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Verification of Operational Weather Prediction Models March to May 2023

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Pink-footed geese at Maridalsvannet, resting on their way to arctic areas. Tens of thousands pass each spring. Photo: Jan Erik Haugen.

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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

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 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	$\left(\frac{1}{n}\sum_{i=1}^{n}(f_i - o_i - \mathsf{M}E)^2\right)^{1/2}$	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	$\frac{\frac{1}{n}\sum_{i=1}^{n}(f_i - \bar{f})(o_i - \bar{o})}{\mathsf{SD}(f)\mathsf{SD}(o)}$	-1 to 1	1

In the formula for COR the following definitions are used

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

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

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. Both MEPSctrl and ECMWF underestimate the temperature for the different groups of stations, but MEPSctrl shows less underestimation than ECMWF. AA25 somewhat overestimates the temperature for Svalbard stations, and varies around zero for the North Scandinavian stations. All models show diurnal variation in the errors. 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 near surface wind speeds are affected by the upgrade to cycle 43 both by modifications in the turbulence scheme and by the physiography upgrade. ECOCLIMAP Second Generation has new tree heights and a more ”binary” separation between patch 1 (low vegetation) and 2 (trees). The largest effect of the change is seen at coastal stations with increased diurnal cycle in wind speed and less underestimation during day. The post processing of wind speed was changed on 1 June 2021 by downscaling to 1km resolution to better represent local topography. The mean absolute error indicates very slightly smaller errors of wind speed after post processing, while the threshold 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. Both have more errors for both very small amounts and very high amounts, than precipitation in the mid range.

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

Case studies by forecasters

Case 1. Wind event in Lofoten and Vesterålen 25 May 2023

A wind event with strong south to southwesterly winds in Lofoten and Vesterålen on 25 May 2023 shows that the forecast for 10m wind is generally good, but underforecasts the strongest winds which occurred at around 3 UTC in the morning (figure 1). Also at Andenes, which is slightly sheltered on southerly winds, the peak values in MEPS is slightly too low, even though the wind speed is only 13 m/s. Figure 2 shows timeseries from four stations in the area.

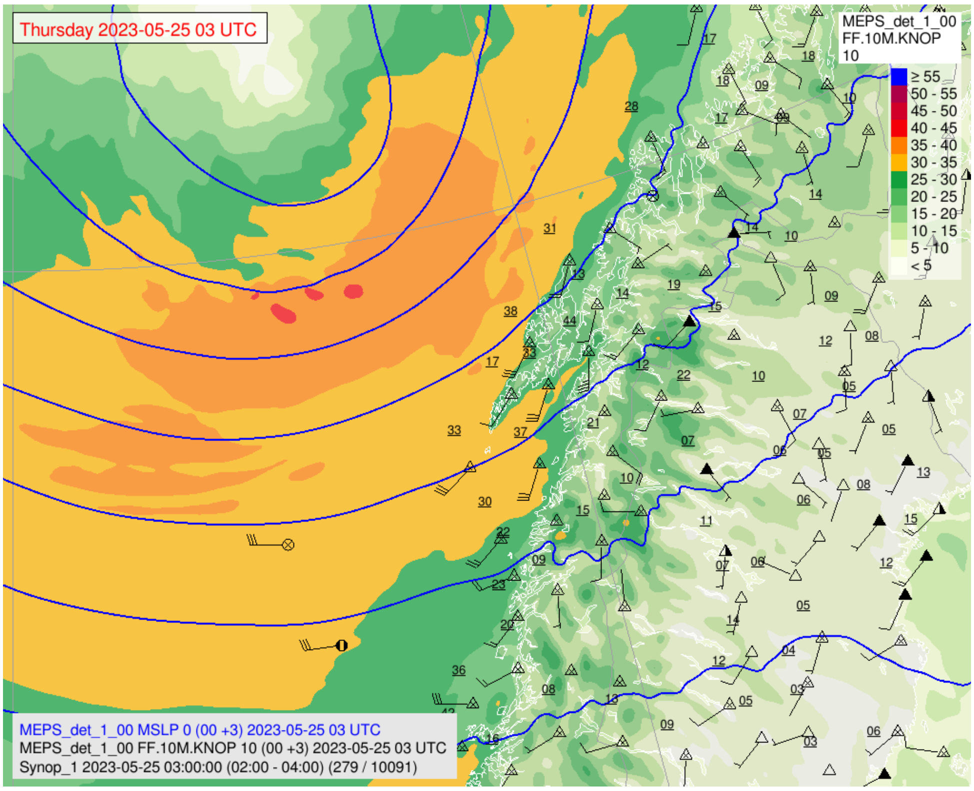


Figure 1: The wind event in Lofoten and Vesterålen on the morning of 25 May 2023. Observations in black with number for past 1hr max wind (in knots).

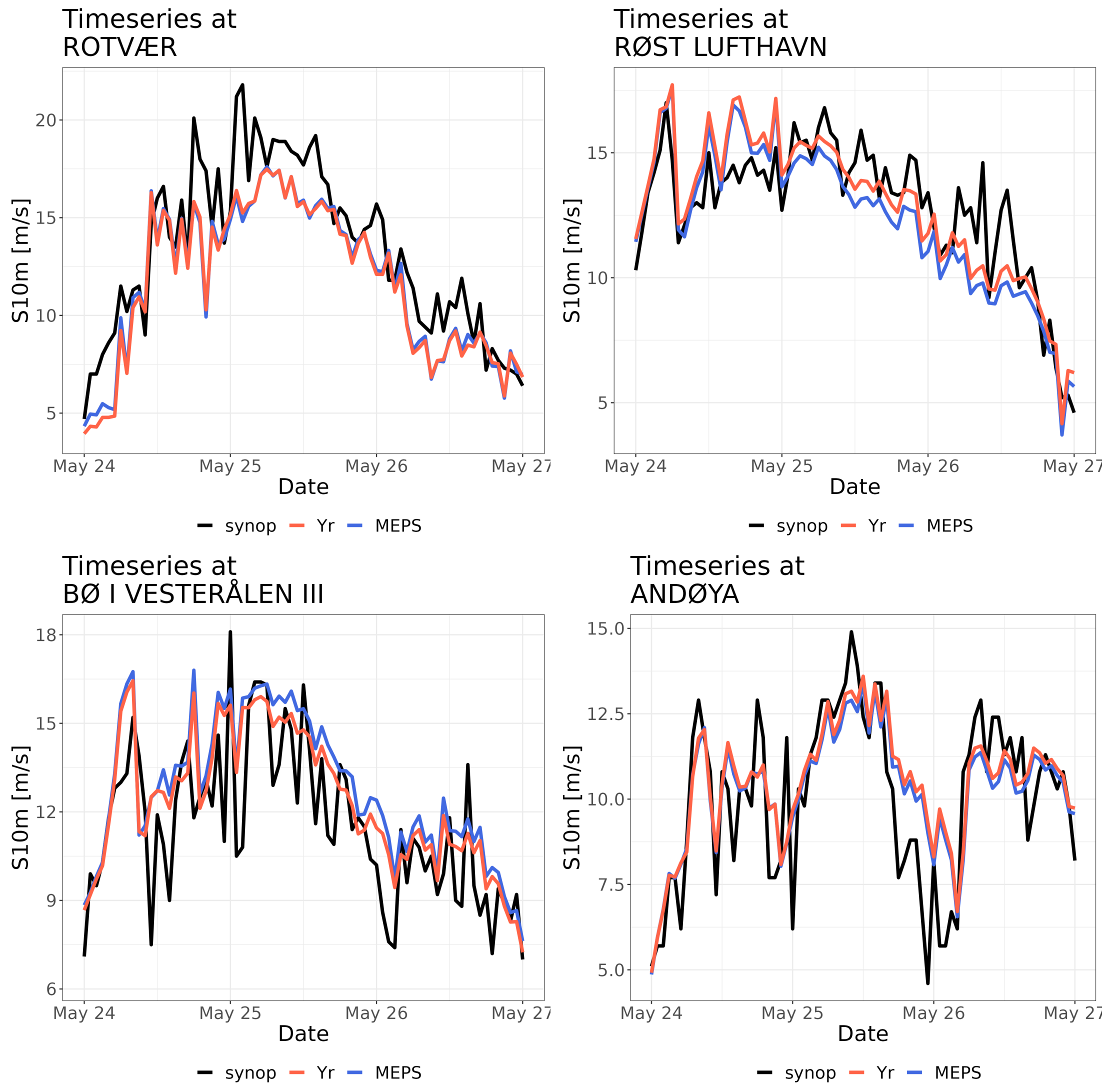


Figure 2: 10m wind speed (m/s) for 24-26 May from MEPS 00+6,+7,...,+29 (blue) and the post-processed YrPP (red) plotted against observations (black). The strongest winds occured at 3 UTC on the morning of 25 May.

Case 2. Precipitation event 30-31 March 2023

On 30-31 March an almost stationary front gave heavy snowfall in northern Troms and western Finnmark, which caused several severe avalanches with four fatalities. The combination of wind and snow gave severe undercatchment at the observing stations, but observations of accumulated snow (cm) gives an impression of the amounts (Table 1).

Station	30 March 6 UTC	31 March 6 UTC	1 April 6 UTC
Gjerdvassbu	2	24	22
Sjursnes	27	13	9
Lyngseidet	12	28	15
Lenangsøyra	4	11	13
E6 Djupvik	12	10	12
Breivikeidet	20	48	21
Sopnesbukt	4	11	10
Tromsø	5	12	13

Table 1: 24h accumulated snow (cm)

Gjerdvassbu in the Lyngen alps has little undercatchment because of its sheltered location and should be expected to observe values close to the actual maxima in the area. It received 24cm of snow during the 30th and till the 31st 6 UTC. Breivikeidet received the most snow in this event with 48cm/24hrs of snow till 6 UTC on the 31st, and 89cm during the whole event from the 29th to the 31st. The Breivikeidet measurement is supported by unofficial reports from the neighboring area.

Figure 3 shows the forecast and observed 24 hour precipitation on 31 March. Compared to observations and using the crude approximation of 1cm snow $\sim$1mm precipitation, the MEPS model is generally forecasting too much snow, with values of more than 30mm/24hrs throughout the area and max values of more than 130mm/24hrs. AROME-Arctic has slightly less precipitation, but is still overforecasting quite severely. This behavior in high intensity precipitation events is typical for the currently used HARMONIE models with AROME physics on a 2.5×2.5 km^2 grid. The EC-HIRES, in comparison, generally gives more than 20mm/24hrs in the area, but the max values of 40 to 47mm/24hrs are much more in line with what is observed in this case.

Another case of moderate to severe precipitation from 10 April in southern Norway is shown in figures 4 and 5 for MEPS and ECMWF respectively. Also in this case the MEPS is forecasting too high maxima, and also overforecasting the rain further inland and downstream in areas that received only moderate amounts. In this case the EC-HIRES is also overforecasting the 24 hour precipitation, but to a lesser degree than MEPS.

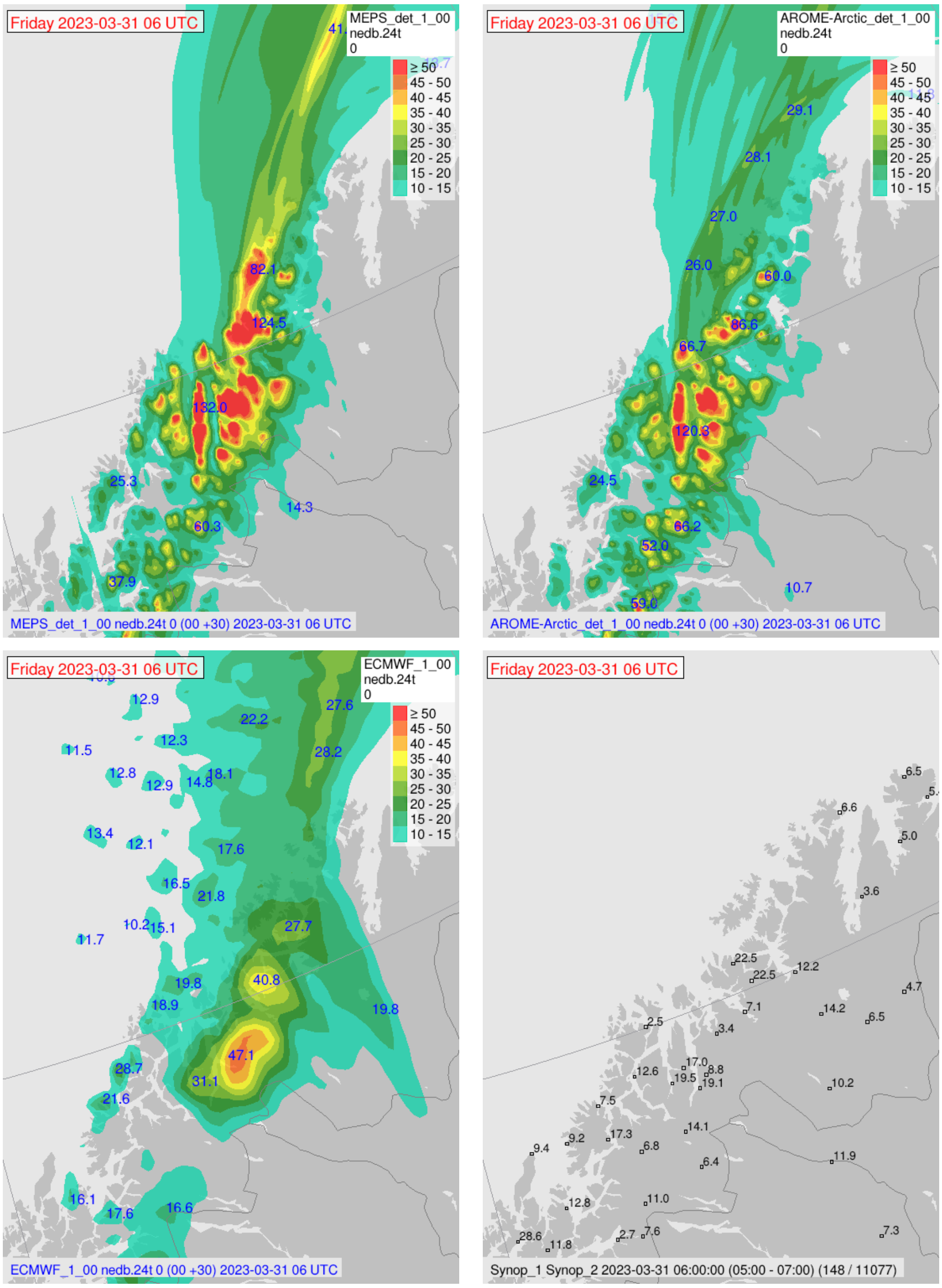


Figure 3: 24 hour precipitation for 31 March from MEPS (upper left), AROME-Arctic (top right) EC-HIRES (bottom left) and observed (bottom right). Local maxima are shown as blue numbers.

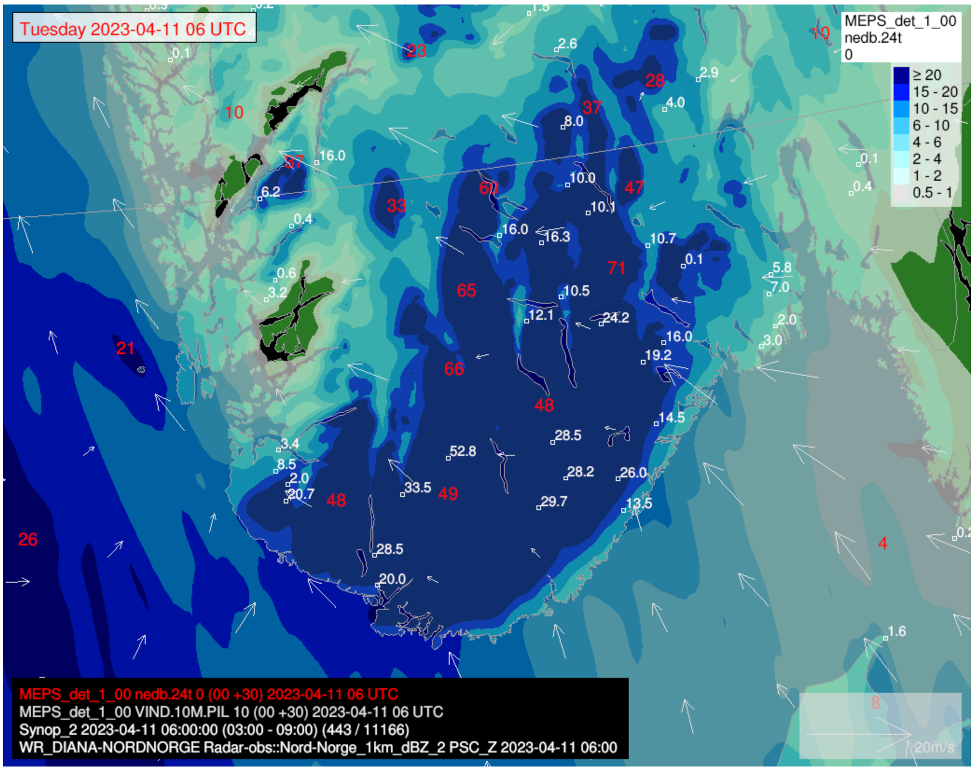


Figure 4: MEPS 00 from 10 April. Blue shading is 24hrs precipitation, with maximum values as red numbers. Observations are in white. MSLP are in gray lines. 10m wind is indicated with white arrows.

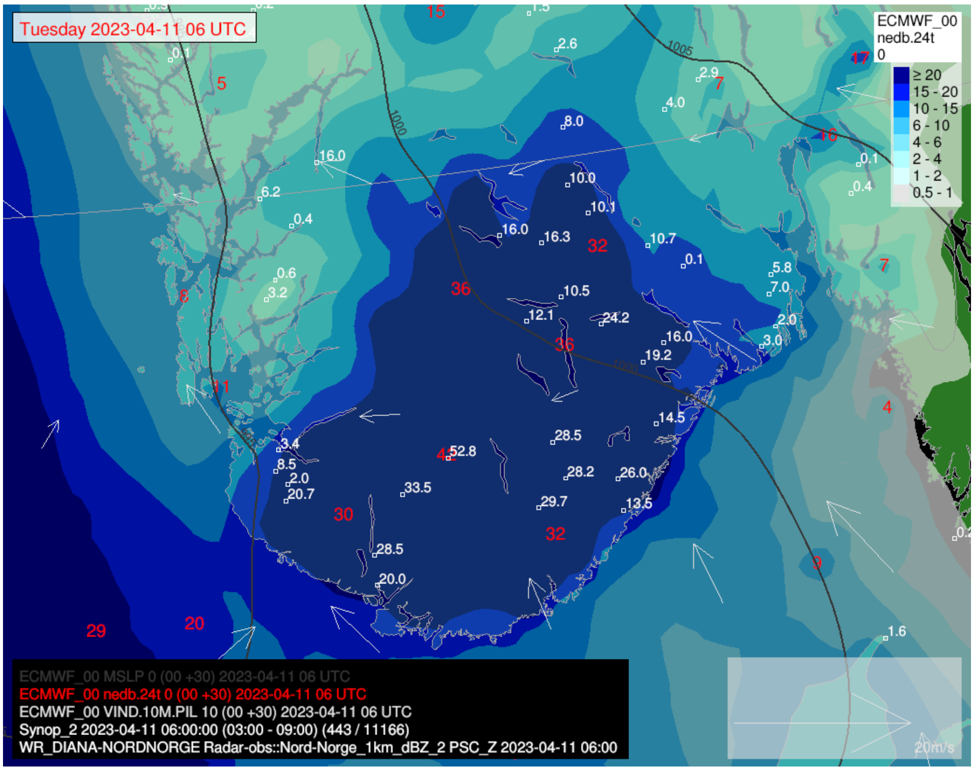


Figure 5: Same as figure 4, but with forecast from EC-HIRES.

Case 3. Fog 16-19 April 2023

In April there was a prolonged episode with light southerly winds in the North Sea, and some patches of fog, but also large cloud and fog free areas and with several degrees dew point depression at the 2m level. MEPS did in this period forecast quite a large extent of the fog, without this being reflected in observations or from satellite images. The 2m temperature dropped considerably in the fog, and led to a rapid increase in the area covered by the model fog. The figures 6-8 shows wind and fog from MEPS on 16-18 April.

Figure 9 shows 2m temperature and dew point temperature at a later stage of the fog event, at 0 UTC on the 19th. In the northwestern part of the image the 2m temperature and dew point temperature are almost equal, and the model is indicating fog here. Compared to the observations, the prognostic 2m temperature is too low, and also the dew point temperature is too low within the model fog area. The sounding (figure 10) shows a difference in both temperature and dew point temperature mainly in the lowest model levels.

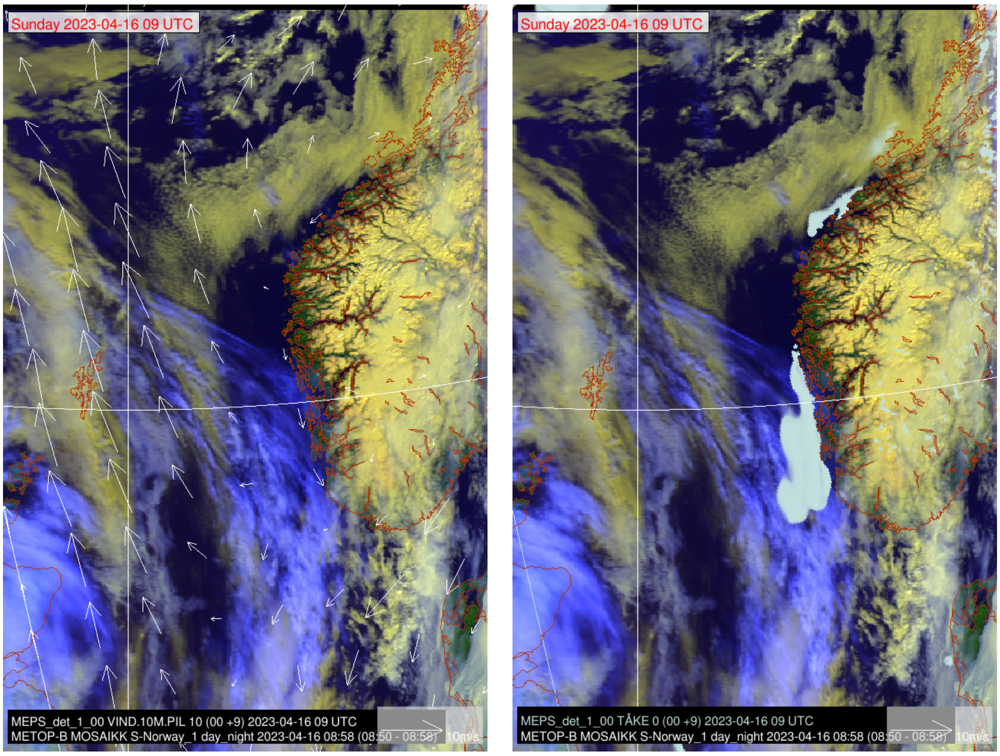


Figure 6: 10m wind (left) and fog (right) from MEPS at 16 April 9 UTC.

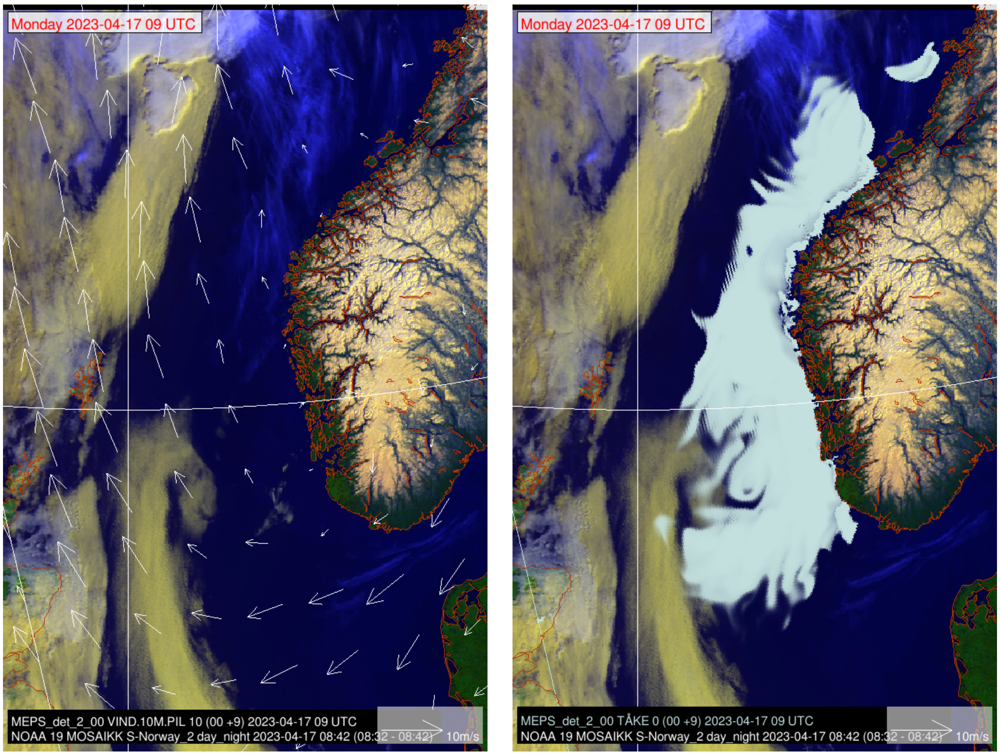


Figure 7: 10m wind (left) and fog (right) from MEPS at 17 April 9 UTC.

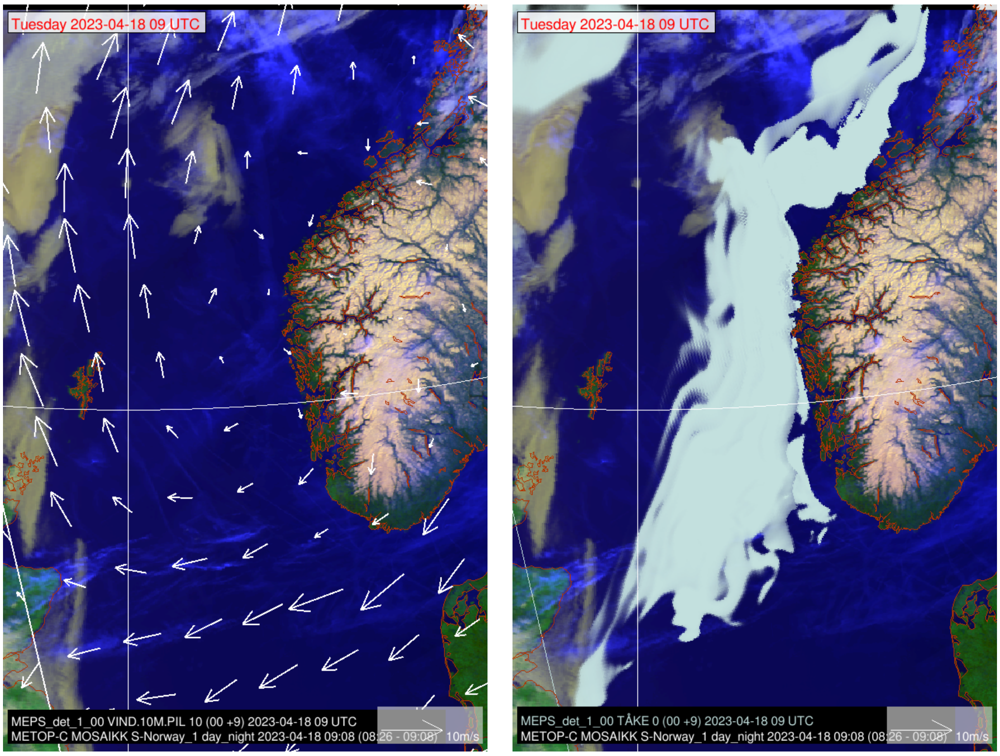


Figure 8: 10m wind (left) and fog (right) from MEPS at 18 April 9 UTC.

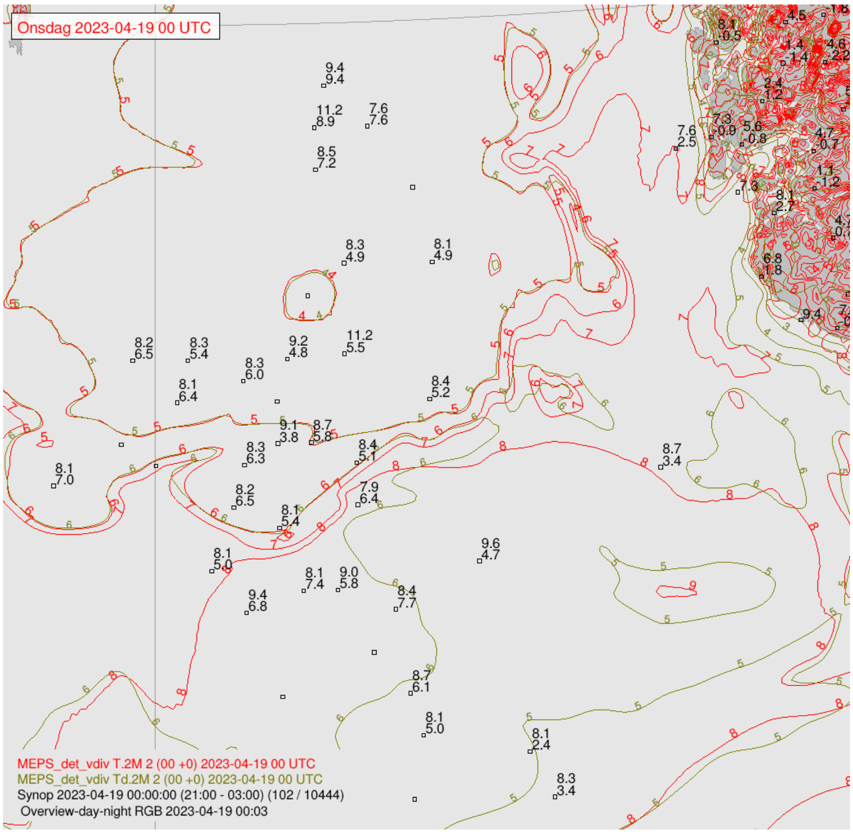


Figure 9: 2m temperature (red) and dew point temperature (green) at 19 April 0 UTC. Observations are shown in black with 2m temperature at the top and dew point temperature bottom.

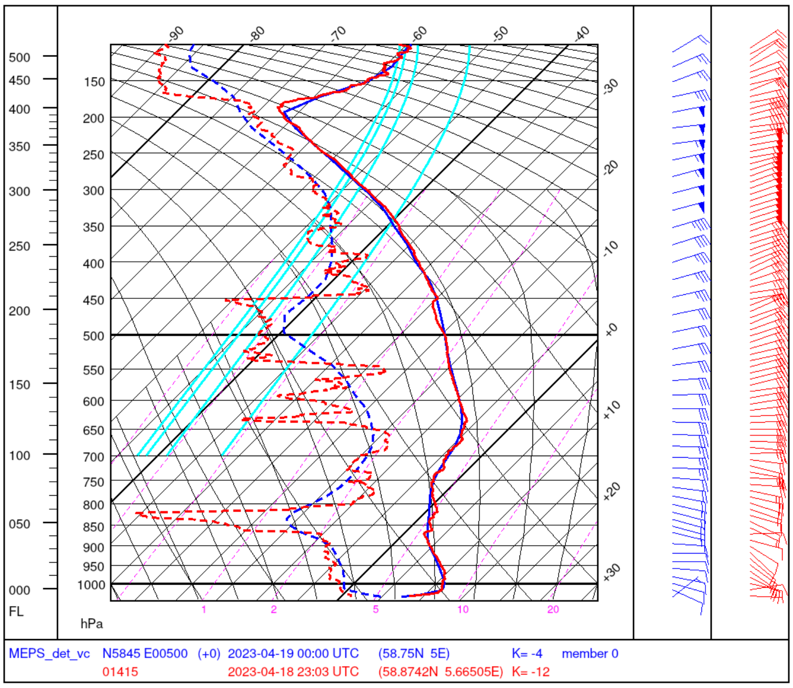
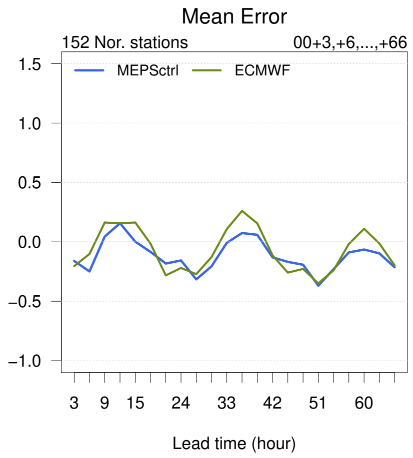
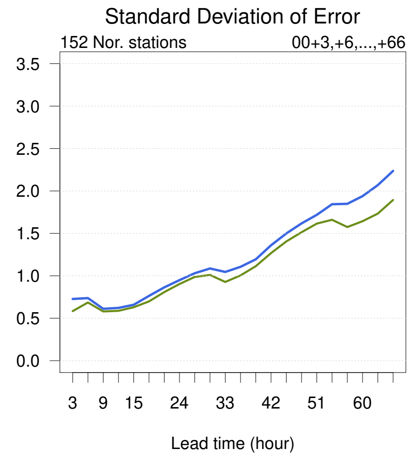
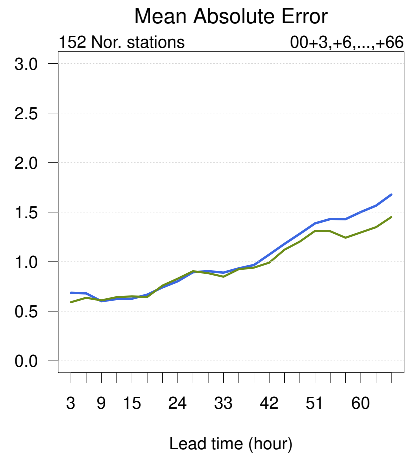


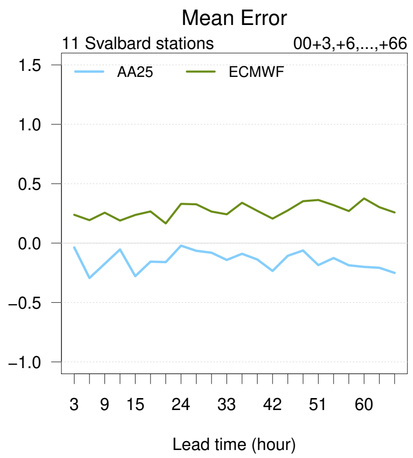
Figure 10: The sounding from Sola, 01415 (red) compared to MEPS (blue).

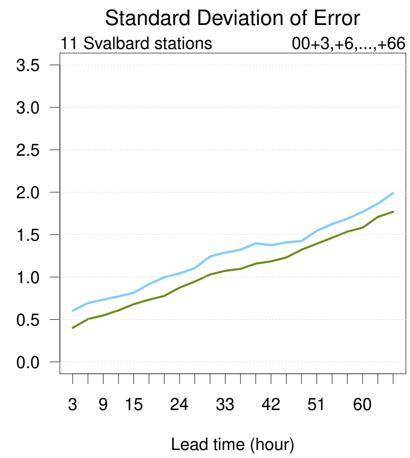
Summarized statistics

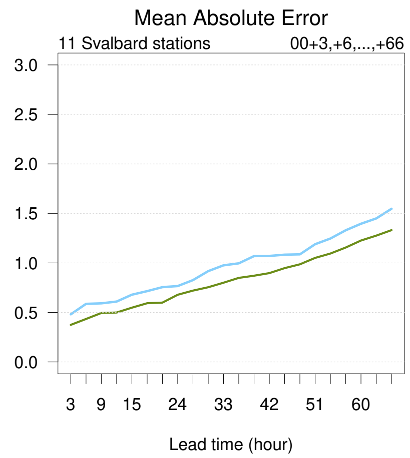

Mean Error
152 Nor. stations
00+3,+6,...,+66
MEPSctrl
ECMWF
Lead time (hour)

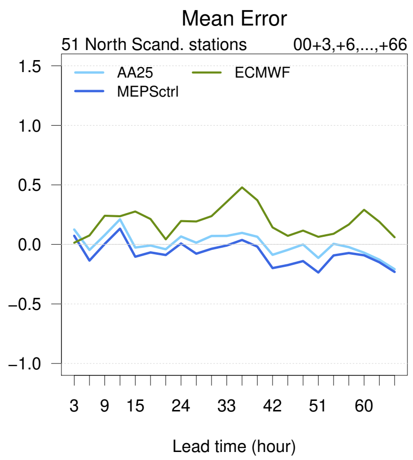

Standard Deviation of Error
152 Nor. stations
00+3,+6,...,+66
Lead time (hour)

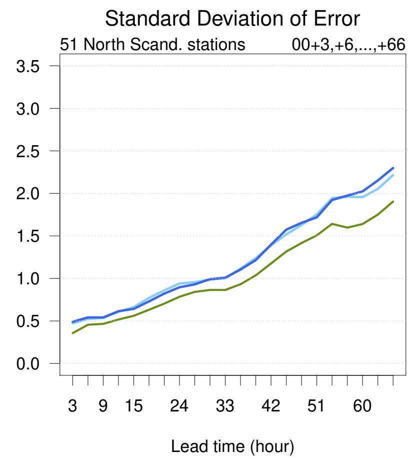

Mean Absolute Error
152 Nor. stations
00+3,+6,...,+66
Lead time (hour)

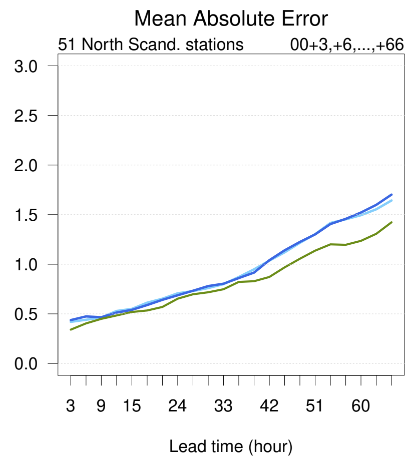

Mean Error
11 Svalbard stations
00+3,+6,...,+66
AA25
ECMWF
Lead time (hour)

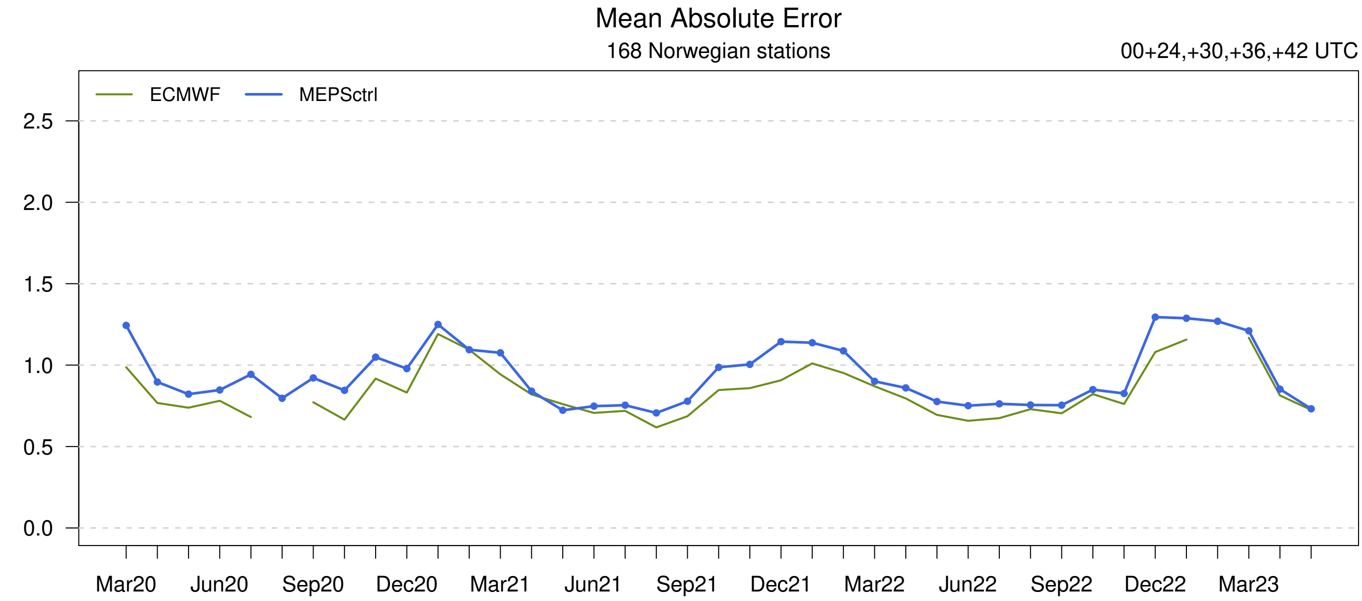

Standard Deviation of Error
11 Svalbard stations
00+3,+6,...,+66
Lead time (hour)

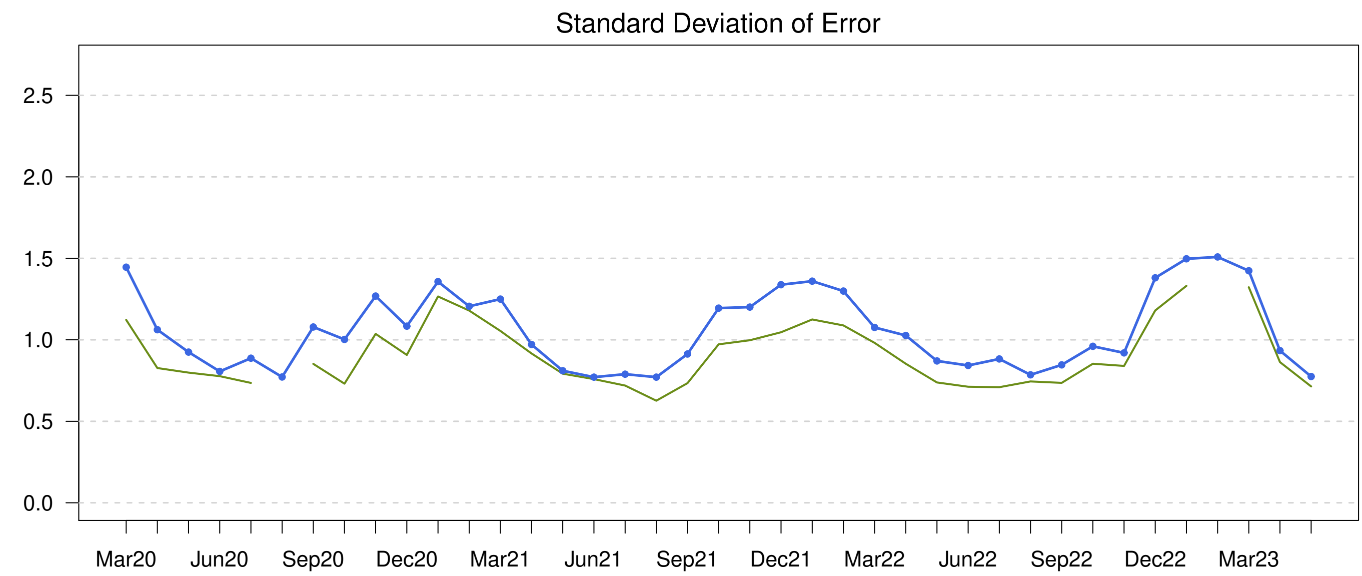

Mean Absolute Error
11 Svalbard stations
00+3,+6,...,+66
Lead time (hour)

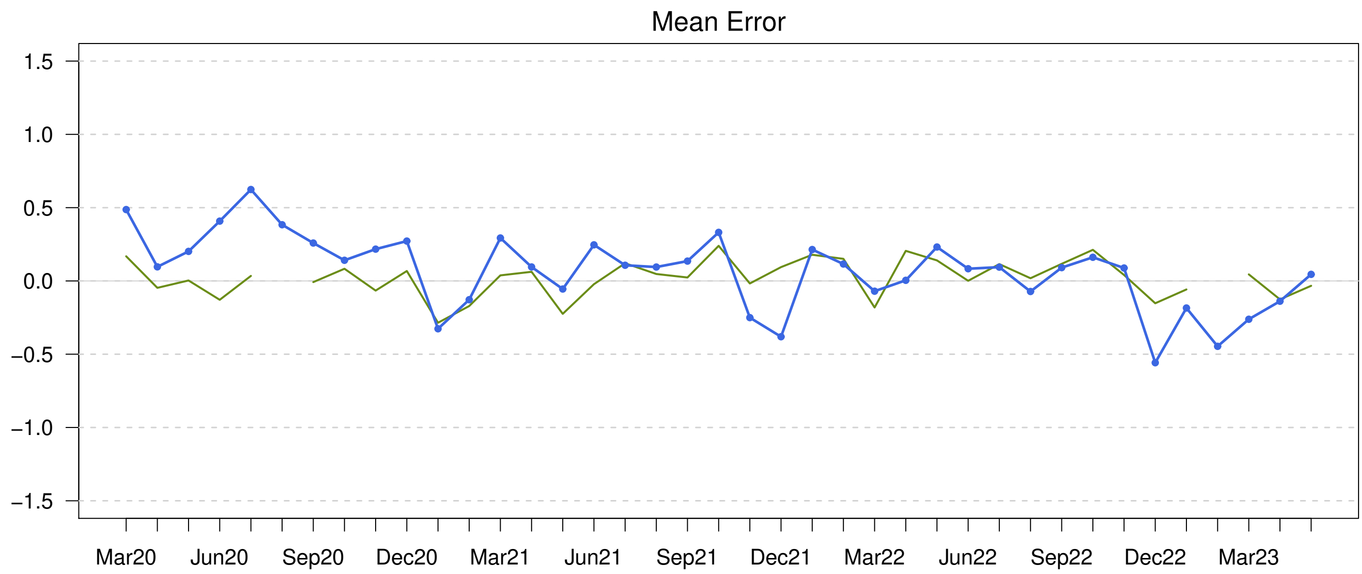

Mean Error
51 North Scand. stations
00+3,+6,...,+66
AA25
MEPSctrl
ECMWF
Lead time (hour)

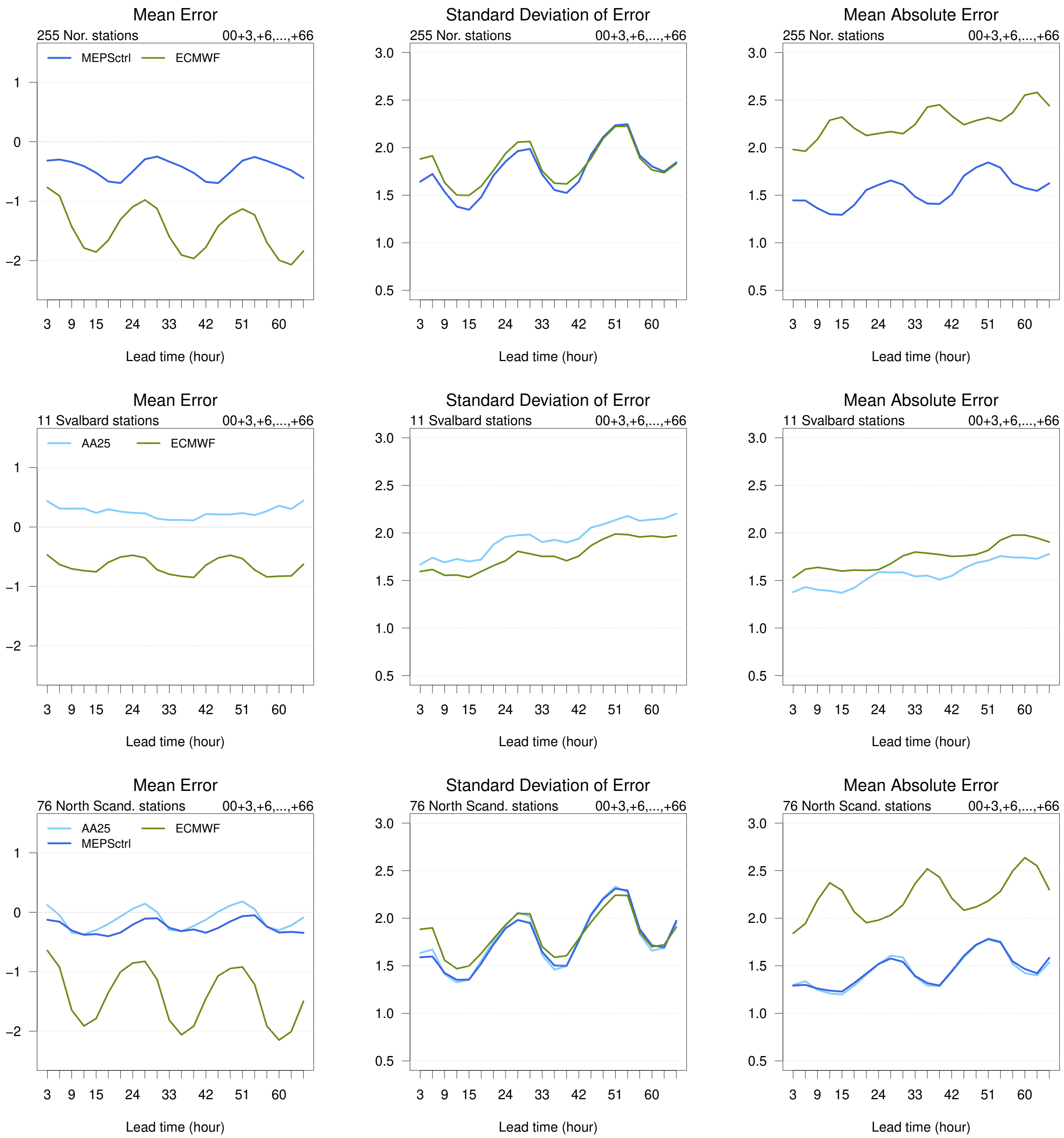

Standard Deviation of Error
51 North Scand. stations
00+3,+6,...,+66
Lead time (hour)


Mean Absolute Error
51 North Scand. stations
00+3,+6,...,+66
Lead time (hour)


Mean Absolute Error
168 Norwegian stations
00+24,+30,+36,+42 UTC
ECMWF
MEPSctrl
2.5
2.0
1.5
1.0
0.5
0.0
Mar20
Jun20
Sep20
Dec20
Mar21
Jun21
Sep21
Dec21
Mar22
Jun22
Sep22
Dec22
Mar23

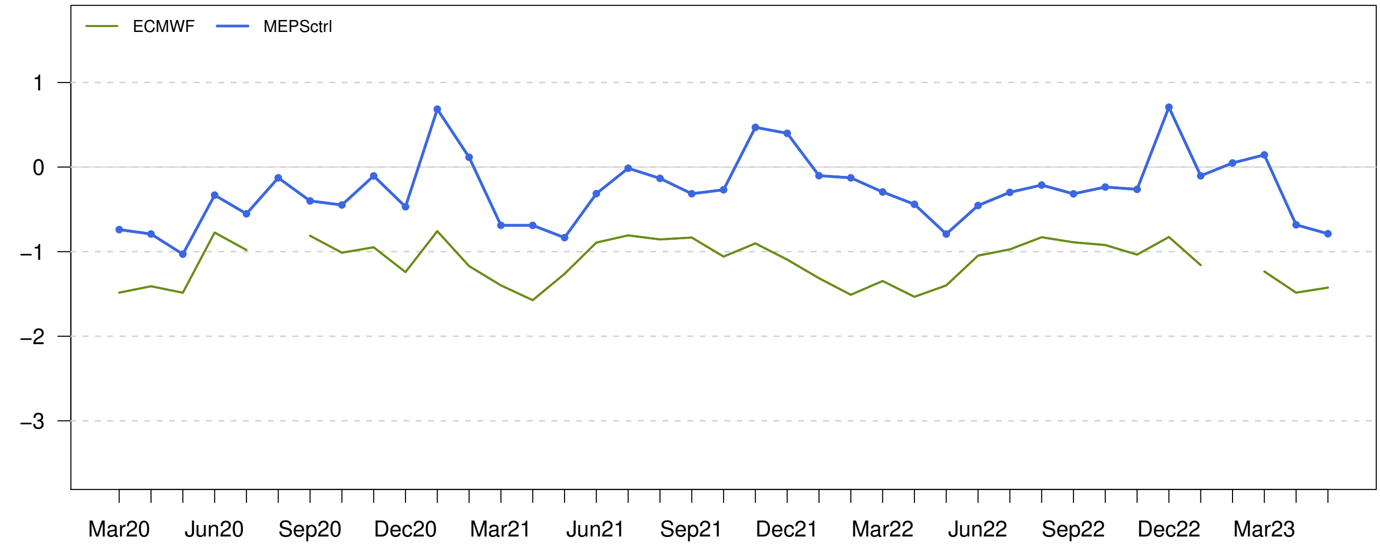

Standard Deviation of Error
2.5
2.0
1.5
1.0
0.5
0.0
Mar20
Jun20
Sep20
Dec20
Mar21
Jun21
Sep21
Dec21
Mar22
Jun22
Sep22
Dec22
Mar23


Mean Error
1.5
1.0
0.5
0.0
−0.5
−1.0
−1.5
Mar20
Jun20
Sep20
Dec20
Mar21
Jun21
Sep21
Dec21
Mar22
Jun22
Sep22
Dec22
Mar23

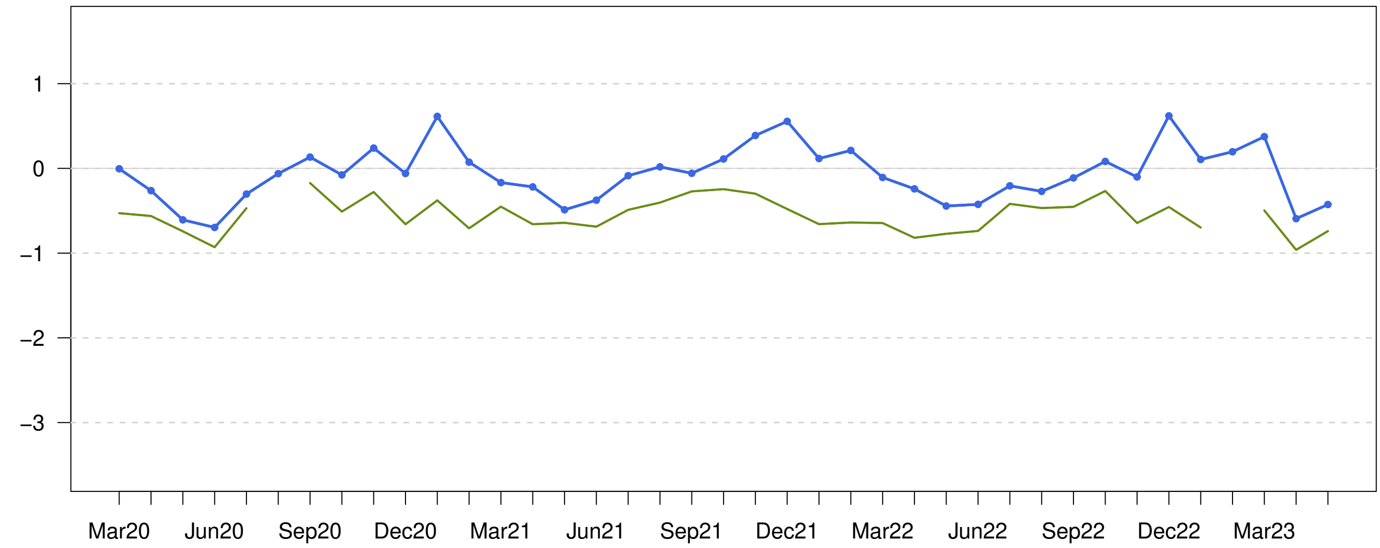

Mean Error
255 Nor. stations
00+3,+6,...,+66
MEPSctrl
ECMWF
Standard Deviation of Error
255 Nor. stations
00+3,+6,...,+66
Mean Absolute Error
255 Nor. stations
00+3,+6,...,+66
Mean Error
11 Svalbard stations
00+3,+6,...,+66
AA25
ECMWF
Standard Deviation of Error
11 Svalbard stations
00+3,+6,...,+66
Mean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

Mean Error

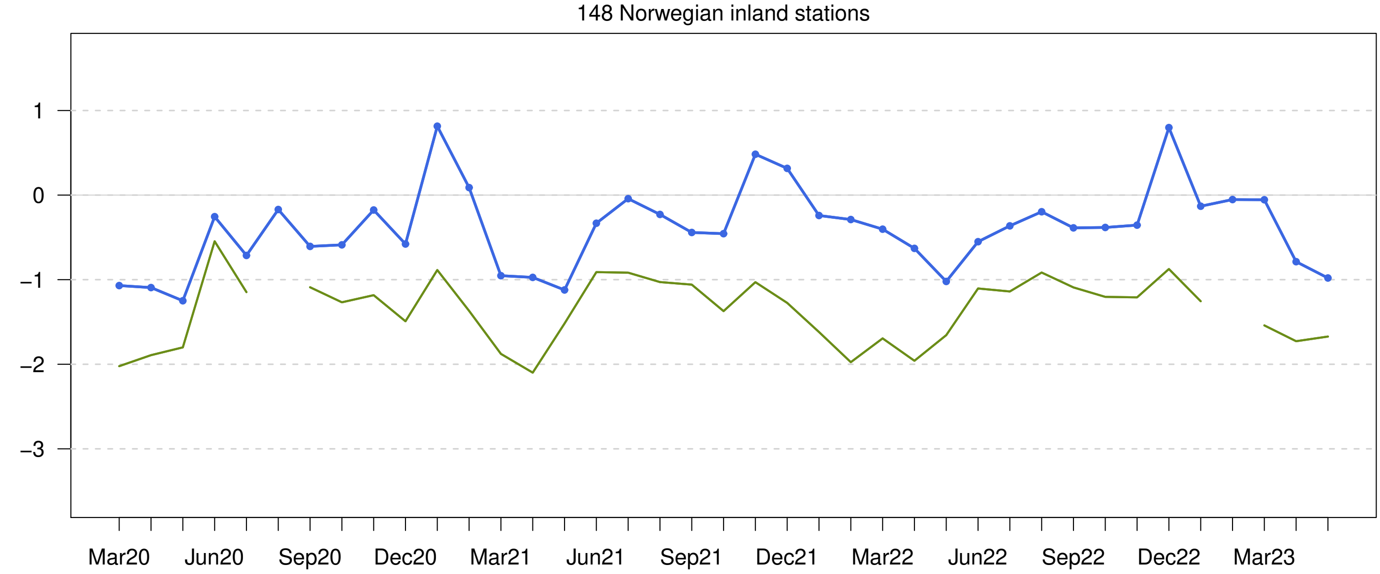
263 Norwegian stations 00+24,+30,+36,+42 UTC



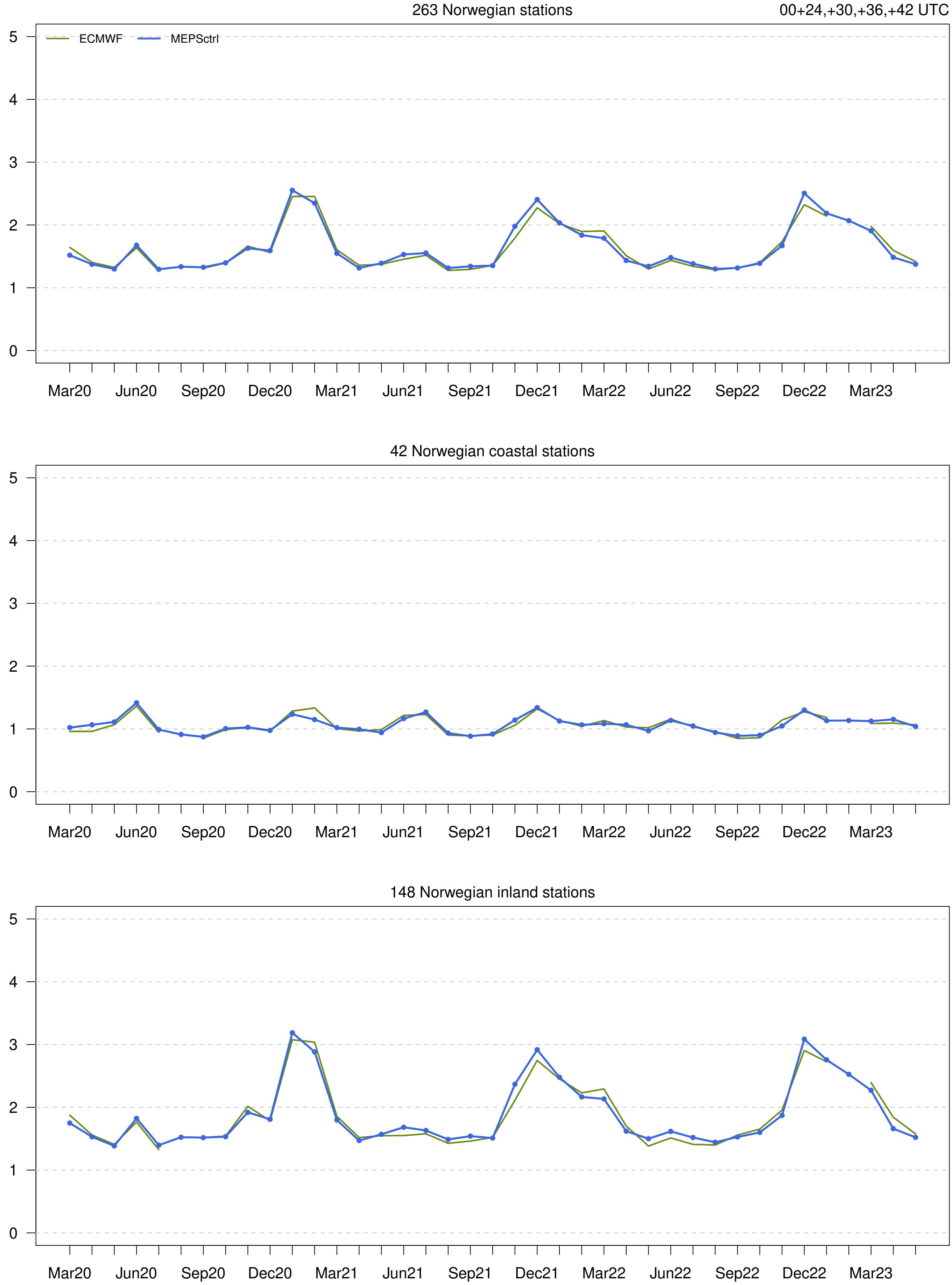
42 Norwegian coastal stations



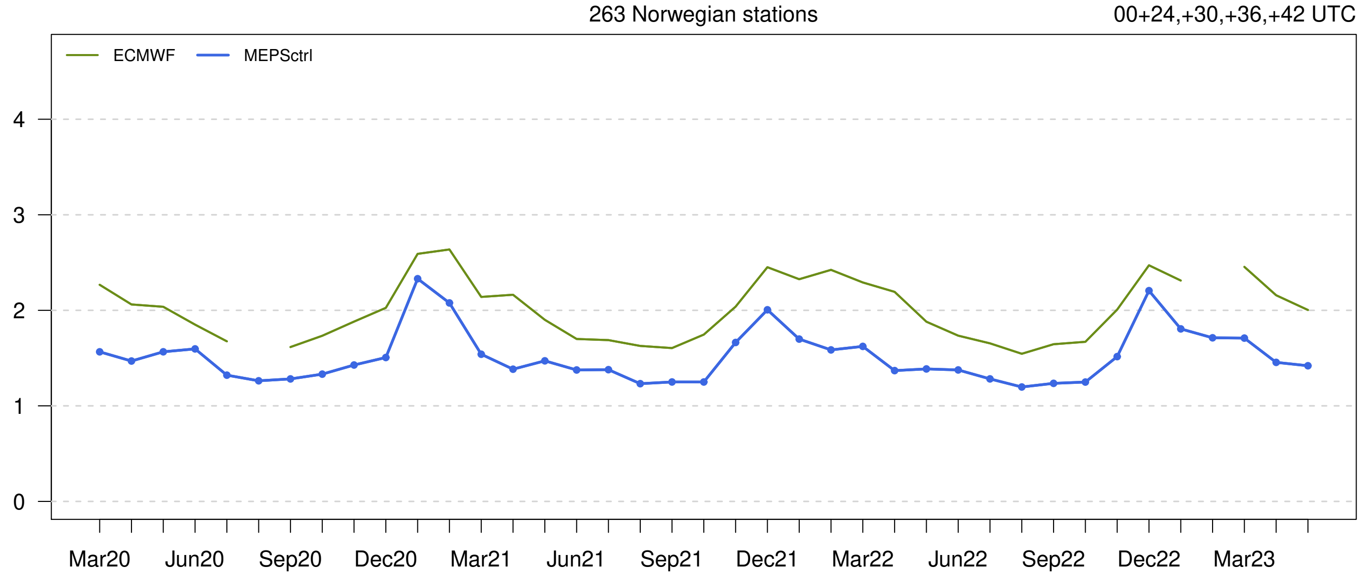
148 Norwegian inland stations

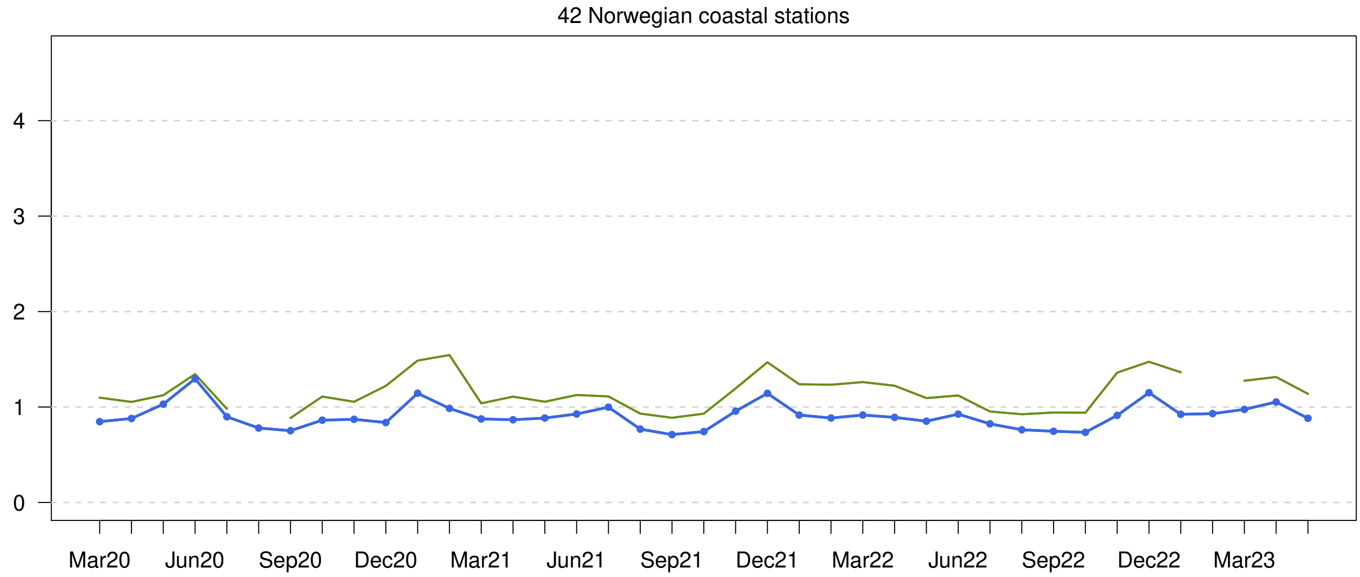


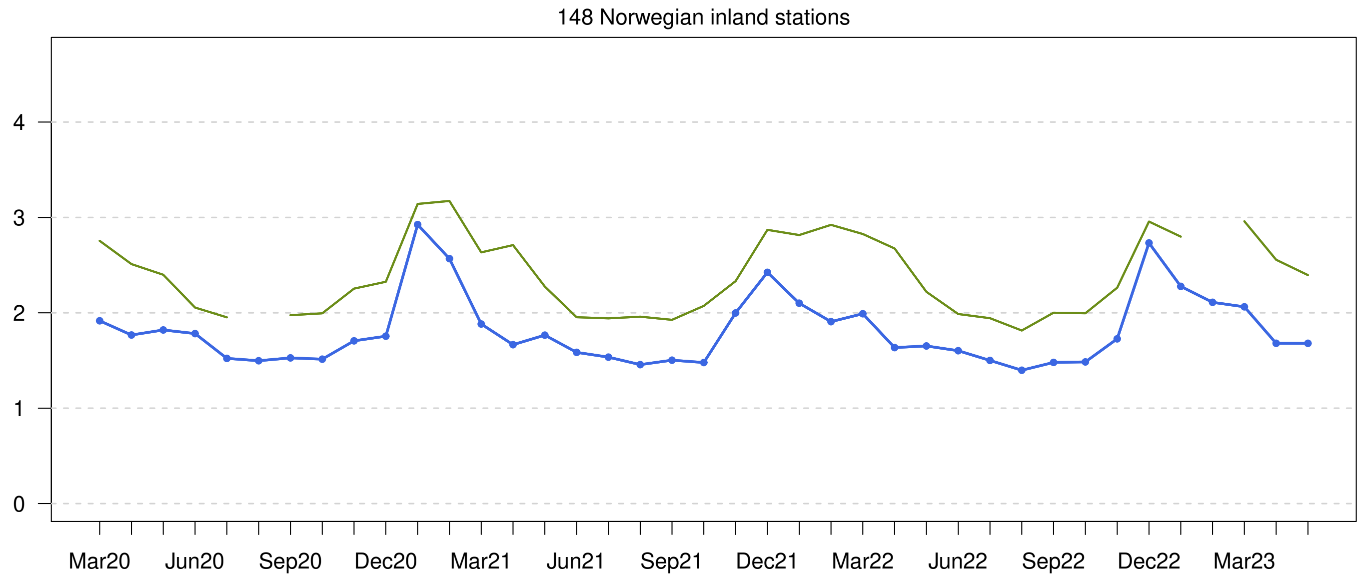
Standard Deviation of Error



Mean Absolute Error

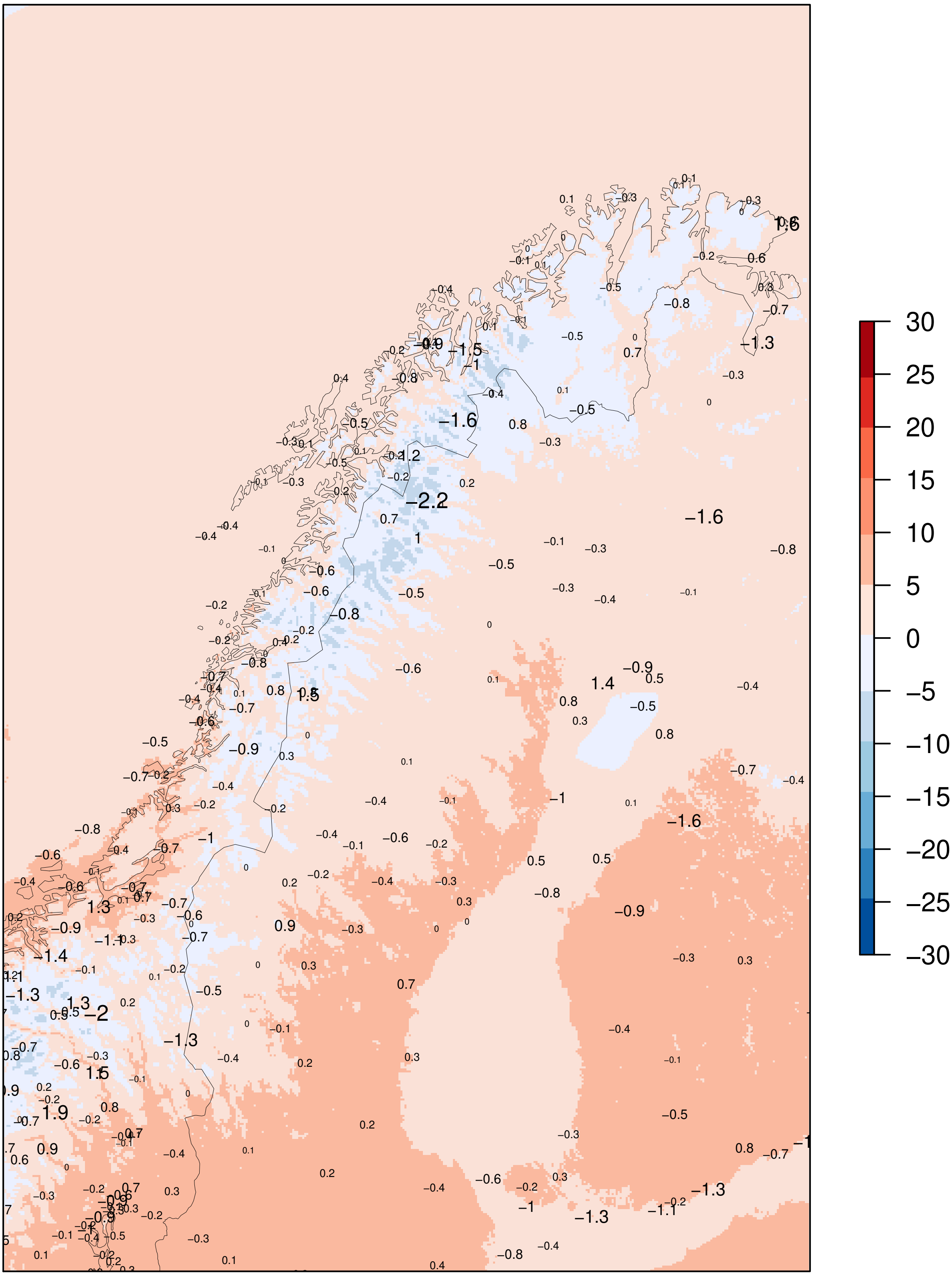




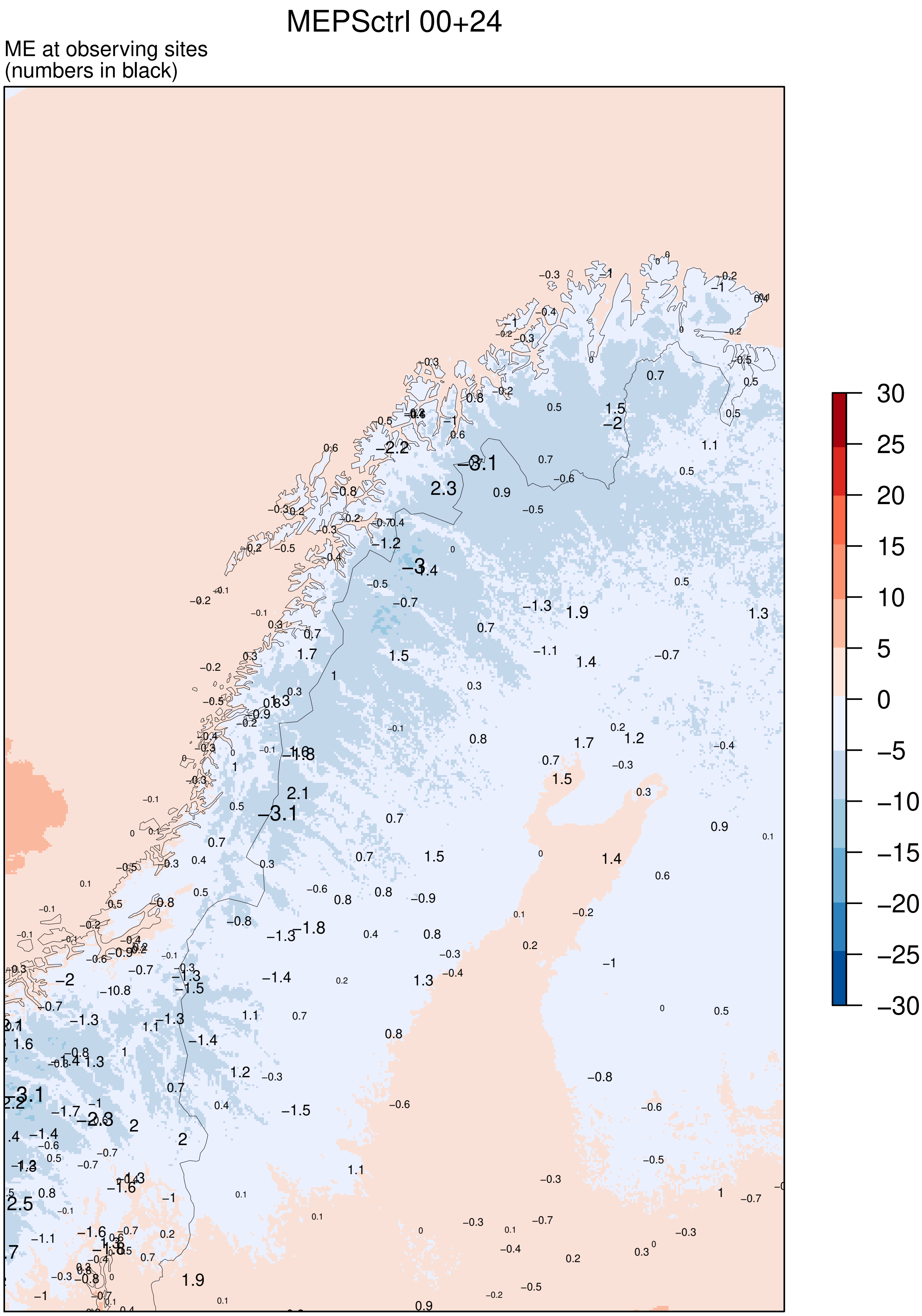


MEPSctrl 00+12

ME at observing sites
(numbers in black)



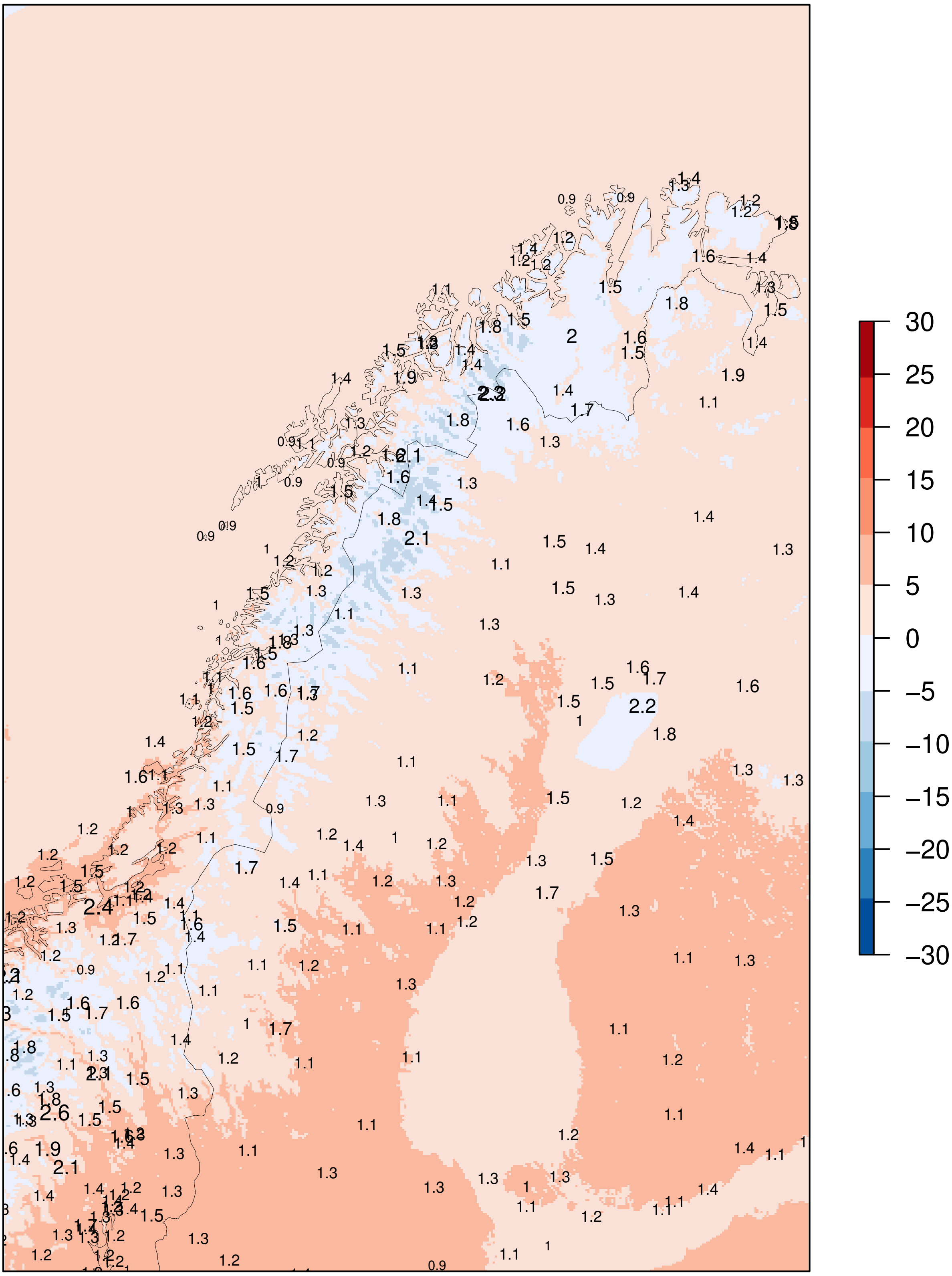
Model "climatology"   01.03.2023 – 31.05.2023



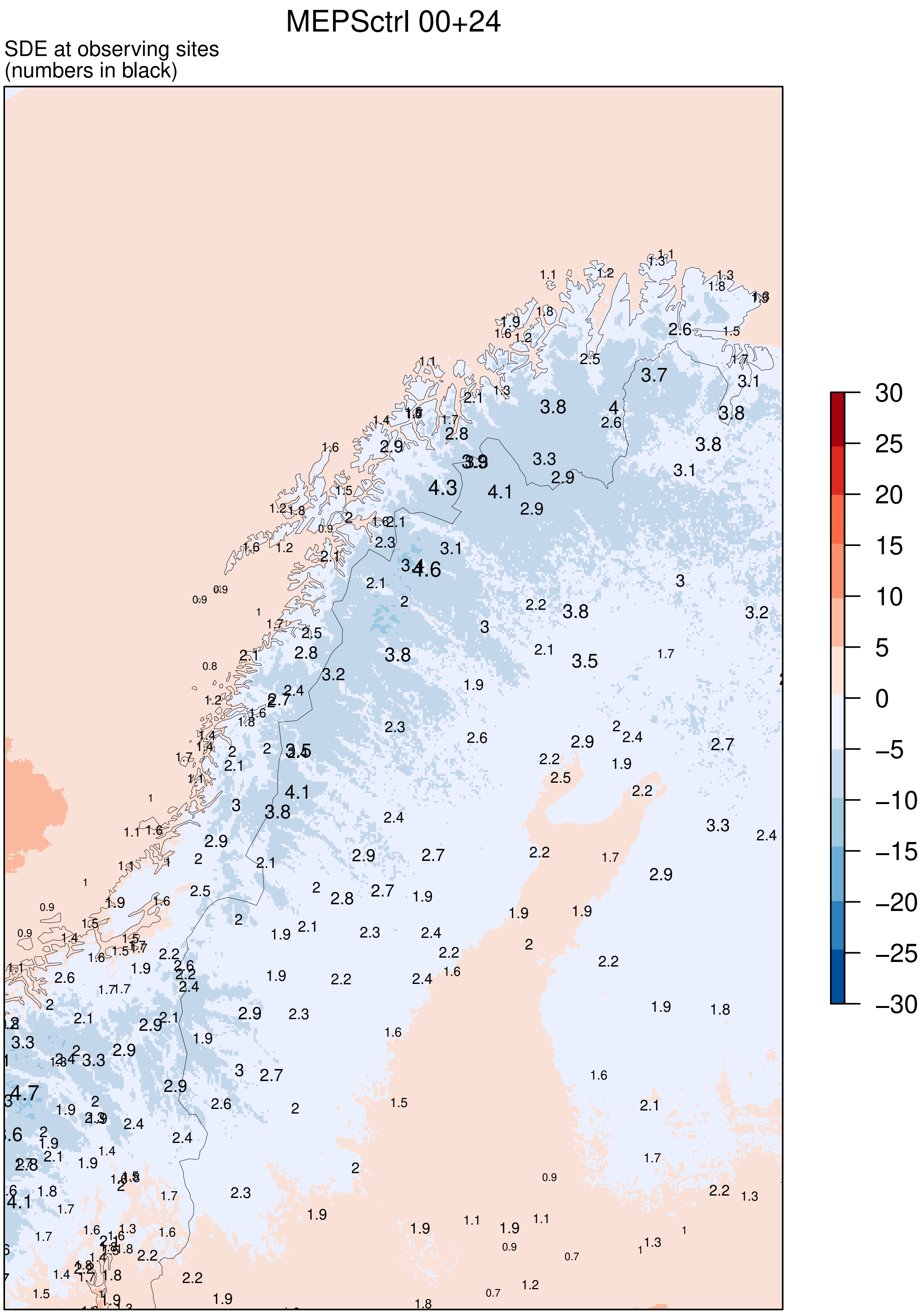
Model "climatology" 01.03.2023 – 31.05.2023

MEPSctrl 00+12

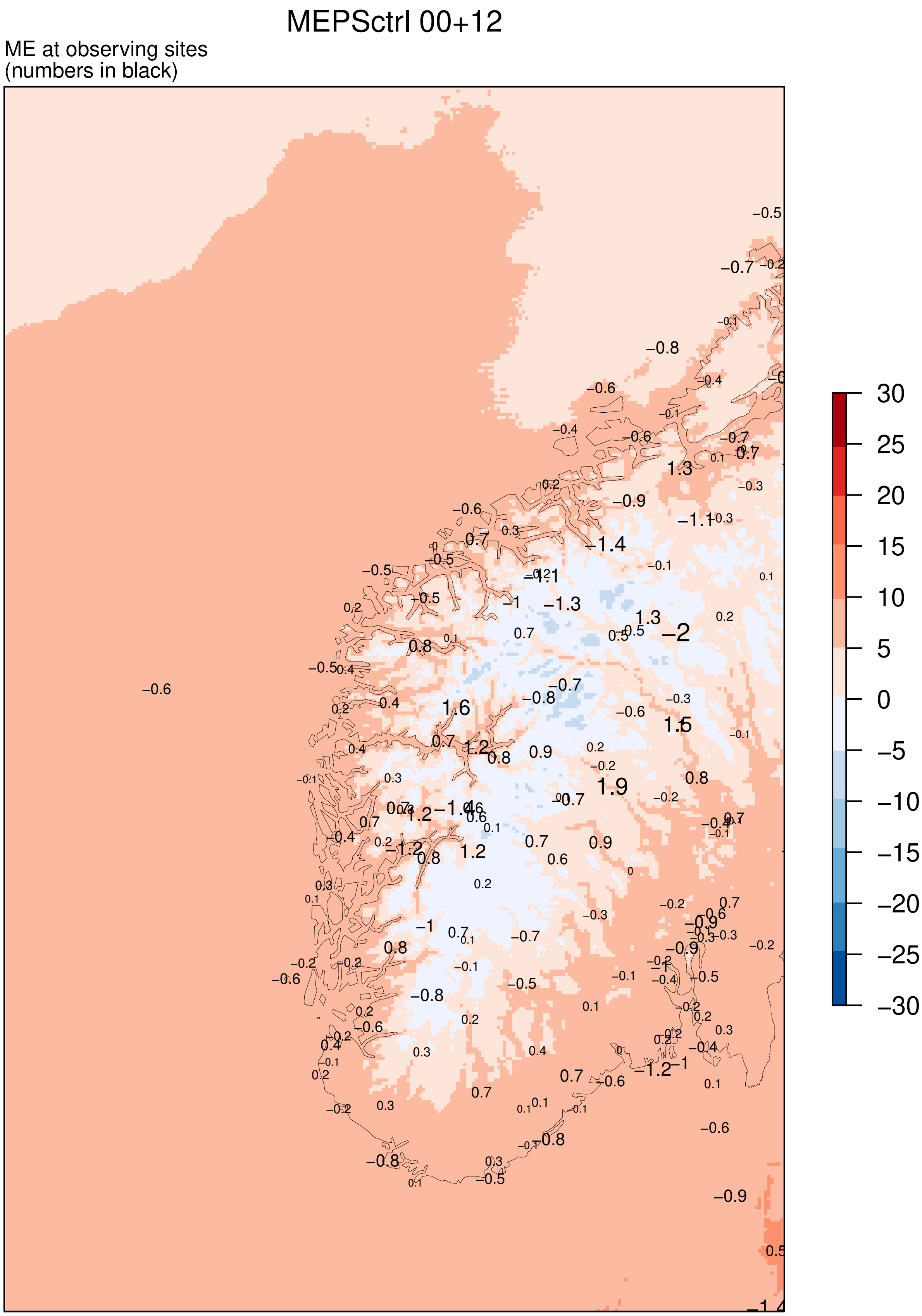
SDE at observing sites
(numbers in black)



Model "climatology" 01.03.2023 – 31.05.2023



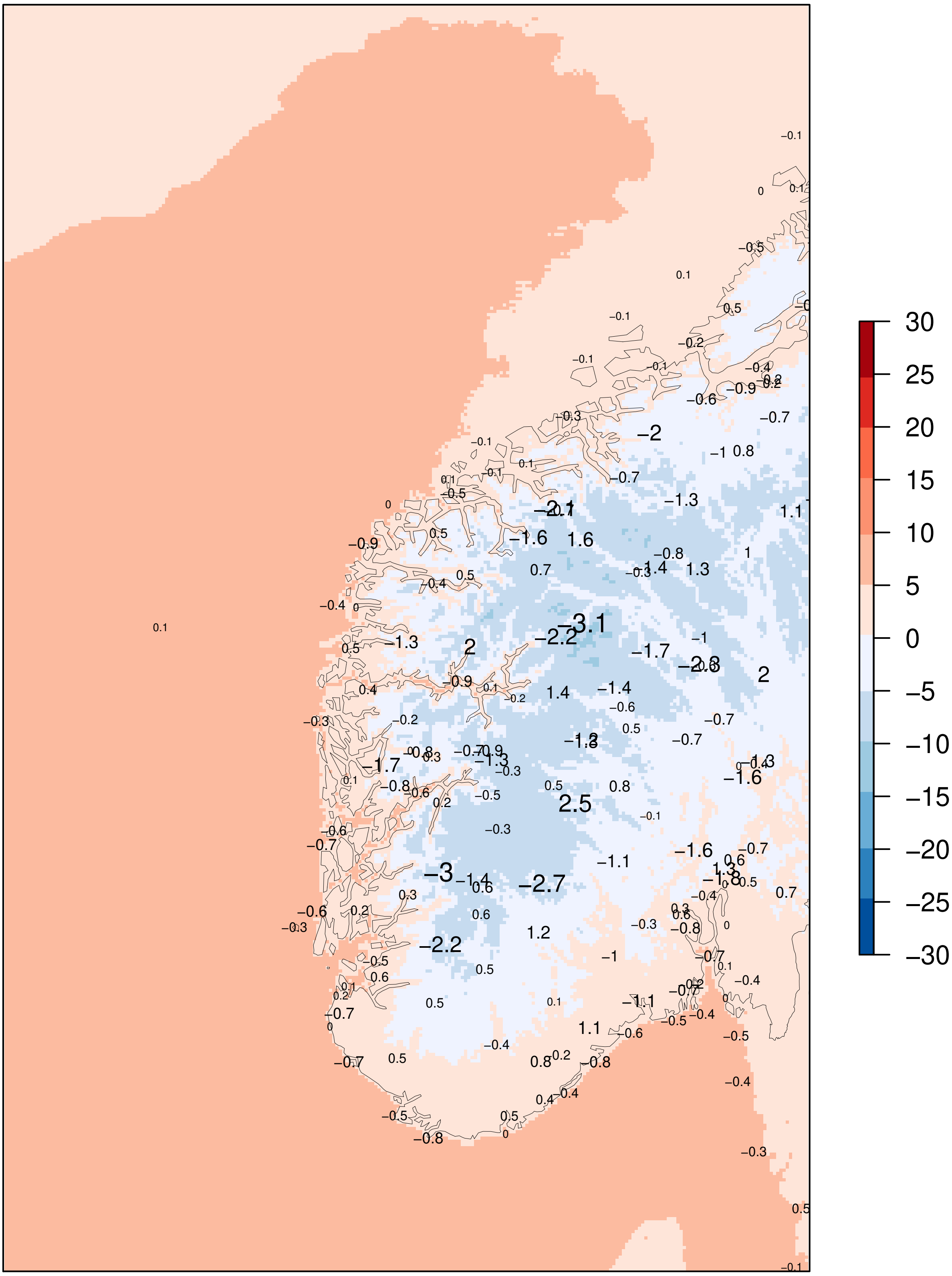
Model "climatology" 01.03.2023 – 31.05.2023



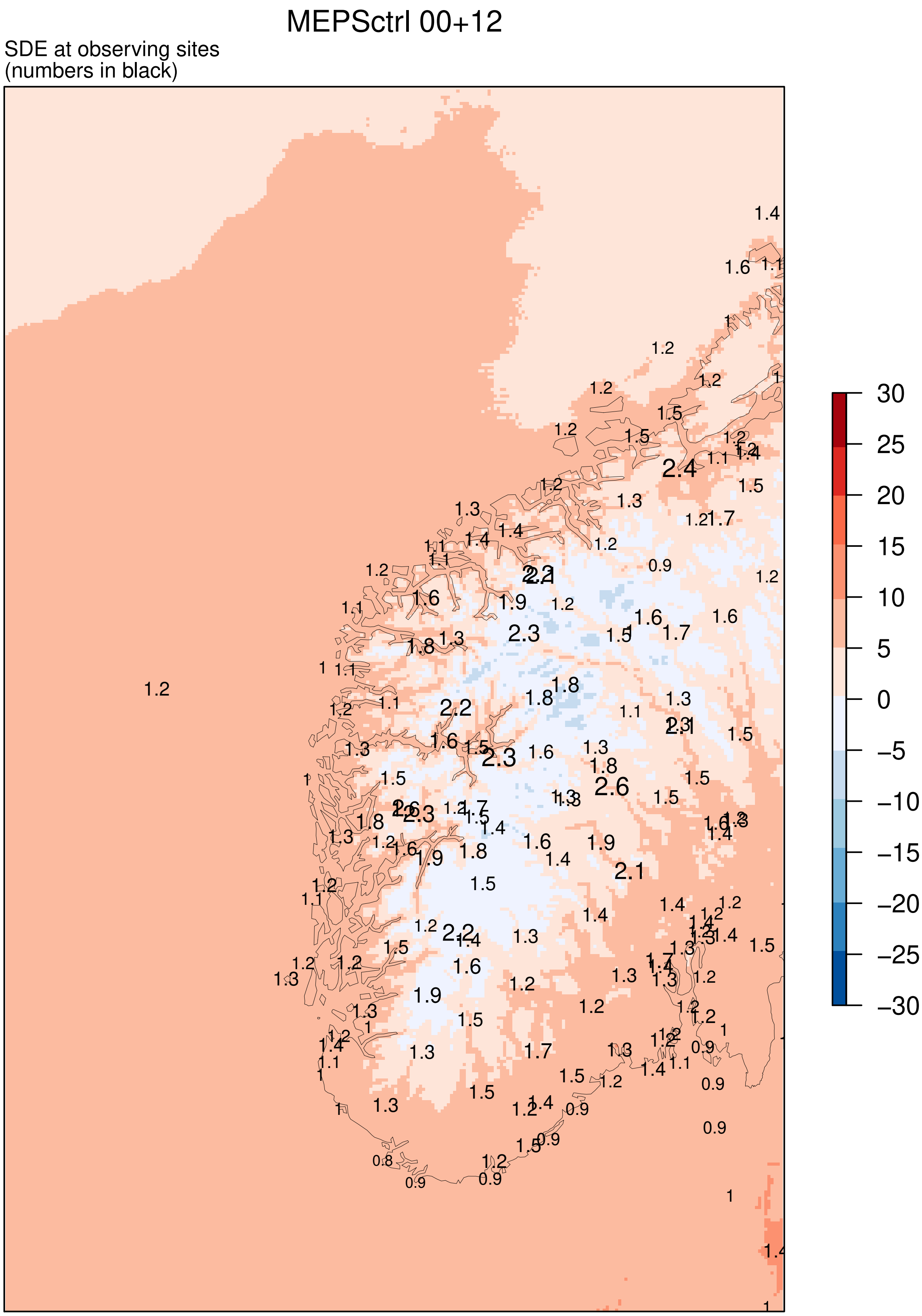
Model "climatology" 01.03.2023 – 31.05.2023

MEPSctrl 00+24

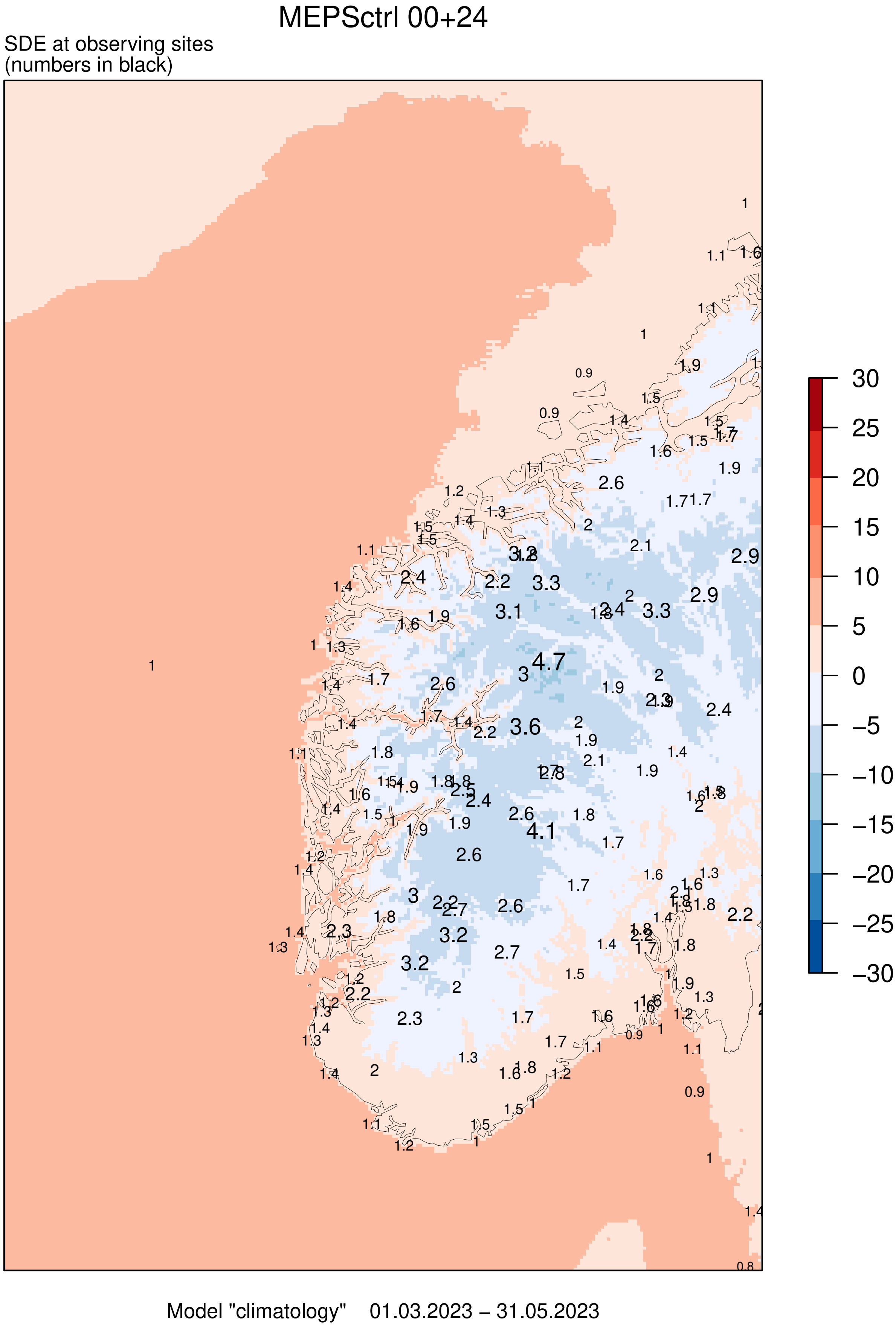
ME at observing sites
(numbers in black)



Model "climatology" 01.03.2023 – 31.05.2023

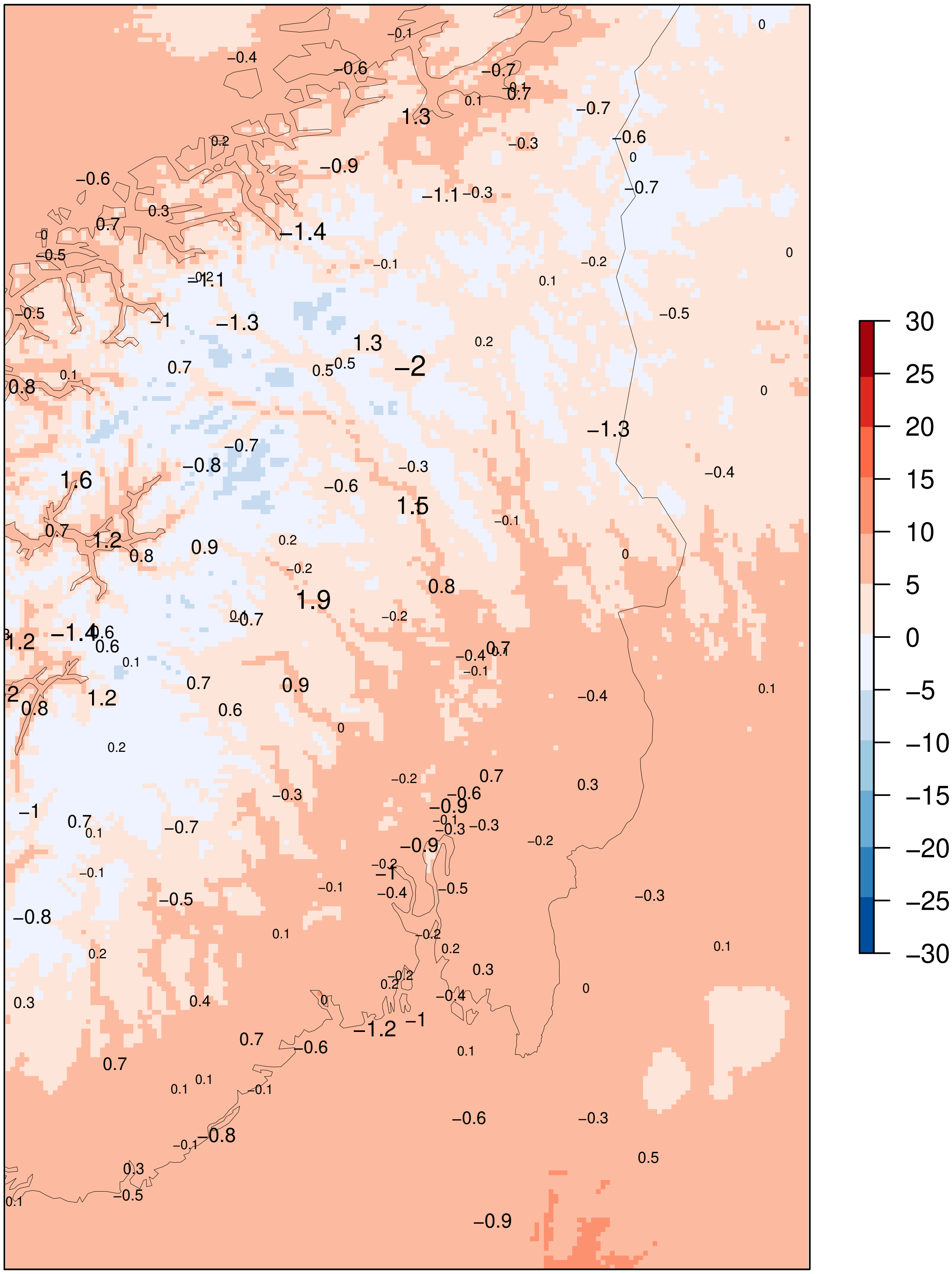


Model "climatology"   01.03.2023 – 31.05.2023


MEPSctrl 00+24
SDE at observing sites
(numbers in black)
30
25
20
15
10
5
0
−5
−10
−15
−20
−25
−30
Model "climatology" 01.03.2023 – 31.05.2023

MEPSctrl 00+12

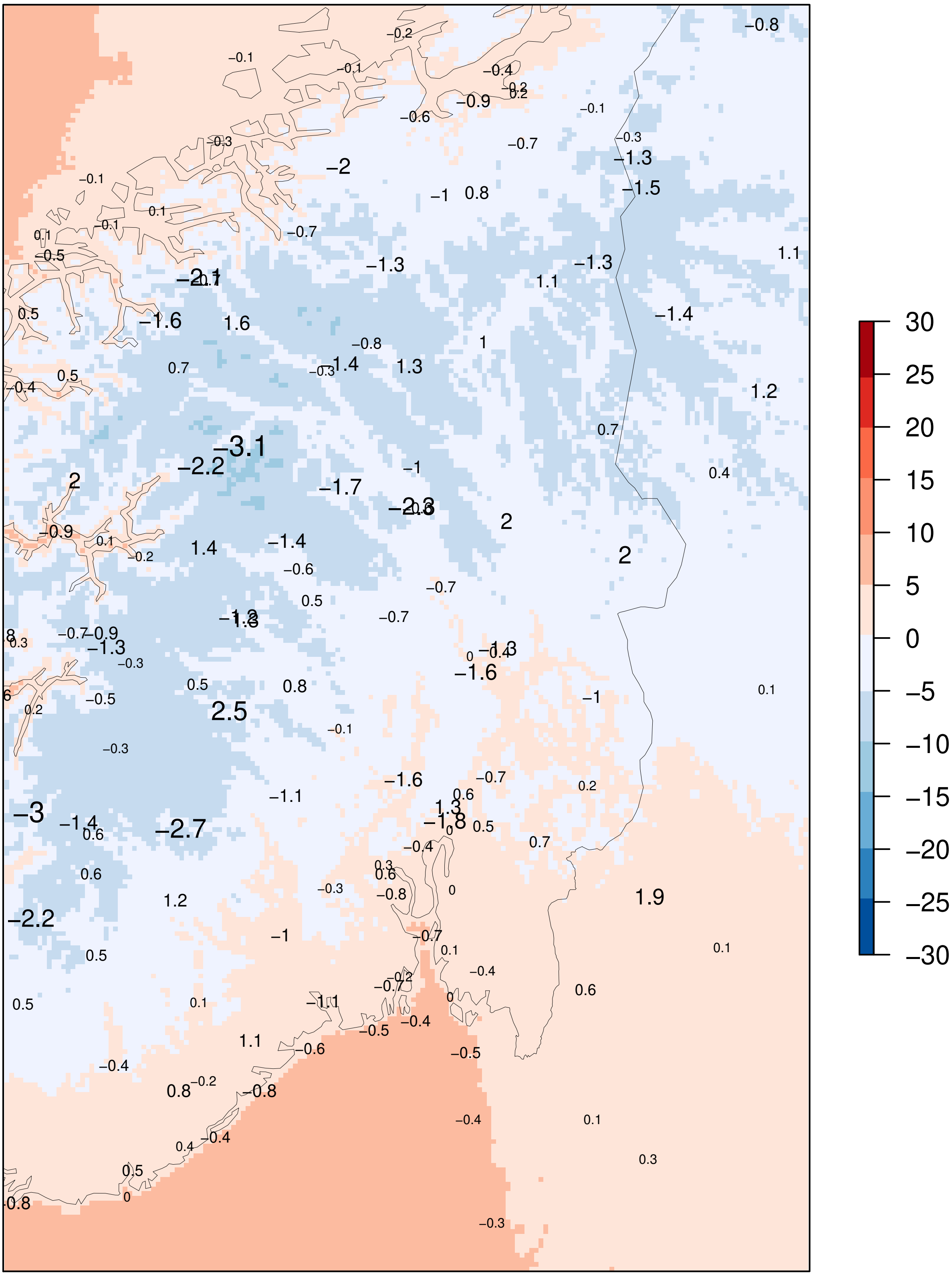
ME at observing sites
(numbers in black)



Model "climatology" 01.03.2023 – 31.05.2023

MEPSctrl 00+24

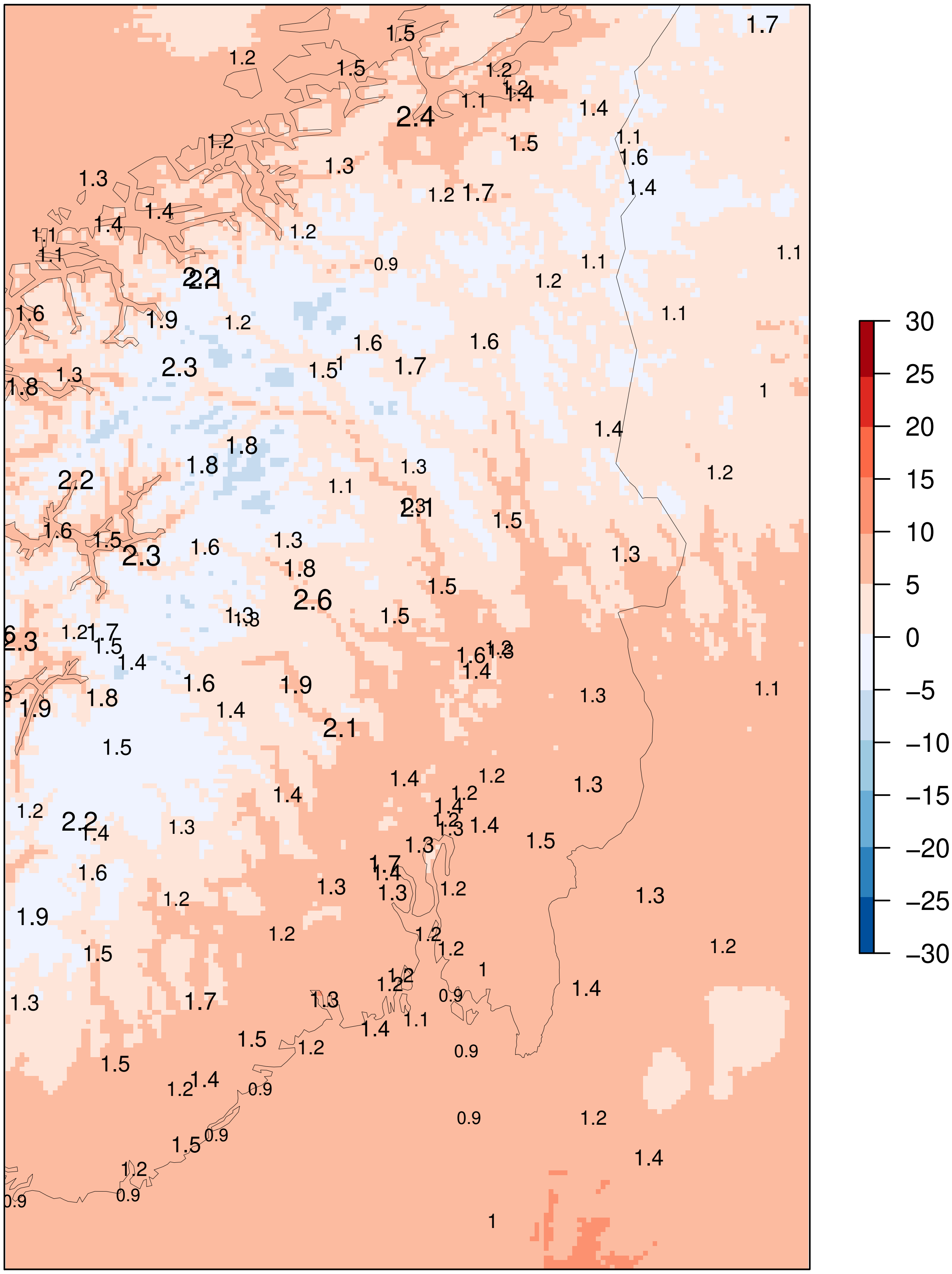
ME at observing sites
(numbers in black)



Model "climatology" 01.03.2023 – 31.05.2023

MEPSctrl 00+12

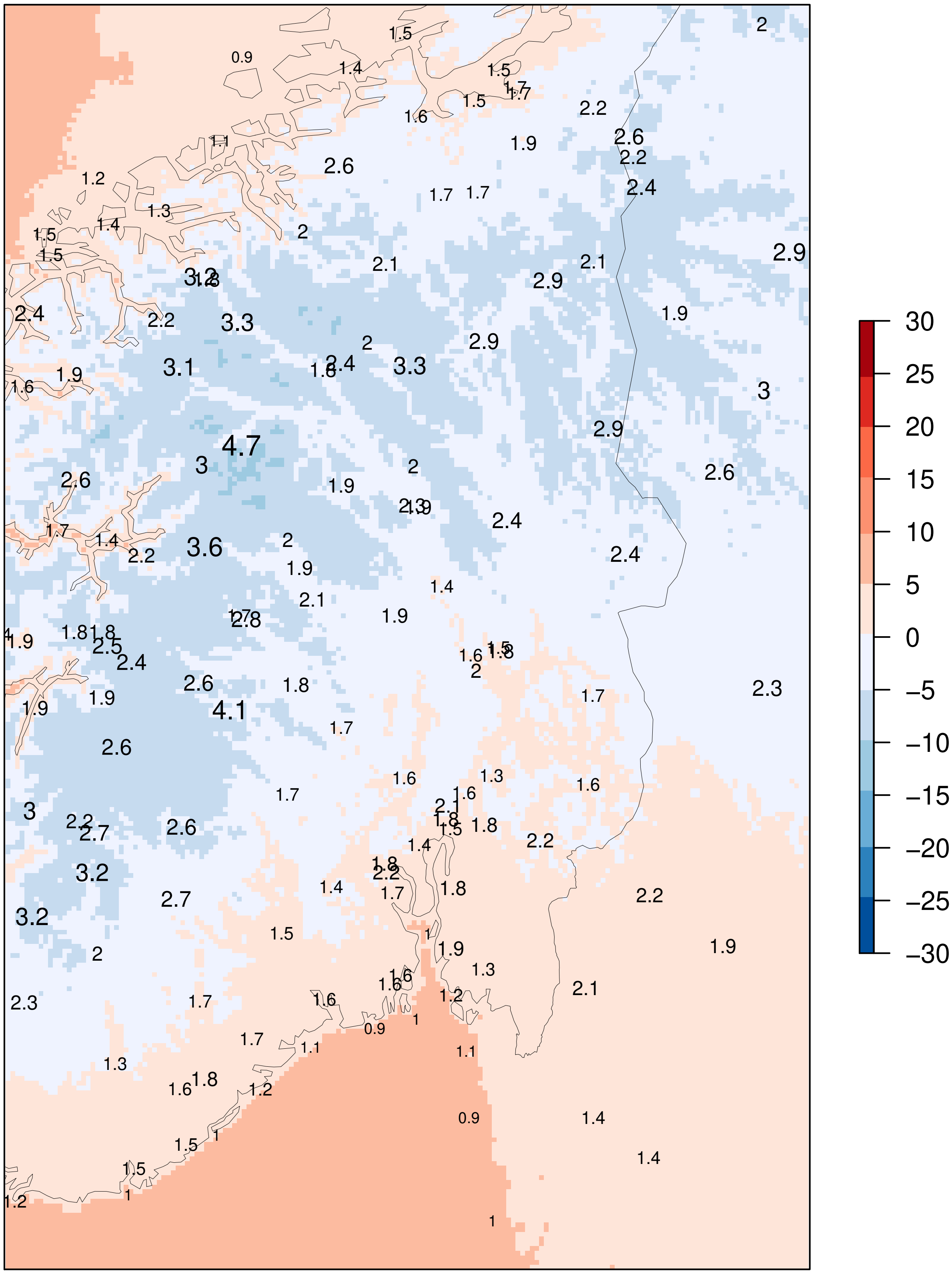
SDE at observing sites
(numbers in black)



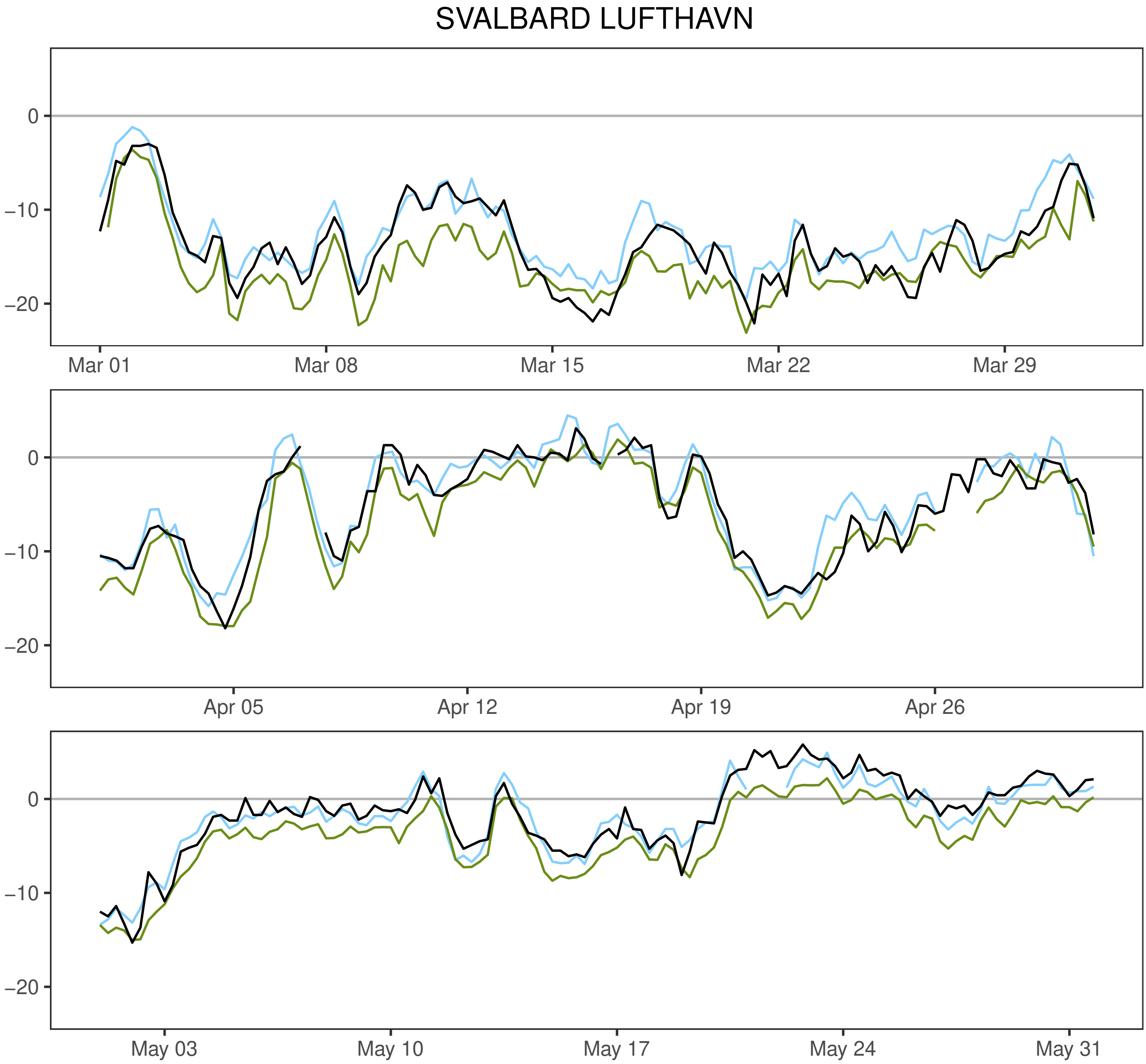
Model "climatology" 01.03.2023 – 31.05.2023

MEPSctrl 00+24

SDE at observing sites
(numbers in black)

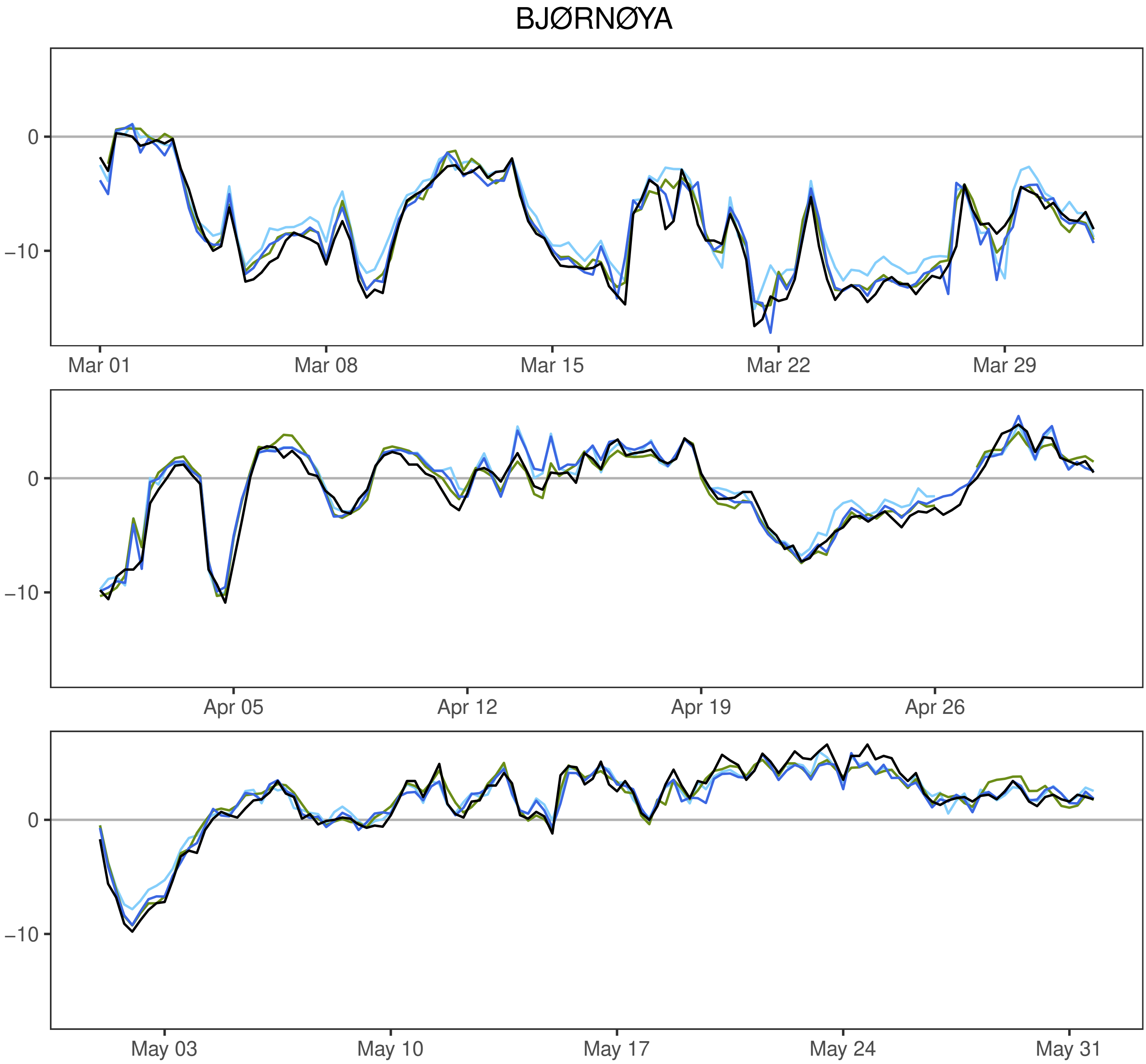


Model "climatology" 01.03.2023 – 31.05.2023



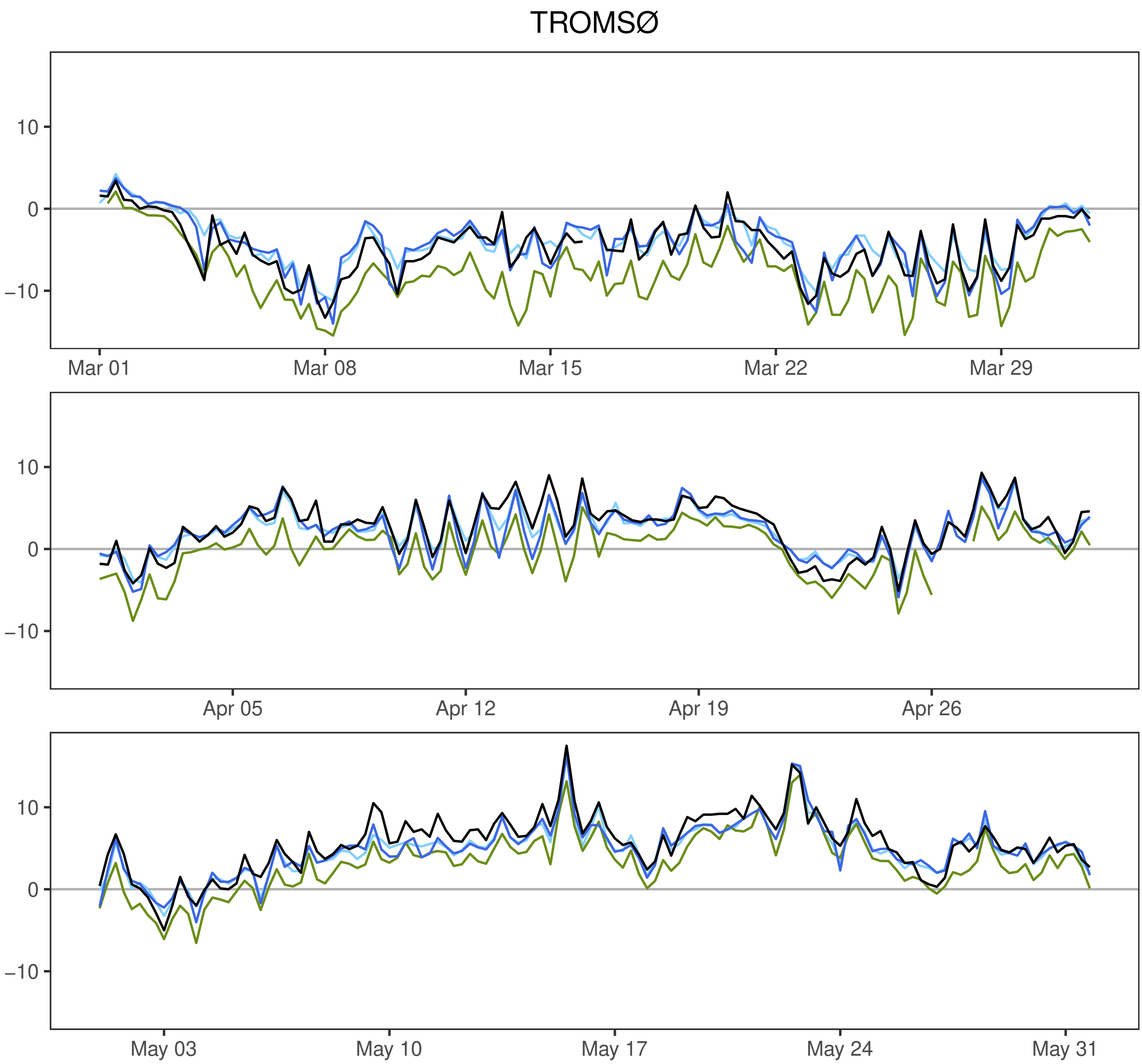
	Min	Mean	Max	Std	N
synop: 00,06,12,18	−22.1	−6.9	5.8	6.9	365
AA25: 12+18,+24,+30,+36	−19.5	−6.5	4.9	6.3	360
ECMWF: 12+18,+24,+30,+36	−23.1	−8.9	2.2	6.8	363

	ME	SDE	RMSE	MAE	Max.abs.err.	N
AA25−synop	0.5	1.8	1.8	1.4	6.8	356
ECMWF−synop	−2.0	1.7	2.6	2.2	8.1	356



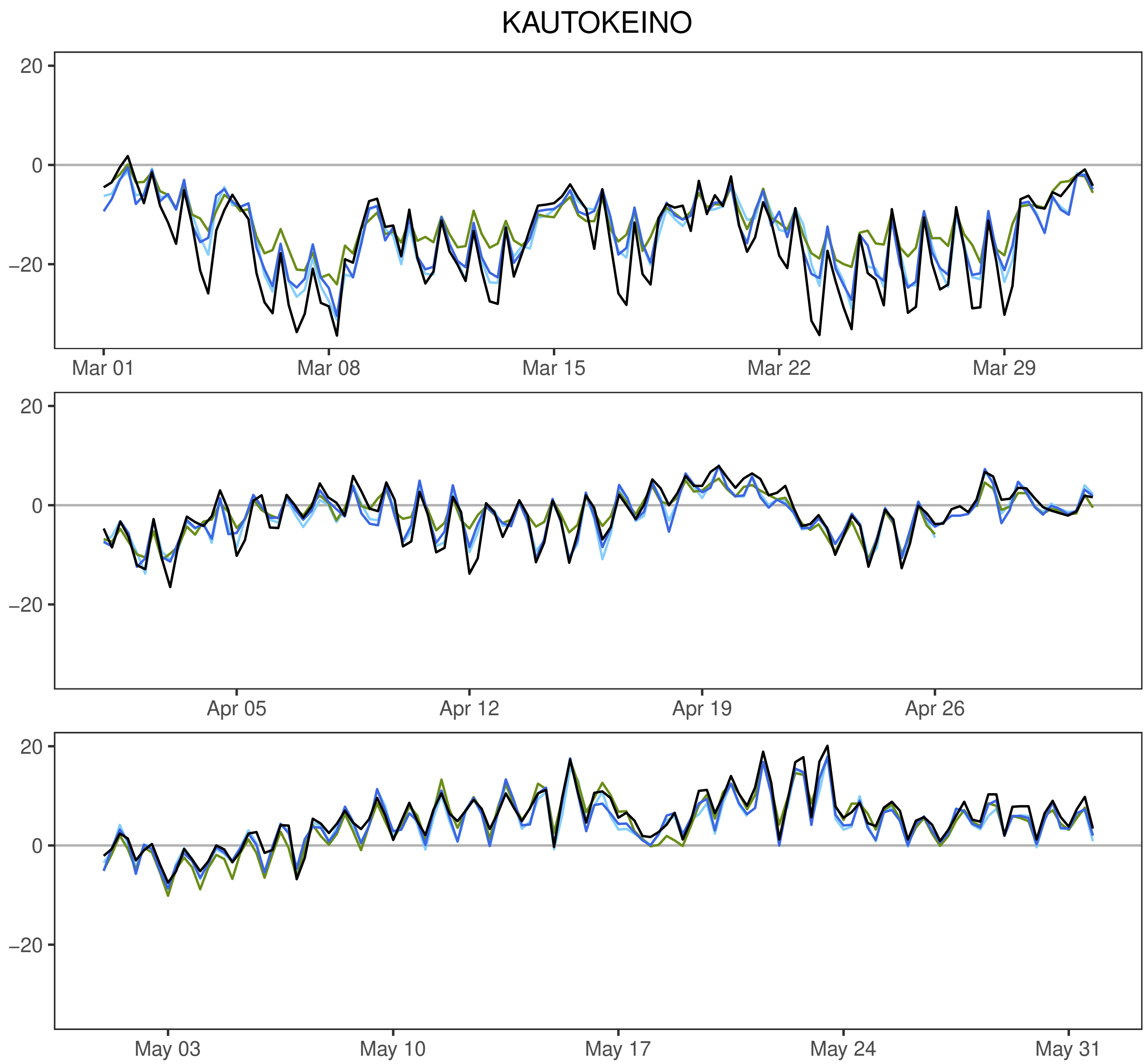
	Min	Mean	Max	Std	N
synop: 00,06,12,18	−16.6	−2.6	6.6	5.6	368
MEPSctrl: 12+18,+24,+30,+36	−17.2	−2.4	5.8	5.4	368
AA25: 12+18,+24,+30,+36	−15.1	−2.1	6.0	5.0	360
ECMWF: 12+18,+24,+30,+36	−14.9	−2.4	5.3	5.4	363

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl−synop	0.2	1.0	1.0	0.7	5.6	359
AA25−synop	0.6	1.1	1.3	1.0	5.4	359
ECMWF−synop	0.2	0.9	0.9	0.7	4.5	359



	Min	Mean	Max	Std	N
synop: 00,06,12,18	−13.3	1.2	17.5	5.5	367
MEPSctrl: 12+18,+24,+30,+36	−14.0	1.0	16.4	5.0	368
AA25: 12+18,+24,+30,+36	−11.2	1.0	16.3	4.7	360
ECMWF: 12+18,+24,+30,+36	−15.5	−1.6	13.9	5.9	363

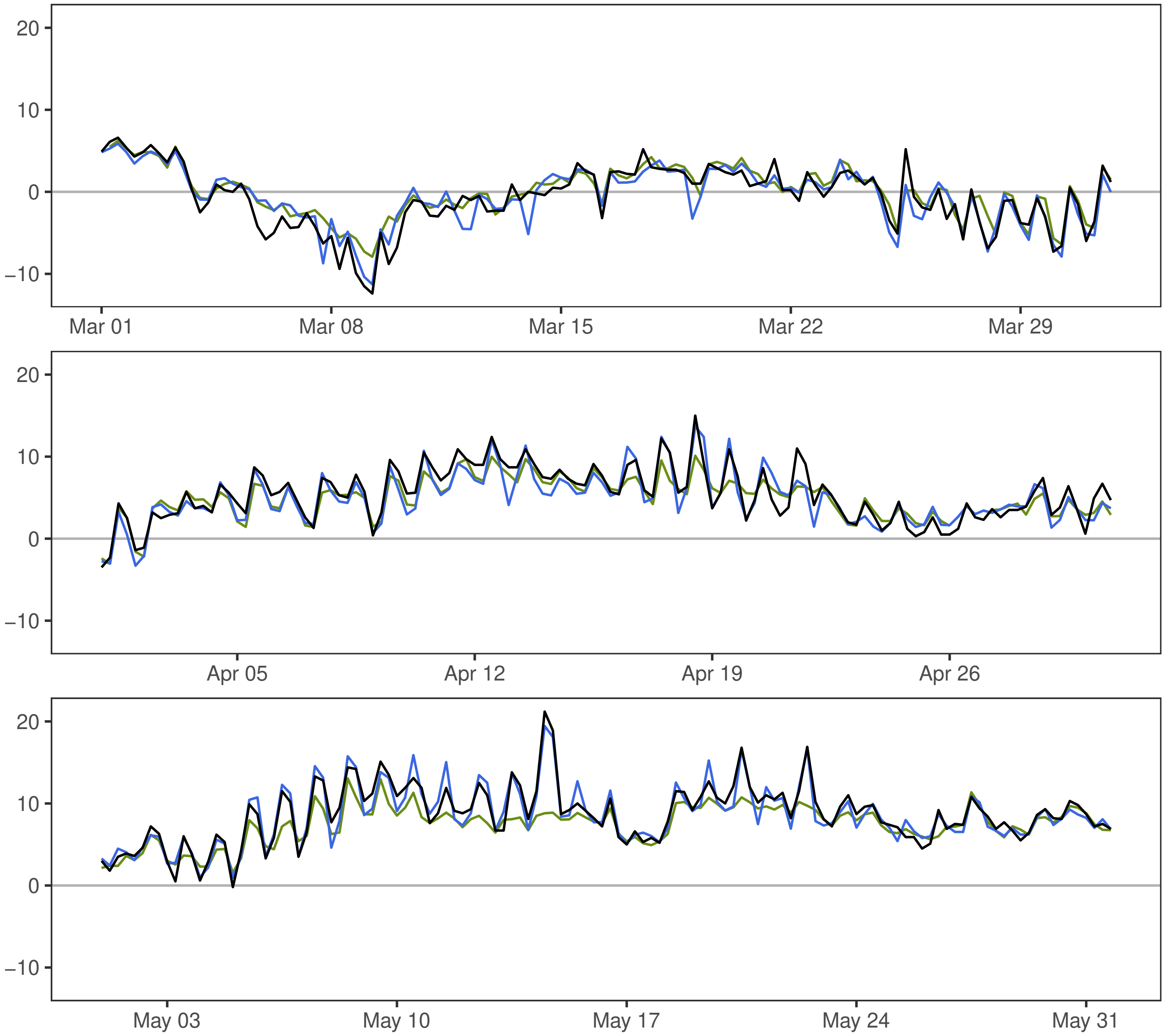
	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl−synop	−0.2	1.5	1.5	1.2	6.0	358
AA25−synop	−0.1	1.4	1.4	1.1	5.5	358
ECMWF−synop	−2.8	1.5	3.2	2.8	8.9	358



	Min	Mean	Max	Std	N
synop: 00,06,12,18	−34.4	−4.0	20.1	11.0	368
MEPSctrl: 12+18,+24,+30,+36	−30.4	−3.8	17.8	9.3	368
AA25: 12+18,+24,+30,+36	−31.2	−4.2	18.1	9.4	360
ECMWF: 12+18,+24,+30,+36	−24.1	−3.1	17.8	8.4	363

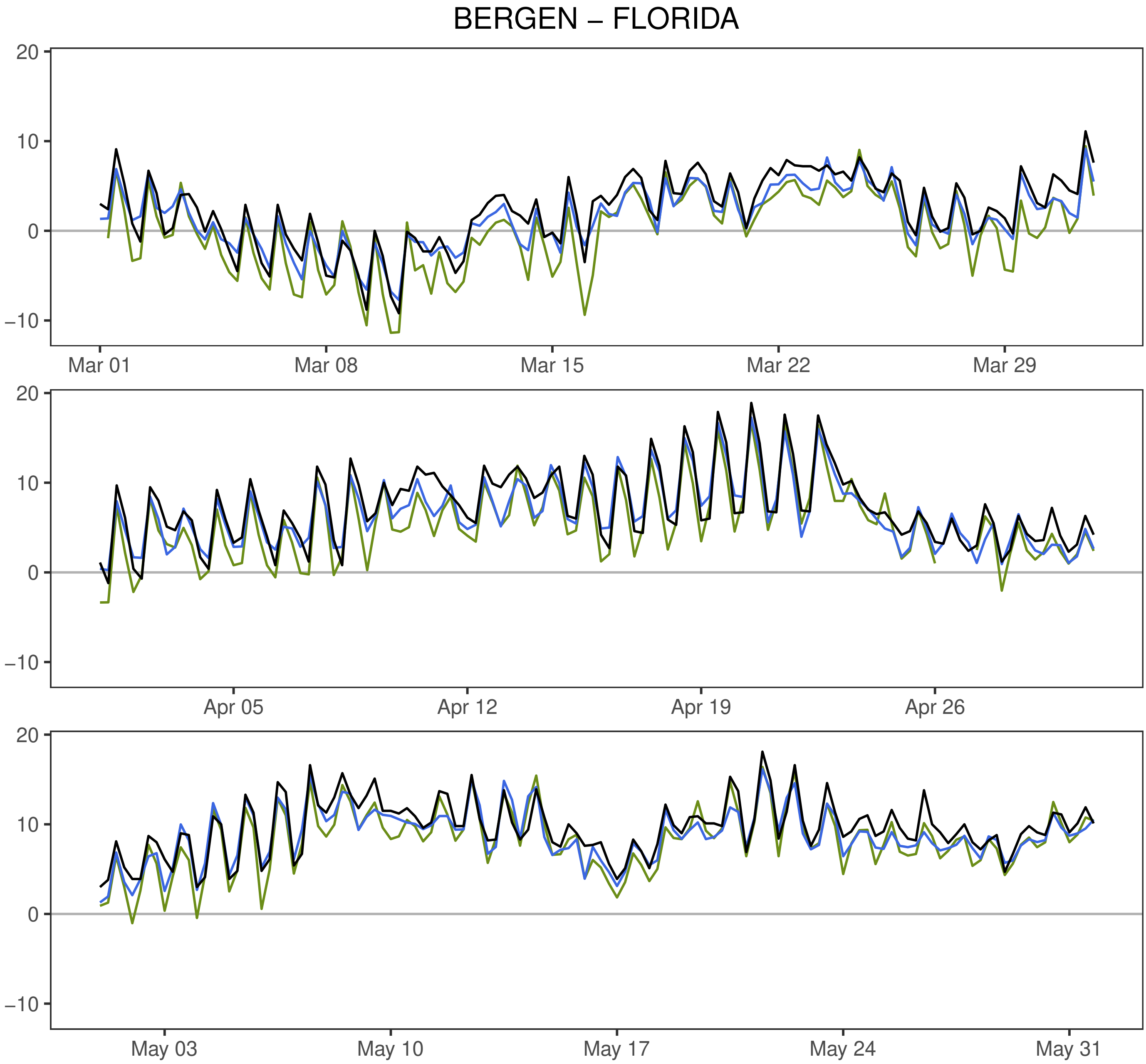
	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl−synop	0.3	2.9	2.9	2.1	11.5	359
AA25−synop	0.1	2.7	2.7	2.0	11.4	359
ECMWF−synop	1.0	3.9	4.0	2.7	15.4	359

ØRLAND III



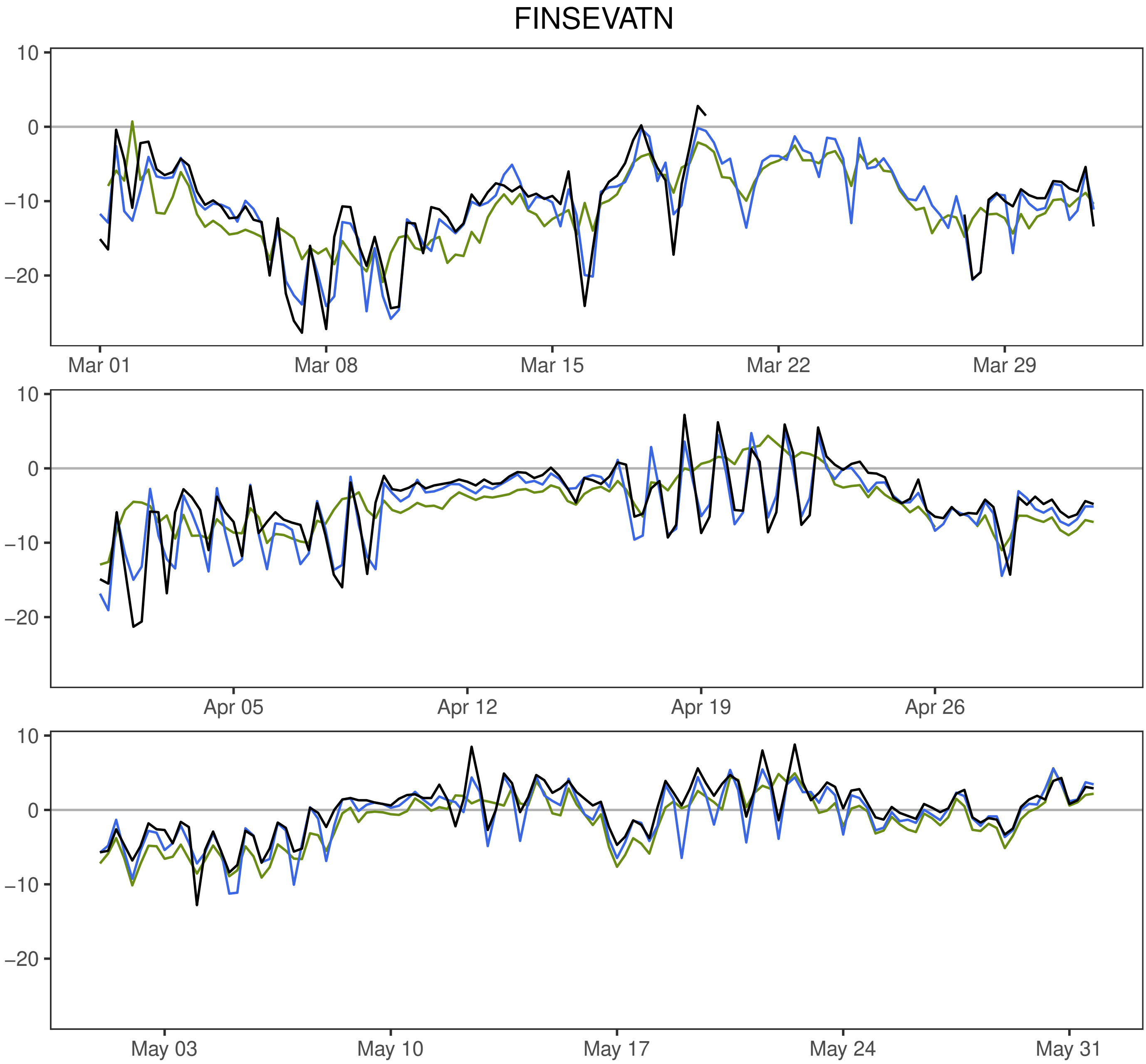
	Min	Mean	Max	Std	N
synop: 00,06,12,18	−12.4	4.4	21.2	5.3	368
MEPSctrl: 12+18,+24,+30,+36	−11.3	4.3	19.4	5.1	368
ECMWF: 12+18,+24,+30,+36	−7.9	4.1	13.1	4.1	363

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl−synop	−0.2	1.4	1.4	1.1	5.2	363
ECMWF−synop	−0.3	1.8	1.9	1.3	12.4	363



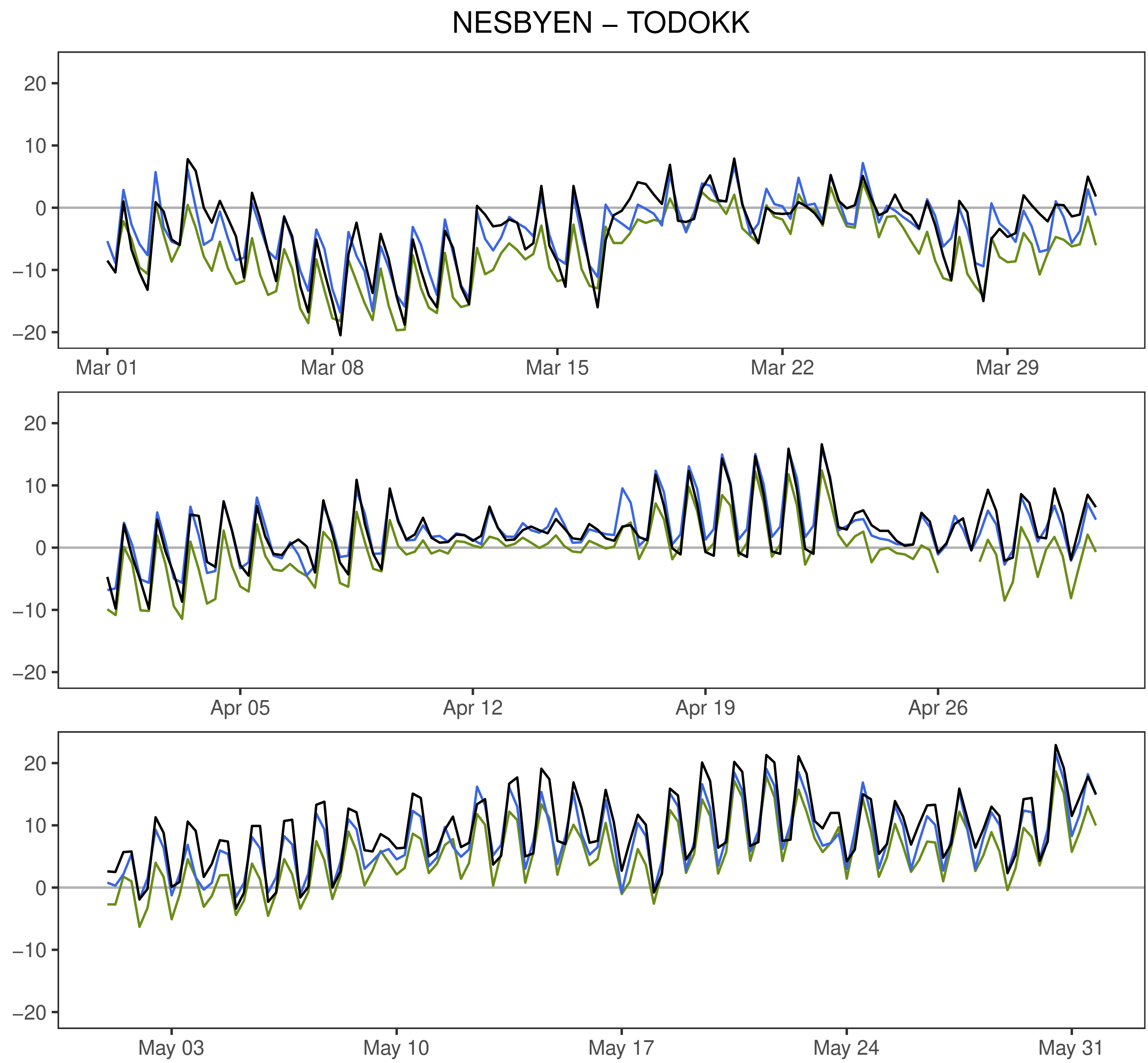
	Min	Mean	Max	Std	N
synop: 00,06,12,18	–9.2	6.4	18.9	4.9	368
MEPSctrl: 12+18,+24,+30,+36	–7.7	5.6	17.3	4.6	368
ECMWF: 12+18,+24,+30,+36	–11.4	4.6	16.8	5.3	363

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl–synop	–0.8	1.3	1.6	1.3	4.8	363
ECMWF–synop	–1.9	1.5	2.4	2.0	8.3	363



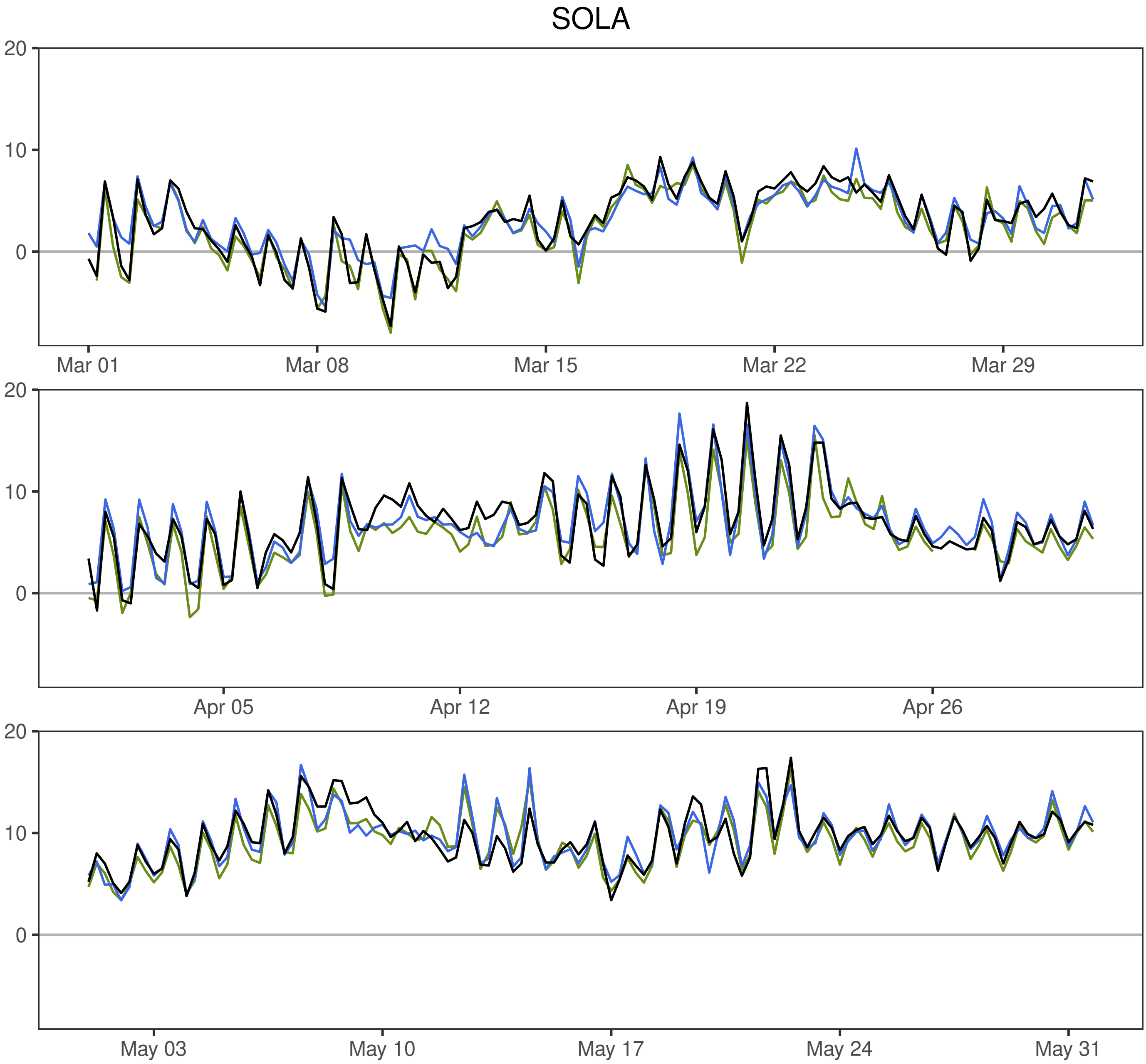
	Min	Mean	Max	Std	N
synop: 00,06,12,18	−27.7	−4.7	8.8	6.6	337
MEPSctrl: 12+18,+24,+30,+36	−25.8	−5.5	5.6	6.2	368
ECMWF: 12+18,+24,+30,+36	−20.9	−5.6	5.6	5.5	363

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl−synop	−0.8	2.1	2.2	1.6	9.0	332
ECMWF−synop	−0.8	3.8	3.9	2.9	16.8	332



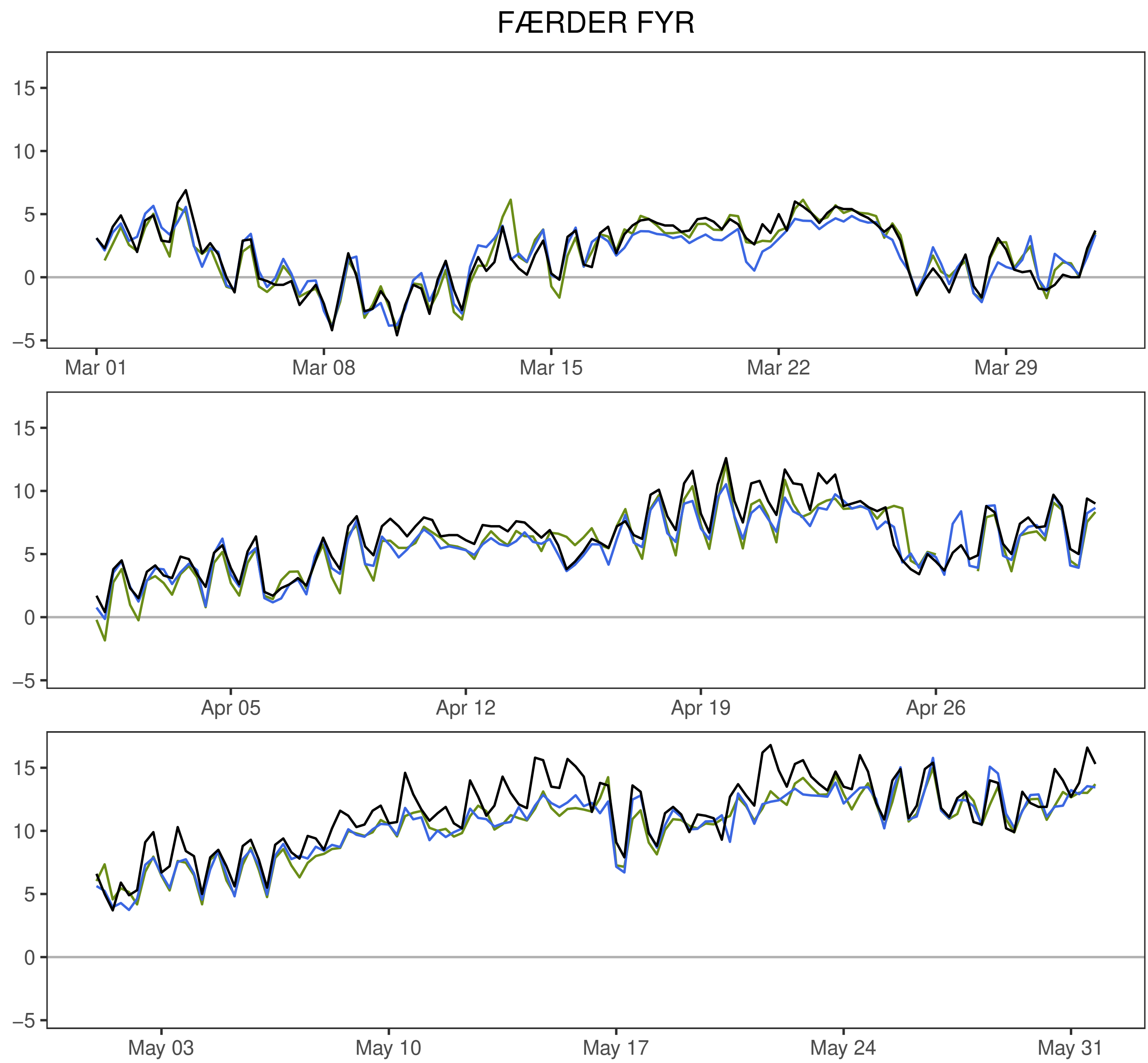
	Min	Mean	Max	Std	N
synop: 00,06,12,18	–20.5	2.8	22.9	7.7	368
MEPSctrl: 12+18,+24,+30,+36	–16.9	2.4	21.5	6.8	368
ECMWF: 12+18,+24,+30,+36	–19.7	–0.7	18.7	7.3	363

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl–synop	–0.4	2.4	2.4	1.9	7.5	363
ECMWF–synop	–3.5	2.5	4.3	3.7	9.9	363



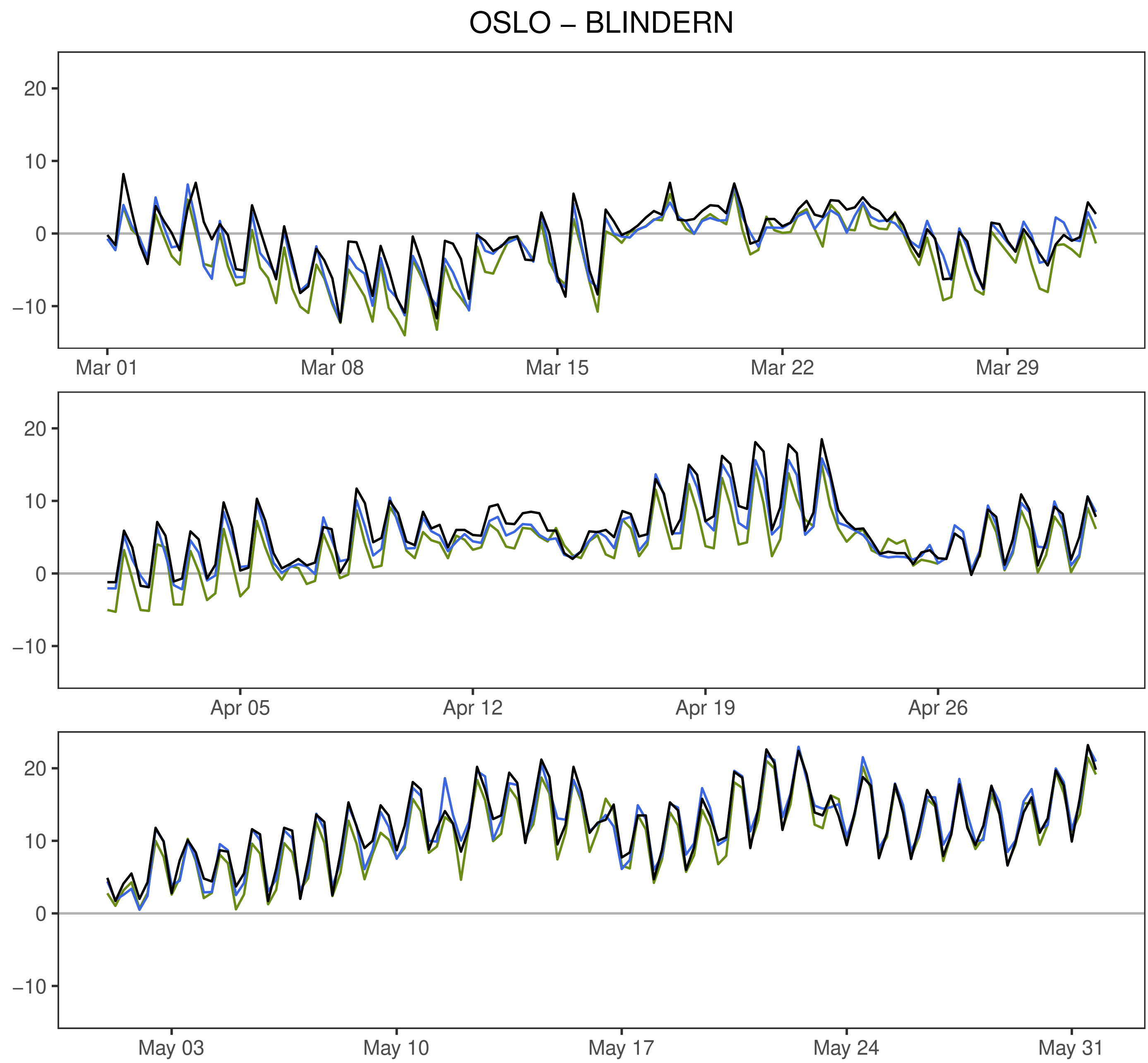
	Min	Mean	Max	Std	N
synop: 00,06,12,18	−7.3	6.4	18.7	4.3	368
MEPSctrl: 12+18,+24,+30,+36	−5.4	6.5	17.7	4.1	368
ECMWF: 12+18,+24,+30,+36	−8.0	5.7	16.3	4.2	363

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl−synop	0.0	1.4	1.4	1.0	4.6	363
ECMWF−synop	−0.7	1.2	1.4	1.1	5.4	363



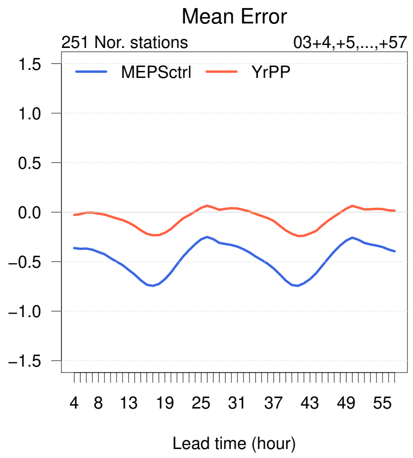
	Min	Mean	Max	Std	N
synop: 00,06,12,18	−4.6	6.6	16.8	4.8	368
MEPSctrl: 12+18,+24,+30,+36	−4.0	6.0	15.8	4.3	368
ECMWF: 12+18,+24,+30,+36	−4.0	6.0	15.0	4.4	363

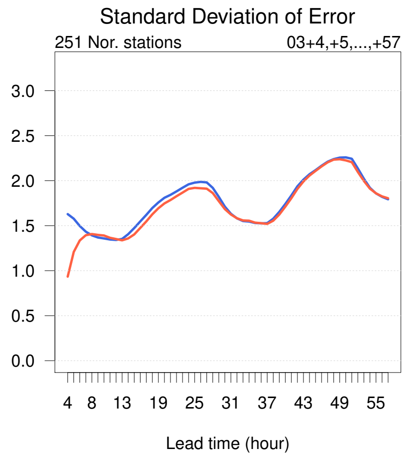
	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl−synop	−0.6	1.1	1.2	1.0	4.5	363
ECMWF−synop	−0.6	1.1	1.3	1.0	4.6	363

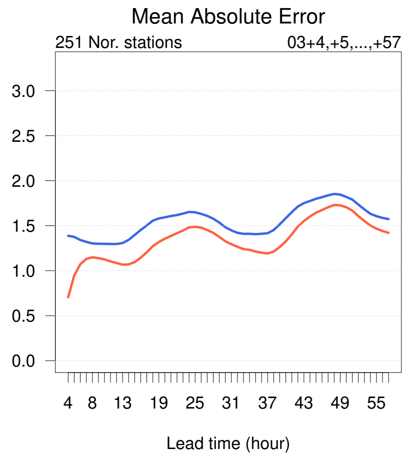


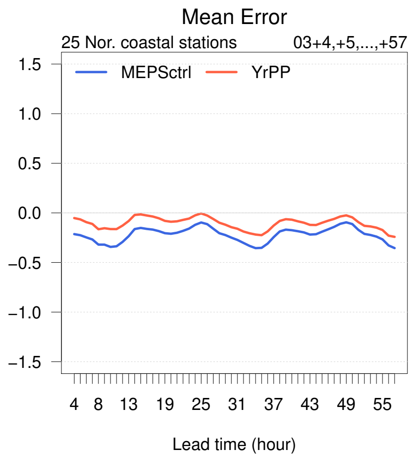
	Min	Mean	Max	Std	N
synop: 00,06,12,18	–12.2	5.9	23.2	6.9	368
MEPSctrl: 12+18,+24,+30,+36	–12.2	5.3	23.0	7.1	368
ECMWF: 12+18,+24,+30,+36	–14.0	4.0	22.9	7.3	363

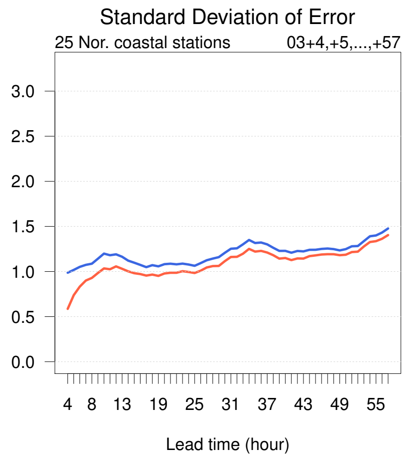
	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl–synop	–0.6	1.4	1.5	1.2	6.1	363
ECMWF–synop	–1.9	1.6	2.5	2.0	7.2	363

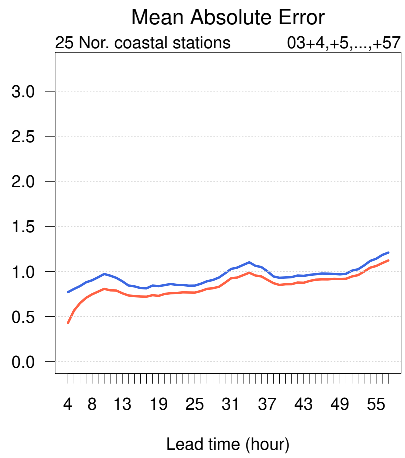

Mean Error
251 Nor. stations
03+4,+5,...,+57
MEPSctrl
YrPP
1.5
1.0
0.5
0.0
−0.5
−1.0
−1.5
4 8 13 19 25 31 37 43 49 55
Lead time (hour)

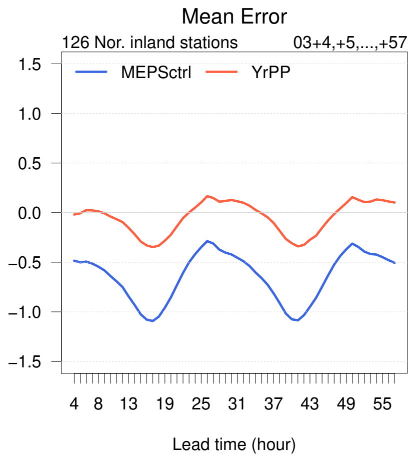

Standard Deviation of Error
251 Nor. stations
03+4,+5,...,+57
3.0
2.5
2.0
1.5
1.0
0.5
0.0
4 8 13 19 25 31 37 43 49 55
Lead time (hour)

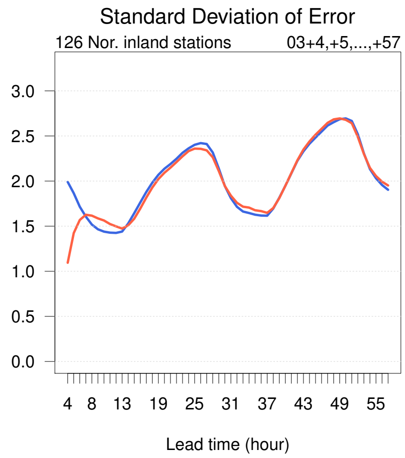

Mean Absolute Error
251 Nor. stations
03+4,+5,...,+57
3.0
2.5
2.0
1.5
1.0
0.5
0.0
4 8 13 19 25 31 37 43 49 55
Lead time (hour)

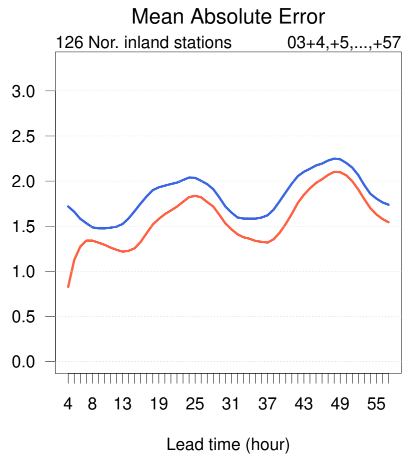

Mean Error
25 Nor. coastal stations
03+4,+5,...,+57
MEPSctrl
YrPP
1.5
1.0
0.5
0.0
−0.5
−1.0
−1.5
4 8 13 19 25 31 37 43 49 55
Lead time (hour)

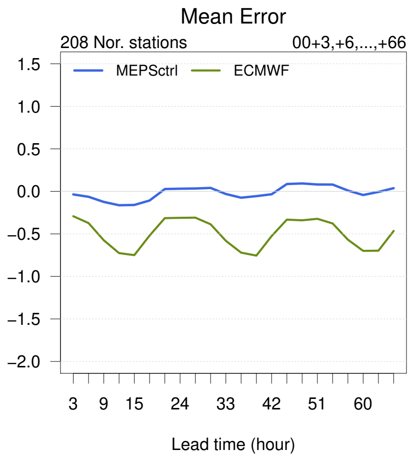

Standard Deviation of Error
25 Nor. coastal stations
03+4,+5,...,+57
3.0
2.5
2.0
1.5
1.0
0.5
0.0
4 8 13 19 25 31 37 43 49 55
Lead time (hour)

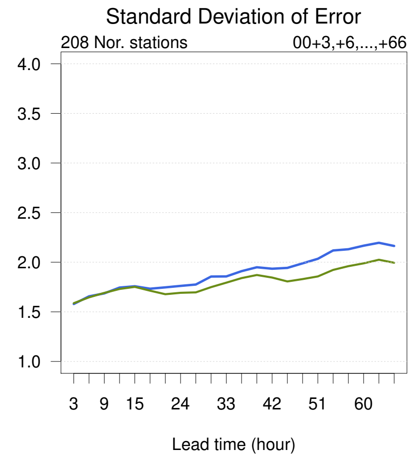

Mean Absolute Error
25 Nor. coastal stations
03+4,+5,...,+57
3.0
2.5
2.0
1.5
1.0
0.5
0.0
4 8 13 19 25 31 37 43 49 55
Lead time (hour)

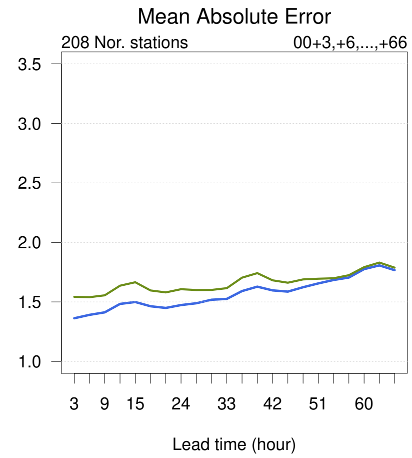

Mean Error
126 Nor. inland stations
03+4,+5,...,+57
MEPSctrl
YrPP
1.5
1.0
0.5
0.0
−0.5
−1.0
−1.5
4 8 13 19 25 31 37 43 49 55
Lead time (hour)

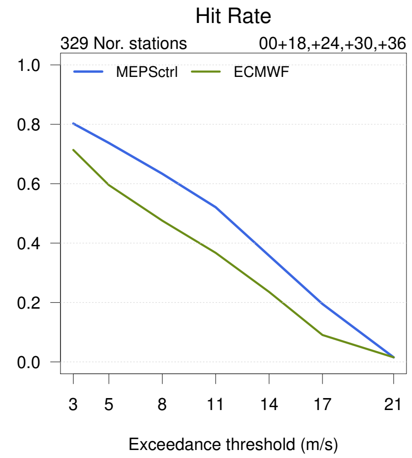

Standard Deviation of Error
126 Nor. inland stations
03+4,+5,...,+57
3.0
2.5
2.0
1.5
1.0
0.5
0.0
4 8 13 19 25 31 37 43 49 55
Lead time (hour)

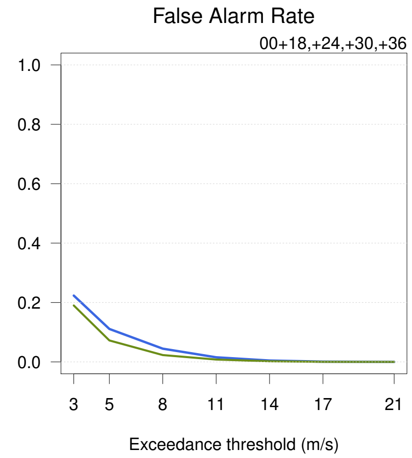

Mean Absolute Error
126 Nor. inland stations
03+4,+5,...,+57
3.0
2.5
2.0
1.5
1.0
0.5
0.0
4 8 13 19 25 31 37 43 49 55
Lead time (hour)

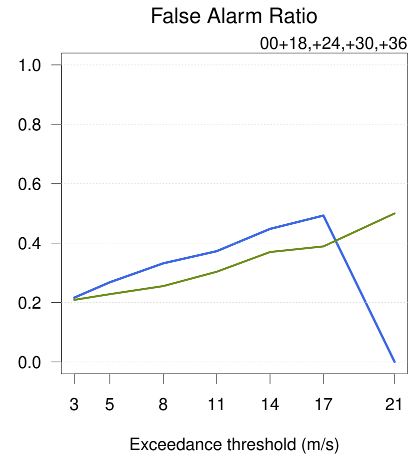

Mean Error
208 Nor. stations
00+3,+6,...,+66
MEPSctrl
ECMWF
1.5
1.0
0.5
0.0
−0.5
−1.0
−1.5
−2.0
3 9 15 24 33 42 51 60
Lead time (hour)

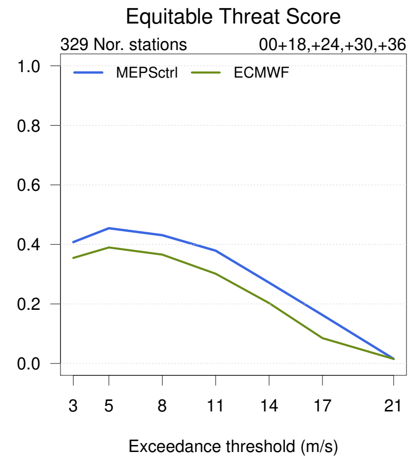

Standard Deviation of Error
208 Nor. stations
00+3,+6,...,+66
4.0
3.5
3.0
2.5
2.0
1.5
1.0
3 9 15 24 33 42 51 60
Lead time (hour)

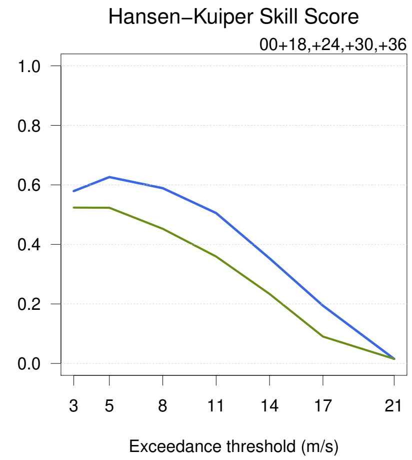

Mean Absolute Error
208 Nor. stations
00+3,+6,...,+66
3.5
3.0
2.5
2.0
1.5
1.0
3 9 15 24 33 42 51 60
Lead time (hour)

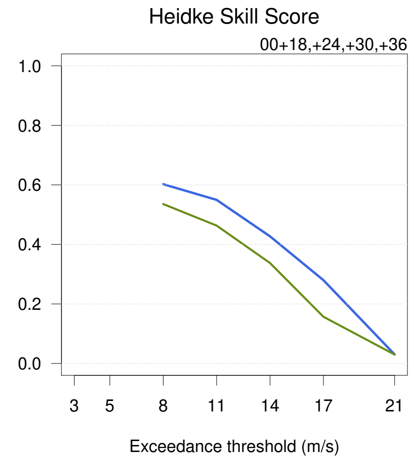

Hit Rate
329 Nor. stations
00+18,+24,+30,+36
MEPSctrl
ECMWF
1.0
0.8
0.6
0.4
0.2
0.0
3 5 8 11 14 17 21
Exceedance threshold (m/s)

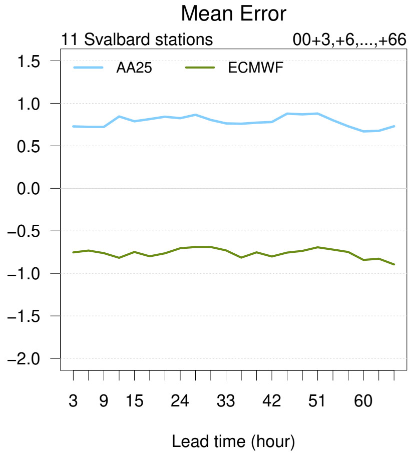

False Alarm Rate
00+18,+24,+30,+36
1.0
0.8
0.6
0.4
0.2
0.0
3 5 8 11 14 17 21
Exceedance threshold (m/s)

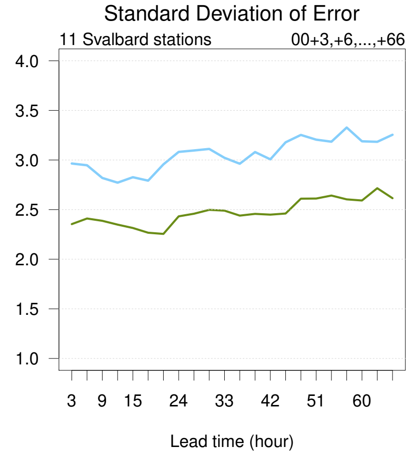

False Alarm Ratio
00+18,+24,+30,+36
1.0
0.8
0.6
0.4
0.2
0.0
3 5 8 11 14 17 21
Exceedance threshold (m/s)

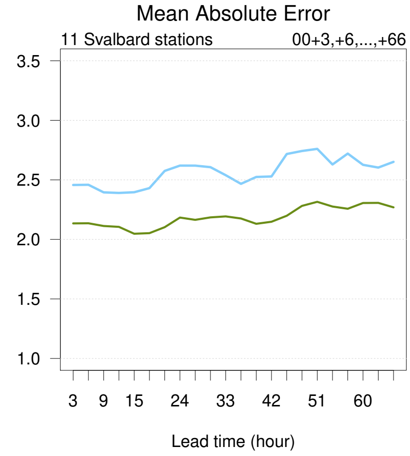

Equitable Threat Score
329 Nor. stations
00+18,+24,+30,+36
MEPSctrl
ECMWF
1.0
0.8
0.6
0.4
0.2
0.0
3 5 8 11 14 17 21
Exceedance threshold (m/s)

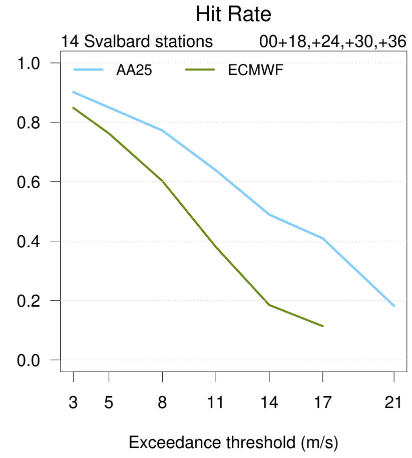

Hansen−Kuiper Skill Score
00+18,+24,+30,+36
1.0
0.8
0.6
0.4
0.2
0.0
3 5 8 11 14 17 21
Exceedance threshold (m/s)

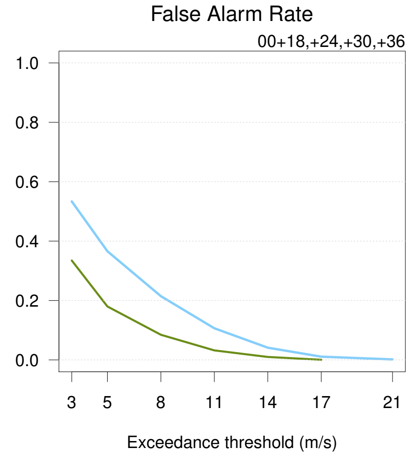

Heidke Skill Score
00+18,+24,+30,+36
1.0
0.8
0.6
0.4
0.2
0.0
3 5 8 11 14 17 21
Exceedance threshold (m/s)

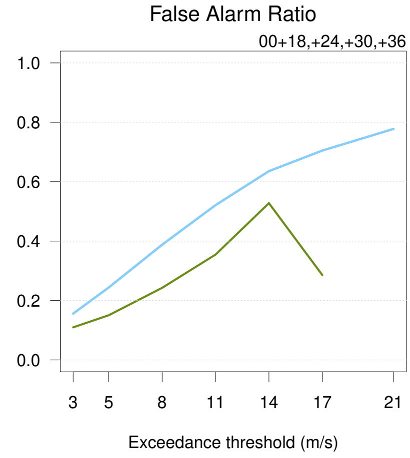

Mean Error
11 Svalbard stations
00+3,+6,...,+66
AA25
ECMWF
Lead time (hour)

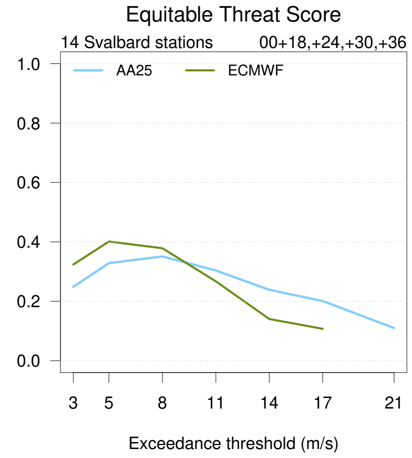

Standard Deviation of Error
11 Svalbard stations
00+3,+6,...,+66
Lead time (hour)

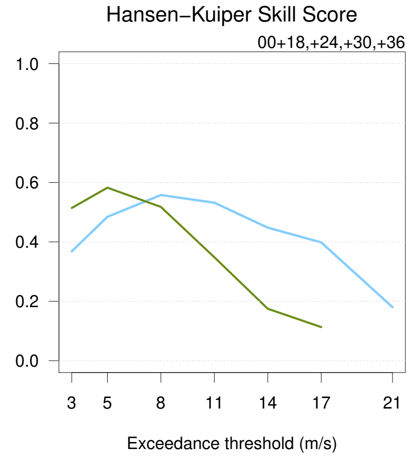

Mean Absolute Error
11 Svalbard stations
00+3,+6,...,+66
Lead time (hour)

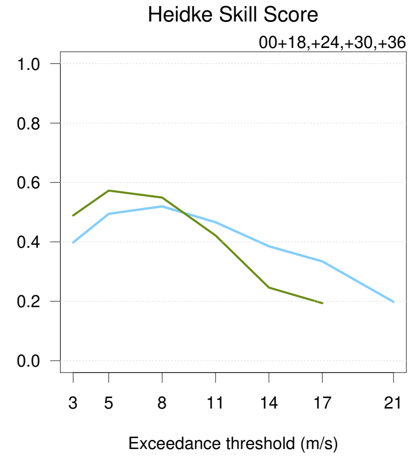

Hit Rate
14 Svalbard stations
00+18,+24,+30,+36
AA25
ECMWF
Exceedance threshold (m/s)

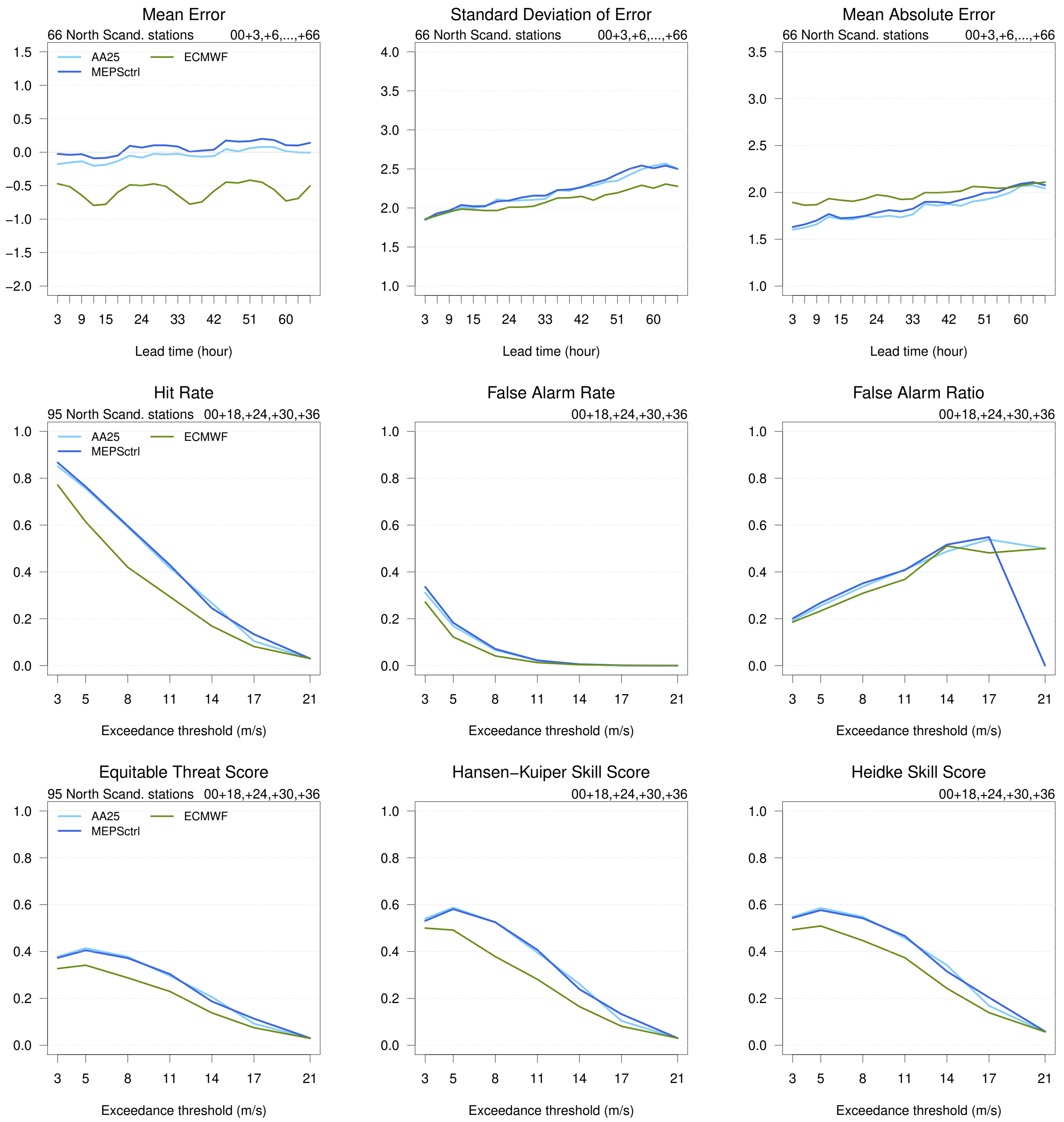

False Alarm Rate
00+18,+24,+30,+36
Exceedance threshold (m/s)


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

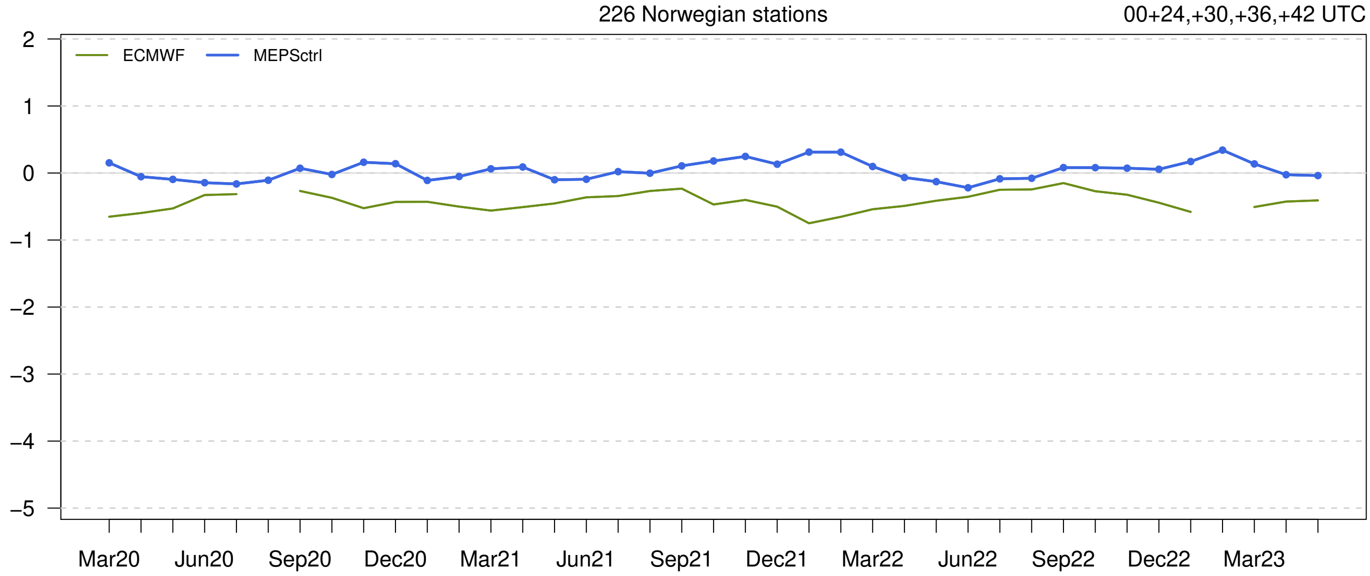

Equitable Threat Score
14 Svalbard stations
00+18,+24,+30,+36
AA25
ECMWF
Exceedance threshold (m/s)

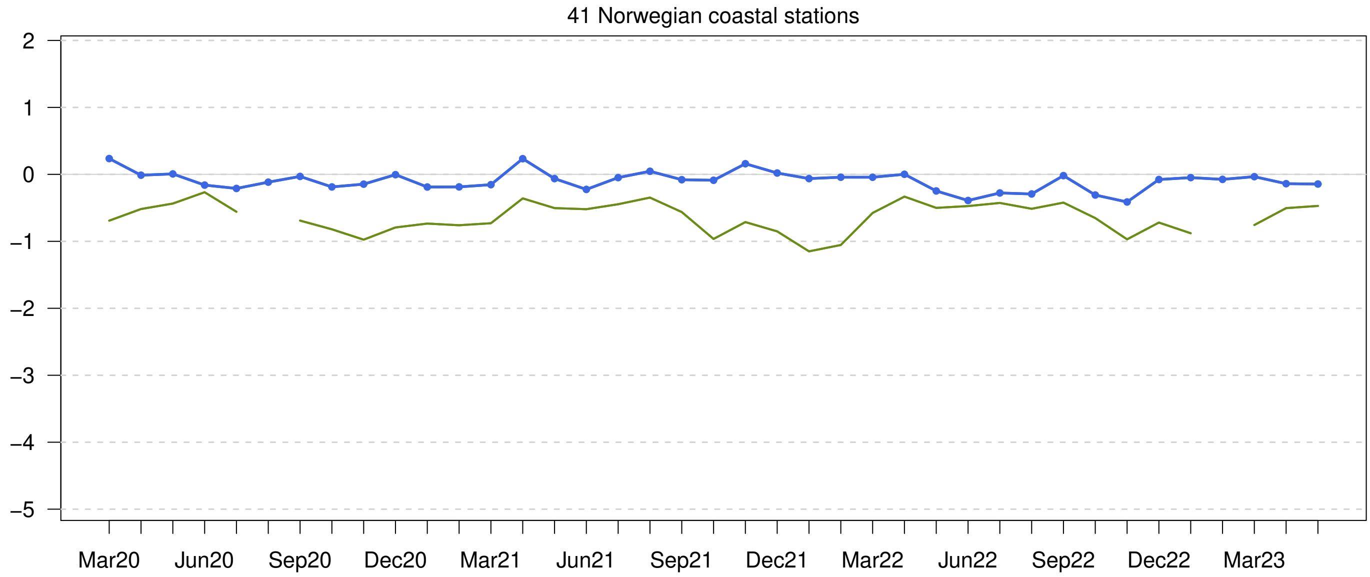

Hansen–Kuiper Skill Score
00+18,+24,+30,+36
Exceedance threshold (m/s)

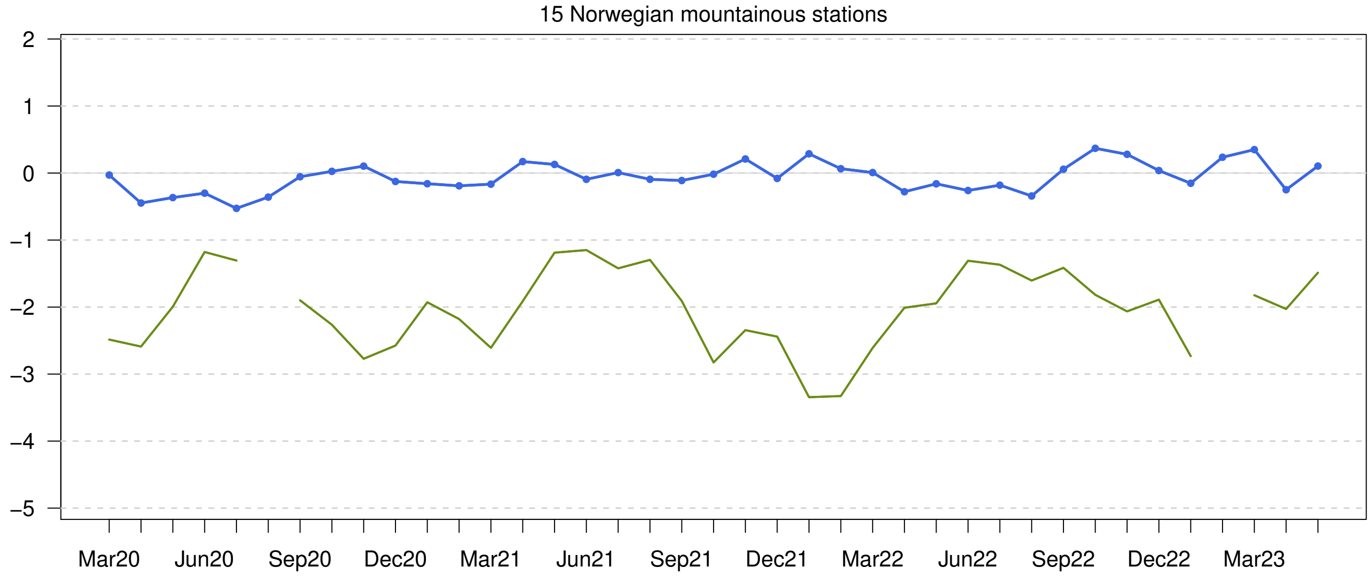

Heidke Skill Score
00+18,+24,+30,+36
Exceedance threshold (m/s)

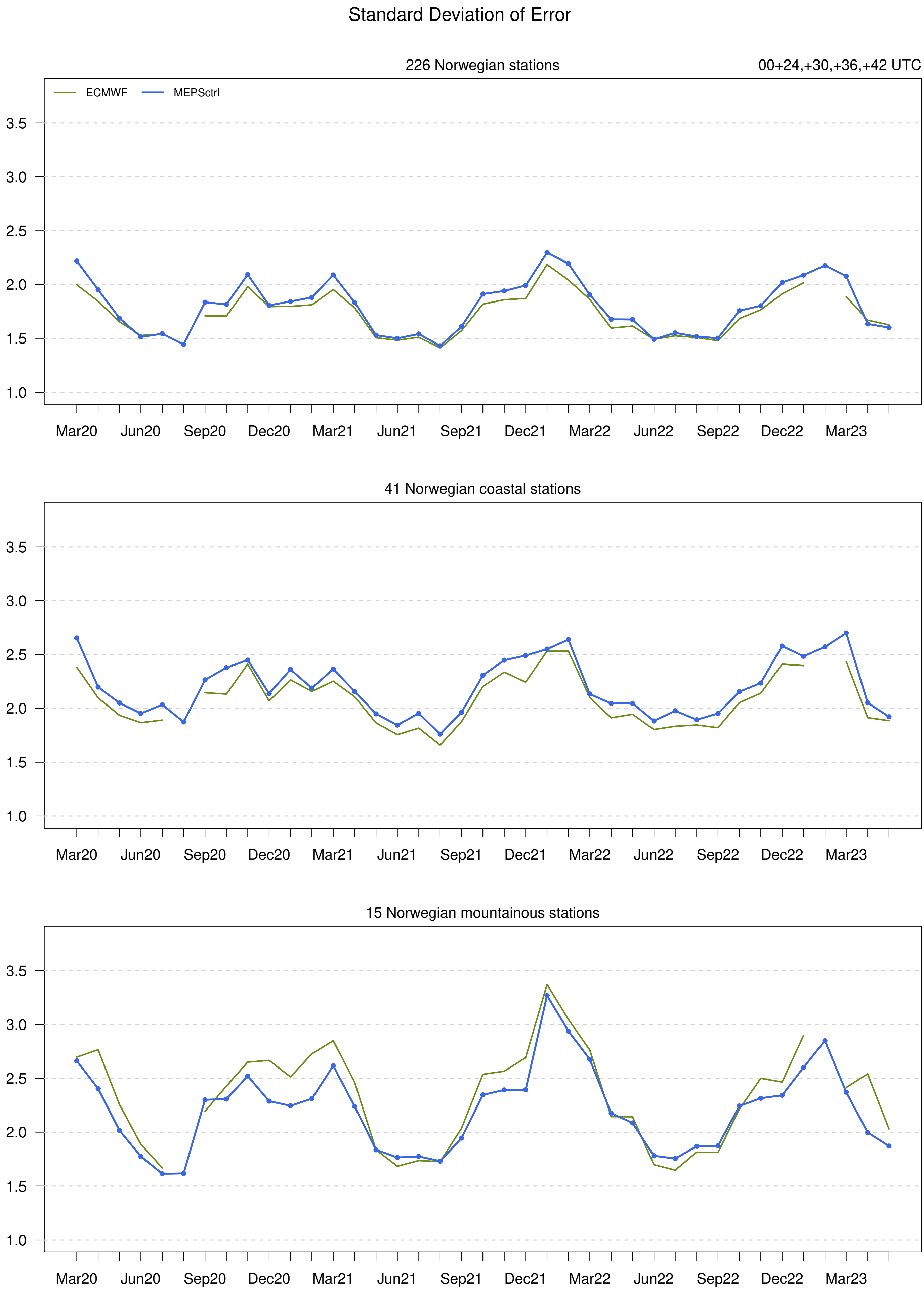

Mean Error
66 North Scand. stations
00+3,+6,...,+66
AA25
MEPSctrl
ECMWF
Lead time (hour)
Standard Deviation of Error
66 North Scand. stations
00+3,+6,...,+66
Lead time (hour)
Mean Absolute Error
66 North Scand. stations
00+3,+6,...,+66
Lead time (hour)
Hit Rate
95 North Scand. stations
00+18,+24,+30,+36
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


226 Norwegian stations
00+24,+30,+36,+42 UTC
ECMWF
MEPSctrl
2
1
0
−1
−2
−3
−4
−5
Mar20
Jun20
Sep20
Dec20
Mar21
Jun21
Sep21
Dec21
Mar22
Jun22
Sep22
Dec22
Mar23


41 Norwegian coastal stations
2
1
0
−1
−2
−3
−4
−5
Mar20
Jun20
Sep20
Dec20
Mar21
Jun21
Sep21
Dec21
Mar22
Jun22
Sep22
Dec22
Mar23

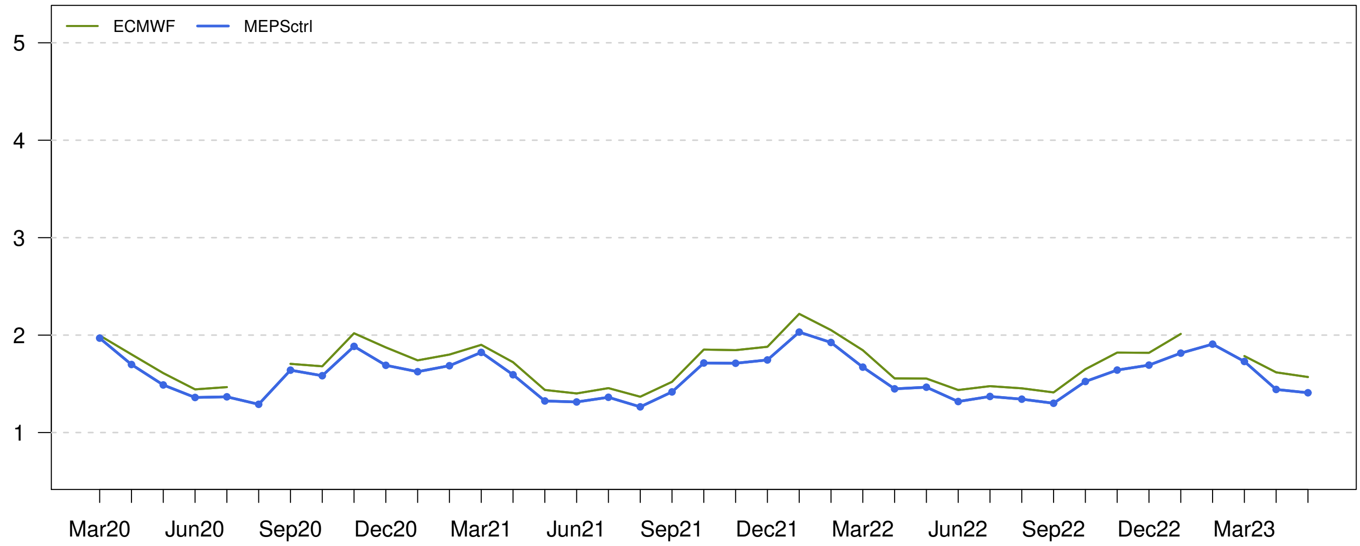

15 Norwegian mountainous stations
2
1
0
−1
−2
−3
−4
−5
Mar20
Jun20
Sep20
Dec20
Mar21
Jun21
Sep21
Dec21
Mar22
Jun22
Sep22
Dec22
Mar23


Standard Deviation of Error
226 Norwegian stations
00+24,+30,+36,+42 UTC
ECMWF
MEPSctrl
3.5
3.0
2.5
2.0
1.5
1.0
Mar20
Jun20
Sep20
Dec20
Mar21
Jun21
Sep21
Dec21
Mar22
Jun22
Sep22
Dec22
Mar23
41 Norwegian coastal stations
15 Norwegian mountainous stations

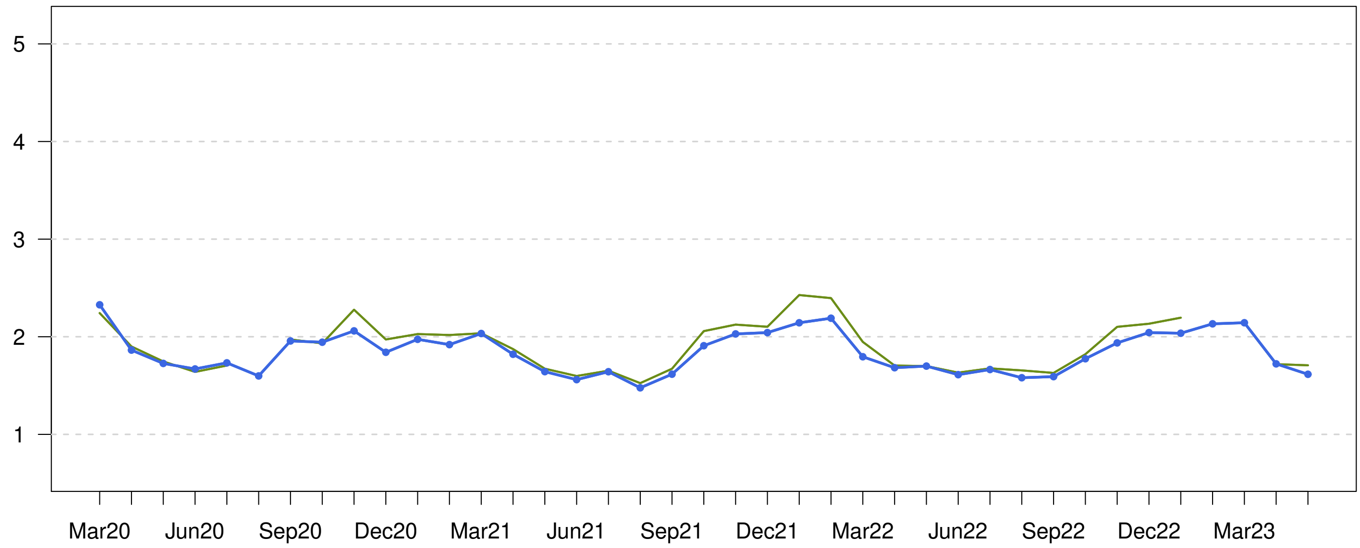
Mean Absolute Error

226 Norwegian stations

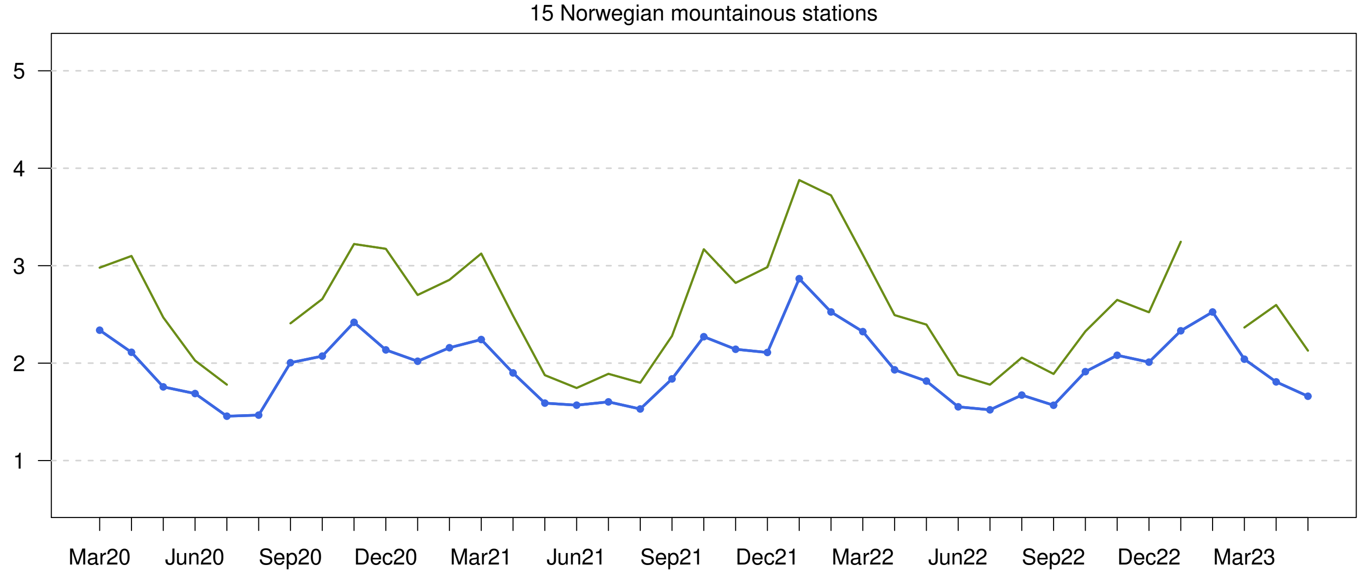
00+24,+30,+36,+42 UTC



41 Norwegian coastal stations

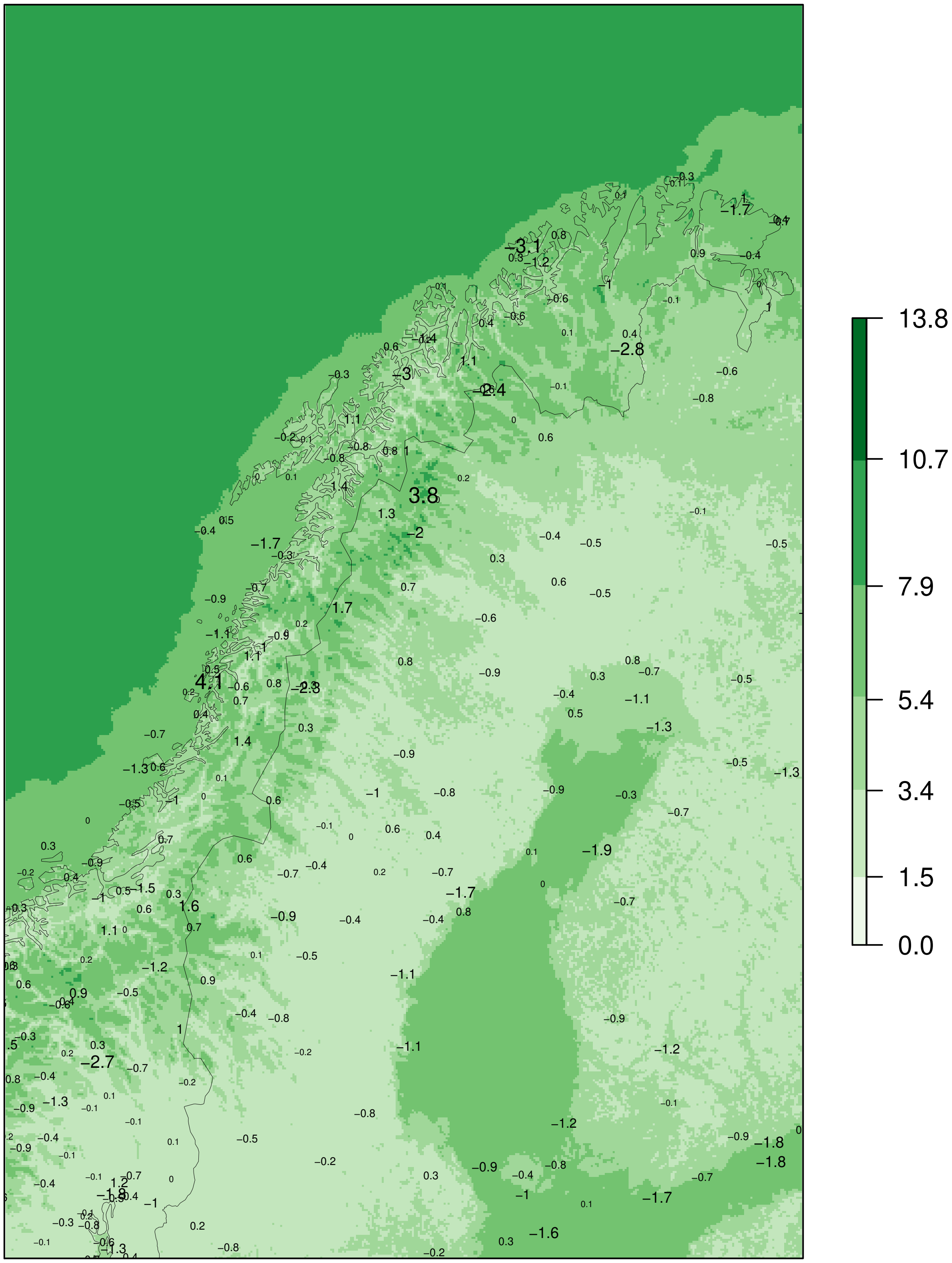


15 Norwegian mountainous stations



MEPSctrl 00+12

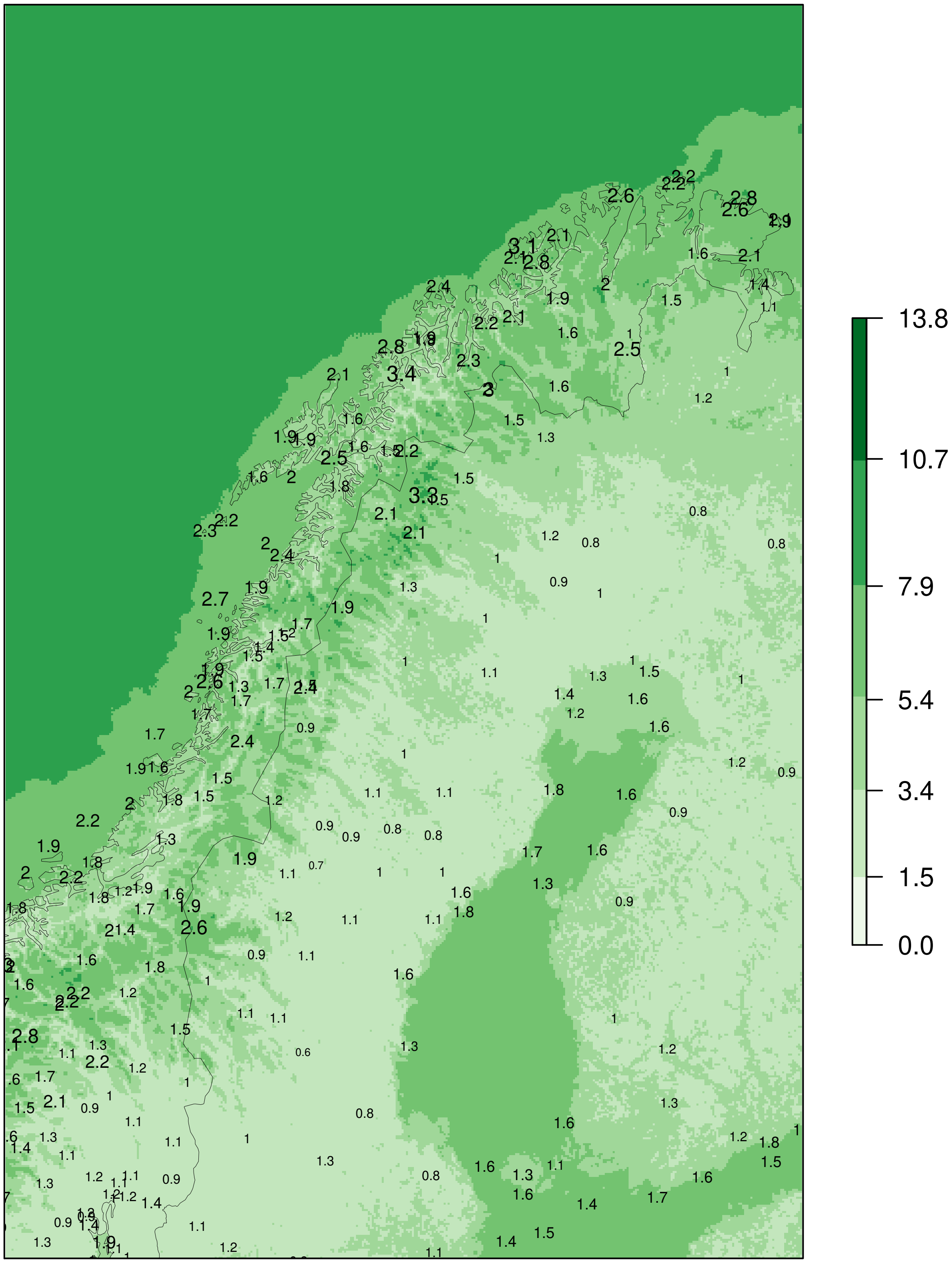
ME at observing sites
(numbers in black)



Model "climatology" 01.03.2023 – 31.05.2023

MEPSctrl 00+12

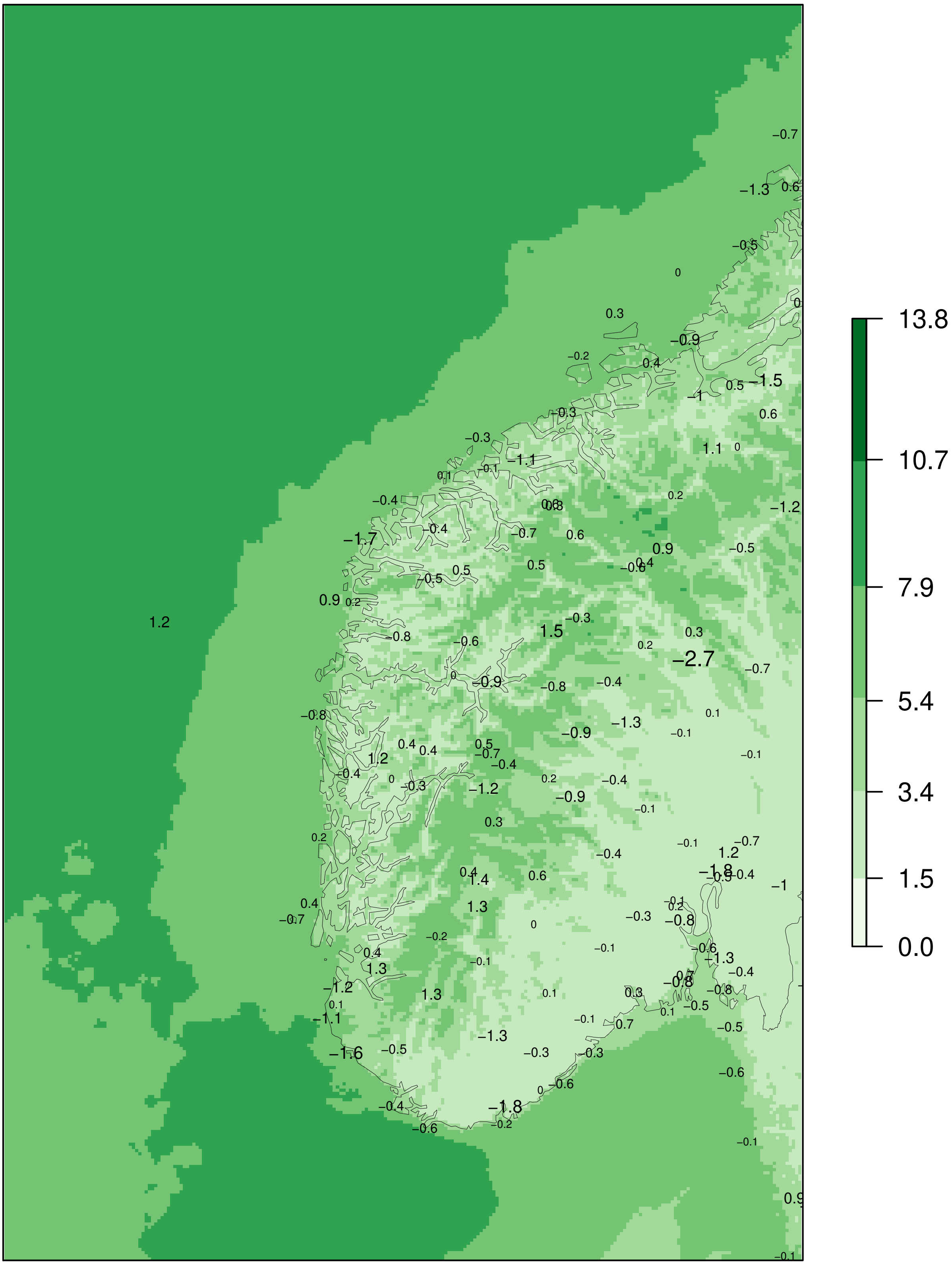
SDE at observing sites
(numbers in black)



Model "climatology" 01.03.2023 – 31.05.2023

MEPSctrl 00+12

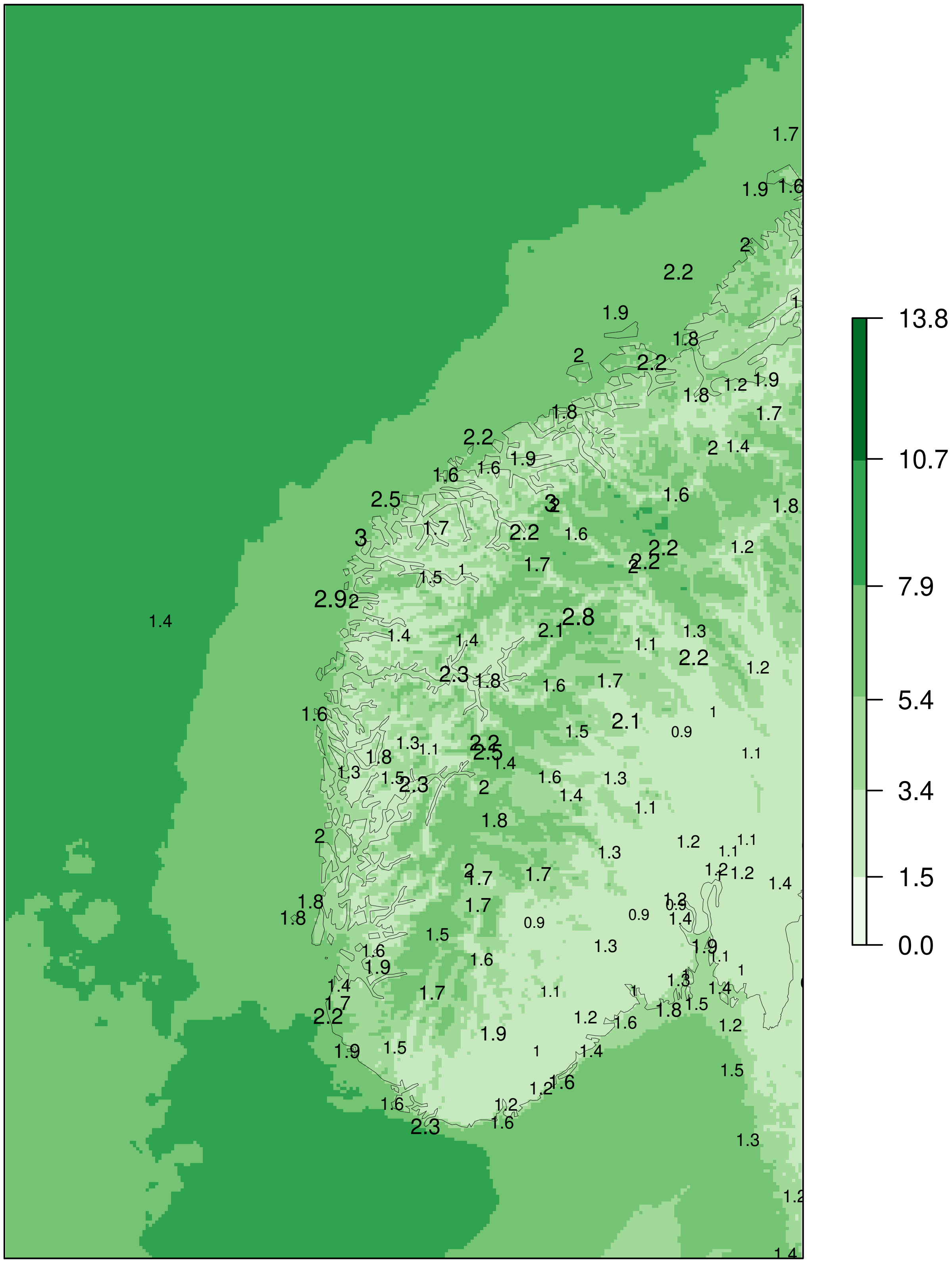
ME at observing sites
(numbers in black)



Model "climatology" 01.03.2023 – 31.05.2023

MEPSctrl 00+12

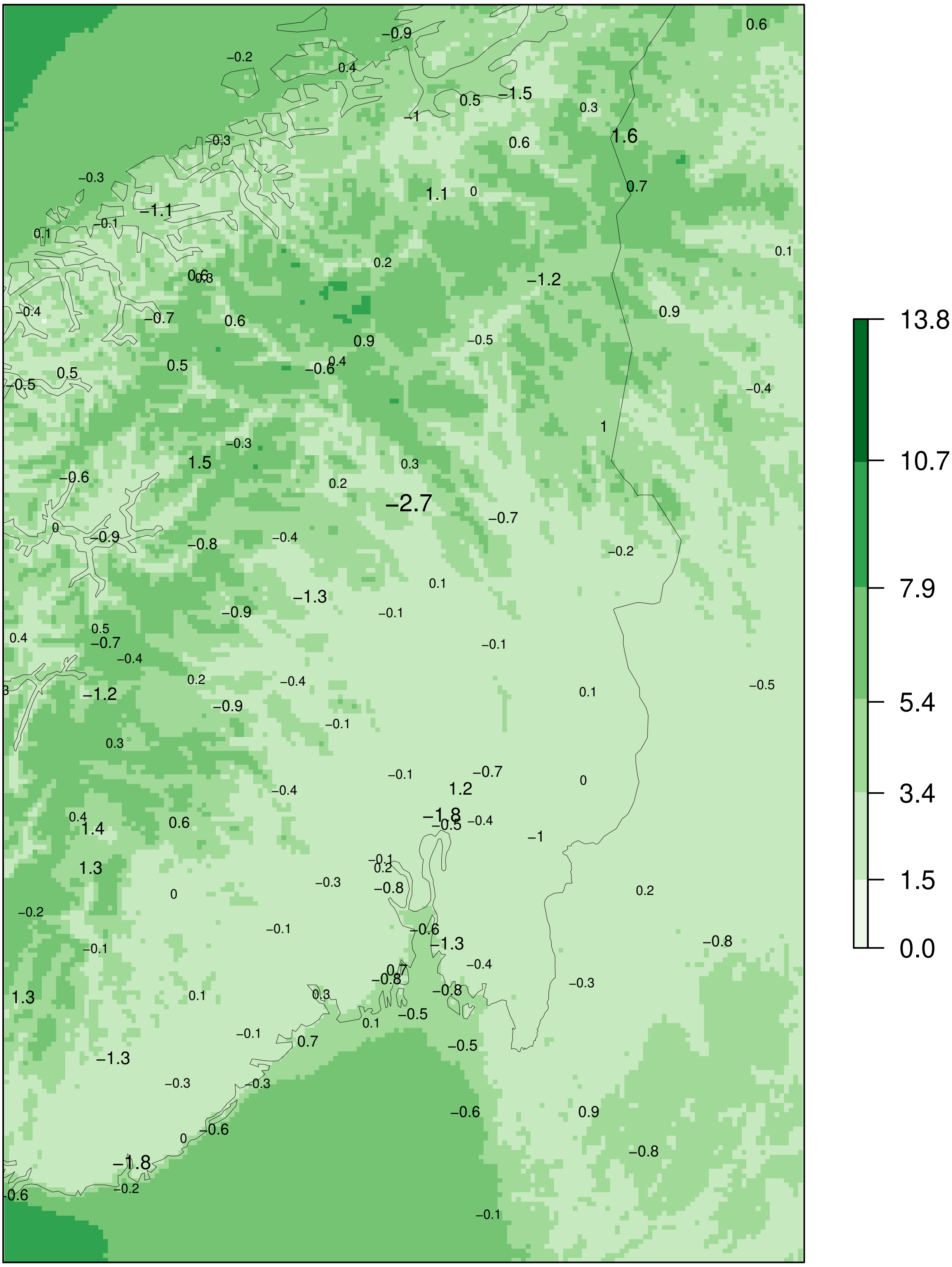
SDE at observing sites
(numbers in black)



Model "climatology" 01.03.2023 – 31.05.2023

MEPSctrl 00+12

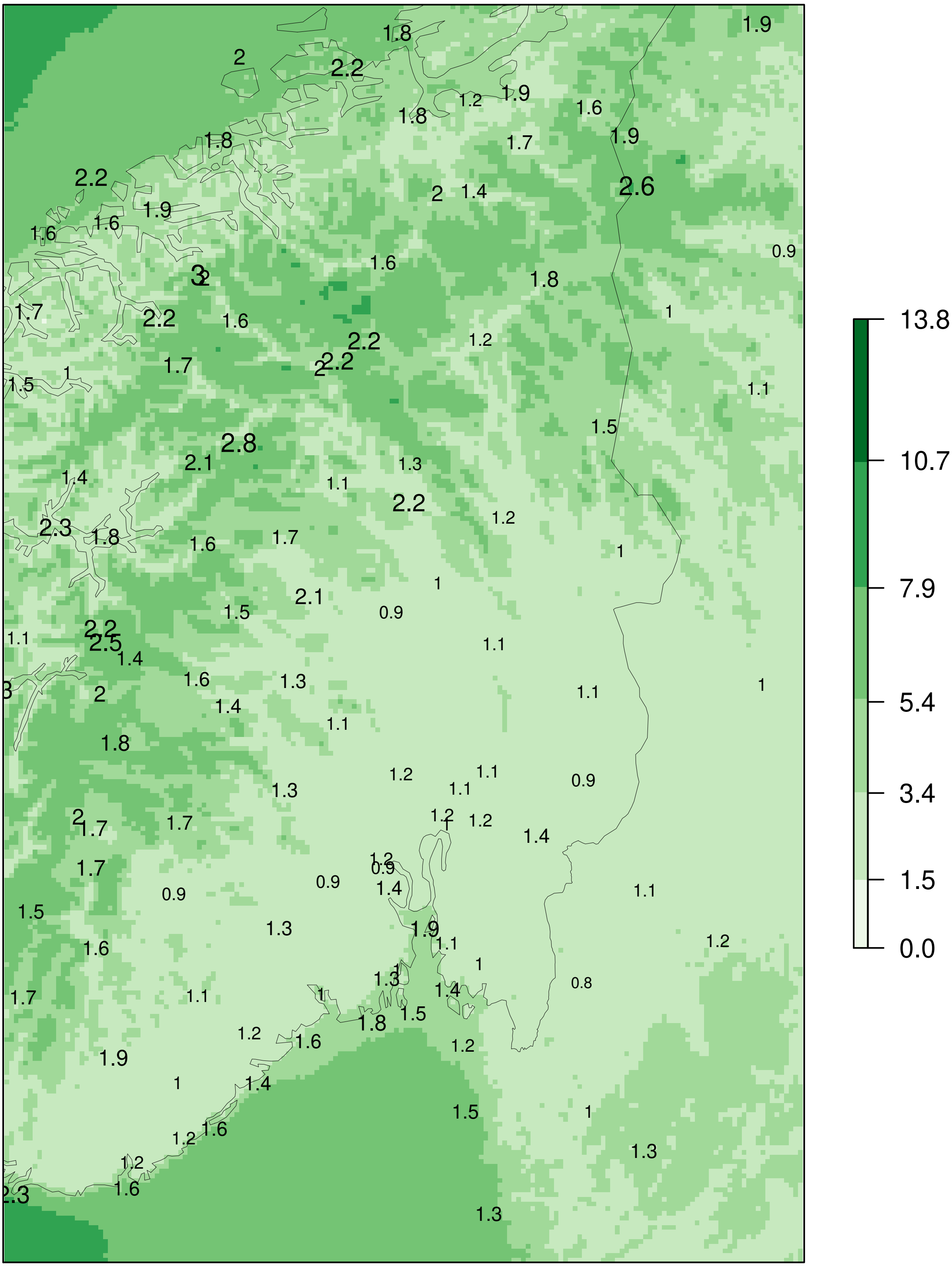
ME at observing sites
(numbers in black)



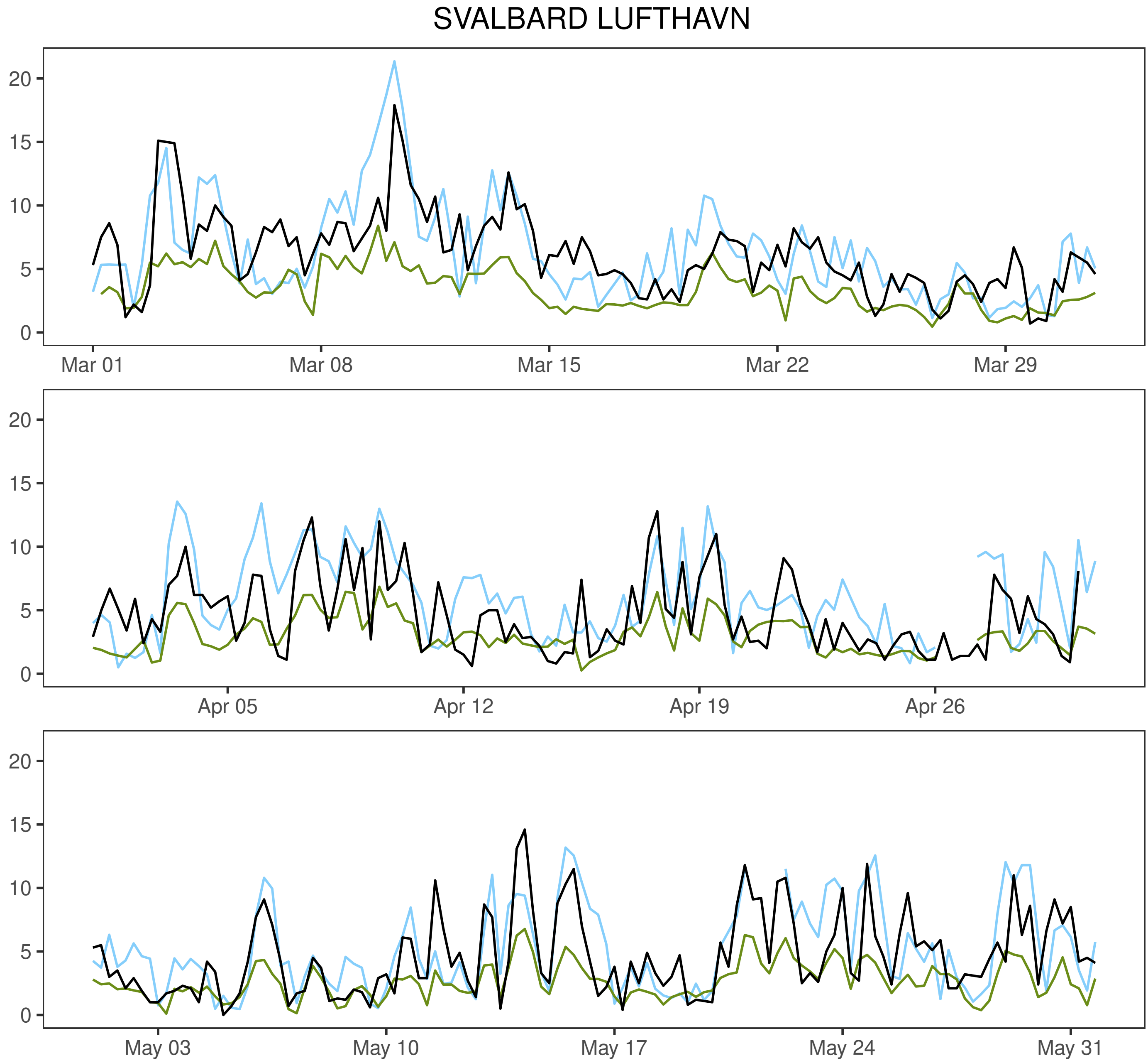
Model "climatology" 01.03.2023 – 31.05.2023

MEPSctrl 00+12

SDE at observing sites
(numbers in black)

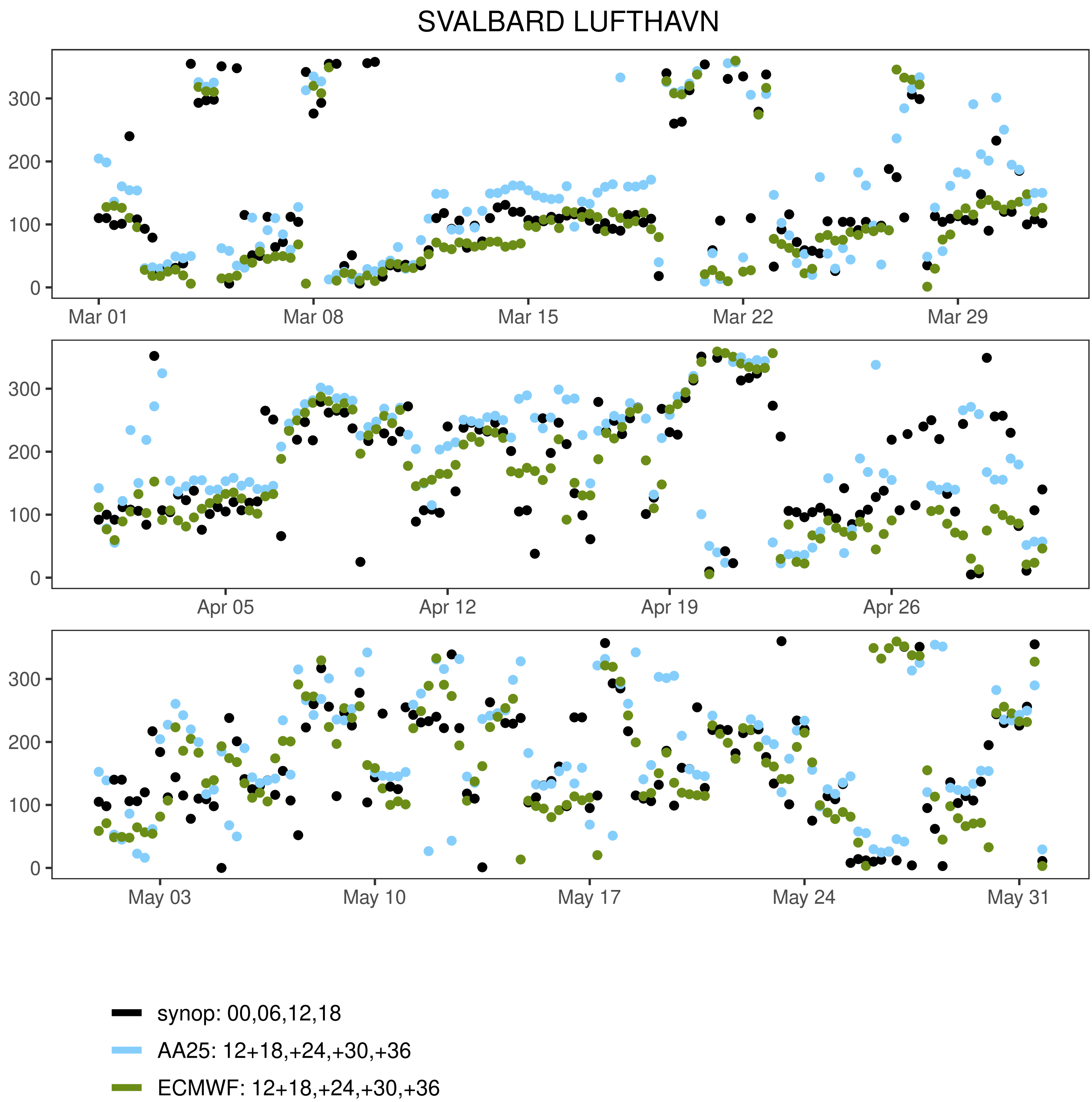


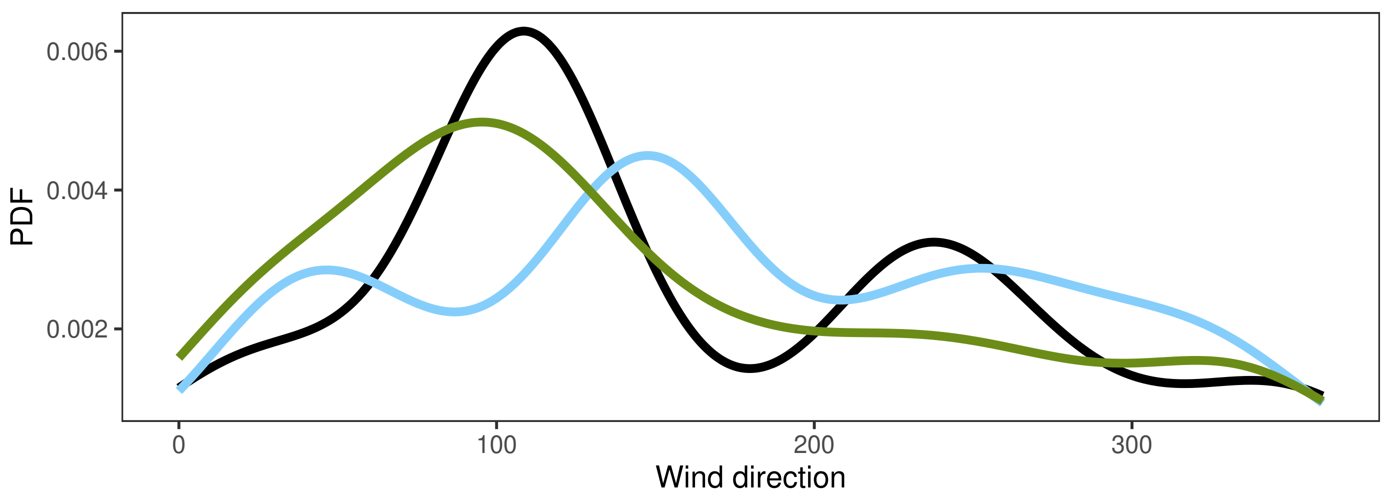
Model "climatology" 01.03.2023 – 31.05.2023

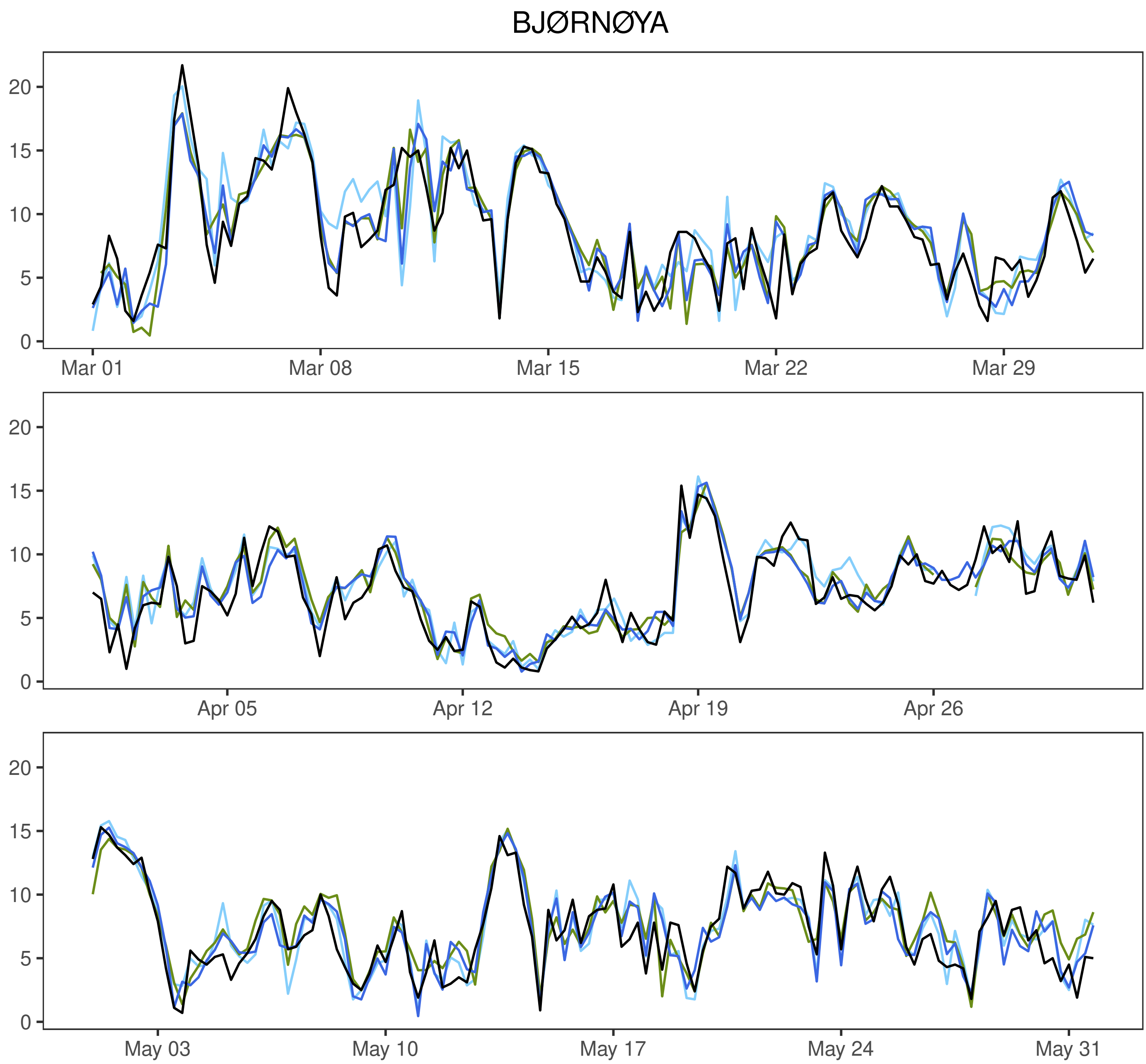


	Min	Mean	Max	Std	N
synop: 00,06,12,18	0.0	5.2	17.9	3.2	367
AA25: 12+18,+24,+30,+36	0.5	5.9	21.4	3.6	360
ECMWF: 12+18,+24,+30,+36	0.1	3.0	8.4	1.5	363

	ME	SDE	RMSE	MAE	Max.abs.err.	N
AA25−synop	0.7	2.9	2.9	2.3	10.7	358
ECMWF−synop	−2.2	2.3	3.2	2.5	10.8	358

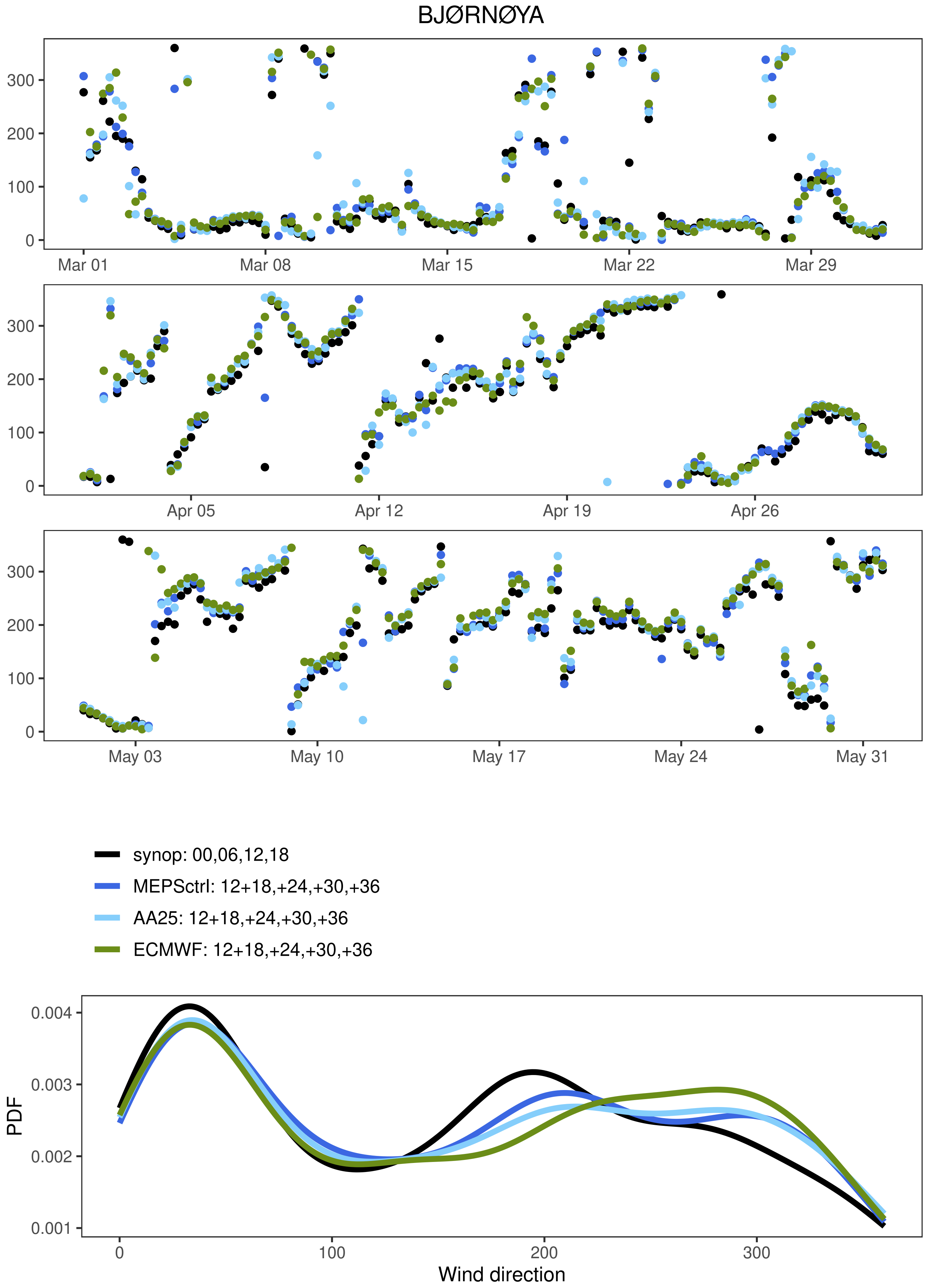

SVALBARD LUFTHAVN
300
200
100
0
Mar 01
Mar 08
Mar 15
Mar 22
Mar 29
Apr 05
Apr 12
Apr 19
Apr 26
May 03
May 10
May 17
May 24
May 31
synop: 00,06,12,18
AA25: 12+18,+24,+30,+36
ECMWF: 12+18,+24,+30,+36

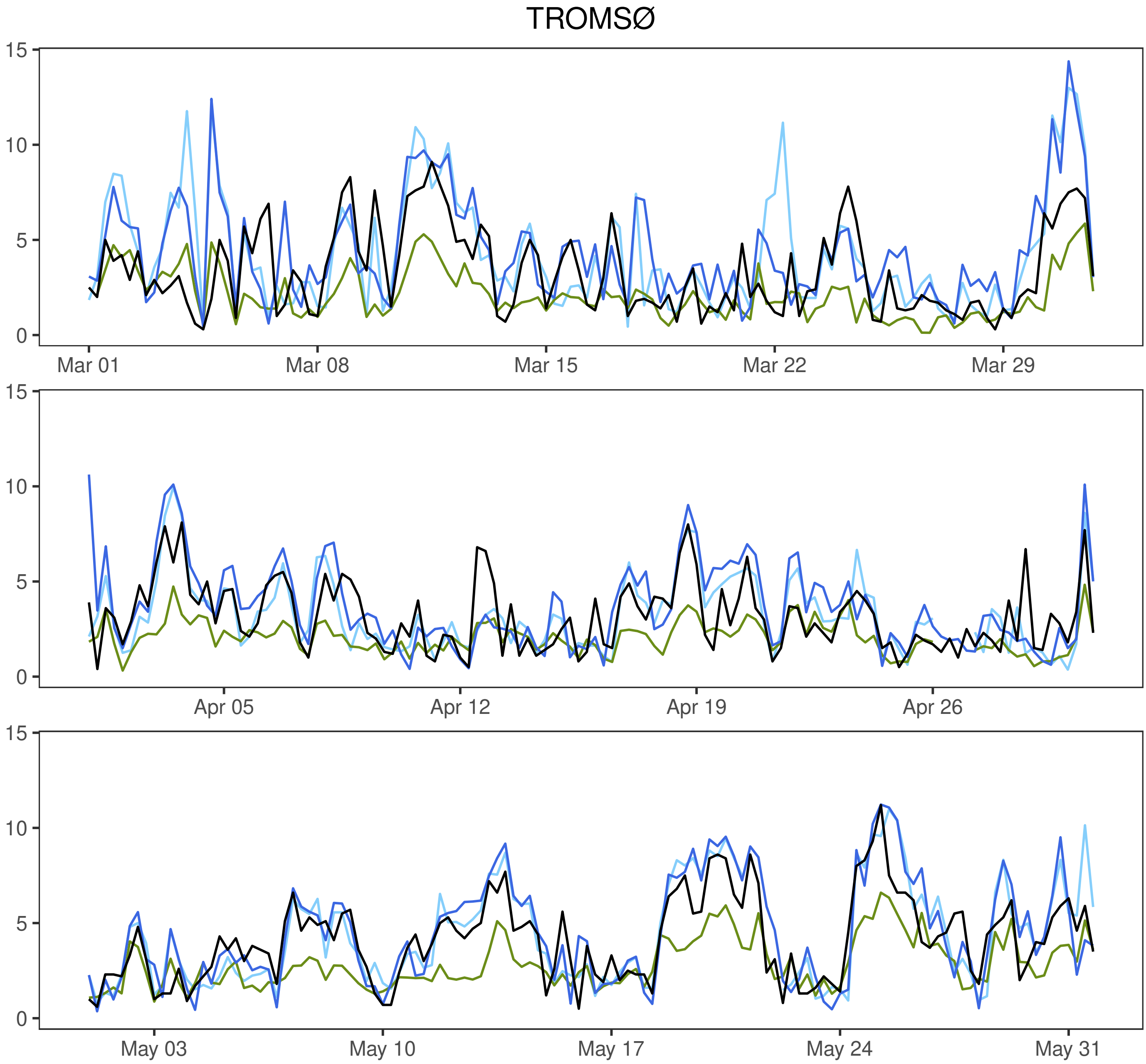

PDF
0.006
0.004
0.002
0
100
200
300
Wind direction



	Min	Mean	Max	Std	N
synop: 00,06,12,18	0.7	7.6	21.7	3.7	368
MEPSctrl: 12+18,+24,+30,+36	0.4	7.8	17.9	3.5	368
AA25: 12+18,+24,+30,+36	0.8	8.0	20.0	3.8	360
ECMWF: 12+18,+24,+30,+36	0.5	8.0	17.9	3.4	363

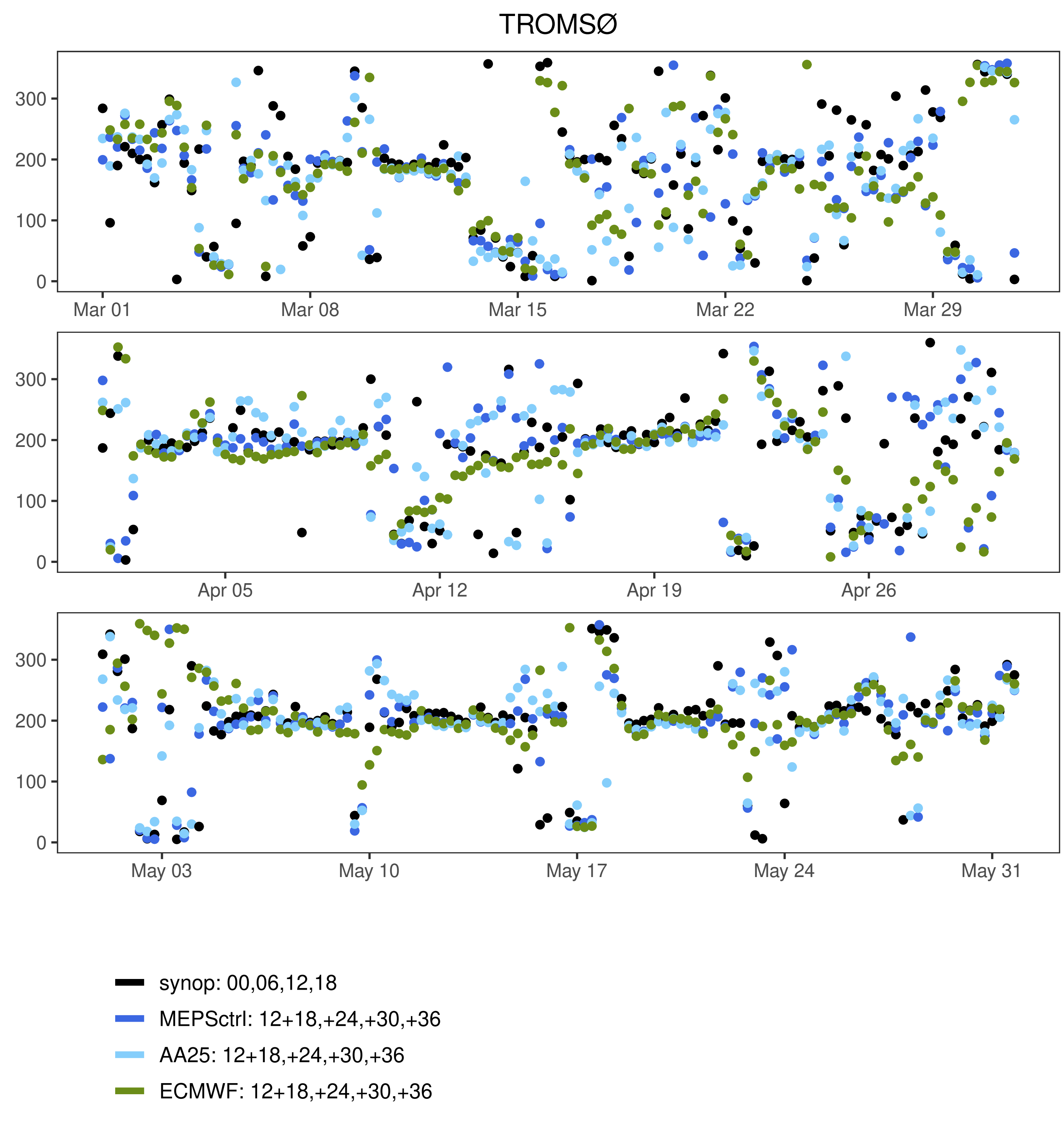
	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl−synop	0.2	1.8	1.8	1.4	9.1	359
AA25−synop	0.4	1.9	2.0	1.5	10.8	359
ECMWF−synop	0.4	1.8	1.8	1.4	8.0	359

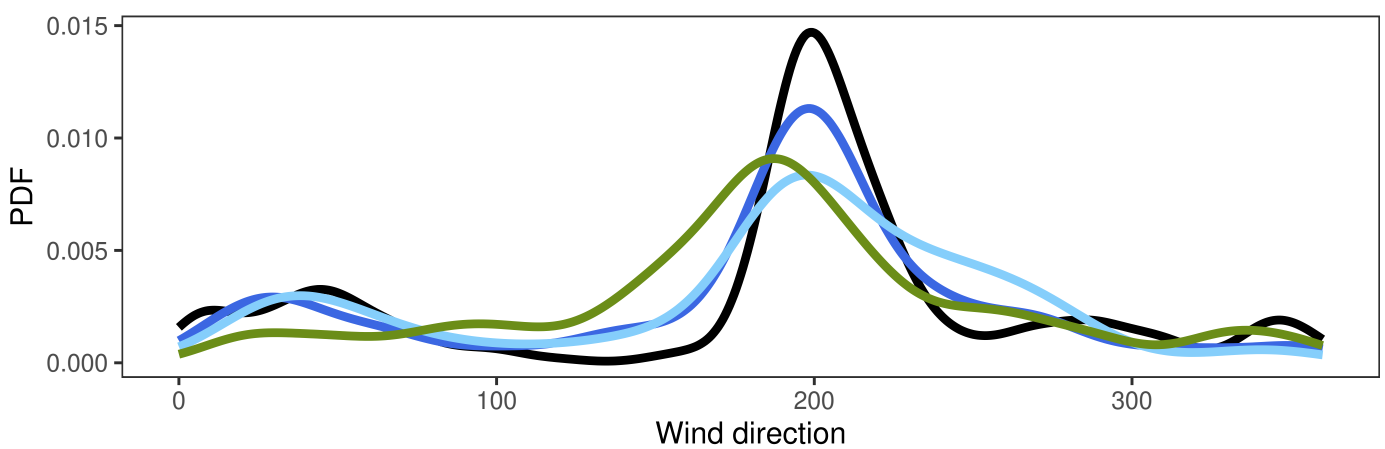

BJØRNØYA
0
100
200
300
Mar 01
Mar 08
Mar 15
Mar 22
Mar 29
Apr 05
Apr 12
Apr 19
Apr 26
May 03
May 10
May 17
May 24
May 31
synop: 00,06,12,18
MEPSctrl: 12+18,+24,+30,+36
AA25: 12+18,+24,+30,+36
ECMWF: 12+18,+24,+30,+36
PDF
0.001
0.002
0.003
0.004
Wind direction

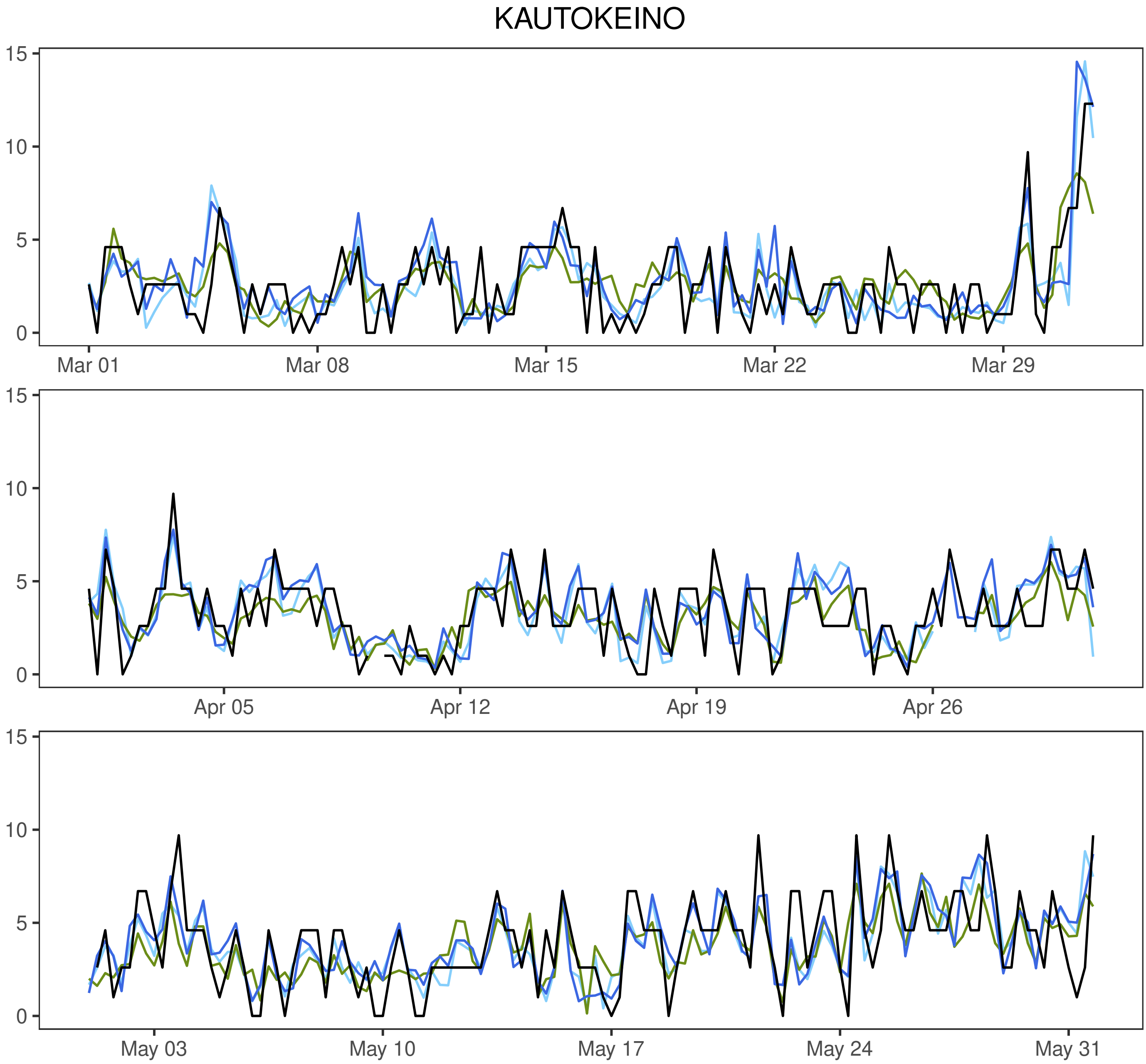


	Min	Mean	Max	Std	N
synop: 00,06,12,18	0.3	3.5	11.2	2.1	368
MEPSctrl: 12+18,+24,+30,+36	0.4	4.2	14.4	2.6	368
AA25: 12+18,+24,+30,+36	0.4	4.0	13.0	2.6	360
ECMWF: 12+18,+24,+30,+36	0.1	2.3	6.6	1.2	363

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl−synop	0.7	1.9	2.0	1.5	10.5	359
AA25−synop	0.4	1.9	2.0	1.4	10.2	359
ECMWF−synop	−1.2	1.6	2.0	1.5	6.0	359

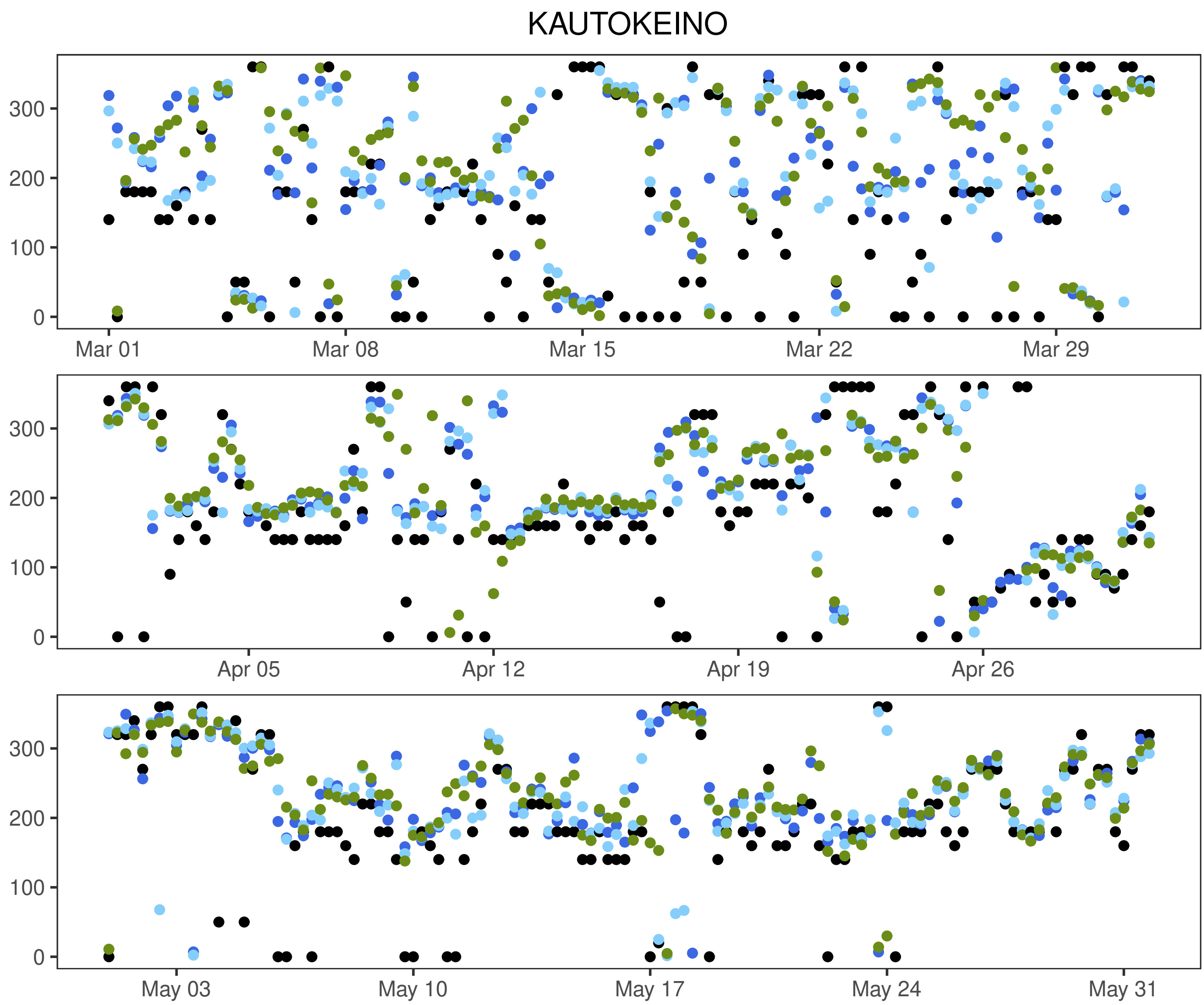

TROMSØ
300
200
100
0
Mar 01
Mar 08
Mar 15
Mar 22
Mar 29
Apr 05
Apr 12
Apr 19
Apr 26
May 03
May 10
May 17
May 24
May 31
synop: 00,06,12,18
MEPSctrl: 12+18,+24,+30,+36
AA25: 12+18,+24,+30,+36
ECMWF: 12+18,+24,+30,+36


0.015
0.010
0.005
0.000
PDF
0
100
200
300
Wind direction

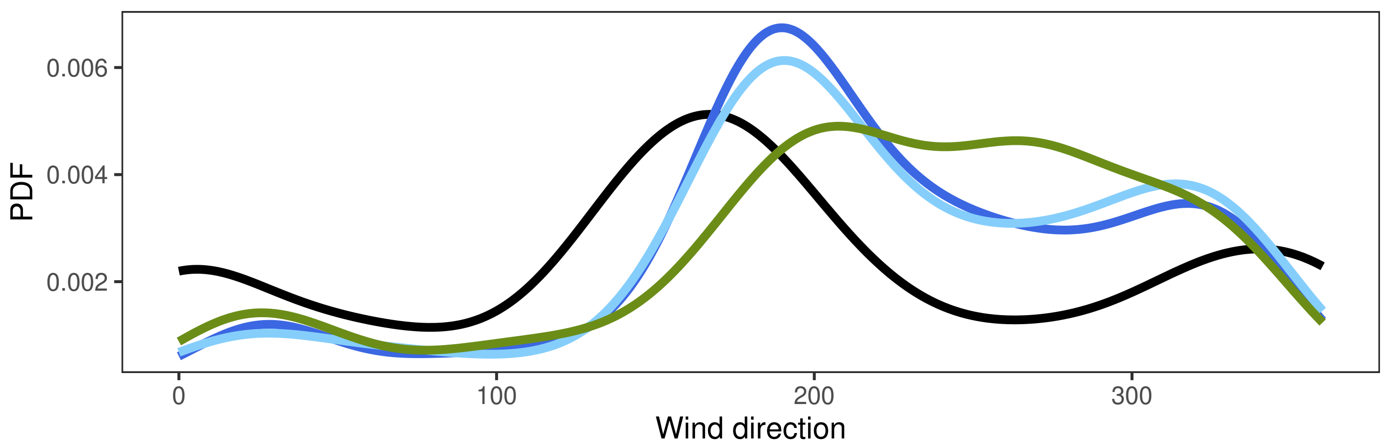


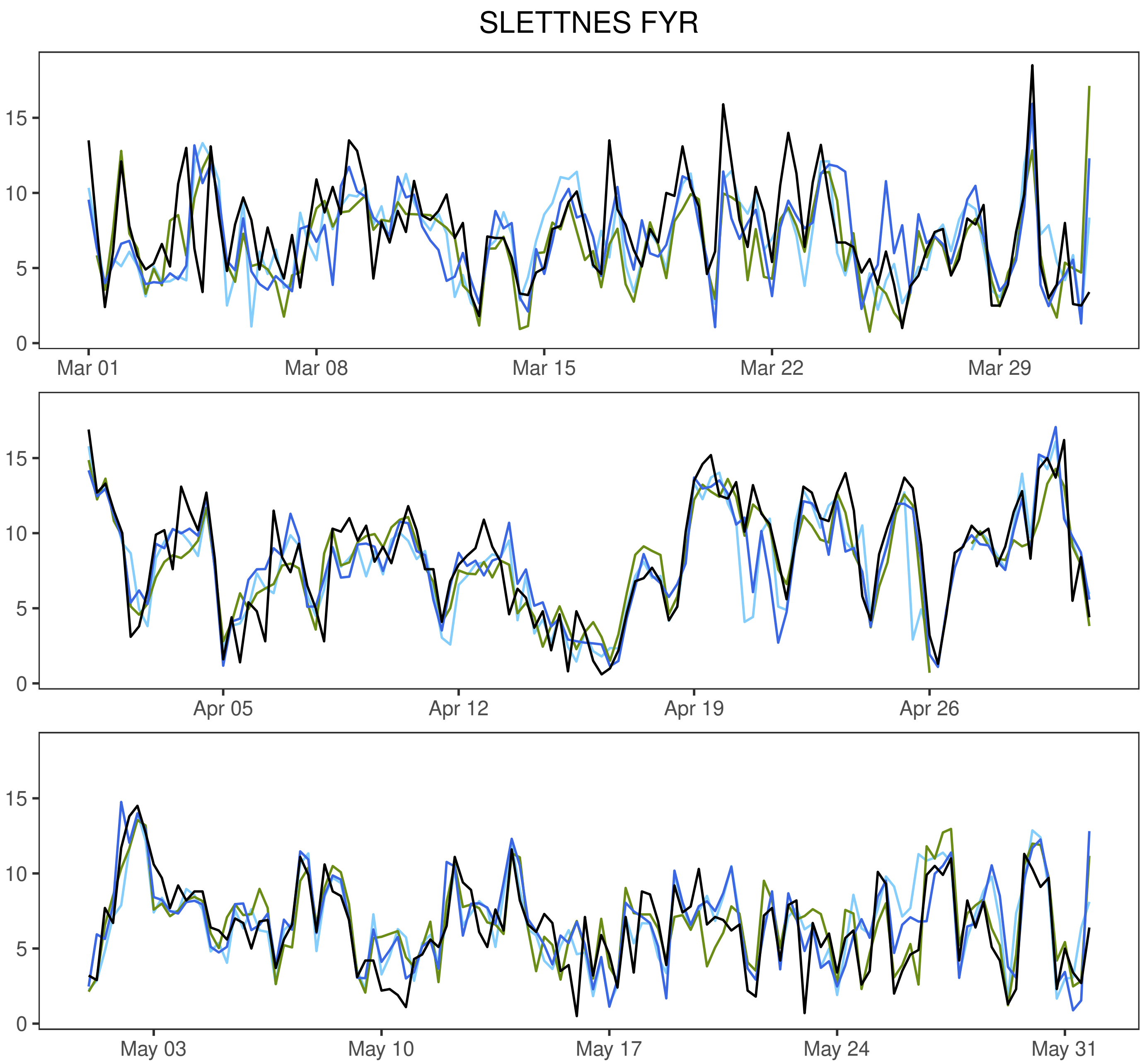
	Min	Mean	Max	Std	N
synop: 00,06,12,18	0.0	3.3	12.3	2.3	366
MEPSctrl: 12+18,+24,+30,+36	0.3	3.5	14.6	2.1	368
AA25: 12+18,+24,+30,+36	0.3	3.2	14.6	2.0	360
ECMWF: 12+18,+24,+30,+36	0.1	3.1	8.6	1.5	363

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl–synop	0.2	1.6	1.7	1.3	7.9	357
AA25–synop	0.0	1.7	1.7	1.3	6.2	357
ECMWF–synop	−0.1	1.7	1.7	1.4	5.9	357



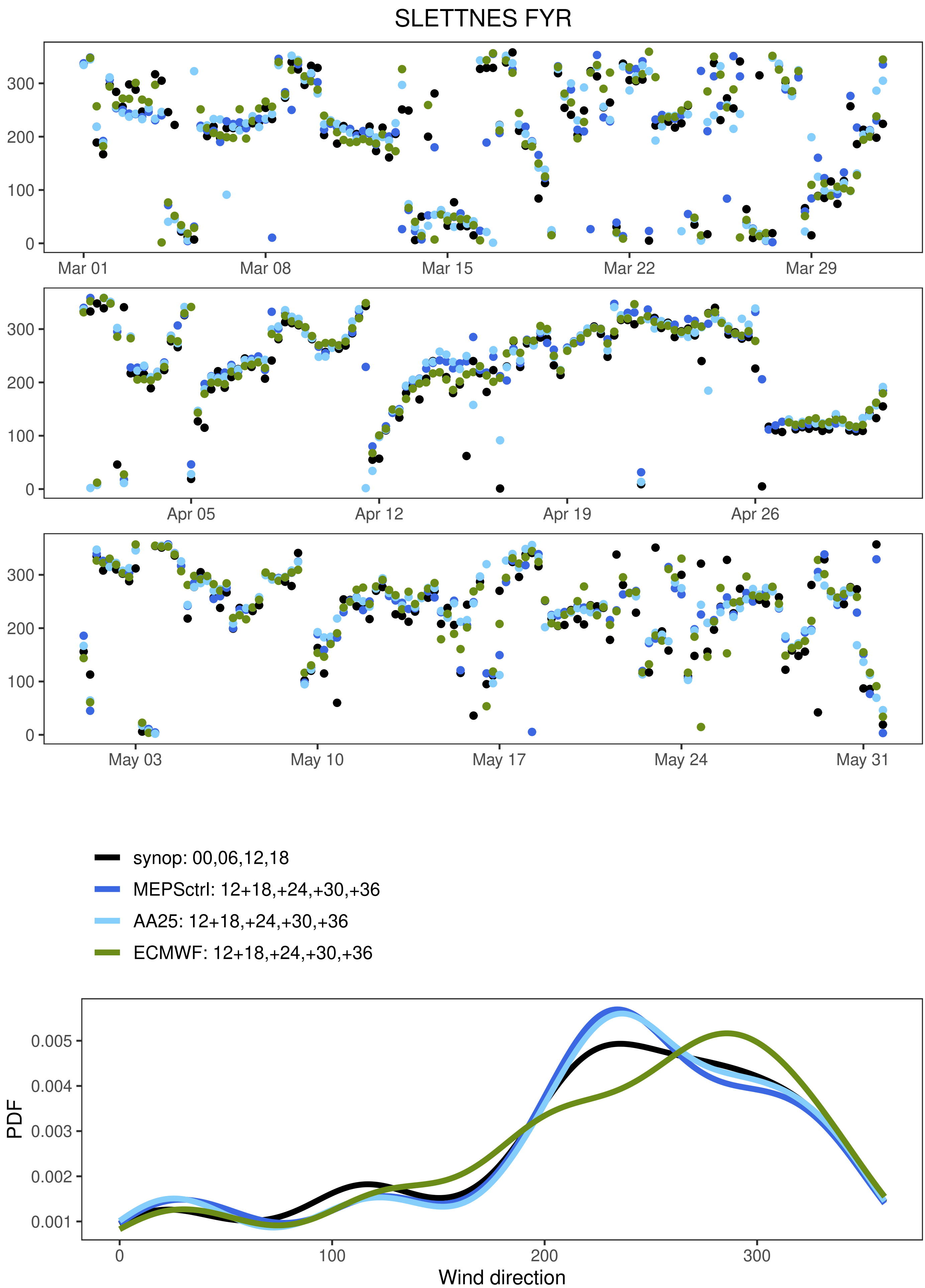
synop: 00,06,12,18
MEPSctrl: 12+18,+24,+30,+36
AA25: 12+18,+24,+30,+36
ECMWF: 12+18,+24,+30,+36

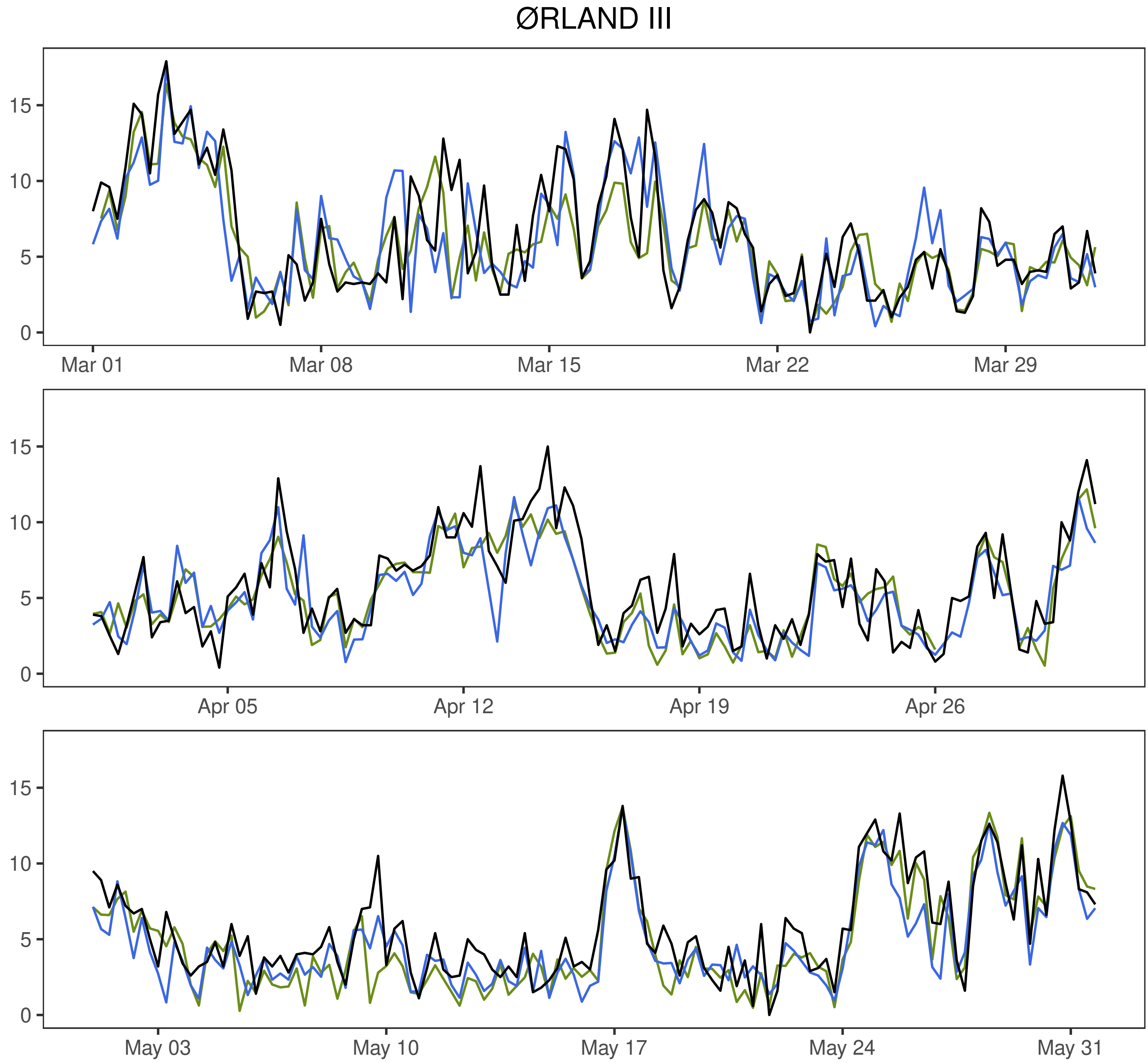




	Min	Mean	Max	Std	N
synop: 00,06,12,18	0.5	7.4	18.5	3.4	368
MEPSctrl: 12+18,+24,+30,+36	0.9	7.3	17.1	3.0	368
AA25: 12+18,+24,+30,+36	1.1	7.2	16.1	3.1	360
ECMWF: 12+18,+24,+30,+36	0.7	7.1	17.1	2.9	363

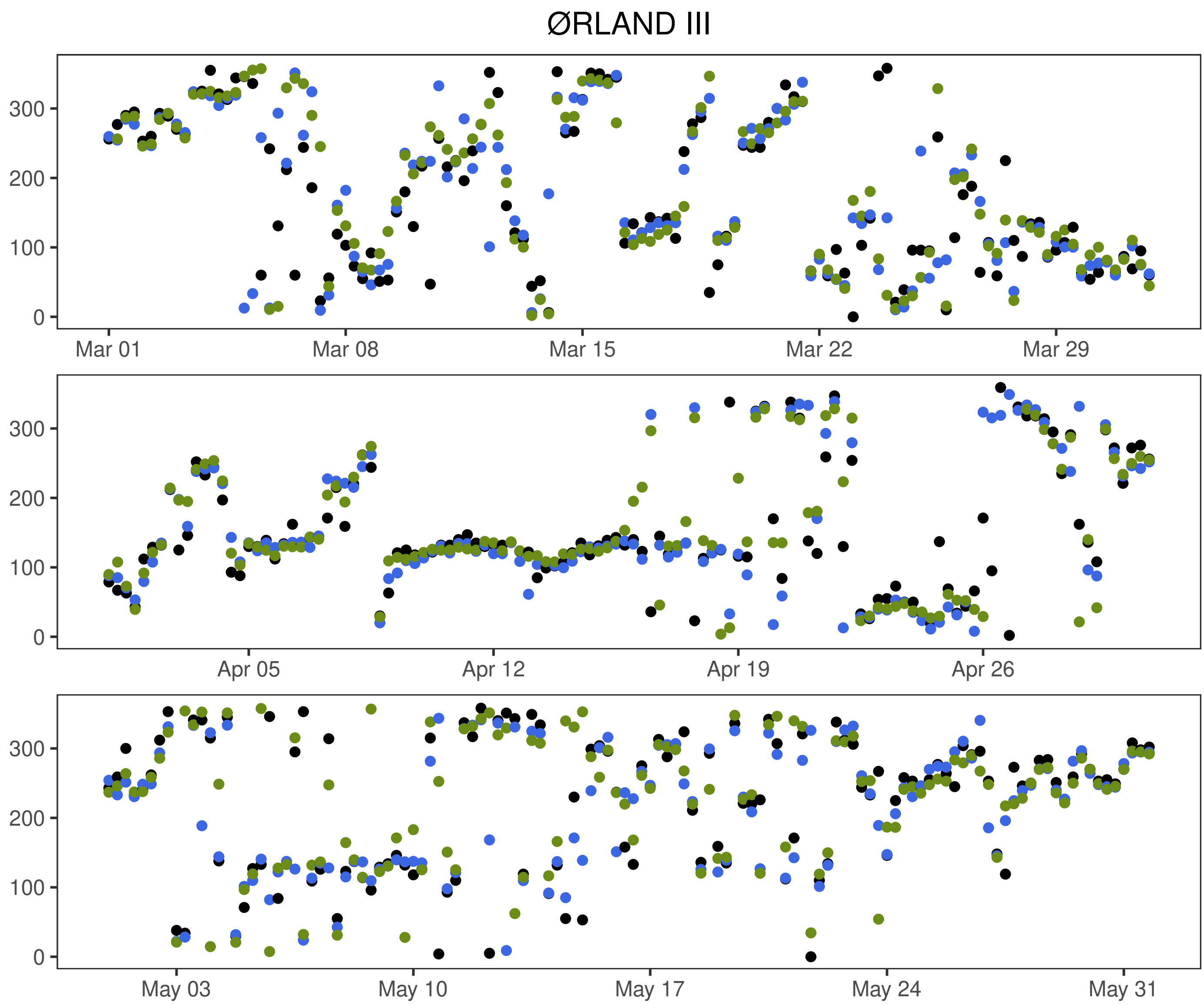
	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl–synop	–0.1	2.4	2.4	1.8	8.9	359
AA25–synop	–0.3	2.5	2.5	1.8	10.1	359
ECMWF–synop	–0.3	2.2	2.2	1.6	13.7	359

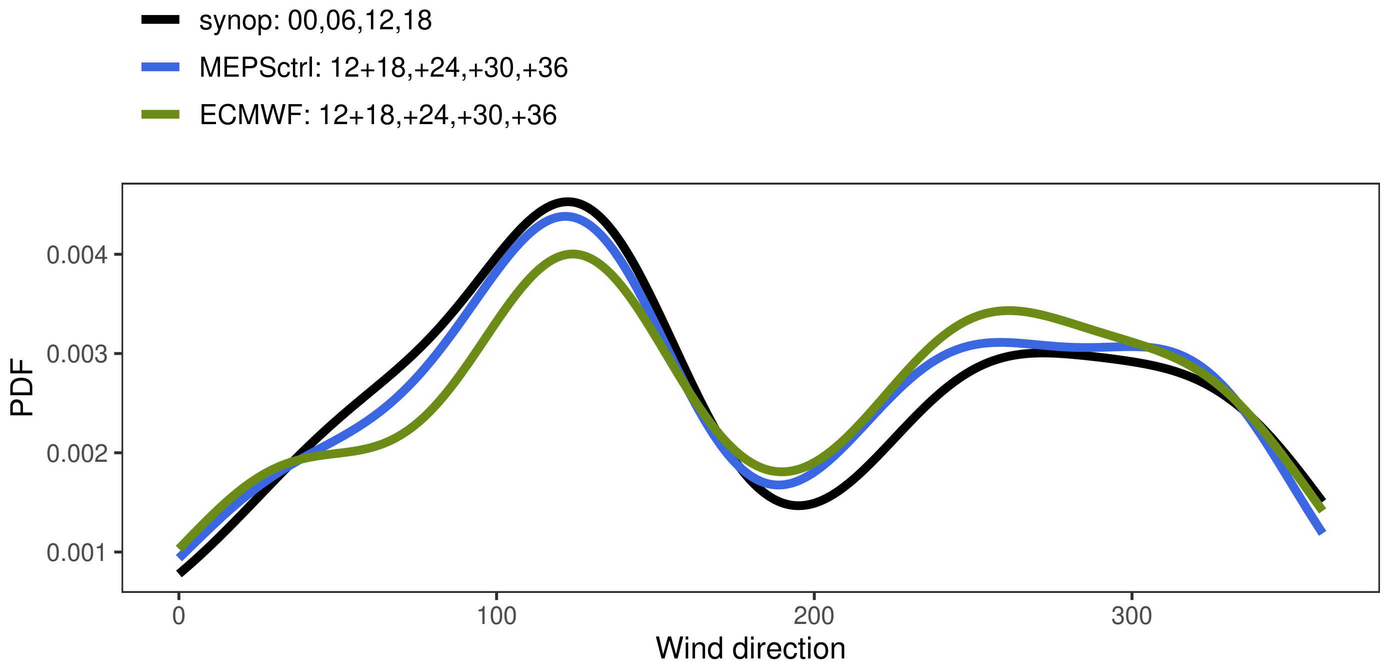

SLETTNES FYR
300
200
100
0
Mar 01
Mar 08
Mar 15
Mar 22
Mar 29
Apr 05
Apr 12
Apr 19
Apr 26
May 03
May 10
May 17
May 24
May 31
synop: 00,06,12,18
MEPSctrl: 12+18,+24,+30,+36
AA25: 12+18,+24,+30,+36
ECMWF: 12+18,+24,+30,+36
PDF
0.005
0.004
0.003
0.002
0.001
0
100
200
300
Wind direction

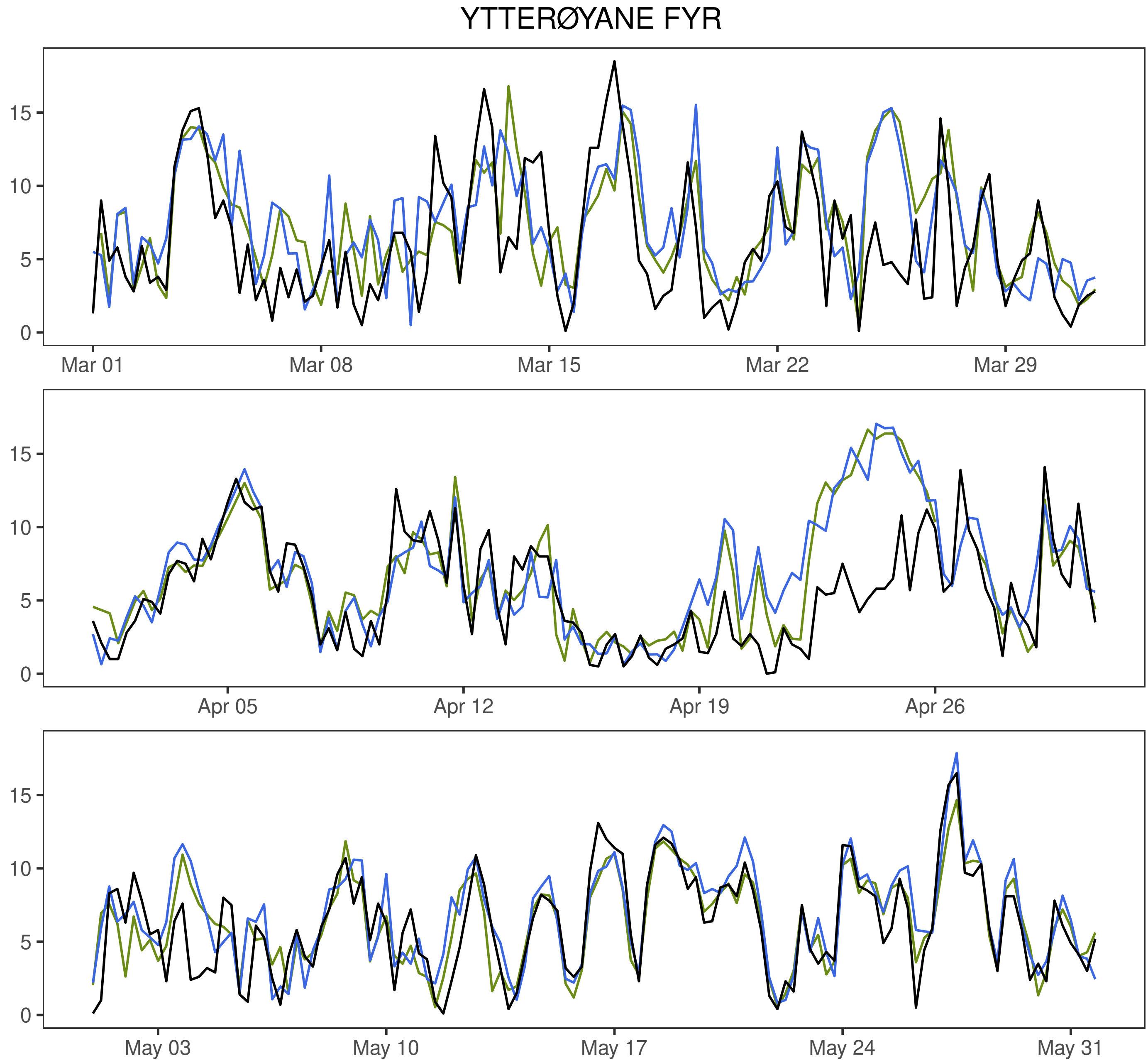


	Min	Mean	Max	Std	N
synop: 00,06,12,18	0.0	5.9	17.9	3.6	368
MEPSctrl: 12+18,+24,+30,+36	0.4	5.2	17.6	3.2	368
ECMWF: 12+18,+24,+30,+36	0.2	5.3	16.4	3.2	363

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl−synop	−0.6	2.2	2.3	1.7	9.1	363
ECMWF−synop	−0.6	2.0	2.1	1.6	9.5	363

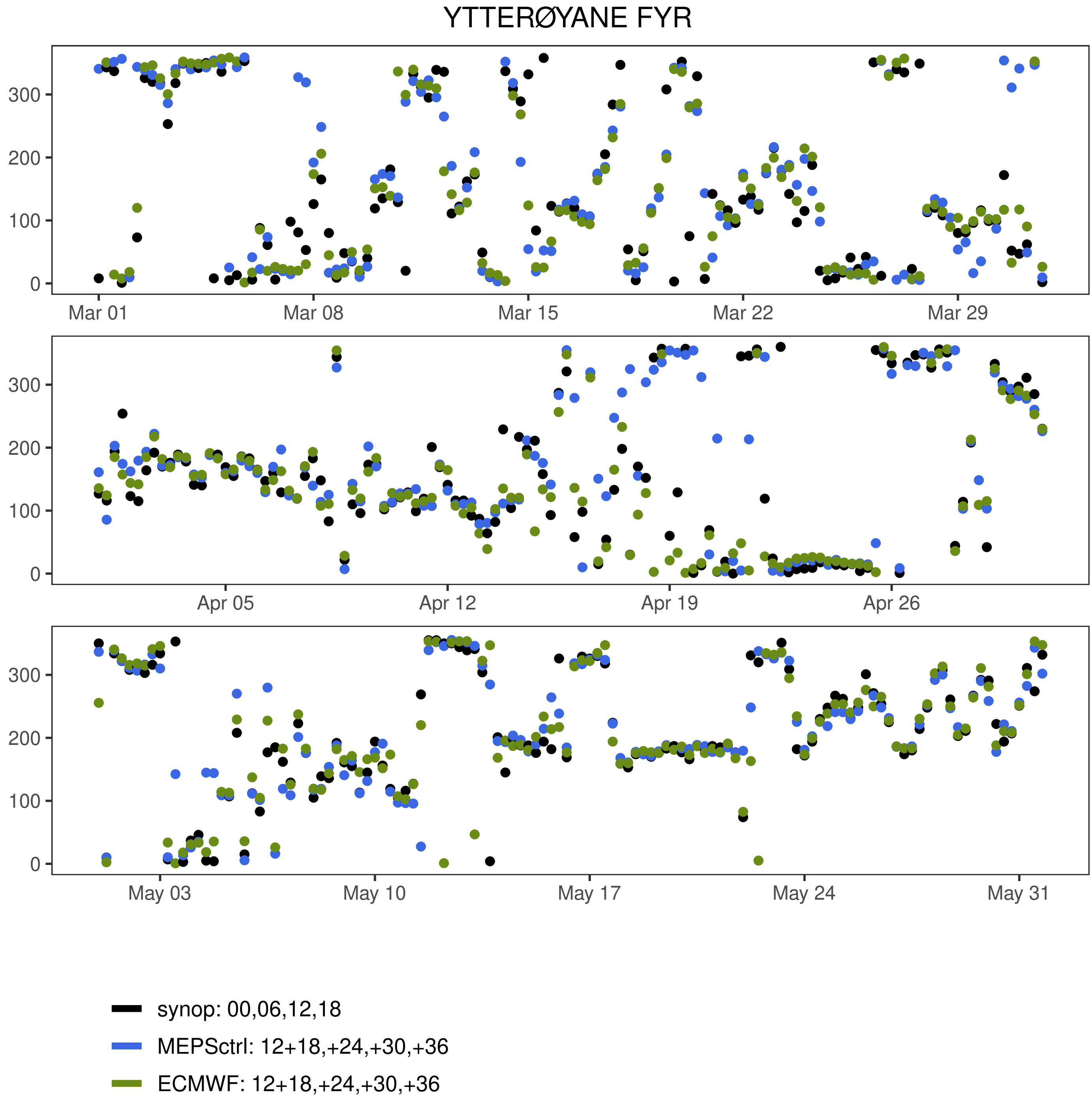

ØRLAND III
300
200
100
0
Mar 01
Mar 08
Mar 15
Mar 22
Mar 29
Apr 05
Apr 12
Apr 19
Apr 26
May 03
May 10
May 17
May 24
May 31

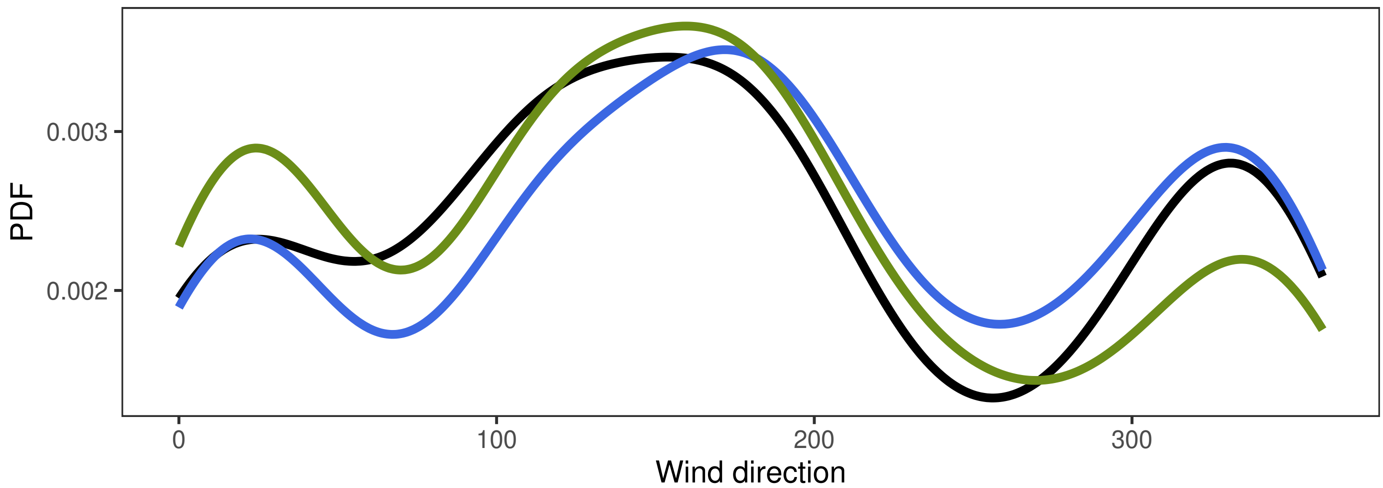

synop: 00,06,12,18
MEPSctrl: 12+18,+24,+30,+36
ECMWF: 12+18,+24,+30,+36
PDF
0.004
0.003
0.002
0.001
0
100
200
300
Wind direction

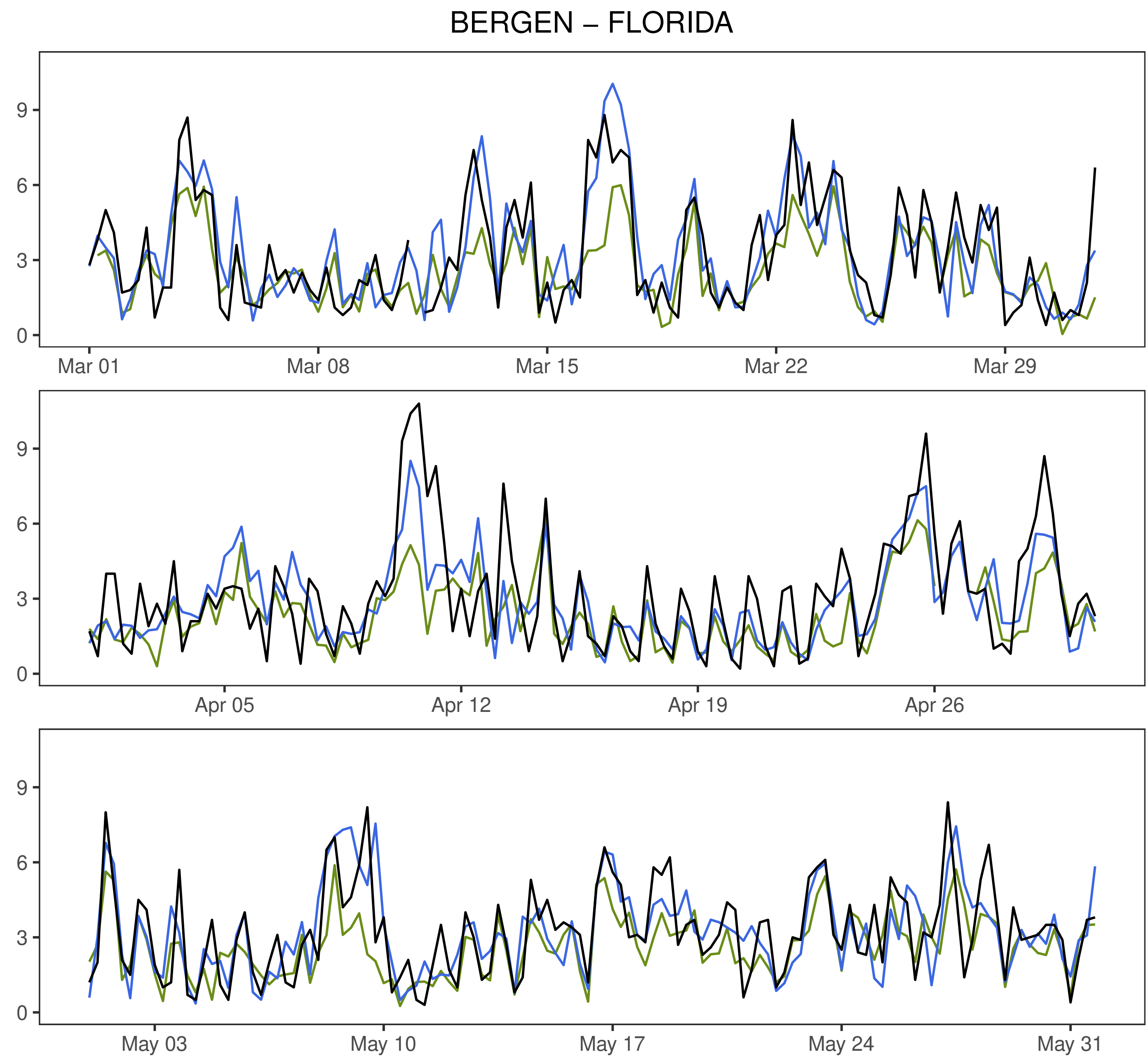


	Min	Mean	Max	Std	N
synop: 00,06,12,18	0.0	6.0	18.5	3.8	368
MEPSctrl: 12+18,+24,+30,+36	0.5	7.1	17.9	3.7	368
ECMWF: 12+18,+24,+30,+36	0.4	6.8	16.8	3.6	363

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl−synop	1.1	3.1	3.3	2.4	11.3	363
ECMWF−synop	0.8	3.0	3.1	2.2	11.6	363

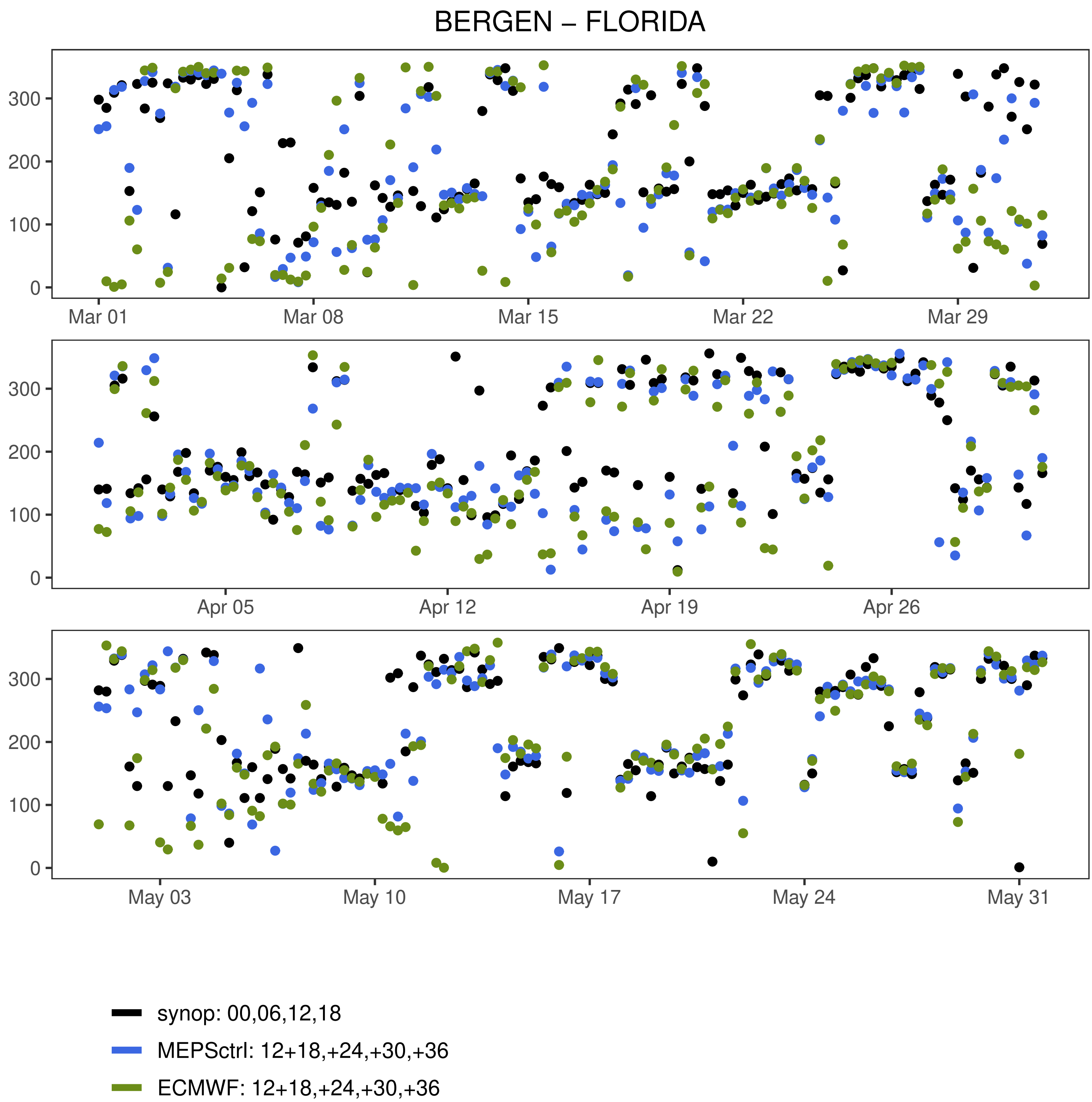

YTTERØYANE FYR
0
100
200
300
Mar 01
Mar 08
Mar 15
Mar 22
Mar 29
Apr 05
Apr 12
Apr 19
Apr 26
May 03
May 10
May 17
May 24
May 31
synop: 00,06,12,18
MEPSctrl: 12+18,+24,+30,+36
ECMWF: 12+18,+24,+30,+36

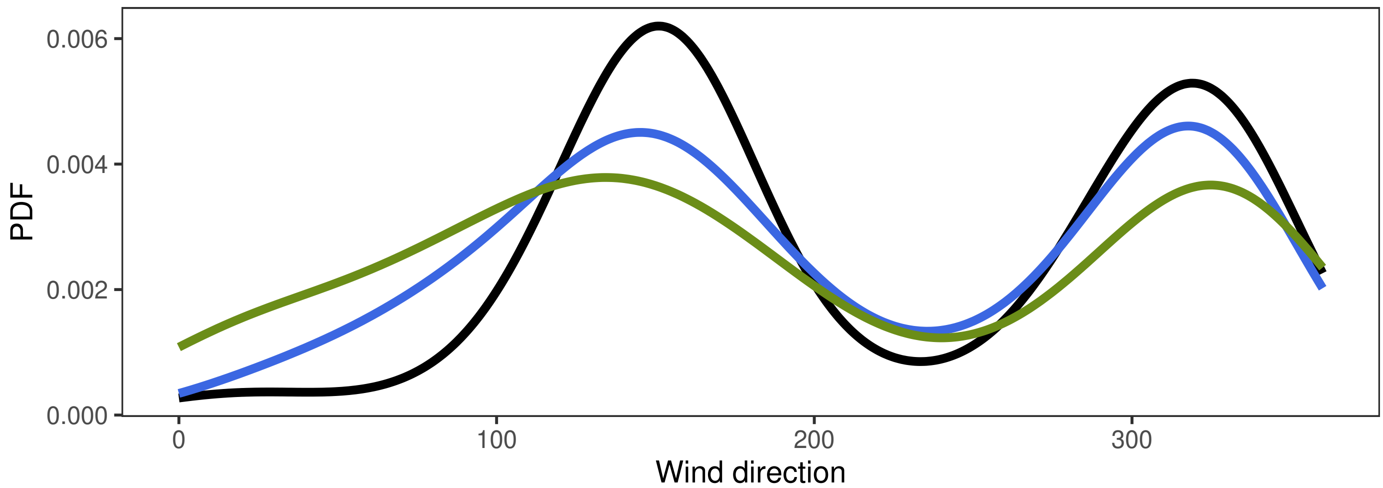

PDF
0.002
0.003
0
100
200
300
Wind direction

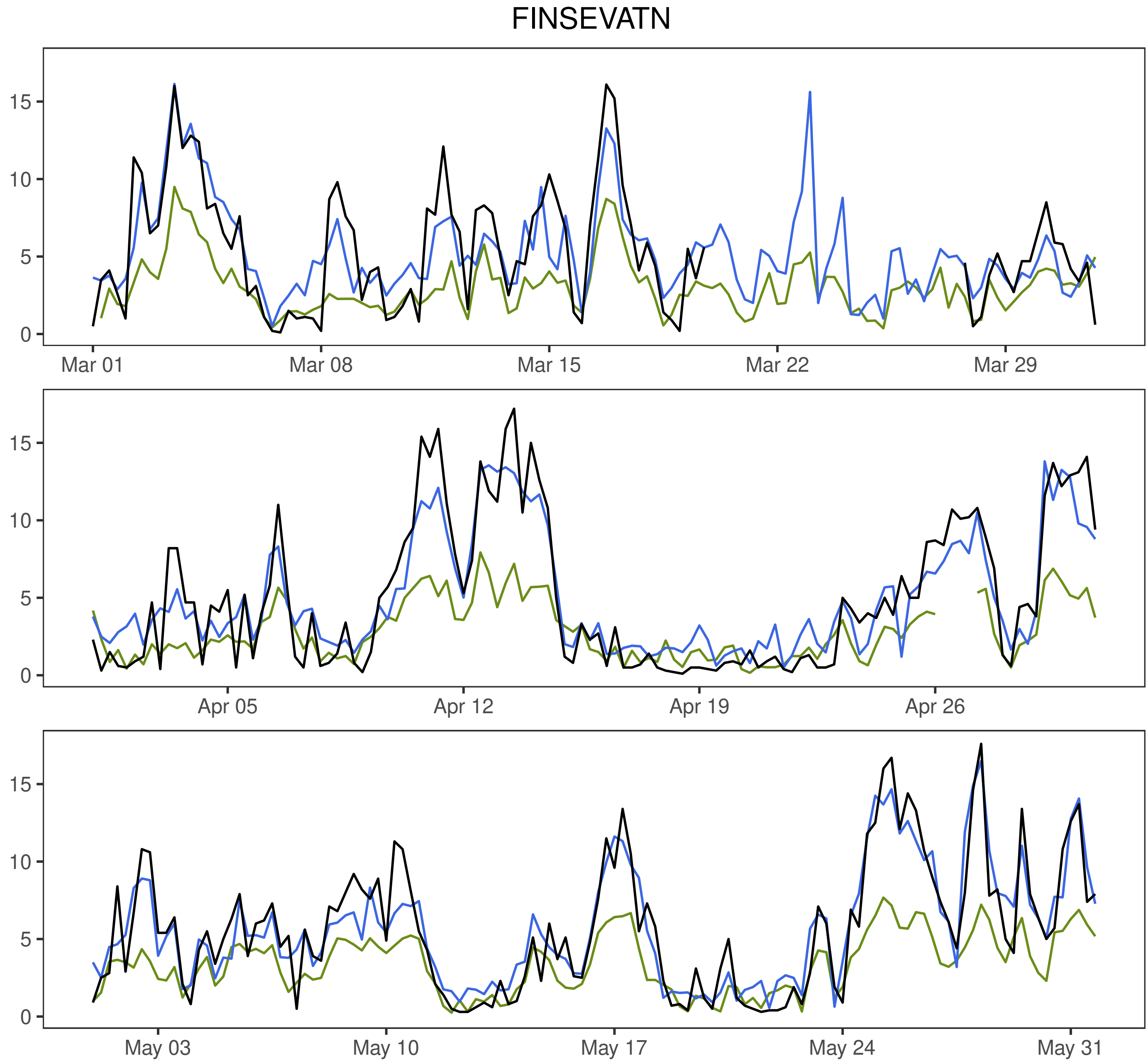


	Min	Mean	Max	Std	N
synop: 00,06,12,18	0.2	3.2	10.8	2.1	367
MEPSctrl: 12+18,+24,+30,+36	0.4	3.1	10.0	1.8	368
ECMWF: 12+18,+24,+30,+36	0.0	2.5	6.3	1.3	363

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl–synop	–0.1	1.4	1.4	1.1	4.7	362
ECMWF–synop	–0.7	1.5	1.6	1.2	6.4	362

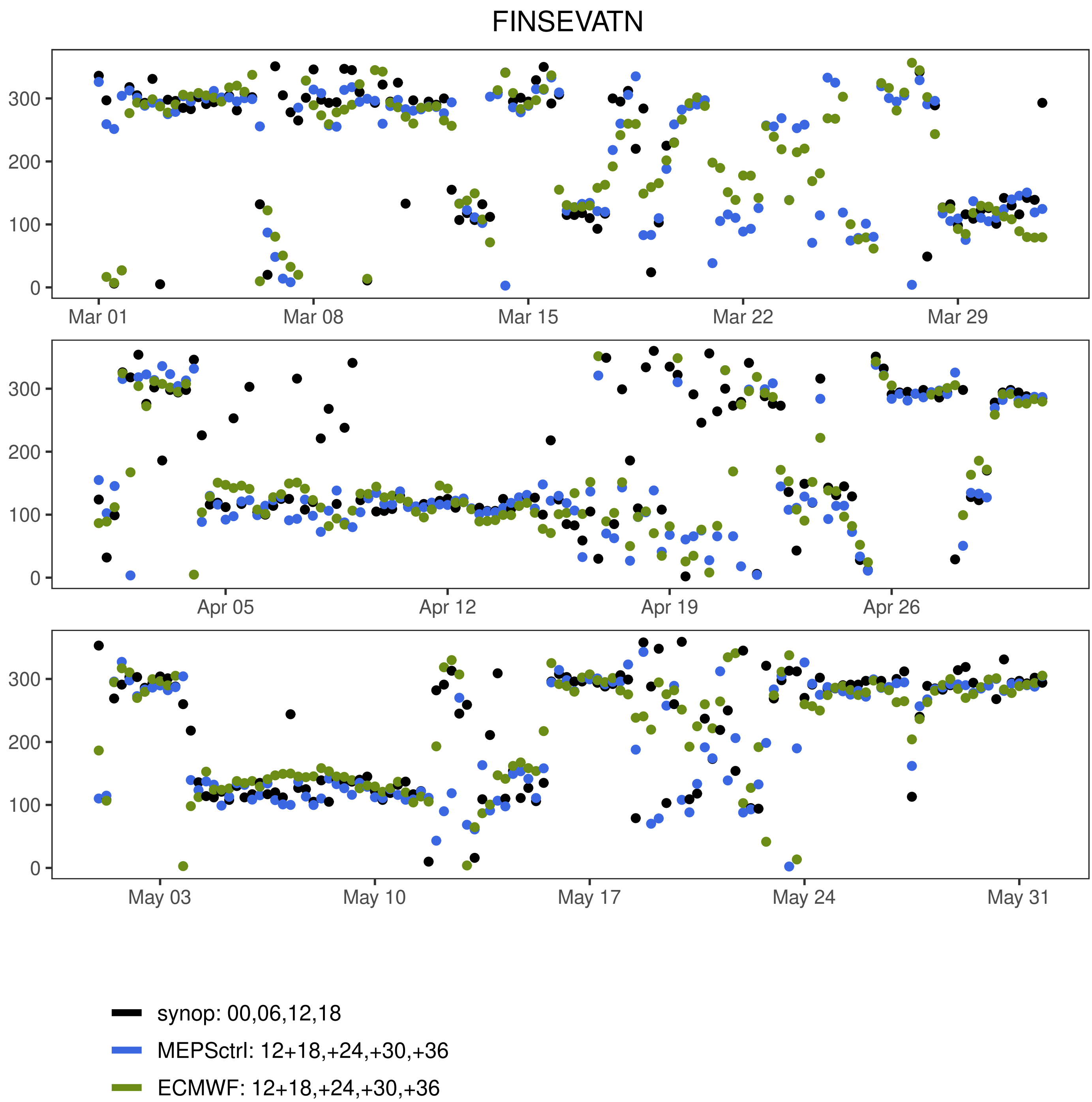

BERGEN – FLORIDA
300
200
100
0
Mar 01
Mar 08
Mar 15
Mar 22
Mar 29
Apr 05
Apr 12
Apr 19
Apr 26
May 03
May 10
May 17
May 24
May 31
synop: 00,06,12,18
MEPSctrl: 12+18,+24,+30,+36
ECMWF: 12+18,+24,+30,+36

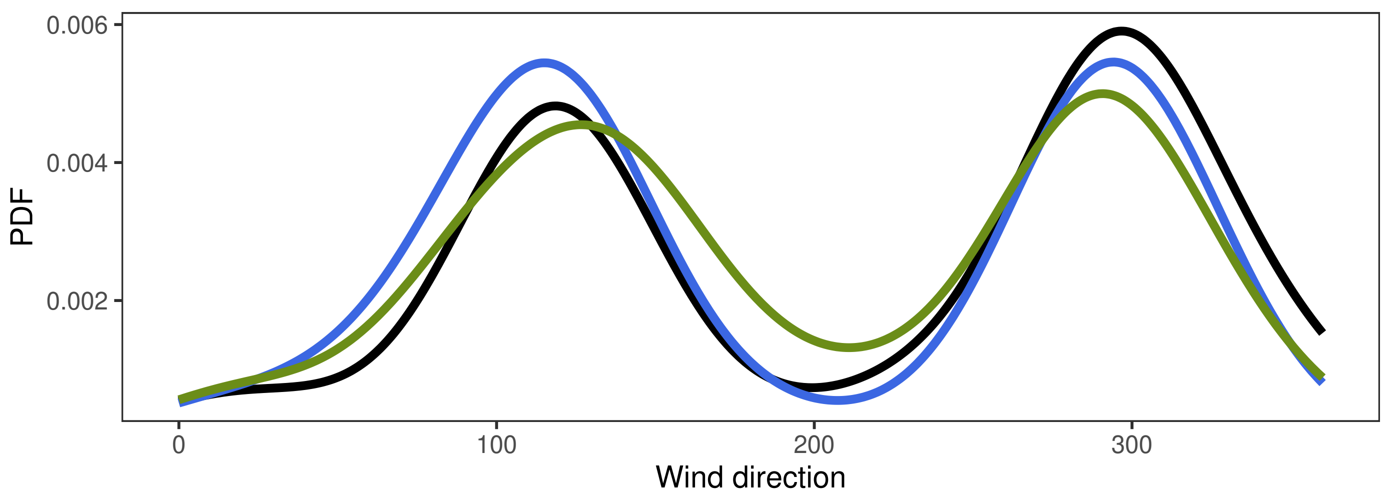

PDF
0.006
0.004
0.002
0.000
0
100
200
300
Wind direction



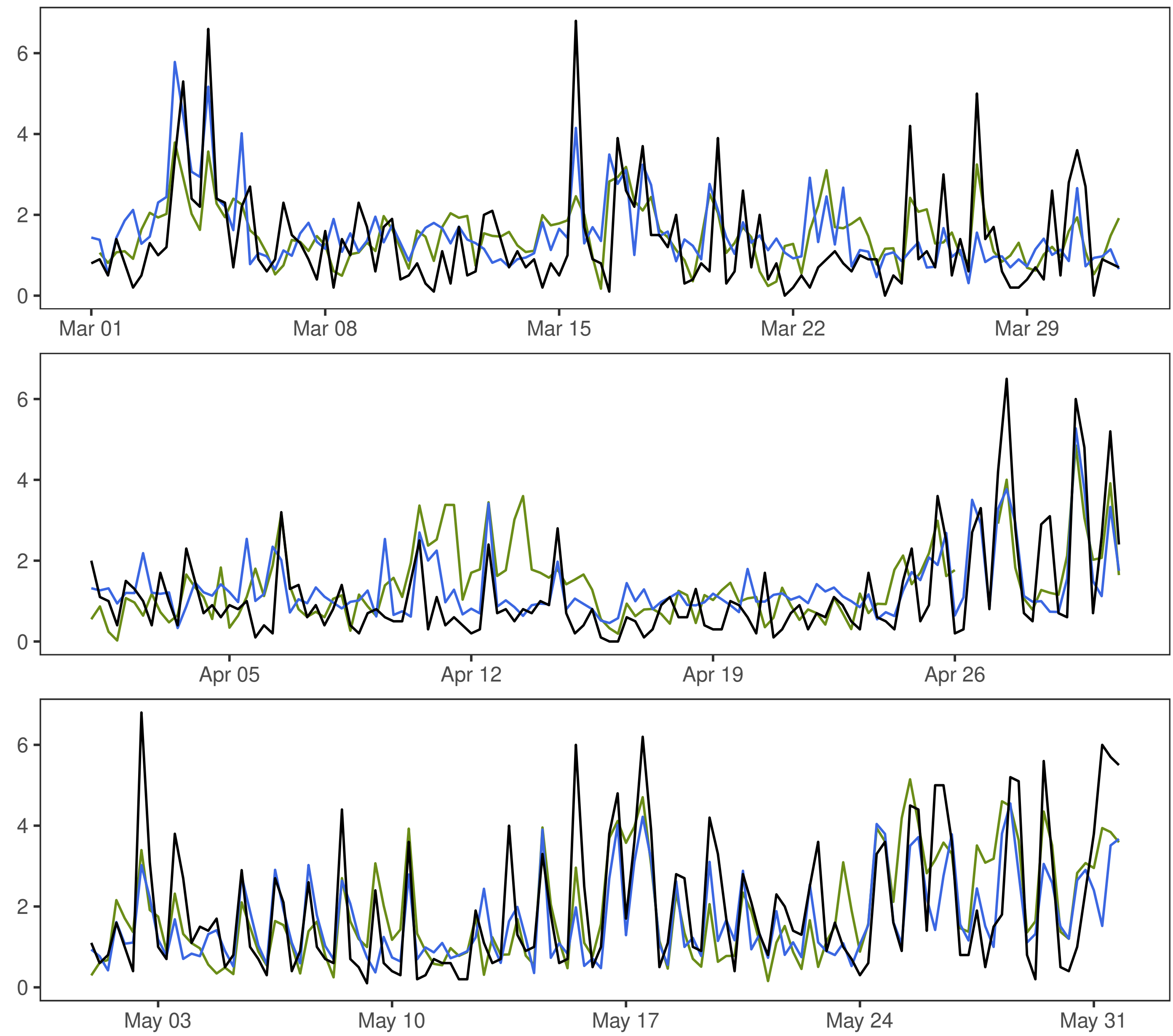
	Min	Mean	Max	Std	N
synop: 00,06,12,18	0.1	5.4	17.6	4.3	337
MEPSctrl: 12+18,+24,+30,+36	0.5	5.3	16.5	3.5	368
ECMWF: 12+18,+24,+30,+36	0.2	3.1	9.5	1.9	363

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl–synop	0.0	1.9	1.9	1.5	5.8	332
ECMWF–synop	–2.2	2.8	3.6	2.6	10.8	332


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

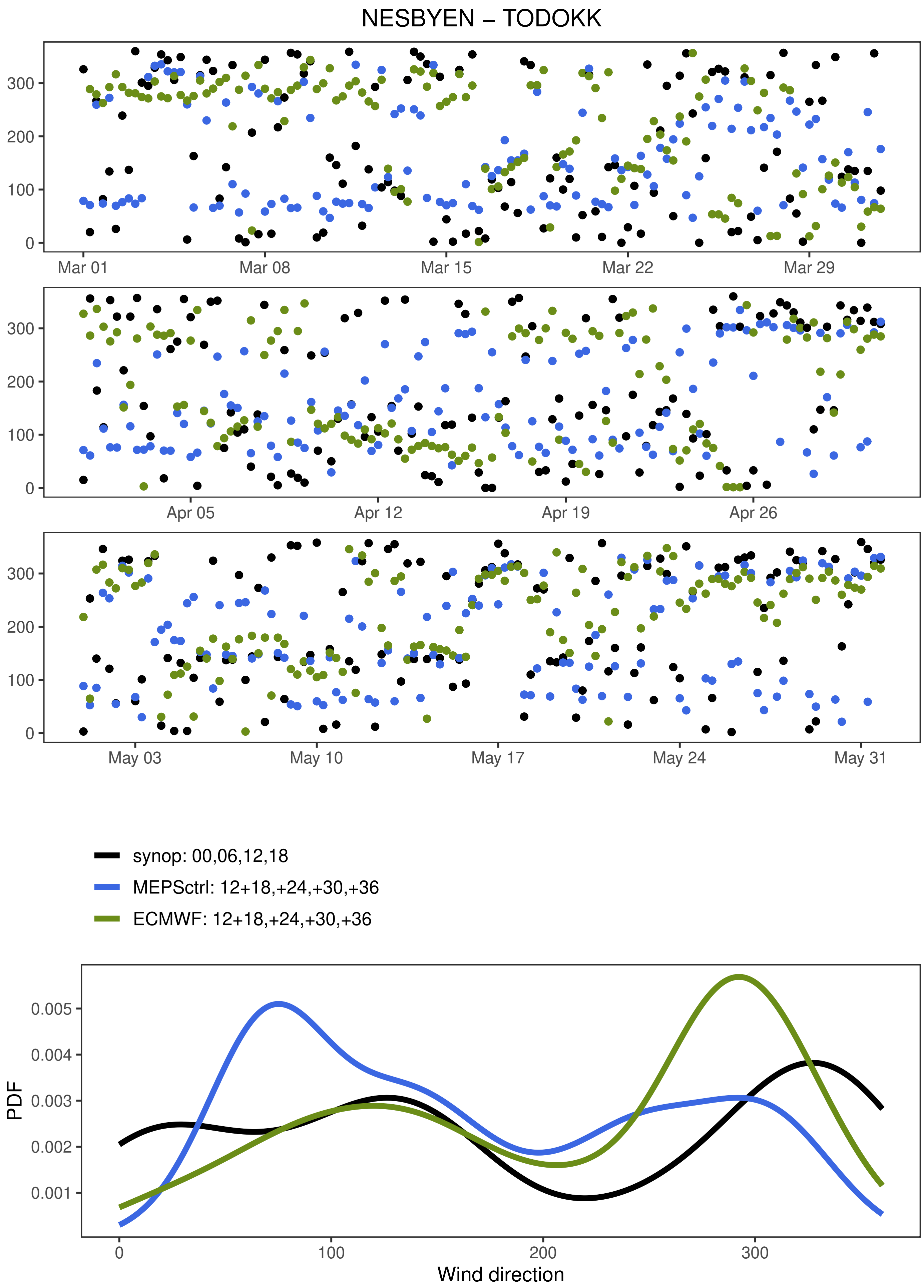

0.006
0.004
0.002
PDF
0
100
200
300
Wind direction

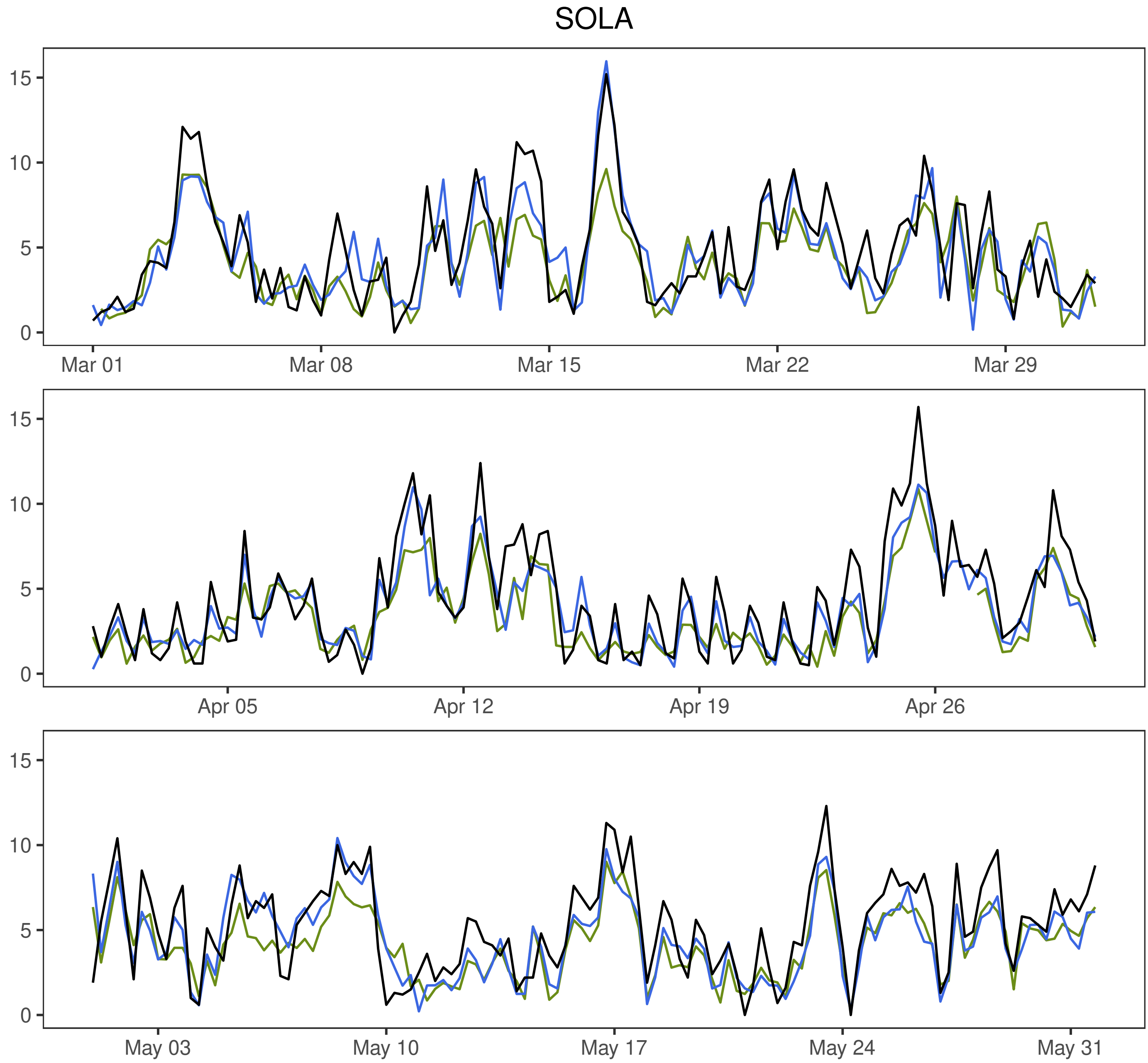
NESBYEN – TODOKK



	Min	Mean	Max	Std	N
synop: 00,06,12,18	0.0	1.5	6.8	1.4	368
MEPSctrl: 12+18,+24,+30,+36	0.3	1.5	5.8	0.9	368
ECMWF: 12+18,+24,+30,+36	0.0	1.6	5.1	1.0	363

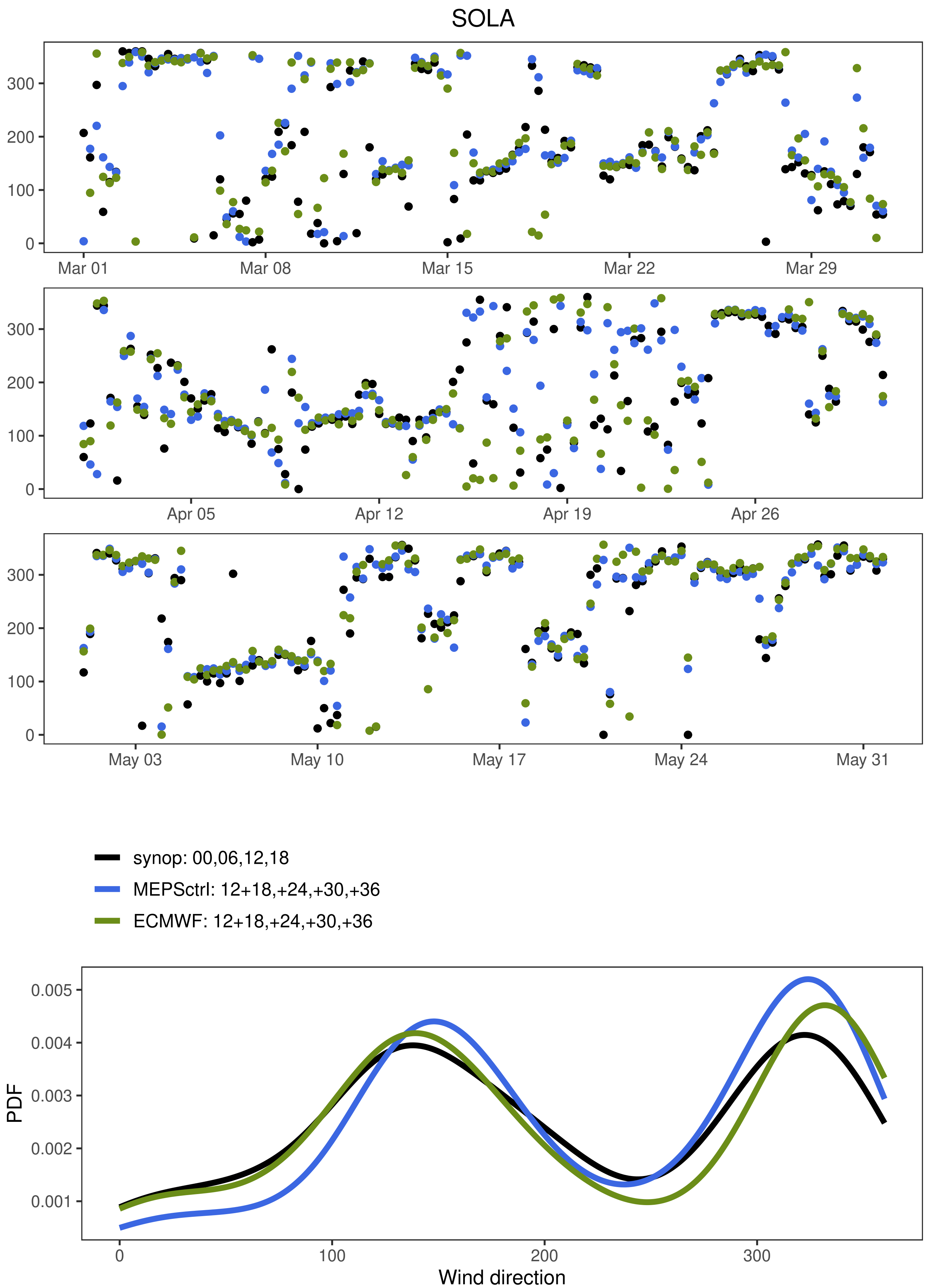
	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl–synop	0.0	1.1	1.1	0.8	4.5	363
ECMWF–synop	0.1	1.1	1.1	0.8	4.3	363

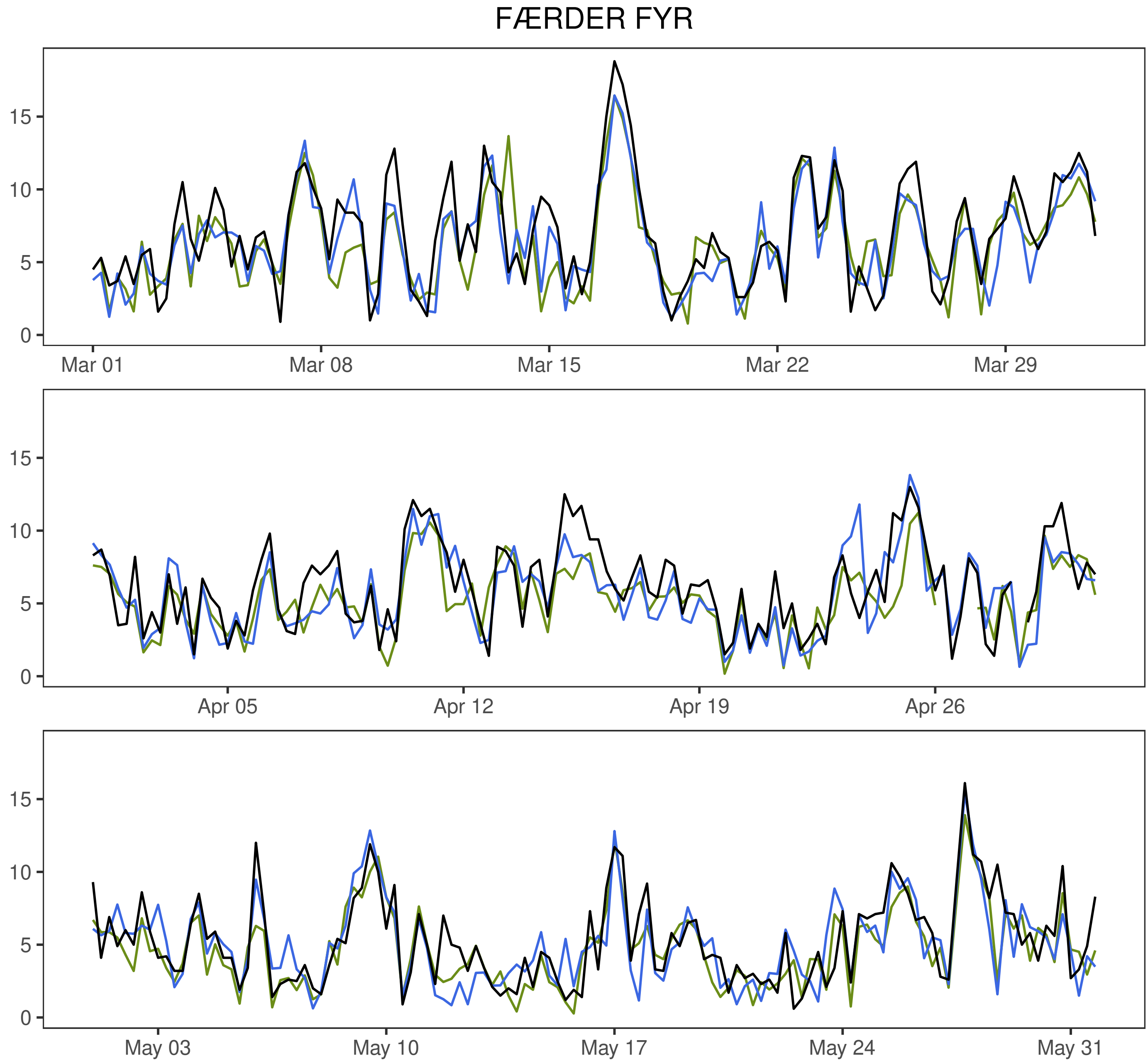

NESBYEN – TODOKK
300
200
100
0
Mar 01
Mar 08
Mar 15
Mar 22
Mar 29
Apr 05
Apr 12
Apr 19
Apr 26
May 03
May 10
May 17
May 24
May 31
synop: 00,06,12,18
MEPSctrl: 12+18,+24,+30,+36
ECMWF: 12+18,+24,+30,+36
PDF
0.005
0.004
0.003
0.002
0.001
0
100
200
300
Wind direction



	Min	Mean	Max	Std	N
synop: 00,06,12,18	0.0	4.9	15.7	3.0	368
MEPSctrl: 12+18,+24,+30,+36	0.2	4.3	16.0	2.6	368
ECMWF: 12+18,+24,+30,+36	0.2	3.9	10.9	2.2	363

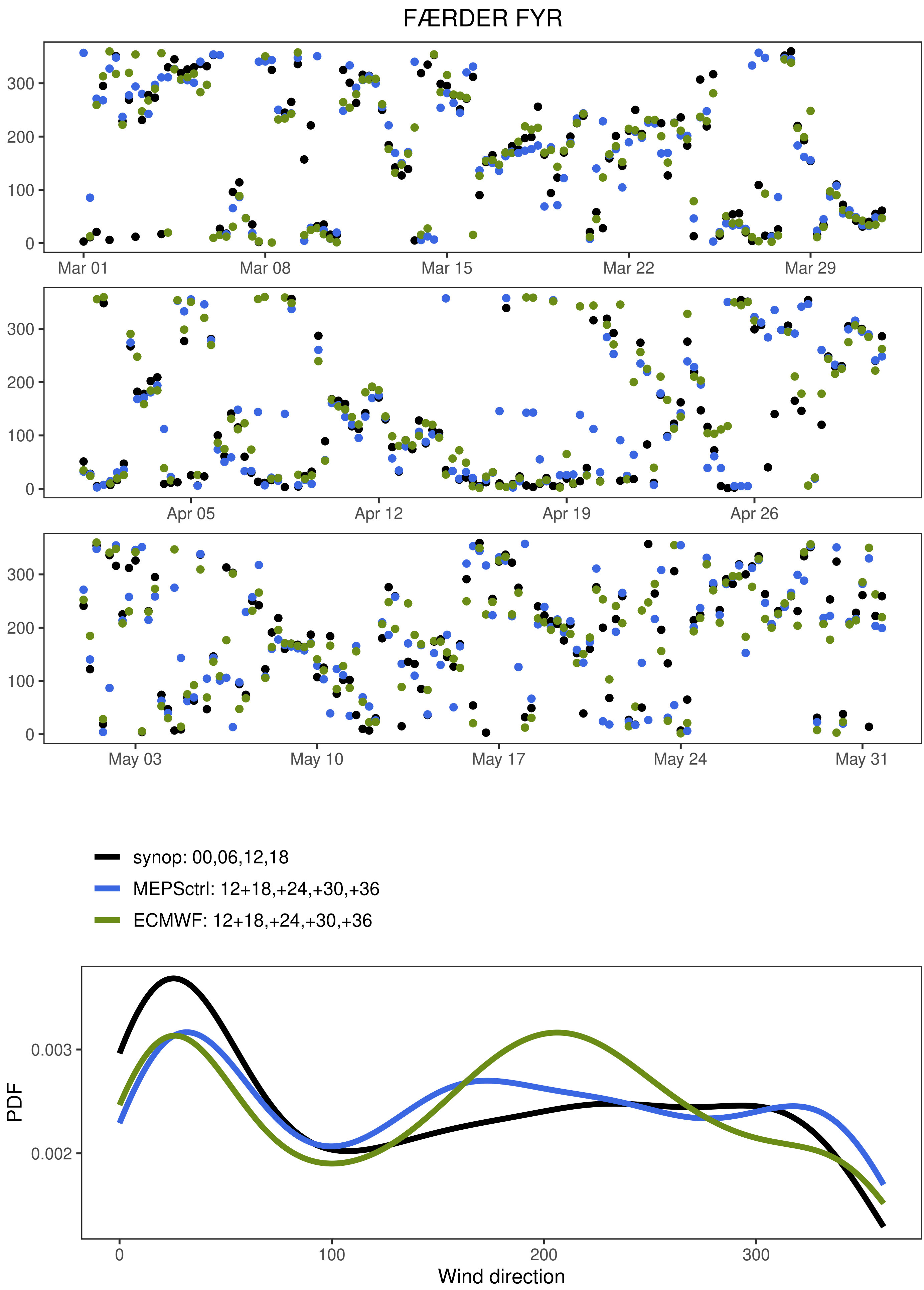
	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl–synop	–0.6	1.5	1.6	1.3	6.4	363
ECMWF–synop	–1.0	1.7	1.9	1.6	5.6	363

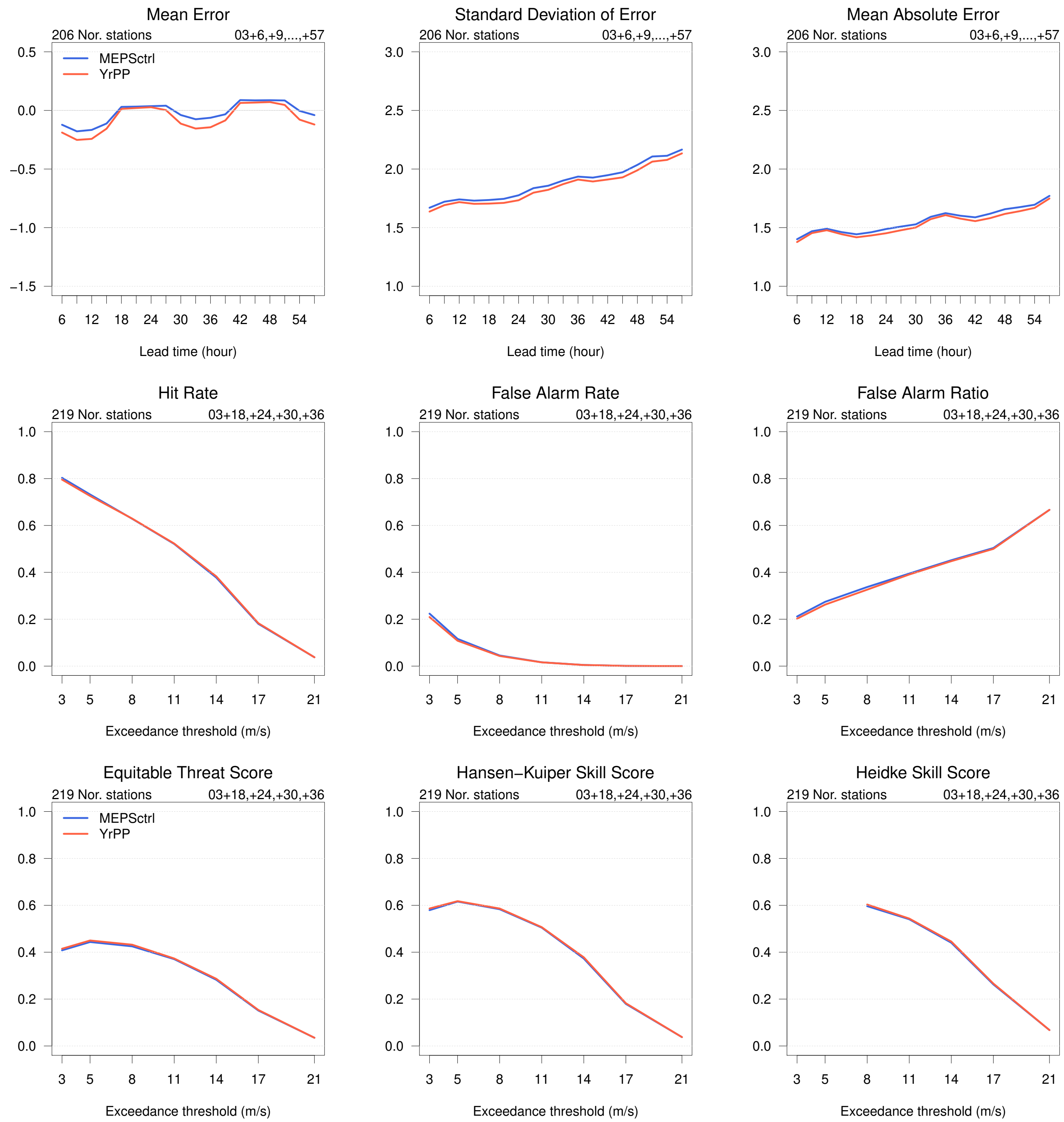

SOLA
300
200
100
0
Mar 01
Mar 08
Mar 15
Mar 22
Mar 29
Apr 05
Apr 12
Apr 19
Apr 26
May 03
May 10
May 17
May 24
May 31
synop: 00,06,12,18
MEPSctrl: 12+18,+24,+30,+36
ECMWF: 12+18,+24,+30,+36
PDF
0.005
0.004
0.003
0.002
0.001
0
100
200
300
Wind direction

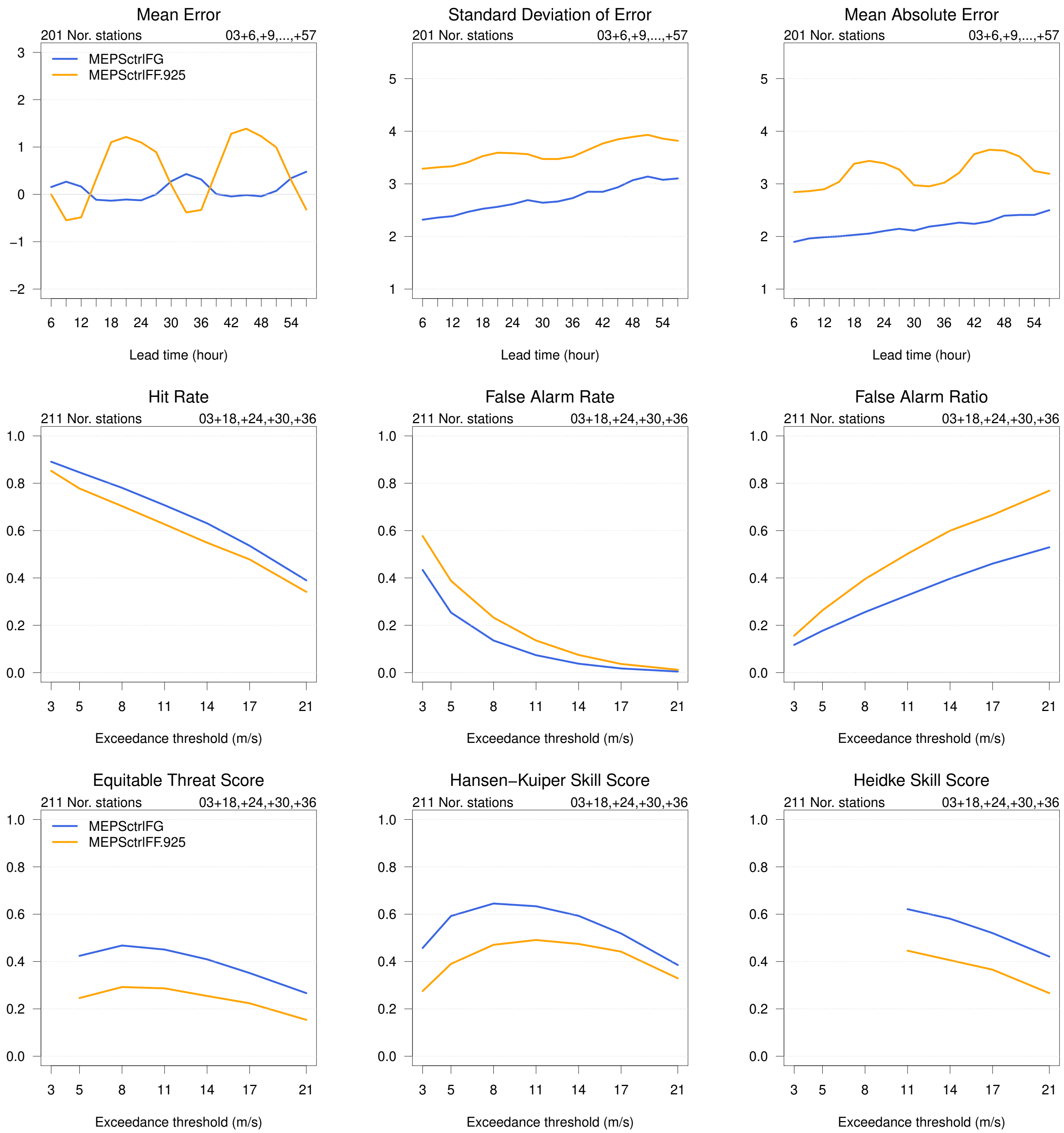


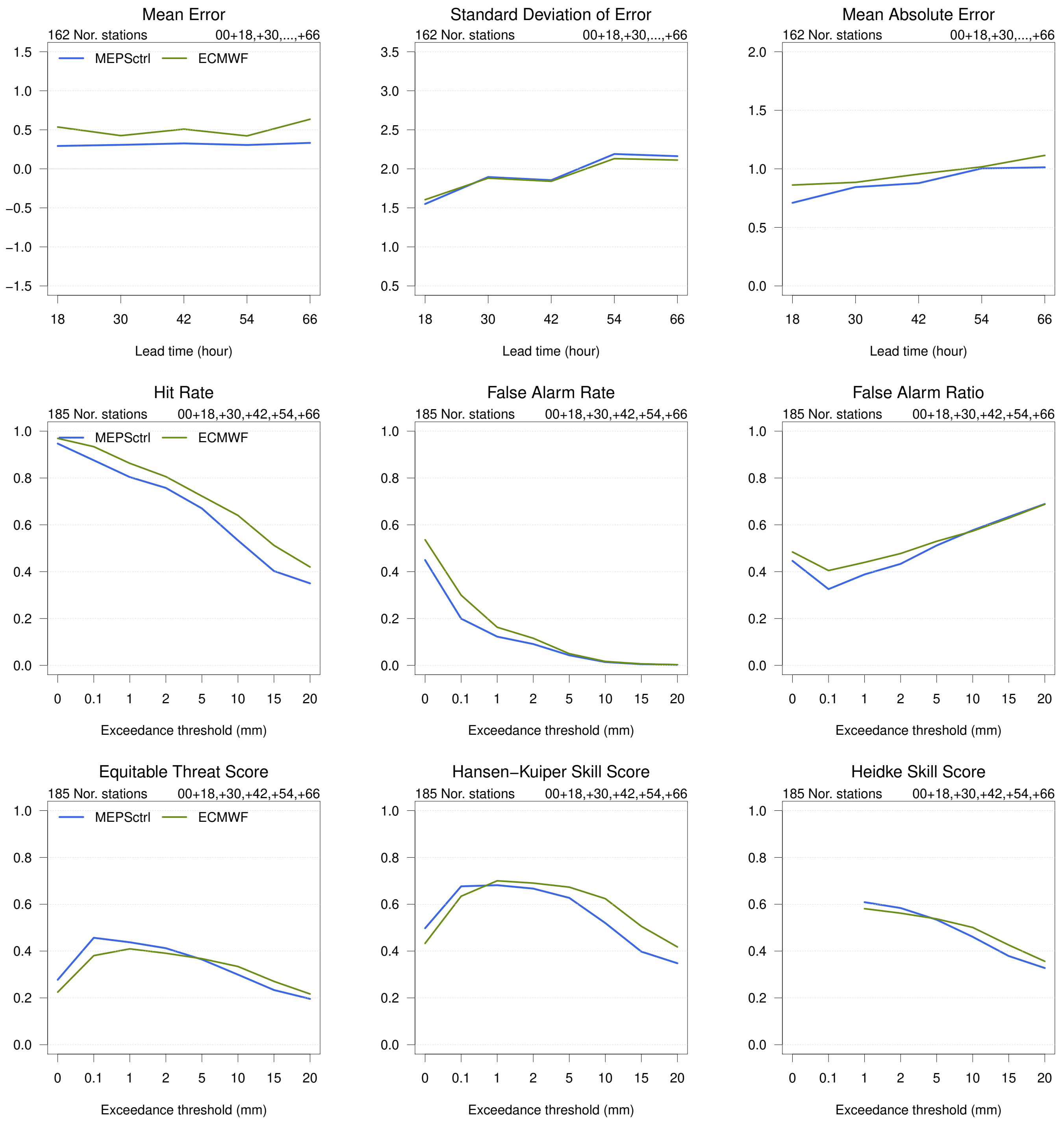
	Min	Mean	Max	Std	N
synop: 00,06,12,18	0.6	6.2	18.8	3.2	367
MEPSctrl: 12+18,+24,+30,+36	0.6	5.7	16.4	3.0	368
ECMWF: 12+18,+24,+30,+36	0.2	5.4	16.4	2.8	363

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl–synop	–0.5	1.9	2.0	1.5	8.9	362
ECMWF–synop	–0.7	1.9	2.0	1.5	9.4	362

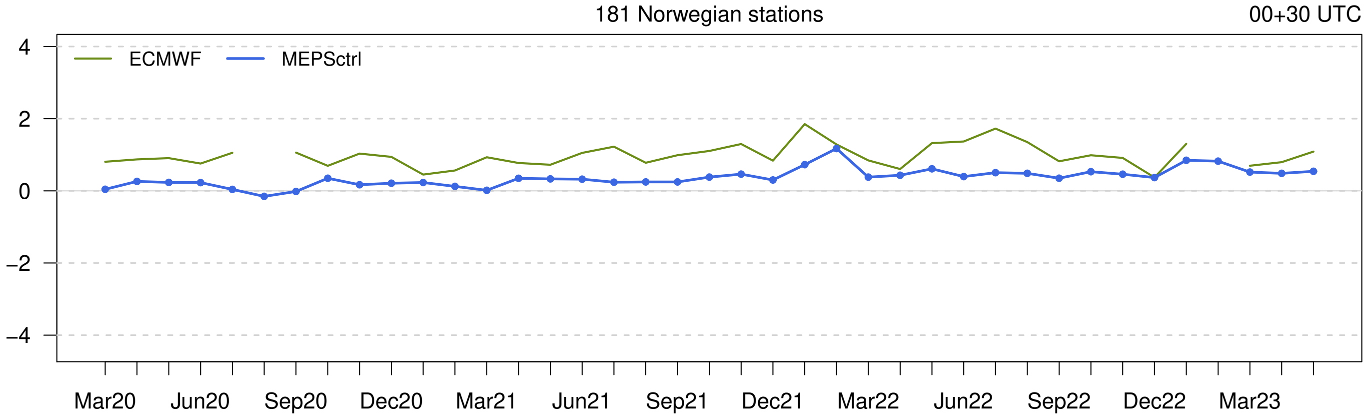

FÆRDER FYR
0
100
200
300
Mar 01
Mar 08
Mar 15
Mar 22
Mar 29
Apr 05
Apr 12
Apr 19
Apr 26
May 03
May 10
May 17
May 24
May 31
synop: 00,06,12,18
MEPSctrl: 12+18,+24,+30,+36
ECMWF: 12+18,+24,+30,+36
PDF
0.002
0.003
Wind direction

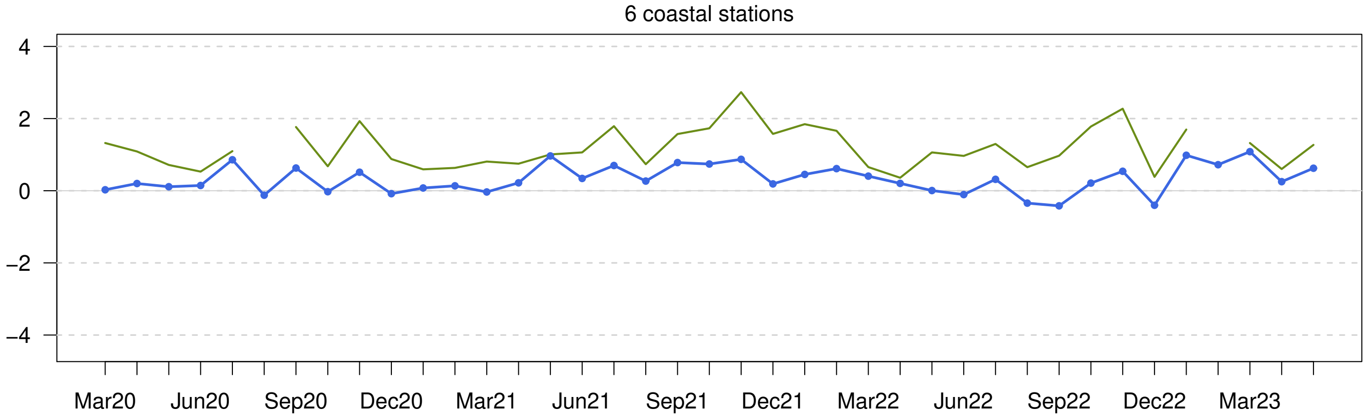

Mean Error
206 Nor. stations
03+6,+9,...,+57
MEPSctrl
YrPP
Lead time (hour)
Standard Deviation of Error
206 Nor. stations
03+6,+9,...,+57
Lead time (hour)
Mean Absolute Error
206 Nor. stations
03+6,+9,...,+57
Lead time (hour)
Hit Rate
219 Nor. stations
03+18,+24,+30,+36
Exceedance threshold (m/s)
False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

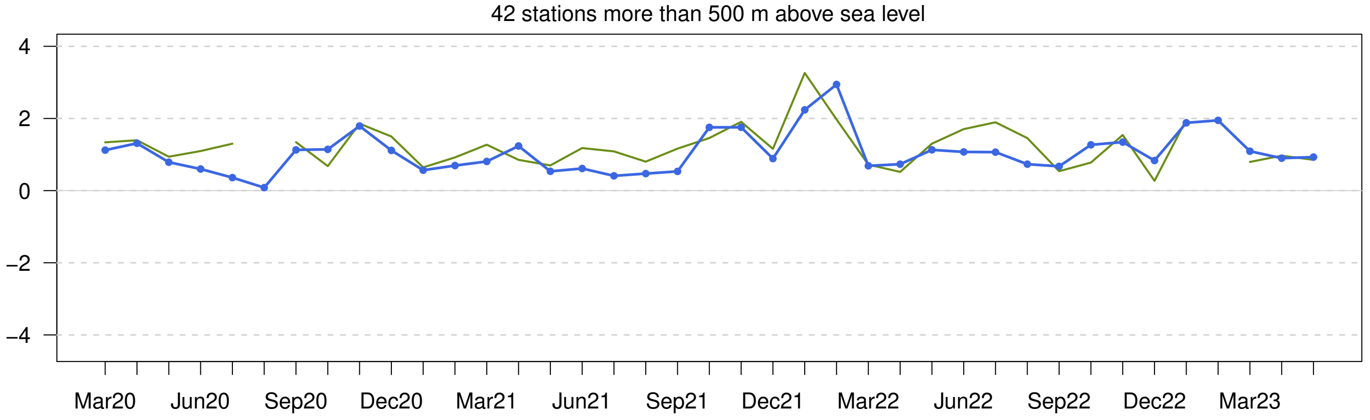

Mean Error
201 Nor. stations
03+6,+9,...,+57
MEPSctrlFG
MEPSctrlFF.925
Lead time (hour)
Standard Deviation of Error
201 Nor. stations
03+6,+9,...,+57
Lead time (hour)
Mean Absolute Error
201 Nor. stations
03+6,+9,...,+57
Lead time (hour)
Hit Rate
211 Nor. stations
03+18,+24,+30,+36
Exceedance threshold (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)

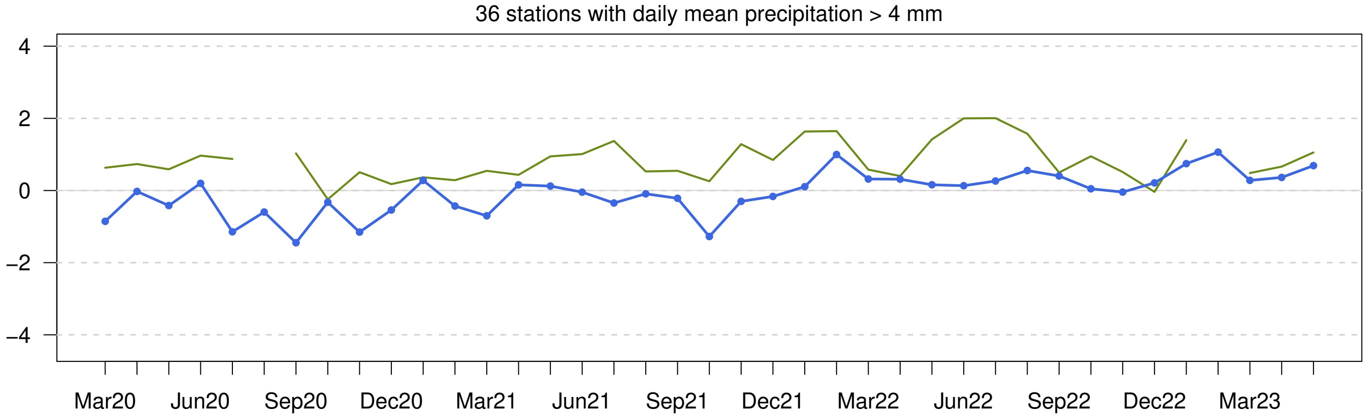

Mean Error
162 Nor. stations
00+18,+30,...,+66
MEPSctrl
ECMWF
Lead time (hour)
Standard Deviation of Error
162 Nor. stations
00+18,+30,...,+66
Lead time (hour)
Mean Absolute Error
162 Nor. stations
00+18,+30,...,+66
Lead time (hour)
Hit Rate
185 Nor. stations
00+18,+30,+42,+54,+66
MEPSctrl
ECMWF
Exceedance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

Mean Error

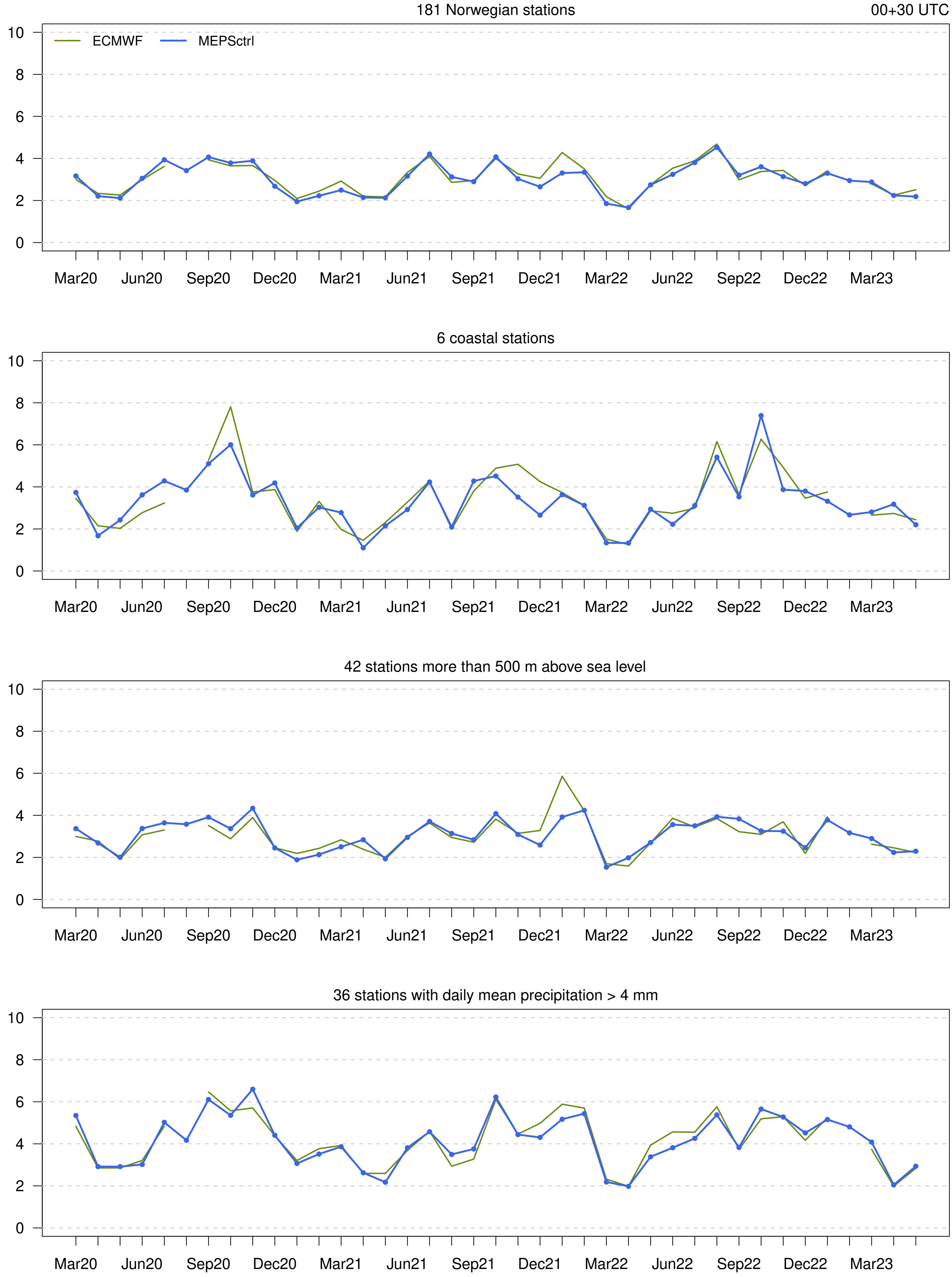

181 Norwegian stations
00+30 UTC
ECMWF
MEPSctrl
4
2
0
−2
−4
Mar20
Jun20
Sep20
Dec20
Mar21
Jun21
Sep21
Dec21
Mar22
Jun22
Sep22
Dec22
Mar23


6 coastal stations
4
2
0
−2
−4
Mar20
Jun20
Sep20
Dec20
Mar21
Jun21
Sep21
Dec21
Mar22
Jun22
Sep22
Dec22
Mar23

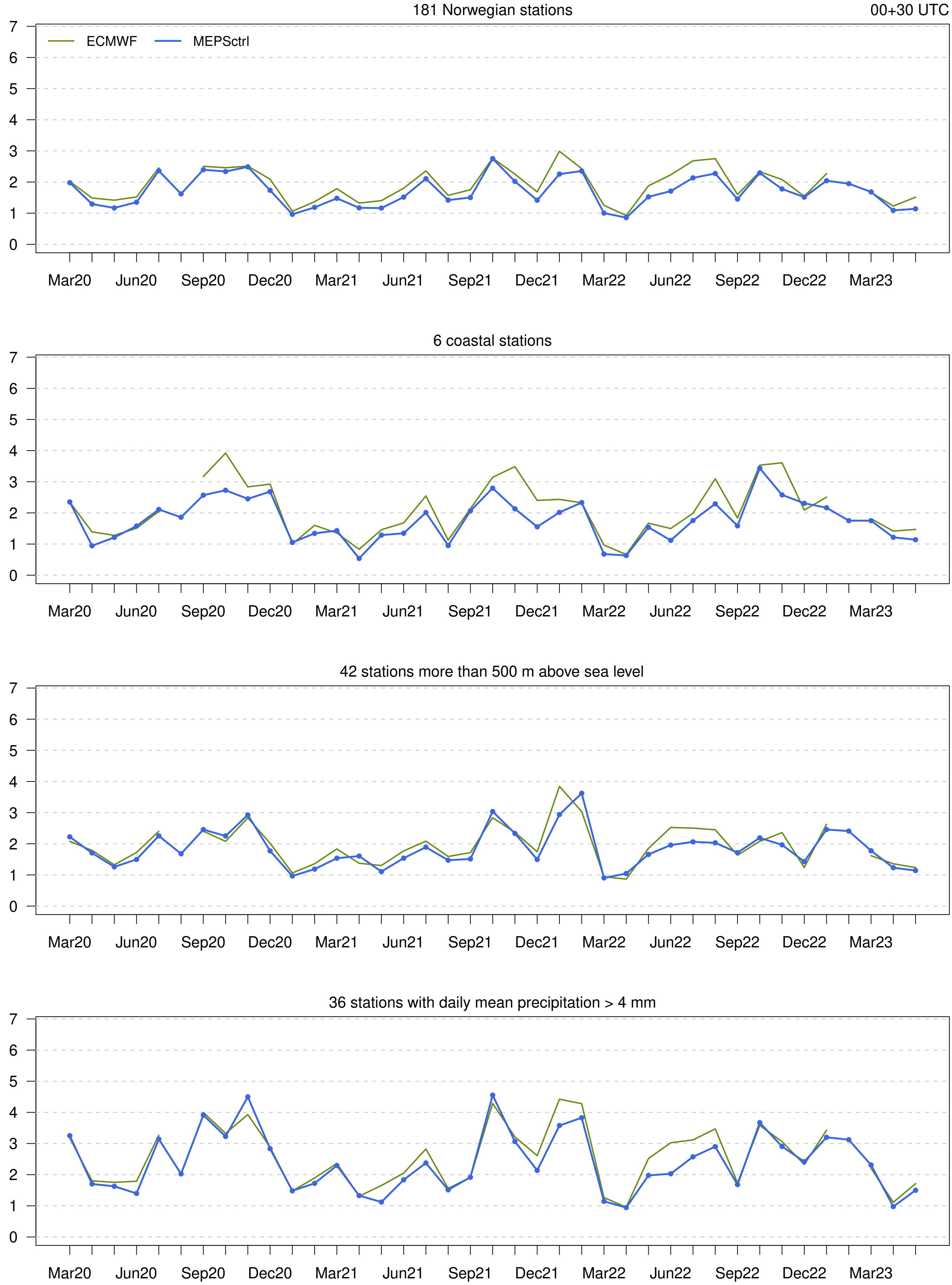

42 stations more than 500 m above sea level
4
2
0
−2
−4
Mar20
Jun20
Sep20
Dec20
Mar21
Jun21
Sep21
Dec21
Mar22
Jun22
Sep22
Dec22
Mar23


36 stations with daily mean precipitation > 4 mm
4
2
0
−2
−4
Mar20
Jun20
Sep20
Dec20
Mar21
Jun21
Sep21
Dec21
Mar22
Jun22
Sep22
Dec22
Mar23

Standard Deviation of Error

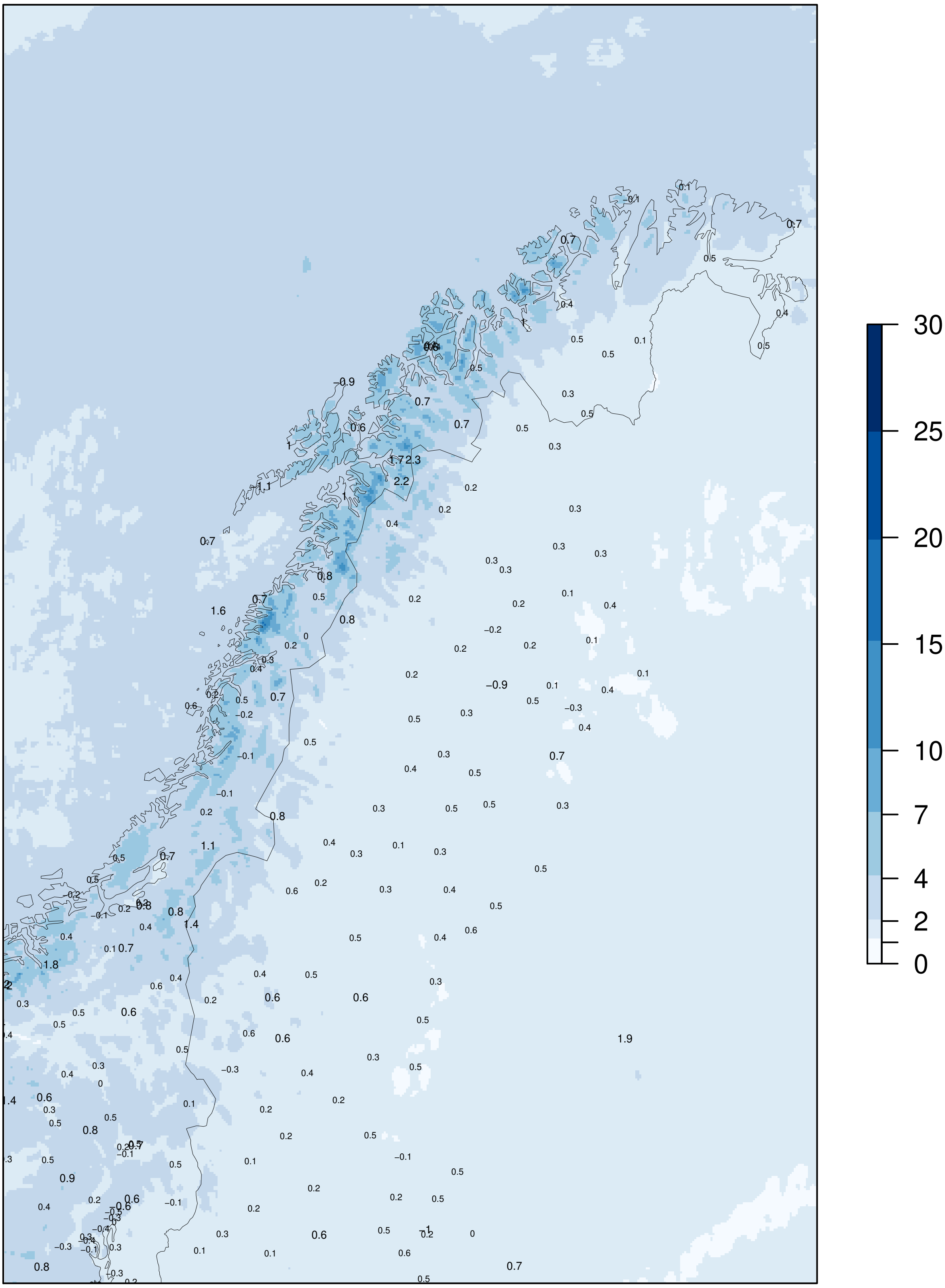


Mean Absolute Error

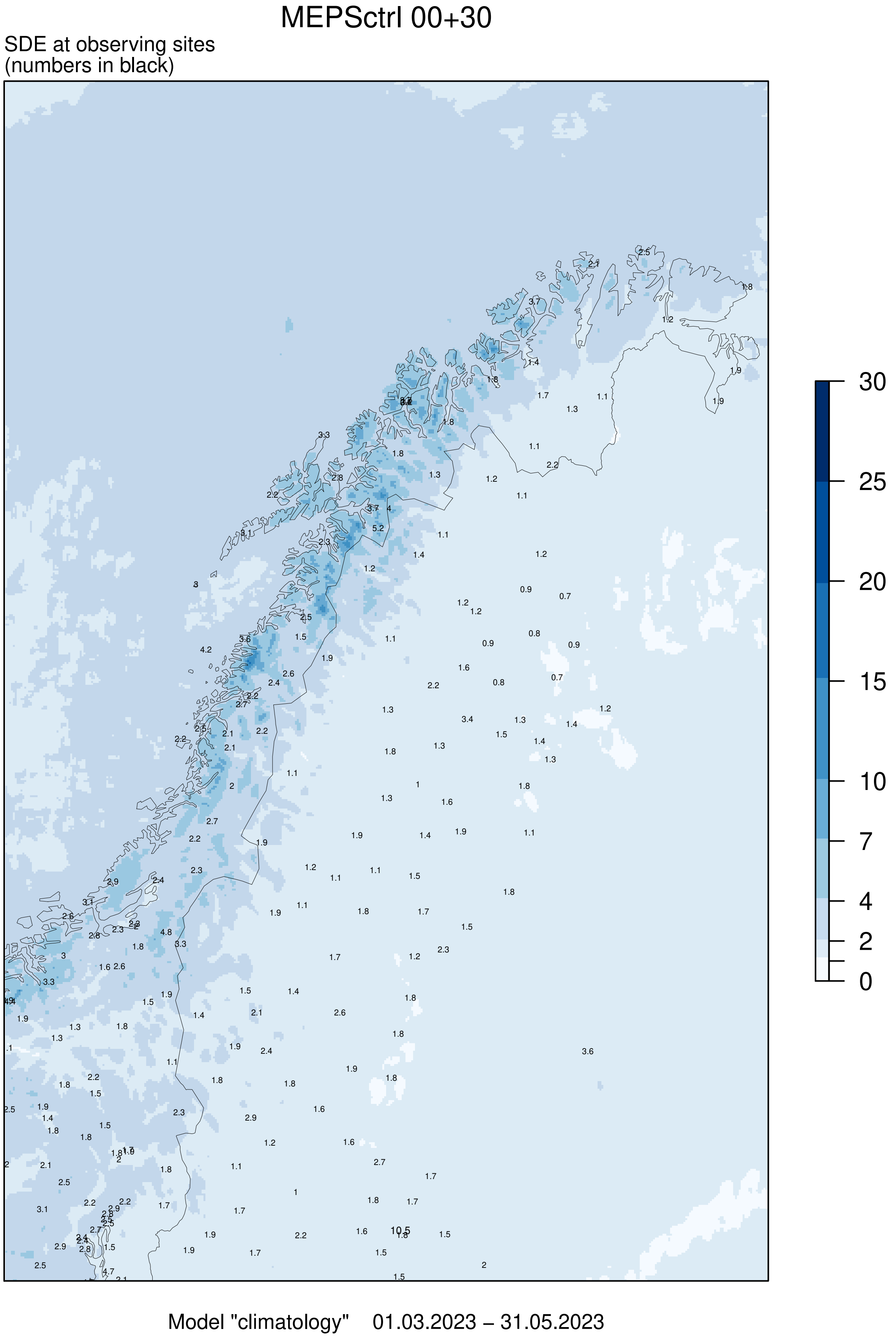


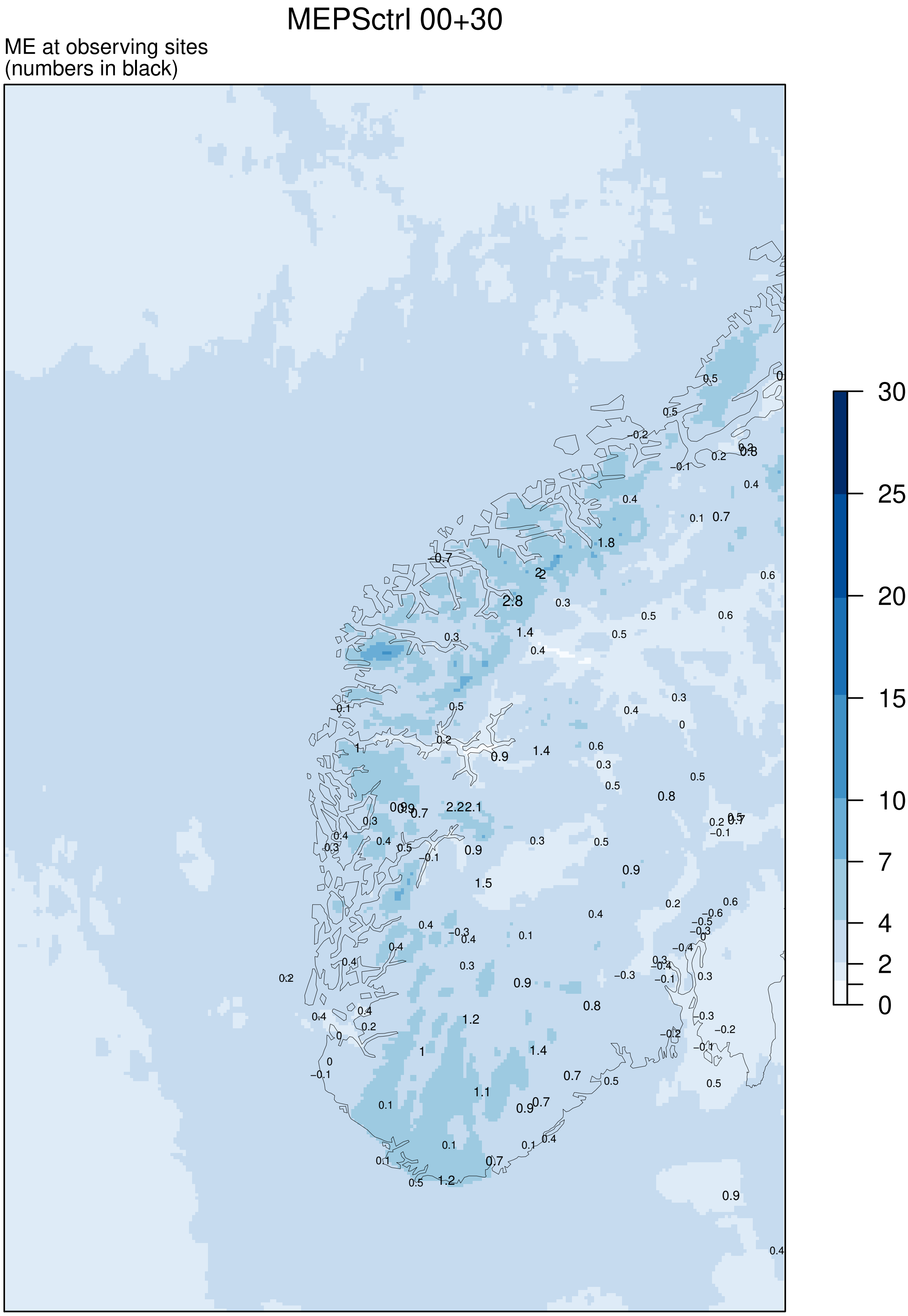
MEPSctrl 00+30

ME at observing sites
(numbers in black)



Model "climatology" 01.03.2023 – 31.05.2023

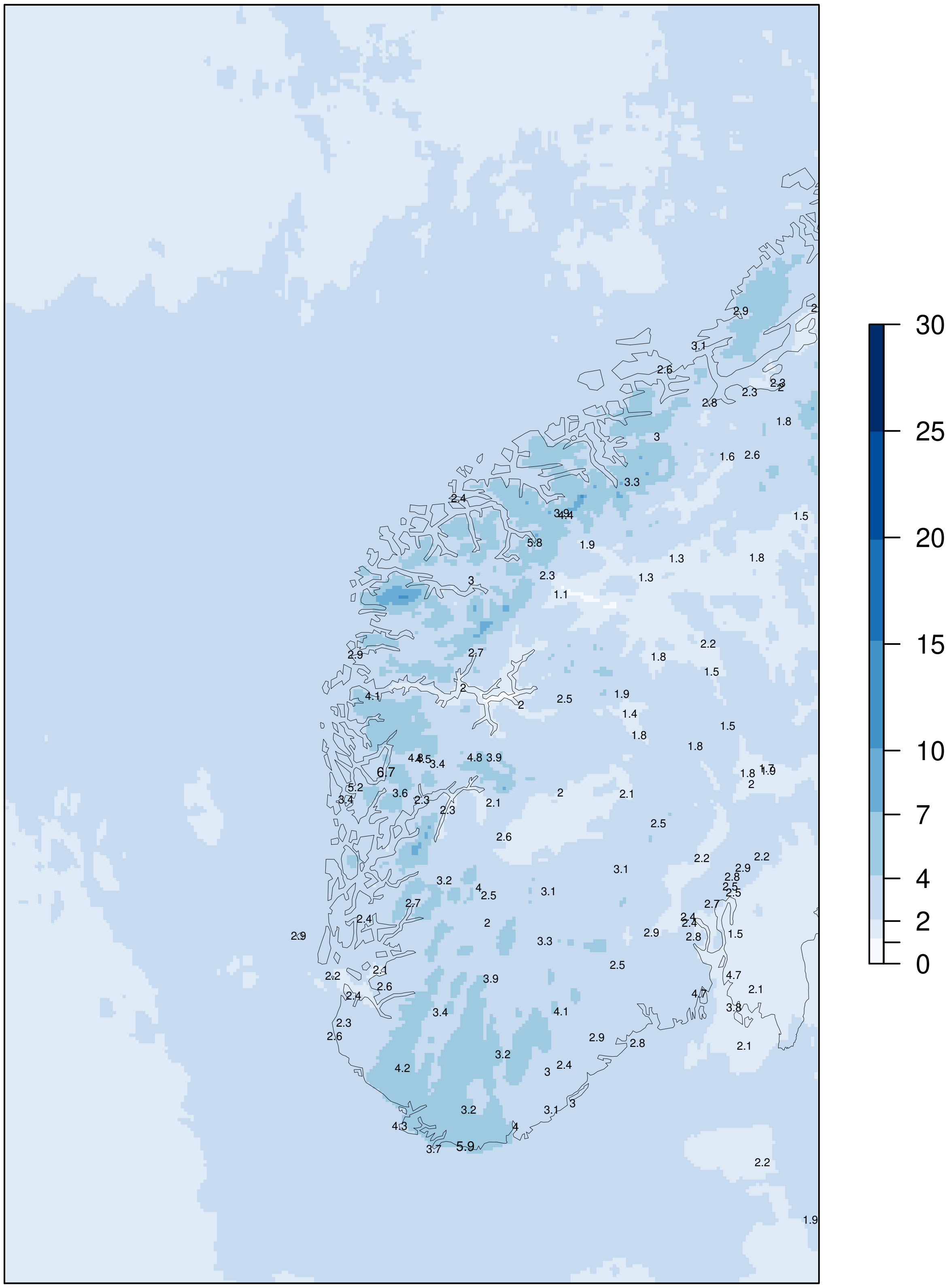

MEPSctrl 00+30
SDE at observing sites
(numbers in black)
30
25
20
15
10
7
4
2
0
Model "climatology" 01.03.2023 – 31.05.2023



Model "climatology" 01.03.2023 – 31.05.2023

MEPSctrl 00+30

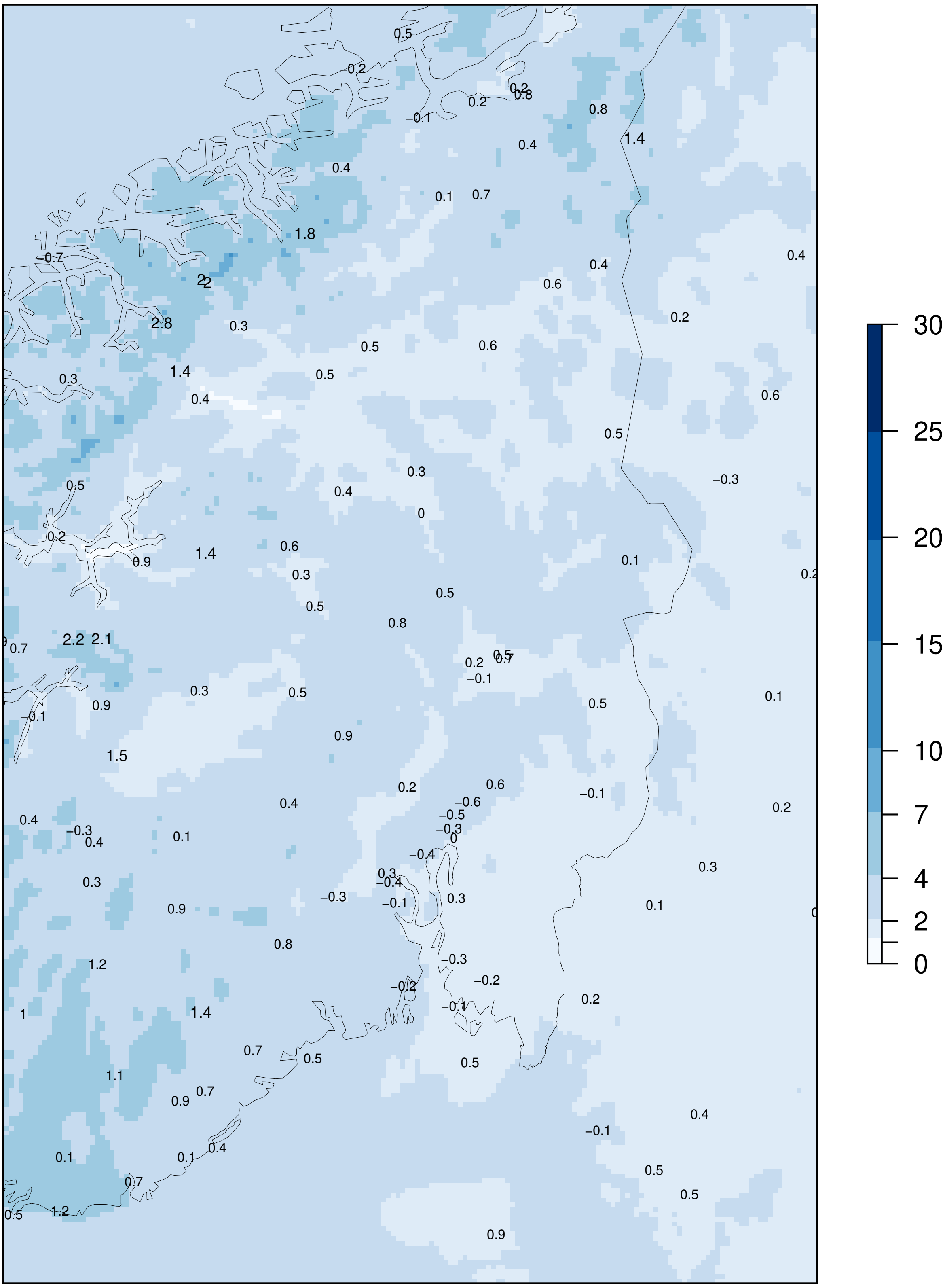
SDE at observing sites
(numbers in black)



Model "climatology"   01.03.2023 – 31.05.2023

MEPSctrl 00+30

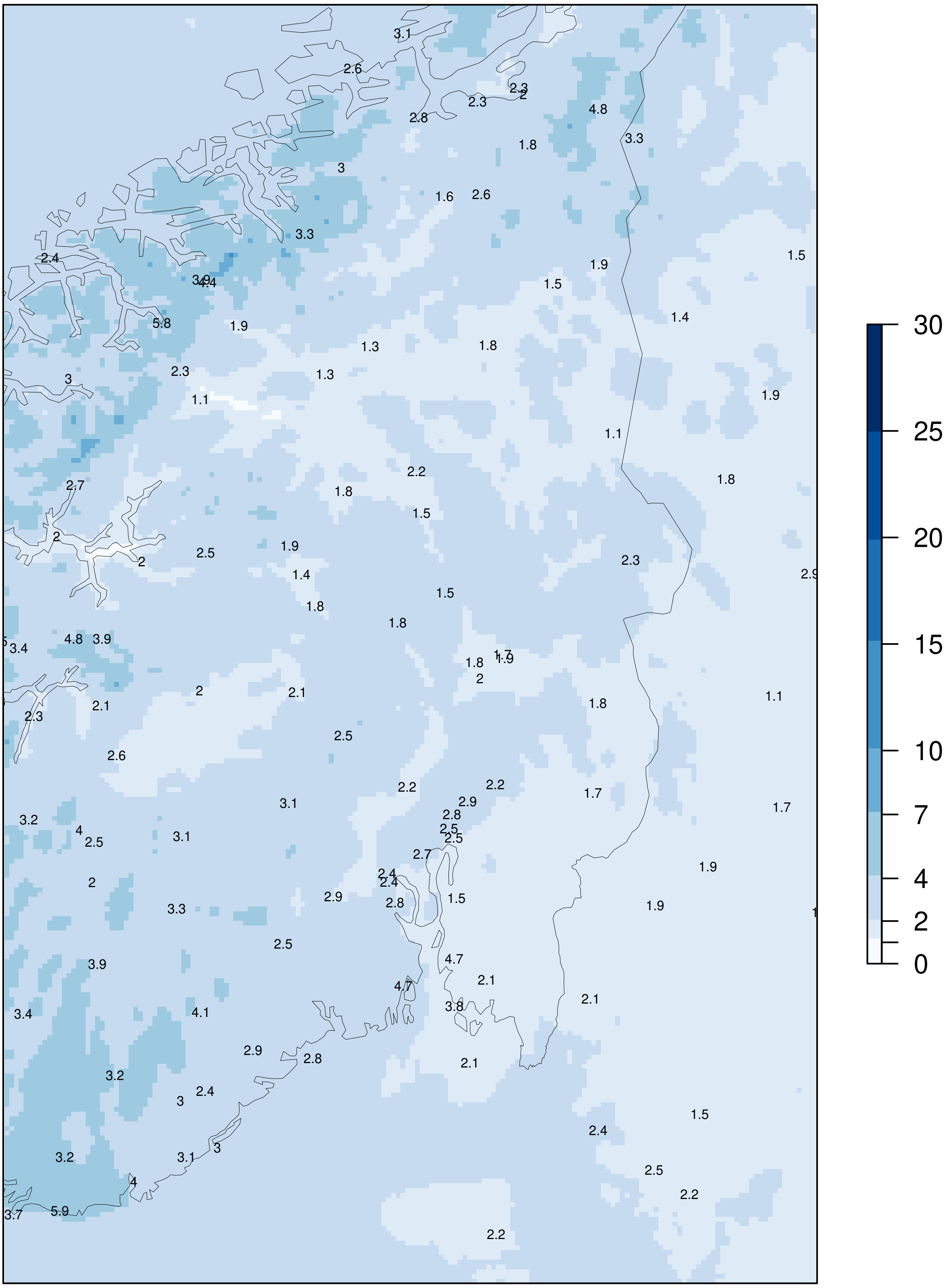
ME at observing sites
(numbers in black)



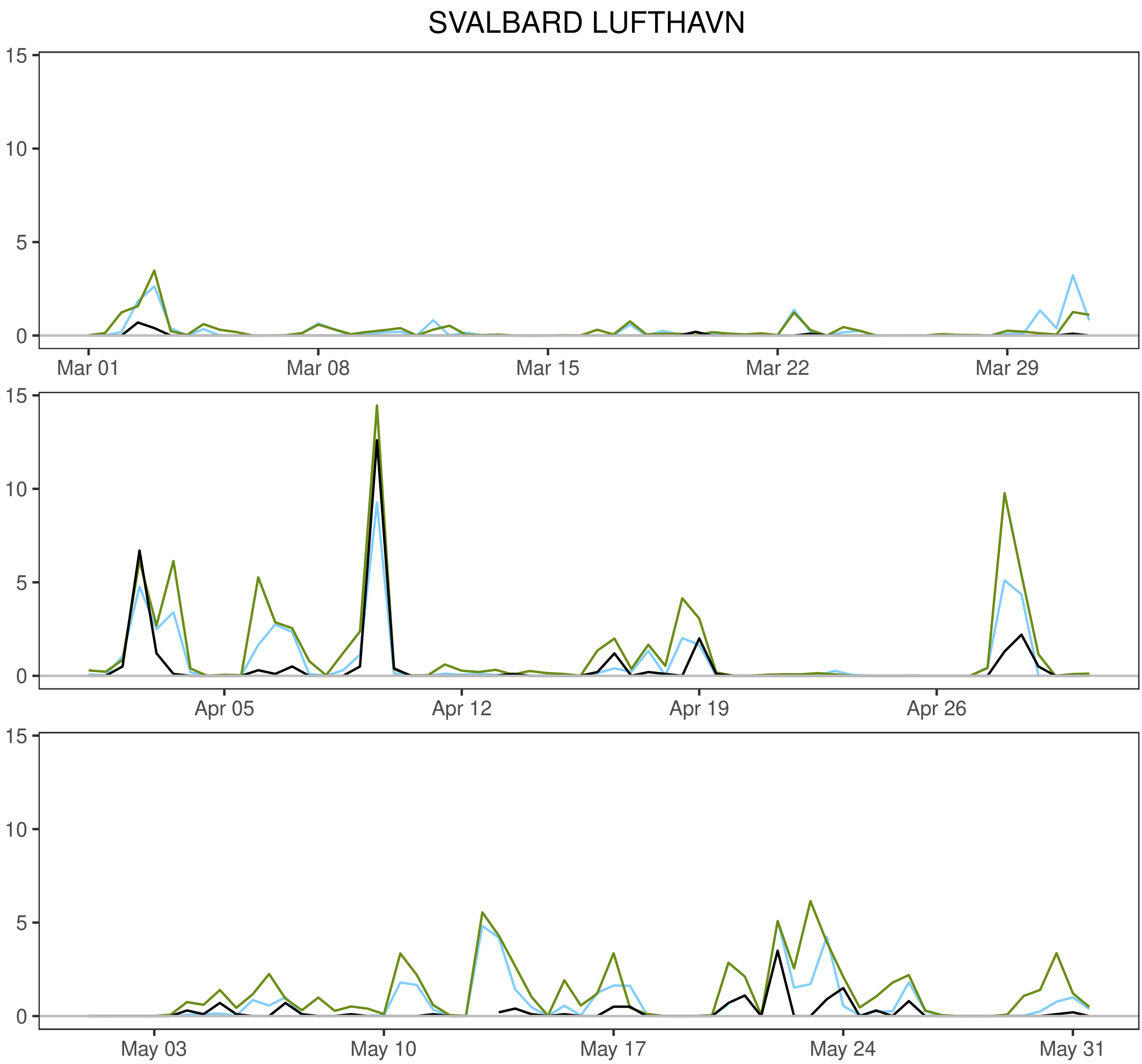
Model "climatology" 01.03.2023 – 31.05.2023

MEPSctrl 00+30

SDE at observing sites
(numbers in black)

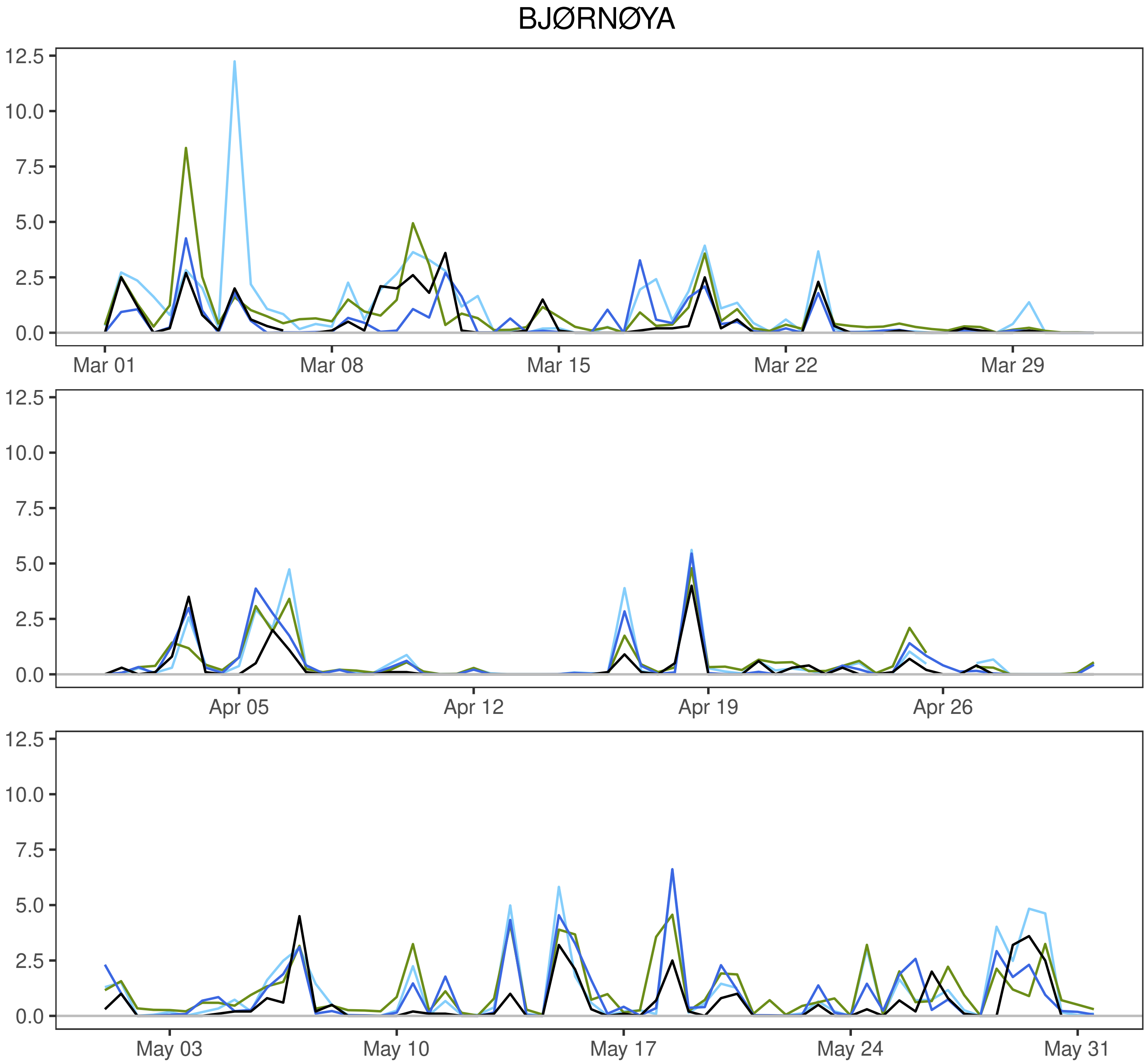


Model "climatology" 01.03.2023 – 31.05.2023



	Min	Mean	Max	Std	N
synop: 06,18	0.0	0.2	12.6	1.1	183
AA25: 12+18,+30	0.0	0.6	9.3	1.2	180
ECMWF: 12+18,+30	0.0	1.0	14.5	1.8	182

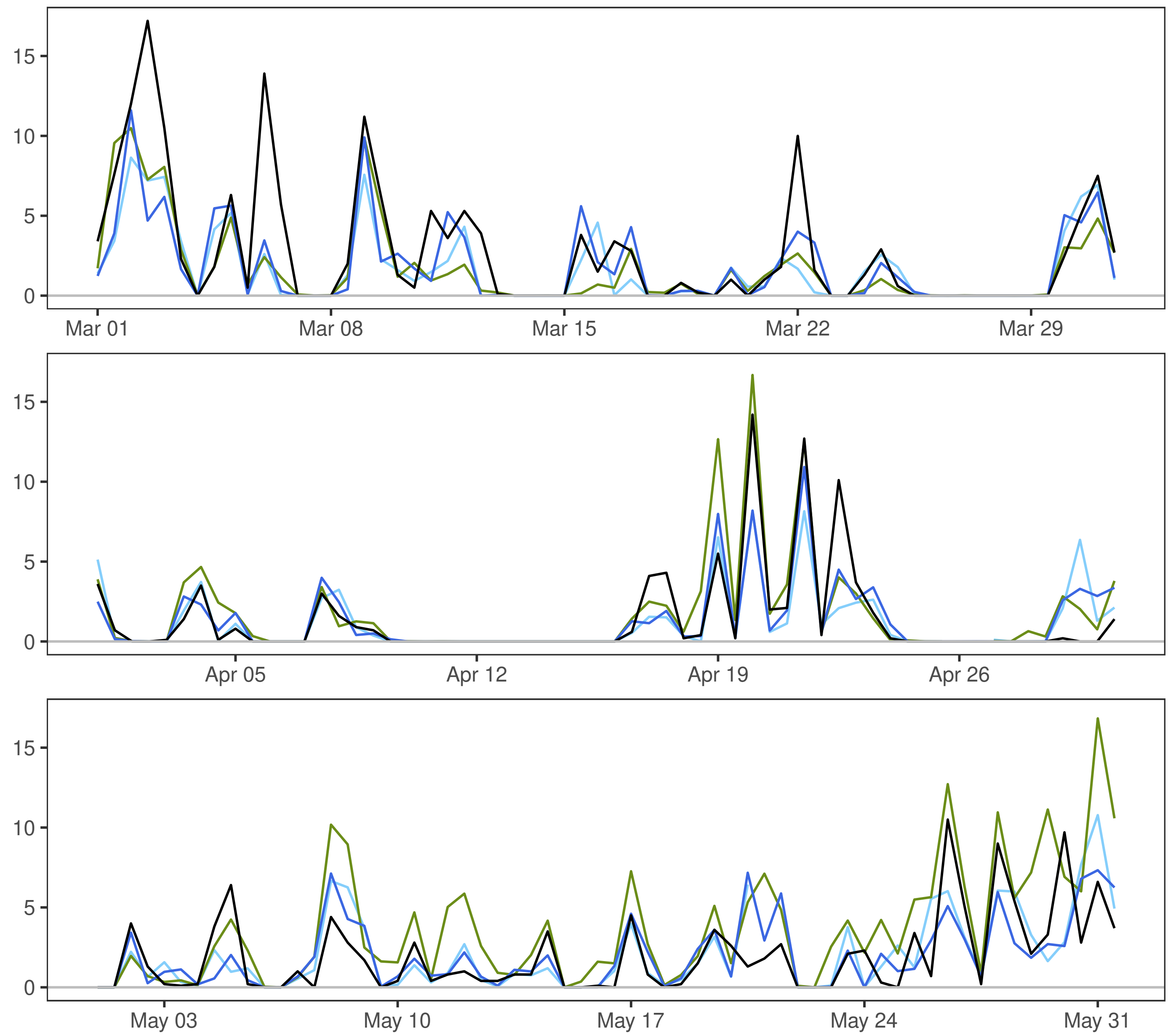
	ME	SDE	RMSE	MAE	Max.abs.err.	N
AA25−synop	0.3	0.8	0.9	0.4	4.0	179
ECMWF−synop	0.7	1.2	1.4	0.7	8.5	179



	Min	Mean	Max	Std	N
synop: 06,18	0.0	0.5	4.5	0.9	182
MEPSctrl: 12+18,+30	0.0	0.6	6.6	1.1	184
AA25: 12+18,+30	0.0	0.9	12.2	1.6	180
ECMWF: 12+18,+30	0.0	0.8	8.3	1.2	182

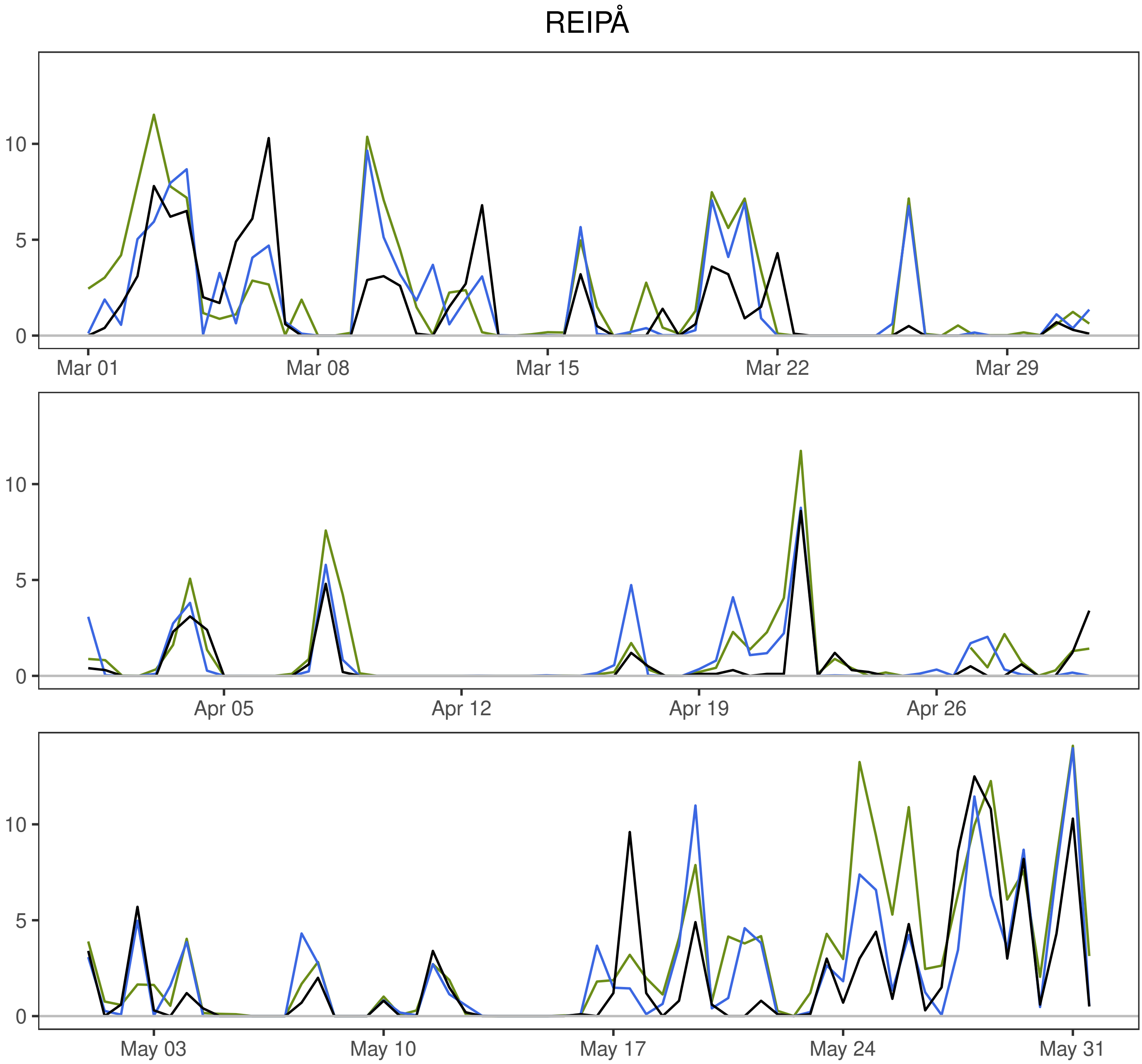
	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl−synop	0.2	0.9	0.9	0.5	4.1	178
AA25−synop	0.5	1.1	1.2	0.6	10.2	178
ECMWF−synop	0.4	0.9	1.0	0.6	5.6	178

TROMSØ



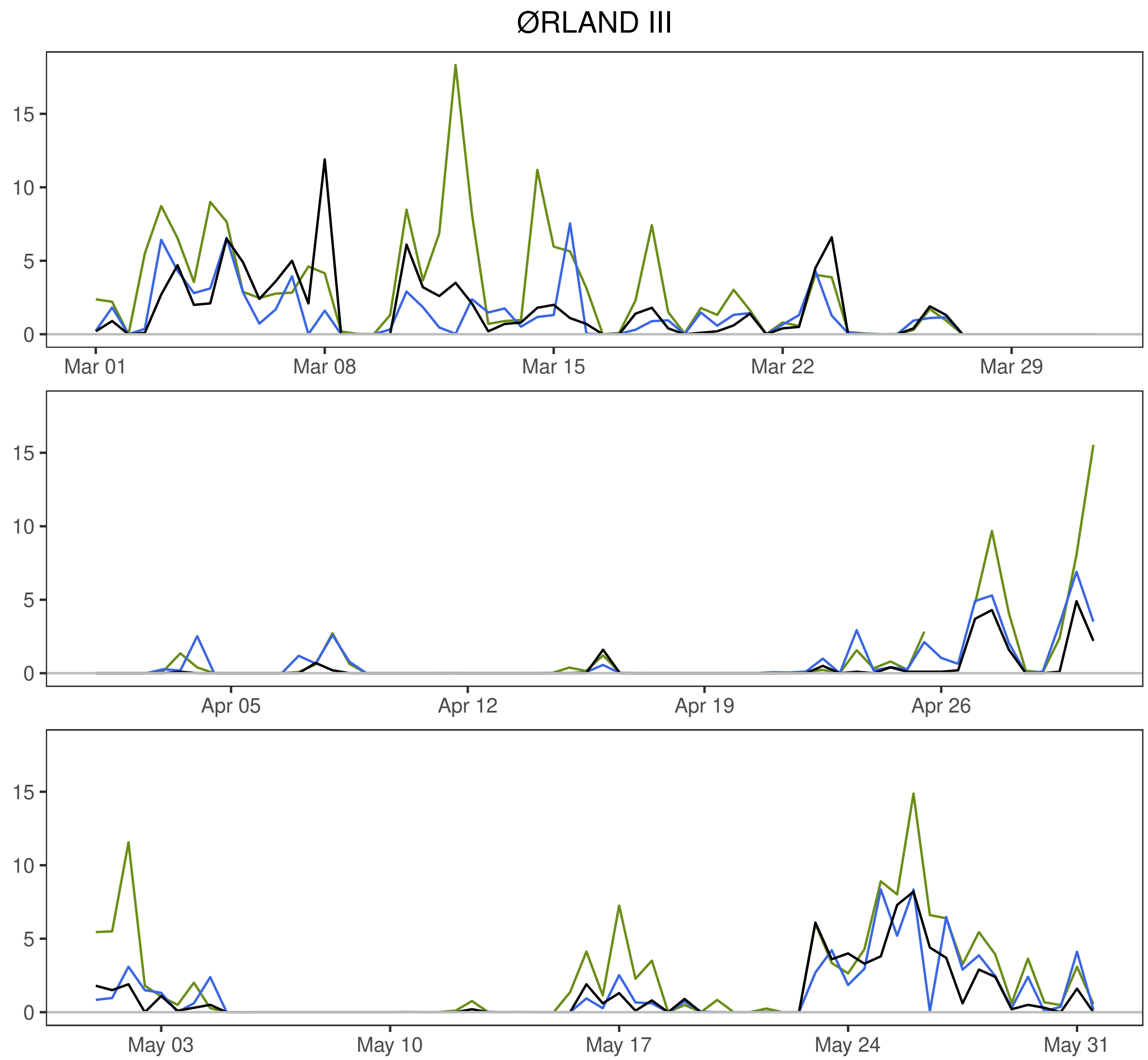
	Min	Mean	Max	Std	N
synop: 06,18	0.0	2.0	17.2	3.2	184
MEPSctrl: 12+18,+30	0.0	1.7	11.6	2.3	184
AA25: 12+18,+30	0.0	1.6	10.8	2.3	180
ECMWF: 12+18,+30	0.0	2.4	16.8	3.3	182

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl−synop	−0.3	2.2	2.2	1.2	12.5	180
AA25−synop	−0.4	2.3	2.3	1.2	11.3	180
ECMWF−synop	0.3	2.4	2.4	1.4	11.5	180



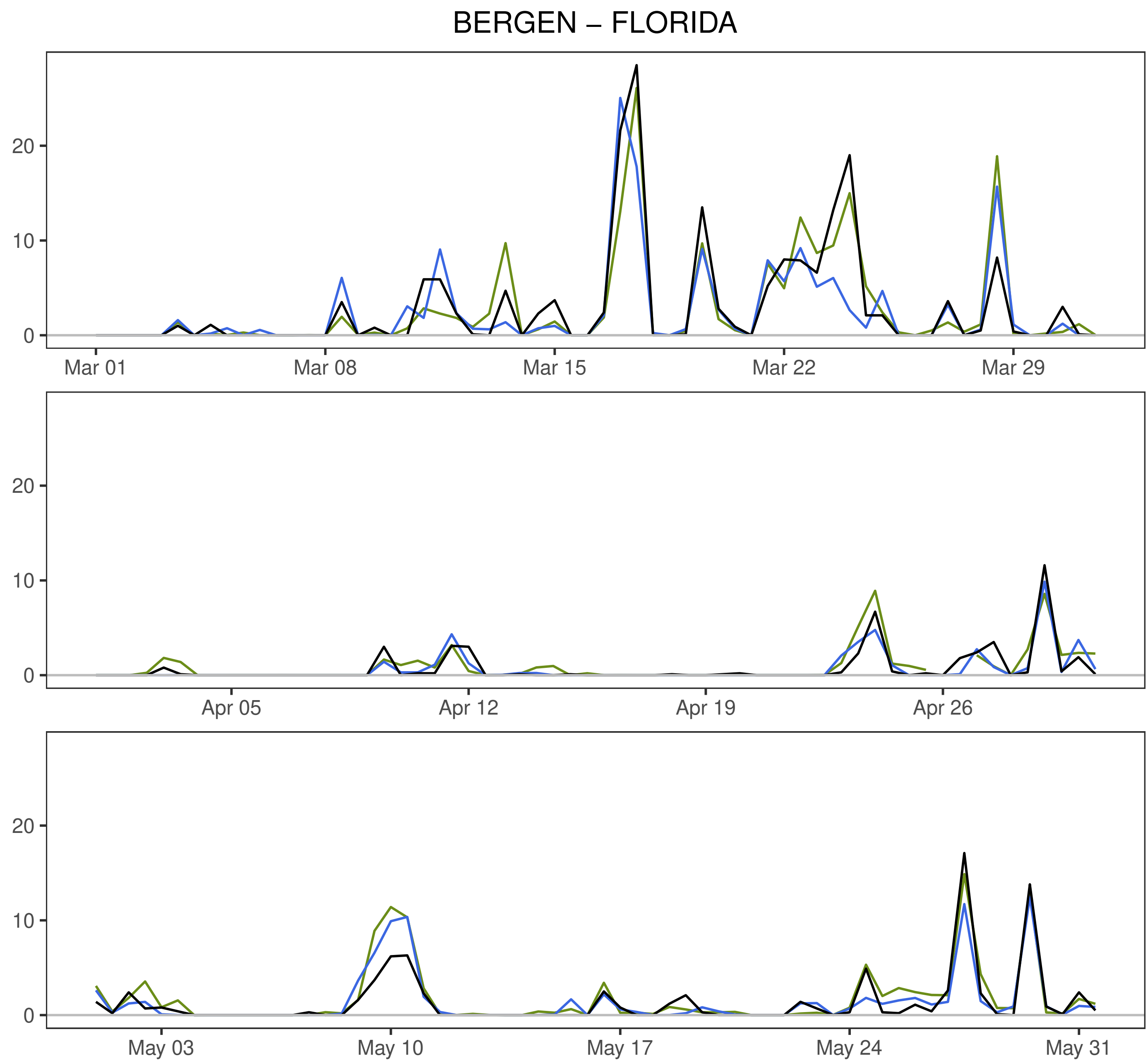
	Min	Mean	Max	Std	N
synop: 06,18	0.0	1.3	12.5	2.4	184
MEPSctrl: 12+18,+30	0.0	1.6	14.0	2.6	184
ECMWF: 12+18,+30	0.0	2.0	14.1	3.0	182

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl–synop	0.3	1.8	1.9	1.0	8.2	182
ECMWF–synop	0.7	2.1	2.2	1.2	10.2	182



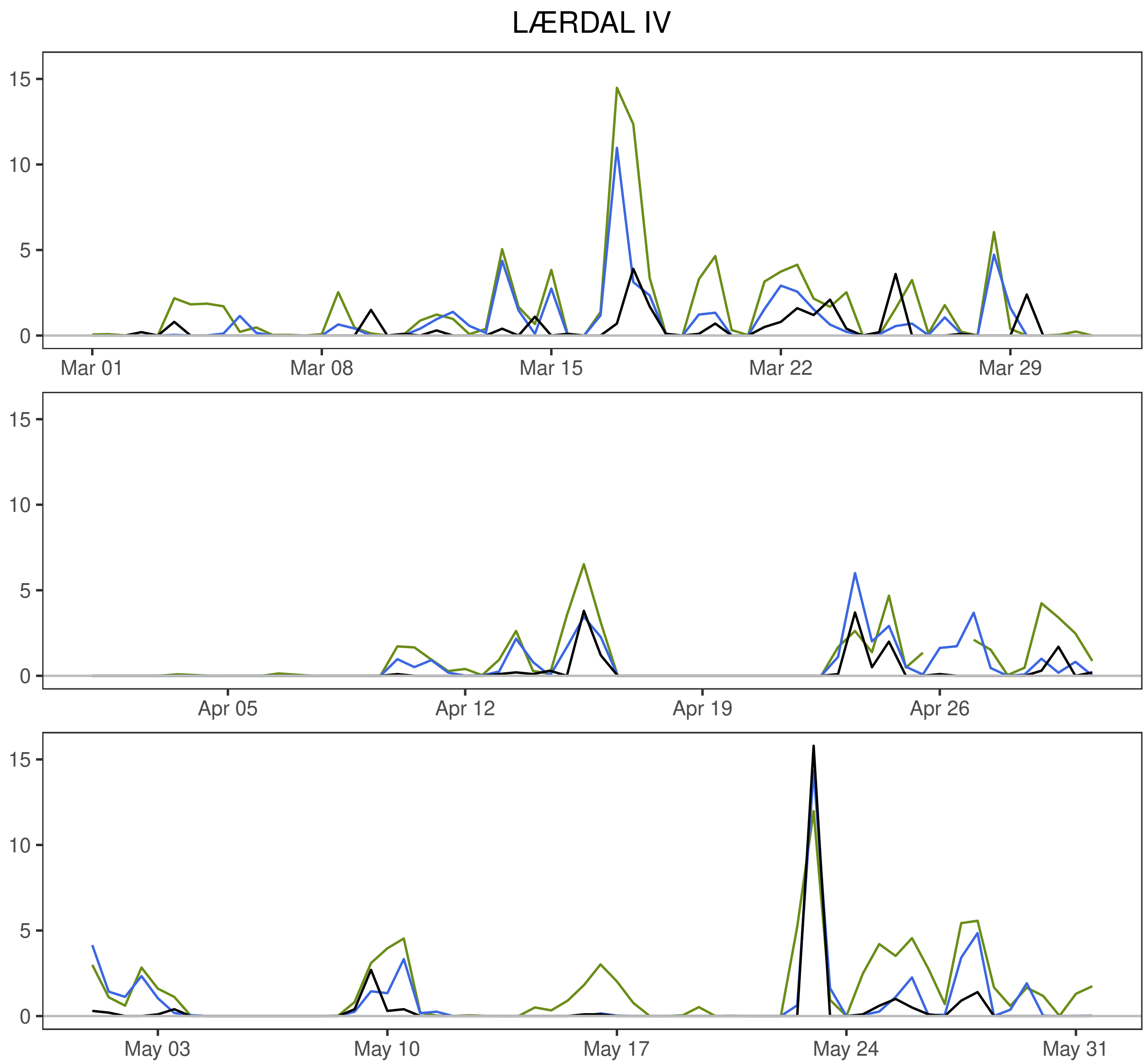
	Min	Mean	Max	Std	N
synop: 06,18	0.0	1.0	11.9	1.8	184
MEPSctrl: 12+18,+30	0.0	1.0	8.3	1.7	184
ECMWF: 12+18,+30	0.0	2.0	18.3	3.2	182

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl−synop	0.1	1.5	1.5	0.7	10.3	182
ECMWF−synop	1.0	2.4	2.6	1.2	14.8	182



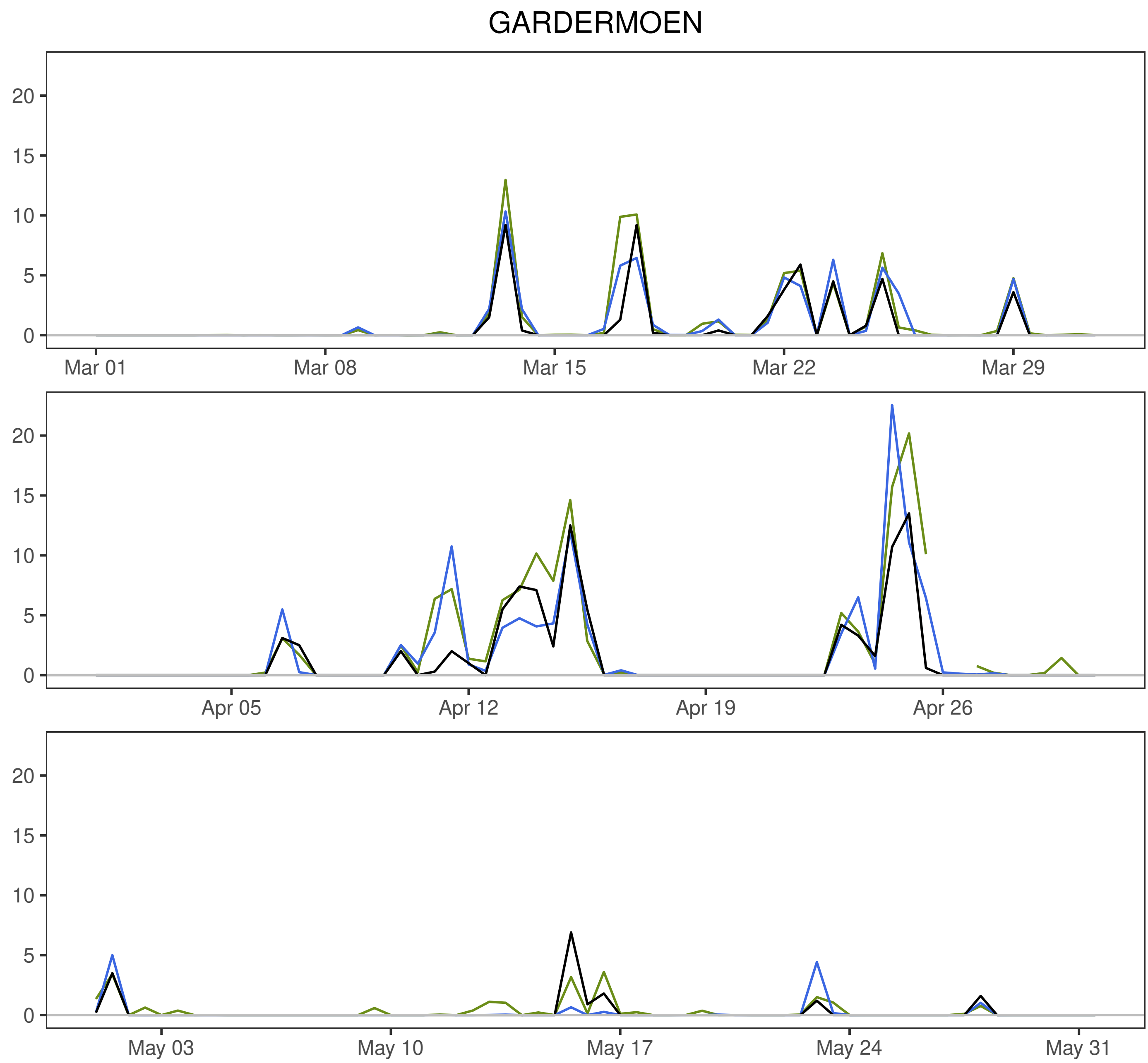
	Min	Mean	Max	Std	N
synop: 06,18	0.0	1.7	28.5	3.9	184
MEPSctrl: 12+18,+30	0.0	1.5	25.0	3.4	184
ECMWF: 12+18,+30	0.0	1.8	26.1	3.8	182

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl–synop	–0.1	2.0	2.0	0.9	16.3	182
ECMWF–synop	0.2	1.7	1.7	0.9	10.7	182



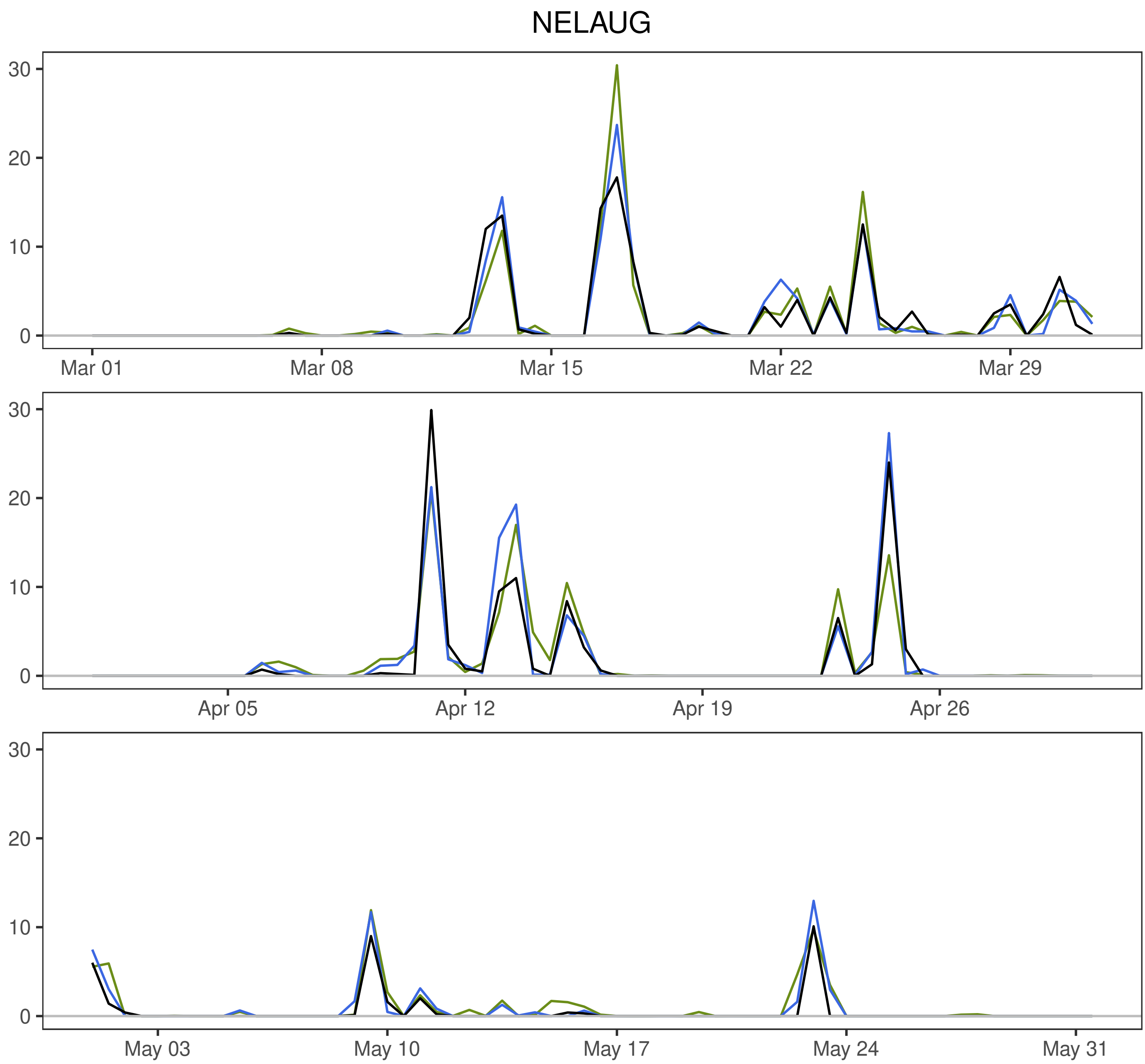
	Min	Mean	Max	Std	N
synop: 06,18	0.0	0.3	15.8	1.3	184
MEPSctrl: 12+18,+30	0.0	0.7	14.4	1.7	184
ECMWF: 12+18,+30	0.0	1.3	14.5	2.1	182

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl−synop	0.4	1.2	1.3	0.6	10.3	182
ECMWF−synop	0.9	1.8	2.0	1.1	13.8	182



	Min	Mean	Max	Std	N
synop: 06,18	0.0	0.8	13.5	2.2	184
MEPSctrl: 12+18,+30	0.0	1.0	22.5	2.7	184
ECMWF: 12+18,+30	0.0	1.2	20.2	3.1	182

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl−synop	0.2	1.5	1.5	0.5	11.8	182
ECMWF−synop	0.4	1.4	1.5	0.5	9.5	182



	Min	Mean	Max	Std	N
synop: 06,18	0.0	1.4	29.9	4.0	184
MEPSctrl: 12+18,+30	0.0	1.6	27.3	4.2	184
ECMWF: 12+18,+30	0.0	1.6	30.4	3.9	182

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl–synop	0.2	1.4	1.5	0.6	8.7	182
ECMWF–synop	0.2	1.8	1.9	0.7	12.6	182