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Verification of Operational Weather Prediction Models March to May 2022

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More information...

Verification results are also available on internal web pages

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

About this report

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

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

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

Models

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

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

Analysis and lead times of forecasts are denoted by e.g. 00+30 UTC which indicates forecast generated at 00 UTC and valid 30 hours later.

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

Post processed forecasts

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

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

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 http://www.cnrm.meteo.fr/gmapdoc/ and http://hirlam.org/.

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

AROME physics

AROME (Applications of Research to Operations at MEsoscale) is targeted for horizontal resolution 2.5 km or finer. It uses physical parameterizations based on the French academia model Meso-NH and the external surface model SURFEX. AROME has been operational at Météo-France since 18 December 2008 with a horizontal resolution of 2.5 km and 65 vertical layers, and from April 2015 1.3 km and 90 vertical layers.

SURFEX as surface model

SURFEX (Surface externalisée) is developed at Météo-France and academia for offline experiments and introduced in NWP models to ensure consistent treatment of processes related to surface. Météo-France uses SURFEX in all their configurations. Surface modelling and assimilation benefit from the possibility of running offline experiments. SURFEX is also used for offline applications in e.g. hydrology, vegetation monitoring and snow avalanche forecasts.

SURFEX includes routines to simulate the exchange of energy and water between the atmosphere and 4 surface types (tiles); land, sea (ocean), lake (inland water) and town. The land or nature tile can be divided further into 12 vegetation types (patches). ISBA (Interaction between Soil Biosphere and Atmosphere) is used for modelling the land surface processes. There are 3 ISBA options; 2- and 3-layer force restore and a diffusive approach, where the first one is used in HIRLAM. Towns may be treated by a separate TEB (Town Energy Balance) module. Seas and lakes are also treated separately. The lake model, FLAKE (Freshwater LAKE), has recently been introduced in SURFEX. A global ECOCLIMAP database which combines land cover maps and satellite information gives information about surface properties. The orography is taken from gtopo30.

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

Data assimilation

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

Surface analysis

Surface analysis is performed by CANARI (Code d'Analyse Nécessaire à ARPEGE pour ses Rejets et son Initialisation) (Taillefer, 2002). The analysis method is Optimal Interpolation and only conventional synoptic observations are used. 2 meter temperature and relative humidity observations are used to update the surface and soil temperature and moisture.

The snow analysis is also performed with CANARI in analogy with the HIRLAM snow analysis. Snow depth observations are used to update Snow Water Equivalent. The snow fields are analysed only at 06 UTC as there are very few snow depth observations at 00, 03, 09, 12, 15, 18 and 21.

The Sea Surface Temperature (SST) and Sea Ice Concentration (SIC) is not analysed, but taken from the boundaries. ECMWF uses the OSTIA (Operational Sea Surface Temperature and Sea Ice Analysis) product, including SST from UK Met Office and SIC from MET. SST and SIC for the Baltic Sea have since 26 November 2015 been taken from ocean models run at SMHI; first HIROMB and since 26 April 2017 NEMO.

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

Upper air analysis

MEPS runs three dimensional variational (3D VAR) data assimilation using conventional observations from synop stations, ships, radiosondes and aircrafts and AMSU-A and AMSU-B/MHS data from polar orbiting NOAA and METOP satellites. GNSS were introduced 17 February 2015, radar reflectivities 16 June 2015, IASI 26 November 2015 and ASCAT 17 March 2016.

Boundary fields

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

Verification measures

All model forecasts in this report are verified against observations by interpolating (linear) the grid based forecasts to the observational sites. As a consequence, it should be noted that it is the models' abilities to forecast the observations that is being quantifed and assessed. Thus, there is no attempt in this report to verify area averaged precipitation for example.

Verification is carried out both for raw and categorized forecasts. In the following, let $f_1,...,f_n$ denote the forecasts and $o_1,...,o_n$ the corresponding observations.

Forecasts of continuous variables

The verification statistics applied to continuous variables are defined in the table below.

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

In the formula for COR the following definitions are used

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

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

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

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

Forecasts of categorical variables

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

		event observed	
		yes	no
event forecasted	yes	a	b
	no	c	d

Verification statistics for such forecasts are listed in the following table

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

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

Observations

All observations come from Klimadatavarehuset at MET. Only synop stations are used. From June 1 2021, both the model wind speed and the post-processed wind speed are verified against mean wind observations, FF. The model wind gust is verified against the observed wind gust, FG. FF and FG are defined as follows:

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

Summary of the results

Summarized statistics show that ECMWF in general 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. The models tend to underestimate the temperature for the different groups of stations, with the exception of AA25 for Svalbard stations. The standard deviation of error is slightly higher for ECMWF for Norwegian station, while somewhat higher for AA25 than ECMWF for Svalbard stations. For the North Scandinavian stations, AA25 and MEPSctrl give almost identical results, while ECMWF clearly underestimates the temperature. Still, the errors are small, indicating that the timing of the temperature changes is generally good.

The upgrade of MEPS from cycle 40 to cycle 43 on 23 March 2021 had some effect on near surface temperatures. The new physiography data set - ECOCLIMAP Second Generation - has a new albedo data set leading to a slight increase in daytime temperatures in the summer season. The mean error plotted as a function of lead time shows that the temperature forecasts still are a little bit too cold during the day, but the underestimation is reduced as compared to the previous spring. 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 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 was changed on 1 June 2021 by downscaling to 1km resolution to better represent local topography. The change implies that the post processed wind speed represents the mean wind speed rather than the maximum mean wind speed as before this change was introduced. The mean error indicates a somewhat larger underestimation of 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. ECMWF has on average more precipitation than MEPS which this spring had mean errors very close to (and above) 0. Evaluated by skill scores, ECMWF performs a little bit better, but both have more errors for both very small amounts and very high amounts, than precipitation in the mid range. MEPSctrl performs better than ECMWF for small amounts and no precipitation.

The models perform better for temperature and wind speed during summer months than during winter. A possible cause is that storm activity is challenging to predict accurately, and there are often more severe storms and generally higher winds during winter months than summer. Situations with inversion with low local minima may also play a role in winter temperature errors. Precipitation is challenging to predict throughout the year with less clear trends. AA25 and MEPSctrl show very similar results, which is expected since both are HARMONIE with AROME physics, horizontal resolution defined by a 2.5×2.5 km^2 grid.

Case studies by forecasters

Case 1. Wind in Northern Norway May 2022

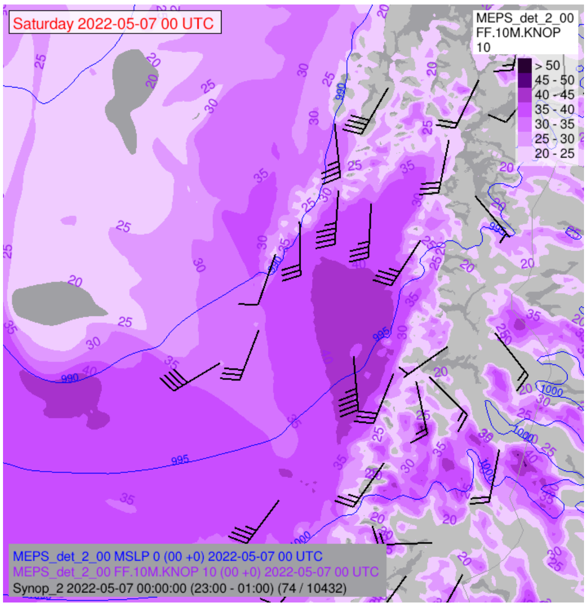


Figure 1: The wind from MEPSctrl at 7 May 00 UTC plotted against wind observations. There is some underestimation of the wind at the coast and in the mountains.

A wind event from 7 May illustrates mixed performance (figure 1). Point verification from the event in figure 2 shows examples of good performance from MEPS at the coastal stations, e.g. Bodø and Røst, but also some instances of underestimation, e.g at Leknes airport in the western part of Lofoten.

There were two reports of poor performance in forecasting of light wind associated with terrain in this period, on 7 March and 29 May, shown in figure 3 and 4 respectively.

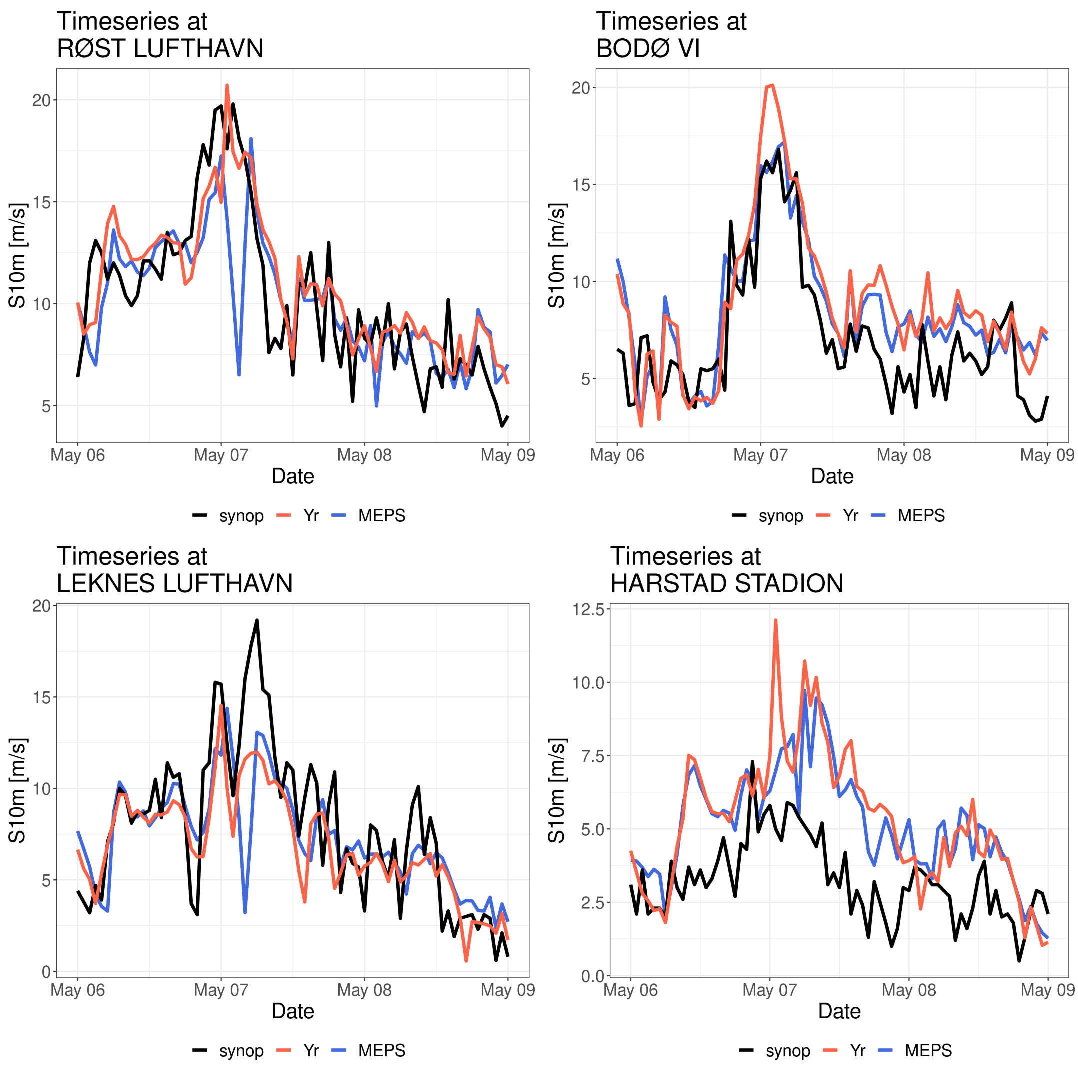


Figure 2: Plots of wind from 6 May to 9 May through the wind event on the night to the 7 May. Both Røst, Bodø and Leknes are coastal stations. Harstad can be considered more sheltered, and here MEPS did overestimate the 10m wind.

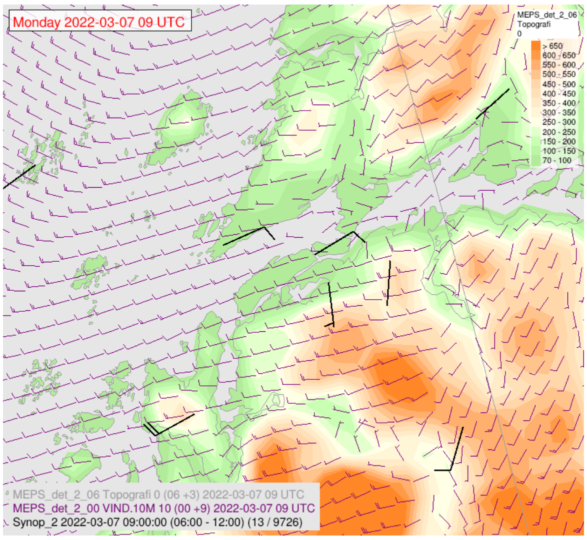


Figure 3: Wind on 7 March 09 UTC. In Bodø a weak easterly drainage wind at low levels is not picked up by MEPSctrl. This situation is common in Bodø which normally has a strong forcing from large scale terrain in the area, most notably the fjord system south of Bodø which is 3-5km wide and about 60km in length.

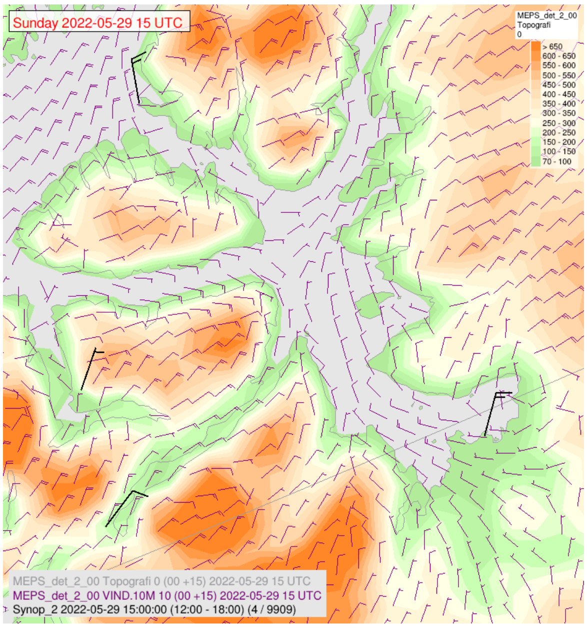


Figure 4: Wind on 29 May 15 UTC. The model wind seems here to follow the terrain of the fjord and the mountains to the west of Alta, whereas the wind in reality followed the large-scale northeasterly wind in the area. This situation lasted for several hours.

Case 2. Cloud cover 9 March 2022

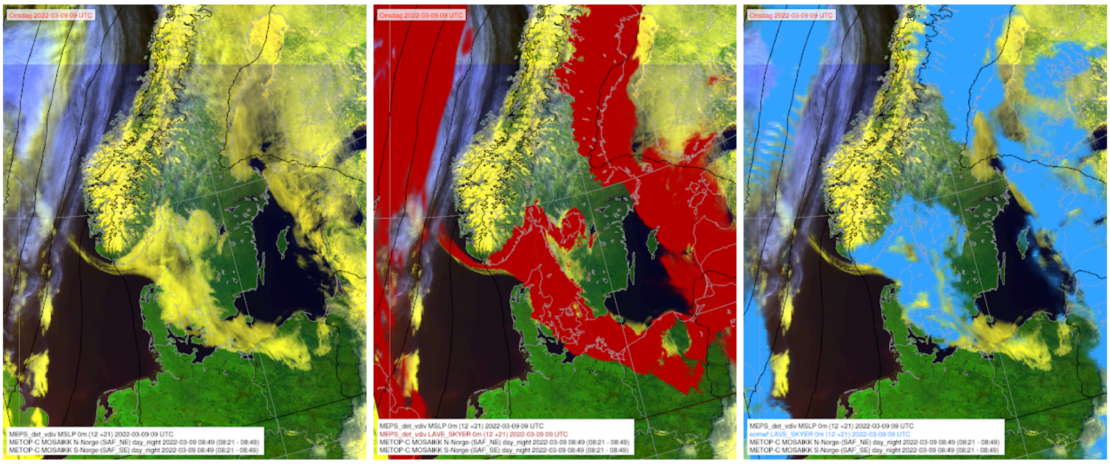


Figure 5: Cloud cover seen from satellite (left), with low clouds from MEPS (center), and with low clouds from ECMWF (right).

Figure 5 shows satellite images of clouds on 9 March. The cloud cover was well forecast by both MEPS and ECMWF.

Case 3. High clouds 14 March 2022

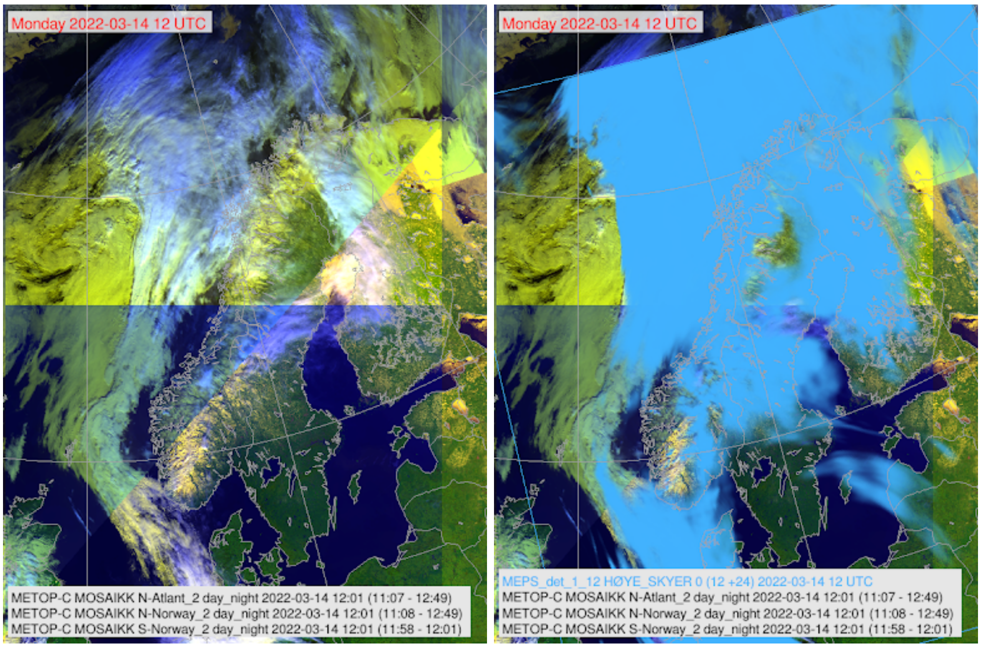


Figure 6: Cloud cover seen from satellite (left) and with high clouds from MEPS (right).

Figure 6 shows too much high clouds in MEPS on 14 March. Figure 7 shows a dew point depression of approximately 5°C, which may be the cause of high clouds.

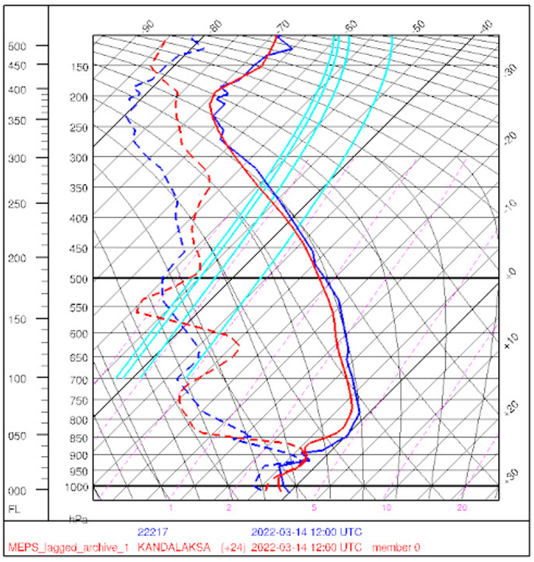


Figure 7: Dew point temperature.

Case 4. Low clouds 14 April 2022

There were several reports on missing low clouds, similar to previously reported. Figure 8 shows a case from Southeast Norway on 14 April.

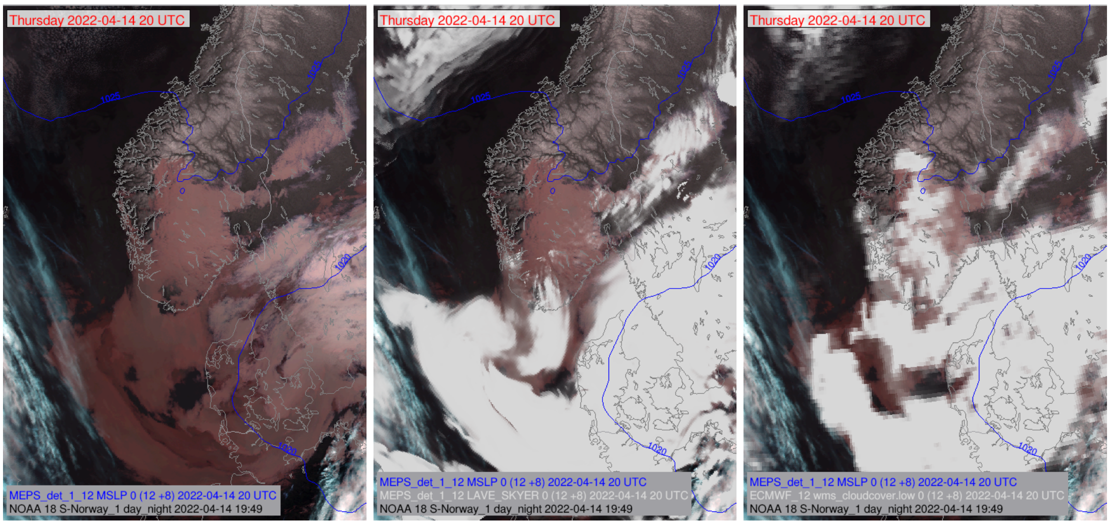


Figure 8: Low clouds on 14 April 20 UTC. This situation lasted from noon on the 14 through to the morning on the 15 and is typical for the tendency in MEPS to underestimate low stratiform clouds. Left: NOAA with low clouds as smooth reddish areas. Centre: MEPSctrl 12+8hrs with low clouds as greyish shading. Right: ECMWF 12+8hrs with low clouds as greyish shading

Case 5. Precipitation 11 April 2022

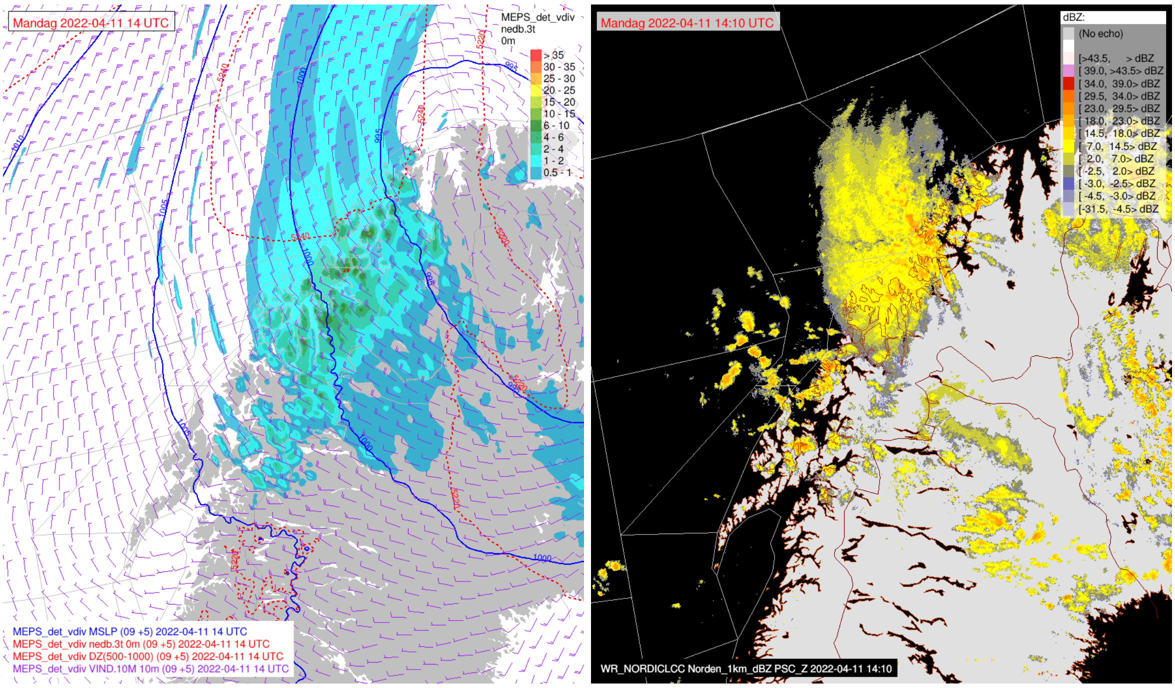


Figure 9: Left: Frontal precipitation (blue/green shading) from MEPSctrl from 11th April in Troms and West-Finnmark agrees well with the radar signature (right image). Right: The radar image shows considerable convective precipitation west of the frontal system and also in northern Sweden that is not forecast by MEPSctrl.

There is a noticeable reduction of reports of missing precipitation after the 25 January update. A case from 11 April confirms the general impression that the model is better at forecasting frontal than convective precipitation (figure 9).

Case 6. Fog 31 May 2022

There are two reports of excessive extent of model fog: One in the Arome-Arctic domain, and one from the coast of Northern Norway. These are shown in figure 10.

A fog case from 31 May shows the large uncertainty in the models concerning fog. The fog was observed in the Varangerfjord area and extended eastwards to the Kanin peninsula. MEPS had too low horizontal extent, and AROME-Arctic was covering a far too large area. In the cloud free area the actual temperature was from 5 to 9°C, and dew point temperatures was around 1°C (figure 11). In the observed fog, the temperature and dew point temperatures was around 2°C, which shows the considerable radiative cooling effect of the fog layer. Figure 12 shows the corresponding prognostic soundings from the Varangerfjord area. Both MEPS and AROME-Arctic had realistic temperature and dew point temperature in the respective fog/no-fog areas. This indicates that it is the onset of fog and the treatment of the moisture, rather than temperatures and radiation that is the cause of the uncertainty in the fog prognosis.

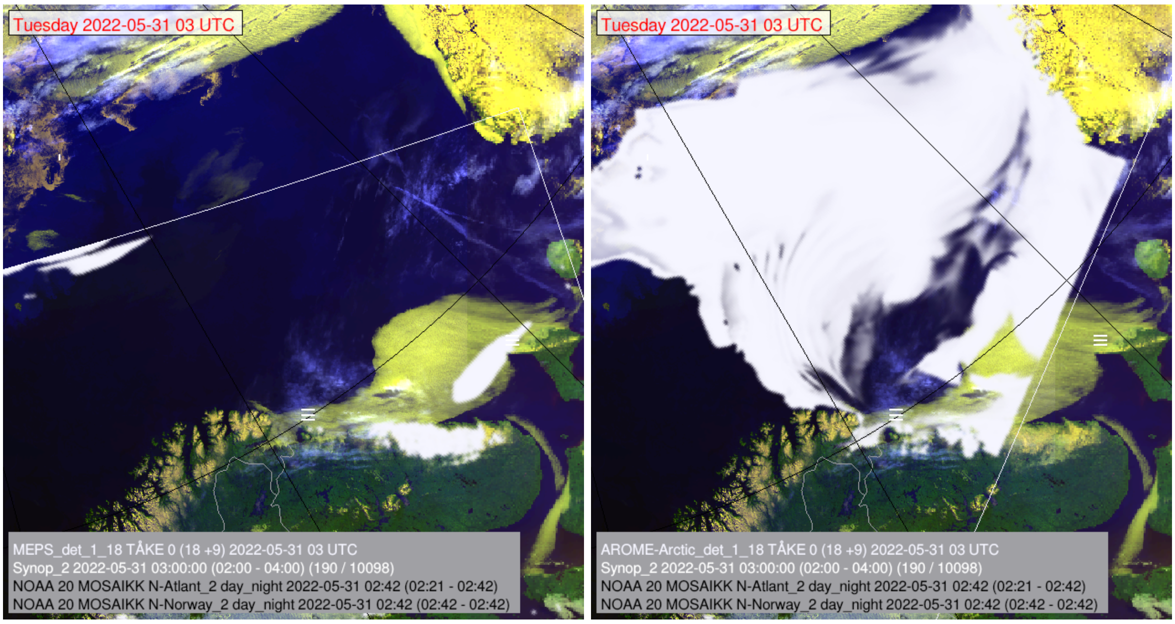


Figure 10: Left: MEPS 18+9 from 31 May (light gray shading). In the satellite image, the actual fog is seen as yellow areas. Right: AROME-Arctic 18+9 had a much larger extent of the fog.

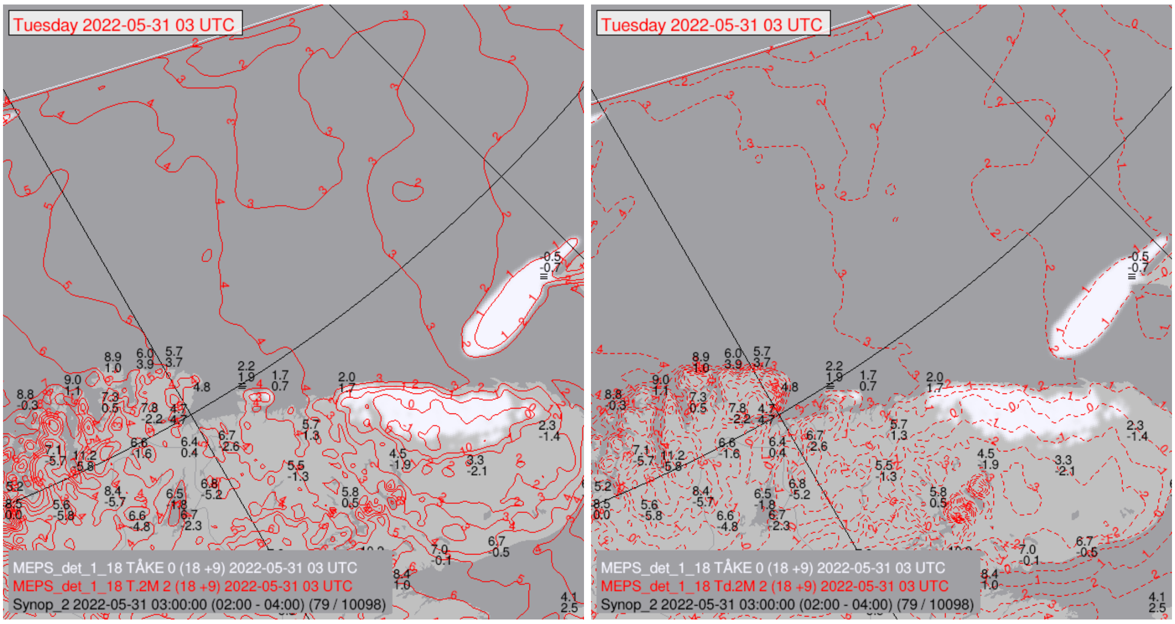


Figure 11: Left: MEPSctrl 18+9hrs T2m plotted against observations (upper black number). Right: MEPSctrl 18+9hrs Td2m plotted against observations (lower black number).

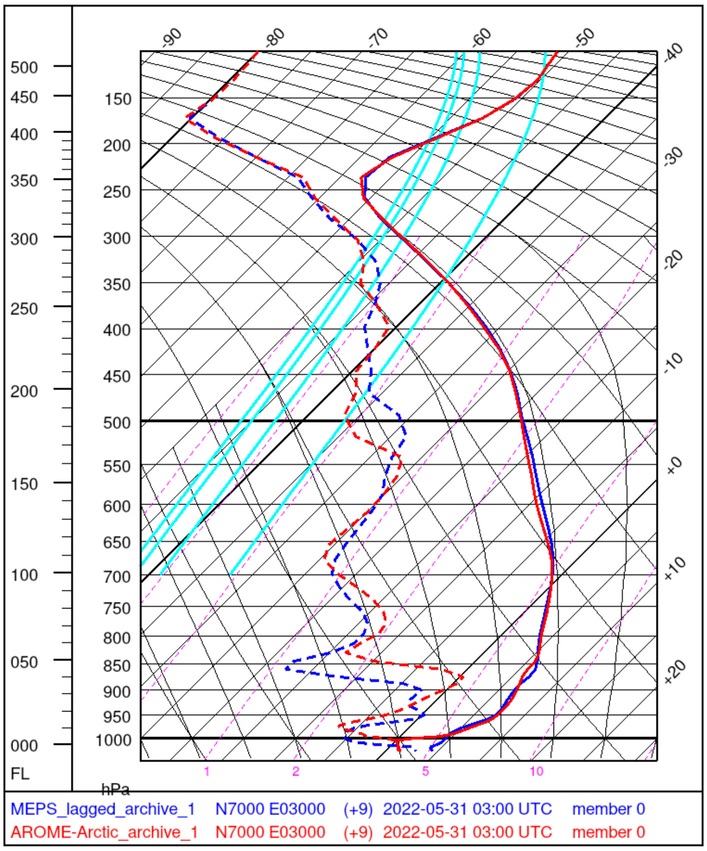
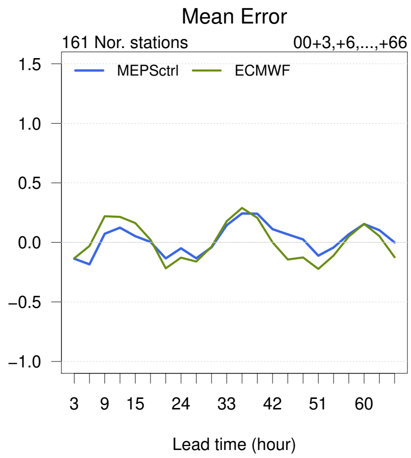
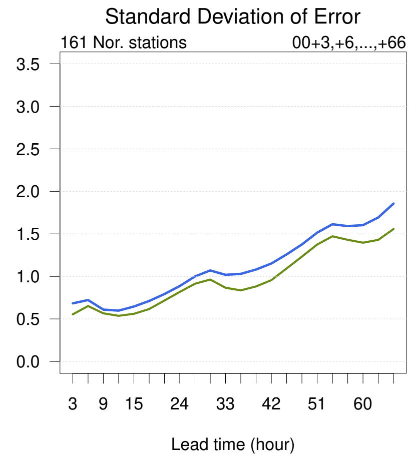
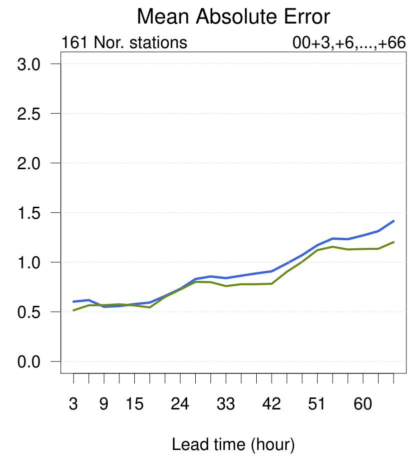


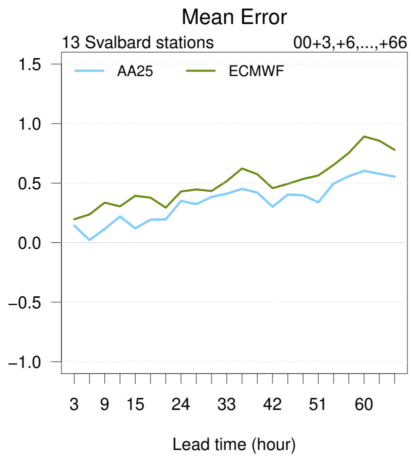
Figure 12: Corresponding prognostic sounding from the Varangerfjord area shows a very moist layer with fog in the boundary layer in the AROME-Arctic (red) while the MEPSctrl was much drier and cloud free. Both models had realistic T and Td profiles for fog and cloud free areas, but the location of the fog was severely off in both.

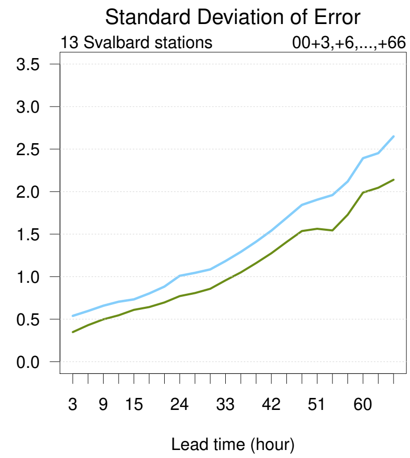
Summarized statistics

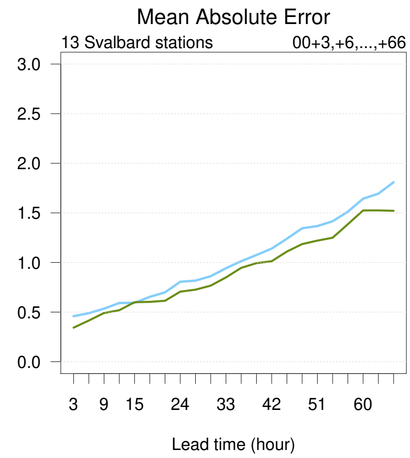

Mean Error
161 Nor. stations
00+3,+6,...,+66
MEPSctrl
ECMWF
1.5
1.0
0.5
0.0
−0.5
−1.0
3 9 15 24 33 42 51 60
Lead time (hour)

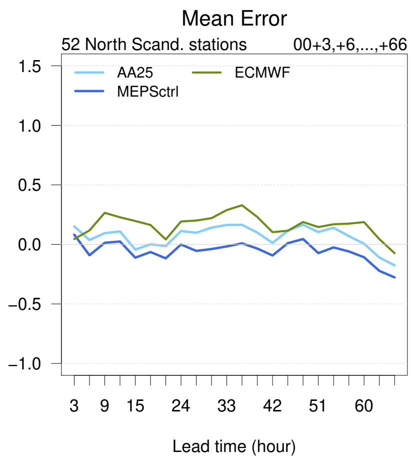

Standard Deviation of Error
161 Nor. stations
00+3,+6,...,+66
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
3 9 15 24 33 42 51 60
Lead time (hour)

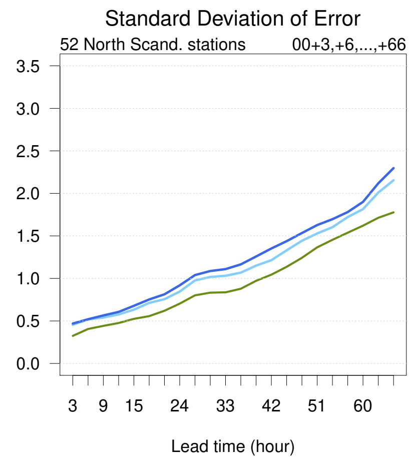

Mean Absolute Error
161 Nor. stations
00+3,+6,...,+66
3.0
2.5
2.0
1.5
1.0
0.5
0.0
3 9 15 24 33 42 51 60
Lead time (hour)

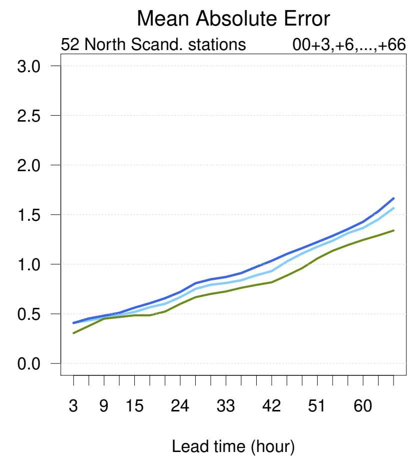

Mean Error
13 Svalbard stations
00+3,+6,...,+66
AA25
ECMWF
1.5
1.0
0.5
0.0
−0.5
−1.0
3 9 15 24 33 42 51 60
Lead time (hour)

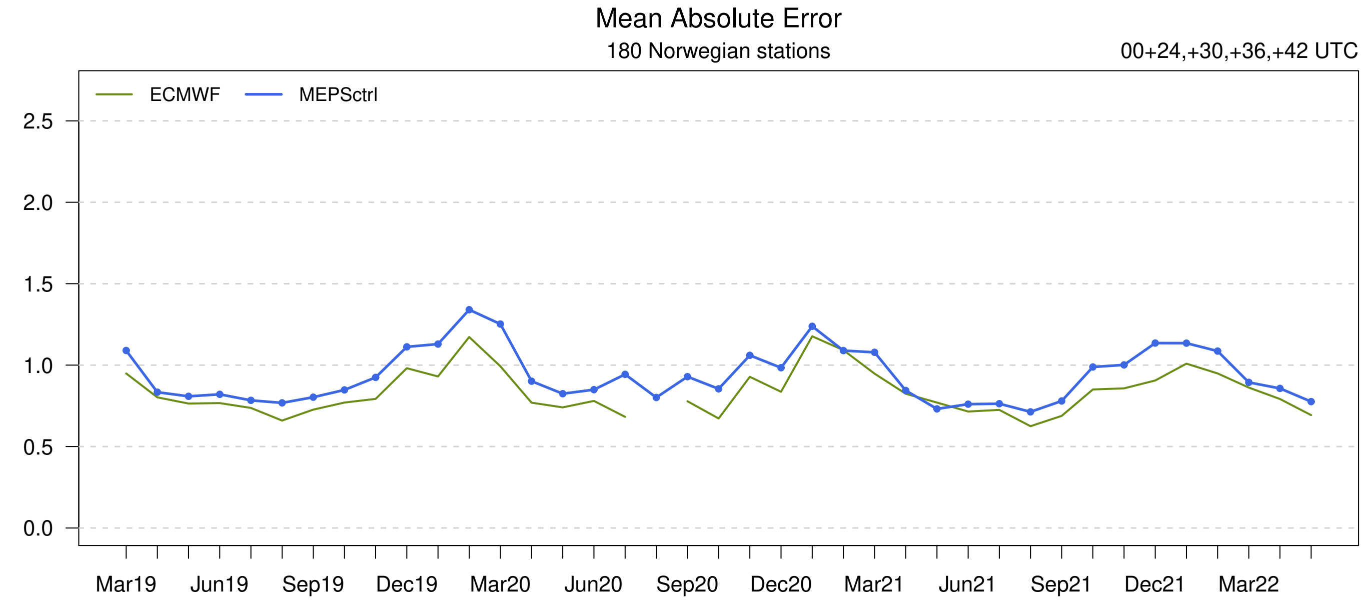

Standard Deviation of Error
13 Svalbard stations
00+3,+6,...,+66
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
3 9 15 24 33 42 51 60
Lead time (hour)

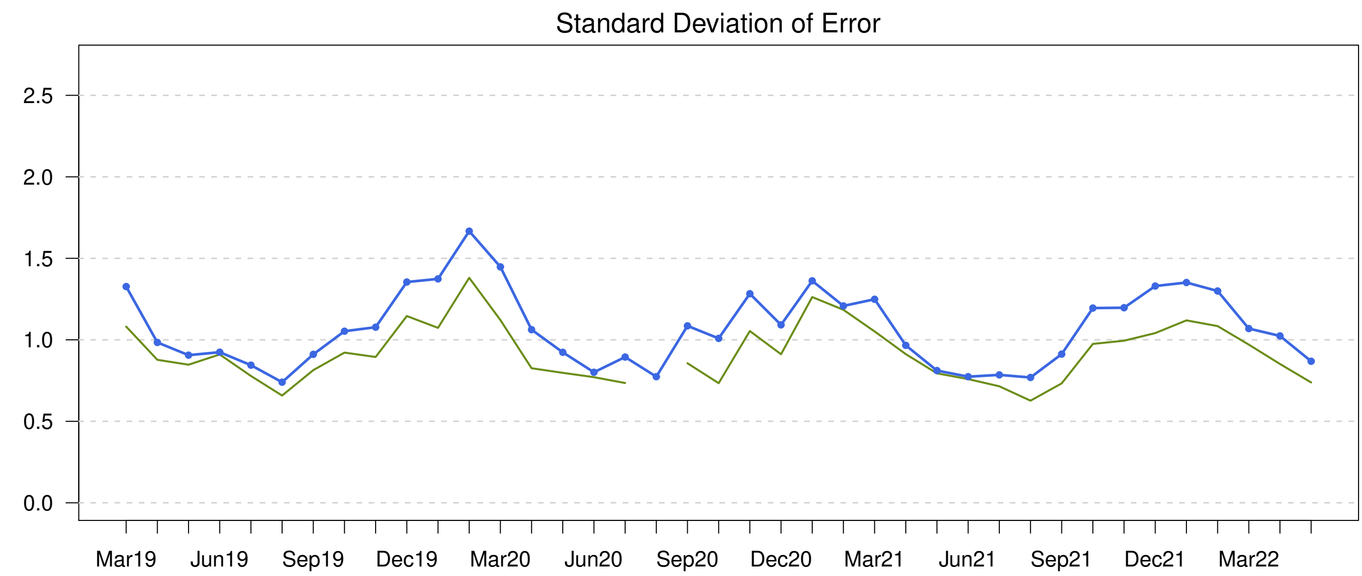

Mean Absolute Error
13 Svalbard stations
00+3,+6,...,+66
3.0
2.5
2.0
1.5
1.0
0.5
0.0
3 9 15 24 33 42 51 60
Lead time (hour)

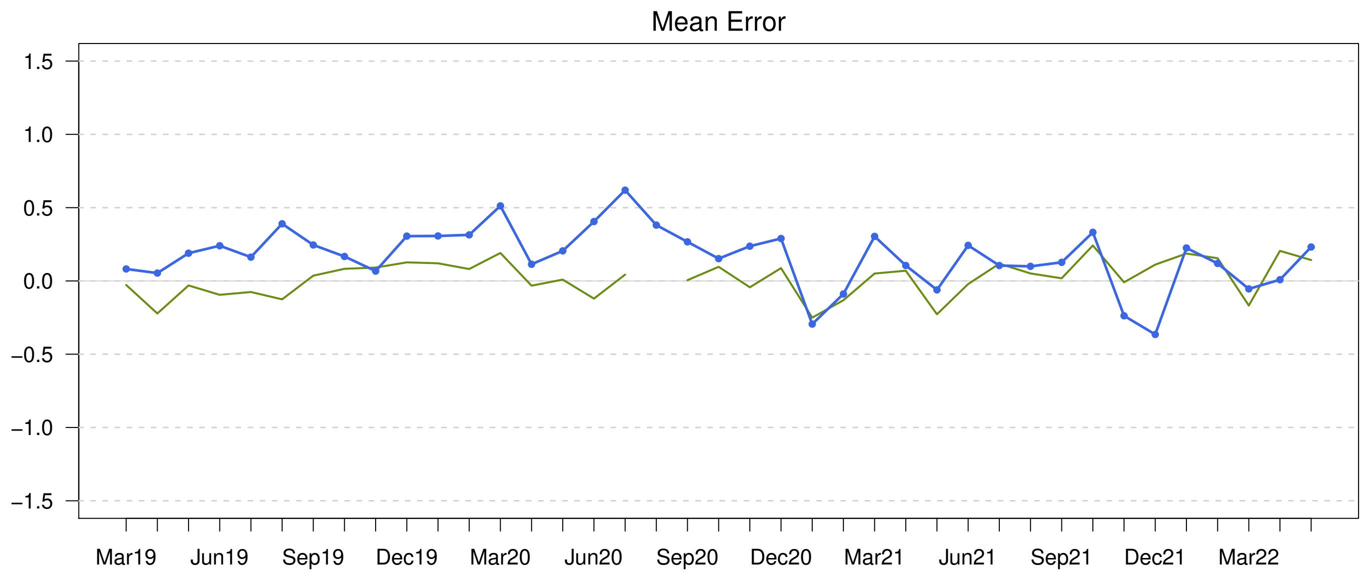

Mean Error
52 North Scand. stations
00+3,+6,...,+66
AA25
MEPSctrl
ECMWF
1.5
1.0
0.5
0.0
−0.5
−1.0
3 9 15 24 33 42 51 60
Lead time (hour)

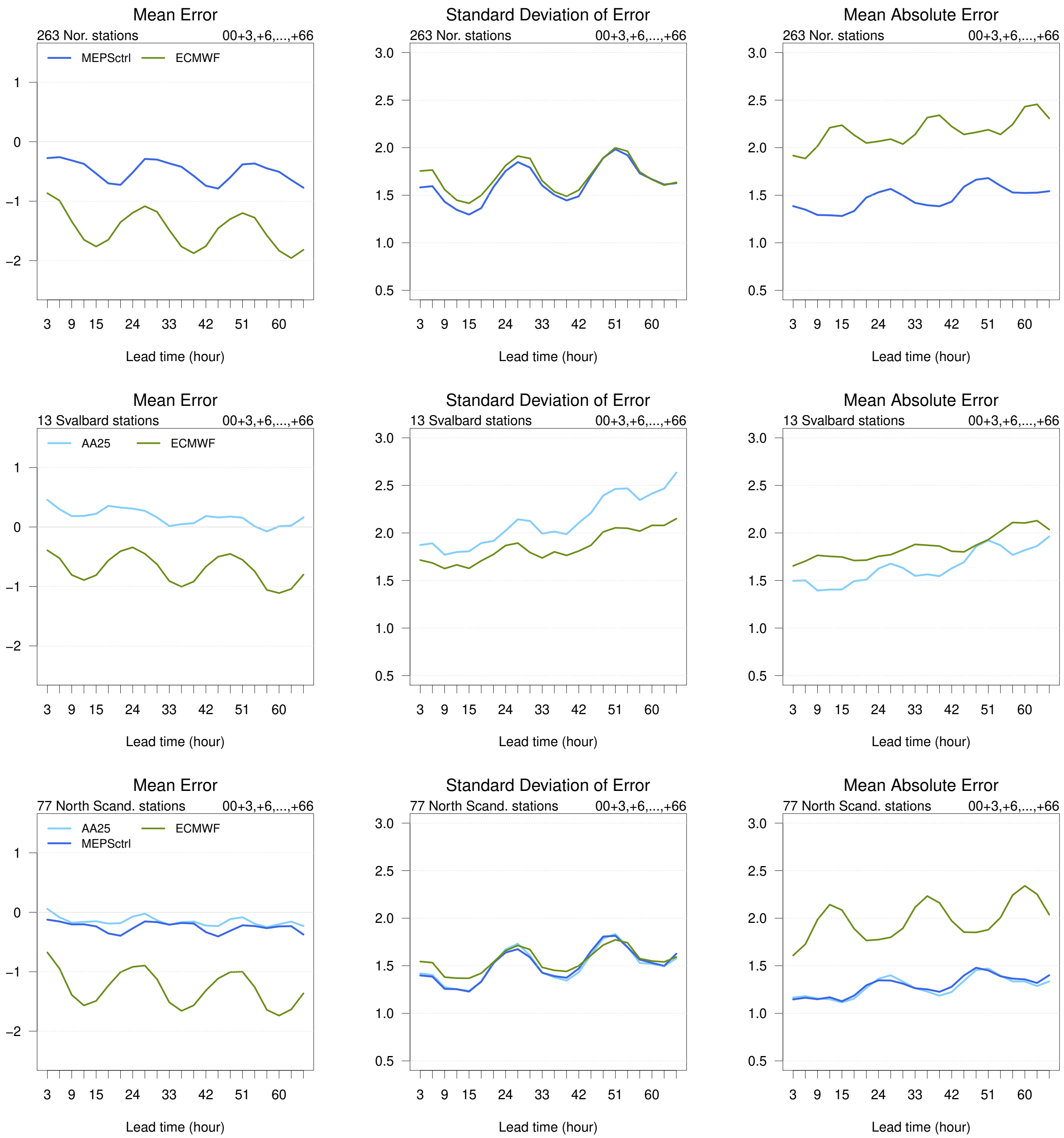

Standard Deviation of Error
52 North Scand. stations
00+3,+6,...,+66
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
3 9 15 24 33 42 51 60
Lead time (hour)


Mean Absolute Error
52 North Scand. stations
00+3,+6,...,+66
3.0
2.5
2.0
1.5
1.0
0.5
0.0
3 9 15 24 33 42 51 60
Lead time (hour)


Mean Absolute Error
180 Norwegian stations
00+24,+30,+36,+42 UTC
ECMWF
MEPSctrl
2.5
2.0
1.5
1.0
0.5
0.0
Mar19
Jun19
Sep19
Dec19
Mar20
Jun20
Sep20
Dec20
Mar21
Jun21
Sep21
Dec21
Mar22

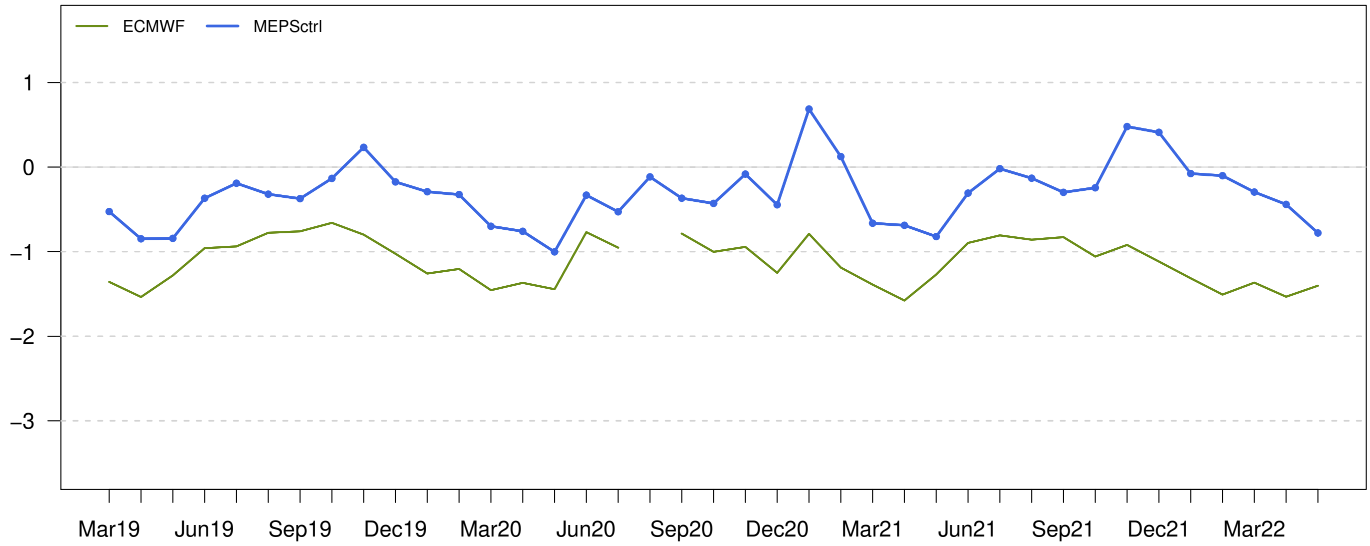

Standard Deviation of Error
2.5
2.0
1.5
1.0
0.5
0.0
Mar19
Jun19
Sep19
Dec19
Mar20
Jun20
Sep20
Dec20
Mar21
Jun21
Sep21
Dec21
Mar22


Mean Error
1.5
1.0
0.5
0.0
−0.5
−1.0
−1.5
Mar19
Jun19
Sep19
Dec19
Mar20
Jun20
Sep20
Dec20
Mar21
Jun21
Sep21
Dec21
Mar22

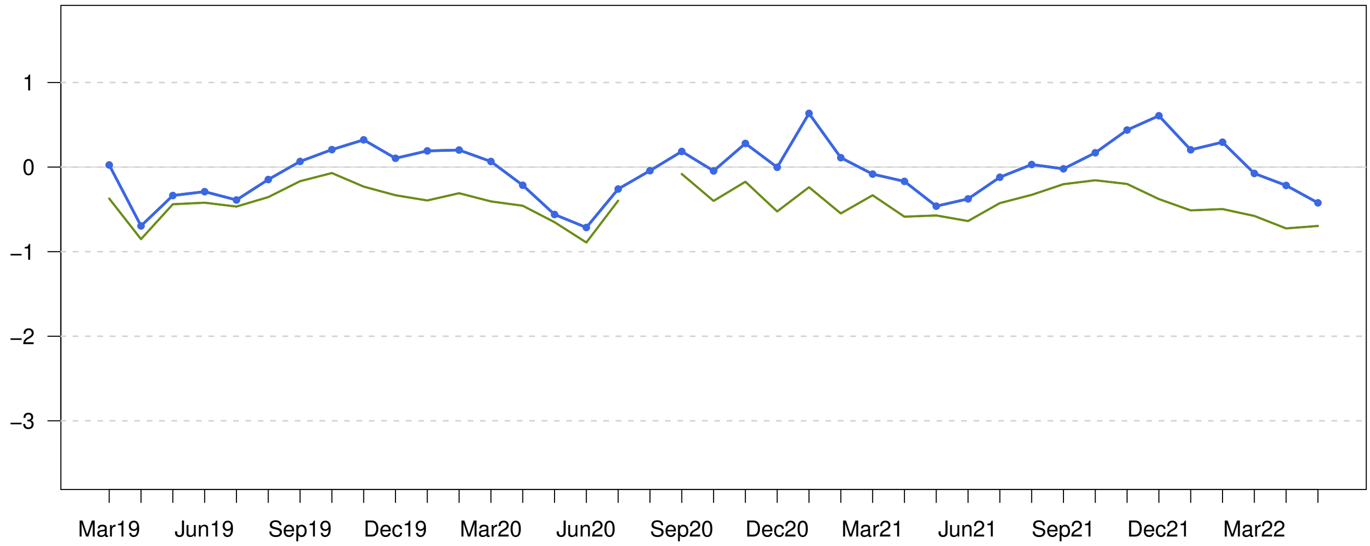

Mean Error
263 Nor. stations
00+3,+6,...,+66
MEPSctrl
ECMWF
Standard Deviation of Error
263 Nor. stations
00+3,+6,...,+66
Mean Absolute Error
263 Nor. stations
00+3,+6,...,+66
Mean Error
13 Svalbard stations
00+3,+6,...,+66
AA25
ECMWF
Standard Deviation of Error
13 Svalbard stations
00+3,+6,...,+66
Mean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

Mean Error

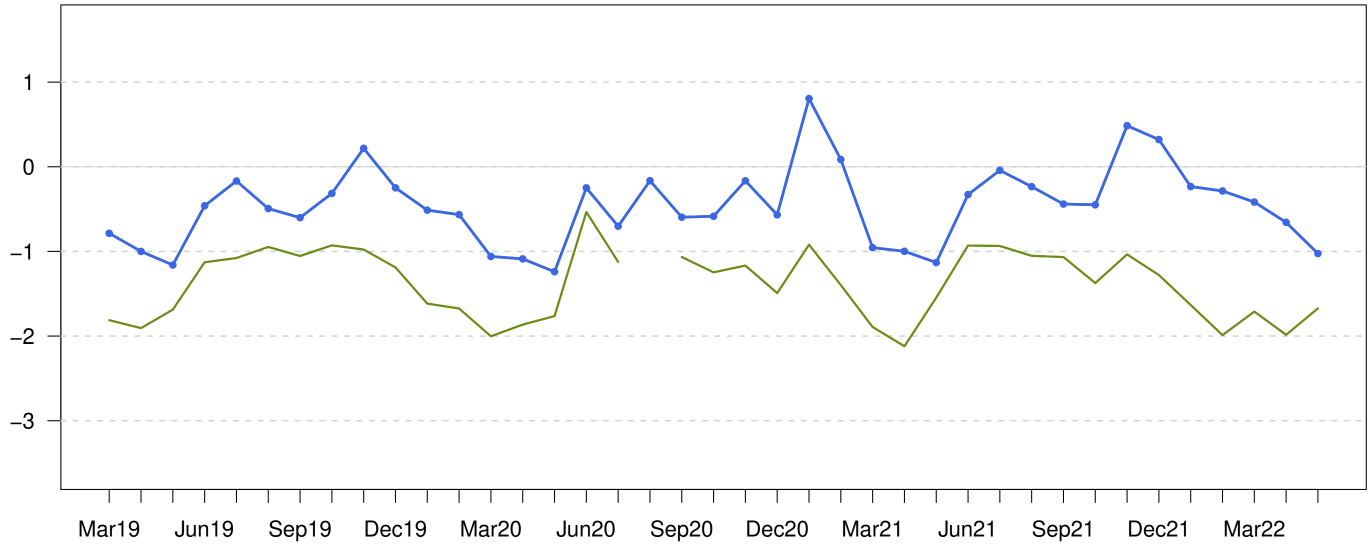
275 Norwegian stations 00+24,+30,+36,+42 UTC



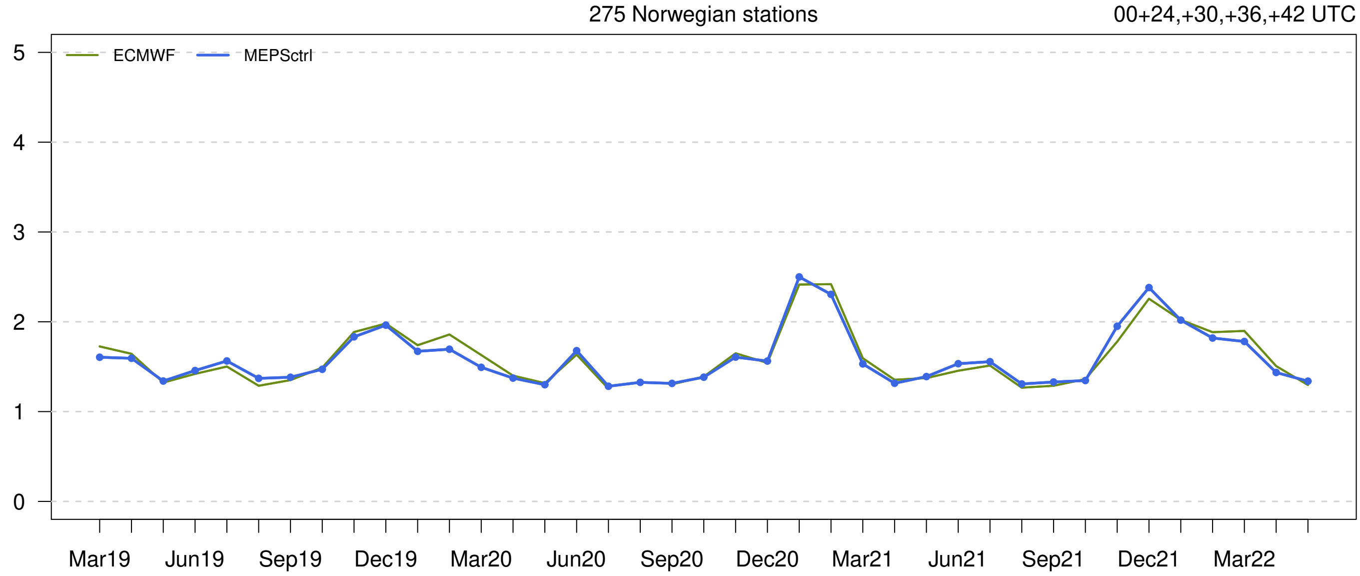
48 Norwegian coastal stations

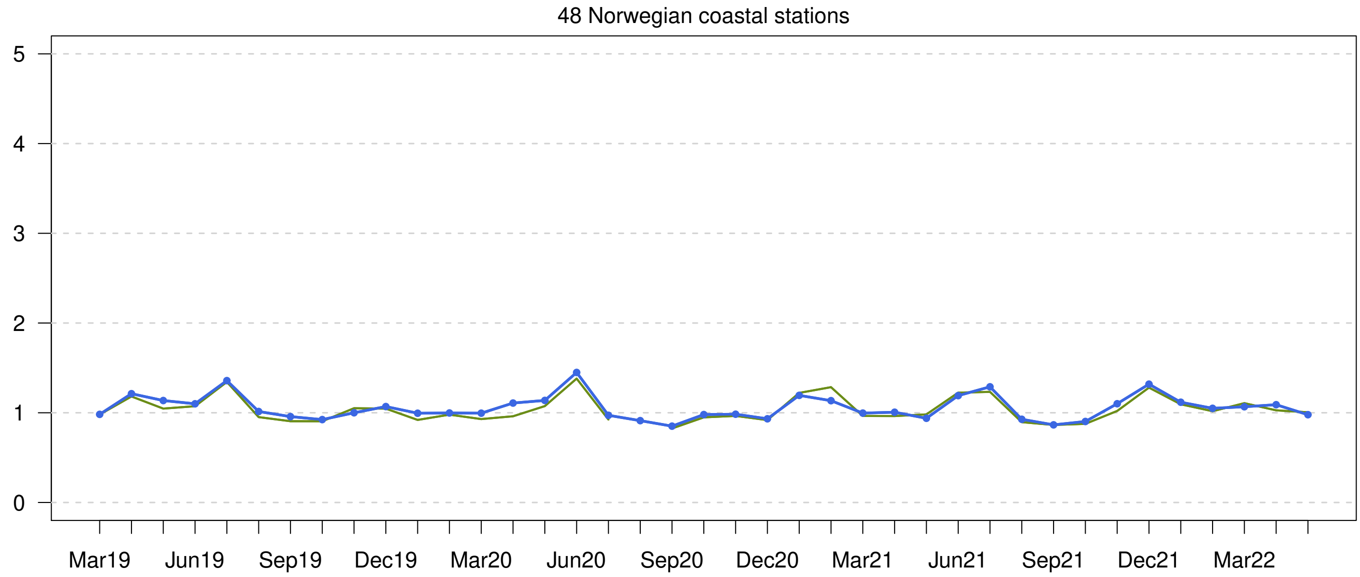


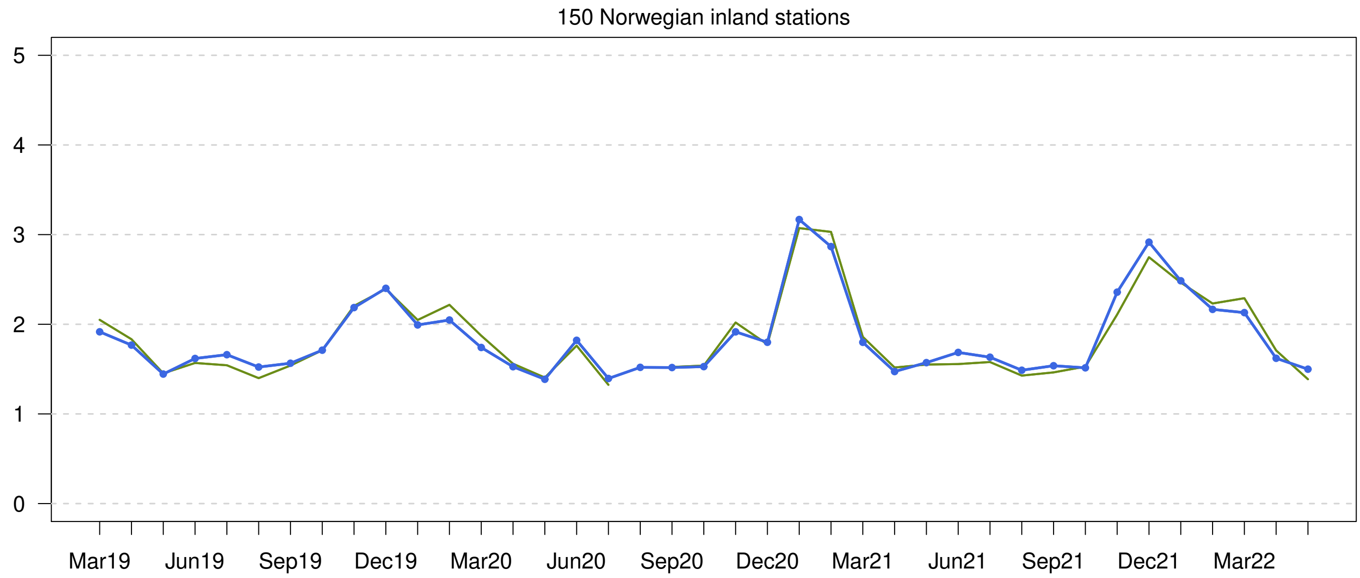
150 Norwegian inland stations



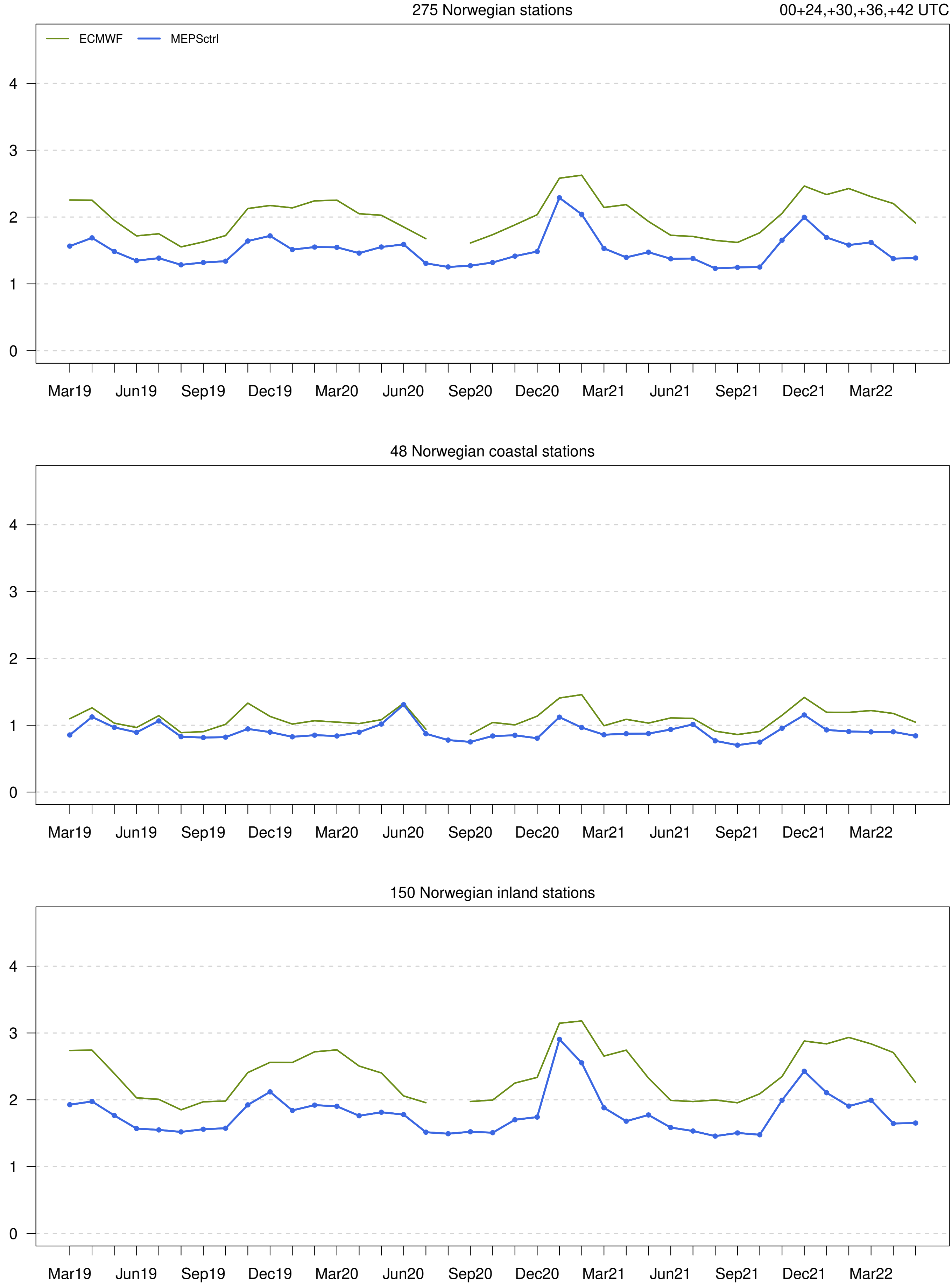
Standard Deviation of Error

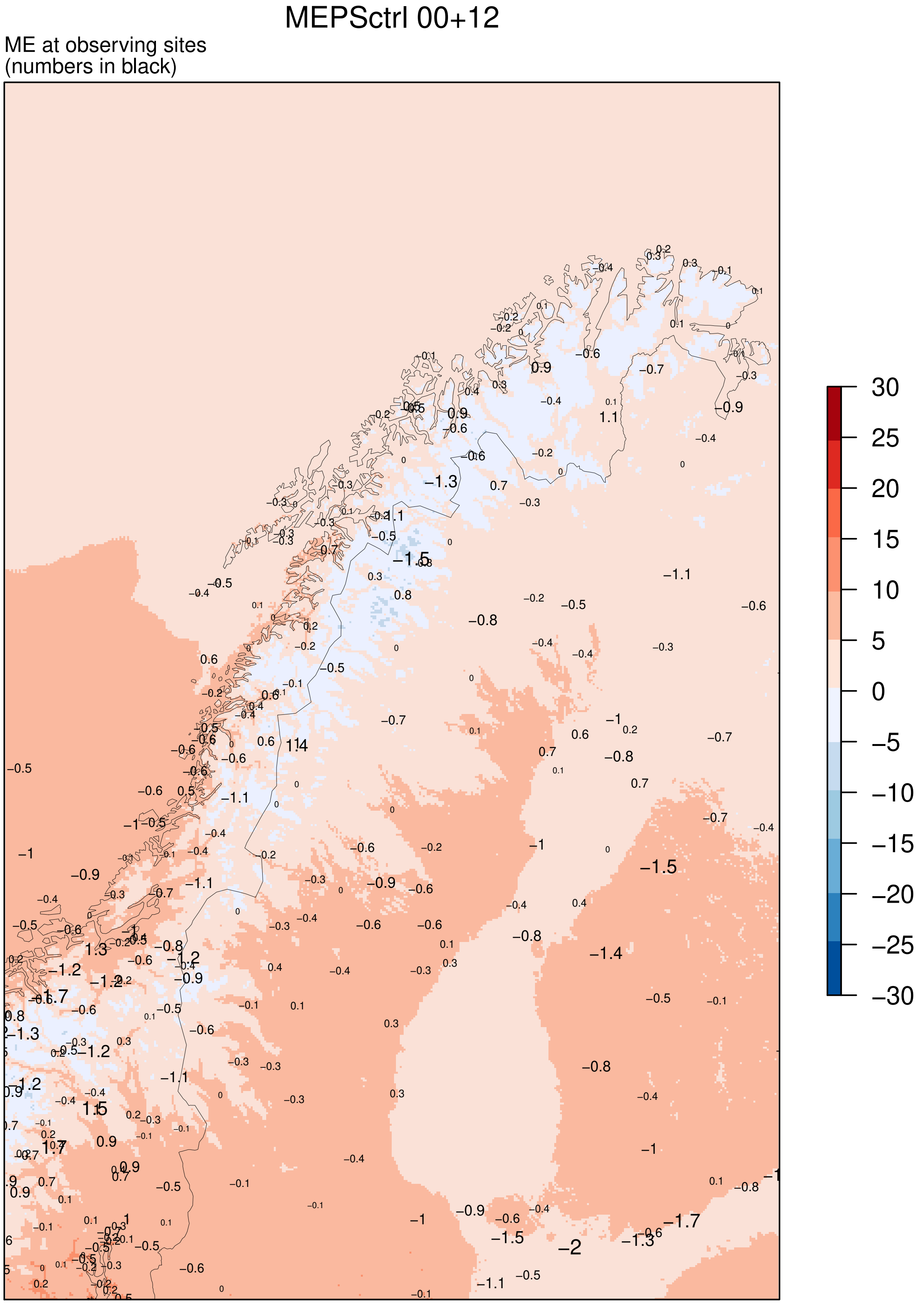






Mean Absolute Error

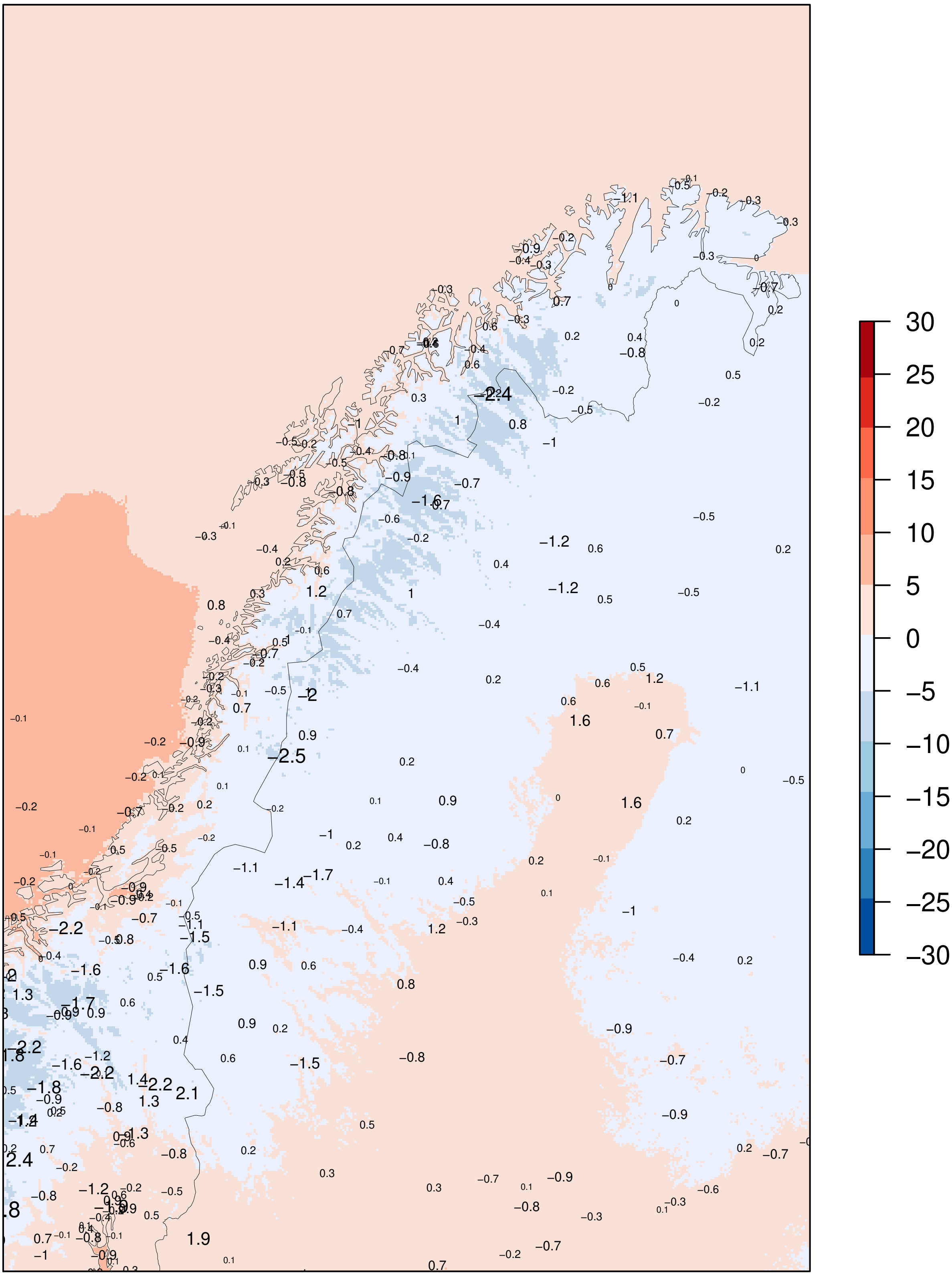




Model "climatology" 01.03.2022 – 31.05.2022

MEPSctrl 00+24

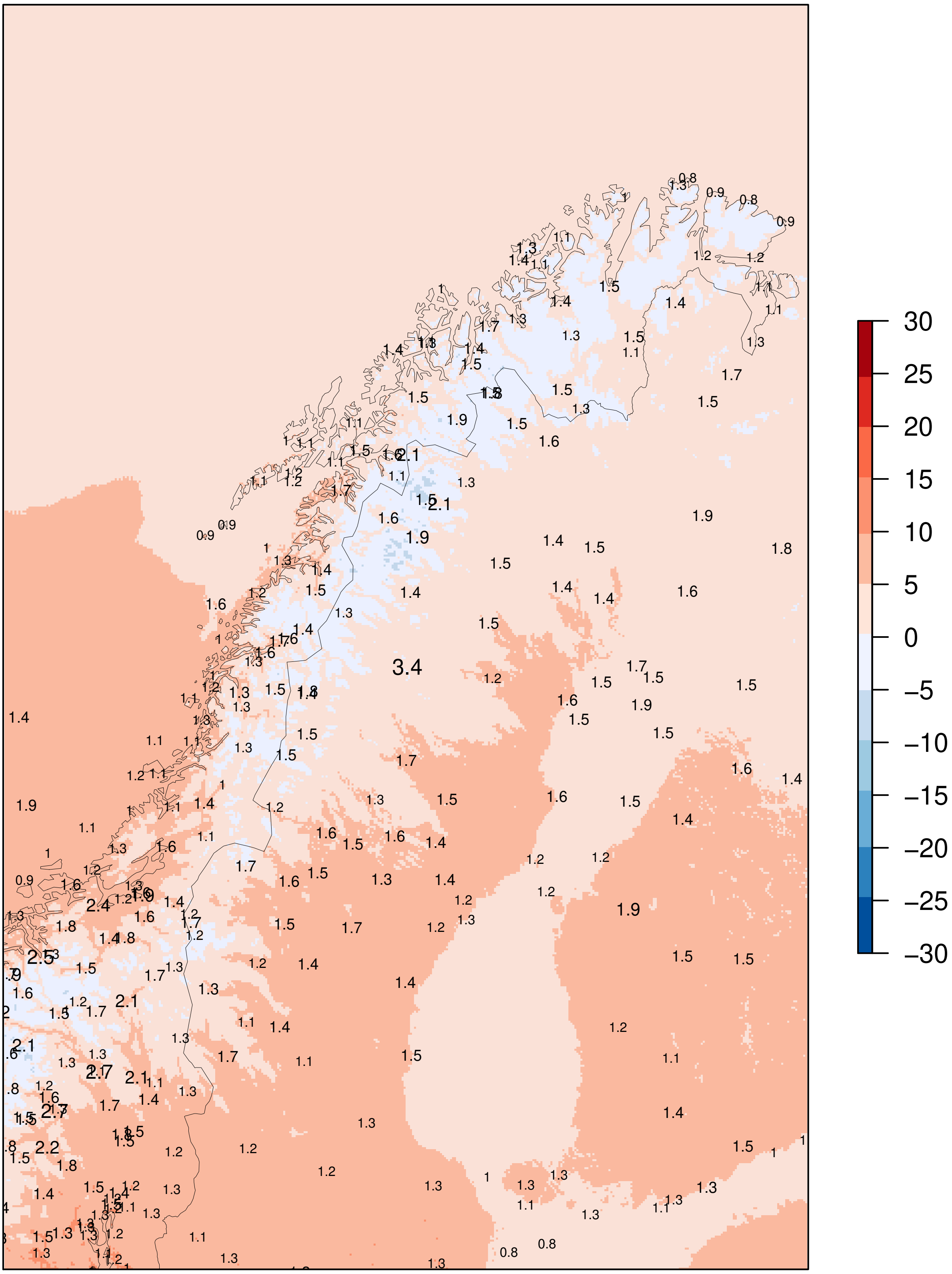
ME at observing sites
(numbers in black)



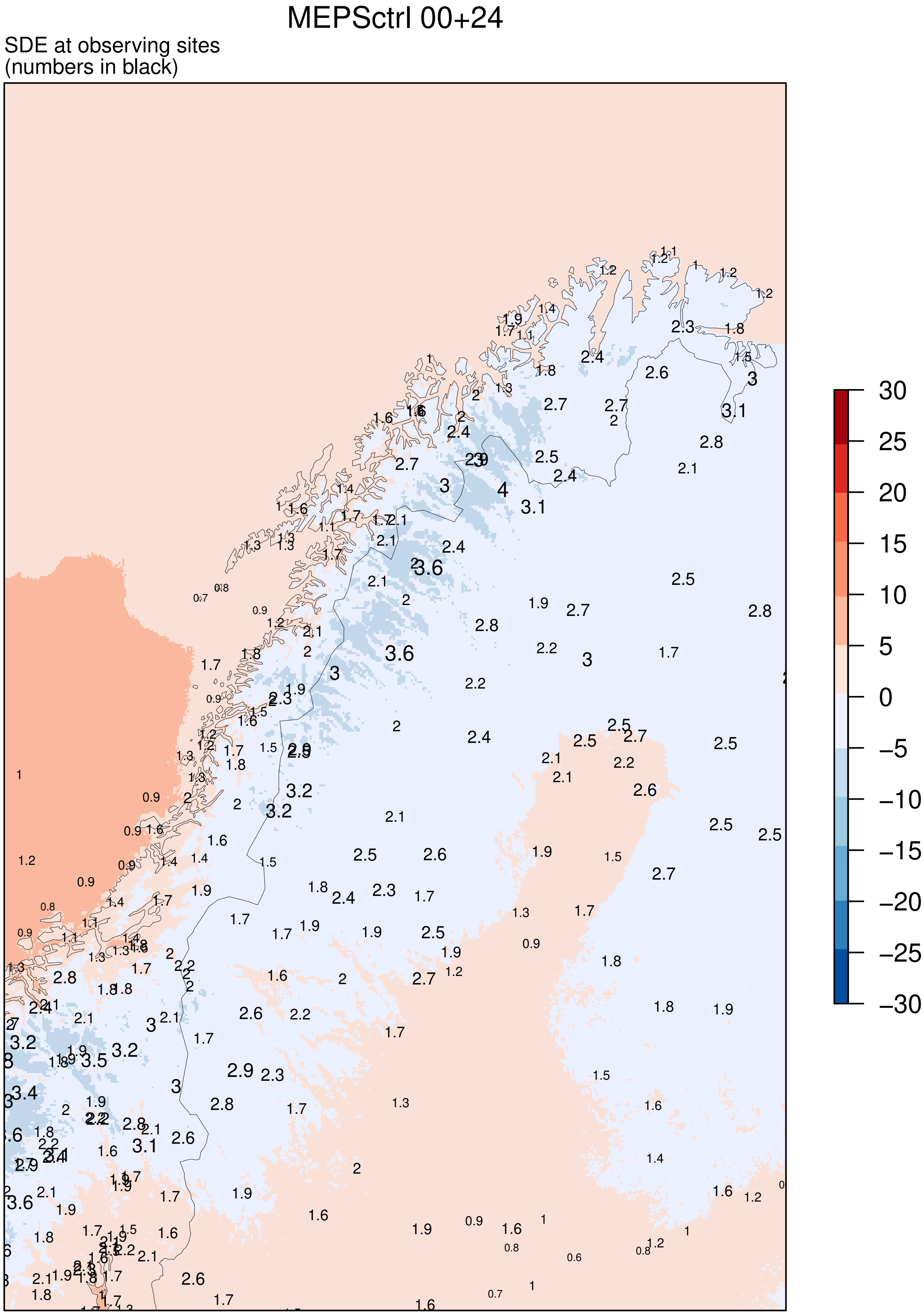
Model "climatology" 01.03.2022 – 31.05.2022

MEPSctrl 00+12

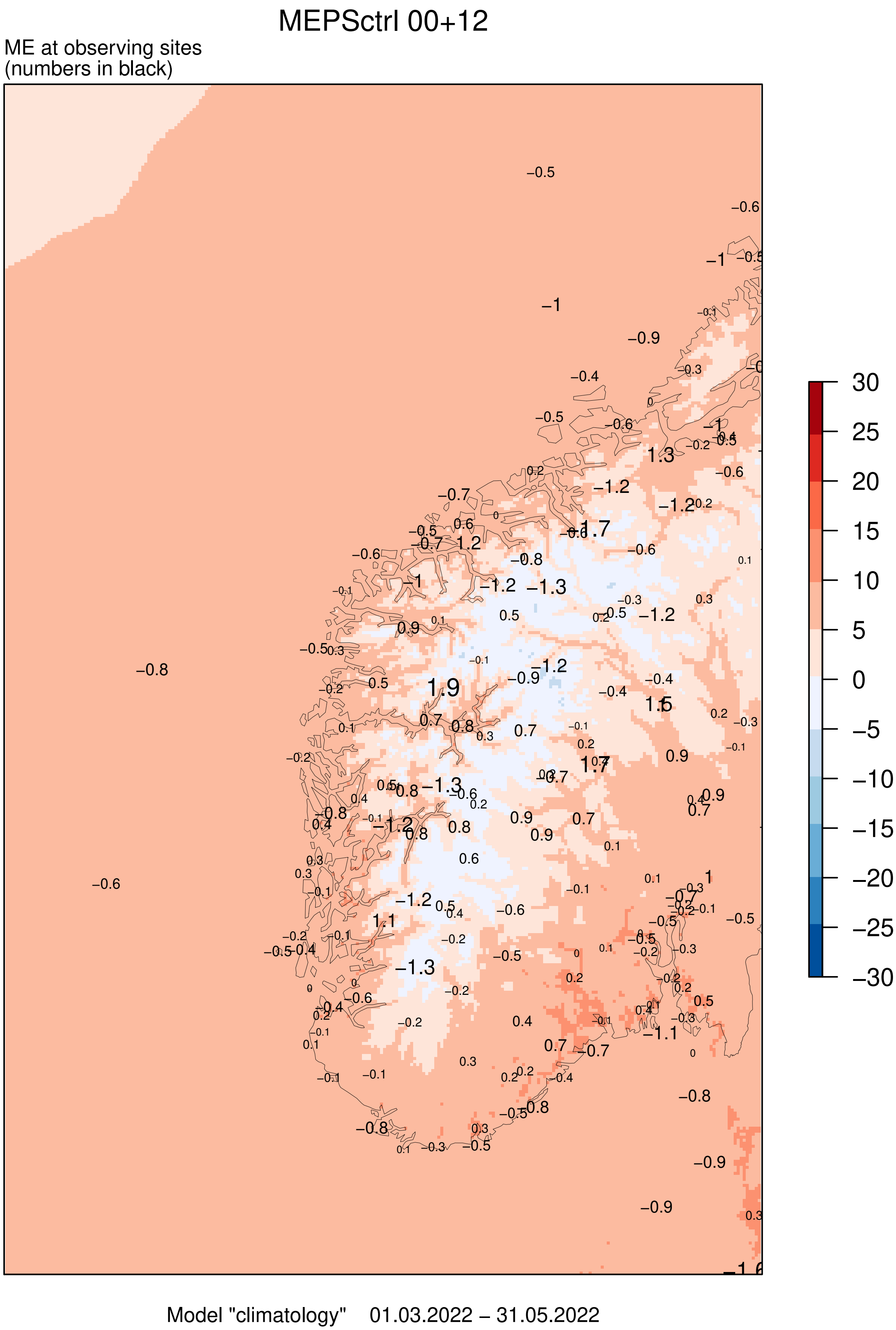
SDE at observing sites
(numbers in black)

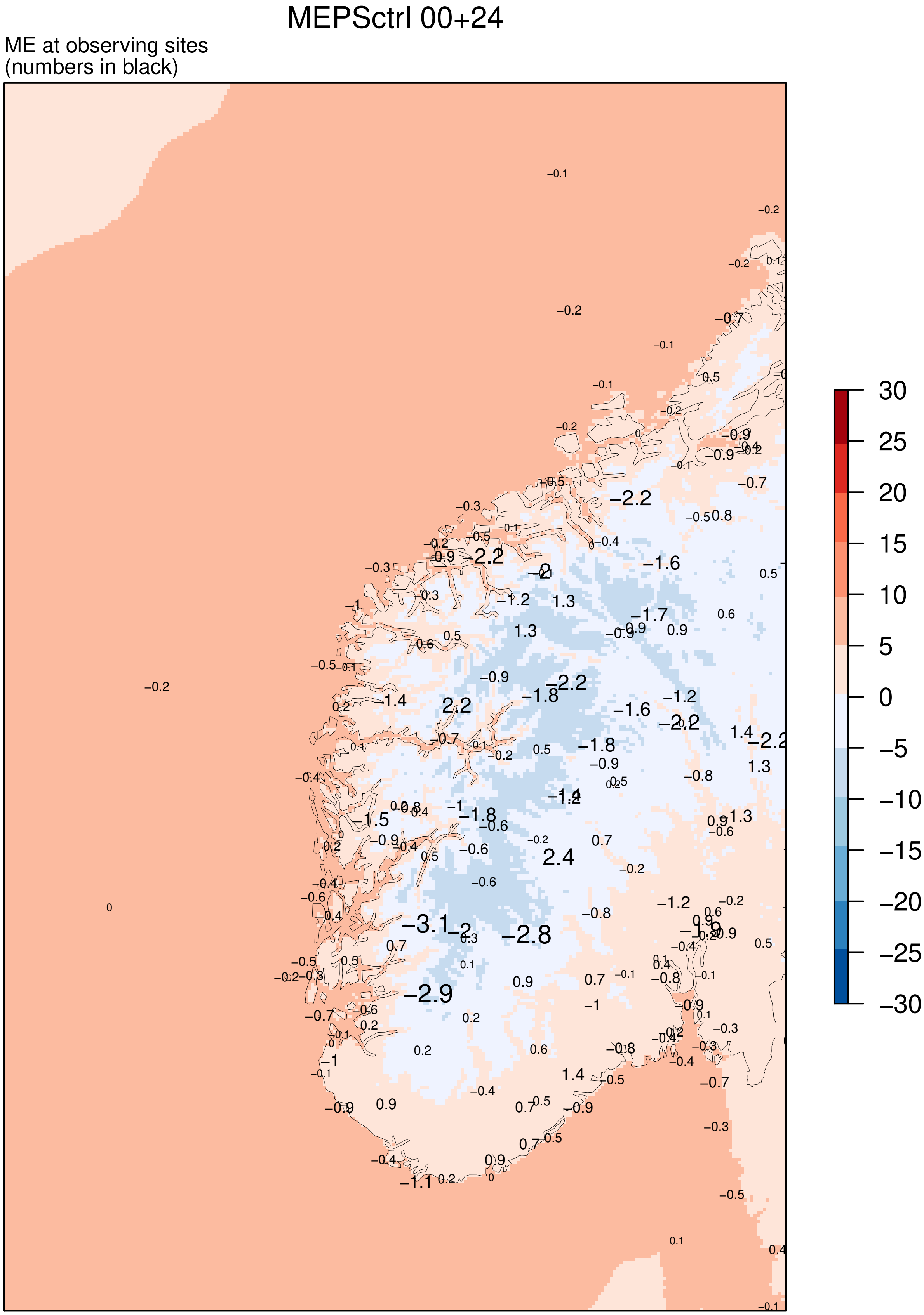


Model "climatology" 01.03.2022 – 31.05.2022



Model "climatology" 01.03.2022 – 31.05.2022

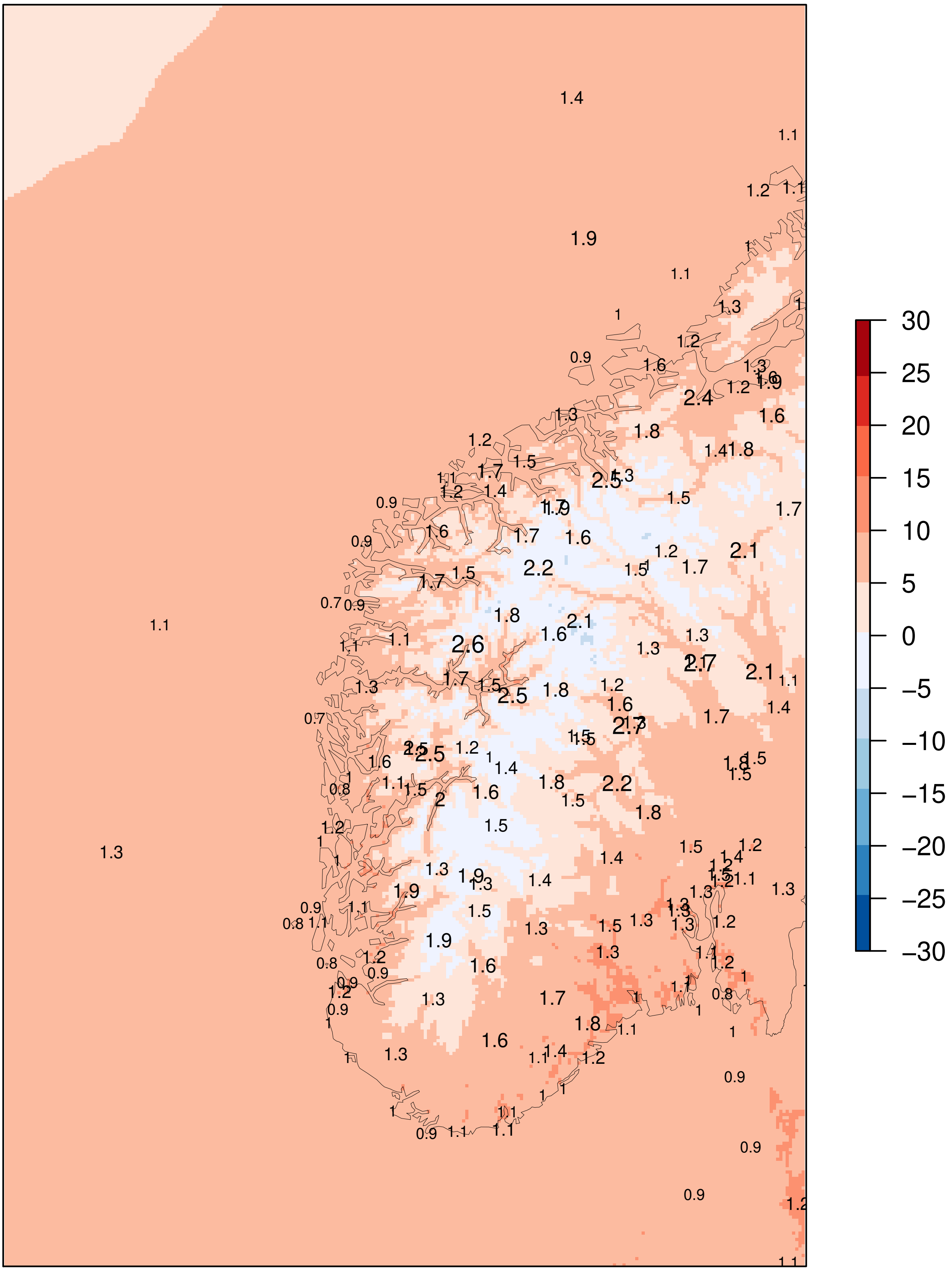

MEPSctrl 00+12
ME at observing sites
(numbers in black)
30
25
20
15
10
5
0
−5
−10
−15
−20
−25
−30
Model "climatology" 01.03.2022 – 31.05.2022



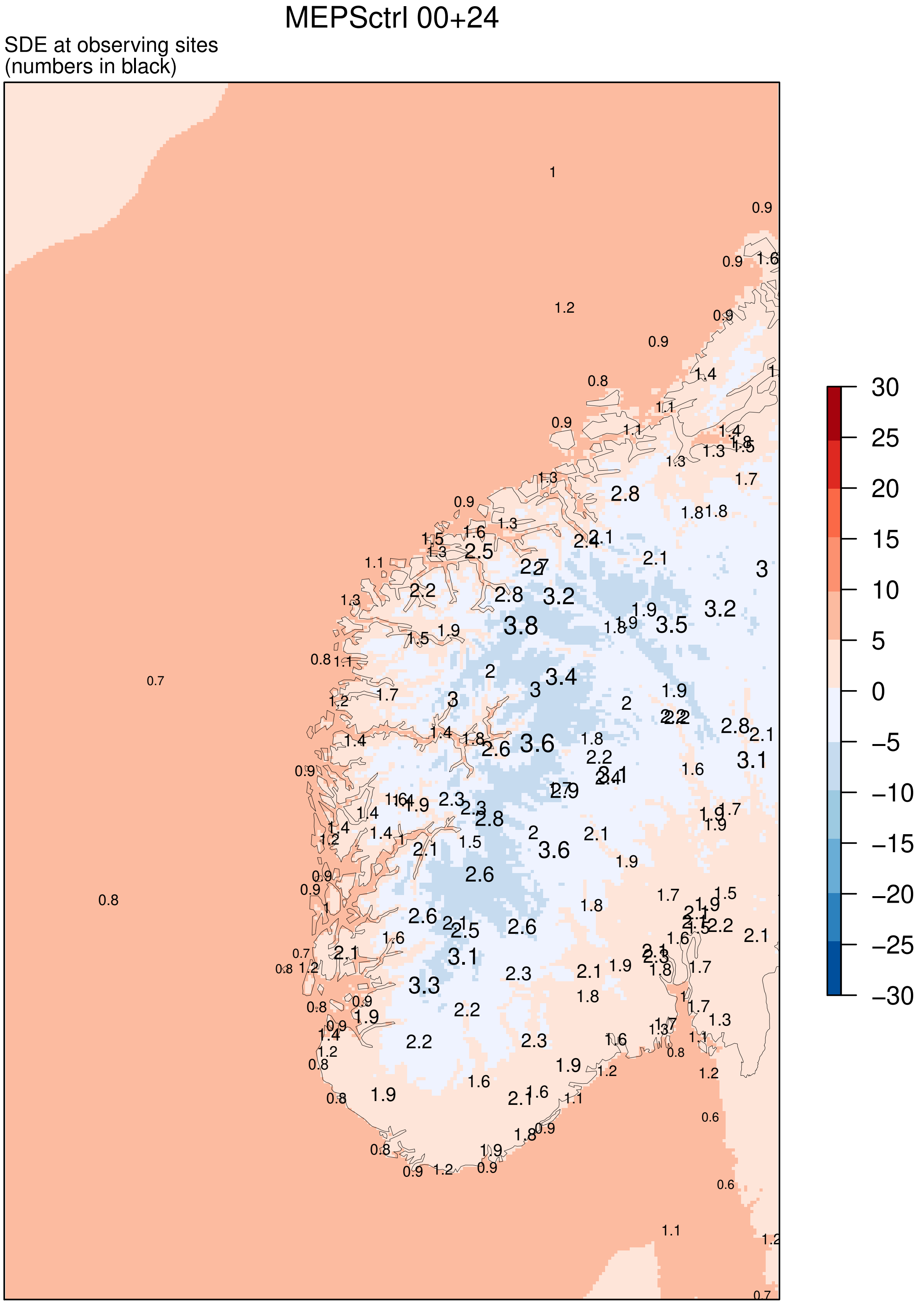
Model "climatology" 01.03.2022 – 31.05.2022

MEPSctrl 00+12

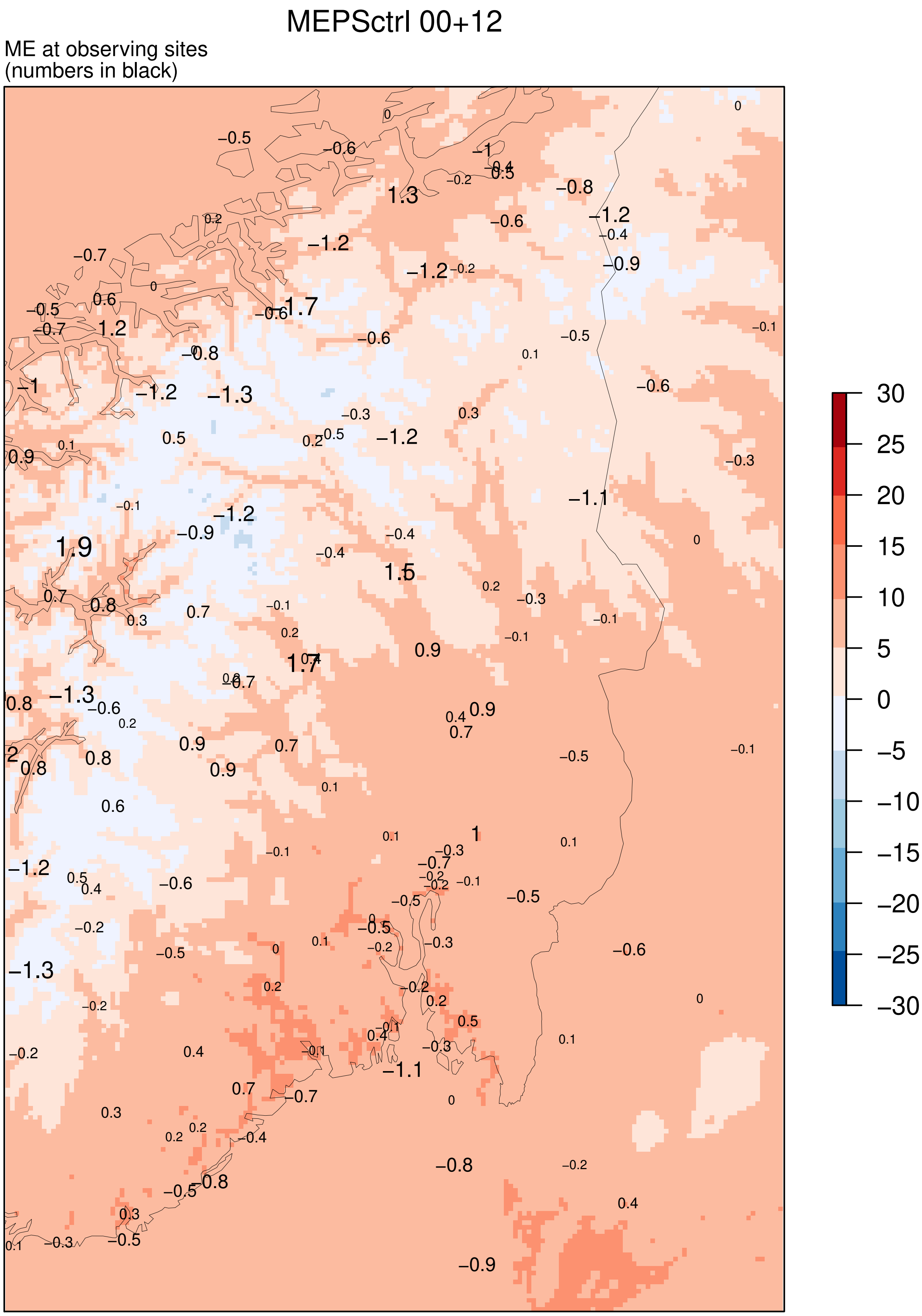
SDE at observing sites
(numbers in black)



Model "climatology" 01.03.2022 – 31.05.2022



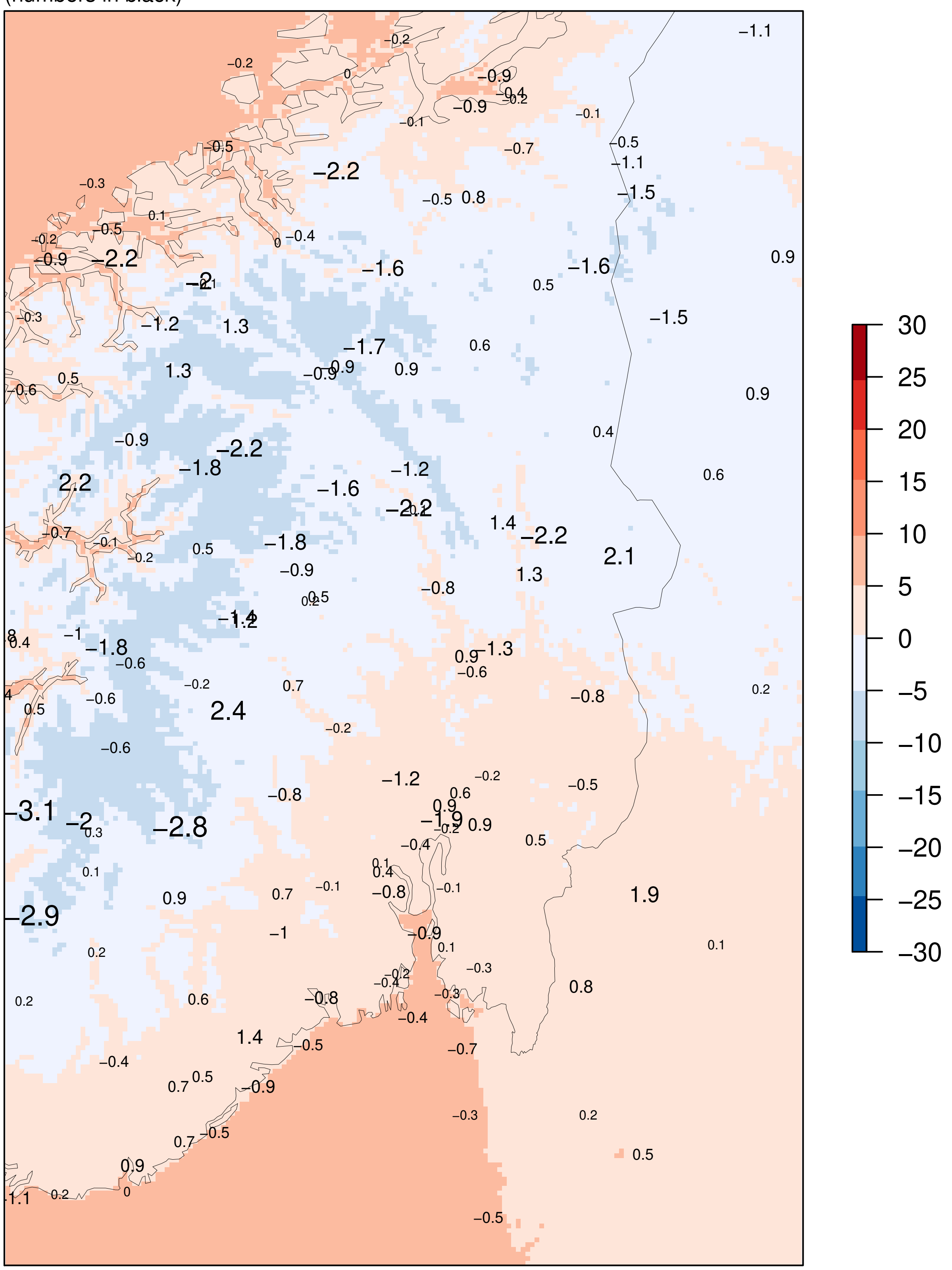
Model "climatology" 01.03.2022 – 31.05.2022



Model "climatology" 01.03.2022 – 31.05.2022

MEPSctrl 00+24

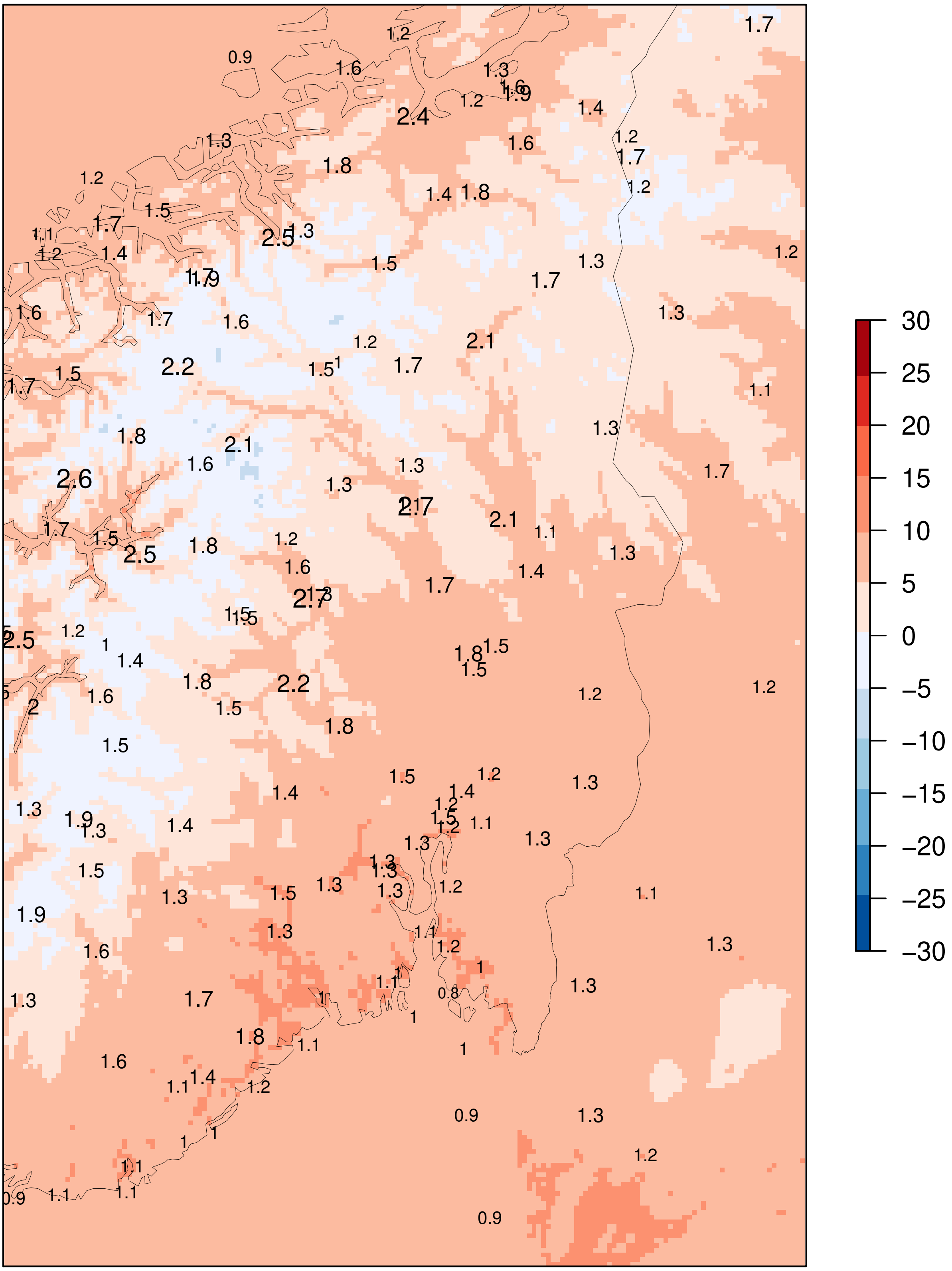
ME at observing sites
(numbers in black)



Model "climatology" 01.03.2022 – 31.05.2022

MEPSctrl 00+12

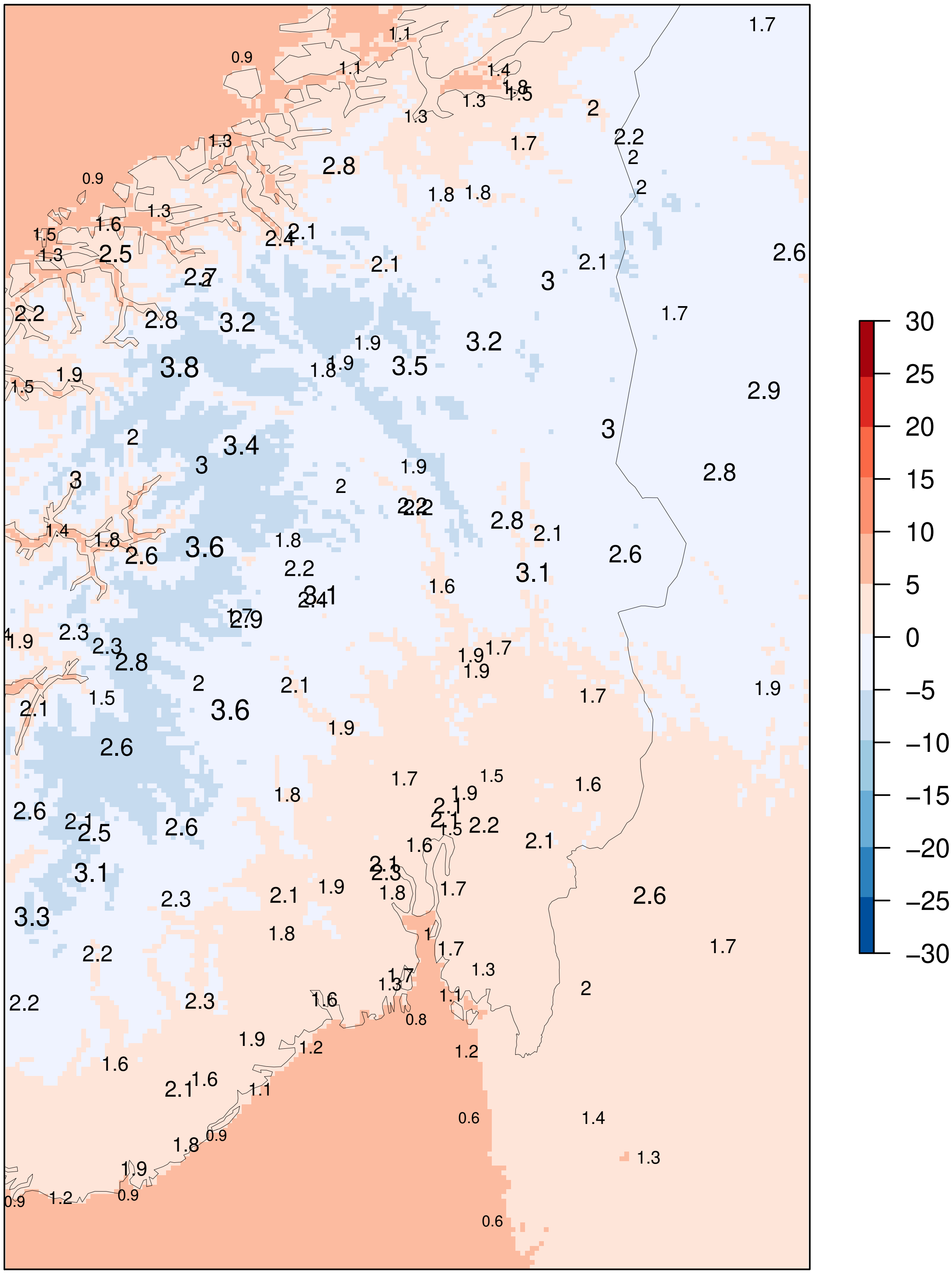
SDE at observing sites
(numbers in black)



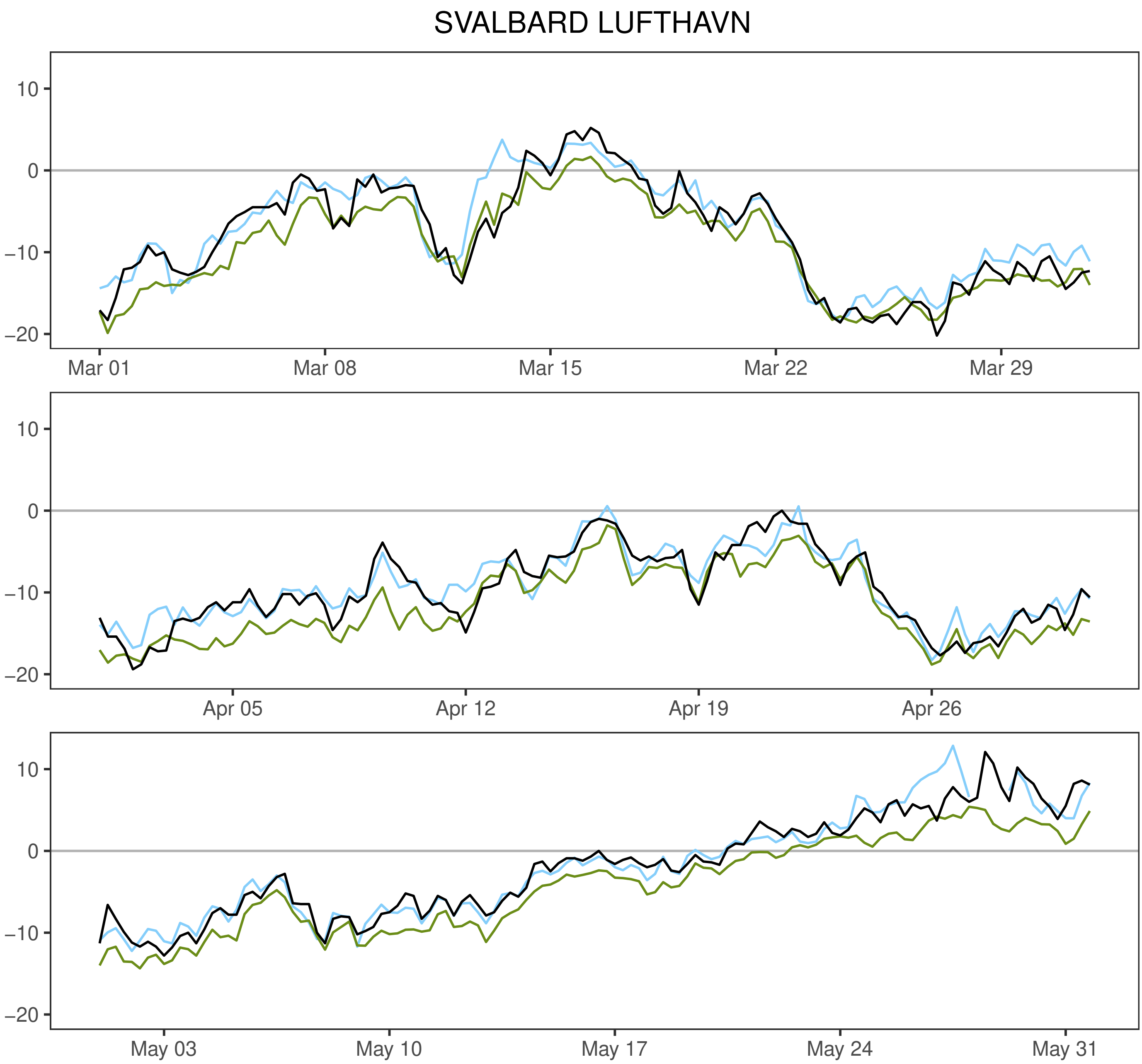
Model "climatology" 01.03.2022 – 31.05.2022

MEPSctrl 00+24

SDE at observing sites
(numbers in black)

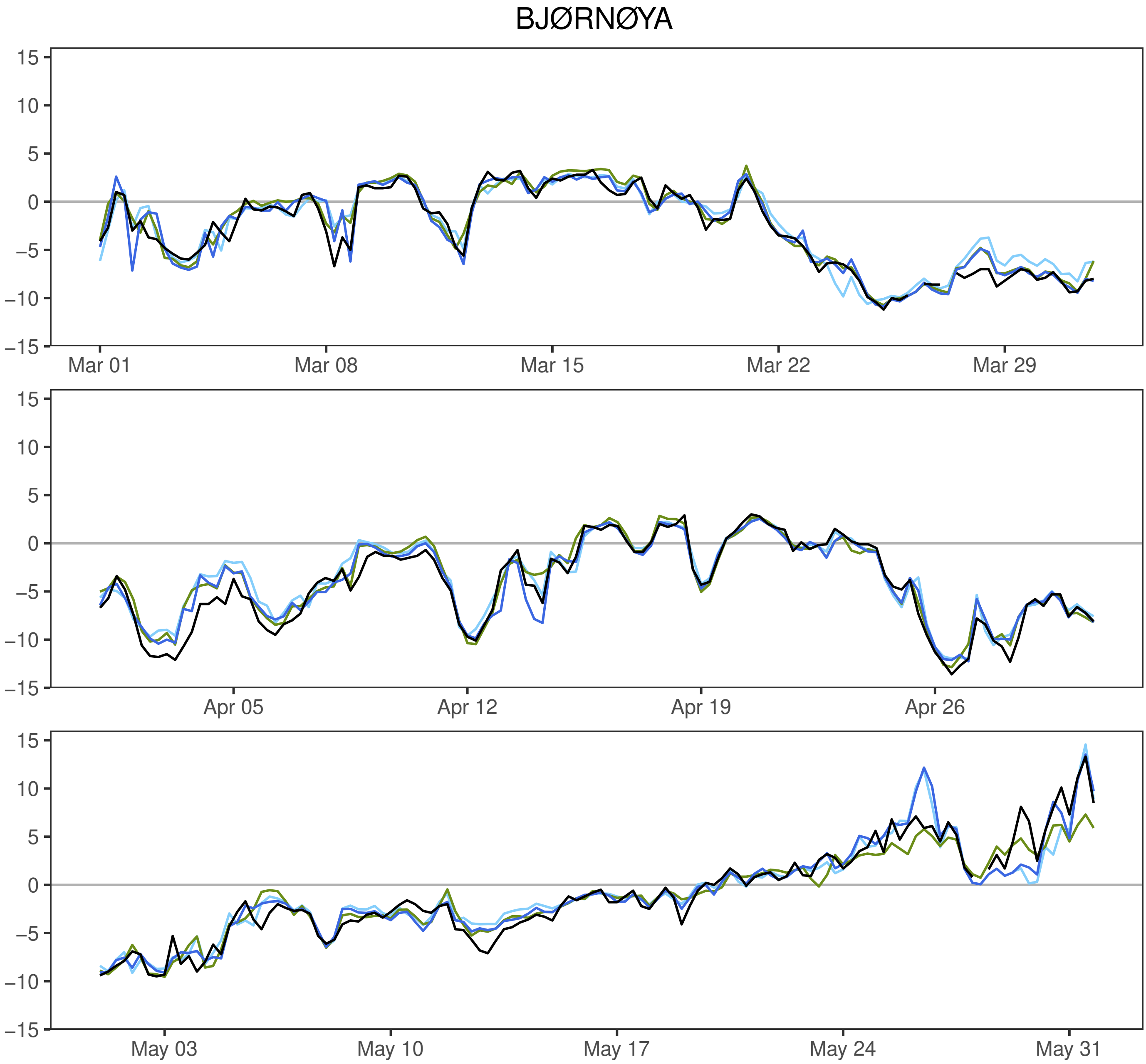


Model "climatology" 01.03.2022 – 31.05.2022



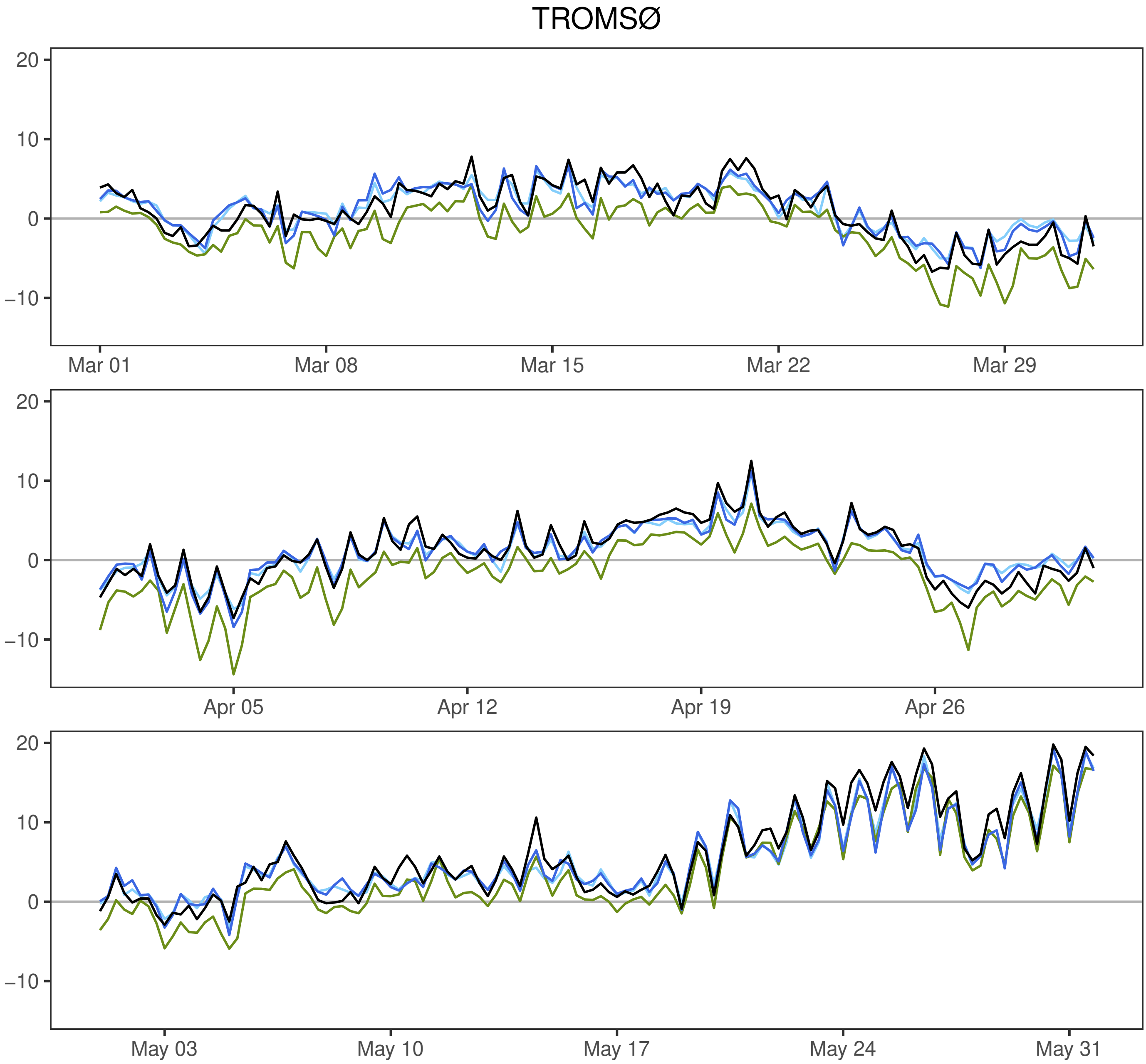
	Min	Mean	Max	Std	N
synop: 00,06,12,18	−20.2	−6.5	12.1	6.8	368
AA25: 12+18,+24,+30,+36	−18.4	−6.2	12.9	6.4	364
ECMWF: 12+18,+24,+30,+36	−19.9	−8.4	5.4	6.2	368

	ME	SDE	RMSE	MAE	Max.abs.err.	N
AA25−synop	0.5	1.9	2.0	1.4	9.7	364
ECMWF−synop	−1.9	1.7	2.6	2.2	7.6	364



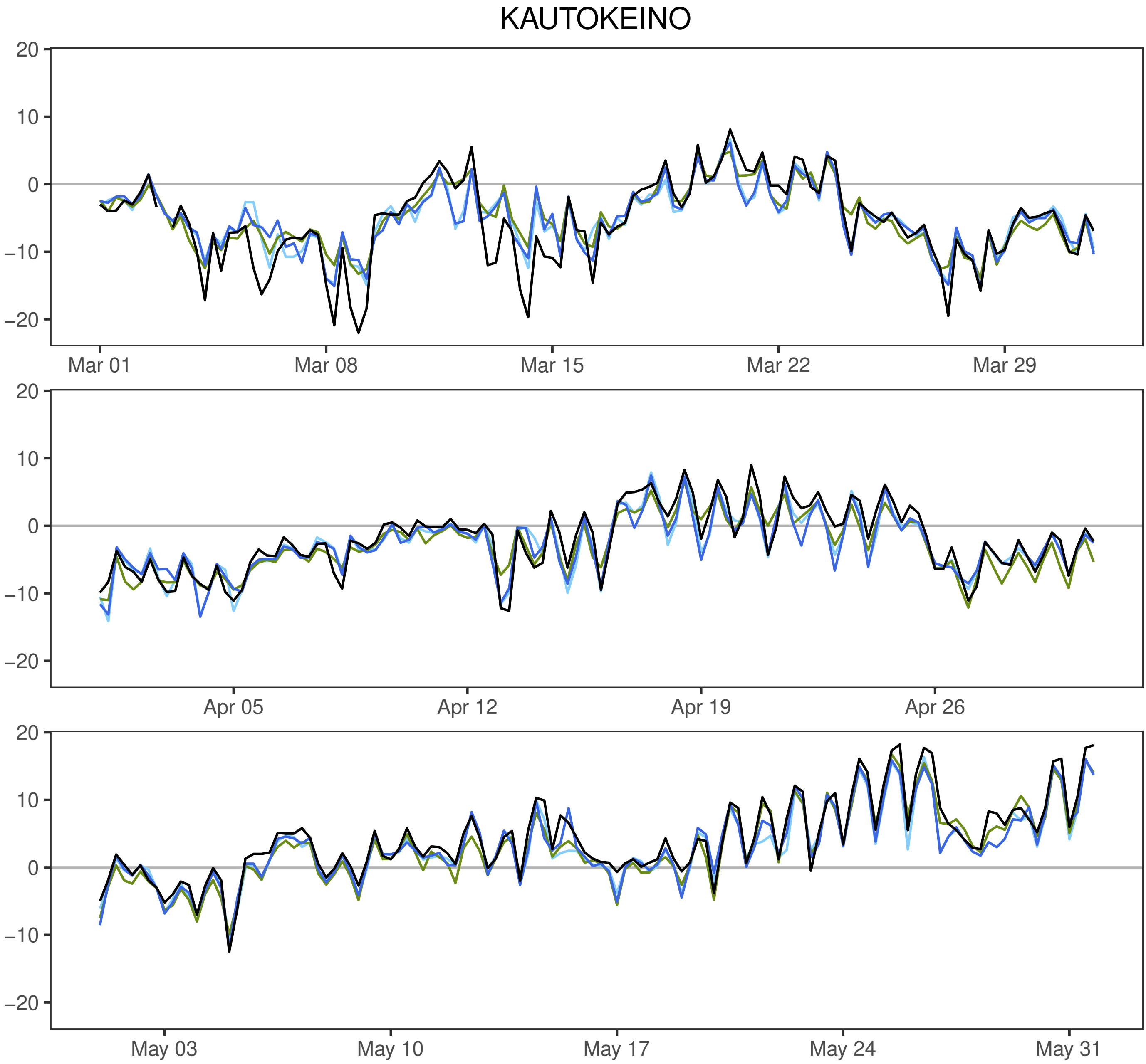
	Min	Mean	Max	Std	N
synop: 00,06,12,18	−13.6	−2.6	13.3	4.6	365
MEPSctrl: 12+18,+24,+30,+36	−12.3	−2.5	13.5	4.5	368
AA25: 12+18,+24,+30,+36	−12.0	−2.3	14.6	4.3	364
ECMWF: 12+18,+24,+30,+36	−12.9	−2.5	7.3	4.2	368

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl−synop	0.2	1.2	1.3	0.9	6.3	362
AA25−synop	0.4	1.4	1.5	1.1	6.5	362
ECMWF−synop	0.2	1.2	1.2	0.9	6.0	362



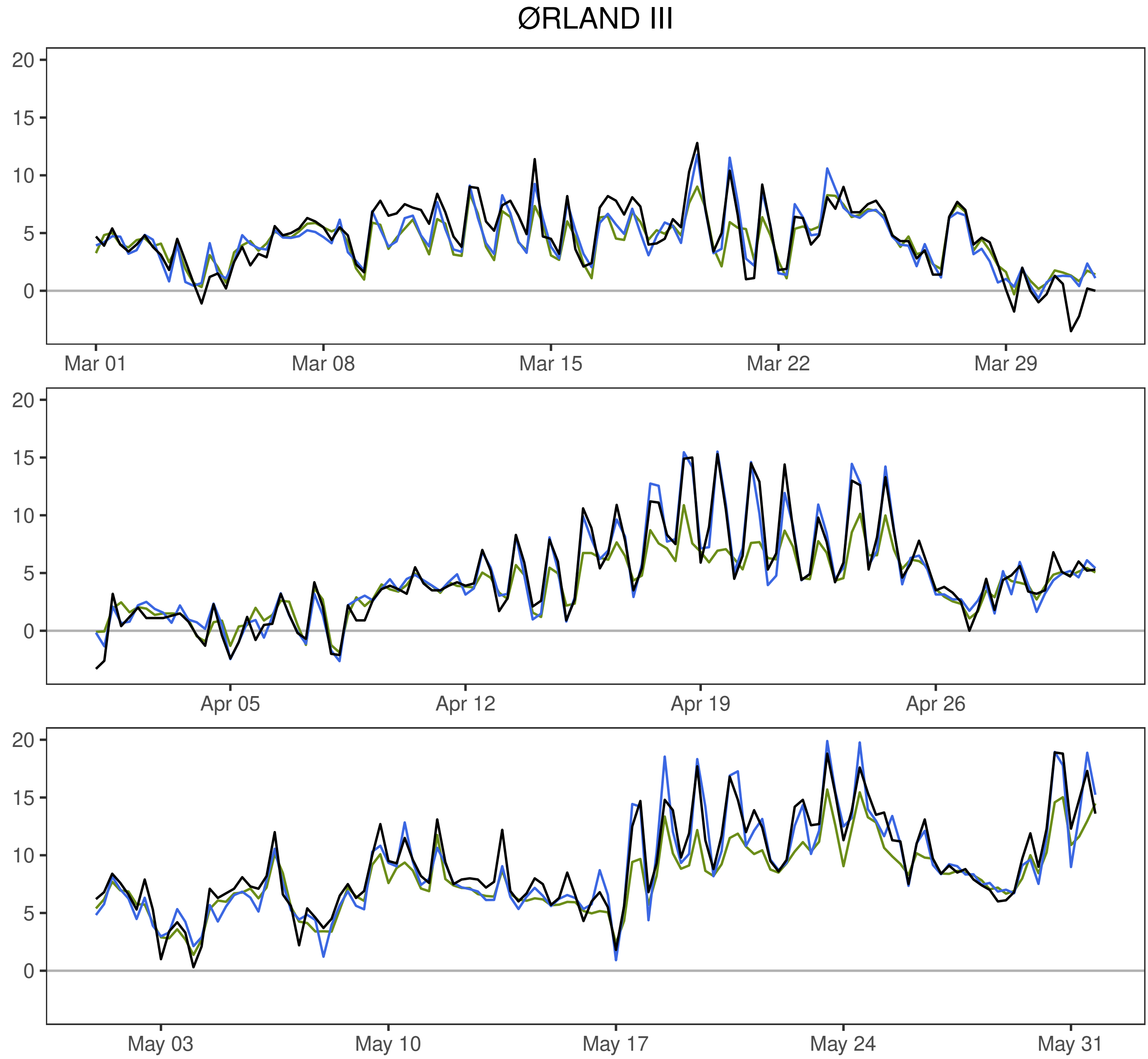
	Min	Mean	Max	Std	N
synop: 00,06,12,18	−7.3	2.7	19.8	5.1	368
MEPSctrl: 12+18,+24,+30,+36	−8.4	2.6	19.2	4.4	368
AA25: 12+18,+24,+30,+36	−6.2	2.6	19.3	4.3	364
ECMWF: 12+18,+24,+30,+36	−14.4	0.2	17.1	5.3	368

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl−synop	−0.1	1.4	1.4	1.1	5.3	364
AA25−synop	0.0	1.4	1.4	1.1	6.3	364
ECMWF−synop	−2.5	1.3	2.9	2.5	7.1	364



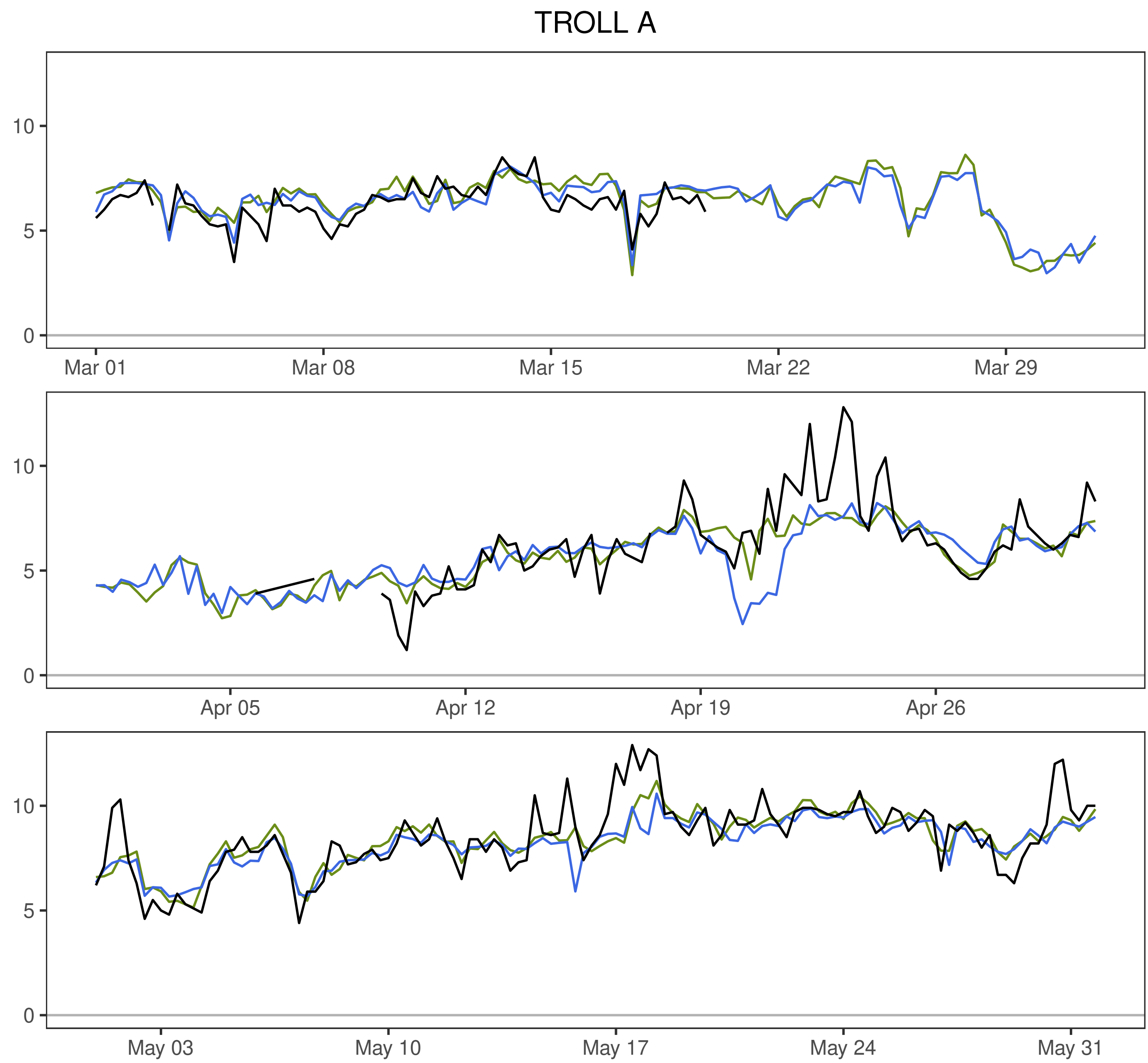
	Min	Mean	Max	Std	N
synop: 00,06,12,18	−22.0	−1.1	18.2	6.9	367
MEPSctrl: 12+18,+24,+30,+36	−15.6	−1.5	16.1	5.9	368
AA25: 12+18,+24,+30,+36	−15.7	−1.6	16.3	5.8	364
ECMWF: 12+18,+24,+30,+36	−13.9	−1.6	16.7	5.9	368

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl−synop	−0.4	2.4	2.4	1.7	10.8	363
AA25−synop	−0.4	2.3	2.4	1.7	9.8	363
ECMWF−synop	−0.5	2.3	2.4	1.7	10.3	363



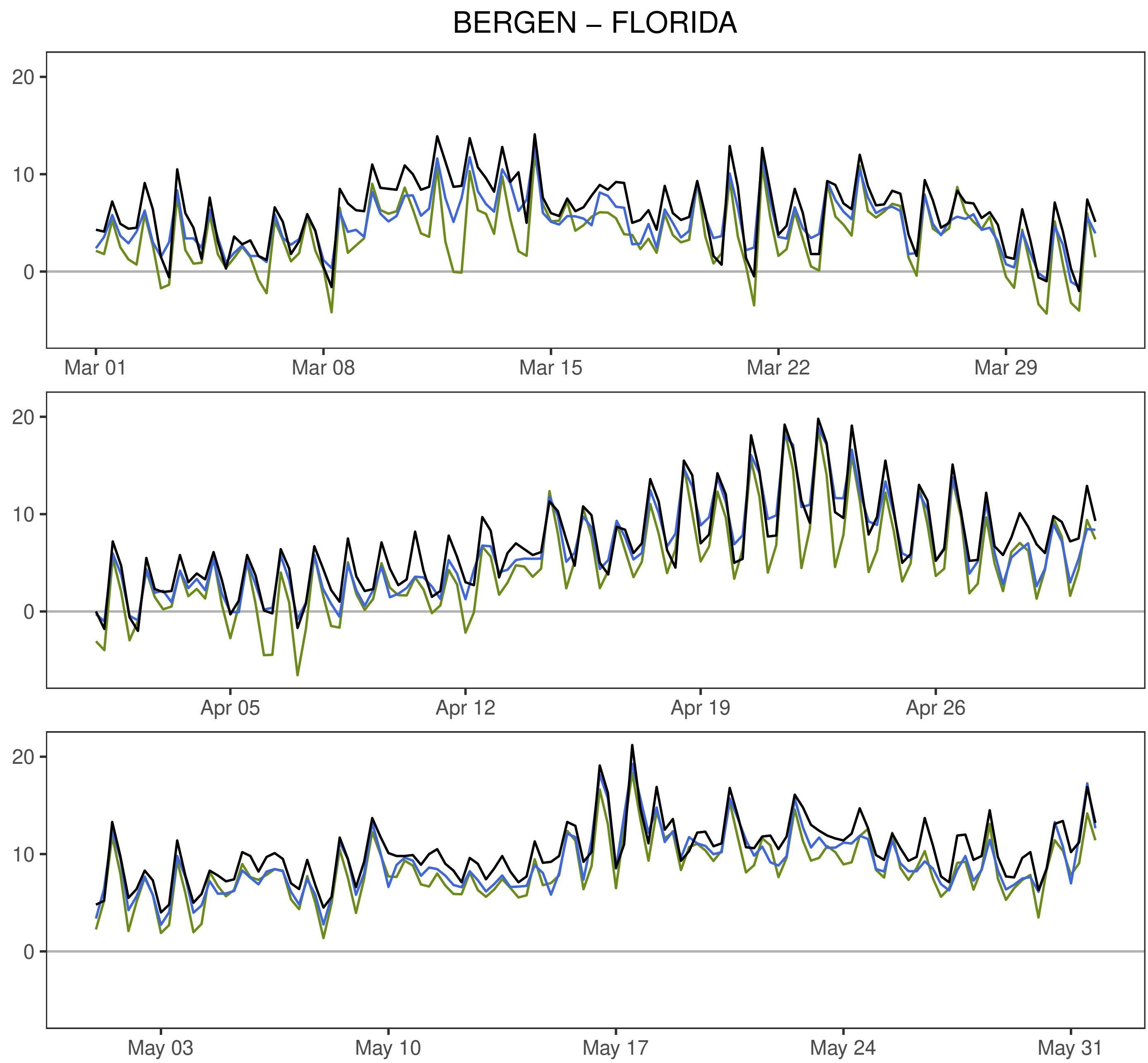
	Min	Mean	Max	Std	N
synop: 00,06,12,18	−3.5	6.2	18.9	4.3	368
MEPSctrl: 12+18,+24,+30,+36	−2.6	6.0	19.9	4.1	368
ECMWF: 12+18,+24,+30,+36	−1.9	5.5	15.7	3.1	368

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl−synop	−0.2	1.2	1.2	0.9	4.8	368
ECMWF−synop	−0.7	1.7	1.8	1.3	8.4	368



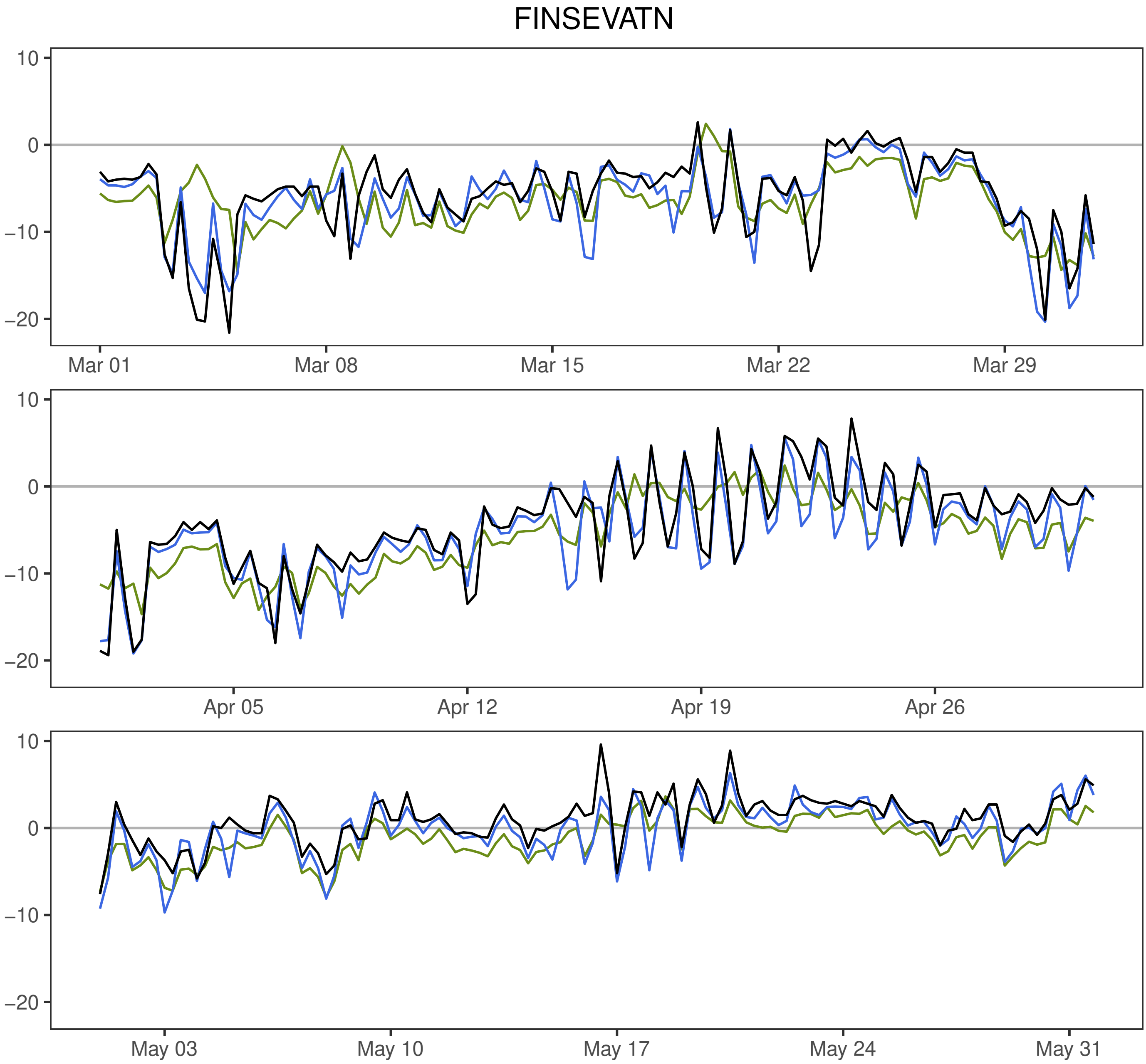
	Min	Mean	Max	Std	N
synop: 00,06,12,18	1.2	7.2	12.9	2.0	292
MEPSctrl: 12+18,+24,+30,+36	2.4	6.7	10.6	1.6	368
ECMWF: 12+18,+24,+30,+36	2.7	6.8	11.2	1.7	368

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl–synop	–0.2	1.2	1.2	0.8	5.2	292
ECMWF–synop	0.0	1.1	1.1	0.8	5.3	292



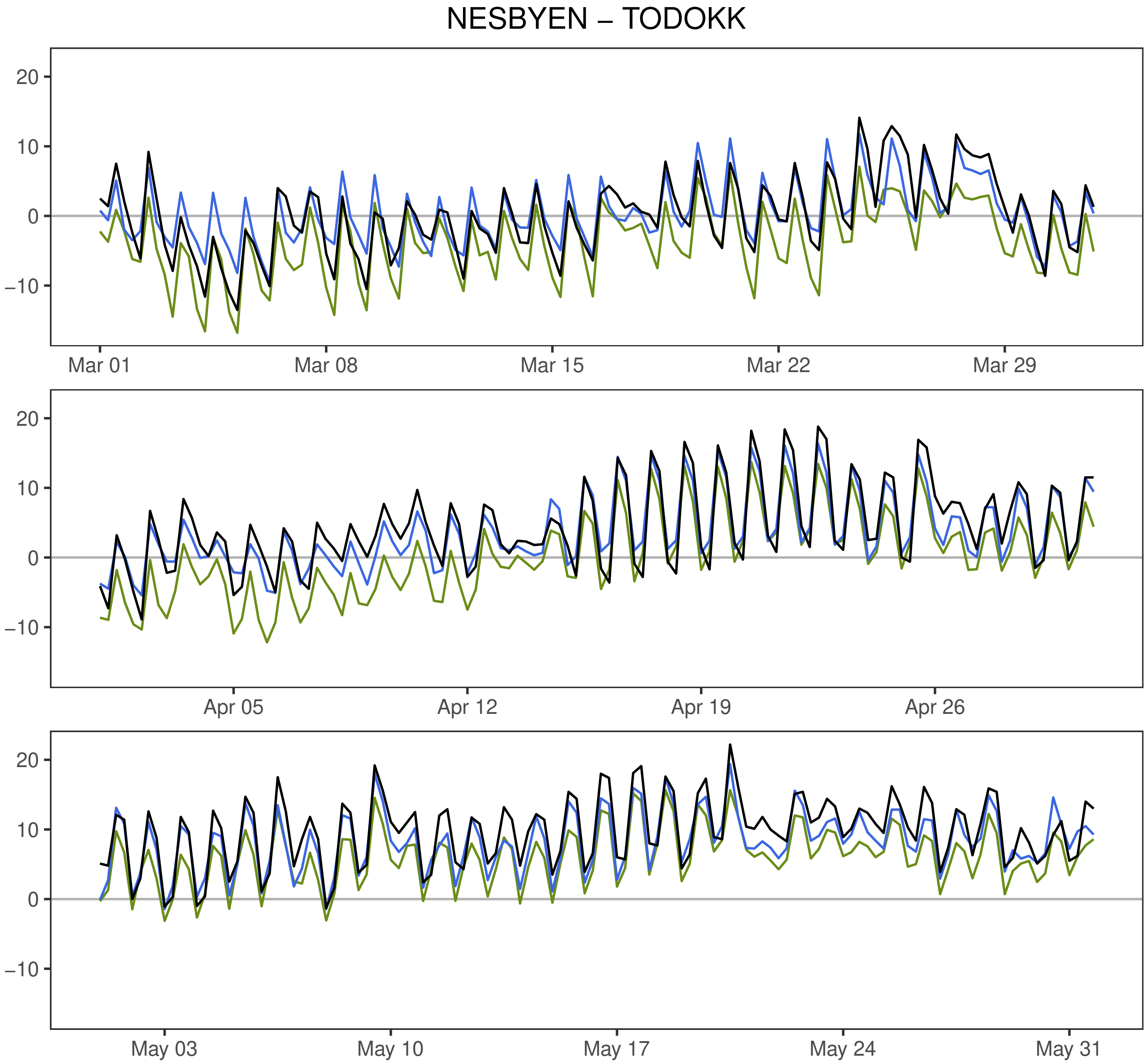
	Min	Mean	Max	Std	N
synop: 00,06,12,18	–2.0	7.8	21.2	4.2	368
MEPSctrl: 12+18,+24,+30,+36	–1.6	6.8	19.3	3.9	368
ECMWF: 12+18,+24,+30,+36	–6.6	5.7	18.7	4.3	368

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl–synop	–1.0	1.3	1.7	1.4	4.6	368
ECMWF–synop	–2.2	1.4	2.6	2.2	8.9	368



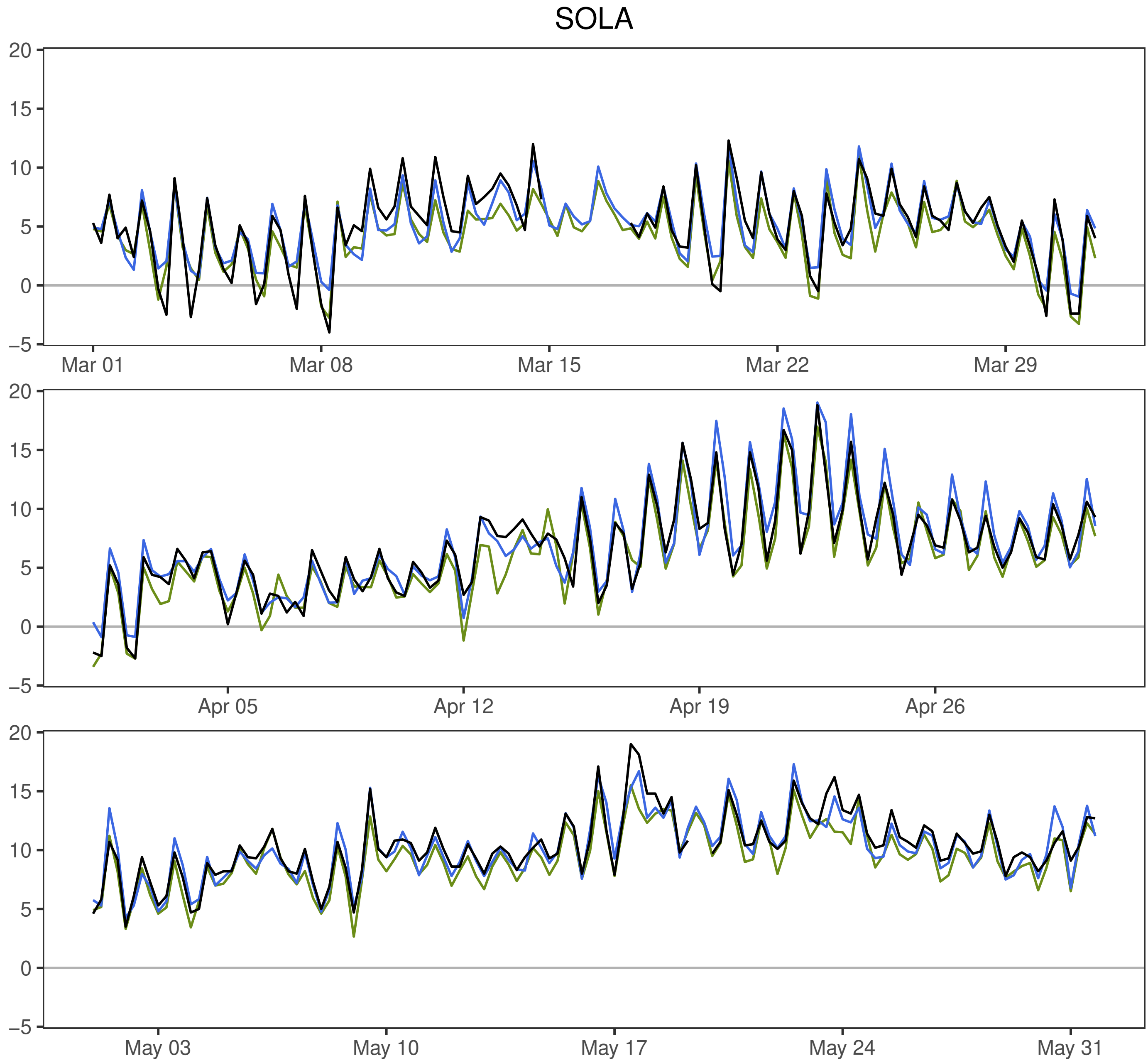
	Min	Mean	Max	Std	N
synop: 00,06,12,18	−21.6	−3.1	9.6	5.3	368
MEPSctrl: 12+18,+24,+30,+36	−20.3	−4.0	6.3	5.1	368
ECMWF: 12+18,+24,+30,+36	−14.7	−4.4	3.6	4.1	368

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl−synop	−0.9	2.1	2.3	1.6	9.9	368
ECMWF−synop	−1.4	3.4	3.6	2.9	17.8	368



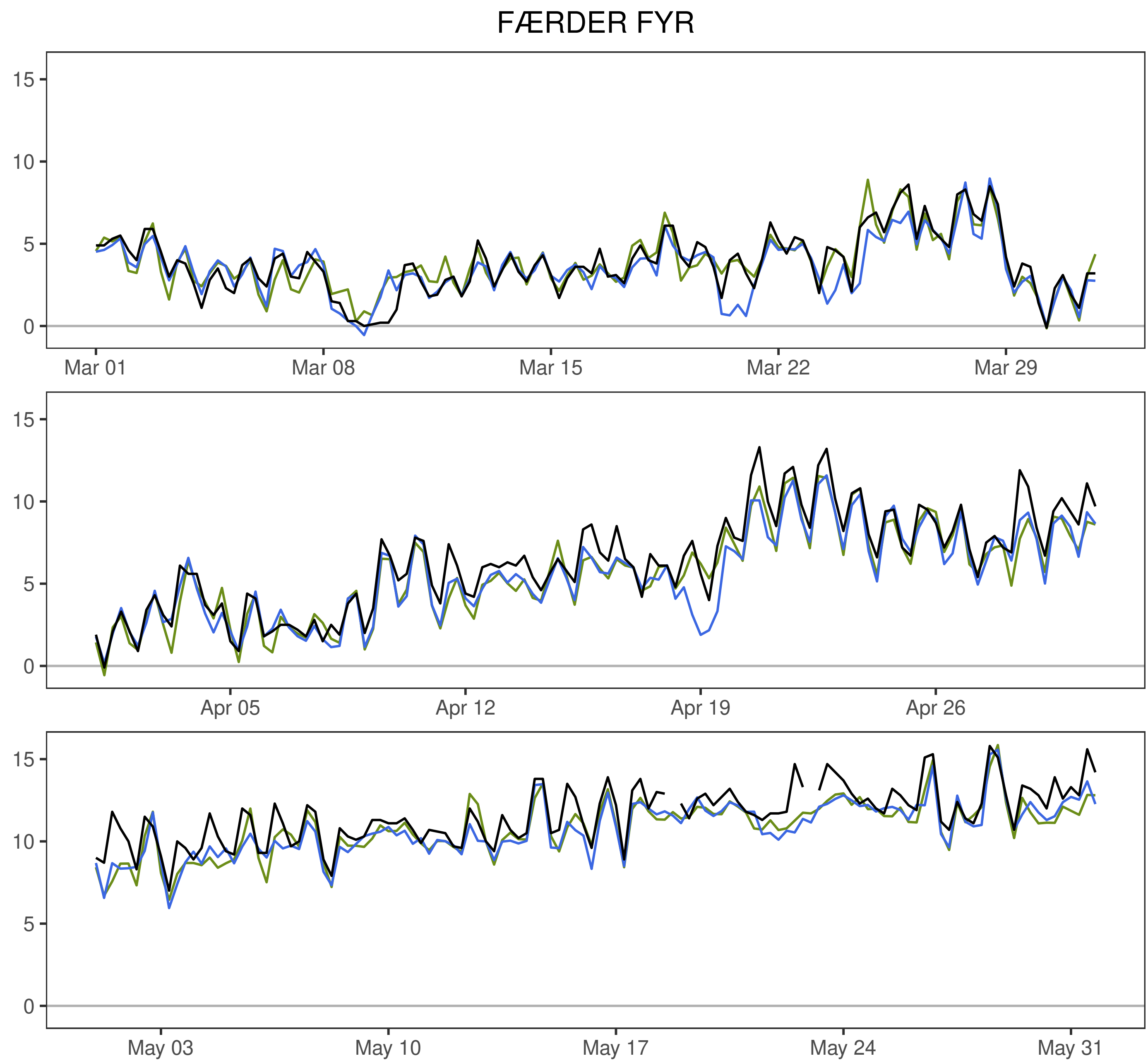
	Min	Mean	Max	Std	N
synop: 00,06,12,18	–13.5	4.8	22.2	6.9	368
MEPSctrl: 12+18,+24,+30,+36	–9.5	4.2	19.4	5.8	368
ECMWF: 12+18,+24,+30,+36	–16.8	0.9	15.7	6.6	368

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl–synop	–0.6	2.4	2.5	2.1	9.1	368
ECMWF–synop	–3.9	2.4	4.6	4.1	10.9	368



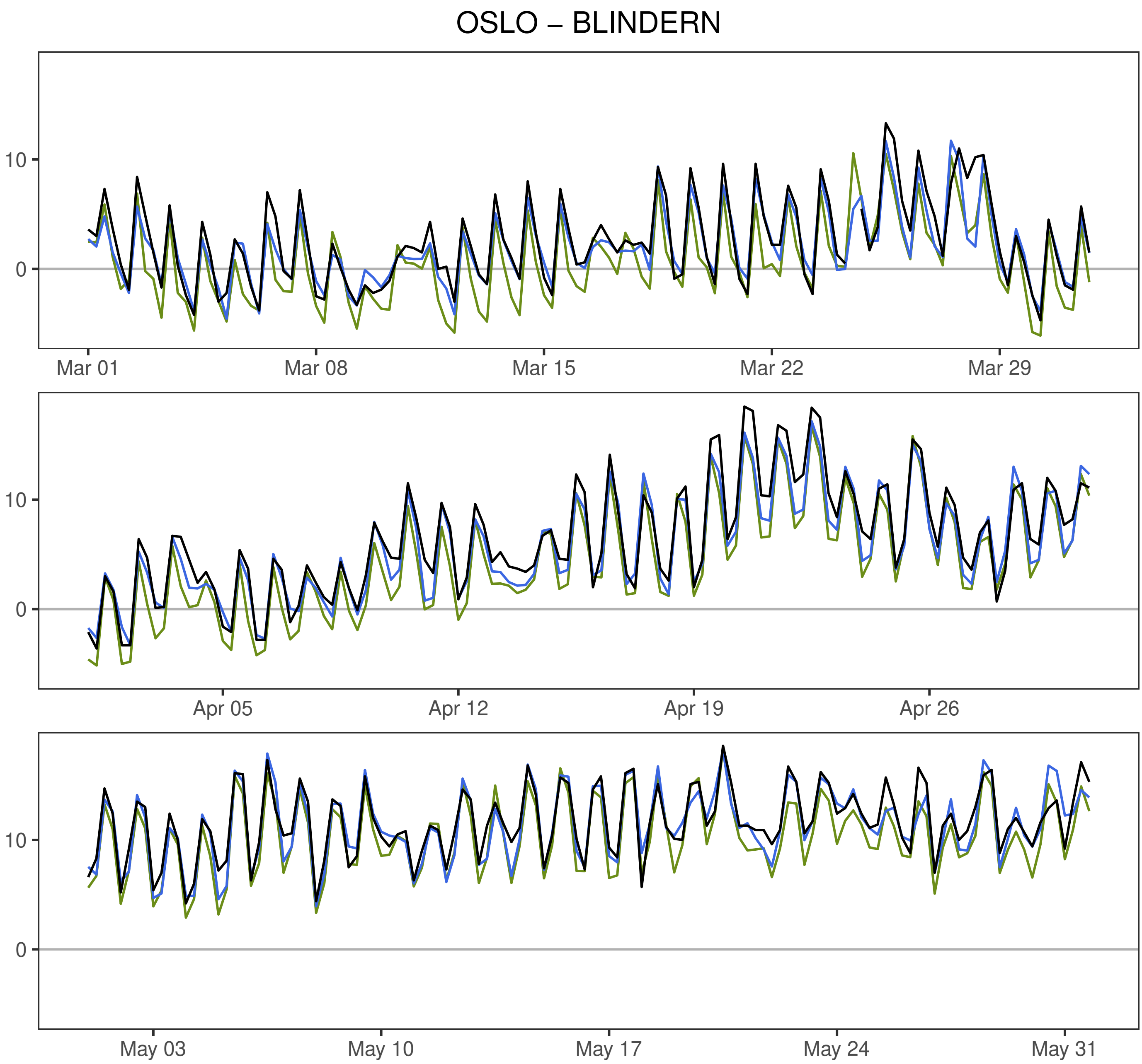
	Min	Mean	Max	Std	N
synop: 00,06,12,18	−4.0	7.4	19.0	4.1	356
MEPSctrl: 12+18,+24,+30,+36	−1.0	7.5	19.0	3.9	368
ECMWF: 12+18,+24,+30,+36	−3.4	6.5	17.0	3.8	368

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl−synop	0.1	1.3	1.3	1.0	4.6	356
ECMWF−synop	−0.9	1.1	1.4	1.1	4.9	356



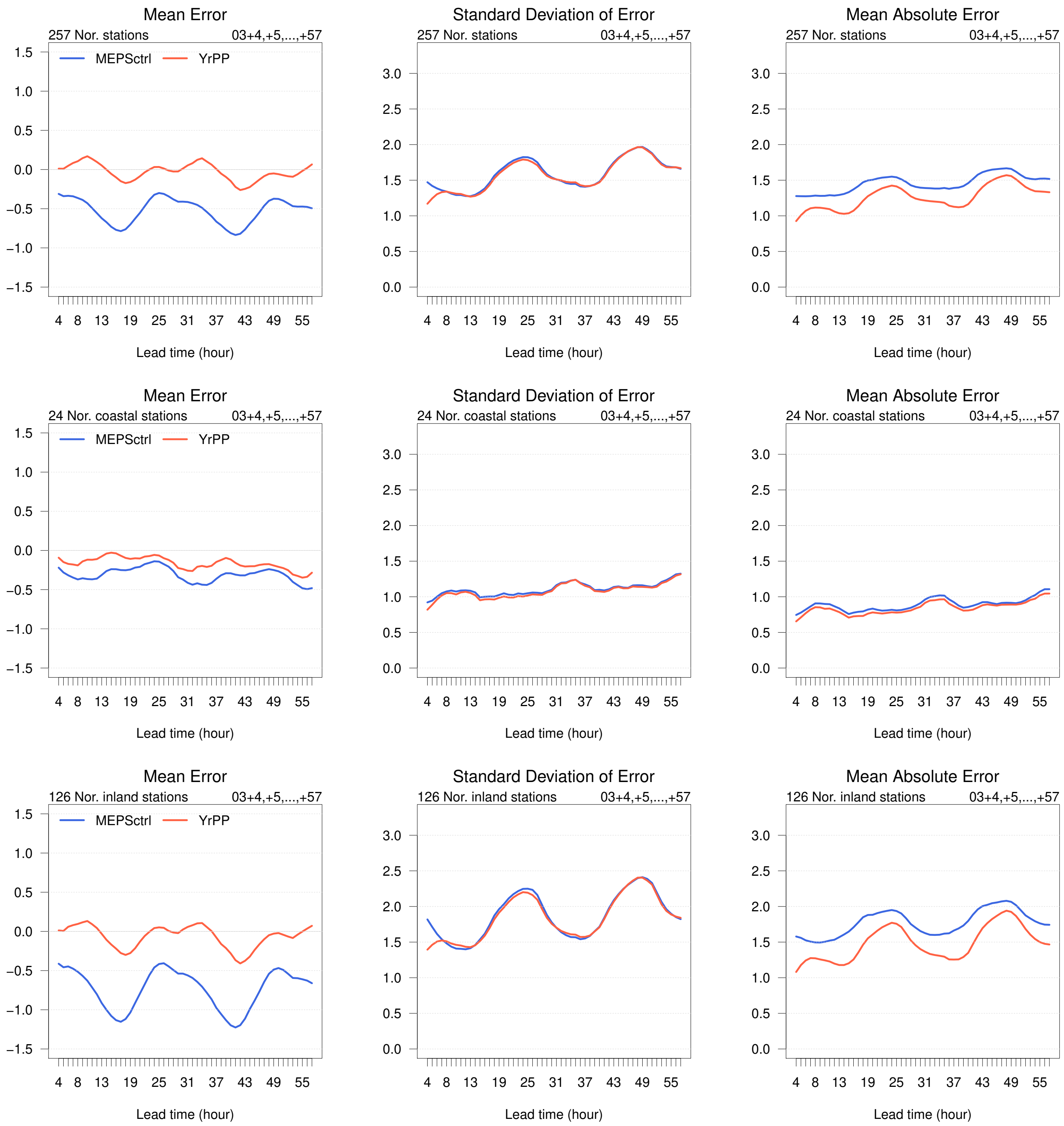
	Min	Mean	Max	Std	N
synop: 00,06,12,18	−0.1	7.3	15.8	4.0	366
MEPSctrl: 12+18,+24,+30,+36	−0.6	6.6	15.6	3.7	368
ECMWF: 12+18,+24,+30,+36	−0.6	6.8	15.9	3.6	368

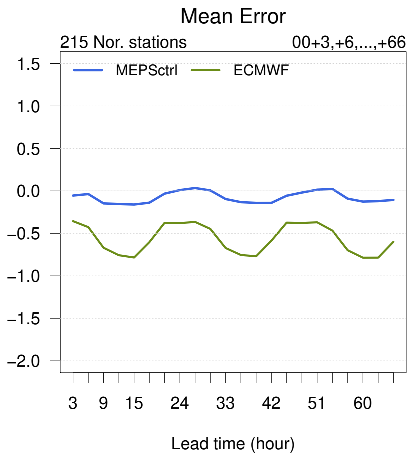
	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl−synop	−0.7	0.9	1.1	0.8	4.5	366
ECMWF−synop	−0.5	0.9	1.0	0.8	4.2	366

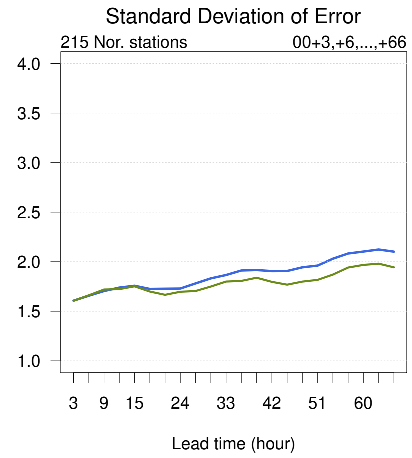


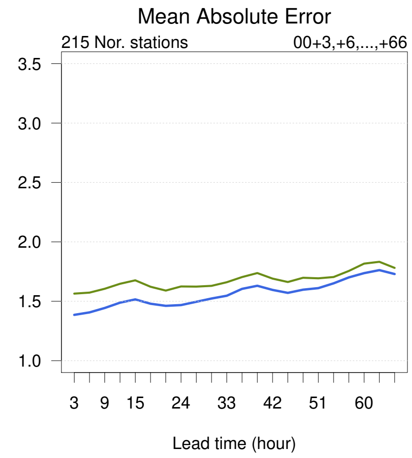
	Min	Mean	Max	Std	N
synop: 00,06,12,18	−4.7	6.9	18.6	5.6	367
MEPSctrl: 12+18,+24,+30,+36	−4.5	6.4	18.2	5.5	368
ECMWF: 12+18,+24,+30,+36	−6.1	5.2	18.3	5.8	368

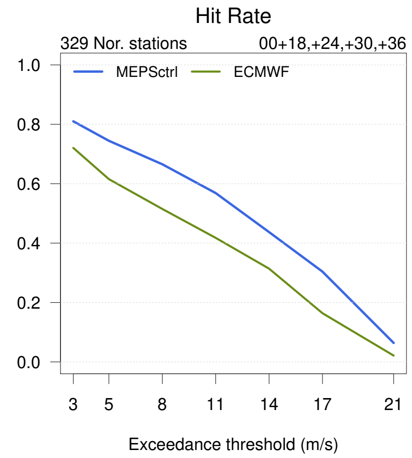
	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl−synop	−0.5	1.3	1.4	1.1	8.2	367
ECMWF−synop	−1.7	1.4	2.2	1.9	6.2	367

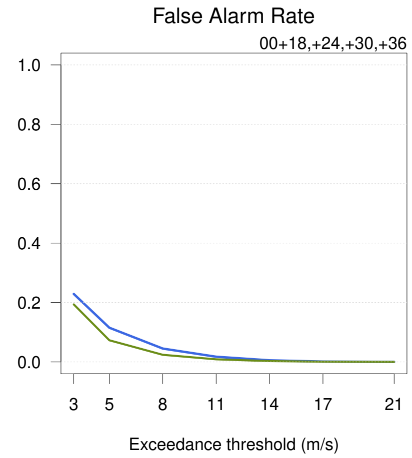

Mean Error
257 Nor. stations
03+4,+5,...,+57
MEPSctrl
YrPP
Lead time (hour)
Standard Deviation of Error
257 Nor. stations
03+4,+5,...,+57
Lead time (hour)
Mean Absolute Error
257 Nor. stations
03+4,+5,...,+57
Lead time (hour)
Mean Error
24 Nor. coastal stations
03+4,+5,...,+57
MEPSctrl
YrPP
Lead time (hour)
Standard Deviation of Error
24 Nor. coastal stations
03+4,+5,...,+57
Lead time (hour)
Mean Absolute Error
24 Nor. coastal stations
03+4,+5,...,+57
Lead time (hour)
Mean Error
126 Nor. inland stations
03+4,+5,...,+57
MEPSctrl
YrPP
Lead time (hour)
Standard Deviation of Error
126 Nor. inland stations
03+4,+5,...,+57
Lead time (hour)
Mean Absolute Error
126 Nor. inland stations
03+4,+5,...,+57
Lead time (hour)

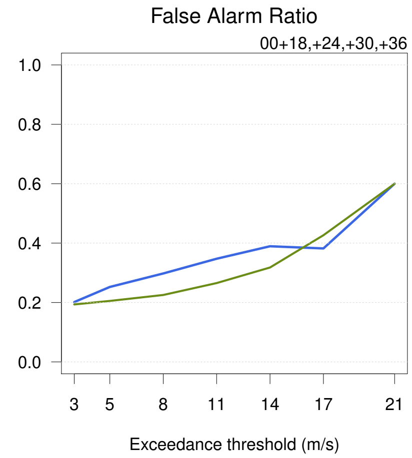

Mean Error
215 Nor. stations
00+3,+6,...,+66
MEPSctrl
ECMWF
Lead time (hour)

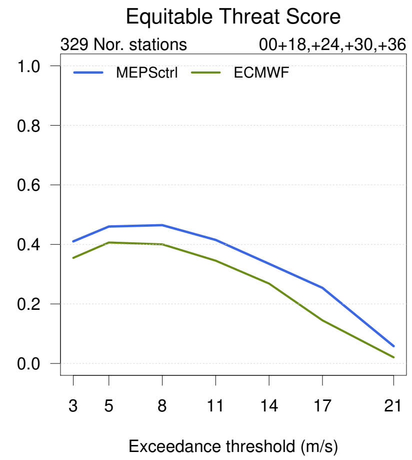

Standard Deviation of Error
215 Nor. stations
00+3,+6,...,+66
Lead time (hour)

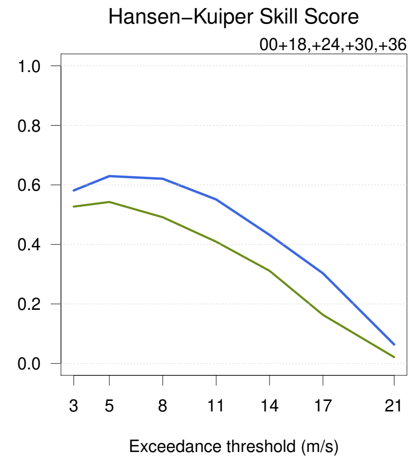

Mean Absolute Error
215 Nor. stations
00+3,+6,...,+66
Lead time (hour)

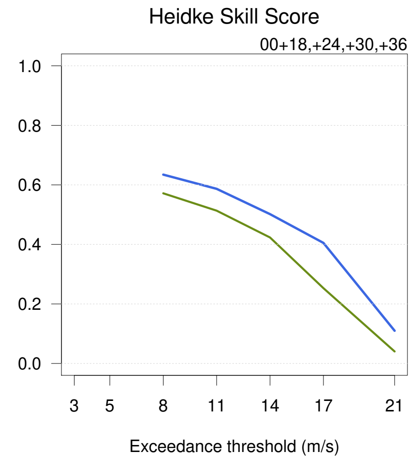

Hit Rate
329 Nor. stations
00+18,+24,+30,+36
MEPSctrl
ECMWF
Exceedance threshold (m/s)

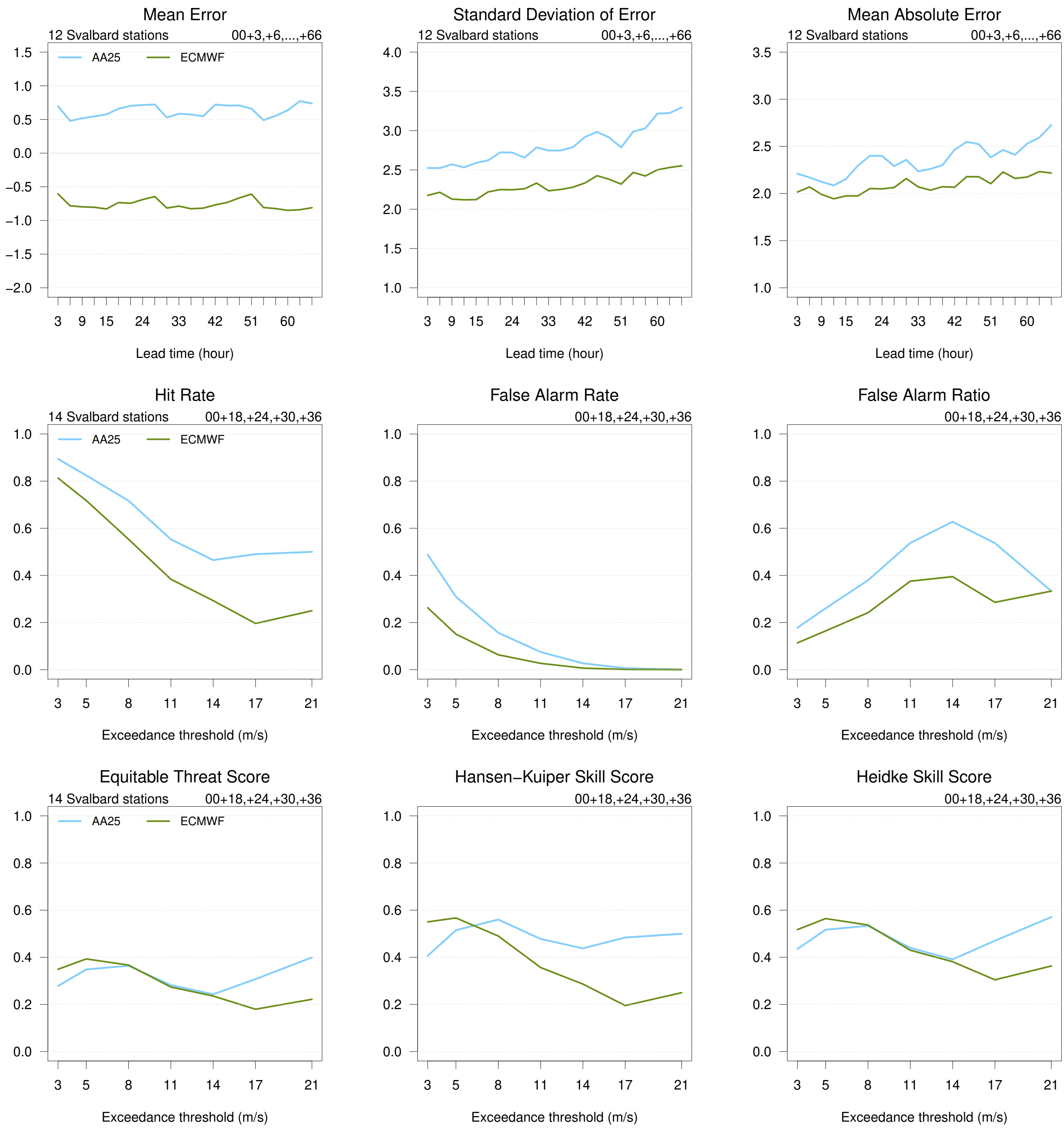

False Alarm Rate
00+18,+24,+30,+36
Exceedance threshold (m/s)

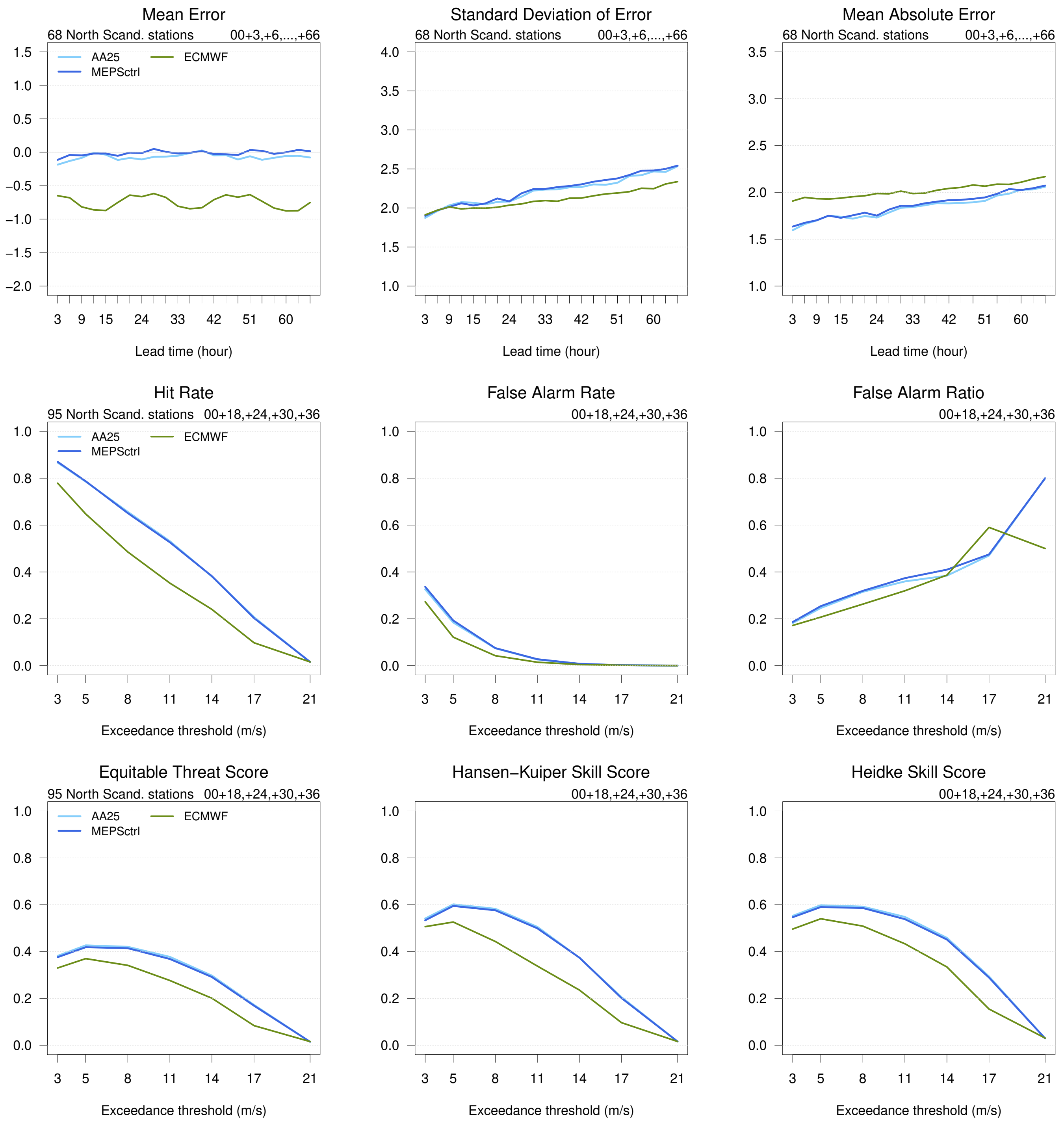

False Alarm Ratio
00+18,+24,+30,+36
Exceedance threshold (m/s)


Equitable Threat Score
329 Nor. stations
00+18,+24,+30,+36
MEPSctrl
ECMWF
Exceedance threshold (m/s)

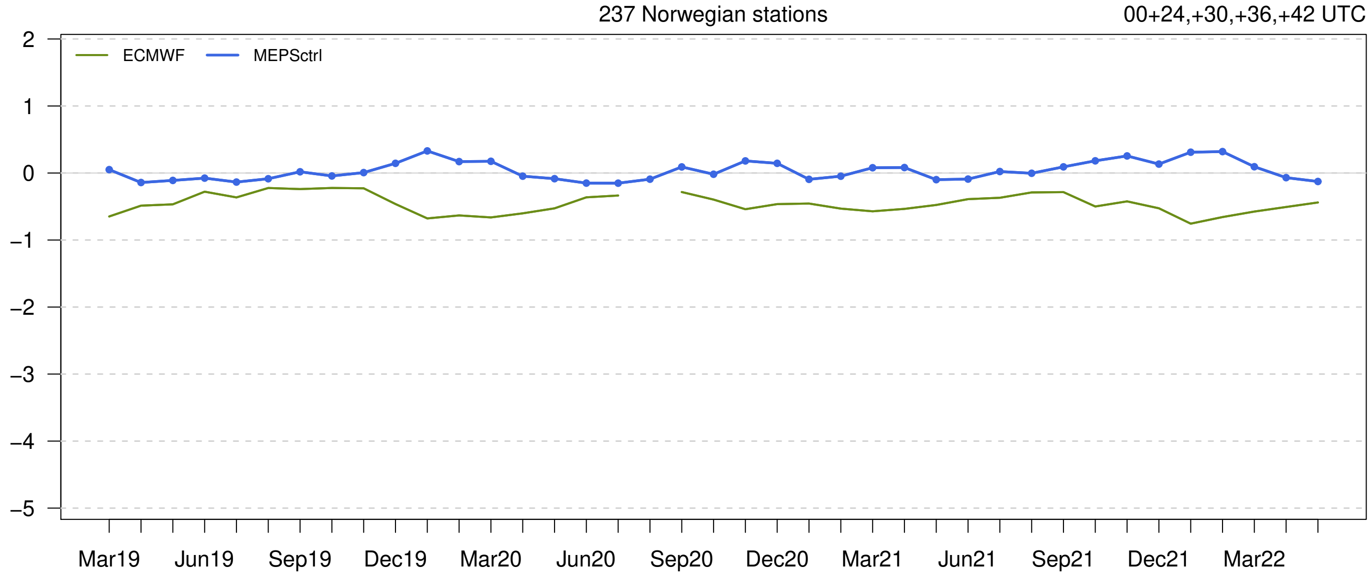

Hansen−Kuiper Skill Score
00+18,+24,+30,+36
Exceedance threshold (m/s)

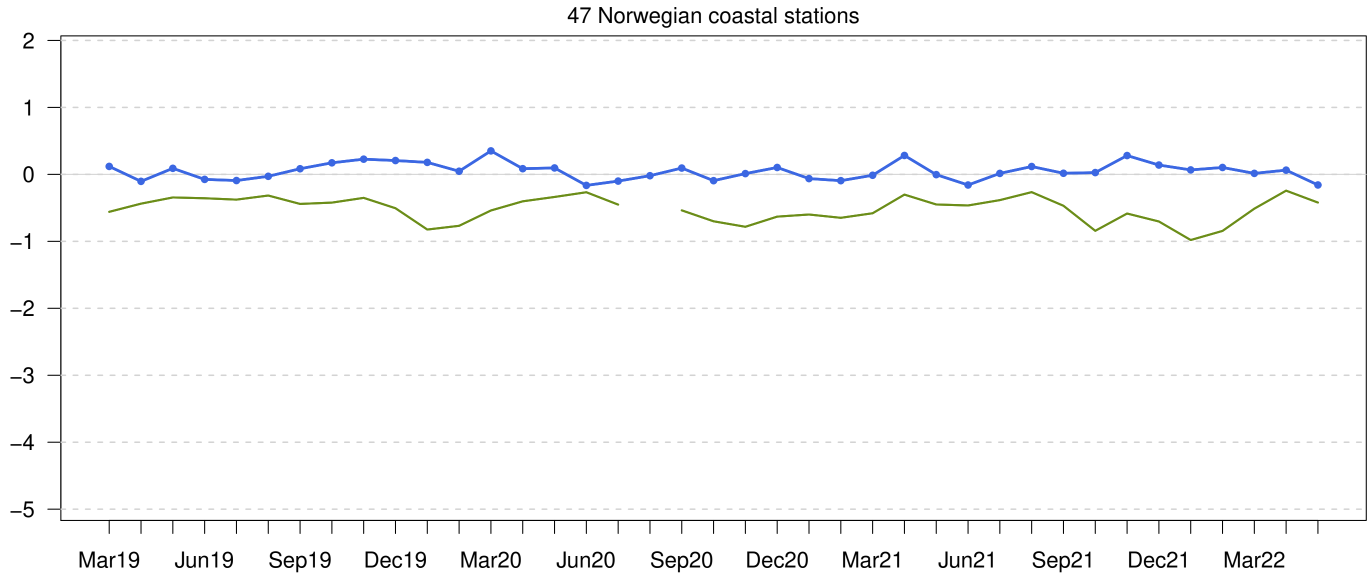

Heidke Skill Score
00+18,+24,+30,+36
Exceedance threshold (m/s)

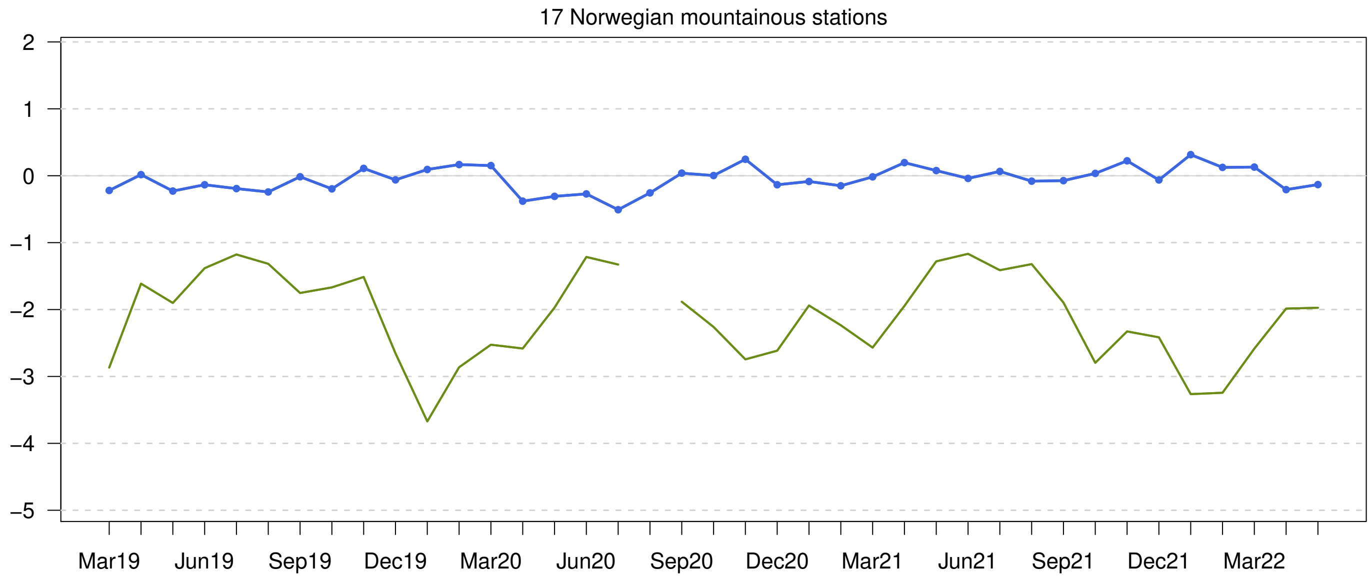

Mean Error
12 Svalbard stations
00+3,+6,...,+66
AA25
ECMWF
Lead time (hour)
Standard Deviation of Error
12 Svalbard stations
00+3,+6,...,+66
Lead time (hour)
Mean Absolute Error
12 Svalbard stations
00+3,+6,...,+66
Lead time (hour)
Hit Rate
14 Svalbard stations
00+18,+24,+30,+36
AA25
ECMWF
Exceedance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


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

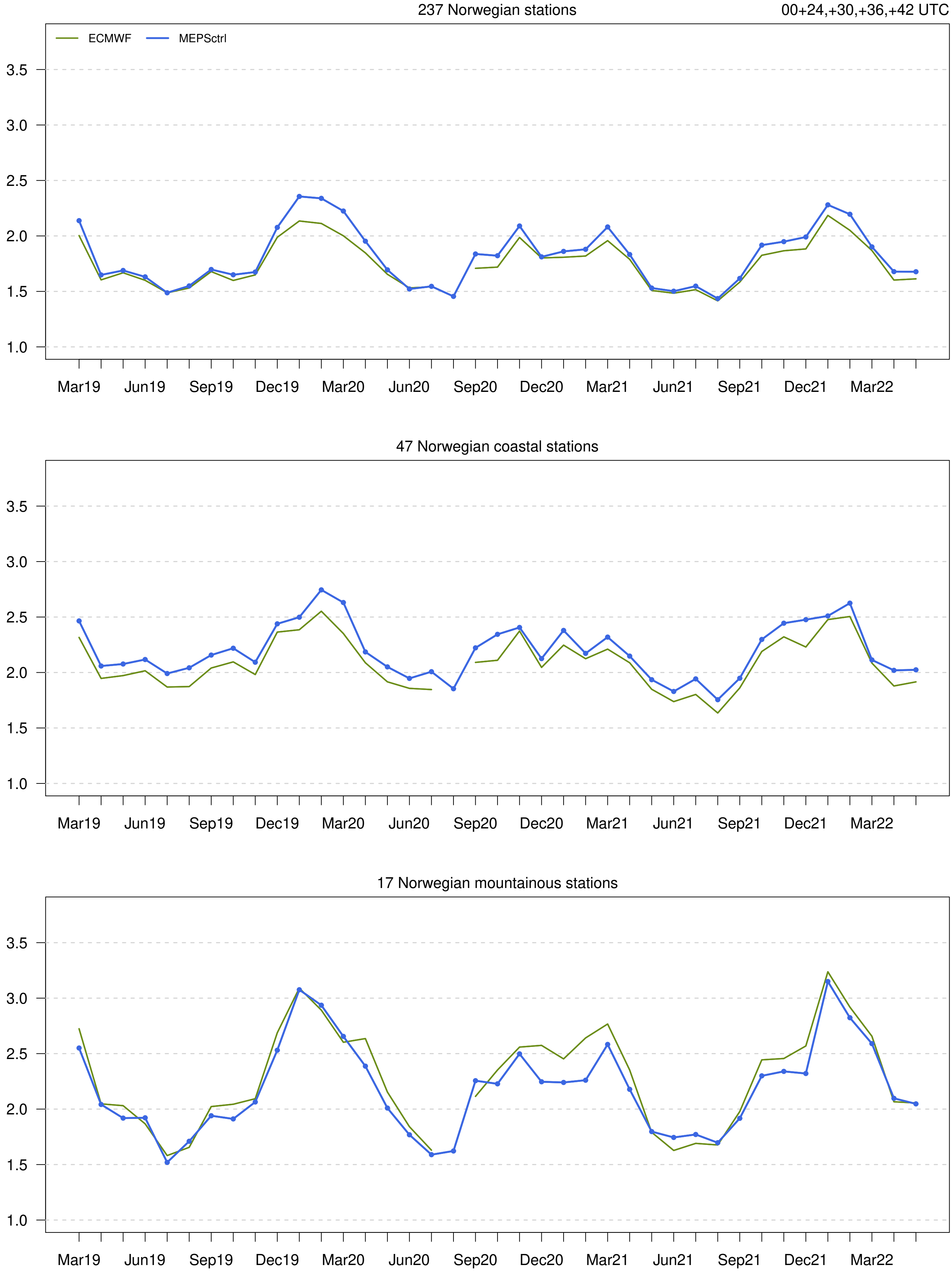
Mean Error


237 Norwegian stations
00+24,+30,+36,+42 UTC
ECMWF
MEPSctrl
2
1
0
−1
−2
−3
−4
−5
Mar19
Jun19
Sep19
Dec19
Mar20
Jun20
Sep20
Dec20
Mar21
Jun21
Sep21
Dec21
Mar22

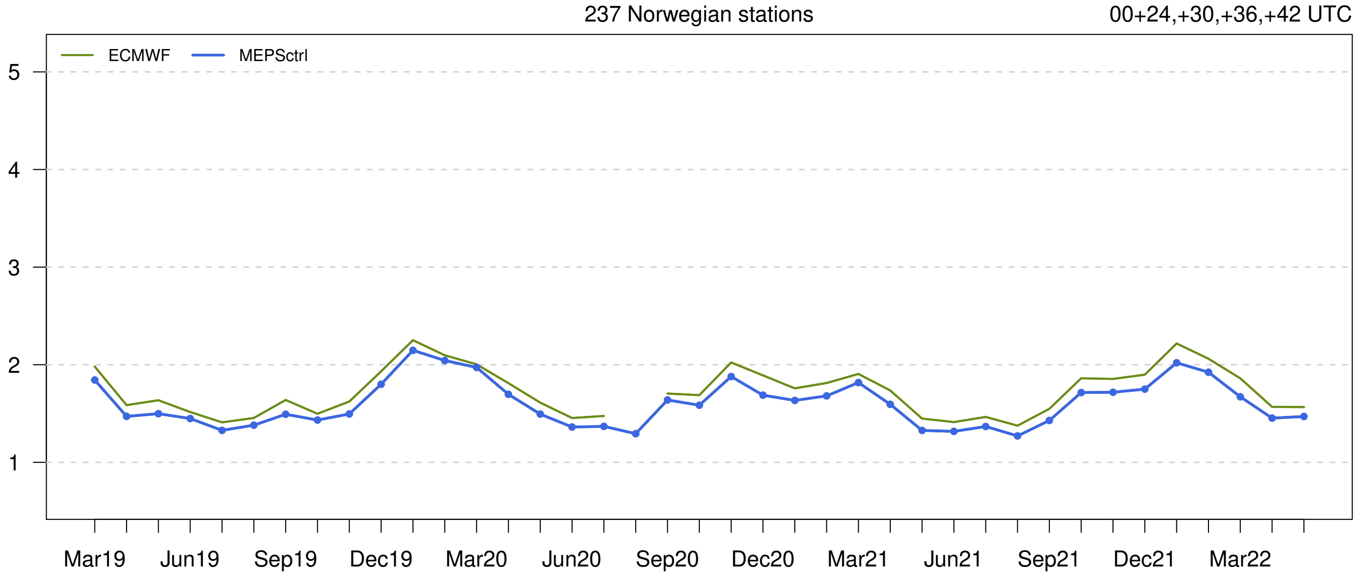

47 Norwegian coastal stations
2
1
0
−1
−2
−3
−4
−5
Mar19
Jun19
Sep19
Dec19
Mar20
Jun20
Sep20
Dec20
Mar21
Jun21
Sep21
Dec21
Mar22

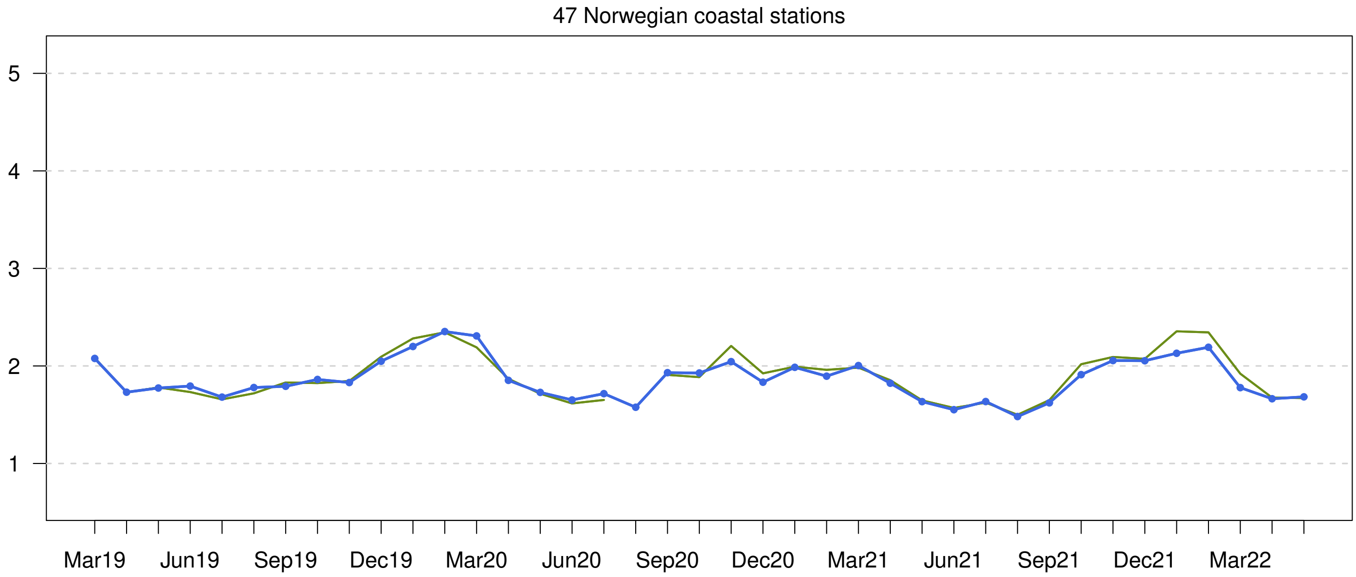

17 Norwegian mountainous stations
2
1
0
−1
−2
−3
−4
−5
Mar19
Jun19
Sep19
Dec19
Mar20
Jun20
Sep20
Dec20
Mar21
Jun21
Sep21
Dec21
Mar22

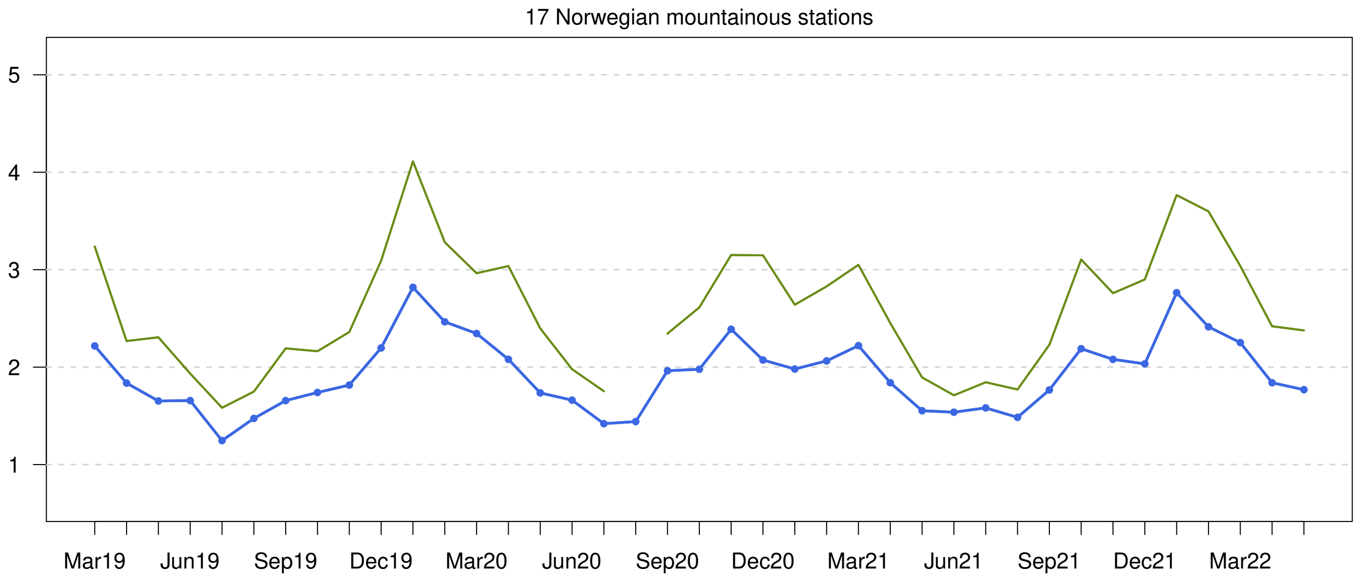
Standard Deviation of Error



Mean Absolute Error

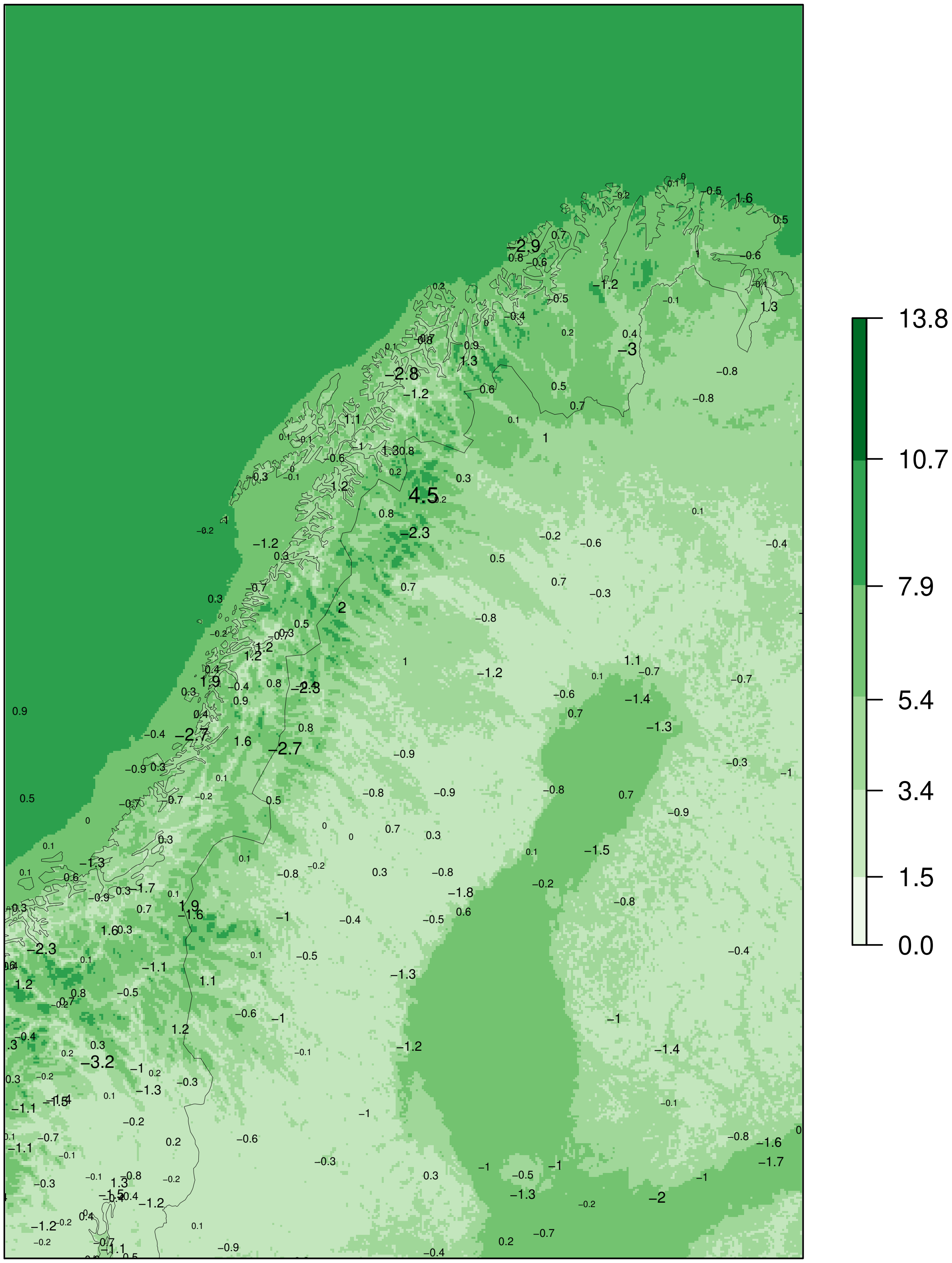






MEPSctrl 00+12

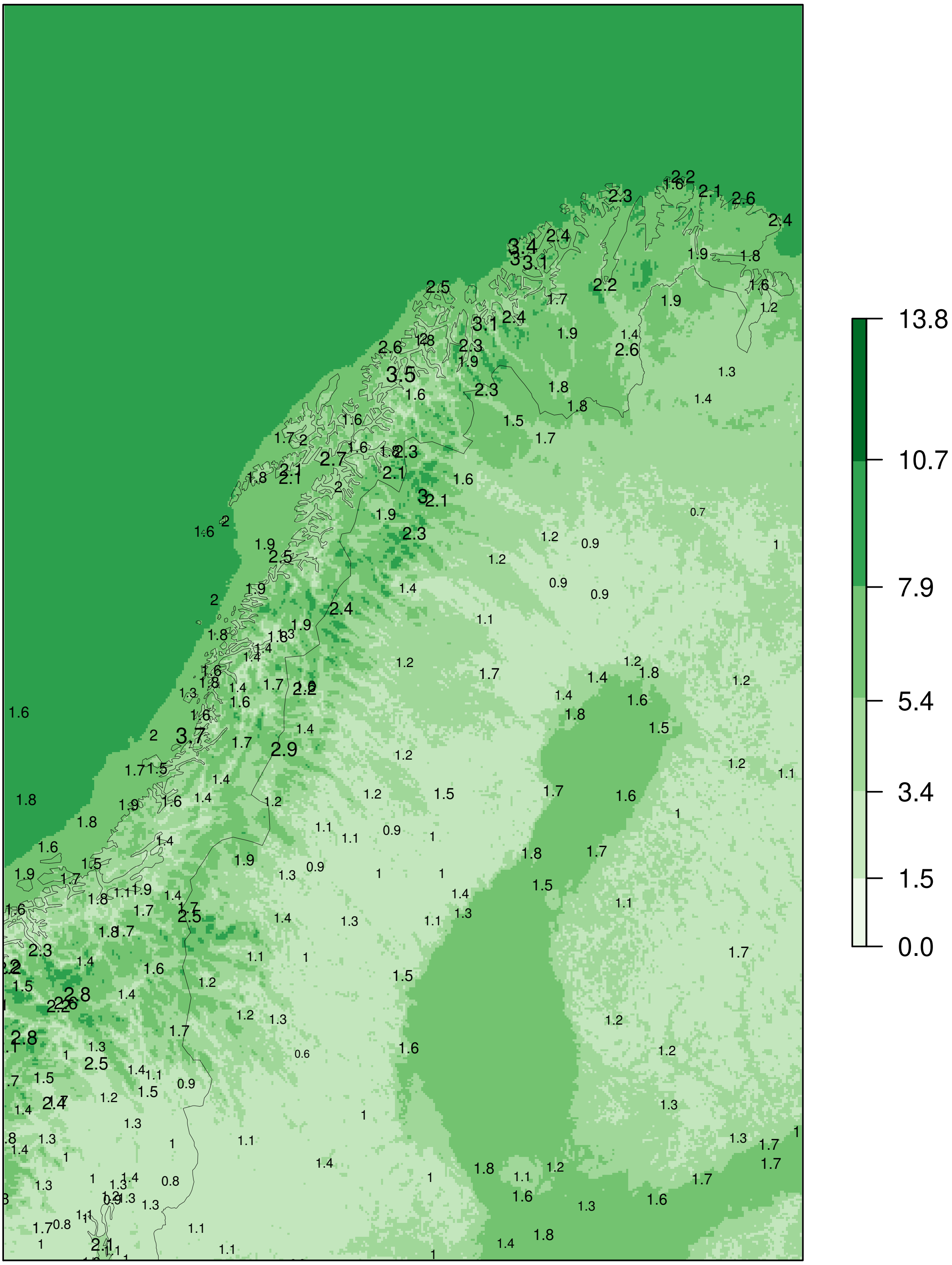
ME at observing sites
(numbers in black)



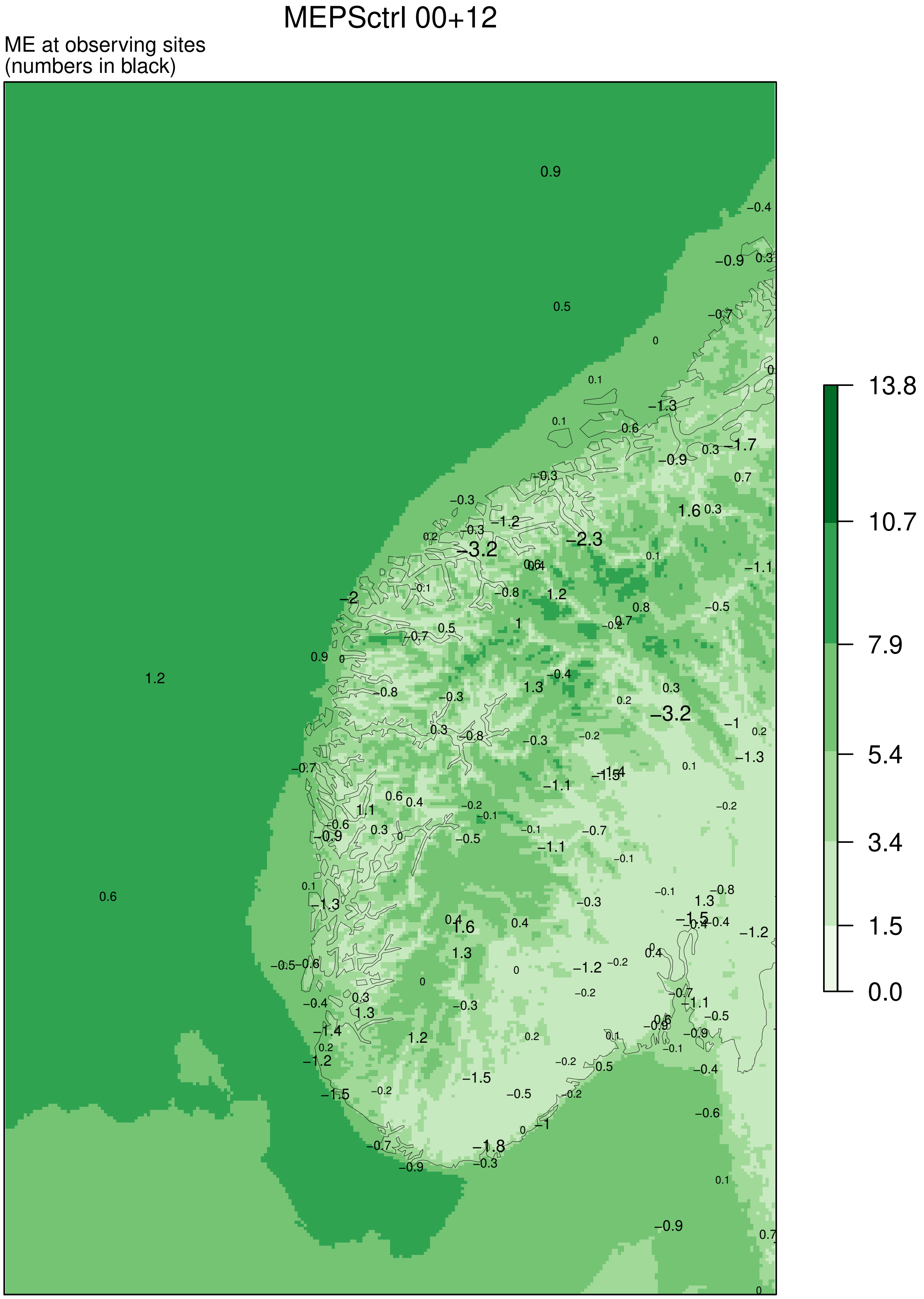
Model "climatology" 01.03.2022 – 31.05.2022

MEPSctrl 00+12

SDE at observing sites
(numbers in black)



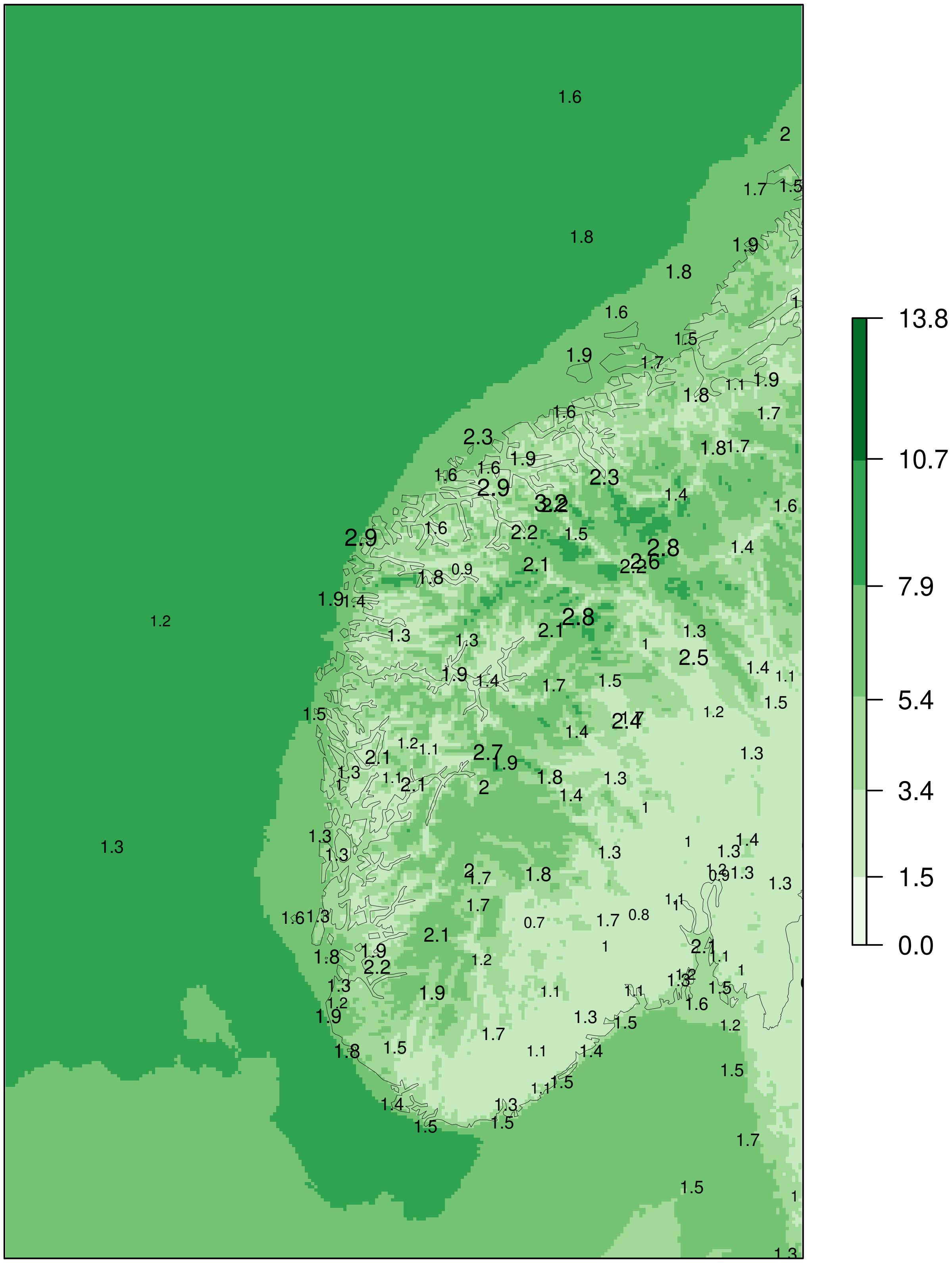
Model "climatology" 01.03.2022 – 31.05.2022



Model "climatology"   01.03.2022 – 31.05.2022

MEPSctrl 00+12

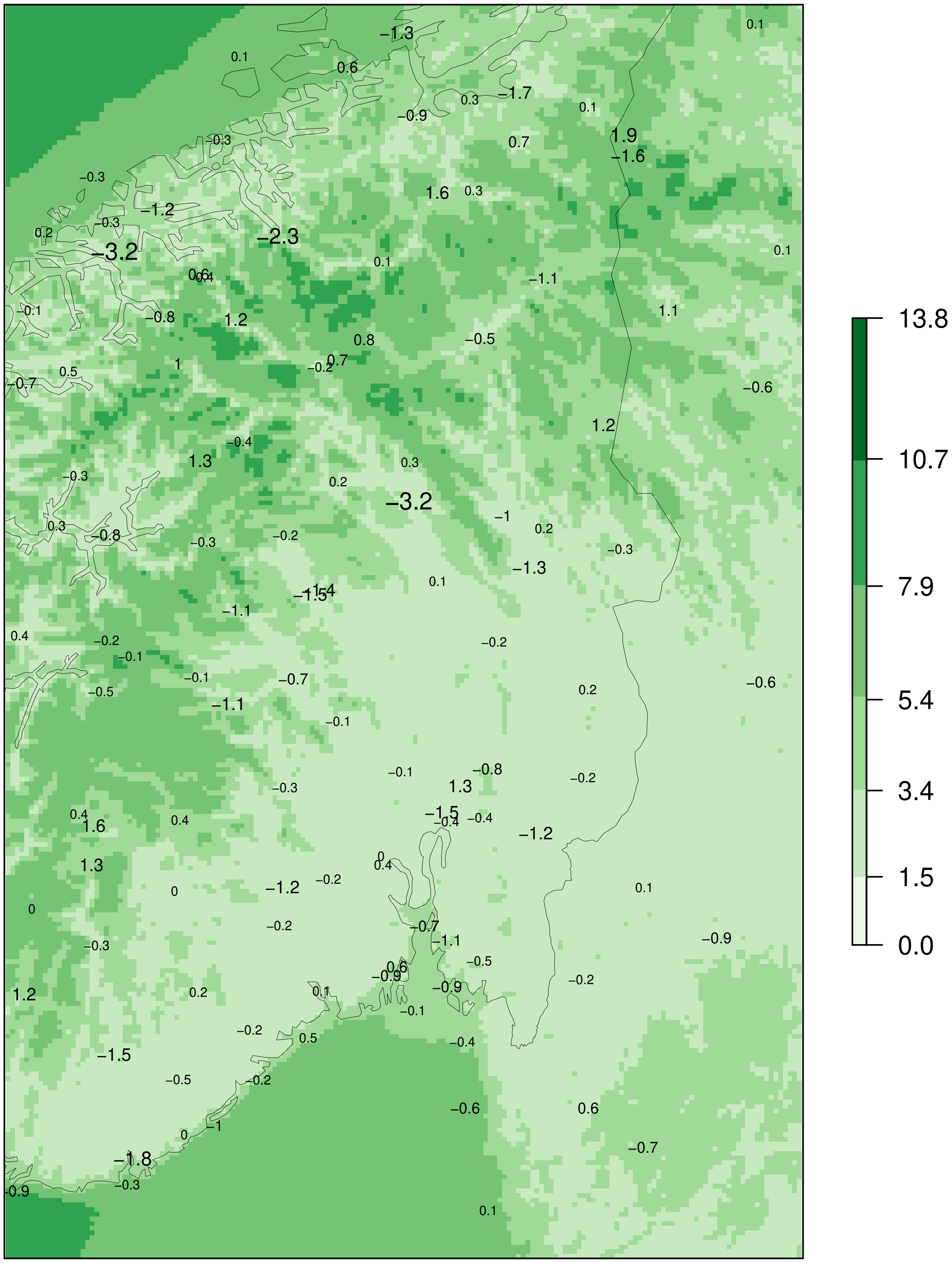
SDE at observing sites
(numbers in black)



Model "climatology" 01.03.2022 – 31.05.2022

MEPSctrl 00+12

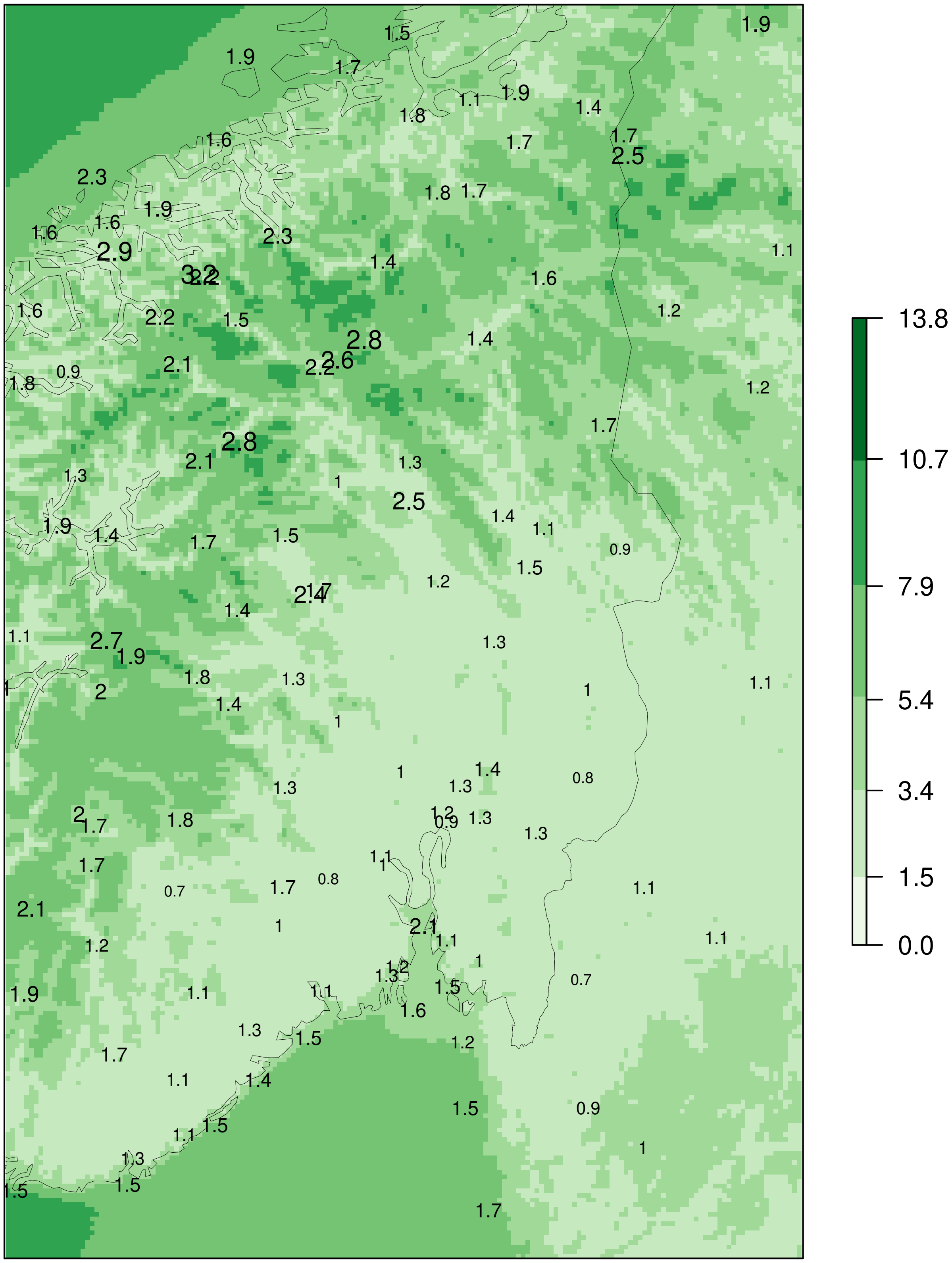
ME at observing sites
(numbers in black)



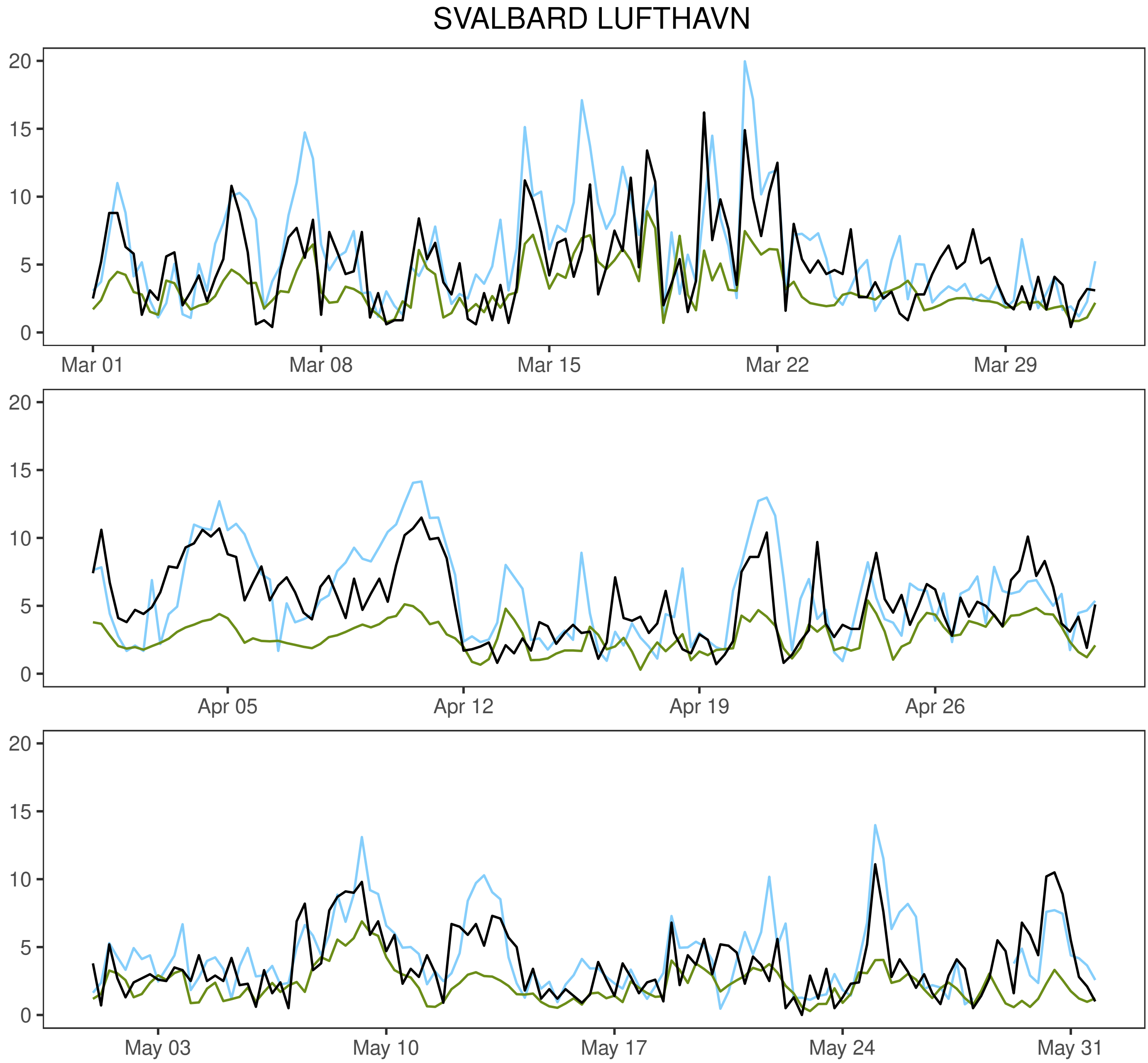
Model "climatology" 01.03.2022 – 31.05.2022

MEPSctrl 00+12

SDE at observing sites
(numbers in black)

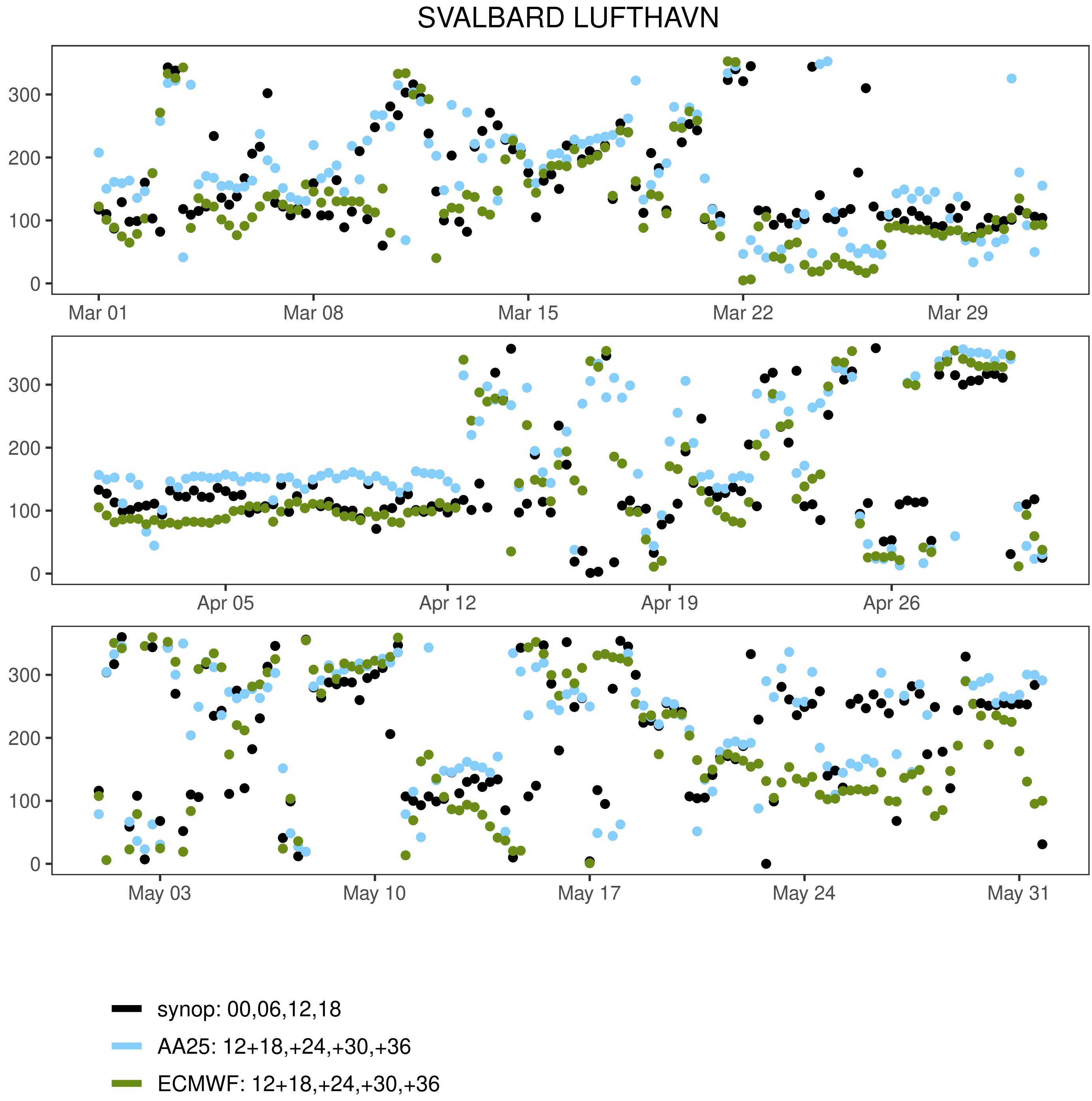


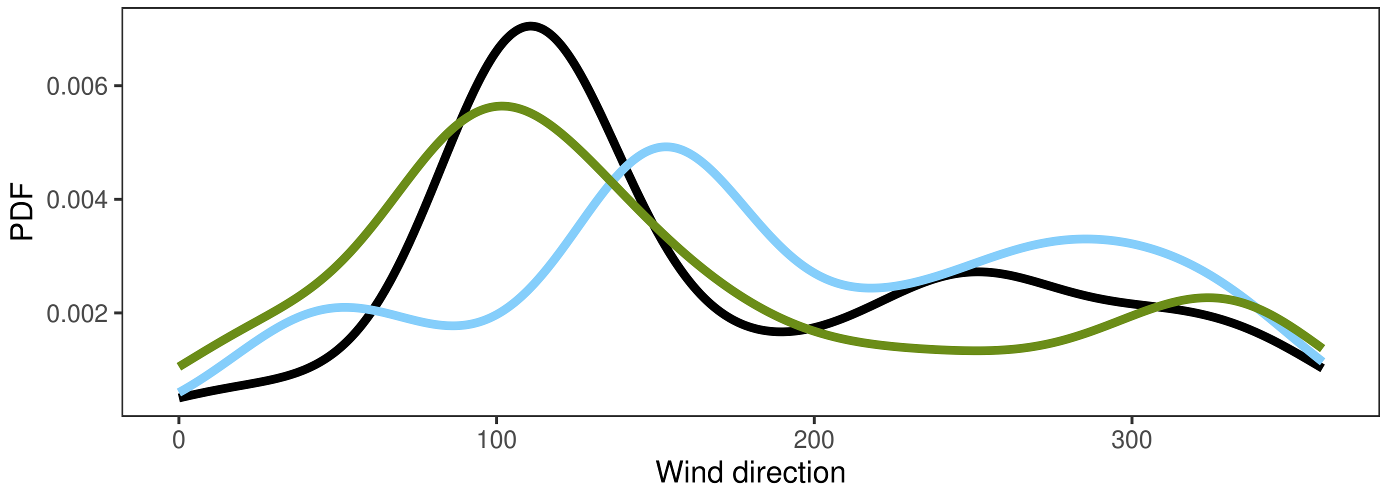
Model "climatology" 01.03.2022 – 31.05.2022

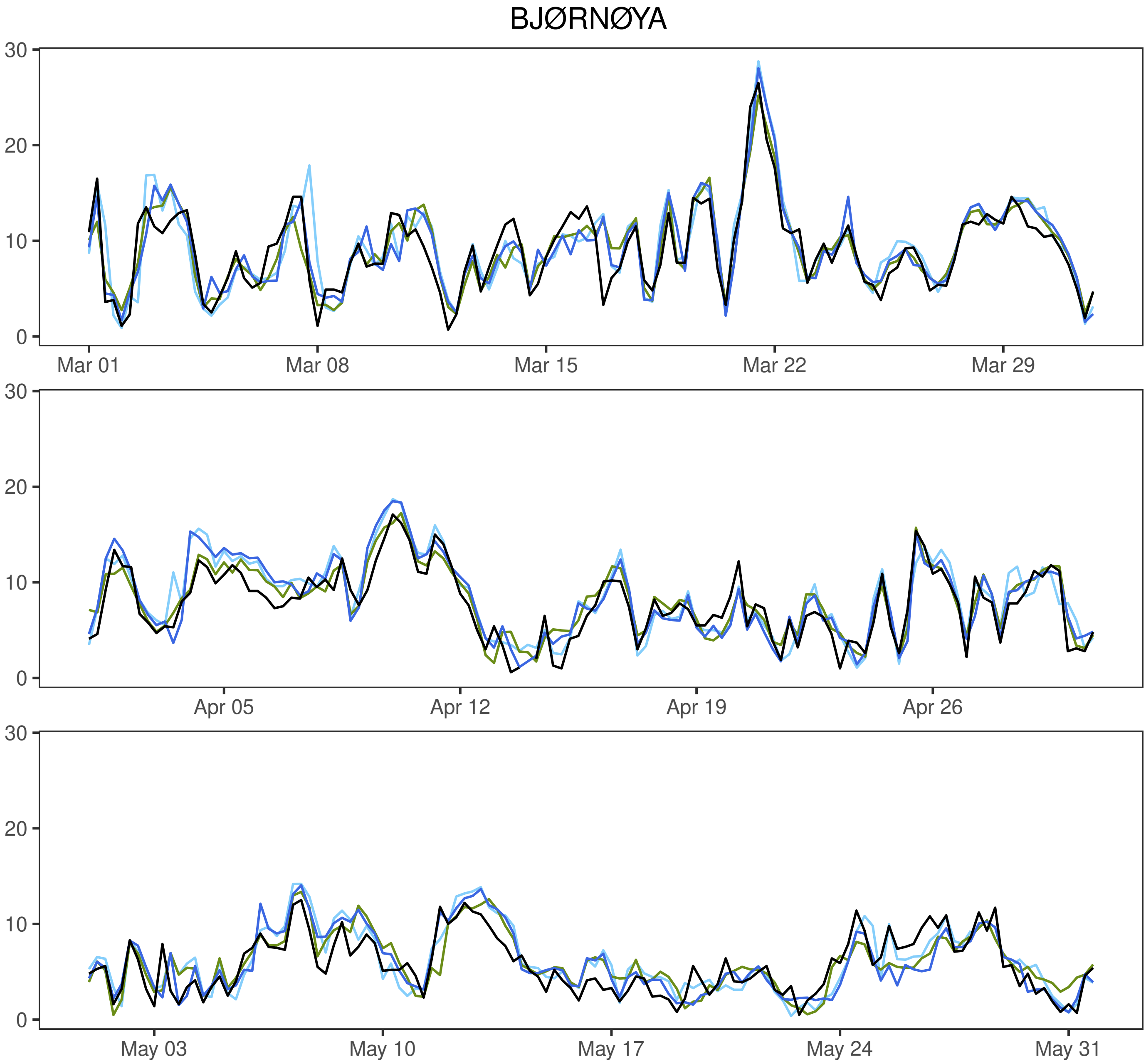


	Min	Mean	Max	Std	N
synop: 00,06,12,18	0.0	4.7	16.2	2.9	368
AA25: 12+18,+24,+30,+36	0.5	5.4	20.0	3.4	364
ECMWF: 12+18,+24,+30,+36	0.3	2.8	8.9	1.5	368

	ME	SDE	RMSE	MAE	Max.abs.err.	N
AA25−synop	0.7	2.6	2.7	2.1	11.0	364
ECMWF−synop	−1.9	2.2	2.9	2.2	10.2	364

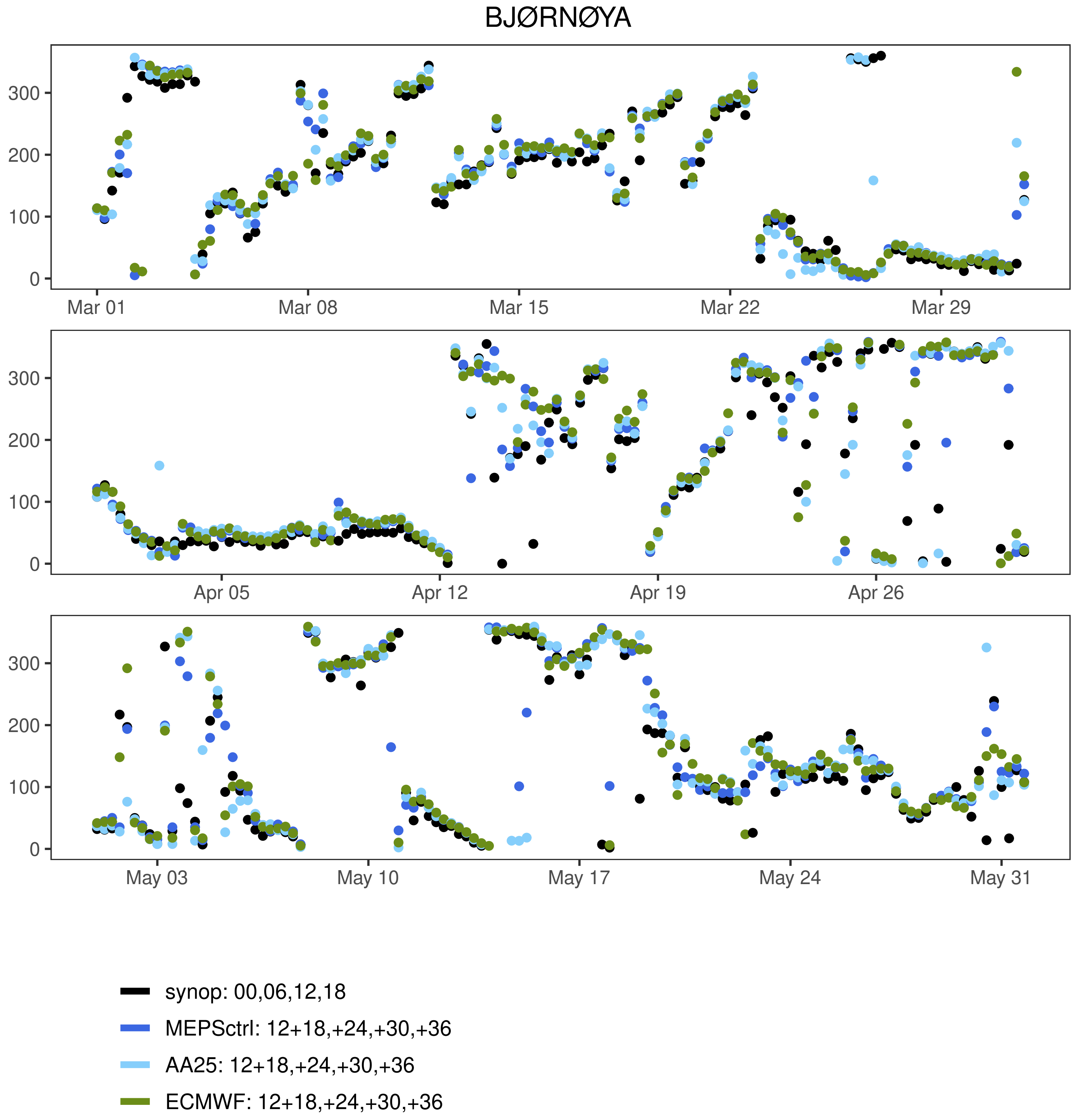

SVALBARD LUFTHAVN
300
200
100
0
Mar 01
Mar 08
Mar 15
Mar 22
Mar 29
Apr 05
Apr 12
Apr 19
Apr 26
May 03
May 10
May 17
May 24
May 31
synop: 00,06,12,18
AA25: 12+18,+24,+30,+36
ECMWF: 12+18,+24,+30,+36

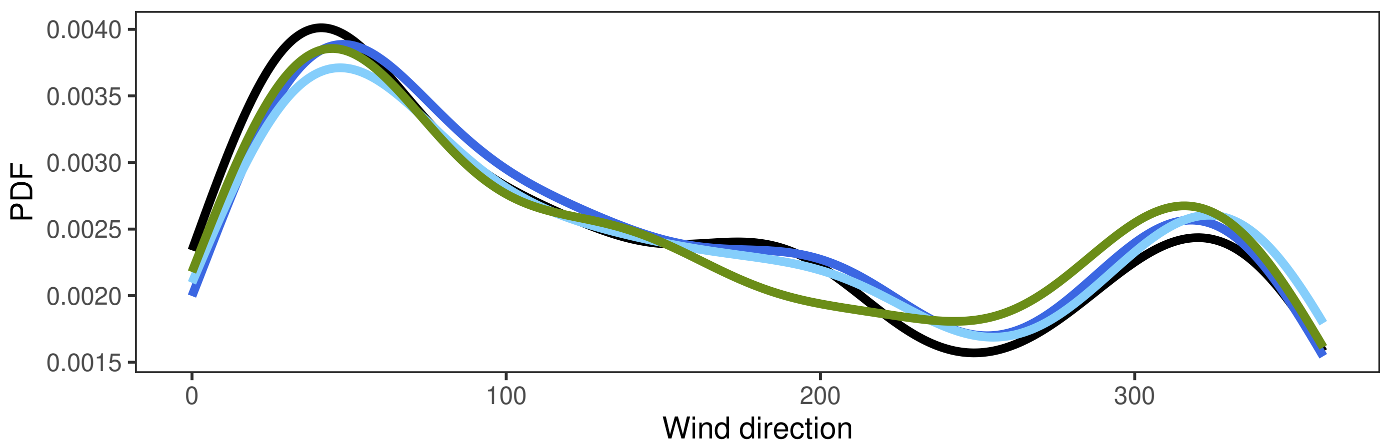

PDF
0.006
0.004
0.002
0
100
200
300
Wind direction

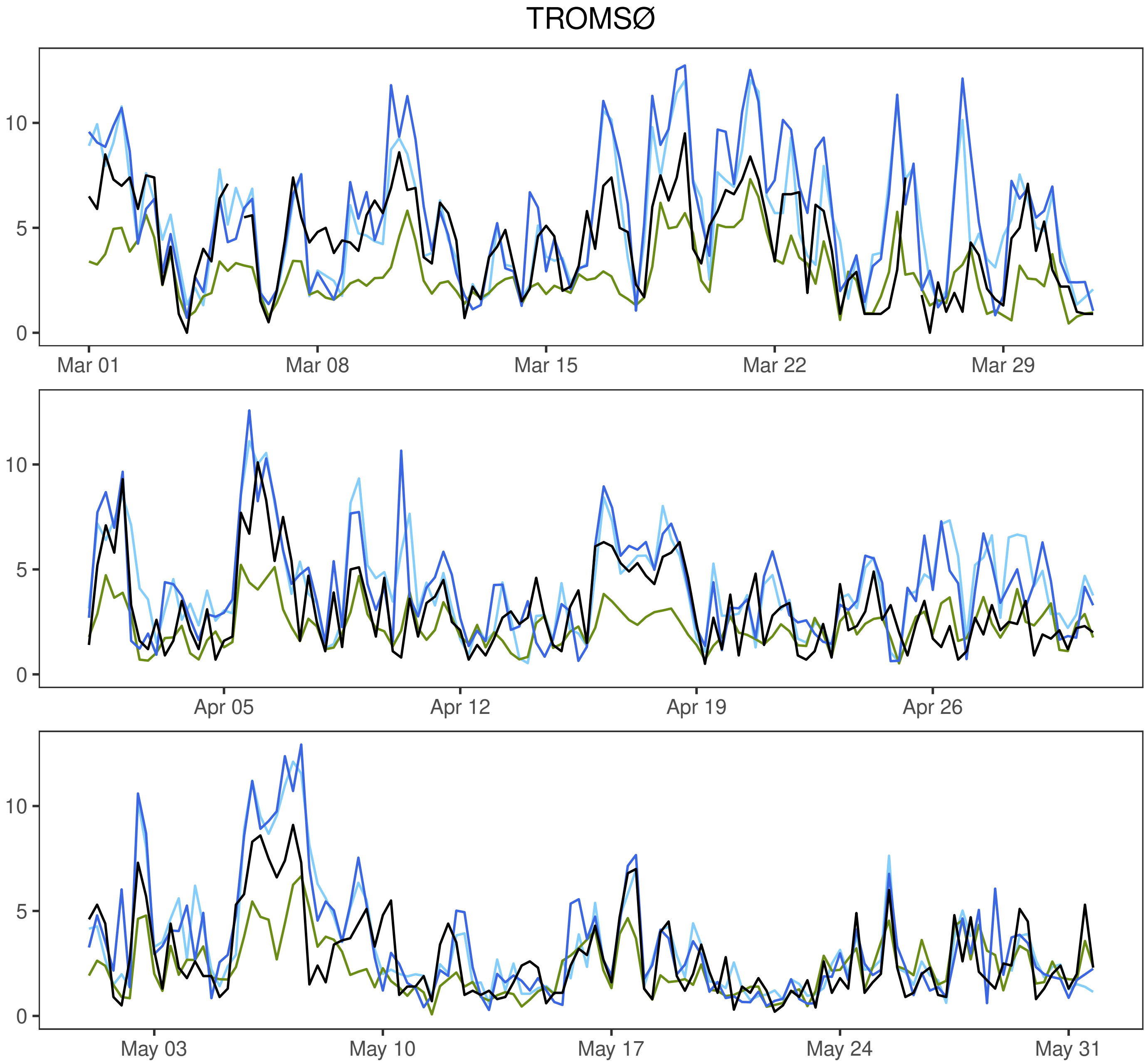


	Min	Mean	Max	Std	N
synop: 00,06,12,18	0.5	7.5	26.5	3.9	367
MEPSctrl: 12+18,+24,+30,+36	0.8	7.9	28.0	4.2	368
AA25: 12+18,+24,+30,+36	0.4	8.0	28.8	4.3	364
ECMWF: 12+18,+24,+30,+36	0.5	7.8	25.2	3.7	368

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl−synop	0.4	2.0	2.0	1.6	9.2	363
AA25−synop	0.6	2.2	2.3	1.7	12.0	363
ECMWF−synop	0.3	1.8	1.8	1.4	8.8	363

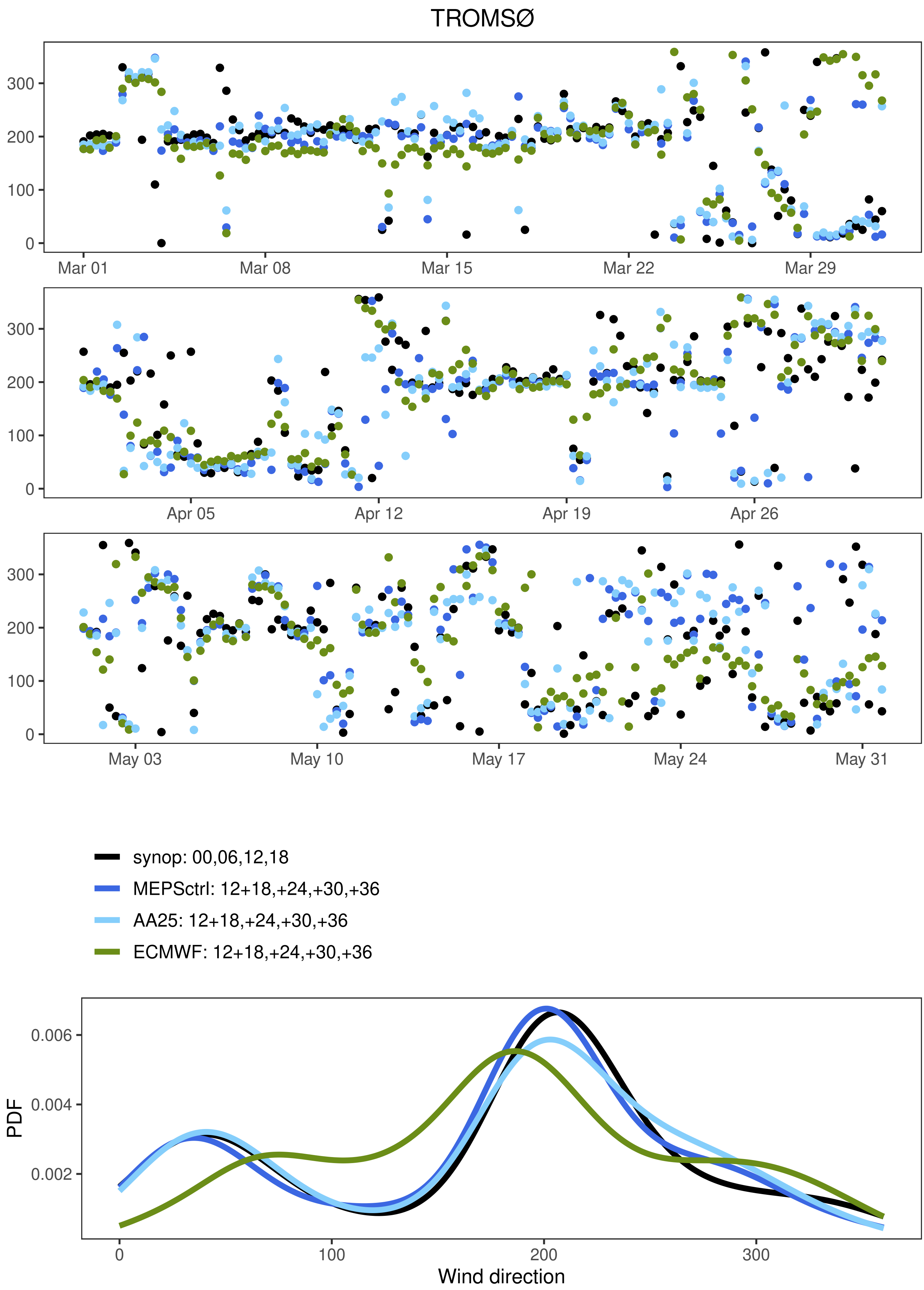

BJØRNØYA
300
200
100
0
Mar 01
Mar 08
Mar 15
Mar 22
Mar 29
Apr 05
Apr 12
Apr 19
Apr 26
May 03
May 10
May 17
May 24
May 31
synop: 00,06,12,18
MEPSctrl: 12+18,+24,+30,+36
AA25: 12+18,+24,+30,+36
ECMWF: 12+18,+24,+30,+36

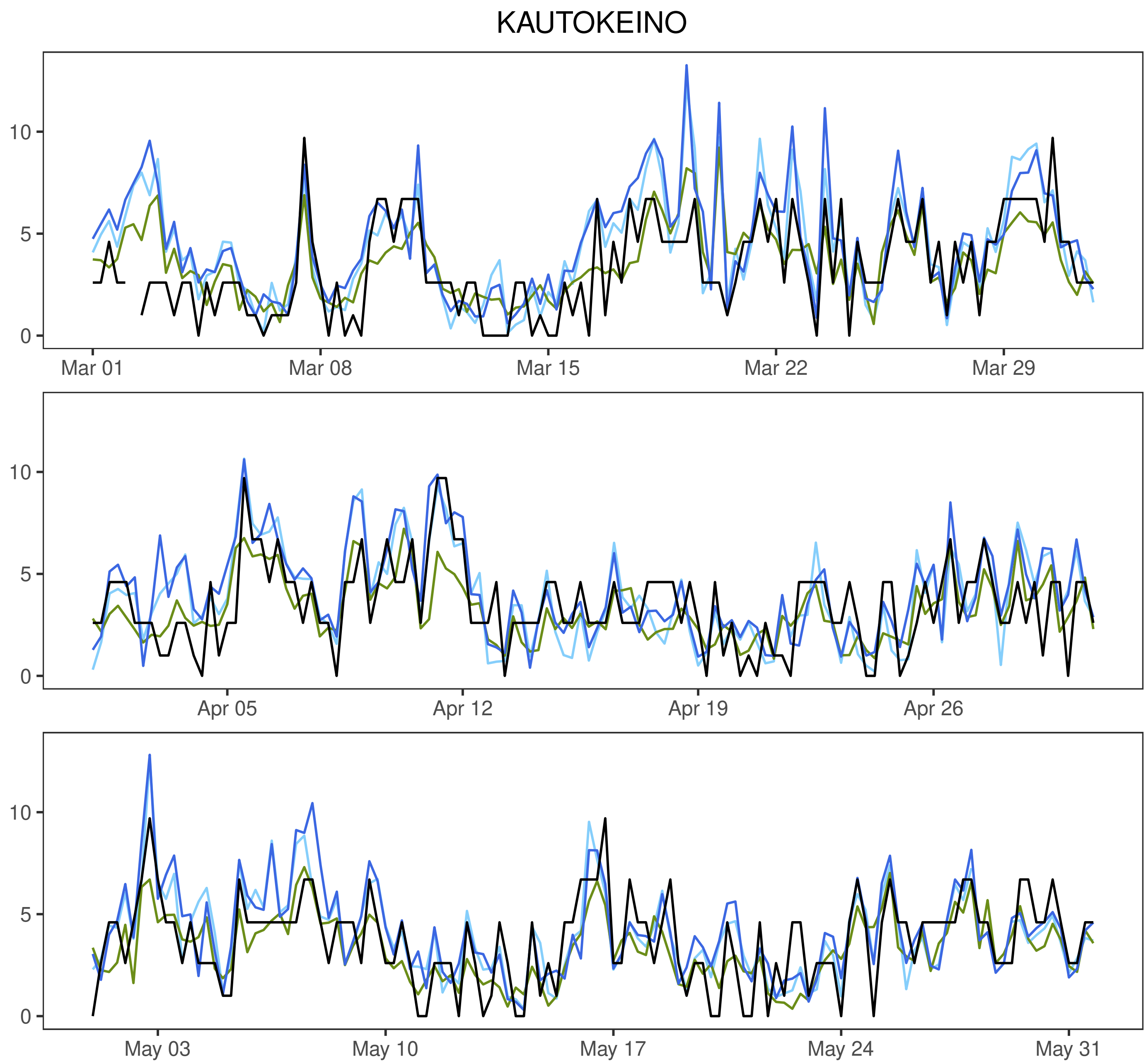

PDF
0.0040
0.0035
0.0030
0.0025
0.0020
0.0015
0
100
200
300
Wind direction



	Min	Mean	Max	Std	N
synop: 00,06,12,18	0.0	3.4	10.1	2.2	366
MEPSctrl: 12+18,+24,+30,+36	0.3	4.4	12.9	2.9	368
AA25: 12+18,+24,+30,+36	0.5	4.3	12.1	2.7	364
ECMWF: 12+18,+24,+30,+36	0.1	2.5	7.3	1.3	368

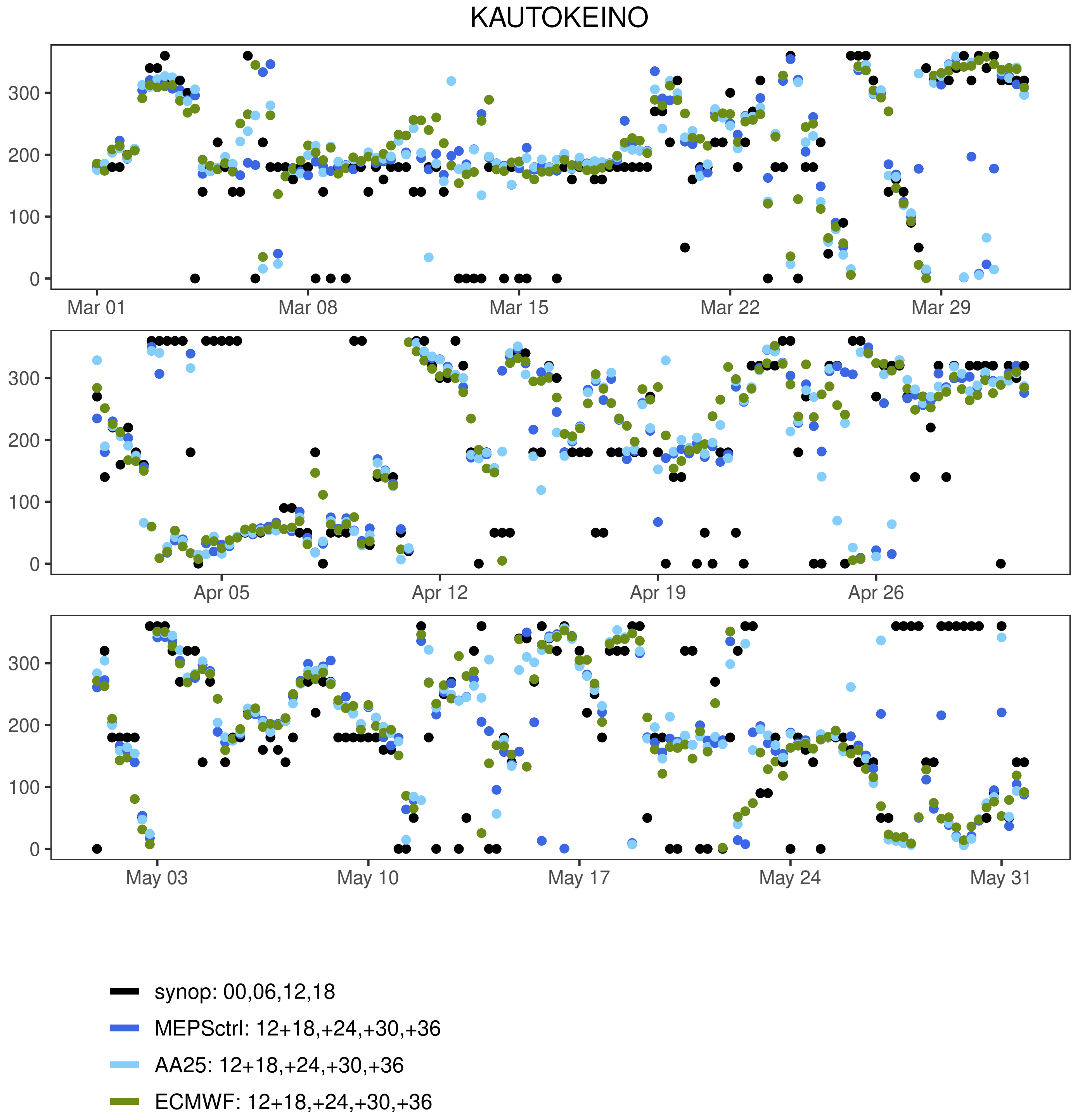
	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl–synop	1.0	2.0	2.2	1.6	11.1	362
AA25–synop	0.9	1.9	2.0	1.5	9.1	362
ECMWF–synop	−1.0	1.6	1.8	1.4	6.1	362

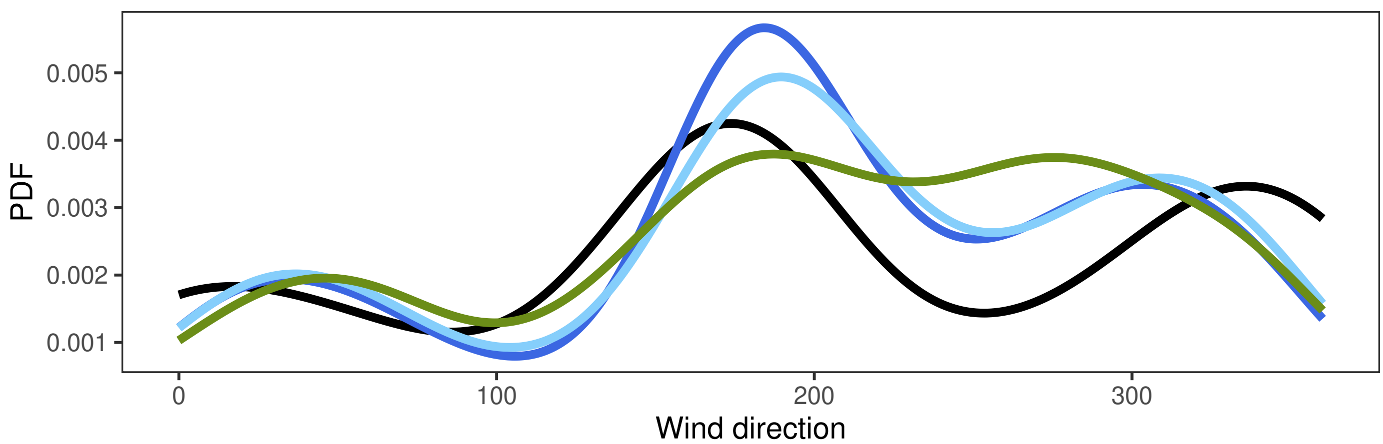

TROMSØ
Mar 01
Mar 08
Mar 15
Mar 22
Mar 29
Apr 05
Apr 12
Apr 19
Apr 26
May 03
May 10
May 17
May 24
May 31
synop: 00,06,12,18
MEPSctrl: 12+18,+24,+30,+36
AA25: 12+18,+24,+30,+36
ECMWF: 12+18,+24,+30,+36
PDF
Wind direction

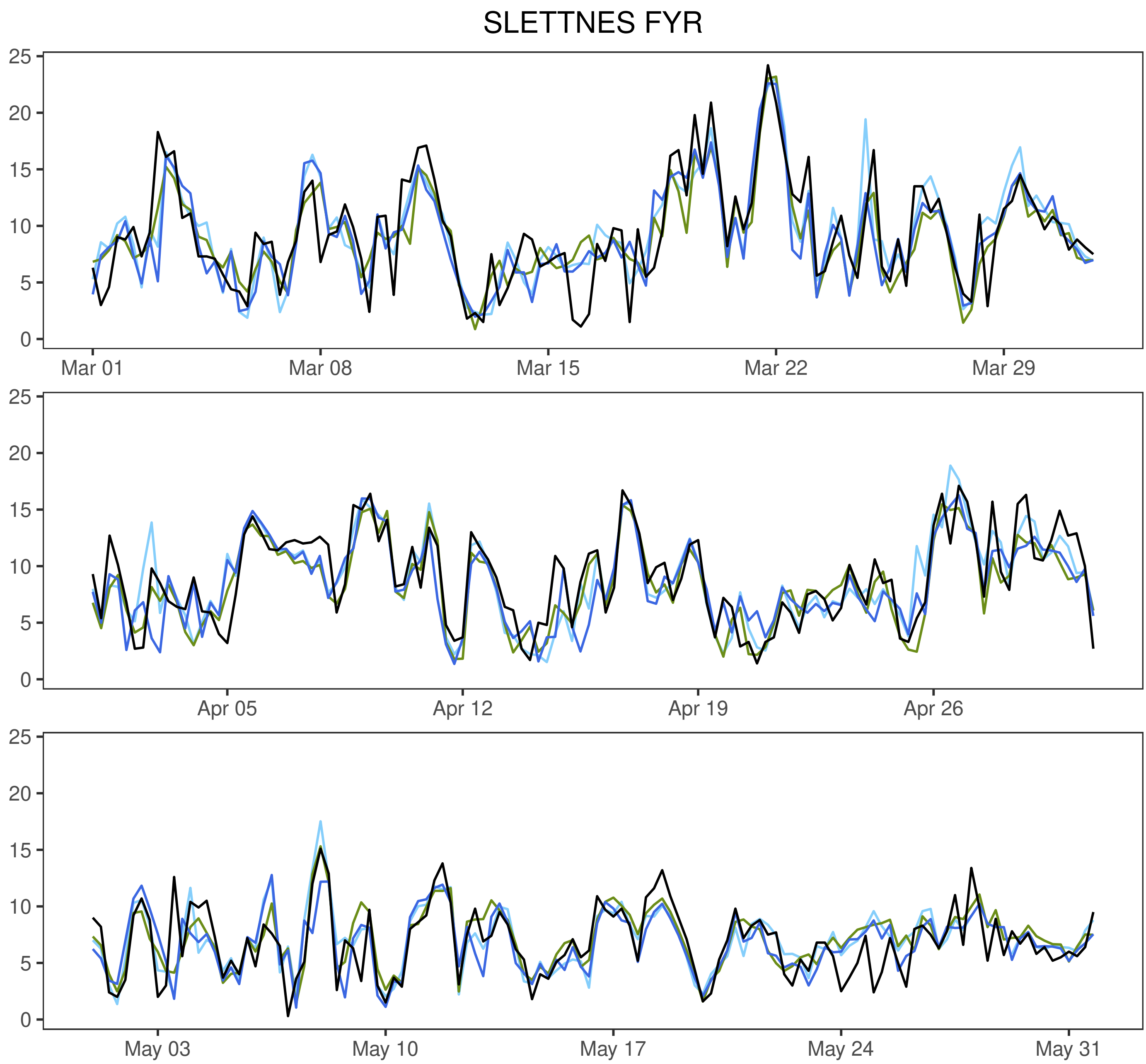


	Min	Mean	Max	Std	N
synop: 00,06,12,18	0.0	3.5	9.7	2.2	367
MEPSctrl: 12+18,+24,+30,+36	0.3	4.3	13.3	2.4	368
AA25: 12+18,+24,+30,+36	0.1	4.1	12.6	2.3	364
ECMWF: 12+18,+24,+30,+36	0.4	3.4	9.2	1.6	368

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl−synop	0.8	1.9	2.1	1.6	8.8	363
AA25−synop	0.6	1.8	1.9	1.5	7.7	363
ECMWF−synop	−0.1	1.7	1.7	1.4	6.6	363

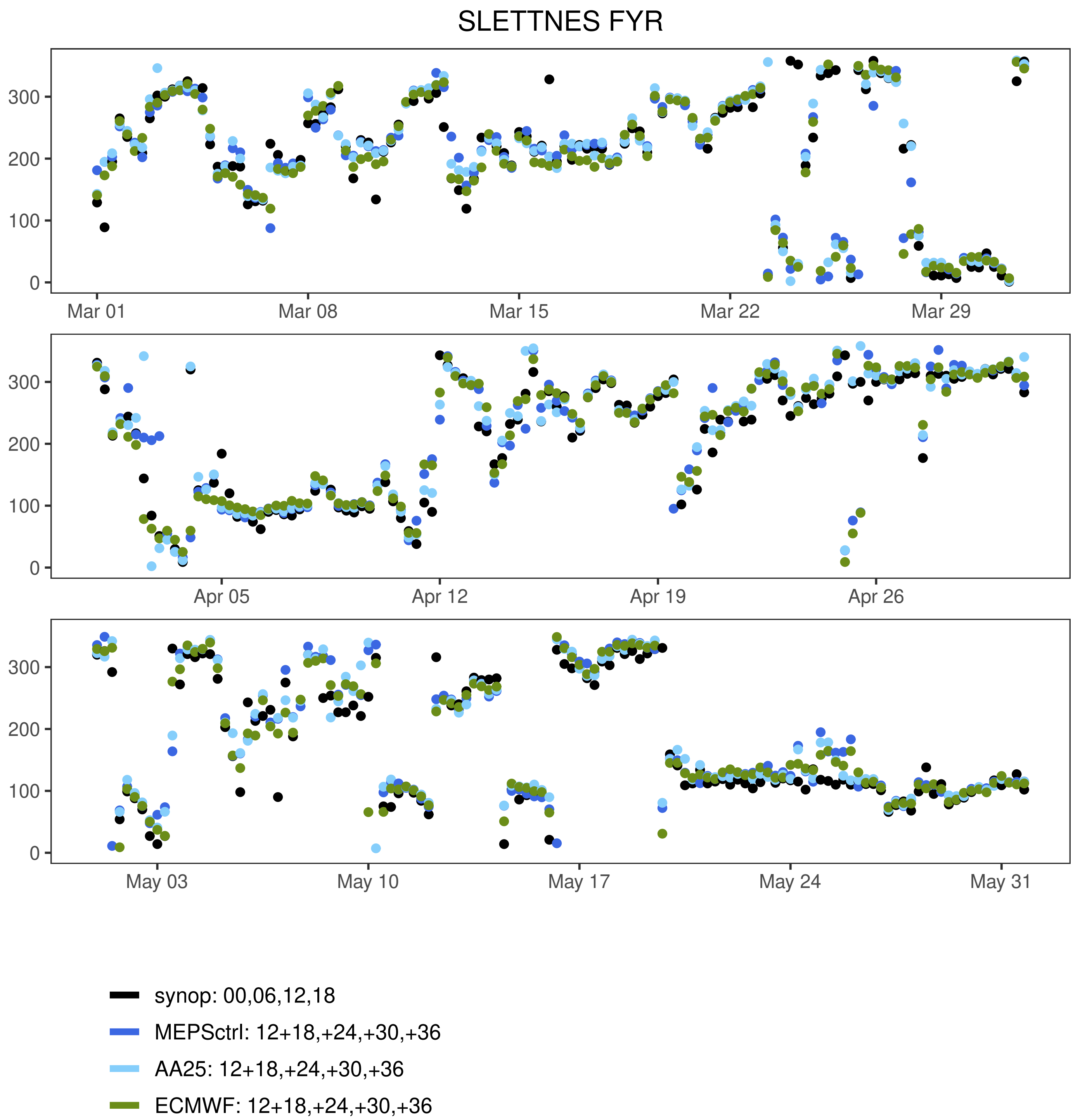

KAUTOKEINO
300
200
100
0
Mar 01
Mar 08
Mar 15
Mar 22
Mar 29
Apr 05
Apr 12
Apr 19
Apr 26
May 03
May 10
May 17
May 24
May 31
synop: 00,06,12,18
MEPSctrl: 12+18,+24,+30,+36
AA25: 12+18,+24,+30,+36
ECMWF: 12+18,+24,+30,+36

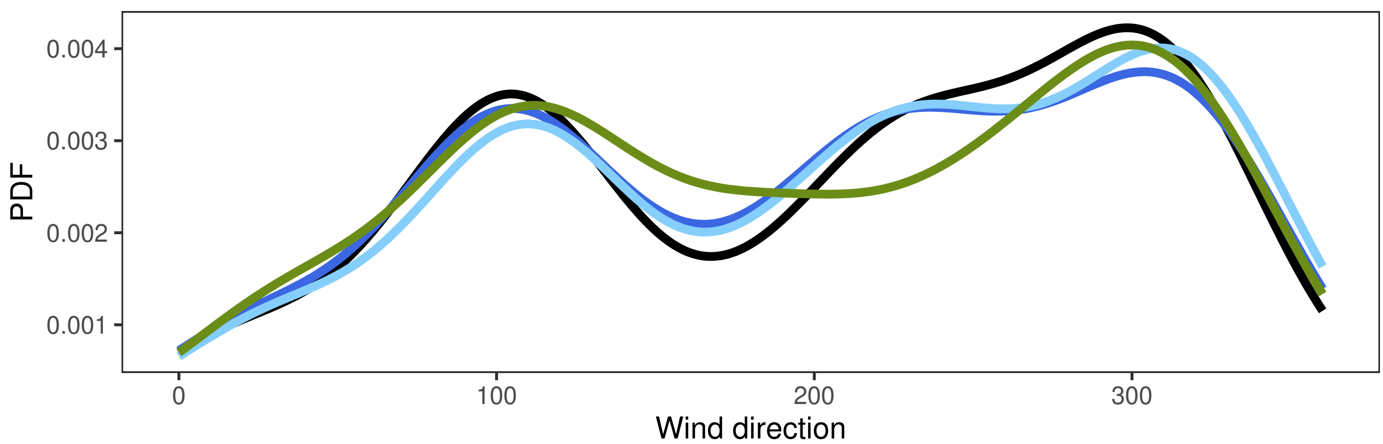

PDF
0.005
0.004
0.003
0.002
0.001
0
100
200
300
Wind direction

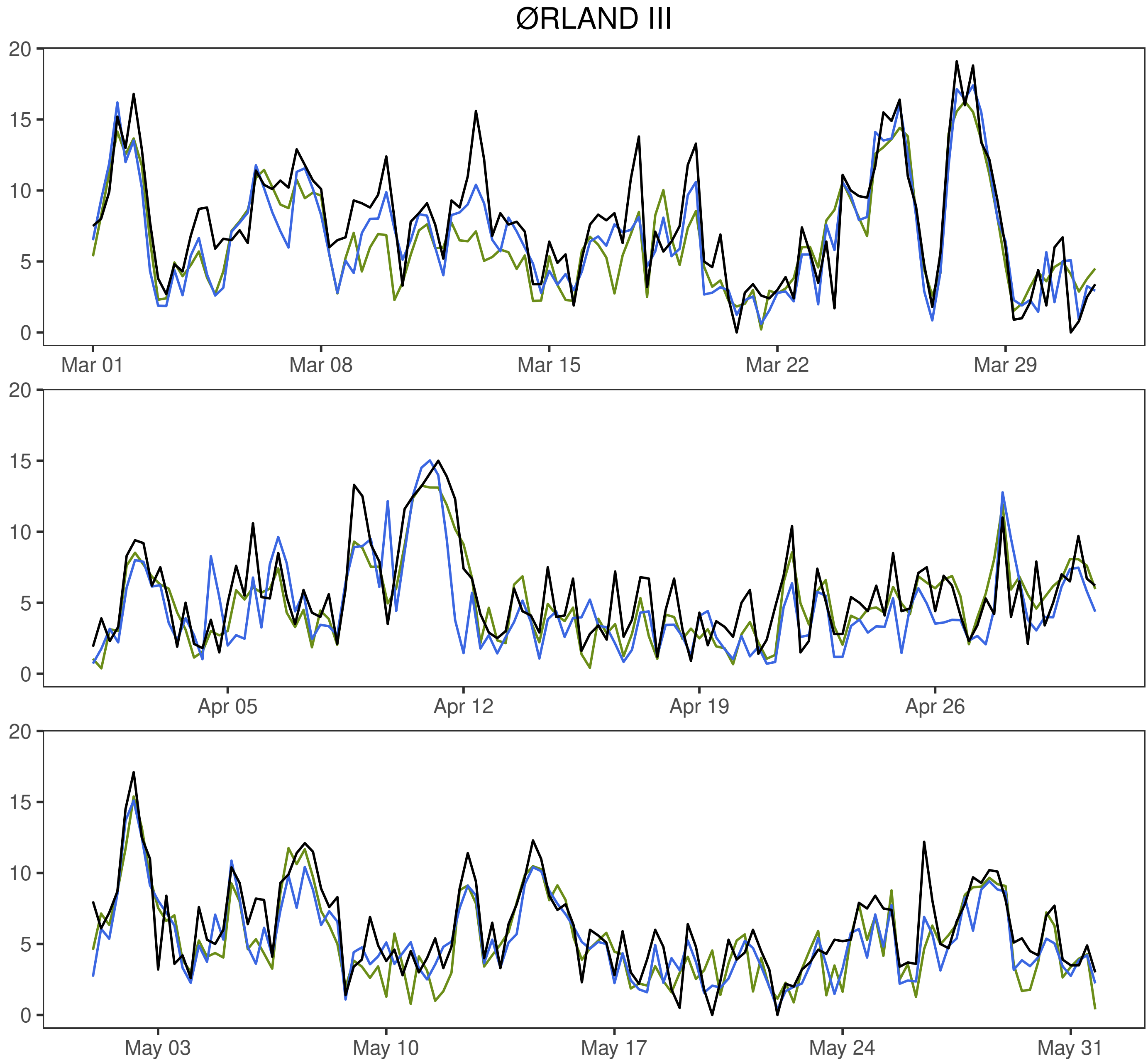


	Min	Mean	Max	Std	N
synop: 00,06,12,18	0.3	8.4	24.2	4.1	368
MEPSctrl: 12+18,+24,+30,+36	1.1	8.1	22.6	3.6	368
AA25: 12+18,+24,+30,+36	1.4	8.5	23.1	3.8	364
ECMWF: 12+18,+24,+30,+36	0.9	8.2	23.2	3.4	368

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl–synop	−0.3	2.6	2.6	2.0	13.2	364
AA25–synop	0.0	2.5	2.5	1.8	10.5	364
ECMWF–synop	−0.3	2.2	2.2	1.7	8.5	364

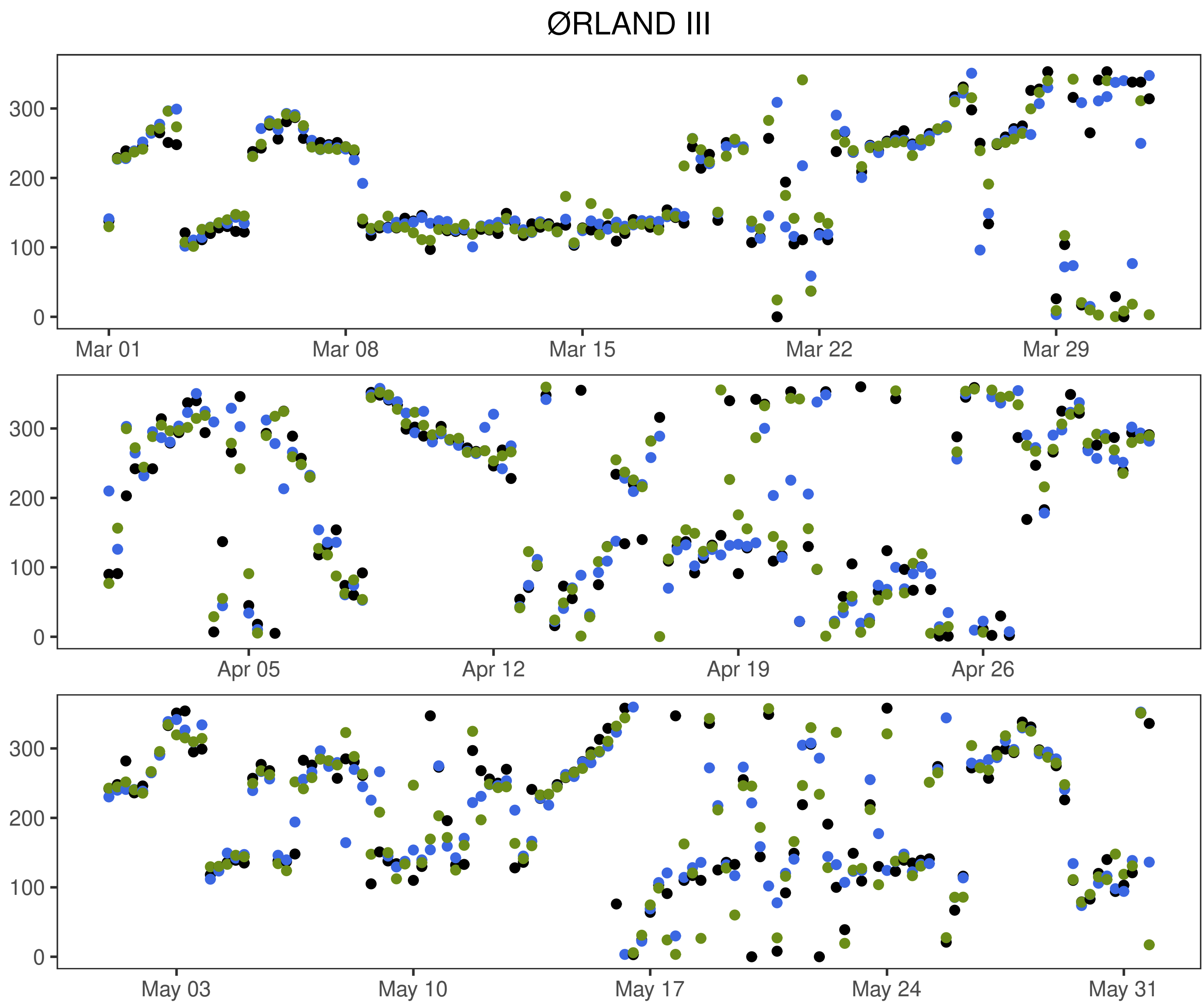

SLETTNES FYR
300
200
100
0
Mar 01
Mar 08
Mar 15
Mar 22
Mar 29
Apr 05
Apr 12
Apr 19
Apr 26
May 03
May 10
May 17
May 24
May 31
synop: 00,06,12,18
MEPSctrl: 12+18,+24,+30,+36
AA25: 12+18,+24,+30,+36
ECMWF: 12+18,+24,+30,+36

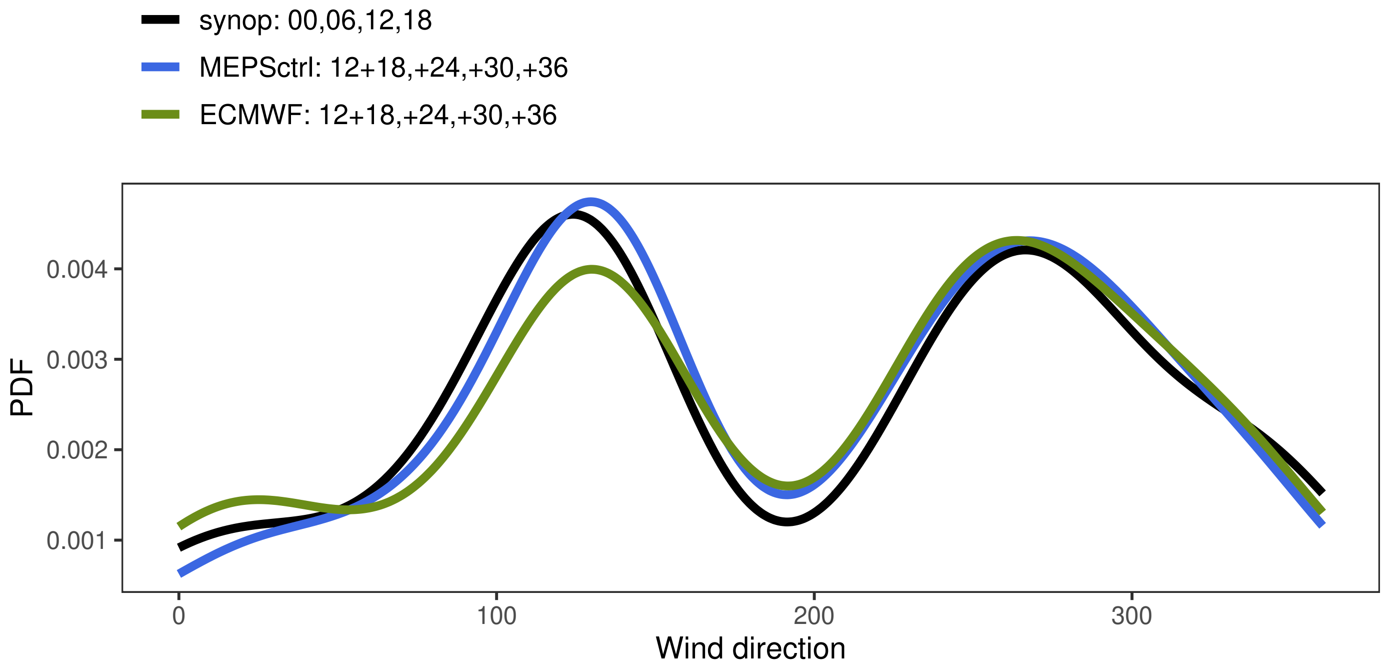

PDF
0.004
0.003
0.002
0.001
0
100
200
300
Wind direction

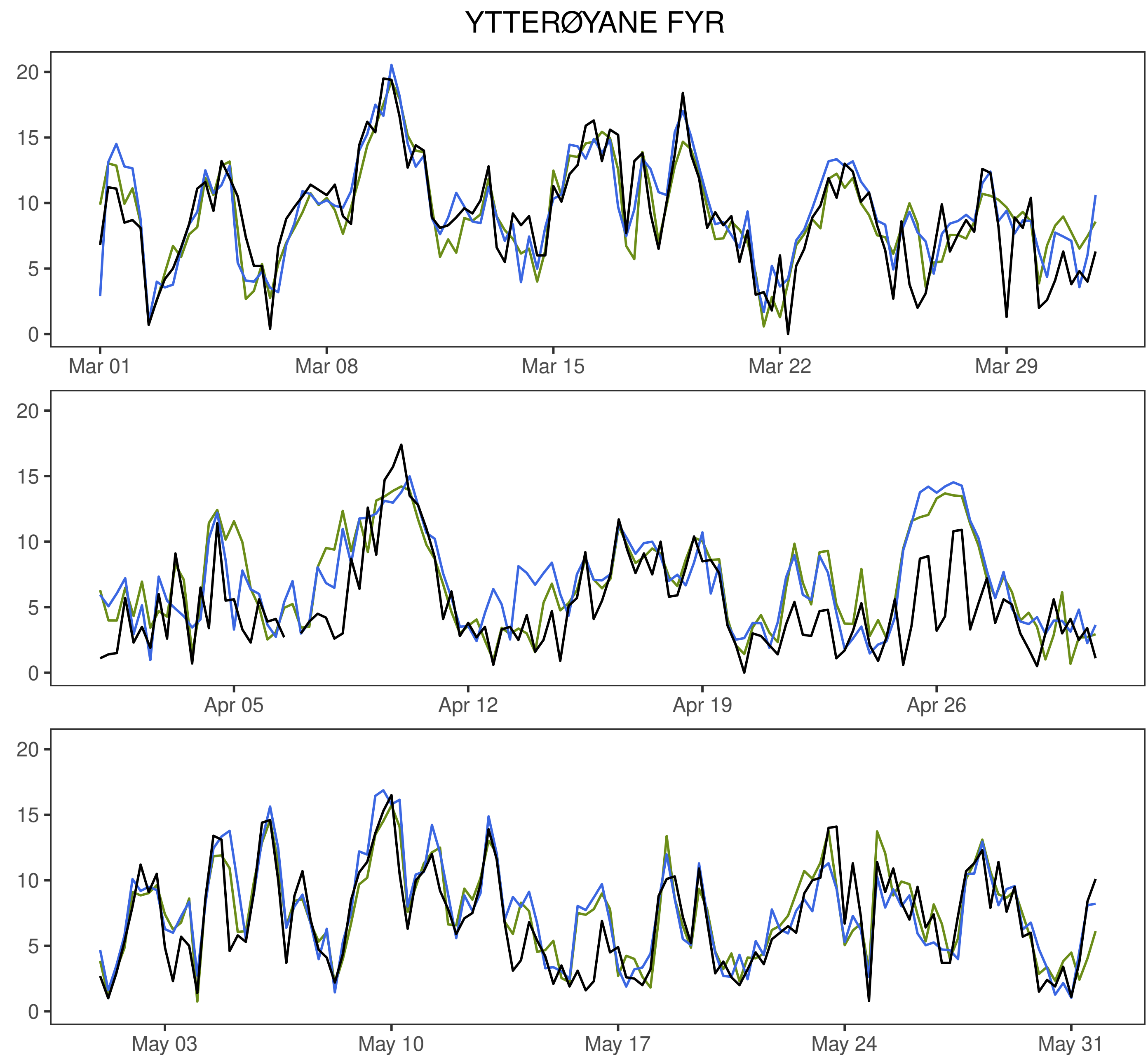


	Min	Mean	Max	Std	N
synop: 00,06,12,18	0.0	6.5	19.1	3.6	368
MEPSctrl: 12+18,+24,+30,+36	0.4	5.5	17.4	3.4	368
ECMWF: 12+18,+24,+30,+36	0.2	5.6	16.3	3.2	368

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl–synop	–0.9	1.9	2.1	1.6	8.7	368
ECMWF–synop	–0.8	1.9	2.1	1.6	8.5	368

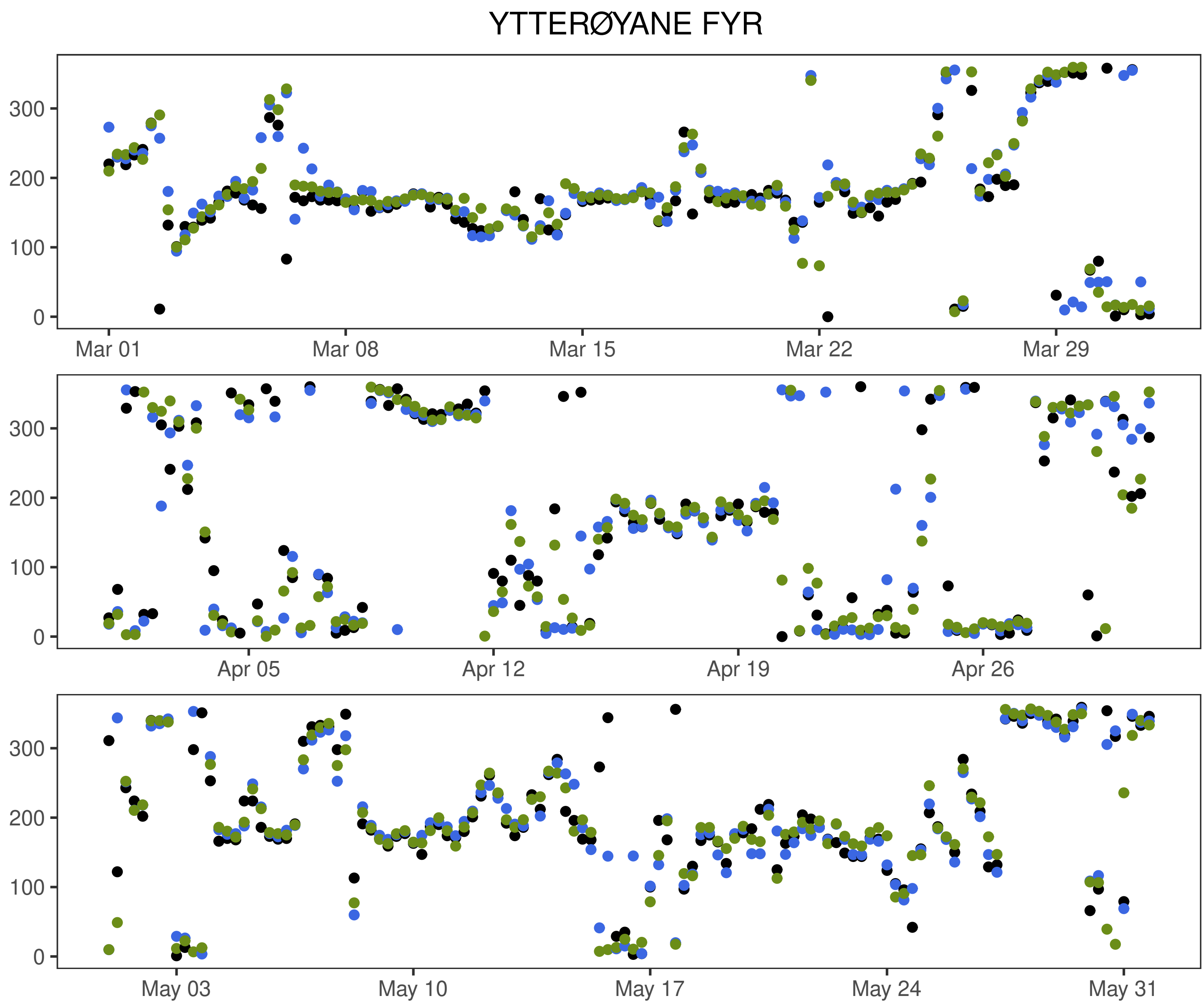

ØRLAND III
300
200
100
0
Mar 01
Mar 08
Mar 15
Mar 22
Mar 29
Apr 05
Apr 12
Apr 19
Apr 26
May 03
May 10
May 17
May 24
May 31

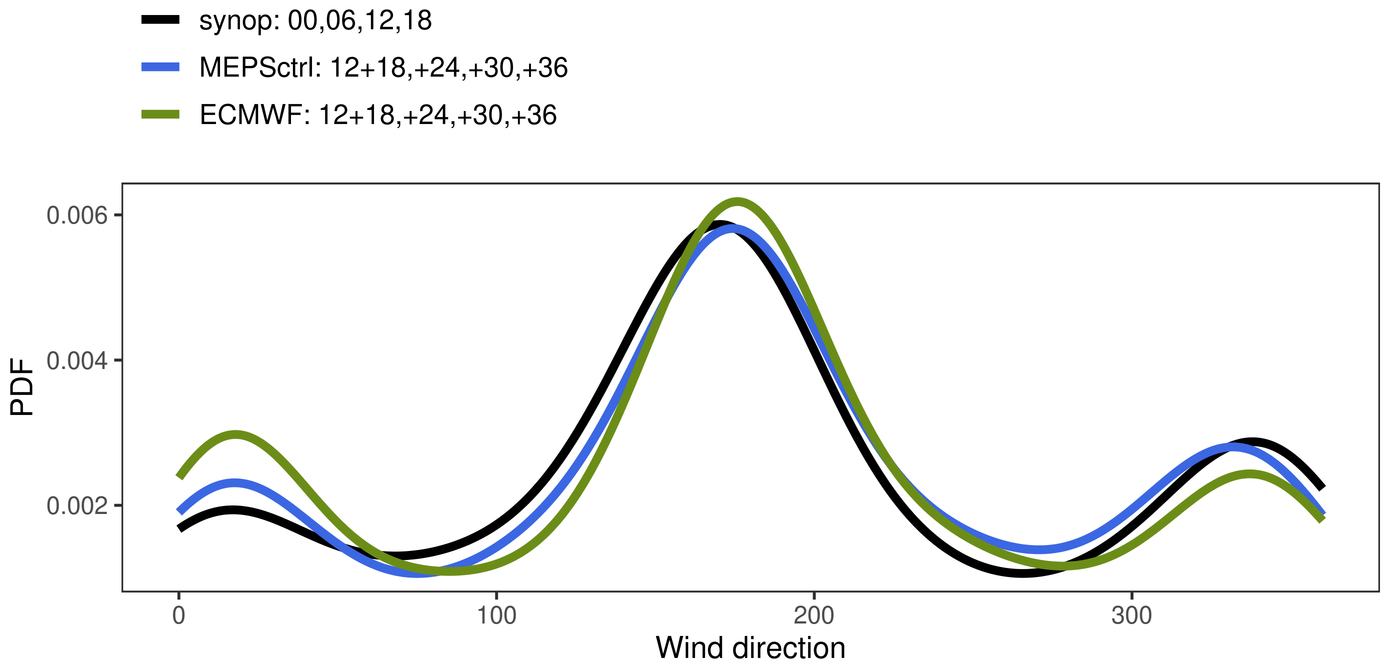

synop: 00,06,12,18
MEPSctrl: 12+18,+24,+30,+36
ECMWF: 12+18,+24,+30,+36
PDF
0.004
0.003
0.002
0.001
0
100
200
300
Wind direction

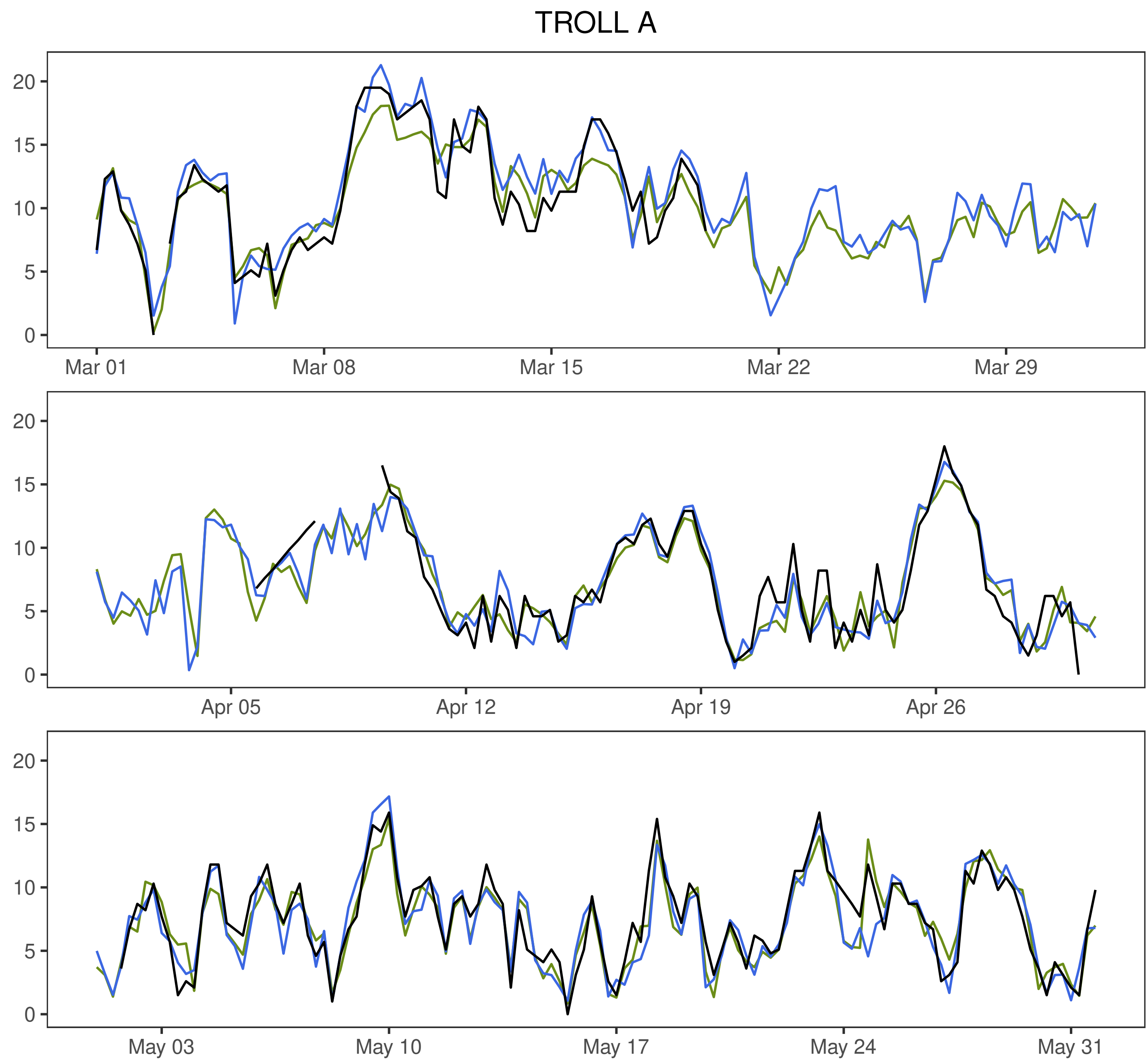


	Min	Mean	Max	Std	N
synop: 00,06,12,18	0.0	7.1	19.5	4.1	367
MEPSctrl: 12+18,+24,+30,+36	1.0	8.0	20.5	3.8	368
ECMWF: 12+18,+24,+30,+36	0.6	7.8	19.3	3.6	368

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl−synop	0.9	2.5	2.6	1.9	10.5	367
ECMWF−synop	0.7	2.4	2.5	1.8	10.1	367

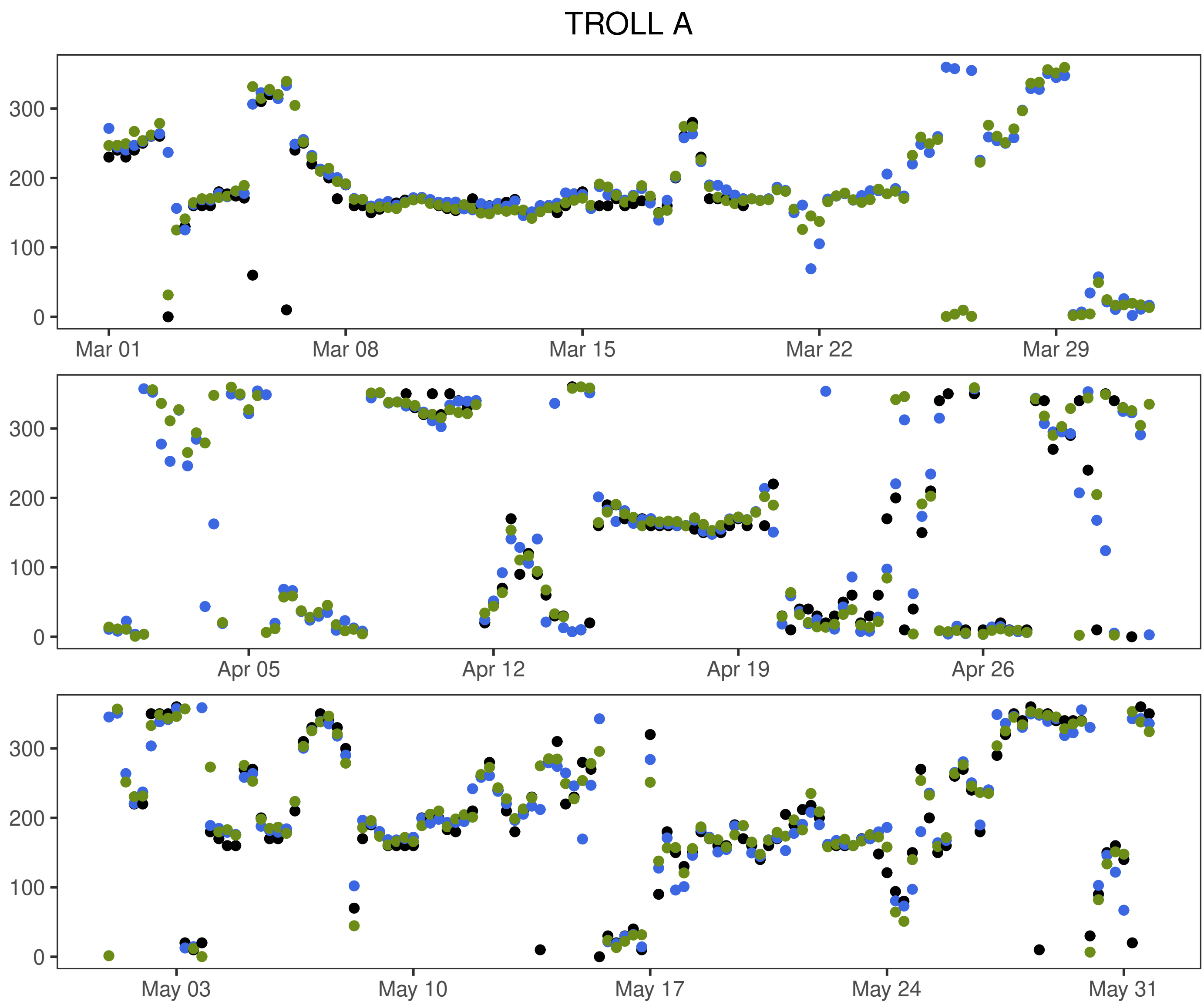

YTTERØYANE FYR
300
200
100
0
Mar 01
Mar 08
Mar 15
Mar 22
Mar 29
Apr 05
Apr 12
Apr 19
Apr 26
May 03
May 10
May 17
May 24
May 31

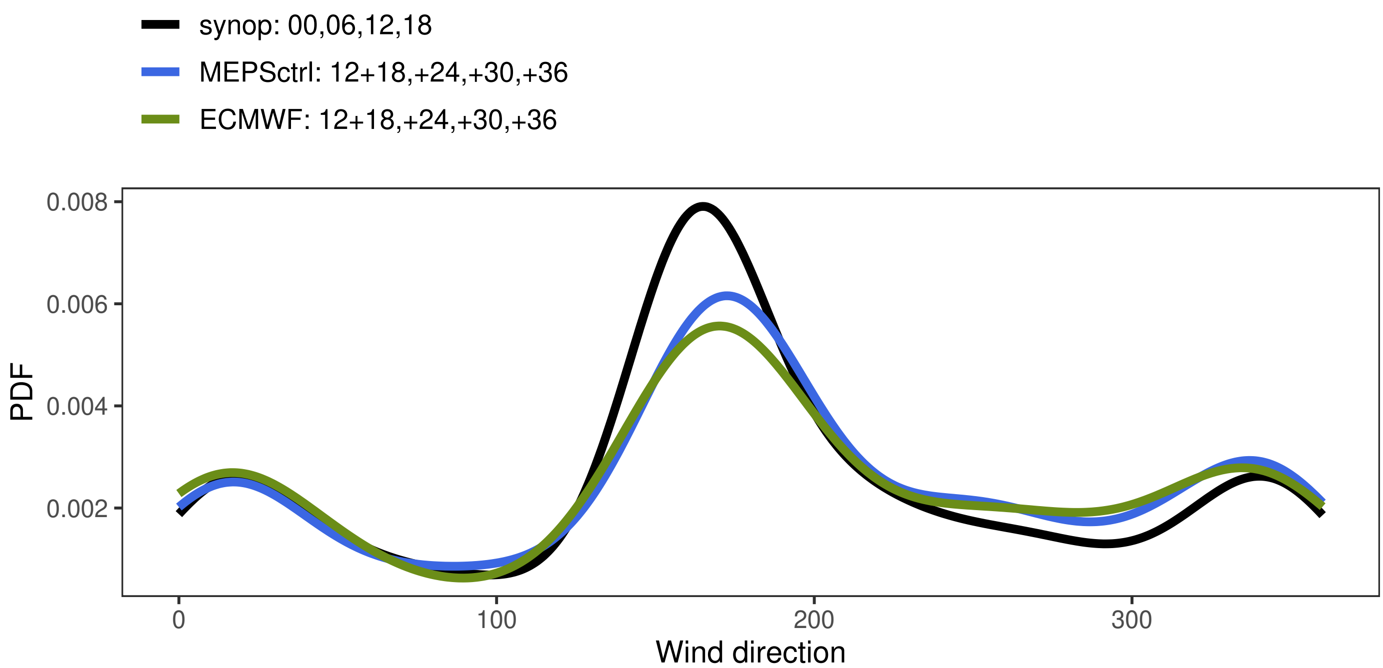

synop: 00,06,12,18
MEPSctrl: 12+18,+24,+30,+36
ECMWF: 12+18,+24,+30,+36
PDF
0.006
0.004
0.002
0
100
200
300
Wind direction

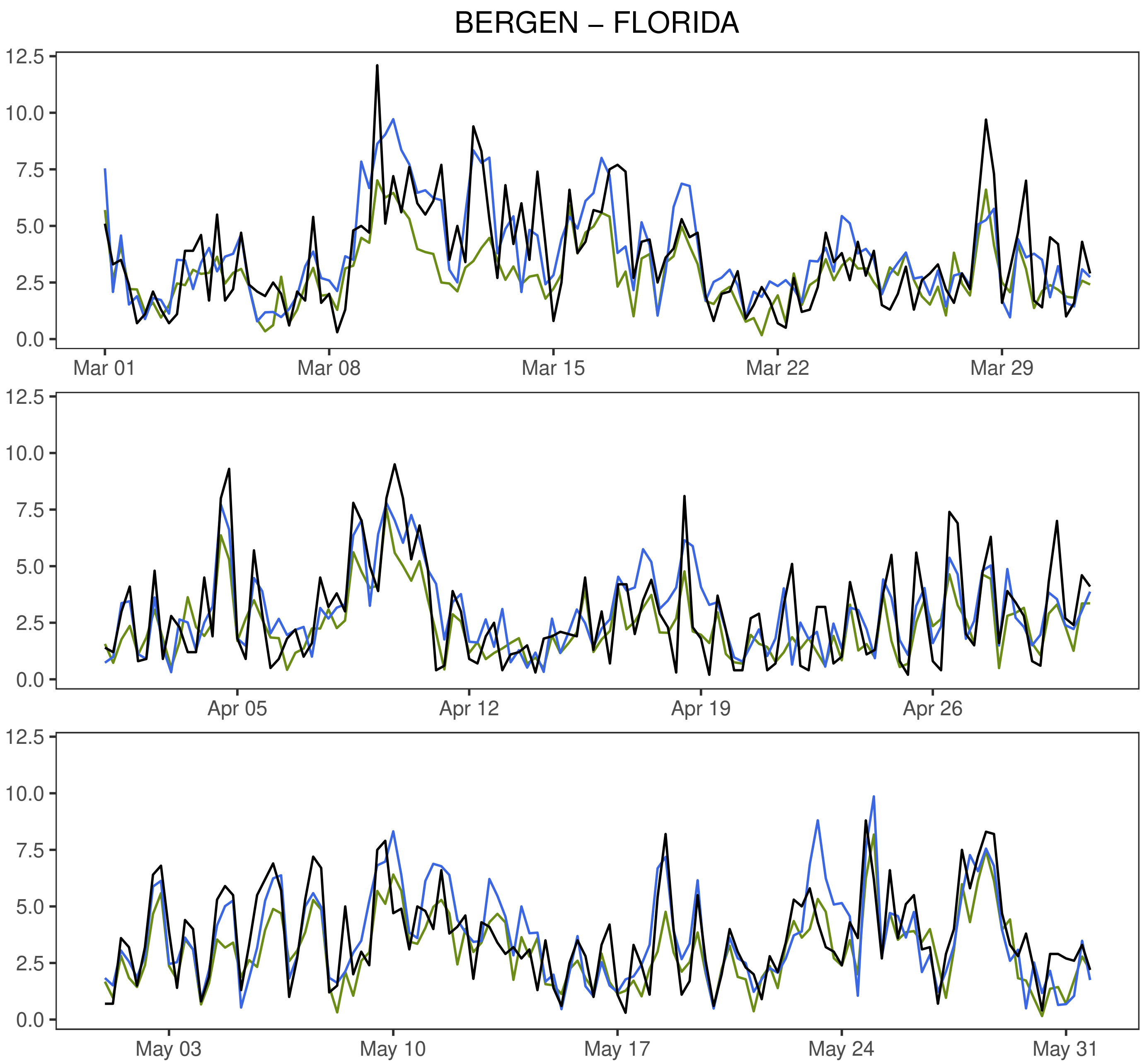


	Min	Mean	Max	Std	N
synop: 00,06,12,18	0.0	8.5	19.5	4.3	288
MEPSctrl: 12+18,+24,+30,+36	0.3	8.4	21.3	4.2	368
ECMWF: 12+18,+24,+30,+36	0.2	8.1	18.1	3.7	368

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl−synop	0.1	1.7	1.7	1.3	7.2	288
ECMWF−synop	−0.2	1.6	1.6	1.3	5.7	288

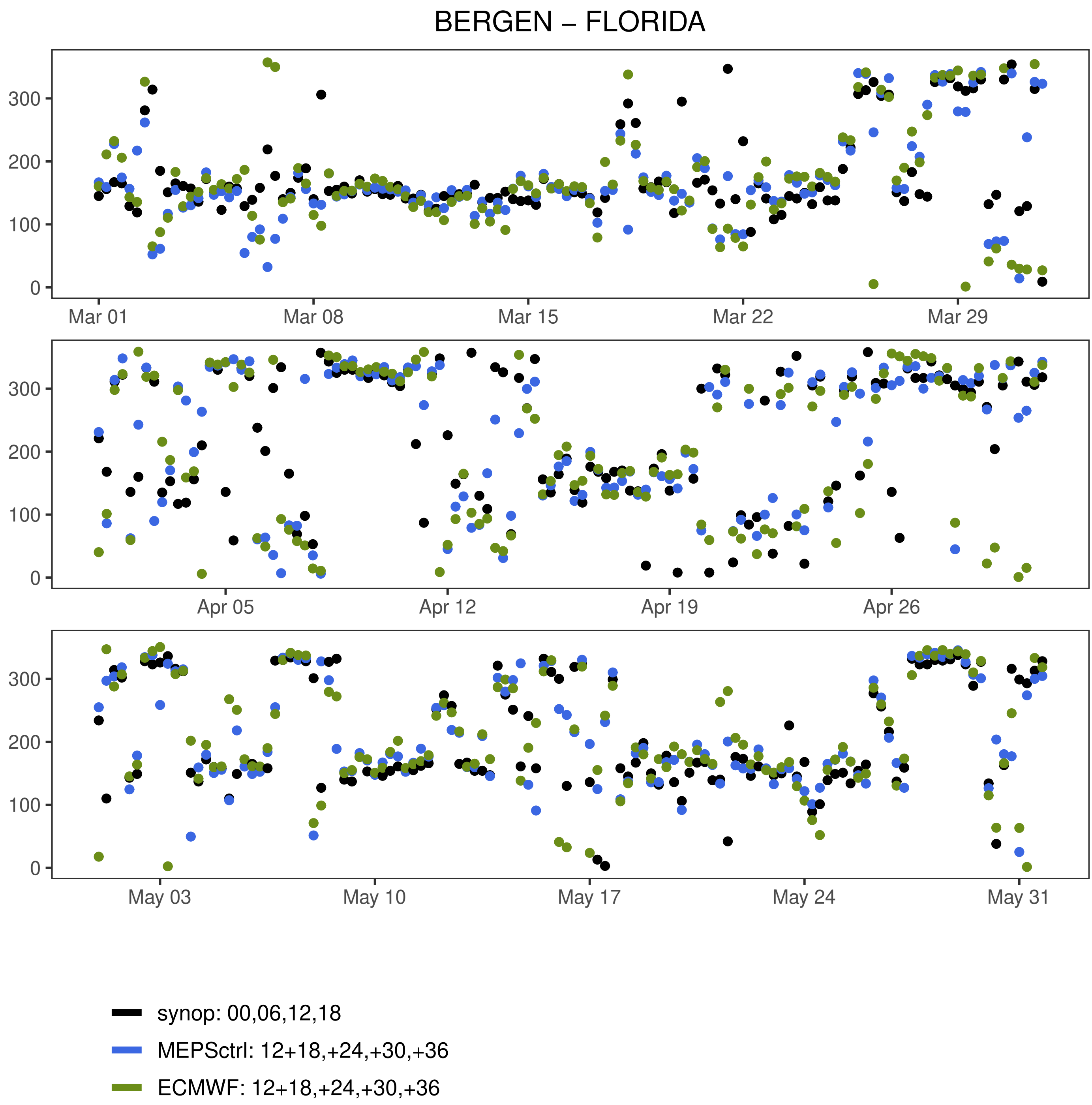

TROLL A
300
200
100
0
Mar 01
Mar 08
Mar 15
Mar 22
Mar 29
Apr 05
Apr 12
Apr 19
Apr 26
May 03
May 10
May 17
May 24
May 31

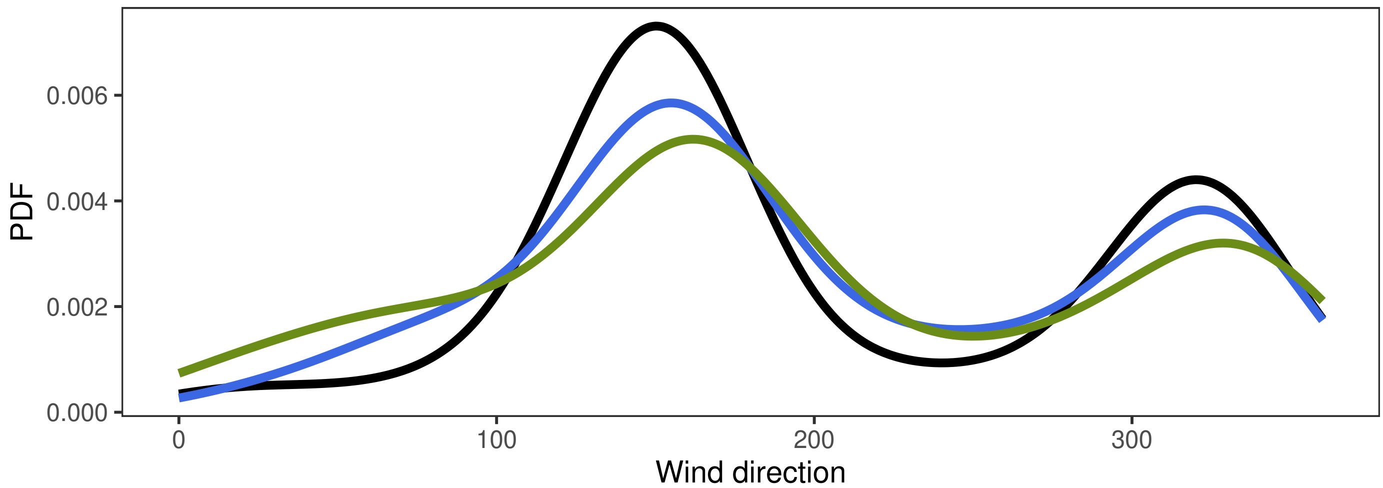

synop: 00,06,12,18
MEPSctrl: 12+18,+24,+30,+36
ECMWF: 12+18,+24,+30,+36
0.008
0.006
0.004
0.002
PDF
0
100
200
300
Wind direction

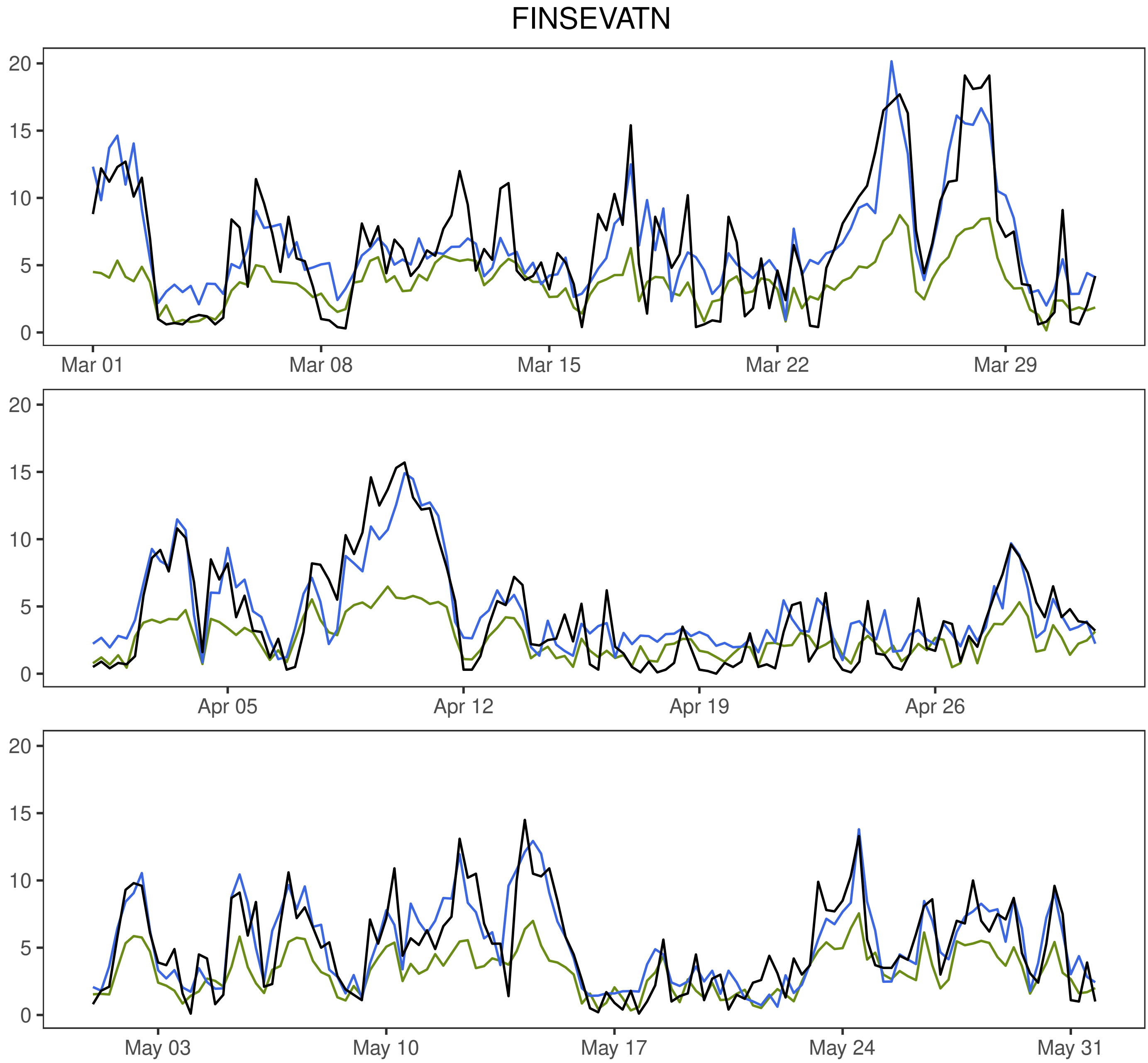


	Min	Mean	Max	Std	N
synop: 00,06,12,18	0.2	3.4	12.1	2.2	368
MEPSctrl: 12+18,+24,+30,+36	0.3	3.5	9.9	2.0	368
ECMWF: 12+18,+24,+30,+36	0.2	2.8	8.2	1.5	368

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl–synop	0.1	1.5	1.5	1.2	4.5	368
ECMWF–synop	−0.6	1.4	1.6	1.2	6.0	368

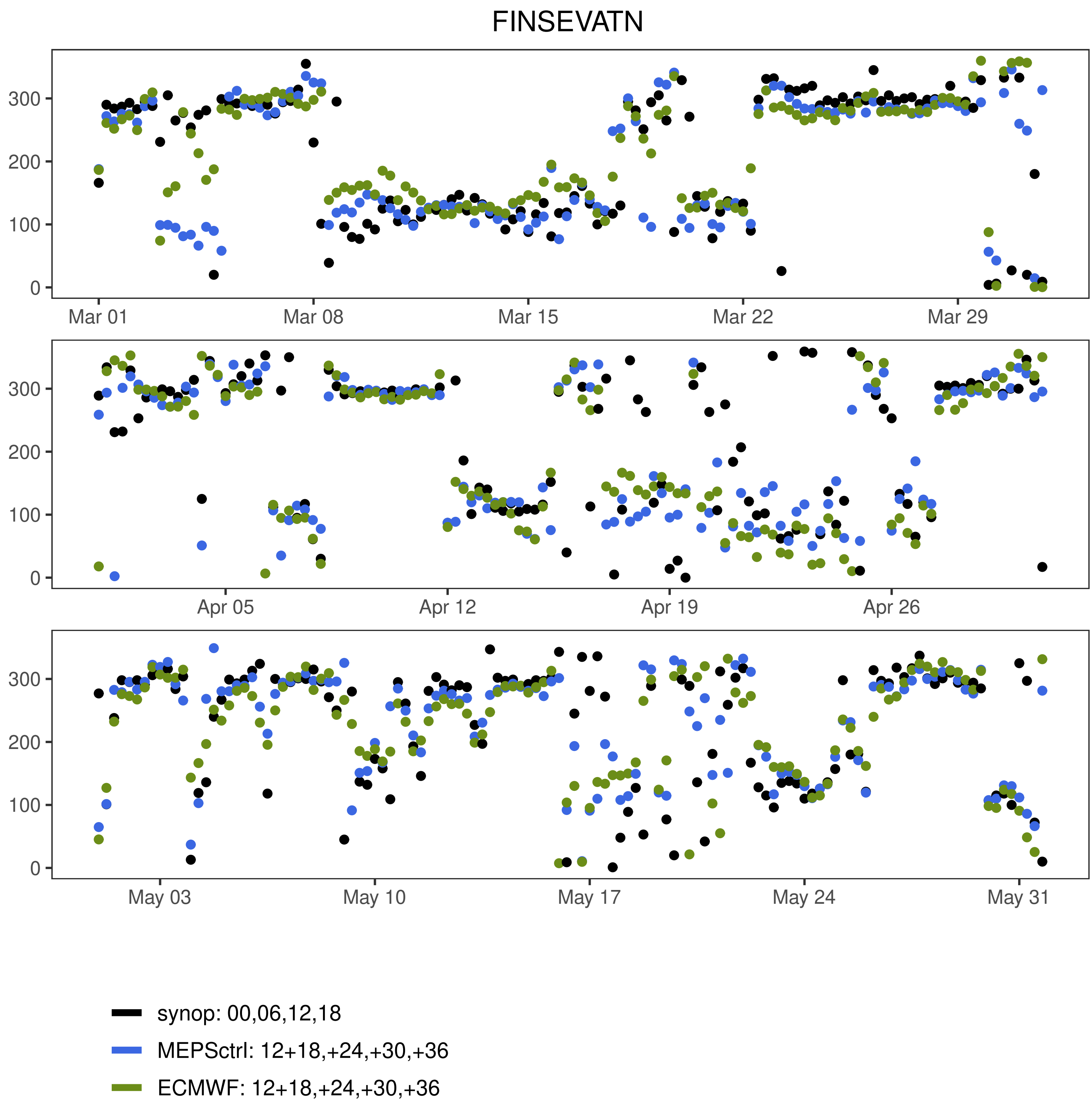

BERGEN – FLORIDA
300
200
100
0
Mar 01
Mar 08
Mar 15
Mar 22
Mar 29
Apr 05
Apr 12
Apr 19
Apr 26
May 03
May 10
May 17
May 24
May 31
synop: 00,06,12,18
MEPSctrl: 12+18,+24,+30,+36
ECMWF: 12+18,+24,+30,+36

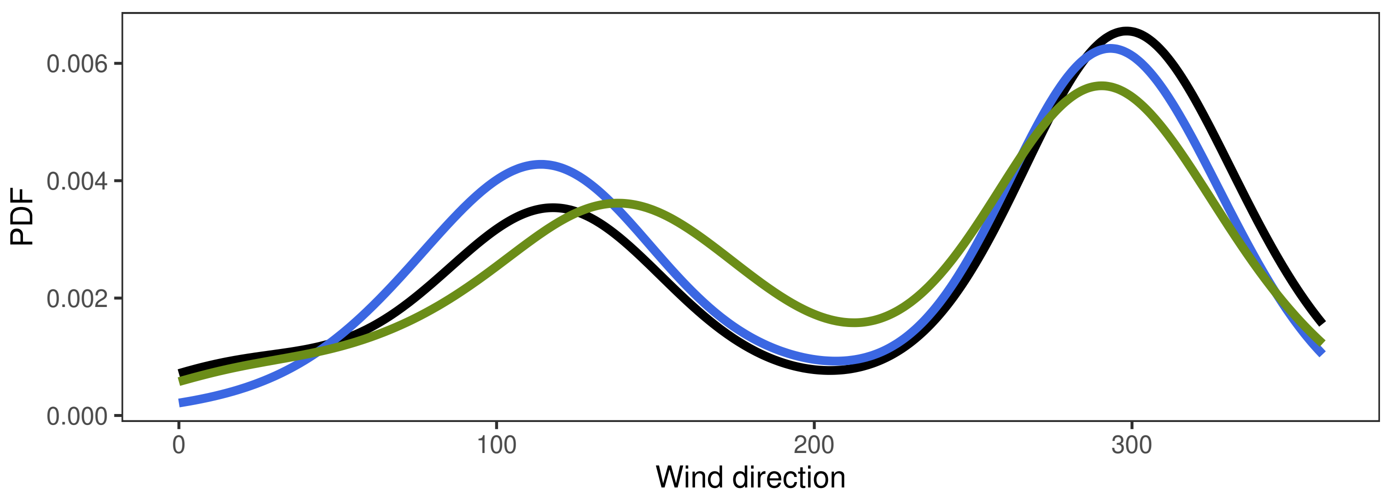

PDF
0.006
0.004
0.002
0.000
0
100
200
300
Wind direction

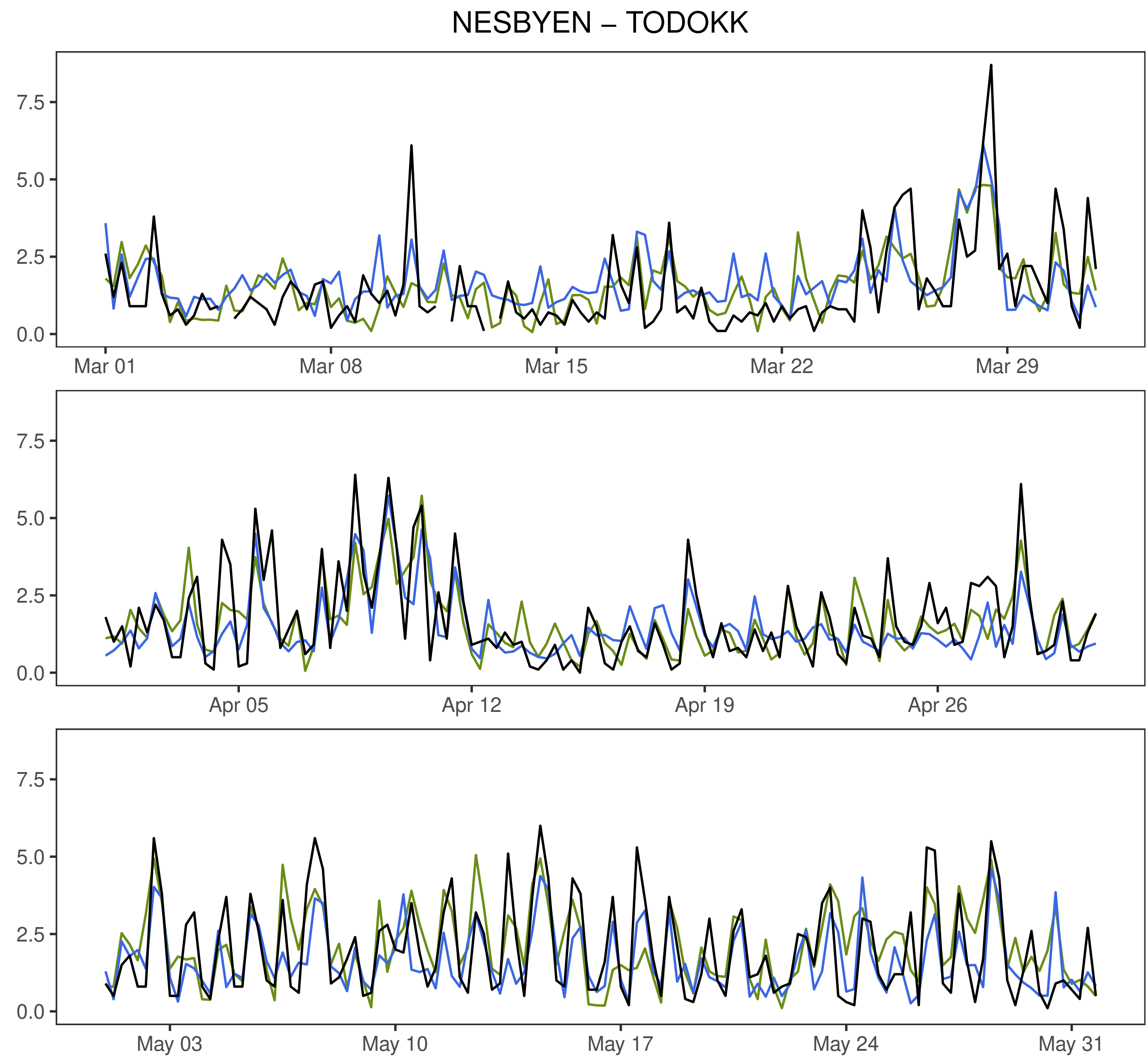


	Min	Mean	Max	Std	N
synop: 00,06,12,18	0.0	5.3	19.1	4.1	368
MEPSctrl: 12+18,+24,+30,+36	0.6	5.5	20.2	3.4	368
ECMWF: 12+18,+24,+30,+36	0.2	3.2	8.7	1.7	368

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl−synop	0.2	2.1	2.1	1.7	8.4	368
ECMWF−synop	−2.1	2.8	3.5	2.6	11.4	368

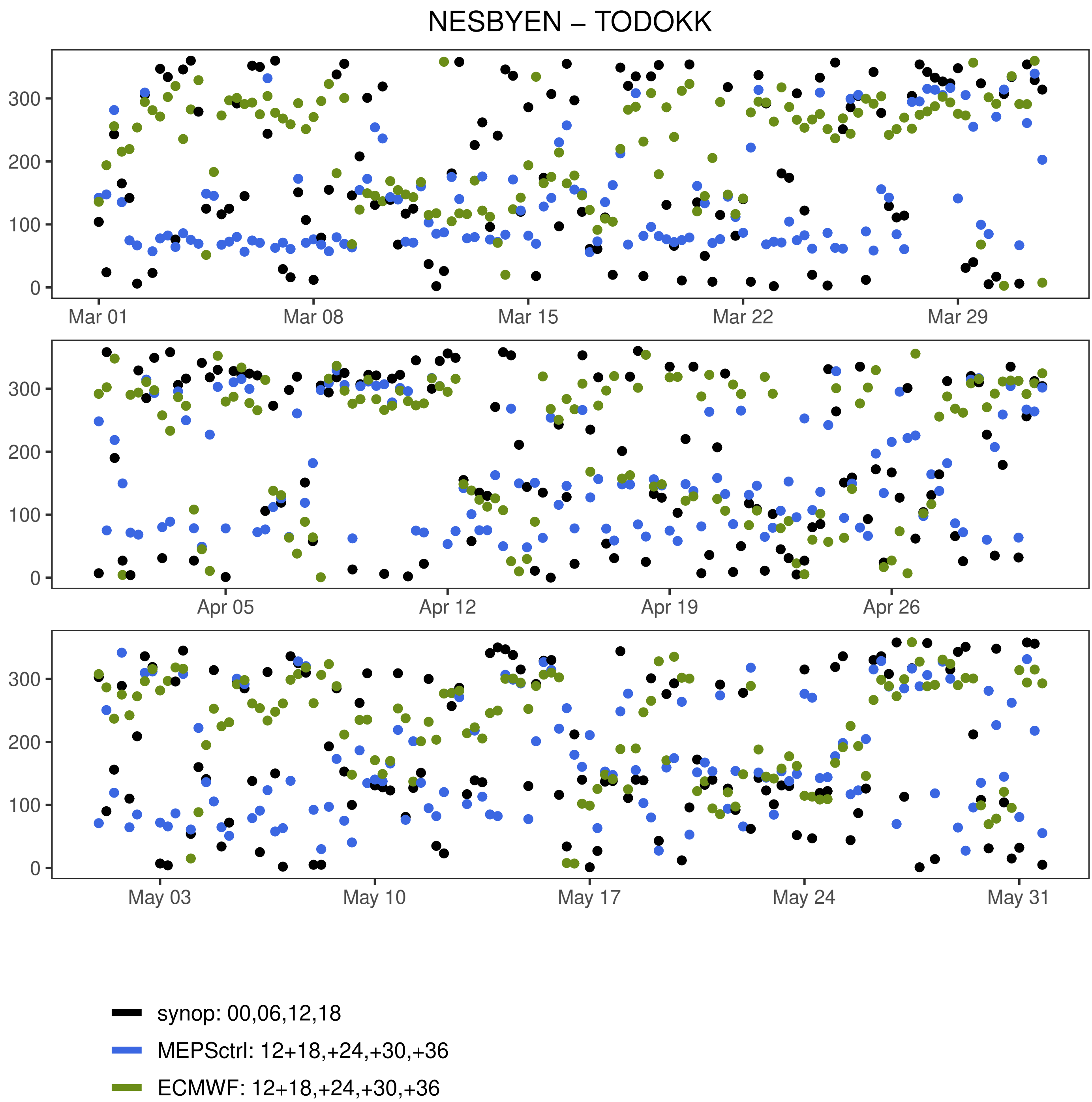

FINSEVATN
300
200
100
0
Mar 01
Mar 08
Mar 15
Mar 22
Mar 29
Apr 05
Apr 12
Apr 19
Apr 26
May 03
May 10
May 17
May 24
May 31
synop: 00,06,12,18
MEPSctrl: 12+18,+24,+30,+36
ECMWF: 12+18,+24,+30,+36

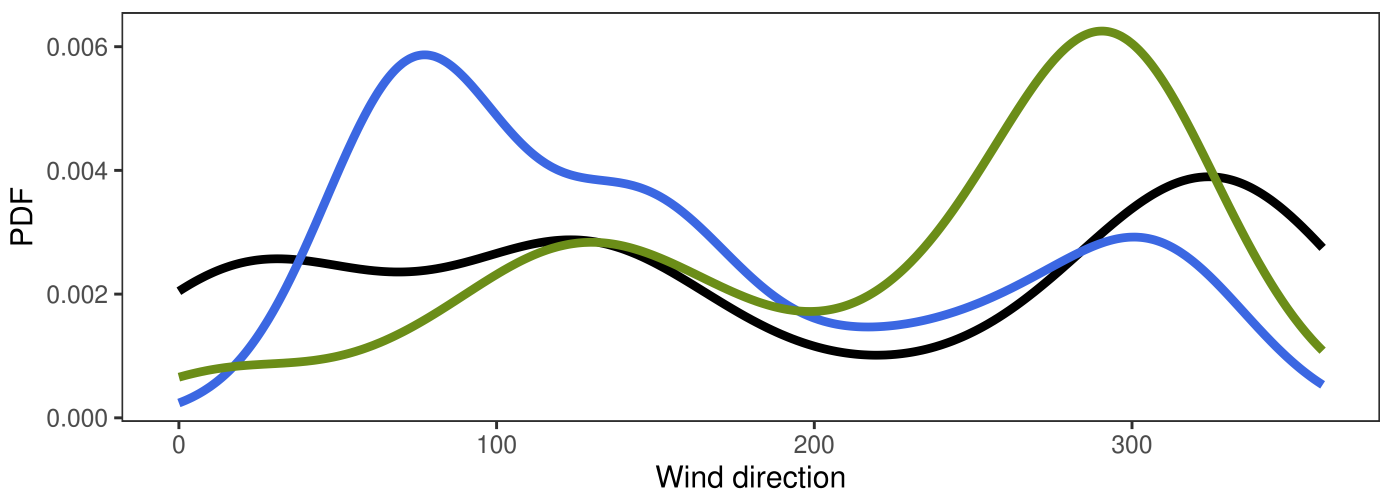

0.006
0.004
0.002
0.000
PDF
0
100
200
300
Wind direction

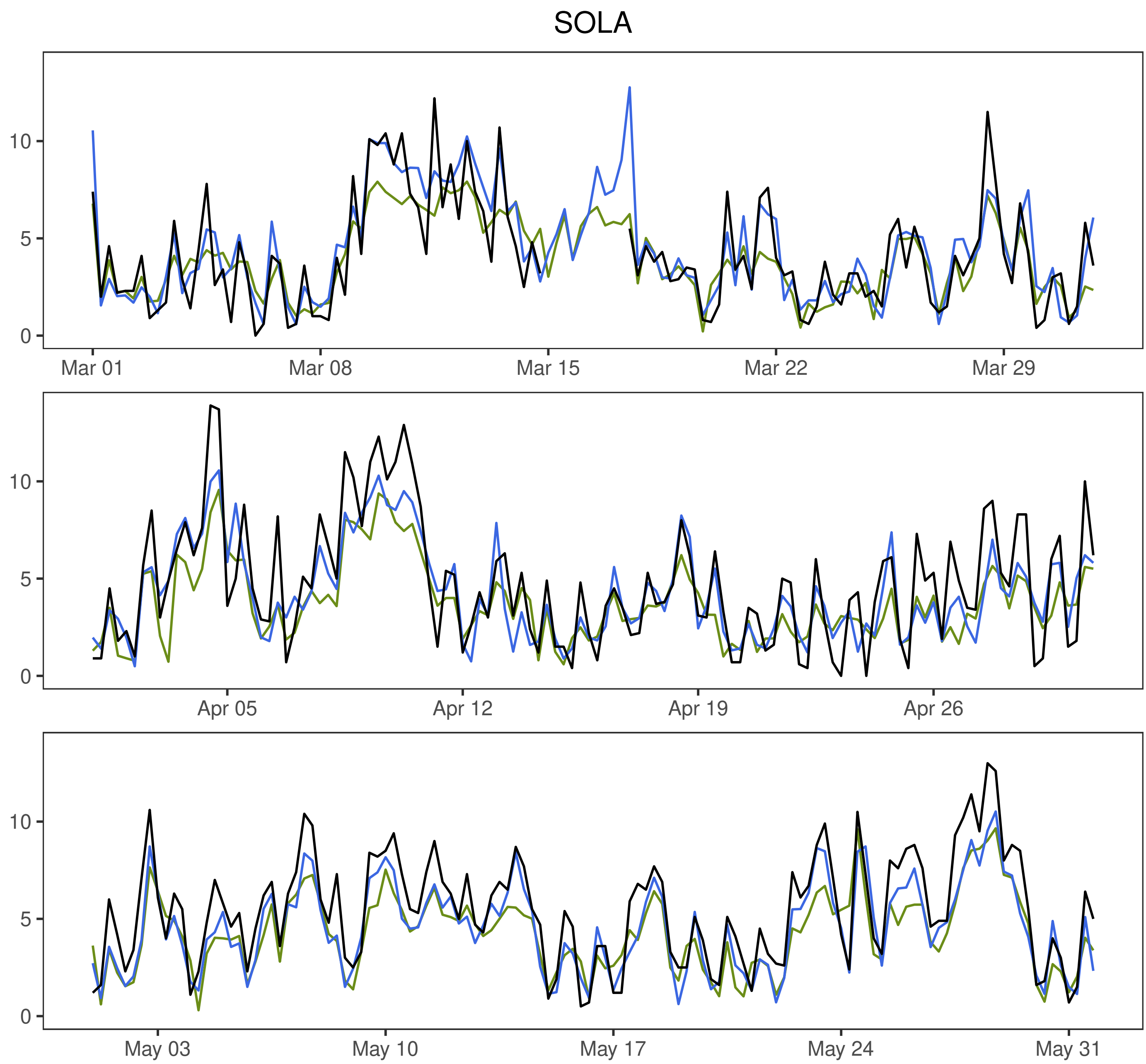


	Min	Mean	Max	Std	N
synop: 00,06,12,18	0.0	1.7	8.7	1.5	365
MEPSctrl: 12+18,+24,+30,+36	0.3	1.6	6.1	1.0	368
ECMWF: 12+18,+24,+30,+36	0.1	1.8	5.7	1.1	368

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl–synop	–0.1	1.1	1.1	0.8	3.7	365
ECMWF–synop	0.1	1.1	1.1	0.8	4.5	365

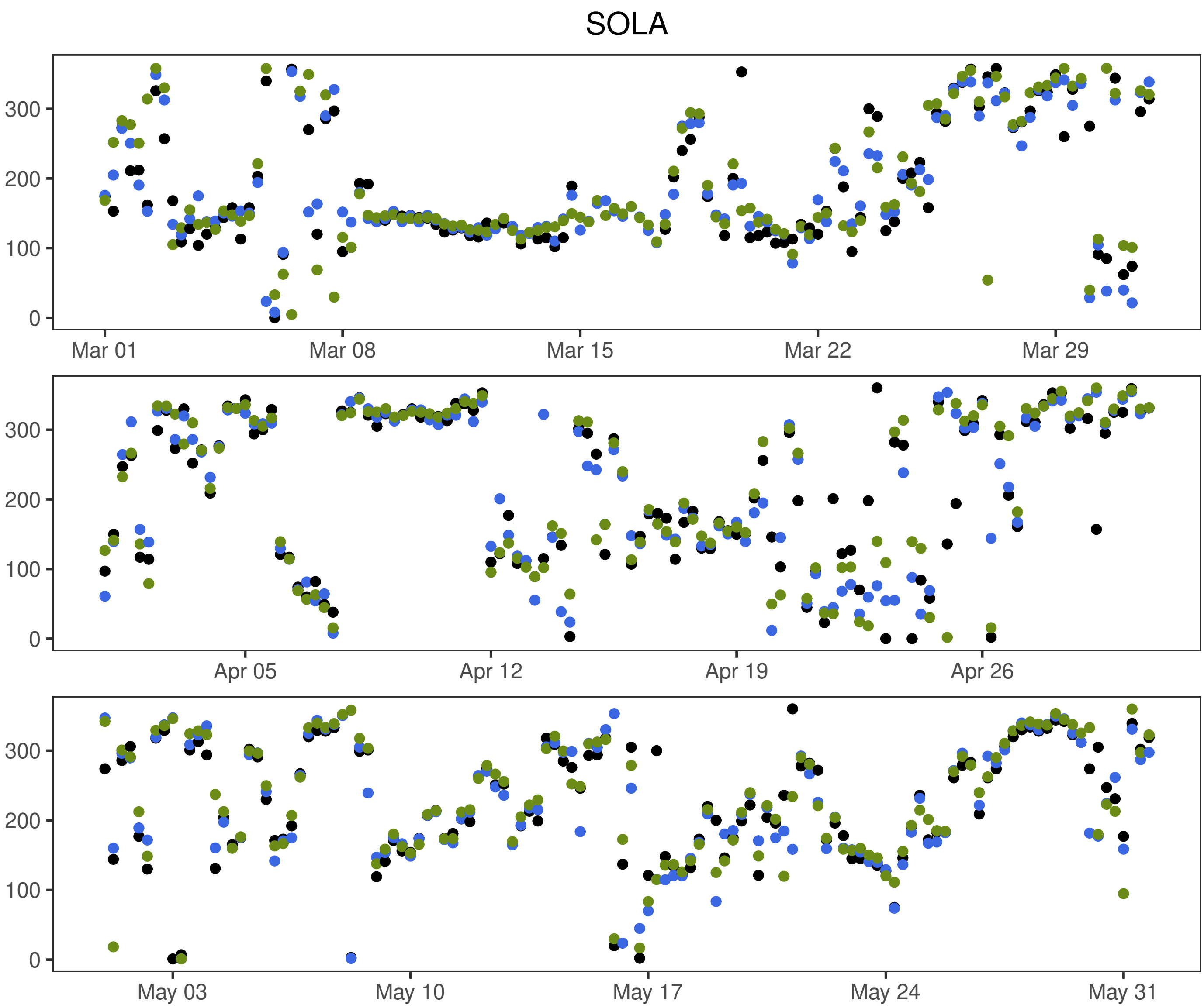

NESBYEN – TODOKK
0
100
200
300
Mar 01
Mar 08
Mar 15
Mar 22
Mar 29
Apr 05
Apr 12
Apr 19
Apr 26
May 03
May 10
May 17
May 24
May 31
synop: 00,06,12,18
MEPSctrl: 12+18,+24,+30,+36
ECMWF: 12+18,+24,+30,+36


PDF
0.000
0.002
0.004
0.006
0
100
200
300
Wind direction



	Min	Mean	Max	Std	N
synop: 00,06,12,18	0.0	4.8	13.9	3.0	358
MEPSctrl: 12+18,+24,+30,+36	0.5	4.4	12.8	2.5	368
ECMWF: 12+18,+24,+30,+36	0.2	4.0	9.7	2.0	368

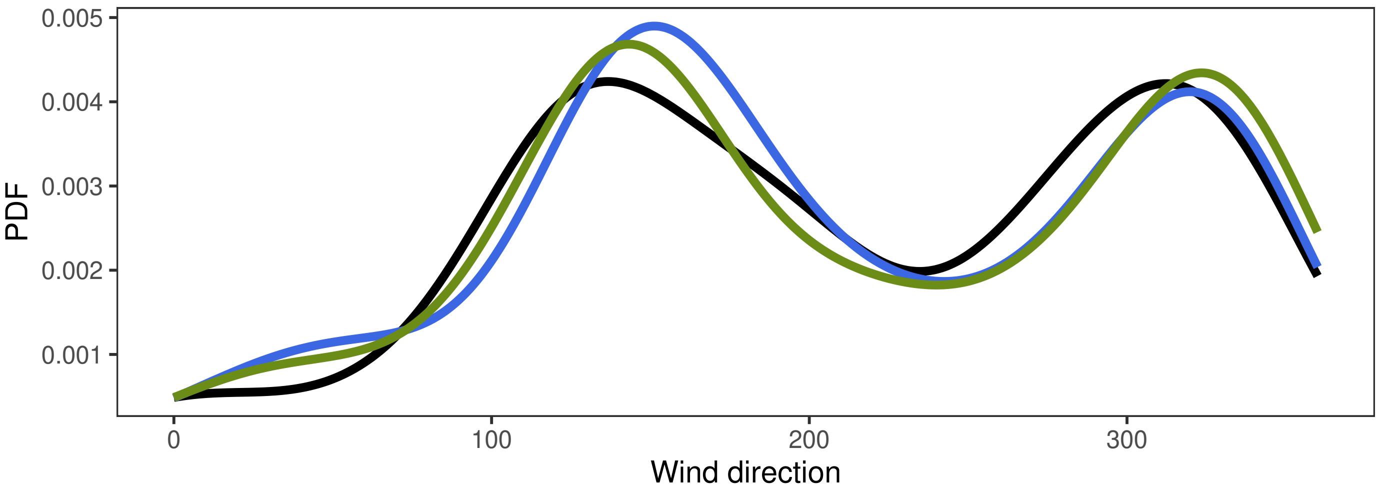
	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl–synop	−0.4	1.5	1.6	1.2	7.3	358
ECMWF–synop	−0.8	1.7	1.9	1.5	6.0	358

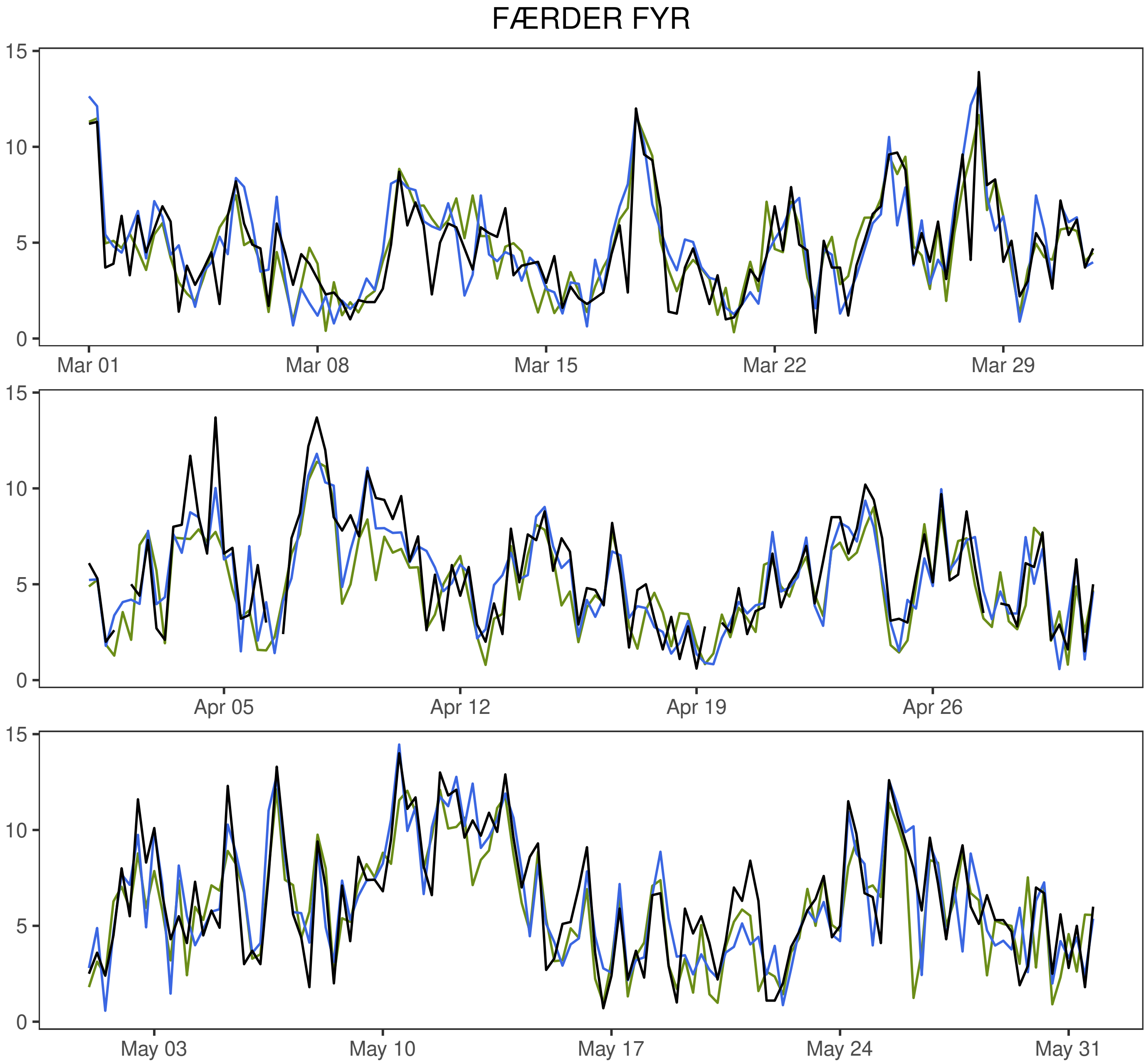


synop: 00,06,12,18

MEPSctrl: 12+18,+24,+30,+36

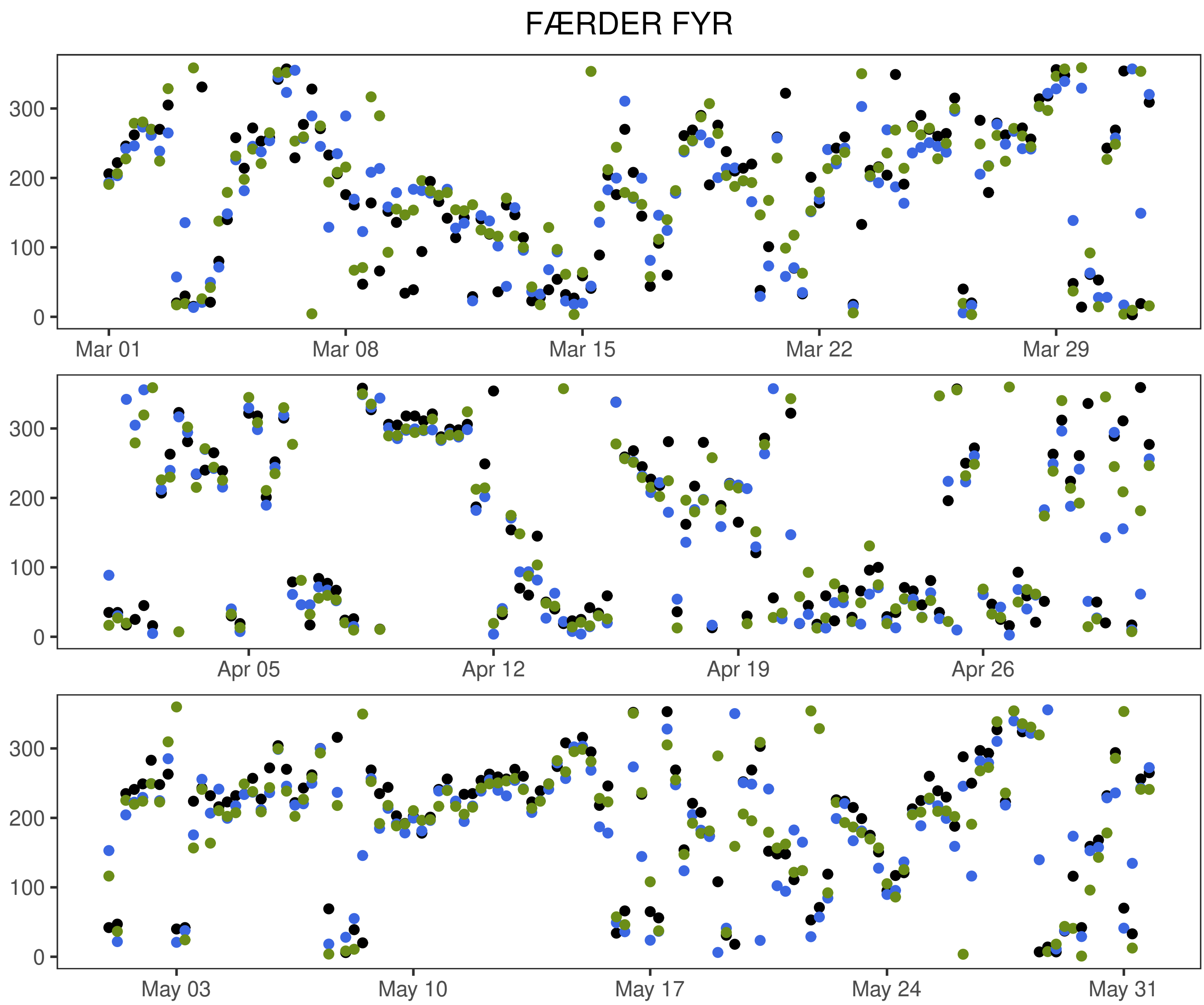
ECMWF: 12+18,+24,+30,+36

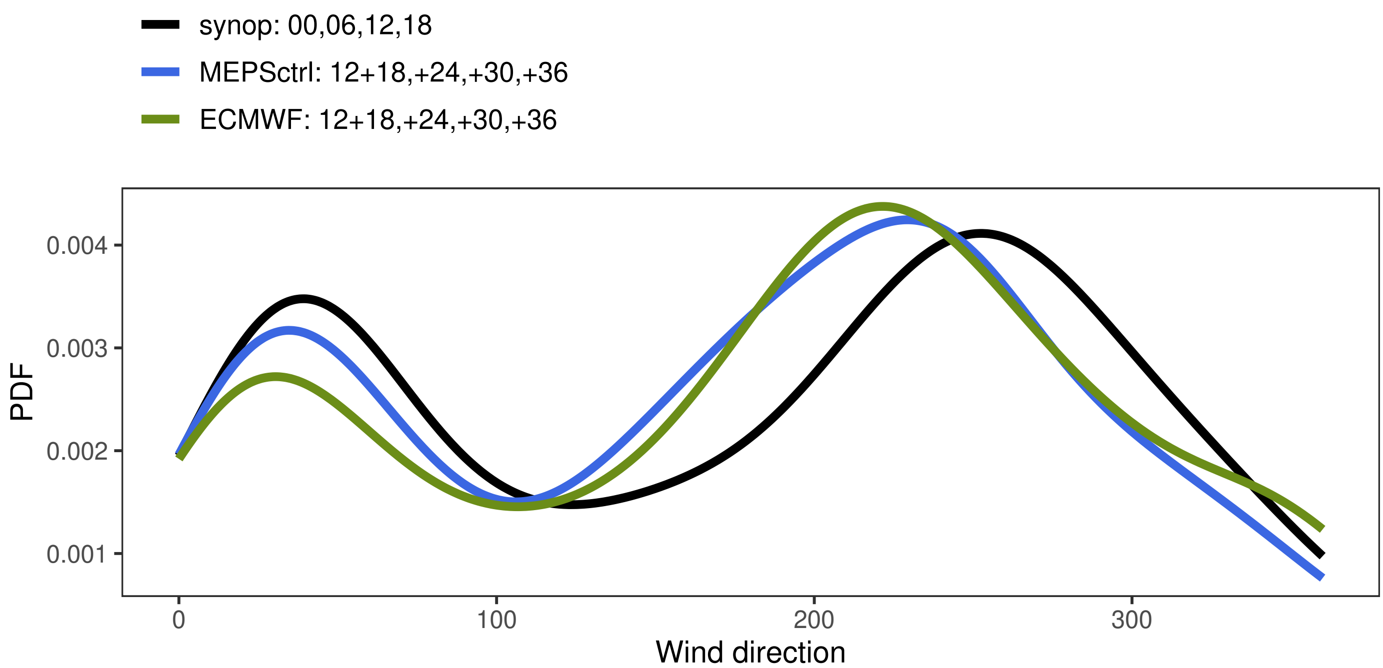


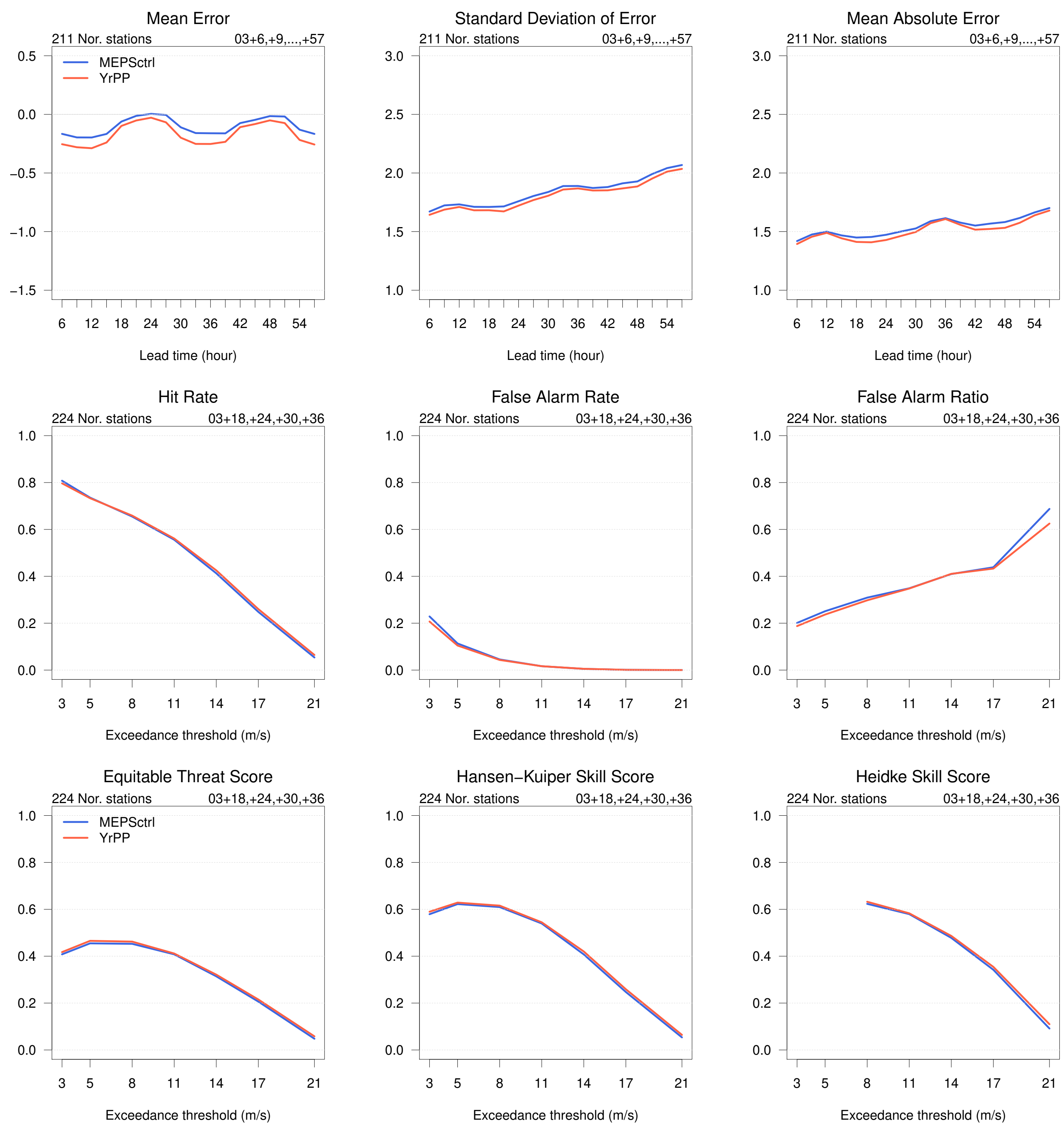


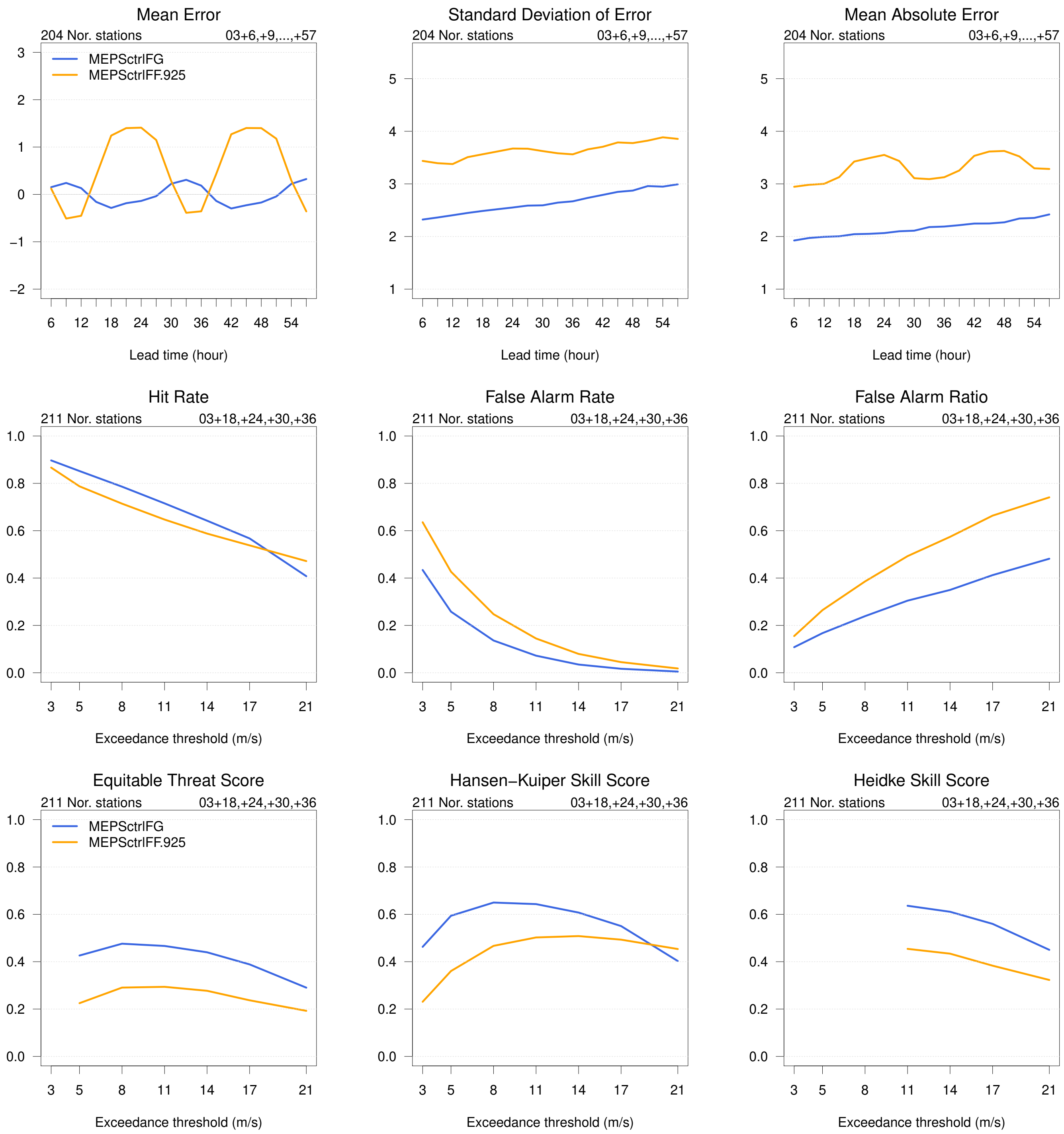
	Min	Mean	Max	Std	N
synop: 00,06,12,18	0.3	5.6	14.0	2.9	364
MEPSctrl: 12+18,+24,+30,+36	0.6	5.5	14.5	2.8	368
ECMWF: 12+18,+24,+30,+36	0.3	5.2	12.1	2.6	368

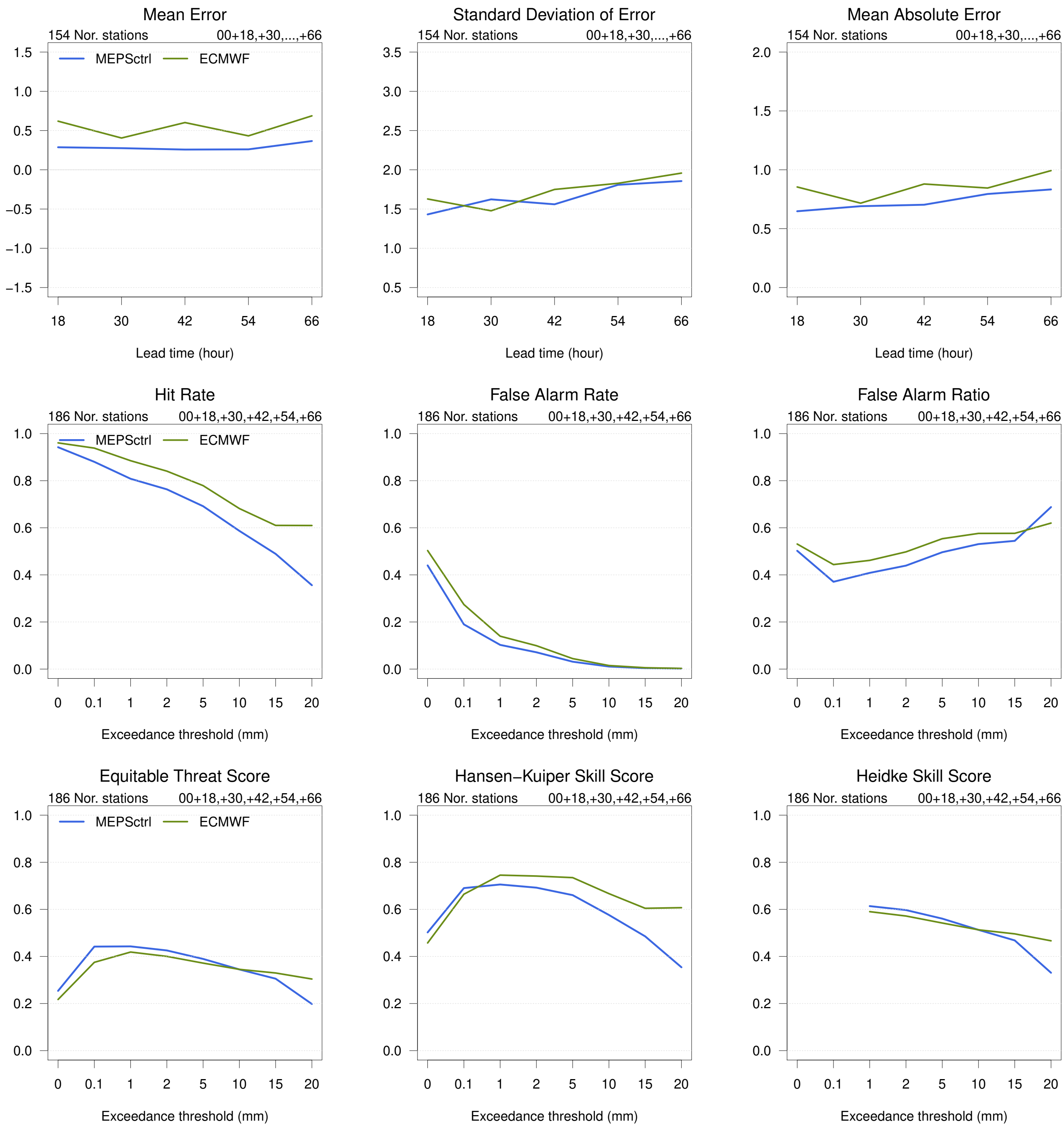
	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl−synop	0.0	1.6	1.6	1.2	8.1	364
ECMWF−synop	−0.3	1.7	1.7	1.3	6.8	364


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

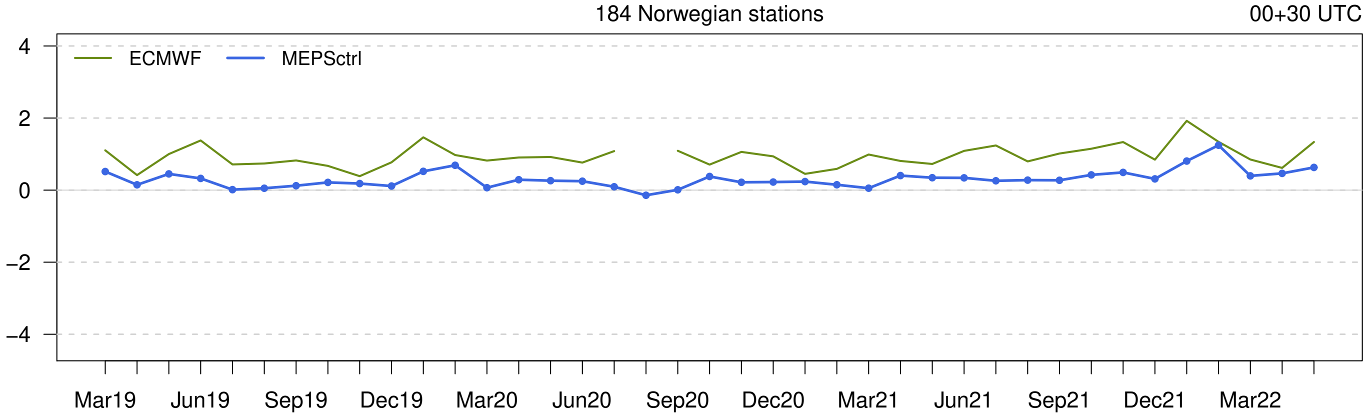

synop: 00,06,12,18
MEPSctrl: 12+18,+24,+30,+36
ECMWF: 12+18,+24,+30,+36
PDF
0.004
0.003
0.002
0.001
0
100
200
300
Wind direction

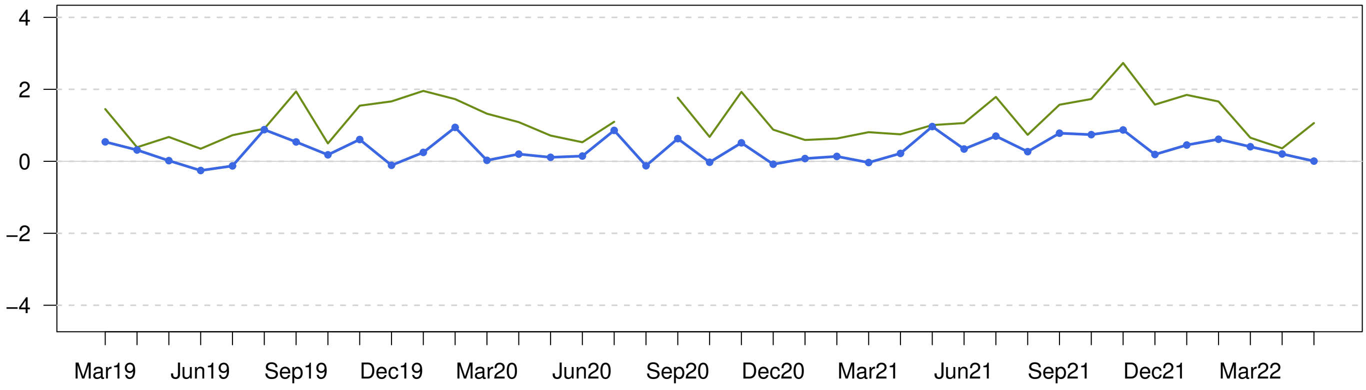

Mean Error
211 Nor. stations
03+6,+9,...,+57
MEPSctrl
YrPP
Lead time (hour)
Standard Deviation of Error
211 Nor. stations
03+6,+9,...,+57
Lead time (hour)
Mean Absolute Error
211 Nor. stations
03+6,+9,...,+57
Lead time (hour)
Hit Rate
224 Nor. stations
03+18,+24,+30,+36
Exceedance threshold (m/s)
False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

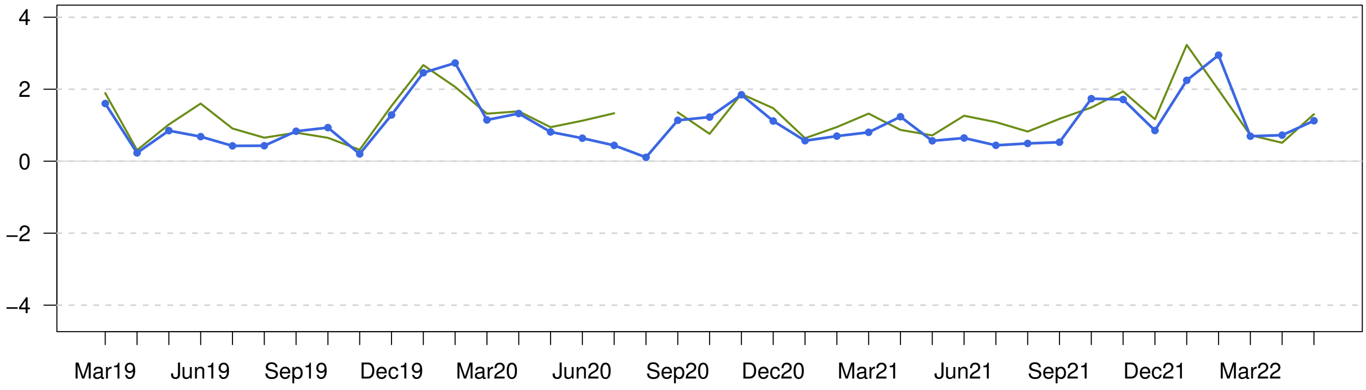

Mean Error
204 Nor. stations
03+6,+9,...,+57
MEPSctrlFG
MEPSctrlFF.925
Lead time (hour)
Standard Deviation of Error
204 Nor. stations
03+6,+9,...,+57
Lead time (hour)
Mean Absolute Error
204 Nor. stations
03+6,+9,...,+57
Lead time (hour)
Hit Rate
211 Nor. stations
03+18,+24,+30,+36
Exceedance threshold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

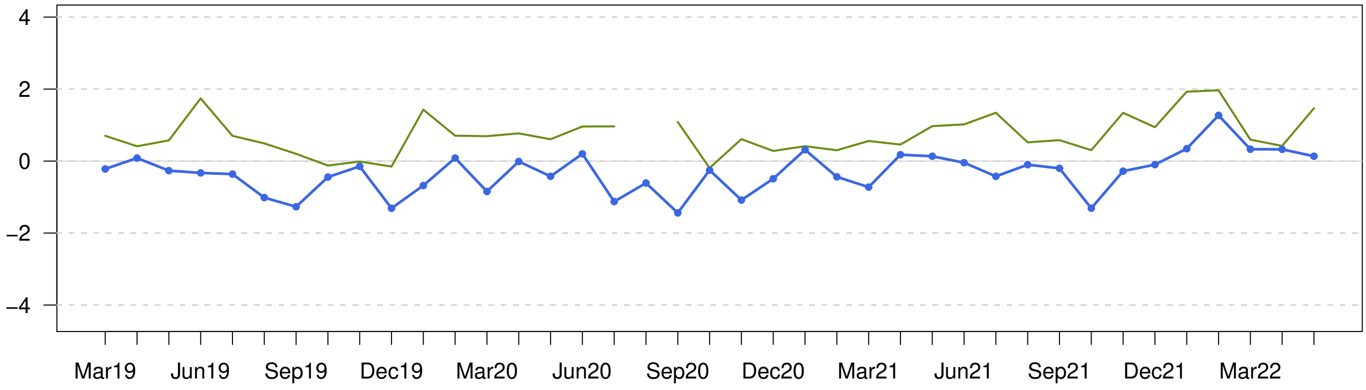

Mean Error
154 Nor. stations
00+18,+30,...,+66
MEPSctrl
ECMWF
Lead time (hour)
Standard Deviation of Error
154 Nor. stations
00+18,+30,...,+66
Lead time (hour)
Mean Absolute Error
154 Nor. stations
00+18,+30,...,+66
Lead time (hour)
Hit Rate
186 Nor. stations
00+18,+30,+42,+54,+66
MEPSctrl
ECMWF
Exceedance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

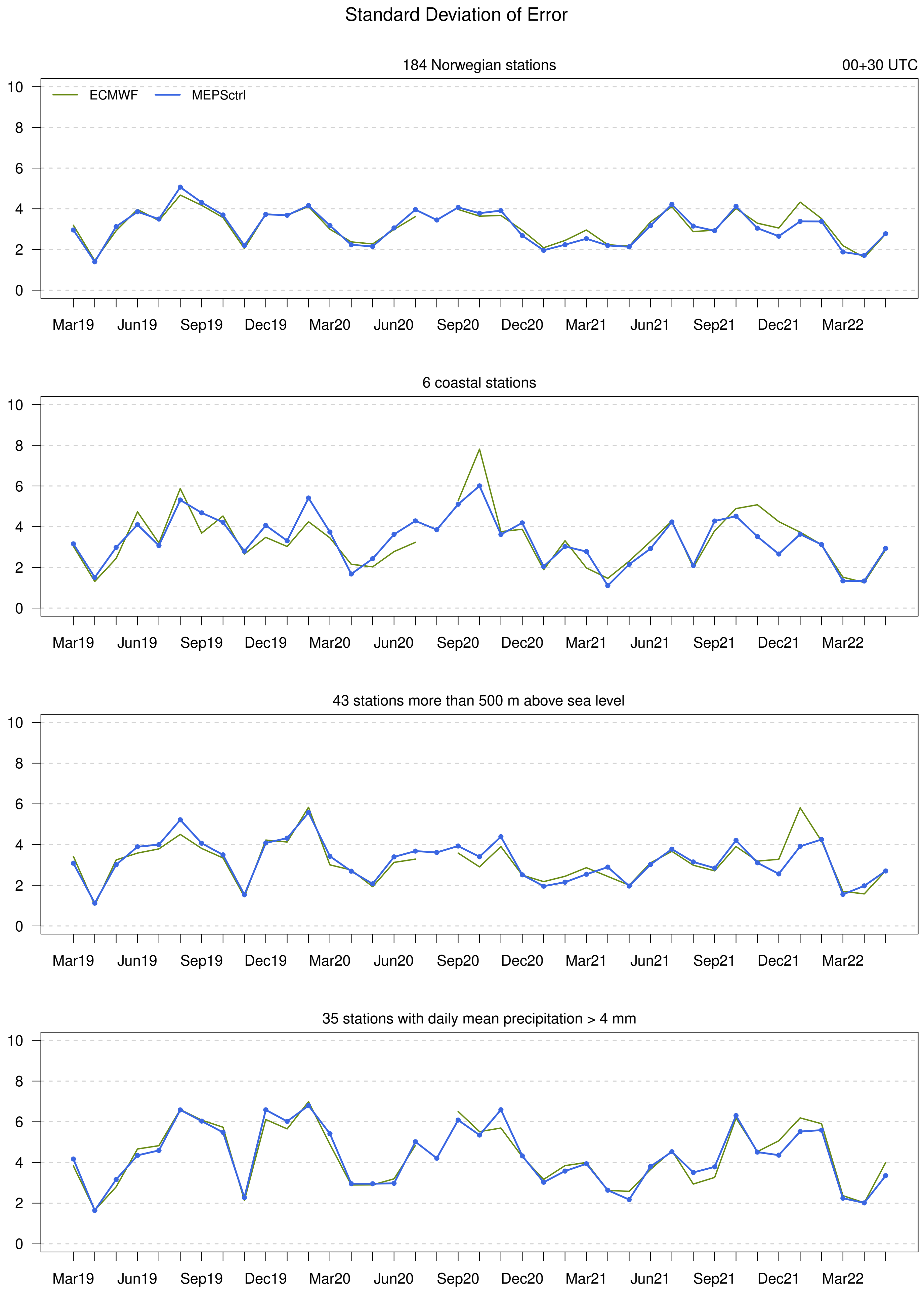
Mean Error


184 Norwegian stations
00+30 UTC
ECMWF
MEPSctrl
4
2
0
−2
−4
Mar19 Jun19 Sep19 Dec19 Mar20 Jun20 Sep20 Dec20 Mar21 Jun21 Sep21 Dec21 Mar22

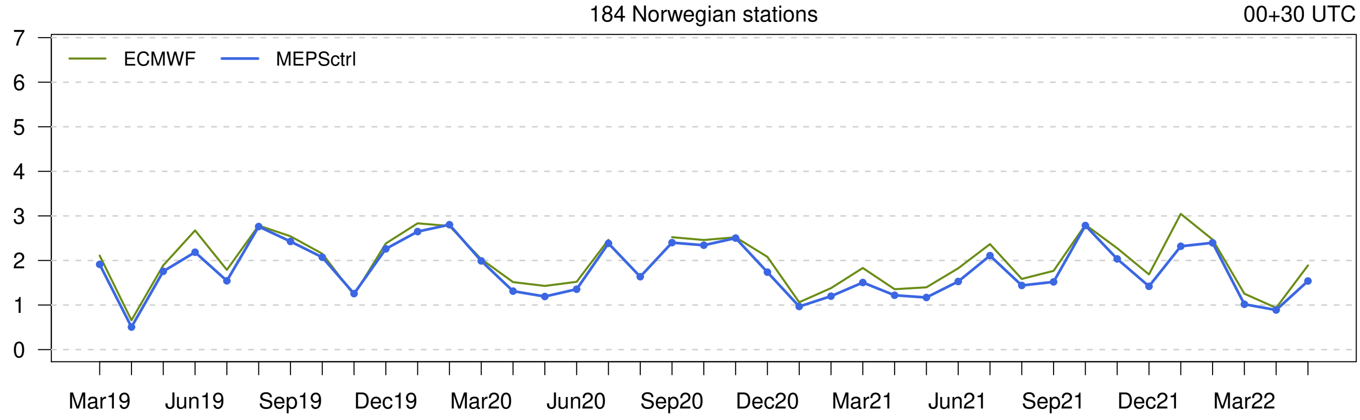

6 coastal stations
4
2
0
−2
−4
Mar19 Jun19 Sep19 Dec19 Mar20 Jun20 Sep20 Dec20 Mar21 Jun21 Sep21 Dec21 Mar22

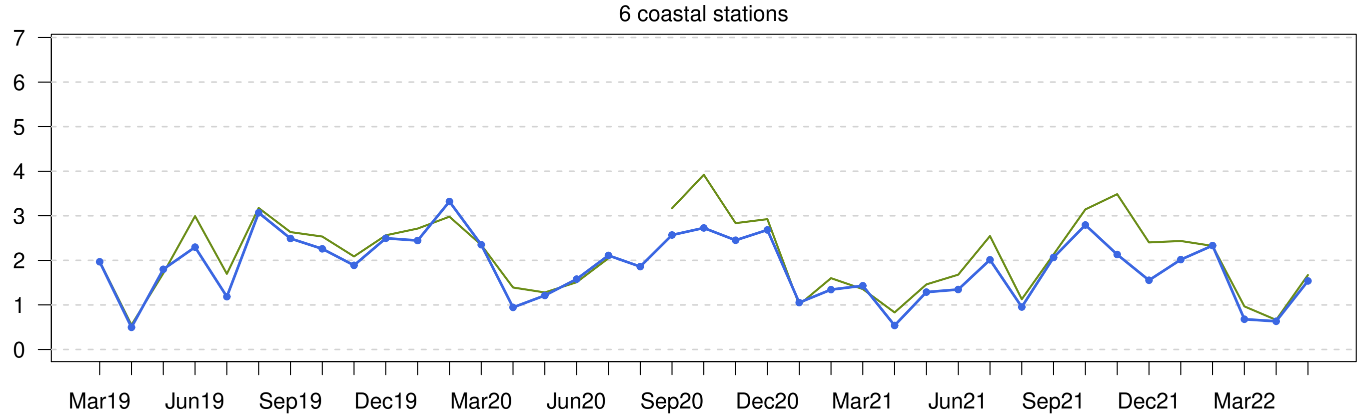

43 stations more than 500 m above sea level
4
2
0
−2
−4
Mar19 Jun19 Sep19 Dec19 Mar20 Jun20 Sep20 Dec20 Mar21 Jun21 Sep21 Dec21 Mar22

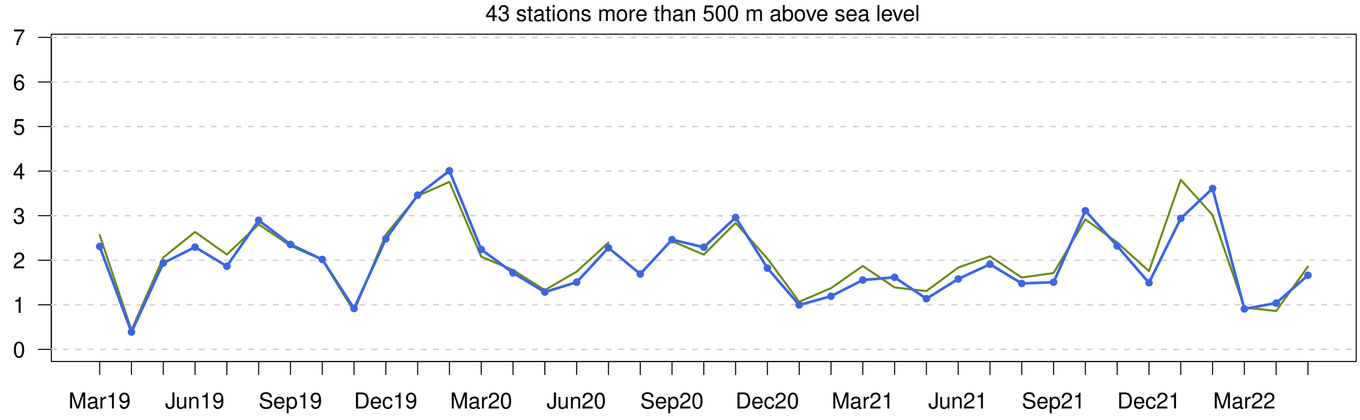

35 stations with daily mean precipitation > 4 mm
4
2
0
−2
−4
Mar19 Jun19 Sep19 Dec19 Mar20 Jun20 Sep20 Dec20 Mar21 Jun21 Sep21 Dec21 Mar22

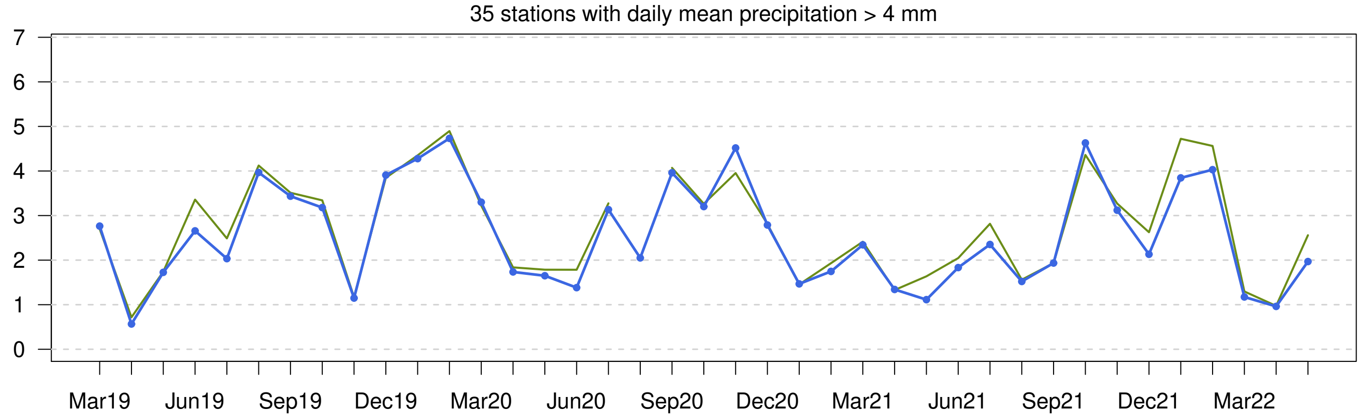

Standard Deviation of Error
184 Norwegian stations
00+30 UTC
ECMWF
MEPSctrl
6 coastal stations
43 stations more than 500 m above sea level
35 stations with daily mean precipitation > 4 mm
Mar19 Jun19 Sep19 Dec19 Mar20 Jun20 Sep20 Dec20 Mar21 Jun21 Sep21 Dec21 Mar22
0 2 4 6 8 10

Mean Absolute Error



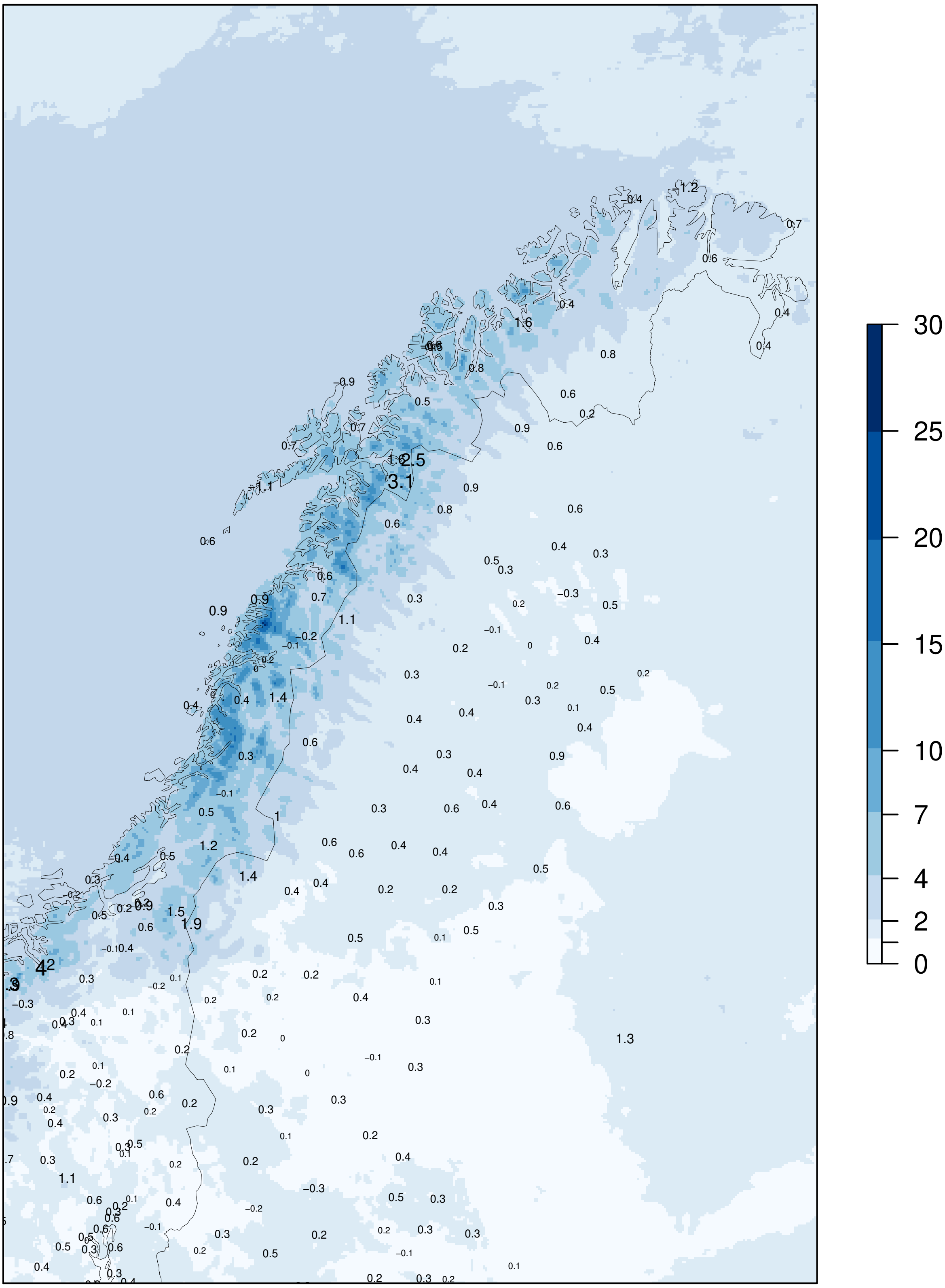




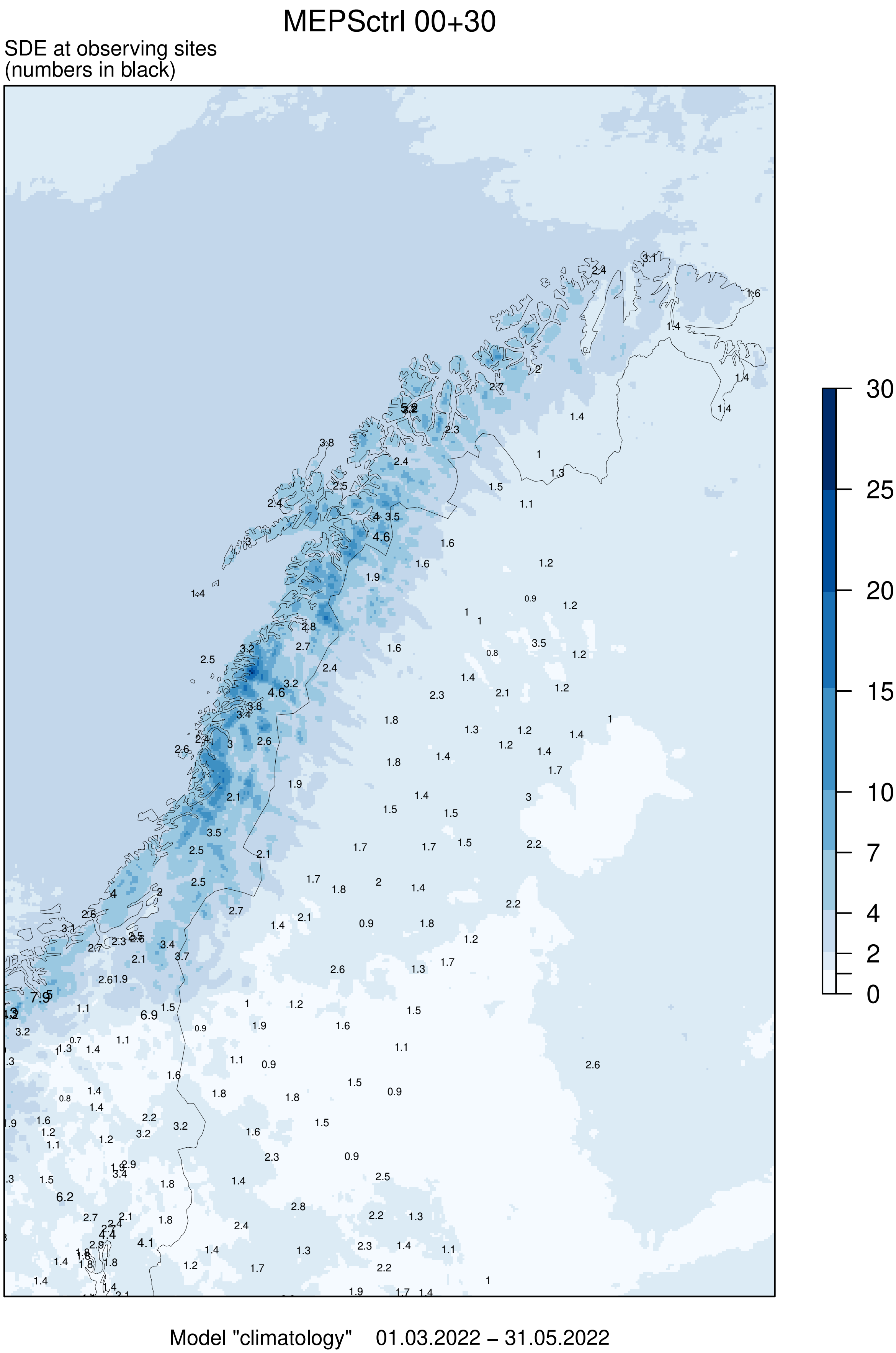


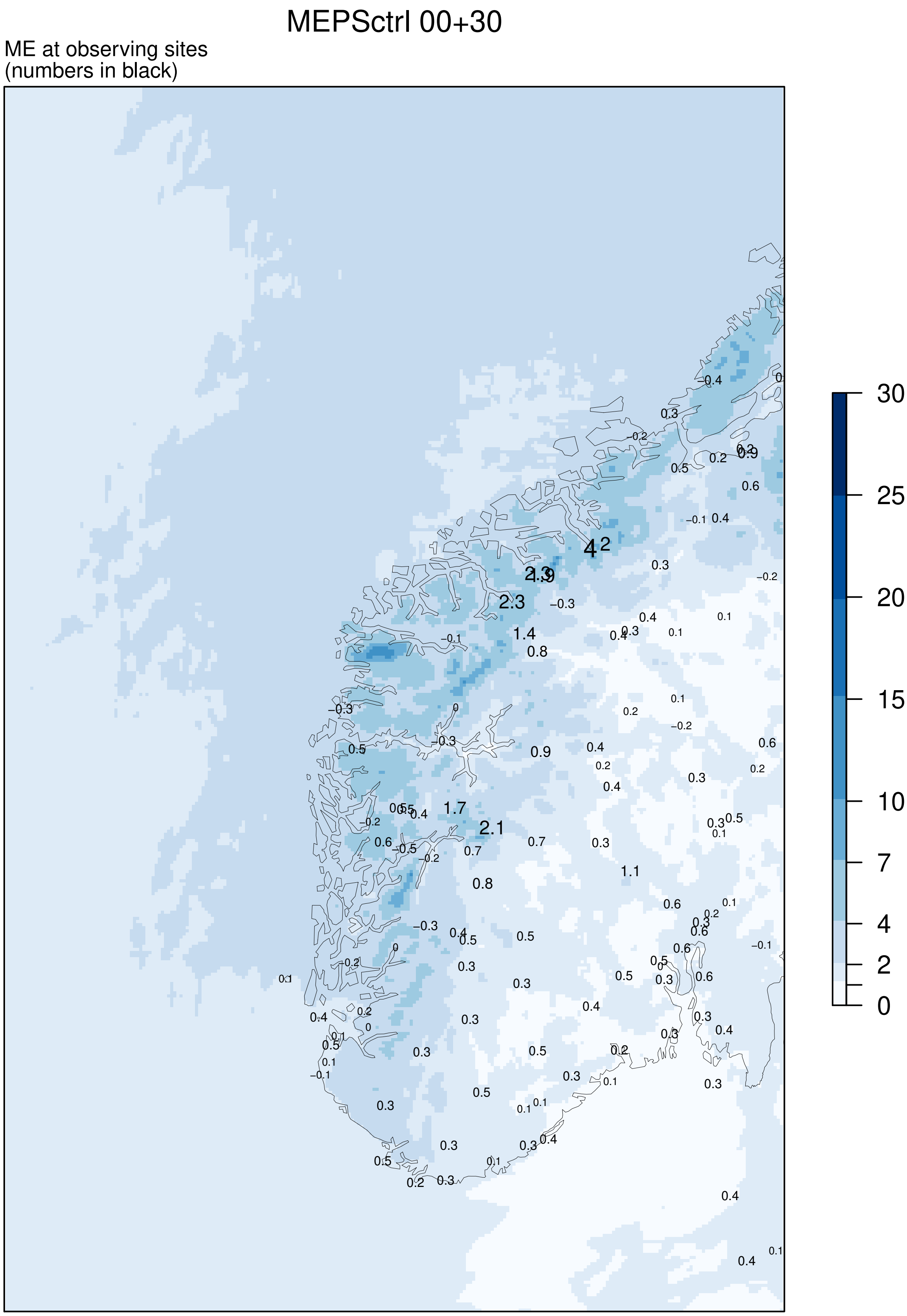
MEPSctrl 00+30

ME at observing sites
(numbers in black)



Model "climatology"   01.03.2022 – 31.05.2022

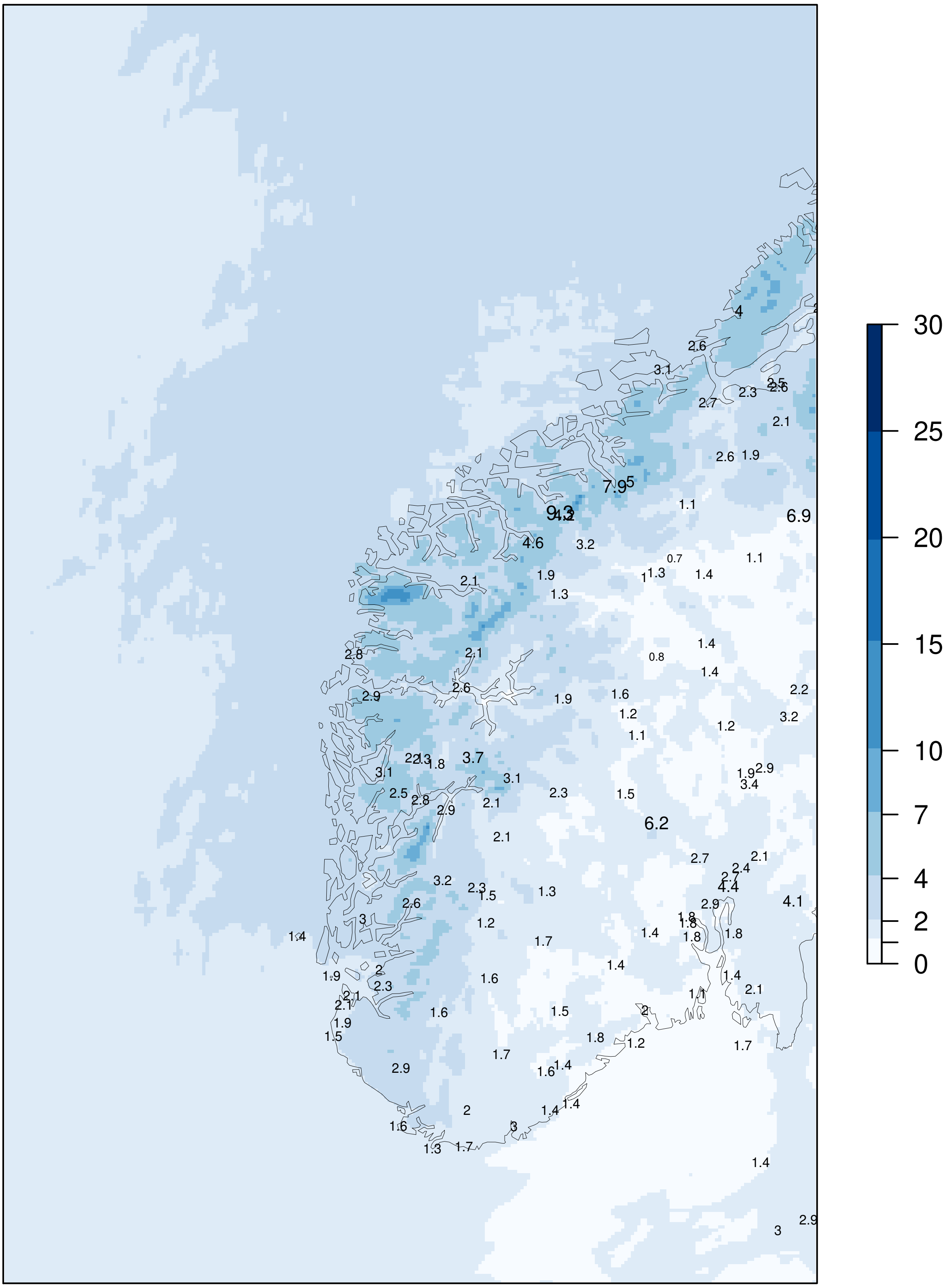

MEPSctrl 00+30
SDE at observing sites
(numbers in black)
30
25
20
15
10
7
4
2
0
Model "climatology" 01.03.2022 – 31.05.2022



Model "climatology" 01.03.2022 – 31.05.2022

MEPSctrl 00+30

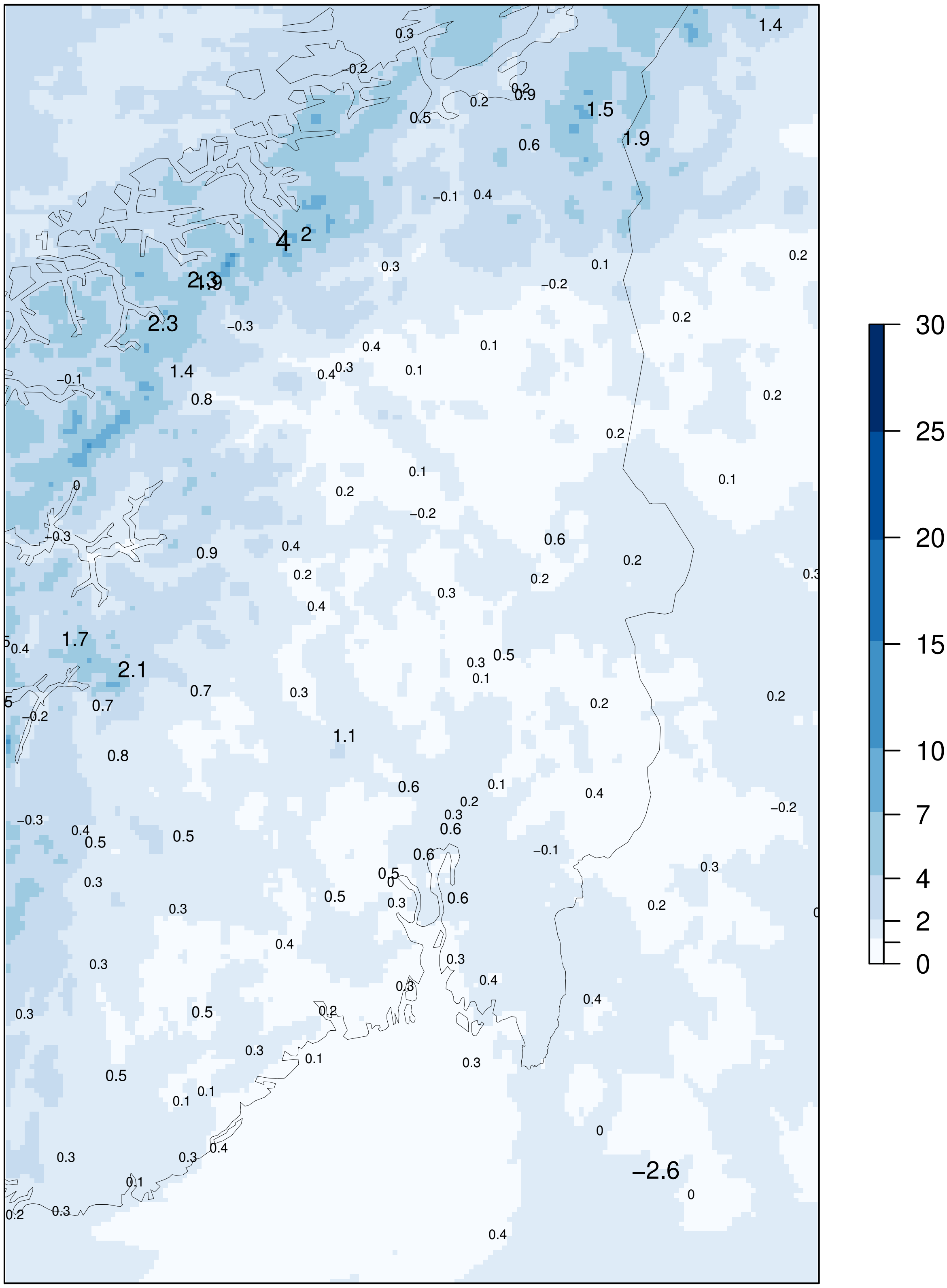
SDE at observing sites
(numbers in black)



Model "climatology" 01.03.2022 – 31.05.2022

MEPSctrl 00+30

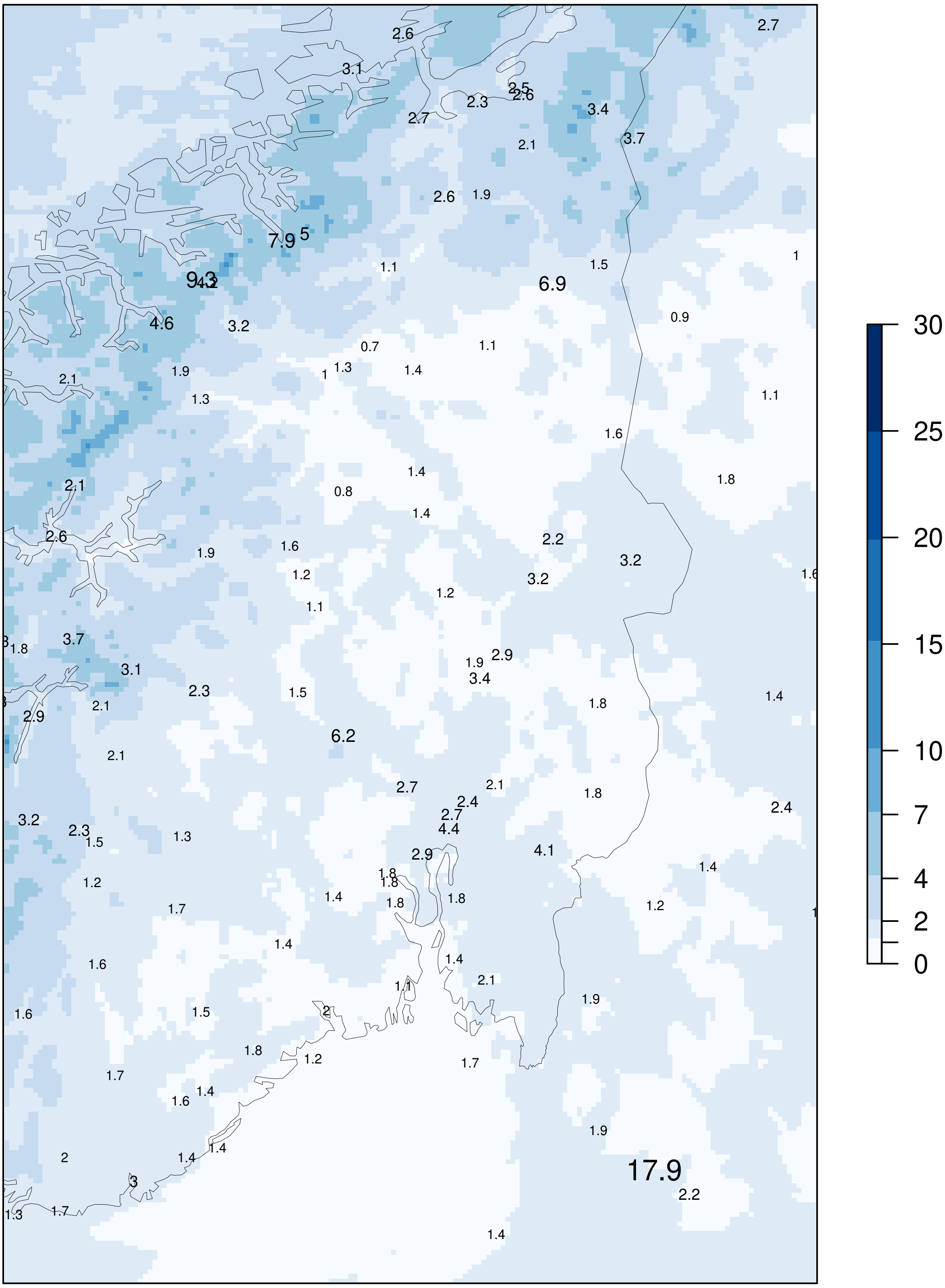
ME at observing sites
(numbers in black)



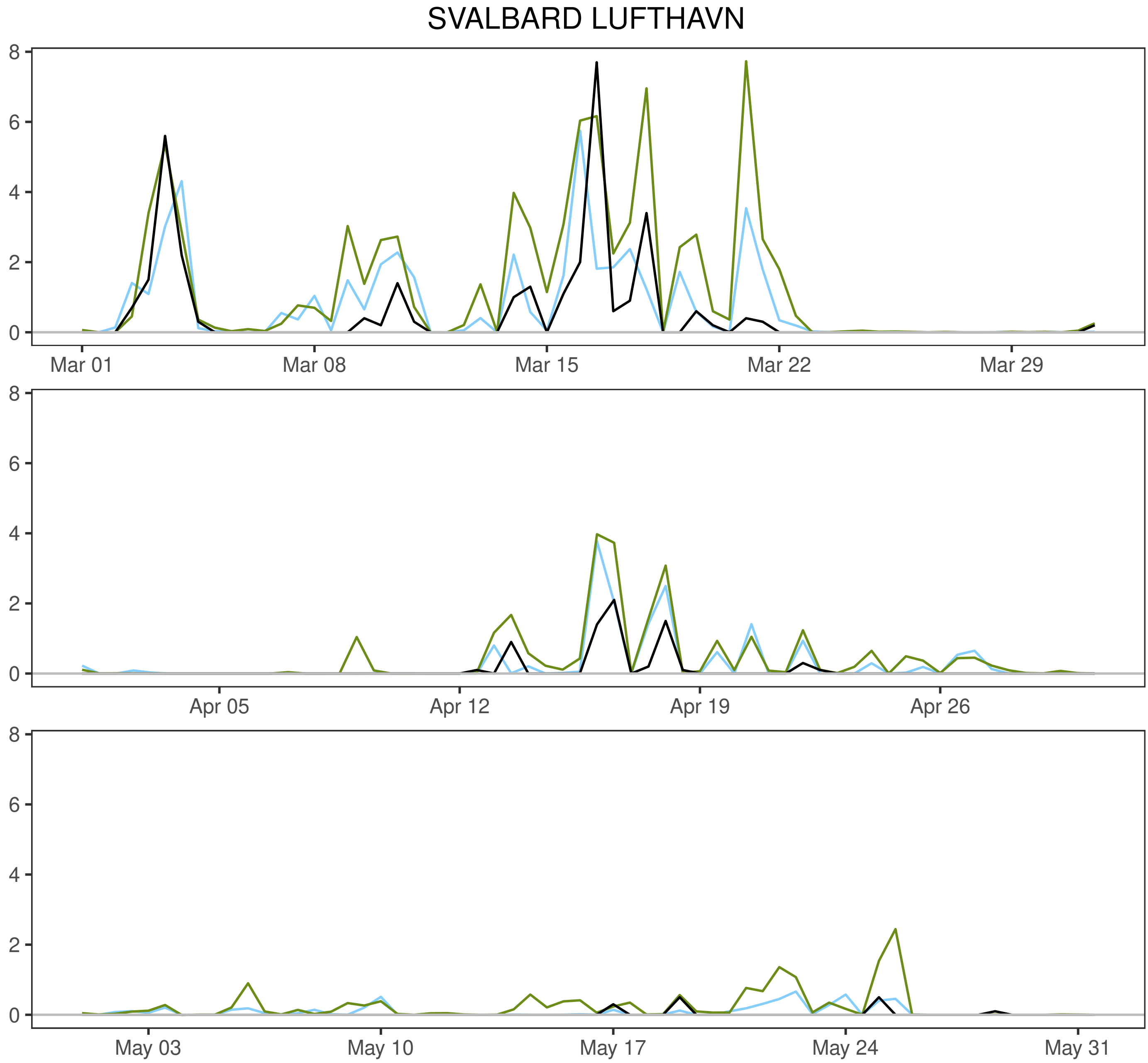
Model "climatology" 01.03.2022 – 31.05.2022

MEPSctrl 00+30

SDE at observing sites
(numbers in black)

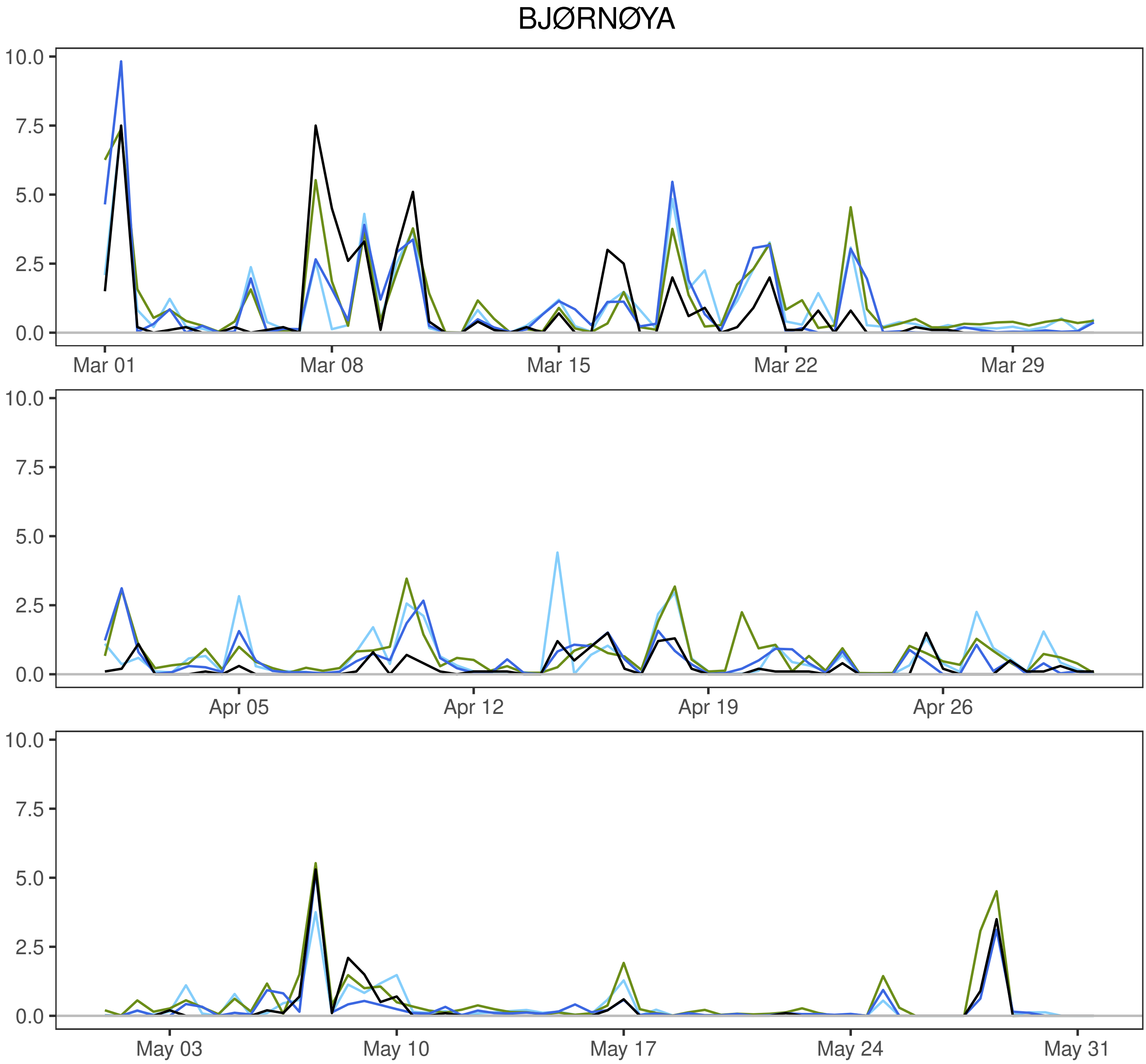


Model "climatology" 01.03.2022 – 31.05.2022



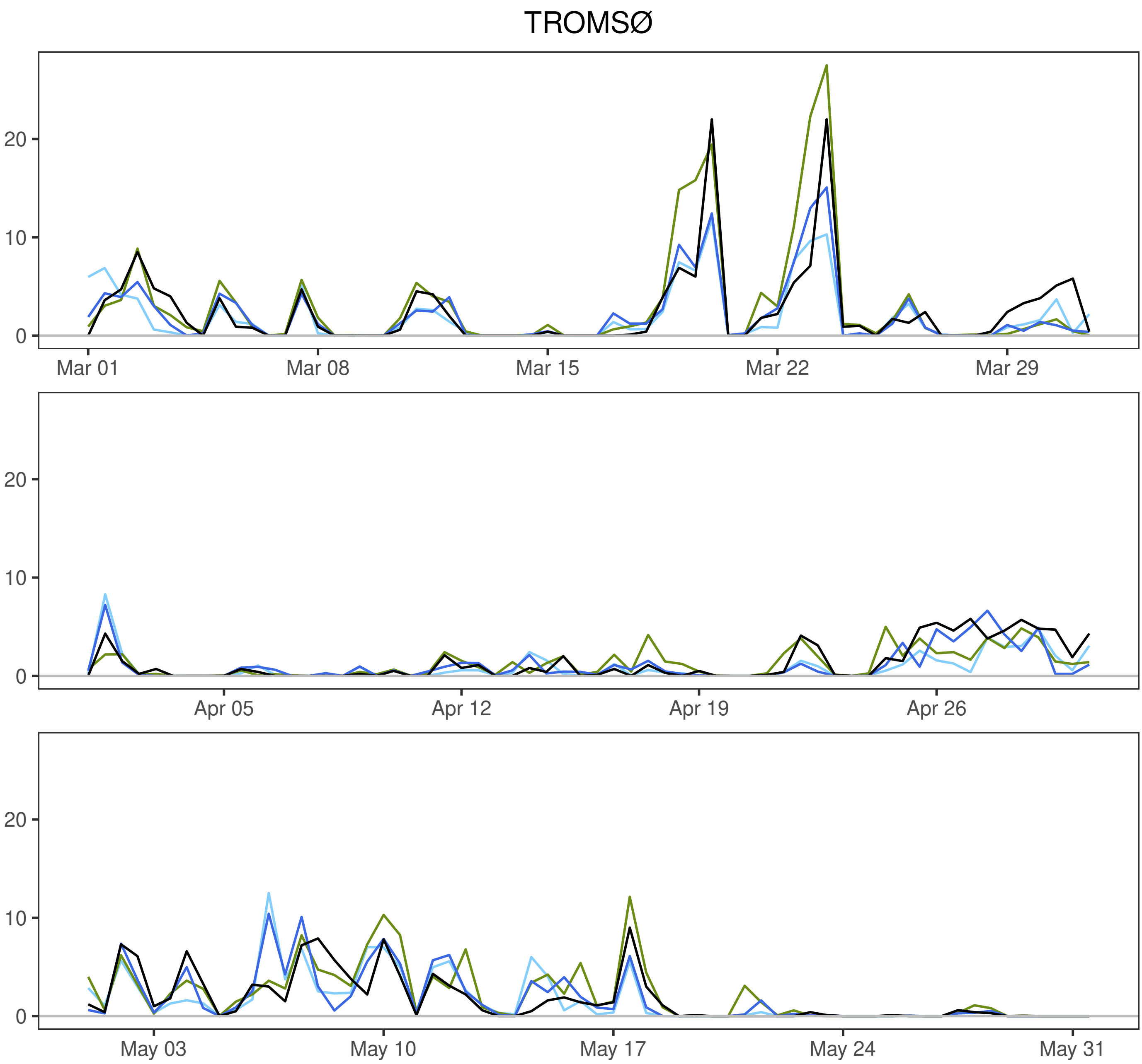
	Min	Mean	Max	Std	N
synop: 06,18	0.0	0.2	7.7	0.8	184
AA25: 12+18,+30	0.0	0.4	5.7	0.8	182
ECMWF: 12+18,+30	0.0	0.7	7.7	1.3	184

	ME	SDE	RMSE	MAE	Max.abs.err.	N
AA25−synop	0.2	0.8	0.8	0.3	5.9	182
ECMWF−synop	0.4	0.9	1.0	0.5	7.3	182



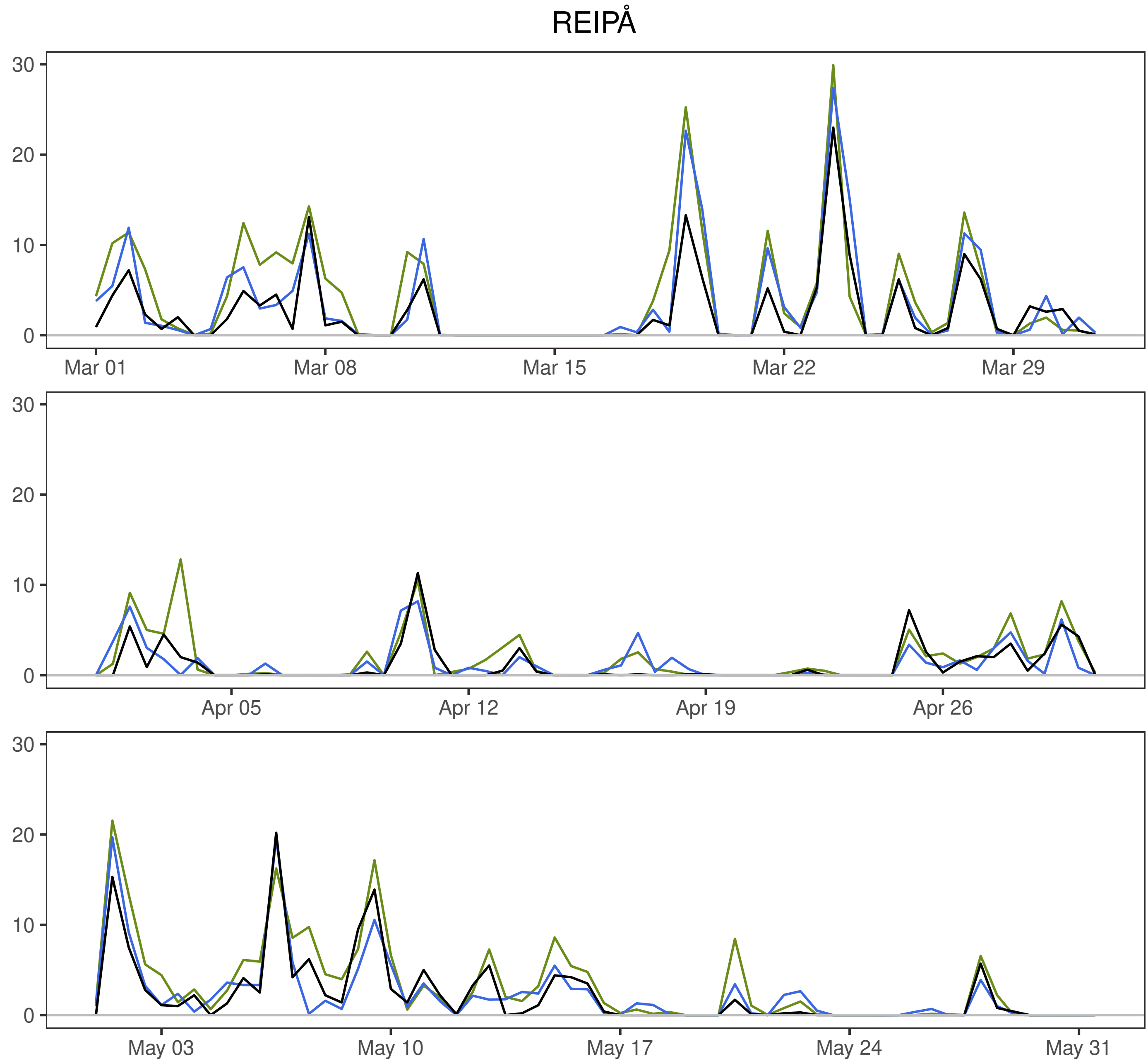
	Min	Mean	Max	Std	N
synop: 06,18	0.0	0.5	7.5	1.1	184
MEPSctrl: 12+18,+30	0.0	0.6	9.8	1.2	184
AA25: 12+18,+30	0.0	0.6	7.4	1.1	182
ECMWF: 12+18,+30	0.0	0.8	7.4	1.2	184

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl−synop	0.2	0.8	0.8	0.4	4.8	182
AA25−synop	0.2	0.8	0.9	0.5	4.9	182
ECMWF−synop	0.3	0.8	0.9	0.5	4.8	182



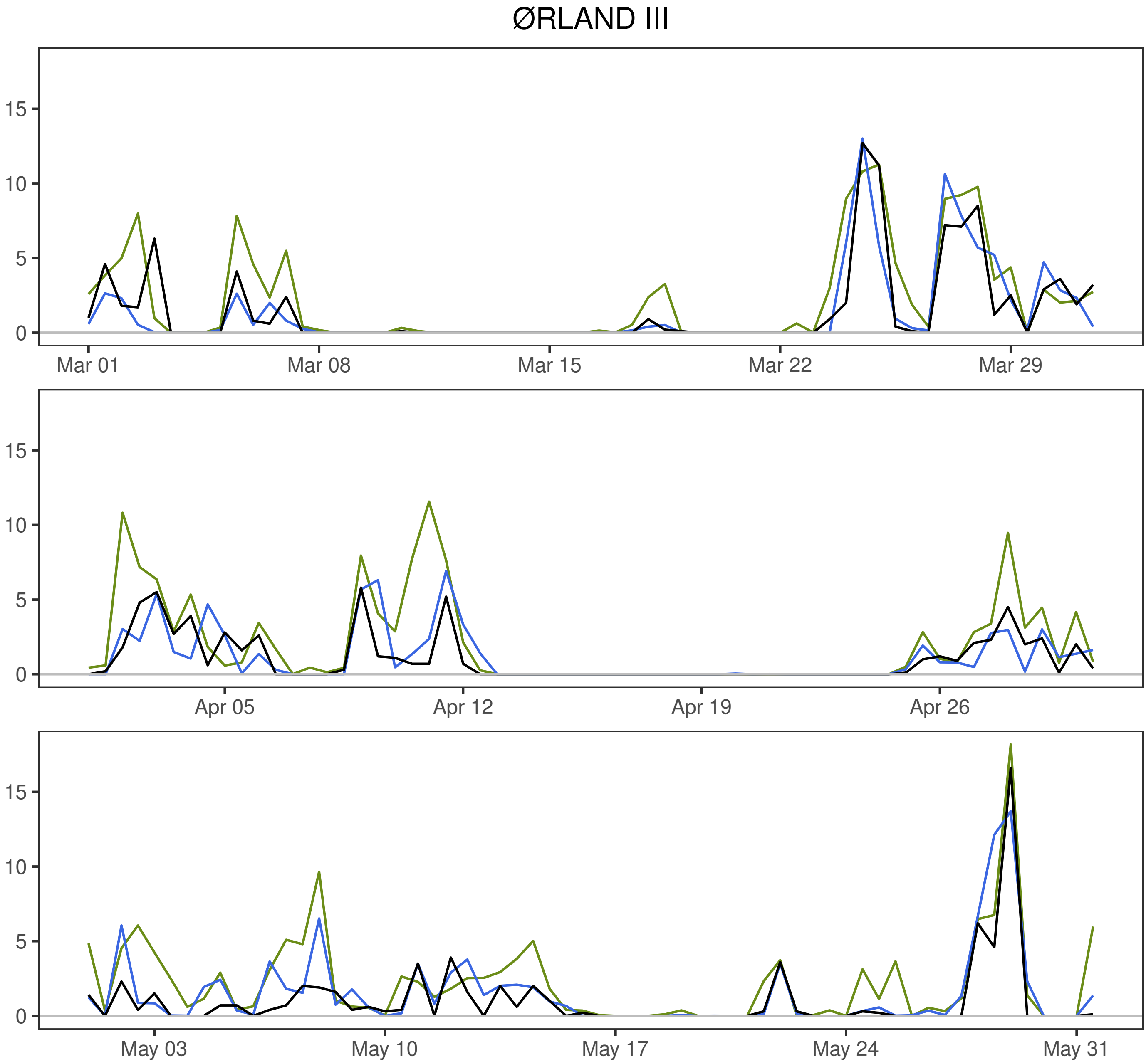
	Min	Mean	Max	Std	N
synop: 06,18	0.0	1.9	22.0	3.1	184
MEPSctrl: 12+18,+30	0.0	1.7	15.1	2.7	184
AA25: 12+18,+30	0.0	1.5	12.5	2.4	182
ECMWF: 12+18,+30	0.0	2.2	27.5	3.8	184

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl−synop	−0.2	1.8	1.8	1.0	9.6	182
AA25−synop	−0.4	2.1	2.1	1.1	11.7	182
ECMWF−synop	0.3	2.1	2.1	1.1	15.2	182



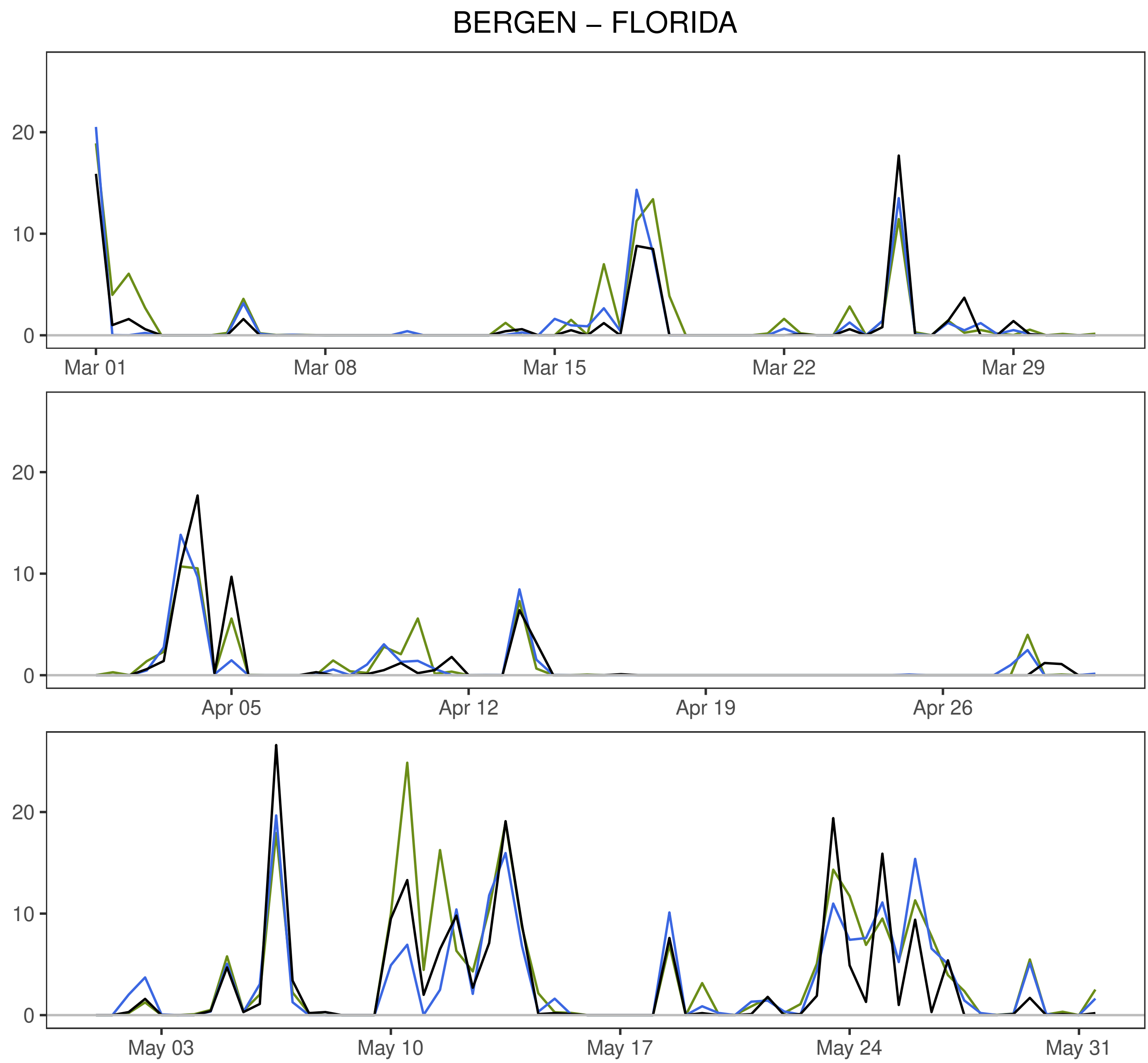
	Min	Mean	Max	Std	N
synop: 06,18	0.0	2.0	23.0	3.6	184
MEPSctrl: 12+18,+30	0.0	2.4	27.4	4.2	184
ECMWF: 12+18,+30	0.0	3.1	29.9	4.8	184

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl−synop	0.4	1.9	1.9	1.1	9.4	184
ECMWF−synop	1.2	2.3	2.6	1.5	11.9	184



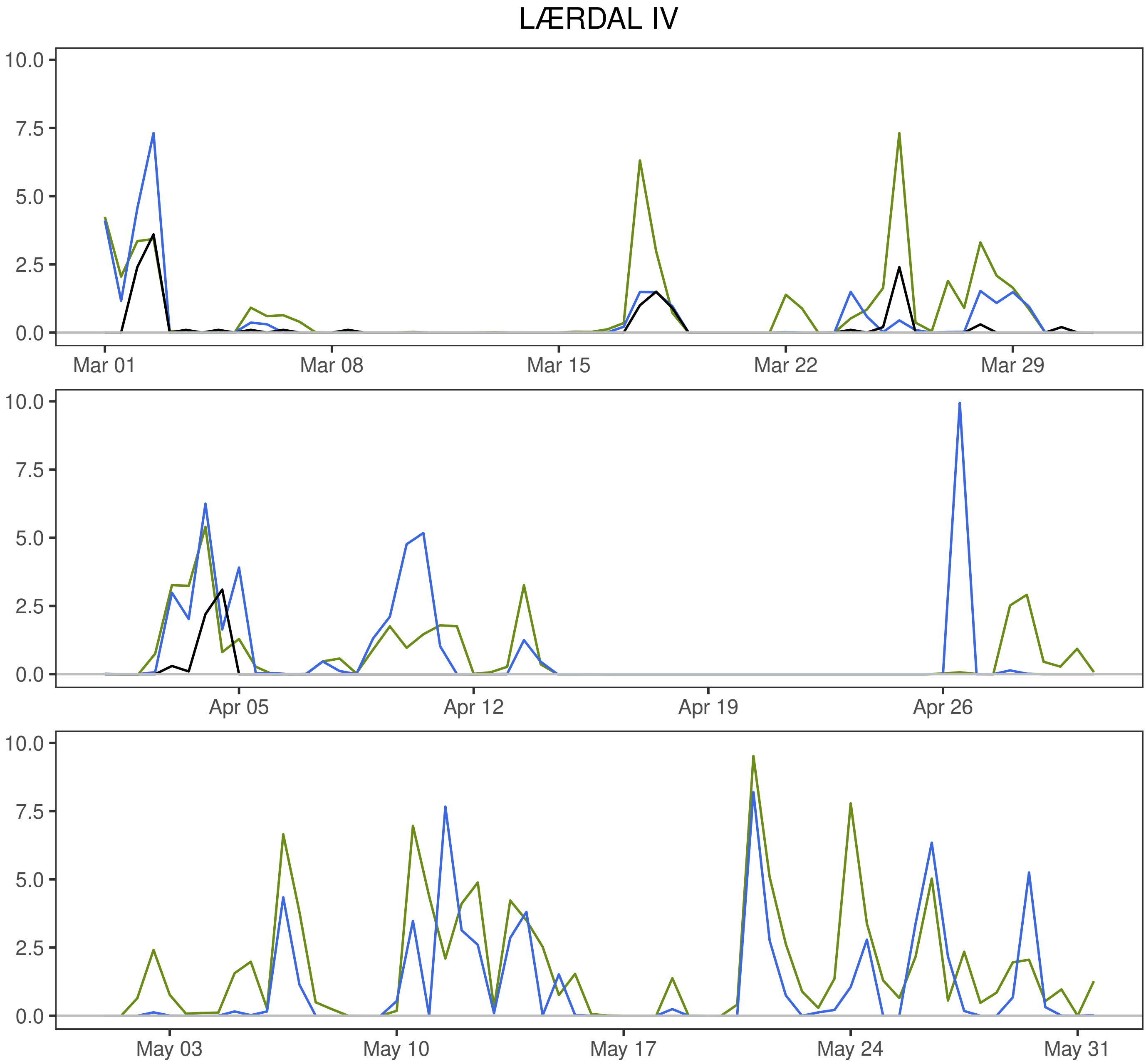
	Min	Mean	Max	Std	N
synop: 06,18	0.0	1.2	16.6	2.3	184
MEPSctrl: 12+18,+30	0.0	1.3	13.7	2.4	184
ECMWF: 12+18,+30	0.0	2.1	18.2	3.1	184

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl−synop	0.2	1.4	1.4	0.7	7.5	184
ECMWF−synop	1.0	1.9	2.1	1.2	10.9	184



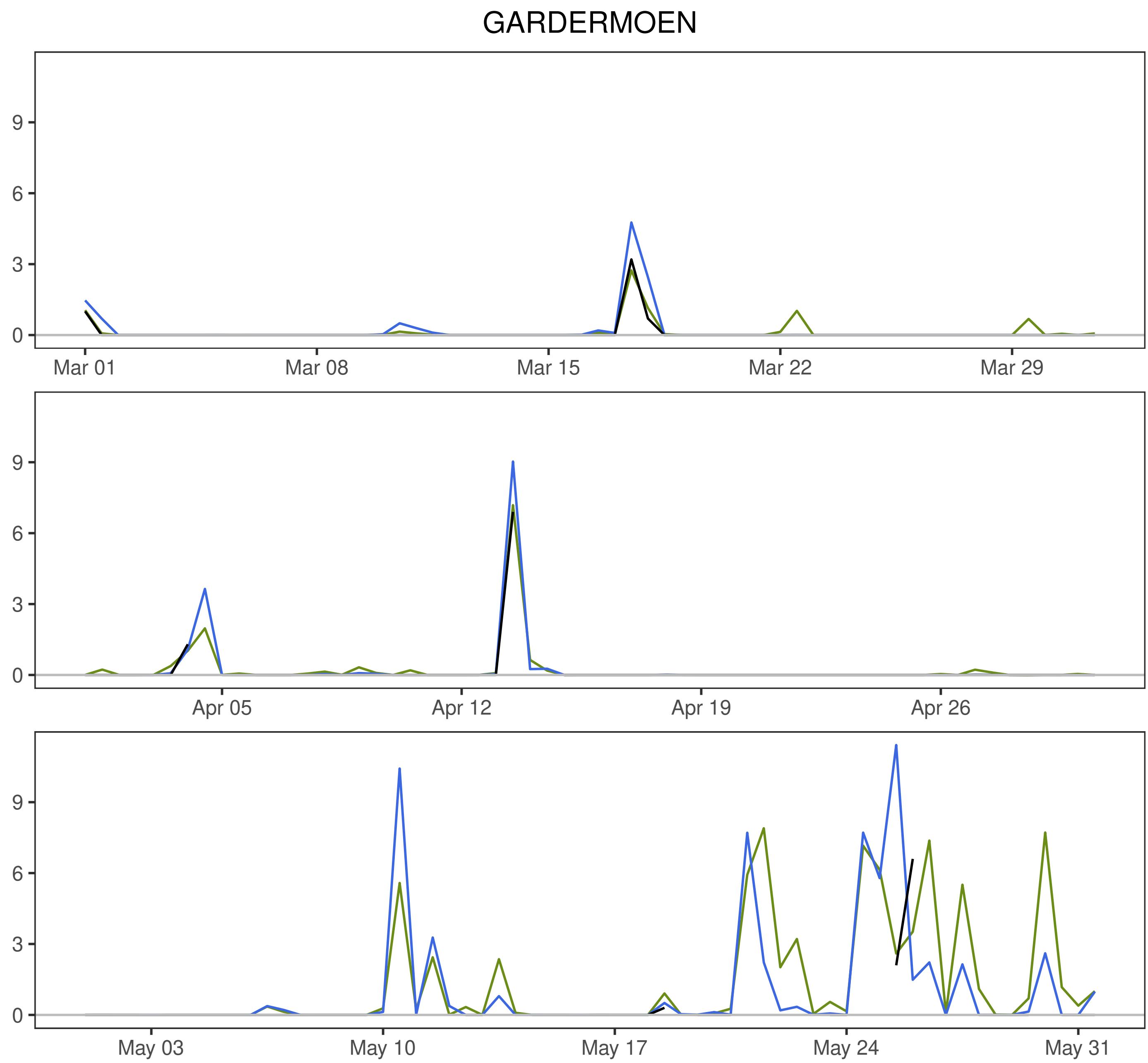
	Min	Mean	Max	Std	N
synop: 06,18	0.0	1.7	26.6	4.2	184
MEPSctrl: 12+18,+30	0.0	1.7	20.5	3.8	184
ECMWF: 12+18,+30	0.0	2.1	24.9	4.3	184

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl–synop	0.0	2.0	2.0	0.9	8.4	184
ECMWF–synop	0.4	2.2	2.3	1.1	11.6	184



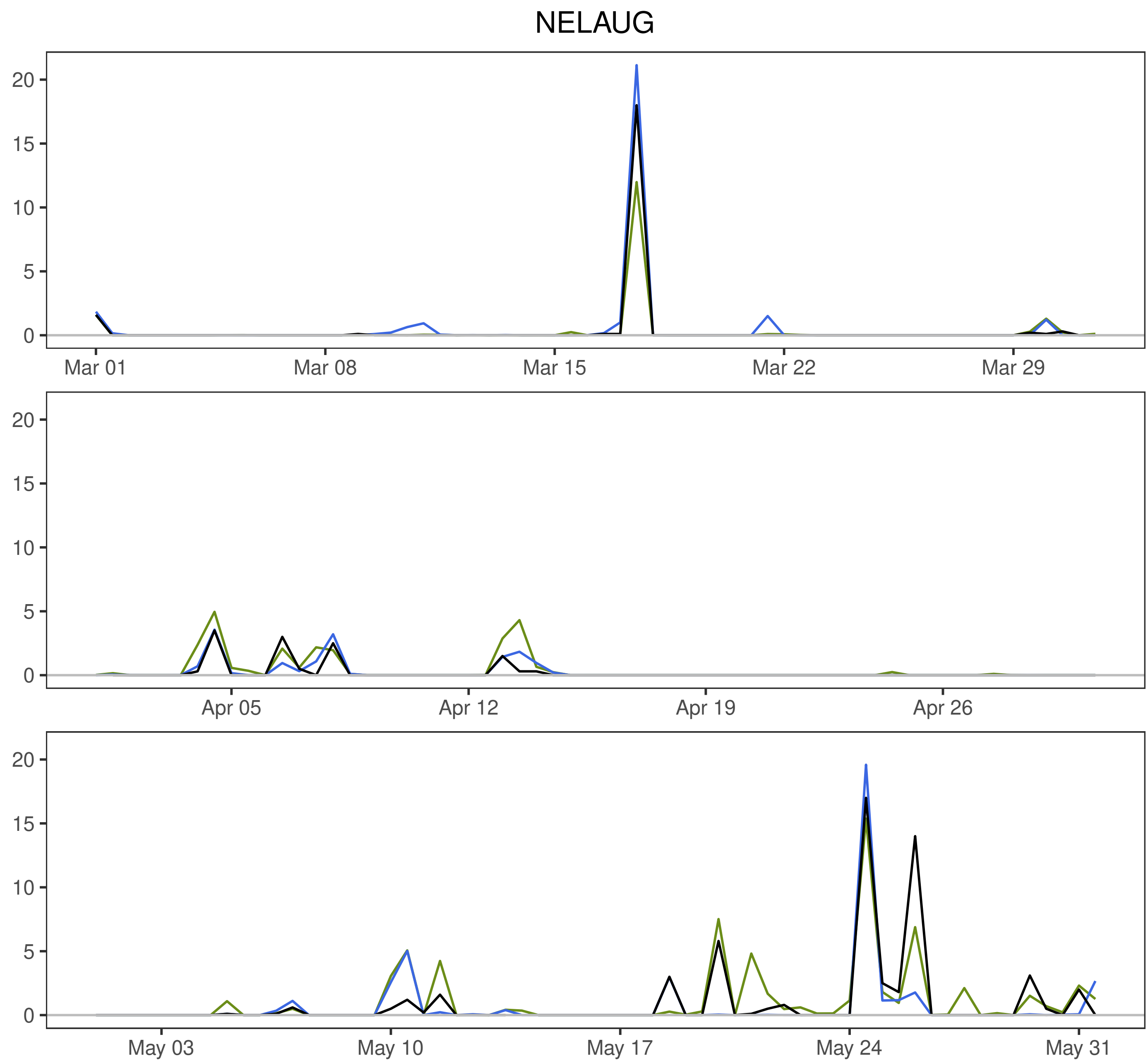
	Min	Mean	Max	Std	N
synop: 06,18	0.0	0.2	3.6	0.7	87
MEPSctrl: 12+18,+30	0.0	0.8	9.9	1.7	184
ECMWF: 12+18,+30	0.0	1.1	9.5	1.7	184

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl−synop	0.5	1.2	1.3	0.6	5.2	87
ECMWF−synop	0.6	1.2	1.3	0.7	5.3	87



	Min	Mean	Max	Std	N
synop: 06,18	0.0	0.2	6.9	0.8	164
MEPSctrl: 12+18,+30	0.0	0.5	11.4	1.7	184
ECMWF: 12+18,+30	0.0	0.5	7.9	1.5	184

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl–synop	0.1	0.9	0.9	0.2	9.3	164
ECMWF–synop	0.1	0.4	0.4	0.1	3.1	164



	Min	Mean	Max	Std	N
synop: 06,18	0.0	0.5	18.0	2.2	182
MEPSctrl: 12+18,+30	0.0	0.5	21.1	2.2	184
ECMWF: 12+18,+30	0.0	0.6	15.4	1.8	184

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl–synop	0.0	1.2	1.2	0.3	12.2	182
ECMWF–synop	0.1	1.0	1.0	0.3	7.1	182