hour)

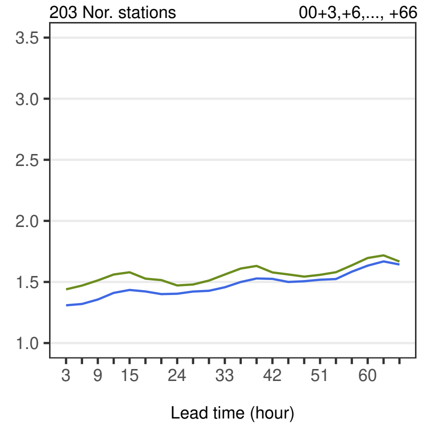
Mean Error



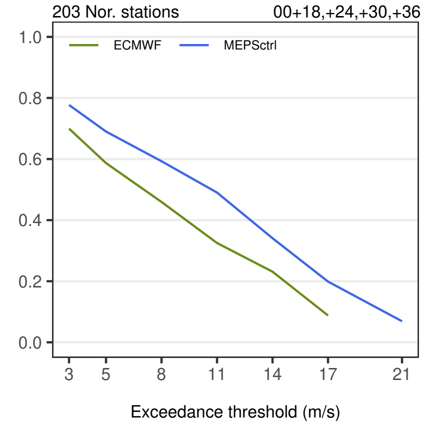
Standard Deviation of Error



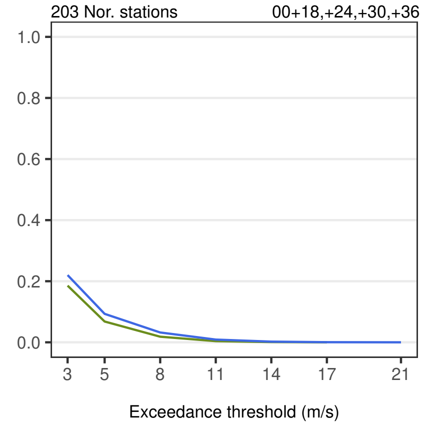
Mean Absolute Error



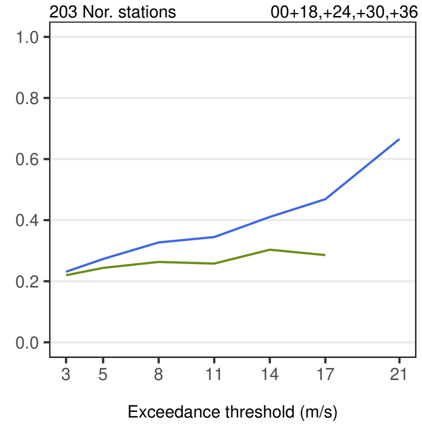
Hit Rate



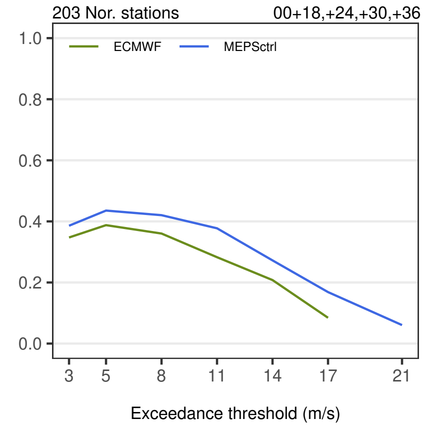
False Alarm Rate



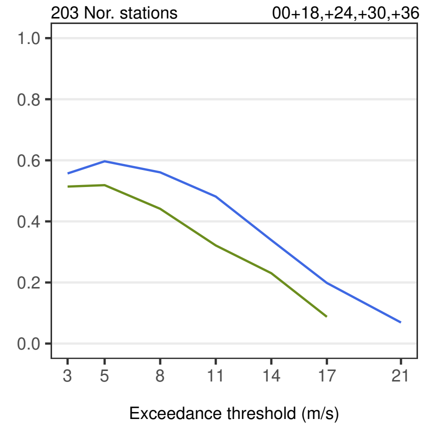
False Alarm Ratio



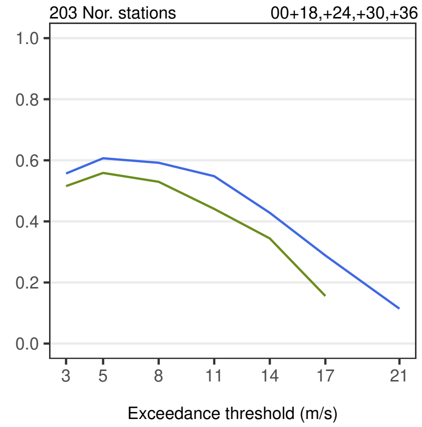
Equitable Threat Score

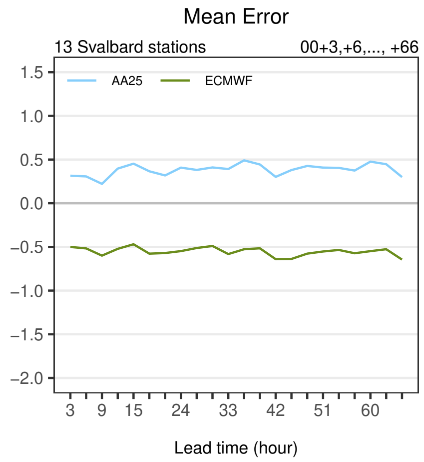


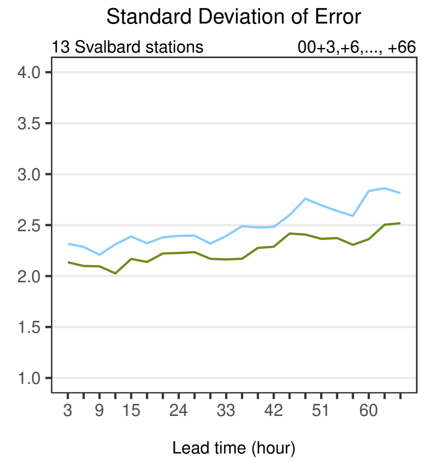
Kuiper Skill Score

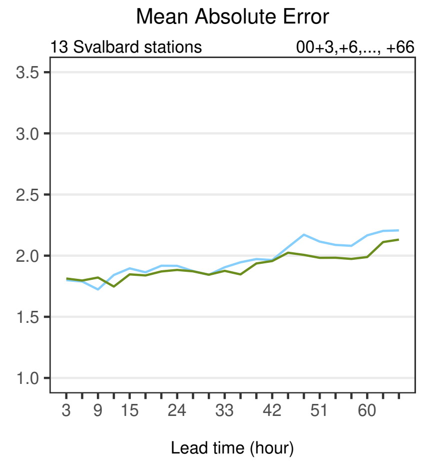


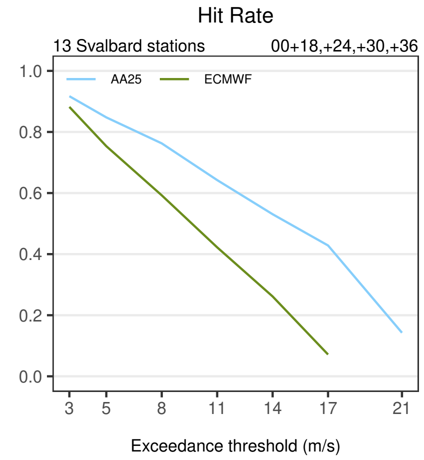
Heidke Skill Score

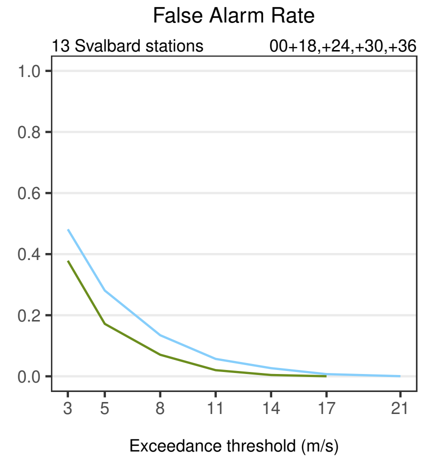


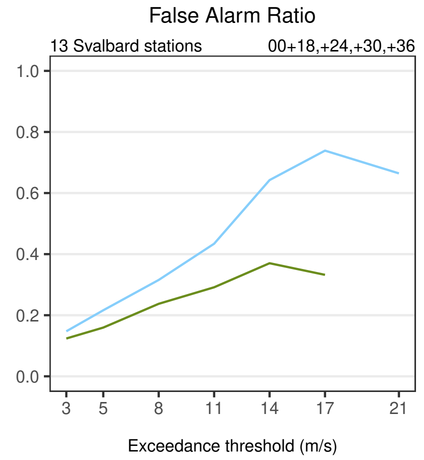

Mean Error
13 Svalbard stations
00+3,+6,..., +66
AA25
ECMWF
Lead time (hour)

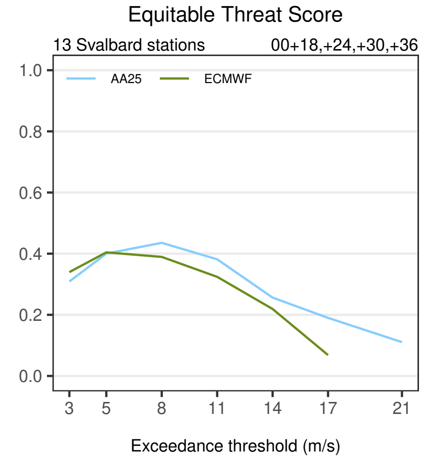

Standard Deviation of Error
13 Svalbard stations
00+3,+6,..., +66
Lead time (hour)

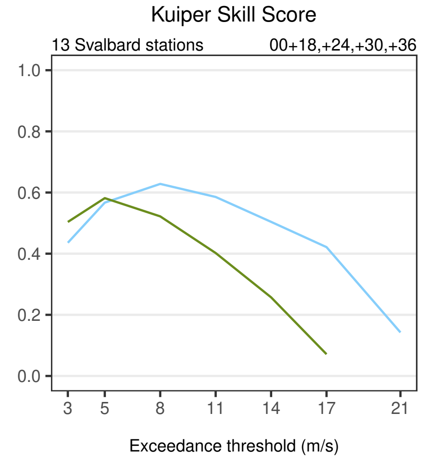

Mean Absolute Error
13 Svalbard stations
00+3,+6,..., +66
Lead time (hour)

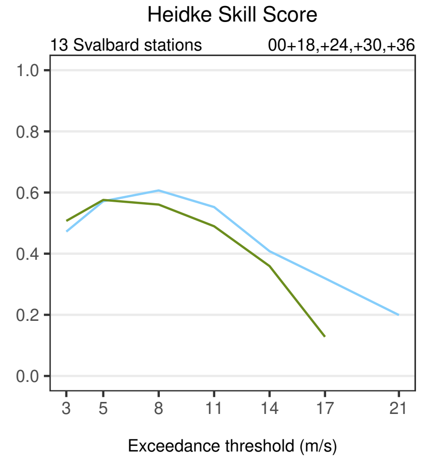

Hit Rate
13 Svalbard stations
00+18,+24,+30,+36
AA25
ECMWF
Exceedance threshold (m/s)

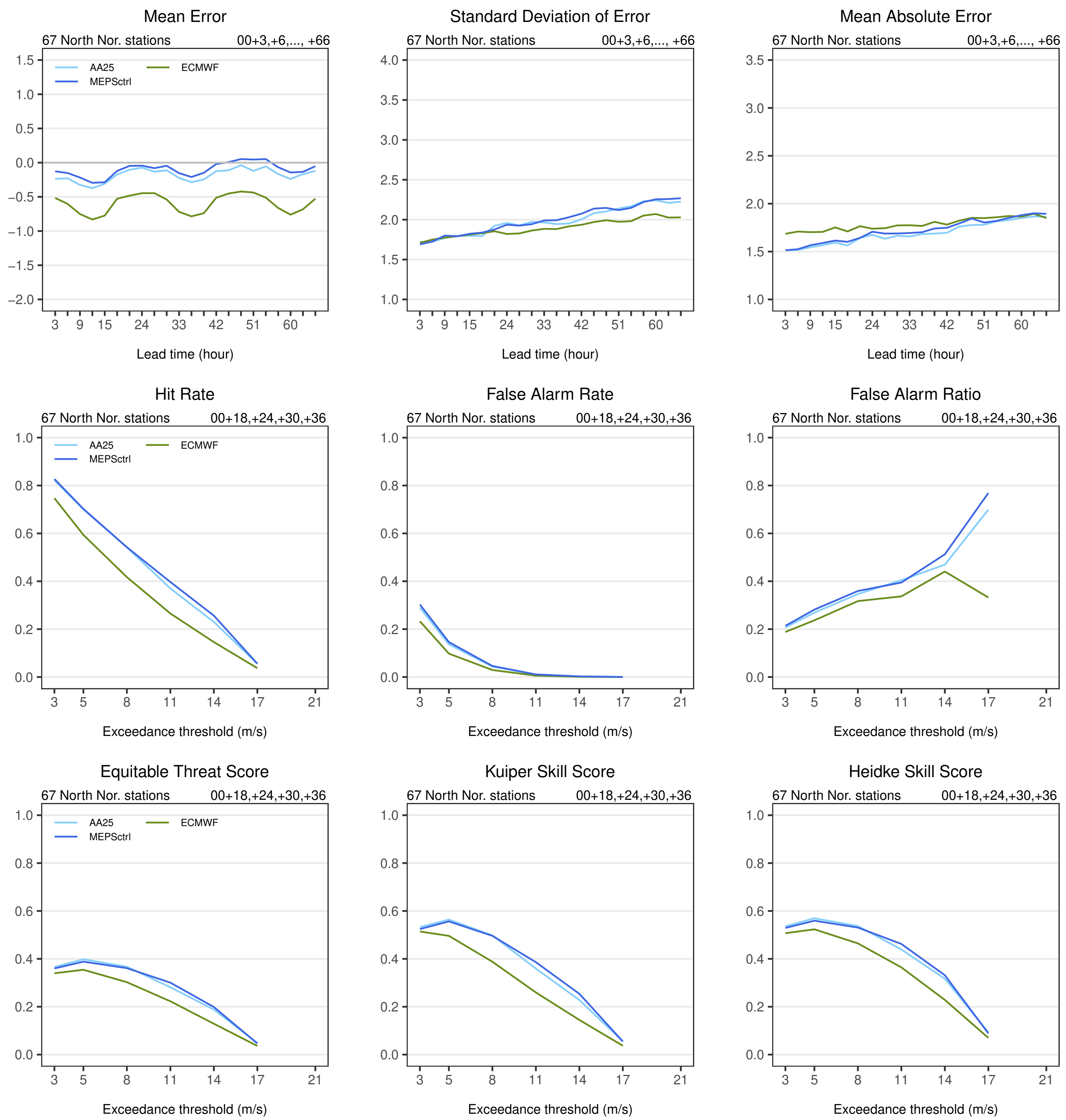

False Alarm Rate
13 Svalbard stations
00+18,+24,+30,+36
Exceedance threshold (m/s)


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)

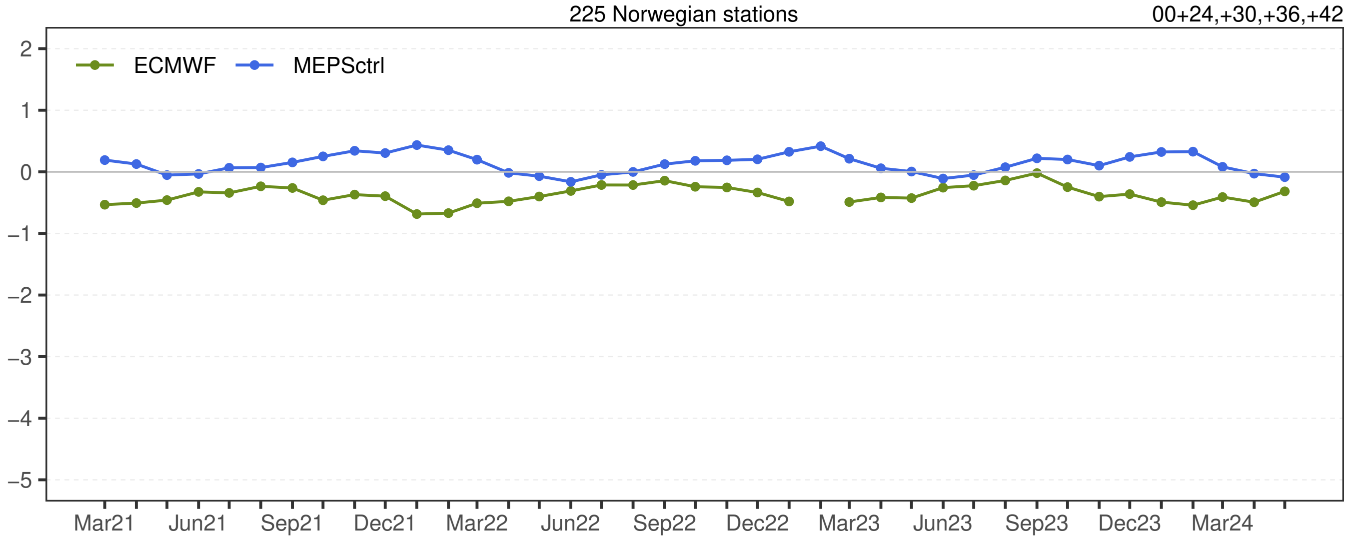

Kuiper Skill Score
13 Svalbard stations
00+18,+24,+30,+36
Exceedance threshold (m/s)

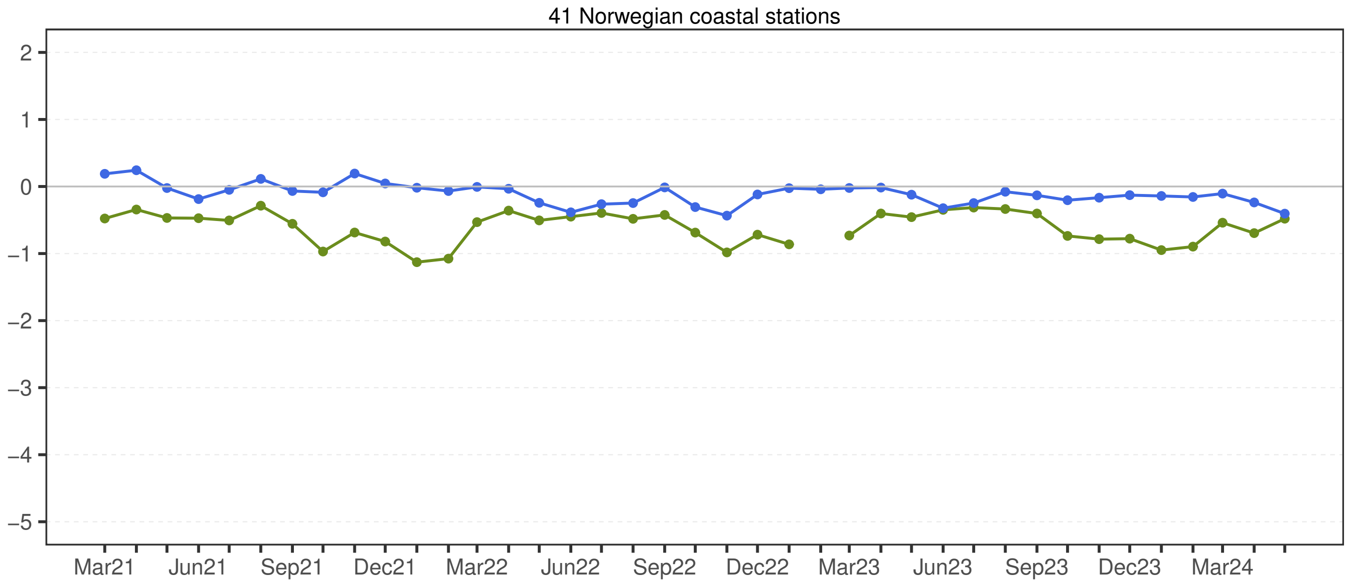

Heidke Skill Score
13 Svalbard stations
00+18,+24,+30,+36
Exceedance threshold (m/s)

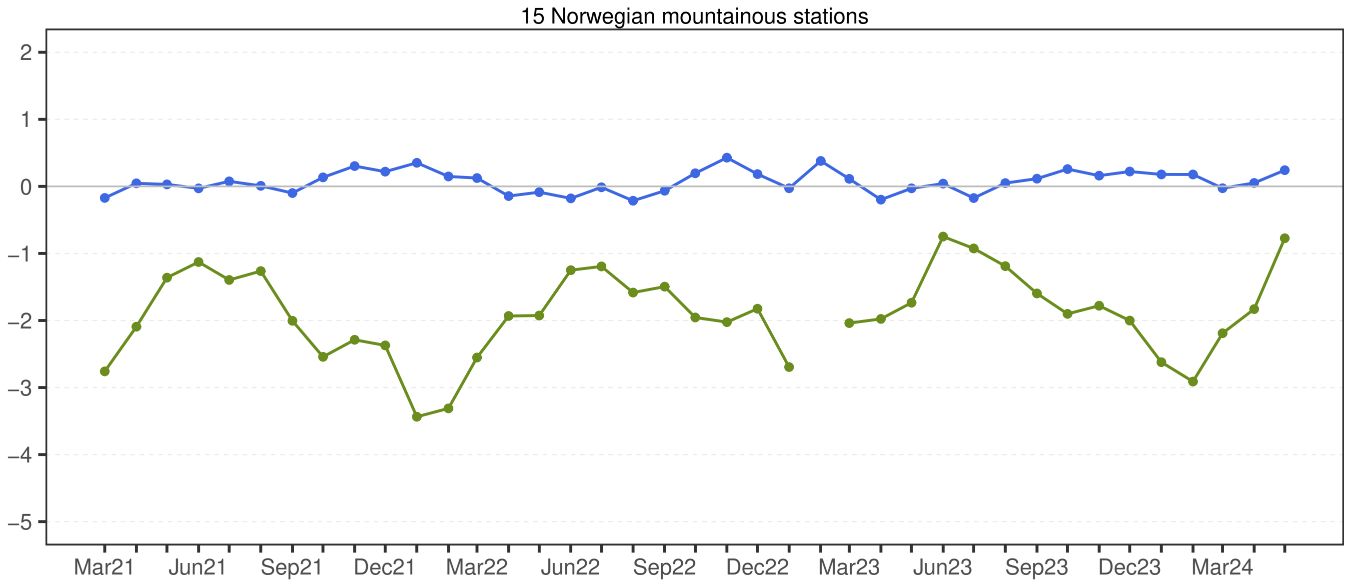


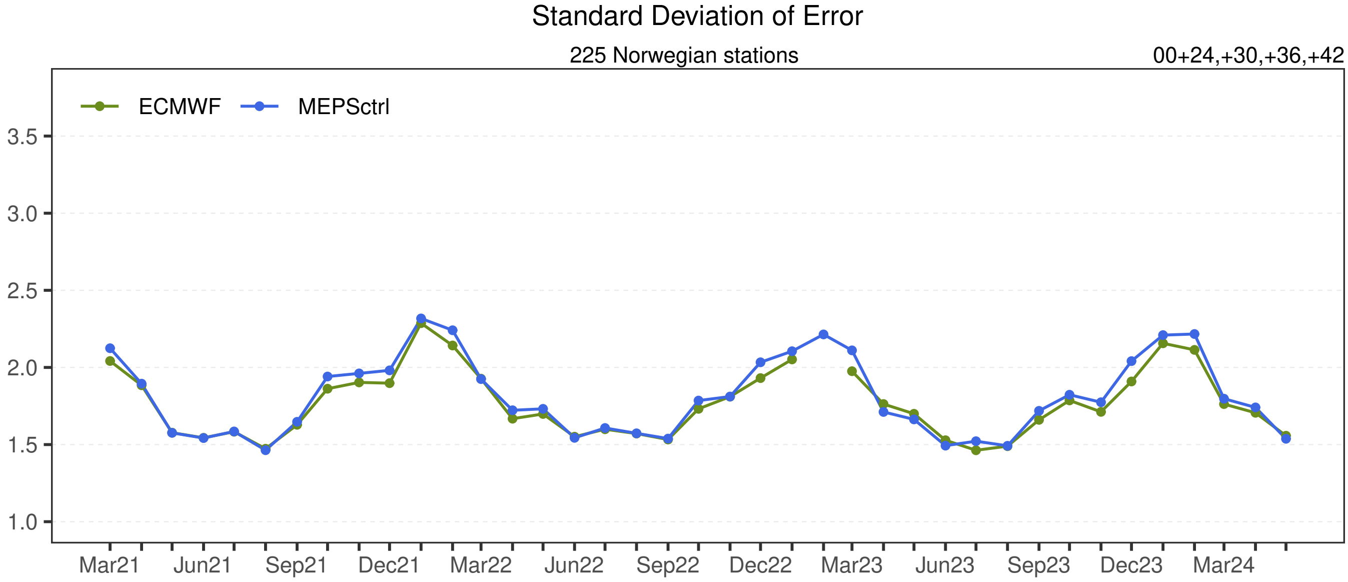
Mean Error
67 North Nor. stations
00+3,+6,..., +66
AA25
MEPSctrl
ECMWF
Lead time (hour)
Standard Deviation of Error
67 North Nor. stations
00+3,+6,..., +66
Lead time (hour)
Mean Absolute Error
67 North Nor. stations
00+3,+6,..., +66
Lead time (hour)
Hit Rate
67 North Nor. stations
00+18,+24,+30,+36
AA25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

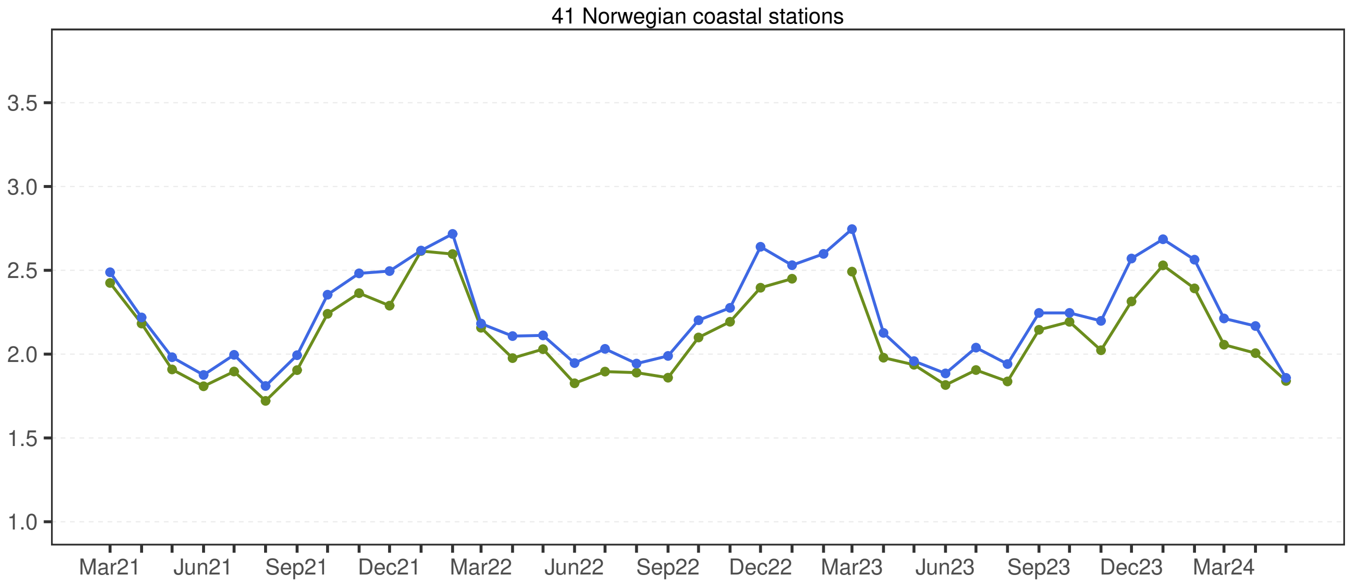
Mean Error

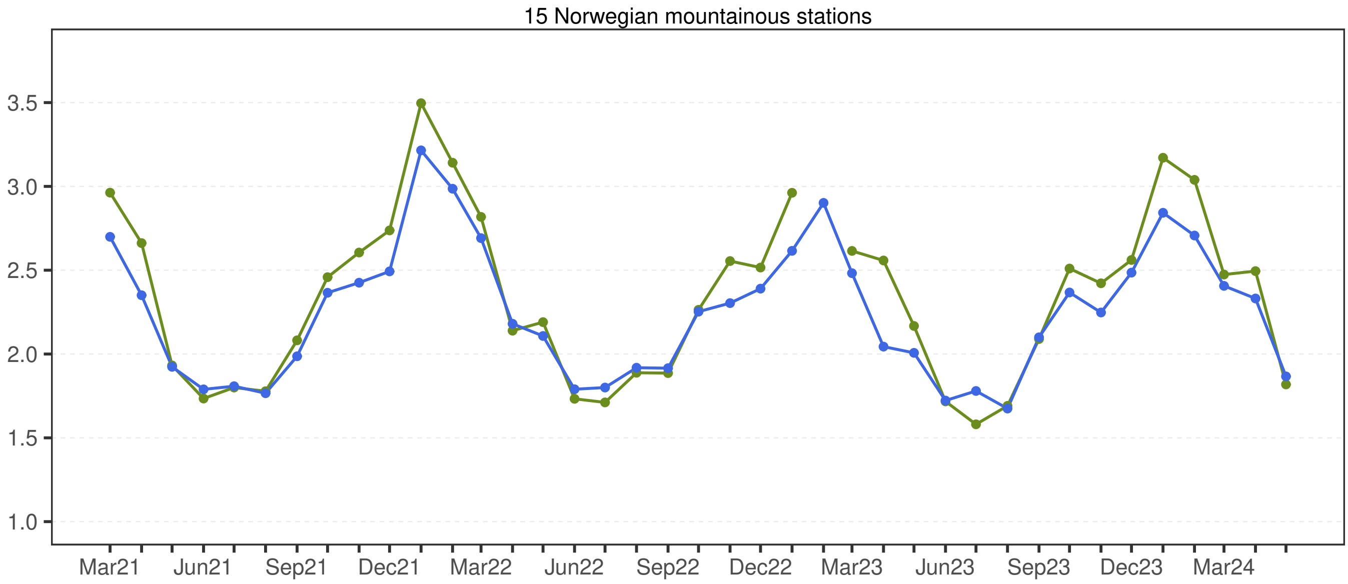

225 Norwegian stations
00+24,+30,+36,+42
ECMWF
MEPSctrl
2
1
0
−1
−2
−3
−4
−5
Mar21 Jun21 Sep21 Dec21 Mar22 Jun22 Sep22 Dec22 Mar23 Jun23 Sep23 Dec23 Mar24

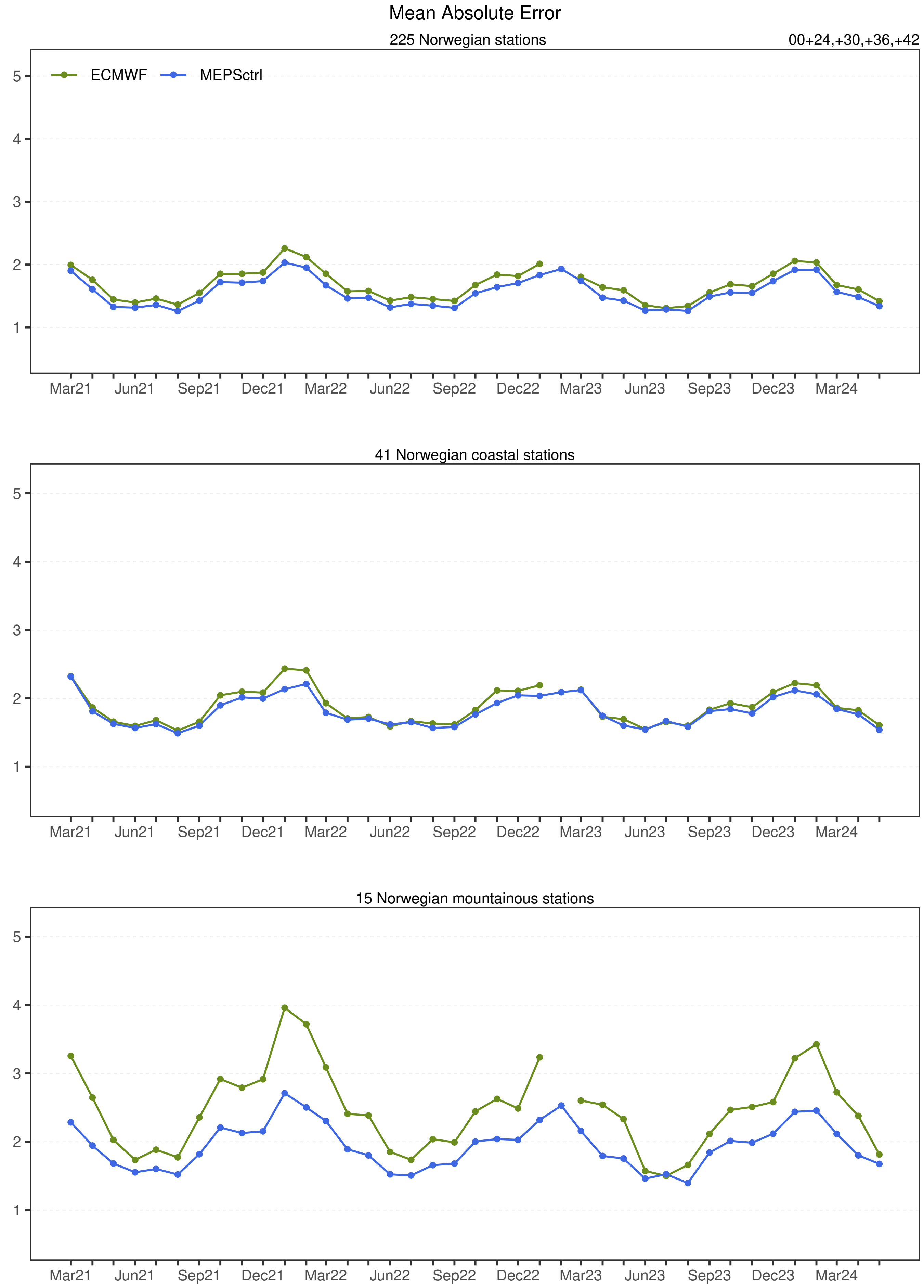

41 Norwegian coastal stations
2
1
0
−1
−2
−3
−4
−5
Mar21 Jun21 Sep21 Dec21 Mar22 Jun22 Sep22 Dec22 Mar23 Jun23 Sep23 Dec23 Mar24

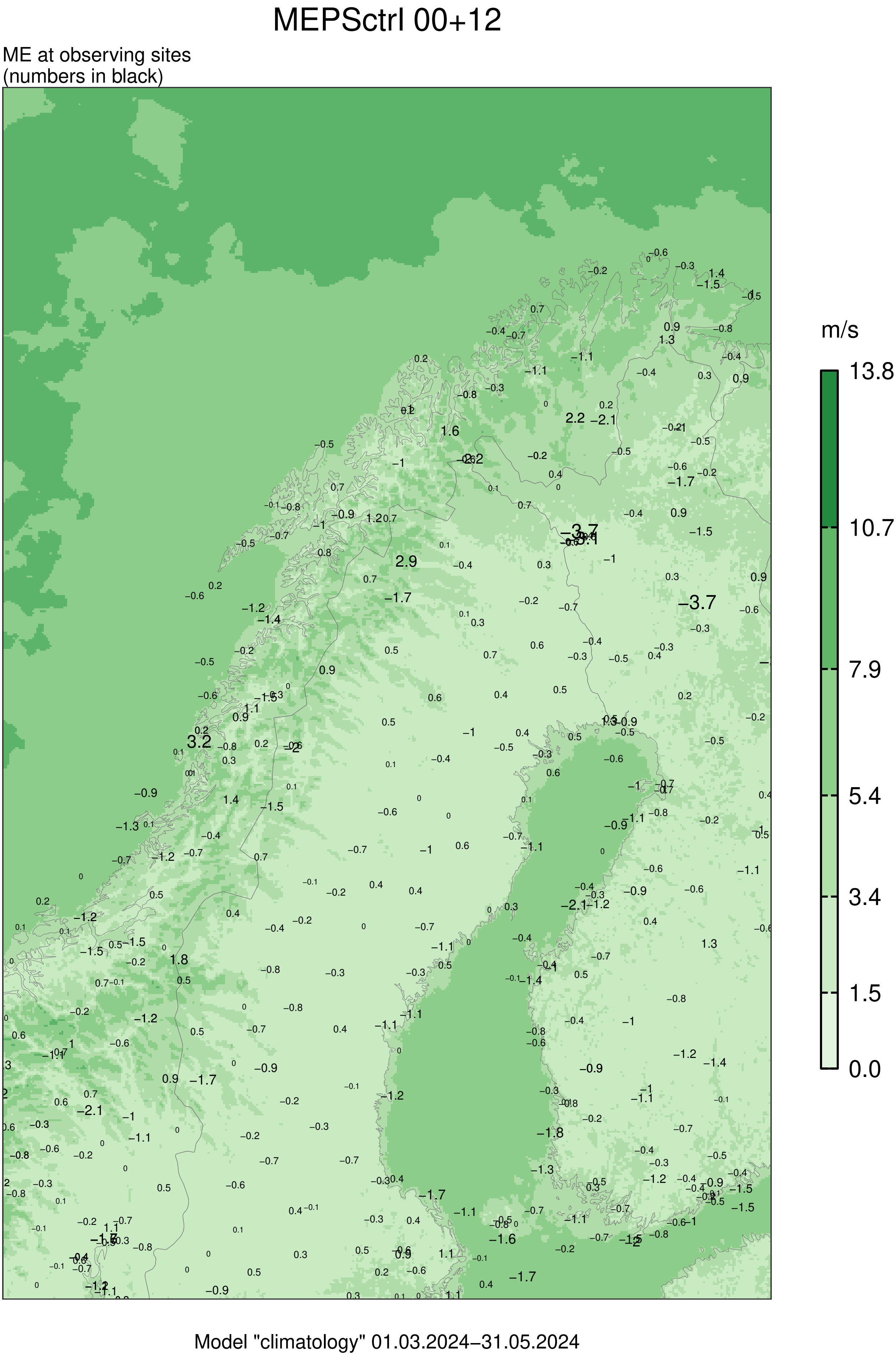

15 Norwegian mountainous stations
2
1
0
−1
−2
−3
−4
−5
Mar21 Jun21 Sep21 Dec21 Mar22 Jun22 Sep22 Dec22 Mar23 Jun23 Sep23 Dec23 Mar24


Standard Deviation of Error
225 Norwegian stations
00+24,+30,+36,+42
ECMWF
MEPSctrl
3.5
3.0
2.5
2.0
1.5
1.0
Mar21 Jun21 Sep21 Dec21 Mar22 Jun22 Sep22 Dec22 Mar23 Jun23 Sep23 Dec23 Mar24


41 Norwegian coastal stations
3.5
3.0
2.5
2.0
1.5
1.0
Mar21 Jun21 Sep21 Dec21 Mar22 Jun22 Sep22 Dec22 Mar23 Jun23 Sep23 Dec23 Mar24

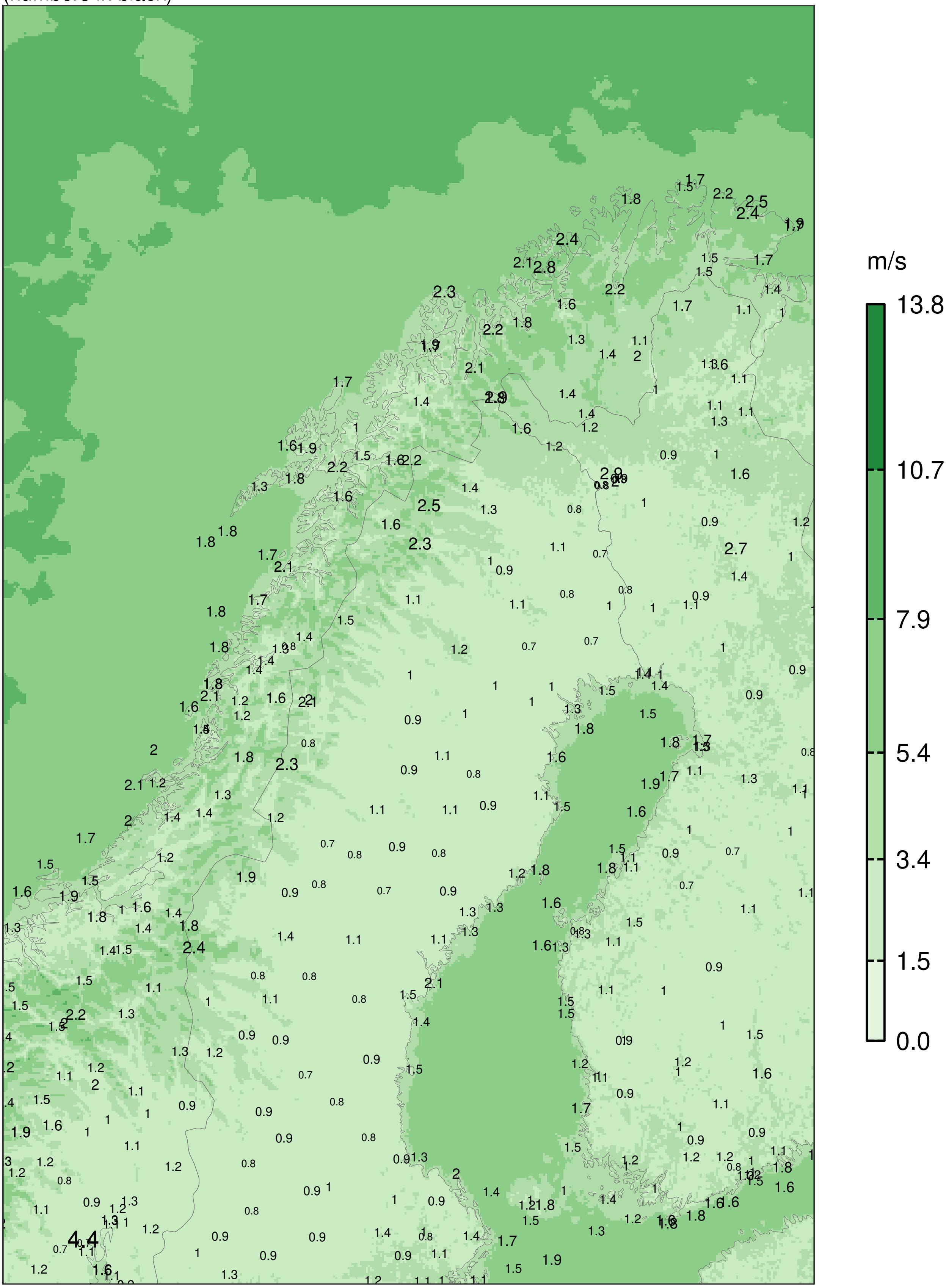

15 Norwegian mountainous stations
3.5
3.0
2.5
2.0
1.5
1.0
Mar21 Jun21 Sep21 Dec21 Mar22 Jun22 Sep22 Dec22 Mar23 Jun23 Sep23 Dec23 Mar24


Mean Absolute Error
225 Norwegian stations
00+24,+30,+36,+42
ECMWF
MEPSctrl
1
2
3
4
5
Mar21
Jun21
Sep21
Dec21
Mar22
Jun22
Sep22
Dec22
Mar23
Jun23
Sep23
Dec23
Mar24
41 Norwegian coastal stations
15 Norwegian mountainous stations


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" 01.03.2024–31.05.2024

MEPSctrl 00+12

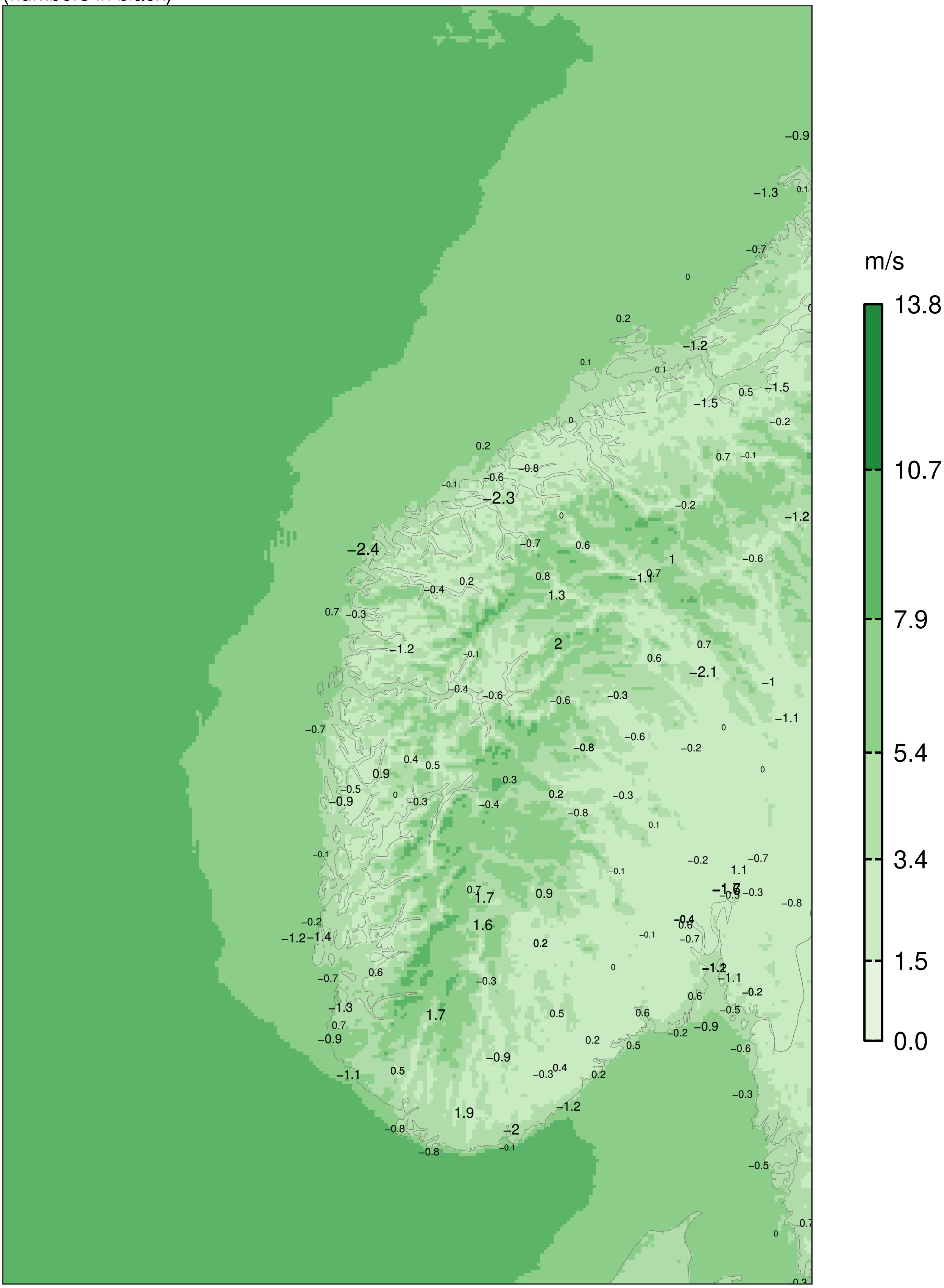
SDE at observing sites
(numbers in black)



Model "climatology" 01.03.2024–31.05.2024

MEPSctrl 00+12

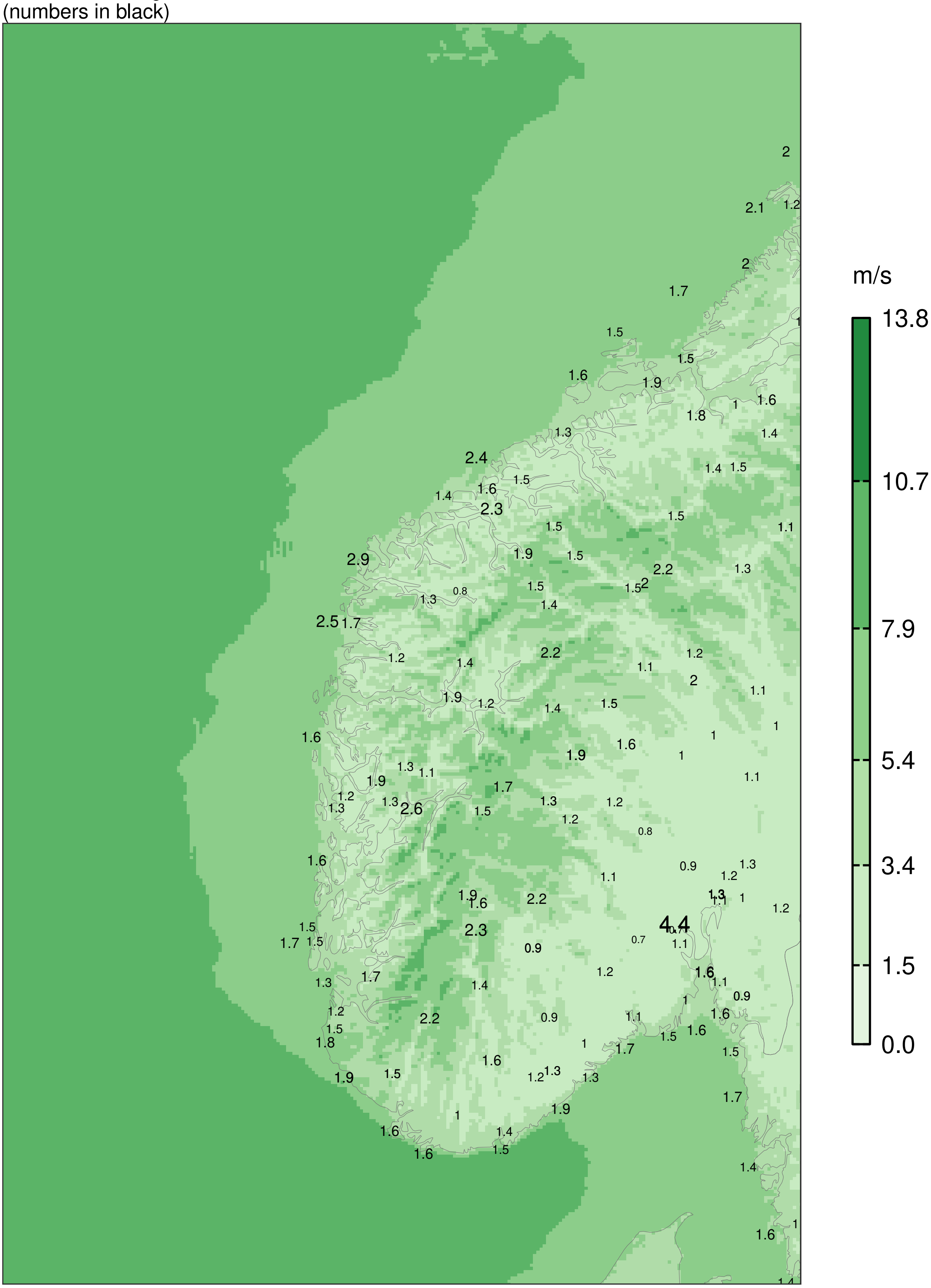
ME at observing sites
(numbers in black)



Model "climatology" 01.03.2024–31.05.2024

MEPSctrl 00+12

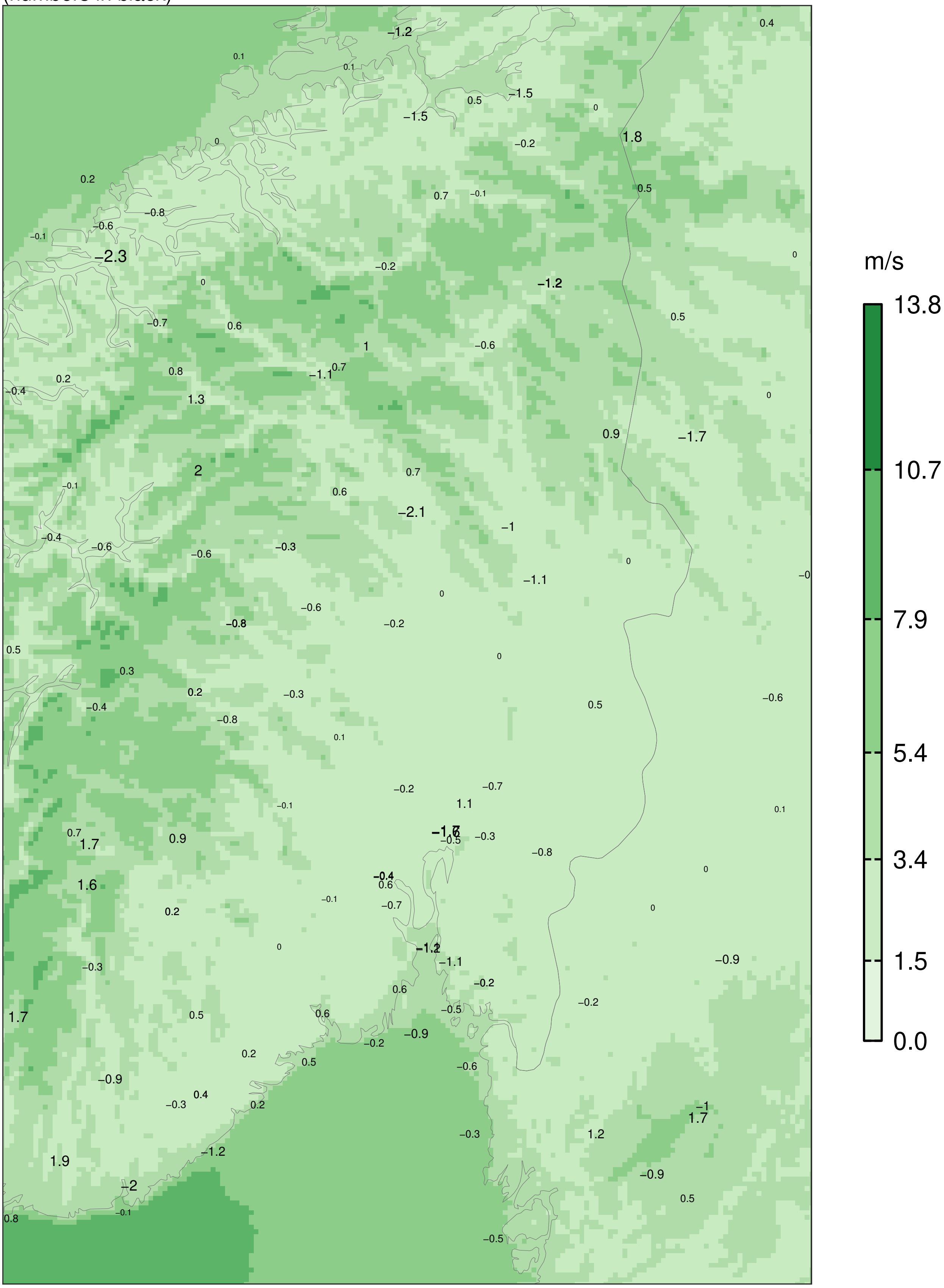
SDE at observing sites
(numbers in black)



Model "climatology" 01.03.2024–31.05.2024

MEPSctrl 00+12

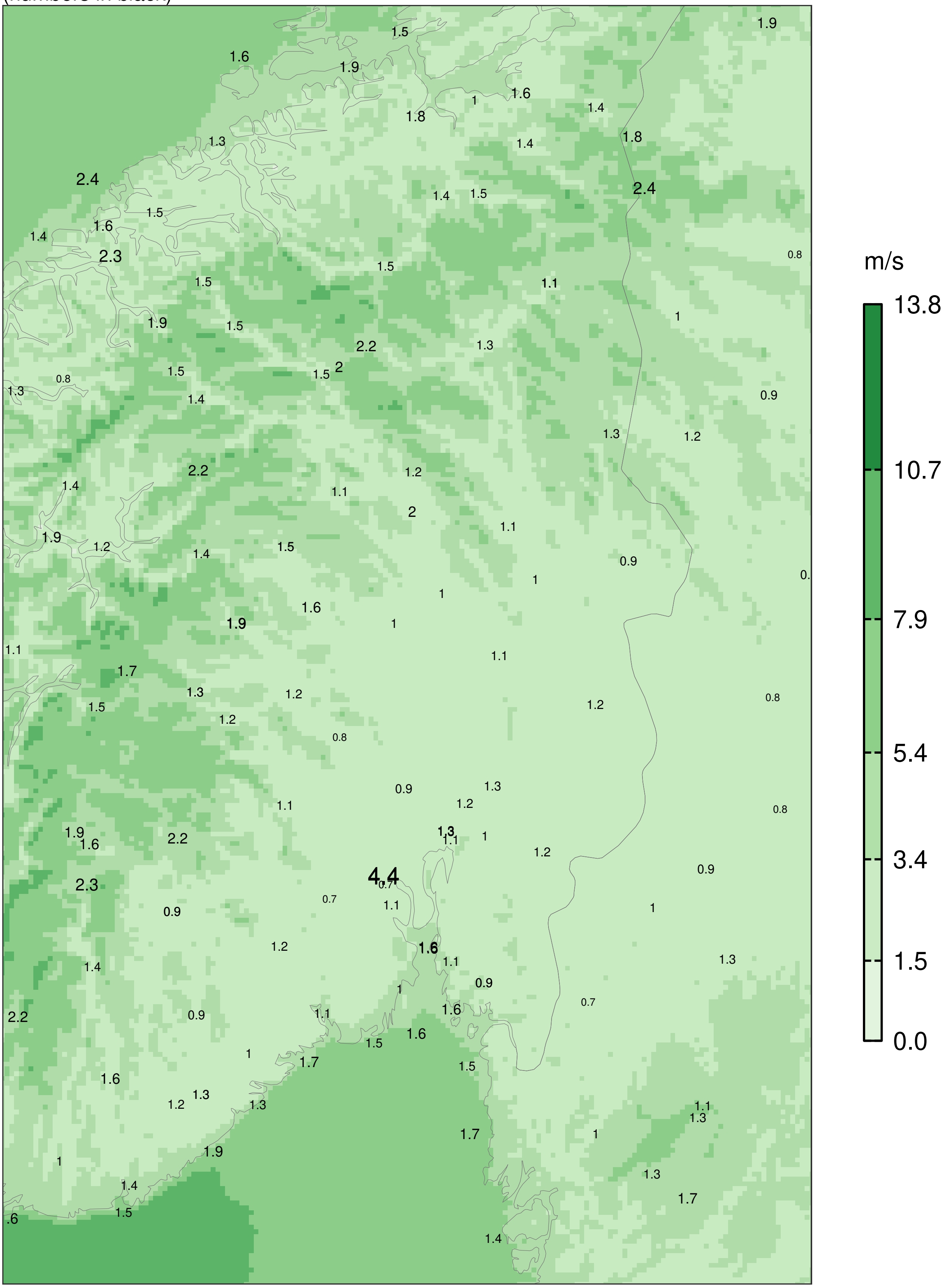
ME at observing sites
(numbers in black)



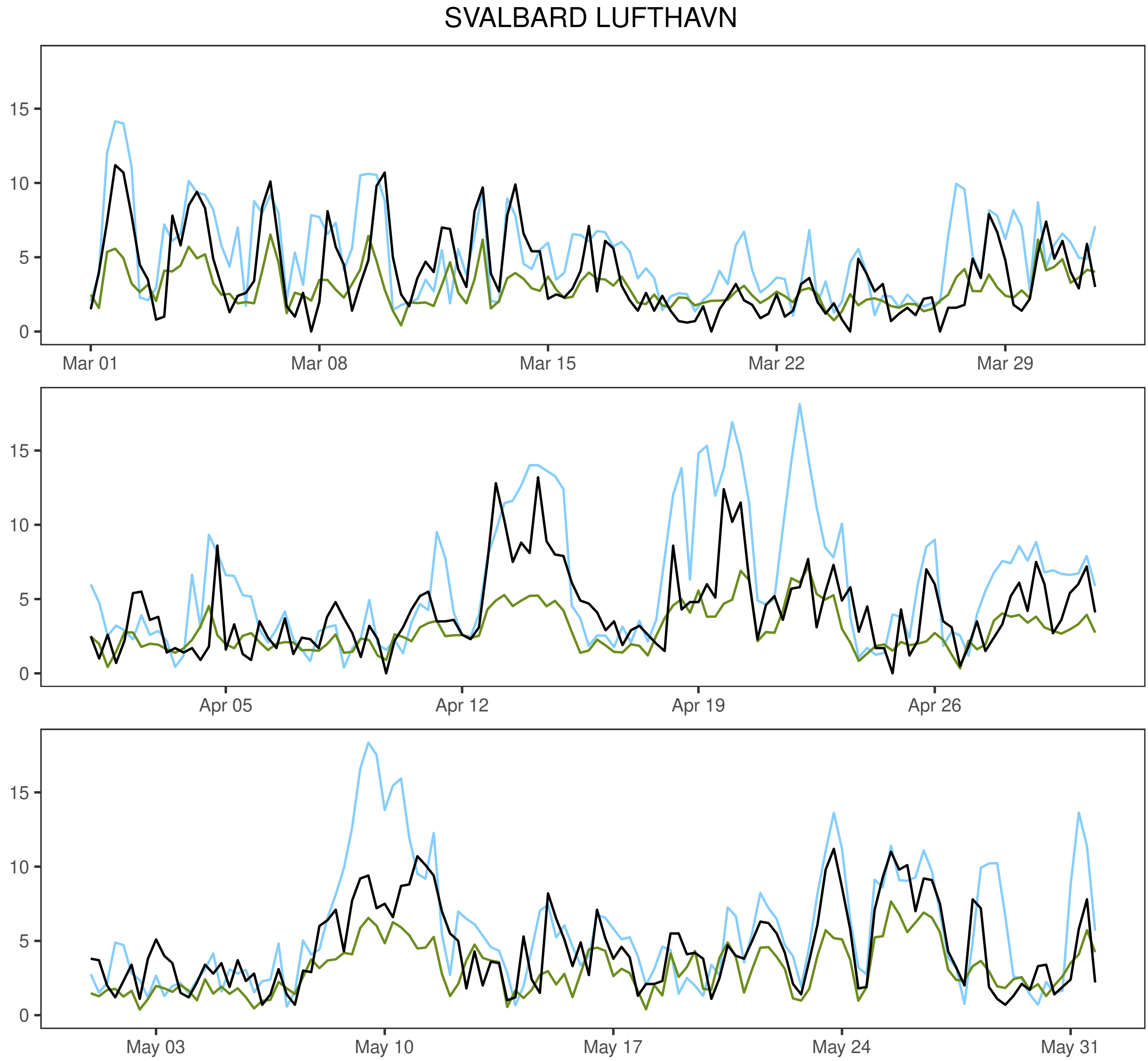
Model "climatology" 01.03.2024–31.05.2024

MEPSctrl 00+12

SDE at observing sites
(numbers in black)

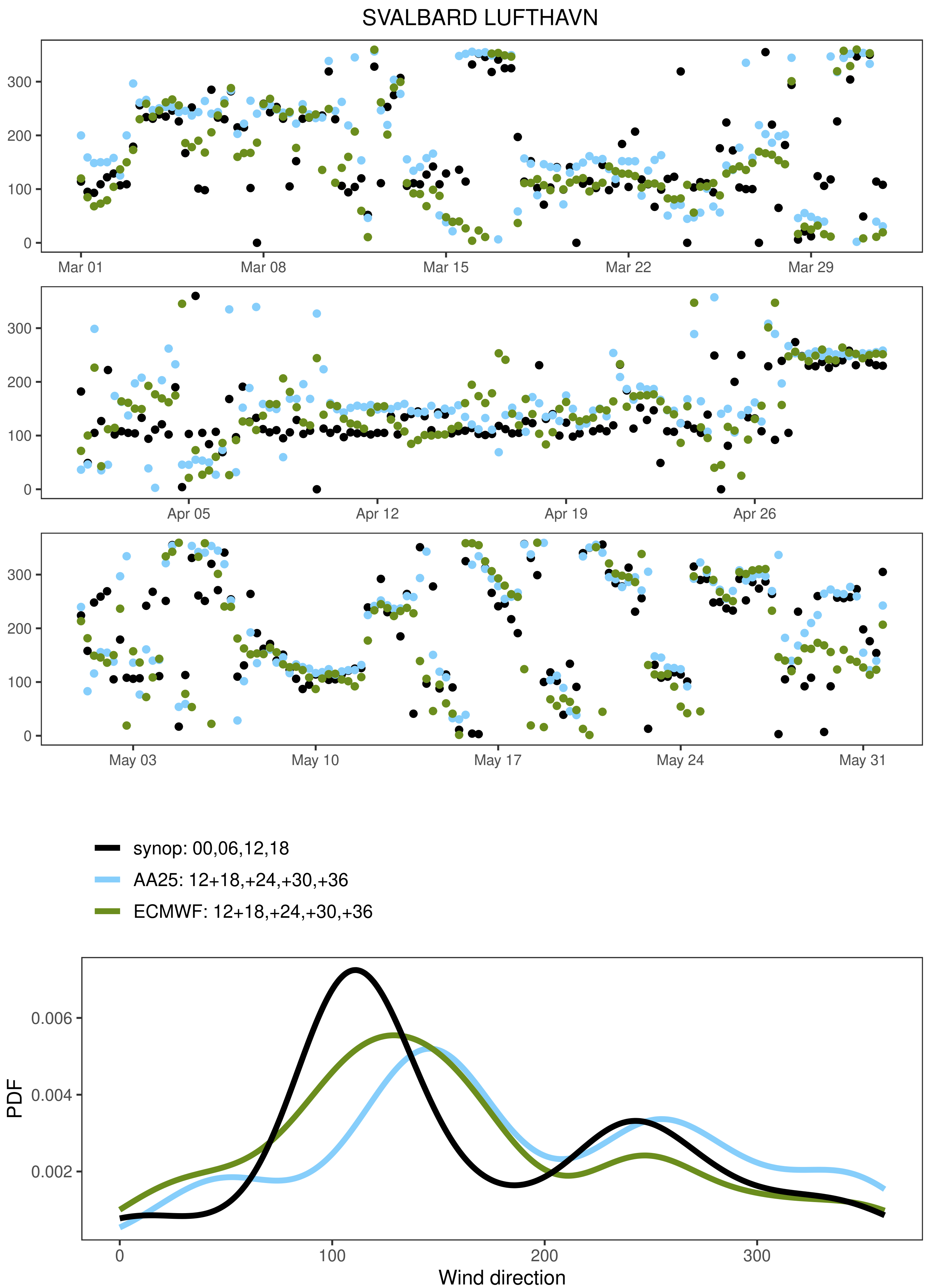


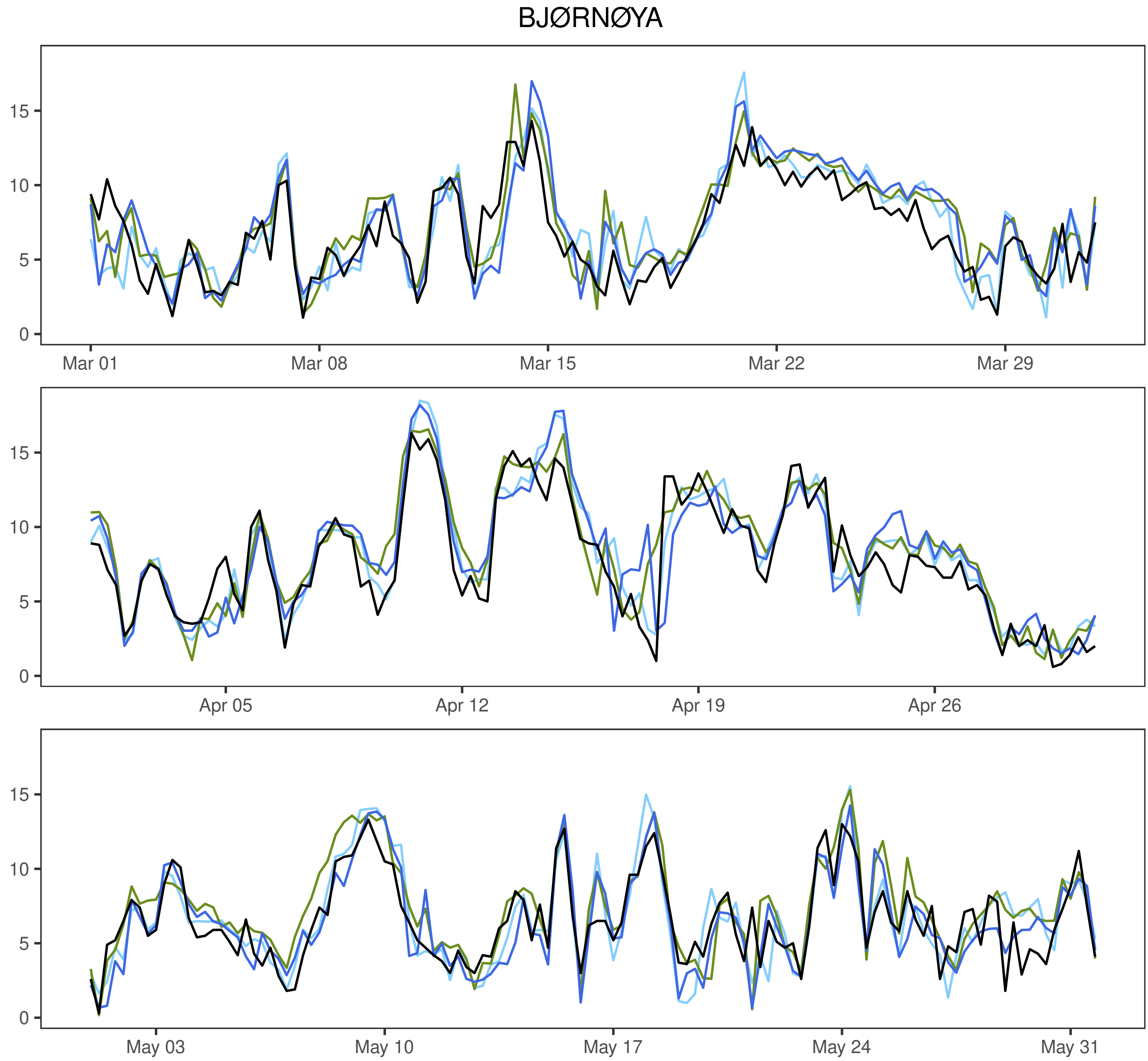
Model "climatology" 01.03.2024–31.05.2024



	Min	Mean	Max	Std	N
synop: 00,06,12,18	0.0	4.2	13.2	2.8	368
AA25: 12+18,+24,+30,+36	0.4	5.7	18.4	3.8	368
ECMWF: 12+18,+24,+30,+36	0.3	3.0	7.7	1.5	368

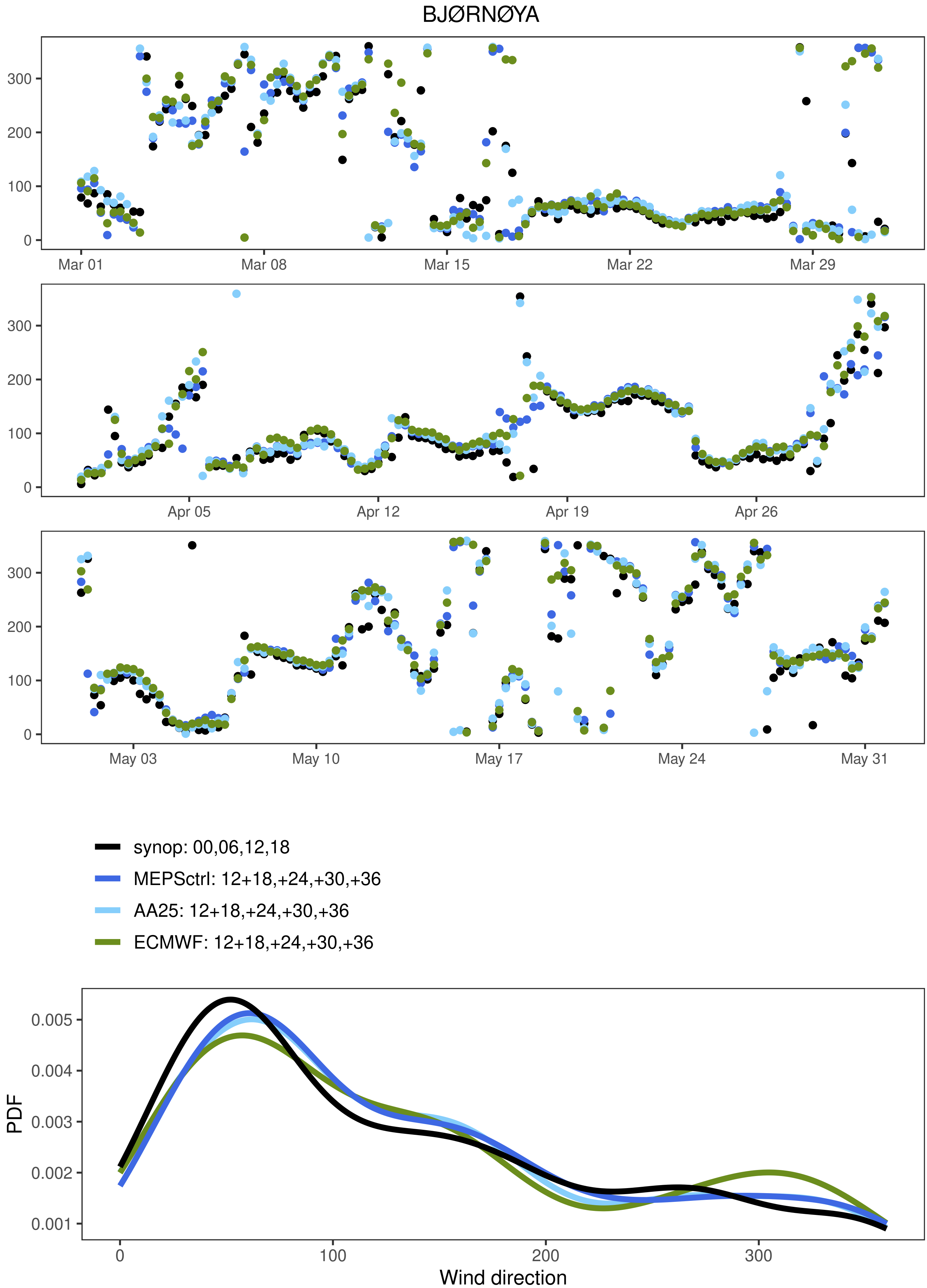
	ME	SDE	RMSE	MAE	Max.abs.err	N
AA25 – synop	1.5	2.8	3.1	2.3	12.3	368
ECMWF – synop	−1.2	2.0	2.3	1.8	8.0	368

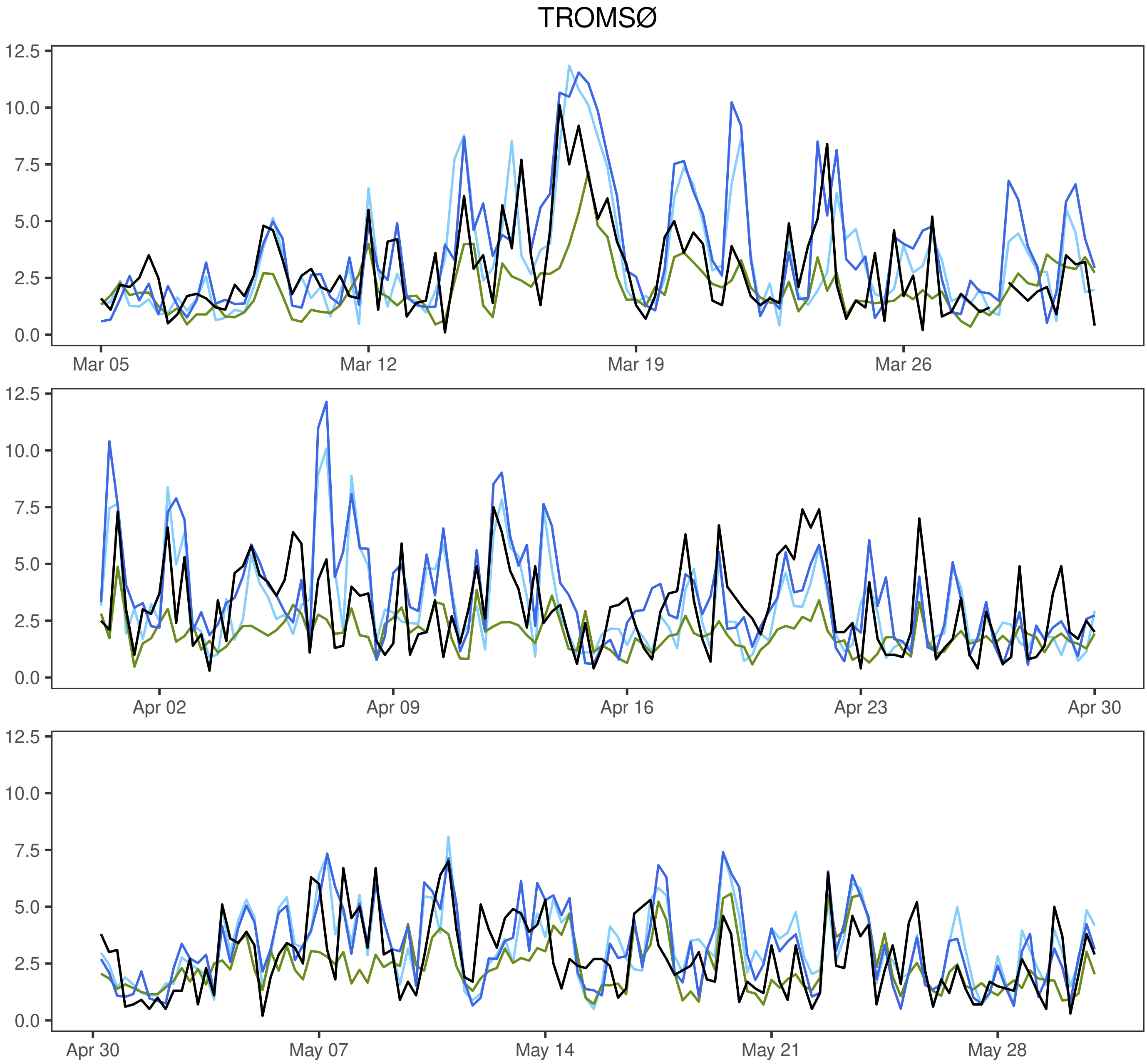

SVALBARD LUFTHAVN
300
200
100
0
Mar 01
Mar 08
Mar 15
Mar 22
Mar 29
Apr 05
Apr 12
Apr 19
Apr 26
May 03
May 10
May 17
May 24
May 31
synop: 00,06,12,18
AA25: 12+18,+24,+30,+36
ECMWF: 12+18,+24,+30,+36
PDF
0.006
0.004
0.002
0
100
200
300
Wind direction



	Min	Mean	Max	Std	N
synop: 00,06,12,18	0.3	7.0	16.3	3.3	368
MEPSctrl: 12+18,+24,+30,+36	0.7	7.3	18.2	3.6	368
AA25: 12+18,+24,+30,+36	1.0	7.3	18.5	3.6	368
ECMWF: 12+18,+24,+30,+36	0.2	7.8	16.8	3.4	368

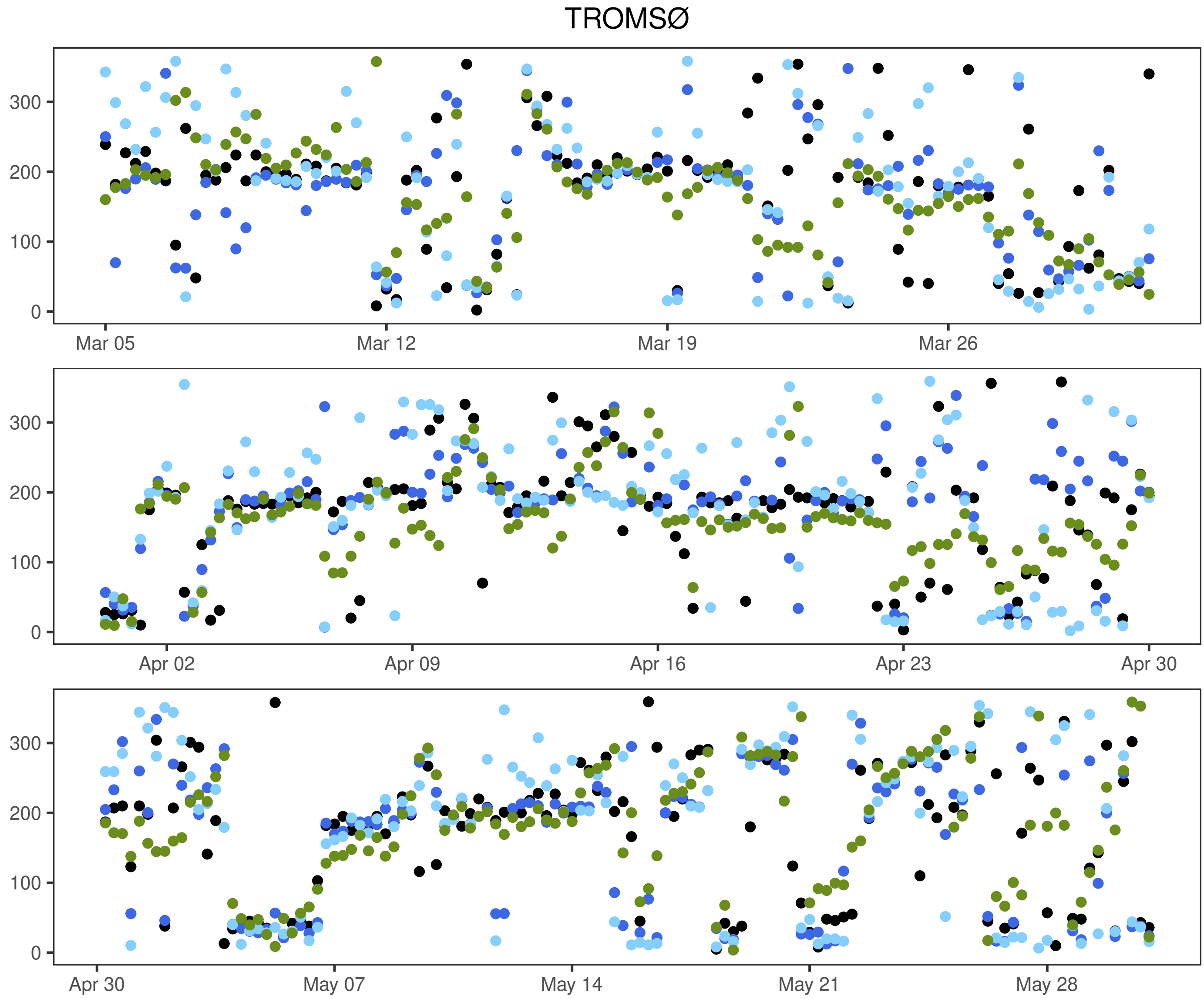
	ME	SDE	RMSE	MAE	Max.abs.err	N
MEPSctrl – synop	0.3	2.0	2.0	1.5	9.8	368
AA25 – synop	0.3	1.8	1.8	1.4	6.6	368
ECMWF – synop	0.8	1.7	1.9	1.4	7.8	368

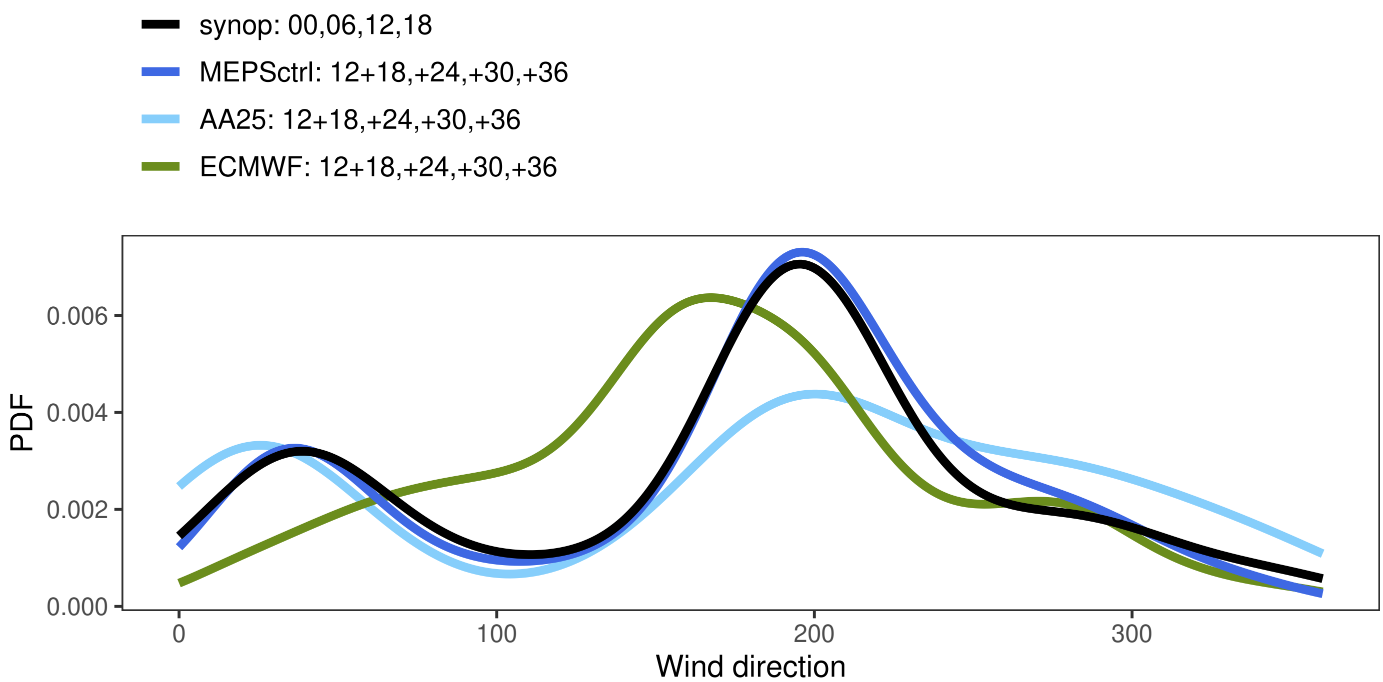

BJØRNØYA
300
200
100
0
Mar 01
Mar 08
Mar 15
Mar 22
Mar 29
Apr 05
Apr 12
Apr 19
Apr 26
May 03
May 10
May 17
May 24
May 31
synop: 00,06,12,18
MEPSctrl: 12+18,+24,+30,+36
AA25: 12+18,+24,+30,+36
ECMWF: 12+18,+24,+30,+36
PDF
0.005
0.004
0.003
0.002
0.001
0
100
200
300
Wind direction

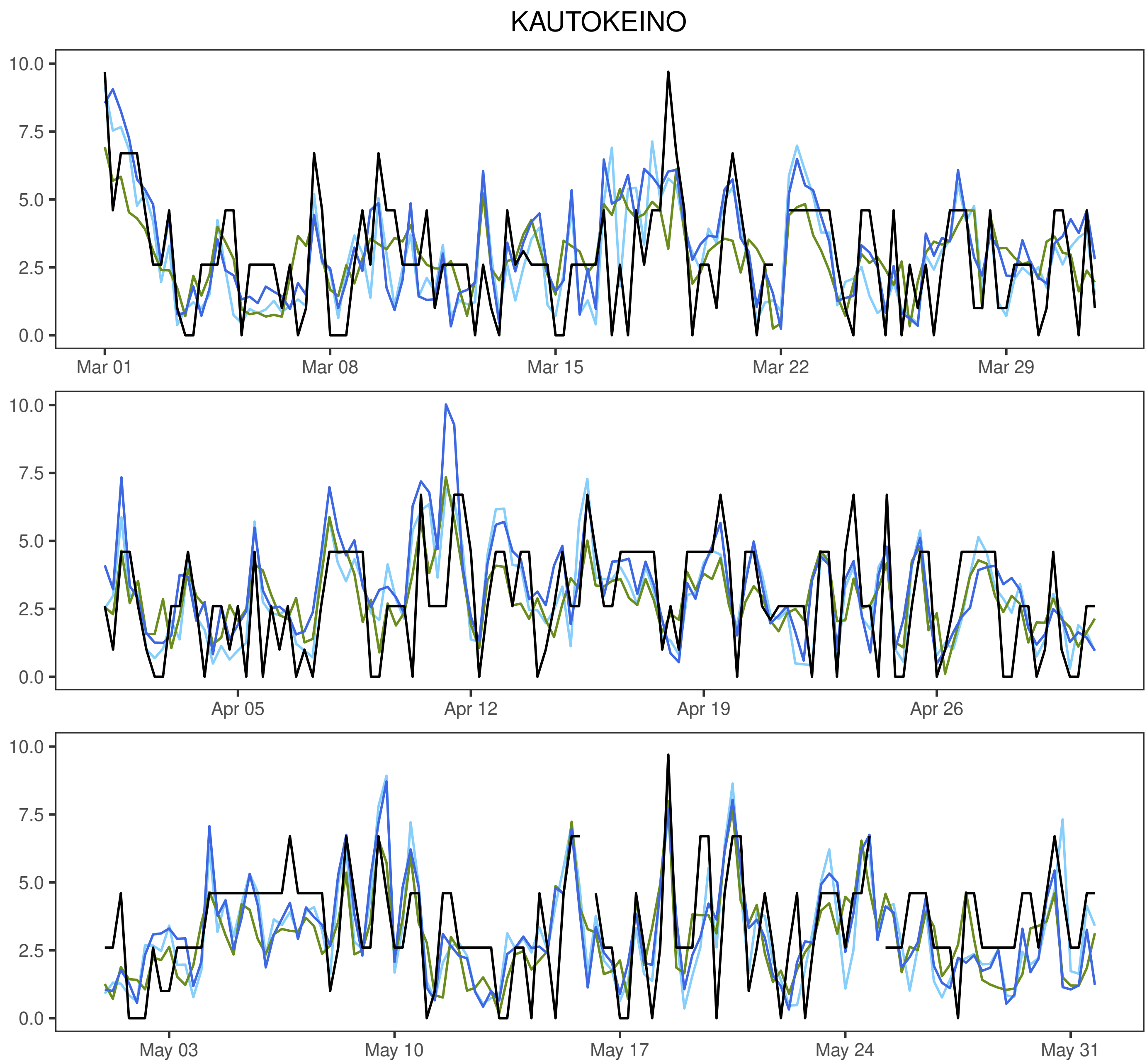


	Min	Mean	Max	Std	N
synop: 00,06,12,18	0.1	2.9	10.1	1.8	348
MEPSctrl: 12+18,+24,+30,+36	0.5	3.5	12.1	2.2	349
AA25: 12+18,+24,+30,+36	0.4	3.2	11.8	2.0	349
ECMWF: 12+18,+24,+30,+36	0.4	2.1	7.2	1.0	349

	ME	SDE	RMSE	MAE	Max.abs.err	N
MEPSctrl – synop	0.6	1.9	2.0	1.5	8.3	348
AA25 – synop	0.3	1.8	1.8	1.4	5.7	348
ECMWF – synop	−0.8	1.6	1.8	1.4	7.2	348

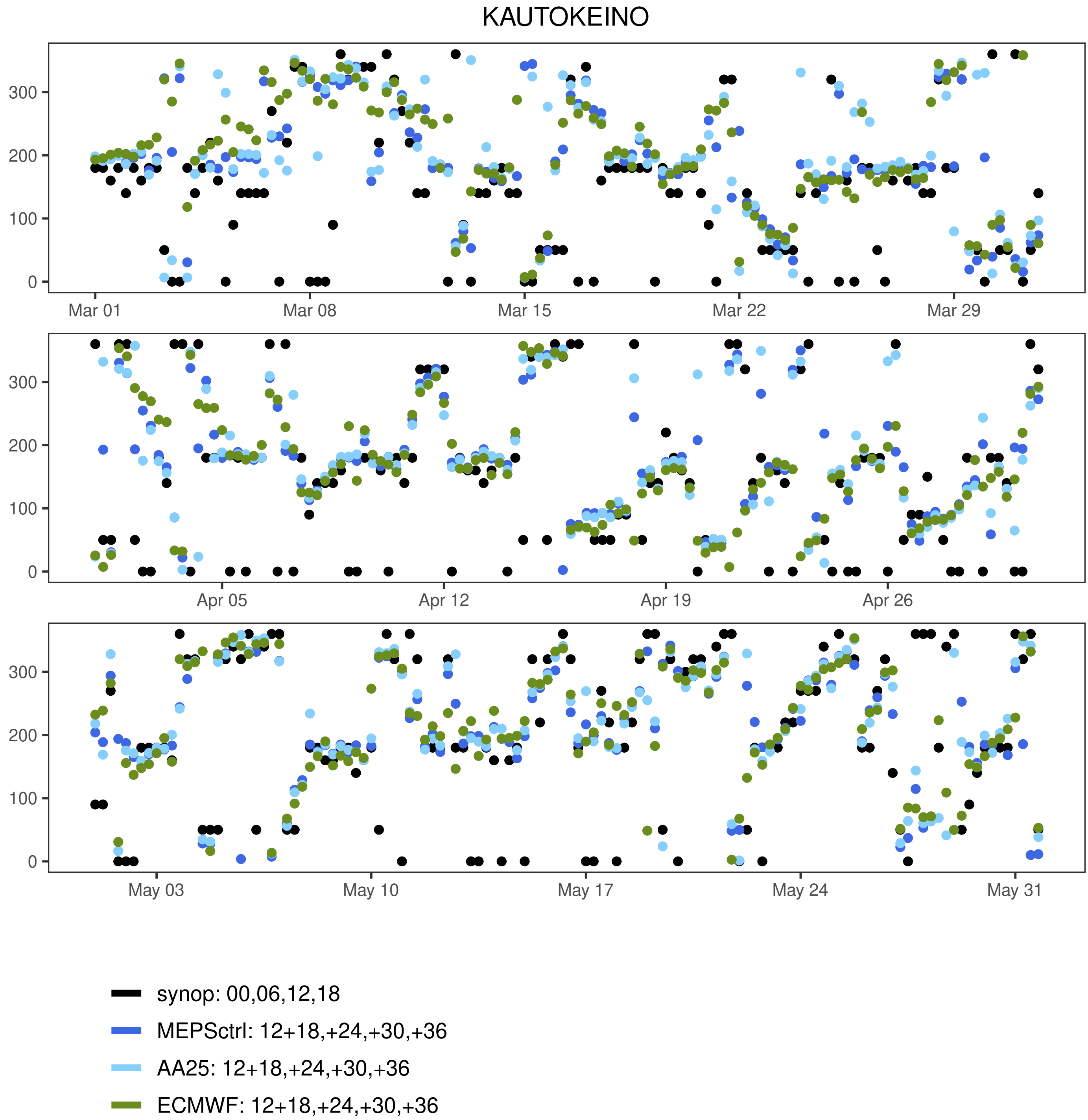

TROMSØ
300
200
100
0
Mar 05
Mar 12
Mar 19
Mar 26
Apr 02
Apr 09
Apr 16
Apr 23
Apr 30
May 07
May 14
May 21
May 28

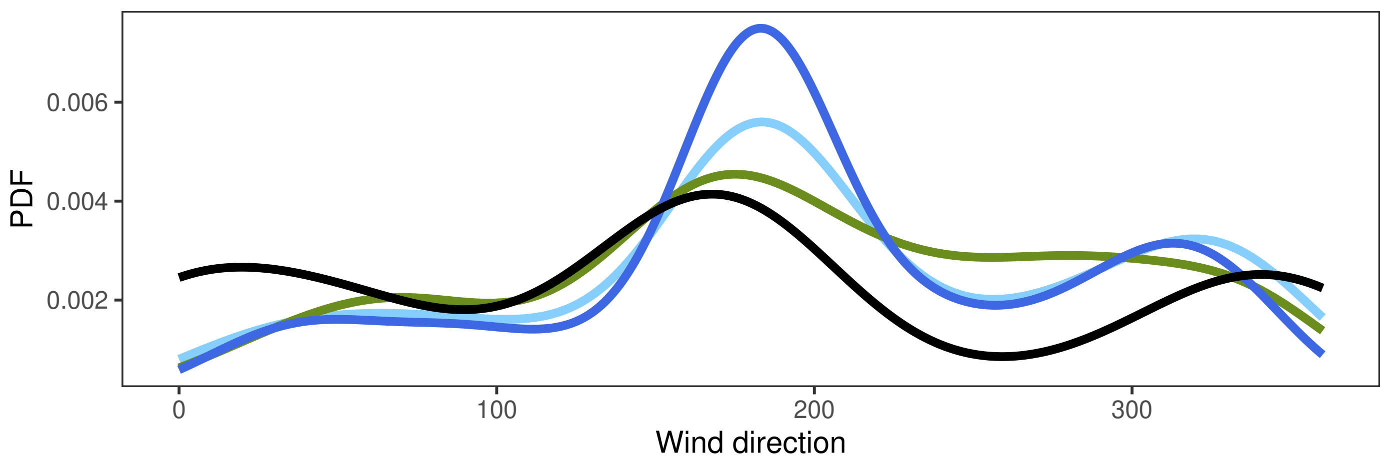

synop: 00,06,12,18
MEPSctrl: 12+18,+24,+30,+36
AA25: 12+18,+24,+30,+36
ECMWF: 12+18,+24,+30,+36
PDF
0.006
0.004
0.002
0.000
0
100
200
300
Wind direction

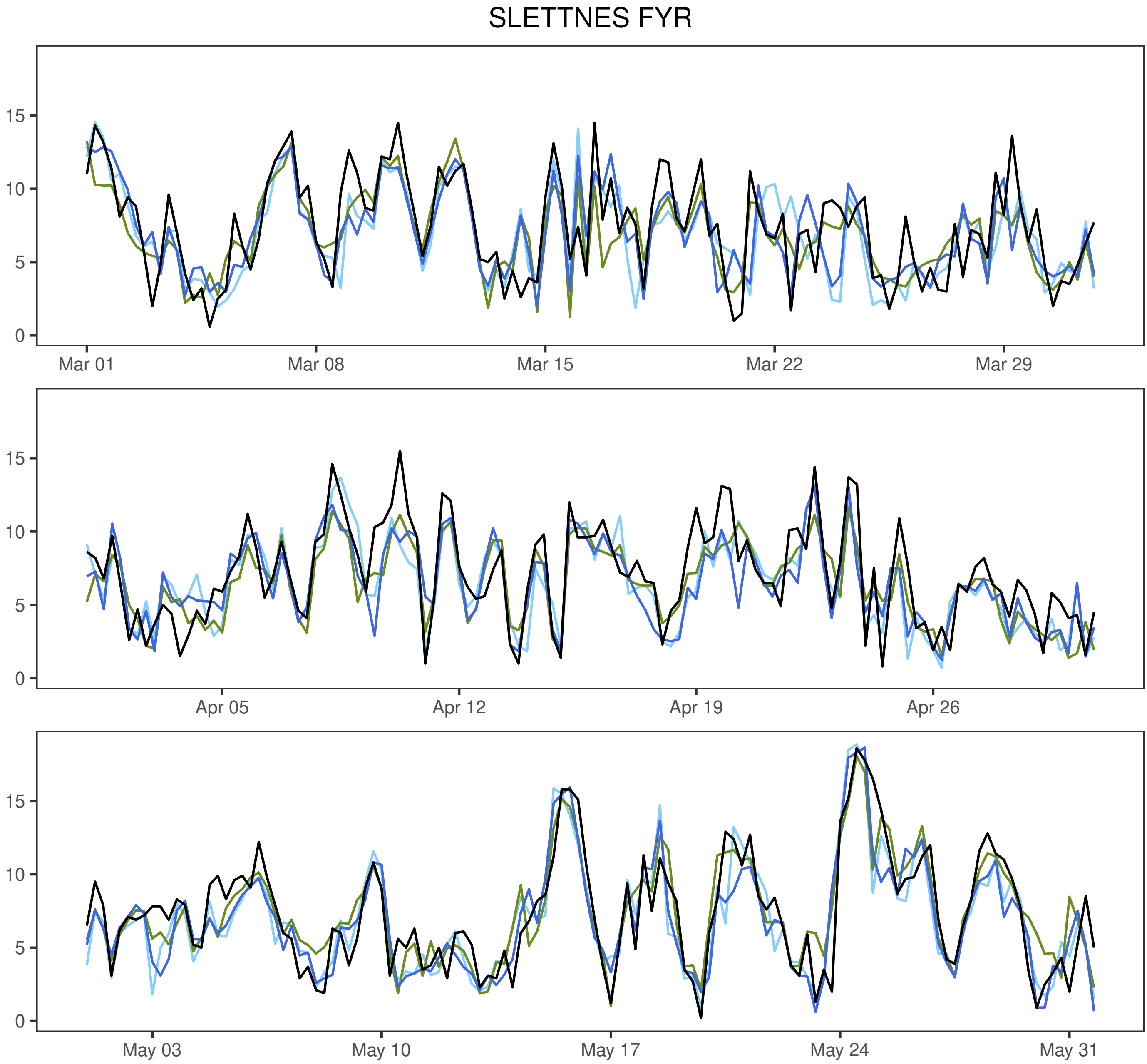


	Min	Mean	Max	Std	N
synop: 00,06,12,18	0.0	3.0	9.7	2.0	365
MEPSctrl: 12+18,+24,+30,+36	0.2	3.2	10.0	1.8	368
AA25: 12+18,+24,+30,+36	0.3	3.0	9.1	1.8	368
ECMWF: 12+18,+24,+30,+36	0.1	2.9	8.0	1.4	368

	ME	SDE	RMSE	MAE	Max.abs.err	N
MEPSctrl – synop	0.2	1.8	1.8	1.4	7.4	365
AA25 – synop	–0.1	1.7	1.7	1.4	6.9	365
ECMWF – synop	–0.1	1.7	1.7	1.4	6.5	365

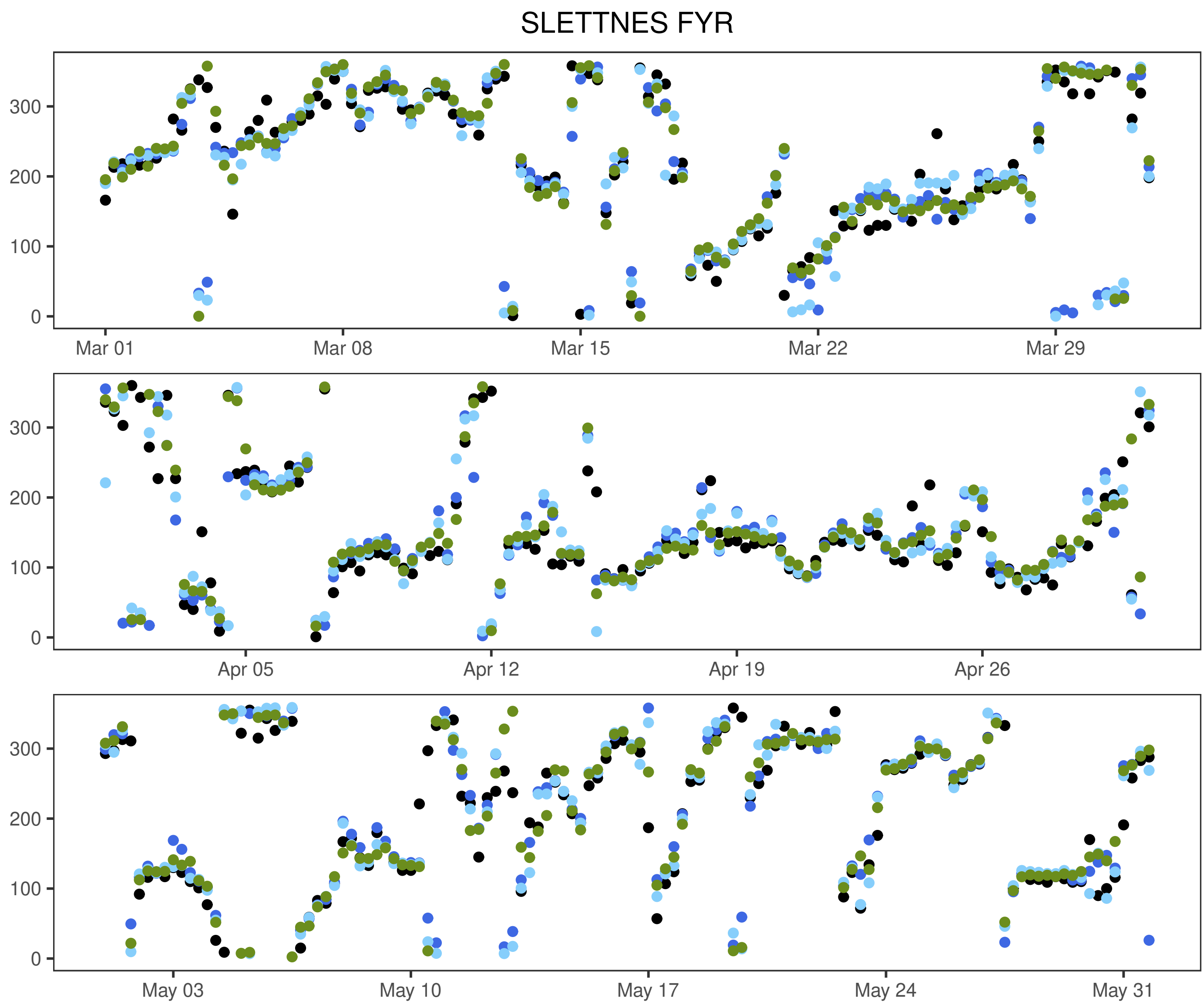

KAUTOKEINO
300
200
100
0
Mar 01
Mar 08
Mar 15
Mar 22
Mar 29
Apr 05
Apr 12
Apr 19
Apr 26
May 03
May 10
May 17
May 24
May 31
synop: 00,06,12,18
MEPSctrl: 12+18,+24,+30,+36
AA25: 12+18,+24,+30,+36
ECMWF: 12+18,+24,+30,+36

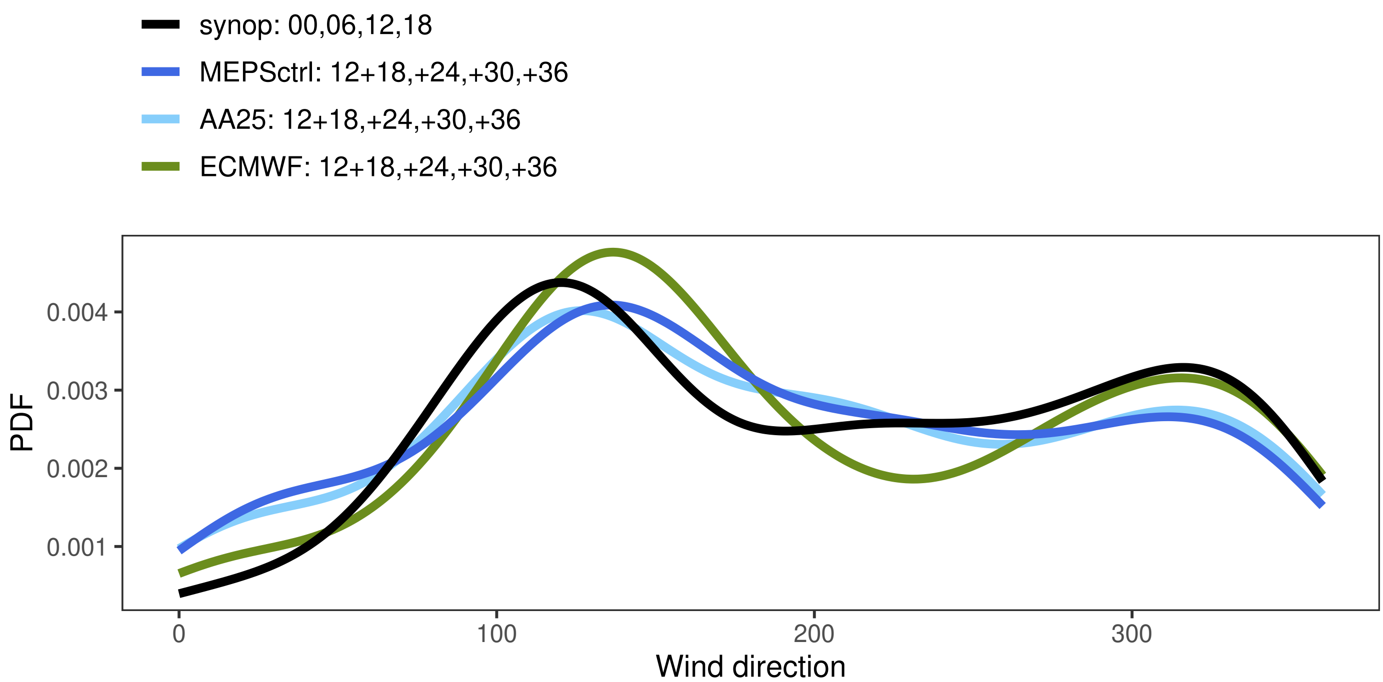

PDF
0.006
0.004
0.002
0
100
200
300
Wind direction

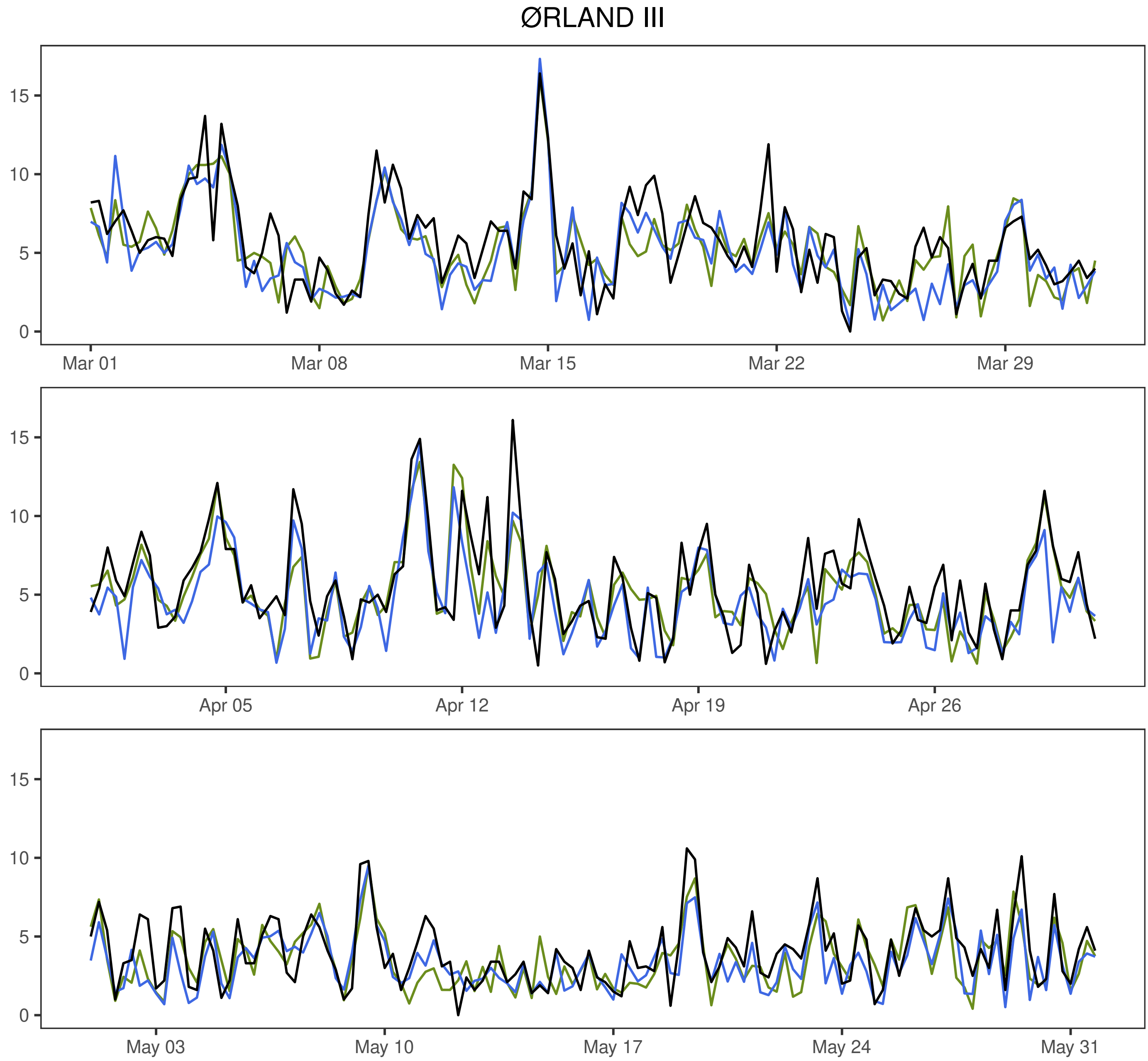


	Min	Mean	Max	Std	N
synop: 00,06,12,18	0.2	7.3	18.6	3.5	368
MEPSctrl: 12+18,+24,+30,+36	0.6	6.8	18.6	3.2	368
AA25: 12+18,+24,+30,+36	0.7	6.7	18.8	3.2	368
ECMWF: 12+18,+24,+30,+36	1.0	6.9	18.1	2.9	368

	ME	SDE	RMSE	MAE	Max.abs.err	N
MEPSctrl – synop	–0.5	2.1	2.2	1.7	7.8	368
AA25 – synop	–0.5	2.3	2.4	1.8	8.4	368
ECMWF – synop	–0.3	2.0	2.0	1.6	6.5	368

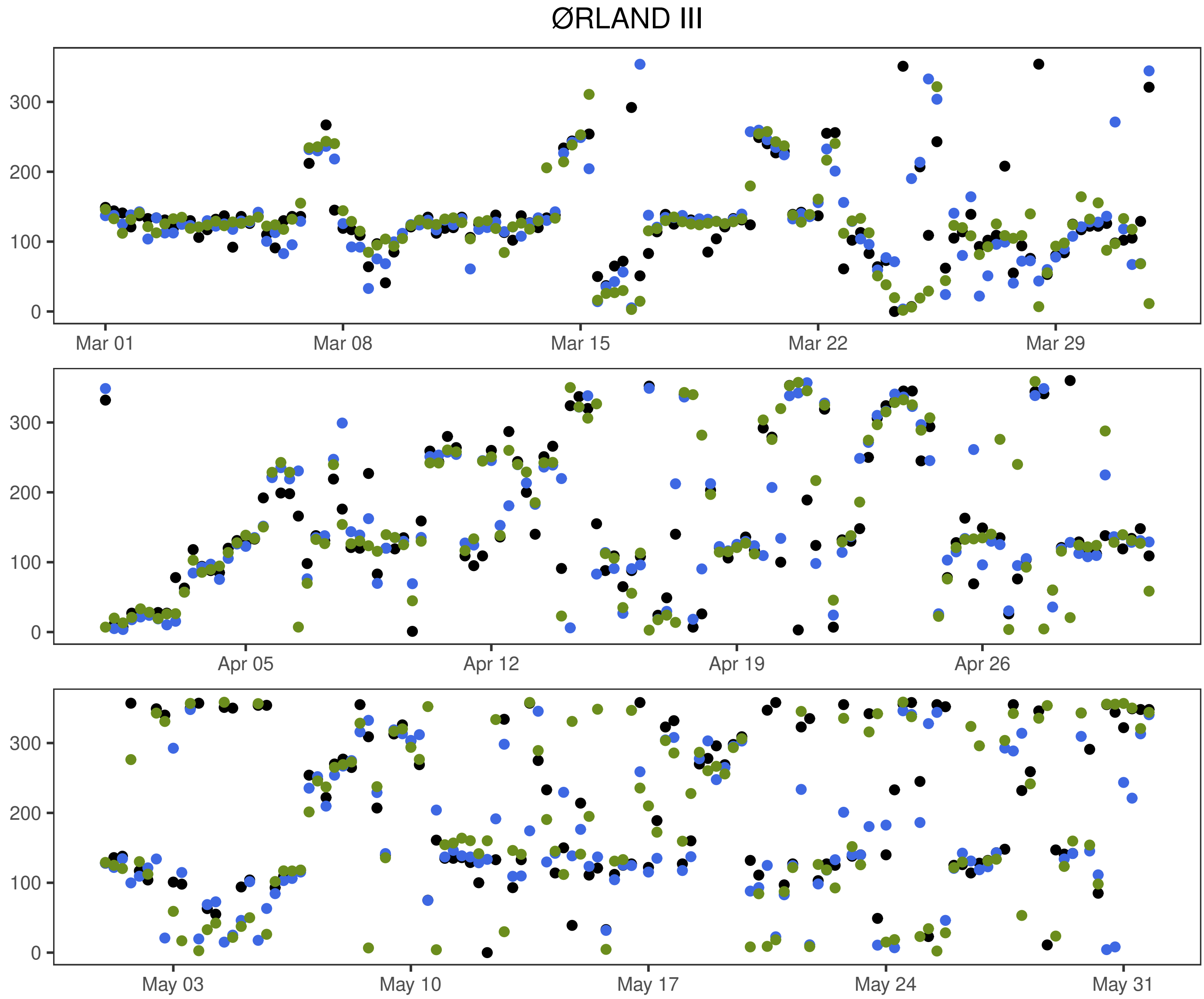

SLETTNES FYR
300
200
100
0
Mar 01
Mar 08
Mar 15
Mar 22
Mar 29
Apr 05
Apr 12
Apr 19
Apr 26
May 03
May 10
May 17
May 24
May 31

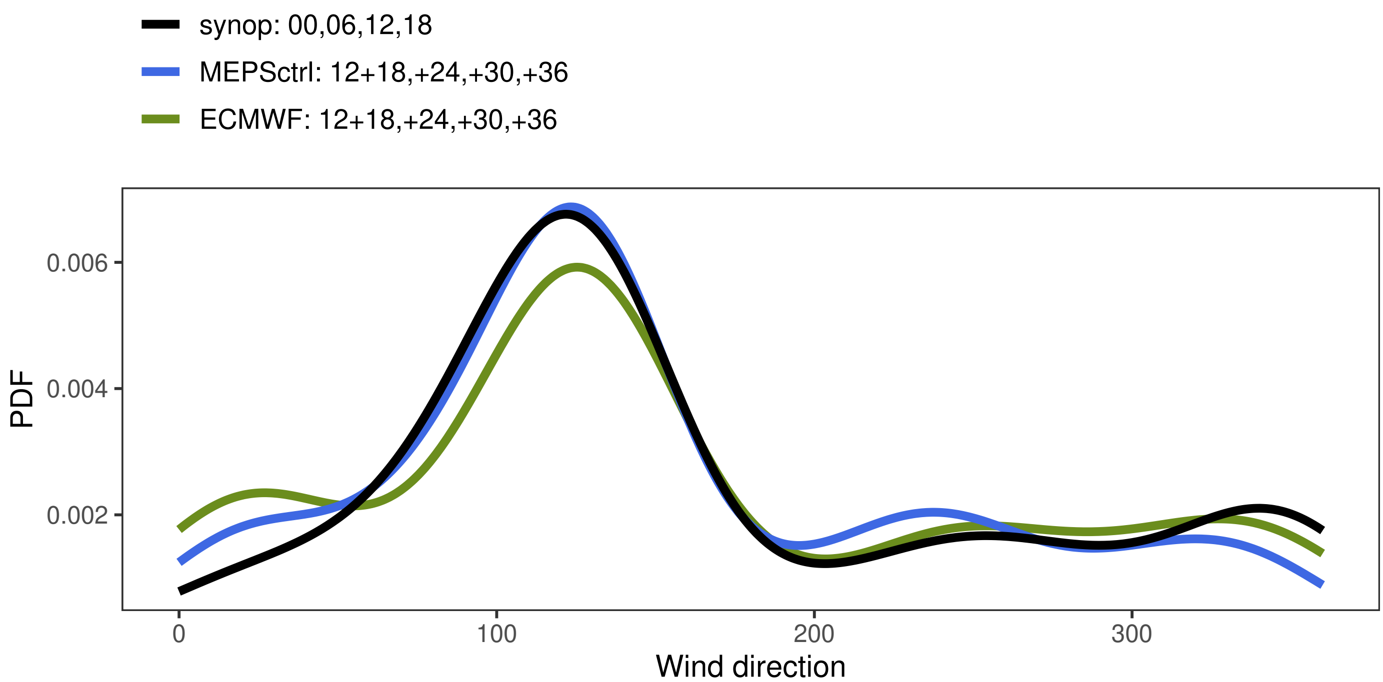

synop: 00,06,12,18
MEPSctrl: 12+18,+24,+30,+36
AA25: 12+18,+24,+30,+36
ECMWF: 12+18,+24,+30,+36
PDF
0.004
0.003
0.002
0.001
0
100
200
300
Wind direction

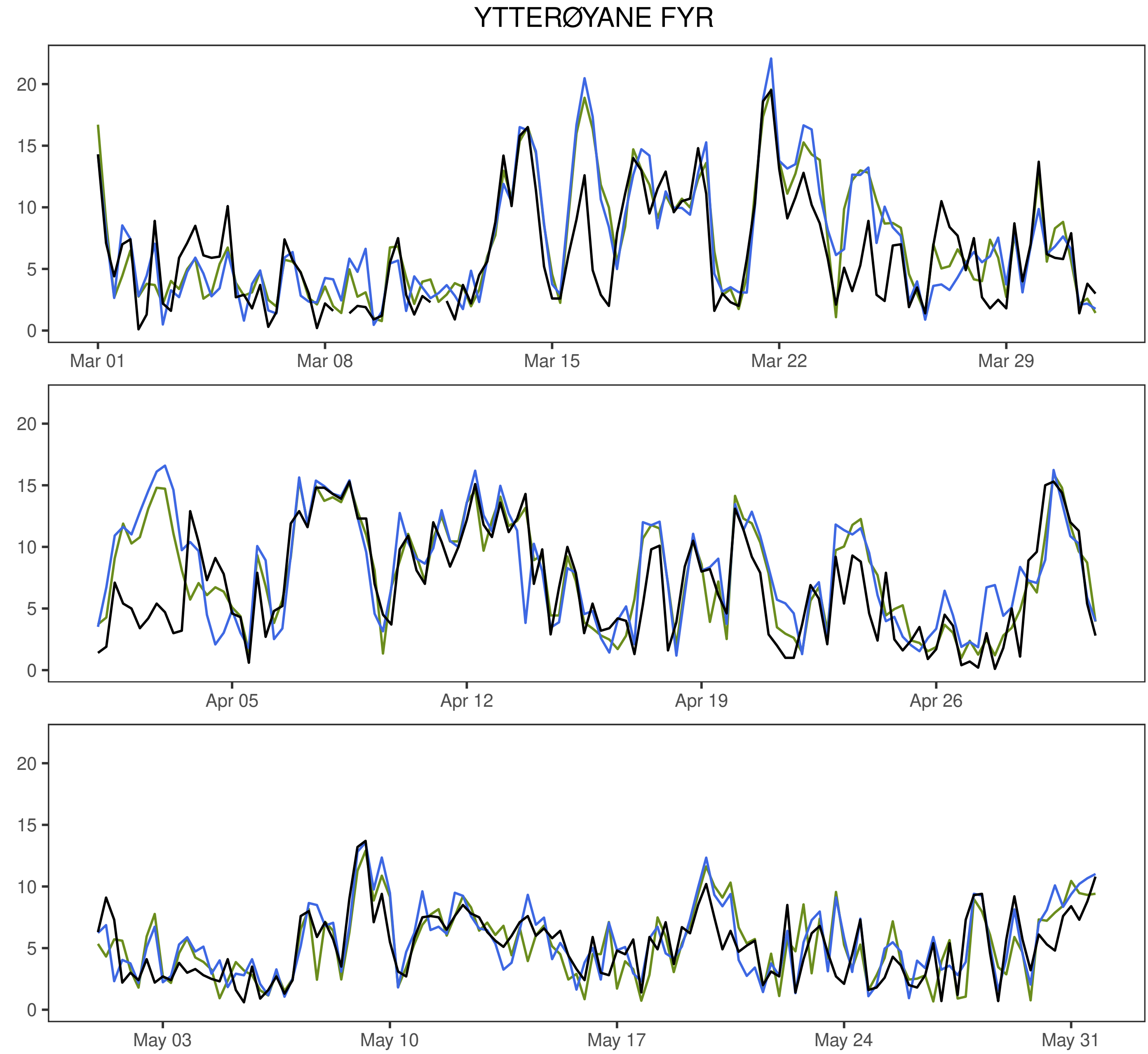


	Min	Mean	Max	Std	N
synop: 00,06,12,18	0.0	5.1	16.4	2.8	368
MEPSctrl: 12+18,+24,+30,+36	0.4	4.3	17.3	2.5	368
ECMWF: 12+18,+24,+30,+36	0.4	4.7	16.2	2.5	368

	ME	SDE	RMSE	MAE	Max.abs.err	N
MEPSctrl – synop	–0.7	1.7	1.9	1.4	8.4	368
ECMWF – synop	–0.4	1.8	1.8	1.4	9.9	368

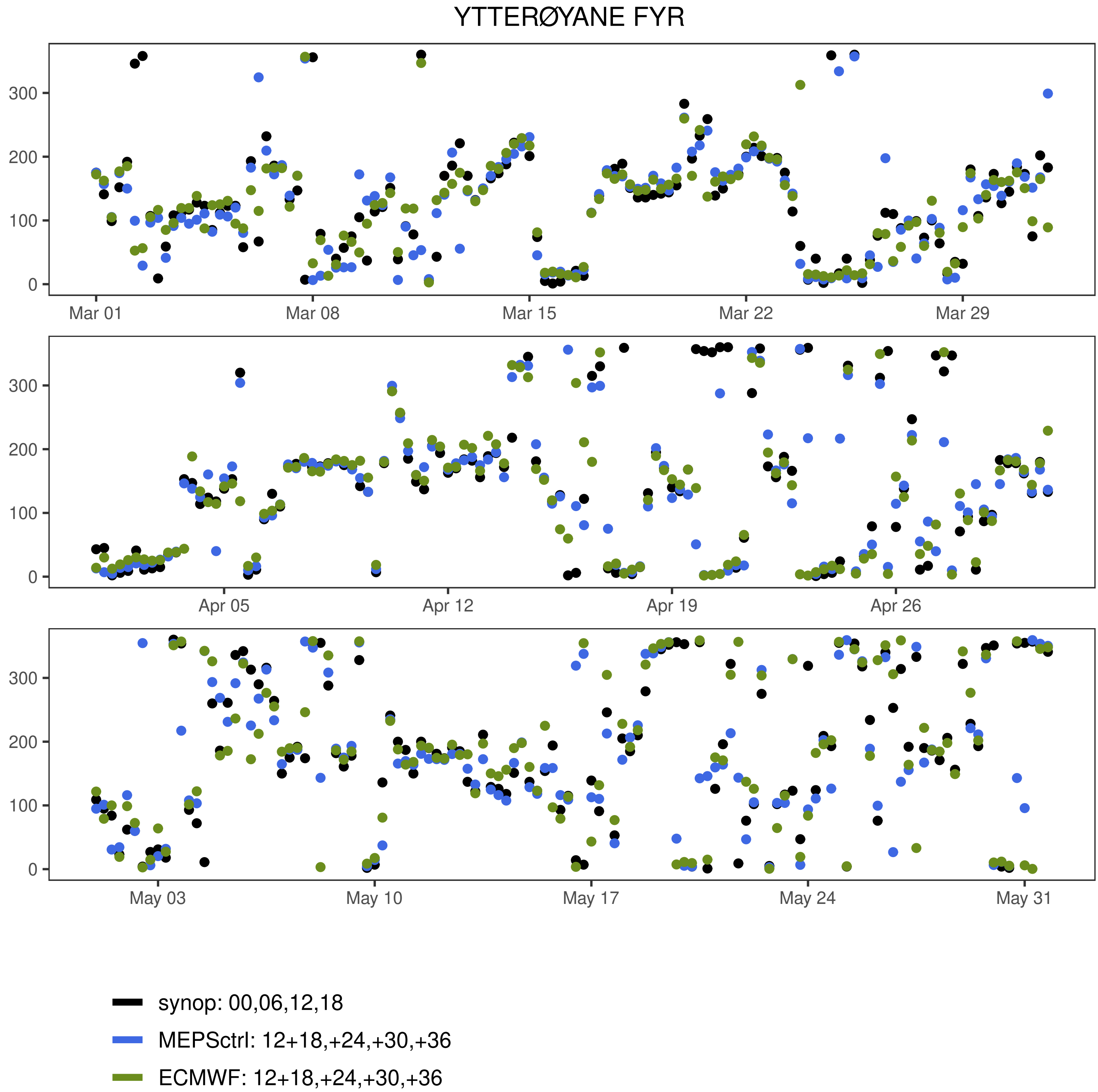

ØRLAND III
300
200
100
0
Mar 01
Mar 08
Mar 15
Mar 22
Mar 29
Apr 05
Apr 12
Apr 19
Apr 26
May 03
May 10
May 17
May 24
May 31

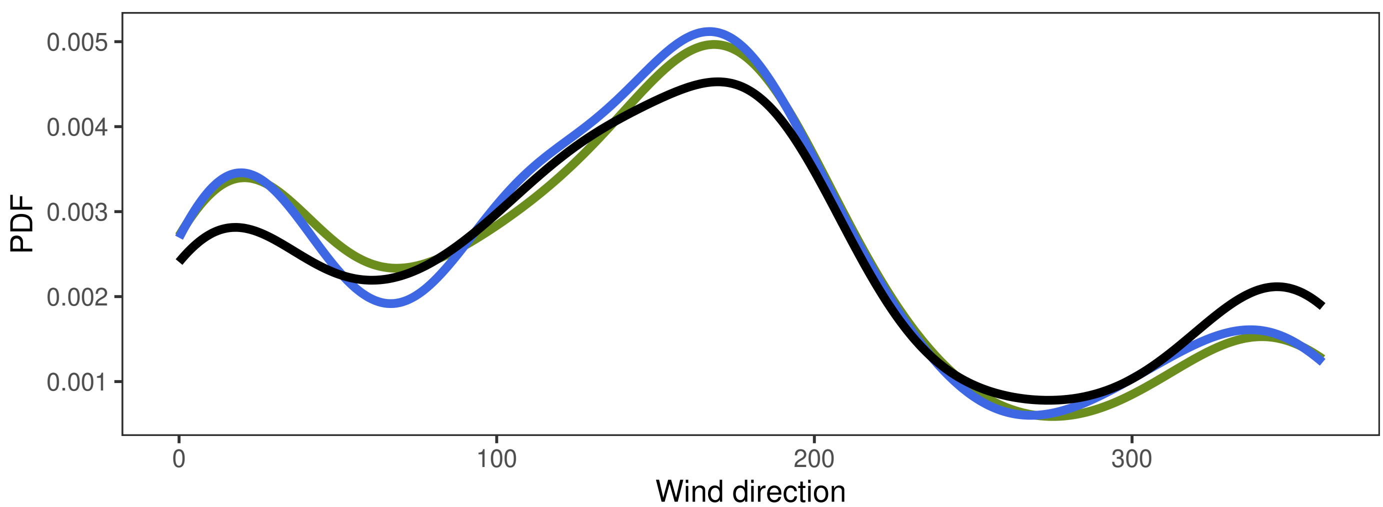

synop: 00,06,12,18
MEPSctrl: 12+18,+24,+30,+36
ECMWF: 12+18,+24,+30,+36
PDF
0.006
0.004
0.002
0
100
200
300
Wind direction

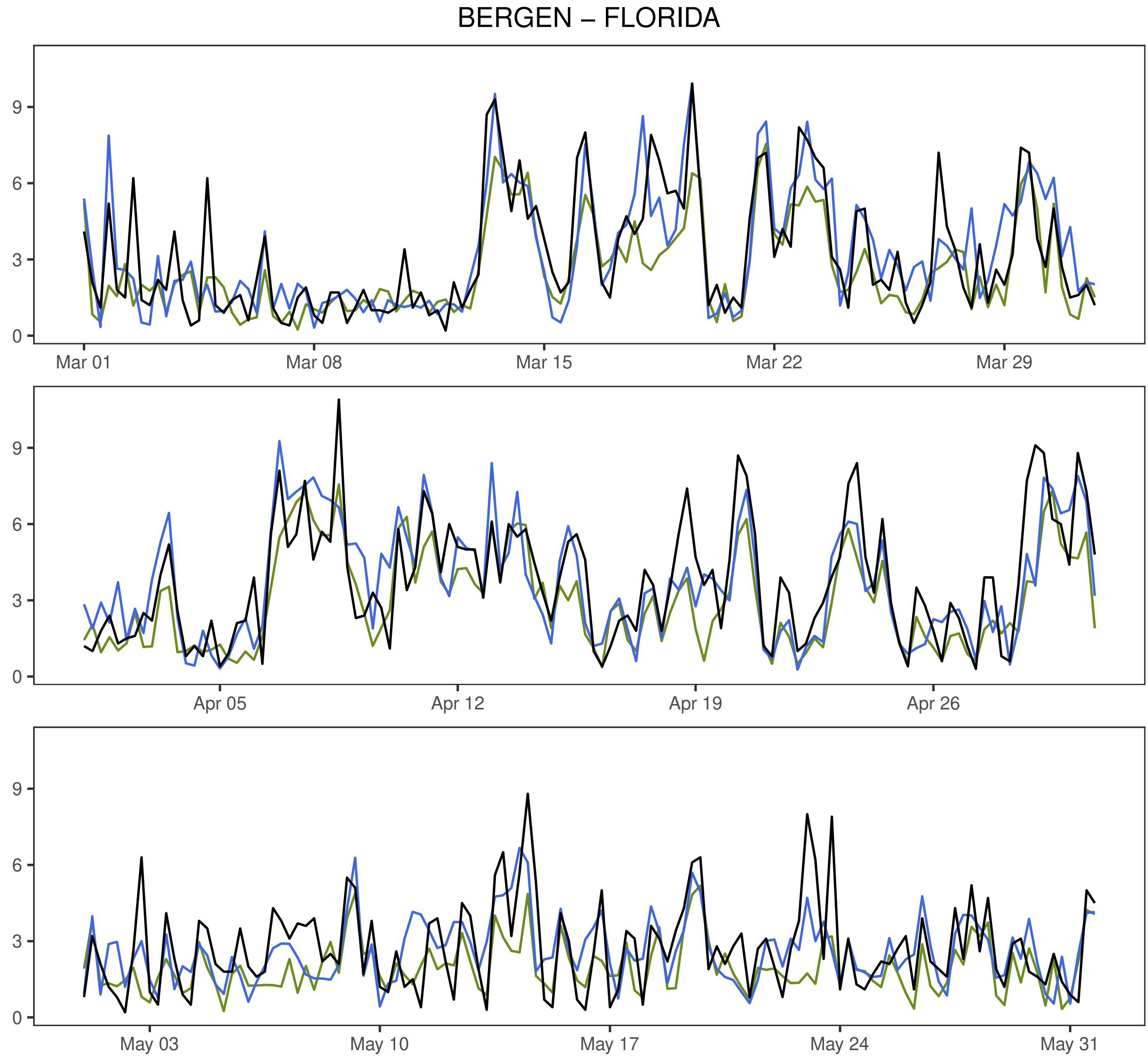


	Min	Mean	Max	Std	N
synop: 00,06,12,18	0.1	6.1	19.5	3.9	366
MEPSctrl: 12+18,+24,+30,+36	0.5	6.9	22.1	4.2	368
ECMWF: 12+18,+24,+30,+36	0.7	6.7	19.6	4.1	368

	ME	SDE	RMSE	MAE	Max.abs.err	N
MEPSctrl – synop	0.8	2.9	3.0	2.1	12.5	366
ECMWF – synop	0.6	2.6	2.7	1.9	11.4	366

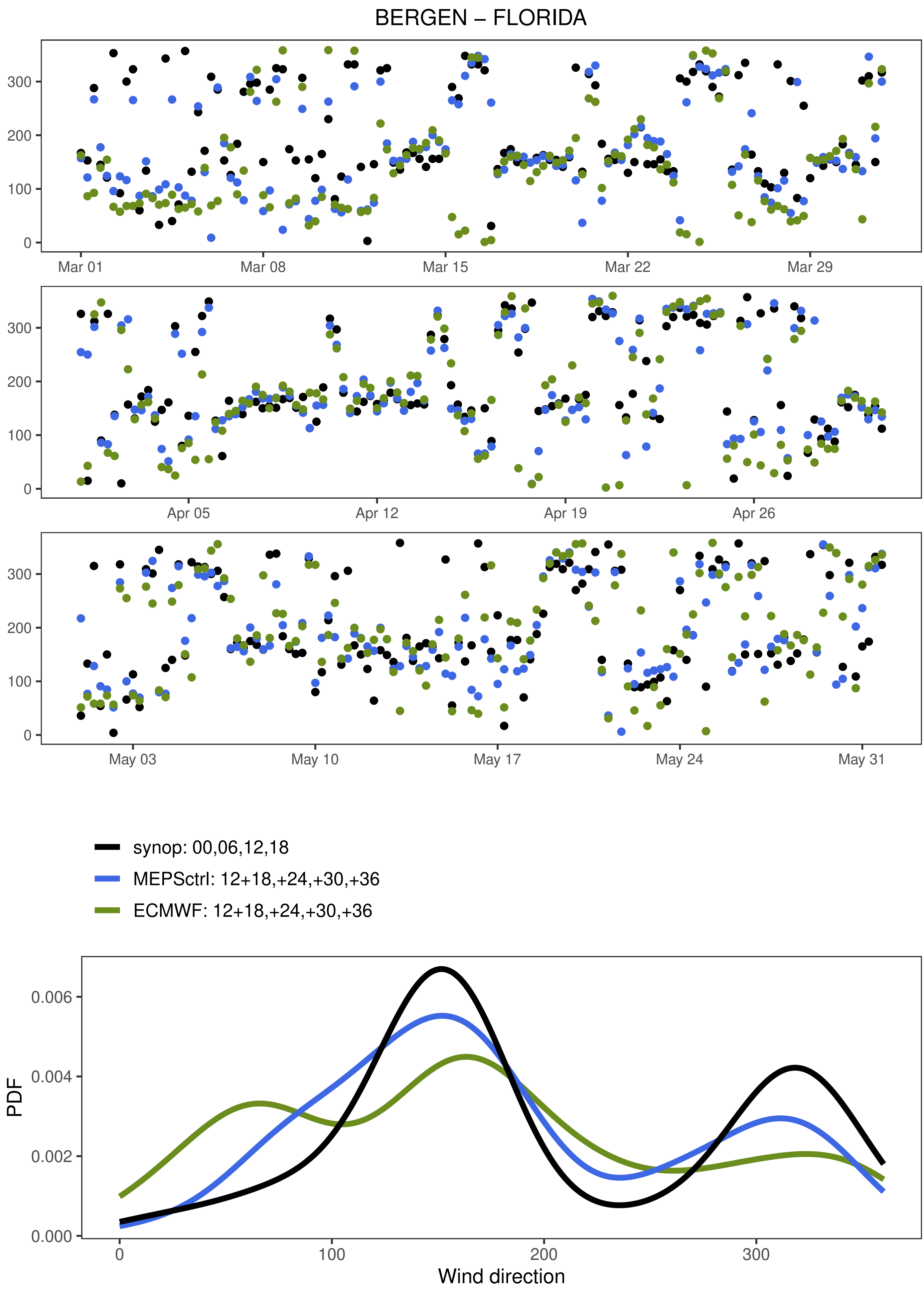

YTTERØYANE FYR
300
200
100
0
Mar 01
Mar 08
Mar 15
Mar 22
Mar 29
Apr 05
Apr 12
Apr 19
Apr 26
May 03
May 10
May 17
May 24
May 31
synop: 00,06,12,18
MEPSctrl: 12+18,+24,+30,+36
ECMWF: 12+18,+24,+30,+36

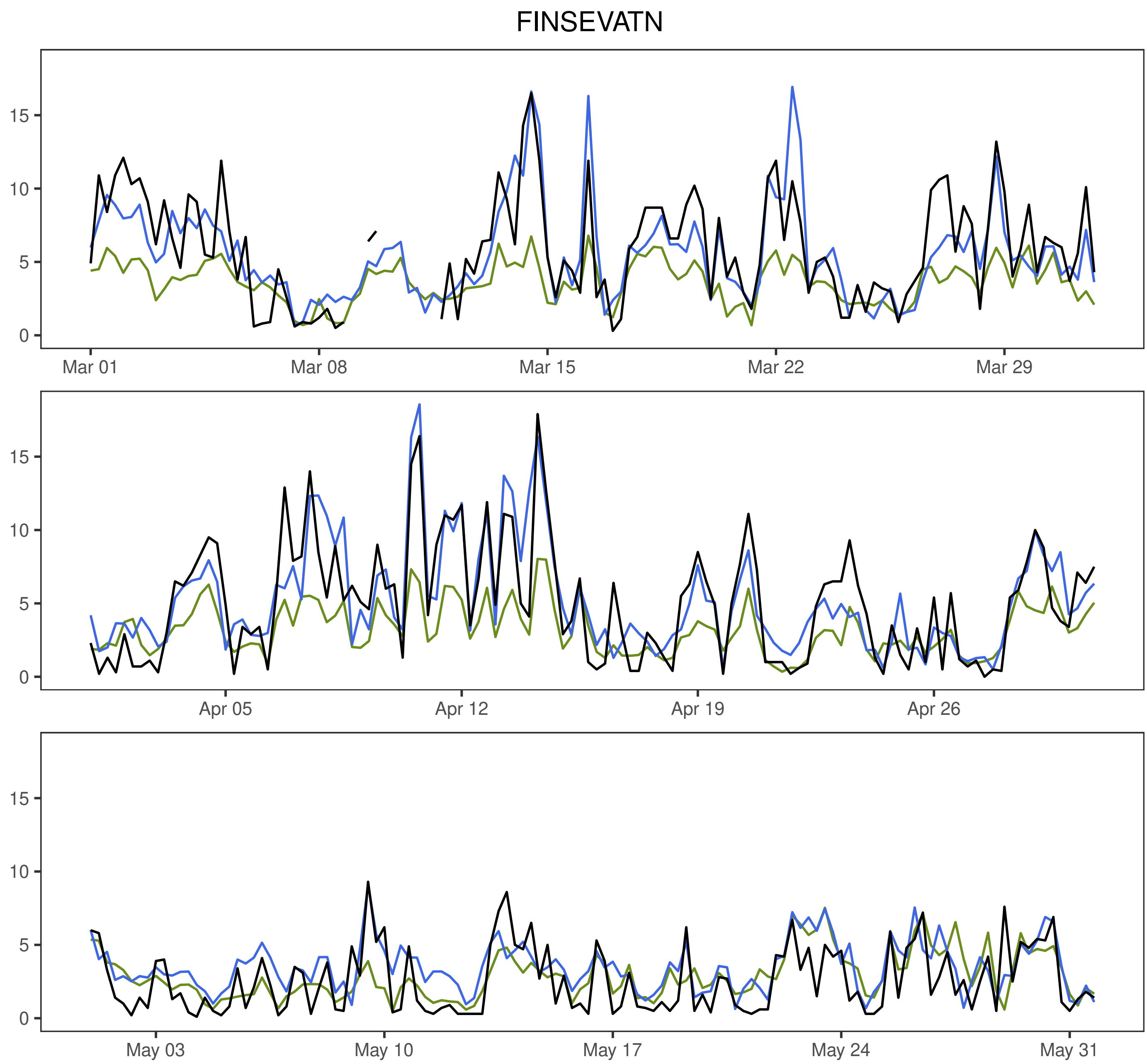

PDF
0.005
0.004
0.003
0.002
0.001
0
100
200
300
Wind direction



	Min	Mean	Max	Std	N
synop: 00,06,12,18	0.2	3.2	10.9	2.2	368
MEPSctrl: 12+18,+24,+30,+36	0.3	3.2	9.9	2.0	368
ECMWF: 12+18,+24,+30,+36	0.2	2.5	7.6	1.7	368

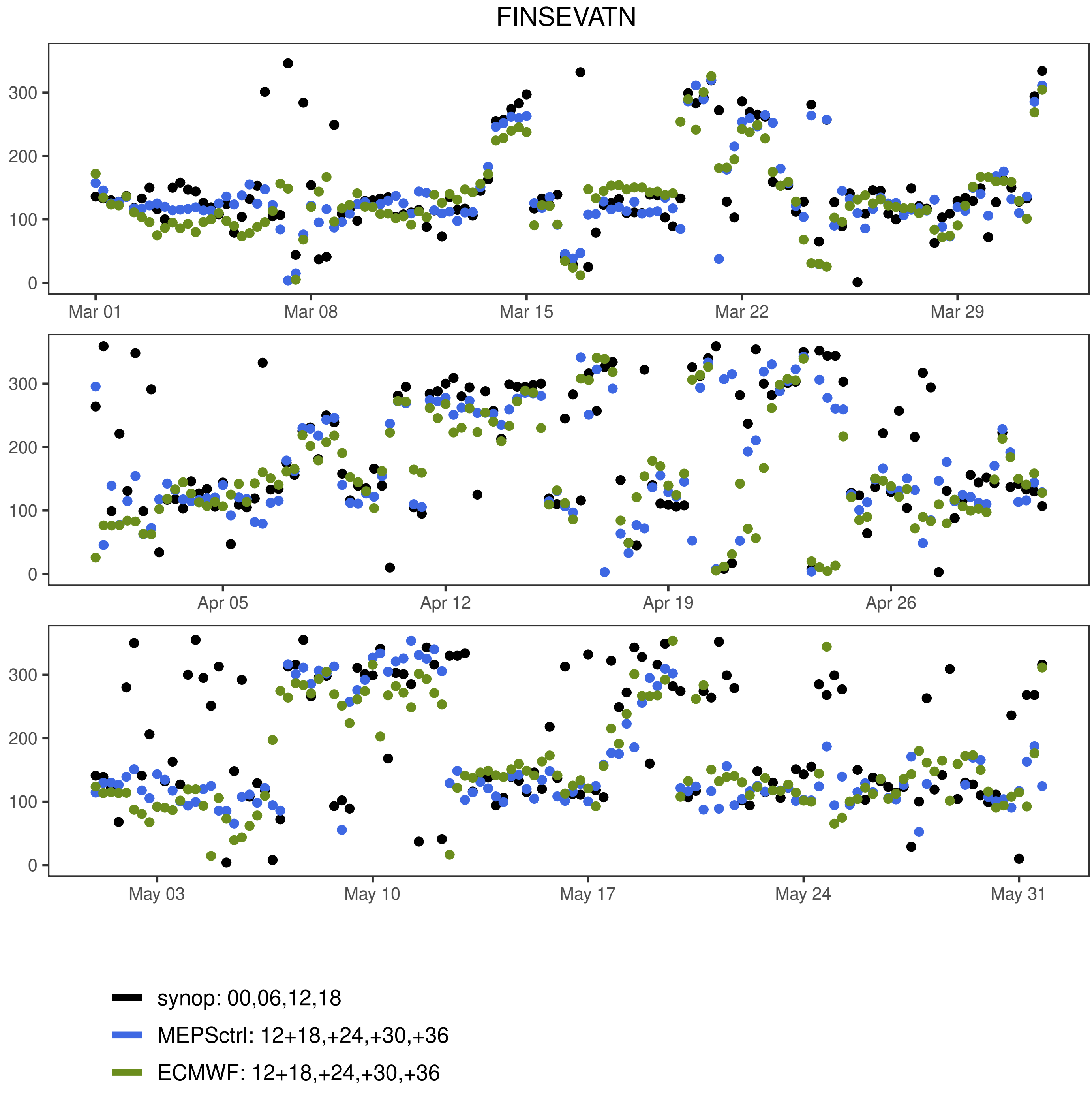
	ME	SDE	RMSE	MAE	Max.abs.err	N
MEPSctrl – synop	–0.1	1.5	1.5	1.2	5.5	368
ECMWF – synop	–0.7	1.4	1.6	1.2	6.3	368

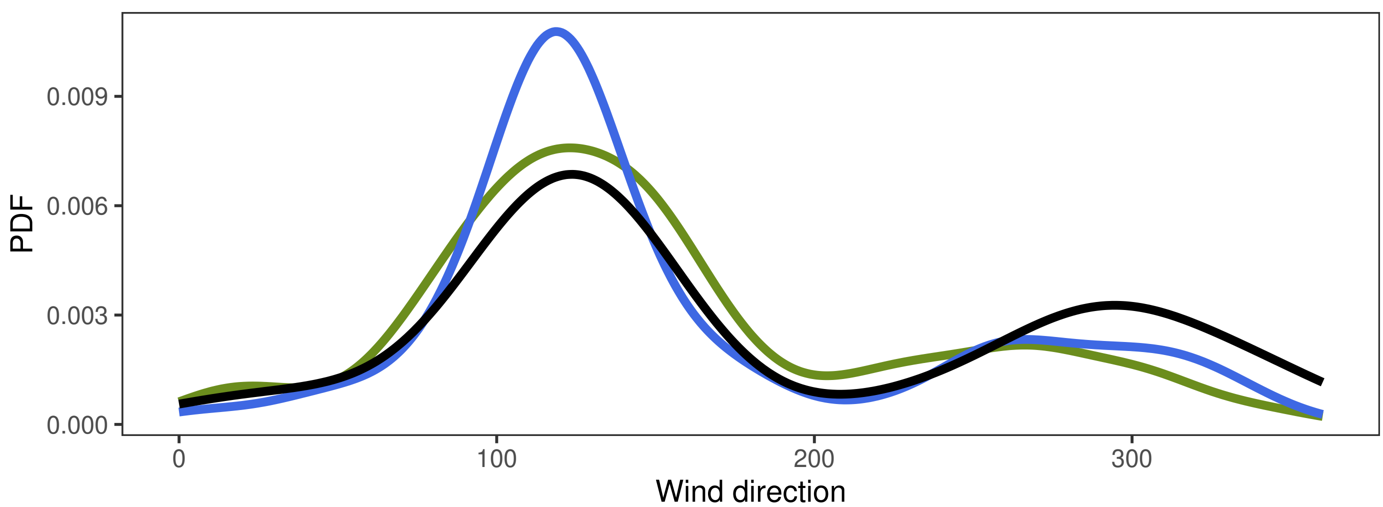

BERGEN – FLORIDA
0
100
200
300
Mar 01
Mar 08
Mar 15
Mar 22
Mar 29
Apr 05
Apr 12
Apr 19
Apr 26
May 03
May 10
May 17
May 24
May 31
synop: 00,06,12,18
MEPSctrl: 12+18,+24,+30,+36
ECMWF: 12+18,+24,+30,+36
PDF
0.000
0.002
0.004
0.006
Wind direction

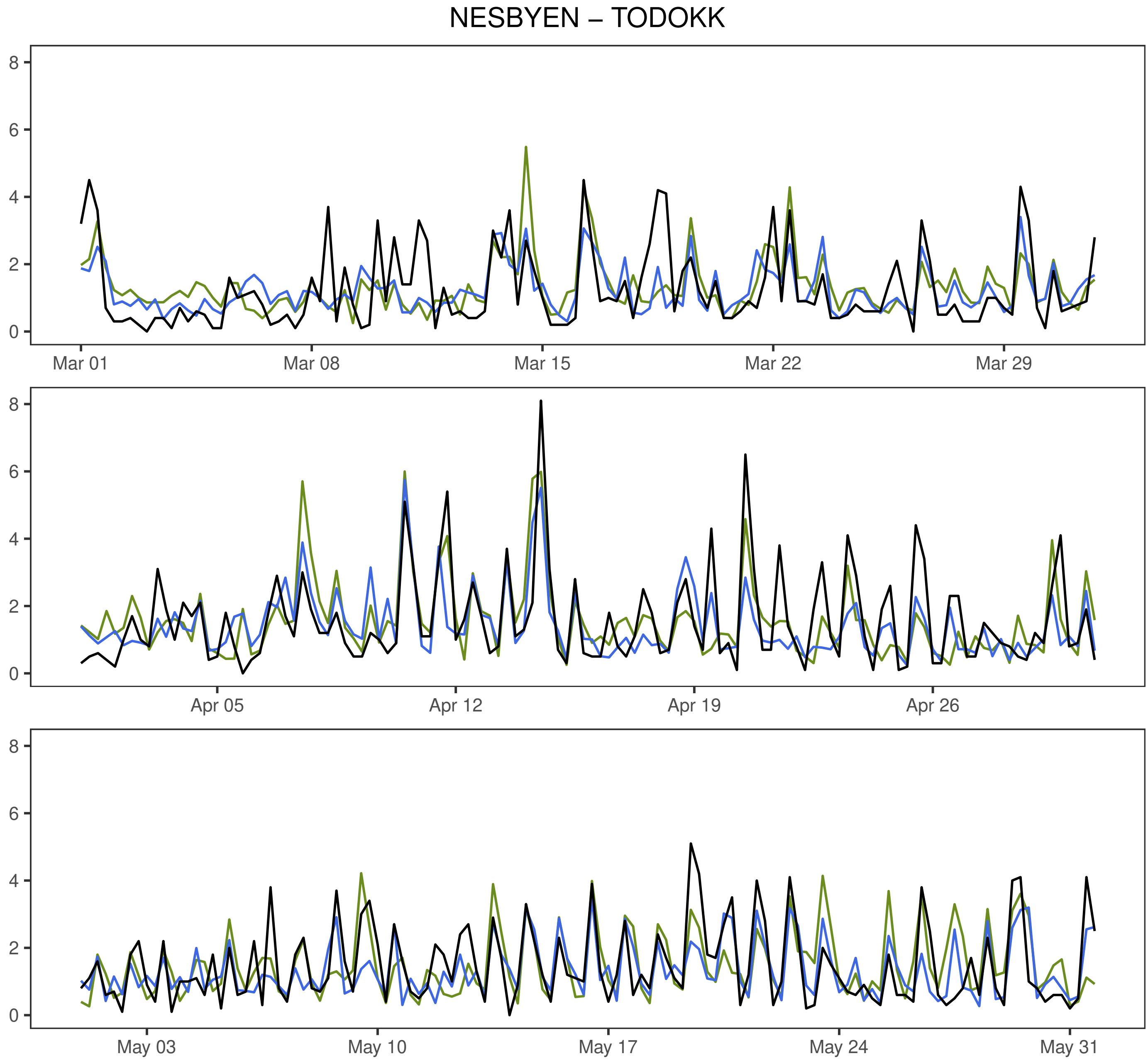


	Min	Mean	Max	Std	N
synop: 00,06,12,18	0.0	4.5	17.9	3.6	360
MEPSctrl: 12+18,+24,+30,+36	0.5	4.8	18.6	3.1	368
ECMWF: 12+18,+24,+30,+36	0.3	3.2	8.0	1.6	368

	ME	SDE	RMSE	MAE	Max.abs.err	N
MEPSctrl – synop	0.3	2.1	2.1	1.7	8.5	360
ECMWF – synop	–1.2	2.6	2.9	2.2	10.0	360

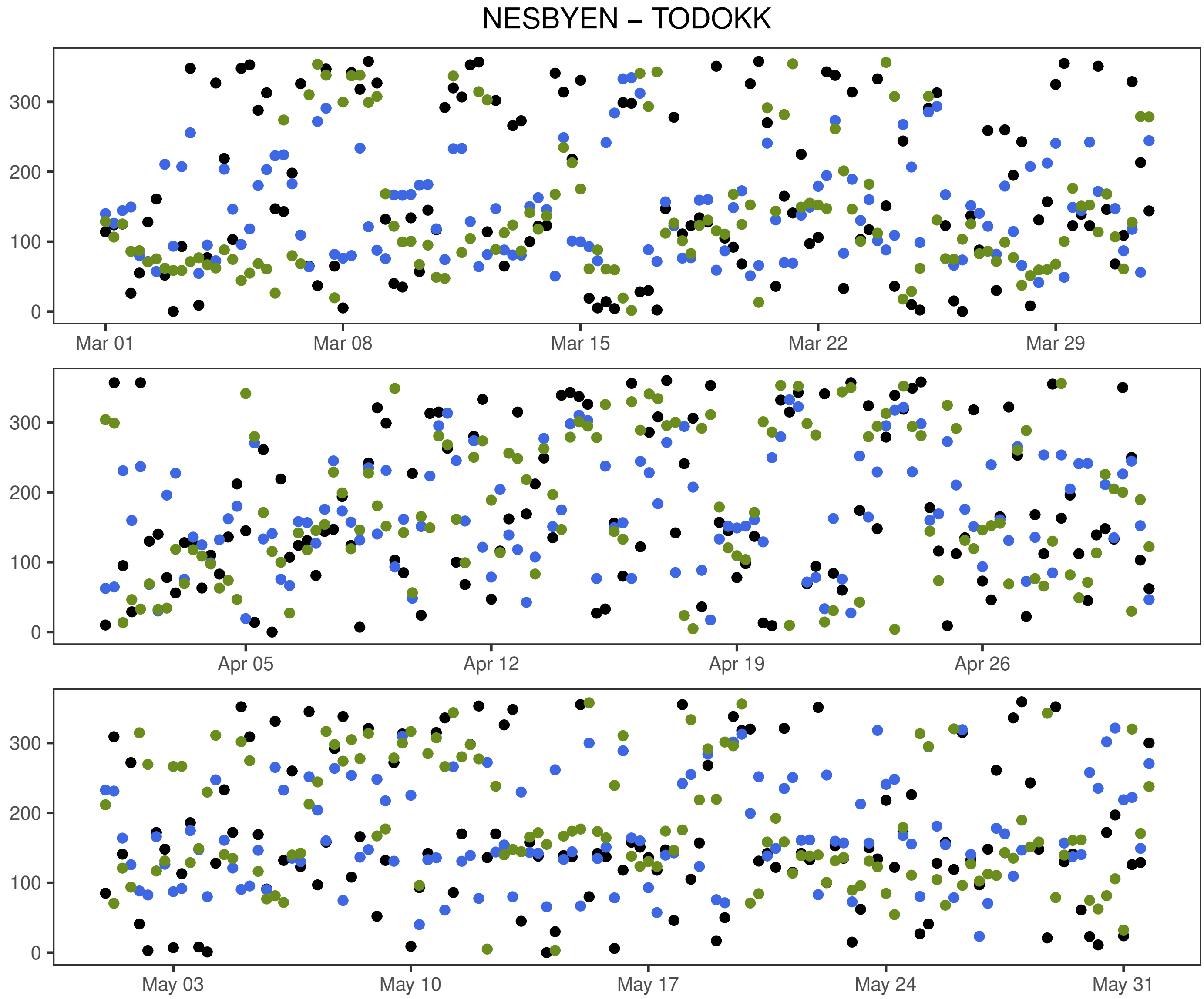

FINSEVATN
300
200
100
0
Mar 01
Mar 08
Mar 15
Mar 22
Mar 29
Apr 05
Apr 12
Apr 19
Apr 26
May 03
May 10
May 17
May 24
May 31
synop: 00,06,12,18
MEPSctrl: 12+18,+24,+30,+36
ECMWF: 12+18,+24,+30,+36

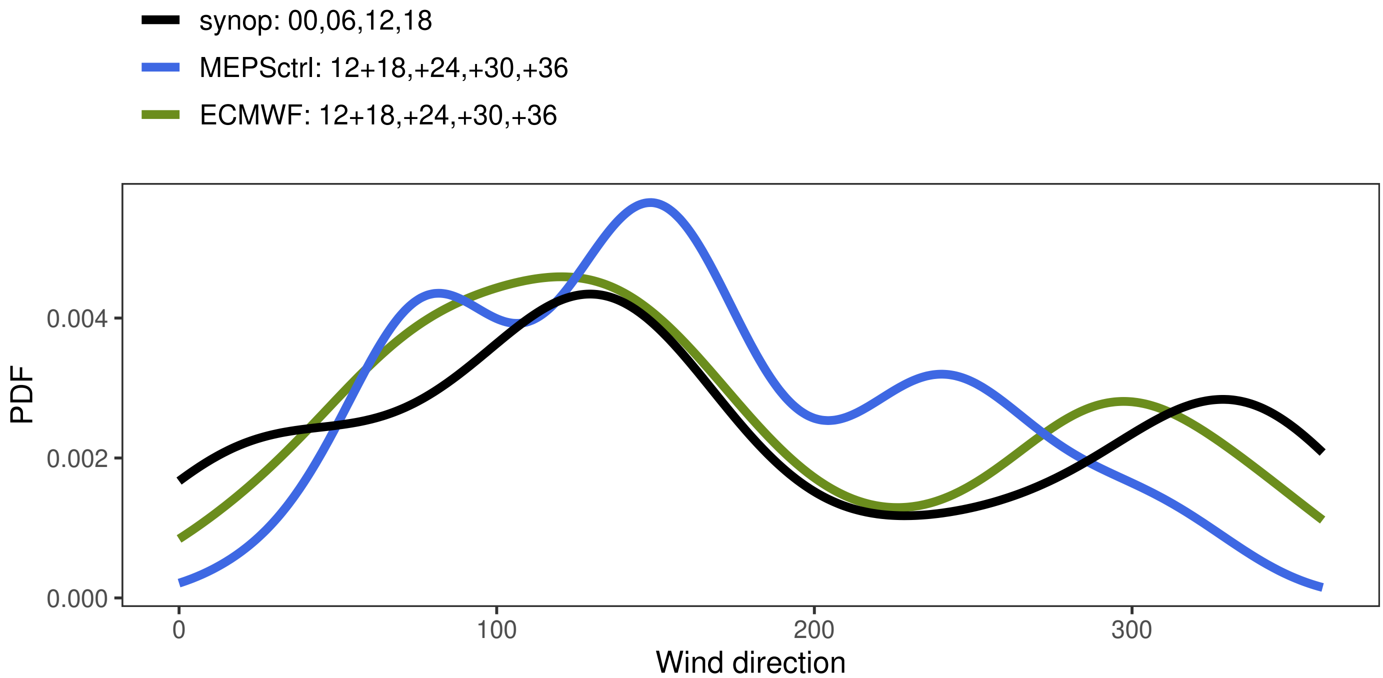

PDF
0.009
0.006
0.003
0.000
0
100
200
300
Wind direction



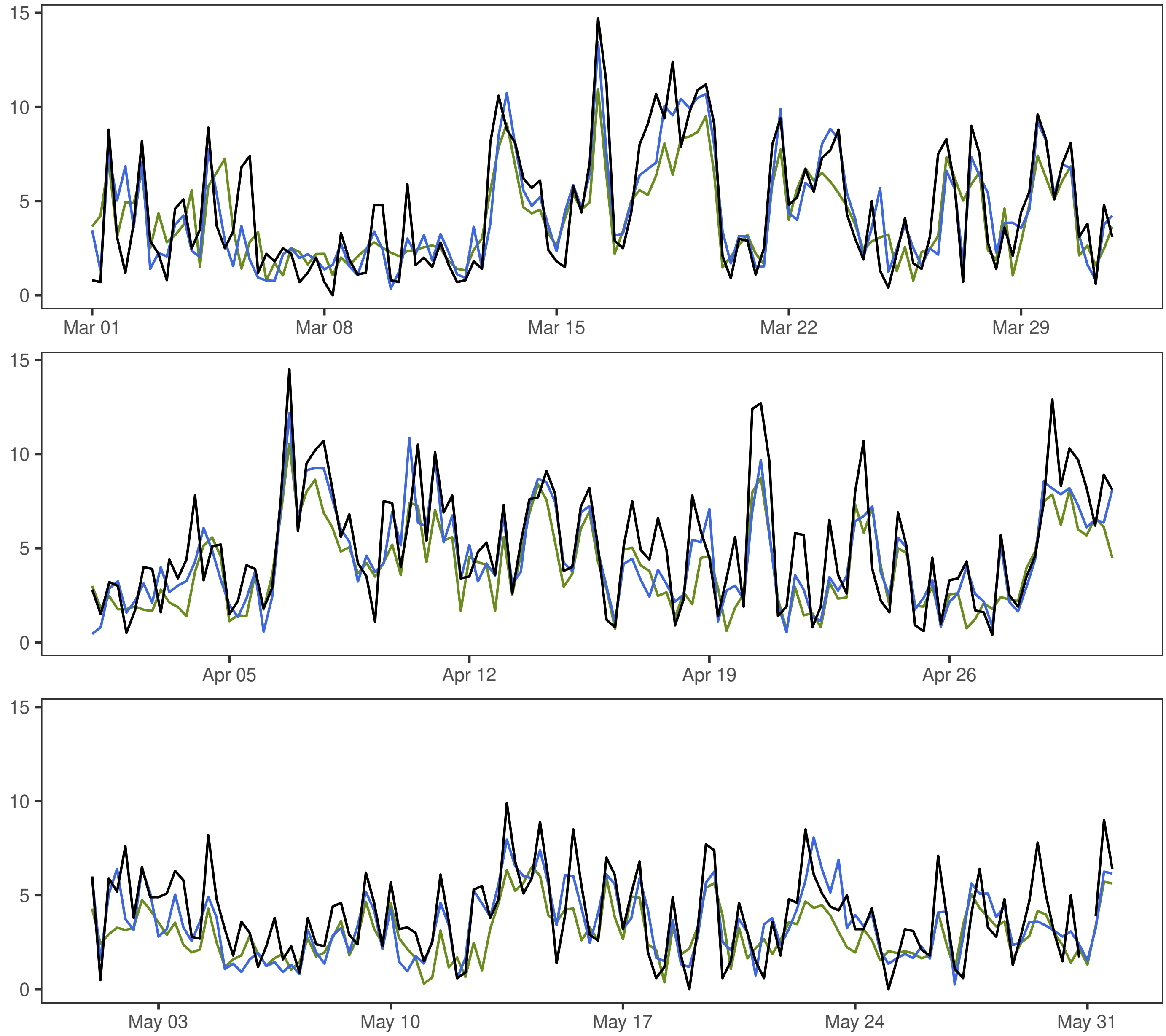
	Min	Mean	Max	Std	N
synop: 00,06,12,18	0.0	1.4	8.1	1.2	368
MEPSctrl: 12+18,+24,+30,+36	0.2	1.3	5.7	0.8	368
ECMWF: 12+18,+24,+30,+36	0.2	1.5	6.0	1.0	368

	ME	SDE	RMSE	MAE	Max.abs.err	N
MEPSctrl – synop	–0.1	0.9	1.0	0.7	4.0	368
ECMWF – synop	0.0	1.0	1.0	0.8	3.7	368


NESBYEN – TODOKK
300
200
100
0
Mar 01
Mar 08
Mar 15
Mar 22
Mar 29
Apr 05
Apr 12
Apr 19
Apr 26
May 03
May 10
May 17
May 24
May 31

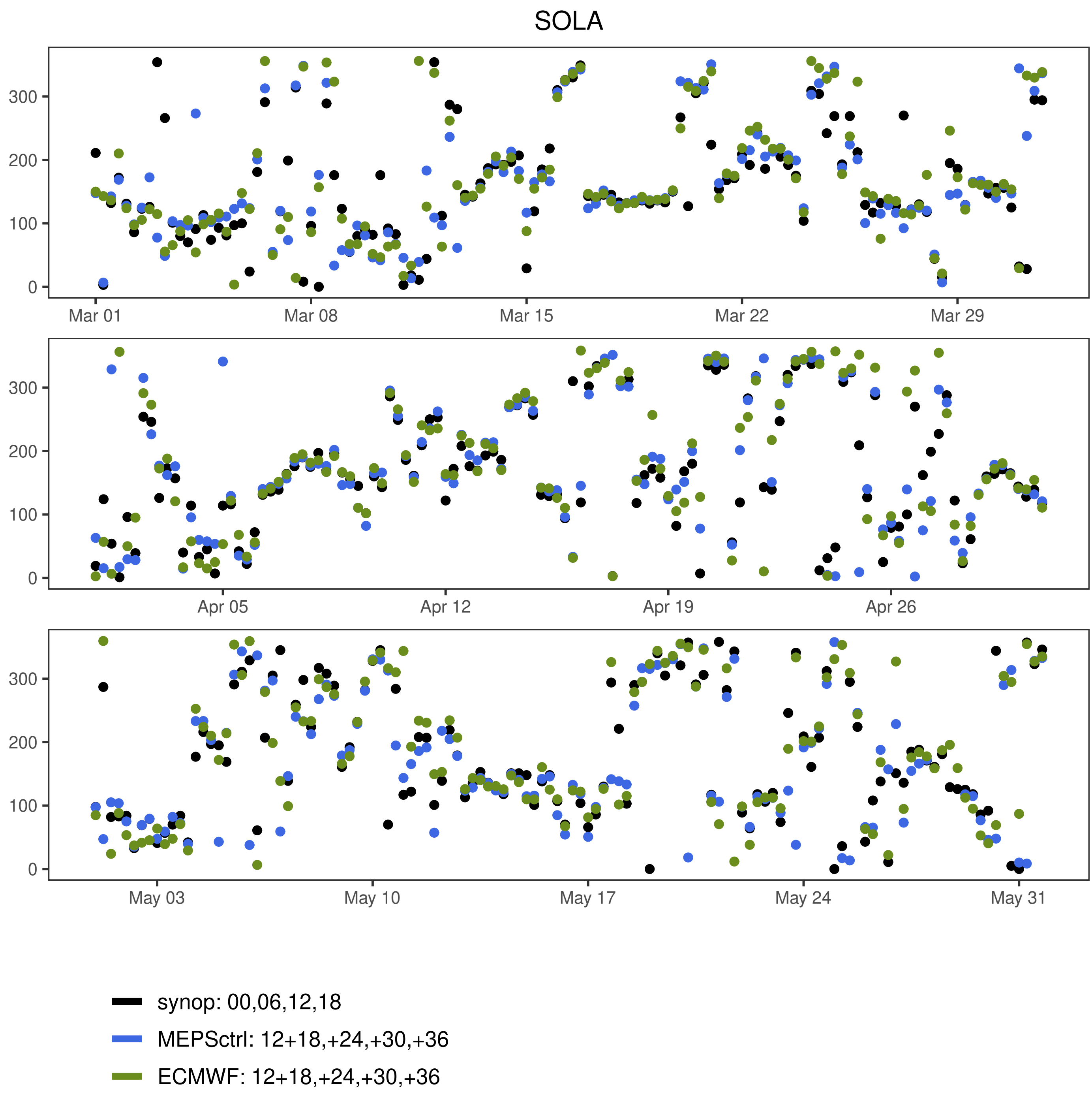

synop: 00,06,12,18
MEPSctrl: 12+18,+24,+30,+36
ECMWF: 12+18,+24,+30,+36
PDF
0.004
0.002
0.000
0
100
200
300
Wind direction

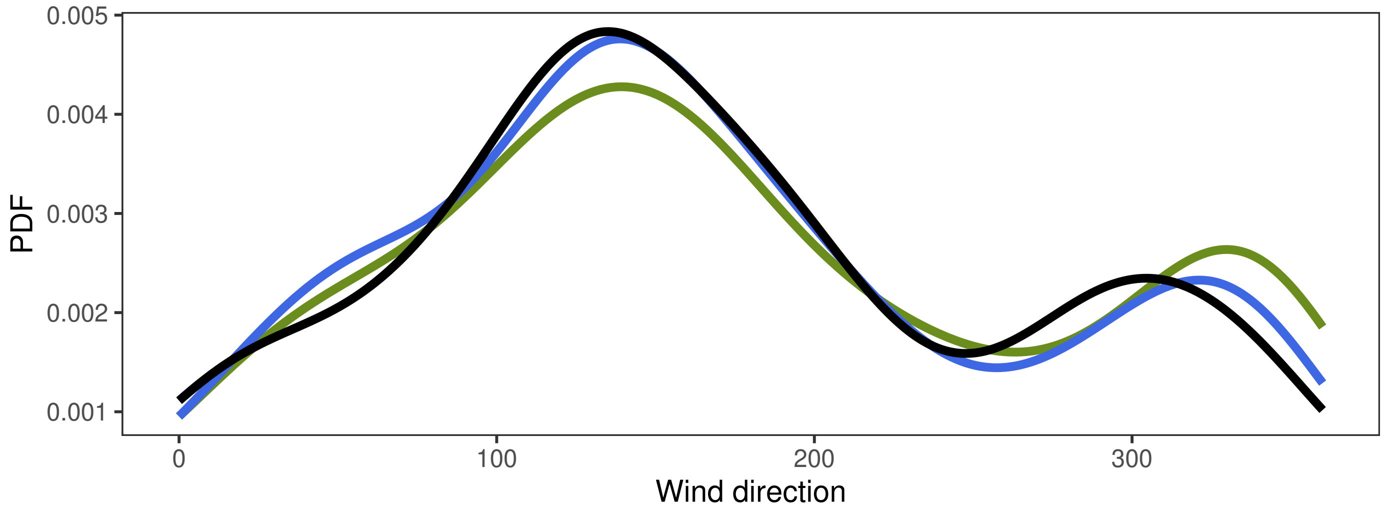
SOLA

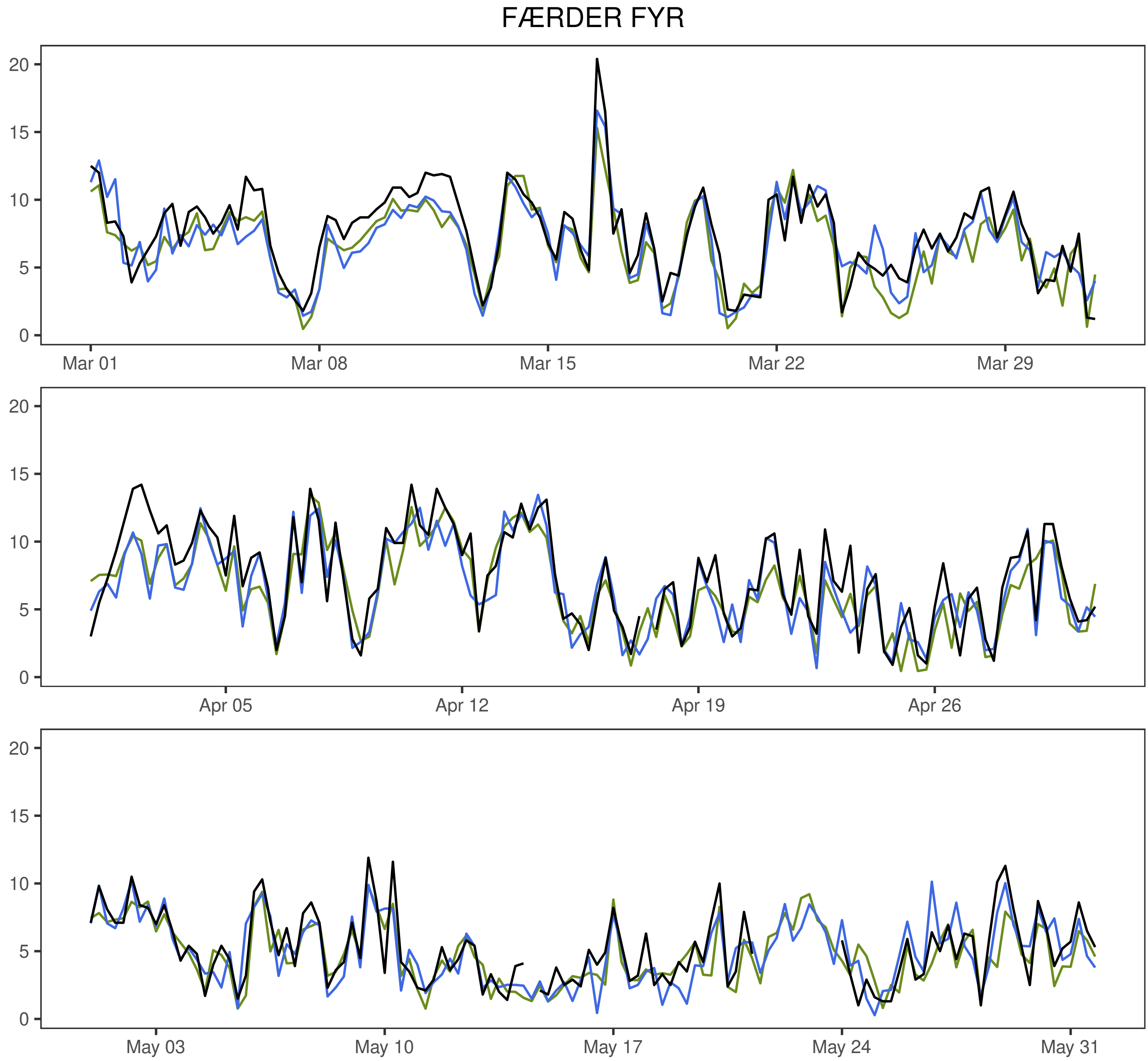


	Min	Mean	Max	Std	N
synop: 00,06,12,18	0.0	4.5	14.7	2.9	367
MEPSctrl: 12+18,+24,+30,+36	0.3	4.1	13.5	2.4	368
ECMWF: 12+18,+24,+30,+36	0.3	3.7	10.9	2.0	368

	ME	SDE	RMSE	MAE	Max.abs.err	N
MEPSctrl – synop	–0.4	1.5	1.6	1.2	5.6	367
ECMWF – synop	–0.8	1.8	2.0	1.5	6.0	367

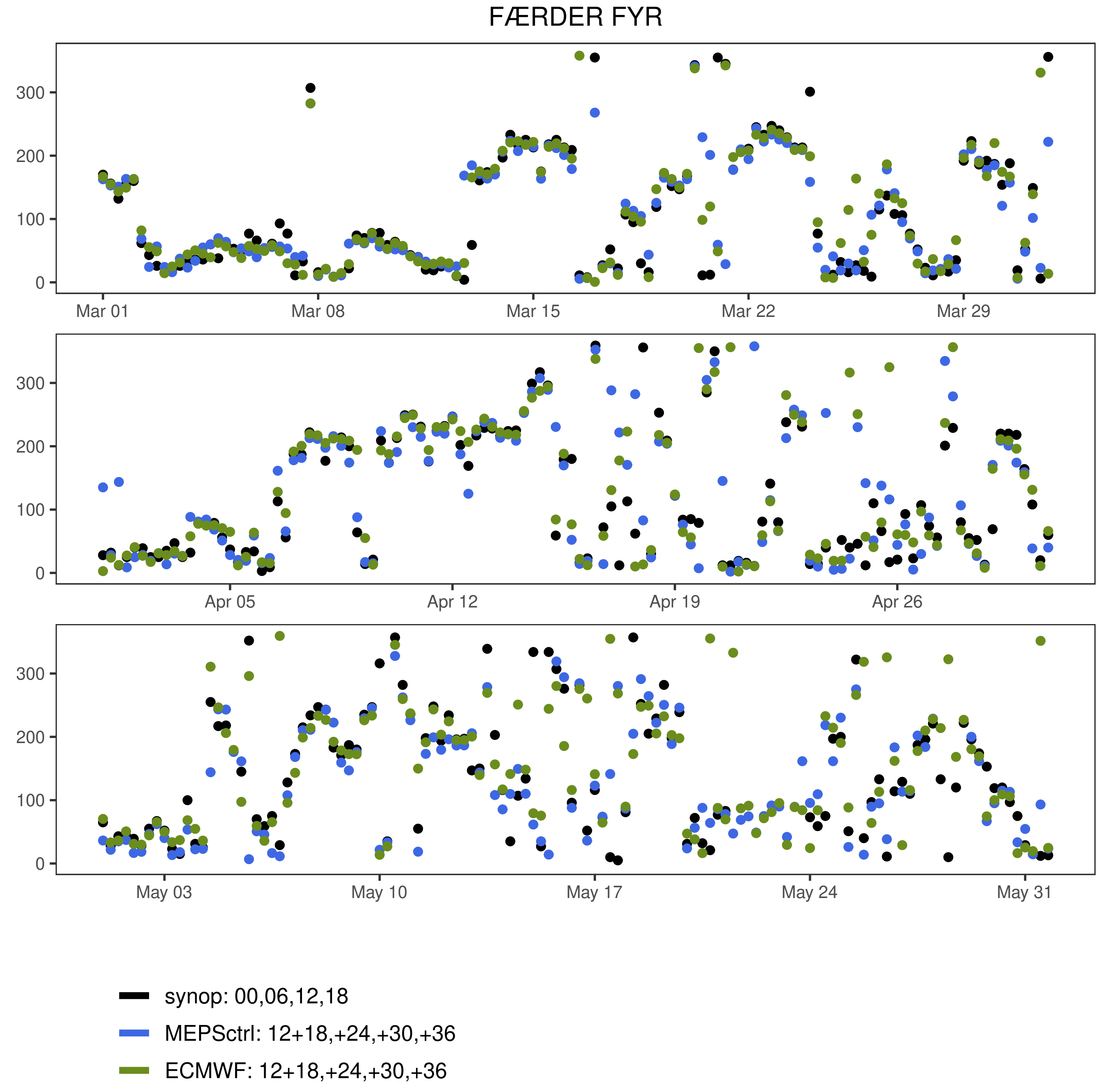

SOLA
300
200
100
0
Mar 01
Mar 08
Mar 15
Mar 22
Mar 29
Apr 05
Apr 12
Apr 19
Apr 26
May 03
May 10
May 17
May 24
May 31
synop: 00,06,12,18
MEPSctrl: 12+18,+24,+30,+36
ECMWF: 12+18,+24,+30,+36

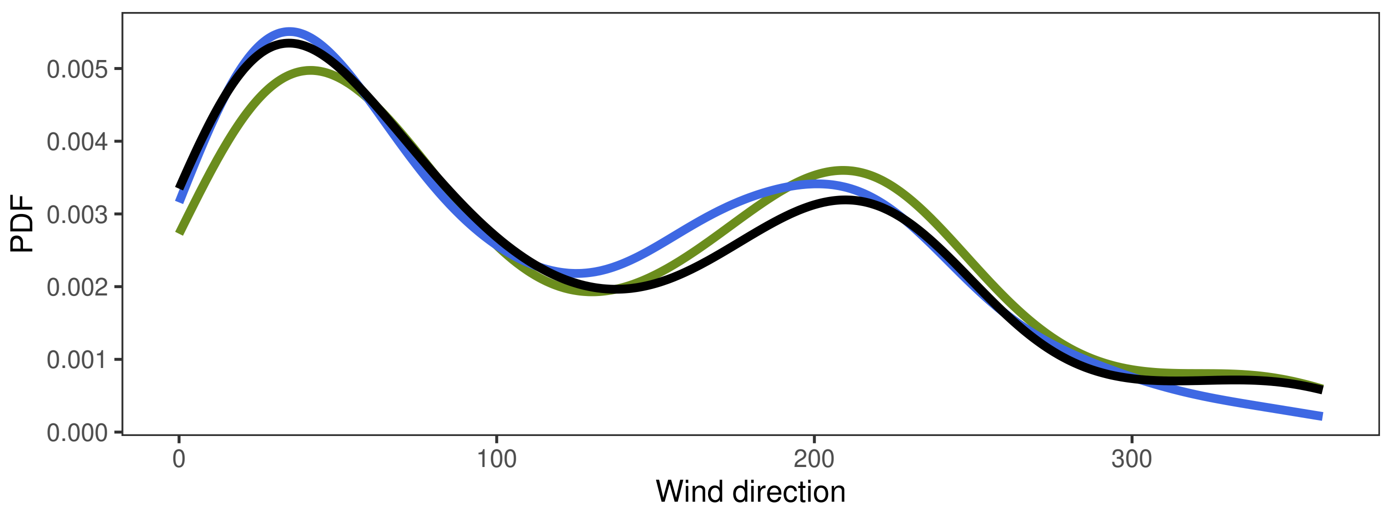

PDF
0.005
0.004
0.003
0.002
0.001
0
100
200
300
Wind direction

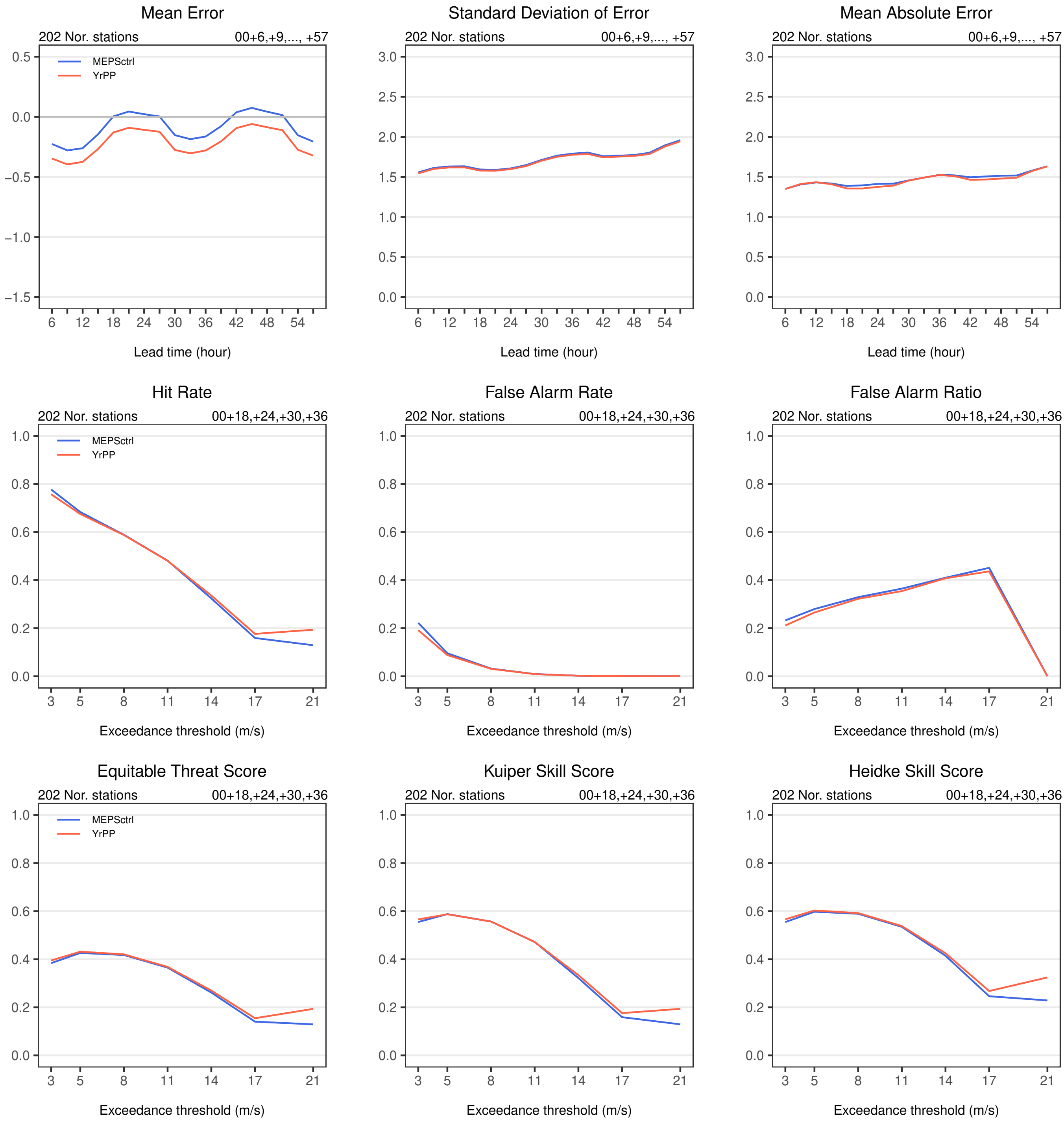


	Min	Mean	Max	Std	N
synop: 00,06,12,18	0.9	6.7	20.4	3.3	356
MEPSctrl: 12+18,+24,+30,+36	0.3	6.2	16.6	3.0	368
ECMWF: 12+18,+24,+30,+36	0.4	6.0	15.3	2.9	368

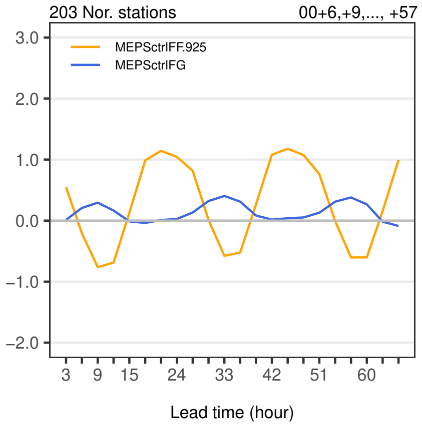
	ME	SDE	RMSE	MAE	Max.abs.err	N
MEPSctrl – synop	−0.5	1.6	1.7	1.3	6.5	356
ECMWF – synop	−0.8	1.5	1.7	1.3	6.3	356


FÆRDER FYR
300
200
100
0
Mar 01
Mar 08
Mar 15
Mar 22
Mar 29
Apr 05
Apr 12
Apr 19
Apr 26
May 03
May 10
May 17
May 24
May 31
synop: 00,06,12,18
MEPSctrl: 12+18,+24,+30,+36
ECMWF: 12+18,+24,+30,+36

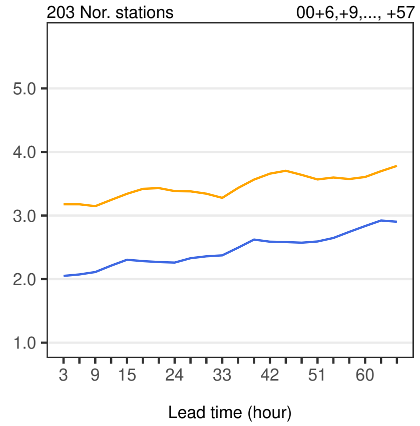

PDF
0.005
0.004
0.003
0.002
0.001
0.000
0
100
200
300
Wind direction


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

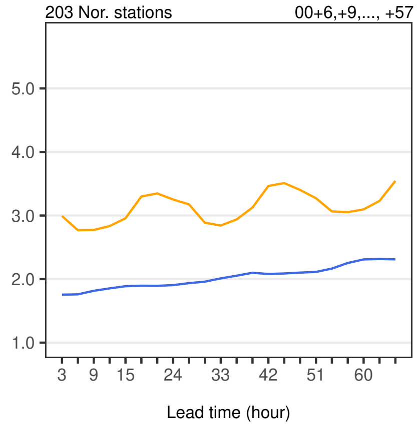
Mean Error



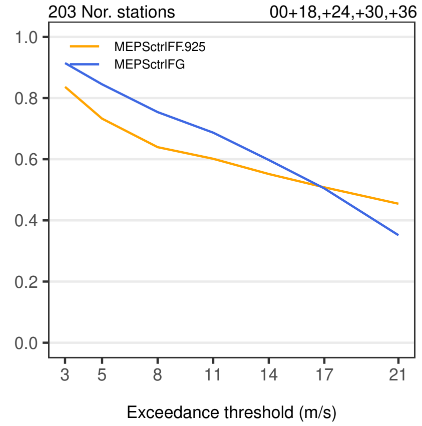
Standard Deviation of Error



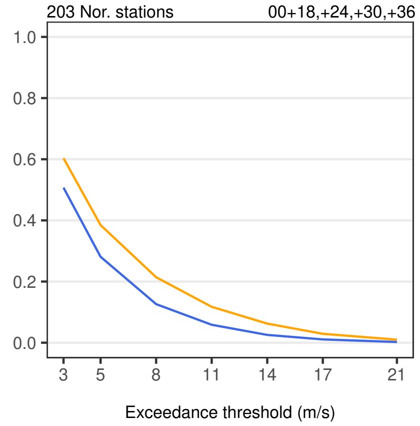
Mean Absolute Error



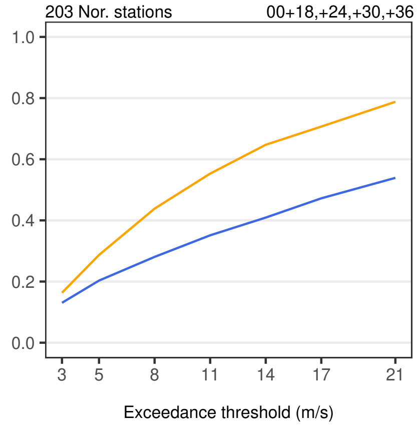
Hit Rate



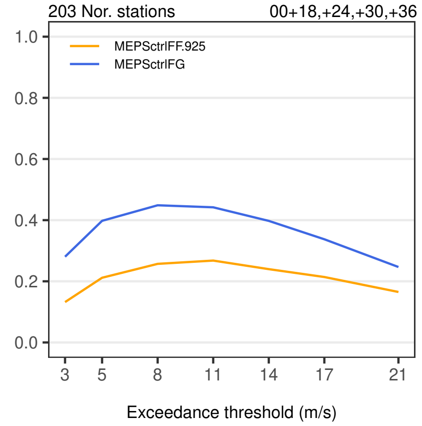
False Alarm Rate



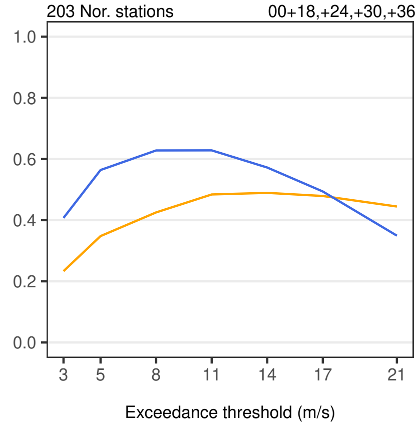
False Alarm Ratio



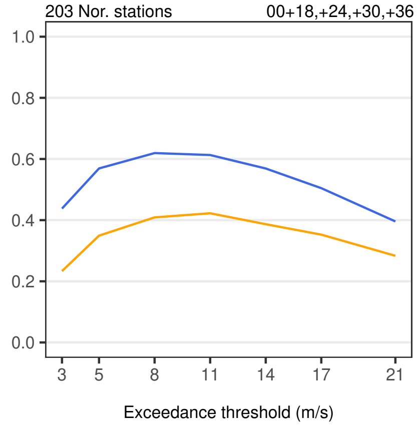
Equitable Threat Score



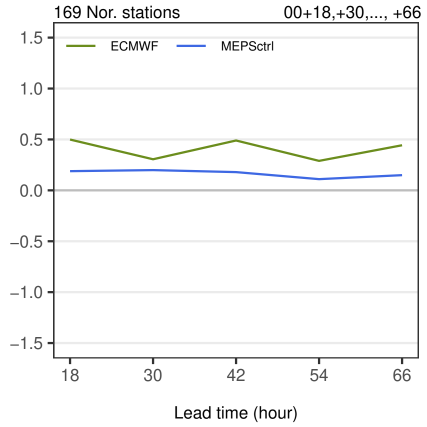
Kuiper Skill Score



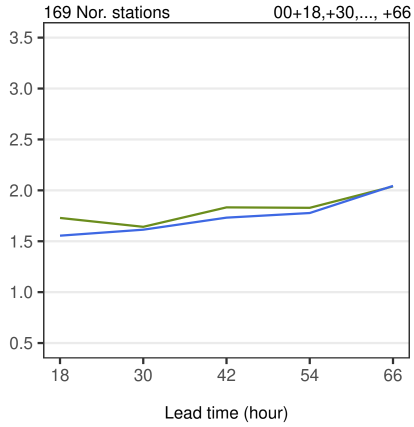
Heidke Skill Score



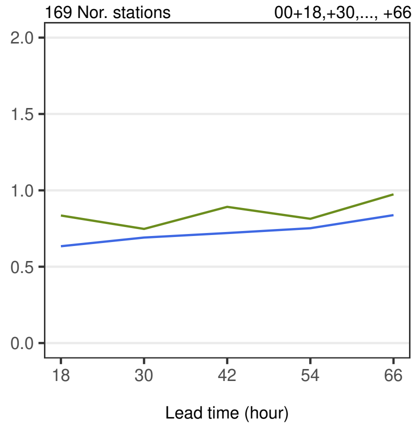
Mean Error



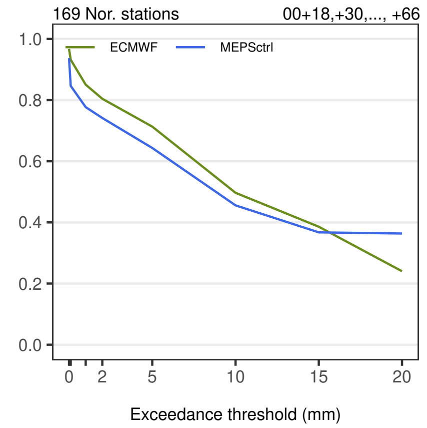
Standard Deviation of Error



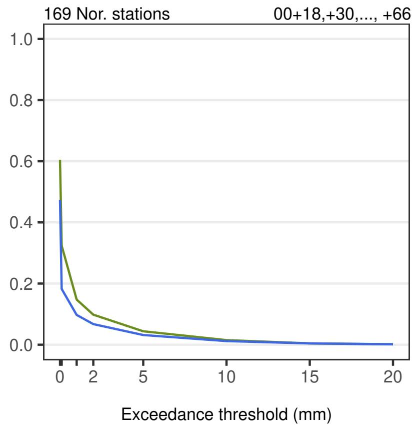
Mean Absolute Error



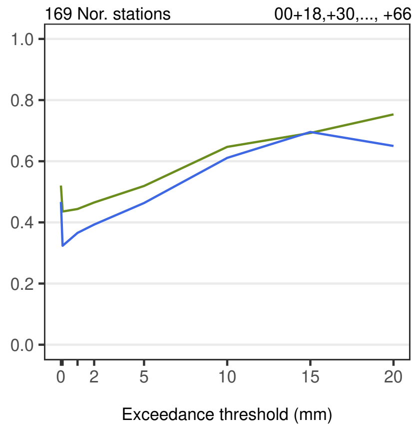
Hit Rate



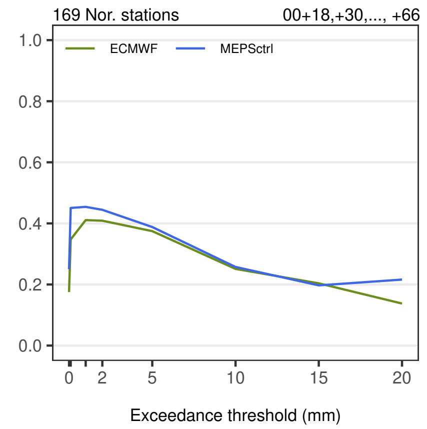
False Alarm Rate



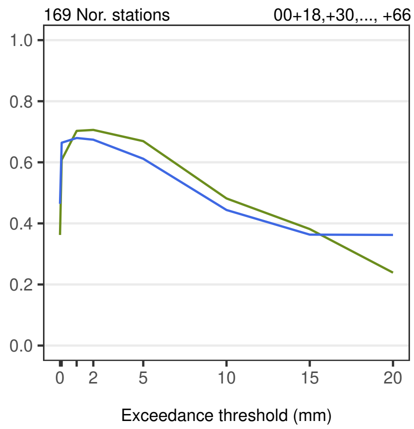
False Alarm Ratio



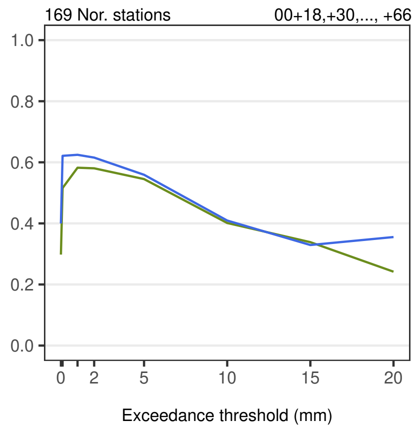
Equitable Threat Score

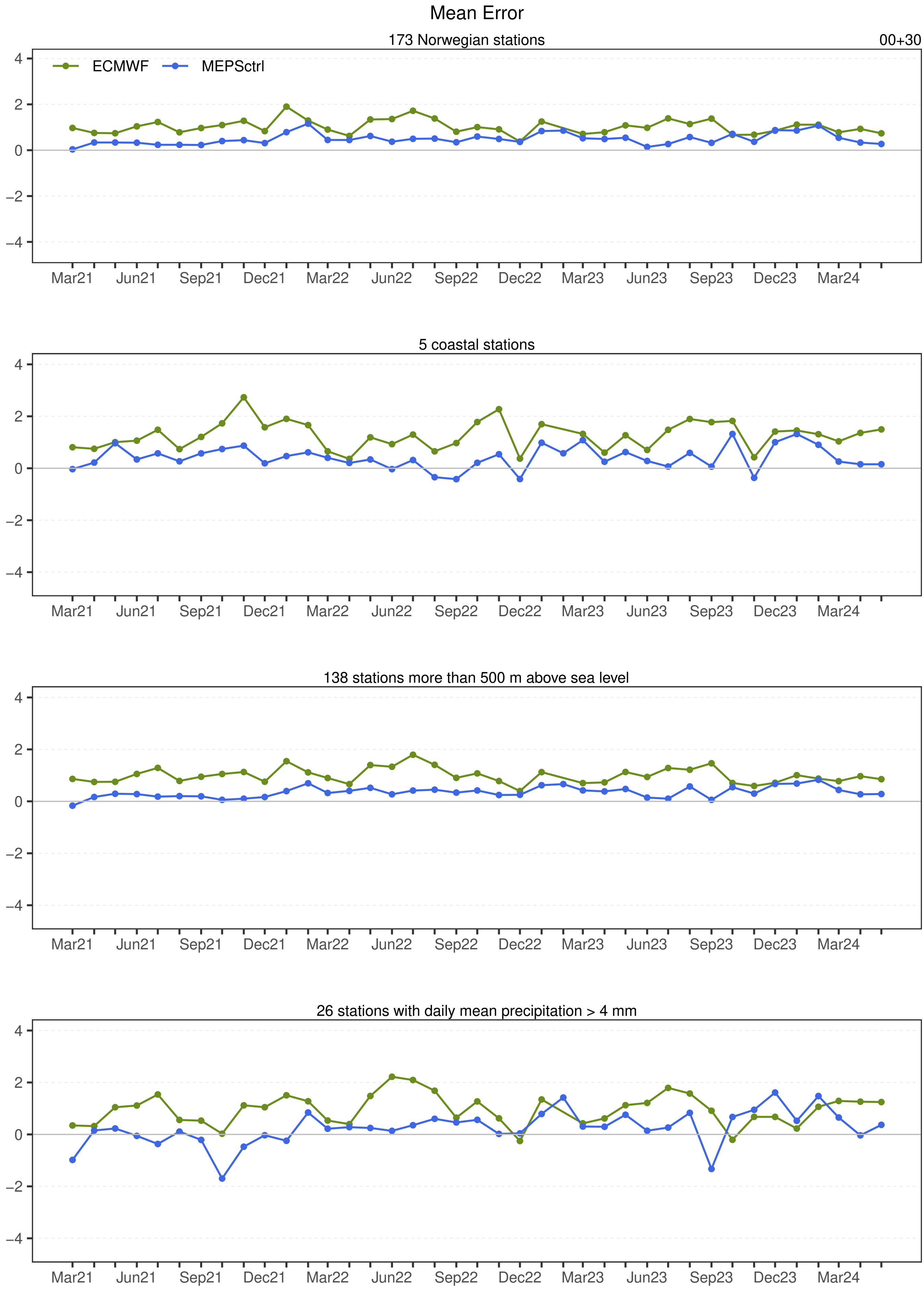


Kuiper Skill Score



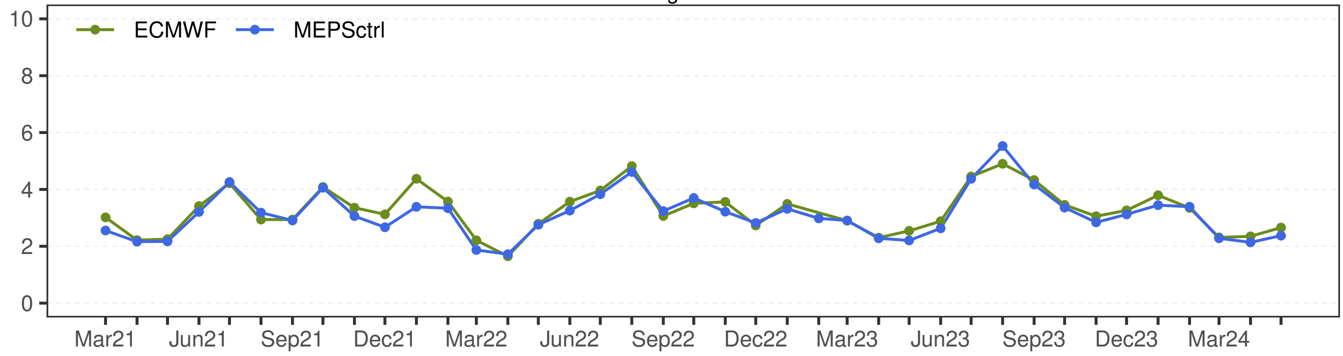
Heidke Skill Score



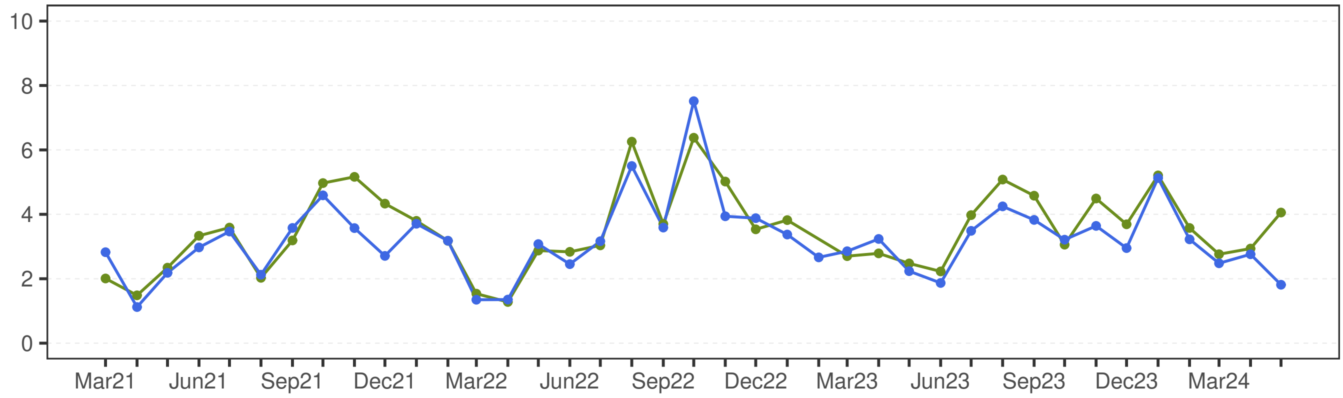

Mean Error
173 Norwegian stations
00+30
ECMWF
MEPSctrl
4
2
0
−2
−4
Mar21
Jun21
Sep21
Dec21
Mar22
Jun22
Sep22
Dec22
Mar23
Jun23
Sep23
Dec23
Mar24
5 coastal stations
138 stations more than 500 m above sea level
26 stations with daily mean precipitation > 4 mm

Standard Deviation of Error

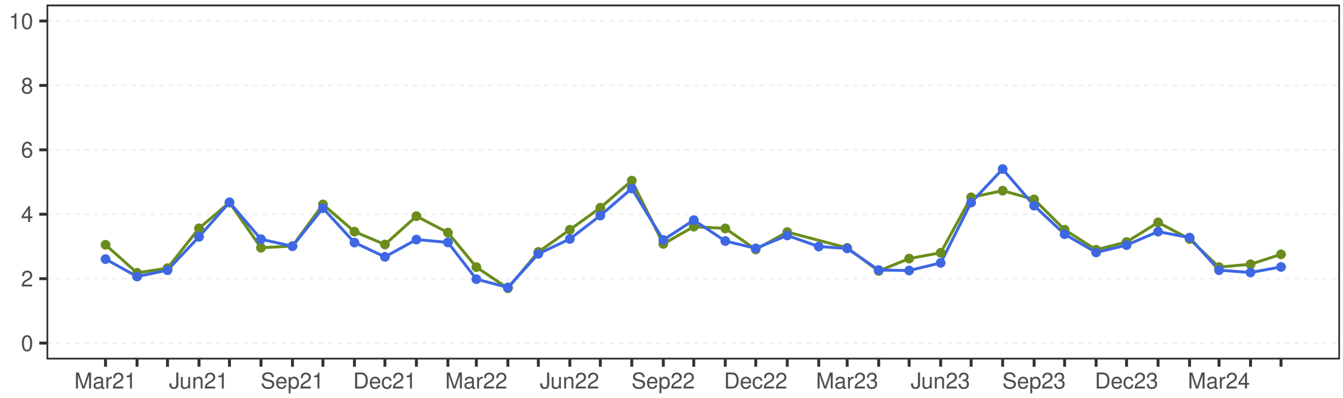
173 Norwegian stations 00+30



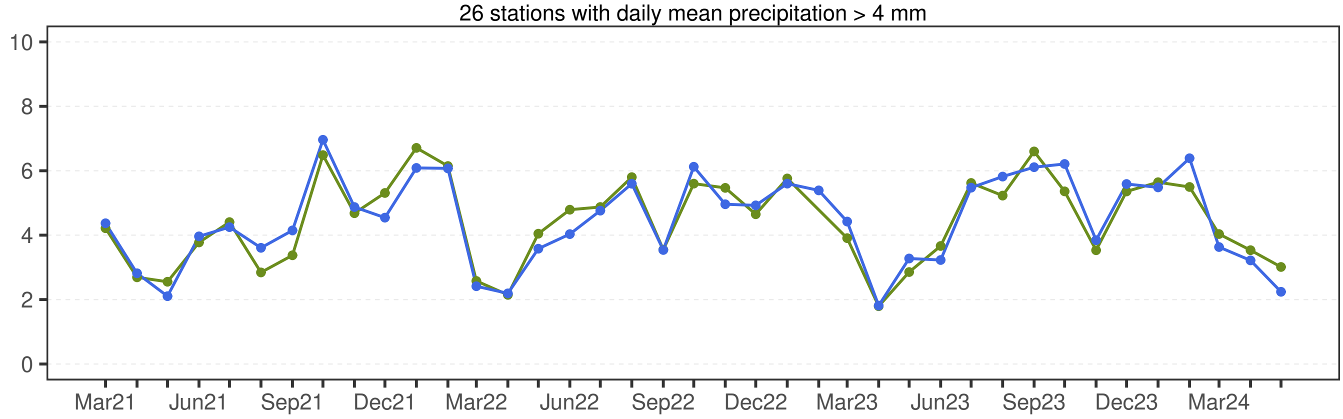
5 coastal stations

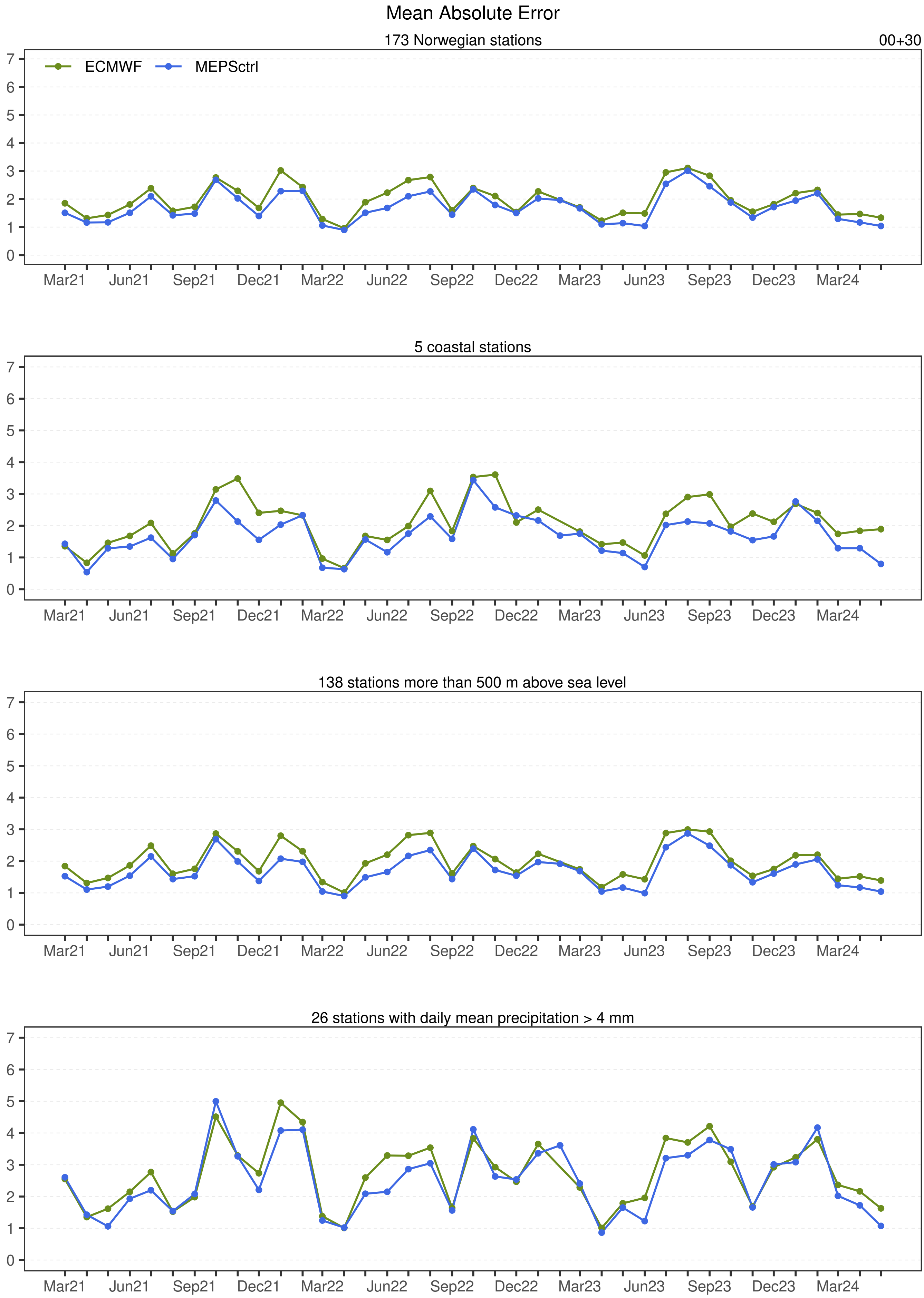


138 stations more than 500 m above sea level



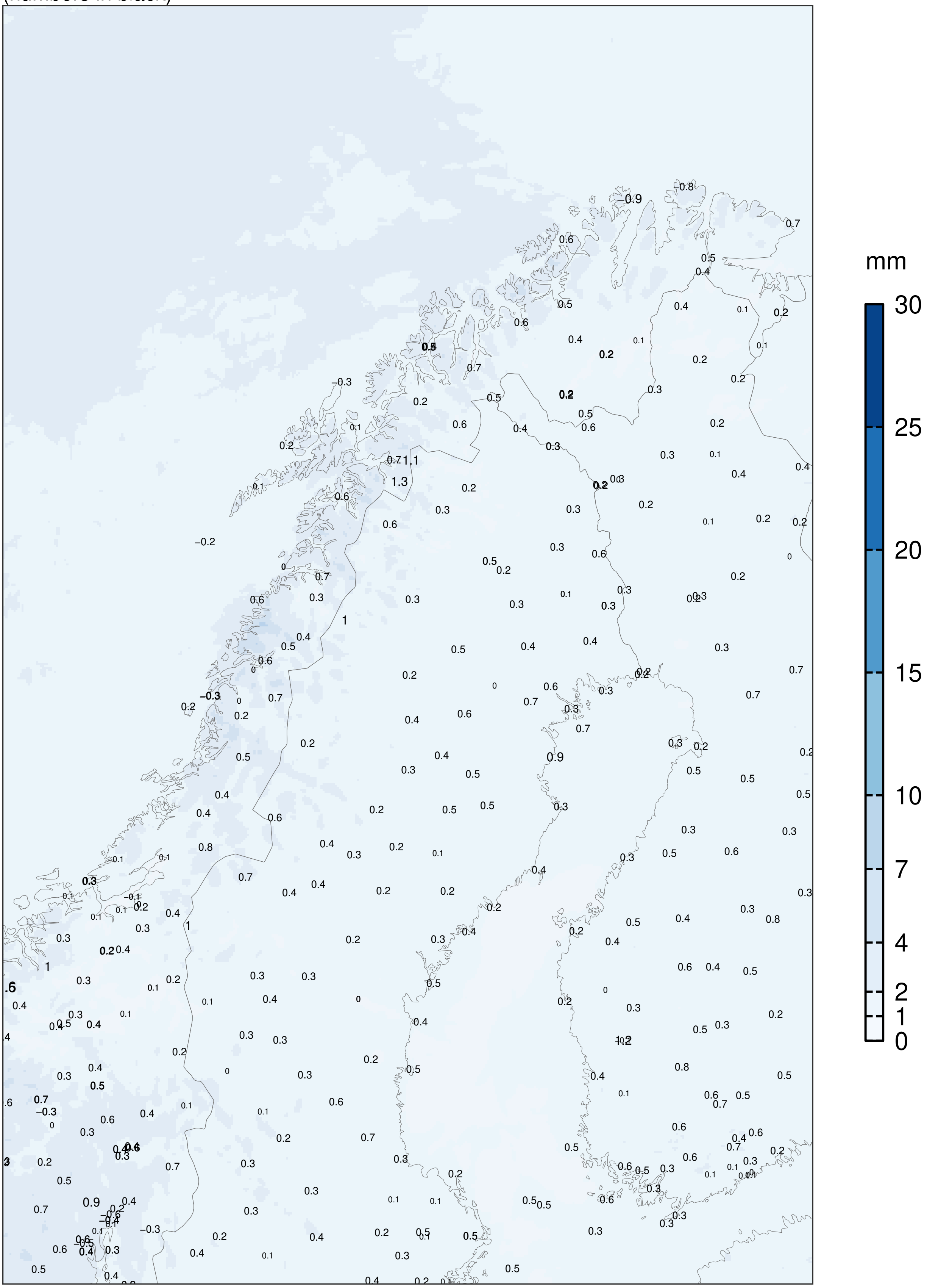
26 stations with daily mean precipitation > 4 mm



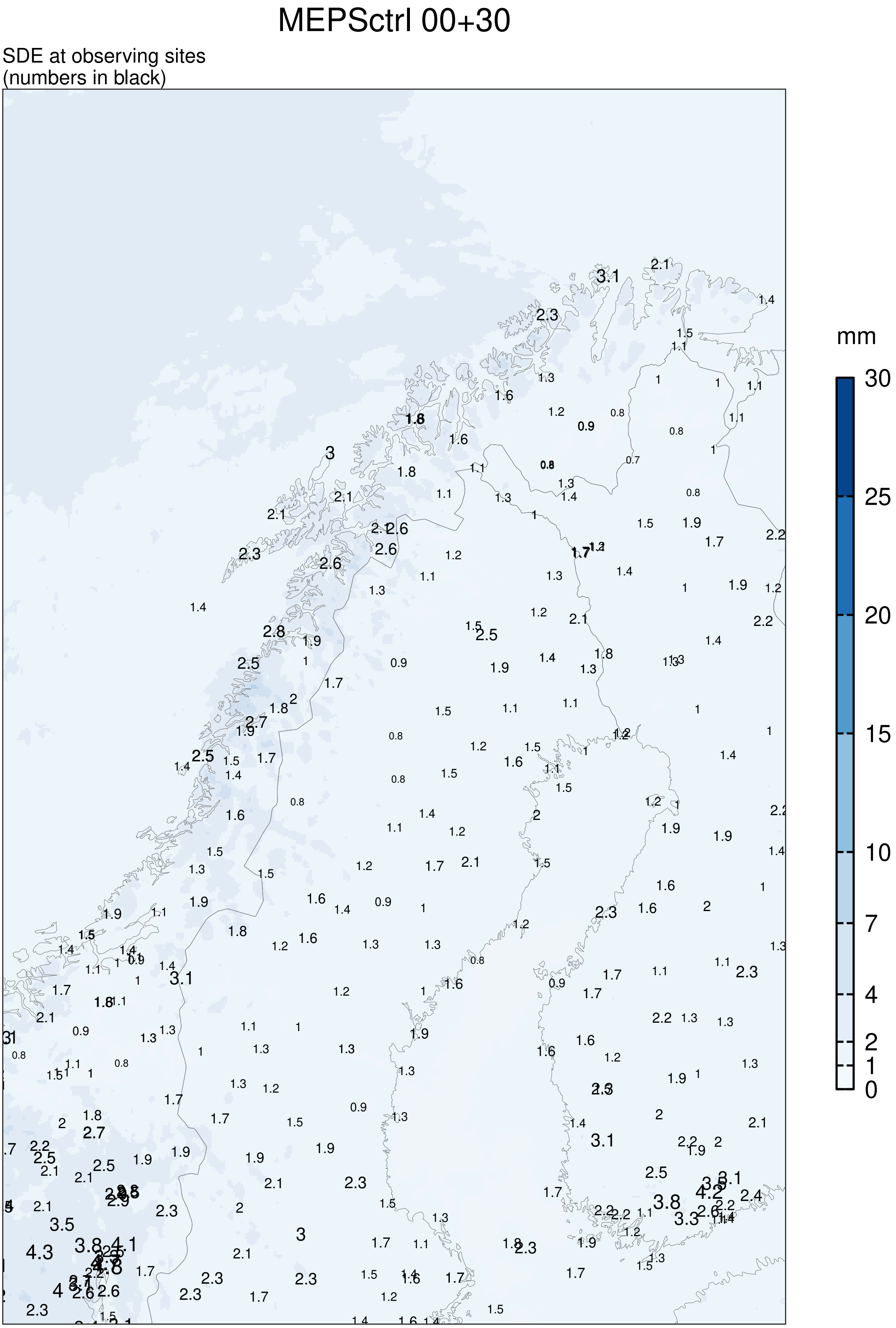

Mean Absolute Error
173 Norwegian stations
00+30
ECMWF
MEPSctrl
5 coastal stations
138 stations more than 500 m above sea level
26 stations with daily mean precipitation > 4 mm
Mar21
Jun21
Sep21
Dec21
Mar22
Jun22
Sep22
Dec22
Mar23
Jun23
Sep23
Dec23
Mar24

MEPSctrl 00+30

ME at observing sites
(numbers in black)



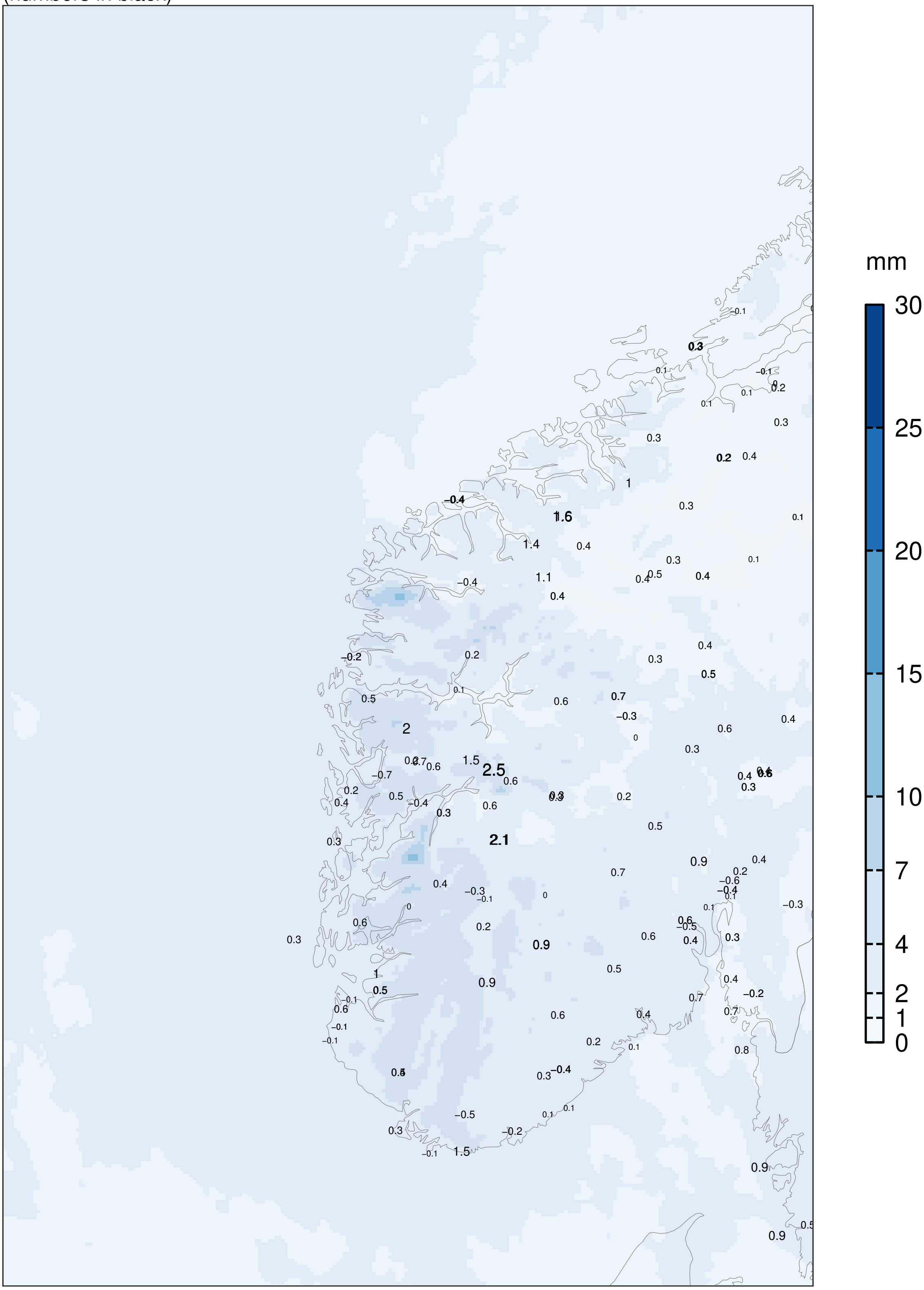
Model "climatology" 01.03.2024–31.05.2024



Model "climatology" 01.03.2024–31.05.2024

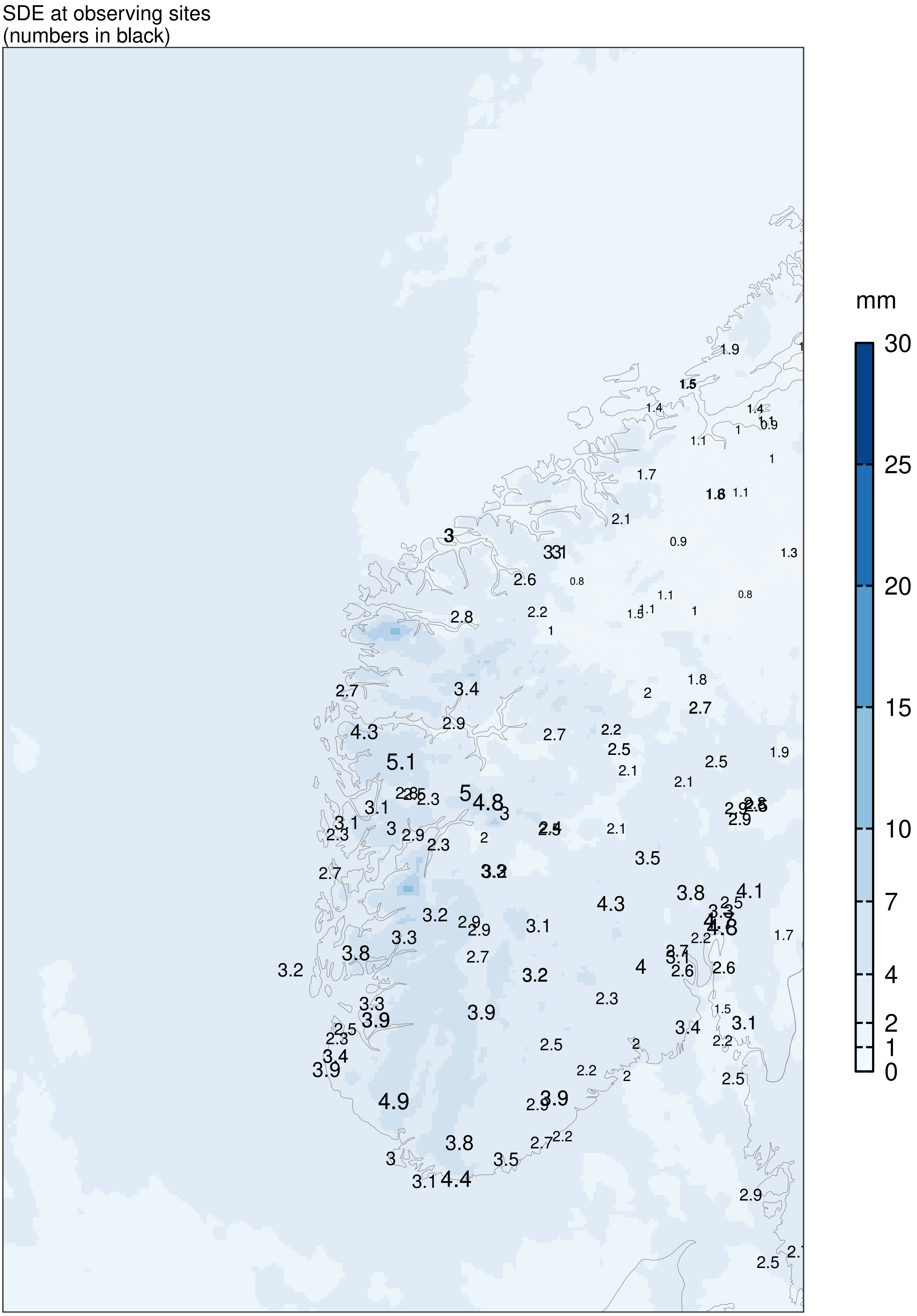
MEPSctrl 00+30

ME at observing sites
(numbers in black)



Model "climatology" 01.03.2024–31.05.2024

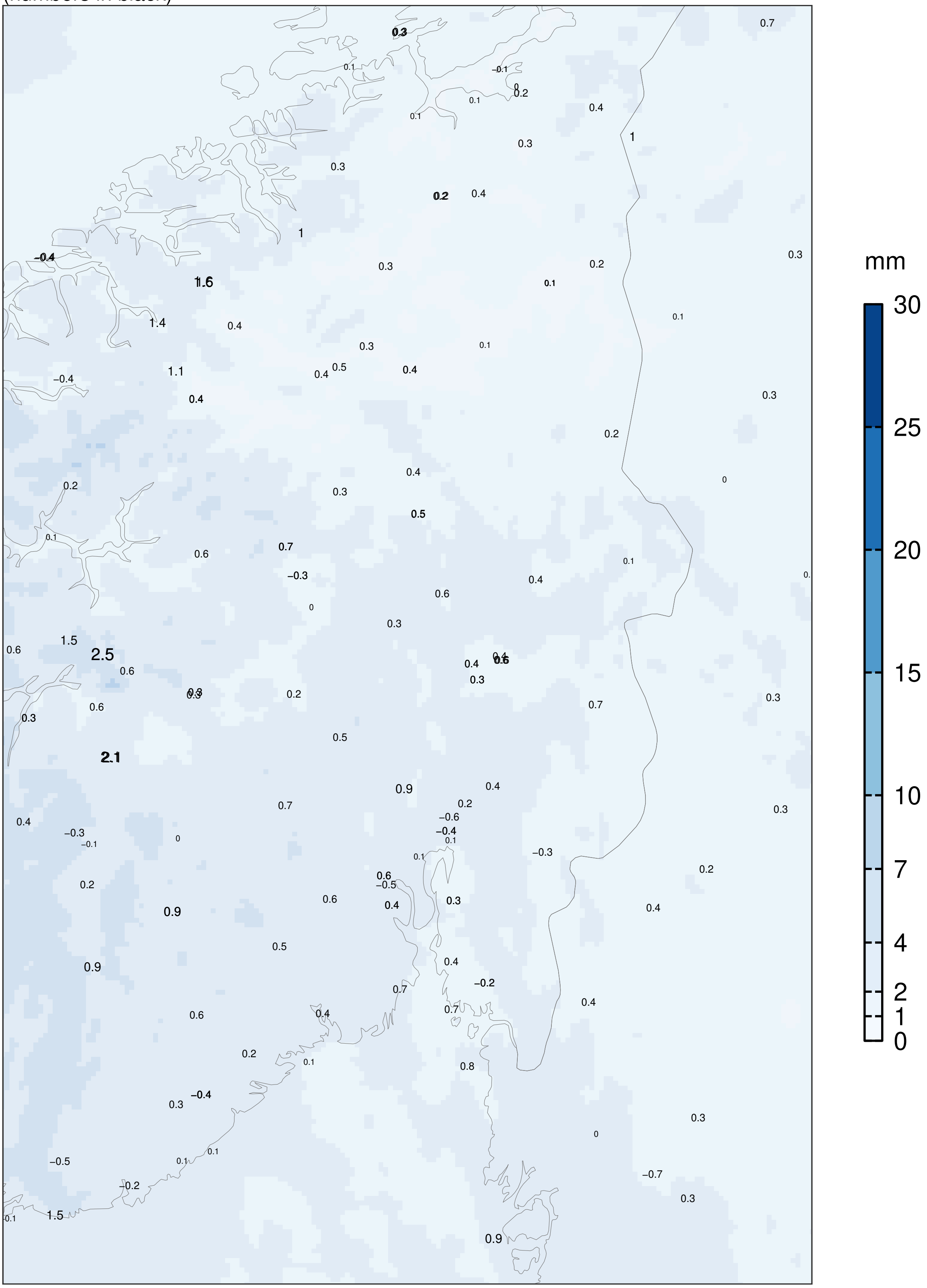
MEPSctrl 00+30



Model "climatology" 01.03.2024–31.05.2024

MEPSctrl 00+30

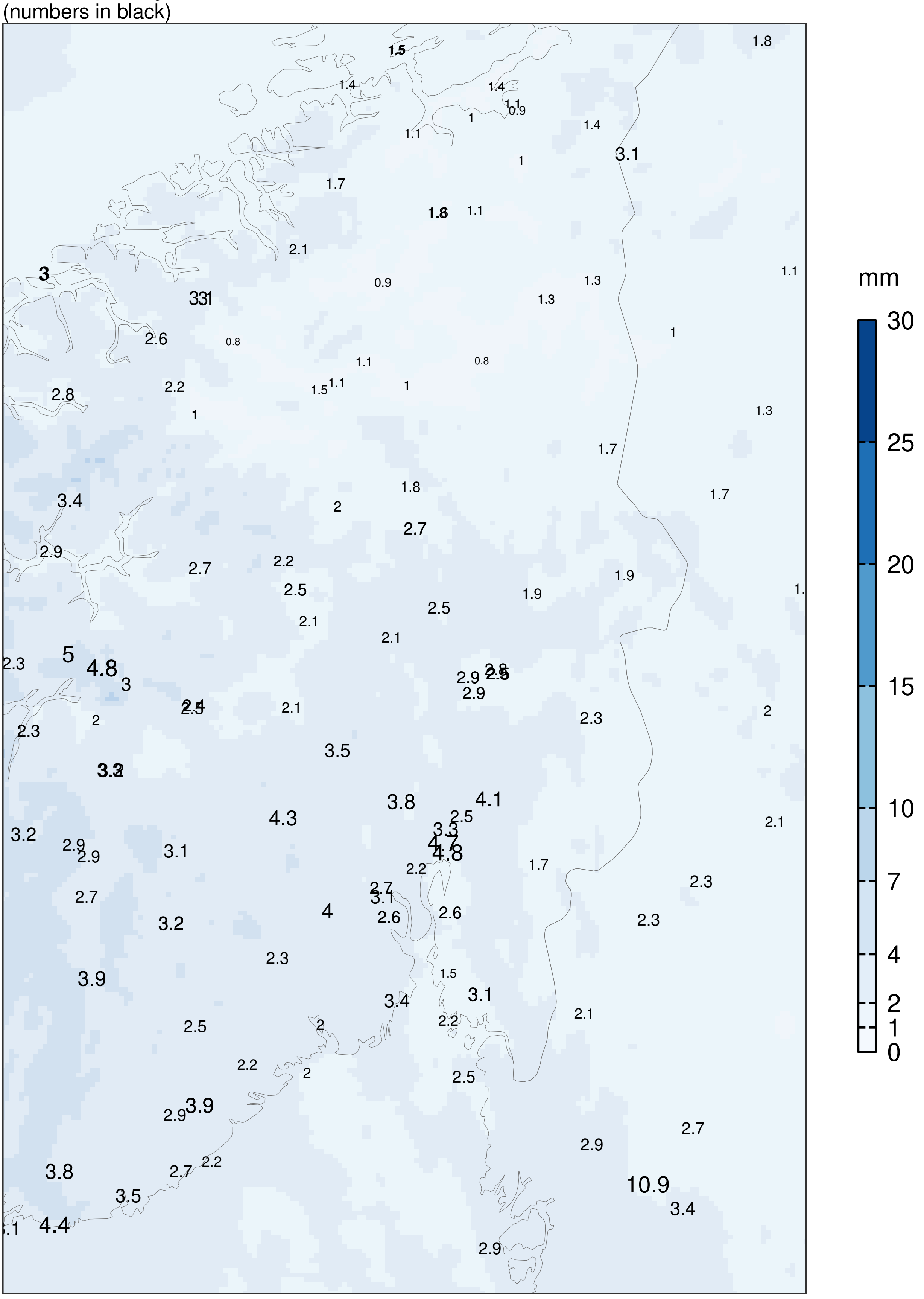
ME at observing sites
(numbers in black)



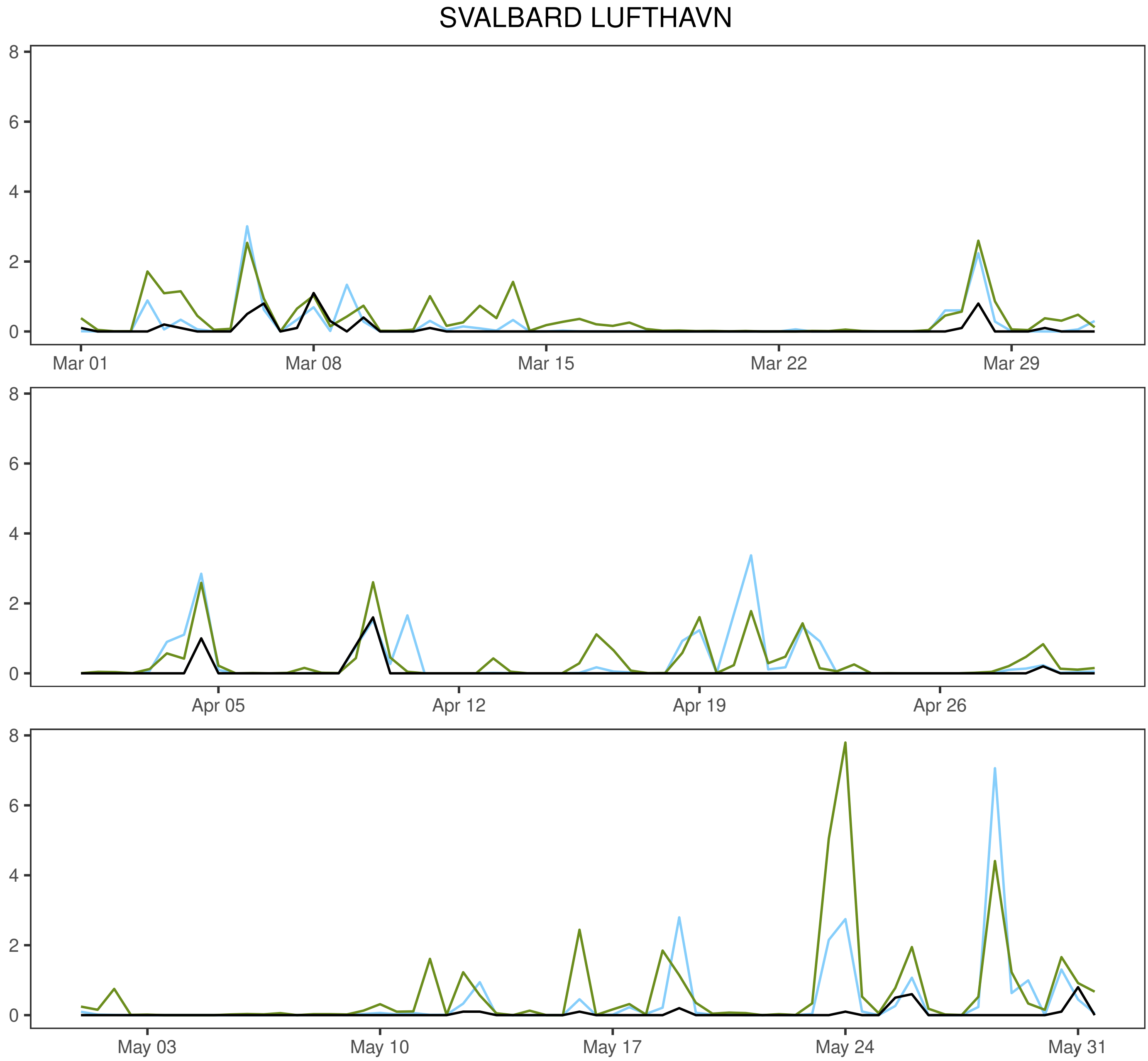
Model "climatology" 01.03.2024–31.05.2024

MEPSctrl 00+30

SDE at observing sites
(numbers in black)

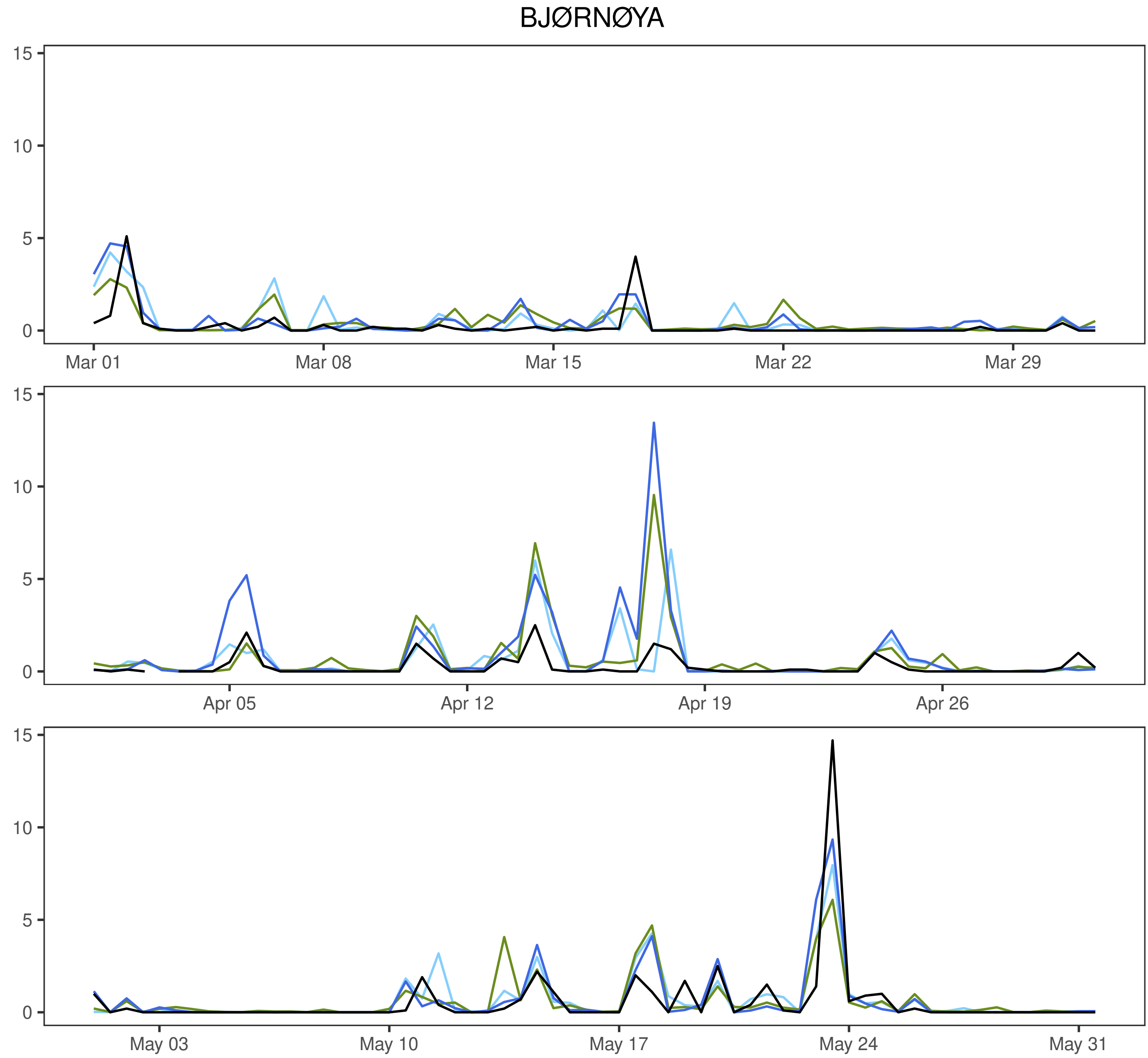


Model "climatology" 01.03.2024–31.05.2024



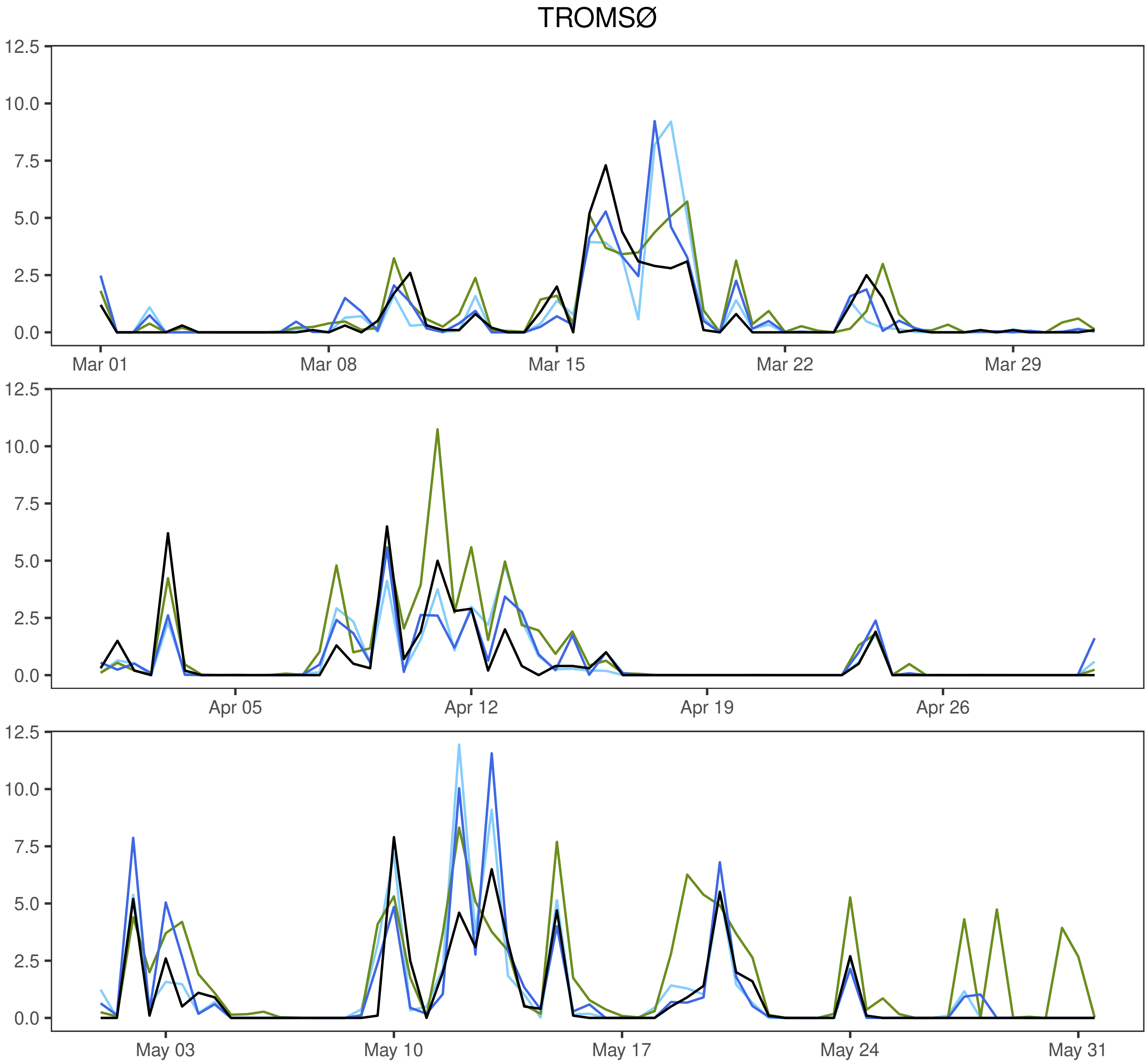
	Min	Mean	Max	Std	N
synop: 06,18	0.0	0.1	1.6	0.2	184
AA25: 12+18,+30	0.0	0.3	7.1	0.8	184
ECMWF: 12+18,+30	0.0	0.4	7.8	0.9	184

	ME	SDE	RMSE	MAE	Max.abs.err	N
AA25 – synop	0.2	0.7	0.8	0.3	7.1	184
ECMWF – synop	0.4	0.9	0.9	0.4	7.7	184



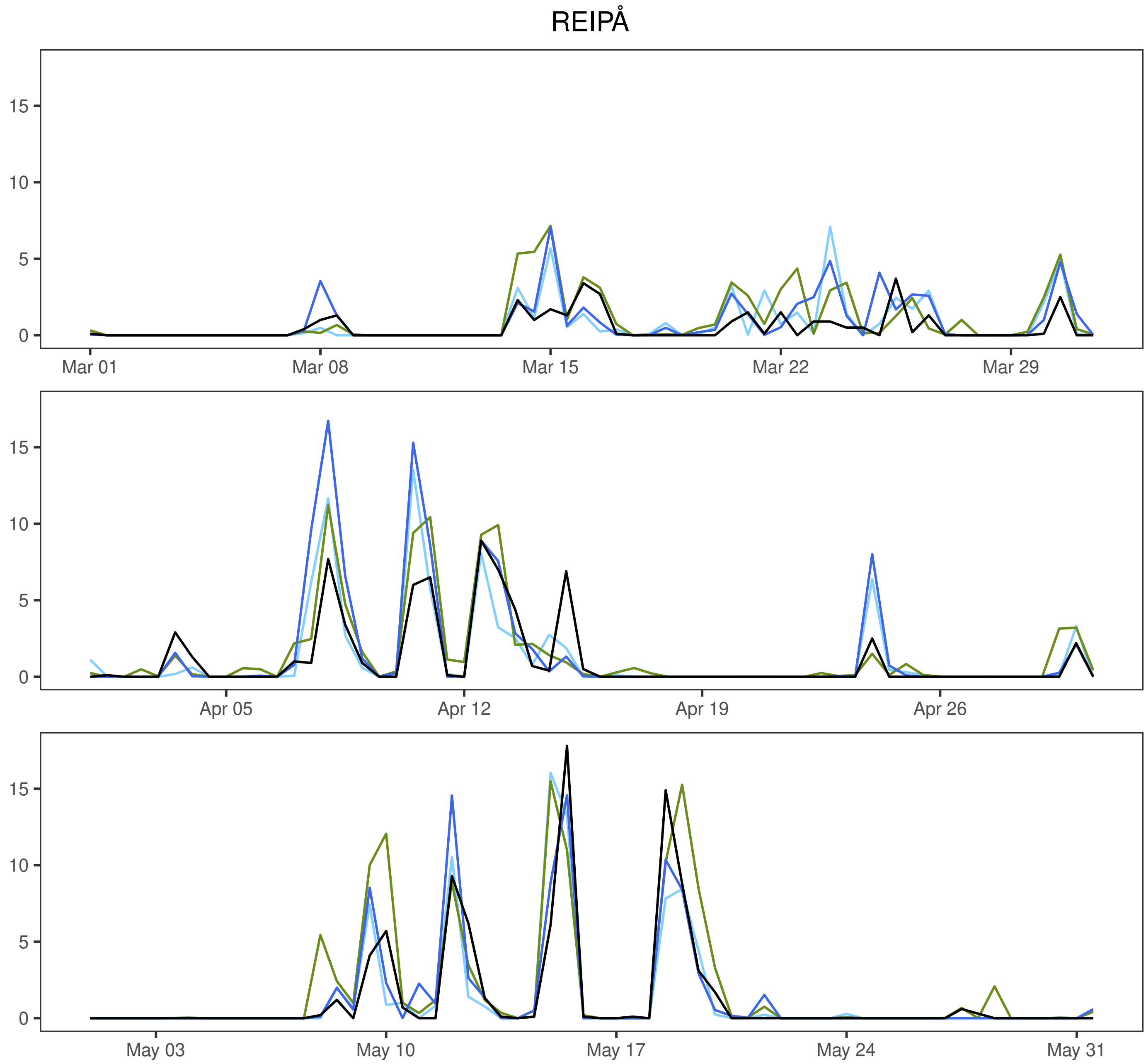
	Min	Mean	Max	Std	N
synop: 06,18	0.0	0.4	14.7	1.3	183
MEPSctrl: 12+18,+30	0.0	0.7	13.4	1.6	184
AA25: 12+18,+30	0.0	0.6	8.0	1.2	184
ECMWF: 12+18,+30	0.0	0.6	9.5	1.2	184

	ME	SDE	RMSE	MAE	Max.abs.err	N
MEPSctrl – synop	0.3	1.3	1.3	0.5	11.9	183
AA25 – synop	0.2	1.0	1.0	0.5	6.7	183
ECMWF – synop	0.2	1.2	1.2	0.5	8.6	183



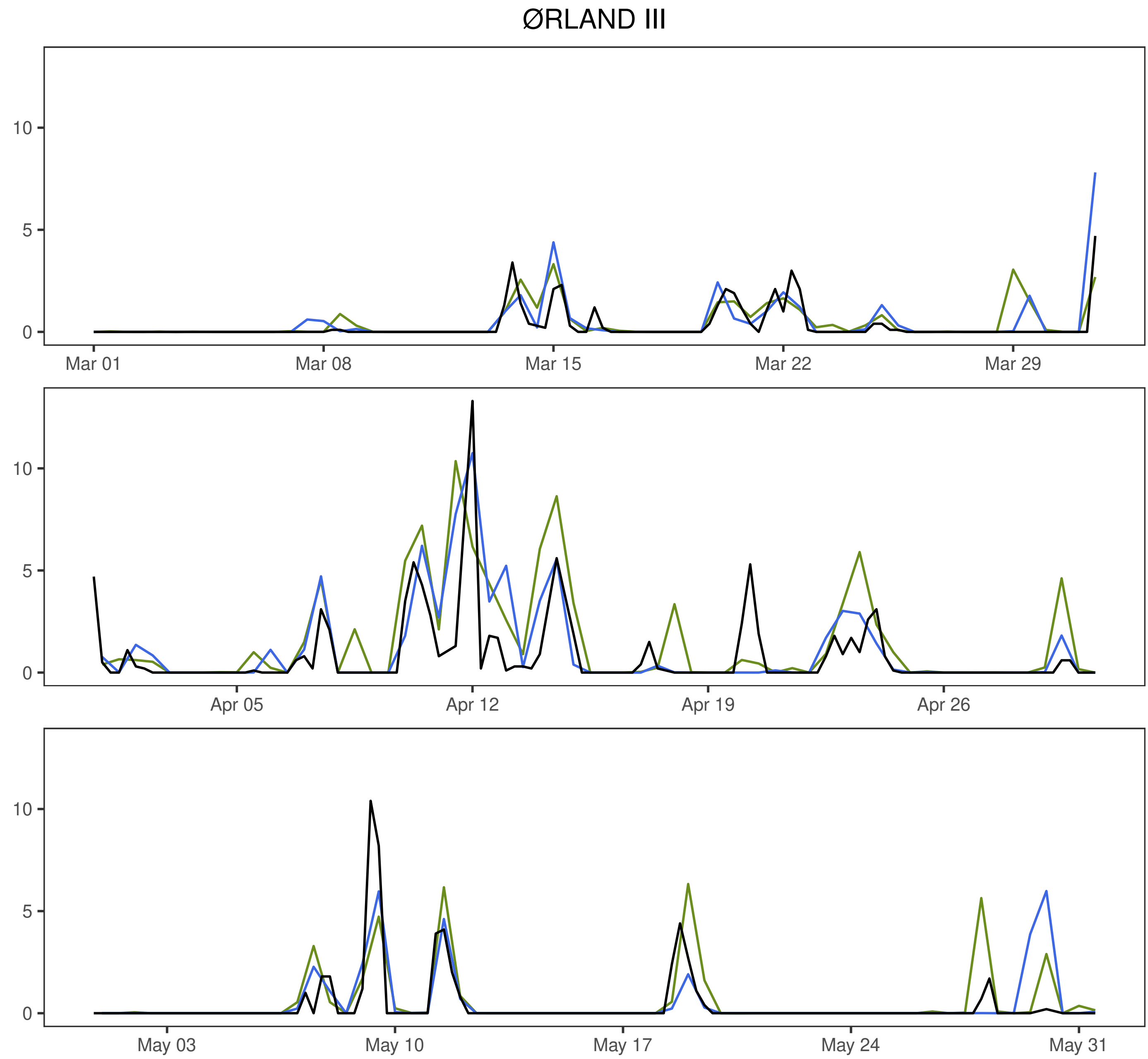
	Min	Mean	Max	Std	N
synop: 06,18	0.0	0.8	7.9	1.6	184
MEPSctrl: 12+18,+30	0.0	0.9	11.6	1.8	184
AA25: 12+18,+30	0.0	0.9	11.9	1.8	184
ECMWF: 12+18,+30	0.0	1.3	10.7	2.0	184

	ME	SDE	RMSE	MAE	Max.abs.err	N
MEPSctrl – synop	0.1	1.1	1.1	0.5	6.3	184
AA25 – synop	0.1	1.2	1.2	0.5	7.3	184
ECMWF – synop	0.5	1.3	1.4	0.7	5.7	184



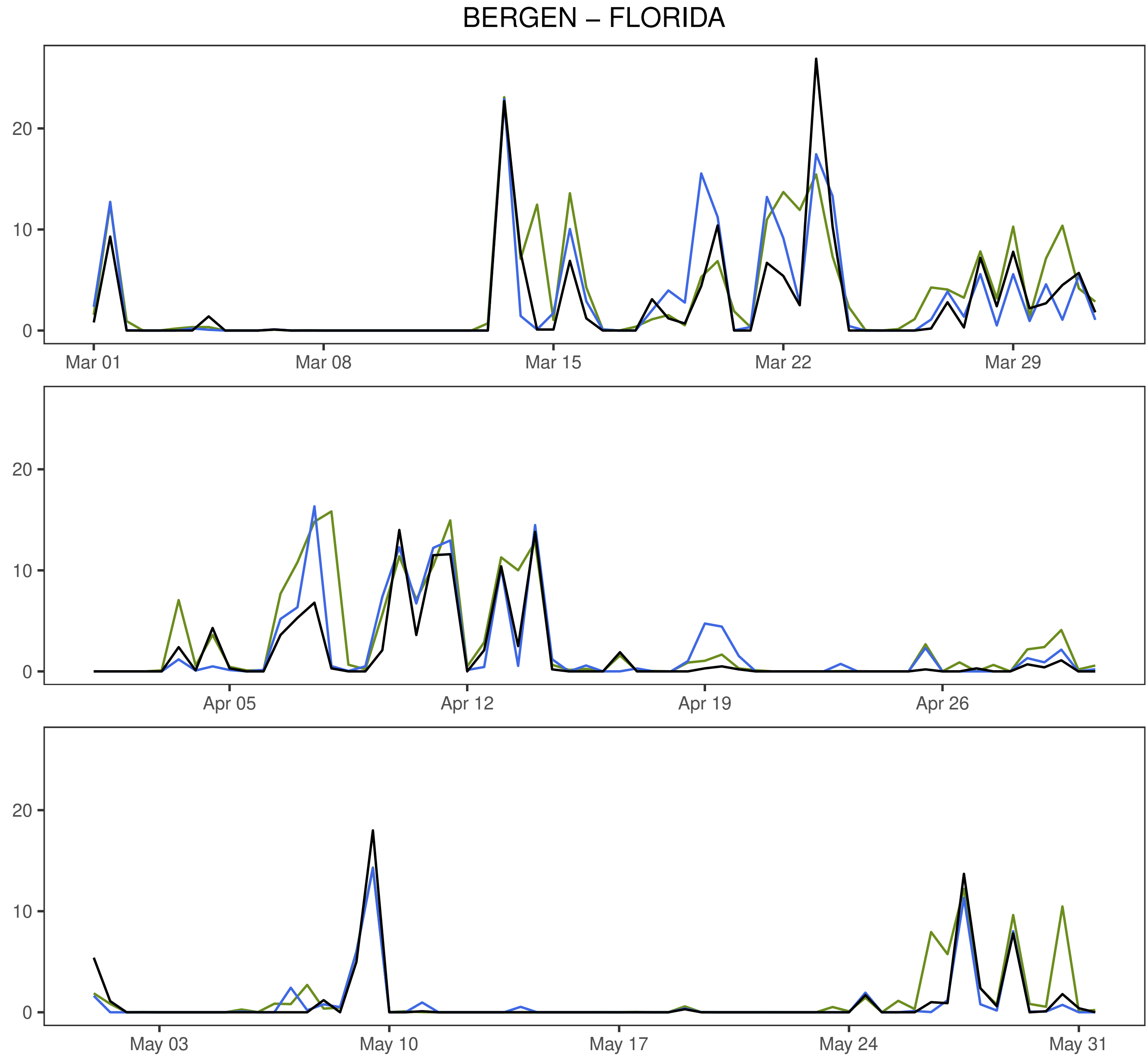
	Min	Mean	Max	Std	N
synop: 06,18	0.0	1.0	17.8	2.5	184
MEPSctrl: 12+18,+30	0.0	1.3	16.7	3.0	184
AA25: 12+18,+30	0.0	1.1	16.0	2.6	184
ECMWF: 12+18,+30	0.0	1.4	15.5	3.0	184

	ME	SDE	RMSE	MAE	Max.abs.err	N
MEPSctrl – synop	0.3	1.7	1.7	0.7	9.3	184
AA25 – synop	0.1	1.7	1.7	0.7	9.9	184
ECMWF – synop	0.5	1.7	1.8	0.8	9.4	184



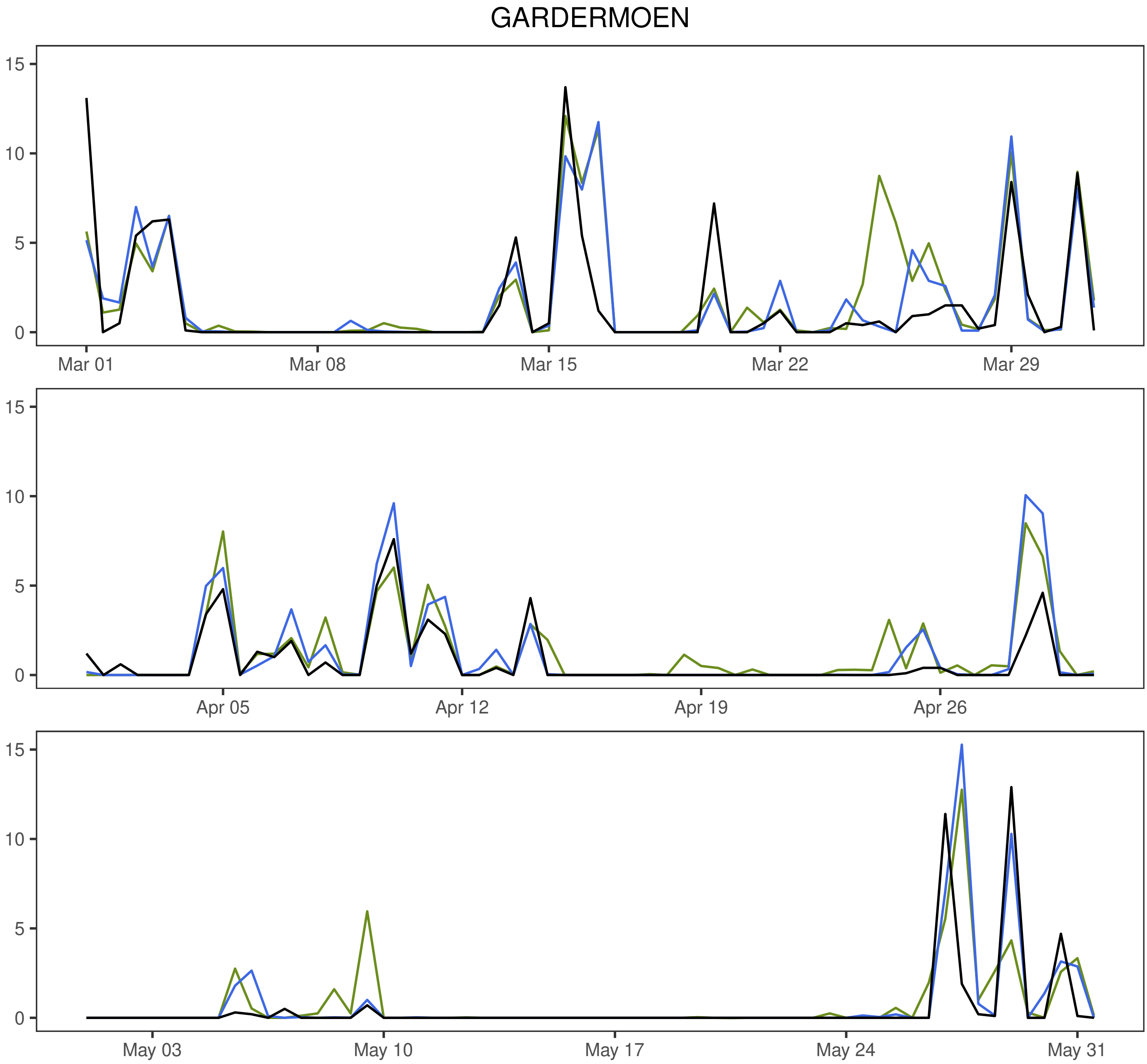
	Min	Mean	Max	Std	N
synop: 00,06,12,18	0.0	0.5	13.3	1.4	342
MEPSctrl: 12+18,+30	0.0	0.7	10.7	1.7	184
ECMWF: 12+18,+30	0.0	0.8	10.4	1.8	184

	ME	SDE	RMSE	MAE	Max.abs.err	N
MEPSctrl – synop	0.2	1.1	1.1	0.4	6.5	184
ECMWF – synop	0.3	1.4	1.4	0.6	9.1	184



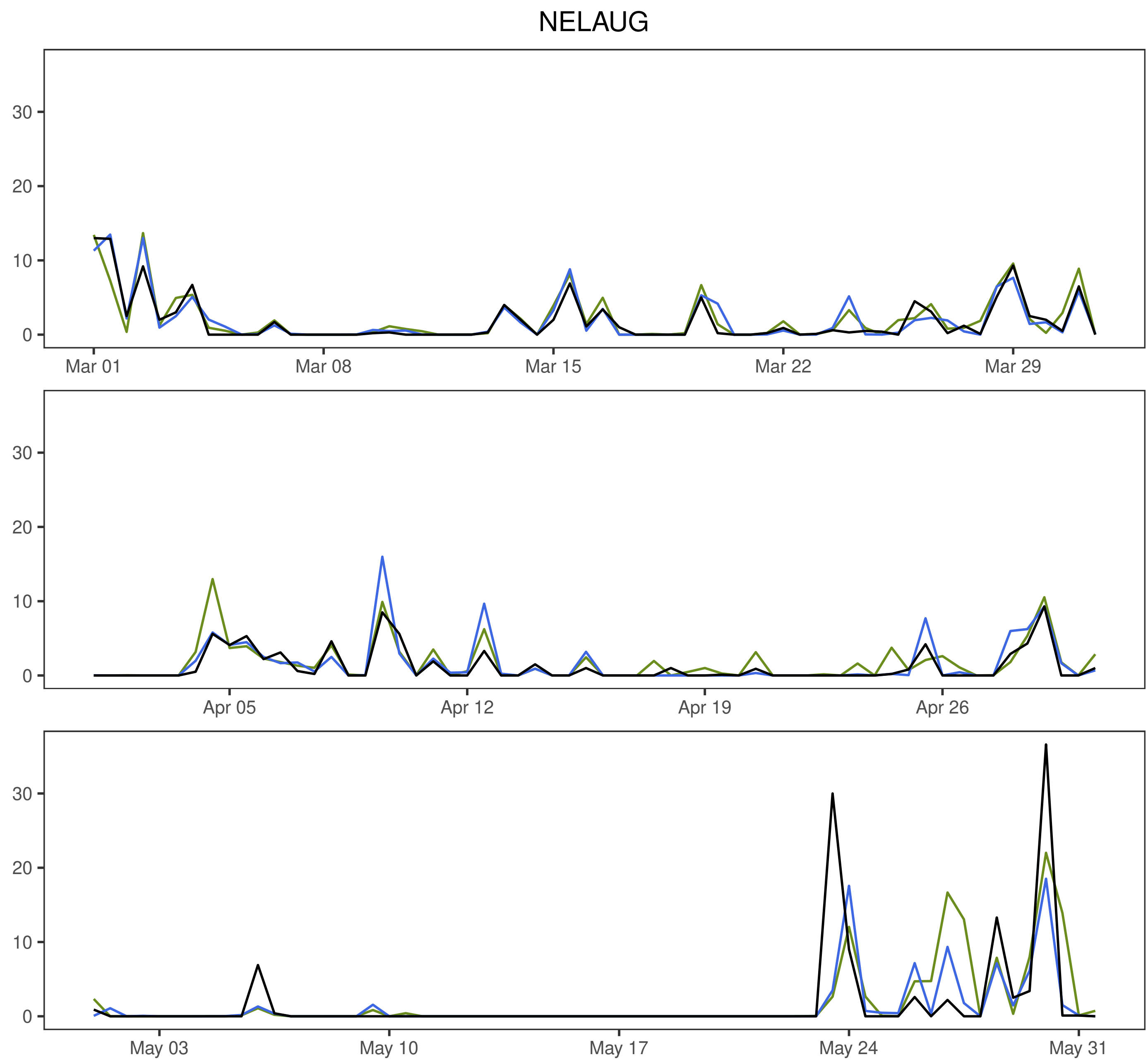
	Min	Mean	Max	Std	N
synop: 06,18	0.0	1.7	26.9	4.0	184
MEPSctrl: 12+18,+30	0.0	2.0	22.9	4.1	184
ECMWF: 12+18,+30	0.0	2.6	23.1	4.4	184

	ME	SDE	RMSE	MAE	Max.abs.err	N
MEPSctrl – synop	0.2	1.9	1.9	0.8	11.1	184
ECMWF – synop	0.8	2.6	2.7	1.3	15.5	184



	Min	Mean	Max	Std	N
synop: 06,18	0.0	0.9	13.7	2.4	184
MEPSctrl: 12+18,+30	0.0	1.2	15.3	2.7	184
ECMWF: 12+18,+30	0.0	1.3	12.8	2.5	184

	ME	SDE	RMSE	MAE	Max.abs.err	N
MEPSctrl – synop	0.3	1.8	1.8	0.7	13.4	184
ECMWF – synop	0.4	2.0	2.0	0.9	10.9	184



	Min	Mean	Max	Std	N
synop: 00,06,18	0.0	1.6	36.6	4.2	185
MEPSctrl: 12+18,+30	0.0	1.6	18.5	3.3	184
ECMWF: 12+18,+30	0.0	1.9	22.0	3.6	184

	ME	SDE	RMSE	MAE	Max.abs.err	N
MEPSctrl – synop	0.0	2.9	2.9	0.9	26.5	184
ECMWF – synop	0.3	3.2	3.2	1.2	27.4	184